Spectrometer Optics

with Septum

presented
by

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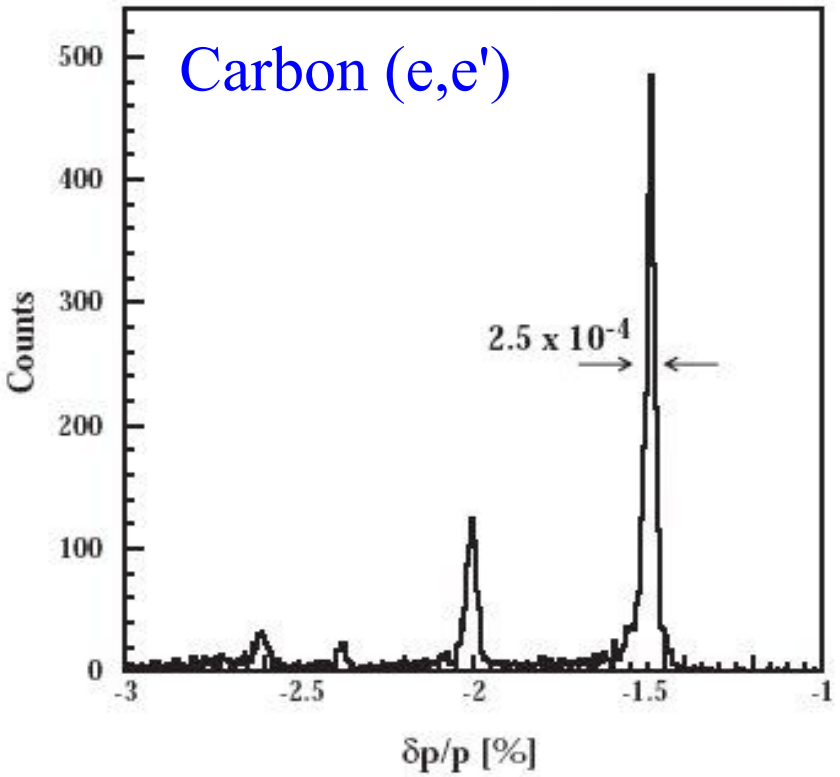
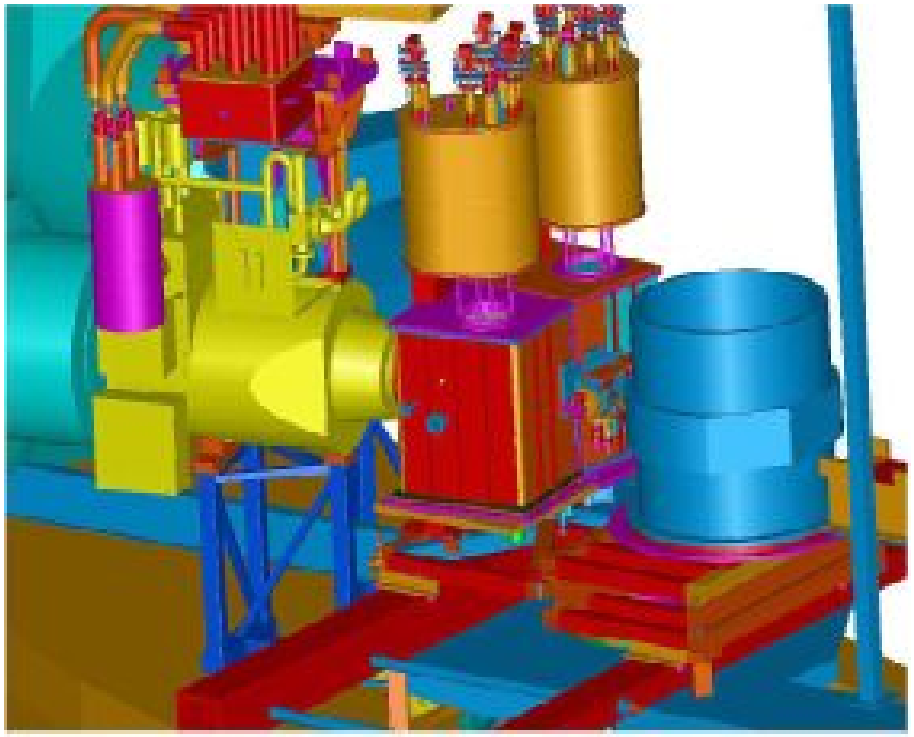
Typical HRS System

- Four Optical Elements (QQDQ)
- Design Resolution 1.0E-4 FWHM momentum resolution
- NIM Paper Shows 2.5E-4 FWHM momentum resolution
- Multiple Coulomb Scattering Is The Reason For The Difference

