Use of Micropattern Detectors in Future Upgrades at RHIC

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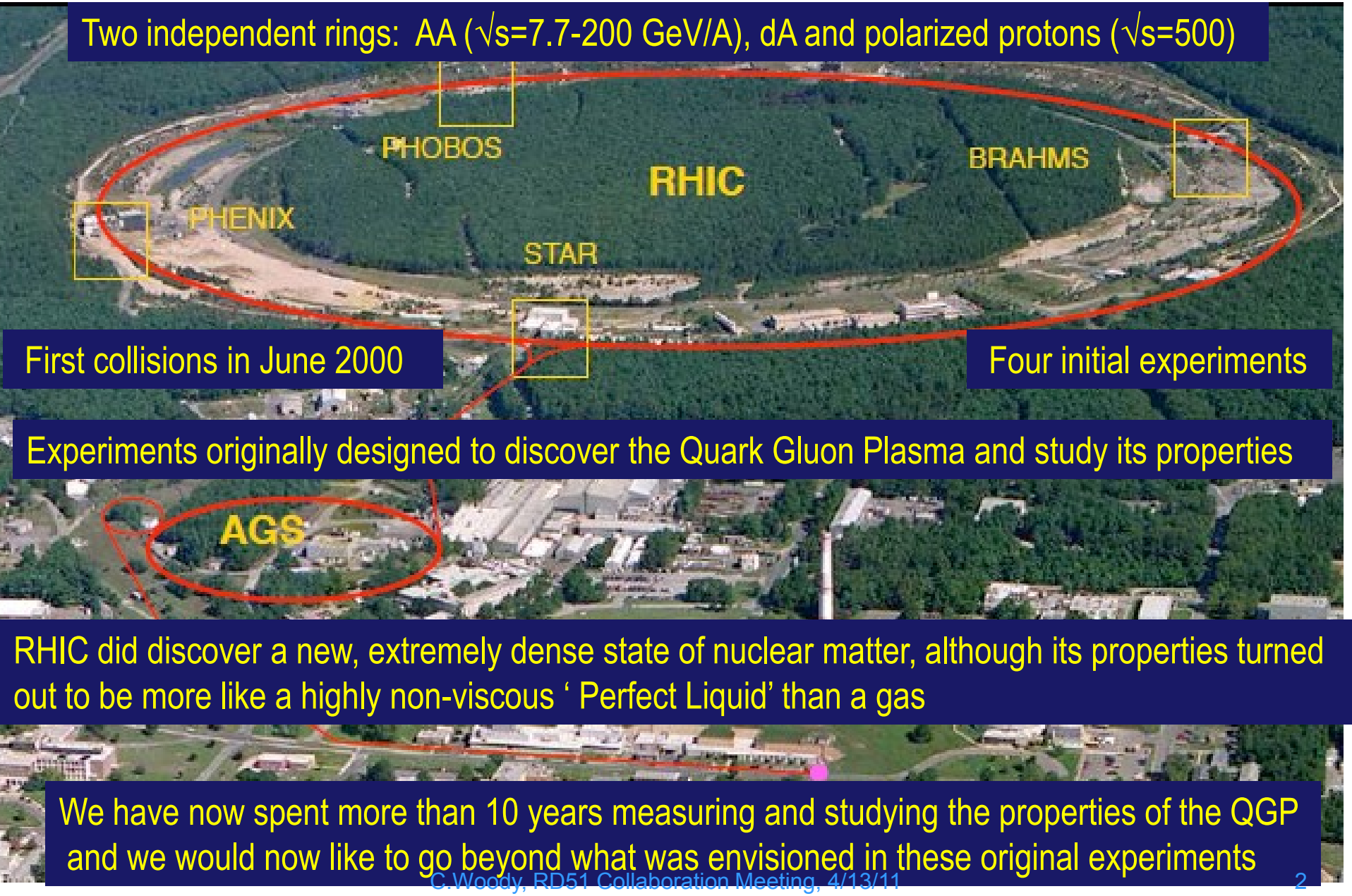
BNL

RD51 Collaboration Meeting

April 13, 2011

RHIC



Two independent rings: AA ($\sqrt{s}$=7.7-200 GeV/A), dA and polarized protons ($\sqrt{s}$=500)

First collisions in June 2000

Four initial experiments

Experiments originally designed to discover the Quark Gluon Plasma and study its properties

RHIC did discover a new, extremely dense state of nuclear matter, although its properties turned out to be more like a highly non-viscous ‘ Perfect Liquid’ than a gas

We have now spent more than 10 years measuring and studying the properties of the QGP and we would now like to go beyond what was envisioned in these original experiments

Complementarity of RHIC & LHC Physics Programs

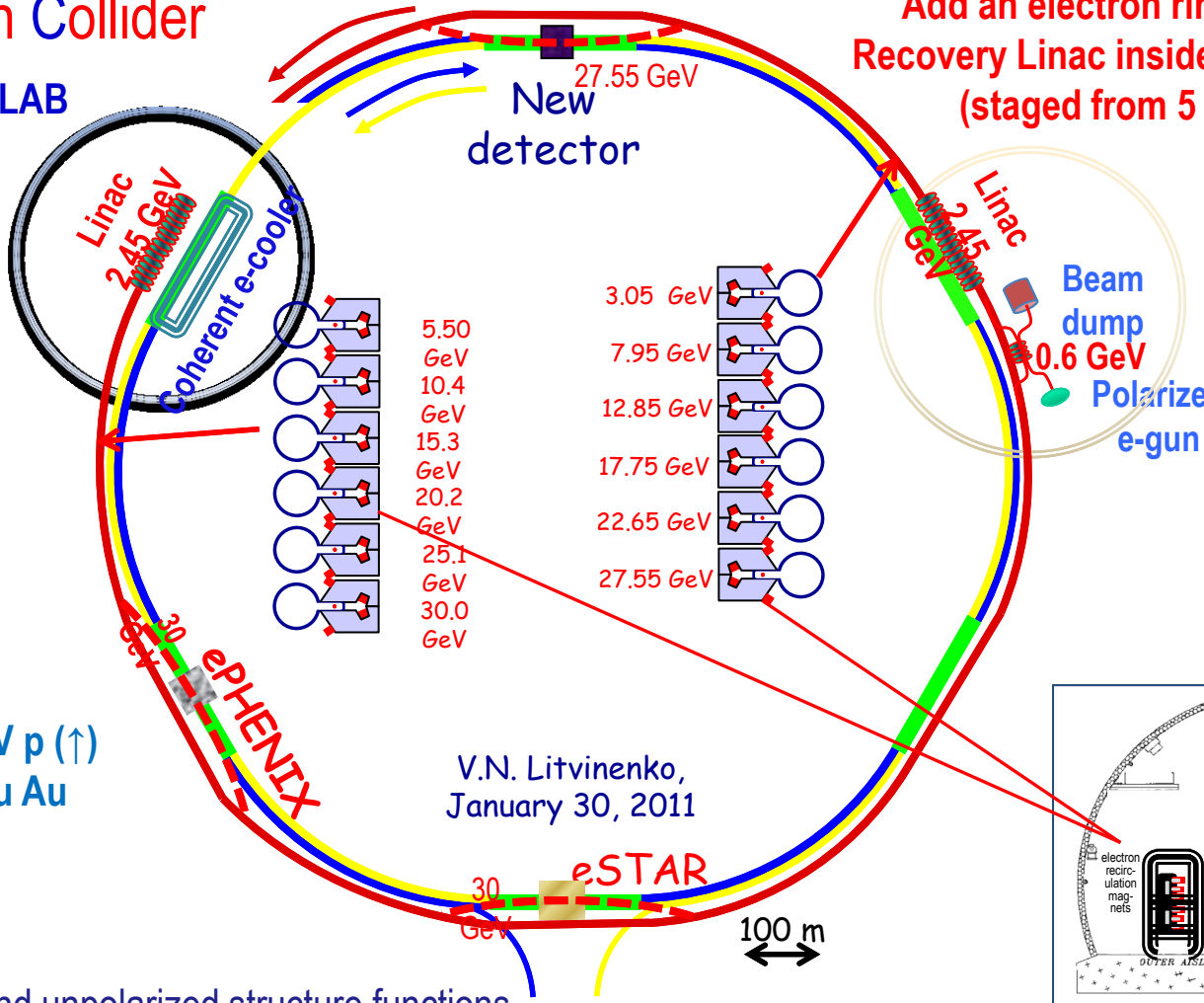
- RHIC is an extremely flexible facility capable of colliding light to heavy ions of different species over a wide range of center of mass energies, allowing one to "dial in" the medium properties one wishes to study. It also allows critical comparison studies of cold nuclear matter and initial state effects by providing proton(deuteron)-nucleus collisions at the same $\sqrt{s}$. It is also the worlds highest energy polarized proton collider.
- With suitable upgrades, RHIC experiments can measure jets in the energy range of $15 < E_T < 60$ GeV, which is below the optimal range for LHC and spans a large energy scale for the medium. This energy range is dominated by quark jets at RHIC, whereas higher energy jets at LHC are predominantly gluon jets.
- RHIC is a dedicated collider capable of delivering very high luminosity heavy ion collisions over extended running periods, producing large data sets that are required for the study of jets, high mass quarkonia states and other rare processes.

