01

PHENIX

The PHENIX Experiment at RHIC

Status, performance, observation of first collisions

S. Aronson

BNL

July 27, 2000

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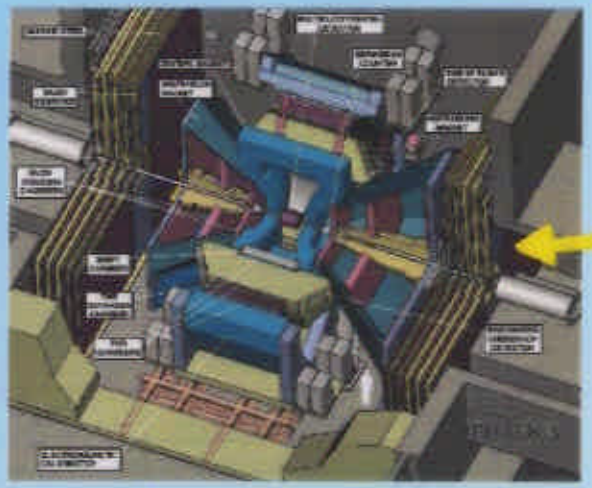
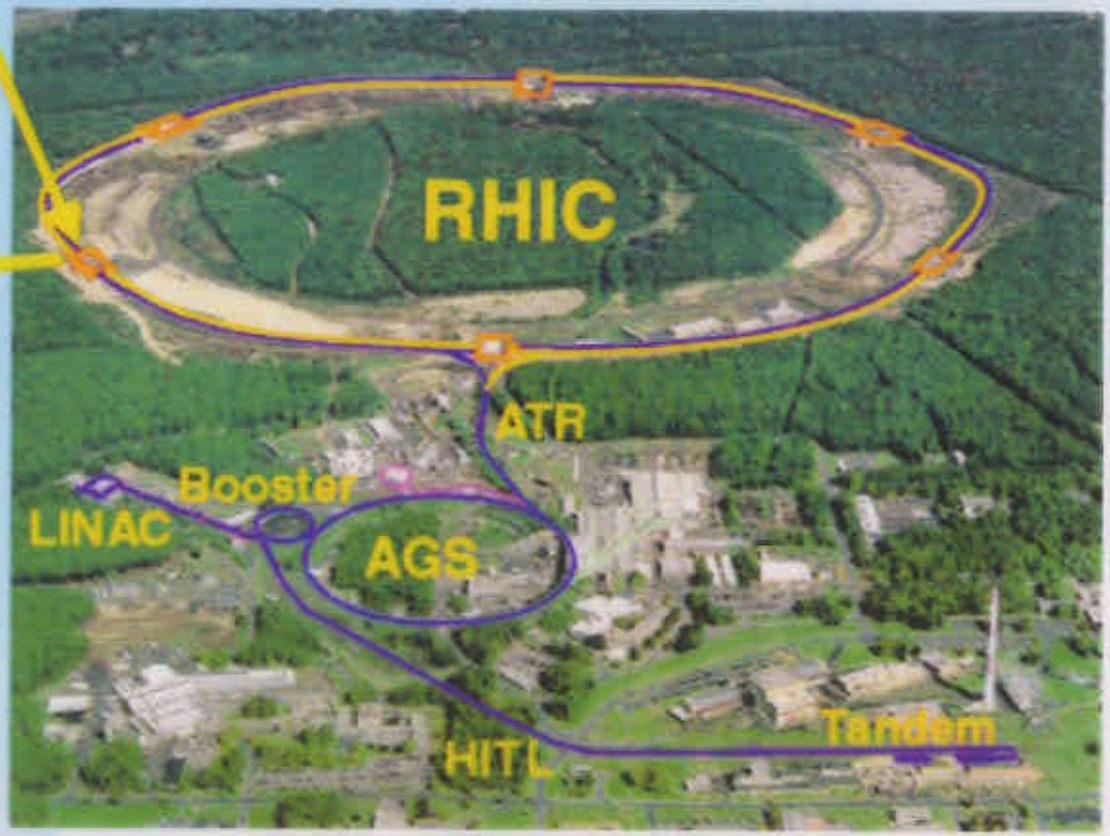
RHIC - current status

PHENIX



- 12 subsystems
- 400,000 channels
- 3000 tons



RHIC - Current Status

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- First collisions in mid-June 2000

	Design	June 2000
Lorentz γ	100	70
Bunches/ring	60	6
Ions/bunch	10^9	10^8
β^*(m)	2	3
Luminosity (cm^{-2} sec^{-1})	5.5×10^{26}	2.5×10^{23}

- Interaction rate ~few Hz: consistent with nuclear + coulomb $\cong$ 11b
- Initial performance: good and improving fast

PHENIX

Brookhaven Science Associates
U.S. Department of Energy

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Who/Where is PHENIX?

Brazil:	Sao Paolo
Canada:	McGill
China:	Academia Sinica, CIAE
France:	SUBATECH
Germany:	Münster
India:	BARC, Banaras Hindu University
Israel:	Weizmann Institute
Japan:	CNS, Hiroshima, KEK, Kyoto, Nagasaki RIKEN, RIKEN BNL Res. Cent.., TITech., Tokyo, Tsukuba, Waseda
Korea:	Korea, Myongji, Yonsei
Russia:	IHEP Protvino, JINR Dubna, Kurchatov, PNPI, St. Petersburg STU
Sweden:	Lund

U.S. National Labs: BNL, LANL, LLNL, ORNL

U.S. Universities: Abilene Christian, Alabama-Huntsville, California-Riverside, Columbia, Florida St., Georgia St., Iowa St., New Mexico, New Mexico St., SUNY-Stony Book, Tennessee, Vanderbilt

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PHENIX Physics Goals:

Search for and study of **quark gluon plasma** in relativistic **heavy ion** collisions.

- Focus on **lepton and photon signatures** to probe early time in collision (but some hadrons signatures also)
- High rate, sophisticated triggers → rare and high p_T processes

Study of **spin physics** in **polarized p - p** interactions at $50 \leq \sqrt{s} \leq 500$ GeV/c.

- Spin of the proton; structure functions (e.g., ΔG)
- Parity violating asymmetries (e.g., in W production) as a probe of new physics

Early physics goals:
heavy ions

PHENIX is:

- sensitive to all time-scales of the collision, via a broad array of probes
- unique at RHIC in detecting e, μ, γ signals

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Timescale	Probe	Required Elements	Available Year-1?
Initial Collision	***Hard Scattering***		
	Single "jet" via leading particle	E or W	Yes
	photon + "jet"	E and W	Yes?
Deconfinement	***High-Mass Vector Mesons***		
	J/Ψ, Ψ' screening	N, S, E+W	Observation
	Υ (non)screening	N,S	No
Chiral Restoration	***Low-Mass Vector Mesons***		
	ρ, ω, φ mass, width	E+W	Yes?
	φ branching ratios	E+W	Yes?
QGP Thermalization	***Photons***		
	π^0, η, η'	E	Yes
	continuum direct: very soft	E	Yes
QGP Thermalization	***Dileptons***		
	non-resonant: 1-3 GeV	N,S,E+W	Yes?
	soft continuum, <1 GeV	E+W	No
QGP Thermalization	***Heavy Quark Production***		
	open charm	(N or S) + E	No
	open charm via single lepton	N,S,E	Yes
Hadronization	***Hadrons***		
	HBT Interferometry, π/K	E	Yes
	strangeness production: K, φ	E	Yes
	spectra of identified hadrons	E	Yes
Hydrodynamics	***Global Variables***		
	E_T, dN/dy	E, MVD	Yes

