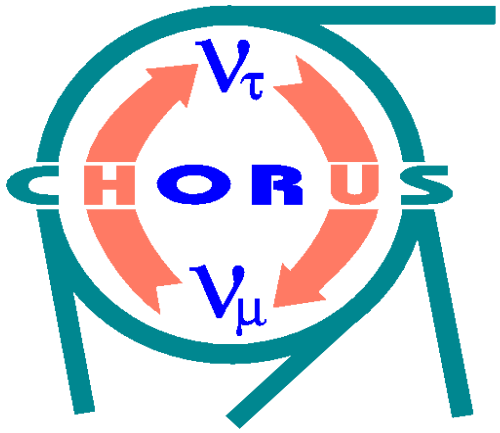
CHORUS Results on Charm Physics



Belgium (Brussels, Louvain-la-Neuve),
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Israel (Haifa), Italy (Bari, Cagliari,
Ferrara, Naples, Rome, Salerno),
Japan (Toho, Kinki, Aichi, Kobe, Nagoya,
Osaka, Utsunomiya), Korea (Gyeongsang),
The Netherlands (Amsterdam),
Russia (Moscow), Turkey (Adana,Ankara,Istanbul)

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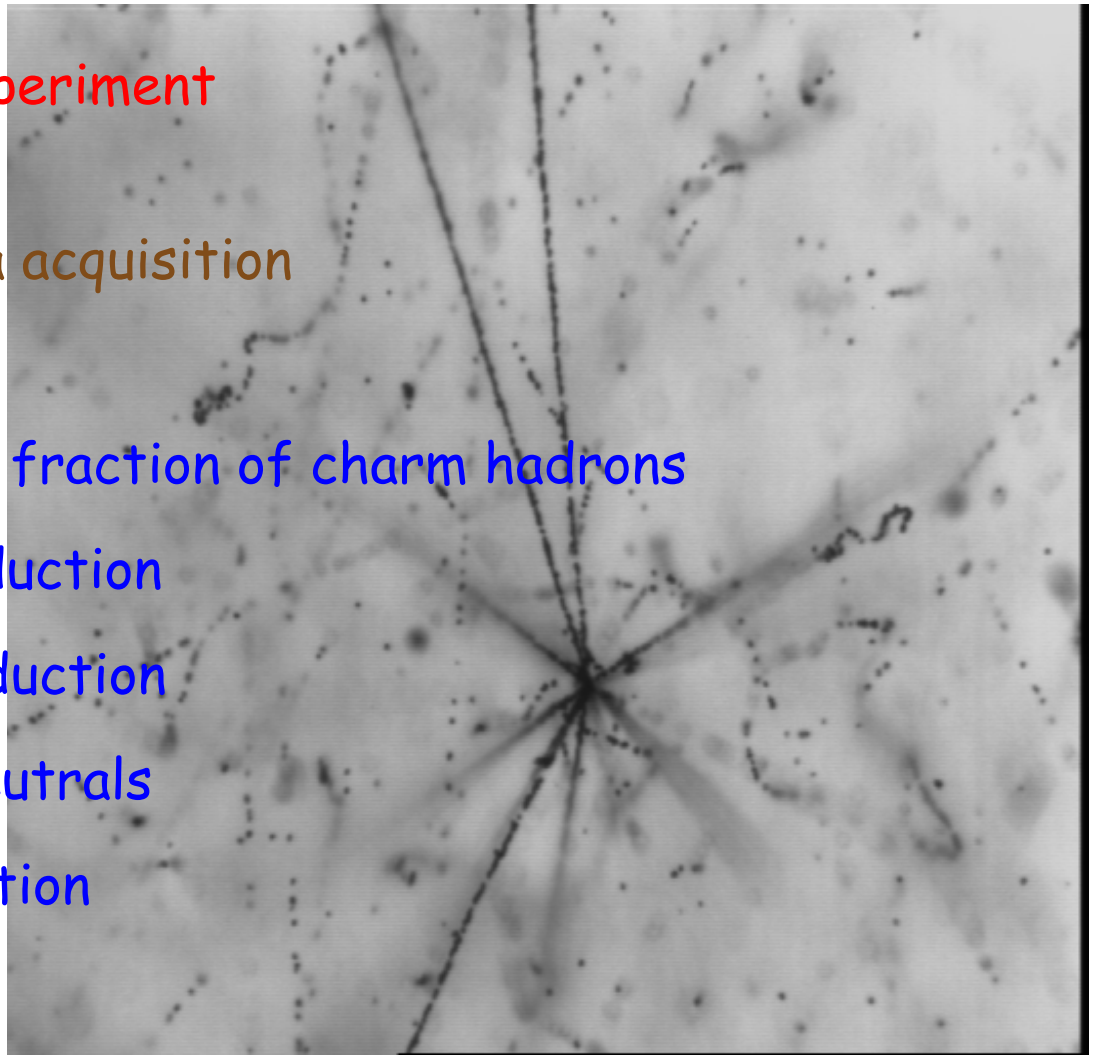
Les Rencontres de Physique de la Vallée d'Aoste
La Thuile, Aosta Valley (Italy)
9 – 15 March 2003

Outline

- Brief description of the experiment
  - CHORUS detector
  - Automatic emulsion data acquisition
- Results on charm analysis
  - Semi-leptonic branching fraction of charm hadrons
  - Measurement of Λ_c production
  - Measurement of D^0 production
  - Measurement of $D^0 \rightarrow$ neutrals
  - Associate charm production
- Conclusions



