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Max-Planck-Institut
für Physik
(Werner-Heisenberg-Institut)

Inclusive V^0 Hadroproduction with the SELEX Experiment at FERMILAB

Miguel Angel Olivo Gómez, MPI für Physik, München

O U T L I N E

- Introduction
- The SELEX (E781) Experiment
- The Measurement Technique
- The Preliminary Results
- Summary

INTRODUCTION

WHY DID WE PERFORM OUR MEASUREMENTS ? ? ?

- Basically, No Theory based on first principles for hadroproduction.
- No high statistics hadroproduction measurements for strange particles.
- These measurements had never been done in a single experiment.
- These measurements could either support or not the current models.

- The particle production is classified by:
  - ⋆ Inclusive Production: Only one of the produced particles is identified in each collision. For example, $p\,p \longrightarrow \overline{\Lambda}\,X$.
  - ⋆ Exclusive Production: When all of the produced particles are identified in each collision. For example, $p\,p \longrightarrow p\,\overline{\Lambda}\,\Sigma^{+}\,n$.
- The particle production is characterized by:
  - ⋆ The transverse momentum: p_T
  - ⋆ The longitudinal momentum: p_L
- For the longitudinal momentum we use the Feynman scaling variable:

$$x_F = \frac{p_L^{cm}}{p_{max}^{cm}}$$

INCLUSIVE Λ, $\overline{\Lambda}$ AND K_s PRODUCTION MEASUREMENTS

- HERA-B used a proton beam at 920 GeV/c on C, Al, Ti and W targets and measured: (Eur.Phys.J. C **29** (2003), 181)

  $d\sigma/dx_F$ over $-0.12 \leq x_F \leq 0$.

  $d\sigma/dp_T^2$ over $0 \leq p_T^2 \leq 1.2$ (GeV/c)^2.

- WA89 used Σ^- and π^- beams at 345 GeV/c on Cu and C targets and measured: (Eur.Phys.J. C **26** (2003), 357)

  $d\sigma/dx_F$ over $0 \leq x_F \leq 0.8$ for Λ and $\overline{\Lambda}$.

  $d\sigma/dx_F$ over $0 \leq x_F \leq 0.7$ for K_s.

  $d\sigma/dp_T^2$ over $0 \leq p_T^2 \leq 4$ (GeV/c)^2 with Σ^- beam.

  $d\sigma/dp_T^2$ over $0 \leq p_T^2 \leq 2.2$ (GeV/c)^2 with π^- beam.

INCLUSIVE Λ AND $\overline{\Lambda}$ PRODUCTION MEASUREMENTS

- E769 used $\pi^{\pm}$, $K^{\pm}$ and p beams at 250 GeV/c on Be, Al and W targets and measured Λ-$\overline{\Lambda}$ asymmetry as a function of x_F and p_T^2 over: (Phys.Lett. B 559 (2003), 179)

  $-0.12 \leq x_F \leq 0.12$ and $0 \leq p_T^2 \leq 3$ (GeV/c)^2 for $+$ beams.
  $-0.16 \leq x_F \leq 0.4$ and $0 \leq p_T^2 \leq 10$ (GeV/c)^2 for $-$ beams.

- E791 used a π^- beam at 500 GeV/c on 4 diamond and 1 platinum targets and measured Λ-$\overline{\Lambda}$ asymmetry as a function of: (Phys.Lett. B 496 (2000), 9)

  x_F over $-0.12 \leq x_F \leq 0.12$.
  p_T^2 over $0 \leq p_T^2 \leq 4$ (GeV/c)^2.

SELEX (E781) MEASUREMENTS

- We used $\mathbf{4}$ beams: $\boldsymbol{\Sigma^-}$ (at $\mathbf{611}$ GeV/c), $\boldsymbol{\pi^-}$ (at $\mathbf{604}$ GeV/c), proton (at $\mathbf{525}$ GeV/c) and $\boldsymbol{\pi^+}$ (at $\mathbf{520}$ GeV/c) on $\mathbf{2}$ Cu and $\mathbf{3}$ diamond targets and measured:

  $\mathbf{d}\boldsymbol{\sigma}/\mathbf{d}\boldsymbol{x_F}$ over $\mathbf{0.1} \leq \boldsymbol{x_F} \leq \mathbf{1}$.

  $\mathbf{d}\boldsymbol{\sigma}/\mathbf{d}\boldsymbol{p_T}$ over $\mathbf{0} \leq \boldsymbol{p_T} \leq \mathbf{3.25}$ (GeV/c).

  $\mathbf{d}\boldsymbol{\sigma}/\mathbf{d}\boldsymbol{p_T^2}$ over $\mathbf{0} \leq \boldsymbol{p_T^2} \leq \mathbf{11}$ (GeV/c)$^{\mathbf{2}}$.

- And we measured $\boldsymbol{\Lambda}$-$\overline{\boldsymbol{\Lambda}}$ asymmetry as a function of $\boldsymbol{x_F}$ and $\boldsymbol{p_T}$ over:

  $\mathbf{0.1} \leq \boldsymbol{x_F} \leq \mathbf{1}$.

  $\mathbf{0} \leq \boldsymbol{p_T} \leq \mathbf{3.25}$ (GeV/c).

- A model based on quark counting rules and phase arguments:

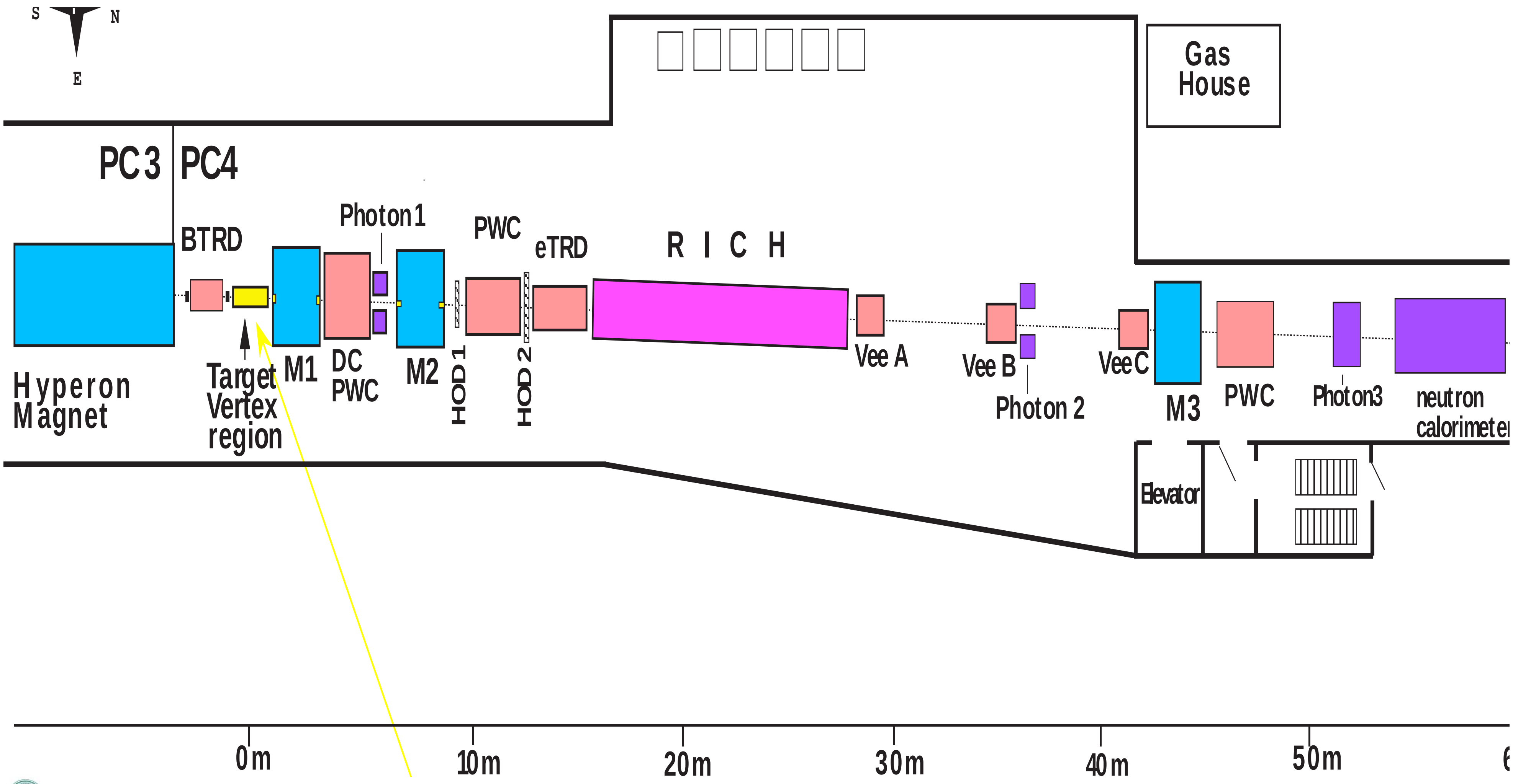
Blankenbecler and Brodsky (Phys.Rev. D **10** (1974), 2973)

$$\frac{\mathrm{d}\sigma}{\mathrm{d}x_F \mathrm{d}p_T^2} \propto (1 - x_F)^n \exp(-bp_T^2)$$

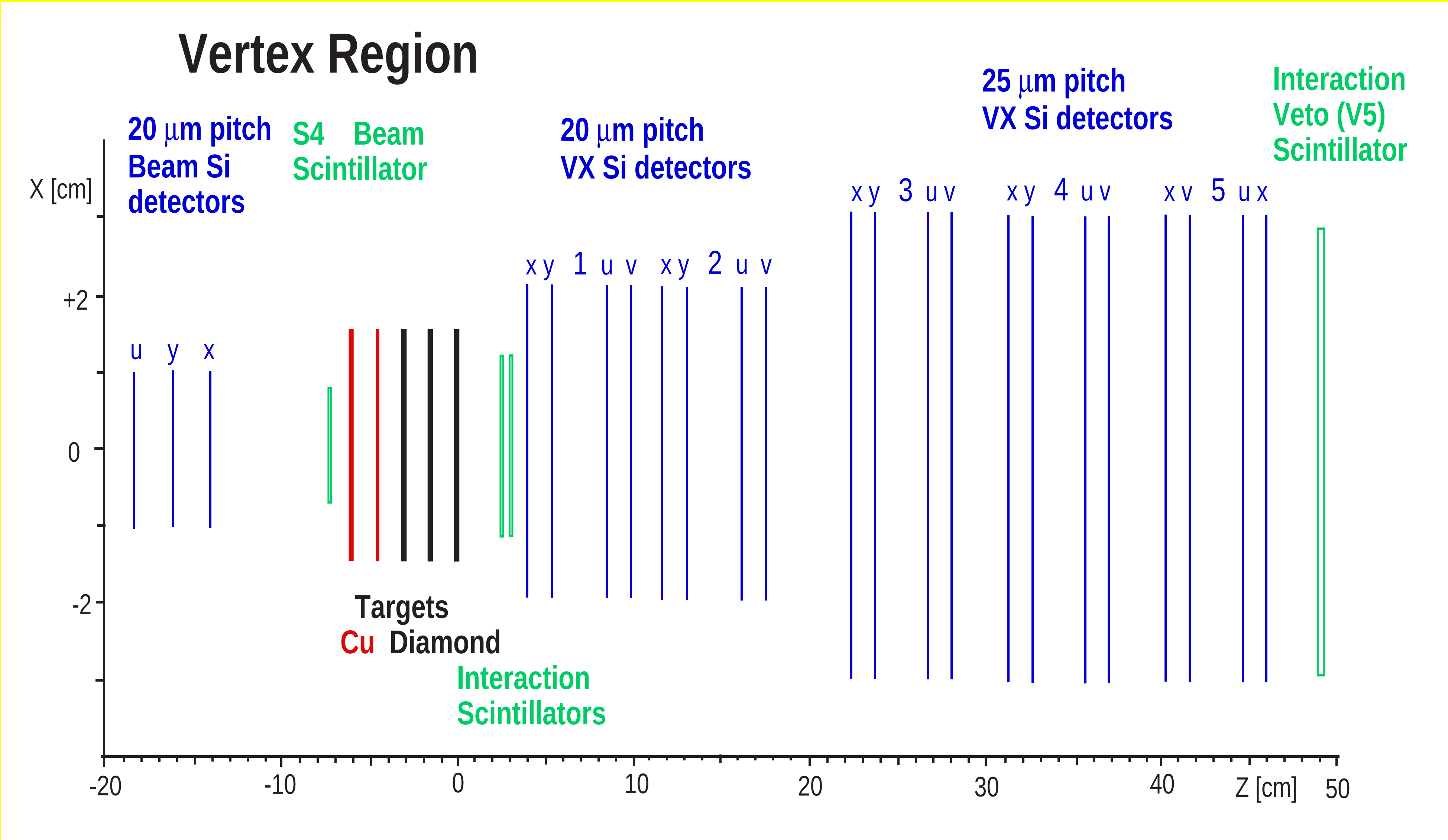
THE SELEX (E781) EXPERIMENT

THE SELEX SPECTROMETER

- A Fixed Target Experiment with forward production ($x_F > 0.1$)
- Data taken 1996/97. RICH PID above ≈ 22 GeV/c
- 20 highly-efficient SSD's with 6.5 μm resolution

