MeRHIC and eRHIC

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on behalf of eRHIC design development group:

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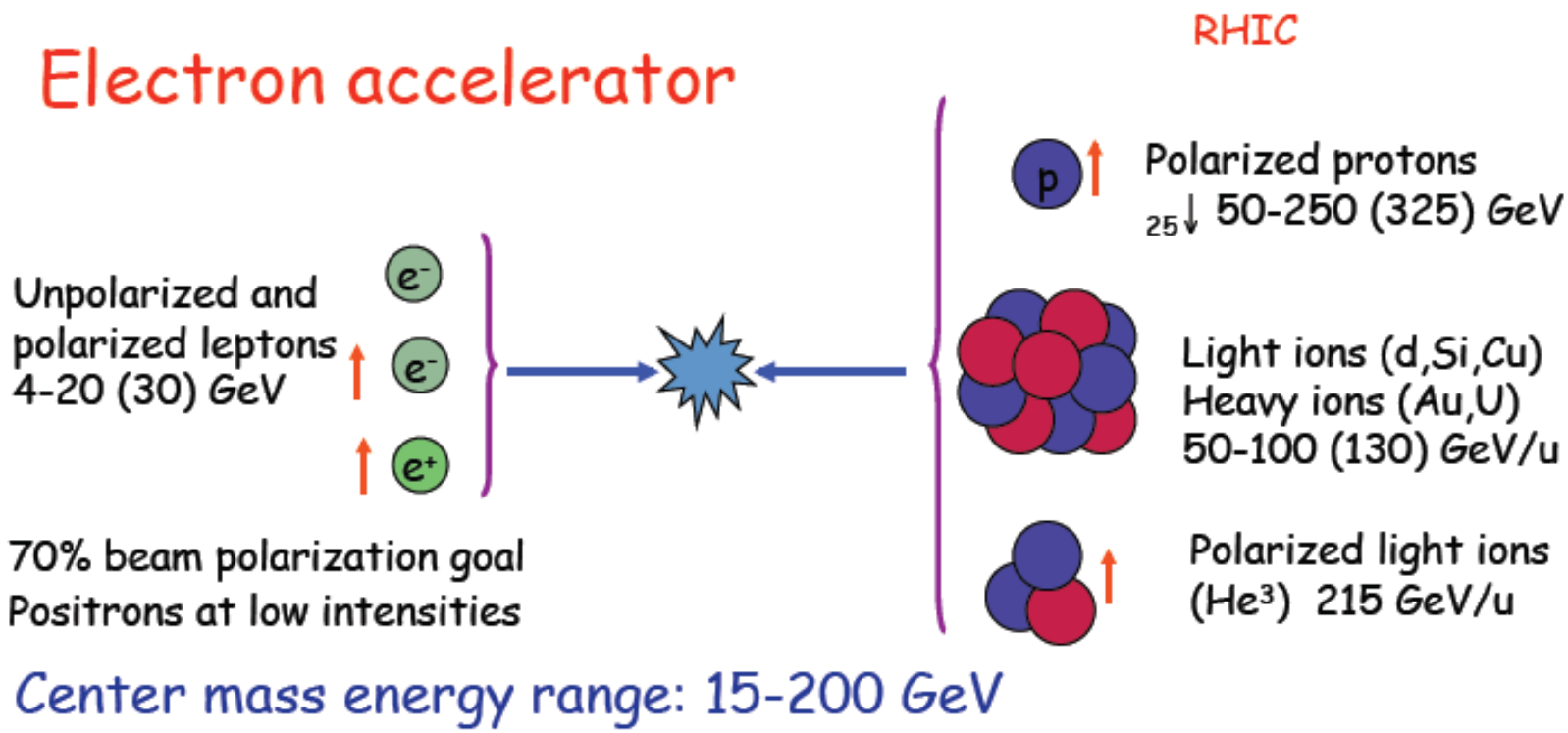
RHIC Retreat 2009

Project Scope



eRHIC Goals:

- high luminosity (>10^{33} $cm^{-2}s^{-1}$) for e-p collision
- high electron energy (20 GeV) for e-Au experiments

