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Bariones, Kaones e Instrumentación en Altas Energías

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Este proyecto pertenece a la física fundamental que estudia las partículas más elementales que constituyen la materia y sus interacciones, el proyecto tiene tres objetivos:

1. Contribuir con mediciones precisas de producción y tiempos de vida en física de bariones extraños o encantados, usando datos tomados de los experimentos SELEX [1] en Fermilab y WA89 [2] en CERN.

2. Diseñar dos detectores Cherenkov (RICH) para el experimento CKM [3] en Fermilab, usando la experiencia ganada en SELEX.

3. Establecer un laboratorio de instrumentación en altas energías en San Luis Potosí.

Miembros del proyecto dieron pláticas del trabajo en: INAOE, Benemérita Universidad Autónoma de Puebla, XIII Reunión Anual de la DPC de la SMF, Fermilab, CINVESTAV, VII Mexican Workshop on Particles and Fields. Estamos trabajando activamente en el proyecto, y en las siguientes líneas reportamos el avance de cada sub-proyecto.

Bariones extraños y encantados

El experimento WA89 tiene cuatro publicaciones en 1999, la primera medición del tamaño electromagnético del Σ^- [4], la producción de resonancias del Ξ [5], la asimetría en la producción de mesones y bariones encantados [6], y la medición de la sección transversal de la producción de charm [7]. En SELEX, que terminó la captura de datos en Septiembre 1997, se reportaron primeros resultados en congresos internacionales [8, 9], esta aceptada una publicación sobre la primera observación del decaimiento $\Lambda_c^+ \rightarrow pK^-\pi^+$ [10], y esta enviada una publicación sobre la sección transversal total con haces diferentes [11].

RICHes para CKM

Se publicaron dos artículos sobre el RICH en SELEX [12, 13]. Parámetros del RICH que operó en el experimento SELEX fueron usados para simular los RICHes del experimento CKM [14].

Laboratorio de Altas Energías

Con el objetivo de probar prototipos de fotomulitiplicadores y espejos para los RICHes de CKM, se instaló un laboratorio en el Instituto de Física de la UASLP. En este momento las primeras pruebas de la operación están comenzando.

Referencias

[1] http://fn781a.fnal.gov

[2] http://vsnhd1.cern.ch

[3] http://www.fnal.gov/projects/ckm/Welcome.html

[4] WA89 Collaboration, M.I. Adamovich et al., *Eur. Phys. J.* **C8** (1999) 59-66.

[5] WA89 Collaboration, M.I. Adamovich et al., *Eur. Phys. J.* **C11** (1999) 271-278.

[6] WA89 Collaboration, M.I. Adamovich et al., *Eur. Phys. J.* **C8** (1999) 593-601.

[7] WA89 Collaboration, M.I. Adamovich et al., enviado a *Eur. Phys. J.* **C**, hep-ex/9908061.

[8] SELEX Collaboration, F.G. Garcia, S.Y. Jun et al., *Proceedings of DPF99*, hep-ex/9905003.

[9] SELEX Collaboration, M. Iori et al., *Proceedings of EPS-HEP99.* hep-ex/9910039.

[10] SELEX Collaboration, S.Y. Jun et al., aceptado en *Phys. Rev. Lett.*, hep-ex/9907062.

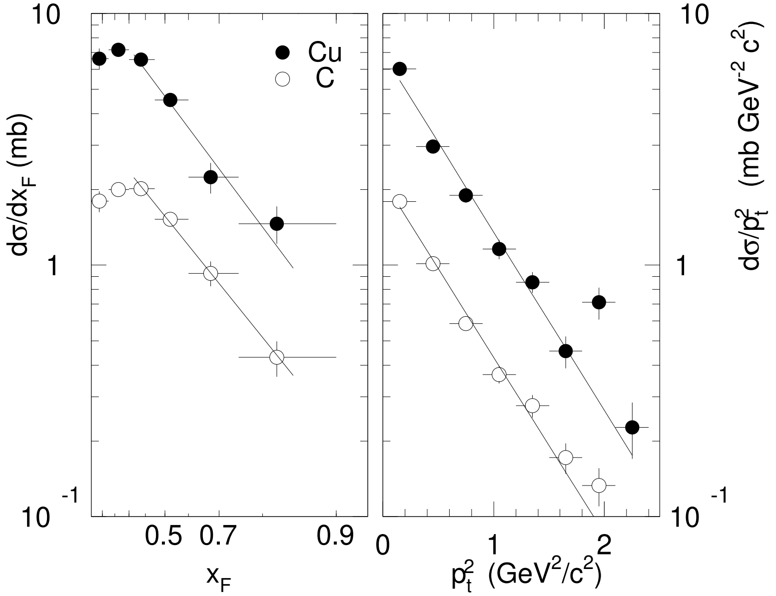
[11] SELEX Collaboration, U. Dersch et al., enviado a *Nuclear Physics B*, hep-ex/9910052.

[12] J. Engelfried et al., *Nucl. Instr. and Meth.* **A431** (1999) 53-69.

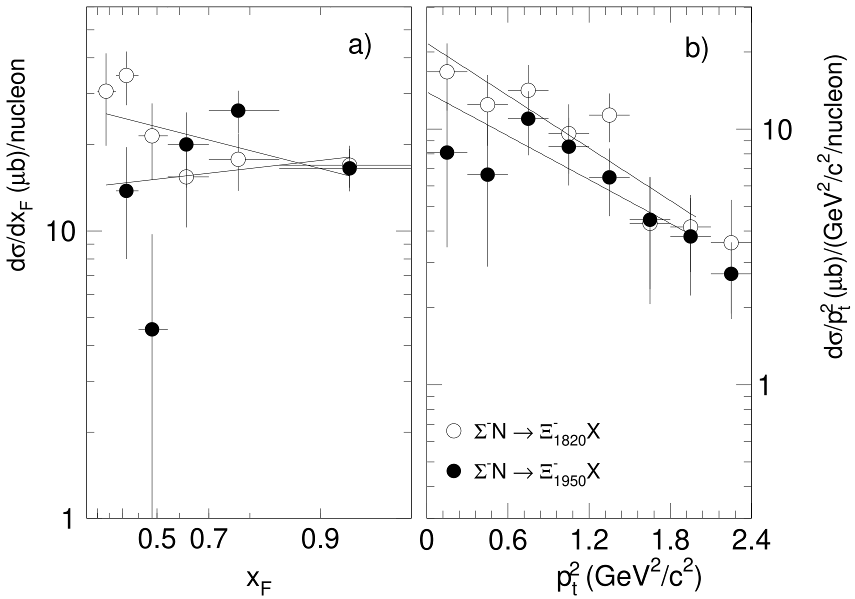
[13] J. Engelfried et al., *Nucl. Instr. and Meth.* **A433** (1999) 149.

[14] R. Coleman et al., *FERMILAB-P-0905* (1998).

Production of $\Xi^\star$ Resonances with Σ^-



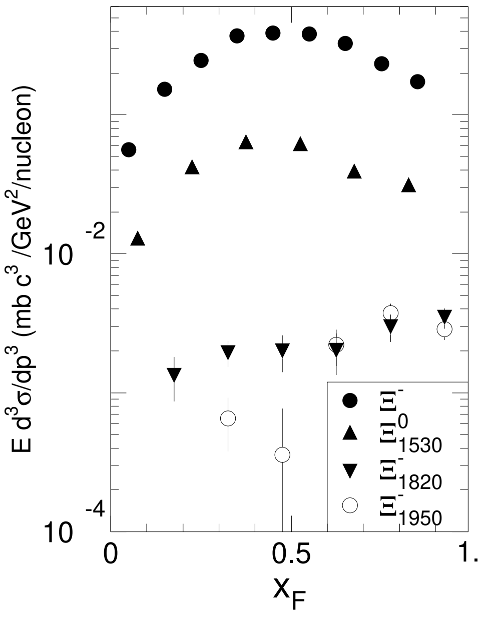
$d\sigma/dx_F$ and $d\sigma/dp_t^2$ of inclusive Ξ^0_{1530} production by Σ^- in copper and carbon.



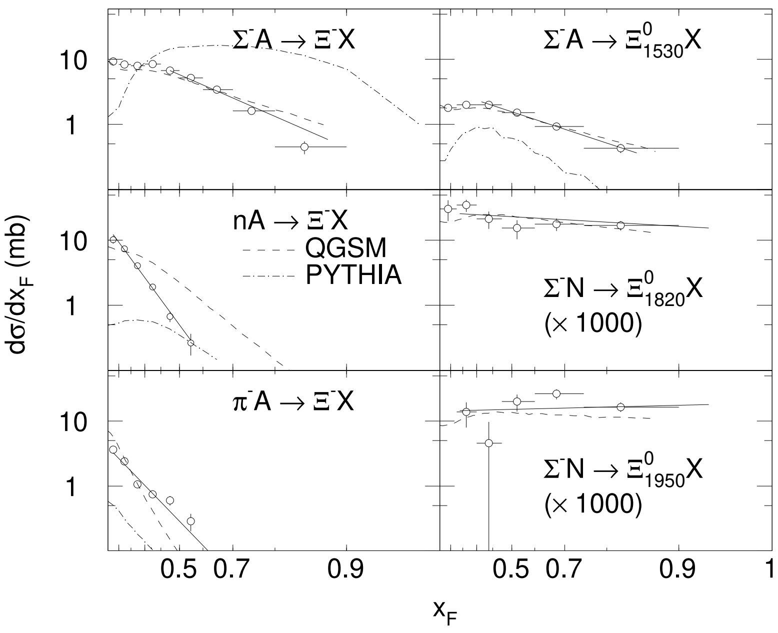
Differential cross section time branching ratio per nucleon of inclusive Ξ^-_{1820} and Ξ^-_{1950} production by Σ^-.

Parametrization of cross-sections:

$$\sigma \propto (1 - x_F)^n e^{-bp_t^2}$$



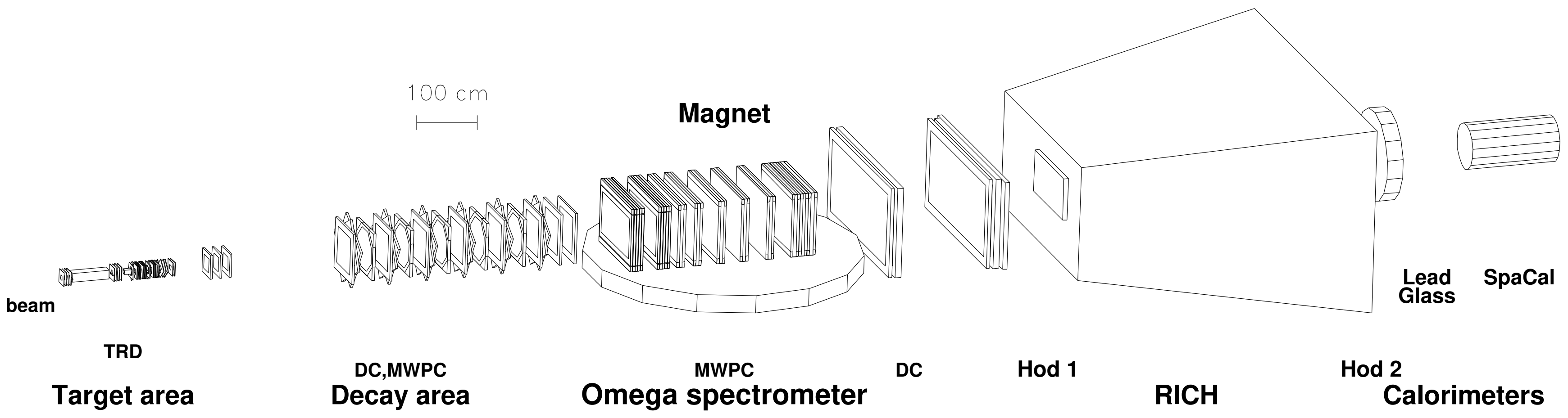
Invariant cross section per nuclean of inclusive Ξ^- and $\Xi^\star$ production by Σ^-.

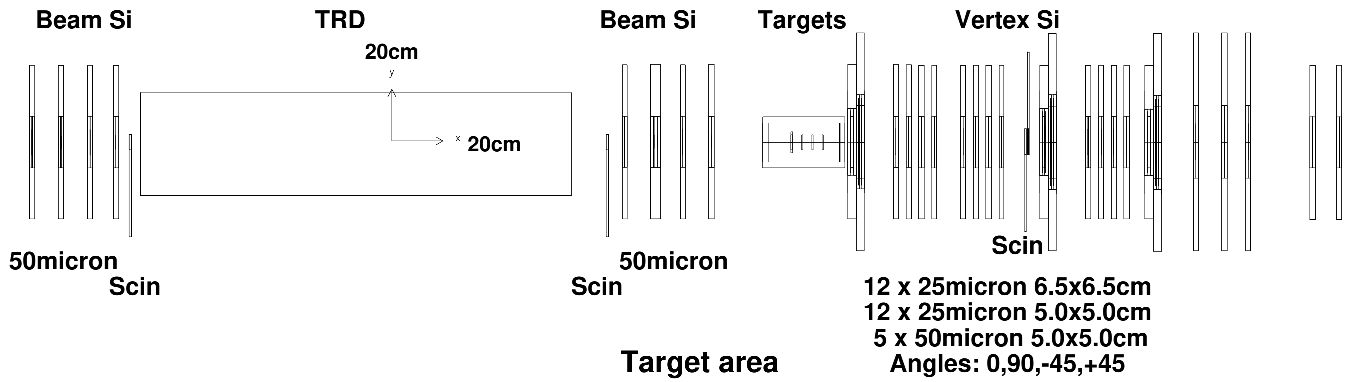


Comparison of differential cross sections of inclusive Ξ hyperon production with PYTHIA and QGSM predictions. The QGSM cross section for excited Ξ's were normalized to measured value. The solid line represents our fit.

