Measurement of the weak neutral form-factor of the proton at high momentum transfer

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Strange Form Factors Are Not Shown To Be Zero

Flavor separation is required to understand nucleon structure implication of high-Q^2 form factors measurements

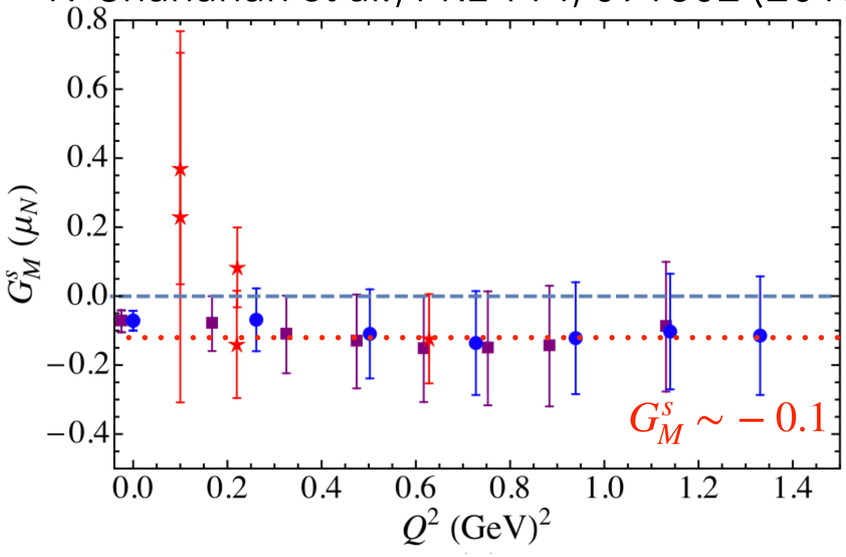
Based on charge symmetry, $u \leftrightarrow d$, but this is an untested assumption above Q^2~0.8 GeV^2

Earlier studies at low Q^2, typically more sensitive to G_E^s, do not extrapolate to a tight constraint at high Q^2

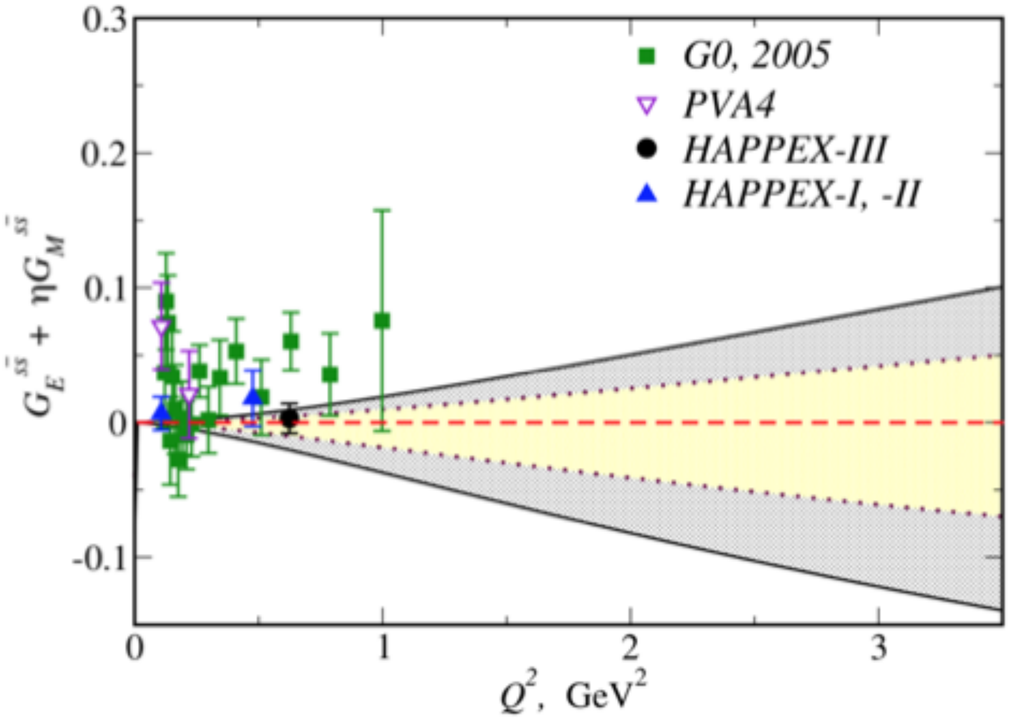
Even lattice results, which looked very small for low Q^2, do not reduce as fast as the dipole shape with Q^2

The weak neutral-current form-factor from parity violation can provide the required bound on this quantity.

