Preparations for BONuS12 experiment

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On behalf of BONuS12 Detector design group

CLAS collaboration- Deep processing working group
8 March 2018

Outline

- Overview of BONuS12 experiment.
- BONuS12 RTPC.

  -Design of BONuS12 RTPC

  -Construction and prototyping of BONuS12 RTPC
- Future plans

- Structure of proton and neutron have been studied through inelastic scattering experiments.

  At leading order

$$F_2^p = x\left[\frac{4}{9}u(x) + \frac{1}{9}d(x)\right]$$

$$F_2^n = x\left[\frac{4}{9}d(x) + \frac{1}{9}u(x)\right]$$

- At large x (x->1)

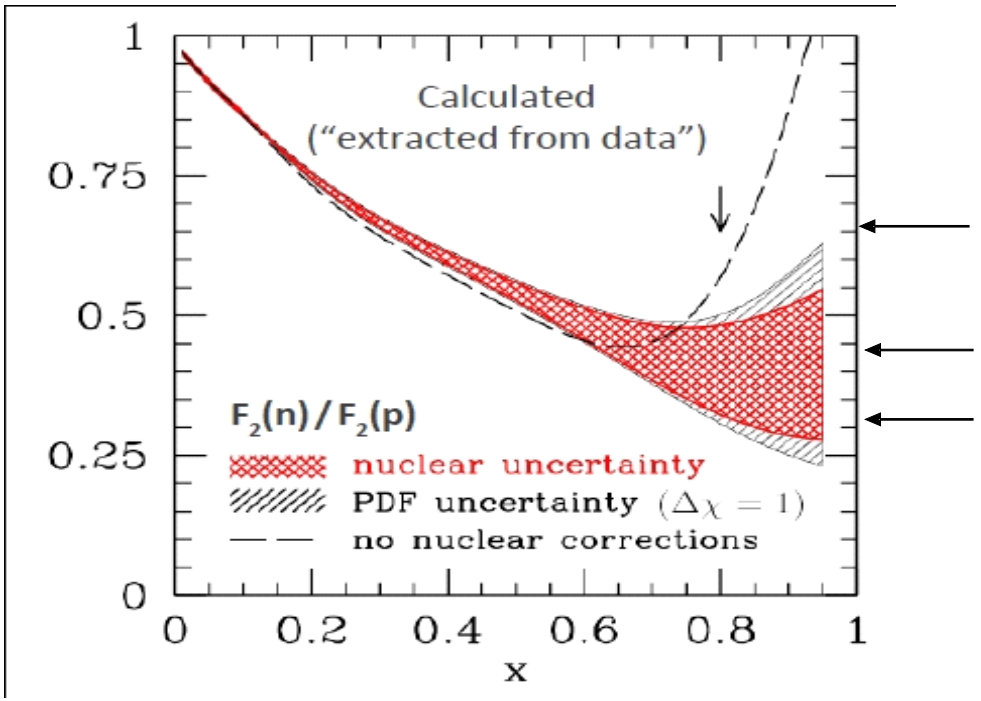
$$\frac{F_2^n}{F_2^p} = \frac{1 + 4\frac{d}{u}}{4 + \frac{d}{u}}$$

- *u* quark is well determined from proton data. Free neutron target would provide comparable information on *d* quark.

Structure of proton have been studied in great details.
Due to lack of free neutron targets, much less is known about structure of neutron.

Even F_2^n not well known for x>0.6

*Accardi et al. PRD **84**, 014008 (2011)*



Non-perturbative models

SU(6) spin flavor

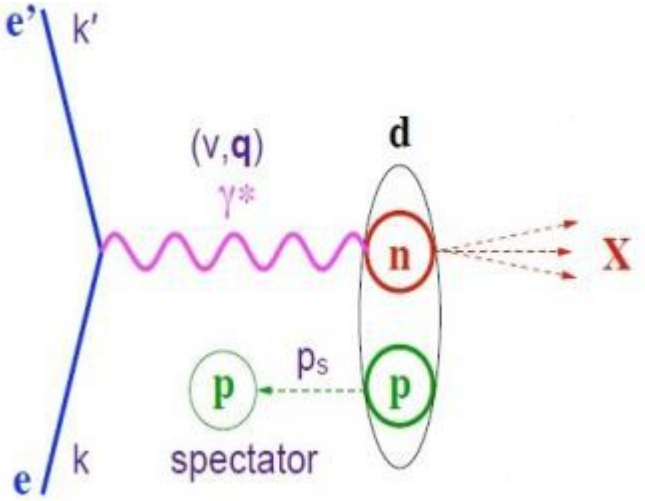
Hard gluon exchange

S=0 diquark dominance

BONuS experiment (Barely Off-shell Nucleon Structure)

- BONuS will study the neutron structure using deep inelastic scattering on a unpolarized deuterium target in large x Bjorken region.
- d(e,e' P_s)X
- Tag spectator proton

  (70<P_s<150 MeV/c)with RTPC.
- Detect scattered electron with JLab Hall B CLAS



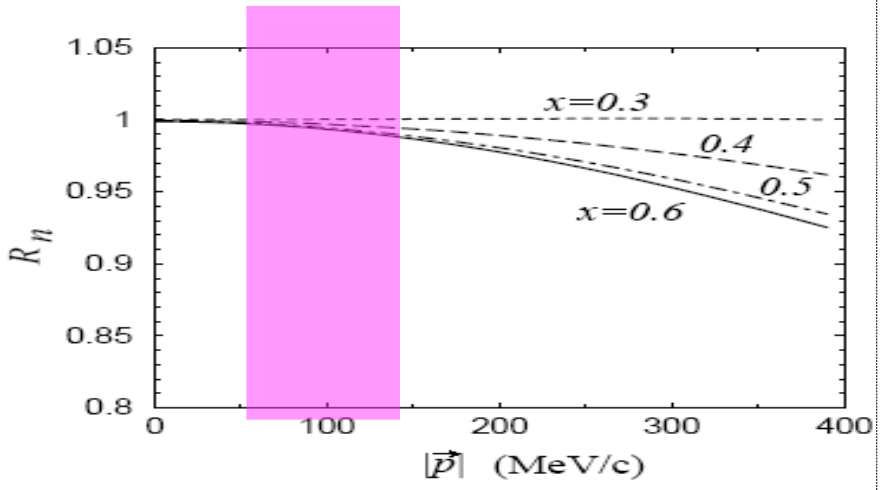
Spectator tagging method

- The momentum of spectator proton is used to interpret initial momentum of the neutron which is weakly bound to the deuterium target.
- Selecting backward, low momentum spectator protons minimizes:

