EC plans in connection with eRHIC

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ILCDR08 – Cornell University, Ithaca, New York
10 July 2008

Outline

1. **E-cloud in RHIC**
   dynamic pressure rise, instabilities, emittance growth

2. **E-cloud in eRHIC/ELIC**
   bunch spacing and bunch intensity

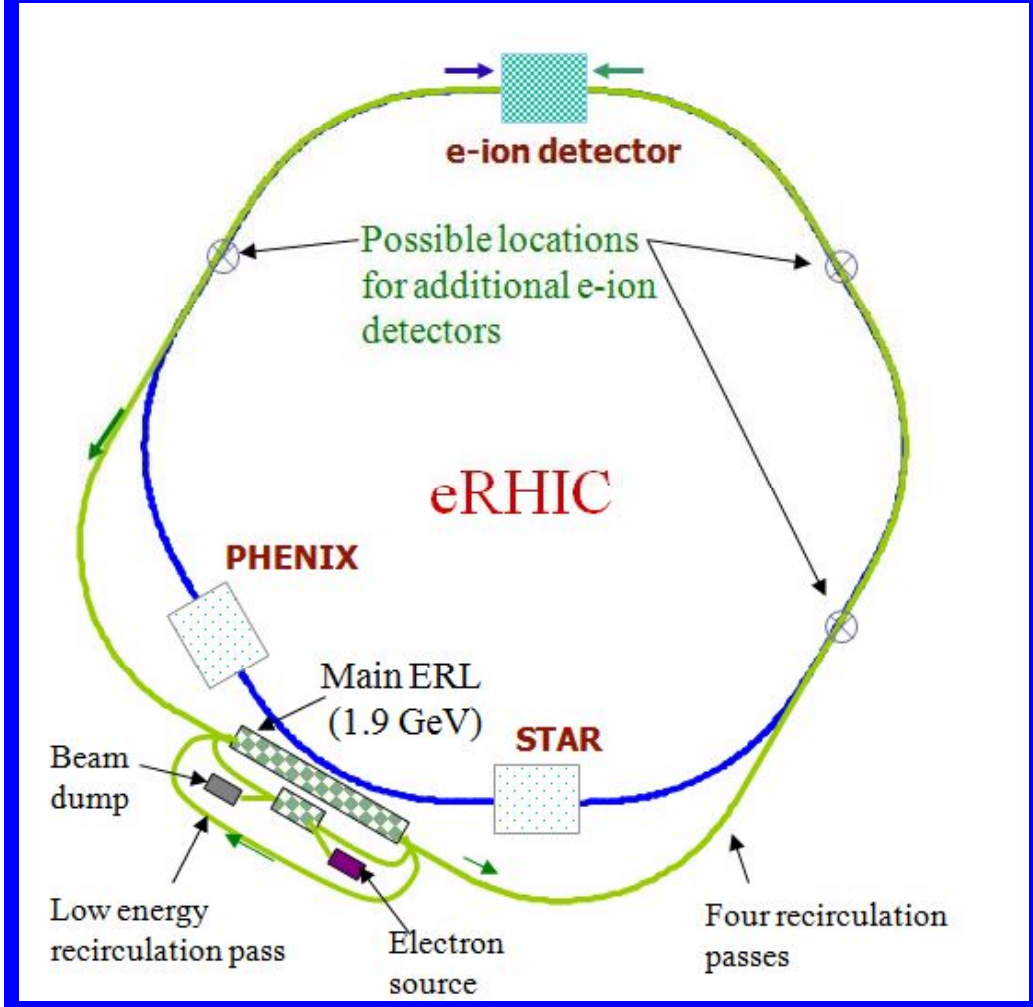
3. **Possible experiments at CesrTA**
   maximization of average ion bunch current

Relativistic Heavy Ion Collider

- 2 superconducting rings
- 3.8 km length
- operation since 2000
- 5 experiments so far

- only operating ion collider (up to gold 100 GeV/n)
- first and only polarized proton collider

ERL-based eRHIC



- 10 GeV electron energy
  (possible upgrade to 20 GeV)
- 5 recirculation passes
  (4 of them in the RHIC tunnel)
- Multiple e-p/A IPs
- Polarization transparency at all energies for the e-beam
- Ability to take full advantage of transverse cooling of the hadron beams

