

# RHIC Run 22 Plans and Highlights

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11/9/2021



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# Overview

- Run 22 Operational modes
- Available equipment
- Experiments for operation

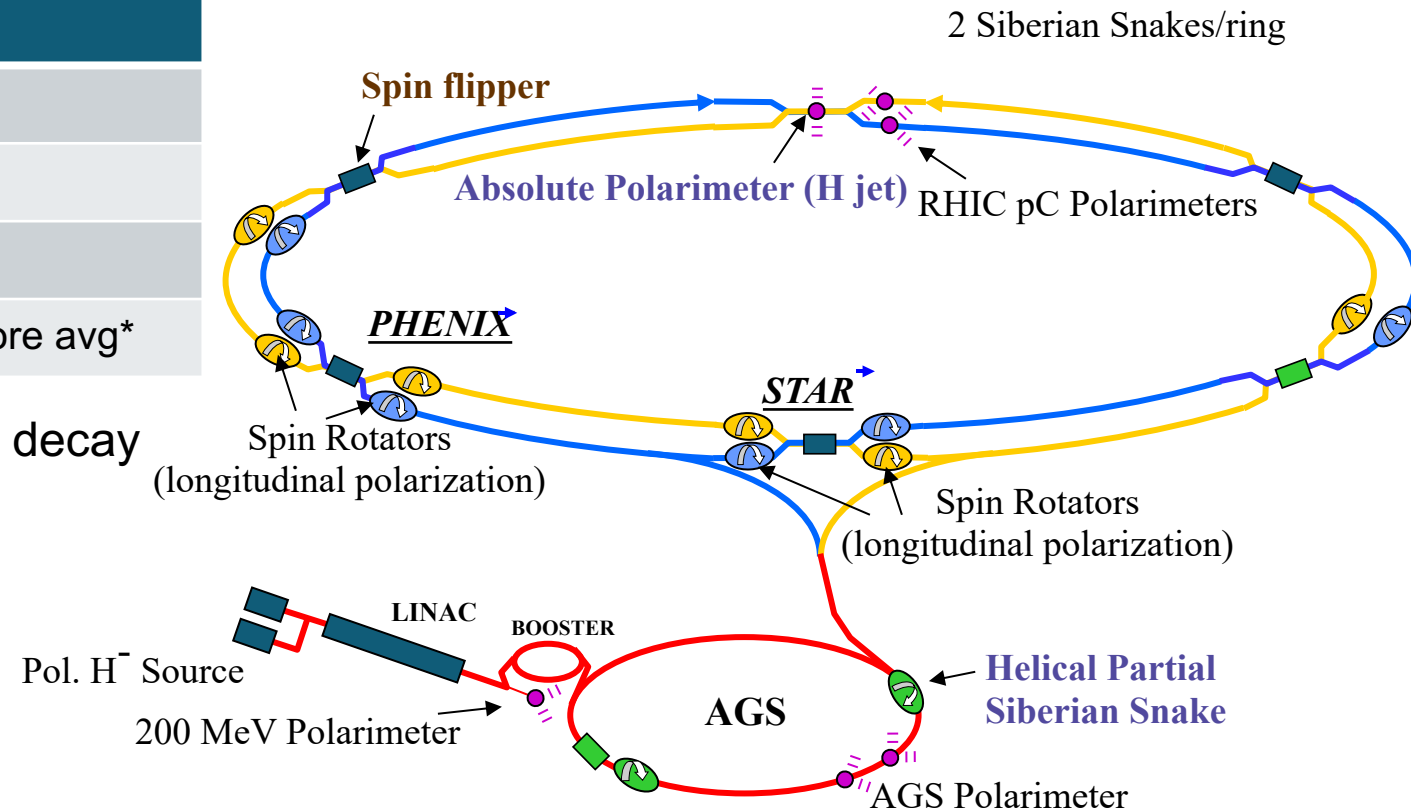


# RHIC Polarized Beam Complex

	Max Energy [GeV]	Pol. At Max Energy [%]	
Source+Linac	0.2	82-84	
Booster	2.5	~80-84	
AGS	23.8	67-70	p-Carbon
RHIC	255	55-60	Jet, full store avg*

