E12-07-108: (GMp)
Precision Measurement of the Proton Elastic Cross Section at High Q^2

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(for the E12-07-108 Collaboration)

Hall A Collaboration Meeting
16th December 2013

Goals for GMp Experiment

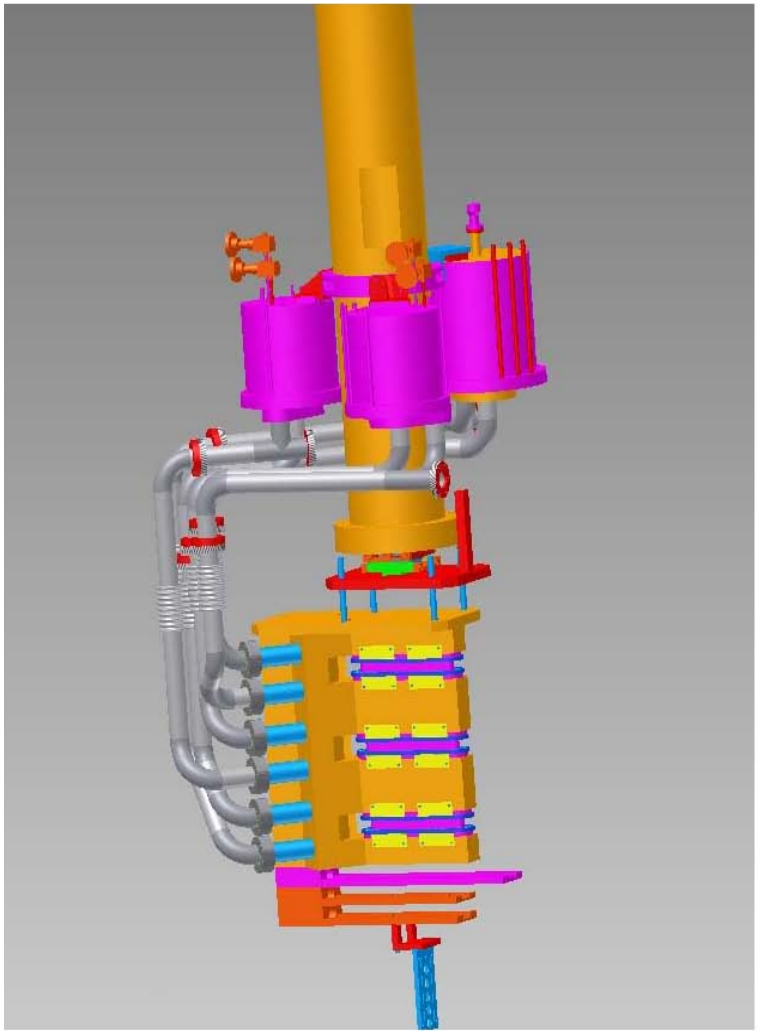
- Accurately measure e-p elastic cross section in kinematics similar to other JLab form factor measurements (Q^2 = 7 – 14 GeV^2)
- Improve accuracy of the cross section by as much as a factor of 5 (< 2%) over previous measurements
- Key input to all form factor experiments, and many of other experiments where elastic scattering is used for normalization
- Approved for 24 PAC days

$$\frac{d\sigma}{d\Omega} = \sigma_{\text{Mott}} \frac{\epsilon (G_E^p)^2 + \tau (G_M^p)^2}{\epsilon(1+\tau)}, \qquad \sigma_{\text{Mott}} = \left(\frac{\alpha}{2E} \frac{\cos\frac{\theta}{2}}{\sin^2\frac{\theta}{2}} \right)^2 \frac{E'}{E}$$

$$\tau = Q^2/4M_p \text{ and } \epsilon = [1 + 2(1+\tau)\tan^2\theta/2]^{-1}$$

Cryo Target Configuration

- 15 cm LH2
  - Large 3 inch cell
  - Vertical flow
  - Reduce density fluctuation
- Large vertical acceptance requirement for DVCS (20 degrees)
- Solid targets
  - less than 2% radiation length for March running
  - Standard dummy target (Al foil)
  - Standard optics target (5 foils)
  - Empty

