DVCS on the Deuteron

4th Year Seminar
April 20th, 2010

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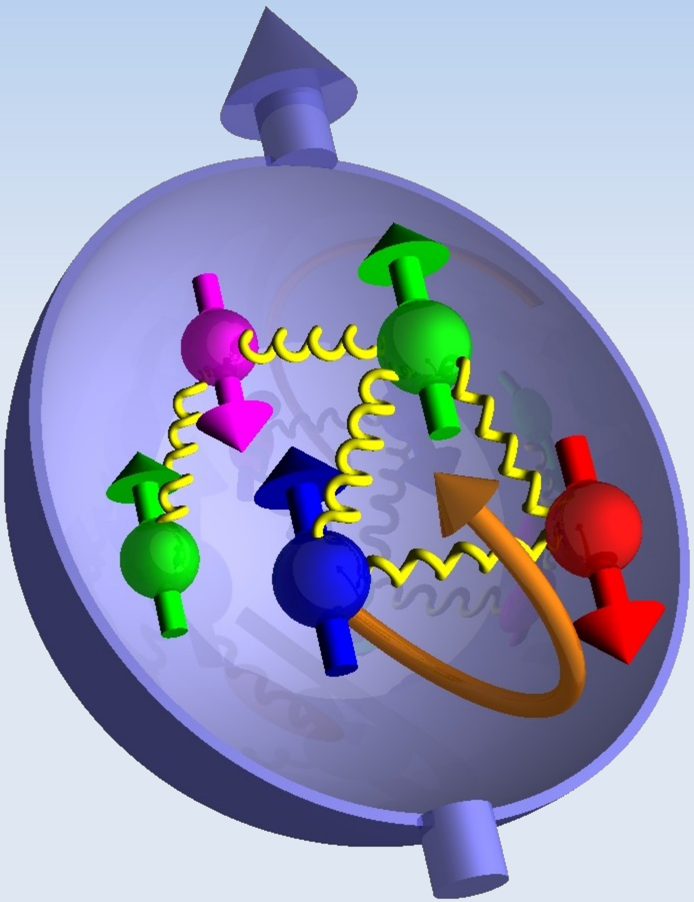
Outline

- Overview of Topic
- CLAS Detector
- DNP process
- Collaboration
  - Target NMR measurements
  - Cooking

Spin of the Nucleon

- Protons and Neutrons are composed of quarks held together by gluons
- Spin ½ particles
- Where does spin come from?



Spin Crisis

- Spin not accounted for by quarks alone
  - Contributions from valence quarks, sea quarks, gluons, angular momentum
- Only ~25% nucleon spin carried by quarks
- What are the contributions from each part?

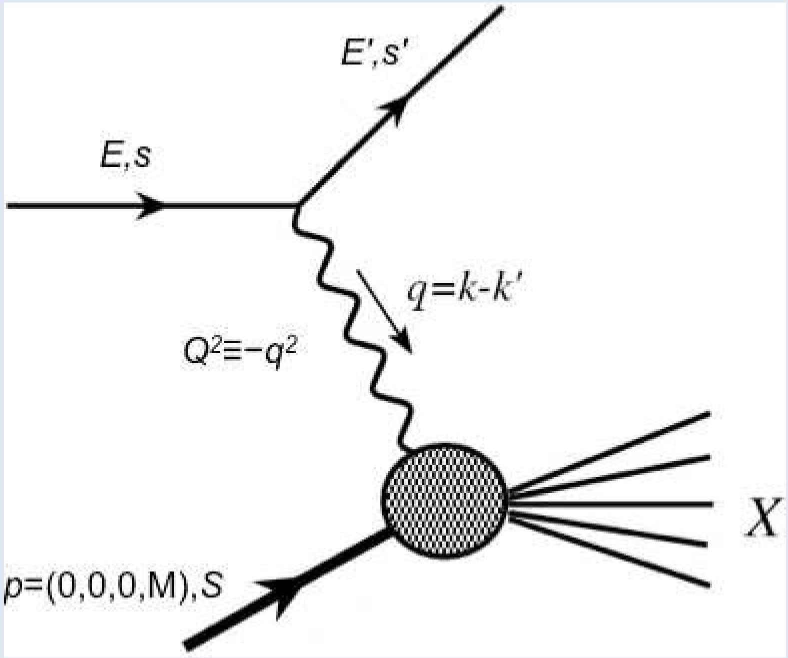
$$\frac{1}{2} = S_q + \Delta G + L_z$$

Scattering

- How do we investigate internal structure of a nucleon?
- High energy beams resolve details of nucleon
- Variables:

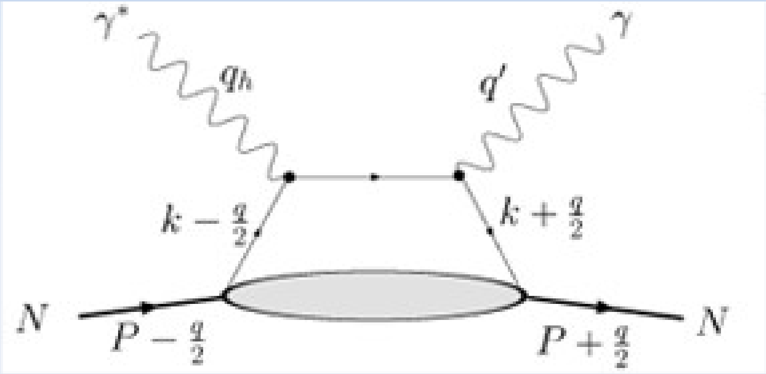
  Q^2: Square of 4-momentum transferred to target

  Bjorken x: Fraction of nucleon's momentum, in Breit frame, carried by struck quark



Deeply Virtual Compton Scattering

- Virtual photon comes from incoming electron
- Allows access to angular momentum inside nucleon



Jefferson Lab

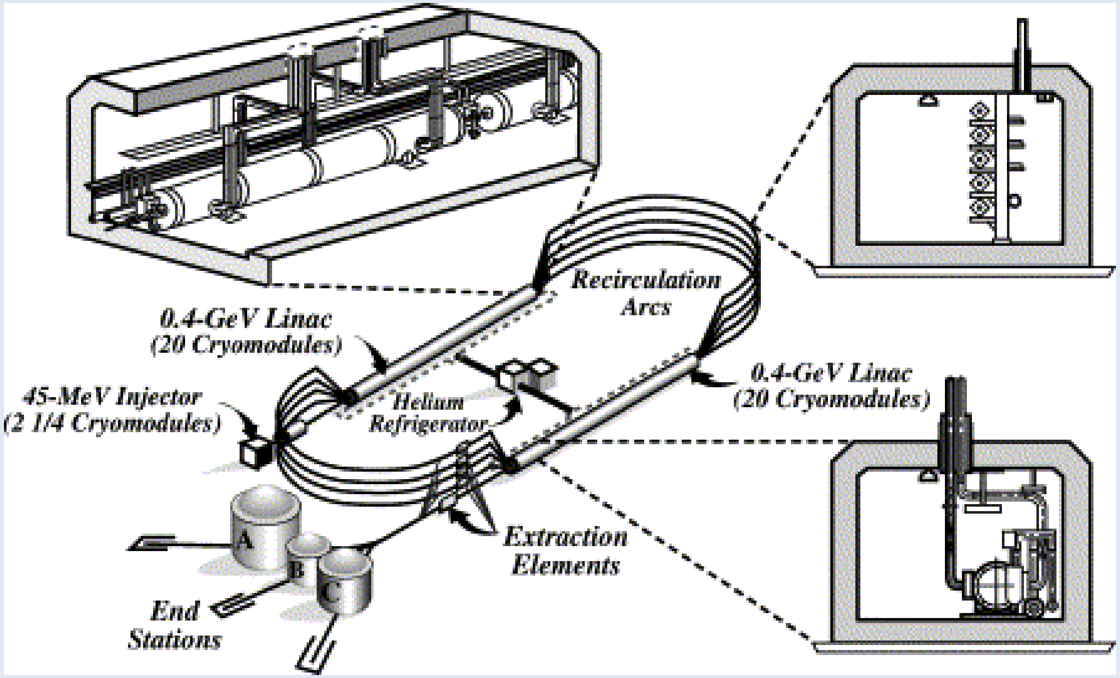
- 6 GeV electron beam
- 3 experimental halls
- eg1-dvcs is a Hall B experiment

