MEIC Detector Design

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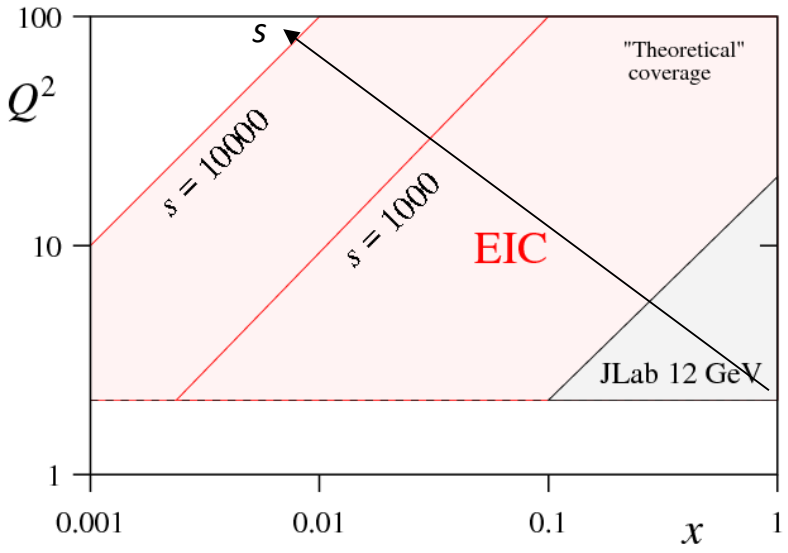
Outline

1. General Overview

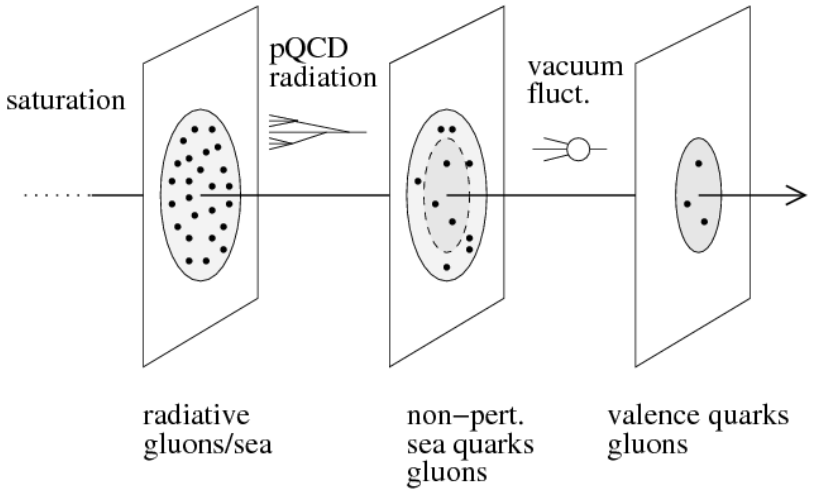
2. Central detector

3. Small-angle detection

To cover all the physics, we need...



C. Weiss



$Q^2 \sim (ys)x$

Range in y

- For large or small y, uncertainties in the kinematic variables become large
- Detecting only the electron $y_{max} / y_{min} < 10$
- Also detecting all hadrons $y_{max} / y_{min} < 100$
  - Requires hermetic detector (no holes)

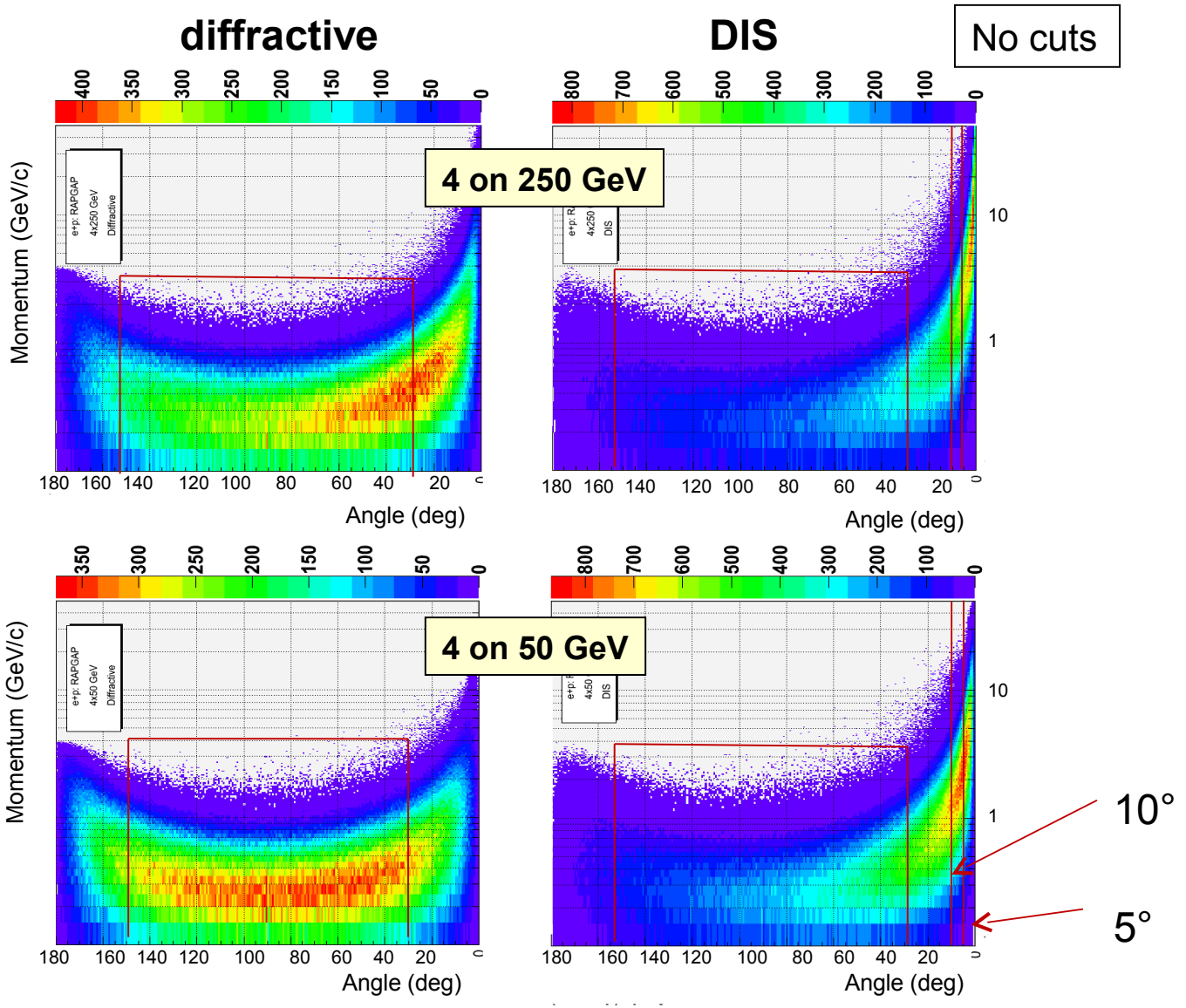
Range in s

- Accelerator considerations limit s_{min}
  - Depends on s_{max}

Variable kinematics

- At fixed s, changing the ratio E_e / E_{ion} can for some reactions improve resolution, pid, and acceptance.

DIS and diffractive mesons



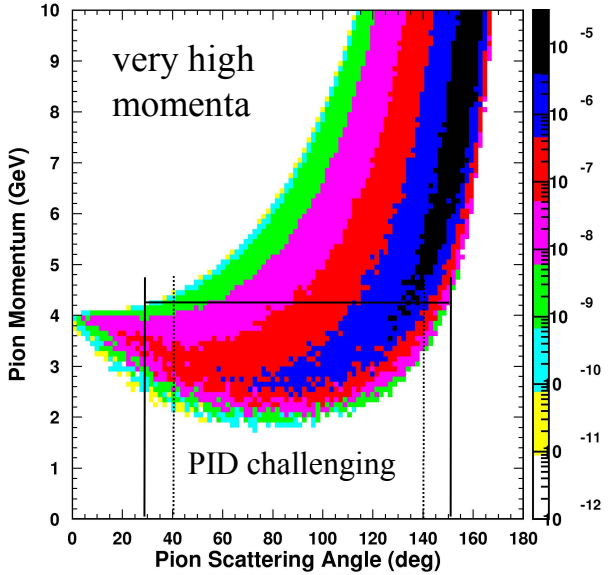
But this is not the full story!