P. Shanahan *et al.*, PRL 114, 091802 (2015)



T.Hobbs & J.Miller, 2018



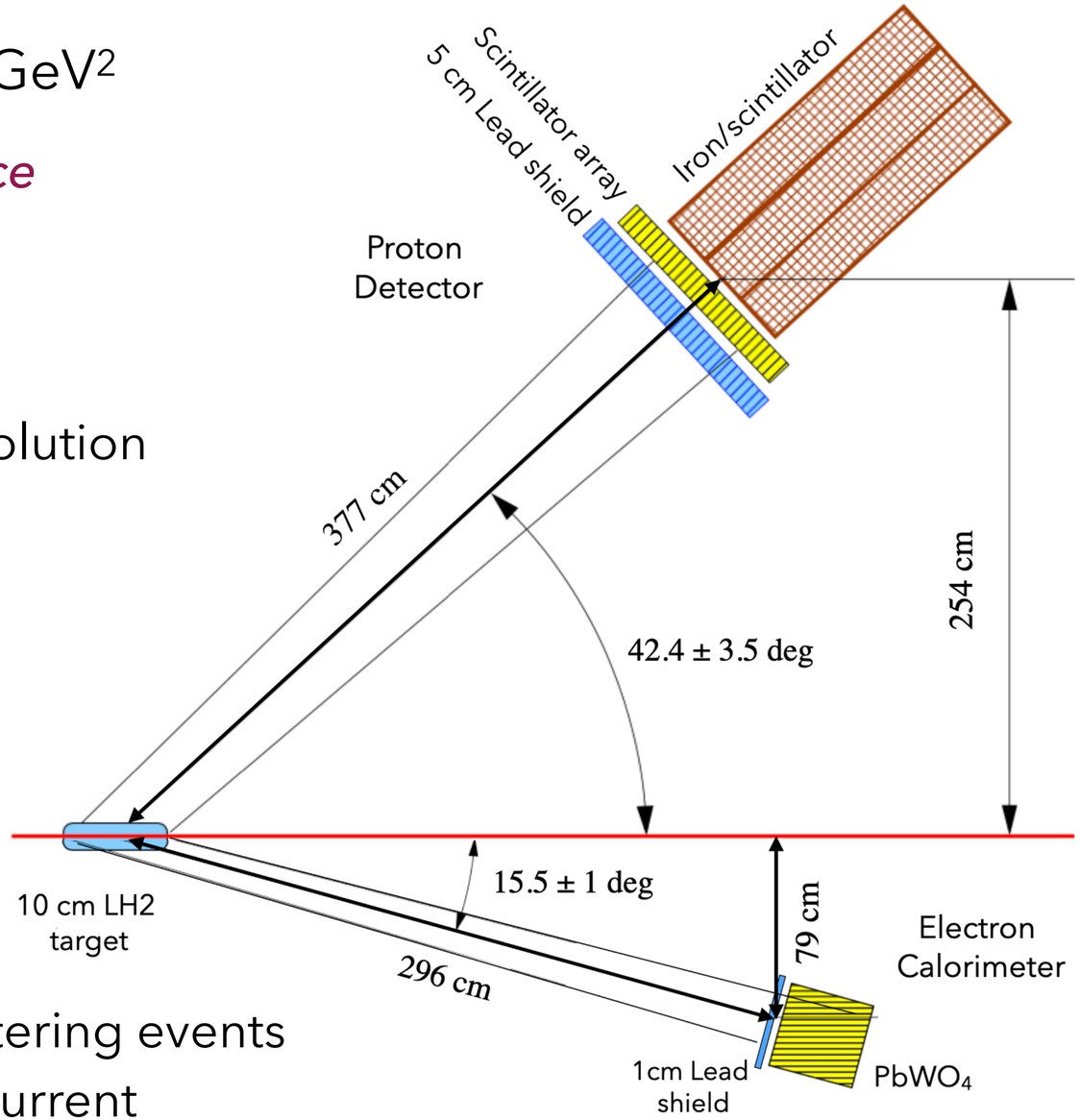
Follows work from *Phys.Rev.C* 91 (2015) 3, 035205
(LFWF to tie DIS and elastic measurements in a simple model)

