The GMp Experiment in 2014

Vincent Sulkosky

Longwood University
for the E12-07-108 Collaboration

Hall A DVCS Collaboration Meeting

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Outline

- The GMp Experiment:
  - Goals and Physics Motivation
- Equipment Updates
  - Target: cryo and wire target
  - Scattering Chamber and Restrictions
  - HRS Detector Packages
- Beam Characterization
  - Charge (BCMs)
  - Energy (ARC, etc)
- Preparation Status (See Barak's Talk)

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Introduction

In the Born approximation, the elastic cross section for elastic *ep* scattering can be written:

$$\frac{d\sigma}{d\Omega} = \sigma_{\mathrm{Mott}} \frac{\epsilon(G_E^p)^2 + \tau(G_M^p)^2}{\epsilon(1 + \tau)},$$

where

$$\sigma_{\mathrm{Mott}} = \left(\frac{\alpha}{2E} \frac{\cos\frac{\theta}{2}}{\sin^2\frac{\theta}{2}} \right)^2 \frac{E'}{E},$$

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

Goals for GMp

➢ 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 factors and many of other experiments, where elastic scattering is used for normalization

➢ Approved for 24 PAC days

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Kinematics

E_e (GeV)	Q^2 (GeV)^2	θ_e (deg)	E' (GeV)	ϵ	Rate (Hz)	Time (hours)	Events
4.8**	7.0	71.0	1.08	0.25	0.80	5.2	30k
6.6	7.0	35.4	2.87	0.62	6.21	0.7	30k
6.6	8.0	42.0	2.35	0.51	1.90	2.2	30k
5.8**	9.0	77.0	1.00	0.18	0.16	26.1	30k
6.6	9.0	52.0	1.78	0.37	0.40	10.3	30k
8.8	9.0	29.3	4.00*	0.67	2.82	2.9	30k
6.6	10.0	67.0	1.25	0.23	0.12	34.1	30k
8.8	10.0	33.3	3.46*	0.59	1.09	7.6	30k
8.8	11.0	38.0	2.94	0.51	0.44	9.4	30k
8.8	12.0	44.0	2.42	0.41	0.17	23.8	30k
8.8	13.0	53.0	1.86	0.30	0.05	69.0	24k
11.0	13.0	31.3	4.06*	0.58	0.30	21.7	24k
11.0	14.0	35.0	3.53*	0.50	0.14	40.3	20k

PAC Approved 24 days

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Numbers assume 80 μA for 15 days!

