

# ***First Polarized Proton Collisions at PHENIX***

DIS2002 in Cracow

May 2, 2002

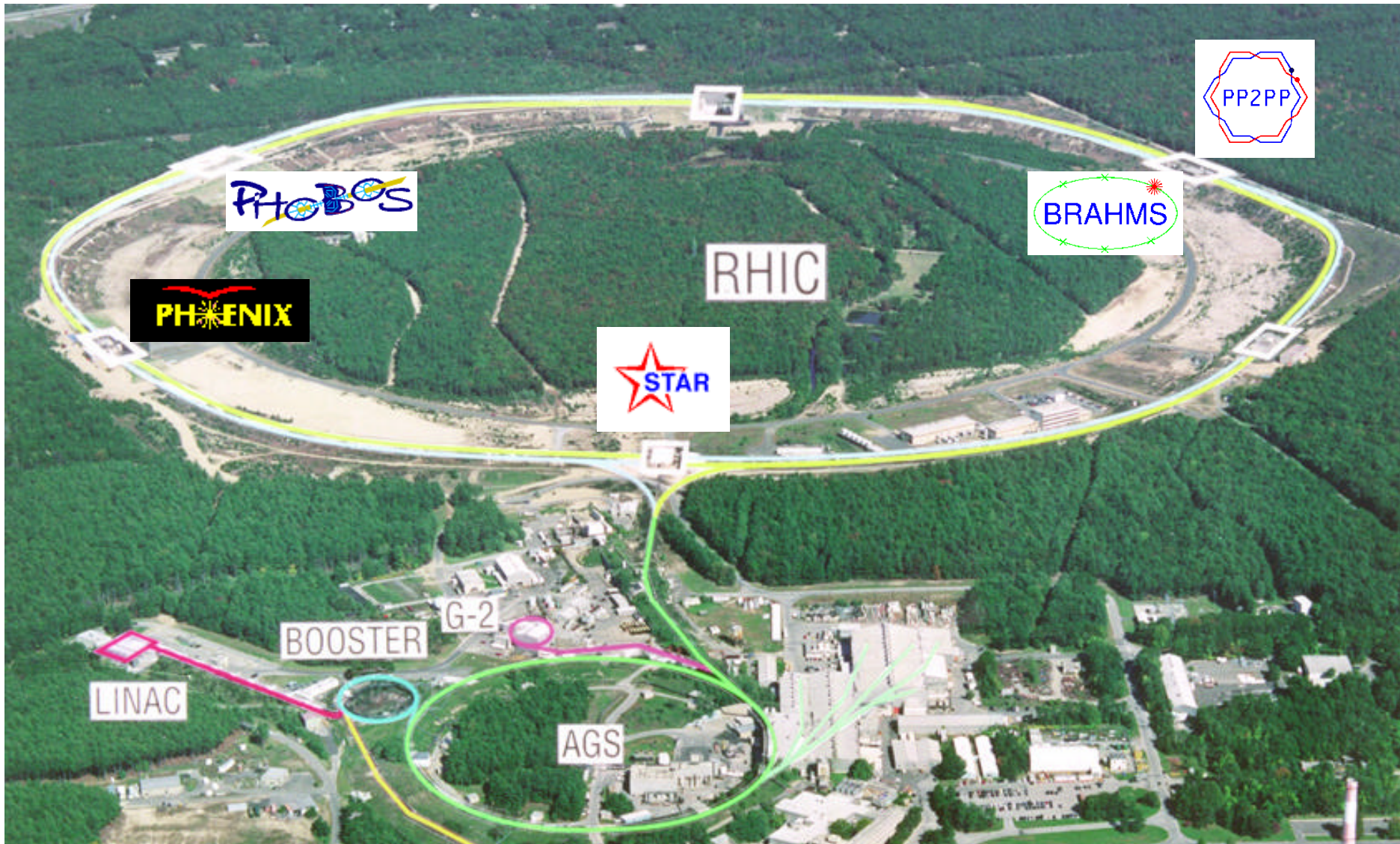
Yuji Goto (RIKEN/RBRC)

for the PHENIX Collaboration

# *Outline*

- Introduction
- Run-2 (2001-2002) summary
- $A_N$  measurements at PHENIX
- $A_N$  measurements at IP12
- Summary