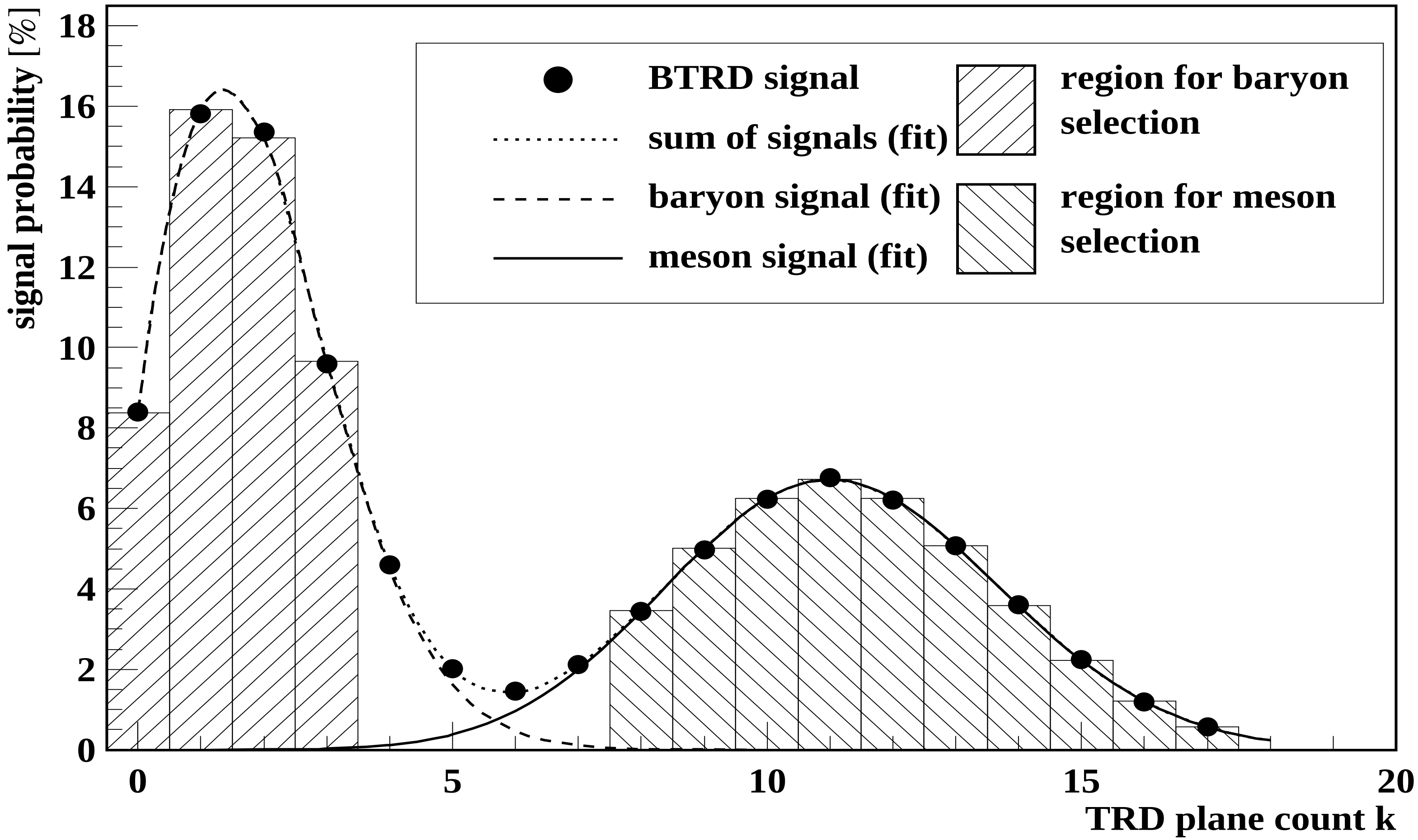


THE SELEX SPECTROMETER



THE BEAM TRANSITION RADIATION DETECTOR (BTRD)

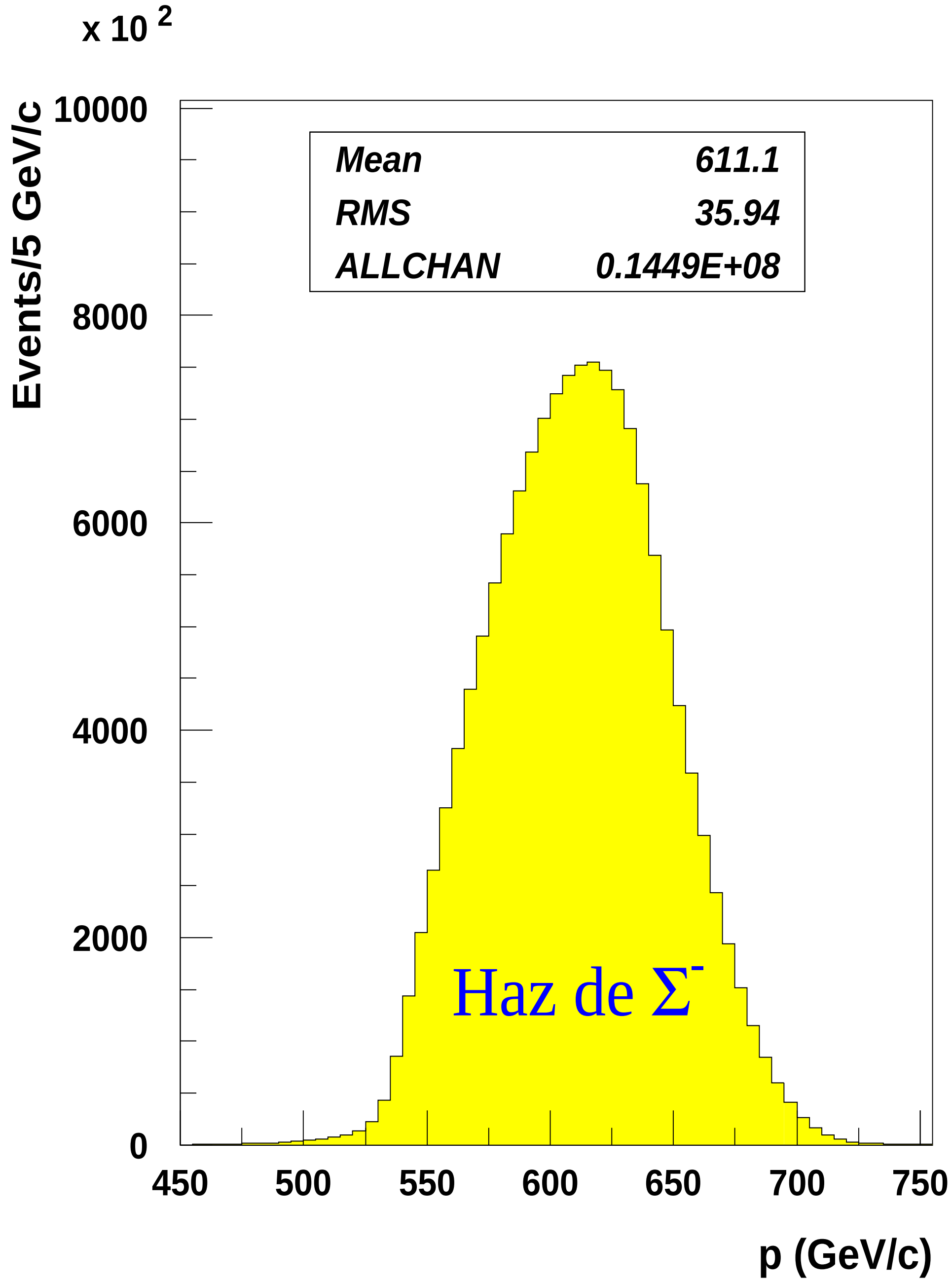
- 10 modules, each of them with a radiator and 3 PWC (Planes).
- The radiation emission probability is proportional to γ
- A π with the same energy than a Σ or proton, activates more planes.
- $k =$ activated planes number.

