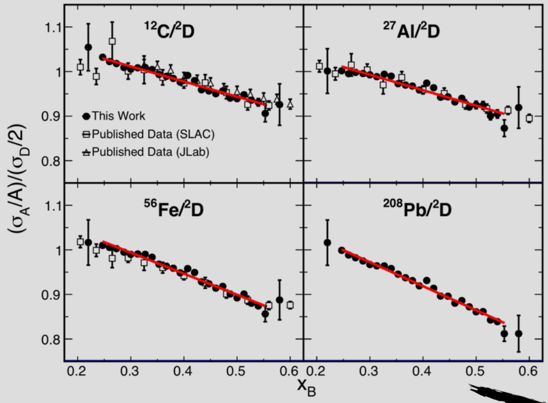
The Large Area/Acceptance Detector (LAD) experiment (E12-11-107) - Status

Carlos Ayerbe Gayoso
On behalf of the LAD experiment group

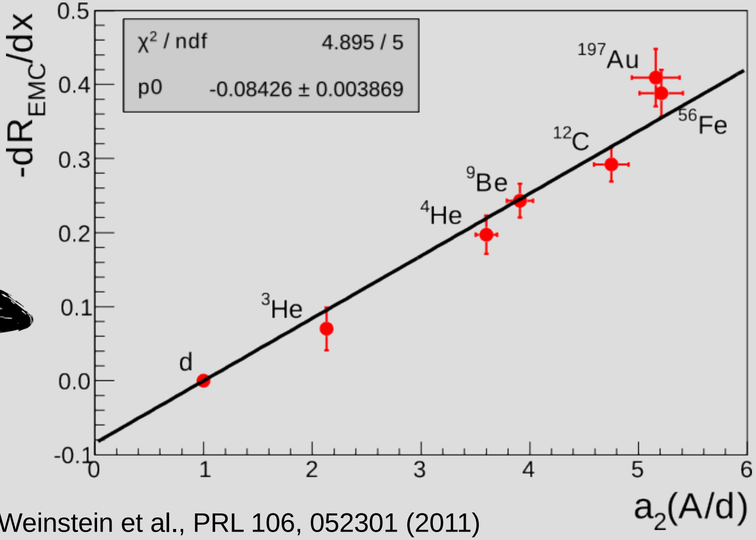
Motivation

The EMC effect is a **modification of the nucleon SF** in bound nucleus.

There is a **high correlation** between the EMC effect strength and the probability of a nucleon to be part of SRC pairs for a given nuclei.

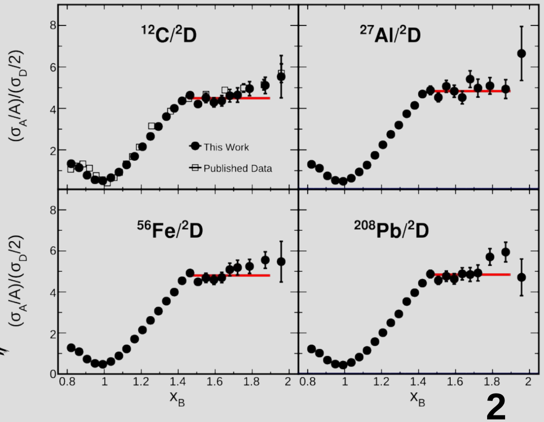


B. Schmookler et al. (CLAS collaboration), Nature 566, 354 (2019)



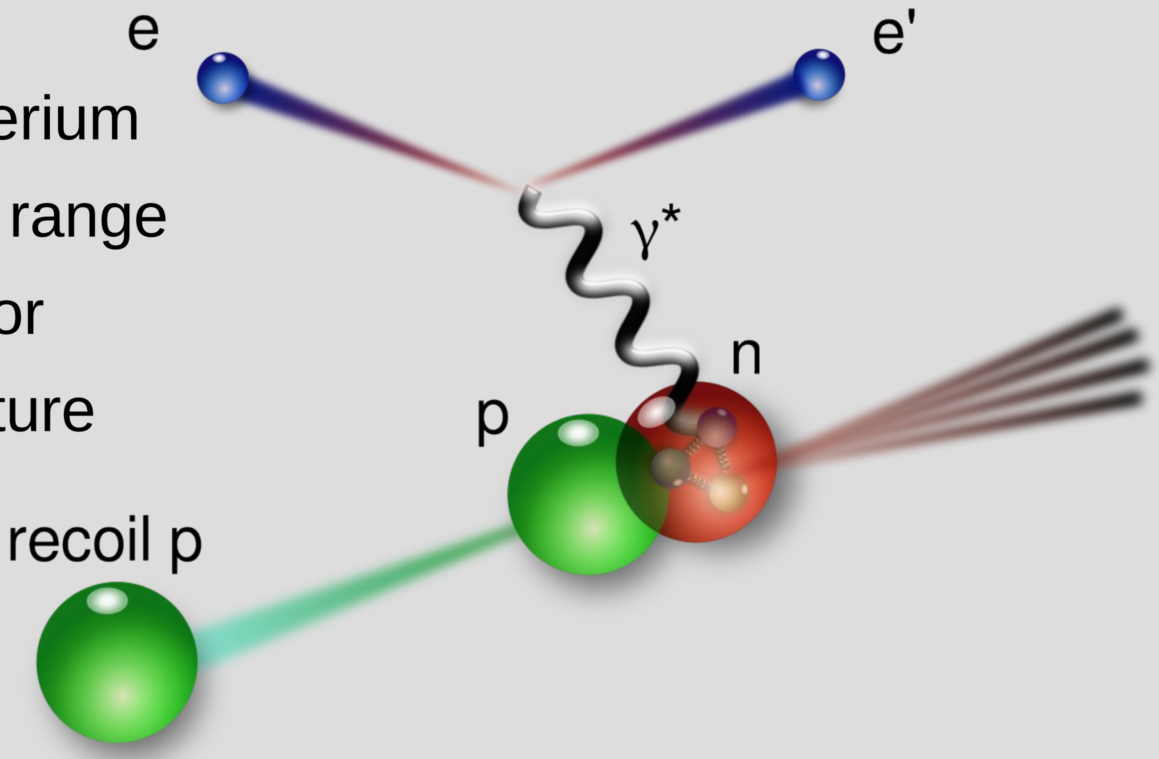
L. B. Weinstein et al., PRL 106, 052301 (2011)
O. Hen et al., PRC 85, 047301 (2012)

