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Future Measurements of the Spin-Dependent Proton Flavor Structure with the PHENIX Muon Arms

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for the PHENIX Collaboration

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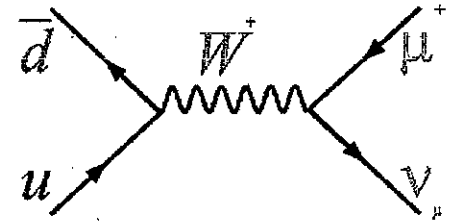
Outline



- Physics Overview
- RHIC Spin and The PHENIX Detector
- Measurements with the Muon Arms
- Outlook

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Probing Flavor Structure

recall $\sigma(pp \rightarrow W^{\pm})$:

$$\frac{d\sigma^{W+}}{dy} = G_F \pi \frac{\sqrt{2}}{3} \frac{M_W^2}{s} \left[u(x_1,M_W^2)\,\bar{d}(x_2,M_W^2)+u(x_2,M_W^2)\,\bar{d}(x_1,M_W^2)\right]$$

unpolarized:

$$R_W = \frac{\frac{d\sigma^{W-}}{dy}}{\frac{d\sigma^{W+}}{dy}} \text{ is sensitive to } \frac{\bar{\mathbf{d}}}{\bar{\mathbf{u}}}$$

longitudinally polarized: $A_L = \dfrac{\sigma_- - \sigma_+}{\sigma_- + \sigma_+}$ & $\Delta f = f_+^- - f_+^+$

$$A_L^{W^+} = \frac{\Delta u(x_1)\bar{d}(x_2) - \Delta\bar{d}(x_1)u(x_2)}{u(x_1)\bar{d}(x_2)+\bar{d}(x_1)u(x_2)} \qquad A_L^{W^-} = \frac{\Delta d(x_1)\bar{u}(x_2) - \Delta\bar{u}(x_1)d(x_2)}{d(x_1)\bar{u}(x_2)+\bar{u}(x_1)d(x_2)}$$

Flavor Structure Sensitivity:

$\vec{p}p \rightarrow W^{\pm}$

for $x_1 \gg x_2$ (larger y_W):