\* Includes both ramp loss and store decay

	Relative Ramp Polarization Loss (Run 17, full run avg)
AGS	17 %
RHIC	8 %



# Run 22 Operational Modes

- Physics program modes

Species	RHIC Top Energy [GeV/n]	Purpose
Pol. Protons	255	Colliding beam physics (16 wks)
Au	26.5	CeC X (2 wks)

→ PAC recommended finishing CeC time 'early' (first two months of operation)

- APEX modes

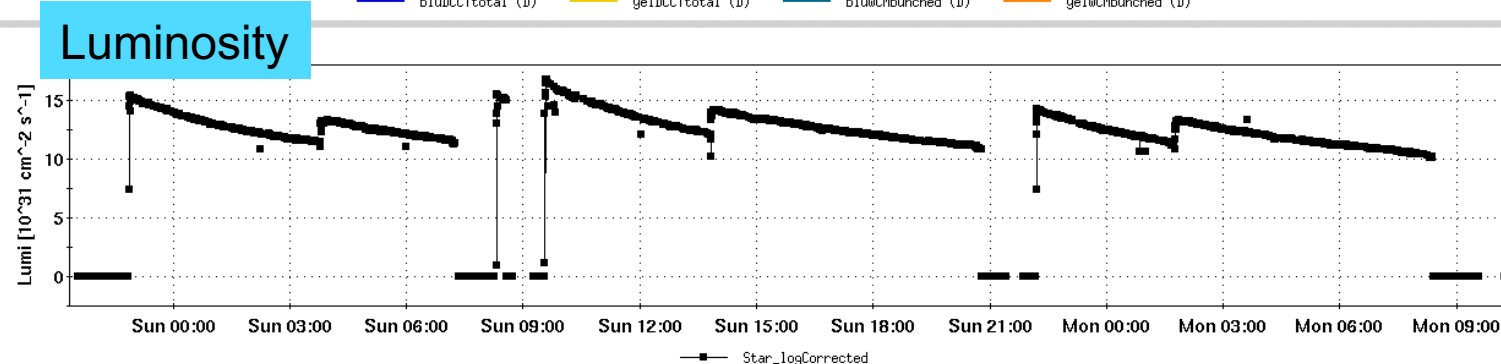
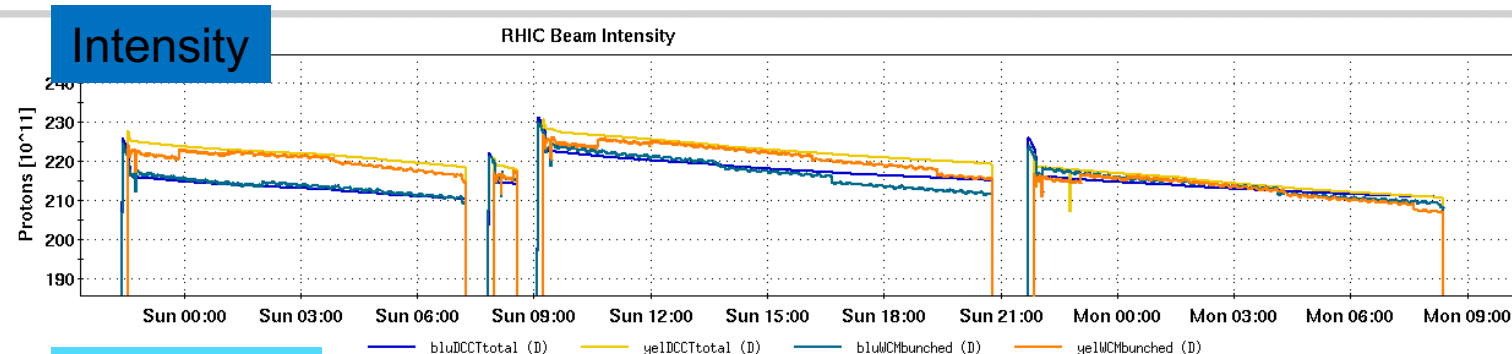
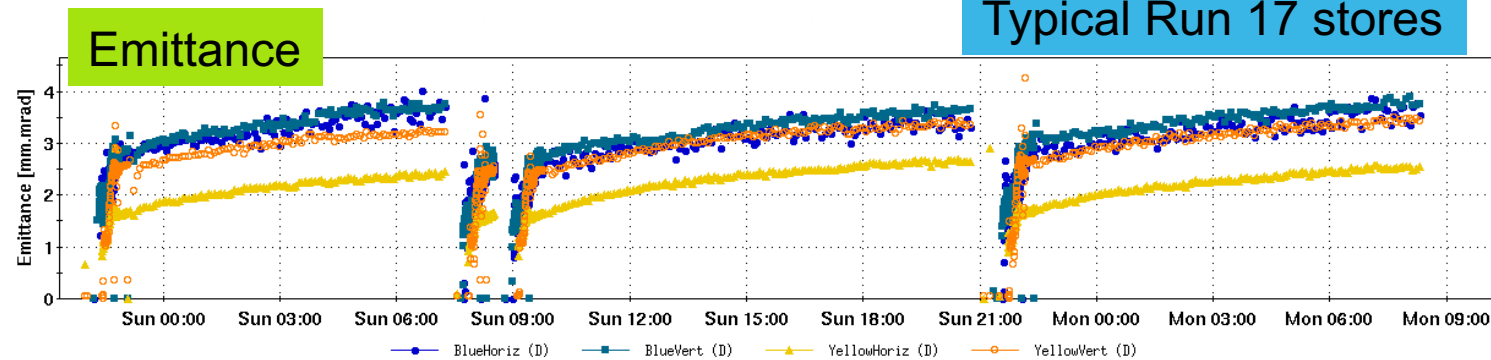
Species	RHIC Top Energy [GeV/n]	Purpose
$^3\text{He}$ (unpolarized)	100	Polarimetry development (blue)
Au	3.85	LEReC experiments