The planned measurement

Aim for $Q^2 = 2.5\ GeV^2$

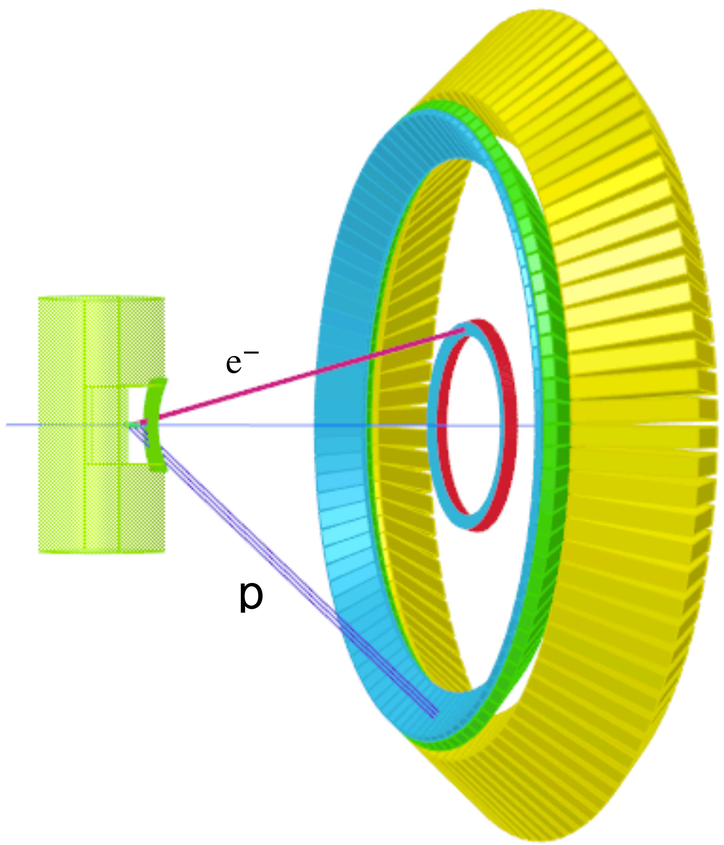
Identify elastic kinematics with electron-proton coincidence

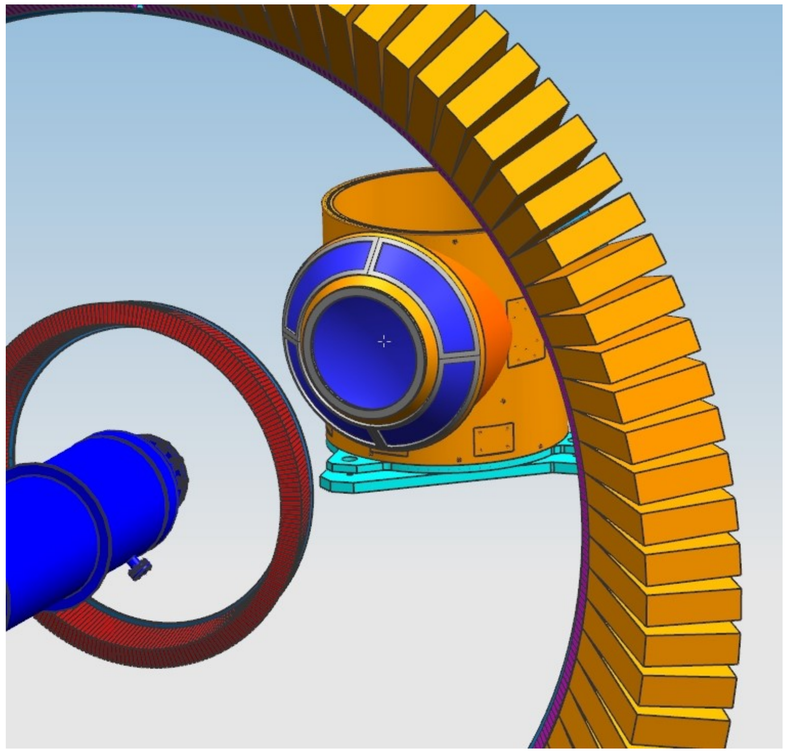
- Angular e-p correlation
- High resolution calorimeter for electron trigger
- Calorimeter for proton trigger
- Scintillator array on proton arm, to improve position resolution



