Run Group-M Update

Justin Estee

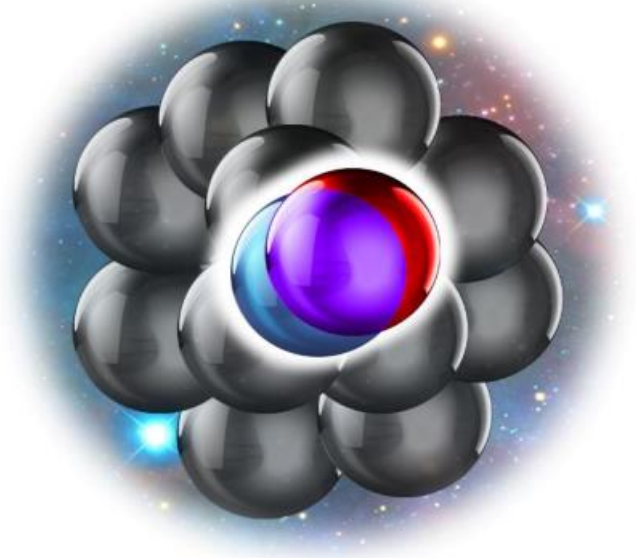
Run Group-M

- RGM is made up of two proposals will investigate two important physics processes:
- Short Range Correlations E12-17-006A
- Electrons for Neutrinos   E12-17-006

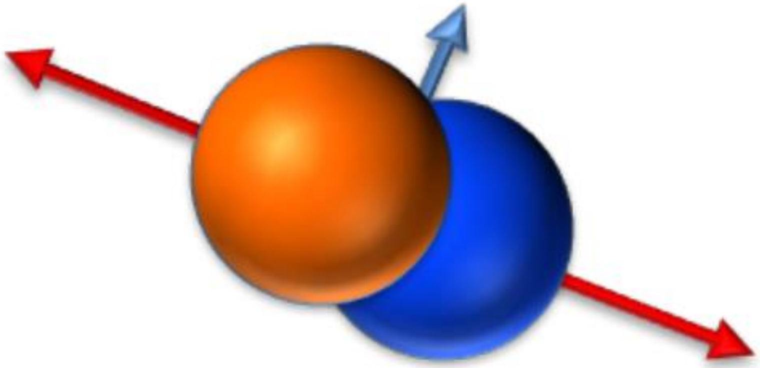
Short Range Correlations (SRCs)

