

An Overview of the RHIC Experimental Program

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Columbia University**

**RHIC Winter Workshop at LBNL
January 7, 1999**

Outline

- 1. RHIC Status/Schedule**
- 2. BRAHMS**
- 3. PHENIX**
- 4. PHOBOS**
- 5. STAR**
- 6. Comparison of physics capabilities**
- 7. Expected day-1 configurations**

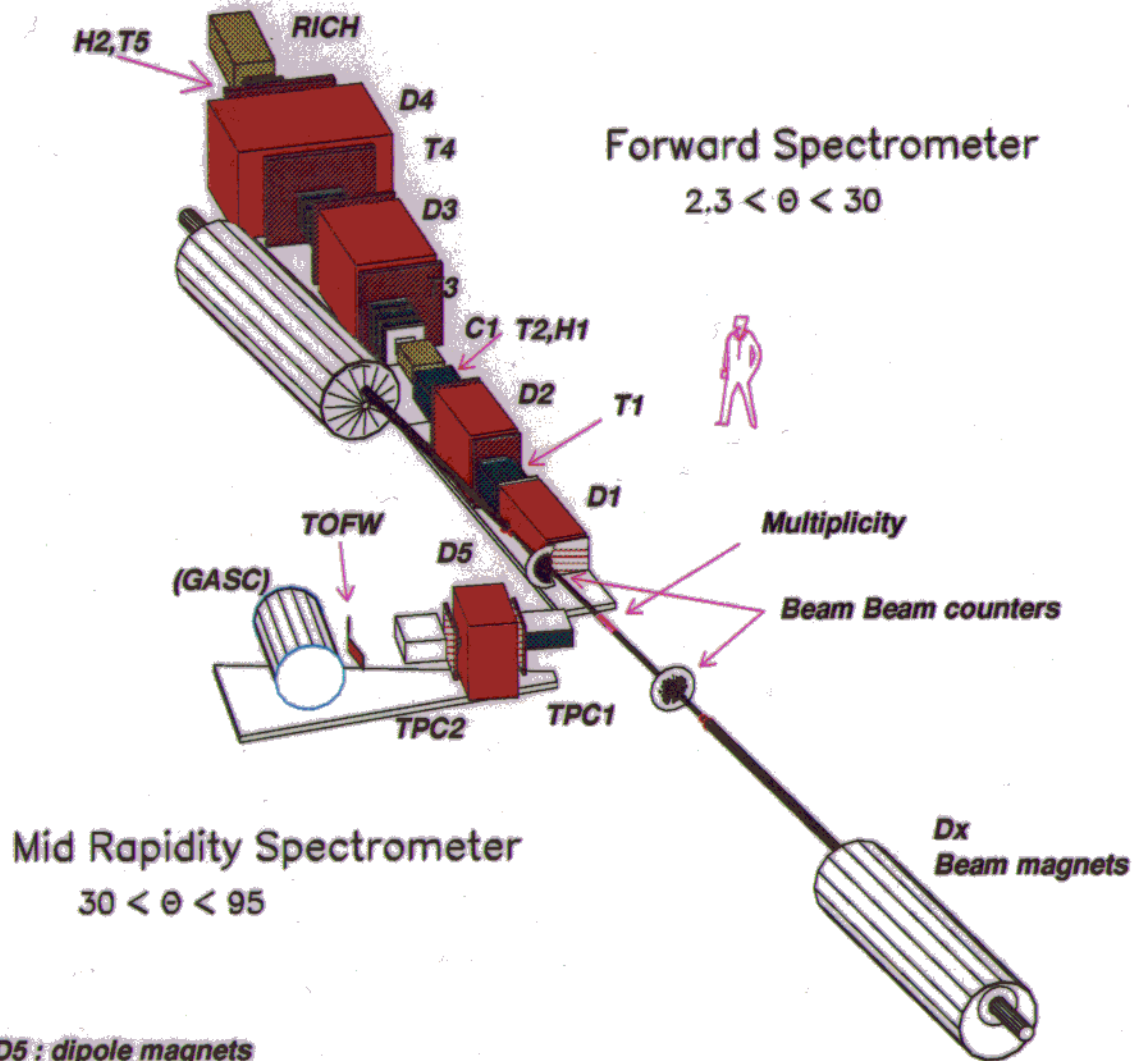
The RHIC Collider



Accelerator Schedule

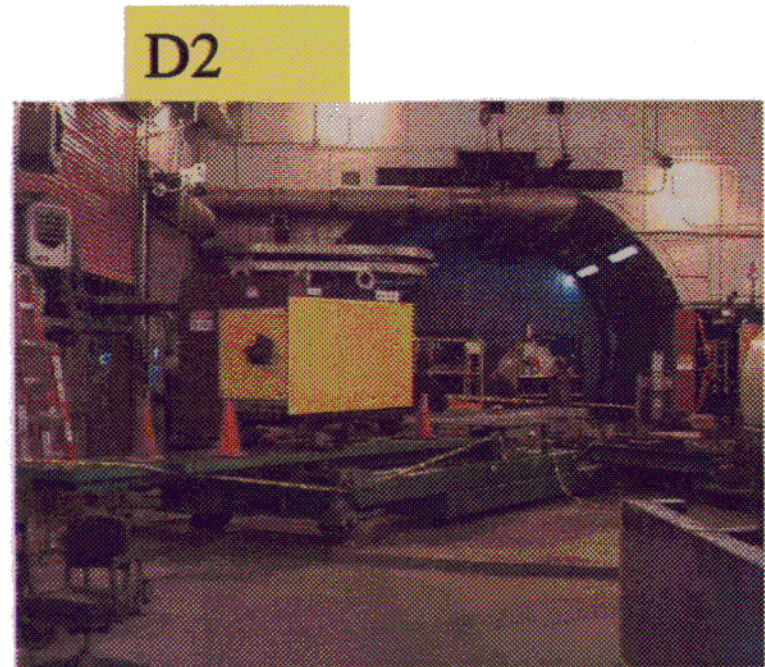
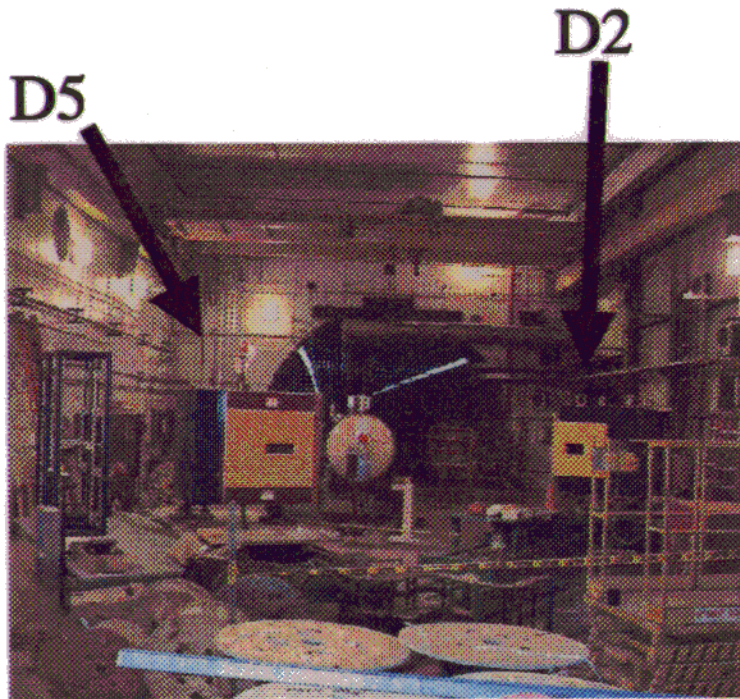
- October 6, 1998 - RHIC announces completion of magnet construction
- March 1, 1999 - RHIC Starts cool-down
- March 1999 - Attempt to circulate beam in one ring
- June-July 1999 - Commissioning run
- November 1999 - Start of "year-1" physics run

The Brahms Experiment @ RHIC



D1,D2,D3,D4,D5 : dipole magnets
 T1,T2,T3,T4,T5, TPC1 TPC2: tracking detectors
 H1,H2,TOFW : Time-of-flight detectors
 RICH, GASC : Cherenkov detectors

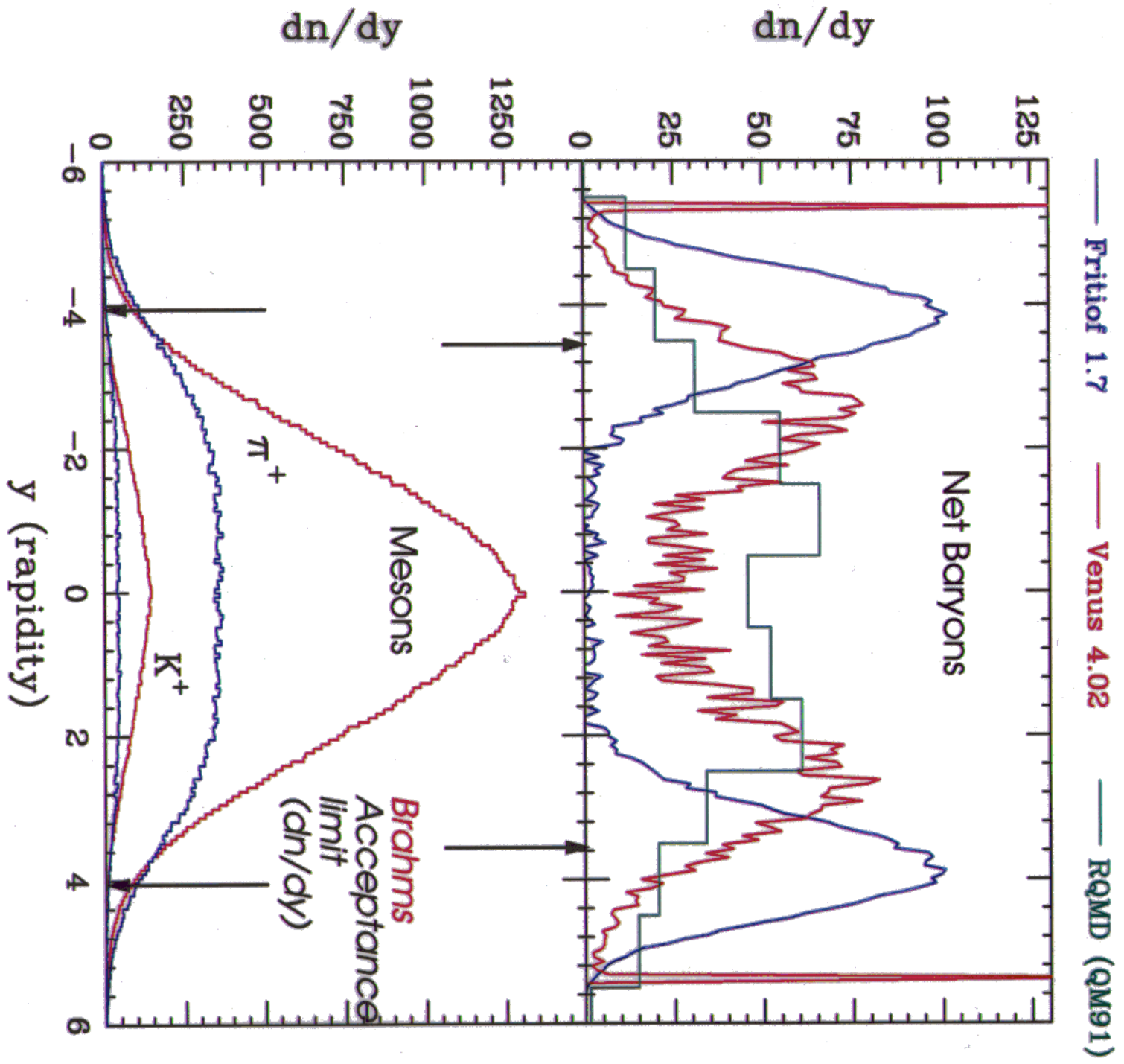
BRAHMS Magnets D1 and D2 on Platforms in 2 o'clock



