RHIC Electron Cooling
Collaboration Workshop, May 24-26, 2006

- Welcome! This workshop is important to us at RHIC and we hope that you will find it interesting.
- The workshop is targeted at the critical issues of the RHIC Electron Cooler:
  - Calculations of the performance of the cooler
  - The performance of the electron photo-injector
- Objectives
  - Enhance understanding and confidence
  - Generate Research & Development Plan

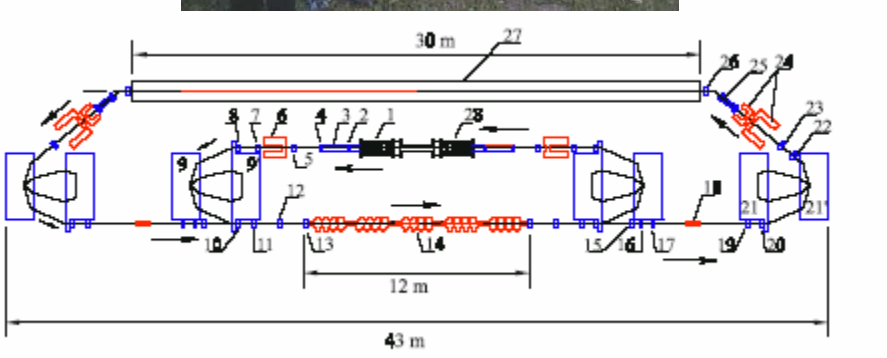
The goals of RHIC II (Wolfram Fischer)

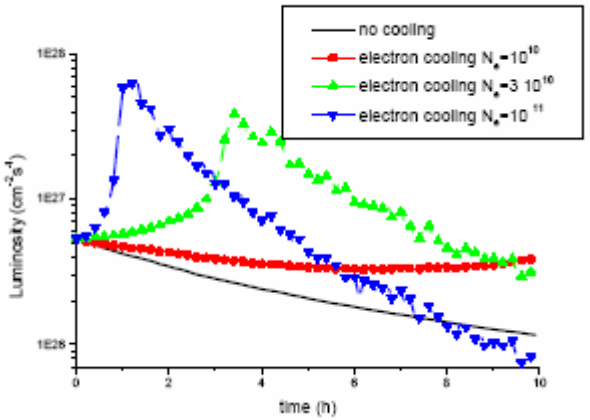
Quantity	Unit	Design 1999	Achieved 2005	Enhanced Design 2008	RHIC II ≥2012
Au^{79+} on Au^{79+}					
Beam energy	GeV/n		— 100 —		
Number of bunches	...	60	45	— 112 —	
Bunch population, initial	10^9	1.0	1.1	— 1.0 —	
β-function at IP	m	2.0	1.0	1.0	0.5
Peak luminosity	$10^{26}cm^{-2}s^{-1}$	12	15	32	90
Average store luminosity	$10^{26}cm^{-2}s^{-1}$	2	5	8	70
polarized p^+ on polarized p^+					
Beam energy	GeV	250	100	— 250 —	
Number of bunches	...	60	106	— 112 —	
Bunch population, initial	10^{11}	1.0	0.9	— 2.0 —	
β-function at IP	m	2.0	1.0	1.0	0.5
Peak luminosity	$10^{30}cm^{-2}s^{-1}$	15	10	220	750
Average store luminosity	$10^{30}cm^{-2}s^{-1}$	10	7	150	500
Average store polarization	%	–	46	70	70