Short range, short lived,
highly correlated pairs

r-space

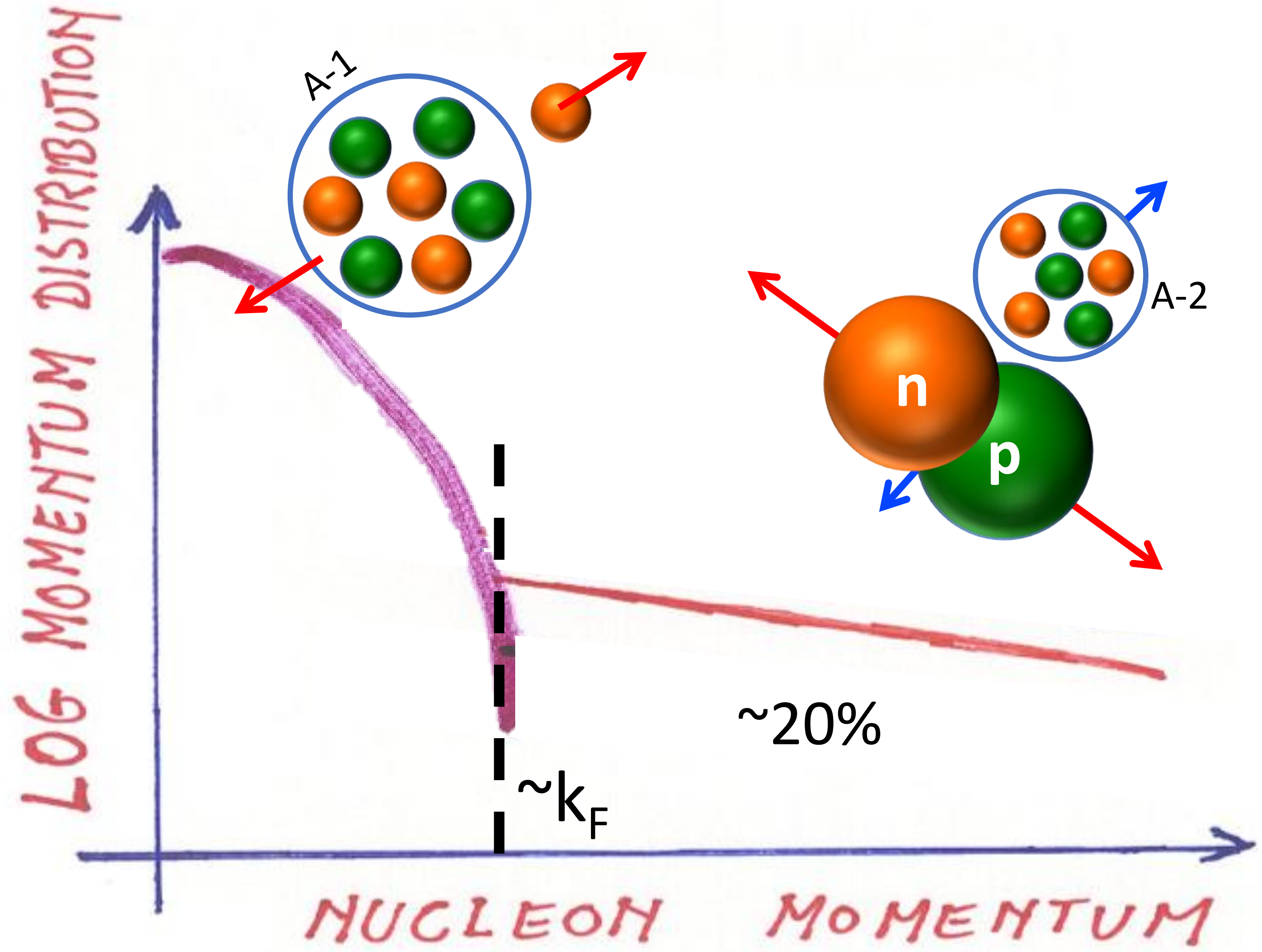


High relative momentum
Low center of mass momentum

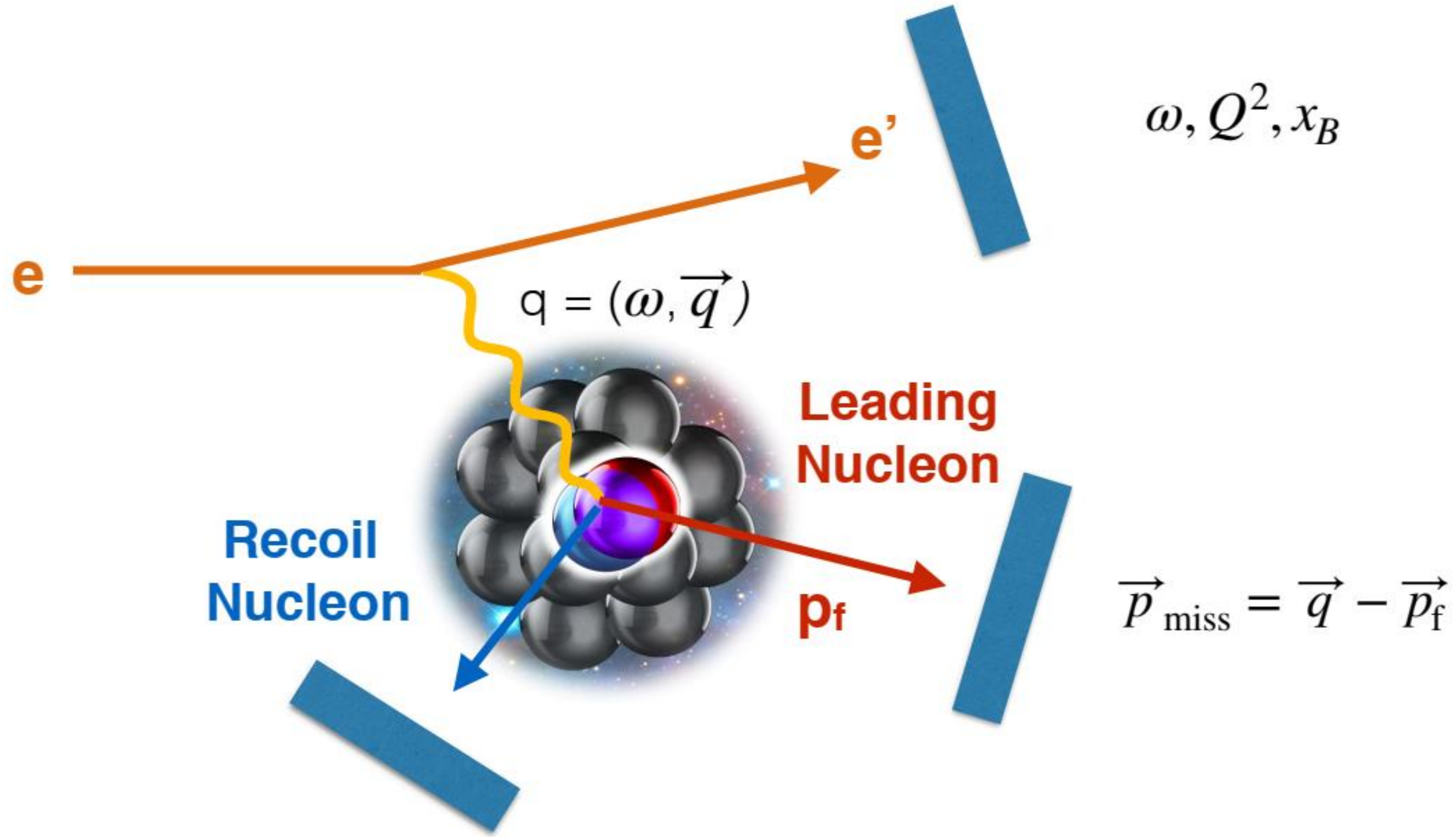


k-space

High momentum tail



Electron scattering off an SRC pair

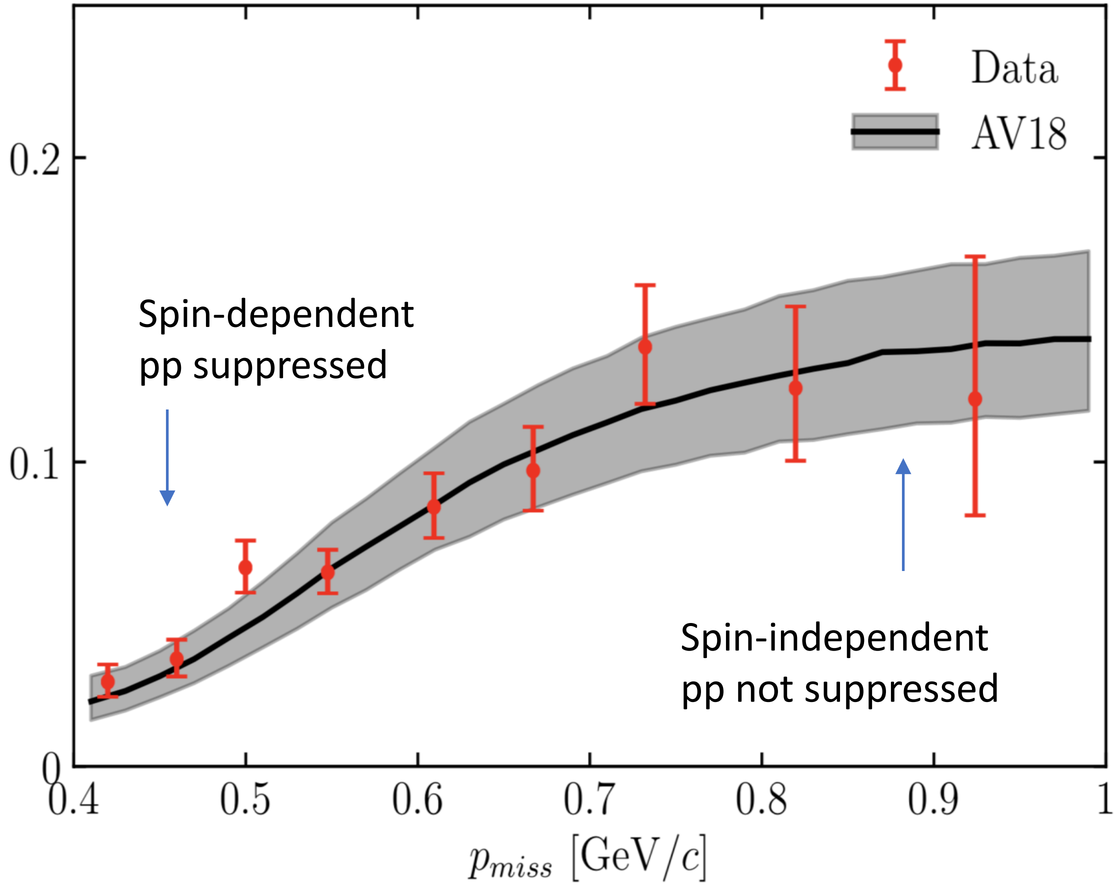


- (e,e') inclusive
- (e,e'N)
- (e,e'NN)

SRC Program Previous Success

A. Schmidt et al. Nature 578, 540(2020)

$$\frac{^{12}C(e,e'pp)}{^{12}C(e,e'p)}$$



SRC Program Previous Success

- Tremendous success of the CLAS6 data mining SRC program with few signal counts (Science, Nature, etc.)
- With increased luminosity and CLAS12 we are expecting 10 -40x more data
- Over a wider range of nuclei
- Explore more observables and mass and isospin scaling

<u>2018-20 SRC CLAS Publications:</u>

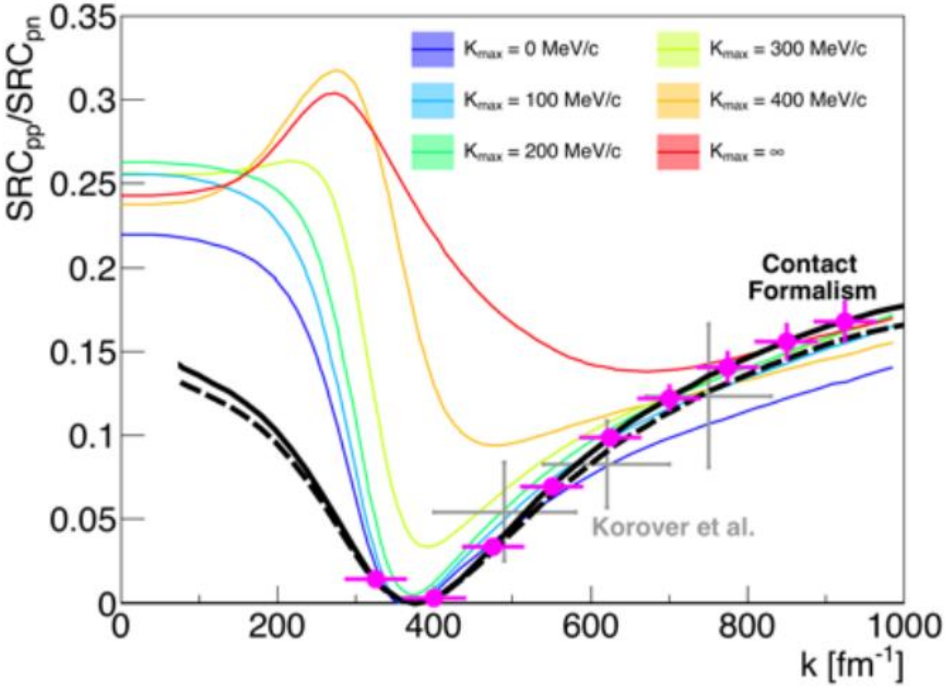
- Nature 578, 540 (2020)
- Nature 566, 354 (2019)
- Nature 560, 617 (2018)
- PRL 122, 172502 (2019)
- PRL 121, 092501 (2018)
- Phys. Lett. B 797, 134792 (2019)

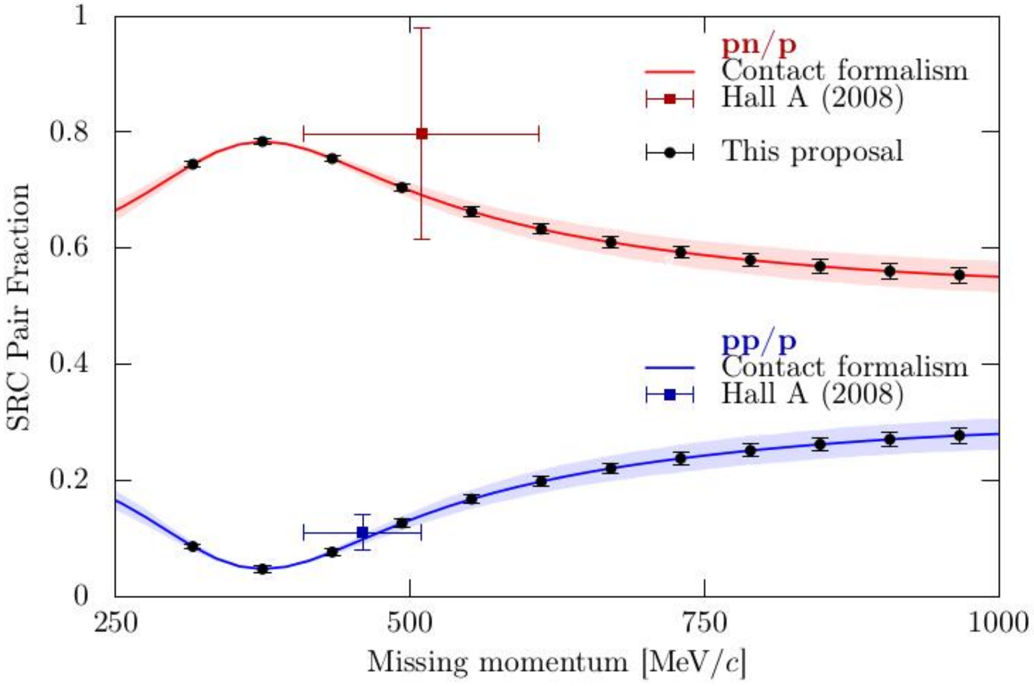
Follow up Theory Publications

- Phys. Lett. B 805, 135429 (2020)
- Phys. Lett. B 791, 242 (2019)
- Phys. Lett. B 785, 304 (2018)
- Phys. Lett. B 780, 211 (2018)

Goals of RGM

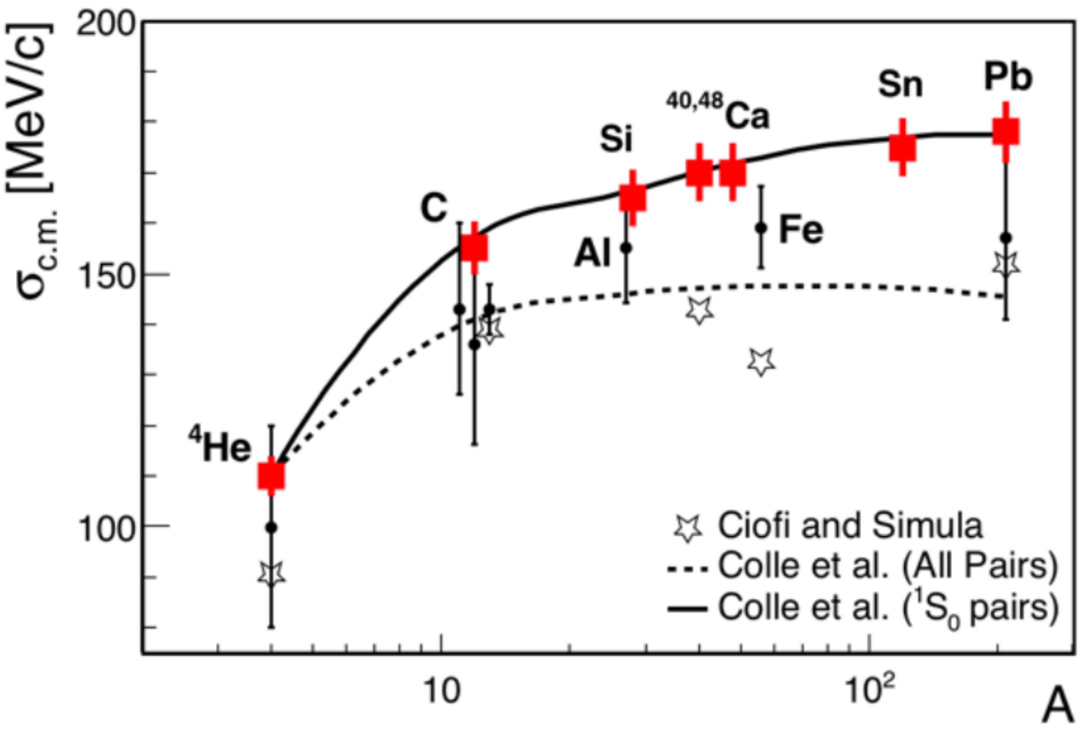
- Constrain NN interaction and nuclear wave function





Goals of RGM

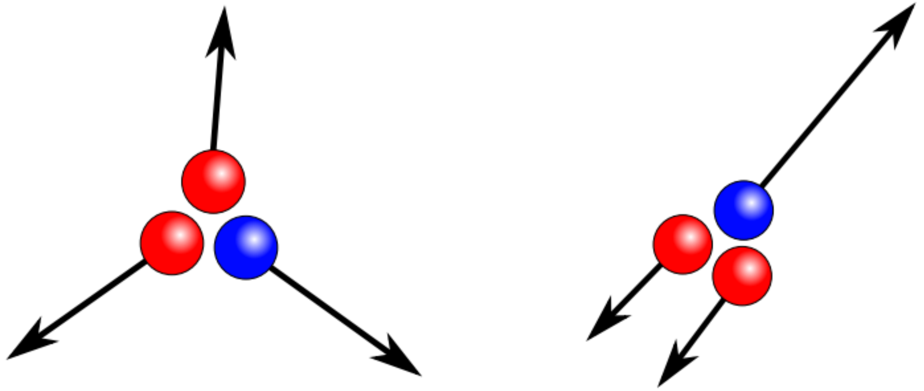
- Constrain NN interaction and nuclear wave function
- SRC formation processes



