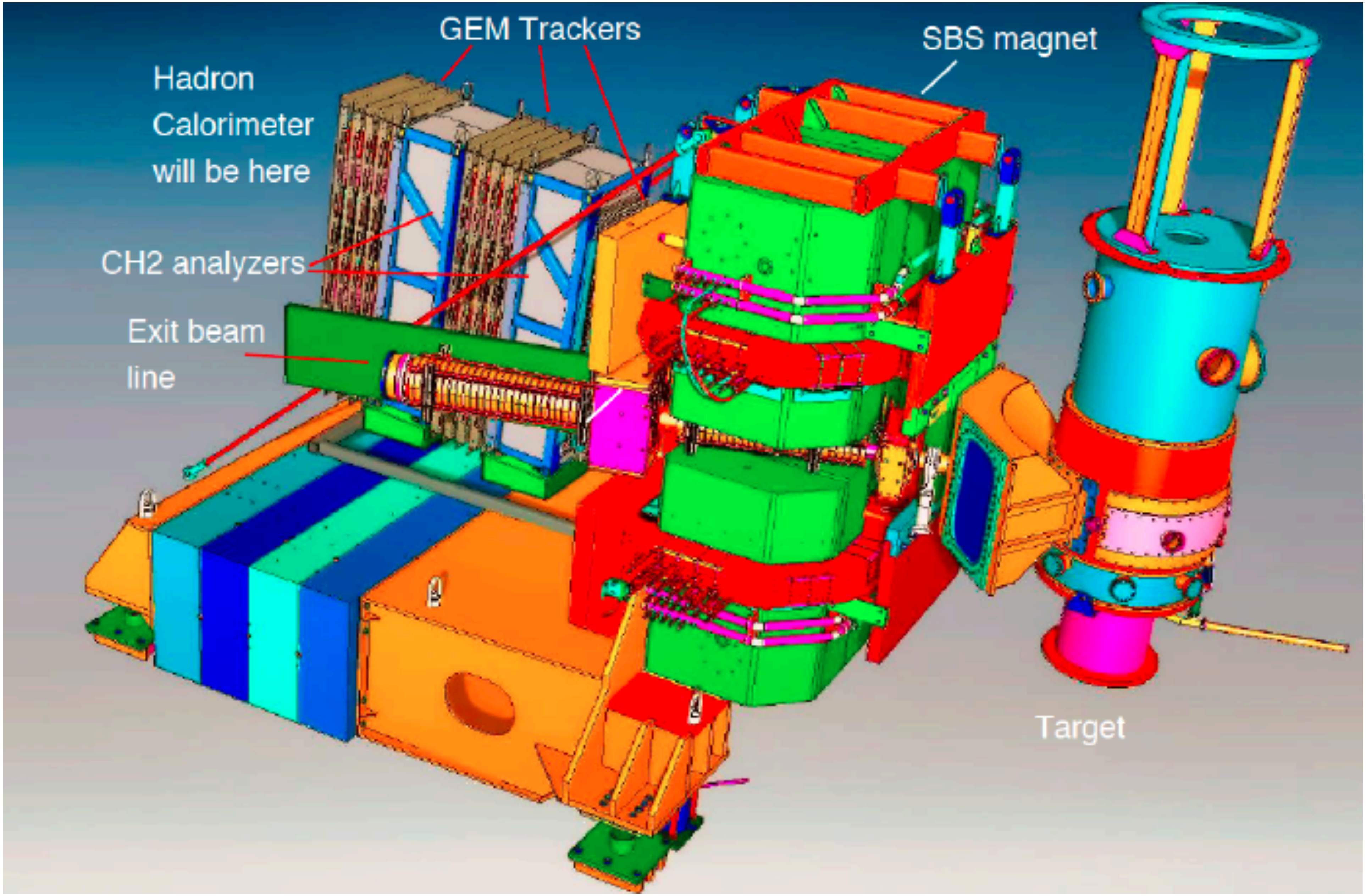
Super Bigbite Spectrometer (SBS) Project

Nilanga Liyanage
(for the SBS Collaboration)

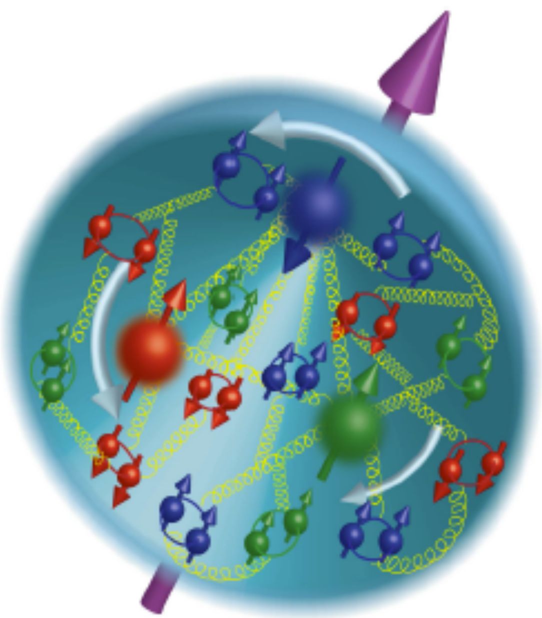

GEM Trackers
SBS magnet
Hadron
Calorimeter
will be here
CH2 analyzers
Exit beam
line
Target

SBS Program Status

- All sub-system work moving ahead very well.
- Installation expected to start May 2020
- SBS collaboration meeting in a month: Feb 26-27

Nucleon Elastic Form Factors

- The Form Factors (FF) are fundamental quantities which describe internal structure of the nucleons
- Related to charge and magnetization distributions of the nucleon
- Investigation of FFs provide a powerful tool toward understanding of non-perturbative QCD and confinement
- Much experimental progress in past two decades: unexpected results that is inspiring theoretical progress.

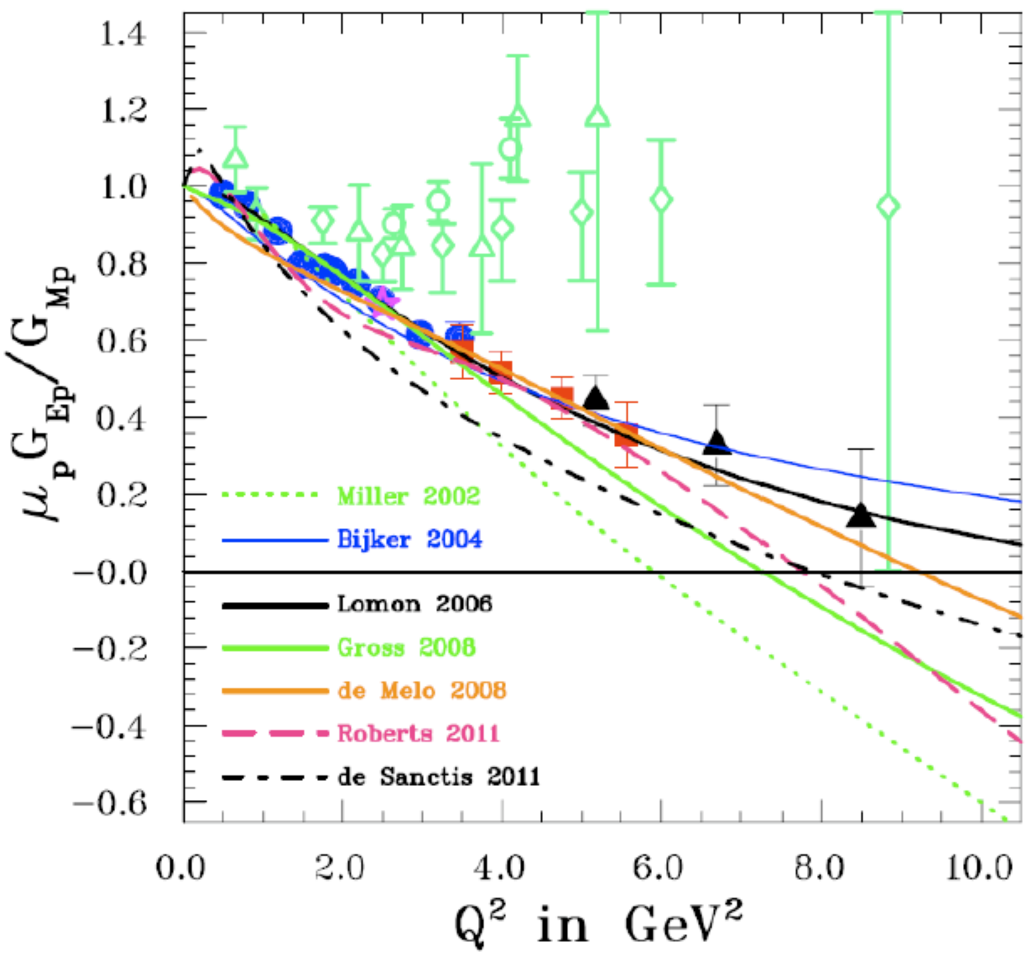


Standard Model is not complete till we figure out non-perturbative QCD and confinement.

- How does the nucleon acquire its mass: only 2% of the nucleon mass comes from Higgs.
- How does the confinement come about ?

G_{Ep}/G^{Mp} data at high Q^2

Several calculations able to reproduce the new data.