Need e-cooling for these

Evolution of the cooler: 2000~2001 Budker jump-starts

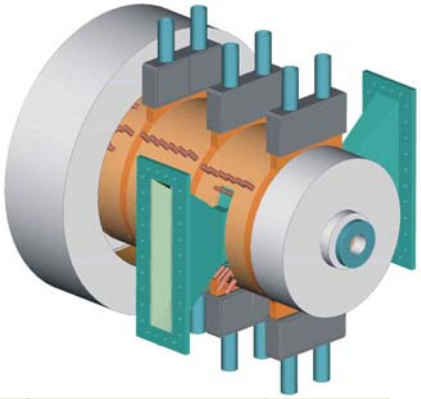
- The original design by BINP, led by V. Parkhomchuk
  - ~6 nC considered,
  - 120 mA ave. current
- 2 MeV DC gun
- 350 MHz SRF linac
- 1 Tesla solenoid

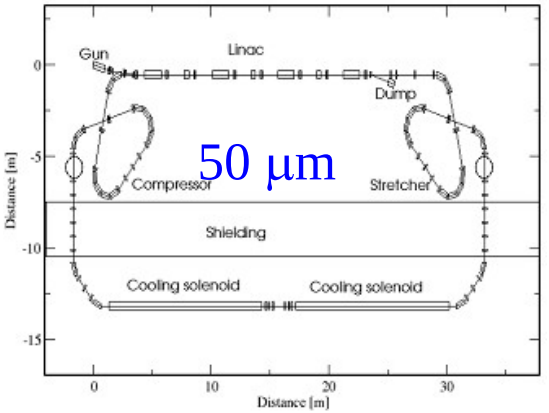


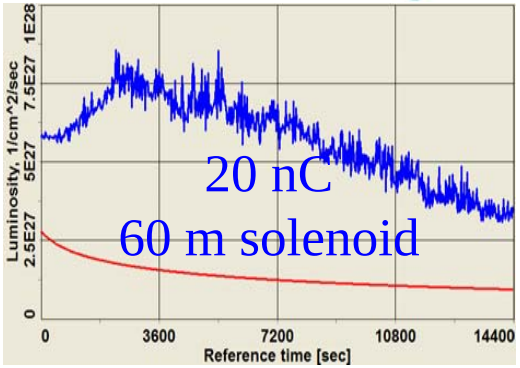


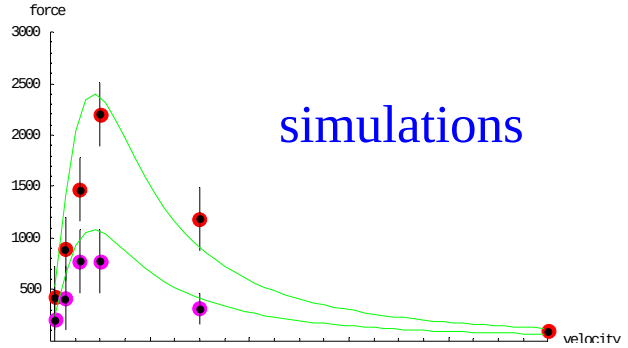
Evolution of the cooler: 2001~2005, magnetized cooling

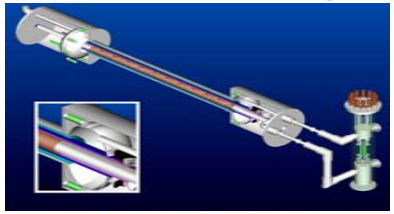
- JINR / BETACOOL
- Tech-X / VORPAL
- Benchmarking
  @ Celsius
- ERL development
- Beam dynamics
- Solenoid design