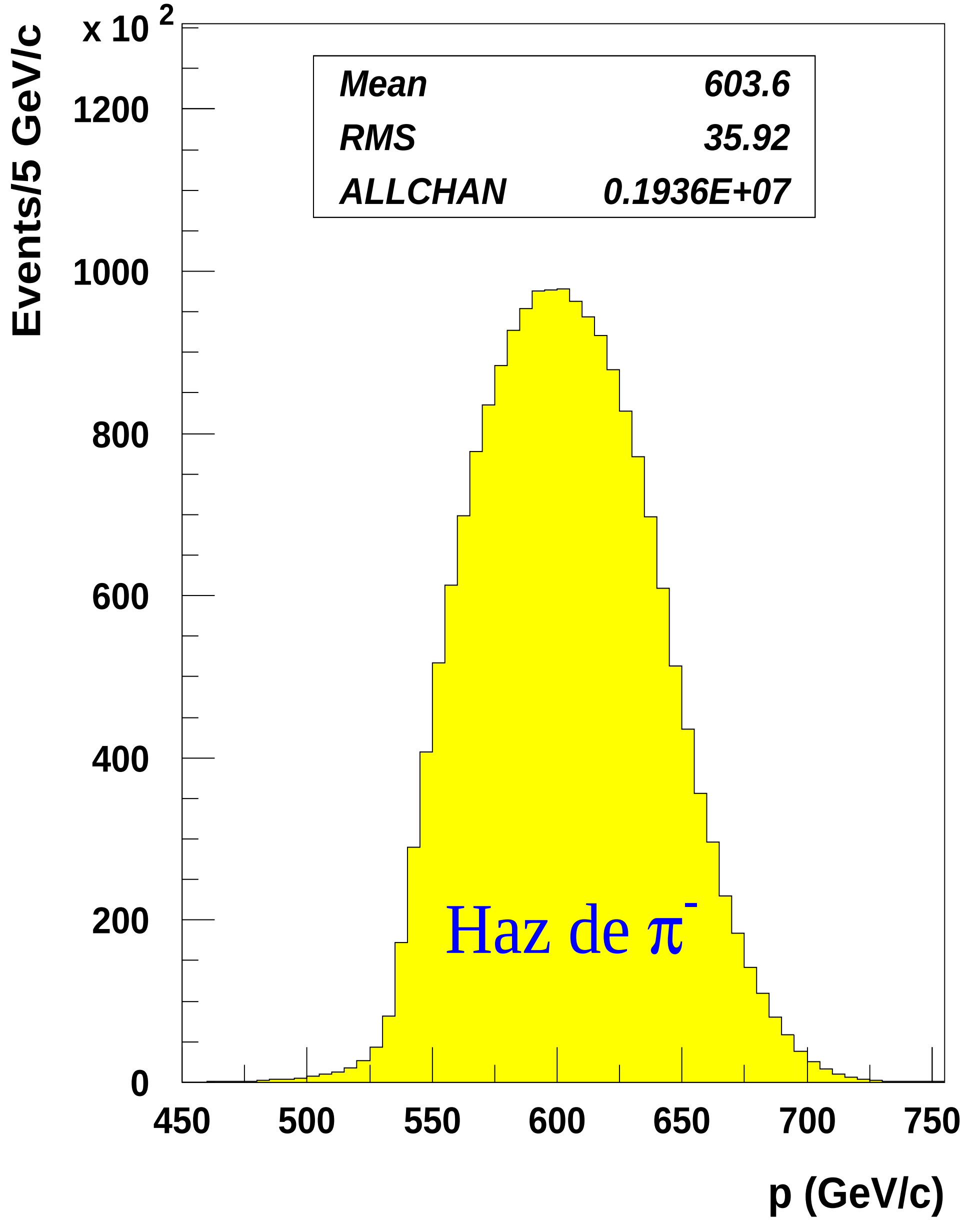


THE BEAM COMPOSITION

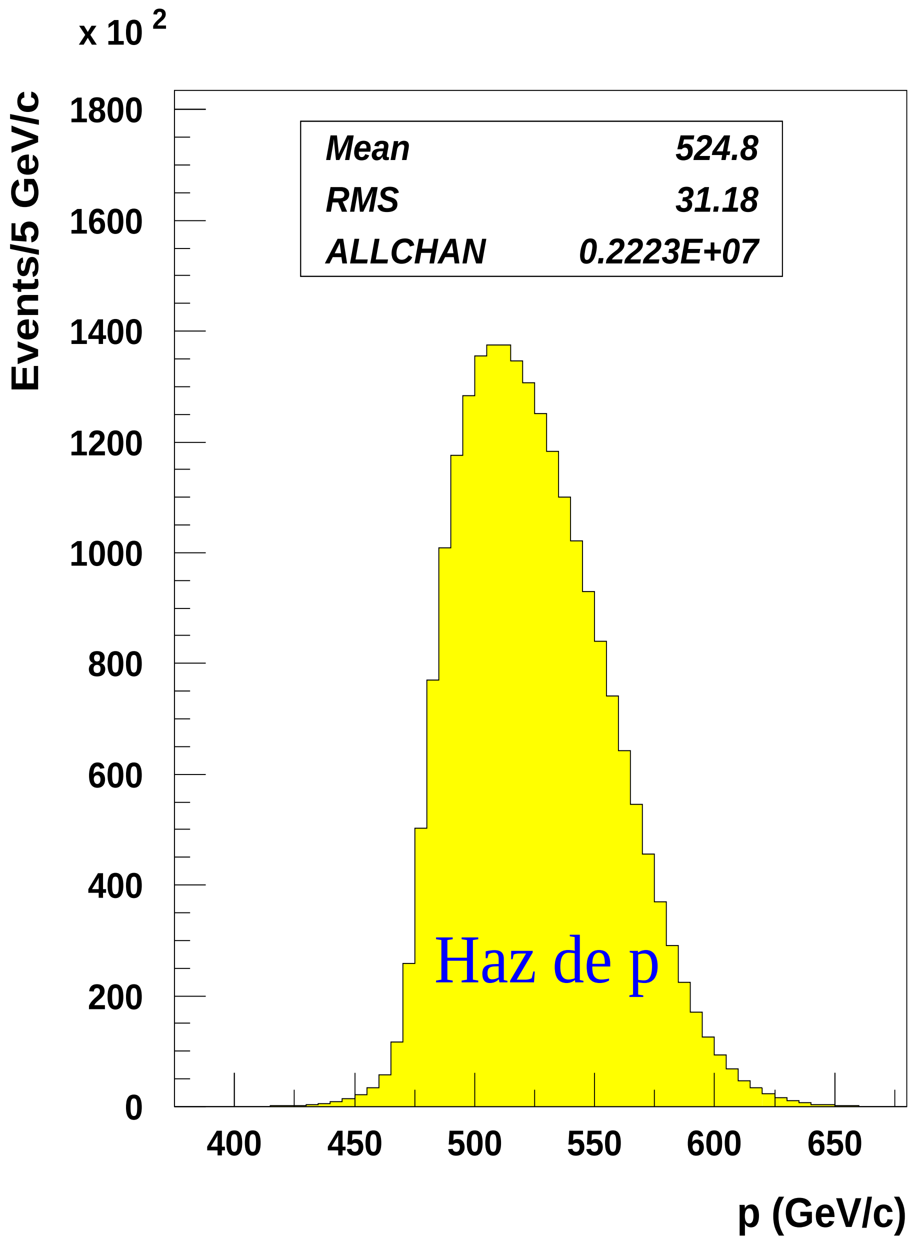
- The negative beam consists of: (Nucl.Phys. B **579** (2000), 277):
  - The baryon fraction $= \mathbf{47.5 \pm 1.6}$ %
    - $\mathbf{97.52 \pm 4.70}$ % of $\mathbf{\Sigma^-}$
    - $\mathbf{2.48 \pm 0.15}$ % of $\mathbf{\Xi^-}$
  - The meson fraction $= \mathbf{52.5 \pm 1.6}$ %
    - $\mathbf{96.95 \pm 4.71}$ % of $\boldsymbol{\pi^-}$
    - $\mathbf{3.05 \pm 1.91}$ % of $\boldsymbol{K^-}$
- The positive beam consists of: (Nucl.Phys. B **579** (2000), 277):
  - The baryon fraction $= \mathbf{91.9 \pm 1.4}$ %
    - $\mathbf{97.06 \pm 2.28}$ % of protons
    - $\mathbf{2.94 \pm 0.76}$ % of $\mathbf{\Sigma^+}$
  - The meson fraction $= \mathbf{8.1 \pm 1.4}$ %
    - **70** % of $\boldsymbol{\pi^+}$
    - **30** % of $\boldsymbol{K^+}$