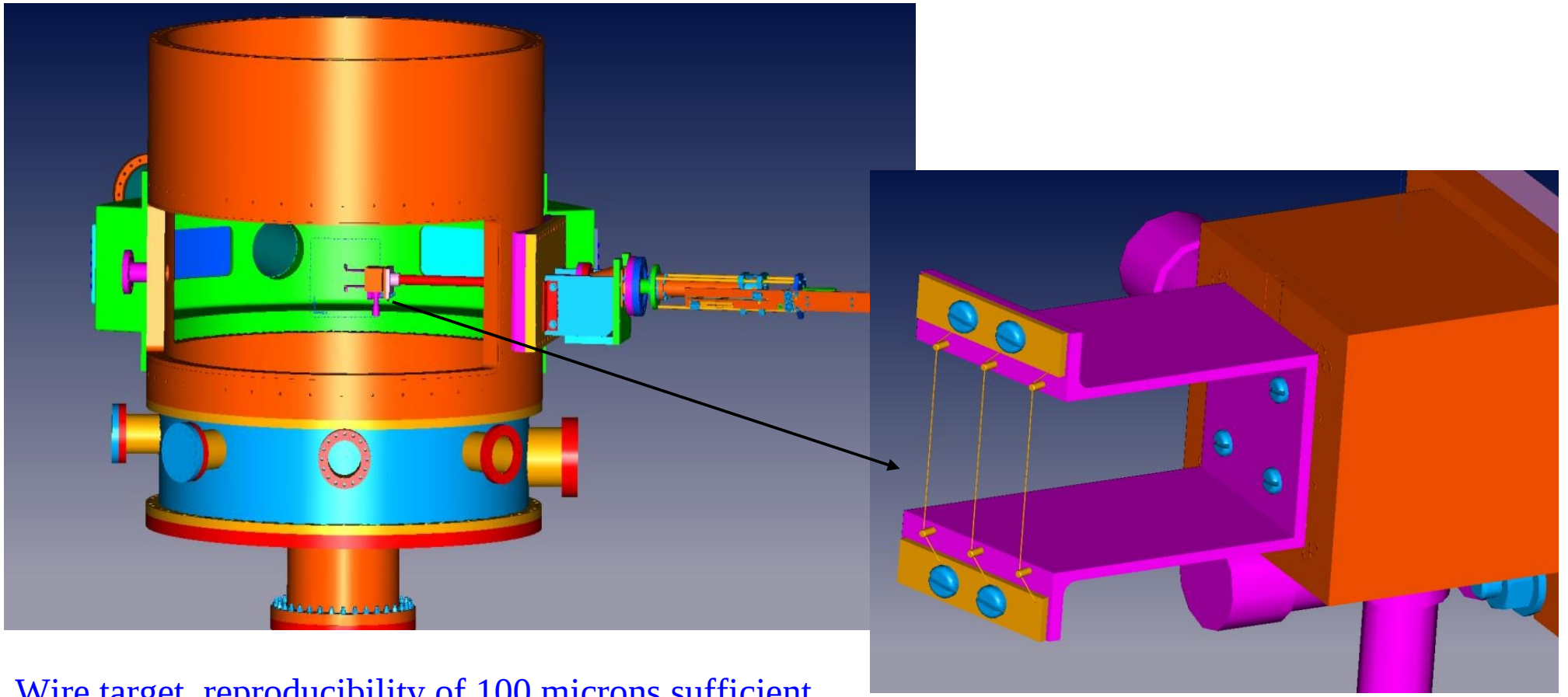


Updates from
D. Meekins

Wire Target for Pointing/Angle

Wires:

- 0.5” apart along the beamline
- 1/16” (~1.6 mm) apart transverse to beam

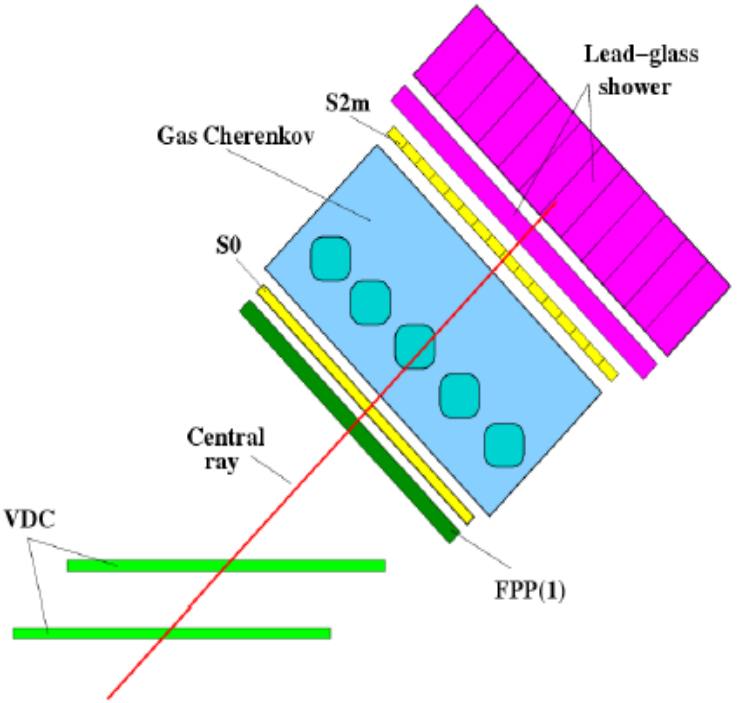


Wire target, reproducibility of 100 microns sufficient

Design completed, parts ordered, assembly in progress

HRS Detector Stack

- Standard detector stack
- Replace old VDC disc. cards with new MAD cards (done)
- Install one straw chamber in each spectrometer (done)
  - Determine reconstruction efficiency to 0.5%
- Replace aging PMTs in Gas Cerenkov with new 5” Tubes (in progress)
- Use wavelength shifter (WLS) for Gas Cerenkov PMTs (WLS tests done)

