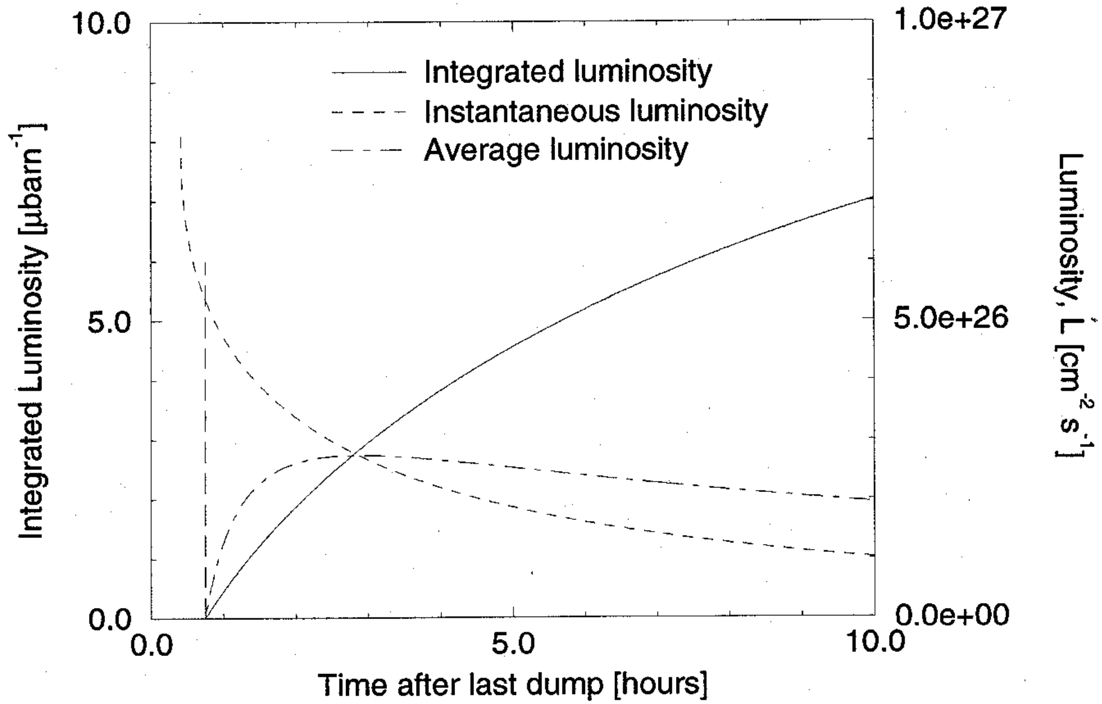
RHIC design luminosity

$$L = \frac{3 f_{rev} \gamma}{2} \frac{N_b N^2}{\varepsilon \beta^*} = 9 \text{ to } 1 \times 10^{26} \text{cm}^{-2} \text{s}^{-1} \text{ over } 10 \text{ hours}$$

$$N_b = 56\,;\, N = 1 \times 10^9 ; \varepsilon = 15 \text{ to } 40\pi\mu\text{m}; \beta^* = 2\text{m}$$



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RHIC luminosity upgrade

- ‘Enhanced’ luminosity (x4) possible with existing machine:
  - Double the number of bunches to 112
  - Decrease β^* from 2 m to 1m
- Further luminosity upgrades are limited by intra-beam scattering and require beam cooling at full energy!
- Feasibility study on RHIC electron cooling by BINP (V. Parkhomchuk et al.) shows that luminosity can be increased ten times.
- Bunched electron beam requirements for 100 GeV/u gold beams: $E = 54$ MeV, $\langle I \rangle \leq 100$ mA, electron beam power: ≤ 5 MW!
- Requires high brightness, high power, energy recovering superconducting linac, almost identical to IR FEL at TJNAF
- First linac based, bunched electron beam cooling system used at a collider
- First high p_t electron cooler to avoid recombination of e^- and Au^{79+}

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Heavy Ion Luminosity Upgrades

	RDM	RDM+	RHIC II
Initial emittance(95%) πμm	15	15	15
Final emittance (95%) πμm	40	40	5
Beta function at IR [m]	2.0	1.0	1.0 → 0.5
Number of bunches	60	120	120
Bunch population [10^9]	1	1	1
Beam-beam parameter per IR	0.0016	0.0016	0.004
Angular size at IR [μrad]	108	153	95
RMS beam size at IR [μm]	216	150	95
Peak luminosity [10^{26} cm^{-2} s^{-1}]	8	32	83
Average luminosity [10^{26} cm^{-2} s^{-1}]	2	8	70

RDM and RDM+ assume 10 hr stores

RHIC II includes electron beam cooling and assumes 5 hr stores since burn-off is high

