QM2001

Antiproton Production and Re-absorption in p+A Collisions at the AGS

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Overview

- E910 Experiment
- Centrality in p+A Collisions
- Antiproton Production
  - Beam energy
  - Target Size
  - Centrality
- Re-absorption Cross Section
- Comparison with Antilambda
- What have we learned?

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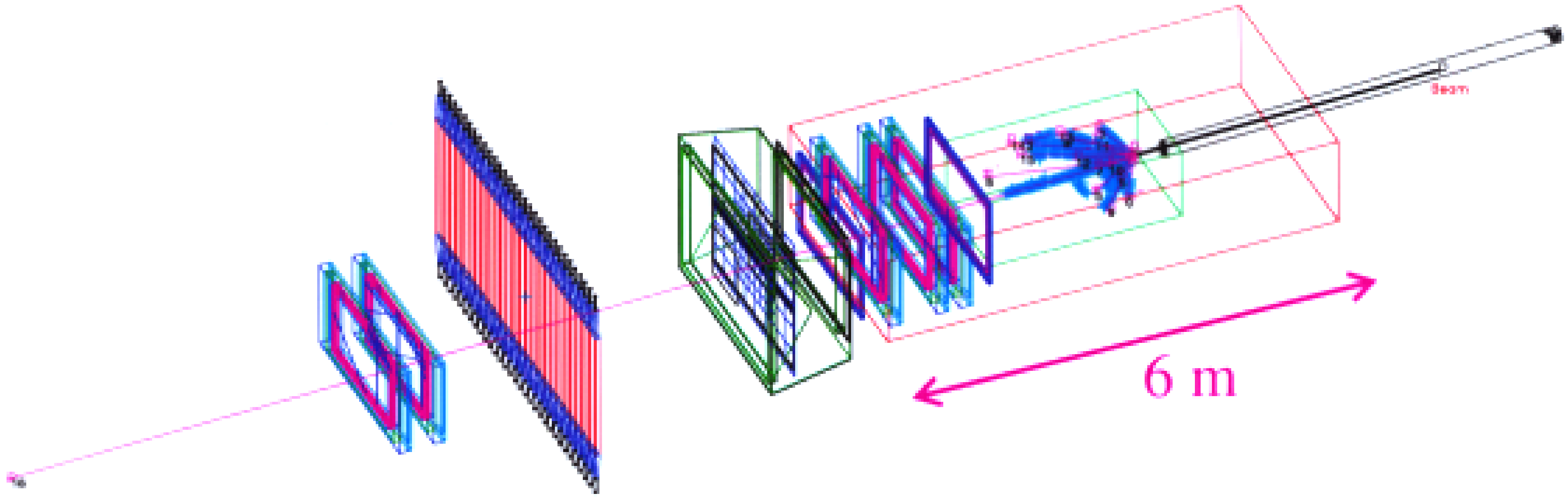
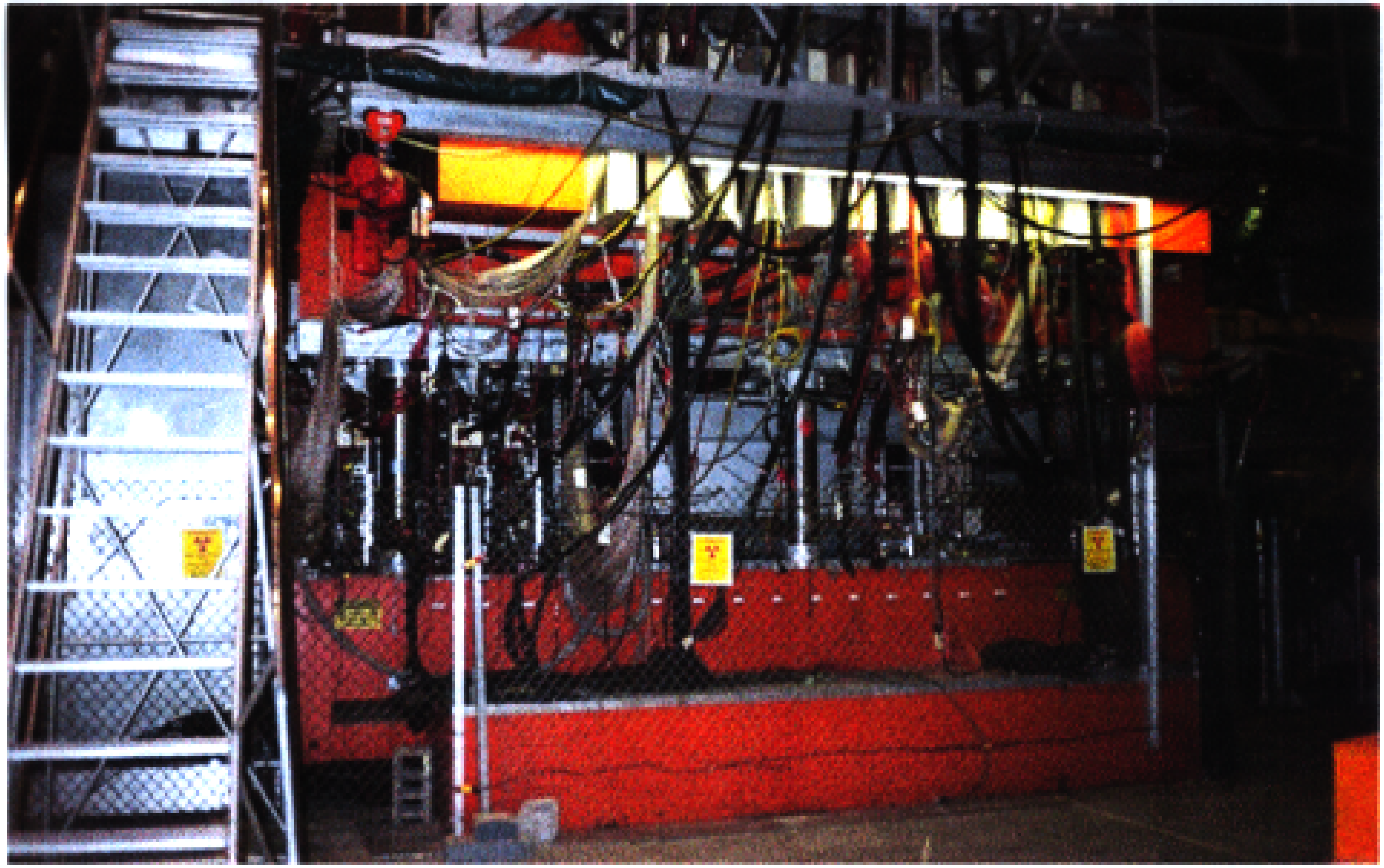
E910 Spectrometer
at the
MPS Facility of the AGS



