Readiness and Plans: RG-F (The BONuS12 Experiment)

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clas CEBAF Large Acceptance Spectrometer

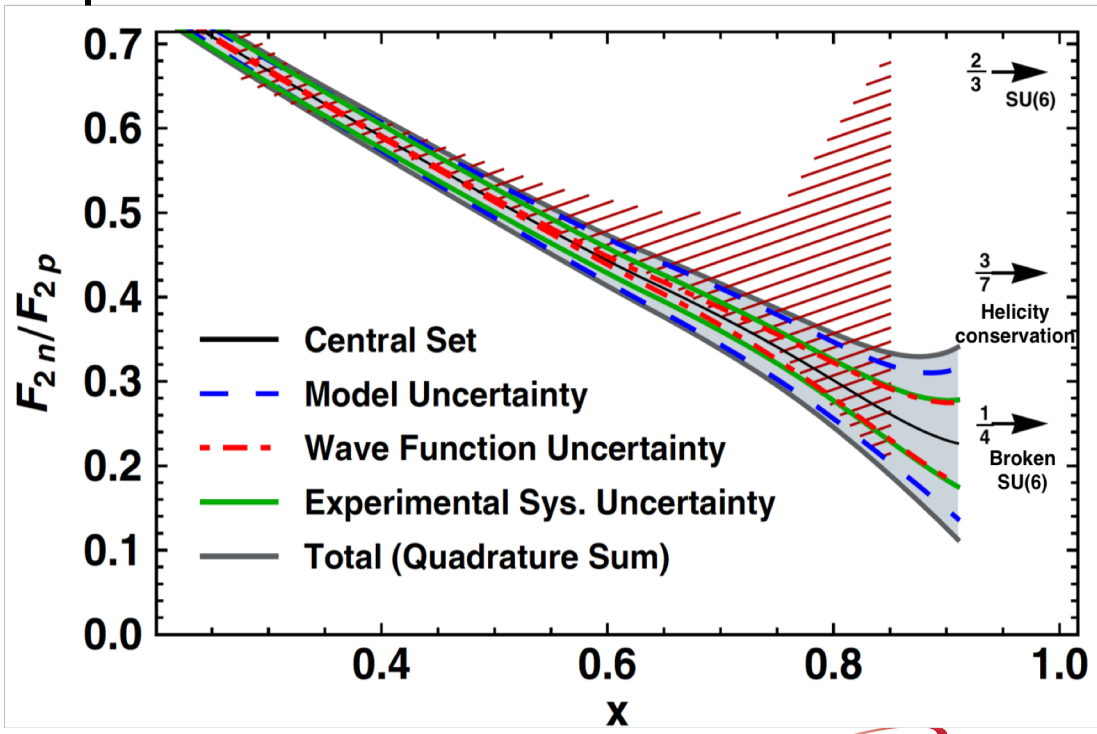
Jefferson Lab

Outline

- Overview of the BONuS12 Experiment
- Experimental components of BONuS12
- Current status of BONuS12
- Future plans

Neutron Scattering: background

- Unavailability of free neutron target because of the short Life time (average decay time ~ 15 min)
- Stable only inside the nucleus (bound state)
- Required nuclear correction to extract data from bound state, which are model dependent
  - ✓ Off-shell correction
  - ✓ Final state correction
  - ✓ Fermi motion



The BONuS12 Experiment

Barely Off-shell Nucleon Structure (BONuS) at Jefferson Lab's 12 GeV

- ✓ Study the nearly-free Neutron Structure Function (F_2^n) at large Bjorken-x, and improve the asymptotic value of d/u ratio

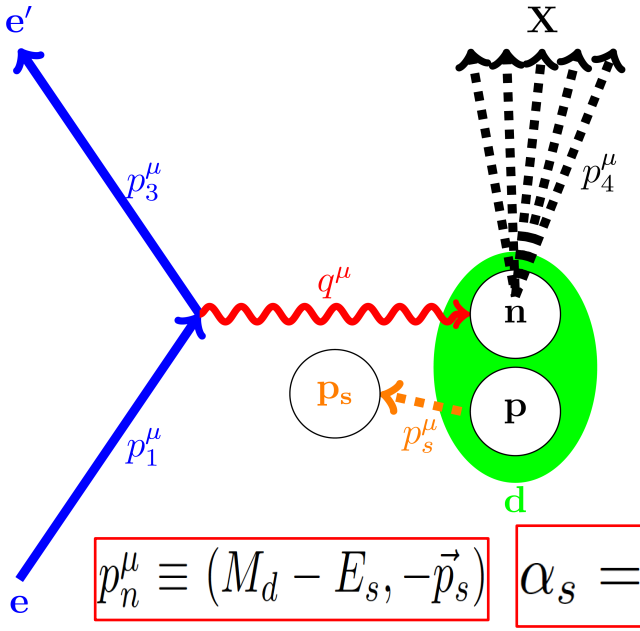
$$\frac{d^2\sigma}{dx\,dQ^2} \approx \frac{4\pi\alpha^2}{Q^4}\left[\frac{(1-y)}{x} + \frac{y^2}{2x}\right]F_2(x)$$

DIS Regime

$$\frac{d}{u} \approx \frac{4F_2^n/F_2^p - 1}{4 - F_2^n/F_2^p}$$

- ✓ Reduced nuclear uncertainty by choosing Spectator angle > 120° and spectator momentum < 100 MeV/c

- ✓ Spectator tagging technique in deuteron for neutron scattering



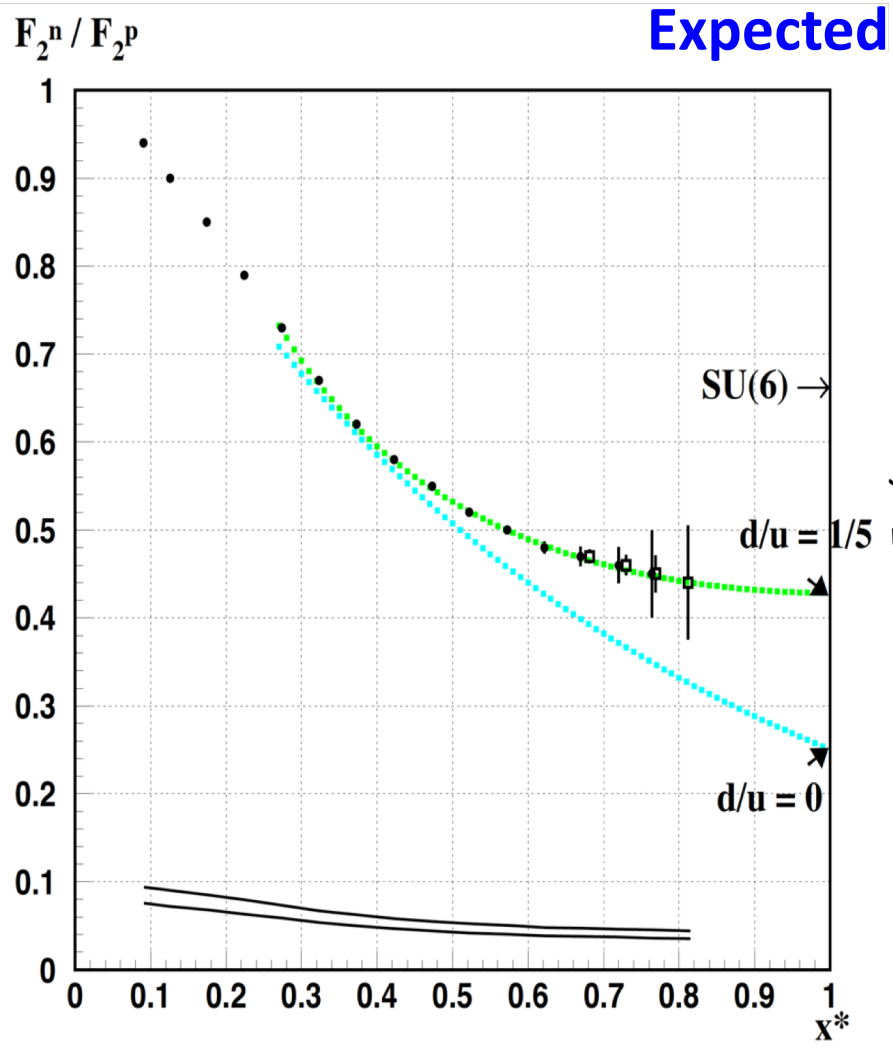
$$p_n^\mu \equiv (M_d - E_s, -\vec{p}_s) \qquad \alpha_s = \frac{E_s - \vec{p}_s\cdot\hat{q}}{M_s}$$

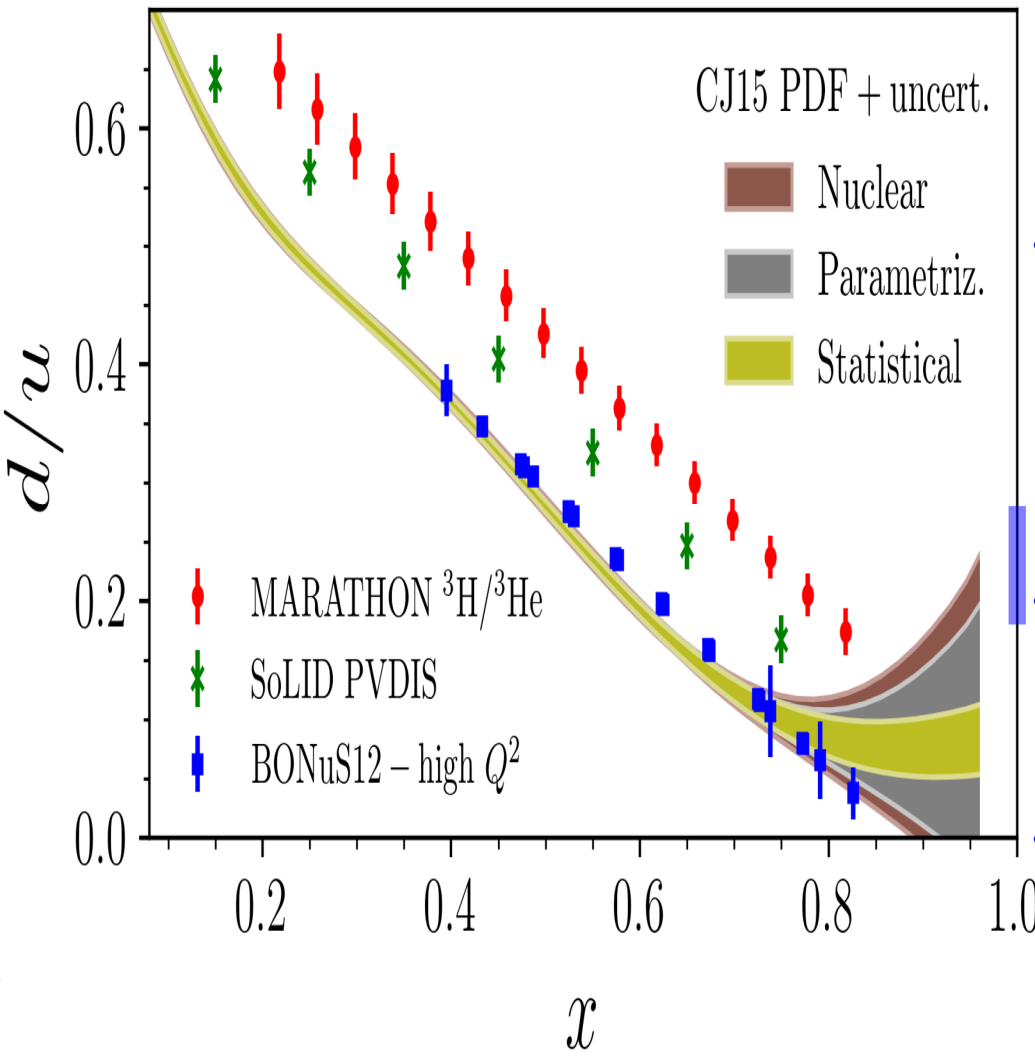
$$x^* = \frac{Q^2}{2p_n^\mu q_\mu} \approx \frac{Q^2}{2M\nu(2-\alpha_s)}$$