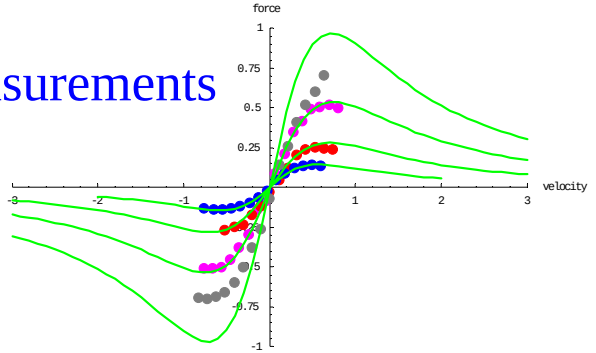






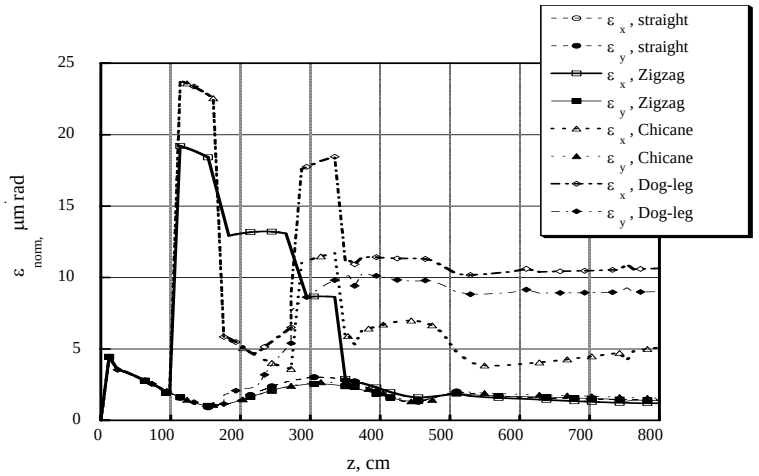


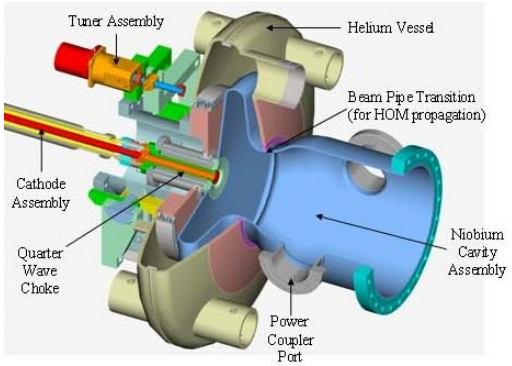




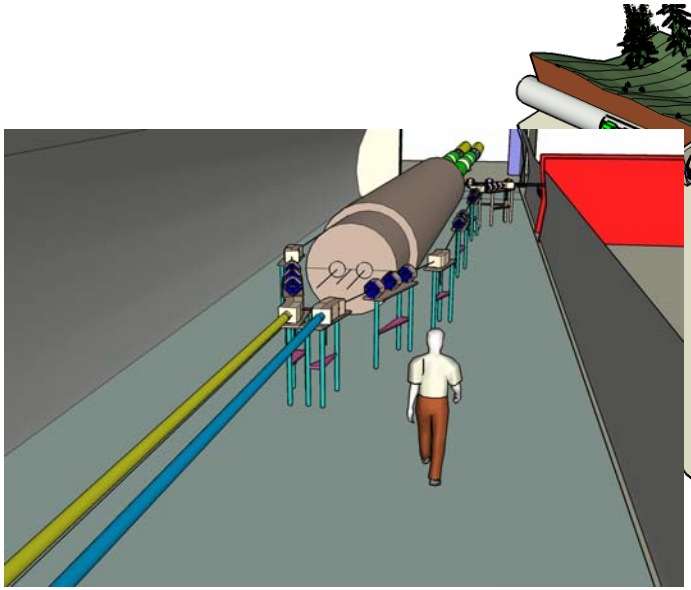
Evolution of the cooler: 2005~2006 Enter non-magnetized cooling