eRHIC

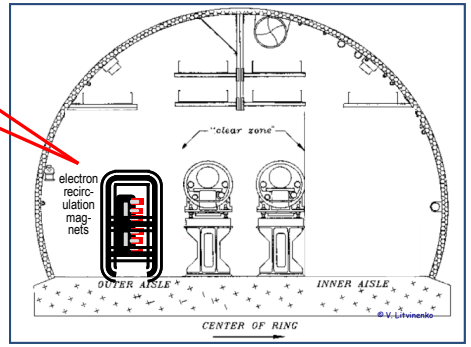
Electron Ion Collider

Partner with JLAB (ELIC)

Add an electron ring and Energy Recovery Linac inside the RHIC tunnel (staged from 5 to 30 GeV)



RHIC: 325 GeV p (↑) or 130 GeV/u Au



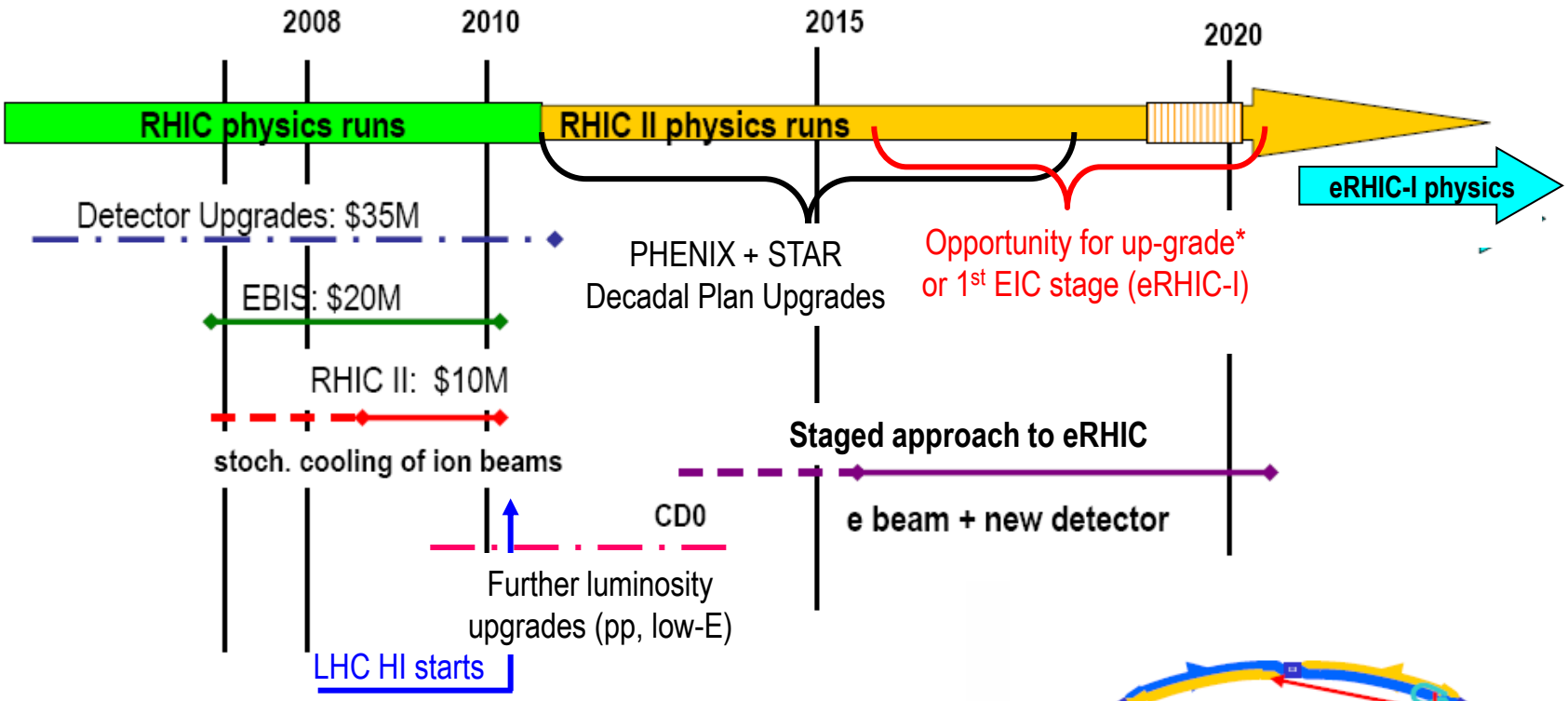
ep → Polarized and unpolarized structure functions

Study of gluon contribution to proton spin at small x ($L \sim 10^{34}$ cm^{2}s^{-1})

eA → Nuclear parton distribution functions

Heavy ions give coherent contributions to the gluon density in the collision, enhancing the ability to study gluon saturation effects at small $x \sim 10^{-5}$ ($L \sim 10^{32}$ cm^{2}s^{-1})

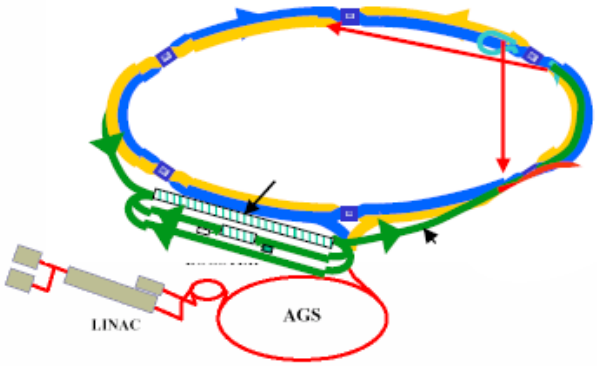
A Long Term (Evolving) Strategic View for RHIC



Legend:

- ***R&D***
- ***Construction***
- ***Multiple small projects***

CD0: DOE Critical Decision, mission need



PHENIX Detector

Central Spectrometer Tracking Systems

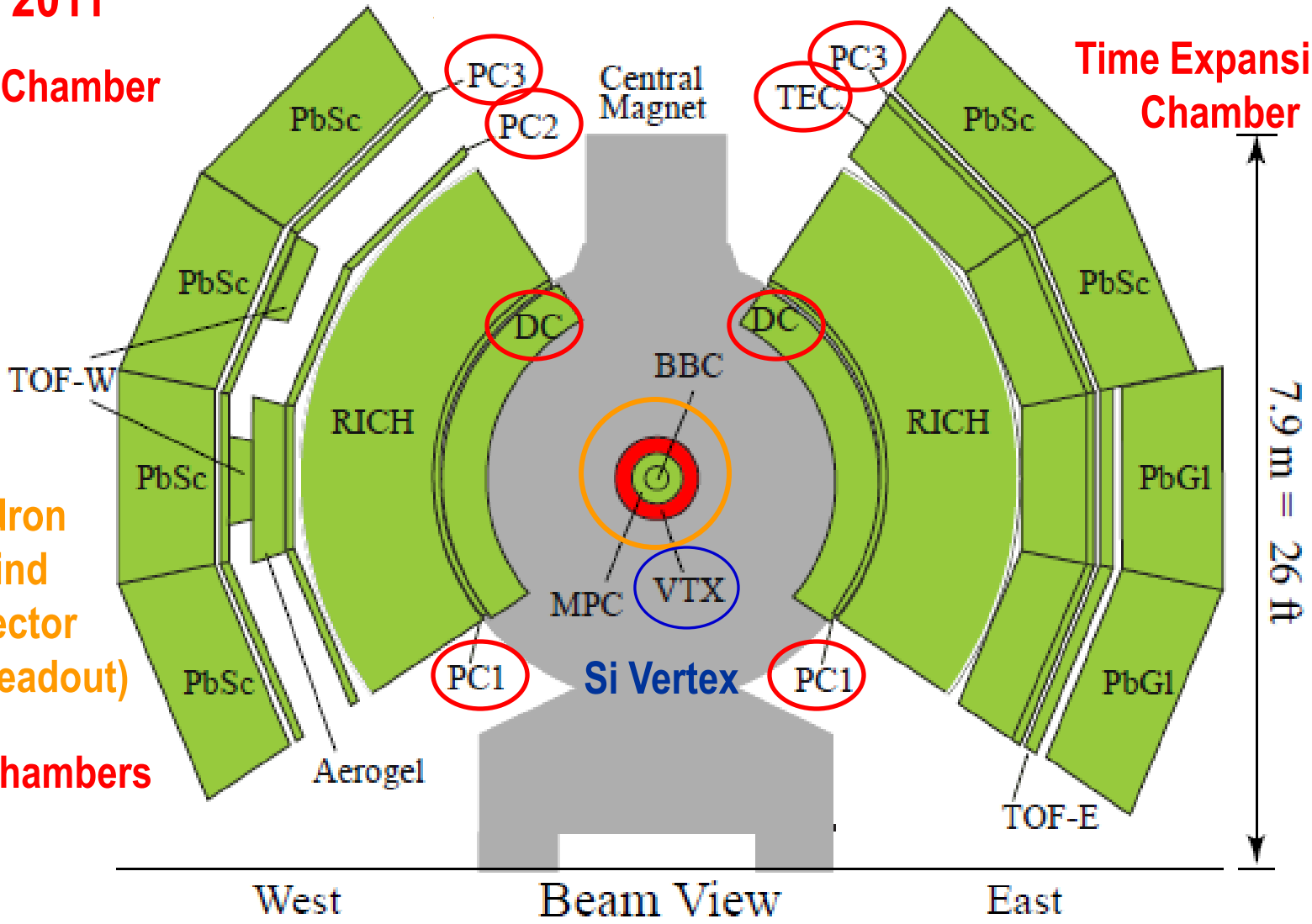
2011

Drift Chamber

Time Expansion Chamber

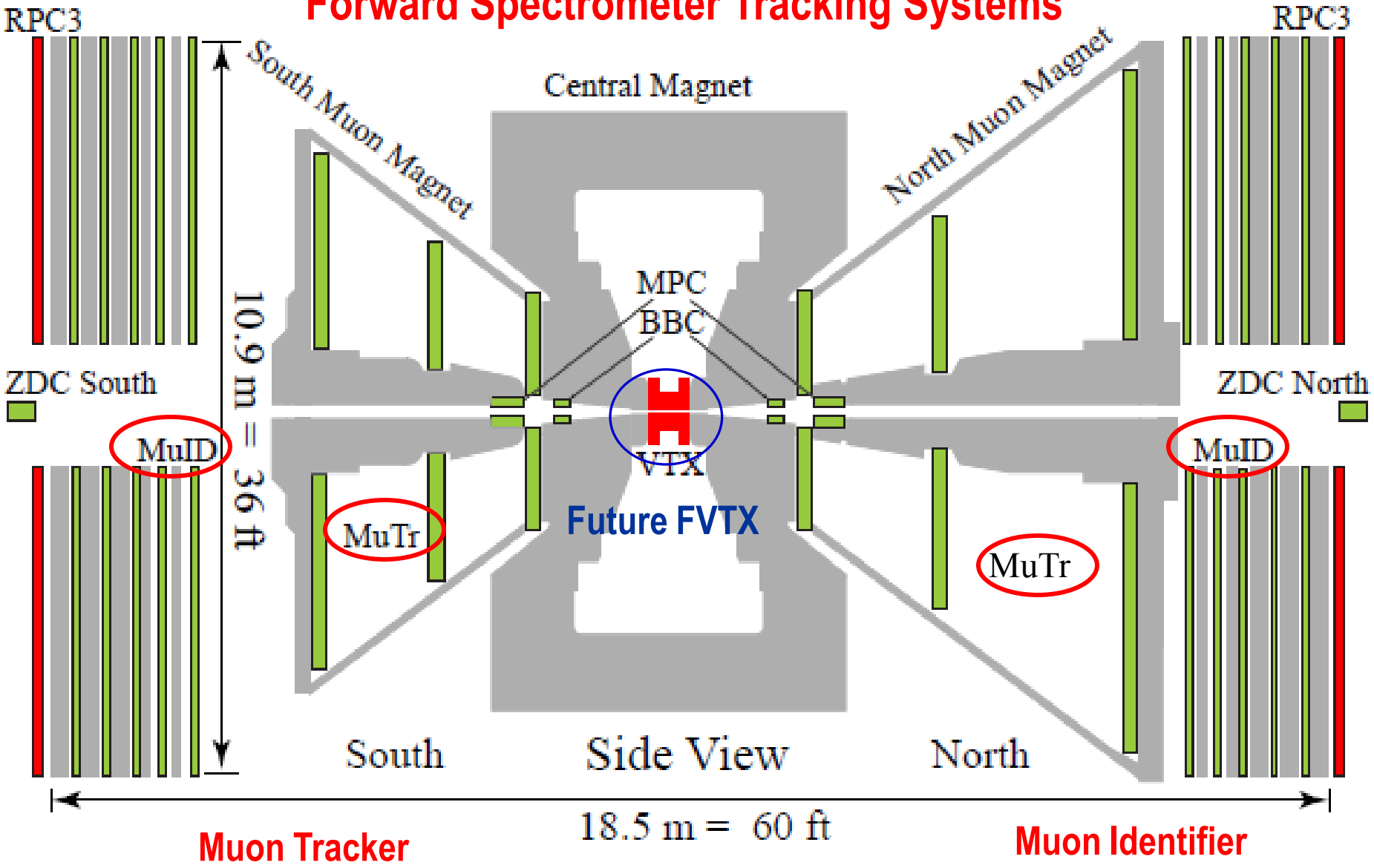
Hadron Blind Detector (GEM readout)

