AGS: source upgrade, projections, pulse quads, emittance

(20 min: piece of cake...good luck)

L. Ahrens RHIC Retreat 2009

Source upgrade and projections:

For the (source/LEBT): stay tuned for Deepak’s talk:

One goal from Anatoli: to recover the 85% 200MeV polarization we have had in the past.

Other projections:

The injector held stable this run. (Historically polarization deterioriates without explanation late in runs. This year this did not happen.) So the basic configuration (snake strengths, ramp rates) are robust - not to be abandoned lightly.

The system for jumping the horizontal resonances is ready for use.

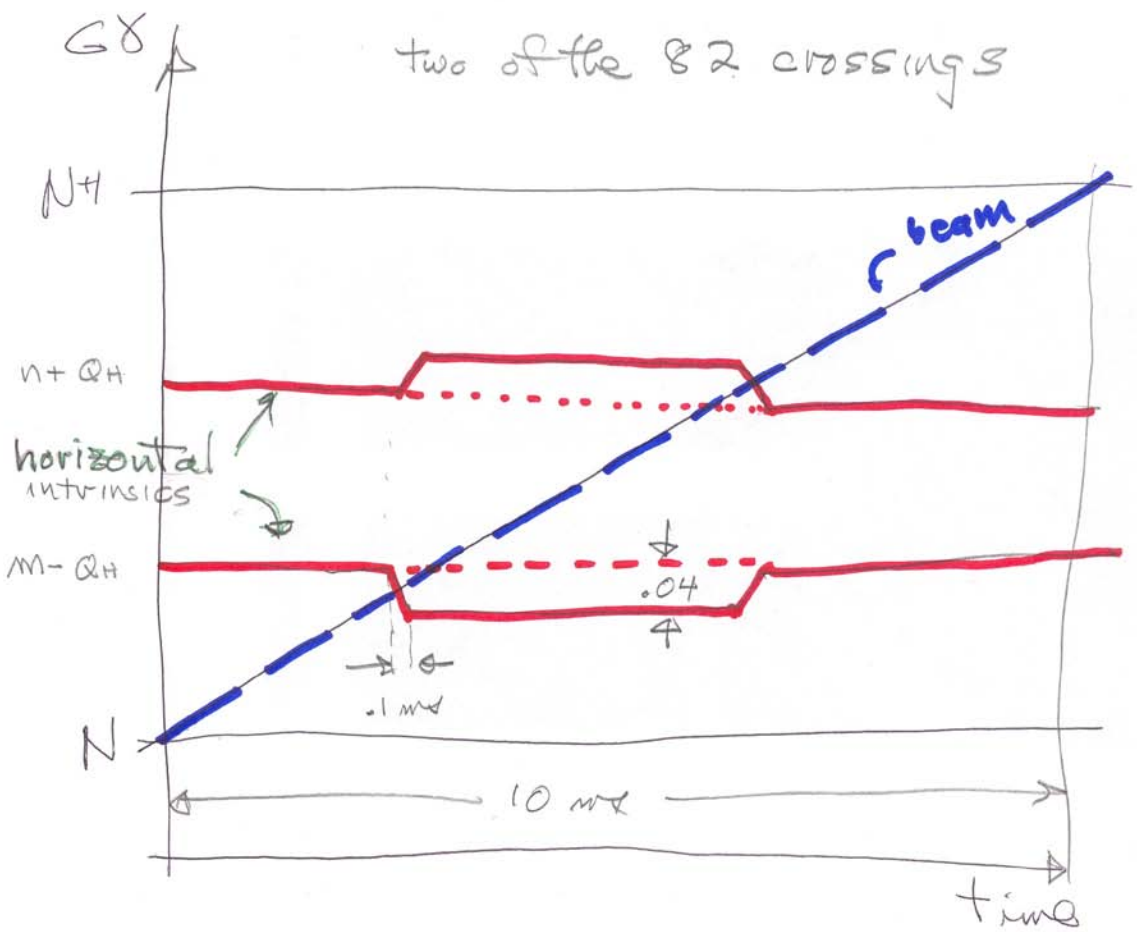
Pulsed quads

Pulsed Quads

motivation:

We lose (10-20)% of the (linac) 200MeV polarization by AGS extraction. Some of that loss occurs when the beam crosses the horizontal intrinsic resonances ($G\gamma=M+/-Qh$). This condition (different M's) is satisfied 82 times between ags injection $G\gamma=4.5$ and transfer to RHIC $G\gamma=45.5$. The polarization loss at each crossing is inversely proportional to the speed at which the resonance condition is crossed by the beam. Because the resonance condition depends on the horizontal tune, shifting the tune during the crossing changes the crossing speed and hence can reduce the polarization loss. The new pulsed quad system does this.