•Descriptions differ in details, but nearly all are directly or indirectly related to quark angular momentum

Dyson-Schwinger equations, as continuum approach to QCD (Roberts et al.)

Modified pQCD scaling prediction by Ji,Belitsky et al: includes quark angular momentum component

pQCD prediction for large Q^2:

$$S \to Q^2 F_2/F_1$$

pQCD updated prediction:

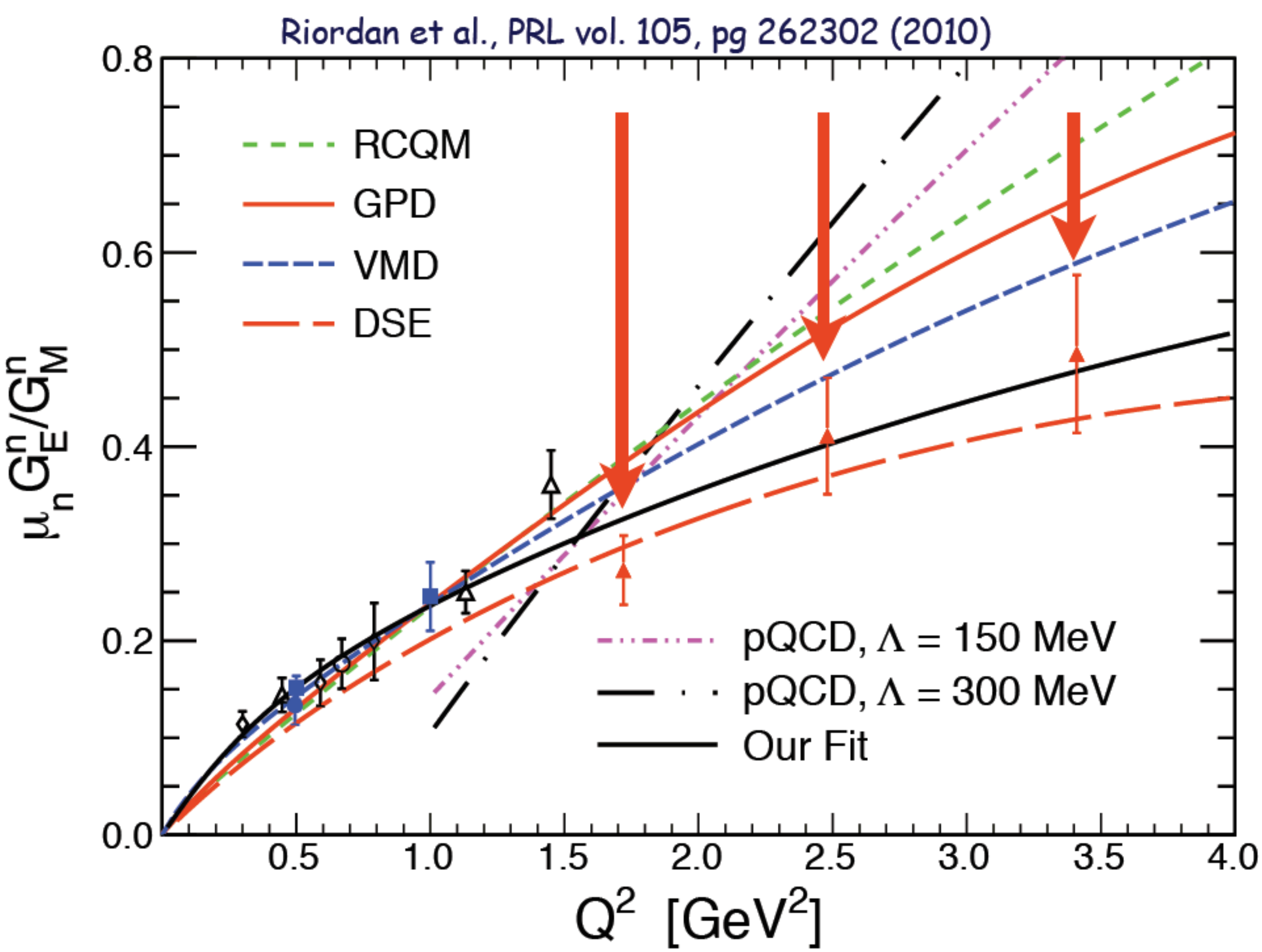
$$S \to [Q^2/\ln^2(Q^2/\Lambda^2)]\ F_2/F_1$$

VMD fits

New $\mu G_{En}/G_{Mn}$ results

The pQCD scaling with
logarithmic corrections (Ji, Belitsky) is too high

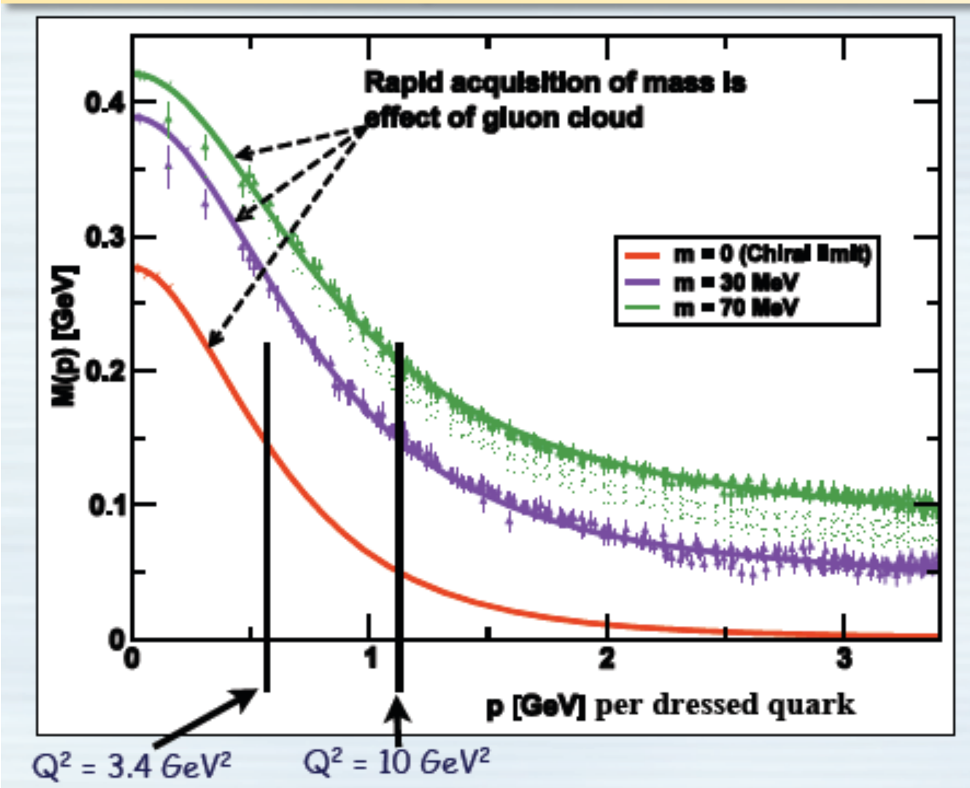
Relativistic
constituent quark
models also too high



Dyson
Schwinger Equation
approach is in
good agreement with our
high Q2 data

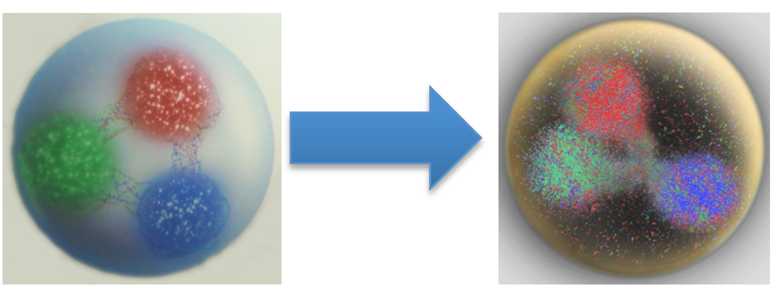
We clearly need higher Q2 data to distinguish between these models

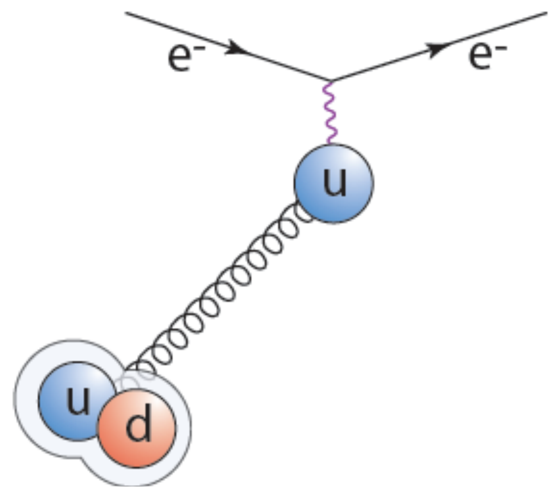
Dyson-Schwinger Equations based approach to non-perturbative QCD – Roberts et al.