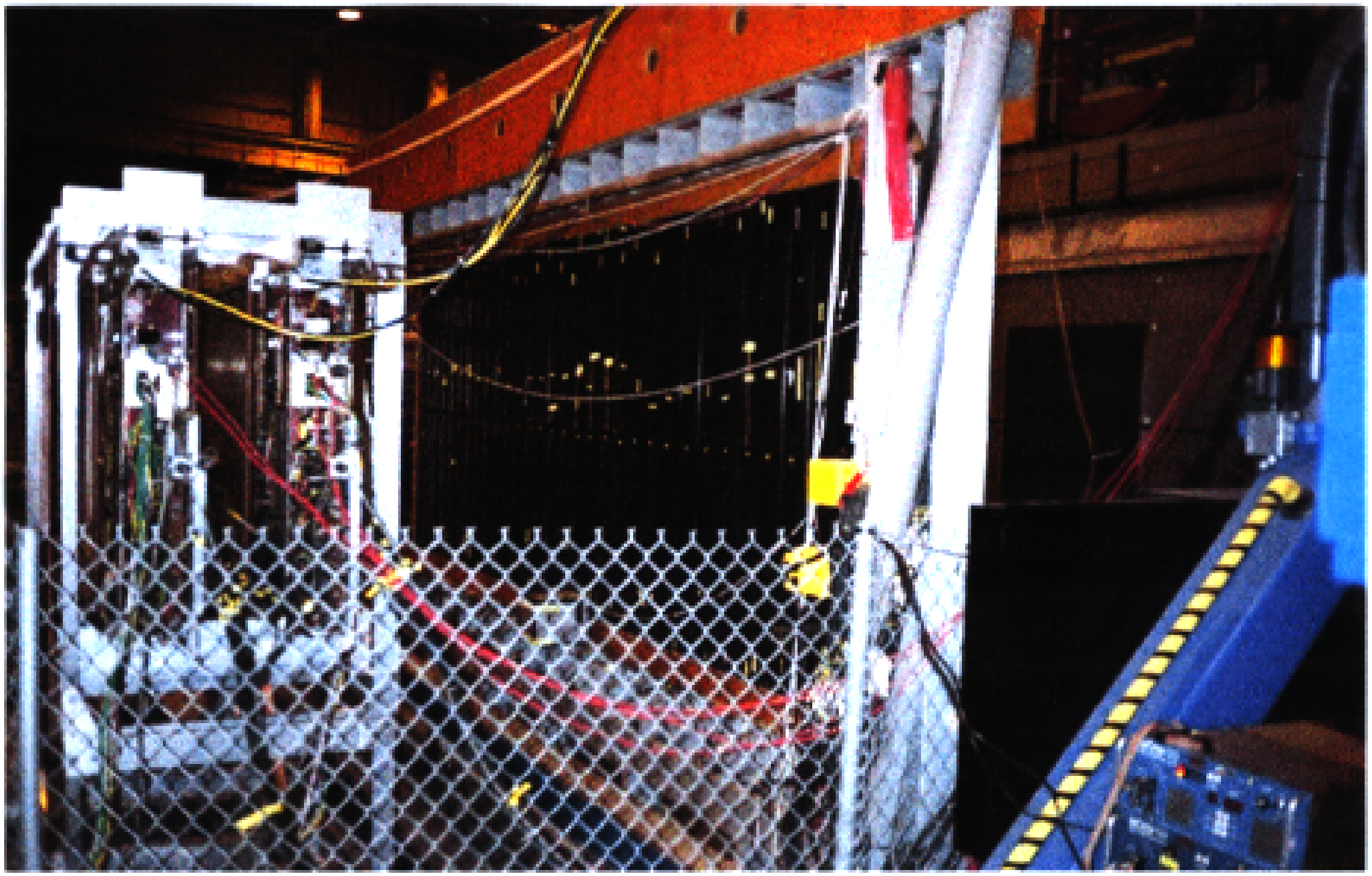
- MPS Magnet
- EOS TPC
- Downstream tracking:
  - MPS Drift Chambers, Wire Chambers
- PID:
  - TPC dE/dx, TOF, Segmented Cherenkov

- Spring 96 Proton Run at AGS
- Be, Cu, Au, U targets
- 6, 12.5, 18 GeV/c Beam Momenta
- O(15) Million Central and MinBias Triggers

