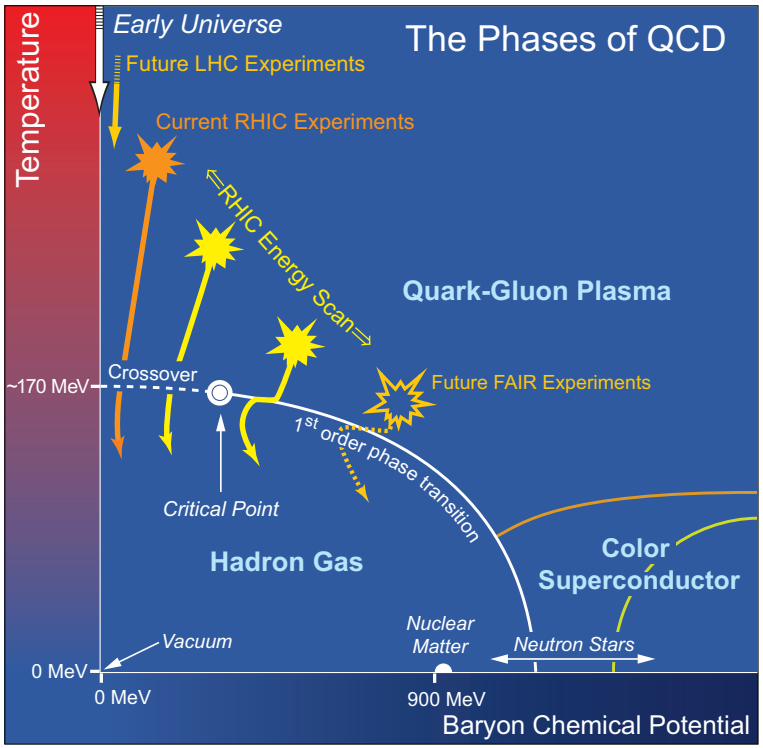
FIRST OPERATIONAL EXPERIENCE WITH AN INTERNAL HALO TARGET AT RHIC

Christoph Montag, BNL

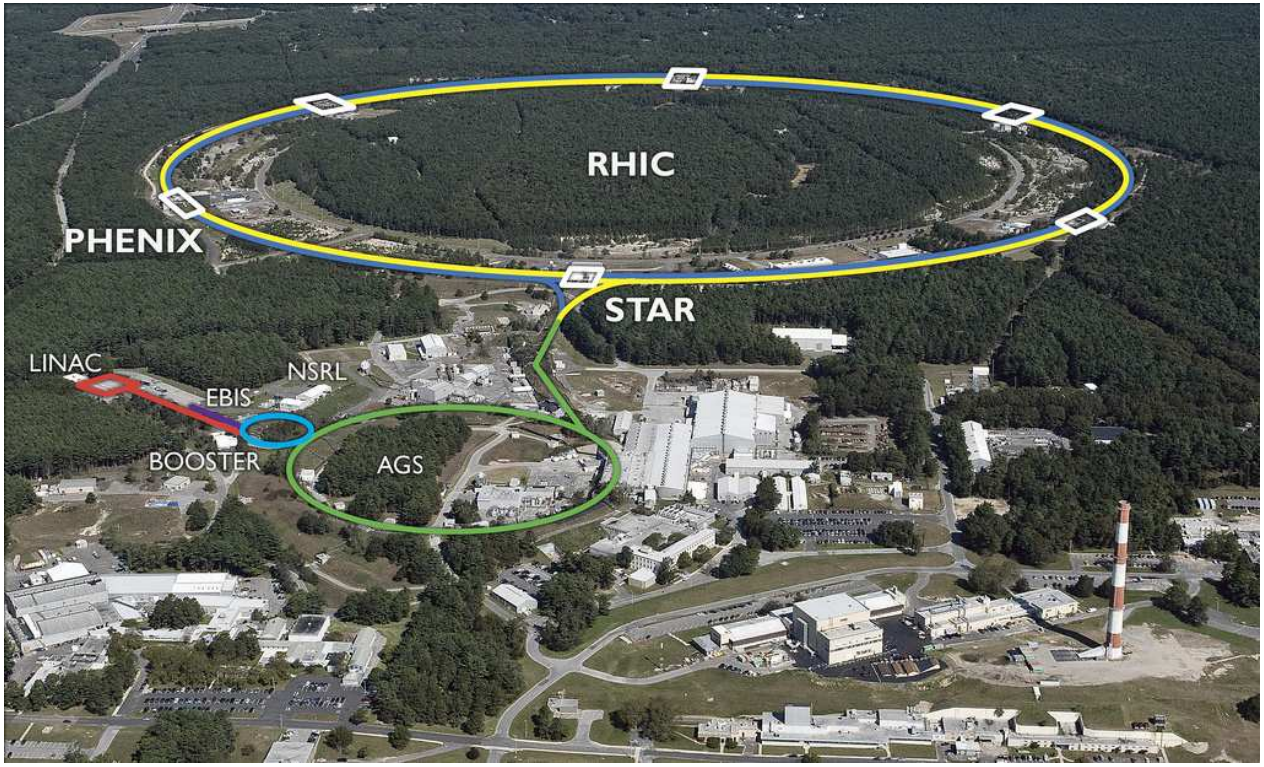
IPAC'16, May 11, 2016

Motivation - Search for the QCD Critical Point



Search for the QCD critical point requires beam energy scan in gold-gold collisions at center-of-mass energies between 5 GeV/nucleon and 30 GeV/nucleon

The Relativistic Heavy Ion Collider



Circumference: $C = 3833.845\,\mathrm{m}$

Nominal Au beam energy range: $E = 10\,\mathrm{GeV/n}{-}100\,\mathrm{GeV/n}$

Energy range for critical point search extends well below design energies