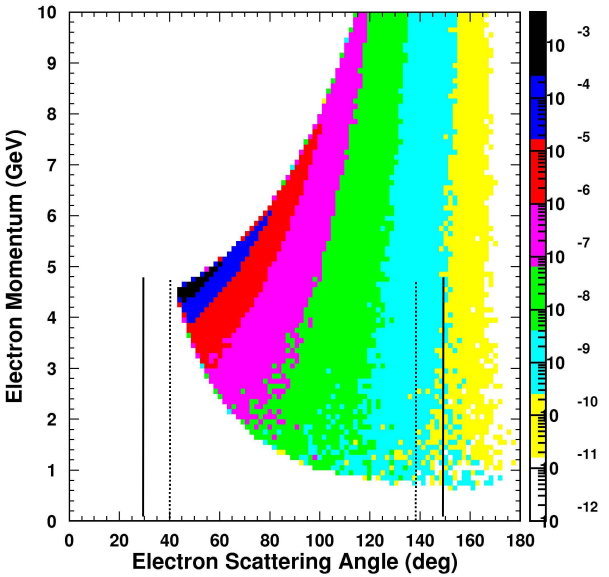
Exclusive light meson kinematics ($Q^2 > 10$ GeV^2)

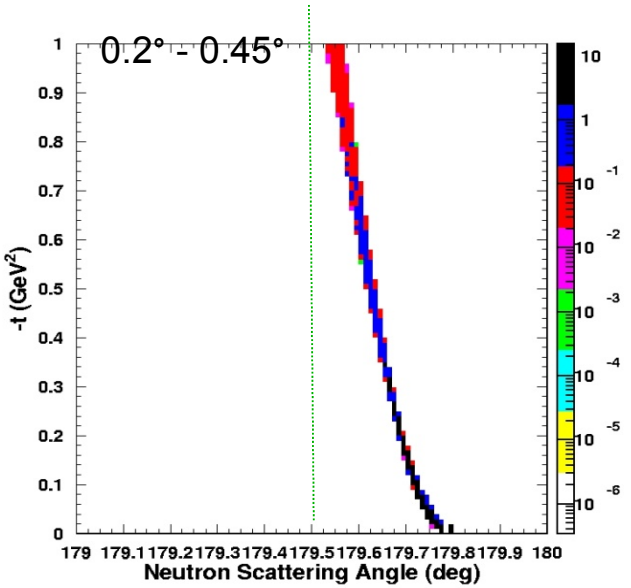
$ep \rightarrow e'\pi^+ n$

mesons | scattered electrons | recoil baryons

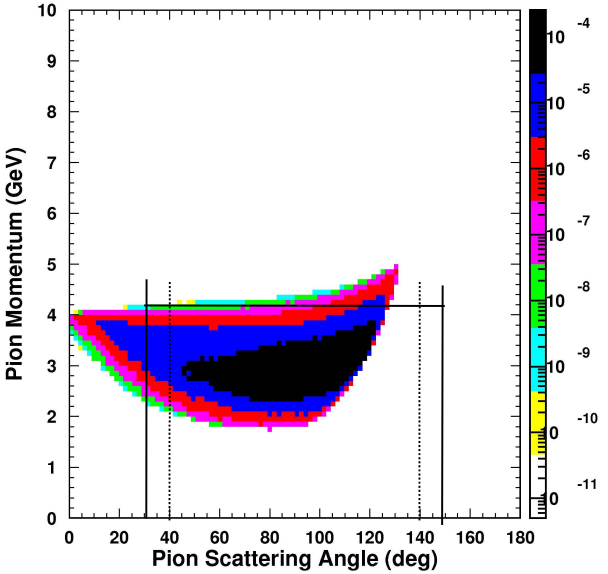
4 on 250 GeV

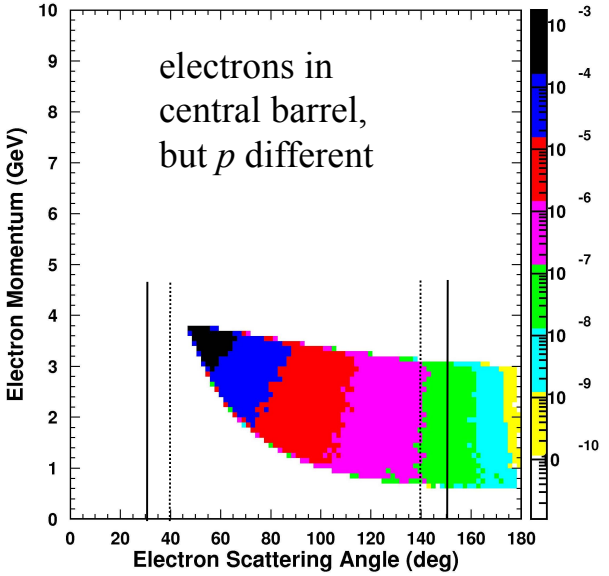


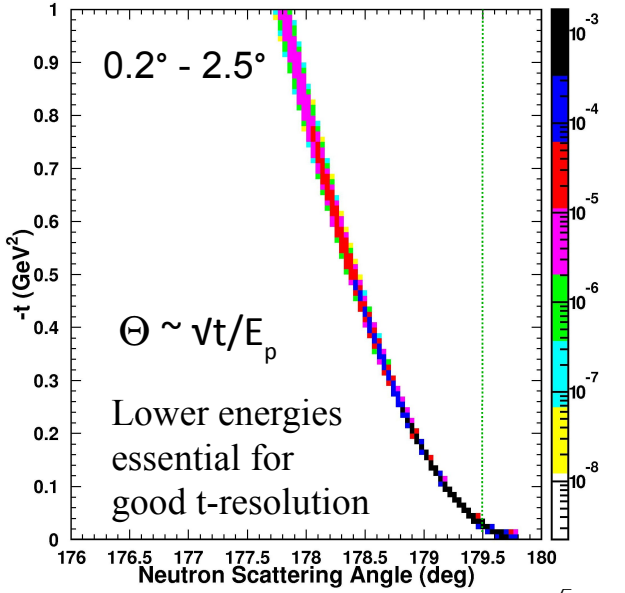




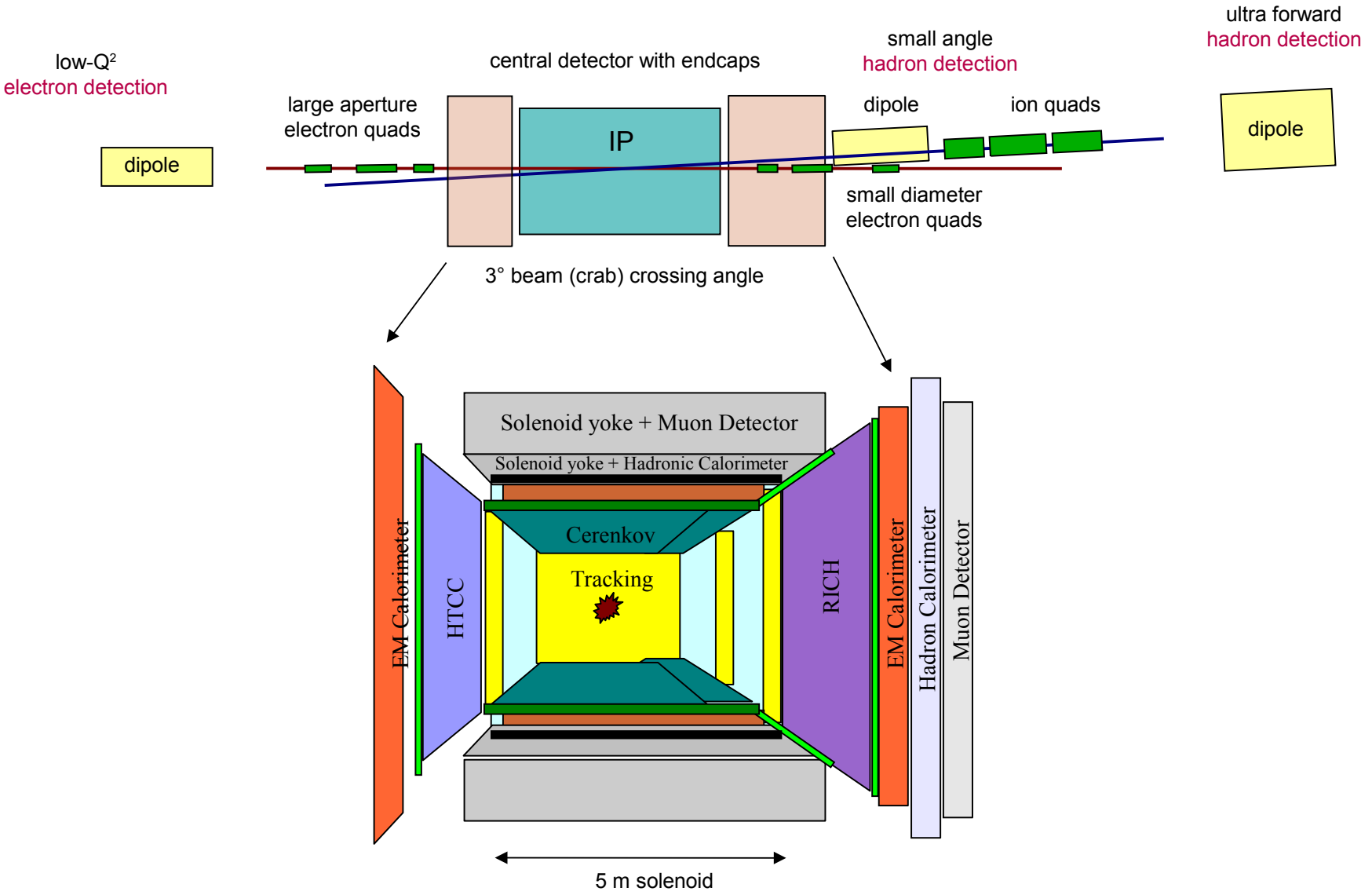
4 on 30 GeV



