Review of the Fixed Target Operation at RHIC in 2020

C. Liu

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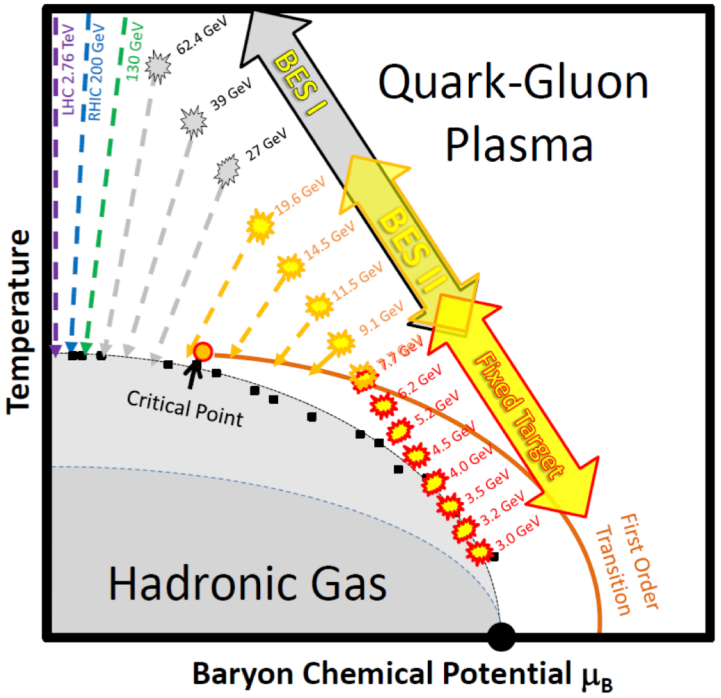
BROOKHAVEN NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