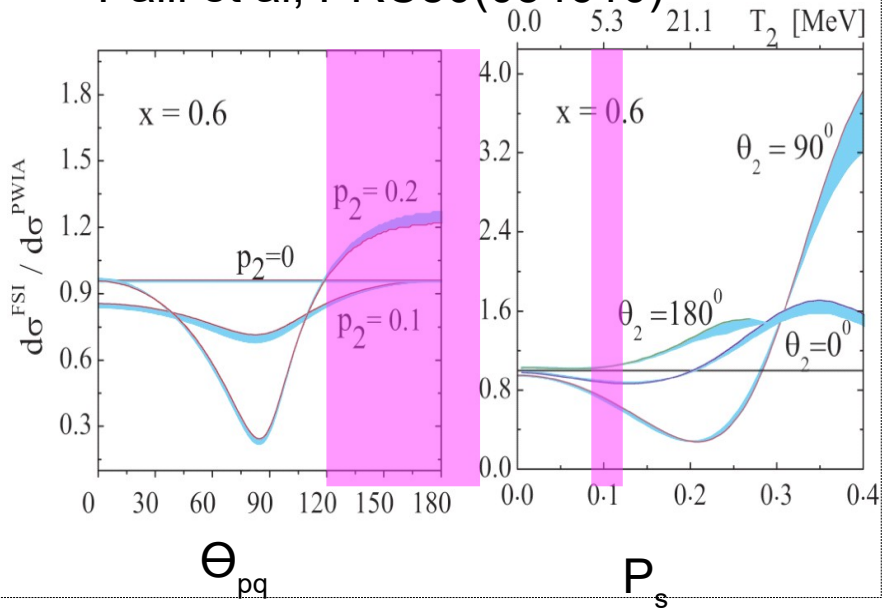
  -Off shell effects

  -Final state interactions

Meinitchouk et al, PLB335(94)11



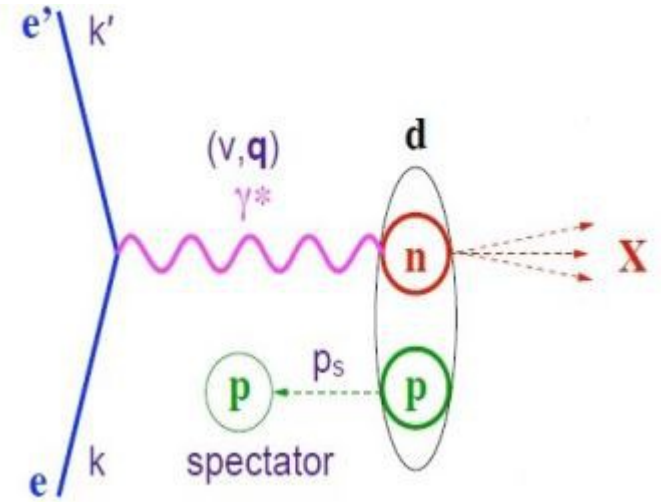
Palli et al, PRC80(054610)