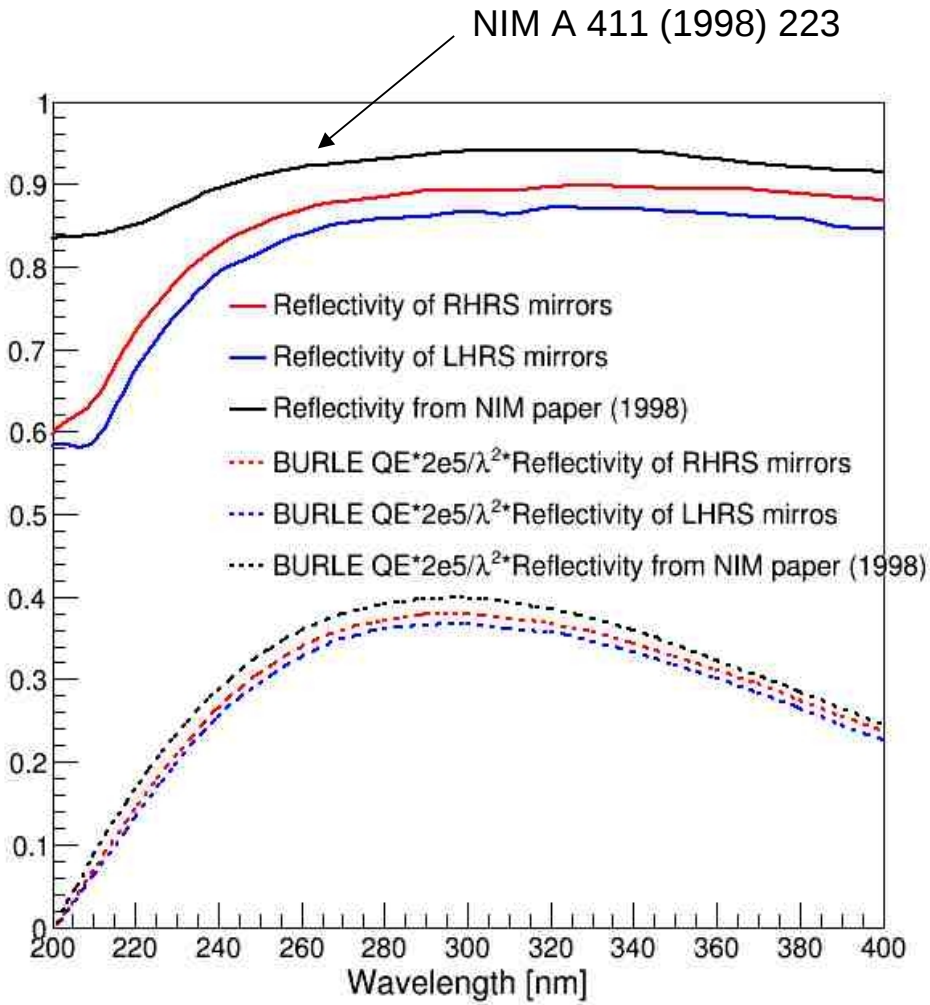


FPP Updates

- Straw chamber installed in both spectrometers
- All cables connected, signals to FASTBUS TDCs
- HV distribution is operational
- Left HRS gas flow is operational, need gas line in Right HRS
- Signals checkout with cosmics (in progress)

Gas Cerenkov Updates: Mirror Reflectivity

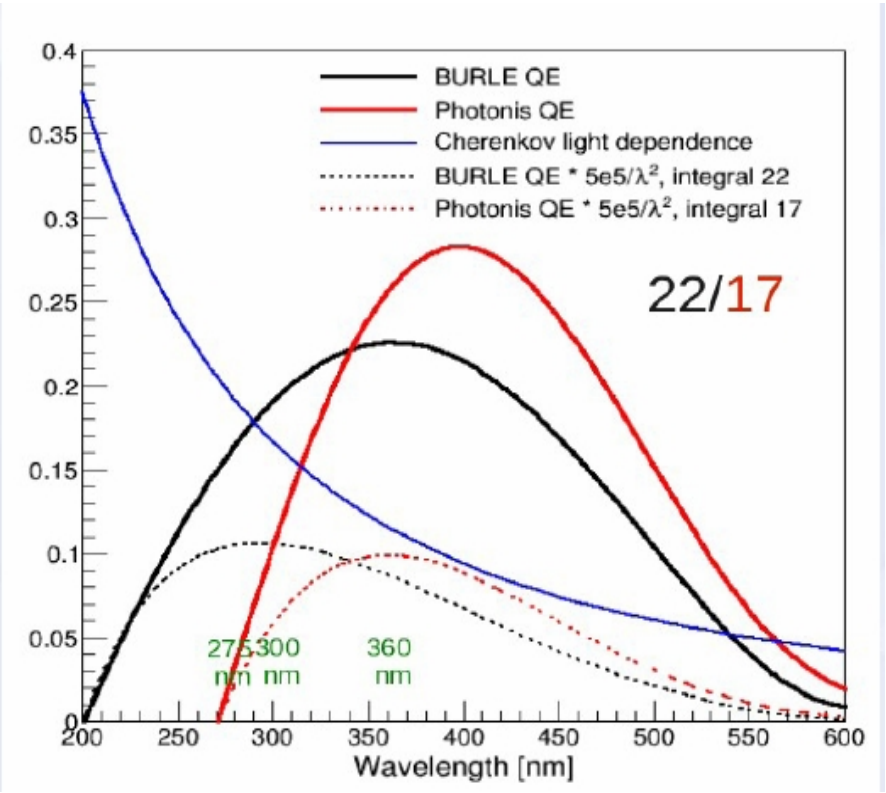
- Mirror Reflectivity tests done
- Deterioration in reflectivity was observed for all tested mirrors
  - ~ 30% near 200 nm
  - ~ 6% around 300 nm
- Reduction of combined efficiency due to drop in reflectivity:
  - For BURLE : ~ 8 %
  - For ET Tubes : ~ 7%
- Mirror alignment finished
- GC installed in HRS stack, no PMTs yet