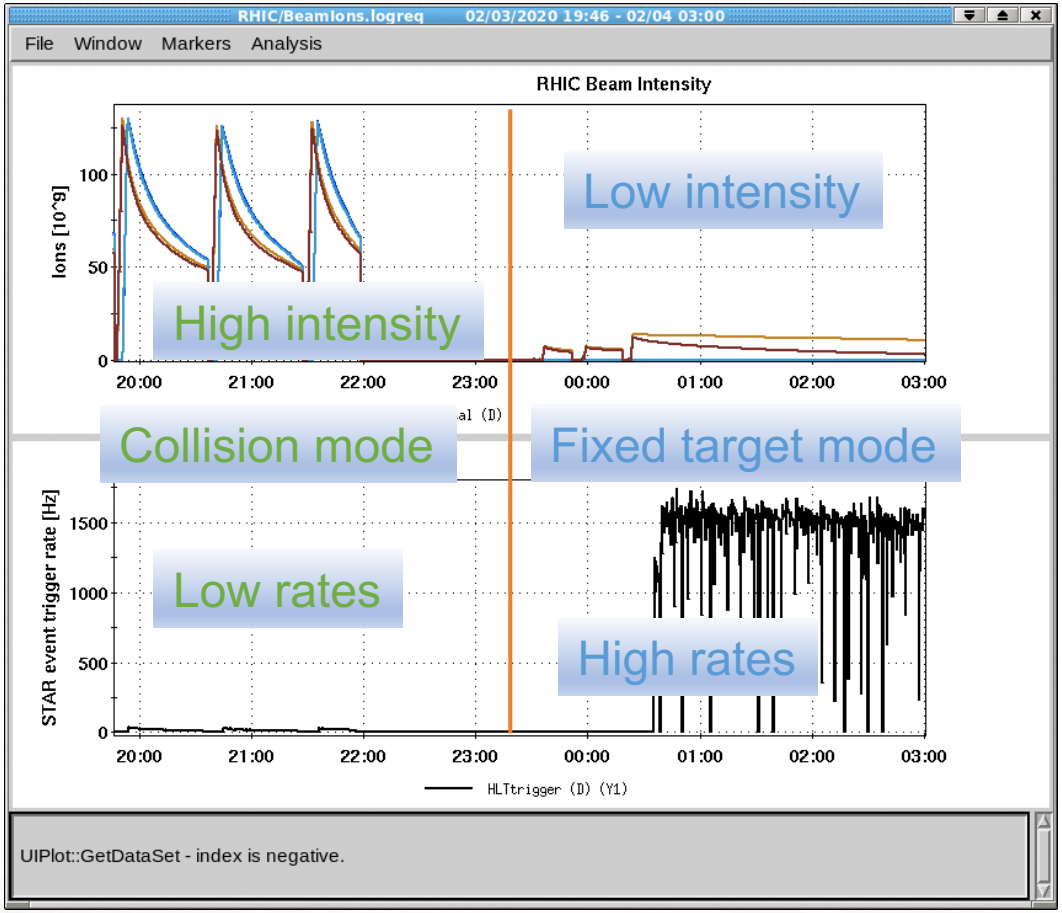
Beam Energy Scan at RHIC

- To explore the first-order phase transition and determine the location of a possible critical point.
- Collision mode: scanning the phase diagram with collisions at variable beam energy from 3.85 to 9.8 GeV.
- Fixed target mode: with RHIC energy range, the center-of-mass energy range in fixed target mode can be extended below 7.7 GeV, and the experimental rate is much higher.

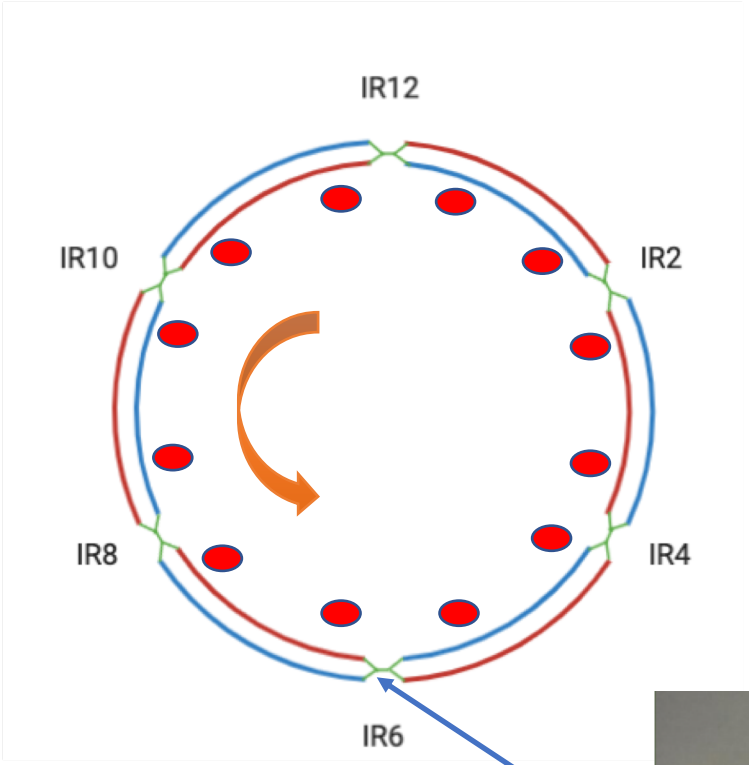


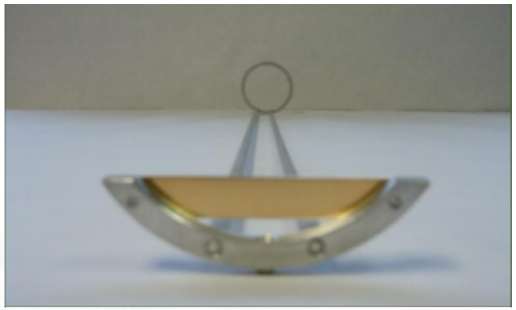
Can we discover QCD critical point at RHIC. RIKEN BNL Research Center Report No. BNL-75692-2006.
D. Cebra, "Studying the Phase Diagram of QCD Matter at RHIC," Extreme QCD Meeting, Stony Brook University, New York, 2014.

