

Small Longitudinal Emittance Setup in Injectors with Gold Beam for Beam Energy Scan in RHIC

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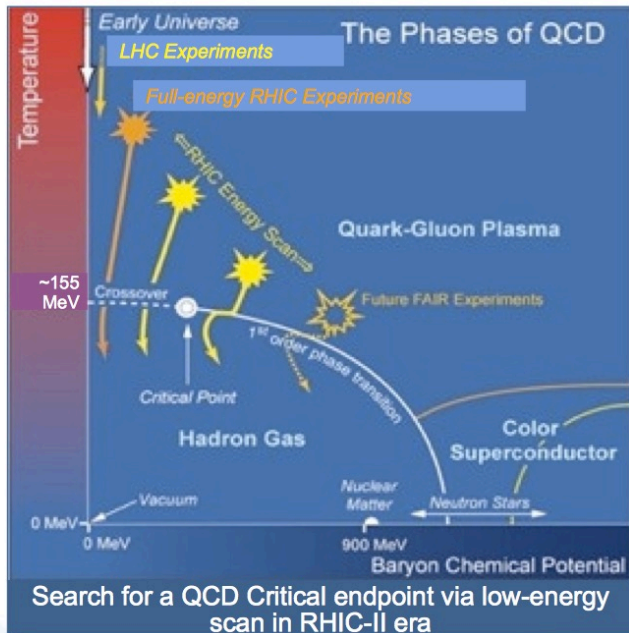


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Low Energy Scan at RHIC

Quantify properties of the QGP and features of the QCD phase diagram as functions of temperature and net quark density from the onset of deconfinement toward even earlier universe conditions.

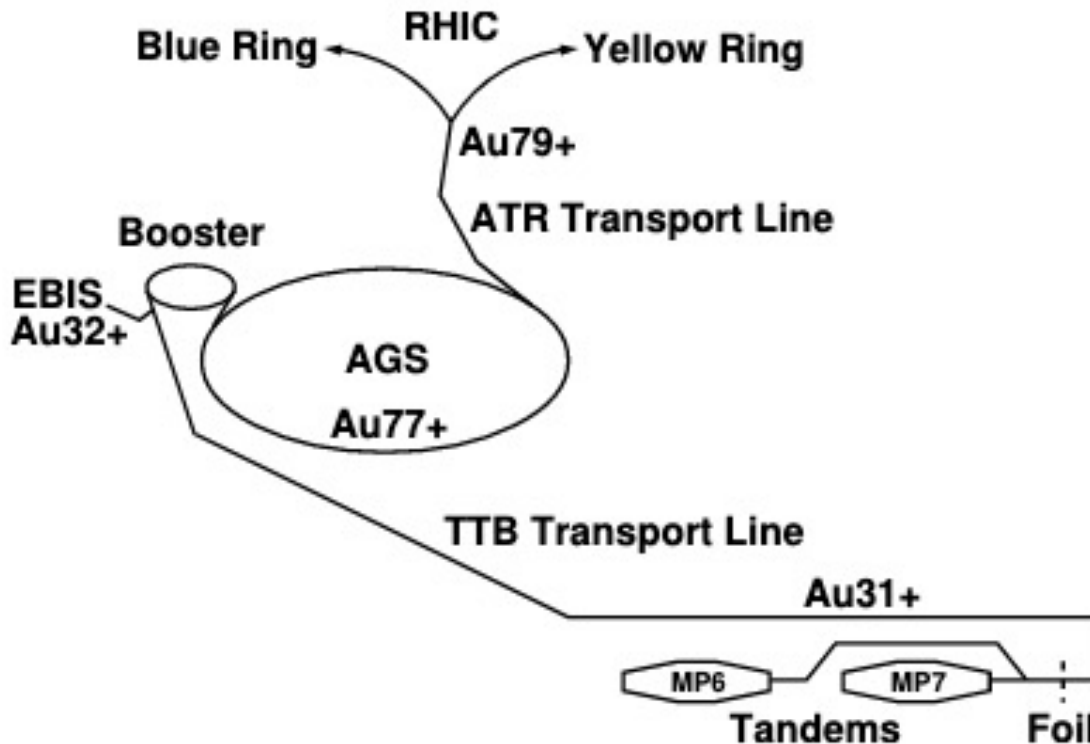


Exploit new discovery potential in searches for a QCD critical point and for the nature and influence of quantum fluctuations in initial densities and gluon vacuum excitations.

