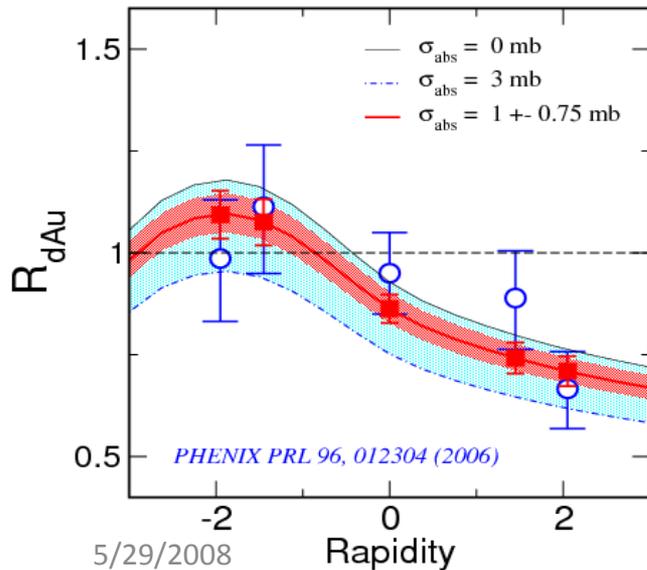


PHENIX Run8 Achievements & Summary

Mike Leitch for PHENIX
RHIC/AGS User Mtg., 29 May 2008

- Luminosity, Performance, J/ψ 's
- Efficiency & Interaction diamond size
- Data Acquisition (DAQ)
- p+p Polarization & Spin goals
- Low Energy Au+Au test
- Shutdown & Future



Projected
Run8 d+Au
 J/ψ R_{dAu}
improvement



PHENIX Data Sets

Run	Year	Species	\sqrt{s} (GeV)	$\int Ldt$	N_{tot} (samp.)	Data Size
Run1	2000	Au + Au	130	$1 \mu b^{-1}$	10 M	3 TB
Run2	2001/02	Au + Au	200	$24 \mu b^{-1}$	170 M	10 TB
		Au + Au	19		< 1 M	
		p + p	200	$0.15 pb^{-1}$	3.7 B	20 TB
Run3	2002/03	d + Au	200	$2.74 nb^{-1}$	5.5 B	46 TB
		p + p	200	$0.35 pb^{-1}$	6.6 B	35 TB
Run4	2003/04	Au + Au	200	$241 \mu b^{-1}$	1.5 B	270 TB
		Au + Au	62.4	$9 \mu b^{-1}$	58 M	10 TB
Run5	2005	Cu + Cu	200	$3 nb^{-1}$	8.6 B	173 TB
		Cu + Cu	62.4	$0.19 nb^{-1}$	0.4 B	48 TB
		Cu + Cu	22.4	$2.7 \mu b^{-1}$	9 M	1 TB
		p + p	200	$3.8 pb^{-1}$	85 B	262 TB
Run-6	2006	p + p	200	$10.7 pb^{-1}$	230 B	310 TB
		p + p	62.4	$0.1 pb^{-1}$	28 B	25 TB
Run-7	2007	Au + Au	200	$813 \mu b^{-1}$	5.1 B	650 TB
Run-8	2007/08	d + Au	200	$80 nb^{-1}$	160 B	437 TB
		p + p	200	$5.2 pb^{-1}$	115 B	118 TB
		Au + Au	9.2			

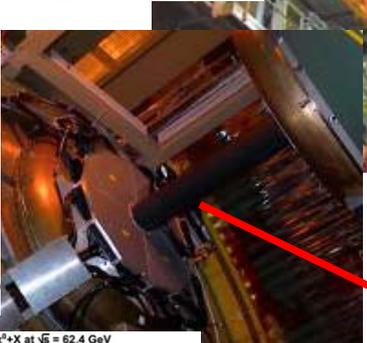
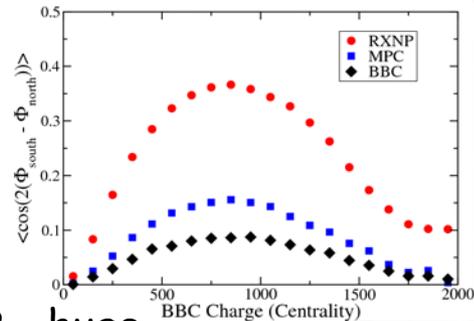
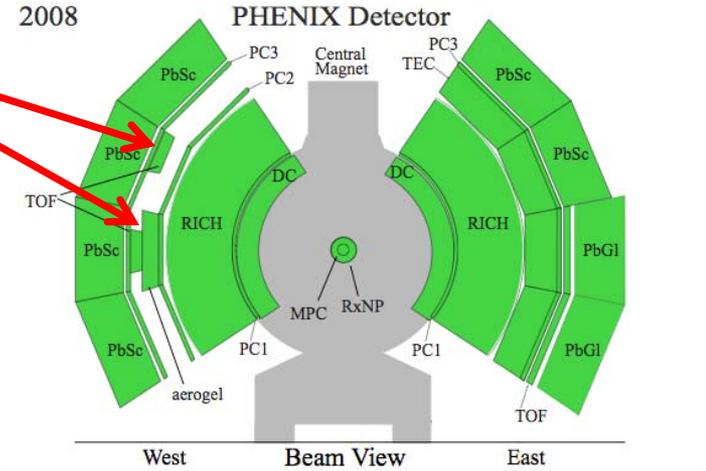
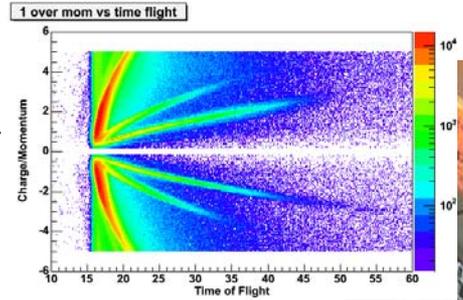
3 x AuAu

30 x dAu

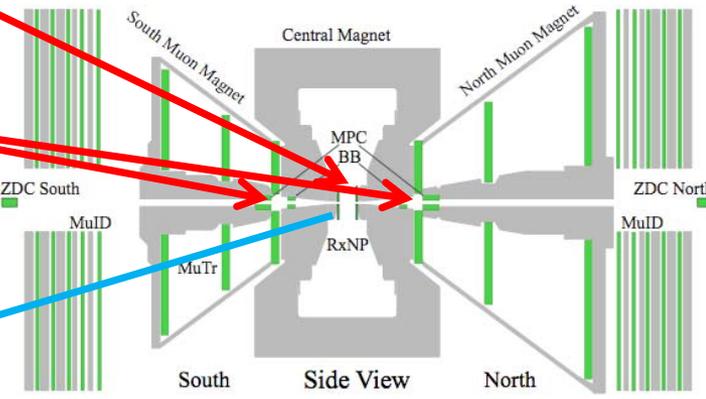
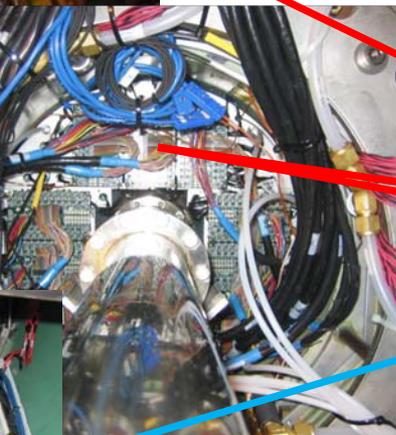
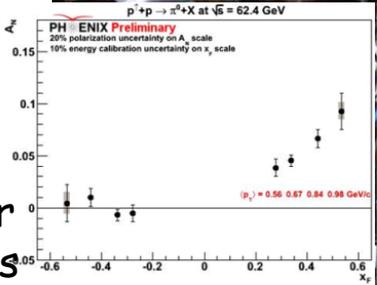
Collided 4 different species in 8 years: Au+Au, d+Au, p+p, Cu+Cu
 6 energies run: 9.2 GeV, 19 GeV, 22.5 GeV, 62.4 GeV, 130 GeV, 200 GeV

PHENIX Detector Configuration for Run8

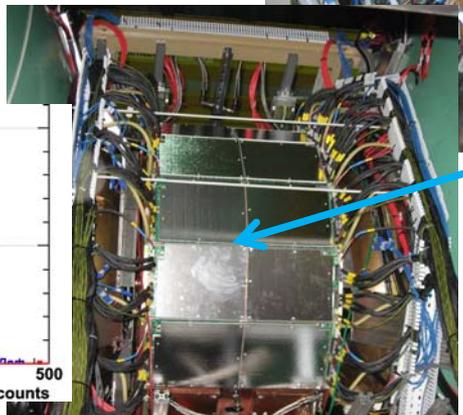
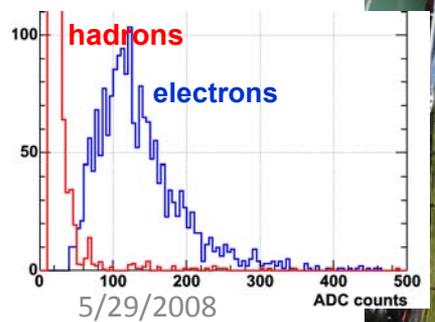
PID at higher p_T with TOF-W