- 6.6 GeV beam energy
- electron at 15.5 degrees, proton at 42.4 degrees
- A_{PV} = 150 ppm, 4% precision goal, so 3×10^{10} elastic scattering events
- $\mathcal{L} = 1.7 \times 10^{38}\ cm^{-2}/s$, 10 cm LH_2 target and 65 μA beam current
- Full azimuthal coverage, ~42 msr

Experimental concept

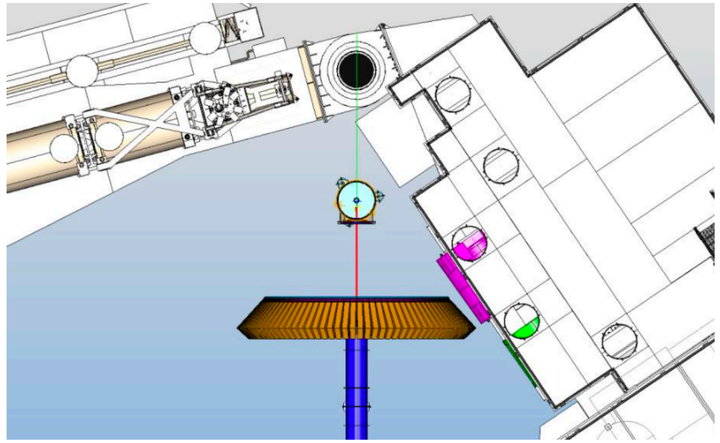


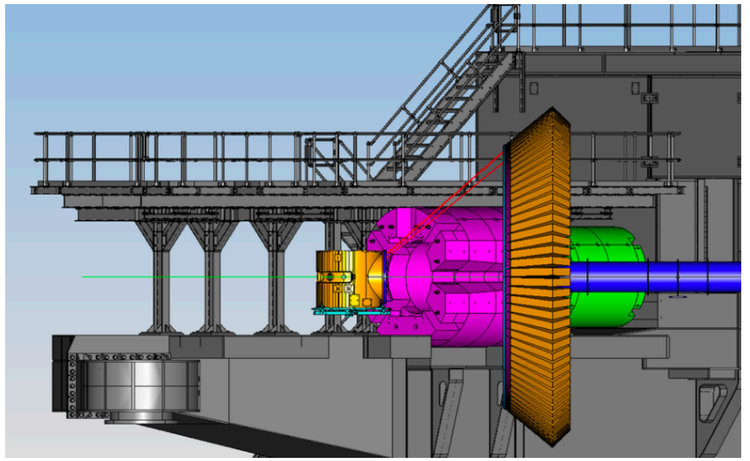


Preliminary design of scattering chamber

He bag will reduce backgrounds between target chamber and exit beampipe

This fits in Hall C (but it's tight)