Expected Precision
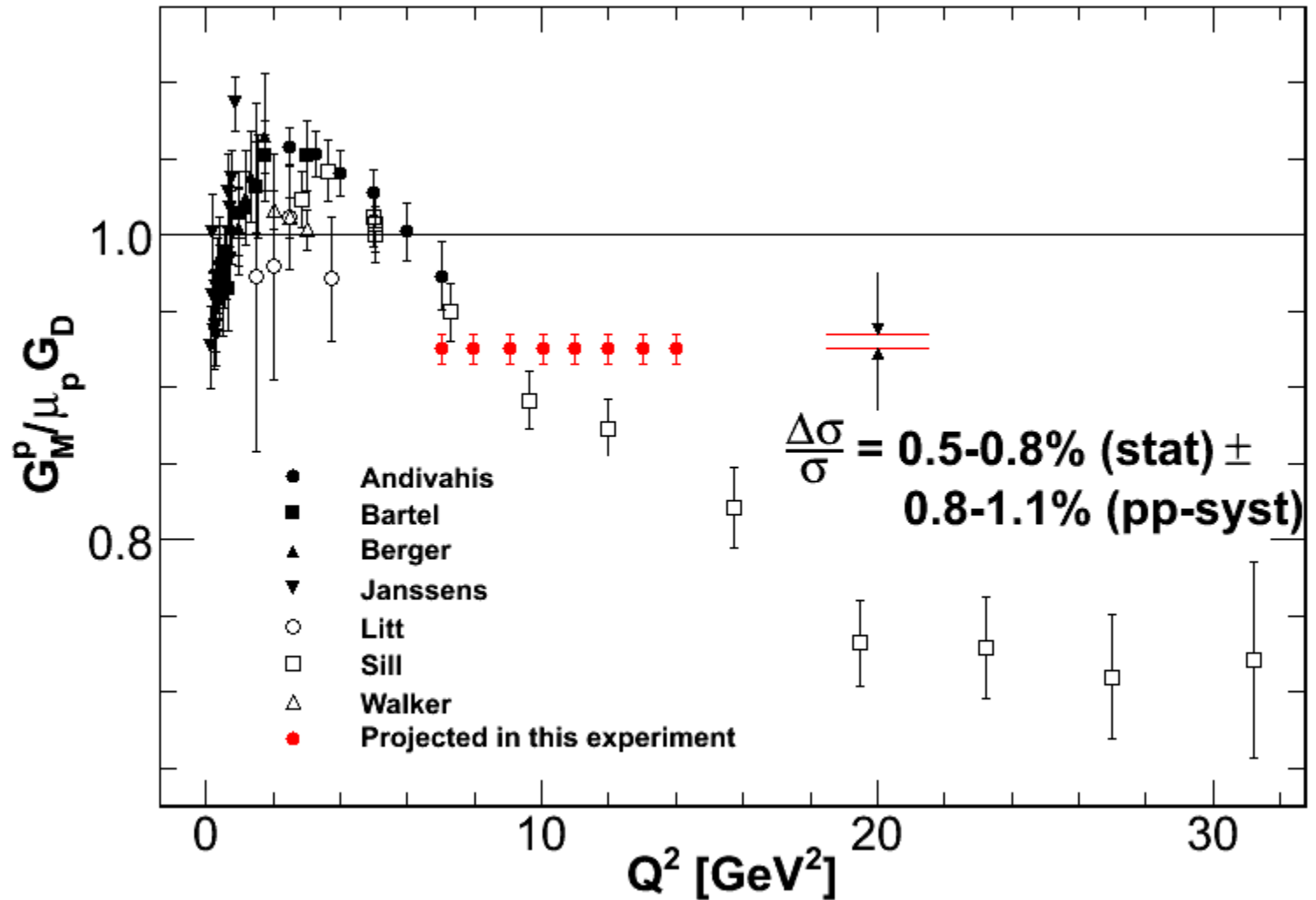
Systematic Uncertainties

Uncertainties give in Δσ/σ (%)

Source	Point-to-point	Normalization
Incident energy	<0.3	
Scattering Angle	0.1-0.3	
Incident Beam Angle	0.1-0.2	
Radiative Corrections*	0.3	0.4
Beam Charge	0.3	0.4
Target Thickness/Density Fluctuations	0.2	0.5
Spectrometer Acceptance	0.4-0.8	0.6-1.0
Endcap Subtraction	0.1	0.1
Detector efficiencies/dead time	0.3	0.4
Sum in quadrature	0.8-1.1	1.0-1.3

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Control of Systematics

➢ DAQ and Trigger:

   ➢ EDTM pulser for dead time measurements

   ➢ Achieved 10 kHz with 20% dead time

➢ Tracking efficiency:

   Use front chambers of FPP with VDCs

➢ Target density

   ➢ Use precise optics to provide software cuts on vertex

   ➢ Use race-track cell targets with vertical flow to minimize fluctuations

➢ Solid angle: a benefit of improved optics

➢ Scattering angle: precise determination of target location using crosshair wire target

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Modifications to Instrumentation

➢ Strong arm wire target:
  ➢ Design completed
  ➢ Cost: $3k to $5k, saved $8k by using old radiator mechanism

➢ HRS detector stacks:
  ➢ Design completed
  ➢ Add one chamber of FPP to both stacks
  ➢ Attach S0 to FPP chamber
  ➢ Shorten extension box for LHRS gas Cherenkov by 10 cm
  ➢ Cost: $20k (mostly from labor, **trying to reduce this cost**)

➢ Target scattering chamber
  ➢ Design completed, components should be onsite.
  ➢ Allows to run DVCS (LHRS) and GMp (RHRS) concurrently
  ➢ Cost: ~ $50k

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Beamline

Critical Items:

1. Energy
   a. ARC measurement will be recommissioned in Spring 2014
   b. Single Hall Spin Dance will not be attempted until later: Requires Compton and Møller polarimeters.
   c. Elastics may not be feasible, especially at the higher energies as a cross check.