$$W^{*2} = (p_n^\mu + q^\mu)^2 \approx M^2 - Q^2 + 2M\nu(2-\alpha_s)$$

Expectation of BONuS12

Expected Results





Experimental Components

- Detector system
  - Standard CLAS12 detector (without MVT and SVT) ⟶ *electron+ X*
  - Newly designed Radial Time Projection Chamber (RTPC) ⟶ *proton*
- Data Acquisition system (DAQ)
  - Standard CLAS12 DAQ ⟶ *electron + X*
  - DREAM based DAQ for the RTPC ⟶ *proton*
- Simulation and Analysis
  - Implementation of the RTPC in standard CLAS12 software: GEANT4 Monte Carlo (GEMC) for simulation and COATJAVA for analysis
- Target of pressurized Deuterium gas

Upgraded Electron beam of energy 11 GeV at Hall B

Proposed beam time: 42 days

Luminosity: $2 \times 10^{34}\ cm^{-2}\ s^{-1}$

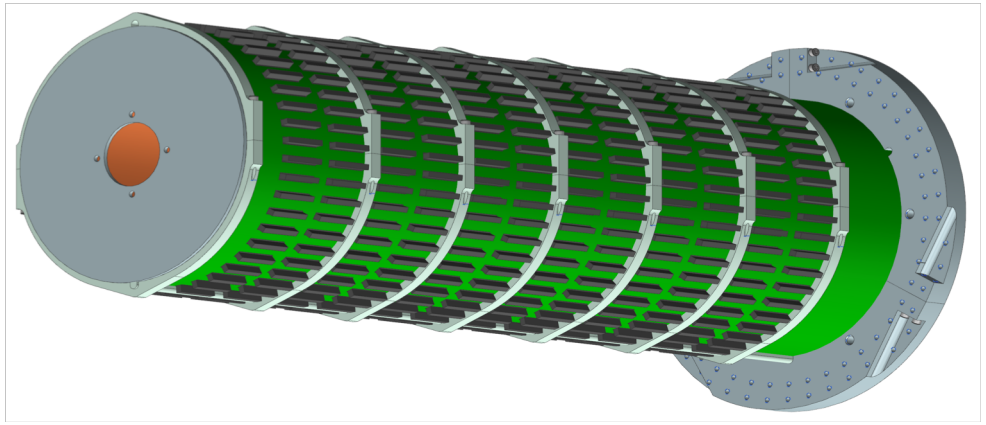
Status Update: Working groups

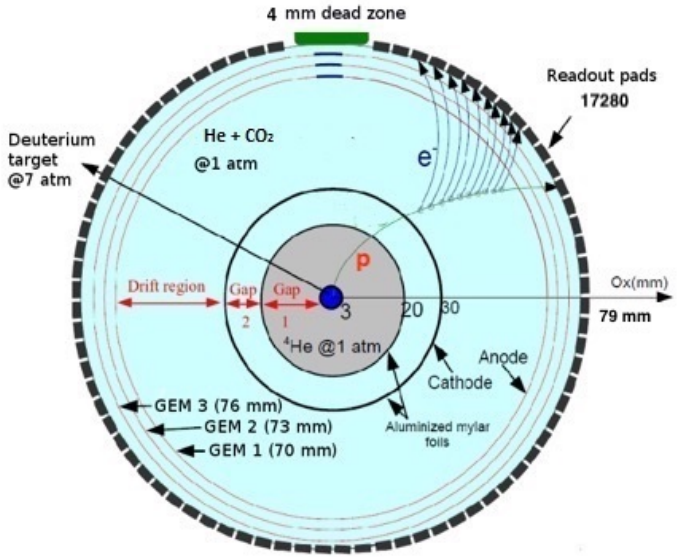
Working on Five different groups:

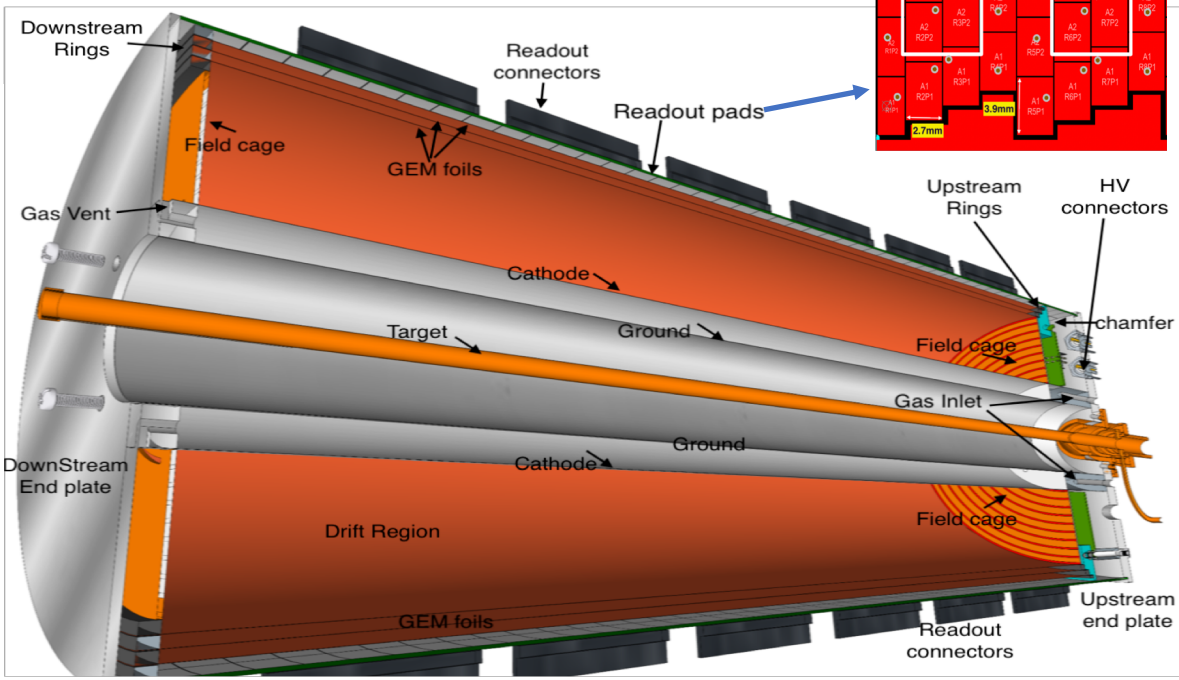
1. Detector Design
   - design and construct the Radial Time Projection Chamber (RTPC)
2. DAQ and prototype testing
   - test the target, high voltage supply, drift gas and the DAQ
3. Simulation and Analysis
   - develop the RTPC simulation, analysis and tracking code
4. Gas and Slow controls
   - design gas flow system and slow-control of the RTPC
5. CLAS12 Integration
   - details of installing and de-installing of the RTPC and MVT+SVT

Status: Detector design

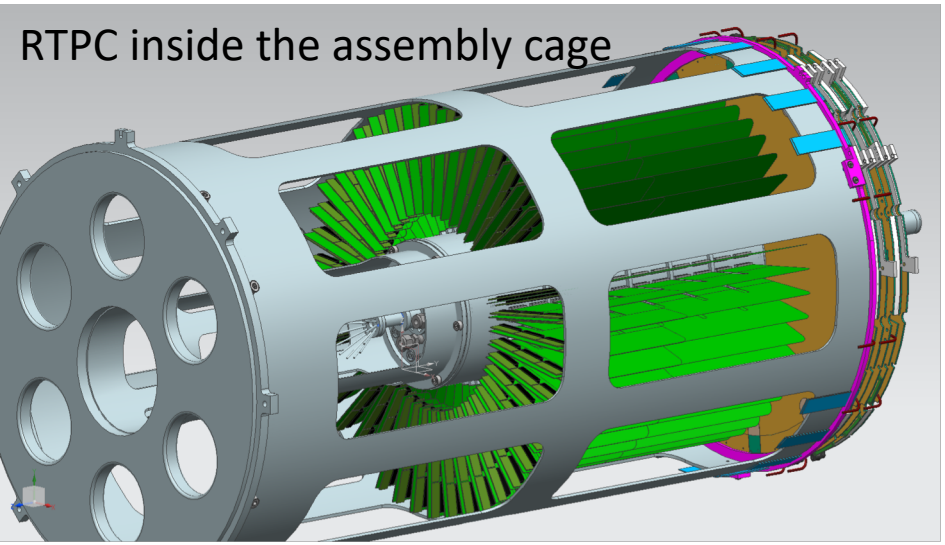
- RTPC: triple GEM cylindrical detector of length 40 cm and radius 8 cm
- Drift gas: He+CO_2 mixture (80:20)
- Active region: radially 4 cm (3 cm - 7 cm)
- Readout pads: 17280 (2.7mm × 4 mm)