Challenges at Low Collision Energies

- Space charge limits bunch intensity
- Beam-beam in space charge dominated beams requires near-integer tunes
- Apertures limit achievable β^*
- Power supply resolution Limits machien tuneability
- ...

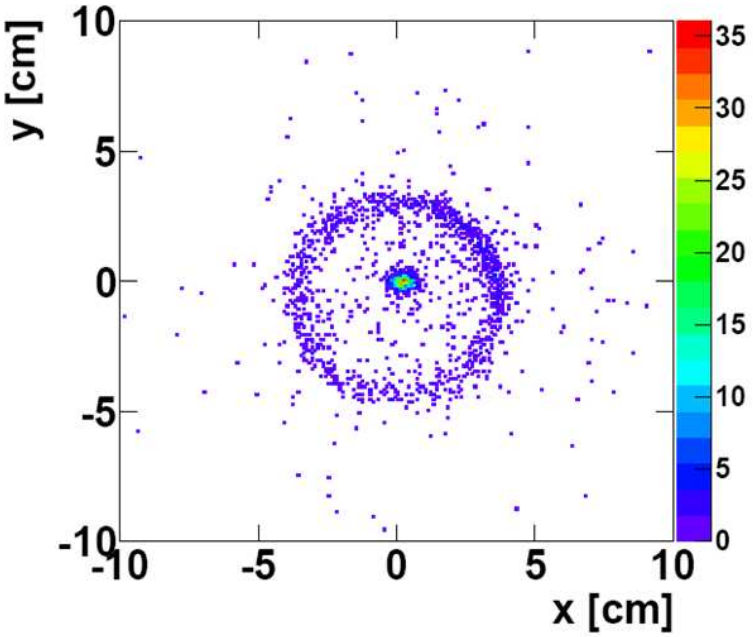
History of Low Energy Running at RHIC

beam energy [GeV/n]	$\sqrt{s_{\mathrm{NN}}}$ [GeV/n]	run duration [days]	no. of events
9.8	19.6	10	36 M
7.3	14.6	24	20 M
5.75	11.5	10	12 M
3.85	7.7	32	4 M
2.5	5.0	0.2	1

Event rates at low energies are very low, making collider mode operation inefficient

