eRHIC studies

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Motivation

- Proton/ion beam parameters in eRHIC differ from presently achieved beam parameters.
- Smaller transverse and longitudinal emittances by cooling (CEC):
  - Relatively large space charge (0.035)
  - Larger peak current
- Two studies are planned to test the feasibility of eRHIC proton beam parameters:
  1. Study of bunch length limits
  2. Interplay of space-charge and beam-beam effects
- Study on the hadron energy limits. (?)

Study of bunch length limits

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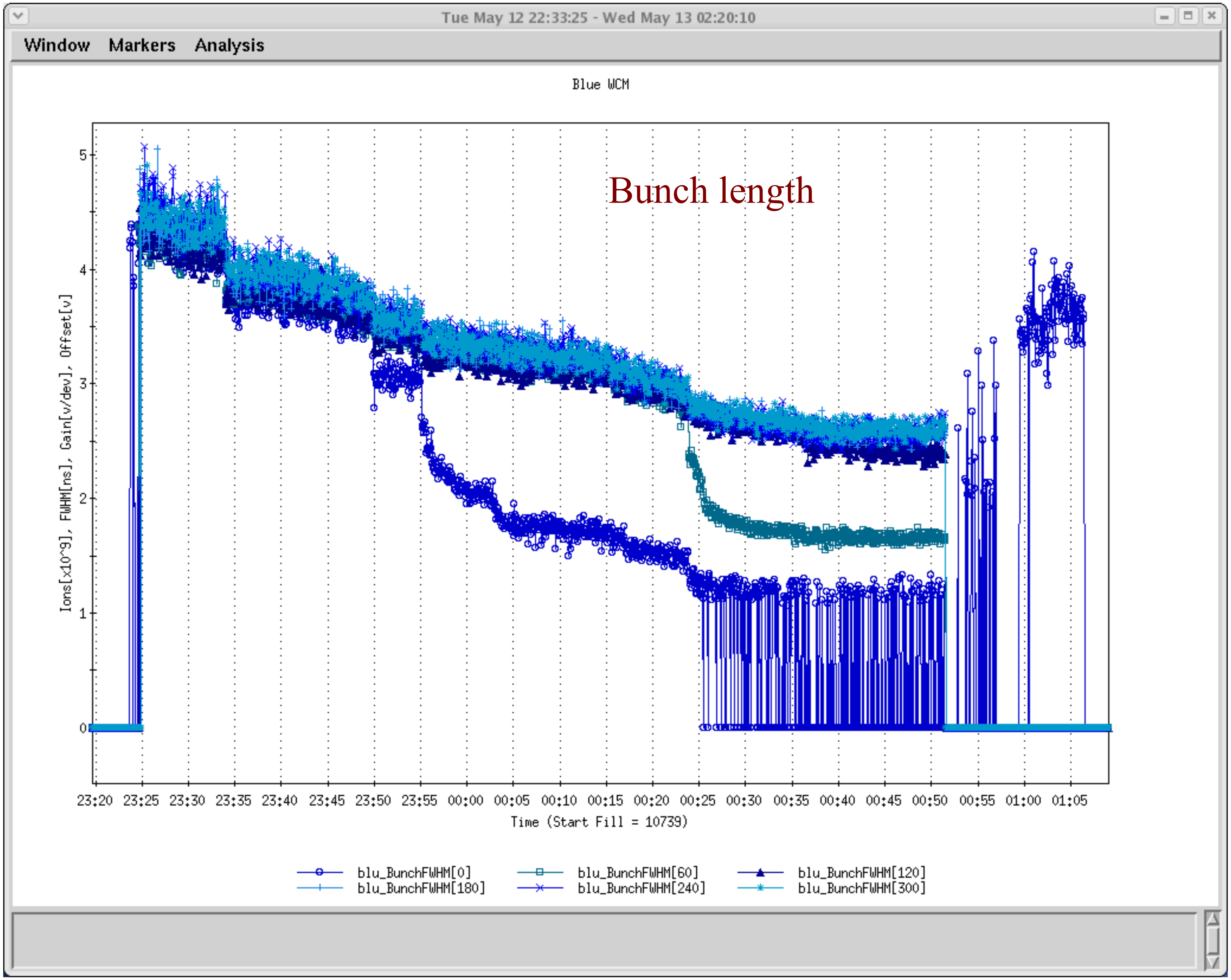
Goals:

- To identify and observe effects which may put limits on the minimum bunch length in RHIC.
- To distinguish the limitation coming from resistive wall heating and electron cloud (vacuum, pipe heating) and identify the heat load on the beam pipe from both effects.