BRAHMs TPC under test

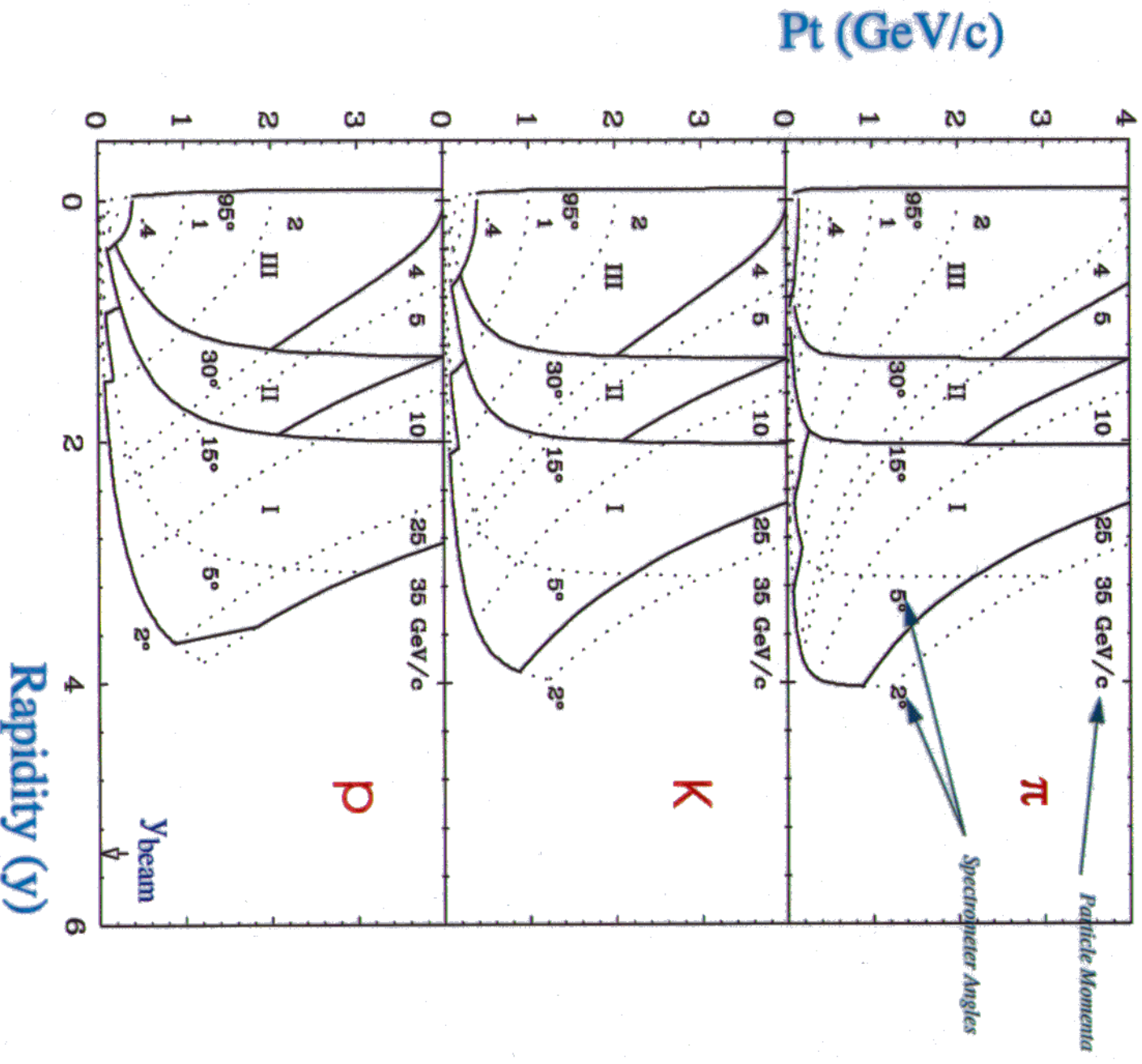


Central Au + Au at RHIC



Acceptance of BRAHMS

Geometrical Acceptance + PID



Region I : With the full Forward Arm

Region II : With the D1 - D2 (Forward Arm) Complex alone

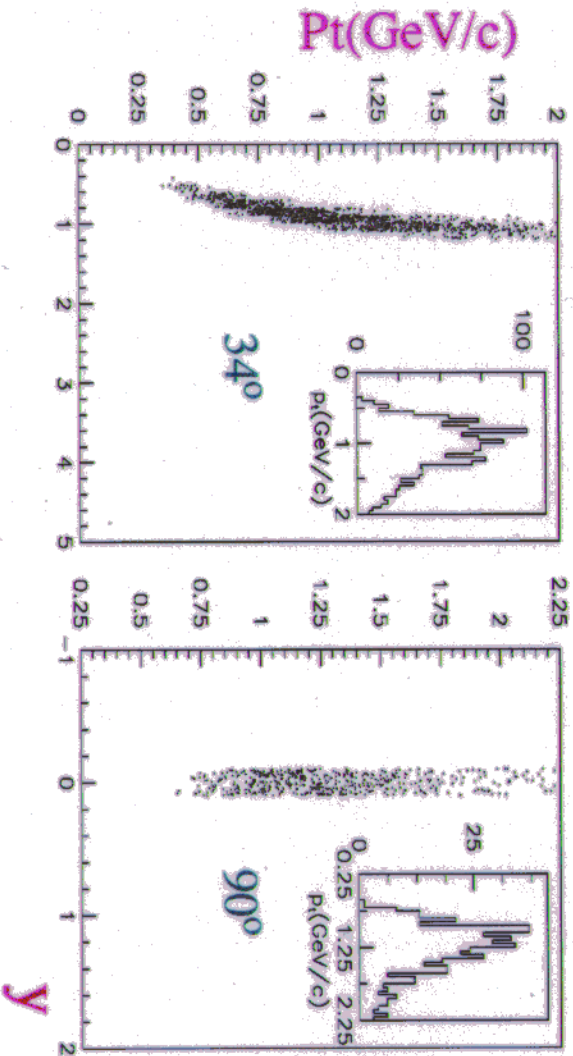
Region III : With the Mid-Rapidity Arm

$\phi(1020)$ Measurement

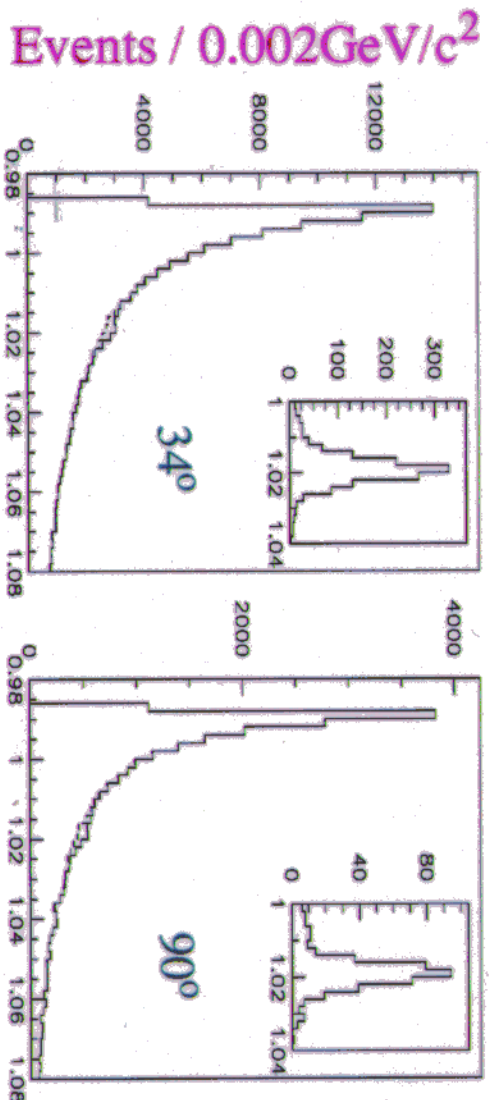
□ QGP \rightarrow Chiral Symmetry Restoration

☞ ϕ production enhancement, mass and width shift

❖ $\phi \rightarrow K^+K^-$ Channel at the Mid-Rapidity Spectrometer



↑ Accepted $y - p_t$ distributions (Inlets : P_t)



with $\delta p/p = 1\%$
 $\Gamma(\phi) \sim 7.5 \text{ MeV}/c^2$

$m(K^+K^-)(\text{GeV}/c^2)$

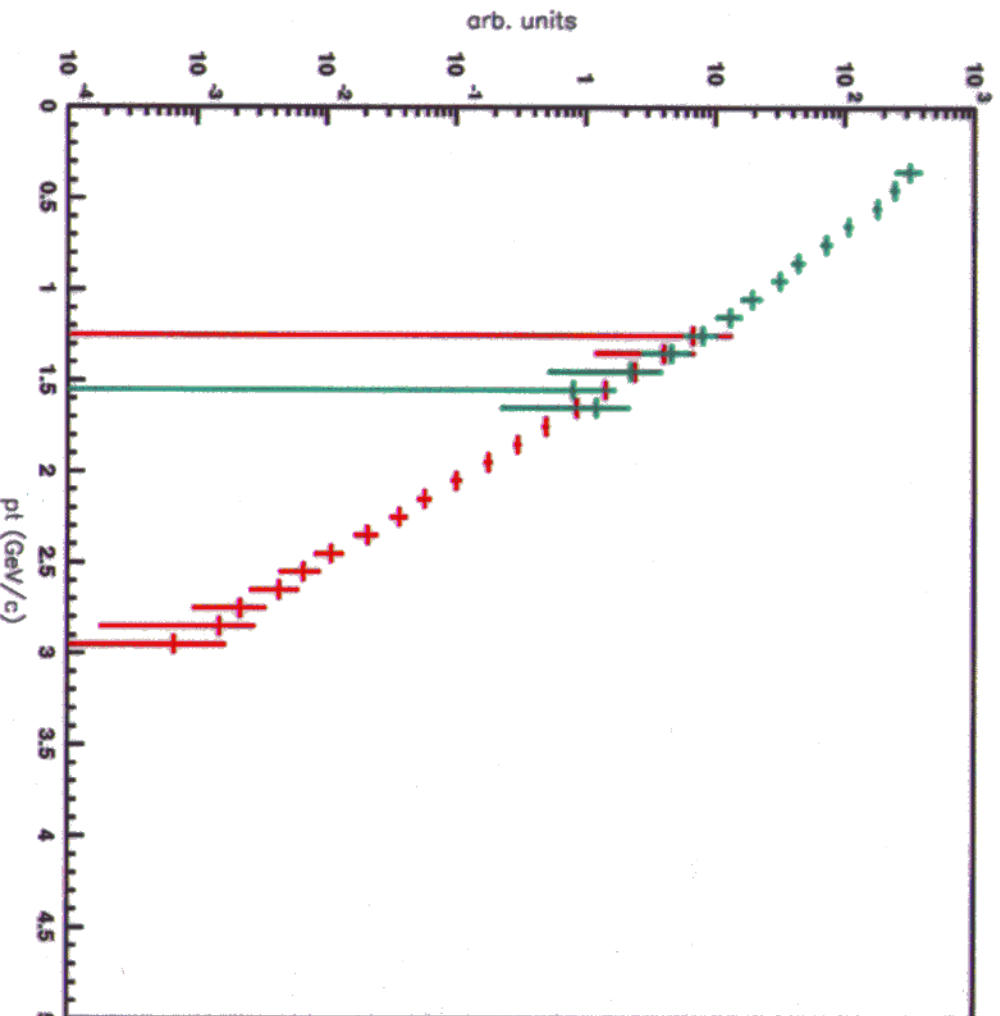
↑ Accepted K^+K^- mass (dots : combinatorial background)
 (Inlets : signal – background)

High- p_t in Brahmms

High p_t measurements

Example of quality of spectrum of π^+ at $y=2.4$. The measurement can be done for central Au+Au collisions in about 1 week in 2 settings of magnetic fields.

Extensions to $p_t \approx 6$ GeV/c with Δp_t of .5 GeV/c can be done in another week.

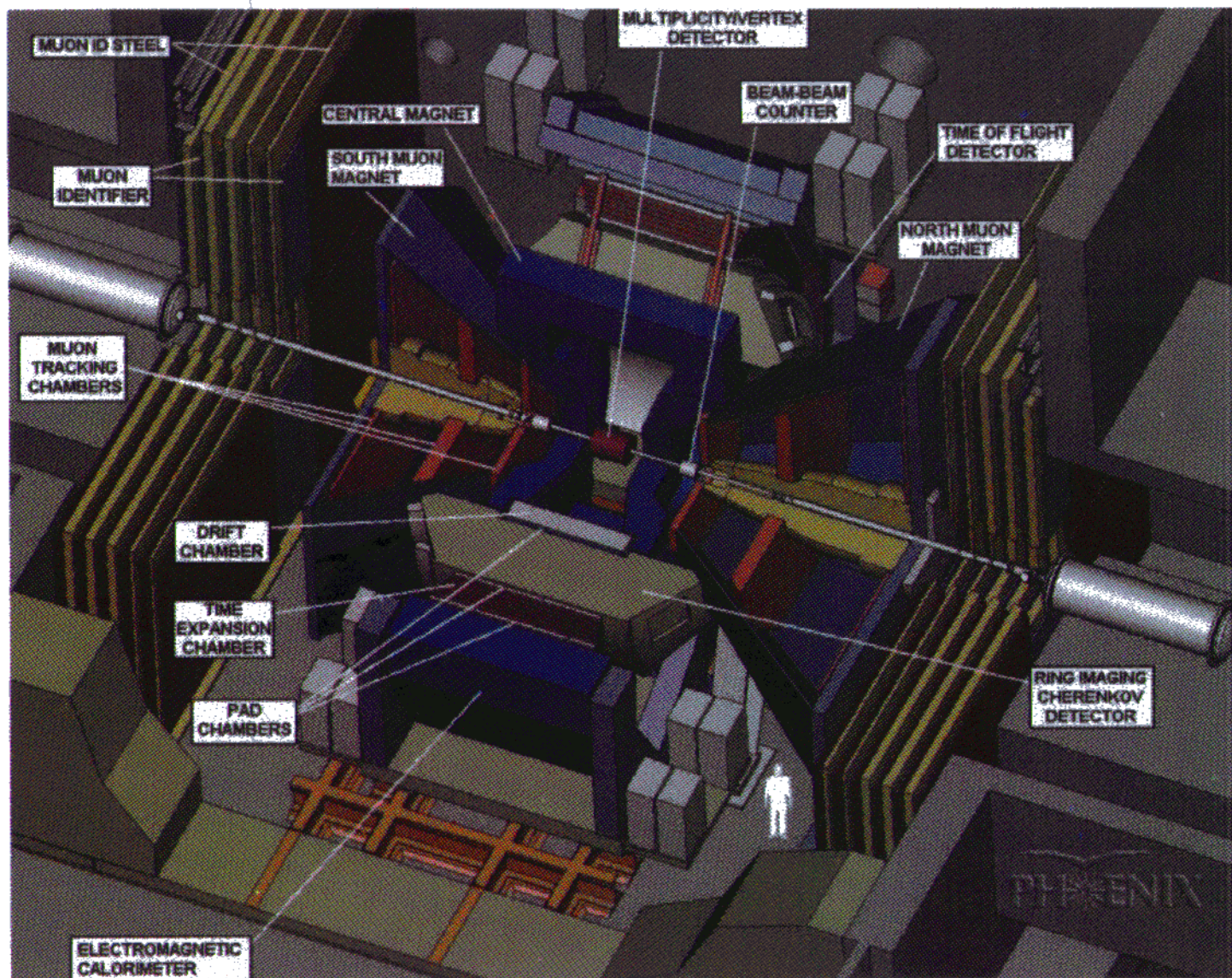


July 6-16, 1997

RHIC Theory Workshop

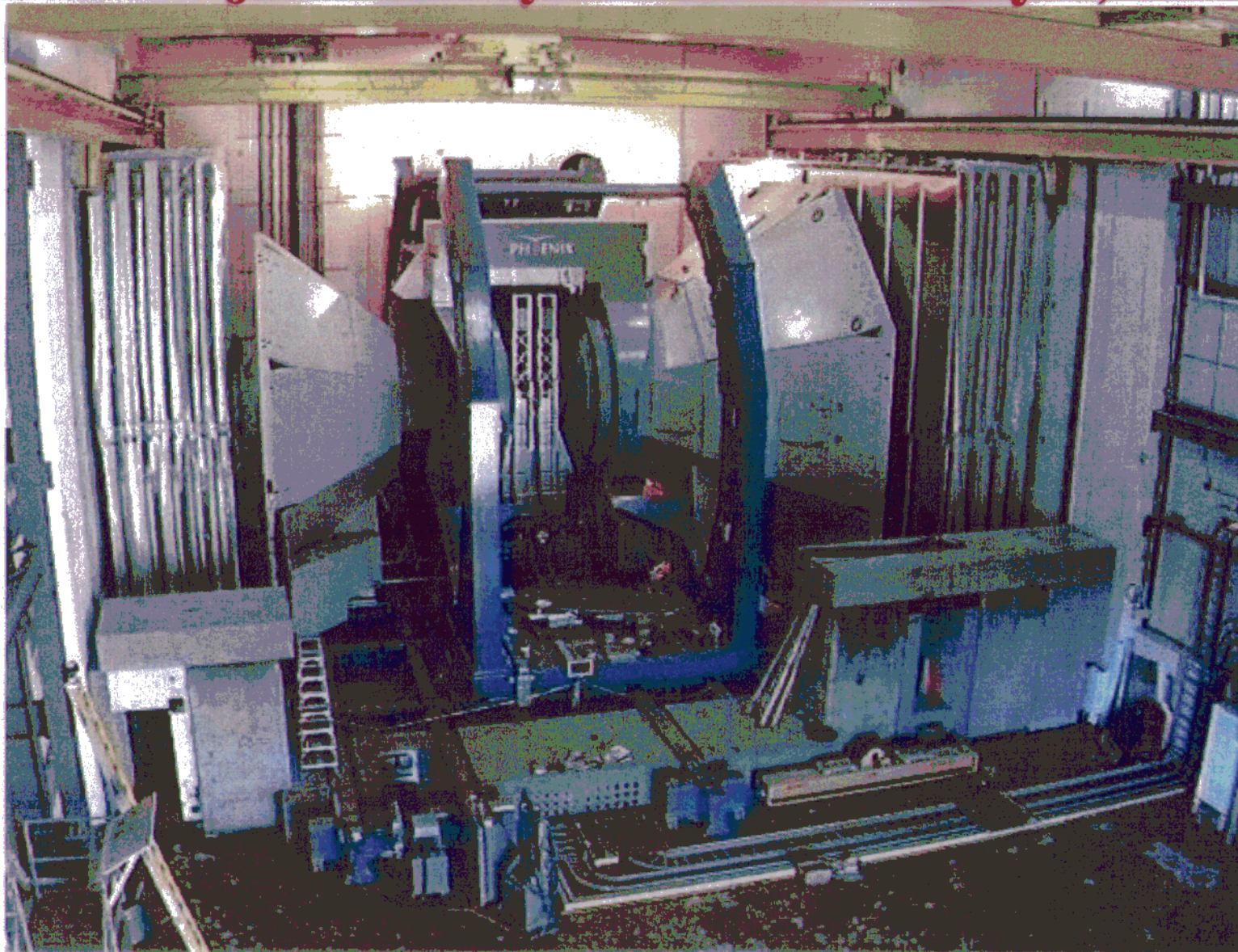
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The PHENIX Experiment @ RHIC



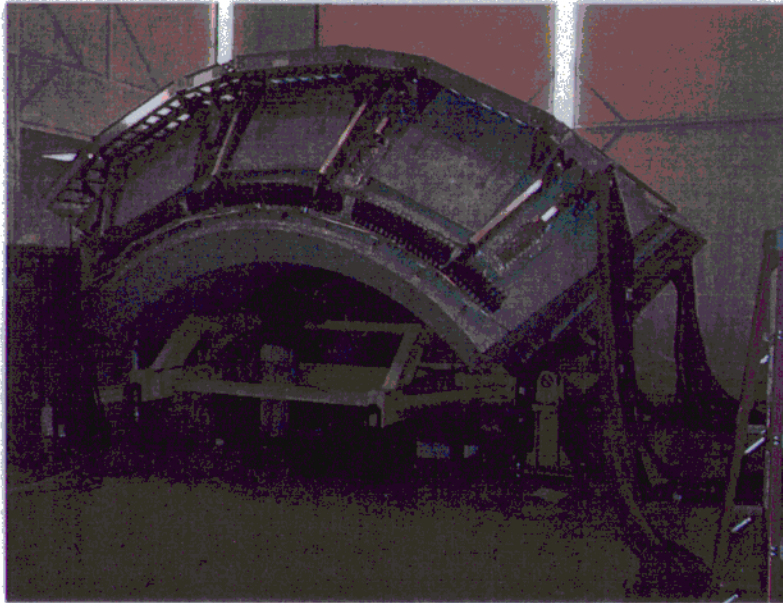
- Mid-rapidity hadron, γ , e spectrometers, forward μ spectrometers
- Silicon multiplicity/vertex detector
- Particle identification by TOF, Cherenkov, dE/dx , absorber penetration