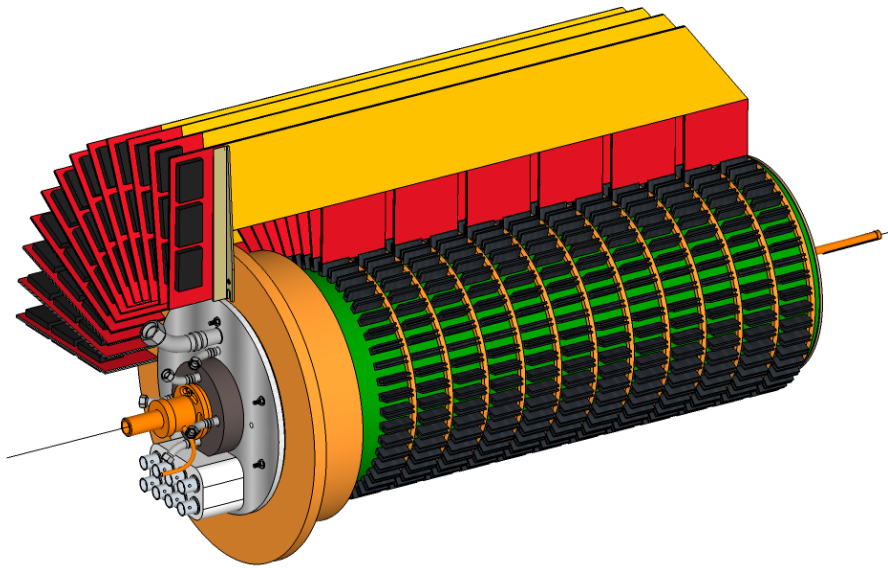


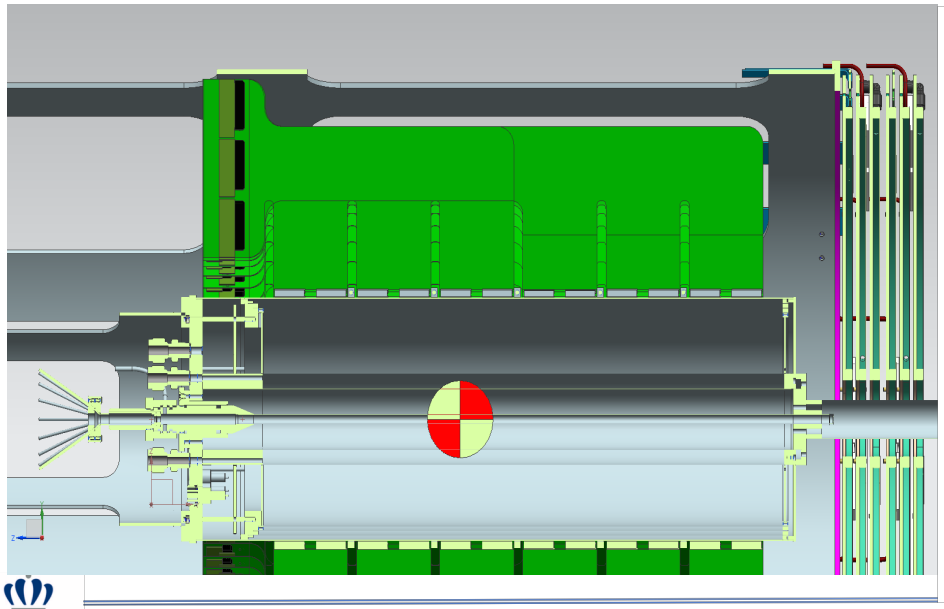


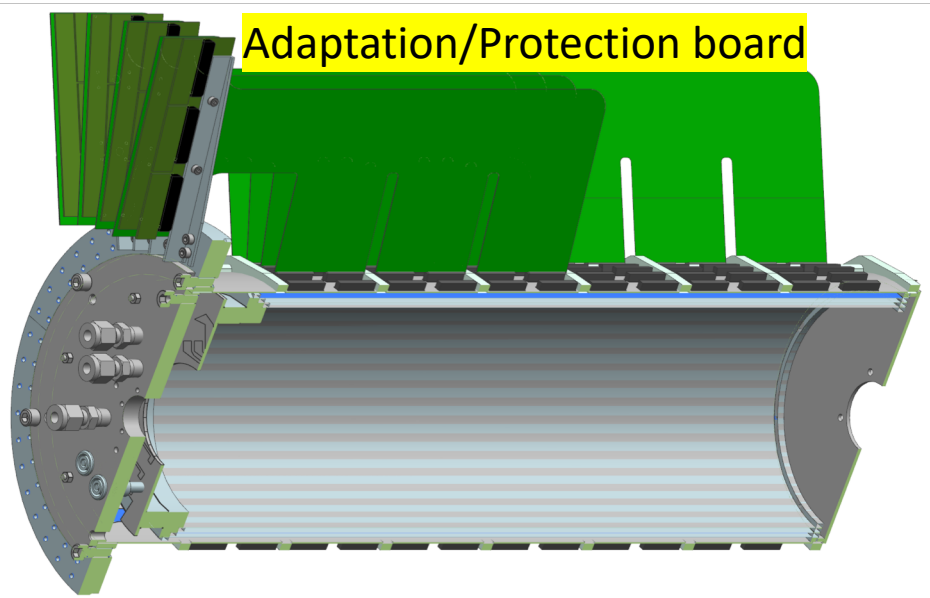


Status: Detailed design

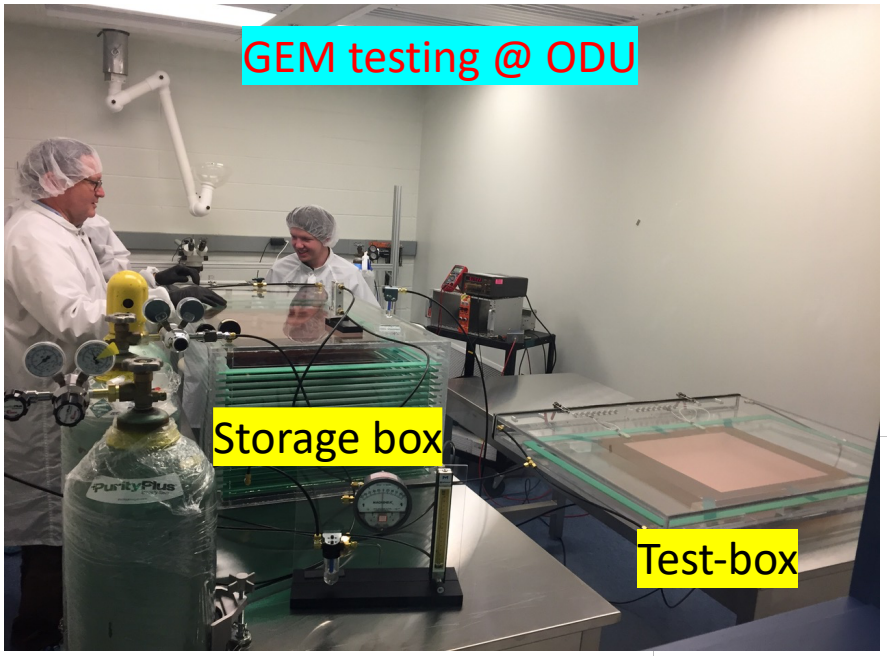


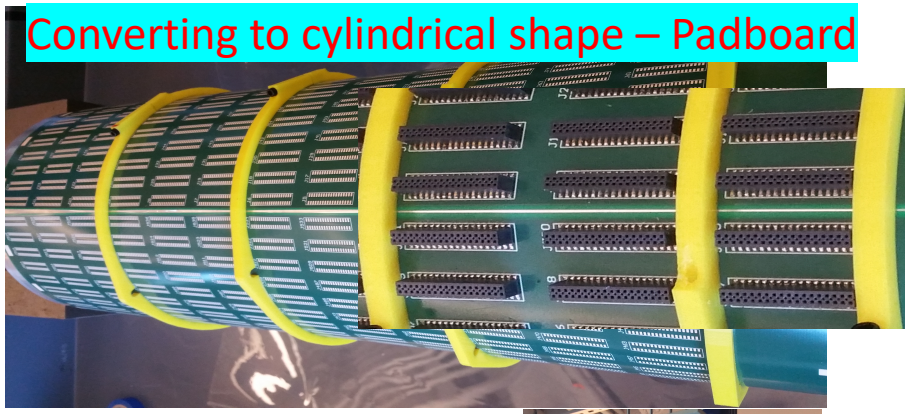


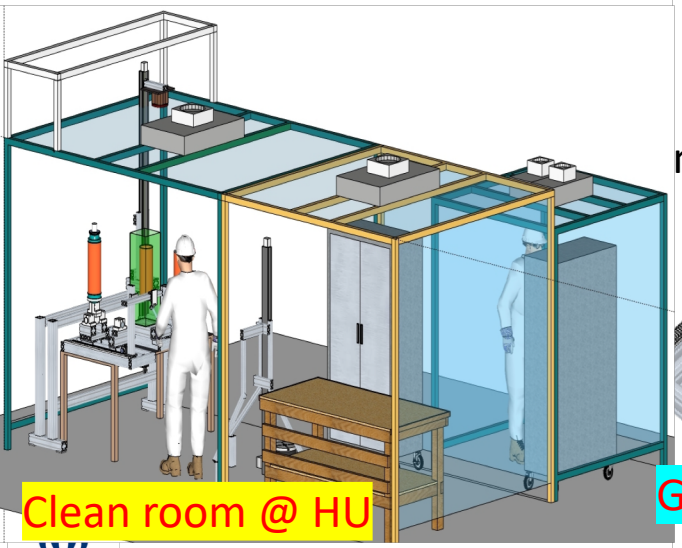


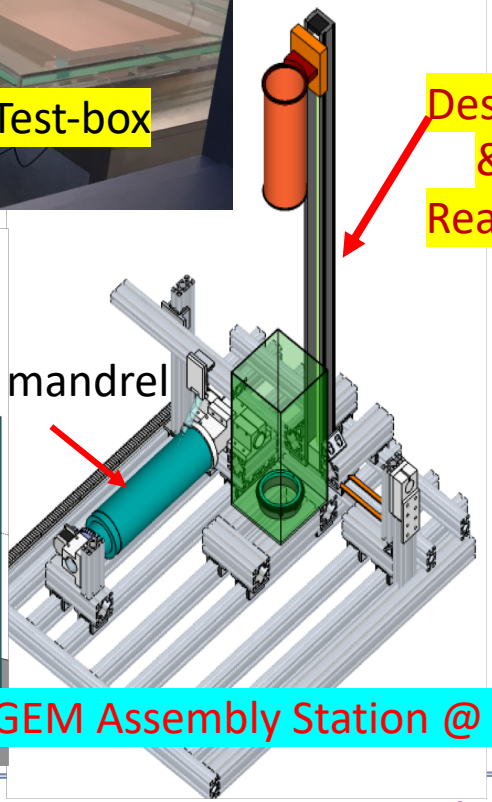


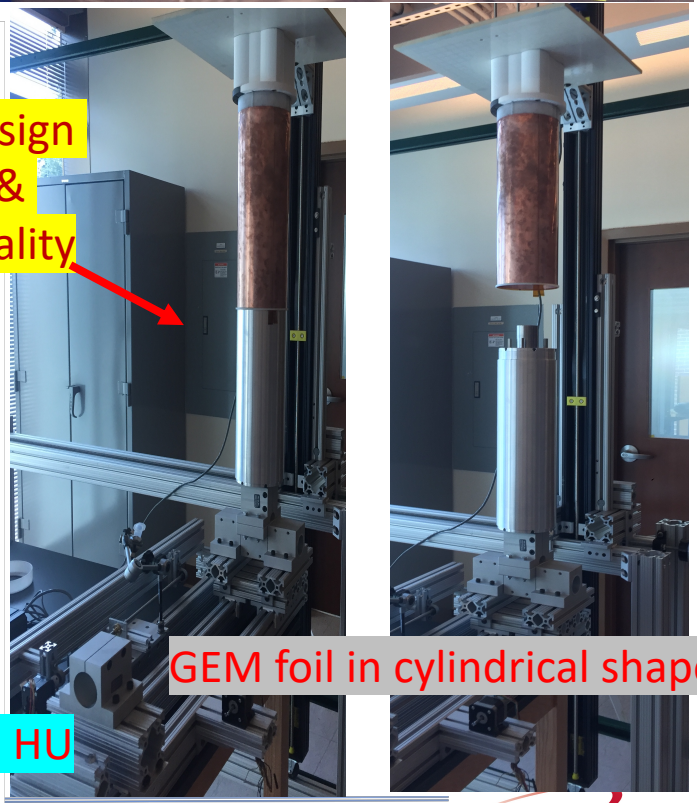