Approaching transition study in Run-9

- ~2h time spent to verify if we could approach the transition at fixed energy, using gammaT quads only:
  - Beam losses when large step of gammaT quad change was used
  - Some model problems when trying to calculate the required tune correction.
  - Considerable closed orbit change.
  - Conclusion: a dedicated ramp and tune/orbit feedbacks are needed to prevent beam losses during the experiment.

Approaching transition using gammaT quads. Run-9.



Plans for 2012

- Inject the proton bunches with intensities about 2-2.5e11.

  Use 28 MHz RF system with highest possible voltage and, possibly, quad pumping technique in AGS.
- Use a dedicated ramp:
  - Initial part of the ramp: ramping down the gammaT quad settings, with coresponding tune corrections.
  - Second part of the ramp: slow (~few minutes) deceleration to the transition energy
- Record cryo-temperatures, vacuum conditions, transverse and longitudinal beam sizes (emittances).
- Possible complications: increased space charge effect and instabilities when shortening bunch.

Interplay of space-charge and beam-beam effects

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Previous APEX studies on this subject
(motivation: understanding of limitations
for low-energy RHIC): $\Delta Q_{sc} \gg \xi$

- **Accelerator Physics Experiments (APEX) May and June 2009:**

p+p: at beam γ=25 (modest space-charge, large beam-beam)

- **APEX March 2010:**

Au+Au ions: γ=10.5 (modest space-charge, small beam-beam)

- **Several APEX and Low-Energy RHIC run May - June 2010:**

Au+Au ions: γ=6.1 and γ=4.1 (large space-charge, small beam-beam)

-results published in HB2010 and PAC11 proceedings.

Proposed 2011 APEX studies in RHIC with protons:

Motivation:

- to address eRHIC parameters/luminosity
- could help regular pp RHIC operation as well

First relevant studies were already done in 2009:

- **Accelerator Physics Experiments (APEX) May and June 2009:**

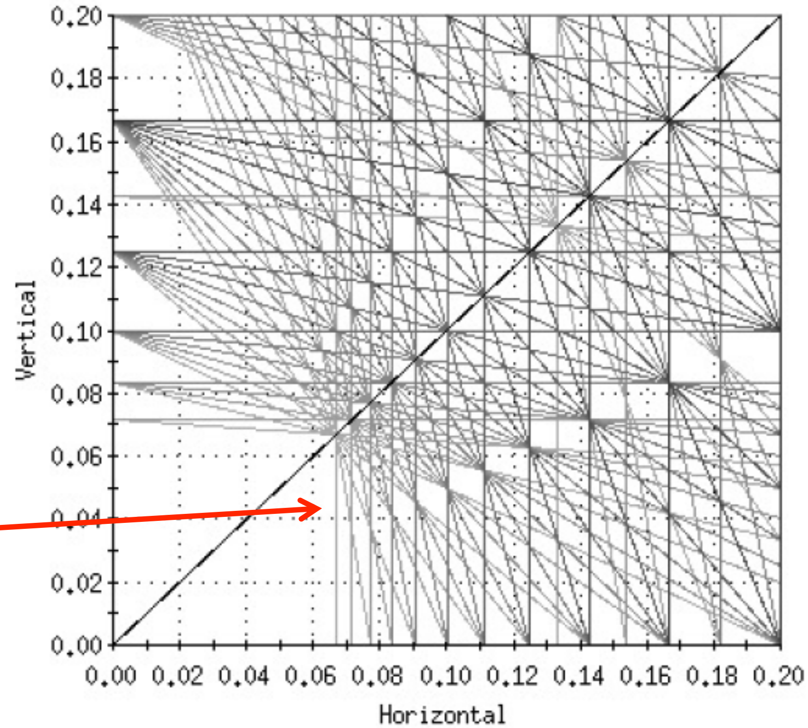
p+p: at beam γ=25 (modest space-charge, large beam-beam)

$$\Delta Q_{sc} > \xi$$

Protons at standard injection energy (γ=25):