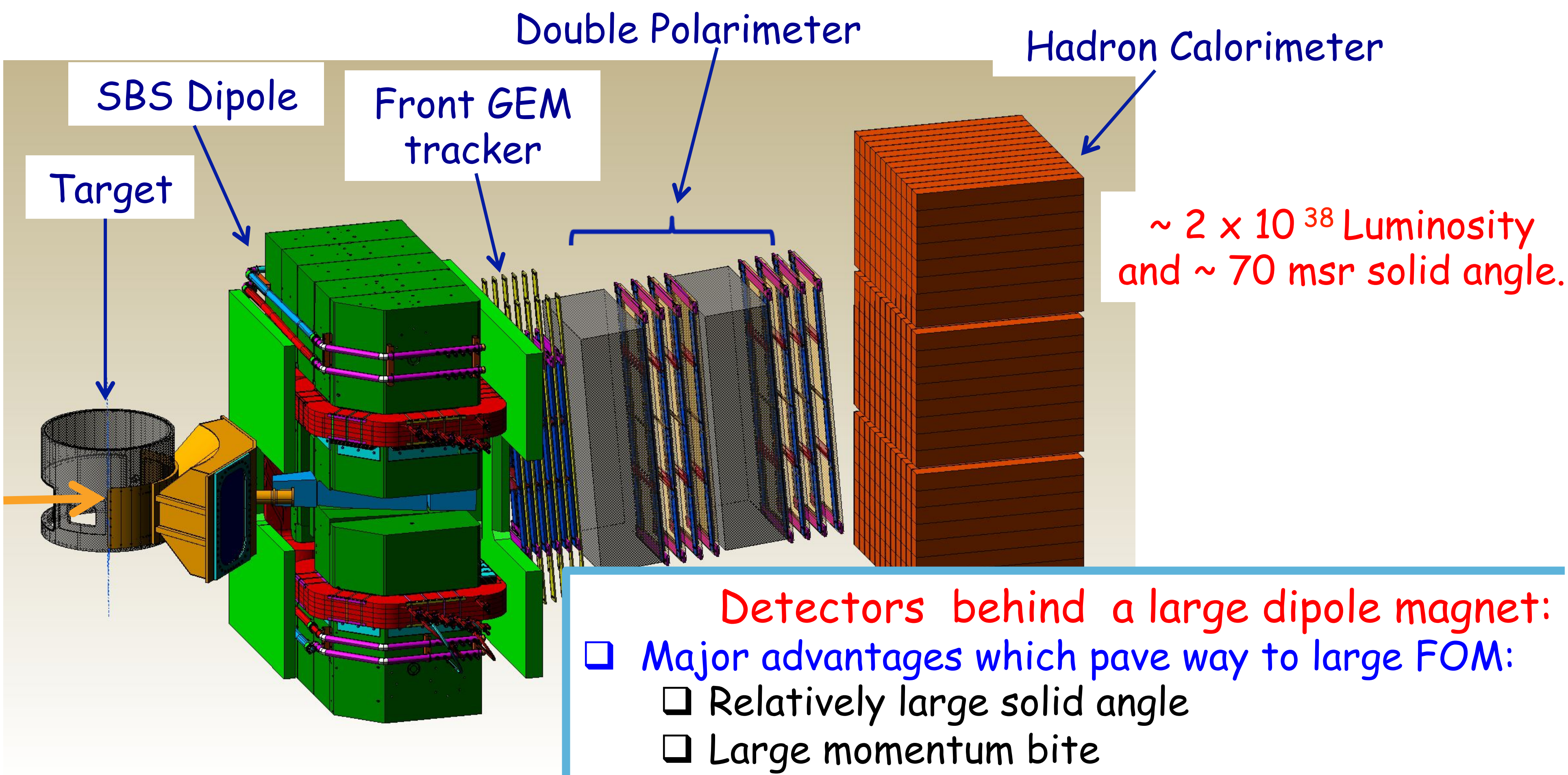
- Well suited to Relativistic Quantum Field Theory. Non Perturbative, continuum approach to QCD
- Hadrons as composites of current Quarks and Gluons
- Incorporates di-quark degrees of freedom.
- Confinement and DCSB are readily expressed
- Prediction: owing to DCSB in QCD, strong diquark correlations exist within baryons

Dynamic generation of mass





Jefferson lab Super Bigbite Spectrometer (SBS)

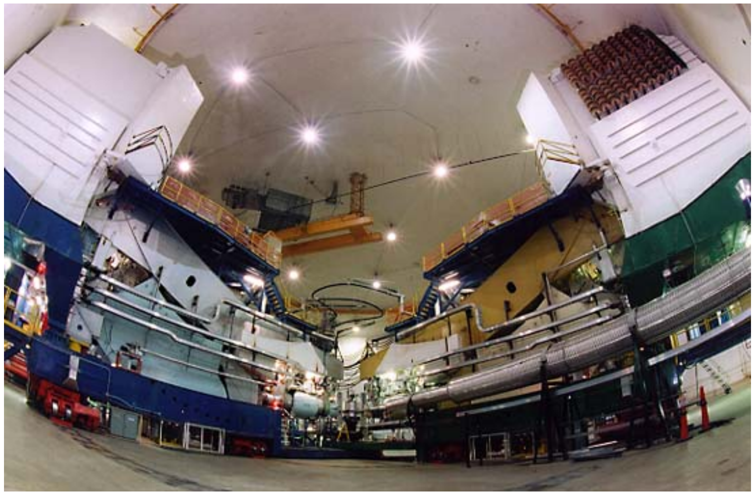


Detectors behind a large dipole magnet:

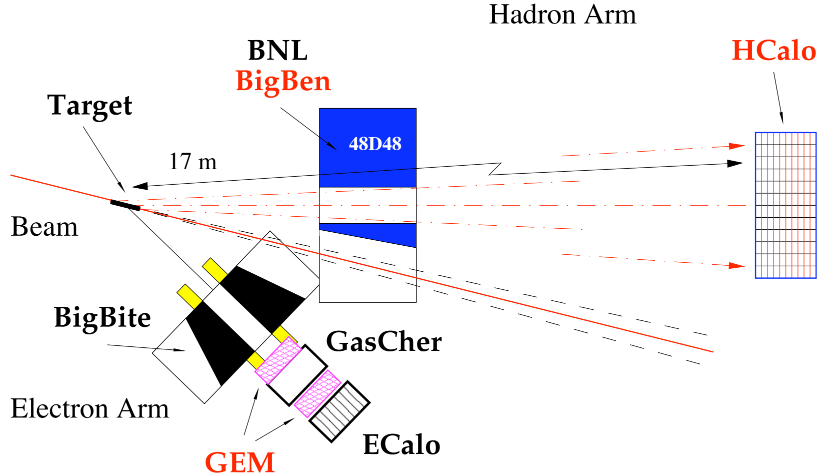
- Major advantages which pave way to large FOM:
  - Relatively large solid angle
  - Large momentum bite
  - Straight line track analysis.
  - Detectors shielded from charged particle background.
- Consequences:
  - High rates at detectors.
  - Need good coordinate resolution.

SBS experimental setup

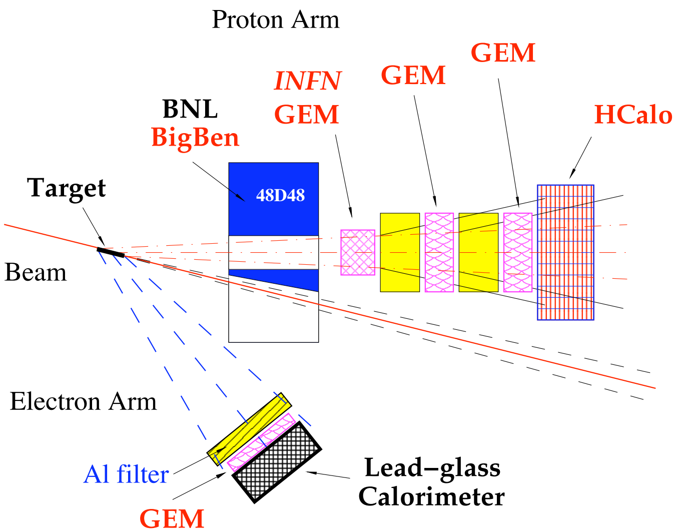
Proton magnetic form factor: E12-07-108



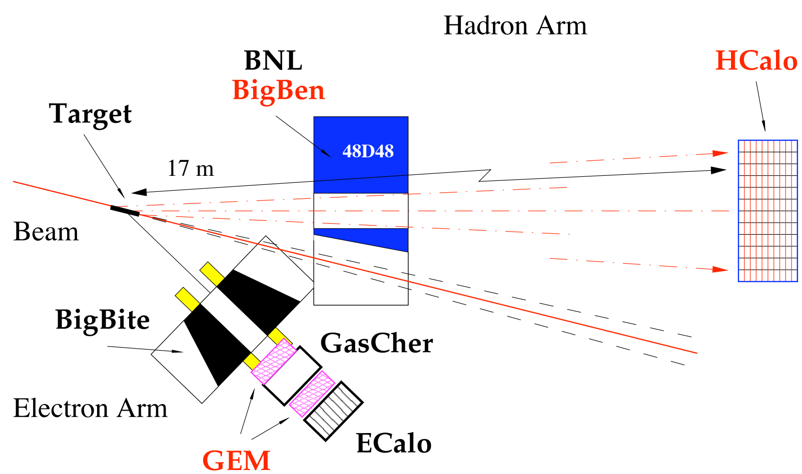
Neutron/proton form factors ratio: E12-09-019



