

Measurements of the Generalized Gerasimov-Drell-Hearn Integral at Intermediate and Low Q^2 in Hall A.

A. Deur, Jefferson Lab
for the Hall A collaboration

USER GROUP MEETING

June 12, 2006

The GDH Sum Rules

At $Q^2 = 0$, original GDH sum rule (1966):

$$\int_{\nu_{\text{thr}}}^{\infty} (\sigma_A - \sigma_P) \frac{d\nu}{\nu} = \frac{-4\alpha\pi^2 S \kappa^2}{M^2}$$

σ_A, σ_P : photoproduction cross sections

ν : photon energy

S: Target spin

κ : anomalous magnetic moment

Valid for any kind of target (nucleon, nuclei, ...).

Only hypothesis open to question: non-subtraction hypothesis.

Checked on proton (~10%, Mainz, ELSA), ongoing checks on neutron.

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At $Q^2 > 0$, *generalized* GDH sum rule (Ji and Osborne):

$$\frac{8}{Q^2} \int_0^1 g_1 dx = S_1(0, Q^2)$$

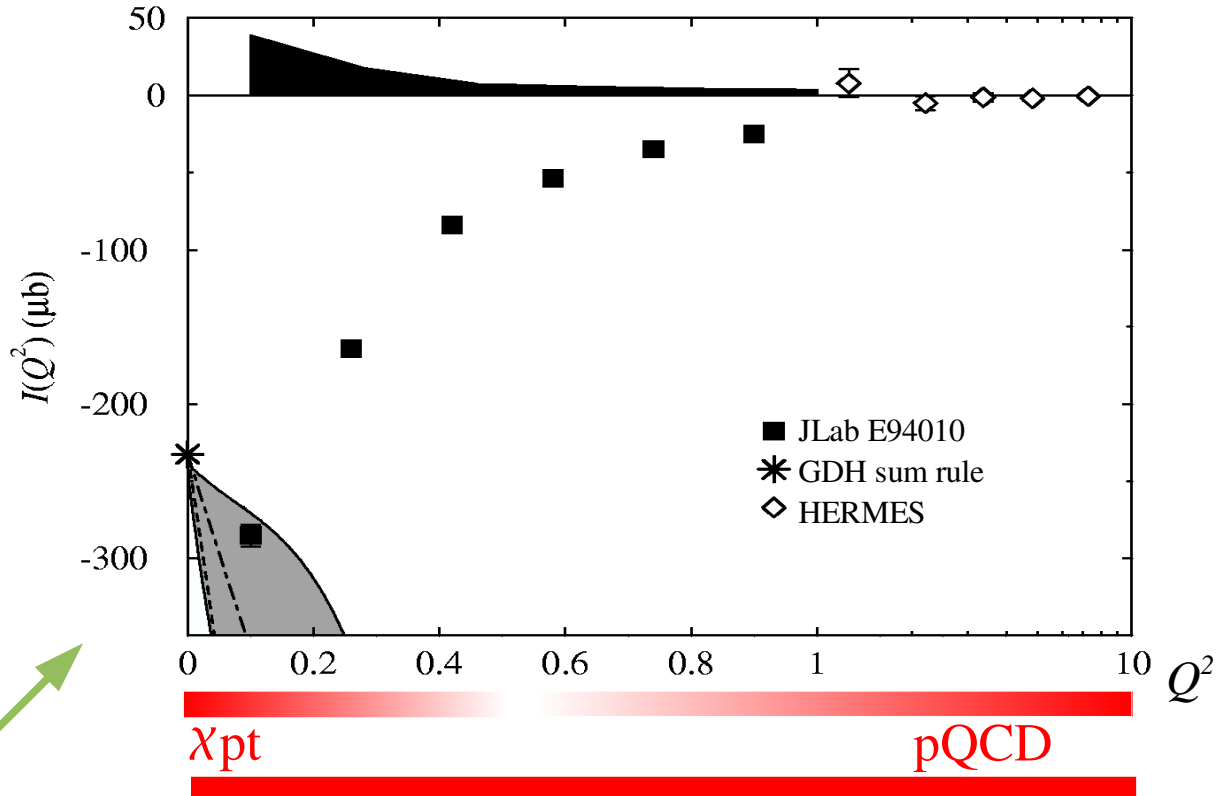
$S_1(\nu, Q^2)$: spin-dependent forward

Compton amplitude

Interest of the Generalized GDH Sum Rule

Can be measured *and* can be in principle computed at any Q^2 .

