Spin Effects in Large Rapidity Neutral Pion Production with STAR FPD

Larisa Nogach
IHEP, Protvino

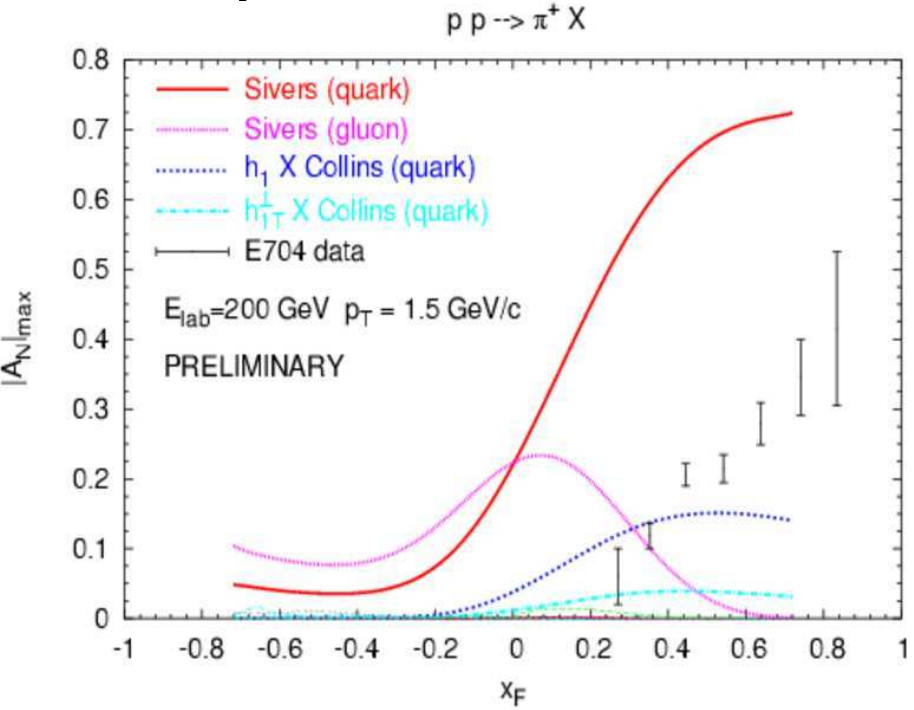
Outline

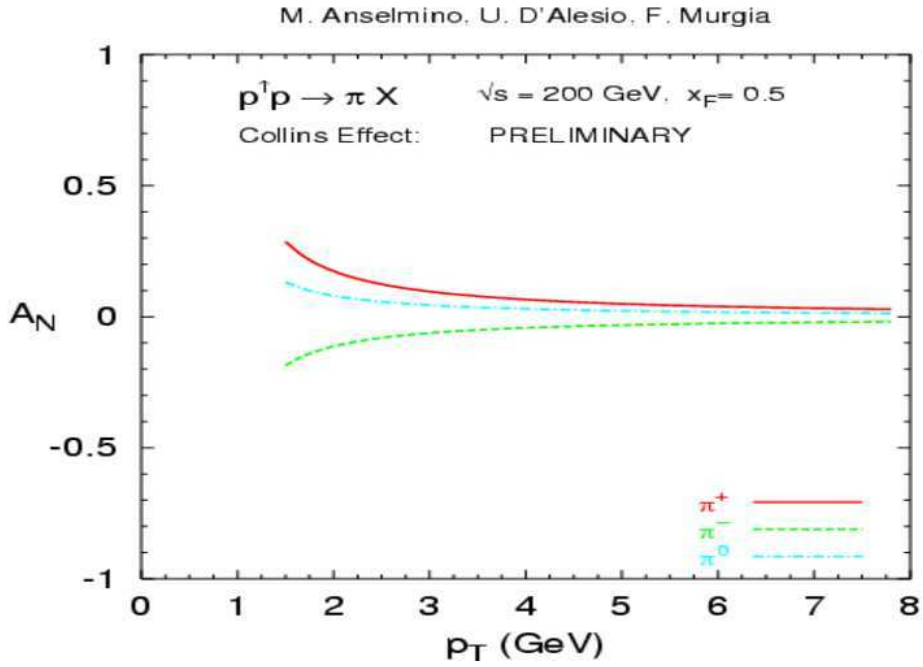
- Introduction
- FPD configuration and data acquired in Run5
- Data analysis
- π^0 analyzing power from Run3&Run5 data
- Summary and near-term plans

Motivation

$$p^{\uparrow} + p \rightarrow \pi^0 + X$$

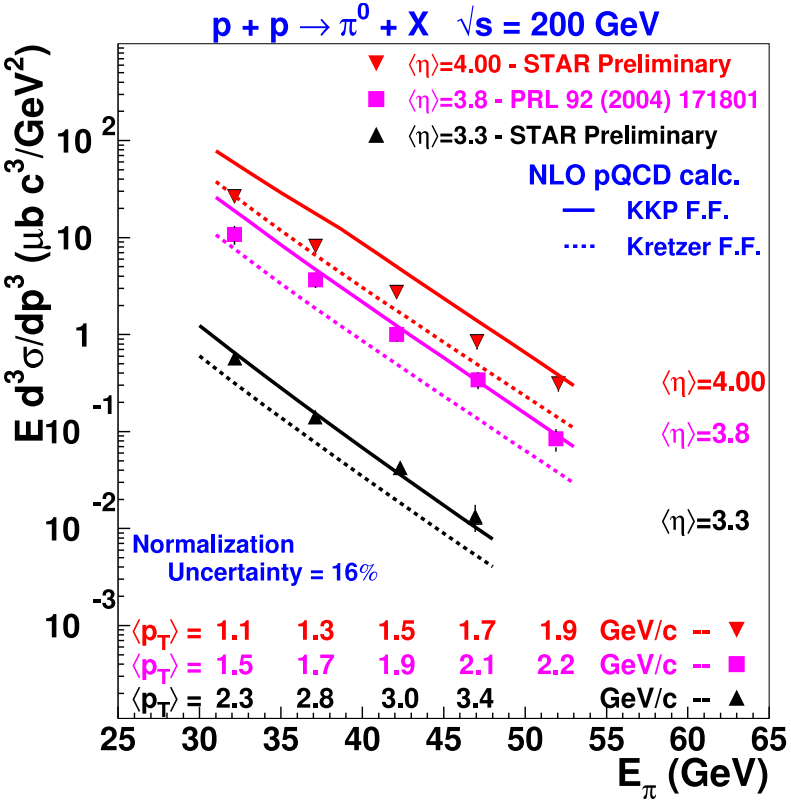
U. D'Alesio, SPIN2004
URL: http://www.ts.infn.it/events/SPIN2004/talks/12T_2_16501710_DalesioU.pdf