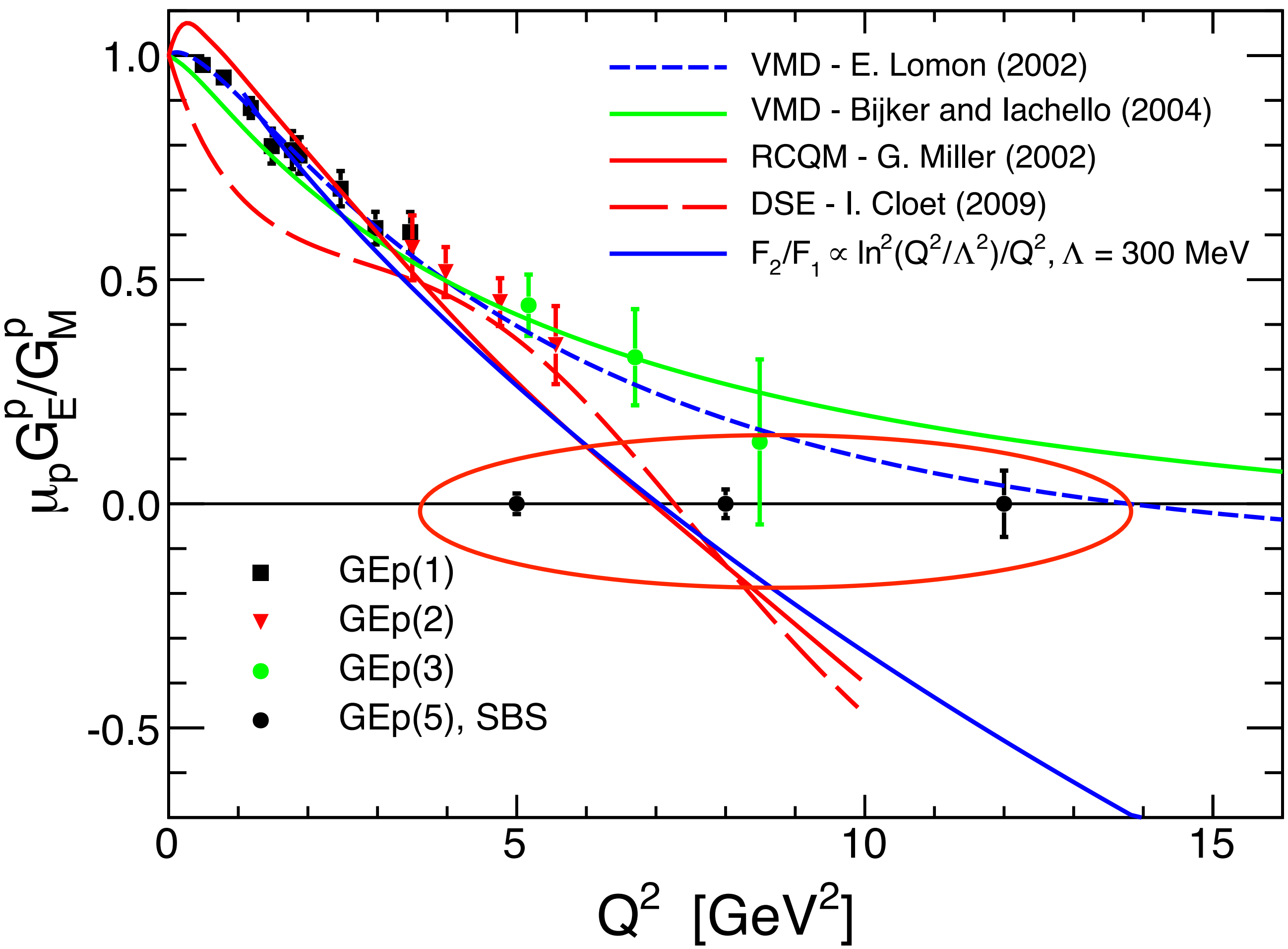
Proton form factors ratio, GEp(5): E12–07–109



