Stochastic Cooling Status and Plans

Mike Brennan and Mike Blaskiewicz

DOE RHIC S&T Review

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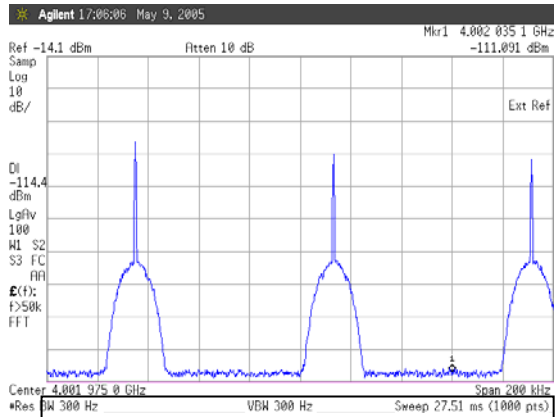
Outline

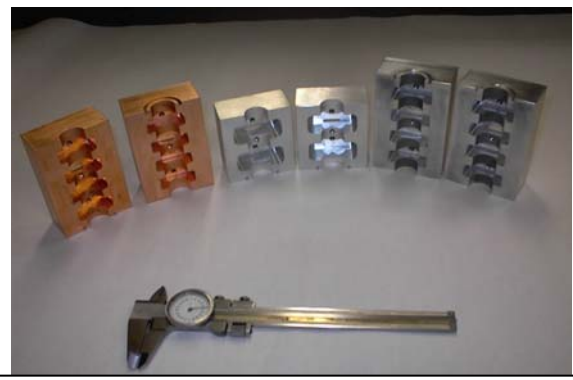
- Background
  - Why
  - How
- Results
  - Cooling tests with protons
  - Operational cooling for Gold
  - Development of microwave link
- Status
  - Technical problems
  - New filter concept for transverse cooling
  - Progress on new installation
- Plans
  - Luminosity projections
  - Full system layout
  - Ideas for extending performance

Background

- Why RHIC needs cooling
  - IBS causes spontaneous beam heating
  - Emittance growth reduces luminosity
  - De-bunching causes beam loss
  - Cooling counteracts IBS heating
- Why are we just now building Stochastic Cooling?
  - **Bunched-beam** stochastic cooling is required
  - Until now bunched-beam S.C. has been problematic
  - Coherent components in the Schottky spectrum are the obstacle
- Technical innovations developed here
  - System bandwidth of 5-9 GHz, cooling time of ½ hour
  - High Q cavity kickers use 20 Watts each
  - Fiber optic components at 9 GHz,
  - (electro-absorption modulator)
  - Bunched beam filters, to reduce dynamic range in signal



Coherent components on top of Schottky signal



High-Q cavity kickers, 200 MHz spacing, 10 MHz bandwidth

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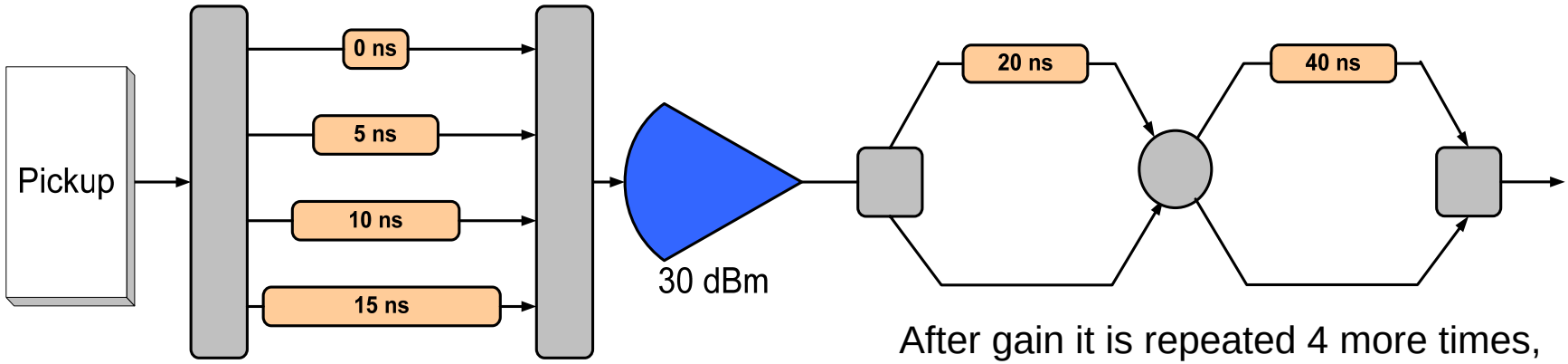
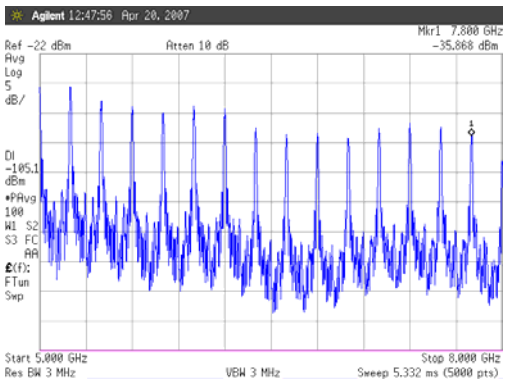
Solution to the Coherent Line Problem