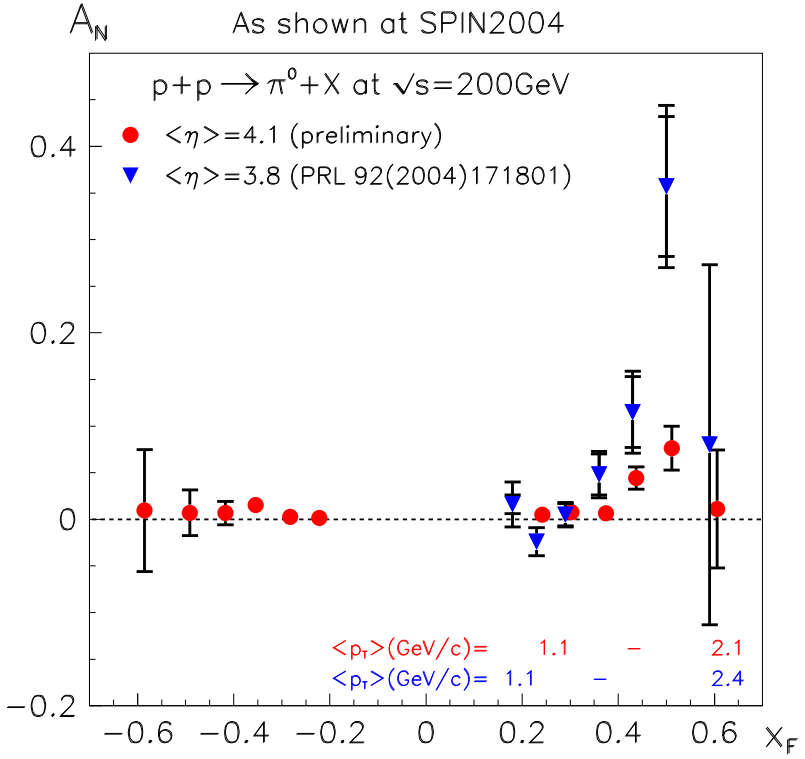


- A number of theoretical models predict non-zero spin effects at large x_F $\Rightarrow$ more precise measurements are needed to distinguish between different dynamics
- p_T-dependence of A_N: QCD models expect $1/p_T$ decrease of A_N

Previous Measurements of π^0 Cross Section and A_N at STAR



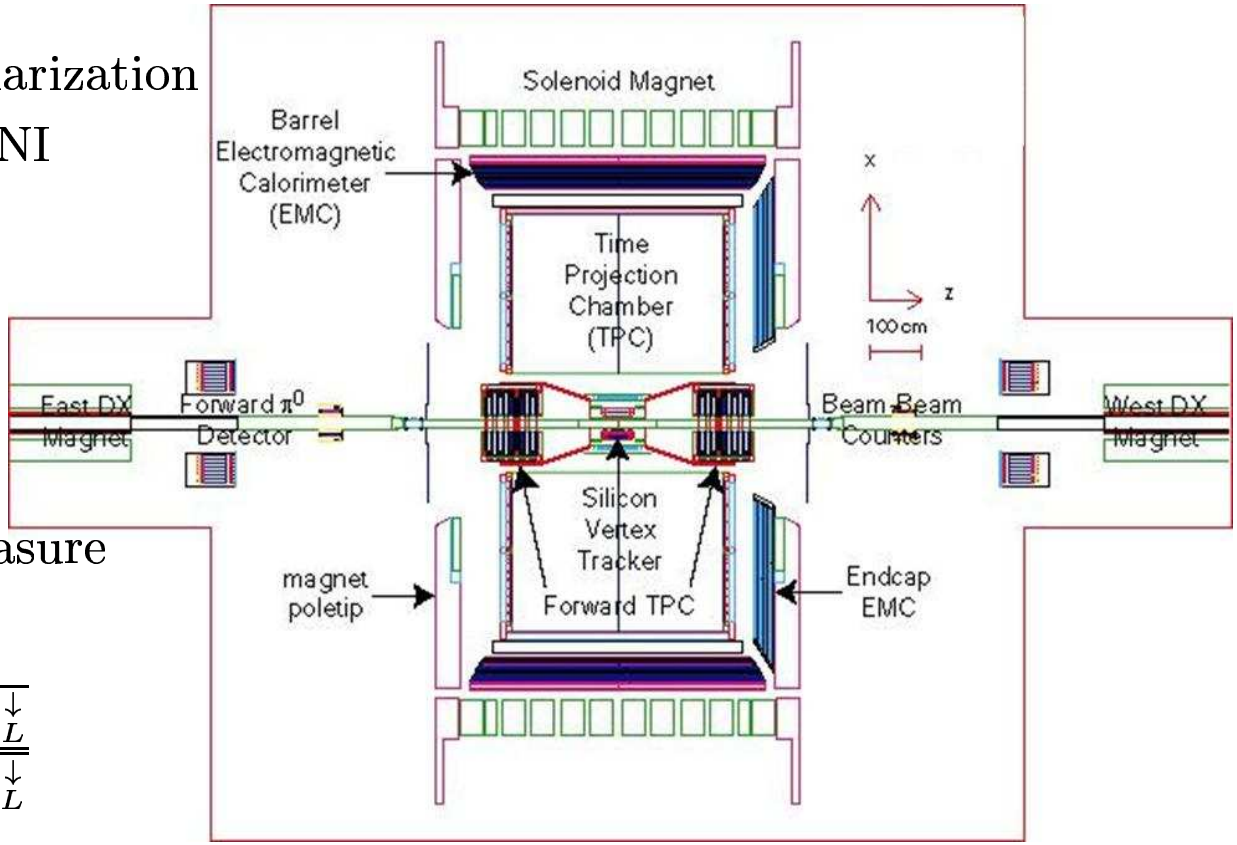
NLO pQCD calculations by W.Vogelsang et al.



Beam polarization used was determined with online calibration of the CNI polarimeter

Run5 Detector Layout and Data

0.4 pb^{-1} with transverse polarization P_{beam}~45%, measured by CNI polarimeter (online data)



"Cross ratio" method to measure the asymmetry:

$$A_N = \frac{1}{P_{beam}} \frac{\sqrt{N_L^{\uparrow} \cdot N_R^{\downarrow}} - \sqrt{N_R^{\uparrow} \cdot N_L^{\downarrow}}}{\sqrt{N_L^{\uparrow} \cdot N_R^{\downarrow}} + \sqrt{N_R^{\uparrow} \cdot N_L^{\downarrow}}}$$

Data Analysis

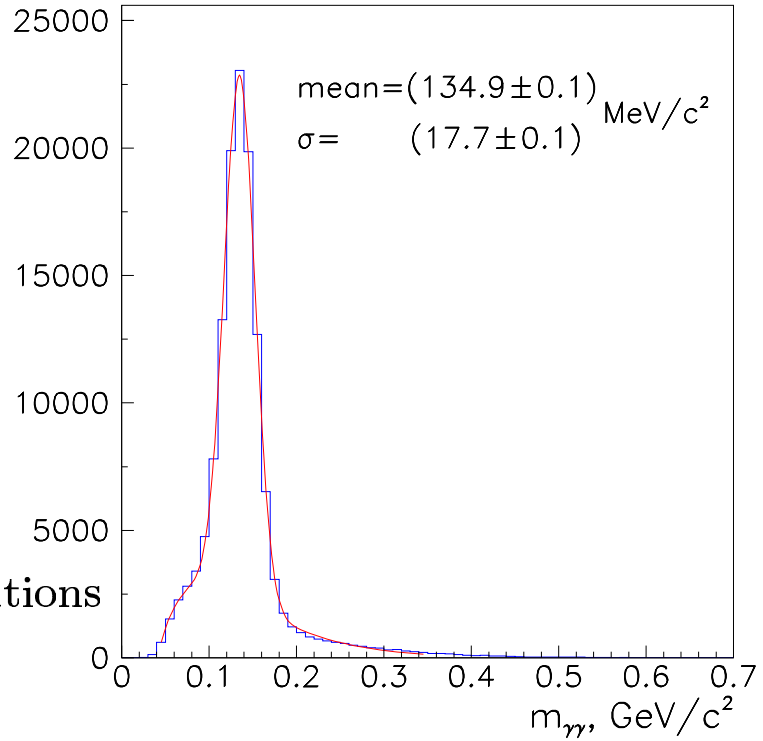
- Use of electromagnetic shower shape to reconstruct e/γ in the FPD
- Event selection criteria:

  $E_{tot} > 20$ GeV

  $N_\gamma \geq 2$

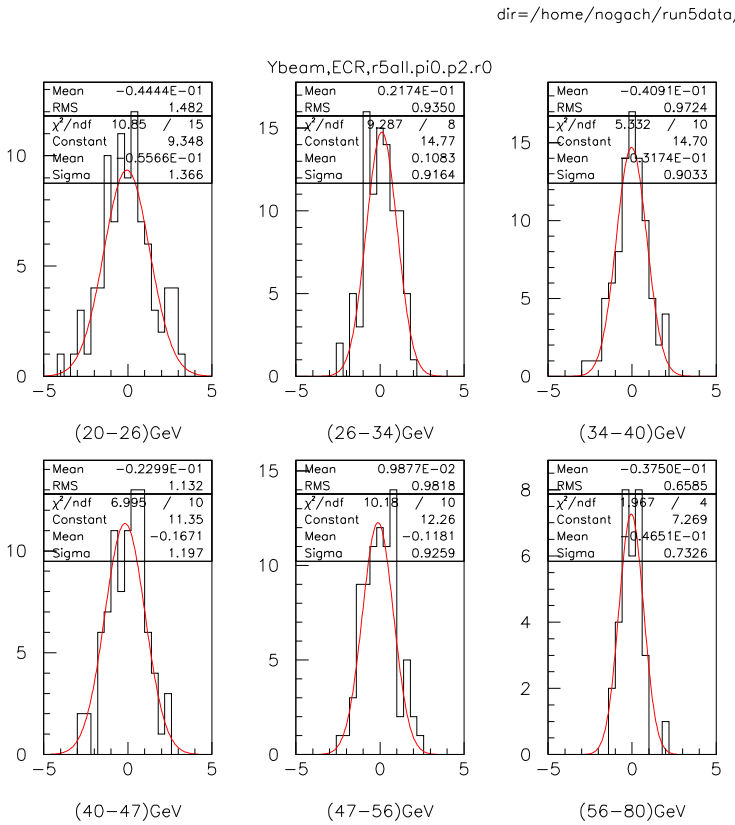
  $z_{\gamma\gamma} = |E_1 - E_2|/(E_1 + E_2) < 0.7$

  $0.07 < m_{\gamma\gamma} < 0.3$ GeV/c^2
- Calibration:
  - gains are determined from π^0 peak position in 2γ invariant mass distributions sorted by high tower
  - energy dependent gain corrections
  - run dependent gain corrections

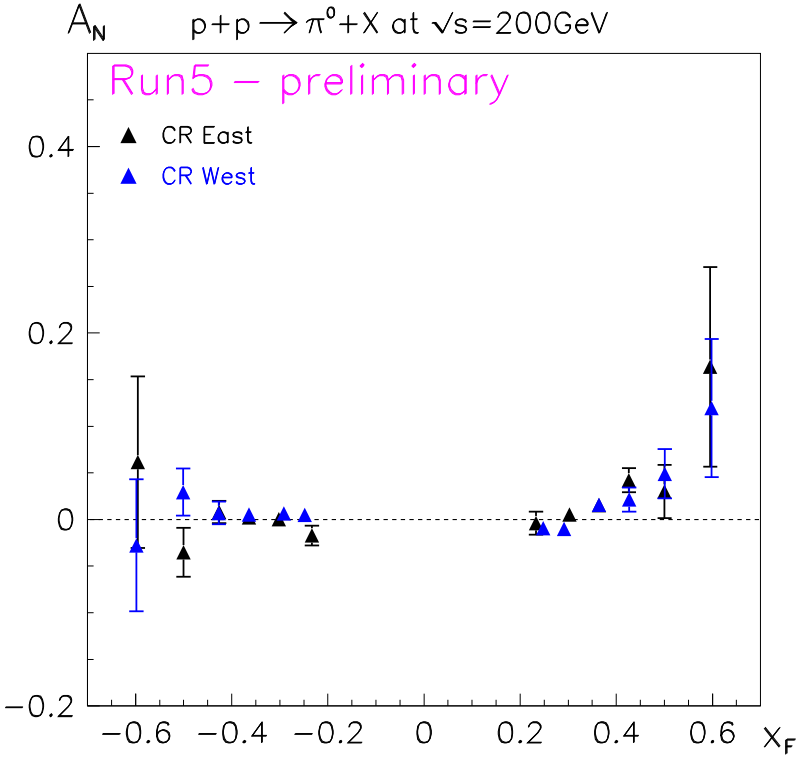


Study of Systematics

$$(A_N^{irun} - < A_N >)/\Delta A_N^{irun}$$

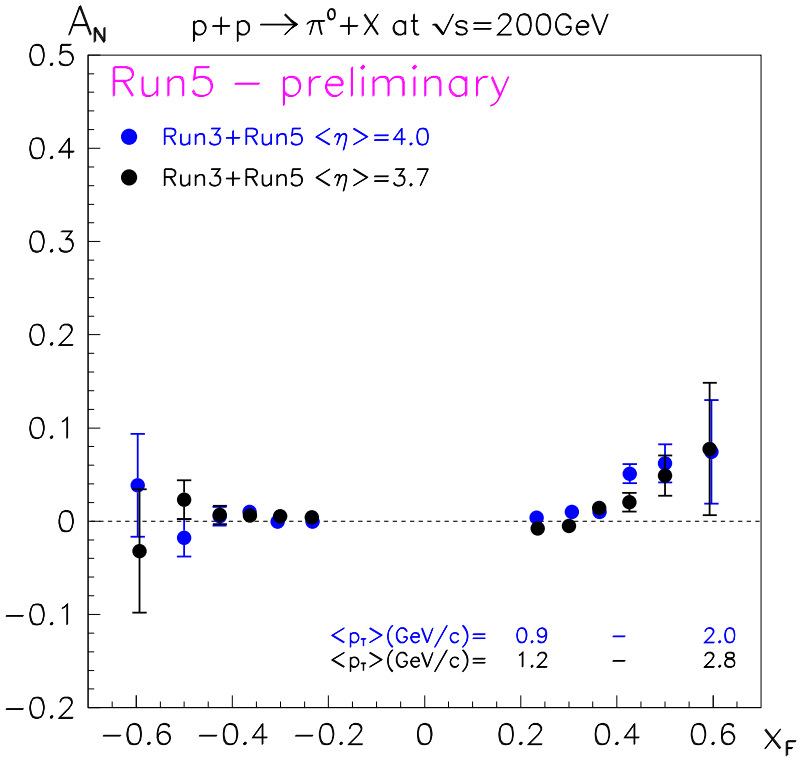


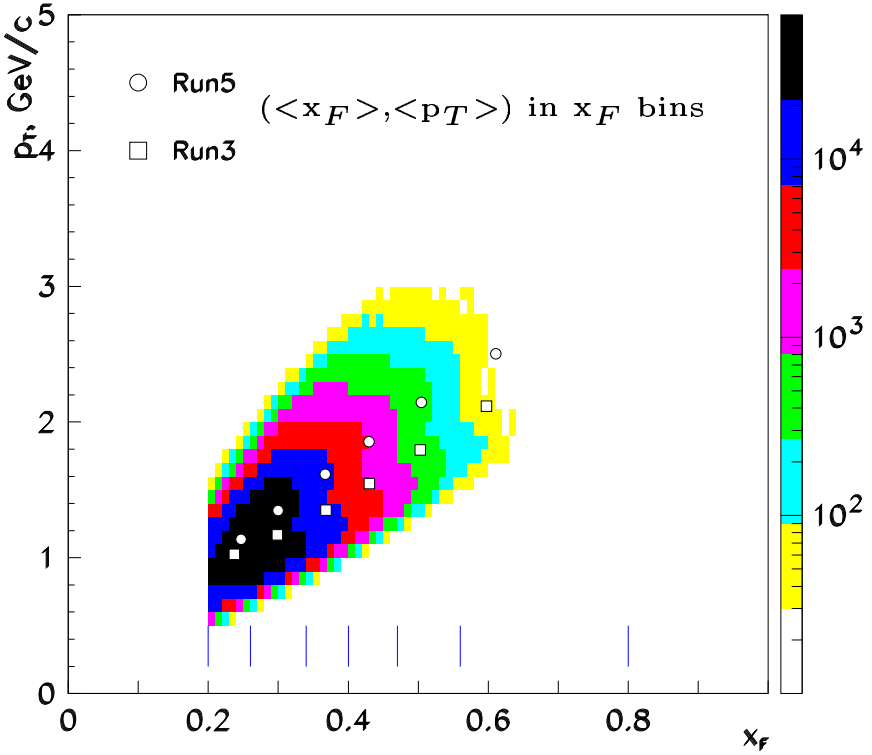
Width of the distributions
is generally consistent with statistics