CHORUS detector

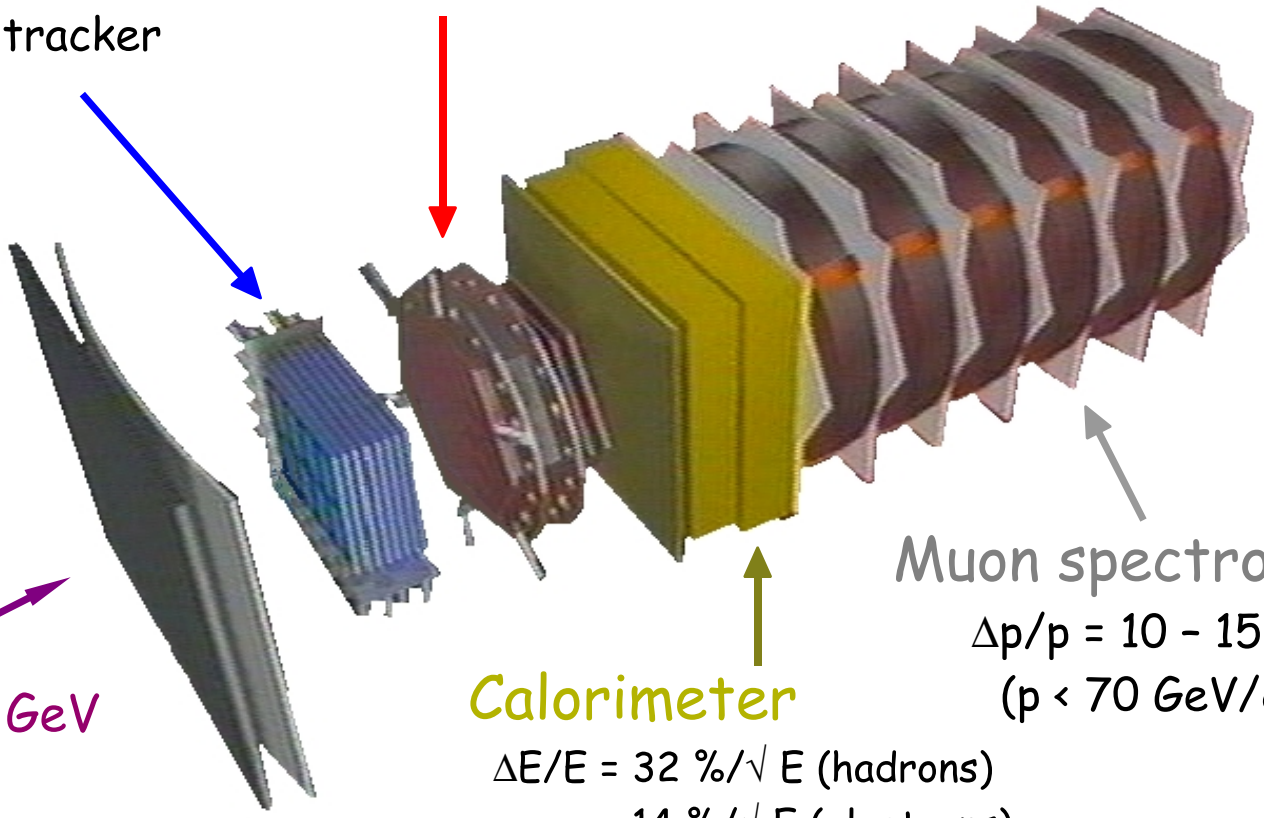
Active target

nuclear emulsion target (770kg)

scintillating fiber tracker

Air-core magnet

$\Delta p/p = 0.035\ p\ (GeV/c) \oplus 0.22$



ν_μ

~ 27 GeV

CERN SPS

Veto

Calorimeter

$\Delta E/E = 32\ \%/\sqrt{E}$ (hadrons)

$= 14\ \%/\sqrt{E}$ (electrons)

$\Delta\theta_h = 60$ mrad @ 10 GeV

Muon spectrometer

$\Delta p/p = 10 - 15\%$

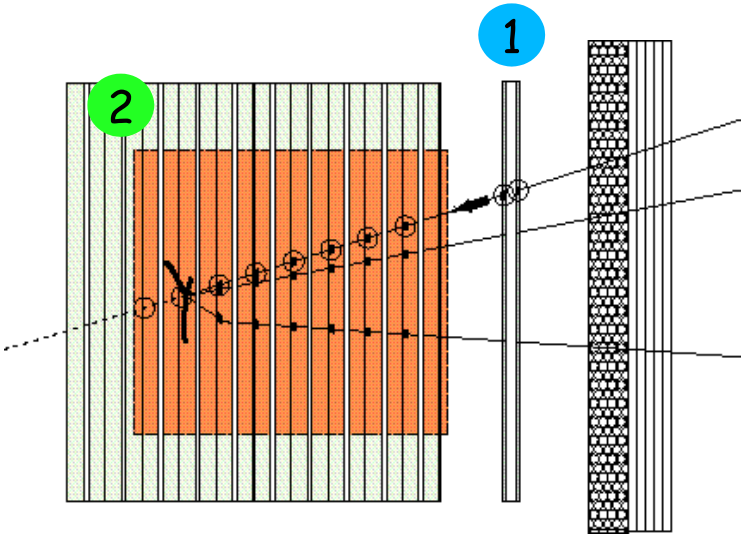
$(p < 70\ GeV/c)$

Automatic emulsion data acquisition

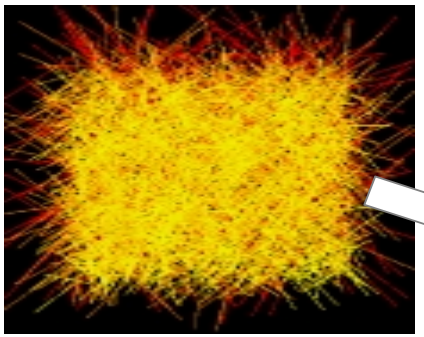
1. Location of ν interaction vertex guided by electronic detector.