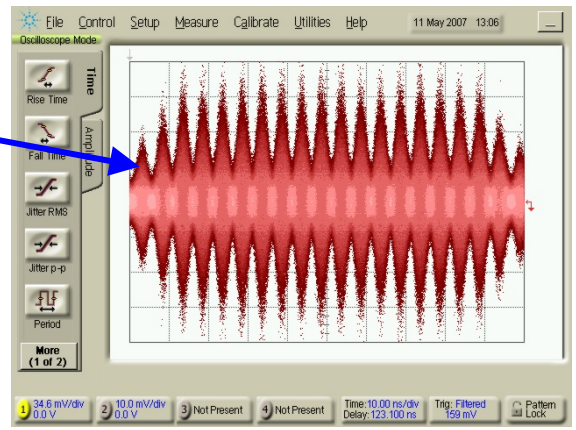
The 5 ns bunch signal is split and repeated 4 times, reducing the peak by 1/4

After gain it is repeated 4 more times, to 80 ns. The time between bunches.

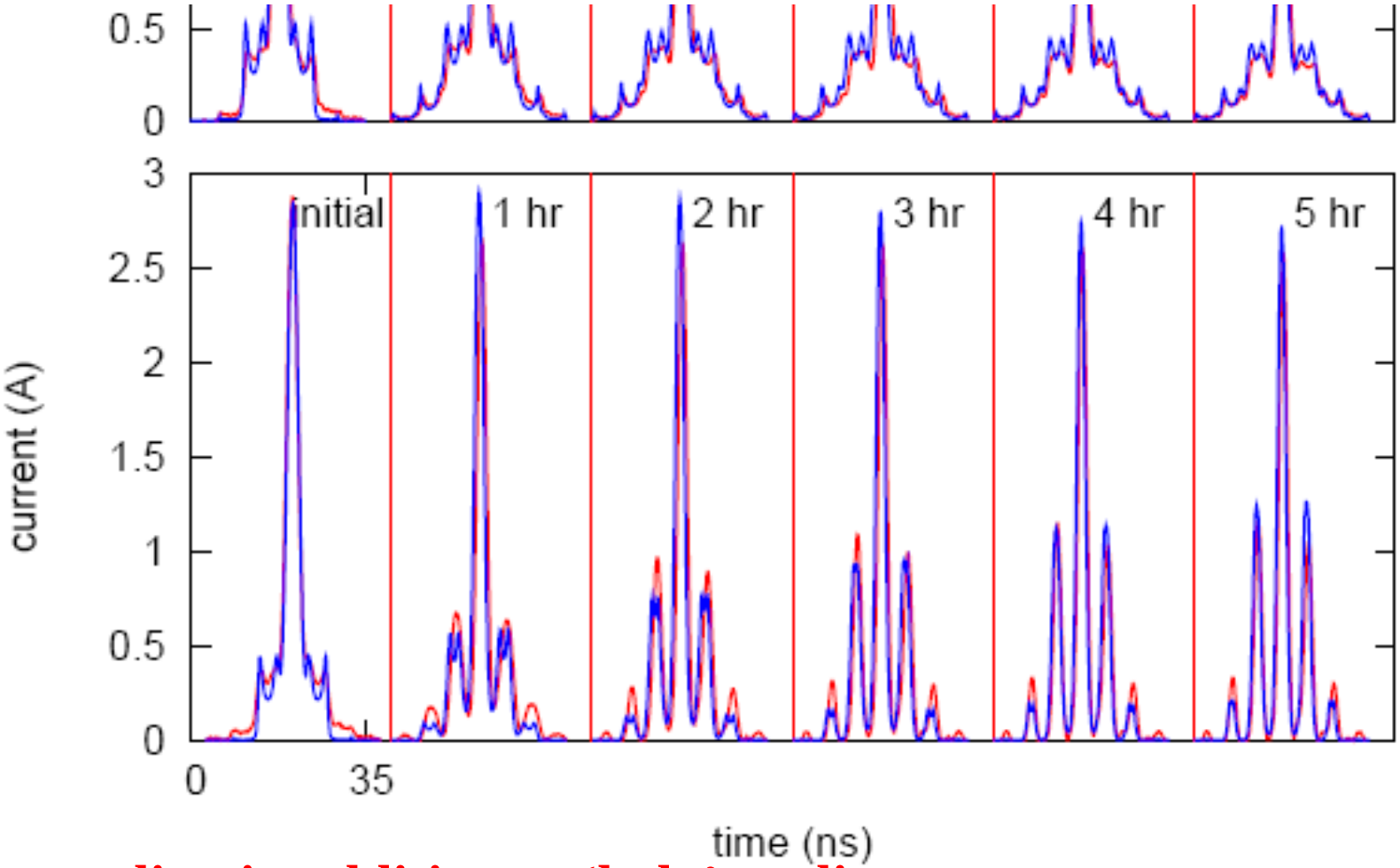


Time domain

Frequency domain



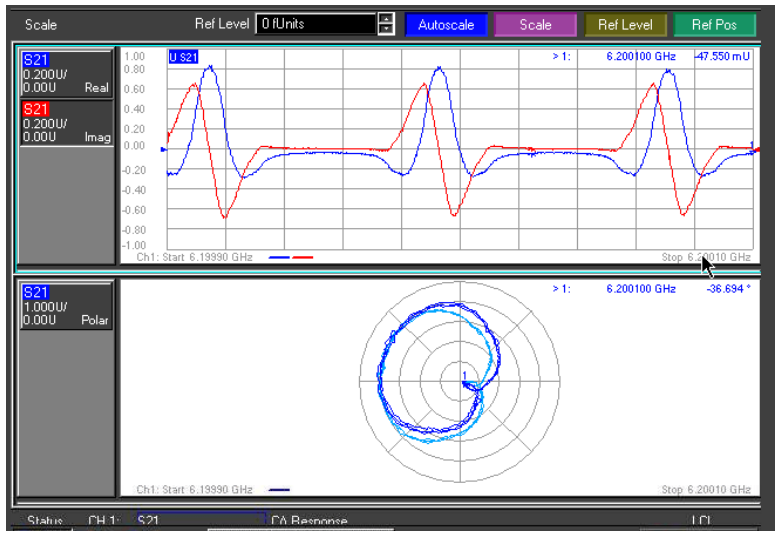
Results



Core cooling in addition to ‘halo’ cooling

Results

- Cutting the chord is the key to longitudinal cooling
  - "bad mixing" with 2/3 turn delay limits cooling
  - Strong longitudinal cooling is needed when cooling the transverse plane
  - Using the microwave link to "cut the chord" saves big$
  - Beam Transfer Functions and Signal Suppression were measured with deuterons in the Blue ring