Accelerator based on energy recovery linacs can achieve those goals

Staging Approach

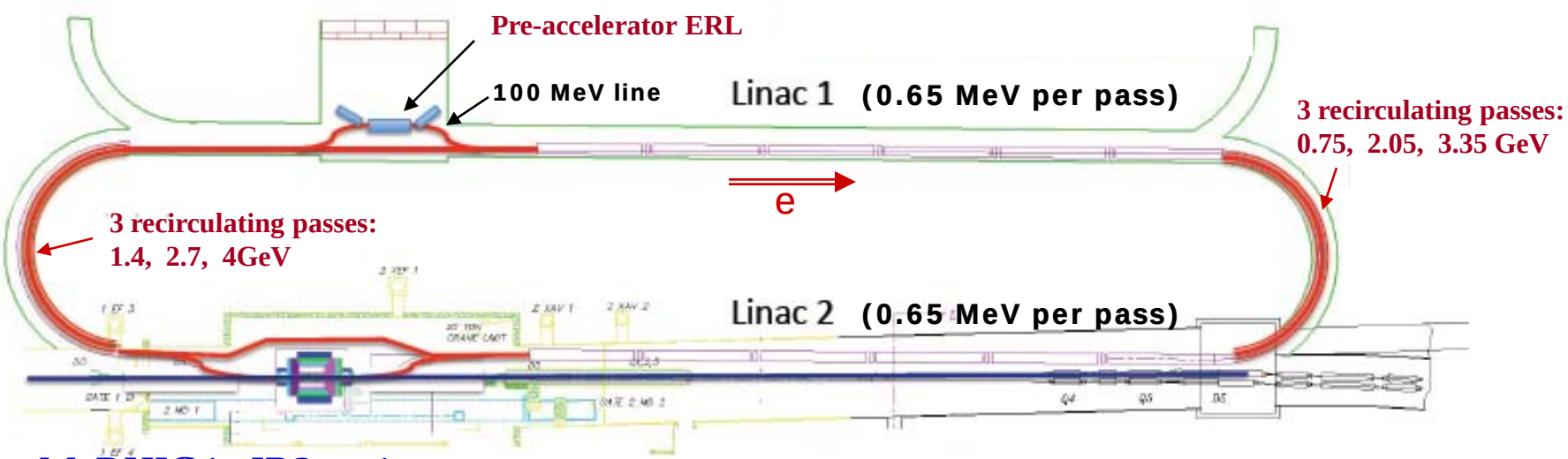
- MeRHIC : Medium Energy Electron-Ion Collider
  - Accelerator an detector located at IP2 region
  - 4 GeV e- x 250 GeV p, L~10^{32}-10^{33} cm^{-2} s^{-1}
- eRHIC, High energy and luminosity
  - Polarized 20 GeV e- x 250 (325) GeV p, L>10^{33} cm^{-2} s^{-1}
  - 20 GeV e x 100 (120) Gev/n Au, full luminosity
  - and 30 GeV e x 100 (120) Gev/n Au, ~1/5 of full luminosity
- Future possible eRHIC upgrades
  - <u>Higher luminosity (Coherent e-cooling, smaller beta*, copper covered RHIC pipe)</u>

    Polarized 20 GeV e- x 250 (325) GeV p, L~10^{35} cm^{-2} s^{-1}
  - <u>Or High energy operation with one new 800 GeV RHIC ring</u>
    - Polarized 20 GeV e- x 800 GeV p, L~10^{34} cm^{-2} s^{-1}
    - 30 GeV e x 300 (120) Gev/n Au, L~10^{32} cm^{-2} s^{-1}

First stage: Medium energy collider MeRHIC

4 GeV electron accelerator

$L = 10^{32}\ cm^{-2}s^{-1}$ (10^{33} with cooling)