2. Full data taking around ν interaction vertex called Netscan

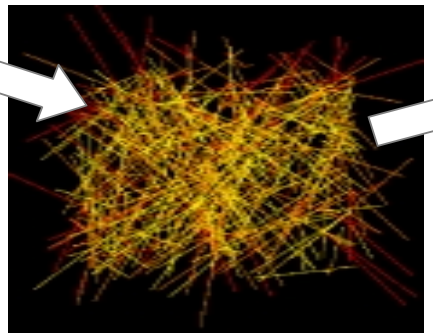
   Volume : 1.5 x 1.5 mm^2 x 6.3 mm
   Angular acceptance : 400 mrad
   ~ 11 minutes / event



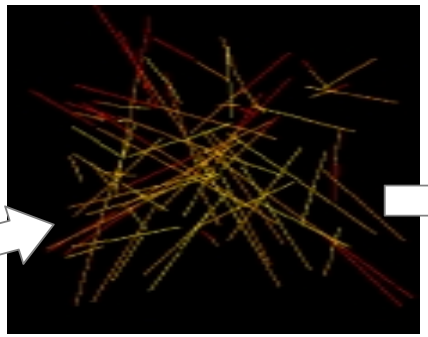
3. Offline tracking and vertex reconstruction



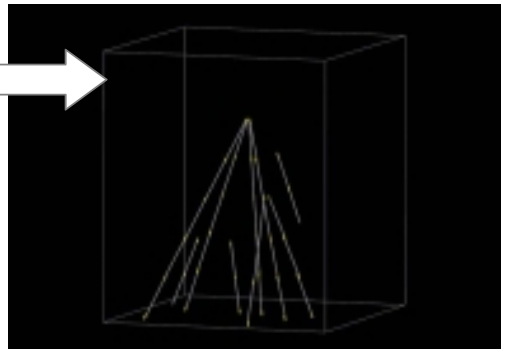
Track segments from 8 plates overlapped



At least 2-segment connected tracks



Eliminate passing through tracks



Reconstruct full vertex topology

Semi-leptonic branching fraction of charm hadrons

Motivations

Dimuon events induced by ν interaction provides information on:

CKM matrix elements ($|V_{cd}|$,$|V_{cs}|$), charm mass and strange quark content of the nucleon

Charm candidate selection

Two tracks in emulsion from different vertex matched to tracks in electronic detector

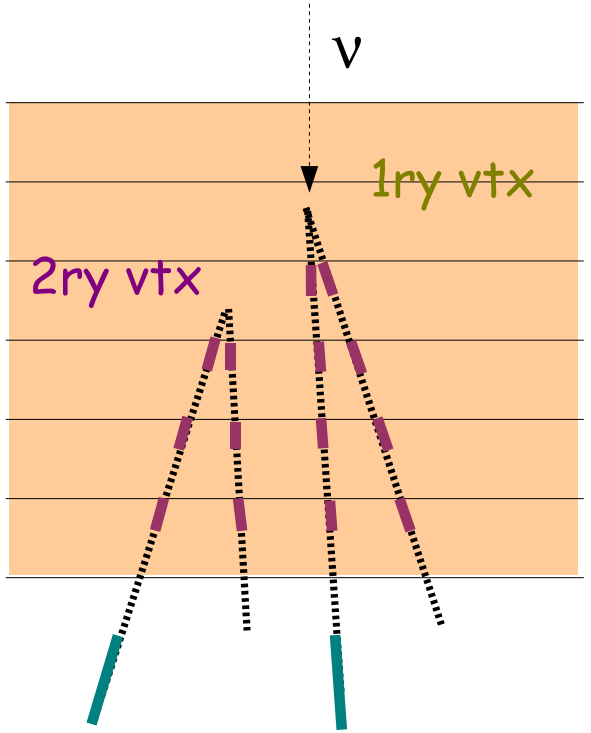
1055 events from 56,172 CC events

Visual inspection of the events by eye-scan for the selection purity check ($\frac{1}{4}$ samples)

Selection purity = 0.91 ± 0.02

Corrected number of selected events:

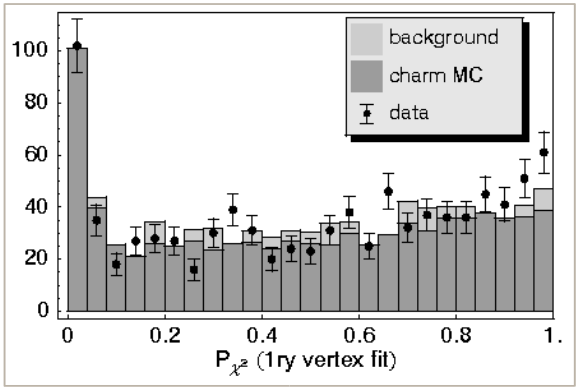
$N^{selected} = 956 \pm 35$

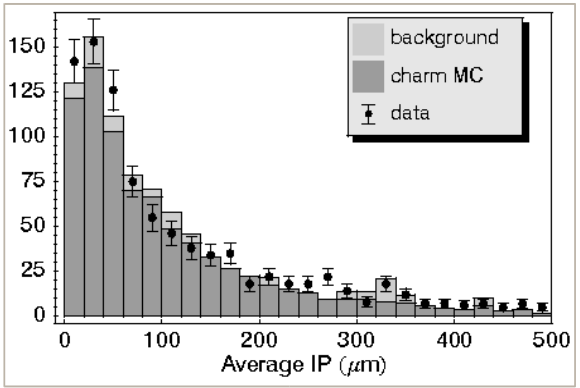


Semi-leptonic branching fraction of charm hadrons

Simulation

Hybrid MC simulation merging MC ν interaction to real netscan data which do not have vertex representing real background





Ratio of selection efficiency between $D_i \to$ any and $D_i \to \mu X$

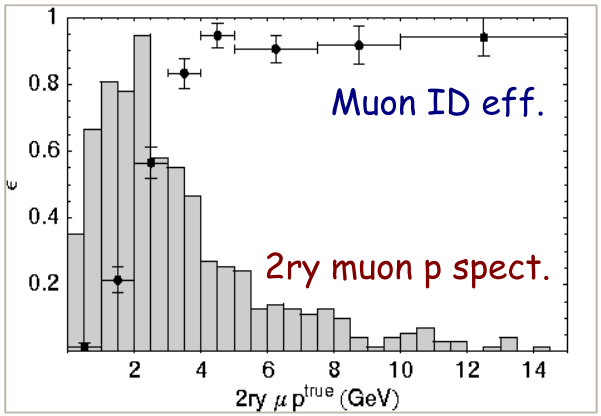
$$R = \frac{\sum_{D_i} \varepsilon_{D_i} \cdot f_{D_i}}{\sum_{D_i} \varepsilon_{D_i}^{\mu} \cdot f_{D_i}} = 1.01 \pm 0.05$$

Muon identification

Average efficiency ~ 55 % and purity ~ 60 %

Number of events with 2ry muon:

$$N_{2\mu}^{selected} = 88 \pm 10\ (stat.) \pm 8\ (syst.)$$



Semi-leptonic branching fraction of charm hadrons

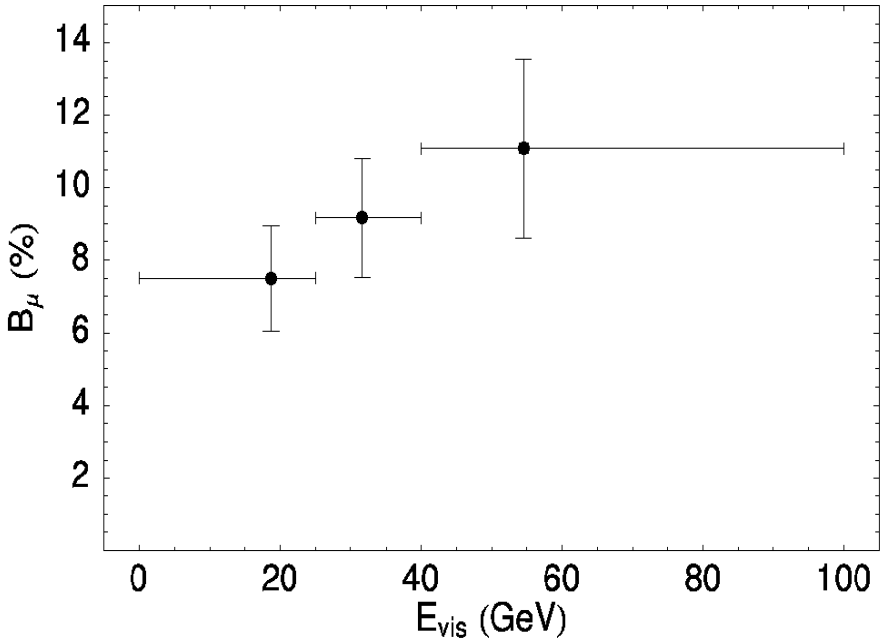
Average B_μ

$$B_\mu = \sum_{D_i} f_{D_i} \cdot BR(f_{D_i} \to \mu X) = \frac{N_{2\mu}^{selected}}{N^{selected}} \cdot R$$

$$= 0.093 \pm 0.009(stat.) \pm 0.009(syst.)$$

Uncertainties:
- MC description of muon ID
- Fragmentation fractions
- Selection efficiencies

On the basis of the visible energy, the energy dependence of B_μ can be determined.



Measurement of Λ_c production

Strategy

A statistical approach using flight length distribution

(Because PID for hadron is very difficult.)