B. Schmookler et al. (CLAS collaboration), Nature 566, 354 (2019)



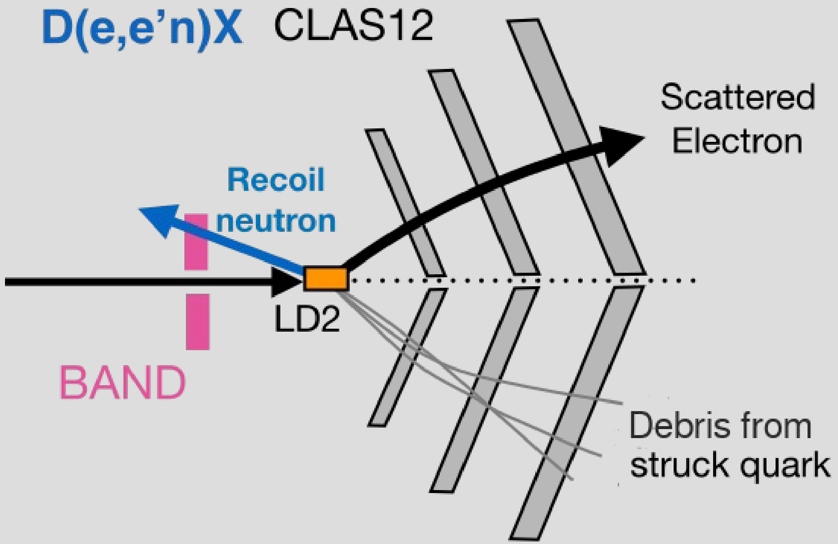
LAD will test the EMC-SRC hypothesis

- Spectator-tagged DIS on deuterium
- tag protons in 200–700 MeV/c range
- new Large Acceptance Detector
- Learn about the partonic structure of nucleons in SRCs



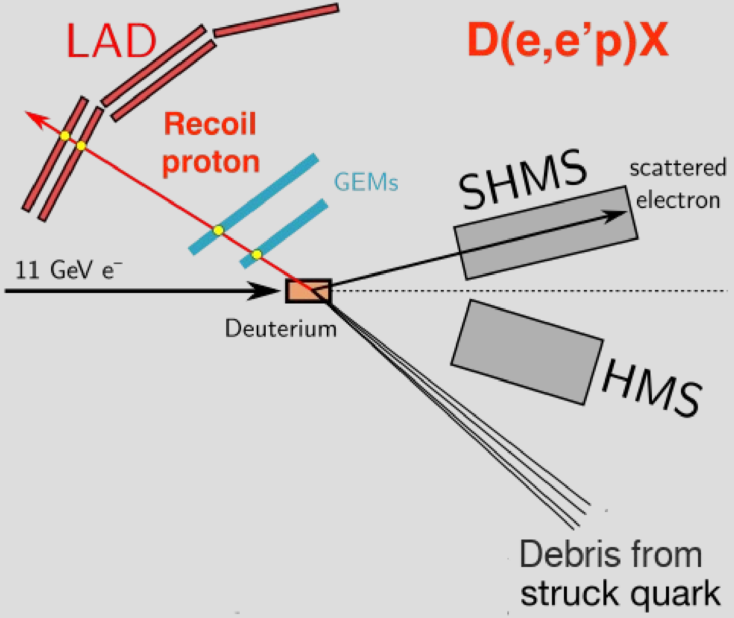
EMC-SRC tagged experiments at JLab

Hall B:
CLAS 12 + Backward Angle Neutron Detector (BAND)



- Run Group B
- Analysis under review

Hall C:
SHMS/HMS + Large Angle Detector (LAD)

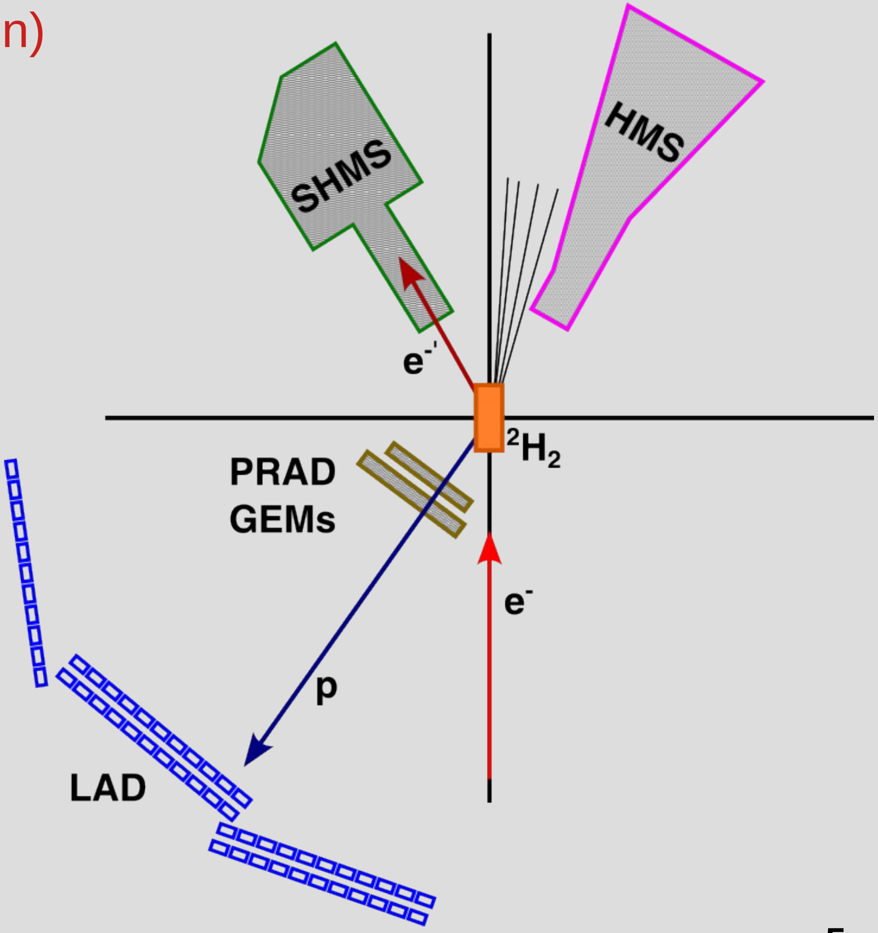


- Run in 2024!

