Stochastic Cooling Progress

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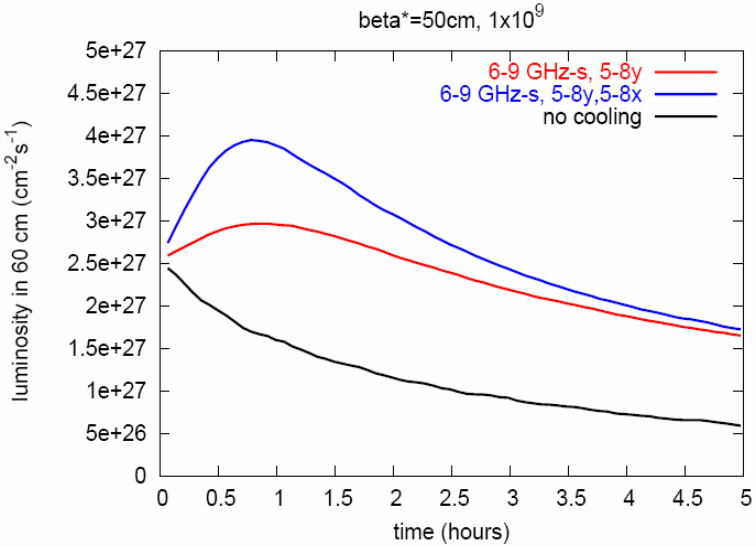
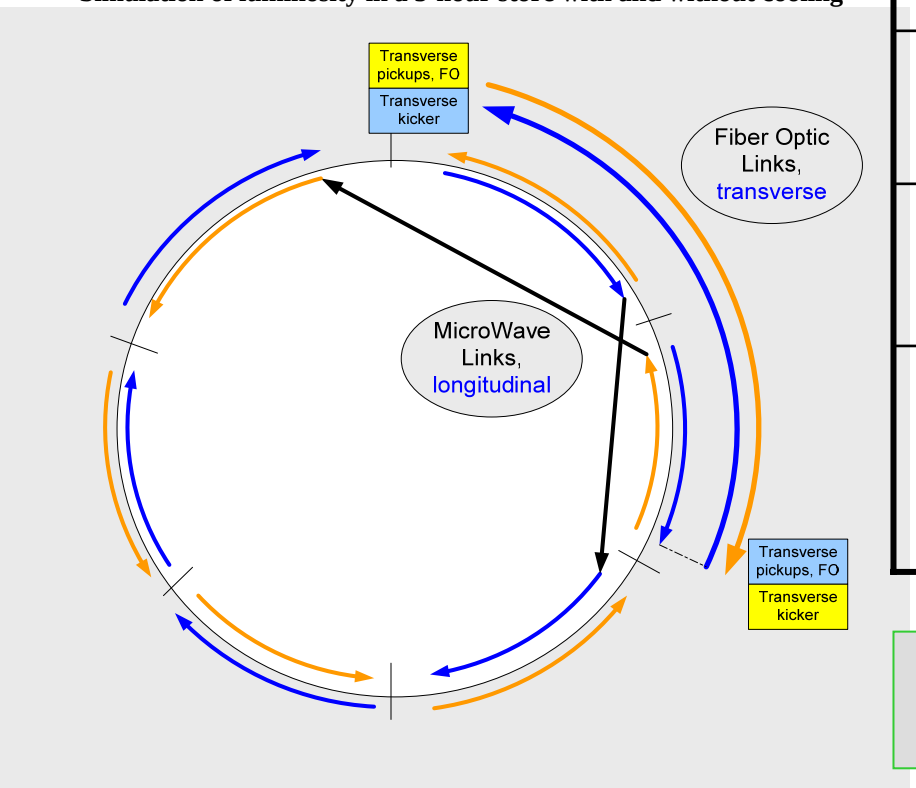
Outline