Neutron form factors ratio, GEn(2):E12-09-016

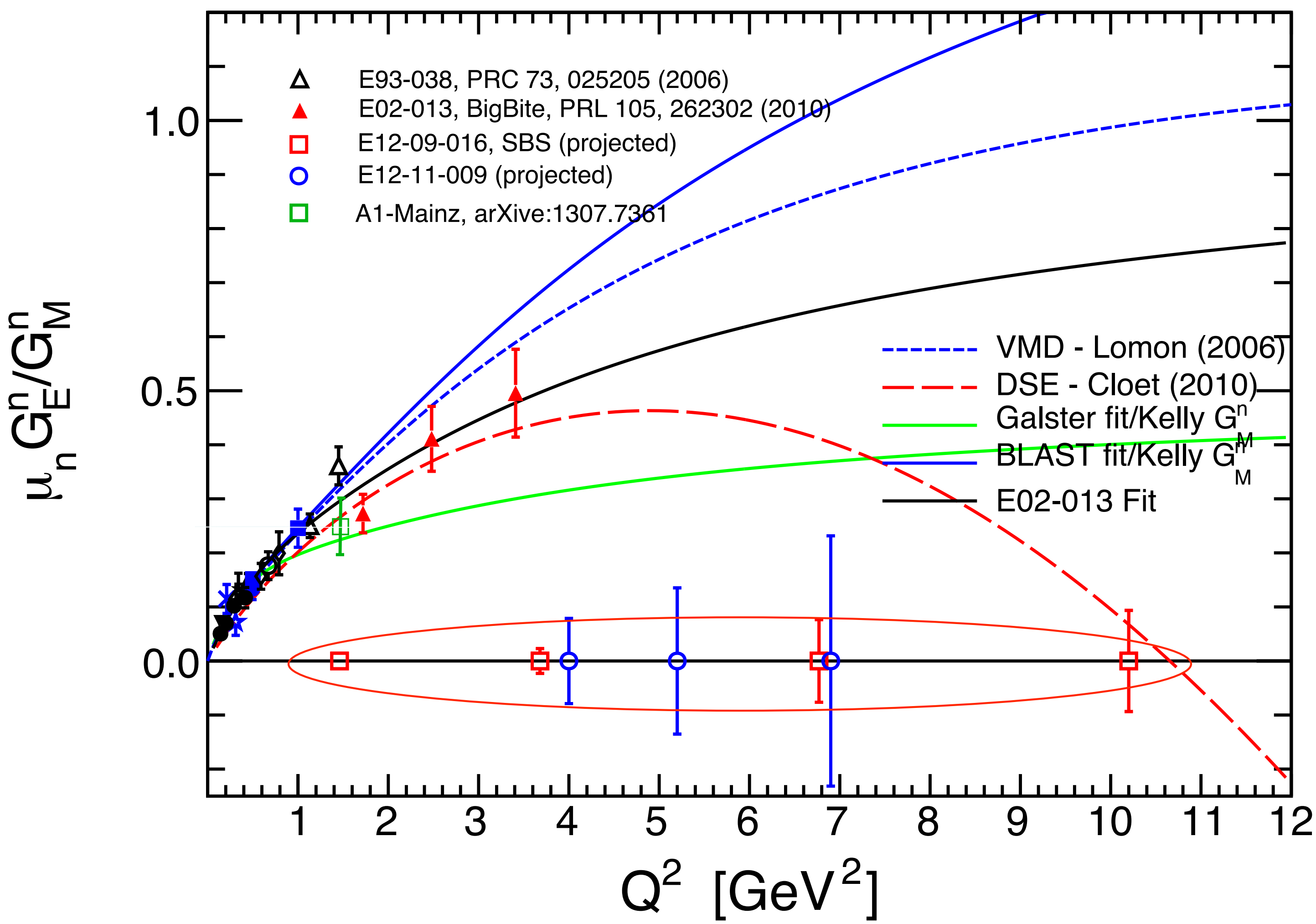


12 GeV GEp experiment



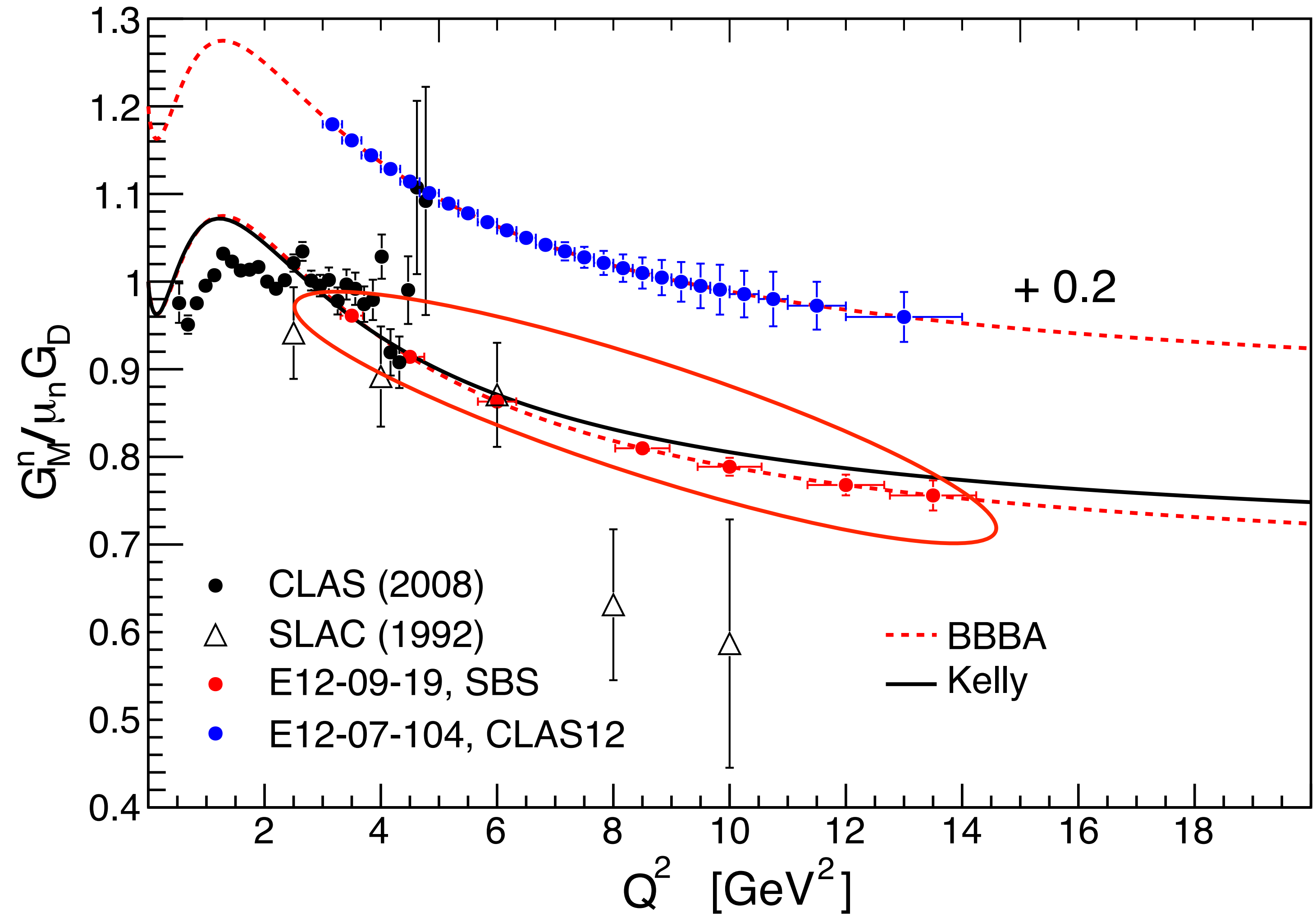
12 GeV GEn experiment

Asymmetry in the polarized electron scattering from the polarized ^{3}He

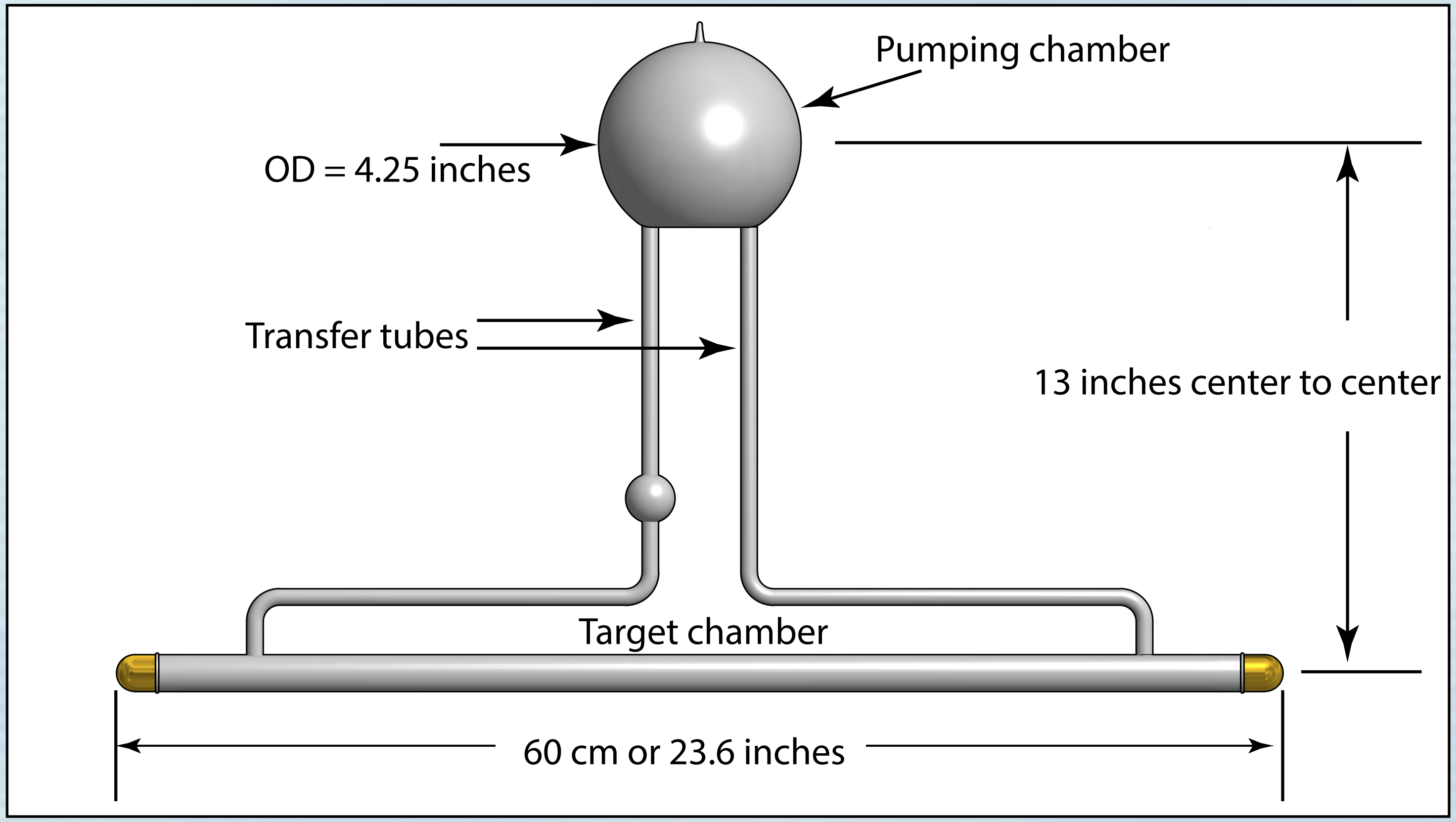


12 GeV GMn experiment

Ratio of the cross sections $D(e, e'n)$ and $D(e, e'p)$



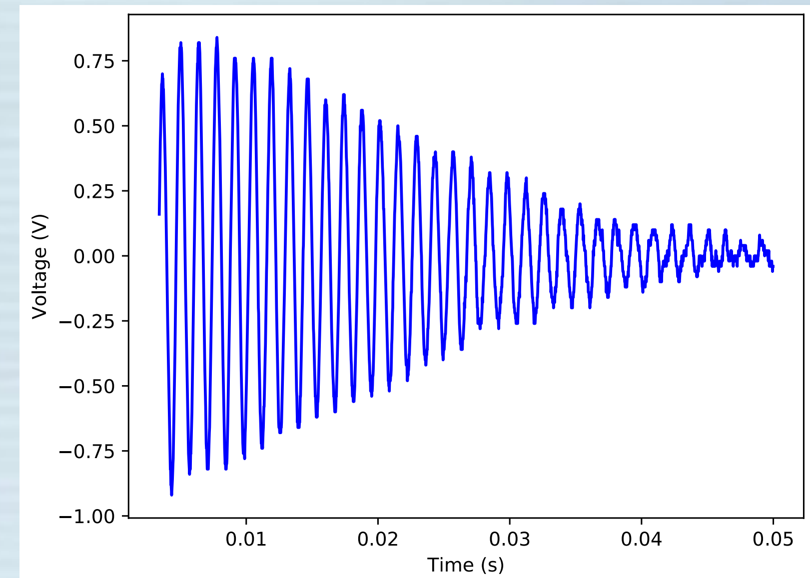
Glass-and-metal target cell development

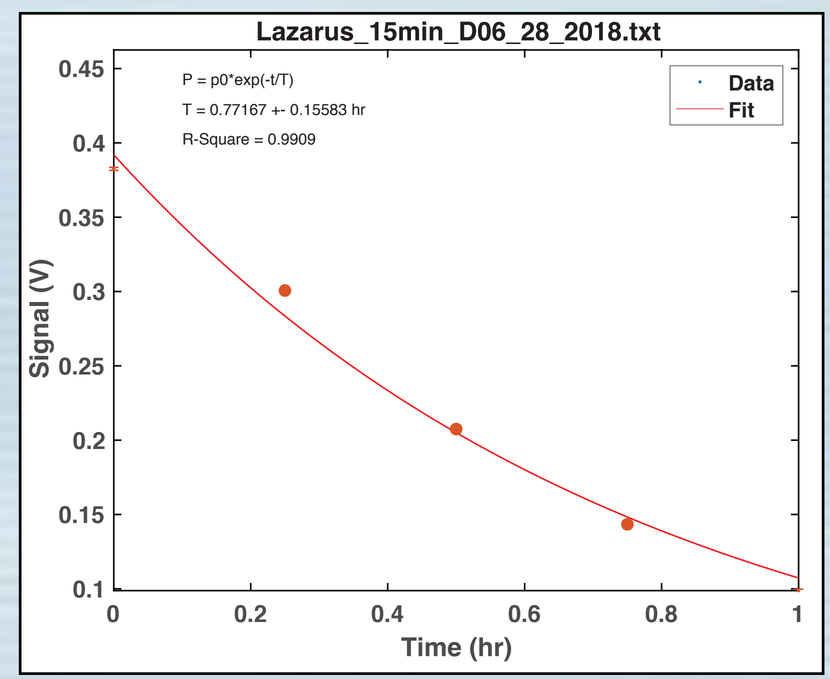


G_E^n-style Stage-II target cell design

Nearly ready to begin testing the Mark-II end-window assembly

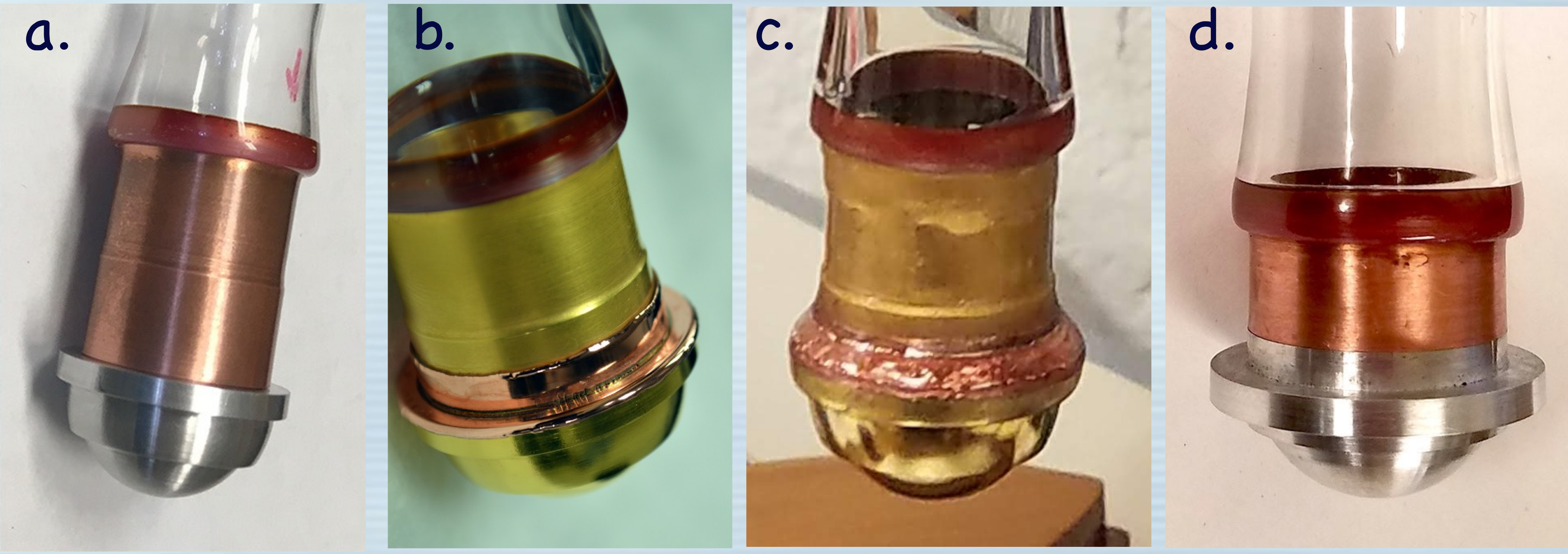
Test of Lazarus - first test cell containing thin (6 mil) aluminum window





Lifetime was short, but there were multiple problems with the cell, so we considered this a partial success.