RXNP - huge improvement in AuAu reaction plane



Two MPC's - nice for asymm dAu collisions



HBD out for rework until next year

Waste No Rare Triggers - the PHENIX Strategy

Actual trigger setup & rates for one of the hottest Run8 dAu runs

- > 90% livetime
- 85kHz MB (BBC_{VtxCut}) rate

MPC Forward Calorimeter

central-arm γ, π^0, π^\pm , etc

thresh:
2.8 GeV
3.5 GeV
2.1 GeV

$J/\psi \rightarrow e^+e^-$

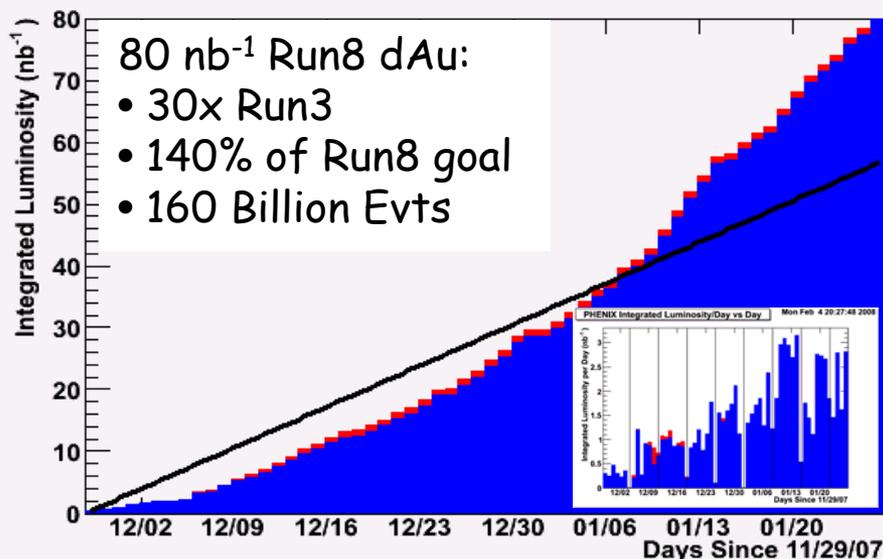
$J/\psi \rightarrow \mu^+\mu^-$

Name	Bit Mask	Scale Down	State	Raw Trigger Rate	Scaled Trigger Rate	Livetime
Clock	0x00000001	999999	Enabled	602604.36	8.63	-0.29
RxNP&BBC	0x00000002	9999999	Enabled	33118.29	0.00	0.92
BBCLL1(>0 tubes)	0x00000004	120	Enabled	85200.89	643.69	0.91
BBCLL1(noVertexCut)	0x00000008	1800	Enabled	154658.48	78.51	0.91
ZDCLL1wide	0x00000010	1000	Enabled	48078.30	44.10	0.92
ZDCLL1narrow	0x00000020	160	Enabled	19016.74	108.44	0.92
MPC_4x4	0x00000040	0	Enabled	90.87	80.79	0.89
MPC_2x2	0x00000080	0	Enabled	86.95	77.64	0.89
ERTLL1_4x4a	0x00000100	1	Enabled	1681.27	751.77	0.89
ERTLL1_4x4b	0x00000200	0	Enabled	175.82	145.79	0.83
ERTLL1_4x4c	0x00000400	9999999	Enabled	7990.56	0.00	0.89
ERTLL1_2x2&BBCLL1	0x00000800	9999999	Enabled	11003.82	0.00	0.92
ERTLL1_4x4a&BBCLL1	0x00001000	0	Enabled	374.23	342.59	0.92
ERTLL1_4x4b&BBCLL1	0x00002000	0	Enabled	143.43	131.17	0.91
ERTLL1_4x4c&BBCLL1	0x00004000	0	Enabled	1092.14	999.25	0.91
ERTLL1_E&BBCLL1	0x00008000	0	Enabled	20.80	477.83	0.92
MUIDLL1_N1D&BBCLL1	0x00010000	2	Enabled	609.28	185.55	0.91
MUIDLL1_S1D&BBCLL1	0x00020000	8	Enabled	3480.49	353.66	0.91
MUIDLL1_N1H&BBCLL1	0x00040000	2	Enabled	692.98	211.43	0.92
MUIDLL1_S1H&BBCLL1	0x00080000	8	Enabled	2376.20	241.81	0.92
MUIDLL1_N2D&BBCLL1	0x00100000	0	Enabled	8.62	7.78	0.90
MUIDLL1_S2D&BBCLL1	0x00200000	0	Enabled	266.15	242.01	0.91
(MUIDLL1_N1D&S1D)&BBCLL1	0x00400000	0	Enabled	38.03	34.48	0.91
MPC_4x4&BBCLL1	0x00800000	0	Enabled	54.97	50.29	0.91
MPC_4x4&BBCLL1(noVertexCut)	0x01000000	0	Enabled	81.16	73.92	0.91

(32 triggers total - some not shown)