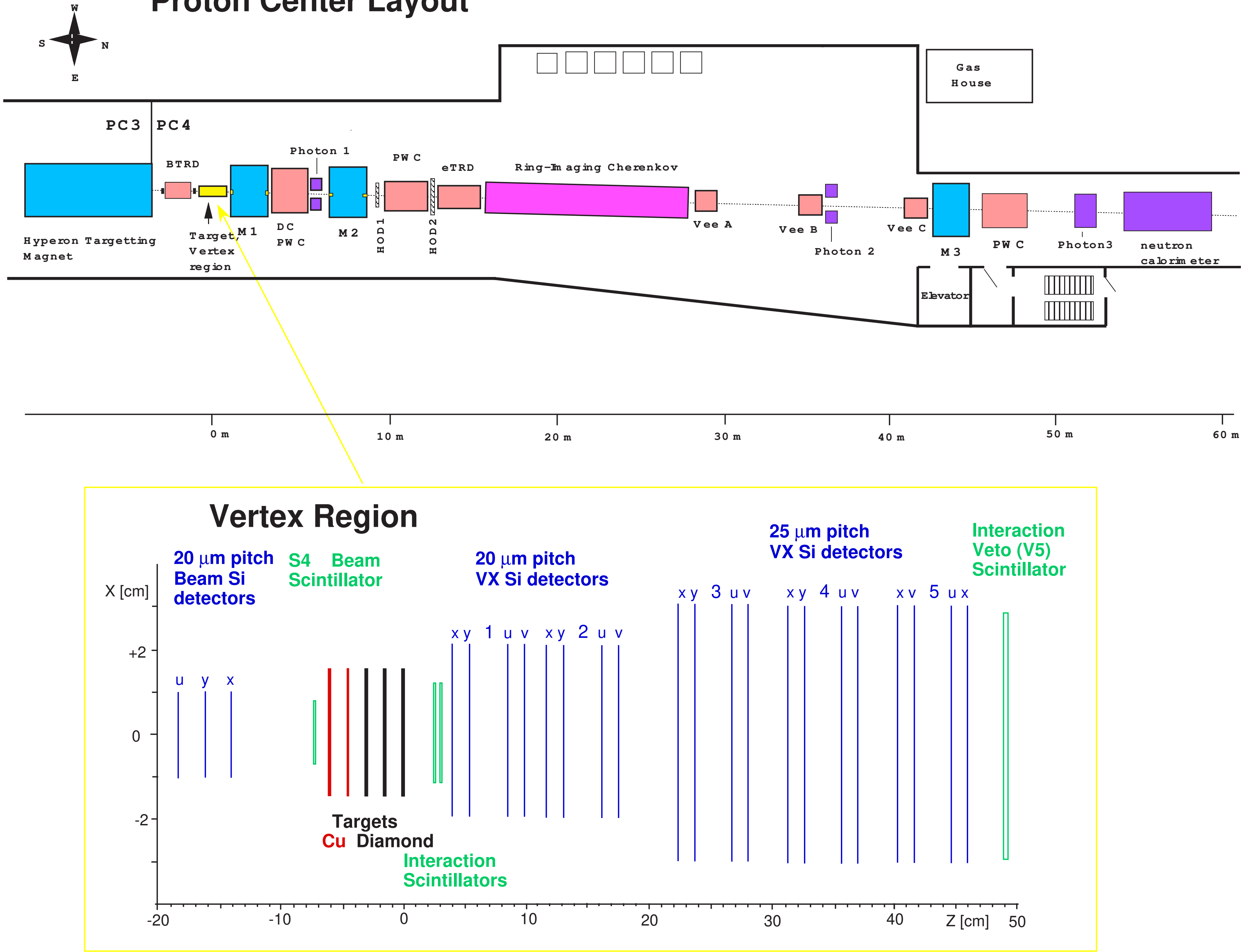
WA89 Collaboration, M.I. Adamovich et al.:
Production of $\Xi^\star$ resonances in Σ^- induced reactions at 345 GeV/c.
Eur. Phys. J. **C11** (1999) 271-278.

WA89
Hyperon beam
1993 layout





Selex (E781)
Proton Center Layout



The SELEX Collaboration

N. Akchurin[p], V.A. Andreev[k], A.G. Atamantchouk[k], M. Aykac[p], M.Y. Balatz[h], N.F. Bondar[k], A. Bravar[t], P.S. Cooper[e], L.J. Dauwe[q], G.V. Davidenko[h], U. Dersch[i], A.G. Dolgolenko[h], D. Dreossi[t], G.B. Dzyubenko[h], R. Edelstein[c], L. Emediato[s], A.M.F. Endler[d], J. Engelfried[e,m], I. Eschrich[i,1], C.O. Escobar[s,2], A.V. Evdokimov[h], I.S. Filimonov[j,3], F.G. Garcia[s], M. Gaspero[r], S. Gerzon[l], I. Giller[l], V.L. Golovtsov[k], Y.M. Goncharenko[f], E. Gottschalk[c,e], P. Gouffon[s], O.A. Grachov[f,4], E. Gülmez[b], He Kangling[g], M. Iori[r], S.Y. Jun[c], A.D. Kamenskii[h], M. Kaya[p], J. Kilmer[e], V.T. Kim[k], L.M. Kochenda[k], K. Königsmann[i,5], I. Konorov[i,6], A.P. Kozhevnikov[f], A.G. Krivshich[k], H. Krüger[i], M.A. Kubantsev[h], V.P. Kubarovsky[f], A.I. Kulyavtsev[f,c], N.P. Kuropatkin[k], V.F. Kurshetsov[f], A. Kushnirenko[c], S. Kwan[e], J. Lach[e], A. Lamberto[t], L.G. Landsberg[f], I. Larin[h], E.M. Leikin[j], Li Yunshan[g], Li Zhigang[g], M. Luksys[n], T. Lungov[s,7], D. Magarrel[p], V.P. Maleev[k], D. Mao[c,8], Mao Chensheng[g], Mao Zhenlin[g], S. Masciocchi[i,9], P. Mathew[c,10], M. Mattson[c], V. Matveev[h], E. McCliment[p], S.L. McKenna[o], M.A. Moinester[l], V.V. Molchanov[f], A. Morelos[m], V.A. Mukhin[f], K.D. Nelson[p], A.V. Nemitkin[j], P.V. Neoustroev[k], C. Newsom[p], A.P. Nilov[h], S.B. Nurushev[f], A. Ocherashvili[l], G. Oleynik[e,8], Y. Onel[p], E. Ozel[p], S. Ozkorucuklu[p], S. Patrichev[k], A. Penzo[t], S.I. Petrenko[f], P. Pogodin[p], B. Povh[i], M. Procario[c], V.A. Prutskoi[h], E. Ramberg[e], G.F. Rappazzo[t], B.V. Razmyslovich[k], V.I. Rud[j], J. Russ[c], P. Schiavon[t], V.K. Semyatchkin[h], J. Simon[i], A.I. Sitnikov[h], D. Skow[e], V.J. Smith[o], M. Srivastava[s], V. Steiner[l], V. Stepanov[k], L. Stutte[e], M. Svoiski[k], N.K. Terentyev[k,c], G.P. Thomas[a], L.N. Uvarov[k], A.N. Vasiliev[f], D.V. Vavilov[f], V.S. Verebryusov[h], V.A. Victorov[f], V.E. Vishnyakov[h], A.A. Vorobyov[k], K. Vorwalter[i,11], J. You[c], Zhao Wenheng[g], Zheng Shuchen[g], R. Zukanovich-Funchal[s]

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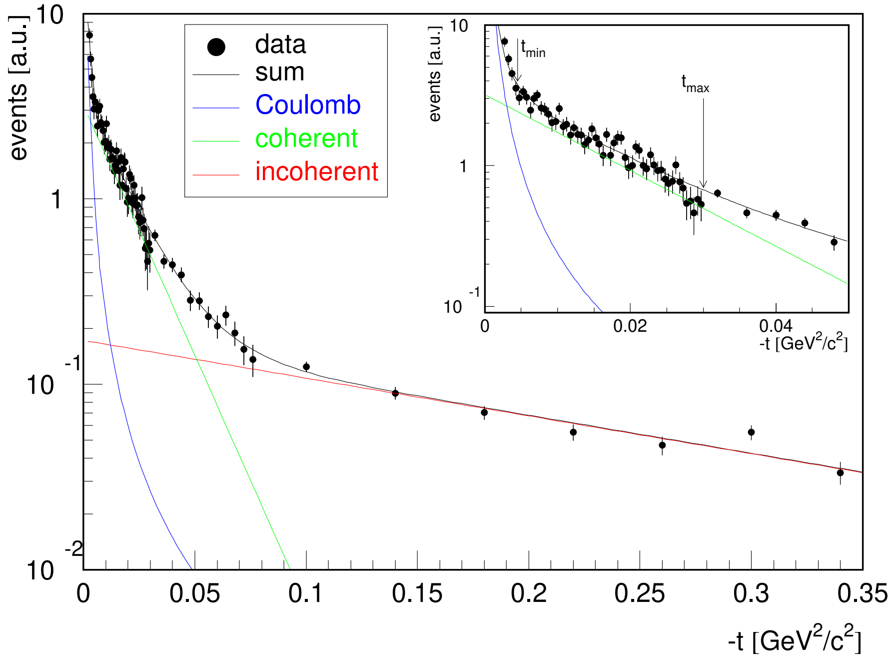
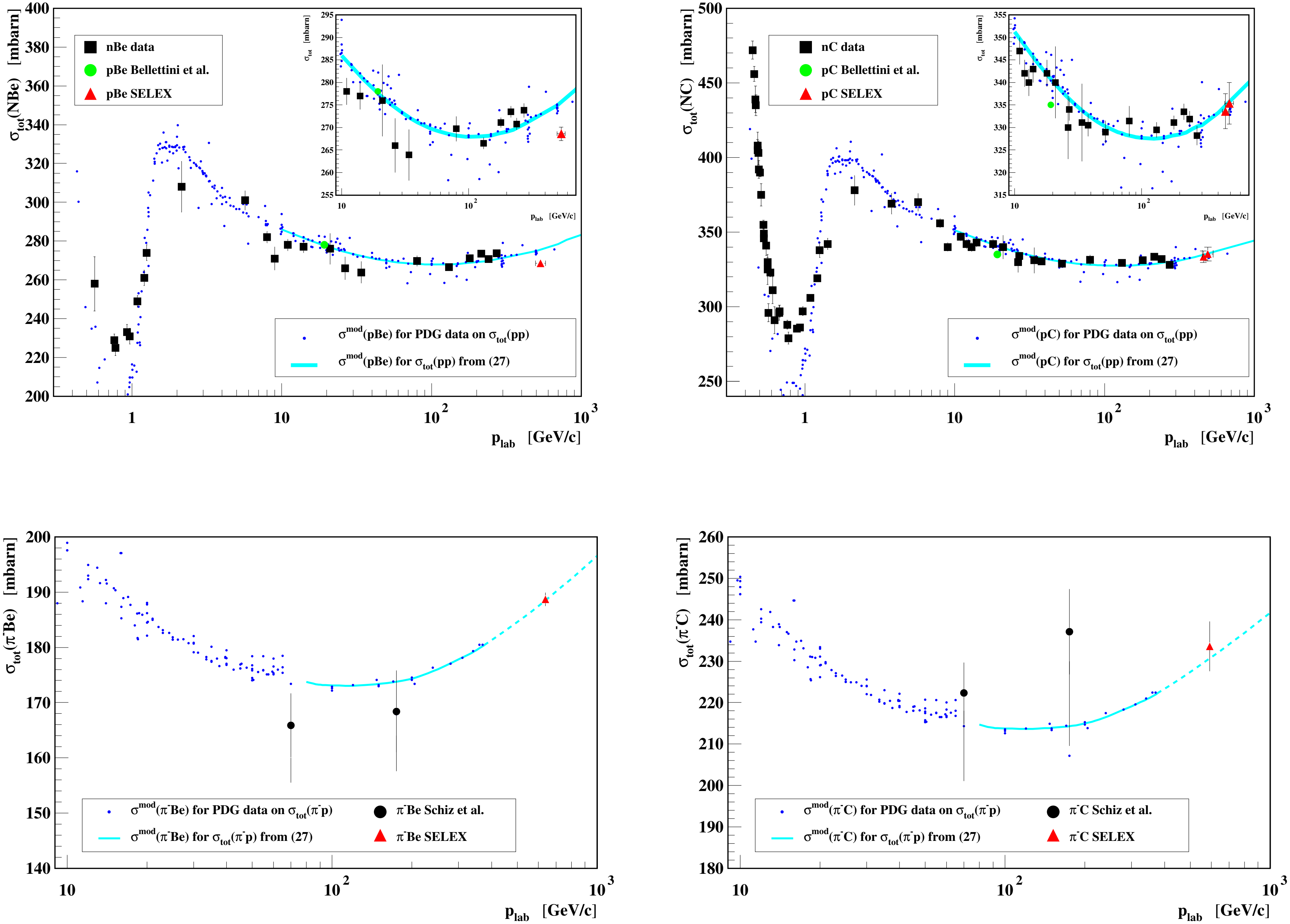
Total Cross Section Measurements with π^-, Σ^- and protons



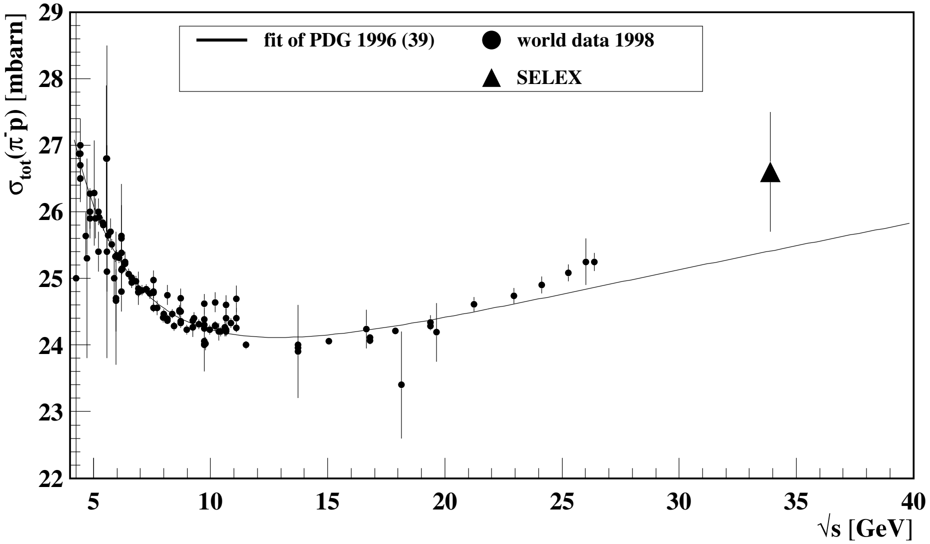
Differential Scattering spectrum for Σ^- Carbon:

Clear visibility of Coulomb, coherent, and incoherent region

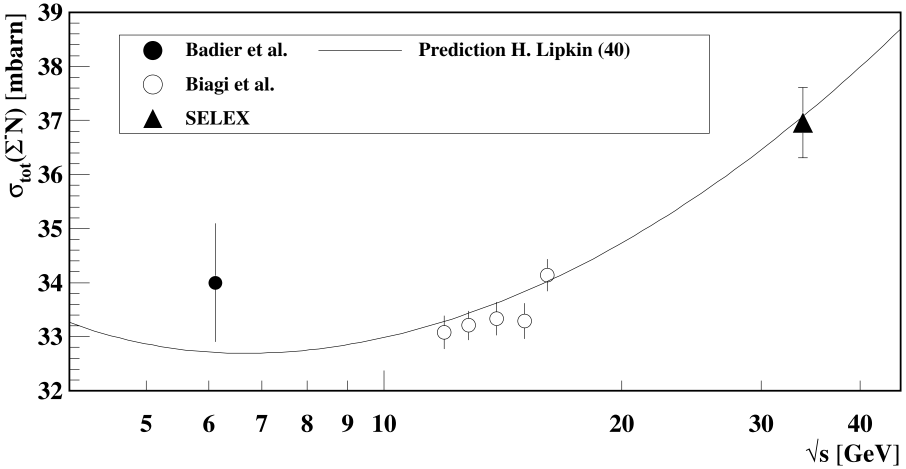
Restrict to coherent region, extrapolate to $t = 0$



nBe data
pBe Bellettini et al.
pBe SELEX
σ^{mod}(pBe) for PDG data on σ_{tot}(pp)
σ^{mod}(pBe) for σ_{tot}(pp) from (27)
σ_{tot}(NBe) [mbarn]
p_{lab} [GeV/c]
nC data
pC Bellettini et al.
pC SELEX
σ^{mod}(pC) for PDG data on σ_{tot}(pp)
σ^{mod}(pC) for σ_{tot}(pp) from (27)
σ_{tot}(NC) [mbarn]
p_{lab} [GeV/c]
$\sigma^{mod}(\pi^-Be)$ for PDG data on $\sigma_{tot}(\pi^-p)$
$\sigma^{mod}(\pi^-Be)$ for $\sigma_{tot}(\pi^-p)$ from (27)
π^-Be Schiz et al.
π^-Be SELEX
$\sigma_{tot}(\pi^-Be)$ [mbarn]
p_{lab} [GeV/c]
$\sigma^{mod}(\pi^-C)$ for PDG data on $\sigma_{tot}(\pi^-p)$
$\sigma^{mod}(\pi^-C)$ for $\sigma_{tot}(\pi^-p)$ from (27)
π^-C Schiz et al.
π^-C SELEX
$\sigma_{tot}(\pi^-C)$ [mbarn]
p_{lab} [GeV/c]