Early physics goals:
heavy ions

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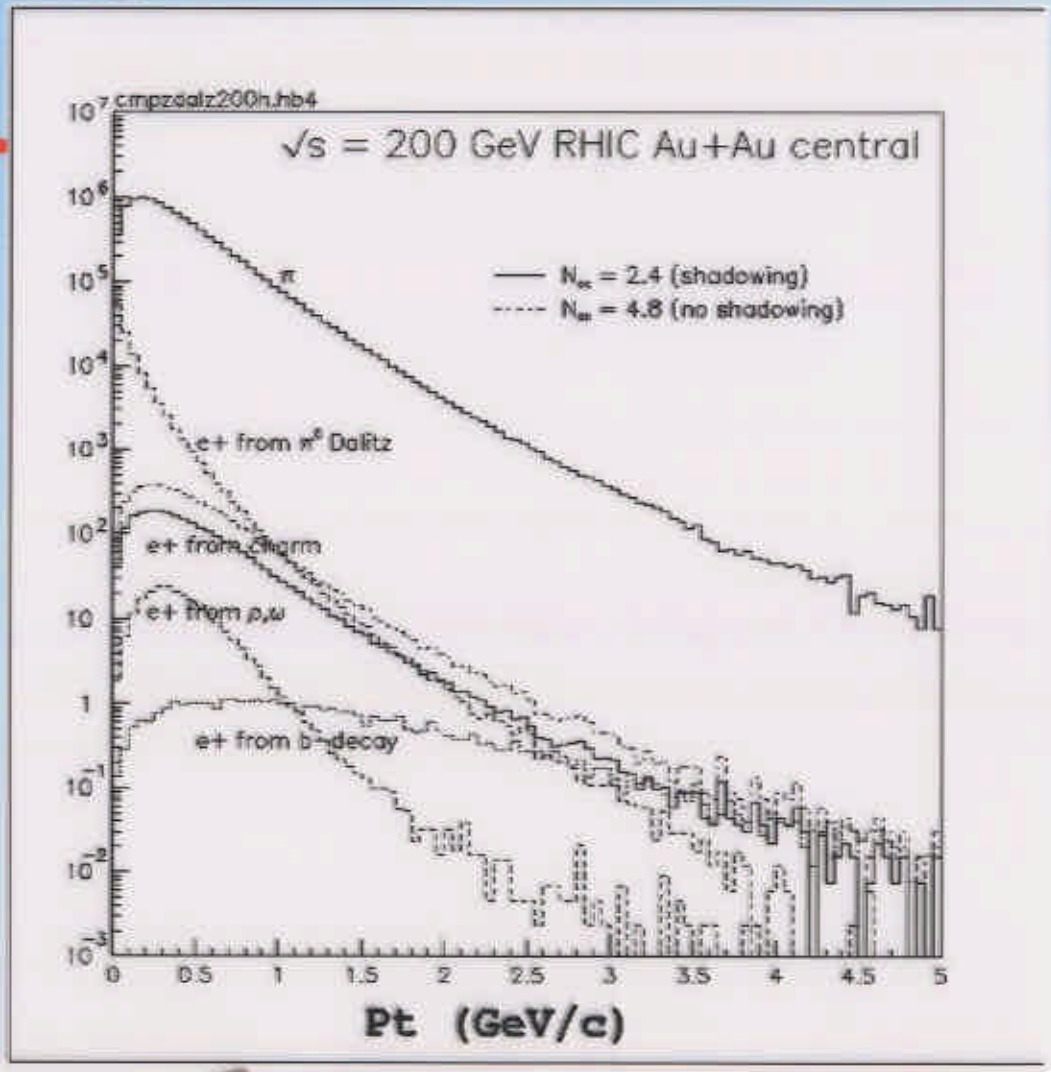
Example:

- open charm production via single high p_T electrons
- This year: ~1k events above 1 GeV/c

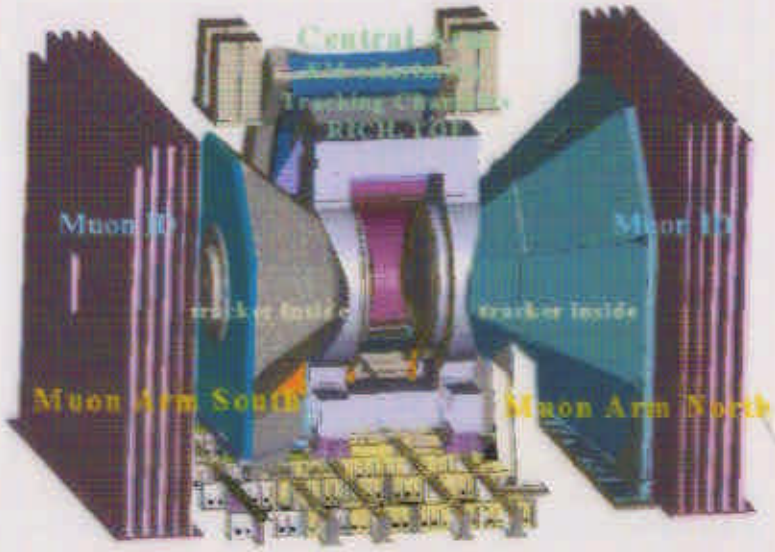


RHIC Spin Project
RIKEN BNL Collaboration

- PHENIX Muon Arm with LANL and Polarized Beam Acceleration with BNL Spin Rotators for **PHENIX and STAR** will be fabricated and installed under this collaboration

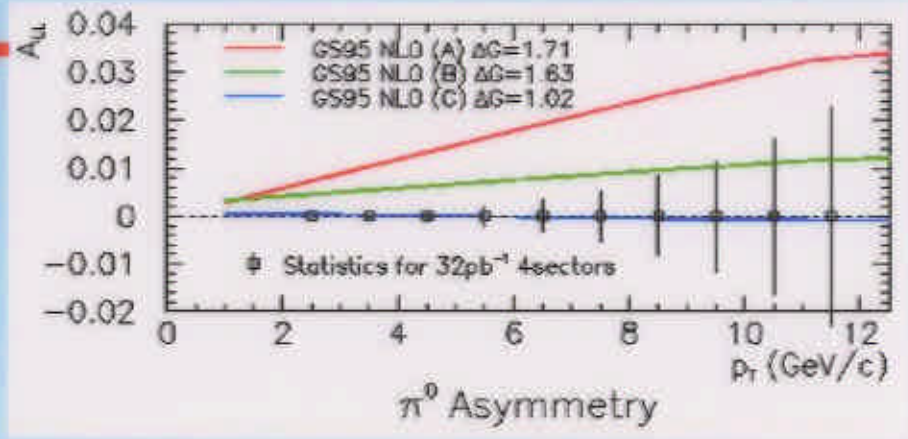
$50 \le \sqrt{s} \le 500\text{GeV}; P_B \approx 70\%\ \ L \approx 2.0 \times 10^{32}\,\text{cm}^{-2}\,\text{sec}^{-1}$ @500GeV

Siberian snake to maintain polarization
Spin Rotators to obtain given polarization

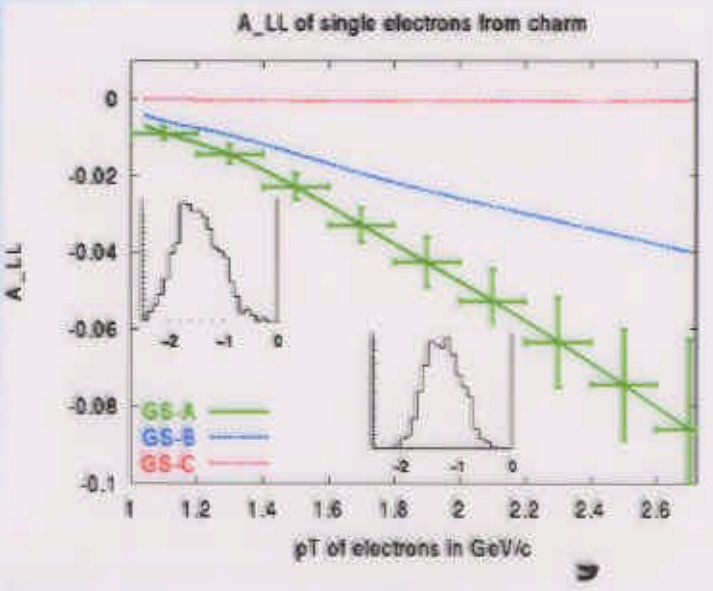


Early physics goals:
polarized protons

- neutral/charged pions
  - QCD jet production
  - asymmetry → ΔG
    - $\sqrt{s}$=200GeV
    - 32pb^{-1} (10% luminosity)
    - 400M events
    - x_g : 0.05 – 0.15
- single electron
  - open charm production
  - asymmetry → ΔG $\sqrt{s}$=200GeV
    - 32pb^{-1} (10% luminosity)
    - x_g : 0.005 – 0.2



