Report on the Electron-Ion Collider Workshop: Electron-Nucleon Exclusive Reactions

March 14-15, 2010

- Bad storms, cancelled flights, closed roads, cold meeting room
- Good food, great physics

Organized by Users Group; Sponsored by JLab and JSA Initiatives Fund

Organizational Details

- Organizing Committee:
  - Ron Gilman
  - Tanja Horn
  - Pawel Nadel-Turonski
  - Christian Weiss
- Web pages (agenda includes links to all talks): http://www.physics.rutgers.edu/np/2010rueic-home.html

Talks on...

- Overview/Introduction: Meziani, Ent, Krafft, Nadel-Turonski, Weiss
- Exclusive Meson Production: Guidal, Horn, Stepanyan
- Form Factors: Miller, Afanasev, Ron, Gaskell
- DVCS: Munoz-Camacho, Schweitzer, Liuti
- Novel QCD Effects: Brodsky
- J/ψ and gluonic structure: Chudakov, Vogt, Strikman, Liuti
- Nuclear Processes: Guzey, Sargsian, Hyde
- Meson/baryon spectroscopy: Gan, Strikman

One slide per talk?

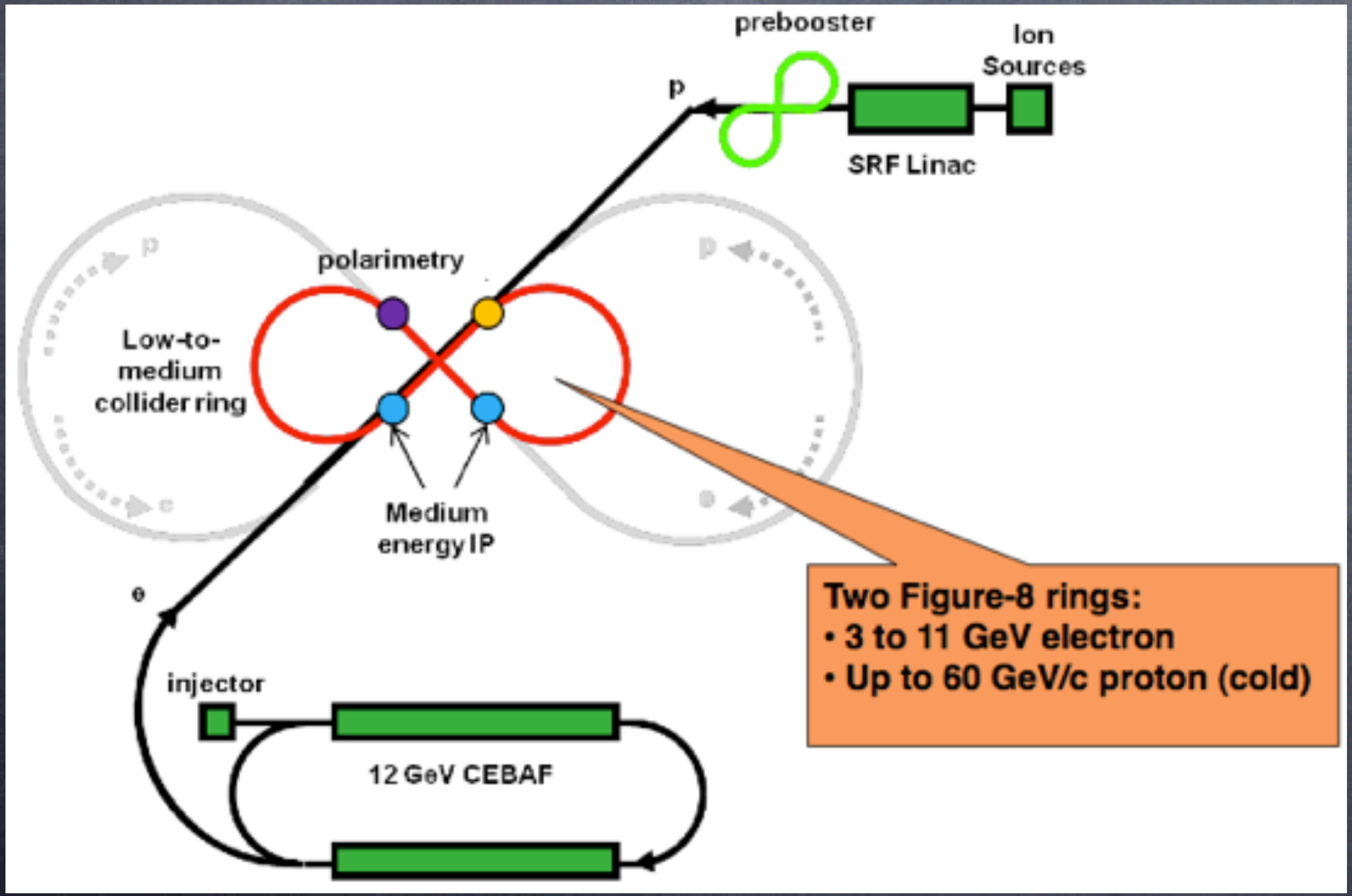
- It is traditional to review a conference by presenting one slide per talk
- Here we will just have a few slides from a few of the earlier talks

Overview, R. Ent

- Ongoing joint BNL/JLab activity, next EIC collaboration meeting July 29-31 @ Catholic U.
- New machines take ~20 years ⇒ EIC in 2020s?
- Science: nucleon/nuclear structure in QCD - spin, 3D imaging, strong color fields - and EW tests
- mEIC@JLab design considerations: access to sea quarks/gluons ($x>0.01$ or so), deep exclusive scattering at $Q^2 > 10$, range in Q^2
- Parameters (up for discussion): $L > 10^{34}/cm^2s$, $E_e \sim 3-5$ (up to 11) GeV and $E_p \sim 20-60$ GeV for synchroton radiation, symmetric kinematics, range of s

Accelerator Design, G. Krafft

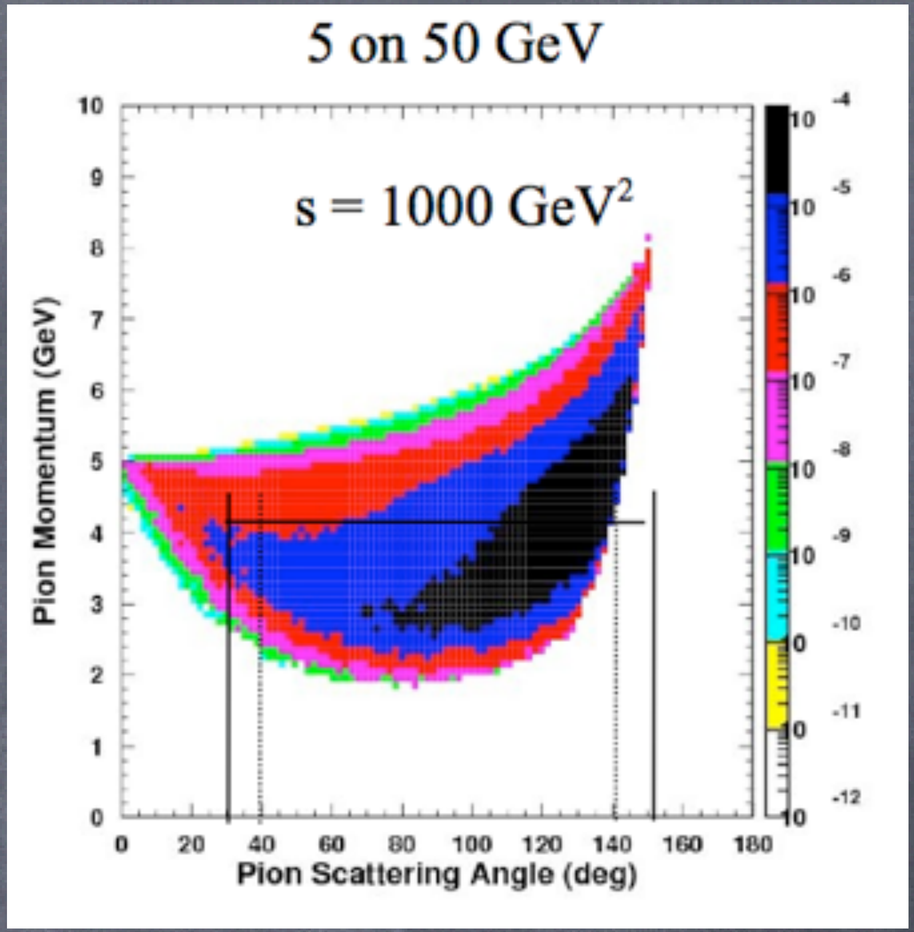
- Goals: use CEBAF + new ion complex to get high luminosity ($>5\times10^{33}/cm^2s$), multiple detectors, highly polarized (>80%) beams
- Working on detailed mEIC design due in ~3 months, leaving upgrade path to full 11x250 GeV^2 EIC
- A ≤ 208, polarized p, d, ^3He, maybe Li