Cartoon: 2 of the 82 Crossings: The point is to increase the crossing rate of the blue line across the red – from dotted to solid by shifting the horizontal tune. To get a significant effect forced into this rather tight box – must hit ~ the center of this 100usec shifting period. (100 usec translates into .01 in Ggamma and in tune).



some of the challenges:

We wanted a system test during the just completer run (and got it). I think Thomas started us off less than a year ago.

First to get the necessary hardware (two quadrupoles with fast pulsing power supplies) built and into the ring on a very short time scale - reminded me a bit of my childhood up at Cornell. (Woody, Jianlin Mi, Pablo Rosas ++).

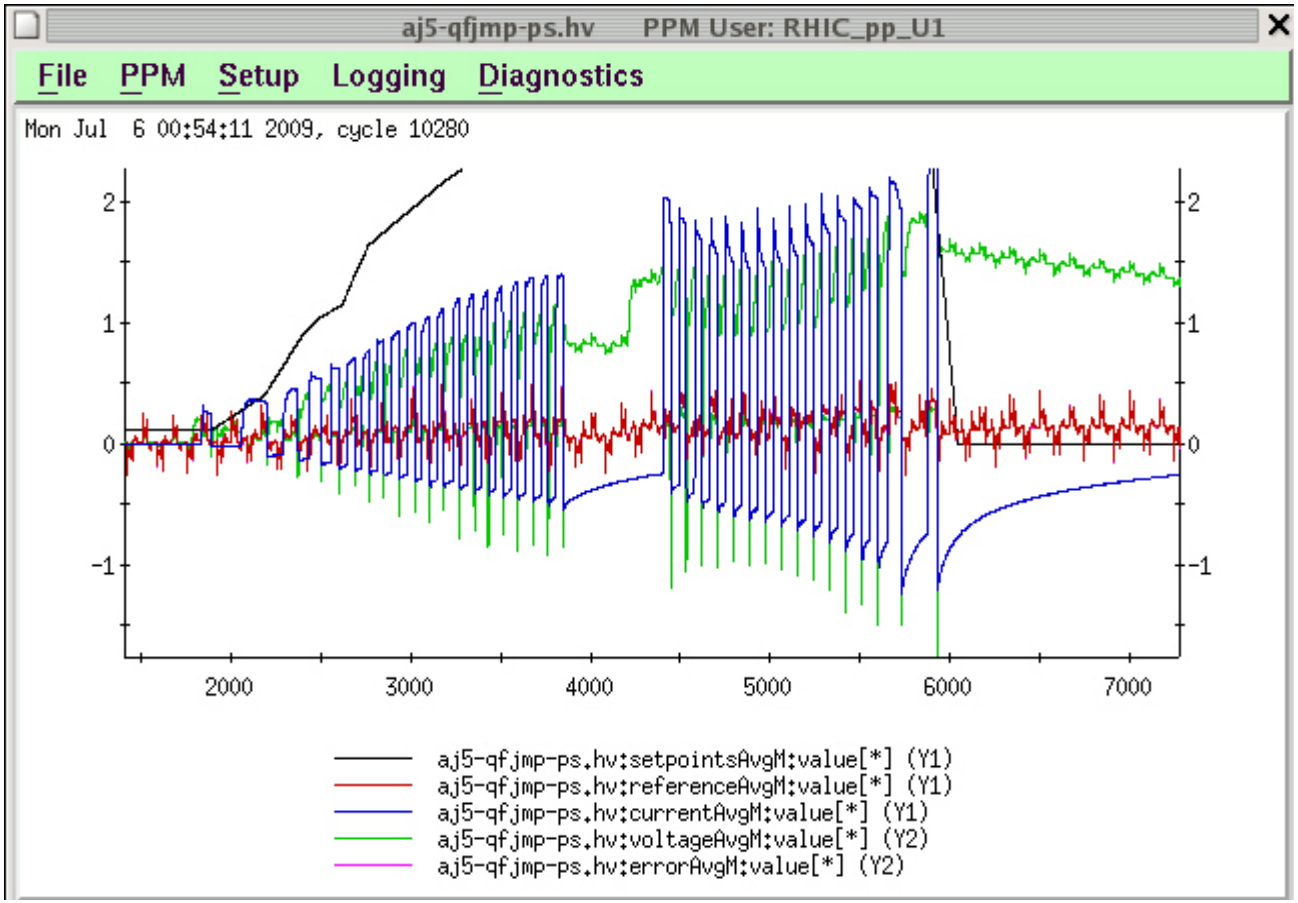
Simulation effort: check whether we can tolerate the associated vertical tune jumping – (Qv ~ 9 and Qv moved ~half as much as horizontal. Vertical emittance growth from nonadiabatic changes in beta and offset quads? (Haixin and Fanglei).