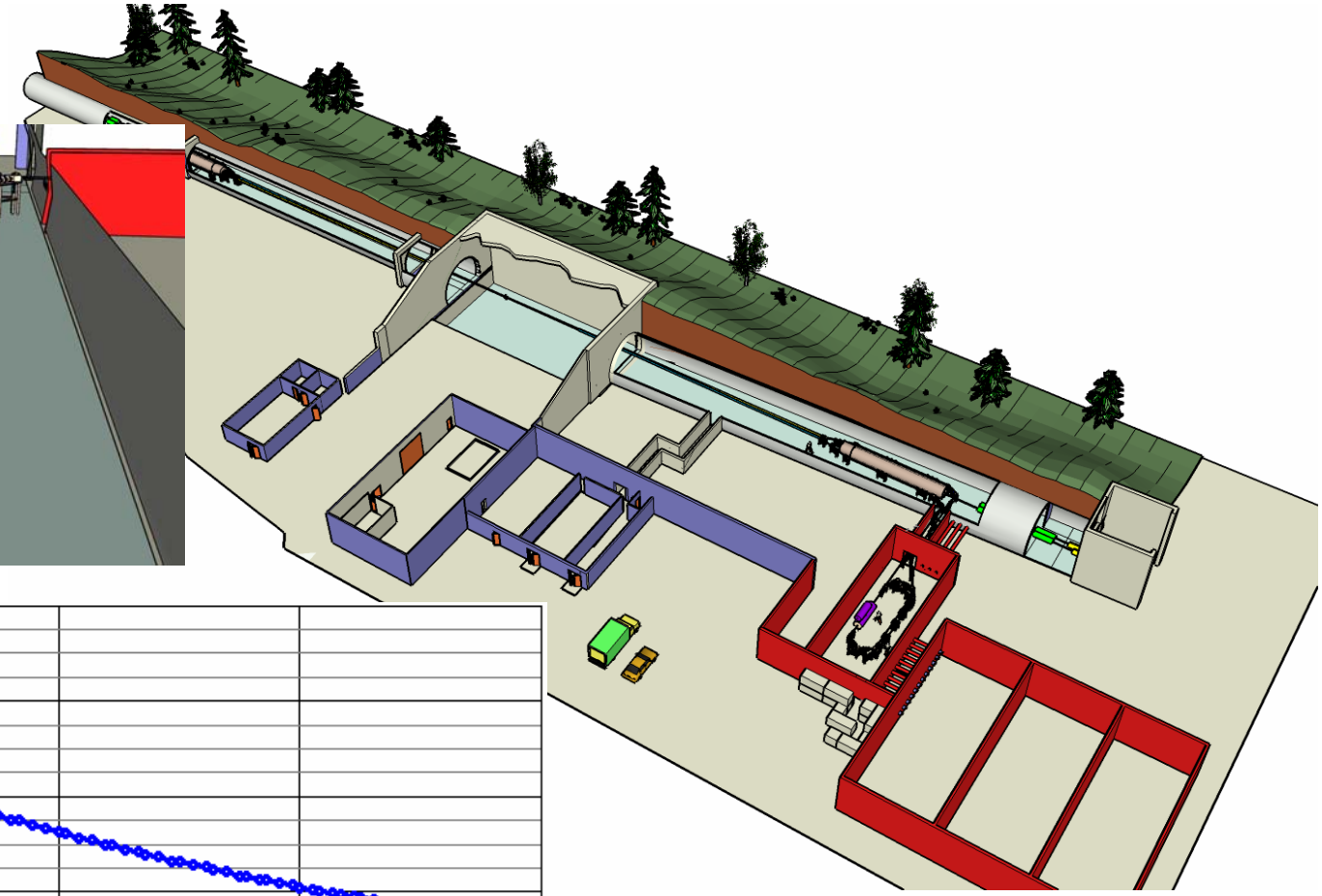
- Originally suggested by Derbenev
- Becomes possible with good brightness thanks to:
  - SRF gun
  - Z-bend
- Proof-of-principle at FNAL recycler

