Full-acceptance Detector Concept of the MEIC at JLab

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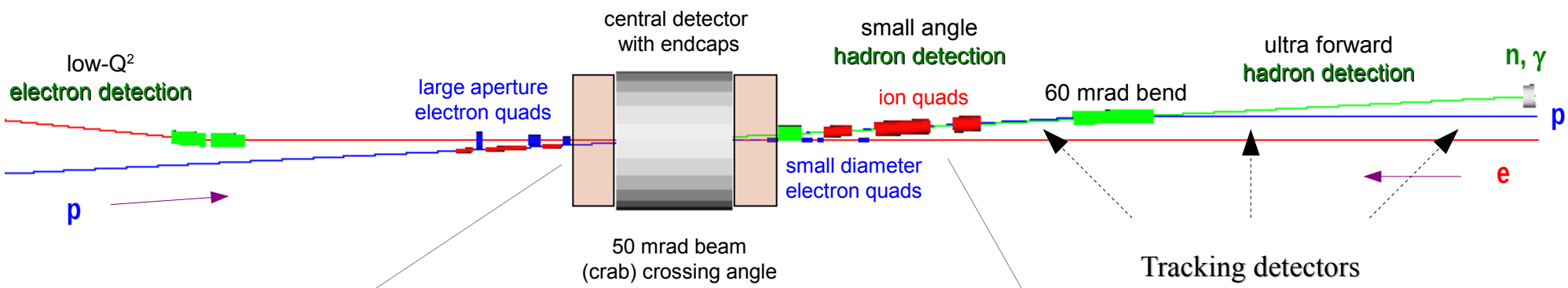
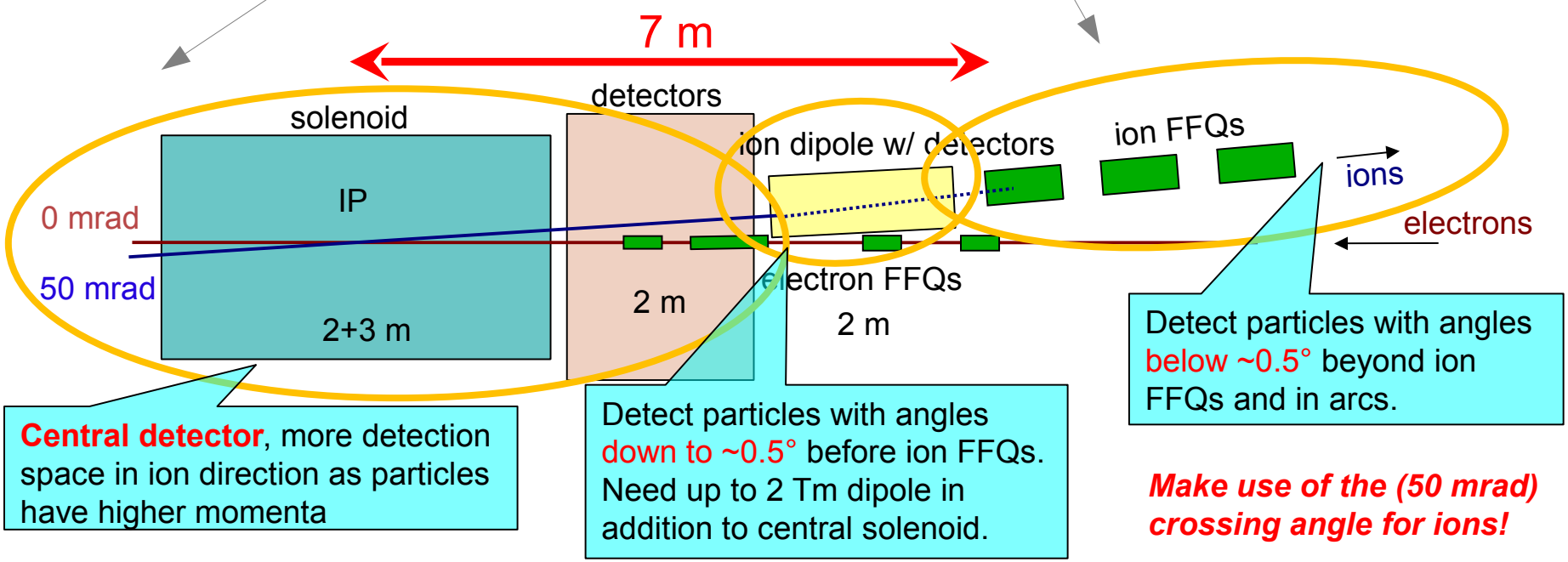
for the EIC Study Group at JLab

