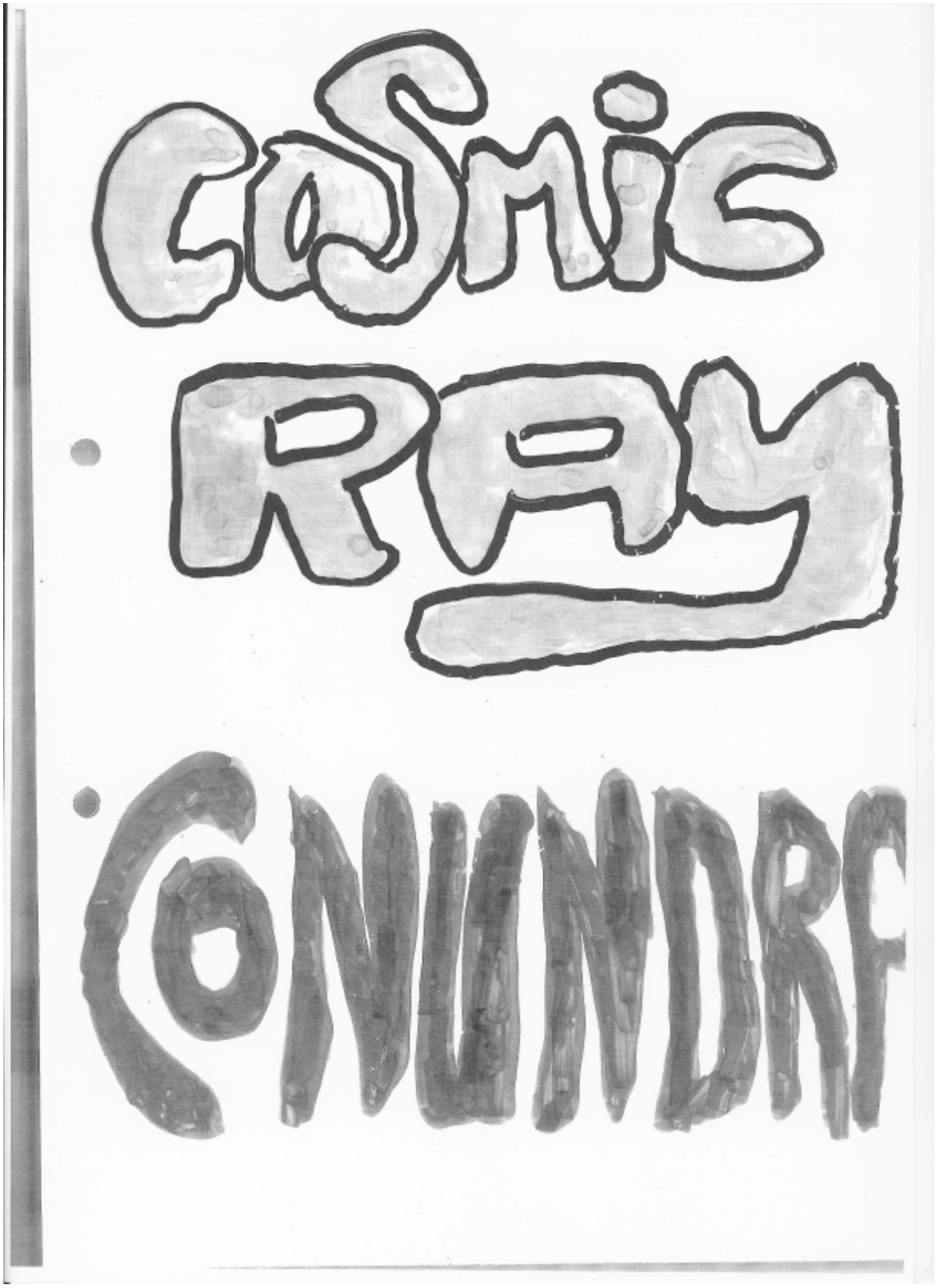
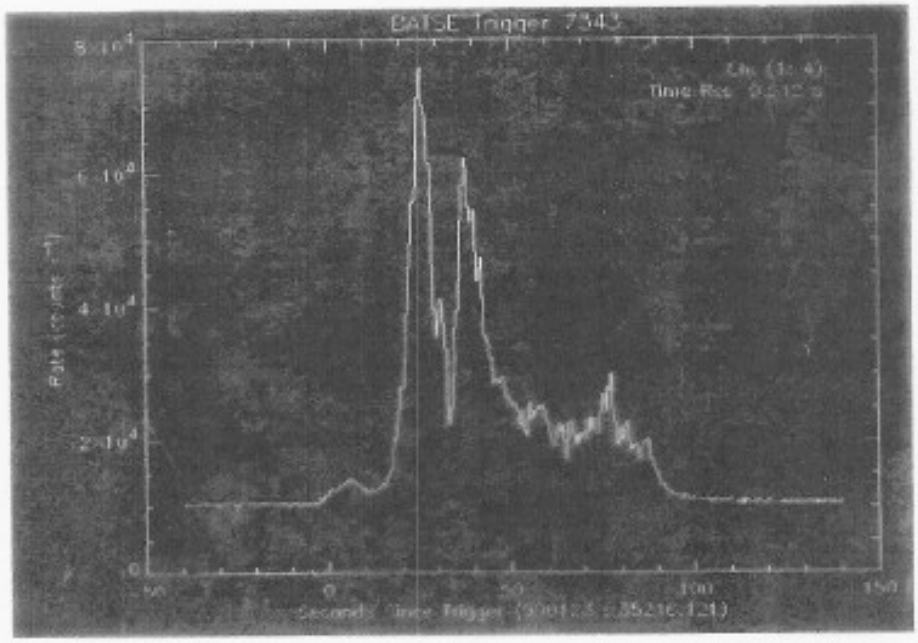
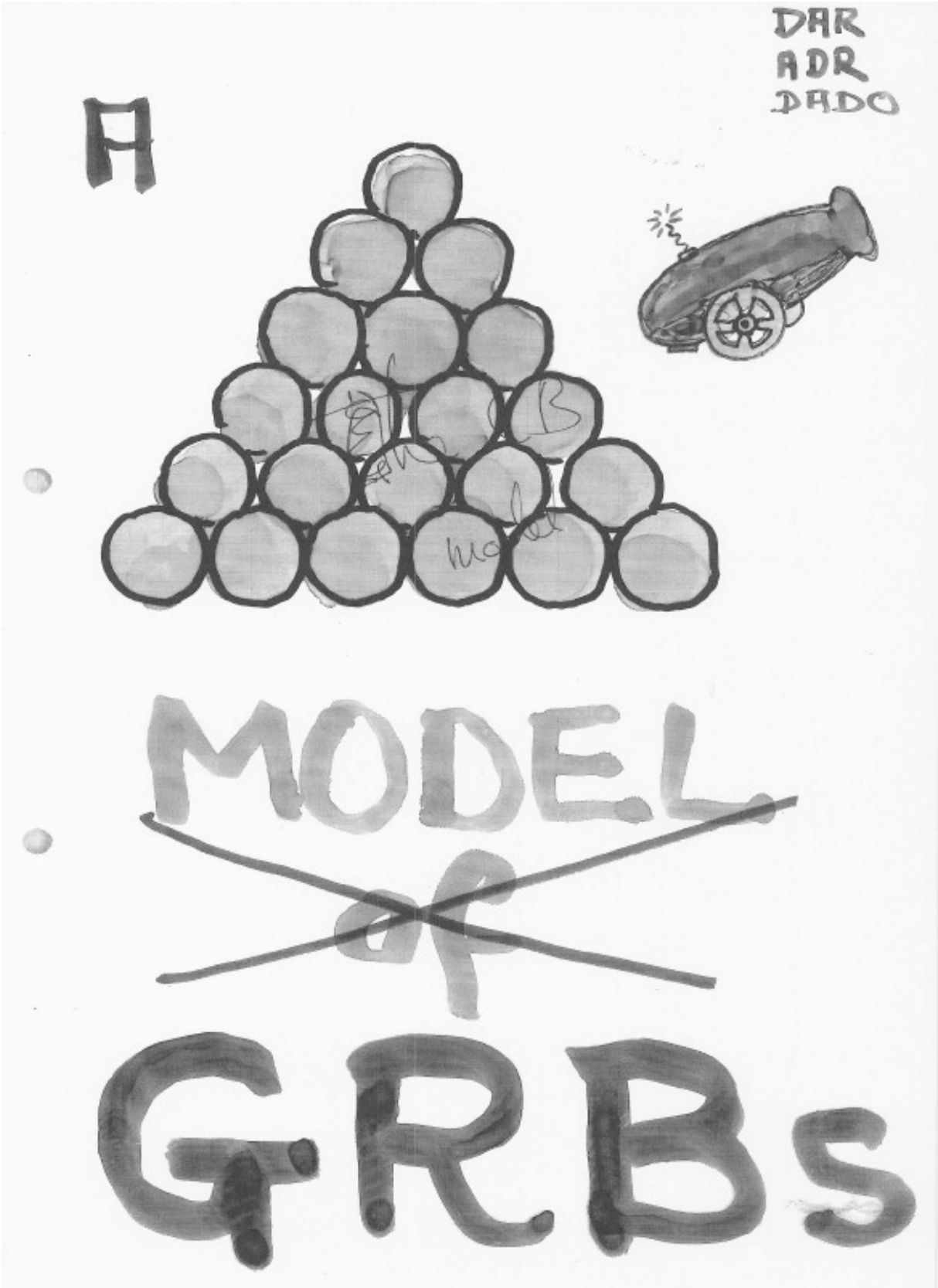