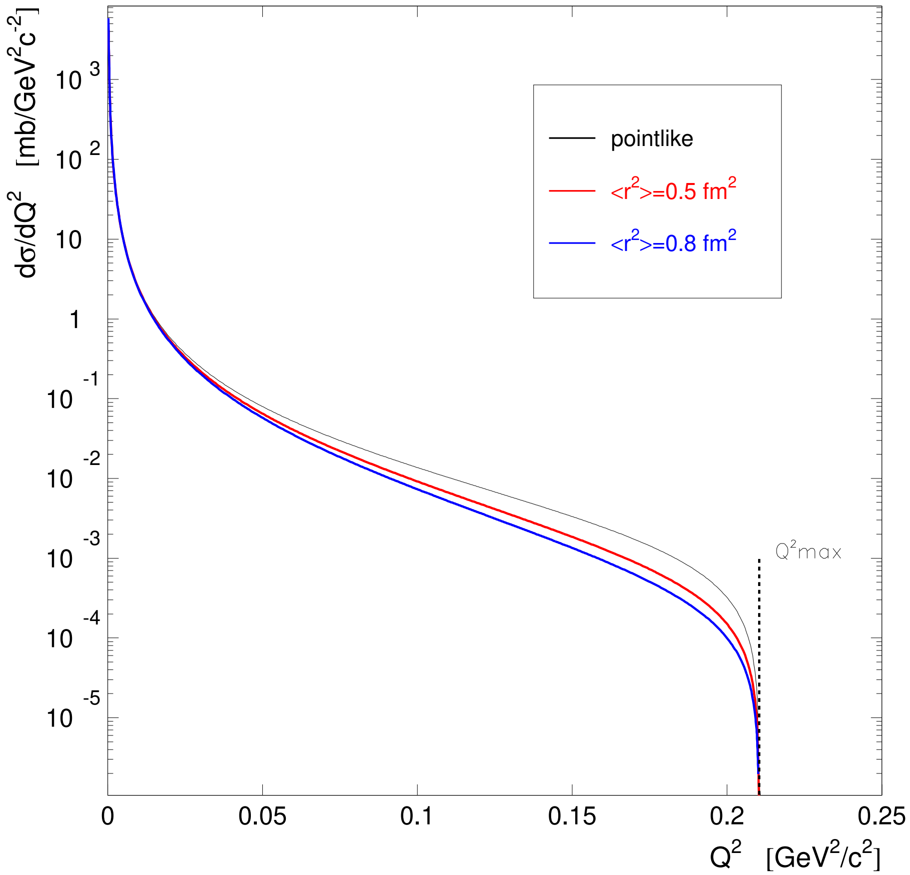
Existing data for σtot$(\pi^- p)$.

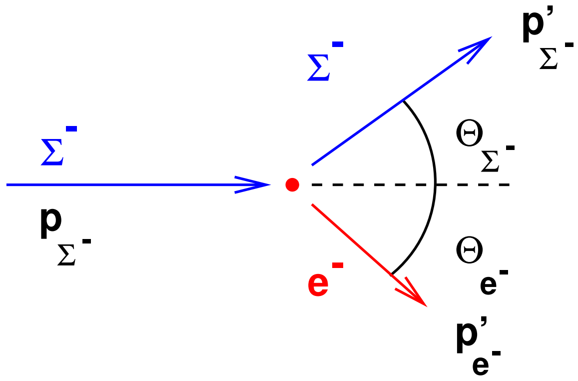


Existing data for σtot$(\Sigma^- p)$.

SELEX Collaboration, U. Dersch et al.:
Total Cross Section Measurements with π^-, Σ^- *and Protons on Nuclei and Nucleons around* 600 *GeV/c*
enviado a *Nuclear Physics B*, hep-ex/9910052.

Σ^- Charge Radius

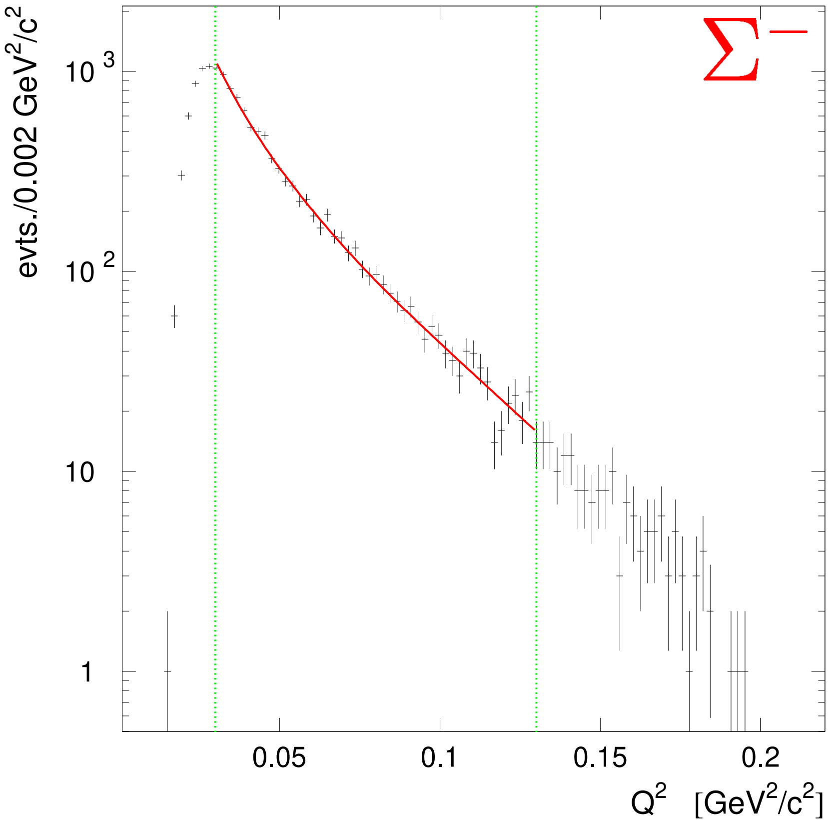




$$\frac{d\sigma}{dQ^2} = \frac{4\pi\alpha^2\hbar^2}{Q^4}\left(1 - \frac{Q^2}{Q^2_{\max}}\right) \cdot F^2(G_E, G_M, Q^2)$$

$$G_E(Q^2) = \frac{1}{\kappa - 1} G_M(Q^2) = \left(1 + \frac{1}{12} Q^2 < r^2_{\mathrm{ch}} >\right)^{-2}$$

Preliminary Results



	SELEX $\langle r^2\rangle[fm^2]$	$\langle r^2\rangle[fm^2]$
Σ^-	$0.60 \pm 0.08 \ \pm 0.08$	
p	$0.70 \pm 0.06 \ \pm 0.06$	0.72 ± 0.01 [a]
π^-	$0.50 \pm 0.06 \ \pm 0.06$	0.44 ± 0.01 [b]

[a] Mergell *el al*, Nucl.Phys.A **596**, (1996) 596

[b] Amendolia *el al* [NA7 Collaboration], Nucl.Phys.B **277**, (1986) 168

Total Charm Cross Section

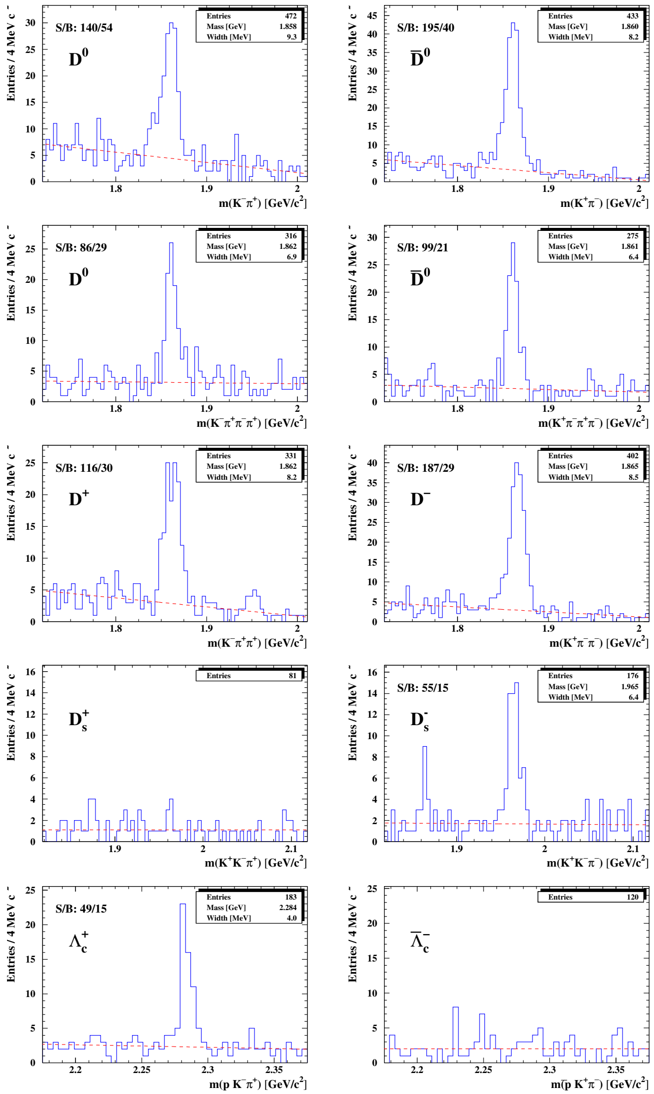
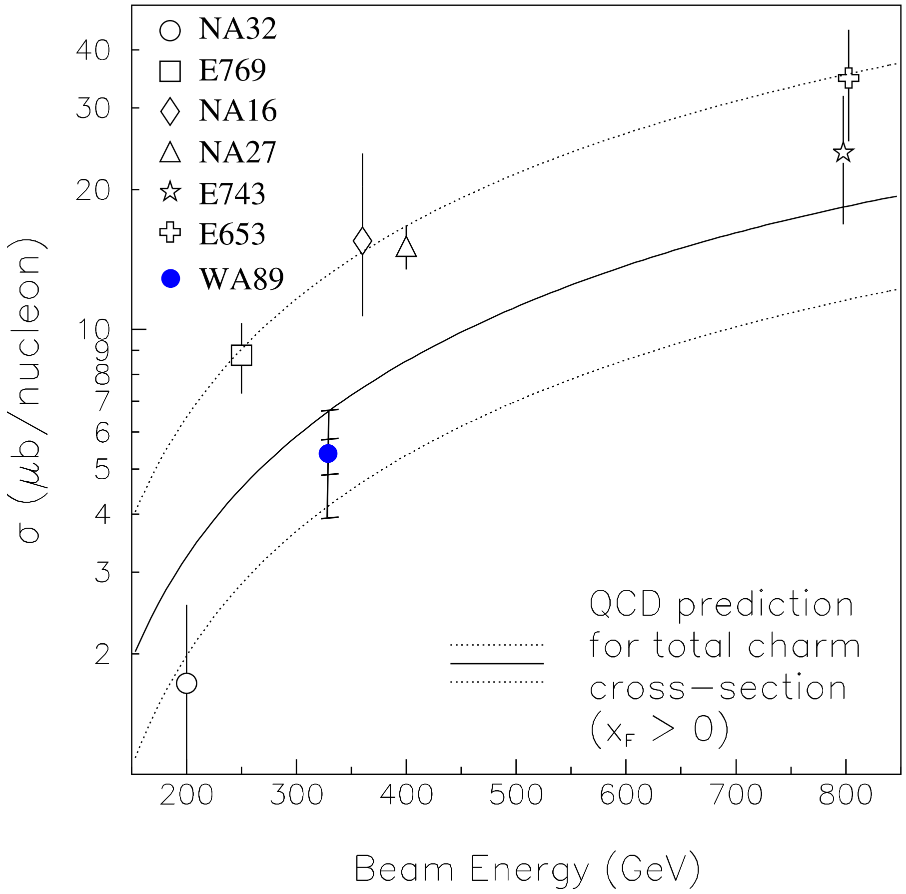


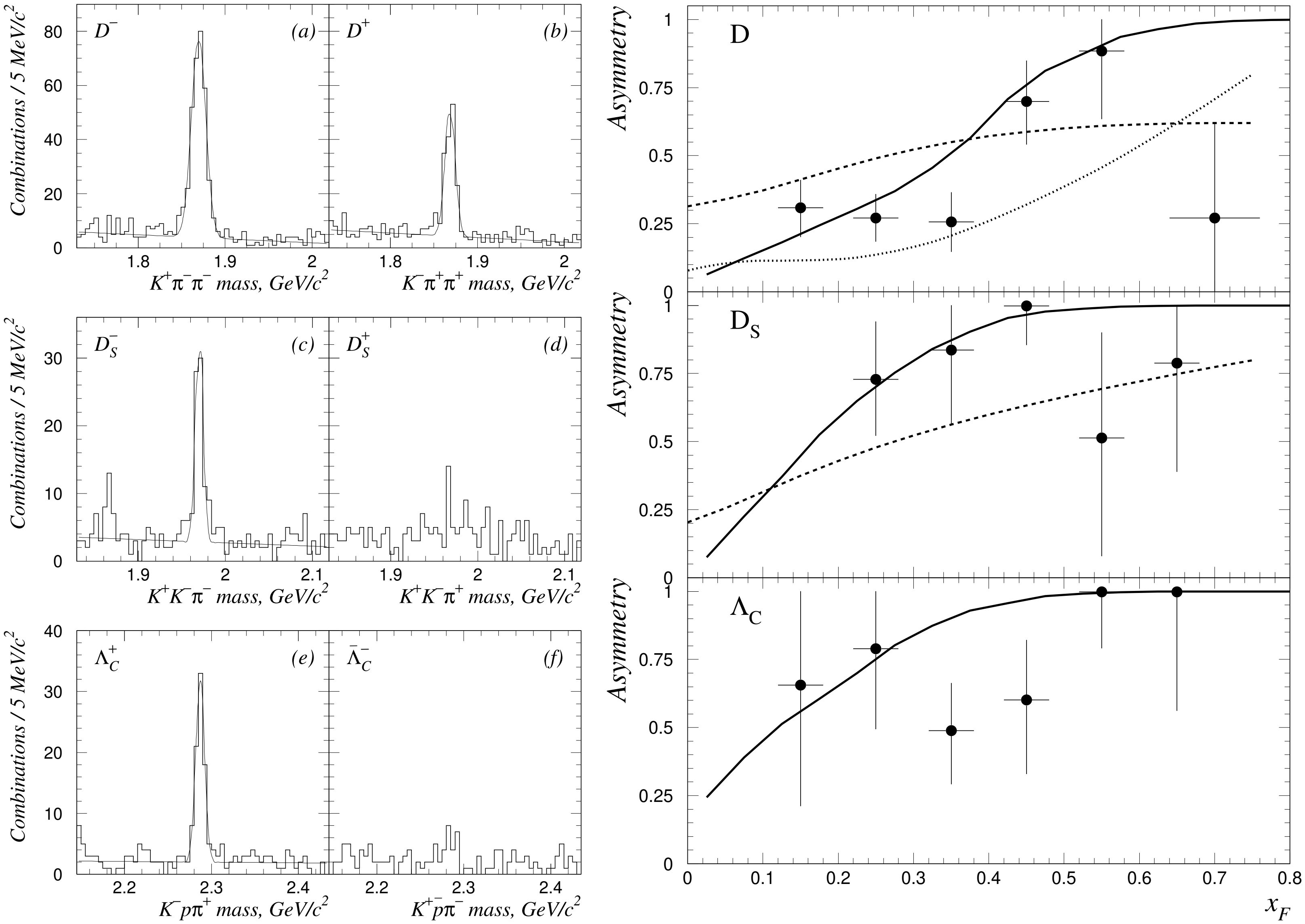
Figure Mass spectra in different decay channels used for the cross section measurement.