Status: Detector construction





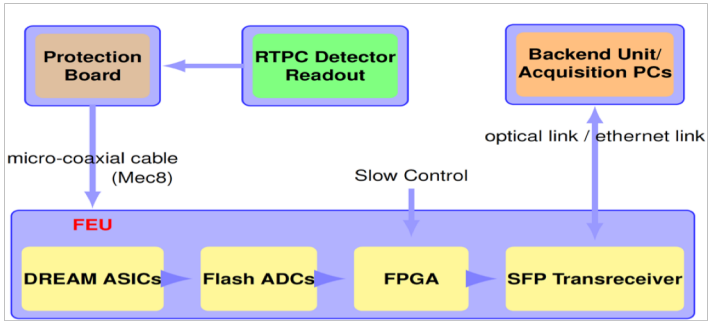


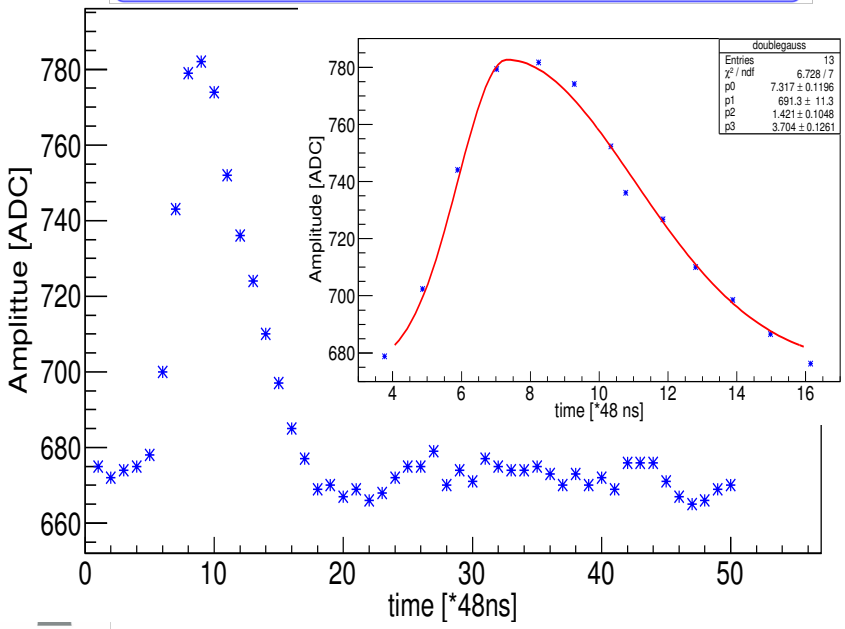


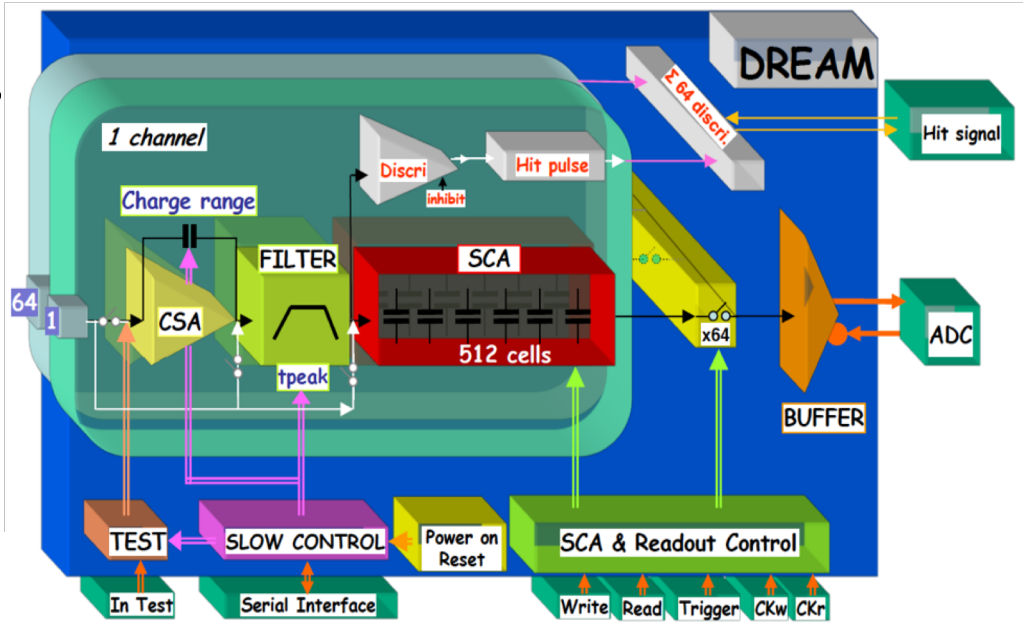


Status: Data acquisition (DAQ)

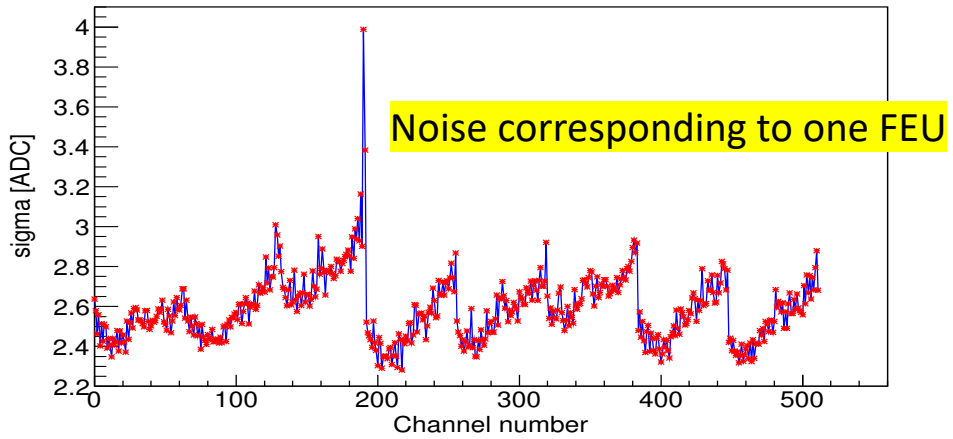
- DREAM chip : Integrated signal processing components for 64 channels
- Low noise and available on site
- Fulfill the BONuS12 requirement