π^0 Asymmetry



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The PHENIX Detector:

2000 configuration

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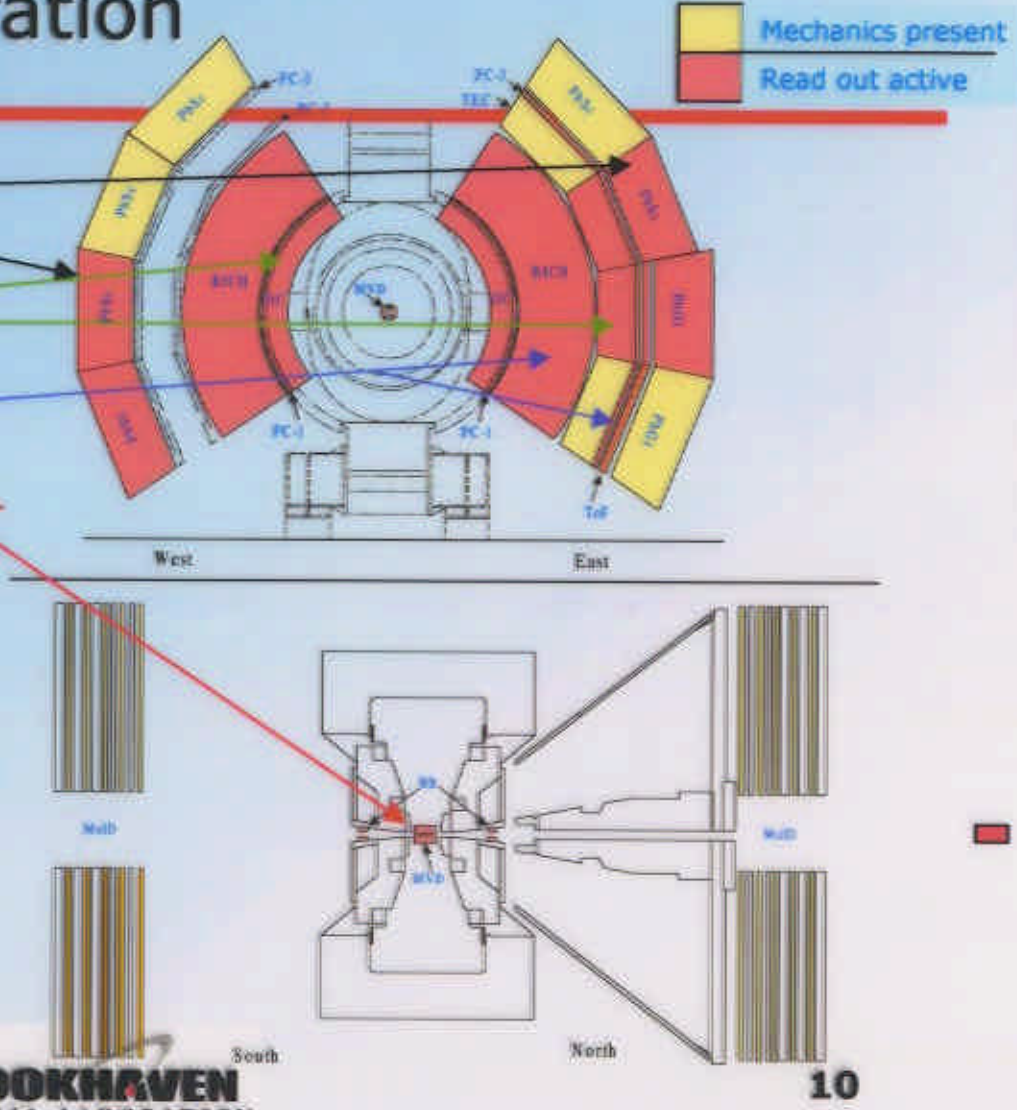
Calorimetry -
Pb-glass, Pb-scint.

Tracking
Drift, Pad, Time Exp.

PID - RICH, TOF

Global - Si, Beam-Beam, Zero-Deg.

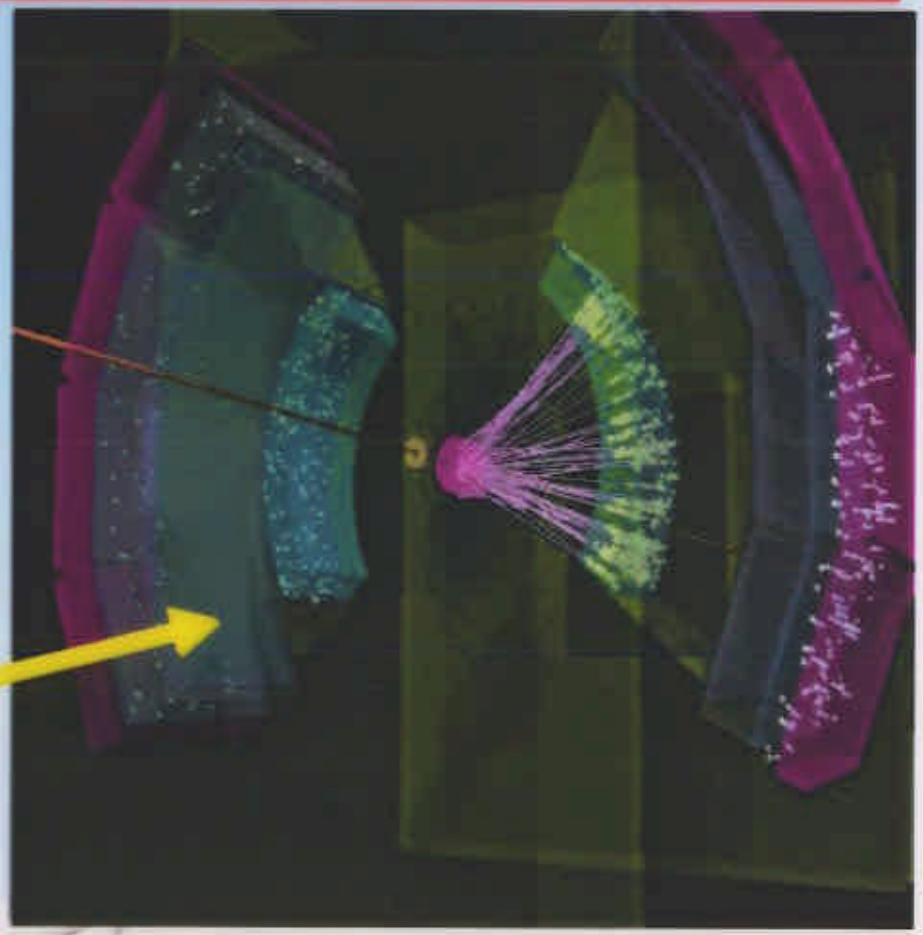
- PHENIX (currently)
  - 9 of 12 subsystems now installed & active
  - 200,000 channels