Pad Chambers



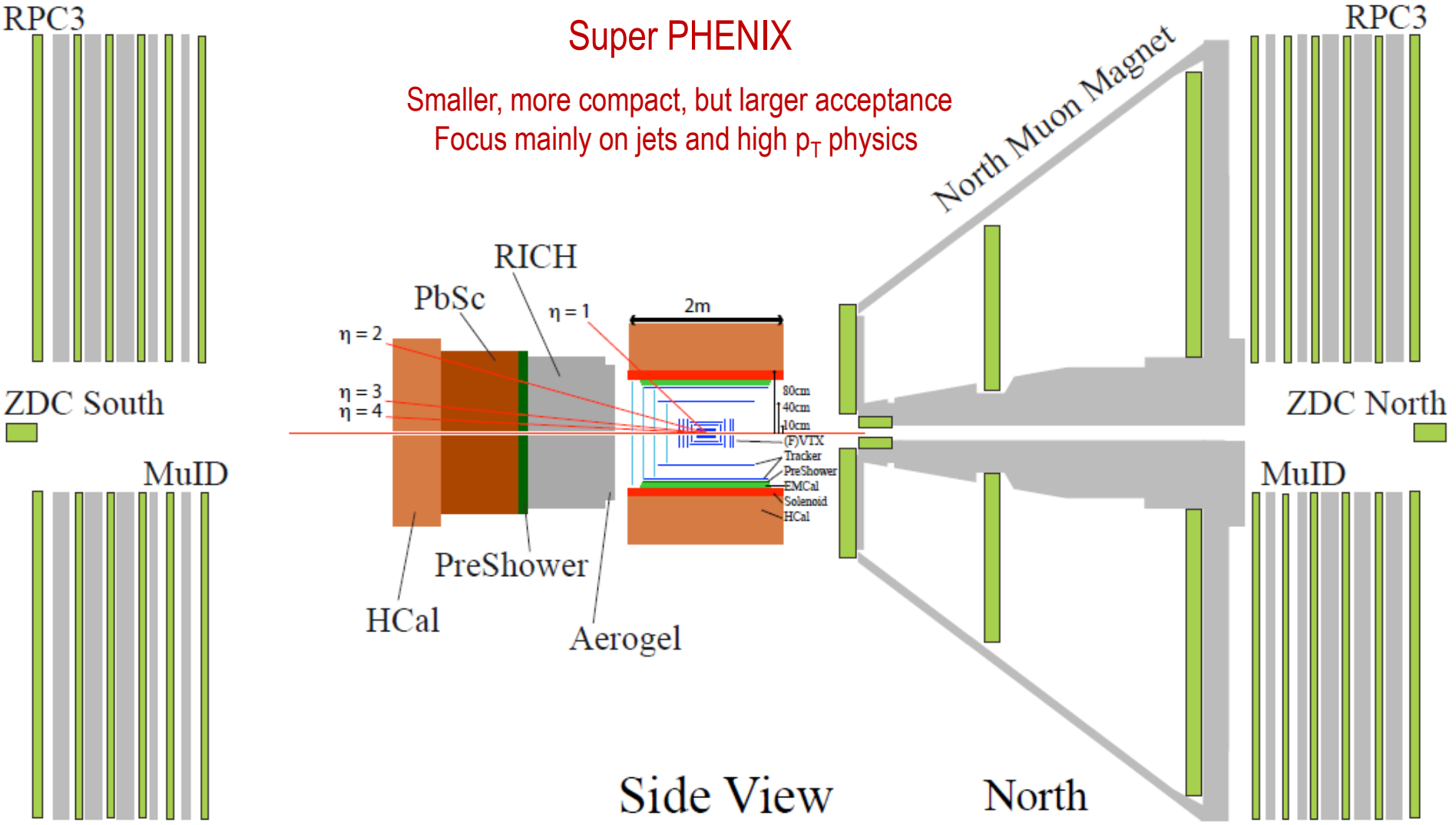
PHENIX Detector

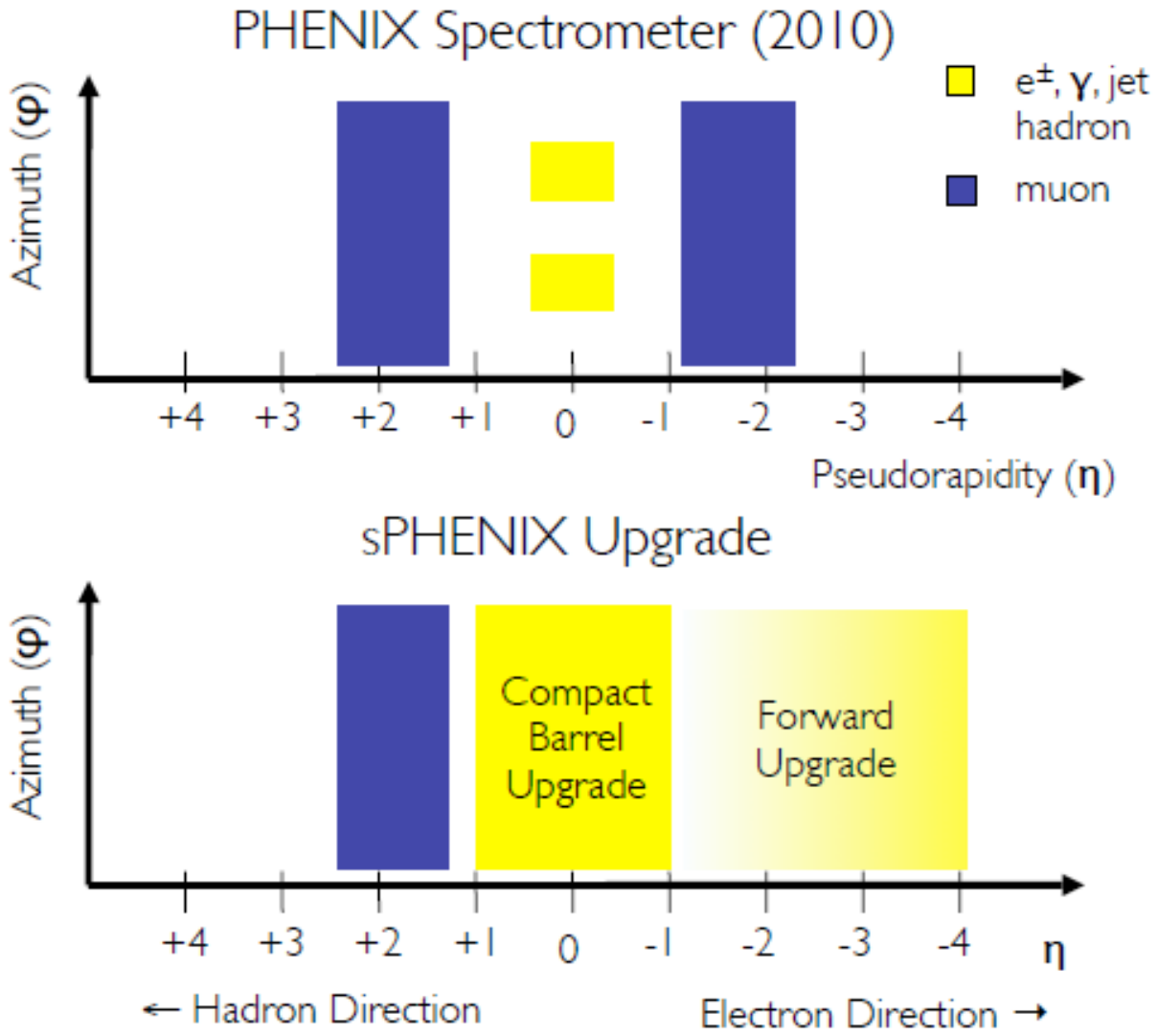
Forward Spectrometer Tracking Systems



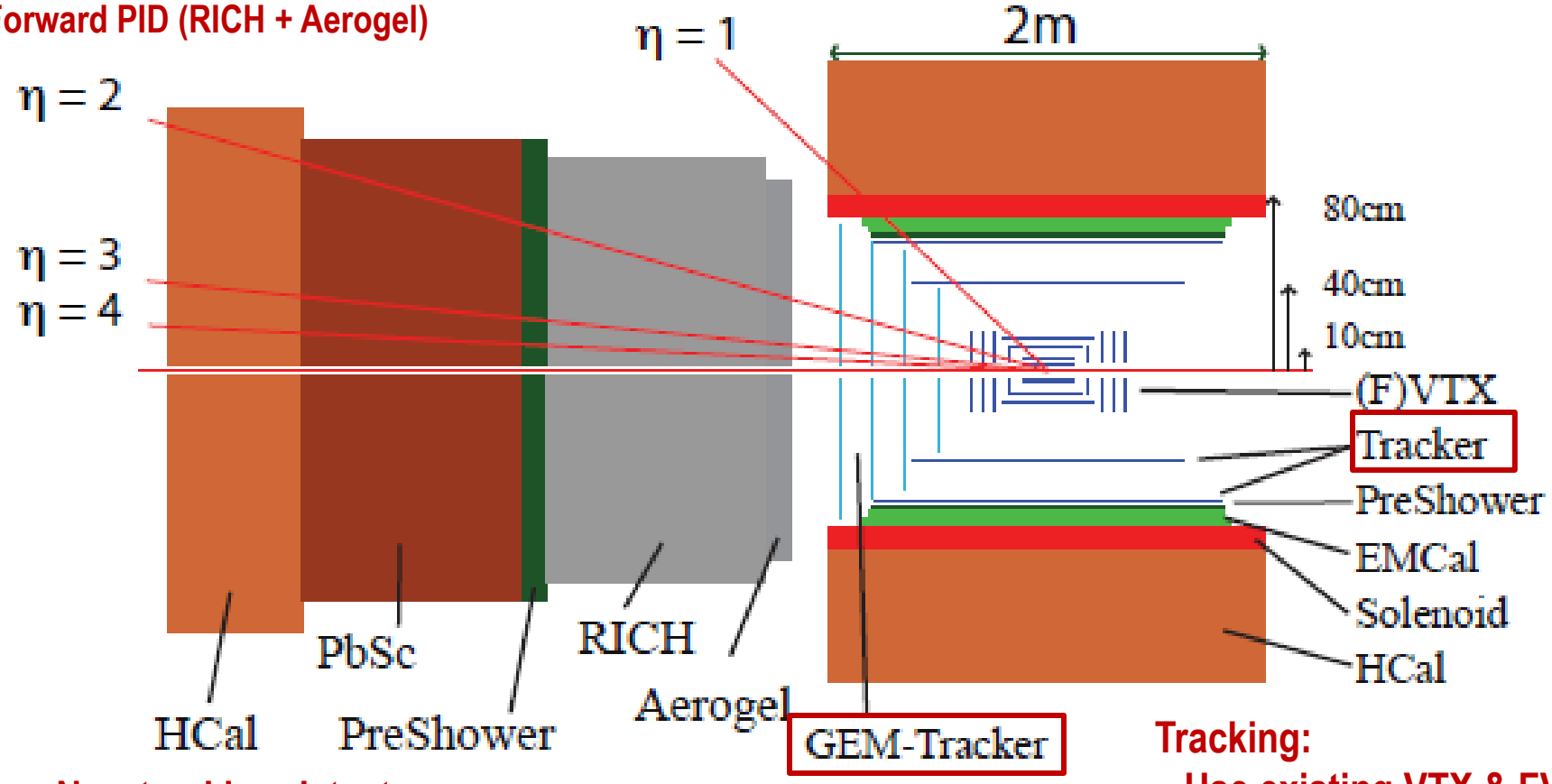
Super PHENIX

Smaller, more compact, but larger acceptance
Focus mainly on jets and high p_T physics