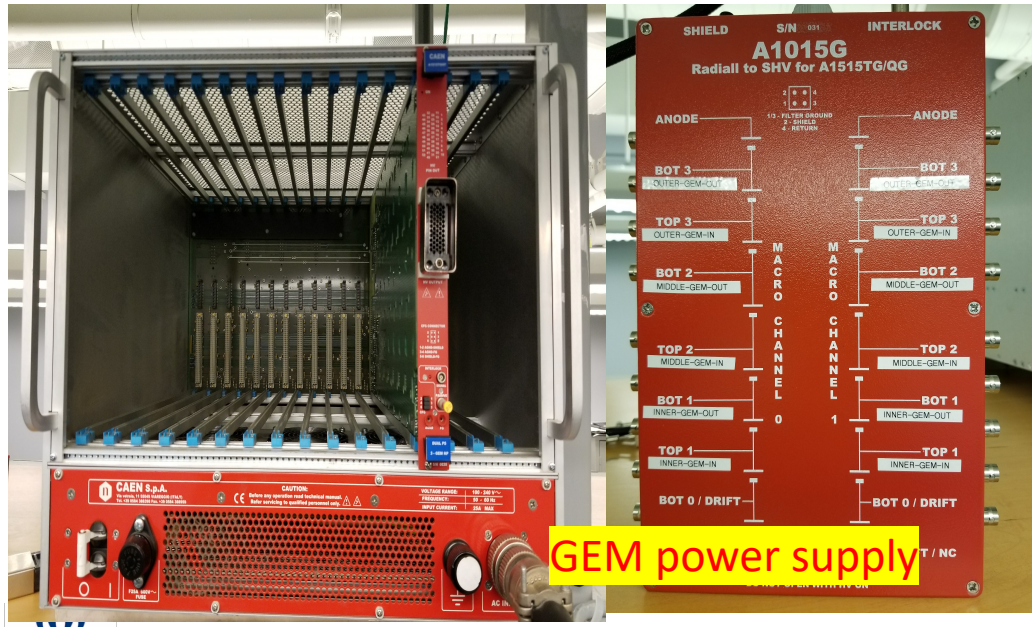


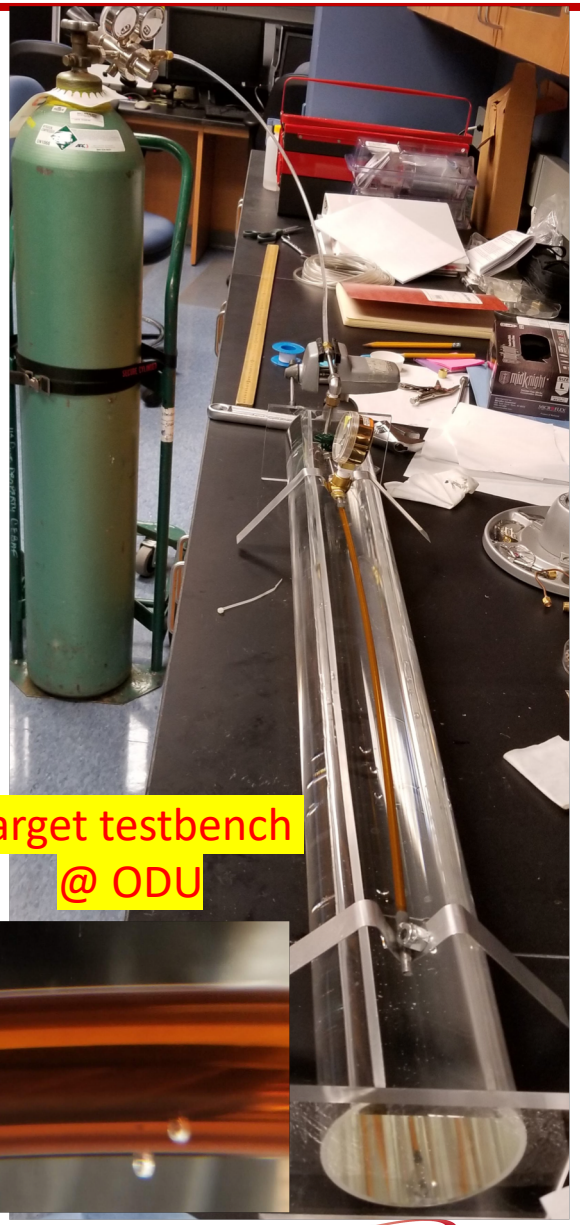
Dead timeless Readout Electronics ASIC for Micromegas



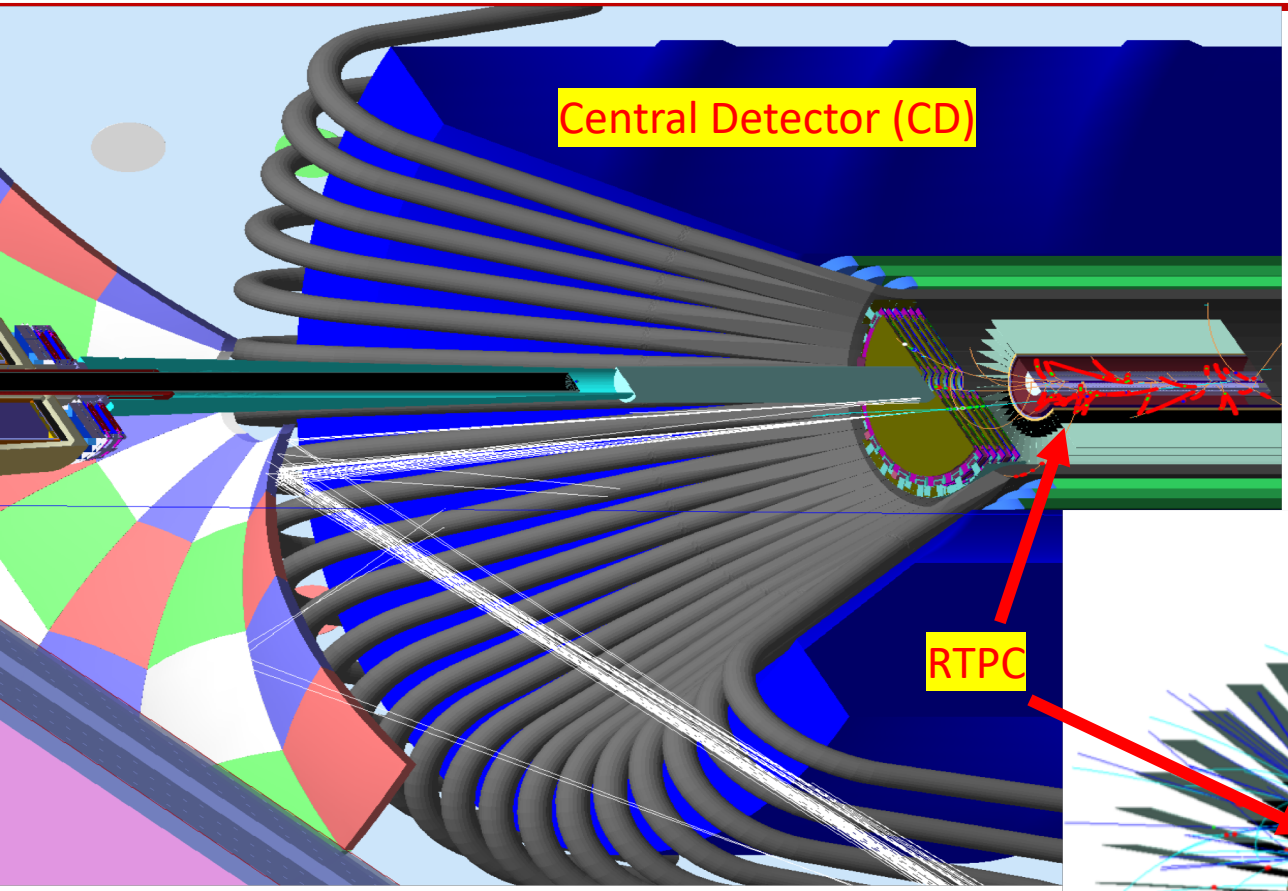
Status: Target and HV testing

- Target: Kapton tube of length 50 cm, diameter 6 mm and wall thickness 50 µm
  - Test of bursting limit: >150% (required ~ 110 psi)
  - Test of leakage: optimum foil for minimum leakage
  - Sagging and straightness: tension required at ends?
- HV: CAEN power supply for GEMs
  - no external potential divider in RTPC
  - will be operated in GEM mode

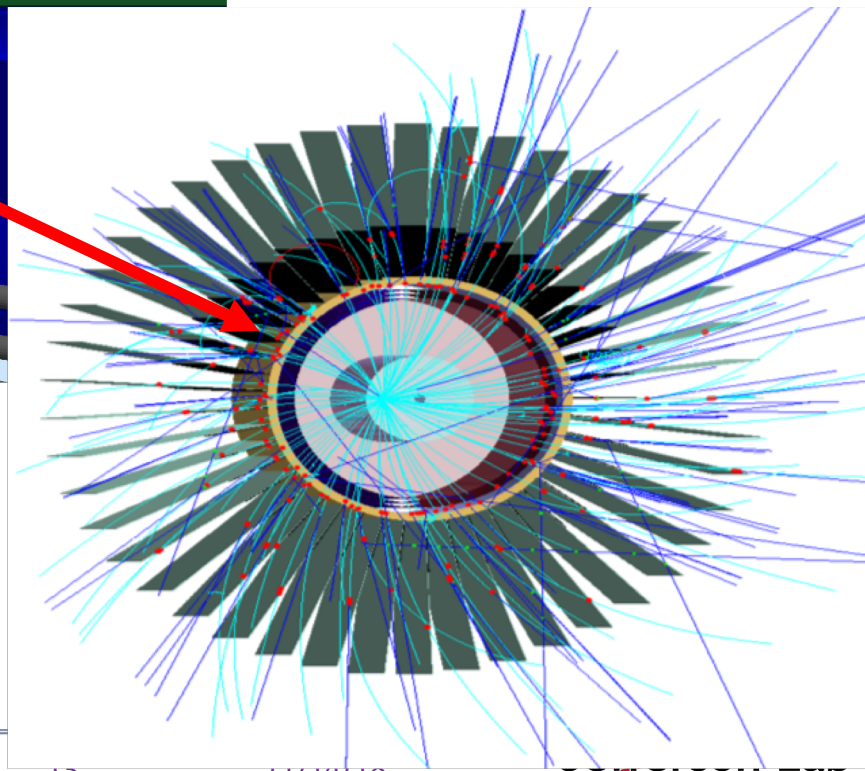




Status: Simulation



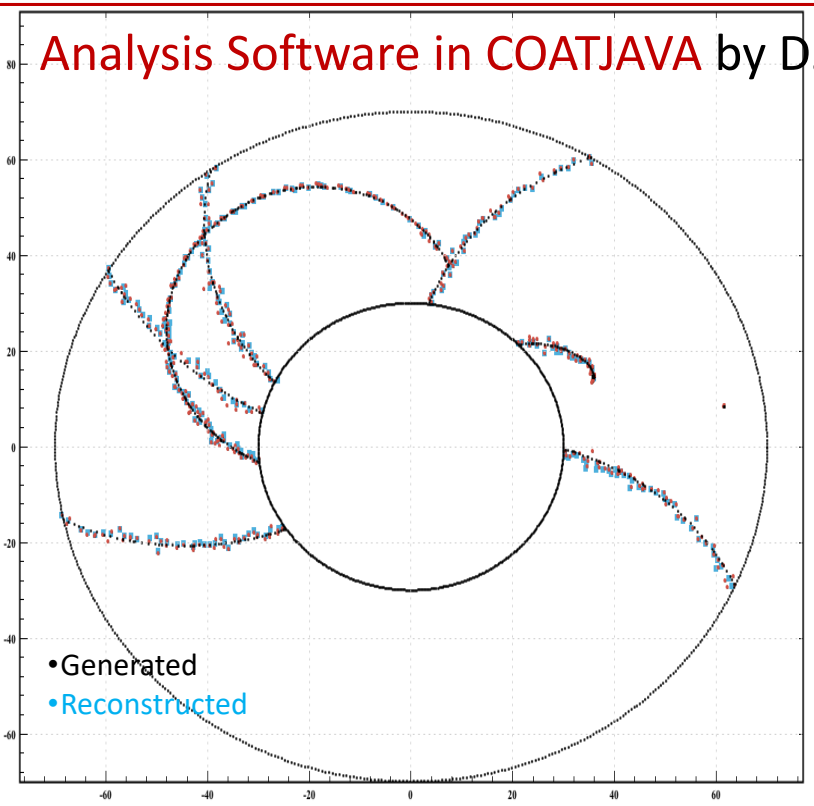
GEANT4 Monte Carlo (GEMC) Simulation of the RTPC by N. Dzbenski, ODU