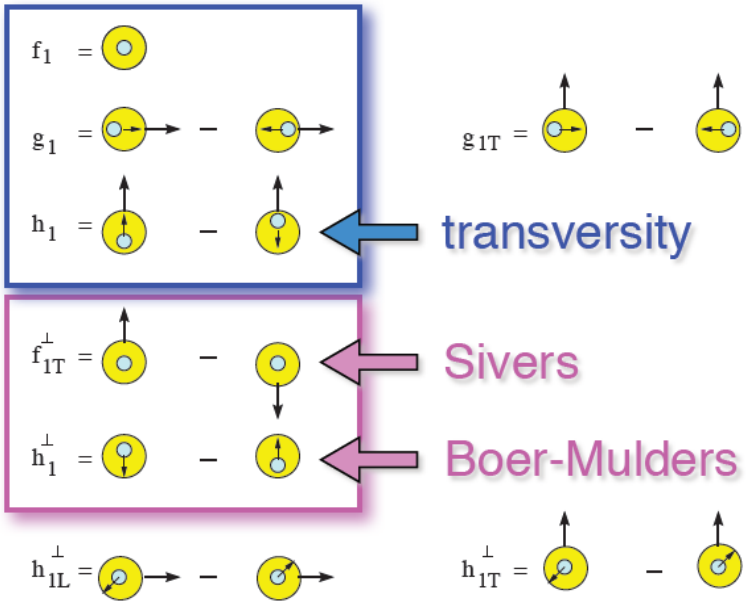


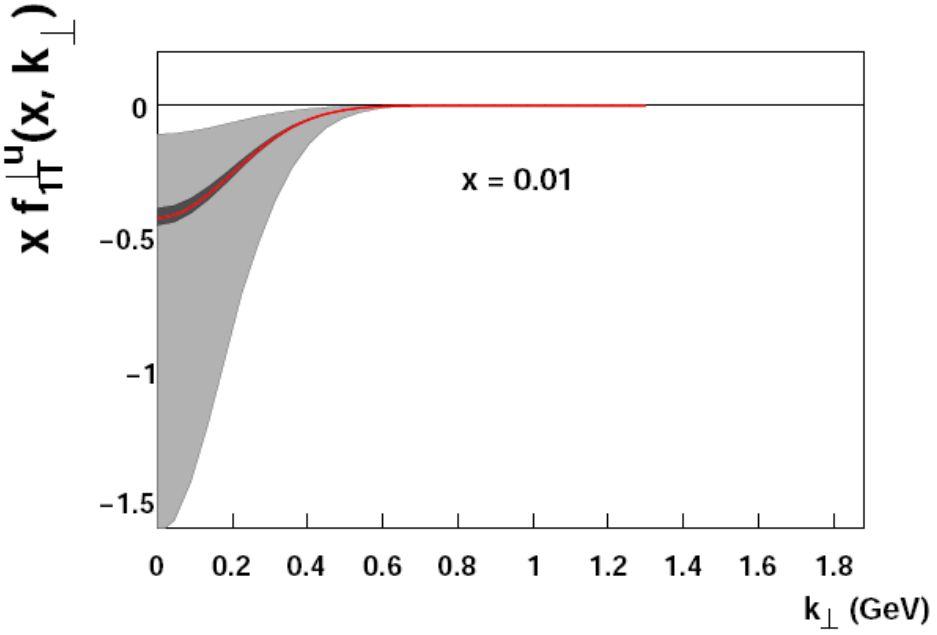


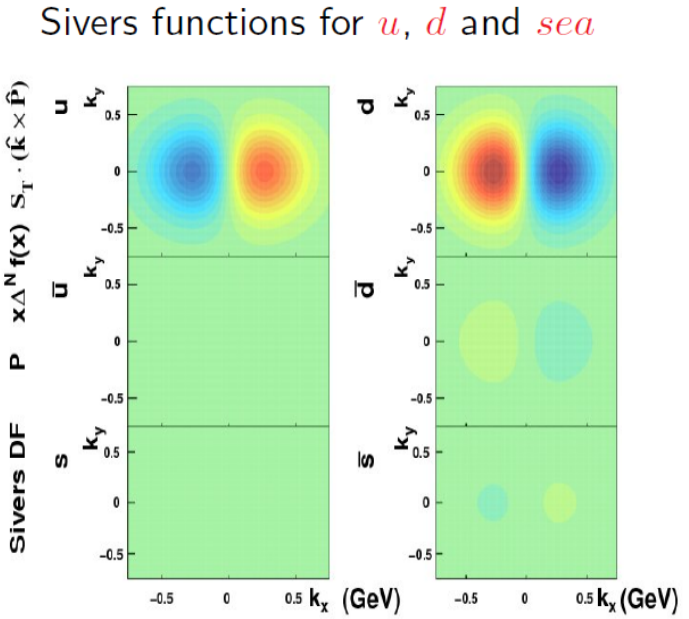
Extended detector – overview



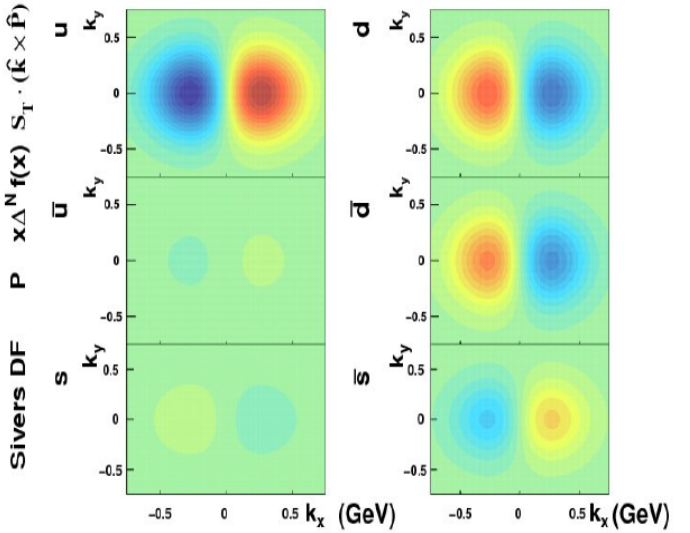
Transverse Momentum Distributions (TMDs)





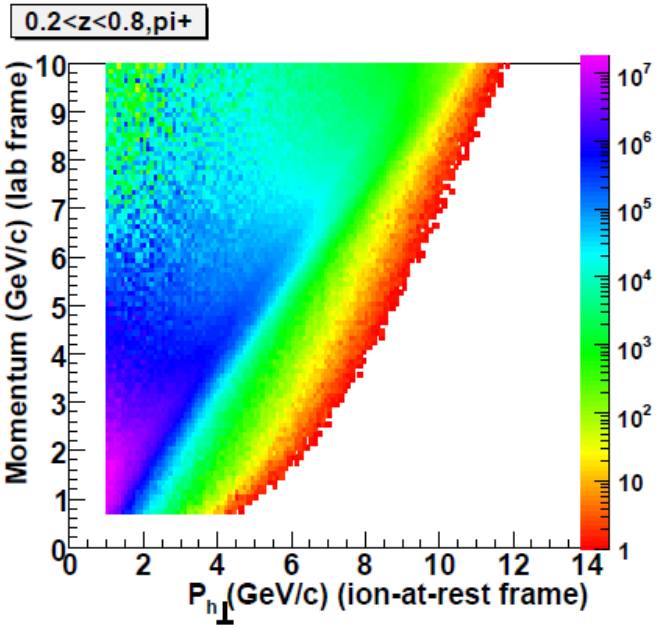


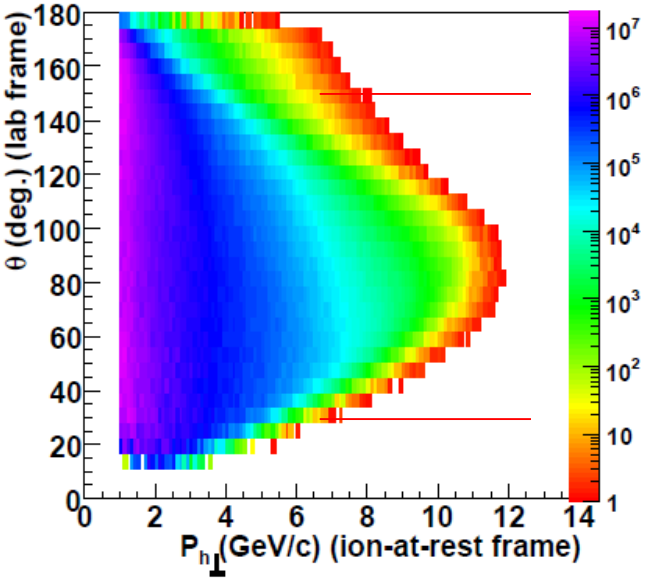
$x = 0.2$



$x = 0.01$

Measuring semi-inclusive meson production (SIDIS)