The Major Facility Hall on January 4, 1999

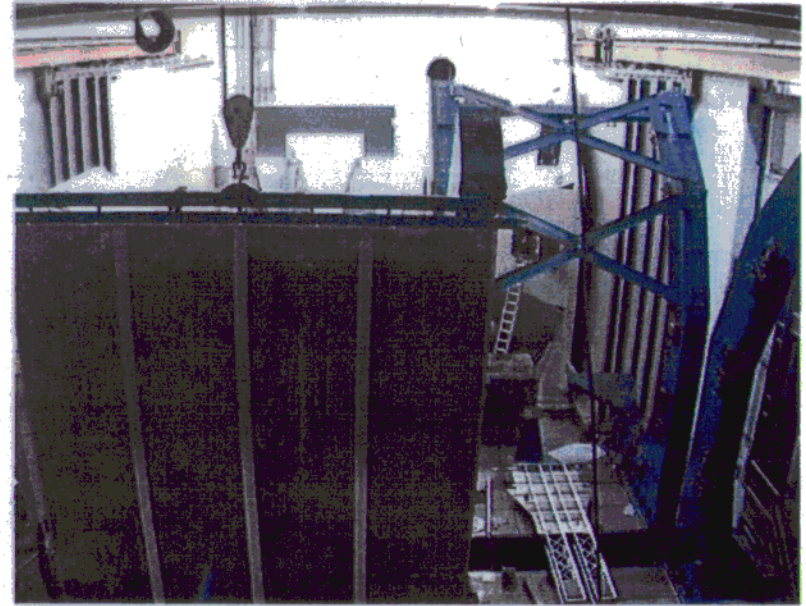


- μ -id panels, West Arm EM-calorimeter fully installed
- Central magnet being mapped
- Shield wall construction under way

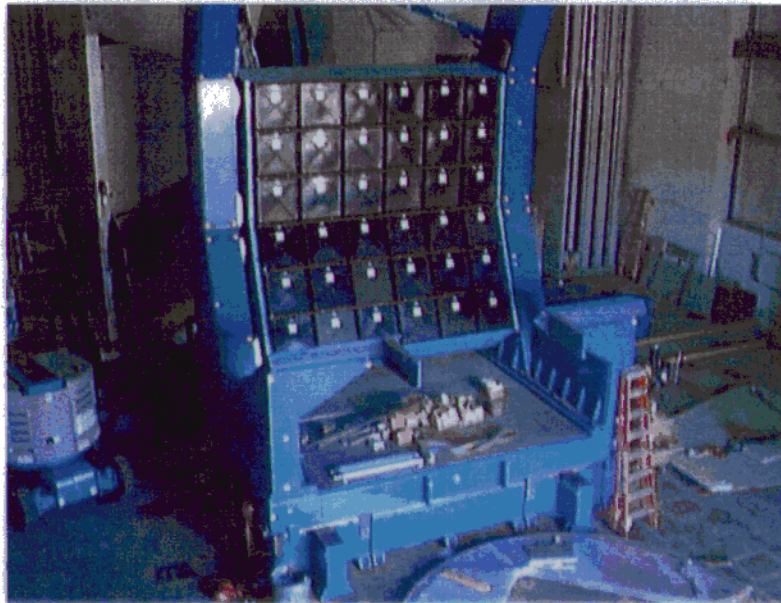
PHENIX Construction Pictures



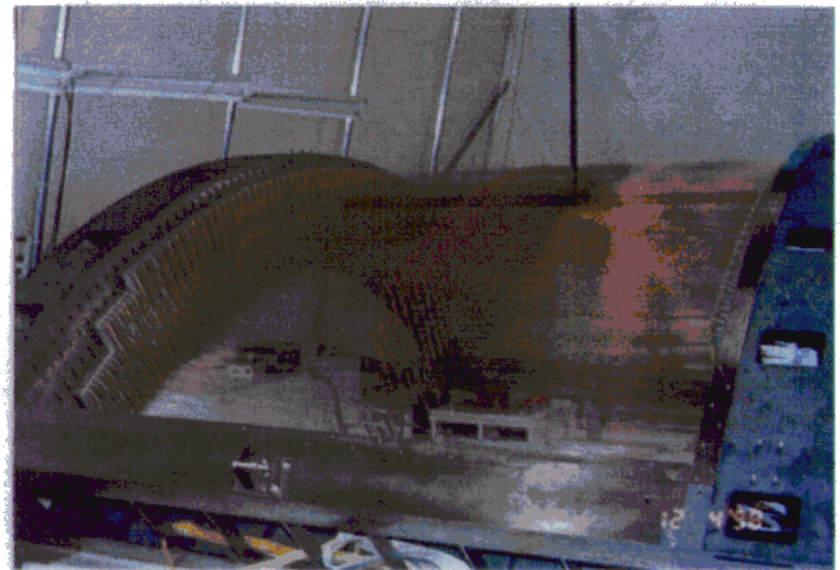
Fully Assembled RICH Vessel



μ identifier panel installation

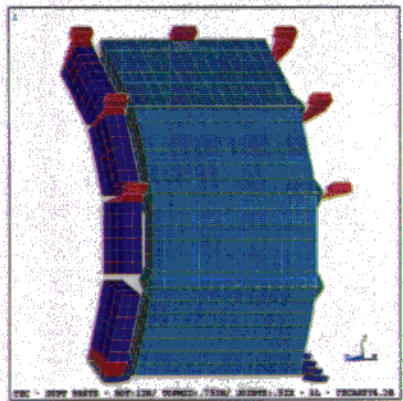
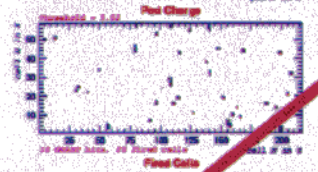
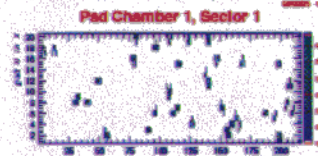
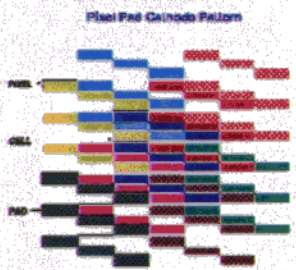
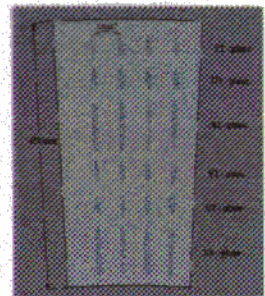
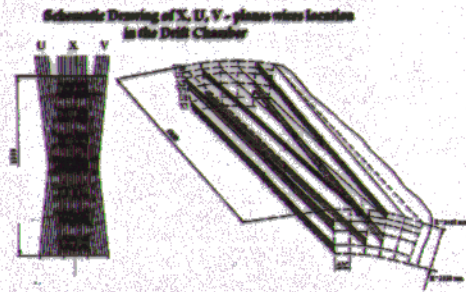


EM-Cal installation on West ARM

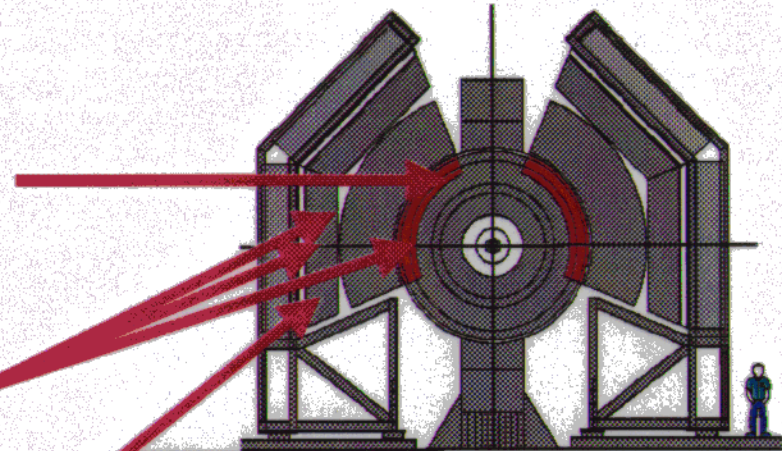


Nearly complete DC (done now)

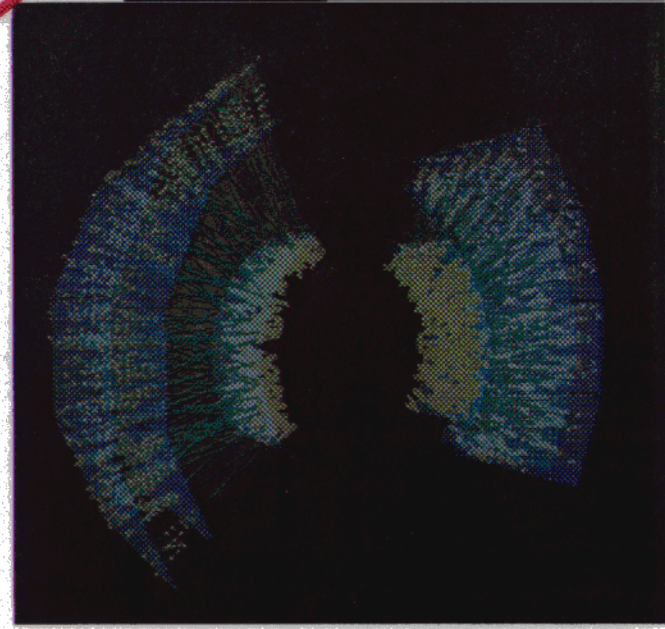
Tracking in the PHENIX central Arms



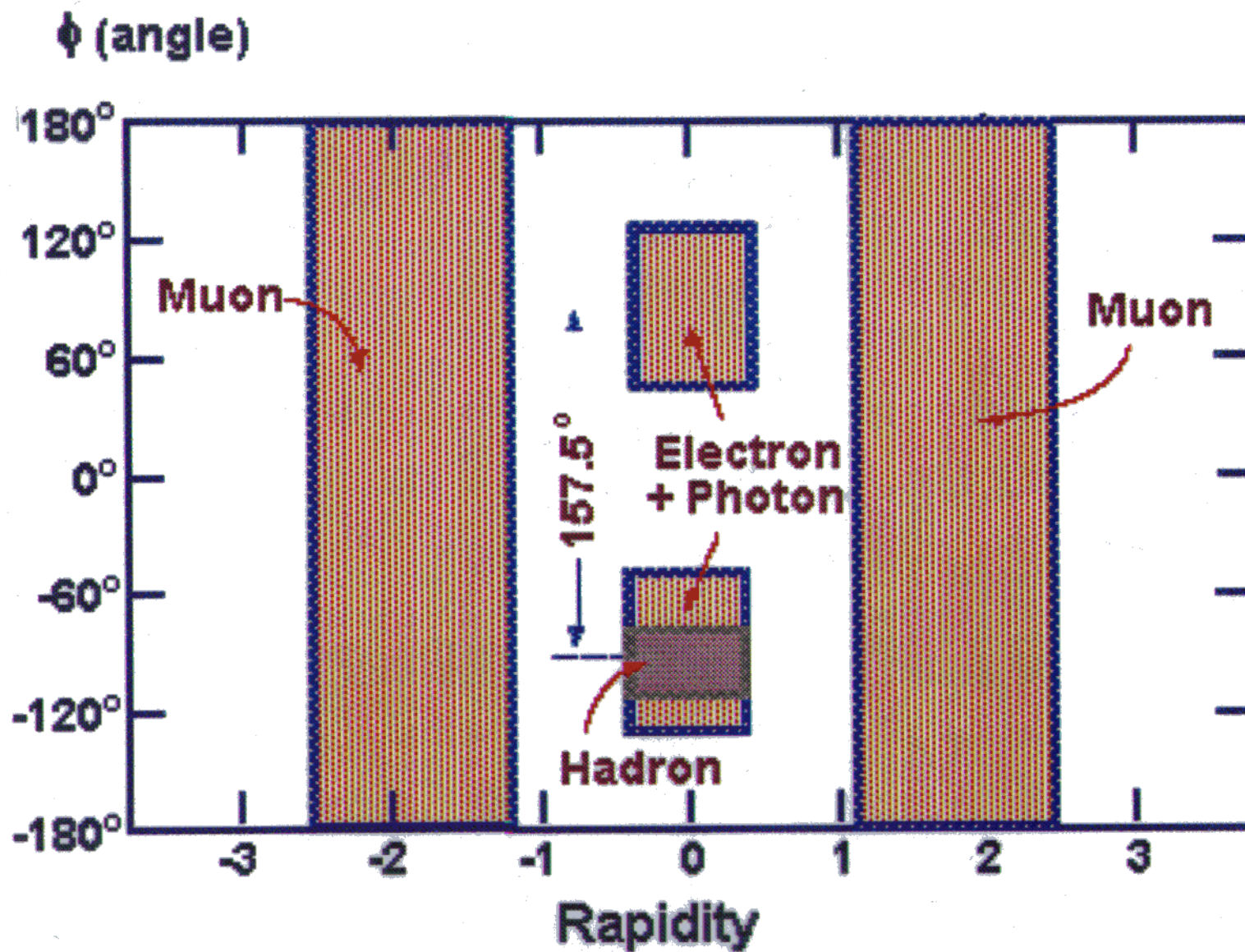
PHENIX 8.1
 FEB 26 1999
 12:52:42
 PLOT 001
 BLENDED
 DELL 1000



STACK :
 ERROR : undefined
 OFFENDING COMMAND : mysetup



PHENIX Acceptance



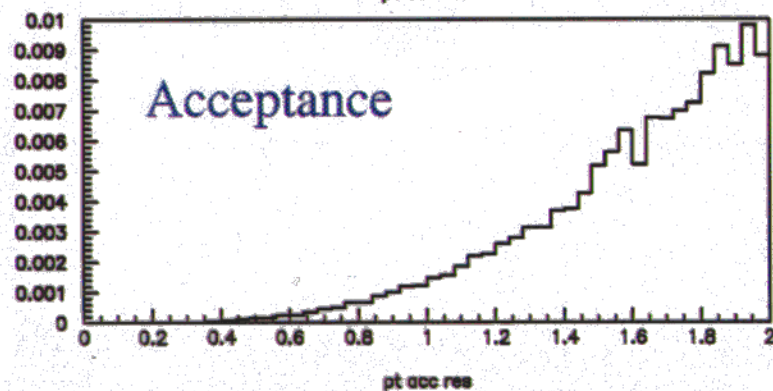
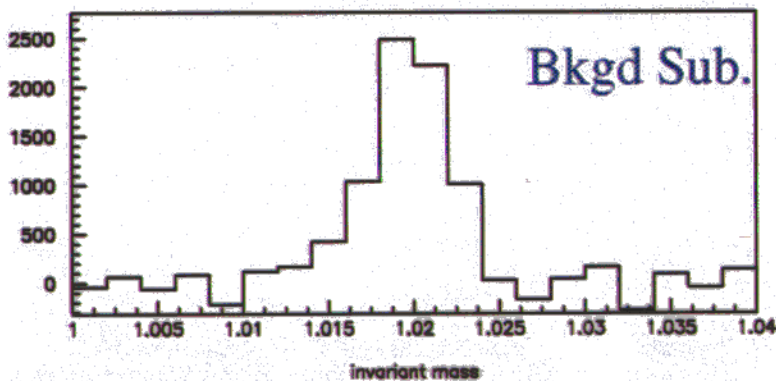
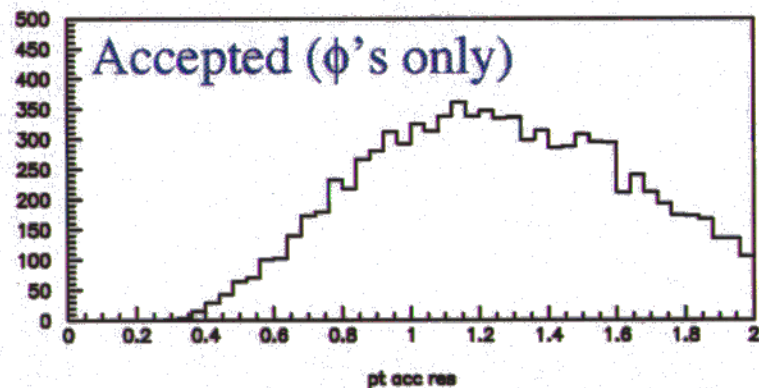
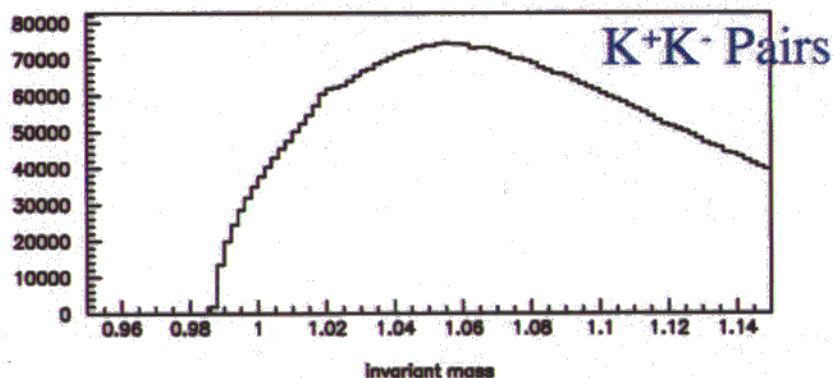
PHENIX Vector Meson Measurements