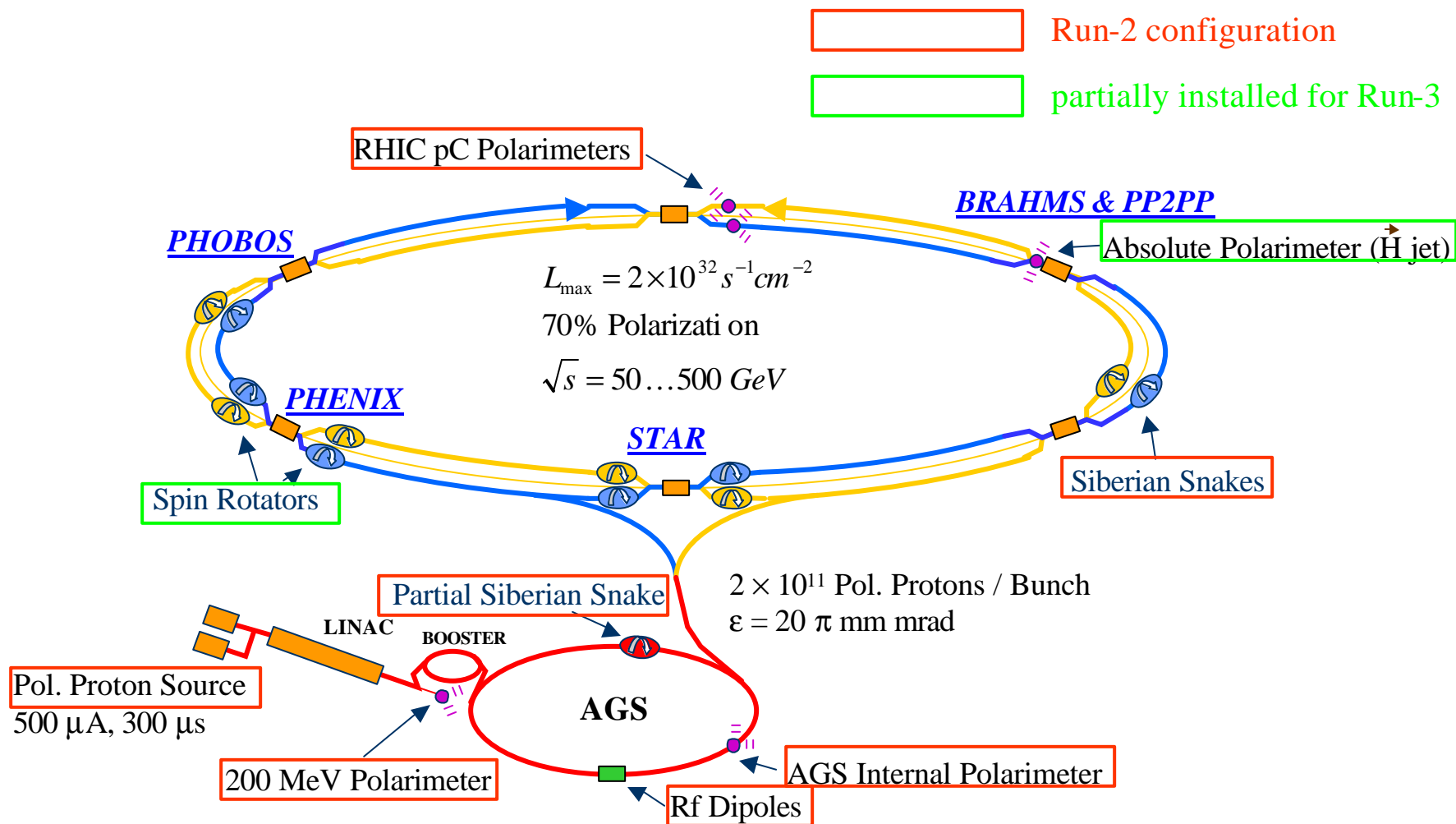
# *RHIC*



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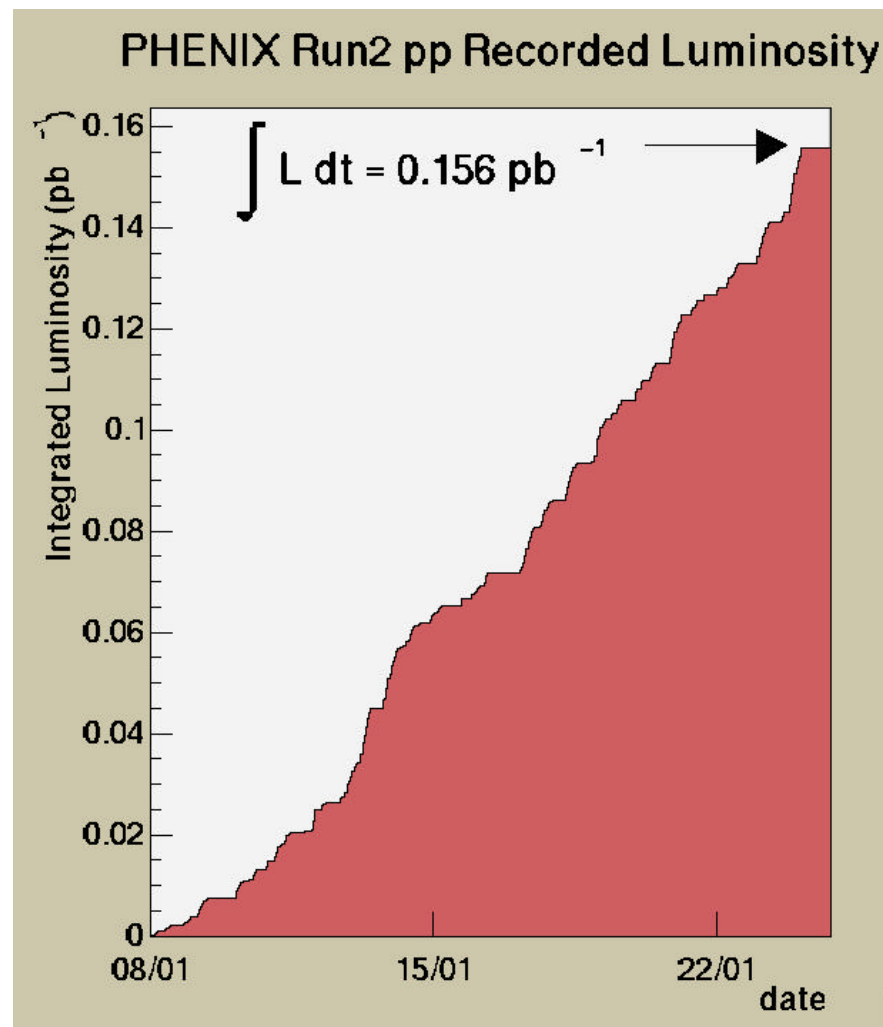
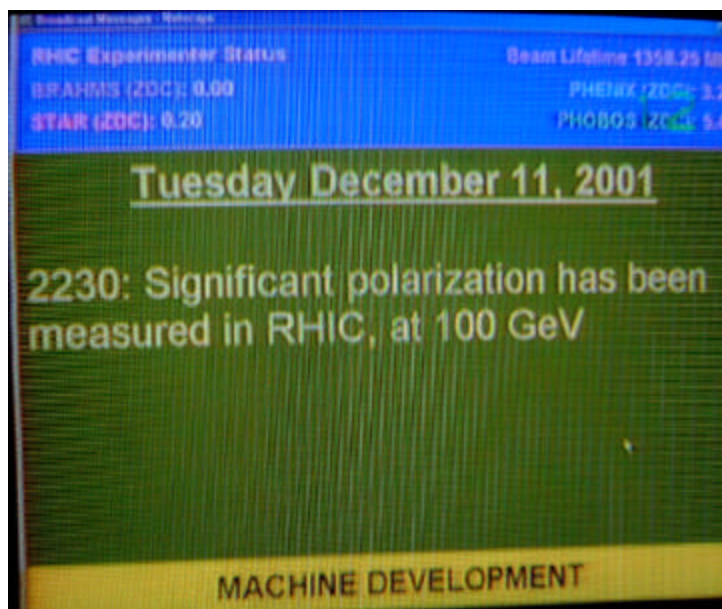
# RHIC Polarized Proton Collider





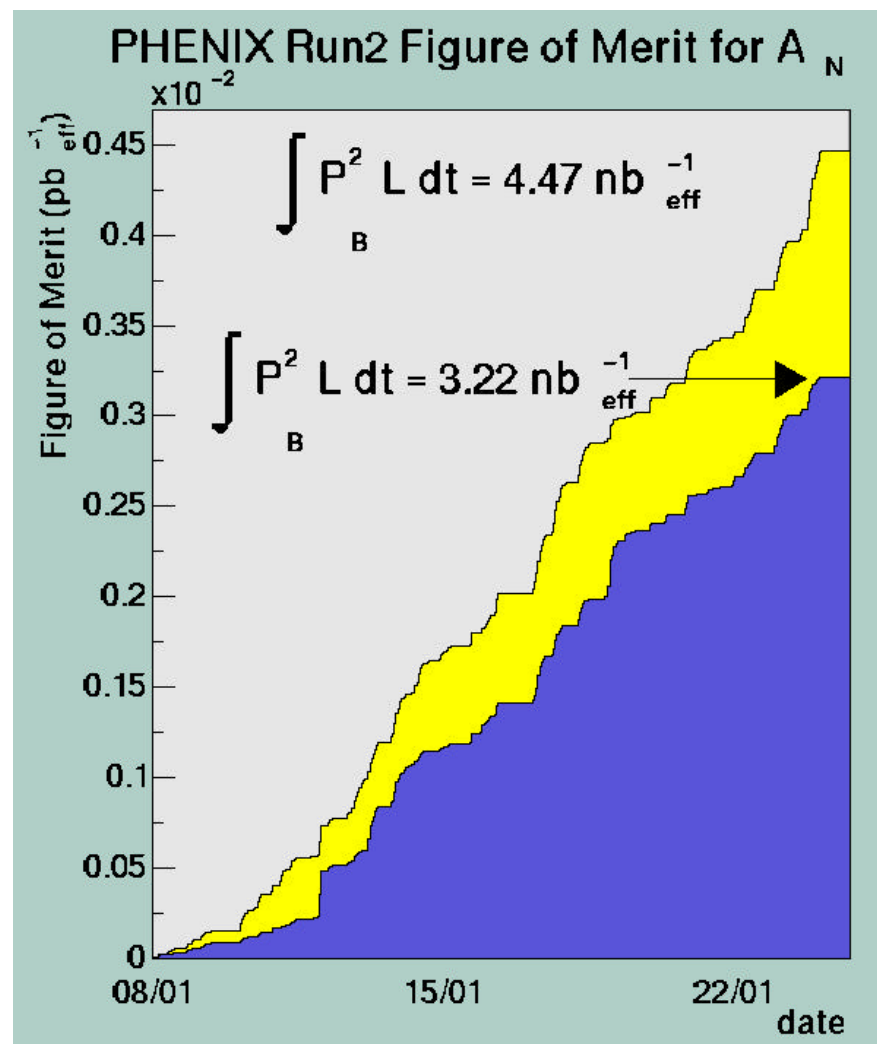
# *Run-2 (2001-2002) Summary*

- First polarized proton collisions !
  - Dec. 11, 2001 !!
  - integrated luminosity  $0.18 \text{ pb}^{-1}$
  - $L = 1.5 \times 10^{30} \text{ cm}^{-1} \text{ sec}^{-1}$  at maximum



# Run-2 (2001-2002) Summary

- Low polarization
  - $\langle P_{\text{yellow}} \rangle = 17\%$
  - $\langle P_{\text{blue}} \rangle = 14\%$
  - 25 % at maximum
- No  $A_{LL}$  measurement
  - no gluon polarization data
  - proposing in Run-3 (2002-2003)
    - integrated luminosity  $> 3 \text{ pb}^{-1}$
    - polarization  $> 40\%$
- $A_N$  measurement
  - first results will come soon