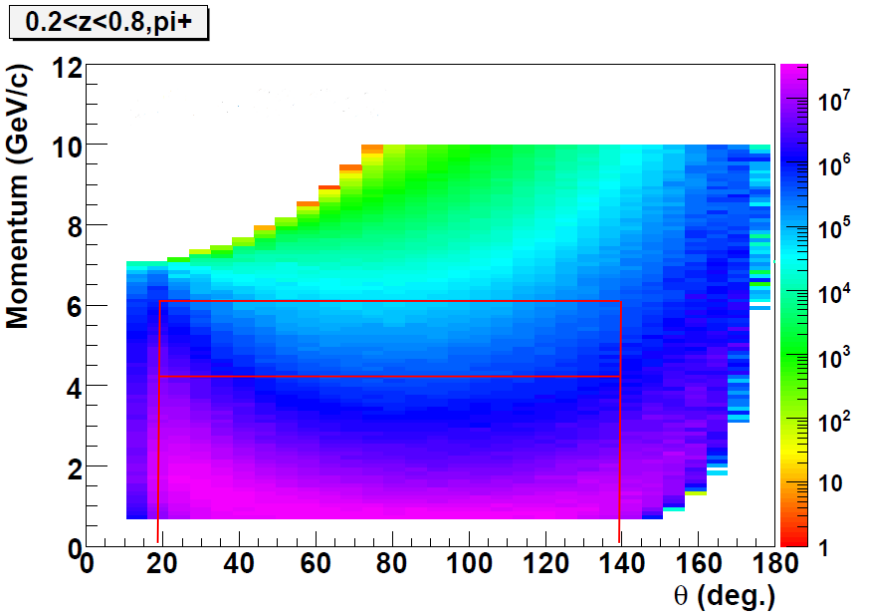




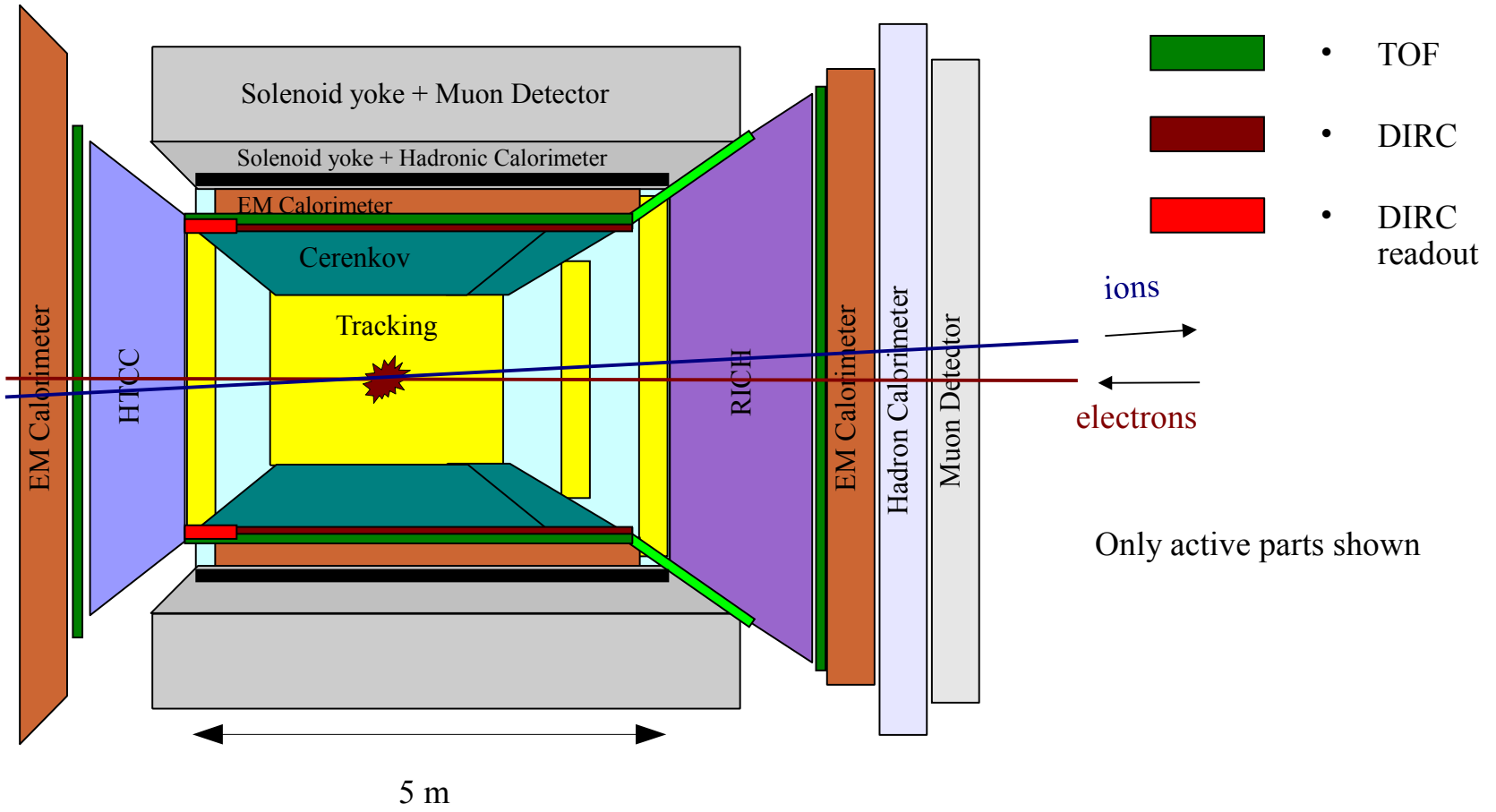
11 on 60 GeV

- Momentum of quark: k_T
- Momentum of meson: $p_T \neq k_T$
- p_T defined with respect to photon, not electron
  - Boosted along beam direction
  - Thus, generally, $p^{lab} > p_T^{rest}$

- TMDs require detection and identification of mesons (π/K) with lab momenta >> 1 GeV/c.
- Colinear factorization requires $p_T \sim Q$.

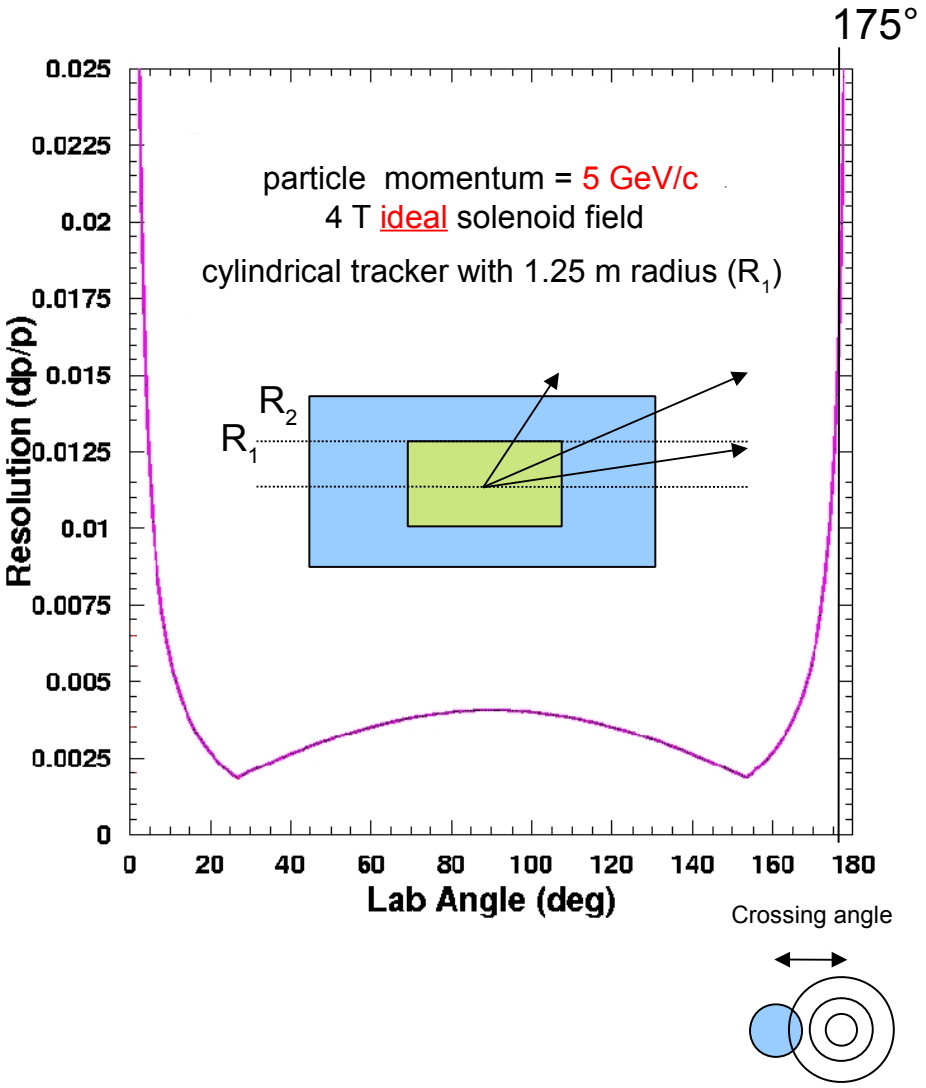


MEIC central detector



- Need particle identification and good resolution over a wide momentum range
- Sensors need to be compact and resistant to radiation and magnetic fields

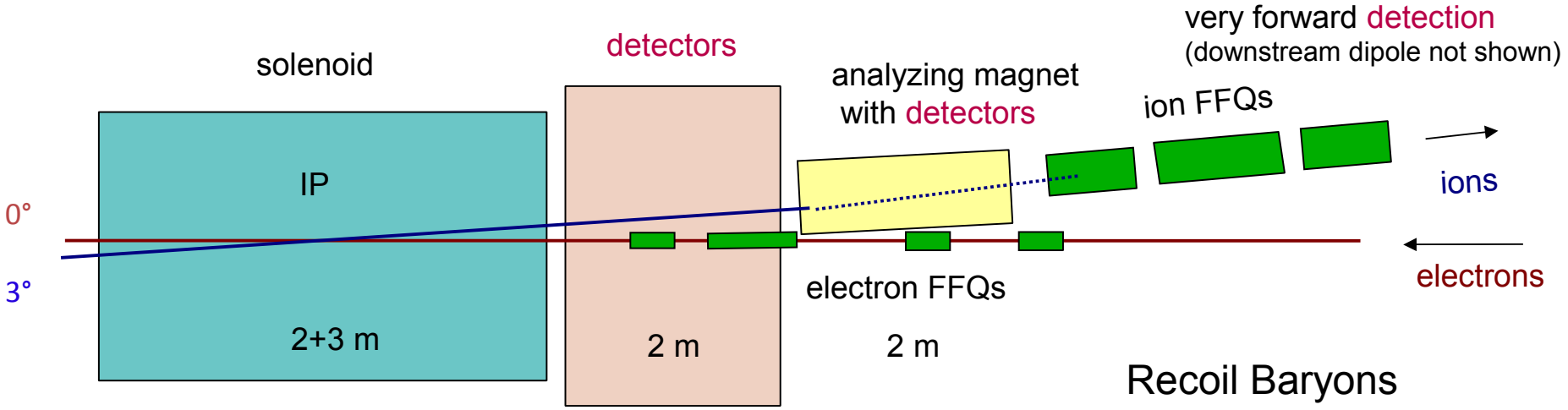
Tracking: momentum resolution in a solenoid field