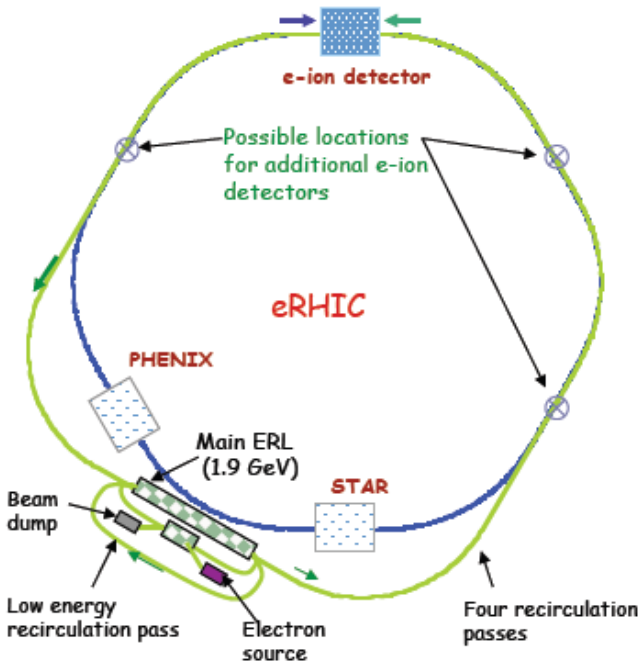
MeRHIC in IR2 region:

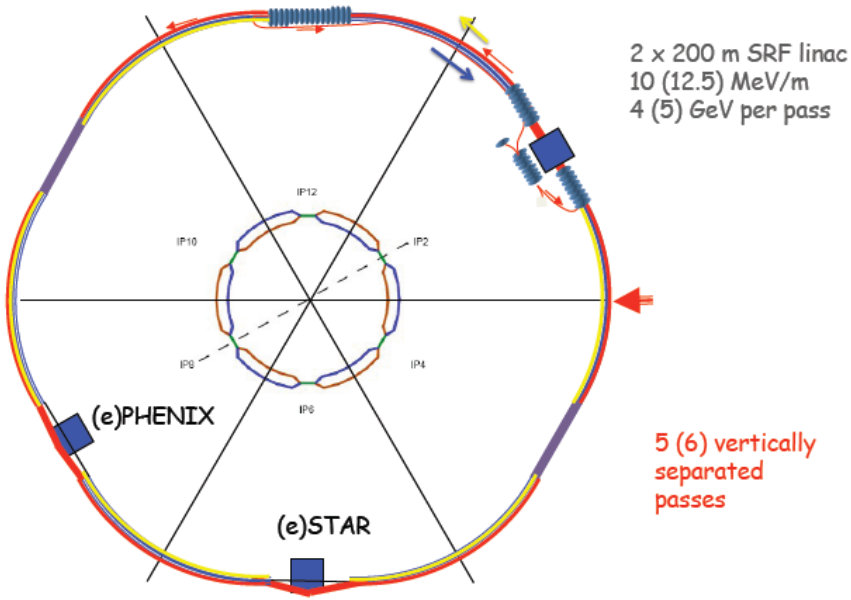
- asymmetric detector hall is very appropriate for asymmetric detector for e-p collisions
- long wide (7.3m) tunnel on one side from the IR can contain an ERL

Acceleration done by two main ERLs (one in the tunnel). Based on 703 MHz SRF cavities. Injector system (polarized gun, bunching system, pre-accelerator ERL) and the beam dump are outside of the tunnel.

Recirculation passes consist of warm magnets; acceptable synchrotron radiation power.