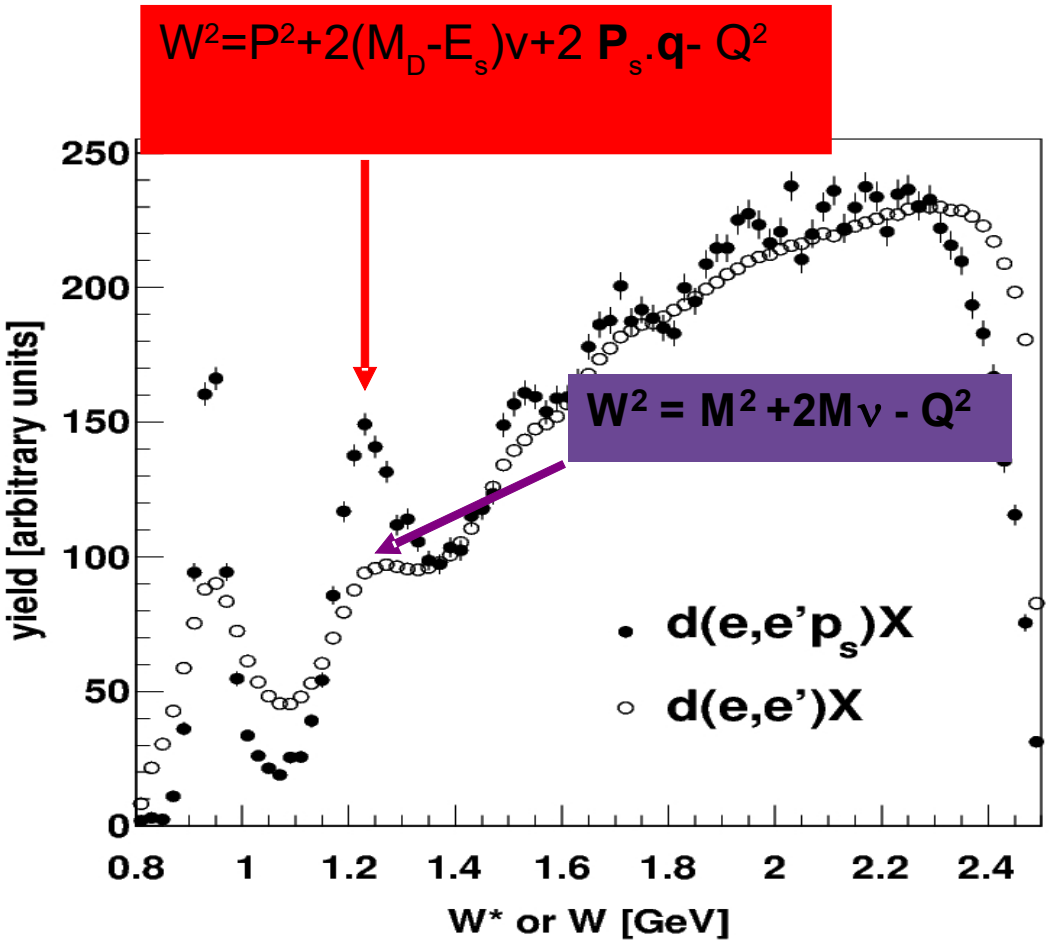


Kinematic reconstruction with tagged proton

- Backward P is spectator
- Neutron is off-shell
- $P_n = -P_p$

Correct for Neutron momentum



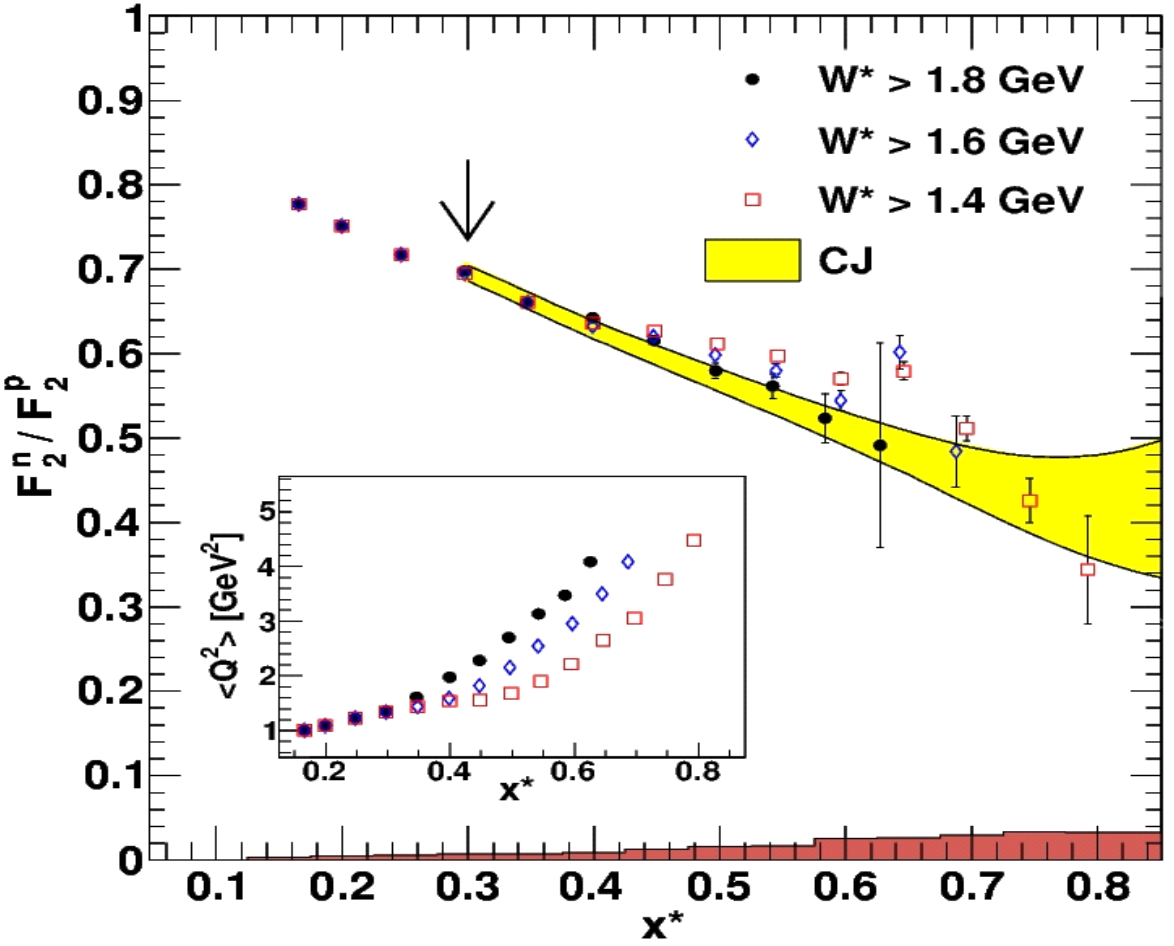


Results of the BONuS6 experiment

N.Baillie et al., PRL 108 (2012) 199902

$$\frac{F_2^n}{F_2^p} = \frac{F_2^n}{F_2^d} \times \frac{F_2^d}{F_2^p}$$

With F_2^d/F_2^p from Bosted/Christy fits. PRC**77**(08)065206, PRC**81**(10)055213



The lower W* cuts reduce statistics but increase resonance effect at x>0.6.

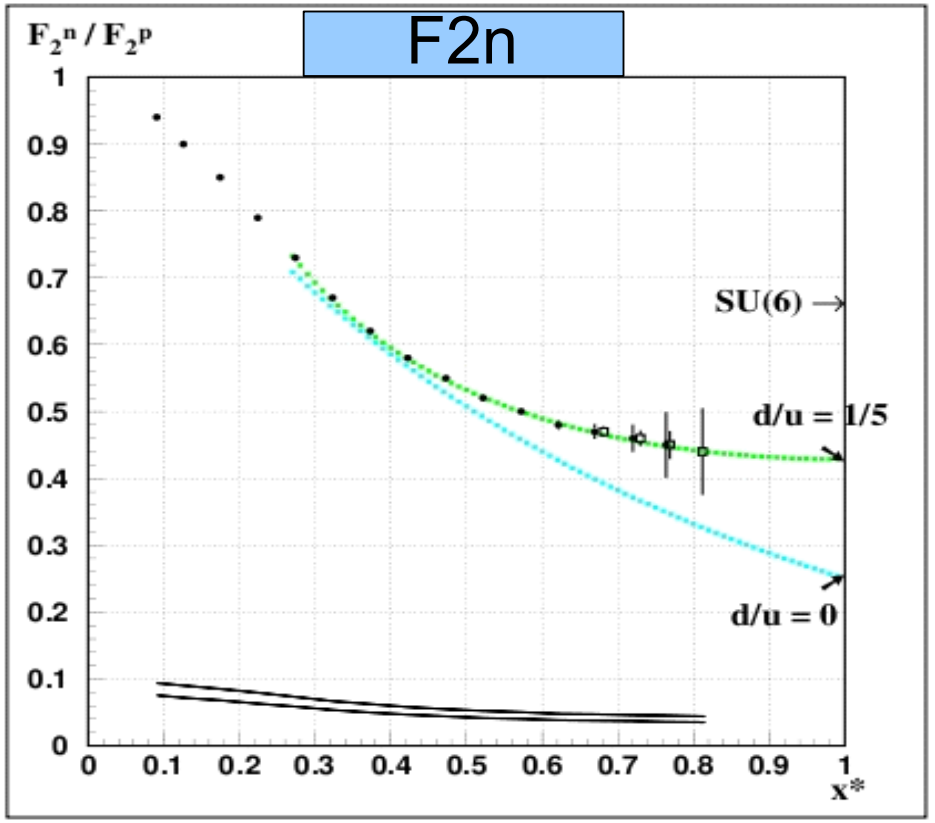
BONuS12 experiment

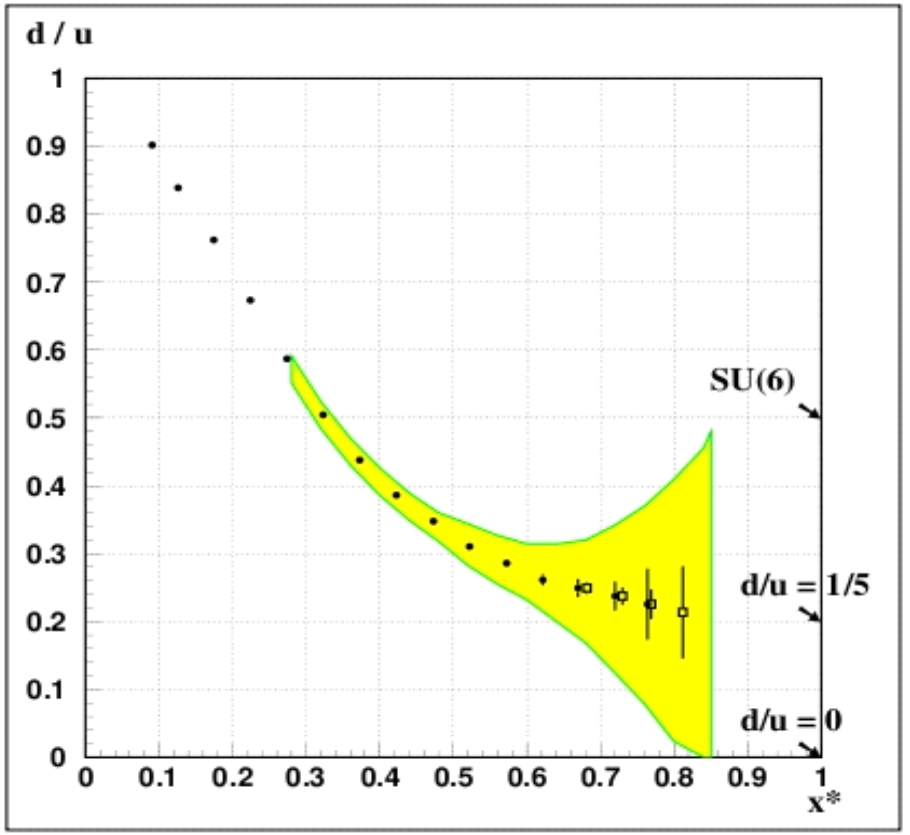
- BONuS12 is extension of BONuS6.