Results from East and West
N/S detectors agreed ⇒ averaged

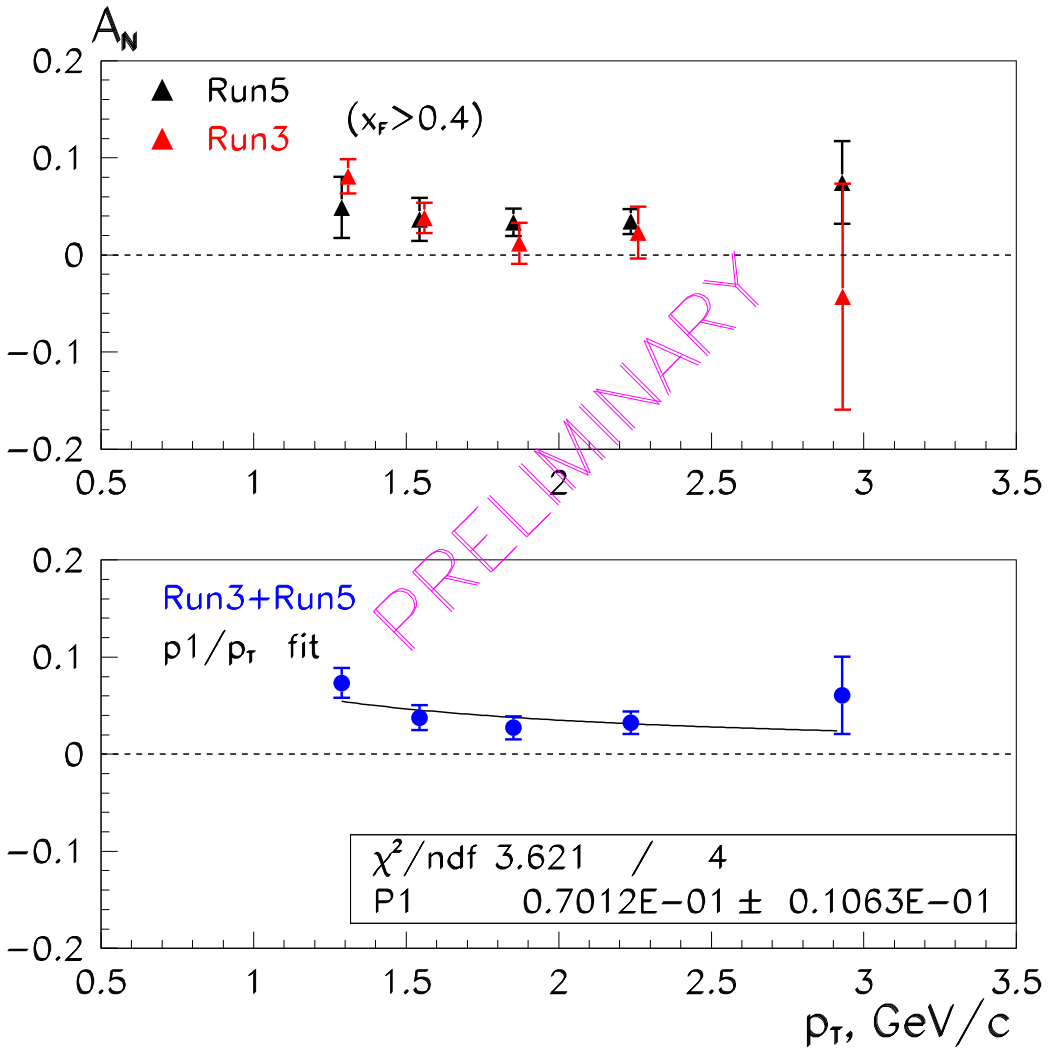
$A_N(x_F)$ at $\sqrt{s} = 200$ GeV





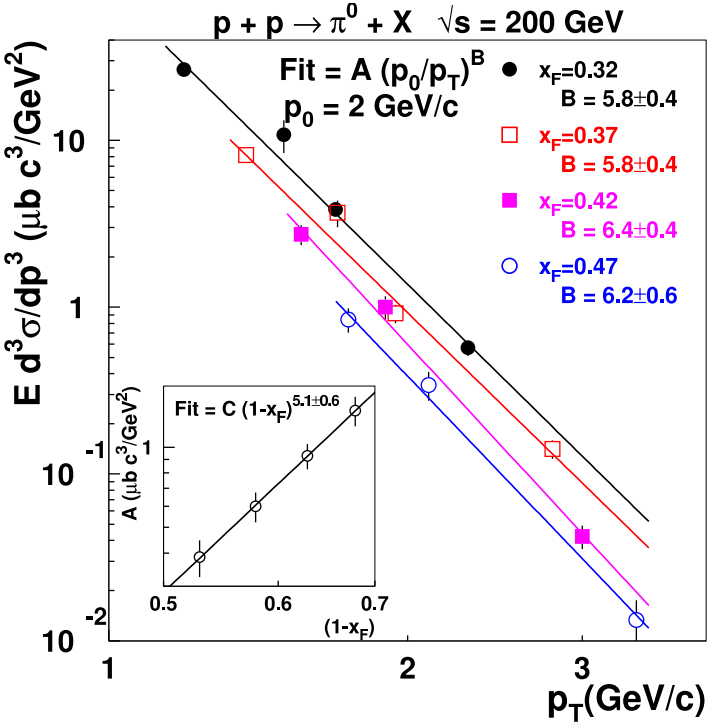
- A_N at negative x_F is consistent with zero
- A_N at positive x_F is consistent with zero up to $x_F \sim 0.3$, then grows with increasing x_F

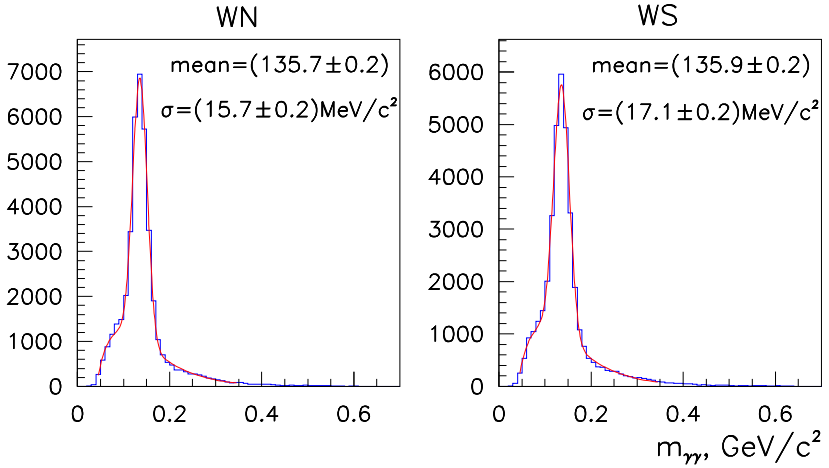
p_T-dependence of A_N at $x_F > 0.4$



- Hint of A_N decrease with p_T from Run3&Run5 data
- More data needed to establish (fixed x_F) p_T-dependence