PHENIX Integrated Luminosity vs Day

Mon Feb 4 20:27:48 2008



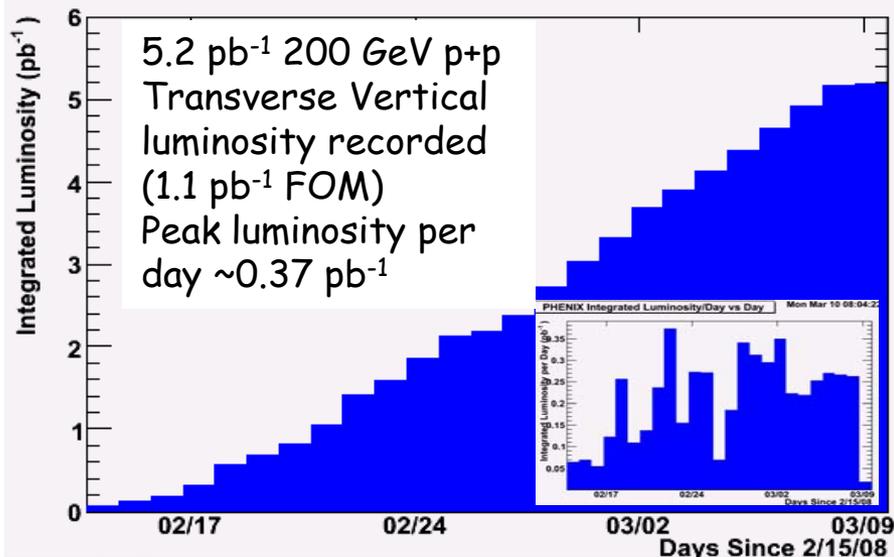
dAu

- peaks above 3 nb⁻¹ per day
- one day > total Run3 luminosity of 2.7 nb⁻¹

pp - almost no progress on luminosity & polarization development towards future

PHENIX Integrated Luminosity vs Day

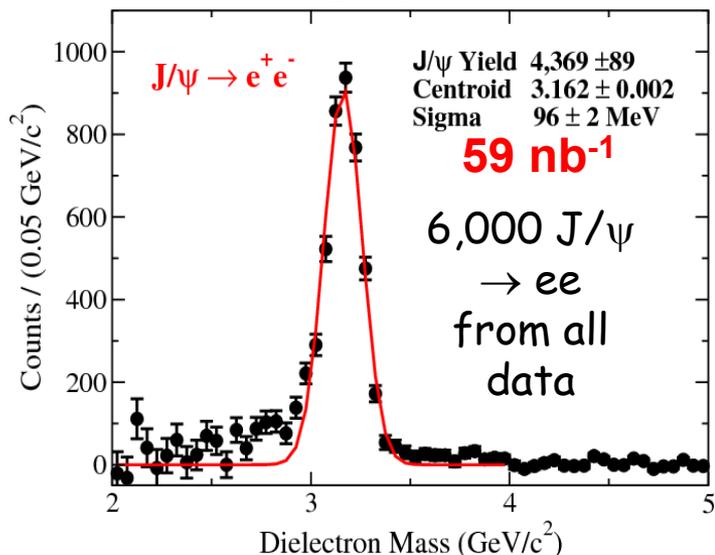
Mon Mar 10 08:04:2



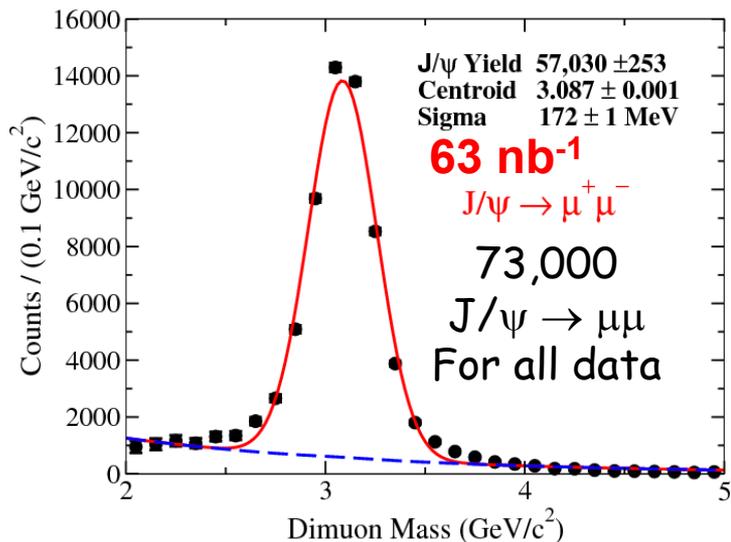
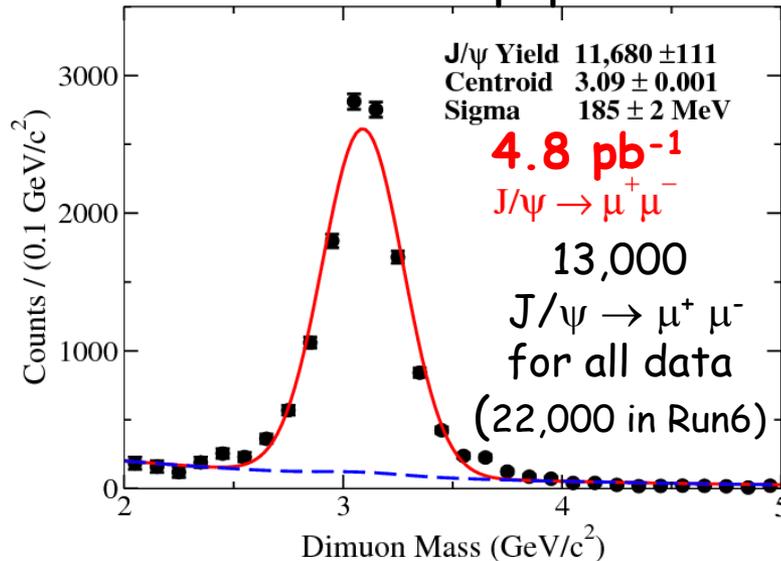
Run	Energy	Long.	Trans.
02	200 GeV		0.15 pb ⁻¹
03	200 GeV	0.35 pb ⁻¹	
04	200 GeV	0.12 pb ⁻¹	
05	200 GeV	3.4 pb ⁻¹	0.16 pb ⁻¹
06	200 GeV	7.5 pb ⁻¹	2.7 pb ⁻¹
06	62.4 GeV	0.08 pb ⁻¹	0.02 pb ⁻¹
08	200 GeV		5.2 pb ⁻¹

PHENIX J/ ψ 's from Run8

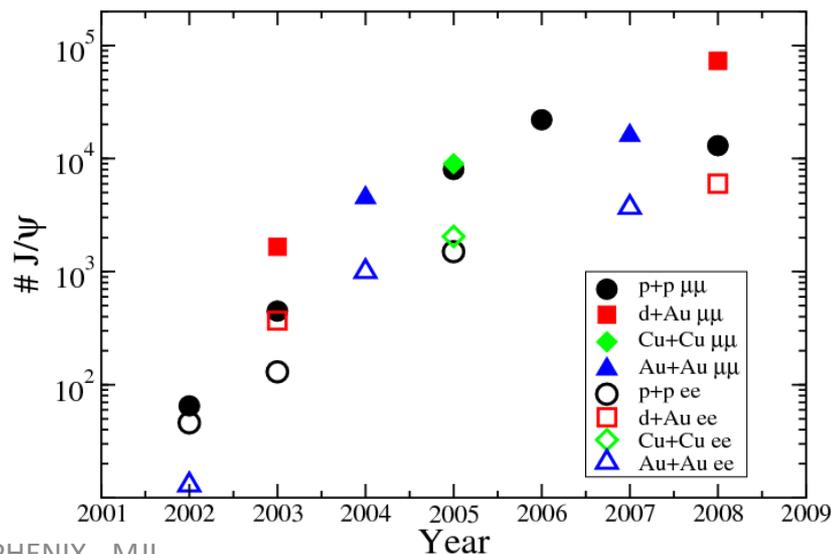
200 GeV d+Au



200 GeV p+p



PHENIX - Approx. #'s J/ ψ vs Year



Efficiency for Run8 d+Au and p+p

About 50% of CA delivered luminosity is useful luminosity within our ± 30 cm vertex range

Given that, PHENIX efficiencies in Run7 were:

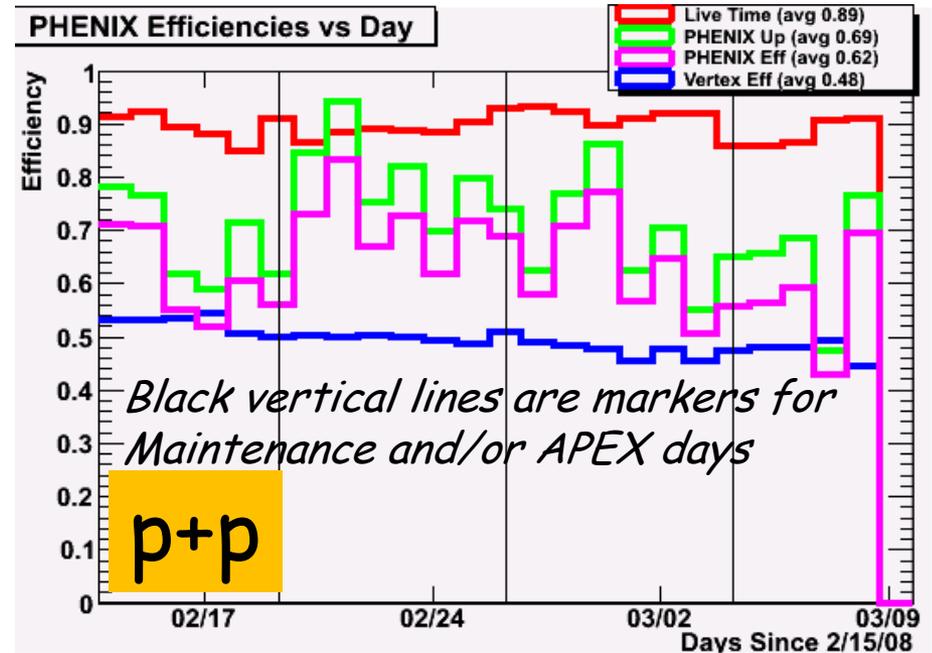
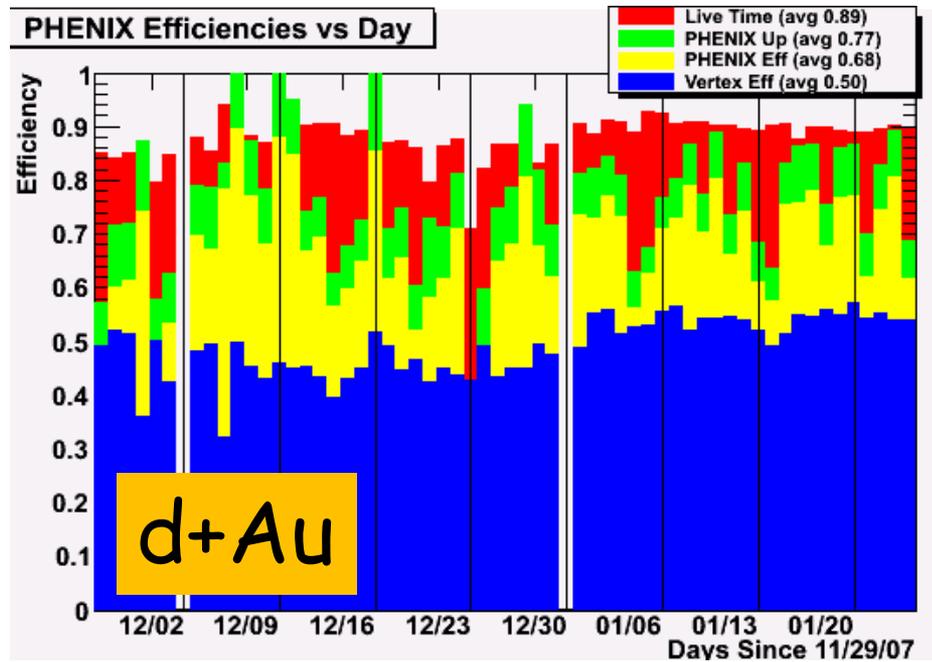
200 GeV d+Au

- Live Time - 89%
- PHENIX up - 77%
- Overall - 68%

200 GeV p+p

- Live Time - 89%
- PHENIX up - 69%
- Overall - 62%

(where 10% correction for loss due to CNI measurements is made)