$$A_L^{W^+} \sim \frac{\Delta u(x_1)}{u(x_1)}$$

$$A_L^{W^-} \sim \frac{\Delta d(x_1)}{d(x_1)}$$

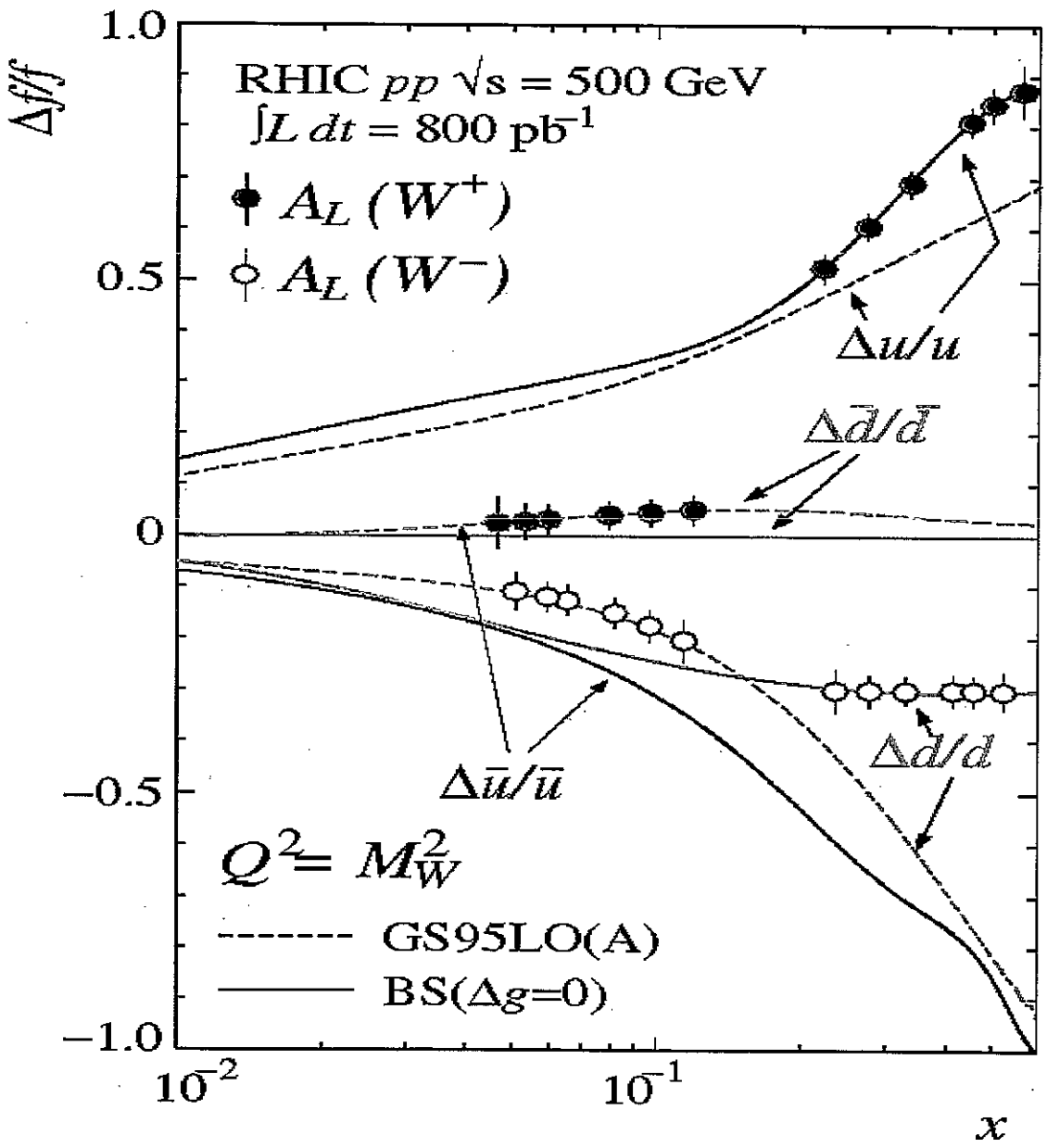
for $x_2 \gg x_1$:

$$A_L^{W^+} \sim \frac{-\Delta \bar{d}(x_1)}{\bar{d}(x_1)}$$

$$A_L^{W^-} \sim \frac{-\Delta \bar{u}(x_1)}{\bar{u}(x_1)}$$

for explicit x and y_w see

C. Bourrely and J.Soffer,
Nucl. Phys. B445 341–379 (1995)



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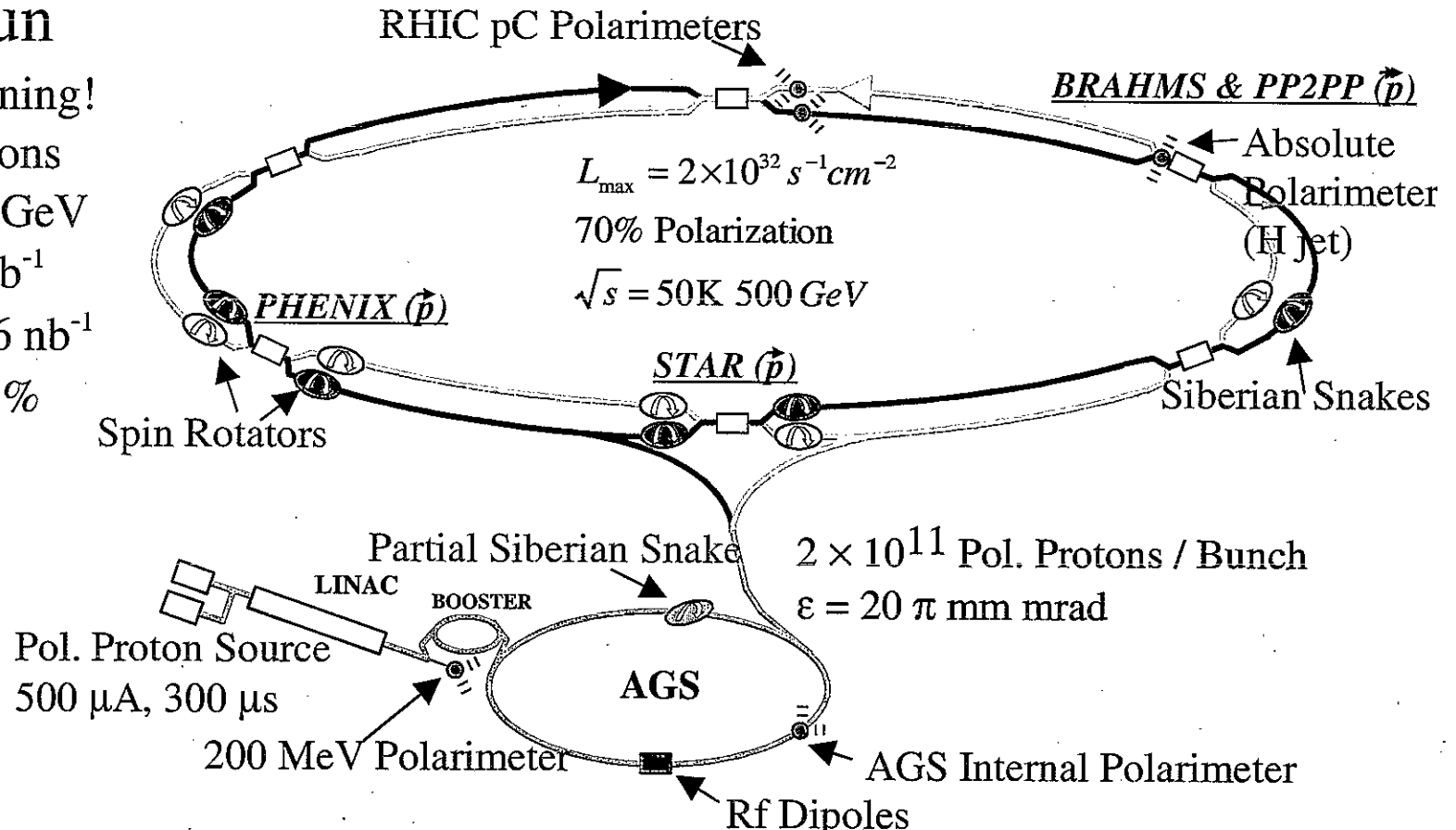
RHIC Spin

2001-2 Spin Run

- Successful commissioning!
- Transversely pol. protons accelerated to $\sqrt{s}$ =200 GeV
- RHIC delivered 700 nb^{-1}
- PHENIX recorded 156 nb^{-1}
- Max polarization = 25%



2002-3 Spin Run

- Spin rotator magnets for longitudinal polarization
- Expected integrated Luminosity > $3pb^{-1}$
- Expected polarization > 40%
- Possible test at $\sqrt{s}$ = 500 GeV

<u>Possible future enhancements</u>:

- Polarized jet target for absolute polarization
- Snake to improve AGS polarization
- more selective triggering (PHENIX)

