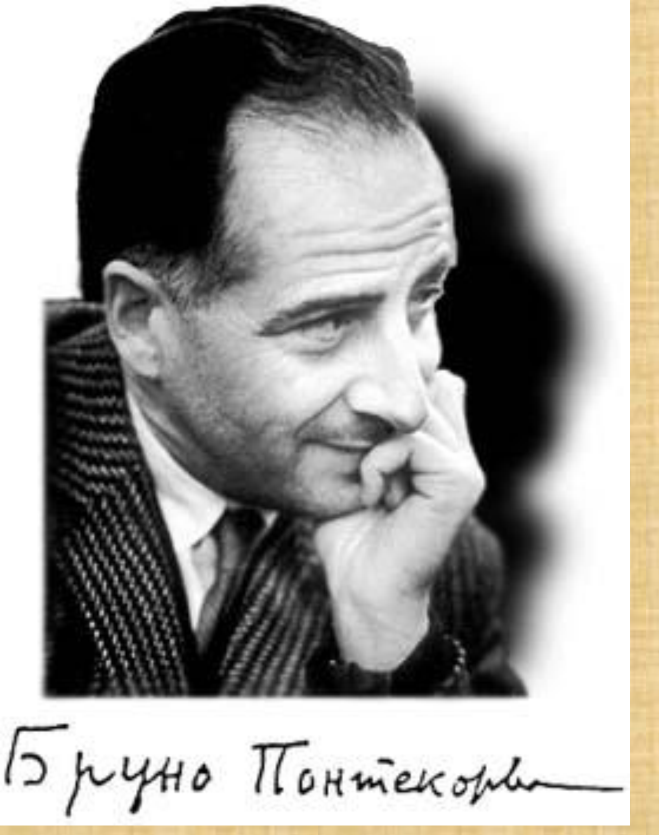
Bruno Maximovich Pontecorvo

i due quaderni di appunti durante il primo anno e mezzo di lavoro a Dubna

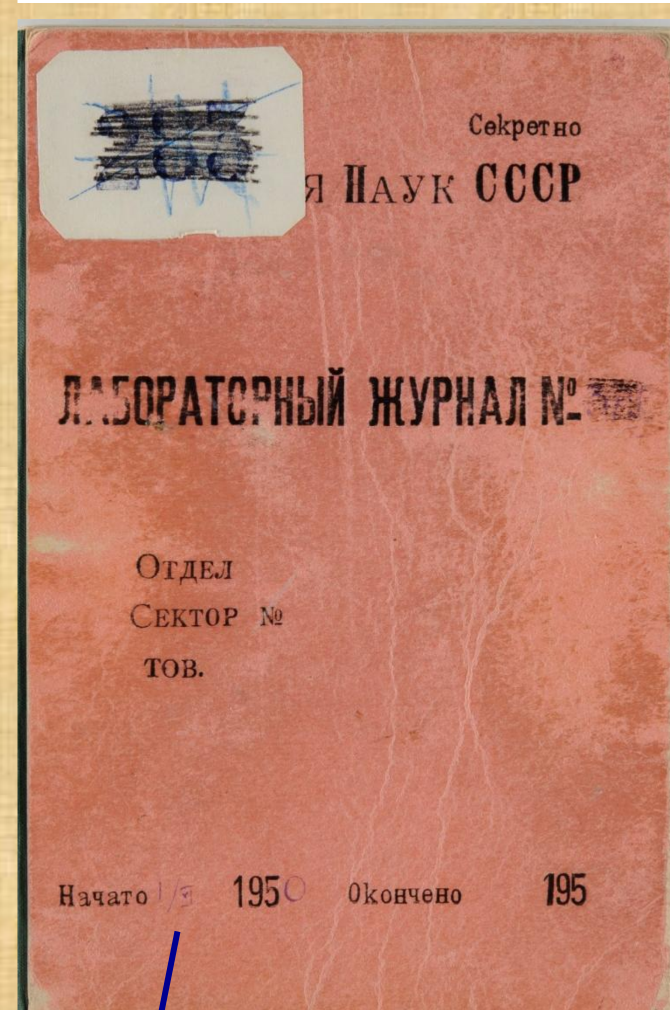


SIF – Pisa
25 Settembre 2014

Gloria Spandre
Rino Castaldi
INFN-Pisa

I/XI 1950 Primo Quaderno: da 01/11/1950 a ≤ 30/11/1950

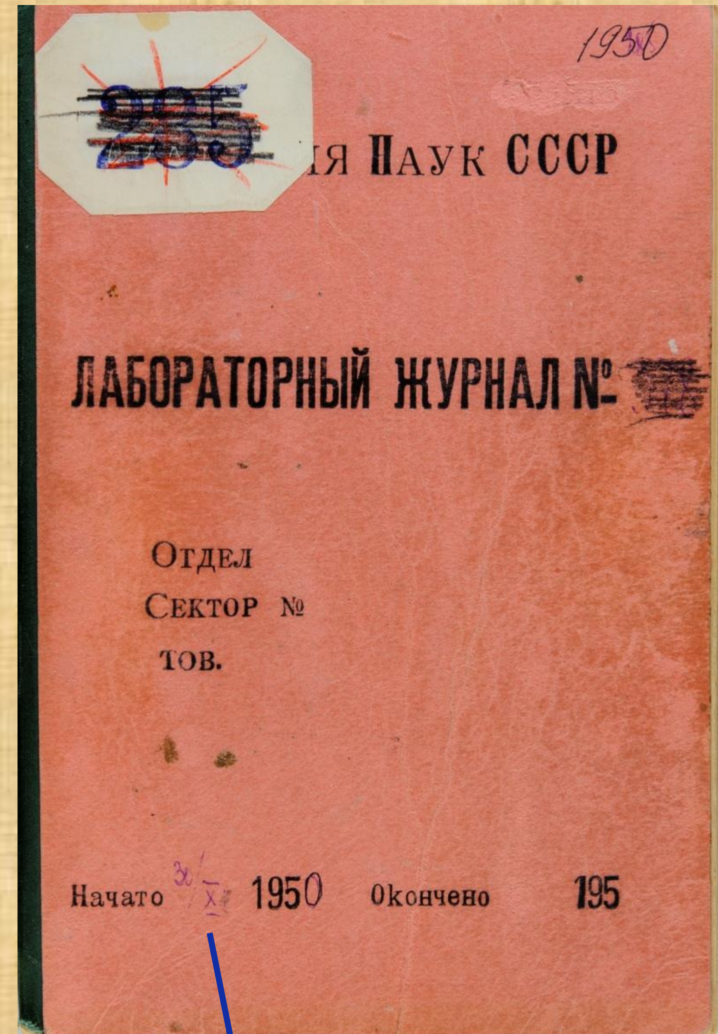
da 14/09/1950 a ≥ 24/03/1952

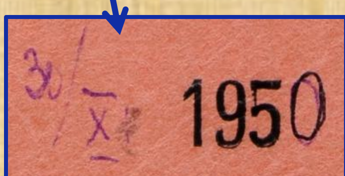


Lo scorso anno, nel centenario della nascita di Bruno Pontecorvo,abbiamo avuto, grazie al figlio Gil, un quaderno inedito di appunti che lo scienziato scrive di proprio pugno in lingua inglese nel suo primo anno e mezzo di attività di ricerca presso il Laboratorio di Problemi Nucleari di Dubna. La copertina e la prima pagina del quaderno riportano la data del primo novembre 1950, proprio il giorno in cui Pontecorvo inizia il suo lavoro al Laboratorio di Dubna.

Pontecorvo dopo solo nove pagine smette di scivere i suoi appunti su questo quaderno per poi riprendere a scrivervi dall'ultima pagina, capovolgendolo, solo l'anno seguente, il 14 settembre 1951.

30/XI 1950 Secondo quaderno: da 30/11/1950 a ≥ 18/07/1951





Cosa ha fatto Pontecorvo dal novembre 1950 al settembre1951 e perché ha smesso di scrivere su questo primo quaderno solo pochi giorni dopo aver iniziato a lavorare al sincrotrone di Dubna?
Con l'aiuto del figlio Gil siamo riusciti a ritrovare un secondo quaderno in cui viene descritta la sua attività di ricerca durante i mesi mancanti nel primo quaderno.
La copertina riporta la data del 30 novembre 1950 mentre l'ultima data che si trova scritta sul quaderno è quella del 18 luglio 1951, nove pagine prima della fine del quaderno.

Attraverso la preziosa documentazione di questi due quaderni inediti (anche se, come vedremo, Pontecorvo molto spesso più che scriverci ci scarabocchia formule, numeri e grafici disordinati) abbiamo potuto ricostruire gli interessi scientifici, il lavoro sperimentale, la personalità e anche alcune grandi intuizioni che questo grande scienziato ha avuto nel suo primo anno e mezzo di permanenza in Russia.

… Ma procediamo con ordine …

Chi è Bruno Pontecorvo come uomo e come scienziato quando, nel settembre del 1950 all'età di 37 anni decide di abbandonare tutto per andare a vivere in Russia?

Quali sono i motivi per cui prende questa drastica decisione? decisione che cambierà irrevocabilmente non solo tutta la sua vita ma anche quella della moglie e dei figli.

Persona che crede fermamente nel Comunismo

Bruno Pontecorvo è un comunista convinto che crede in una società socialista ispirata ad un profondo senso di giustizia e di eguaglianza:

Scrive in una nota autobiografica del 1988: *"Le mie opinioni politiche sono di sinistra. In origine esse erano dovute soprattutto al mio odio per il fascismo e, io penso ora, al senso di giustizia inculcatomi da mio padre....., opinioni dominate da una categoria non logica che io chiamo adesso "religione", una specie di "credo fanatico"....."*

Un fisico sia sperimentale che teorico con idee geniali

Nel 1934 Bethe e Peierls avevano valutato che i neutrini potevano penetrare ben 10^{+16} Km (~1000 anni luce) di materia solida prima di interagire, e pertanto concludevano che: *"it is therefore absolutely impossible to observe processes of this kind with neutrinos created in nuclear trasformations".*

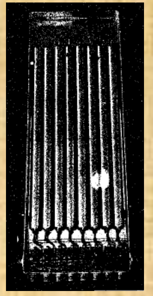
Pontecorvo nel 1945 propone di rivelare i neutrini con la reazione $\nu + {}^{37}Cl_{17} \rightarrow {}^{37}Ar_{18} + e^-$.

È un'idea geniale che solo dopo molti anni verrà ripresa e messa in pratica da altri che per questo otterranno il premio Nobel.

Subito dopo l'esperimento di Conversi, Pancini e Piccioni e l'interpretazione datane da Fermi,Teller and Weisskopf, Pontecorvo scrive nel suo famoso articolo del '47: *"there exists fundamental analogy between β-processes and processes of emission and absorbtion of charged mesons ".*

Per primo concepisce l'universalità muone-elettrone nelle interazioni deboli !

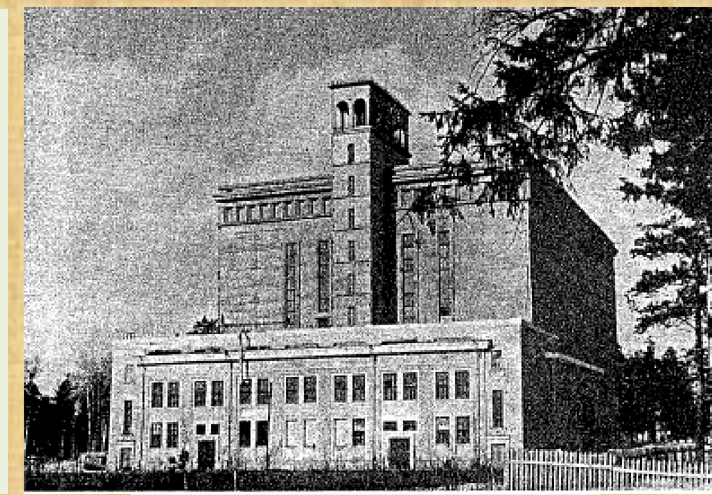
Quando nel '50 arriva in Russia ha appena pubblicato un articolo di rivista (*"Recent development in proportional counter technique)* sui rivelatori a gas proporzionali con alta amplificazione; rivelatori non molto diversi dai moderni rivelatori a gas che si usano tutt'oggi. Con essi ha studiato le proprietà fondamentali del μ e del suo decadimento: *la particella carica nel decadimento è un elettrone; è cinematicamente consistente con un decadimento in un elettrone e due neutrini; non si osservano decadimenti* $\mu \rightarrow e+\gamma$



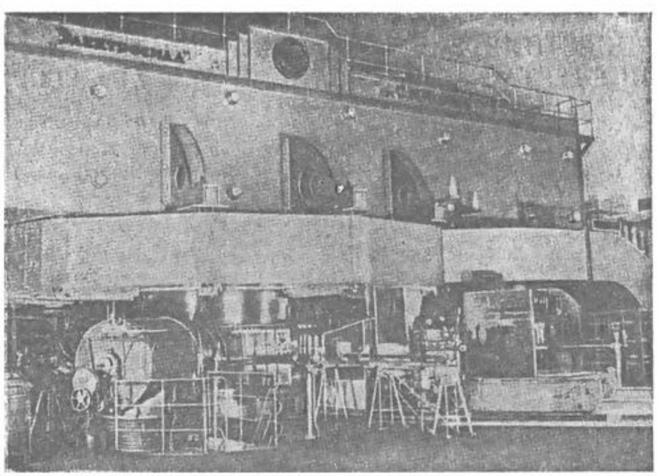
Una nuova vita e nuovi esperimenti a Dubna

Sicuramente Bruno Pontecorvo deve essere stato entusiasta di arrivare allo “Institute of Nuclear Problems” di Dubna all’inizio di Novembre 1950, dove poteva lavorare al sincrociclotrone dell’istituto che all’epoca era il più potente del mondo e per di più vivere in una società che proclamava di voler realizzare il vero comunismo.

La sua fama di geniale discepolo di Fermi lo precede e suscita grande entusiamo tra i fisici del Laboratorio. È abitudine anche tra colleghi del laboratorio chiamarsi col nome seguito dal patronimico e risulta quindi a tutti molto imbarazzante chiamarlo semplicemente Bruno, il suo solo nome di battesimo. Il padre di Bruno si chiamava Massimo per cui decisero di chiamarlo Bruno Maximovich, nome che gli rimase per sempre.



Edificio del sincrociclotrone



Il sincrociclotrone

	Kind of accelerated particles and their energy		
	280 MeV deuterons	560 MeV α’s	480 MeV protons
Internal target current (μA)	1	0,025	0,2—0,3
Extracted proton flux at a distance of 10 m from the magnetic channel ($cm^{-2}\ sec^{-1}$)	—	—	$1\cdot 10^{8}$ (E_p = 460 MeV)
Neutron flux at the maximum of the angular distribution 2 m from the internal target ($cm^{-2}\ sec^{-1}$)	$8\cdot 10^{7}$	$2\cdot 10^{5}$	$5\cdot 10^{6}$
Neutron energy at the maximum of the energy distribution (MeV)	120	120	380
Halfwidth of the angular neutron distribution (radian)	0,17	0,35	0,55
Process responsible for neutron production	Stripping	α-particle disintegration	charge exchange

Parametri dei fasci disponibili nel 1950

I/XI 1950 Primo Quaderno: da 01/11/1950 a $\leq$ 30/11/1950
da 14/09/1951 a $\geq$ 24/03/1952

1/11/1950: Pontecorvo inizia il suo lavoro di ricerca presso il sincrociclotrone dello "Institute of Nuclear Problems" di Dubna. La segretezza è rigorosa: non si può prendere appunti e scrivere formule se non su un quaderno ufficiale che viene riconsegnato a fine giornata e controllato periodicamente dalle autorità.

Questa è la foto del primo quaderno di appunti dove Pontecorvo annota giornalmente la sua attività scientifica presso il sincrociclotrone di Dubna a partire dal suo primo giorno di lavoro.

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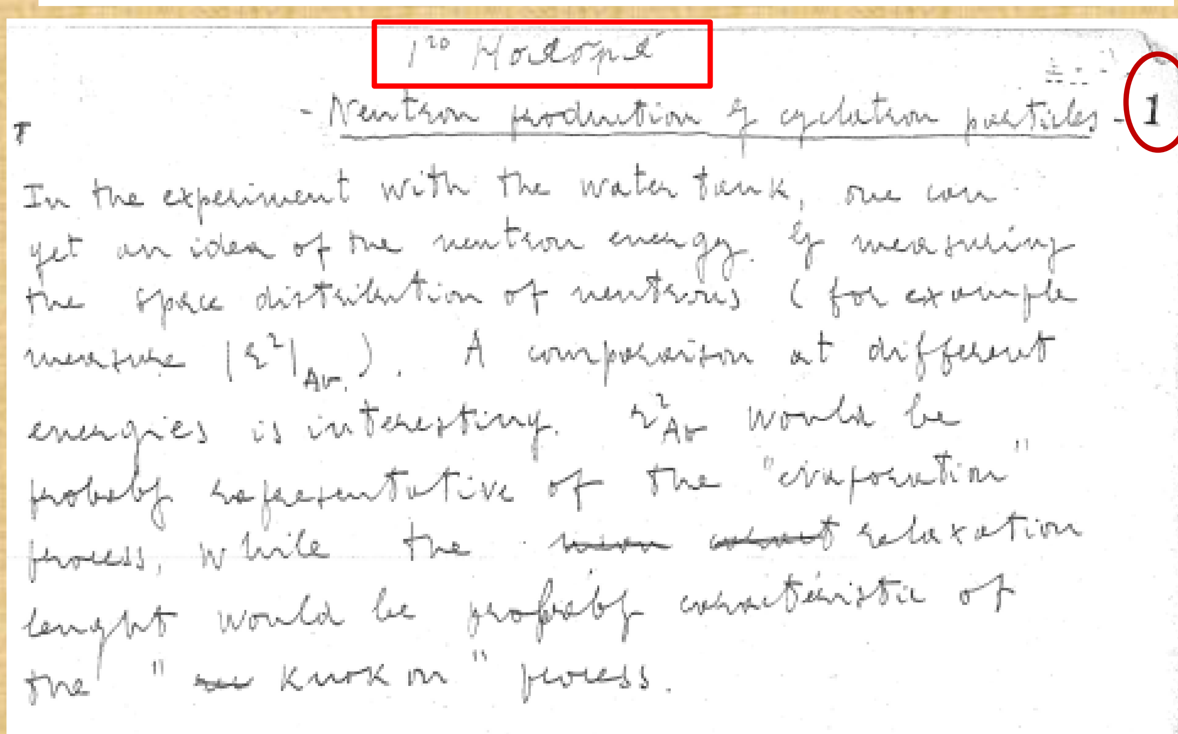
Pagina 1 del primo quaderno

Pontecorvo è subito interessato alla possibilità che offre il sincrotrone di produrre fasci di neutroni; immediatamente propone un metodo per stimarne la distribuzione in energia.

1 Novembre (1950)

- Neutron production by cyclotron particles -



- Neutron production by cyclotron particles - 1

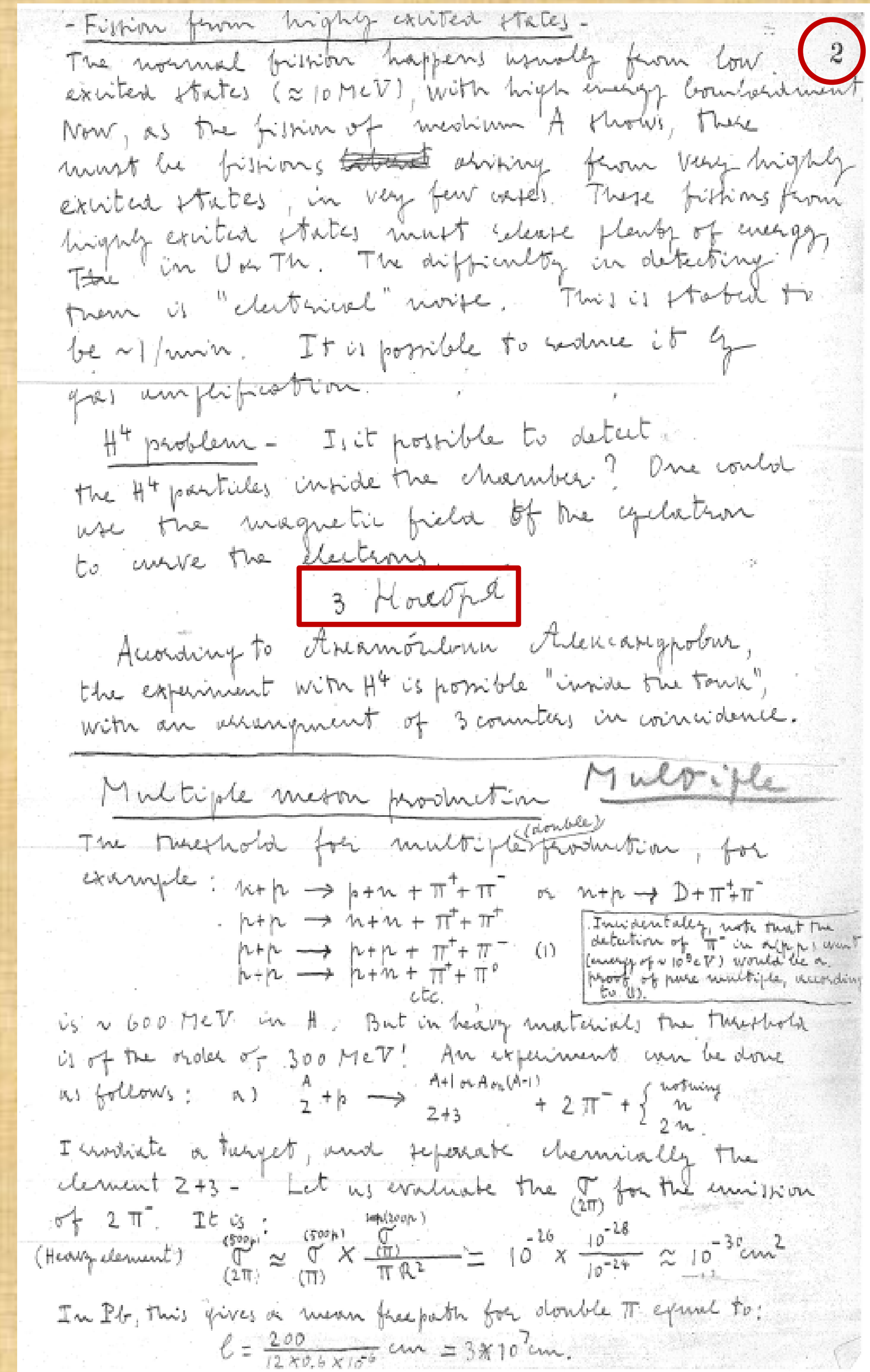
In the experiment with the water tank, one can get an idea of the neutron energy by measuring the space distribution of neutrons (for example measure $(r^2)_{Av.}$). A comparison at different energies is interesting. r^2_{Av} would be probably representative of the "evaporation" process, while the ~~mean~~ ~~about~~ relaxation lenght would be probably characteristic of the "knock on" process.

"In the experiment with the water tank, one can get an idea of the neutron energy by measuring the space distribution of neutrons (for example measure $r^2|_{Av.}$)."

(I neutroni sono prodotti a partire da un fascio di particelle α accelerate a 560 MeV e fatte collidere su una targhetta interna. Pertanto la loro distribuzione in energia non è conosciuta).

Pagina 2: *3 Novembre (1950)*

Pontecorvo scrive nel quaderno le sue idee su quali siano gli esperimenti interessanti da fare con questo acceleratore e quali siano le tecniche e i rivelatori più idonei per realizzarli


- Fission from highly excited states -
The normal fission happens usually from low excited states (≈ 10 MeV), with high energy bombardment. Now, as the fission of medium A shows, there must be fissions ~~[illegible]~~ arising from very highly excited states, in very few cases. These fissions from highly excited states must release plenty of energy, ~~The~~ in U or Th. The difficulty in detecting them is "electrical" noise. This is stated to be ~1/min. It is possible to reduce it by gas amplification.

H^4 problem - Is it possible to detect the H^4 particles inside the chamber? One could use the magnetic field of the cyclotron to curve the electrons.

3 Ноября

According to Анатолий Александрович, the experiment with H^4 is possible "inside the tank", with an arrangement of 3 counters in coincidence.

Multiple meson production   Multiple

The threshold for multiple (double) production, for example: $n+p \rightarrow p+n+\pi^+ + \pi^-$ or $n+p \rightarrow D+\pi^+ + \pi^-$

$p+p \rightarrow n+n+\pi^+ + \pi^+$

$p+p \rightarrow p+p+\pi^+ + \pi^-$ (1)

$p+p \rightarrow p+n+\pi^+ + \pi^0$

etc.

Incidentally, note that the detection of π^- in p,p (energy of ~10^8 eV) would be a proof of pure multiple, according to (1).

is ~ 600 MeV in H. But in heavy materials the threshold is of the order of 300 MeV! An experiment can be done as follows: a) $^{A}_{Z} + p \longrightarrow {}^{A+1 \text{ or } A \text{ or } (A-1)}_{Z+3} + 2\pi^- + \{\text{nothing}, n, 2n\}$

Irradiate a target, and separate chemically the element Z+3. Let us evaluate the $\sigma_{(2\pi)}$ for the emission of $2\pi^-$. It is:

(Heavy element) $\sigma^{(500p)}_{(2\pi)} \approx \sigma^{(500p)}_{(\pi)} \times \frac{\sigma^{H(200p)}_{(\pi)}}{\pi R^2} = 10^{-26} \times \frac{10^{-28}}{10^{-24}} \approx 10^{-30}\ cm^2$

In Pb, this gives a mean free path for double π equal to: $l = \frac{200}{12 \times 0.6 \times 10^{-6}}$ cm $= 3 \times 10^7$ cm.