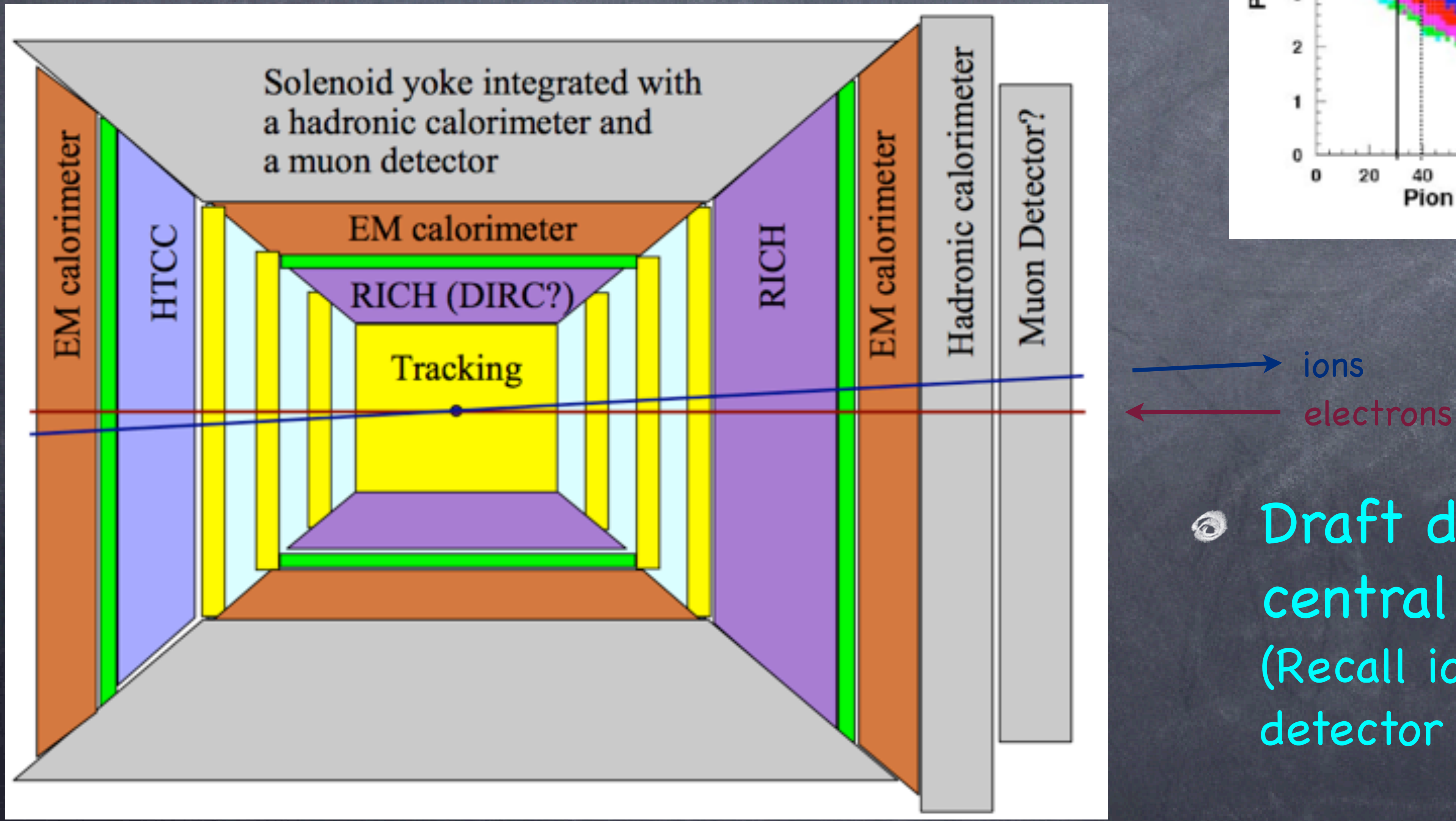


- Vertical-stacked rings, e's bent 100 mr for IPs
- Synchroton vs space charge ⇒ ring size (C=634 m)
- $d_{IP-quad}$: 3-4 m (e), 7 m (p)
- 5 mm long bunches @ 1.5 GHz

Detector Design, P. Nadel-Turonski

- Example of kinematics: deep exclusive pion electroproduction, $Q^2 > 10\ GeV^2$