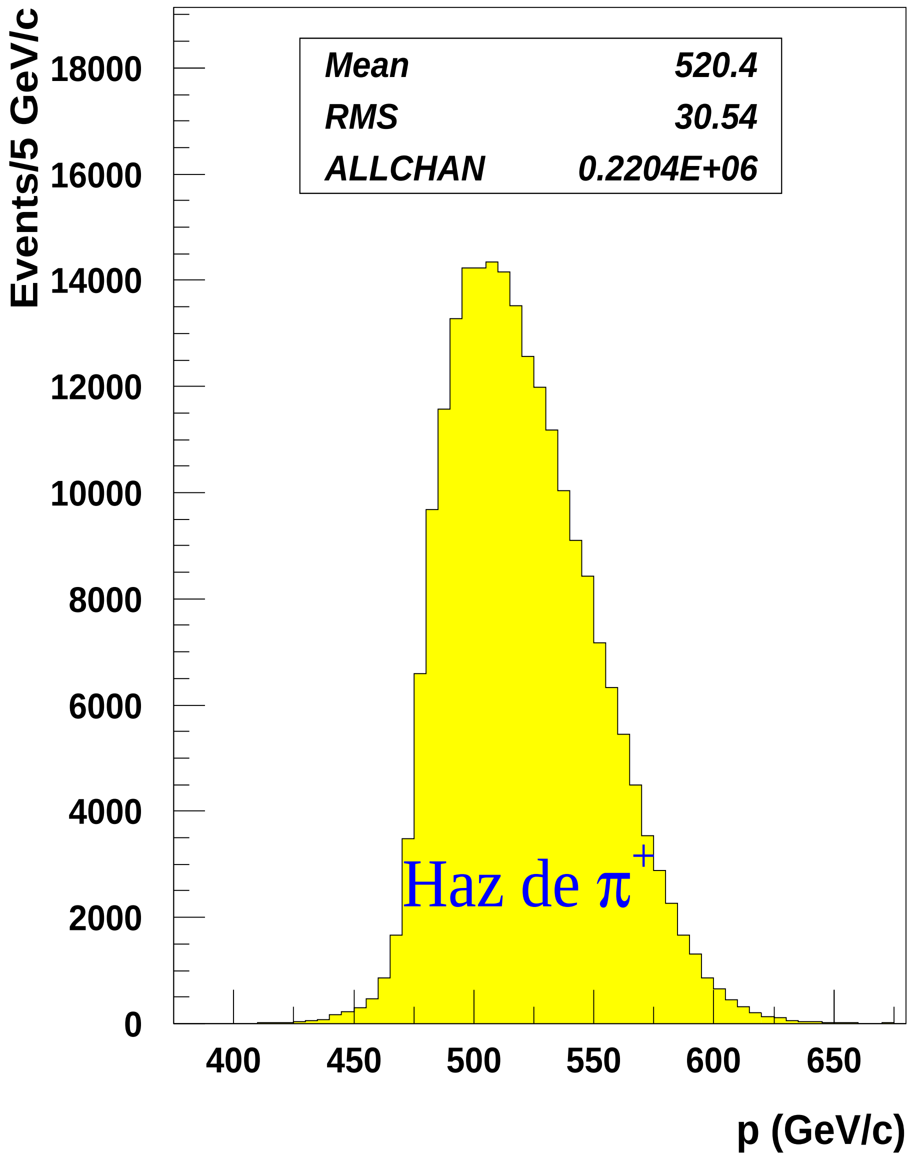
NEGATIVE BEAM MOMENTUM DISTRIBUTIONS





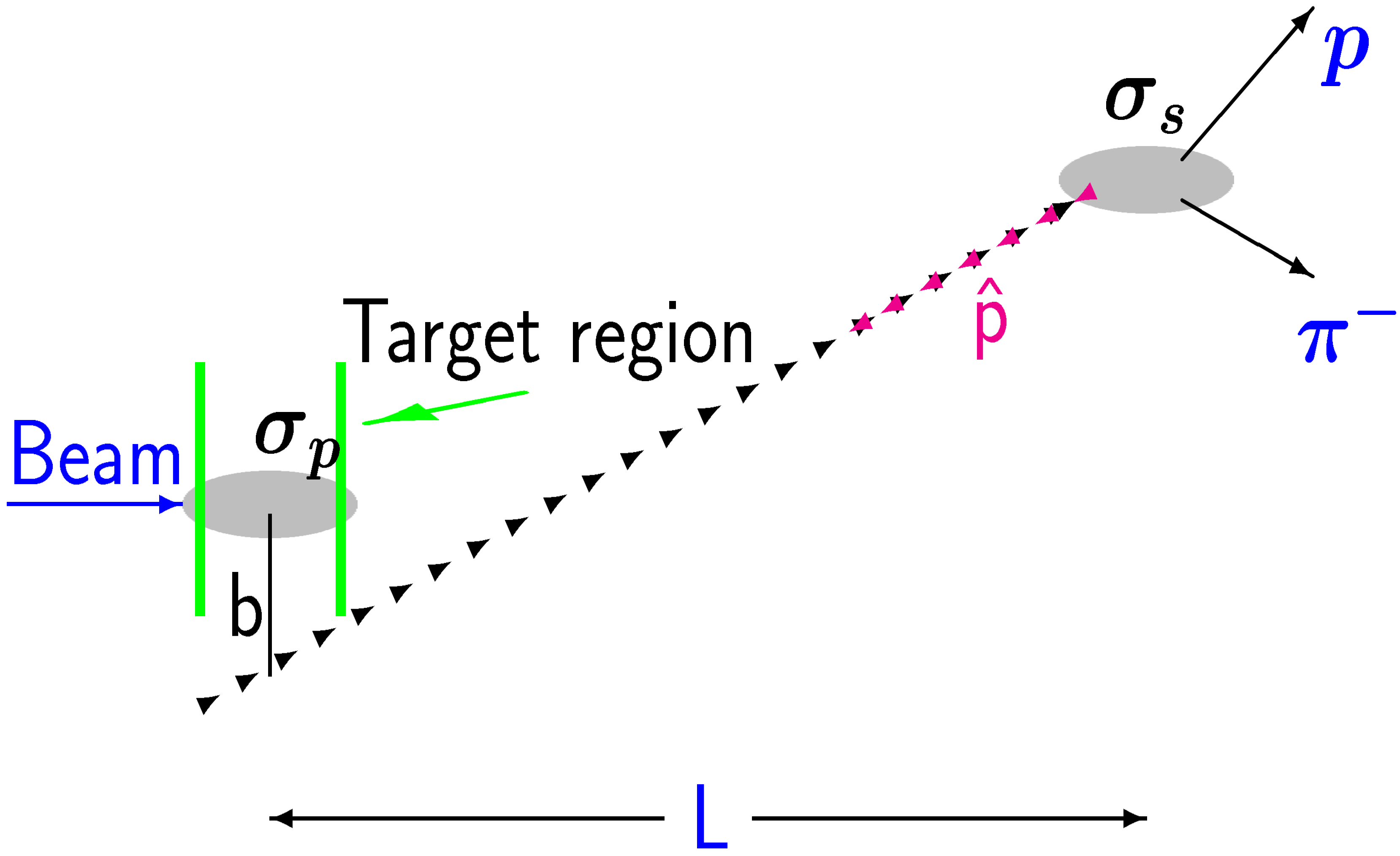
POSITIVE BEAM MOMENTUM DISTRIBUTIONS



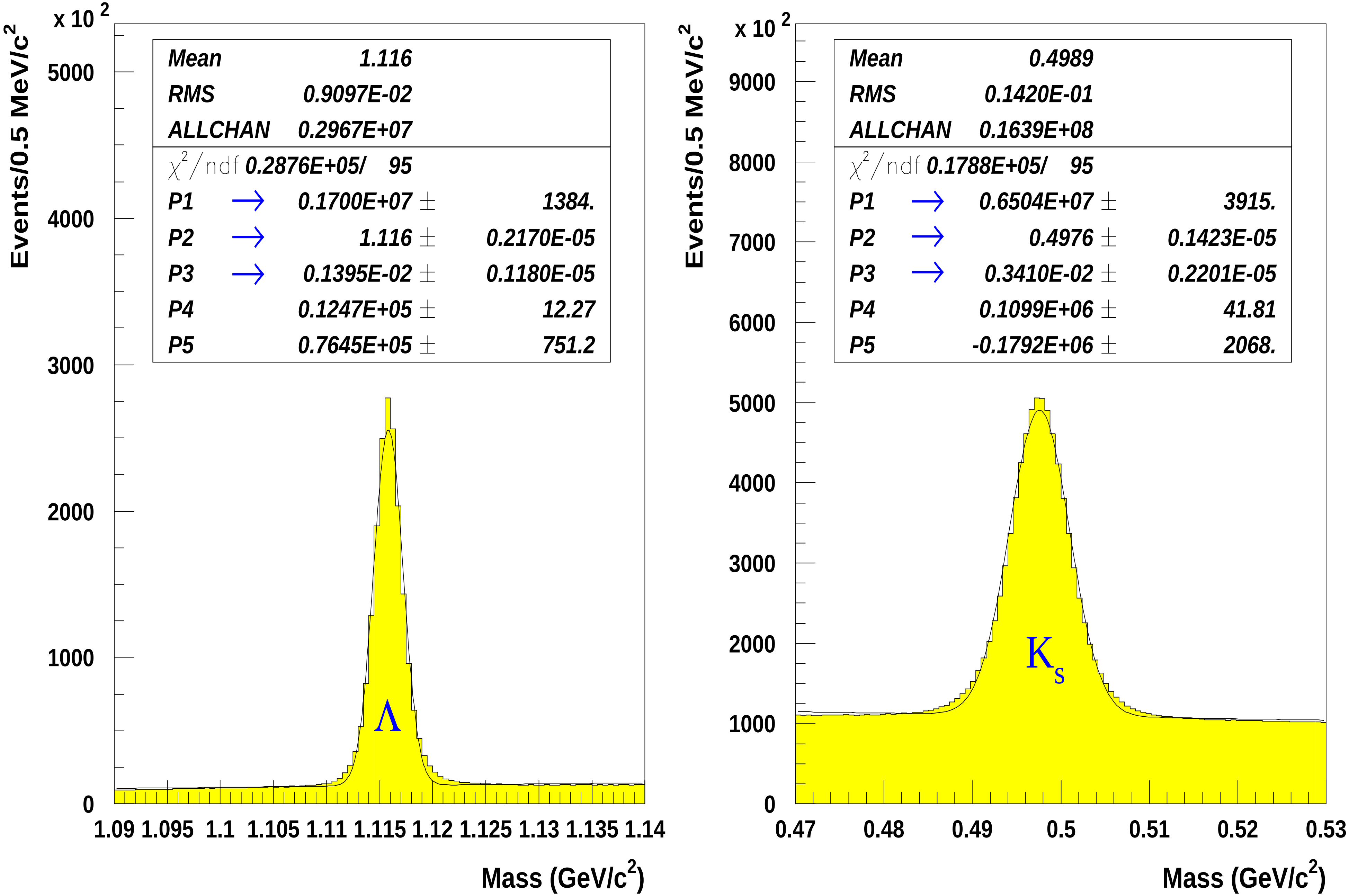


MEASUREMENT TECHNIQUE

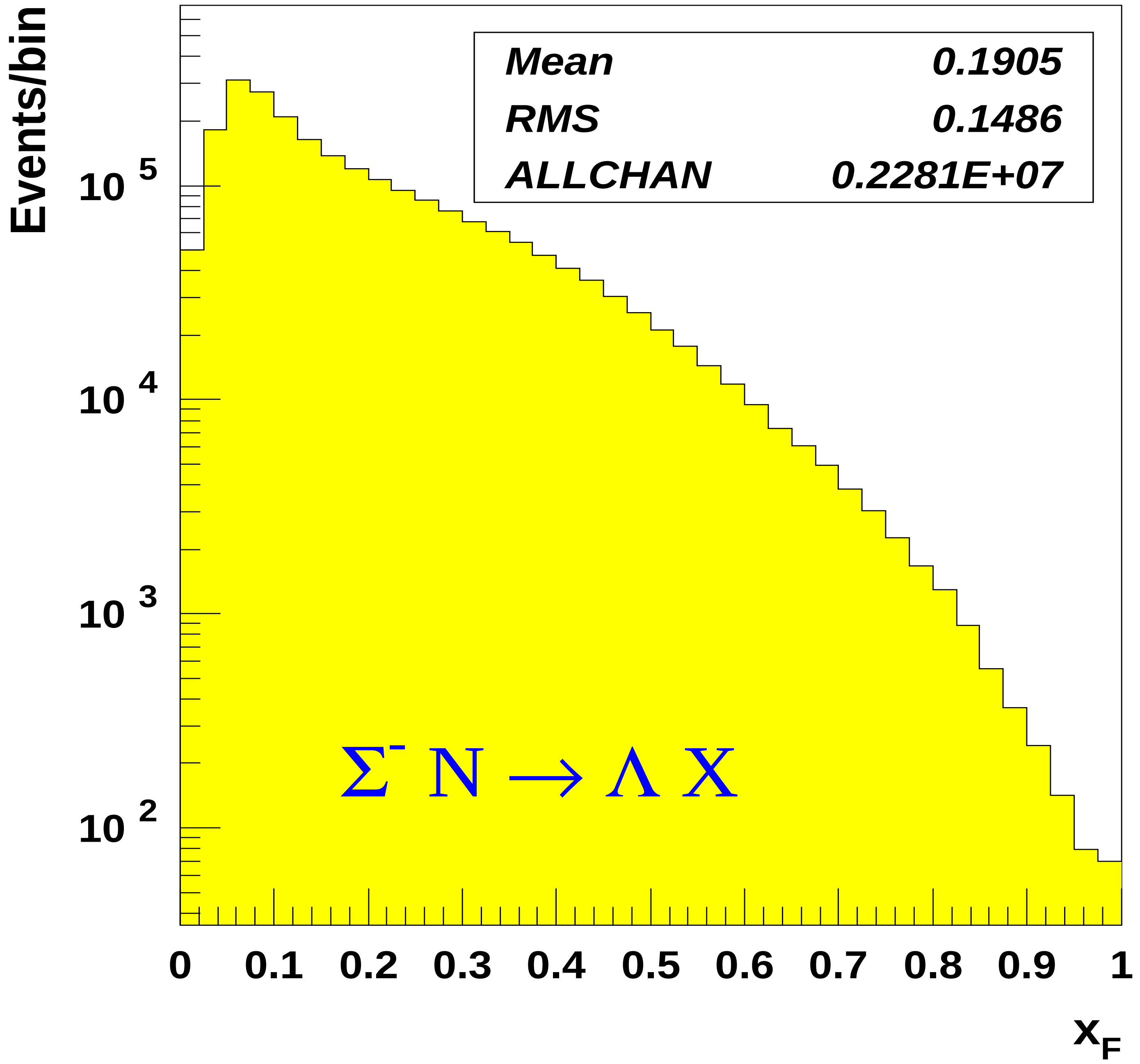
PARTICLE CANDIDATE IDENTIFICATION



CANDIDATE INVARIANT MASS DISTRIBUTION



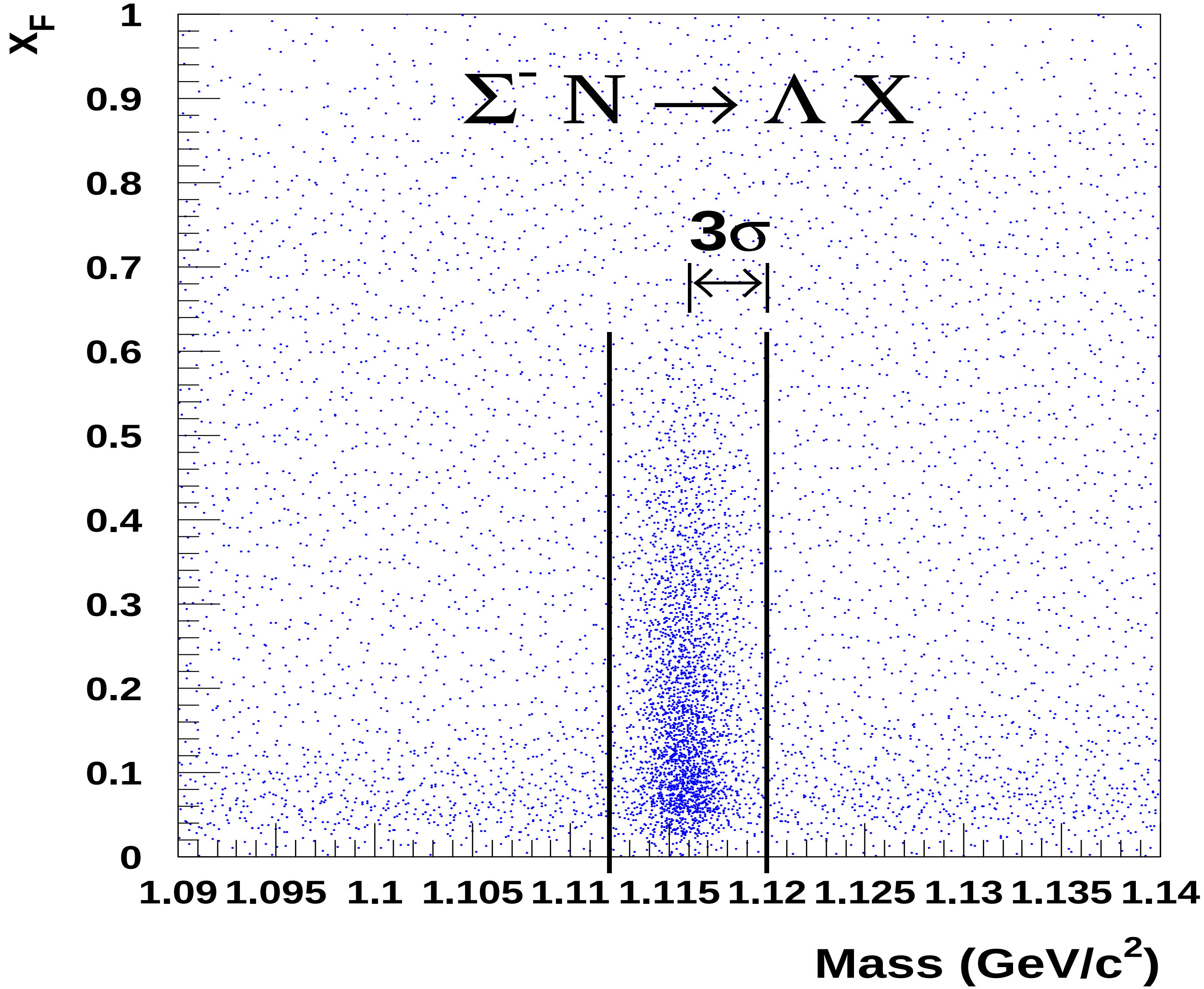
CANDIDATE x_F DISTRIBUTION FOR EACH BEAM