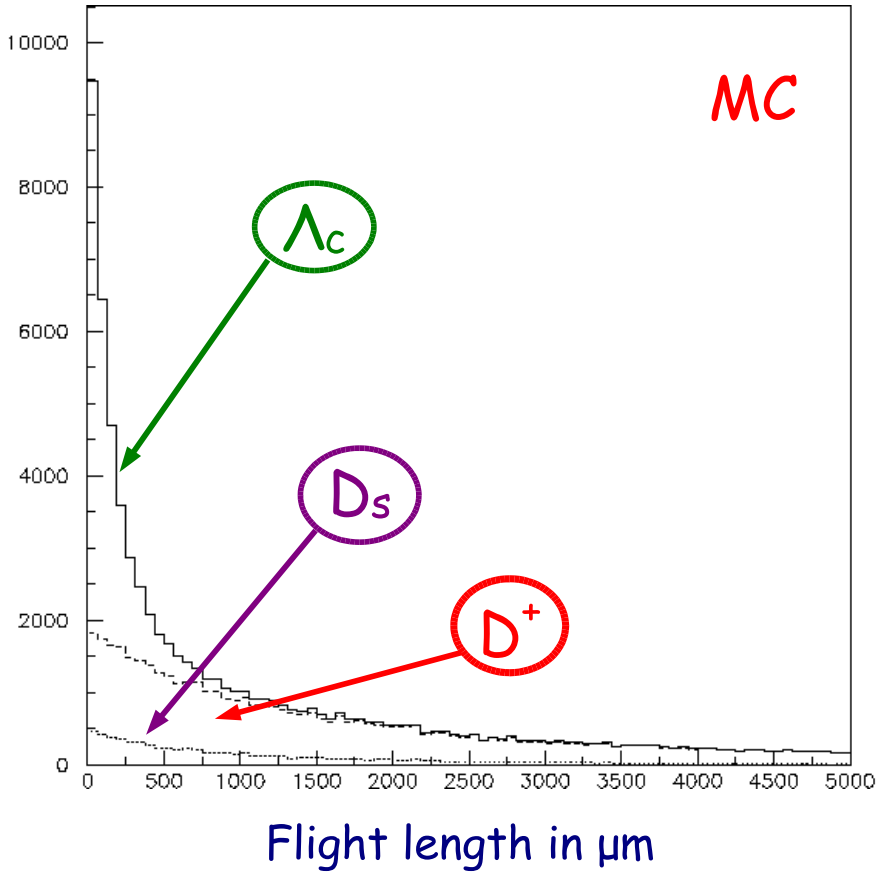
Short flight decay :

Λ_c enriched sample

Long flight decay :

D^+, D_s dominant

Two different set of criteria have been adopted.



Measurement of Λ_c production

Candidate selection

Short flight decay (A)

Daughter track : Distance to the muon 5 μm to 30 μm

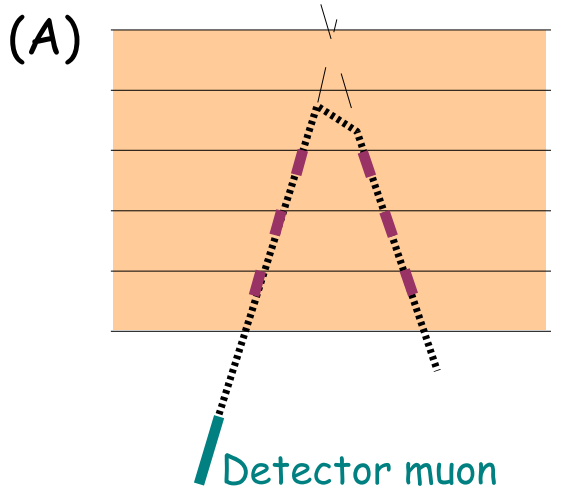
1614 events from 50,414 CC events were selected for visual inspection

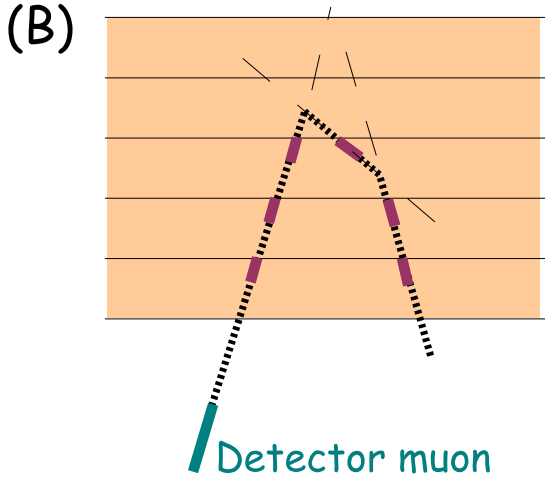
Long flight decay (B)