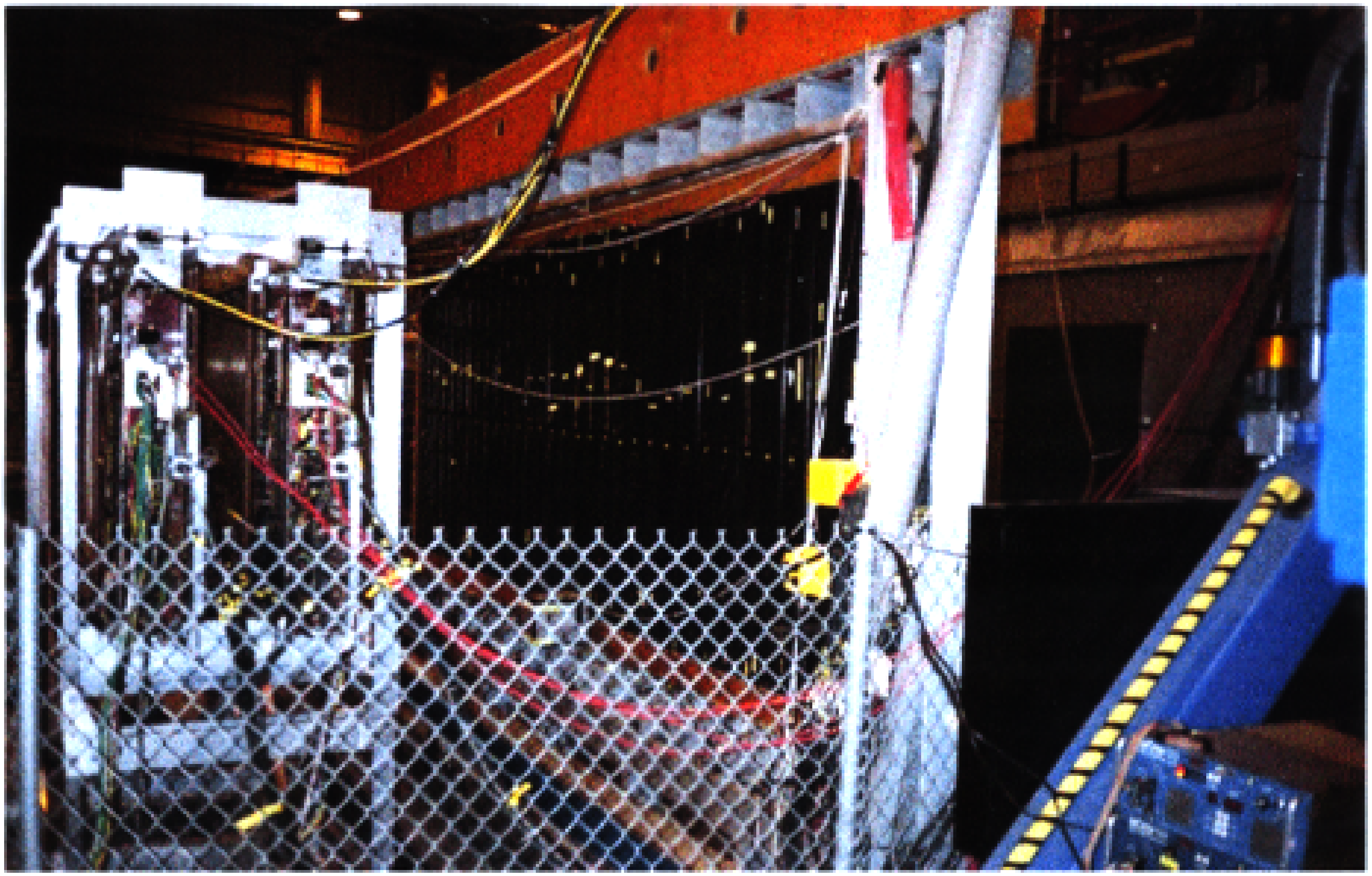
MPS Magnet



TOF Wall



TOF Wall

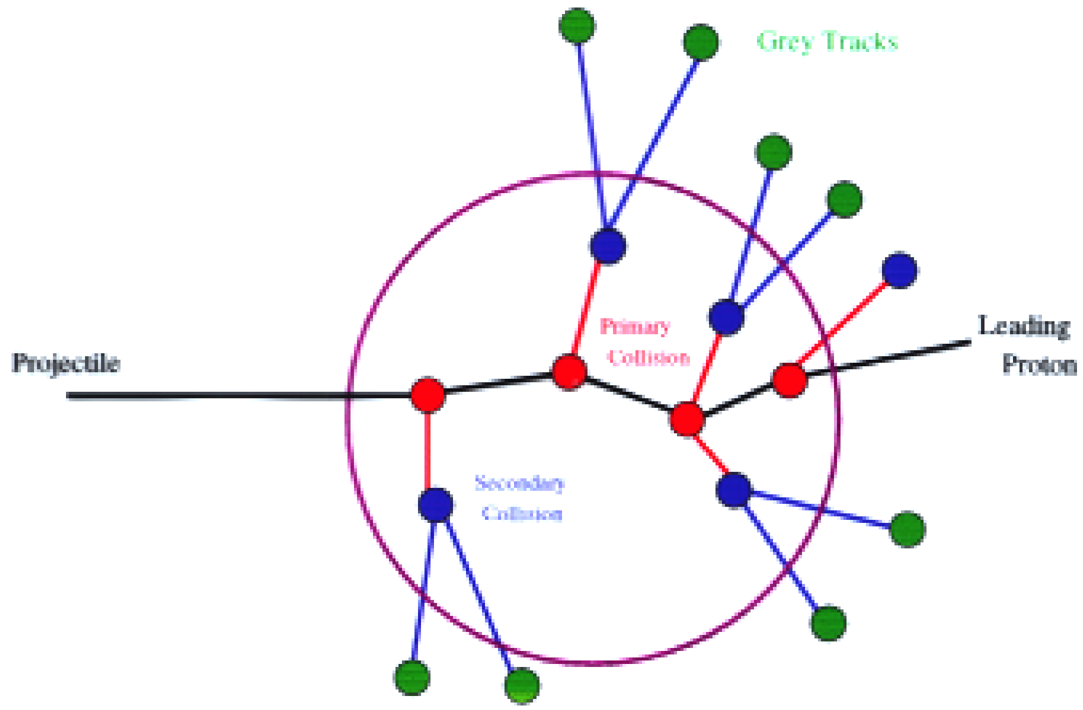


Centrality in E910

- Centrality is defined in terms of the number of projectile collisions ν
- ν is determined from the number of grey tracks N_g
- N_g is defined as the number of slow protons and deuterons
- $\nu = \langle\nu\rangle(N_g)$

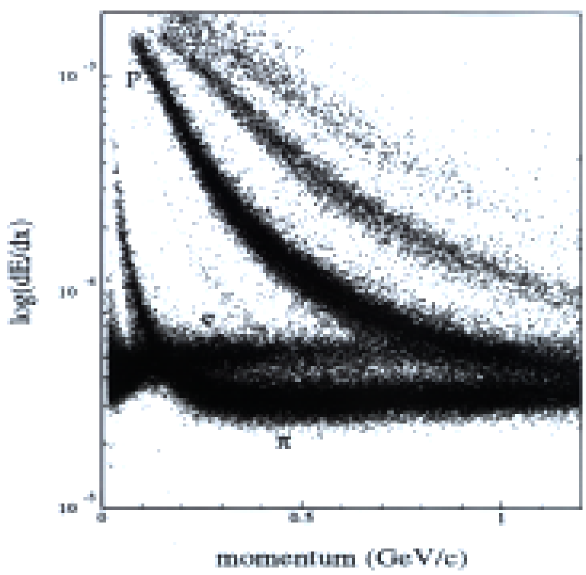
(Chemakin et al., Phys. Rev. C**60** (1999) 024902.)

"Grey Tracks"



Grey tracks:

- "slow protons"- $0.25 < p < 1.2$ GeV/c
- "slow deuterons"- $0.5 < p < 2.4$ GeV/c



Relate N_g to ν

Physics Goals

- Characterize the centrality of an event by the number projectile collisions
- Antiproton re-absorption
  - system size
  - collision geometry

Antiprotons

Targets: Au, Cu, Be

Beam momenta: 12.3 and 17.5 GeV/c

Measure of ν

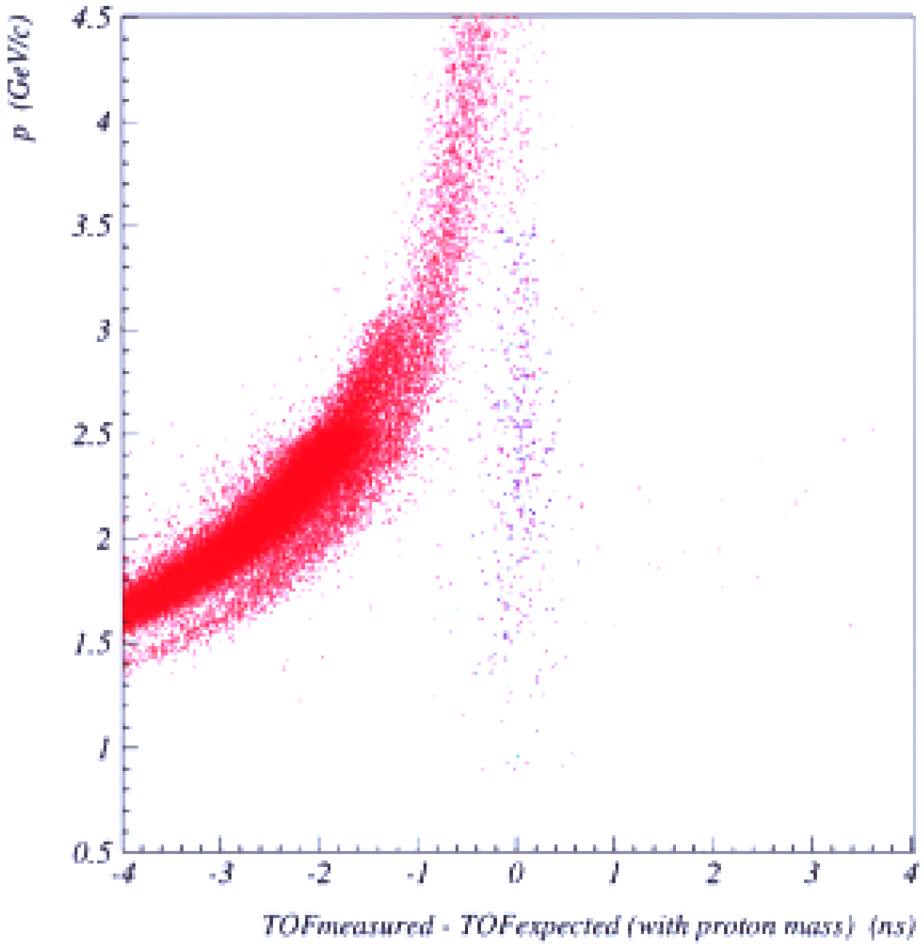
To address:

- Production Mechanism
- Re-absorption in the Nucleus

Identification of Antiprotons

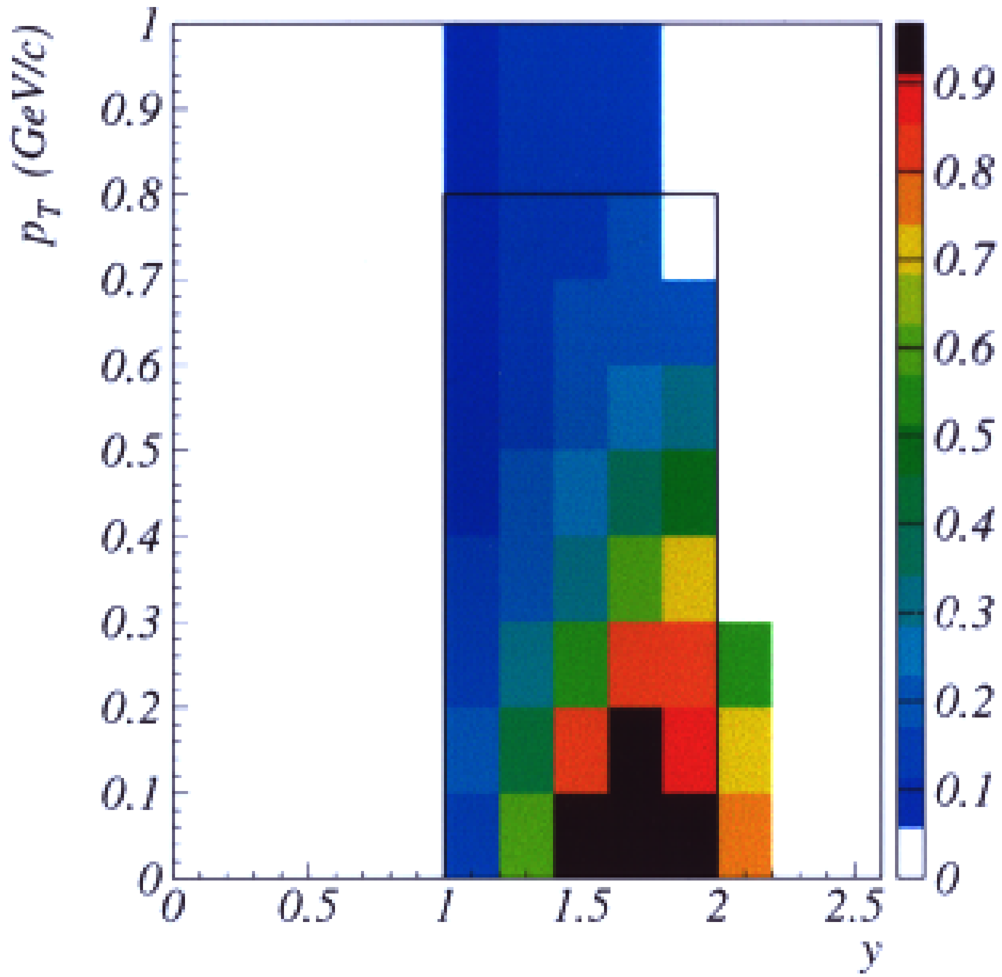
PID with TOF

~ 4 million interactions of 17.5 GeV/c p+Au

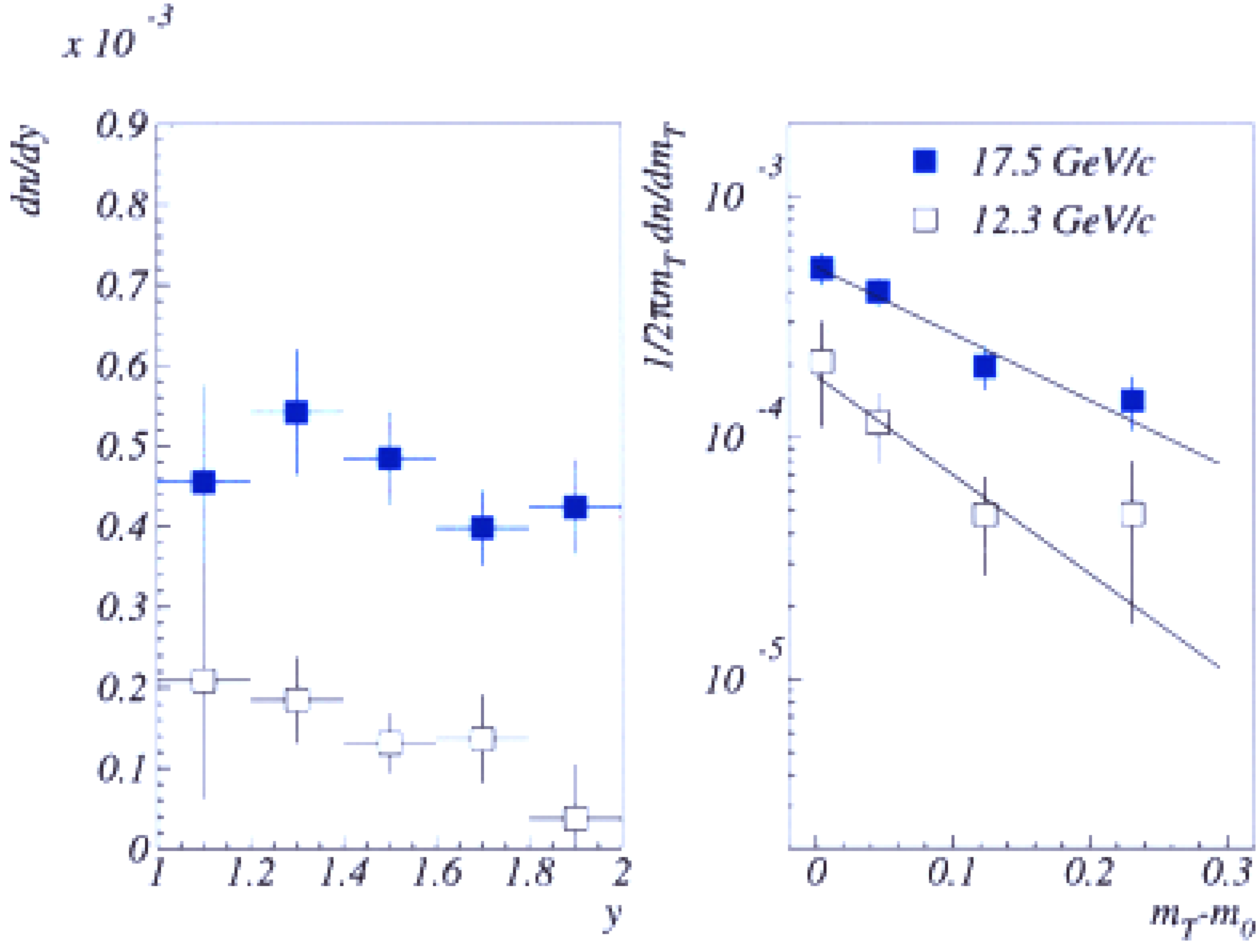


Antiproton Acceptance

- Acceptance with momentum reconstruction
- Results shown in y-p_T coverage shown by solid lines
- Antilambda feeddown estimated <~ 5%