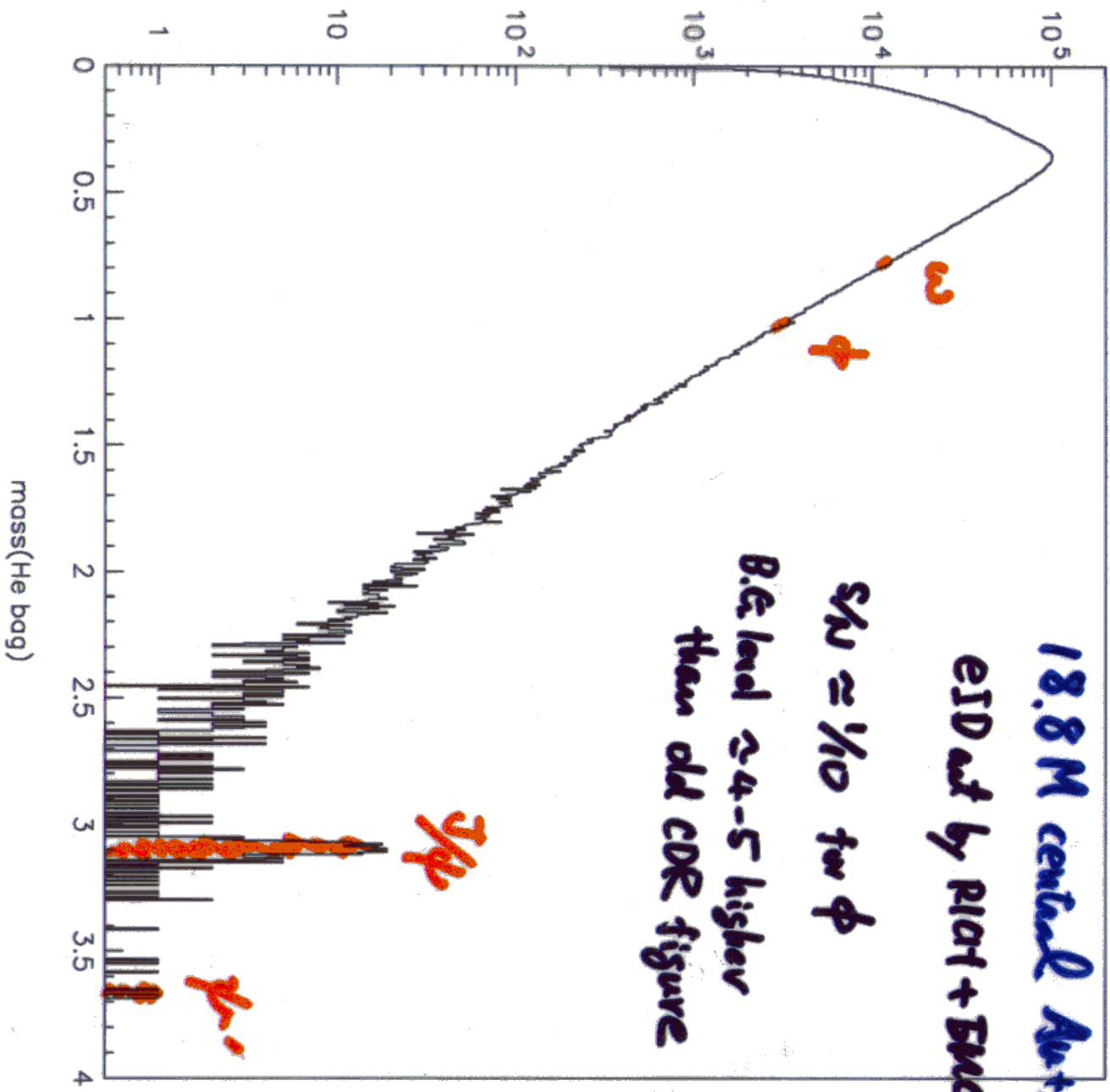
Assumptions re: RHIC performance

- By end of year one -- RHIC reach 10% design Luminosity
- Year-1 integrated Luminosity of $20 \mu\text{b}^{-1}$
- 120 Million min-bias events, 12 Million central events

$\phi \rightarrow \text{KK}$

- Assuming 1/2 of one arm -- day-1 configuration (TOF from EM-cal)
- Low-pt cutoff due to PHENIX single particle p cut, K decay
- “Central” events (10 %) -- 10K ϕ 's ($\sim 1/3$ of total)





PHENIX Vector Meson Measurements (2)

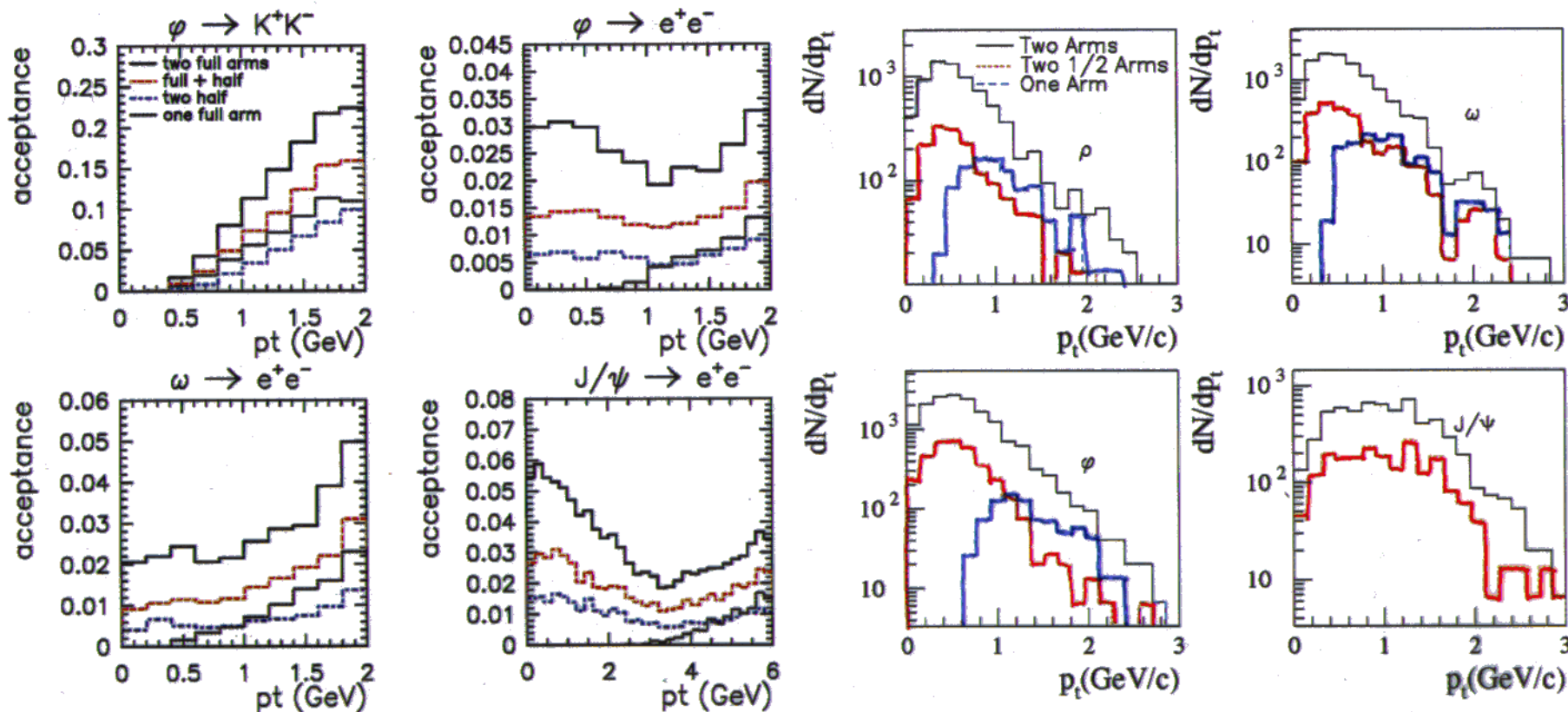
VR $\rightarrow ee$ decays

- Acceptance depends critically (compared to $\phi \rightarrow KK$) on PHENIX configuration
- Little or no acceptance in 1 arm -- need at least two 1/2 arms

\rightarrow Need more than PHENIX day-1 for VR $\rightarrow e^+e^-$

- For two 1/2 arms and 12 Million central Au+Au
- Note: this does not include hadron backgrounds

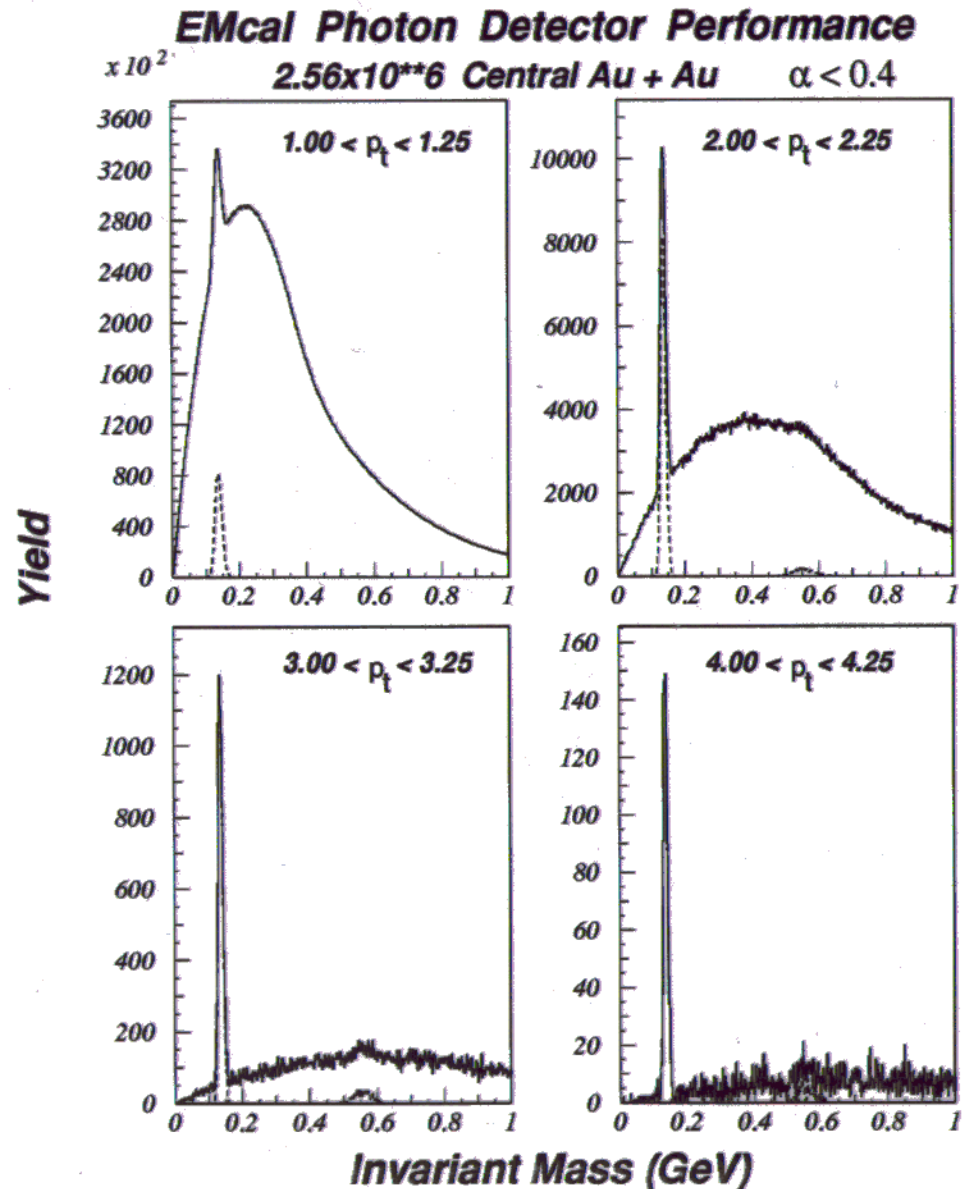
Vector Meson	S/B	Yield	Uncertainty
ρ	1/1264	300	600
ω	1/40	380	130
ϕ	1/5	200	35
J/ψ	$\gg 1$	320	20

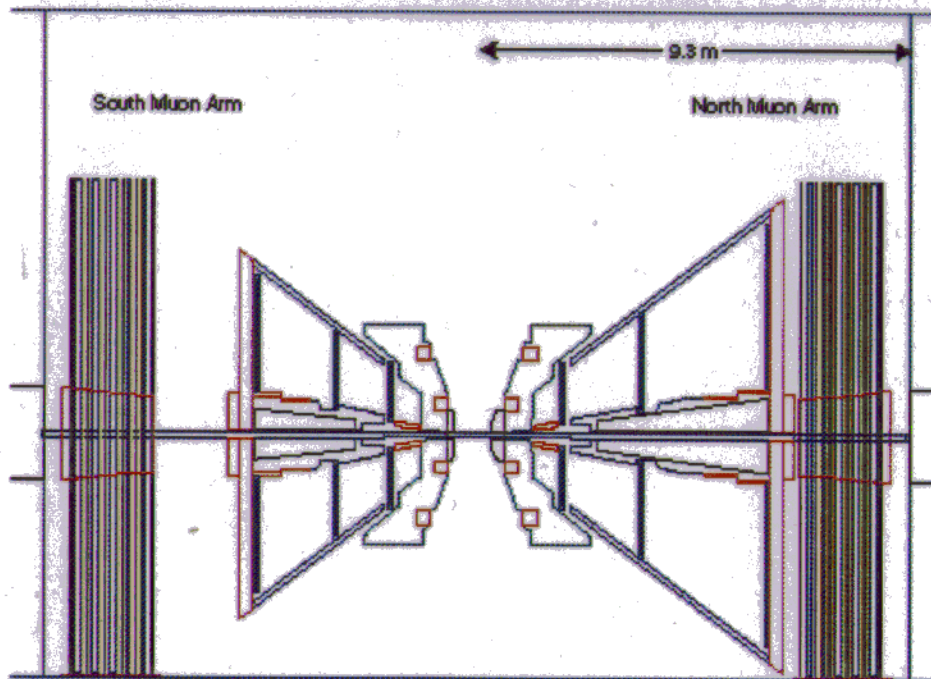


PHENIX π^0 Reconstruction

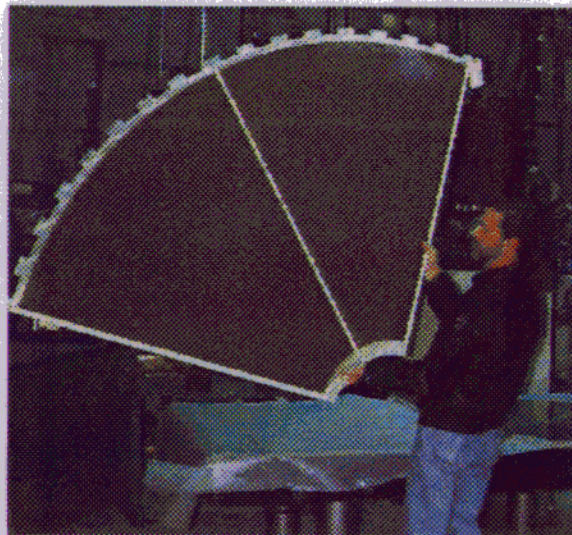
- These results are “old”
- Do not include “albedo”
 - matters for $p_t < 2$ GeV/c
- Include asymmetry cut
- $S/B > 1$ for $p_t > 1.5-2$
- For high- p_t single π^0
 - Good acceptance, resolution
 - High rate: $\sim 1/\text{hour}$ @ 10 GeV for 10% design luminosity
- Direct photons
 - Situation is murky
 - Albedo background is a serious problem.
 - Systematics, systematics,....
 - \rightarrow “doable” for $p_t > 2$ GeV/c
 - π^0 photons start overlapping @ 10-15 GeV/c