Plot by Longwu Ou

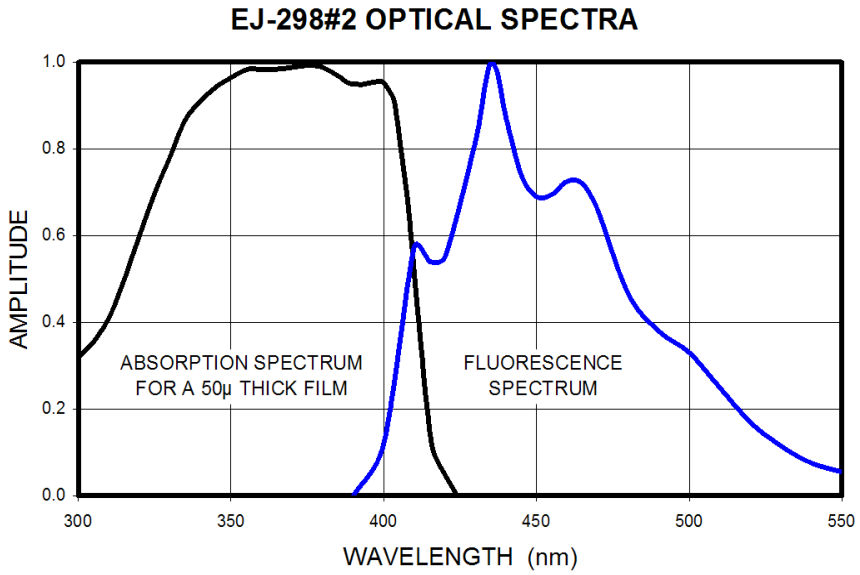
Wavelength Shifter (WLS) for PMTs

- Will use new PMTs (ET Enterprises, model: 9390KB)
- Test wavelength shifter (WLS) to increase efficiency
  - Goal : at least 10 PE in experiment
- Tested four different WLS samples using a bench setup



Plot by V. Sulkosky

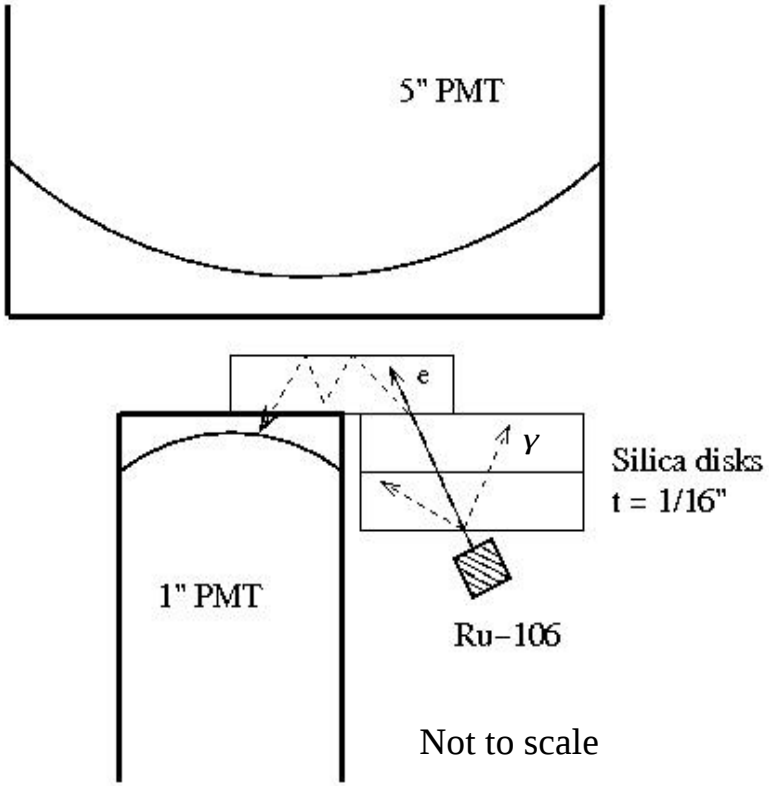
WLS EJ-298#2 paint (Eljen Technology)