  BONuS12 will be run to improve statistics at high Q^2 .

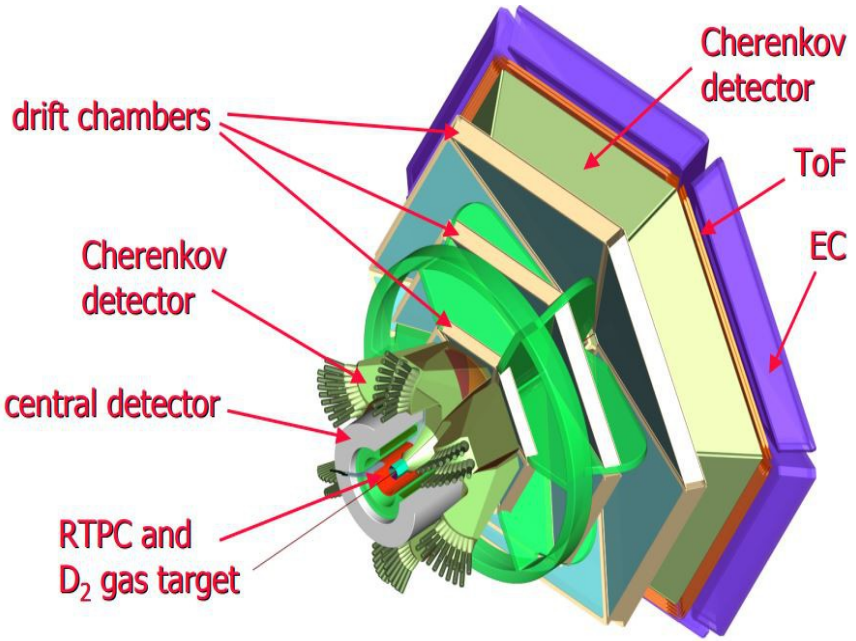
  To minimize the effects on resonance region the experiment will run in large x, out side the resonance region.

  Estimated precision of proposed BONuS experiment at 11 GeV .





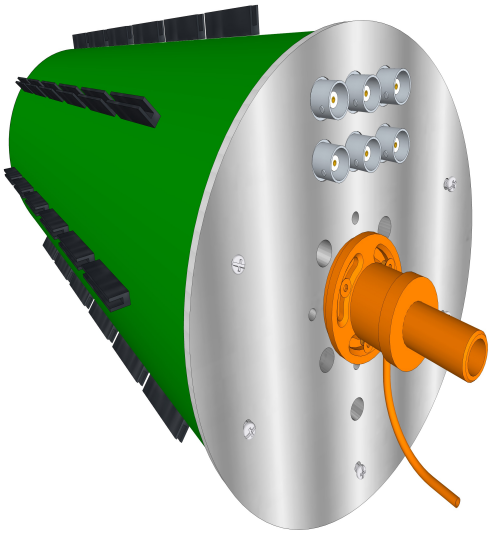
CLAS12 spectrometer



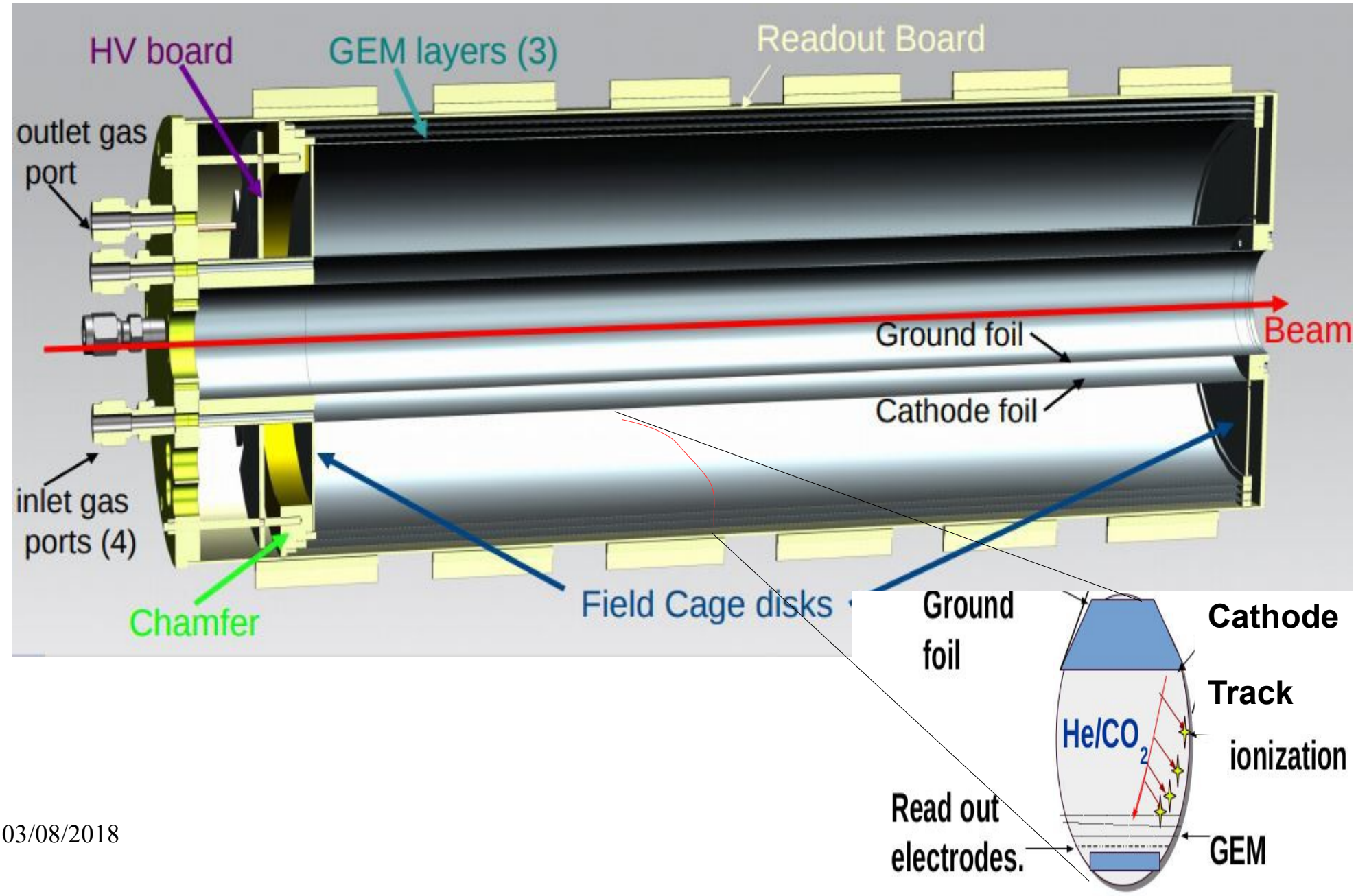
-Detect electrons in CLAS12 spectrometer.
-Detect slow protons in RTPC.
-Solenoid field allows momentum determination

BONuS12 RTPC

- Improvements over BONuS6
- Double RTPC and target length ->increase luminosity to $2x10^{34}$ $cm^{-2}s^{-1}$.
- Increase drift region from 3 cm to 4 cm ->improve momentum resolution
- Reduce material and better reconstruction algorithm -> lower threshold momentum of proton.
- Increase phi acceptance.