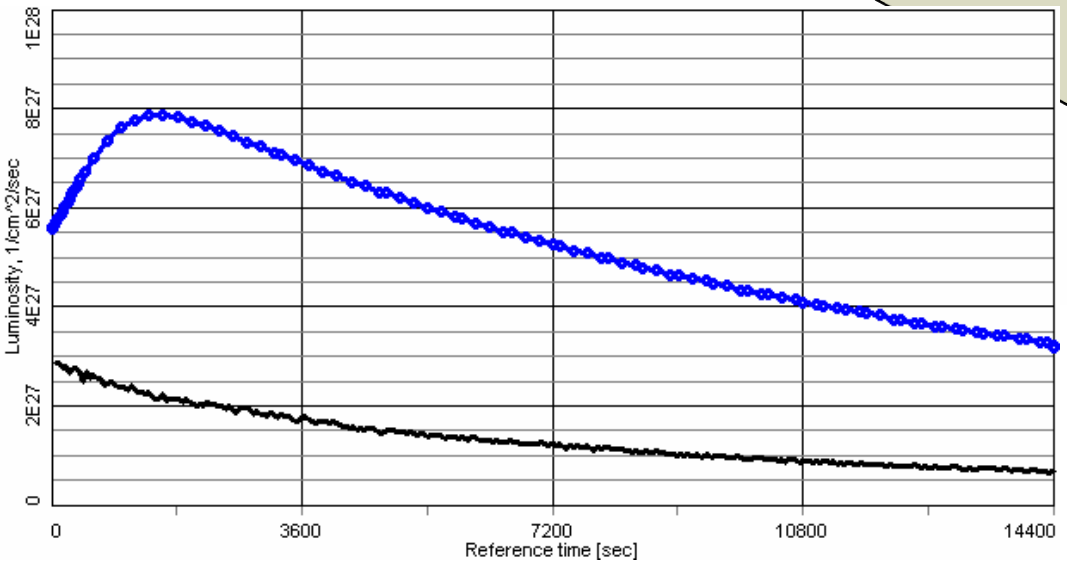




The current layout of the cooler in RHIC

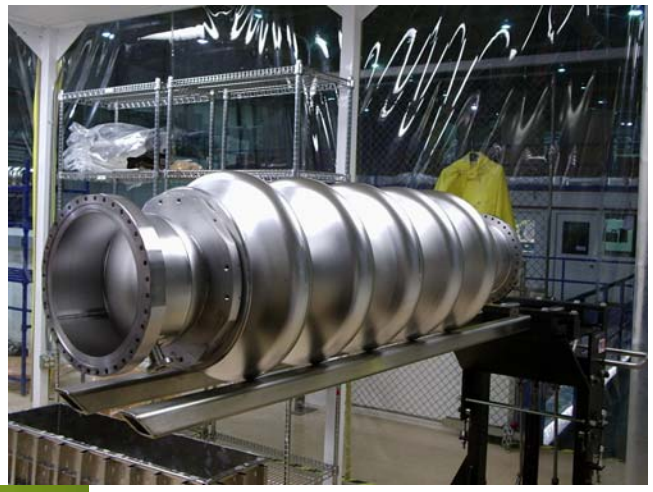


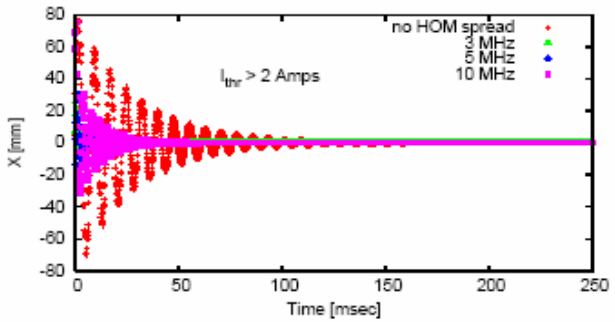


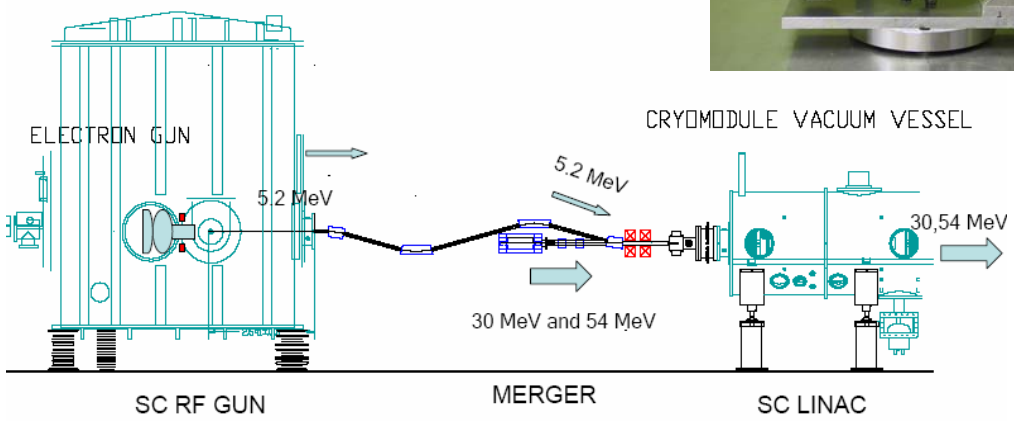


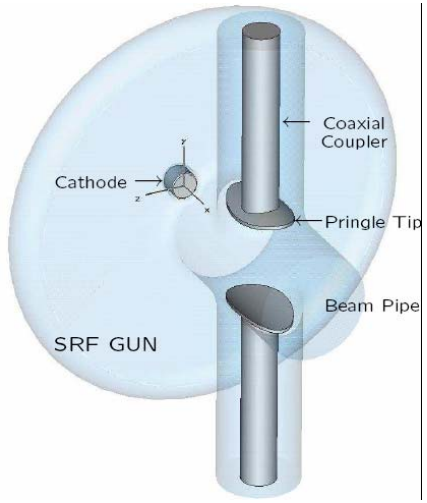
R&D on ERL and beam dynamics

- Ampere 5-cell cavity
- Z-bend
- SRF gun



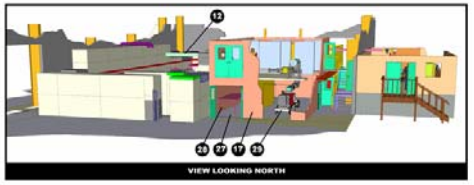


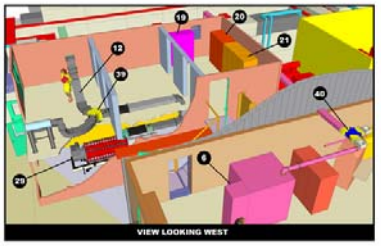


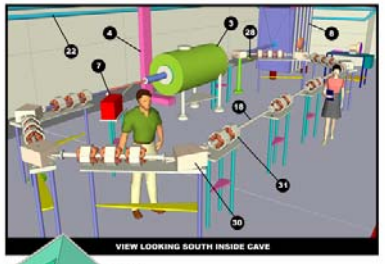


ERL


VIEW LOOKING EAST (ROOF CLOSED)