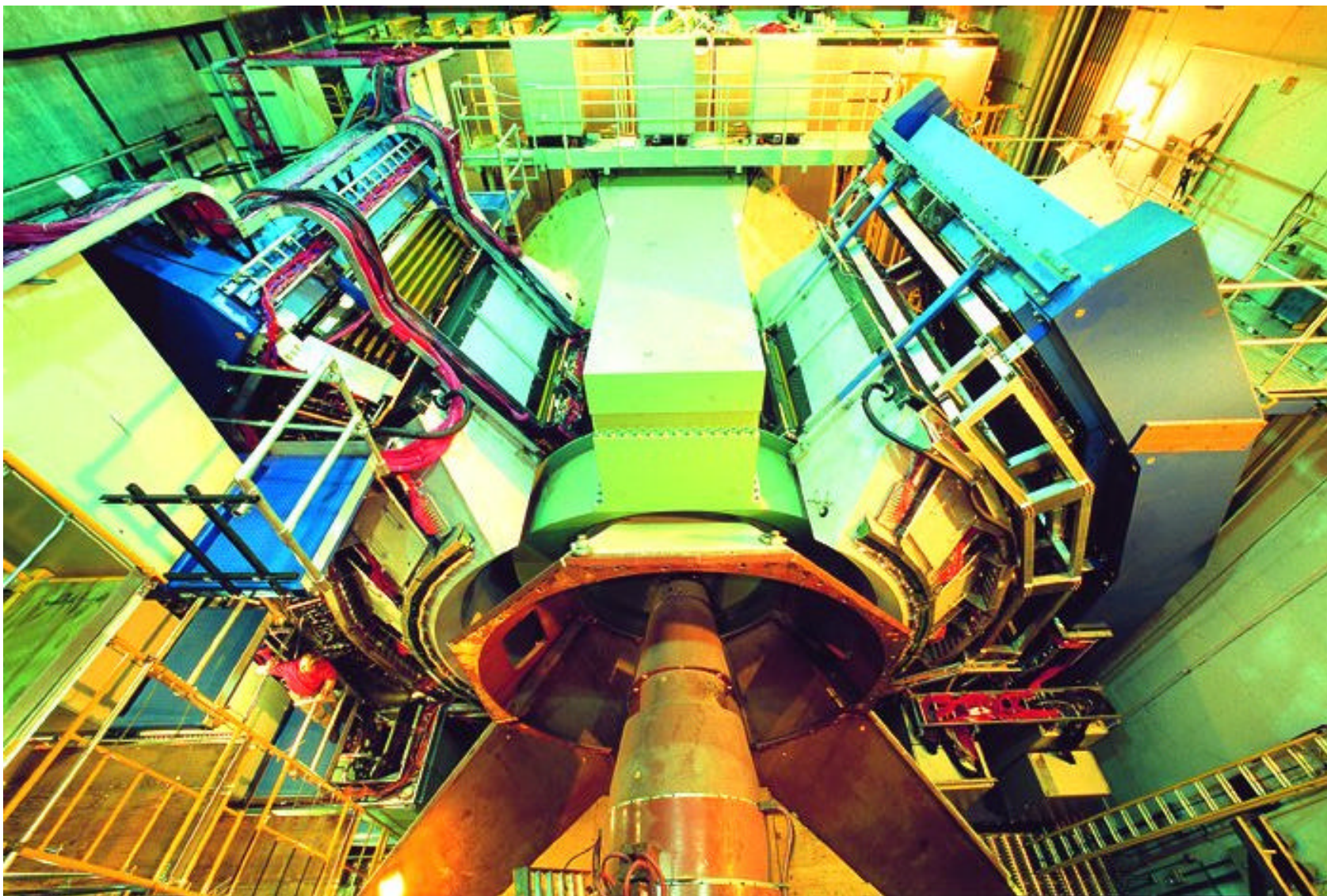


# *$A_N$ Measurements at PHENIX*

- Central arm
  - mid-rapidity measurements
  - $x_F \sim 0$
  - asymmetry to  $p_T = 8 \text{ GeV}/c$  (cross section to  $p_T = 20 \text{ GeV}/c$ )
  - neutral pion, charged hadrons(, single-e, J/ $\psi$ , photon)
- Muon arm
  - forward measurements
  - $p > 2 \text{ GeV}/c \leftrightarrow p_T > 0.4 \text{ GeV}/c, 1.2 < \mathbf{h} < 2.4$
  - single- $\mu$ (, J/ $\psi$ , e- $\mu$  coincidence)



# *PHENIX in Run-2*



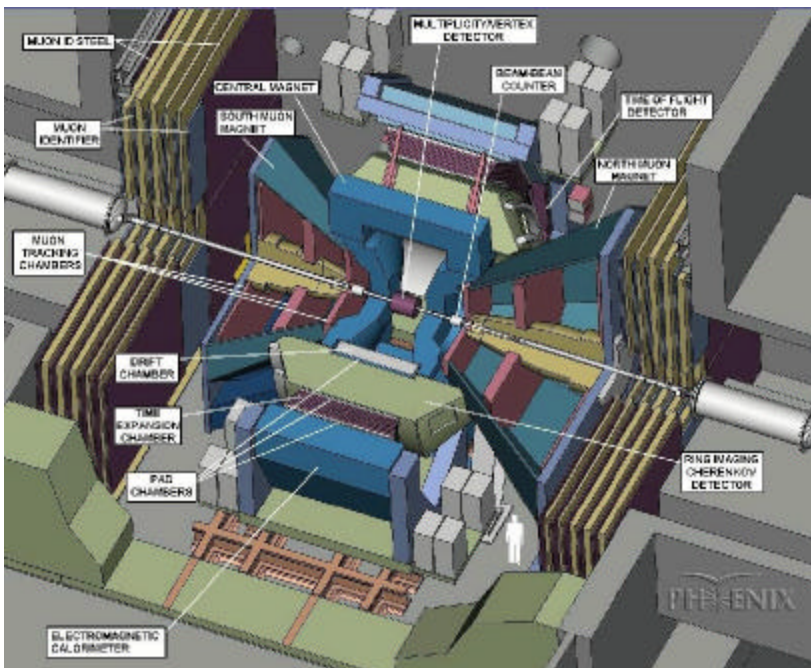
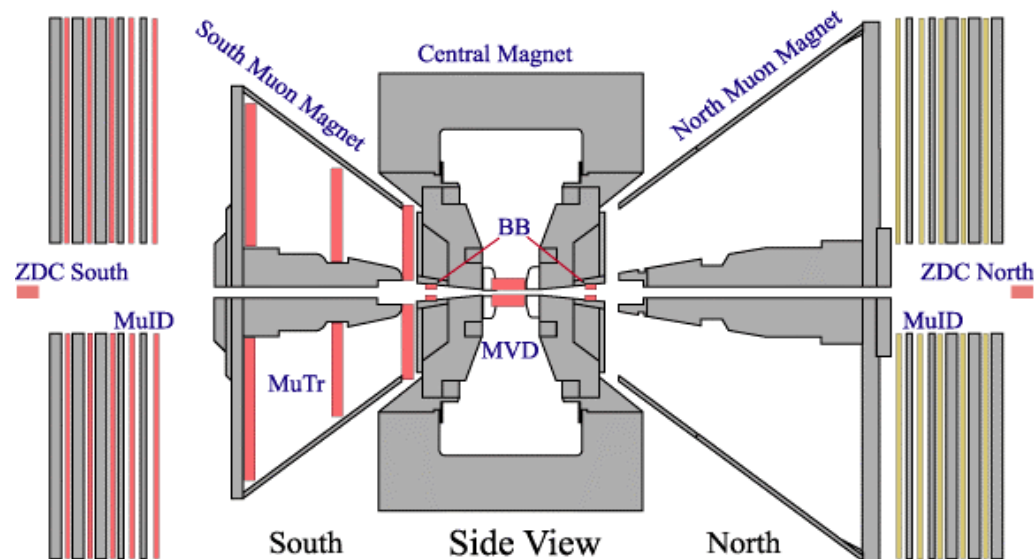
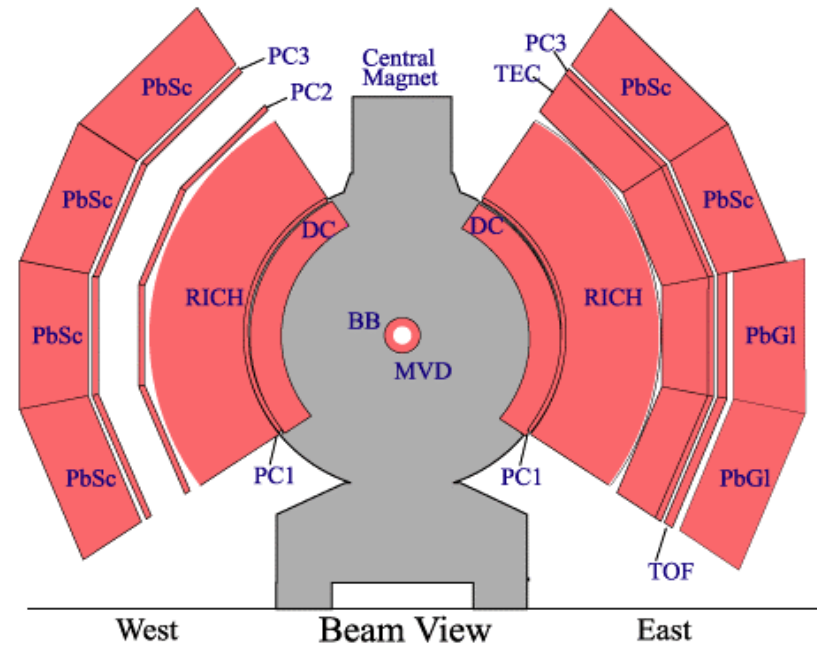
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# *PHENIX in Run-2*

