RHIC Experimental Background

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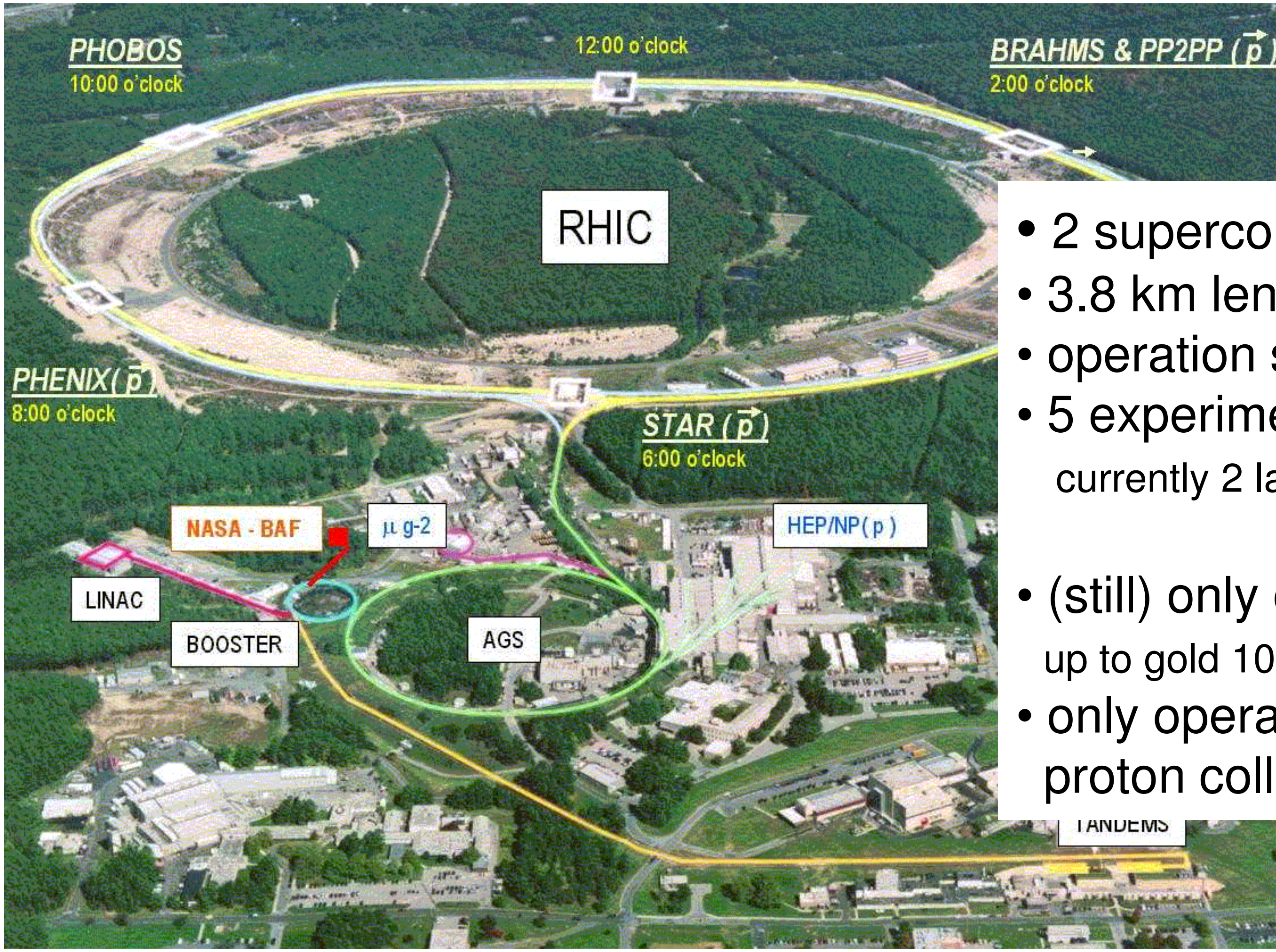
Workshop on Experimental Conditions and
Beam Induced Detector Backgrounds, CERN

3 April 2008

Topics

- RHIC overview
- Collimator layout and control
- Experimental background signals and control
- Beam-gas background

Relativistic Heavy Ion Collider



- 2 superconducting rings
- 3.8 km length
- operation since 2000
- 5 experiments so far,
  currently 2 large ones

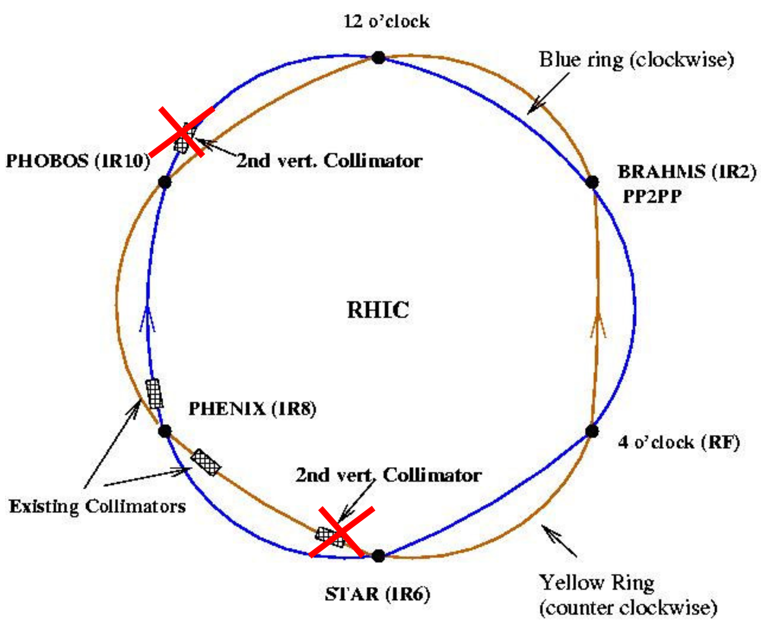
- (still) only operating ion collider
  up to gold 100 GeV/nucleon
- only operating polarized
  proton collider

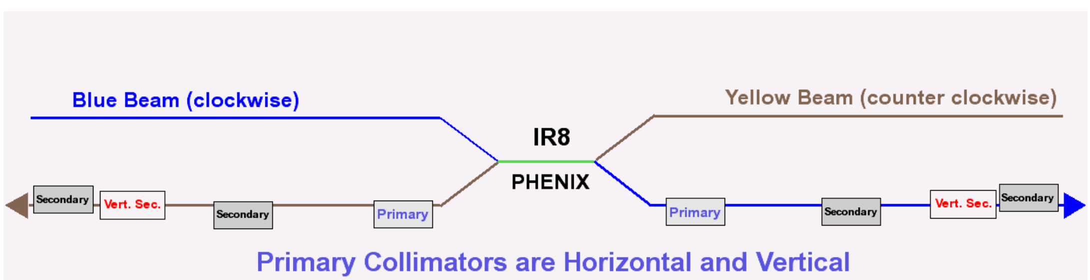
RHIC running modes to date

▪ Au–Au	4.6, 10, 28, 31, 65, <u>100</u> GeV/n
▪ d–Au	<u>100</u> GeV/n
▪ Cu–Cu	11, 31, <u>100</u> GeV/n
▪ polarized p–p	11, 31, <u>100</u>, 205, 250 GeV

Some modes only for days – fast machine setup essential.