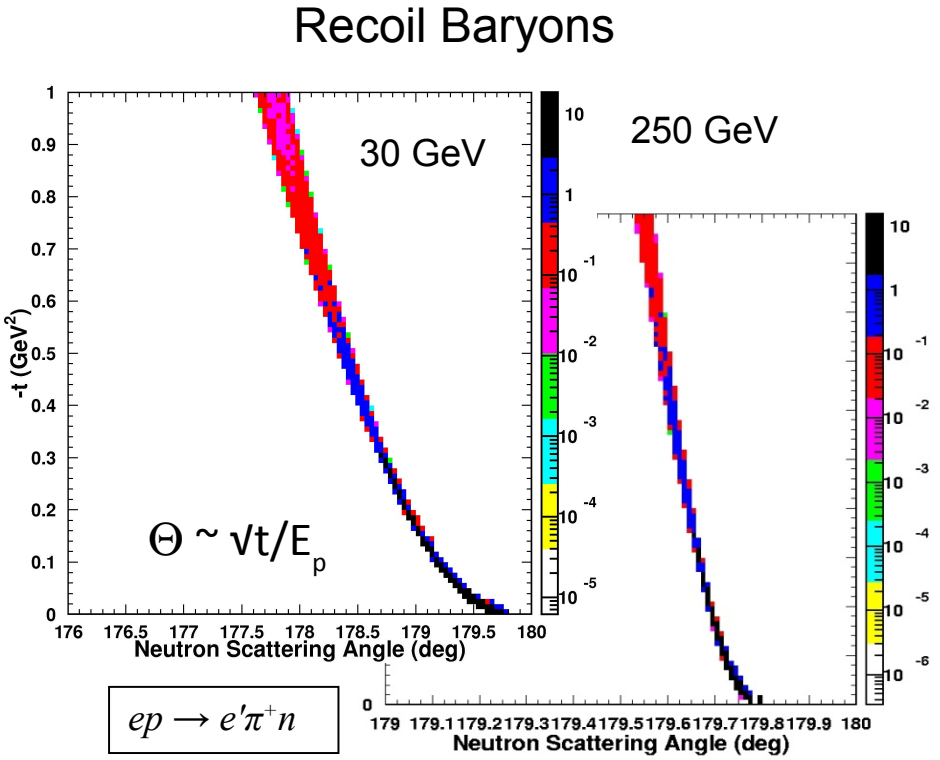
$\Delta p/p \sim \sigma p / BR^2$

- Tracker (not magnet!) radius R is important at central rapidities
- Only solenoid field B matters at forward rapidities
- A 2 Tm dipole covering 3-5° can eliminate divergence at small angles
- A beam crossing angle moves the region of poor resolution away from the ion beam center line.
  - 2D problem!

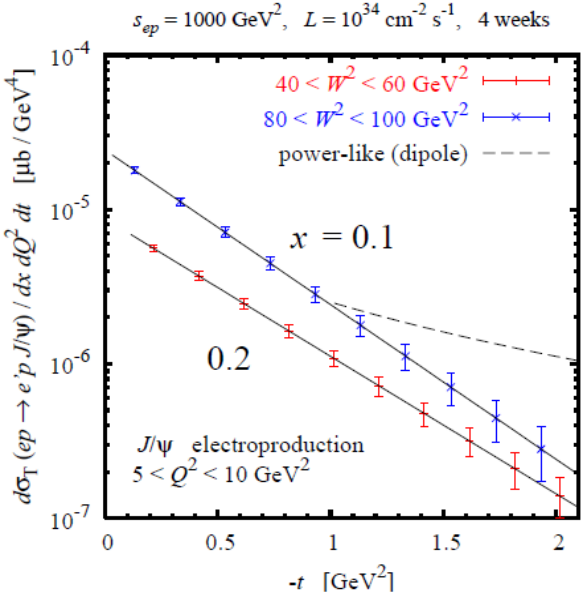
Three-stage forward hadron detection strategy

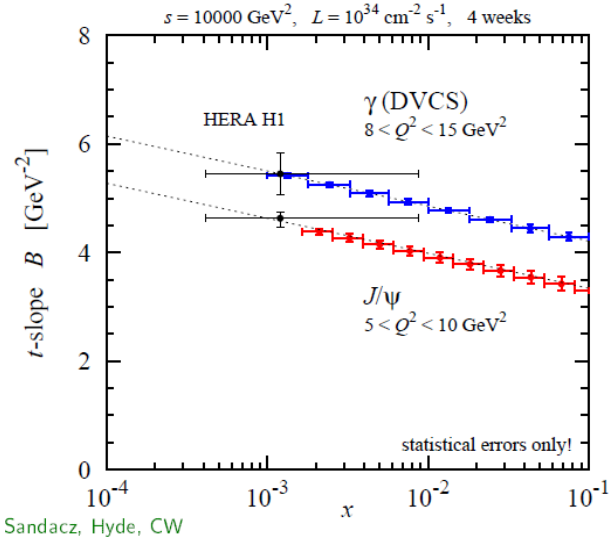


- Central solenoid-based detector covers most angles.
- An intermediate detection stage using 2 Tm dipole covering angles from 0.5-1° to 3-5°.
- Particles scattered at angles below 0.5-1° are detected after the FFQs.



Transverse quark and gluon imaging (GPDs)