Dead reckon the crossing times. Gain from a single crossing is too small to measure. Tunes and energy measurement are required to be known to significantly higher accuracy than in the past. (Dave Maffei's turn-by-turn fitting of the rapidly decohering horizontal kick response, Peggy Harvey's Ggamma machinery – these pieces just happened to be available.)

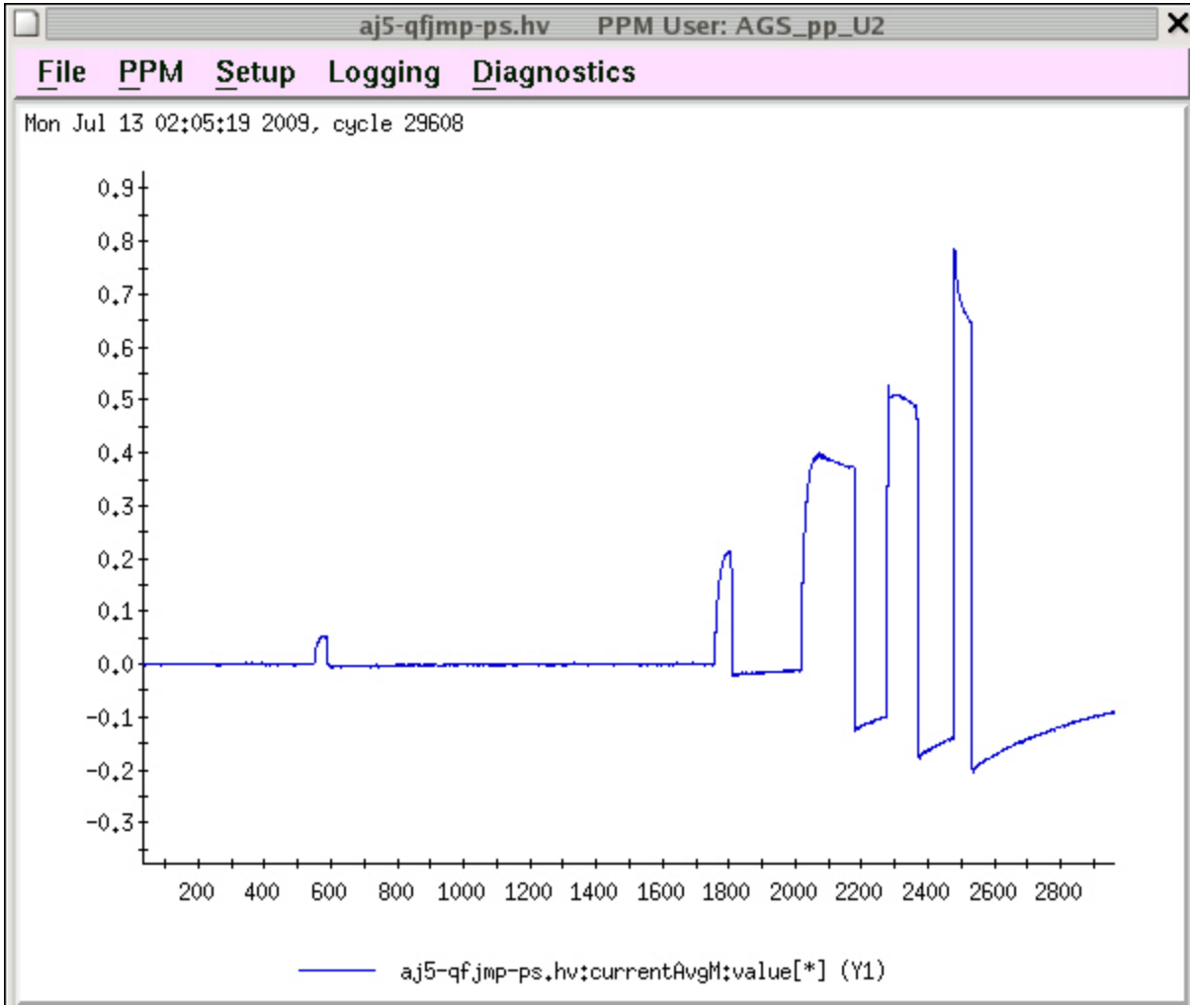
Controls – software to put the thing together. (Wenge Fu).