- Fission from highly excited states -

……… The difficulty in detecting them is "electrical" noise. This is stated to be ~1/min. It is possible to reduce it by gas amplification

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3th November

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Multiple meson production

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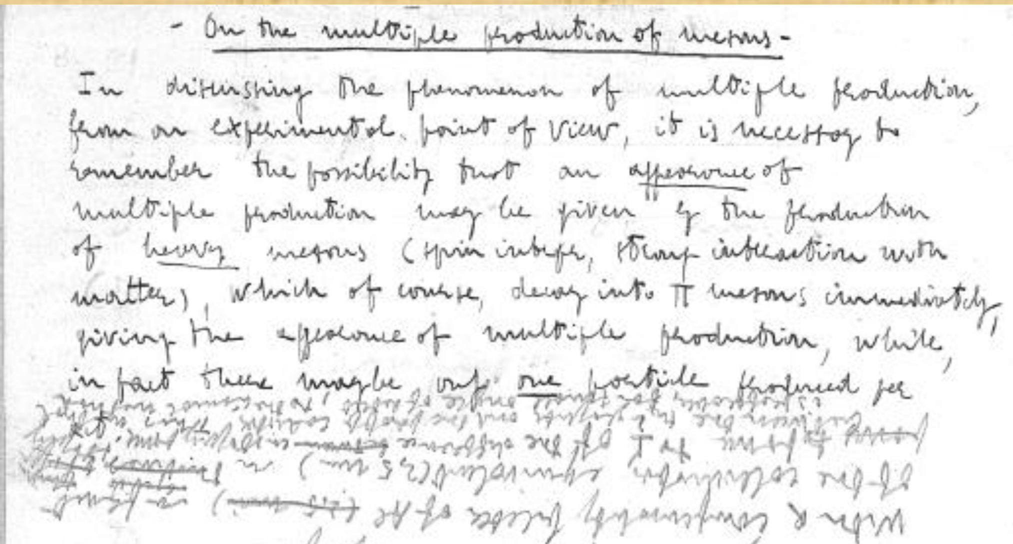
$p+p \rightarrow p+n+\pi^+ + \pi^0$

etc.

is ~ 600 MeV in H. But in heavy material the threshold is of the order of 300 MeV. An experiment can be done as follows: ……..

A pagina 9 Pontecorvo scrive un ultimo breve commento “On the multiple production of mesons”. Nella restante parte della pagina c’è scritto, in senso capovolto, il un draft di un articolo.


- On the multiple production of mesons -

In discussing the phenomenon of multiple production, from an experimental point of view, it is necessary to remember the possibility that an appearance of multiple production may be given by the production of heavy mesons (spin integer, strong interaction with matter), which of course, decay into π mesons immediately, giving the appearance of multiple production, while, in fact there maybe only one particle produced per

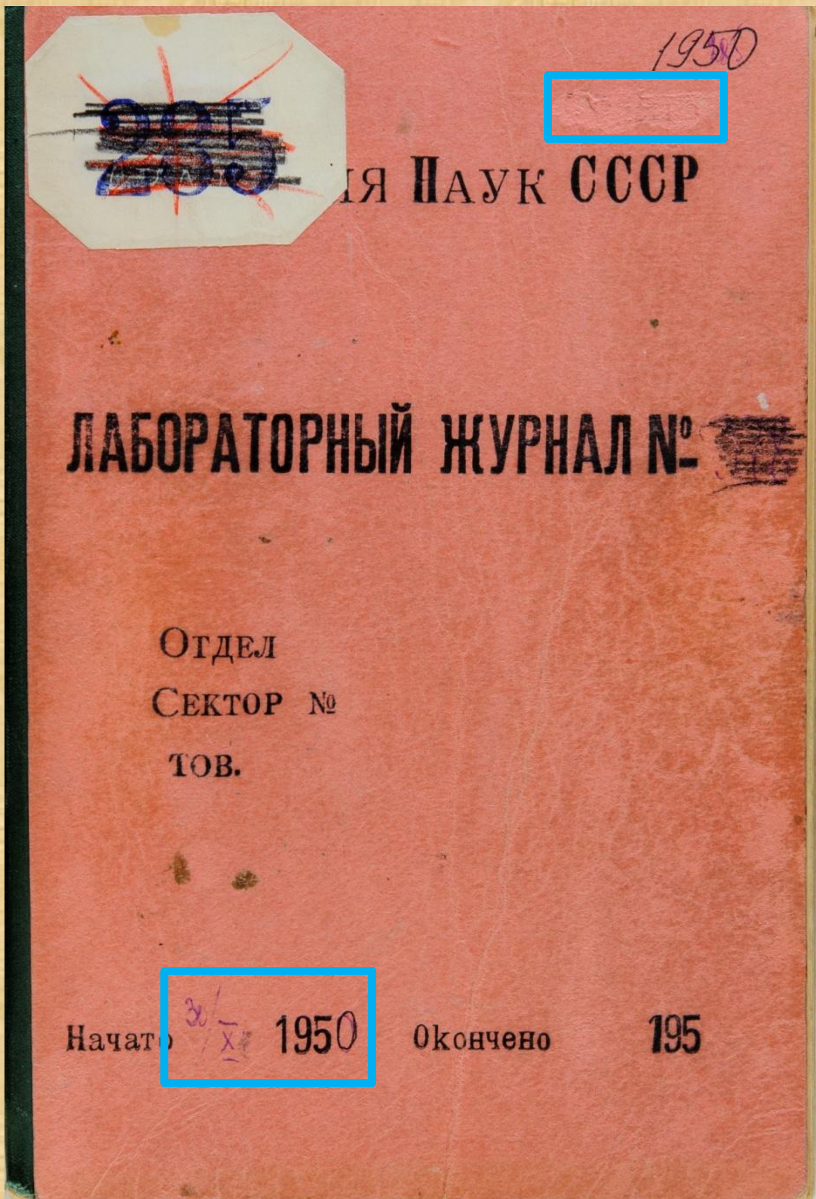
-*__On the multiple production of mesons__* –

In discussing the phenomenon of multiple production , from an experimental point of view, it is necessary to remember the possibility that an <u>appearance</u> of multiple production may be given by the production of <u>heavy</u> mesons (spin integer, strong interaction with matter), which of course decay into π mesons immediately , giving the appearance of multiple production, while, in fact there maybe only one particle produced per hit.

…. with a compensating filter of Al ~~(2.5cm)~~ in front of the collimator, equivalent (2.5cm) in…This method is preferable for small angle of detect(ion) to the ……(?) method .

Dopo le prime 9 pagine Pontecorvo smette di scrivere su questo quaderno e riprende a scriverci il 14 settembre del 1951 girando il quaderno e iniziando dall’ultima pagina.
Nelle pagine successive, e fino alla fine del quaderno senza ulteriori interruzioni, descrive l’attività scientifica sua e del suo gruppo riportando giornalmente i progressi di questo e di altri successivi esperimenti, annotando i conteggi della presa dati e delle misure effettuate, commentando i risultati delle analisi dei dati raccolti e scrivendo infine le bozze dei relativi articoli che verranno poi pubblicati in russo come report interni del laboratorio.
L’ultima data che si trova sul quaderno è quella del 24 marzo 1952, poche pagine prima che termini il quaderno completando di scrivere questa pagina, la numero 9, che come abbiamo detto, aveva parzialmente scritto nel novembre del 1950.
Pontecorvo sta qui finendo di scrivere il draft dell’esperimento *__Production of neutral mesons by neutrons.__* Queste ultime righe riguardano le misure del flusso del fascio di neutroni.

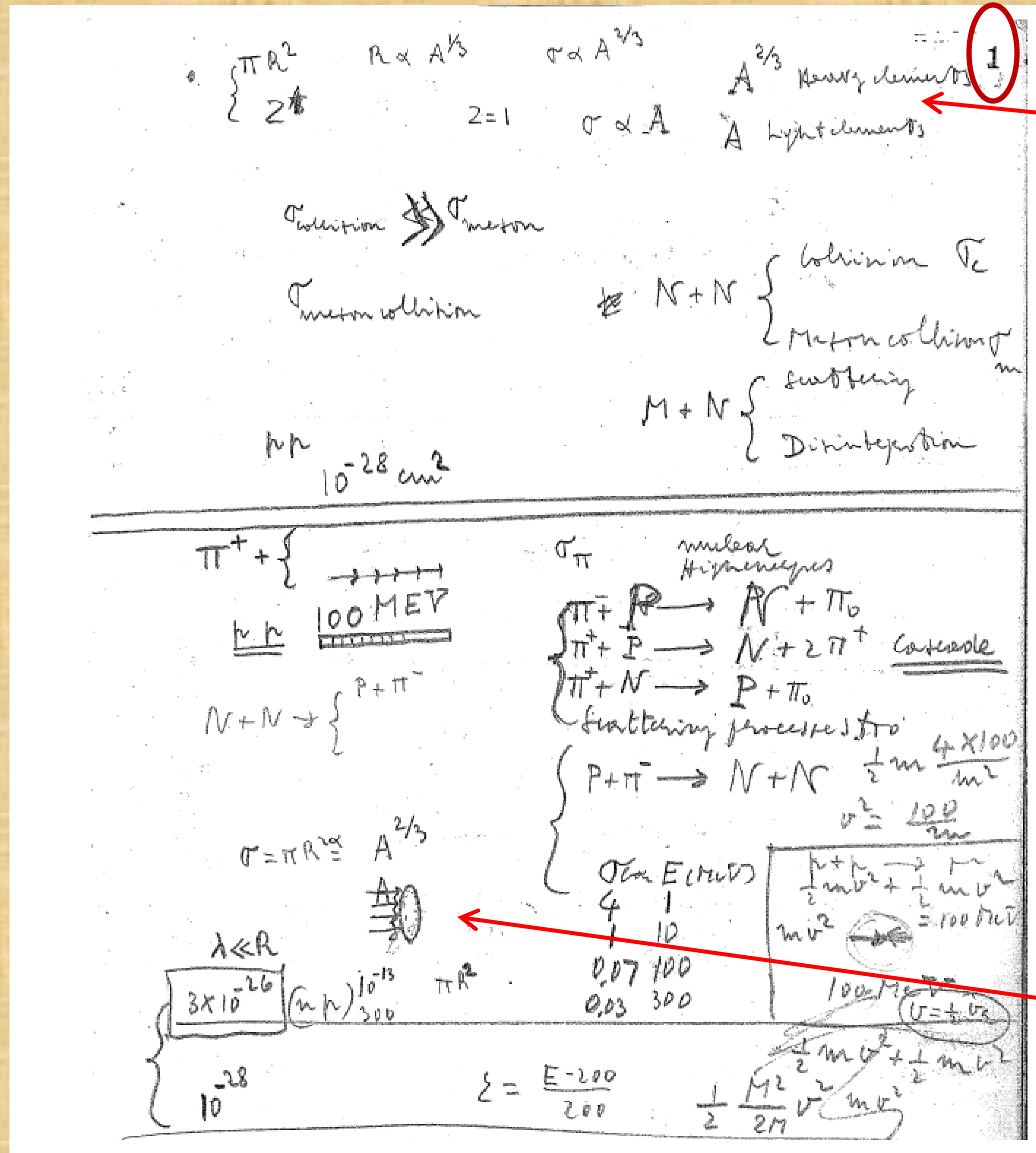
30/XI 1950 Secondo quaderno: da 30/11/1950 a ≥ 18/07/1951

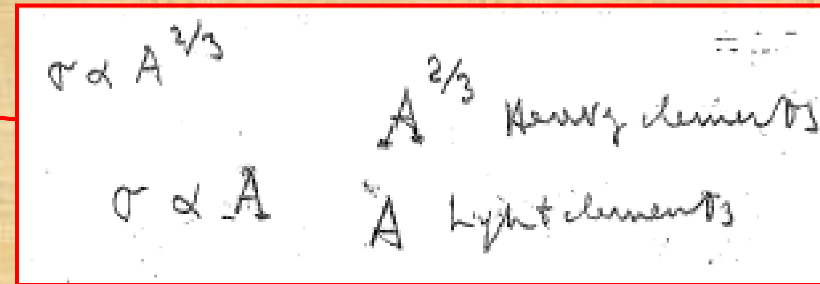


In questo secondo quaderno, sulla cui copertina è riportata la data del 30 Novembre 1950, Pontecorvo continua ad annotare idee, calcoli, misure e appunti di varia natura su possibili esperimenti da fare con il sincrociclotrone dello "Institute of Nuclear Problems" di Dubna.

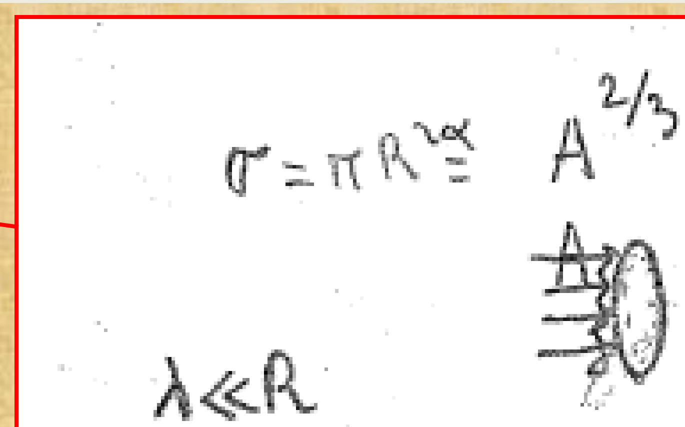
Per qualche strano motivo Pontecorvo dopo aver scritto solo nove pagine di appunti sul primo quaderno, alla fine di Novembre del 1950 inizia a scrivere su un nuovo quaderno identico al primo in cui approfondisce e comincia a mettere in pratica alcune delle idee a cui aveva accennato nelle prime pagine del primo quaderno. Si noti che la parola Секретно (Segreto) in alto a destra è stata cancellata; probabilmente è avvenuto successivamente quando queste ricerche sono diventate non più segrete o forse (ma questa è solo una mia fantasia) è stato lo stesso Pontecorvo a farlo ed è proprio questo il motivo per cui cambia quaderno quasi subito: non vuole un quaderno ufficiale ma solo un brogliaccio.

Pagina 1 del secondo quaderno

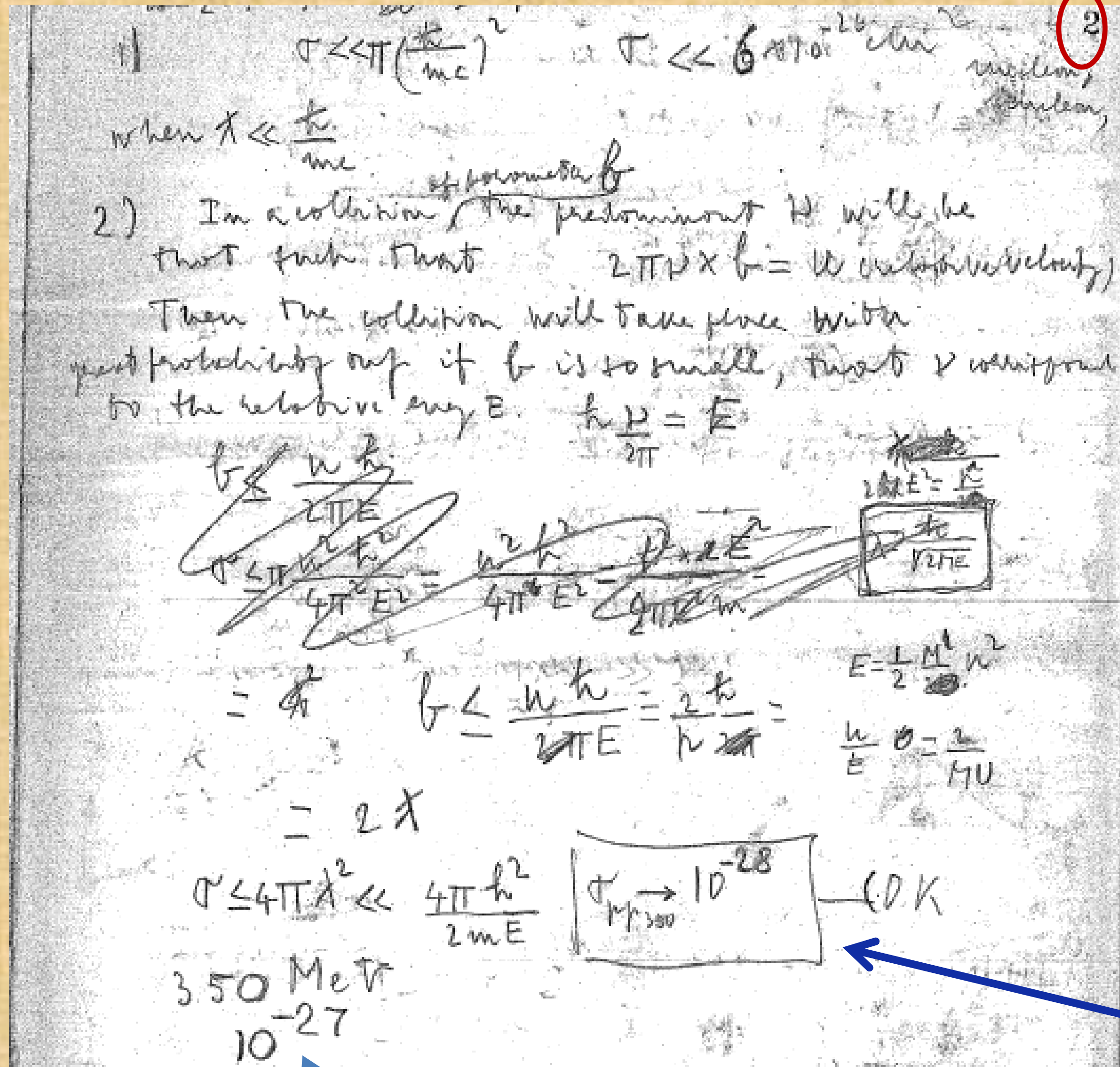




Pontecorvo inizia il quaderno valutando con considerazioni di tipo geometrico l'ordine di grandezza delle sezioni d'urto totale e di produzione di mesoni nell'urto nucleone-nucleone e nucleone-nuclei.



Pagina 2 del secondo quaderno



1) $\sigma \ll \pi \left(\frac{\hbar}{mc}\right)^2$ $\sigma \ll 6 \times 10^{-26}$ cm² nucleon, nucleon,

when $\lambda\!\!\!^- \ll \frac{\hbar}{mc}$

2) In a collision of parameter b the predominant ν will be that such that $2\pi\nu \times b = u$ (relative velocity)

Then the collision will take place with great probability only if b is so small, that ν corresponds to the relative energy E. $\frac{h\nu}{2\pi} = E$

$E = \frac{1}{2} M u^2$

$b \le \frac{u\hbar}{2\pi E} = \frac{2\hbar}{\mu\,\cdots}$

$= 2\lambda\!\!\!^-$

$\sigma \le 4\pi\lambda\!\!\!^{-2} \ll \frac{4\pi\hbar^2}{2mE}$

$\sigma_{pp\,350} \to 10^{-28}$ O.K.

350 MeV 10^{-27}

Pontecorvo continua per alcune pagine a valutare con considerazioni di tipo geometrico l'ordine di grandezza delle sezioni d'urto totale e di produzione di mesoni nell'urto nucleone-nucleone e nucleone-nuclei.

1) $\sigma \ll \pi\,\hbar^2/(mc)^2$ $\sigma \ll 6 \times 10^{-26}$ **cm²** nucleon, nucleon,

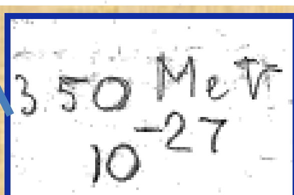
when $\lambda\!\!\!^- \ll \hbar/mc$

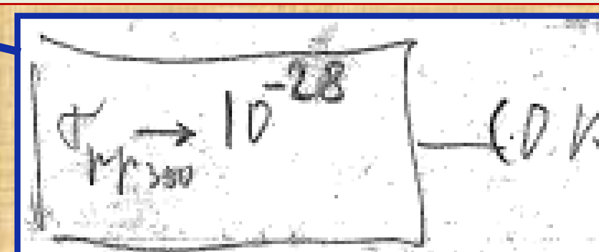
2) In a collision of parameter *b* the predominant ν will be that such that $2\pi\nu \times b = u$ (relative velocity) Then the collision will take place with great probability only(?) if *b* is so small that ν corrisponds to the relative energy $\hbar\nu/2\pi = E$ (?!! $\hbar\nu 2\pi = E \rightarrow \nu = E/2\pi\hbar$)

$b \le u/2\pi\nu = u/2\pi\,(2\pi\hbar/E) = 2\hbar/mu = 2\hbar/p = 2\lambda\!\!\!^-$ $\{E = 1/2mu^2 \rightarrow u/E = 2/mu = 2/p\}$

$\sigma \le \pi b^2 \le 4\pi\lambda\!\!\!^{-2} = 4\pi\,\hbar^2/(mu)^2 \rightarrow$

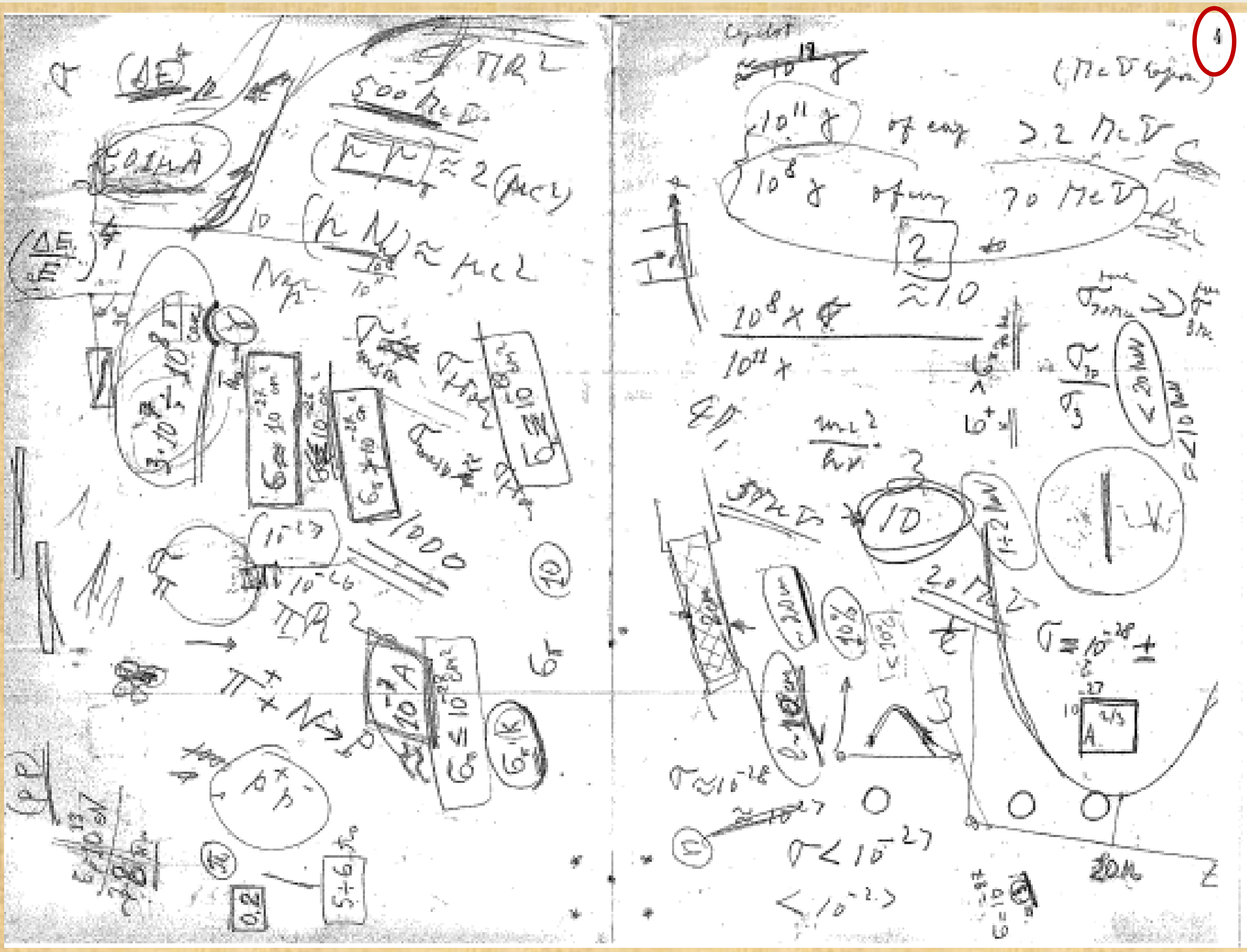
$\sigma \ll 4\pi\,\hbar^2/(2mE)$



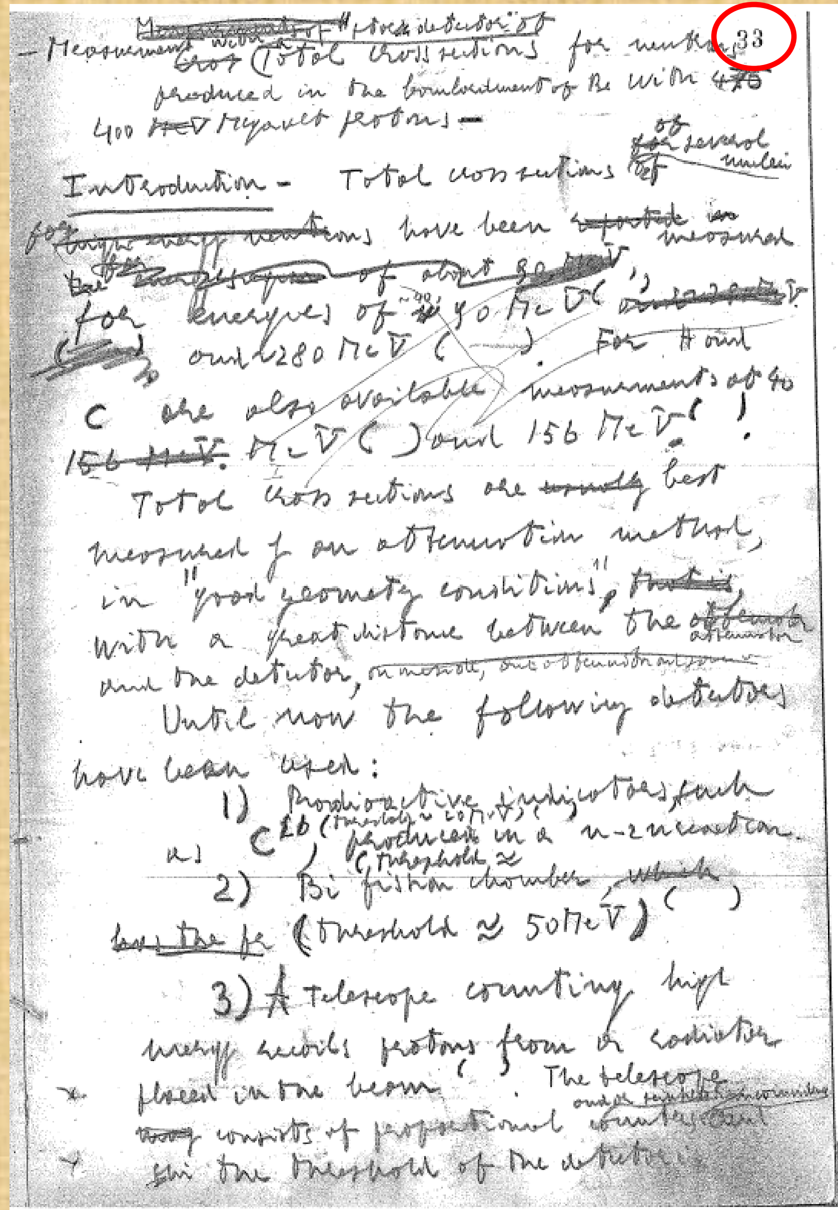


Pagina 4 del secondo quaderno

Pontecorvo molto spesso usa le pagine di questi quaderni solo come un "brogliaccio" scarabocchiandovi in modo disordinato e senza alcun ordine logico numeri, formule e grafici, forse solo per fissare i pensieri e le idee che gli turbinano nella mente. Risulta pertanto spesso difficile capire con esattezza, gli esperimenti e le misure che Bruno e il suo gruppo vogliono fare.