Parent track : distance to the muon < 5 μm

Distance between daughter and parent 5μm to 30 μm

586 events from 56,761 CC events were selected for visual inspection





Samples after flight length cut

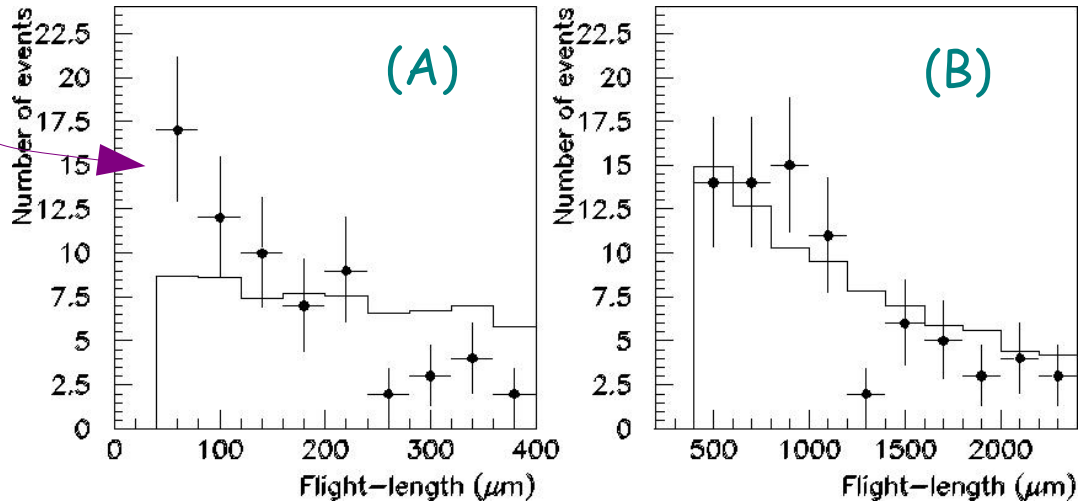
	1 prong	3 prong
(A) 40 mm < FL < 400 mm	62	66
(B) 400 mm < FL < 2400 mm	133	195

Measurement of Λ_c production

Flight length distribution of 3 prong events

Λ_c Signal

Histogram : MC of D^+, D_s
normalised to data



Results

Combining (A) and (B) dividing 1 prong from 3 prong,
taking into account efficiency and background

Λ_c = 861 ± 198(stat.) ± 98(syst.) $^{+140}_{-54}$(QE)

BR($\Lambda_c \rightarrow$ 3 prong) = 0.24 ± 0.07(stat.) ± 0.04(syst.)

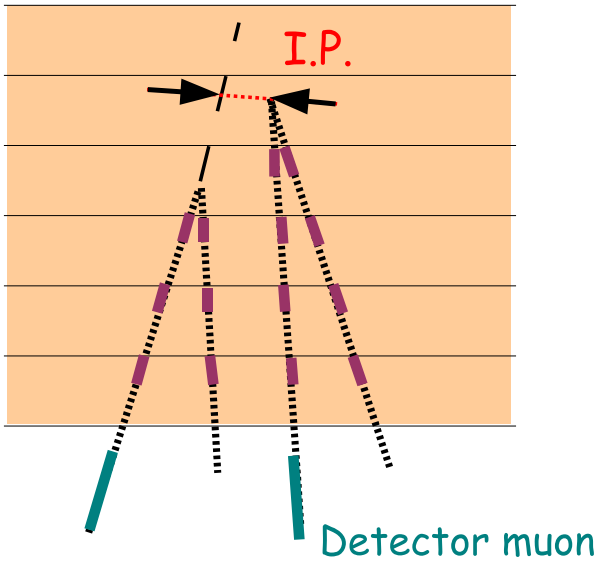
$\sigma(\Lambda_c)/\sigma(CC) \times BR(\Lambda_c \rightarrow 3\ prong)$ = 0.37 ± 0.10(stat.) ± 0.02(syst.) x 10^{-2}

$\sigma(\Lambda_c)/\sigma(CC)$ = 1.54 ± 0.35(stat.) ± 0.18(syst.) x 10^{-2}

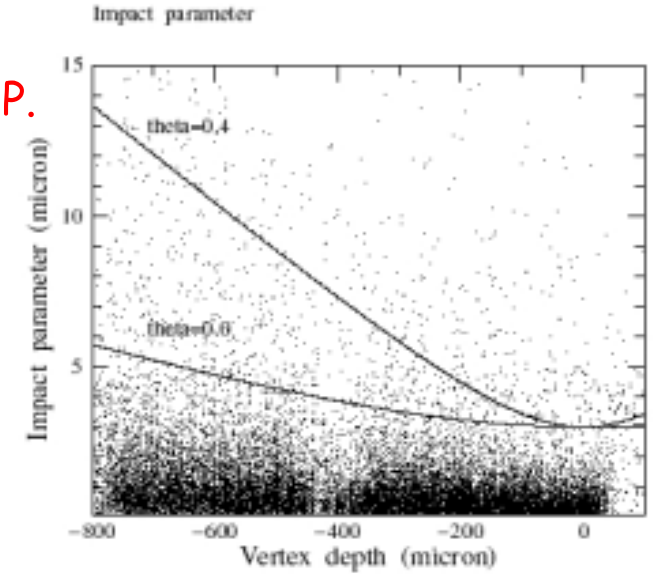
Measurement of D^0 production

Candidate selection

- Primary track matched to detector muon
- Daughter track matched to detector track
- 3 ~ 13 μm < I.P. wrt. 1ry vtx < 400 μm



I.P.