First Collisions

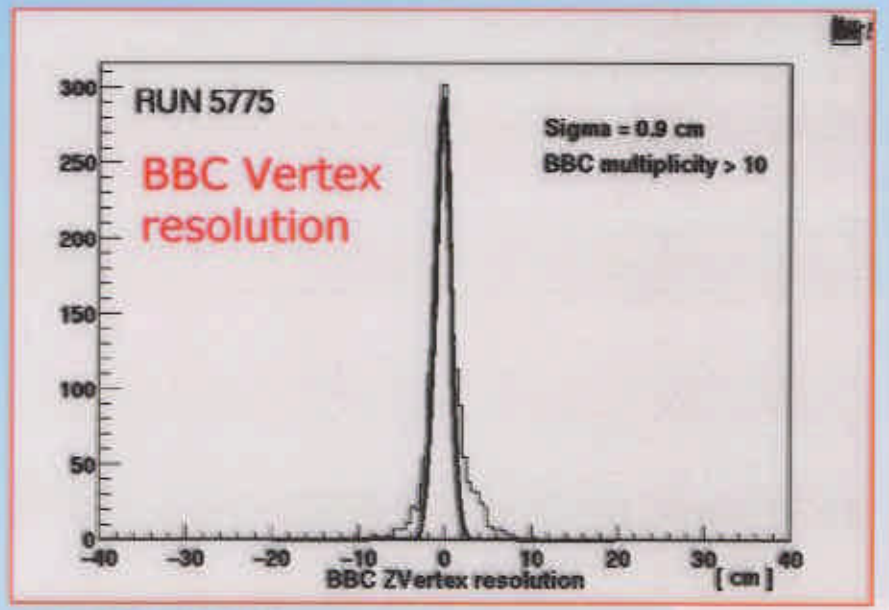
June 15 - July 5, 2000

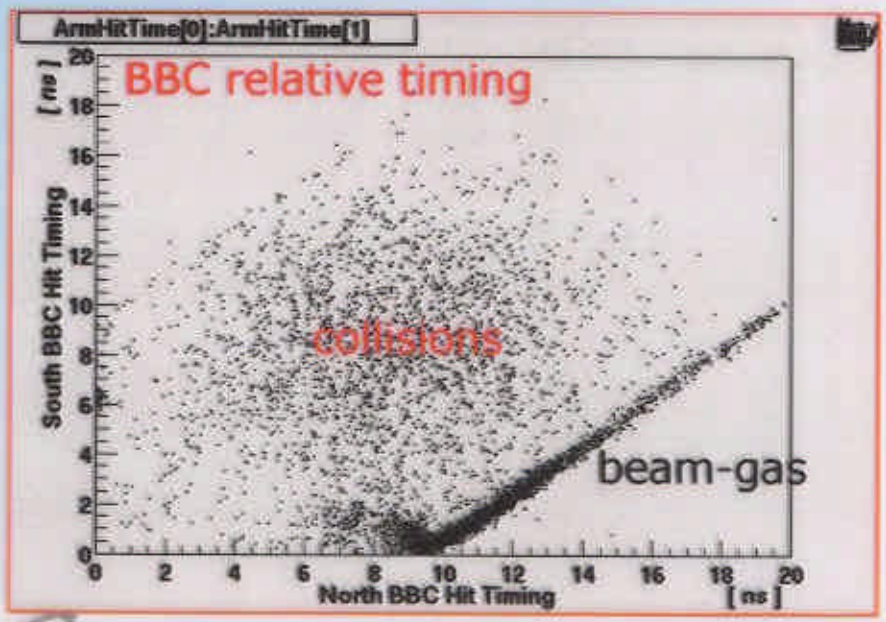
- About 80k minimum bias Au-Au triggers at $\sqrt{s}$ = 130 GeV/A
  + a few k at $\sqrt{s}$ = 56 (SPS $\sqrt{s}$ = 17)
- Partial event display of 130 GeV/A event
  - Magnet field = 0



Interaction trigger, collision geometry

- BBC (beam-beam counter)
  - start timing, vertex location
  - multiplicity





Zero Degree Calorimeter

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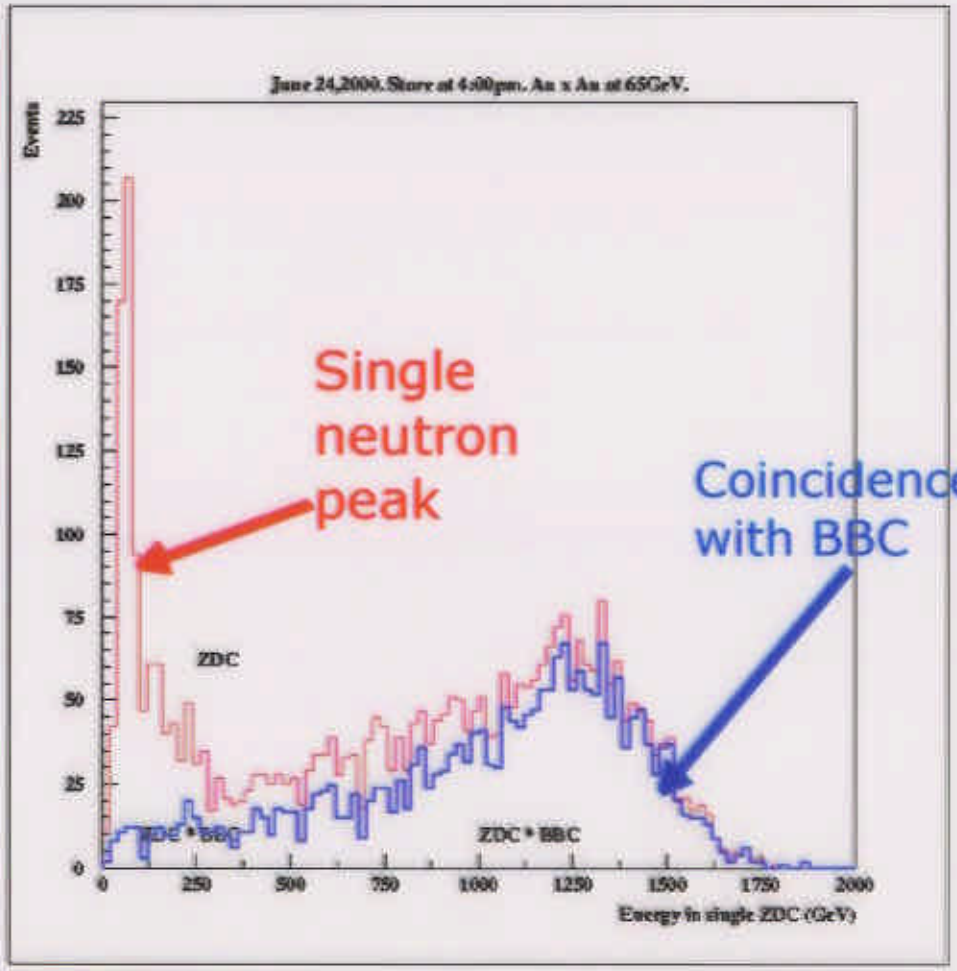
- Tungsten/quartz fiber hadron calorimeter
  - –forward neutrons
- Luminosity monitoring, min. bias triggering
- ZDC's the same for all intersection regions