Pagine 33-36: Draft "Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with ~~475~~ 400 Megavolt protons –"



Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with 400 Megavolt protons

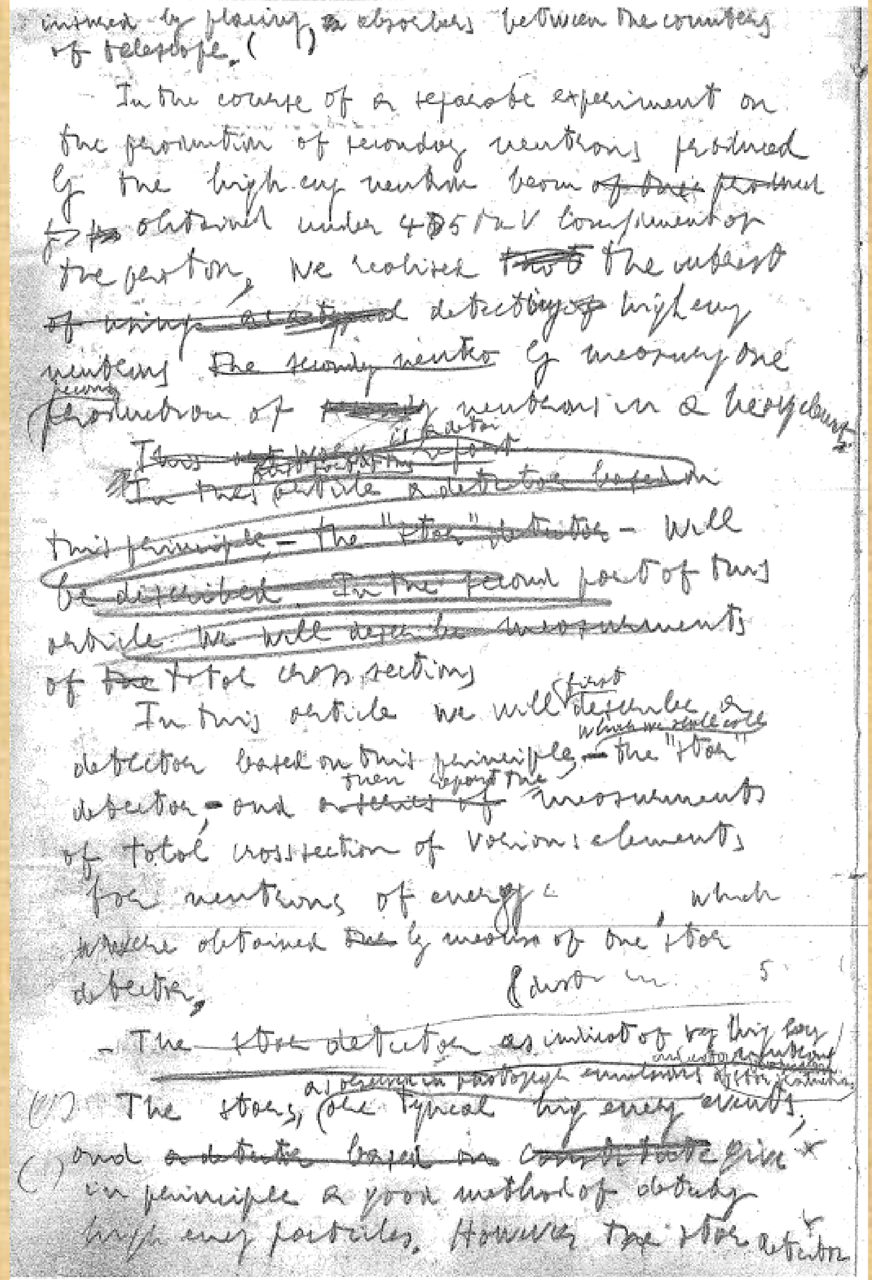
Introduction – Total cross section of several nuclei have been measured for energies of ~ 40, 90 MeV ( ) and ~ 280 MeV ( ). For H and C are also available measurements at 40 MeV ( ) and 156 MeV ( ).

Total cross sections are ~~usually~~ best measured by(?) an attenuation method, in "good geometry conditions", with a great distance between the attenuator and the detector.

Until now the following detectors have been used:

1) Radioactive indicators, such as C^{11}, (threshold ~ 20 MeV) ( ) produced in a n-2n reaction (threshold ≈
2) Bi fission chamber (threshold ≈ 50 MeV) ( )
3) A telescope counting high energy recoils protons from a radiator placed in the beam ( ) The telescope consists of proportional and a scintillting counters in coincidence (?) the threshold of the detector is

Pagine 33-36: Draft "Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with ~~475~~ 400 Megavolt protons –"



insured by placing absorbers between the counters of telescope. ( )

In the course of a separate experiment on the production of secondary neutrons produced by the high energy neutron beam obtained under 475 MeV bombardment(??) of the proton, we realized the interest of detecting high energy neutrons by measuring one secondary production of neutrons in a heavy element.

In this article we will first describe a detector based on this principle – which we shall call the "star detector"- and then report the measurements of total cross section of various elements for neutrons of energy , which were obtained by means of the star detector.

The stars, as observed in photograph emulsions are typical big energy events, and give in principle a good method of detecting high energy particles. However the star detector

Pagine 33-36: Draft "Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with ~~475~~ 400 Megavolt protons –"

based on photographes would be ….. because of the long time necessary for the analysis of the measurements. An alternative star detector could consist of one ionizing chamber detecting the ionization of charged particles, mainly protons and α's released in the evaporation process. Such chamber could be used to register only pulses bigger than a certain value. However it is easy to see that a star ionization chamber in practice has a very small sensitivity, unless very high pressures of a heavy gas like Xe are used. A different solution of the process is to detect neutrons (order of energy (?) of few MeV) emitted in the evaporation process. This method has the advantage that a very high thikness of star producing material (order of a mean free path of the high energy neutrons) can be used. It is true that the secondary neutrons will be detected with a small efficiency (≈ was ≈ 10^{-4}); however the high multiplicity of neutron production per inelastic collision (≈ 10 in a heavy element) and the very large thikness which can be used make the overall sensitivity high. For example, a neutron beam of energy ≈ 400 MeV, and intensity $3X10^3$/sec/cm^2 gave

Pagine 33-36: Draft "Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with ~~475~~ 400 Megavolt protons –"

in our detector (Pb + BF_3 in paraffine block) gave 2500 pulses/min. The secondary neutrons were detected in the arrangment , usually called "long counter" consisting of a BF_3 counter ….. long, and …. Diameter imbedded in a paraffine blok. The caracteristic of this long counter in paraffine is that its neutron sensitivity is not very sensitive of the energy in Fn (?) region 50 KeV– 10 MeV.While this feature is not very important on the experiment on total cross section, it may be very useful in other application of the "star detector".
Another advantage of the detector, for use with pulsed sources, in particular as a monitor, is the fact that the process of diffusion of the thermal neutrons, which are detected in the counter, smooth out the distribution of intensity of the (?) neutrons during the cyclotron proton pulse (the proton current pulse distributionis known to have peak and valleys) As a consequences of this fact it is possible to count

I contatori per neutroni BF^3 (pag. 17)

March 10, 1951

BF^3 counters
No 1, brass, 30 cm pressure BF^3, contains effectively:
20.8×10^{19} atoms of B^{10} in total.
No 2, glass, 10 cm pressure BF_3, contains effectively:
3.4×10^{19} atoms of B^{10} in total

kompare counter

glass	brass
2x64+44	32x64+60
3x67+28	29x64+4

70

March 10,1951

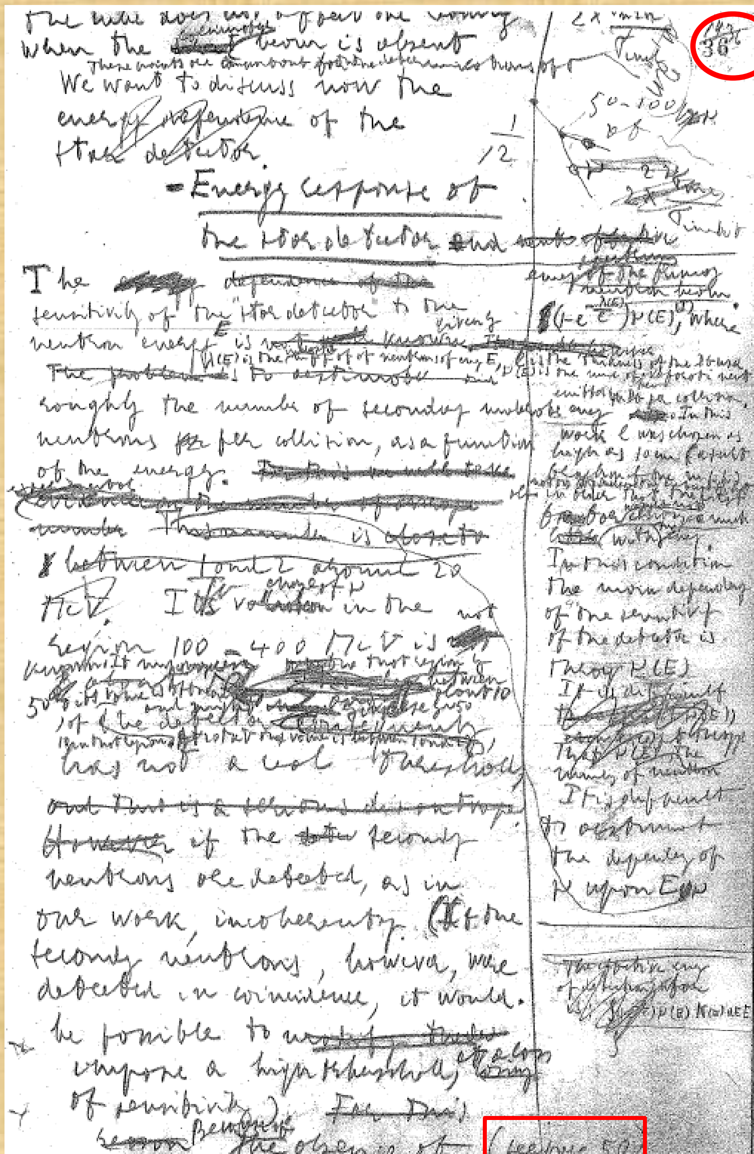
BF^3 counters
N. 1, brass, 30 cm pressure BF^3, contains effectively :
20.8×10^{19} atoms of B^{10} in total
N. 2, glass, 10 cm pressure BF^3, contains effectively :
3.4×10^{19} atoms of B^{10} in total

----

kompare counter

glass	*brass*
2x64+44	*32x64+60*
3x64+28	*29x64+4*

Pagine 33-36: Draft "Measurement with a "star detector" of total cross sections for neutrons produced in the bombardment of Be with ~~475~~ 400 Megavolt protons –"



Pag. 36

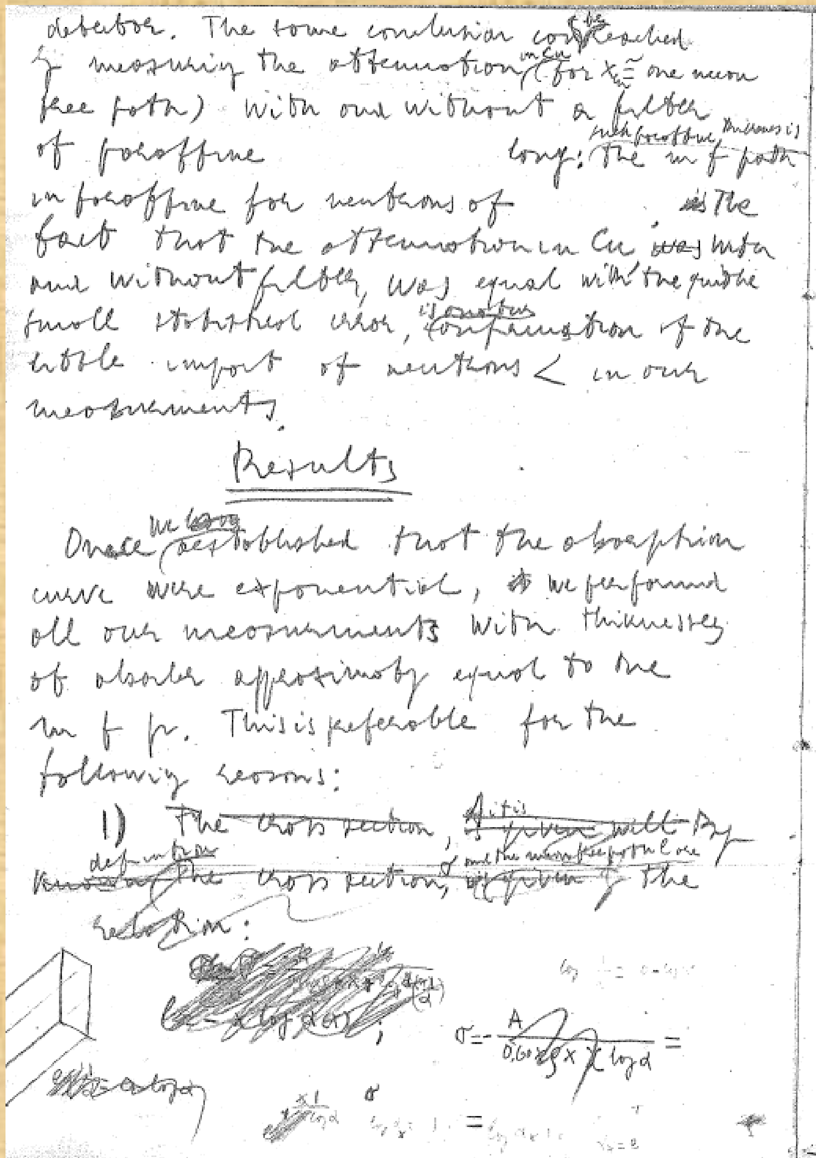
the cube does not affect the reading when the collimator of the beam is absent. These points are important for the determination of σ.
We want to discuss now the energy dependence of the star detector.

- Energy response of the star detector

The sensitivity of the "star detector" to the neutron energy is given by roughly the number of secondary neutrons per collision, as function of the energy. The value(?) of ν in the region 100-400 MeV is not know. ????? between 50 ??? 10 ???. The detector consequently has not a real threshold, if the secondary neutrons are detected, as in our work, incoherently. (if the secondary neutrons, however, were detected in coincidence, it would be possible to impose a high threshold, at loss of sensitivity) Because of the absence of (see page 50)

(see page 50)

Page 50:
a threshold , it was necessary to ensure that the presence of low energy neutrons (<<≈100 MeV) did not seriously affect the measurement. This was done...etc



detector. The same conclusion can be reached by measuring the attenuation in Cu (for Xcu ≅ one mean free path) with and without a filter of paraffine .... long: such paraffine thickness is the m f path in paraffine for neutrons of ..... The fact that the attenuation in Cu, with and without filter, was equal with the quite small statistical error, is another information of the stable (?) import (?) of neutrons < in our measurements.

Results

Once we established that the absorption curve were exponential, we performed all our measurements with thickness of absorber approximately equal to the m. f. p. This is preferable for the following reasons:

~~1) The cross section is given by the relation:~~

~~$\sigma =$~~

Measurements in Cu of "Total σ with star detector"

Results (Normalised)

Total σ with star detector
Results (Normalised)

Cu 60 cm + Pb cube	0.0405 ± 0.0012
Cu 60cm, no Pb-cube	0.0389 ± 0.0012
No Cu, no Pb cube	0.0438 ± 0.0016
No Cu, Pb cube	0.542 ± 0.010
Cu 10cm, Pb cube	0.214 ± 0.004
Cu 20cm, Pb cube	0.106 ± 0.002
Cu 30cm Pb cube	0.0627 ± 0.0012
No Cu Pb cube	0.543 ± 0.010
Cu 15cm Pb cube	0.158 ± 0.002
Cu 5cm Pb cube	0.405 ± 0.006 ~~0.360 ± 0.006~~
Cu 25cm Pb cube	0.0845 ± 0.002
Cu 10cm Pb cube	0.218 ± 0.004

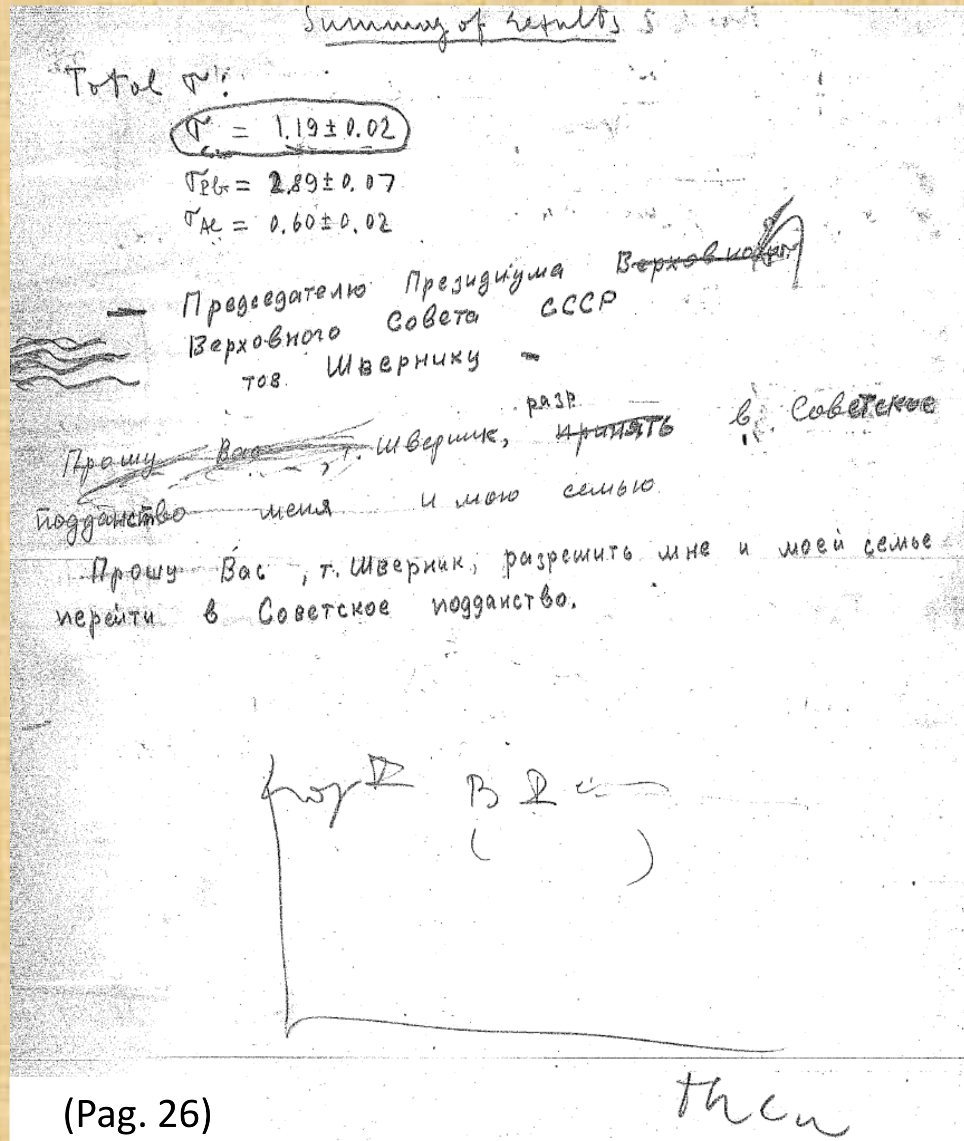
22

No Cu, Pb cube	0.544 ± 0.010
No Cu, No Pb cube	0.0409 ± 0.0018
Cu 10cm, No Pb cube	0.0413 ± 0.0012
Cu 20cm, No Pb cube	0.0413 ± 0.0012

Pb position is not exactly as before, because readings limited. However as close as possible it was put

No Cu, Pb cube (no paraffine)	0.555 ± 0.008
No Cu, Pb cube, paraffin 36 cm before the collimator	0.352 ± 0.005
Cu 10cm, Pb cube, paraffin 36 cm before the Pb cube	0.156 ± 0.003
Cu 10cm, Pb cube (no paraffin)	0.235 ± 0.0035
No Cu, Pb cube	0.551 ± 0.012
AC 30cm, Pb cube [illegible]	0.216 ± 0.003

Risultati di misure di sezione d'urto totale su alcuni nuclei complessi (Cu,Pb,Al)
Per ottenere le sezioni d'urto totali pensa di dover graficare in carta logaritmica i conteggi in funzione dello spessore della targhetta (metodo di trasmissione).
Nel frattempo prova a scrivere in russo la richiesta di cittadinanza sovietica.


Summary of results

Total σ:

σ = 1.19 ± 0.02

σPb = 2.89 ± 0.07

σAl = 0.60 ± 0.02

Председателю Президиума ~~Верховного~~ Верховного Совета СССР тов. Швернику

Прошу Вас, т. Шверник, разрешить мне и моей семье перейти в Советское подданство.

Th Cu

(Pag. 26)

Summary of results

Total σ :

σ_{Cu} = 1.19 ± 0.02

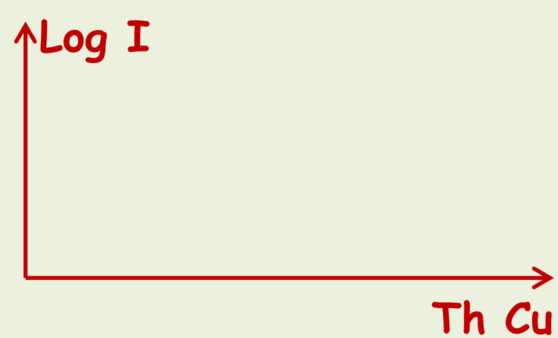
σ_{Pb} = 2.89 ± 0.07

σ_{Al} = 0.60 ± 0.02

-- Presidente del Praesidium del Soviet supremo dell'URSS Compagno Shvernik (товарищу швернику)

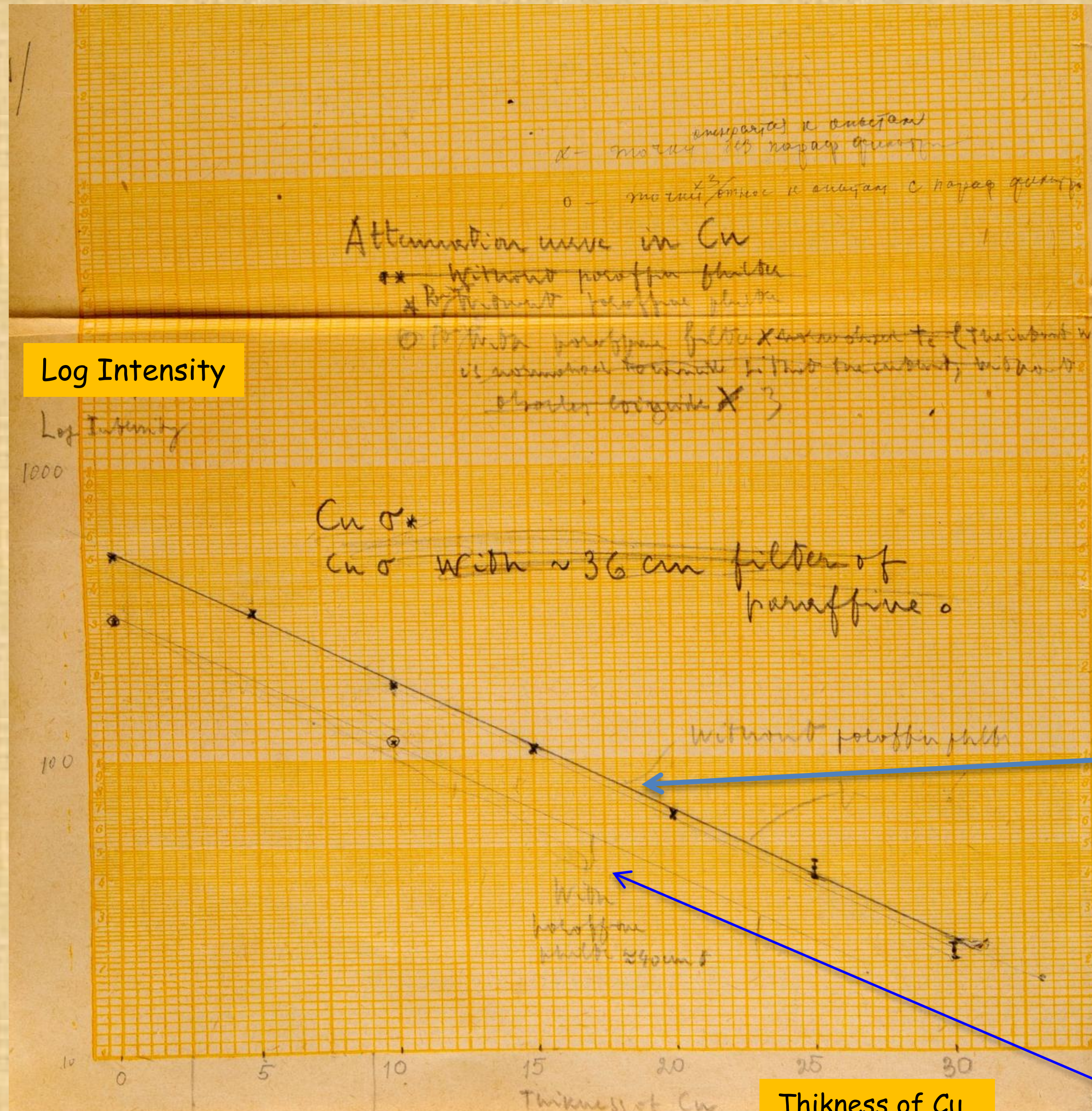
Vi chiedo, compagno Shvernik, di permettere a me e alla mia famiglia di diventare cittadino sovietico.

