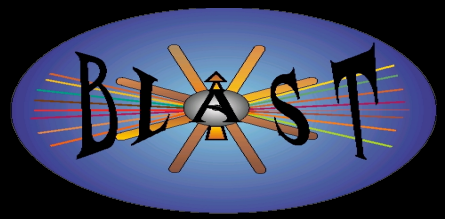
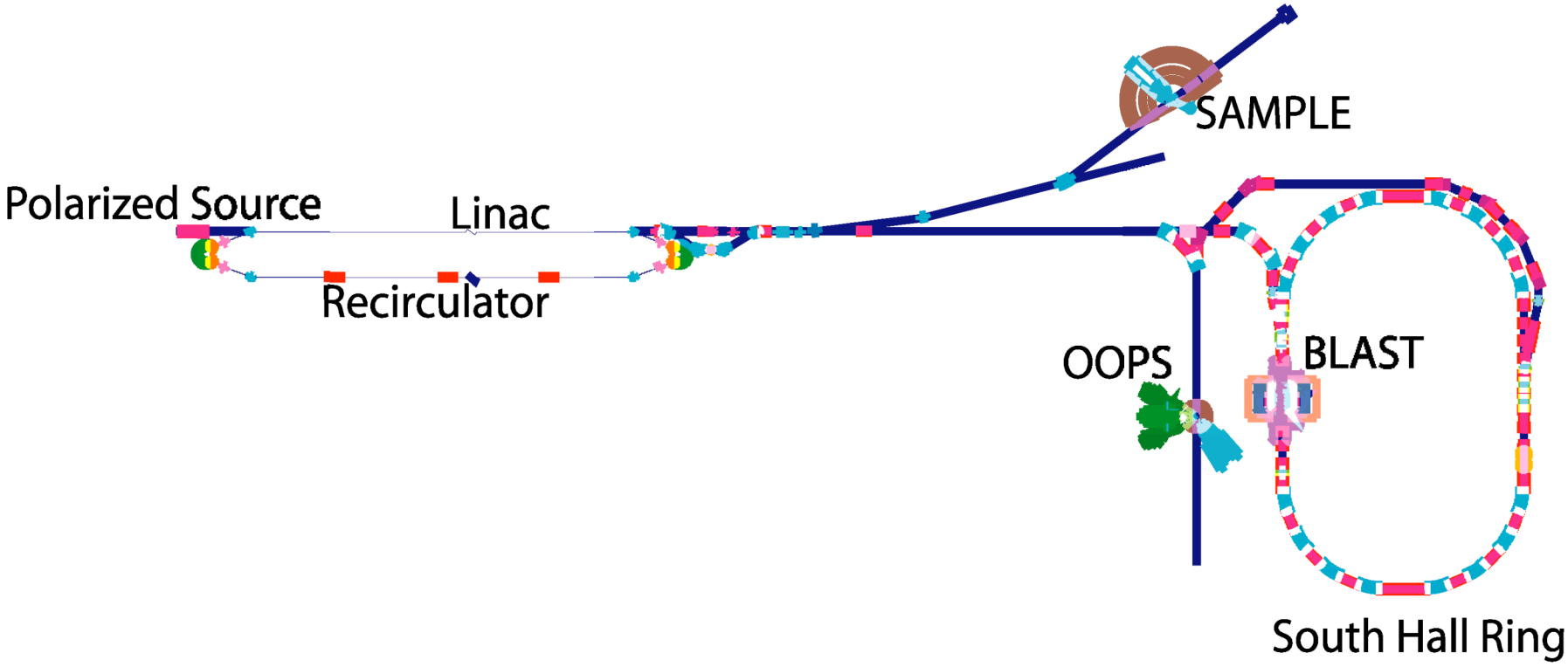
BLAST

- Bates Large Acceptance Spectrometer Toroid
- Polarized electron beam to 1 GeV
- Polarized, internal, gas targets of pure H, D, or He-3
- Symmetric detector
- Systematic study of spin dependent electro-magnetic interaction of few nucleon systems