V. Ptitsyn, EIC Collaboration Meeting, 05/19/08

E-cloud in RHIC

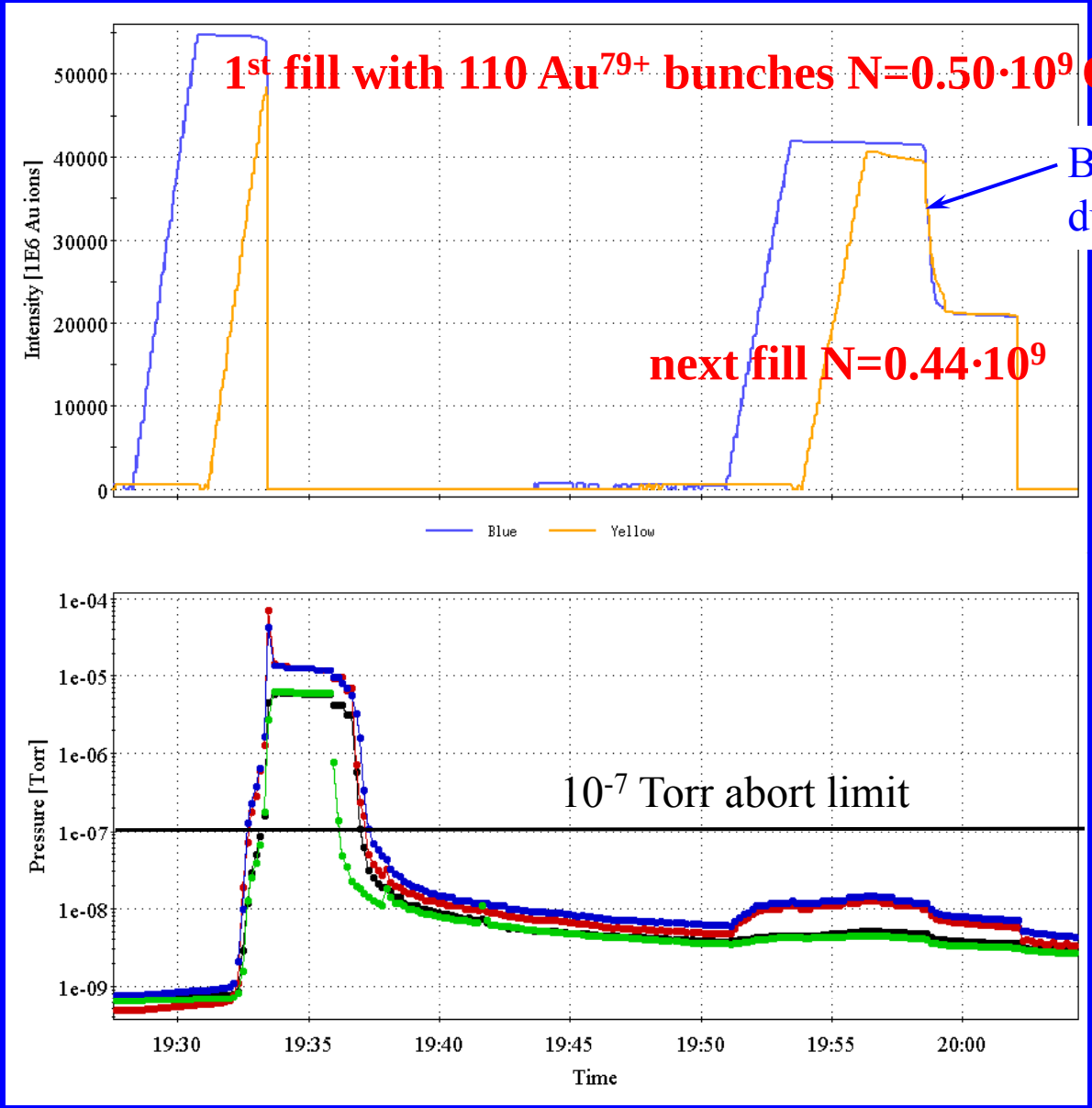
3 areas of concern:

1. **Dynamic pressure rise**
   currently not a concern,
   NEG coated pipes in warm sections, pre-pumping in cold sections

2. **Instabilities at transition**
   e-clouds lower instability threshold,
   instability is main ion intensity limit (protons do not cross transition)

3. **Incoherent emittance growth** (p at injection)
   installation of new 9 MHz cavity (h = 120 compared to
   h = 360 now) will result in longer bunches and reduced e-cloud

First pressure rise observation



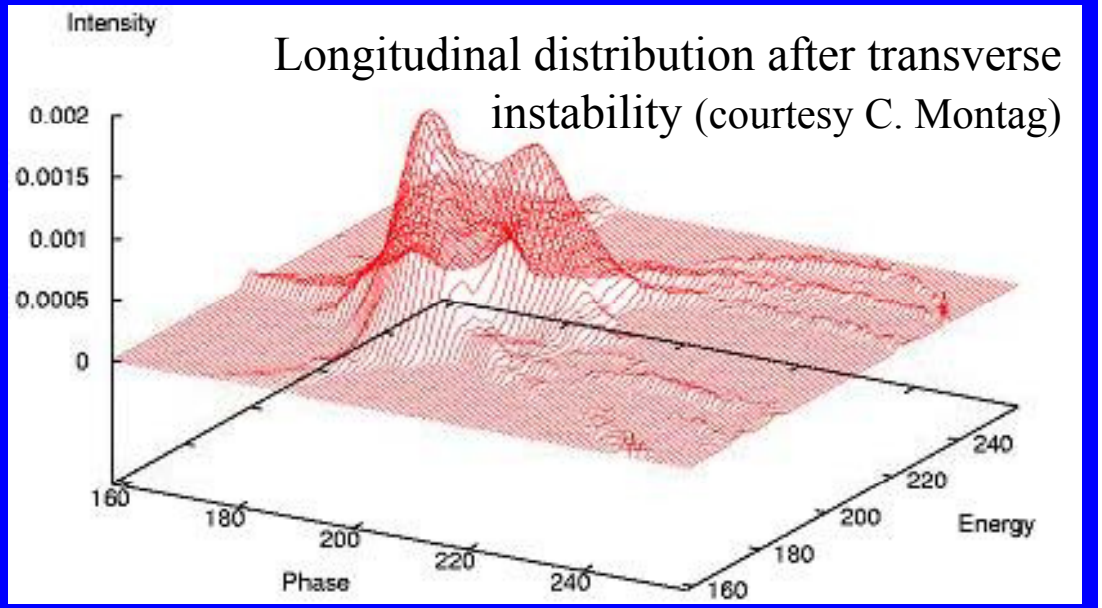
E-cloud observation: beam instability

Crossing transition with slowly ramping sc. magnets (all ions except protons)

→ Instability limits bunch intensities for ions (~1.5 – 2.0×10^{11} e)

→ Instability is fast (τ =15 ms), transverse, single bunch

- γ_t-jump implemented
- Octupoles near transition
- Chromaticity control
  (need ξ-jump for higher bunch intensities)