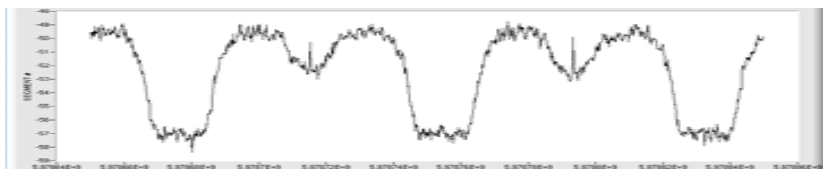


System Beam Transfer Function with Deuterons and Microwave link

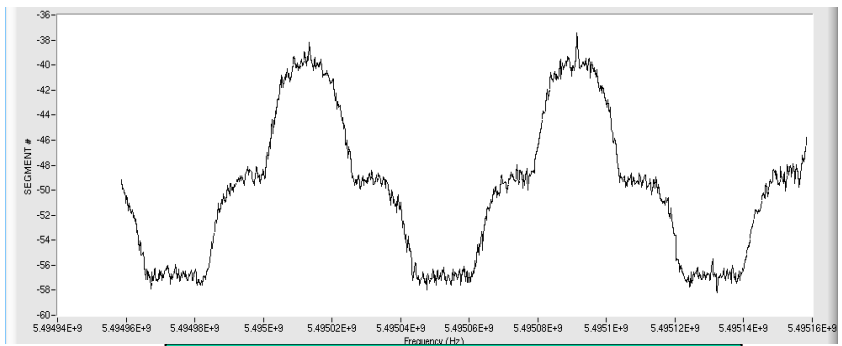
Results

- Many rf vacuum feedthrus leaked (will be replaced with new in-house design)
- Using the Tevatron planar loops pickups for the transverse system
  - We have not been able to get good common mode rejection over the full bandwidth
  - Good common mode rejection is necessary for transverse cooling
  - This imposes more severe demands on the performance of the fiber optic filter
  - We need to repair these pickups and eventually develop a new pickup