Continue explorations of the role of soft gluons in cold nuclear matter (gluon saturation, gluon and sea quark contributions to the proton spin).

Due to the energies lower than the normal injection energy, there are strict requirements for the bunch intensity and longitudinal emittance for the injectors to met.

Accelerator Complex as RHIC Injectors



Injector Setup with Au

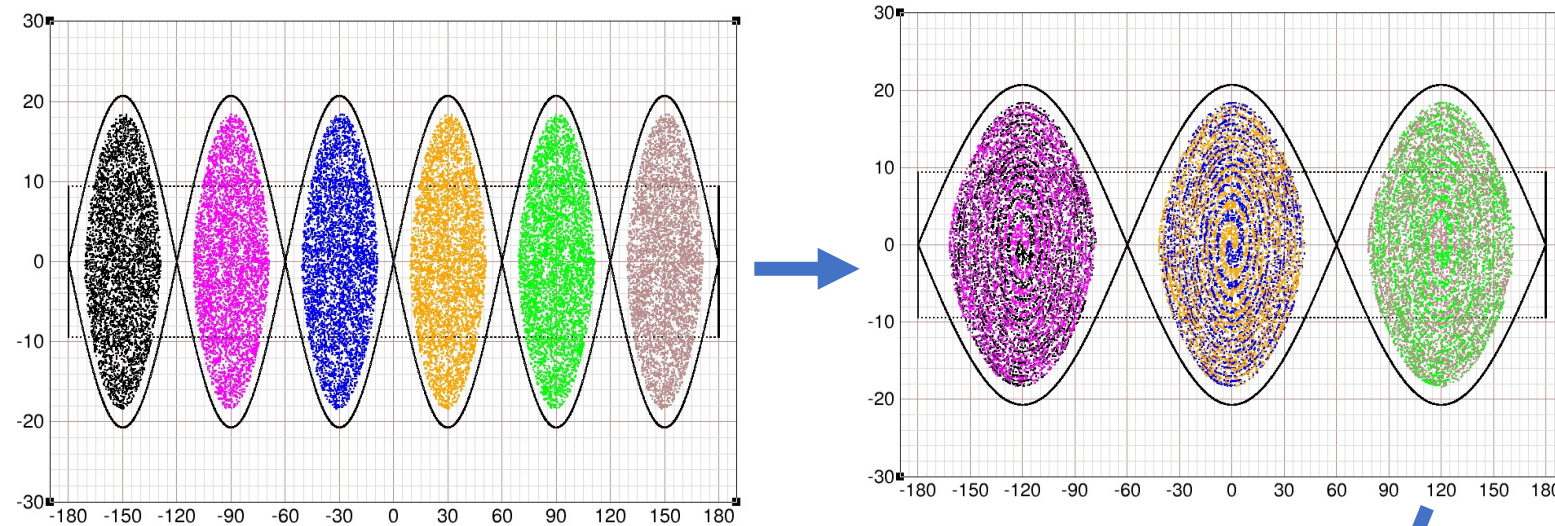
- BES-II operation requires five energies: 9.8GeV (normal injection energy), 7.3GeV (below but close to transition energy in the AGS), 5.75GeV, 4.59GeV and 3.85GeV.
- Overall, the gain of luminosity expected from BES-II is a factor four over that of BES-I.
- We need higher bunch intensity while still maintain the longitudinal emittance under control.