MIT-BATES Linear Accelerator Laboratory



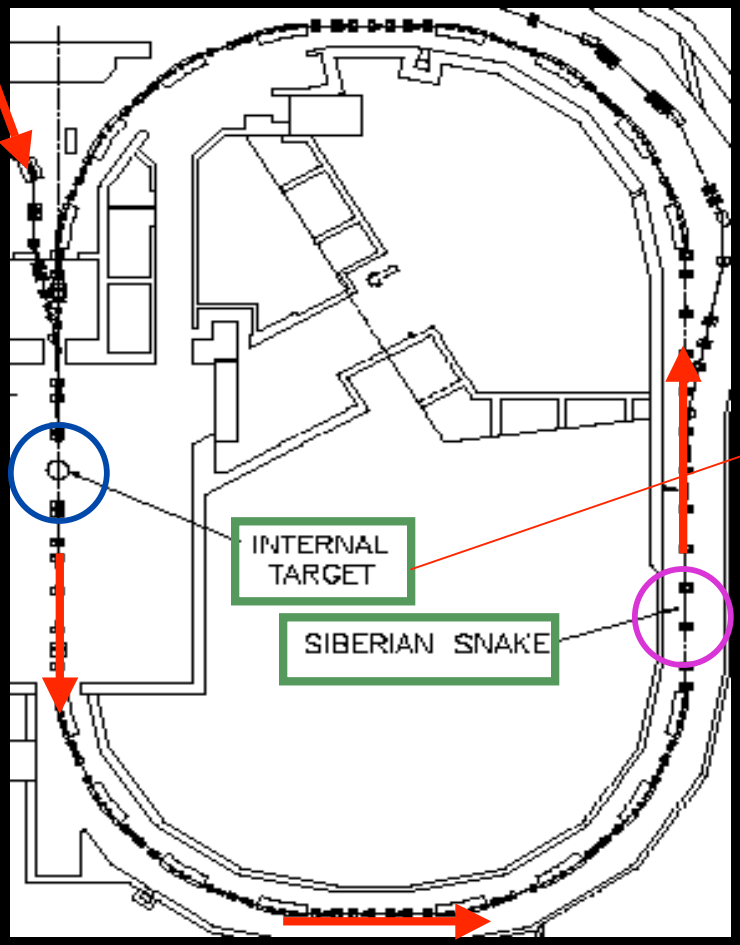
1 GeV electrons, 70% polarisation

150 mA, 25 min. lifetime

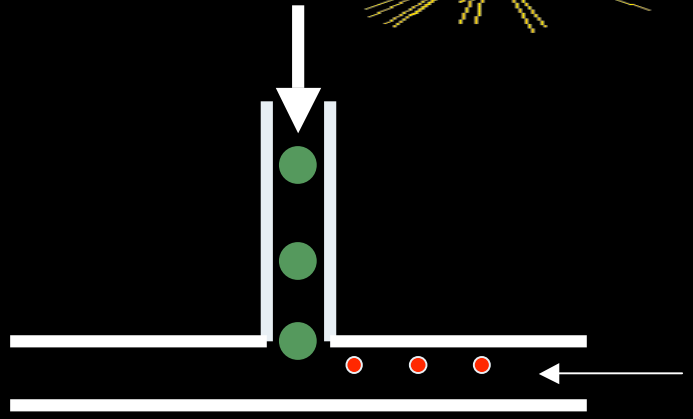
Siberian snake

Spin flipper

Polarized Internal Gas Target



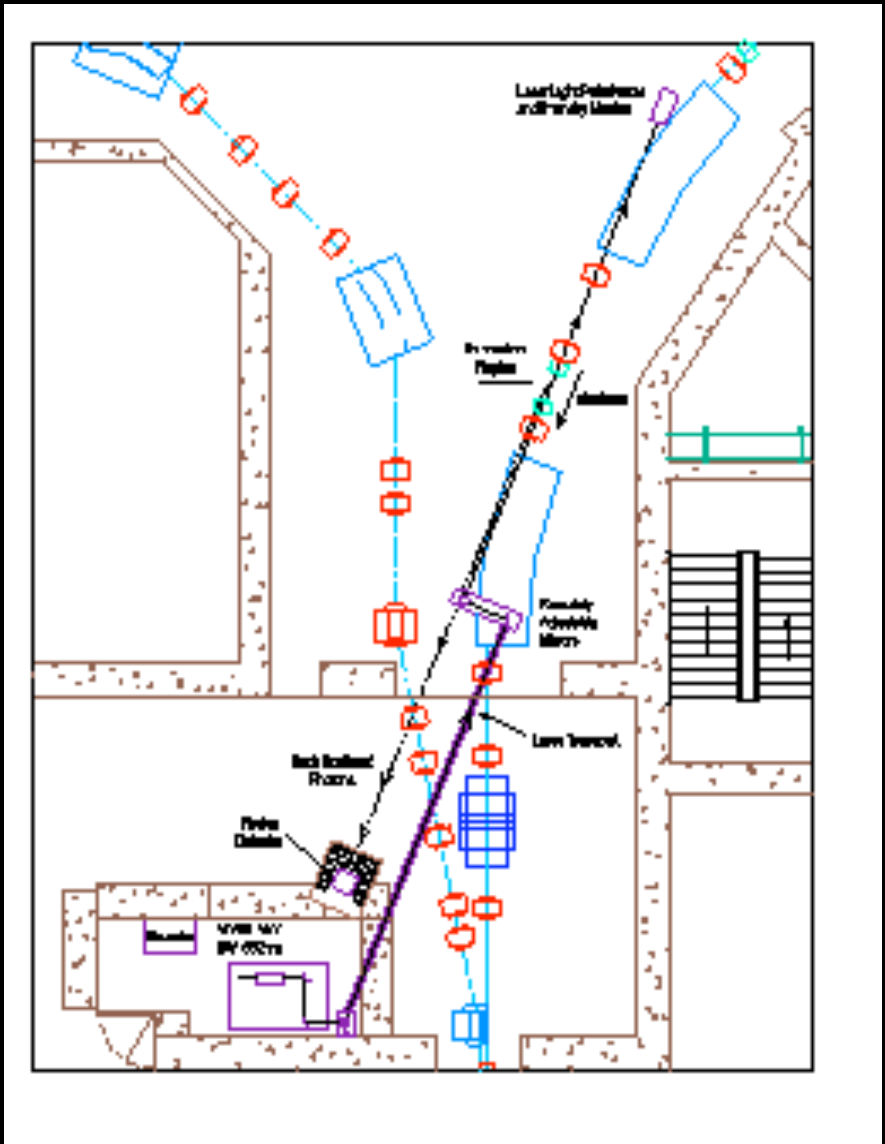
South Hall Ring



- pure target
- high polarization
- thin cell walls
- low holding field

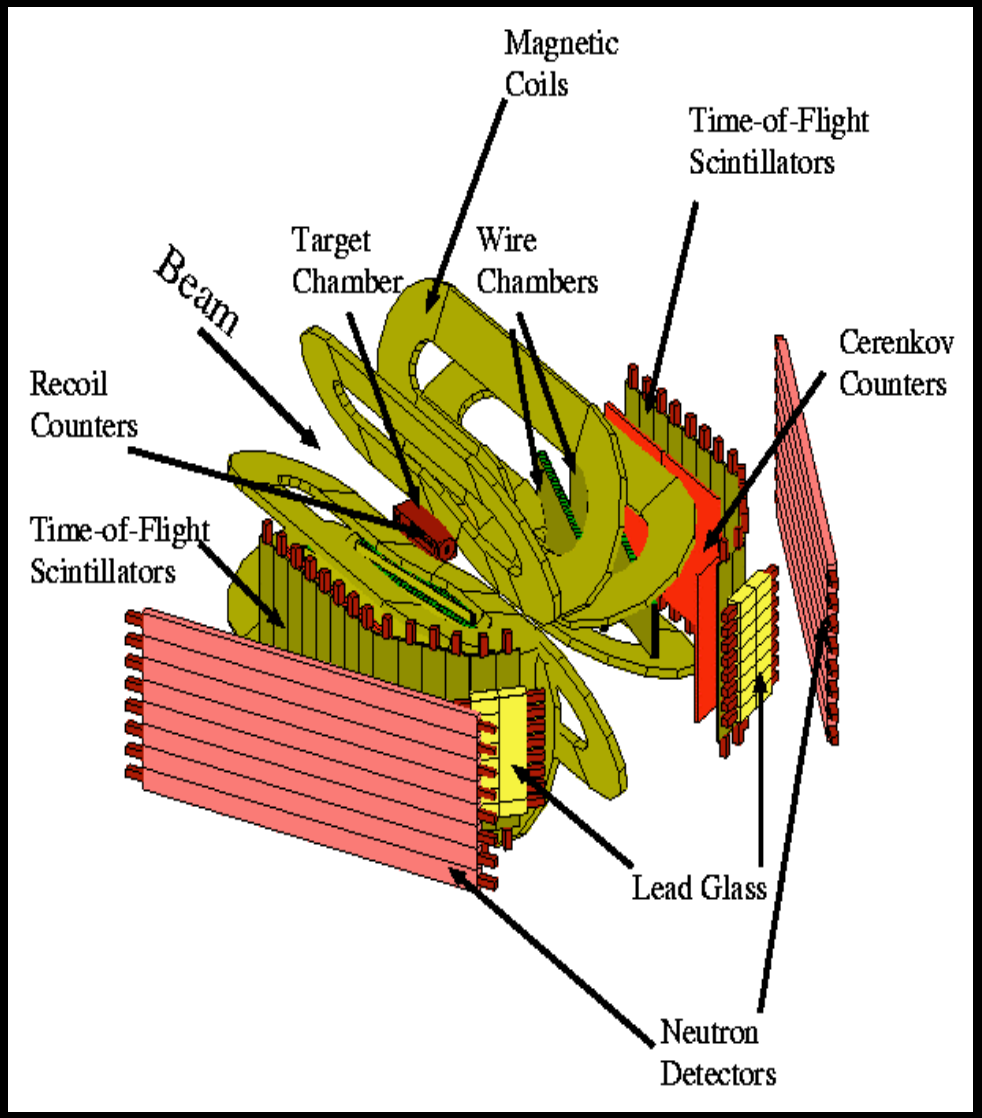
$L = 10^{32}\text{-}10^{33}$ atoms cm^{-2} s^{-1}

Compton and Möller Polarimeters



- Compton polarimeter
  - Laser light incident on electron beam
  - Detect backscattered photons in CsI
  - Online measure of beam polarisation
- Möller polarimeter
  - Symmetric Möller angles
  - Check on target polarisation
  - Doubles as luminosity monitor
  - Also beam quality monitor

BLAST Detector



- Toroidal magnetic field
- Symmetric detector design
- Opposing sectors instrumented
  - Silicon strip recoil detectors
    - Recoil D and He
  - Wire chambers
    - Charged particle tracking in 3D
  - Cerenkov detectors
    - Electron / pion identification
  - Time of Flight scintillators
    - Trigger
    - Time differences
  - Lead glass calorimeter
  - Neutron scintillators
    - Upgrade with LADS bars