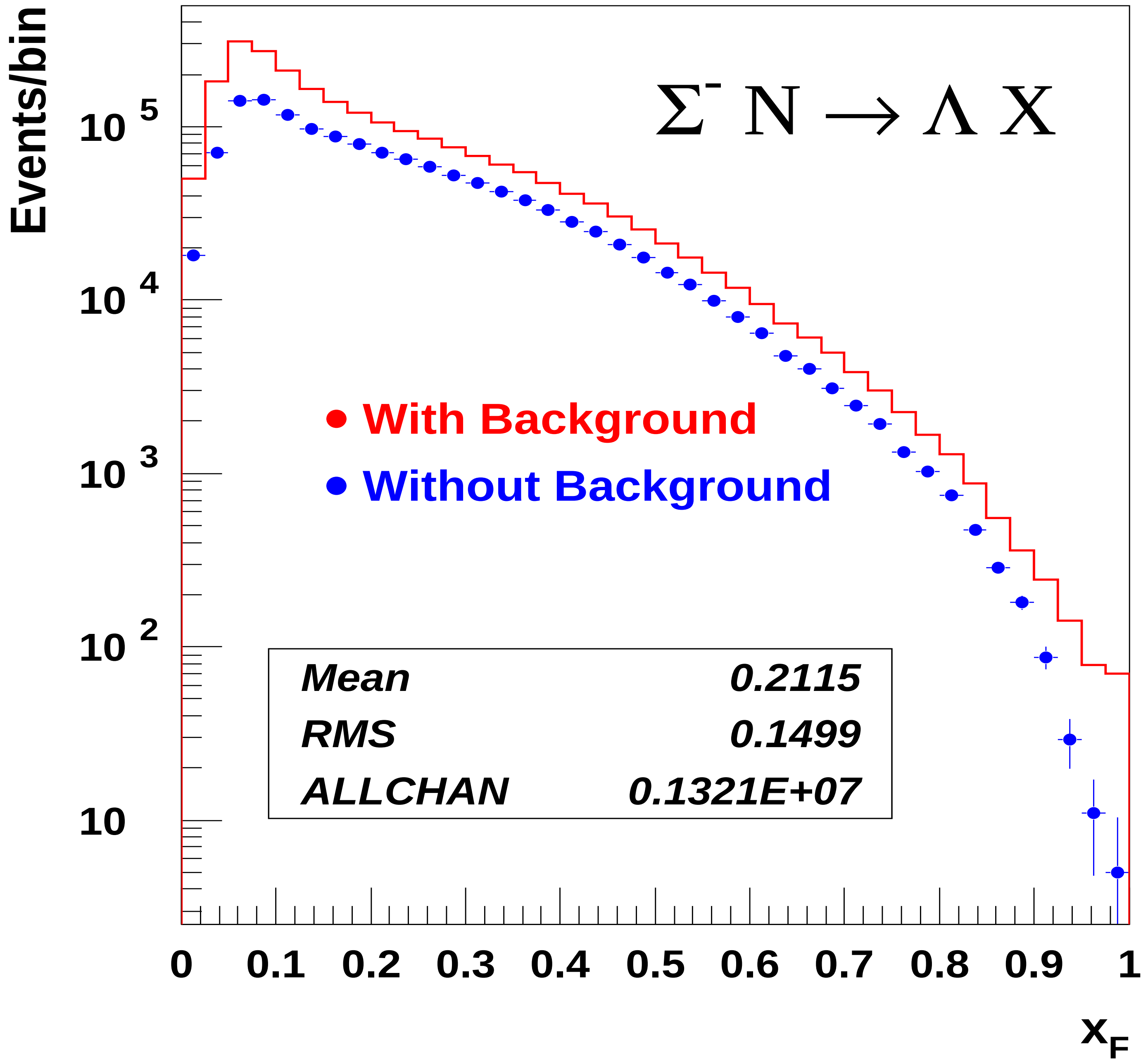
SIDEBAND SUSTRACTION TECHNIQUE

$(\mu - 3\sigma, \mu + 3\sigma) = A =$ Signal + Bckgr $C = B - A =$ Bckgr

$(\mu - 6\sigma, \mu + 6\sigma) = B =$ Signal + 2∗Bakgr Signal $= A - C$



Λ DISTRIBUTION AS A FUNCTION OF X_F



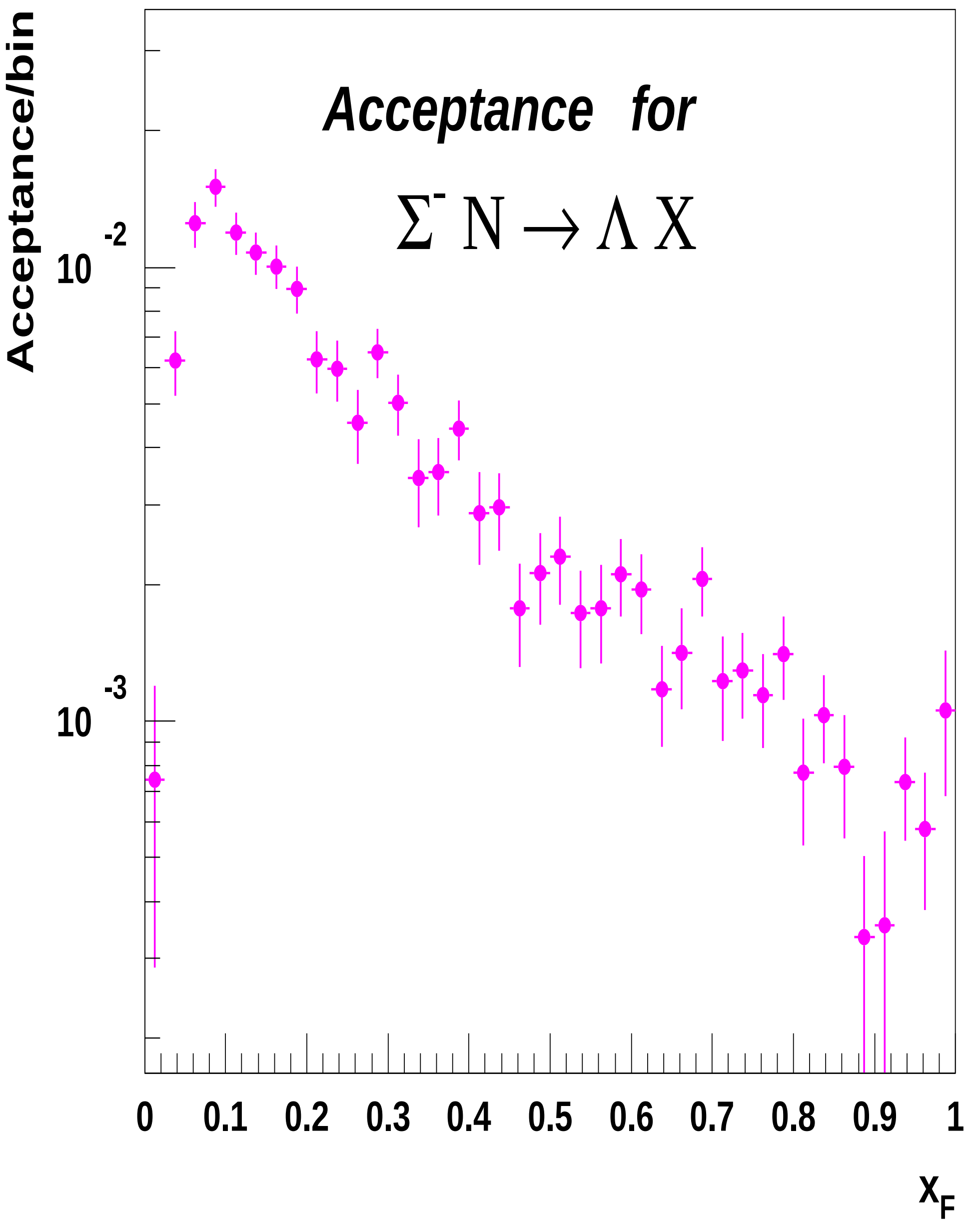
What does it mean?

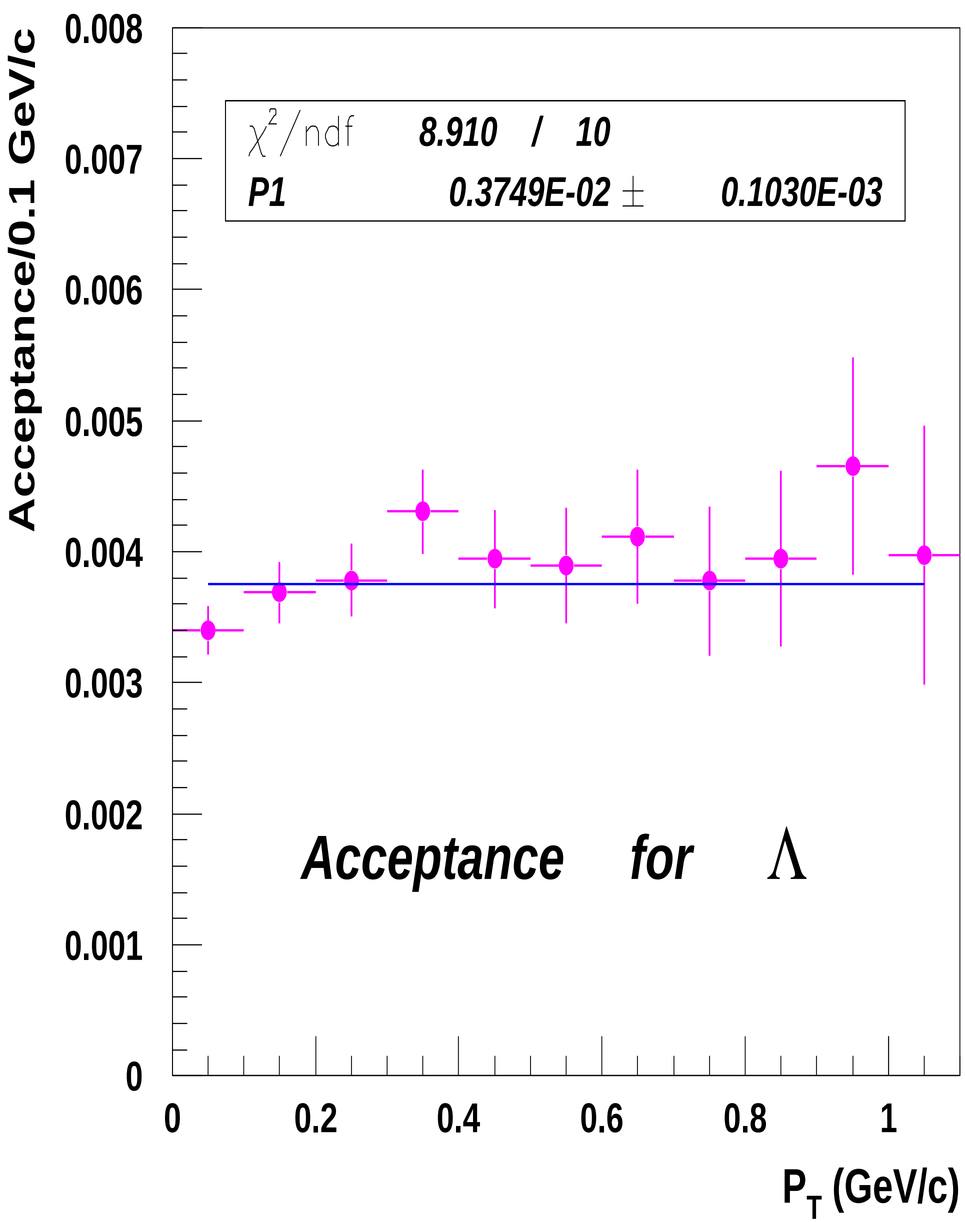
Experiment (hardware and software) efficiency for reconstructing a particle as a function of x_F.

How do we obtain the acceptance?

- 10^6 Λ are generated with EDG based on model A ($n = 0$ and $b = 2$).
- Embedding: These Λ are embedded in a sample of 10^6 real events from SELEX, and only some of them are reconstructed by SOAP. For example, 10^3.
- $Acceptance = 10^3(x_F)/10^6(x_F)$

THE ACCEPTANCE AS A FUNCTION OF x_F AND P_T





THE ACCEPTANCE EVENT CORRECTION

- But a smooth acceptance distribution is needed. This is NOT our case.
- Survival probability: Probability that a particle travels a distance x.

$$P(x) = \exp\left(-\frac{x}{\gamma c \tau}\right)$$

- Acceptance $=$ Prob. that a particle decays where it can be identified. Let d be the distance throughout the length of the detector where it happens, therefore,

$$Acceptance = \frac{\int_0^d P(x)\mathrm{d}x}{\int_0^\infty P(x)\mathrm{d}x}$$

$$Acceptance(x_F) \approx 1 - \exp\left(-\frac{d}{c\tau\sqrt{\left(\frac{p_{beam}c\ x_F}{Mc^2}\right)^2 + 1}}\right)$$