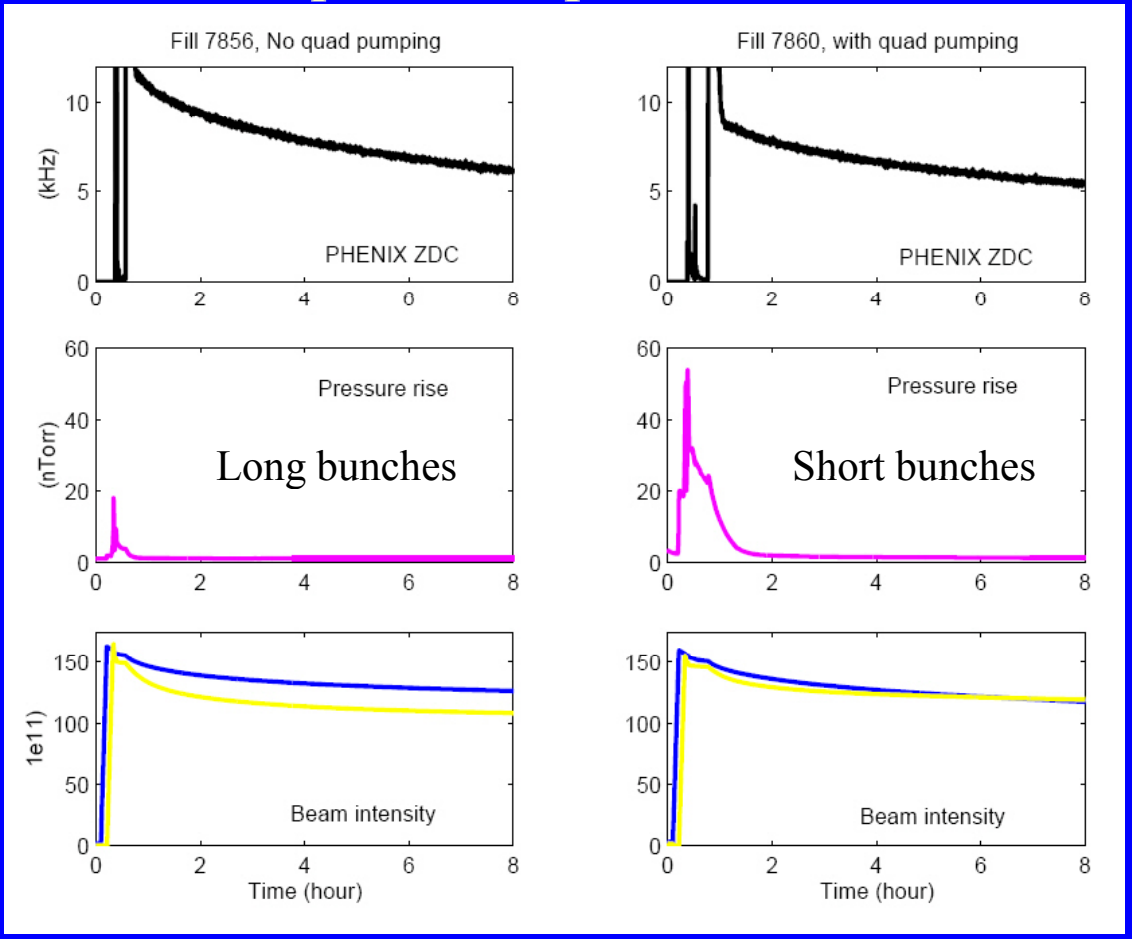
Longitudinal distribution after transverse instability (courtesy C. Montag)

→ Electron clouds can lower stability threshold, will gain more operational experience in current Au-Au run

E-cloud observation: emittance growth

2 polarized proton stores

Courtesy S.Y. Zhang



Short bunches with same intensity lead to smaller luminosity.

[Single short-bunch store only for comparison. ε-growth from reasons other than e-cloud possible.]

[E. Benedetto et al., "Simulation study on electron …", PRST-AB 8, 124402 (2005); **E. Benedetto et al., "Incoherent effects of electron clouds in proton storage rings", PRL 97, 034801 (2006);** S.Y. Zhang and V. Ptitsyn, "Proton beam emittance growth in RHIC", PRST-AB 11, 051001 (2008).]

Proton beams in RHIC and eRHIC

Parameter	**Unit**	**RHIC** latest	**eRHIC** ERL current base	**eRHIC** other ERL
Energy	GeV	250	250	250
Bunch spacing	ns	**107**	**71**	**?**
Bunch intensity	10^{11}	**2.0**	**2.0**	**?**
Rms emittance, norm.	μm	20	6	6
Rms bunch length	cm	**80**	**20**	**?**