Workshop on EIC Detector R&D Simulations
BNL, October 8-9, 2012

Full-acceptance detector – strategy

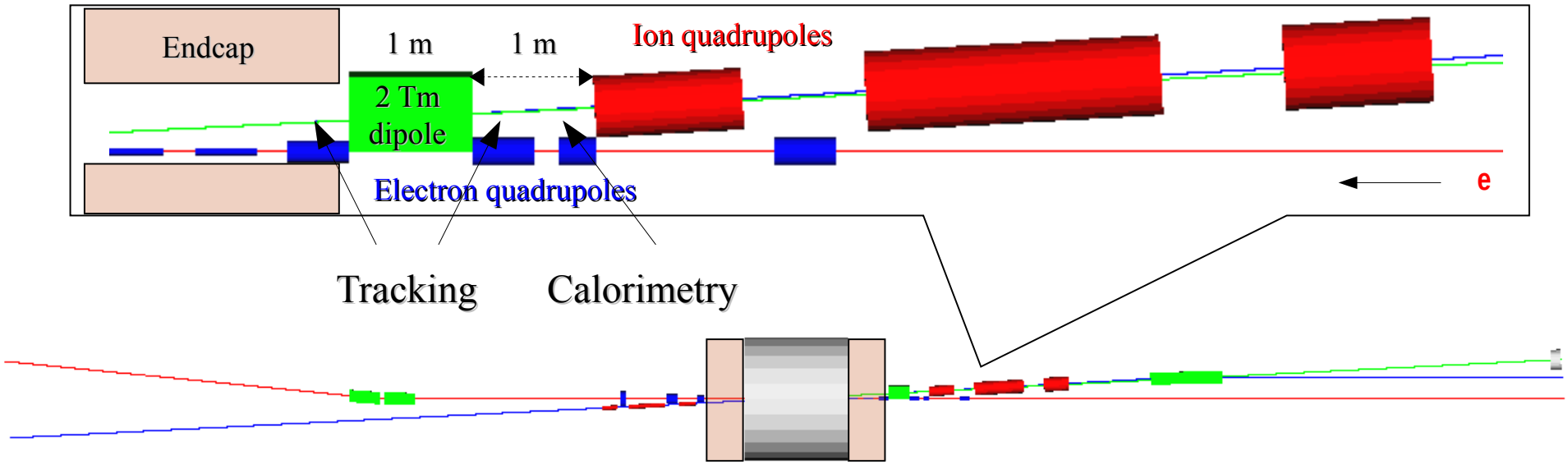
No other magnets or apertures between IP and FP!

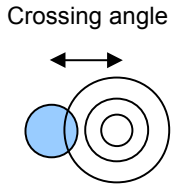




Make use of the (50 mrad) crossing angle for ions!