BLAST Toroid

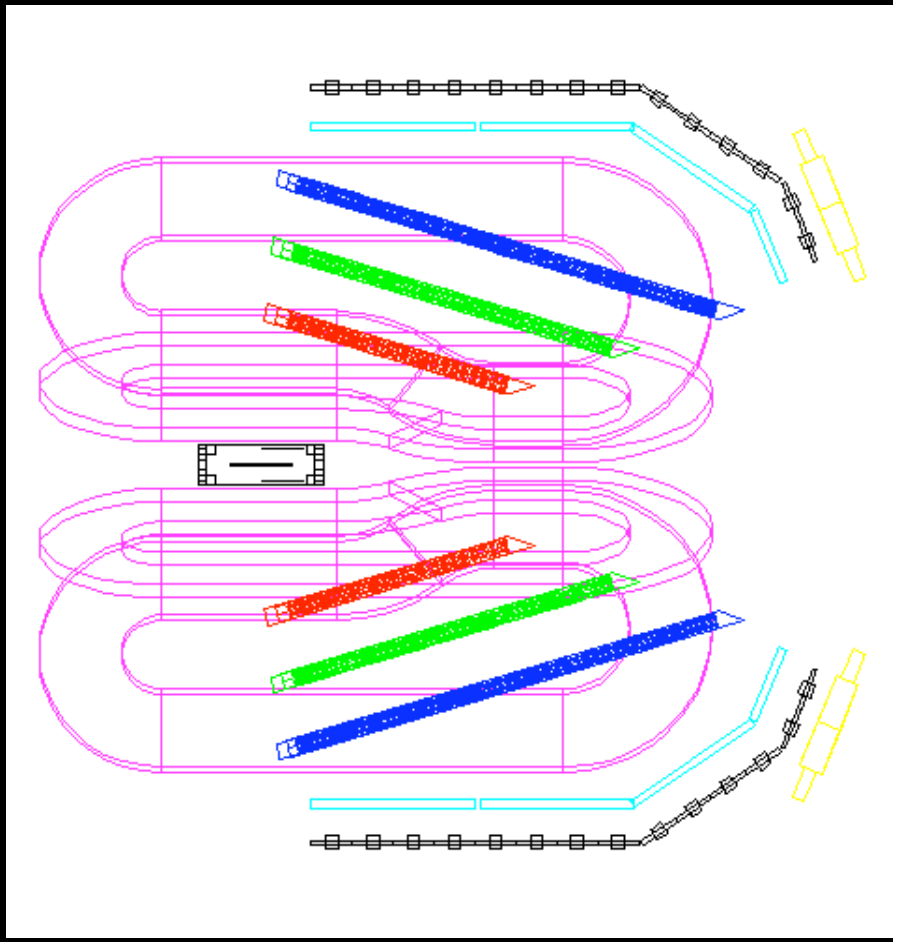
8 copper coils

6730 A

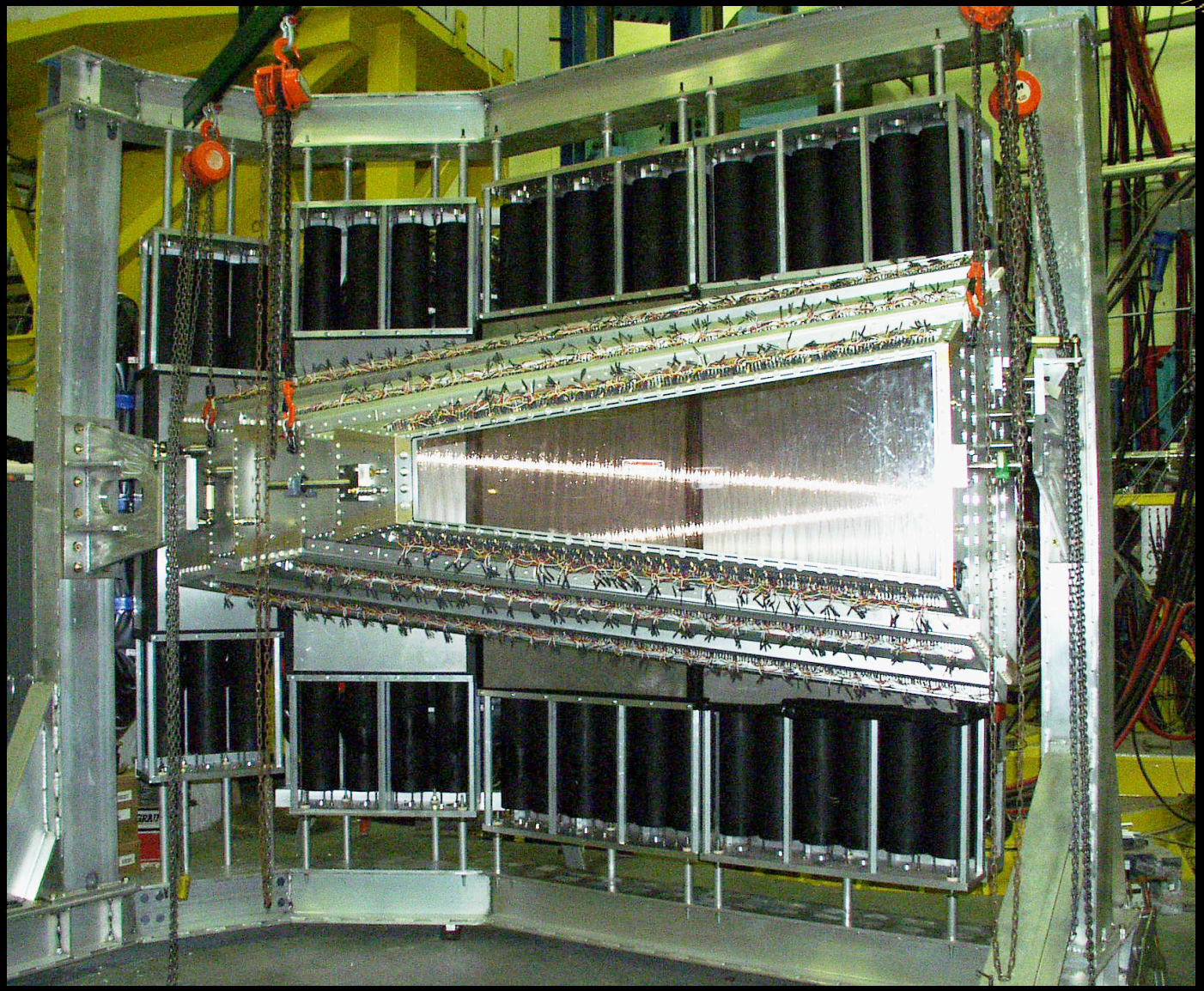
Max B 3.7 kG

BLAST Detector

- Symmetric detector subtends
  - 20-80 deg polar angle
  - +/-17 deg azimuthal angle
- Wire chambers
  - 3 chambers per sector
    - single gas volume
  - 2 superlayers of drift cells / chamber
    - +/- 5 deg stereo
  - 3 sense layers / superlayer
  - 1-2% momentum resolution
- Cerenkov, TOF, Lead Glass
- Programmable, scalable trigger
  - Simultaneous experiments
    - Inclusive / exclusive
    - Elastic / quasi-elastic / production

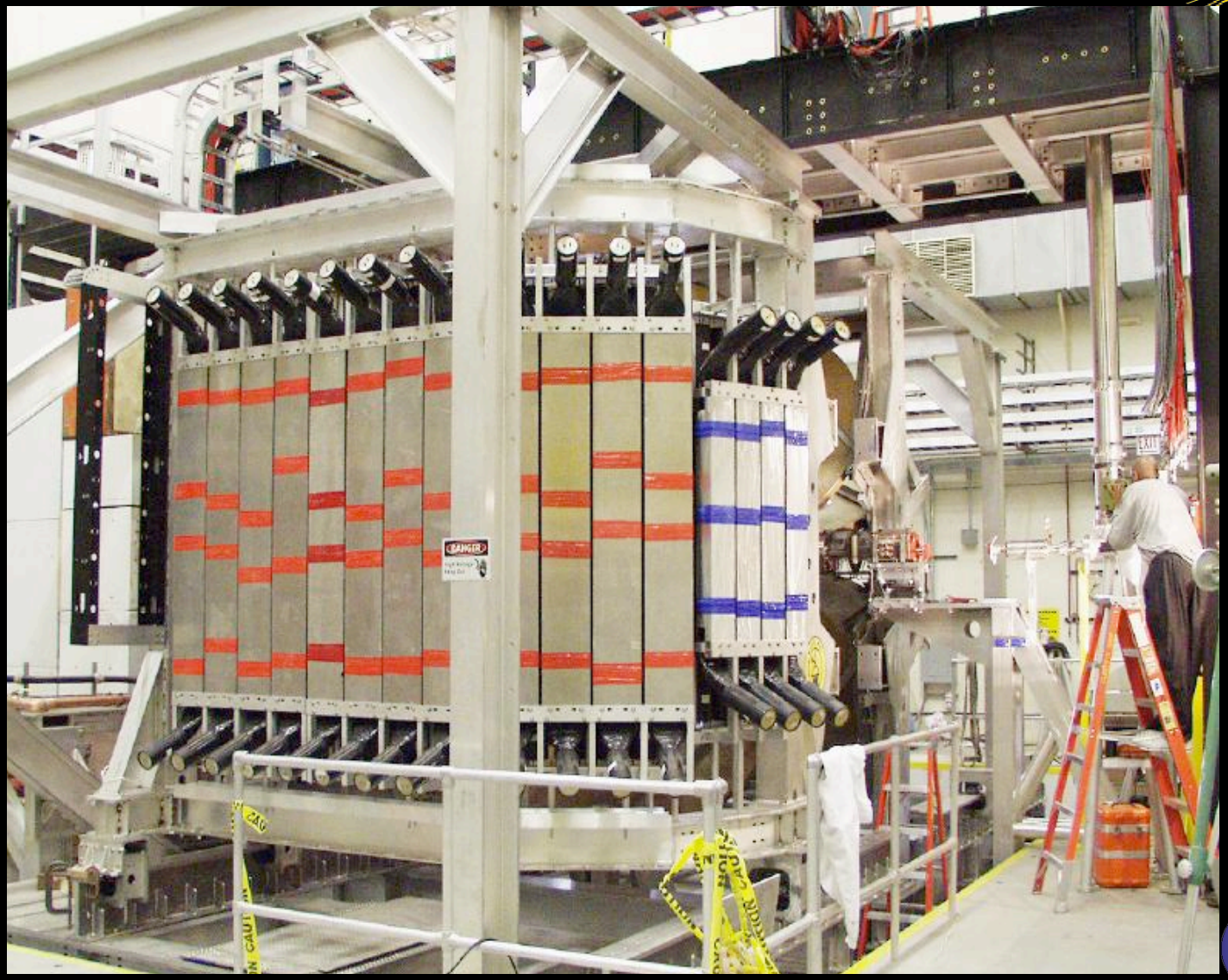


BLAST Sub-detector Assembly



- Wire chamber
- Cerenkov
- TOF (behind)
- Fits between coils
- Independent motion