Separated p_T and x_F dependences of π^0 Cross Section



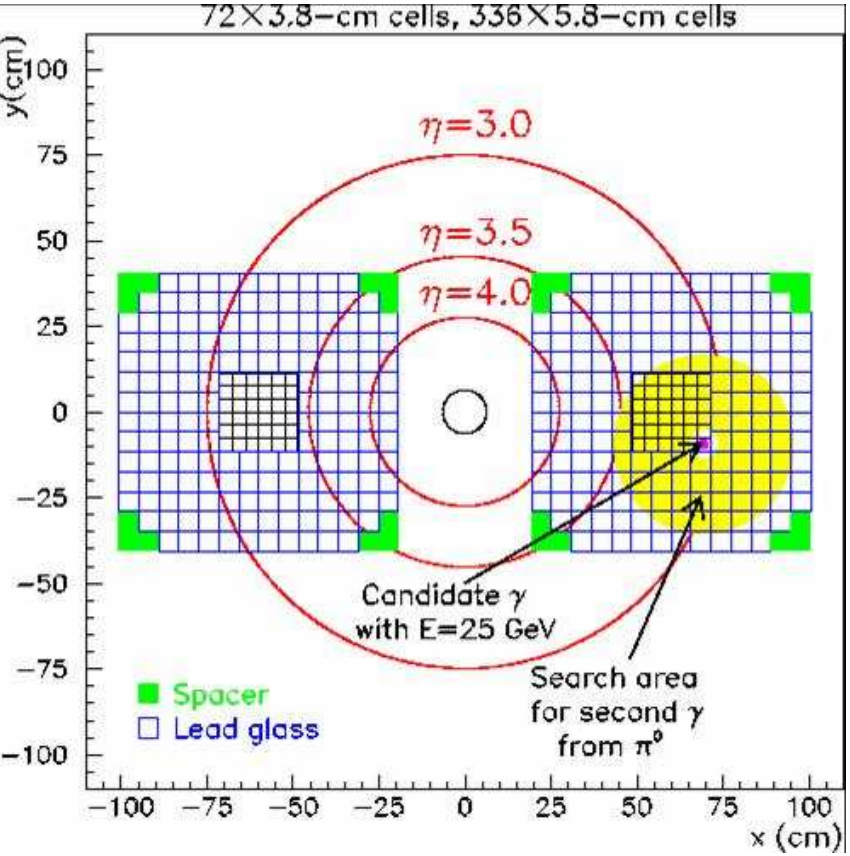


FPD data at $\sqrt{s} = 410$ GeV may test pQCD scaling of π^0 cross section

$$E\frac{d^3\sigma}{dp^3} \propto \left(\frac{\sqrt{s}}{2p_T}\right)^A \left(\frac{1}{p_T}\right)^B (1-x_F)^N$$

$N \approx 5, \quad A + B \approx 6,$ pQCD scaling gives $B = 4$

Plans for the Near-term Future

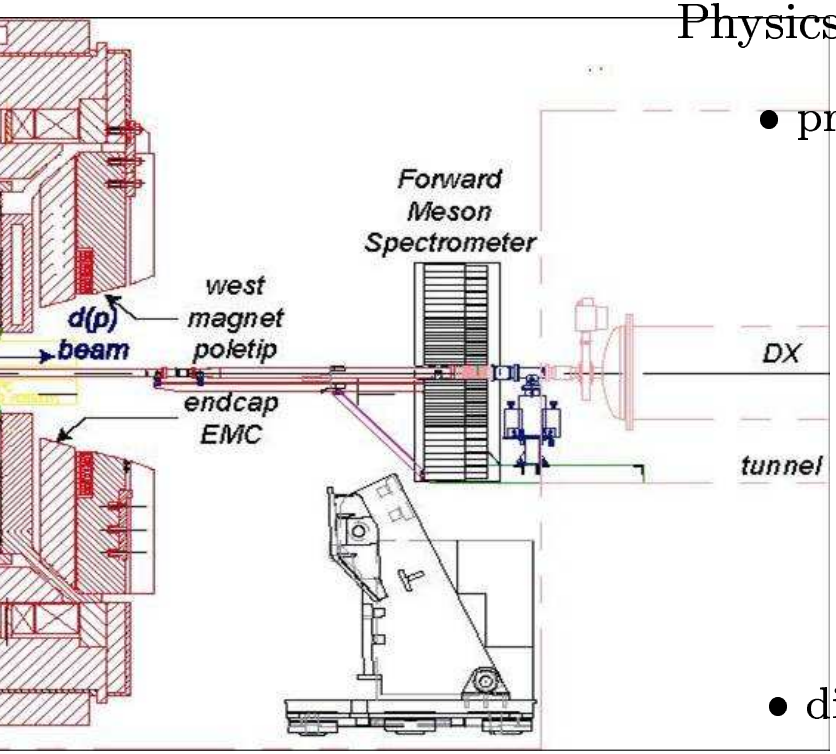


Existing N/S/T/B detectors well suited to large rapidity inclusive π^0 reconstruction

Implementation of interim forward calorimeter (FPD++) designed for single photons detection is planned for Run6:

- inner matrix of 3.8x3.8x45 cm^3 lead-glass cells to reconstruct γ/π^0 up to $\sim$60 GeV
- outer matrix of 5.8x5.8x60 cm^3 lead-glass cells for isolation over broad $\Delta\eta - \Delta\phi$ range

Outlook: Forward Meson Spectrometer



Physics motivation:

- probing gluon saturation in p(d)+Au collisions via:
  - large rapidity particle production
    $(\pi^0, \eta, \omega, \gamma, K^0, J/\psi)$
    detected through γ or $e^{\pm}$ decays
  - forward di-jet surrogates $(\pi^0 - \pi^0)$
    probe gluons with smallest Bjorken-x
    in Au nucleus
  - di-jets with large rapidity interval
    (Mueller-Navelet jets)
- disentangling dynamical origin of large x_F
  analyzing power in $p^{\uparrow} + p$ collisions