- Full central arms
- South muon arm

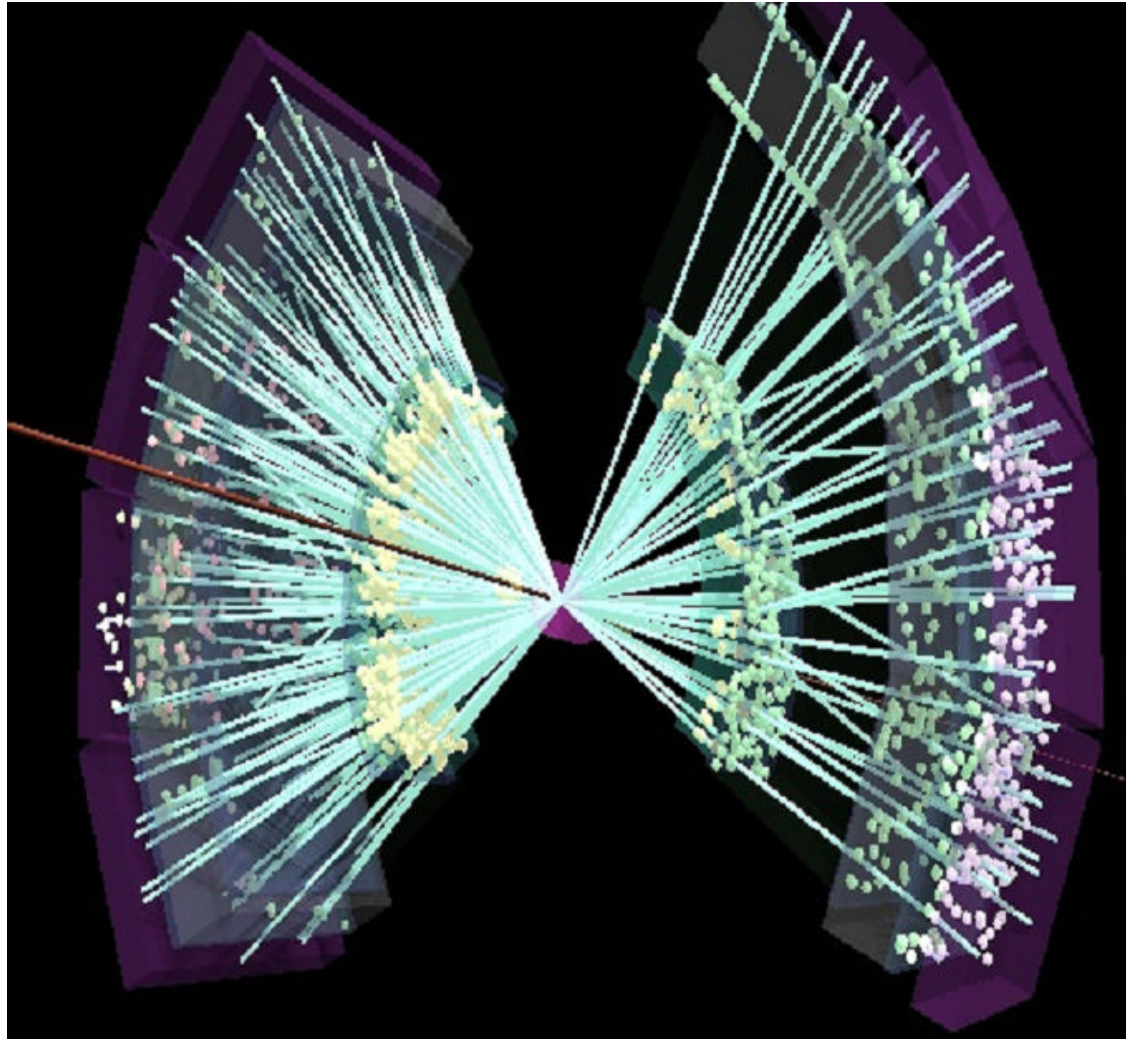


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# *PHENIX in Run-2*

- $\sqrt{s_{NN}}=200\text{GeV}$  heavy-ion (Au+Au) collision

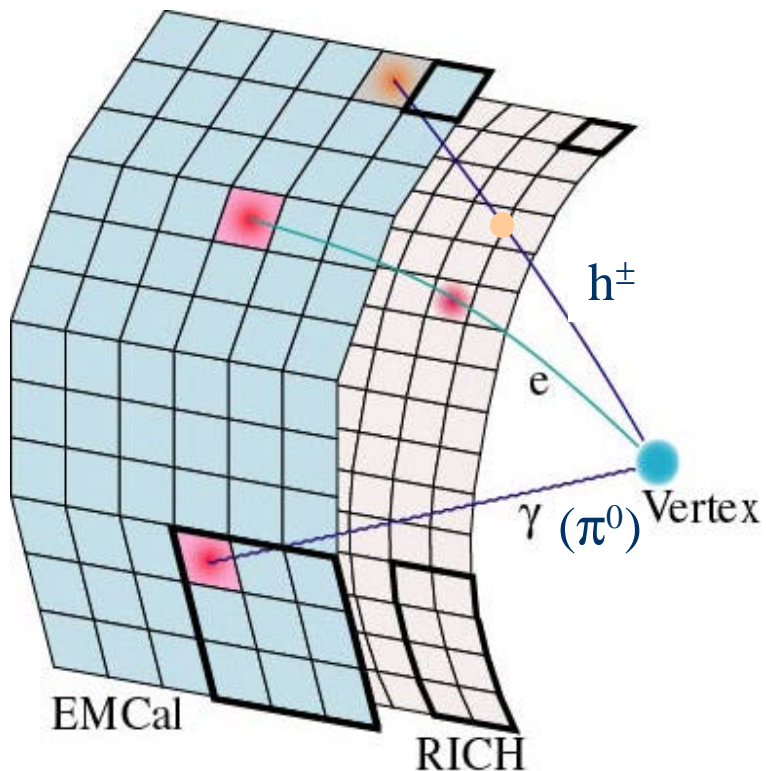


# *PHENIX in Run-2*

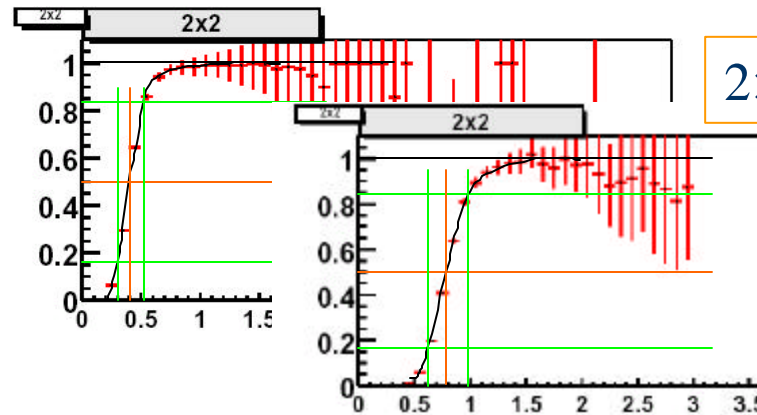
- For p+p collisions
  - new triggers
    - EMCal-RICH trigger
    - MuID trigger
  - new counters
    - NTC (additional interaction trigger & luminosity monitor)
    - T0 counter (TOF start counter) + PCR (photon conversion rejector)
  - luminosity scalers
    - crossing-by-crossing scalers
    - 32-bit $\times$ 120 $\times$ 4 scalers
  - DAQ
    - 1kHz & 70MB/sec

# Triggers

- EMCal-RICH trigger

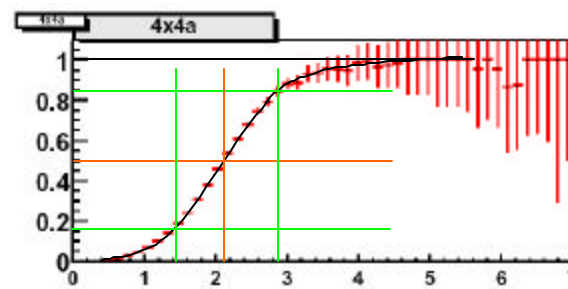


## EMCal high- $p_T$ trigger (PbSc)



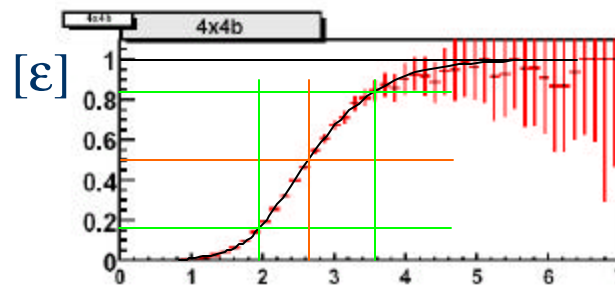
2x2 tile

0.4 GeV  
or 0.8 GeV  
threshold



4x4 tile (low)