So where are we?

one of the two quads pulsing throughout most of the cycle. After careful orbit tuning (by Waldo) the emittance growth (IPM at RHIC transfer flattop) was small.



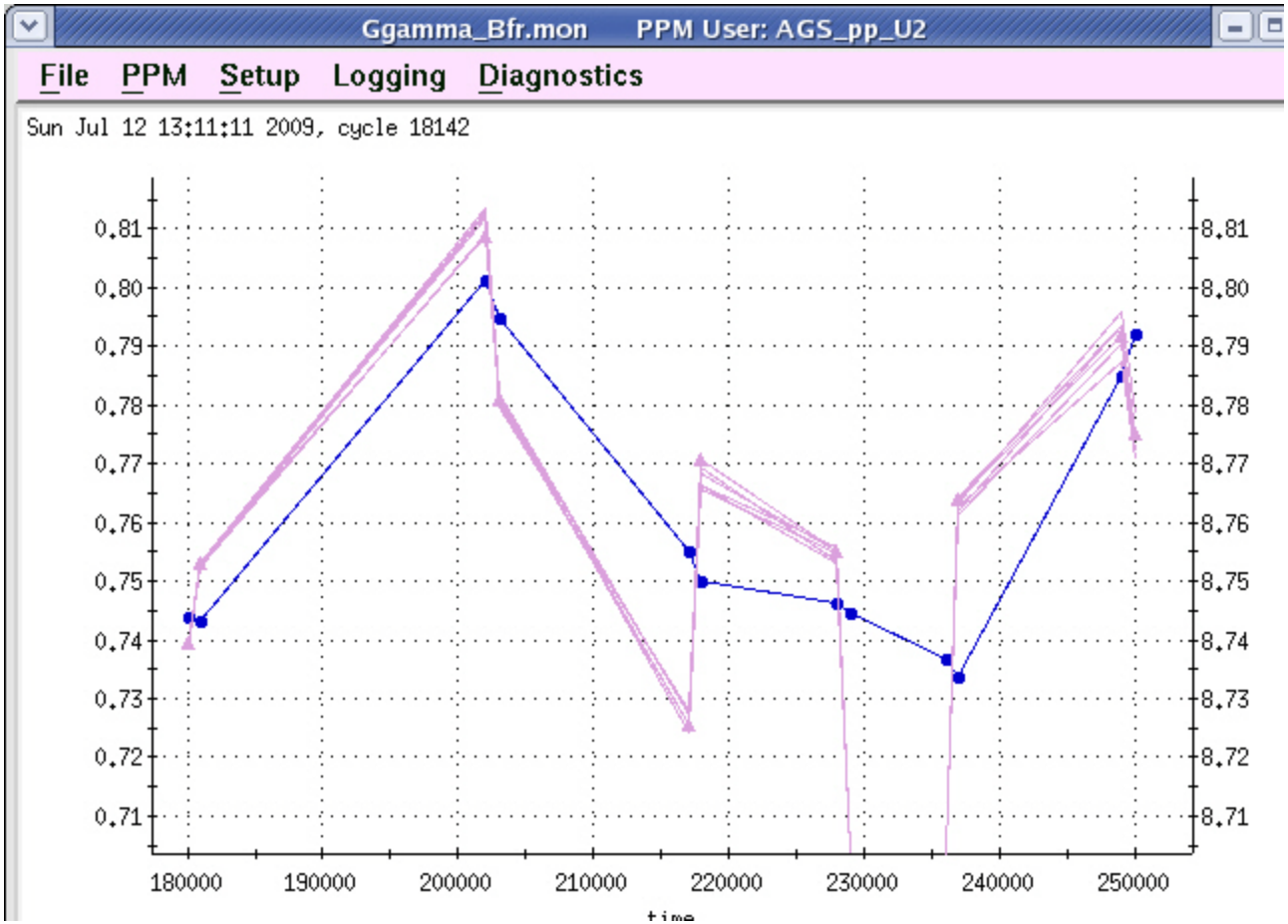
And at the end we worked with the first six jumps. Allowed measuring any effect at a low energy – analyzing power of the CNI larger by nearly the factor 7. Rate only slightly lower that at full energy.