Hadron detection prior to ion quadrupoles

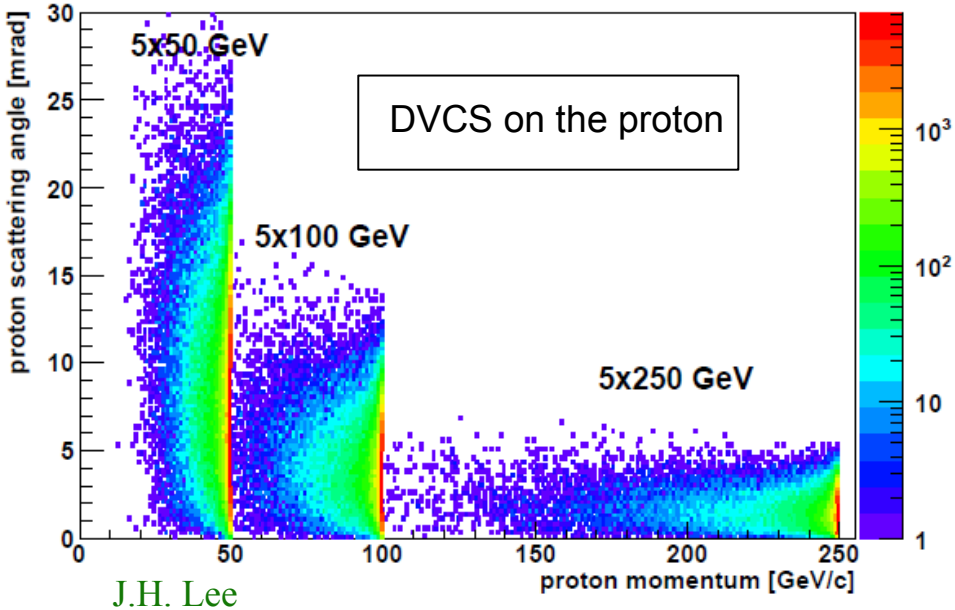




- Large crossing angle (50 mrad)
  - Moves spot of poor resolution along solenoid axis into the periphery
  - Minimizes shadow from electron FFQs

- Large-acceptance dipole further improves resolution in the few-degree range

Recoil baryon detection

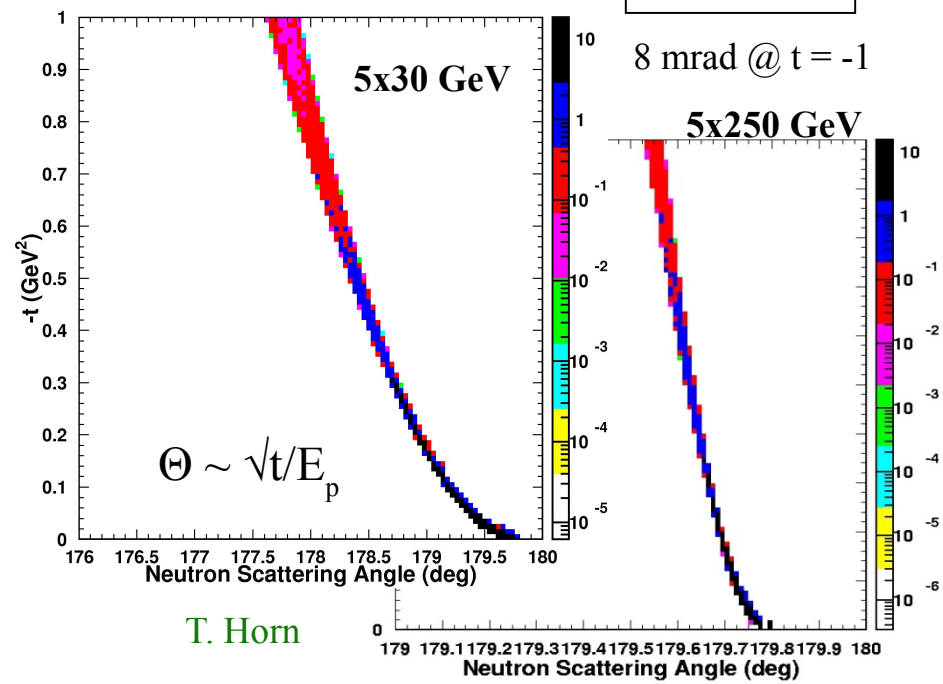


J.H. Lee

40 mrad @ t = -1 GeV^2

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

8 mrad @ t = -1



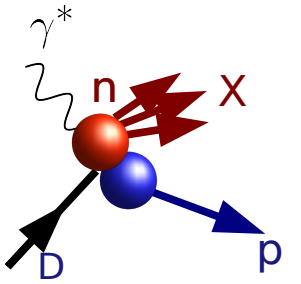
T. Horn

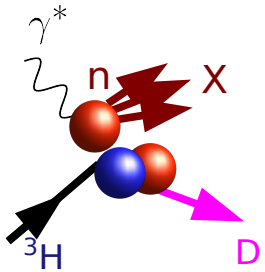
- At high proton energies, recoil baryons are scattered at small angles
  - Lower proton energies give better small-*t* acceptance and resolution in ***-t***
  - Higher proton energies give better large-*t* acceptance at for a given *maximum* ring energy
    - Lower maximum ring energy gives better acceptance at the *actual* running energy