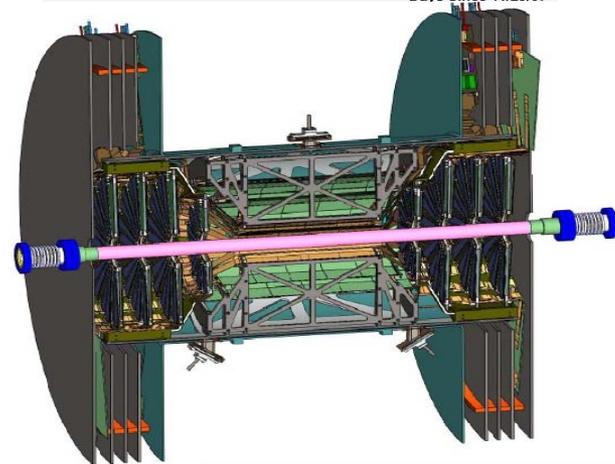
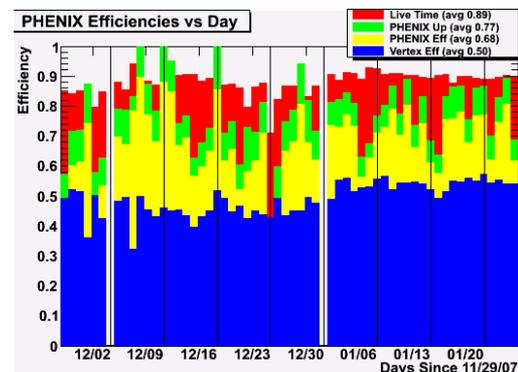
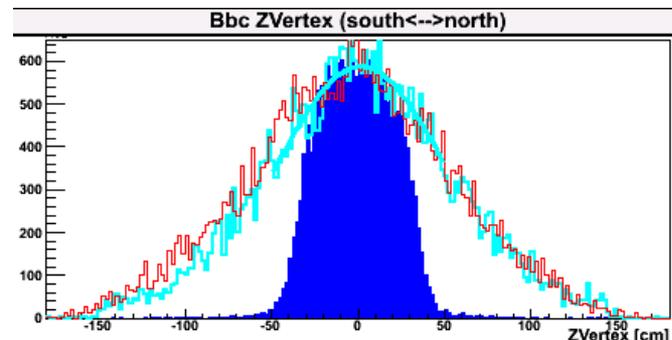


The Persistent Problem of Interaction Diamond Sizes

With present interaction diamond z-size only about 50% of the CA delivered luminosity fits within our ± 30 cm vertex range

- with Stochastic Cooling (longitudinal) and full voltage 200 Mhz RF it is thought that the vertex can be narrowed to ± 20 cm for AuAu collisions
- super Beta quads could help
- for pp collisions 9 Mhz cavity will help

- but the Vertex detector upgrades require ± 10 cm cuts, which even for ± 20 cm distributions, will give only a 38% efficiency!



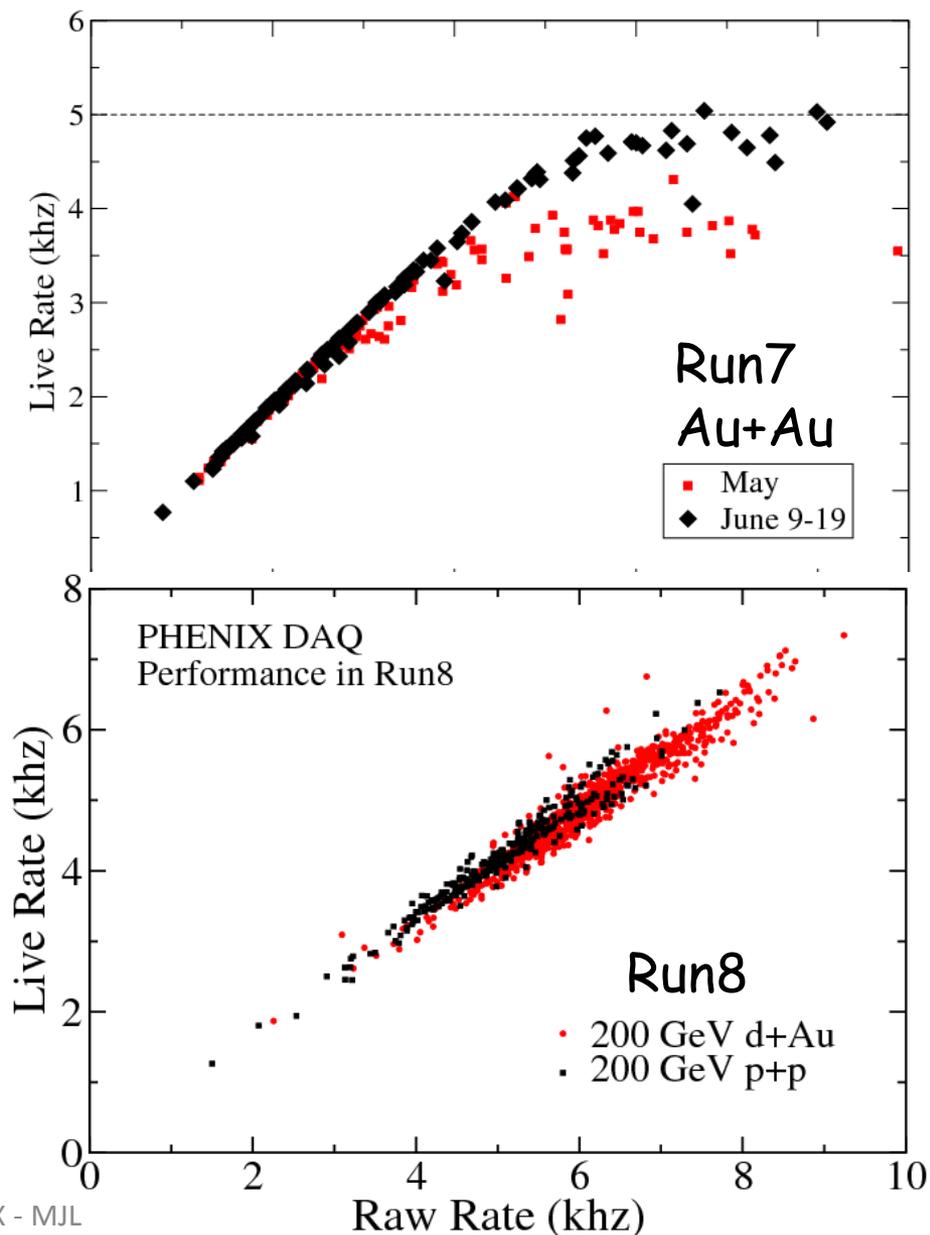
PHENIX Data Acquisition (DAQ)

Run7 DAQ performance:

- up to 5 khz min-bias event rate with 700 Mb/sec throughput

Run8 trigger & DAQ performance:

- triggers set to avoid saturation of DAQ bandwidth
- event rates up to 7 khz



PHENIX DAQ/Trigger Planned Improvements

Near Term, building on Run7/8 progress - goal 7 khz events rate

- improved front-end data compression (FPGA reprogramming)
- faster Master Timing Module (GTM) recovery from 4-events buffered
- modernize and increase numbers of Buffer Boxes for data storage
- muon identifier 2-D road-finder trigger

Longer Term - higher speeds with larger data volume from upgrade detectors

- forward rapidity muon trigger upgrade - primarily for W triggers
 - new muon tracker lvl-1 capable electronics
 - RPC to identify high momentum (with above) and reject out-of-time backgrounds
- faster data collection modules (DCM-II)
- faster Event Builder ethernet Switch (10 GB)
- additional BBC lvl-1 boards to provide multiple z-vertex cuts
- Global lvl-1 with >32 triggers
- stable clock through injection, ramps, dumps
- new EmCal front-end electronics to provide stable, sharp turn-on triggers
- lvl-1 trigger systems for silicon vertex detectors
- de-multiplex (part of) the front-end electronics

Polarized Proton Accelerator Developments?

