Response to Recommendations of last Machine Advisory Committee Meeting

BROOKHAVEN NATIONAL LABORATORY

Thomas Roser
C-AD Machine Advisory Committee Meeting
November 8-9, 2004

MAC Responses

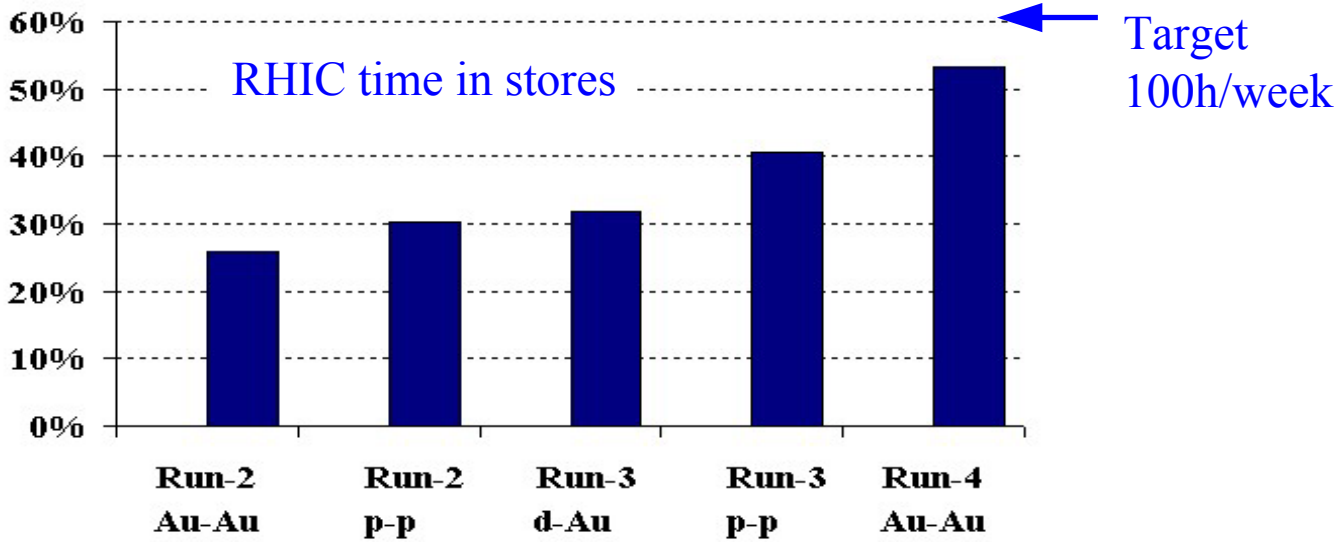
General Comments:

- "In view of the expected difficulties to achieve the ambitious performance goals, the committee would like to encourage pursuing the R&D vigorously. On the other hand, the success of the R&D program is uncertain. Therefore it appears to be vital to develop alternative solutions or fall back solutions for increased luminosity in RHIC."
  - IBS is a fundamental limitation for RHIC gold-gold luminosity increases beyond the "enhanced" level to be discussed at this review
  - Recent detailed confirmation of IBS calculations in RHIC. Transverse emittance growth is strongly dependent on dispersion.
  - Only electron cooling can provide x 10 luminosity increase
  - Additional improvements are being pursued:
    - Stochastic cooling (x ~ 1.5)
    - Reduced dispersion (x ~ 1.5)
    - Reduced beta-star (x ~ 1.5)

MAC Responses

RHIC performance:

- "The committee would like to mention that despite the impressive achievements there is room for improving the overall efficiency, the accelerator availability, and the time between physics runs. A systematic assessment should be undertaken to identify the reasons for inefficiencies and every effort should be made to remove sources of inefficiencies."
  - The systematic effort to improve RHIC availability and efficiency is continuing.
  - A specific plan for RUN-5 was developed at the annual RHIC retreat (June 7-9, 2004). Goal is 60% of calendar time at store.