Analysis by T. Awes



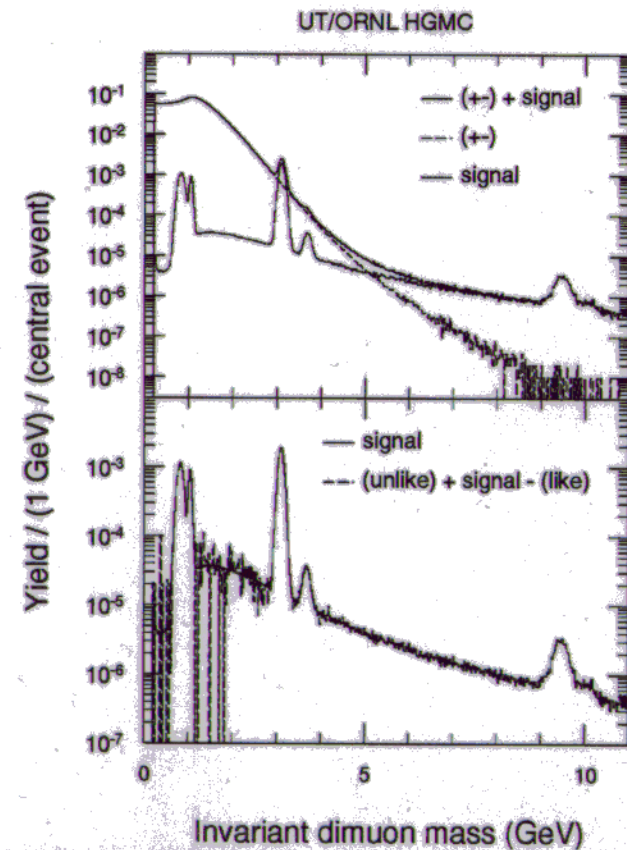


A prototype muon tracker sector

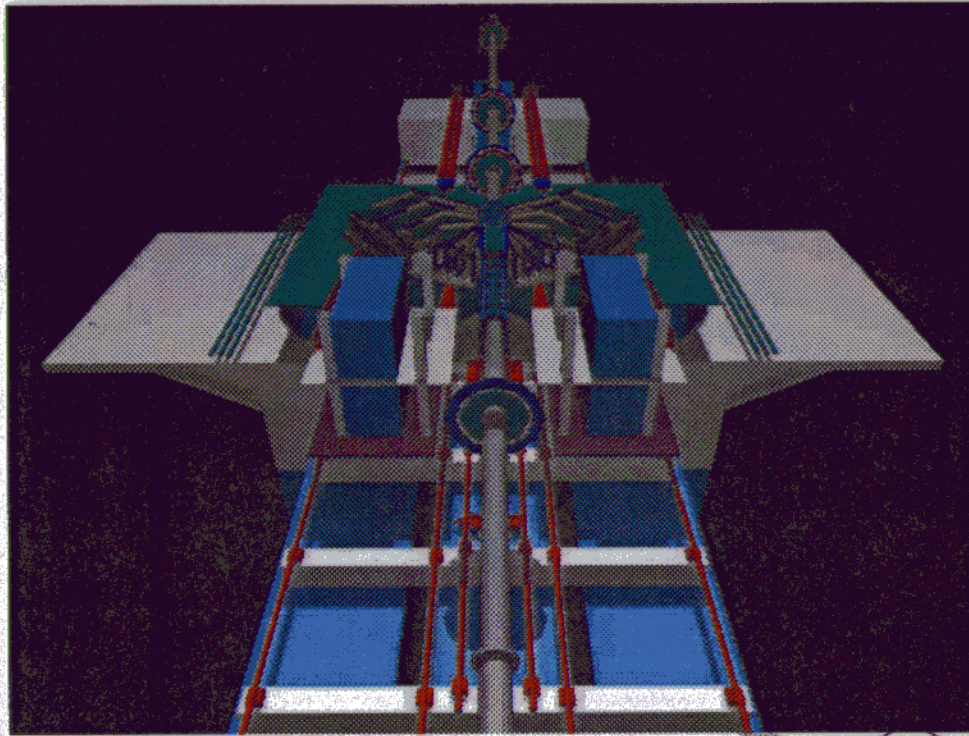


Muon Identification

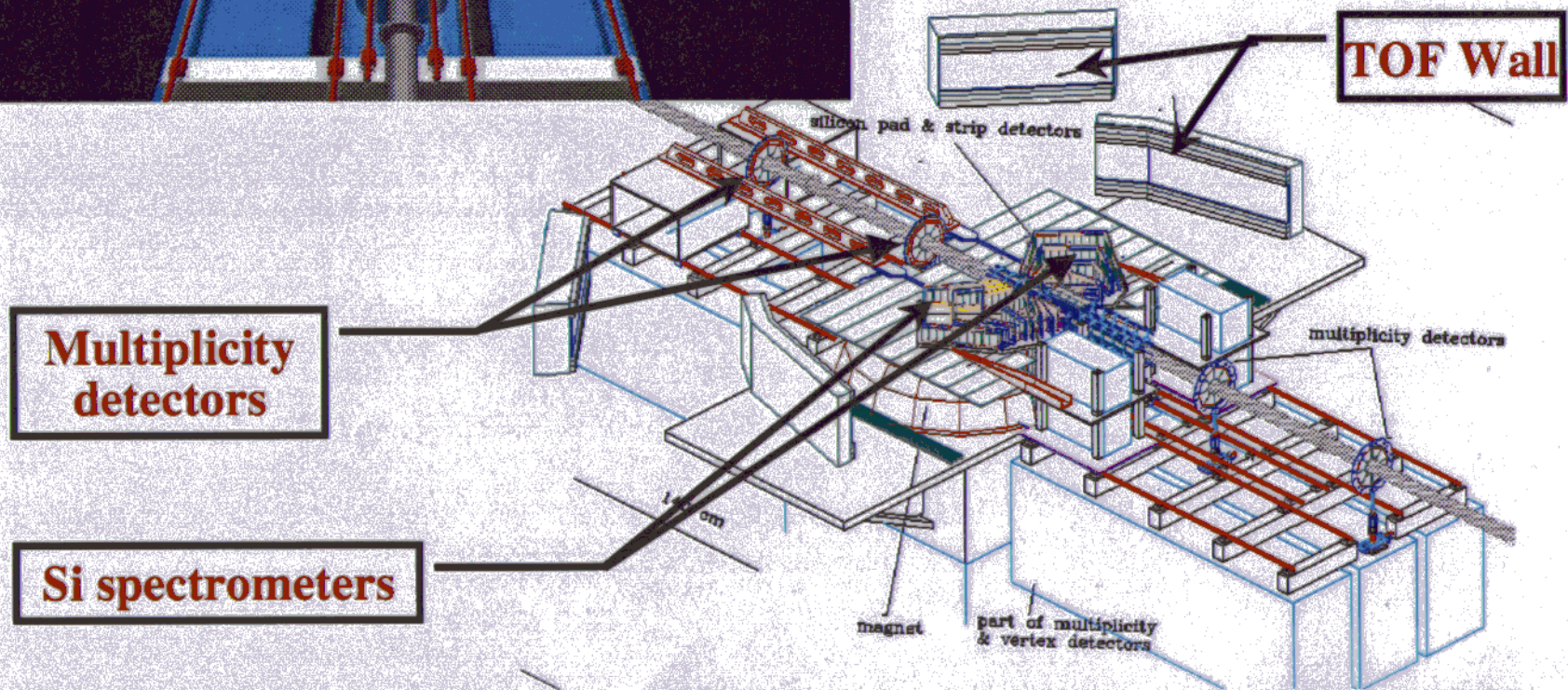
- Absorb hadrons in central magnet yoke.
- Measure the remaining particles.
- Absorb remnant hadrons in μ -Id steel.



The PHOS experiment @ RHIC

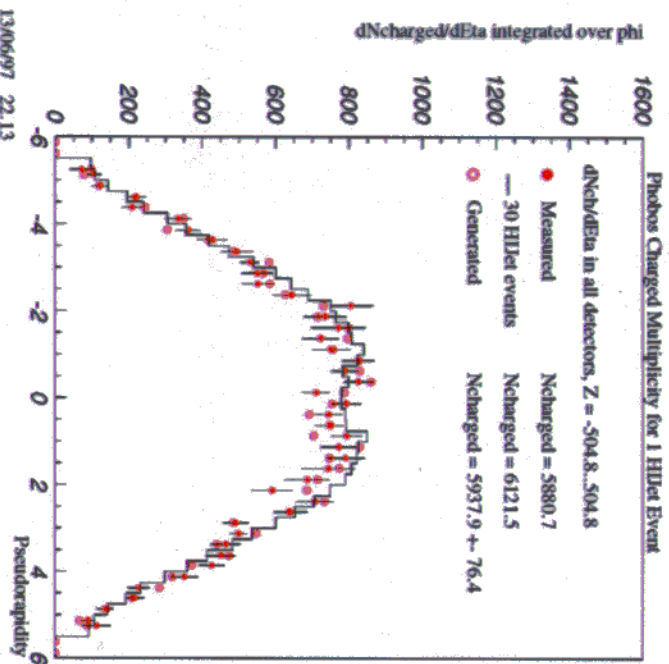
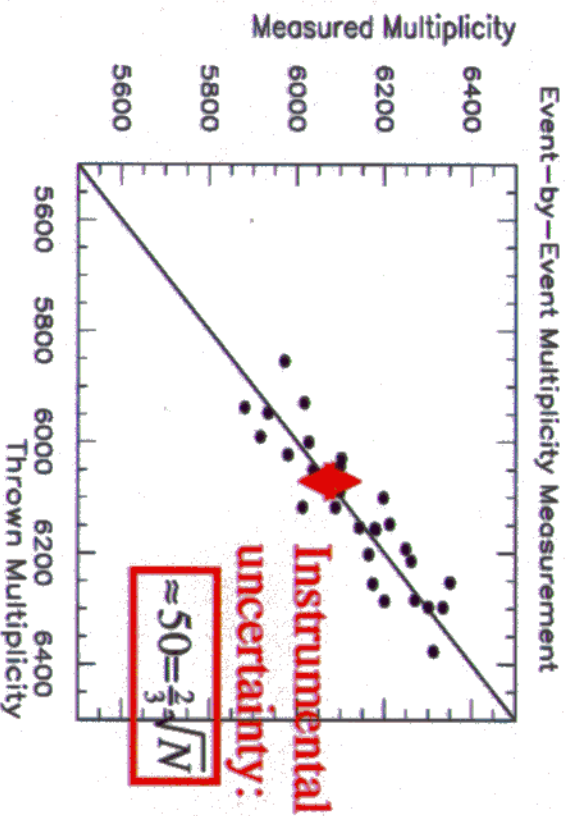


- Two near-mid-rapidity spectrometers
 - $\Delta\eta = 1$ centered on $\eta = 0.5$
 - $\Delta\phi = 11^\circ$
- $dn/d\eta$ for $|\eta| < 5.4$!!!
 - $\delta\eta = 0.1, \delta\phi = \pi/16$
- Si technology everywhere
- Except for TOF walls



Multiplicity Measurements

PHOBOS
M. Baker
June TAC



Monte-Carlo
Study of
performance

Including

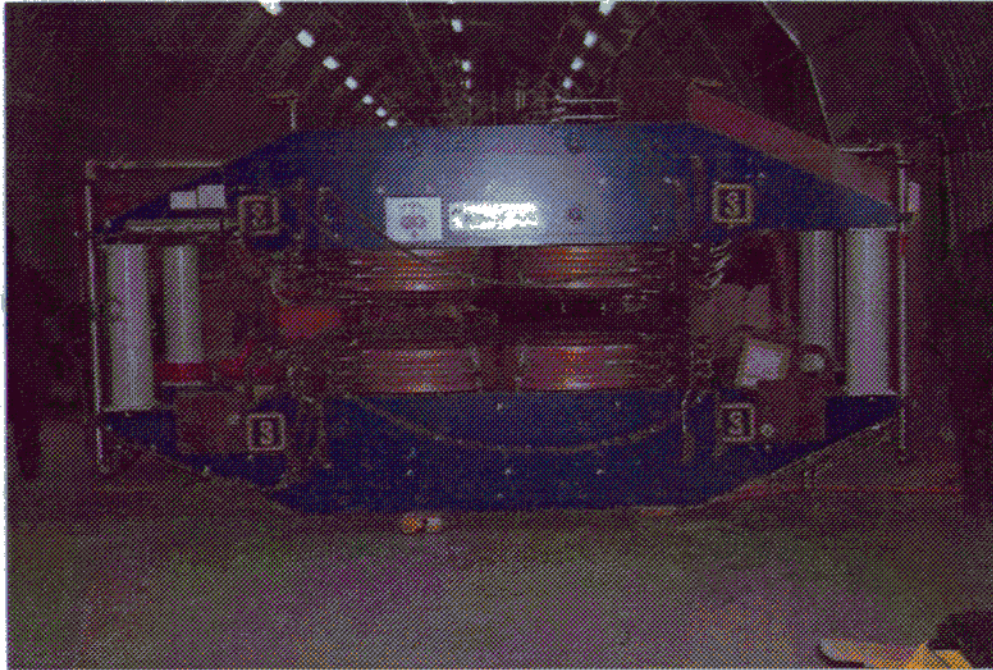
- Landau tails
- Conversions
- Secondaries

July 6-16, 1997

RHIC Theory Workshop

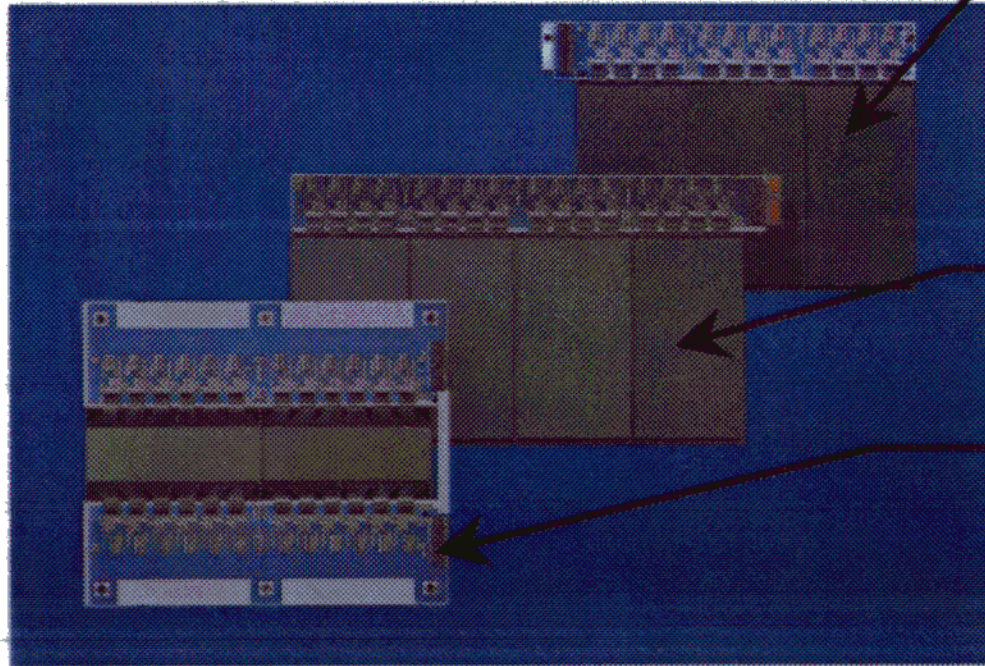
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PHOBOS Construction



- The PHOBOS magnet in the 10 O'clock hall
- Moved here after assembly/testing @ AGS

Spectrometer Si detectors



Used in last 2 planes

- Each of 3 “sensors” has:
 - 256 pads: 4 rows, 64 cols
 - each pad 0.667 x 19 mm.

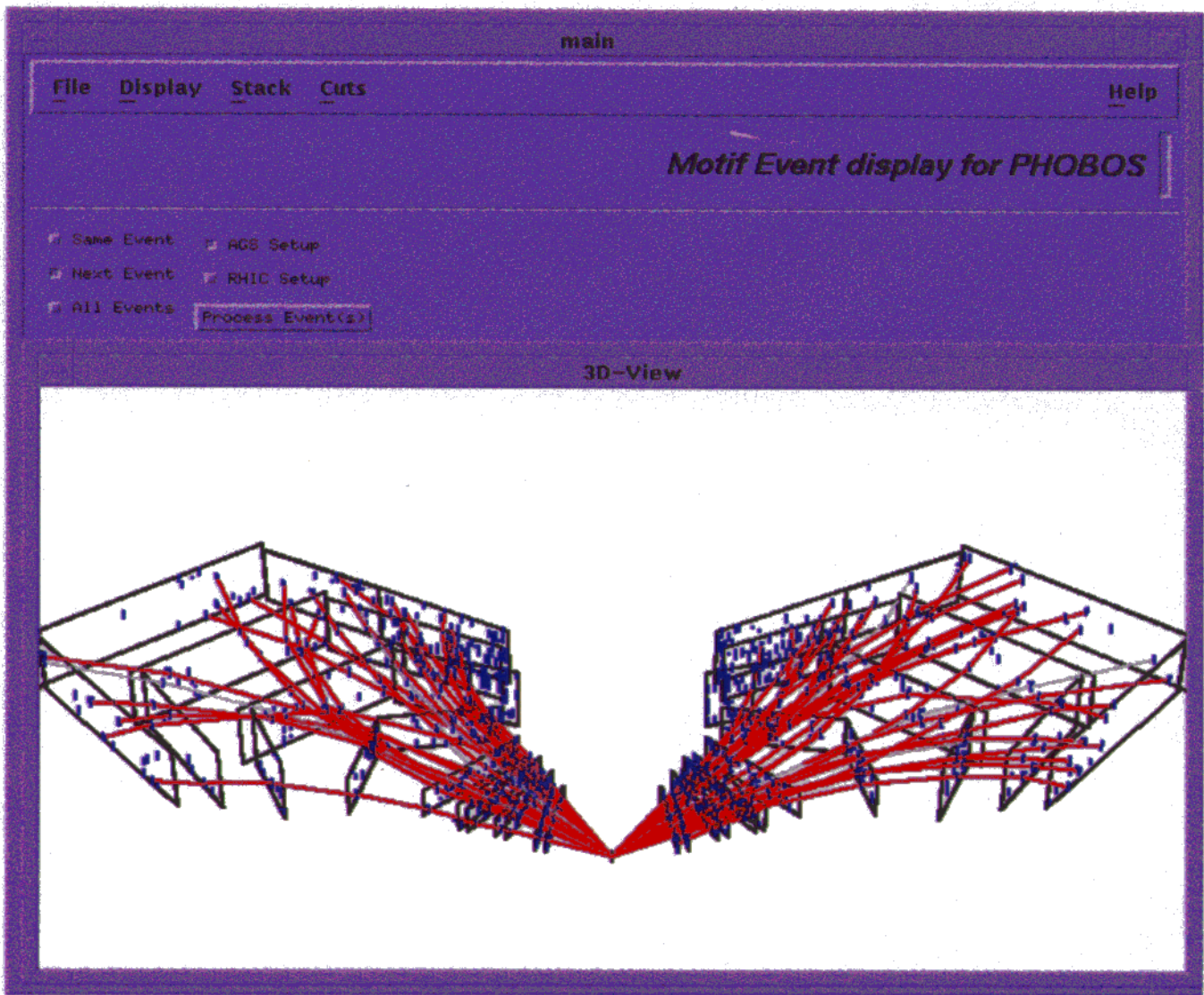
Used in rear planes

- Each sensor same as above

Used in front 4 planes

- Each of 2 sensors has:
 - 1540 pads: 22 rows, 70 cols
 - each pad 1x1 mm

Au+Au Central Event ?