Major Merge Scheme: 12->6->2 in the AGS

- Requirements: EBIS source needs to reliably provide 12 pulses per super cycle; Booster merge energy needs to be raised to meet power line perturbation limit; AGS beam dump system needs to work properly (prevent possible holes on beam pipe).
- The LLRF upgrade allowed better bunch merge in the Booster, at a higher merge porch, and 6->3->1 merge in the AGS.
- Since the L10 RF cavity frequency can be raised, the higher merge energy in AGS is an obvious thing to do for space charge mitigation. It would also allow for $h=10$ acceleration and mitigate space charge.

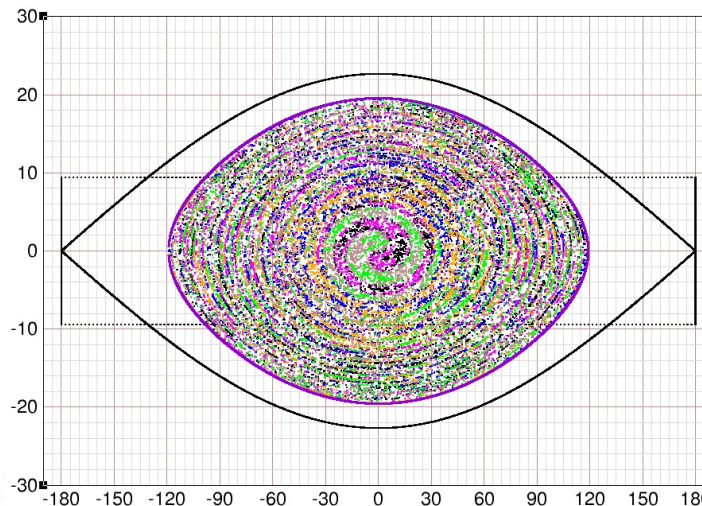
AGS 6->3->1 Merge

Done by Kip Gardner



Initial six Au77+ bunches to be merged. Total emittance of 6 bunches is 0.60 eV-s per nucleon.

The point: The simulation shows that with the available RF voltages and merging times one can merge the 6 bunches into 1 with only small emittance growth.



The area inside the match border is 0.612 eV-s per nucleon, growth is just 2 percent (small).

AGS Bunch Merge (12->6->2)