Comparing Mark-I and Mark-II window assemblies



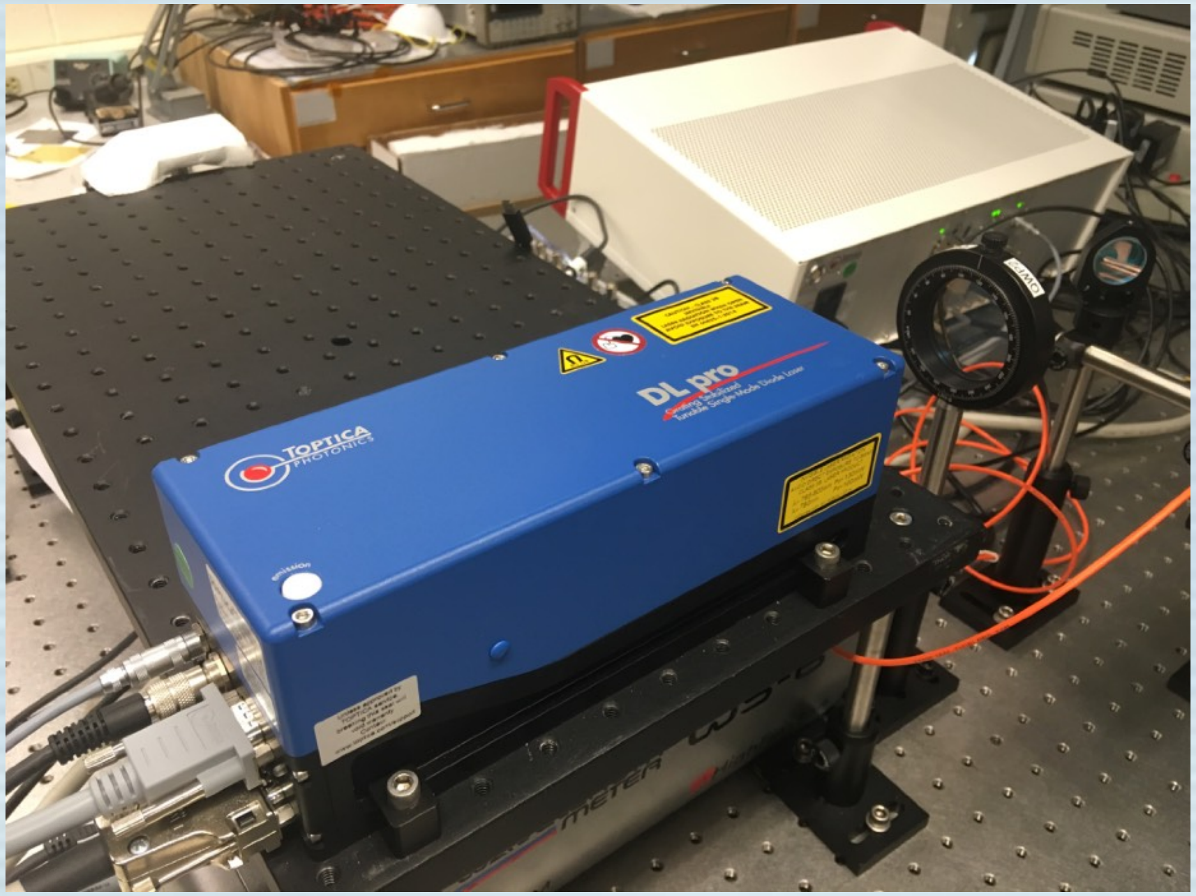
a. Mark-I design prior to "electro-welding".
b. Mark-I design after electro-welding.
c. Mark-I design after repairing leaks.
d. Mark-II design that eliminates the aluminum/copper junction occurring at an inside corner.

Single-frequency laser cell characterization

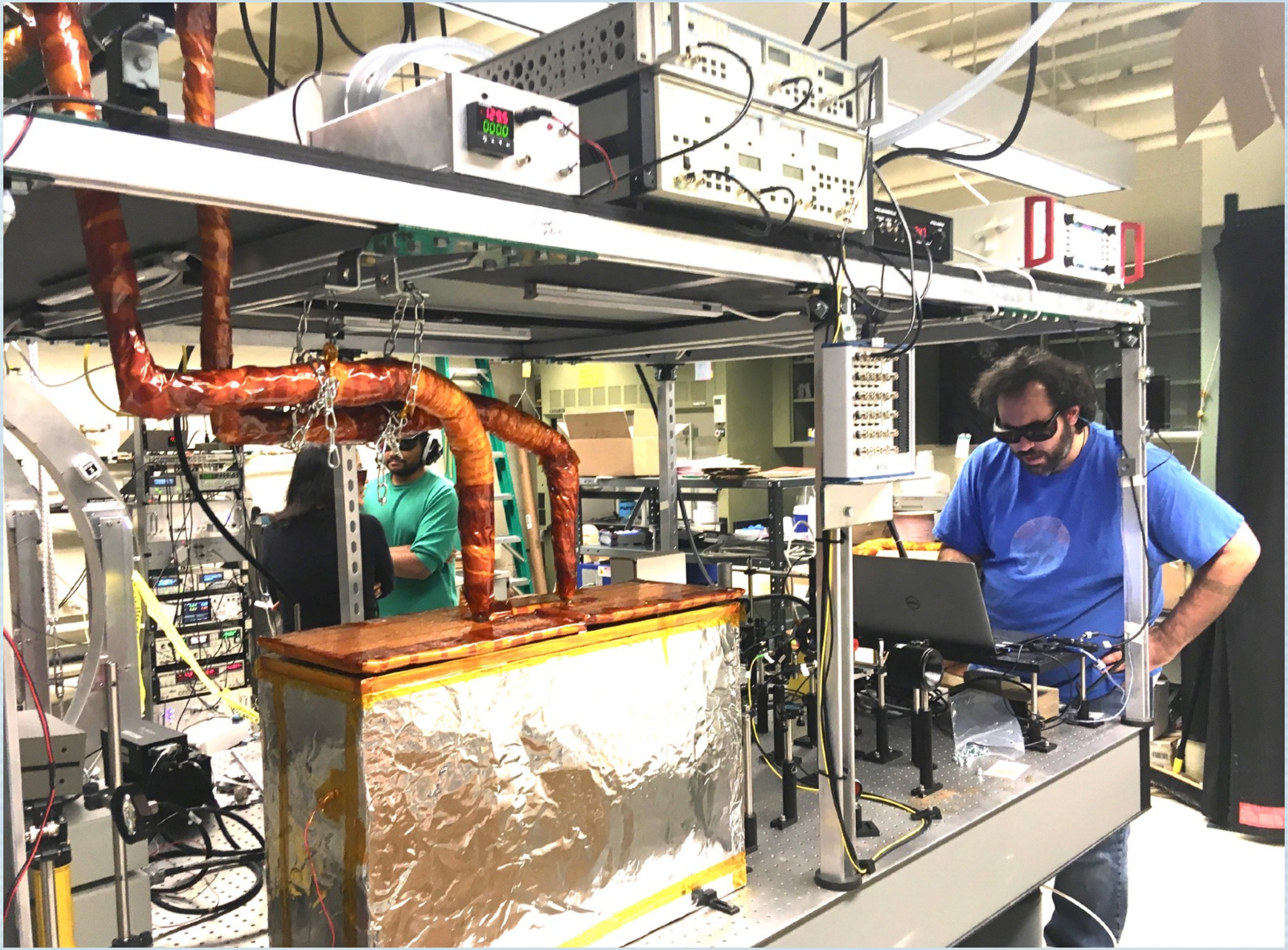
- Provides ~1% determination of pressure in cells even after they have been sealed.
- Provides measure of the ratio of K to Rb for that particular cell under operating conditions. It is critical to keep this within a certain range when constructing targets.
- Provides measurements of glass thicknesses at various points in the cell - critical for radiative corrections and other issues.