2.1 GeV  
threshold

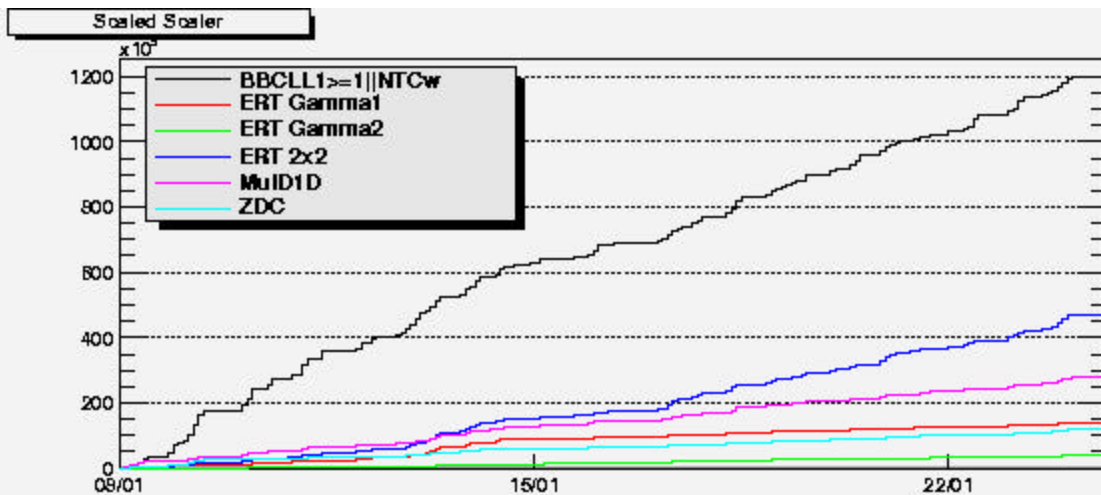


4x4 tile (high)

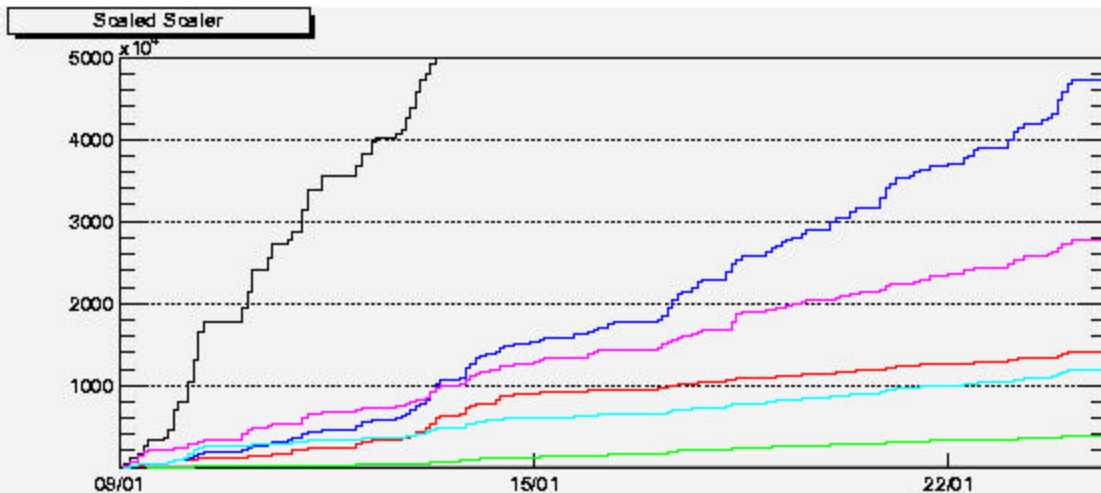
2.7 GeV  
threshold



# Triggers



- minimum-bias trigger
  - 200M events
  - comparison with heavy-ion data

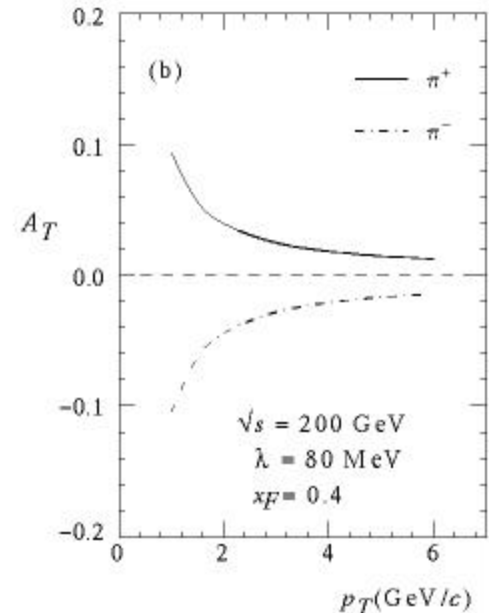
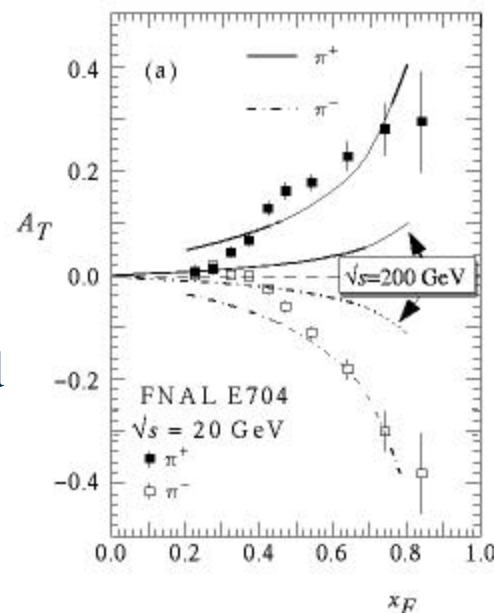
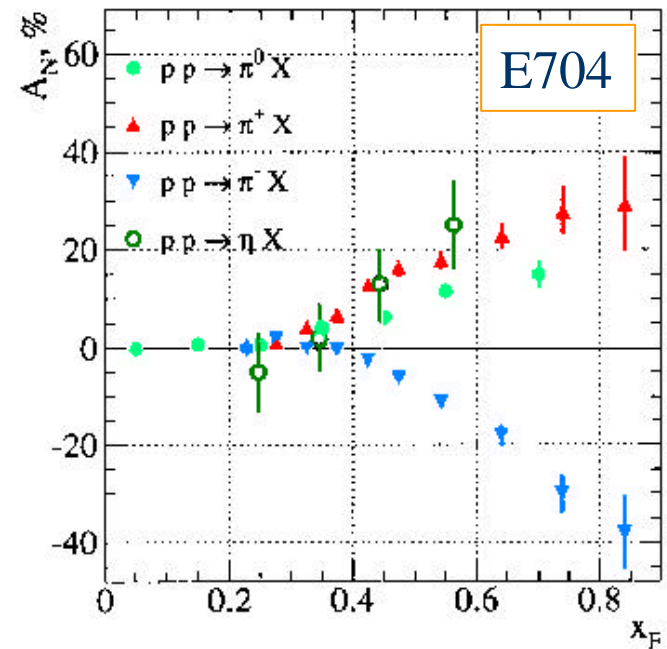


- EMCal-RICH trigger
  - 2 $\times$ 2 tile trigger
  - 800 MeV thr.
  - 60M events
  - to trigger photon,  $\pi^0$ , charged hadrons, electron