VIEW LOOKING NORTH


VIEW LOOKING WEST

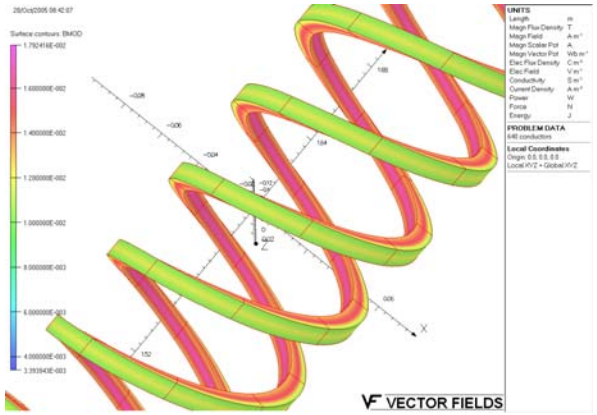

VIEW LOOKING SOUTH INSIDE CAVE

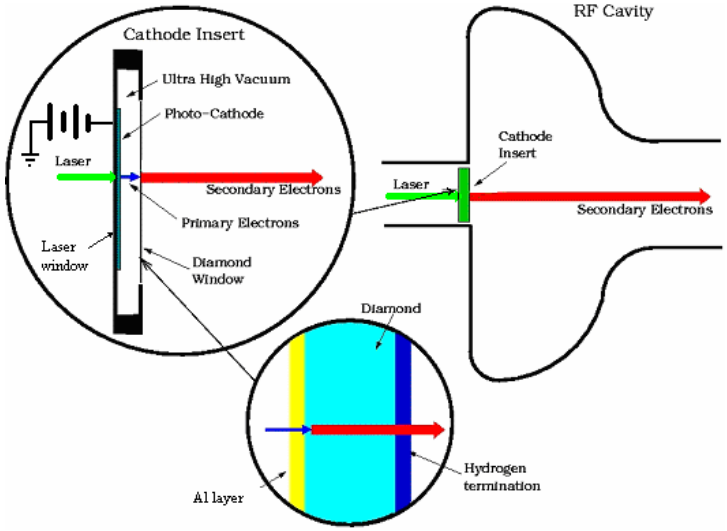
Notable features of the RHIC cooler I

- A high energy cooler: Electron energy up to 60 MeV for gold, as high as 150 MeV for protons, but also lower energies.
- Non-magnetized electron cooling:
  - Same approach as the FNAL Recycler cooler
  - New direction for BNL (as of about one year ago)
- Use a single electron accelerator to cool the two counter-rotating RHIC rings
- Use of a high-current ERL
- Double pass acceleration

Notable features of the RHIC cooler II

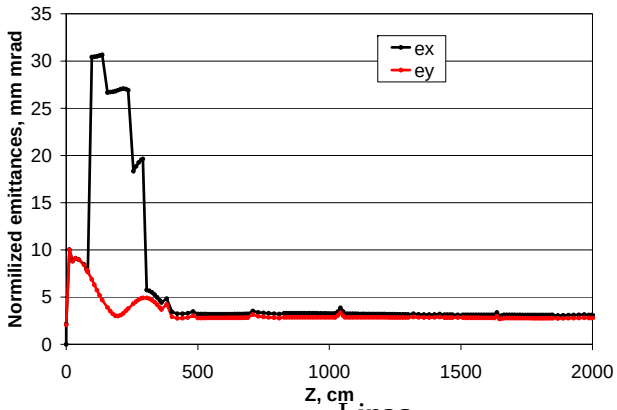
- High-brightness and high-current electron gun
  - Use of SRF gun for best emittance.
  - Possible use of diamond-amplified photocathode.
- Z-bend injection.
- Possible helical undulator for reduction of recombination.