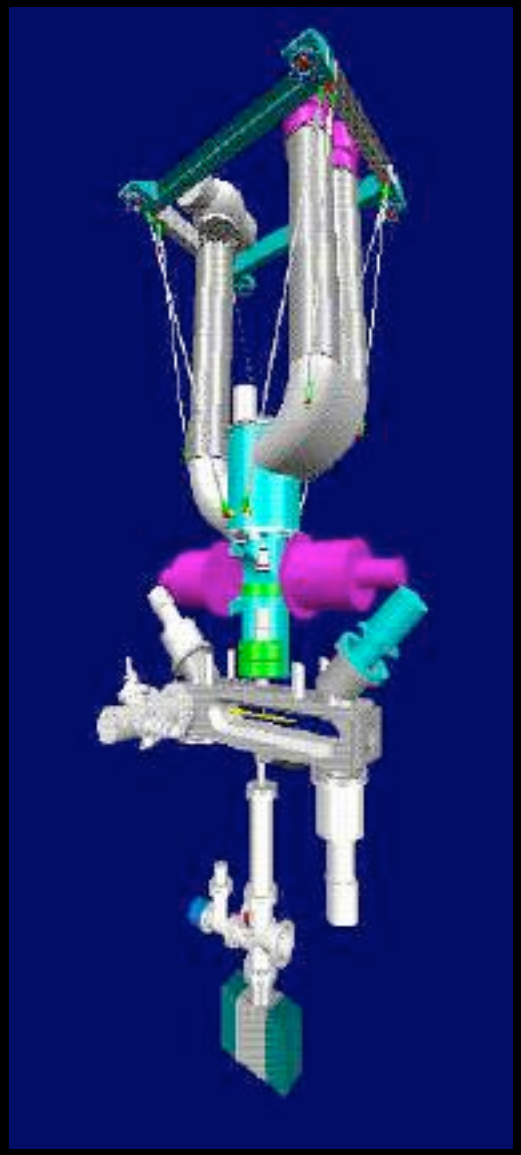
BLAST



TOF
Scintillators

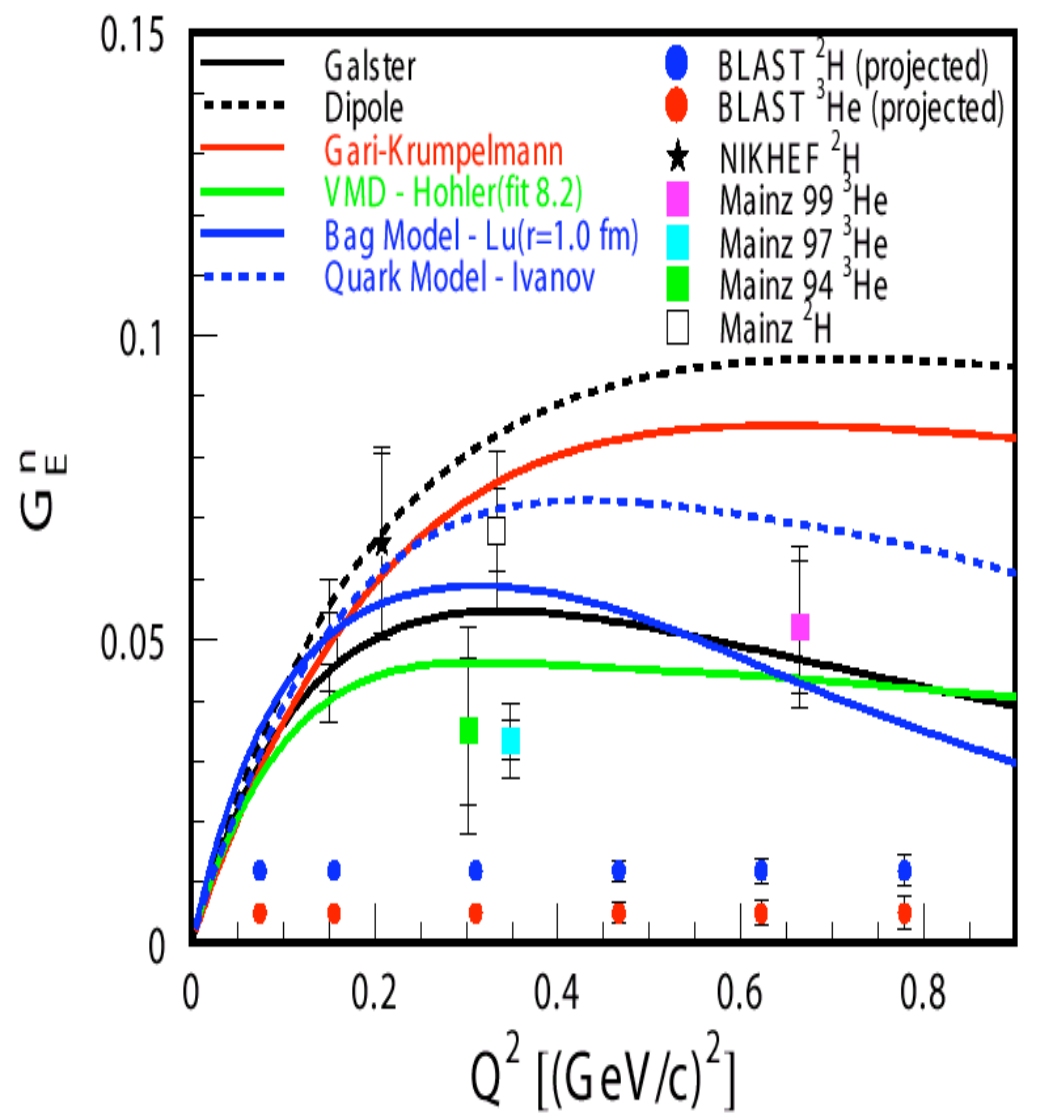
Trigger
Timing

Internal Targets



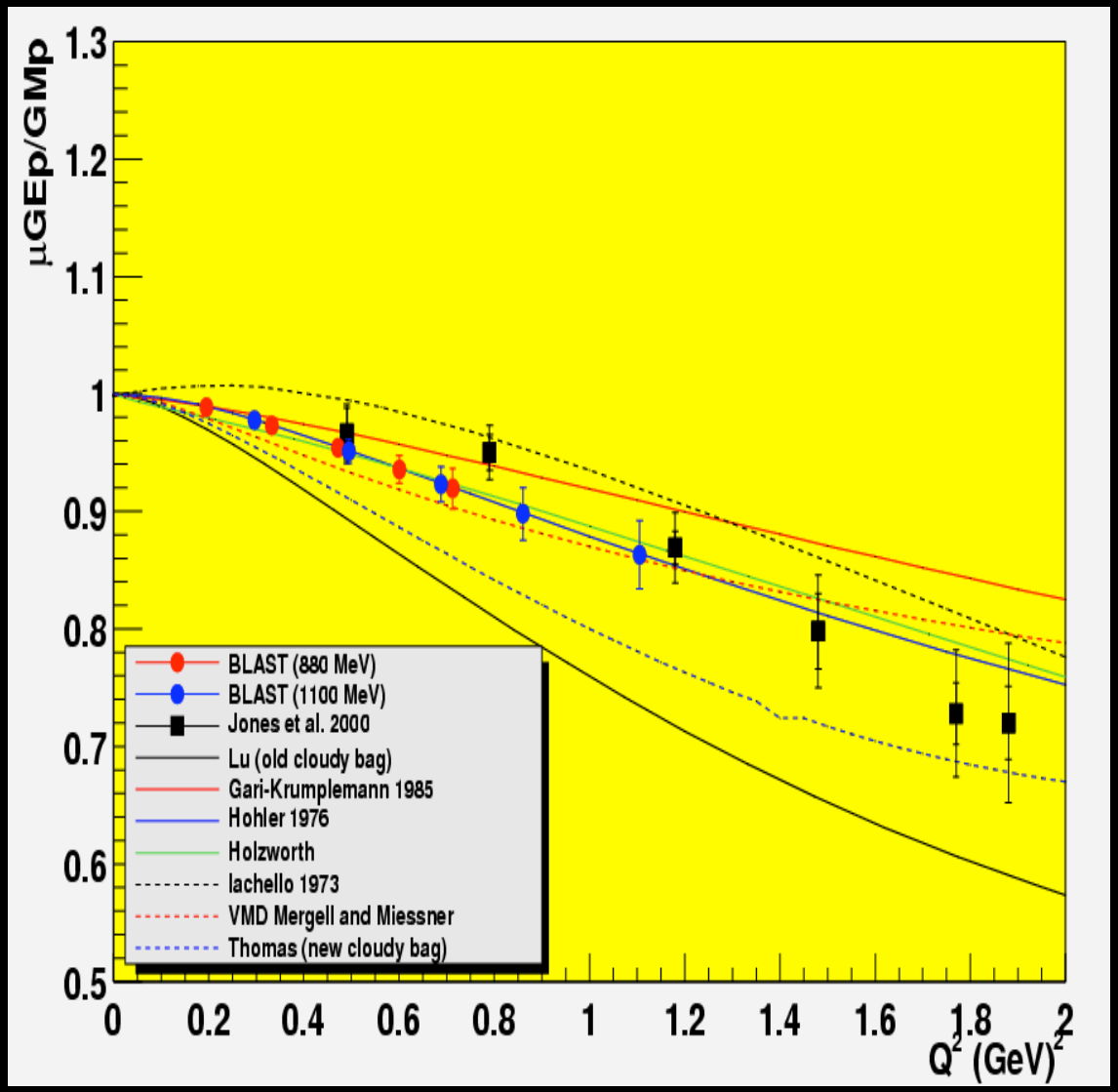
- Atomic beam source internal target
  - 5 x 10**13 atoms /cm**2
  - 80% polarization
  - Polarized hydrogen
  - Vector and tensor polarized deuterium
  - Change polarization every 20 s, ~1 second deadtime
    - Flip spin during run
      - Reduce systematics
    - Flip vector and tensor polarizations
      - Simultaneous measurements
- Laser driven source (LDS)
  - 10**15 - 10**16 atoms/cm**2
- Polarized helium-3
  - Effective polarized neutron target
  - Independent measurement for neutron form factor
- Ion polarimeter
  - Direct measure of tensor polarization
  - Mass spectrometer

Neutron Charge and Magnetic Form Factors



- Quasi-elastic scattering from both D and He-3
  - Effective polarized neutron targets
  - Cross check results
- Common, symmetric detector simultaneous measurements of (e,e'p), (e,e'n)
- Internal target
  - Rapid spin flip
  - Pure target
- Minimize systematic errors