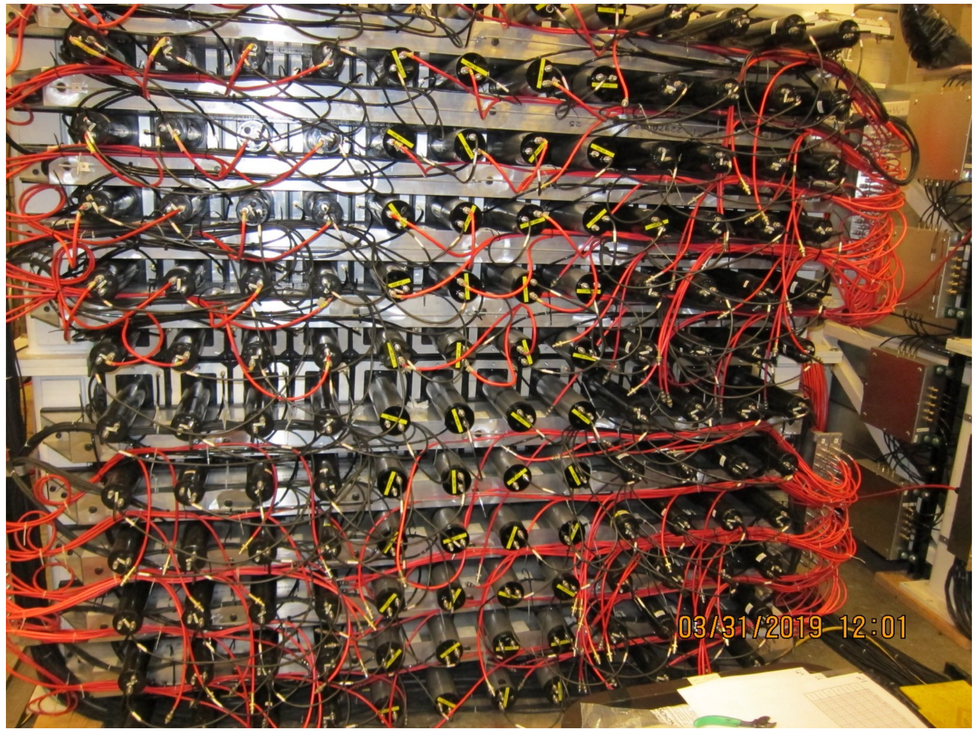
Calorimeter components

NPS electromagnetic calorimeter

- 1200 $PBWO_4$ scintillators, PMTs + bases

SBS hadronic calorimeter

- 288 iron/scintillator detectors, PMTs + bases



Detector System

HCAL - hadron calorimeter

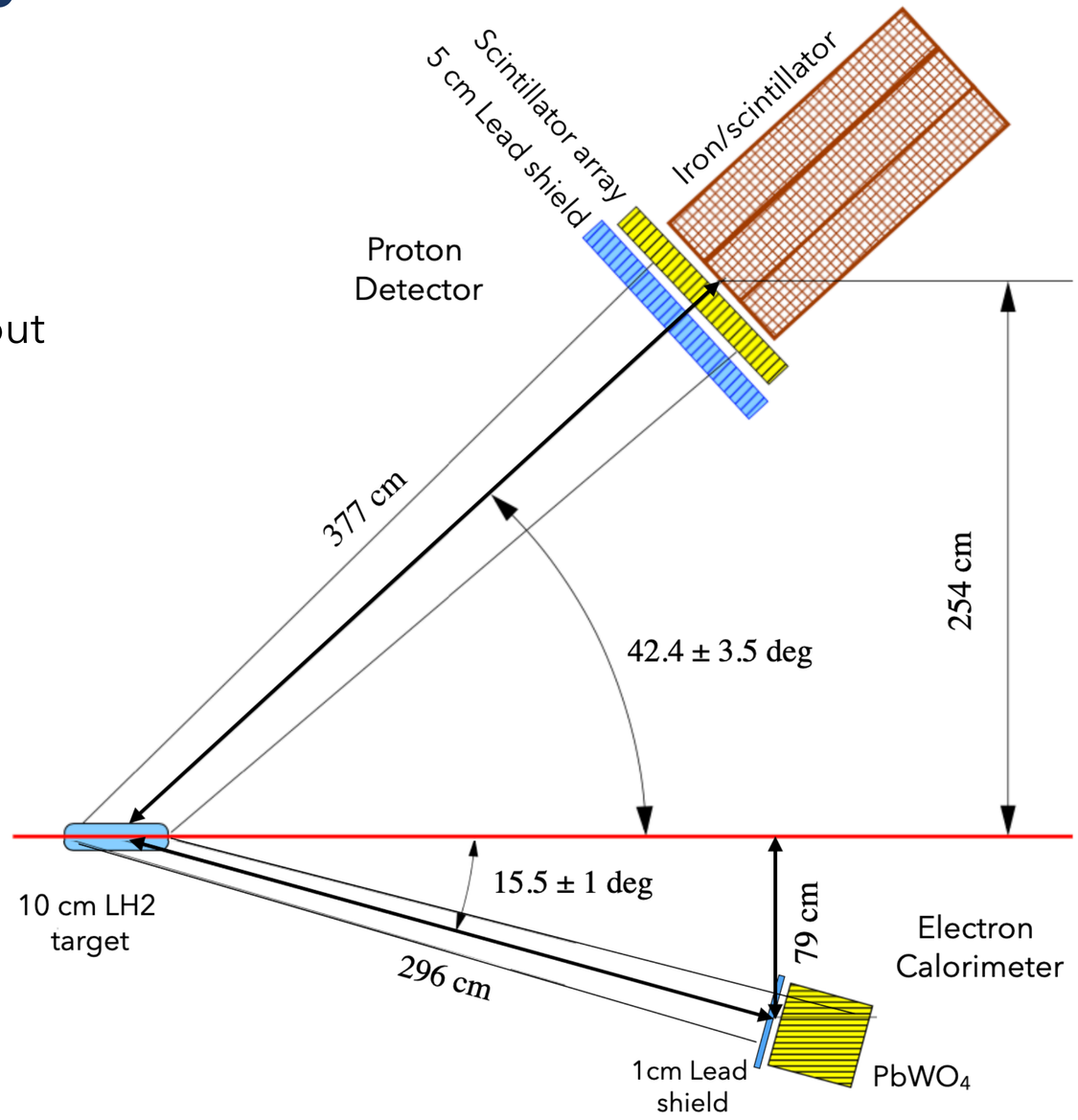
- Detector elements from the SBS HCAL
- 288 blocks, each 15.5 x 15.5 x 100 cm^3
- iron/scintillator sandwich with wavelength shifting fiber readout