1derujula.jpg

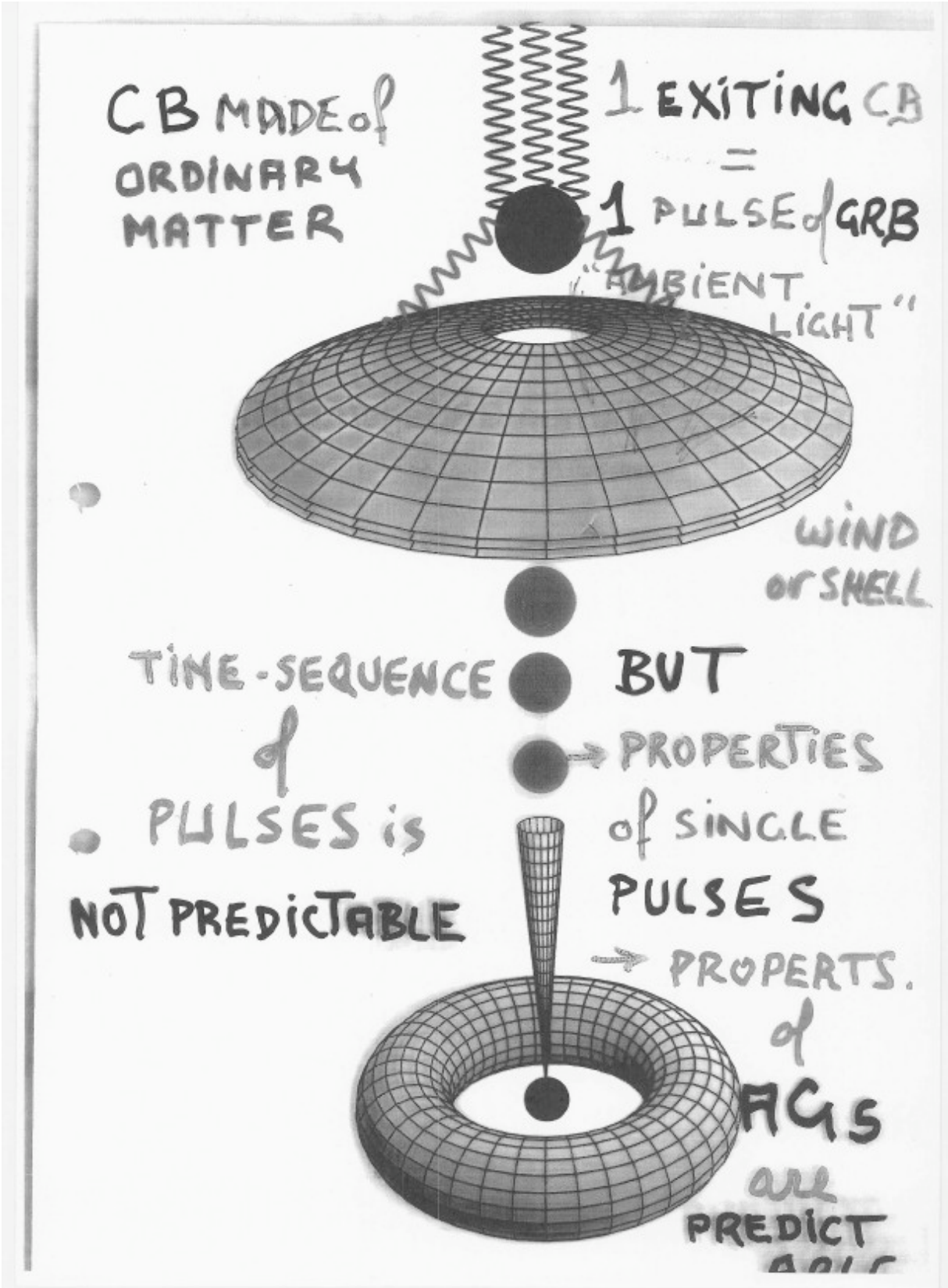
GRB 990123 $E_\gamma > 20$ keV



2derujula.jpg



3derujula.jpg



4derujula.jpg

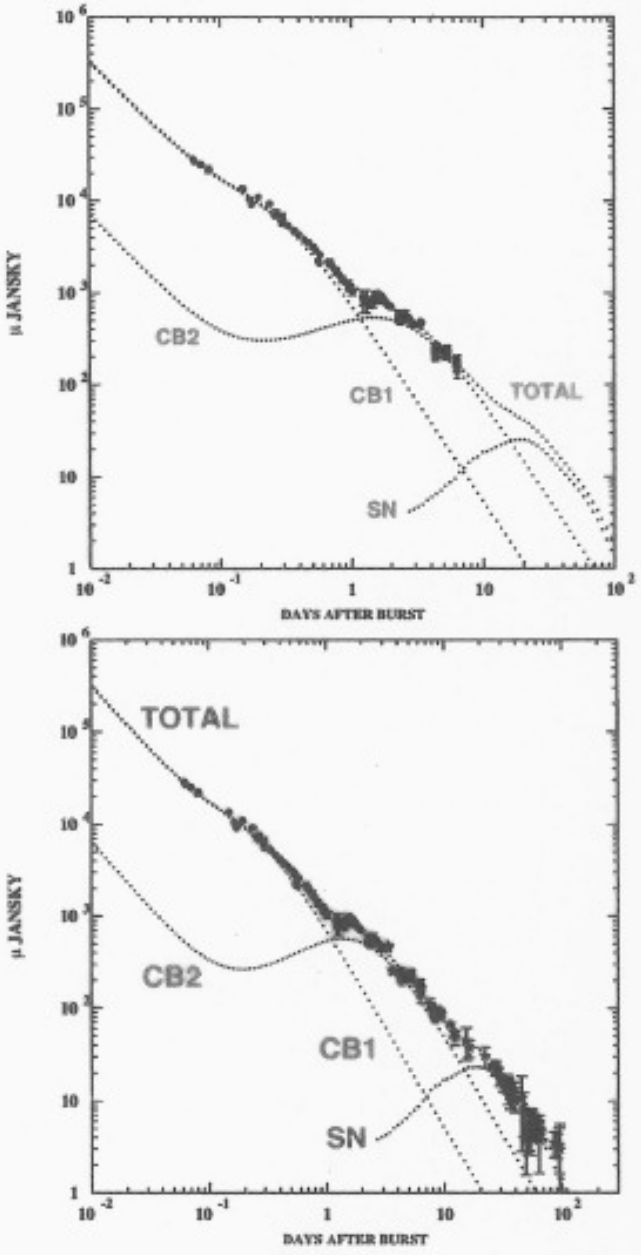
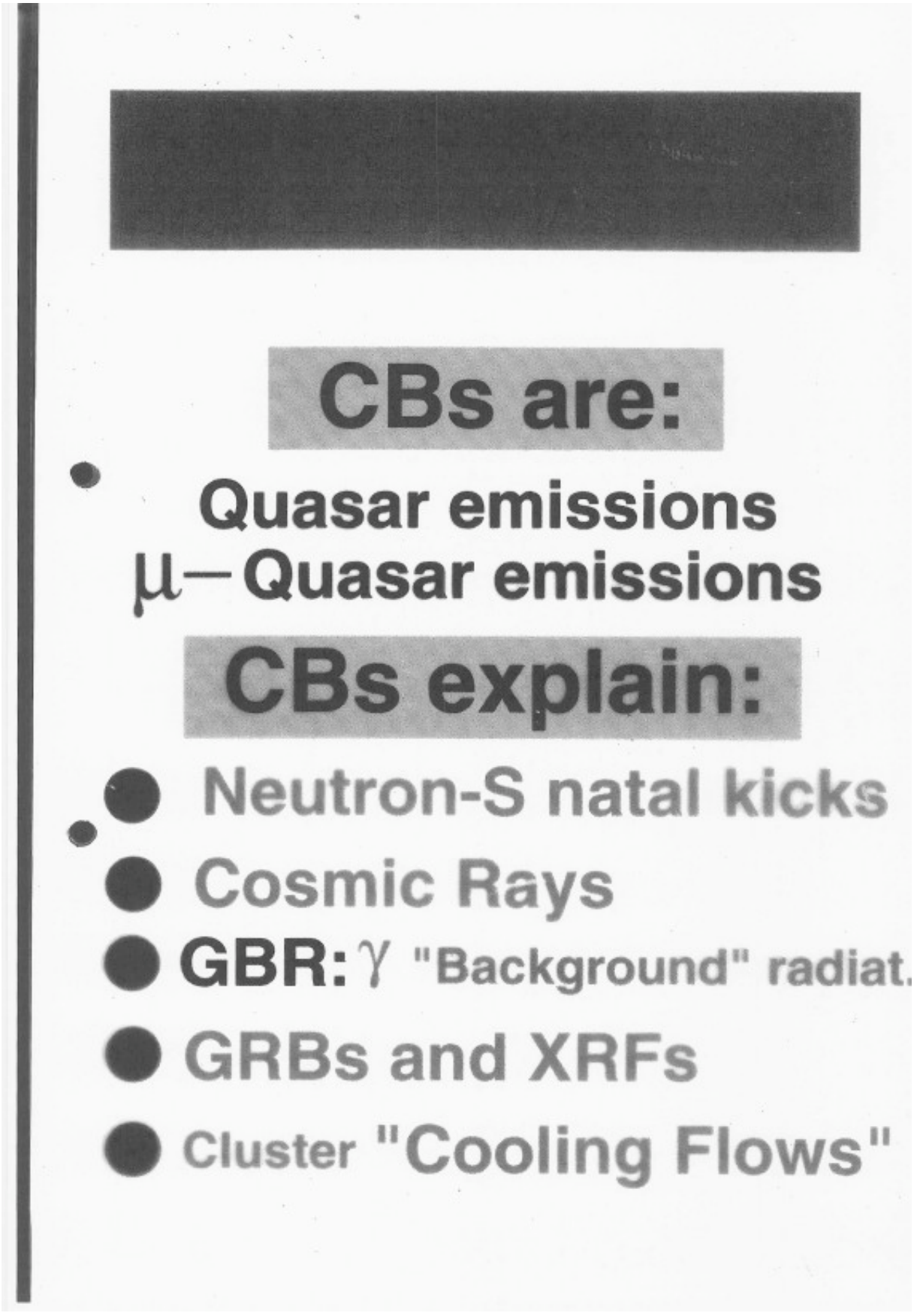


Fig. 19.— Upper panel: The R-band AG of GRB 030329, used along with other optical data to predict, in the CB model, the presence of a SN akin to SN1998bw (Dado, Dar & De Rújula 2003???). Lower panel: The subsequent data (the ⋆ symbols) are added.

5derujula.jpg



6derujula.jpg

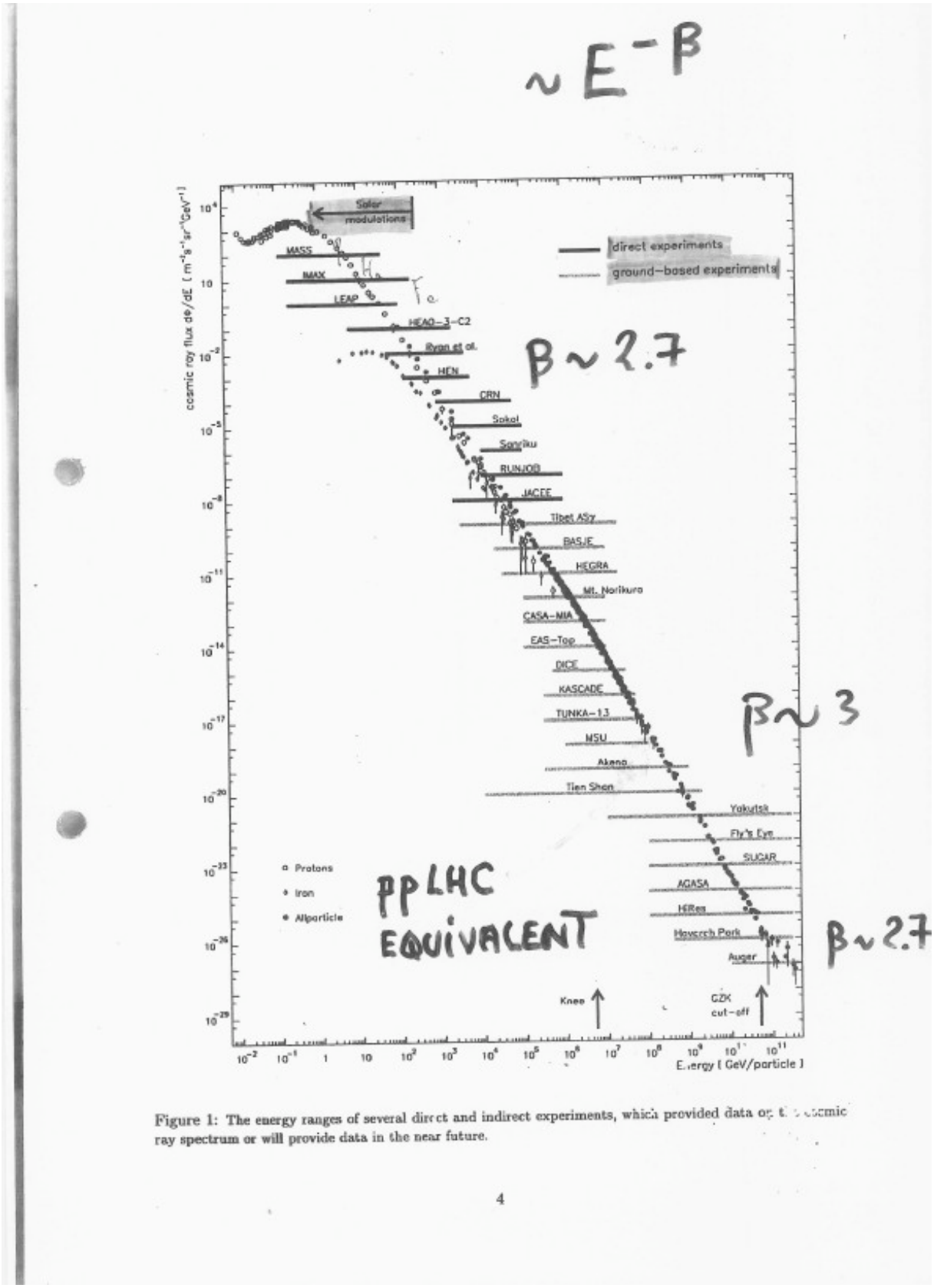
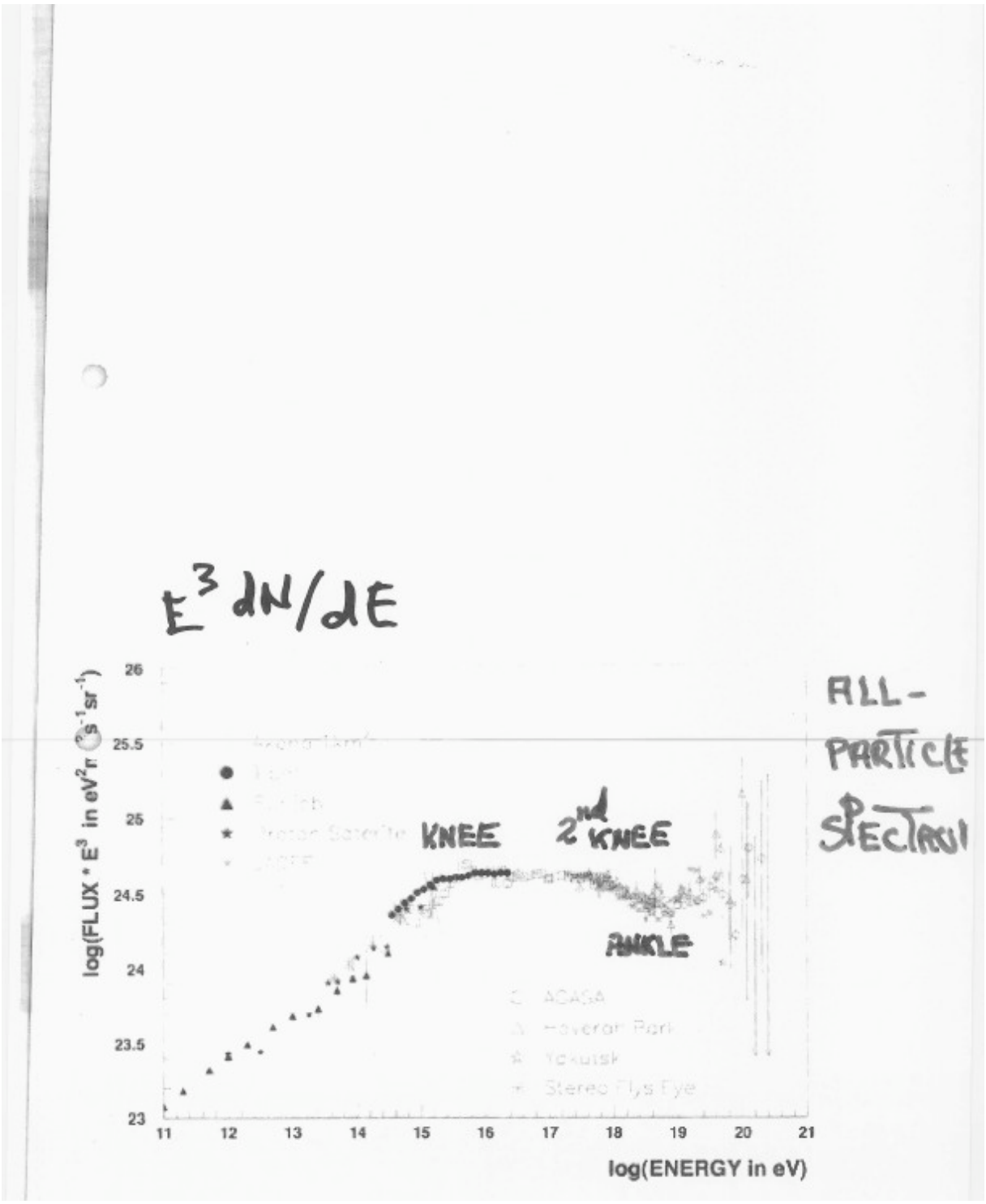


Figure 1: The energy ranges of several direct and indirect experiments, which provided data on the cosmic ray spectrum or will provide data in the near future.