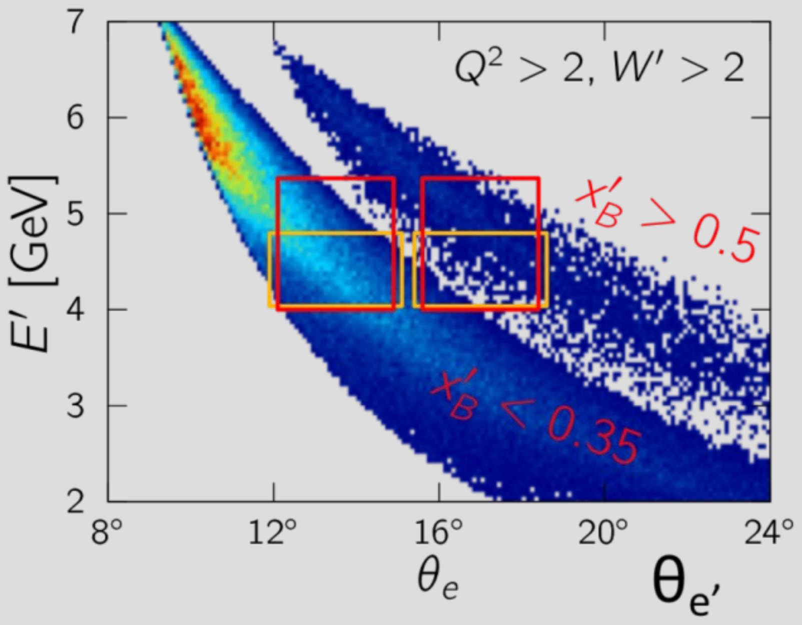
Slide courtesy of A. Schmidt

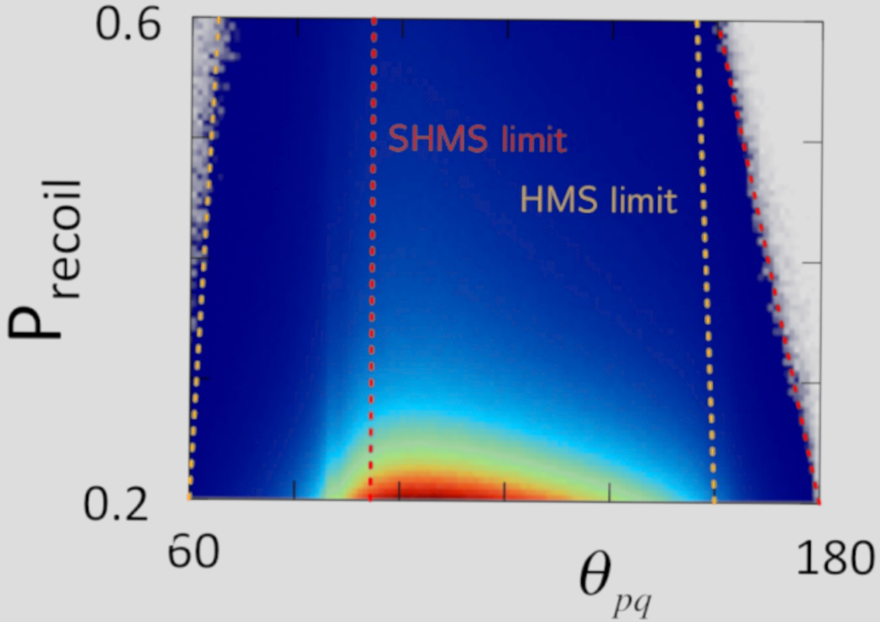
LAD Experimental Settings

- Beam energy **11 GeV** and 6.6 GeV (calibration)
  - Beam currents ~ 1-2uA
- Target: 20 cm liquid D2
- Luminosity: 1.2×10^{37} cm^{-2} s^{-1} per nucleon
- Standard HMS for electrons
  - Momentum: 4.4 GeV
  - Angles: **13.5°, 17°** and 21.7° (calibration)
- Standard SHMS for electrons
  - Momentum: **4.4 GeV** and 5.1 GeV (calibration)
  - Angles: 13.5° and 17°
- LAD detector for **recoil protons**
- PRAD GEMs for **tracking**
- Duration: 34 PAC days