Collimator Layout

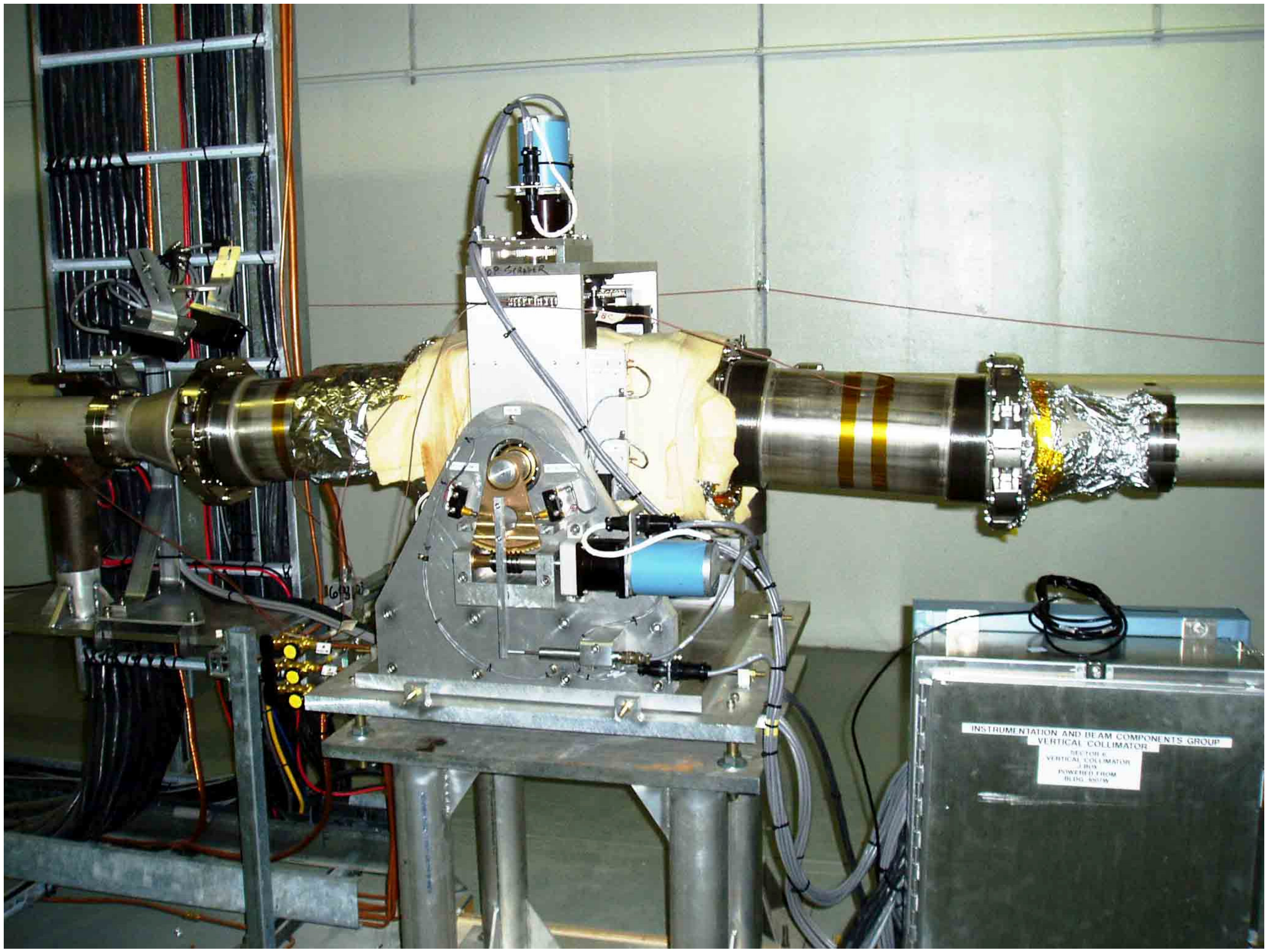




In RHIC collimators are used for experimental background reduction and abort gap cleaning only!

- Collimators around IR8
- Primaries are dual plane (L-shaped)
- All collimators have single jaw
- All collimators are in one straight section between Q3 and Q4
- Each collimator has a set of local loss monitors (Pin diodes)
- 2nd vertical collimators are not used (not efficient)

A RHIC collimator



Collimator Control: setup

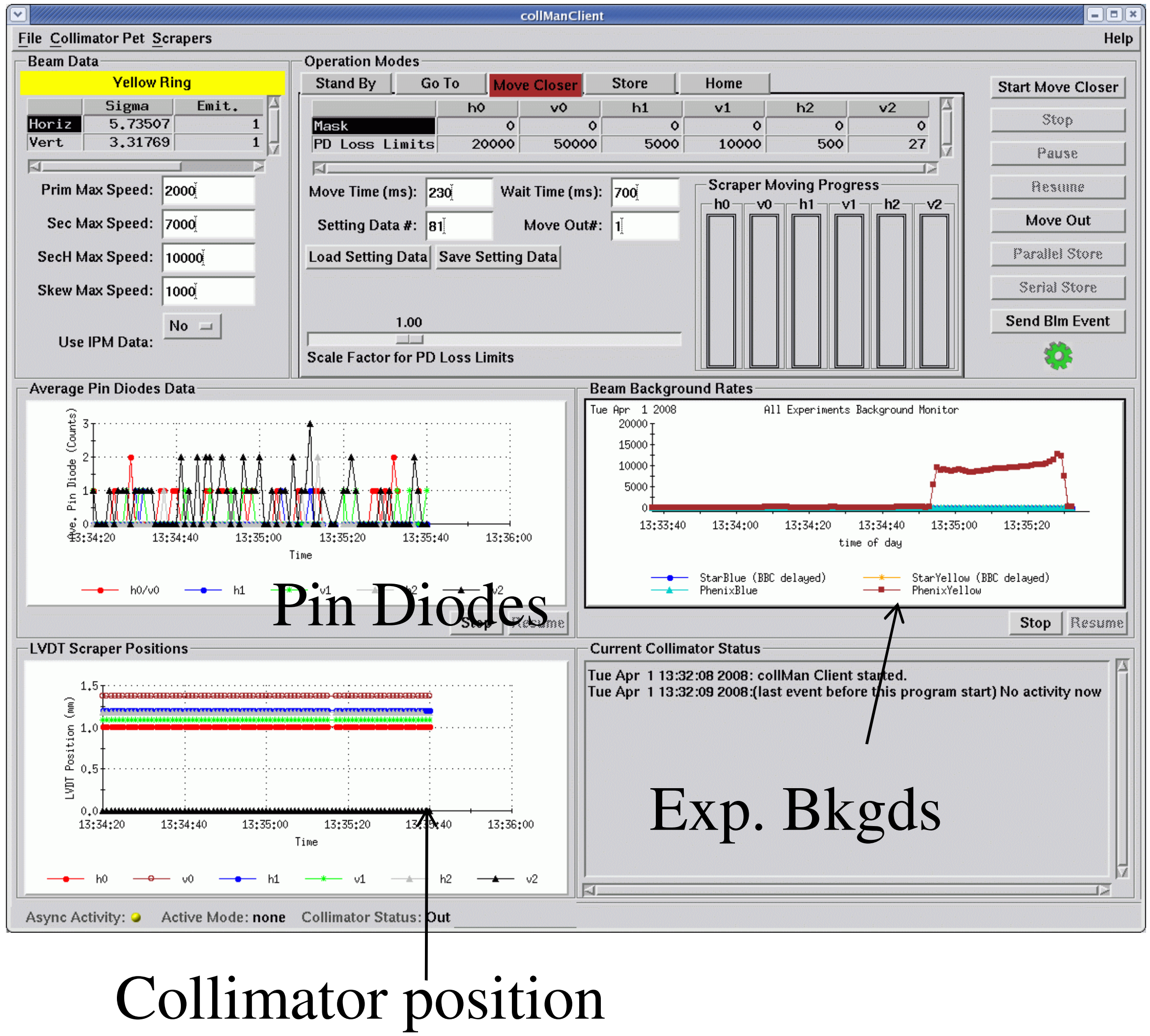
Move Closer

Used for setting up collimators:

Uses local loss monitor (Pin Diodes) signal to stop movement

Moves all collimator jaws (5) in preset order (typically plane by plane)

Fine adjustment is done with "Store" mode afterwards



Collimator Control: adjust

Final adjustments can be done in units of:

- Sigma
- mm
- Steps

Fine adjustments typically need to be done every other store. Final set points will be saved in to preset position. Quality is based on exp. Bkgd. Signal and strongly depends on their quality.