- MuID trigger
  - 30M events
  - to trigger single- $\mu$

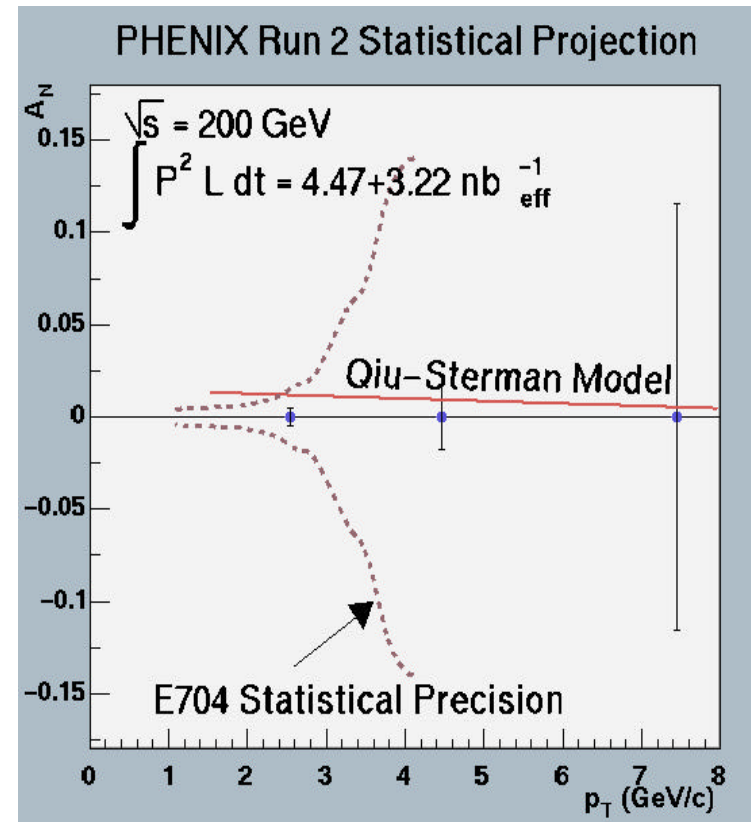
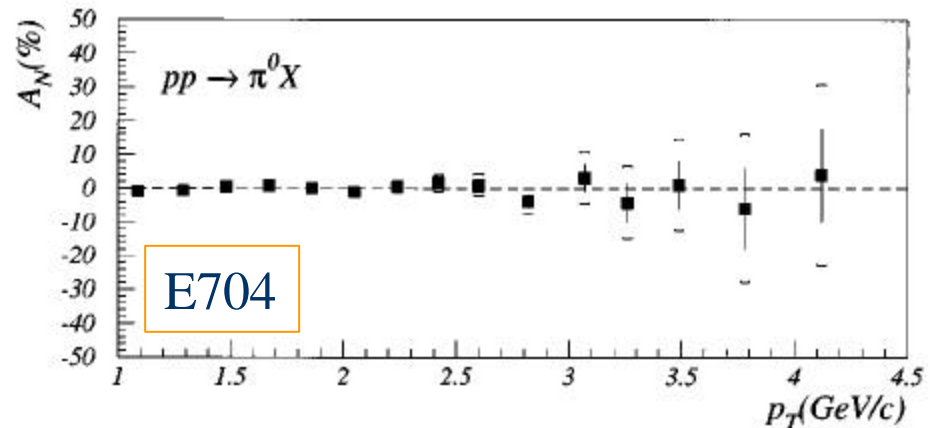
# $A_N$ Predictions

- Forward region
  - E704  $\pi^0/\pi^\pm/\eta$  asymmetries
    - unexpected large at large- $x_F$ 
      - $\sqrt{s} = 20$  GeV
      - $0.2 < p_T < 2.0$  GeV/c
  - many theoretical models developed
    - Qiu & Sterman
      - twist-3 effect
    - Anselmino *et al.*
      - time-reversal odd fragmentation function
  - more experimental data expected
    - kinematic dependence



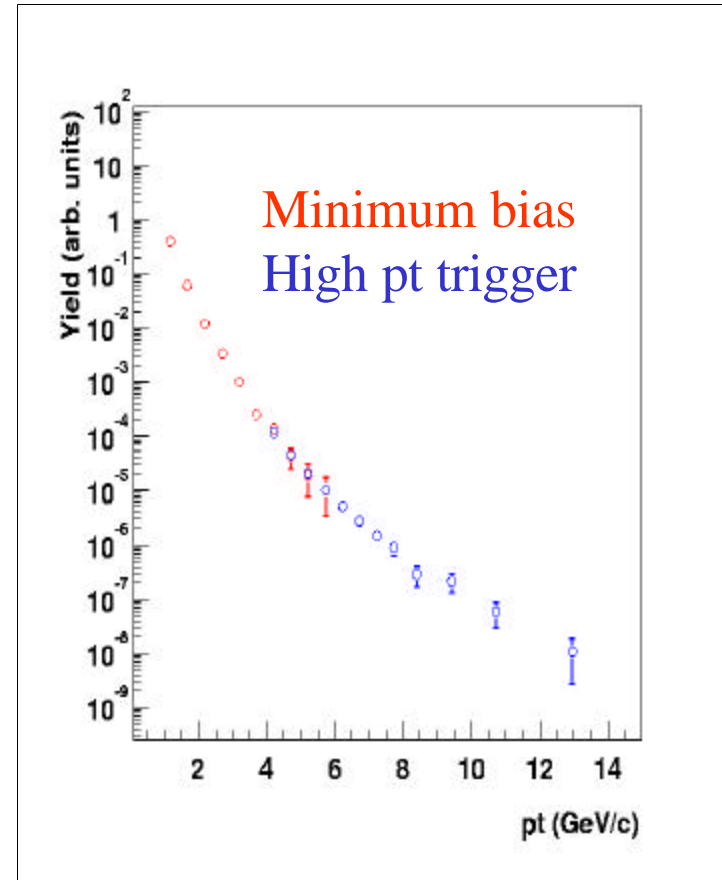
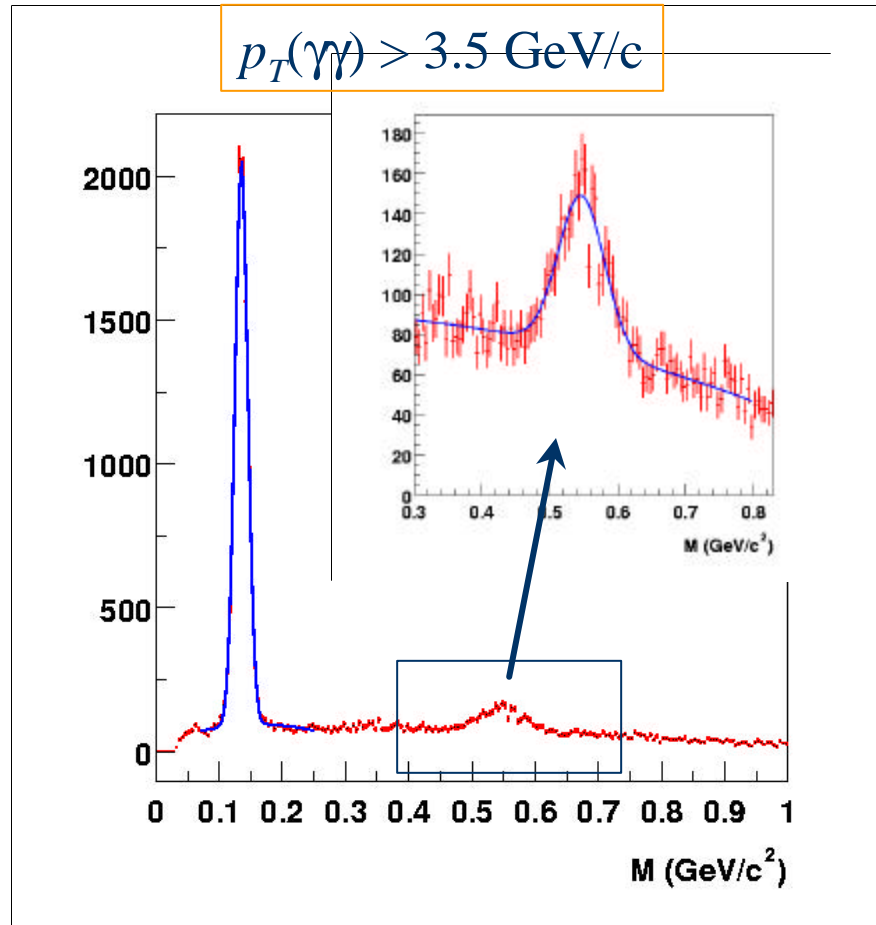
# $A_N$ Measurements at PHENIX Central Arm

- Mid-rapidity region
  - E704 data
    - small asymmetry at  $x_F \sim 0$ 
      - consistent with zero
    - no large asymmetry like lower energy data
    - small statistics, especially at high- $p_T$ 
      - more than 10% error
  - PHENIX central arm
    - $p_T < 8$  GeV/c,  $x_F \sim 0$
    - neutral pion, charged hadrons