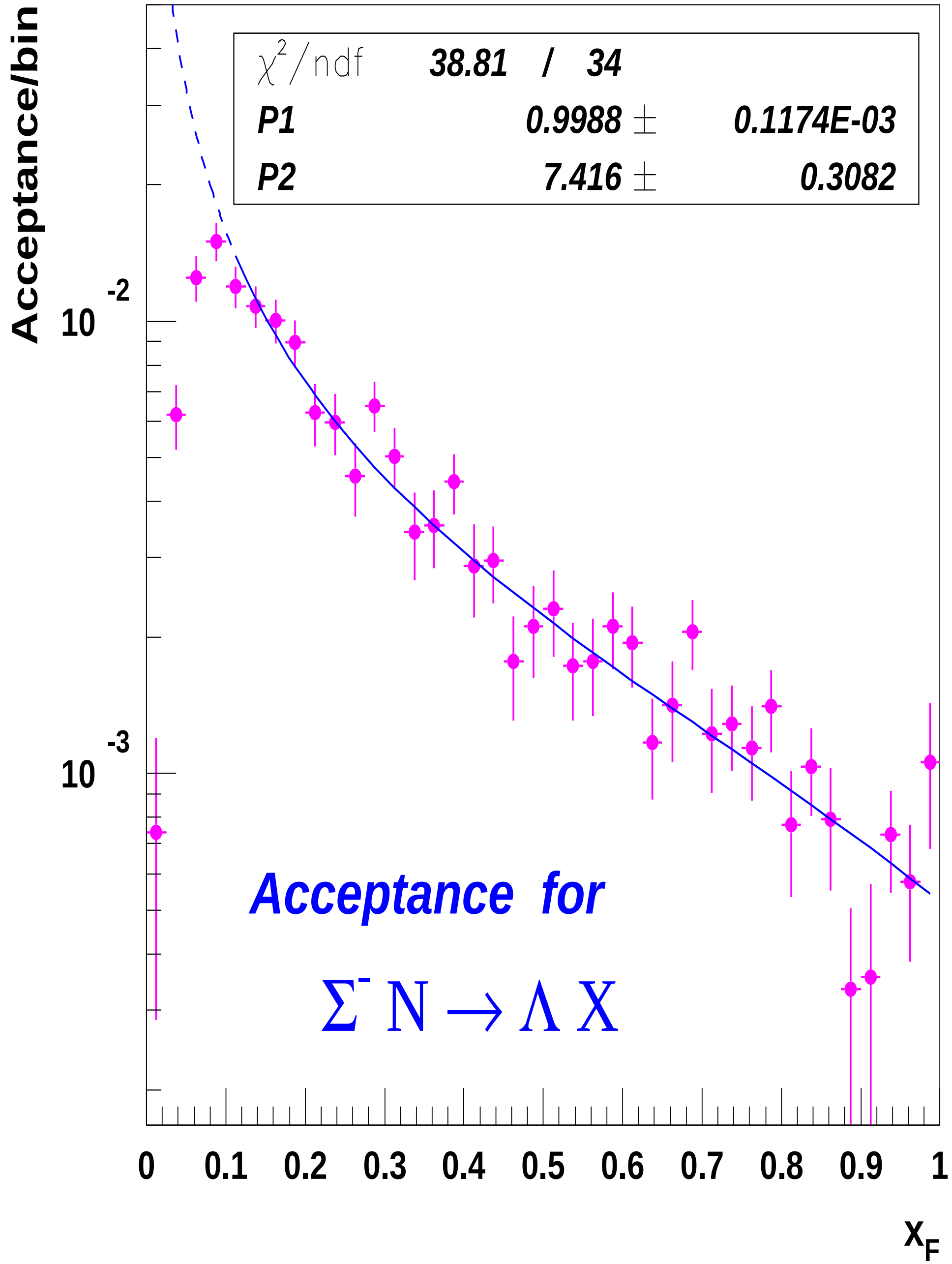
THE ACCEPTANCE EVENT CORRECTION

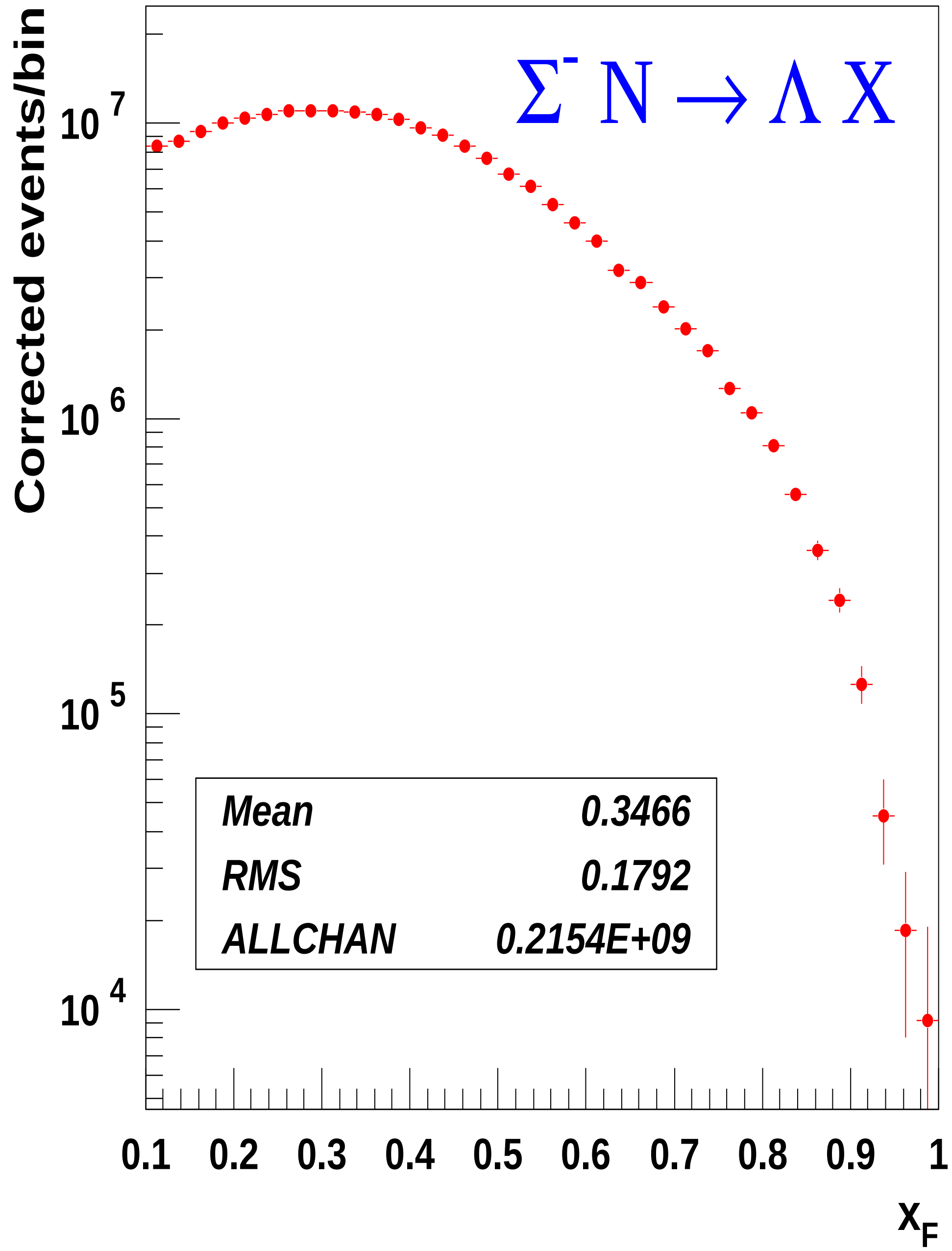
- Then, the following function is fitted to the acceptance (non-smooth) x_F distribution of the produced Λ by the Σ^- beam.

$$Acceptance(x_F) = p_1 - \exp\left(-\frac{p_2}{7.89\sqrt{\left(\frac{611.1\ x_F}{1.115683}\right)^2 + 1}} \right)$$

- We use this function with the fit-parameters to perform the acceptance event correction.

THE ACCEPTANCE EVENT CORRECTION

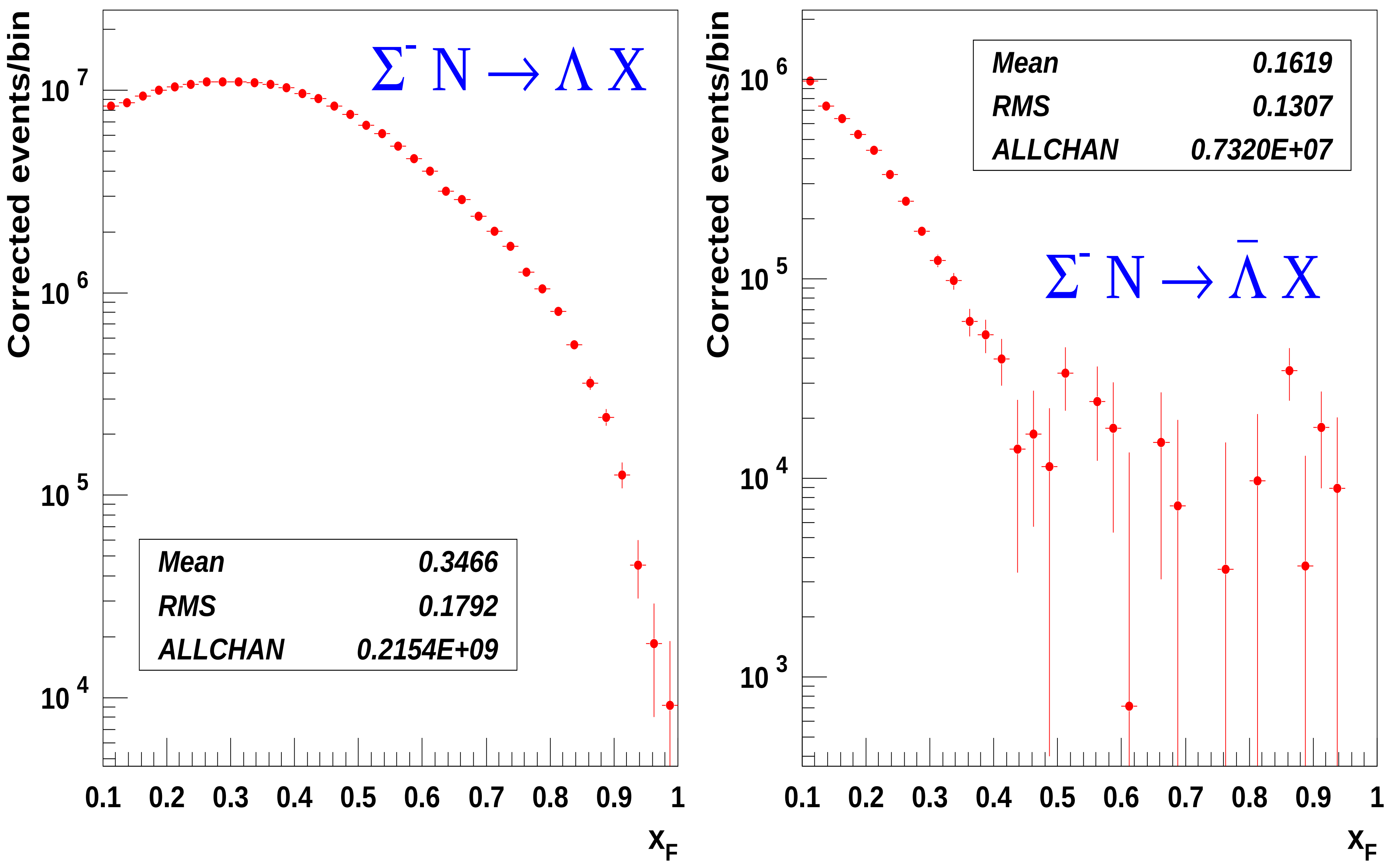




PRELIMINARY RESULTS

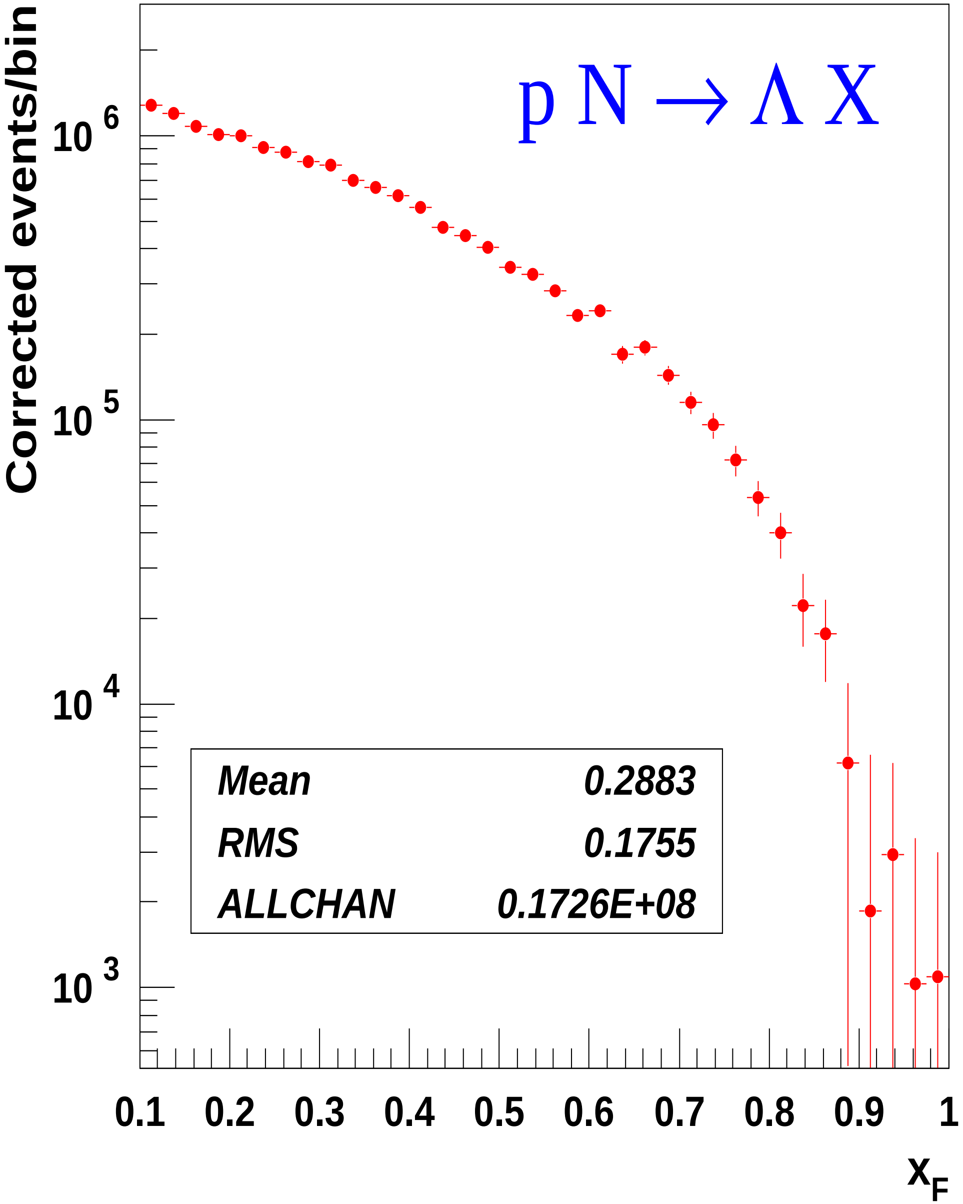
PRELIMINARY RESULTS ! ! !