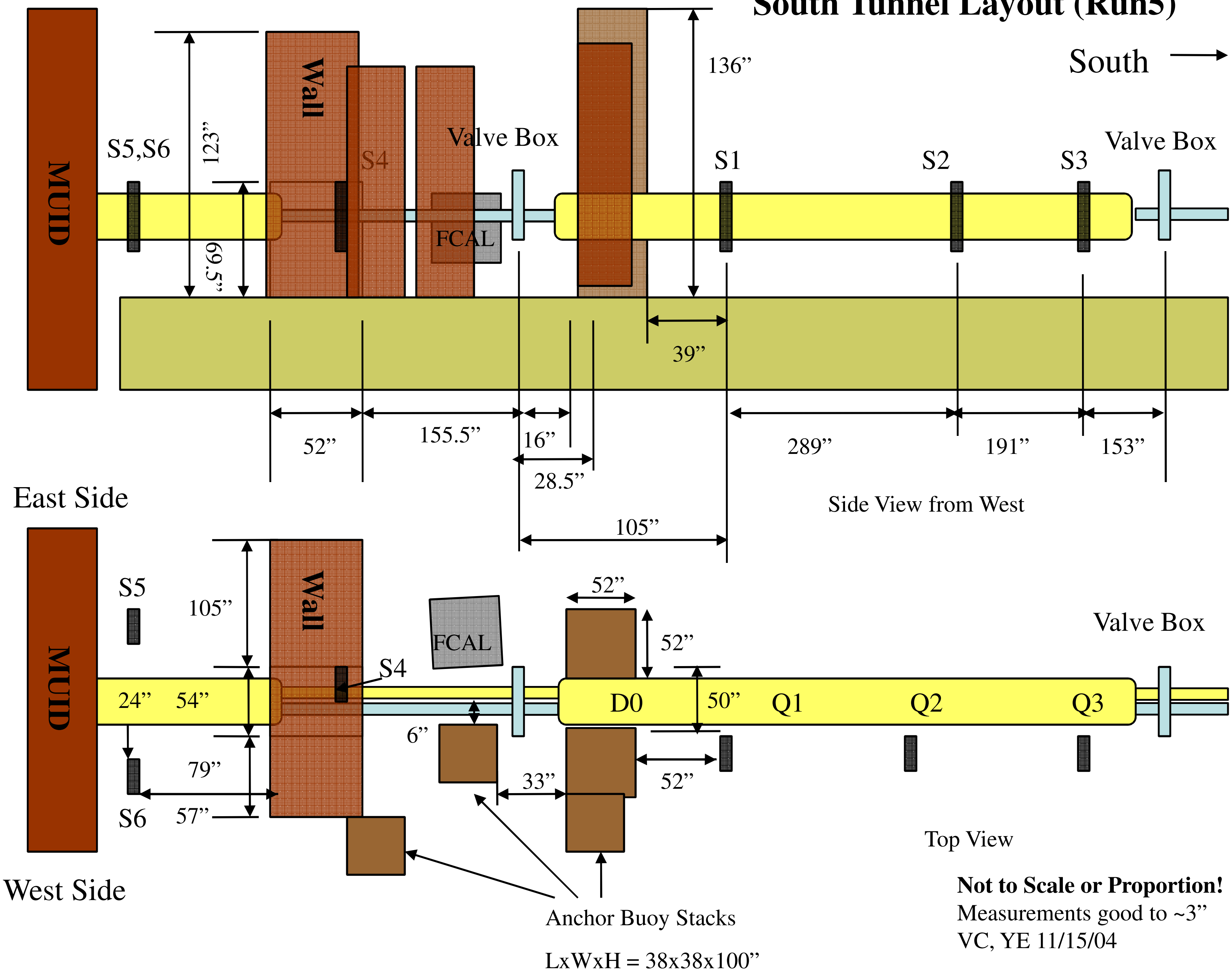
Collimator Control: operation

Automatic ramp/store sequencer moves collimators into preset “goTo” position. These positions typically drift slightly from store to store and are optimized manually at the beginning of each store.

Experimental Background signals

- Collimation efficiency strongly depends on reliability, availability and quality of experimental background signals.
- Typical problems:
  - Signal depends on detectors that are not turned on early in the store
  - Signals depends on DAQ to run (unreliable)
  - Signals are not compatible between experiments
  - Upper limits apply and keep changing between years and depend on shielding
  - Signals are contaminated with collision contributions
    - Amounts of that contamination varies between years and experiments
- Provided background signals are substantially different between the experiments!
  - PHENIX: tunnel scintillators
  - STAR: out of time signal from their BBC detector (directional)

South Tunnel Layout (Run5)

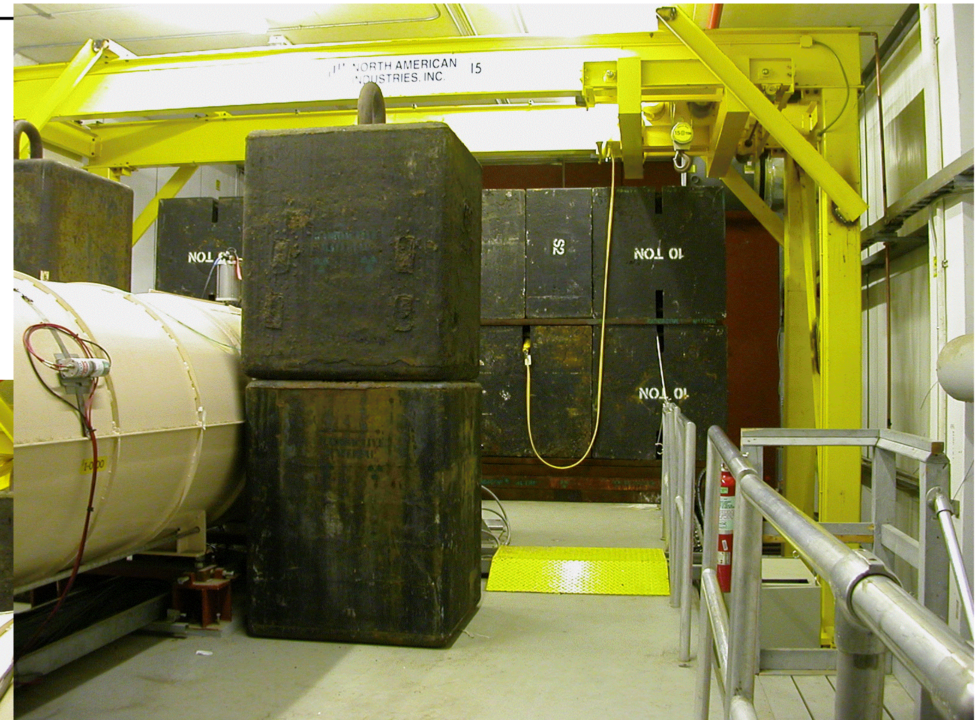


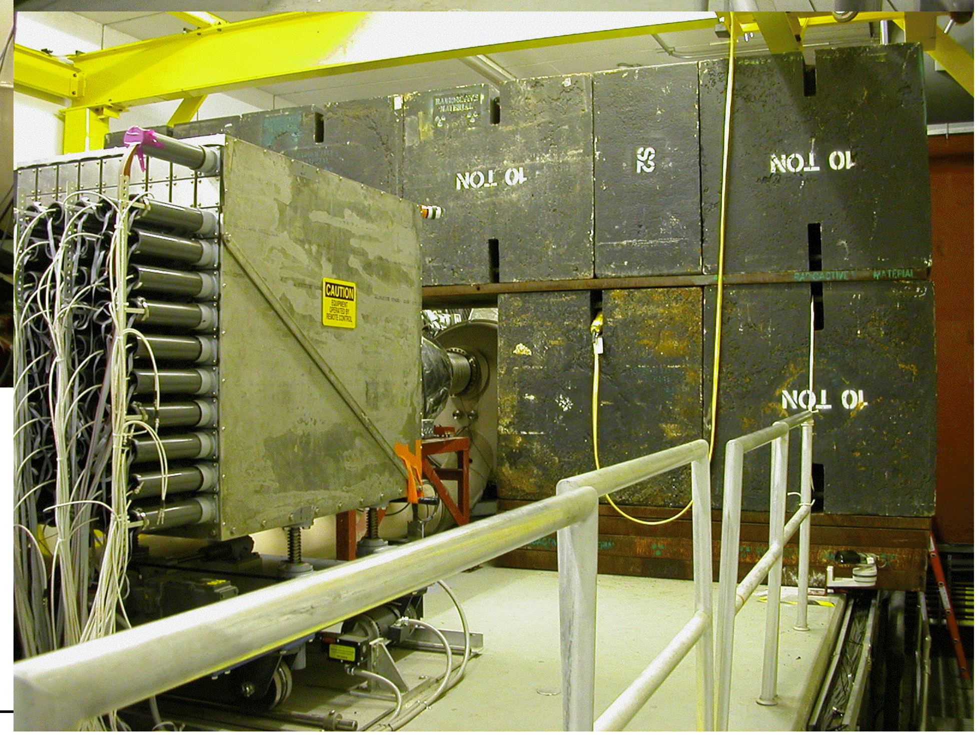
Not to Scale or Proportion!
Measurements good to ~3”
VC, YE 11/15/04