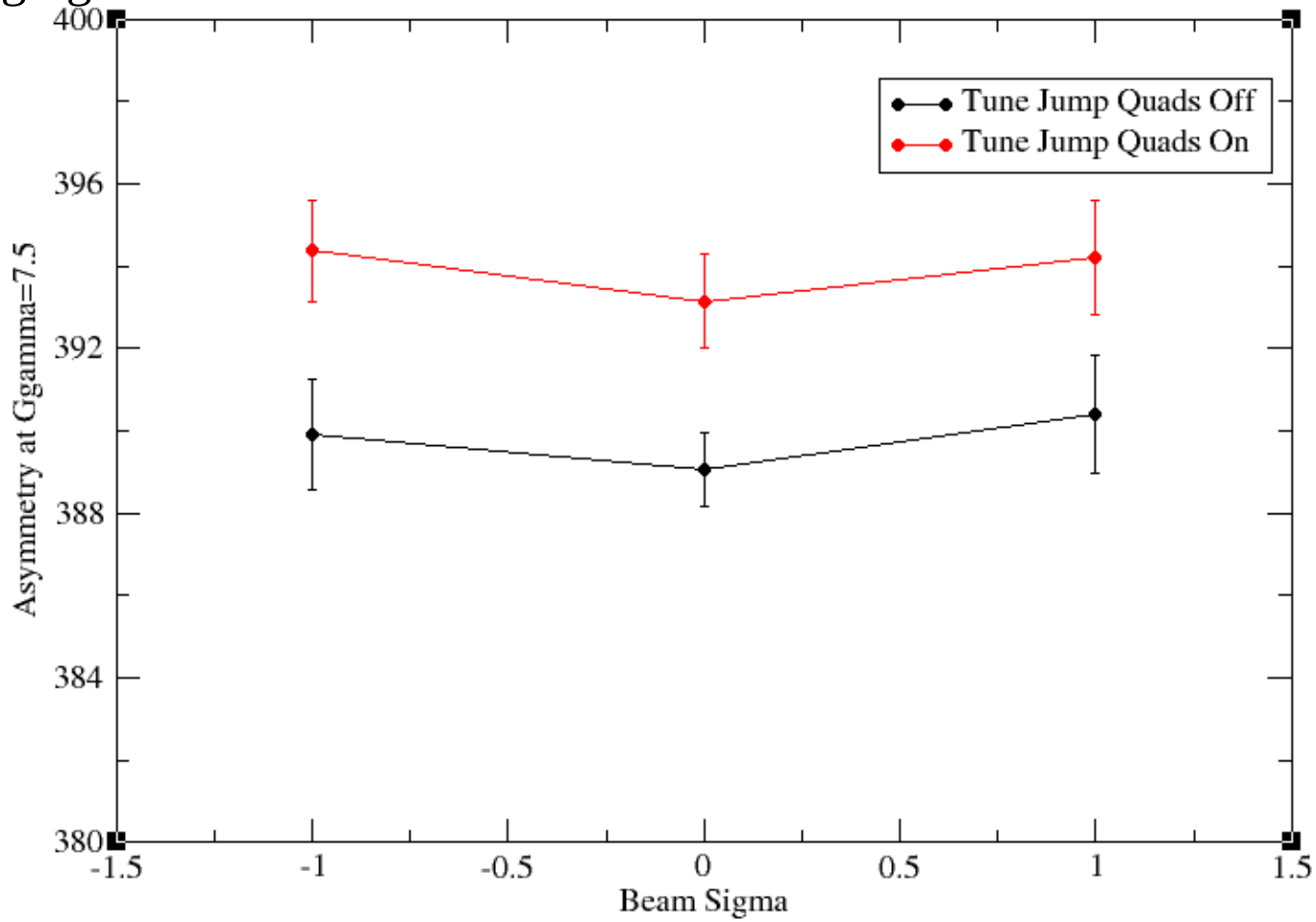
A compact view of the “crossings”: where the beam Gγ = (m+/- Qx)

The application figures out the raw crossing times from these data sets, applies ramp rate dependent corrections to move to the predicted crossing times and then generates a set of times for the 4 power supplies for each crossing.

Measured (coarse bracketing each resonance) hori tunes and beam energies (from the Gauss clock and beam radius) vs time.



Effect of pulsing these quads on the magnetic cycle ending on the Gγ=7.5 magnetic porch. (Data taken "parasitically" over the last few days of the just ended "DTRA" run, i.e. very new – preliminary –data, but a significant effect.) Encouraging.



Hori: CNI target location in the beam: 0 = centered.

What’s left to do? A partial list:

Commission the system – from “engineering” to “operational”.