- The overall plan for stochastic cooling of heavy ions
- Recent results from tests with protons
- Reconfiguration for FY10 Gold-Gold operations
- Progress toward the complete system
- Upgrading for higher bunch intensities



Simulation of luminosity in a 5-hour store with and without cooling



Overall Plan

System/Ring	Yellow	Blue
Longitudinal	Operated 2007 Au-Au, 2008 d-AU	Tested with deuterons 2008
Vertical	Tested with protons 2009 p-p	Will be installed 2009
Horizontal	Will be installed 2010 ARRA funded	Will be installed 2010 ARRA funded
Upgrade for 1.5×10^9 ions per bunch (only an idea)	Extend frequency range 6-12 GHz	Extend frequency range 6-12 GHz

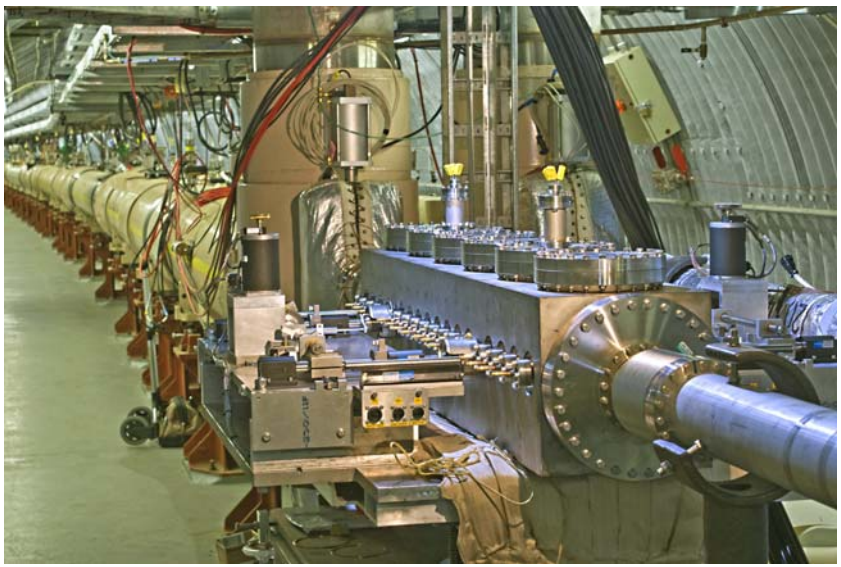
For 12 GHz we contemplate Palmer cooling with pickups in the arcs (cold bore)

Building the Yellow Vertical Kicker

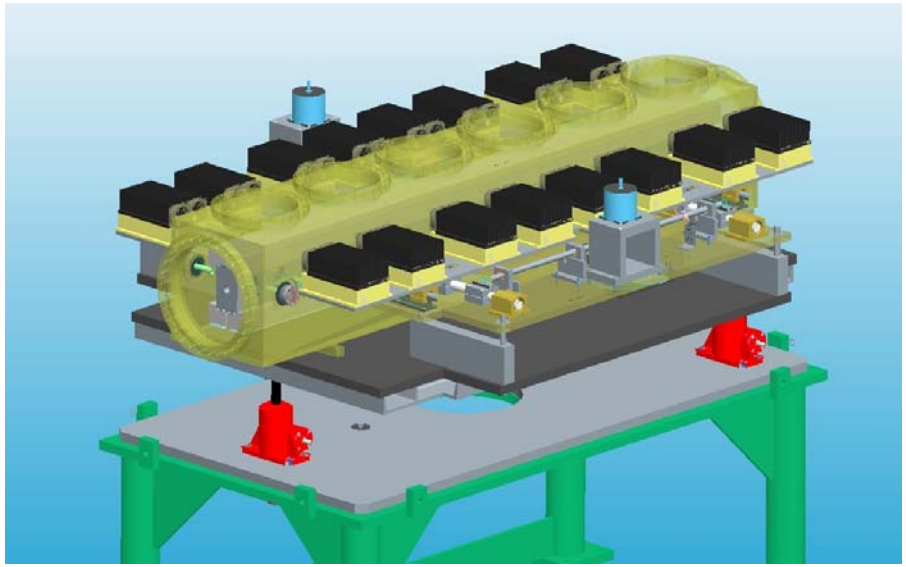
- We wanted to make a design that could be made commercially
- The cavity structure was essentially the same but the implementation was a new concept
- Mechanical tolerances at 8 GHz are challenging.