Experimental shielding

Scintillator at Q1

East Side





West Side

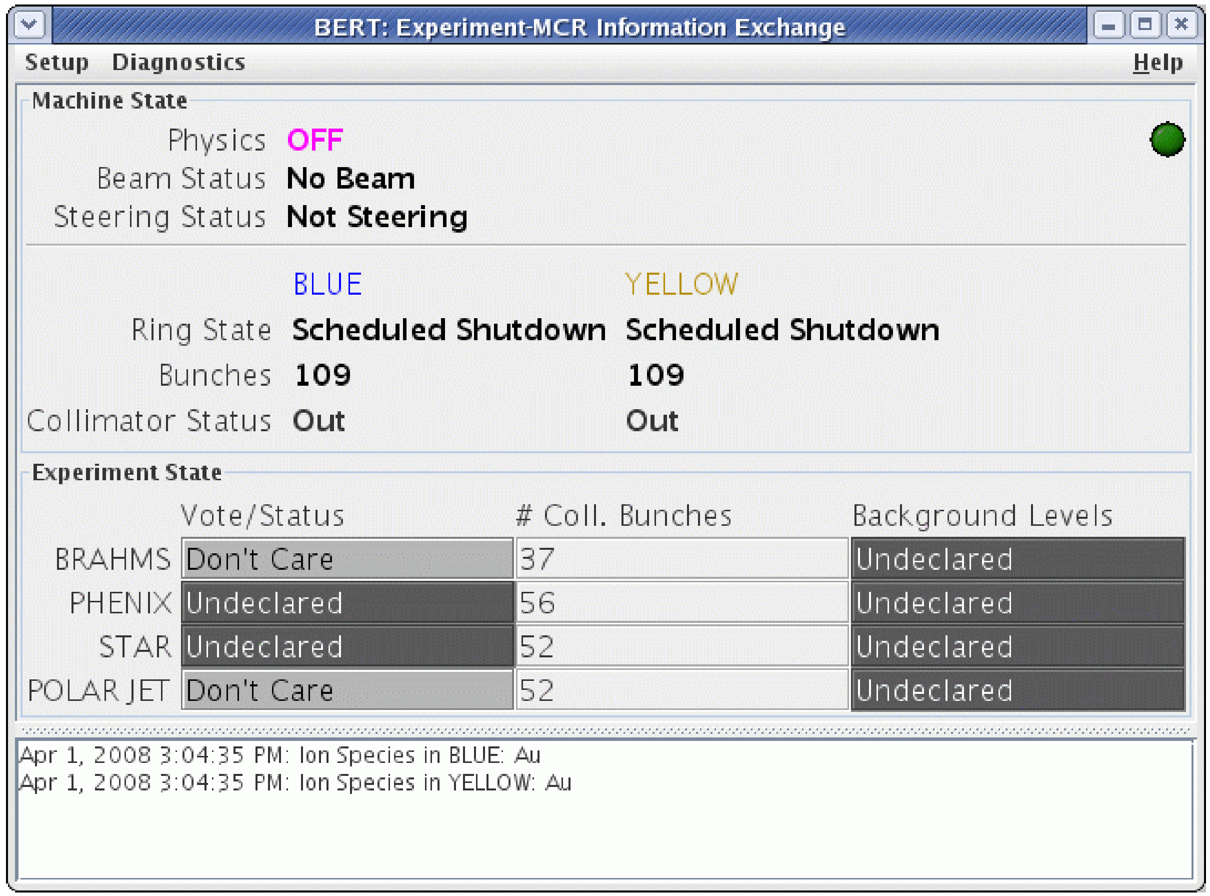
South Tunnel at PHENIX
(STAR has similar shielding)

Communication with experiments

Experiments can view the RHIC elog.

Communication via TV screens and telephone

Information Exchange GUI: BERT with input from the experiments



Collimation per plane:

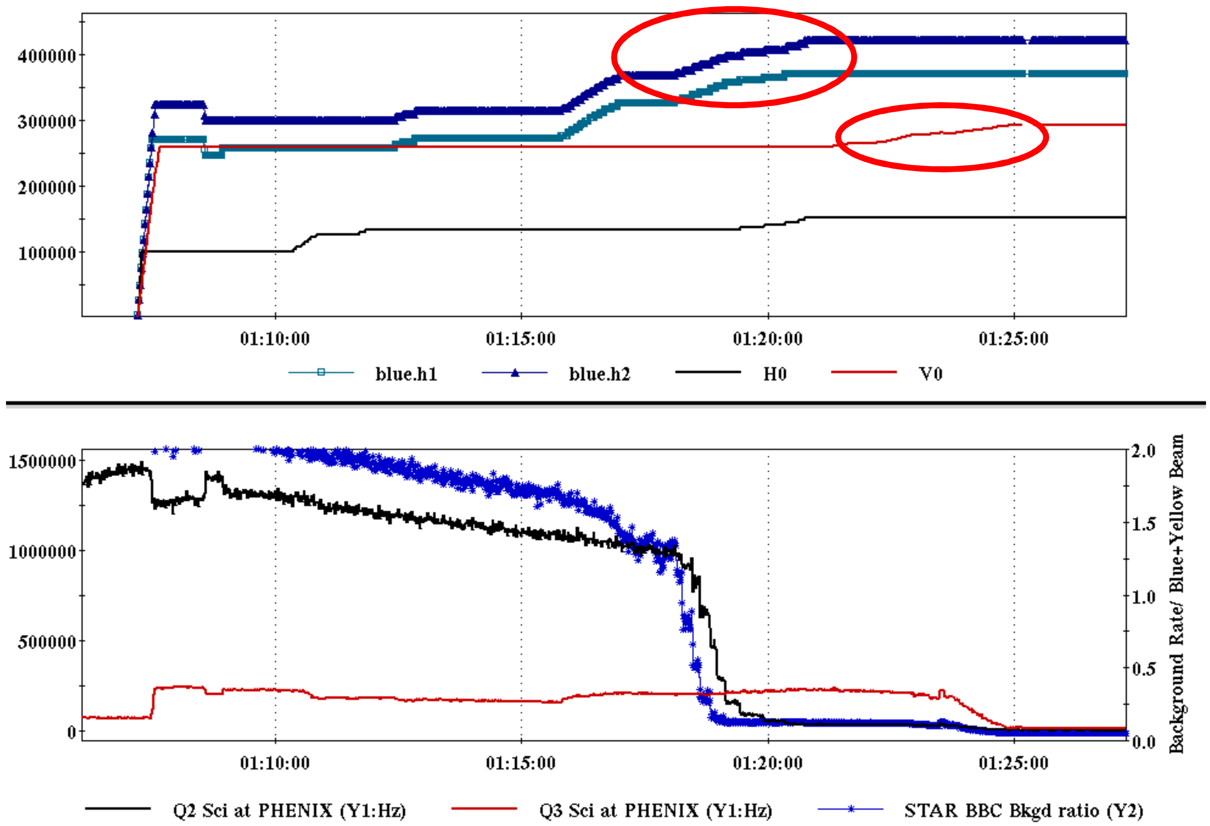
Individual planes on the following slide

Q2: max. of beta fct. In horizontal plane

Q3: max of beta fct. In vertical plane

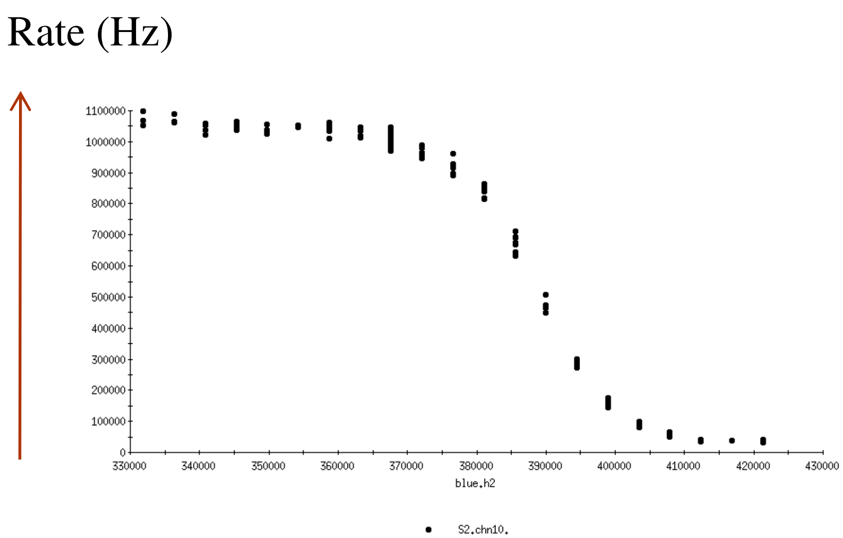
The two planes are fully decoupled!

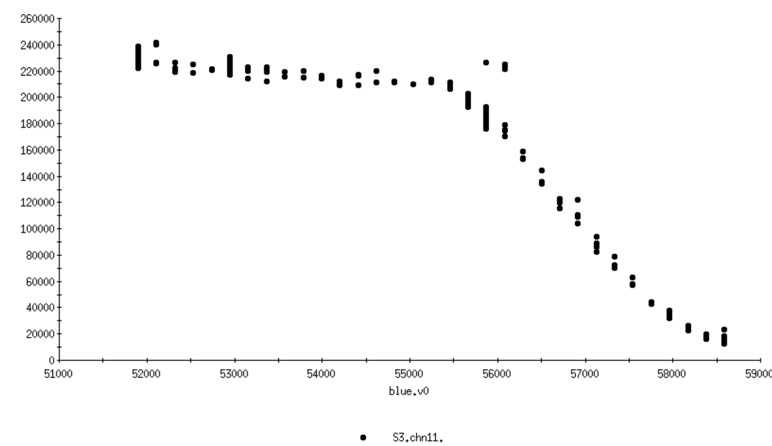
The STAR signal is inclusive and sees an effect for both planes.