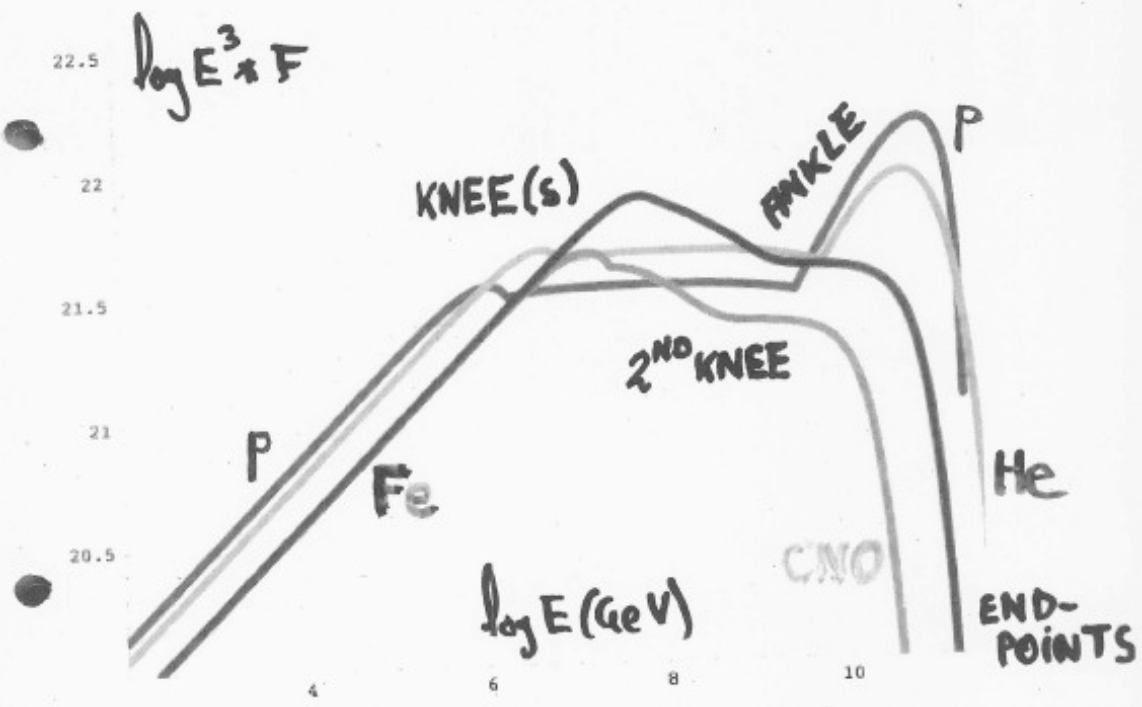
4

7derujula.jpg



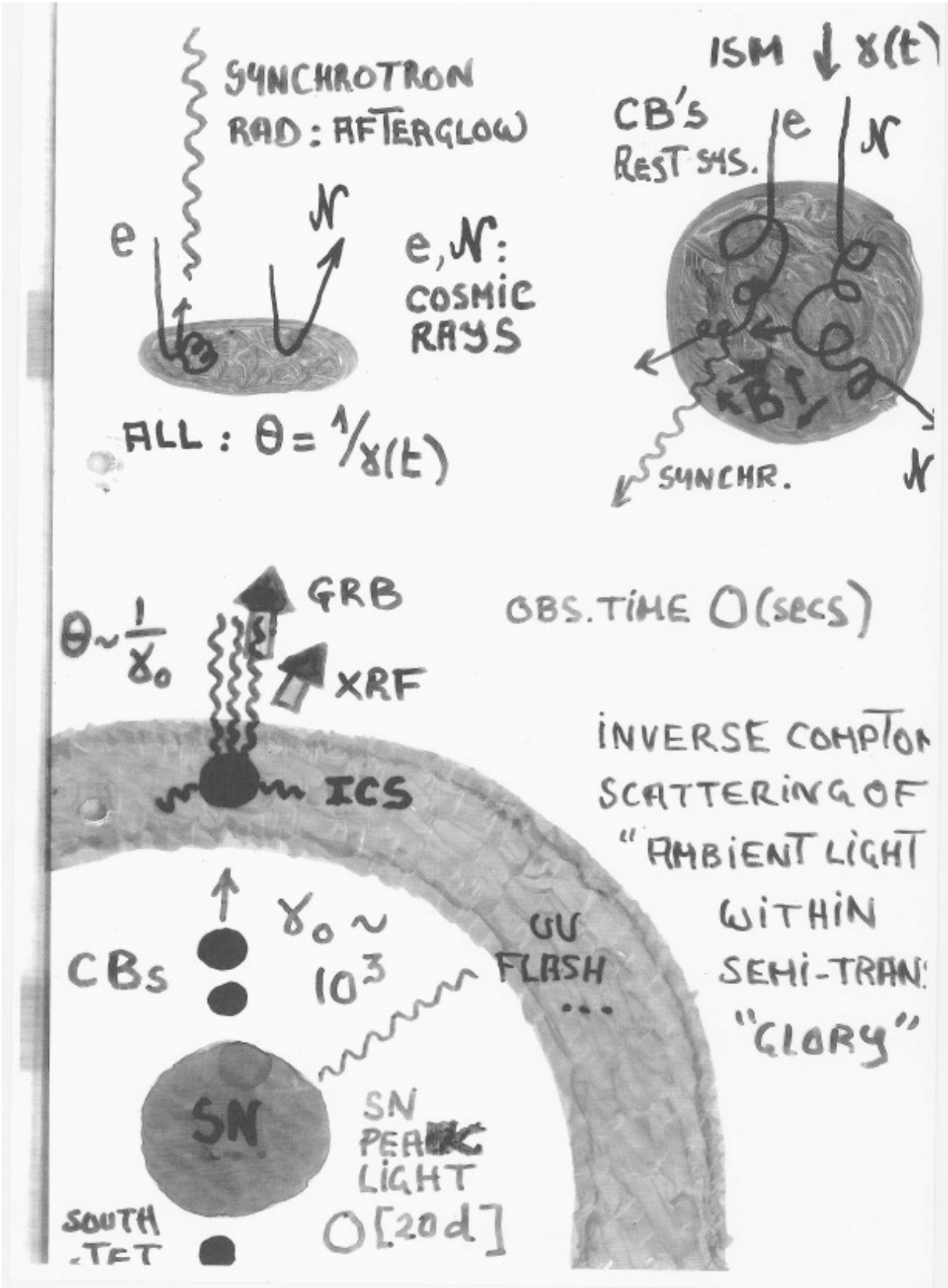
8derujula.jpg

CHANGES OF SPECTRAL SLOPES,
CHANGES OF COMPOSITION (E)
POSITION OF "FEATURES"



ALL PREDICTED,
NOT TUNED, OR
PUT IN BY

9derujula.jpg

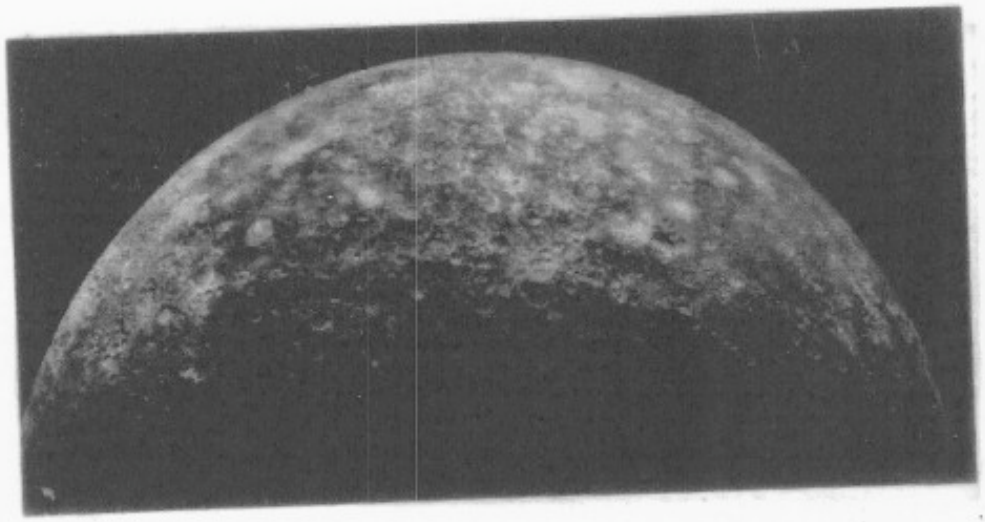


10derujula.jpg

11derujula.jpg

$$\gamma_0 \approx 10^3$$

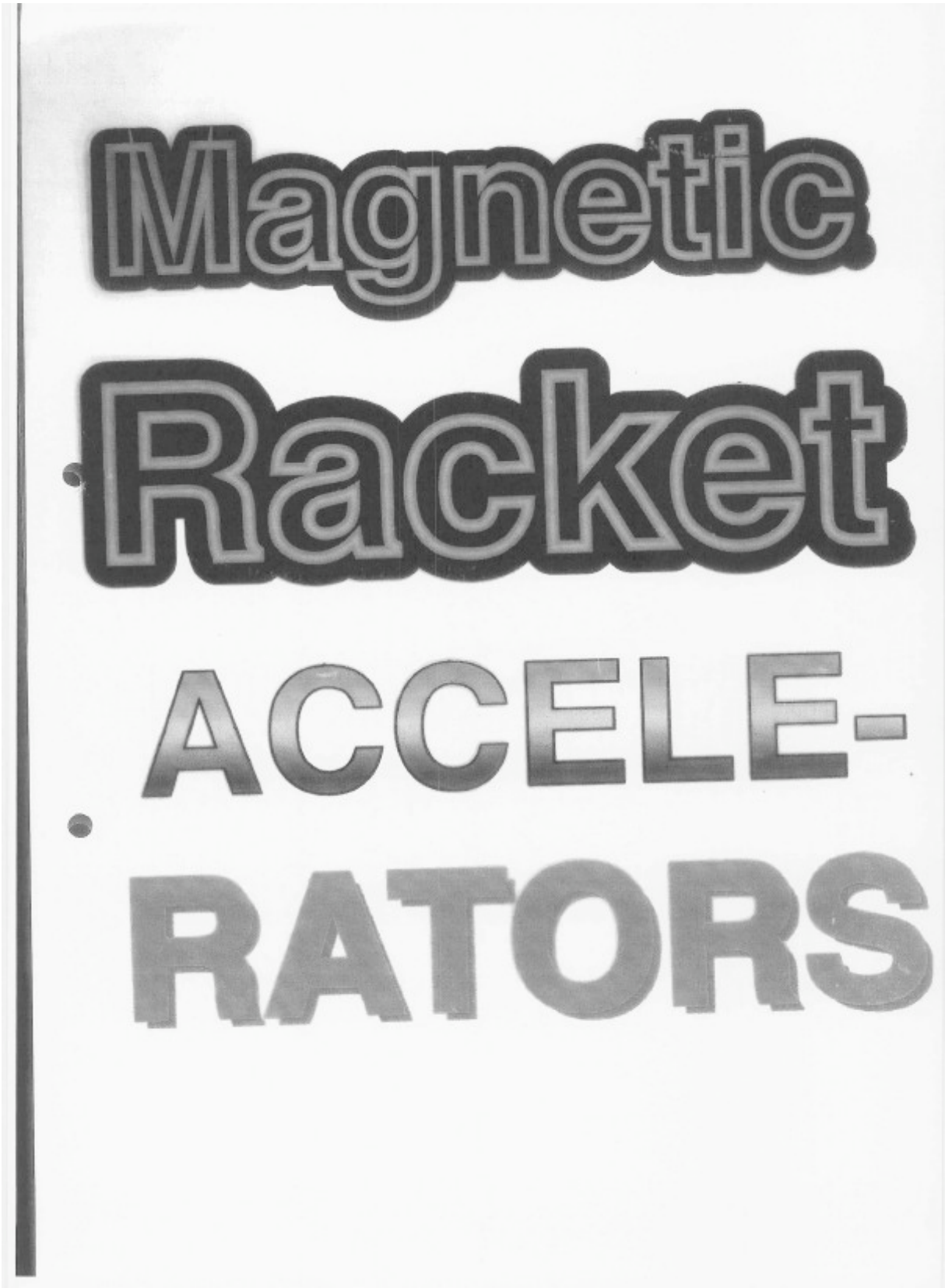
$e\,pp \rightleftharpoons ppp \sim 10^{50}$