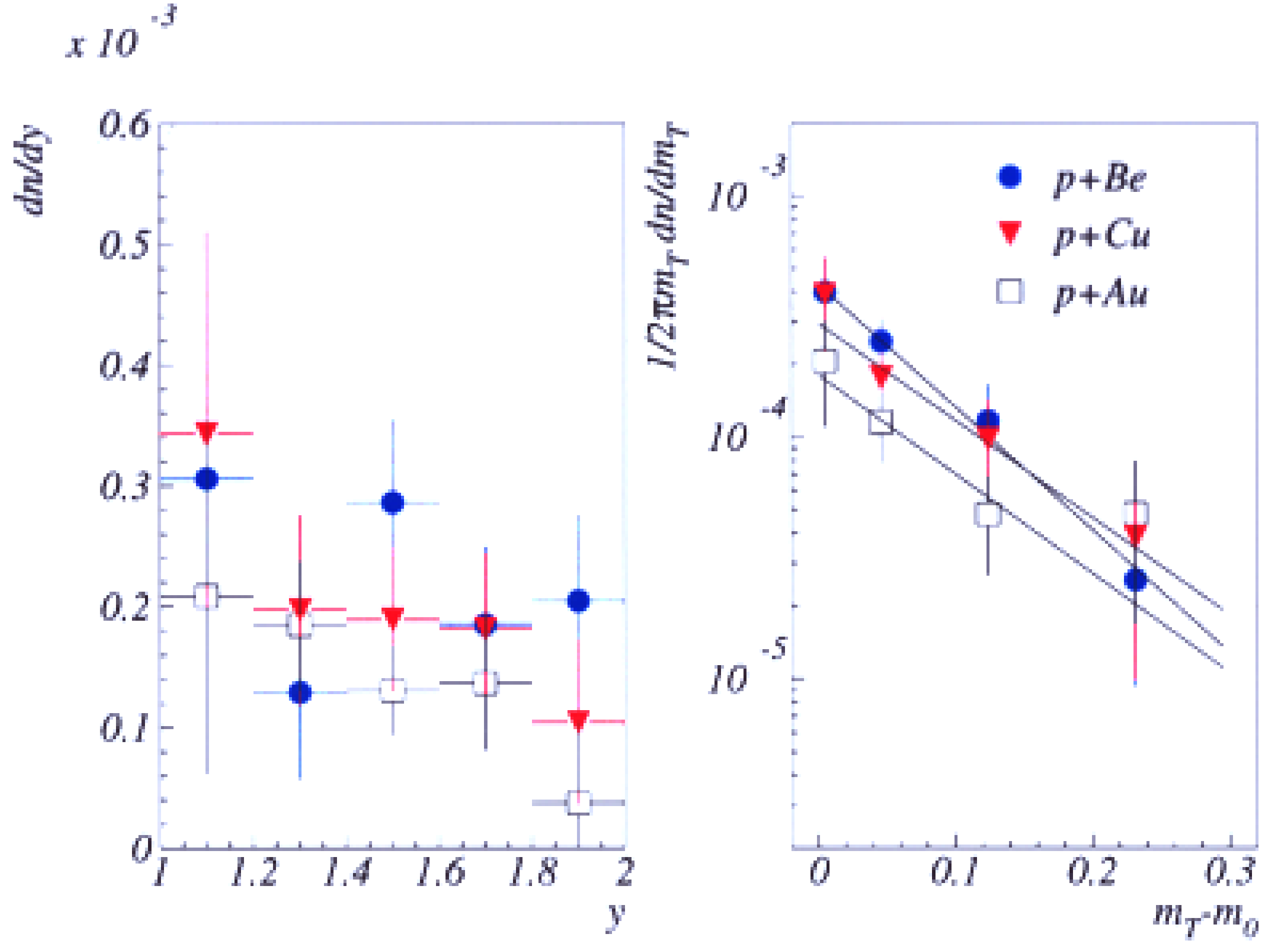


Measured Yields p+Au
Comparison at Different Beam Momenta



$p_T < 800$ MeV/c   y = [1.0,2.0]

Measured Yields 12.3 GeV/c
Comparison of Different Targets



p_T < 800 MeV/c   y = [1.0,2.0]

Inverse Slopes of m_T Distributions

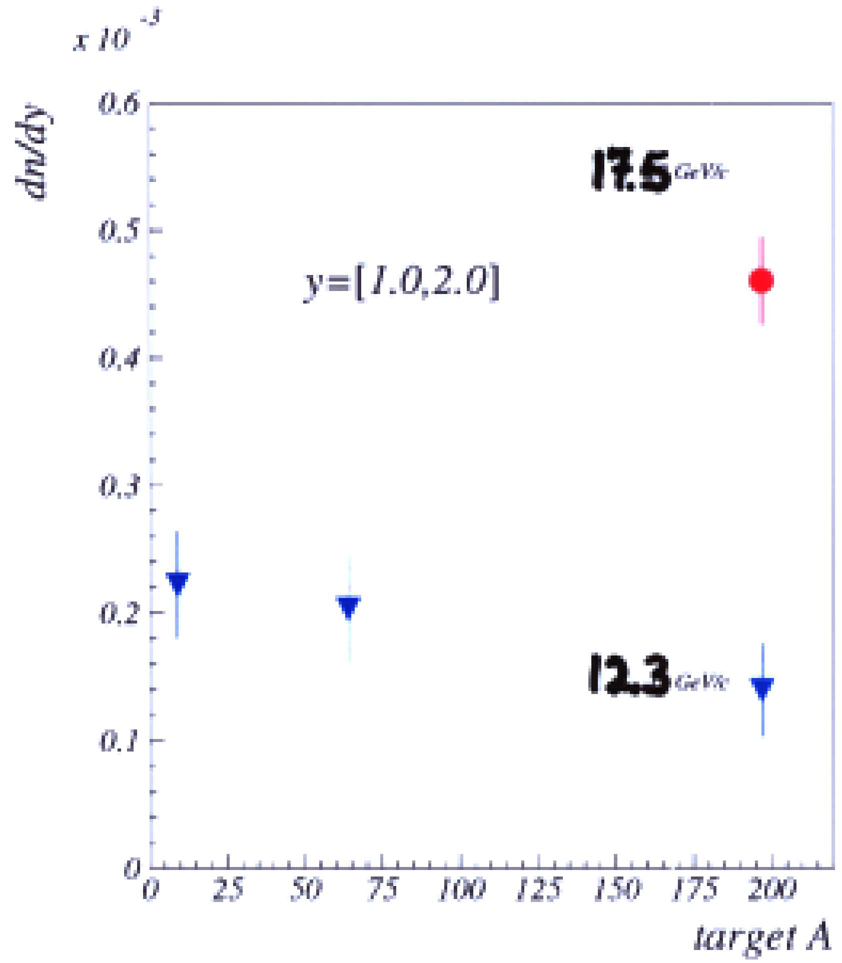
$$1/(2\pi m_T)\, dn/dm_T = C_0\, e^{-(m_T - m_0)/T}$$