Finding working point where effects of beam-beam are minimized for regime ΔQ_{sc}=0.03, ξ=0.01-0.02 (this is regime of interest for eRHIC).

resonances to 15th order



For small ΔQ_{sc} (~0.03), eRHIC:

We should be able to find better working point.

Run-11 studies:

- We wanted to start with injecting protons for w.p. (Qx,Qy)=(0.08,0.07)
- Explore effect of beam-beam for different bunch intensities and different working points

Did not get beam time during pp Run-11.

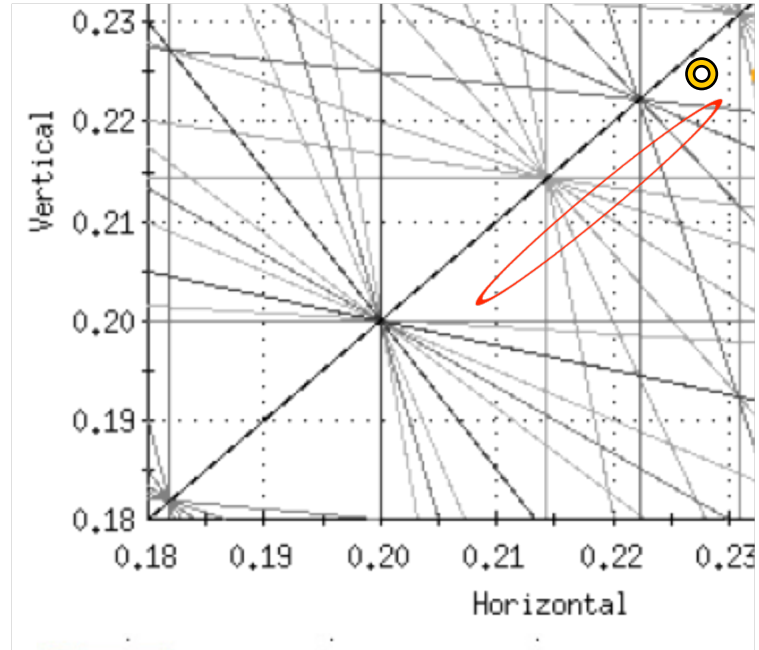
Instead of protons experiment was done with Au ions in a more relaxed regime “weak beam-beam”:

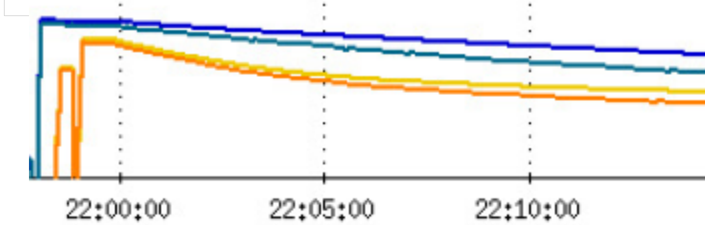
Finding working point where effects of beam-beam are minimized at least for a very weak beam-beam for regime: $\Delta Q_{sc}=0.03$, $\xi=0.002$ (per IP), for N=1.5e9 (Au ions)