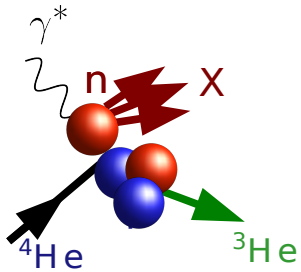
- Good recoil baryon detection requires
  - Wide range of proton (deuteron) energies
  - Small beam size to reach low -t (relies on optics and highly efficient cooling)

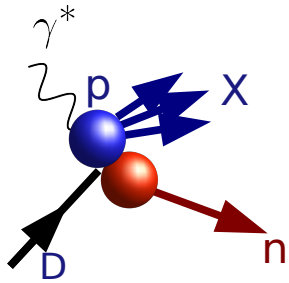
Spectator (and fragment) detection / tagging

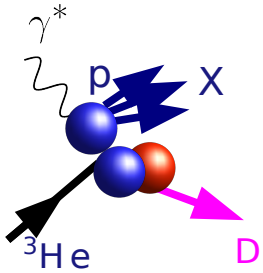
Quasi-free neutron		(Quasi)-free proton	
target	spect.	target	spect.
D	p	p	
^{3}H	D	D	n
		^{3}He	D
^{4}He	^{3}He	^{4}He	^{3}H

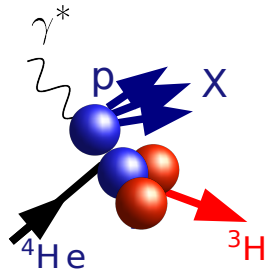












Ultra-forward hadron detection – requirements

1. Good acceptance for ion fragments (rigidity different from beam)

- Large downstream magnet apertures
- Small downstream magnet gradients (realistic peak fields)

2. Good acceptance for recoil baryons (rigidity similar to beam)

- Small beam size at second focus (to get close to the beam)
- Large dispersion (to separate scattered particles from the beam)

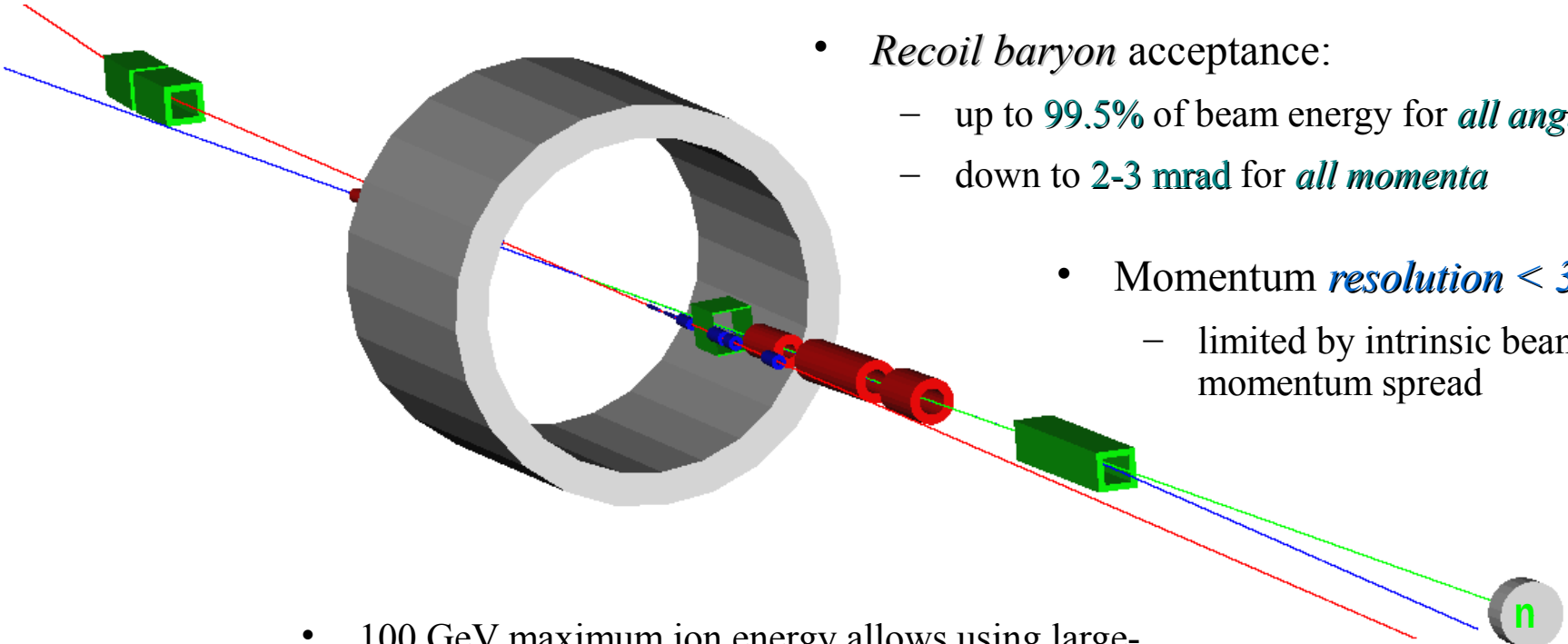
3. Good momentum- and angular resolution