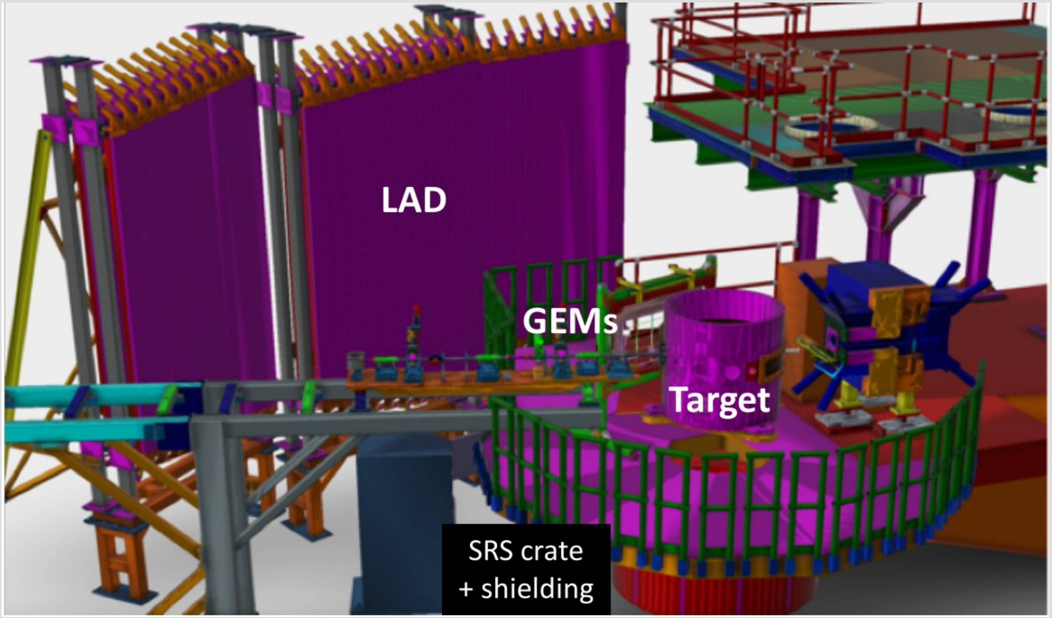
Kinematic coverage

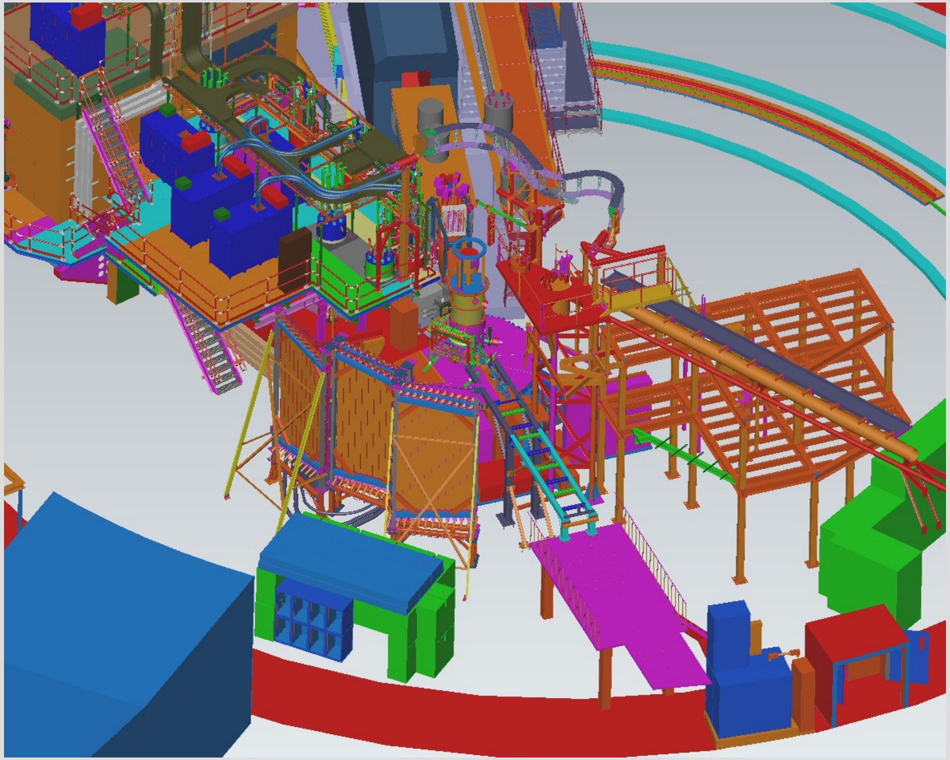




Courtesy of A. Schmidt

CAD drawings – Hall C+LAD



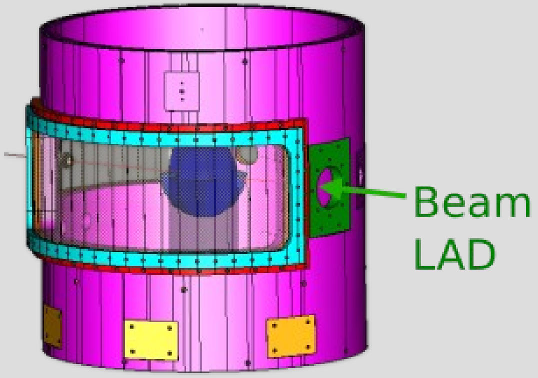


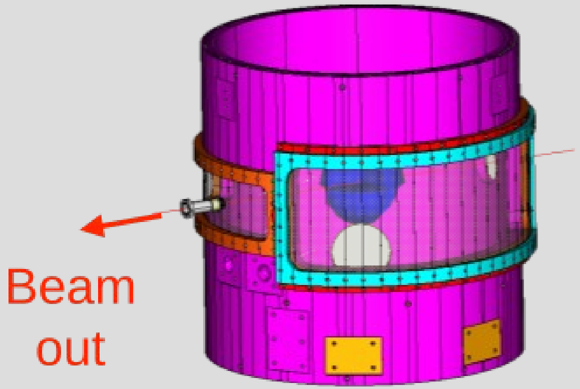
Rotated Scattering Chamber

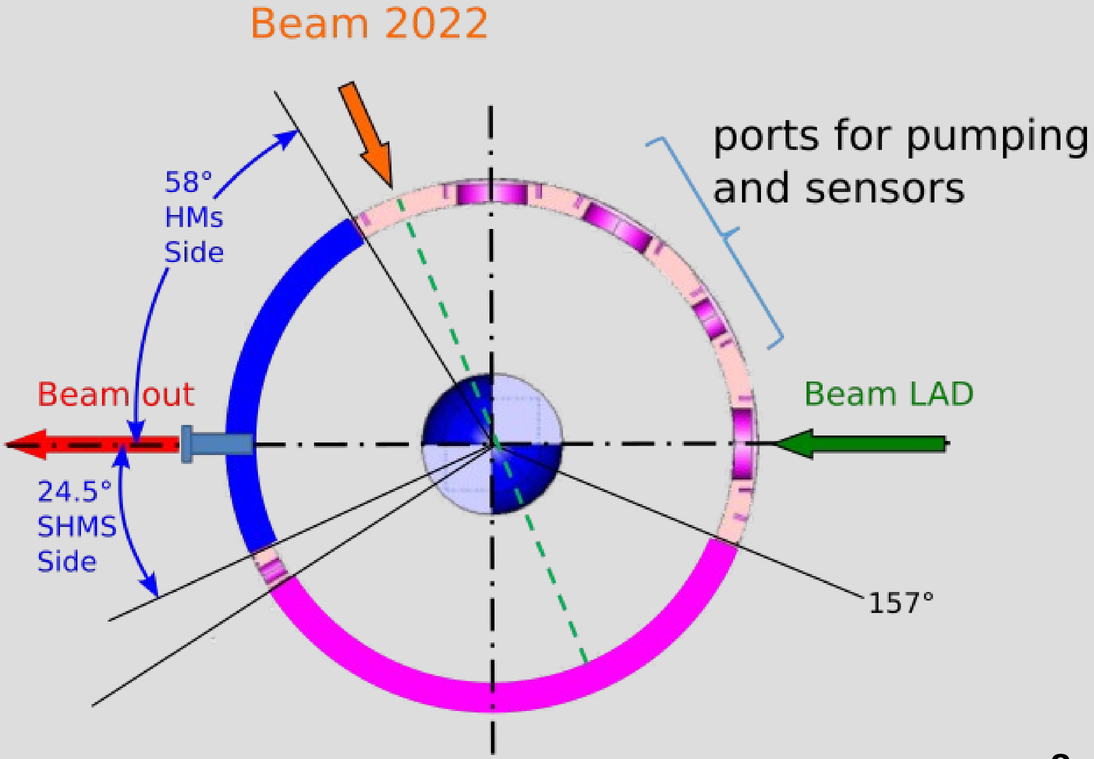
Using existing chamber

• Chamber rotated compared to current setup placing **larger window** in position to act as the window for the LAD Detector