(nella parte cancellata c'è scritto male in russo la stessa cosa)



Questo plot su carta logaritmica si trova inserito alla pagina delle misure precedenti (pag.22)

Attenuation curve in Cu



Log Intensity

Thikness of Cu

Attenuation curve in Cu

~~** without paraffine filter~~

⋆ Point without paraffine filter

o Point with paraffine filter

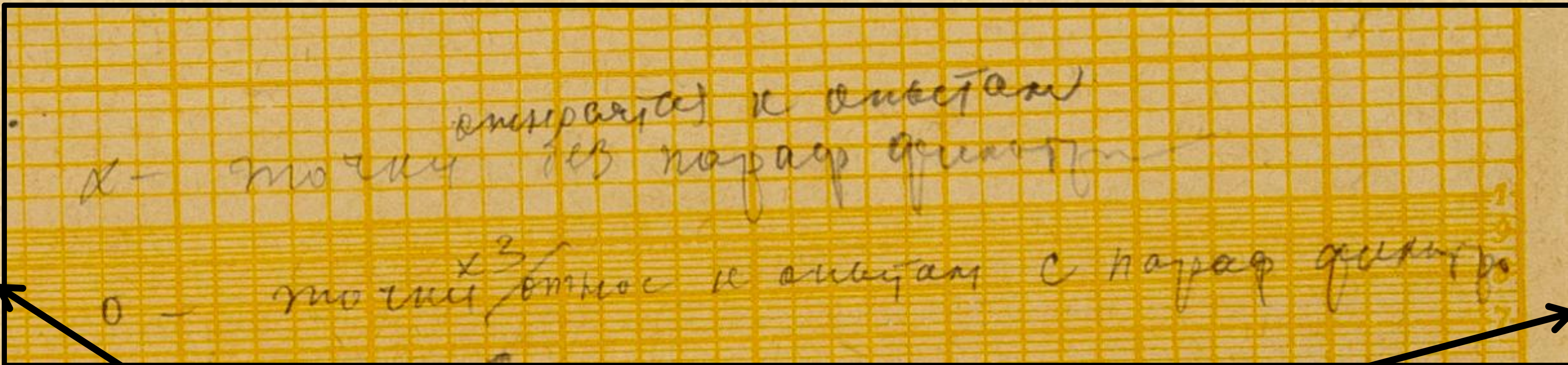
X ~~normalized to (The intensity is normalized ?? so that the intensity without absorber ??~~ X 3

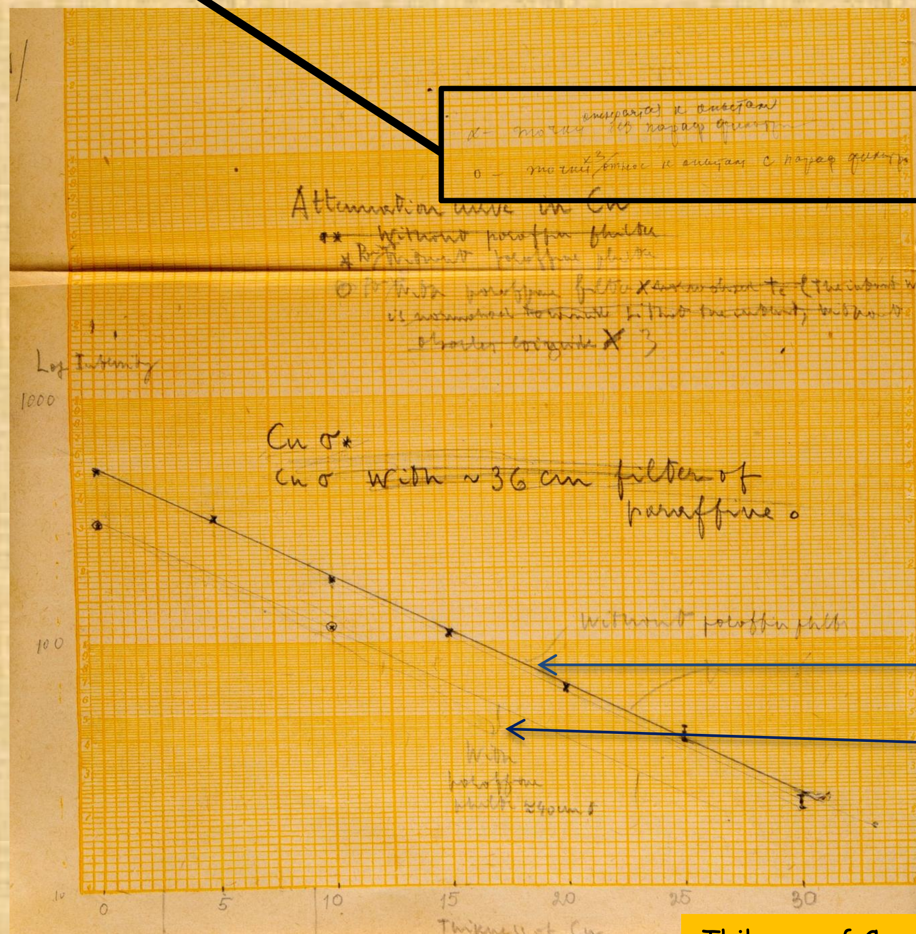
Cu σ ⋆

Cu σ with ~ 36 cm filter of paraffine **O**

Without paraffine filter

With paraffine filter ≈ 40 cm





Attenuation curve in Cu
~~** without paraffine filter~~
⋆ Point without paraffine filter
o Point with paraffine filter
X ~~normalized to (The intensity is normalized ??~~
~~so that the intensity without absorber ??~~ X 3

Cu σ ⋆
Cu σ with ~ 36 cm filter of paraffine **O**

Without paraffine filter

With paraffine filter ≈ 40 cm

Questo plot su carta logaritmica si trova inserito alla pagina delle misure precedenti (pag.22)

Thikness of Cu

Le misure di sezione d'urto totale vengono estese a altri nuclei complessi

Program — Cu?, Sn, Fe, U, C, Paraff

I) Pb, no absorber
II) No Pb, no absorber
III) No Pb, 3 or 4 absorbers Sn, Fe, C
IV) Pb, no absorber
V) Pb + U
VI) Pb + Sn
VII) Pb + Fe
VIII) Pb + U
IX) Pb + O
X) Pb + C
XI) Pb + Paraff
~~XII) Pb + Cu (5cm)~~
XIII) Pb no absorber
XIII) Pb + Paraffin
XIV) Pb + paraffin
XV) 5 Cu
XVI) 10cm Cu
XVII) No Pb no absor

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Total σ

A – Normalized results

Pb, no absorber	0.612 ± 0.009
No Pb, no absorber	0.0413 ± 0.0016
No Pb, Sn 20 cm	0.0394 ± 0.0016
No Pb, Fe 12 cm	0.0397 ± 0.0020
No Pb, C 40 cm	0.0405 ± 0.0020
Pb, no absorber	0.605 ± 0.009
Pb, Sn 20 cm	0.166 ± 0.002
Pb, Fe 12 cm	0.220 ± 0.003
Pb, U 10 cm	0.154 ± 0.002
Pb, no absorber	0.597 ± 0.006
Pb, C 40 cm	0.224 ± 0.003
Pb, Paraffine 80 cm	0.280 ± 0.003
Pb, no absorber	0.603 ± 0.008
Pb, Paraffin 80 cm	0.207 ± 0.003
Pb, C 40 cm	0.221 ± 0.002
Pb Cu 5 cm	0.360 ± 0.005

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		85	95	280	156±3	270 Bi	1440
H	0.034 ± 0.005	0.083	0.074	0.033 ± 0.003	0.0463±0.0011	0.038 ± 0.002	0.16
C	0.325 ± 0.006	0.550	0.50	0.279 ± 0.004	0.330±0.013	0.288 ± 0.003	0.53
Al	0.60 ± 0.02	1.12	0.99	0.566 ± 0.018		0.555 ± 0.008	
Fe	1.11 ± 0.03			[illegible]			
Cu	1.19 ± 0.02	2.22	2.09	1.19 ± 0.02		1.145 ± 0.0015	
Sn	2.02 ± 0.04	3.28	3.18	1.83 ± 0.03		1.87 ± 0.03	
Pb	2.89 ± 0.07	4.53	4.38	2.83 ± 0.03		2.84 ± 0.03	
U	3.40 ± 0.07	5.03	4.3	3.14 ± 0.05		3.29 ± 0.03	

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Pontecorvo prova ad interpretare le misure di sezione d'urto totale su nuclei complessi in termini del "opaque nucleus model"

R (10^{-13} cm)	Z	$2\pi R^2$	$\sigma_{total\,400}/2\pi R^2$	$1-\sigma^{400}/2\pi R^2$	$\sigma_{total\,95}/2\pi R^2$	$1-\sigma_{total\,90}/2\pi R^2$	λ^{400} (10^{-13})	λ^{90}
3.5	C	0.62	0.51	0.49	0.80	0.20	6.2	
4.1	Al	1.06	0.57	0.43	0.94	0.06	6.4	
5.5	Cu	1.90	0.65	0.35			6.4	
6.7	Sn	2.80	0.72	0.28			6.4	
8.1	Pb	4.10	0.70	0.30			8.1	
8.5	U	4.50	0.75	0.25			7.0	

Start all over again:

R, opaque:

$$R=(1.3+1.37A^{1/3})\times10^{-13}\ \text{cm}$$

Probability of no collision when the neutron hits the nucleus $= 1-\frac{\sigma_{inelast}}{\pi R_1^2}\approx 1-\frac{\sigma_{total}}{2\pi R_1^2}=$

$$=\int_0^R \frac{2\pi x}{\pi R^2} e^{-\frac{2\sqrt{R^2-x^2}}{\lambda}}dx = (\text{where } \lambda \text{ is the mean free path in nuclear matter})$$

$$=\left(\frac{\lambda^2}{2R^2}\right)\left[1-\left(1+\frac{2R}{\lambda}\right)e^{-2R/\lambda}\right]= \left(\text{Let us call } R/\lambda=a\right)$$

$$=\frac{1}{2a^2}\left[1-(1+2a)e^{-2a}\right]$$

$$R_1 = R + 1.3\times10^{-13} = (1.3+1.37\times A^{1/3})\times10^{-13}\ \text{cm}$$

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R (10^{-13}cm), Z, $2\pi R^2$, $\sigma_{total400}/2\pi R^2$, $1-\sigma^{400}/2\pi R^2$, $\sigma_{total95}/2\pi R^2$,, $1-\sigma^{90}/2\pi R^2$, $\lambda^{400}(10^{-13})$, λ^{90}

Start all over again:

R, opaque :

$$R_{(1)}=(1.3+1.37A^{1/3})\times10^{-13}\ \text{cm}$$

Probability of no collision when the nucleon hits the nucleus = $1-\sigma_{inel.}/\pi R^2\approx1-\sigma_{total}/2\pi R^2=$

$$=\int_0^R \frac{2\pi x}{\pi R^2} e^{-\frac{2\sqrt{R^2-x^2}}{\lambda}}dx =$$

(where λ is the mean free path in nuclear matter) ($R/\lambda=a$)

$= 1/(2a^2)[1-(1+2a)e^{-2a}]$

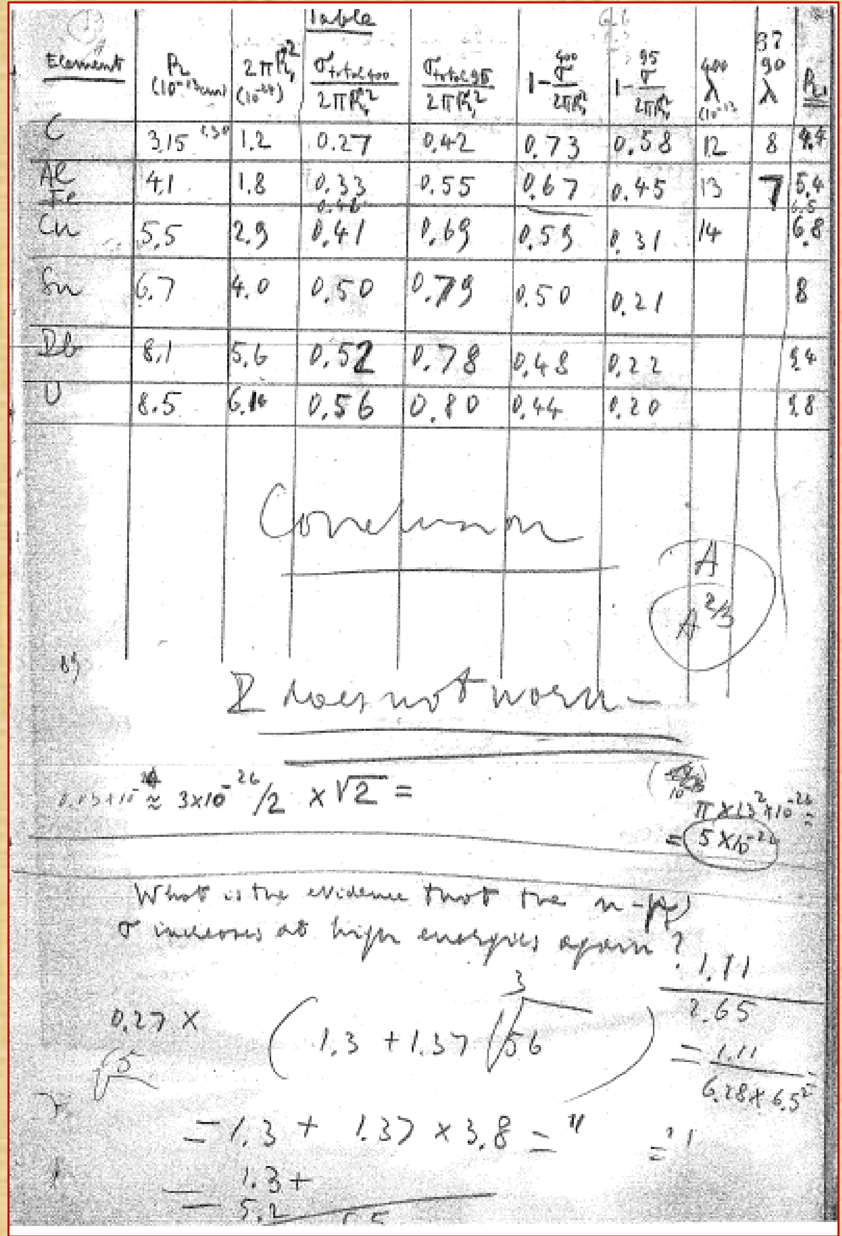
$R_1=R+1.3\times10^{-13}=(1.3+1.37\times A^{1/3})\times10^{-13}$ cm

The "nuclear radius" R is defined conventionally by the empirical relation $R=(1.3+1.37A^{1/3})\times10^{-13}$, which is the best fit to data of total cross section for neutrons of ~ 15 MeV (opaque nucleus model)

Pag. 74

The "nuclear radious" R is defined conventionally by the empirical relation $R=(1.3+1.37A^{1/3})\times10^{-13}$, which is the best fit to data of total cross section for neutrons of ~ 15 MeV **(opaque nucleus model)**

Pontecorvo prova ad interpretare le misure di sezione d'urto totale su nuclei complessi



Element	R (10^{-13}cm)	$2\pi R_1^2$ (10^{-24})	$\sigma_{total400}/2\pi R_1^2$	$\sigma_{total95}/2\pi R_1^2$	$1-\sigma^{400}/2\pi R_1^2$	$1-\sigma^{95}/2\pi R_1^2$	λ^{400}	λ^{90}	R_1
C	3.15	1.2	0.27	0.42	0.73	0.58	12	8	4.4
Al / Fe	4.1	1.8	0.33	0.55	0.67	0.45	13	7	5.4
Cu	5.5	2.9	0.41	0.69	0.53	0.31	14		6.8
Sn	6.7	4.0	0.50	0.79	0.50	0.21			8
Pb	8.1	5.6	0.52	0.78	0.48	0.22			9.4
U	8.5	6.16	0.56	0.80	0.44	0.20			9.8

Conclusion

Z does not work –

What is the evidence that the n-p σ increases at high energies again?

Table

Element, R (10^{-13}cm), $2\pi R_1^2$(10^{-24}), $\sigma_{total400}/2\pi R_1^2$, $\sigma_{total95}/2\pi R_1^2$, $1-\sigma^{400}/2\pi R_1^2$, $1-\sigma^{95}/2\pi R_1^2$, λ^{400}(10^{-13}), λ^{90}, R_1

Conclusion

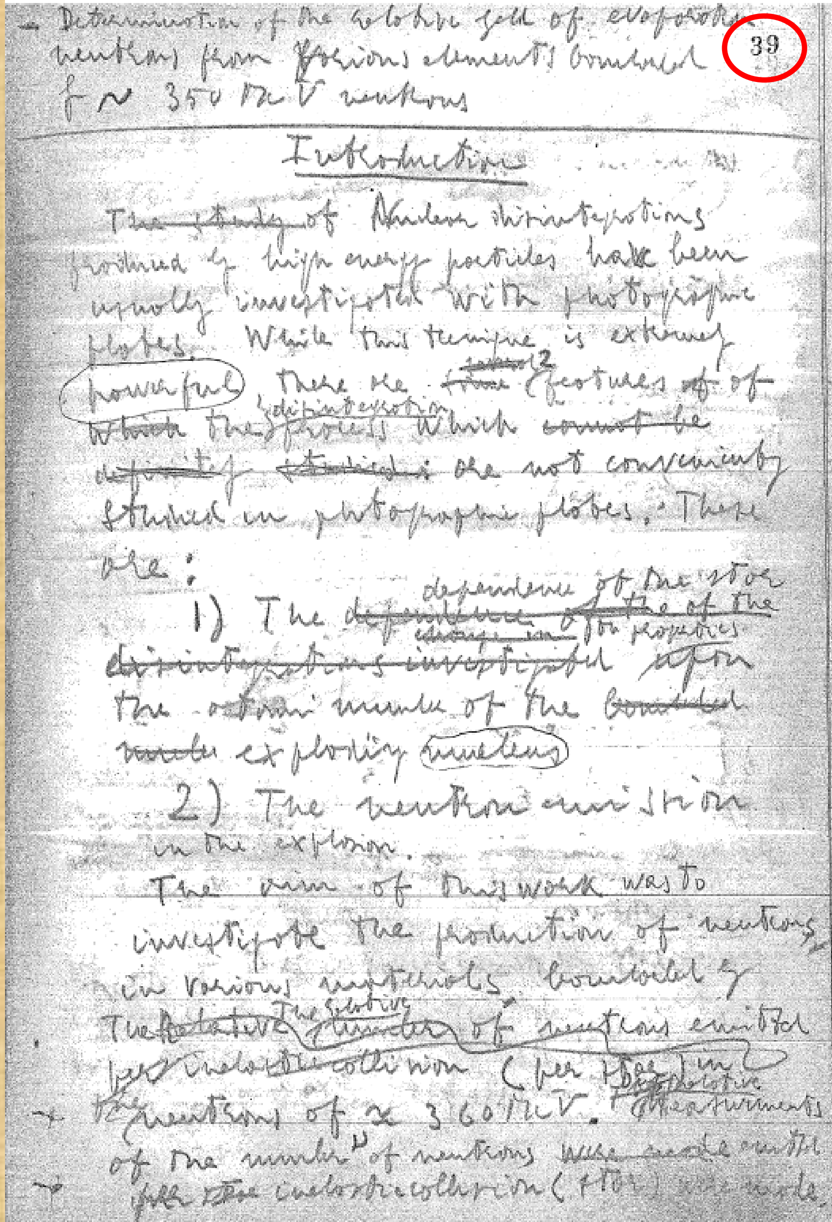
A

$A^{2/3}$

Z does not work -

What is the evidence that the n-p σ increases at high energy again ?

Pagine 39-47: Draft "Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons."



Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons.

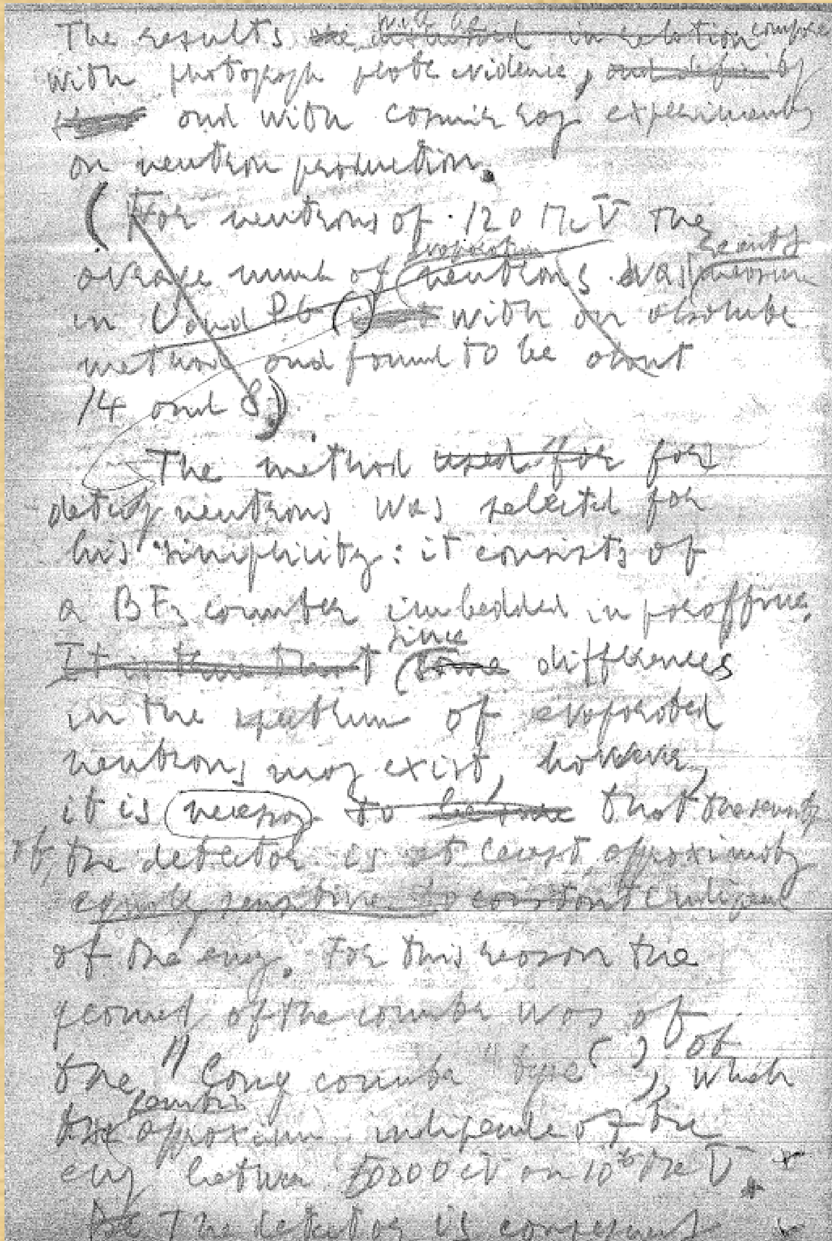
Introduction

Nuclear disintegrations produced by high energy particles have been usually investigated with photographic plates. While this thecnique is extremely powerful, there are 2 features of the disintegration process which are not conveniently studied in photograhic plates. These are:

1) The dependence of the star properties upon the atomic number of the exploding nucleus
2) The neutron emission in the explosion.

The aim of this work was to investigate the production of neutrons in various material bombarded by neutrons of ≈ 360 MeV . Relative measurements of the number of neutrons emitted per inelastic collision (star) were made.

Pagina 40: Draft "Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons."

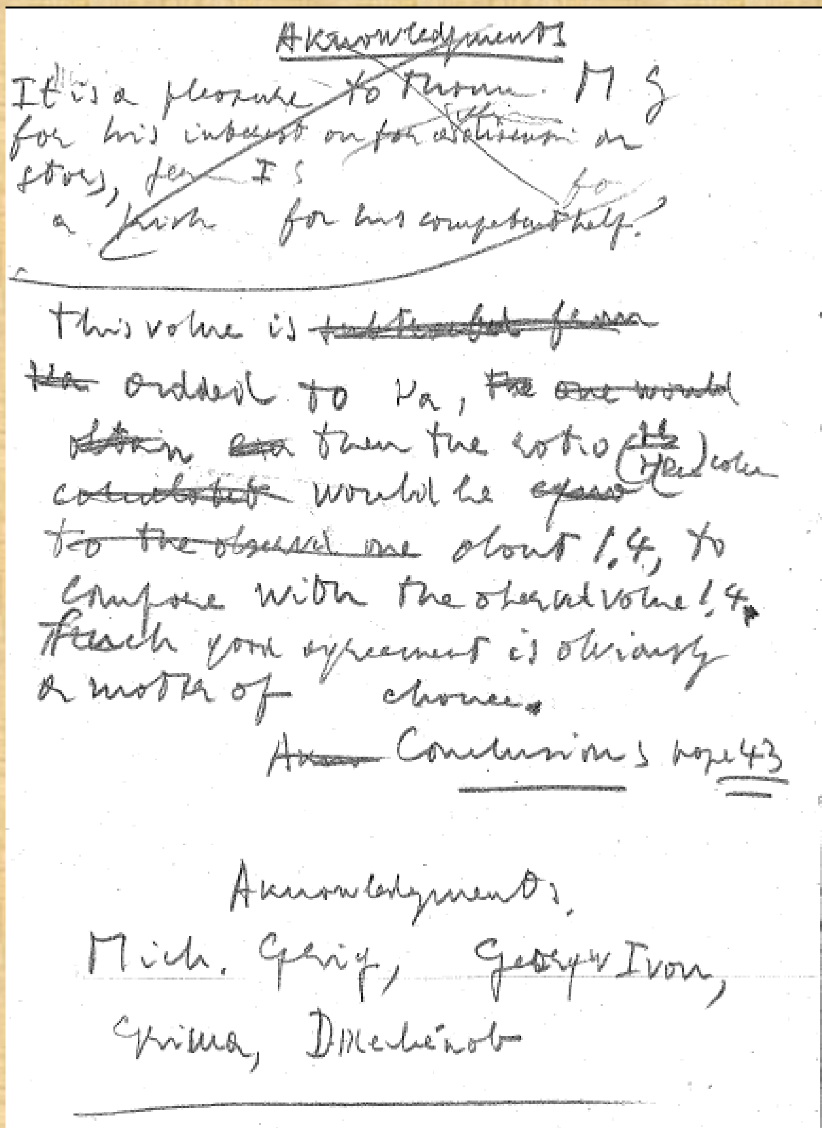


The results will be compared with photograph plate evidence, and with cosmic ray experiments on neutron production. ~~(for neutrons of 120 MeV the average number of evaporation neutrons was recently measured in U and Pb with an absolute method and found to be about 14 and 8)~~.