Total charm production cross section per nucleon by Σ^- (WA89) and protons.

WA89 Collaboration, M.I. Adamovich et al.:
Determination of the Total $c\bar{c}$ Production Cross Section in 340 *GeV/c* Σ^-*–Nucleus Interactions.*
Eur. Phys. J. **C** (2000), DOI 10.1007/s100520000318, hep-ex/9908061.

Charm Production Asymmetry

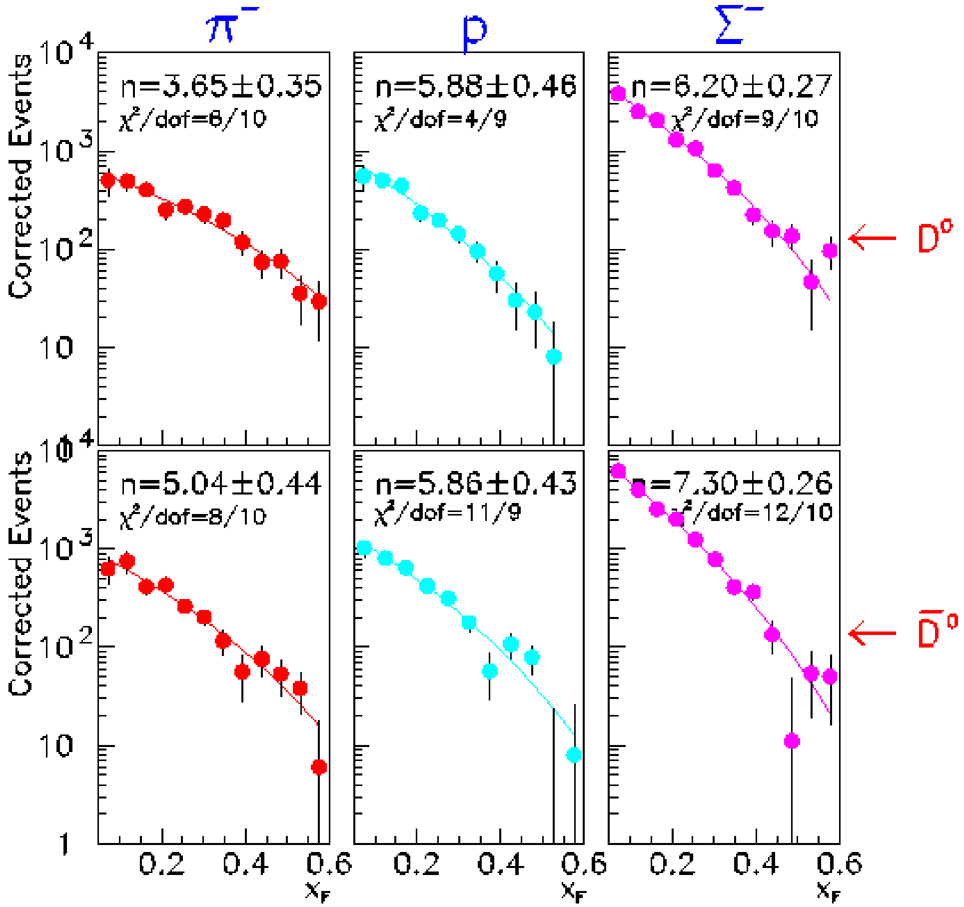


WA89 Collaboration, M.I. Adamovich et al:

Charge asymmetries for D, D_s and Λ_c production in Σ^-–nucleus interactions at 340 GeV/c.

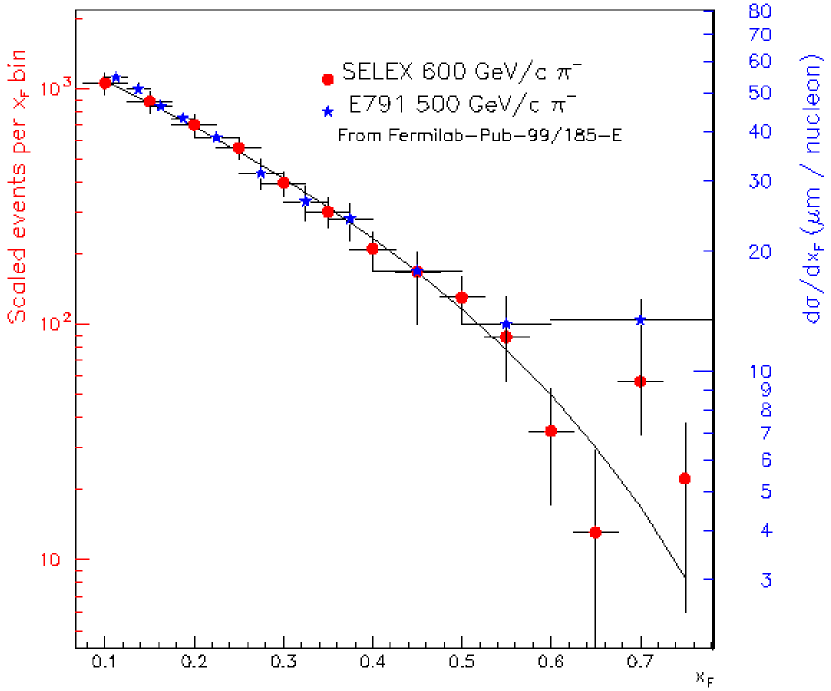
Eur. Phys. J. **C8** (1999) 593-601.

x_F distributions for D^0 and $\overline{D^0}$



Fit: $(1-x_F)^n$

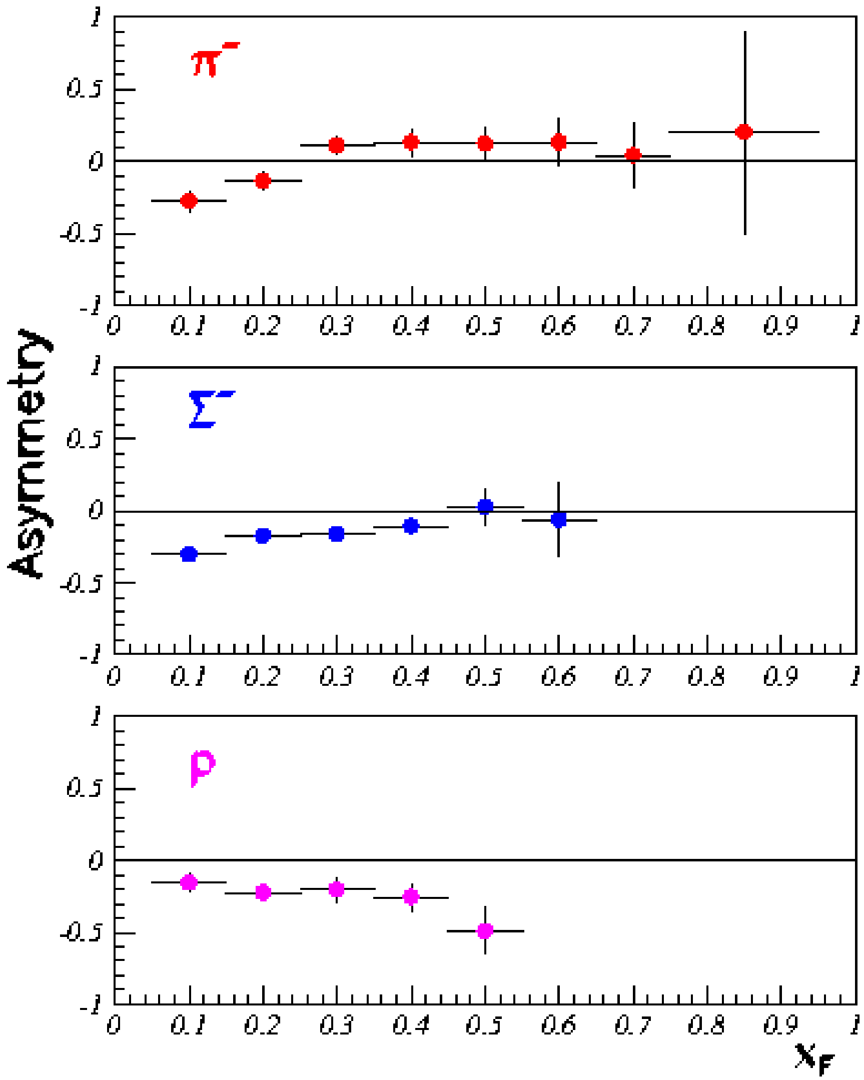
x_F distributions for $D^0 + \overline{D^0}$ (π^- beam)



Up to $x_F \sim 0.5$ SELEX and E791 data agree well
No evidence for rise at large x_F at SELEX

SELEX Collaboration, Preliminary

D^0 Asymmetry



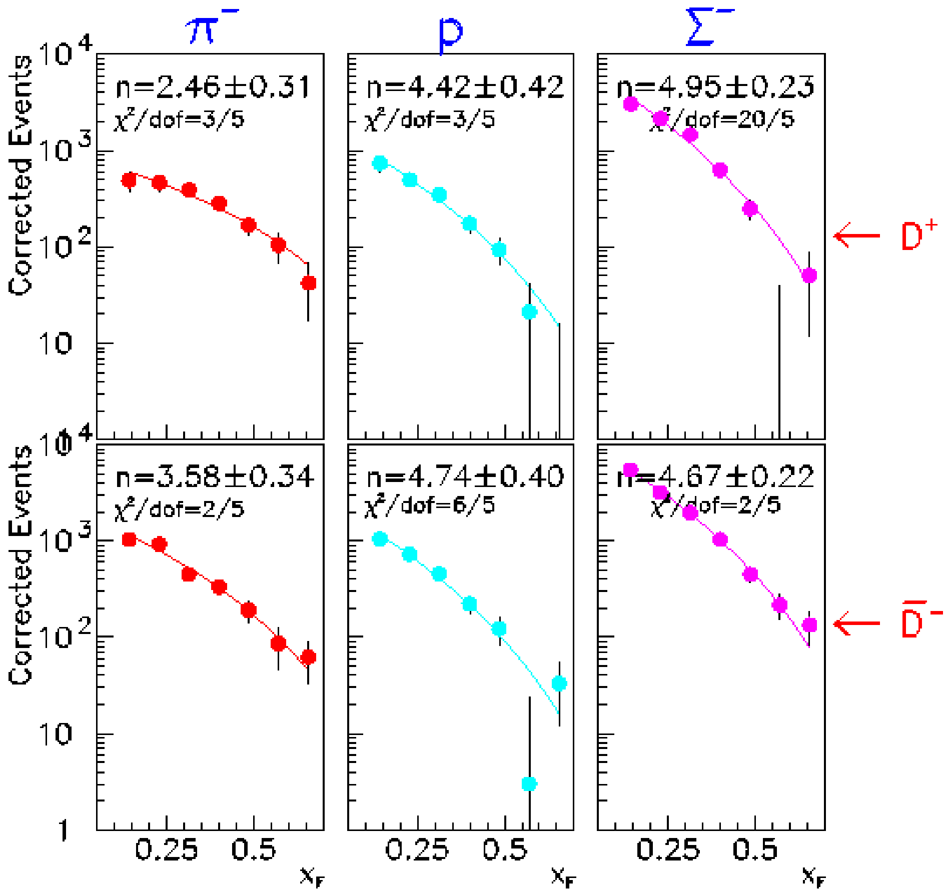
$$A = \frac{N_{D^0} - N_{\overline{D}^0}}{N_{D^0} + N_{\overline{D}^0}}$$

$A = 0 \rightarrow$
$N_{D^0} = N_{\overline{D}^0}$
$A = 1 \rightarrow$
$N_{D^0} \gg N_{\overline{D}^0}$
$A = -1 \rightarrow$
$N_{D^0} \ll N_{\overline{D}^0}$

Small value for $D^0 - \overline{D}^0$ asymmetry

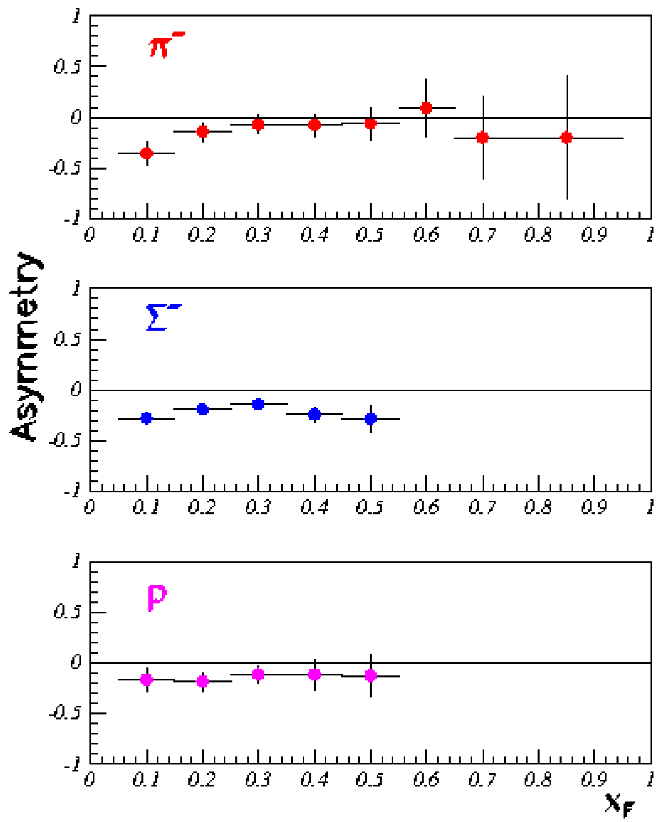
SELEX Collaboration, Preliminary

x_F distributions for $D^\pm$



Fit: $(1-x_F)^n$

$D^\pm$ Asymmetry



$A = \frac{N_{D^+} - N_{D^-}}{N_{D^+} + N_{D^-}}$

$A = 0 \rightarrow N_{D^+} = N_{D^-}$

$A = 1 \rightarrow N_{D^+} \gg N_{D^-}$

$A = -1 \rightarrow N_{D^+} \ll N_{D^-}$

Asymmetry is small for all beams and flat in x_F

SELEX Collaboration, Preliminary

$D^{\pm}$ Asymmetry (π^{-} beam)