2. Charge
   a. Standard Beam Current Monitor (BCM) electronics
   b. For Spring 2014, the original electronics will be used, while the Kharkov group:
      Check status, obtain experience, determine problems/issues
   c. The electronics will be upgraded to that used for QWeak.
   d. The Unser will also play a pivotal role in Hall A.

HRS Optics and Angle: Crosshair Target

Wires:

➢ 0.5" apart along the beamline

➢ 1/16" (~1.6 mm) apart transverse to beam
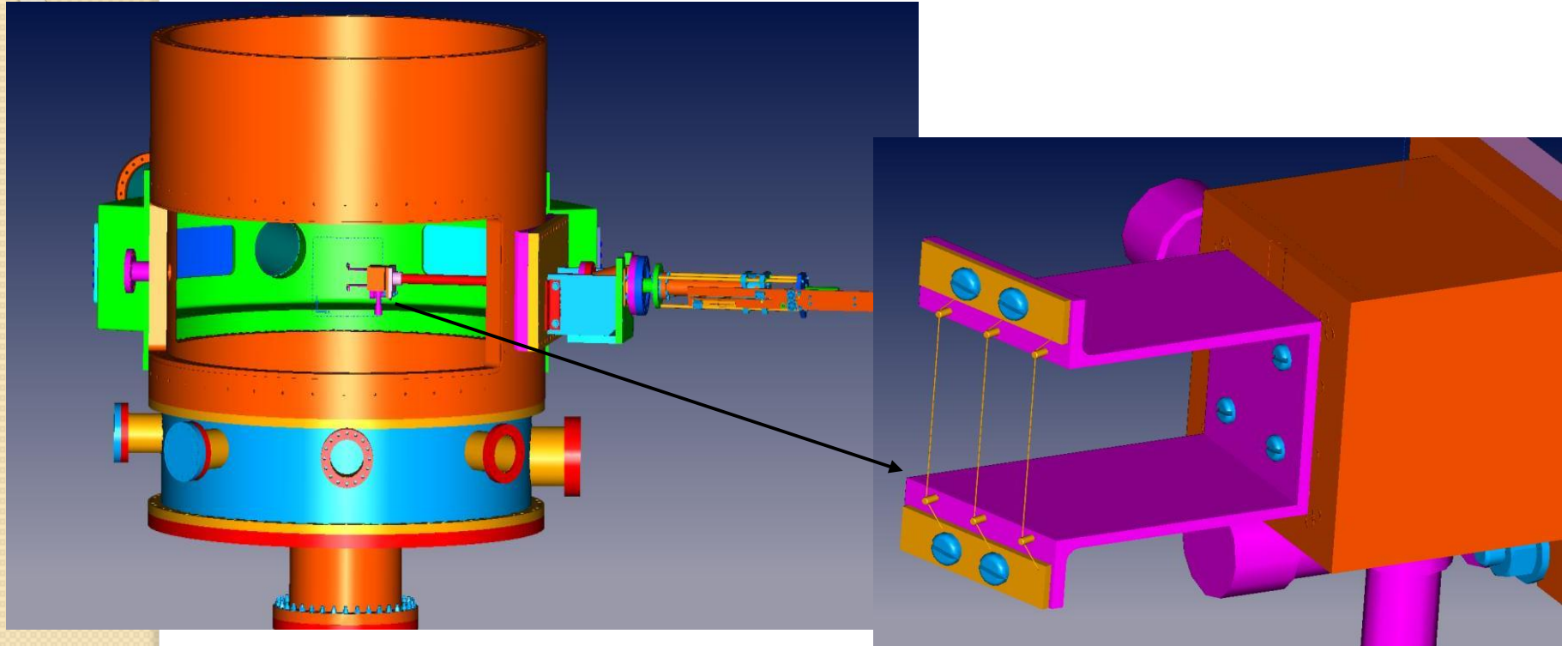
Wire target, reproducibility of 100 microns sufficient

Design being changed by Dave Meekins, should be finalized early next year.