The method for detecting neutrons was selected for his simplicity: it consists of a BF^3 counter imbedded in paraffine, since differences in the spectrum of evaporated neutrons may exist, however, it is necessary that the sensitivity of the detector is at least appromimately ~~equally sensitive to~~ constant indipendent of the energy. For this reason the geometry of the counter was of the "long counter" type () ,, of what(?) ?? approximate independence of the energy between 50000 eV on 10^6 MeV.

The detector is consequently satisfactory to detect "evaporation neutrons from stars, of which by far the great majority have energy < 20 MeV ()

Pagina 47 : Draft "Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons."



~~Acknowledgements~~

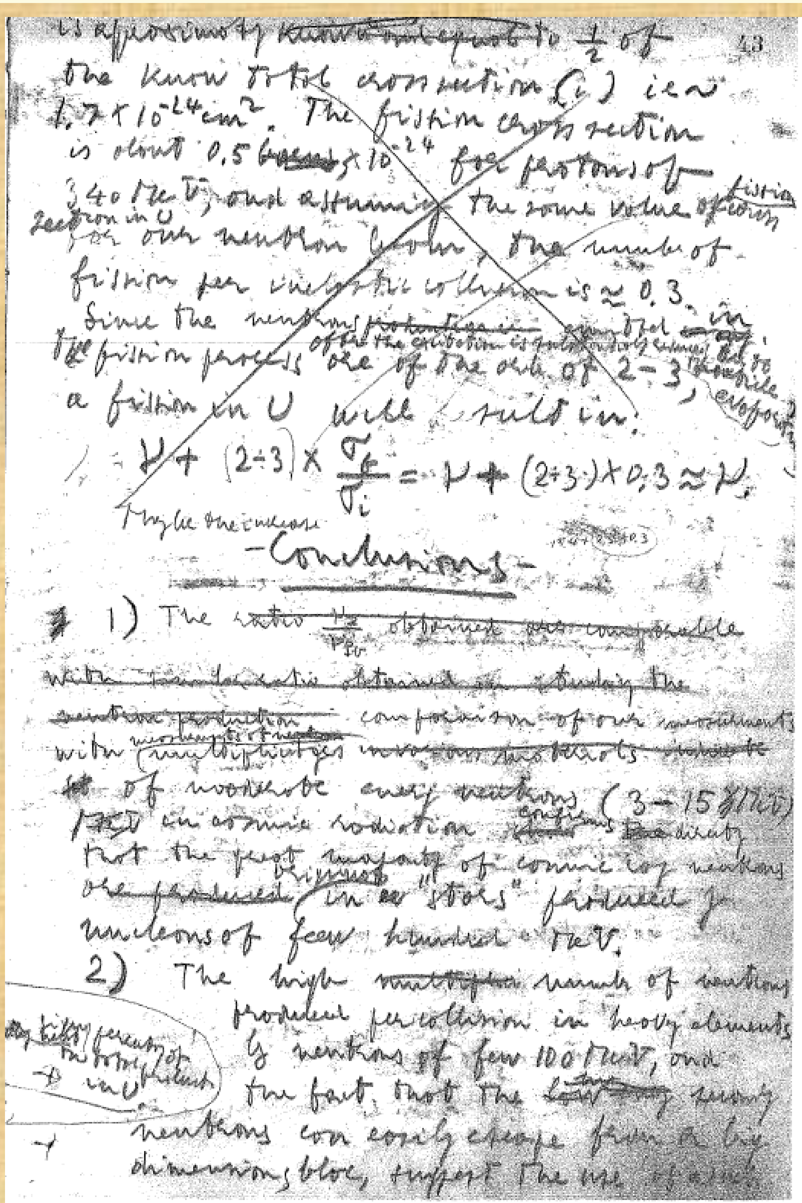
~~It is a pleasure to thanks M G for his interest on for a ..discussion on stars ?? I S A ?? For his competent help.~~

This value is added to ν_a, then the ratio $(\nu_Z/\nu_{pb})_a^{calc}$ would be about 1.4, to compare with the observed value 1.4. Such good agreement is obviously a matter of chance.

Conclusions page 43

Acknowledgements
Mich. G., ...

Pagina 43: Draft "Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons."

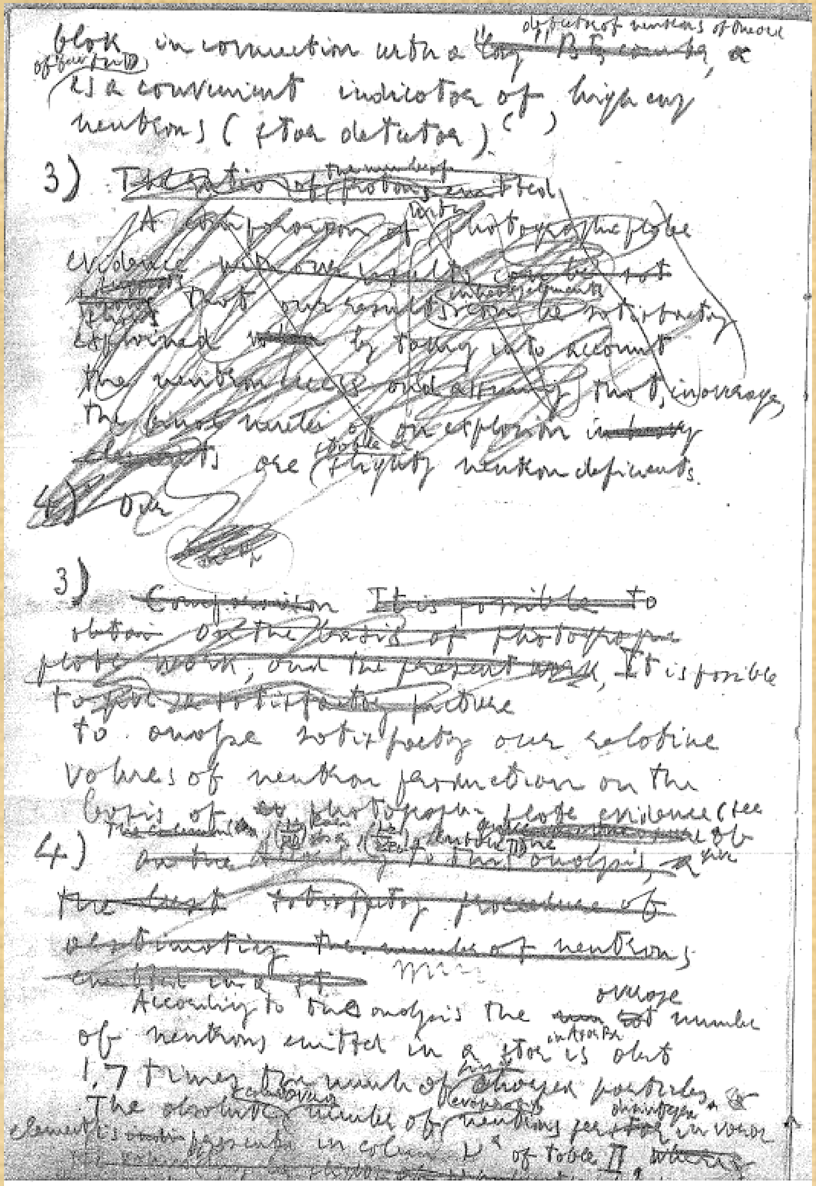


Conclusions

1) The comparison of our measurements with measurements of multiplicities of moderate energy neutrons (3-15 MeV) in cosmic radiation confirms directly that the great majority of cosmic ray neutrons ??? in "stars" produced by nucleons of few hundred MeV.

2) The high number of neutrons produced per collision in heavy elements by neutrons of few 100 MeV, and the fact that the secondary neutrons can easily escape from a big dimensions bloc, support the use of a such

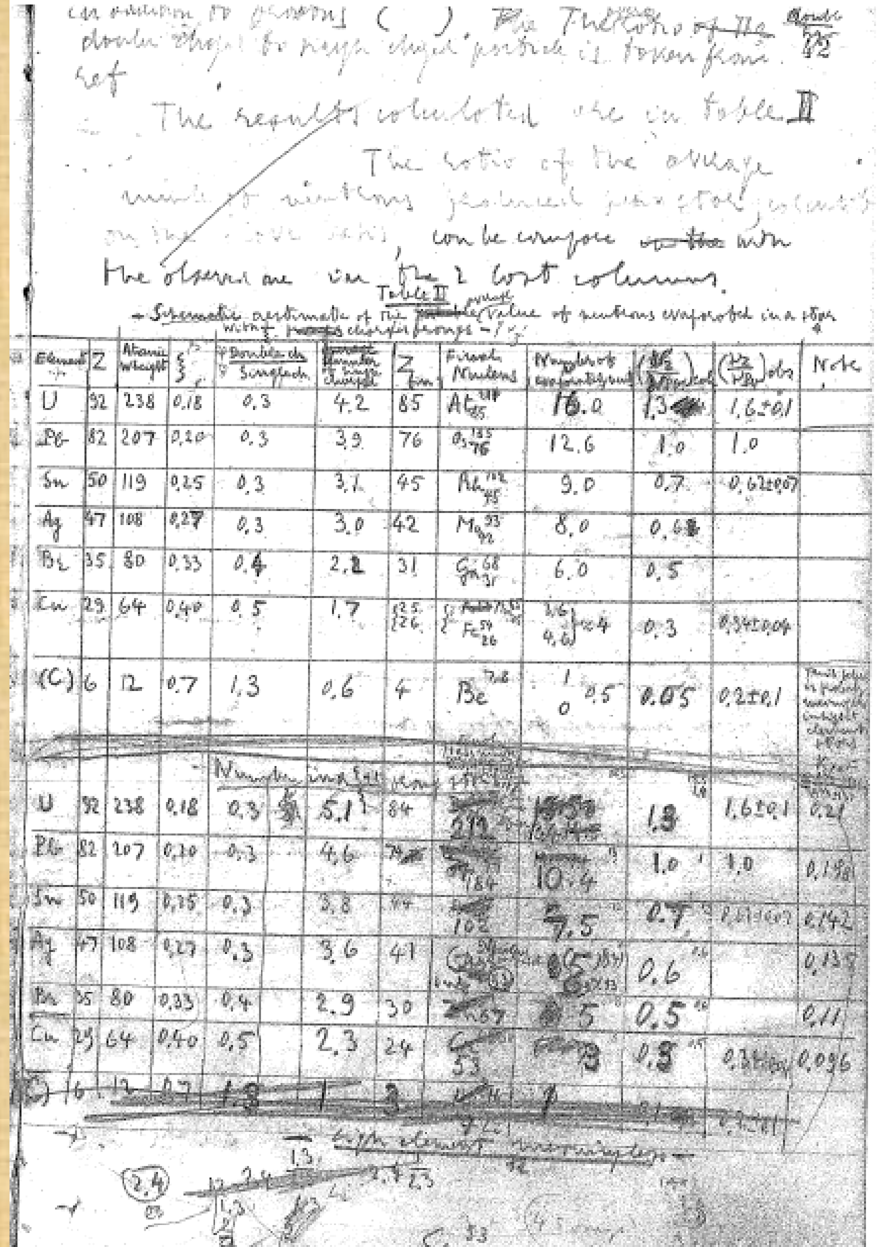
Pagina 44: Draft "Determination of the relative yield of evaporation neutrons from various elements bombarded by ~ 350 MeV neutrons."



Bloc in connection with a ~~"long" BF3 counter~~ detector of neutrons of the order of few MeV is a convenient indicator of high energy neutrons (star detector). ( )
3) It is possible to analize satisfactory our relative values of neutron production on the basis of photographic plate evidence (see $(\nu_Z/\nu_{Pb})_a^{calc}$,$(\nu_Z/\nu_{Pb})^{obs}$ in the table II)
According to the analysis the average number of neutrons emitted in a star in Ag or Pb is about 1.7 times the number of ??? charged particles. The absolute ??? average number of evaporated neutrons per disintegration in various element is presented in column ν^a of table II.

Table II

Schematic estimate of the average value of neutrons evaporated in a star with 1/ξ charged prongs



In addition to protons ( ). The ratio of the double charged to single charged particle is taken from ref. The results calculated are in table II

The ratio of the average number of neutrons produced per star, calculated on the above basis, can be compared with the observed one in the 2 last columns.

Table II

– Schematic estimate of the average value of neutrons evaporated in a star with 1/ξ charged prongs –

Element	Z	Atomic weight	ξ	Double ch/Single ch	Number of single charged	Z_{fin}	Final Nucleus	Number of evaporated neutrons	(ν_Z/ν_{Pb})calc	(ν_Z/ν_{Pb})obs	Note
U	92	238	0,18	0,3	4,2	85	At^{211}_{85}	16.0	1,3	1,6±0,1	
Pb	82	207	0,20	0,3	3,9	76	Os^{185}_{76}	12,6	1,0	1,0	
Sn	50	119	0,25	0,3	3,1	45	Rh^{112}_{45}	9,0	0,7	0,62±0,07	
Ag	47	108	0,27	0,3	3,0	42	Mo^{93}_{42}	8,0	0,6		
Br	35	80	0,33	0,4	2,2	31	Ga^{68}_{31}	6,0	0,5		
Cu	29	64	0,40	0,5	1,7	[illegible]	Fe^{59}_{26}	[illegible]	0,3	0,34±0,04	
(C)	6	12	0,7	1,3	0,6	4	Be	[illegible]	0,05	0,2±0,1	[illegible]

Number in a (ξ+1)/ξ prong stars

Element	Z	Atomic weight	ξ	Double ch/Single ch	Number of single charged	Z_{fin}	Final Nucleus	Number of evaporated neutrons	(ν_Z/ν_{Pb})calc	(ν_Z/ν_{Pb})obs	
U	92	238	0,18	0,3	5,1	84	[illegible]	[illegible]	1,3	1,6±0,1	0,21
Pb	82	207	0,20	0,3	4,6	[illegible]	[illegible]	10,4	1,0	1,0	0,198
Sn	50	119	0,25	0,3	3,8	44	[illegible]	7,5	0,7	[illegible]	0,142
Ag	47	108	0,27	0,3	3,6	41	[illegible]	6,5	0,6		0,135
Br	35	80	0,33	0,4	2,9	30	[illegible]	5	0,5		0,11
Cu	29	64	0,40	0,5	2,3	24	[illegible]	3	0,3	[illegible]	0,096

Light element meaningless

In addition to protons ( ). The average ratio double/single double charged to single charged particle is taken from ref ( ). The results calculated are in table II

The ratio of the average number of neutrons produced per star, calculated on the ???, can be compared with the observed one in the 2 last colums.

Table II

- Schematic estimate of the average value of neutrons evaporated in a star with 1/ξ charged prongs-

Element, Z, Atomic Wheight, ξ, Double ch/Single ch, number of single charged, Z_{fin}, Final Nucleus, Number of evaporated neutrons, (ν_Z/ν_{Pb})calc., (ν_Z/ν_{Pb})obs., Note

This ?? is probably meaningless in light element stars

Number in a (ξ+1)/ξ prong stars

- Light element meaningless -

Table II

Schematic estimate of the average value of neutrons evaporated in a star with 1/ξ charged prongs

Table II

— Schematic estimate of the average value of neutrons evaporated in a star with 1/ξ charged prongs —

Element	Z	Atomic weight	ξ	Double ch. / Single ch.	Average number of single charged	Z_{fin}	Final Nucleus	Number of evaporated neutrons	$(\nu_Z/\nu_{Pb})_{calc}$	$(\nu_Z/\nu_{Pb})_{obs}$	Note
U	92	238	0,18	0,3	4.2	85	At^{211}_{85}	16.0	1,3	1,6±0,1	
Pb	82	207	0,20	0,3	3,9	76	Os^{185}_{76}	12,6	1,0	1,0	
Sn	50	119	0,25	0,3	3,1	45	Rh^{102}_{45}	9,0	0,7	0,62±0,07	
Ag	47	108	0,27	0,3	3,0	42	Mo^{93}_{42}	8,0	0,6		
Br	35	80	0,33	0,4	2,2	31	Ga^{68}_{31}	6,0	0,5		
Cu	29	64	0,40	0,5	1,7	25 / 26	Mn^{55}_{25} / Fe^{54}_{26}	3,6 / 4,6 ≈ 4	0,3	0,34±0,04	
(C)	6	12	0,7	1,3	0,6	4	$Be^{7,8}$	1 / 0 ≈ 0,5	0,05	0,2±0,1	[illegible]

Table II

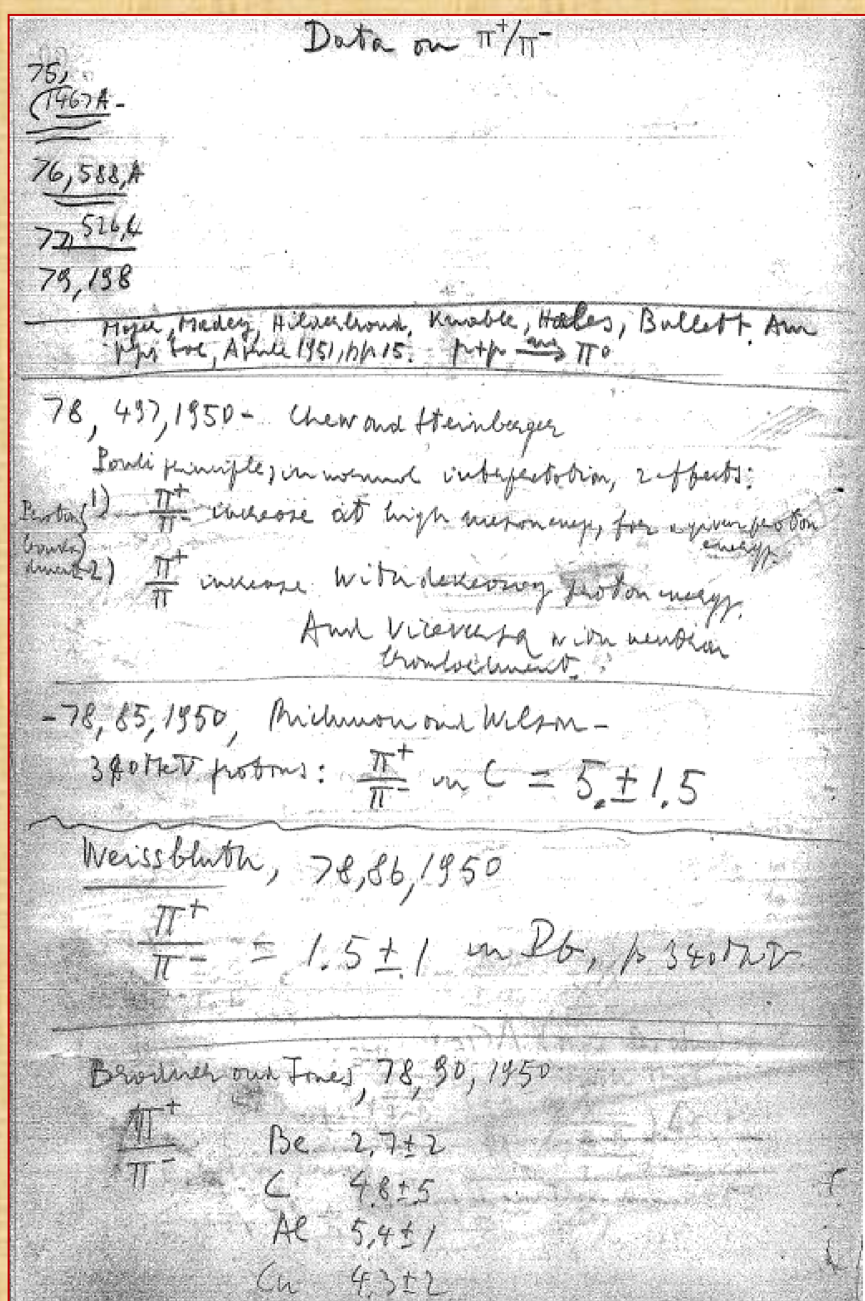
~~Schematic~~ Aestimate of the average value of neutrons evaporated in a star with $(\xi+1)/\xi$ charged prongs

Element, Z, Atomic Weight, ξ, d/s ratio of double to single ch, number of single charged, Z_{fin}, Mass number $A_{final}(a)$, , Mass number $A_{final}(b)$, ν_a^{calc}, ν_b^{calc}, $(\nu_Z/\nu_{Pb})_a^{calc}$, $(\nu_Z/\nu_{Pb})_b^{calc}$,$(\nu_Z/\nu_{Pb})^{obs}$.

Element	Z	Atomic weight	ξ	d/s	Number of single charged	Z final	Mass number A_{final} (a)	Mass number A_{final} (b)	ν_a calc	ν_b calc	$(\nu_Z/\nu_{Pb})_a$	$(\nu_Z/\nu_{Pb})_b$	$(\nu_Z/\nu_{Pb})_{obs}$
U	92	238	0.18	0.3	5.1	84	212	207	13.9	18.4	1.3	1.4	1.4±0.1
Pb	82	207	0.20	0.3	4.6	74	184	181	10.4	13.4	1	1	1
Sn	50	119	0.25	0.3	3.8	44	102	97	7.5	12.5	0.7	0.9	0.62±0.07
Ag	47	108	0.27	0.3	3.6	41	93	90	6	9	0.6	0.7	
Br	35	80	0.33	0.4	2.9	30	67	65	5	7	0.5	0.5	
Cu	29	64	0.44	0.5	2.3	24	53	51	3	5	0.3	0.4	0.34±0.04

Tabella II della slide precedente, rimessa a pulito e trascritta su un foglio separato.

Pontecorvo si tiene ben informato sugli esperimenti fatti in occidente su π^+/π^-


Data on π^+/π^-
75, 1467 A -
76, 588, A
77, 526, 4
79, 198
Moyer, Madey, Hildebrand, Knable, Hales, Bullett, Am Phys Soc, Aprile 1951, pp 15. p+p → no π^0
78, 497, 1950 - Chew and Steinberger
Pauli principle, in normal interpretation, 2 effects:
1) π^+/π^- increase at high meson energy, for a given proton energy
2) π^+/π^- increase with decreasing proton energy
And viceversa with neutron bombardment
- 78, 85, 1950, Richmon and Wilson -
340 MeV protons: π^+/π^- in C = 5. ± 1.5
Weissbluth, 78, 86, 1950
π^+/π^- = 1.5 ± 1 in Pb, p 340 MeV
Brodner and Jones, 78, 90, 1950
π^+/π^- Be 2.7±2; C 4.8±5; Al 5.4±1; Cu 4.3±2

Data on π^+/π^-

75,1467 A; 76,588, A; 77,526 ; 79,198

Mayer (?) et al, ….. …., Aprile 1951, pp 15. p+p → no π^0

78, 497, 1950 - Chew and Steinberger
Pauli principle, in normal interpretation, 2 effects:
1) π^+/π^- increase at high meson energy, for a given proton energy
2) π^+/π^- increase with decreasing proton energy
And viceversa with neutron bombardment

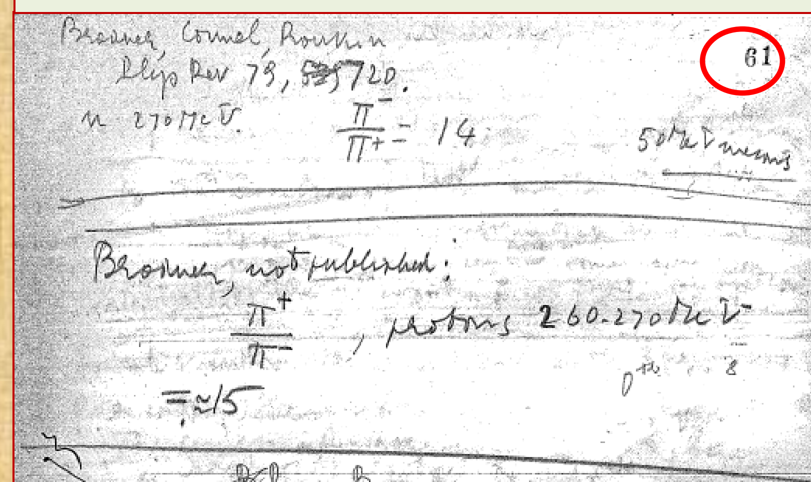
- 78, 85, 1950, Richmon and Wilson –
380 MeV protons: π^+/π^- in C = 5. ± 1.5

Weissbluth, 78,86,1950
π^+/π^- = 1.5 ± 1 in Pb, p 340 MeV

Brodner and Jones, 78,90,1950
π^+/π^- Be 2.7±2; C 4.8±5; Al 5.4±1; Cu 4.3±2

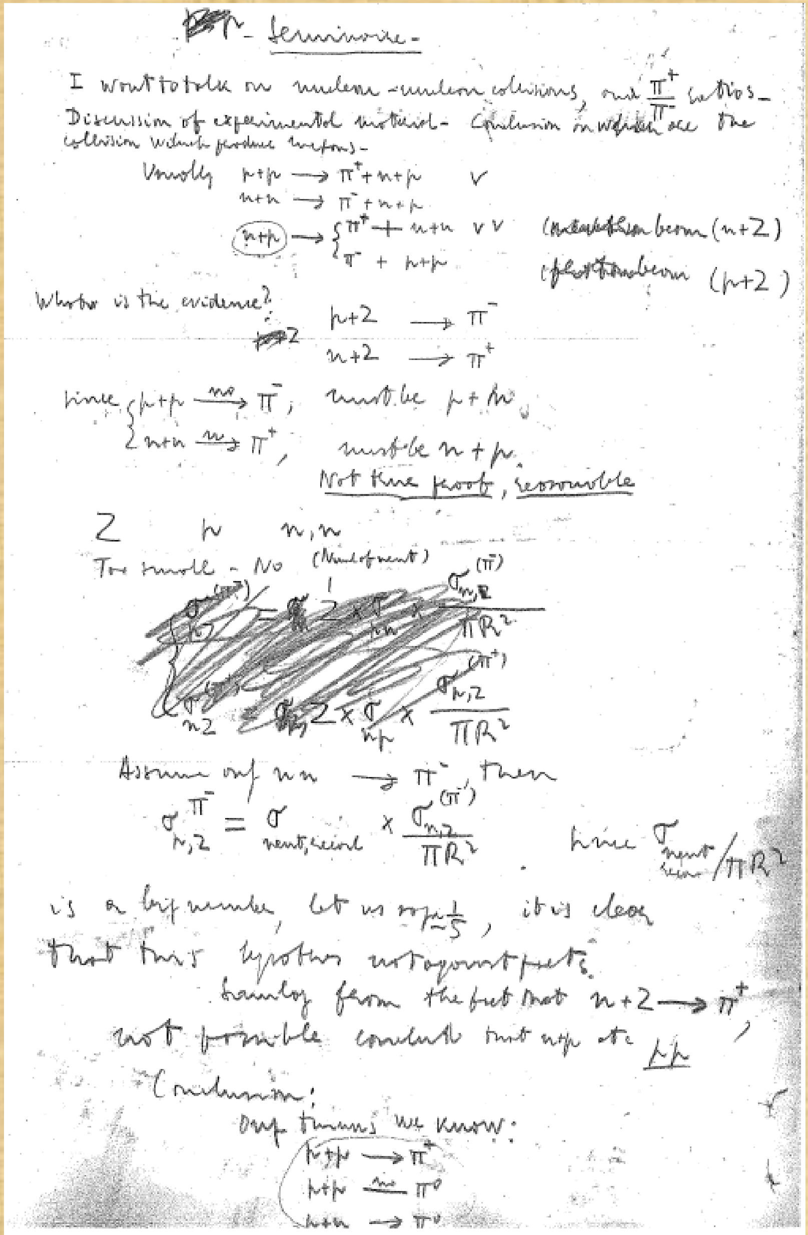
Brauner et al. Phys. Rev. 79, 720
n 270 MeV π^+/π^- =14

Brauner, not published:
π^+/π^- , protons 260-270 MeV = ≈15


Brauner, Cornell, Roukin
Phys Rev 79, 720.
n 270 MeV. π^-/π^+ = 14
50 MeV mesons
Brauner, not published:
π^+/π^-, protons 260-270 MeV
= ≈15
61

Pag. 61

Pag. 64: Seminario di Pontecorvo sul suo programma di ricerca sulle collisioni nucleone-nucleone e sulla misura del rapporto π^+/π^- .