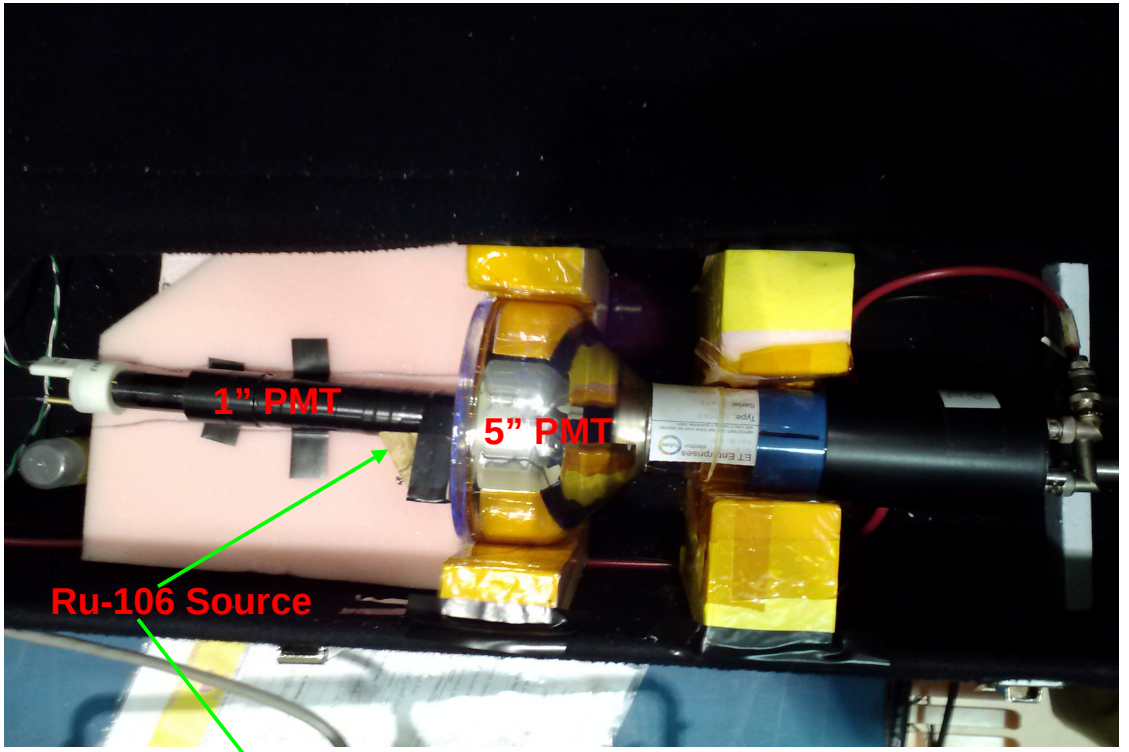


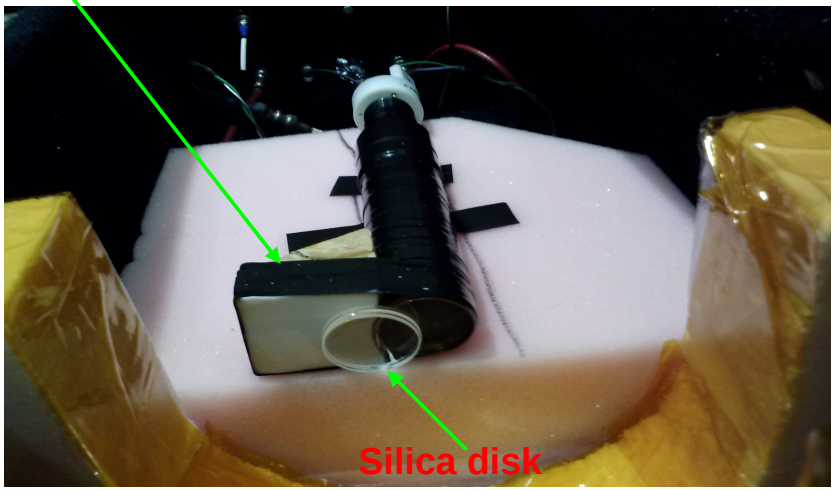
Cerenkov Test Setup

Cerenkov spectrum using beta source (Ru-106) and fused silica disks

Trigger on 1” PMT and integrate pulse from 5” tube (coincidences)







Evaluation of WLS Samples

- Tested four different WLS paint samples:
  - EJ-289 #2 (commercially available)
  - EJ-299-31A
  - EJ-299-31C
  - EJ-299-31E

  } Evaluation samples specially developed by Eljen Technologies

- Sample EJ-299-31E gave the best gain improvement

Setup #	painted(y/n)?	# of PE	% increase in gain
A	no	10.8	-
B	no	10.1	-
C	no	6.13	-
A	yes	14.3	32
B	yes	13.8	37
C	yes	8.63	41

- Different setups corresponds to changes in the location of silica disks
- Results are reproducible with different PMTs and after 7-10 days of re-testing
- EJ-299-31E paint ordered, WLS application on 20 PMTs in early Jan 2014