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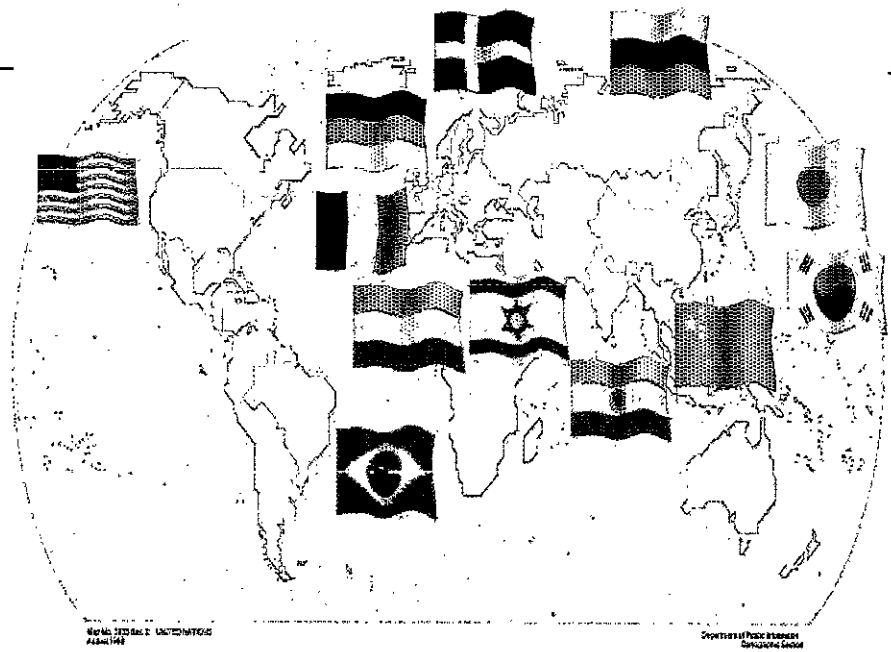
Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	University of Tokyo, Bunkyo-ku, Tokyo
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund



*12 Countries; 57 Institutions; 460 Participants**

USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California – Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of July 2002

Muon Arms

Muon Arms

Track stubs from Muon Identifiers used to seed tracks in the Muon Tracker

Muon Tracker

3 stations of cathode strip chambers per arm

$-1.1 > \eta > -2.2$ (south)

$1.2 < \eta < 2.4$ (north)

$-\pi < \phi < \pi$

position resolution ~ 100μm

Muon Identifier

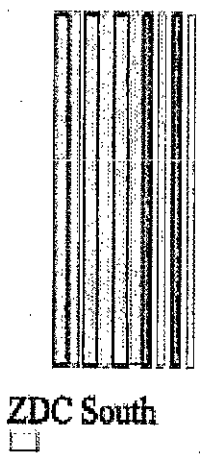
5 layers of plastic proportional (Iarocci) tubes per arm