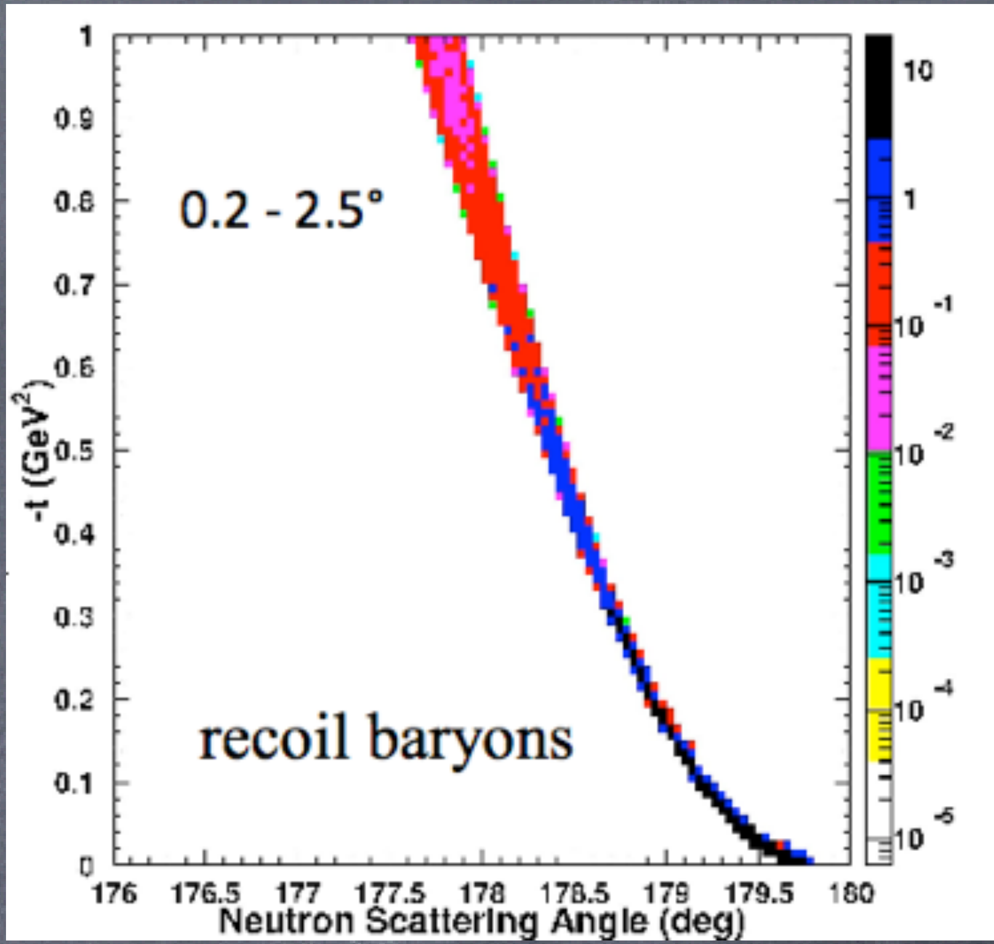


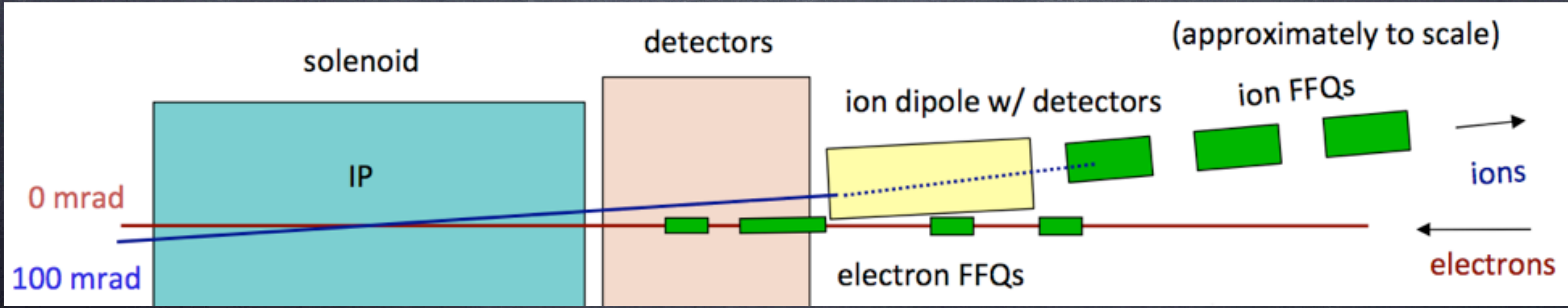
- Draft design for central detector

  (Recall ion plane horizontal, detector shown tilted.)

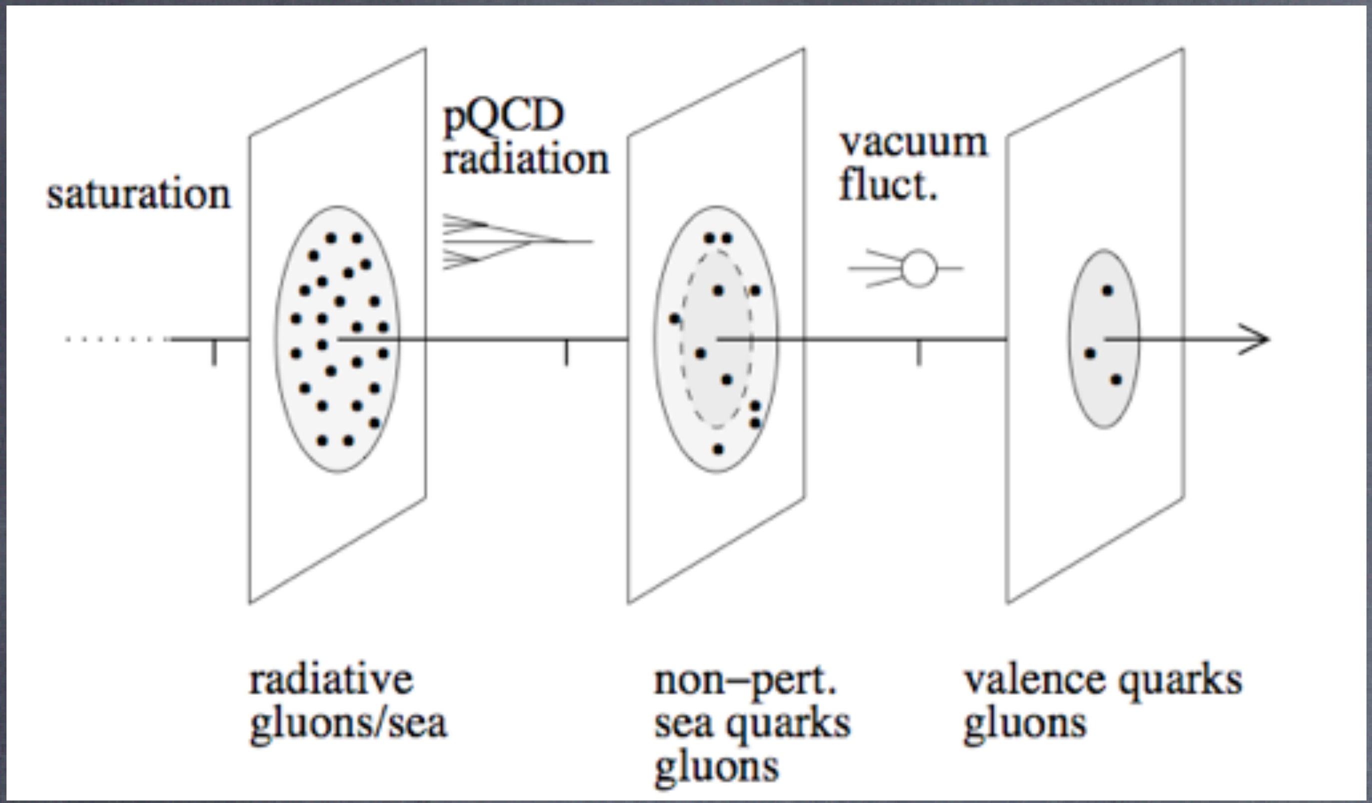
Detector Design, P. Nadel-Turonski

- Recoil baryons go to forward angles
- Example of kinematics: deep exclusive pion electroproduction, 4x30 GeV^2, $Q^2 > 10$ GeV^2
- Draft design for forward ion detector (Recall ion plane horizontal, detector shown tilted.)
- Also interest in forward / low Q^2 electron tagging