Revolution line is balanced out

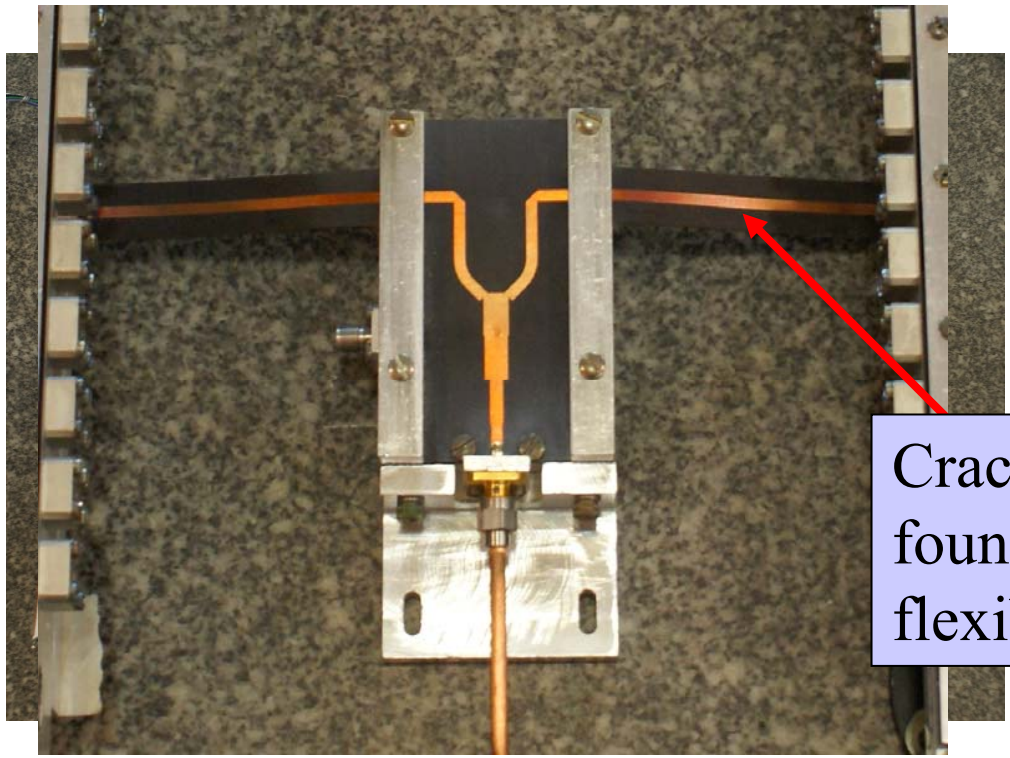


Transverse signal from yellow pickup at 6.0 GHz

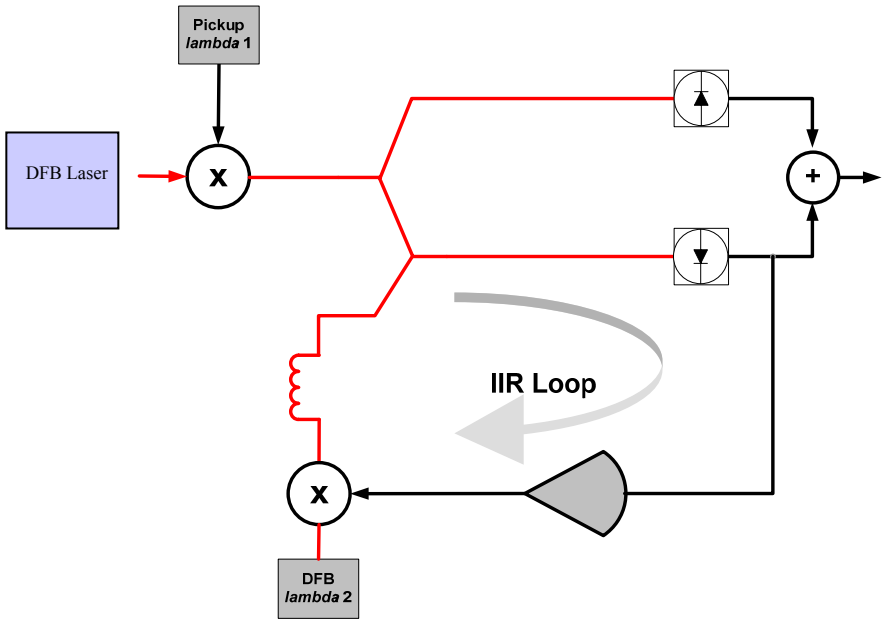


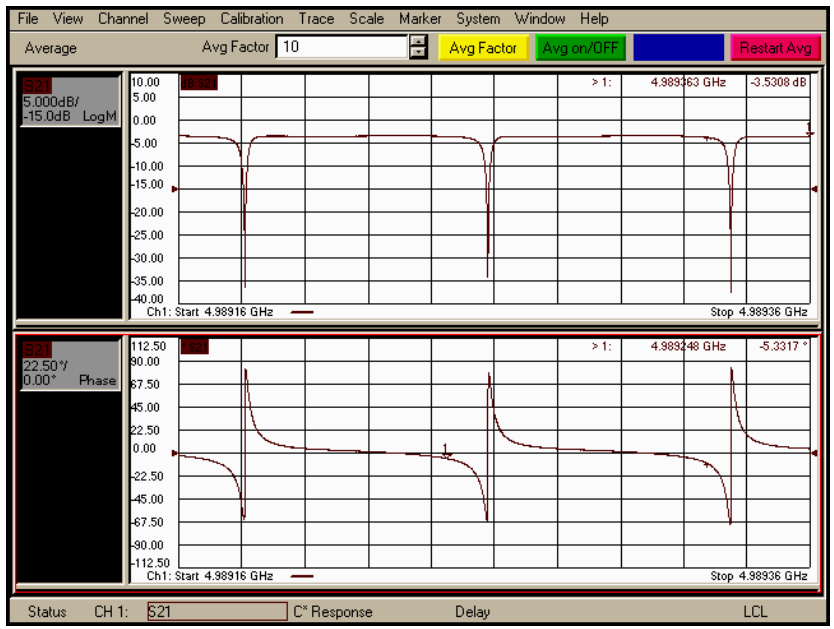
Same pickup at 5.5 GHz

Problem with Planar loops was found after the run