Experiment Background

- eg1-dvcs experiment has three parts
  - Part A: proton target, February 2009
  - Part B: proton target, April-May 2009
  - Part C: deuteron target, August-September 2009
- I switched groups just in time for part C

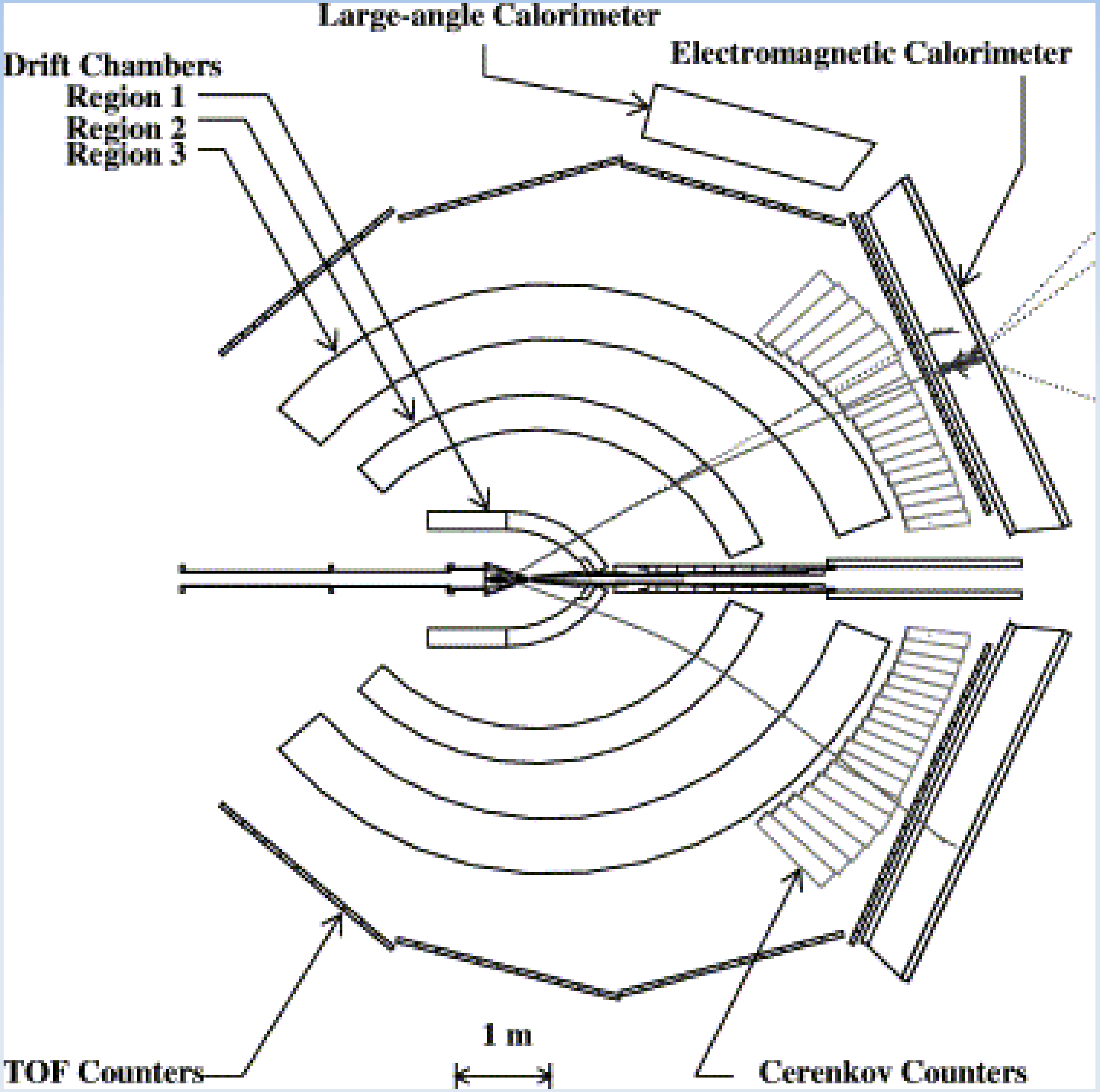
CEBAF

- Continuous Electron Beam Accelerator Facility
- Provides 6 GeV electron beam
- Longitudinally polarized