# $A_N$ Measurements at PHENIX Central Arm

- $\pi^0$  measurement

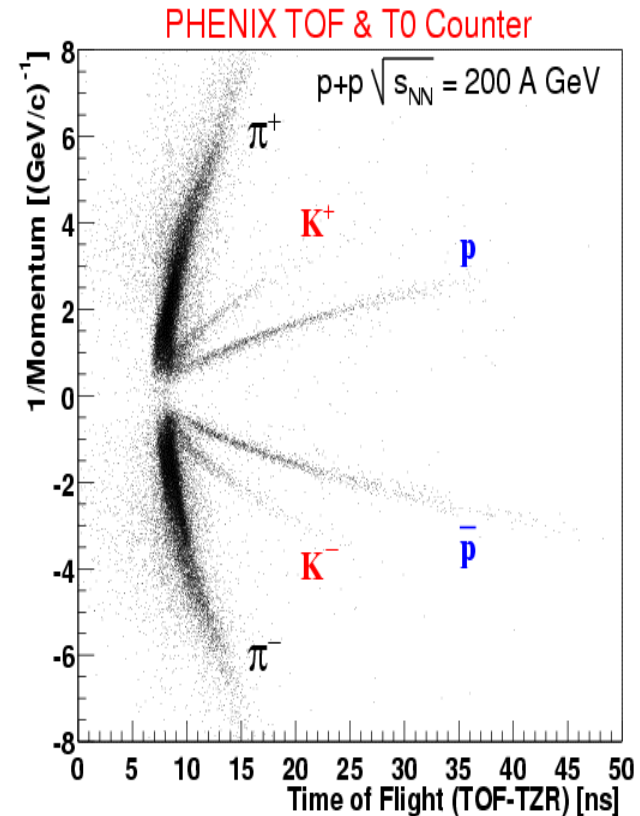
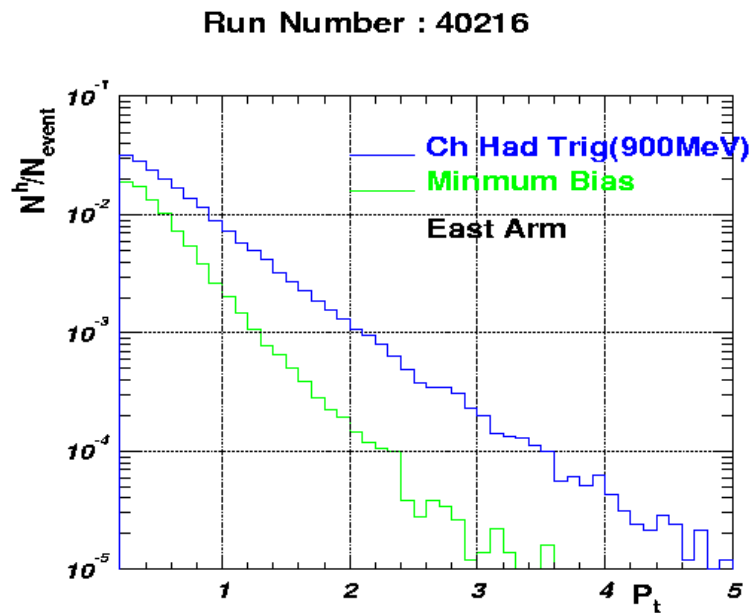




# $A_N$ Measurements at PHENIX Central Arm

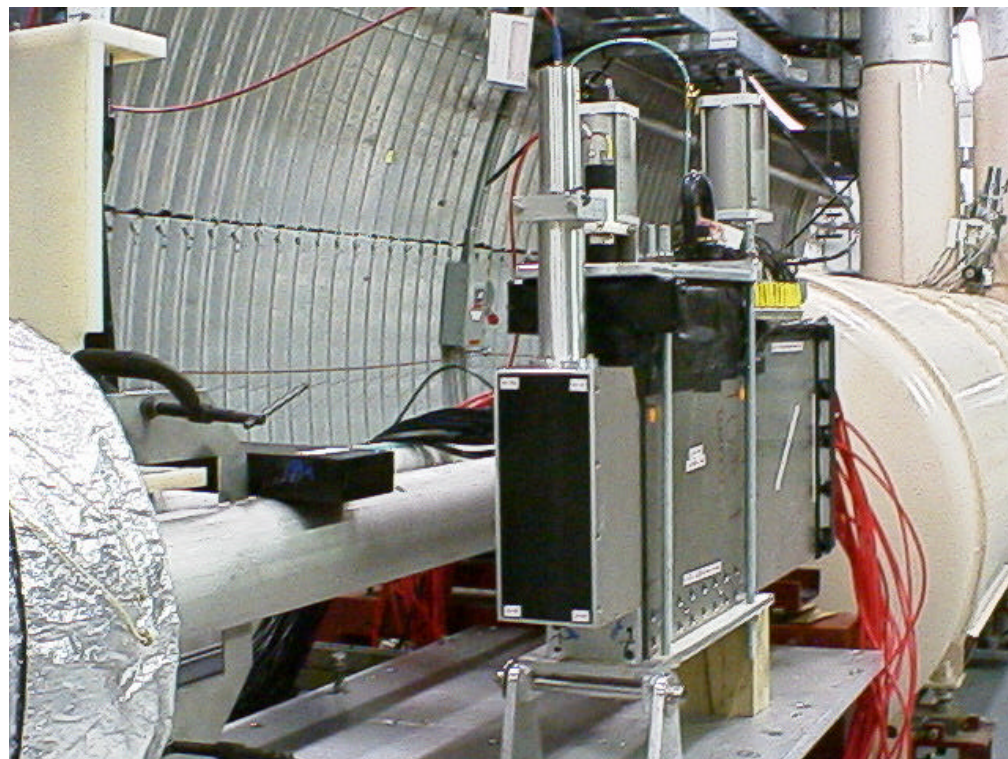
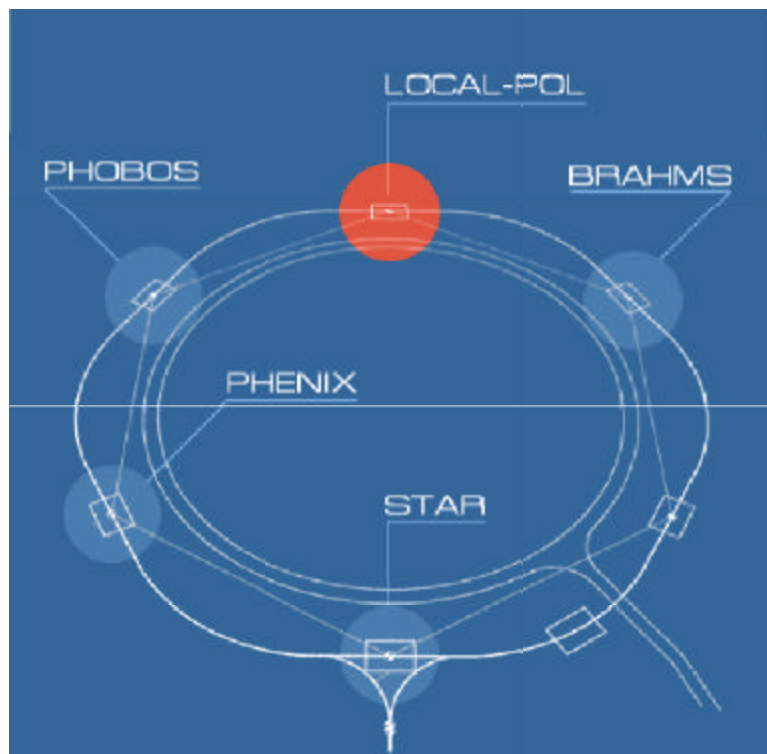
- Charged hadrons