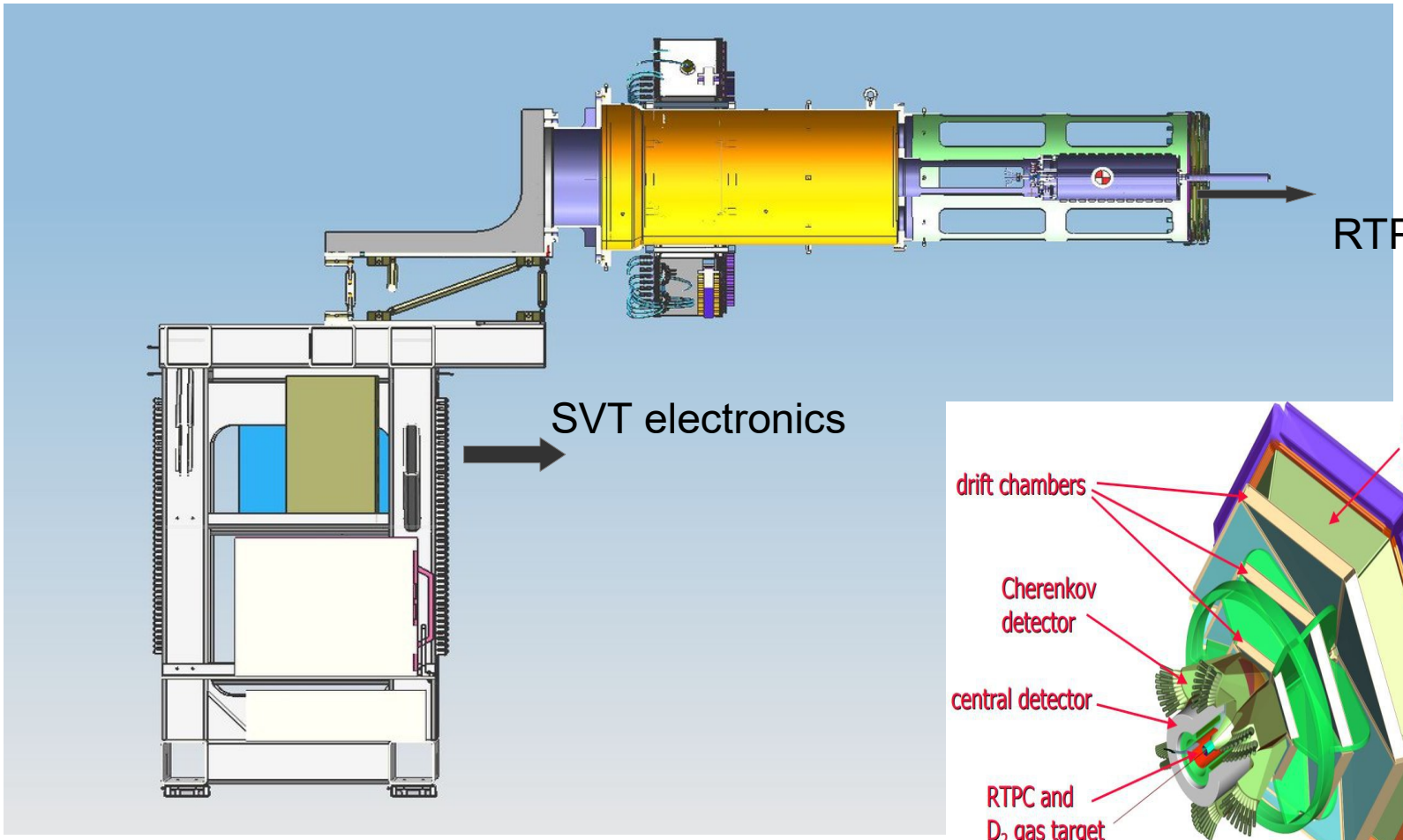


BONuS12 RTPC



BONuS12 integration on CLAS12

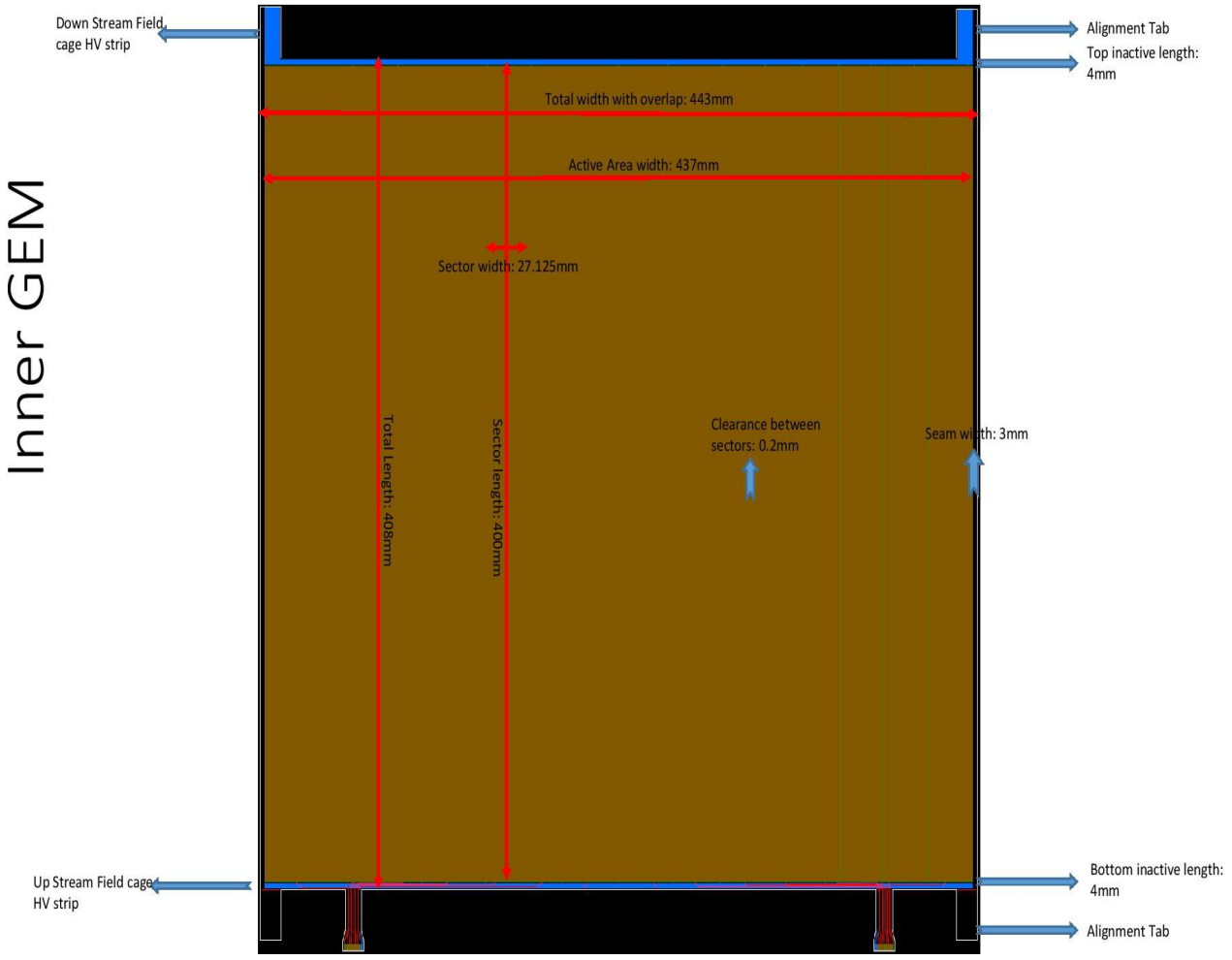
Section view of the BONuS12 detector



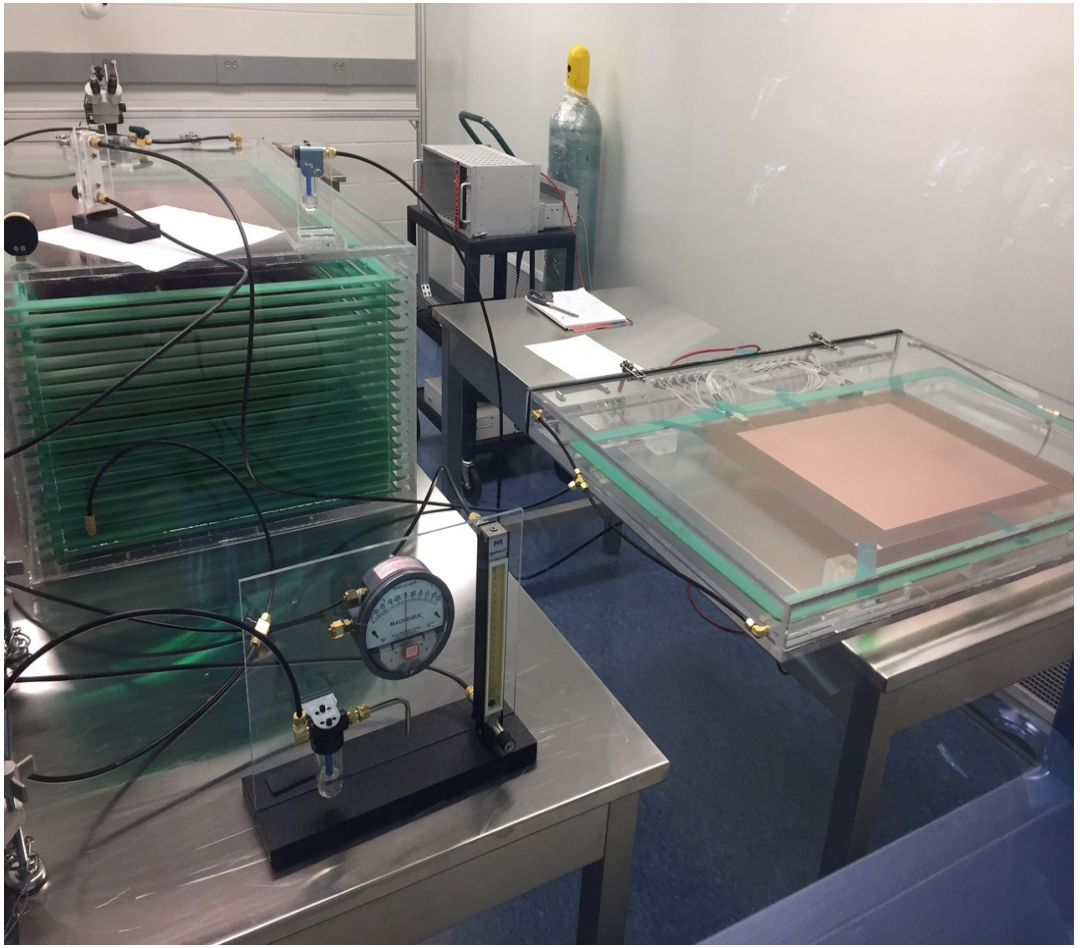