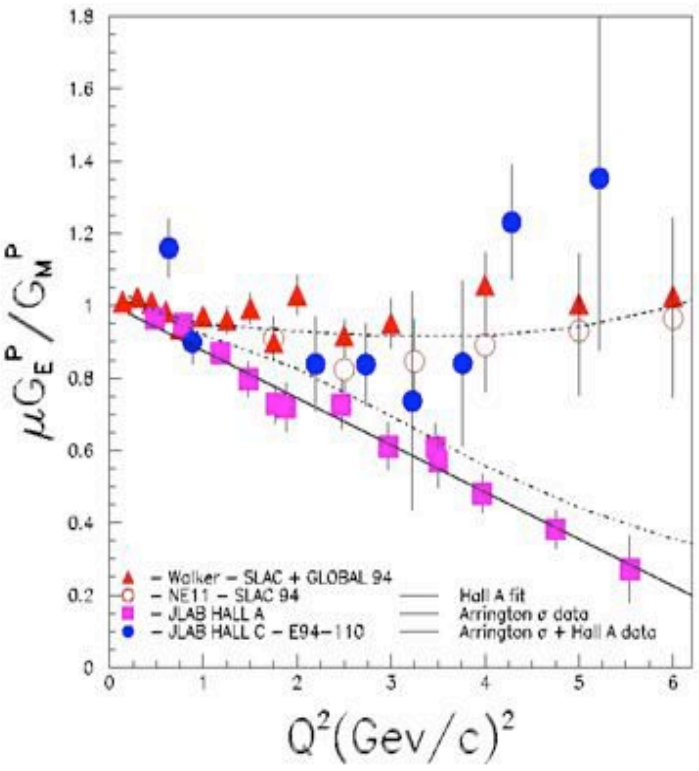
Proton Charge and Magnetic Form Factors



- Elastic ep Scattering
- Q^2: 0.1 - 1.0 $(GeV/c)^2$
- Polarized beam and target
- Measure G_E / G_M
- Benchmark measurement for BLAST spin program

Recent Hall C Results

Hall C Experiment E94-110: Precise Measurement of $R = \sigma_L / \sigma_T$ in the Resonance Region, *Elastics as Calibration Checks*



(Previous) options for solution to disagreement between Rosenbluth and polarization transfer techniques:

- SLAC or Hall A data have some large ε dependent experimental systematic uncertainty
- An unconsidered ε dependent radiative correction
- The two types of measurements are somehow not equivalent

The new Hall C data rule out the possibility for SLAC experimental systematic uncertainty to be the explanation.

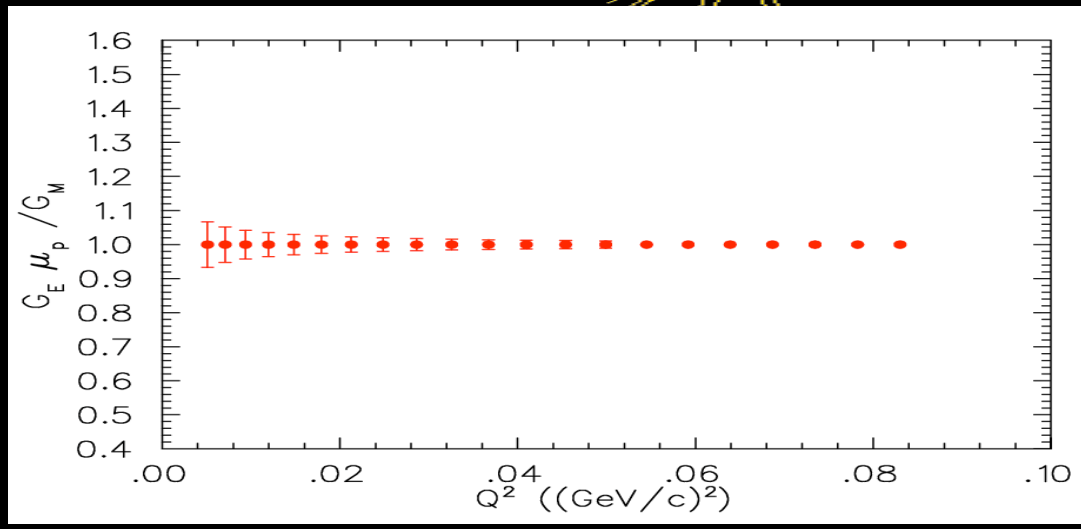
Proton Charge Radius

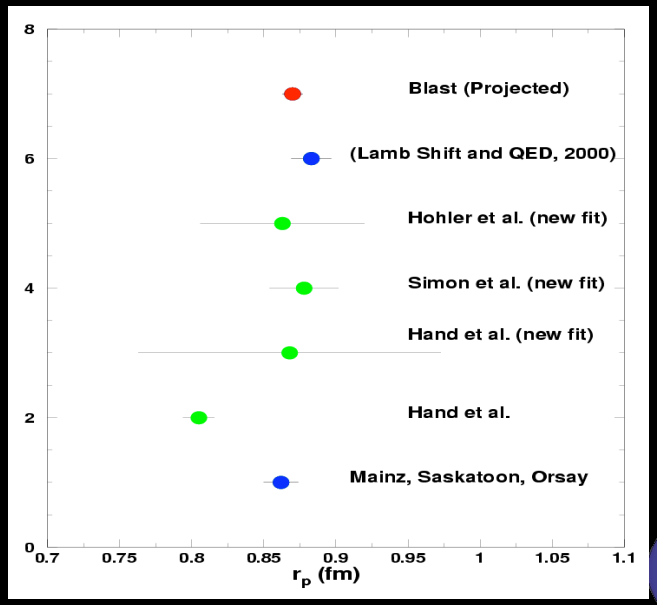
- 275 MeV (Q^2: 0.13-2.2 fm^{-2})
- spin-dependent e-p elastic
- ratio from asymmetry measurements
- magnetic form factor from unpolarized σ (relative)
- Factor of 3 improvement

•QCD: nucleon structure

• QED: Lamb shift

$$r_p = \langle r^2 \rangle^{\frac{1}{2}}; \quad \langle r^2 \rangle = -6\left(\frac{dG_E}{dQ^2}\right)_{Q^2=0}$$





Deuteron Form Factors

- Electro-magnetic structure of D
  - 3 form factors

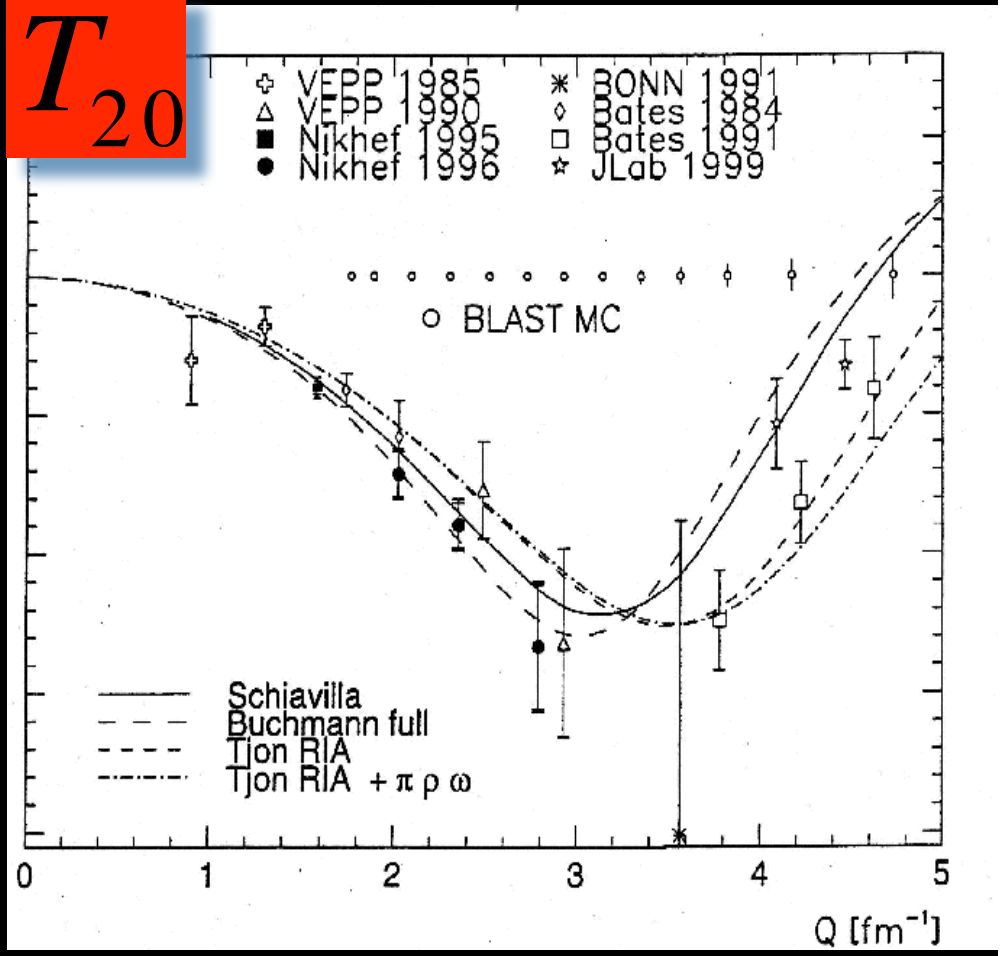
G_C, G_M, and G_Q

  - unpolarised experiments can not separate factors
  - previous experiments measure polarisation of scattered D