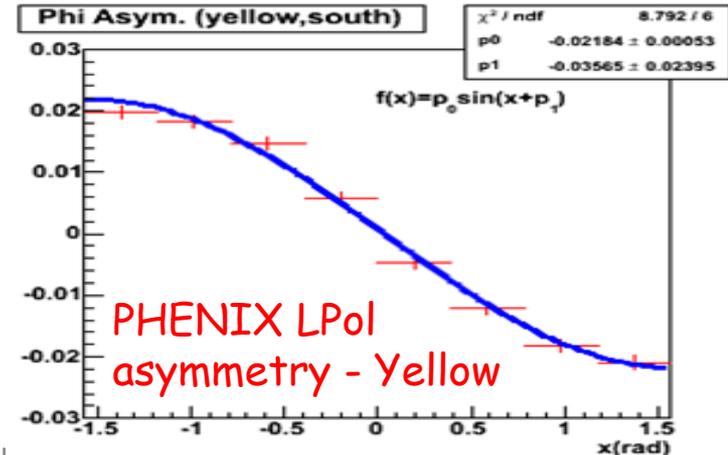
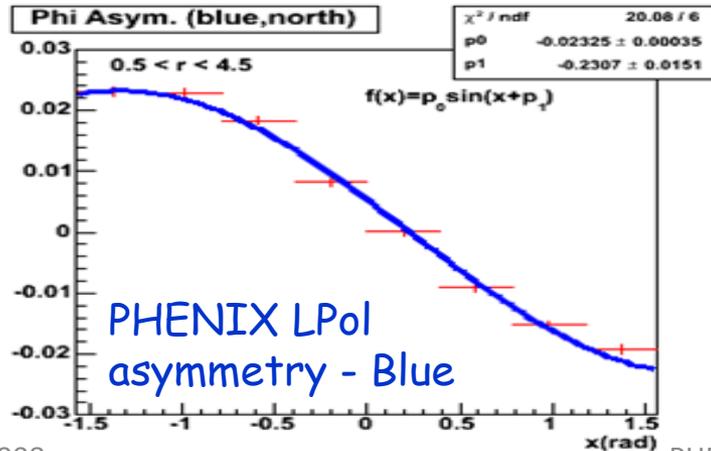
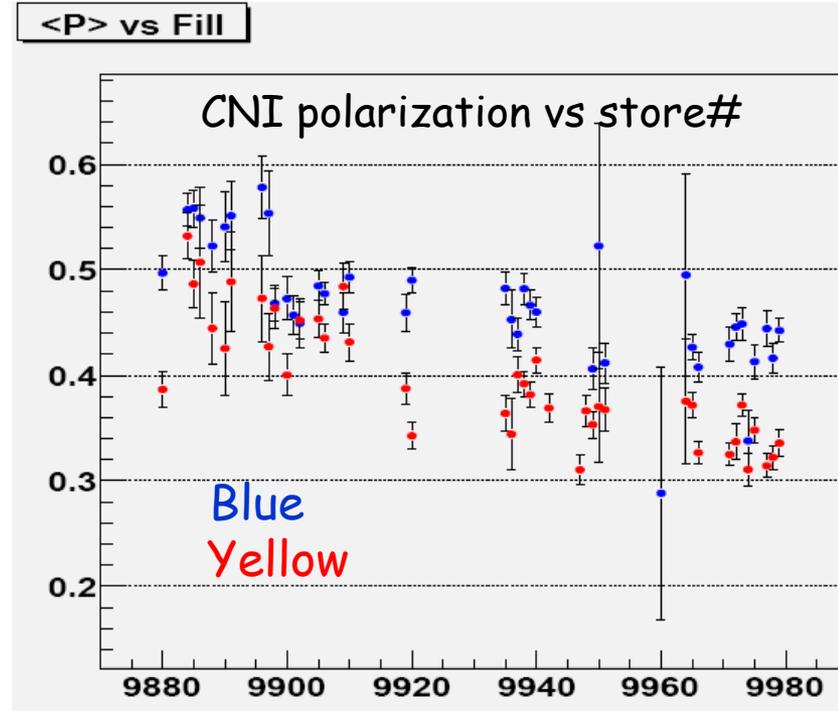
(items listed by Wolfram - 21 Apr 2008 RSC mtg)

Reduction in β^* (from 90cm to 50cm)	+80%	Success in APEX, not in operation
Nonlinear chromaticity correction	+30%	Partial success?
Quadrupole jump in AGS	polarization	Not tried
9 MHz cavity	+25% at $\beta^*=1m$	Hardware was not ready.
LEBT/MEBT + Booster injection modification	+20%	Not tried
Eliminate triplet vibration	+5-10%	No easy solution
Near (half) integer working point (near integer requires damping of triplet vibration or orbit feedback beyond IP)	+40%	Gave up because of triplet vibration
56 MHz cavity		Mainly for HI collisions
Electron lens	+100%??	For the future

The short 2008 p+p run was not so good for accelerator development.
A serious p+p run requires SUBSTANTIAL DEVELOPMENT TIME!

Low Polarization in Run8 p+p

- 50% blue, 41% yellow
- Very little polarization development time
- PHENIX forced to abandon radial polarization
 - x1/2.3 in significance
- Anti-correlation of polarization with intensity
- Jet polarimeter measurements good, especially when both beam done simultaneously
- CNI measurements give large backgrounds & cost ~10% of delivered luminosity
 - need to make them faster
- Local (experimental) polarimetry very useful
 - PHENIX needs to find a way to do it routinely (independent of main DAQ)



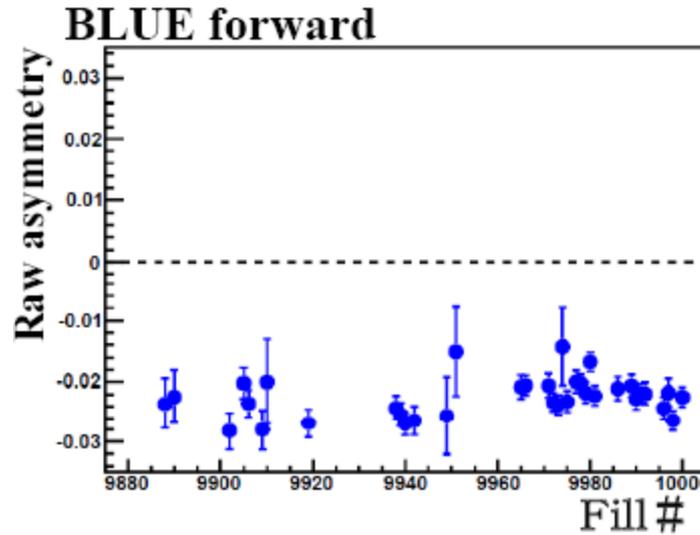
PHENIX Local Polarimeter

PHENIX Local Polarimeter raw asymmetries vs fill #

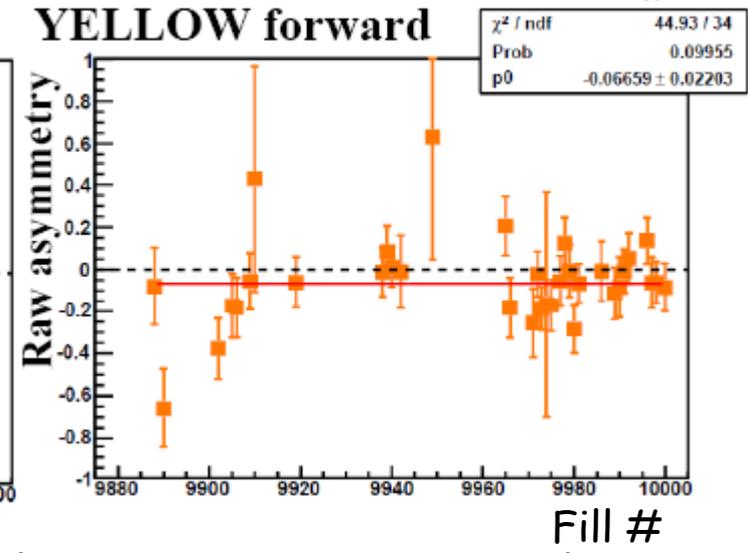
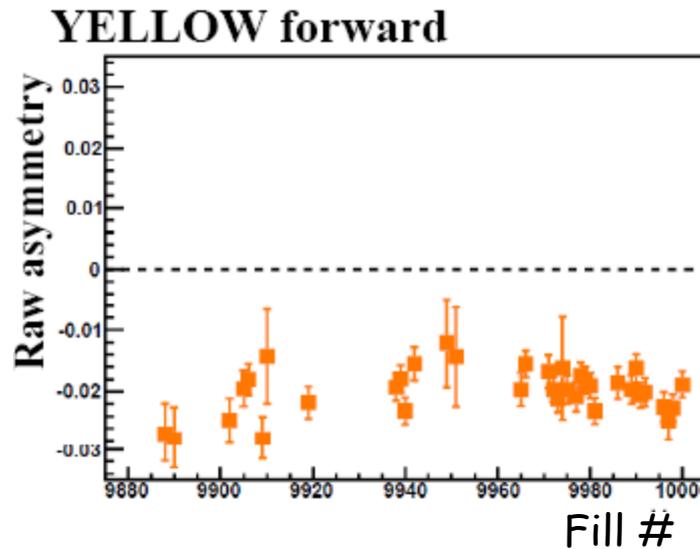
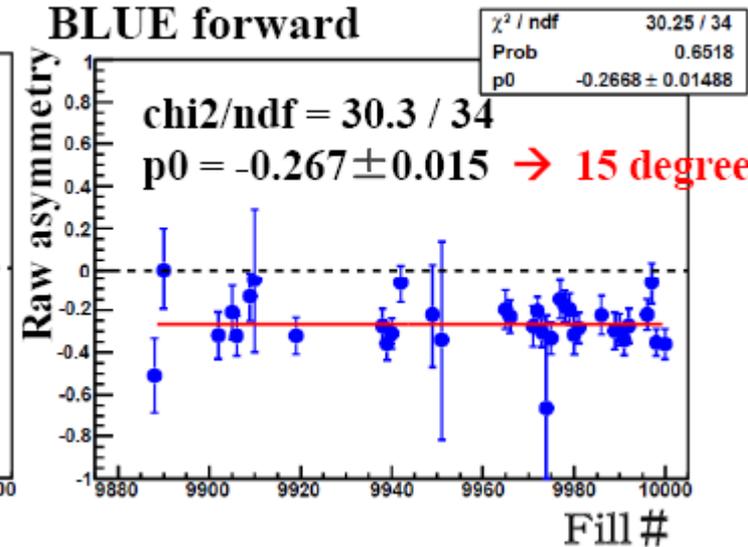
S. Dairaku & J. Koster