Cell Characterization laser

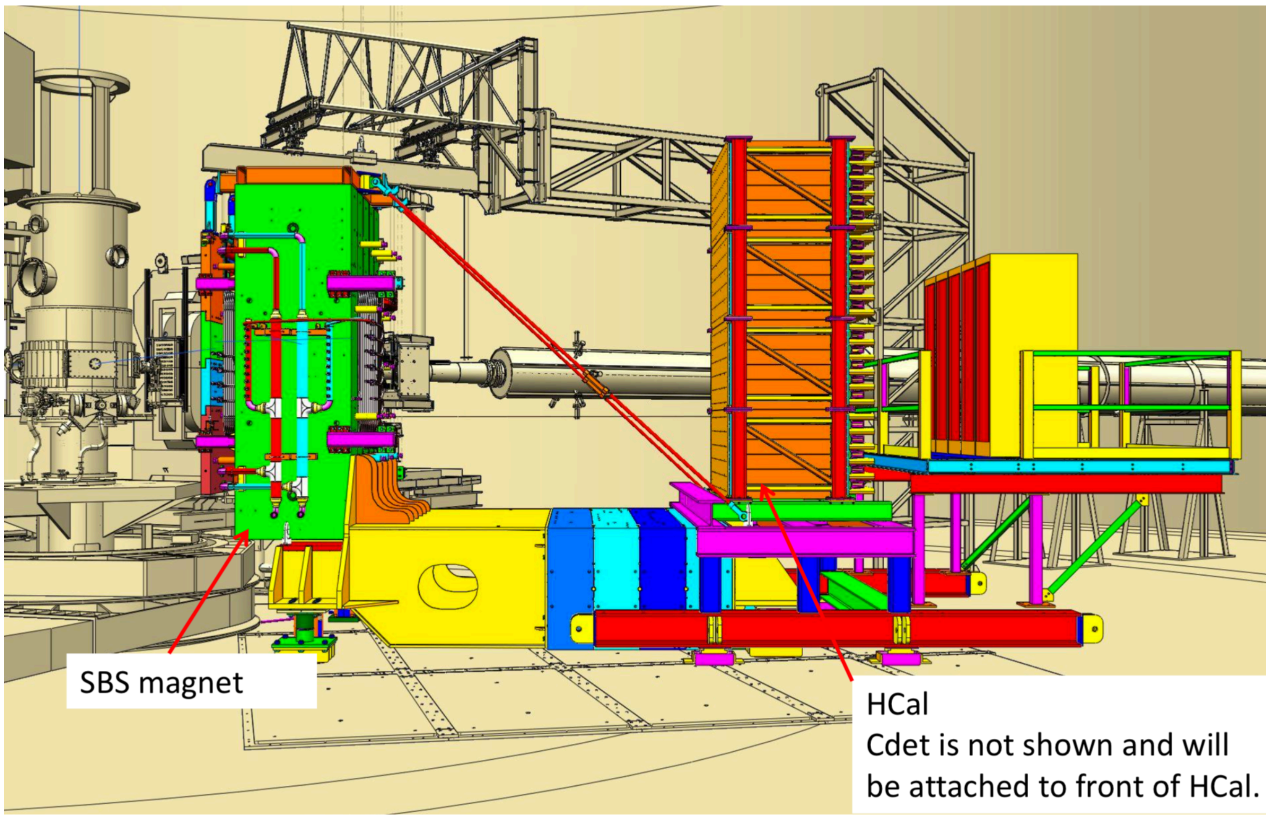
- Requires a scannable single frequency laser.
- Our Coherent 899-29 is just too old!
- We have obtained a new Toptica DL Pro, scannable from roughly 700 - 800 nm. Roughly 100 mW over our frequency range of interest.



Cell Characterization system



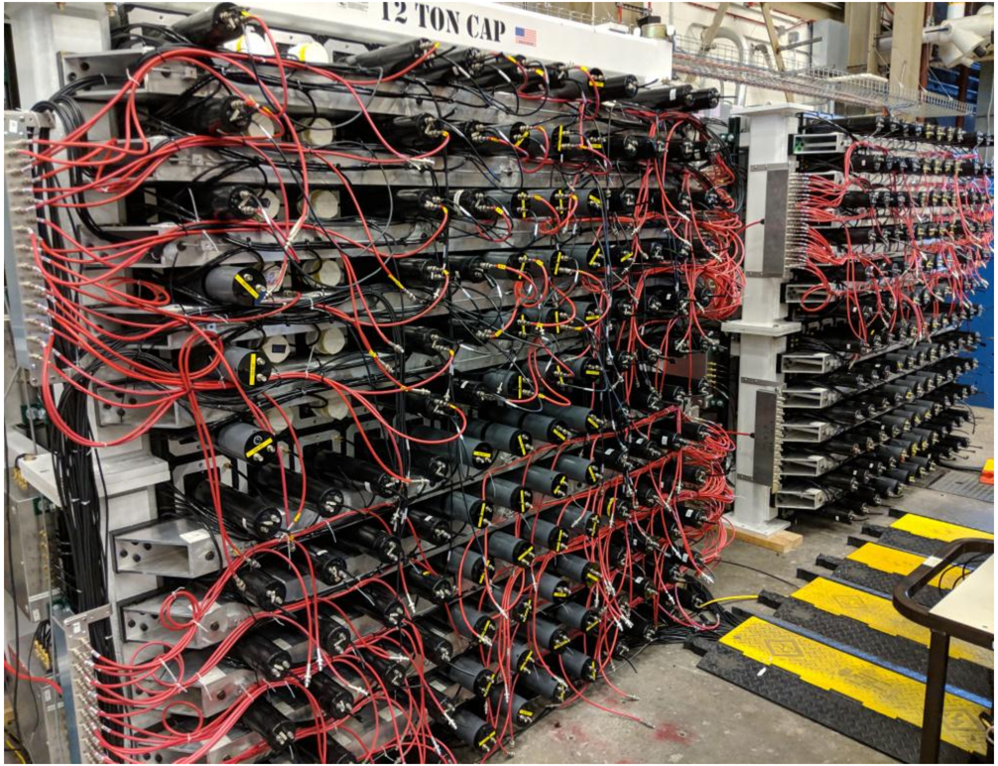
Construction in the SBS projects
WBS2.4: Trigger (RU in PMP) - fADC+



DAQ for HCAL

- 288 channels
- 18 FADC
- Digital summing for GEp triggering
- Two VXS crates
- 5 F1 TDC