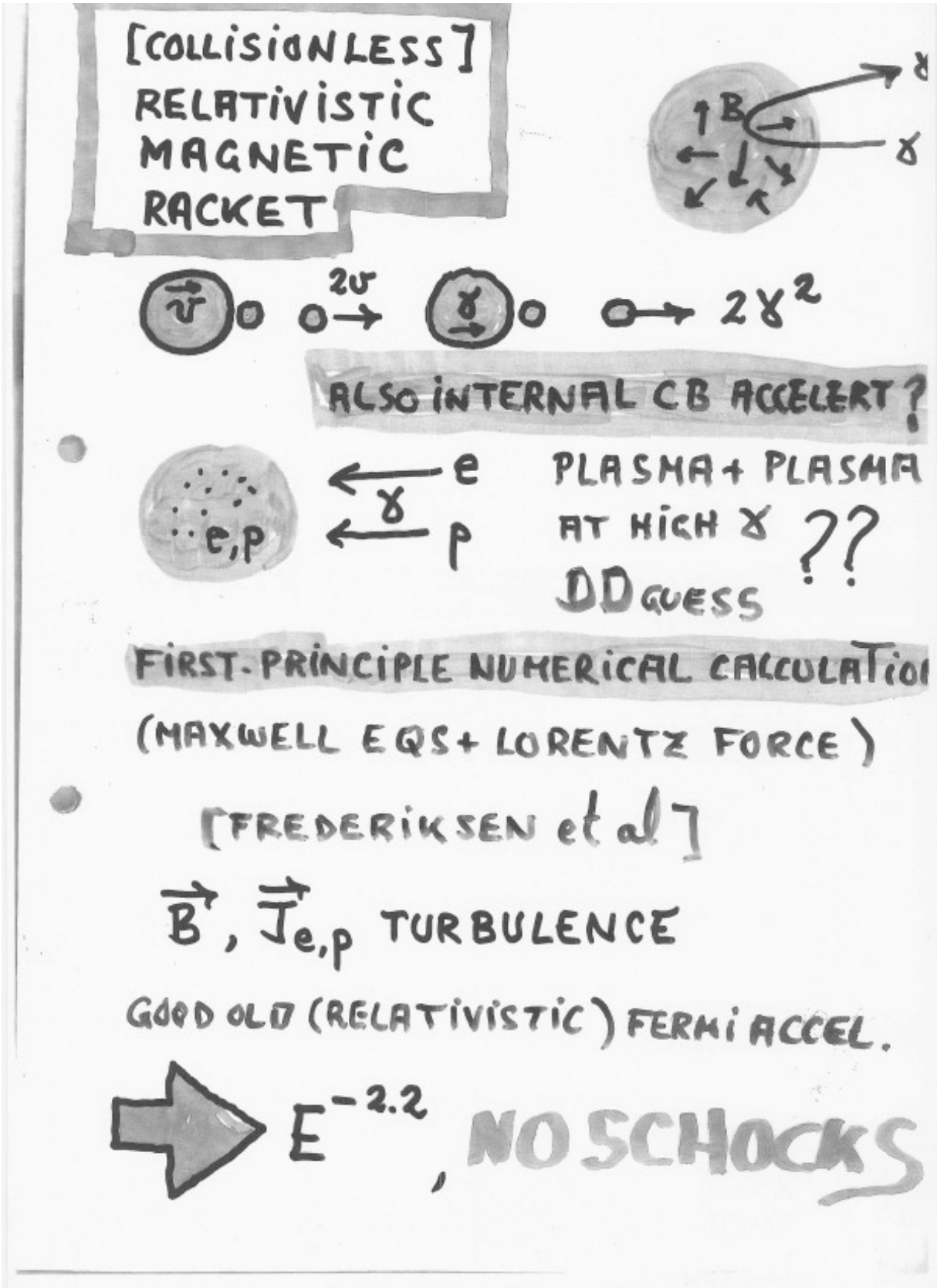
$$v_{CB} \sim \beta_s \frac{c}{\sqrt{3}}, \qquad \beta_s \sim 1$$

$EFF \sim 10^{-2}$

12derujula.jpg

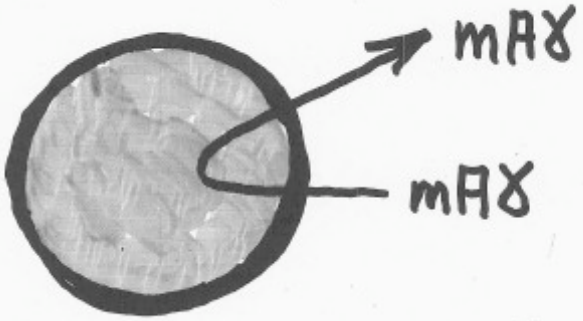


13derujula.jpg

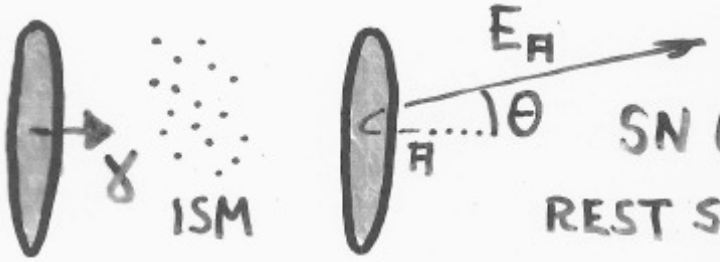


14derujula.jpg

POSITIONS OF THE A— "FLAVOURED" KNEES



CB SYSTEM
ELASTIC
$\gamma = \gamma(t)$



SN (GALAXY)
REST SYSTEM

ANGULAR DISTRIBUTION $\theta \sim 1/\gamma$

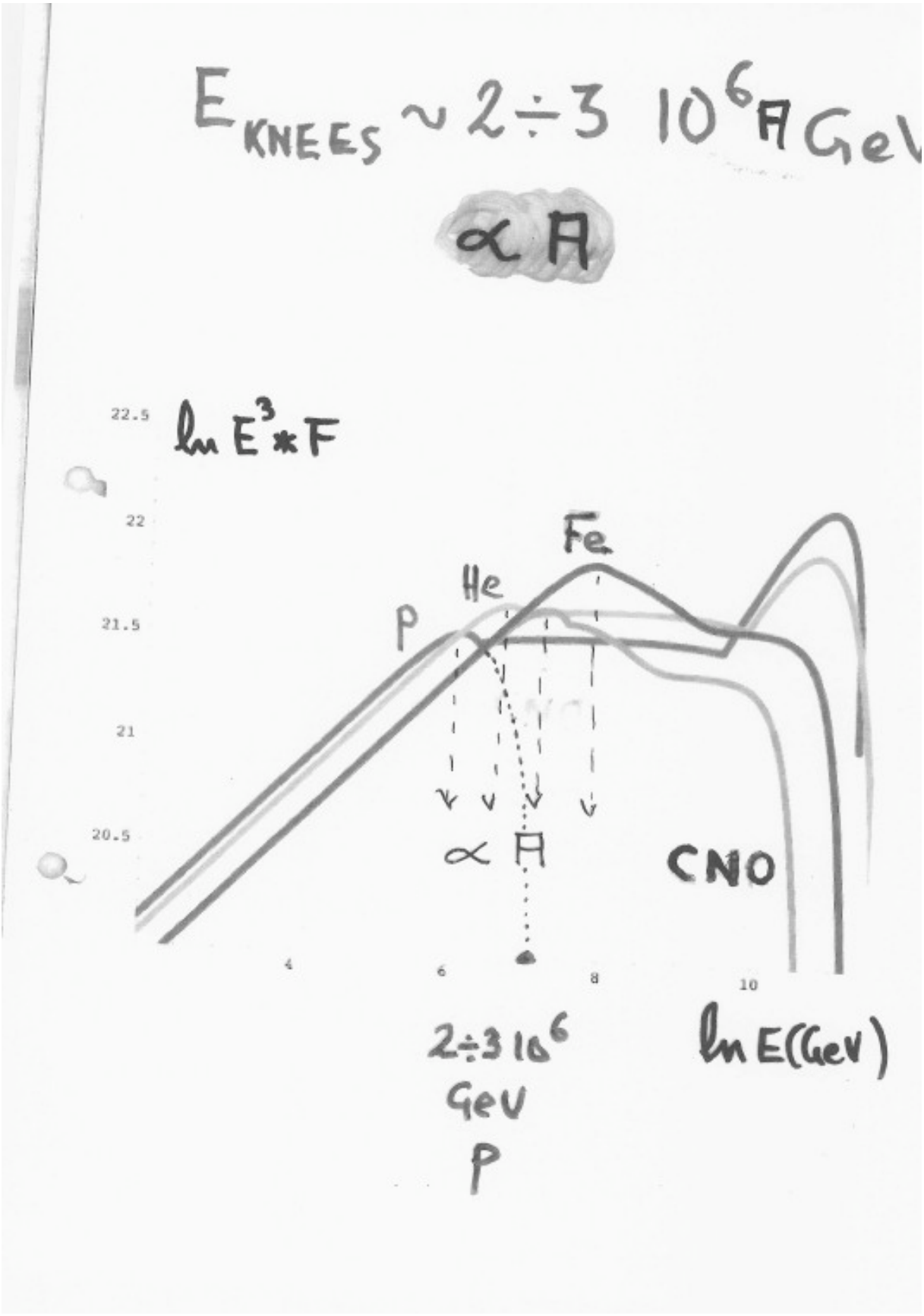
$$m_p A \leq E_A \leq 2 m_p A \gamma^2$$ ENERGY BRACKET

$$\gamma < \gamma_0 \simeq (1 \div 1.5)\ 10^3$$

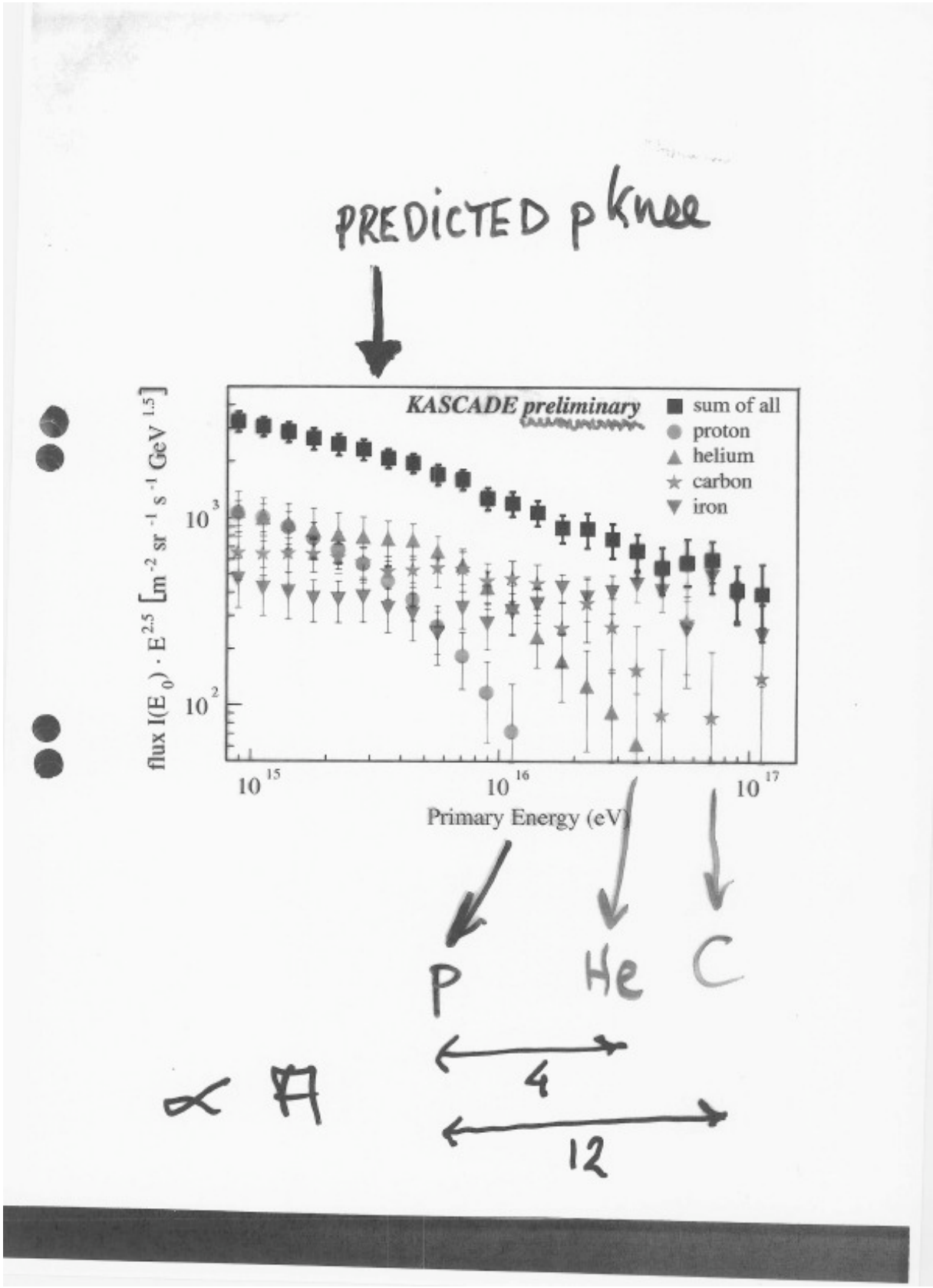
$$E_A[max] \simeq (2 \div 3)\ 10^6\ A\ GeV$$

"FLAVOUR"

15derujula.jpg



16derujula.jpg



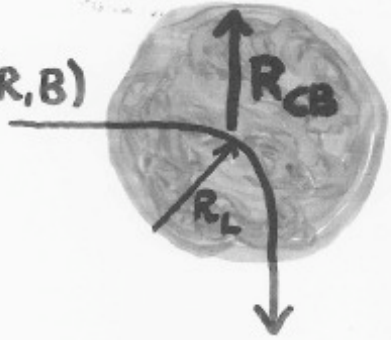
17derujula.jpg

POSITIONS OF THE Z-FLAVOURED "TOE-NAILS"

$R_L > R_{CB}$: ESCAPE

NO ACCELERATION Possible

$R_L(E,B) \rightarrow E(R,B)$



I $E_Z(max) \simeq 9\,10^{16}\,eV\,Z \frac{B}{3G} \frac{R_{CB}}{10^{14}cm} \rightarrow$ F.T.P.