⇒ Suited to check **hadron-parton transition**



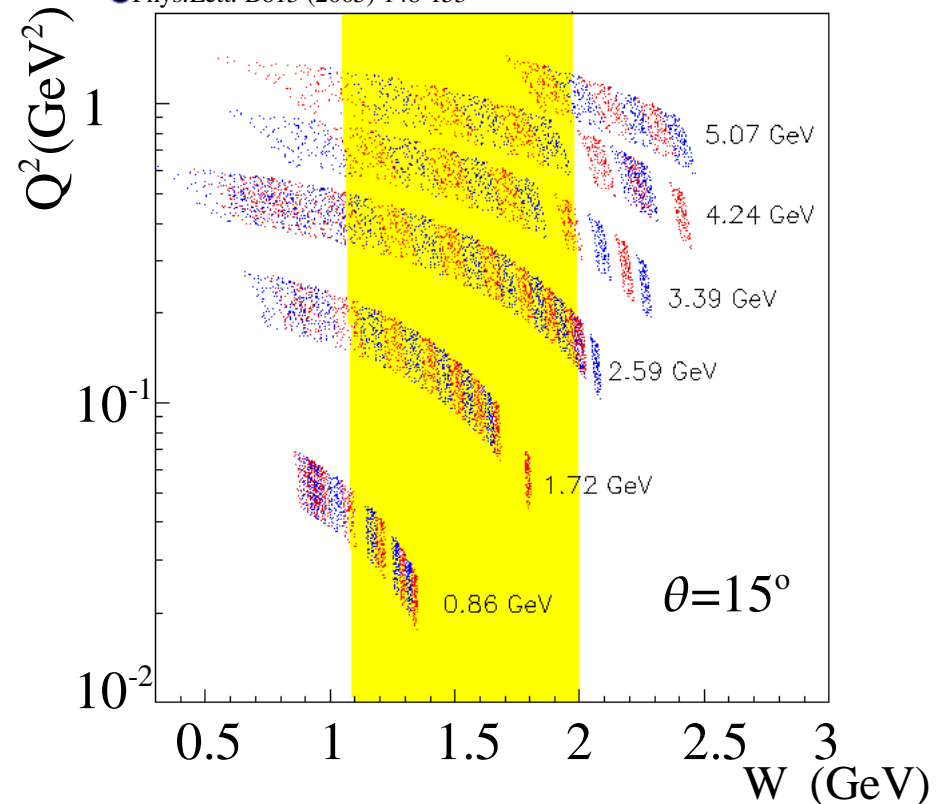
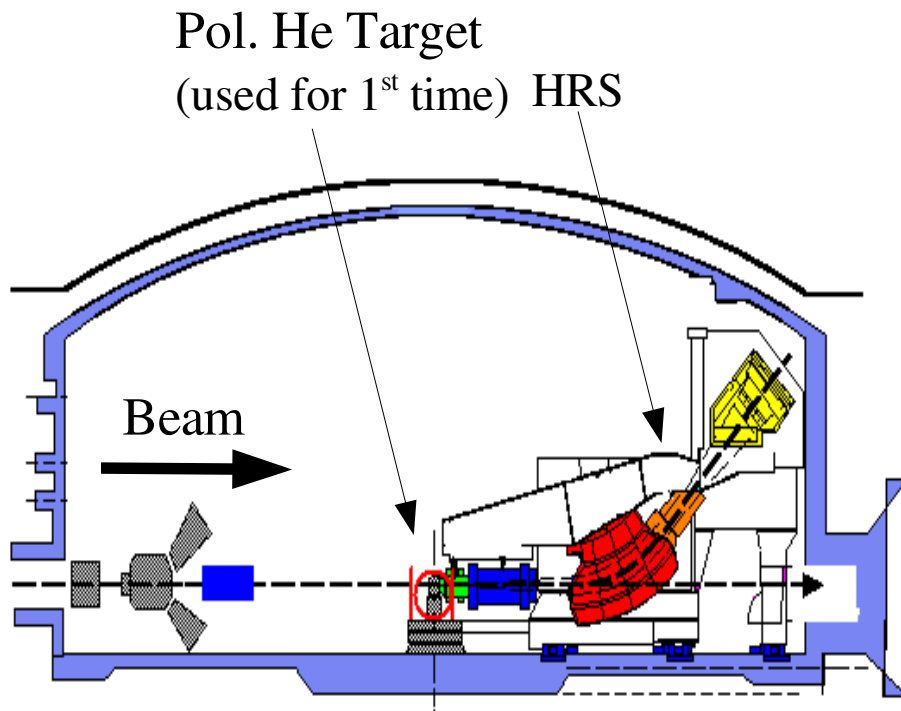
First Hall A measurement on
the neutron generalized GDH sum (1998. E94010)

Lattice QCD

Hall A Experiment E94-010

- ${}^3\text{He}(\vec{e} \rightarrow e')X$
- Study GDH sum on neutron at intermediate Q^2 . (parton-hadron transition).
- Z-E Meiziani, G. Cates and J-P Chen spokespersons.
- Ran in 1998. 1st results published in 2002.

- Phys.Rev.Lett. 89 (2002) 242301
- Phys.Rev.Lett. 92 (2004) 022301
- Phys.Rev.Lett. 93 (2004) 152301
- Phys.Rev.Lett. 93 (2004) 212001 (with Hall BEG1a)
- Phys.Lett. B613 (2005) 148-153



Procedure to Extract the GDH Sum

Generalized GDH sum (Ji and Osborne): $-\frac{8}{Q^2} \int_0^1 g_1 dx$

Other generalizations: $\int_0^1 ag_1 + bg_2 dx$

$$g_1 = \alpha(\sigma^{\uparrow\uparrow} - \sigma^{\uparrow\downarrow}) + \beta(\sigma^{\Rightarrow\uparrow} - \sigma^{\Rightarrow\downarrow}) \quad (\text{similar eq. hold for } g_2)$$