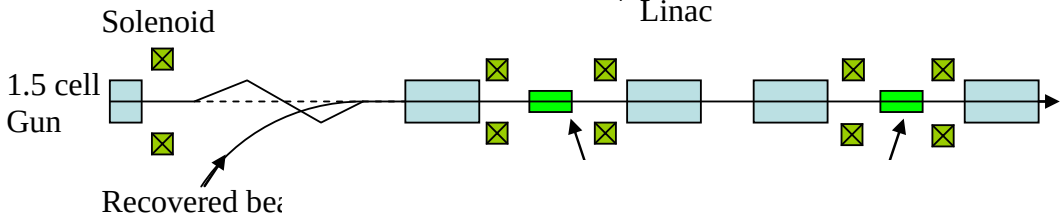


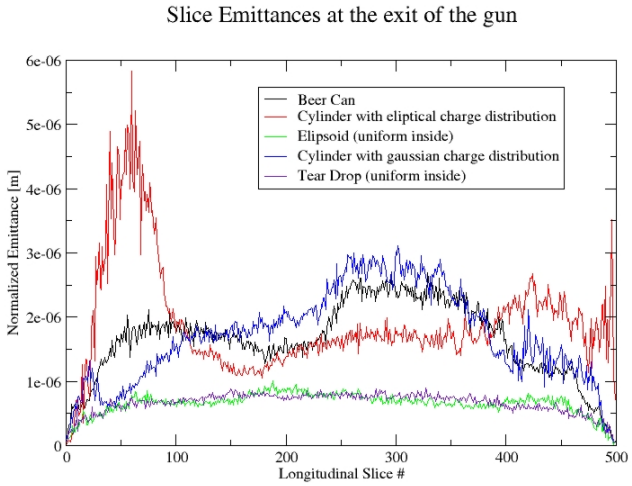


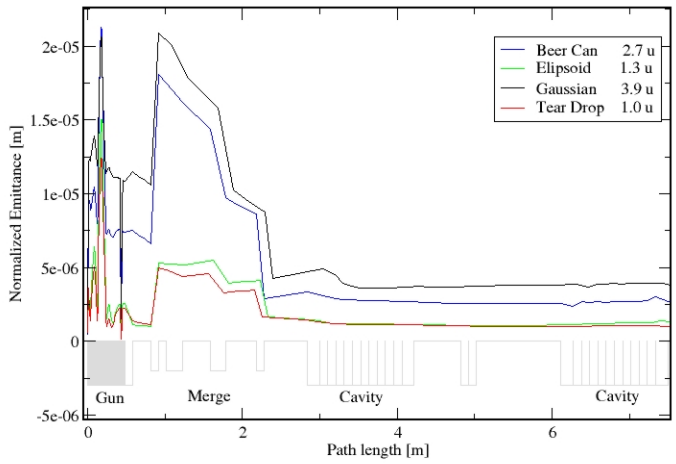
The electron beam performance

- The combination of low frequency (703.75 MHz), SRF gun with high accelerating field and Z-bend allow for a high-charge bunch (5 nC) at a low emittance.
- Further improvement can possibly be made by "designer laser pulse".









A parameter list for the cooler

- Gold ions at 100 GeV/A and protons at 250 GeV
- Ion number per bunch 10^9 gold or 2×10^{11} protons
- Ion charge 79 or 1
- Initial normalized rms emittance 2.5 μm (in both transverse planes)
- Initial momentum spread $5\cdot10^{-4}$
- Initial rms bunch length 19 cm
- 110 stored bunches
- RF frequency (store) 197.043
- Bunch frequency 9.383 MHz
- ERL RF frequency 703.75 MHz
- Harmonic number 2520
- RF voltage 3 MV
- **Cooling section**
- Wiggler, helical, length 80 meters
- Magnetic field range 0.001 Tesla
- Ions β function in wiggler ≥ 400 m
- **Electron beam**
- Energy 54 MeV Bunch charge 5 nC
- rms bunch length 30 ps rms normalized emittance ≤4 μm
- rms relative momentum spread <0.0005

Charge to the Working Groups

- 1. 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.
- 2. Establish the degree of confidence and accuracy we have in the simulations and theory of the generation of high-charge, low emittance bunches from a superconducting photoinjector. Examine the techniques of laser pulse shaping and their effect on emittance. Establish a plan for continued R&D.
- A detailed charge has been prepared.

The agenda

- Plenary session this morning:
  - Performance of the electron accelerator: D. Kayran
  - Electron cooling of RHIC: A. Fedotov
  - RHIC lattice for cooling: S. Tepikian
  - Performance of the FNAL cooler: S. Nagaitsev
- One and a half days for working groups.
- Friday – review of the summaries by working groups, followed by presentation of the summary by Working Group Leaders.