\- <u>Seminaire</u> –

I want to talk on nucleon-nucleon collisions, and π^+/π^- ratios –

Discussion of experimental method –

Conclusion on what (??) are the collision which produce mesons

Usually p+p $\rightarrow \pi^+$+n+p

n+n $\rightarrow \pi^-$+n+p

n+p $\rightarrow \pi^+$+n+n (neutron beam (n+Z)

π^-+p+p (proton beam (p+Z)

What is the evidence ?

p+Z $\rightarrow$ π^-

n+Z $\rightarrow$ π^+

Since p+p $\rightarrow$ no π^-, must be p+n

n+n $\rightarrow$ no π^+, must be n+p

<u>Not true proof</u>, <u>reasonable</u>

Z p n,n

Too smoll – No

Assuming only (?) n n $\rightarrow$ π^-, then

$\sigma^{\pi^-}{}_{p,Z} = \sigma_{neut,recoil} \times \sigma^{\pi^-}{}_{n,Z}/\pi R^2$

since $\sigma_{neut,recoil}/\pi R^2$

is a big number, let us say ≅ 1/5, it is clear

that this hypothesis not against facts.

Similarly from the fact that n+Z $\rightarrow$ π^+,

not possible conclude that n+p etc. <u>p p</u>

Conclusion:

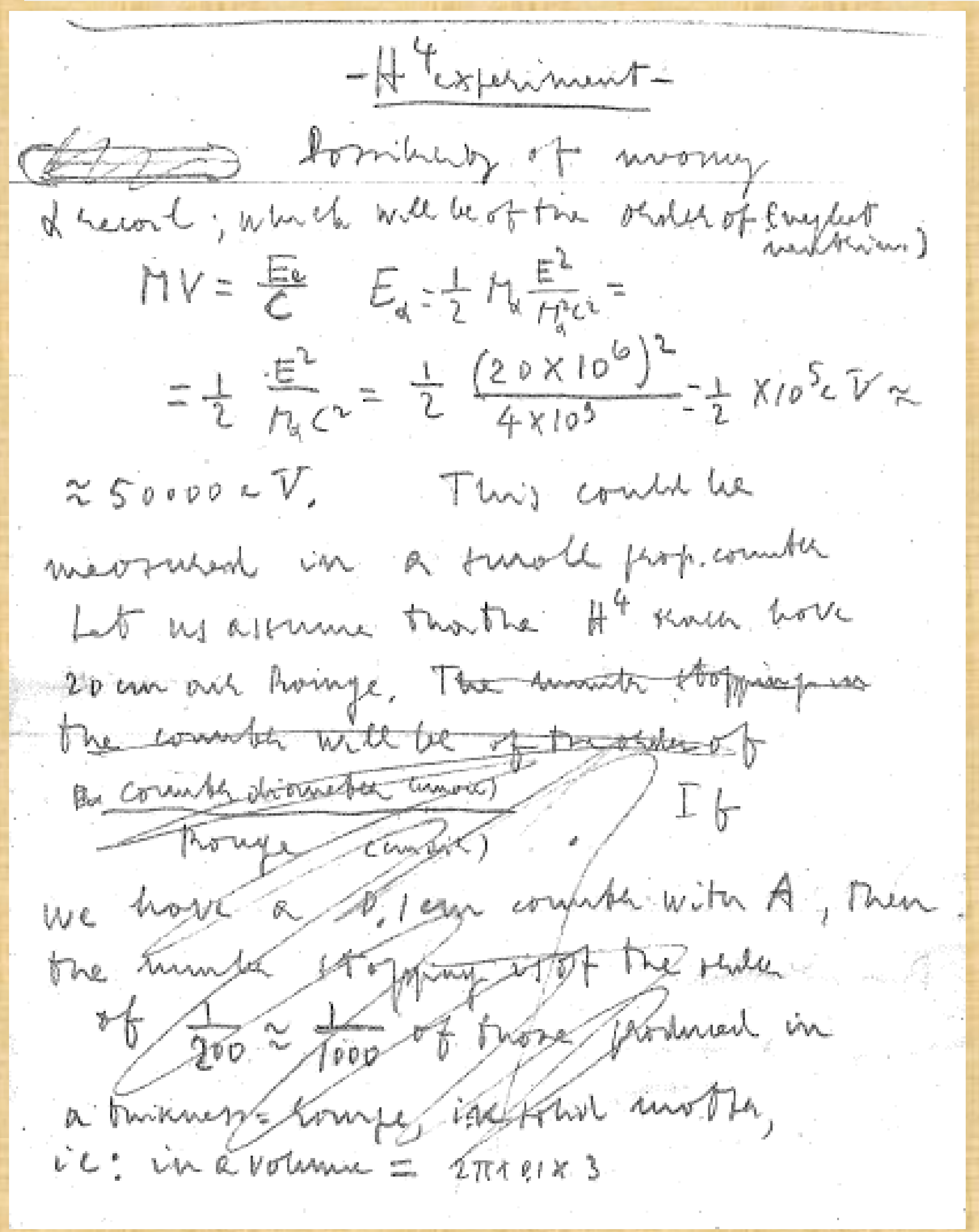
only ??? we know:

p+p $\rightarrow$ π+

p+p $\rightarrow$ no π^0

p+n $\rightarrow$ π^0

Valutazioni sulla fattibilità di un "H4 experiment" (pag.13)



\- H^4 experiment -

~~Possibility~~ Possibility of measuring α recoil; which will be of the order of (neglect neutrinos)

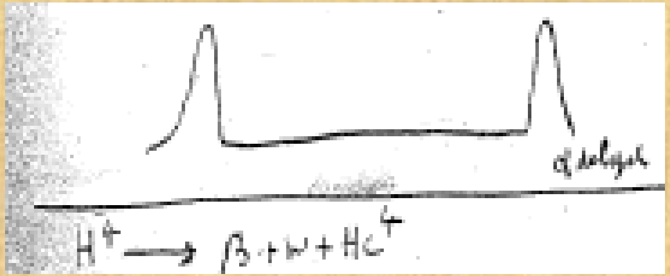
$$MV = \frac{E_e}{c} \quad E_\alpha = \frac{1}{2} M_\alpha \frac{E^2}{M_\alpha^2 c^2} = \frac{1}{2}\frac{E^2}{M_\alpha c^2} = \frac{1}{2}\frac{(20\times10^6)^2}{4\times10^9} = \frac{1}{2}\times10^5 eV \approx$$

≈ 50000 eV. This could be measured in a small prop. counter.
Let us assume that the H^4 track have 20 cm avr Range. ~~The number stopping in the counter will be of the order of the counter diameter (cm avr) / Range (cm avr)~~ If we have a 0.1 cm counter with A, then ~~the number stopping is of the order of $\frac{1}{200} \approx \frac{1}{1000}$ of those produced in a thickness = range, in solid matter, i.e.: in a volume = $2\pi\times0.1\times3$~~

- H^4 experiment -

Possibility of measuring α recoil which will be of the order of (neglect neutrinos) $Mv=E_e/c$ $\quad E_\alpha= \frac{1}{2}M_\alpha E^2/(M_\alpha^2 C^2) = 1/2\, E^2\, (M_\alpha C^2) = \frac{1}{2}\,(20\times10^6)^2 / 4\times10^9 = \frac{1}{2}\, 10^5 eV$ ≈ 50000 eV. This could be measured in a small prop. counter .

Let us assume tat the H^4 track have 20 cm avr (?) Range. ~~The number stopping in the counter will be of the order of counter diameter(cm avr)/Range(cm avr). If we have a 0.1 cm counter with A, then the number of stopping is of the order of 1/200 ≈ 1/1000 of those produced in a thikness range, in solid matter, i.e.: in a volume = 2π×0.1×3~~



H^4 ipotetico stato legato di tre neutroni ed un protone: non è mai stato osservato.

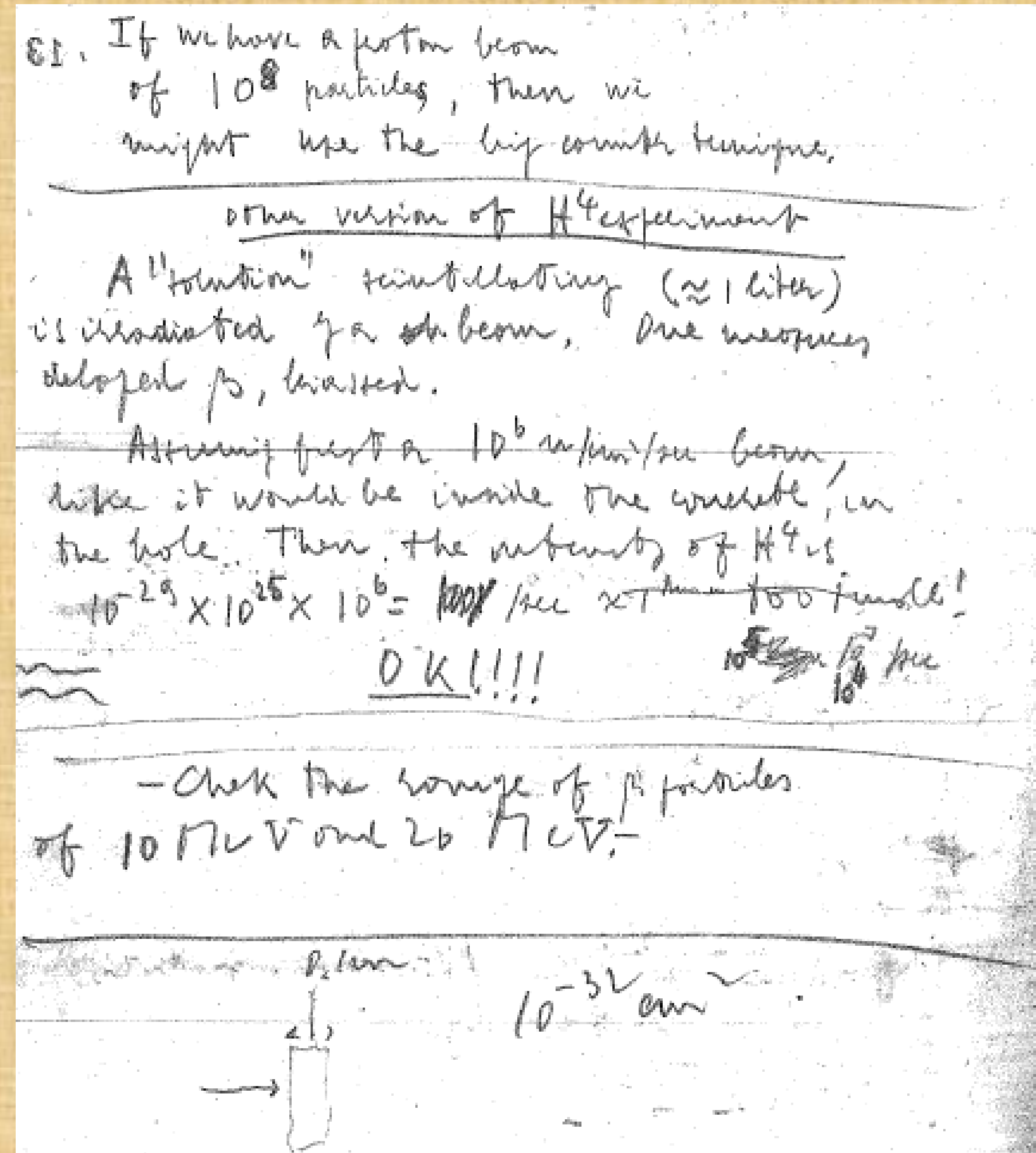
Valutazioni sulla fattibilità di un "H^4 experiment" (pag.13)

The number produced is, per cm^3, $10^{-28}(\sigma)\times N\times 2\times 10^{19}$/sec. To have an intensity of 10/millisec, or 10^4/sec aver. is necessary a ~~N of~~ fantastic intensity. No good. (unless: we <u>irradiate</u> ?? 0.1 per A protons (?)

Let us calculate with a big counter, let us say Lenght 40 cm, diameter 6 cm Volume $\pi\times 9\times 40$ <u>1 liter</u>, atmosferic pressure. This give a rate of H^4 equal to $10^{-28}\times 2\times 10^{22}\times N$ intens av/sec. Intensity ave per pulse = $1/40 \times 10^{-28}\times 2\times 10^{22}\times N = 10$

If this = 10, then N must be $=10^8$/sec/cm^2. We could ?? that in the channel, but the intensity is too big at "?? ??"

Valutazioni sulla fattibilità di un "H^4 experiment" (pag.14)



If we have a proton beam of 10^8 particles, then we might use the big counter tecnique.

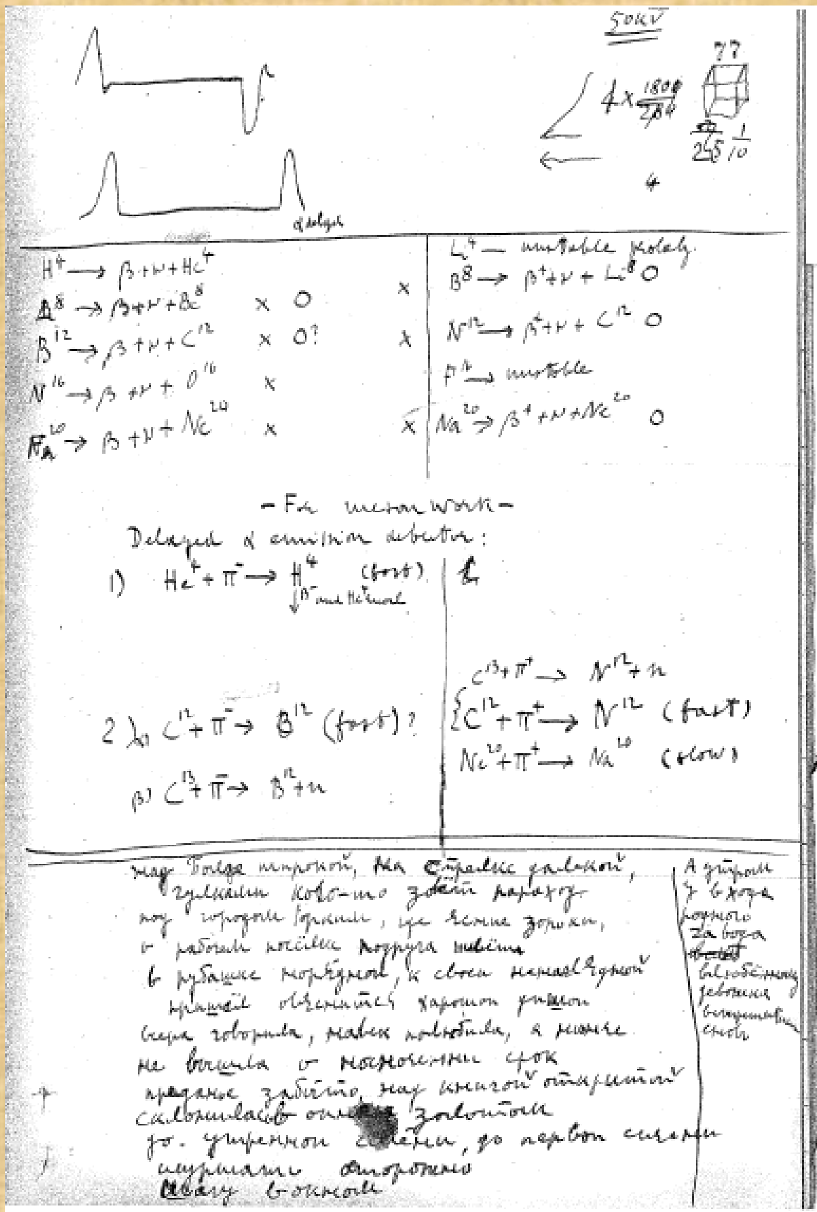
Other version of H^4 experiment

A "solution" scintillating (≈ 1 liter) is irradiated by a beam, One measures delayed β, biassed. Assuming ?? a 10^6 n/cm²/sec beam, like it would be inside the ??, in the hole. Then the intensity of H^4 is $10^{-29} \times 10^{25} \times 10^6 = 100$/sec ~~≈1min too small!~~

OK !!!!

- Chek the range of β particles of 10 MeV and 20 MeV -

Fisica ma anche Poesia



$H^4 \to \beta+\nu+He^4$ | $Li^4 \to$ unstable probably

$Li^8 \to \beta+\nu+Be^8$ x o x | $Be^8 \to \beta^++\nu+Li^8$ o

$B^{12} \to \beta+\nu+C^{12}$ x o? x | $N^{12} \to \beta^++\nu+C^{12}$ o

$N^{16} \to \beta+\nu+O^{16}$ x | $F^{16} \to$ unstable

$F^{20} \to \beta+\nu+Ne^{20}$ x x | $Na^{20} \to \beta^++\nu+Ne^{20}$ o

-For meson work –

Delayed α emission ??? :

1) $He^4+\pi^- \to H^4$ (fast)

$\to \beta^-$ and He^4 recoil

2) α) $C^{12}+\pi^- \to B^{12}$ (fast) ? | $C^{13}+\pi^+ \to N^{12}+n$

| $C^{12}+\pi^+ \to N^{12}$(fast)

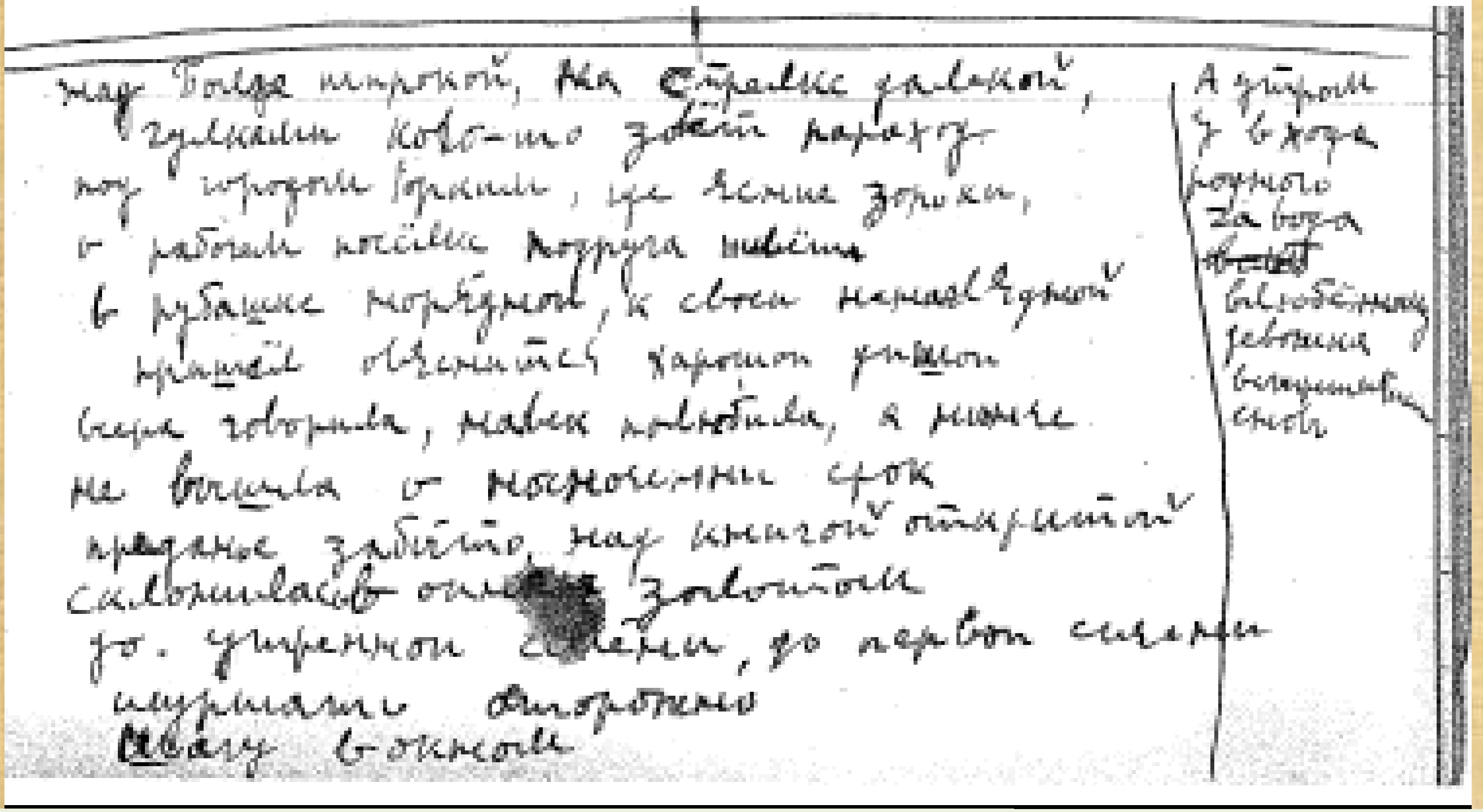
β) $C^{13}+\pi^- \to B^{12}+n$ | $Ne^{20}+\pi^+ \to Na^{20}$(slow)

Lirica di Sormovo
(Сормовская лирическая)

Canzone d'amore (diventata poi canzone) di **Yevgeniy Aronovich Dolmatovsky**

Parla di un fidanzato che si veste a festa e va nella cittadina di Sormovo a trovare la sua bella, ma viene da lei deluso.

Il testo russo della poesia



На Волге широкой,
На стрелке далёкой
Гудками кого-то зовёт пароход.
Под городом Горьким,
Где ясные зорьки,
В рабочем посёлке подруга живёт.

В рубашке нарядной
К своей ненаглядной
Пришёл объясниться хороший дружок:
Вчера говорила —
Навек полюбила,
А нынче не вышла в назначенный срок.

Свиданье забыто,
Над книгой раскрытой
Склонилась подруга в окне золотом.
До утренней смены,
До первой сирены
Шуршат осторожно шаги под окном.

Ой, летние ночки,
Буксиров гудочки...
Волнуется парень и хочет уйти.
Но девушки краше,
Чем в Сормове нашем,
Ему никогда и нигде не найти.

А утром у входа
Родного завода
Влюблённому девушка встретится вновь
И скажет: «Немало
Я книжек читала,
Но нет ещё книжки про нашу любовь».

http://poetryrain.com/authors/dolmatovskiy-evgeniy/10919

https://www.youtube.com/watch?v=Ig0g5-2fK5k

Pagina 85: Siamo ad estate 1951 (~ July 11) e Pontecorvo cerca di definire il programma per l'anno successivo.

Plan of the year

85

I) Anatol Alex +Vladimir

Investigation of the possibility of a stable state of H^4, and, in case of existence of H^4 investigating of its proprerties.

The problem is interesting from the point of view of the ?? light number ?????? on the ?? β decay.

Preliminary experiments should be done within the next few months. The first experiment consists in curving the (hypothetical) β particles in the cyclotron magnetic field and registering them in 3 counters in coincidence, placed at a distance of $\geq$ 10 cm from the cyclotron target. This method should give a rough measurements of $H\rho$, while a measurement of the lifetime (expected value $\approx 10^{-3}$ sec) is made by electronic methods. The H^4 could be produced in the target by nuclear interactions (?): for example Li^8 excite $\rightarrow H^4 + He^4$.

If the first rough experiment is successful, it will take about a year to investigate the properties of H^4 (spectrum, lifetime) and ?? also to study in what condition it is produced.

If the first experiment is not successful, other methods are considered: these are a) detection of H^4 in a long liquid organic scintillation counter, biased so that it does not register ?? β particles by Energy $\leq$ 14 MeV, and ?? by high energy neutron.

b) Detection (on a prop. count. filled with He) ? of delayed α particles ($\approx$few tens KV) corresponding to the recoil of β from H^4

$H^4 \rightarrow He^4 + \beta + \text{neutrino}$. In this experiment, the 50 MeV π^- meson should be used to produce H^4 according to $\pi^- + He^4 \rightarrow H^4 + He^4$ but unfortunately the interest of the problem

Pagina 86: Siamo ad estate 1951 e Pontecorvo cerca di definire il programma per l'anno successivo.

of H^4 is only if a stable (versus ???) H^4 exists. In other words a negative results on H^4 is not significant.
However if the H^4 experiments are negative, the thecniques developed may be used in other problems like the investigation of short life b radioelements (B^{12} etc) under meson bombardment.