  0.001” = 1 bandwidth
- The new design benefits from this experience

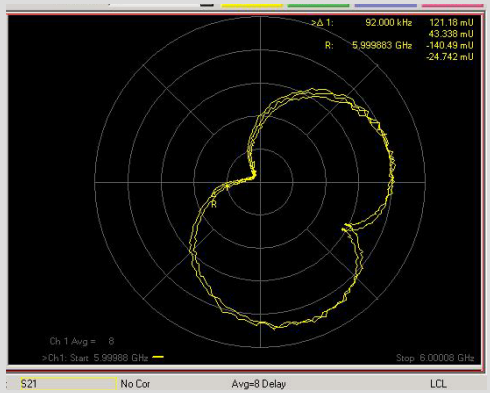
Yellow Vertical Kicker in the Tunnel



Kicker installed in the tunnel

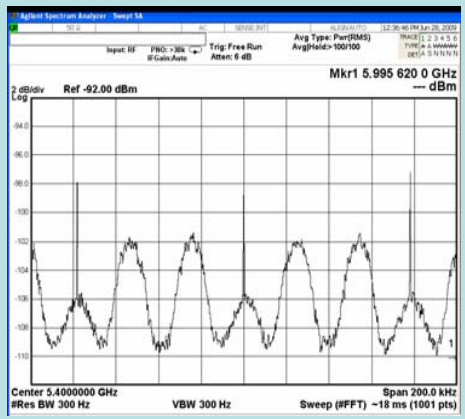


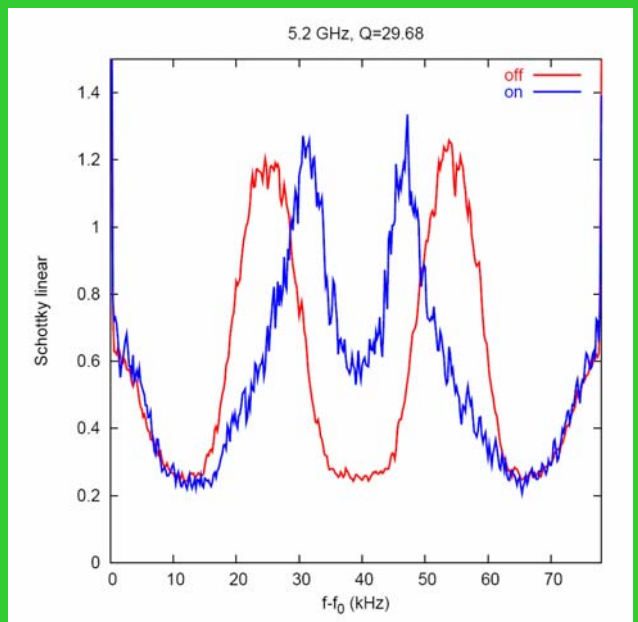
Computer model, with power amplifiers



- The kicker “machine” worked reliably, ie: all the microwave cavities tuned to correct frequencies
- The Beam Transfer Function measurements showed that we have sufficient kick voltage
- Vacuum rf feedthru problem was resolved with an in-house design

- The pickup problems encountered in the previous run were corrected
- Acceptable common mode rejection was obtained across the operating band (5 – 8 GHz)





Signal suppression was achieved with protons
(although the betatron phase advance was not correct for cooling ions)