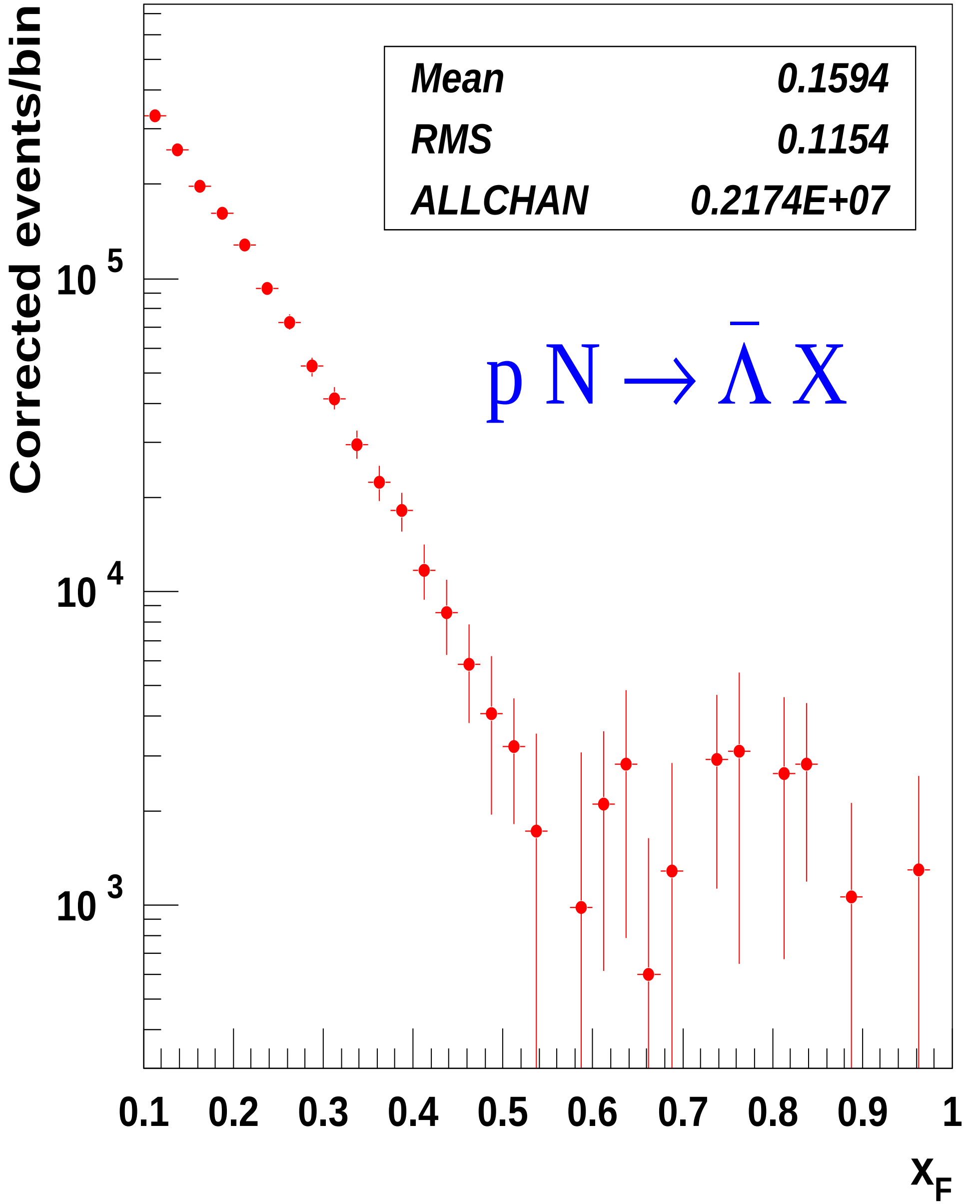
• Only Statistical Errors •



PRELIMINARY RESULTS ! ! !

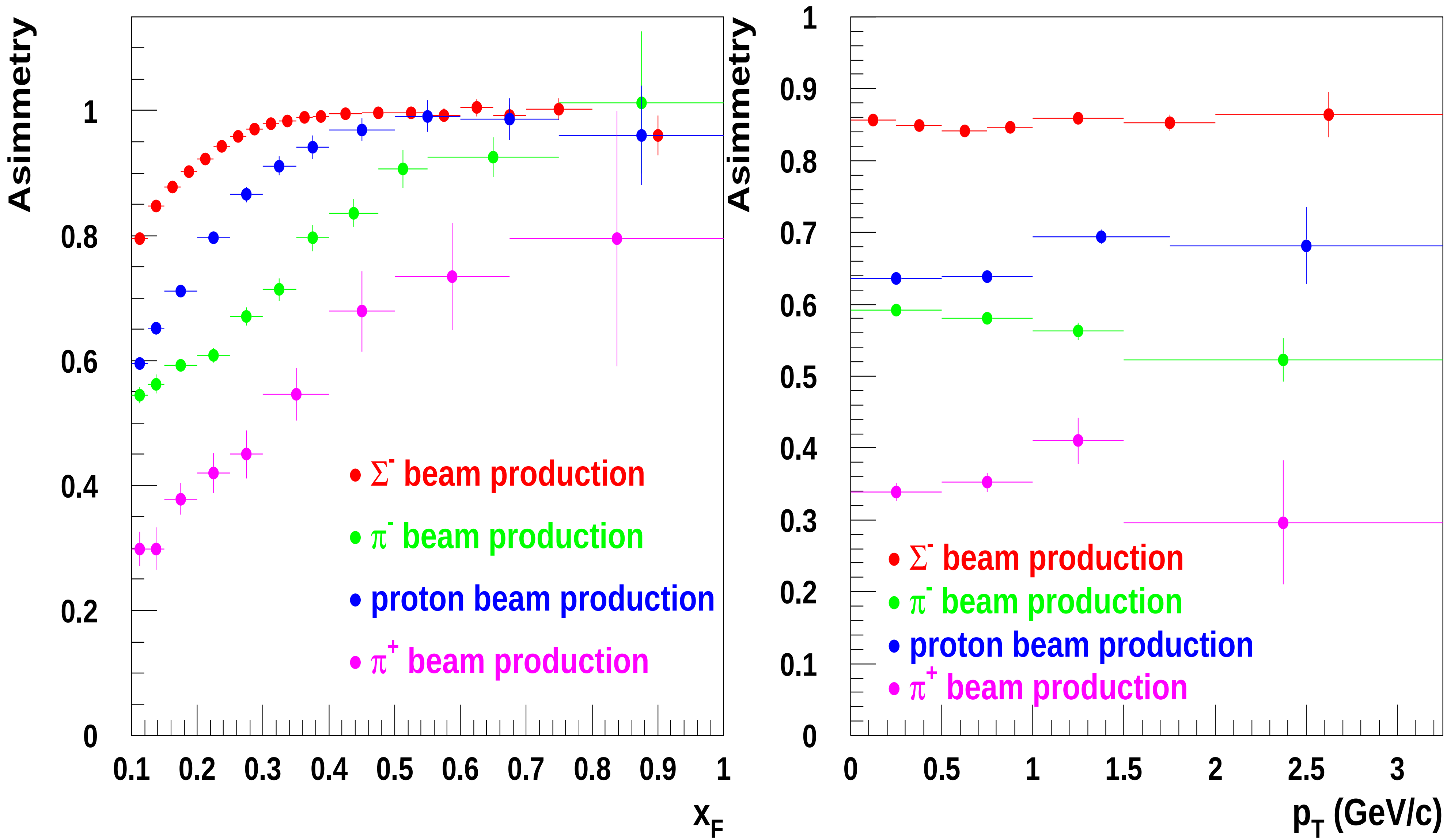
● Only Statistical Errors ●



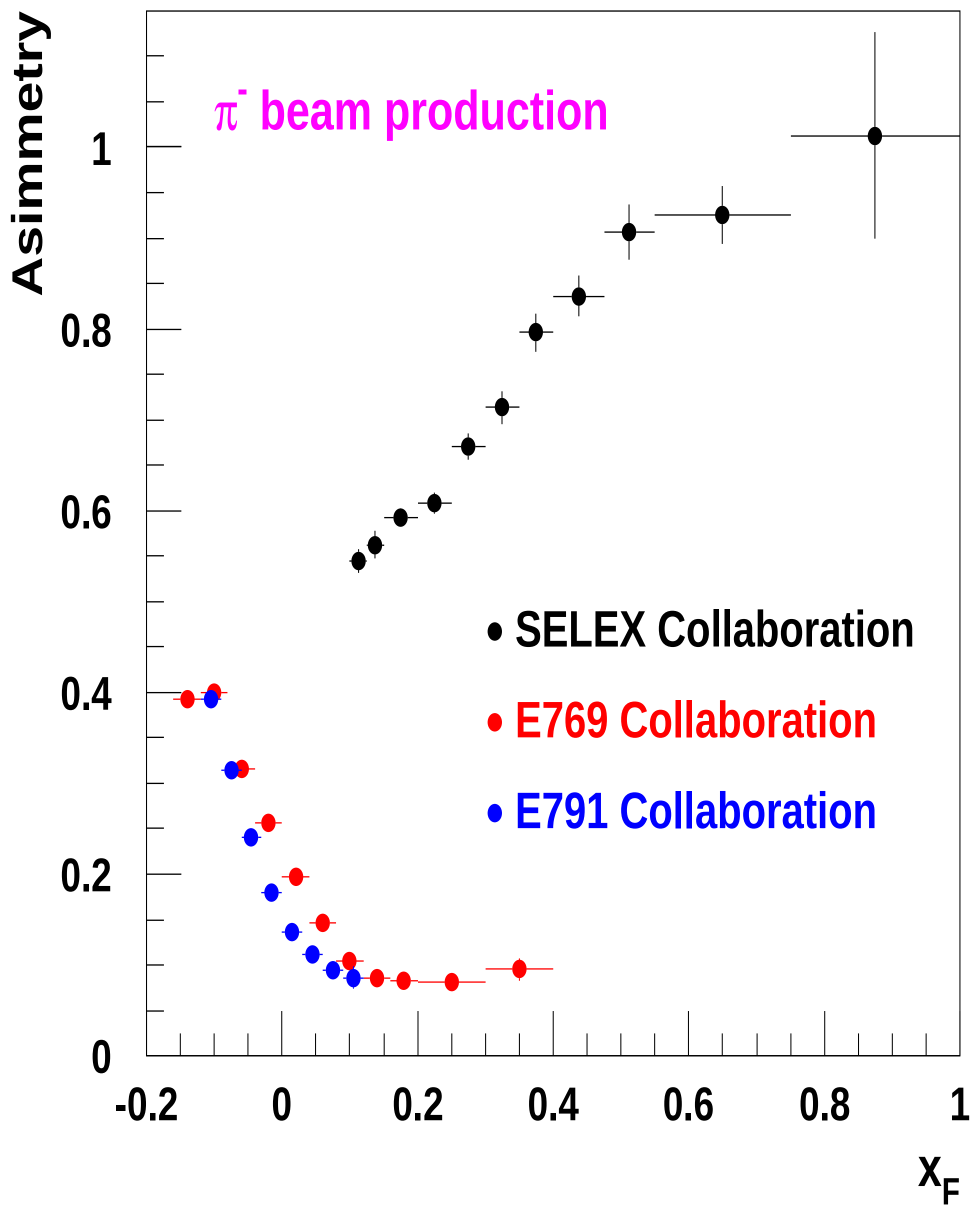


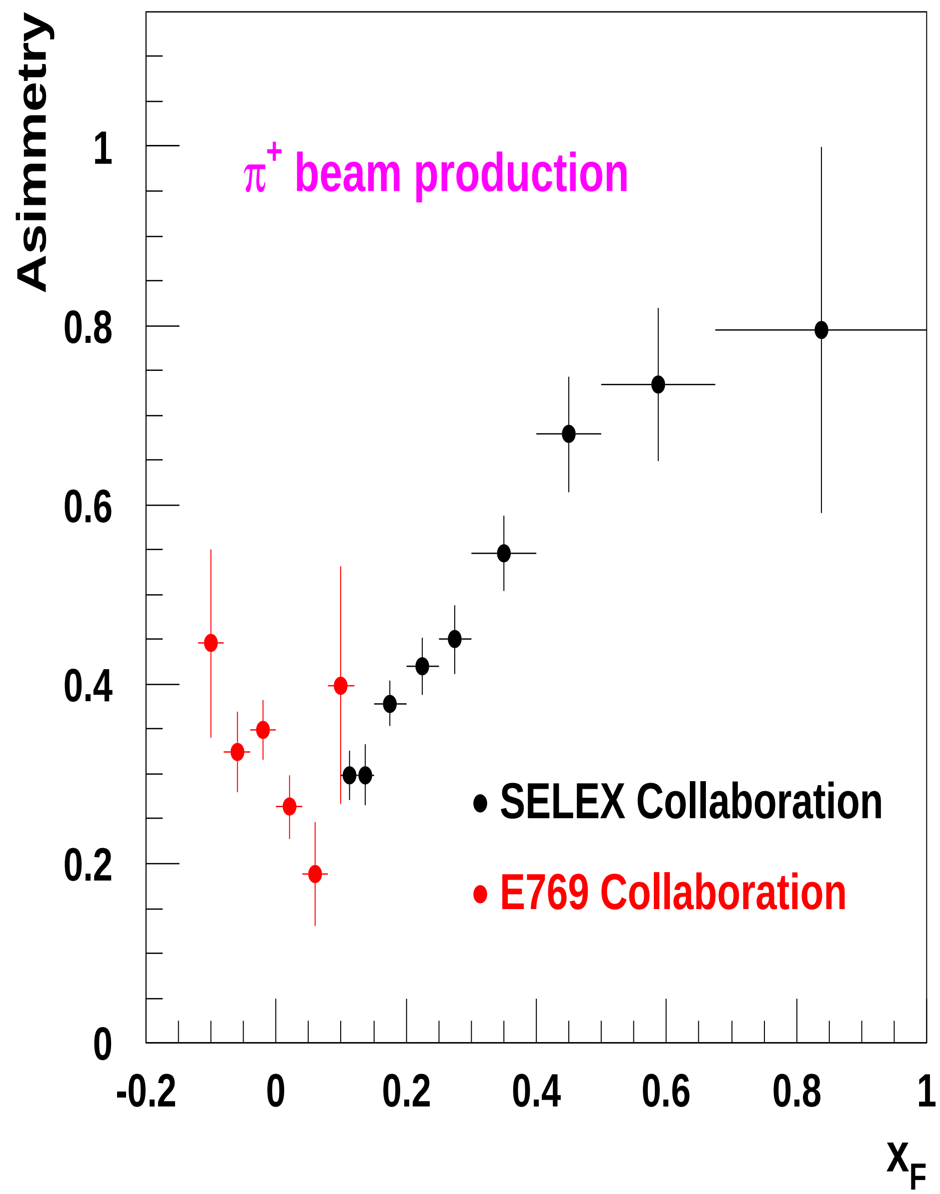
PRELIMINARY RESULTS ! ! !

$$Asimmetry = \frac{N_{par} - N_{antipar}}{N_{par} + N_{antipar}}$$



IN COMPARISON TO . . .