Horizontal Plane

Vertical Plane





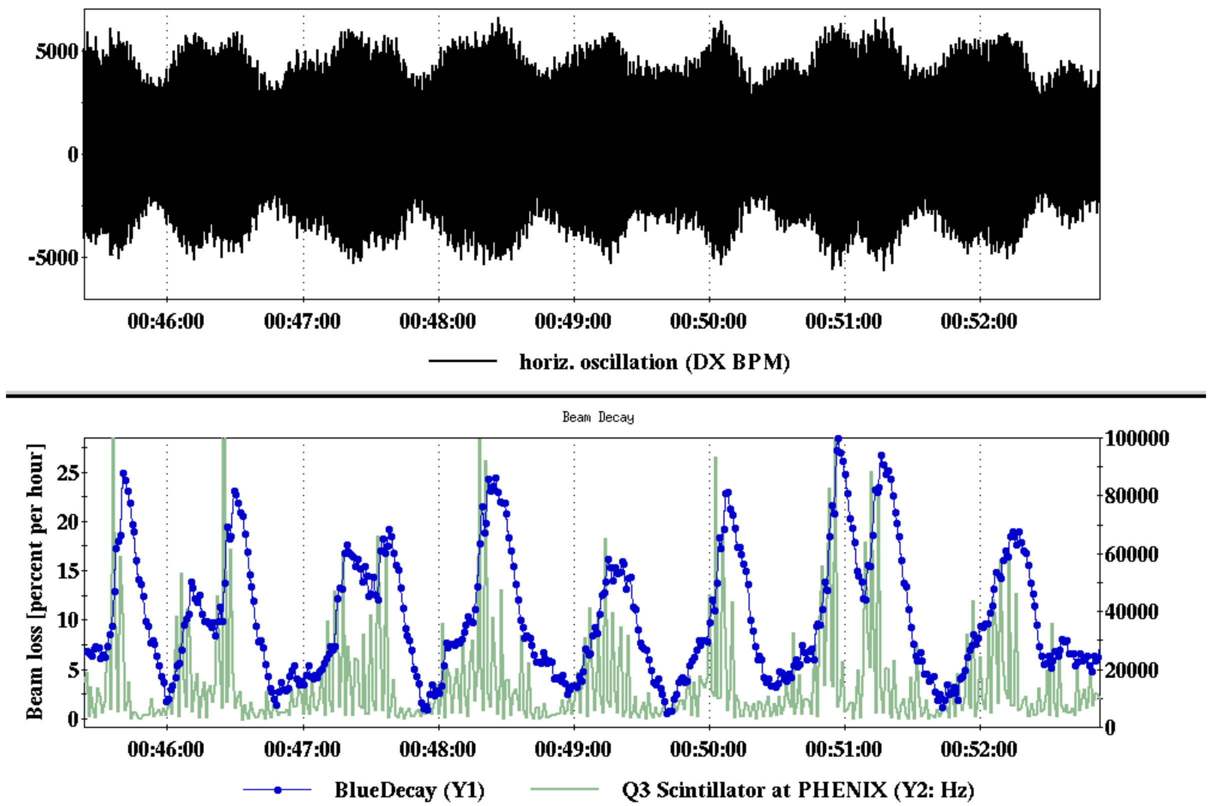
Achieved reduction rate during this collimation setup was in PHENIX x30 (h) and x15 (v) and x30 in STAR.

Collimation depends on working point: near integer

In 2008 a near integer working point was tested in the Blue ring, the beam was very sensitive to orbit errors

10 Hz oscillations caused by mechanical triplet vibrations

Near integer caused the beam decay and background amplitudes to oscillate by an order of magnitude (beating of multiple sources)

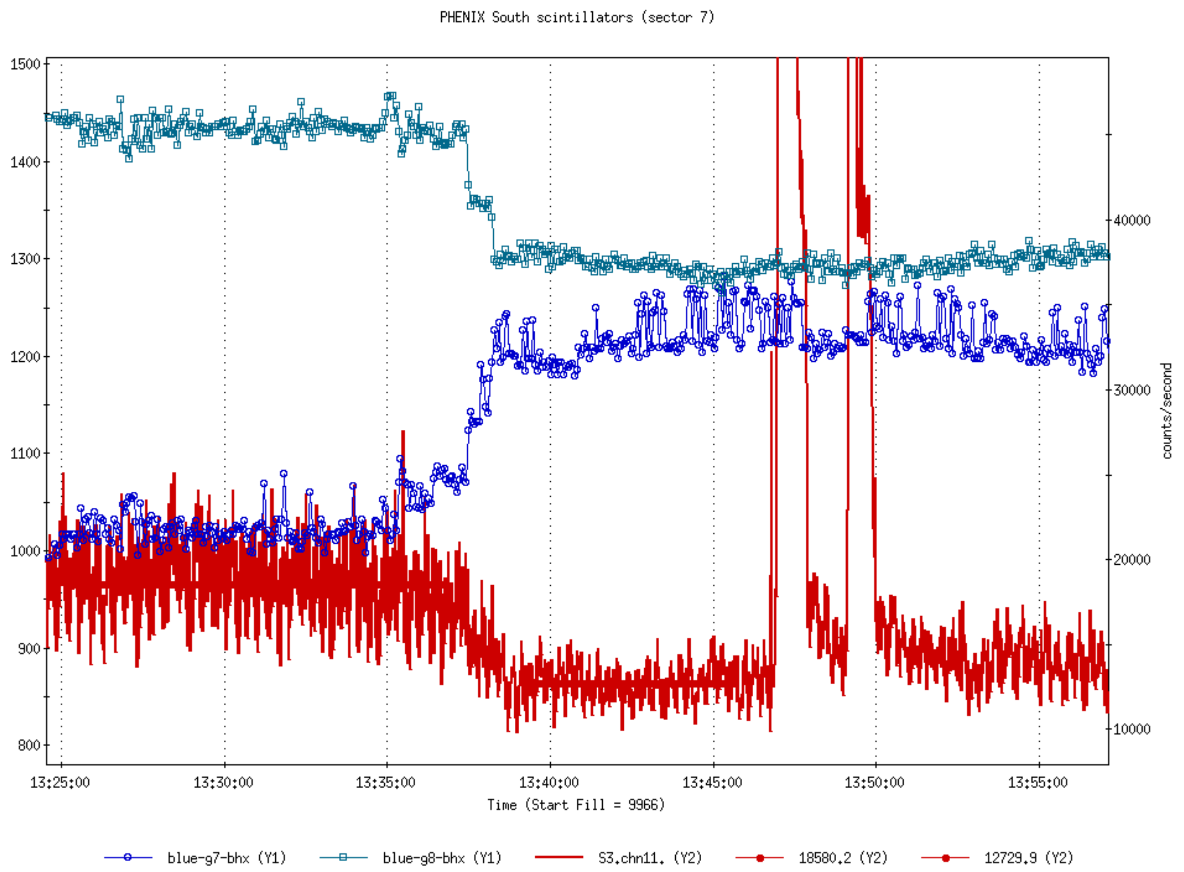


IR Steering

Angle steering (here Blue horizontal angle in IR8) helps experimental backgrounds.

Should be done before collimation since collimators are around IR8 and local beam position changes with IR steering

Reduction here ≈30%

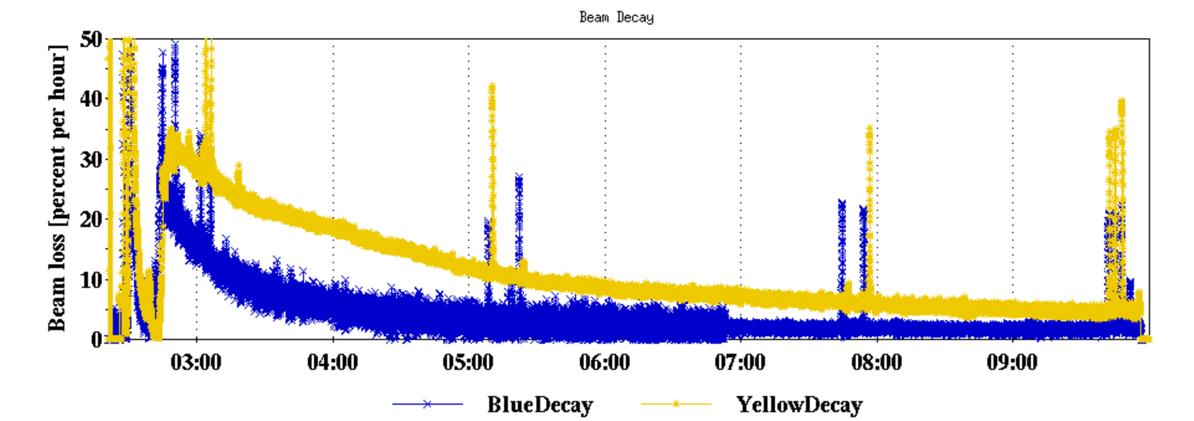


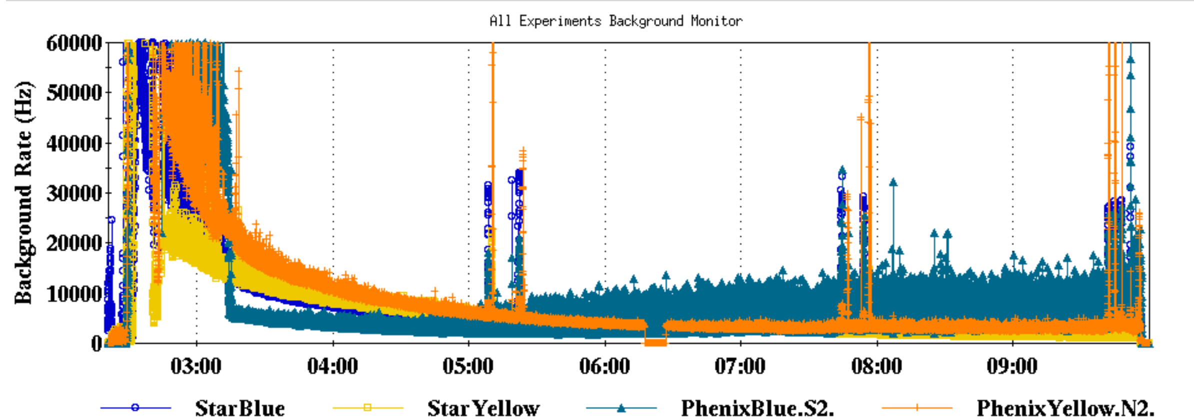
Increasing backgrounds

Beam decay is stable while blue backgrounds increase during the store (happens in only a few stores).