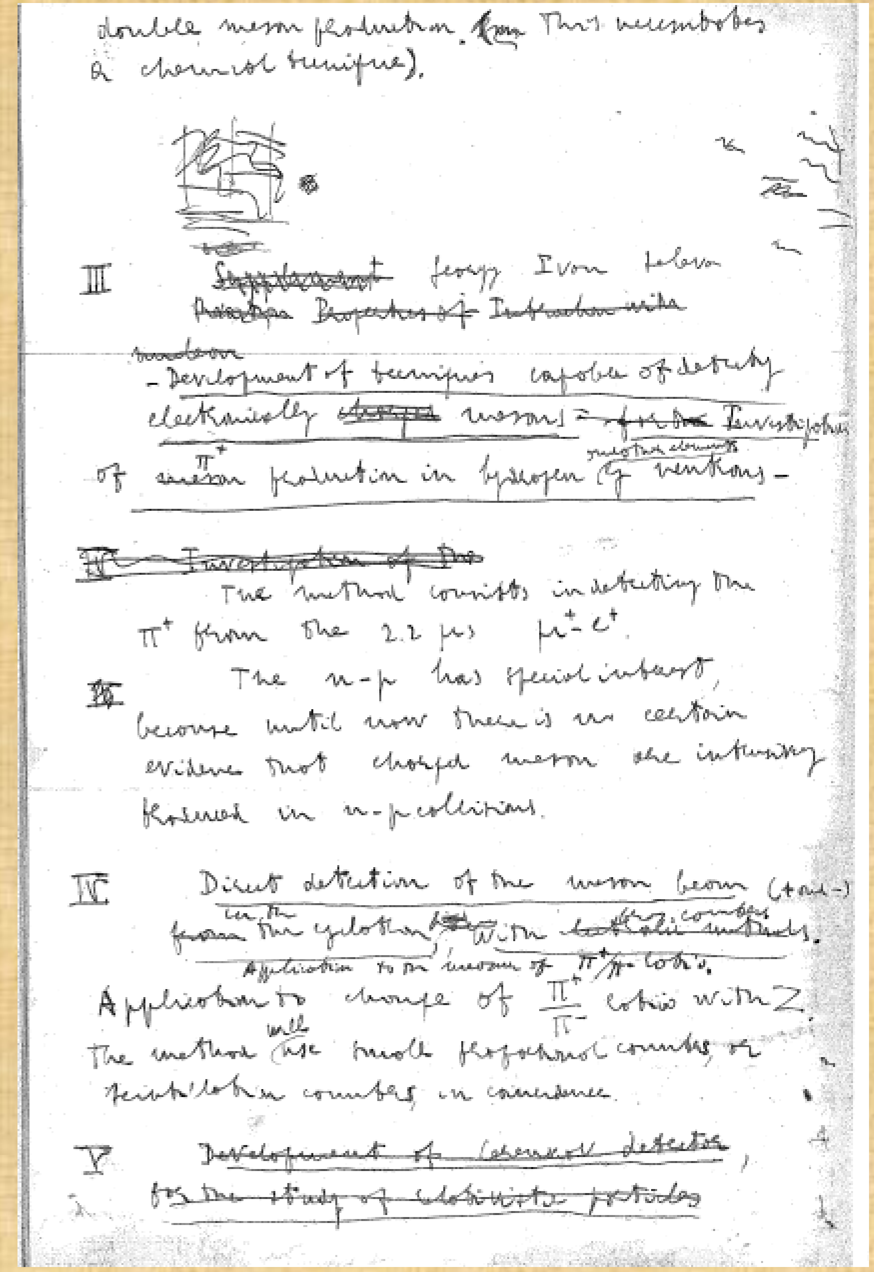
~~Adolph~~

II) Application of the method of radioactive indicators to the investigation of properties of mesons:

When charged mesons interact with nuclei, stars and charge exchange (emission of a π^0) are possible. In both cases radioelements may be produced (For example $B^{10} + \pi^+ \rightarrow C^{11} + \pi^0$) These radioelements can be used a) To determine the cross section for meson charge exchange, for positive and negative mesons ("fast" + and - π 25 Mev or 50 MeV)

~~b)~~ ⊕ To use the radioelements as meson indicators in experiment on mesons.

Pagina 87: Siamo ad estate 1951 e Pontecorvo cerca di definire il programma per l'anno successivo.



double meson production (this necessitates a chemical technique).

III Georgy Ivan Selivan

-Development of techniques capable of detecting elettronically mesons . Investigation of π^+ production in hydrogen and other elements by neutrons.

The method consists in detecting the π^+ from the 2.2μs $\mu^+ - e^+$.

The n – p has special interest because until now there is no certain evidence that charged meson are intensively produced in n-p collisions

IV Direct detection of the meson beam (+ and -) in the cyclotron, with ~~electronic methods~~ ??? Counters.

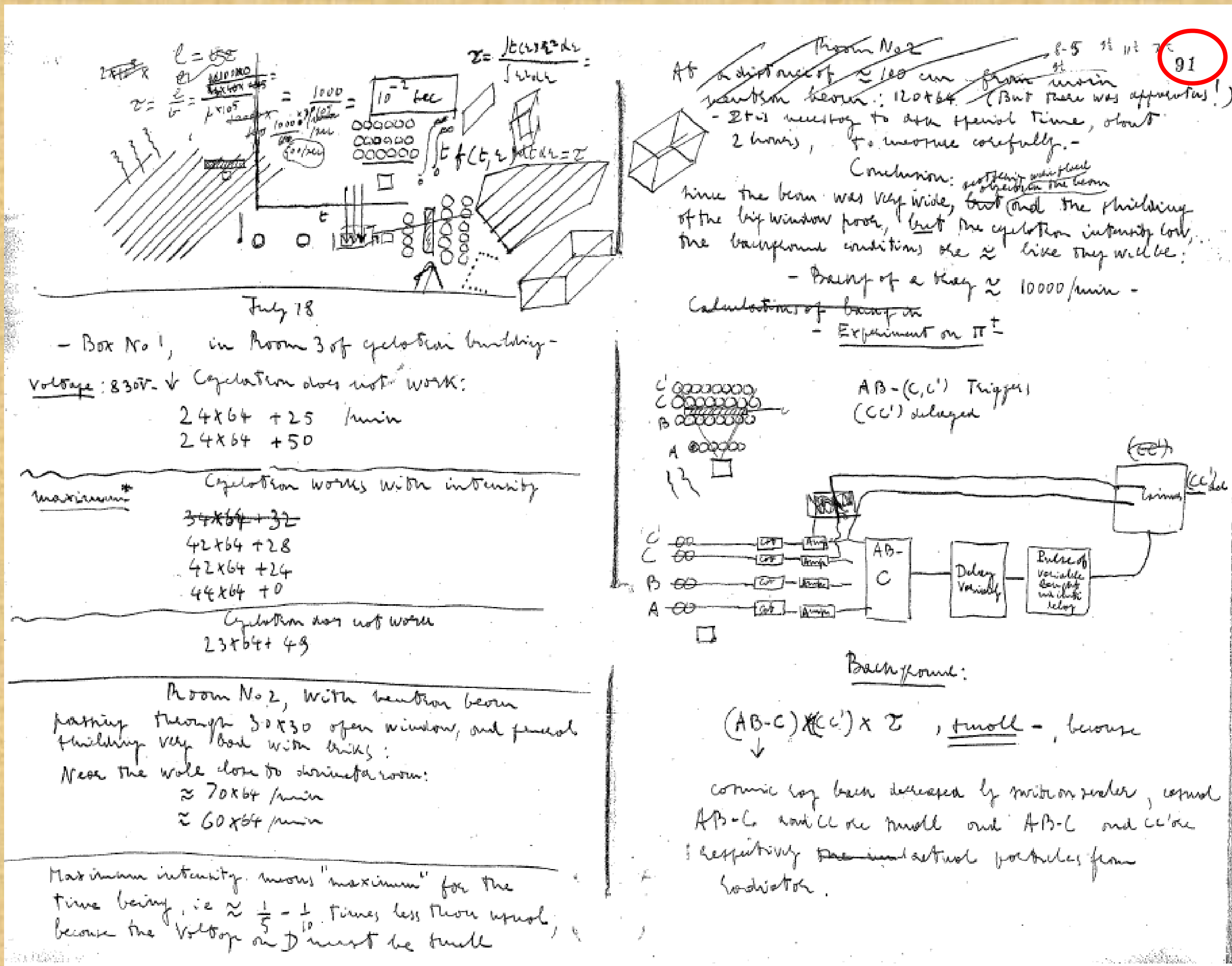
Application to the measure of π^+/π^- ratio.

Application to change of π^+/π^- ratio with Z.

The method will use small photoplates?(?) counters or scintillation counters in coincidence

V ~~Development of Cerenkov detectors, for the study of relativistic particles.~~

Pagina 91: July 18, ultima data presente sul quaderno che contiene ancora 9 pagine. Si inizia ad attuare il programma stabilito con due esperimenti in contemporanea nelle sale sperimentali room 3 e room 2 (con fascio di neutroni).



July 18

– Box No 1, in Room 3 of cyclotron building –

voltage: 830V – Cyclotron does not work:

24×64 + 25 /min
24×64 + 50

maximum* Cyclotron works with intensity

~~34×64 + 32~~
42×64 + 28
42×64 + 24
44×64 + 0

Cyclotron does not work
23×64 + 49

Room No 2, with neutron beam passing through 30×30 open window, and general shielding very bad with bricks:
Near the wall close to [illegible] room:
≈ 70×64 /min
≈ 60×64 /min

Maximum intensity means "maximum" for the time being, i.e ≈ $\frac{1}{5}$ – $\frac{1}{10}$ times less than usual, because the voltage on D must be small

At a distance of ≈ 100 cm from main neutron beam: 120×64 (But there was apparatus!)
– It is necessary to take special time, about 2 hours, to measure carefully. –

Conclusion: since the beam was very wide, and the shielding of the big window poor, but the cyclotron intensity low, the background conditions are ≈ like they will be.

– Background of a tray ≈ 10000/min –

~~Calculations of background~~

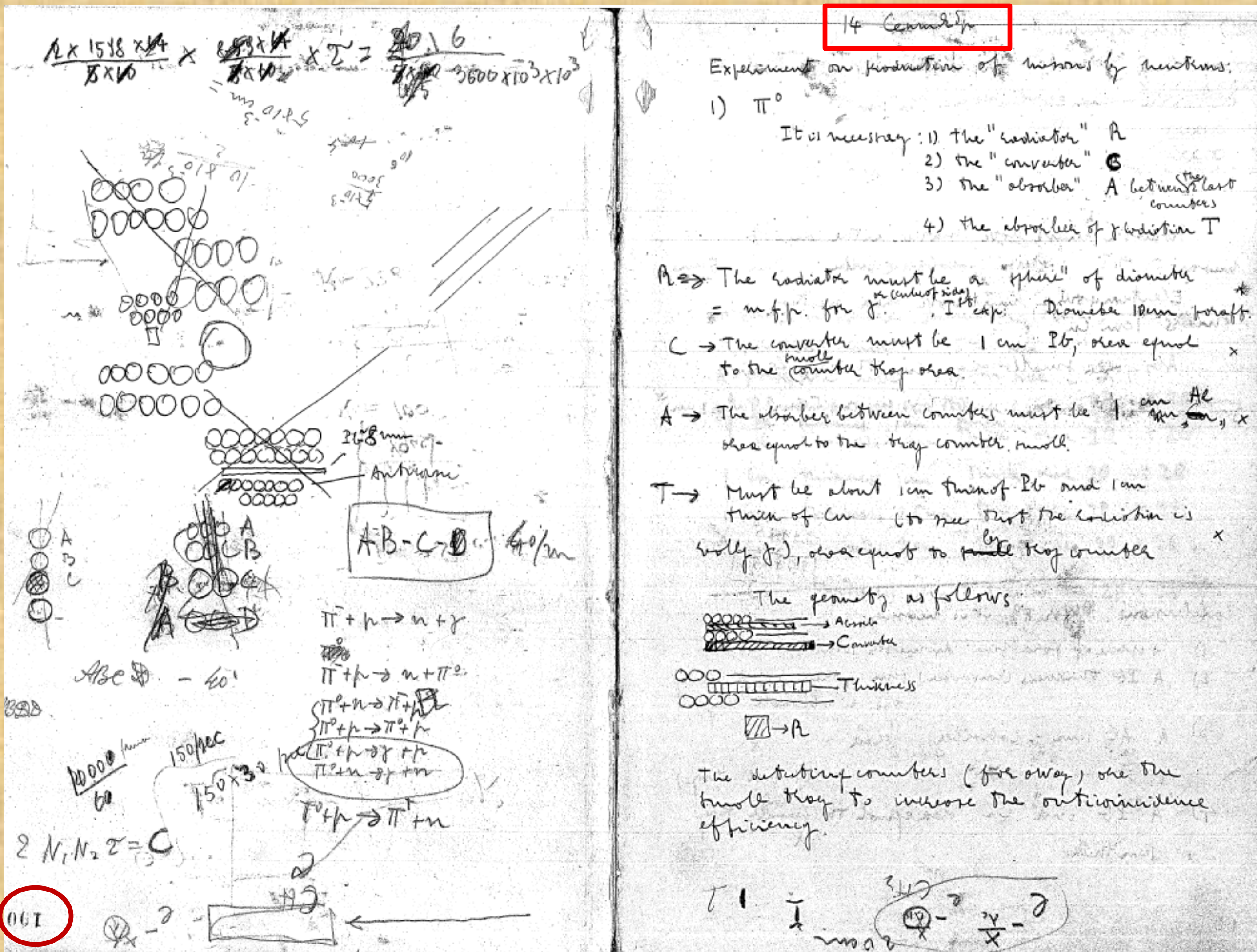
– Experiment on $\pi^{\pm}$ –

AB–(C,C') Triggers
(CC') delayed

Background:

(AB–C)(CC') × τ, small –, because cosmic ray back decreased by [illegible], [illegible] AB–C and CC' are small and AB–C and CC' are respectively actual particles from radiator.

Pontecorvo riprende a scrivere sul primo quaderno il 14 settembre 1951 iniziando dall'ultima pagina (la numero 100) dopo aver capovolto il quaderno. Propone di fare l'esperimento di produzione di mesoni con un fascio di neutroni: **"Experiment on production of mesons by neutrons":**



14 September

Experiment on production of mesons by neutrons:

1) π^0

It is necessary :

1) *the "radiator"* **R**
2) *the "converter"* **C**
3) *the "absorber"* **A** *between the 2 last counters*
4) *the absorber of* γ *radiation* **T**

R → *The radiator must be a "sphere " ....*
....

C → *The converter must be 1 cm Pb,....*
....

A→ *The absorber between counters ....*
....

T→ *Must be about 1 cm thin of Pb,....*
....

The geometry as follows:
....
....

E continua a scrivere quello che oggi chiameremmo il "Technical Proposal" dell'esperimento...

A settembre 1951, meno di un anno dopo il suo arrivo a Dubna, Bruno Maximovich Pontecorvo è un rispettato **group leader di un gruppo di giovani fisici** (Vladimir, Anatol, Alex, Adolph and George Selivanov). In frequenti group meeting assegna ad ogni membro del gruppo il lavoro da fare secondo il programma stabilito e spesso suggerisce come realizzare certe misure

1) Vladimir + Anatol. Alex. : Finish work on H^4, in the present variant, + report. Help of Fritha.

2) Adolph : Finish work on mesons with radioactive indicators + report.

Have β counters ready.

Have α counter ready

3) George

1) Finish work on duty factor + report. –

2) Conclude on the work of production of π^0 in C by neutrons

3) Initiate electronic detection of mesons in forest

4) Finish one ~~unit~~ 3 channel coincidence ~~output~~ canister of 3 liquids + scintillator (10^{-8} sec), on the principle

10^8 1-2, 10^8 1-3, 10^8 2-3 double coincidence 10^{-8}, triple 10^{-6} + 1 channel coincidence anti, external

10^{-6} [10^{-6}] ← external, coincid, anticoincid.

Remember delay of 5×10^{-8} to measure accidental.

4) Anatol : finish work + write 2 reports

a) angular

b) total work on secondary neutrons

Program

1) Measure the effective duty factor of the cyclotron as follows - For this:

a) Measure the resolving time of the system (using continuous sources).

b) Measure the accidental rates when the cyclotron works.

Experiment a: In the cyclotron building with a distance of two ~~trays of~~ CD about 10^m, and with 2 sources, measure:

1) Single rates, and coincidence: CD-A-B moveable limit.,

from this we get 2τ ~~Same without~~

2) Same with no source for correcting values in subsequent experiment.

Experiment b:

1) When cyclotron works, single rates and coincidence rates.

Measurement of α, duty factor.

I) Take 2 single counters. +

II) Put them on the beam, far away x with from each other. and measure A B (AB)

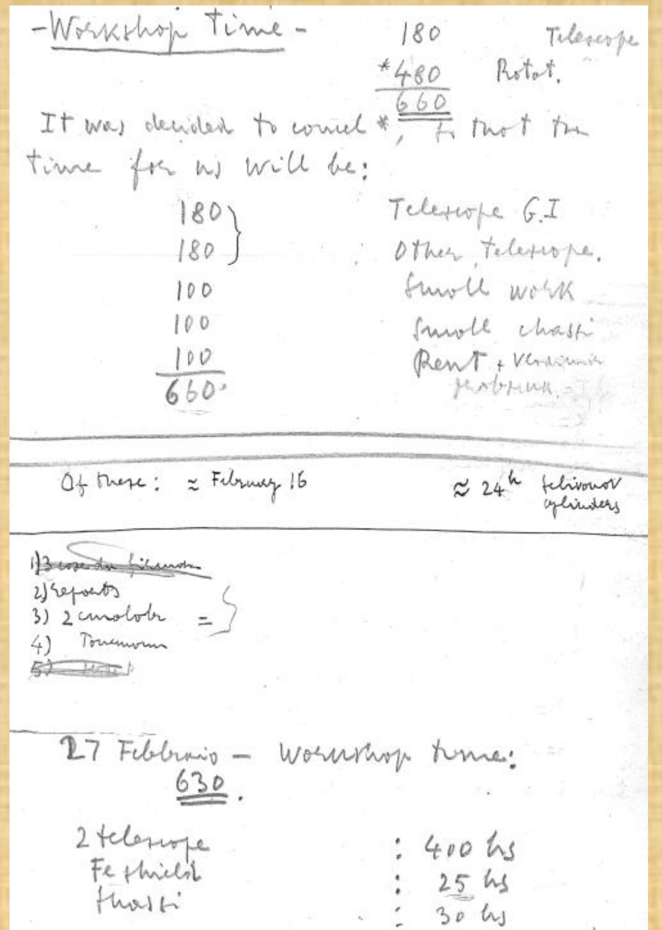
III) ~~Verify that~~ Verify that the cyclotron is constant.

IV) ~~For various condition of~~ Measure also after shutdown, A, B (AB)

V) Write all data relative to the cyclotron

VI) If the experiments are reasonably reproducible, try various conditions of cyclotron.

L'attività di tutto il gruppo è molto ben documentata giornalmente



-Workshop Time-

180 Telescope
*480 Rotat.
660

It was decided to cancel *, so that the time for us will be:

180 Telescope G.I
180 Other telescope.
100 small work
100 small chassis
100 Rent + ...
660.

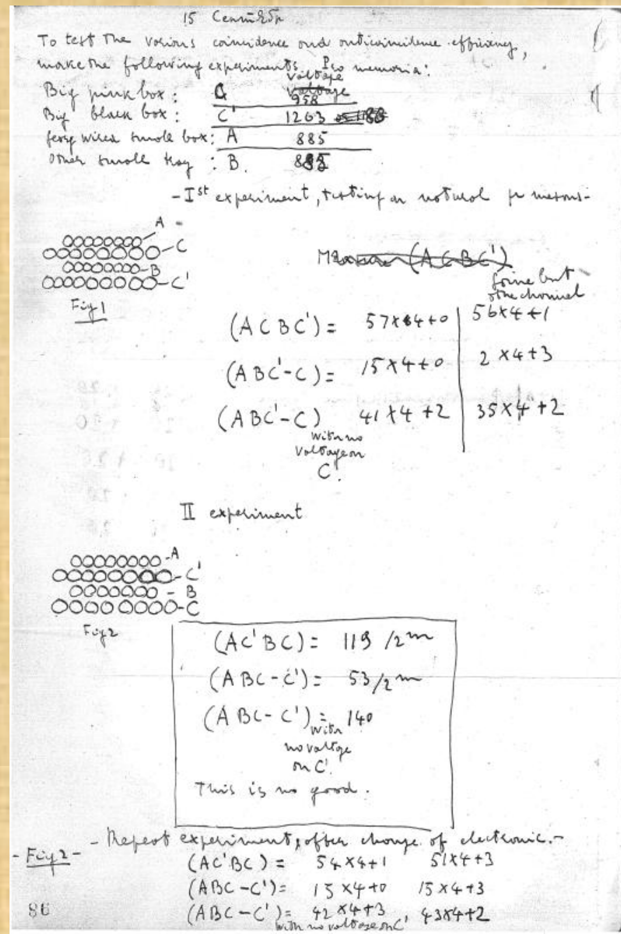
Of these: ≈ February 16 ≈ 24^h ... cylinders

2) Reports
3) 2 ...
4) ...

27 Febbraio – Workshop time:
630.

2 telescope : 400 hs
Fe shield : 25 hs
chassis : 30 hs

Tempo richiesto in officina meccanica per costruire il supporto dei rivelatori



15 ...

To test the various coincidence and anticoincidence efficiency, make the following experiments ... :

Big pink box : C 958
Big black box : C' 1263
... box : A 885
Other small ... : B 885

-Ist experiment, testing on ...-

Fig 1

(ACBC') = 57x4+0 | 56x4+1
(ABC'-C) = 15x4+0 | 2x4+3
(ABC'-C) with no voltage on C' 41x4+2 | 35x4+2

II experiment

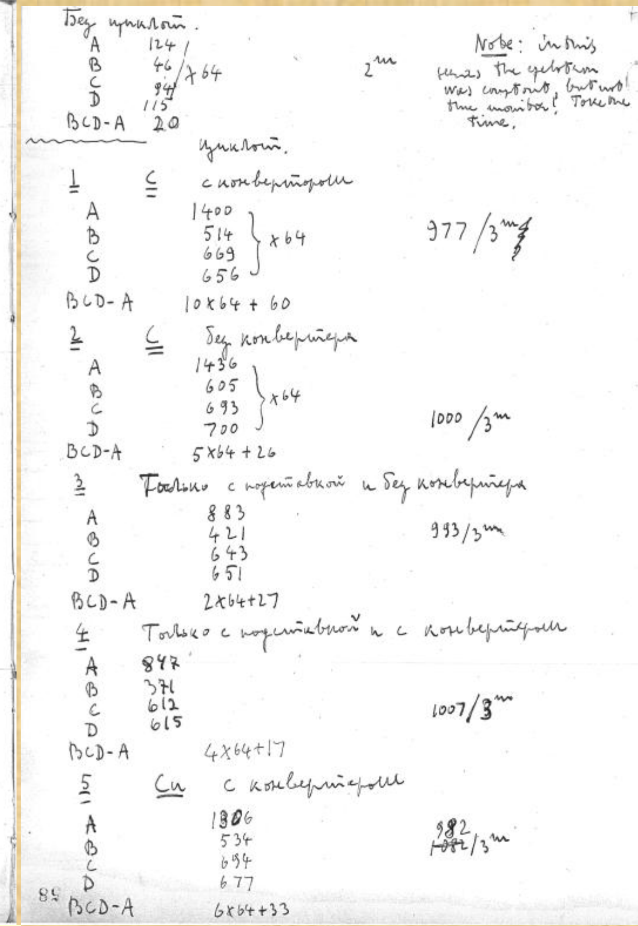
Fig 2

(AC'BC) = 119 /2m
(ABC-C') = 53/2m
(ABC-C') with no voltage on C' = 140

This is no good.

- Fig 2 - - Repeat experiment, after change of electronic.-
(AC'BC) = 54x4+1 51x4+3
(ABC-C') = 13x4+0 15x4+3
(ABC-C') = 42x4+3 with no voltage on C', 43x4+2

Misure di efficienza di varie coincidenze e anticoincidenze dei rivelatori



Без ...
A 124
B 46
C 94 x64
D 115
BCD-A 20

Note: in this series the ... was constant, but not the ... Take the time.

1 ... с ...
A 1400
B 514
C 669 x64
D 656
BCD-A 10x64 + 60 — 977/3m

2 ... без ...
A 1436
B 605
C 693 x64
D 700
BCD-A 5x64 + 26 — 1000/3m

3 Только с ... и без ...
A 883
B 421
C 643
D 651
BCD-A 2x64+27 — 993/3m

4 Только с ... и с ...
A 847
B 371
C 612
D 615
BCD-A 4x64+17 — 1007/3m

5 Cu с ...
A 1806
B 534
C 654
D 677
BCD-A 6x64+33 — 982/3m

La presa dati

Primi report interni sulla produzione di mesoni π

I risultati di tutti gli esperimenti fatti da Pontecorvo ed il suo gruppo nel periodo 1951-1954 al ciclotrone di Dubna furono pubblicati in russo come Report Interni del Laboratorio.
In questi primi esperimenti venne studiata la produzione di mesoni π, carichi e neutri, con protoni e neutroni su bersaglio di protoni e nuclei complessi.
La produzione del π^0 con fascio di neutroni su protoni e nuclei complessi fu studiata per la prima volta nel mondo. *(B.M.Pontecorvo, G.I.Selivanov, RINP,1951)* and *(B.M.Pontecorvo, G.I.Selivanov, RINP,1952; Dokl.Acad. Nauk SSSR,102,253 (1955)).*

- Production of neutral mesons ~~in~~ by neutrons -

Schema: A) Introduction B) Apparatus C) Absolute experiment in Carb D) ~~Relative measurements Discussion in relation to production of mesons~~ E) Relative measurements F) Discussion a) Production b) λ G) Conclusions - Spectrum

Introduction.

~~While~~ Whilst a considerable amount of data have been published (1) in the last years on the production of ~~char~~ mesons by protons and nucleons, the ~~indirect~~ production of ~~charged~~ mesons by neutrons has been so far only the object of a short communication (2) ~~and the production of neutral mesons by neutrons so far had not been observed~~. The following table summarizing ~~the~~ present day information on this subject.

Table I

It ~~is clear~~ may be seen from this table that production of charged and neutral mesons in elementary n-p collisions has not yet been observed and even in complex nuclei the production of neutral mesons by neutrons has not yet been observed. For this reason,
~~Because of the absence of data on this subject,~~
it ~~was natural~~ presents ~~true~~ a considerable interest
~~In the present work we report~~ experiments
~~we have made~~ utilizing the neutrons from the synchrocyclotron of our laboratory, we have investigated (and observed, for the first time), the production of neutral mesons in Hydrogen and complex nuclei by neutrons. ~~The research on~~ The investigation of the production of neutral

Draft in Inglese scritto tra l'11 e il 18 marzo 1952)

„УТВЕРЖДАЮ"

Доктор физико-математич. наук

(М.Г.Мещеряков)

„25" сентября 1952г.