Goals of RGM

- NN interaction and nuclear wave function
- SRC formation processes
- 3N SRC pair observation

1st Observation & A-dependence

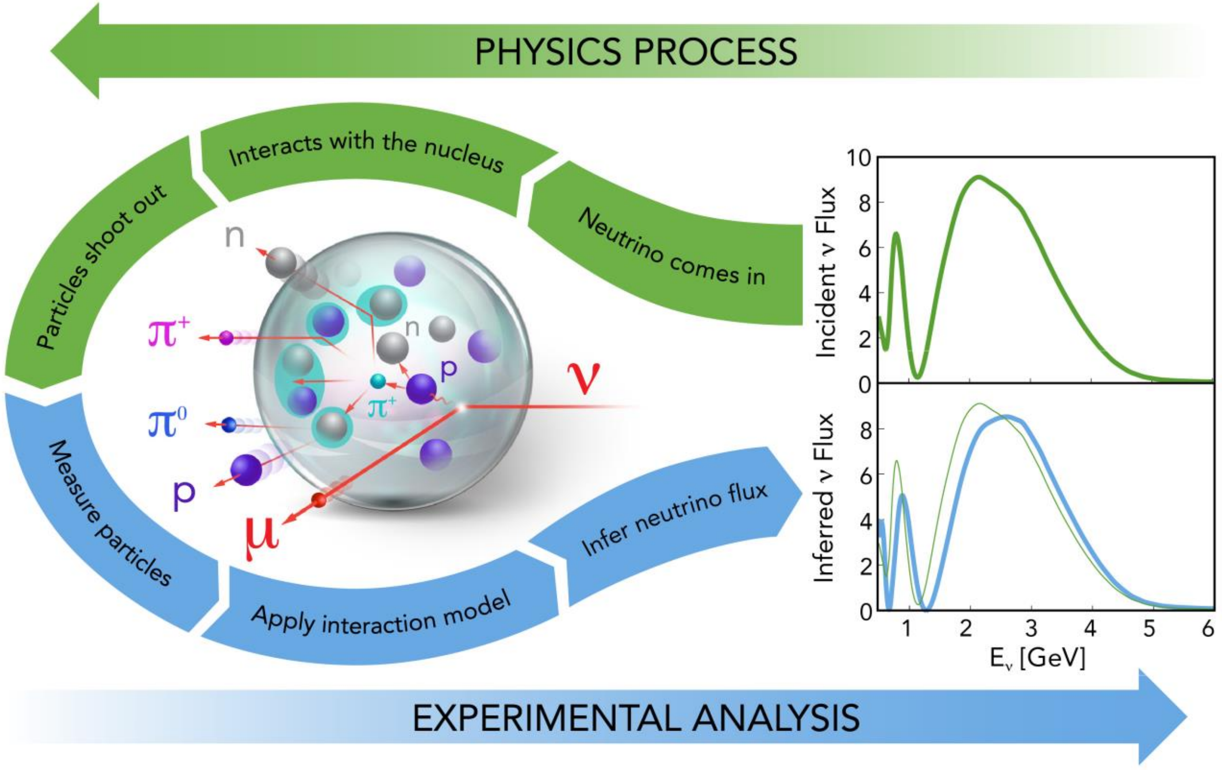


Goals of RGM

- NN interaction and nuclear wave function
- SRC formation processes
- 3N SRC pair observation
- Reaction mechanisms

Electrons for Neutrinos - e4ν

- Neutrino oscillation experiments requires reconstruction of incident neutrino energy
- Requires well understood models for neutrino interaction
- Electrons and neutrinos interact with nuclei in similar ways
- Test energy reconstruction over wide range of nuclei relevant to these experiments



RGM Status

- Beam energies 2, 4, 6 GeV
- 30 PAC days scheduled October
- Standard CLAS12 configuration
  - Forward Tagger off (extra shielding)
  - LTCC empty
  - vacuum pipe downstream of target to reduce backgrounds
  - BAND (Backward Angle Neutron Detector)
- Detailed run plan draft
  - https://bit.ly/3gZXpmE

Run Plan

	Beam Energy	Target	PAC Days
outbending	2	C	1
	2	Ar	1
inbending	4	H	1
	4	C	1
	4	Ar	1
inbending	6	H	1
	6	d	4
	6	^{4}He	4
	6	Sn	2.5
	6	Ar	1.5
	6	^{40}Ca	3
	6	^{48}Ca	3
	6	C	3
	Overhead + empty		3
	Total		30

RGM Targets

- Liquid targets H,D,He,Ar
- Solid targets: C, Sn, Ca
- Target assembly
- Acceptance matching of C, Sn solid targets to liquid targets

RGM Task Force and Milestones

- Weekly RGM meetings
- Monthly Task Force meetings to meet milestones
  - Members: V. Kubarovsky, N. Baltzell, B. Miller, E. Pasyuk

		2020		2021											
		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	**Target**														
1.1	Target design	M1.1													
1.1.1	Target production				M1.2										
1.2	Target test														
2	**CLAS12 Configuration**														
2.1	BAND In		M2.1												
2.2	FT off, shield on, LTCC no need		M2.2												
2.3	TORUS-Solenoid setting (Inb, Oub)					M2.3									
3	**Off-line analysis framework**														
3.1	Identify a cook		M3.1												
3.2	Start data analysis		M3.2												
3.2.1	Trigger validation software					M3.3									
4	**Monte Carlo simulation**														
4.1	Implement target's geometry			M4.1											
4.3	Define electron trigger parameters				M4.2										
4.4	Generate trigger DC roads, Inbending, Outbending, beam energy dependent.				M4.3										
5	**Calibrate data during the run**														
5.1	Organization of the Calibrator team			M5.1											
5.2	Be familiar with the calibration procedures					M5.2									
5.3	Close interaction with CALCOM group			M5.3											
6	**Slow control**														
6.1	Target control GUI				M6.1										
6.2	Slow control of all subsystems ready and tested							M6.2							
7	**On-line monitoring program**														
7.1	Identify on-line monitoring person					M7.1									
7.2	The CLAS12 monitoring program								M7.2.1	M7.2.2	M7.2.3				
8	**On-line monitoring program**														
8.1	Prepare detailed run plan				M8.1										
8.2	The CLAS12 monitoring program							M8.2							
9	**On-line monitoring program**														
9.1	Conduct of operation (COO)														
9.2	Experiment SafetyAssessment Document (ESAD)														

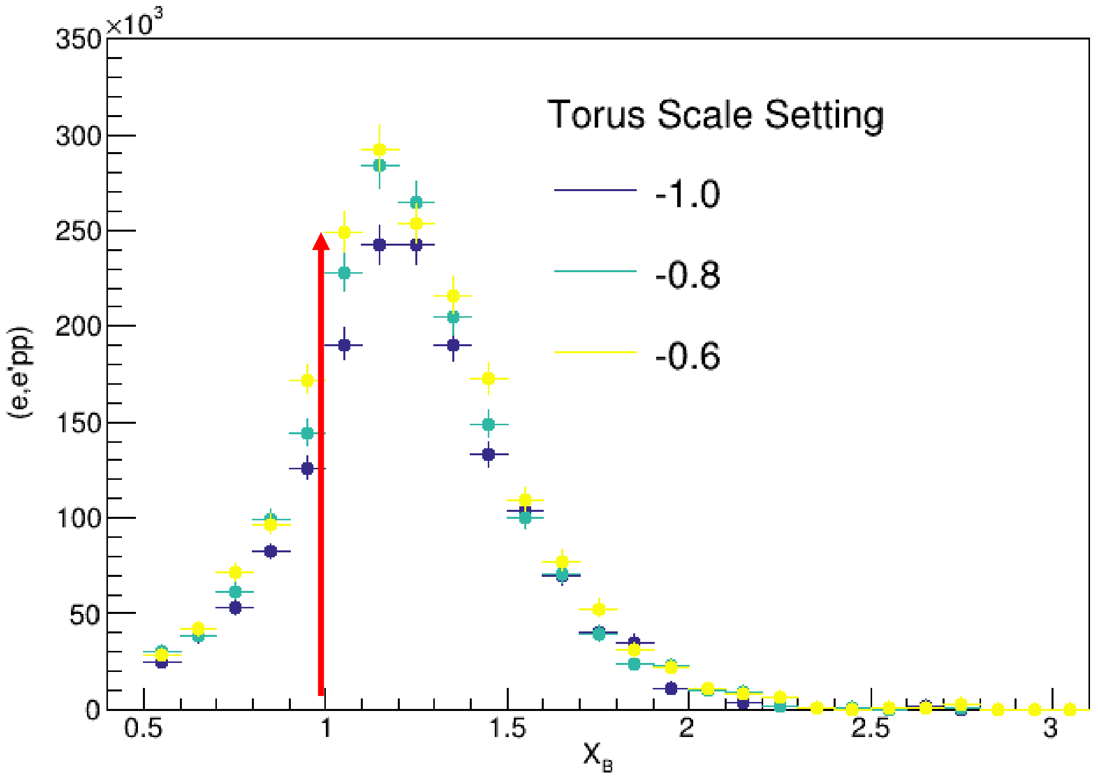
Prior goals (March)

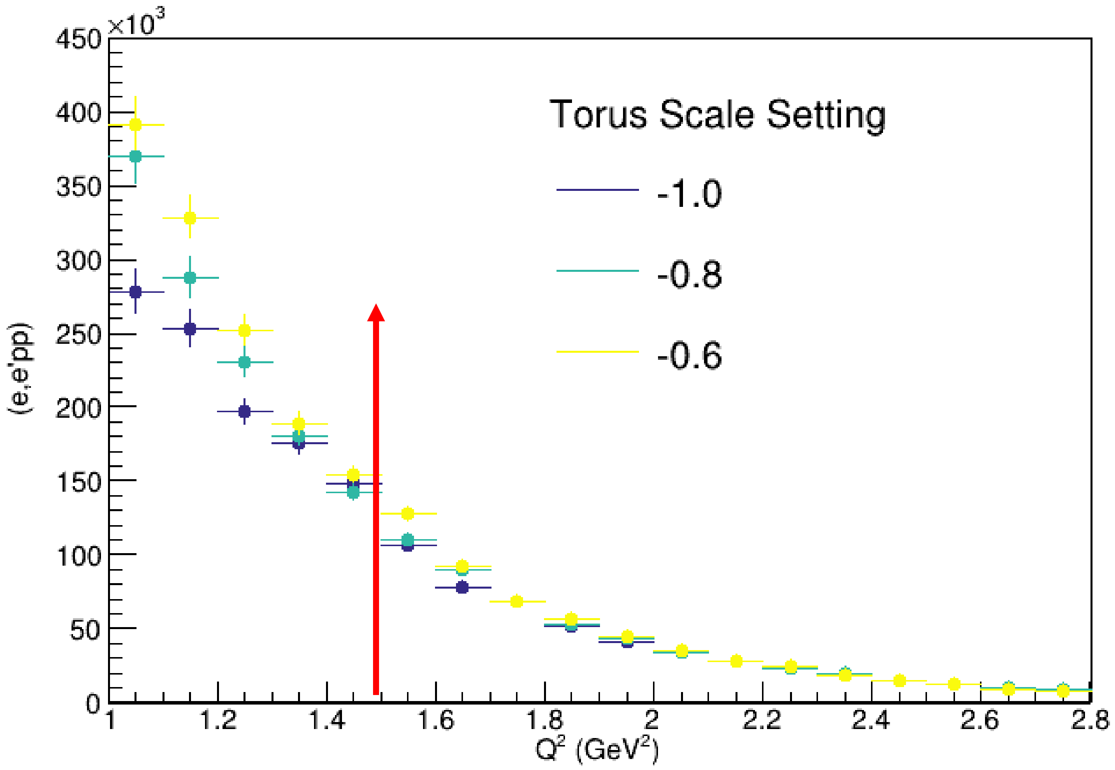
- Data analysis of Deuterium data from RGB
- Developing online monitoring scripts
- Practicing calibration and cooking procedures
- Simulate lower torus field settings in lower beams
  - Lower torus field or not?
- Simulate electron threshold settings
- Cook small set of Engineering runs from RGA which are relevant to RGM (lower beam energies, solenoid, and toroidal fields combinations)

