

A Measurement of proton g_2 and the Longitudinal-Transverse Spin Polarizability

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For the Jefferson Lab Hall A E08-027 ($g2p$) collaboration

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E08-027

g_2^p & the LT Spin Polarizability

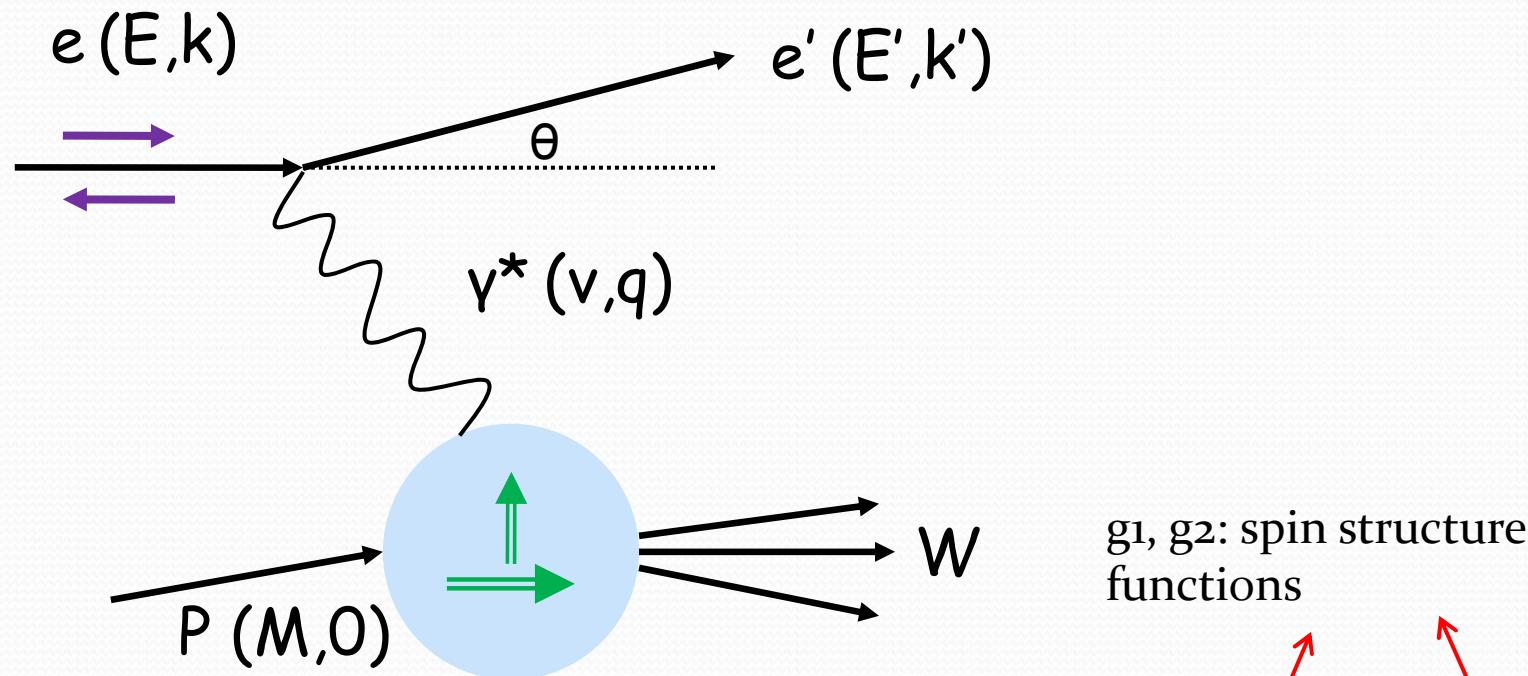
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 - Jian-Ping Chen (JLab)
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 - Karl Slifer (UNH)
- Post Docs
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 - Jie Liu
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Outline

- Introduction
- Physics Motivation
- Experimental Setup
- Status of Data Analysis