- Large dispersion (*e.g.*, 60 mrad bending dipole)
- Long, instrumented magnet-free drift space

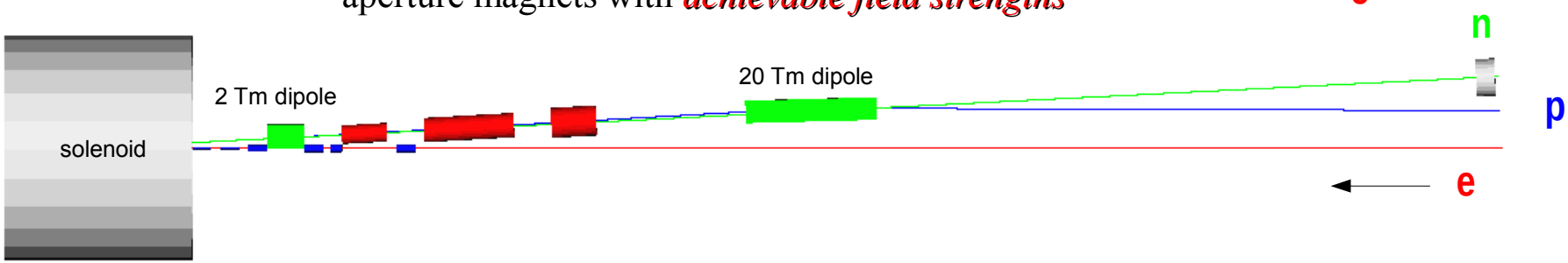
4. Sufficient separation between beam lines (~1 m)

Small-angle hadron detection – summary

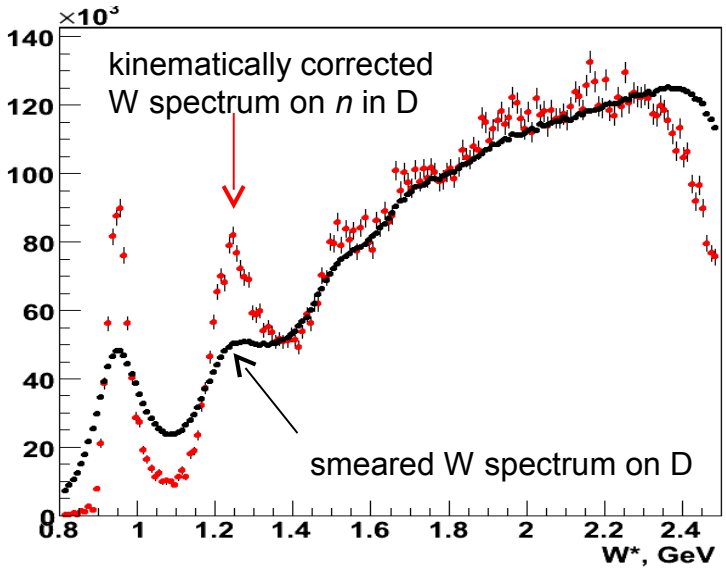
- *Neutron* detection in a 25 mrad cone ***down to zero degrees***
  - Excellent acceptance for ***all ion fragments***
    - *Recoil baryon* acceptance:
      - up to **99.5%** of beam energy for ***all angles***
      - down to **2-3 mrad** for ***all momenta***
    - Momentum ***resolution < $3x10^{-4}$***
      - limited by intrinsic beam momentum spread