Beam-beam and Zero Degree

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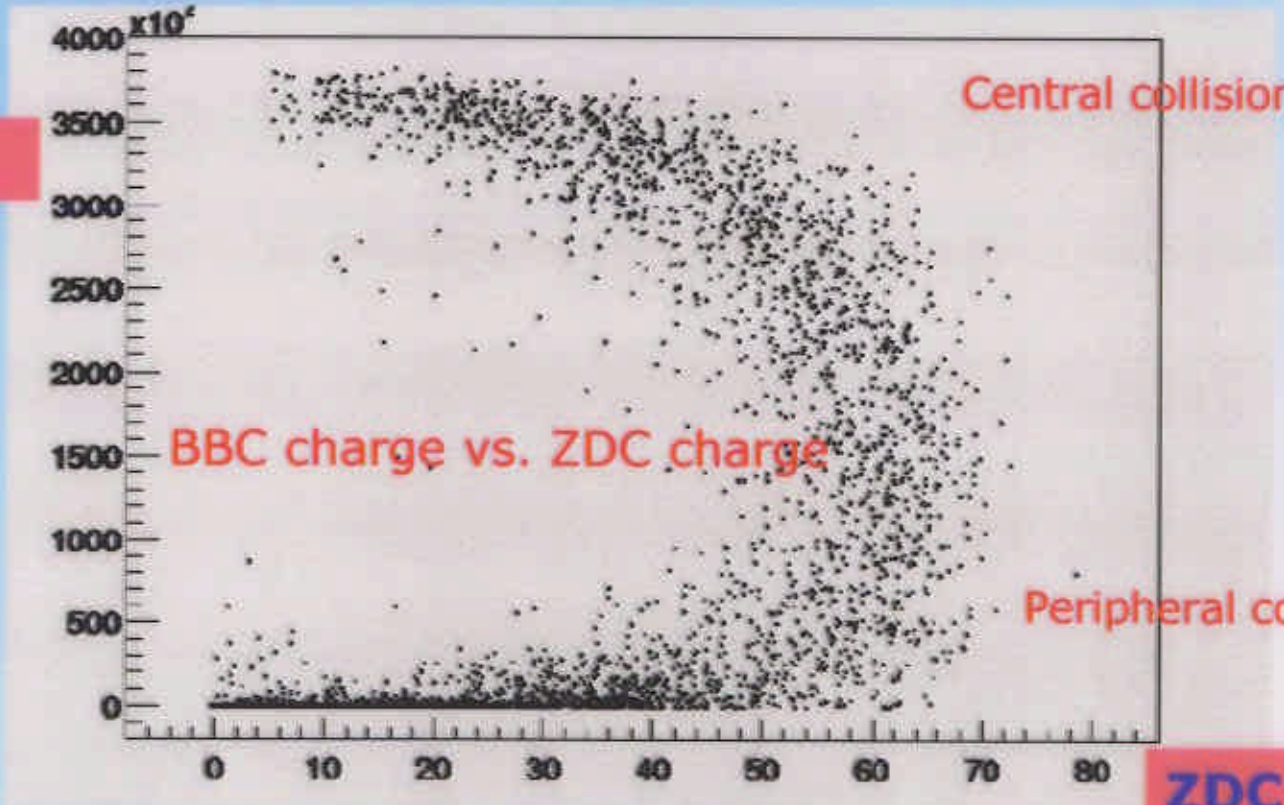
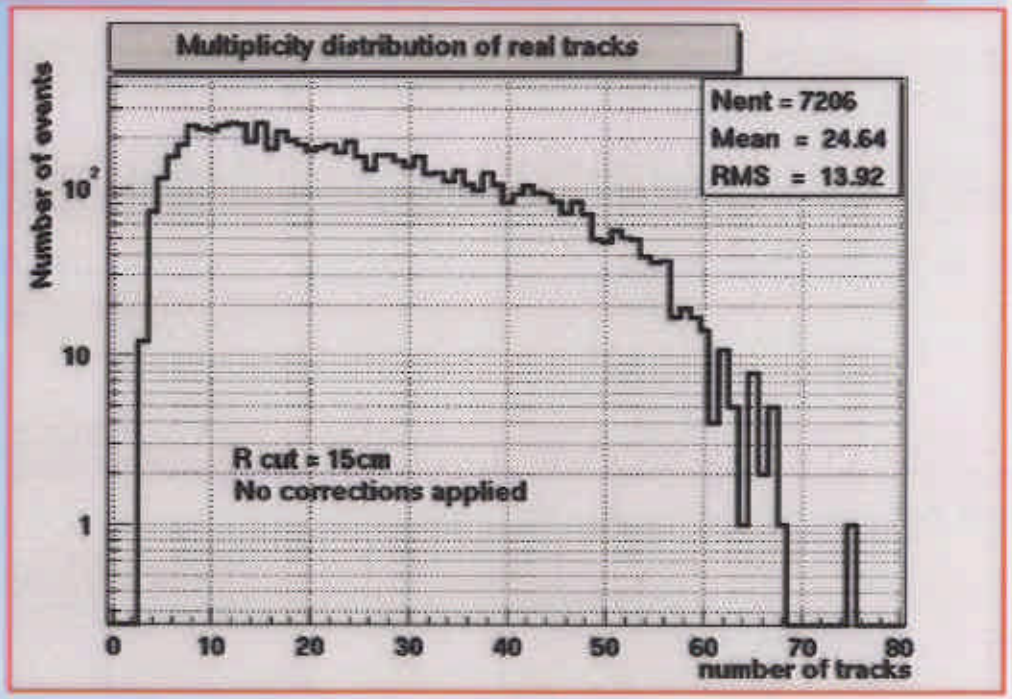


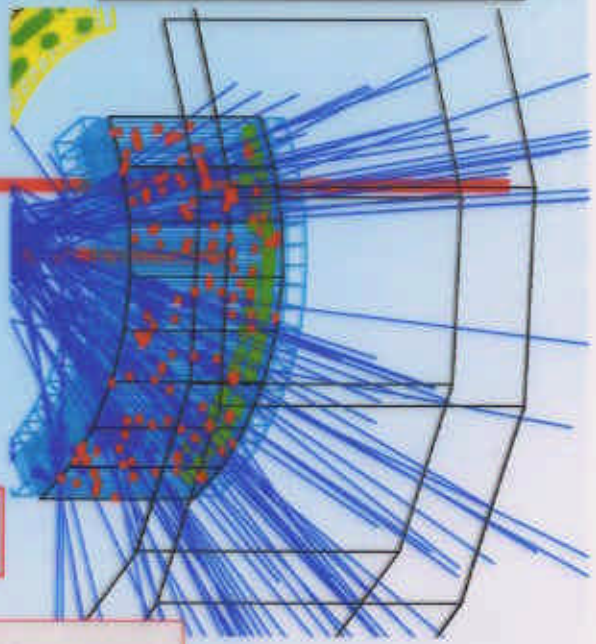
Tracking

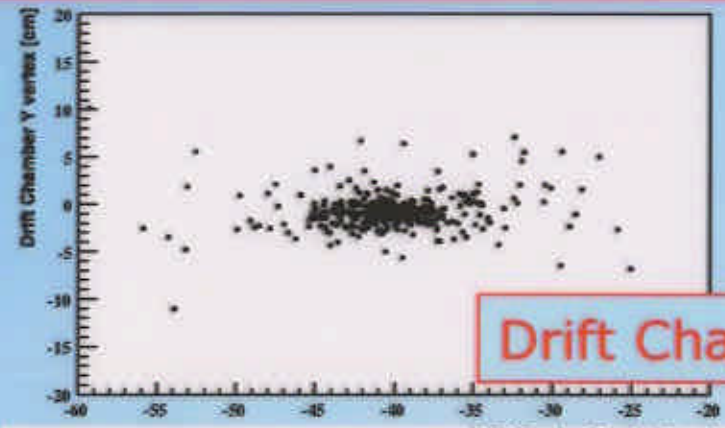
- High particle density
  - Momentum resolution
  - 2-particle separation
  - Electron ID
- ◊ Drift Chamber (momentum)
- ◊ Pad Chambers (space pts.)
- ◊ Time Expansion Chamber (dE/dx)



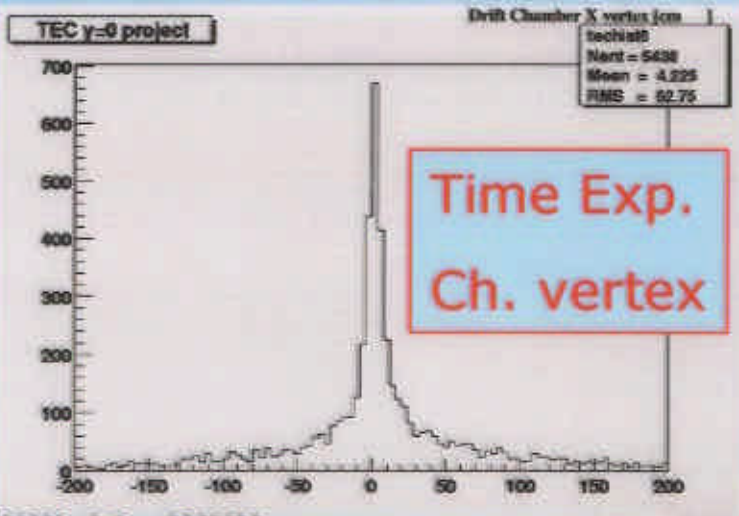
Charged multiplicity in the Pad Chamber system