$B_{CB}[\gamma] = 3G\,(\gamma/10^3)\,(n_p/10^{-3}cm^{-3})^{1/2}$

II $B_{CB}[max][\gamma_0 \sim 10^3] \rightarrow 3G$

I+II CB SYSTEM $E_Z(max) \sim 10^{17}\,eV\,Z$

SN SYSTEM $E_Z(max) = \downarrow * 2\gamma_0$

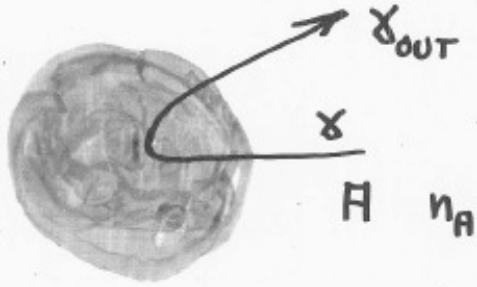
$E_{LARMOR} = (2 \div 3)\,10^{20}\,Z\,eV$

SPECTRE CUT-OFF AT "TOE-NAILS"

18derujula.jpg

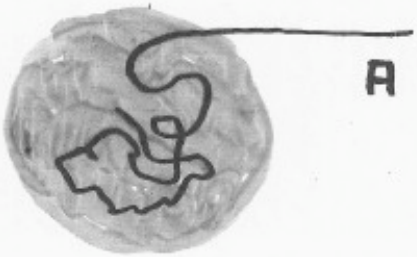
ACB's DECELERATION LAW

$\langle \gamma_{OUT} \rangle \equiv a\,\gamma$ $\quad M_0 \equiv$ INITIAL CB MASS



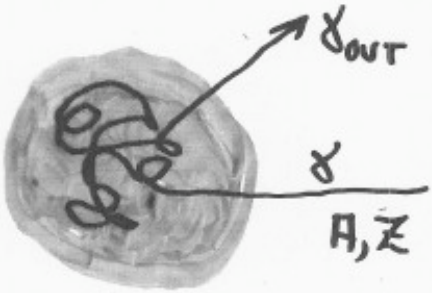
ELASTIC SCATTERING

$a = 1$



FRAGMENTATION

$a = 0$



ACCELERATION

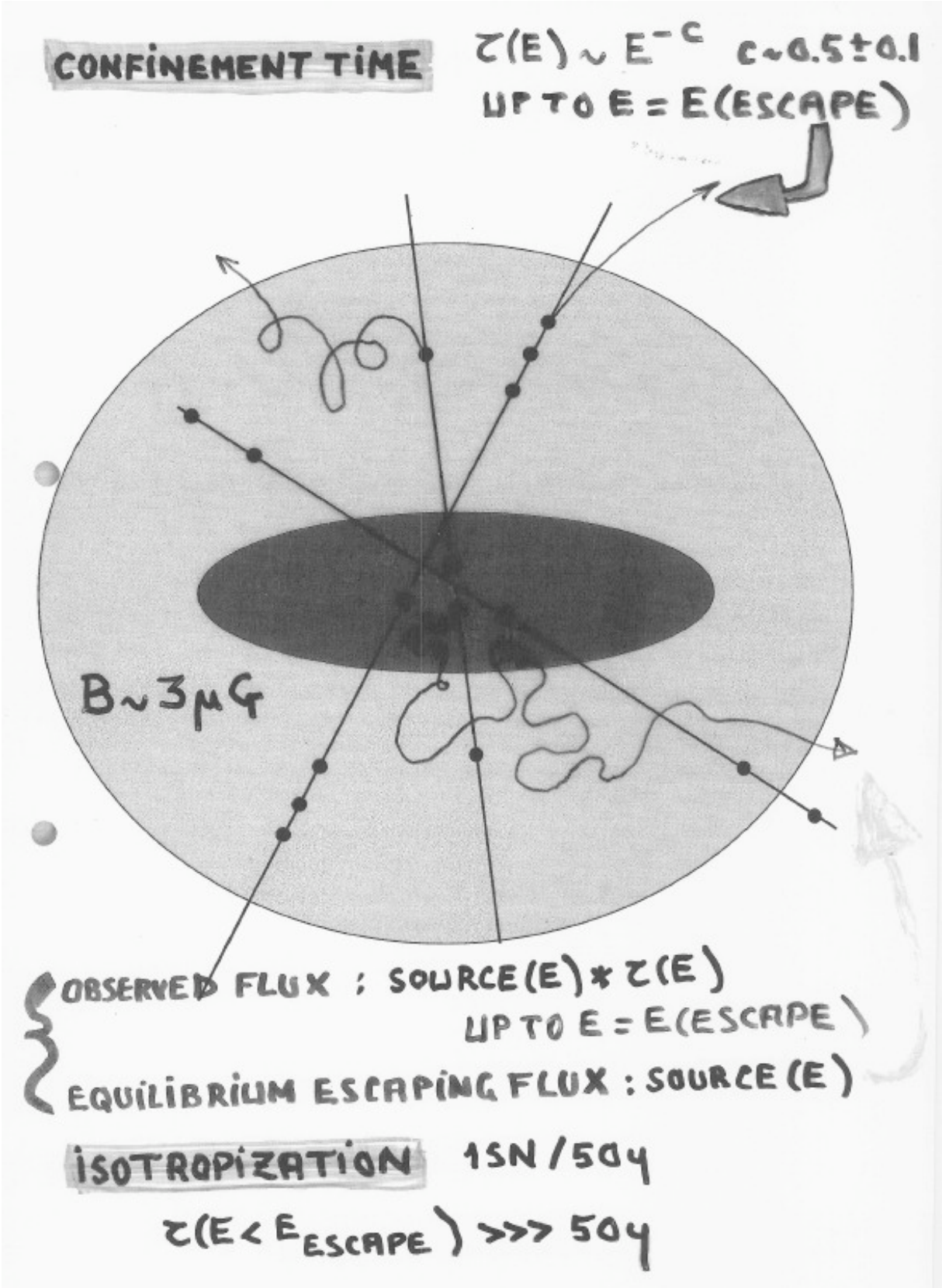
$a > 1$

$$d\gamma / \gamma^{3-a} = -\frac{m_p}{M_0}\,\frac{1}{\gamma_0^{1-a}}\,\langle A \rangle\, dn_A \qquad (\gamma^2 \gg 1)$$

$$\frac{d\gamma}{\gamma^k} \propto dn_A \qquad k \equiv 3 - a$$

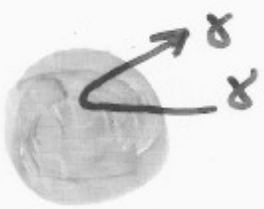
k NOT WELL PRE-DETERMINED ☹!

19derujula.jpg



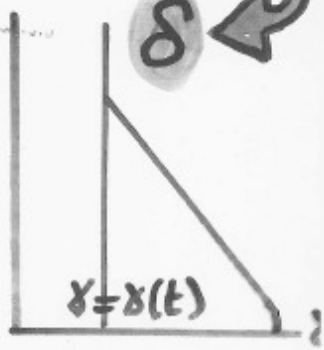
20derujula.jpg

NUCLEI ELASTICALLY SCATTERED



SAY

$$\left.\frac{dN}{d\alpha}\right|_{CB} = \text{CONST.}$$



$\gamma^2 >> 1$

$$\left.\frac{dN}{d\gamma_N}\right|_{SN} = \int_{-1}^{1} \frac{d\cos\alpha}{2} \delta\left(\gamma_N - \gamma\gamma(1+\cos\alpha)\right)$$

$$= \frac{1}{2\gamma^2}\,\theta(1<\gamma_N<2\gamma^2) \quad \gamma > \sqrt{\frac{\gamma_N}{2}}$$

$$\int_{TRAJ} dn_A = \int_1^{\gamma_0} \frac{d\gamma}{\gamma^k} \left.\frac{dN}{d\gamma_N}\right|_{SN} \propto$$

$E_A = 2\gamma_0^2 A m_1$
KNEES

$$\left(\frac{1}{\gamma_N}\right)^{\frac{k+1}{2}} \left[1 - \left[\frac{\gamma_N}{2\gamma_0^2}\right]^{\frac{k+1}{2}}\right] \theta\left[\gamma_N < 2\gamma_0^2\right]$$

CONFINEMENT * IN GALAXY/HALO $\left(\frac{1}{\gamma_N}\right)^C$ UP TO GIVEN ESCAPE ENERGY

DEGE-NERA-CY

$k = 3$ $C = 0.7$ CR SLOPE 2.7

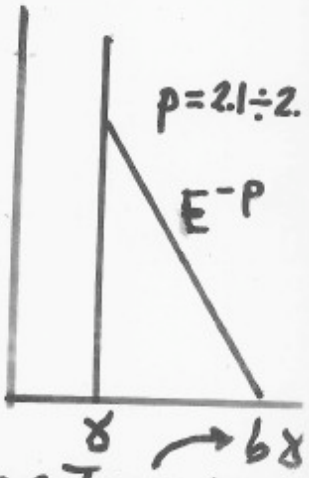
$k = 3.4$ $C = 0.5$ CR SLOPE 2.7

21derujula.jpg

NUCLEI ACCELERATED WITHIN CB

$$\int_{\gamma}^{b\gamma} \frac{d\gamma_a}{\gamma_a^p} \int_{-1}^{1} \frac{d\cos\alpha}{2} \delta\left(\gamma_N - \gamma\gamma_a(1+\cos\alpha)\right) \frac{dN}{d\gamma_a}$$

BOOST — γ_N's LORENTZ FACTOR



LARMOR CUTOFF ($B \propto \gamma$)

$$\propto \int_{\mathrm{Max}\left[\gamma, \frac{\gamma_N}{2\gamma}\right]}^{b\gamma} d\gamma_a/\gamma_a^p \; \frac{1}{2\gamma\gamma_a}$$

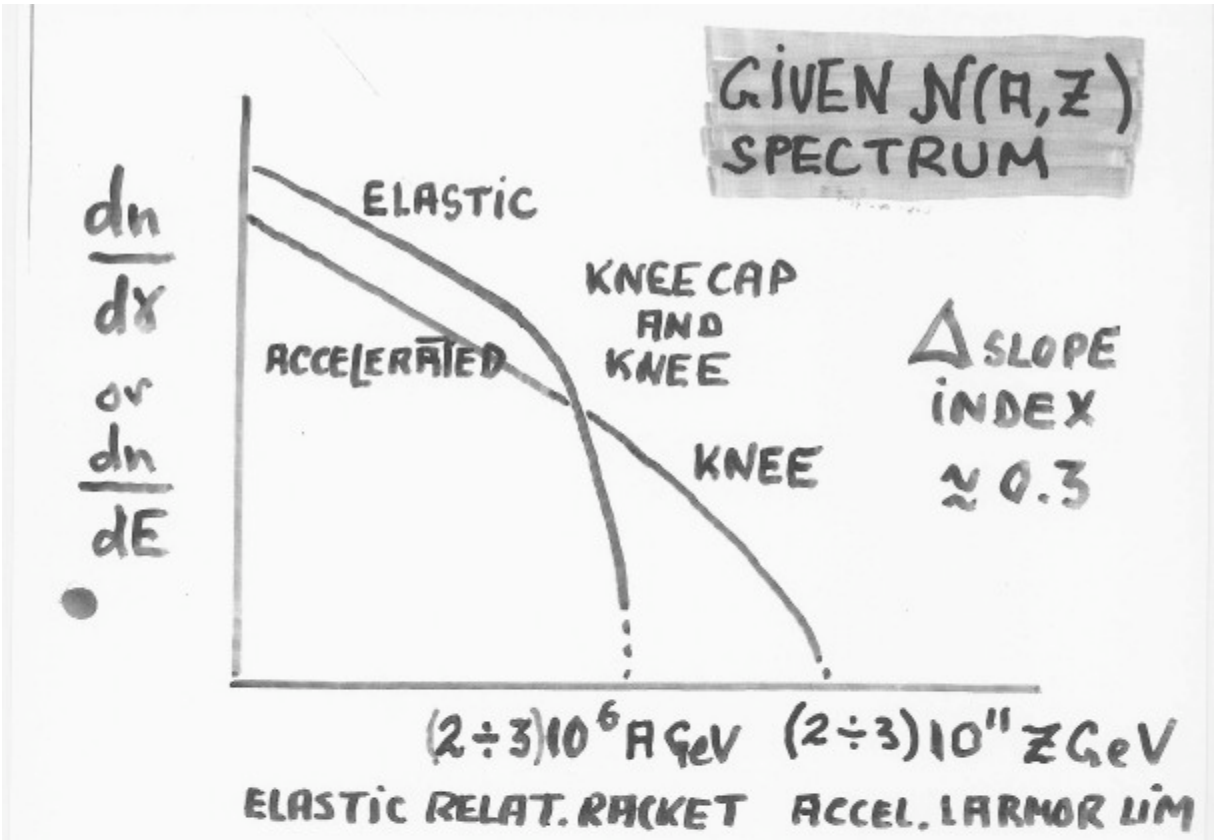
↳ CHANGE OF SLOPE AT 'INSTANT' KNEI (FIKED γ)

$$\int_1^{\gamma_0} \frac{d\gamma}{\gamma^k}$$

→ CHANGE OF SLOPE AT KNEE(S)

$$\gamma_N = 2\gamma_0^2$$

22derujula.jpg



(I) KNEES NOT PUT IN BY HAND ← γ_0

(NATAL KICKS OF N.S. ; GRBs, GRB AGs)

(II) LARMOR CUTOFF NOT BY HAND ← γ_0, B(γ)