	T (MeV/c^2)
18 GeV/c p+Au	157 ± 34
12 GeV/c p+Au	106 ± 62
12 GeV/c p+Cu	108 ± 47
12 GeV/c p+Be	86 ± 19

Integrated dn/dy over y=[1.0,2.0] (p_T<800 MeV/c)

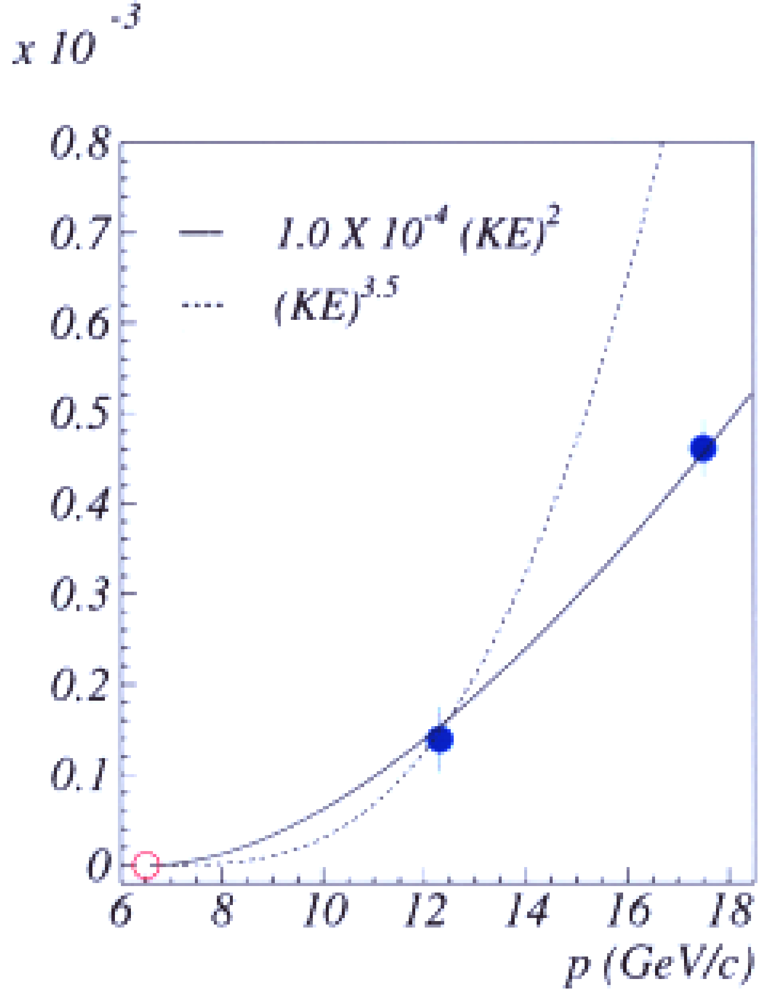
- 17.5 GeV/c p+Au
  $4.61 \pm 0.34 \times 10^{-4}$
- 12.3 GeV/c p+Au
  $1.39 \pm 0.36 \times 10^{-4}$
- 12.3 GeV/c p+Cu
  $2.03 \pm 0.37 \times 10^{-4}$
- 12.3 GeV/c p+Be
  $2.22 \pm 0.42 \times 10^{-4}$

- Increasing yield with beam momentum
- Decreasing yield with target size



Dependence of Yields on Available Kinetic Energy Squared

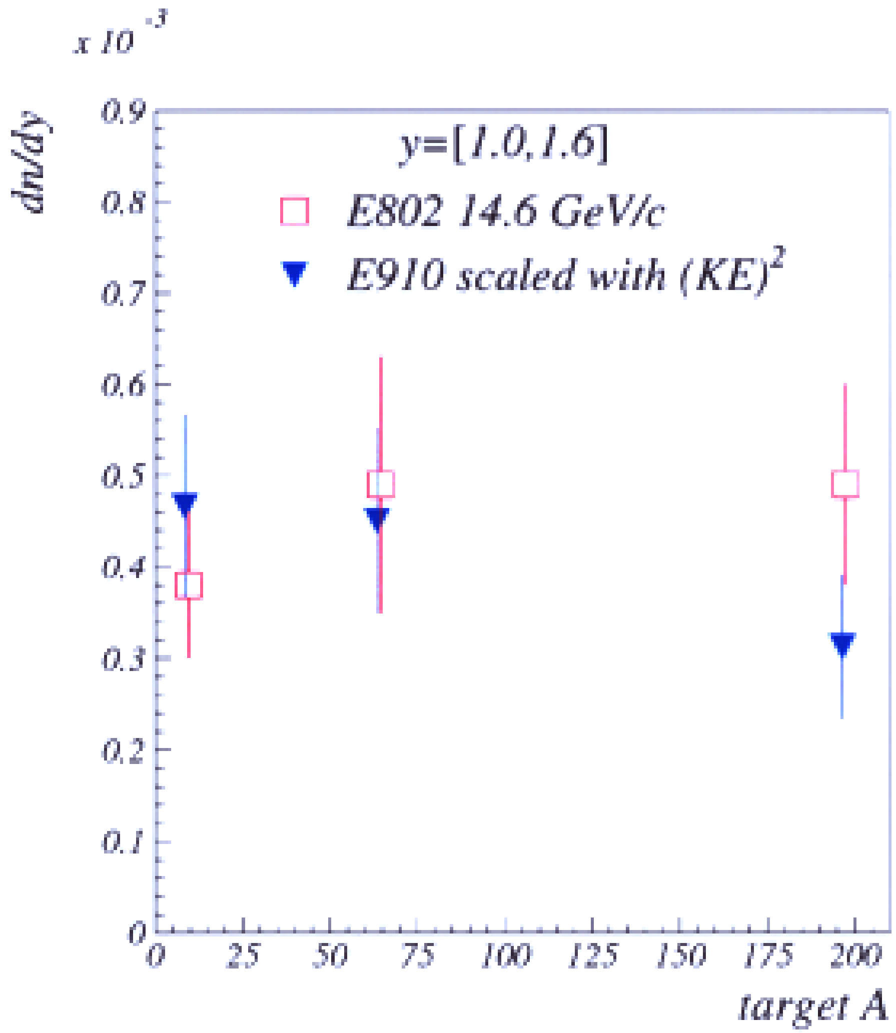
- Antiproton Yields in p+p data found to increase with $(KE)^2 = (\sqrt{s} - 4m_p)^2$ (P.Stankus,thesis,1993.)
- Indicating 3-body final state (instead of 4-body from $(KE)^{3.5}$ dependence)



Comparison with other Experiments

Compare with E802
(T. Abbott *et al*, Phys. Rev. **C**47:1351, 1993.)