- data taken using large fraction of DAQ for a few stores to get high statistics
- need to develop a way to do for all stores in future

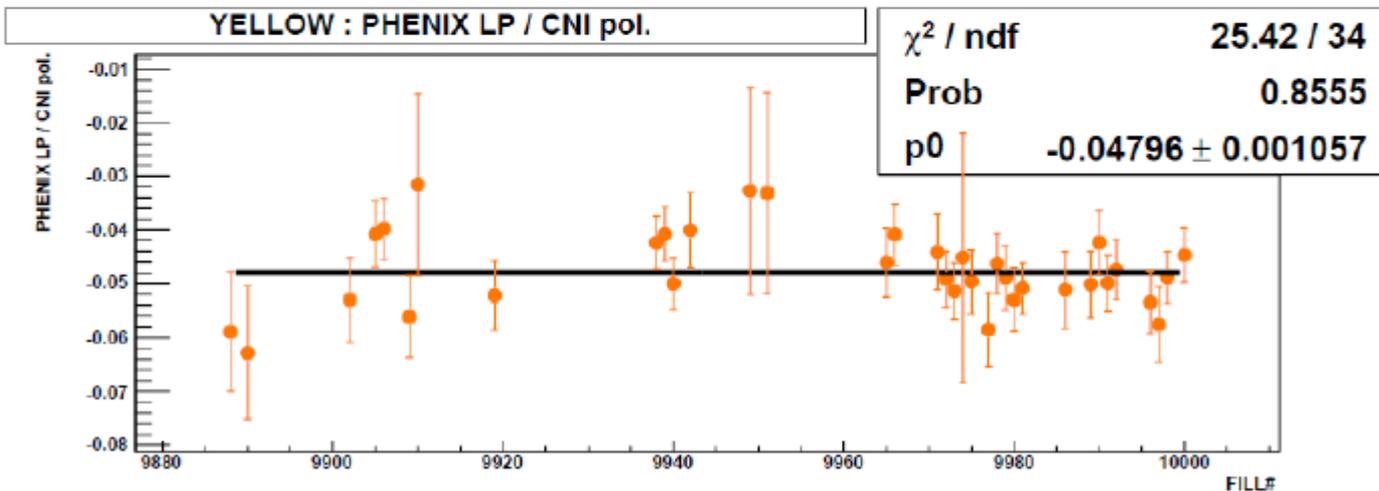
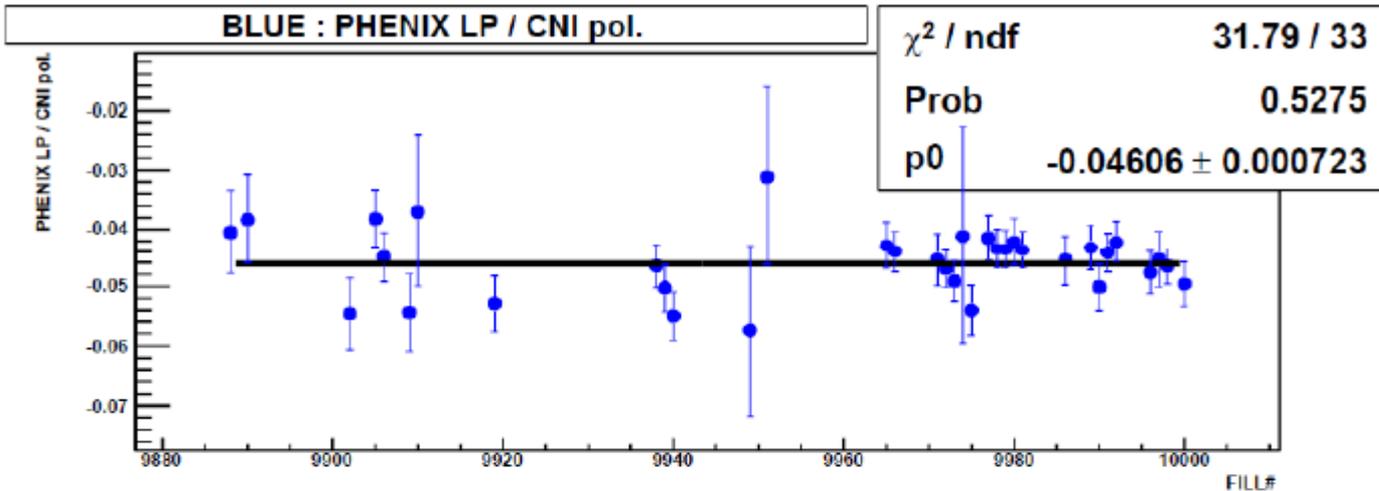
Amplitude



Phase



PHENIX Run8 Local Polarimeter Compared with CNI Measurements



* statistics uncertainty only

S. Dairaku & J. Koster

PHENIX Spin Physics Goals - Can we Get there from here?

$A_{LL}(\pi^0)$ goal is 71 pb⁻¹ with 65% polarization

- gluon contribution (ΔG) to the nucleon spin

$$\frac{A_{LL} \text{ goal}}{\text{Run8 } pp} = \frac{71 \text{ pb}^{-1} \times 0.65^4}{5.2 \text{ pb}^{-1} \times 0.5^2 \times 0.41^2} = 58$$

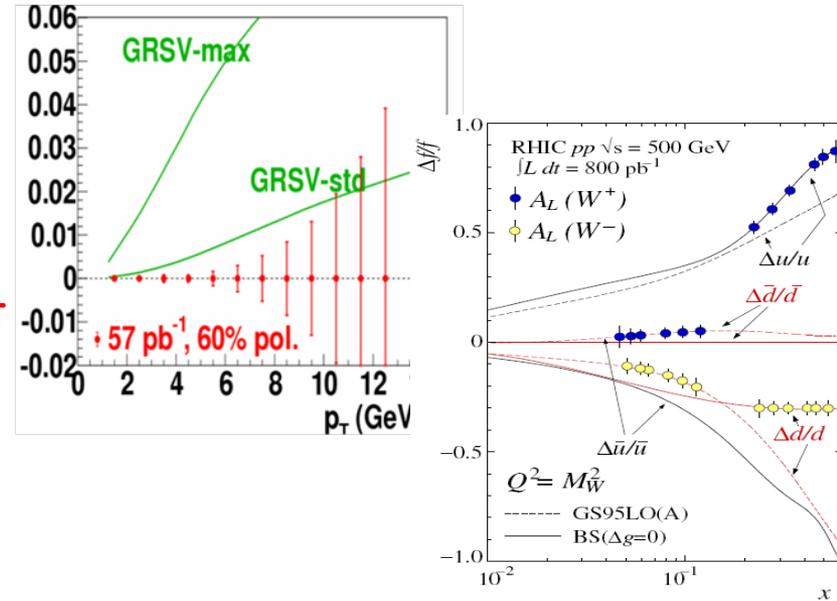
500 GeV W goal is about 300 pb⁻¹ recorded at 70% polarization

- dbar, ubar contribution to the nucleon spin

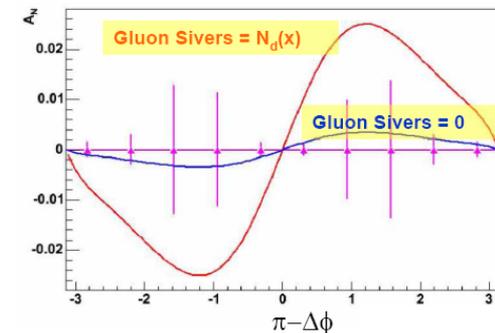
$$\frac{W \text{ goal}}{\text{Run8 } pp} = \frac{300 \text{ pb}^{-1} \times 0.70^2}{5.2 \text{ pb}^{-1} \times 2.5 \times 0.5 \times 0.41} = 55$$

Radial Polarization goal was 7.5-10 pb⁻¹ at 60% polariz.