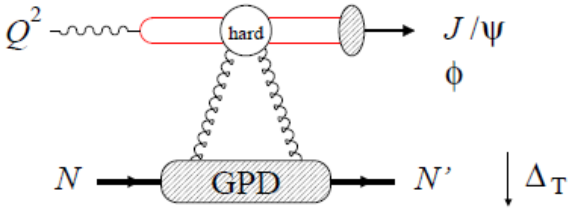


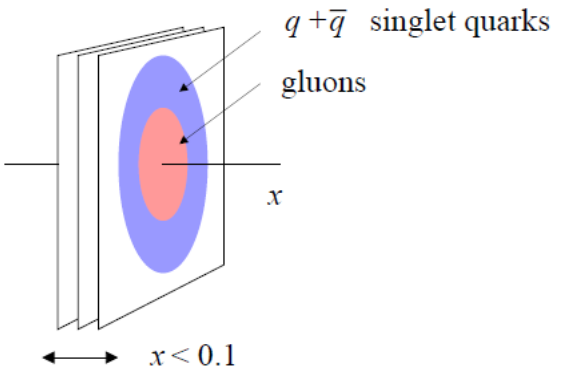


Sandacz, Hyde, CW

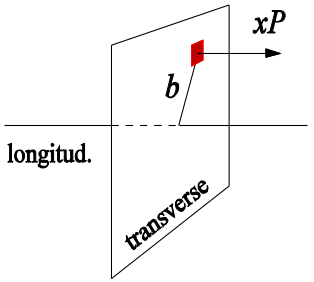
t-slope

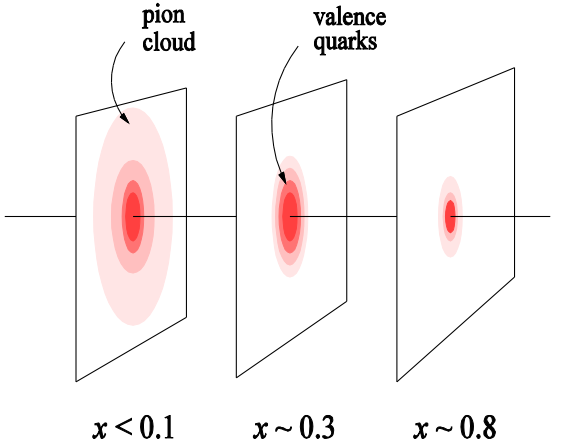
Fourier



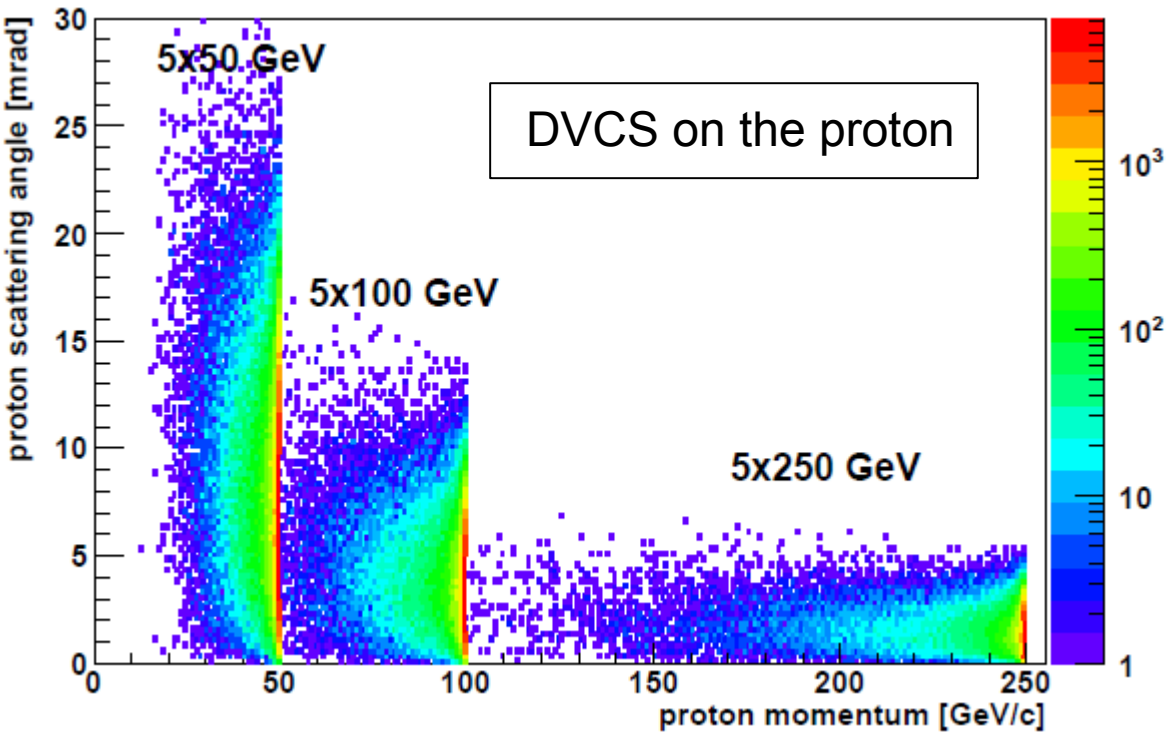


- Example: comparison of J/Ψ production and DVCS
- Is the quark radius larger than the gluon radius?



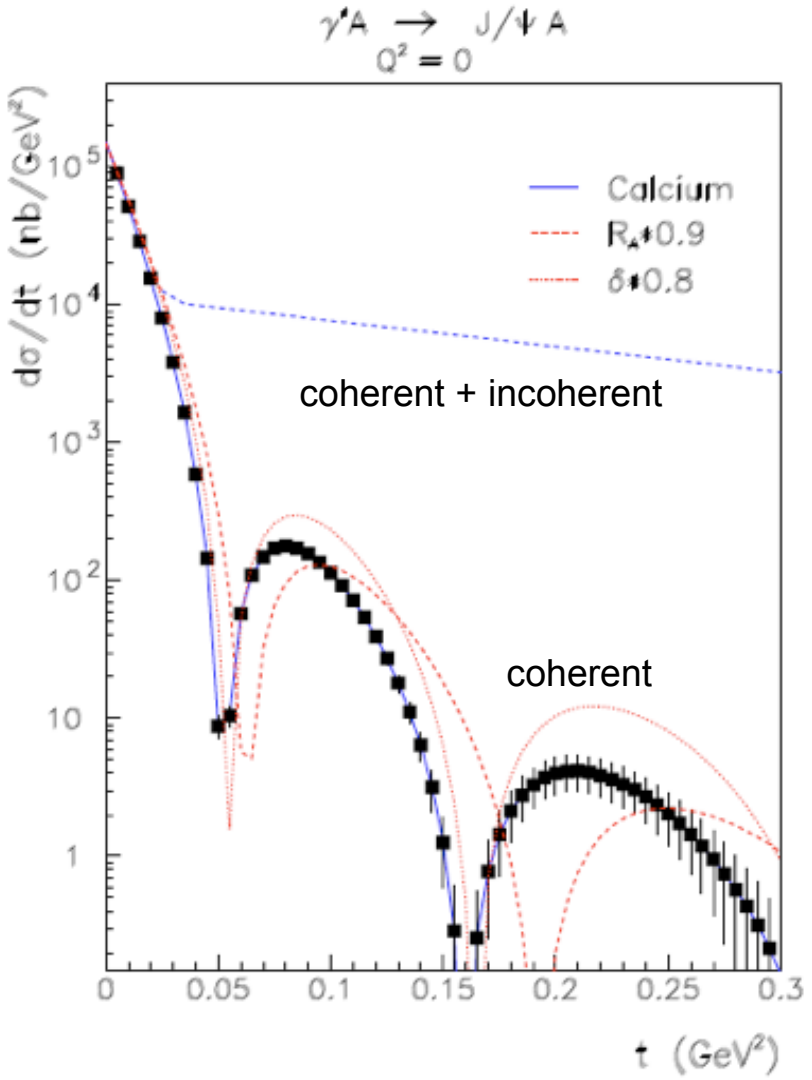


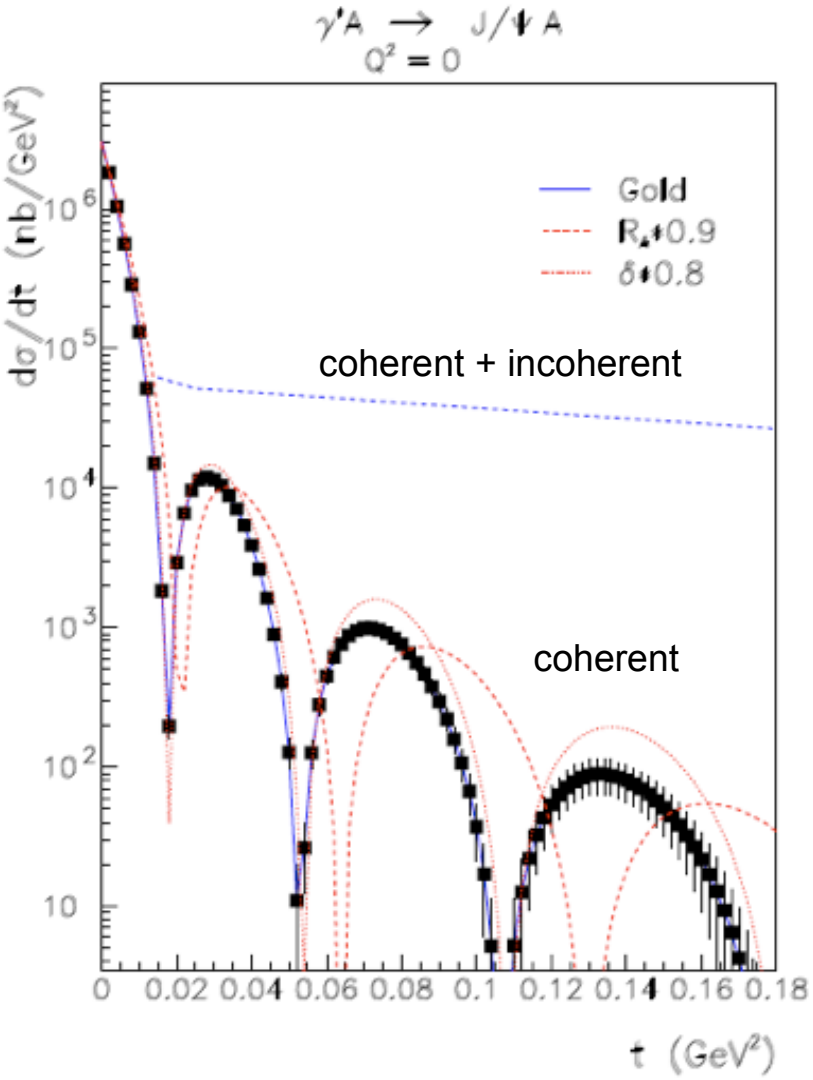
Recoil baryon detection – acceptance and resolution



- Protons from exclusive reactions have very high momenta and small scattering angles
- The resolution of the transverse image depends on the resolution in t (*i.e.*, angle and momentum)
- Good acceptance at high beam energies requires detection down to very small angles