$\uparrow\uparrow$: Target spin

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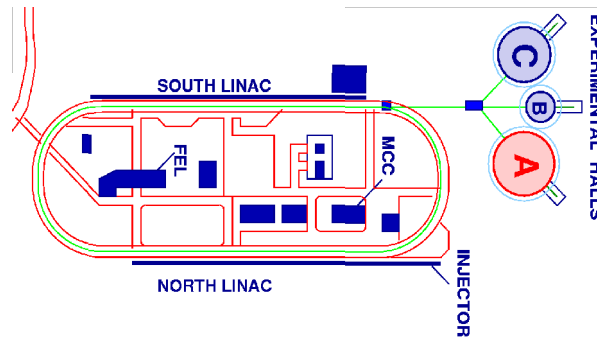
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We need **polarized beam**:
 (JLab beam: 70% pol. (now 85%))



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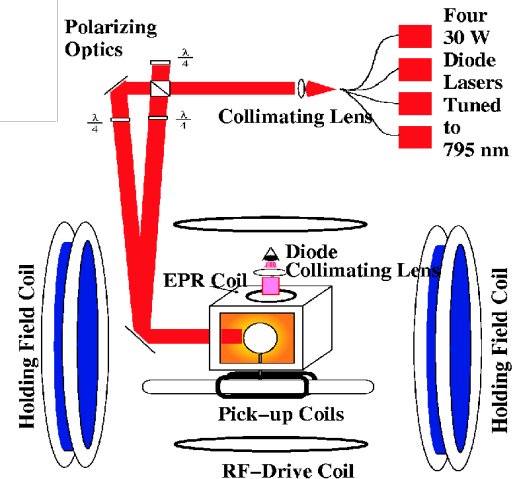
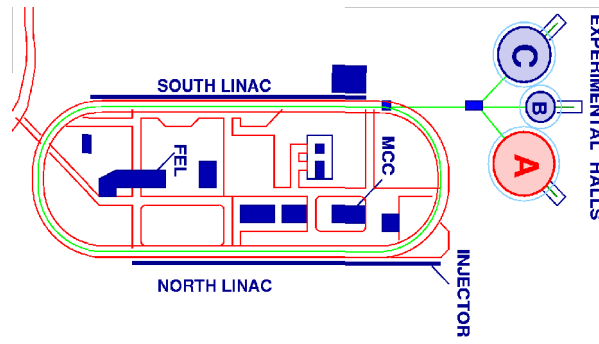
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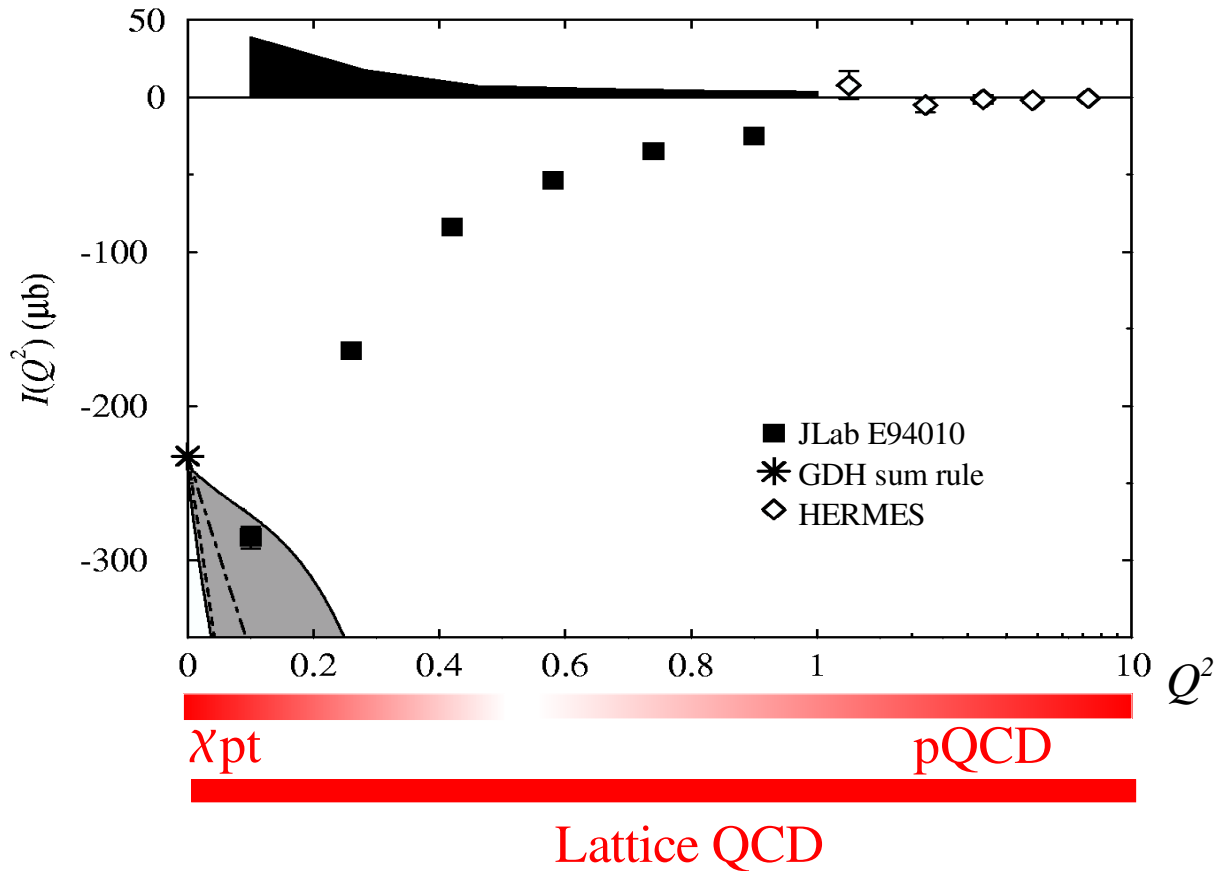
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and