Tracking:
Zero-field studies

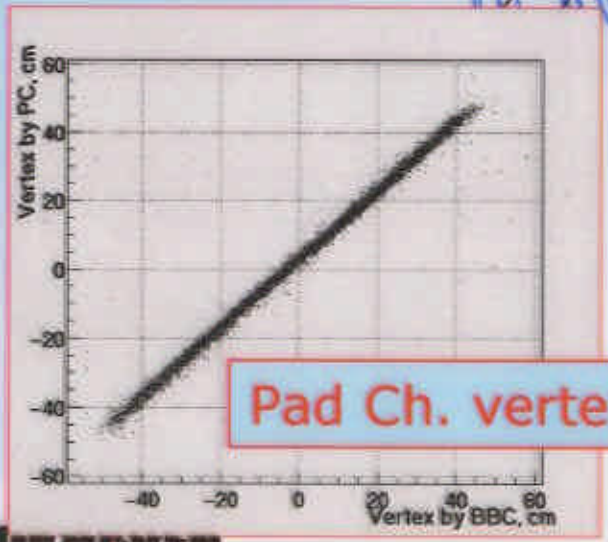




Drift Chamber vertex



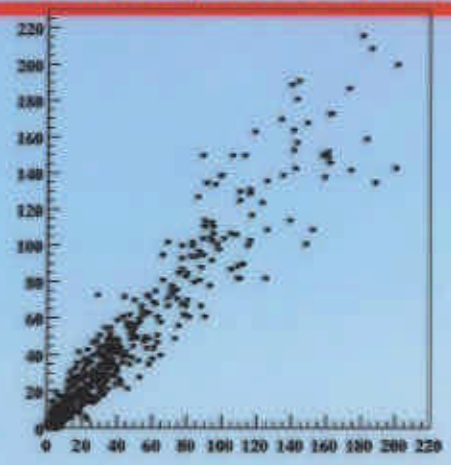
Time Exp.
Ch. vertex



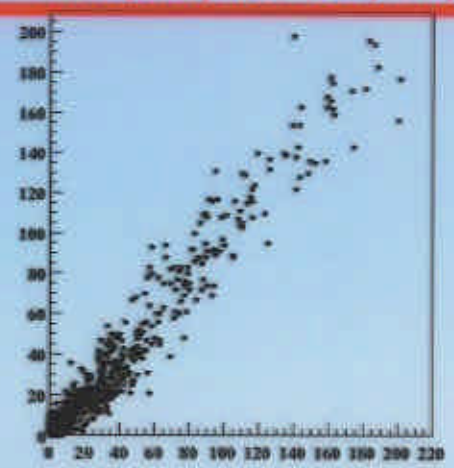
Pad Ch. vertex vs. BBC

Tracking:
Zero-field studies

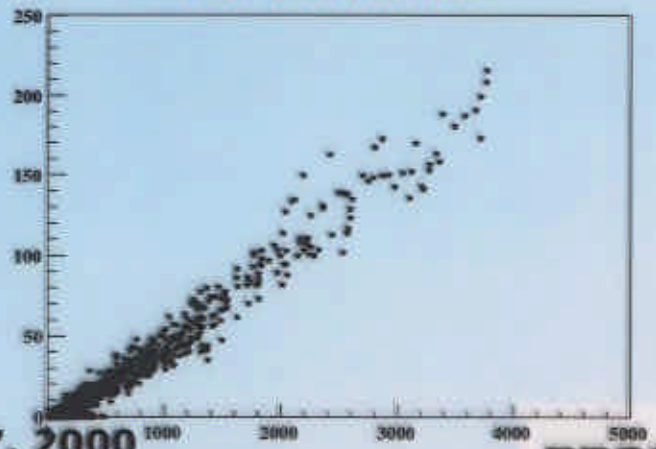
PC 1 (west) vs. PC1 (east)

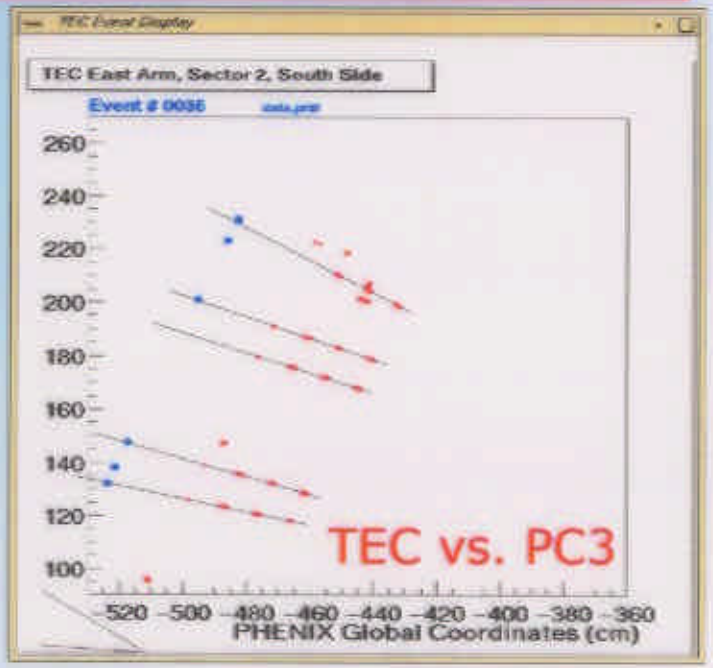


PC3 (east) vs. PC1 (east)



PC1 (east) vs. DC

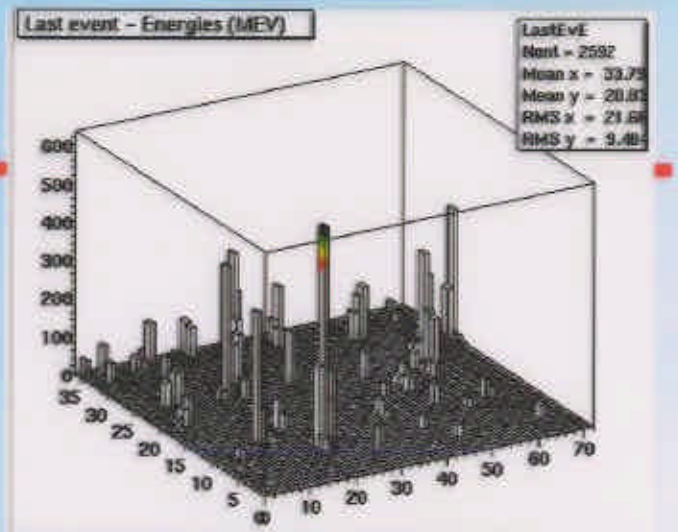


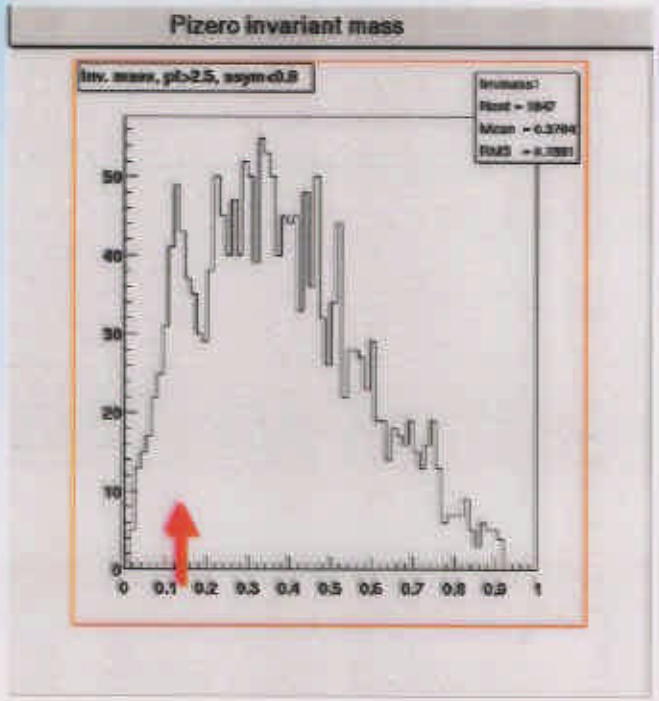


Calorimetry

- High particle density, broad dynamic range
  - good granularity
    $\Delta\eta = \Delta\phi = 0.01$
  - good energy resolution
    ~8%/√E
  - good time resolution
    ~250ps/√E