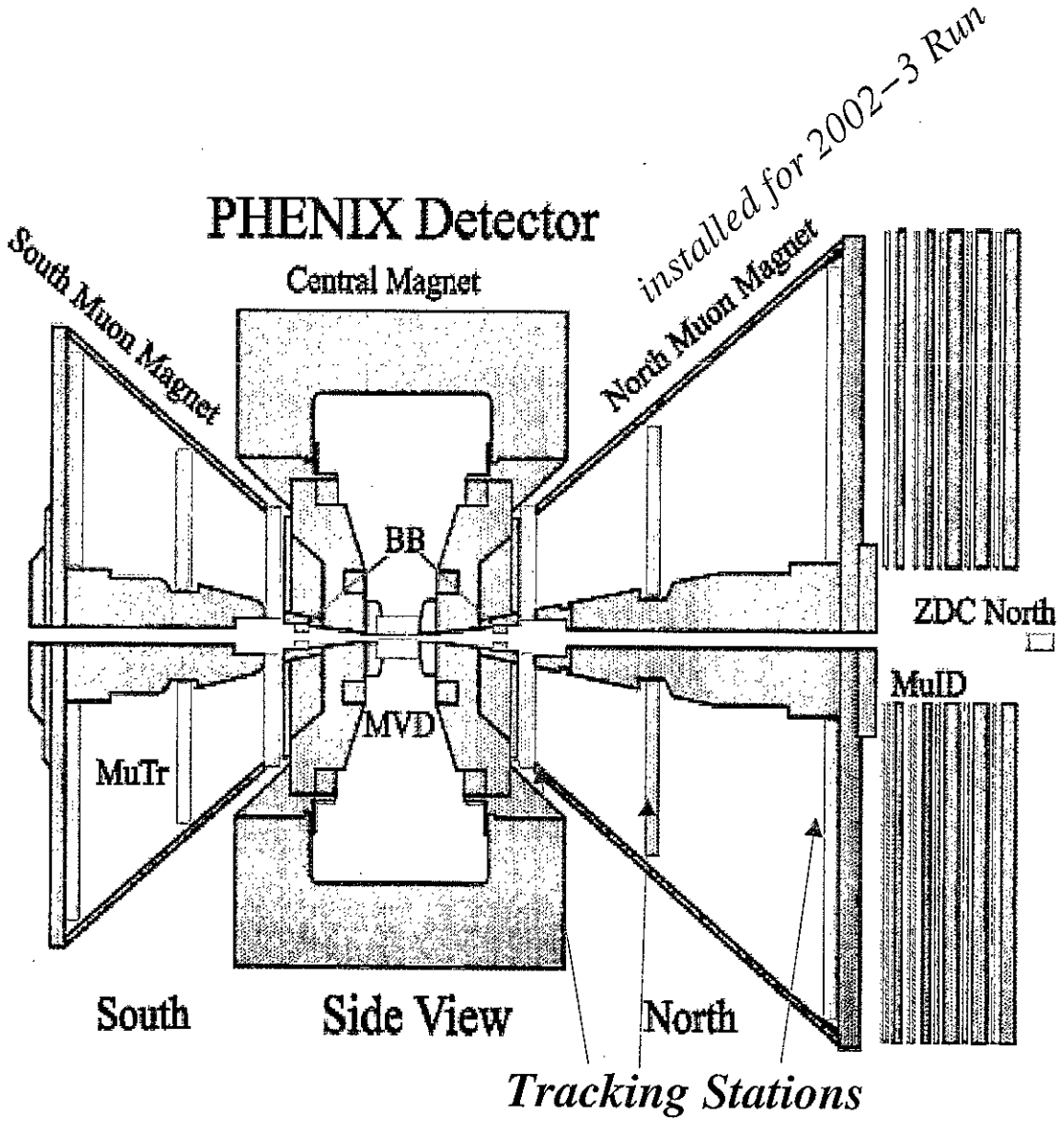
–transversely oriented

–separated by steel absorbers

***p*(μ) > 2 GeV/c**

π/μ rejection = 2.5×10^{-4}