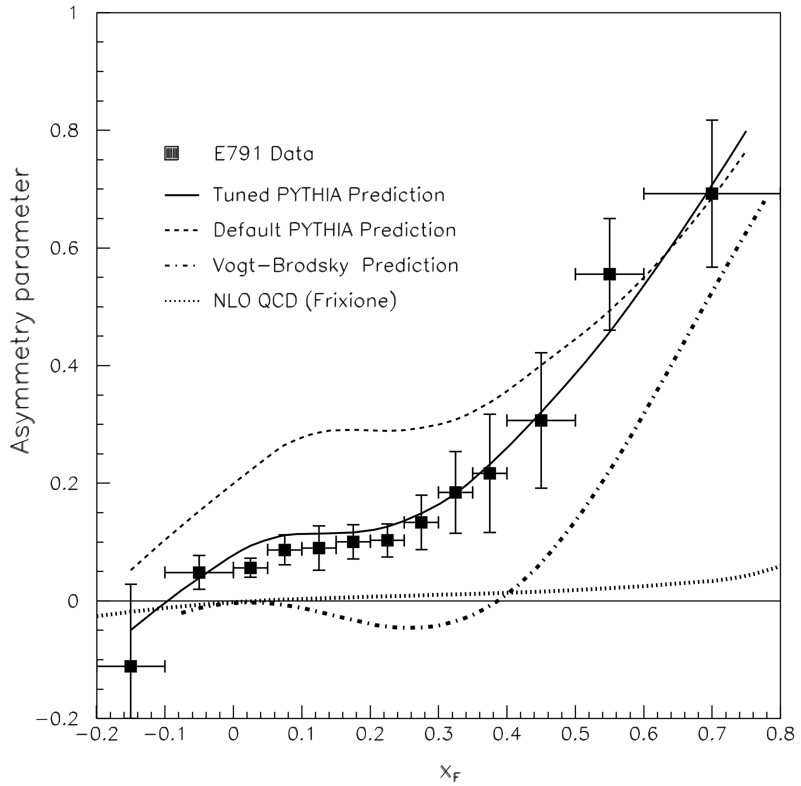
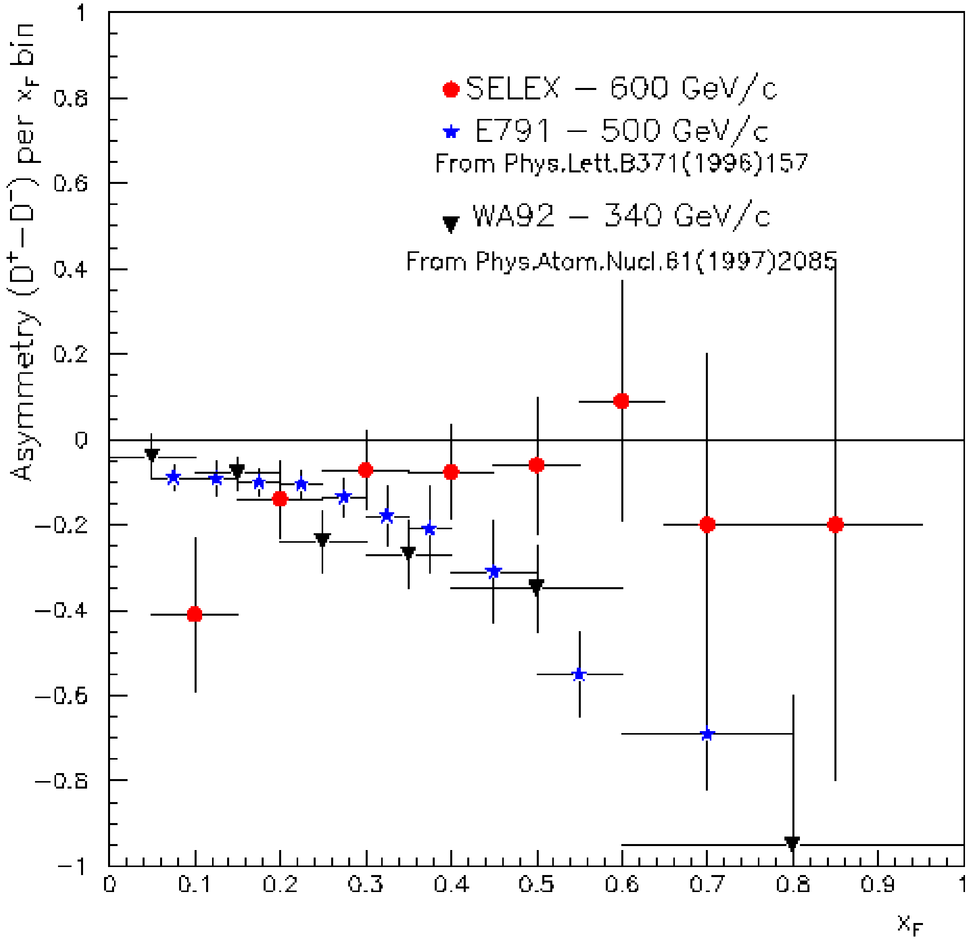
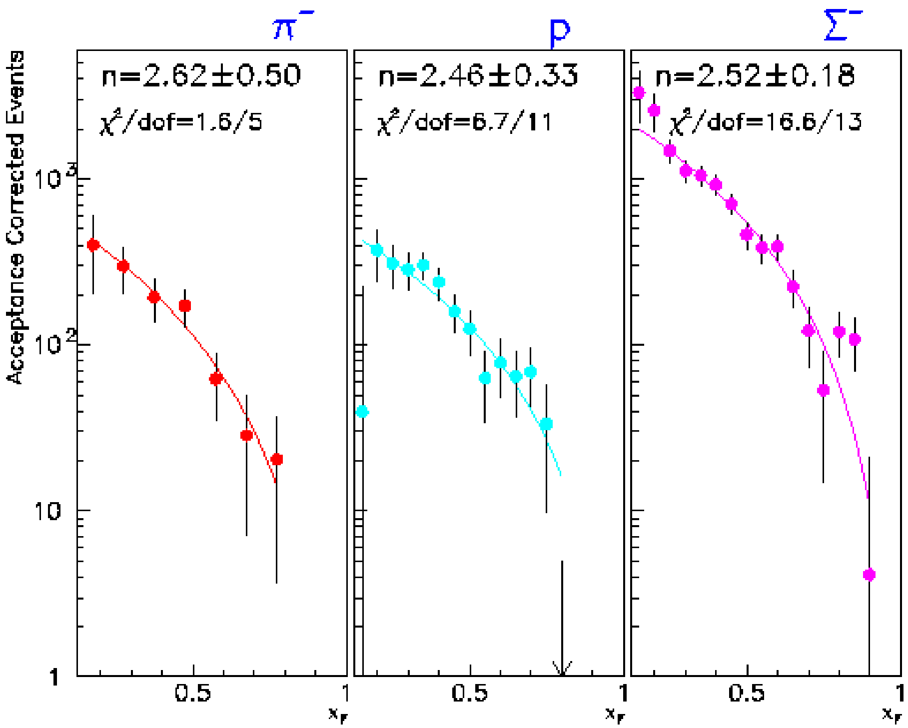


FIG. 3. The $D^{\pm}$ asymmetry A as a function of x_F for E791 data (points with error bars), for three models, and for NLO QCD. The tuned PYTHIA prediction [21] is from the default PYTHIA Monte Carlo software with the c quark mass increased to 1.7 GeV$/c^2$ and the average primordial k_t^2 of partons increased to $(1.0\ \mathrm{GeV}/c)^2$, as discussed in the text. The Vogt-Brodsky prediction is specifically calculated for the E791 beam momentum [23]. Both data and model predictions are for $D^{\pm}$ mesons with p_t^2 less than

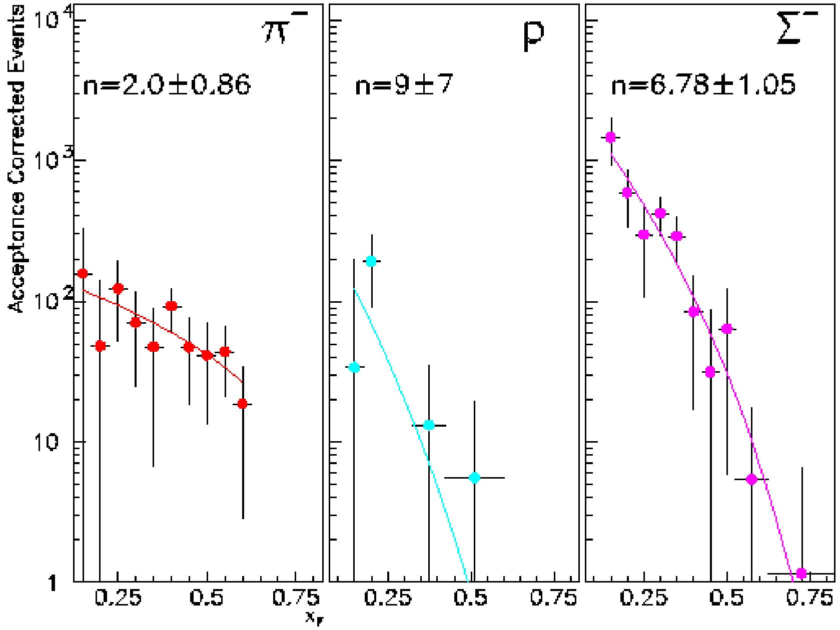


PRELIMINARY SELEX asymmetry for D^{+} is consistent with zero for $x_F > 0.2$

x_F distribution for Λ_c^+



x_F distribution for $\overline{\Lambda_c^-}$



Λ_c^+ is a leading particle for all 3 beam types

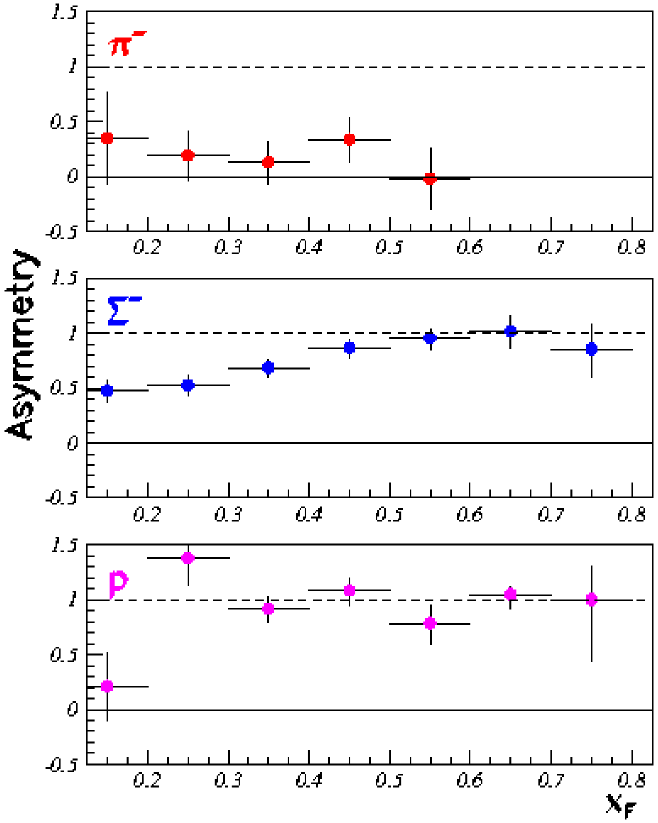
Hard x_F distributions observed

$\overline{\Lambda_c^-}$ is a leading particle when produced by π^- beam

For baryon beams, $\overline{\Lambda_c^-}$ is not a leading particle and they show much softer distribution

SELEX Collaboration, Preliminary

SELEX Λ_c Asymmetry



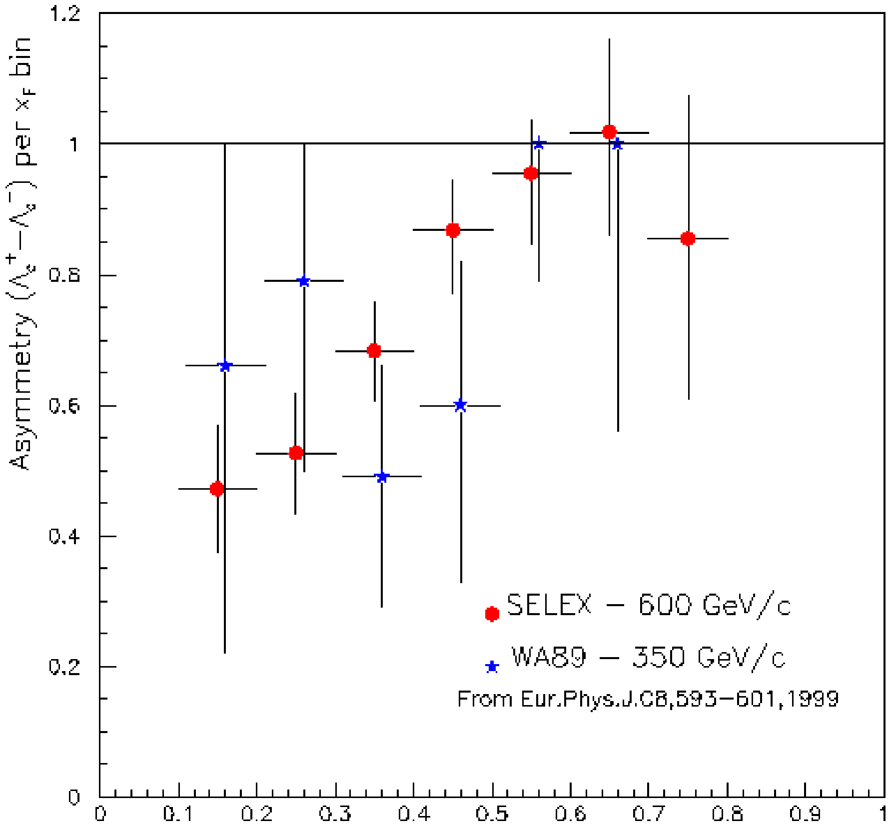
$$A = \frac{N_{\Lambda_c^+} - N_{\overline{\Lambda_c^-}}}{N_{\Lambda_c^+} + N_{\overline{\Lambda_c^-}}}$$

Not limited to $|$Asym.$| < 1$

$A = 0 \rightarrow N_{\Lambda_c^+} = N_{\overline{\Lambda_c^-}}$
$A = 1 \rightarrow N_{\Lambda_c^+} \gg N_{\overline{\Lambda_c^-}}$
$A = -1 \rightarrow N_{\Lambda_c^+} \ll N_{\overline{\Lambda_c^-}}$

π^- asymmetry is small and consistent with flat
Asymmetry grows with increasing x_F for Σ^- beam
Protons produce $\overline{\Lambda_c^-}$ only at low x_F