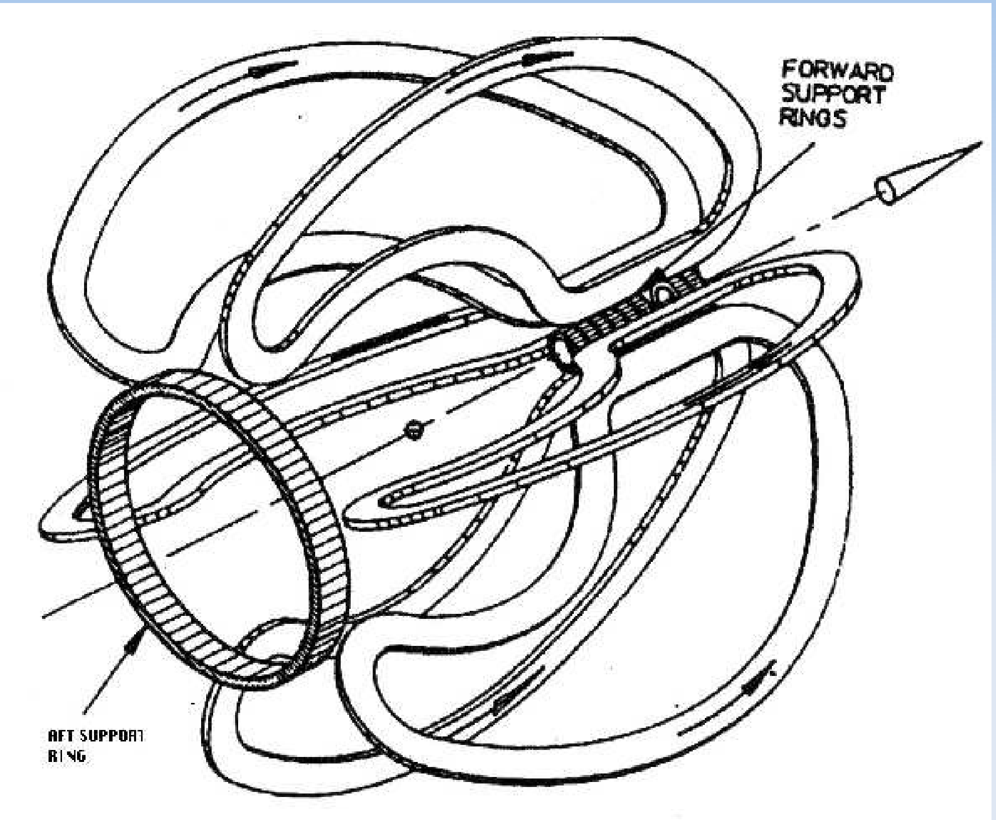
CLAS Detector

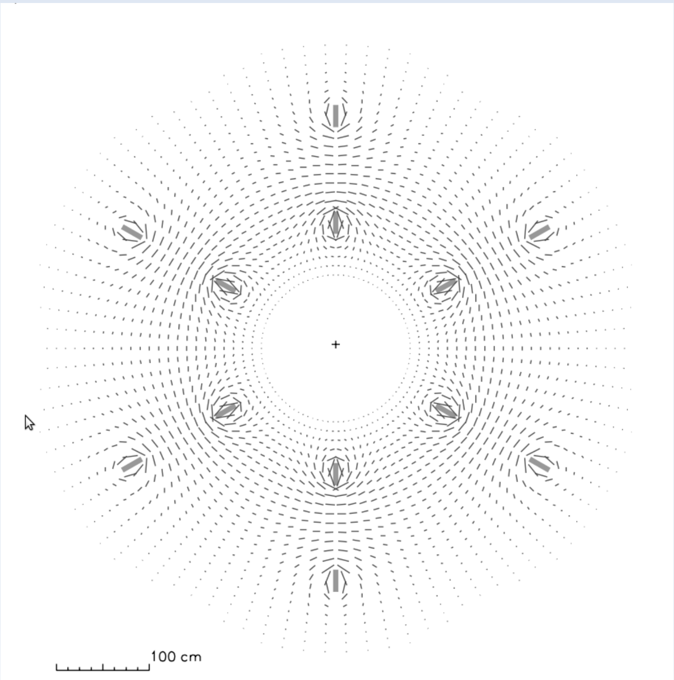
- Superconducting Torus
- Drift Chambers
- Cherenkov Counter
- Scintillation Counter
- Electromagnetic Calorimeter



Superconducting Torus

- Provides Azimuthal Magnetic Field
  - Charge discrimination, momentum resolution
- Allows for polarized target

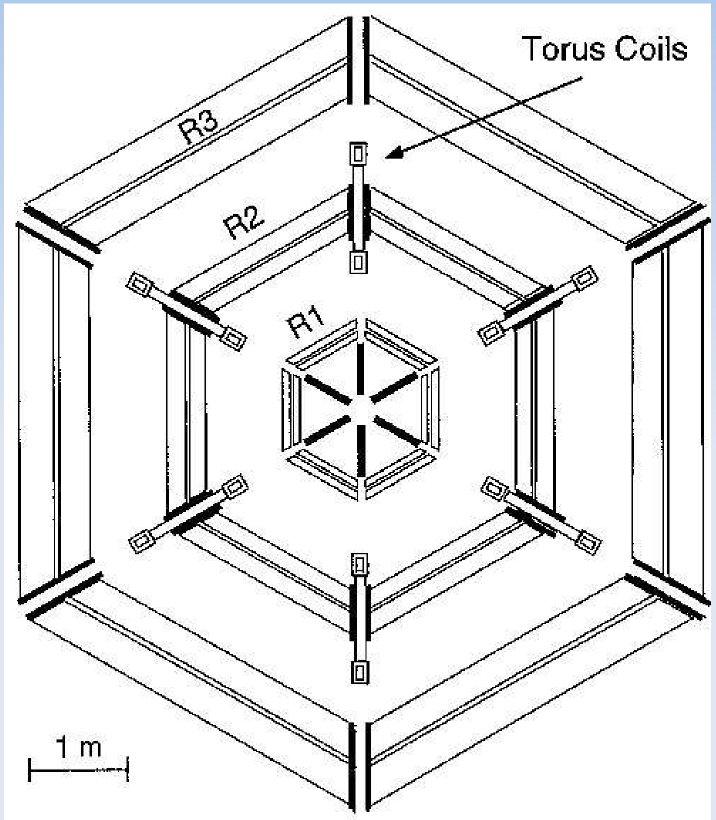


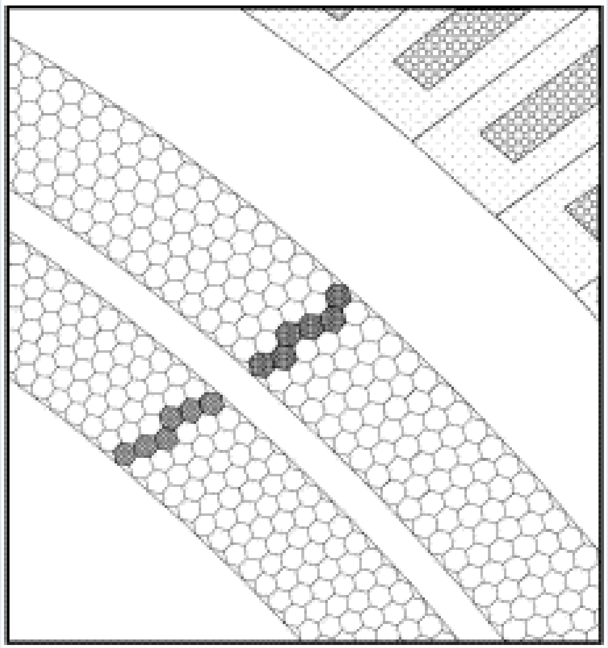


- Divides CLAS into 6 sectors

Drift Chambers

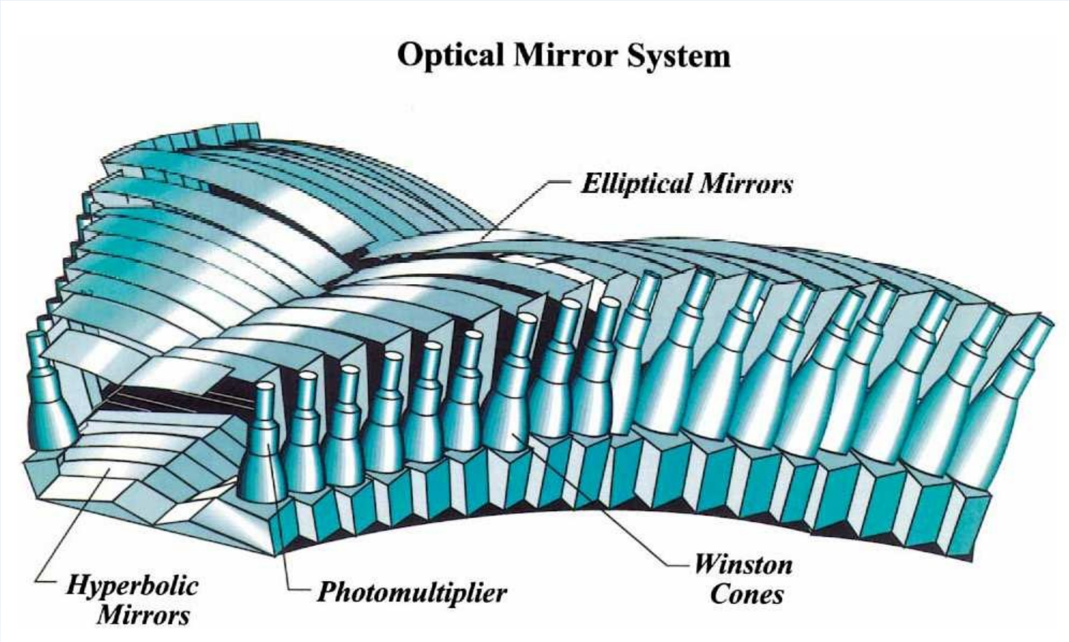
- Multi-wire drift chambers
- Determines particle trajectory
- 3 regions, each divided into 2 superlayers