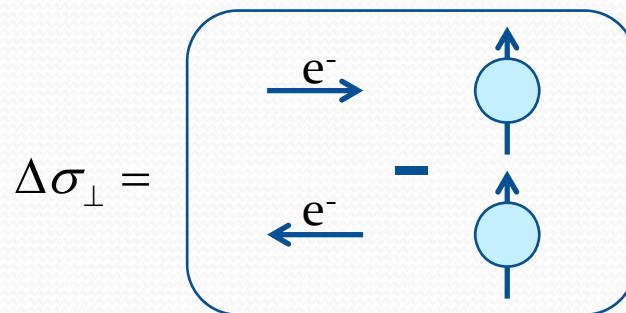
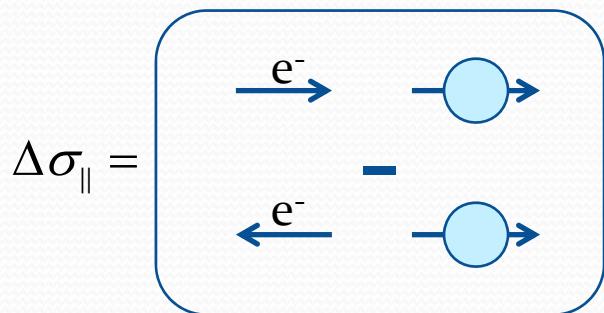
Electron Scattering

- Inclusive polarized differential cross section



$$\frac{d^2\sigma}{d\Omega dE'} = \sigma_{\text{Mott}} \left[\frac{1}{\nu} F_2(x, Q^2) + \frac{2}{M} F_1(x, Q^2) \tan^2 \frac{\theta}{2} + \gamma g_1(x, Q^2) + \delta g_2(x, Q^2) \right]$$

How to Get g_2



$$g_2 = \frac{MQ^2}{4\alpha_e^2} \frac{y}{(1-y)(2-y)} \left[-\Delta\sigma_{||} + \frac{1 + (1-y)\cos\theta}{(1-y)\sin\theta} \Delta\sigma_{\perp} \right]$$

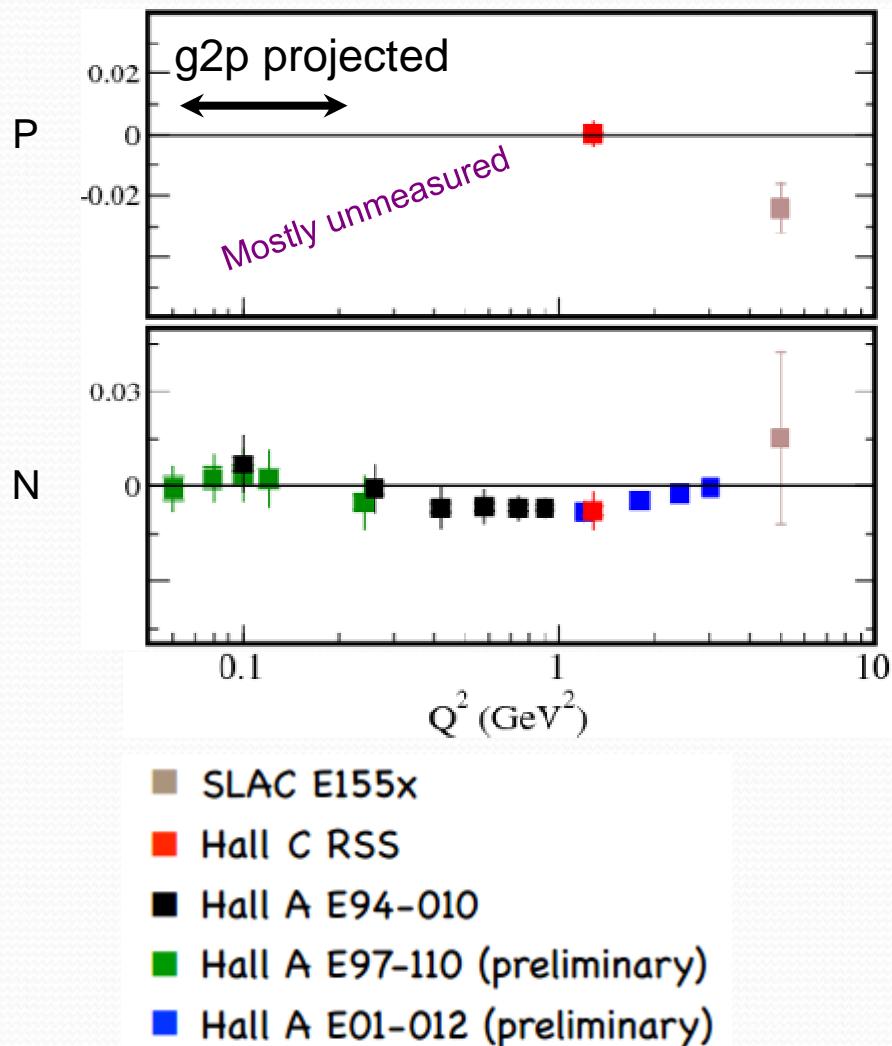
$\Delta\sigma_{||}$ measured by
JLab Hall B EG4
experiment at low Q^2