Pb-glass + Pb-scintillator
  - 25,000 channels





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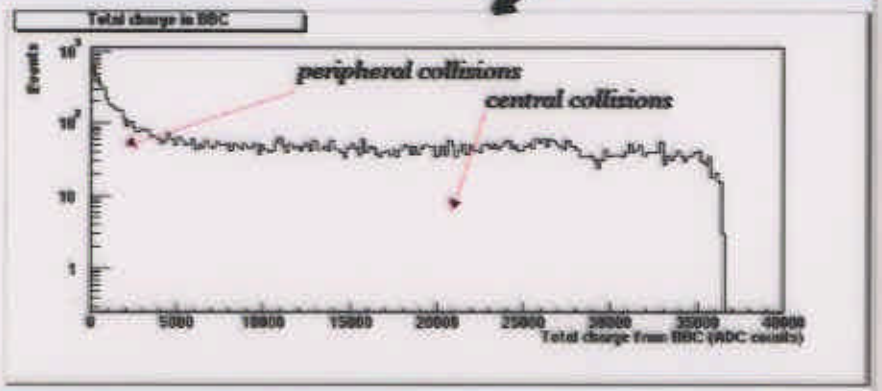
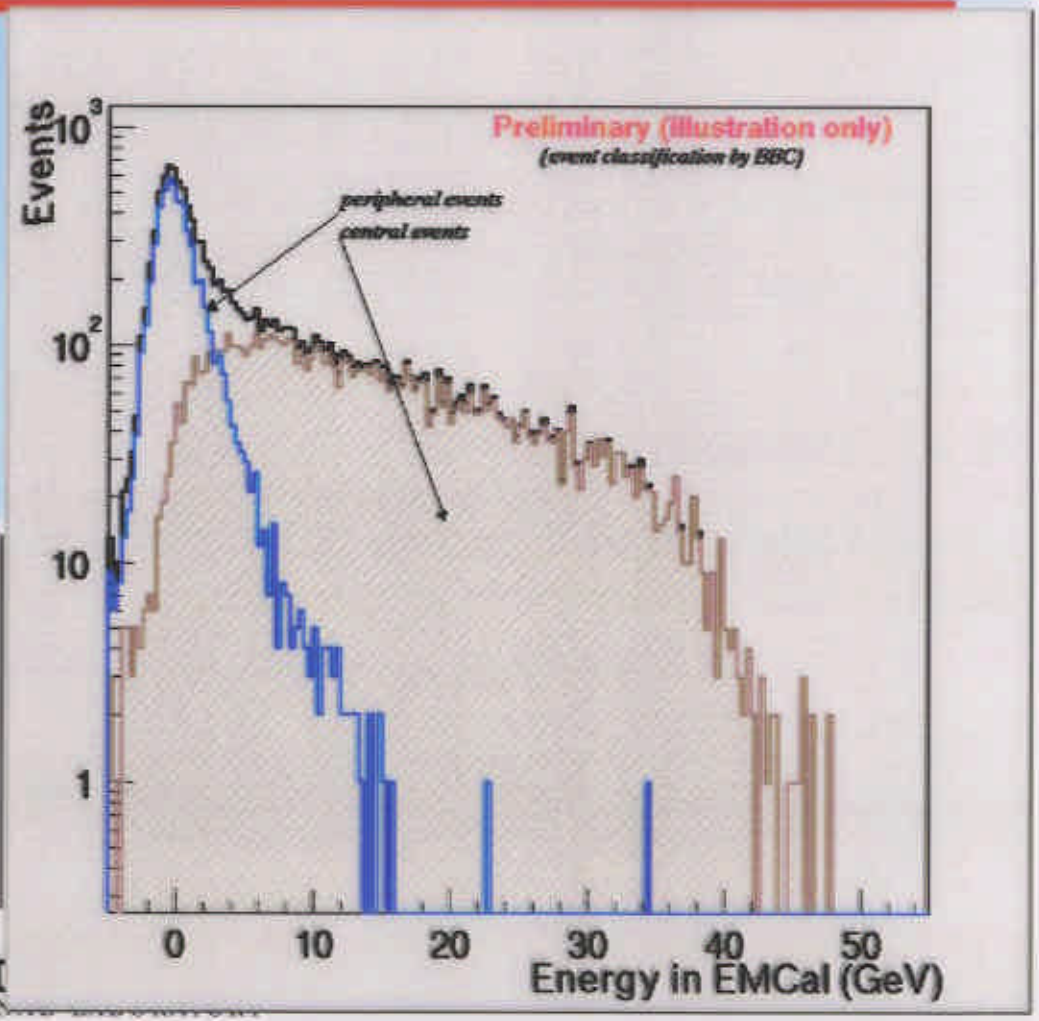
Energy in the Calorimeter

"Central" and "peripheral" separated on the basis of total charge in the beam-beam counters





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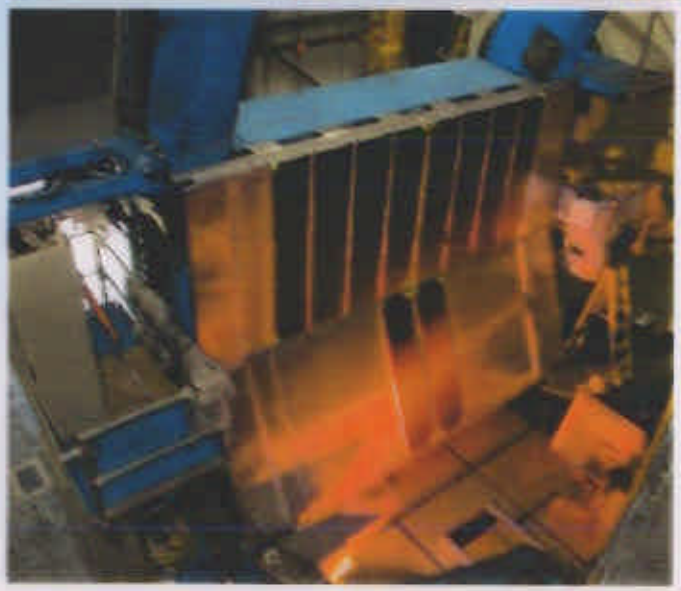
Particle ID

- Mid-rapidity: e, γ, hadrons:
  - Time of Flight* (σ_t = 80ps)
  - Ring-imaging Cherenkov counter*
  - EMCal (σ_t = 250ps)
  - Time Exp. Ch. dE/dx
  - (TRD later)

*(RICH, TOF, BBC funded through Japan/US HEP agreement)