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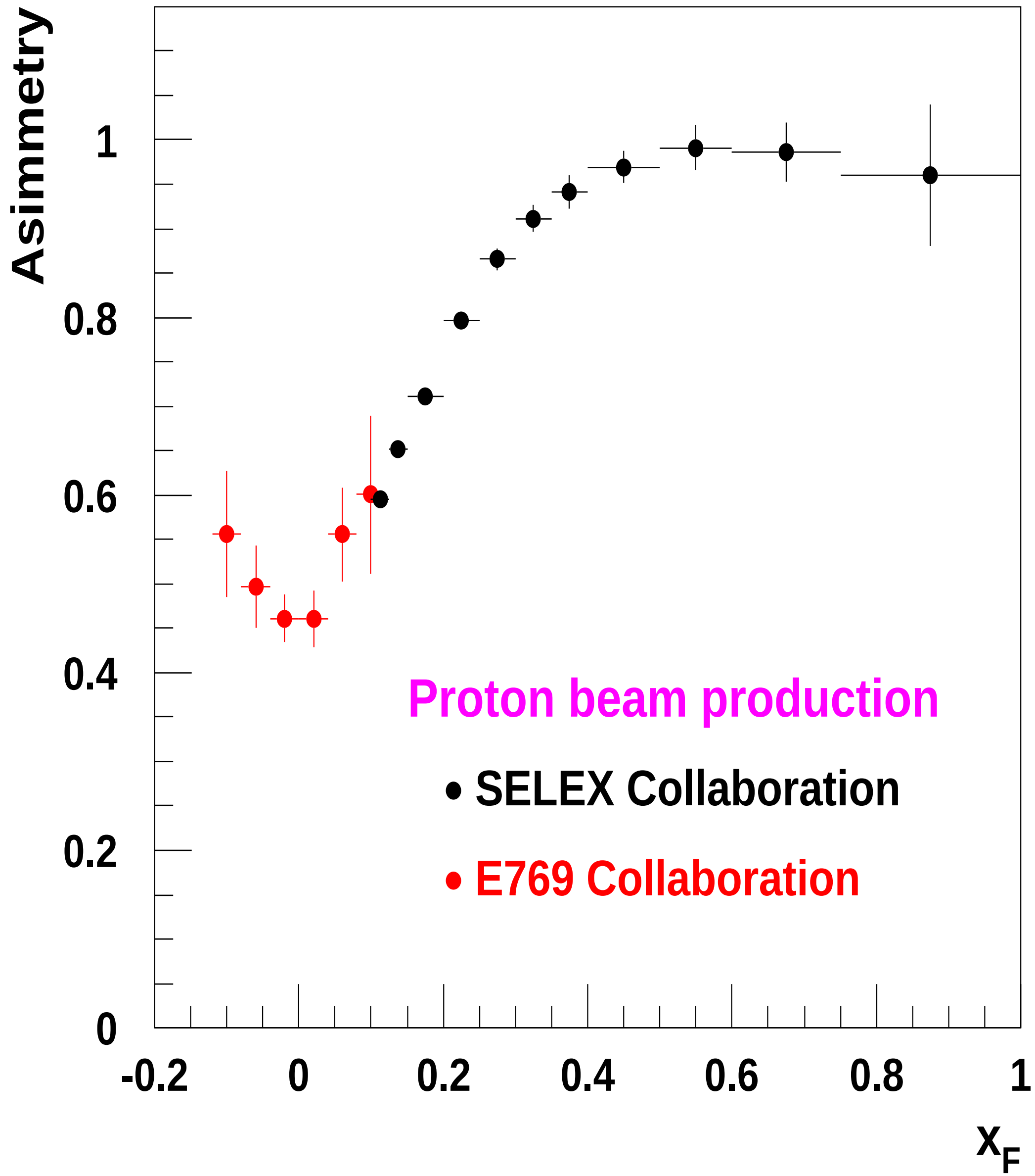
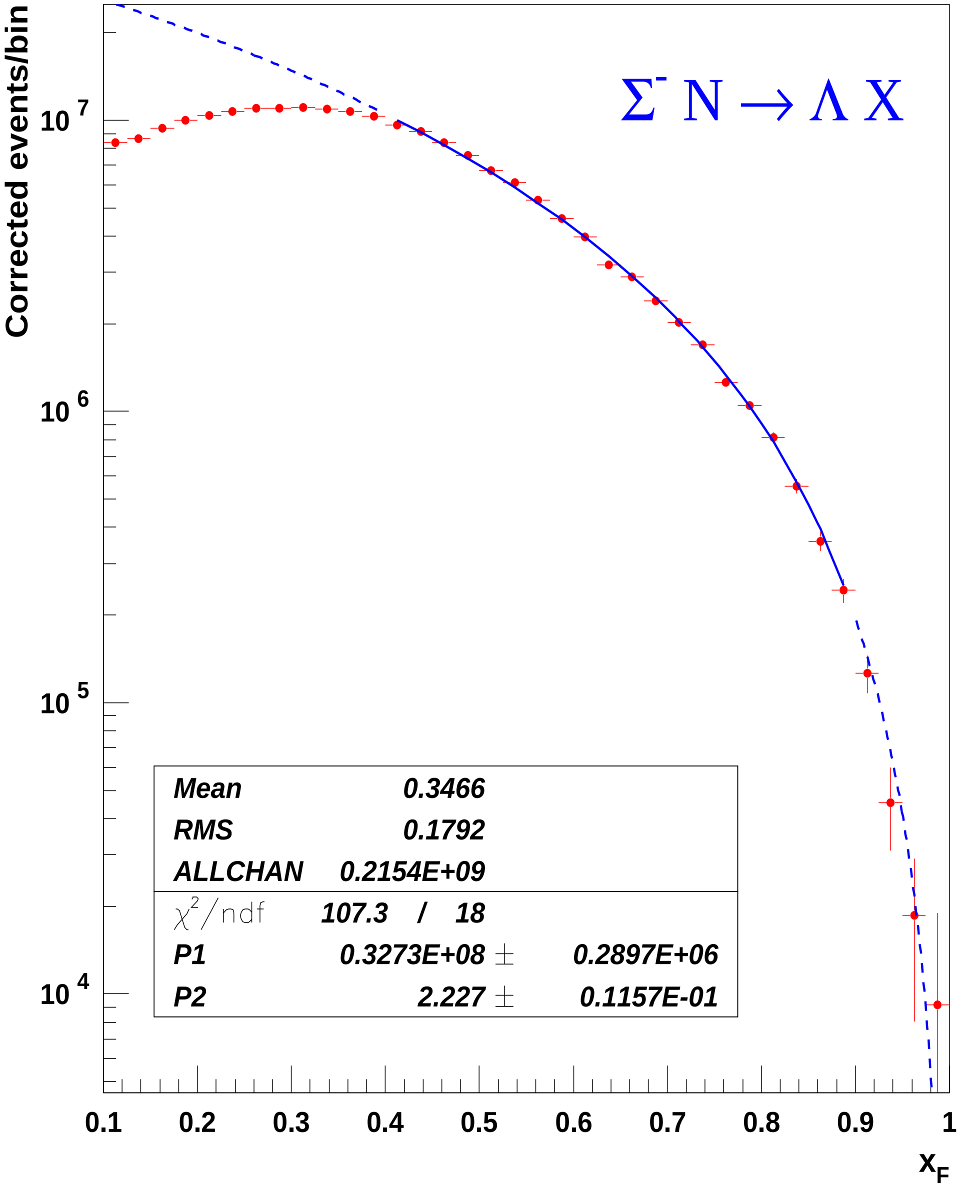
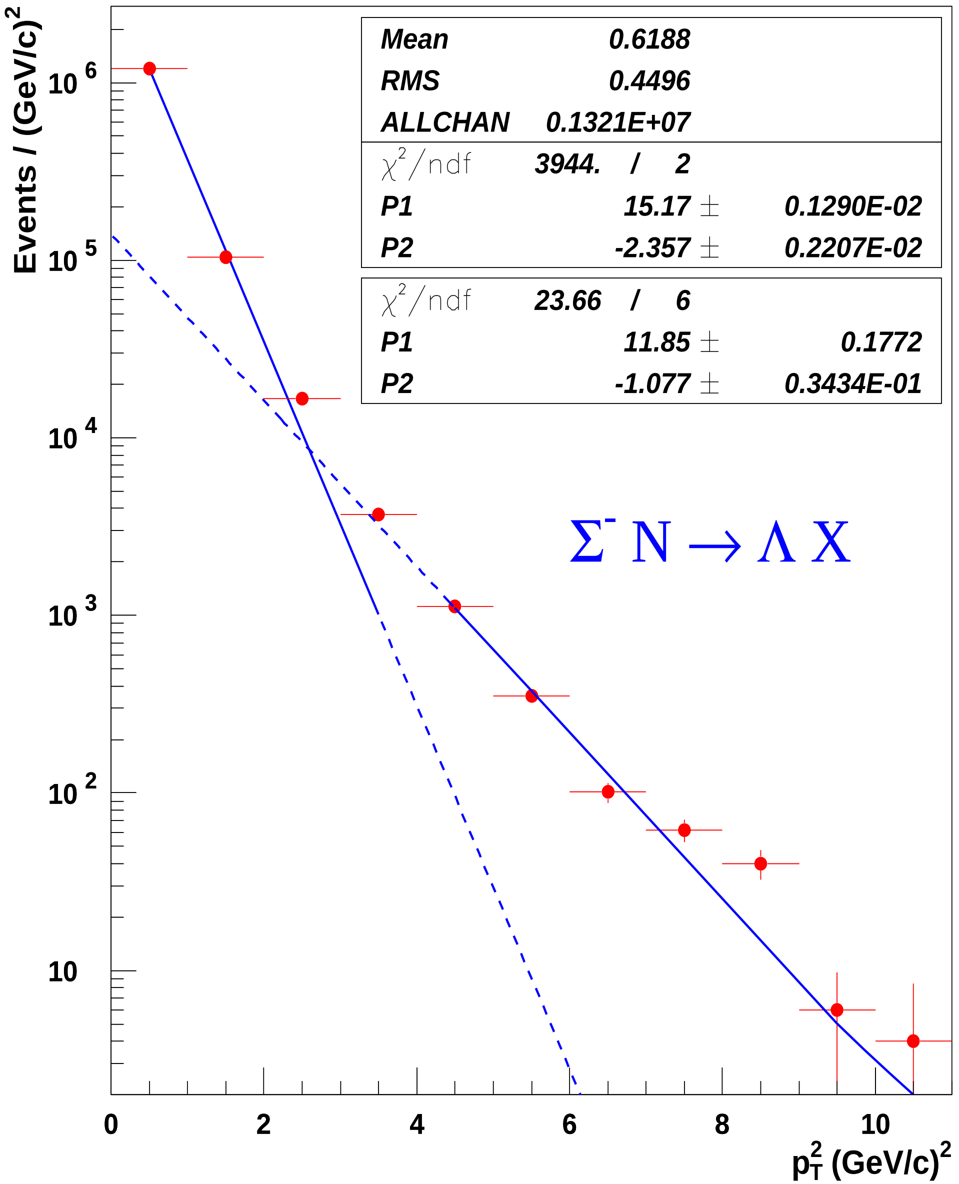


MODEL: DOES NOT WORK !!!

$$P_1(1-x_F)^{P_2}$$

$$\exp\left(P_1 + P_2 \cdot p_T^2\right)$$





SUMMARY

SUMMARY

- Inclusive differential cross sections $\frac{d\sigma}{dx_F}$ and $\frac{d\sigma}{dp_T}$ for the production of Λ, $\overline{\Lambda}$ and K_s in π^-, π^+, Σ^- and proton-nucleon collisions were measured over the ranges $0.1 \leq x_F \leq 1$, $0 \leq p_T \leq 3.25$ GeV/c and $0 \leq p_T^2 \leq 11$ (GeV/c)^2.

- Besides, the Λ-$\overline{\Lambda}$ production asymmetries as a function of x_F and p_T were measured for each beam over the ranges $0.1 \leq x_F \leq 1$ and $0 \leq p_T \leq 3.25$ GeV/c and $0 \leq p_T^2 \leq 11$ (GeV/c)^2.

- The Blankenbecler and Brodsky model does NOT work for the inclusive production of Λ, $\overline{\Lambda}$ and K_s as a function of x_F and p_T.