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Monolithic Active Pixel Silicon Detector for Electron Relativistic Heavy Ion Colliders: Status and Plans

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Abstract

There are still many open questions regarding the nucleon spin structure and transverse-momentum- and impact-parameter-dependent parton distributions in nucleons and nuclei.

The best way to investigate nucleon and ion structure is to built a electron-ion collider (EIC). This collider can be realized at **Brookhaven National Laboratory**, inside the existing RHIC tunnel.

A detector for an EIC will require an excellent vertex tracking system. MAPS silicon detectors are the most promising candidates for this task.

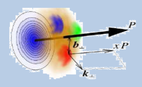
Physics motivations of an electron-ion collider

Spin physics

- What is the polarization of gluons at small x where they are most abundant?
- What is the flavor decomposition of the polarized sea depending on x?

Determine quark and gluon Contributions to the proton spin at last

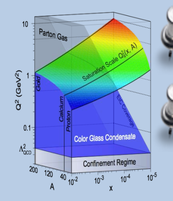
Imaging



- What is the spatial distribution of quarks and gluons in nucleons/nuclei?
- Understand deep aspects of gauge theories revealed by transverse-momentum-dependent distributions.

Possible window to orbital angular momentum

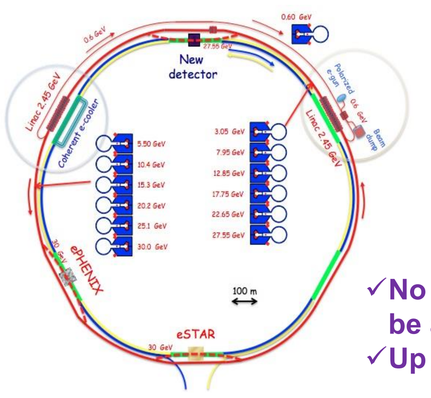
Physics of strong color fields



- What is the spatial distribution of quarks and gluons in nucleons/nuclei?
- How do hard probes in interact with the nuclear medium?

Quantitatively probe the universality of strong color fields in AA, pA, and eA

EIC at RHIC: the **eRHIC** project



Collisions:

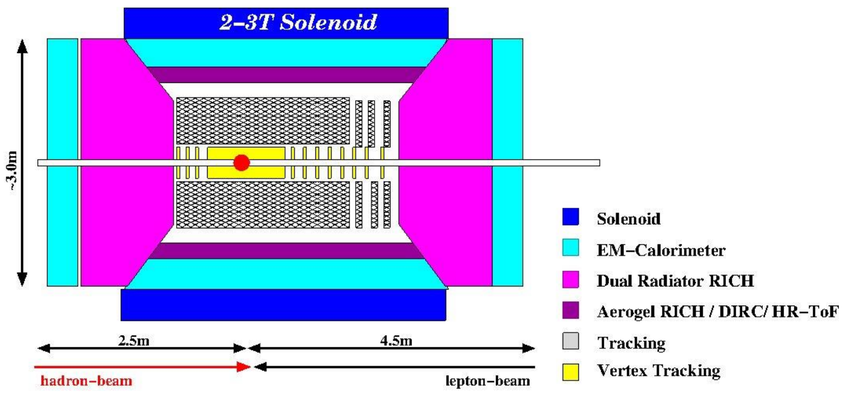
- ✓**Polarized electrons: 5, 10, 20, (30?) GeV**
- ✓**Polarized protons: 100 to 250 GeV**
- ✓**Ions: 50 to 100 GeV per nucleon**

Key-points:

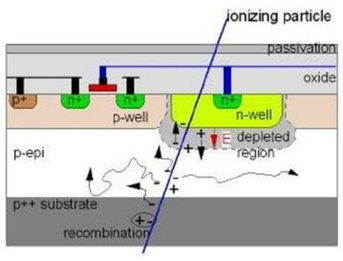
- ✓**Electron beam: novel energy recovery Linacs.**
- ✓**Proton beam: coherent electron cooling.**
- ✓**Crab Crossing Cavities to restore head-to-head bunch collisions .**