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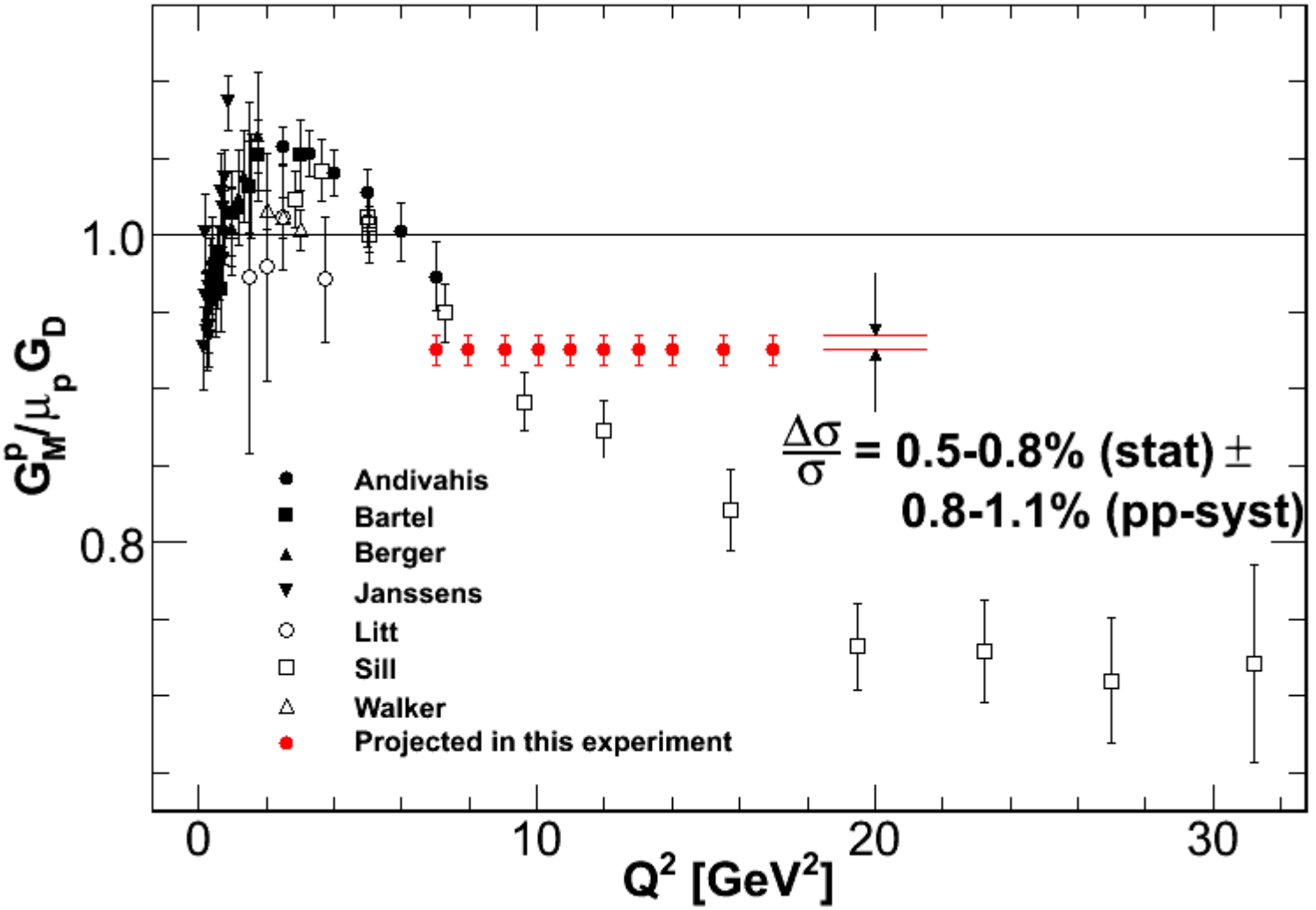
- EJ-299-31E paint ordered, WLS application on 20

Painted surface turns opaque after 3-4 days
But does not affect the improvement in gain

HRS Data Acquisition and Detector Checkout

- Three FASTBUS crates in the configuration
- Cosmic trigger from s0 and s2m coincidence
- Right HRS
  - VDC checkouts done
  - Need to check other detectors (GC, Straw chamber, Shower+preshower)
- Left HRS
  - VDC was checkout done
  - Currently checking pion rejector, gain matching (in progress)
- Online software to check detectors
  - VDC, s0, s2m, pion rejector (done)
  - Working on straw chamber software

Expected Precision



Expected Systematic Uncertainties

Source	$\Delta\sigma/\sigma$ (%)
Point to point uncertainties	
Incident Energy	$<$0.3
Scattering Angle	0.1–0.3
Incident Beam Angle	0.1–0.2
Radiative Corrections*	0.3
Beam Charge	0.3
Target Density Fluctuations	0.2
Spectrometer Acceptance	0.4–0.8
Endcap Subtraction	0.1
Detector efficiencies and dead time	0.3
Sum in quadrature	*0.8–1.1*

* Not including TPE

Expected Systematic Uncertainties

Source	$\Delta\sigma/\sigma$ (%)
Normalization uncertainties	
Beam Charge	0.4
Target Thickness/Density	0.5
Radiative Corrections*	0.4
Spectrometer Acceptance	0.6–1.0
Endcap Subtraction	0.1
Detector efficiencies and dead time	0.4
Sum in quadrature	*1.0–1.3*
Statistics	*0.5–0.8*
Total (Scale+Rand.+Stat.)	**1.2–1.7**