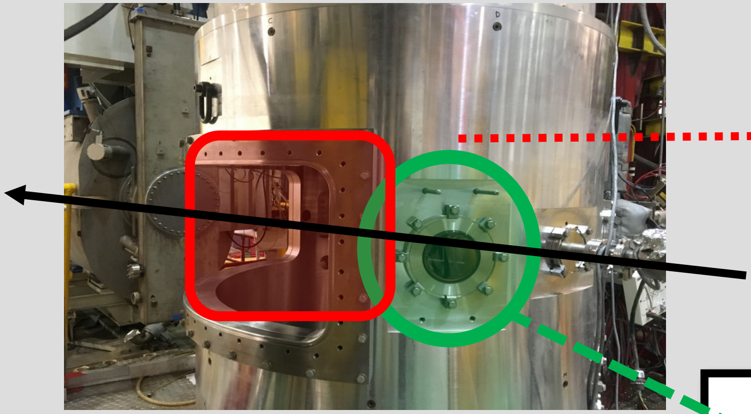
Slide courtesy of F. Hauenstein



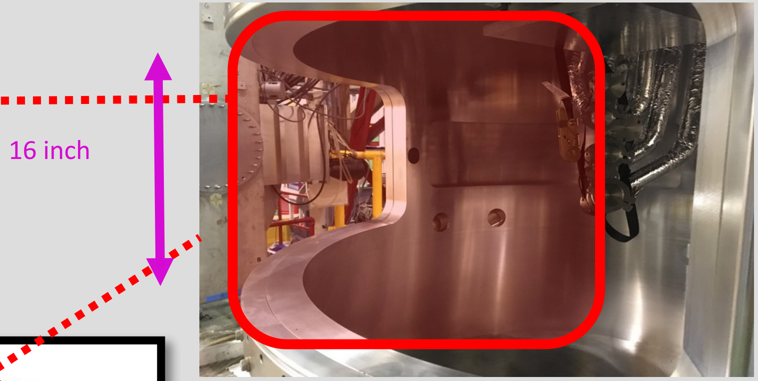


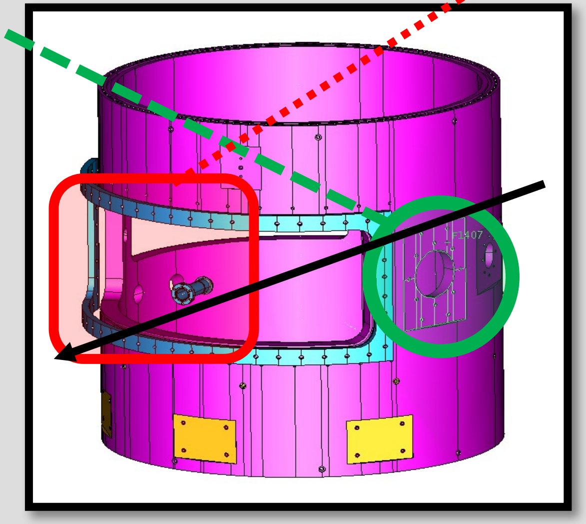


Scattering Chamber with current pictures



Beam direction
2022





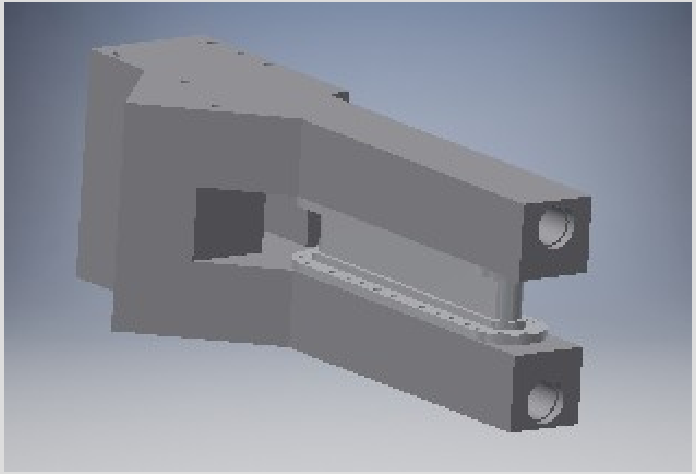
Beam direction 2022

LAD beam in flange

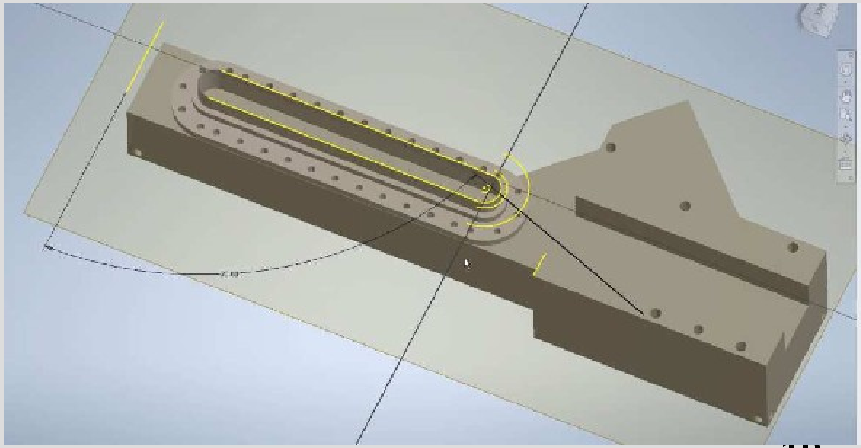
Slide courtesy of F. Hauenstein

Target Ladder

- **LH2**
- **LD2**
- **Empty/Dummy** target for wall subtraction
- **C-Multifoil** (5-6) for optics
- Usual **solid** target for beam checkout



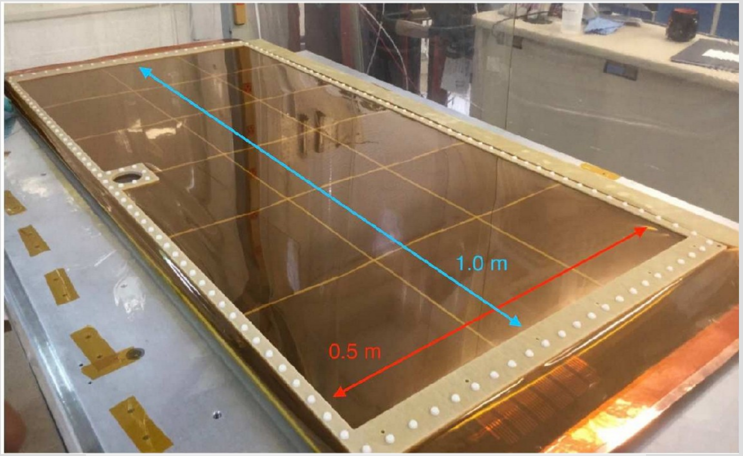
Modified HAPPEX cell to accommodate LAD acceptance
- 20 cm length
- 2 cm width
- 2 cm height