FMS will provide 2π azimuthal coverage for $2.5 < \eta < 4.0$

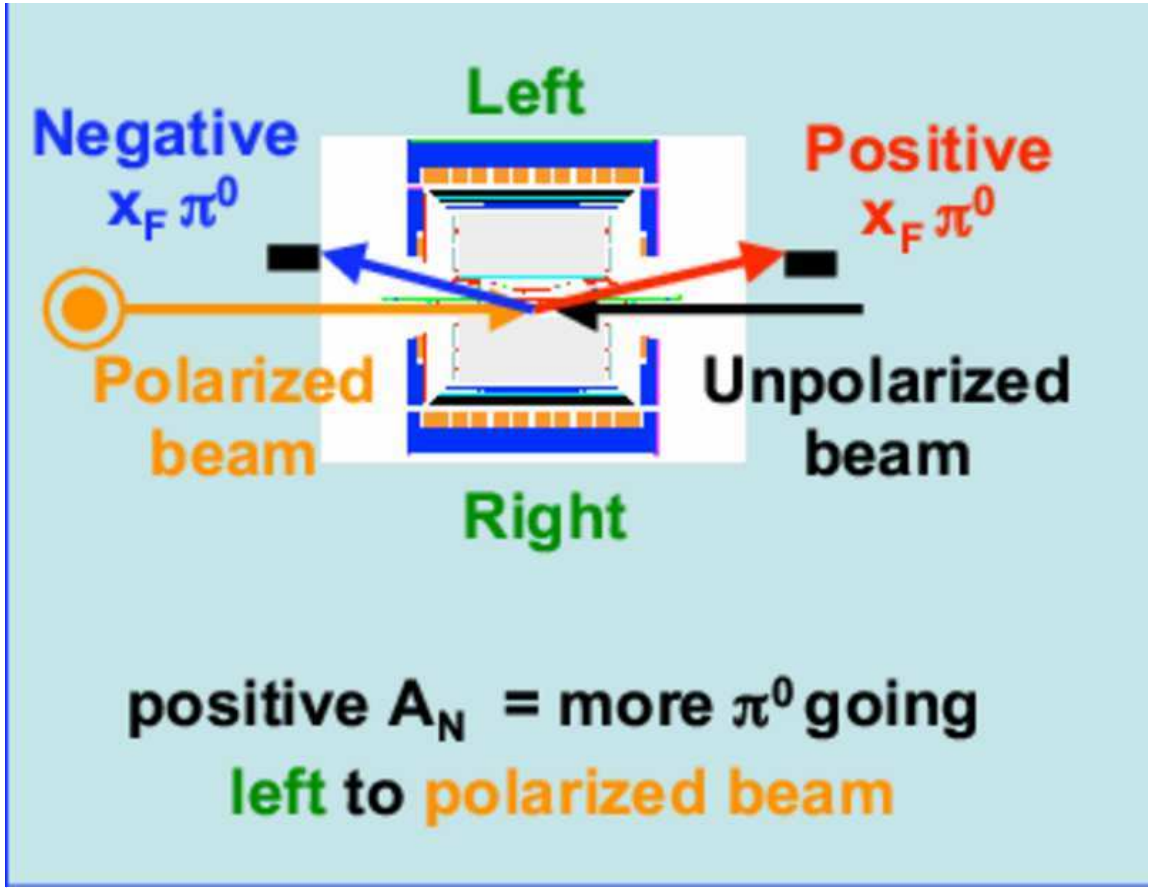
Expected completion by October 2006

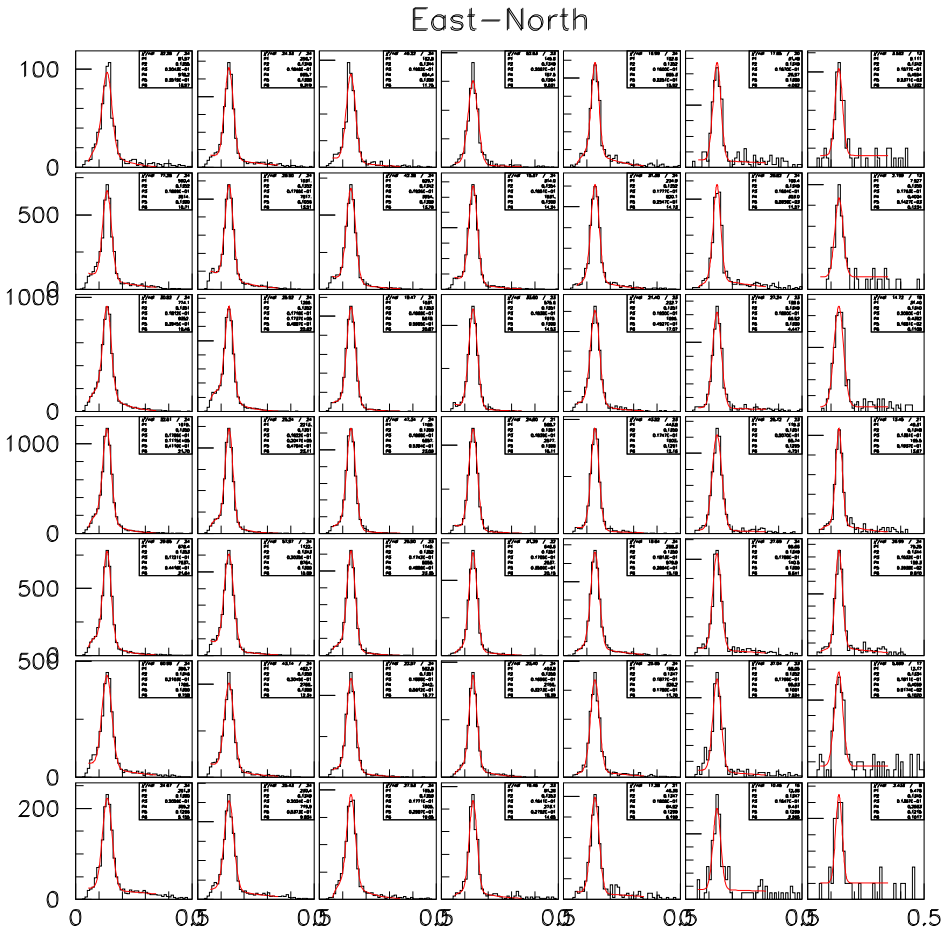
Summary and Plans

- Noticeable A_N for π^0 production in $p^\uparrow + p$ collisions at $\sqrt{s} = 200$ GeV has been observed at $x_F > 0.4$
- First result for the $A_N(p_T)$ was obtained using combined statistics from Run3&Run5. There is a hint that the π^0 analyzing power at $x_F > 0.4$ decreases with increasing p_T.
- To do:
  - study of systematics errors
  - final results for the π^0 asymmetry (final data on beam polarization are required)
  - π^0 cross section at $\sqrt{s} = 410$ GeV
- In Run6:
  - integrated luminosity $\sim$10 pb^{-1} with transverse polarization is requested with $P_{beam}\sim$50% $\Rightarrow \sim$25 times increase in FOM compare to Run3 and Run5 combined data
  - planning enhancement of forward calorimetry in STAR — FPD$_{++}$ — for γ/π^0 separation

Definitions

$$A_N = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} = \frac{\Delta_T \sigma}{2\sigma}$$



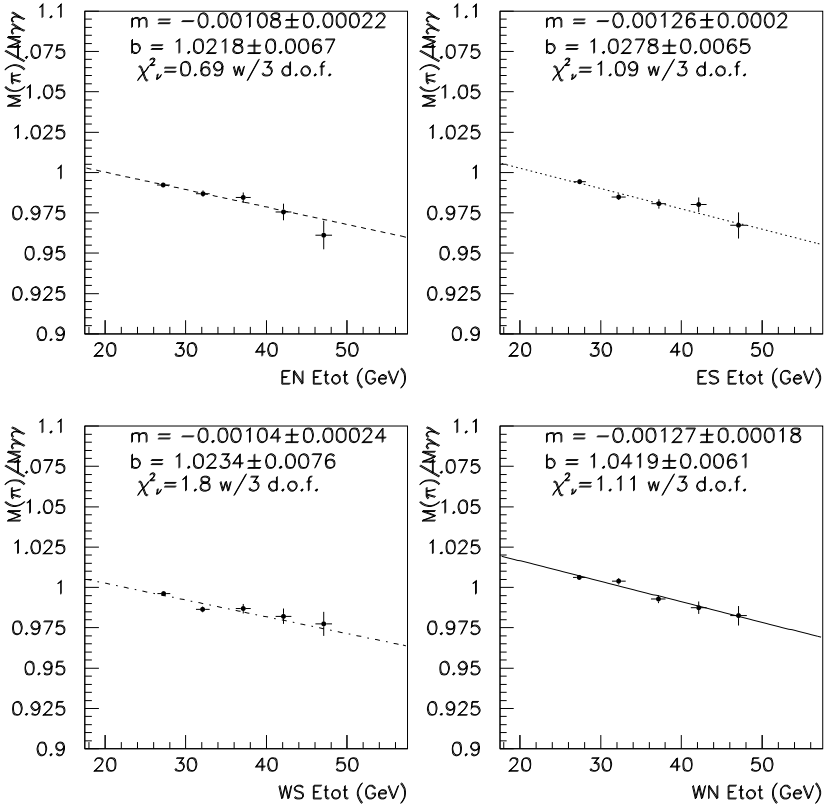


PMT gain matching:

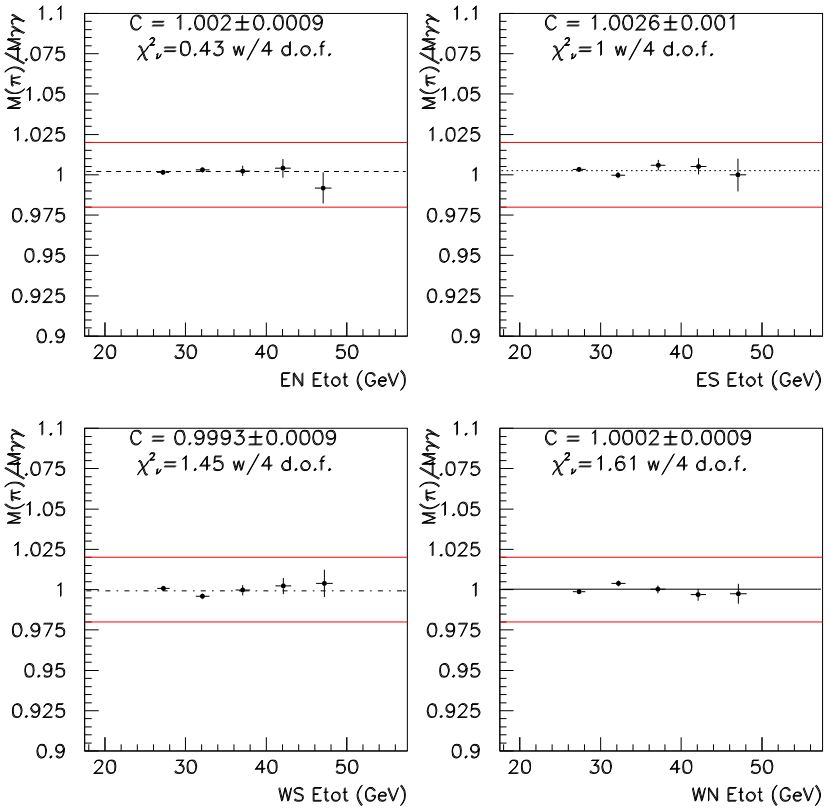
- Gains are determined from π^0 peak position for each tower
- The calibration of FPD is known to an accuracy of 2%