Vertex depth

851 events from 25,693 CC events were selected for visual inspection

Confirmed D^0 sample

2 prong (V2)	226
4 prong (V4)	57

Measurement of D^0 production

Results

Selection efficiencies

V2 : $58.6 \pm 0.7 \times 10^{-2}$

V4 : $70.1 \pm 1.7 \times 10^{-2}$

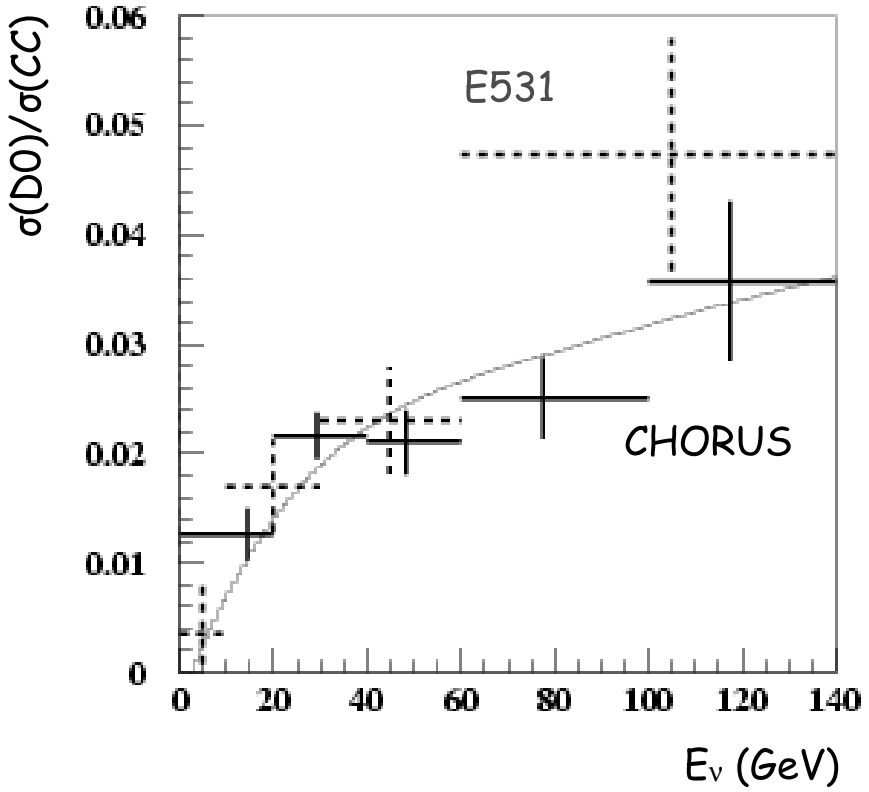
$\sigma(D^0)/\sigma(CC) \times BR(D^0 \rightarrow V2,V4)$

$= 1.99 \pm 0.13(stat.) \pm 0.17(syst.) \times 10^{-2}$

$(D^0 \rightarrow V4) / (D^0 \rightarrow V2)$

$= 23.1 \pm 4.0 \times 10^{-2}$

D^0 production rate
as a function of ν energy



(*) The curve shows a fit based on the slow rescaling model to NOMAD charm data

NEW

Measurement of $D^0 \to$ neutrals

Basic idea

$D^0 \to$ all neutrals

Sum of BR : "V0" + V2 + V4 + V6 + ... = 1

It should be very small.

$$BR(D^0 \to \text{"V0"}) = 1 - V4 \cdot (1 + (V4/V2)^{-1})$$

$BR(D^0 \to V4) = 13.3 \pm 0.7 \times 10^{-2}$ All decay modes measured by another experiments. PDG

$(D^0 \to V4) / (D^0 \to V2) = 23.1 \pm 4.0 \times 10^{-2}$ Inclusive measurement by CHORUS

Result

$$BR(D^0 \to \text{"V0"}) = 29.1 \pm 10.4 \times 10^{-2}$$

Precision to be improved with final statistics.

PDG $BR(D^0 \to$ "V0")

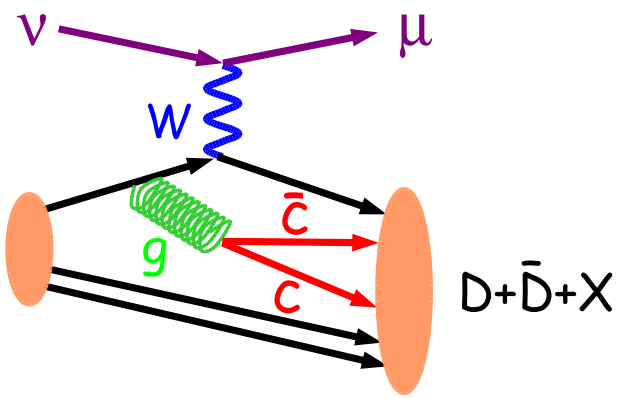
Measured ~ 2.4 %

Guessed ~ 21.8 %

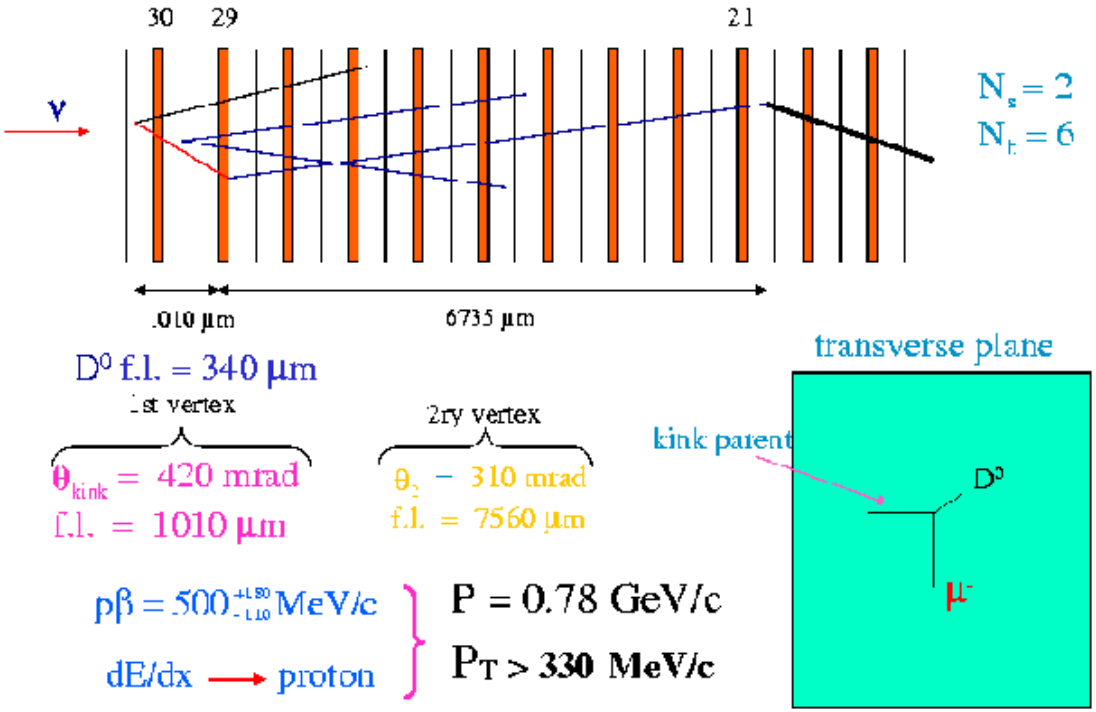
Associate charm production (CC)