Collider operation below 3.85 GeV/n practically impossible

Reconstructed Vertices with 3.85 GeV Colliding Au Beams



Large number of background collision events on detector beampipe

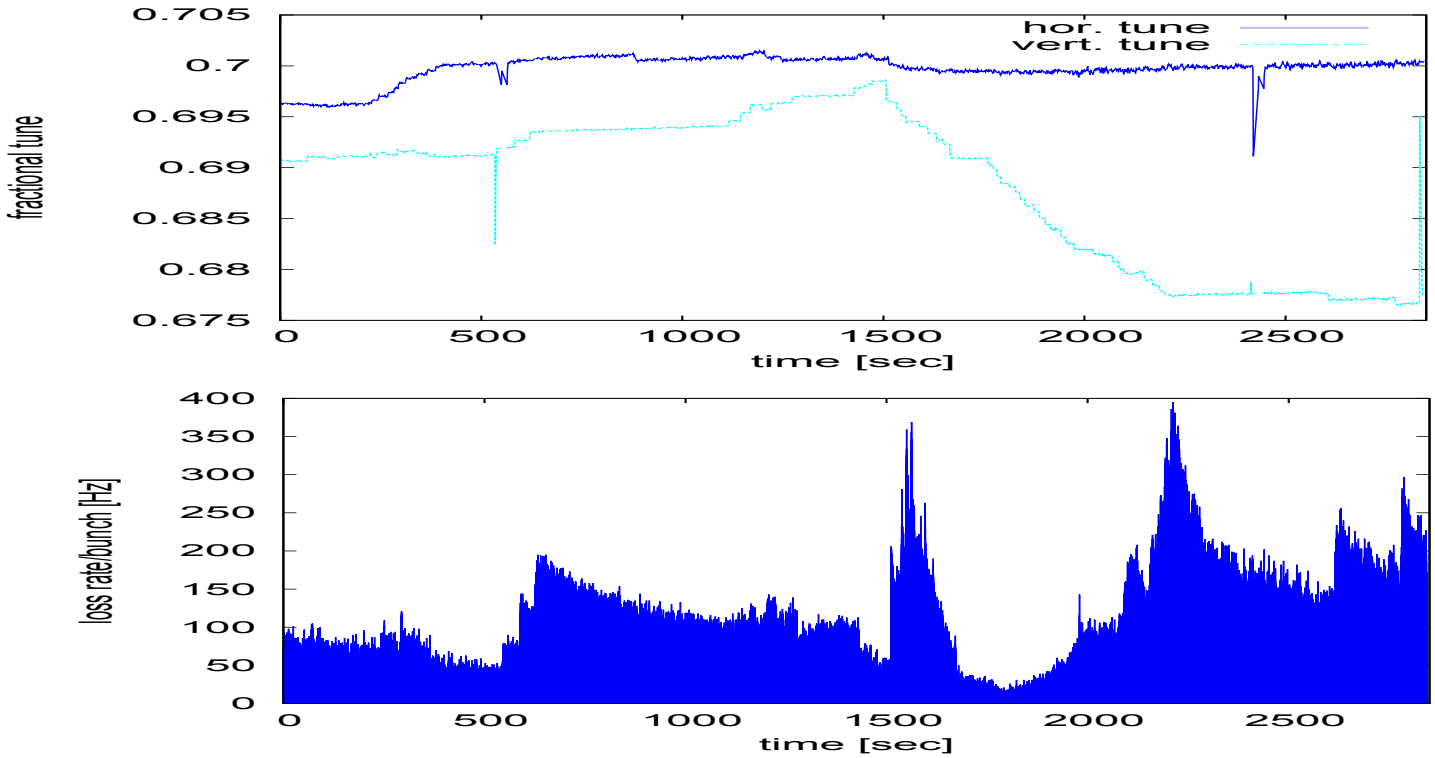
$\Rightarrow$ Idea: Install a dedicated Au target in the detector beampipe

Proof-of-Principle Experiment Using Collimator

- Demonstrate controllability of (target) loss rate, bunch-by-bunch uniformity, and lack of short-term variations
- At injection, insert vertical collimator until it becomes limiting aperture
- Vary horizontal and vertical tunes, observe collimator loss rate

Collimator tests were performed with proton beam, which has very low IBS growth rates