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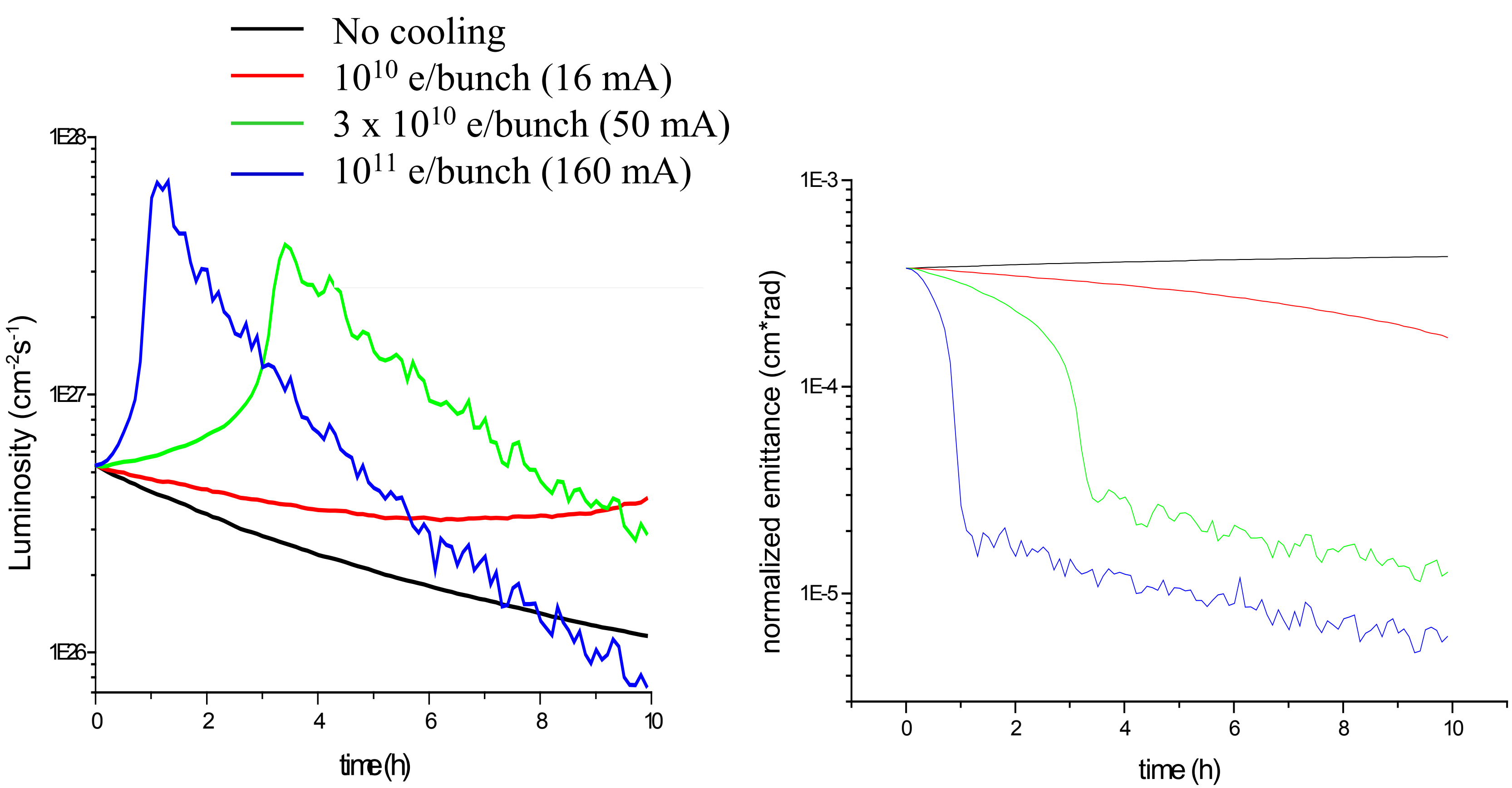
RHIC Luminosity and Emittance with Cooling



Proton Luminosity Upgrades

	RHIC Spin	RHIC II	Future Upgrade
Emittance(95%) πμm	20	12	12
Beta function at IR [m]	1	1	0.3
Number of bunches	112	112	336
Bunch population [10^{11}]	2	2	2
Beam-beam parameter per IR	0.007	0.012	0.012
Angular size at IR [μrad]	112	86	157
RMS beam size at IR [μm]	112	86	47
Luminosity [10^{32} cm^{-2} s^{-1}]	2.4	4.0	40.0