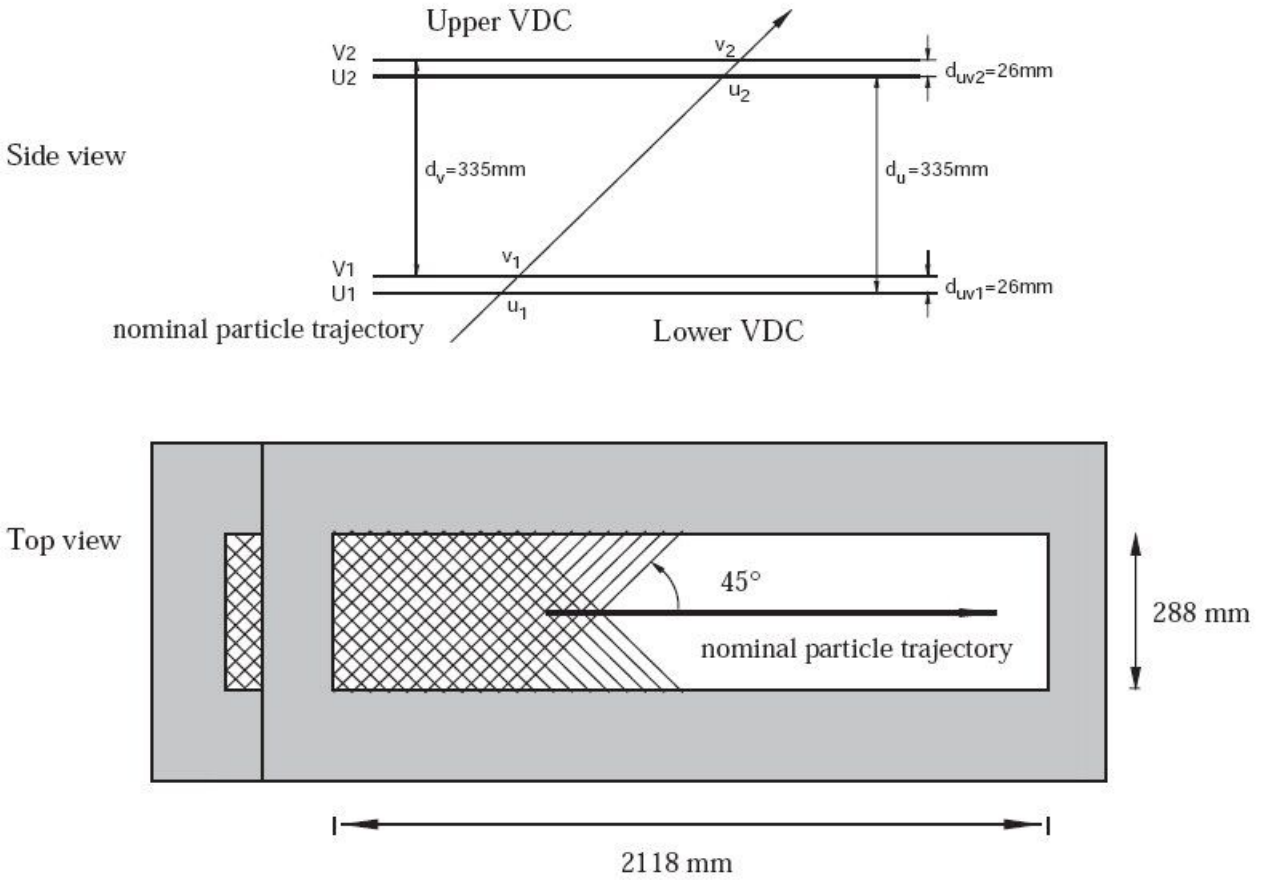


Septum Magnets

- Simply an additional optical element (*D*QQDQ)
- Breaks Mid-plane Symmetry
- Bends particles from as little as 6^{o} to a nominal HRS angle
- Sweeper magnet adds another perturbation (Rob's talk @5pm)



Vertical Drift Chambers



- Particles Pass Through Five Optical Elements (DQQDQ)
- Determine Tracks with VDC
- Particle ID with Later Detectors (Cherenkovs, Calorimeters, etc.)