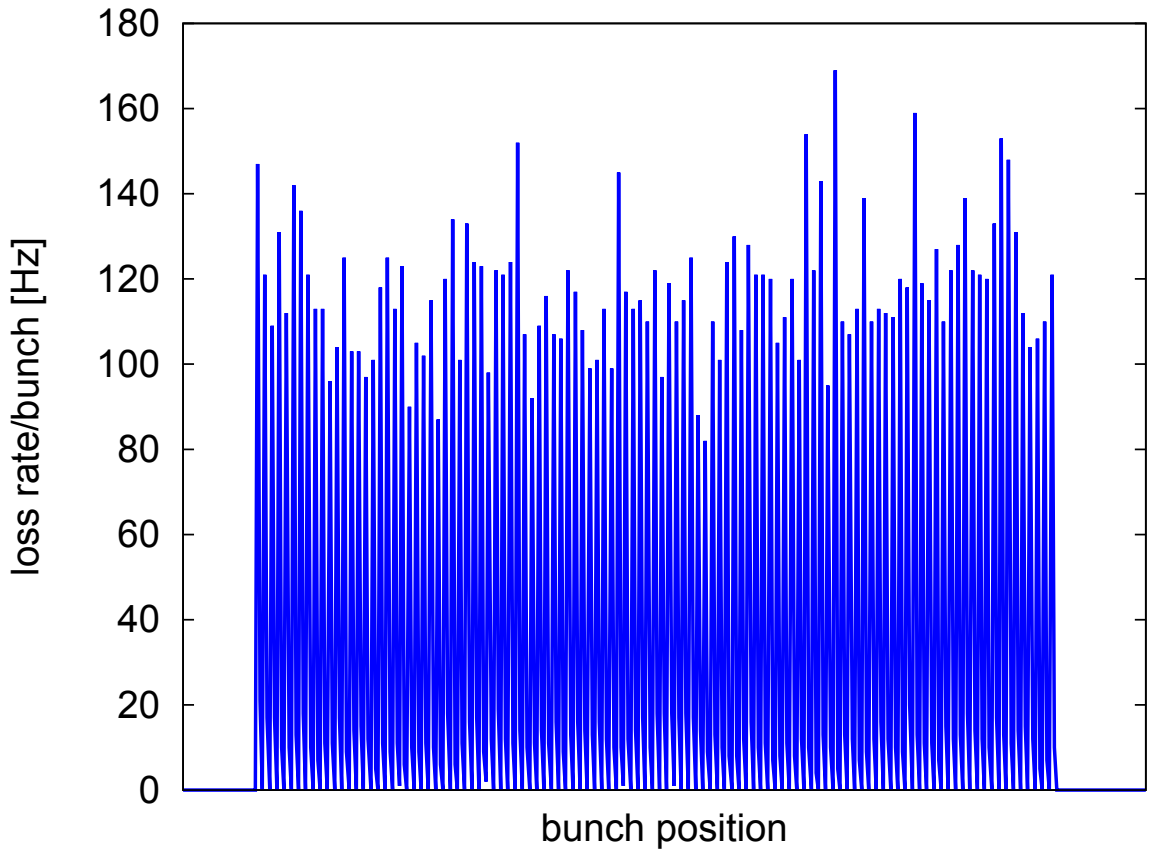
Collimator Loss Rates as Function of Tune