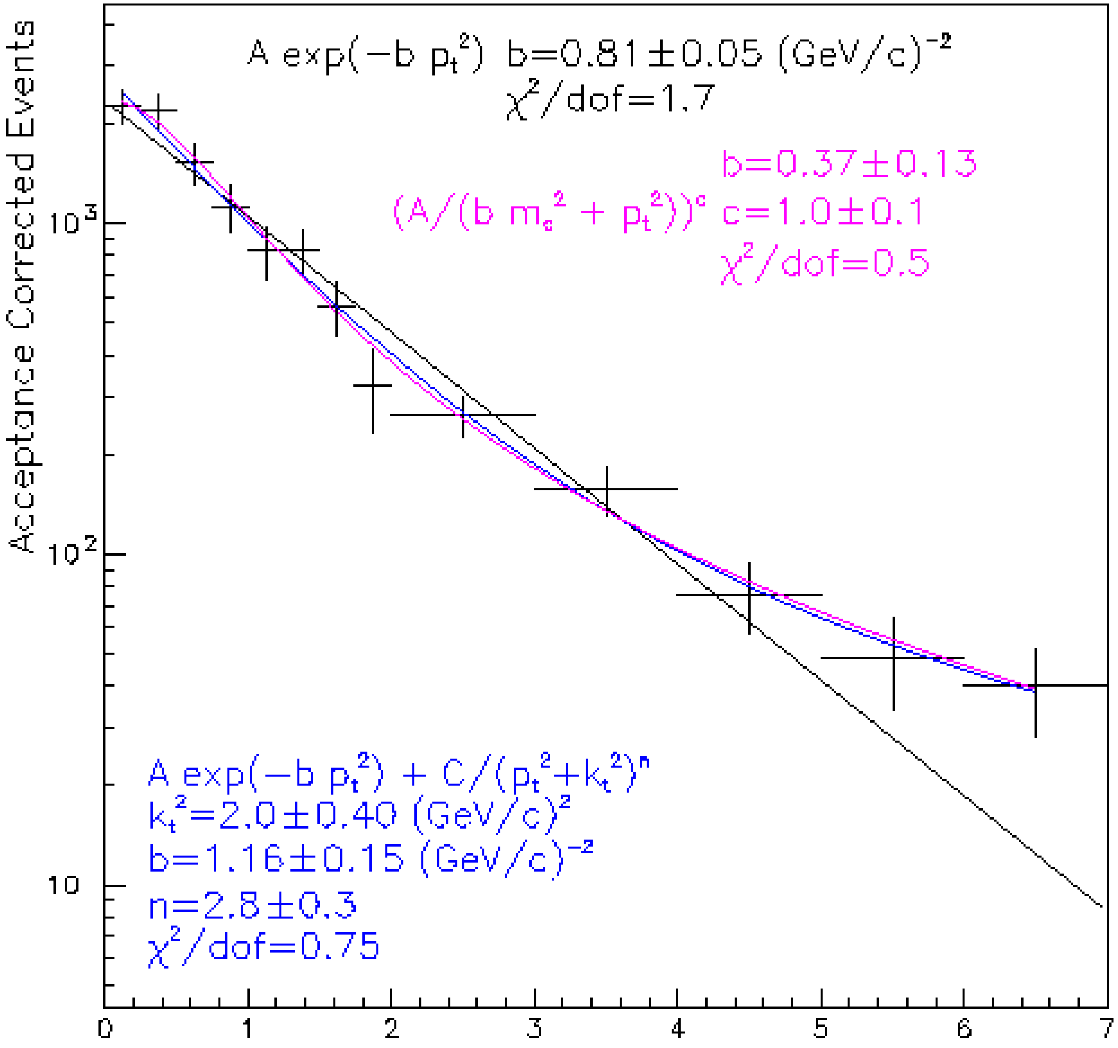
$\Lambda_c^{\pm}$ Asymmetry (Σ^- beam)



SELEX asymmetry for Λ_c agrees with WA89

SELEX Collaboration, Preliminary

p_t^2 distribution for Λ_c^+ (Σ^- beam)



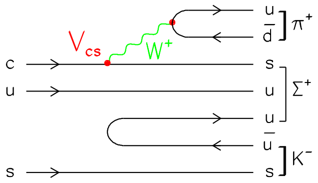
SELEX Collaboration, Preliminary

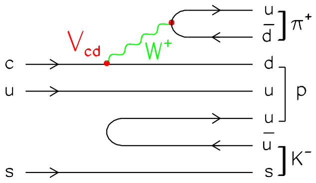
Cabibbo Suppressed Charm Decay

Introduction

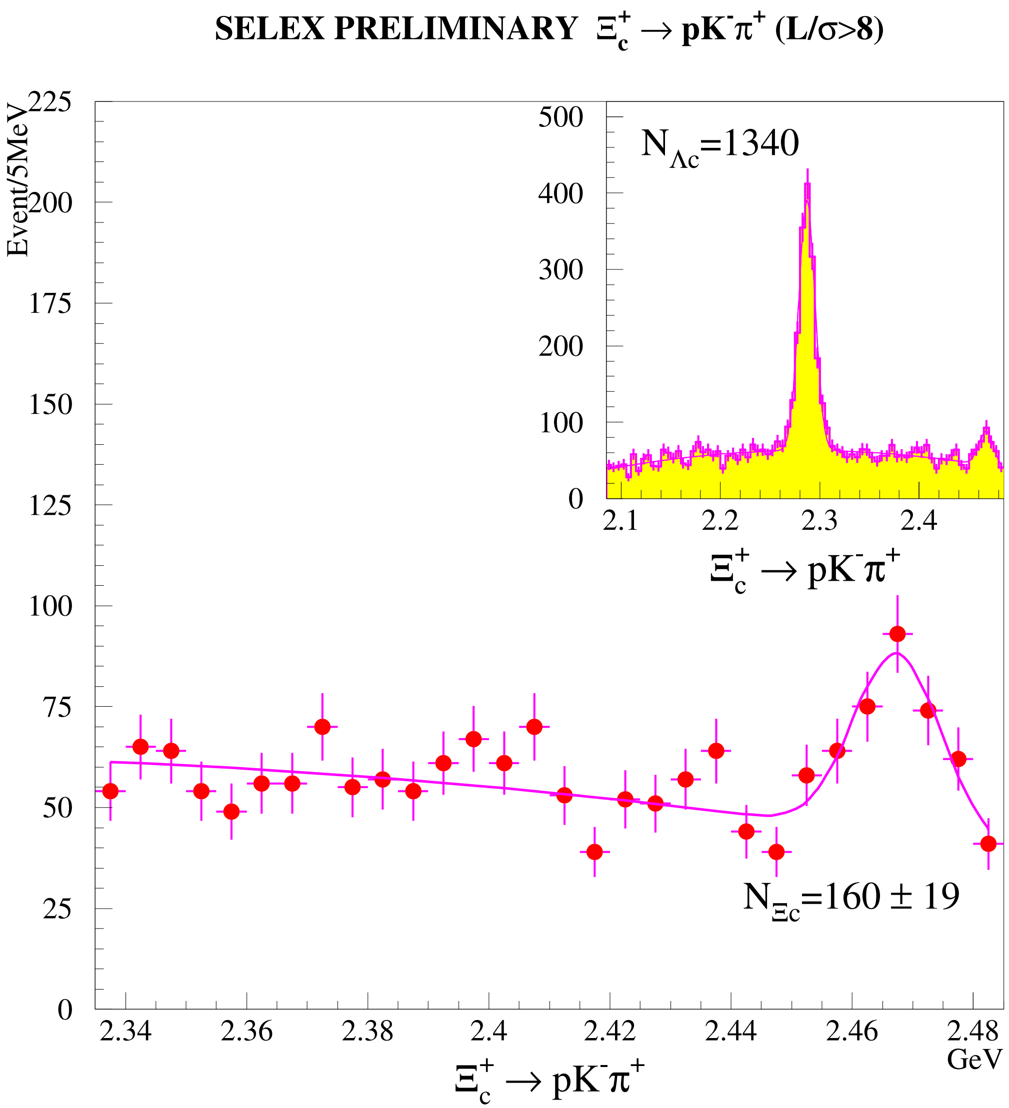
- Charmed Baryon Studies at SELEX(E781)
  - Precision measurement of mass and lifetime
  - Search for new decay modes
  - Study of Cabibbo-suppressed(CS) modes
- Cabibbo-favored vs. Cabibbo-suppressed Mode

$$\Gamma \propto G_F^2 \sum_{q=d,s} |V_{uq}V_{cq}|^2 \mathcal{F}$$



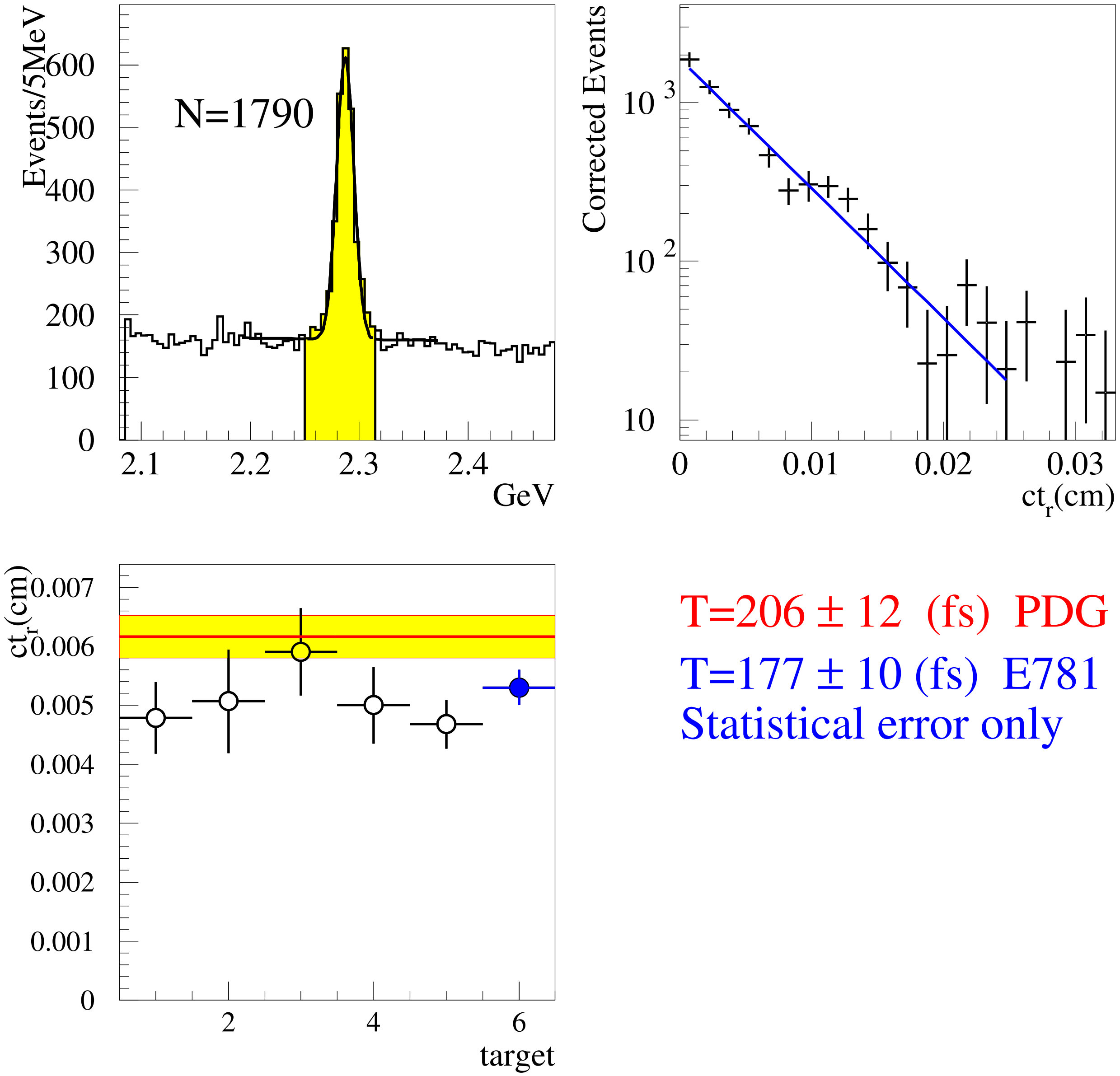


$$\frac{\Gamma_{CS}}{\Gamma_{CF}} \approx \mathcal{O}(\left|\frac{V_{cd}}{V_{cs}}\right|^2 = tan^2\theta_c \approx 0.053)$$



SELEX Collaboration, accepted for publication in *Physical Review Letters* (2000)