No *new* lattice required for any planned operating mode.

# Polarized proton operation

- Polarized proton collisions at 255 GeV
  - 16 weeks
  - + 2 weeks of CeC
- Conditions similar to Run 17
  - $2 \times 10^{11}$  protons/bunch
  - Collisions at IP6 only
    - Cogging: abort gap collision at IP8-2
  - Luminosity capped at  $14 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$ 
    - (limited) Leveling via second beta\* squeeze
    - No crossing angle/misteering
    - *Transverse polarization only (no rotators)*
- Operational RF:
  - Inject/accelerate: 9 MHz+Landau
  - Rebucket: 28 MHz
  - Store: 28 MHz + 197 MHz

Typical Run 17 stores



# Scheduling and plans

11/1-5	- RHIC Dry Run
11/8	- AGS Beam startup
11/15	- RHIC 4K wave start
~0001 on 11/19	- Beam setup in RHIC (Run 17: 12 days of setup to $\hat{p}$ physics)

## Commissioning plan:

- Get to 8 hour  $\hat{p}$  physics stores as soon as possible
  - (Re)Commissioning of  $\hat{p}$  equipment
- Commission injector Au for CeC behind stores
  - Mode switching  $\text{Au} \leftrightarrow \text{pp}$  in the injectors is non-trivial
- Setup AGS Au for LEReC and  $^3\text{He}$  setup as available and required

# RF Availability

Freq [MHz]	Oper. Volts/cav	N cav	Purpose
9	40	1	$\hat{p}$ inj,acc
28	150	2	$\hat{p}$ rebucket, Au acc.
197	10-150	1	$\hat{p}$ 'squeeze', synch tune spread
201 (Landau)	50	1	Au,He transition damping

No operational request for full Au rebucketing -> no conditioning of additional 197 MHz cavities unless there is a request

# Other equipment

- Polarization
  - p-carbon polarimetry
  - Jet polarimeter (and vertical intensity profiles)
  - Snakes
  - **NO rotators** for operation
    - If needed for APEX ('spin navigator' etc), the sooner we know, the better
- Cooling
  - **NO stochastic cooling** for operation
    - (only one APEX request, withdrawn for this run)



# Injector Improvement: Bunch split and merge scheme

Present scheme:

A single pulse from the source remains a single bunch from source to collision

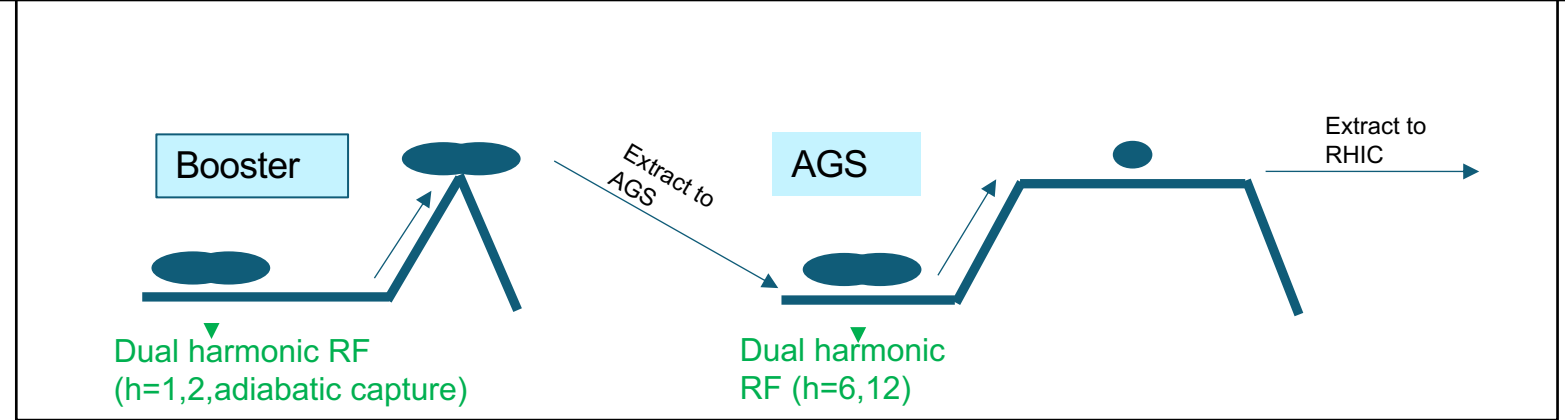
Booster and AGS injection both have defocusing RF harmonics

Add a 1->2 bunch split during acceleration in the Booster

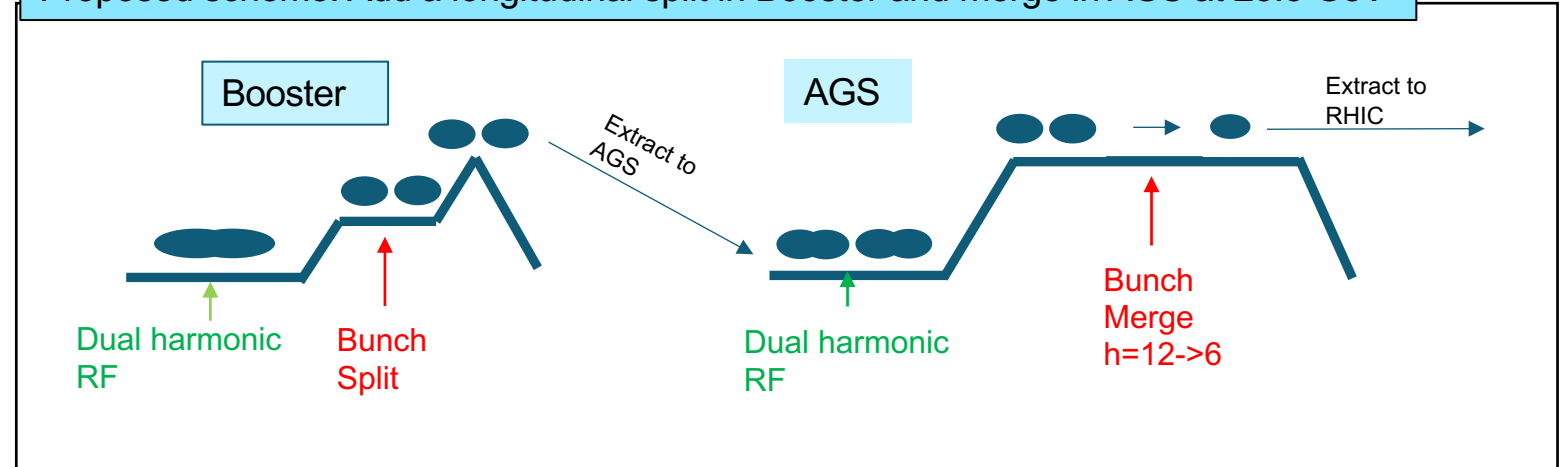
Reduces peak current at AGS injection by  $\sqrt{2}$  (optimally)