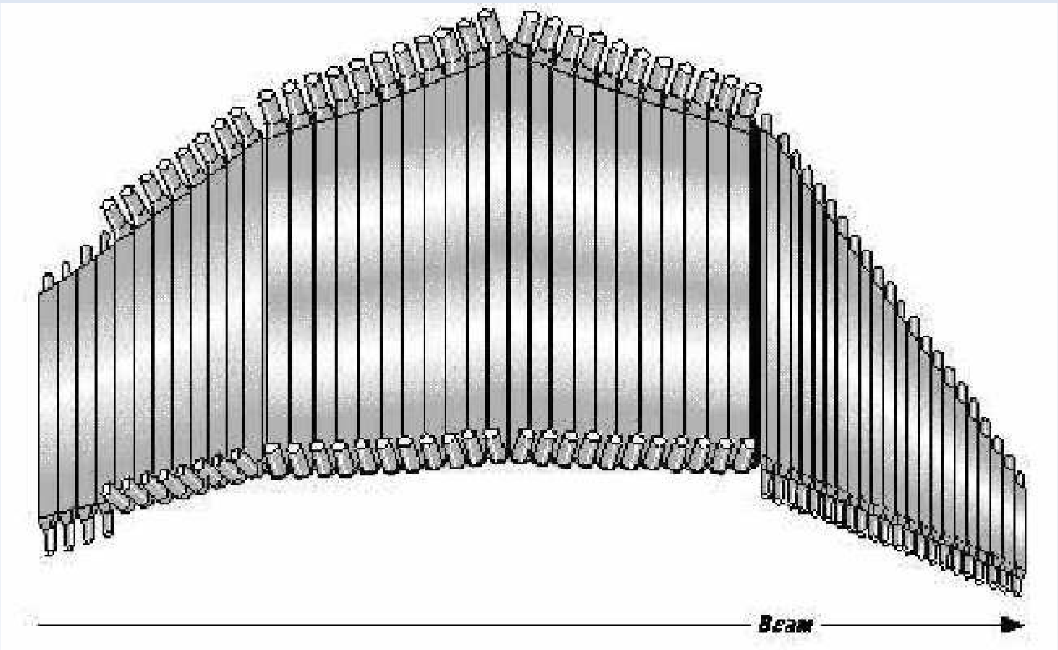
Cherenkov Counter

- Threshold type, to discriminate between charged pions and electrons
- Uses perfluorobutane (C_4F_{10})
  - n = 1.00153
  - Momentum threshold = 2.5 GeV/c for pions, 9 MeV for electrons



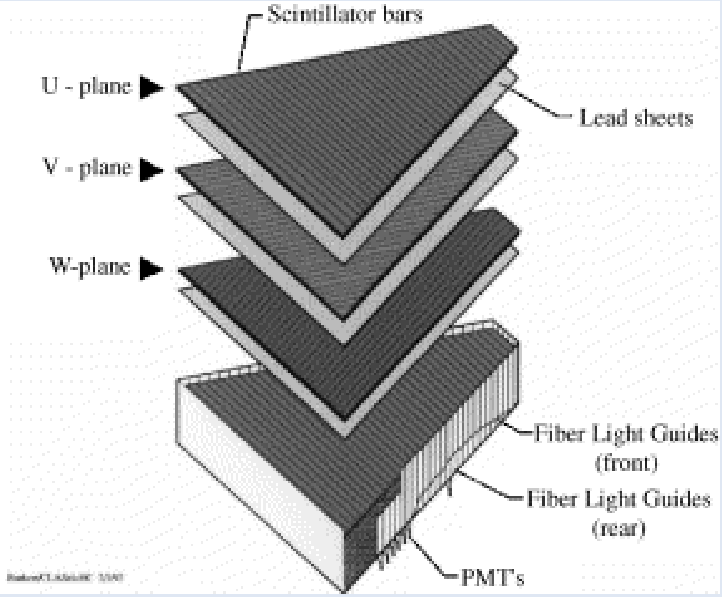
Scintillation Counter

- Scintillator Paddles with photomultipliers
- Time of Flight measurement
  - Electrons travel at nearly the speed of light
  - Calculate start time of interaction
  - Calculate time for other particles from that



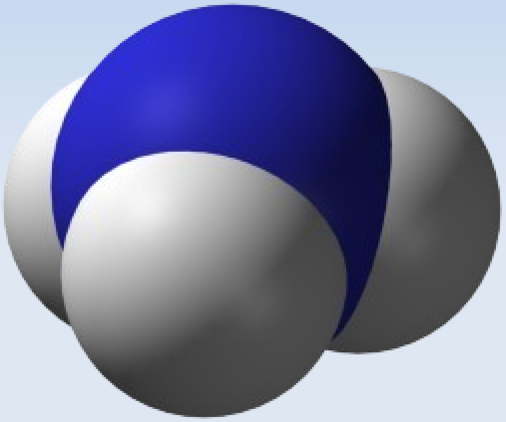
Electromagnetic Calorimeter

- Layers of lead and scintillator
  - Rotated to determine position
- Detect neutral particles
- Discriminate electrons and hadrons
  - Electrons create shower
  - Hadrons are minimum ionizing



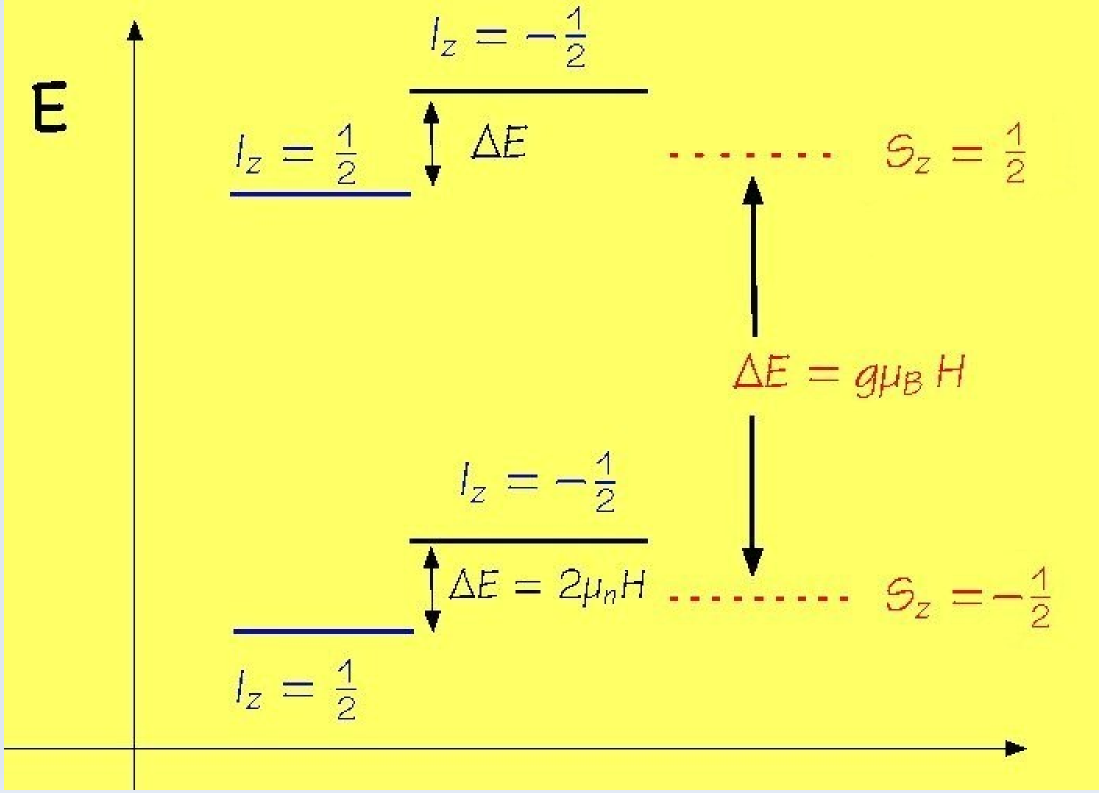
Dynamic Nuclear Polarization

- Provides polarized target for scattering
- Works for proton or deuteron
  - Proton ~95% polarization
  - Deuteron ~50% polarization
- Multiple materials possible
  - NH_3 and ND_3 used for eg1-dvcs