Small drifts and beam growth cause additional scraping in the triplet while beam loss is not visibly increased.

Main cause: 24h period vertical orbit variations (have orbit correction every ½ h now)





Collision contamination of signal

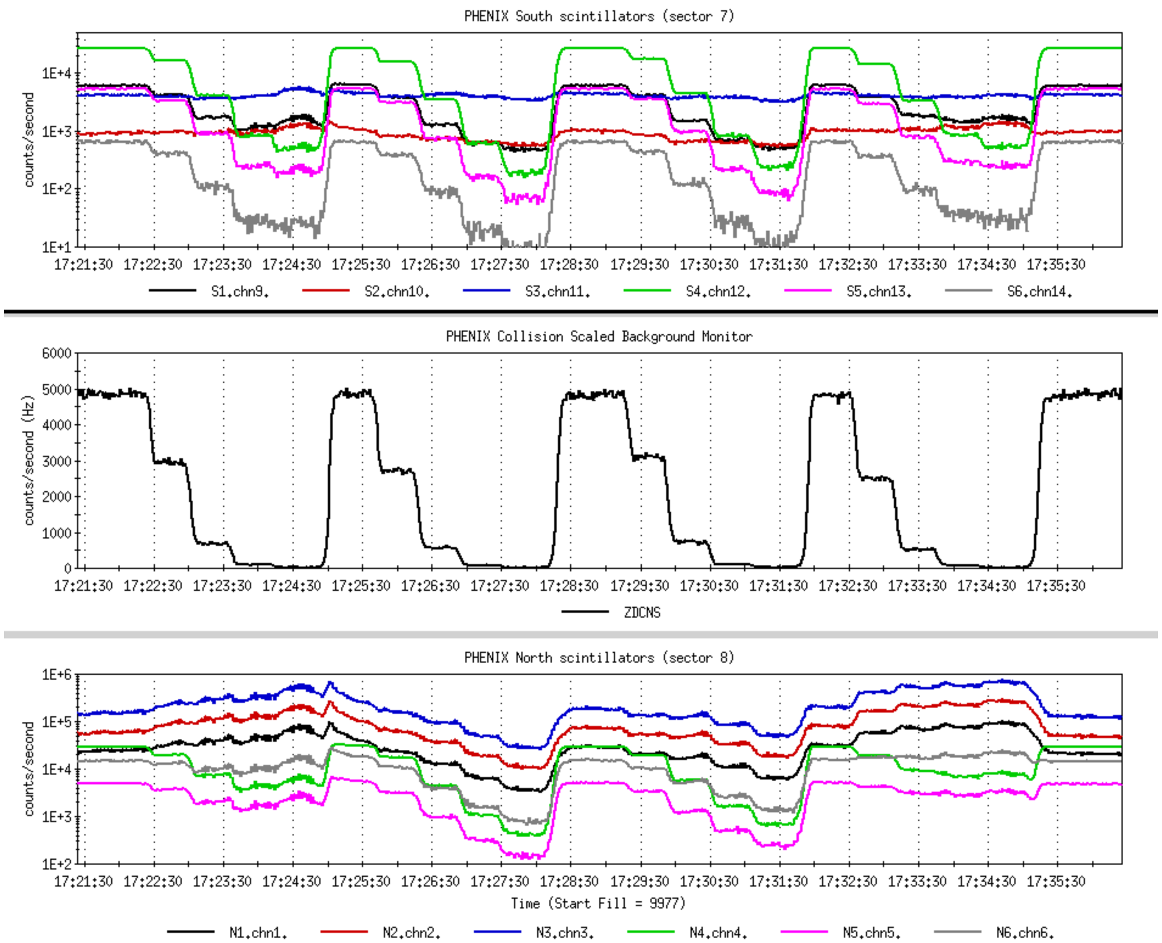
PHENIX

Data taken during a vernier scan with the yellow beam.

South: blue backgrounds

North: yellow backgrounds

N4-N6 and S4-S6 are collision dominated. North triplet scintillators see background caused by scan and the collimators being out.



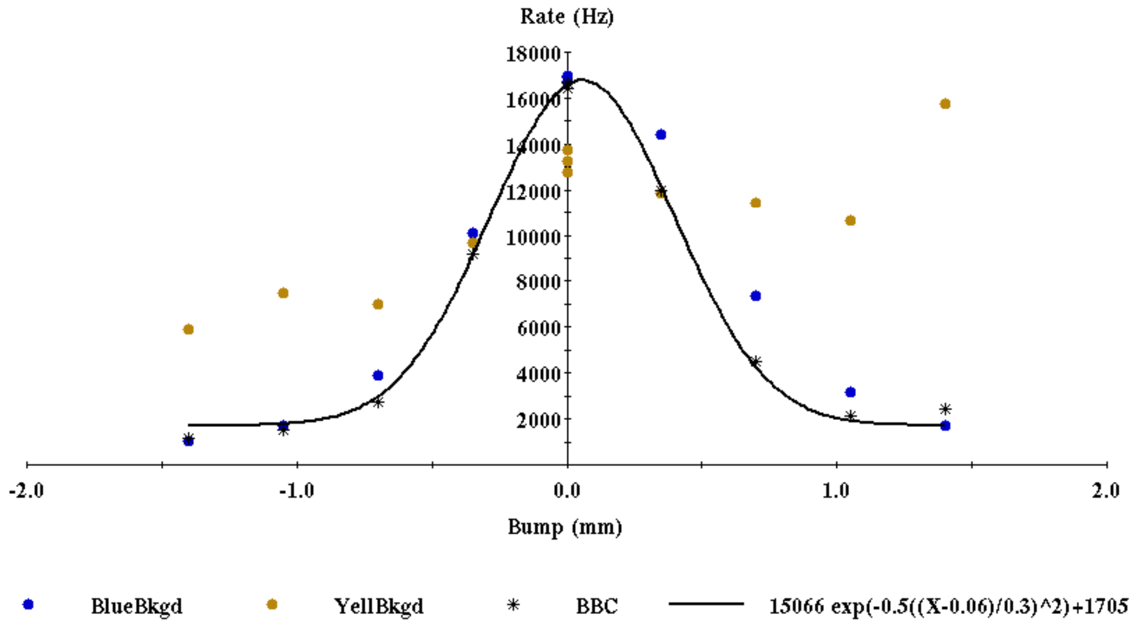
Collision Contamination of signal

STAR

Data taken during a vernier scan (using the yellow beam).

Blue background signal is dominated by collision component.

Yellow background signal is partially collision signal, moving to +0.5 mm cause yellow background.