- VDC Determine x_{fp}, y_{fp}, Θ_{fp}, and Φ_{fp} (deviation from central ray)

The Matrix

```
D 0 0 0  -1.297823e-04  7.615379e-02  9.637660e-03  6.345702e-04 -1.092514e-04
D 0 0 1   2.048980e-03 -2.316325e-02 -1.074187e-02  4.432201e-02  0.000000e+00
D 0 0 2   1.865181e-01 -1.279568e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 0 3   3.287095e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 1 0  -5.244113e-03 -3.295574e-03  8.999926e-03  0.000000e+00  0.000000e+00
D 0 1 1   1.266074e-01  1.310058e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 1 2  -9.311407e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 2 0   3.923673e-01 -6.507622e-01  0.000000e+00  0.000000e+00  0.000000e+00
D 0 2 1   1.086716e+01  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 3 0  -2.189882e+00  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 4 0   1.066728e+02  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 0 5 0   8.931046e+02  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 1 0 0  -1.673742e-02  2.836224e-01 -8.743290e-03 -1.421310e-02  0.000000e+00
D 1 0 1  -2.412976e-02  4.443167e+00  1.985627e+00  0.000000e+00  0.000000e+00
D 1 0 2   5.861019e+01 -8.752642e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 1 1 0   2.095026e+00 -4.072884e-02 -7.324669e-01  0.000000e+00  0.000000e+00
D 1 1 1  -3.250805e+01 -1.369050e+02  0.000000e+00  0.000000e+00  0.000000e+00
D 1 2 0  -7.168032e+01  1.131416e+02  0.000000e+00  0.000000e+00  0.000000e+00
D 1 3 0   2.550197e+02  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 1 4 0  -5.254143e+03  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 2 0 0  -2.768286e+00  3.304200e+00  1.175076e+00  0.000000e+00  0.000000e+00
D 2 0 1  -3.602438e+01  4.985567e+01  0.000000e+00  0.000000e+00  0.000000e+00
D 2 1 0   2.349740e+00 -8.079549e+01  0.000000e+00  0.000000e+00  0.000000e+00
D 2 2 0   1.743694e+03  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 2 3 0  -1.953413e+04  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 3 0 0   9.104714e+01 -1.586437e+02  0.000000e+00  0.000000e+00  0.000000e+00