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# Toward Precision Angle Measurements

1. Collimator plate in front of Q1
2. Crosshair target
   - Both will be carefully surveyed with a FaroArm
   - Expect to achieve angle precision at 0.2 mrads.
3. BPM positions (~ 100 microns)
4. Front floor plates for spectrometers
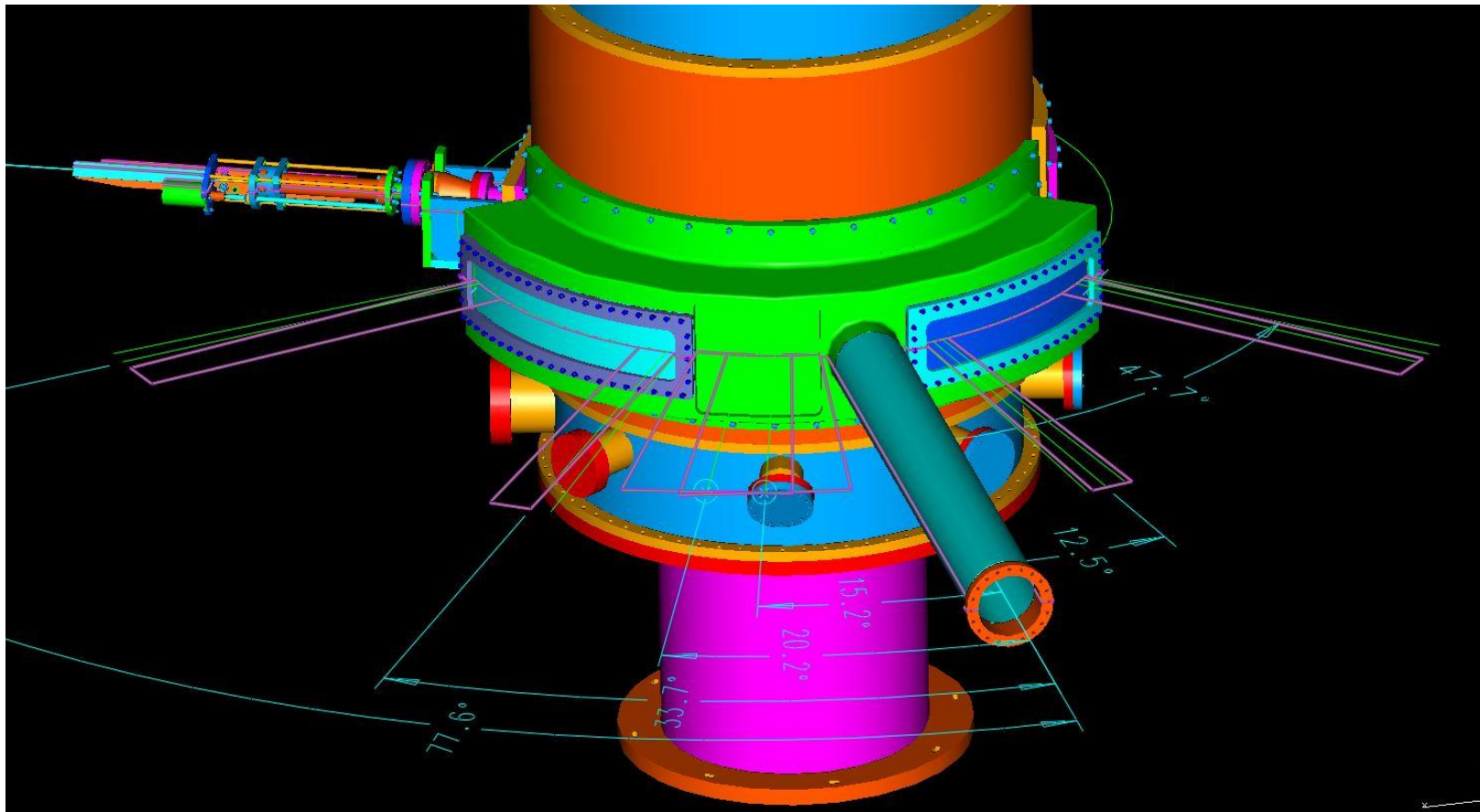5. Linear Variable Differential Transformers (LVDTs) are being revived, sensitive to mis-pointing offsets.