Very preliminary Λ_c lifetime using D^0 to measure efficiency



$T=206 \pm 12$ (fs) PDG

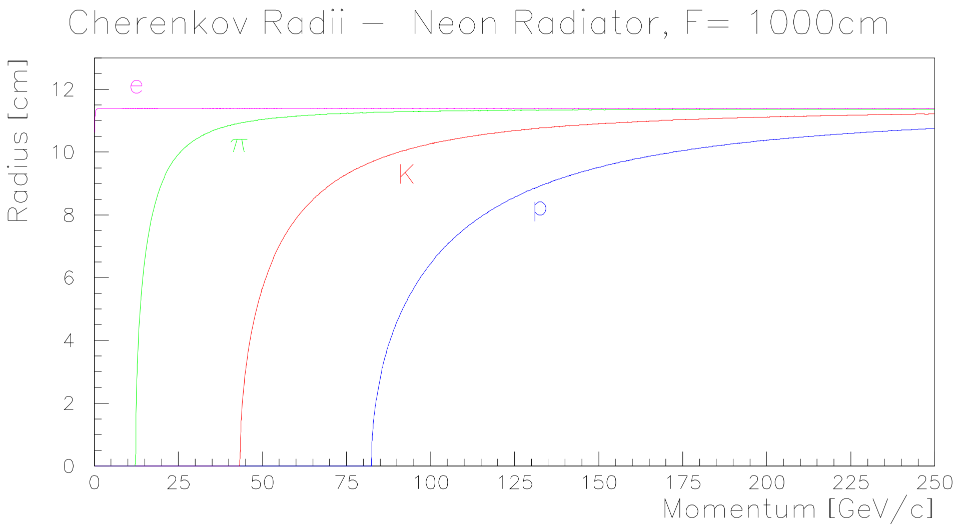
$T=177 \pm 10$ (fs) E781

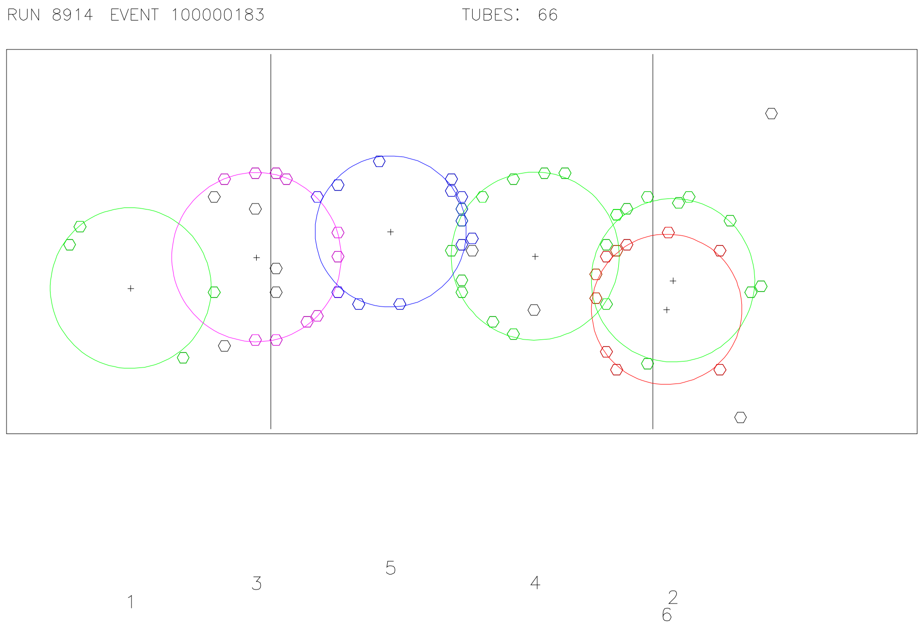
Statistical error only

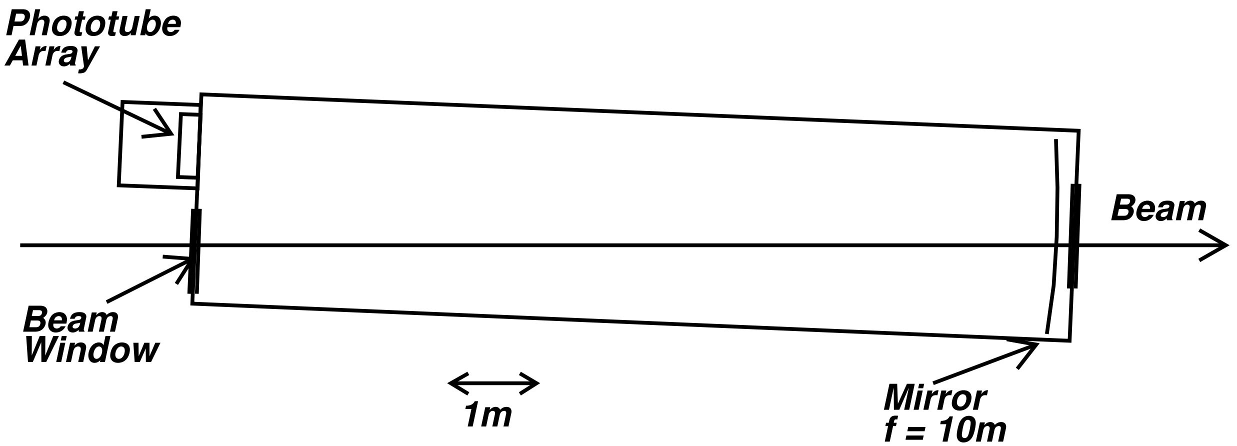
SELEX Collaboration, Preliminary

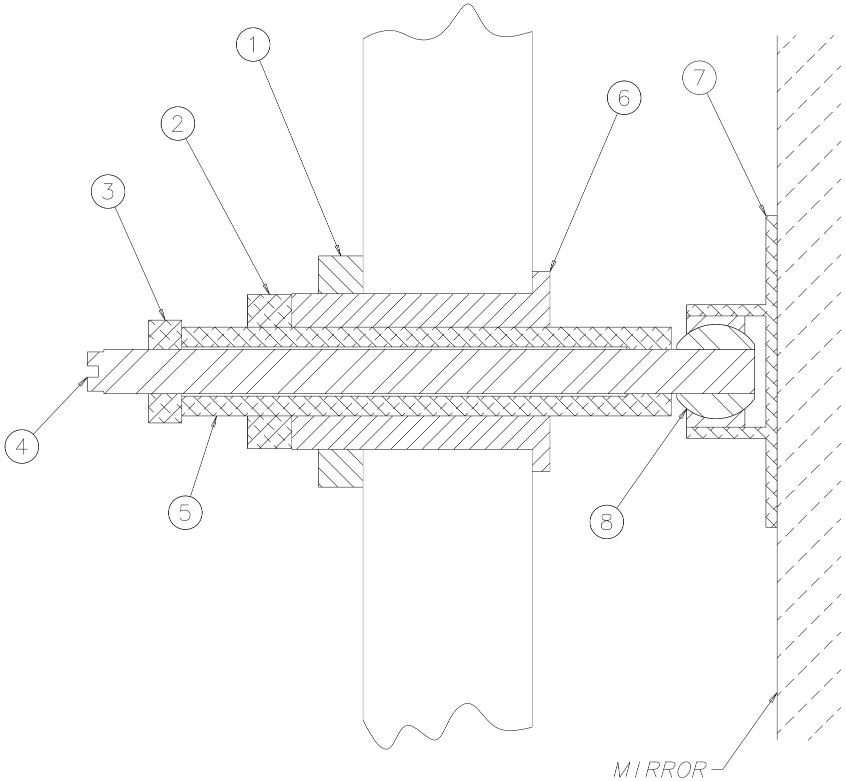
Ring Imaging Cherenkov Counter (RICH)

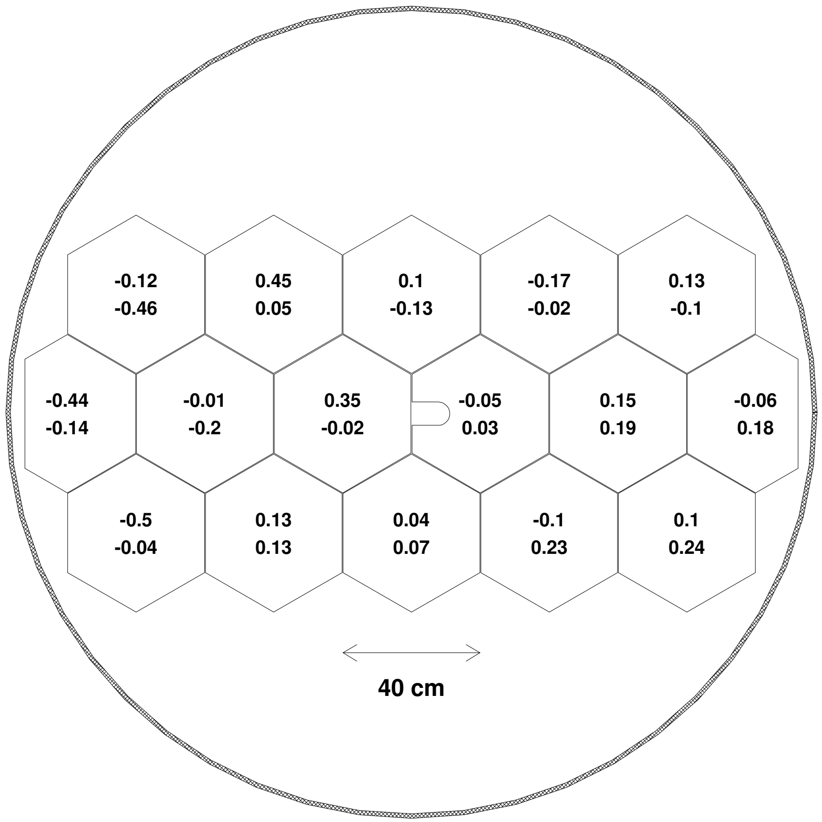
$$\cos\Theta_C = \frac{1}{\frac{v}{c}\cdot n}$$
$$R = L\cdot\tan\Theta_C$$

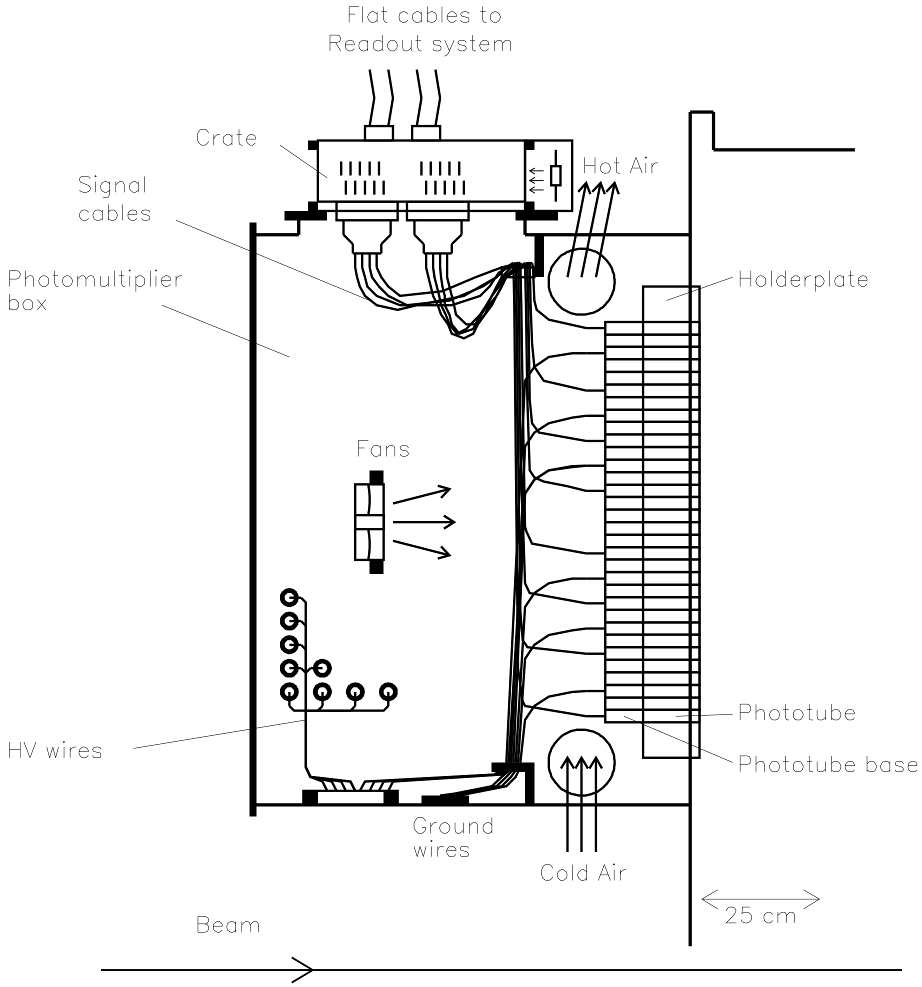


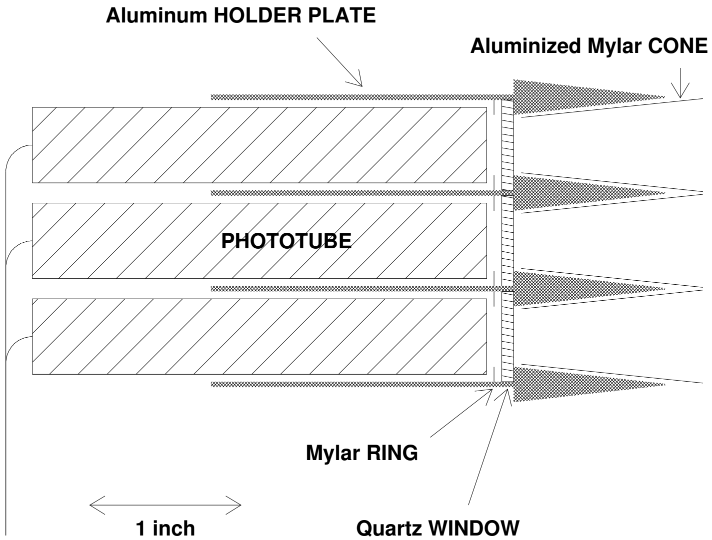


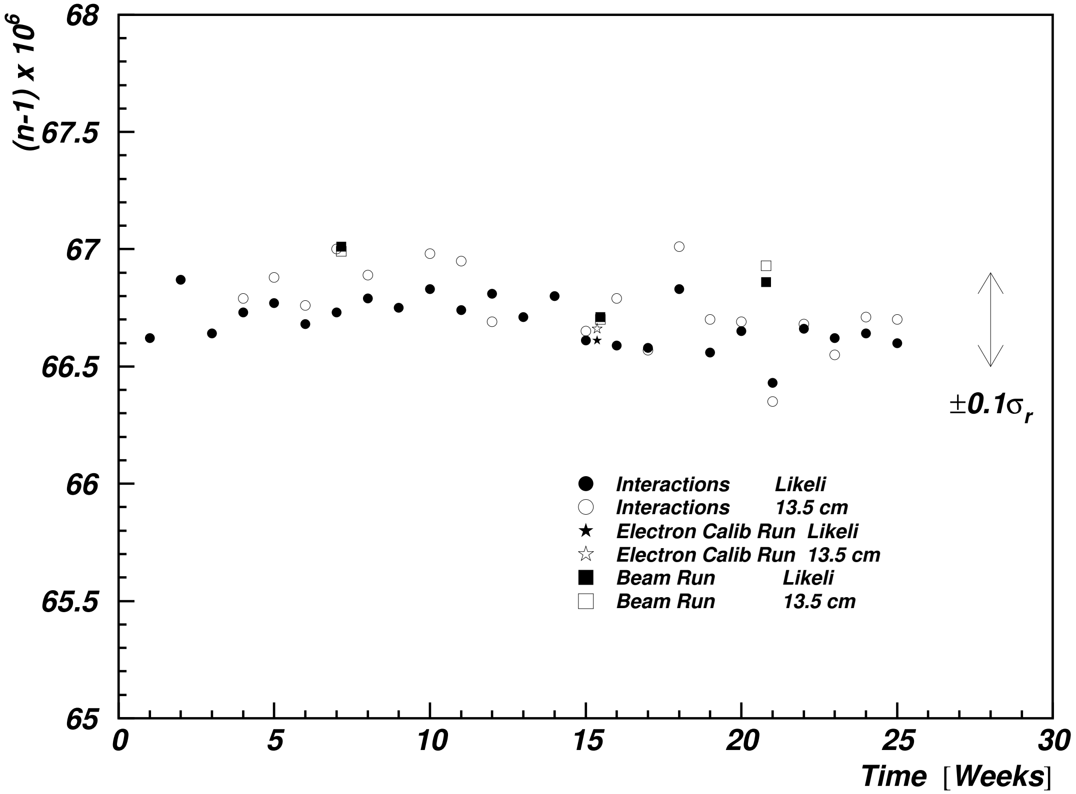

Phototube Array
Beam
Beam Window
1m
Mirror f = 10m

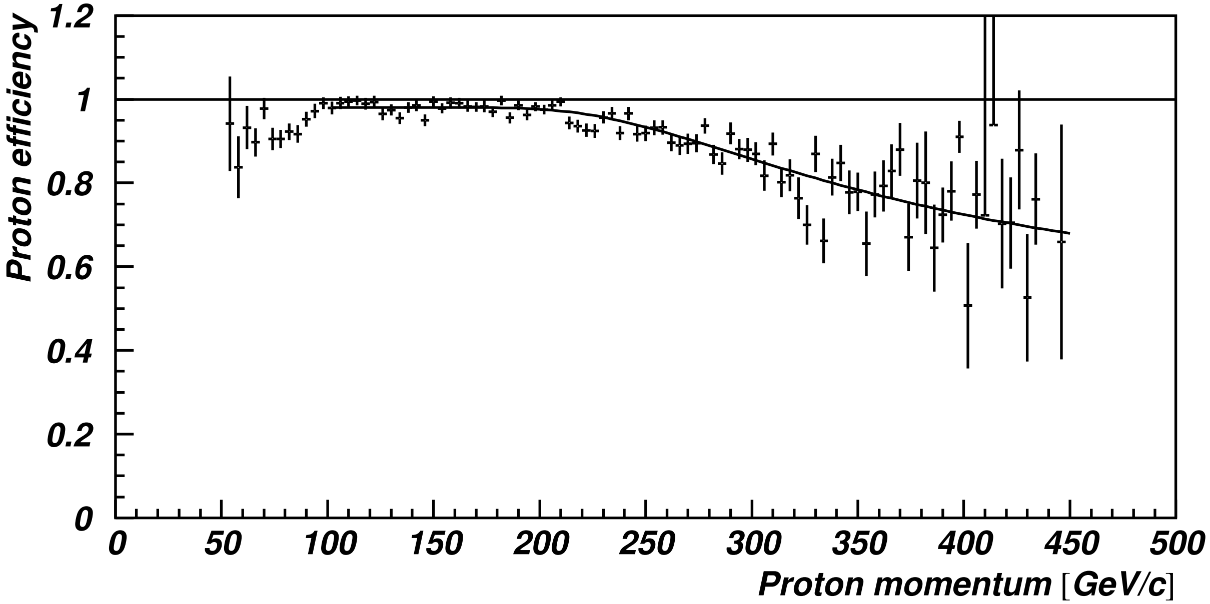

1
2
3
4
5
6
7
8
MIRROR


-0.12 -0.46
0.45 0.05
0.1 -0.13
-0.17 -0.02
0.13 -0.1
-0.44 -0.14
-0.01 -0.2
0.35 -0.02
-0.05 0.03
0.15 0.19
-0.06 0.18
-0.5 -0.04
0.13 0.13
0.04 0.07
-0.1 0.23
0.1 0.24
40 cm