PHENIX Spectrometer (2010)
e±, γ, jet
hadron
muon
Azimuth (φ)
+4
+3
+2
+1
0
-1
-2
-3
-4
Pseudorapidity (η)
sPHENIX Upgrade
Azimuth (φ)
Compact
Barrel
Upgrade
Forward
Upgrade
+4
+3
+2
+1
0
-1
-2
-3
-4
η
← Hadron Direction
Electron Direction →

Solenoid magnet (R~ 80 cm, B~ 2T)
Compact EMCAL w/Prehower
HCAL (2π Central + Forward)
Forward PID (RICH + Aerogel)



New tracking detectors:

Additional layers of Si or GEMs in central region

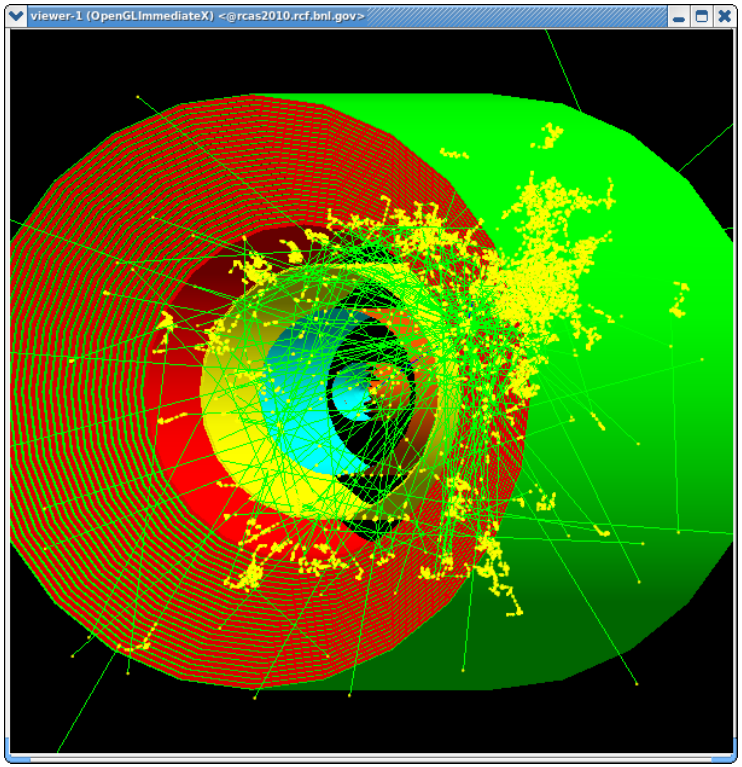
Planar GEM trackers forward

Tracking:

Use existing VTX & FVTX

Tracking Requirements on Spatial Resolution

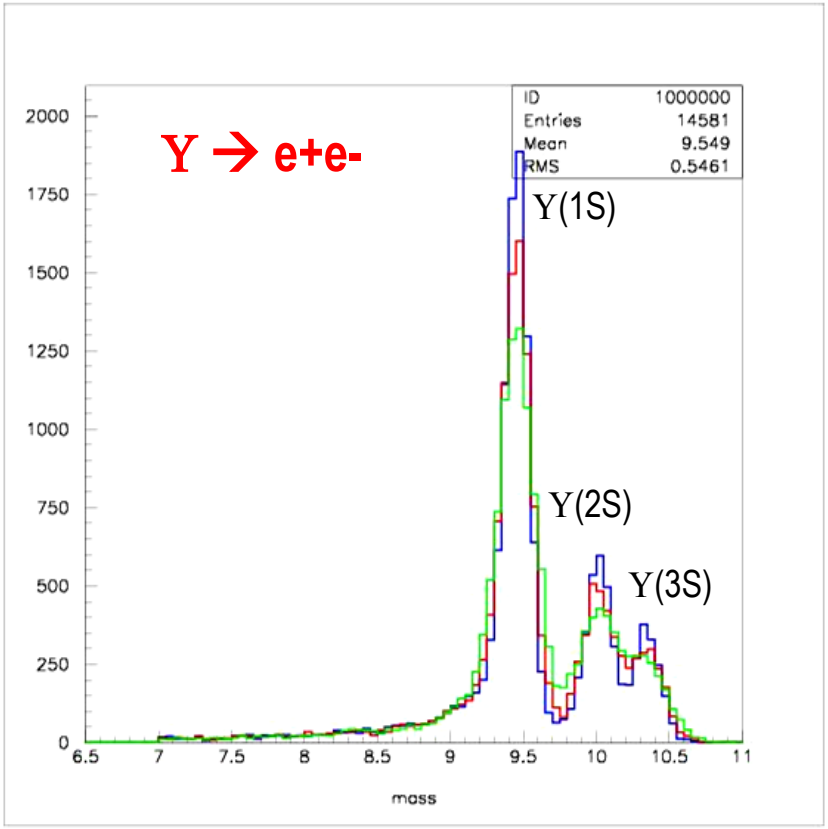
GEANT4 Simulation



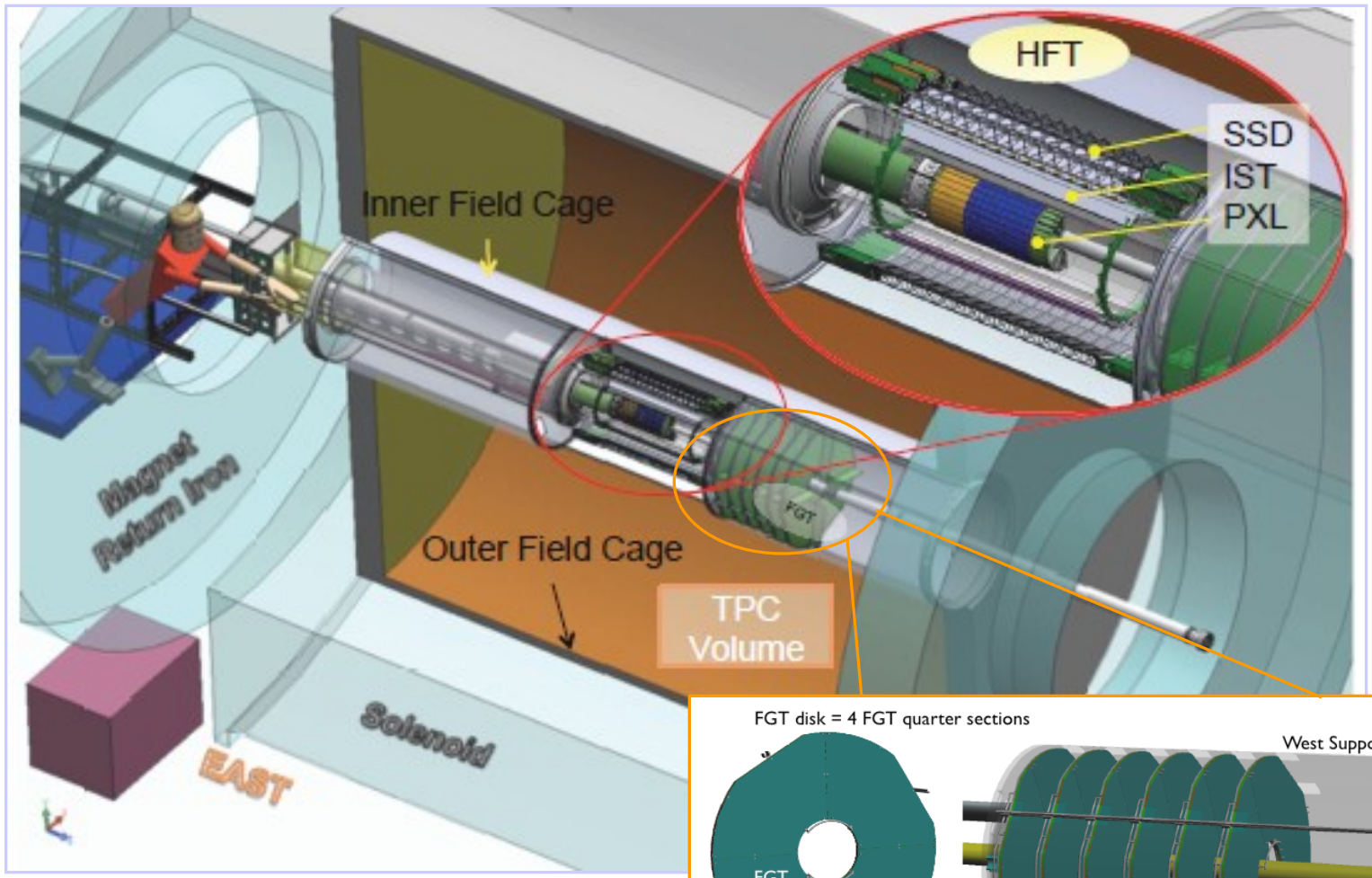
Six tracking layers

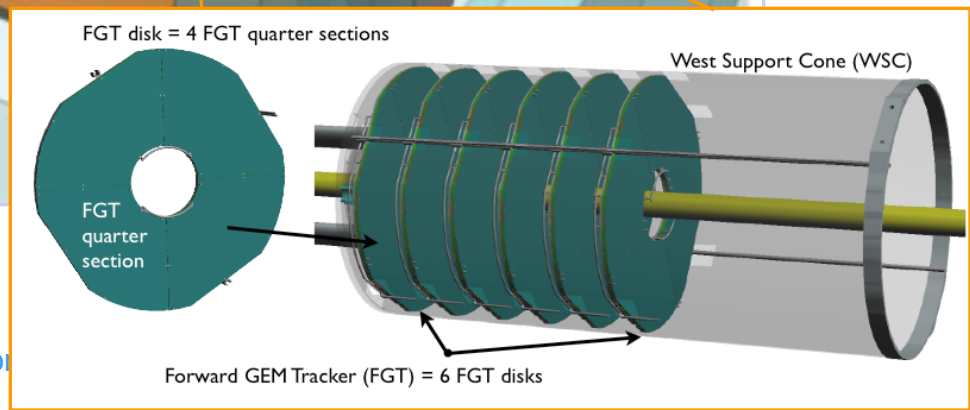
Blue – all 25 μm (80 μm Si strips)
Red -- last two 50 μm
Green – last two 100 μm

Driving physics requirement is to measure and resolve the Upsilon states



STAR Tracking Systems

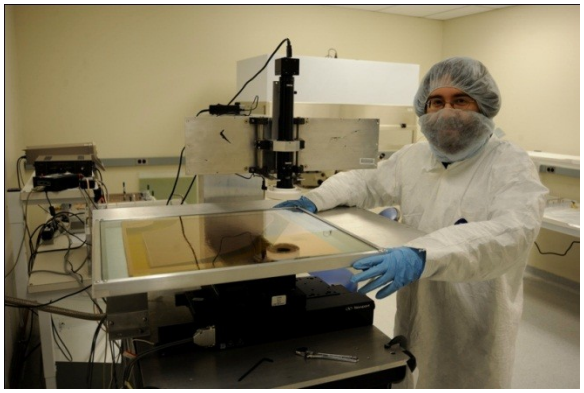




STAR Forward GEM Tracker

Production of GEM foils – collaborative effort of Tech-Etch with BNL, MIT and Yale

B.Surrow



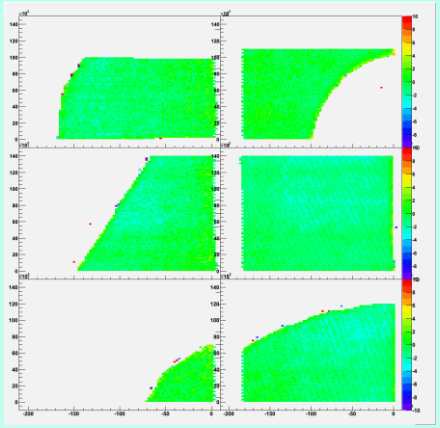
CCD optical scanner

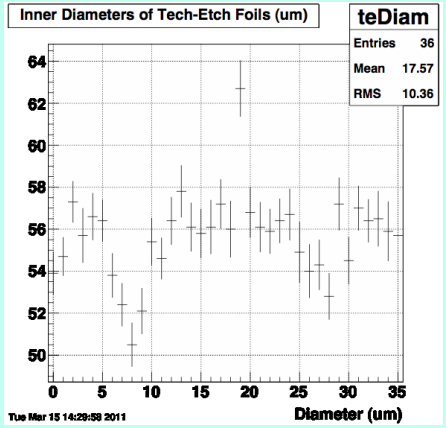
Status

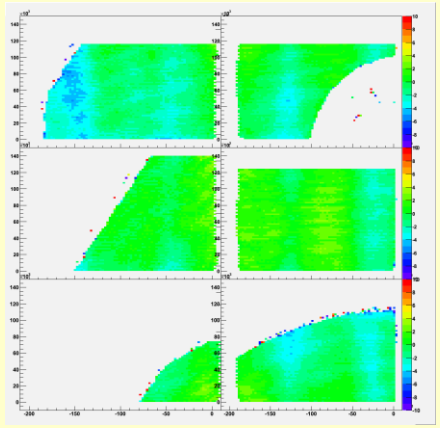
- 24 foils ordered from CERN
- 48 foils ordered from Tech Etch
- Readout foils supplied by Tech Etch
- Installation into STAR scheduled for summer 2011

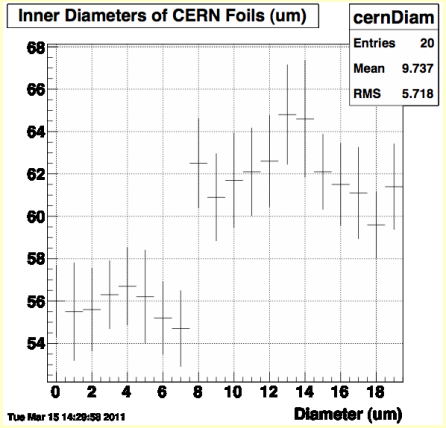
Tech Etch Foil < Better optical uniformity, Slightly higher leakage current

CERN Foil





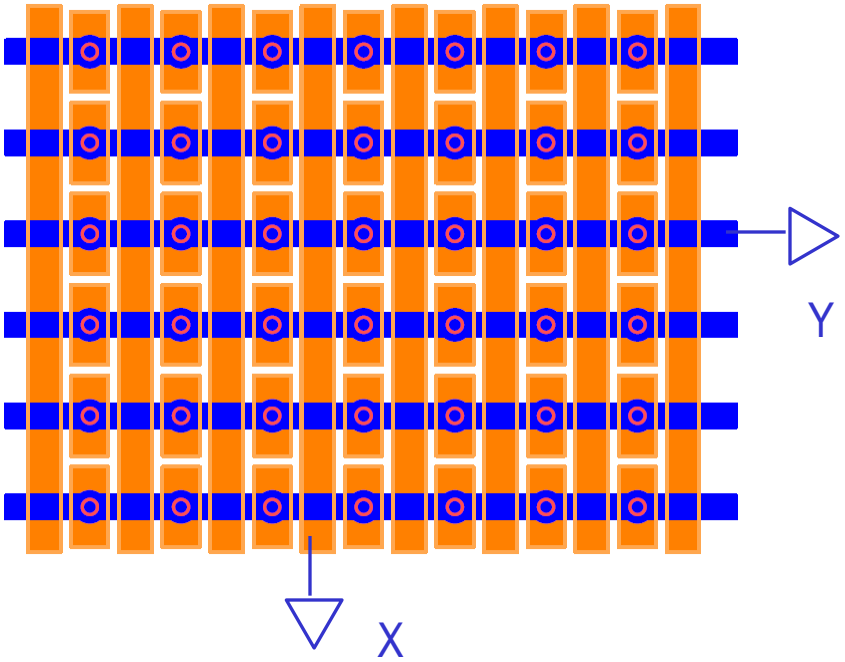




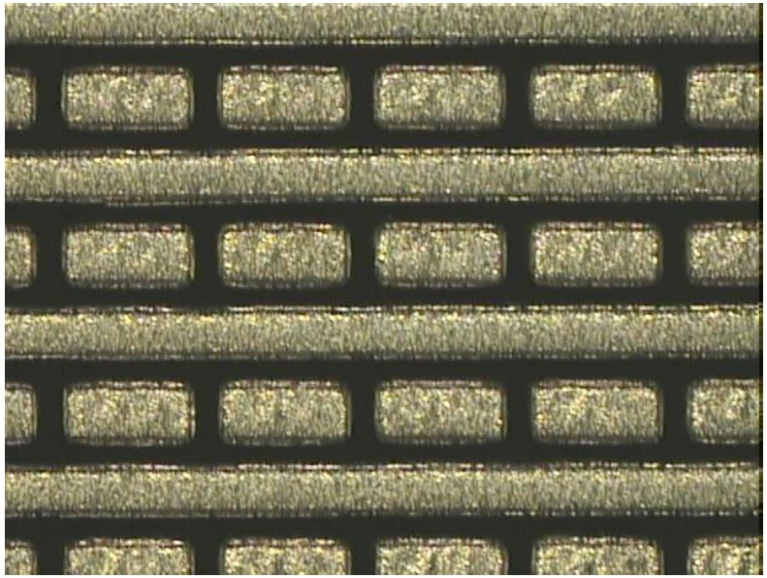
Line and Pad 2D Readout

R.Majka (Yale)