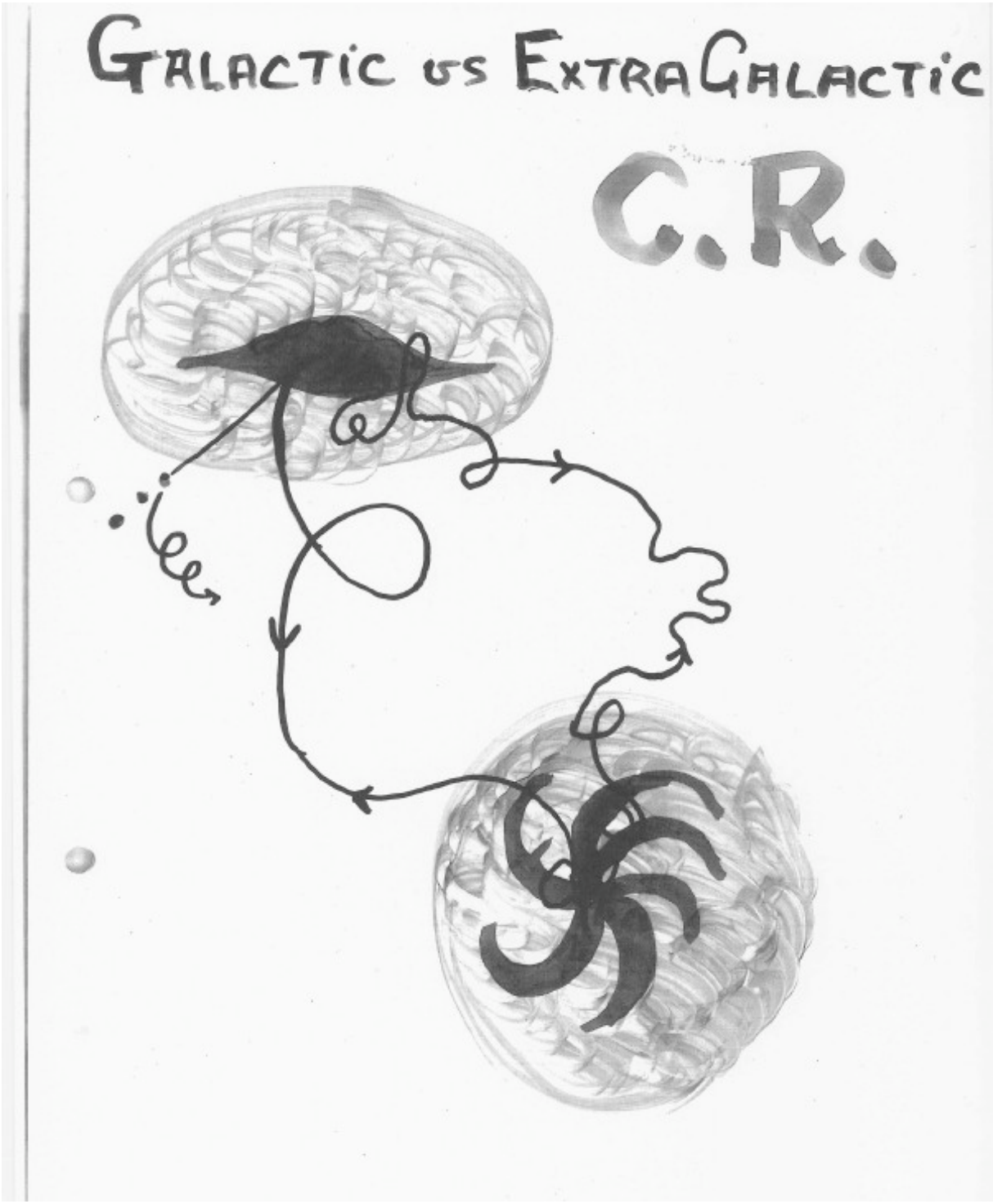
(GRB WIDE-BAND AG SPECTRA)

(III) Δ SLOPE NOT BY HAND ← CB+N KINEMATICS

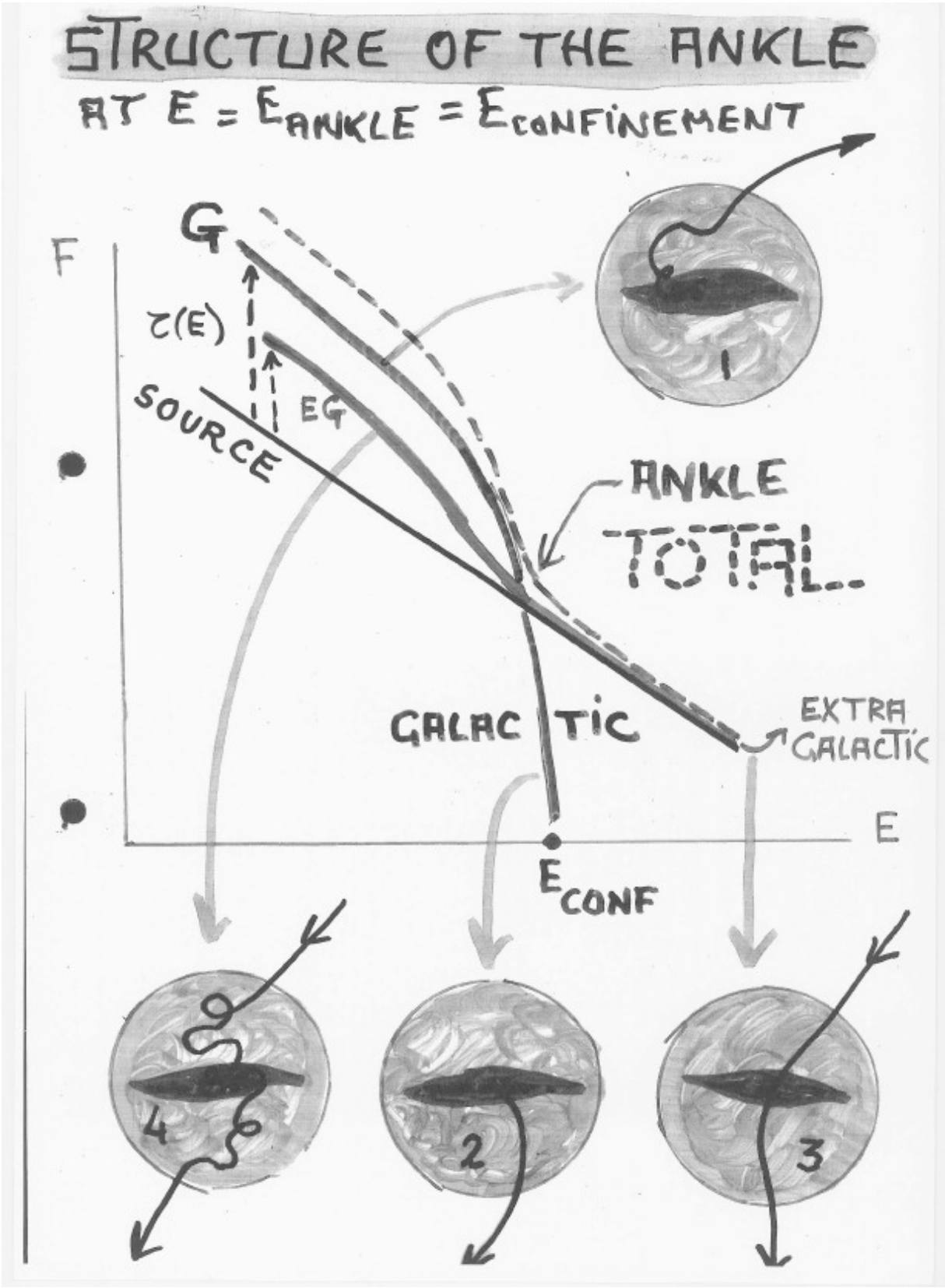
(IV) ONLY k_{eff} (DEC.LAW) TUNED $k \simeq 3.4$

(fork ≃ 0.5)

23derujula.jpg



24derujula.jpg



25derujula.jpg

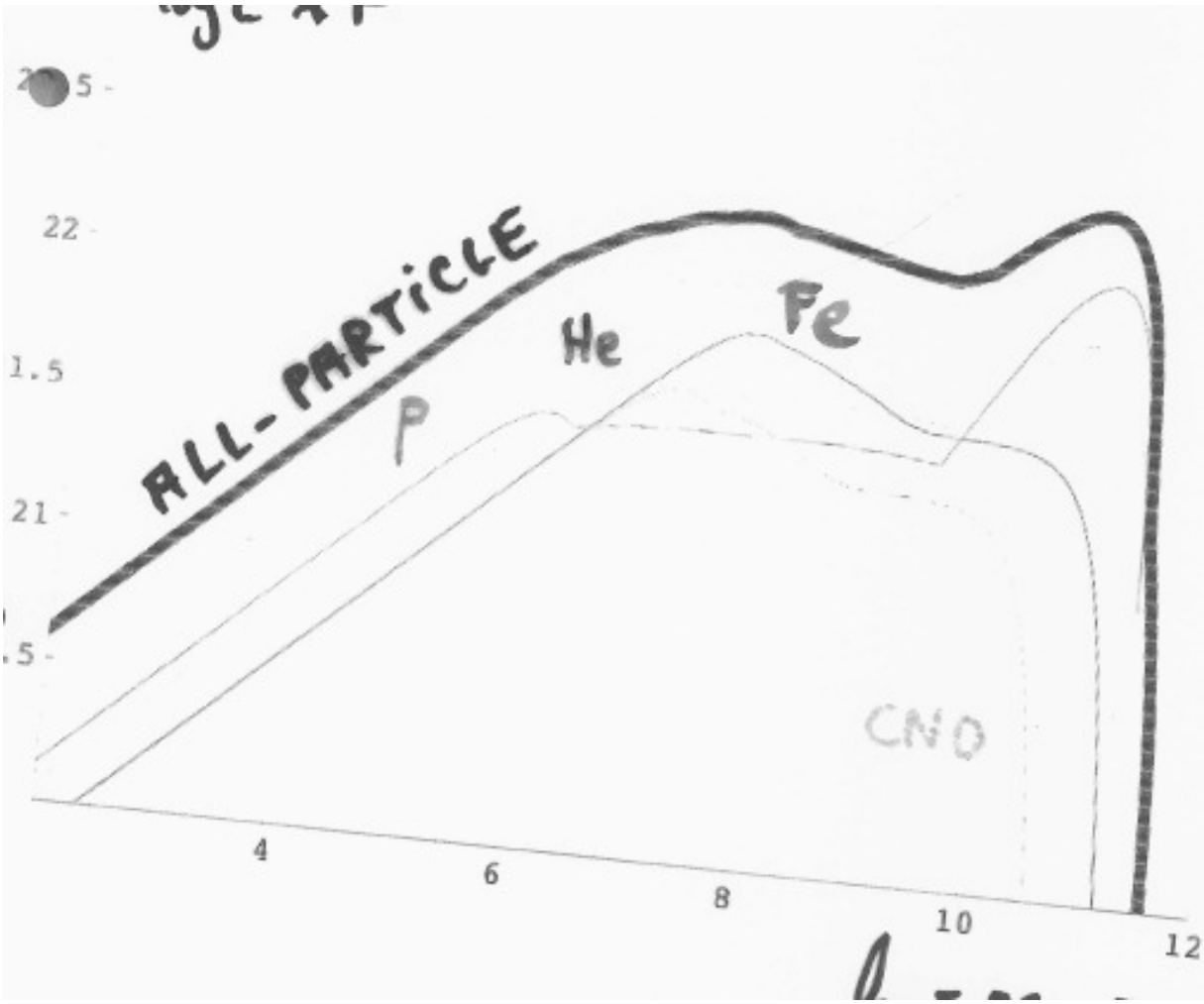
G vs EG FLUX AT THE ANKLE

- $\langle N[\text{PULSES}] \rangle|_{GRB} \cong 6$
- 2 JETS → 12 CBs / SN
- $\gamma_0[CB] \sim 10^3$ $N_B[CB] \sim 10^{50}$
- MILKY WAY → 1 SN / 50 y
  → 2.4 N[★] * AVERAGE GALAXY
- LOCALLY 1 GALAXY / (80 Mpc^3)
- $dN/dE|_{CR} \sim E^{-2.7}$ UP TO ANKLE
- $t_u \sim 10^{10}$ y $h \sim 0.65$
- z-EFFECTS e.g. S.F.R $\sim (1+z)^3$

$$t \text{ NOT } x! \qquad \int_{-t_u}^{0} F[EG]\, dt \Big|_{E=E_A} \sim F[G]\Big|_{E=E_A}$$

FOR THE CR-MODEL OR LUMINOSITY

26derujula.jpg

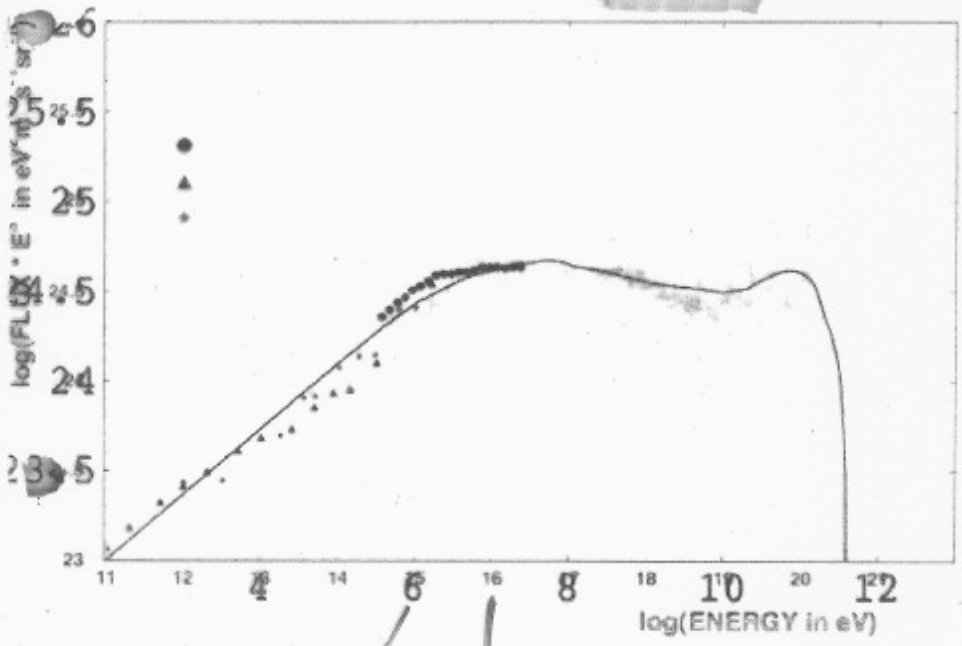


27derujula.jpg

TWO PARAMETERS :