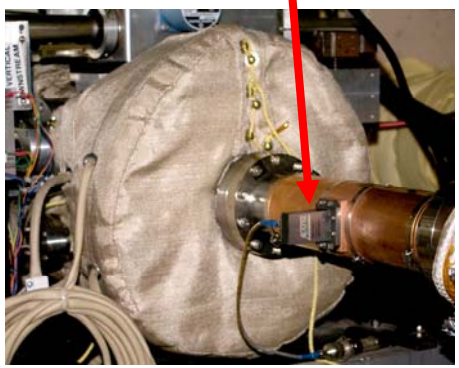
Work for this shutdown

System/Ring	Yellow	Blue
Longitudinal	1. Move to IP 12 2. Upgrade to 9 GHz 3. Install microwave link	1. Tested with deuterons 2008 2. New longitudinal pickup
Vertical	1. Tested with protons 2009 p-p 2. No changes	1. Will be installed 2009 2. Kicker is being assembled now 3. Will use last of the Tevatron pickups
Horizontal	Will be installed 2010	Will be installed 2010
Upgrade for 1.5×10^9 ions per bunch (only an idea)	Extend frequency range 6-12 GHz	Extend frequency range 6-12 GHz

Yellow Longitudinal Gets Upgraded

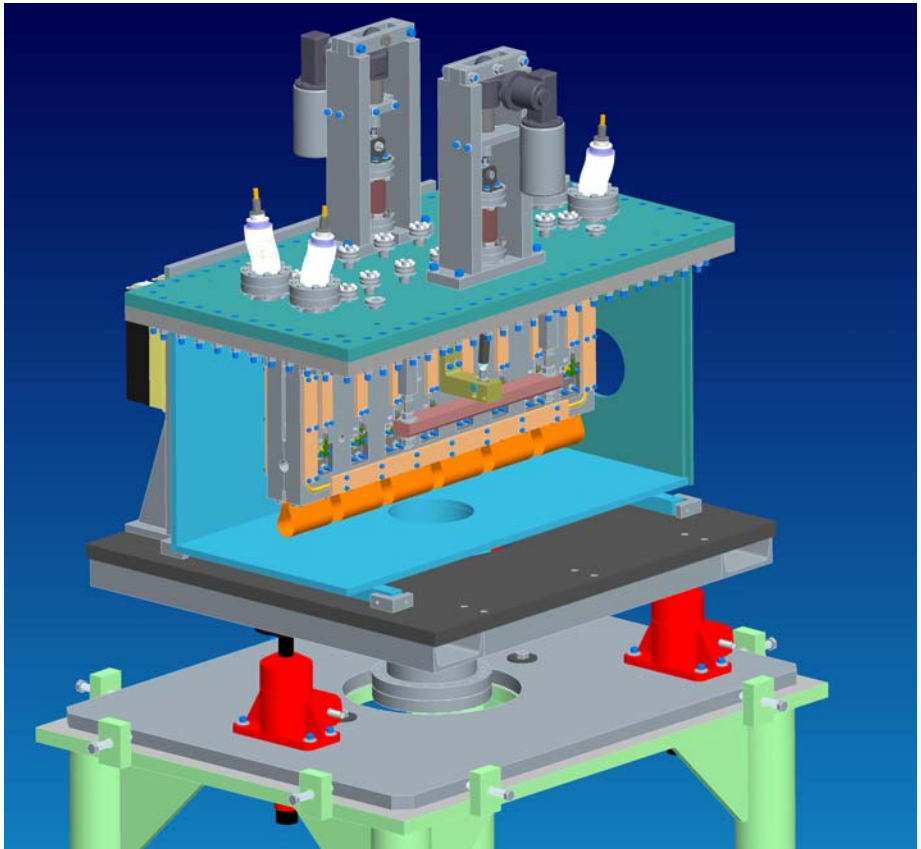
- Cooling in both longitudinal and transverse planes requires more bandwidth for the longitudinal plane
- Smaller transverse emittance increases IBS growth rate