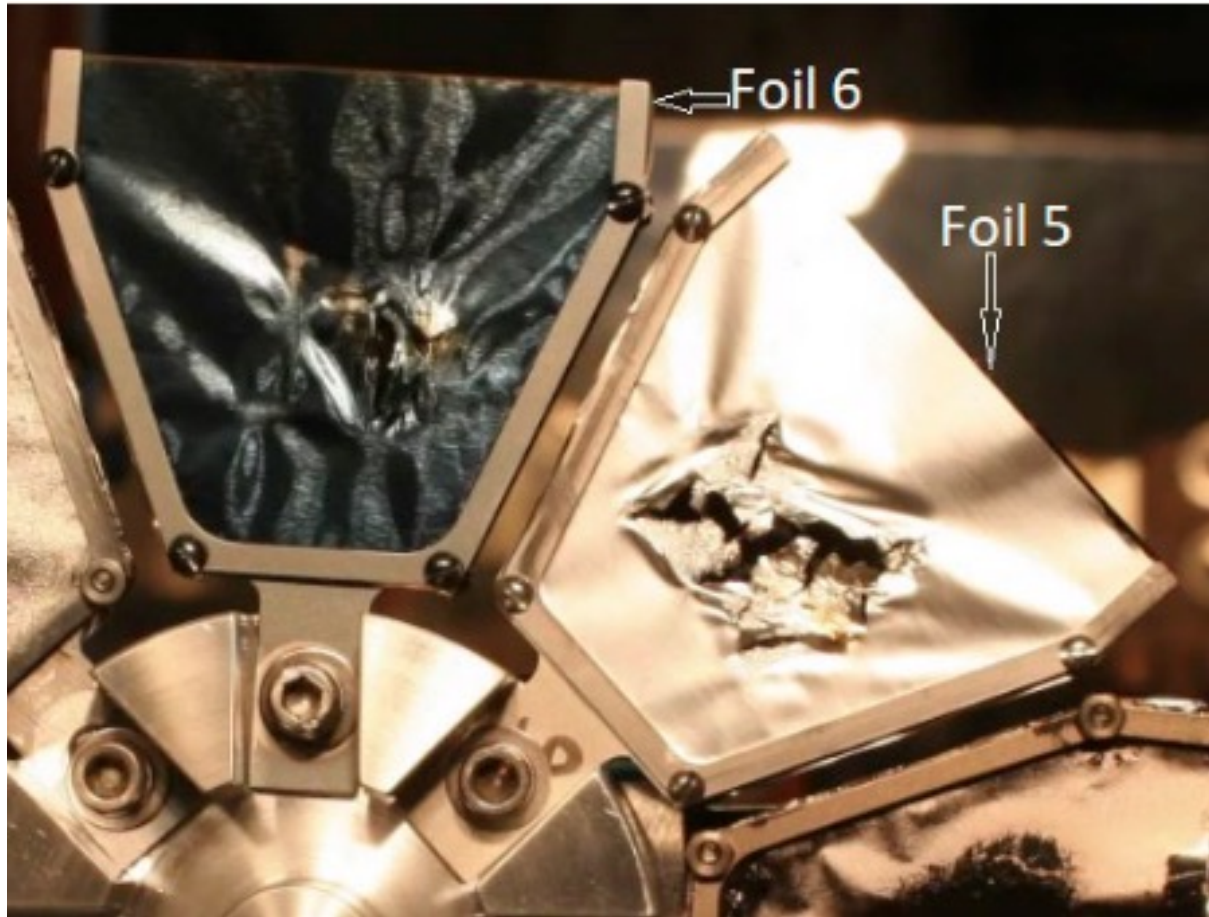


12->6->2 Merge

EBIS vs. Tandem

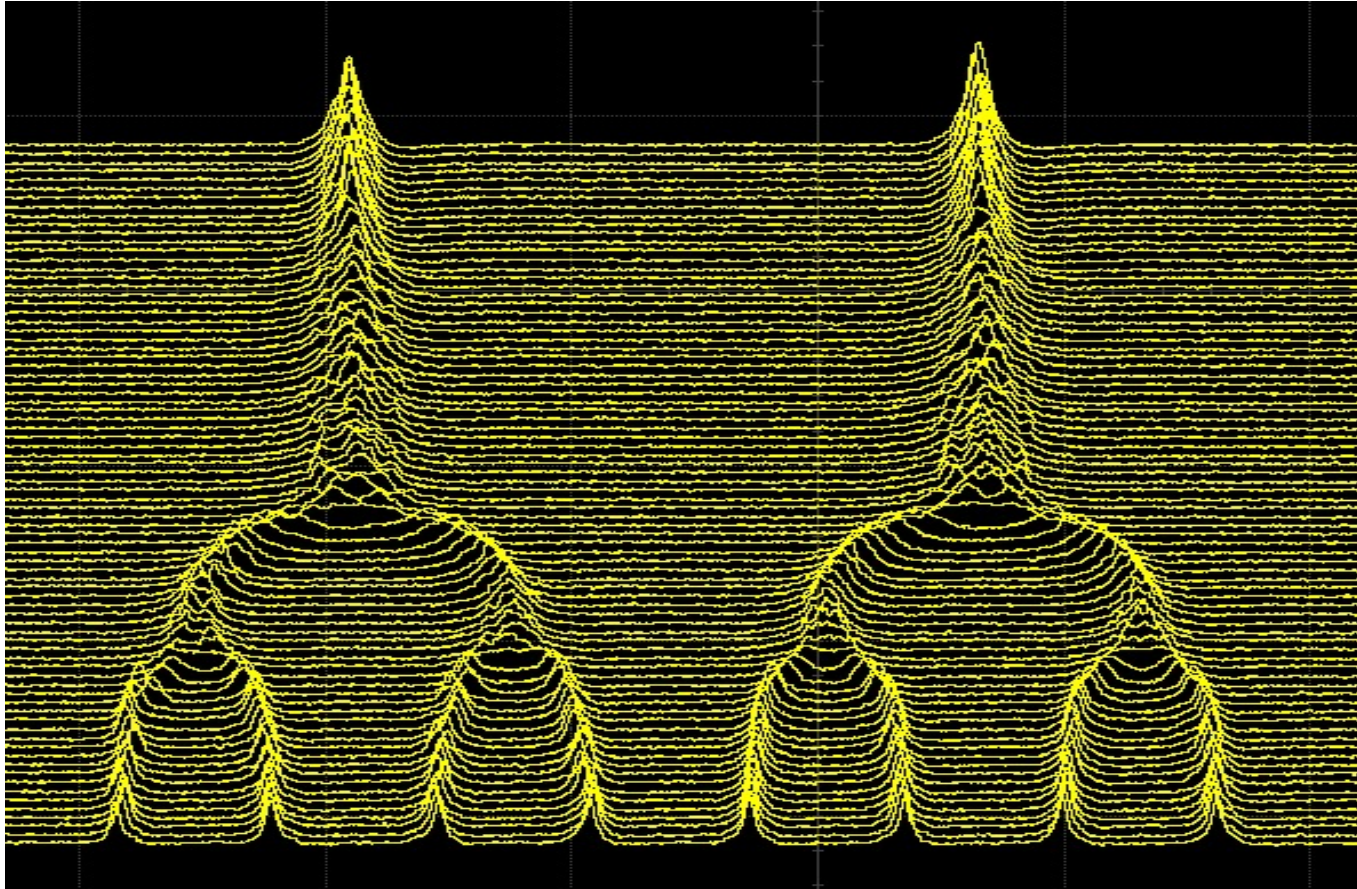
- Two highest energies (9.8GeV and 7.3GeV) were done with beam from EBIS.
- With the modest intensity requirements, smaller longitudinal emittance beam from tandem is very attractive for RHIC operation. For the same longitudinal emittance, Tandem provides twice intensity as EBIS. In addition, Tandem beam intensity can be increased with longer pulse. In addition, Tandem also provides a smaller injection time, which for short low energy stores is a substantial fraction of the duty cycle.
- Tandem was used for 5.75GeV and 3.85GeV. The Tandem pulse was also extended to get higher intensity. The BtA stripping foils sustained the high intensity operation (replaced between runs).

Booster to AGS Line Stripping Foils



Foil 6 was coated with carbon. These foils were replaced after the high intensity operation at 5.75GeV.

Example of Bunch Merge (8->4->2) in the AGS



Summary of Emittance and Bunch Intensity

Table 2: Summary of longitudinal emittance and bunch intensity for various energies.

Energy (GeV)	Source	Merge	emit. (eV-s)	Int. (10^9)	Max No. bunches
9.8	EBIS	12-2	0.817	2.66	2
7.3	EBIS	12-2	0.693	2.5	2
5.75	Tandem	8-4	0.28	2.3	4
4.59	EBIS	12-3	0.530	2.0	3
3.85	Tandem	8-4	0.2	2.3	4

Summary

- Bunch merge is used to get required bunch intensity. Extensive beam studies were carried out in the injectors to establish beam parameters needed for BES-II runs.
- With lower bunch intensity requirement at the two higher energies, the longitudinal emittance at AGS extraction can be reduced by turning off squeeze cavity KL and lowering the L10 cavity voltage.
- For the lower energies, the smaller longitudinal emittance of tandem beam made it the excellent choice to meet the RHIC lower intensity and smaller longitudinal emittance requirements.
- Overall, AGS provided more than planned bunch intensities in all five energies, which established the base for RHIC to meet or exceed the goal to increase luminosity by four times.