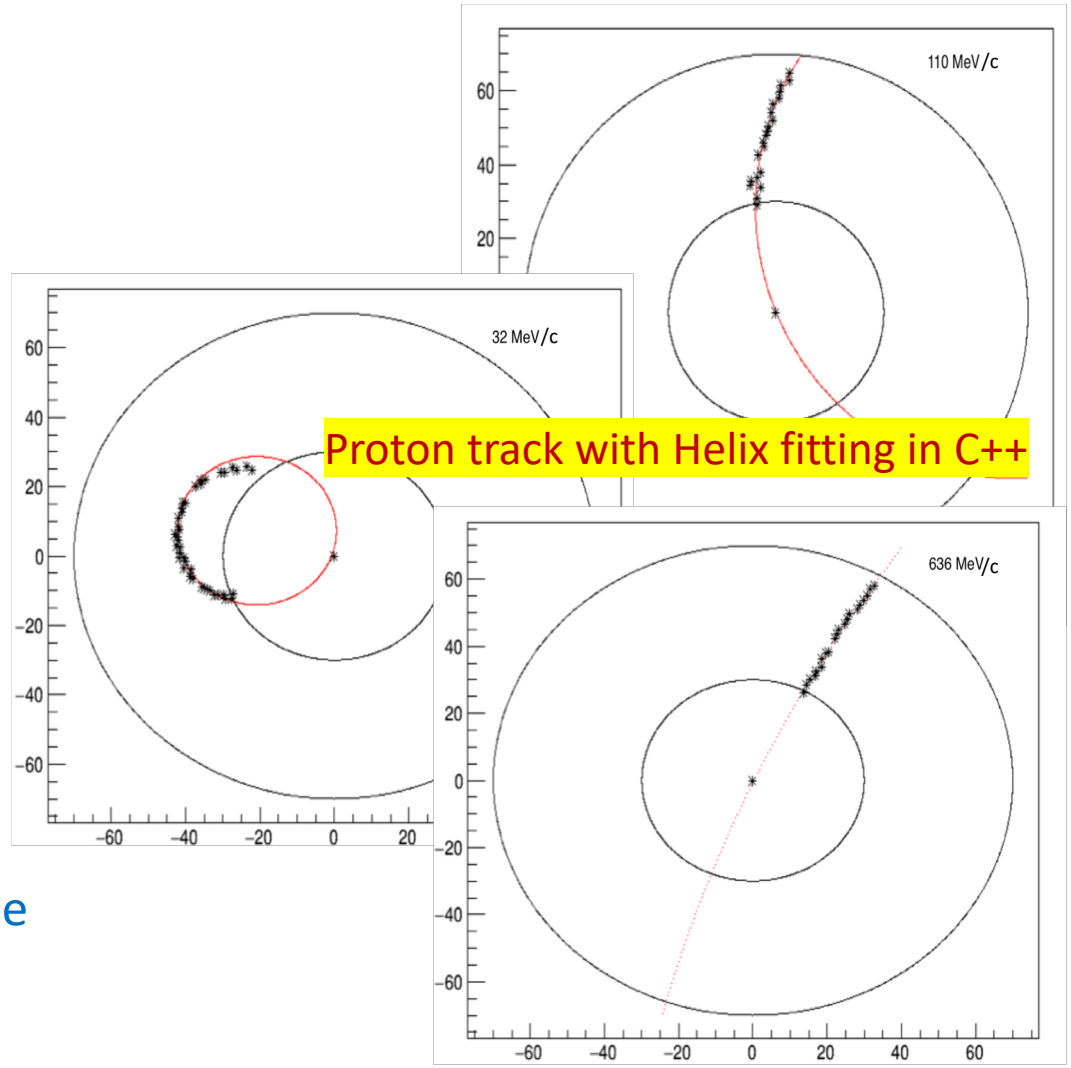


RTPC, implemented within GEMC CLAS tag

Status: Tracking and Analysis

Analysis Software in COATJAVA by D. Payette, ODU



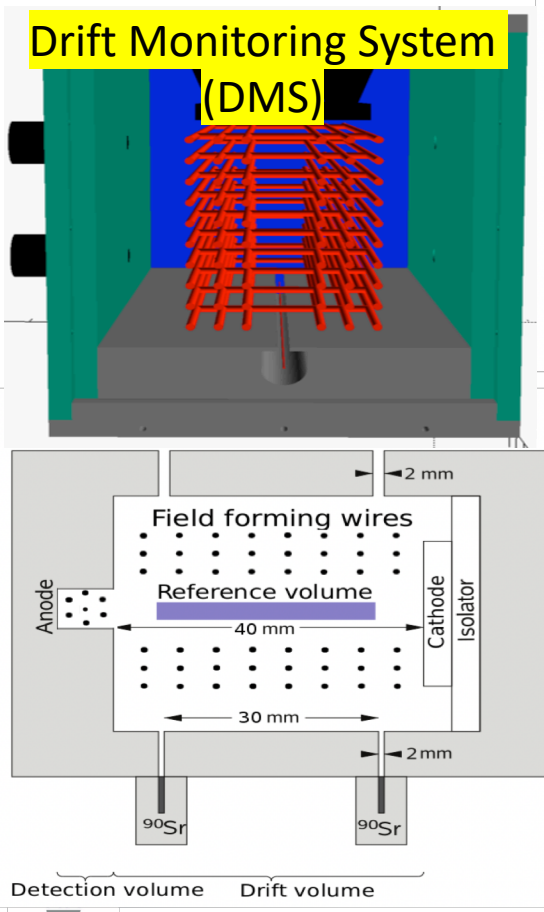


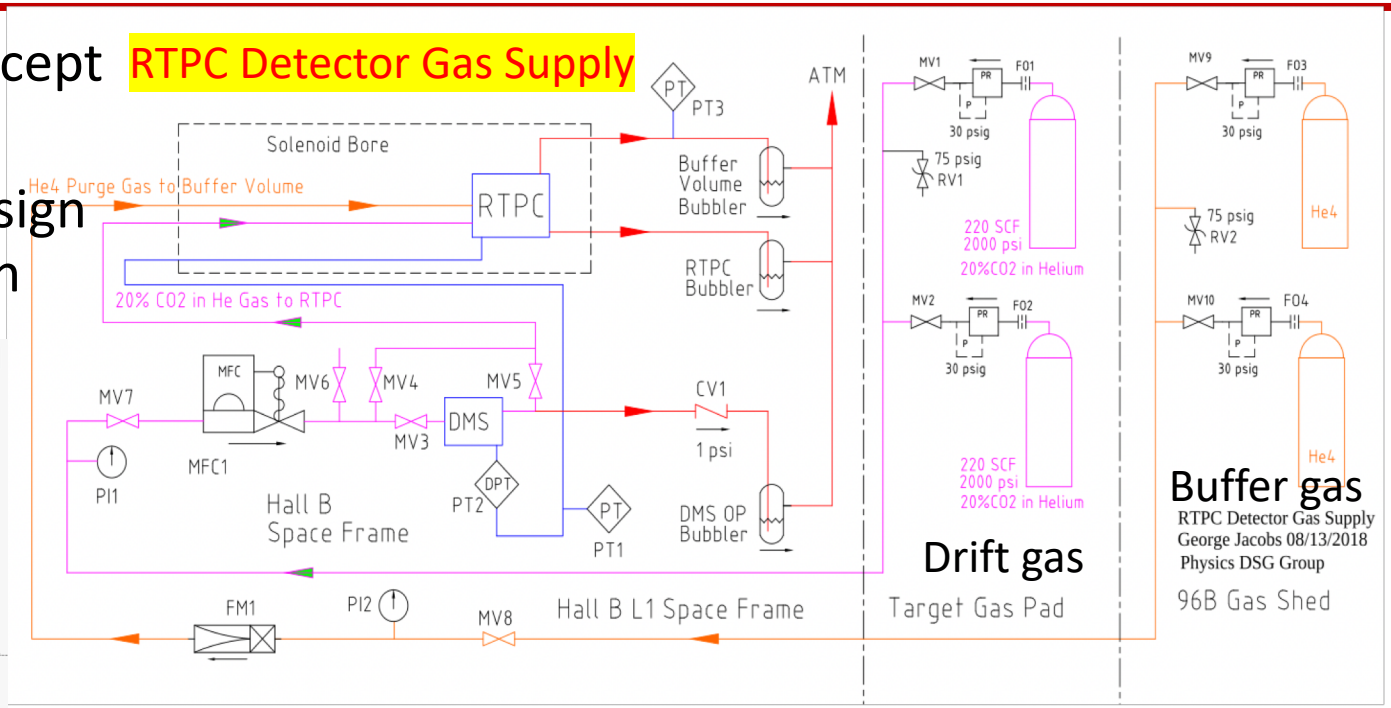
Proton track with Helix fitting in C++

- Solenoidal magnetic field within CD bends the particle track
- RTPC readout provide the data for the projected position and time of the particle track

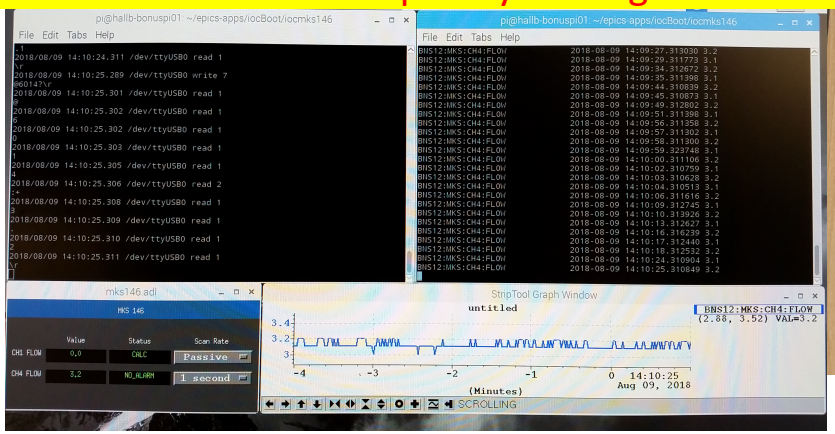
Status: Gas flow and Slow control

- Gas flow system (except DMS) is ready
- Completed DMS design and is available soon