D 3 1 0  -3.951074e+03  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 3 2 0   7.696959e+04  0.000000e+00  0.000000e+00  0.000000e+00  0.000000e+00
D 4 0 0   4.486280e+03 -5.072067e+03  0.000000e+00  0.000000e+00  0.000000e+00
D 5 0 0  -1.915430e+05  2.432509e+05  0.000000e+00  0.000000e+00  0.000000e+00
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- Shown is the Matrix from the Hall A Analyzer db_R.vdc.dat
- Polynominal Expansion in the Focal Plane Variables

$$y_{\rm tg} = \sum_{j,k,l} Y_{jkl} \theta_{\rm fp}^j \, y_{\rm fp}^k \phi_{\rm fp}^l,$$

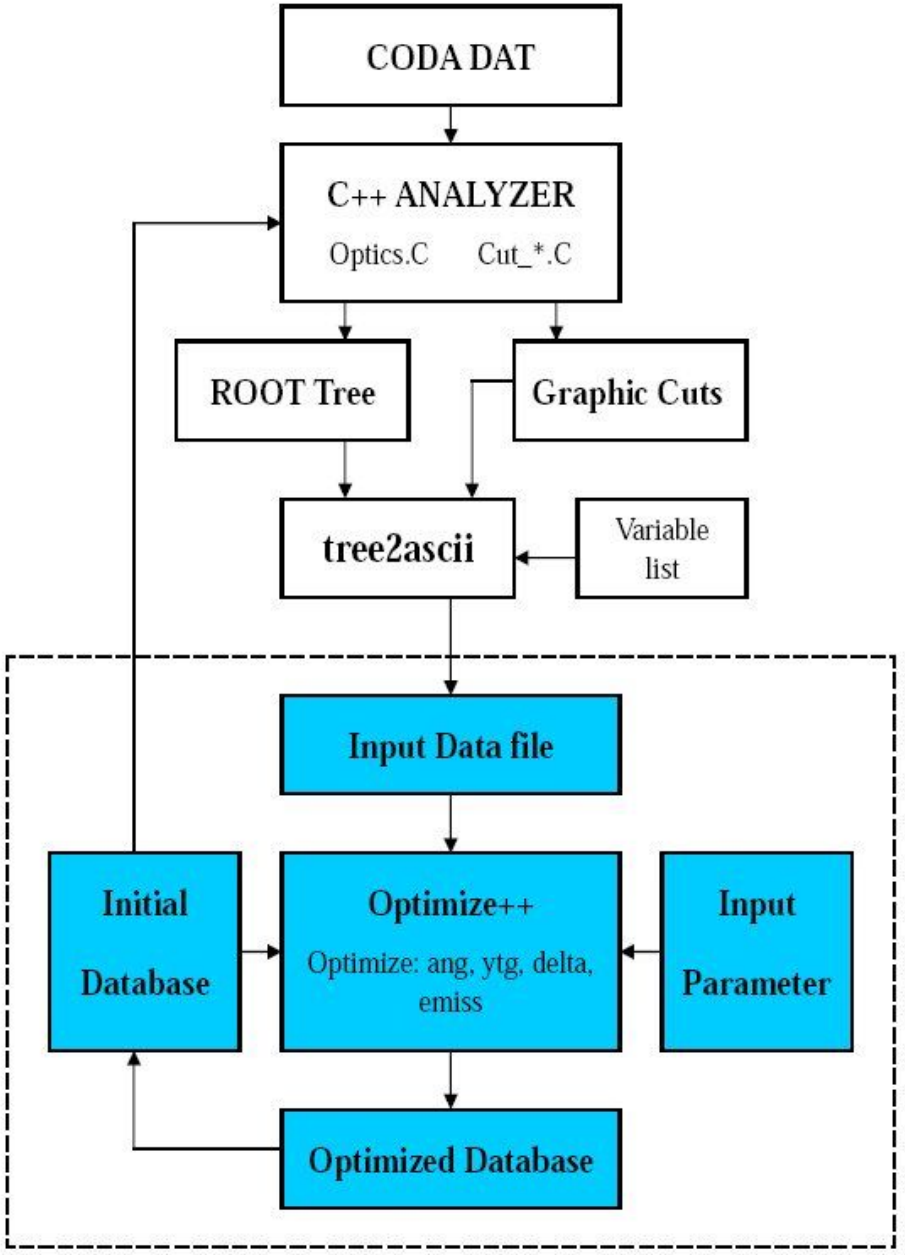
$$\theta_{\rm tg} = \sum_{j,k,l} T_{jkl} \theta_{\rm fp}^j \, y_{\rm fp}^k \phi_{\rm fp}^l,$$

$$\phi_{\rm tg} = \sum_{j,k,l} P_{jkl} \theta_{\rm fp}^j \, y_{\rm fp}^k \phi_{\rm fp}^l, \quad \text{and}$$

$$\delta = \sum_{j,k,l} D_{jkl} \theta_{\rm fp}^j \, y_{\rm fp}^k \phi_{\rm fp}^l$$

$$Y_{jkl} = \sum_{i=0}^{m} C_i x_{\rm fp}^i$$

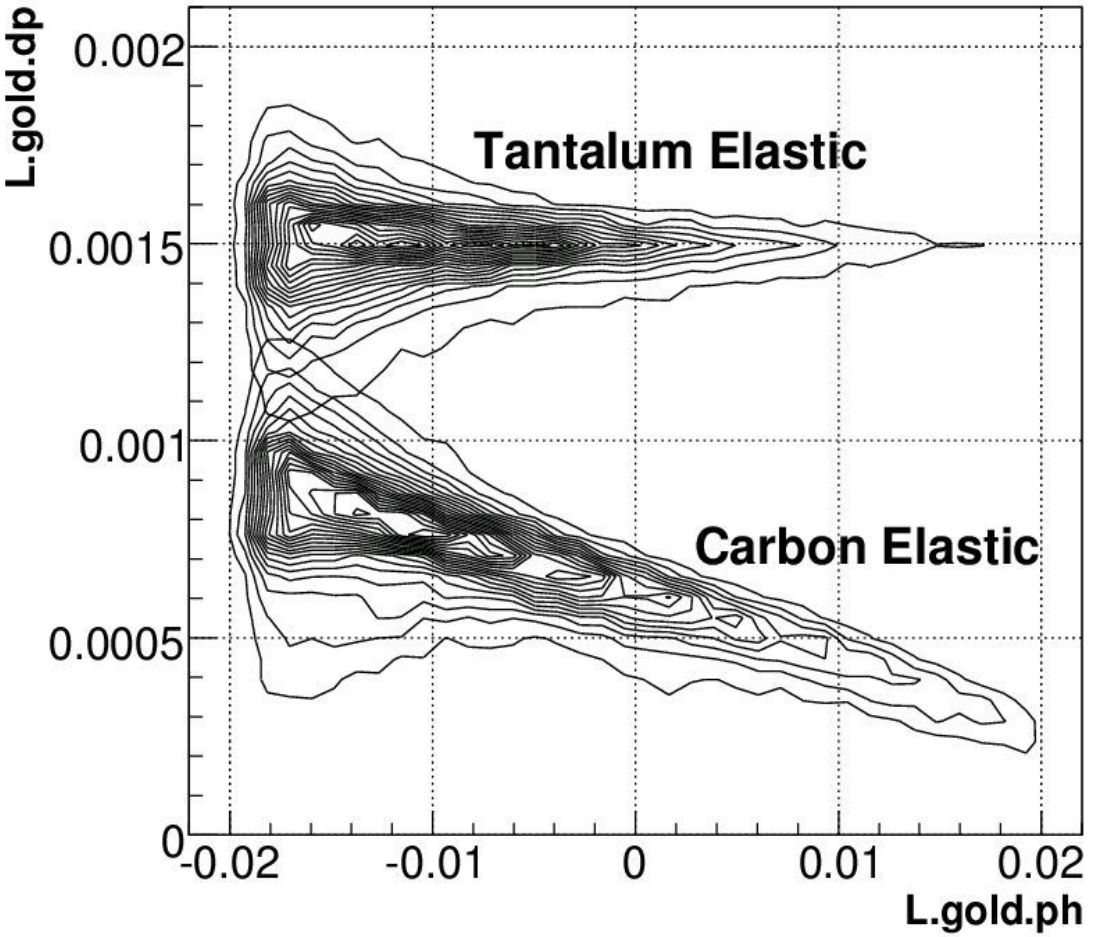
Optimization Procedure



- **Quality** Optics Data
- Analyze with C++ Analyzer
- Place Cuts On Root Tree (elastic peaks, sieve holes, etc.)