eRHIC : two ERL-based design options





More appropriate for parallel operation with p-p experiments

More appropriate for staging approach

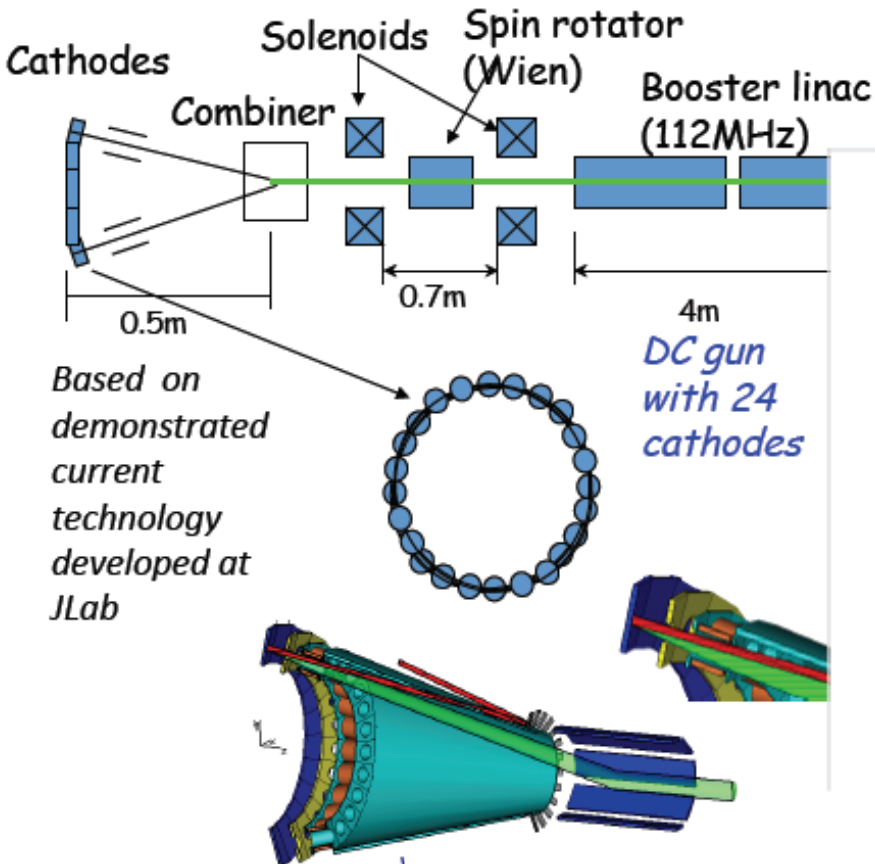
- Acceleration done by ERLs. Reuse and extend SRF system from MeRHIC.
- 4-20 (30) GeV electron design energy range
- Recirculation passes in the RHIC tunnel . Based on compact magnet design
- Multiple electron-hadron interaction points (IPs)
- Full polarization transparency at all energies for the electron beam

R&D items and main challenges

- Electron beam R&D for ERL-based design:
  - High intensity polarized electron source
    - Development of large cathode guns with existing current densities ~ 50 mA/cm^2 with good cathode lifetime.
  - Energy recovery technology for high power beams
    - multicavity cryomodule development; high power beam ERL, BNL ERL test facility; loss protection; instabilities.
  - Development of compact recirculation loop magnets *(for eRHIC)*
    - Design, build and test a prototype of a small gap magnet and its vacuum chamber.
  - Beam-beam effects: e-beam disruption
- Main R&D items for ion beam:
  - Beam-beam effects: electron pinch effect; the kink instability …
  - Polarized 3He acceleration
  - 166 bunches *(for eRHIC)*
- General EIC R&D item:
  - Proof of principle of the coherent electron cooling