## Comparison of minimum-bias and Charged Hadron trigger



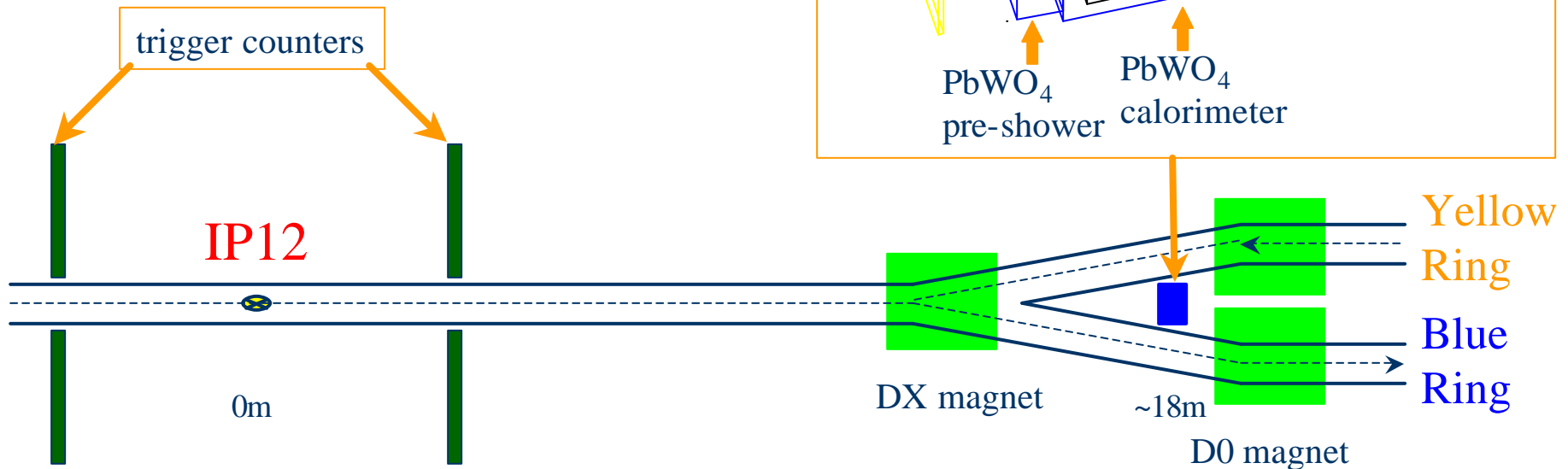
time-of-flight with  $< 100$  psec resolution  
separate  $\pi/K$  up to  $\sim 2.4$  GeV/c

# $A_N$ Measurements at IP12



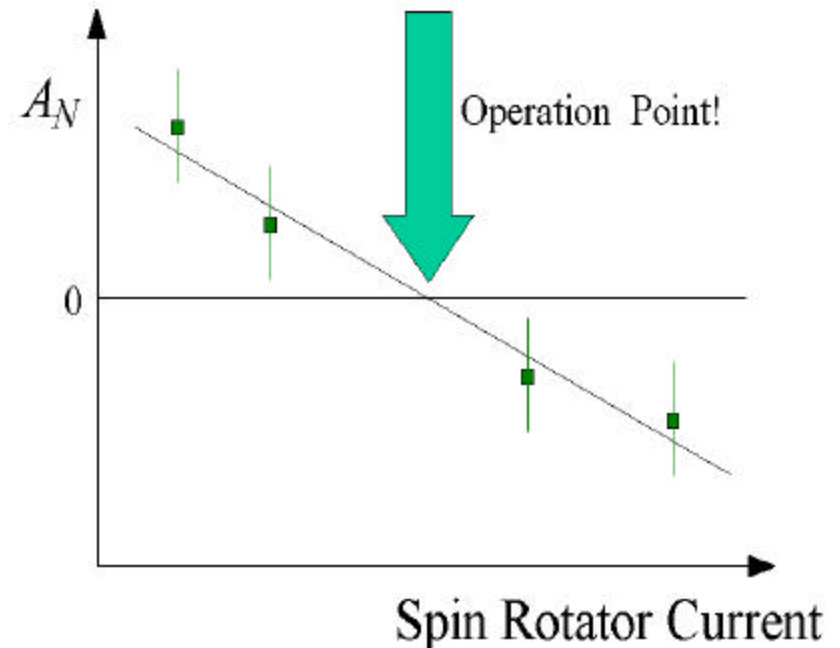
# $A_N$ Measurements at IP12

- Very forward region
  - $p_T < 0.5 \text{ GeV}/c$ ,  $x_F > 0.2$
  - photon,  $\pi^0$  and neutron
  - calorimeter with  $5 \times 12$  array of  $2 \text{ cm} \times 2 \text{ cm} \times 20 \text{ cm}$   $\text{PbWO}_4$  crystals



# $A_N$ Measurements at IP12

- Local polarimeter
  - development of a new polarimeter to be installed at PHENIX
  - to confirm spin dynamics in RHIC ring
  - for the operation with spin rotators in Run-3
    - spin dynamics between spin rotators is completely transparent to the rest of accelerator by design

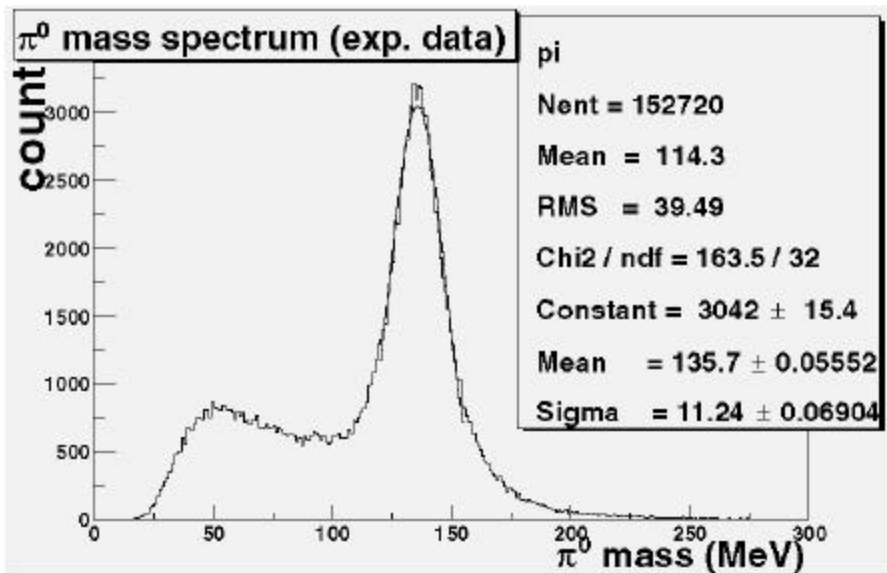




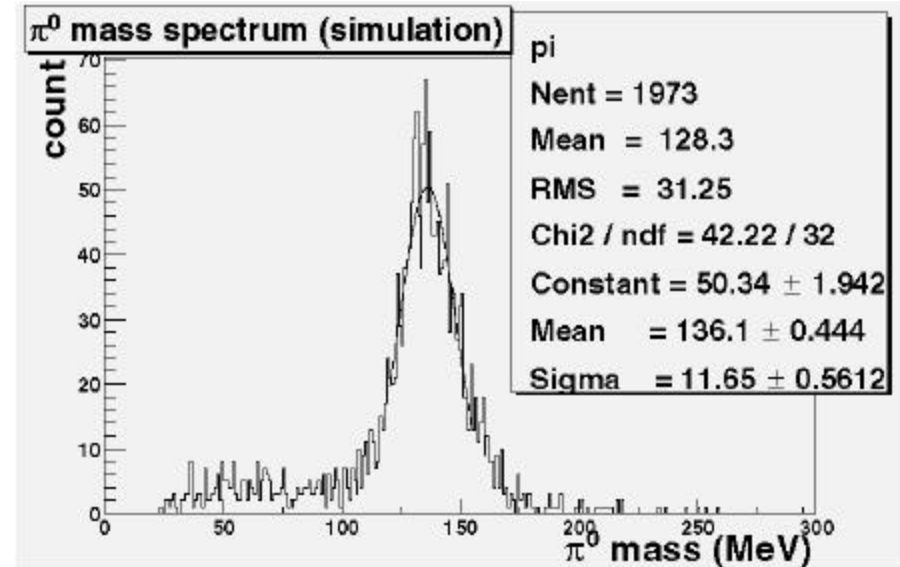
# $A_N$ Measurements at IP12

- Performance
  - 2 photon mass reconstruction

experimental data



PYTHIA+GEANT simulation



# Summary

- RHIC was operated as the first polarized proton collider
  - as well as the heavy-ion collider
- Transverse-spin proton collision data were accumulated in this year
  - luminosity
    - $1.5 \times 10^{30} \text{ cm}^{-2} \text{ sec}^{-1}$  at maximum,  $0.18 \text{ pb}^{-1}$  integrated
  - polarization
    - 25 % at maximum,  $\langle P_{\text{yellow}} \rangle = 17 \%$ ,  $\langle P_{\text{blue}} \rangle = 14 \%$
- Many  $A_N$  measurements at  $\sqrt{s} = 200 \text{ GeV}$  will be obtained soon
  - at PHENIX
    - mid-rapidity photon,  $\pi^0$ , charged hadrons, electron
    - forward muon
  - at IP12
    - very forward photon,  $\pi^0$ , neutron
- Proposing longitudinal-spin proton run in Run-3 (2002-2003)
  - for gluon polarization measurement