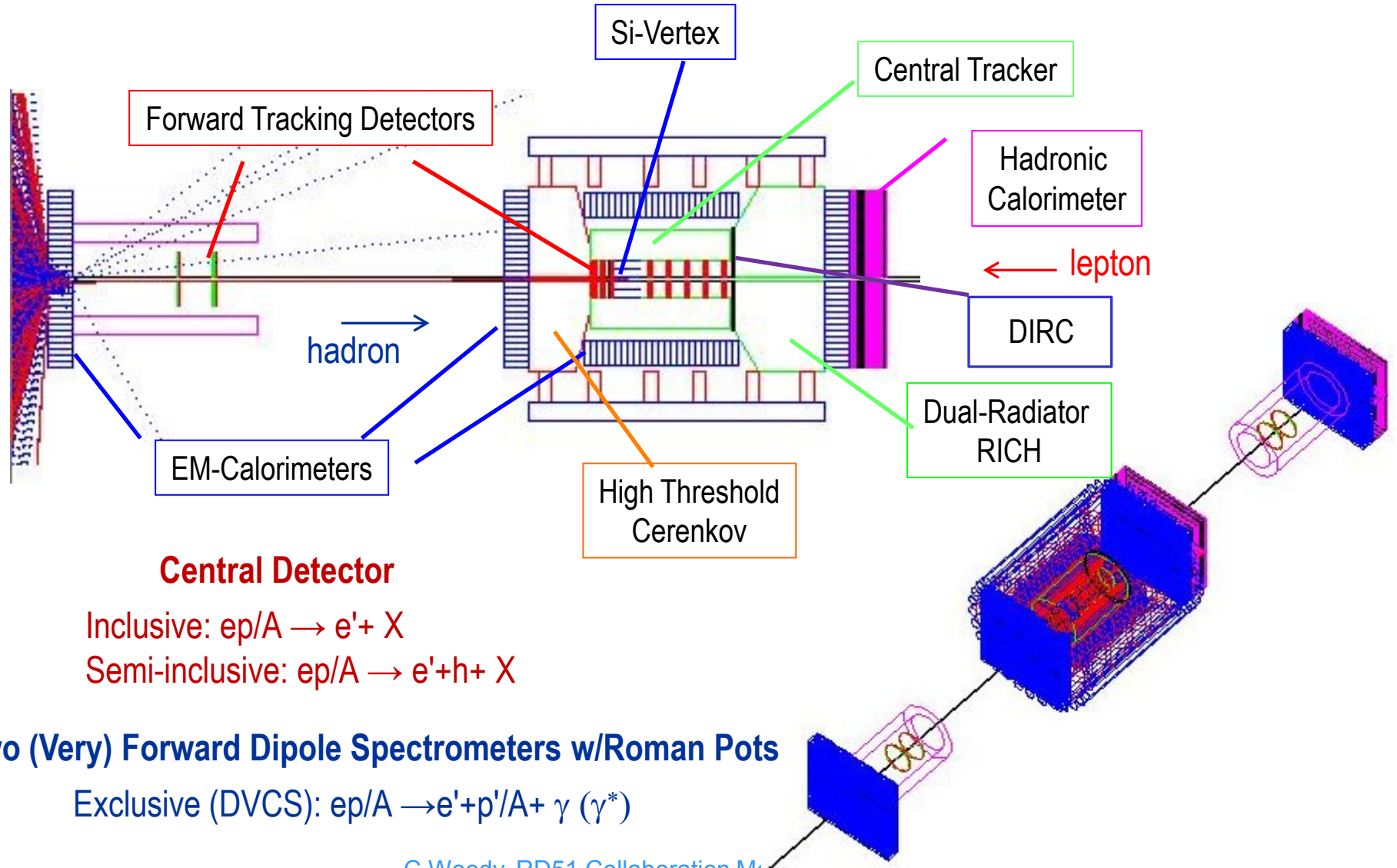
Concept: Have both X & Y readout on the same single layer
Normal strips in one direction on top
Connect pads to strips on bottom with vias for other direction



300 μm line-pad produced by Tech Etch



eRHIC Detectors



Central Detector

Inclusive: ep/A → e'+ X

Semi-inclusive: ep/A → e'+h+ X

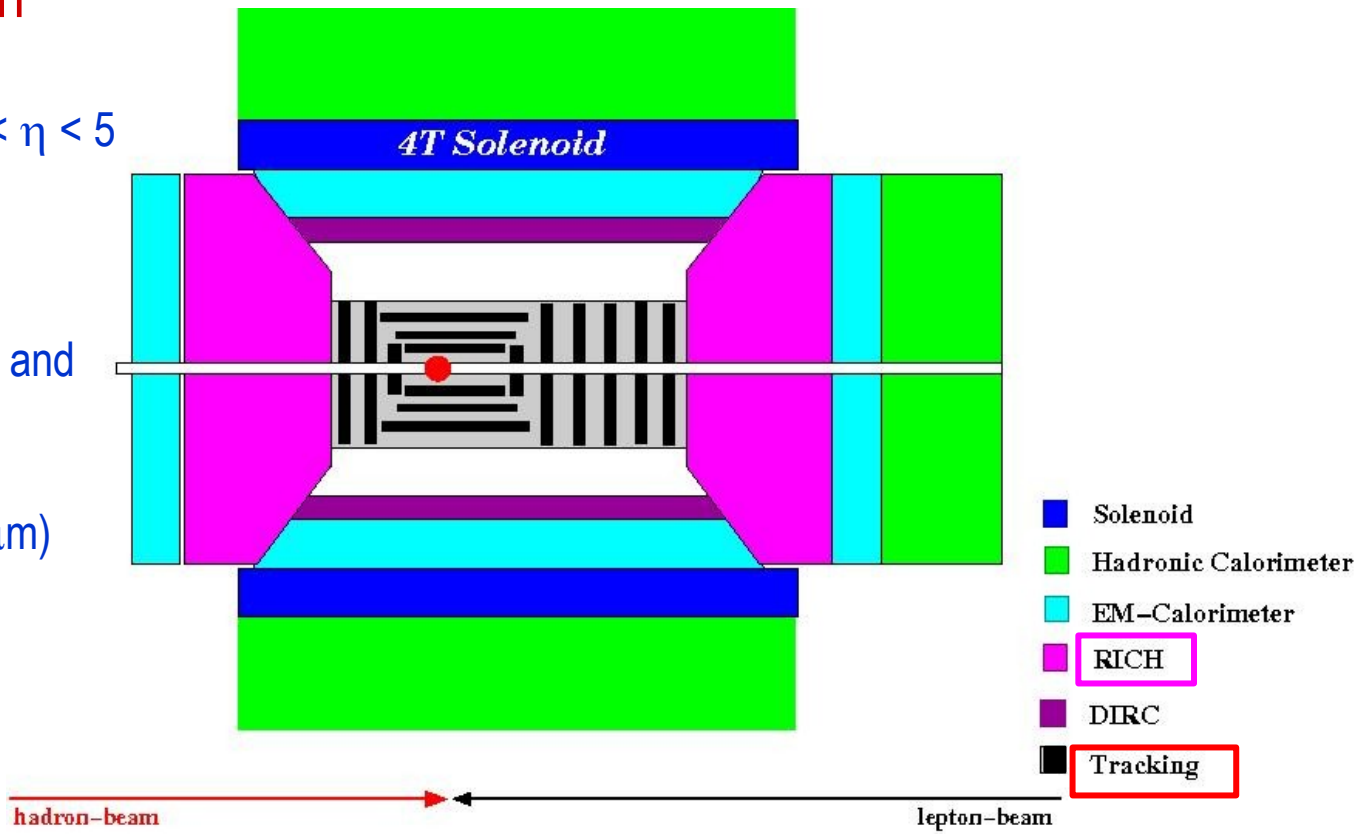
Two (Very) Forward Dipole Spectrometers w/Roman Pots

Exclusive (DVCS): ep/A →e'+p'/A+ γ (γ*)

Central EIC Detector

Conceptual Design

- Large acceptance: $-5 < \eta < 5$
- Asymmetric
- Nearly 4π tracking and EMCAL coverage
- HCAL coverage central and in hadron direction
- Good PID
- Vertex resolution (< 5 μm)



Electron is scatted over large range of angles (up to 165˚)
Low $Q^2 \rightarrow$ low momentum (few GeV)
Requires low mass, high precision tracking