Dynamic Nuclear Polarization

- Requires paramagnetic centers
  - Couple electron spin to nuclear spin
  - Produced by irradiation or chemical doping
- Thermal Equilibrium Polarization:
  - Electron: >99%
  - Proton: ~0.5%



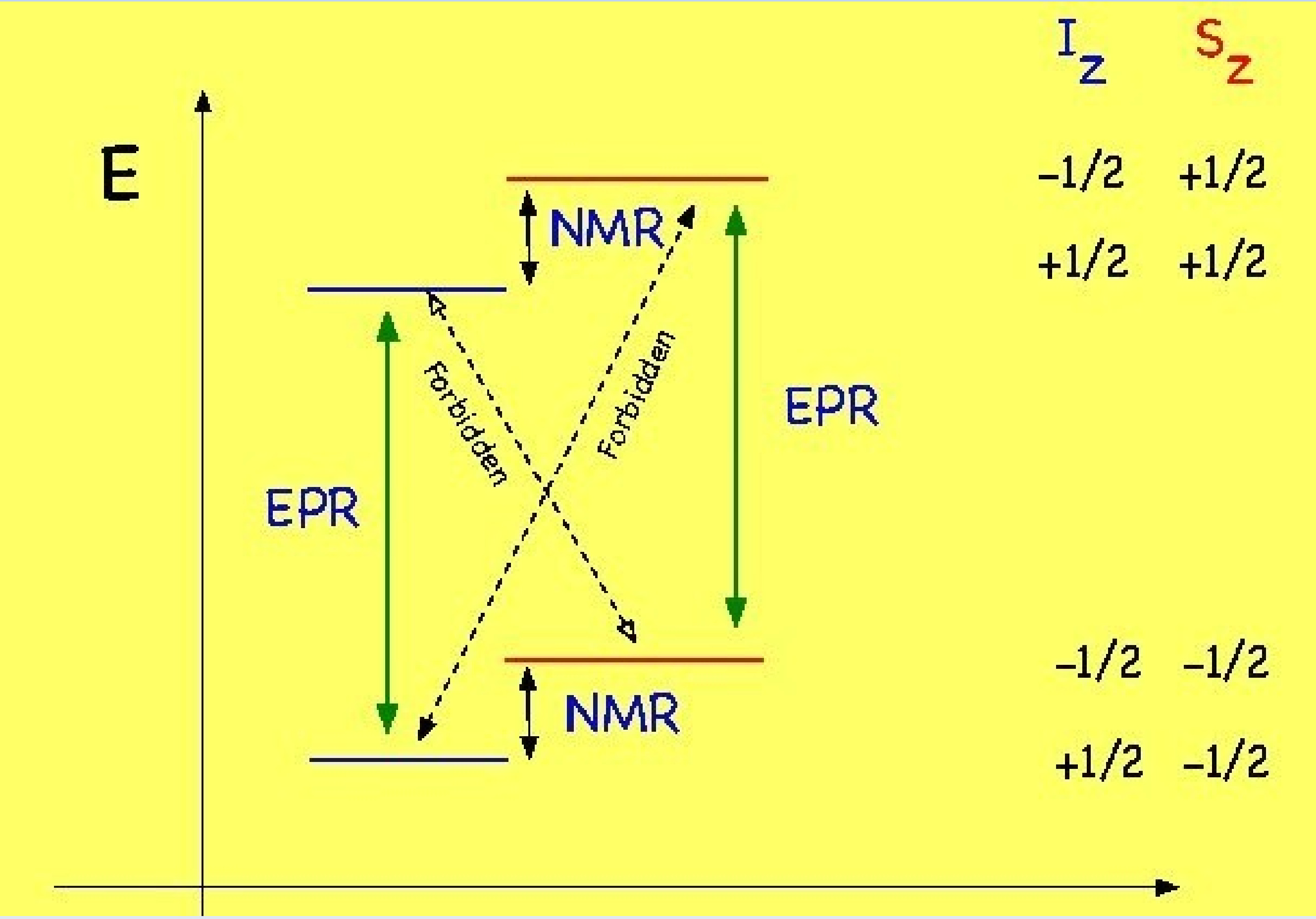
Dynamic Nuclear Polarization

- Microwaves drive ”forbidden” transitions

- Proton relaxation:

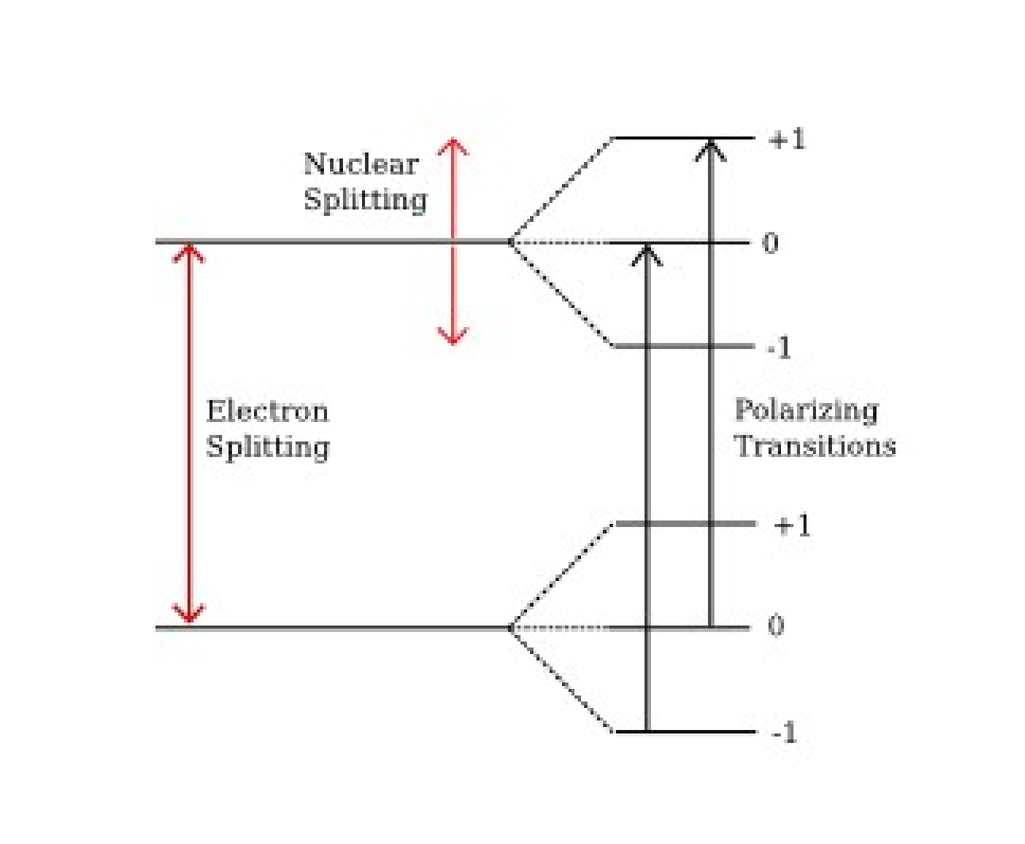
  ~10 minutes
- Electron relaxation:

  ~milliseconds

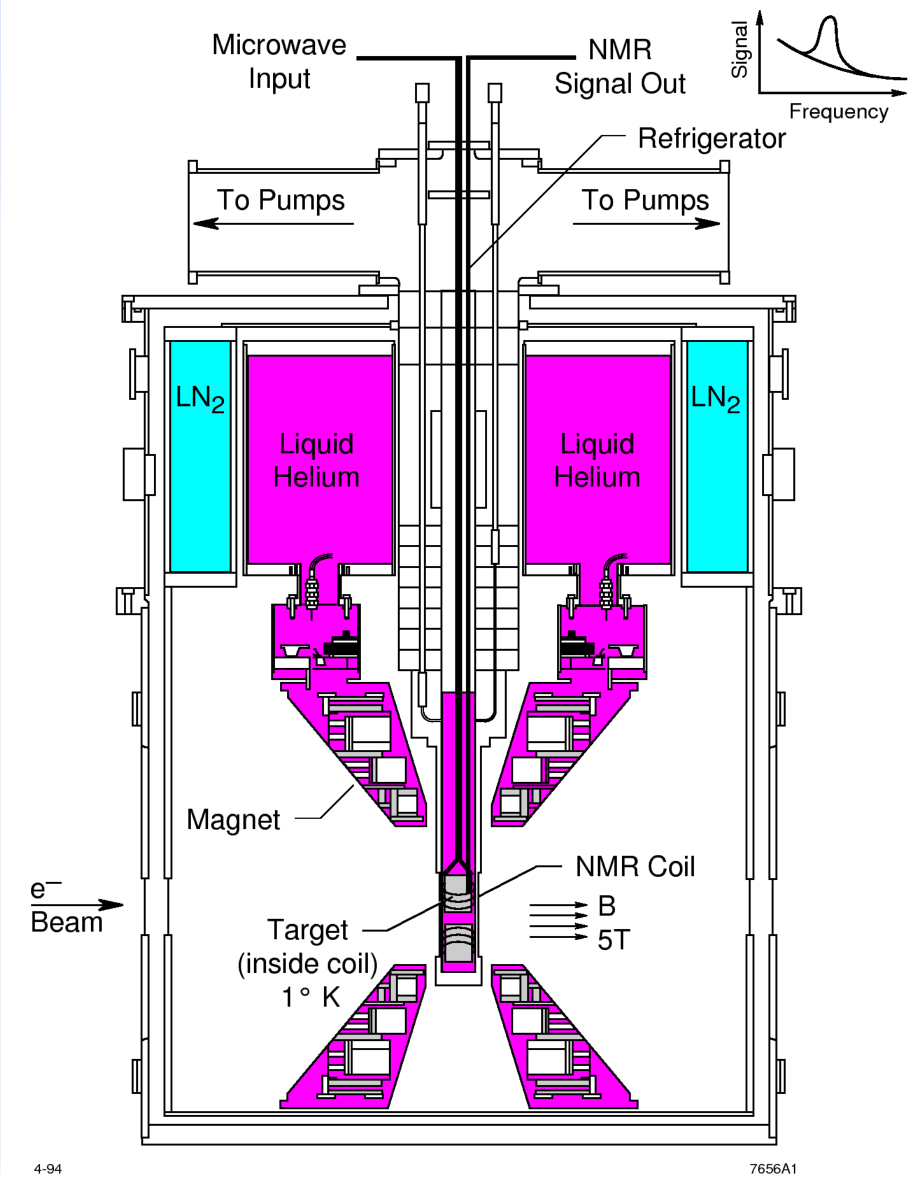


DNP on the Deuteron

- Same process for Deuteron except it's spin 1
- Spin 0 state limits maximum polarization
- Asymmetries give rise to peak shifts