Physics Overview, C. Weiss

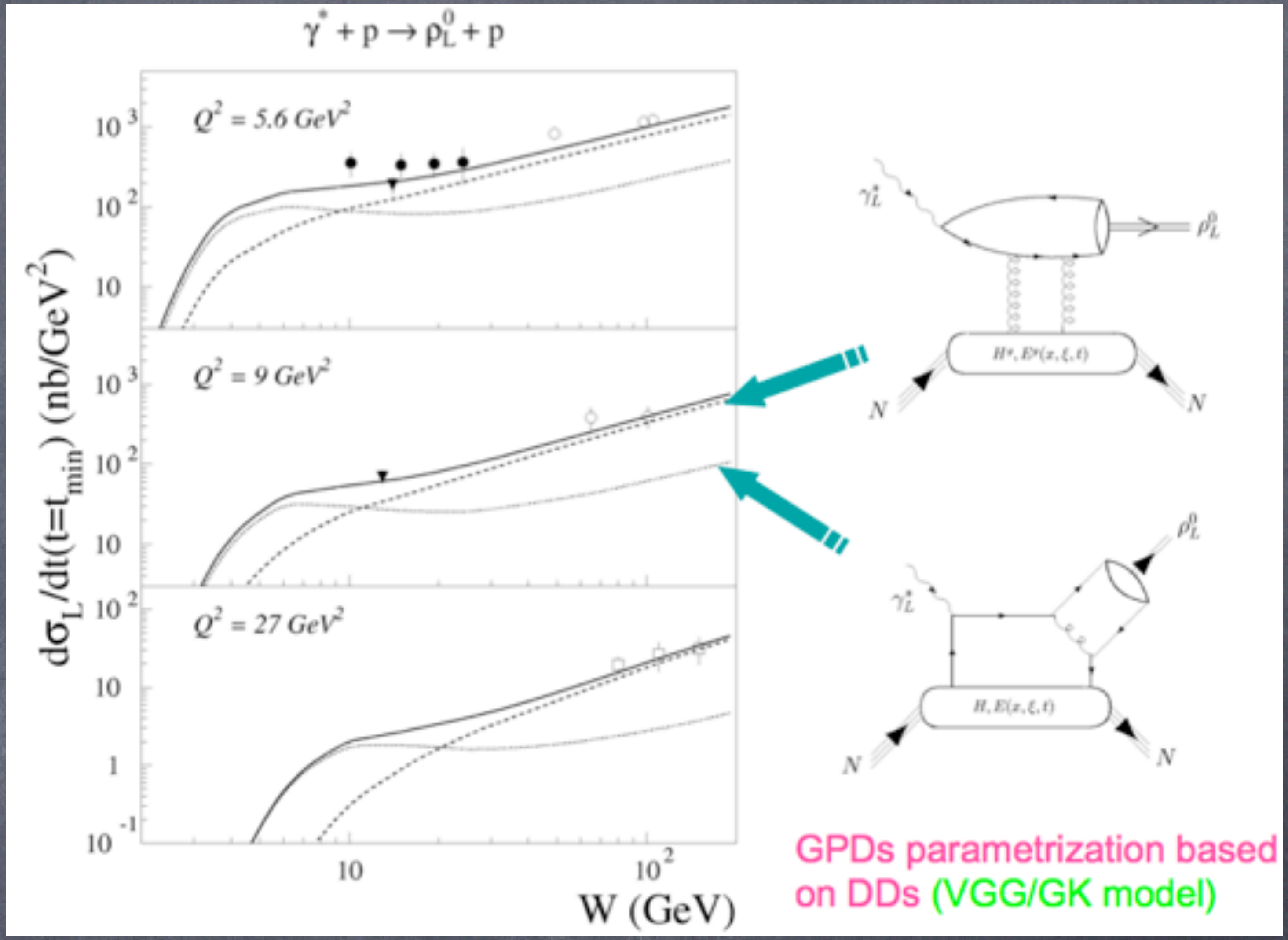


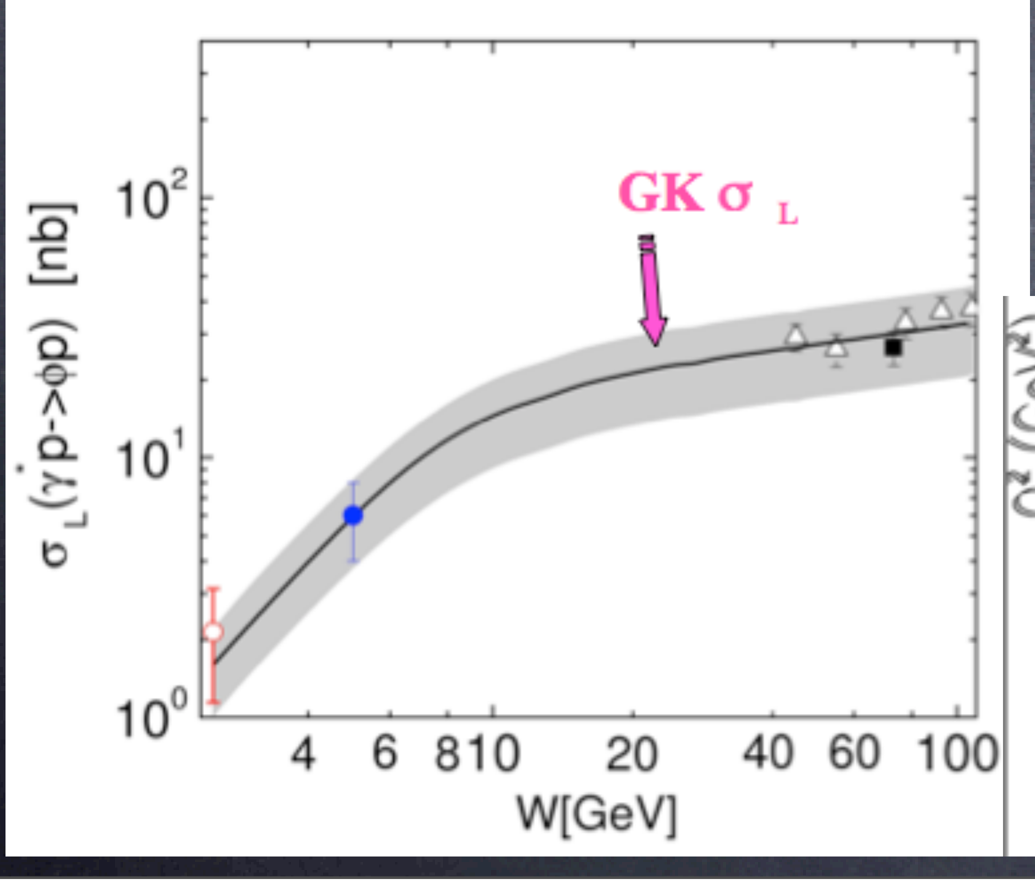
- Nucleon structure, aimed at sea quarks, gluons, and Q^2 dependence, for nonperturbative quark / gluon structure
- Not aimed at valence region, a focus of 12 GeV