Fixed target vs. collision mode



Fixed target experiment setup





Fixed target summary table

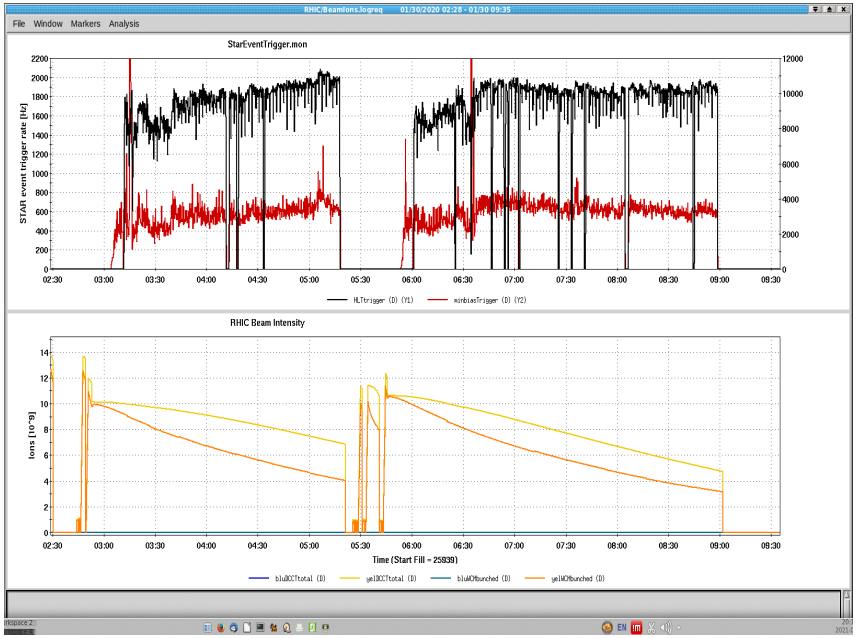
Summary table for the fixed target experiments at RHIC in 2020

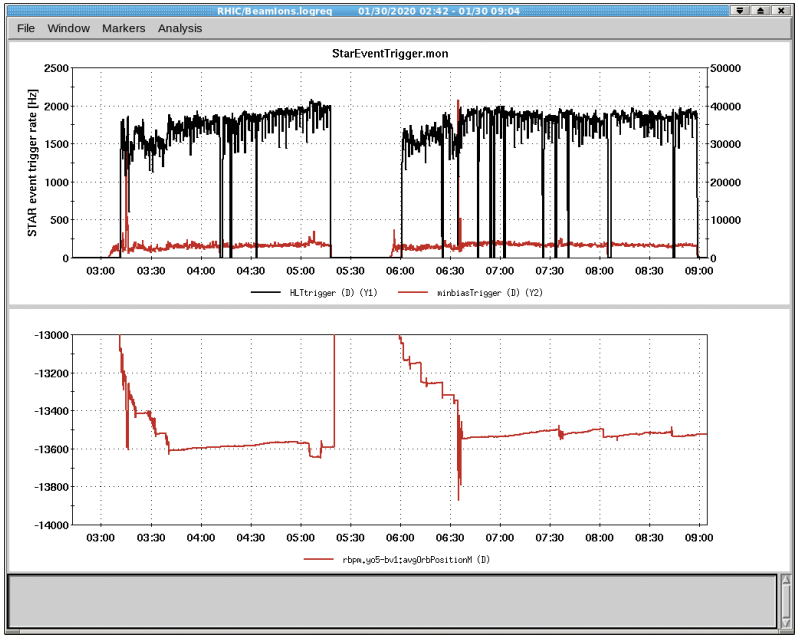
Beam Energy (GeV)	CoM (GeV)	Tunes	β* (m)	Store Length (hrs)	Number of stores	Total Events (M)
5.75	3.5	0.233/0.230	10	6	4	114
7.3	3.9	0.235/0.222	10	5	6	115
9.8	4.5	0.234/0.228	10	4	8	109
13.5	5.2	0.234/0.228	10	15	2	103
19.5	6.2	0.234/0.228	10	21	1	119
31.2	7.7	0.236/0.228	5	13.5	2	114

Ways to control the rate and background

- Large beta function at IP6
  - Relative large beam size at the fixed target
  - Small beam size at the final focusing magnet so the beam can be moved down vertically
- Produce large emittance
  - Injection mismatch
  - Kick beam with tune meter kickers, one kicks one bunch at a time, the other kicks all bunches continuously
  - Set chromaticity close to zero for emittance dilution by instability
- Controlling procedure:
  - Move orbit close to the fixed target
  - Fine tune vertical orbit to control rates
  - Or, fine tune the kicker strength to control rates
  - Move in collimators to control background

Experimental rates in fixed target rate mode





The upper plot shows the fixed target event rate (in black) and min-bias rate (in red) over the time period of two physics stores at 9.8 GeV. The lower plot shows the beam intensity evolution during the stores, total beam intensity in light yellow and bunched beam intensity in dark yellow.

Vertica orbit bump implemented during the fixed target stores to maintain the experimental rates.

Summary

- Fixed target experiments were proposed to extend the energy range for beam energy scan.
- Orbit control has been the primary way to control the rates.
- Beta function at the target, emittance control with kickers, tune and chromaticity settings were the measures to help maintain the rates.