$\Delta\sigma_{\perp}$ measured by this
experiment, combined
with EG4 data to obtain
 g_2^p at low Q^2

Motivation

- Measure the proton transverse spin structure function g_2 in the low Q^2 region ($0.02 < Q^2 < 0.2 \text{ GeV}^2$) for the first time
- Extract δ_{LT} to be a benchmark test of χPT
- Unique opportunity to test the Burkhardt-Cottingham sum rule
- Crucial inputs for hydrogen hyperfine splitting and proton charge radius measurements

BC Sum Rule



$$\int_0^1 g_2(x, Q^2) dx = 0$$

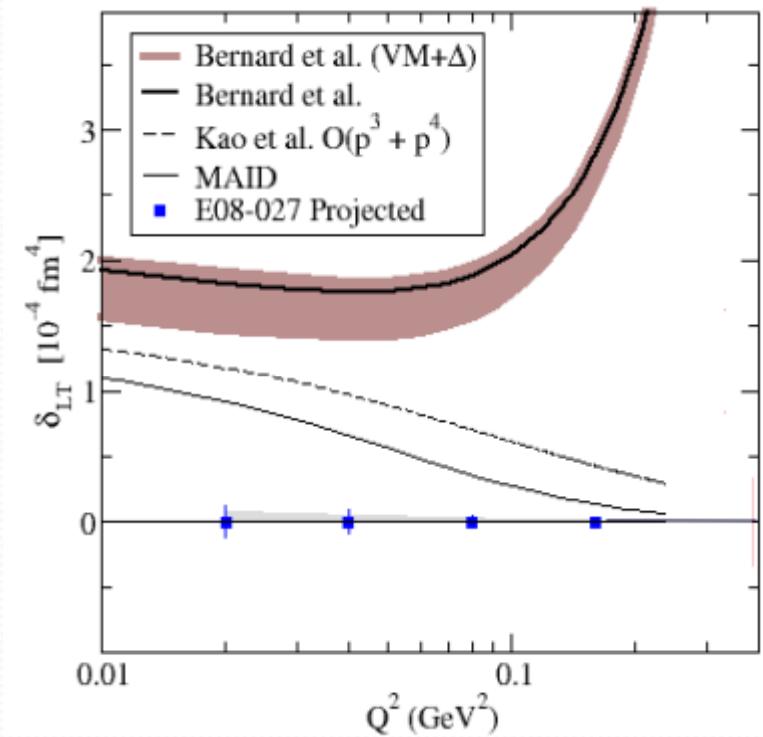
H. Burkhardt and W. N. Cottingham, Annals. Phys., 56(1970)453

- BC satisfied within errors for Neutron
- Inconsistency seen in proton data
- Mostly unmeasured for proton

Spin LT Polarizability

$$\delta_{LT}(Q^2) = \frac{16\alpha M^2}{Q^6} \int_0^{x_0} x^2 [g_1 + g_2] dx$$

- Can be calculated via χ PT
- Neutron data show large deviation from χ PT calculations
- No proton data yet
- δ_{LT} more clean channel than γ_0 to test the chiral dynamics of QCD



