15 GeV Low Energy Run

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Radiation Safety

- Beam energy is still close to regular injection energy
- Should not need additional instrumentation (chipmunks) in AtR, according to D. Beavis/RSC
- Additional chipmunks can be installed within a shift or so, if necessary. Would prefer to get this settled before the run starts

Beam Energy

- With $\gamma_t = 8.5$ in the AGS, 7.5 GeV gold beams would have to be extracted very close to transition - at $\gamma = 8.05$

- Short bunch length and large $\Delta p/p$ near transition make longitudinal matching into RHIC very difficult

- Slightly lowering the beam energy to 7.3 GeV ($\gamma = 7.84$) allows longitudinal matching with 93 kV in the AGS and 400 kV in RHIC (M. Blaskiewicz). It is not yet clear whether the RHIC RF can reach this voltage at that frequency

- This is the lowest energy that can be reached without changing the harmonic number in RHIC

Alternative Scenarios

If RHIC RF cannot reach its full voltage of 400 kV at the lowest frequency of 27.92 MHz:

- Raise AGS transition with γ_t quads to allow matching at a higher energy. Unclear whether power supplies can hold current for a sufficiently long time

- Raise horizontal tune in AGS from 8.7 to 9.2 to raise transition. This would allow to run at 7.8 GeV, which corresponds to 27.95 MHz

Fortunately, the exact energy does not seem too critical for the experiments

Space Charge

Space charge tune shift:

$$\Delta Q_{\mathrm{sc}} = -\frac{Z^2 r_p}{A}\frac{N}{4\pi\beta\gamma^2\epsilon_N}\frac{C}{\sqrt{2\pi}\sigma_s}$$

Assuming RMS emittance $\epsilon_N = 2.5\,\mathrm{mm\,mrad}$ and $\sigma_s = 2\,\mathrm{m}$, the tune shift limit of $\Delta Q_{\mathrm{sc}} = -0.05$ corresponds to

$$N = 2.6 \cdot 10^9$$

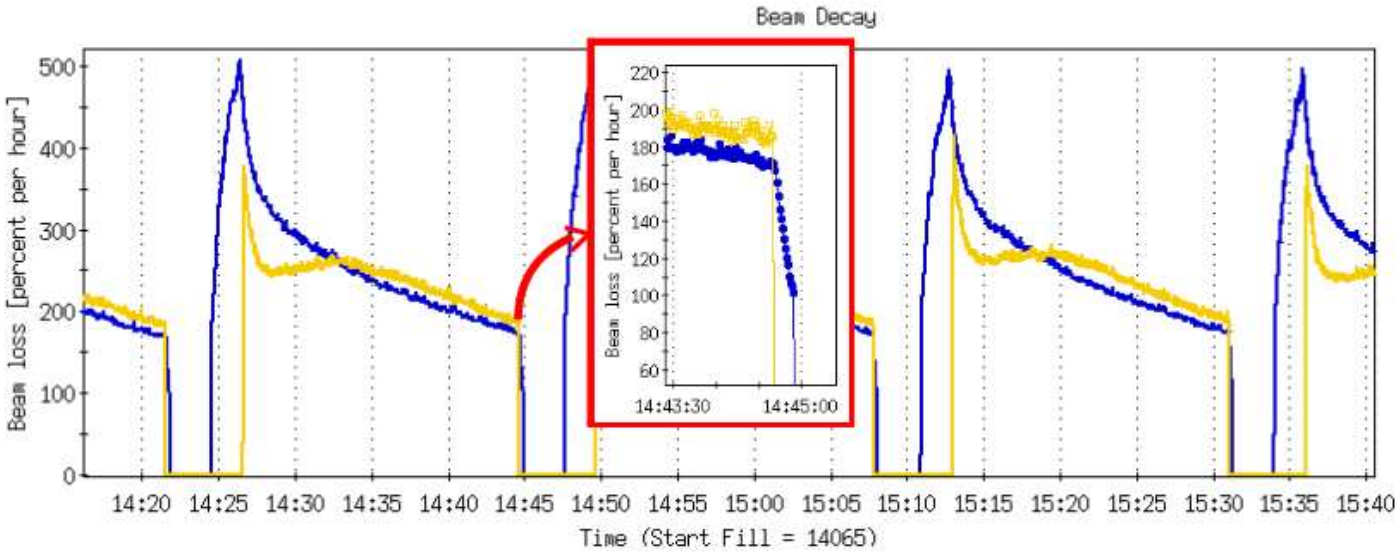
Space charge itself is not an issue

With $N = 1 \cdot 10^9$ Au/bunch and $\beta^* = 3.5\,\mathrm{m}$ we can expect a peak luminosity of