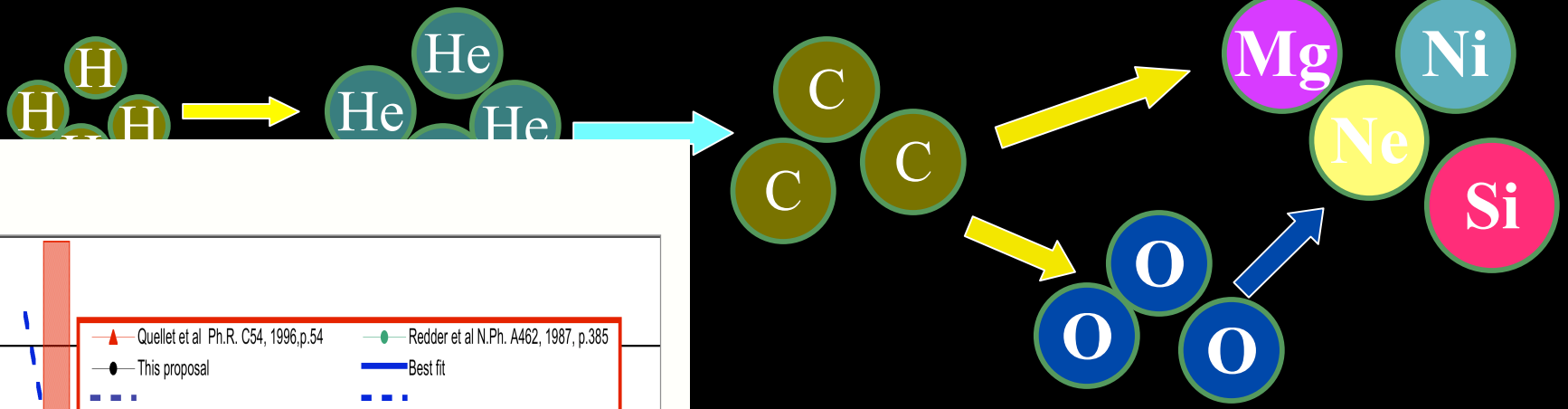
- BLAST measures directly
  - polarised electrons
  - Vector and tensor polarized D

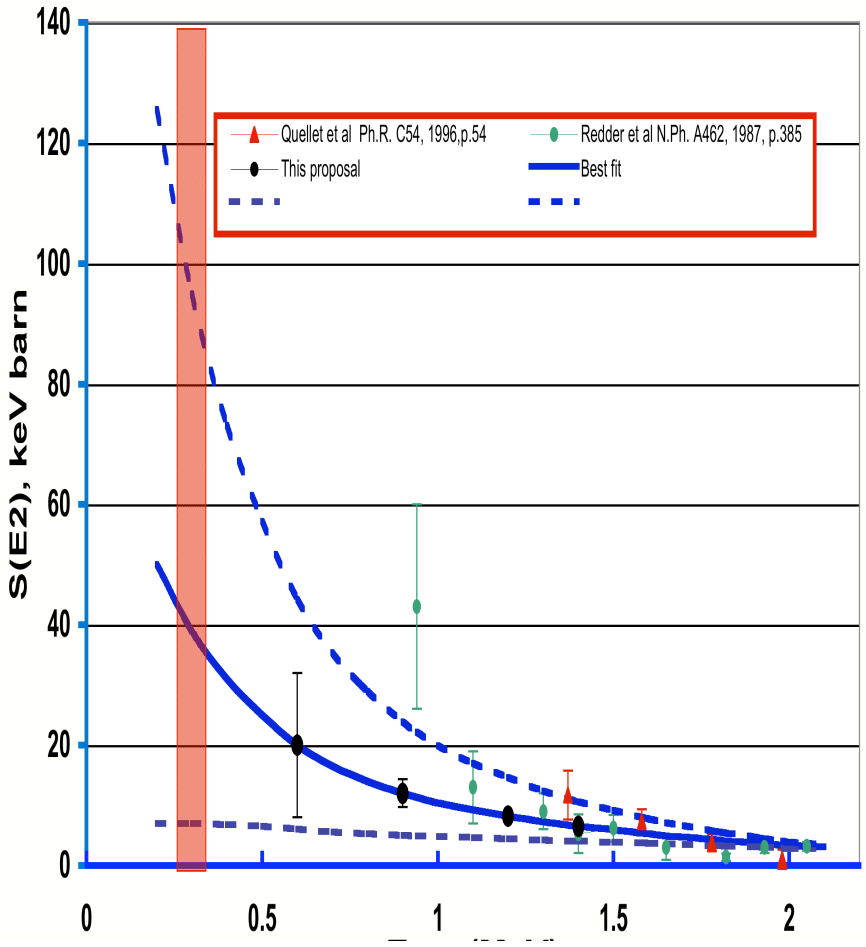
- Nuclear potential models
  - deuteron D state contributions
  - spin-spin interaction

T_{20}



Astrophysics



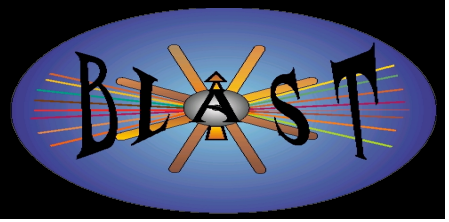


Crucial to astrophysics: $^{12}C(\alpha,\gamma)^{16}O$ at E_α = 300 keV

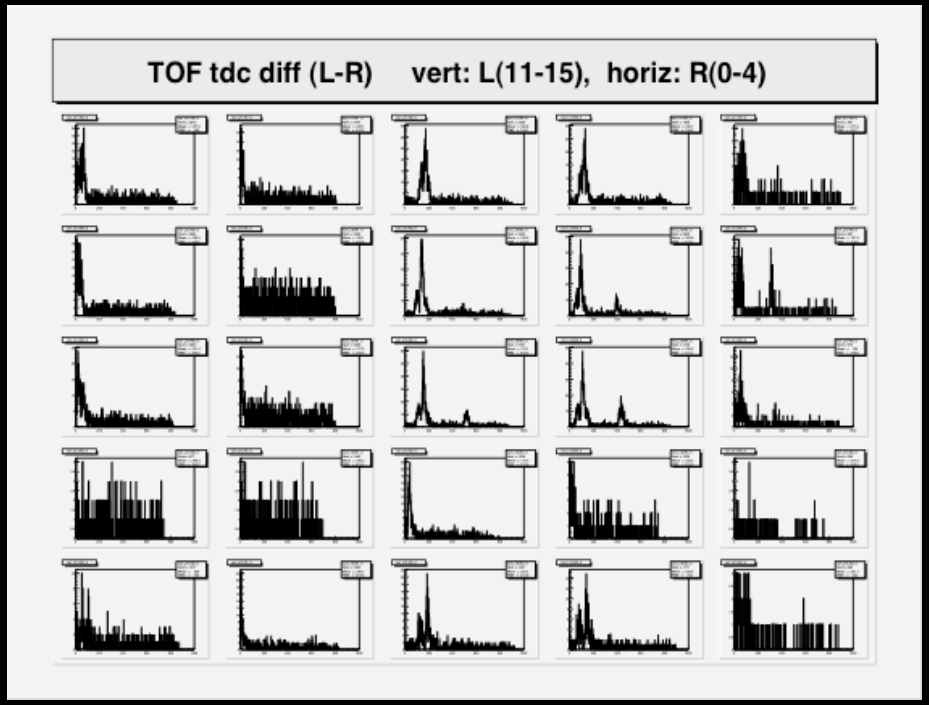
- **New approach : Internal Target**
- **BLAST + recoil**
- **$^{16}O(e,e'\alpha)^{12}C$ reaction at $Q^2 \neq 0$**
- **Concentrate on $Q^2 \rightarrow 0$**
- **Triple coincidence**
- **Low background**

2002 Commissioning

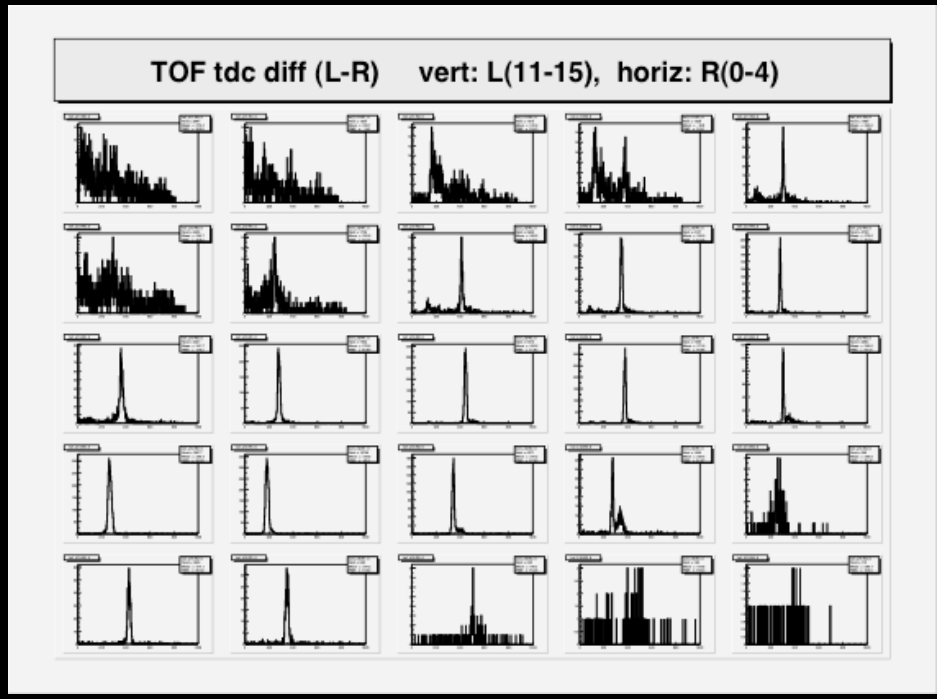
- Summer, 2002
  - Magnetic field mapped
  - TOF, Cerenkov, and Wire chambers installed
  - Optical survey of position
- Fall, 2002
  - Commissioning studies of detector
    - Mostly with unpolarised H target
  - TOF
    - Setup timing for trigger +/- 1 ns
    - Some loss due to magnetic field
      - Added shielding
  - Cerenkov
    - 50% inefficiency with magnetic field
      - Improved shielding being installed this week
- Wire chambers
  - Tracks clearly seen
    - But significant background from space charge noise
      - Sensitive to beam tune
      - Installed beam quality monitor
  - Calibration studies with wire target and no magnetic field
    - Point source, straight tracks
- ABS target
  - Lots of problems - reduced flow
    - Pumping
    - Sextapole magnets weak
    - Operation in tranverse field
      - Spin precession, transport fails