Experimental Setup

Thomas Jefferson National Accelerator Facility

Hall A

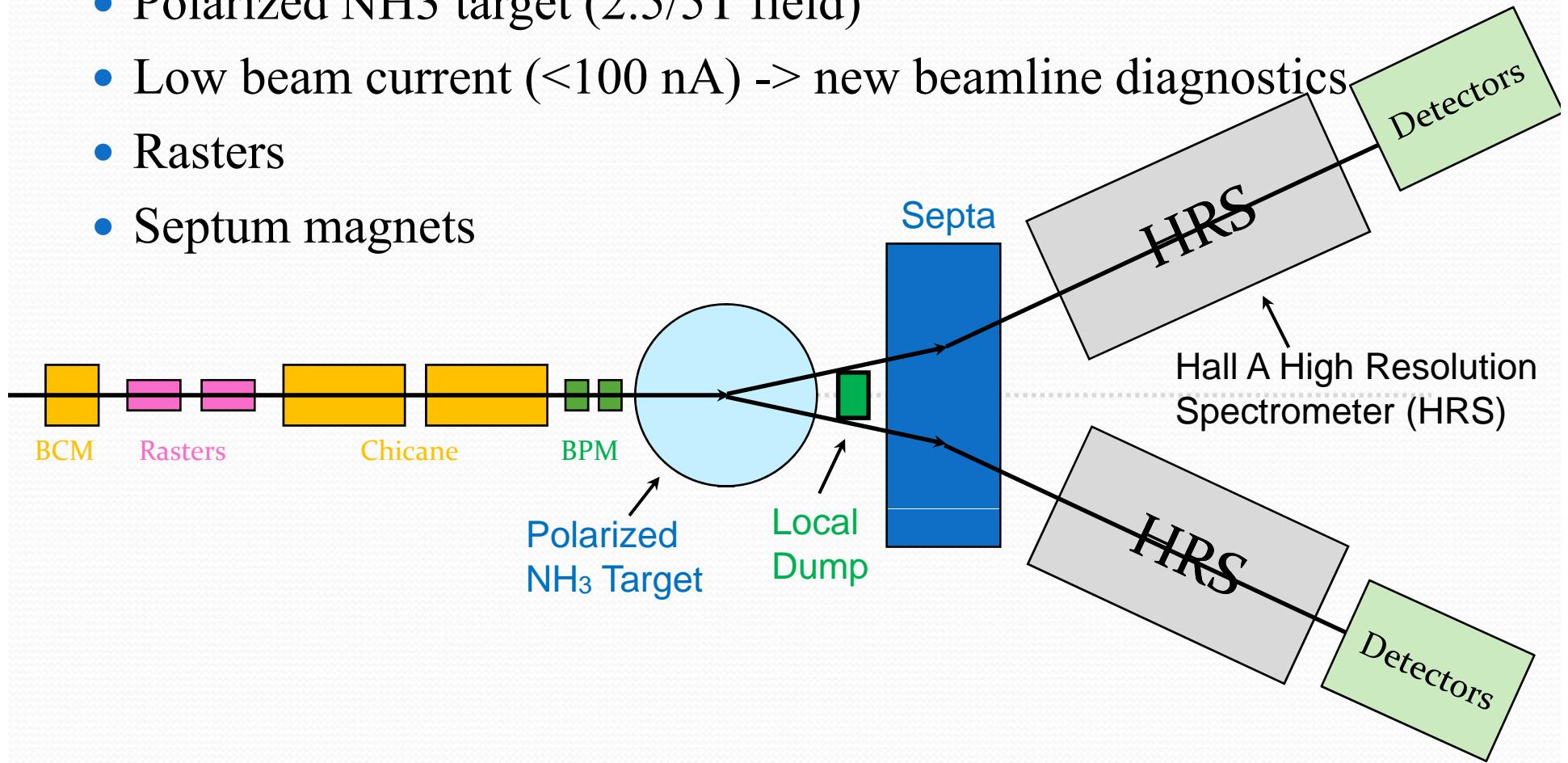
2/29/2012 - 5/18/2012

Hall A



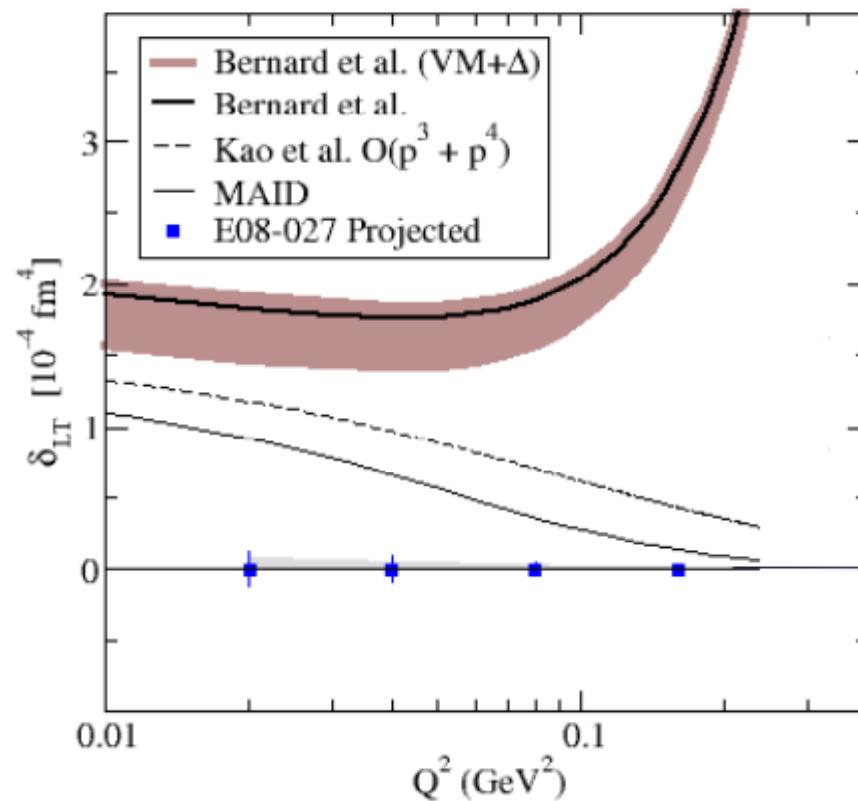
Experimental Setup

- Large Scale Installation in Hall A
 - Polarized NH₃ target (2.5/5T field)
 - Low beam current (<100 nA) -> new beamline diagnostics
 - Rasters
 - Septum magnets