RHIC II : Beam-beam tune shift limited for 2 interaction regions

Future Upgrade: Mini-beta quads and more bunches

Will also require major detector upgrades

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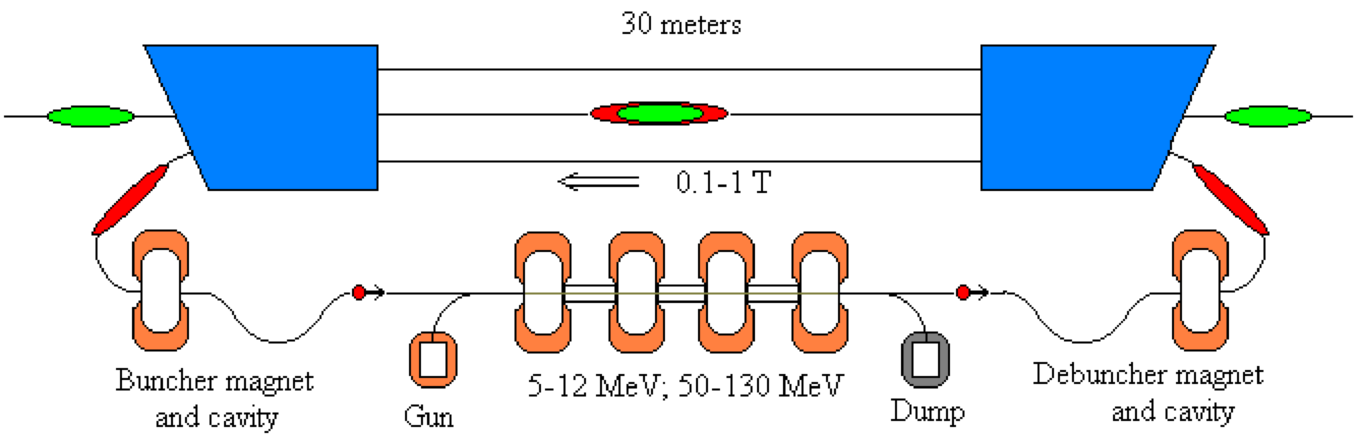
The RHIC Electron Beam Cooler



R&D issues:

- Demonstrate high-brightness, high-current CW photocathode electron gun
- Demonstrate high precision (10 ppm) solenoid for 30 m cooling section.

- Full simulation (space charge, non-linearities, wake fields, beam stability) of transport of magnetized electron beam from cathode to dump
- Develop and benchmark cooling simulation codes