MAC Responses

RHIC performance:

- "The present RHIC performance is limited by beam induced vacuum breakdown. As a possible cure, NEG coating of the warm beam pipes in Sector 8 of the machine is proposed. The committee considers this a promising measure to overcome the performance limitations. However, the committee encourages the RHIC team to pursue the efforts to better understand the sources of the vacuum problems in Sector 8 before any concrete steps in this direction are taken."
  - Simulations show that RHIC vacuum problems can mostly be explained by electron cloud formation.
  - See talk by W. Fischer during this review

MAC Responses

Stochastic Cooling at RHIC:

- "The committee proposes to consider a number of further investigations to assure the success of a bunched beam cooling program:
  It is proposed to determine the viability of the project, and to quantify luminosity increase per cost of the stochastic cooling system.
  Furthermore, the cooling task force should consider staging the ambitious project as a series of subsequent upgrades."
  - First stage cooling test planned for the upcoming run.
  - See talk by Mike Blaskiewicz during this review for status of RHIC stochastic cooling effort.

MAC Responses

Electron Beam Ion Source Pre-Injector:

- "The committee strongly recommends launching a project as soon as possible to replace the present Tandem facility by an EBIS source followed by the RFQ and 2 MeV/u LINAC."
  - Strong support by MAC was very helpful
  - CD0 has been awarded on August 2, 2004
  - First project funds could be available in FY2006
  - Final R&D and CDR update are underway

MAC Responses

Electron Cooling (benchmarking simulations):

- "The committee considers an improved agreement between experimental and calculated cooling times a challenging but mandatory task, which has a direct impact on the possible luminosity improvement factor. The committee suggests strengthening the effort in the laboratory to support the corresponding activities and encourages strongly further collaboration with other electron cooling laboratories."
  - Improved agreement between experimental and calculated cooling times is one of the main tasks of the RHIC Electron Cooling Group. RHIC IBS measurements and theory have been brought into better agreement, up to the precise determination of the dispersion in RHIC.
  - BNL signed an additional MOU on electron cooling R&D with GSI. First benchmarking experiment at Celsius scheduled for December 2004, additional beam time proposal submitted.
  - Additional human resources have been put into the calculation effort

MAC Responses

Electron Cooling (magnetized beam transport):

- "The results should be checked using another computer code to assure the accuracy of the solution. One of the potential sources of simulation errors is the space charge calculation in the low energy part.
  As the success of the electron cooling project depends critically on the novel scheme of beam transport the committee suggests to consider a proof-of-principle demonstration of the concept on an existing facility before the complete demonstration takes place in the ERL prototype."
  - Work on implementing two other codes are in progress. ASTRA is being installed on a UNIX cluster for comparisons. A MARYLIE/ IMPACT version with more capabilities is being developed.
  - Simulations will be made to find in which facility one can run an experiment with similar magnetization AND space-charge conditions. At this point in time it is not clear if there is such a facility before the R&D ERL will be completed.

MAC Responses

Electron Cooling (effect of s.c. cavity):

- "The committee suggests furthermore including studies of the effect of transverse kicks from the super-conducting RF cavities on the beam emittance."
  - A study of the effects of the transverse kicks has been started by simulations. Experimental test will be carried out in the R&D ERL.
  - MAFIA simulations have been carried out on the effect of the coupler kick. The results are satisfactory, due to the very large beam tube diameter.

MAC Responses

Electron Cooling (full simulation):

- "The committee however can see that a large detailed study program still needs to be performed. The committee is concerned about whether there is sufficient understanding of the interplay of IBS, beam-beam effects, wake fields and bunched beam electron cooling."
  - A large detailed study using UAL has been started. The code will bring together RHIC dynamics, IBS, beam-beam and cooling under one unified framework. Plans are being developed to use a massively parallel computer for this purpose.

MAC Responses

Electron Cooling (scaling to RHIC parameters):

- "The committee would like to recommend intensifying the effort in performing systematic comparison of theoretical models with experimental results obtained at existing electron cooler rings for the cooling forces and equilibrium beam parameters. Still it is unclear whether a satisfactory agreement with theory can finally be reached. Therefore the efforts should also focus on the scaling of experimental results obtained at low energy to the high-energy RHIC parameters."
  - RHIC IBS measurements and theory brought into better agreement, up to precise determination of the dispersion in RHIC.
  - First benchmarking experiment on Celsius scheduled for December 2004, additional beam time proposal submitted.
  - Systematic comparisons of theory and experiment are planned and will be part of the collaboration with GSI. Initial program will be completed by December 2005, additional experiments will be planned following this initial phase.