- Create ascii files with focal plane and beam parameters for each kinematics (or breaking kinematics into parts
- Create input parameter file
- Run Optimization Code
- Repeat Until Satisfied
- Remember: Quality Beats Quantity

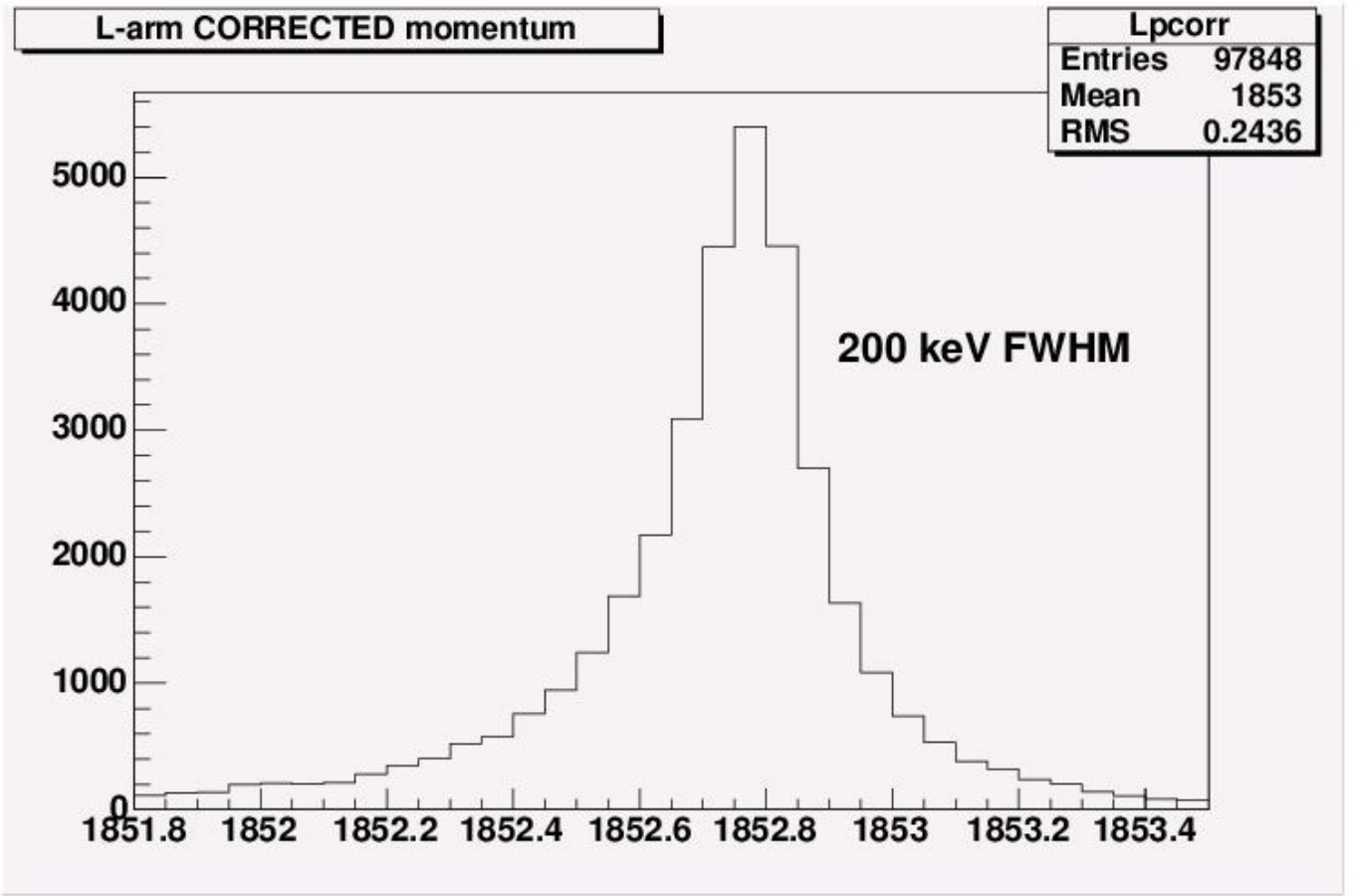
Quality Optics Data

- Beam Parameters
  - Fast Feed Backs
  - Interferometer
- HRS Parameters