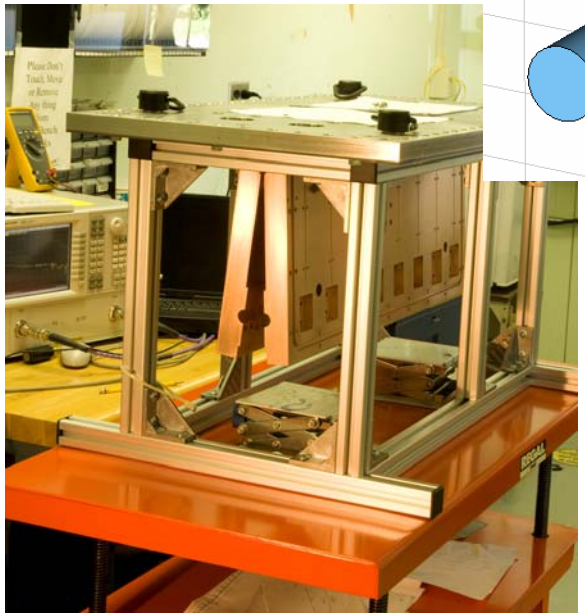
1. We will upgrade the Yellow frequency range from 5-8 GHz to 6-9 GHz
2. Also cut the chord with another microwave link
3. Kicker moves to 12 o'clock IP
4. Jettison the two-turn filter (halo cooling)
5. New longitudinal pickups for both Yellow and Blue

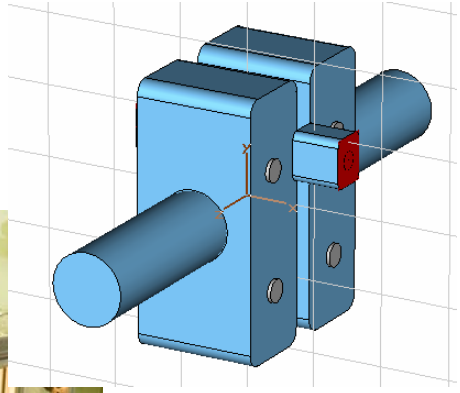


We Designed a new Kicker machine for Blue Vertical

- This design can be built commercially
- The tight tolerances of the microwave cavities were achieved by a commercial machine shop
- We will need to buy four more of these units the horizontal systems
- The accuracy of the beam alignment is design for “set and forget”. Experience has proved that we don’t have to chase the beam