Expectation:  
20% trans. Emittance reduction  
12% rel. polarization improvement  
(measured in Run 13)

Present scheme: Single bunch from source to RHIC, dual harmonic RF at Booster and AGS injection



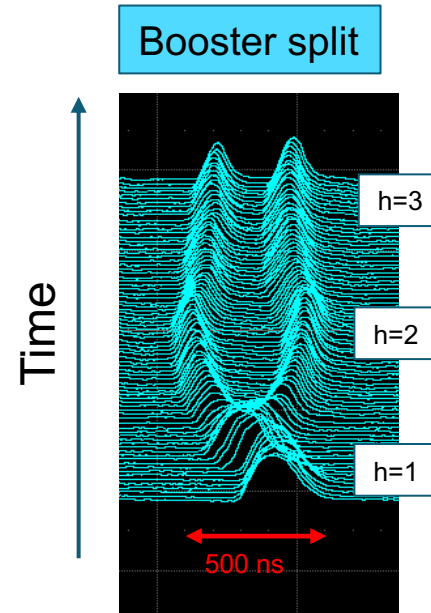
Proposed scheme: Add a longitudinal split in Booster and merge in AGS at 25.5 GeV



# Injector Improvement: Bunch split and merge scheme

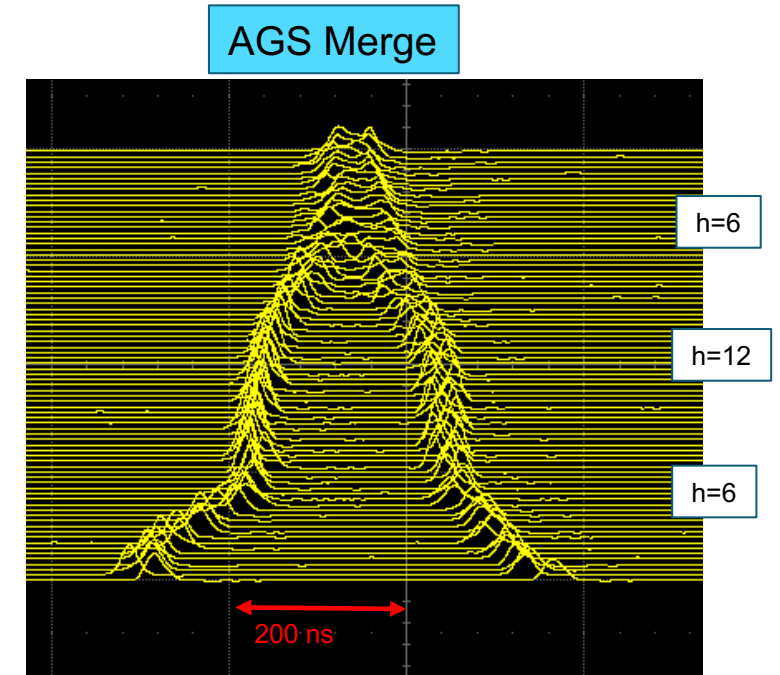
## January 2021 pre-run test

- Test the longitudinal mechanics
- Basic proton setup (no snakes)
- Interleaved with two other proton efforts
- Synch period at AGS flattop is 12 ms
  - Merge takes a full second
  - Hard to maintain constant, adiabatic conditions



### Booster RF:

- Capture on  $h=1$ , defocus ( $h=2$ )
- Accelerate to merge porch
- Split  $h=1 \rightarrow h=2$
- 'Squeeze'  $h=3$  to get bunch spacing for BtA transfer



### AGS RF:

- Capture on  $h=6$ , defocus ( $h=12$ )
- Accelerate to flattop
- Squeeze  $h=6 \rightarrow 12$
- Merge  $h=12 \rightarrow 6$