Commissioning TOF Detector



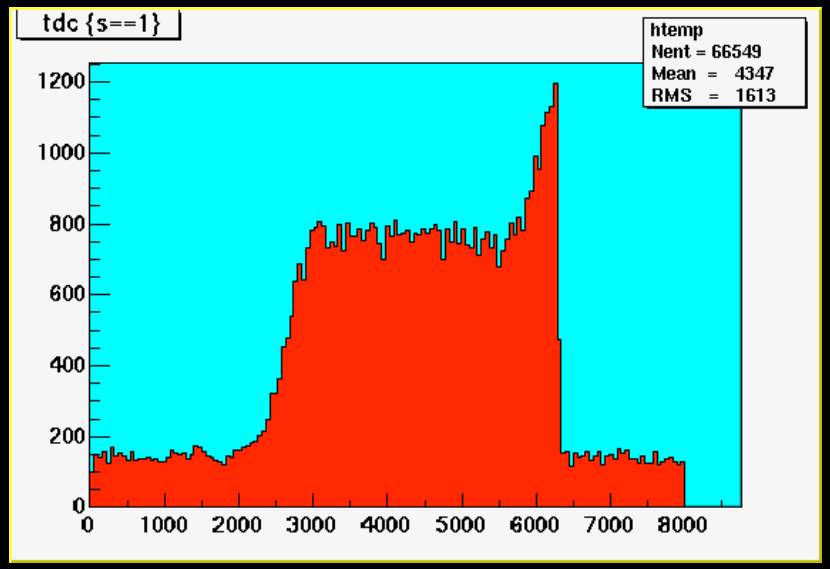
No Hydrogen in target

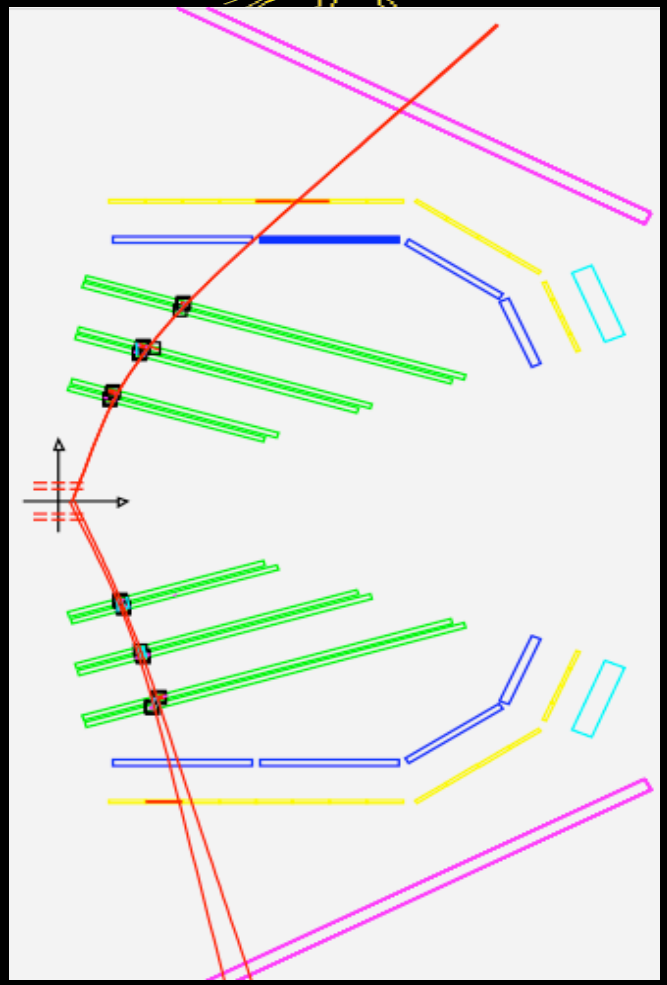


Hydrogen in target

- Timed to +/- 1 ns and trigger established
- Toroid operating at full field (cleans up events)
- Clear ep elastic events from TOF timing alone
  - Cross section in agreement to first order

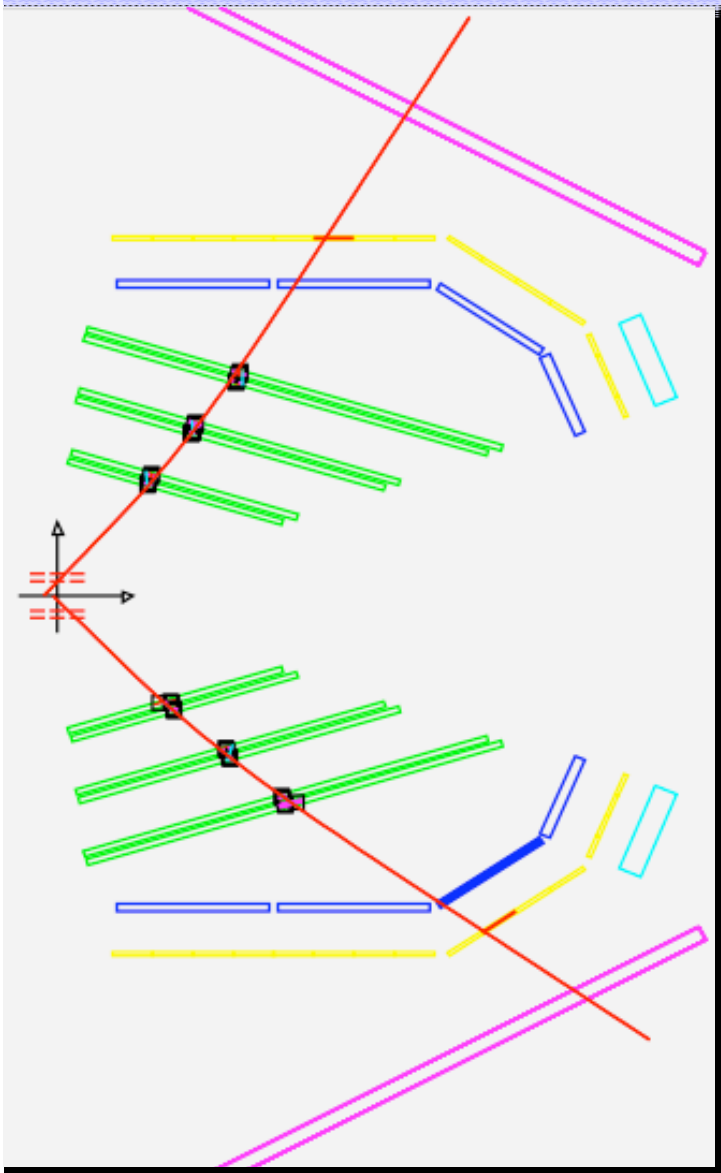
Commissioning Wire Chambers

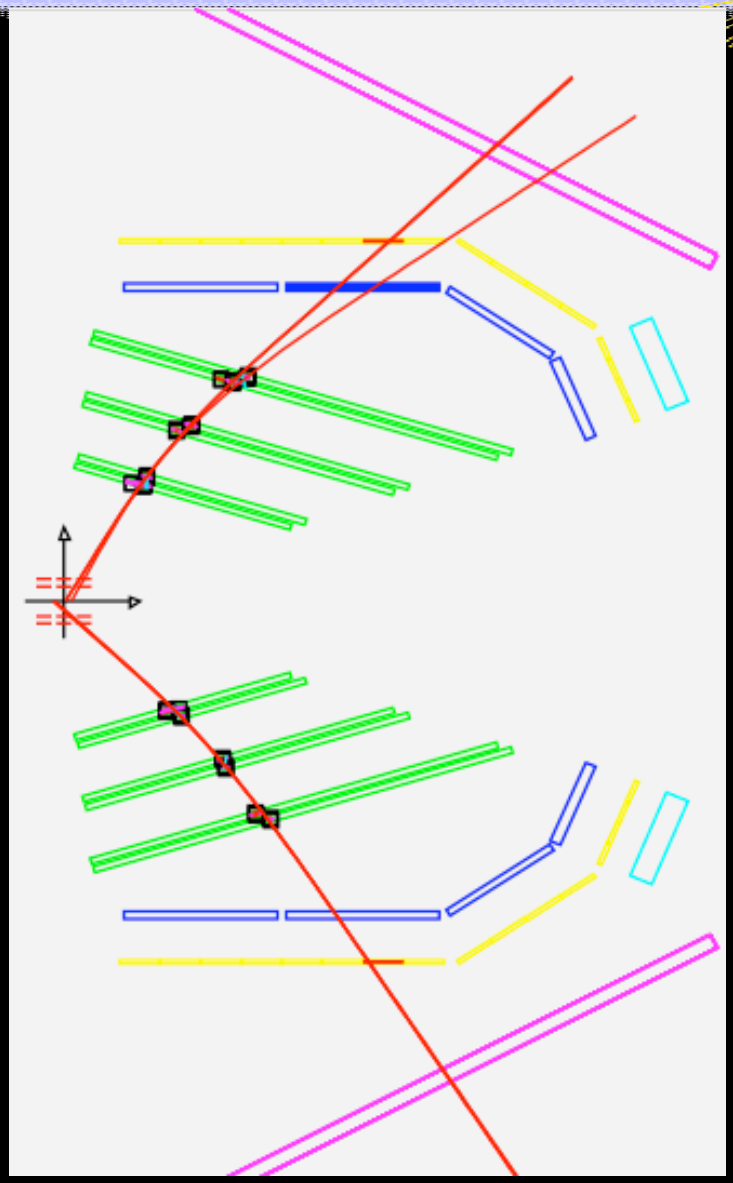




- Wire chambers 70:30 Helium : Isobutane
- After optimising beam steering and tune
  - Beam quality monitor
- Signal to background 5:1
  - No charging over time experienced
  - Actually S/B much better
    - Noise not associated with proper events
  - True events very clean