MAC Responses

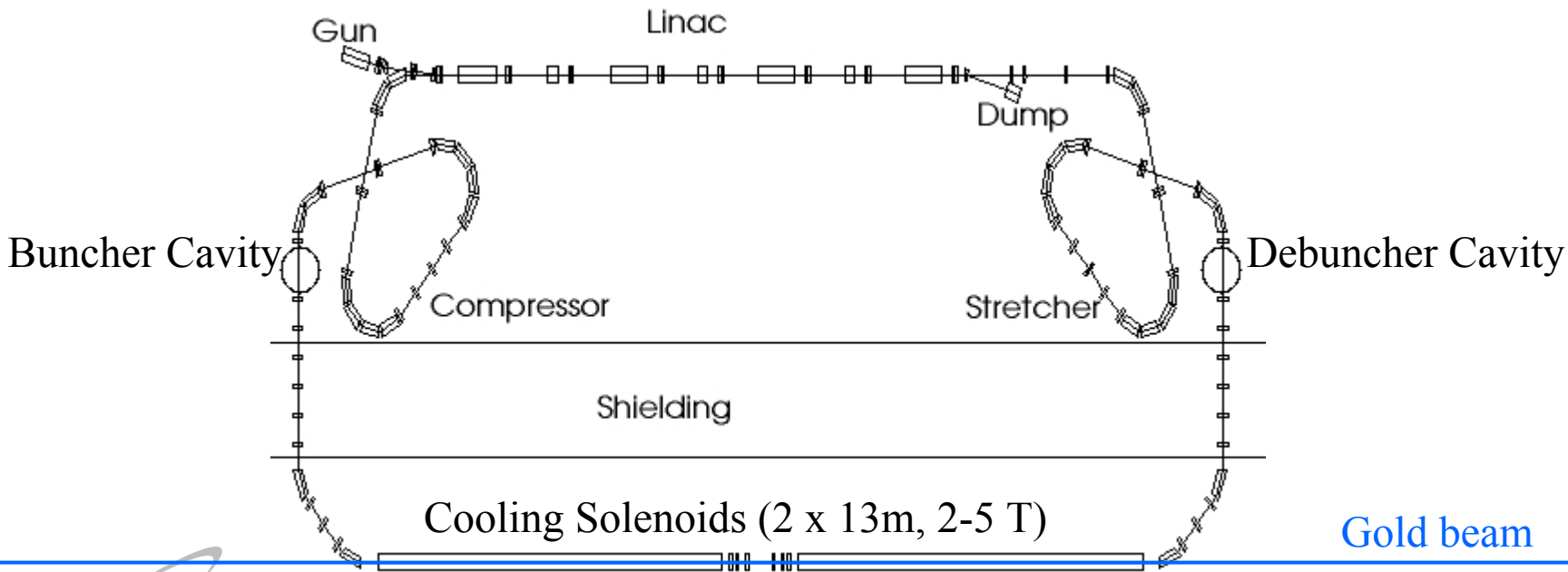
Electron Cooling (collective instabilities):

- "Of concern are also collective instabilities in the cooled beam. The experience in existing cooler machines shows, that the cooling efficiency can be limited by collective instabilities induced by ring impedances. An accompanying study should collect the relevant instability thresholds for the expected cooled beam parameters (Gold ions and protons) in RHIC. A broadband feedback system might be required to fight against (low to medium frequency) collective instabilities."
  - Collective instabilities will be part of the RHIC beam dynamics study with a cooler section.
  - A large detailed study using UAL has been started. The code will bring together RHIC dynamics, IBS, beam-beam and cooling under one unified framework. Plans are being developed to use a massively parallel computer for this purpose.