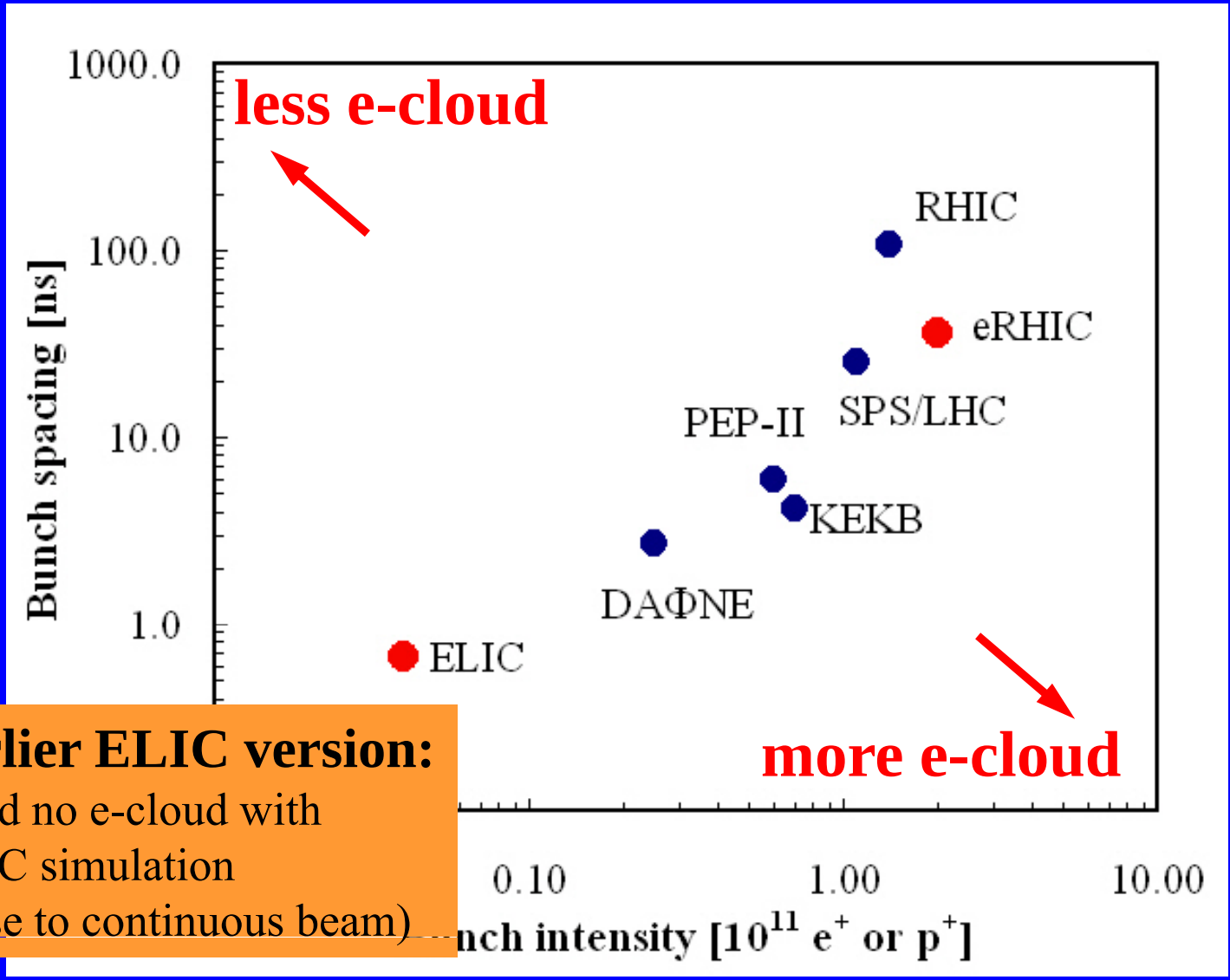
$$L \sim f_{coll} N_e N_p$$

For ERL version, luminosity is proportional to average beam current of both rings