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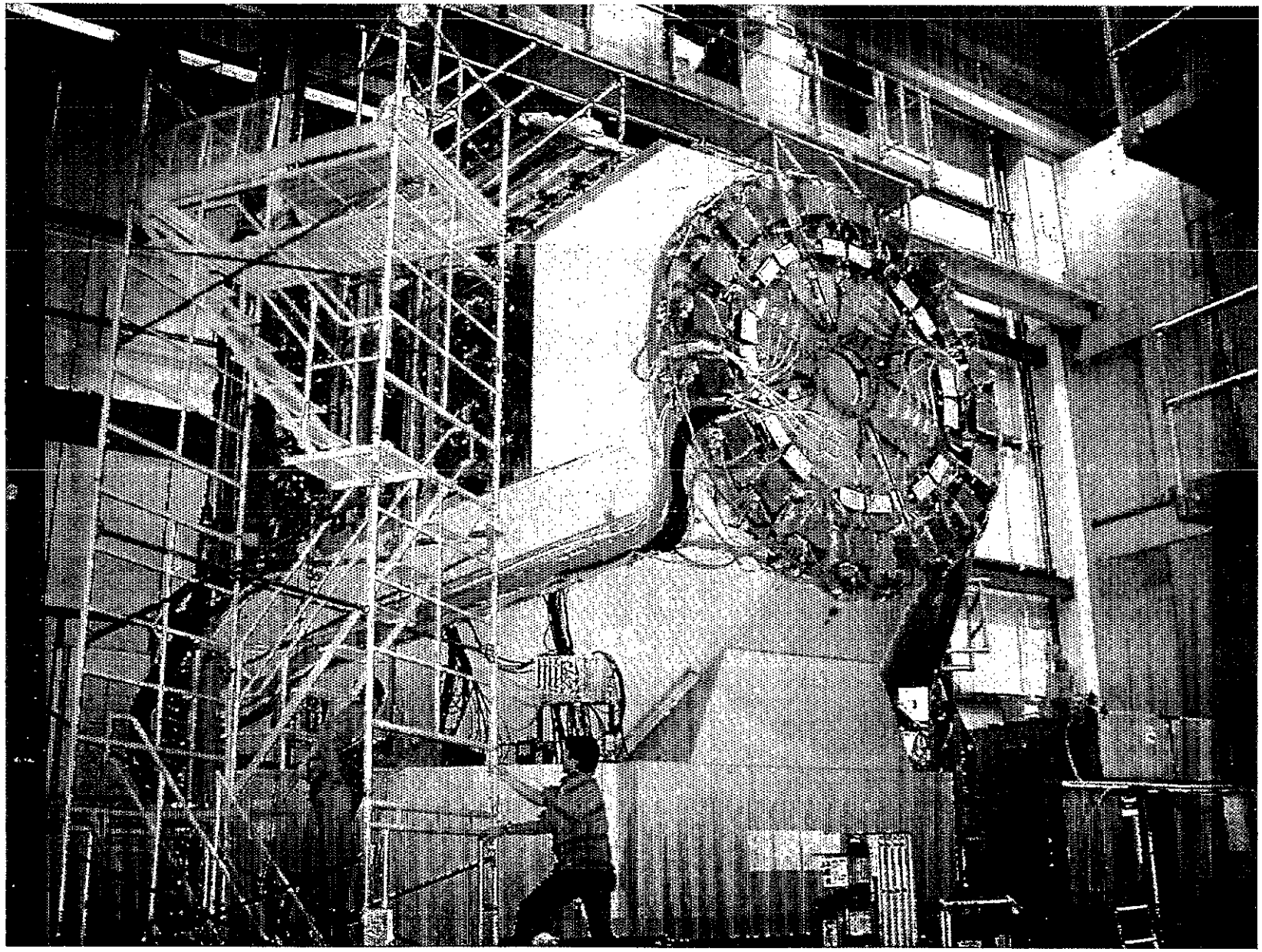
South Tracking Arm