Flat cables to
Readout system
Crate
Signal
cables
Photomultiplier
box
Hot Air
Holderplate
Fans
Phototube
HV wires
Phototube base
Ground
wires
Cold Air
25 cm
Beam


Aluminum HOLDER PLATE
Aluminized Mylar CONE
PHOTOTUBE
Mylar RING
1 inch
Quartz WINDOW


(n-1) x 10^6
68
67.5
67
66.5
66
65.5
65
0
5
10
15
20
25
30
Time [Weeks]
±0.1σr
Interactions Likeli
Interactions 13.5 cm
Electron Calib Run Likeli
Electron Calib Run 13.5 cm
Beam Run Likeli
Beam Run 13.5 cm


Proton efficiency
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
450
500
Proton momentum [GeV/c]

Charged Kaons at the Main Injector

A Proposal for a Precision Measurement of the Decay $K^+ \to \pi^+ \nu \bar{\nu}$ and Other Rare K^+ Processes at Fermilab Using the Main Injector

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G.V. Britvich, V. Kubarovsky, V. Kurshetsov, L. Landsberg, V. Molchanov, V. Obraztsov, S.V. Petrenko, V. Polyakov, D. Vavilov, O. Yushchenko
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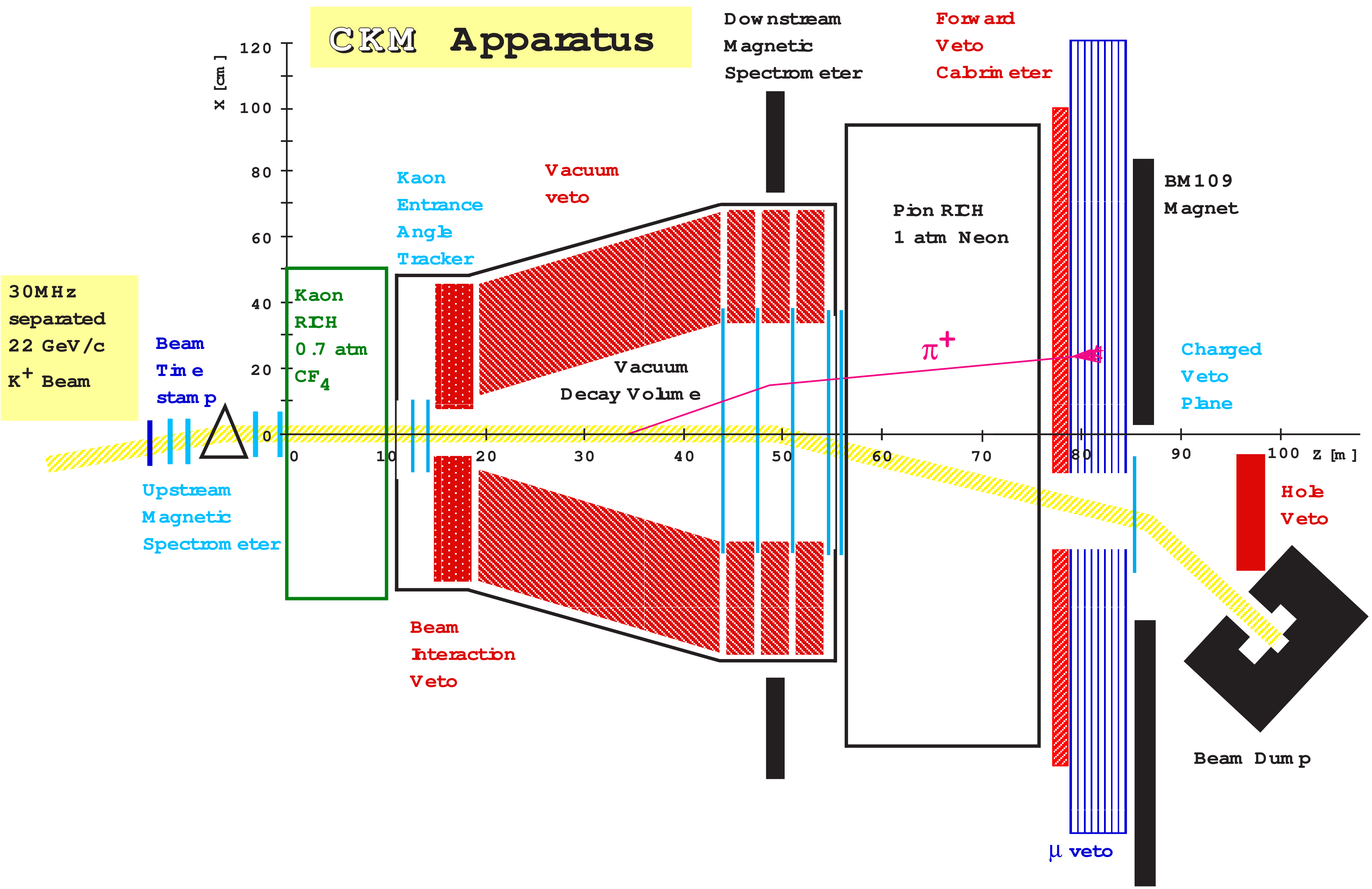
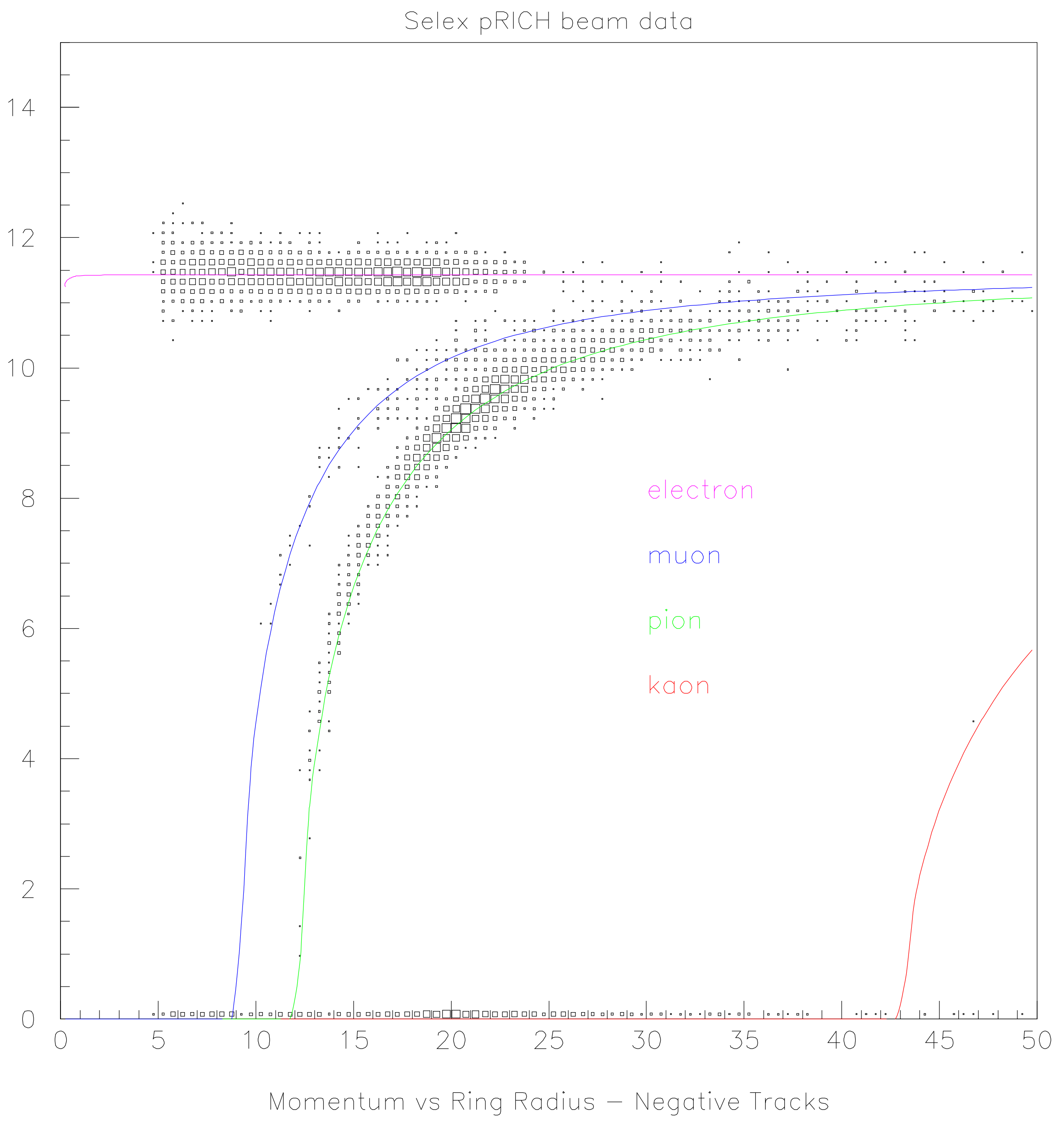
University of Virginia

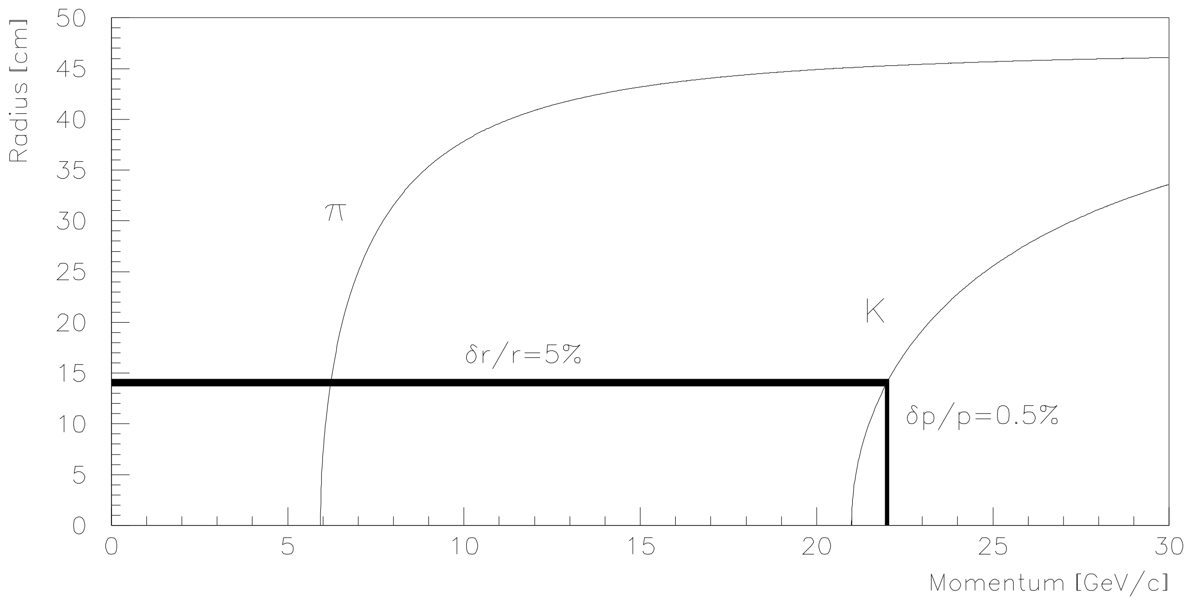
[1]Cospokesmen
[2]Resident at Fermilab, on leave from Tel Aviv University.



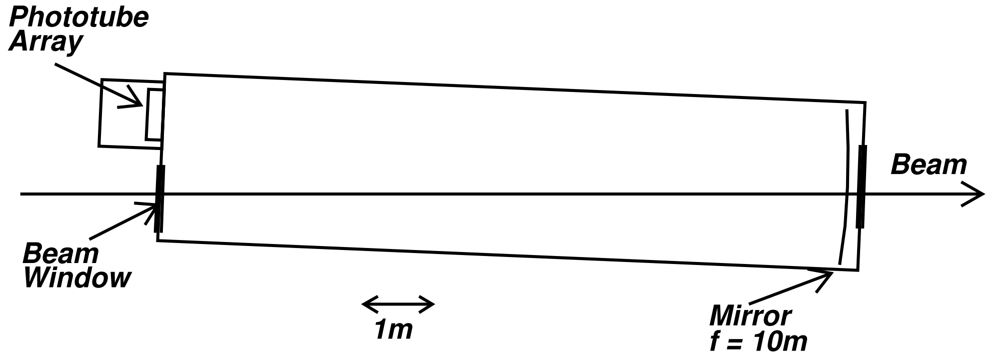
CKM Apparatus
x [cm]
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
z [m]
30MHz
separated
22 GeV/c
K^+ Beam
Beam
Time
stamp
Upstream
Magnetic
Spectrometer
Kaon
RICH
0.7 atm
CF_4
Kaon
Entrance
Angle
Tracker
Vacuum
veto
Beam
Interaction
Veto
Vacuum
Decay Volume
Downstream
Magnetic
Spectrometer
Pion RICH
1 atm Neon
π^+
Forward
Veto
Calorimeter
μ veto
BM109
Magnet
Charged
Veto
Plane
Hole
Veto
Beam Dump



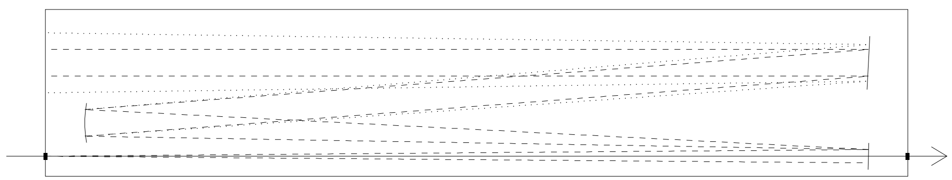
Selex pRICH beam data
14
12
10
8
6
4
2
0
0
5
10
15
20
25
30
35
40
45
50
electron
muon
pion
kaon
Momentum vs Ring Radius — Negative Tracks



Pion RICH: Like SELEX RICH, but with 20 m Vessel



Kaon RICH: 10 m Vessel, folded light path



The Final Signal Plot