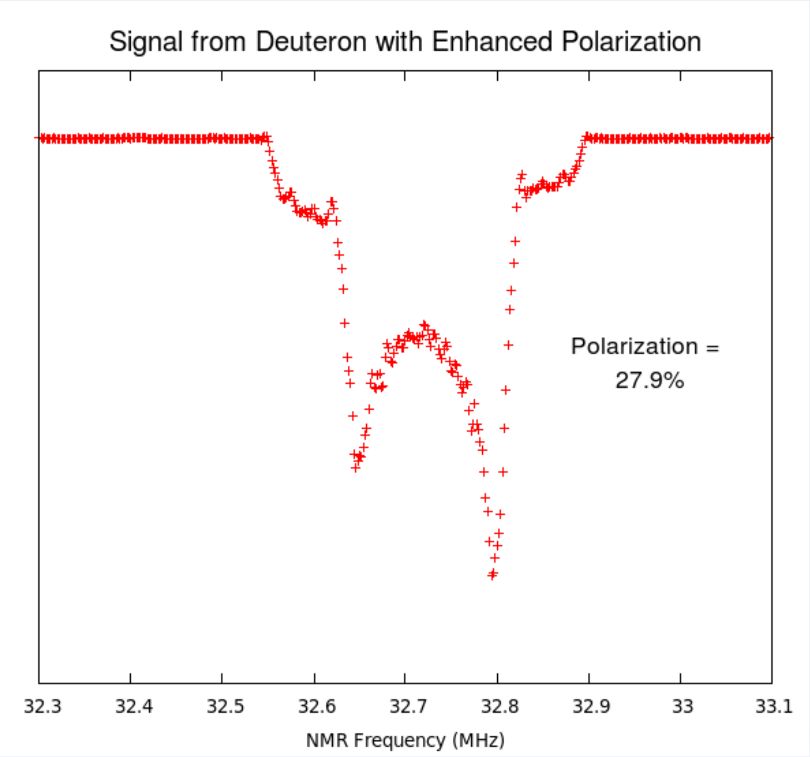
Polarized Target



Polarized Target

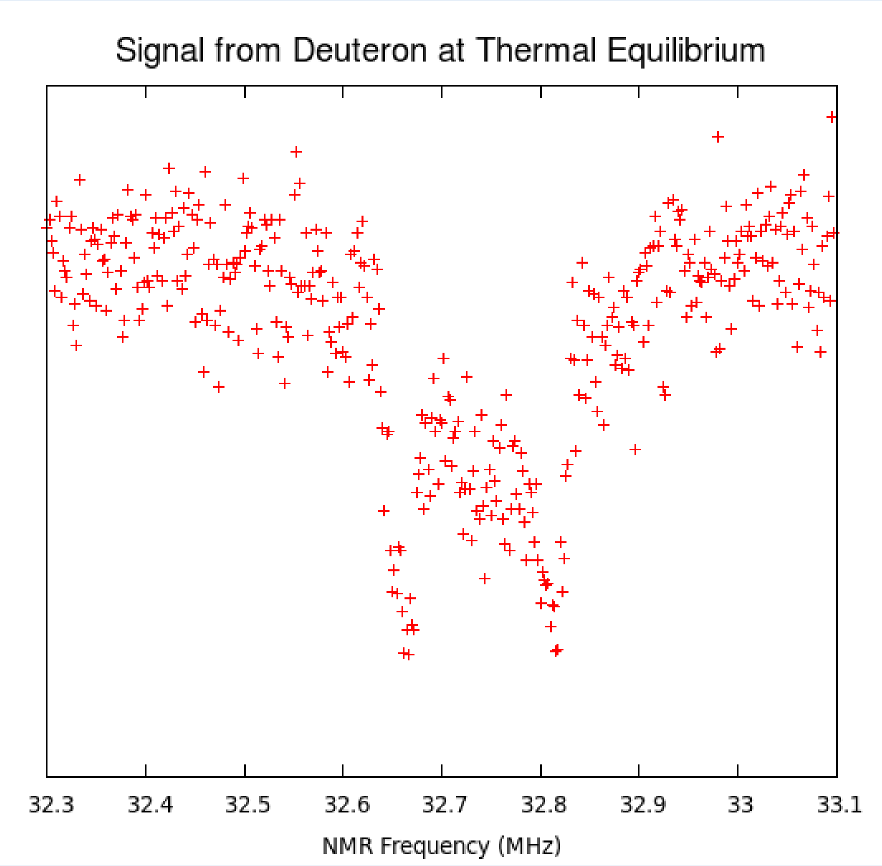
Target NMR

- Nuclear Magnetic Resonance setup used to measure polarization of sample
- Q-meter uses series-LRC resonance to detect small signal
  - Baseline must be subtracted to obtain signal



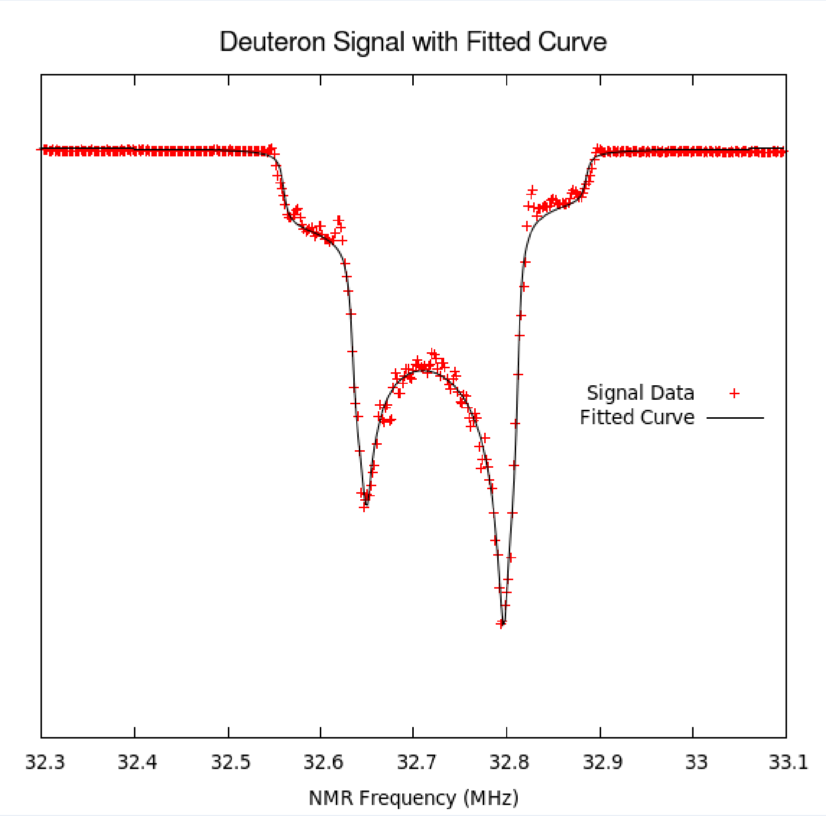
Target NMR

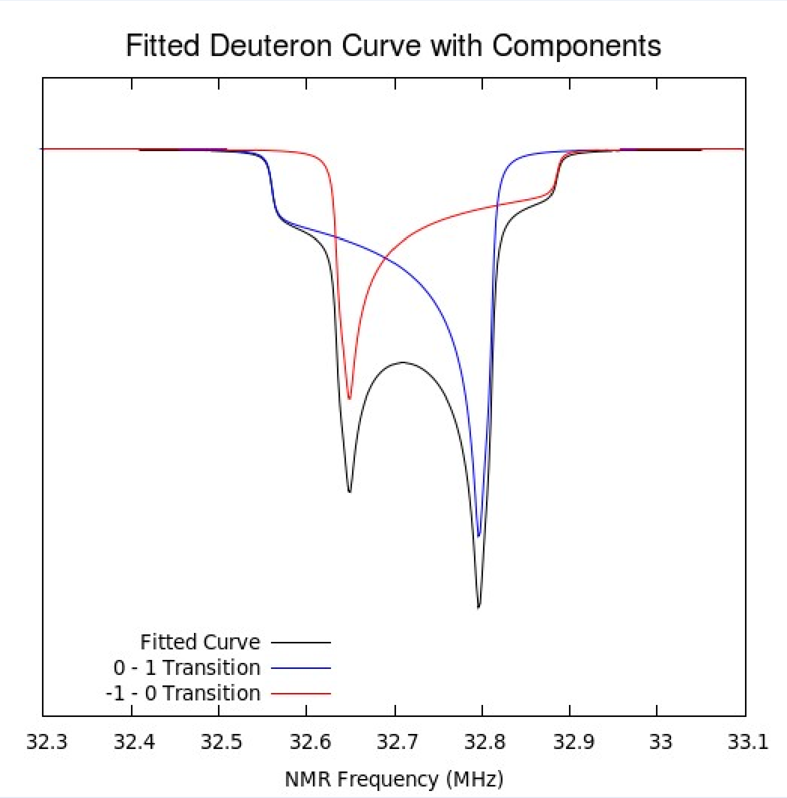
- Thermal Equilibrium measurement relates area of curve to polarization
- Determined from magnetic field and temperature



Target NMR

- Polarization also determined from ratio of two components
- Lineshape is fit to signal, asymmetry parameter determines polarization





Collaboration

- Prohibitive amount of work required for solo completion of full experiment
- Calibrations divided between members
- Multiple physics topics come from each data set