  - Steady Dipole Fields
  - Cycled Quadripoles
- Targets
  - Foils Ideal
  - Heavy and Light Nuclei

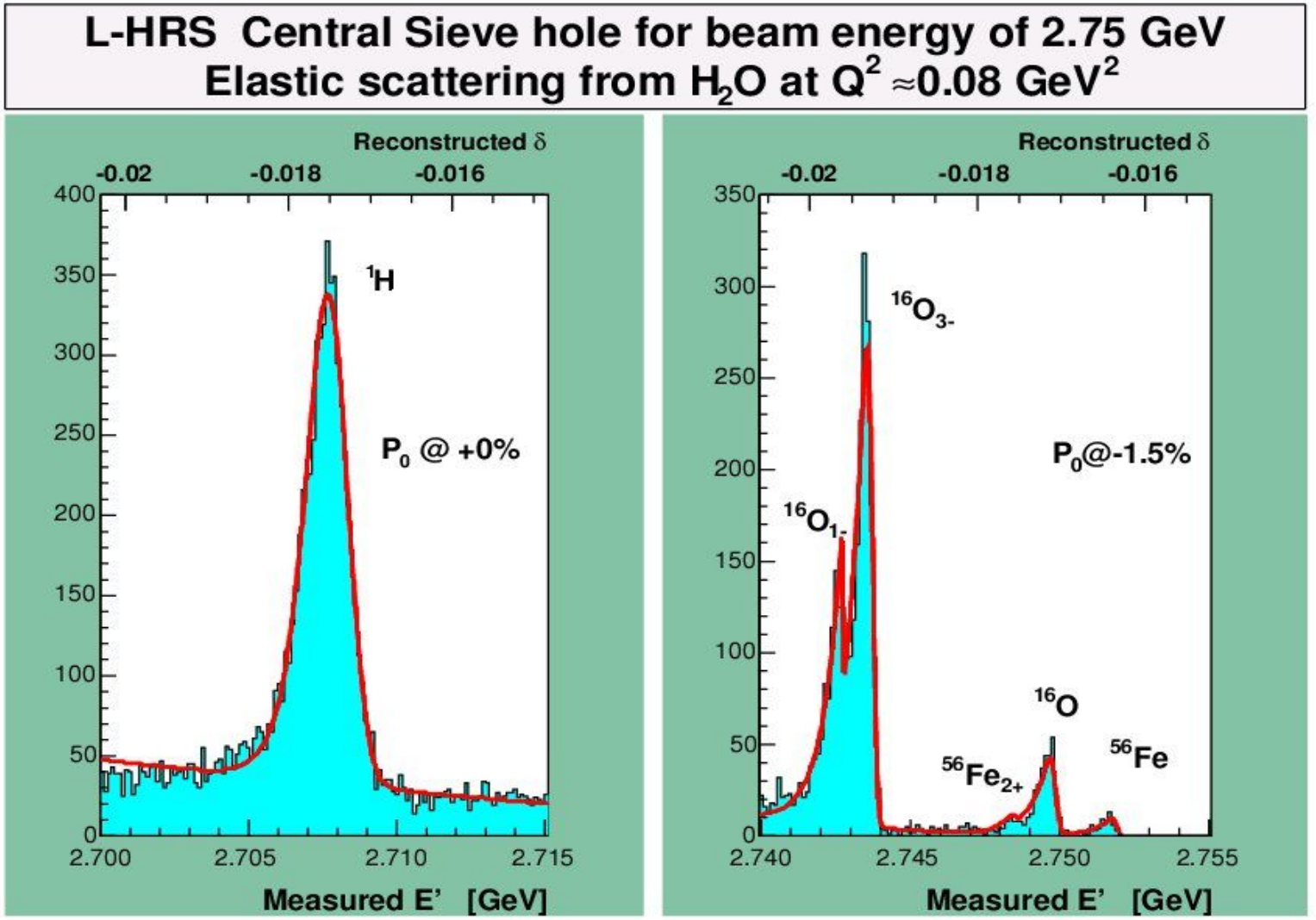


Elastic Tantalum Spectrum

- New Databases Sent to Hyper-nuclear Group
- Their Elastic Tantalum Spectrum Is Shown
- Assuming Other Effects Are Under Control They Are Now Expecting 600keV FWHM Missing Energy Resolution.