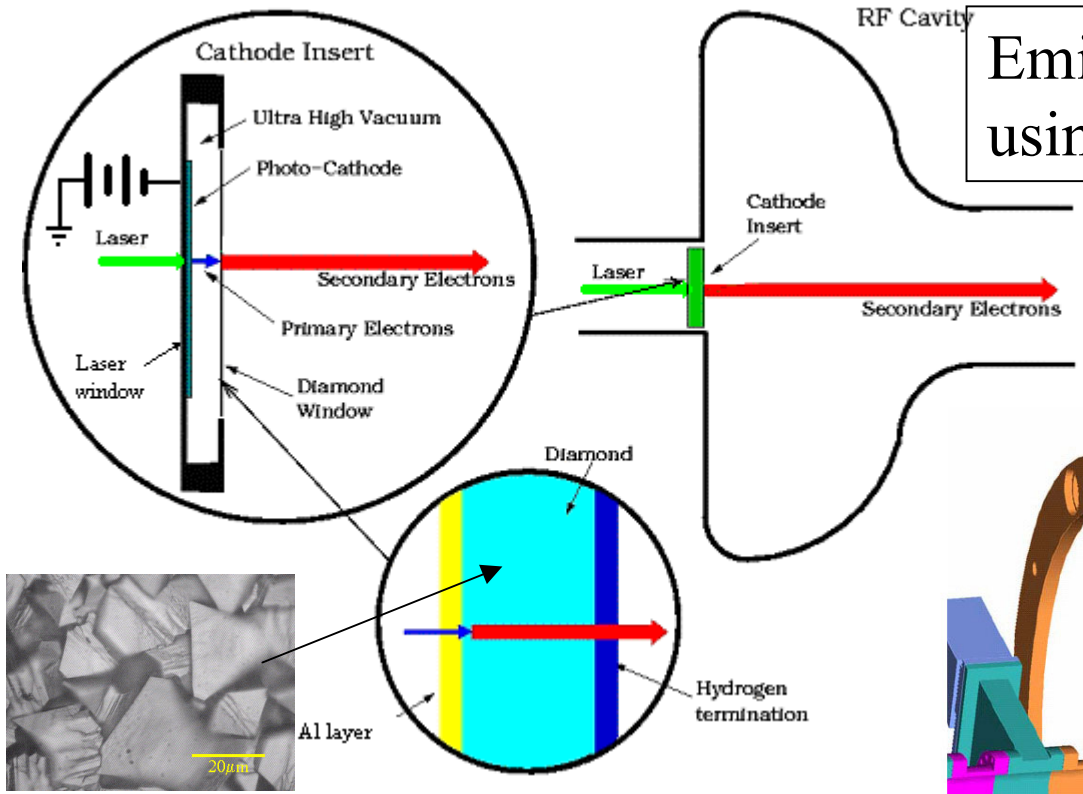
MAC Responses

Subsystems for Electron Cooling:

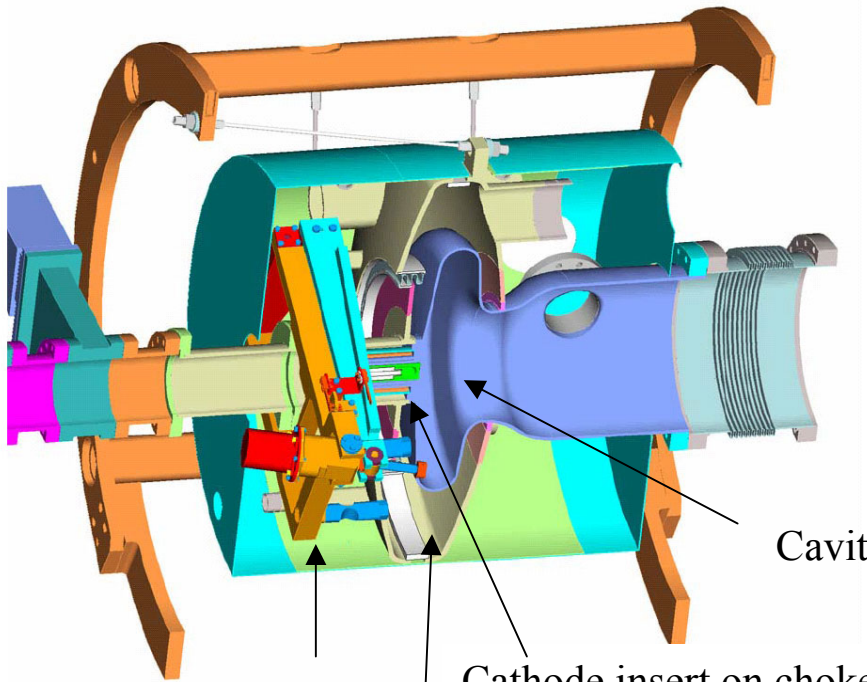
- Update:
  - A Zero'th order Design Report (ZDR) is in an advanced stage of preparation.
  - Improved modeling of cooling RHIC identified need for increased electron bunch charge (20 nC/bunch), higher solenoid magnetic field (5 Tesla) and better beam brightness (40 μrad).