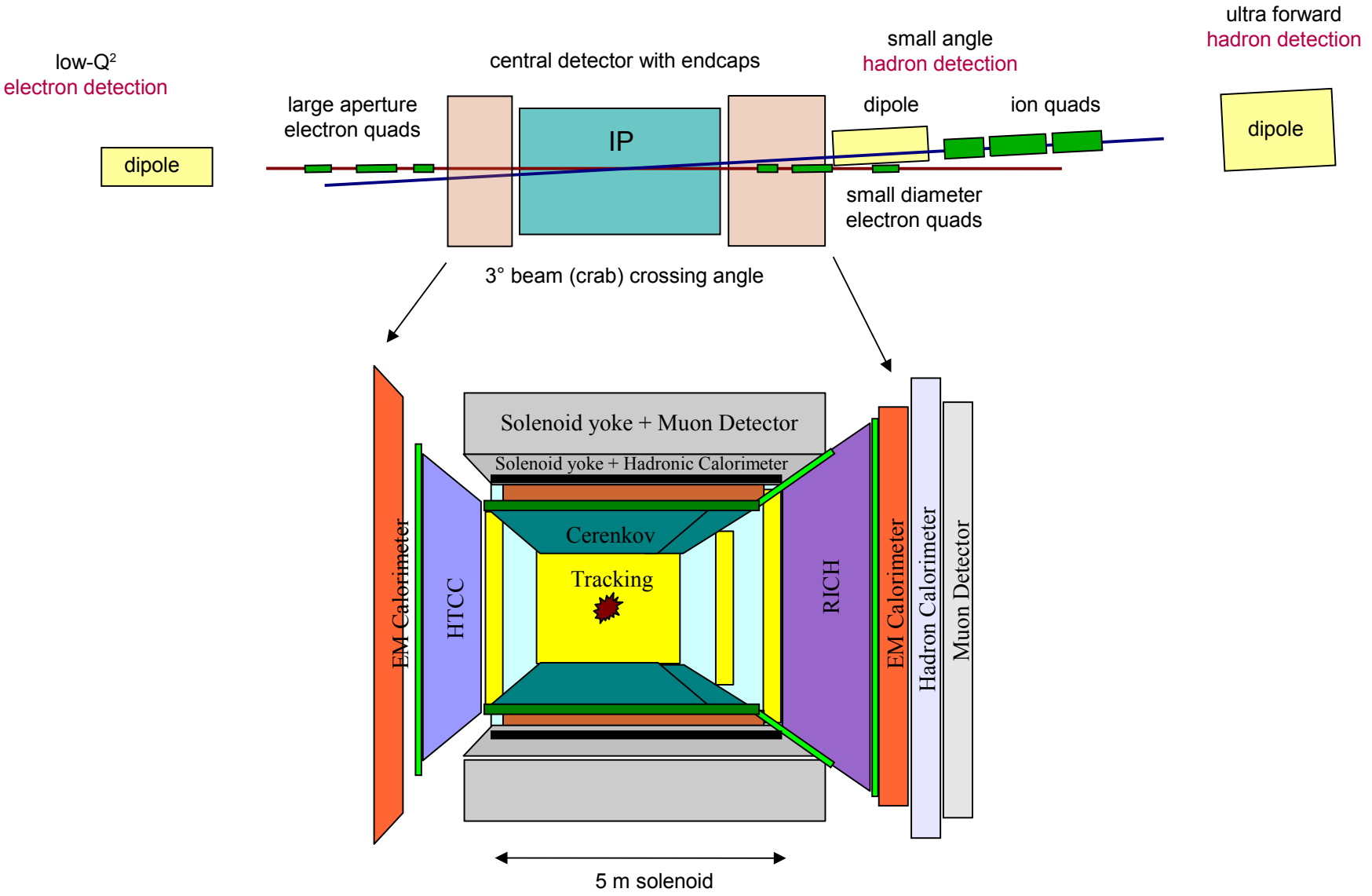
Gluons in nuclei from diffractive J/Ψ photoproduction?





Requires good *acceptance* for all fragments and a p_T *resolution* of about 10 MeV/c

Extended detector – overview

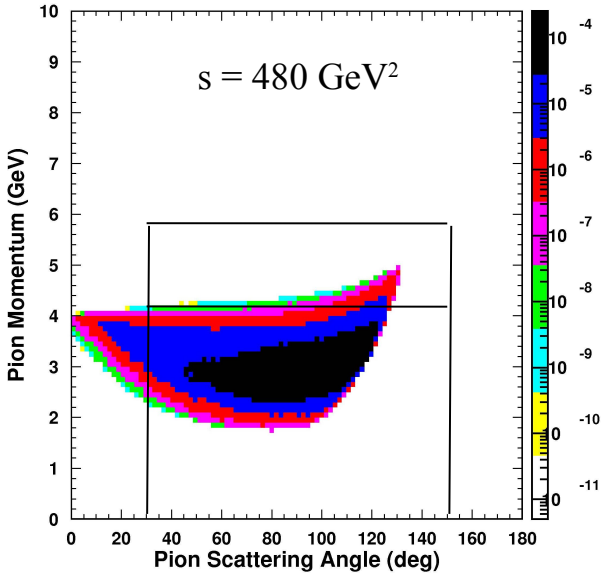


Backup

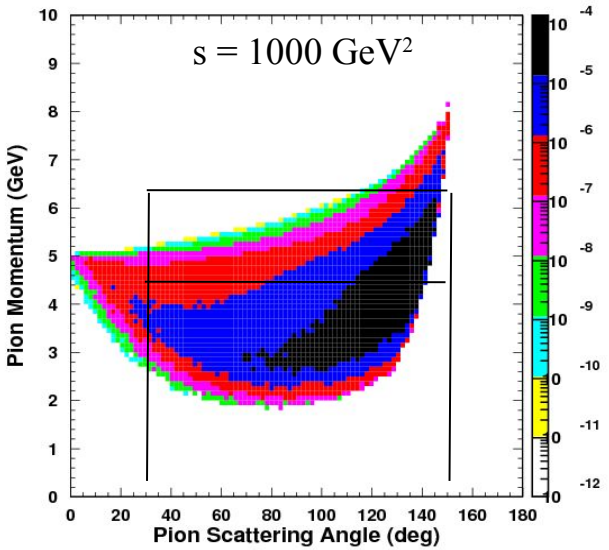
Exclusive mesons ($Q^2 > 10$ GeV^2)

$Q^2 > 10$ GeV^2

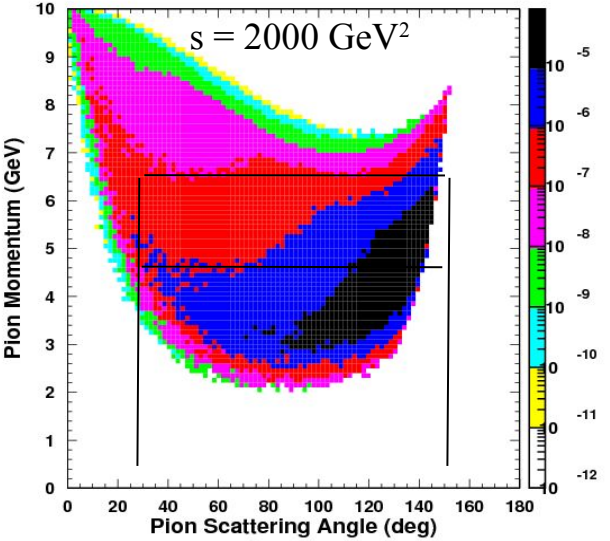
4 on 30 GeV



5 on 50 GeV

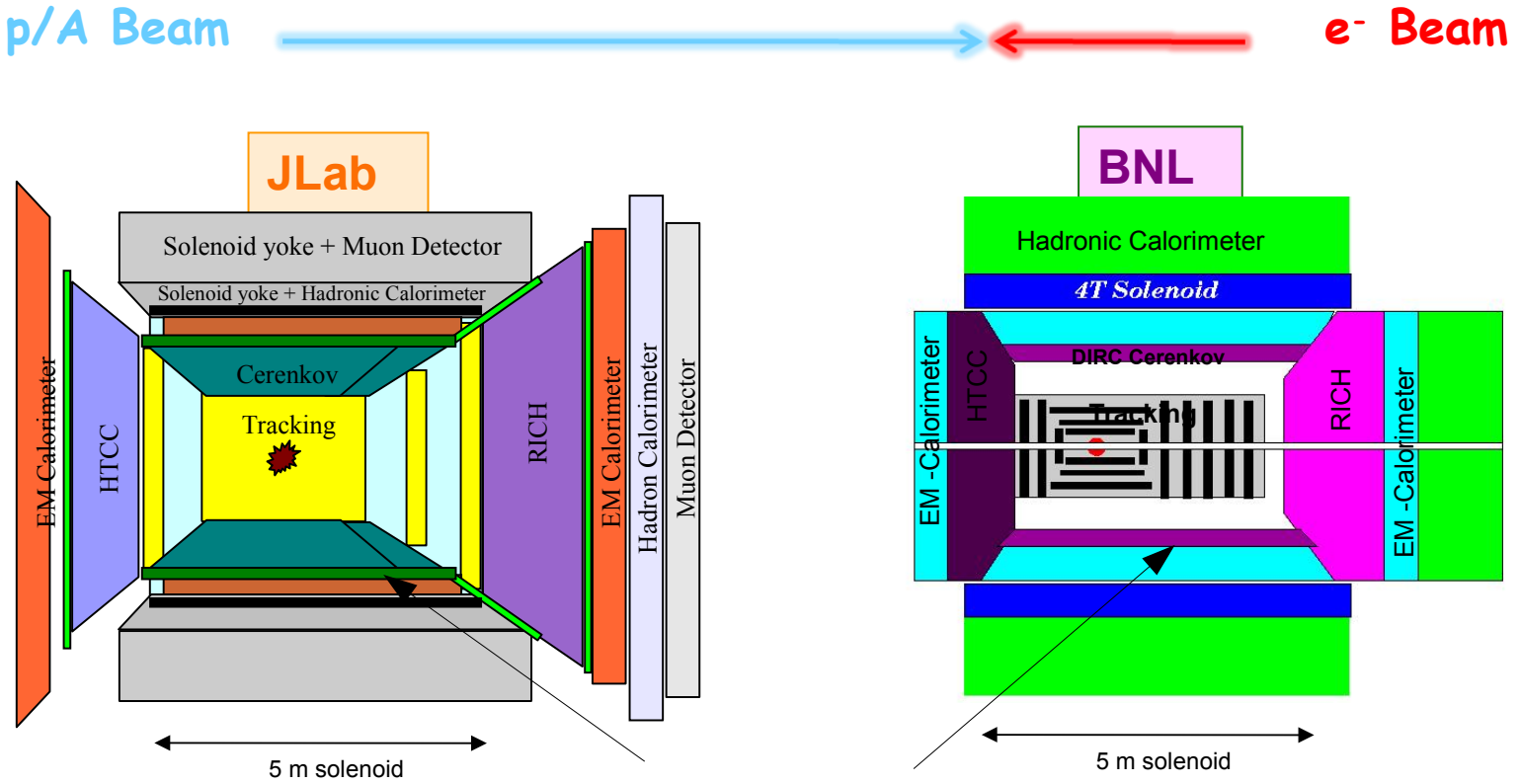


10 on 50 GeV



- π/K separation beyond 4 GeV/c is required already at relatively modest energies.
- Pushing the π/K separation to 6 GeV/c would provide almost full coverage for ion energies of 50 GeV, and partial coverage thereafter.