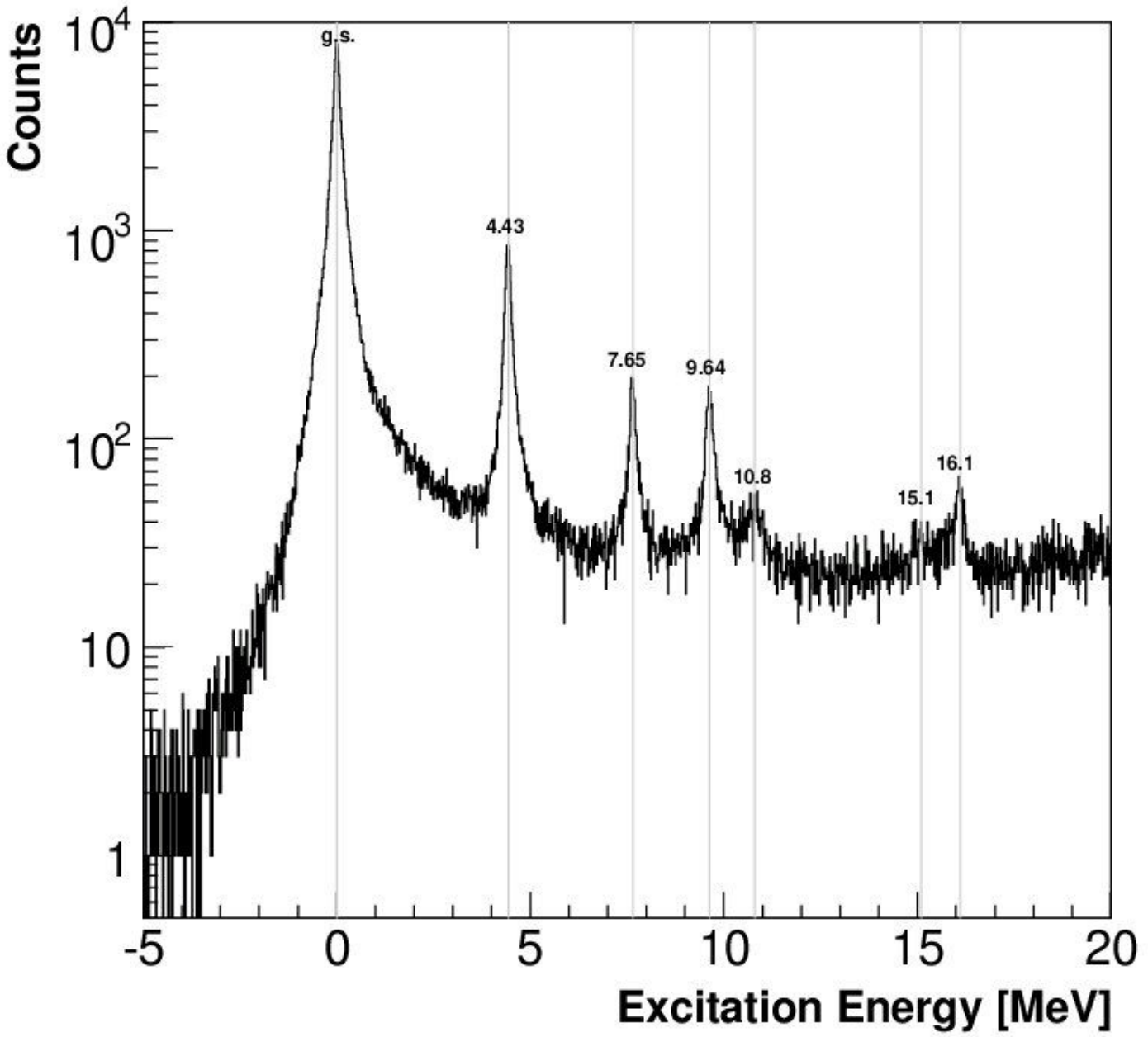


Determination of Central



- Use two different mass nuclear targets and determine angle
- Error of 0.2 mrad with sweeper!

Corrected Elastic Carbon Spectrum



Summary

- Codes For The Optics Optimization of the HRS with or with out the Septum Are Available and Have Been Tested
- Two Mass Method For Determining Angle Is Becoming Standard
  - H_20, C, Ta
  - *Future C-Ta Sandwich*, *H-C Sandwich Possible*
- Both Spectrometers Have Demonstrated 1E-4 FWHM δ Resolution!