CW Photo-cathode and Superconducting rf Gun R&D

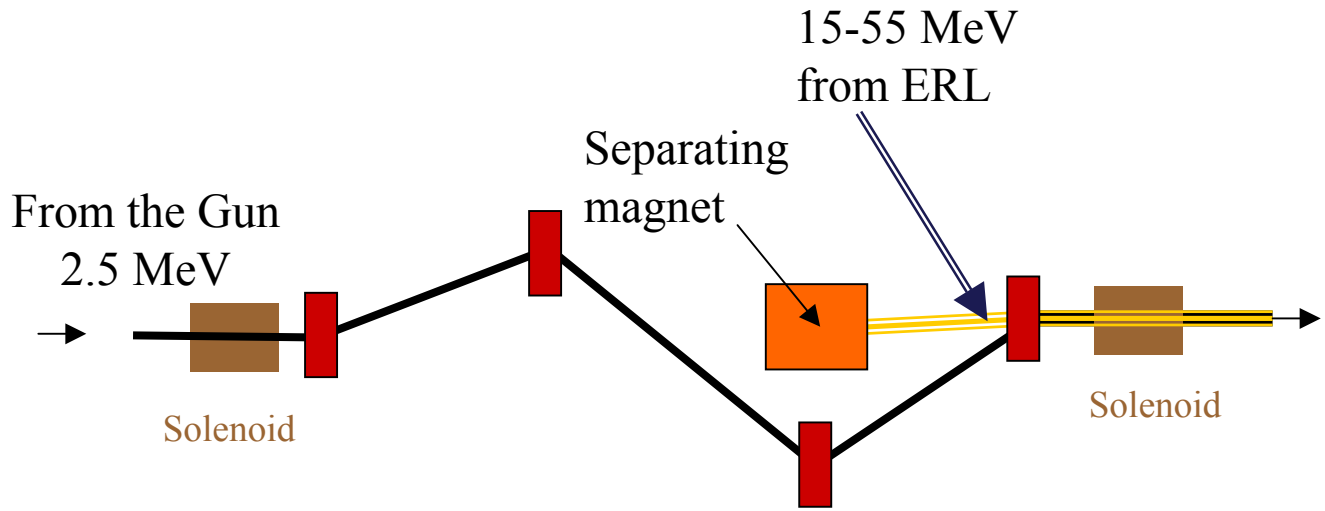


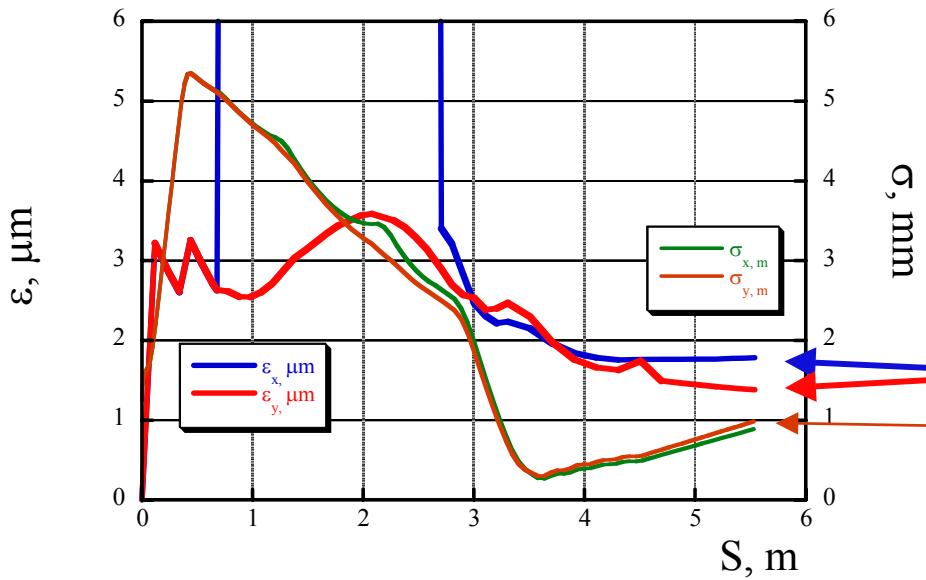
Emission enhancement (x 30-80) using a diamond window



Initial design for a superconducting gun with diamond amplified photo-cathode.

Optimized beam merging optics ("Z-bend")





Charge: 1.4 nC/bunch
Emittances at Linac entrance:
$\varepsilon_x \sim 1.7$ μm, $\varepsilon_y \sim 1.5$ μm

Emittances and
beam sizes
as a function of path length.