$$L = 8 \cdot 10^{24}\mathrm{cm}^{-2}\,\mathrm{sec}^{-1}$$

Beam-beam

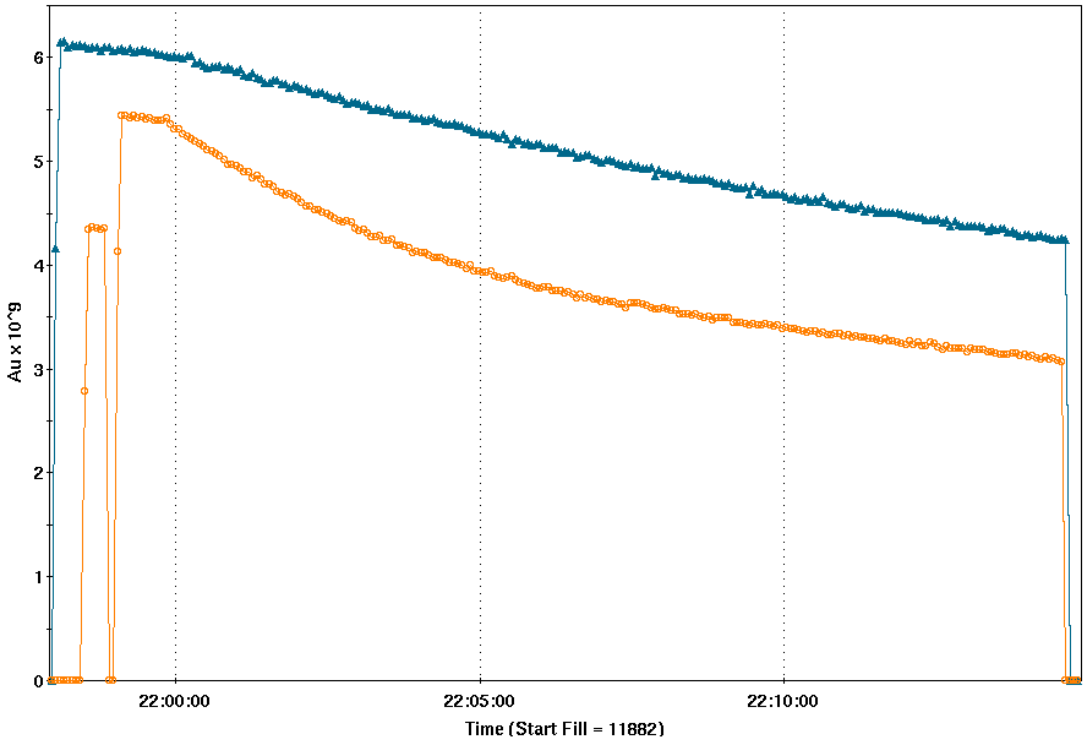
Beam decay rate at 5.75 GeV



Blue beam decay improves dramatically as soon as Yellow is dumped at the end of store

Though $\xi_{\mathrm{beam-beam}} << \Delta Q_{\mathrm{sc}}$, beam-beam has a strong effect on beam lifetime

Intensities at 9.8 GeV, regular working point

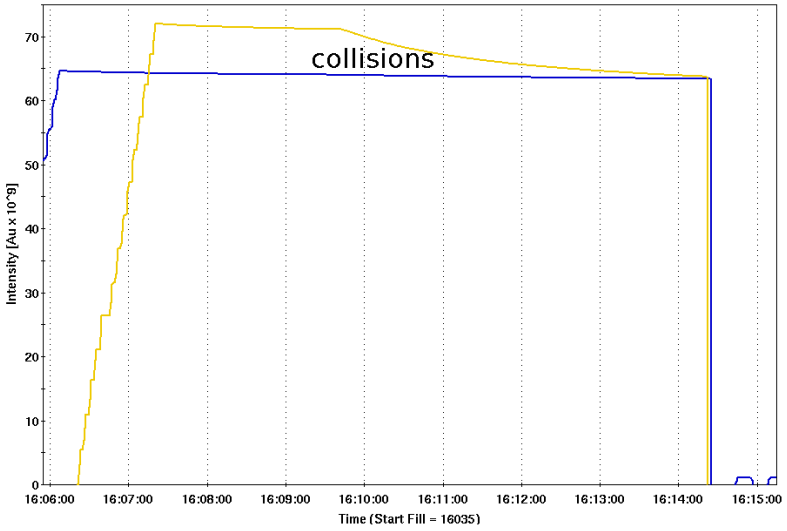


Working point: (.23/.22)

Strong beam-beam effect in both rings with $\Delta Q_{\mathrm{SC}} = -0.03$, $\xi_{\mathrm{beam-beam}} = 0.002$

Intensities at Near-Integer Tunes (APEX), E=9.8 GeV

Near the integer, spacing between nonlinear resonances is largest



Tunes: (.08/.09) in Yellow, (.08/.07) in Blue

No observable beam-beam effect in the Blue ring with $\Delta Q_{\mathrm{sc}} = -0.03$, $\xi_{\mathrm{beam-beam}} = 0.002$ (tunes below diagonal)

Parameters

beam energy	7.3 GeV
harmonic number	360
U_{AGS}	93 kV
$U_{28\,\mathrm{MHz}}$	400 kV
normalized emittance	2.5 mm mrad
rms bunch length	2 m
Space charge tune shift	-0.02
Bunch intensity	$1 \cdot 10^9$
Beam-beam tune shift	-0.003
IBS rates (transv./long.)	3570 sec/1670 sec
β^*	3.5 m
Peak luminosity	$8 \cdot 10^{24}\,\mathrm{cm}^{-2}\,\mathrm{sec}^{-1}$

The Start-Up

- Low energy run will be first, starting with the cool-down

- Hysteresis ramp for low energy goes to 40 GeV; shouldn't need quench protection tuning at slow factor 2 (or higher)

- Quench protection tuning and DX magnet training after low energy run, using the real 100 GeV ramp

- RMMPS upgrade (Carl) during first Maintenance Day

Summary

- Need to lower beam energy from 7.5 to 7.3 GeV to allow proper longitudinal matching

- Getting full voltage at that frequency is not trivial, since RF power heats the cavities and changes the frequency. Frequency range was measured at low power only.

- May have to raise AGS transition, allowing for slightly higher beam energy

- Space charge itself should not be an issue at this energy. However, beam-beam plus space charge may be

- Near-integer tunes may reduce beam-beam effect. On-line model has to allow us to get there.

- Working on simulations to find optimum working point