- Agreement within errors
- Different conclusion



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Mean Antiproton Multiplicity as a Function of ν

Assumptions:

- First collision model

  Dominant antiproton production is in first p+N collision

- Produced antiprotons follow path of projectile, thus re-absorption depends on ν

  ν is a measure of number of mean-free paths antiproton must traverse in nuclear medium

$$\sigma\,(p+A \rightarrow \overline{p}) = \sigma\,(p+p \rightarrow \overline{p})\, e^{-\frac{\sigma_{abs}}{\sigma_{pN}}(\nu-1)}$$

$$\frac{\nu-1}{\sigma_{pN}} = \text{thickness of nucleus seen by antiproton}$$

Mean Antiproton Multiplicity as a Function of ν

- Fit to attenuation factor folded with $P_{N_g}(\nu)$:

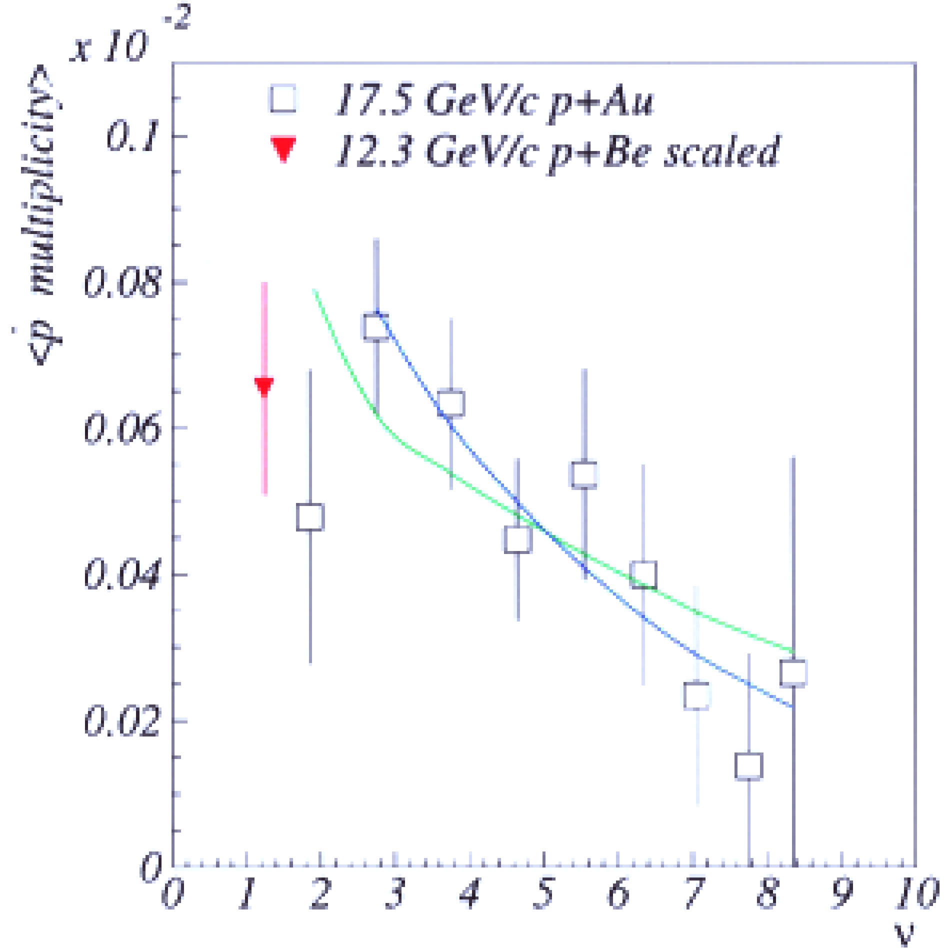
$$\sum_{\nu} P_{N_g}(\nu)\,\sigma(p+p\rightarrow\bar{p})\,e^{-C(\nu-1)}$$

$$C = \frac{\sigma_{abs}}{\sigma_{pN}} = 0.23 \pm 0.09$$

$\Rightarrow$ σ_{abs} = 6.9 ± 2.7 mb

(4.0 ± 1.6 mb)

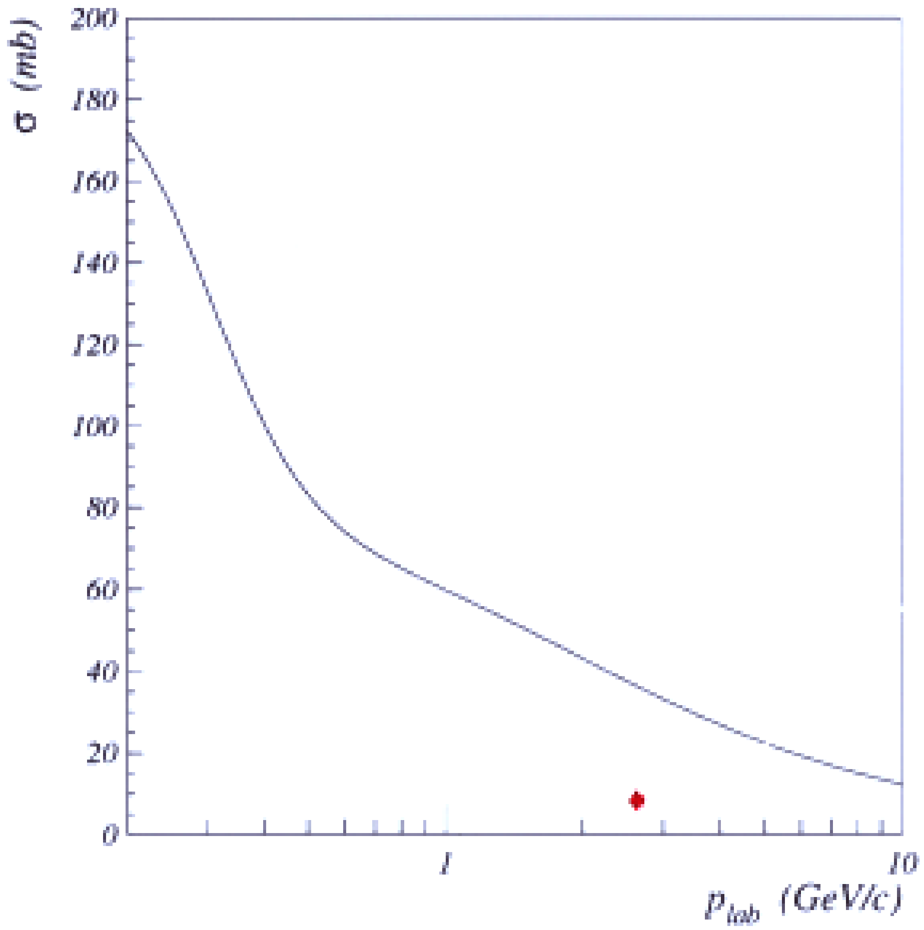
in the context of this model !