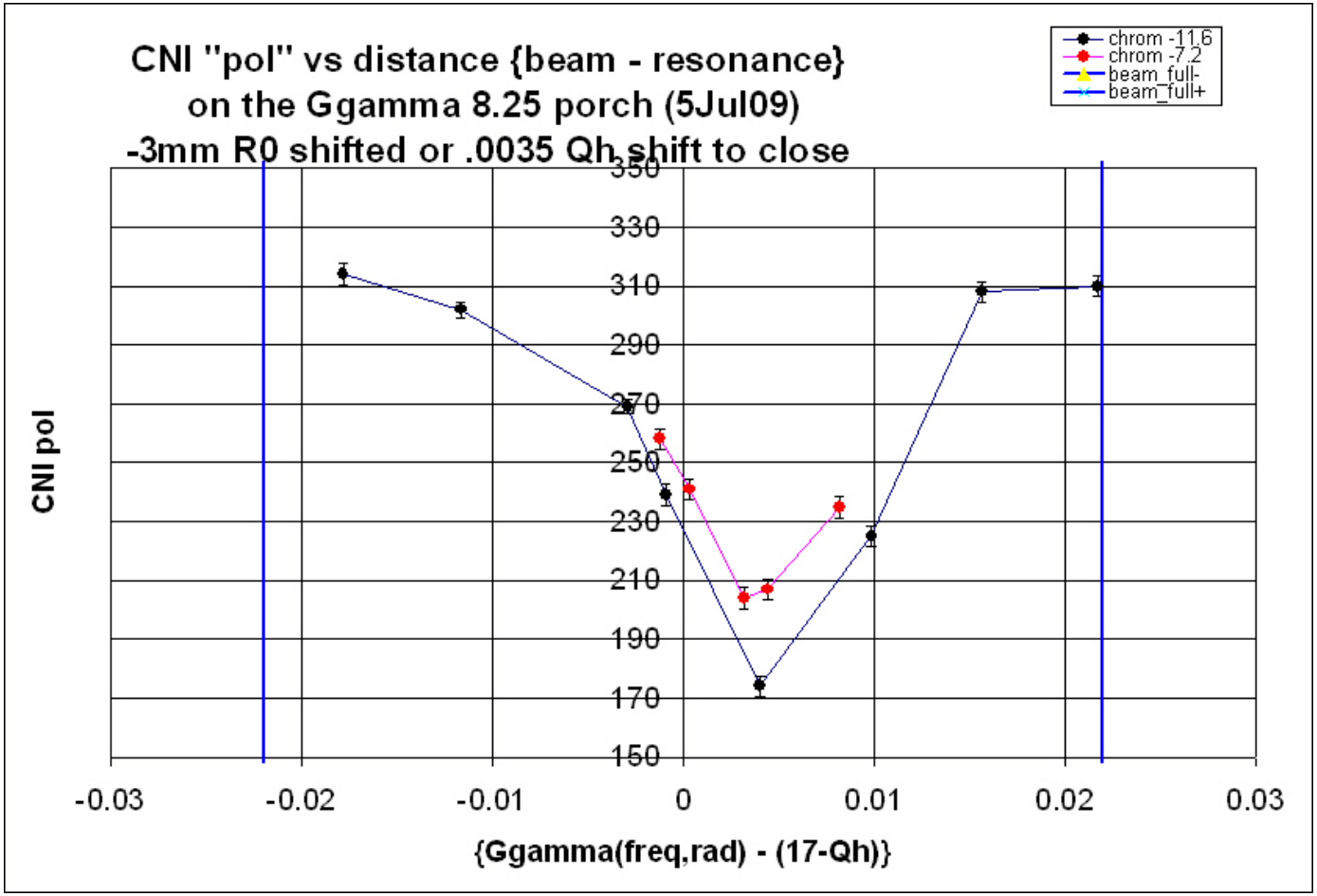
Move from “expert only” tuning of the pulses and timing to an automated systems – more controls and Controls work.

Stroke the calibrations. I am (parochially) thinking of the timing but surely also applies to the power supply voltage functions. Figure how to dead reckon better. Here we need help with the AGS Gauss clock machinery. Subtle dependence of the calibration on dB/dt – if we had a model for the effect we could parameterize and get this within our spec.

Get the five functions logged – in a reasonable way.

Can we really “tune up” this system at all?

A Gγ calibration point: horizontal intrinsic resonance (at Gγ = 17-Qh) located from polarization scan against distance from this resonance on a flat top magnetic field (Gγ and resonance calculated from measured (rf frequency, radius and tune). Also in some sense a measure of one of the intrinsic's strength.



on to Emittance

Longitudinal - an observation in passing:

Look forward to the 9 MHz RHIC era. This will make the longitudinal product from AGS relevant. Presently it is ~ not: we have a large shot-to-shot varying kick of the bunch longitudinal during the AGS-to-RHIC synchro dance. Competitive in size with that generated by the now several times successful “quad pumping”. Any emittance growth associated with this problem is presently not above the radar – above the chronic longitudinal mismatch into RHIC. In the future hopefully it will be.

transverse:

1. can we measure it?