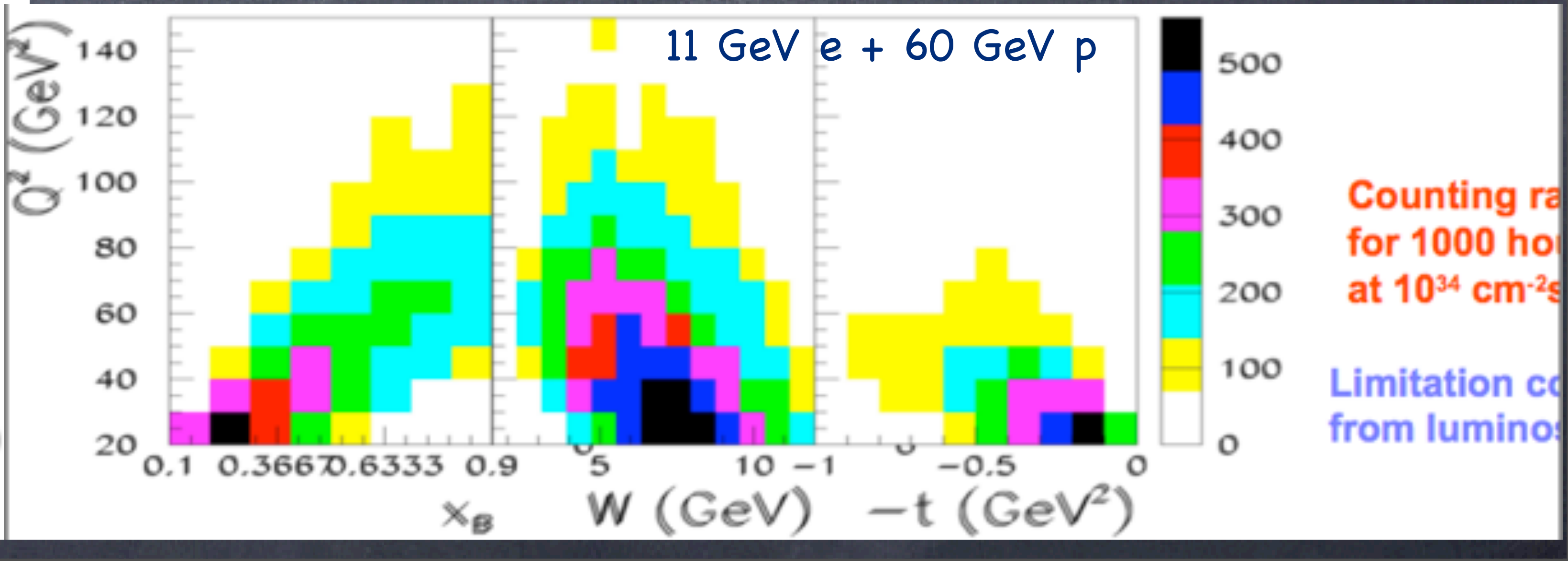
- Physical properties to be measured: parton densities, transverse spatial distributions, orbital angular momentum, correlations, nuclear effects
- Processes: DVCS, DVMP (π, ρ, K, ϕ, J/ψ, ...)
- Nuclear processes: QCD factorization = color transparency, coherent processes, quasi-elastic processes

Exclusive Vector Meson Electroproduction, M. Guidal

- Lots of data from CLAS 6 GeV
  - GPD/handbag models work well for W>5 GeV for ϕ, $\rho^{0,+}$, ω, various issues at lower W, except for ϕ
- Extensive plans for 12 GeV
- Start of simulations for EIC