ECAL - electron calorimeter

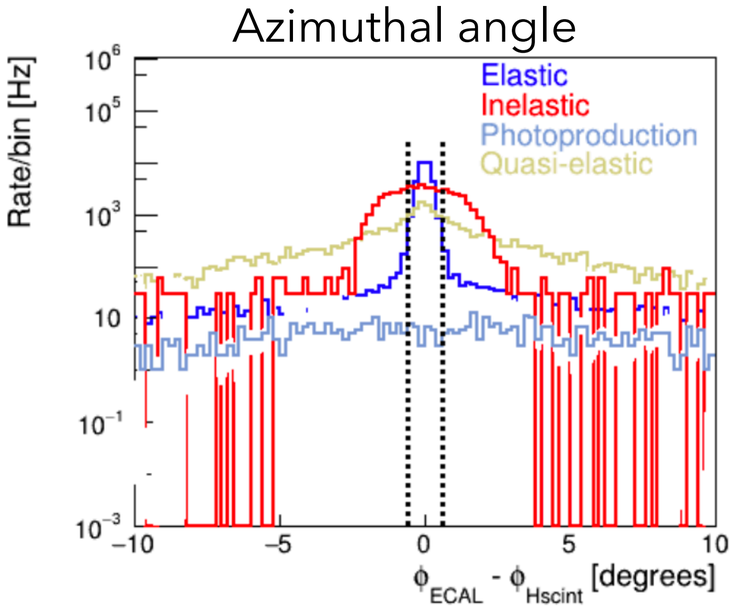
- Detector elements from the NPS calorimeter
- 1200 blocks, each 2 x 2 x 20 cm^3
- $PbWO_4$ scintillator

Scintillator array

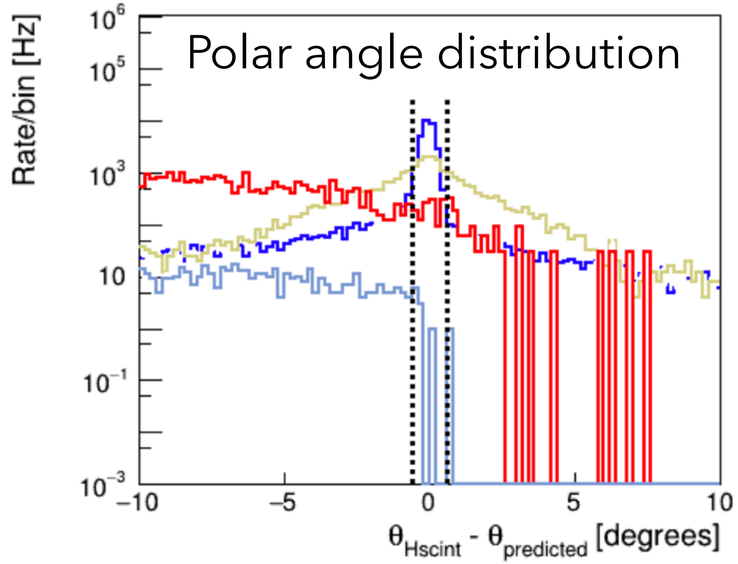
- 7200 plastic scintillators, each 3 x 3 x 10 cm^3
- Wavelength shifting fiber to MA-PMT
- Used for position resolution in front of HCAL