- Sivers - $(7.5 \times 0.60^2) / (5.2 / 2.3 \times 0.5 \times 0.41) = 5.8$ short of goal
 - factor of 2.3 due to not having Radial polarization
- Mono-jets - p+p is baseline for d+Au
 - MPC on both sides for d+Au is a plus

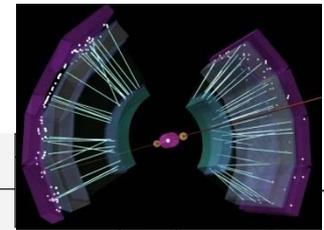


Boer and Vogelsang, hep-ph/0312320

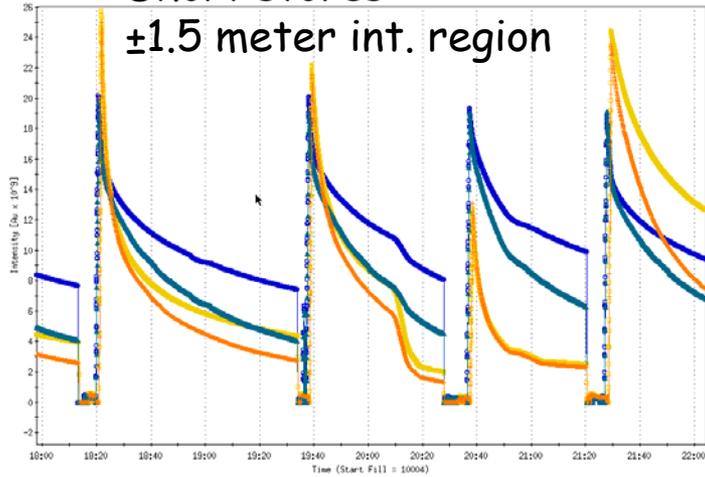


Run9 - Need p+p - can't live another year without a STRONG p+p run with ample development towards higher FOM!

9.2 GeV Au+Au 2-day test Run

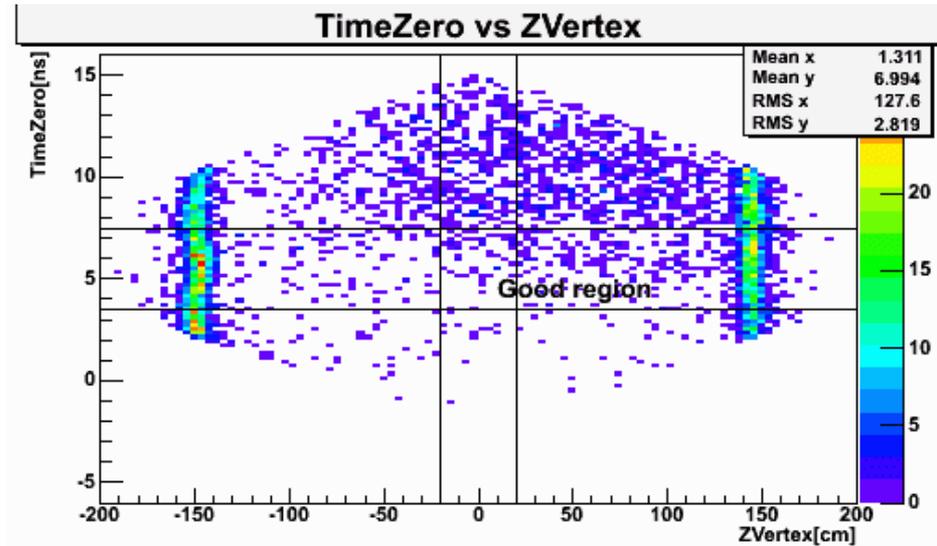
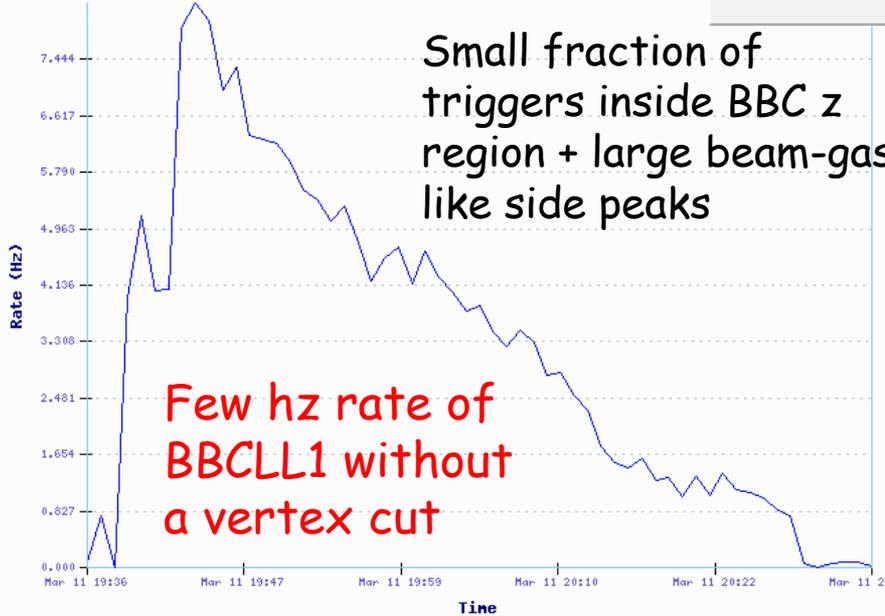
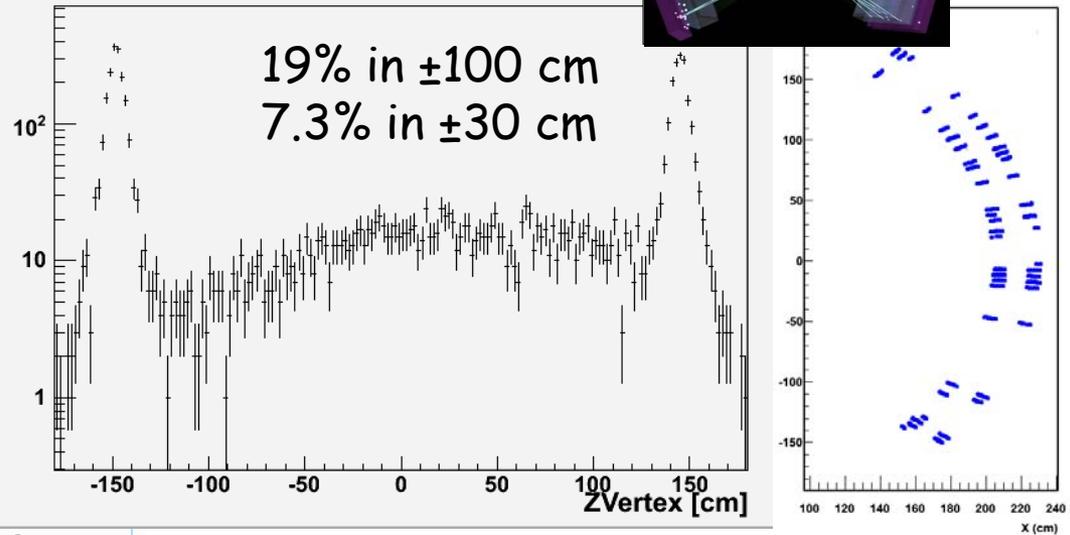


Short stores
±1.5 meter int. region

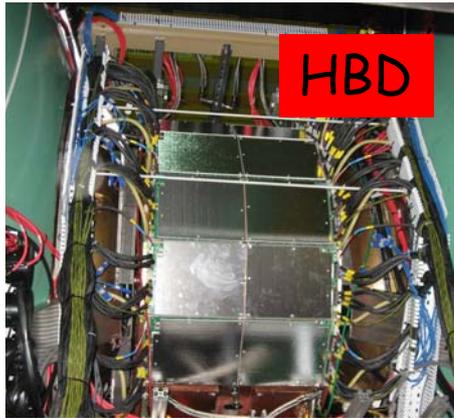


BBCLL1(>0 tubes) no vertex

BBC ZVertex triggered by BBLL1(noVtxCut)