GEMs or possible TPC w/MPGD readout

Possible GEM readout

Summary

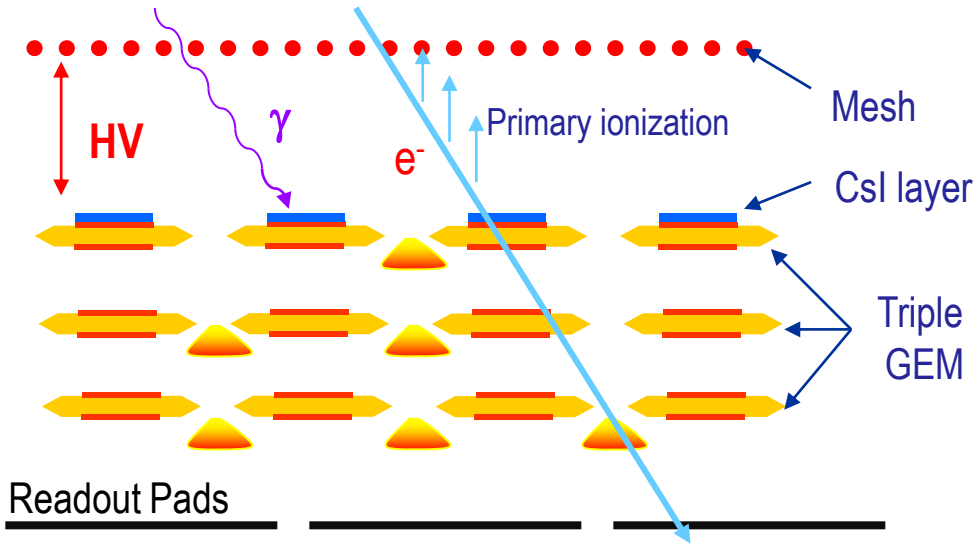
Micropattern Gas Detectors will play a major role in future upgrade detectors for RHIC

Issues and Questions:

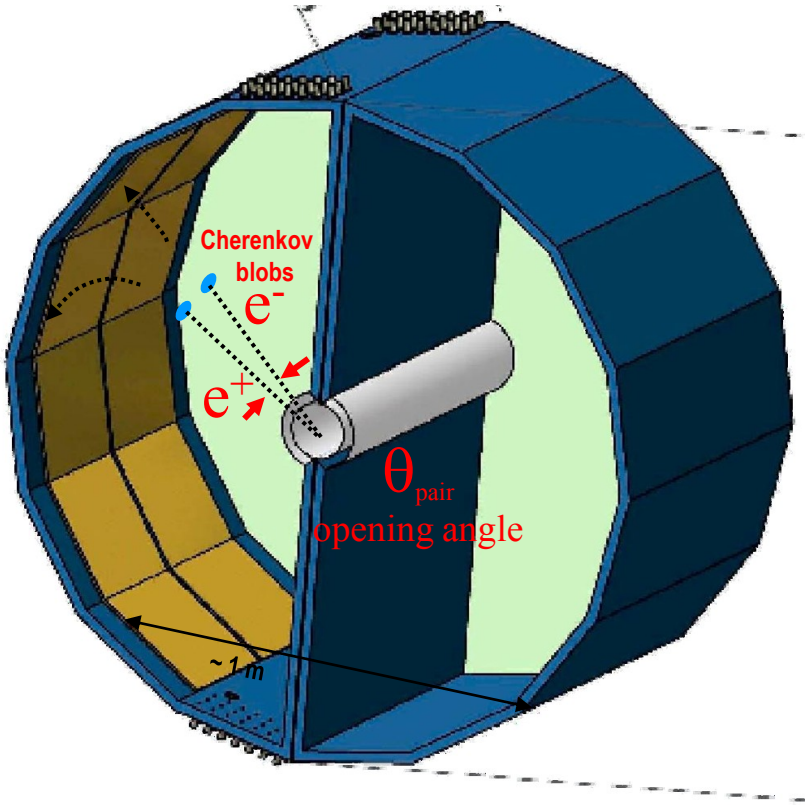
1. What are the limits on the position resolution with MPGD detectors ?
2. Can we build a cylindrical GEM tracker that will work in high multiplicity HI collisions ?
3. How can we reduce the mass of MPGD trackers ?
4. Can a TPC with MPGD readout be used in high luminosity ep and eA collisions ?

Backup Slides

PHENIX HBD

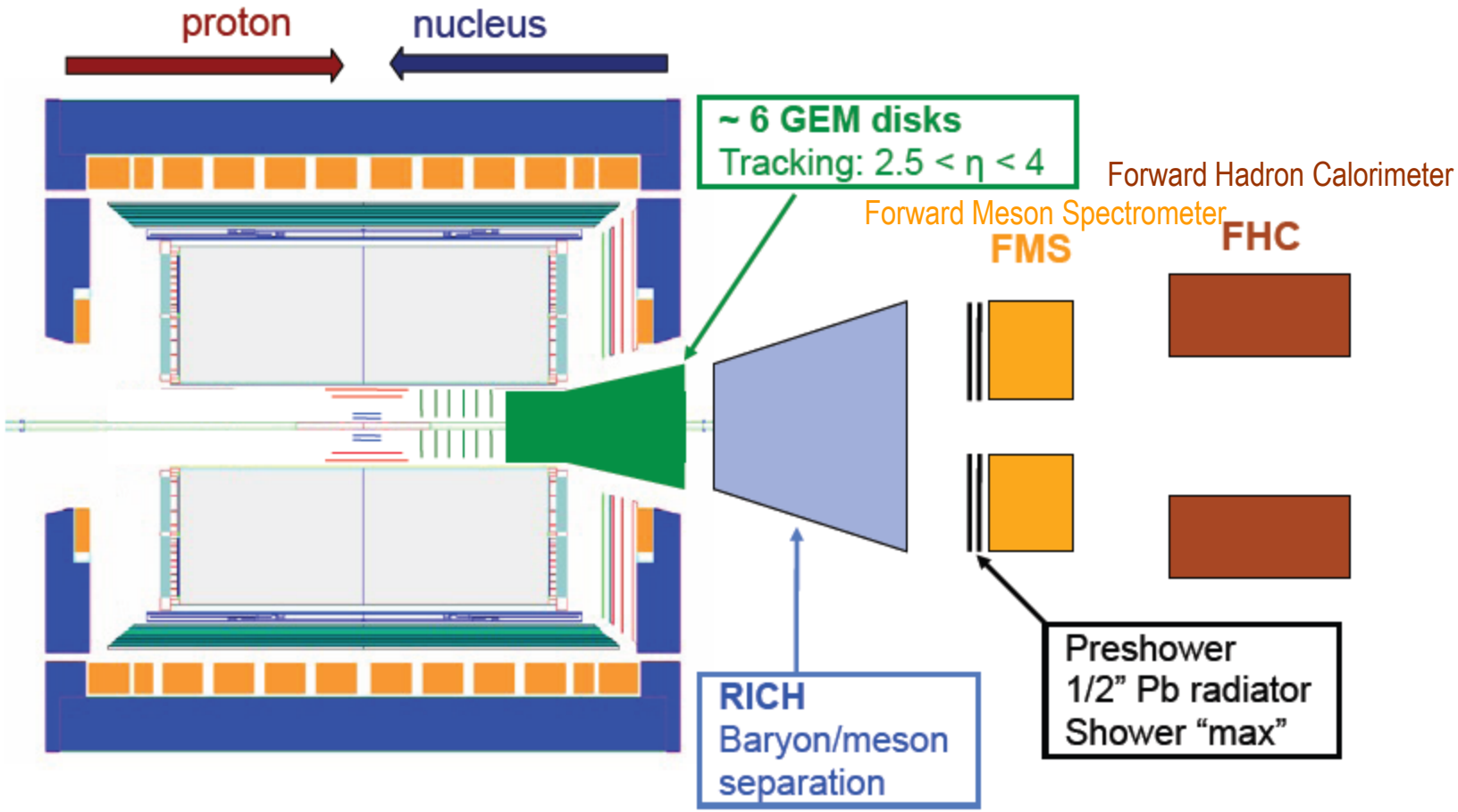


Proximity Focused Cherenkov Detector
Radiator Gas=Working Gas
Gas volume filled with pure CF_4 radiator



- **UV photons produce photoelectrons on a CsI photocathode and are collected in the holes of the top GEM**
- **Primary ionization is drifted away from GEM and collected by a mesh**
- **Triple GEM stack provides gain ~ few x10^3**
- **Amplified signal is collected on pads and read out**

STAR Decadal Plan



Heavy Flavor Tracker, Muon Telescope Detector

STAR near-term HFT, MTD - Heavy-Ion driven upgrades
FGT - W-physics driven

Forward GEM Tracker