Filter is realized with a Fiber Optic Network

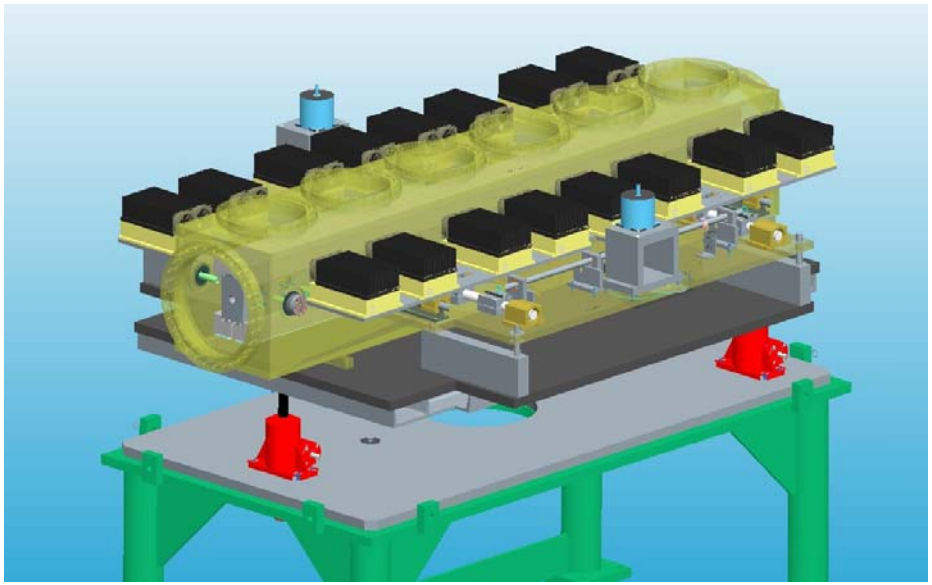




Filter rejects coherent line with no phase change at betatron lines

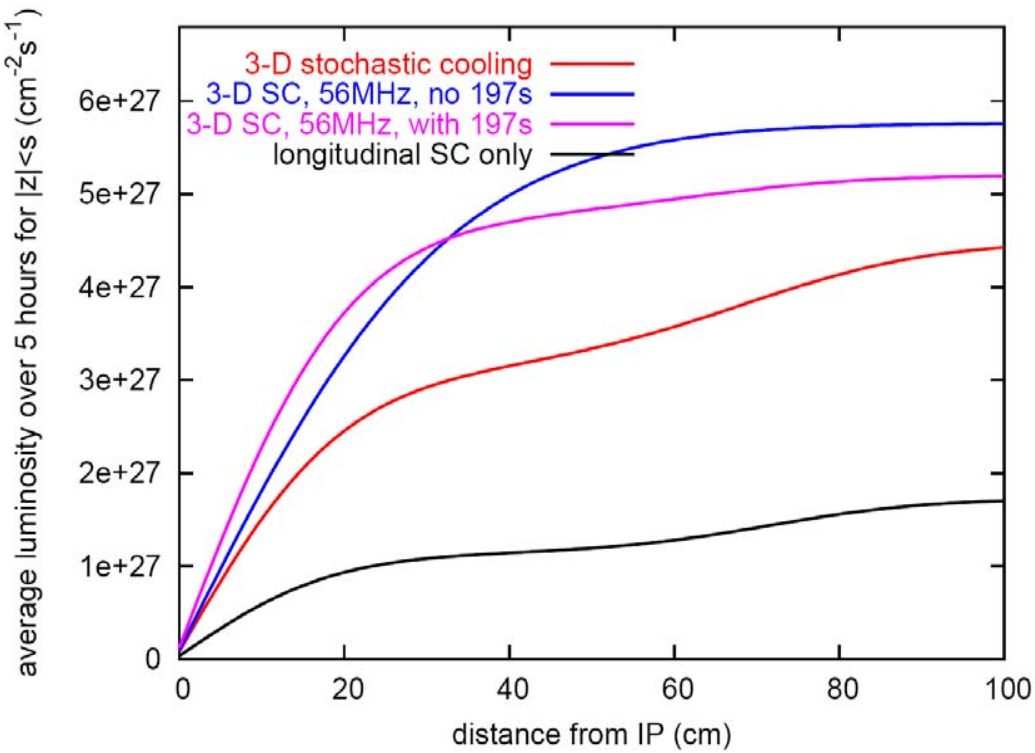
Status

- Technical problems arose during the FY08 run
  - Vacuum leaks in rf feedthrus
  - Motors that move the pickups and kickers got stuck
  - The transverse mode of the pickups did not reject the closed orbit signal
- We have designed and built a new kicker structure for the next system
- Low level electronics will be housed in a trailer relocated from the BRAHMS experiment



