Cooling Group

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Workgroup charge

- Establish the degree of confidence and accuracy we have in the simulations and theory of non-magnetized electron cooling. Examine the performance of this cooling technique for RHIC and evaluate potential difficulties. Establish a plan for continues R&D.

E-Cooling Modelling

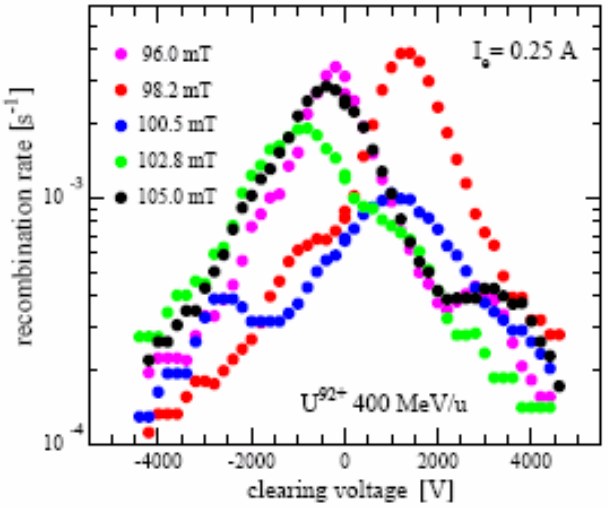
- VORPAL and Beta-cool codes appear to be adequate to describe the cooling process correctly. They serve different purposes.
- Main uncertainties in FNAL RR cooler come from uncertainties in electron beam parameters
- Effects of undulator on the cooling are treated adequately in the VORPAL and Beta-cool
- Effect of arbitrary (with constrains on field integral) dipole field errors along the cooling section on cooling should be studied by VORPAL
  - Coulomb log vs. temperature

Recombination and Undulator

- There is uncertainty in recombination rates at low ion-electron velocities for a given electron temperature
- There is no clear understanding of this discrepancy
  - Recombination seems not a problem for RHIC cooler (and causes 17% loss in integrated luminosity) with following caveats
- Undulator (8 cm, 10 Gs) definitely suppresses the recombination by at least an order of magnitude
- Undulator design seems to be straight forward and does satisfy requirements for the field accuracy

GSI: recombination suppression with transverse electron angle

excitation by electric kick



reduction of recombination rate
by more than a factor of ten

without degradation of cooling

→ poster session

Two-beam instabilities

- In-hand models for two-beam instabilities are adequate
- RHIC cooler is orders of magnitude below instability thresholds (for 5 nC and 1 cm long e-beam)
- It seems that there is no need for e-bunch stretcher
- Studies are needed to see if there is influence of short e-bunches on synchro-betatron resonance for hadrons
- Instability may occur for coolers with magnetized beams and solenoidal field
- Potential explanation of FNAL RR emittance growth is developed by Burov (envelope oscillations)
- Princeton has a program which can be used to simulate emittance growth in FNAL RR

Additional Points

- Consider electron and ion trapping by both electron and ion (hadron) and related space charge effects
- Study influence of bunch-to-bunch charge and position variations in e-beam on emittance of hadron beam.
- Effect of arbitrary field errors along the cooling section on cooling
- Study sensitivity to errors in: transport channel, PS ripple, hysteresis effects, hadron bunch charge variation, etc. on matching of electron beam into the cooling sections (especially on the second pass)
- Space charge defocusing in cooling section must be counteracted by distributed short focusing solenoids (10 m apart, F ~ 1km). Study optimal spacing of lenses. Also study effects of non-uniform density profile on the defocusing effects.
- Put together a budget of angular errors a-la RR-cooler
- Investigate influence of transverse wake-fields of miss-aligned beams in the cooling sections (resistive wall and other impedances)

Possible Experiments

- Measure drag force at RR for currents from 0 to 100 mA
- Understand better properties of electron beam in RR cooler
- Test technique of drag force measurement by exiting coherent synchrotron oscillations by modulating e-beam energy with synchrotron frequency

Instrumentation

- The diagnostics plan presented seemed adequate
- Suggest to separate instrumentation into two parts:
  - Needed only for commissioning
  - Operational

Conclussions

- Very encouraged by the degree of detailed studies and analysis.
- We did not find any show-stoppers in the cooling scenario for the presented RHIC cooler design.