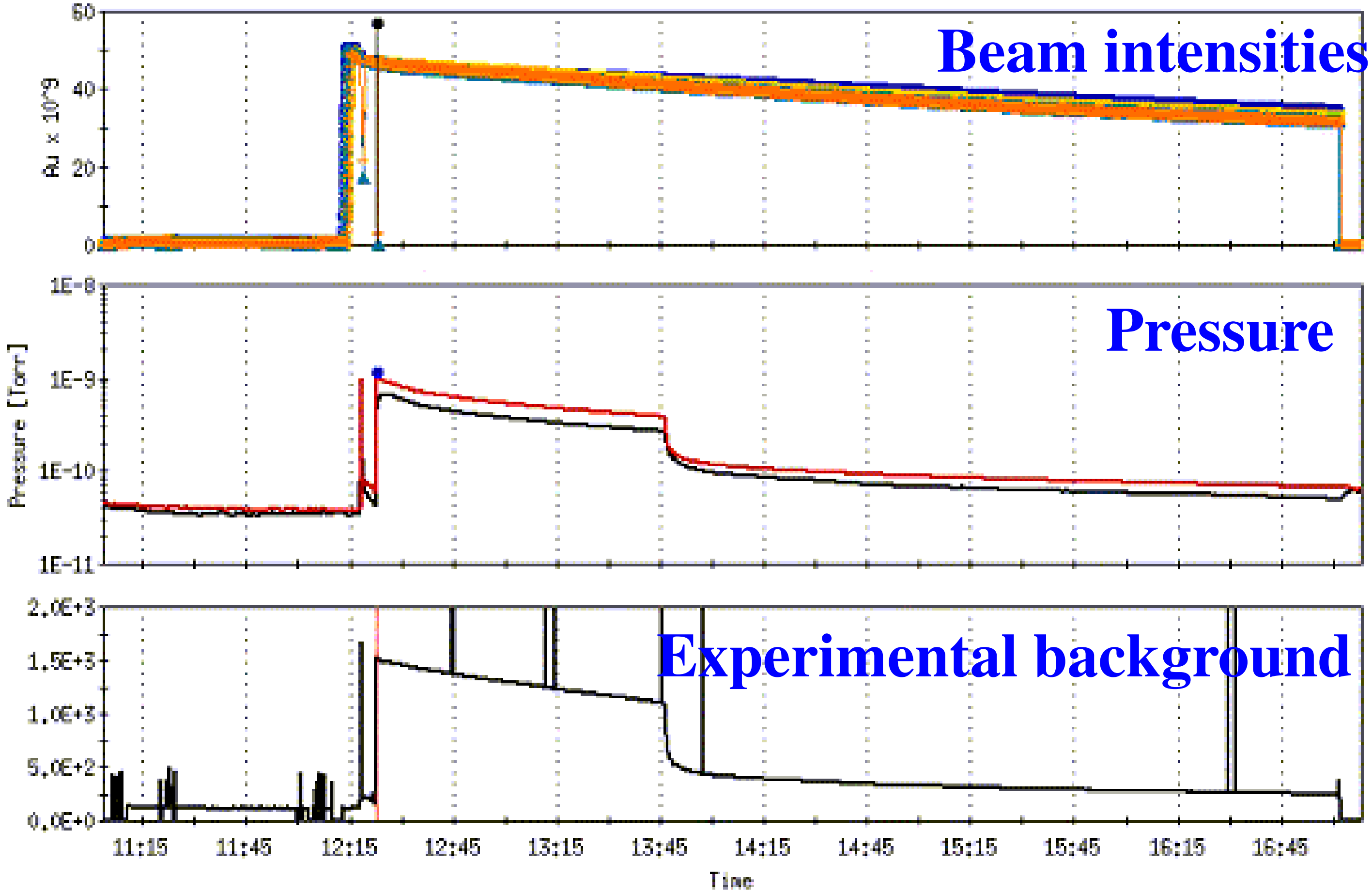
Beam-gas backgrounds

Two experiments of concern:

- PHOBOS:
  e-cloud induced dynamic pressure
  → limited luminosity for all experiments – experiment now finished
  (12m beryllium pipe – not NEG coated)

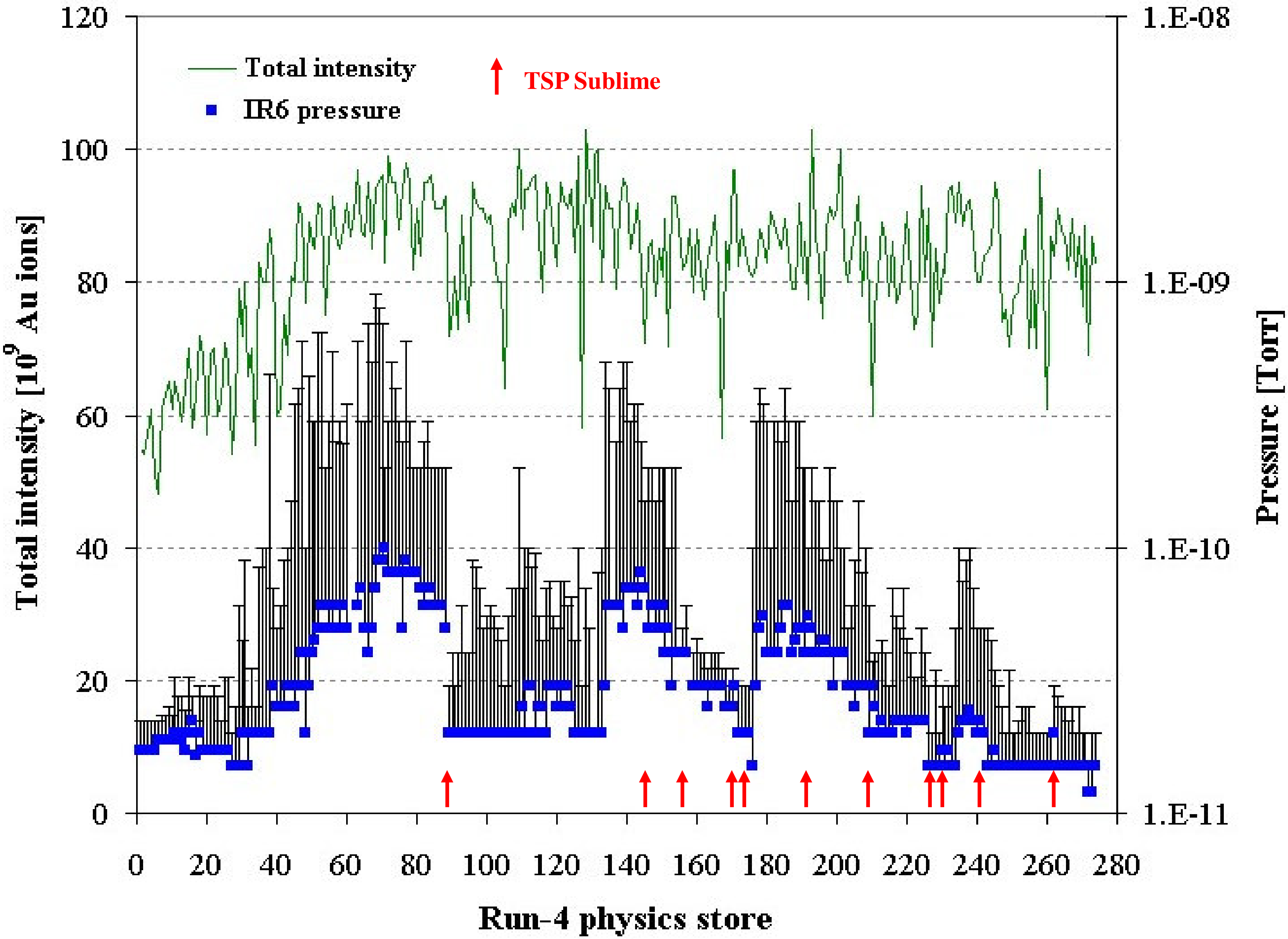
- STAR:
  - background without periodic TSP reconditioning,
    or after polarity change (→ conditions after a few days)
  (for heavy ions only – beam pipe only hot flushed with N_2 at 70°)

PHOBOS: pressure rise after rebucketing (bunch length shortened), sudden pressure drop ~1h later (12m Be)



G. Rumolo, W. Fischer, BNL C-A/AP/146 (2004); Can be understood with combined electron and ion cloud – U. Iriso and S. Peggs, PRST-AB 9, 071002 (2006).]

STAR: effect of TSP sublimation (Run-4 Au-Au 2004)



Summary

- Experimental background is a continuing concern, has held back luminosity at times
- Main tool to reduce experimental background in RHIC is collimation (generally effective)
- Beam-gas background currently under control, may become a concern again with higher luminosity
  (addressed by vacuum upgrade when beam pipe is upgrade)
- Communication between experiments and machine on what is luminosity and background continues
  (a few true background signals from experiments extremely useful)

Additional material

Collimator upgrades: simulation

Status:

RHIC aperture file complete

RHIC collimators imported into SixTrack

Loss maps available and are being compared

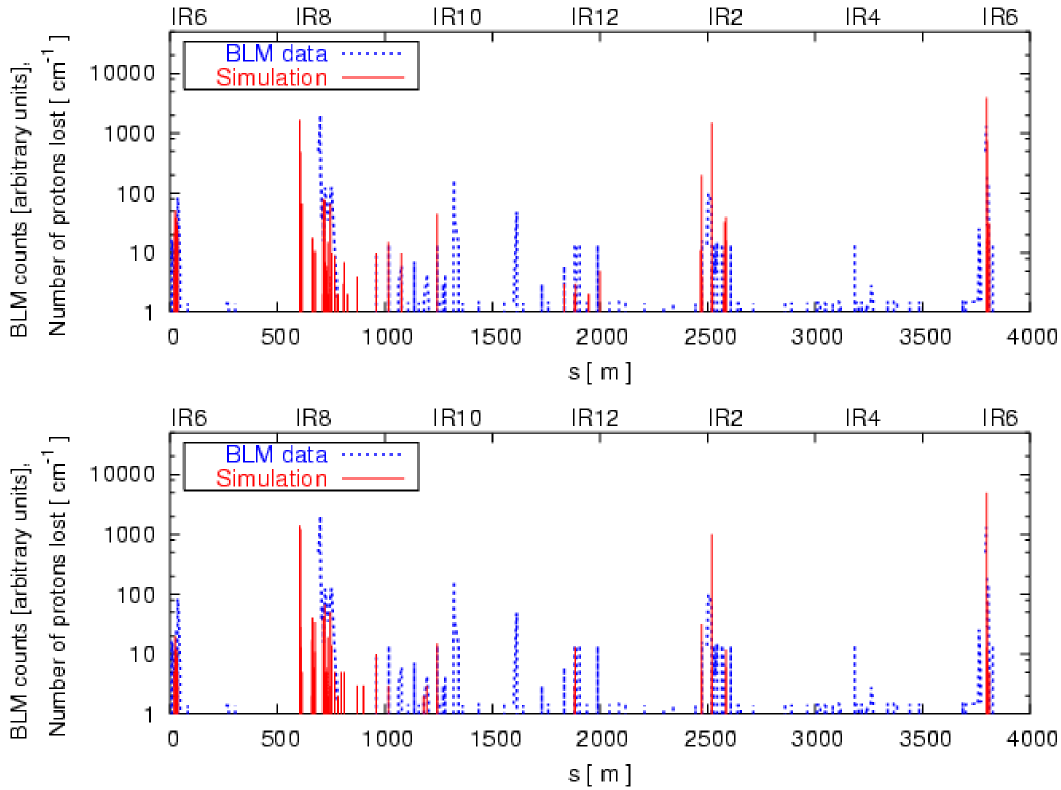
Need to do:

Compare collimation efficiency

Add 2nd vertical collimators and compute efficiency from simulation

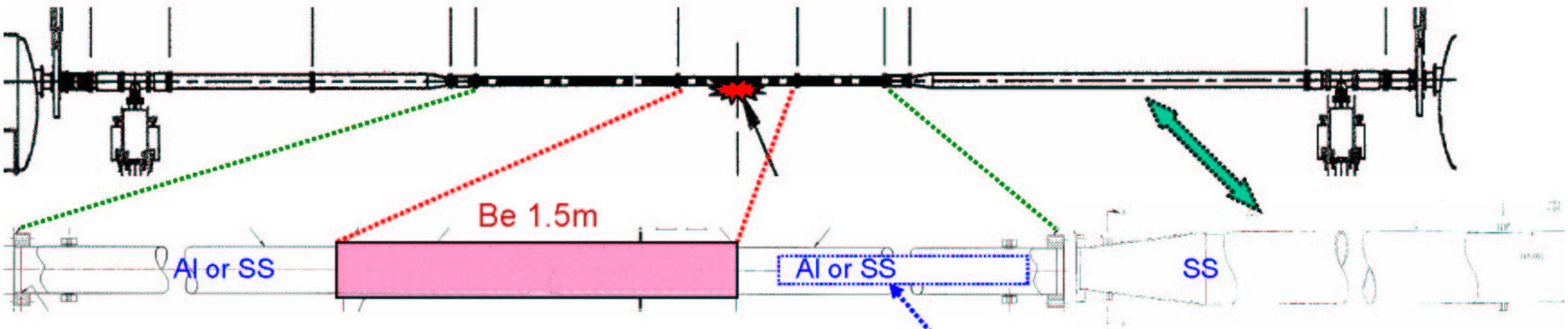
Install 2nd vertical collimators

Picture provided by G. Robert-Demolaize



Discrepancies are under investigation

IR (DX-DX) Typical Layout of Experiment Regions



Stainless steel transition pipes on both sides (7cm⇒12cm)

Install NEG coated Al sleeve 0.25mm thick?

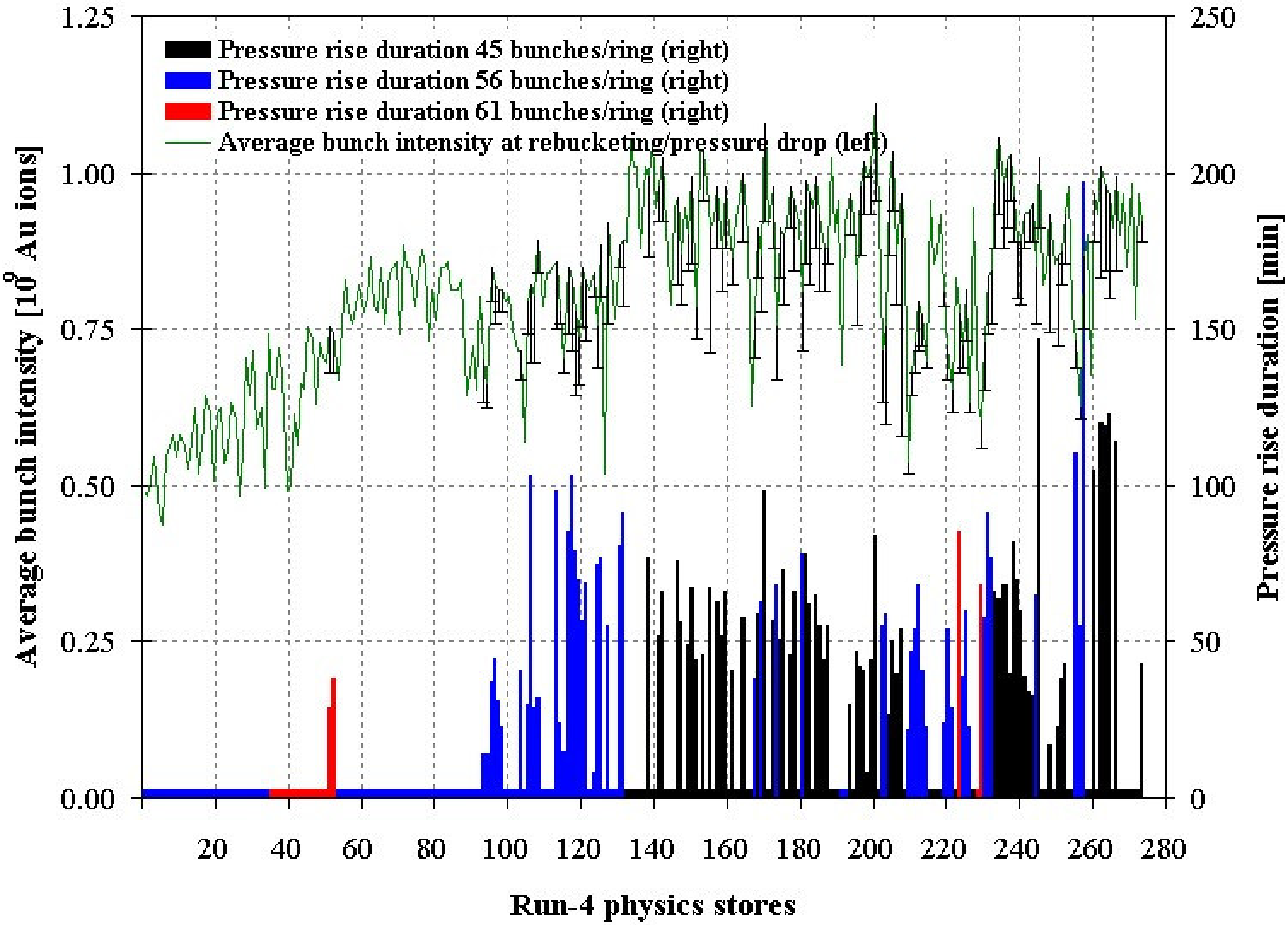
Brahms, Phenix, Star

1mm x 7.6cm Φ Be brazed to Al or SS sections

Phobos: 3 x 4m long Be pipes with Be flanges and bolts

	Brahms	Phenix	Phobos	Star
Central pipe L(m)	7.1	5.5	3 x 4	8.1
Be section L(m)	1.5	1.5	3 x 4	1.5
Brazed material	Al	St. st		Al
Bake Temp (°C)	150	200	200	~100

PHOBOS – Average bunch intensity at rebucketing/pressure drop, and duration of increased pressure sorted by bunch patterns



Remote TSP sublimation at STAR – H.C. Hseuh, Run-4 Retreat

Titanium sublimation pumps (TSP) as main UHV pumps (+ ion pumps)

- 48A x 5min ≈ 10 mono-layers Ti on to ~ 500 cm^2 pump surface
- $\tau \sim 10^3$ sec @ 10^{-7} Torr; 10^5 sec @ 10^{-9} Torr; 10^7 sec @ 10^{-11} Torr
- i.e. Booster: TSP sublimed about once per run
- < 500 mg usable Ti per filament ≈ <100 x 5min sublimation

Did periodical "manual" sublimations in Feb. and Mar. at IR6 and IR10

- To help reduce ΔP
- ~ 1 hour beam-off time: CH_4 release during sublimation (up to 10^{-7} Torr)
- ~ tens minutes to pump away by ion pumps (and cold bore @Q3-Q4)

Need automated sublimation system

- TSP power supplies are capable of remote operation
- Need new software and control interface – done.