Energy Dependent Gain Corrections

Set 501, sum all, Uncorrected, Fit=m*E+b

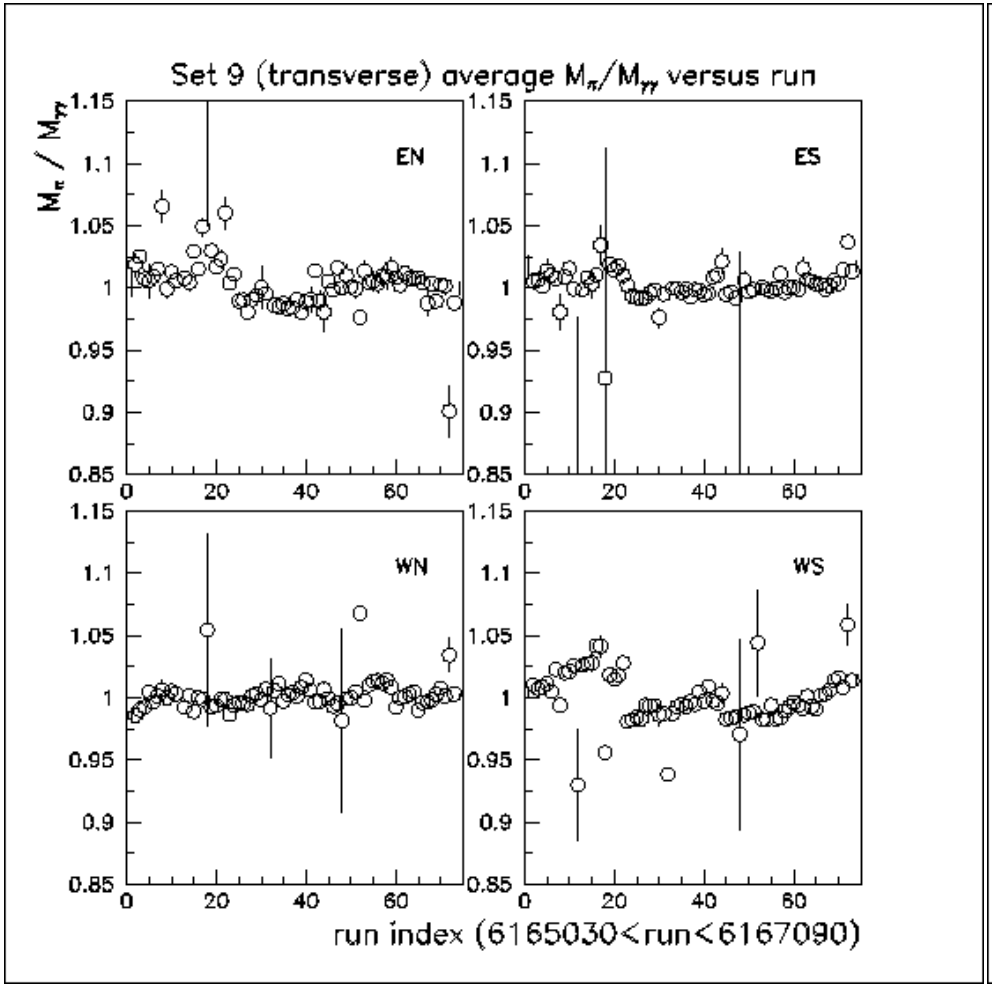


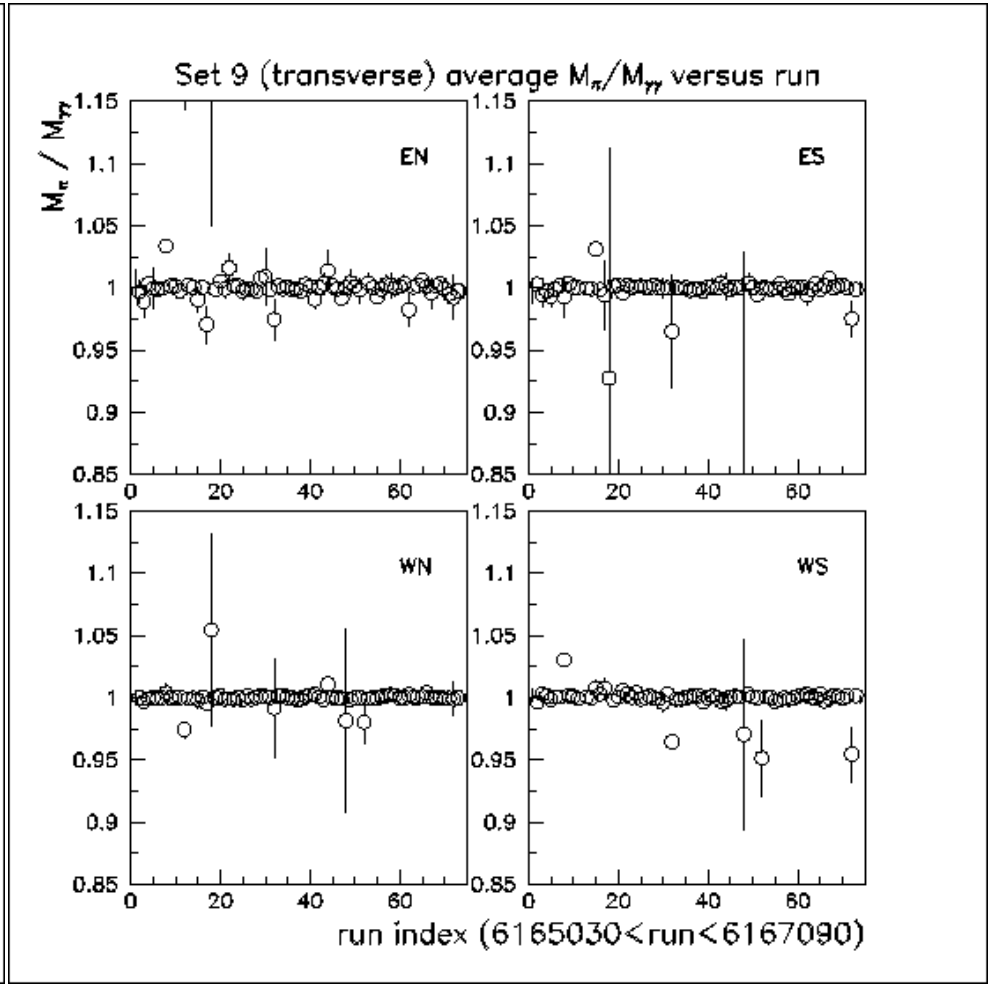
Set 501, sum all, Corrected, Fit=C



Time dependent Gain Corrections

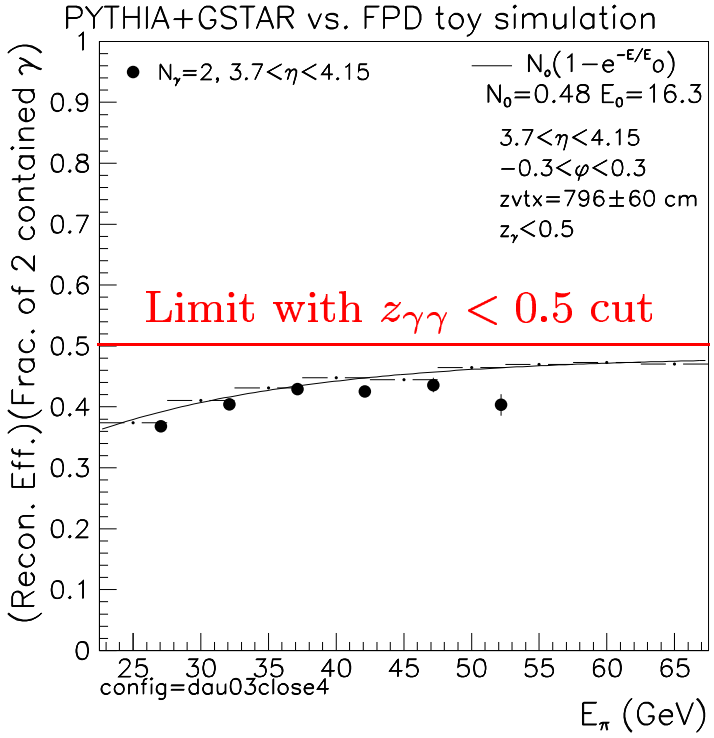
BACKUP

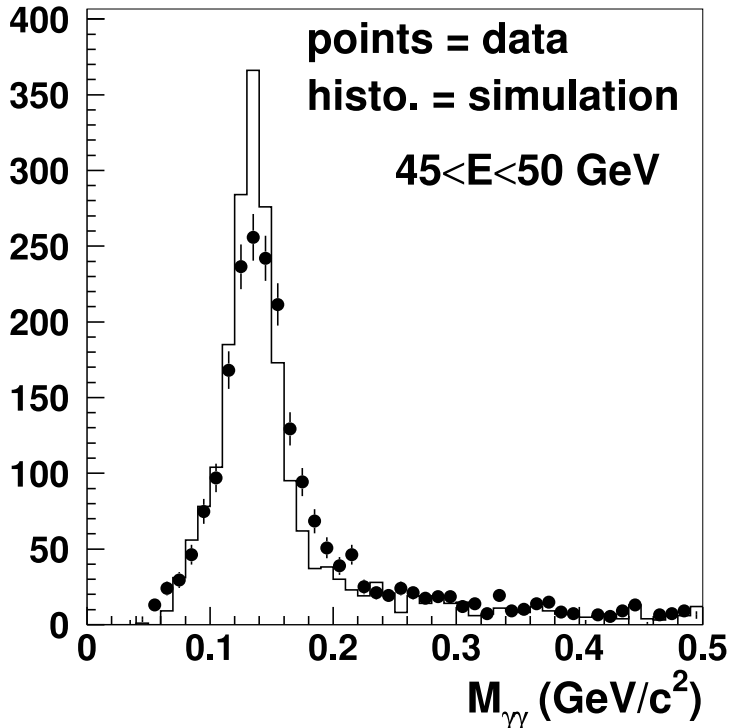




MC-data Comparison

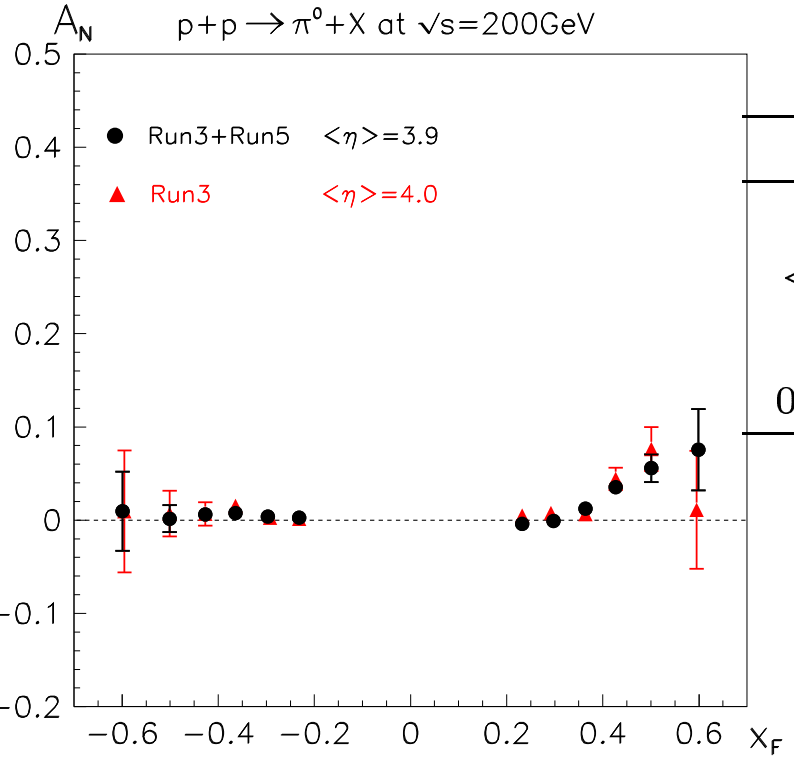
FPD simulations were done using PYTHIA and GSTAR,
and reconstructed with identical code used for the data





Events selection: $N_\gamma = 2$, $z_{\gamma\gamma} = |E_1 - E_2|/(E_1 + E_2) < 0.5$,
Fiducial Volume cut (0.5 cell width from the edge
of the calorimeter), $Etot > 20$ GeV

Statistical significance of the A_N measurements



	Run3	Run5
$\int Ldt, pb^{-1}$	0.2	0.4
$< P_{beam} >$, %	27	45
A_N, % at		
$0.4 < x_F < 0.8$	(5.00 ± 1.05)	(3.50 ± 0.82)

Combined:

$(4.01 \pm 0.64)\%$