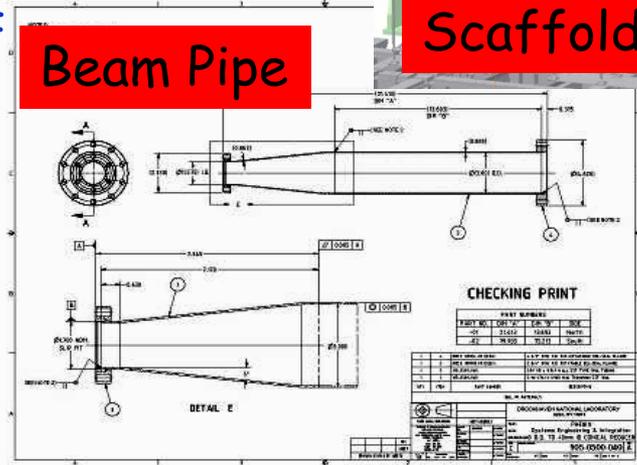


2008 Shutdown Activities at PHENIX

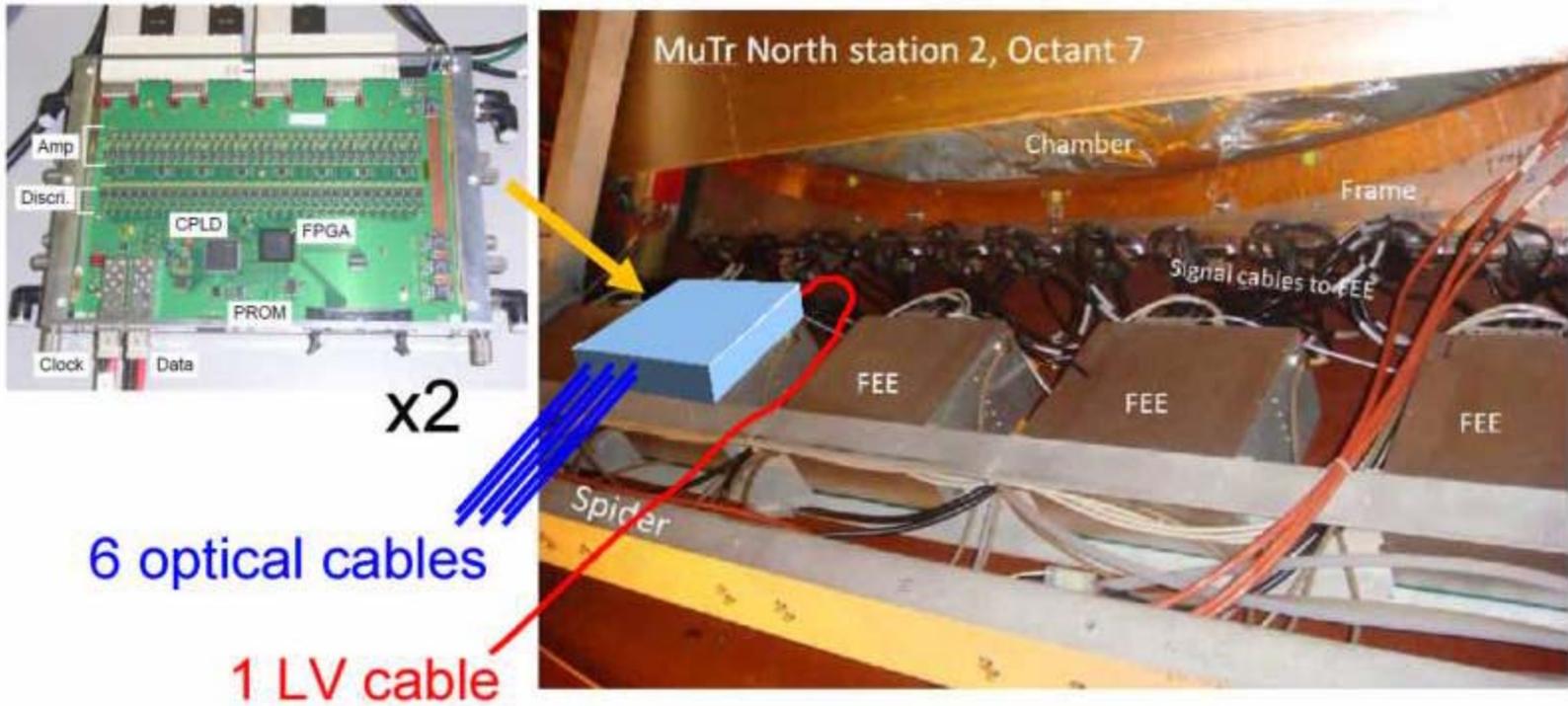


Shutdown work includes:

- HBD reinstallation
- Repairs to:
 - Pad Chamber FEE
 - DC wires
- Muon arms & forward trigger upgrade:
 - Muon Tracking HV
 - FEE installation (north + 1 octant of south)
 - RPC (1/2 octant of south muon arm)
- Scaffolding for above
- New 10 cm diameter beam pipe (if time)



Muon W-Trigger FEE Upgrade - Final Prototype Test During Run8

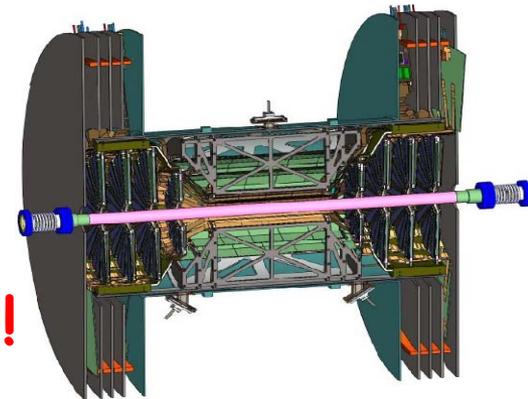
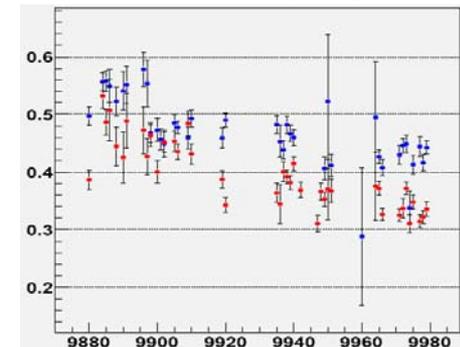
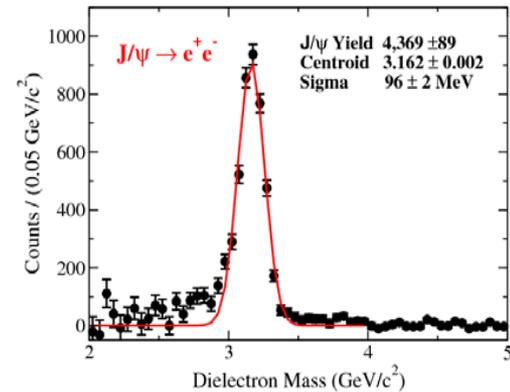


- MuTRG boards will be installed on the 2nd FEE from left.
- 48 strips from gap-2 and 3 each will be connected to the boards.

PHENIX Run8 Summary

- **d+Au was fantastic! - x30 over Run3**
 - baseline for future A+A
 - new level of precision on intrinsic Cold Nuclear Matter physics
 - now p+p is the weakest part of baseline
- **p+p was disappointing**
 - polarization was very poor
 - a strong p+p run with ample beam/polarization development is a must for the future
- **PHENIX efficiency for recording useful luminosity up from 50% in past to 68% now (33% in ± 30 cm)**
 - DAQ developments continue to push to higher event rates
 - but tighter z-vertex requirements in the future will lower fraction of luminosity that is useful

THANKYOU to CA for a great (d+Au) Run!!



Backup Slides

Recorded/Delivered Luminosity Ratio

The useful delivered luminosity is the fraction within $z_{vtx} = \pm 30$ cm, about 50% of what CA quotes

$$\mathcal{E}_{vtx} = N_{BBC}^{\pm 30cm} / N_{BBC}^{Wide}$$

The recorded and delivered luminosity come from the BBC and ZDC, respectively; and their ratio with a small loss due to livetime (LT), gives the PHENIX efficiency

$$\mathcal{E}_{PHENIX} = \frac{(n_{BBC}^{\pm 30cm} * LT) / \sigma_{BBC}^{eff}}{n_{ZDC} / \sigma_{ZDC}^{eff} * \mathcal{E}_{vtx}}$$

Uncertainty is from σ_{ZDC} & what fraction of n_{ZDC} to count (stable beam at beginning of store, not during CNI measurements, etc)

$$\mathcal{E}_{PHENIX} * \mathcal{E}_{VTX} = 0.68 * 0.5 = 0.34$$

	σ_{BBC}^{eff}	σ_{ZDC}^{eff}
d+Au	2.26 b x 88%	0.52 b
p+p	42 mb x 53%	0.31 mb
Au+Au	9.8 b x 92%	9.8 b

	\mathcal{E}_{PHENIX}	LT
d+Au	68%	89%
p+p	62%	89%
Au+Au*	65%	90%

* Last two weeks of Run7 AuAu

Summary of PHENIX Proposal for Run 9-13

RUN	SPECIES	$\sqrt{s_{NN}}$ (GeV)	PHYSICS WEEKS	$\int L dt$ (recorded)	p+p Equiv.
9	p+p Au+Au	200 or 500 200	10 or 5 ~10	25/25 pb ⁻¹ 1.2-1.4 nb ⁻¹	25 pb ⁻¹ 56 pb ⁻¹
10	p+p p+p Au+Au	500/200 62.4, 39, 28, 22.4 62.4, 39, 28	5 or 10 2.5 15	25 pb ⁻¹	25 pb ⁻¹
11	Au+Au p+p	200 500	M 25-M		
12	U+U p+p	200 200	N 25-N		
13	p+p Au+Au	500 various	Q 25-Q		