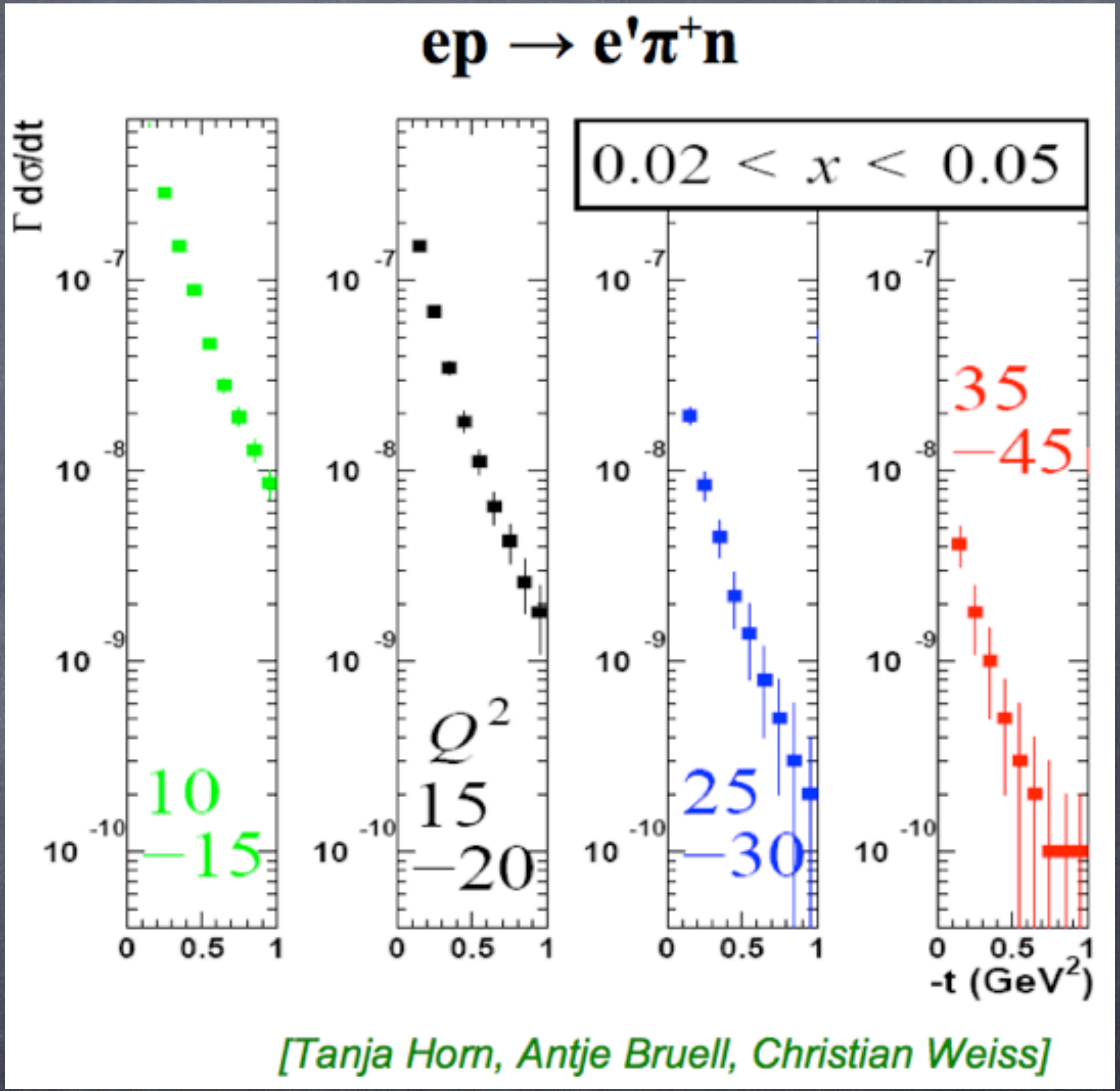






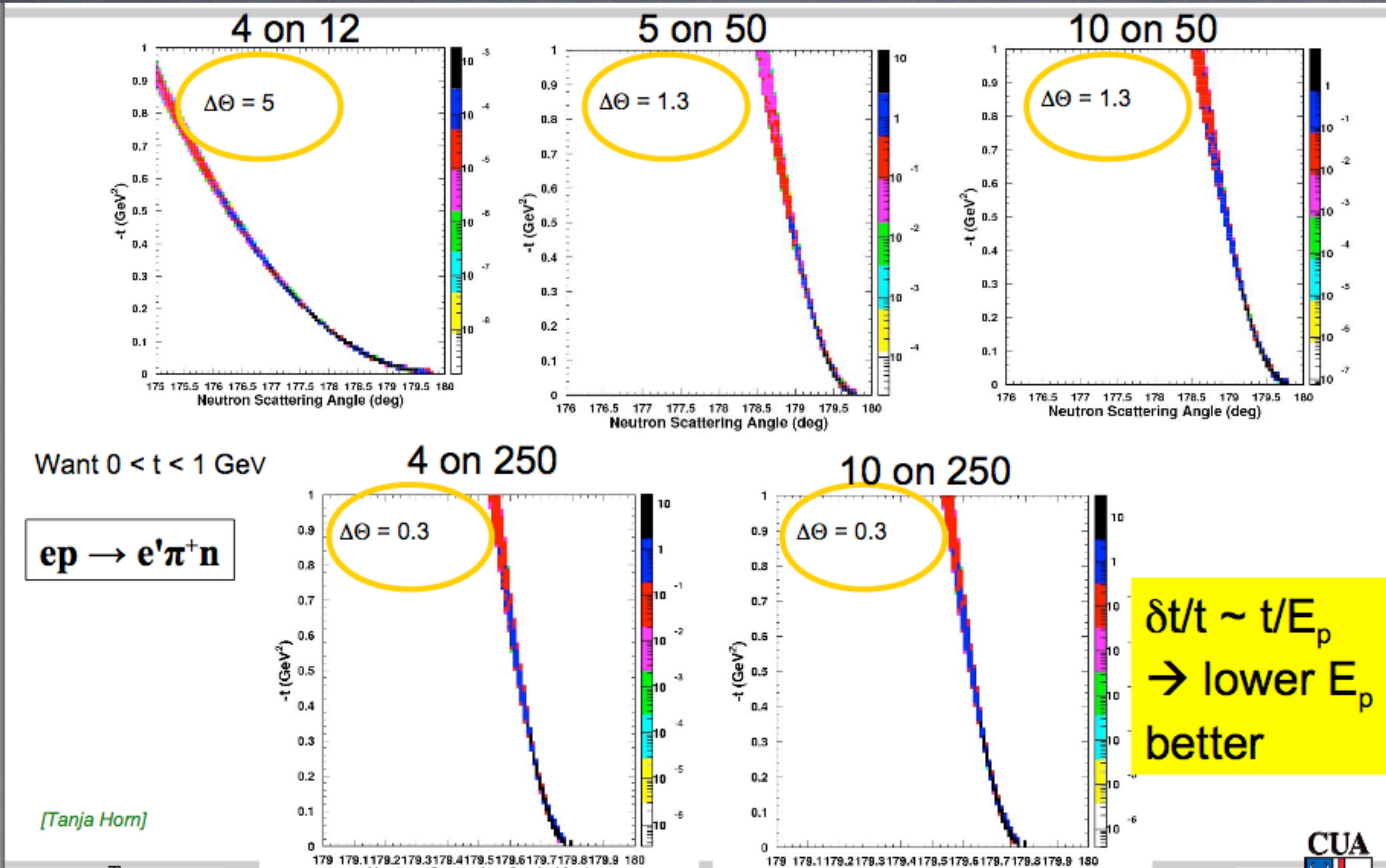
π/K Electroproduction, T. Horn

- Extensive kinematic range and separated cross sections needed to test reacton mechanism (GPD/handbag approach)
  - 6-GeV $\sigma_L \sim Q^{-6}$ predicted by QCD, but σ_T is not $\sim Q^{-8}$
  - EIC pseudodata for 100 days @ 10^{34}, 5+50 GeV
  - $\sigma \sim e^{-bt}$, slope gives access to size of interaction region



π/K Electroproduction, T. Horn

- Need for recoil detection for exclusivity favors lower energy symmetric kinematics to determine recoil baryon better

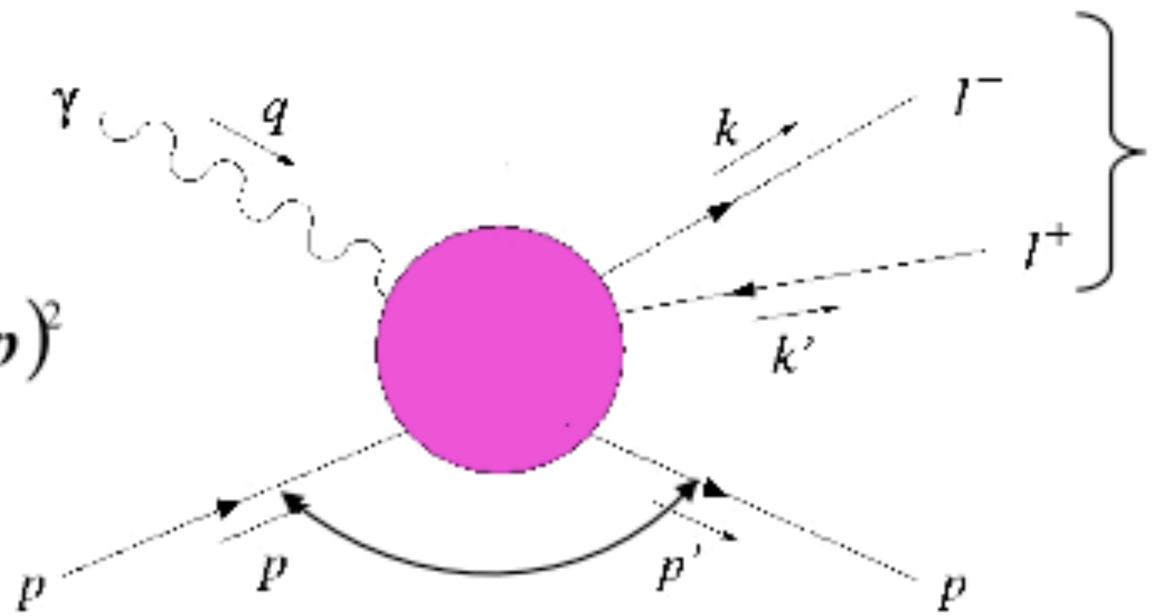


Time-Like Compton Scattering, S. Stepanyan

Information on the real (imaginary) part of the Compton amplitude can be obtained from photoproduction (circularly polarized) of lepton pairs