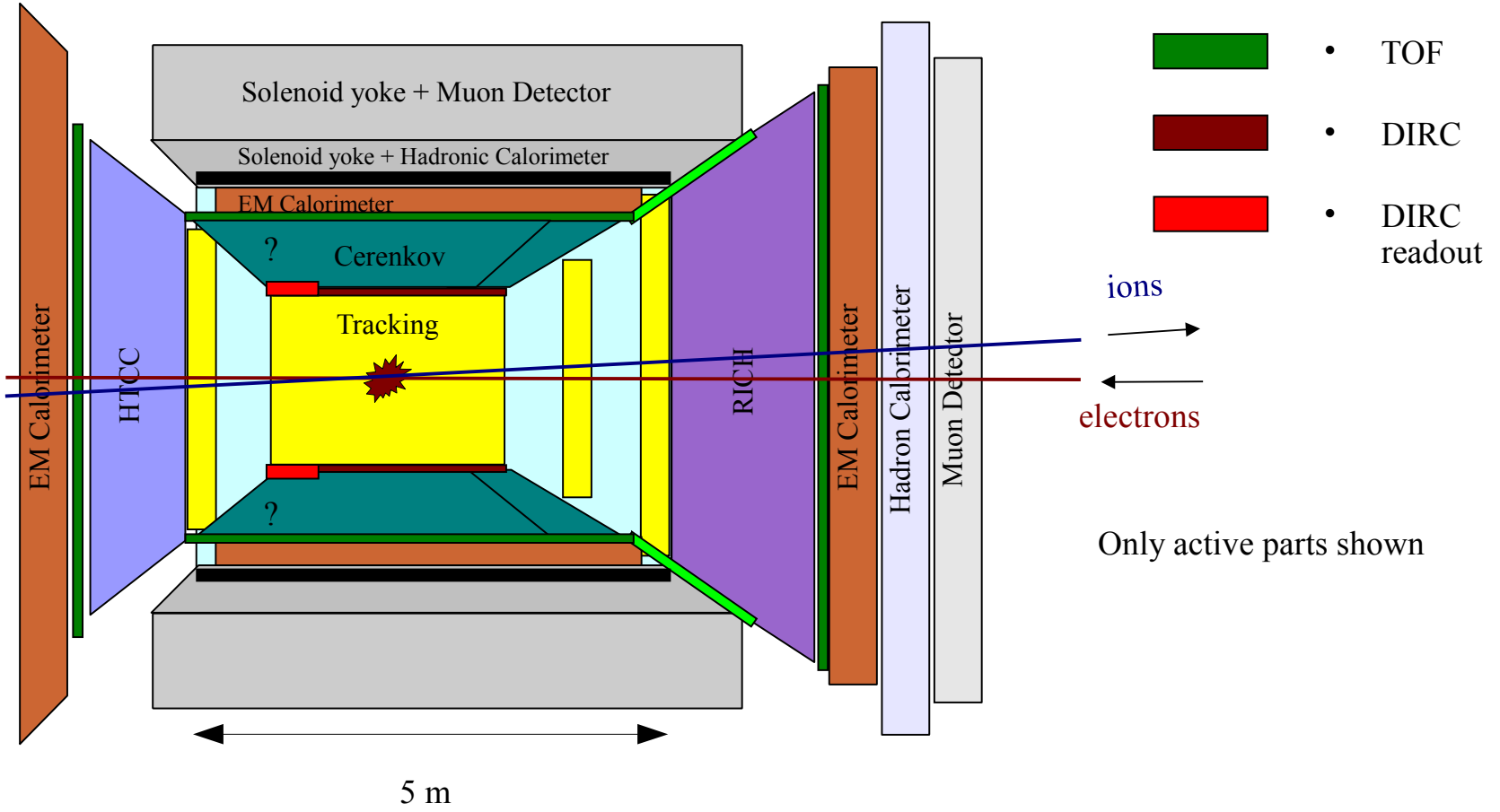
EIC detector cartoons shown at the INT



DIRC detectors

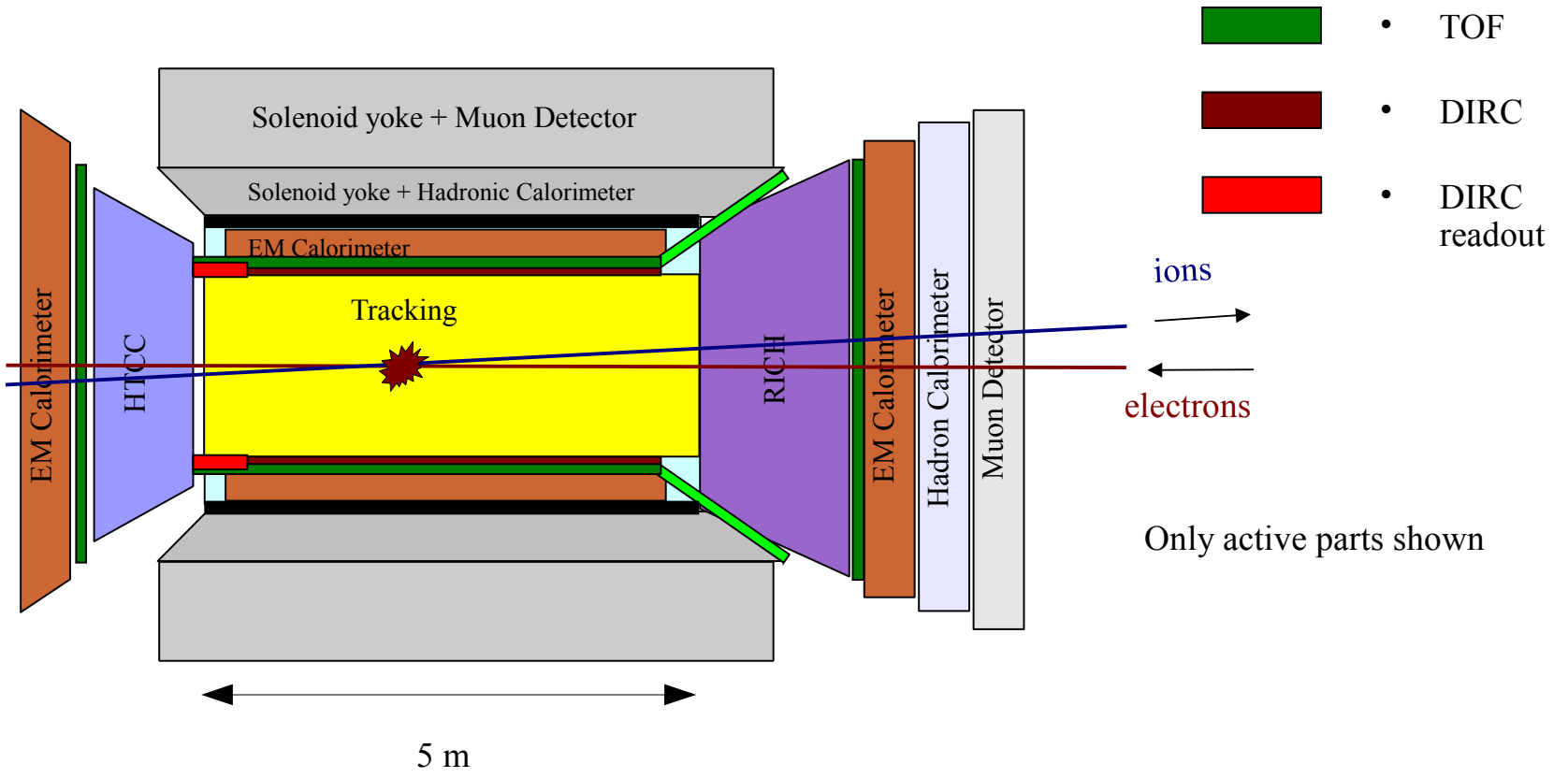
- Both the JLab and BNL versions of the detector shown at the INT included a DIRC
  - DIRC requires about 8 cm radial space (2 cm active)
- JLab cartoon also shows a supplementary Cerenkov in addition to the basic DIRC

DIRC inside of gas Cerenkov



- *Pros:* lower DIRC cost and better timing
- *Cons:* more mass in front of Cerenkov, larger distance to TOF
- Part shadowed by DIRC readout can be optimized

DIRC only



- *Pros:* recuced cost of detectors in endcaps and barrel, DIRC close to TOF and tracking
- *Cons:* smaller pi/K sepration range, sufficient low-energy electron PID?
- *Magnet:* reducing the radius from 2.1 to 1.5 m reduces the ion side bore angle from 35° to 27°, but a smaller magnet can provide a higher field giving better tracking resolution in the 3-27° range
  - Optimum may be a compromise between field and radius (important for resolution at large angles)