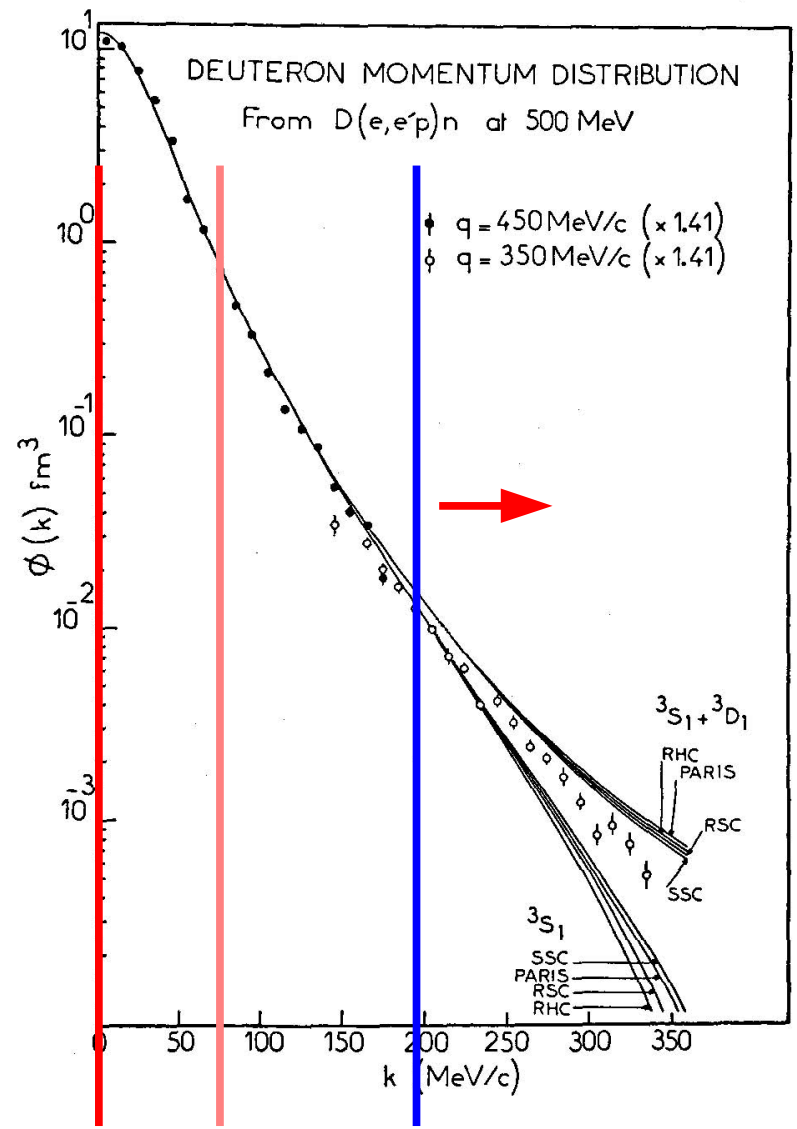
- 100 GeV maximum ion energy allows using large-aperture magnets with ***achievable field strengths***