Completed since last update

- Finished MC simulations for torus settings & electron thresholds
- Final stages of calibrating and a final cook for Engineering Runs
- Solid targets ordered, testing, and are being assembled
- Liquid target cells tested and ready to run

Torus Simulations (6 GeV in-bending)





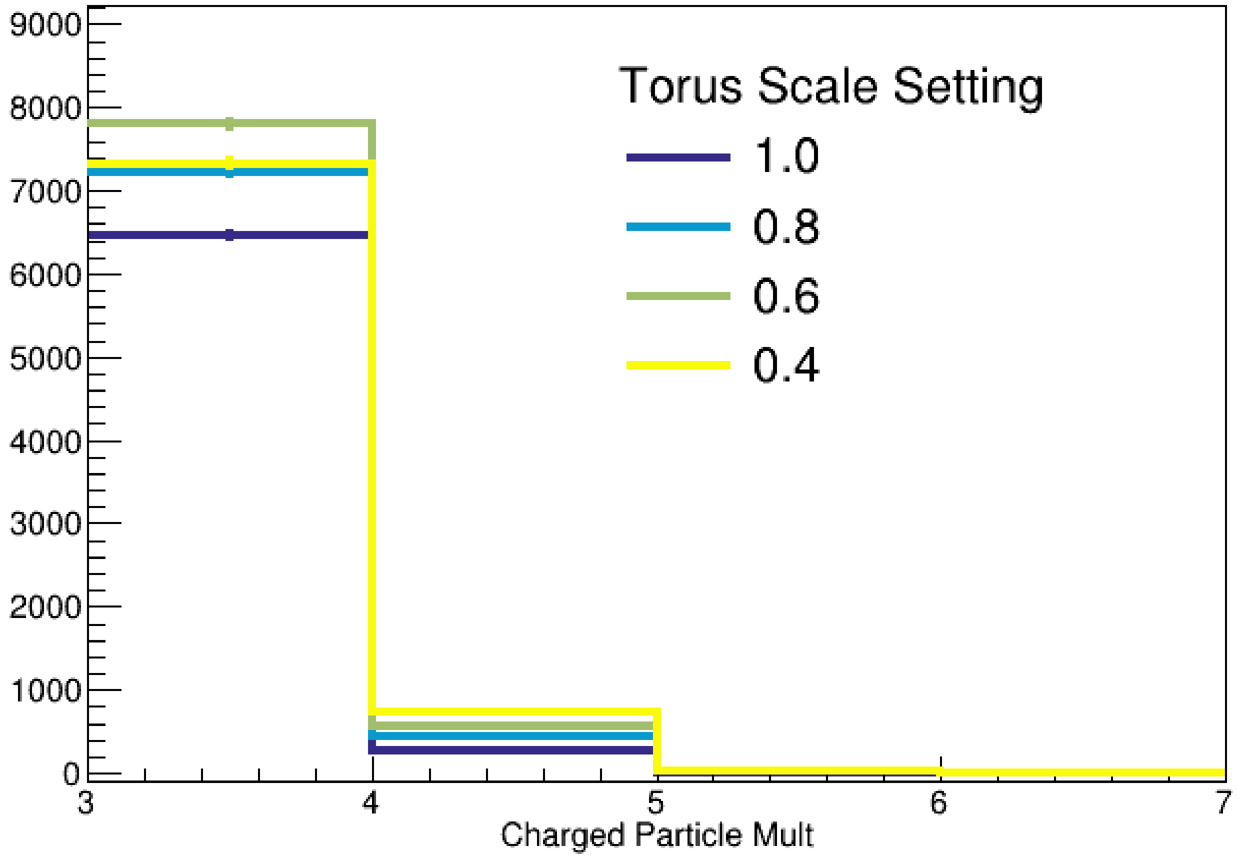
Lowering torus field will:

- Worsen resolution
- Deviate from prior CLAS12 experience
- Provide very little to no increase within the cuts we are taking

- Conclusion: Keep full in-bending. Similar story at 4 GeV staying with previous CLAS12 experience

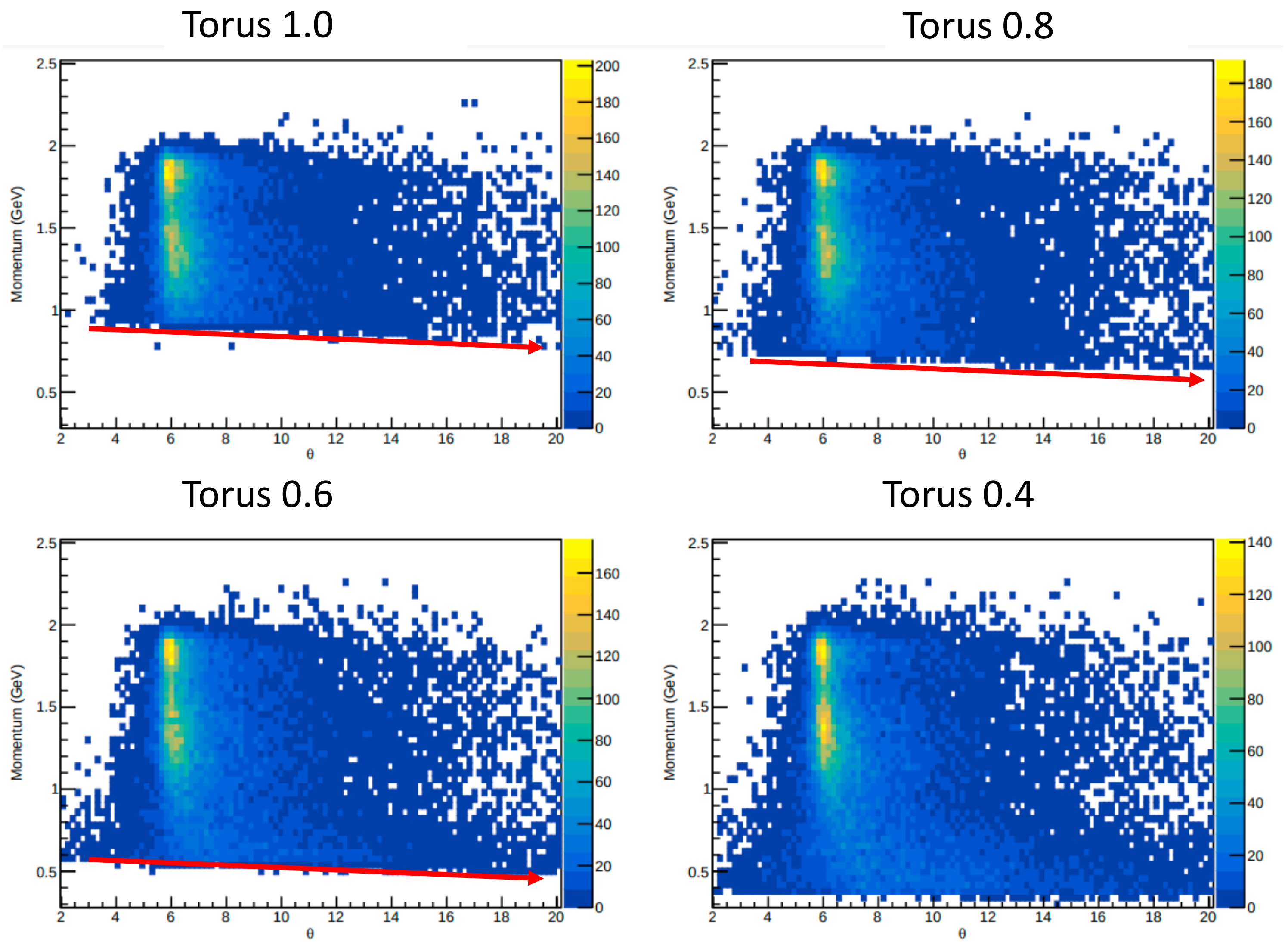
Torus Simulations (2 GeV out-bending)

- 2 GeV is relevant to e4ν (neutrinos) experiment
- Here we want to maximize the charged particle multiplicity > 2
  - Orders of magnitude higher counts Mc = 2
- Maximum between 0.6 and 0.4
- Conclusion: 0.5 out-bending at 2 GeV; also consistent with previous CLAS12 settings



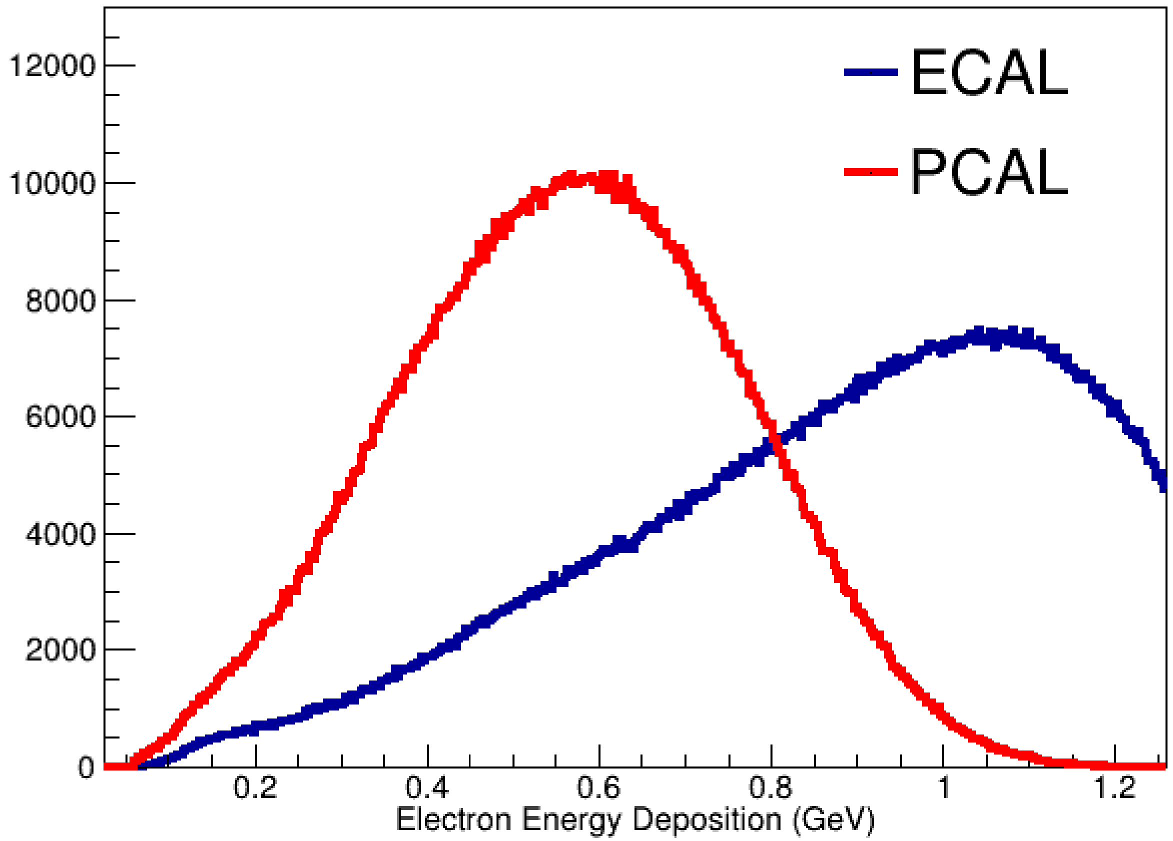
Electron Acceptance Simulations (2 GeV out-bending)