# APEX Results for Operations

## RHIC Imperfections and Resonance Overlap

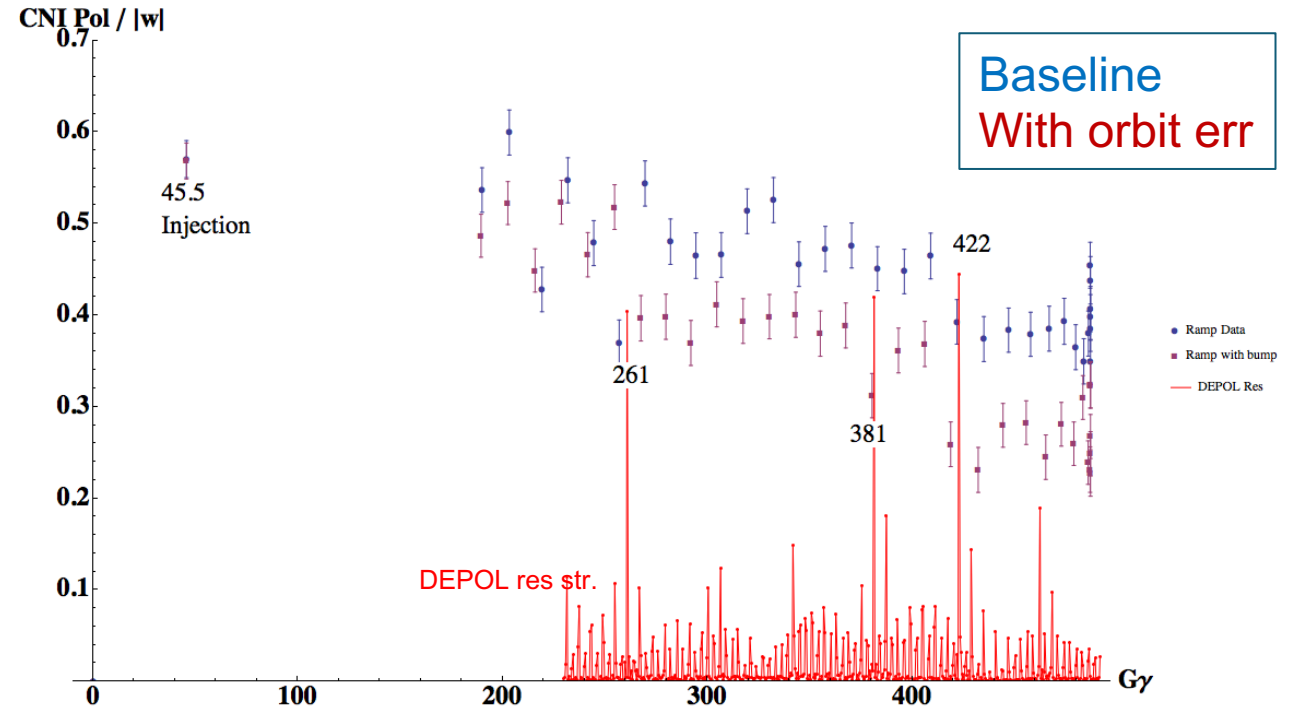
### Run 17 APEX

- Slow ramp (~45 min!)
- Mid-ramp pC measurements
- with and without applied orbit imperfections

### Lessons:

Polarization loss localized at major intrinsics (not obvious from previous full ramp speed measurements)

Worse with a strong overlapping imperfection



# APEX Results for Operations

## RHIC Imperfections and Resonance Overlap

Attempts to infer absolute orbit from measurements are so far unsuccessful

Proposal:

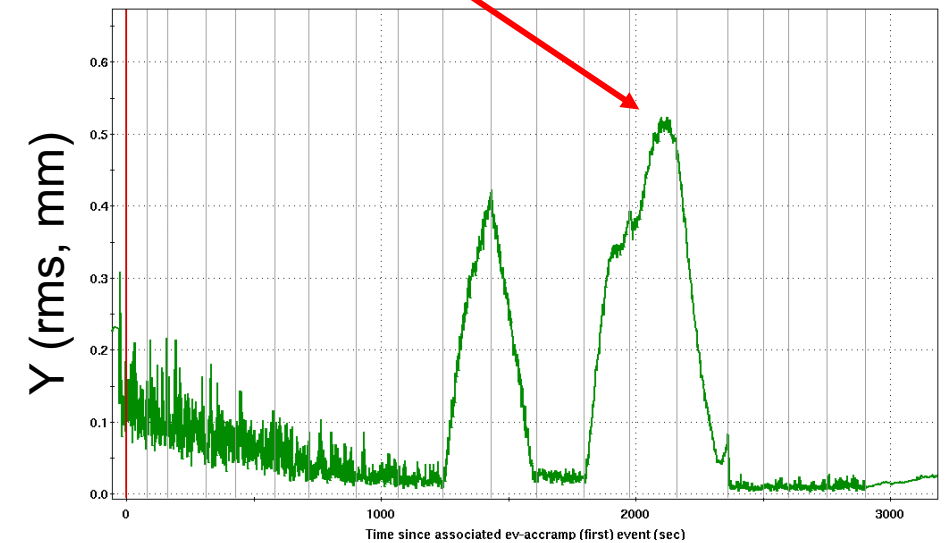
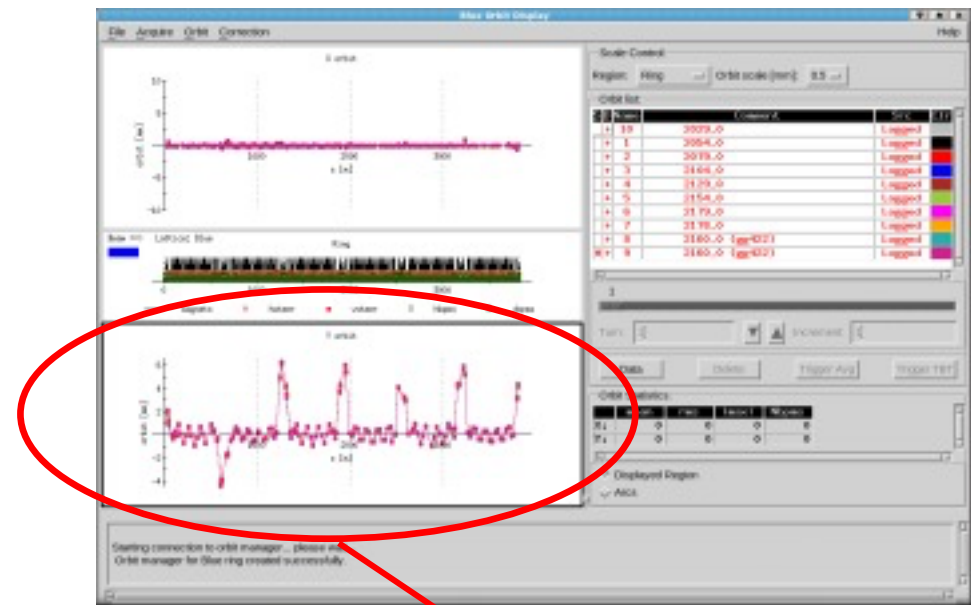
Brute force scan of individual imperfection knobs at three strongest resonances

3 resonances x 2 phases = 6 scans

4 points per scan = 24 points (= 24 ramps, which could be physics ramps)

5 pC measurements at injection and store (each) gets +/- 3% pts uncertainty for transmission each ramp ( $P_{\text{final}}/P_{\text{initial}}$ )

Simulations necessary (underway) to determine optimal scan parameters to get measurable response



Time (s)