Polarized target:
 (^3He target: 35% pol. (now 55%))

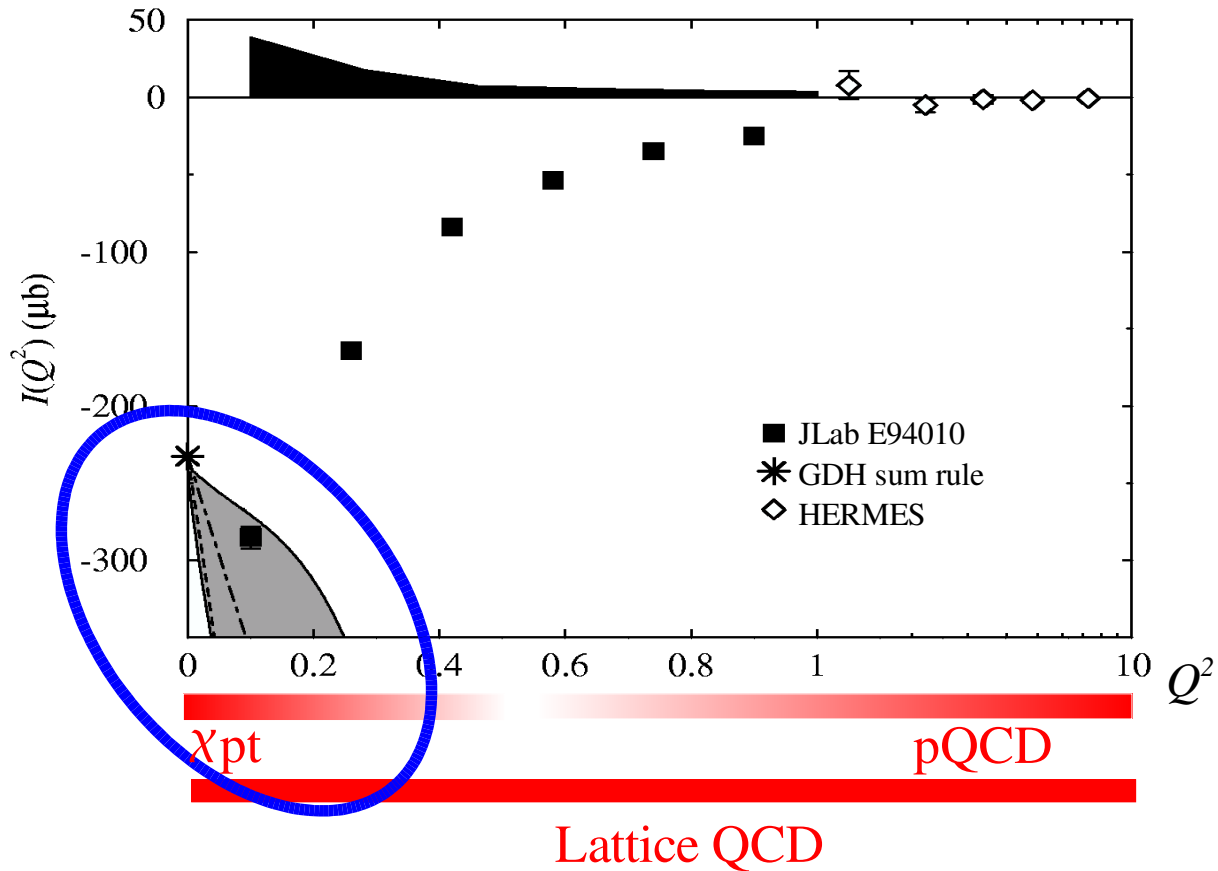


Generalized GDH Sum on Neutron



Amarian *et al.* Phys.Rev.Lett. 89 (2002) 242301

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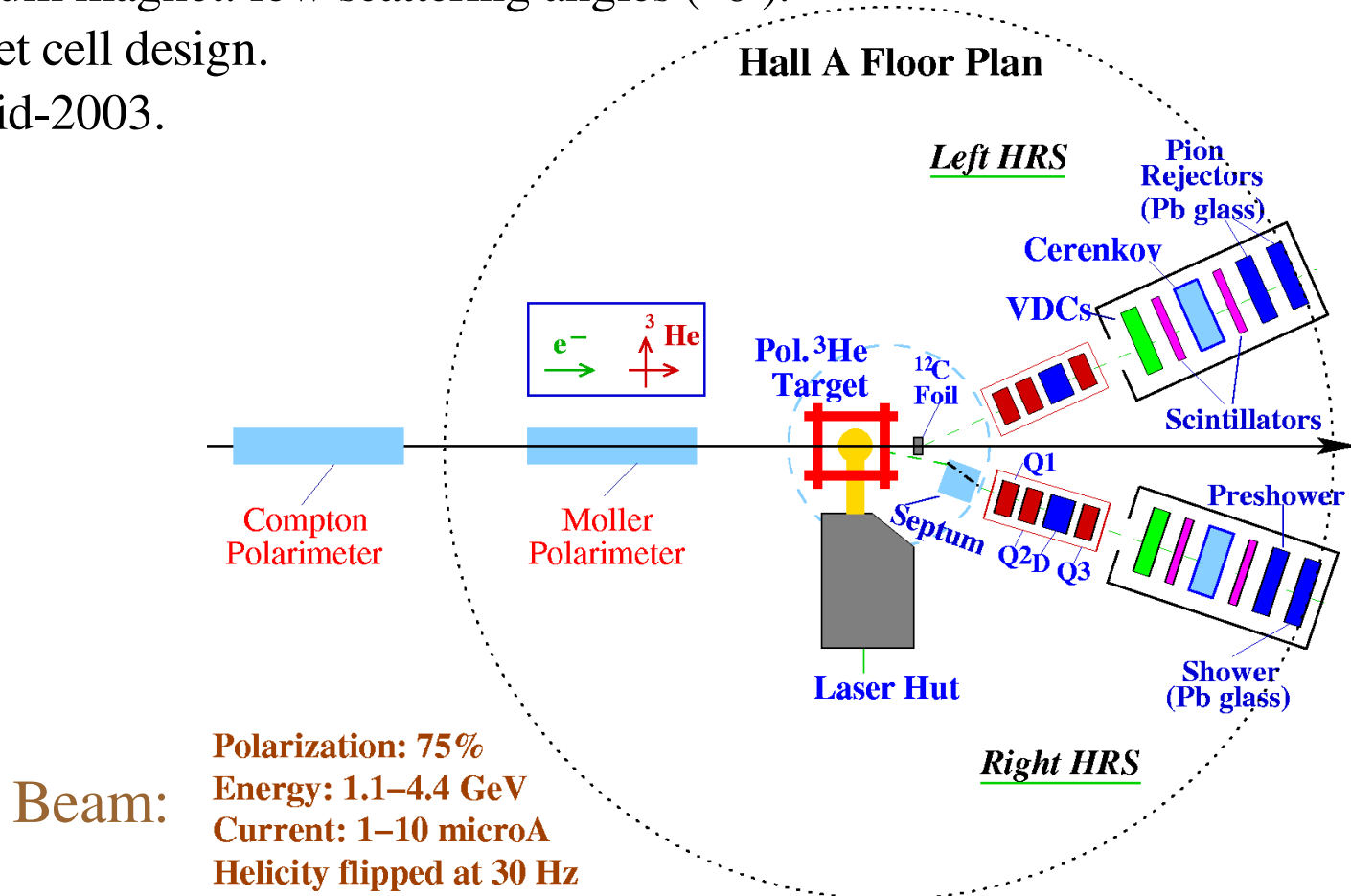


Hall A Experiment E97-110

Spokespersons: J.P Chen (JLab), A. Deur (JLab), F. Garibaldi (INFN)

Students: J. Singh (UVa), V. Sulkosky (W&M), J. Yuan (Rutgers)

- Study GDH sum on neutron at low Q^2 .
- New septum magnet: low scattering angles ($\sim 6^\circ$).
- New target cell design.
- Ran in mid-2003.