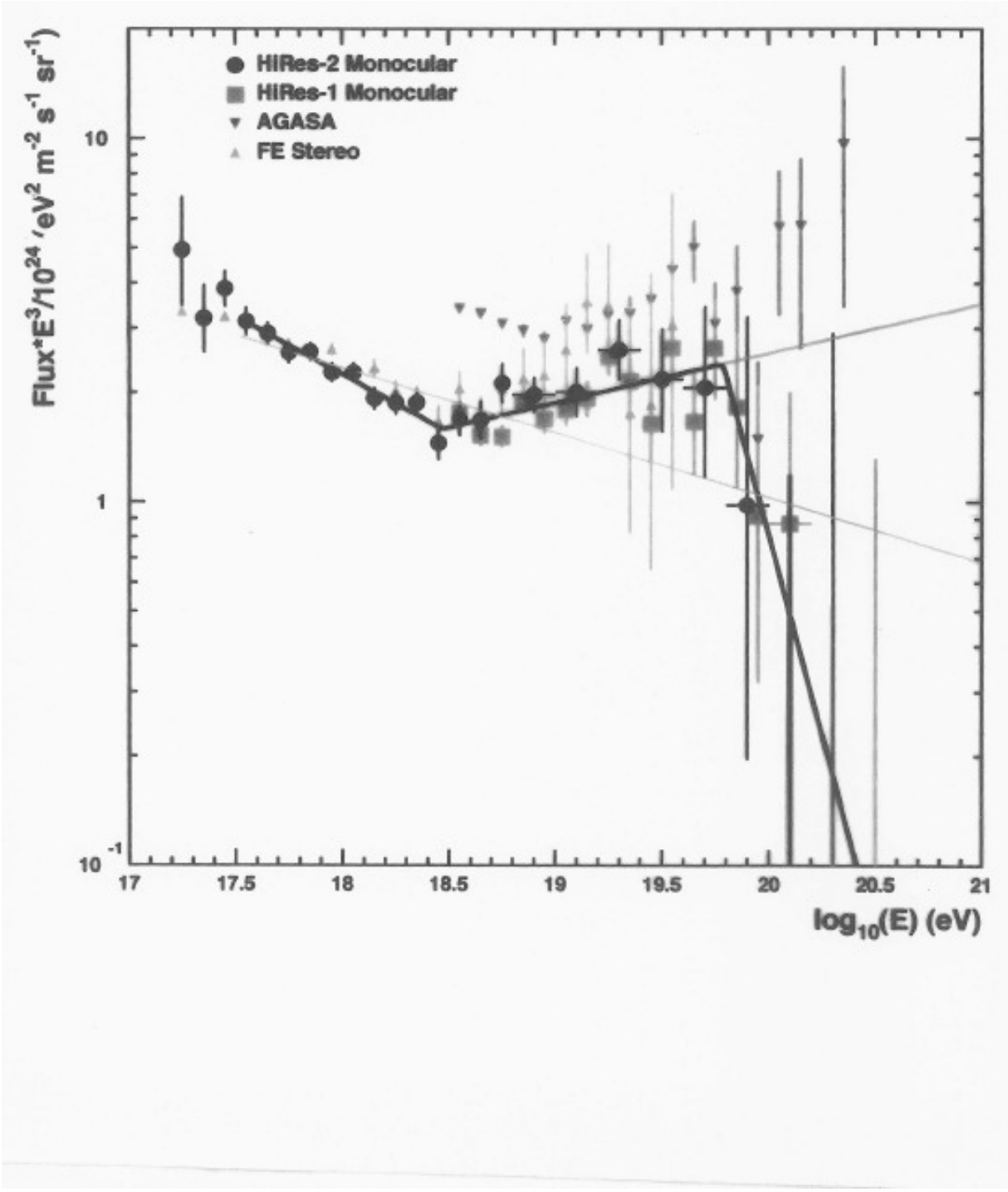
{ OVERALL NORMALIZATION
{ K + C ALL OTHERS PRE-ESTIMATED

$\log E^3 \times F(E)$ ONE MECHANISM

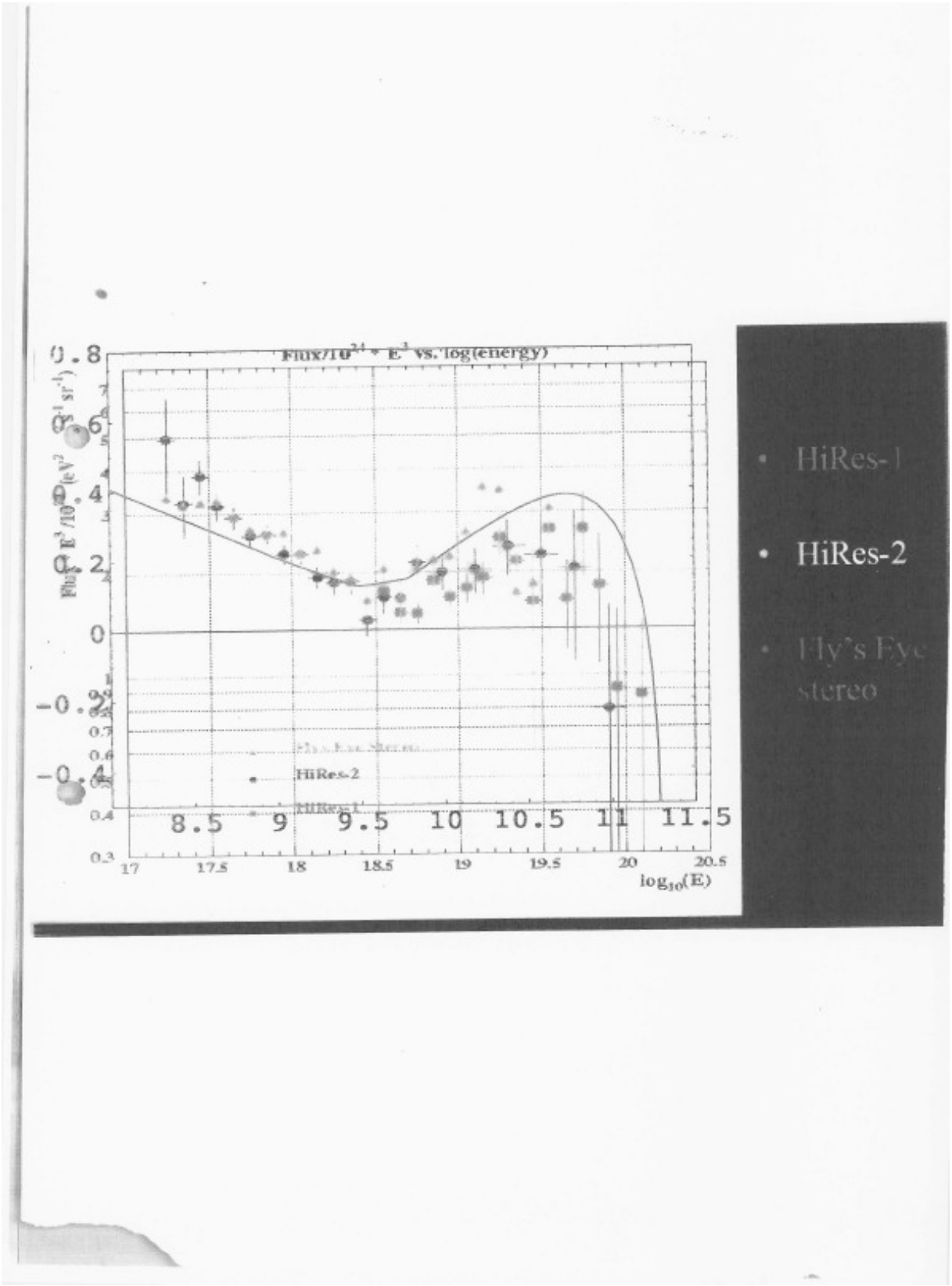


$\log E$(GeV) $\log E$(eV) WOOPS !

28derujula.jpg

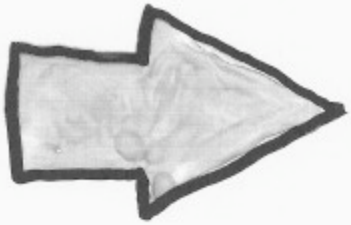


29derujula.jpg



30derujula.jpg

RELATIVISTIC MAGNETIC RACKETS are FLAVOR-BLIND



- IN CB-MODEL

$$\frac{dF(\gamma,A,Z)}{d\gamma} = n_{ISM}(A,Z)\,\mathcal{U}(\gamma)$$

UNIVERSAL (A,Z INDEP)

31derujula.jpg

ABUNDANCES

ISM abund.

$$\frac{dF_A}{dE_A} = \frac{1}{Am_p}\frac{dF_A}{dX} \propto \frac{n_A}{Am_p} X^{-P}$$

$$\propto \frac{n_A}{A}\left(\frac{E_A}{A}\right)^{-P} = n_A A^{P-1} E_A^{-P}$$

BELOW ANKLE: $* \left(\frac{Z}{E_A}\right)^C$

$$\frac{dF_{AZ}}{dE_{AZ}} = K A^{P-1} Z^C n_A E_A^{-(P+C)}$$

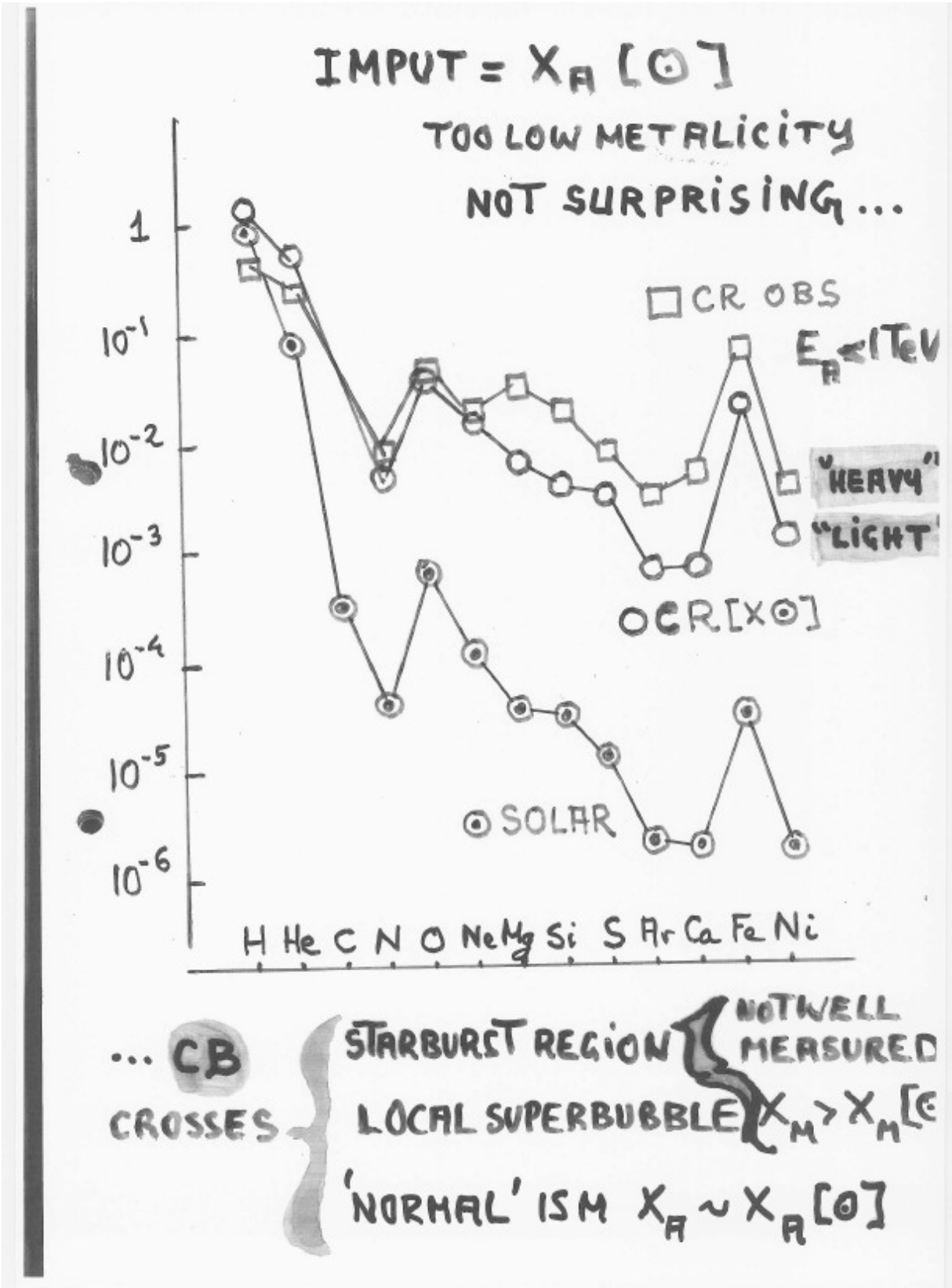
$n_A \propto X_A$ "TARGET" RELATIVE ABUNDANCES