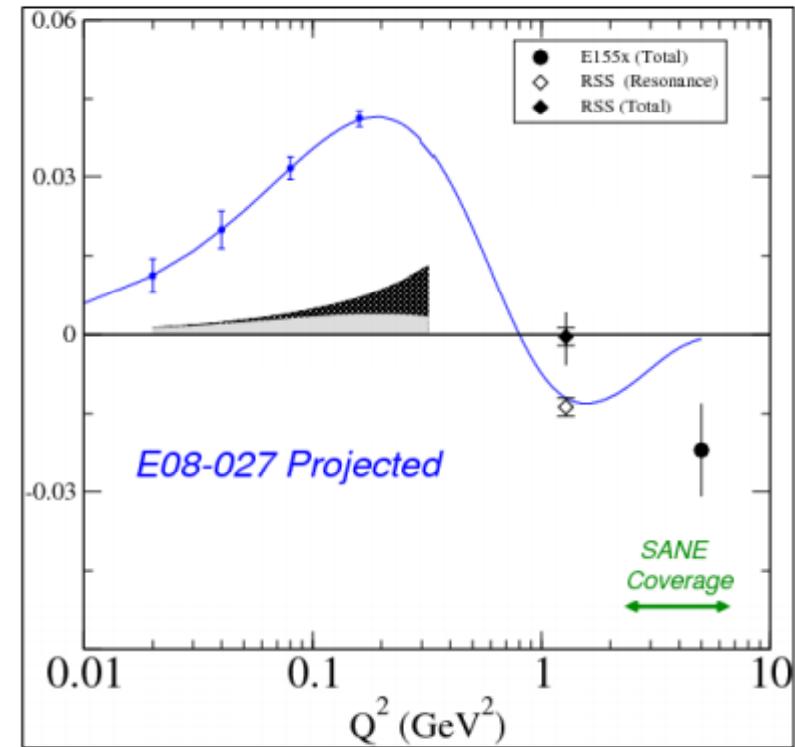


Projections

LT Spin Polarizability



BC Sum Integral Γ_2

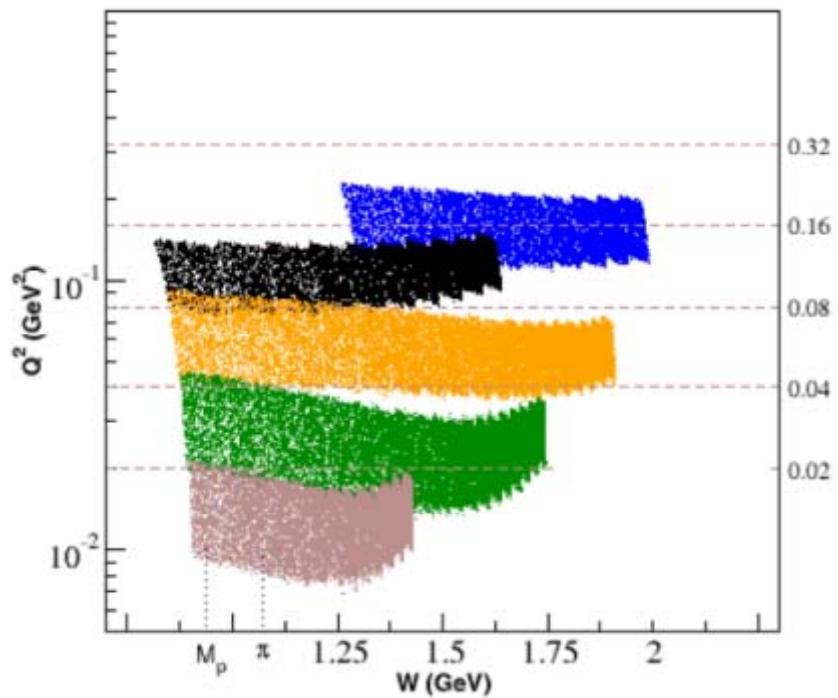


$$\delta_{LT}(Q^2) = \frac{16\alpha M^2}{Q^6} \int_0^{x_0} x^2 [g_1 + g_2] dx$$

$$\int_0^1 g_2(x, Q^2) dx = 0$$

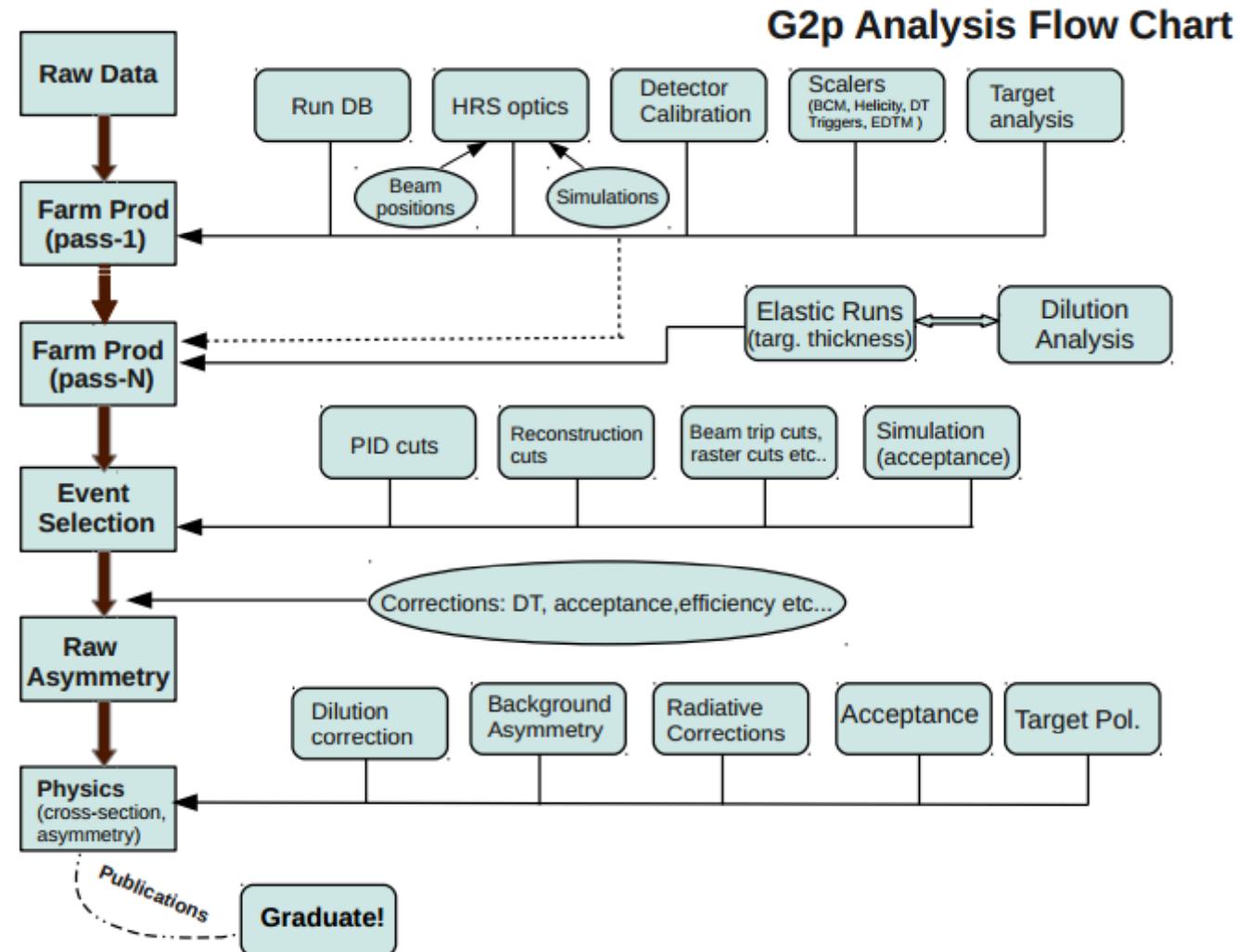
kinematics Coverage

$M_p < W < 2 \text{ GeV}$
 $0.02 < Q^2 < 0.2 \text{ GeV}^2$



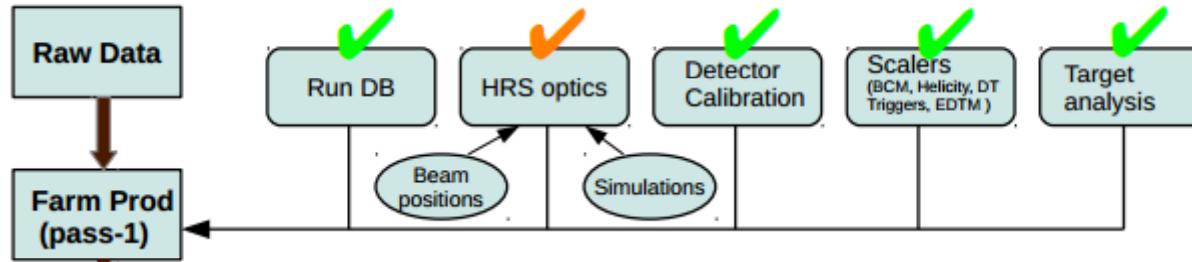
Beam Energy /GeV	Target Field /T
2.254	2.5
1.706	2.5
1.158	2.5
2.254	5.0
3.352	5.0

Status of Analysis



courtesy K. Allada

Status of Analysis



- Complete!
 - Run Database
 - HRS optics w/o target field
 - Detector calibrations
 - Scalers
 - Offline target polarization calibration
- Underway
 - HRS optics with target field
 - Systematic uncertainty study of target polarization
 - Beam position calibration

Optics Talk by
Chao Gu X15

Target Talk by
Melissa
Cummings X15

Summary

- The g2p experiment, ran in spring of 2012, managed to take data covering most of our physics goals
- A first pass replay of production data is now complete, and data quality checks are underway!
- Will provide a definitive measurement of g_2^p in the low Q^2 region for the first time
- Results will shed light on several physics puzzles