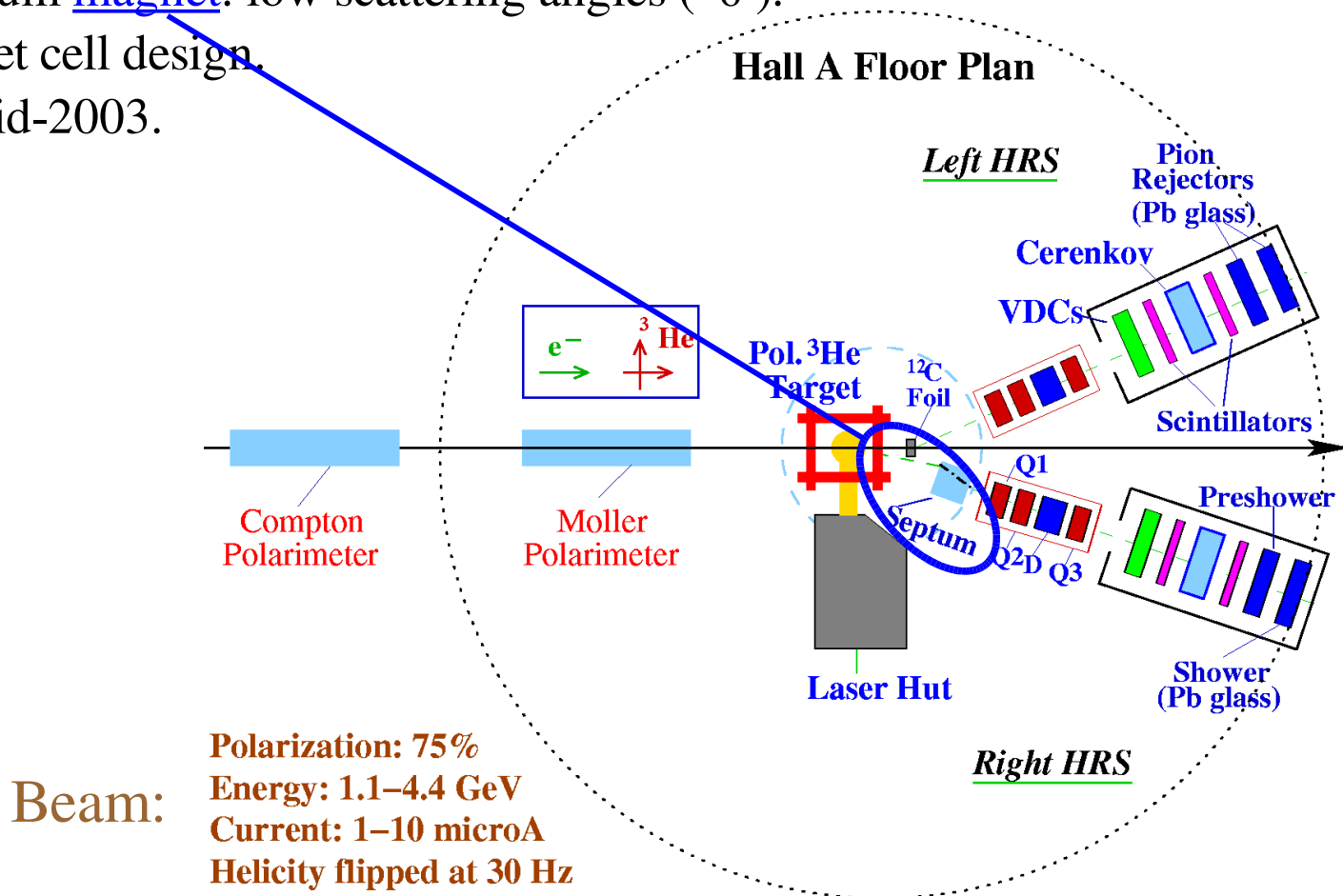


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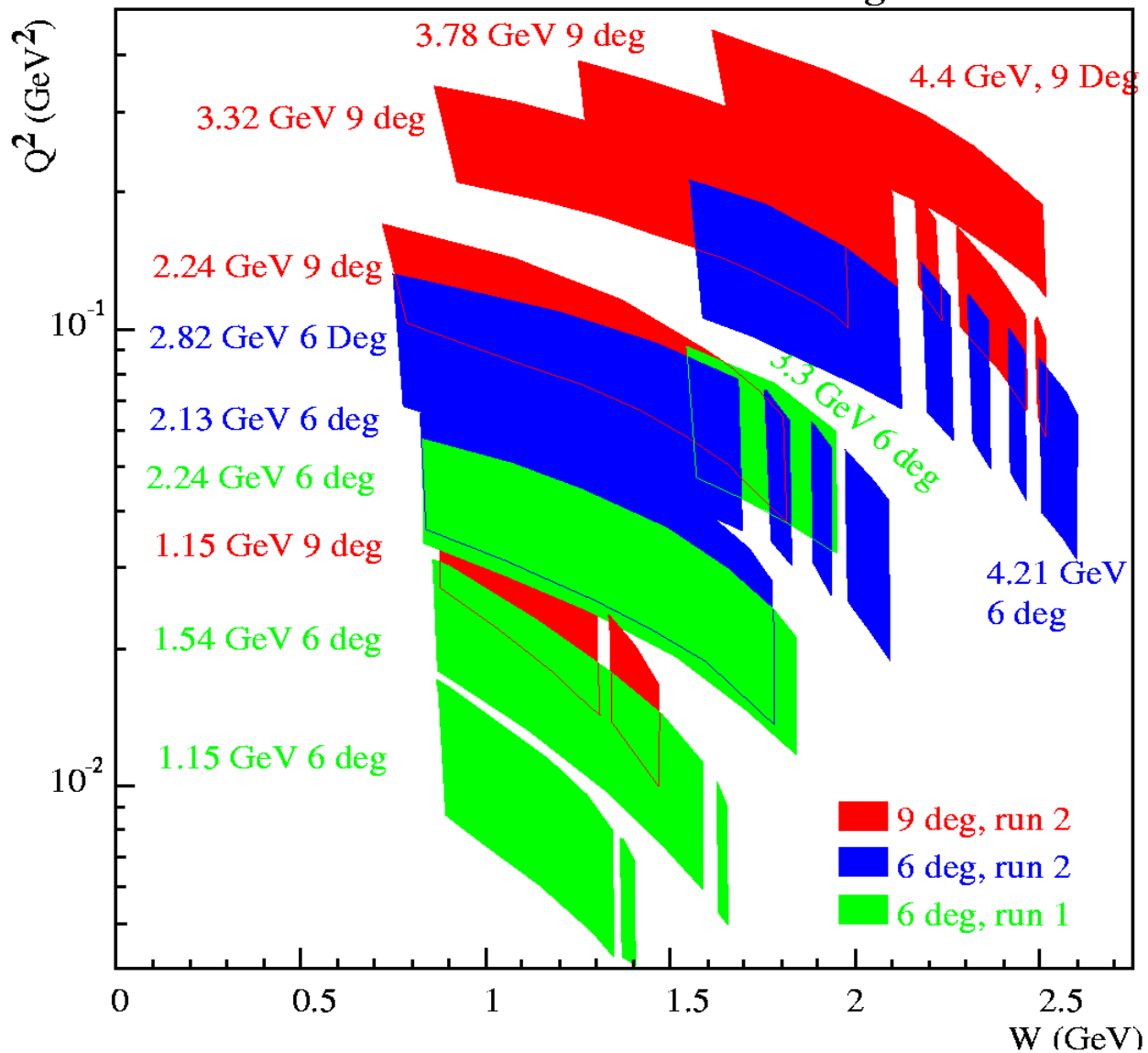
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E97-110 Kinematics Coverage