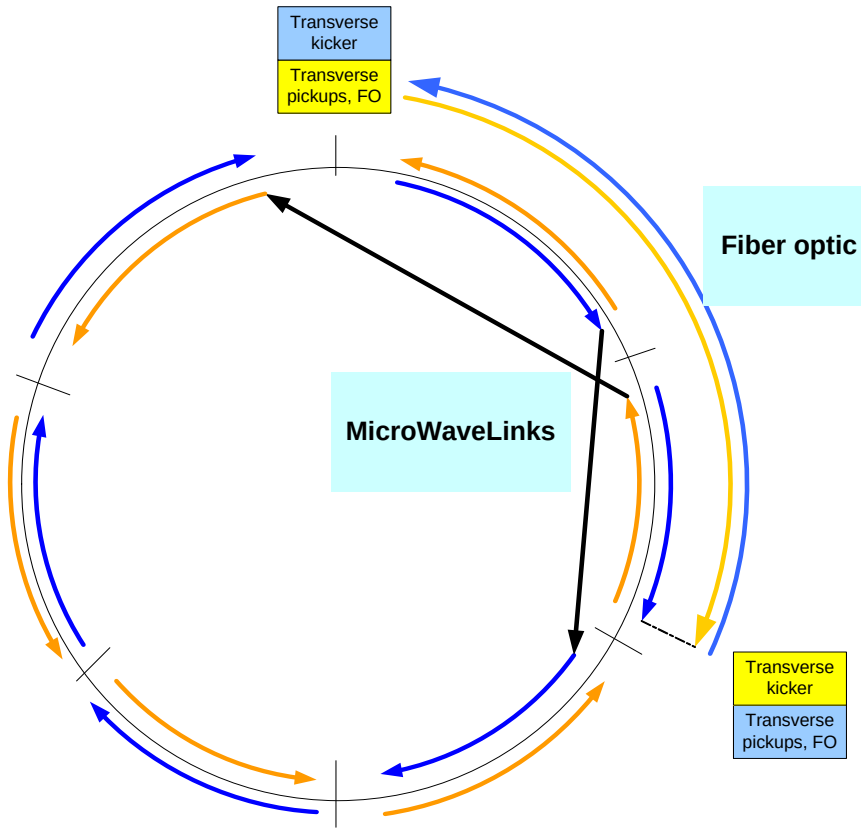
Expected Luminosity as a Function of Vertex Length

- What will the full system produce for luminosity and vertex
  - Calculation by Blaskiewicz
  - 1 x10^9 ions per bunch
  - 0.5 meter β*
  - Implication that 56 MHz cavity is needed
  - With 56 and 197 MHz systems 50% of luminosity is within ±10 cm vertex



Layout of Longitudinal and Transverse Cooling Systems

- Layout on the rings for complete stochastic cooling system
  - We implement the vertical transverse system first because of the 10 Hz closed orbit oscillations
  - Cut the chord for longitudinal
  - We will get started on the Yellow microwave link this summer
  - The upgraded Yellow longitudinal kicker will need a small building to house low-level electronics



Plans

- New ideas
  - We'll need new pickups to go beyond vertical transverse cooling
    - We could copy Fermilab's slotted waveguide pickups
    - We are testing a new concept of using commercial double-ridge-waveguide to coax adapters (appropriate for ions)
  - We would like to have two pickups per plane to accommodate any machine betatron tune
  - To go to 12 GHz we'll need kickers with 10 mm aperture
    - To achieve the same cooling time at 1.5 x 10^9 ions/bunch
    - Could be done with kickers at an IP
    - Offset Blue and Yellow beam vertically by 25 mm

Plans

- What can we accomplish during a pp run?
  - We can exercise the Blue longitudinal system and test repair of the pickups
  - We could cool a low-intensity test bunch (1%)
    - Learn about the effect of coupling on the un-cooled plane
    - We may learn if cooling in both transverse planes is necessary
    - Measuring transverse emittance of the test bunch will be difficult
  - We will not learn about IBS

Conclusions

- Cooling in the longitudinal plane is operational in RHIC
- We will have the first plane of transverse cooling operating in the next ion run
- We are ready to build the remaining planes when funds are available
- We can see possibilities for extending the capability to the cooling system by going to higher frequency (12 GHz)