$$\gamma\ p \rightarrow p\, l^+\, l^- ; \quad l = e, \mu$$

$$s = (q+p)^2$$



$$t = (p-p')^2$$

Hard scale

$$Q'^2 = M^2_{l^+l^-} = (k+k')^2$$

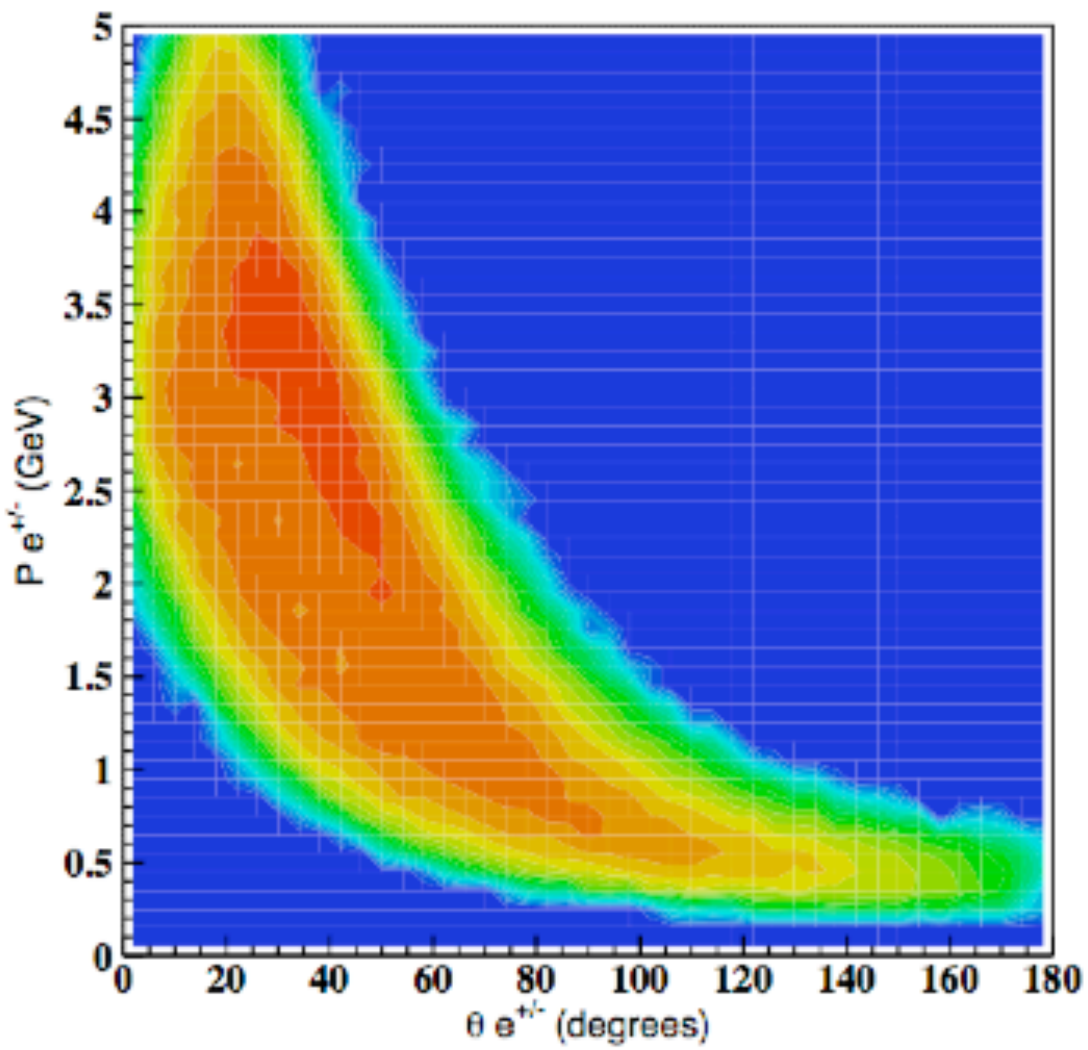
$$\eta = \frac{Q'^2}{2s - Q'^2}$$

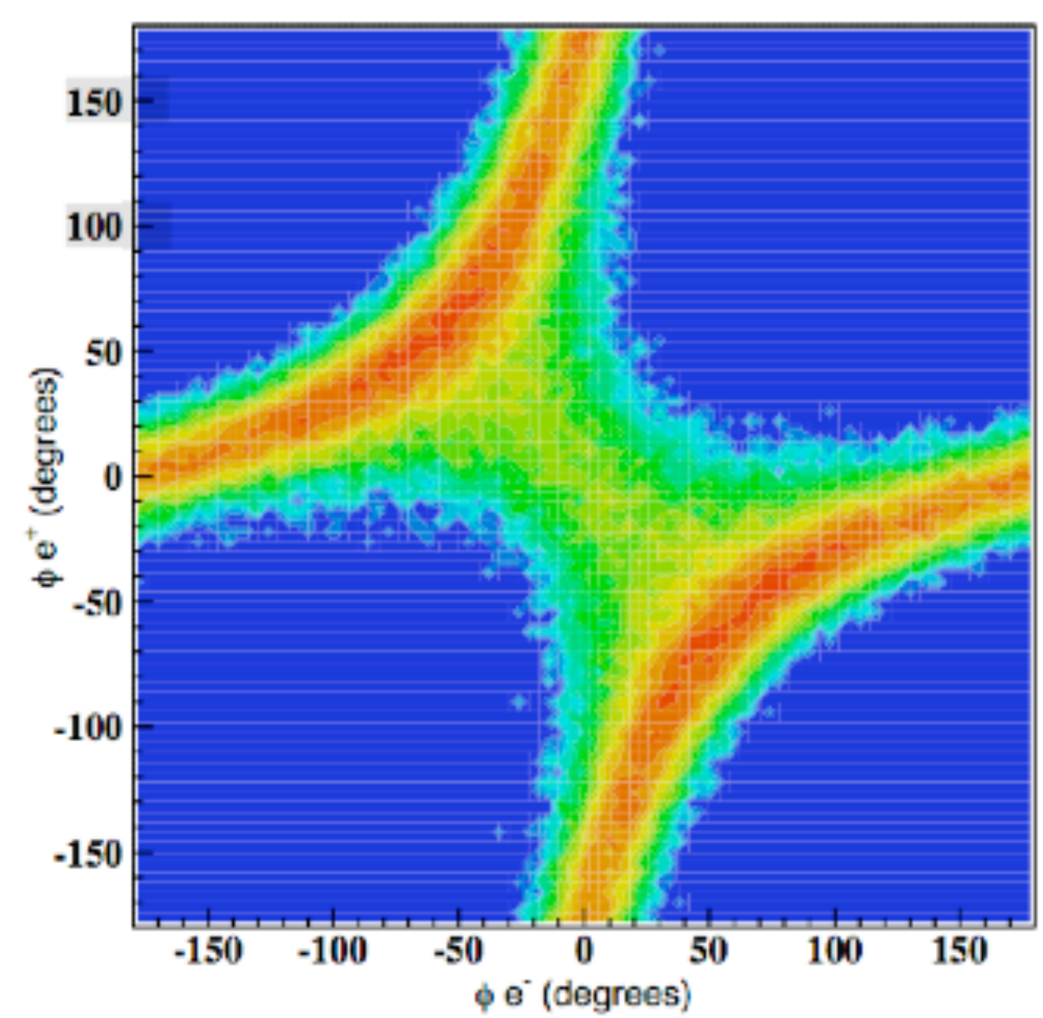
TCS is the inverse process to DVCS. Contributions of higher twists are different for DVCS and TCS processes and hence measuring both will help to obtain stronger constraints on GPDs

Time-Like Compton Scattering, S. Stepanyan

Simpler process to identify than DVCS
Cross section few - 10 pB (B. Pire et al.)
Access to sea quark and gluon GPDs in small-skewedness region

- 1 to 3 GeV scattered electron gets detected in very forward angles, ~0°
- Recoil proton escapes detection
- Two leptons can be detected in the main detector