$p\,\bar{p}$ Annihilation Cross Section

Parameterization by Koch and Dover (Phys.Rev.C40, 145, 1989.)

$\langle p_{lab} \rangle \approx 2.5$ GeV/c



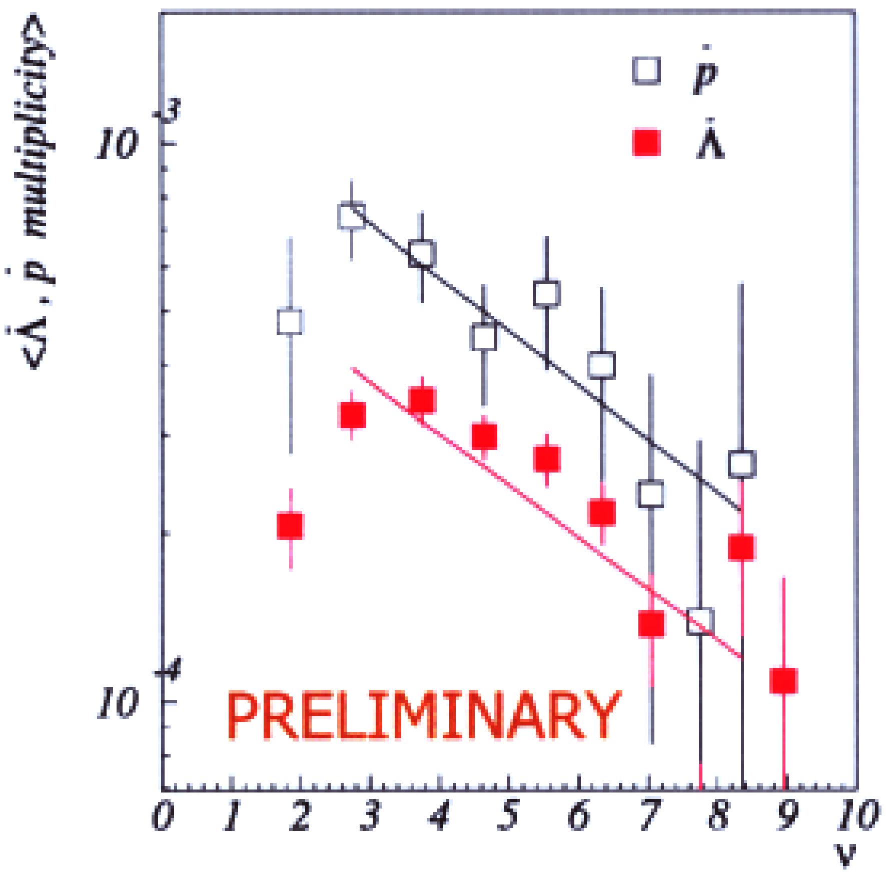
Mean Antilambda Multiplicity as a Function of ν

$\bar{\mathbf{p}}$

$$C = \frac{\sigma_{abs}}{\sigma_{pN}} = 0.23 \pm 0.09$$

$\bar{\Lambda}$

$$C = \frac{\sigma_{abs}}{\sigma_{pN}} = 0.22 \pm 0.04$$

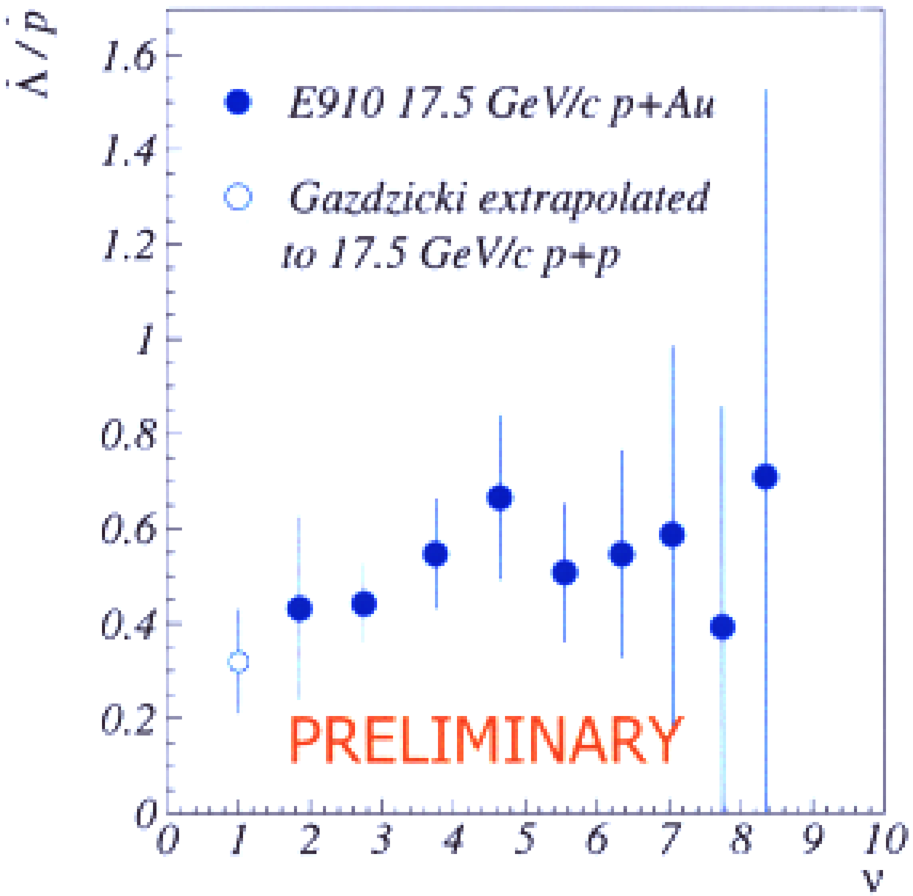


$\bar{\Lambda} / \bar{p}$ vs. ν

- $\bar{p}$ yields for 17.5 GeV/c p+Au as a function of ν
- $\bar{\Lambda}$ yield for p+p

Gazdzicki *et al*, ZP C71, 55 (1996) extrapolated to p_{LAB} = 17.5 GeV/c

- $\bar{p}$ yield at ν=1 from E910 12.3 GeV/c p+Be scaled to 17.5 Gev/c



Conclusions

What have we learned about antiproton production and re-absorption?

- Antiproton yield increases with beam momentum
  - 17.5 GeV/c yields $\sim$ **3.3** $\times$ 12.3 GeV/c yields
  - Yields can be described with dependence on $(KE)^2$
- Antiproton yield decreases with increasing target size
- Yield in p+Au data is $37 \pm 20\%$ less than p+Be data

Conclusions

- Shapes of m_T distributions indicate effects of reabsorption:

  Inverse slope smaller for Be than Au
- Yields decrease with increasing ν
- "Effective" annihilation cross section fraction of free annihilation cross section
  - In medium, $\sigma^*_{anni} \sim 1/5\ \sigma_{anni}$

- Absorption of $\overline{\Lambda}$ very similar to $\overline{p}$