retains current proton rf system

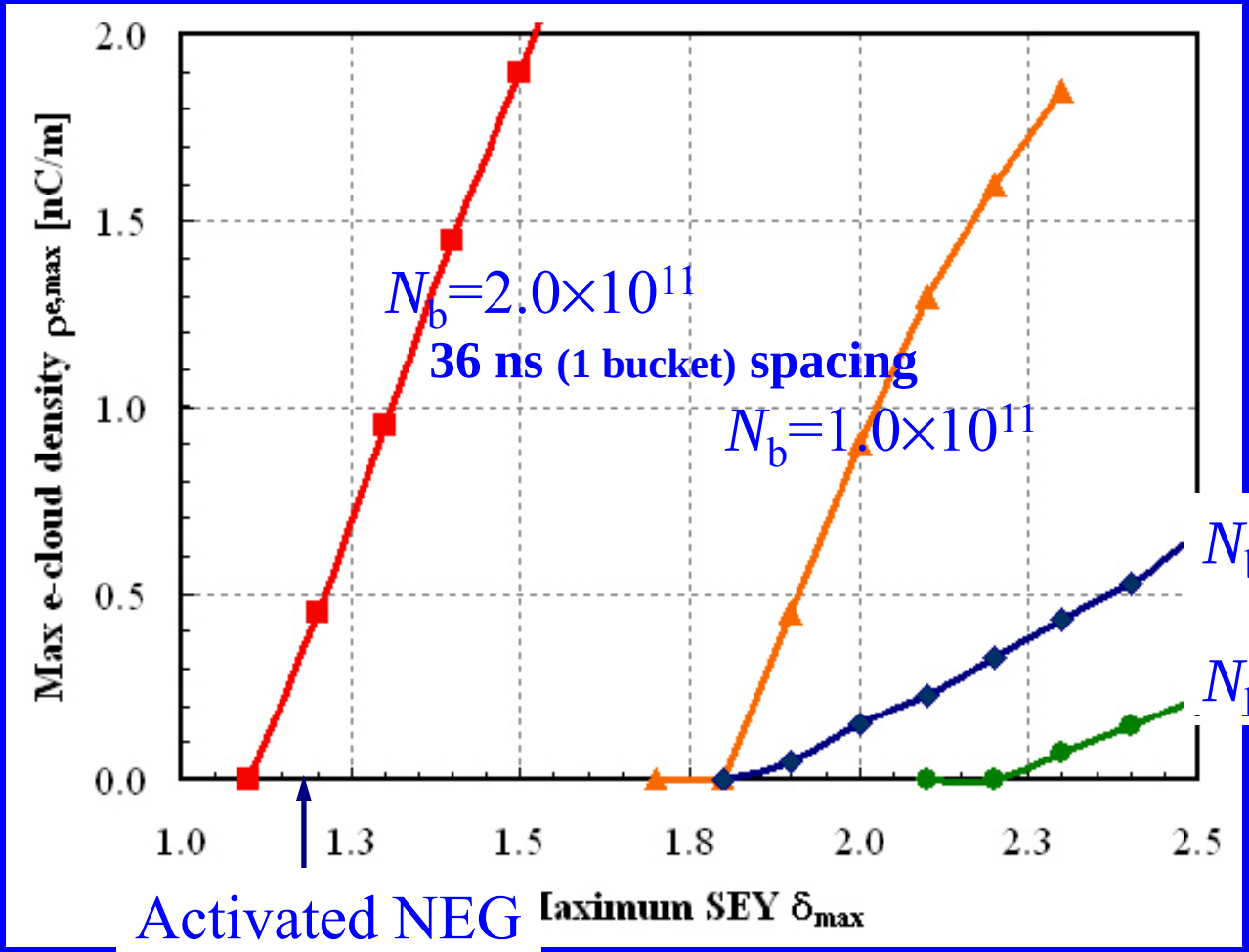
new proton rf system, maximize avg. beam current

Selected machines with electron clouds



Earlier ELIC version:
found no e-cloud with
CSEC simulation
(close to continuous beam)

E-cloud in current RHIC vs. eRHIC



Expect serious e-cloud problems for N_b=2.0×10^{11} and 36 ns bunch spacing (Analysis needed for warm double beam, and cold regions also.)

Possible experiments at CesrTA

Create highest possible <u>average</u> e^+ beam, constrained by electron cloud

- **Maximize bunch charge**
  >2×10^{10}, ideally as high as 2×10^{11}
- **Minimize bunch spacing**
  4 ns possible

eRHIC: I_{avg} = 445 mA CesrTA: I_{avg} = 800 mA (avg. over train)

Generally: test e-cloud density scaling with bunch charge and bunch spacing
(To what extent can this go beyond B-factories?)