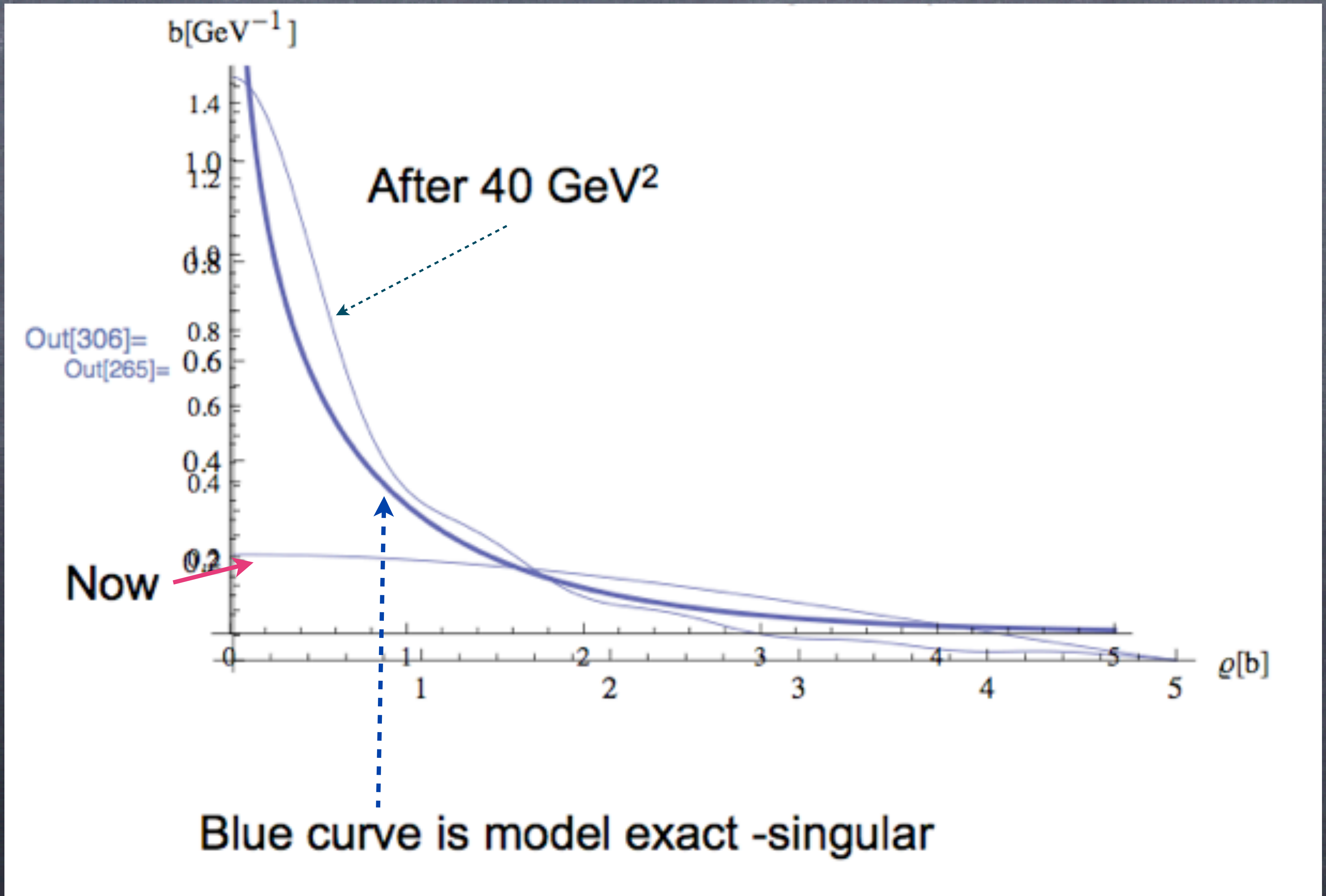


Transverse Charge Densities, J. Miller

Proton charge densities well-enough determined by 6+12 GeV data - wider Q^2 range will likely make little difference

But proton magnetization and neutron charge, magntization densities could use data up to 40 GeV^2

Similar π form factor Q^2 range needed to better determine π charge density

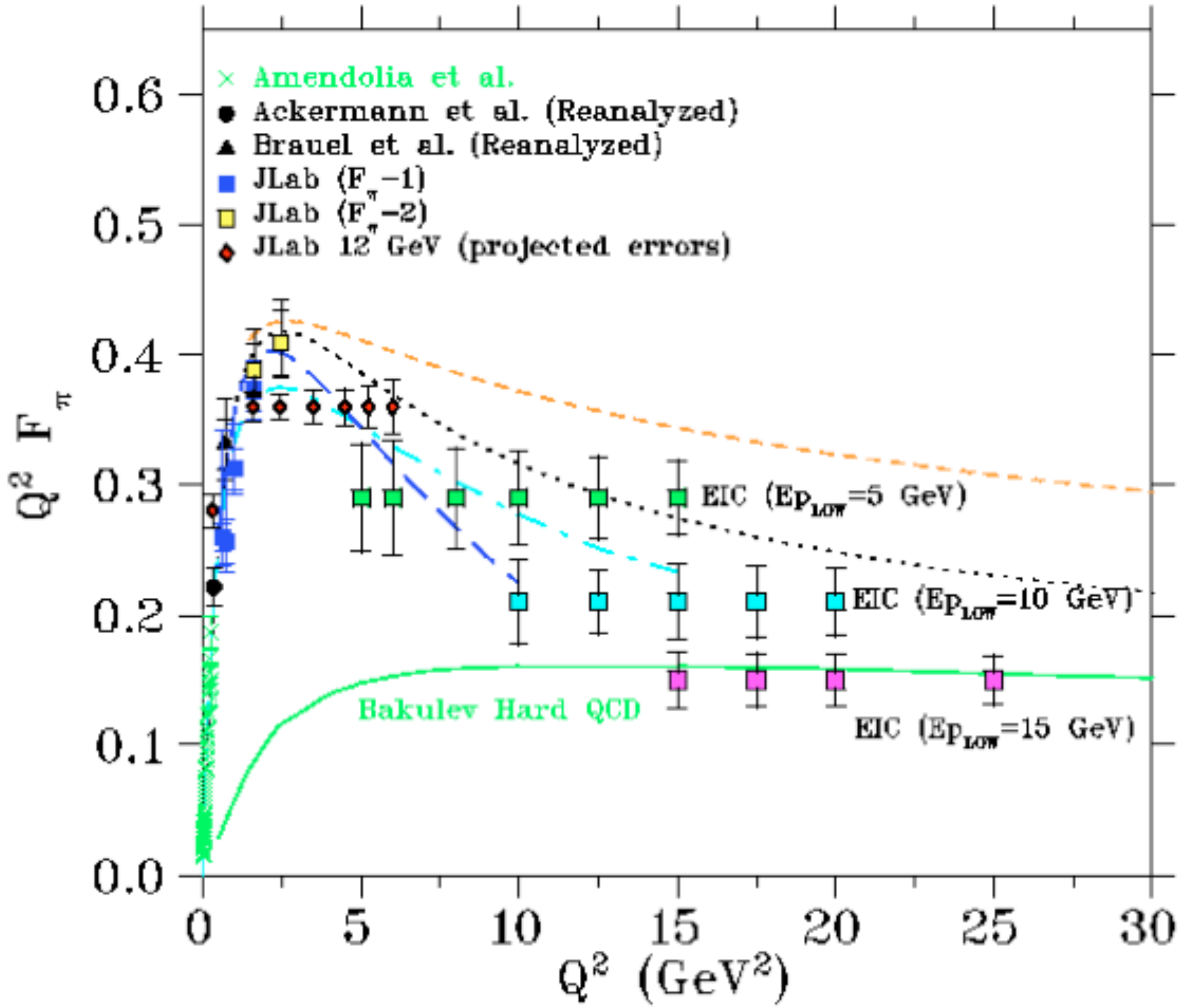


Pion Form Factor, D. Gaskell (+G. Huber)

π form factor over wide Q^2 range with separated cross sections do-able, but challenging

Not shown: kinematic issue - need very forward recoil neutron detector

Also possible to use polarization observables in parallel kinematics to get σ_L



Assumptions:

- **High ε:** 5(e^-) on 50(p).
- **Low ε** proton energies as noted.
- $\Delta\varepsilon$~0.22.
- Scattered electron detection over 4π.
- **Recoil neutrons detected at θ<0.35° with high efficiency.**
- Statistical unc: $\Delta\sigma_L/\sigma_L$~5%
- Systematic unc: 6%/$\Delta\varepsilon$.
- **Approximately one year at L=10^{34}.**