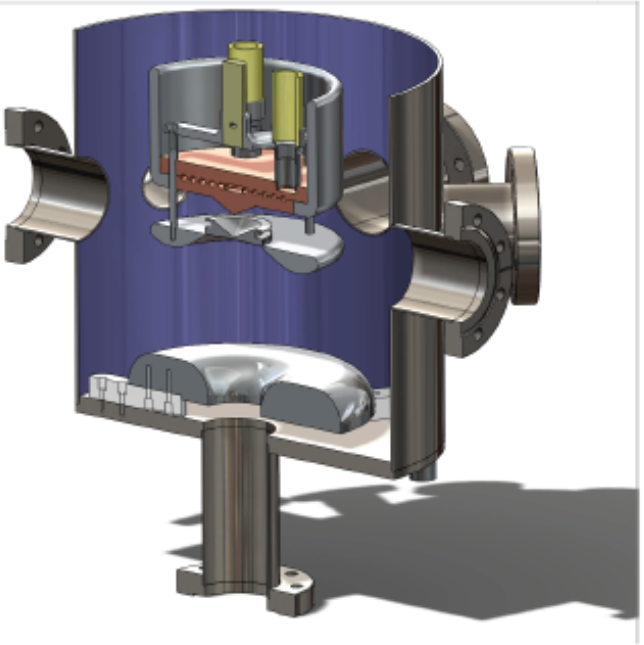
Polarized source for MeRHIC and eRHIC

Main technical challenge: 50 mA CW polarized gun: we are building it



Single cathode DC gun

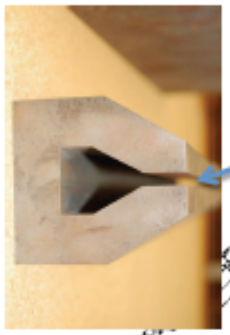
E.Tsentalovich, MIT



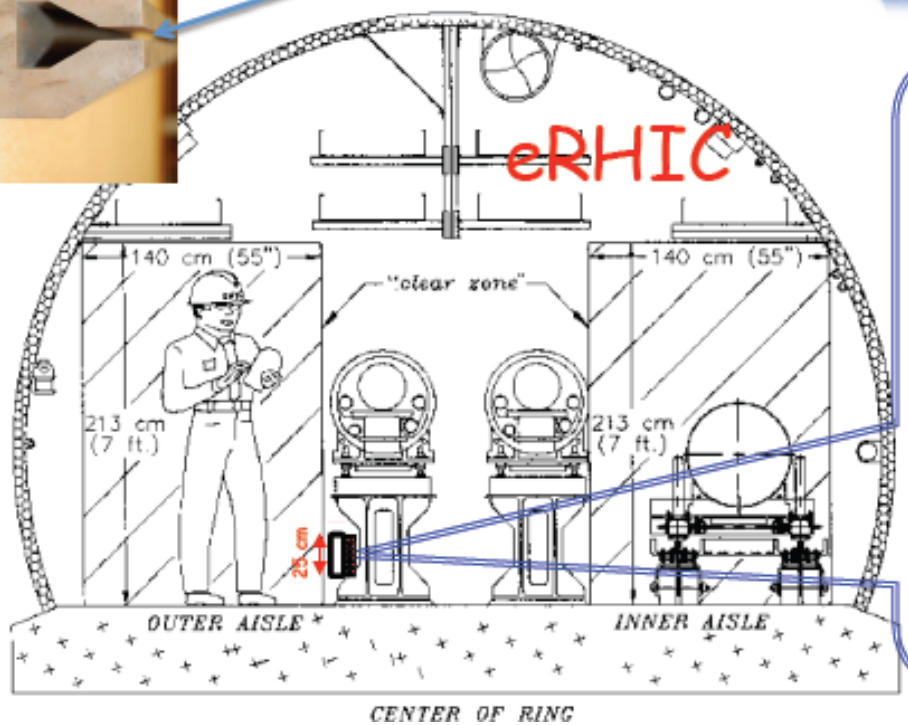
X.Chang, I.Ben-Zvi, T.Rao

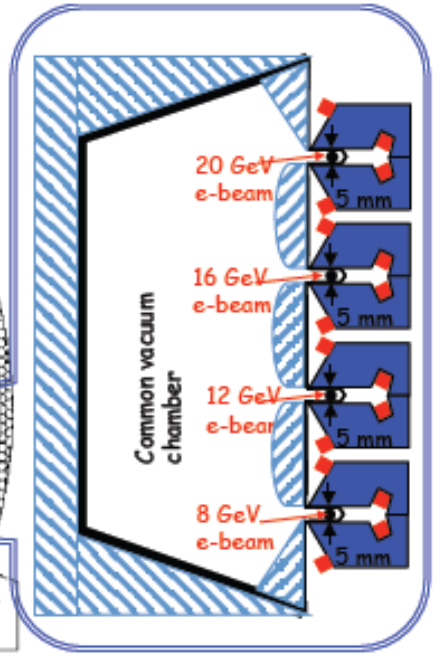
Compact magnet design for eRHIC

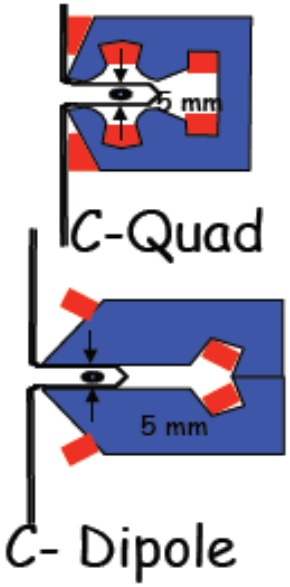
- Small gap provides for low current, low power consumption magnets **(V.Litvinenko)**
  - -> **low cost eRHIC**
- Magnetic design - W.Meng, mechanical engineering - G.Mahler