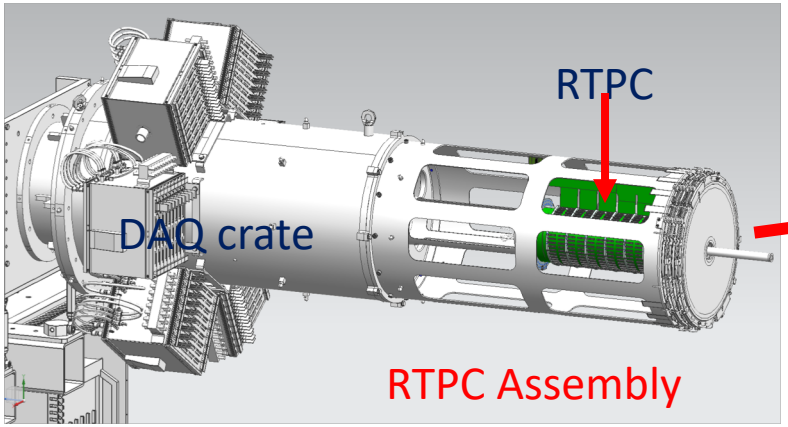


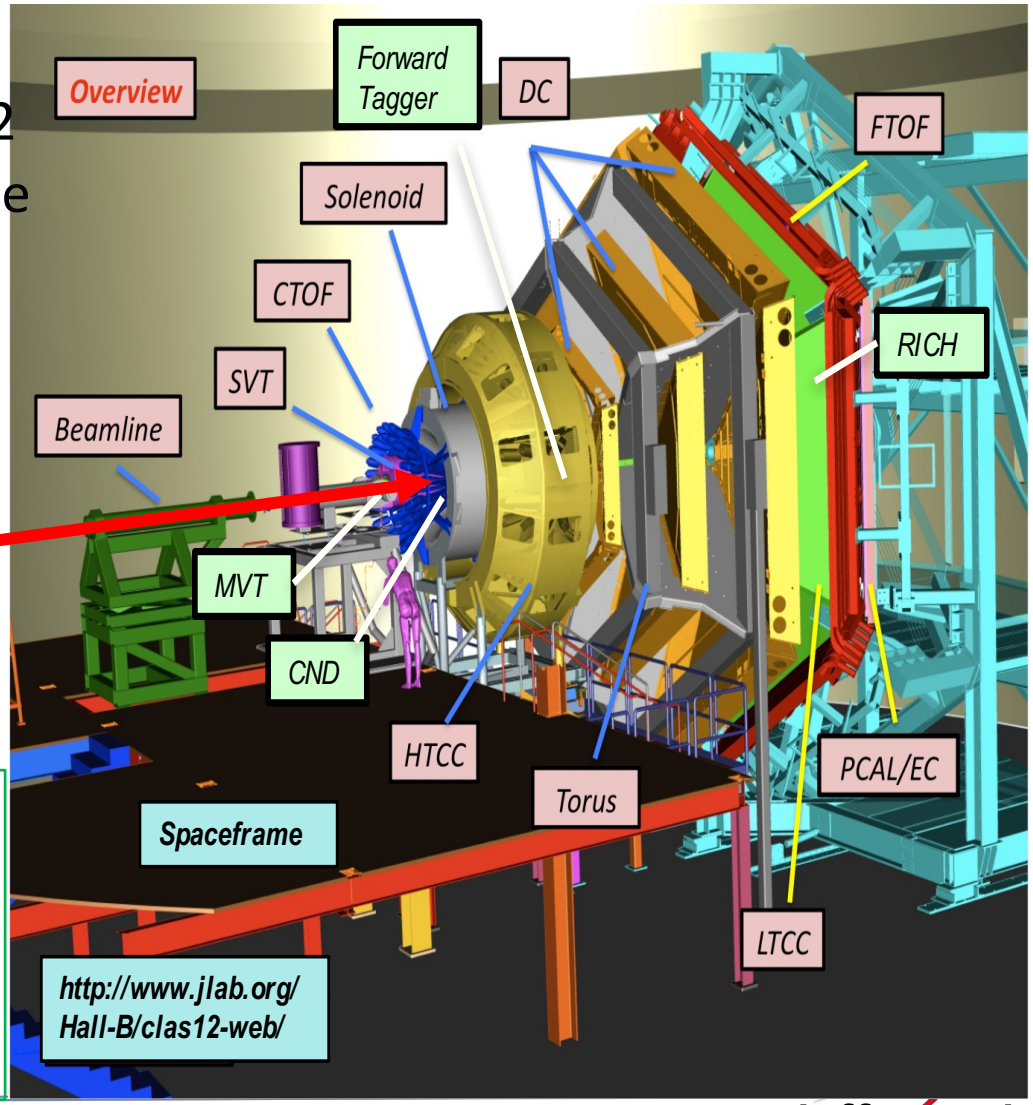
EPICS framework on Raspberry-Pi for gas slow controls @ VUU and W&M



Integration to the CLAS12

- Replace SVT+MVT by the RTPC detector, in coordination with Saclay MicroMegas group
- Use MVT DAQ crate for BONuS12
- Propriety cables dedicated for the RTPC are on order

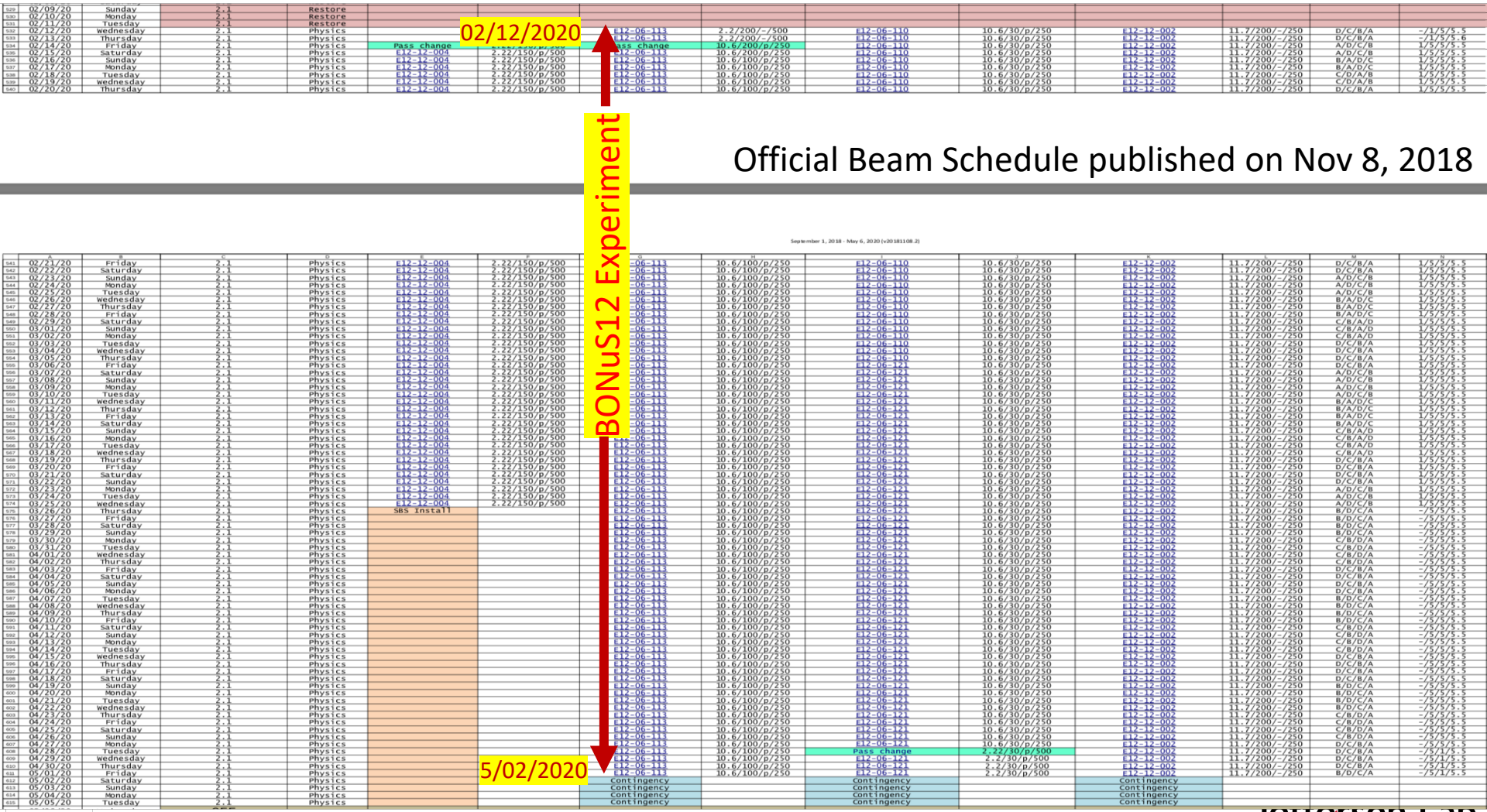




CEBAF Large Acceptance Spectrometer (CLAS) at Hall B

Scheduling of the Experiment

- Experimental Readiness Review (ERR) in May 2017
- Beam scheduling request submitted in July 2017
- Proposed beam time : 42 days (PAC)



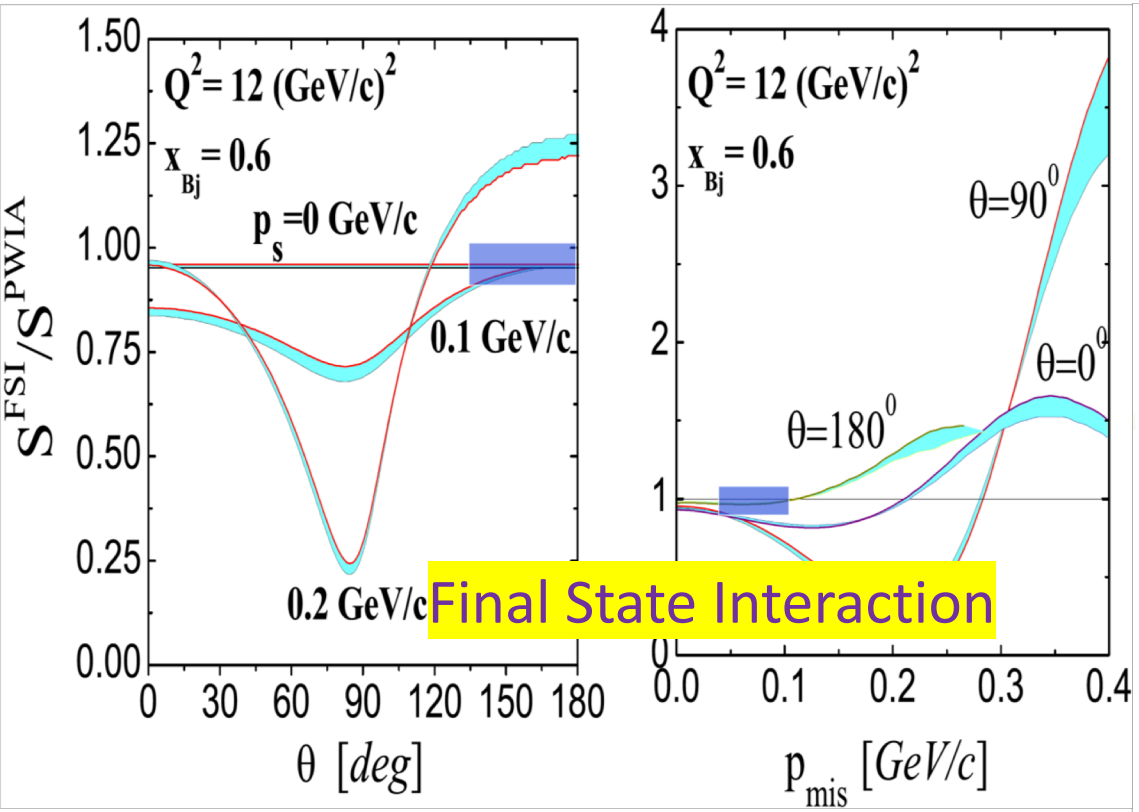
Official Beam Schedule published on Nov 8, 2018