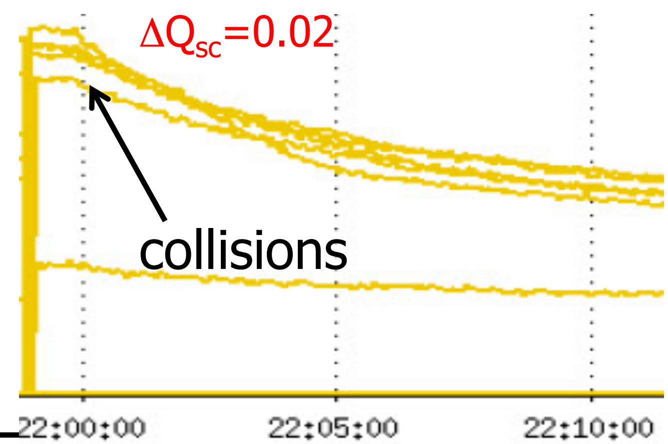
APEX, March 9, 2010:

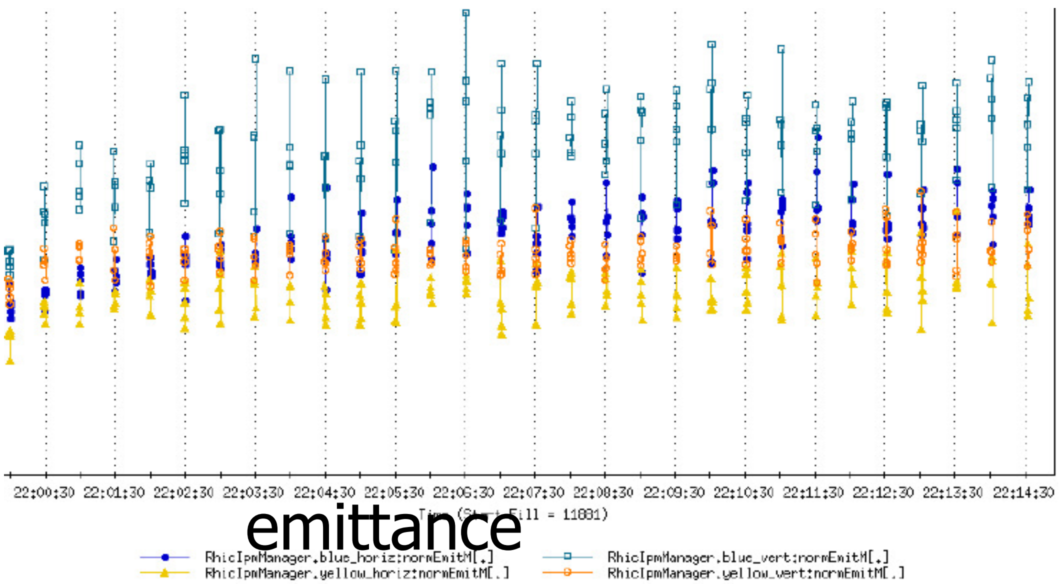
APEX Au ions at γ=10.5
w.p.=(0.228, 0.226)
maximum ΔQ_{sc}=0.03, ξ=0.002