- Beam dynamics – Y.Hao, J.Bengtsson



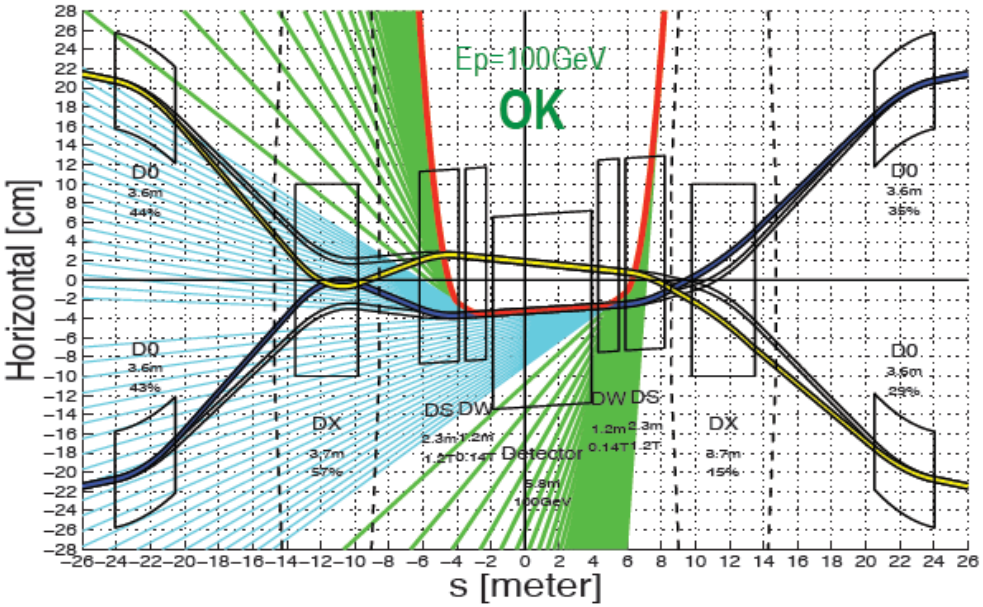
Gap 5 mm total
0.3 T for 30 GeV





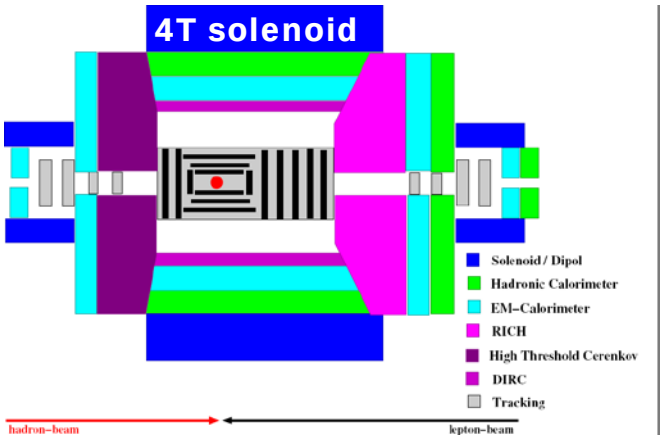


MeRHIC IR Design



J.Beebe-Wang

Proton beam energy can be varied from 80 to 250 GeV.
Additional PSs for independent control of all DX and D0 magnets



- To provide effective SR protection soft bend (DW) (~0.05T) is used for final bending of electron beam
- DS magnets are used by the detector to improve the registration of particles scattered at small angles
- Design without DX magnet under consideration