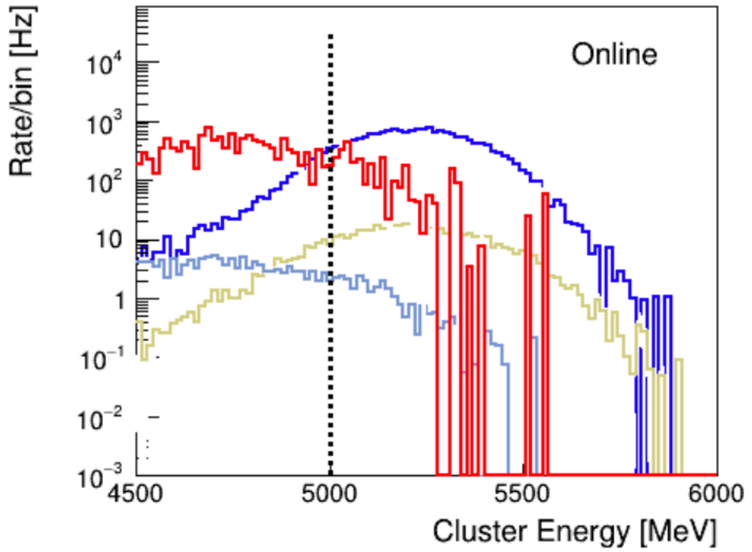


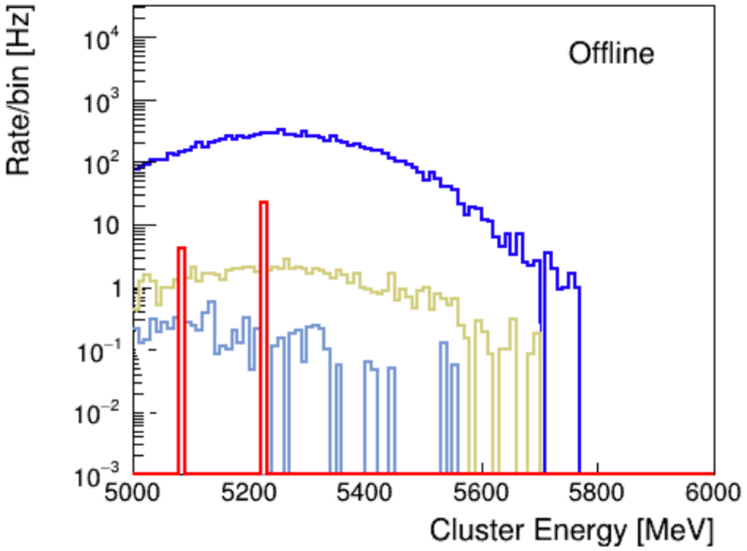
Elastic event discrimination



dashed lines = offline cuts







Online: ECAL vs HCAL coincidence, loose time and geometric cut

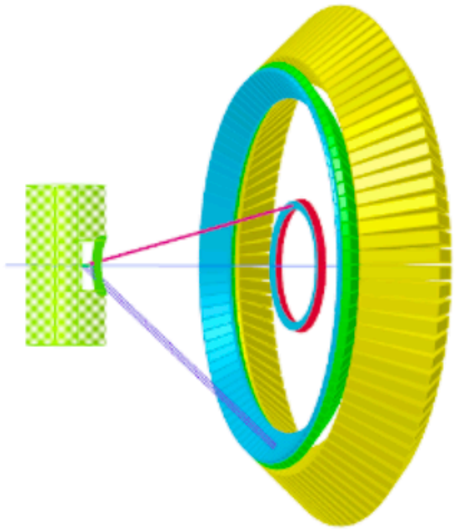
Offline: tighten geometric cut with pixel hodoscope and ECAL cluster center