BUT FOR H/He, RESULTS SIMILAR

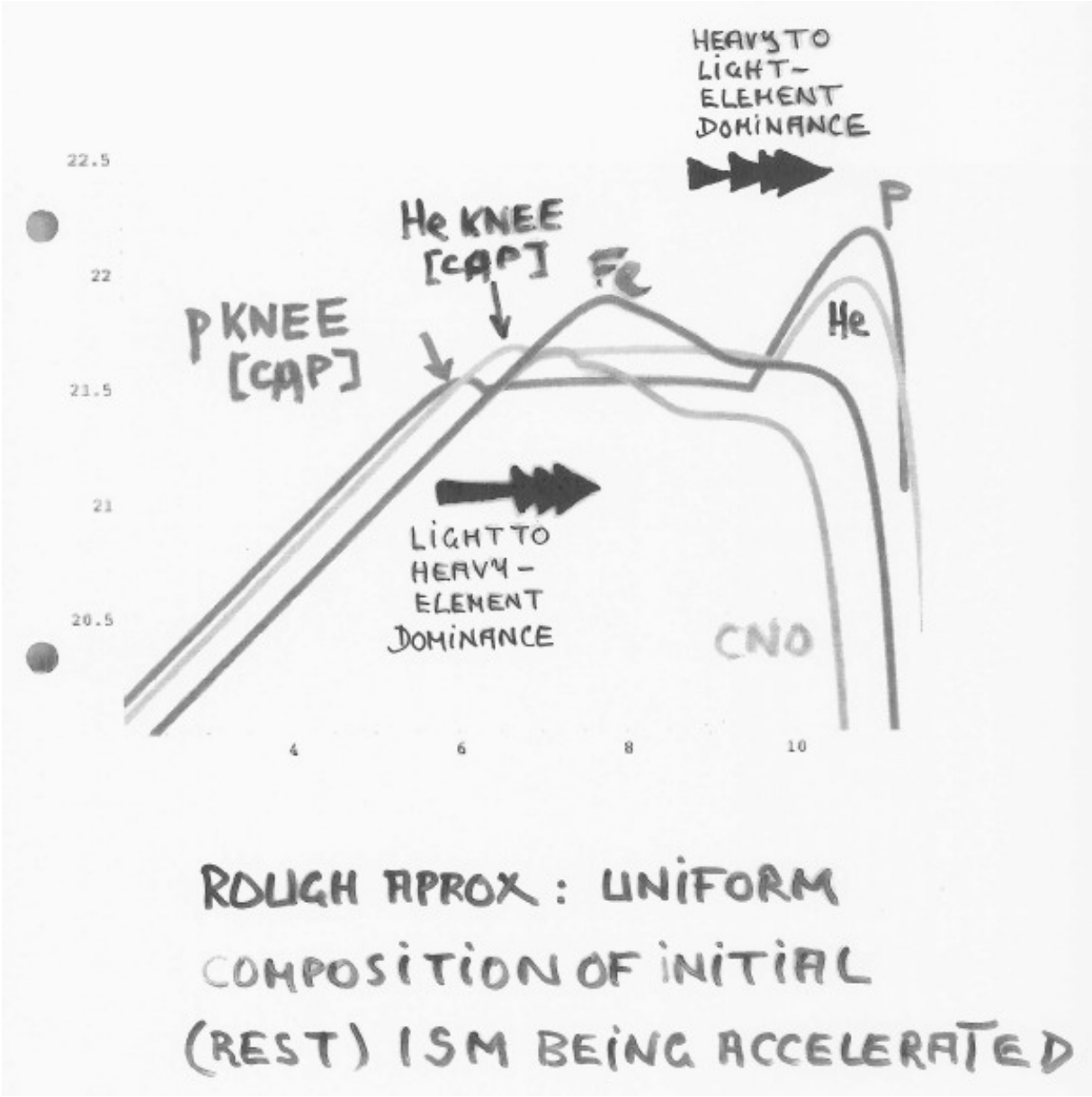
AT FIXED $P+C \simeq 2.7$ < KNEES

$\simeq 3.0$ > KNEES

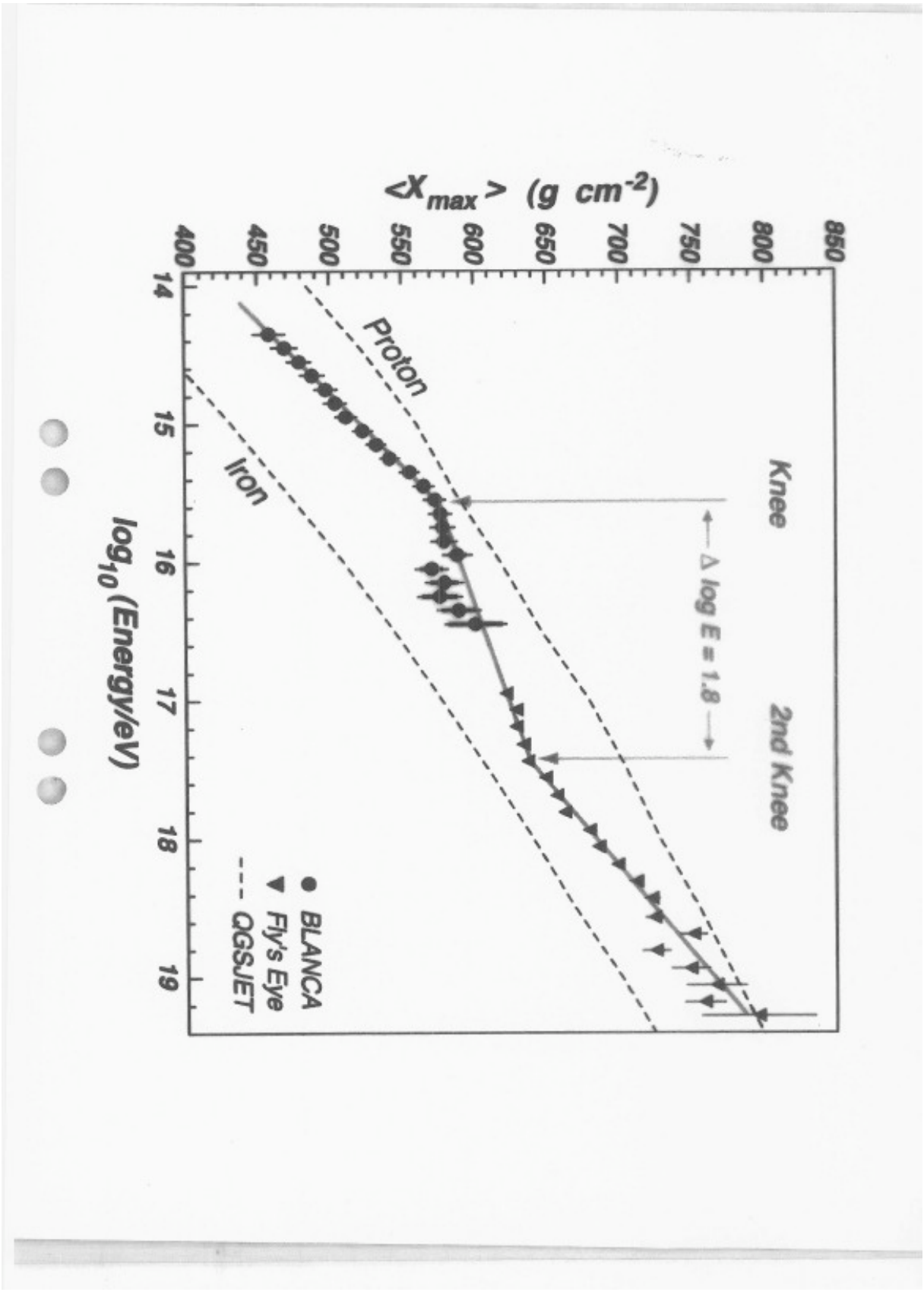
32derujula.jpg



33derujula.jpg



34derujula.jpg



35derujula.jpg

UHE CR CUTOFFS

- GZK H: 10^{20} eV

  He: $4\,10^{20}$ eV

- PHOTODISSOCIATION

  He ~ 10^{20} eV

- CB MODEL ACCELER ENDS AT

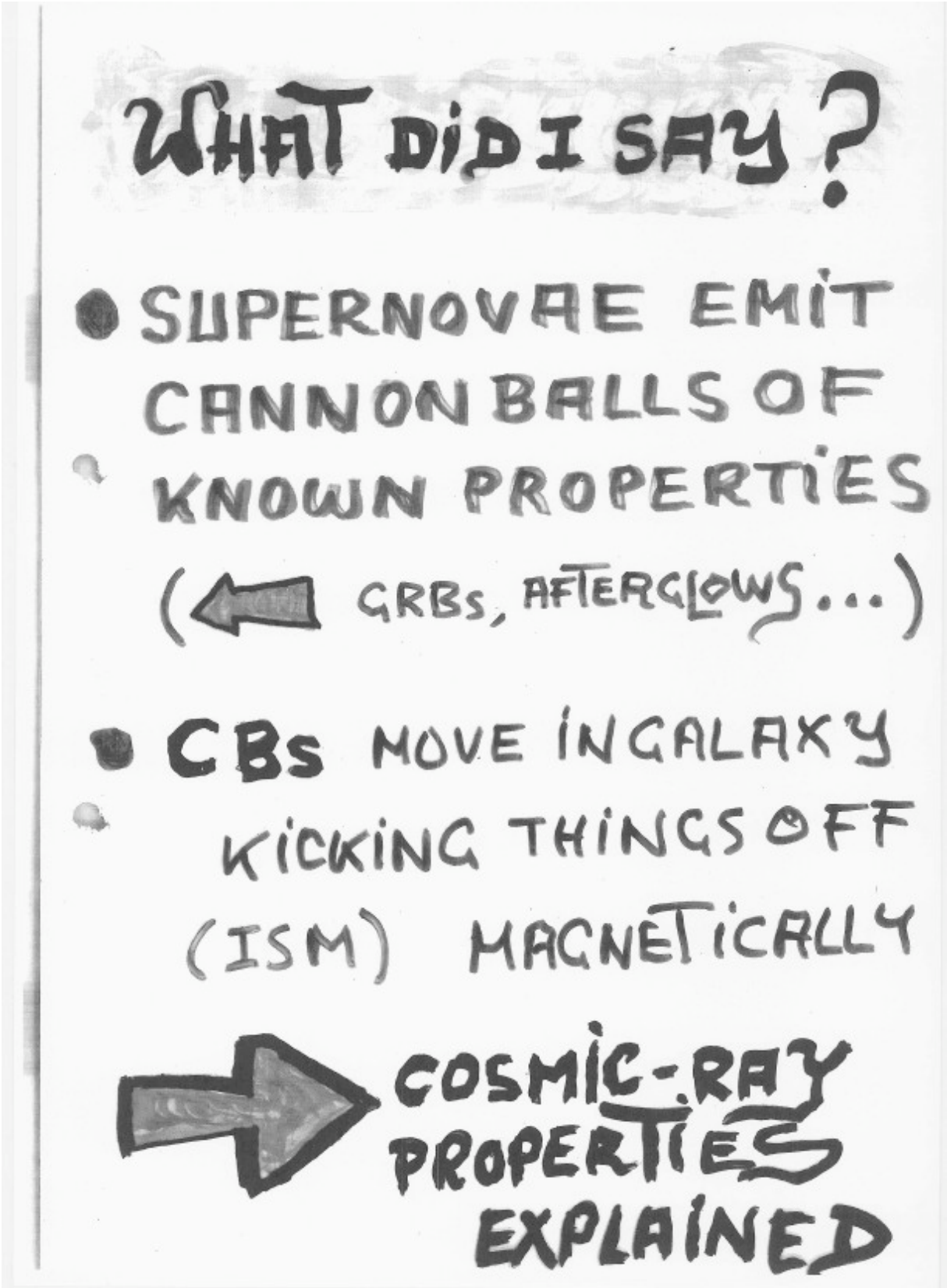
  H: $2\,10^{20}$ eV

  He: $4\,10^{20}$ eV

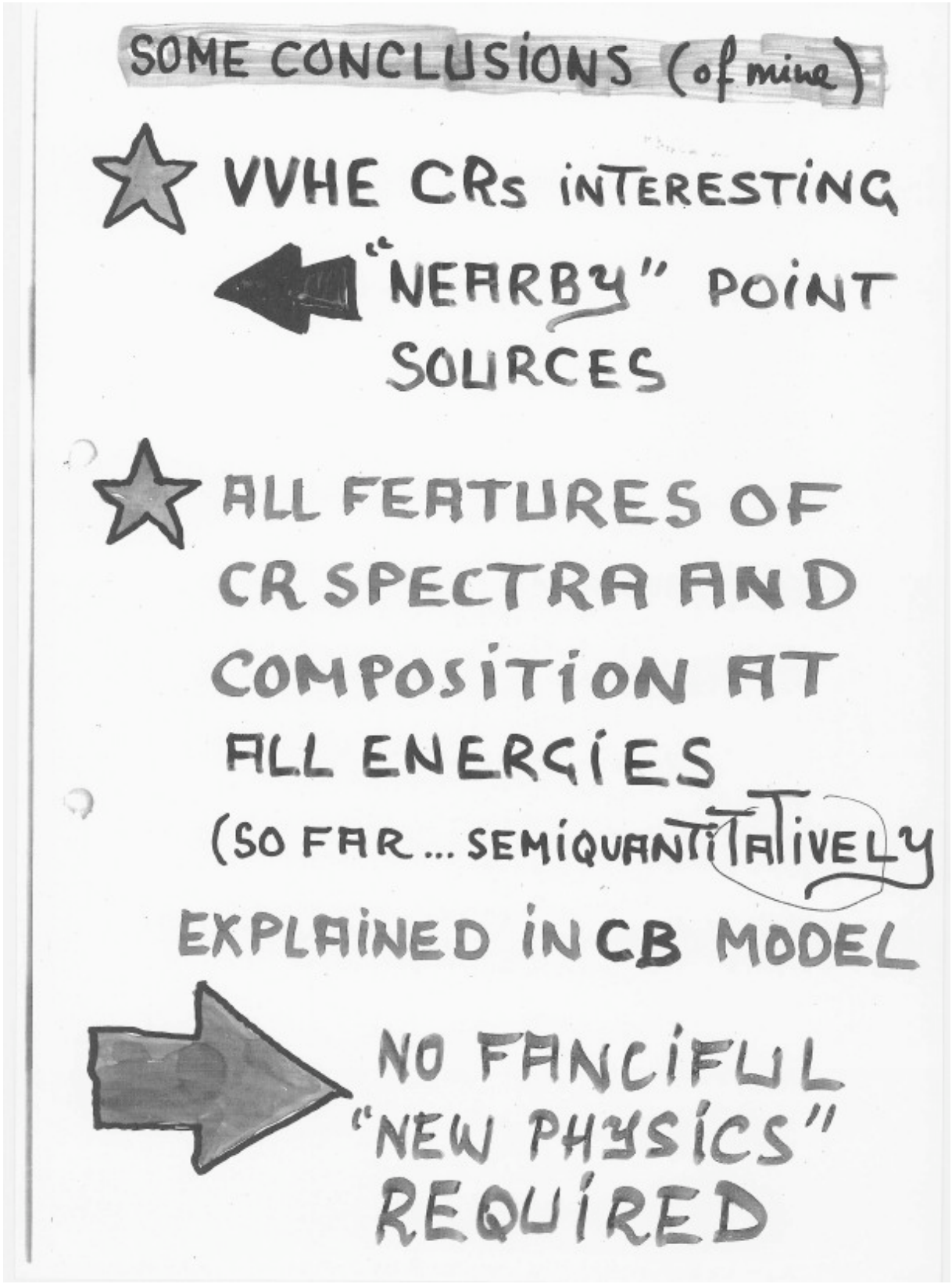
ALL IN THE SAME BALLPARK

+ COMPOSITION DETERMINATION AT VHE VERY ARDUOUS!

36derujula.jpg



37derujula.jpg



38derujula.jpg

39derujula.jpg