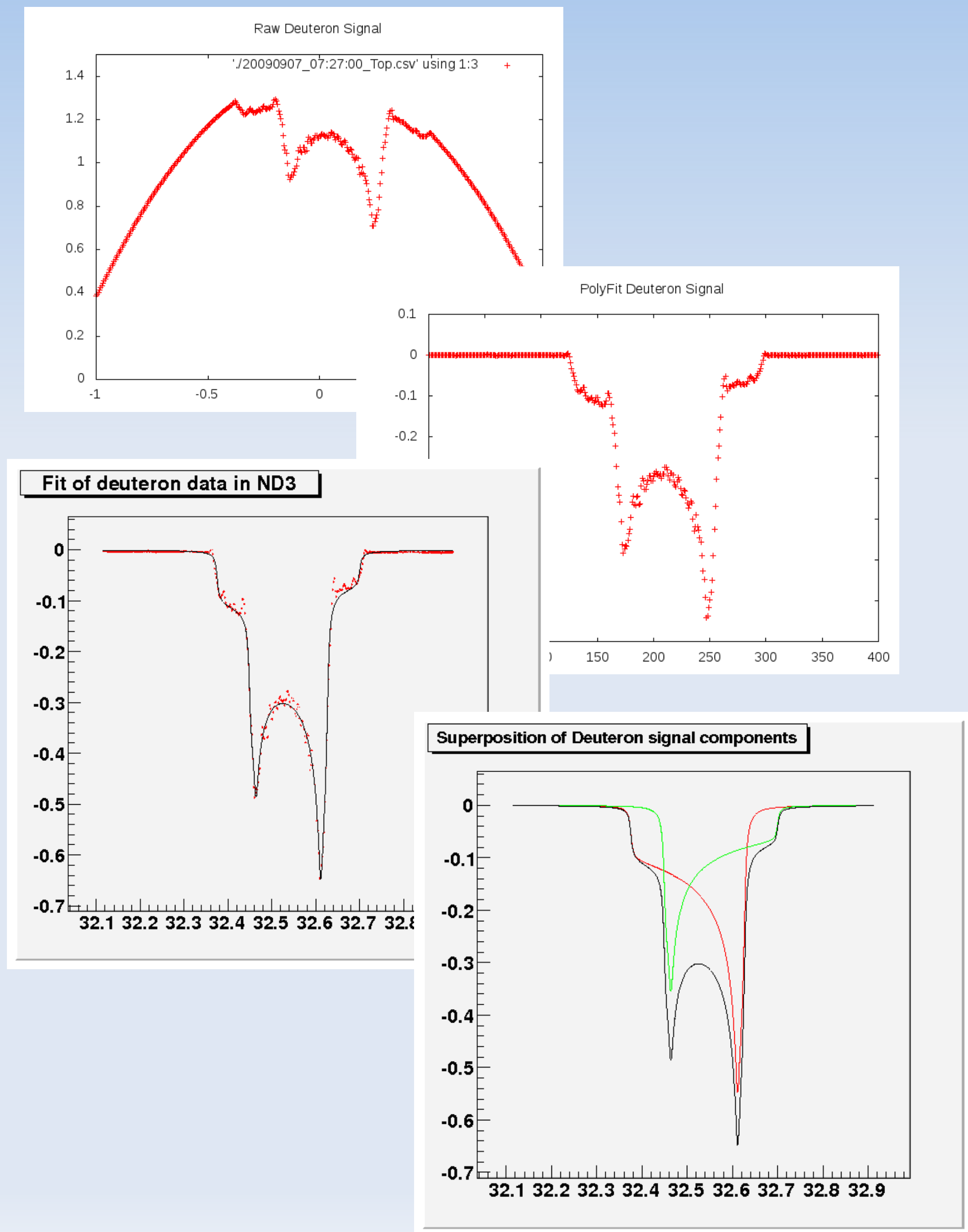
Collaborators

Calibration	In charge
Target NMR	E. Seder (14NH3) and N. Kvaltine (14ND3)
Electromagnetic Calorimeter	E. Seder and C. Smith
Time of flight	H. Baghdasaryan and N. Markhov
Cherenkhov counter	P. Khetarpal and M. Ungaro
Drift chamber	B. Zhao and S. Jawalkar
Inner calorimeter	M. Agashyan and F. Girod
Cooking	E. Seder and N. Kvaltine

Cooking

- Run Numbers: 60242 – 60648
- Approx. 15,000 files
  - Pass 0 finished
- ~1000 failed files
- Switched to 64-bit executable at run 60503

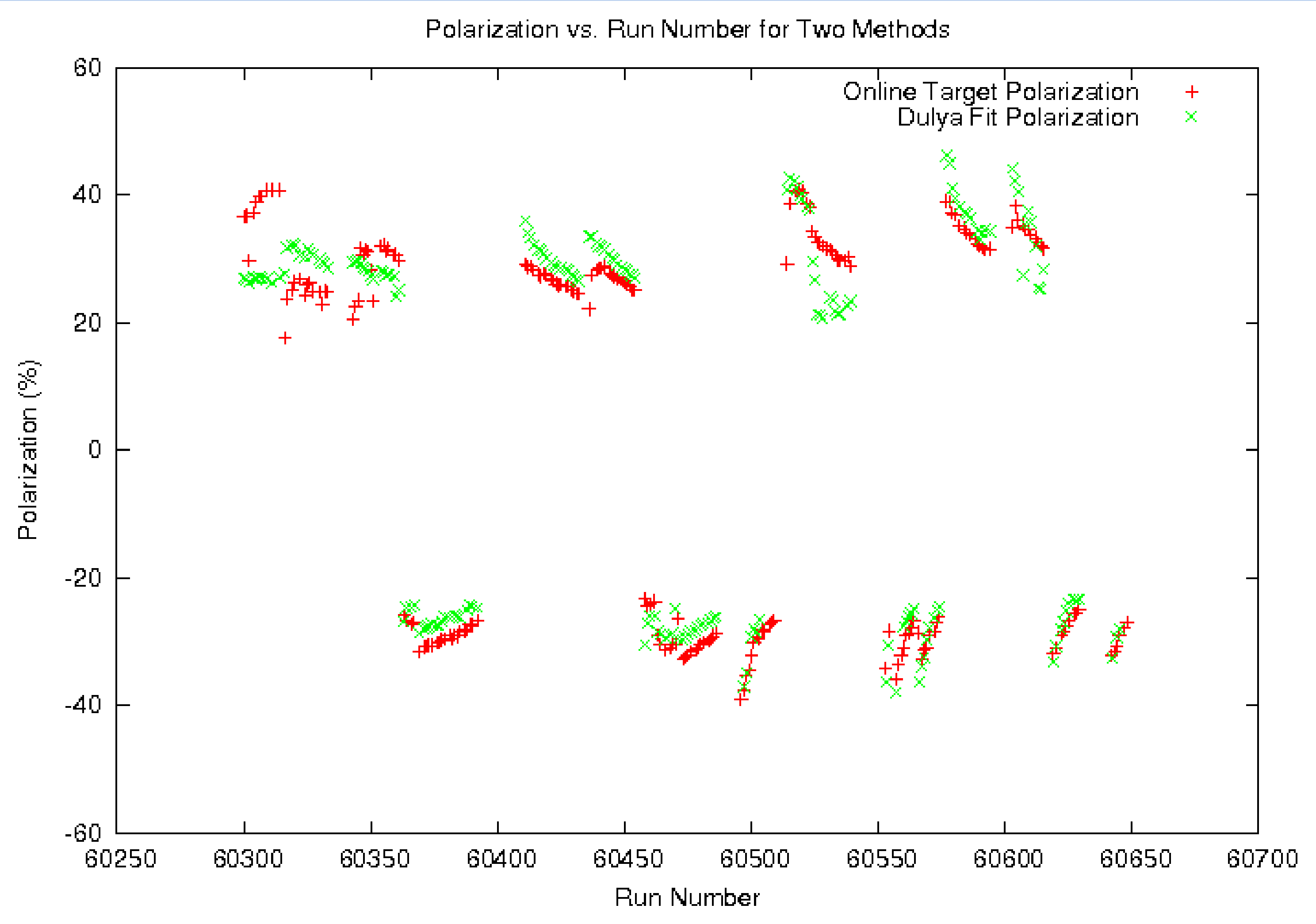
Target NMR Calibration



- 80,000 scans from Run Period
- Subtract Baseline and fit polynomial
- Use Chris Dulya's lineshape fitting program
- Get polarization from ratio of two components

Target NMR

- Compare all runs to Online Polarization



- Next Step: Compare with offline area method

Conclusion

- Shed light on angular momentum distribution of nucleon
- Have assigned responsibilities among collaborators
- Calibration proceeding
- When calibrated, cook files again
- Begin physics analysis