НАУЧНЫЙ ОТДЕЛ
СЕКТОР № 62

ОТЧЕТ
ОБРАЗОВАНИЕ π^0-МЕЗОНОВ В (n – p) и (n–d)
СТОЛКНОВЕНИЯХ.

Начальник сектора № 62
профессор (Б.М.Понтекорво)

Исполнители:
профессор (Б.М.Понтекорво)
Ст.инженер (Селиванов Г.И.)

1952 г.

25 September 1952

REPORT
Production of π^0 mesons in (n-p) and (n-d) collisions

Section leader
Professor (B.M.Pontecorvo)

Executors:
Professor (B.M.Pontecorvo)
Engineer (Selivanov G.I.)

Report Interno in Russo datato 25 settembre1952 gentilmente procuratoci da Gil Pontecorvo

Fisico sperimentale ma anche fisico teorico

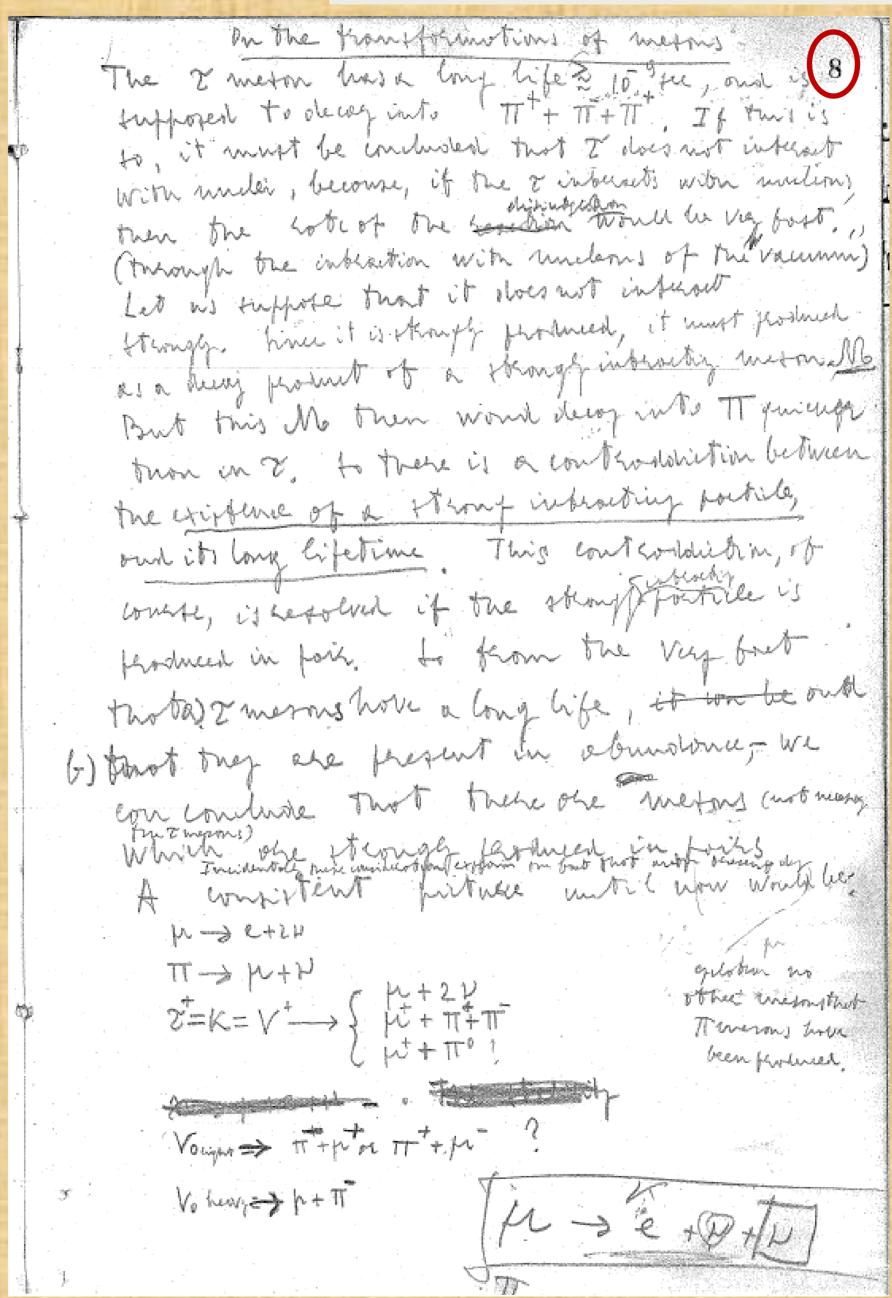
Dalle pagine di questi quaderni emerge la figura di bravo fisico sperimentale che coordina le attività del suo gruppo con competenza e grande rigore scientifico.

Gli esperimenti sull'interazione π–nucleone che in questi anni Pontecorvo realizza col suo gruppo al ciclotrone di Dubna sono certamente molto importanti per capire, almeno da un punto di vista fenomenologico, le interazioni forti.
Con questi esperimenti si conferma che il protone e il neutrone per quanto riguarda le interazioni forti non sono due particelle diverse ma sono la stessa particella in due stati diversi di un nuovo numero quantico chiamato spin isotopico.

Tuttavia l'interesse scientifico di Pontecorvo va ben oltre questi esperimenti, e molte delle sue riflessioni di questi anni riguardano ancora le interazioni deboli.
L'interazione debole aveva da sempre affascinato Pontecorvo, alla cui comprensione aveva già dato contributi fondamentali.

Interessantissimo è ciò che scrive a pagina 8! !

(primi di Novembre del 1950)



On the transformations of mesons -

The τ meson has a long life $>\approx 10^{-9}$ sec, and is supposed to decay into $\pi^+ + \pi^- + \pi^+$. If this is so, it must be concluded that τ does not interact with nuclei, because , if the τ interacts with nucleons then the rate of the disintegration would be very fast.
(trough the interaction with nucleons of the vacuum)
Let us suppose that it does not interact strongly . Since is strongly produced, it must produced as a decay product of a strongly interacting meson M. But this M then would decay into π quicker than in τ. So there is a contradiction between the existence of a strong interacting particle and his long lifetime. This contradiction, ***of course*** *, is resolved if the strongly interacting particle* ***is produced in pair.*** (*) *So from the very fact that a) τ mesons have a long life, b) that they are present in abundance, - we can conclude that there are mesons (not necessarily the τ mesons) which are strongly produced in pairs.*
(incidentally these considerations explain the fact that until present day cyclotron no other mesons that π mesons have been produced.)
A consistent picture until now would be:

$$\mu \to e + 2\nu$$

$$\pi \to \mu + \nu$$

$$\tau^+ = K = V^+ \to \begin{cases} \mu + 2\nu \\ \mu^+ + \pi^+ + \pi^- \\ \mu^+ + \pi^0 \ ? \end{cases}$$

$$V_{0\,light} \to \pi^- + \mu^+ \text{ or } \pi^+ + \mu^- \ ?$$

$$V_{0\,heavy} \to p + \pi^-$$

K

$\mu \to e + (\nu) + \boxed{\nu}$ (**)

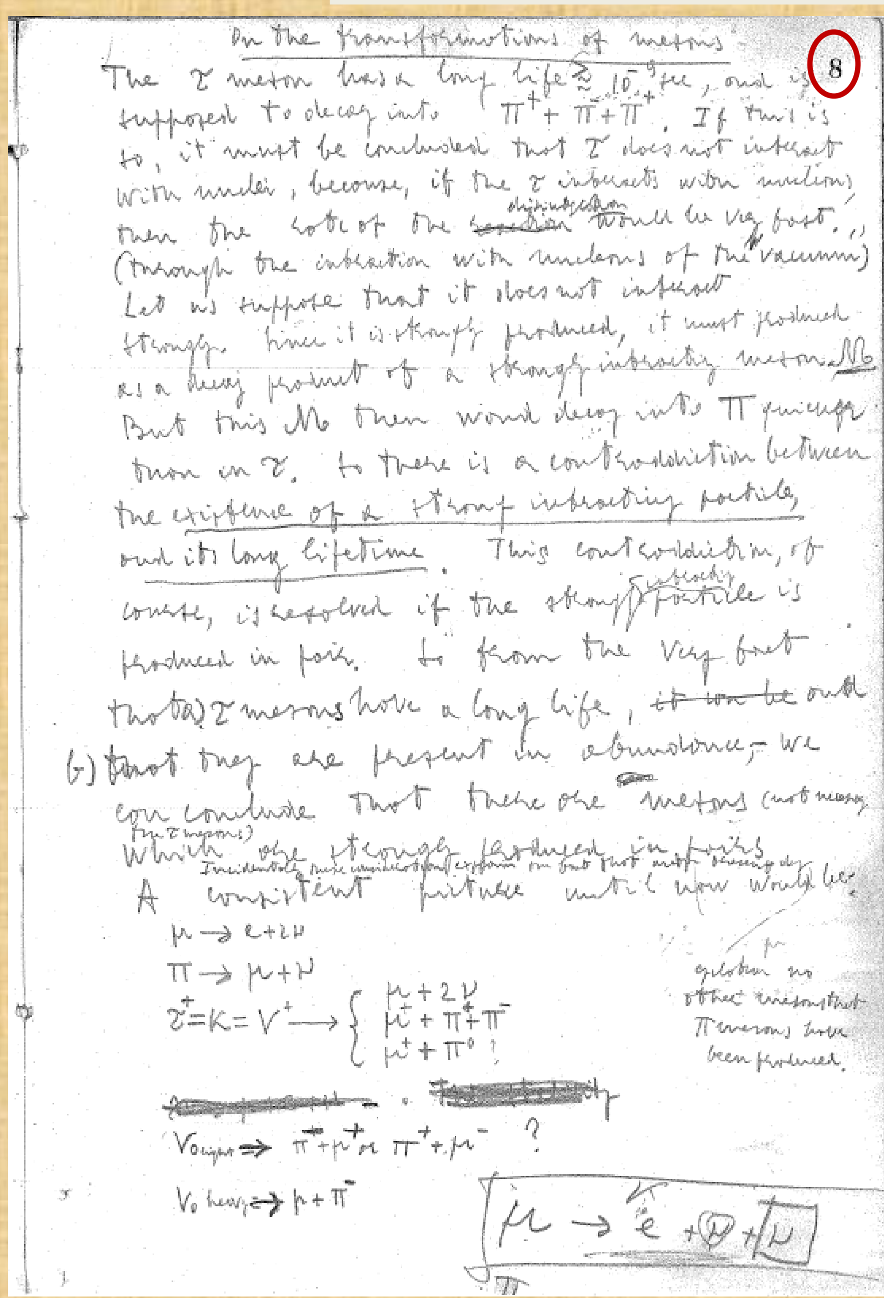
π

(*) **a fine 1950 senza la nozione della stranezza**, è necessaria una profonda intuizione **per proporre che una produzione in coppia risolve la contraddizione**.
(**) forse solo una coincidenza! Due righe prima scrive $\mu \to e + 2\nu$ mentre qui scrive $\mu \to e + \nu + \nu$ indicando i due neutrini con due diversi segni.

Due profonde intuizioni in una singola pagina ?!

Forse c'è una seconda intuizione geniale a pagina 8 !!

(primi di Novembre del 1950)


8

On the transformations of mesons

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$\pi \to \mu + \nu$

$\tau^+ = K = V^+ \to \{ \mu + 2\nu;\ \mu^+ + \pi^+ + \pi^-;\ \mu^+ + \pi^0\ ?$

$V_{0\,light} \to \pi^- + \mu^+$ or $\pi^+ + \mu^-$?

$V_{0\,heavy} \to p + \pi^-$

$\mu \to e + (\nu) + \boxed{\nu}$

On the transformations of mesons -

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$$V_{0\,heavy} \to p + \pi^-$$

$$\mu \xrightarrow{K} e + \textcircled{\nu} + \boxed{\nu} \quad (**)$$

π

(*) **a fine 1950 senza la nozione della stranezza**, è necessaria una profonda intuizione **per proporre che una produzione in coppia risolve la contraddizione.**
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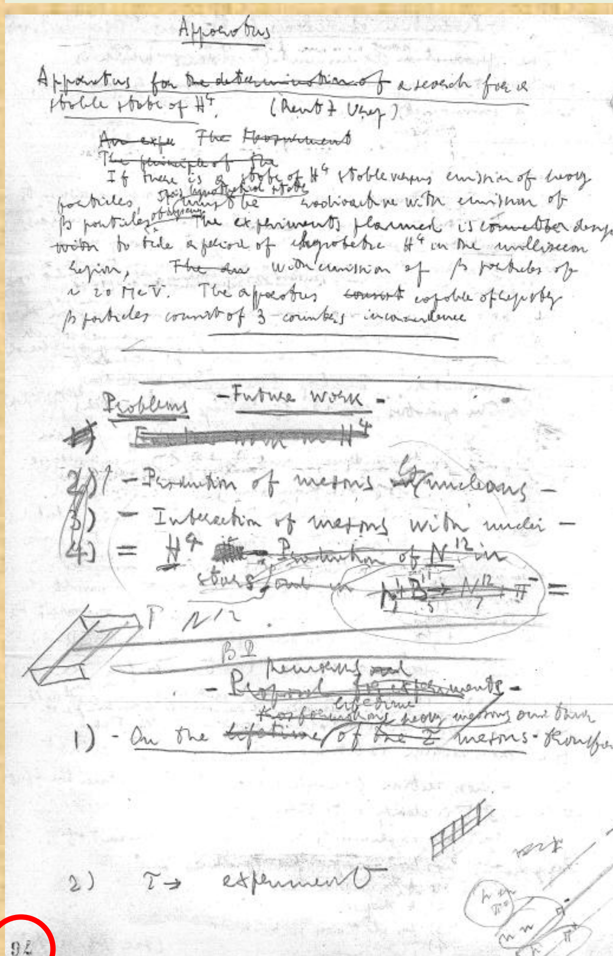
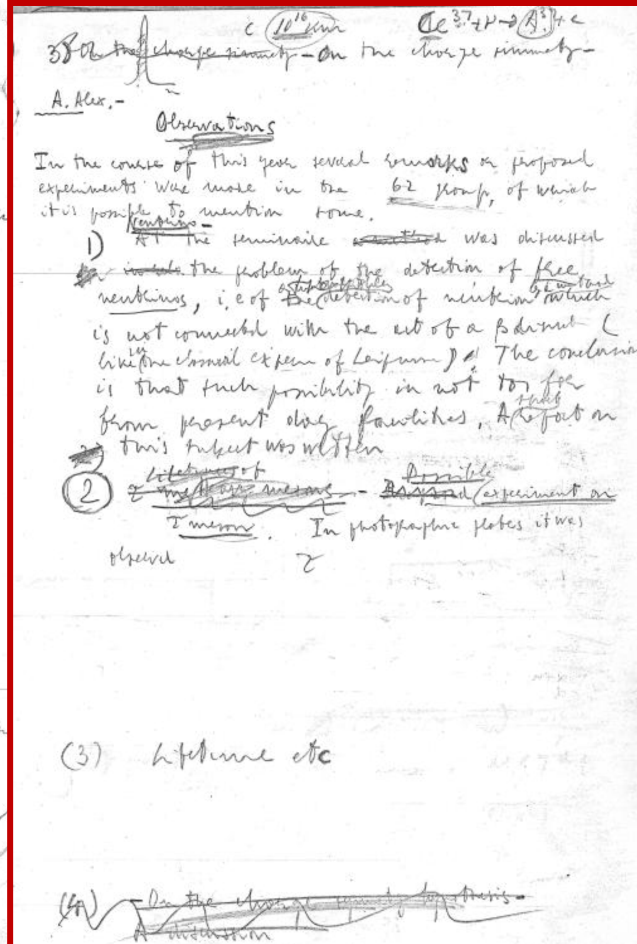
Due profonde intuizioni in una singola pagina ?!

Sul quaderno si trova un'altra pagina (la 76) interessantissima !!

Questa pagina è stata scritta tra il 25 dicembre 1951 e il 30 gennaio 1952.





c *10^16 Km* (*) $Cl^{37} + \nu \rightarrow Ar^{37} + e$

~~3) On the charge symmetry~~ -On the charge symmetry

A. Alex.-

Observations

In the course of this year several remarks or proposed experiments were made in the 62 group, of which it is possible to mention some.

Neutrino -

1) *At the seminaire ~~a method~~ was discussed ~~in rela~~ the problem of the detection of free neutrinos, i.e. of a .... detection of neutrino, a method which is not connected with the act of a β disintegration (like in the classical experiment of Leipunski) The conclusion is that such possibility is not too far from present day facilities, A short report on this subject was written*

(2) *~~Lifetime of τ mes Heavy mesons~~ - Possible experiment on τ meson.*

In photographic plates it was observed τ

(3) *Lifetime etc.*

~~(4) - On the charge symmetry hypothesis~~
~~A discussion~~

Remarks ~~and~~
~~Proposal for experiments~~ -

1) *-On the ~~lifetime transformations~~ lifetime of ~~the τ mesons~~ heavy mesons and their transformation -*

2) τ → experiment

(*) H.Bethe and R.Peierls in Nature 133, 532 (07 April 1934) avevano valutato un limite superiore per la probabilità per il neutrino di interagire con la materia solida e scrivevano: *"For an (neutrino) energy of 2*3x10^6 volts….$\sigma < 10^{-44}$ cm^2(corresponding to a penetrating power of 10^16 Km in solid matter) It is therefore absolutely impossible to observe process of this kind with neutrinos created in nuclear transformation."*

Come rivelare il neutrino

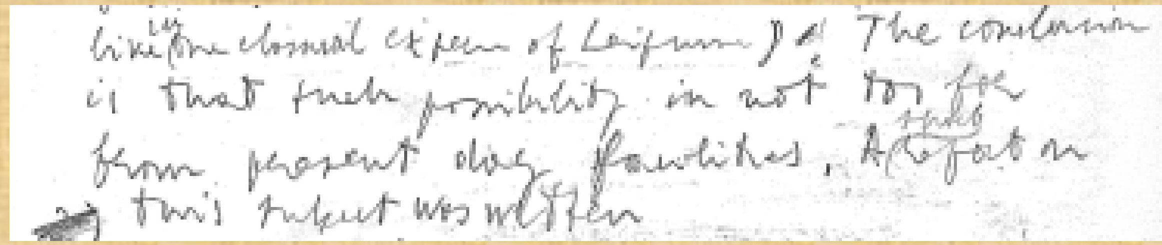
Immagino che Pontecorvo quando scrive, alla fine del 1951, nell'angolo in alto a destra della pagina 76 del quaderno

c (10^{16} km

$Cl^{37} + \nu \rightarrow A^{37} + e$

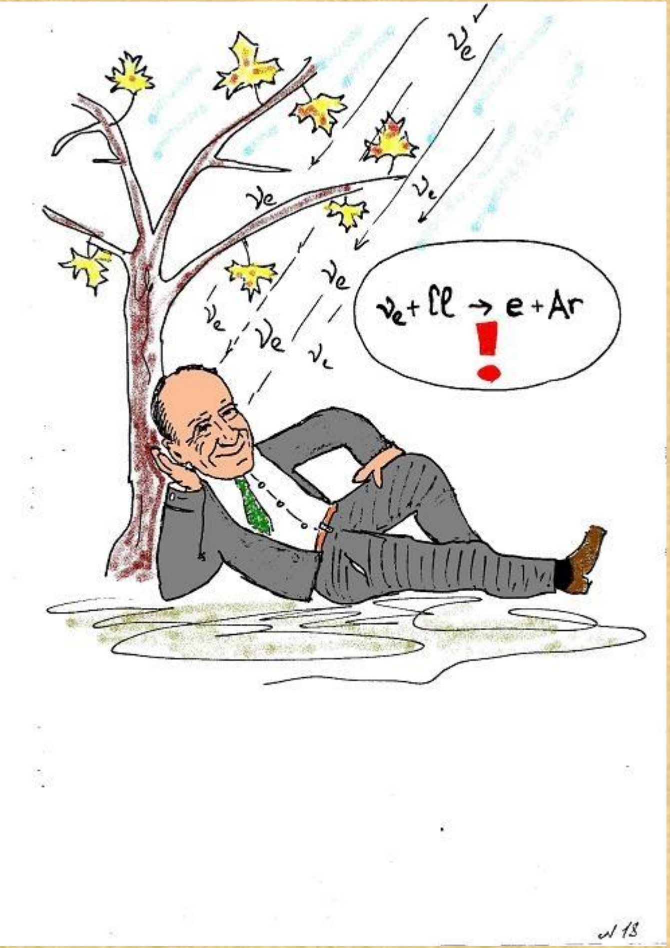
stia valutando il flusso di neutrini e la quantità di Cloro necessaria a rivelare questa particella cosí elusiva da poter attraversare 10^{16} Km di materia solida senza interagire !

Già alla fine del 1951 Pontecorvo pensa di essere in grado di fare l'esperimento Cloro/Argon per rivelare finalmente il neutrino.



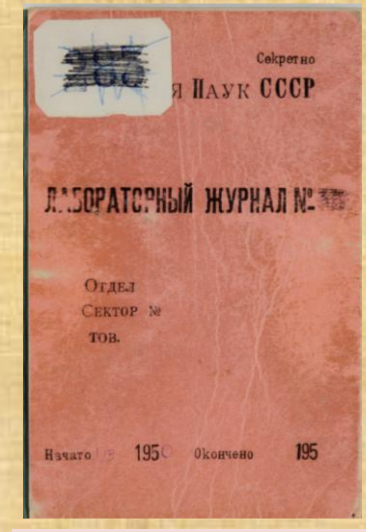
like the classical experiment of Leipunsky) The conclusion is that such possibility is not too far from present day facilities. A short report on this subject was written

Sarebbe veramente interessante trovare questo *"short report"* per sapere come e dove Pontecorvo pensava che fosse possibile per lui fare l'esperimento in Russia. Sfortunatamente questa possibilità non si concretizzò mai; forse perché non aveva a disposizione una miniera o una caverna sufficientemente grande e profonda da provare a rivelare il flusso di neutrini solari o forse semplicemente perché, come testimonia il fisico russo S.S.Gershtein, gli era negato l'accesso ai reattori nucleari che, come aveva scritto nei suoi articoli, sembravano essere una sorgente di neutrini più promettente di quella del sole per fare l'esperimento.

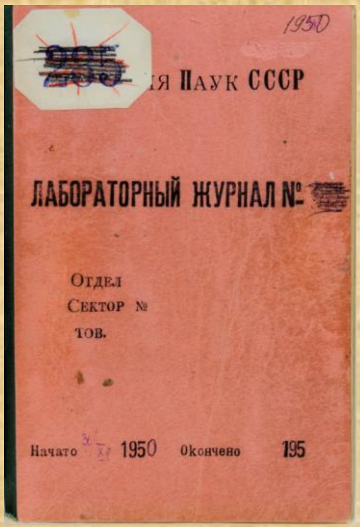


Sognando di rivelare i neutrini solari !
di Misha Bilenky

Conclusioni



01/11/1950 — ≤ 30/11/1950
14/09/1951 — ≥ 24/03/1952

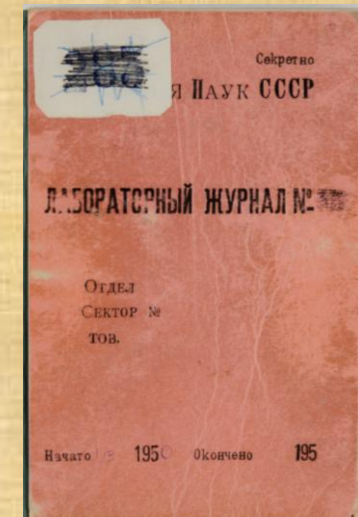


30/11/1950 — ≥ 18/07/1951

Attraverso la preziosa documentazione di questi due quaderni inediti (che molto spesso Pontecorvo usa soltanto come un "brogliaccio" scrivendoci in modo disordinato e senza un particolare ordine logico numeri, formule e grafici, forse solo per fissare i pensieri e le idee che gli turbinano nella mente) è stato possibile ricostruire il lavoro sperimentale, gli interessi scientifici e anche alcune grandi intuizioni che questo grande scienziato ha avuto durante il suo primo anno e mezzo di permanenza in Russia. Questi due documenti sono particolarmente interessanti anche perché spesso sono stati sollevati dubbi su quale sia stata la vera attività scientifica di Bruno Pontecorvo nei primi anni della sua permanenza in Russia.

In questi quaderni c'è la conferma più evidente che Bruno Maximovich Pontecorvo non abbia mai lavorato né contribuito alla realizzazione della bomba atomica russa ma abbia solo fatto ricerca di base in fisica delle particelle elementari.

Ringraziamenti



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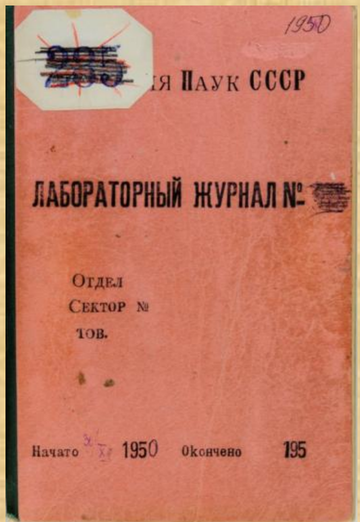

30/11/1950 — ≥ 18/07/1951

I nostri più sinceri ringraziamenti vanno a Gil Pontecorvo, il figlio maggiore di Bruno, che ci ha gentilmente concesso la possibilità di consultare questi documenti inediti. Un ringraziamento particolare ad Elena Volterrani per averci aiutato in ogni fase di questo lavoro, dal ritrovamento dei quaderni alla loro lettura. Ringraziamo Vincenzo Cavasinni e Marco Maria Massai che si stanno prodigando per la realizzazione di un centro Pontecorvo presso il Dipartimento di fisica di Pisa, per il supporto e l'incoraggiamento che ci hanno dato. Ringraziamo poi xxxx per averci tradotto dal alcune pagine scritte in russo che si trovano su questi quaderni. Ringraziamo infine Bruno Sereni e Antonio D'Agnelli dell'Ufficio Documentazione dell'Università di Pisa per l'accurato lavoro fatto nel fotografare in alta risoluzione tutte le pagine di questi quaderni.

Grazie dell'attenzione