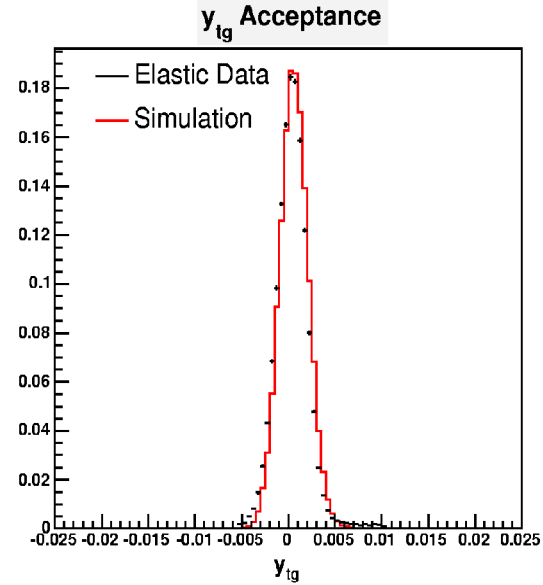
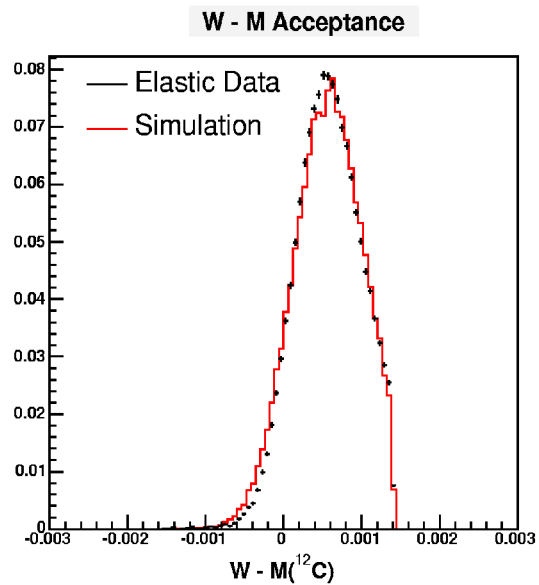
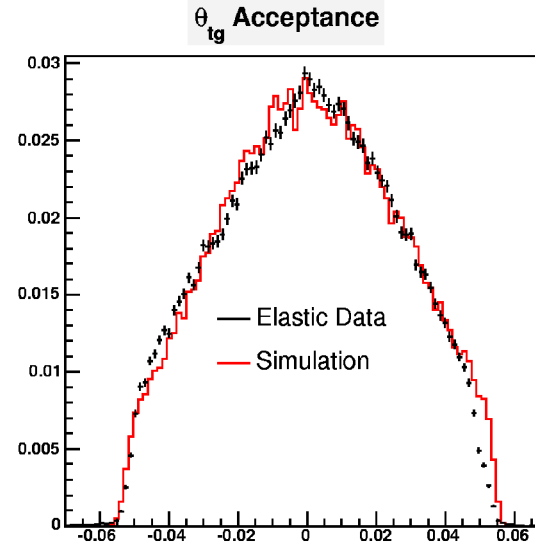
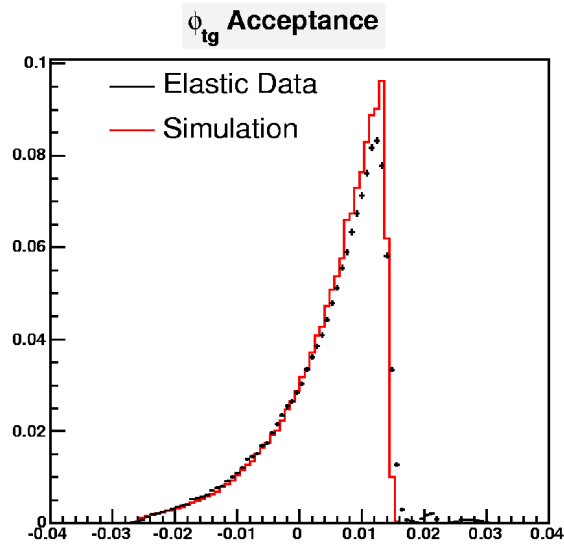
Main Analysis Tasks completed (or near completion)

- Spectrometer+septum optics: done (V. Sulkosky, N. Liyanage).
- Acceptance (+elastic cross section): Almost done for 6° (V. Sulkosky).
- Detector analysis: Almost done (H. Lu & USTC, J. Yuan).
- Target analysis (density, polarization, ...): well underway (J. Singh).
- Background and systematics studies: well underway (A. Beck, A. Deur, T. Holmstrom).