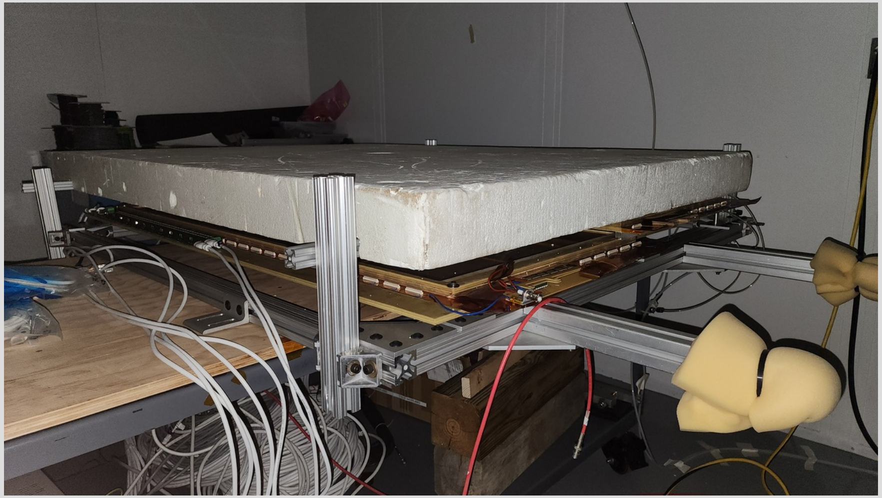


Fabrication by JLab target group

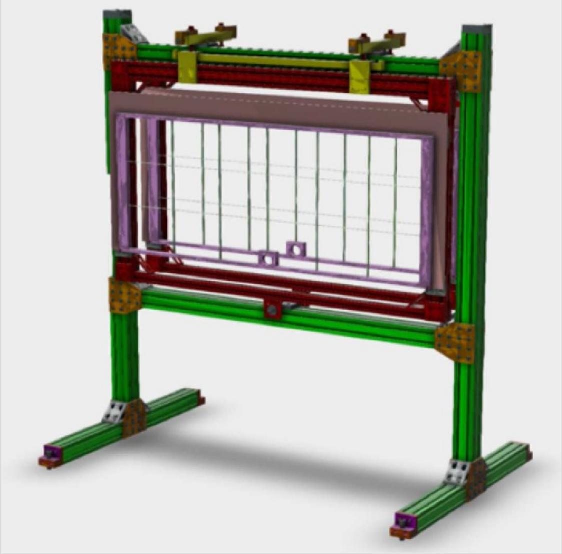
PRAD GEMs

2 GEMs next to scattering chamber
- <1m away from target
- Active area: 120 x 55 cm2
- Separated by 20cm
- HV modules modified to support higher rate like SBS counterpart



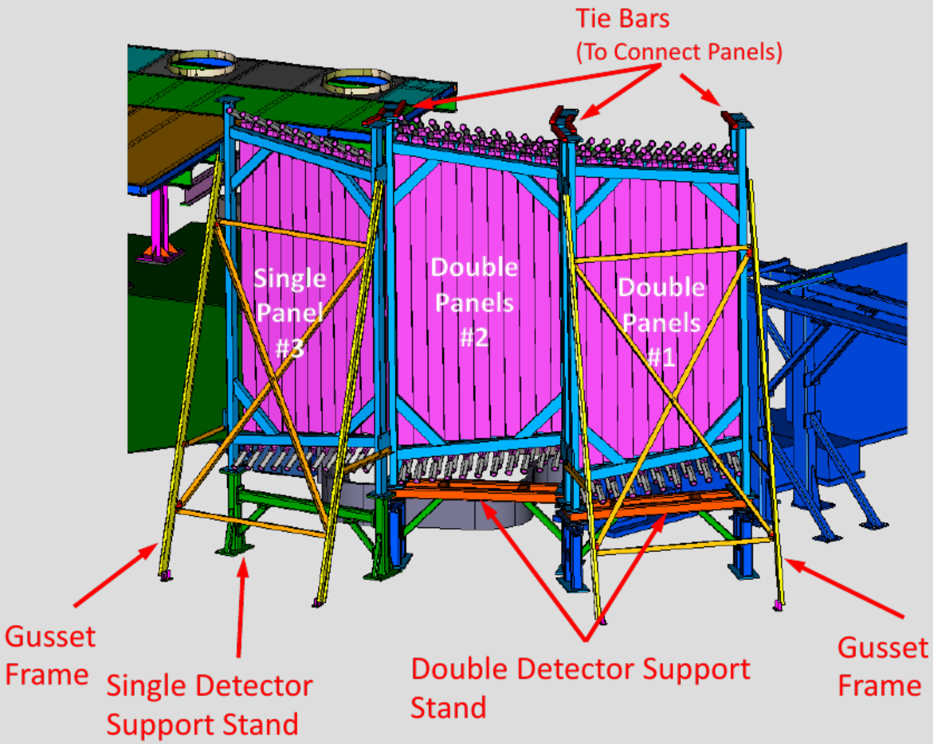


Holly Szumila-Vance



LAD (Hodoscope)

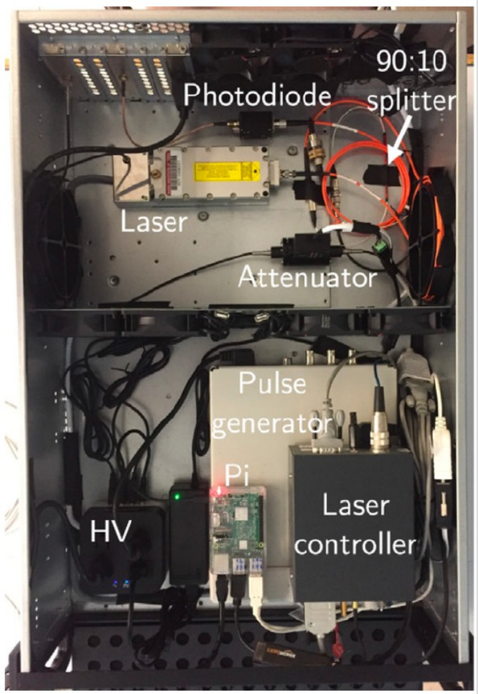
- CLAS TOF scintillators refurbished at ODU
  - stored in ESB
  - stands designed and ready for fabrication

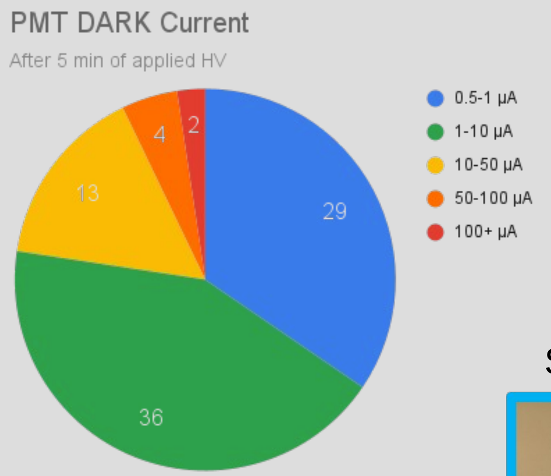


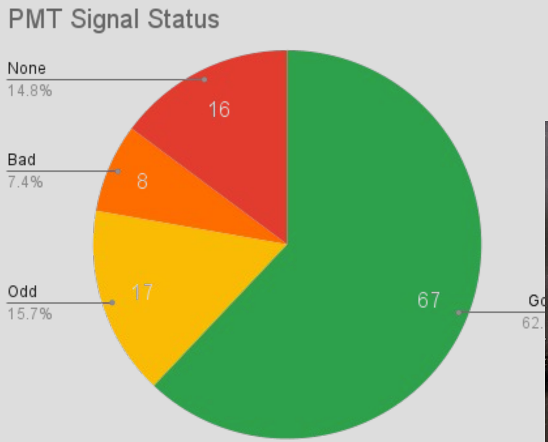
LAD (Hodoscope) status

Laser calibration system
- tested system from BAND (HallB)
- fibers need to be installed
- All components ordered, to be deliver in March