# Spin Tilt at 255 GeV

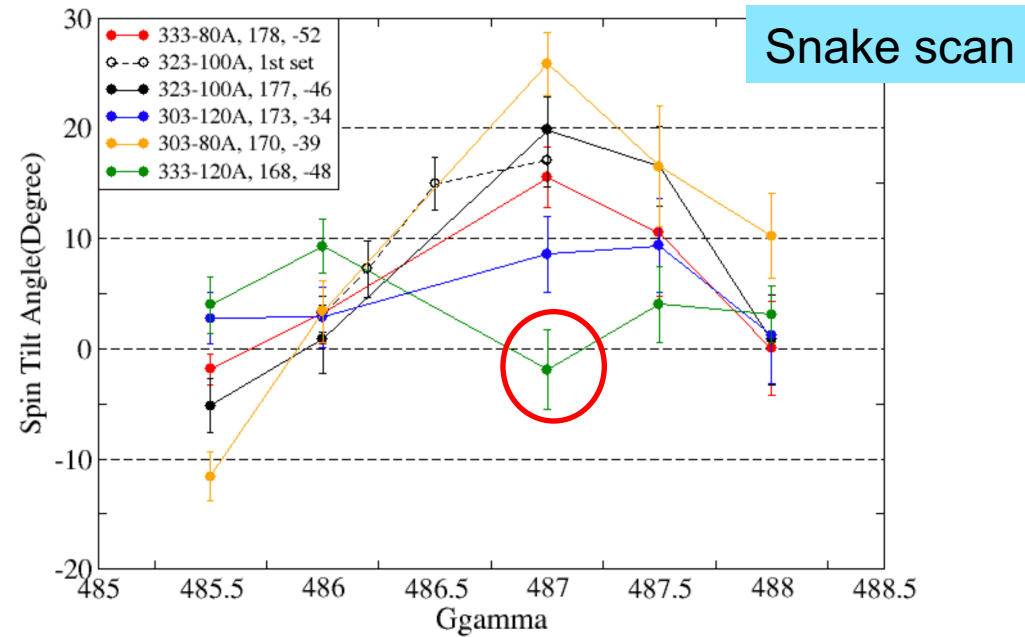
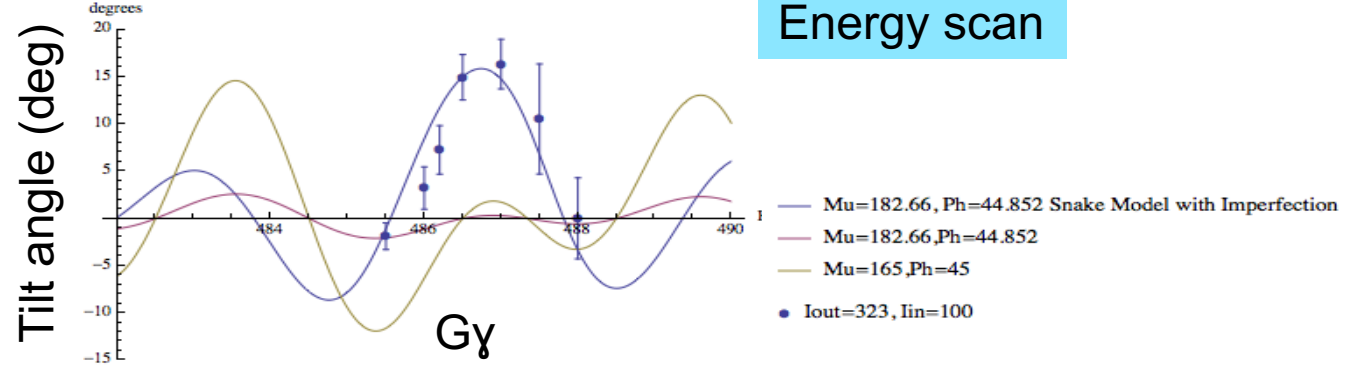
Spin away from vertical by 12-15° at pC location at 255 GeV ( $G\gamma = 487$ )

- Run 17 snake and energy scan
  - Snake detuning+large imperfection (0.2) mimics effect

There *are* snake settings that gave zero tilt at 255 GeV (locally)

**Relevant to EIC:** Understanding both the actual source and corrective mechanisms (not necessarily identical tasks)

Important for determining locations for polarimetry



Measurement by Huang, Marusic, Meot, Ranjbar



# Summary

- RHIC is currently prepared to deliver four operational modes for physics and APEX
  - 255 GeV protons
  - 26.5 GeV/n Au
  - 3.85 GeV/n Au
  - 100 GeV/n He
- A few improvements to operation are expected, two of which are the results of previous APEX experiments