Other works: VDC and background study check: S. Dhamija.

N_2 dilution: X. Zhan.

^{12}C Elastic Cross Section (V. Sulkosky)

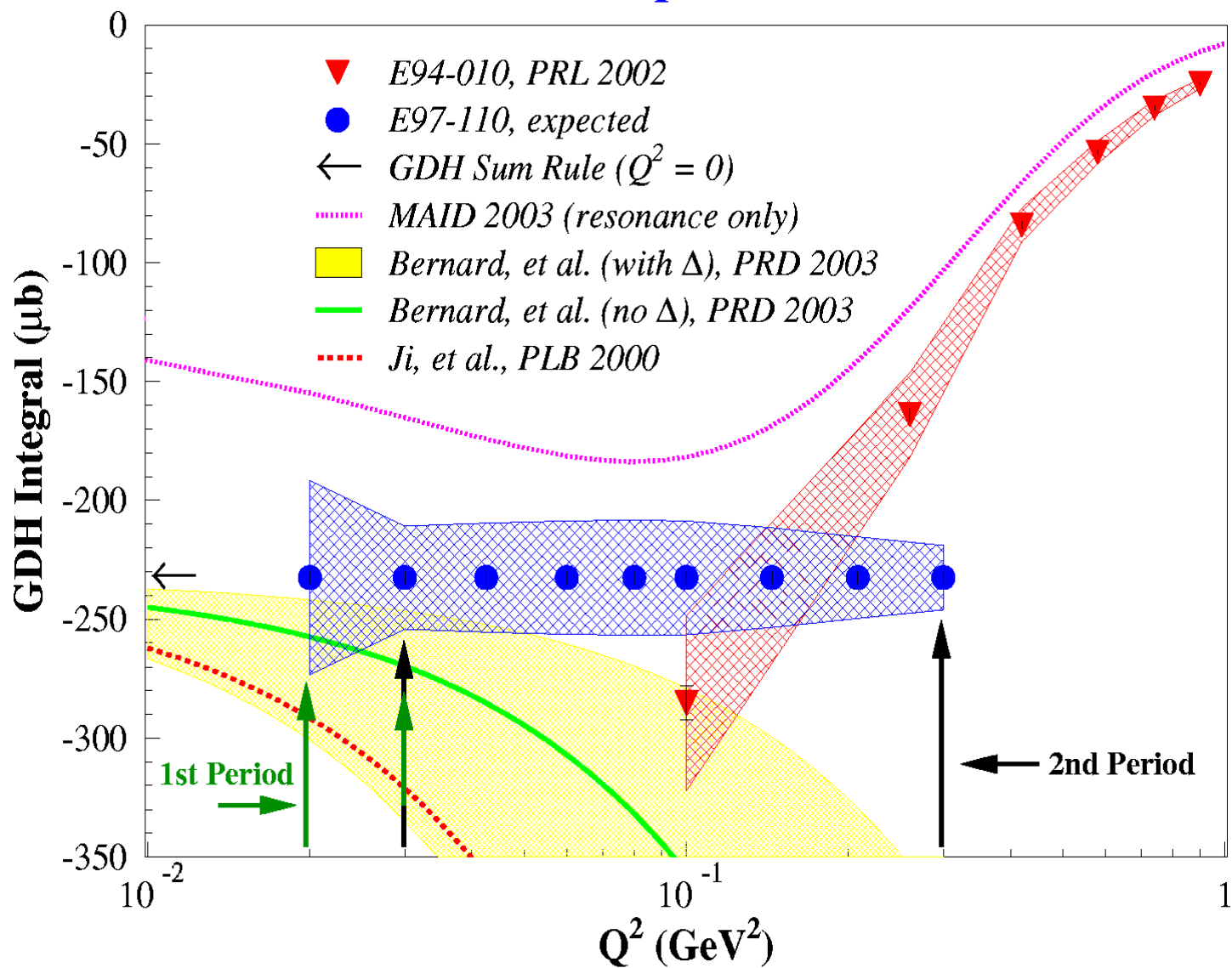


Remaining Main Analysis Tasks

- Acceptance and elastic cross sections for 9° .
- Extract polarized inelastic cross sections.
- Radiative corrections.
- Form the GDH sum at constant Q^2 .
- Analysis of the first period.

We expect first results on GDH sum for 2nd period by August-September.

E97-110 Expected Results



Perspectives

- First results available in a few months.
- Still need to analyze first period (lowest Q^2).
- Complementary experiment done in Hall B on ND_3 (see Yelena's talk).
- Proton will also be available in the same kinematic range (Yelena's talk).

Other physics quantity of interest will be extracted:

- Bjorken sum.
- Generalized polarizabilities.
- Higher moments.
- GDH sum on ^3He .

After this, experimental program on generalized GDH on nucleons will be more or less completed.

The issue of the missing high energy part of the sum will be partly solved with the 12 GeV upgrade (low and intermediate Q^2).