2. can we control it?

3. is it important?

for 3: yes: luminosity - provided the AGS emittance is relevant,

yes: polarization - must be for hori intrinsics (the pulsed quads see below), perhaps less so for vertical – we may have some margin before beam tails stray outside the spin tune gap.

Major effort this year (Deepak's subject) to make use of the smaller beam from Linac. (Deepak, Kevin Brown, Keith Zeno, Vincent Schoefer).

At Booster injection we move from the optics of the normal machine to reduce the beta functions in both planes at the stripping foil. (Along the way we presumably cross the tunes and swap the incoming emittances.)

Scraping in Booster is very effective in reducing the transverse emittances downstream, but what would seem a straight forward connection between emittance and the final polarization at AGS extraction is still a murky business.

Polarization goes down as intensity goes up, but the proof that this dependence is through the emittances is not experimentally convincing. (That the IPM results have their own intensity dependence adds to the difficulty, and the AtR flags are not yet the silver bullet of clarity...)

AGS emittance growth?

In AGS we have struggled with possible emittance grown at the start of or during the acceleration cycle – now for several years.

BtA understanding

Intense effort back in October in BtA to get the modeling there under control. Modest success: the beta functions measured down the line at the end are much closer to the model predictions than apriori. Why? 1) we improved our model inputs: the currents in the quads, and learned these were indeed important at the level that they were wrong. 2) we improved the model handling of Booster extraction and the 30degree bend in that line. (Kevin, Vincent, Roger Bonati +).

AGS matching?

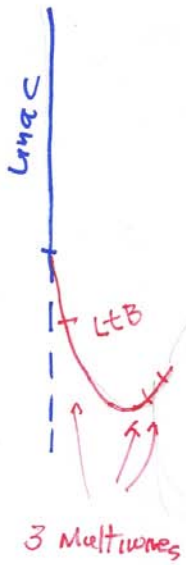
AGS snake model is still “a work in progress” so the matching to AGS is not closed, evidence that this is a major source of emittance growth is weak. But still open and the turn-by-turn implementation of the A15 multiwire is still on the list. (last day progress Lenny DeSanto and Craig Dawson – they manage to see plausible single bunches interacting with the wires!).

AGS growth during acceleration?

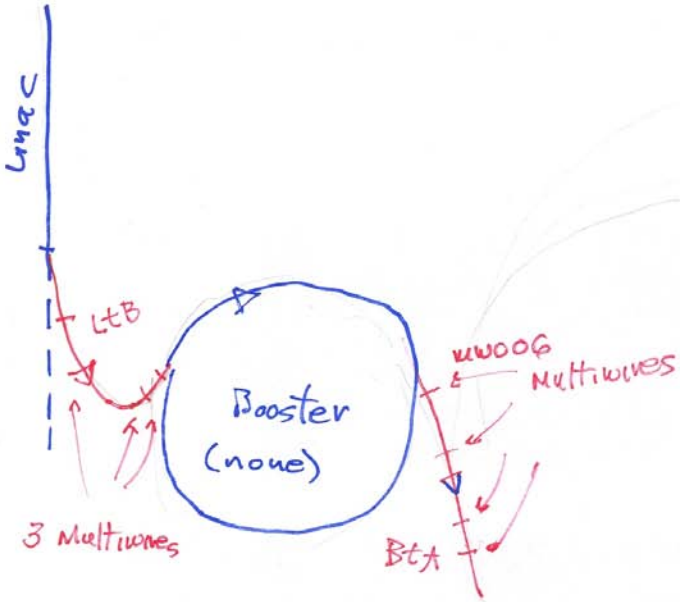
Well, it also shrinks if we deaccelerate... (Kevin)

Next three slides: reference catalogue: transverse emittance, injectors:

So then walking through the transverse measuring measuring systems and statuses:



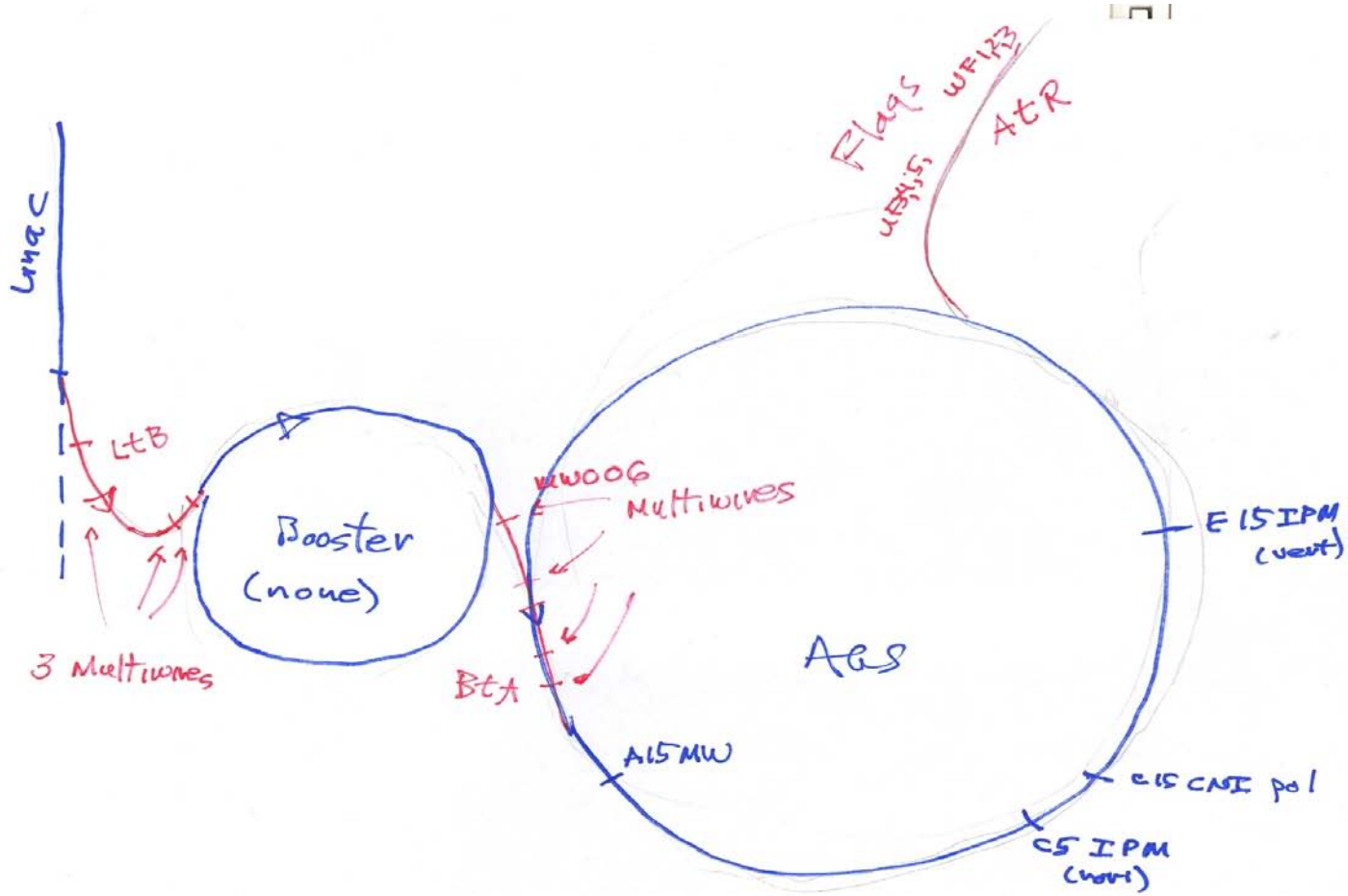
Deepak will talk about emittance and its measurement in the Linac. In the transfer line between Linac and Booster (LtB) there are three “multiwires”. Recently the last two have come to life (one for first time) (thanks Steve Jao). We look forward to better understanding these devices (time dependence of emittance during the pulse?), and the beam in LtB.



In Booster we have no emittance measurement. A multiwire for injection work is on our wish list.

In BtA: four multiwires. These are reliable. The first (MW006) has no quads before it, and has a quad just after for beta measurements (using downstream multiwires in relative mode) - very useful device.

Most emittance tuning (in Linac and LtB and at Booster injection) relies on measuring the beam behavior at MW006. This is also an absolute (perhaps the only) emittance measurement point.



Finally in AGS we have ion collecting IPM's and the CNI polarimeter (hori); and in AtR two sets of flags. The IPM is the only hope for measuring time dependence of emittance growth. Most of what is sees turns out to be reversible -> not real. So used extensively for tuning, but at fixed intensity and energy. The AtR flags are not yet reliable.

end