- Minimum electron momentum accepted depends on the torus strength
- Conclusion: Torus strength of 0.5 out-bending gives sufficiently low electron momenta



Electron threshold settings (6 GeV)

- Relevant threshold quantities:
  - ECAL = EIN + EOUT + PCAL
  - PCAL
- Typical CLAS12 thresholds:
  - ECAL ~100 MeV
  - PCAL ~60 MeV
- Consistent with our simulations
- Increasing threshold does not negatively affect physics signal



Electron threshold settings (2 GeV)

- Relevant threshold quantities:
  - ECAL = EIN + EOUT + PCAL
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- Typical CLAS12 thresholds:
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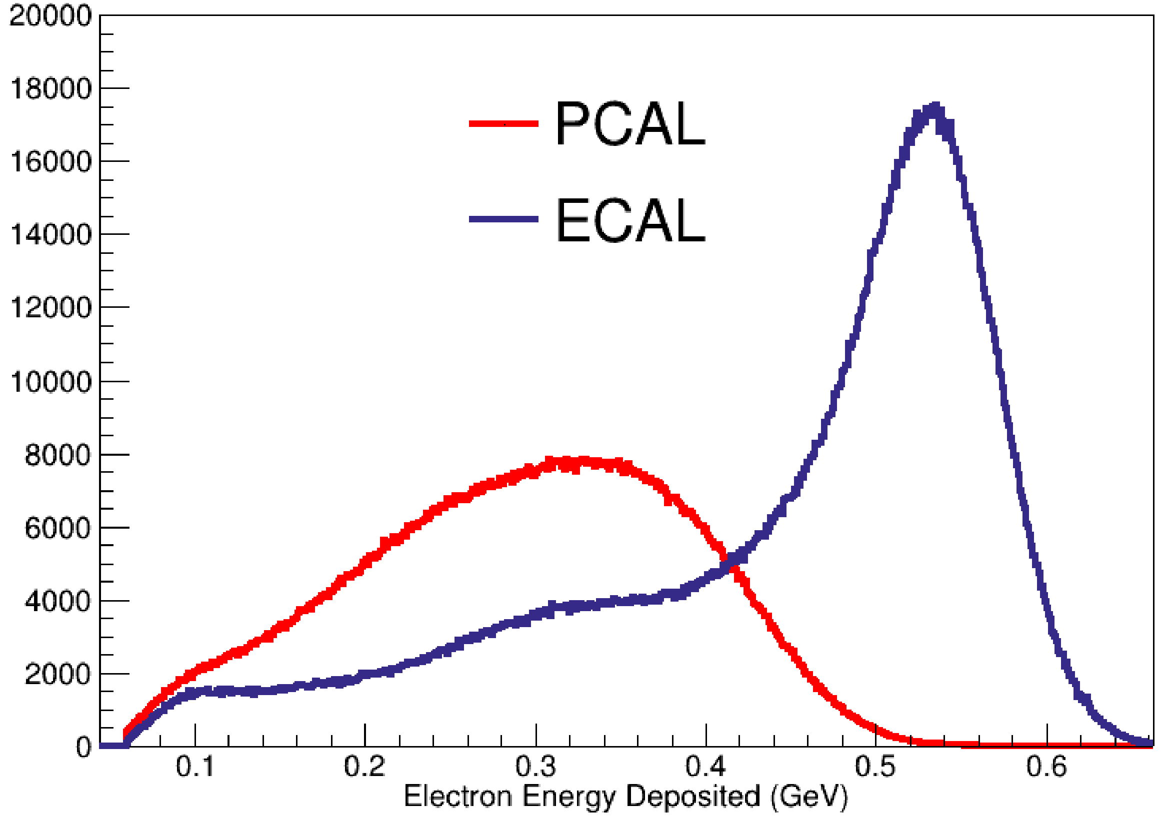
*0.4 out-bending



Current ongoing preparations

- Developed semi-online physics monitoring code CLAS12root
- Combined with typical monitoring plots used to monitor CLAS12 this will ensure we see the expected counts in our physics channels of interest
    - Not expecting any neutron analysis to be semi-online
- BAND installation will be in July
- Ongoing analysis to understand CLAS12 resolutions
- Solid targets should be finished by end of July

RGM calibrations

- Chef and Analysis coordinator involved in CALCOM
- Set of Engineering data calibrated and cooked for Beam offset, FTOF, DC
- HTCC, FT, FTOF, CND remaining calibrations
- Cooking and calibrating this data set has provided a critical preparation for the real online production calibrations and cooking

Looking ahead

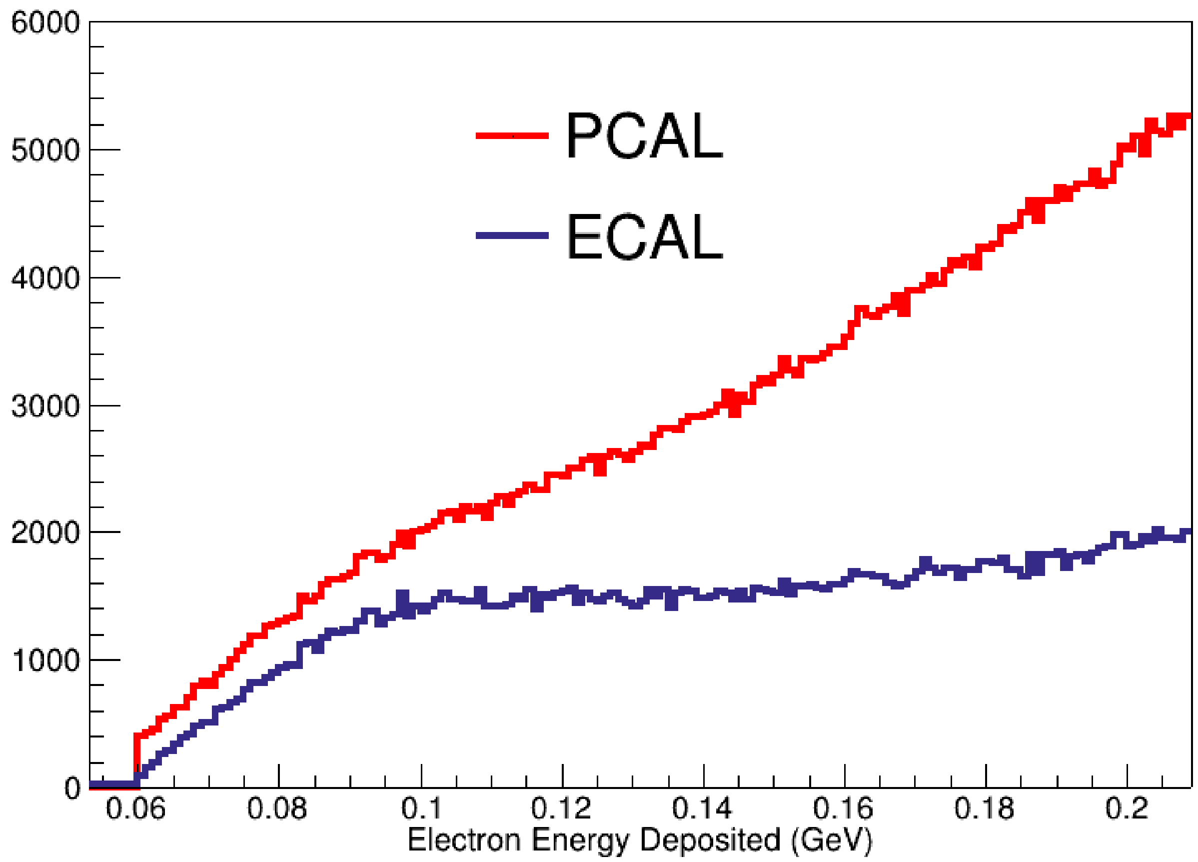
- Install BAND
- Mature online monitoring analysis
- Collect all monitoring scripts and practice/train
- Preparation for data taking and lab access

RGM Targets

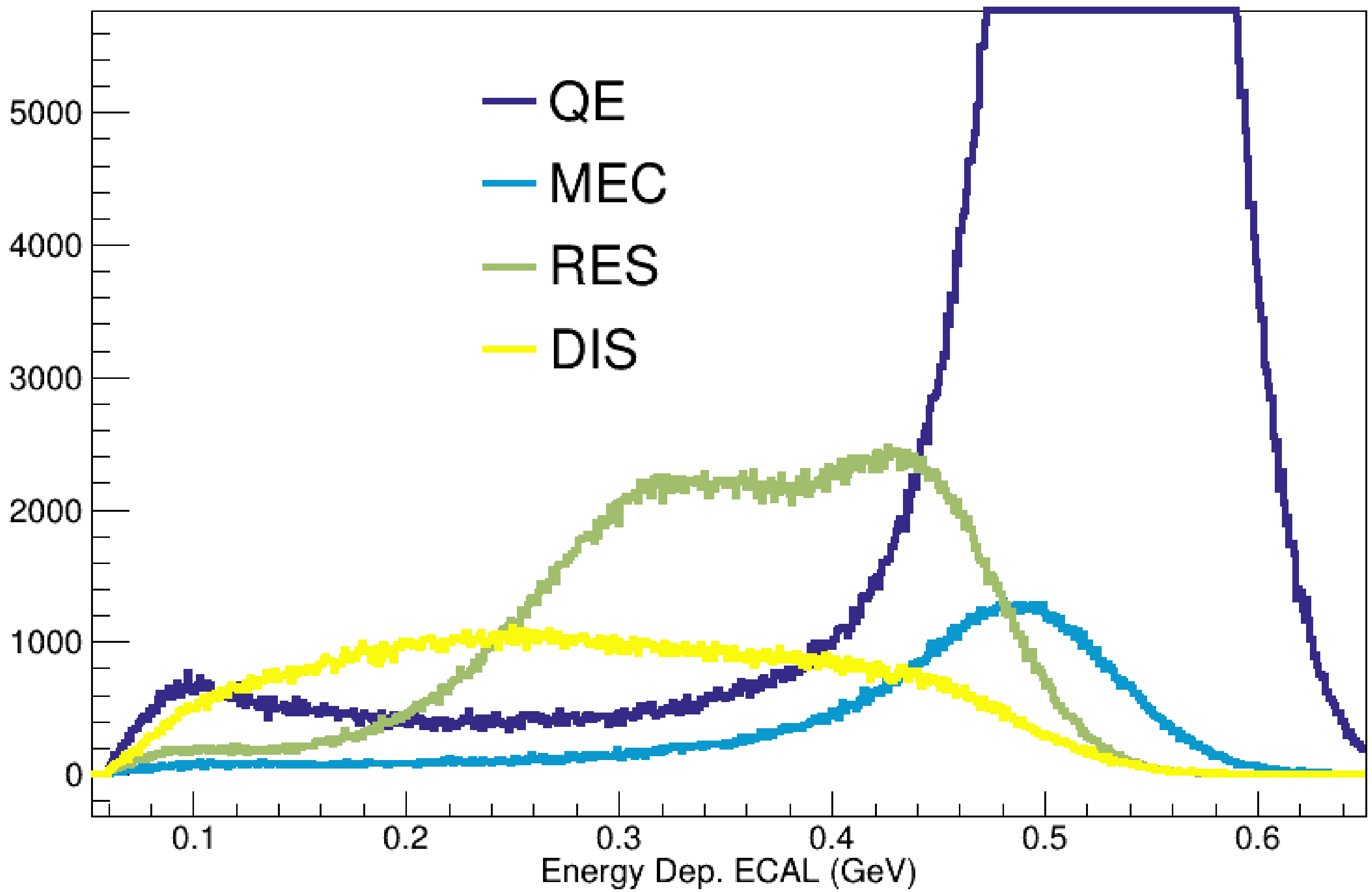
Liquid Targets	Target Thickness (cm)
D	5
He	5
H	5
Ar	0.5