Exclude inelastic background to ~0.2%

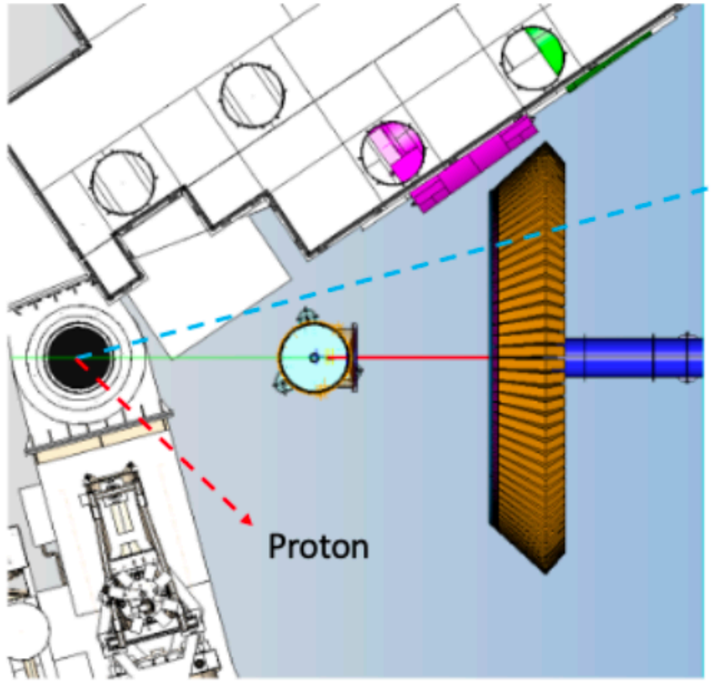
Fraction of total by event type	Offline
Elastic scattering	0.989
Inelastic (pion electro-production)	0.002
Quasi-elastic scattering (target windows)	0.008
π^0 photo-production	0.001

"sideband" analyses will help verify QE and inelastic asymmetries

Next Step - Test Performance of Detector Concept



electron angle 15.5°
proton angle 42.4°



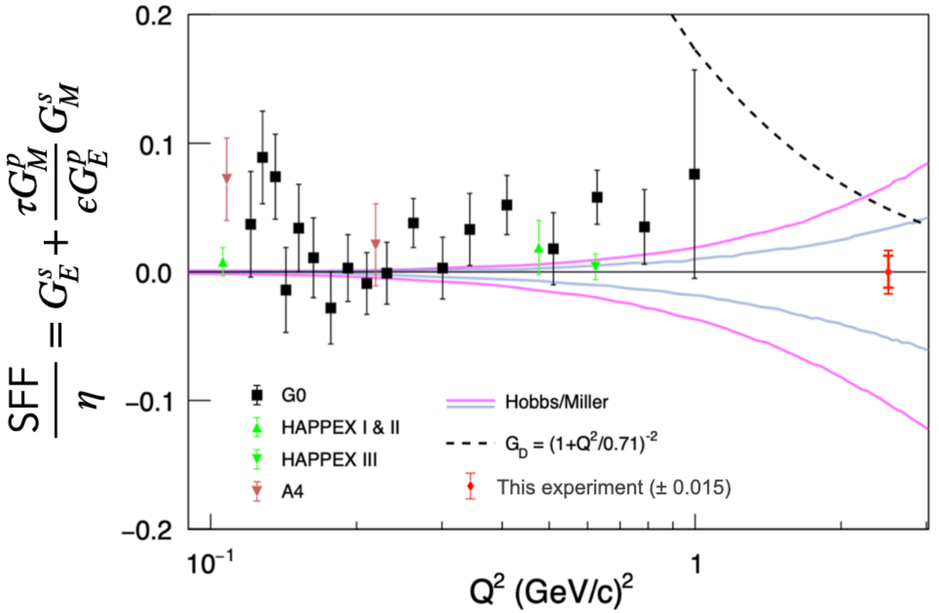
One can position the SHMS to 15.5° to detect electrons, measured in coincidence with a prototype proton detector at 42.4°

Prototype proton detector:

- pixel array of 20 small scintillators with MA-PMT readout + 2x2 SBS HCAL blocks
- FADC readout in spectrometer DAQ
- 50uA on 15cm Hydrogen target at 6.6 GeV, about 2kHz rate into detector
- test elastic identification and background rate and exclusion

“sFF” Strange Form Factors at High Q^2

10+ years after the last sFF searches were performed, a new experiment is now planned for much higher Q^2, motivated by interest in flavor decomposition of electromagnetic form factors



Progress, but significant work still to be done toward beam test

- scintillator array prototype construction (soon to start)
- assemble and test HCAL prototype
- simulation to select proton arm location
- mechanical design of proton arm test stand
- Detail DAQ configuration and prepare analysis