Neutron structure through spectator tagging



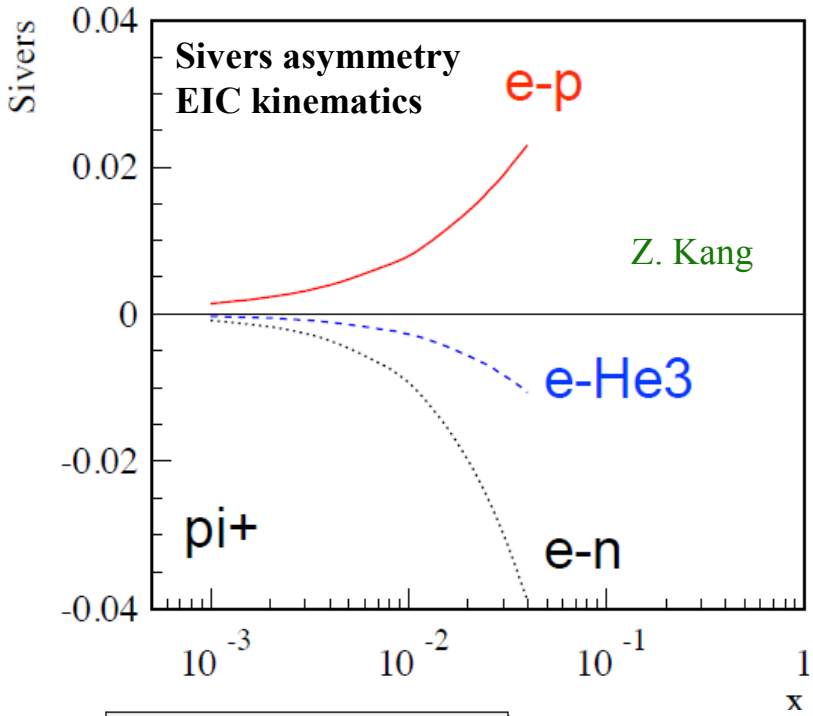
CLAS BoNuS data with tagged spectators



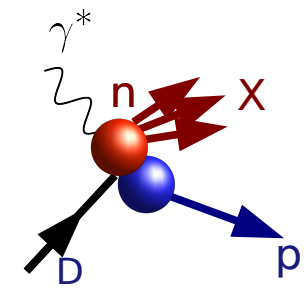
MEIC CLAS + BoNuS CLAS

- In fixed-target experiments, scattering on *bound neutrons* is complicated
  - Fermi motion, nuclear effects
  - Low-momentum spectators
- Spectator tagging at the MEIC will allow flavor separation of spin and sea quark distributions

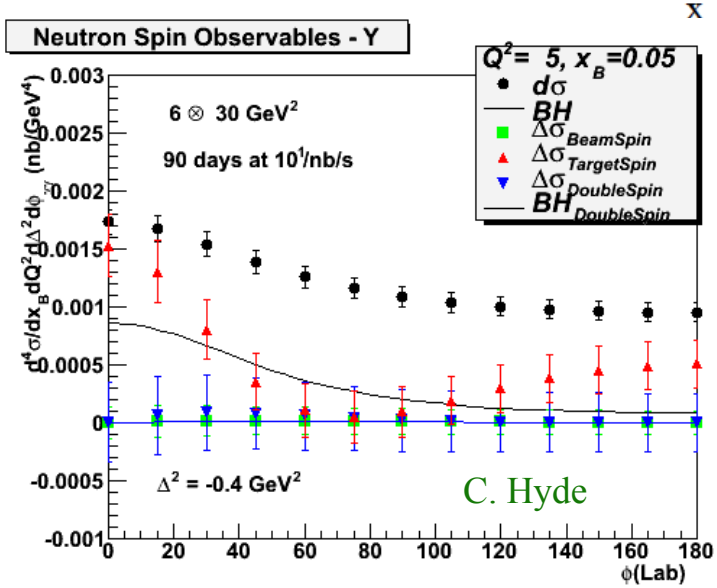
Spectator tagging with polarized deuterium