Loss rates during the tune scan with fixed collimator position at 11.5 mm

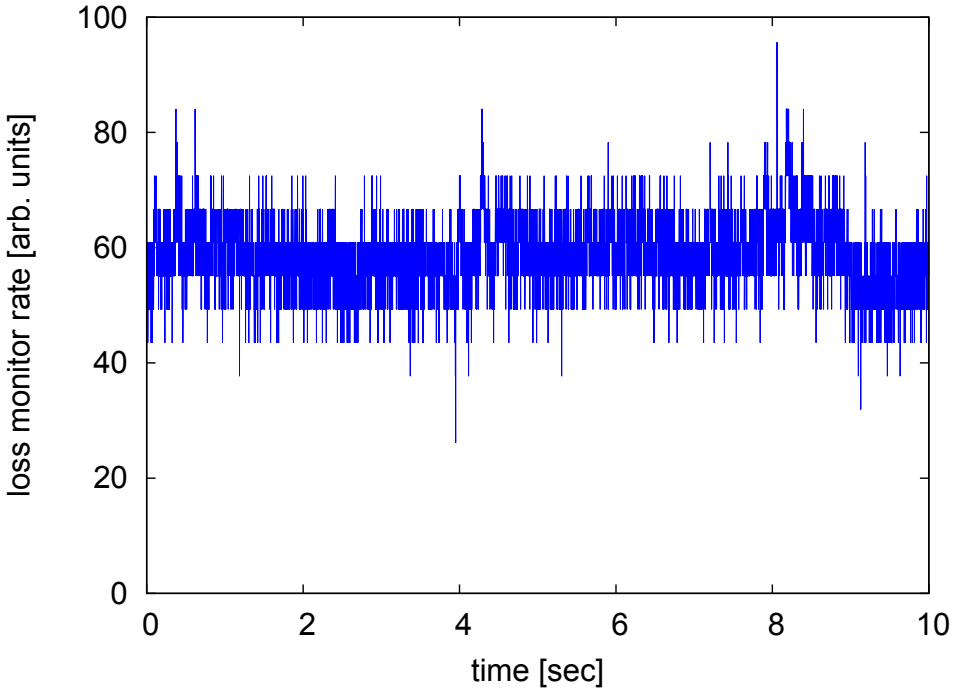
A vertical tune near 2/3 stabilizes the rate

Bunch-by-bunch Loss Rates



All bunches contribute equally

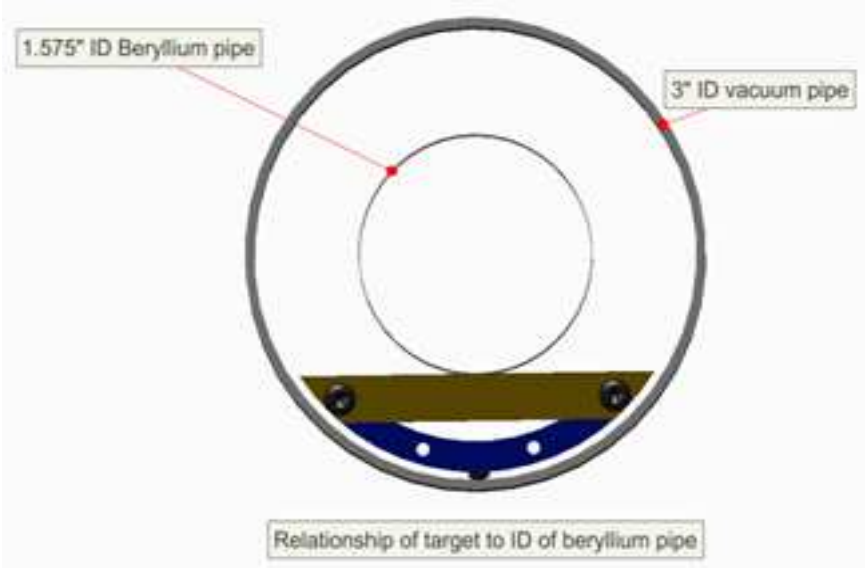
Collimator Loss Monitor Signal at 720 Hz



No fast rate fluctuations due to orbit jitter or target vibration

Successful proof-of-principle experiment warrants design and installation of a dedicated internal gold target in STAR detector