HCAL Activity During 2018

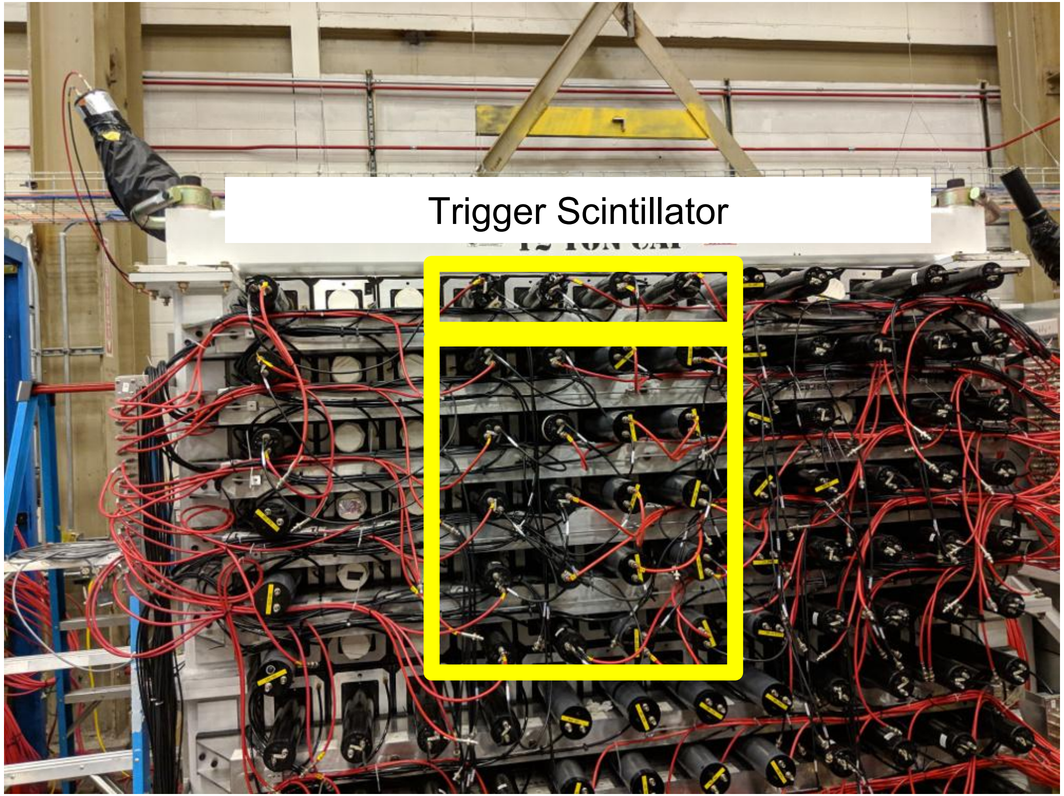


Sub-assemblies as of December 2018

- Sub-assemblies were assembled by Spring '18
    - Many, many thanks to Hall A techs!!!
- Summer: Installed the pulser system (fibers).
- Early Fall: Installed the cables and electronic support system (Thanks Bogdan and Will).
- Late Fall: Tested all PMTs and restarted cosmic tests.

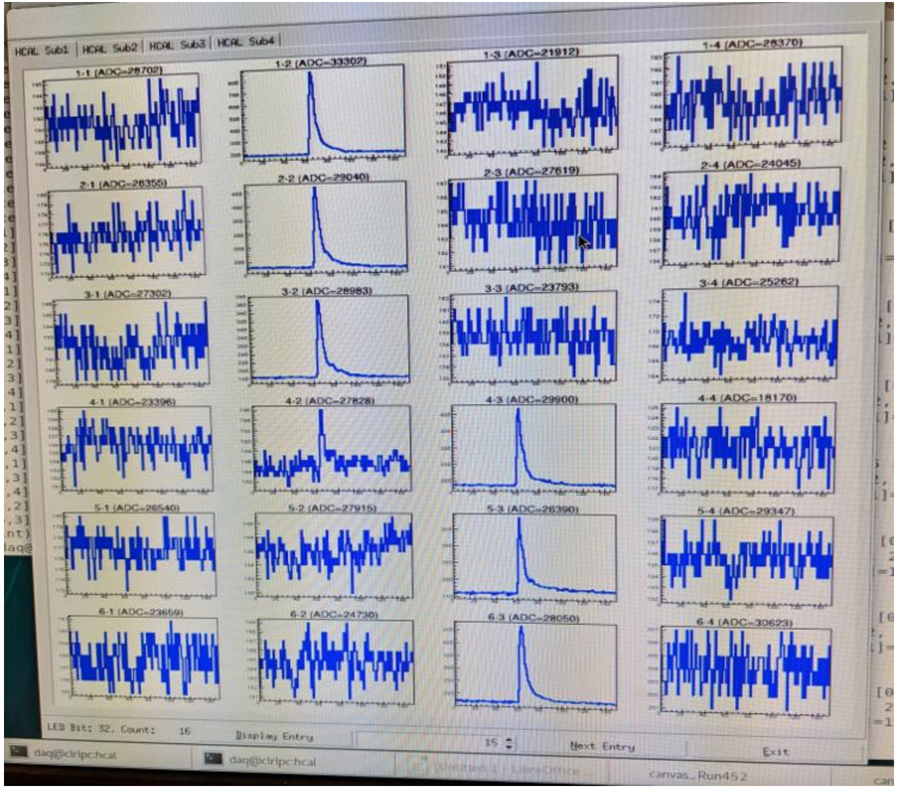
Cosmic Tests (Grease Tests)

- Earlier tests with pulser system showed no need for optical grease.
- Needed to confirm with cosmics.
- Made 6x4 grid of PMTs
- Triggered on scintillator and at least one PMT from top row.



Cosmic Tests (Grease Tests)

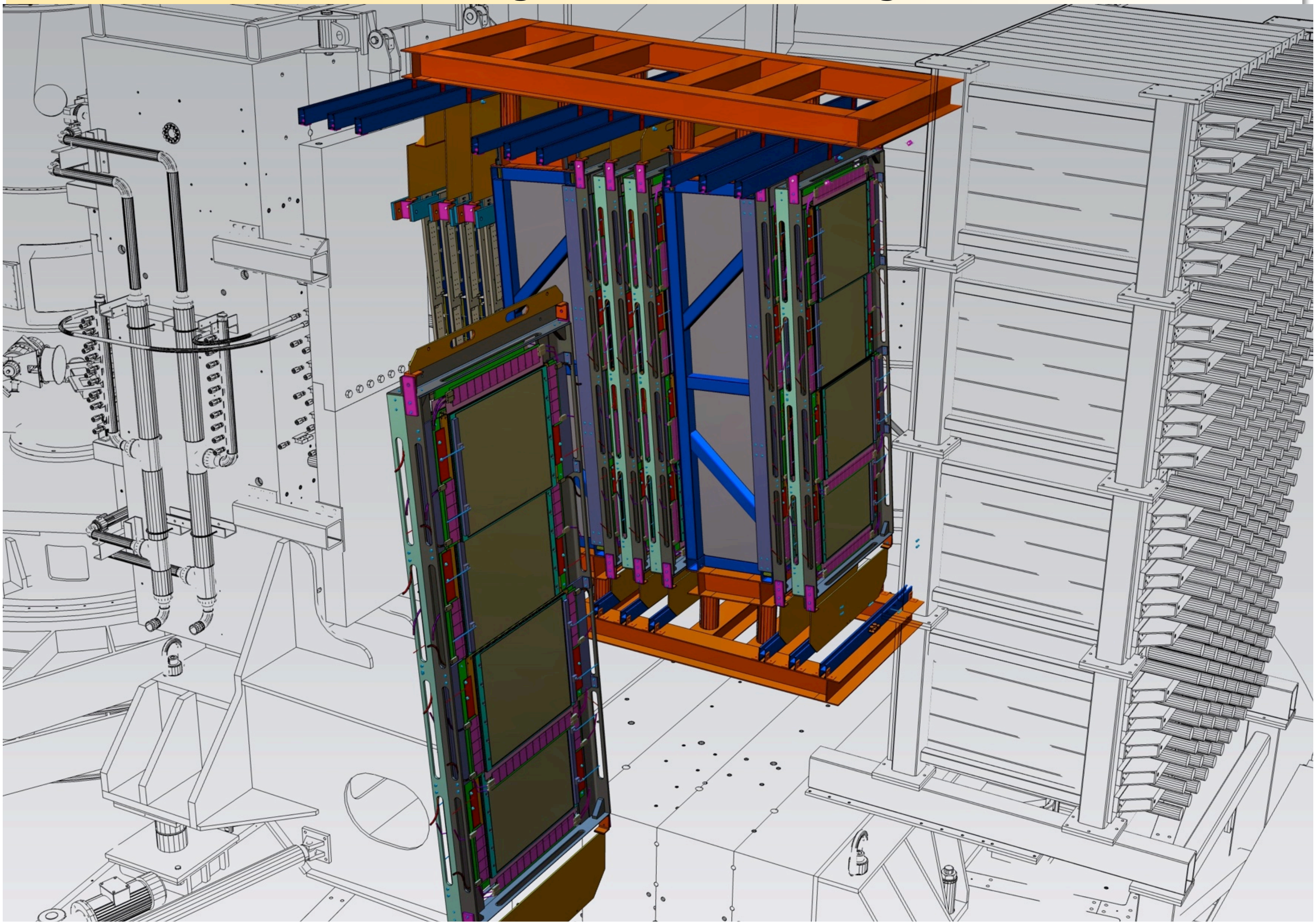
- In order to get good vertical tracks, I required that only one top row PMT have triggered (cut on max ADC value and Amplitude).
  - Then required that each of the PMTs on either side of this column did not have a signal.
- Image shows bad event that will be discarded.



Current Status

- Mechanical assembly complete
- Installed in BigBite detector stack, TED building
- Gas leak around door; work in progress
- HV and signal patch cables installed on BigBite
- All DAQ electronics in portable rack, being assembled for testing
- HV system fully functioning
- All cables in-hand
- 50% of long cables and repeaters installed between BigBite and rack
- Software development in progress

Work in Progress: GEM holding frame



Cosmic Setup (4 chambers = 12 GEM modules)

Setup of UVa GEMs in the EEL Clean Room 124