GEM design

- We have three GEM layers in the RTPC with same design and different dimensions.

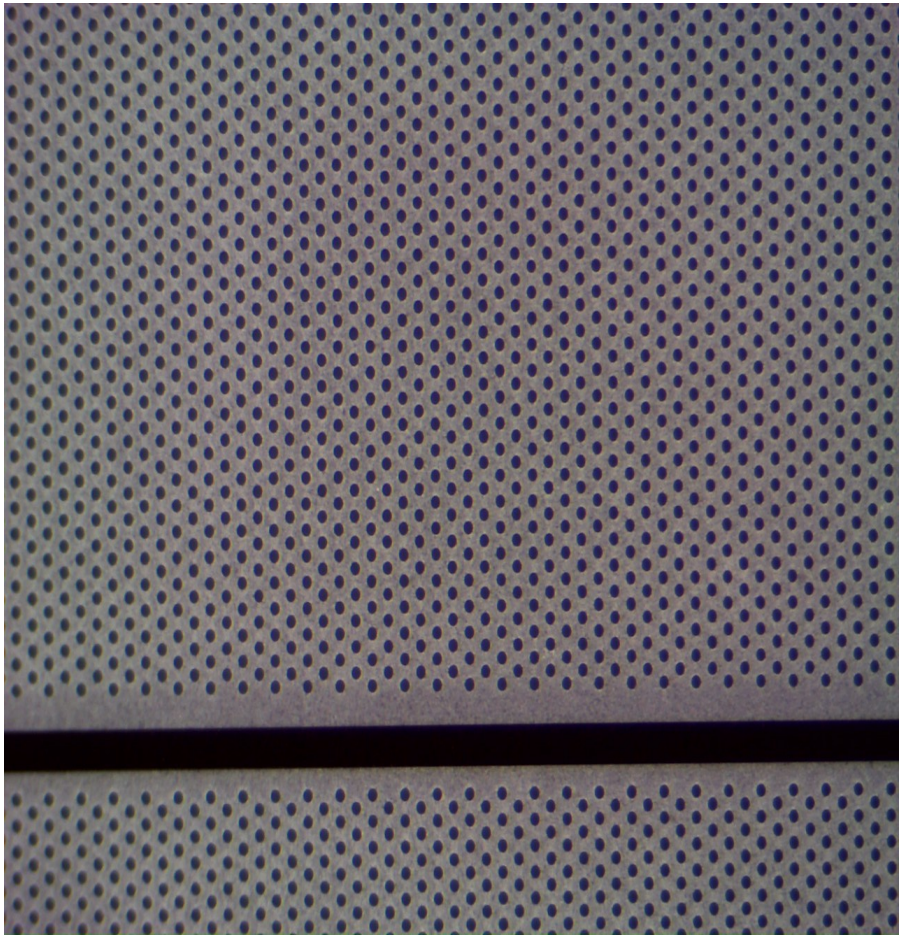
- For each GEM design 8 GEM foils were constructed by CERN.