$\Delta Q_{sc} >> \xi$









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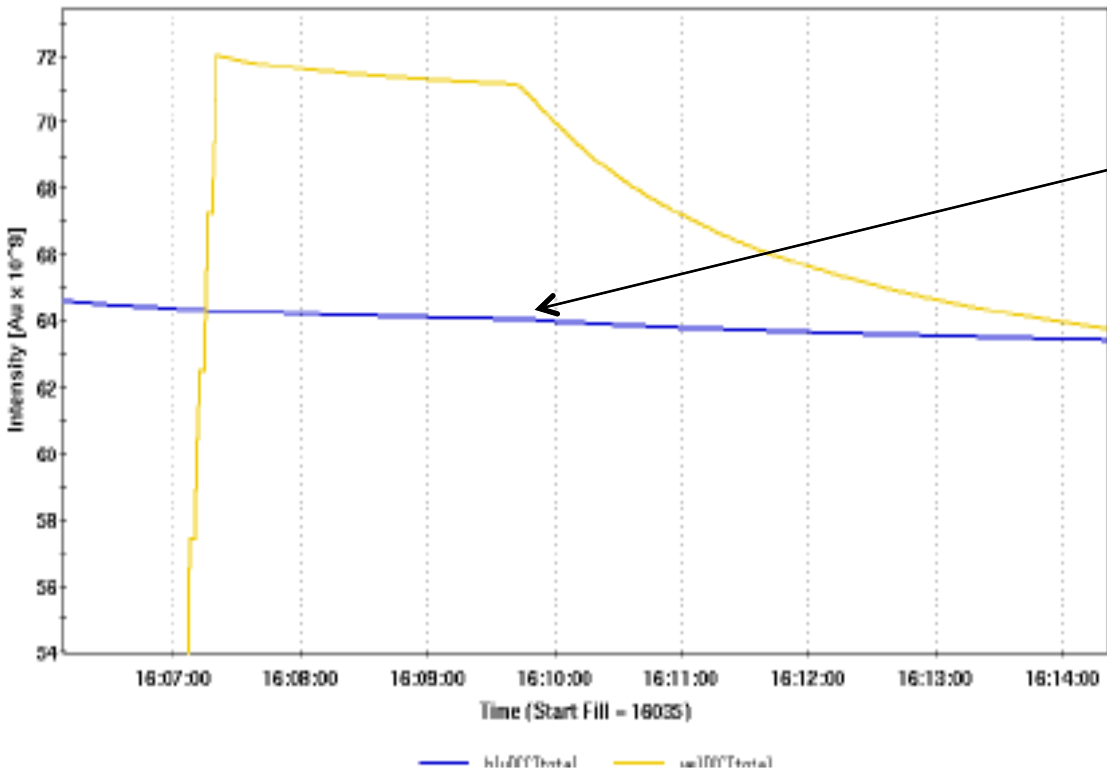
APEX, June 9, 2011

APEX Au ions at γ=10.5
Blue: w.p.=(0.08, 0.07), as planned
Yellow: w.p.=(0.08, 0.09)

maximum ΔQ_{sc}=0.03, ξ=0.002



Almost no effect on beam lifetime in Blue after collisions.

Need to repeat similar experiment with protons !

Maximum hadron energy

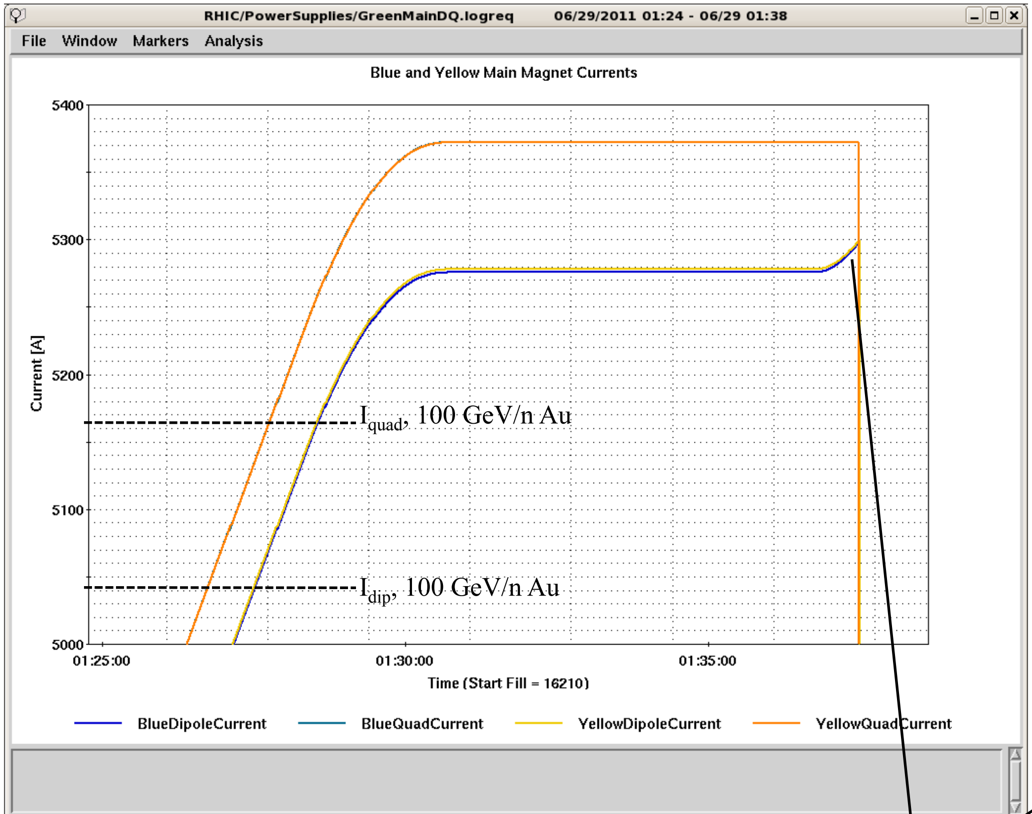
D. Bruno, A. Marusic, the tests at the end of Run-11:

1st step: ramping main quad and dipole magnets up
(excluding DX and D0 magnets, remained at low currents)
3.8% higher field (~5273 A) was achieved proving the feasibility of 100 GeV/n U operation

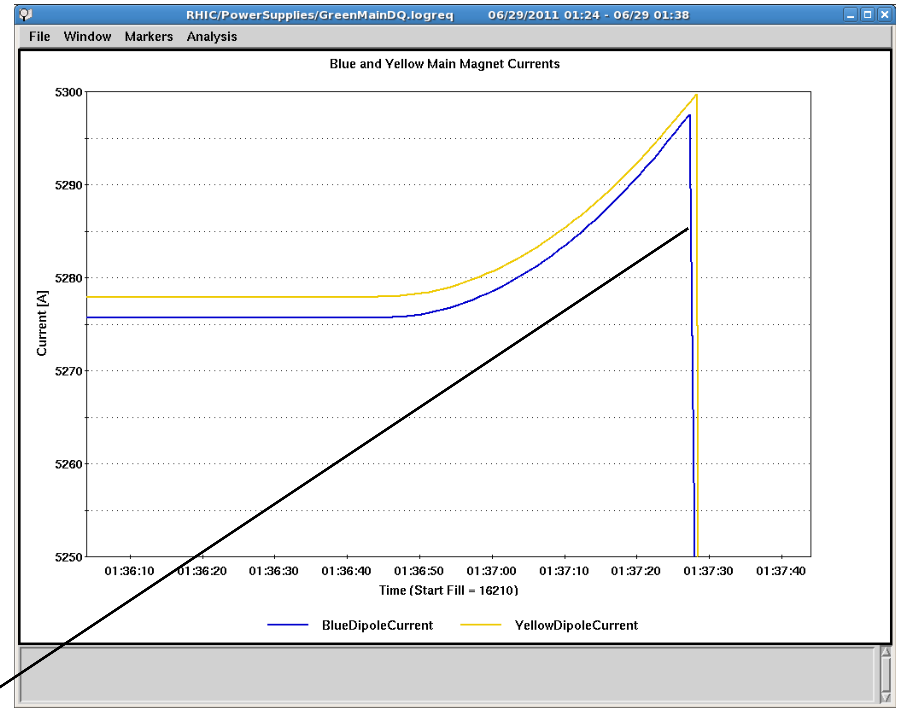
2nd step: attempt to ramp main dipole field further up to 5325A.
Achieved: 5298 A
The dipole magnet quench, in Blue sector 9 (D15-D20)

Waldo's prediction (C-AD Note 422) :
-To reach 10% increase (E_p=275 GeV) : 8±3 quenches in main dipoles
-To reach E_p=325 GeV: at least 400 quenches in main dipoles

Magnet currents during the field ramp tests



Zoomed in, dipole currents



From D.Bruno: 1. Blue looked like it had a training quench of B9DSA3_A2VT which means one of the magnets D15-D20 in sector 9 quenched.
2. All the blue dx heaters fired. I did see the current in the dx and d0 change quickly before the blue qli.

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