Charged-current

Gluon bremsstrahlung



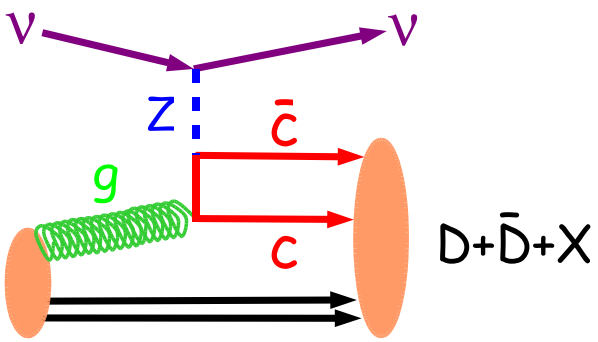
One event has been observed and published.



Associate charm production (NC)

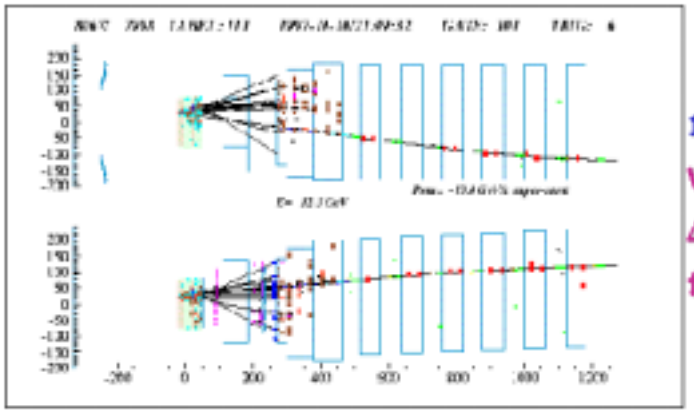
Neutral-current

Z-gluon fusion



NEW

Several candidates have been found.



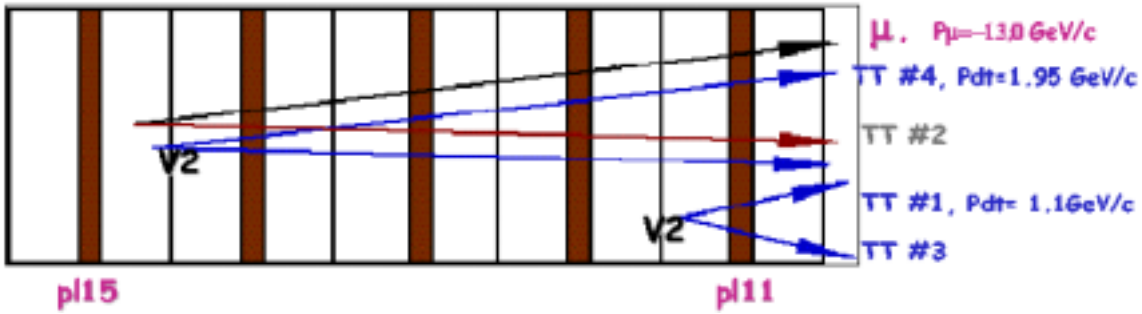
V2&V2 in 0mu

1ry@pl15 Ns=2, Nh=0

V2(1) @pl 15 V2(2) @pl11

Δθ =289.0 mrd Δθ =215.0mrd

fl= 50.1μm fl=2632.0μm



Conclusions

So far, from a subsample of charm data in CHORUS we have measured:

B_μ	Phys. Lett. B, 549 (2002) 48
Λ_c production	To be published in Phys. Lett. B
D^0 production	Phys. Lett. B, 527 (2002) 173
CC associate charm prod.	Phys. Lett. B, 539 (2002) 188
Diffractive D_s^* prod.	Phys. Lett. B, 435 (1998) 458

We are studying:

$D^0 \rightarrow$ neutrals, $D^* \rightarrow D^0 + \pi^+$

Associate charm production in *CC* and NC

Λ_c absolute BR, QE Λ_c production, BR($\Lambda_c \rightarrow \Sigma^\pm + X$)

Charm topological branching fraction, Fragmentation function

Charm production fraction

Anti neutrino charm production

Rare charm decays

Final statistics will be ~ 3,000 charm events.