✓**No other tunnel required: electron beam line will be added in the present RHIC tunnel.**
✓**Up to 3 experimental locations along the ring .**

Preliminary design of the **eRHIC** Detector

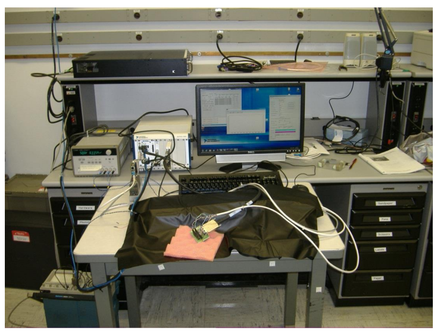


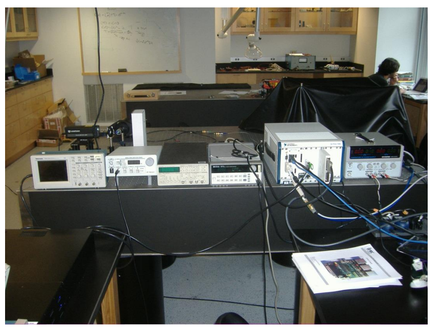
Monolithic Active Pixel Silicon (MAPS) Sensor



- ✓ Sensor and Chip realized in the same CMOS process: cheap to produce and no bump bonding required.
- ✓ No HV bias: electrons collected for thermal diffusion.
- ✓ Works at room temperature: minimal cooling system required (low material budget !).
- ✓ Sensitive area only ~15 microns thick.
- ✓ Very high granularity.

BNL and Columbia University test stations

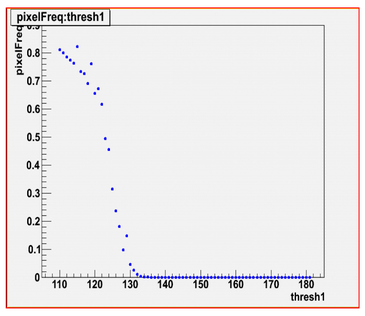


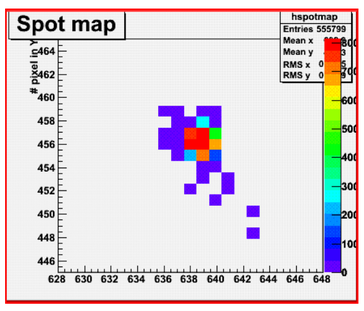


Studies for the eRHIC silicon vertex

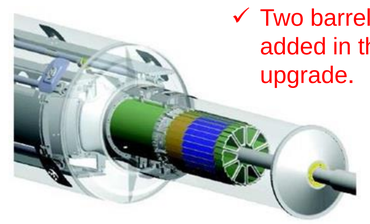
For the eRHIC silicon vertex detector the candidate technology is a MAPS pixel of the e Mimosa family, designed at the **Institut Pluridisciplinaire Ubert Curien (Strasburg)** .
At Brookhaven National laboratory and Columbia University there are two test stations working with the **Mimosa 26** prototype.

Laser source studies:
Left: each point represents the fraction of times the chip registered a hit for that pixel when the laser was fired ~9000 times, as function of threshold value, in mV (horizontal axis). This curve is for a pixel hit localized 2 pixels away from the "center" of the spot.
Right: Beam laser spot i.e. space distribution of the hits when the laser was fired 9000 times.





MAPS implementation in the STAR Detector upgrade (Mimosa 28 Ultimate)



- ✓ Two barrel layers will be added in the next incoming upgrade.

Outlook

The first electron-ion collider (EIC) can be easy realized in BNL using the existing RHIC tunnel. There is already a general design for the collider and the detector: the **eRHIC** project.
Studies are also ongoing in order to use MAPS sensors in a high-precision silicon vertex detector.

Acknowledgements

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