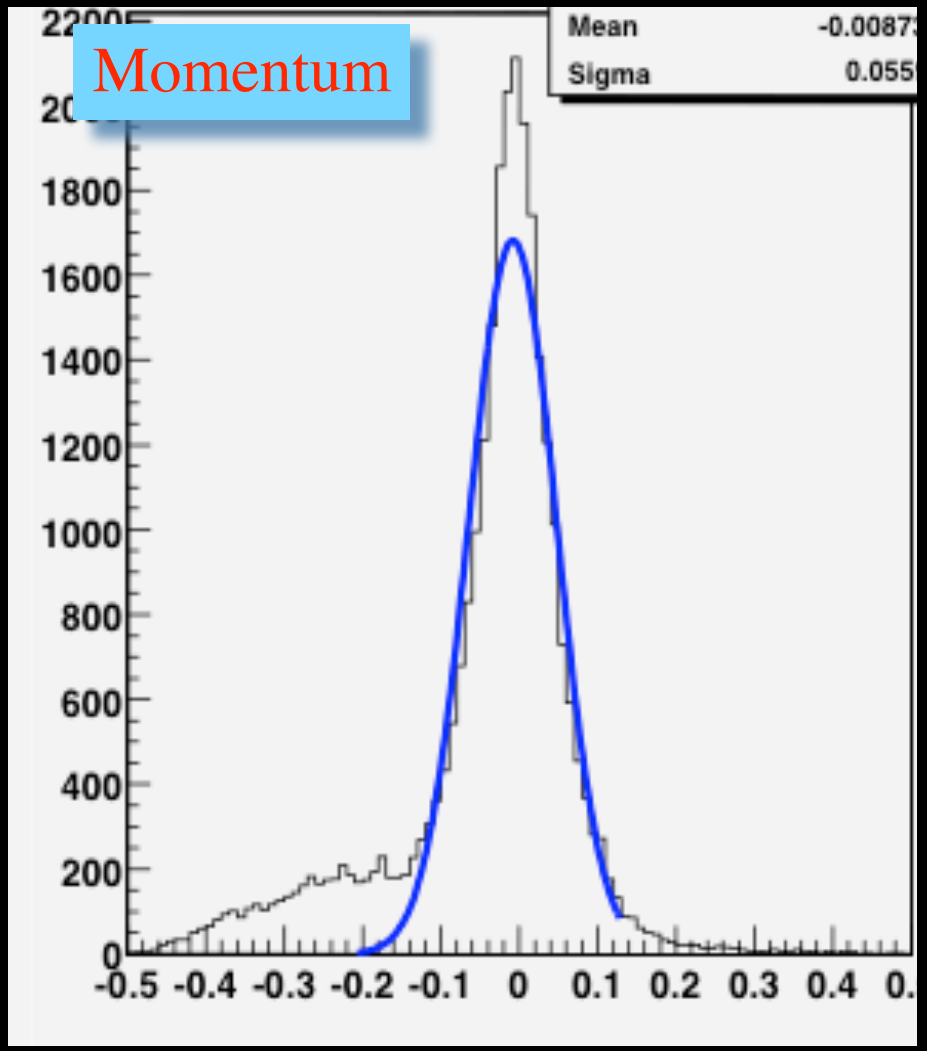
Track Reconstruction

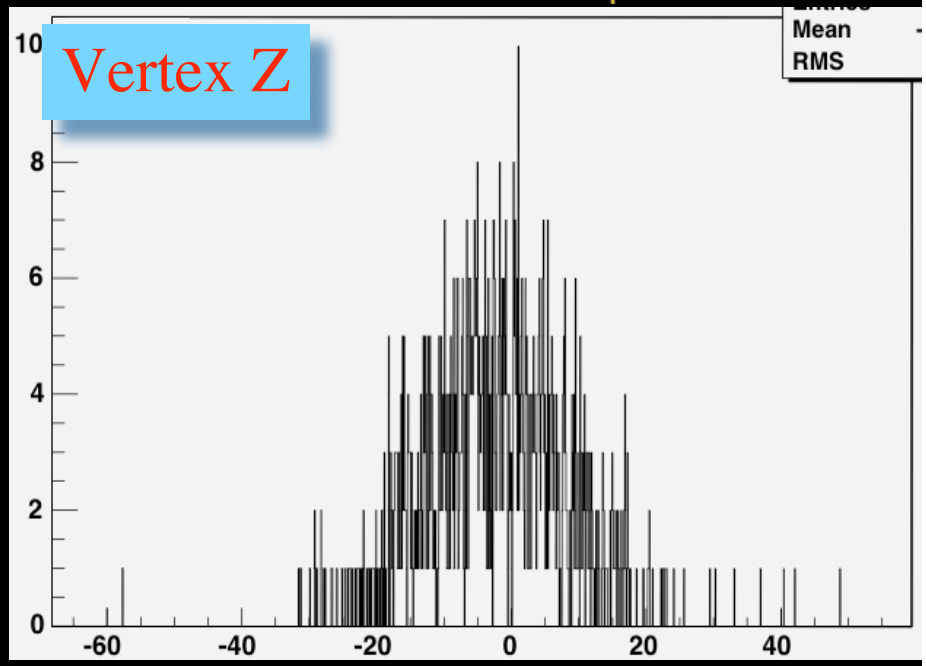




- Still need improved calibration constants
- Double tracks due to multiple hits
- All track solutions shown

ep Track Reconstruction

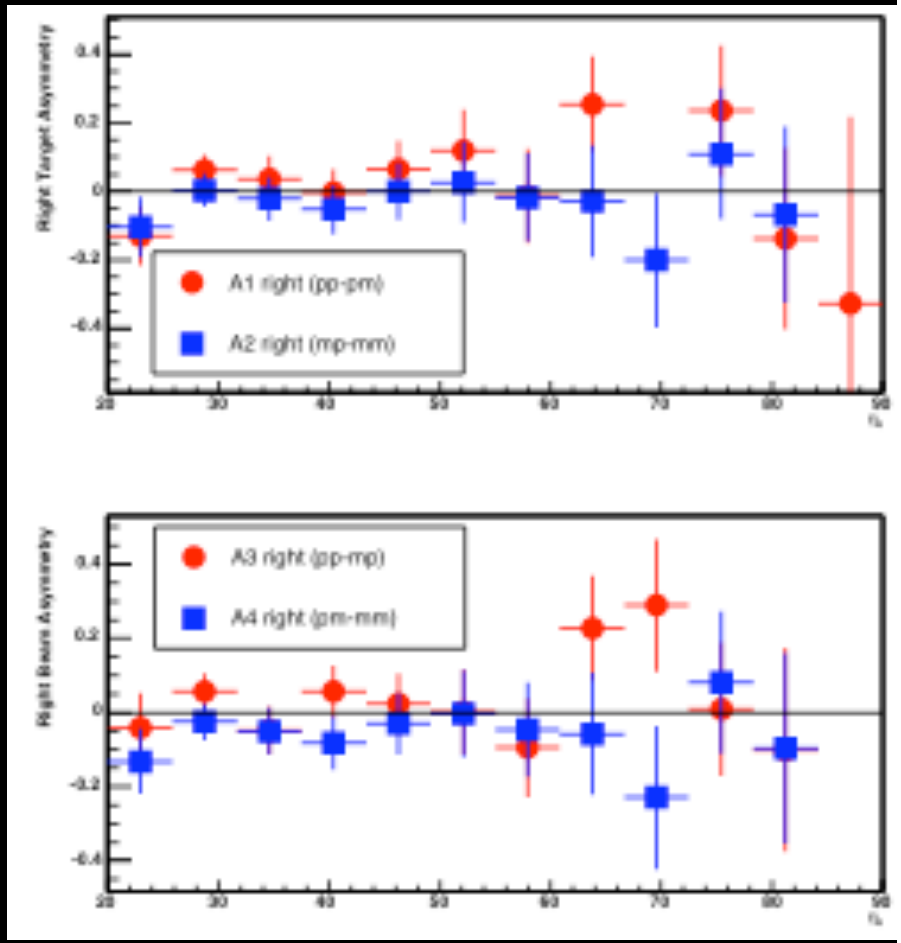




- ΔP/P~5%, Z shows 40 cm target
- Still need to improve calibration
- Energy loss and kinematic constraints still to be implemented

2003 Run Plan

- Shutdown until April, 2003
  - Maintenance, minor upgrades
  - Work on ABS
- Commissioning resumed April
  - Optimised beam with beam quality monitor, verified WC operation
  - Checked timing and trigger
- ABS
  - First polarised H last weekend
  - Indication of asymmetry
    - Old target cell, not cooled
  - Installing ion polarimeter and cooling this week
  - Continue ABS studies to end May
    - New storage cell



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