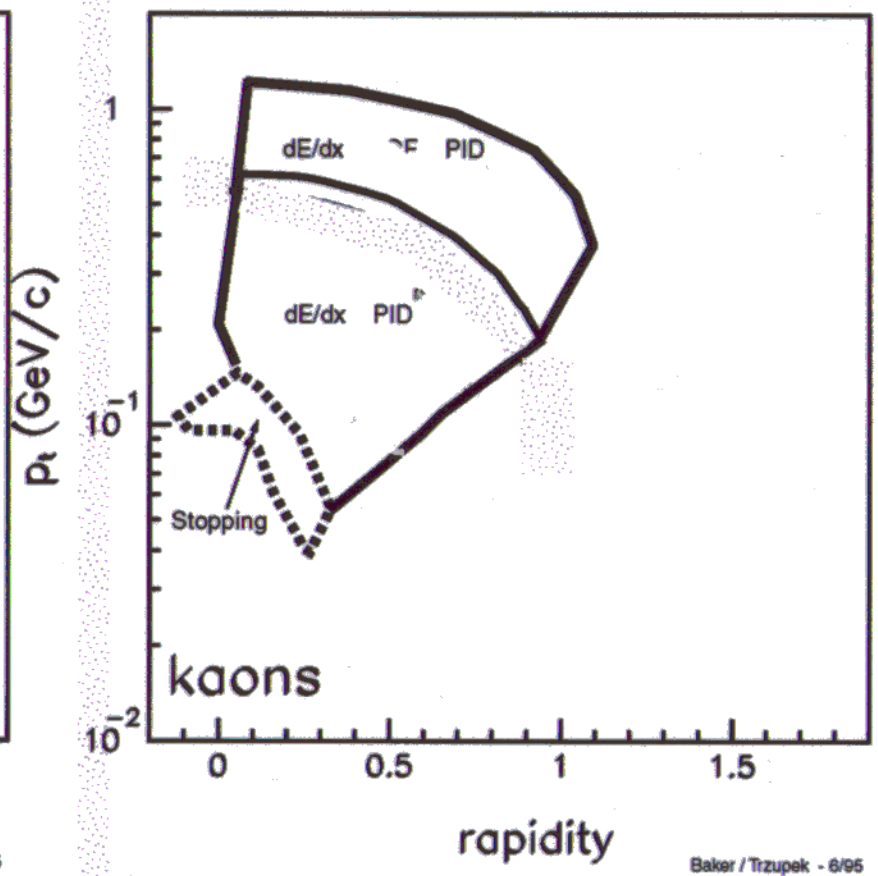
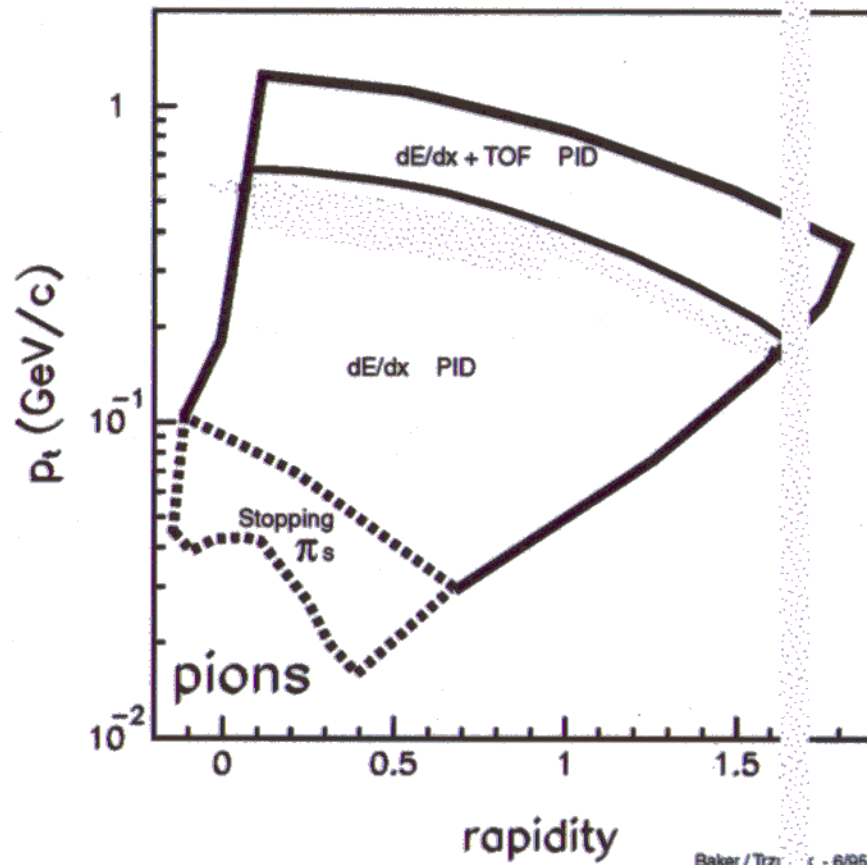
Phobos Central Arms

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PHOBOS Acceptance



July 6-16, 1997

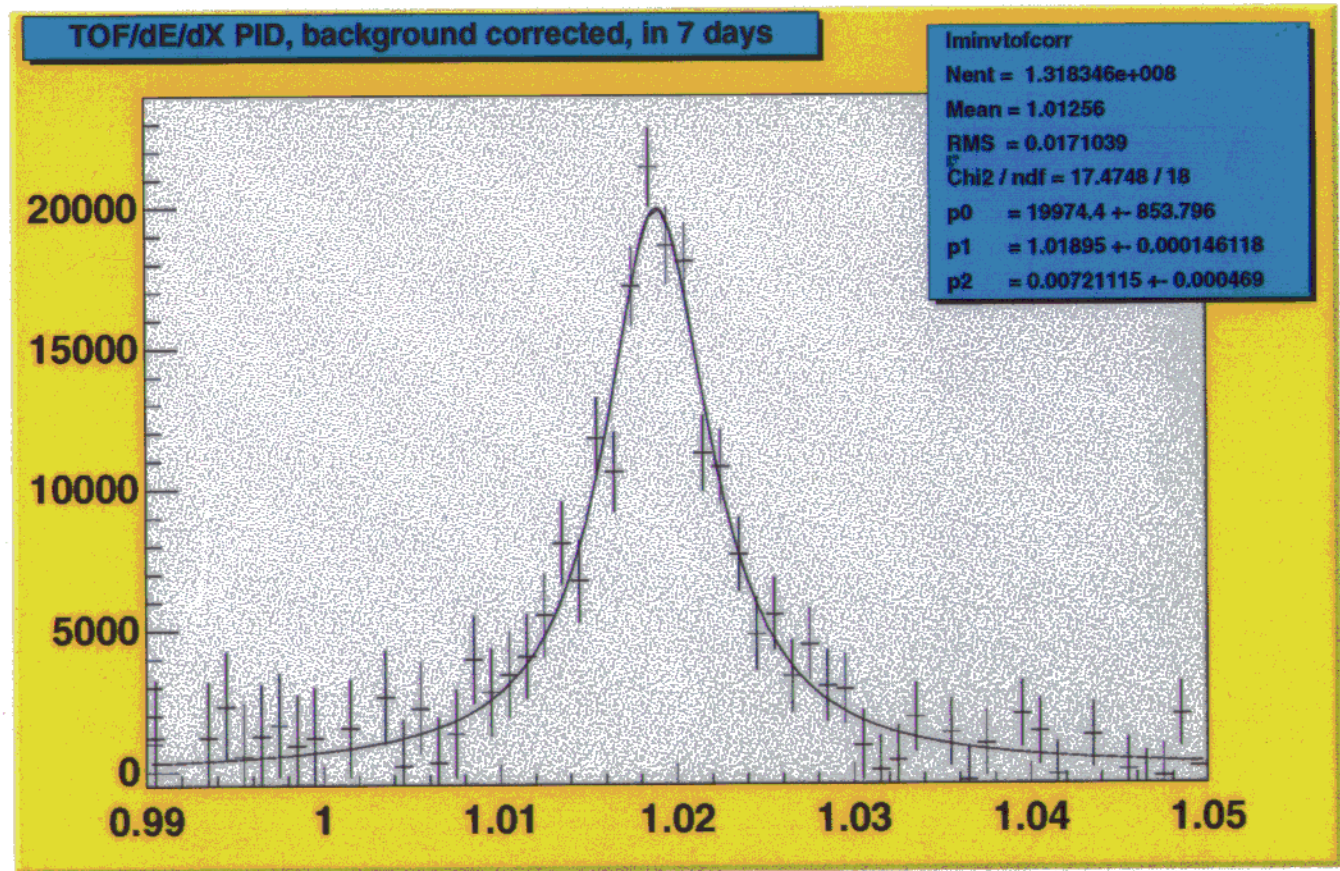
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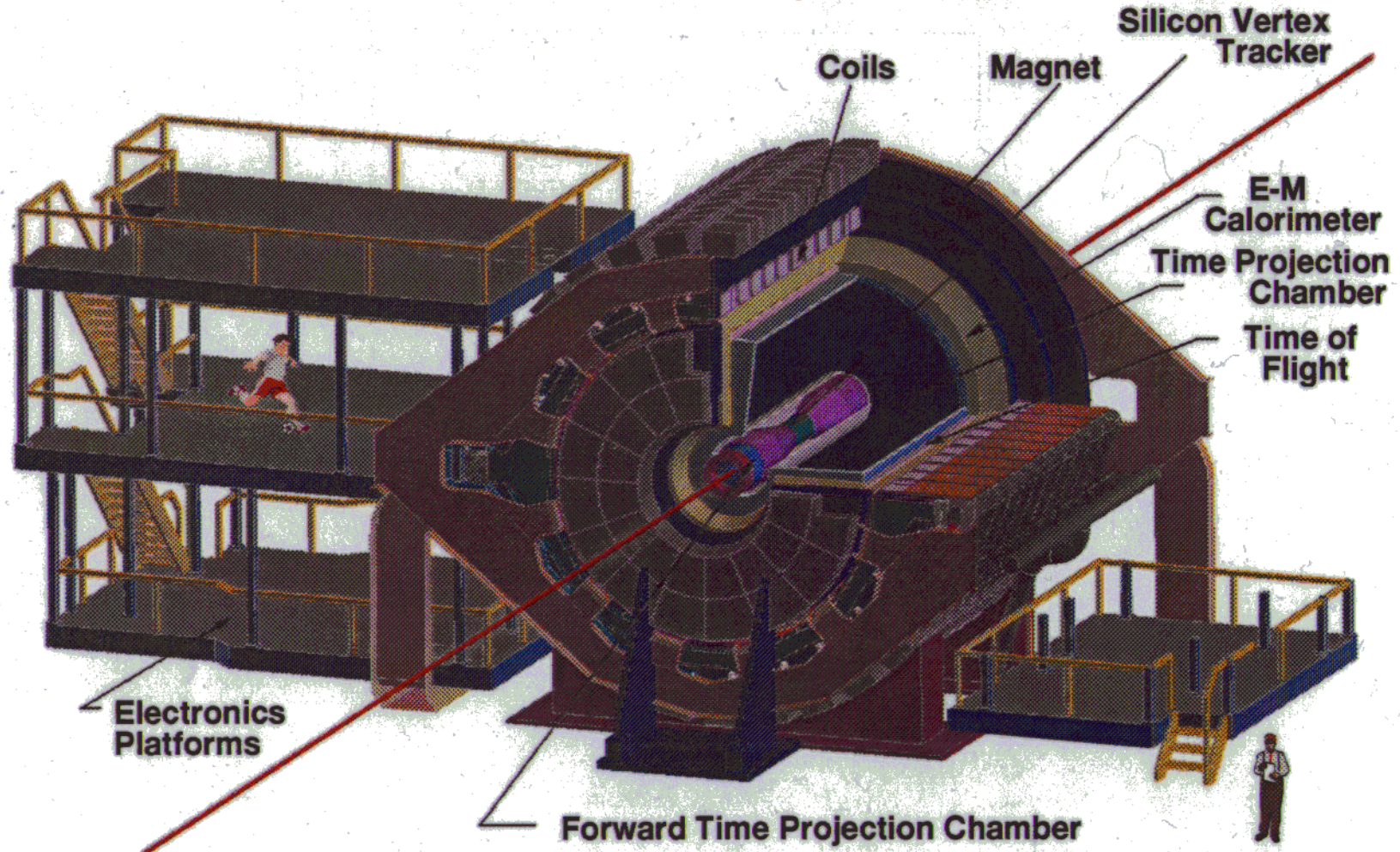
Reconstructed ϕ decays in 1 week (full PID)

$M=1018.95\pm 0.14$ MeV
(1019.41 input)

$\Gamma=5.5\pm 0.7$ MeV
(4.4 input)