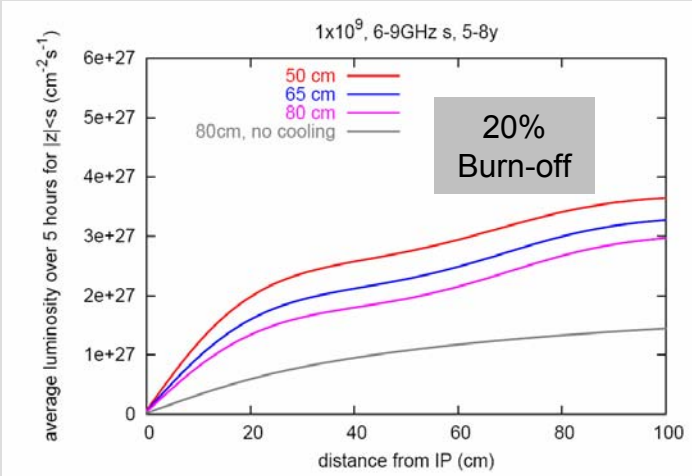


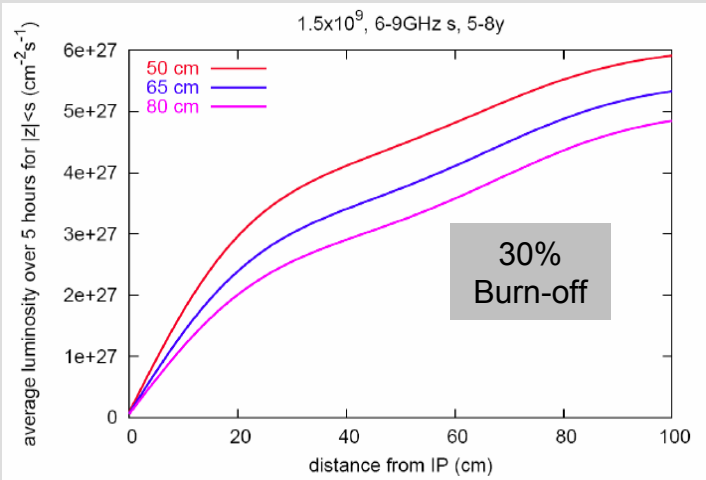


Deflecting cavity for transverse cooling operates in TM_{120} π-mode

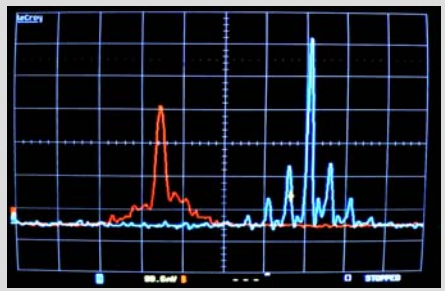
Luminosity Projections,
Average for a 5-hour Store,
As a function of distance from IP (±)