- High voltage tests for the GEM foils are on going in ODU.
- Dry N box keep moisture away from the foils.



High Voltage test apparatus



Microscopic photo of GEM

GEM assembly

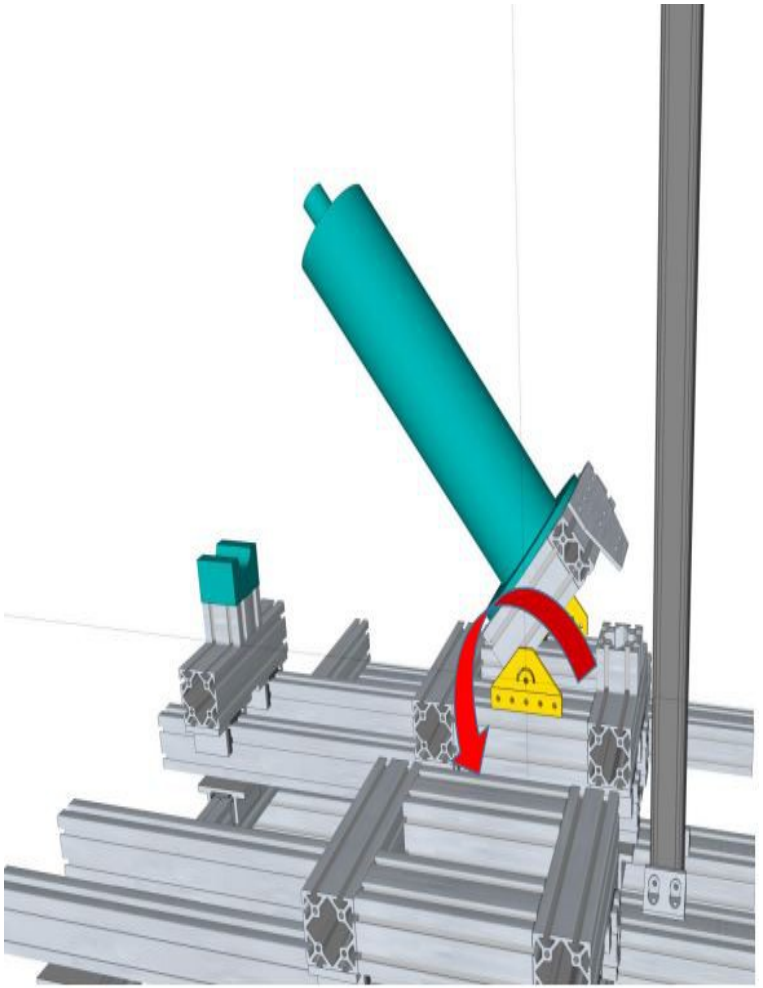
- Building BONuS12 detector assembly tower is on going.

  -GEM foil wrapping station

  -Detector assembly station

  -Actuator

- Mandrell can be rotated for wrapping and removing positions



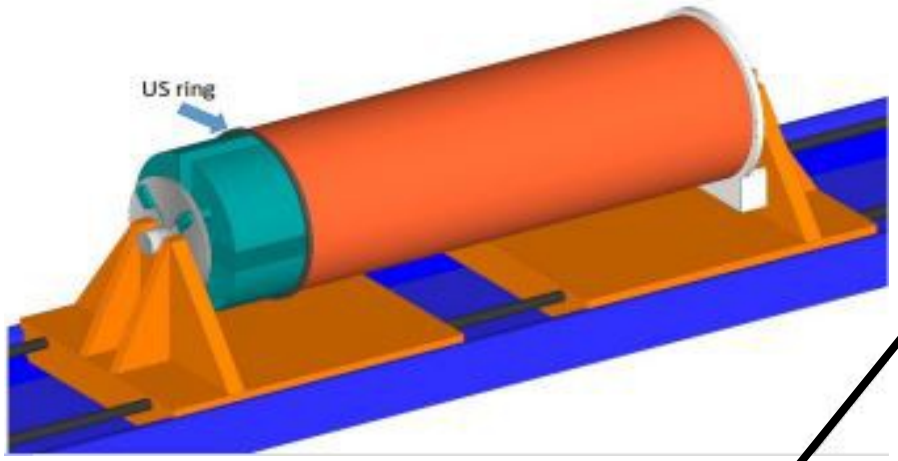
Vertical GEM assembly(I. Albayrak)

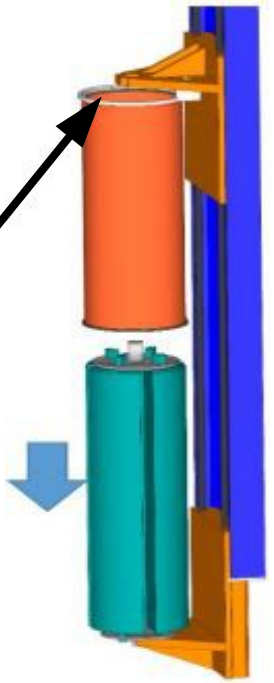
GEM foil stretched around mandrel and epoxy applied to seam and US / DS rings

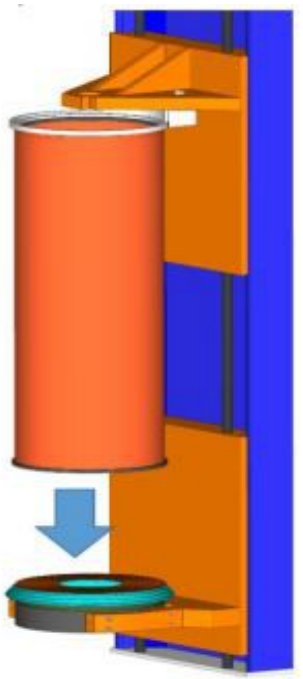
Mandrel lowered from assembly

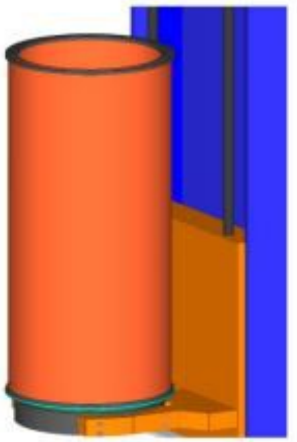
Mandrel replaced With chamfer and GEM lowered and epoxied