* Not including TPE

Manpower

Spokespeople:

J. Arrington, E. Christy, S. Gilad, B. Moffit, V. Sulkosky, B. Wojtsekhowski

Graduate Students:

Longwu Ou (MIT)
Yang Wang (W&M)
Gautam Thir Narayan (Hampton Univ)
Barak Schmookler (MIT) (potential student)

Manpower

- HRS detectors/DAQ:
  - Longwu Ou, Barak Schmookler, Kalyan Allada (MIT)
  - Yang Wang (W&M)
  - Daniel Kirby (CMU)
  - Igor Rachek (Budhker)
  - Vincent Sulkosky (Longwood Univ)
  - Sergey Abrahamyan, Karen Ohanyan, Galust Sargsyan, Albert Shahinyan (YerPhy)
  - Alexandre Camsonne, Bogdan Wojtsekhowski, Robert Michaels, Bill Gunning, Jack Segal, Susan Esp, Chris Cuevas (JLab)

- Online/offline Software
  - Longwu Ou, Barak Schmookler, Kalyan Allada (MIT)
  - Yang Wang (W&M)
  - Ole Hansen (JLab support)

- Target
  - JLab Target group (D. Meekins et al.)
  - Jian-Ping Chen (JLab)

- Simulations:
  - Eric Christy (Hampton)
  - Gautam Thir Narayan (Hampton)
  - Longwu Ou and Barak Schmookler (MIT)

Summary

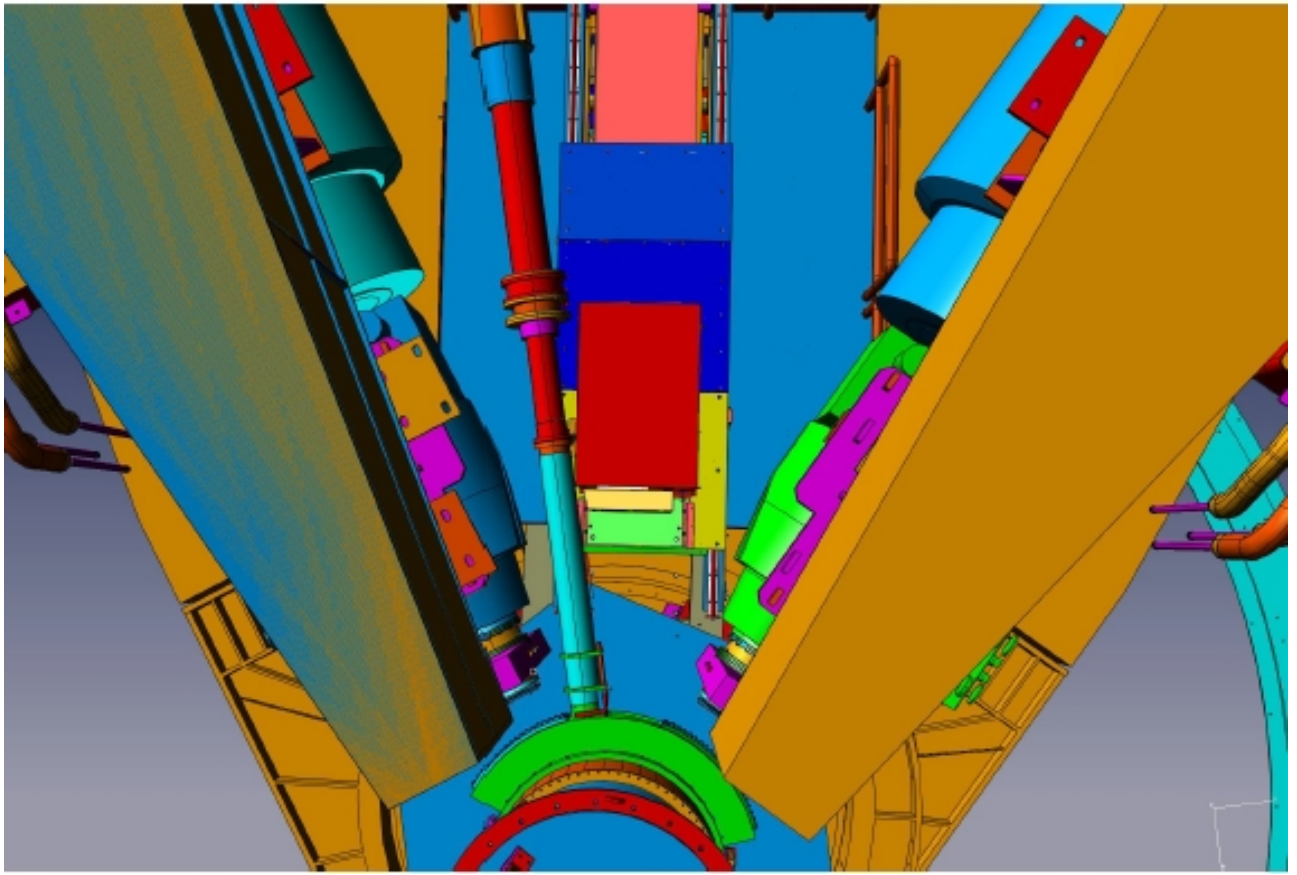
- Precise e-p elastic cross-section measurement at Q^2 up to 14 GeV^2
- Progress made in preparing for the experiment:
  - Target design complete
  - New VDC cards installed
  - Straw chamber installed
  - Refurbishing GC (Mirror reflectivity, alignment, support, WLS on PMTs)
  - Detector checkout in progress
  - Angle measurement, survey plans, floor marks (plates)
- Getting ready for Hall commissioning run in March, 2014
- Full production run in Fall 2014!