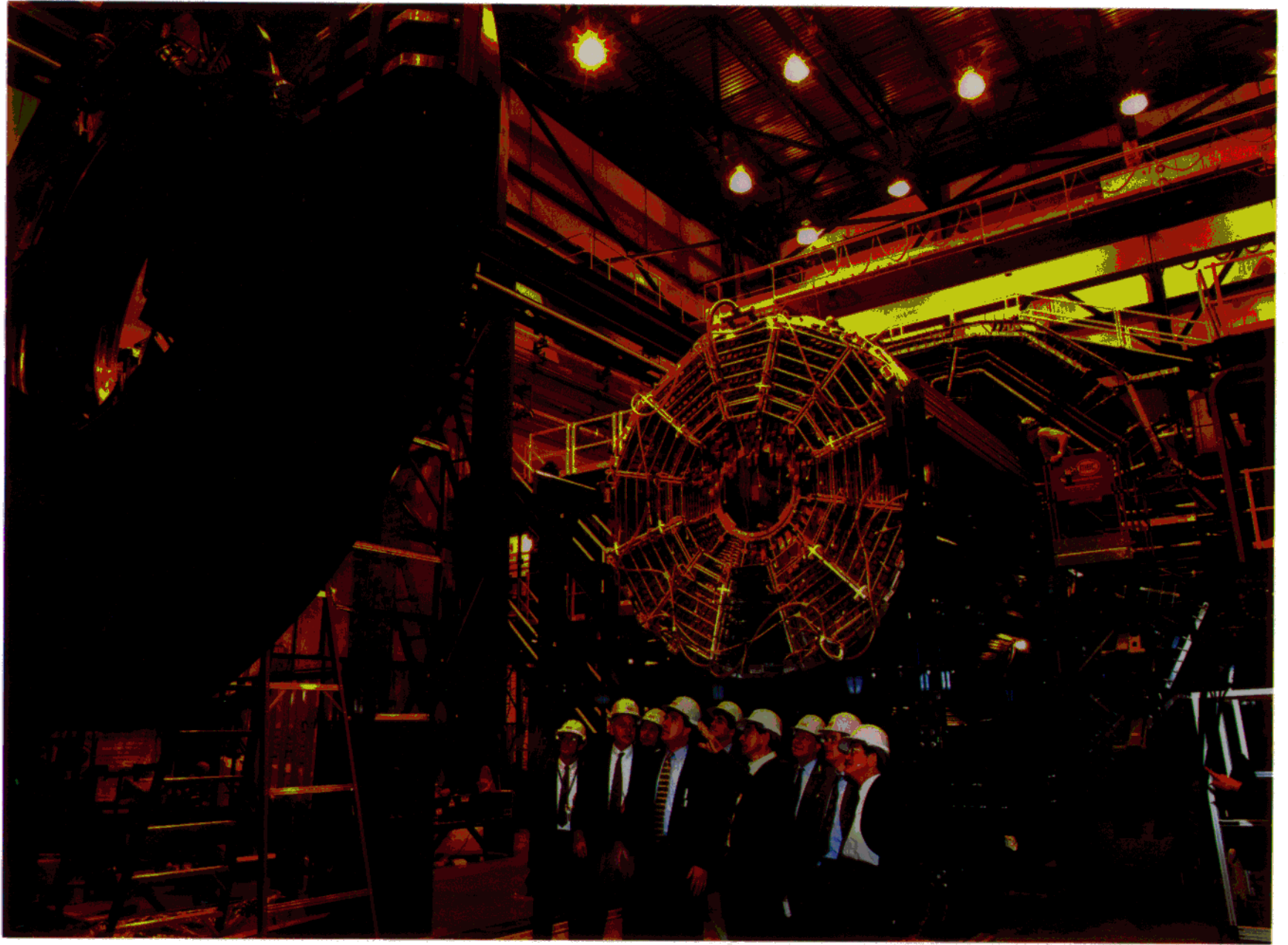


The Solenoidal TPC At RHIC

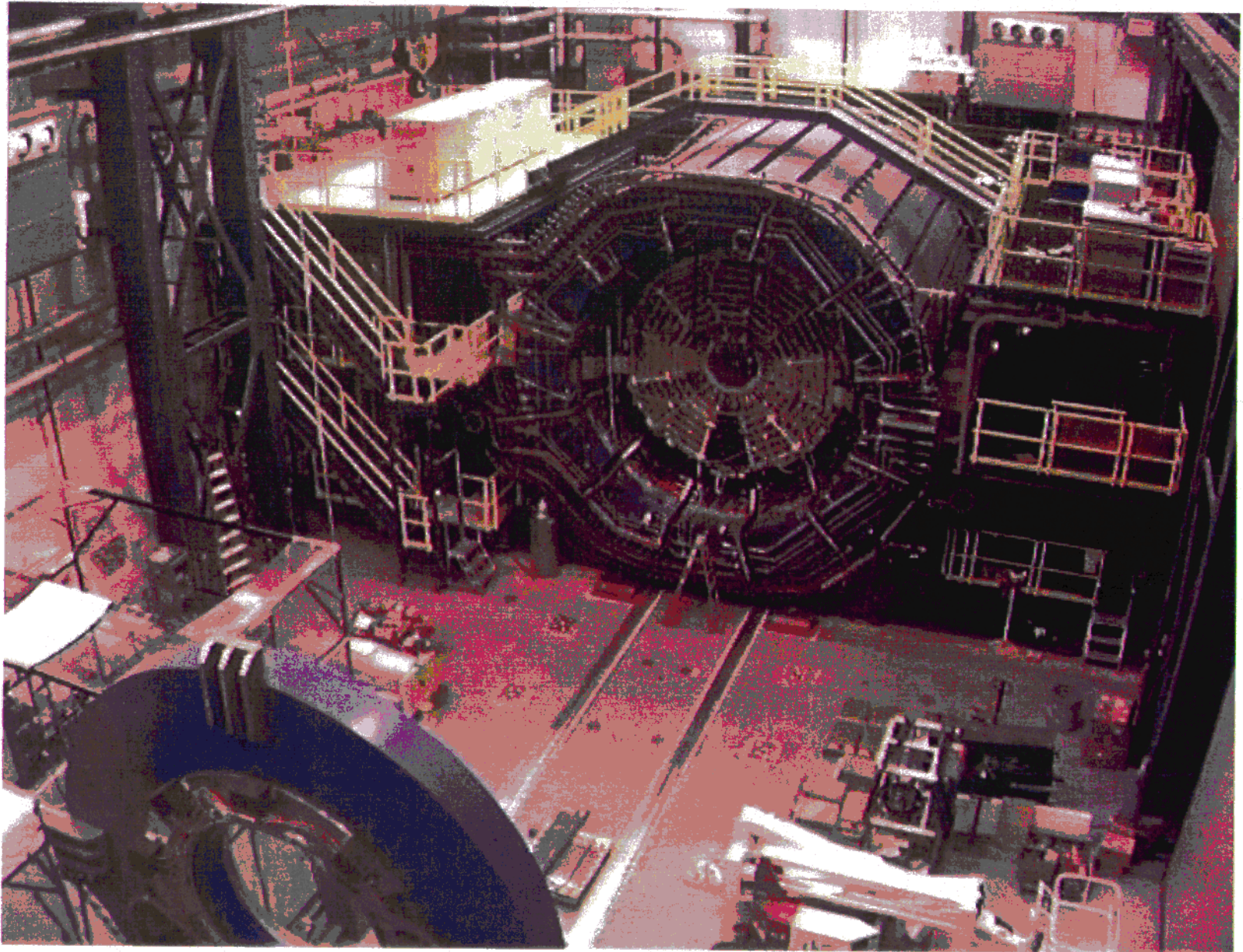


- Large acceptance experiment - **will measure 1000's charged particles**
- Time Projection Chamber + good vertex tracking + EM calorimetry
- Outstanding hadronic signals coverage with some leptonic coverage
- Complimentary to the rest of the RHIC program

26-71-21N



The Wide Angle Hall - Dec 17, 1998



- TPC “on detector” cabling complete (also trigger barrel)

Experimental Signal Coverage(2)

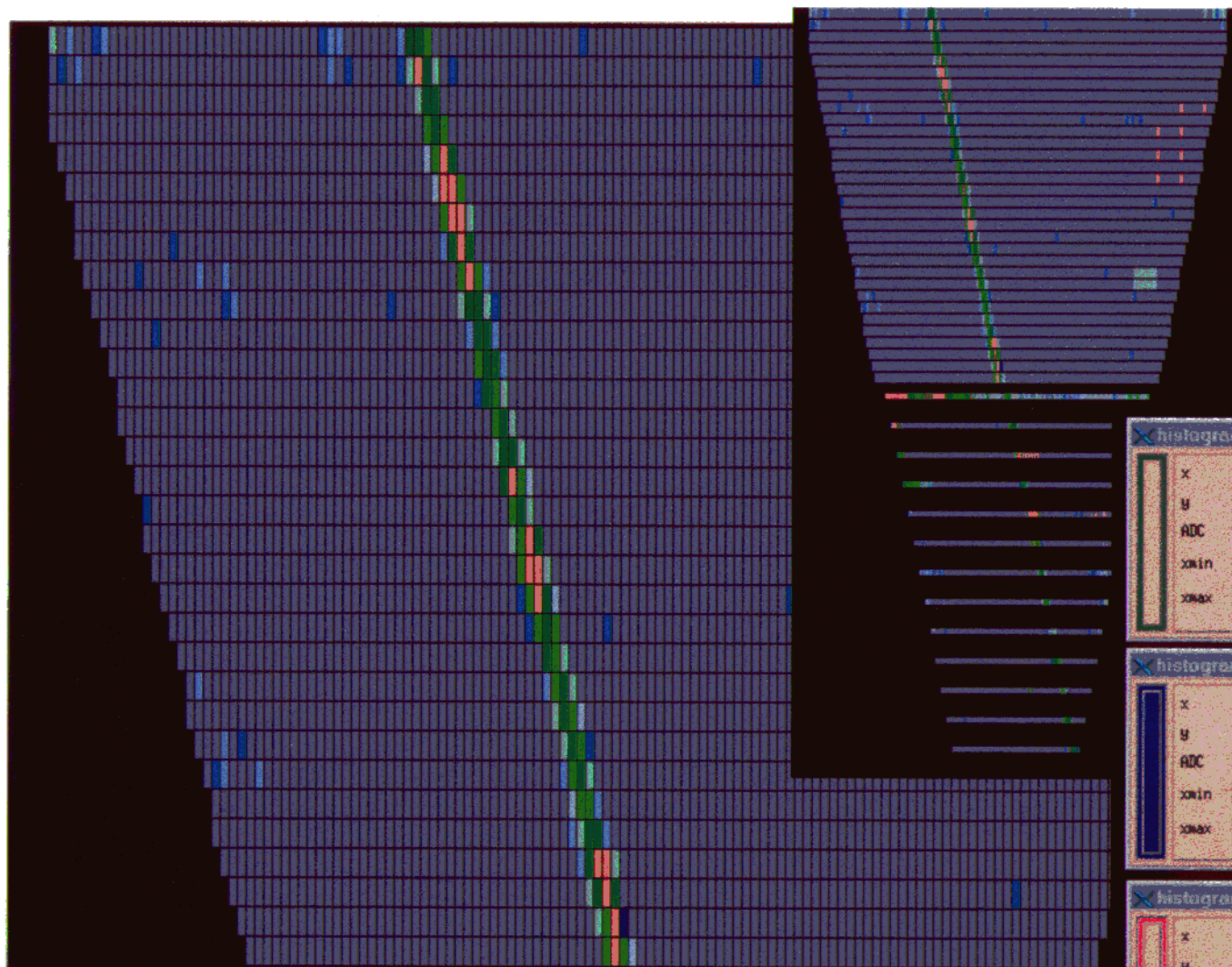
Time scale	Probe	STAR	PHOBOS	BRAHMS	PHENIX
Fluctuations/ X-symmetry restoration	<i>DCC Formation</i>	X	X		?
	<i>Fluctuations, Event-by-Event</i>				
	dN/d η fluctuations	X	X		$\eta < 3$
	event-by-event $\langle p_t \rangle$	X			
	event-by-event K/ π	X			
Hadronization	<i>Hadrons</i>				
	Identified hadron spectra	X	low- p_t	X	X
	HBT Interferometry, π/K	X	low- p_t	X	X
	Strangeness: K ⁺ /K	X	low- p_t	X	X
	Strangeness: Λ , K _s , Ξ	X	?		
	Anti-protons	low- p_t	low- p_t	X	X
	Strange anti-baryons	x			
Hydrodynamics	<i>Global Variables</i>				
	E _b dN/dy	X	X	X	X
	Elliptic flow	X	X		~
	Mt spectra, transverse expansion	X	X	X	X

Summary

- Good coverage of most suggested observables
- Redundancy on many of these -- especially in hadron sector
- The vector resonance/photon signals heavily dependent on PHENIX
– and thus PHENIX's implementation schedule ...

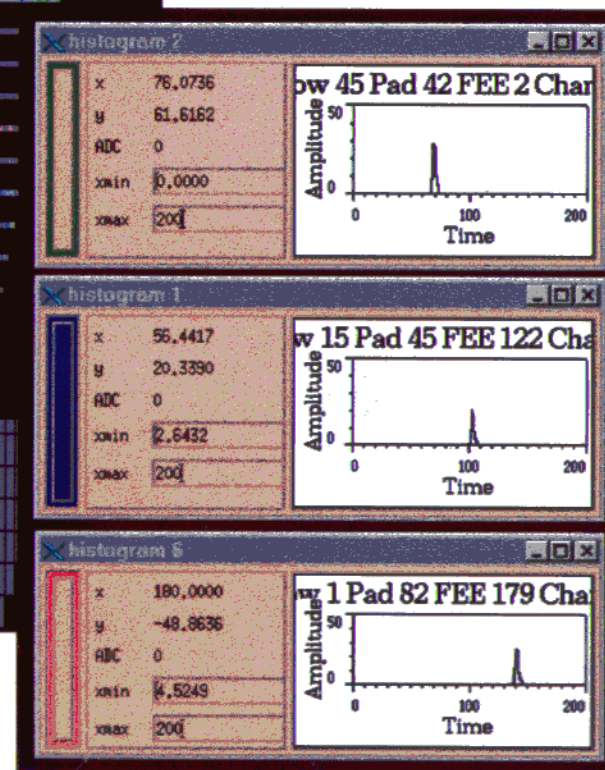
Sector Testing with Cosmic Rays

10/19/98-10/30/98



Drift distance
~ 80 cm

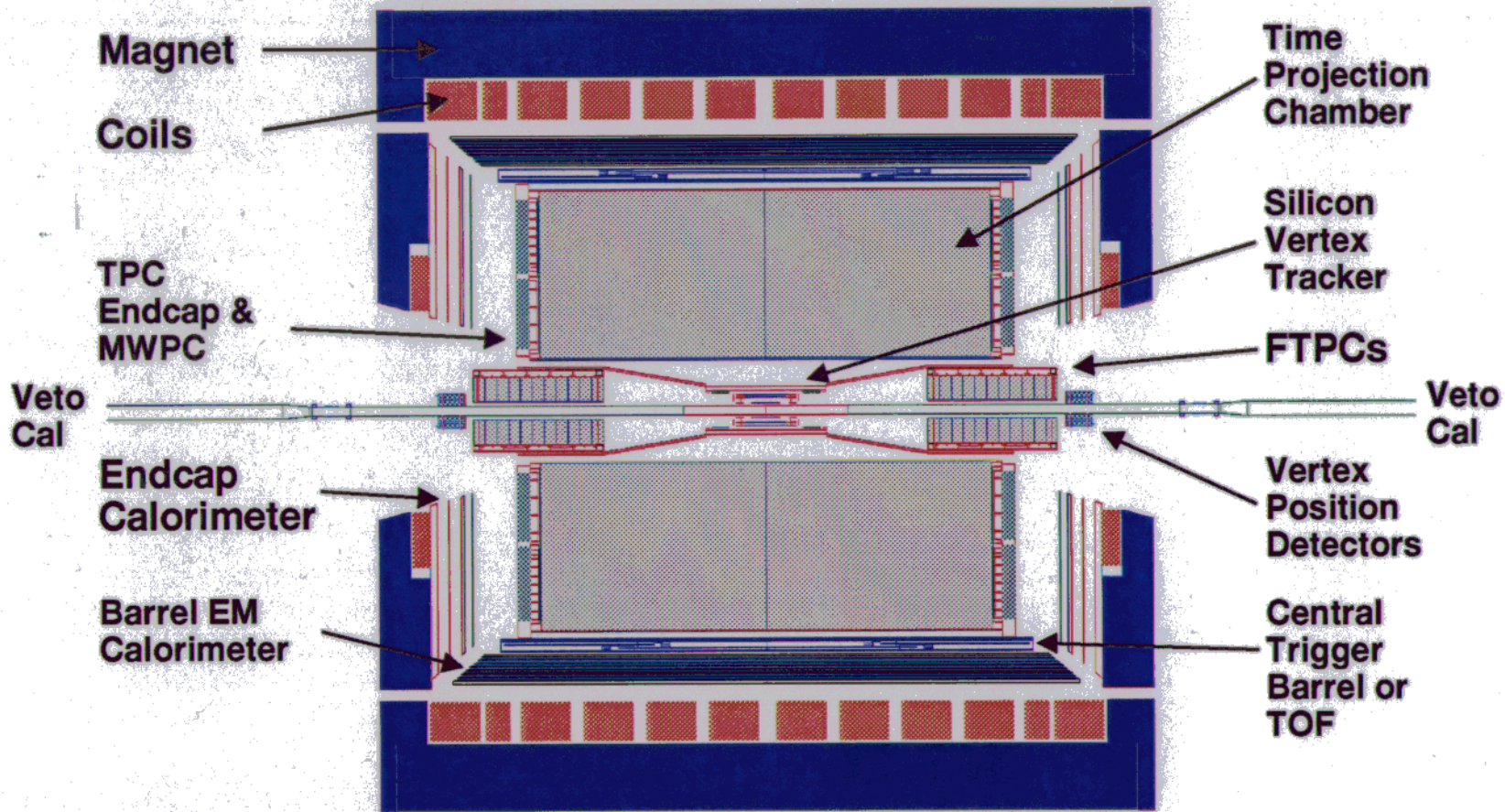
Z drift changes
by ~ 45 cm as
shown in panels