Nuclear Targets	Areal Density (mg cm^{-2})	Target Thickness (mm)
^{40}Ca		
^{48}Ca		
C	400	1.8
^{120}Sn	200	0.3
C (muli-foil)	100	0.5
^{120}Sn (multi-foil)	50	0.07

2 GeV (out-bending) Zoom

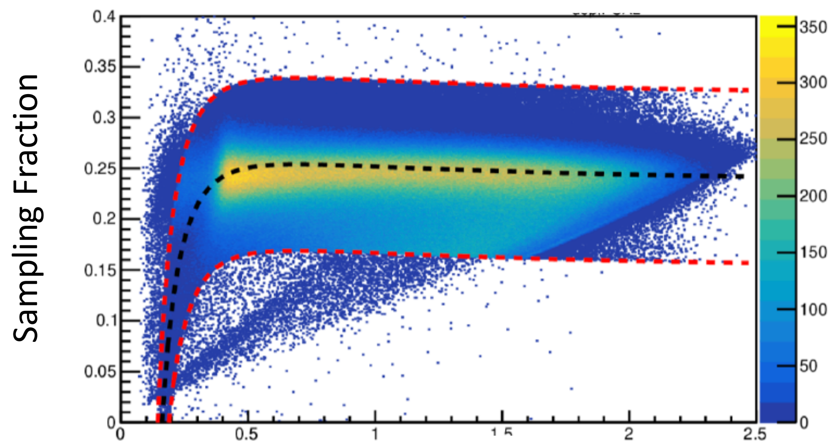


2 GeV (out-bending)

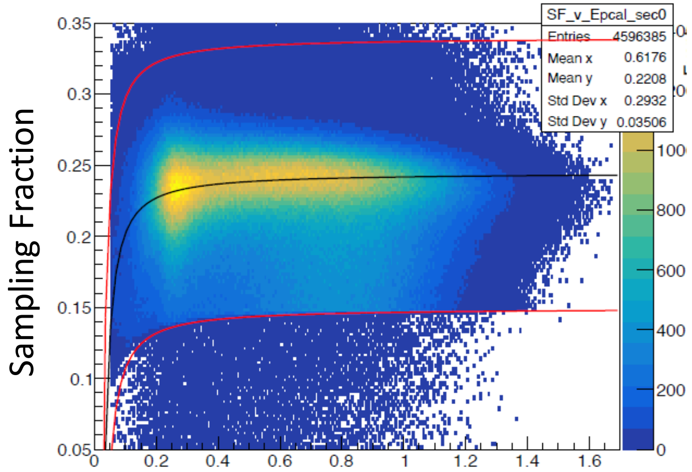


Training Personnel in CLAS12 Analysis

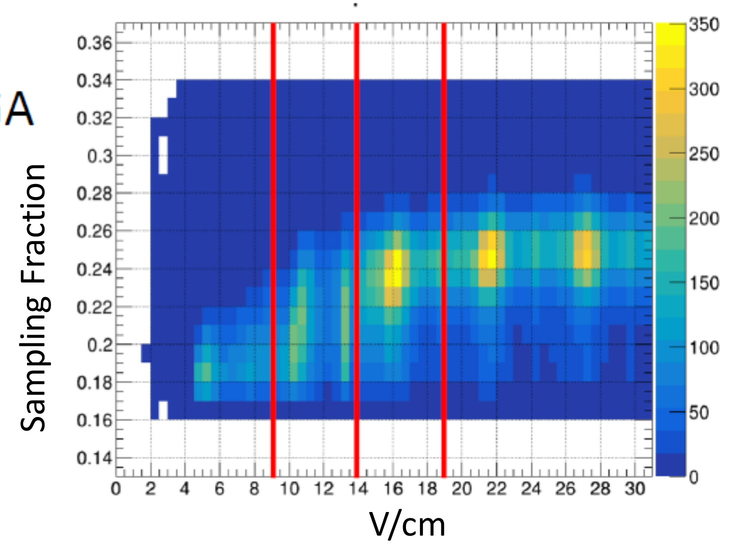
RGA



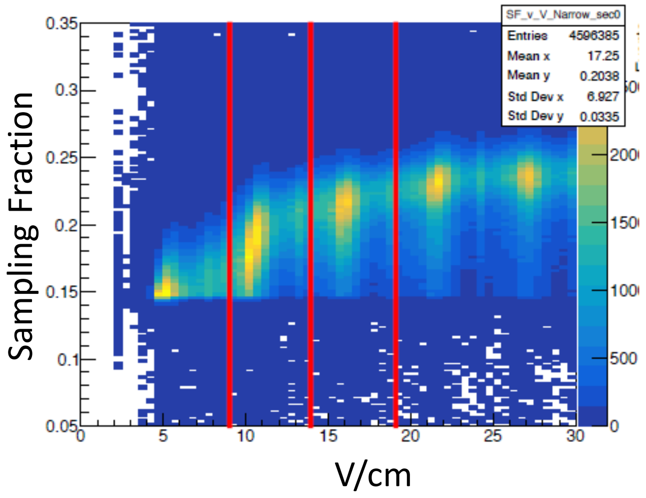
RGB



RGA

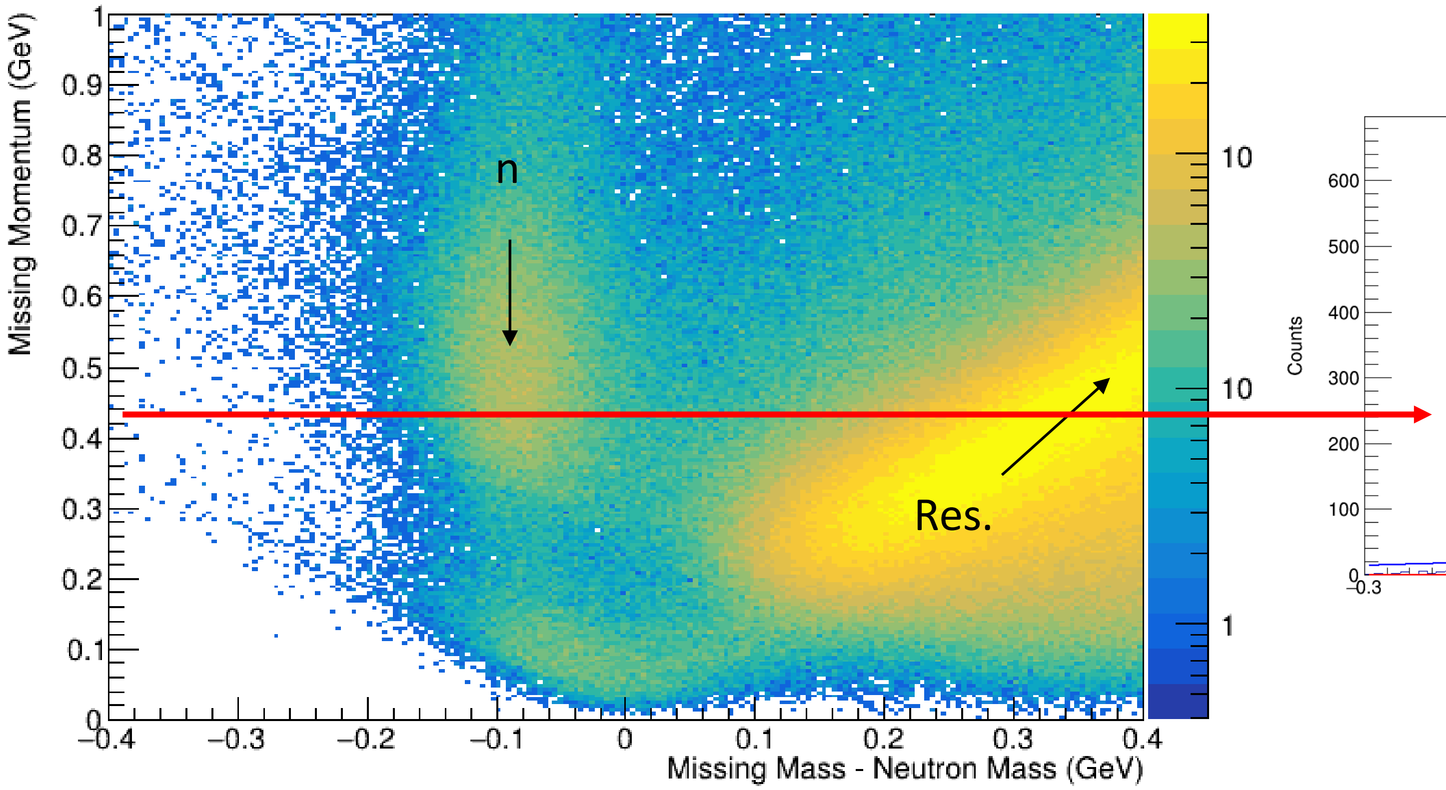


RGB

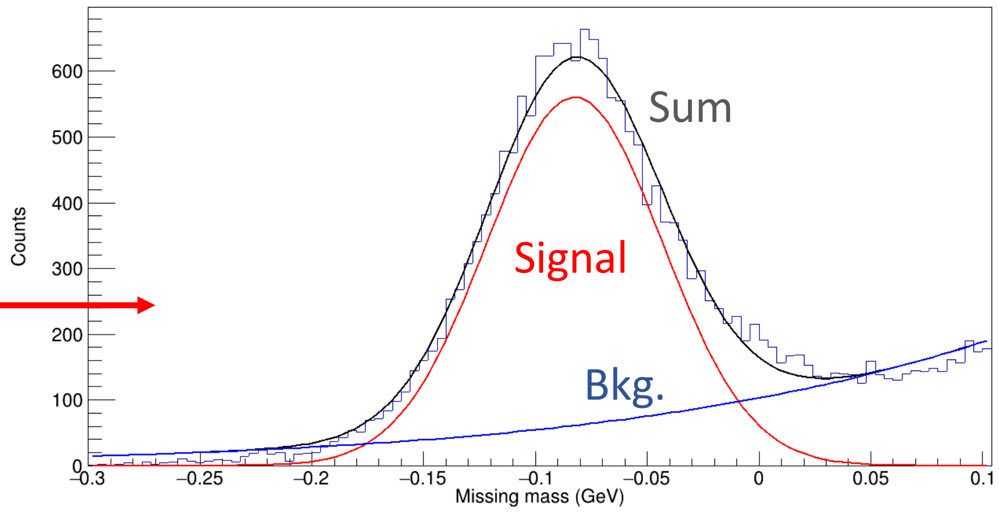


4-GeV Deuterium RGB (e,e’p)n

Protons going in Forward Detector