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New Narrow DVCS Support Stand

DVCS: −8.5° and 2.0 m from target center
HRS-L: 20.2°   HRS-R: -43.0°
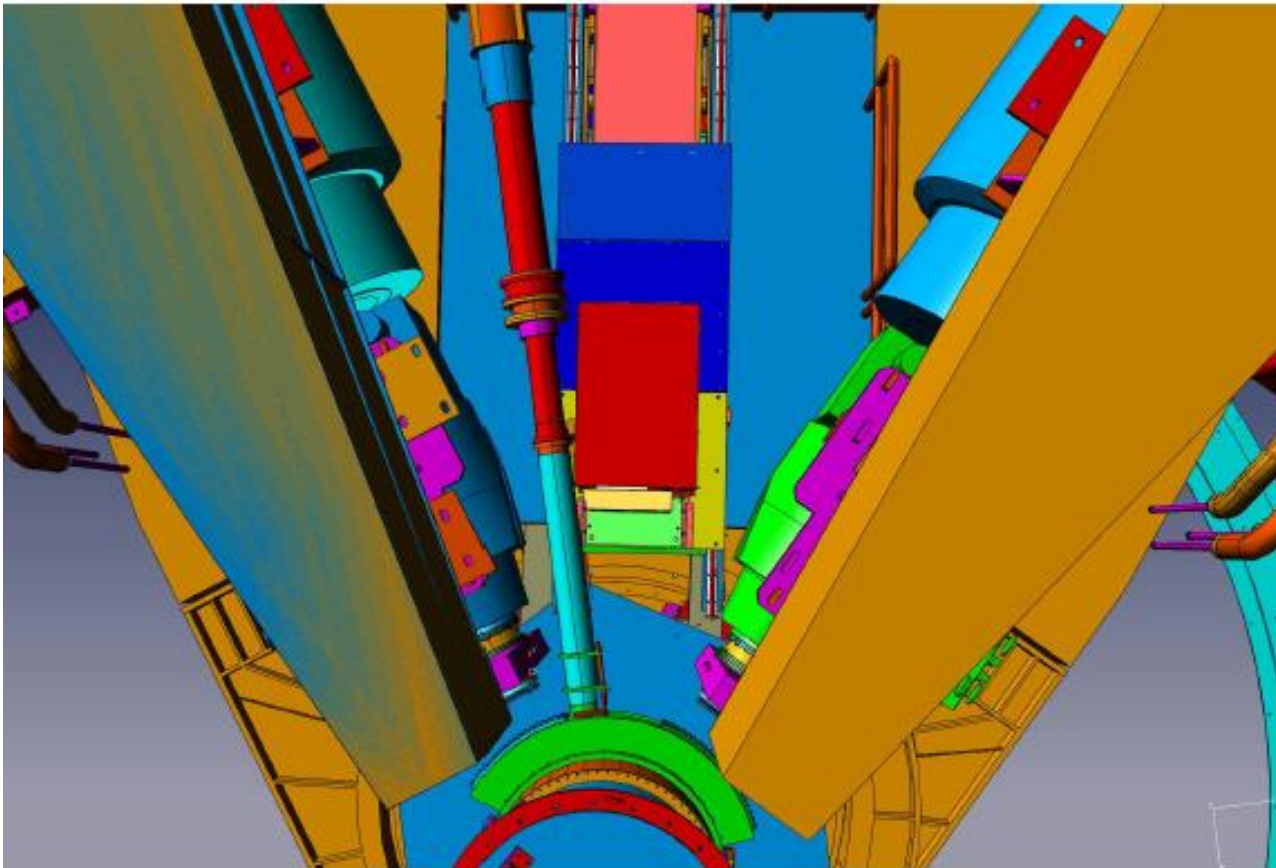
Angle Restrictions