Internal Target at STAR



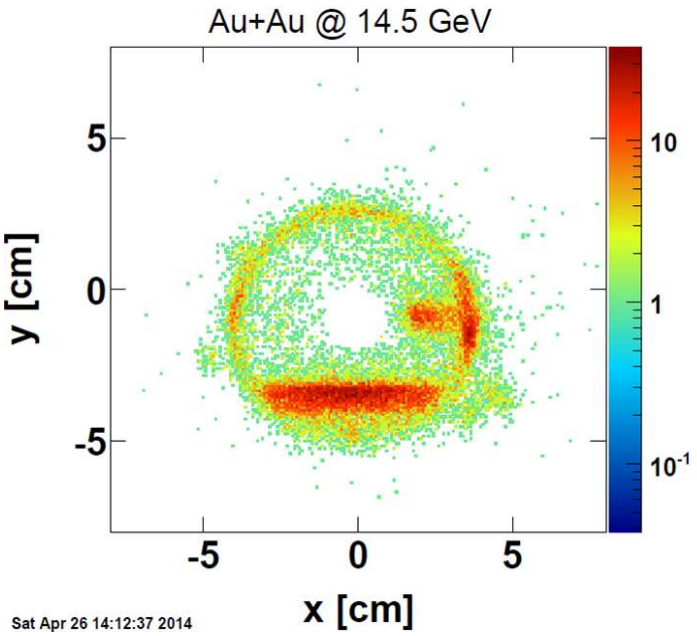
Target is installed 2.05 m from the IP in the Yellow ring

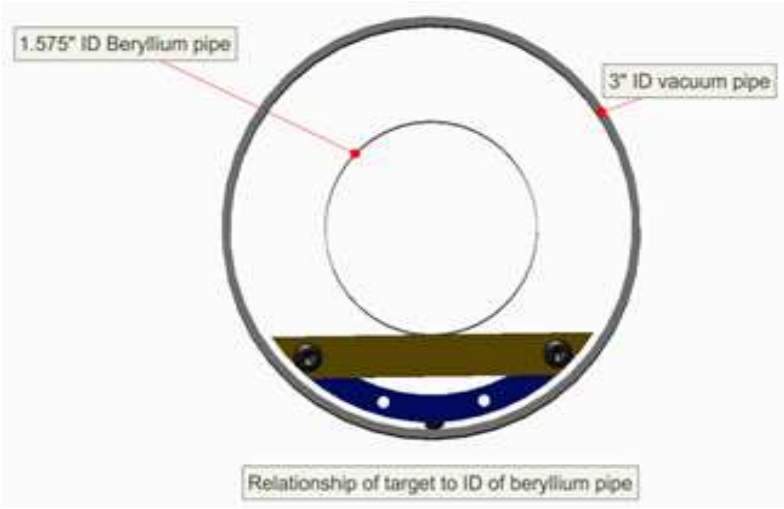
16 mm target aperture would not interfere with high energy operations, but would allow for dedicated target mode

During Run-14 target was installed with 20 mm aperture (same as detector beam pipe) to study background situation

With this aperture the target cannot be hit by circulating beam particles

Imaging the Target with Background Events

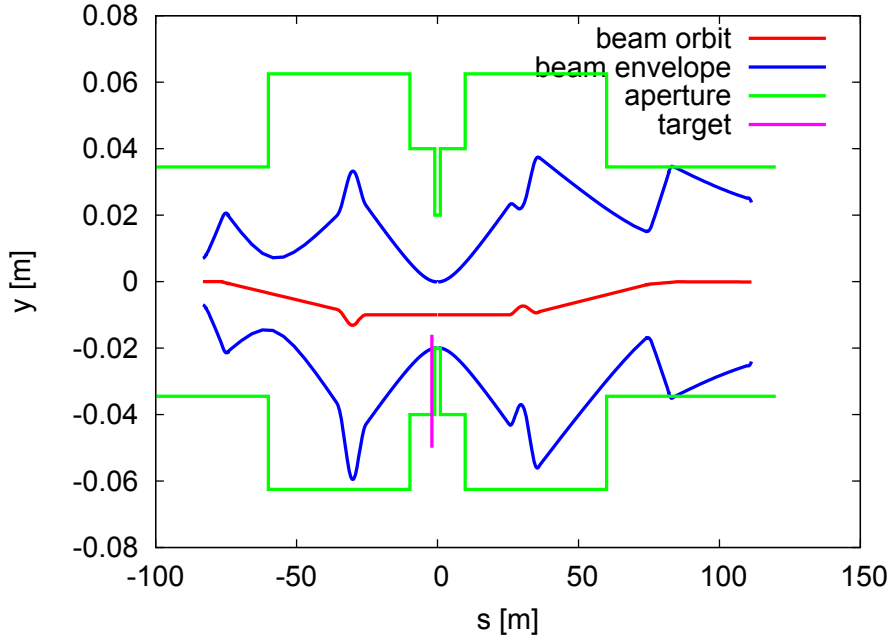




Reconstructed vertices match target geometry

With 20 mm target aperture, these are all background events (likely fragments of Au ions having hit the upstream triplet)