This year with 4 planes of cooling

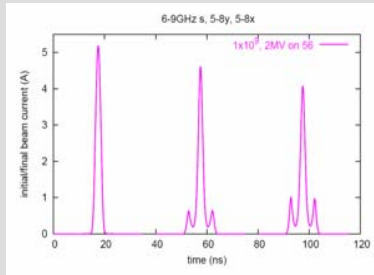




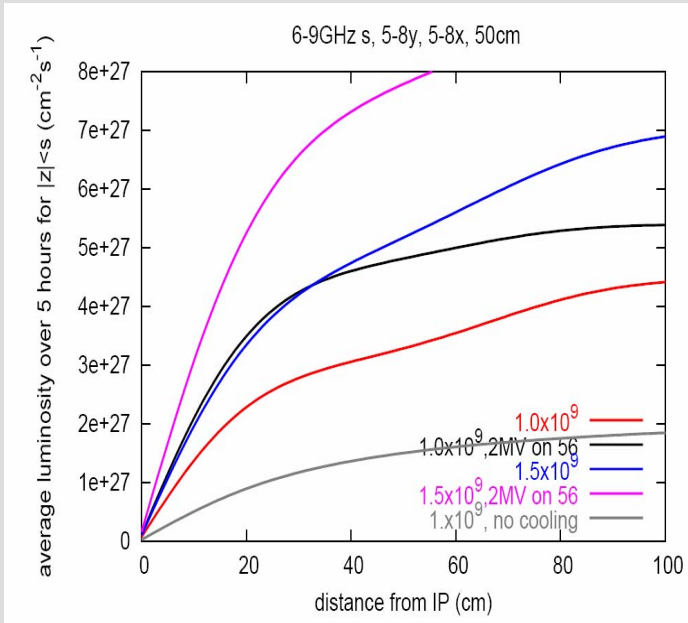
Six planes cooling AND 56 MHz Cavity



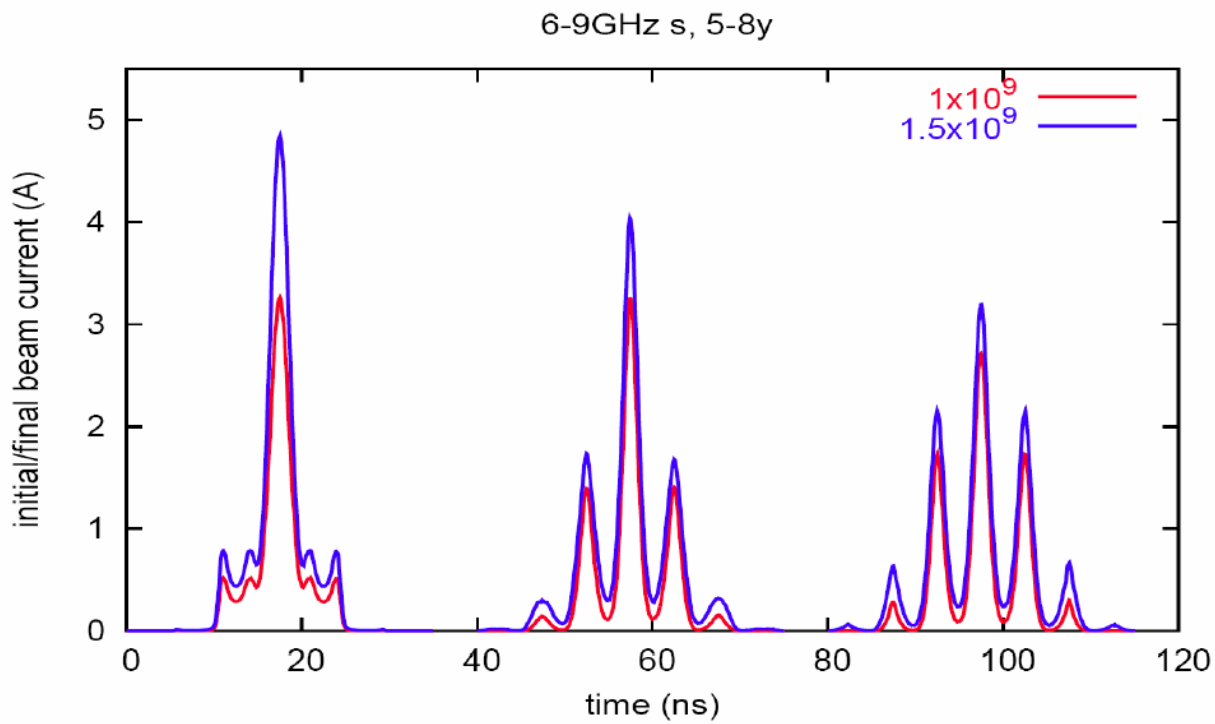
No 56 MHz



With 56 MHz



Satellite Bunches with four planes of cooling and no 56 MHz cavity



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Commissioning Plans

1. Initial checkout of pickups and microwave links
   - Beam at injection with reasonable lifetime
   - Some ring access likely (pickup electronics)
2. Real checkout needs beam at store
   - Need small beam size to close devices to small aperture
   - Rebucketed beam to get 5 ns bunches
   - Need reliable BPMs at Q4s
   - Set up software to read PIN diodes
3. Precise adjustment of pickup-to-kicker delays needs beam at store (six bunches is hard to see the gap)
4. We need to establish reference BTFs for each cavity (4 x16) for all four planes
   - One plane per shift is optimistic
   - The interaction between planes is something new. It likely will require iterating these reference BTFs
   - Commission the software that stabilizes these BTFs
5. Testing and refining TAPE sequences will be on-going as other systems come on line
   - rebucketing
   - Collimation
   - Orbit correction
   - Backgrounds/vacuum
   - We want to switch on cooling as early as possible in a store
6. Ring access will require some priority during commissioning (!)
7. A WILD GUESS……we would have all four systems running three weeks after we have stable beam at store

Conclusions

- We will have two planes of cooling in both rings for this year's gold-gold run
- All four systems will need commissioning with ions
  - Yellow longitudinal is the only system to have run with ions, but it will upgraded to higher bandwidth
  - Blue longitudinal and Yellow vertical have been tested with protons only
- We have designed a new mechanical device for opening and closing the kickers
  - The first one will go into operation this run
  - The design will be produced on the outside for the horizontal systems
- Luminosity projections, based on simulations, predict a luminosity of ~2.5×10^{27} $cm^{-2}s^{-1}$ within ±30 cm of IP