Pedestals at 3σ , Zero B field run: track width < 1 cm



from the inside out



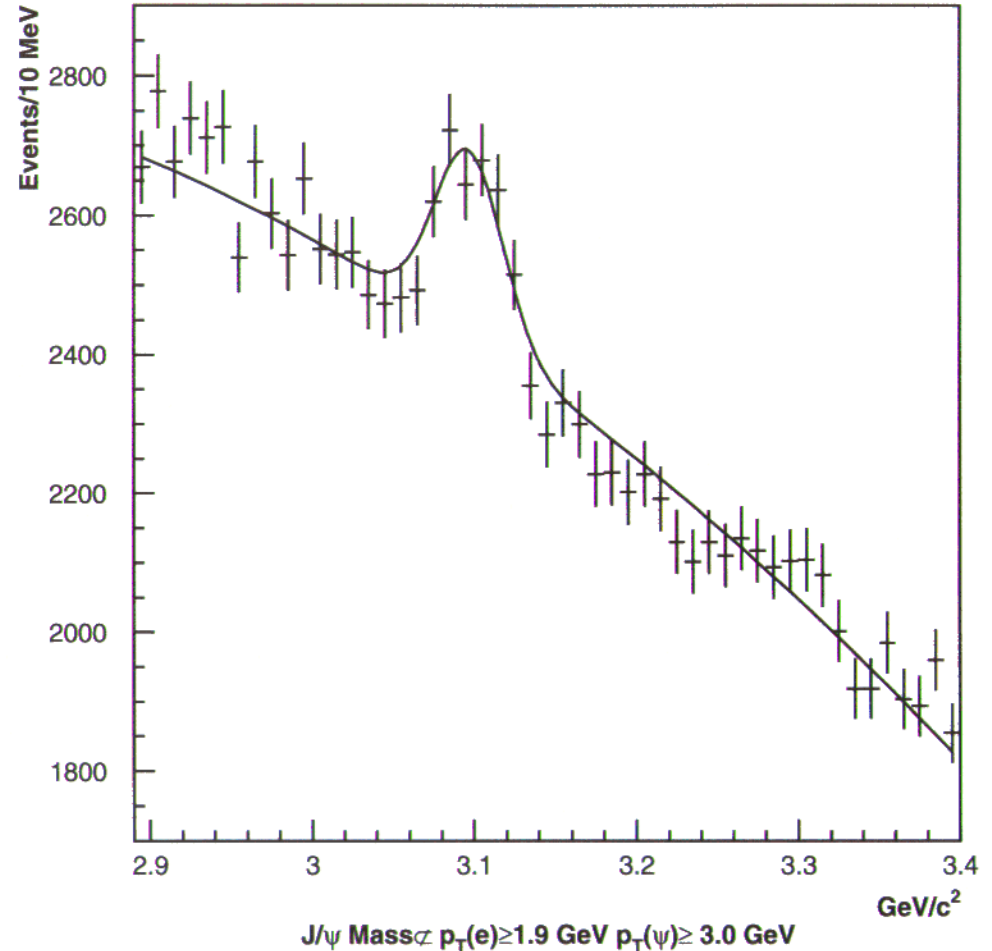
STAR Coverage

- TPC's -- Central: $-1.5 < \eta < 1.5$, Forward: $2.5 < |\eta| < 4$
- Silicon -- Silicon Vertex Tracker + SDD: $-1 < \eta < 1$
- EM Calorimeter -- Barrel: $-1 < \eta < 1$, one endcap: $1 < \eta < 2$
- Particle identification by dE/dx in TPC & SVT, limited TOF

STAR EM Measurements

One Example -- J/ ψ

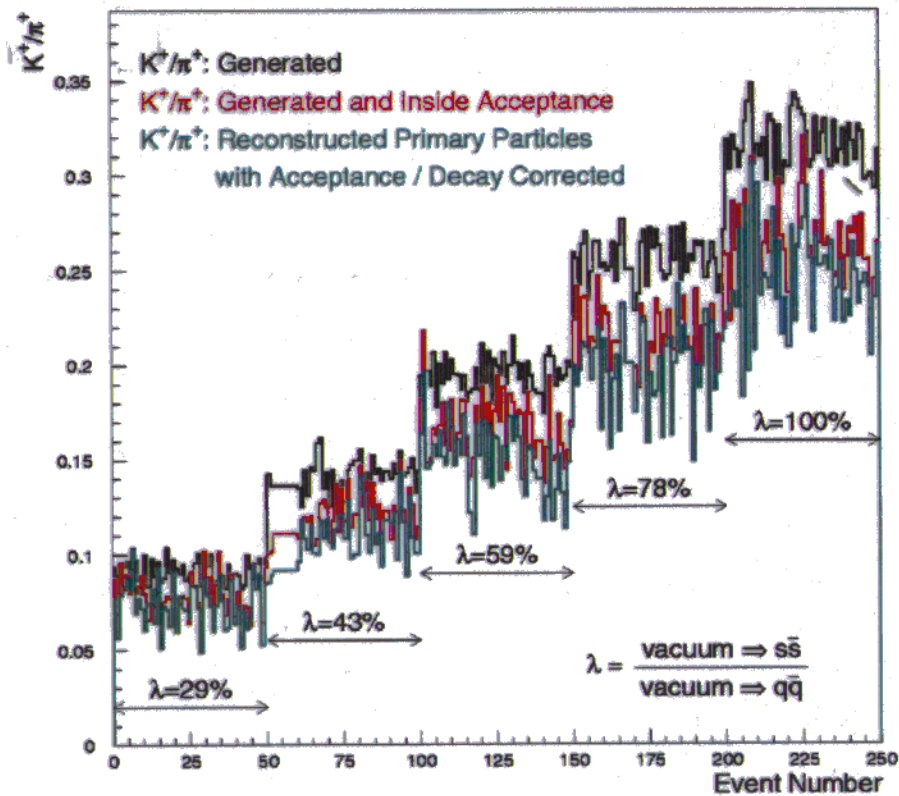
- Analysis by Tom LeCompte
 - Electron id by EM-Cal
 - Fake hadron backgrounds
 - Conversions
 - Dalitz decays
- Significant background to J/ ψ
 - even for $e p_t > 1.9$, $\psi p_t > 3$ GeV/c
- This result ~ 1.5 years old
- Possible improvements
 - dE/dx rejection of hadrons
 - \Rightarrow small hadron reduction
 - improves S/B substantially
 - Shower “shape”
 - STAR RICH
- This was done when calorimeter design was not finalized



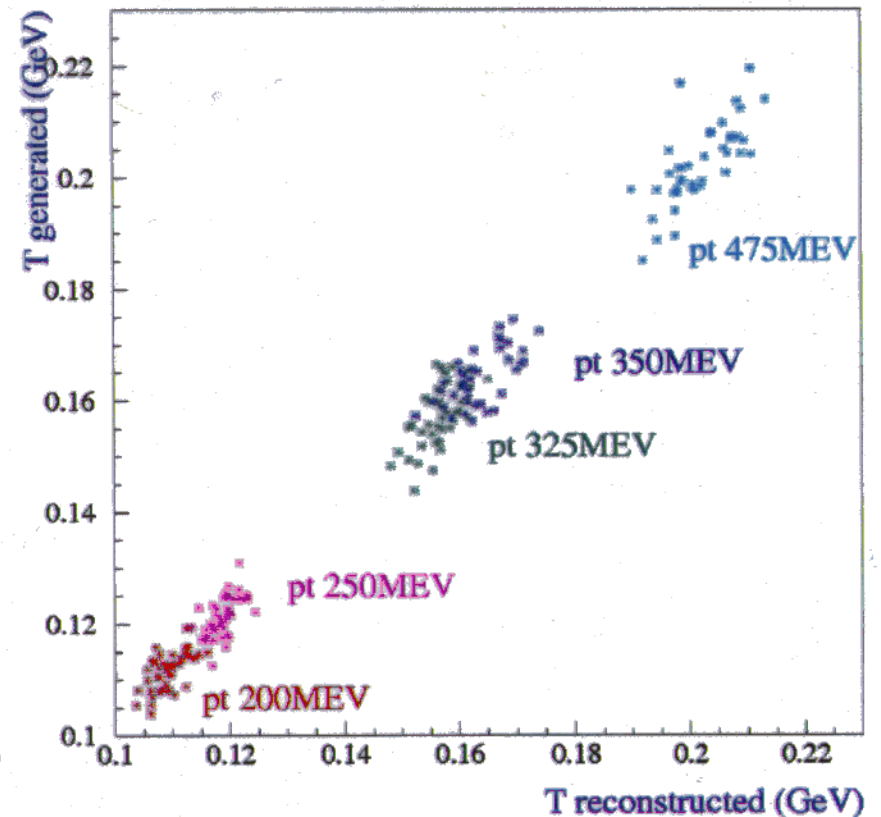


Physics Simulations - Event by Event

Reconstructed K/π ratios Analysis by FQ. Wang hijet events

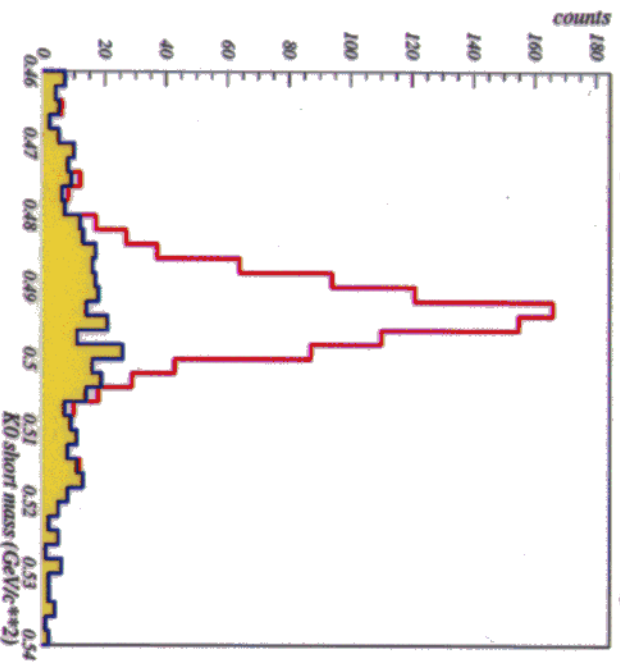


Reconstructed slope parameters Analysis by I. Sakrejda Temperature correlation

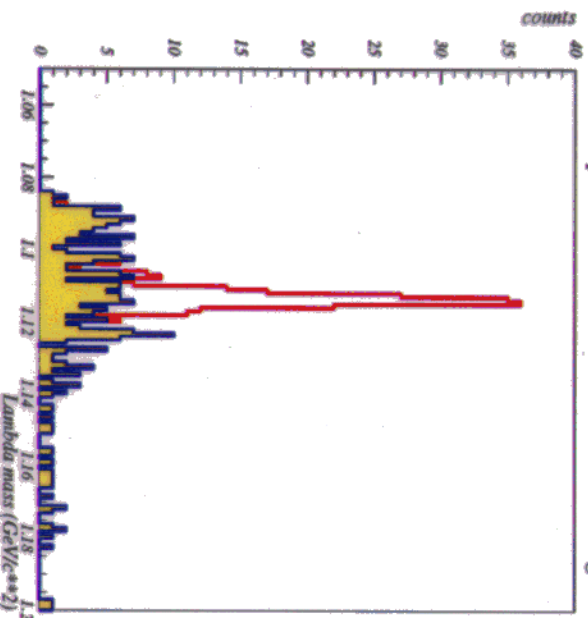


STAR - Strange Decays

Extrapolation to 300 Events = 5 min running

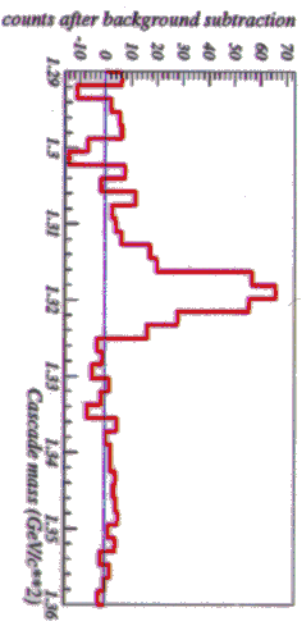
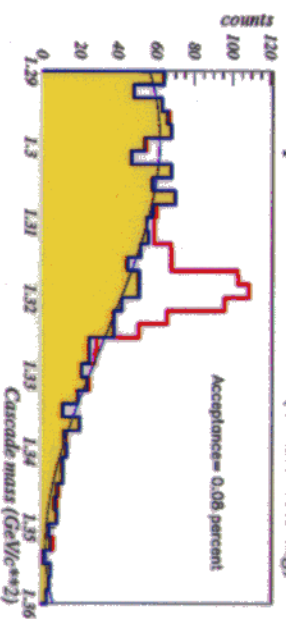


Extrapolation to 300 Events = 5 min running



**HUGE !! Rates
for K_s and Λ
 Ξ is harder
(~ 100 per day)
Still well in hand**

Extrapolation to 100k Events (28 Hrs. running)



July 6-16, 1997

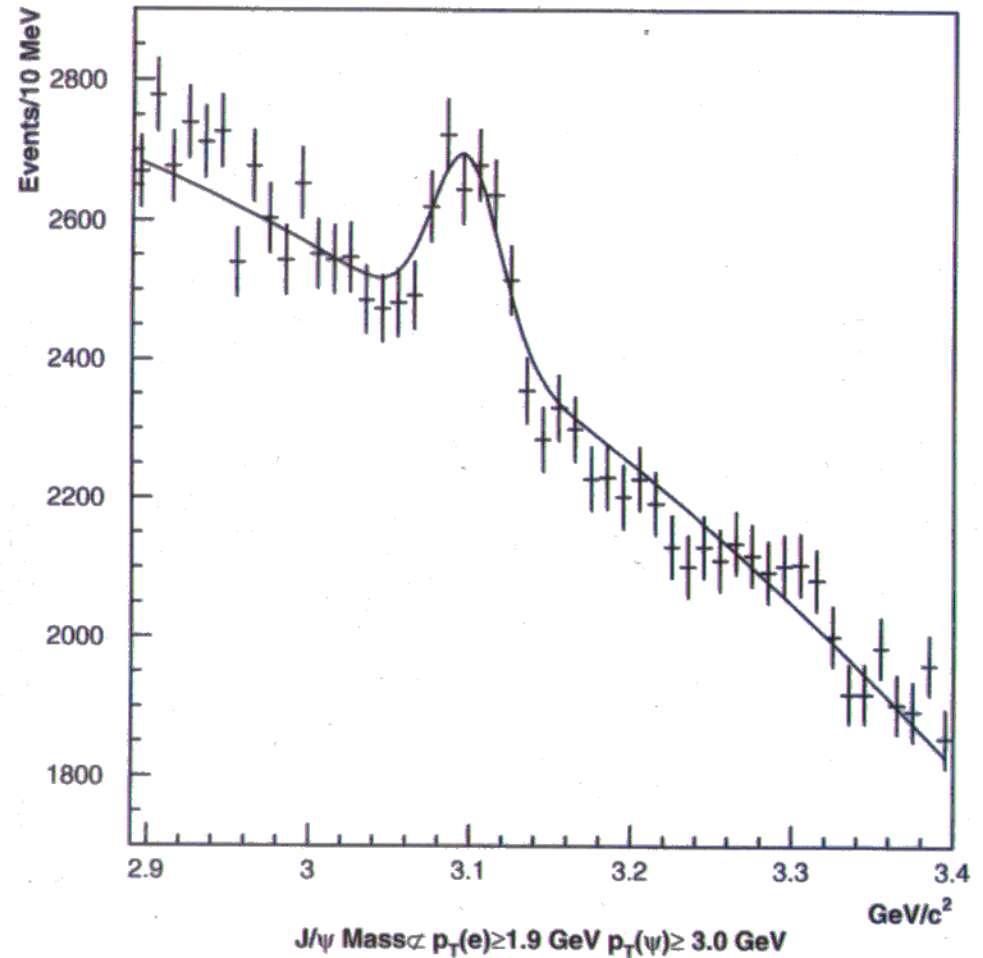
RHIC Theory Workshop

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Experimental Signal Coverage

Timescale	Probe	STAR	PHOBOS	BRAHMS	PHENIX
Initial Collision	<i>Hard Scattering</i>				
	Single jet via leading particle	X		X	X
	photon + jet (leading particle)	$p_T > ?$			X
	2 high- p_T hadron ang. corr.	x			X
	jet + jet	$> 5 \text{ GeV}/c$			
	<i>Mini-jet production</i>				
	$dN/d\eta$	X	X	X	X
	<i>Stopping</i>				
	proton dn/dy @ large y			X	
Deconfinement	<i>High-Mass Vector Mesons</i>				
	$J/\psi, \psi'$ screening	$p_T > 3 \text{ GeV}$			X
	Y (non)screening				X
Chiral Restoration	<i>Low-Mass Vector Mesons</i>				
	$\rho, \omega, \phi \rightarrow$ di-leptons	$p_T > ?$			X
	ϕ branching ratios	maybe			X
	$\phi \rightarrow K^+K^-$	X	X	X	X
QGP Thermalization	<i>Photons</i>				
	π^0, η, η'	$p_T > ?$			X
	continuum direct; very soft				X
QGP Thermalization	<i>Dileptons</i>				
	non-resonant: 1-3 GeV				X
	soft continuum, $< 1 \text{ GeV}$				X
QGP Thermalization	<i>Heavy Quark Production</i>				
	open charm	w/SVT			e- μ
	open charm via single lepton				e or μ