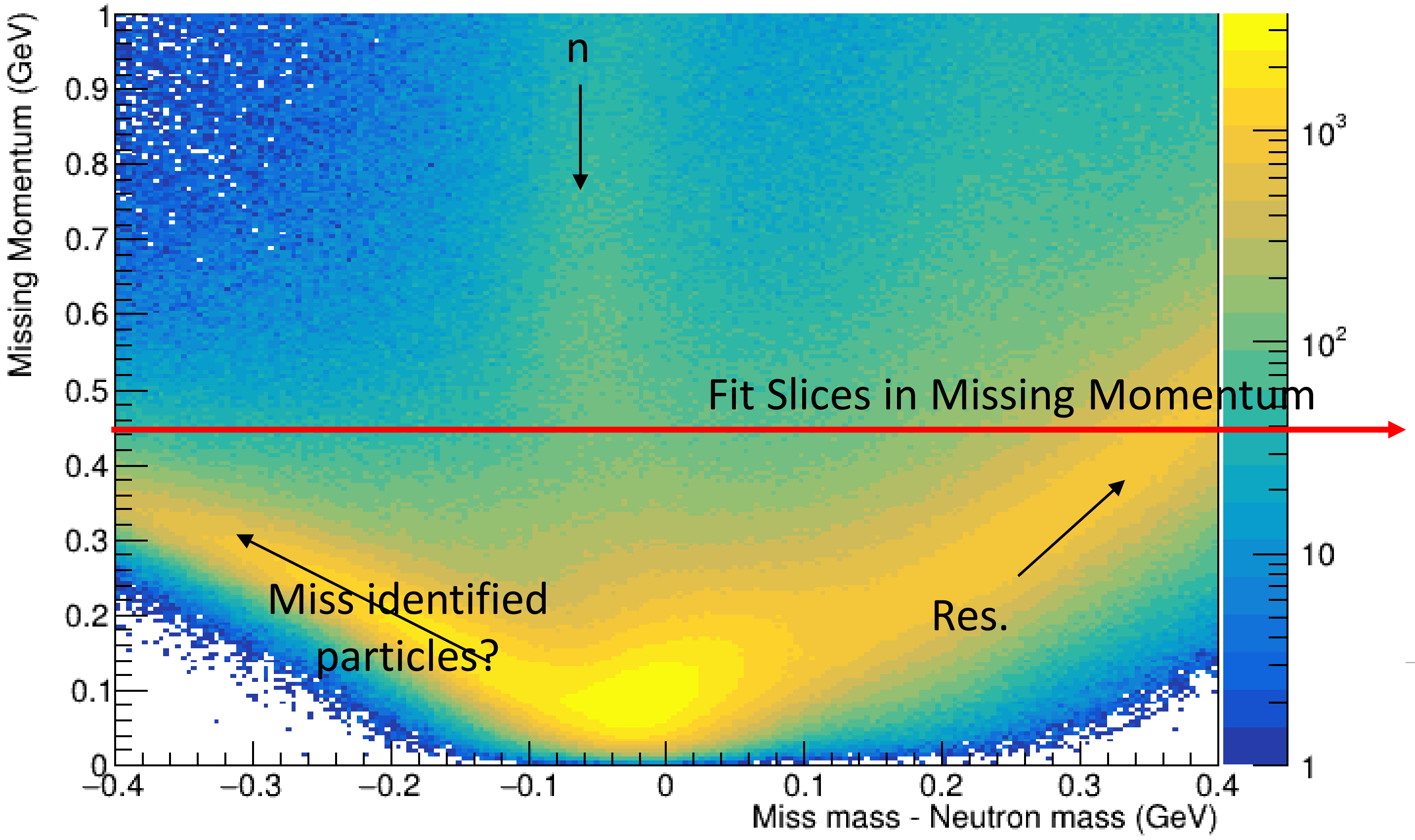


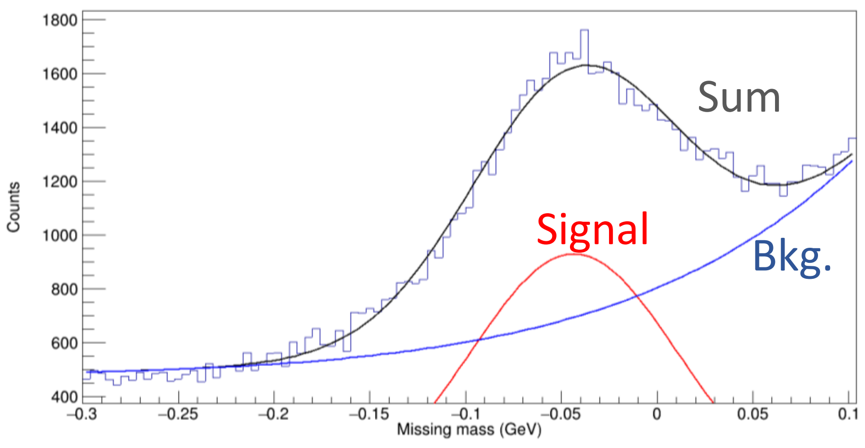
Fit Slices in Missing Momentum



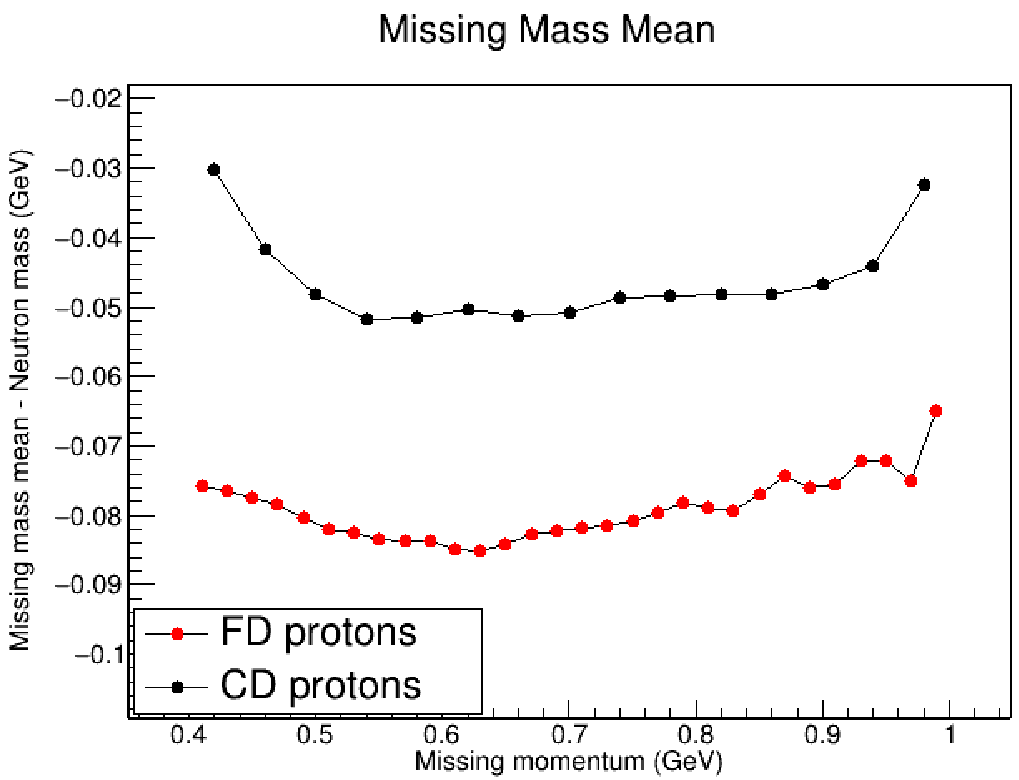
4-GeV Deuterium RGB (e,e'p)n

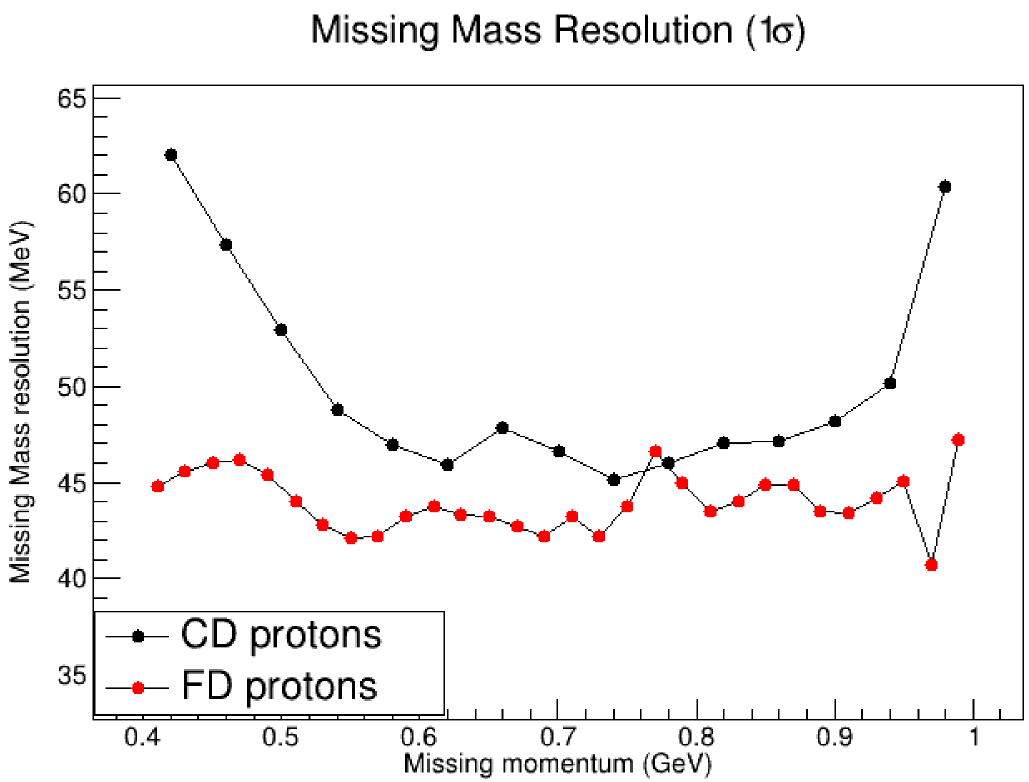
Protons going in Central Detector





Missing Mass Resolution

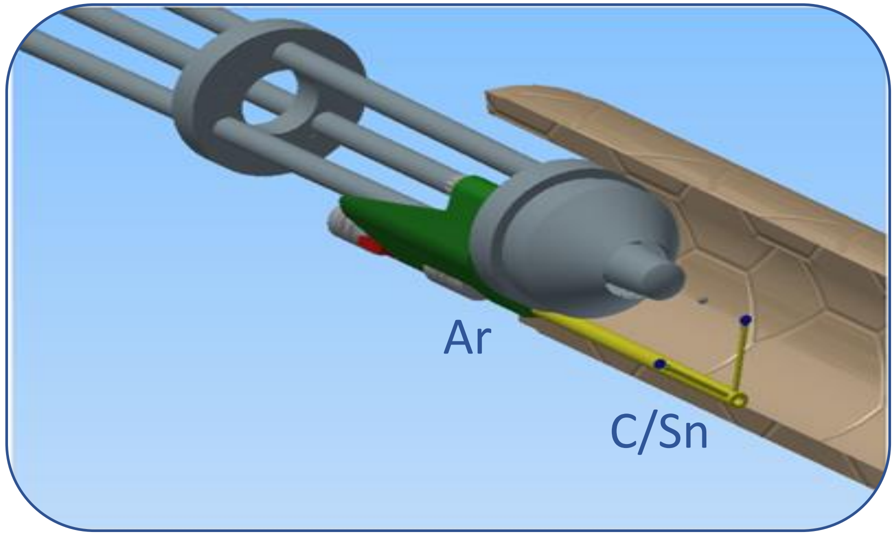


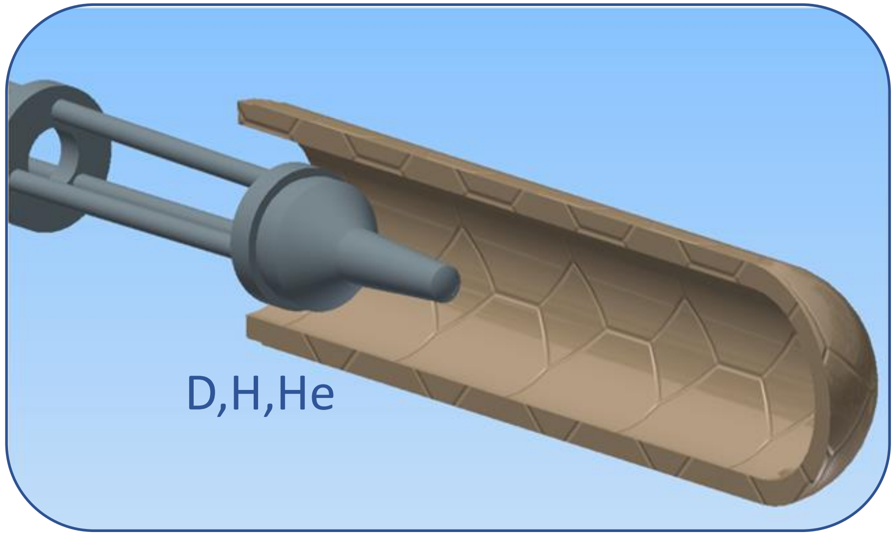


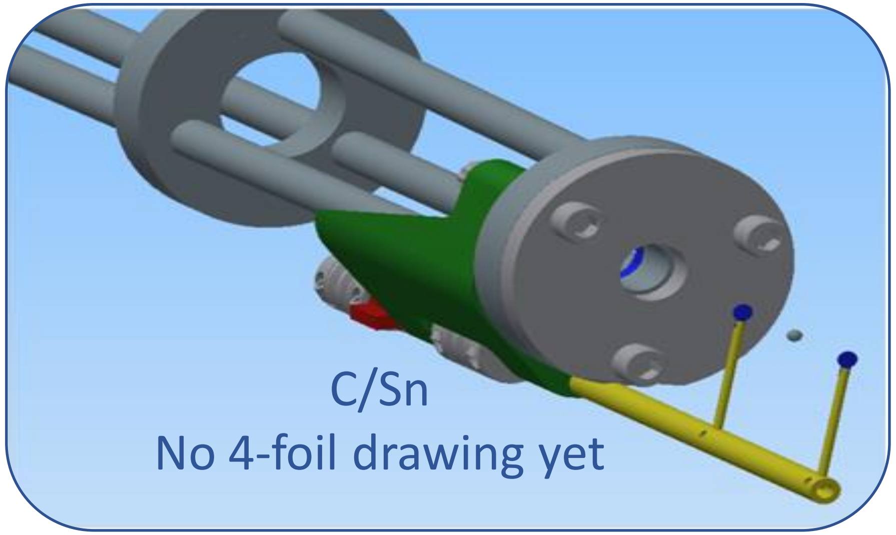
RGM related links

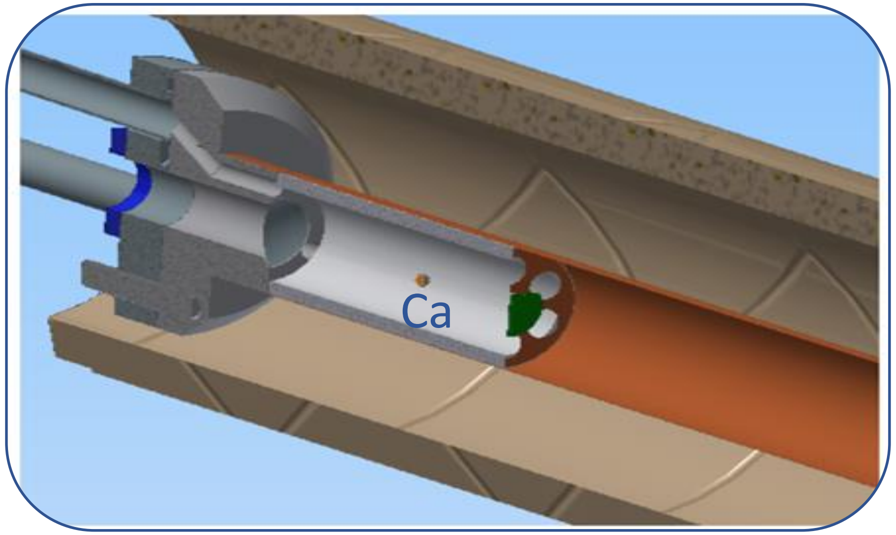
- RGM Weekly meeting
  - https://clasweb.jlab.org/wiki/index.php/Run_Group_M
- RGM Wiki
  - https://wiki.jlab.org/clas12-run/index.php/Run_Group_M