„If one could tag neutron, it typically leads to larger asymmetries“ Z. Kang



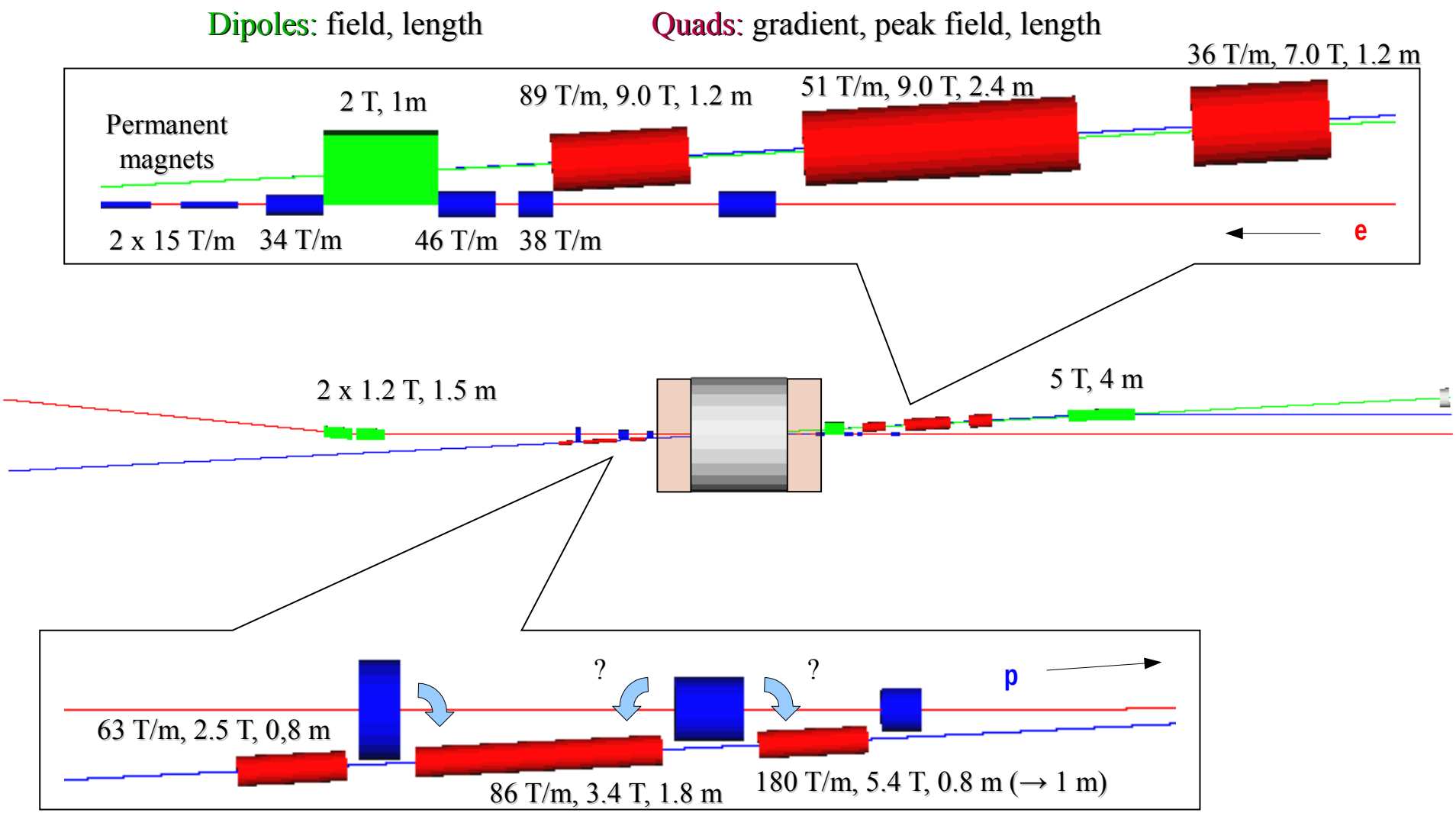
- Longitudinal and *transverse* polarization for d, ^{3}He, and other light ions



- Polarized neutrons are important for probing d-quarks through **SIDIS**

- Polarized *neutrons* are also important for **exclusive reactions**

IR magnets



- In the next, simplified version of the low-Q^2 tagger, ion and electron quads will use common cryostats.