Run 2001–2002 Muon Arm Performance

Design requirements

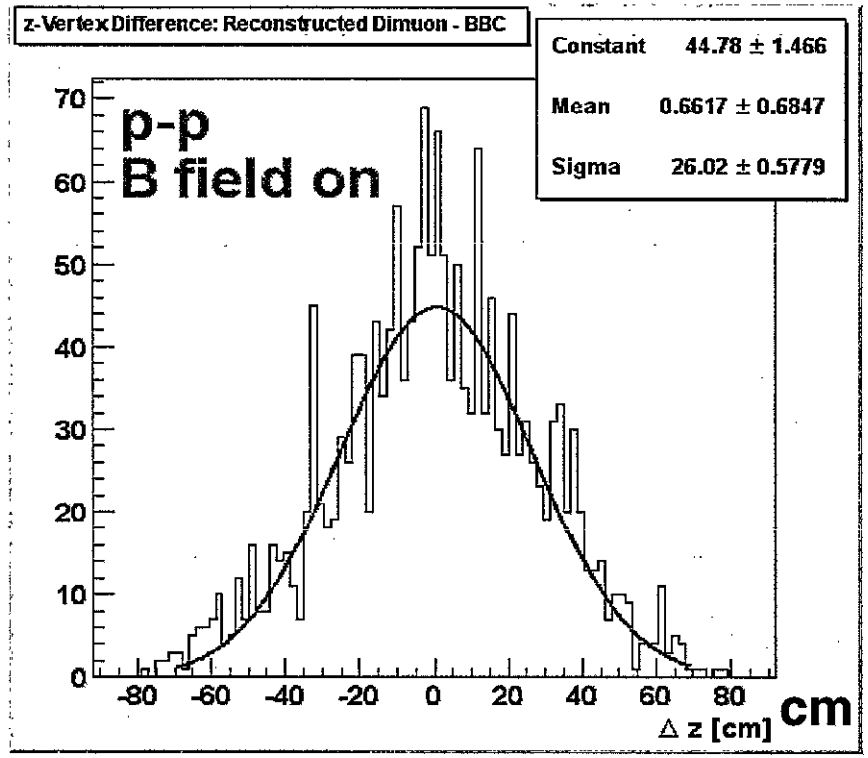
separate

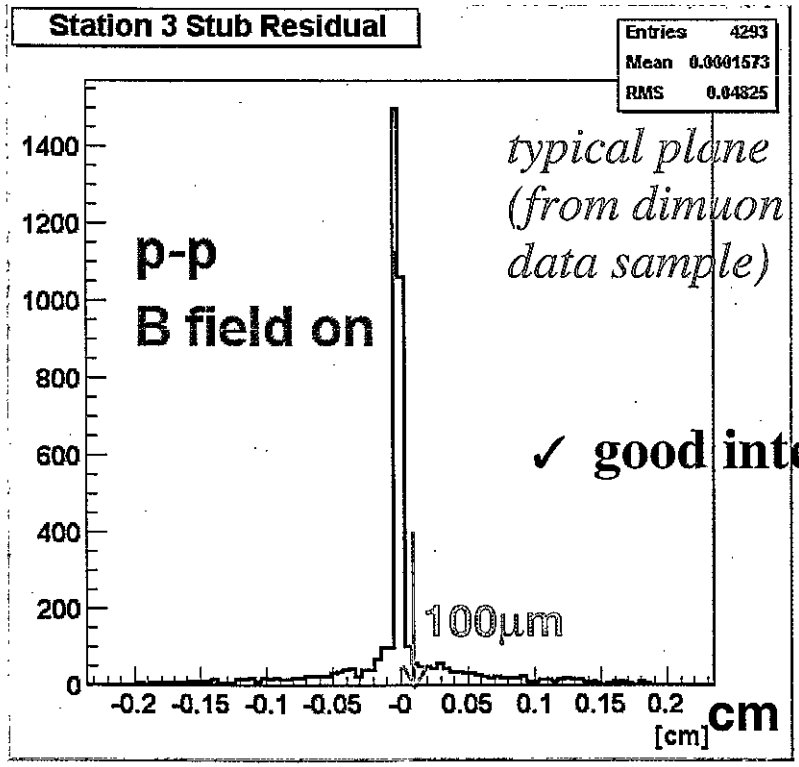
- ϕ from ρ–ω
- J/Ψ from Ψ' (σ_m ~ 100 MeV/c^2)
- Y(1s) from Y(2s+3s) (σ_m ~ 100 MeV/c^2)

determine charge for p(μ)~ 50 GeV/c

$\Rightarrow$ position resolution ~ 100μm

✓ **good global alignment**





✓ **good internal alignment**

Stub = track segment in a station.

Plane Residual = actual position – predicted, where plane is omitted from the fit.

Work–in–Progress: $W^{\pm} \rightarrow \mu^{\pm}\nu$ Acceptance

Signal: single, high p_T μ

Backgrounds: Z, DY, b/c, ...

Previous studies suggest p_T>20 GeV/c significantly reduces DY and heavy flavor, leaving Z/W yield ~ 20%.

Studying Vector Boson acceptance/reduction using ResBos event generator w/ CTEQ 5M.

Cross sections calculated with ResBos.
Acceptance = cuts on detector rapidity and muon p_T>20 GeV/c

Of course, these numbers have significant errors due to generator & its inputs.

	σ	σ × Br	gen. level acceptance	detector sim. efficiency	bkgd cut efficiency	# events 800pb−1
W+	1.2nb	130pb	20%	?	?	?
W−	380pb	40pb	23%	?	?	?
Z	300pb	10pb	19% /μ	?		?
γ*	---	1.3nb	0.03% /μ	?		?

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Outlook

- $W^{\pm}$ production at RHIC provides a unique probe of spin–dependent proton flavor structure.
- $W^{\pm} \rightarrow \mu^{\pm}\nu$ is an exciting prospect with the PHENIX Muon Arms (probing high *y* regions).
- Both Muon Arms will be installed for the next RHIC run and will be fully characterized for a future spin run at $\sqrt{s}$ = 500 GeV.
- Work continues on muon track reconstruction/pattern recognition.
- $W^{\pm} \rightarrow \mu^{\pm}\nu$ efficiency/background reduction is a work–in–progress.
- Possible upgrades to muon triggering for improved event rejection.