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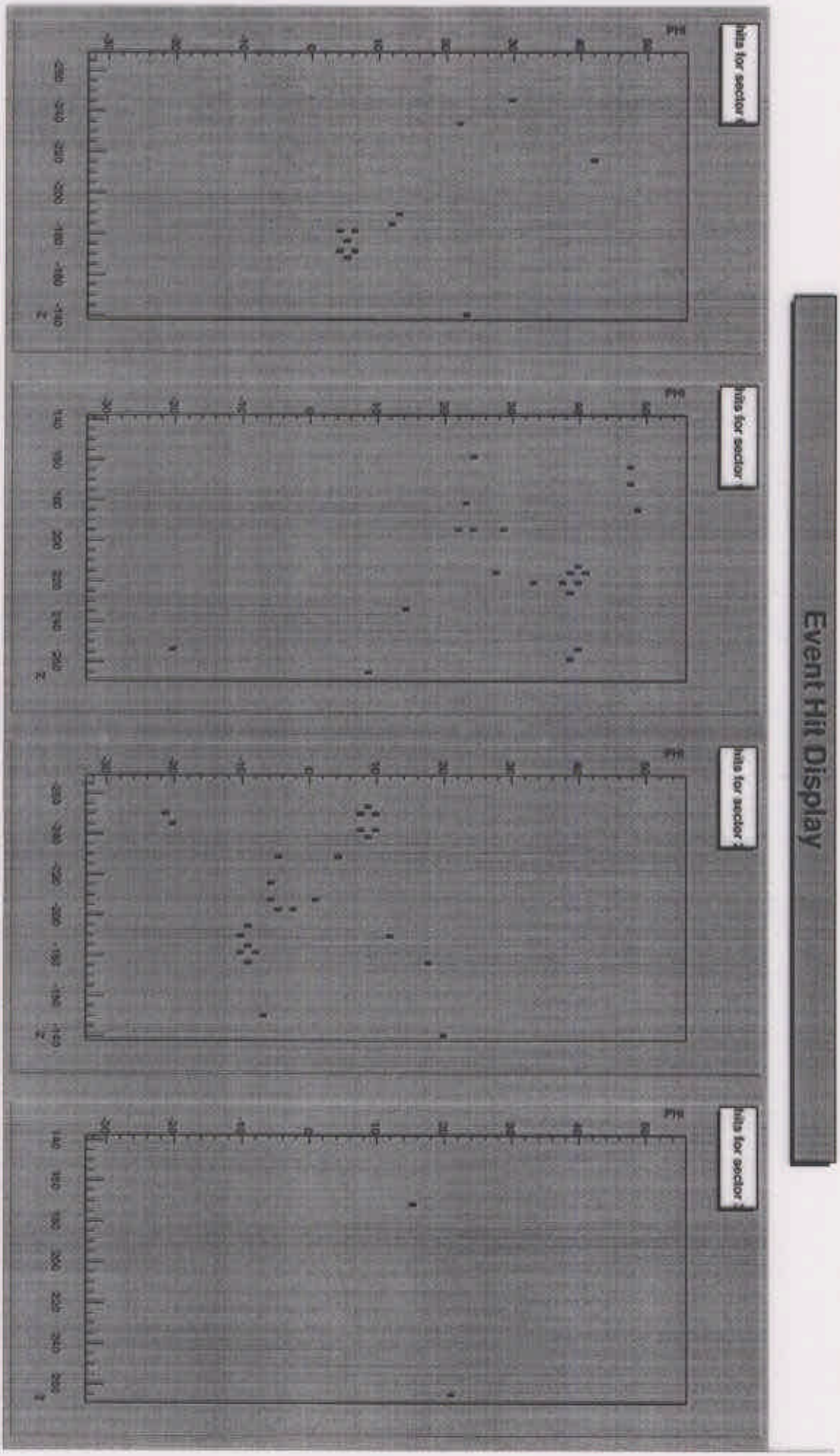
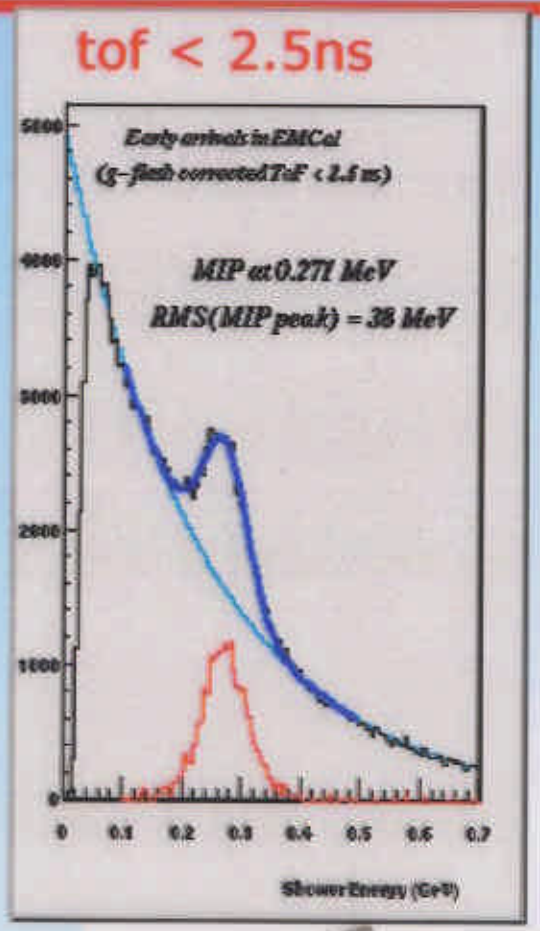
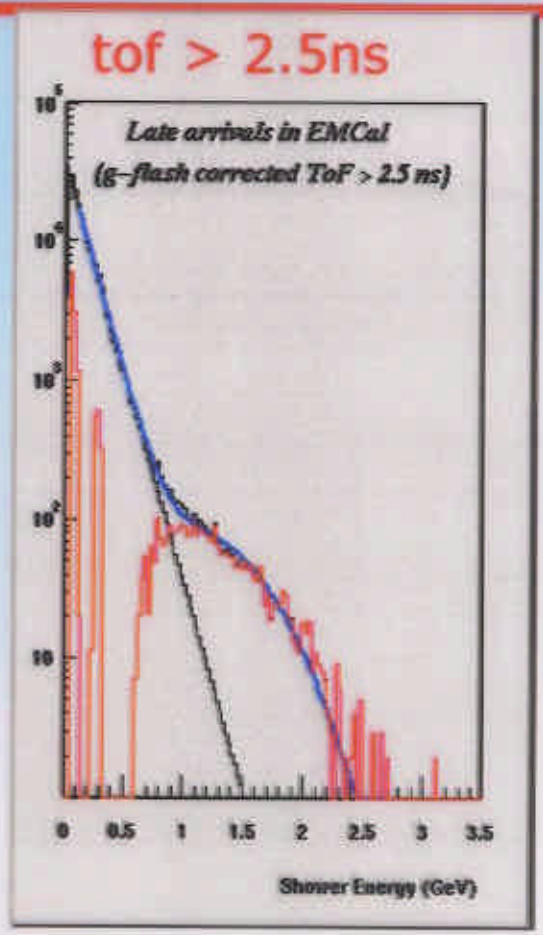

Event Hit Display
hits for sector 4
hits for sector 1
hits for sector 2
hits for sector 3

Particle ID performance

EMCal timing

- resolution ~1ns (width of the "γ flash")





2000 run plan and analysis of current data

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- Au-Au running through August
  - Improving luminosity: several million minimum bias triggers possible
  - polarized proton commissioning in September
- Data in hand (prelim. results in a few weeks)
  - several independent measurements of $dN_{ch}/d\eta$ at $|\eta| \leq 0.35$ versus the number of participants
  - $dE_T/d\eta$ in the same aperture
- Data to be collected in this run
  - p_T spectra of identified hadrons (with TOF array)
  - start looking at single electrons (charm production)
    - electron ID with RICH, EMCal

PHENIX

2001 configuration

- Full instrumentation at mid-rapidity
  - full hadron, electron photon program at $\eta=0$
- Muons at $2.4 \geq \eta \geq 1.1$
  - good dimuon acceptance (and rate) at the J/ψ