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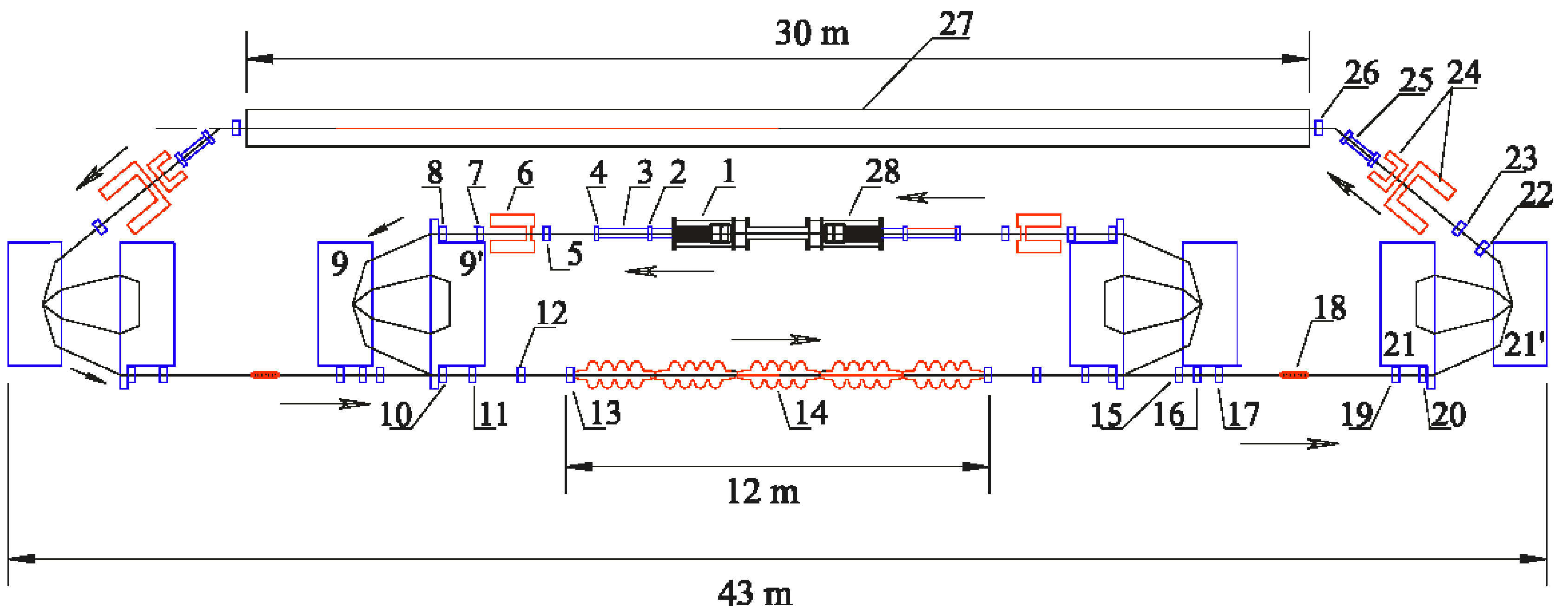
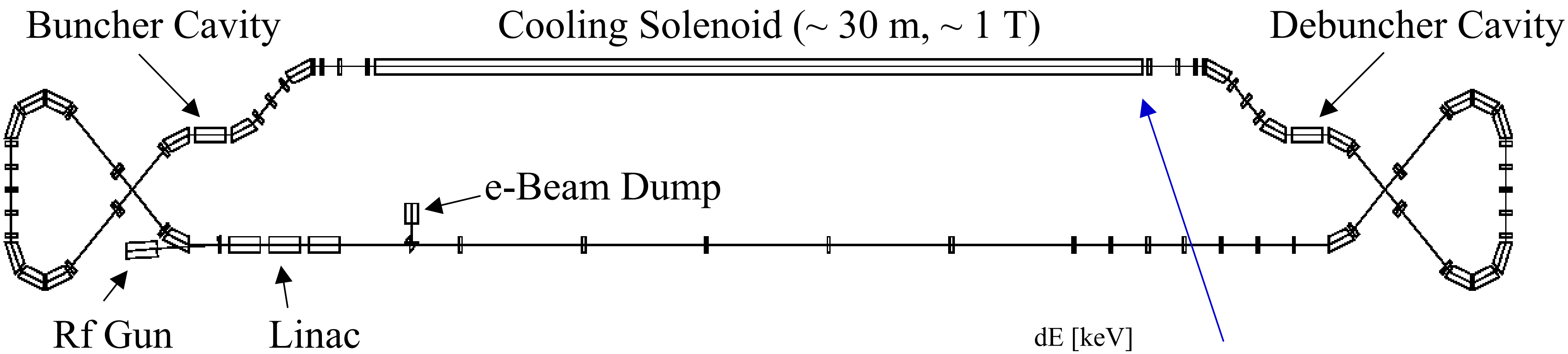
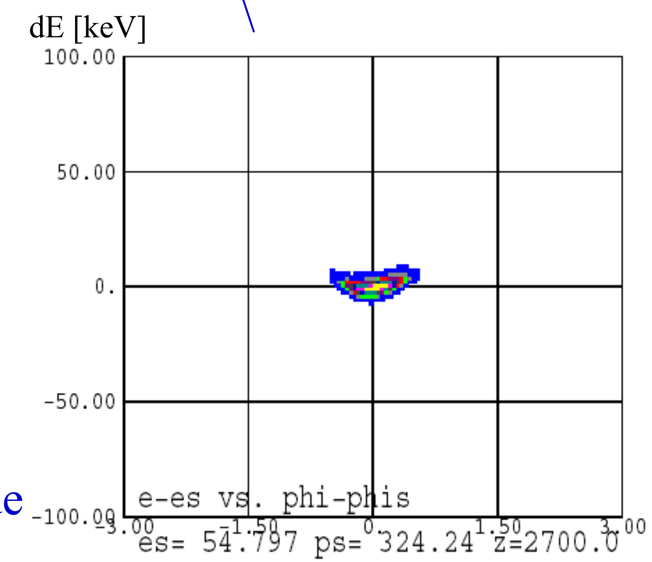
BINP layout for RHIC electron cooler



- Proof-of-principle
- Magnetized e-beam to avoid recombination
- Uses DC e-gun
- Transport using flat beam

Status of RHIC electron cooler R&D





- Modeled 700 MHz 2.5 cell rf photo-cathode gun
- Development with LANL and AES (Navy)
- 10 nC bunches transported from cathode to solenoid with $\sigma(dE/E) \sim 10^{-4}$ (with s.c.)
- Transport of magnetized beam tested w/o going to flat beam
- Solenoid design with $B_T/B_L \sim 10^{-5}$ feasible -> prototype
- 700 MHz SC Linac same as TJNAF IR FEL 100 kW upgrade

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RHIC beam cooling R&D milestones

Rf gun prototype:	Date
Operate laser with super-conducting gun	December 2003
Operate basic beam optical system	June 2004
Demonstrate high-current CW source	April 2005
Obtain high-brightness high-current beam	June 2006
High quality longitudinal phase space	September 2006

Solenoid prototype:	Date
Magnetic design of solenoid complete	June 2003
Magnetic design of correction coils completed	September 2003
Hardware design	September 2003
Mechanical design completed	June 2004
Magnet construction completed	September 2005
Magnet testing completed	June 2006

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