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

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
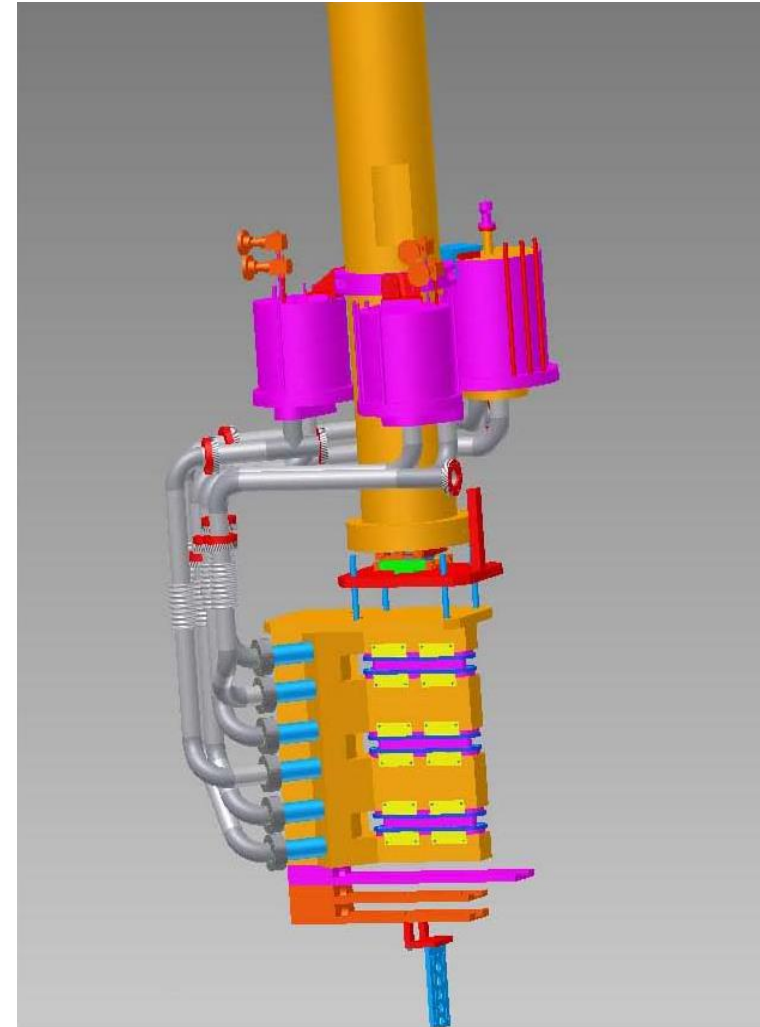
Updates from D. Meekins
Expected for use in March 2014