Florian Hauenstein







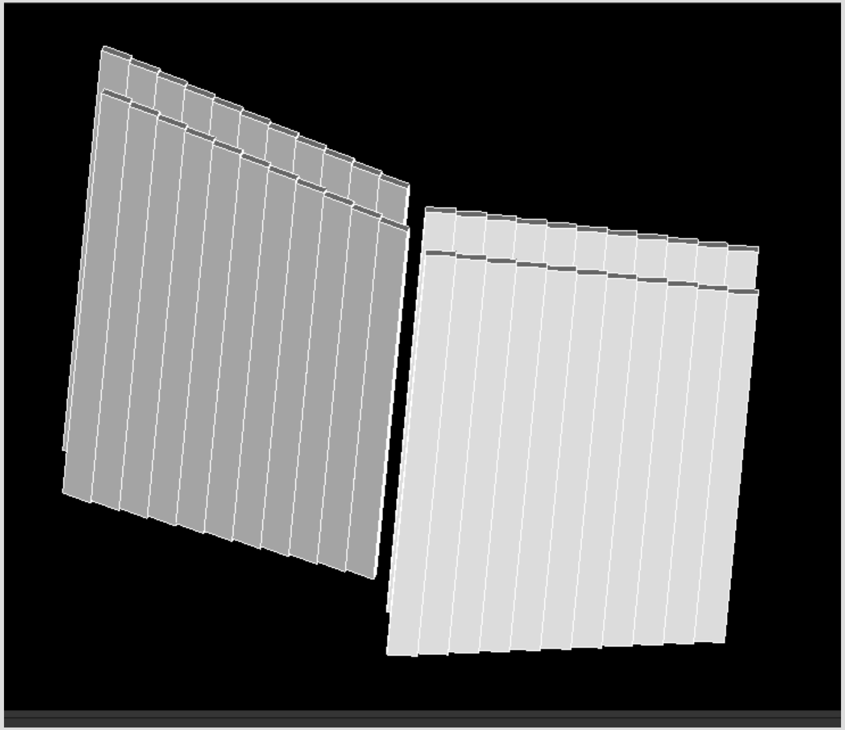
A qualitative study of all bars showed that many bars presented some issues, to be solved at the time of laser fiber installation.

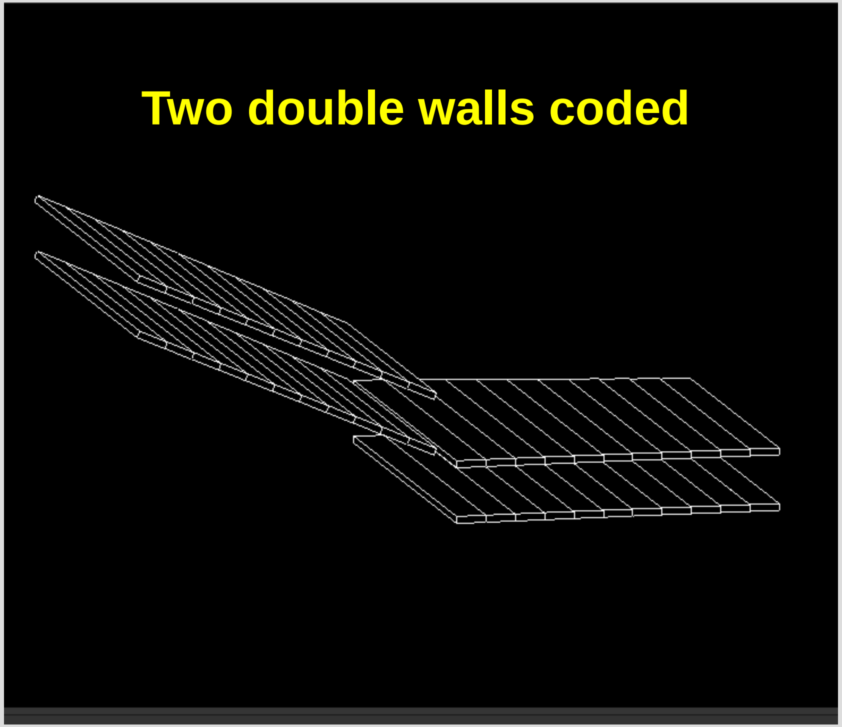
Sara Ratliff

Carlos Ayerbe

Simulation

A Geant4 simulation is under development for the Hodoscope. The GEMs geometry and digitization, will be taken for the SBS simulation g4sbs





Carlos Ayerbe

Hcana integration

THcLADSpectrometer

(THaSpectrometer::AddDetector)

Holly Szumila-Vance

(Tracking Detectors)

(Tracking Detectors)
THcLADGEM
Hit Class
THcLADGEMPlane
TrackingModule

(NonTracking Detectors)

(NonTracking Detectors)
THcLADHodoscope
Hit Class (e.g., THcHodoHit)
THcScintillatorPlane (or other subarray classes)
PhysicsModules as needed (e.g., efficiency..)

Carlos Ayerbe

SBS tracking detectors: Used a standalone base class (SBSGEMTrackerBase) instead of inheriting from THa* classes.

Most of work to be done is track finding process

CoarseProcess (Scintillator hits processed here)
FineProcess (Track projection)

Coordinated with
Sanghwa Park

Estimated timeline

September 2023

GEM:
- Initial tests
- Upgrade of readout
- Gas window

Dec 2023

GEM:
- Test with cosmics
- Implementation in HCANA

LAD:
- Start test of bars (ESB)
- Integration into simulation

March/April 2024

GEM:
- Test in Hall?

LAD:
- Gluing of fibers
- Test with cosmics (combined with GEMs?)