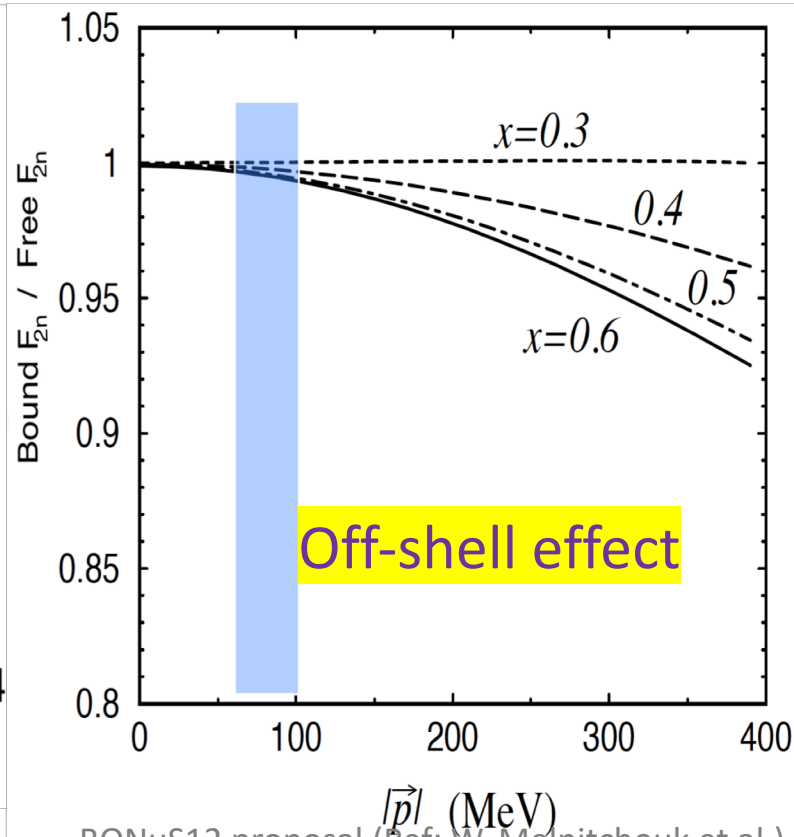
Future plans

- Complete 3-layer GEM package by the end of 2018 and test it
- Complete the first RTPC by early 2019
- Complete the DAQ system by March 2019 and do extensive test on the RTPC through summer 2019
- Complete the design of target, beam-line and installation procedure by the mid-2019
- Complete all the simulation and analysis software by summer 2019 (including Kalman filter tracking)
- Complete Gas system, HV system, Slow control and target by fall 2019
- All components ready for Data taking by November 2019
- Build spare RTPC by fall 2019
- Install the RTPC in the CLAS12: December 20, 2019 - January 30, 2020 (Follow with testing and cosmic rays run)
- Begin commissioning (H target) with low energy beam: February 12, 2020; and begin production data taking on Deuterium within a week

Backup

- Reduction of FSI and Off-shell effect in the BONuS12 experiment choosing spectator angle > 120° and momentum < 100 MeV/c

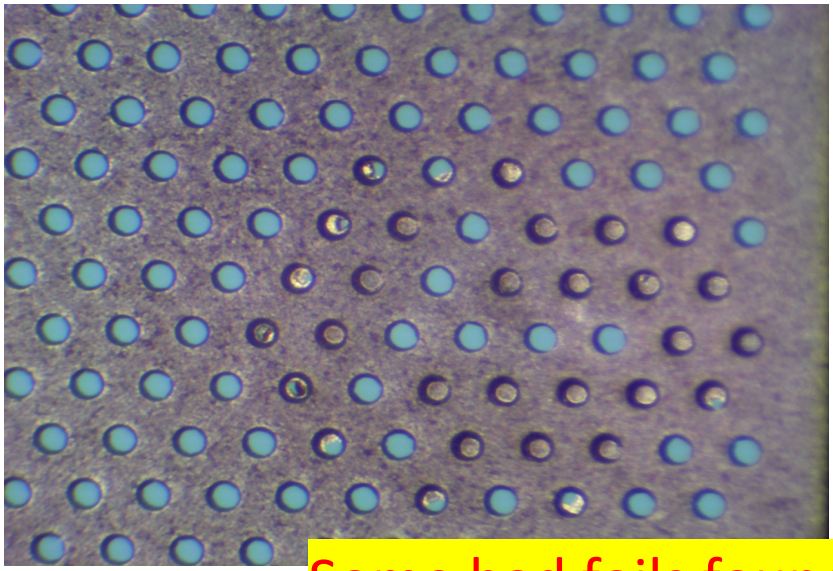


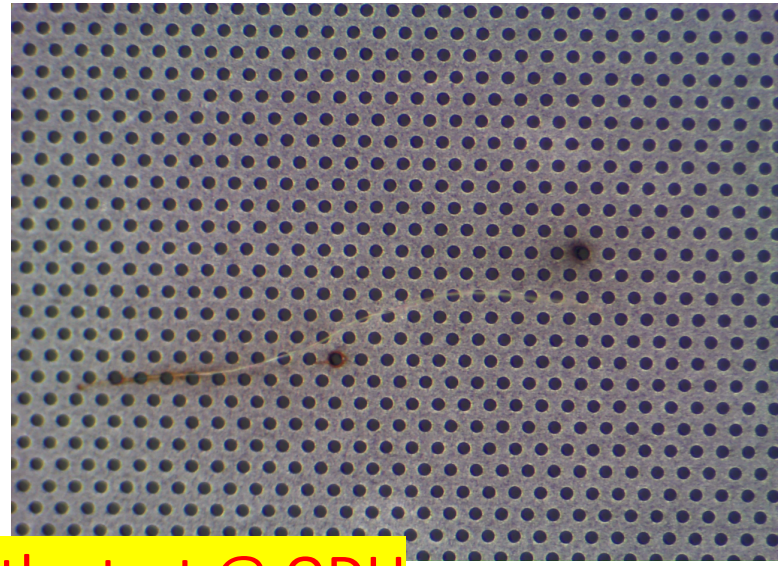


C. Ciofi degli Atti et al., Eur. Phys J. A19, 145 (2004)

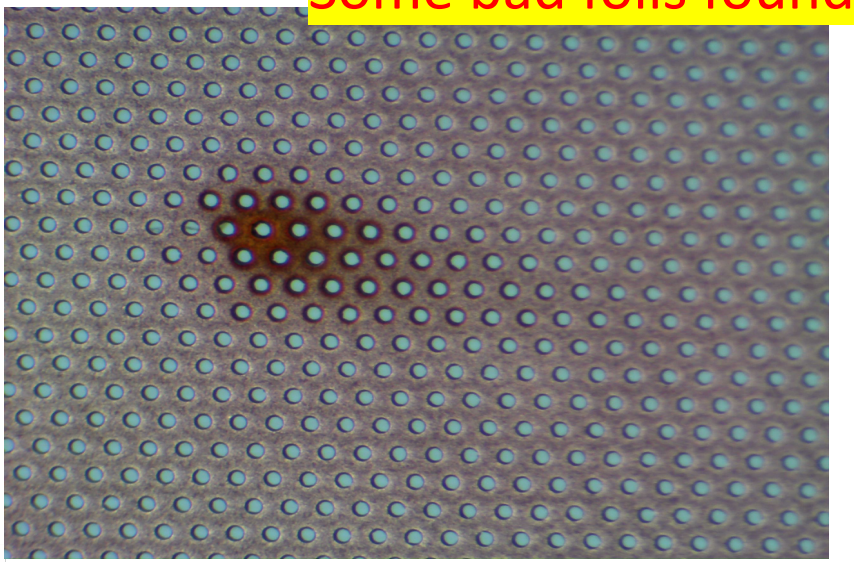
BONuS12 proposal (Ref: W. Melnitchouk et al.)

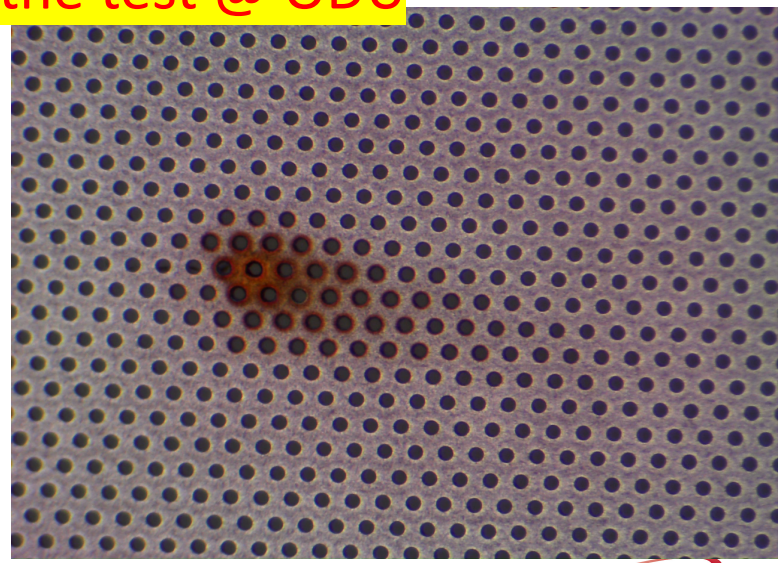
Backup





Some bad foils found in the test @ ODU





Backup

Offline reconstruction:

ADCs $\xrightarrow{\text{Pads' gains } (G_i)}$ $\left\langle \frac{dE}{dX} \right\rangle = \frac{\sum_i \frac{ADC_i}{Gi}}{vtl}$

TDCs $\xrightarrow{\text{Drift speed and paths}}$ Reconstructing chains of hits $\xrightarrow{\text{Known } \vec{B}}$ p/q $\rightarrow$ **PID**