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HRS Detector Stacks

Standard detectors with one plane of FPP

S0

Fpp

Gas Cherenkov

Pion rejector

VDCs
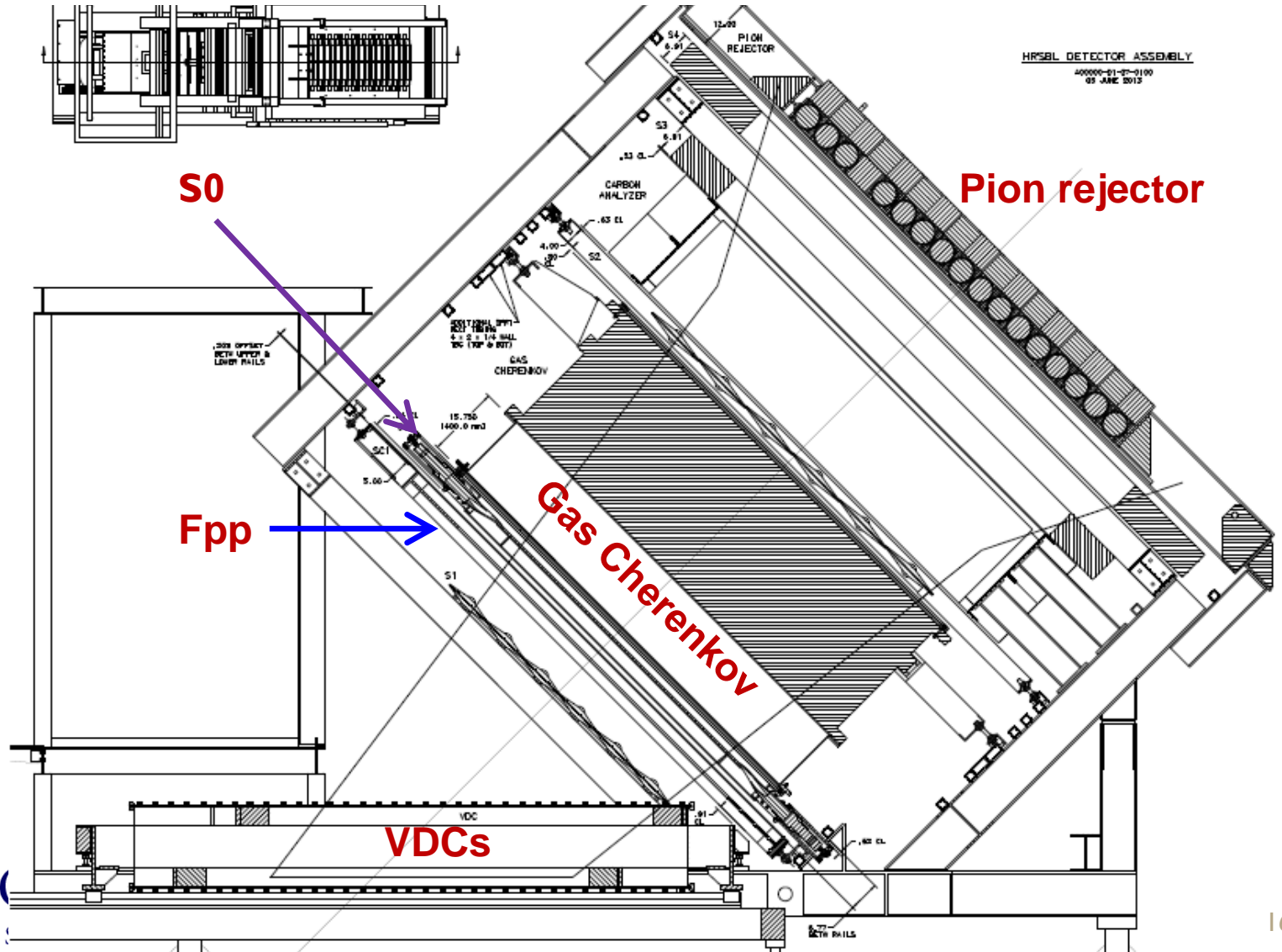
Manpower

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)

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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
  ➢ Much work in the HRS (see Barak's talk)
  ➢ 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!

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DVCS-GMp Cooperation: Dual Running
(Note: This is an old slide but good to start a discussion)

GMp and DVCS install together (except DVCS calorimeter)

1) **GMp runs independently:**

   a) Restrictions on HRS angles from vacuum chamber and DVCS stand

   b) Restrictions on HRS movement from DVCS cables and stand, HRS movement will require manual assistance

2) **One week shutdown to install DVCS calorimeter**

3) **DVCS runs ~ 3 PAC months:**

   GMp takes parasitic data with right HRs at large angles

Stability of all parameters is a key criteria to achieve the required precision for GMp.

Backup

Systematic Uncertainties

Point to point uncertainties

Source	$\Delta\sigma/\sigma$ (%)	Parameters
Incident energy	<0.3	3×10^{-4}
Scattering Angle	0.1-0.3	
Incident Beam Angle	0.1-0.2	
Radiative Corrections*	0.3	
Beam Charge	0.3	1×10^{-3}
Target Density Fluctuations	0.2	
Spectrometer Acceptance	0.4-0.8	0.1 mrad
Endcap Subtraction	0.1	
Detector efficiencies/dead time	0.3	
Sum in quadrature	0.8-1.1	

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

FPP (front chambers)

Problems: gas consumption > 50 l/h HV trips often
due to gas, many dead wires/some electronics.

Done: repair of dead electronics; built parallel gas distribution.

Still to do: HV distribution in one PC; gas distribution should be as wide as a straw block; HV test wires.

Recent: First chamber main work is completed; second in progress and expect completion in 1 month; hardware electronics not yet started.

Already 1 FTE year has been spent on FPP

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VDC Improvements

➢ Upgrade electronics to use 1877S, which allows sparsification

➢ Replace aging A/D cards and reuse BigBite cards

➢ Provide very good stability against oscillations and rate capability of 8 MHz (in full chamber)

➢ LHRS and RHRS completed and tested

➢ Software still needed for Fpp chamber and for cosmics checks

+6.0V | GND

PS +6.0V
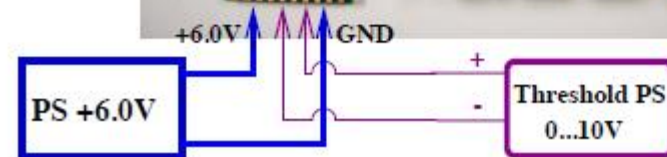
Threshold PS
0...10V

internal threshold
adjustment

13.01.2006

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Gas Cherenkov Improvements

➢ Reflectivity measurements of HRS GCC mirrors in progress

  ➢ **Both HRS mirrors completed**

  ➢ **Two spare mirrors recoated and checked**

➢ Reflectivity is within a few percent of published results

➢ In progress of checking relative response of PMTs and will replace those as needed; ~ 70 to test

➢ Cosmic mirror calibration

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