- RGM Task Force (Monthly)
  - https://clasweb.jlab.org/wiki/index.php/Template:Hall-B_Run_Group_Task_Forces_:_RG-M

RGM Targets

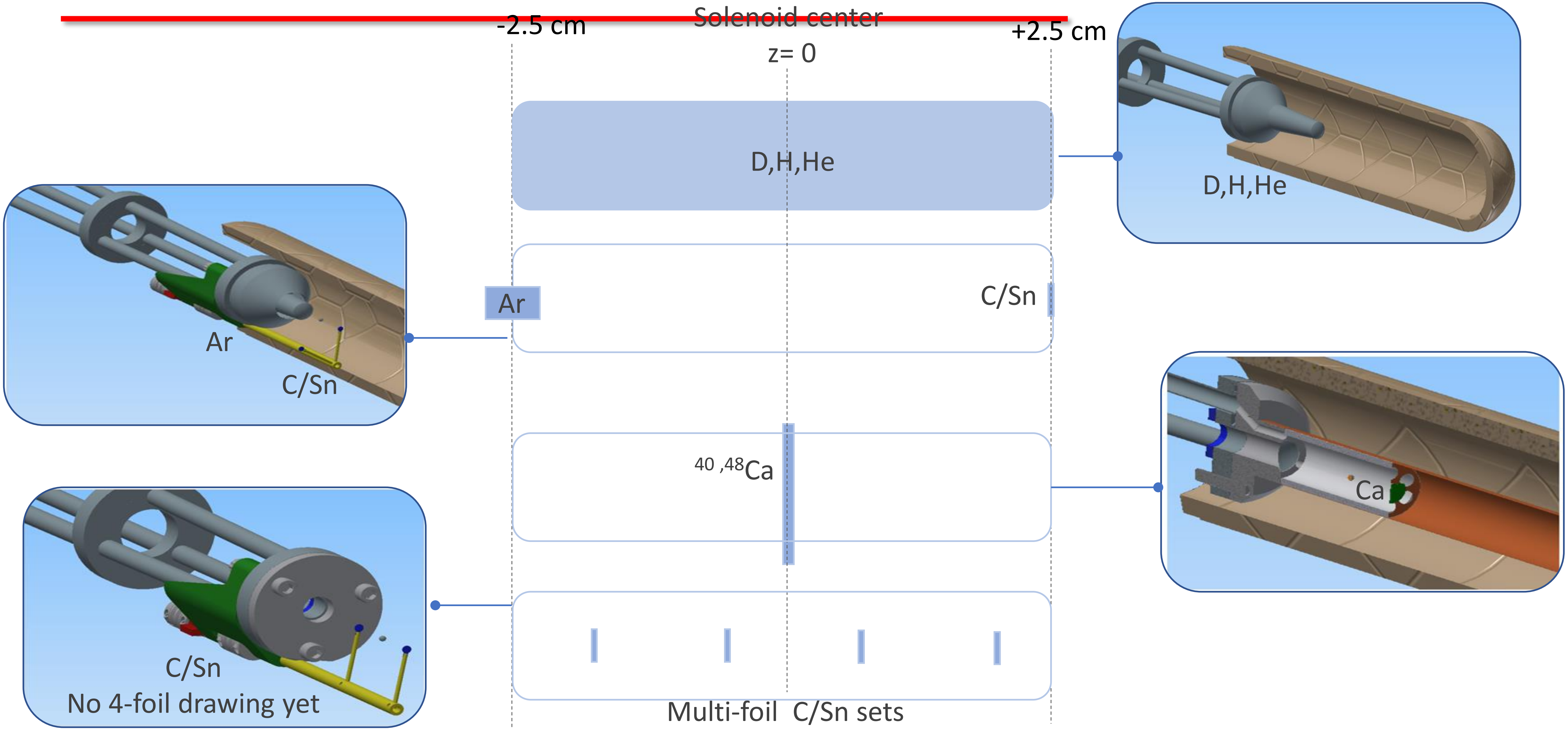








RGM Targets



-2.5 cm
Solenoid center
z= 0
+2.5 cm
D,H,He
D,H,He
Ar
C/Sn
Ar
C/Sn
40 ,48Ca
Ca
C/Sn
No 4-foil drawing yet
Multi-foil C/Sn sets

RGM Targets

- Carbon and Sn targets will have a multi-foil construction
  - approximates the liquid target acceptance
- Target change estimates
  - Empty to Liquid ~ 8 hrs.
  - Liquid ↔ solid target ~ 22 hours
  - Solid → solid target ~ 12 hours