July/August 2024

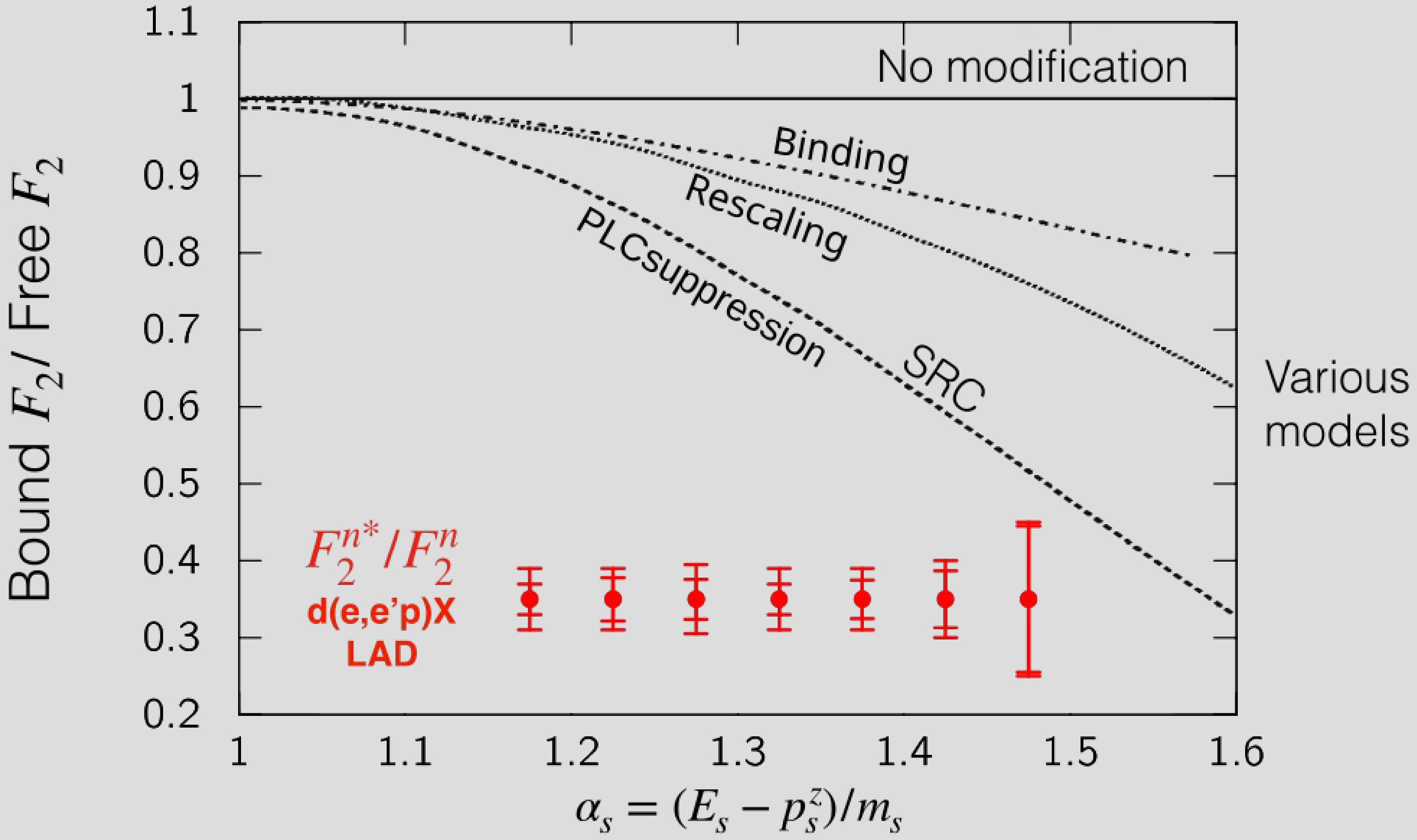
- Installation of detectors in HallC
- Initial calibrations

Sept 2024

Beam Time

Slide courtesy of F. Hauenstein

d(e,e'p)X - Expected Results



Melnitchouk, Sargsian, Strikman, Z.Phys. A359, 99 (1997)

Ready to run

Holly Szumila-Vance

Florian Hauenstein

Sara Ratliff

Lucas Ehringer

Tyler Kutz

Tennessee Postdoc

Your humble server

And Axel Schmidt, Or Hen, Larry Weinstein, Eli Piasetzky, Dien Nguyen, Doug Higinbotham

LAD in some links

- Large Area/Acceptance Detector (LAD) experiment (E12-11-107) Proposal. PAC 38, Aug 2011
  - Jeopardy June 21, 2021
- Experimental Readiness Review July 29, 2020
- A. Schmidt - LAD experiment in Hall C. Oct 19, 2021
- Hall C Meeting 2022 - O. Hen - The LAD Experiment: “In Medium Nucleon Structure Functions, SRC, and the EMC effect”
- Hall C Meeting 2022 - F. Hauenstein -The LAD Experiment: Status and Preparation
- Hall A/C Meeting 2023 - F. Hauenstein - Tagged DIS measurement with LAD

MANDATORY BACKUP SLIDES

Run plan:

6 PAC days: Commission, calibration
34 PAC days: Physics runs

Condition	Scheduled work (Activities)	Total Time (PAC time)	Beam condition
Beam setup	- Sending beam to the Hall - Detector checking: scintillator, TOF, GEMs, spectrometers	2 shifts	6.6 GeV, 1uA
Low energy calibration	- Target LH2, elastic run for momentum calibration, and inclusive cross-section - SHMS at 17^o and 5.048 GeV - HMS at 21.73^o and 4.4 GeV - Delta-scan for momentum calibration (HMS: +/- 3%, 6%, 9%), (SHMS: -13%, -10%, -5%, 5%, 10%, 15%, 20%)	3 shifts	6.6 GeV, 10uA

Slide courtesy of D. Nguyen

Condition	Scheduled work (Activities)	Total Time (PAC time)	Beam condition
3 pass -> 5 pass	- Beam checkout	1 shift	
Multi-foil target run	- HMS to 13.5^o and 4.4 GeV - SHMS to 17^o and 4.4 GeV - Doing GEM alignment - Install sieve and turn GEM off for optic calibration run	3 shifts 3 shifts	10.9 GeV 1 uA 10 uA
Luminosity scan	- Move to LD2 target and run with different currents to do luminosity scan for efficiency and luminosity check	1 shift	0.5, 0.7, 1.2, 1.5 uA
BCM calibration	- 2-3 times during run (needs other halls off)	1 shift	0.2 – 2uA
Physics run setting 1	- Target LD2 - HMS at 13.5^o and 4.4 GeV - SHMS at 17^o and 4.4 GeV - Dummy runs	13 days ~ 5% time	1 uA

Slide courtesy of D. Nguyen

Condition	Scheduled work (Activities)	Total Time (PAC time)	Beam condition
Physics run setting 2	- Target LD2 - HMS at 17^o and 4.4 GeV - SHMS at 17^o and 4.4 GeV - Dummy runs	8 days ~ 5% time	1uA
Physics run setting 3	- Target LD2 - HMS at 17^o and 4.4 GeV - SHMS at 13,5^o and 4.4 GeV - Dummy runs	13 days ~ 5% time	1uA

6 PAC days: Commission, calibration
34 PAC days: Physics runs

- ❑ Move of SHMS with people in hall due to GEMs and SHMS cables
- ❑ Surveys before and after run

Slide courtesy of D. Nguyen

LAD objective

Measuring the in-medium neutron SF (related to EMC effect) at large momentum (SRC signature) tagging the recoil proton, offers an excellent test of the EMC-SRC hypothesis

The simplest nucleus to test is Deuterium

The Large Area Detector (LAD) Experiment was designed to investigate spectator Tagged-DIS (TDIS) involving **high-momentum nucleons** in deuterium. Its aim was to offer fresh perspectives on the overall origin of the EMC effect and, more specifically, **to assess the hypothesis** suggesting that the EMC Effect in nuclei primarily results from the modification of nucleons within short-range correlated (SRC) pairs.