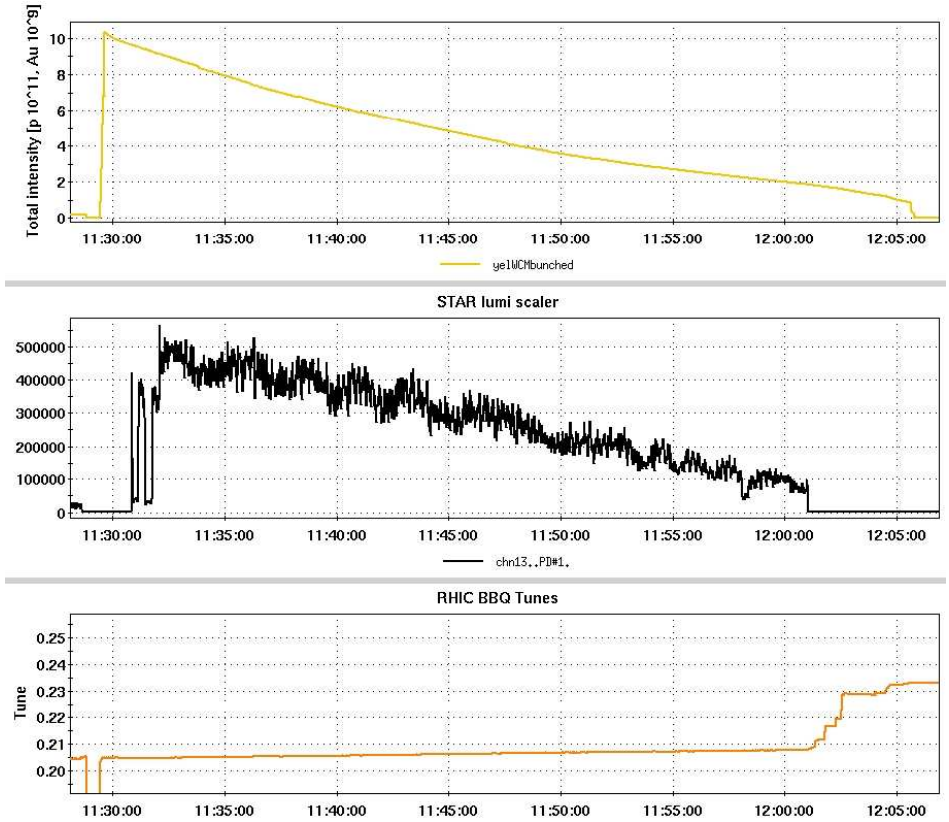
Apertures with the Internal Target



At $\beta^* = 8\,\mathrm{m}$, a 10 mm vertical orbit bump allows the target to become the limiting aperture at 16 mm from the beam pipe center

Existing target was moved to this new position for Run-15 to allow dedicated running

30 min Physics store at 9.8 GeV/n RHIC injection energy



6 Au bunches in the YELLOW ring

STAR recorded 1 million events in 30 minutes at $\sqrt{s_{\mathrm{NN}}} = 4.5\,\mathrm{GeV/n}$

Conclusion

- Collected 1 million events in 30 minutes at $\sqrt{s_{\mathrm{NN}}} = 4.5\,\mathrm{GeV/n}$, compared to a single event in several hours in collider mode at $\sqrt{s_{\mathrm{NN}}} = 5.0\,\mathrm{GeV/n}$

- Physics data are still being analyzed by STAR collaboration

- Internal target mode extends energy reach down to $\sqrt{s_{\mathrm{NN}}} = 3.0\,\mathrm{GeV/n}$, at a beam energy of $3.85\,\mathrm{GeV/n}$

- Internal target provides a very efficient method to study low energy Au-Au collisions at RHIC