Spare Slides

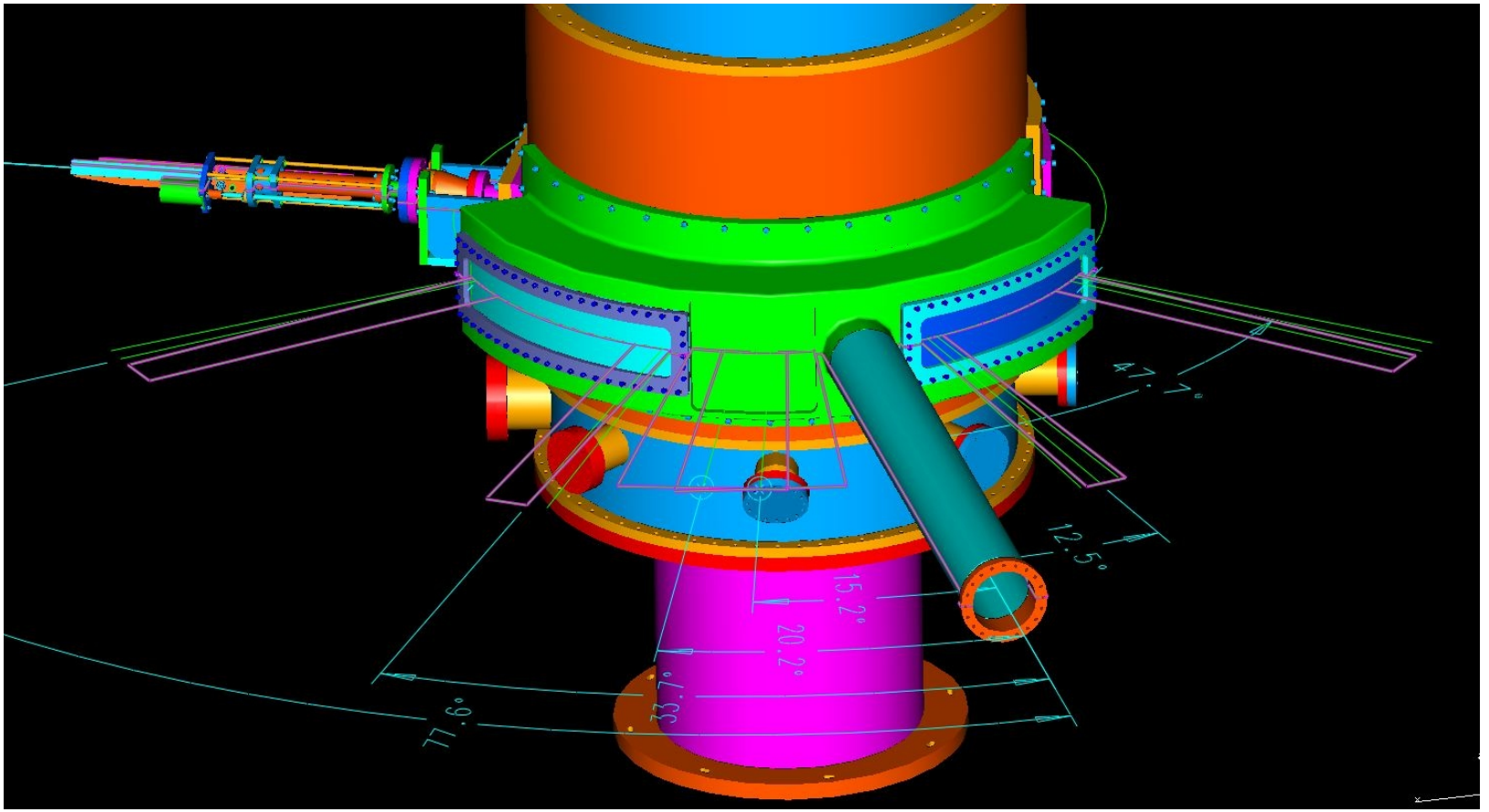
New Narrow DVCS Support Stand

DVCS: –8.5° and 2.0 m from target center

HRS-L: 20.2° HRS-R: -43.0°



Angle Restrictions



- Restrictions from scattering chamber design:
  - LHRS: 12.5o to < 48o (**> 18o with calorimeter**)
  - RHRS: -33.7o to < -78o (**> 45o with calorimeter**)
  - DVCS calorimeter: < -20o