Layers built Inside to outside





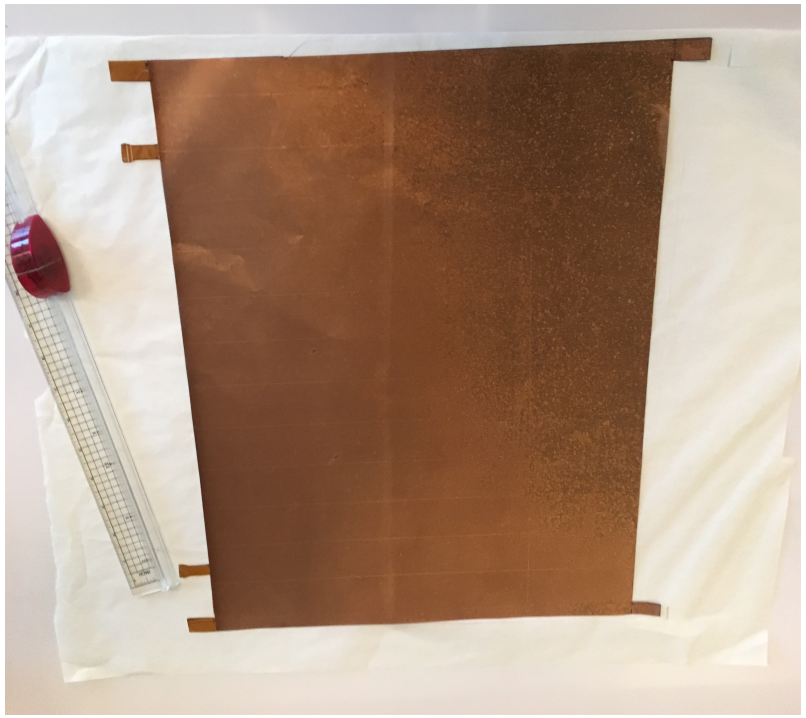


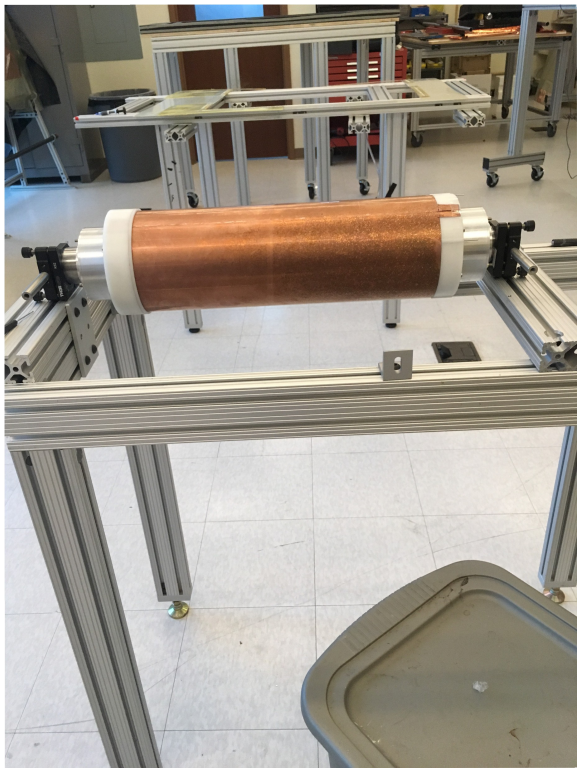


Temporary support used to grip DS ring

Mechanical Design and prototyping

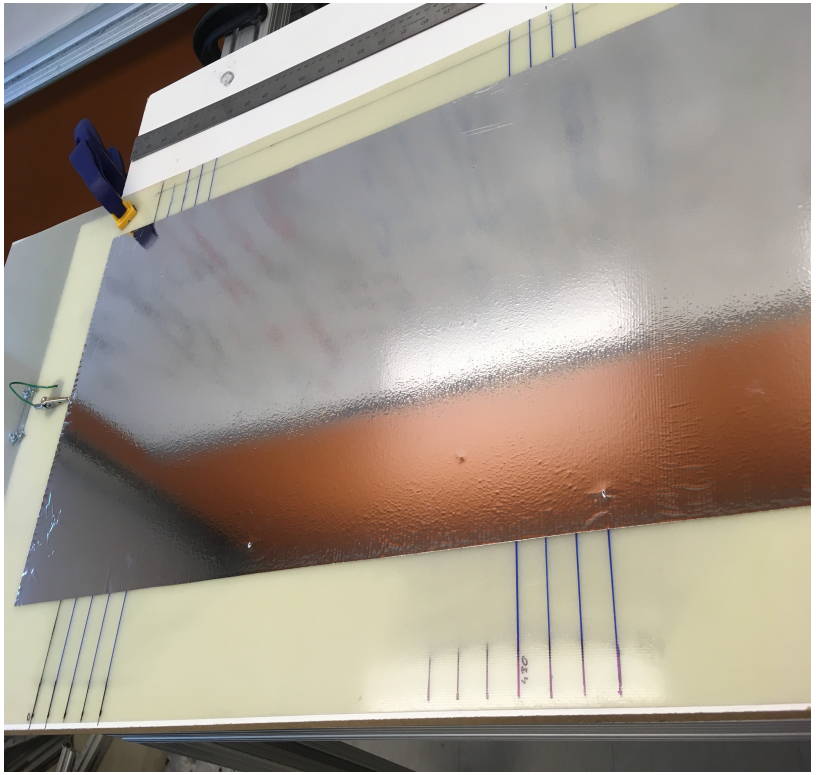
- Mechanical tests for GEM foil gluing is on going in HU. UVA GEM foils is used to cut GEM foil to the exact size and lay out of the BONuS12 GEM foil.
- Single GEM foils are wrapped around the mandrel and then glued to rings (4 mm long) at both ends to define the cylinder.

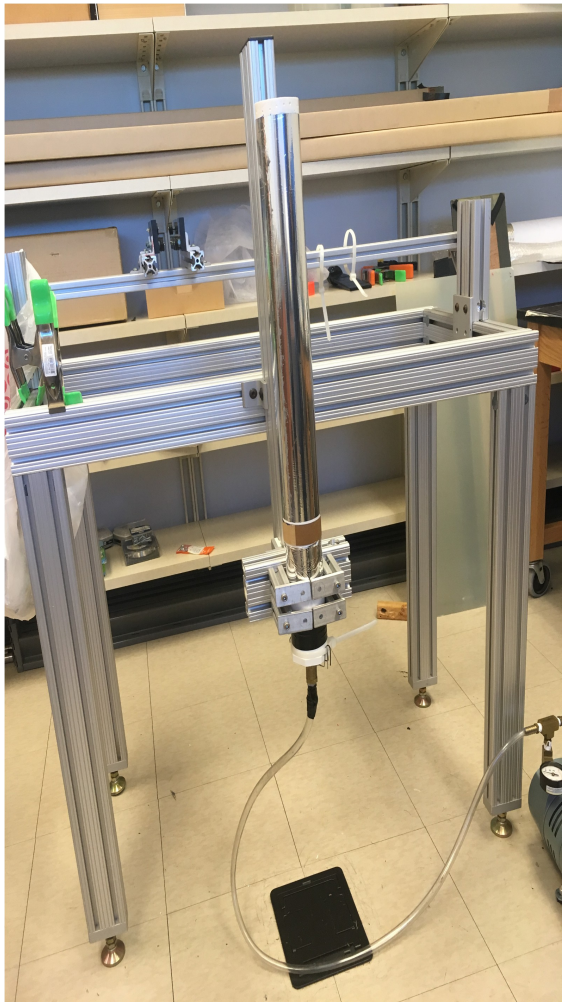




Tests for cathode foil wrapping

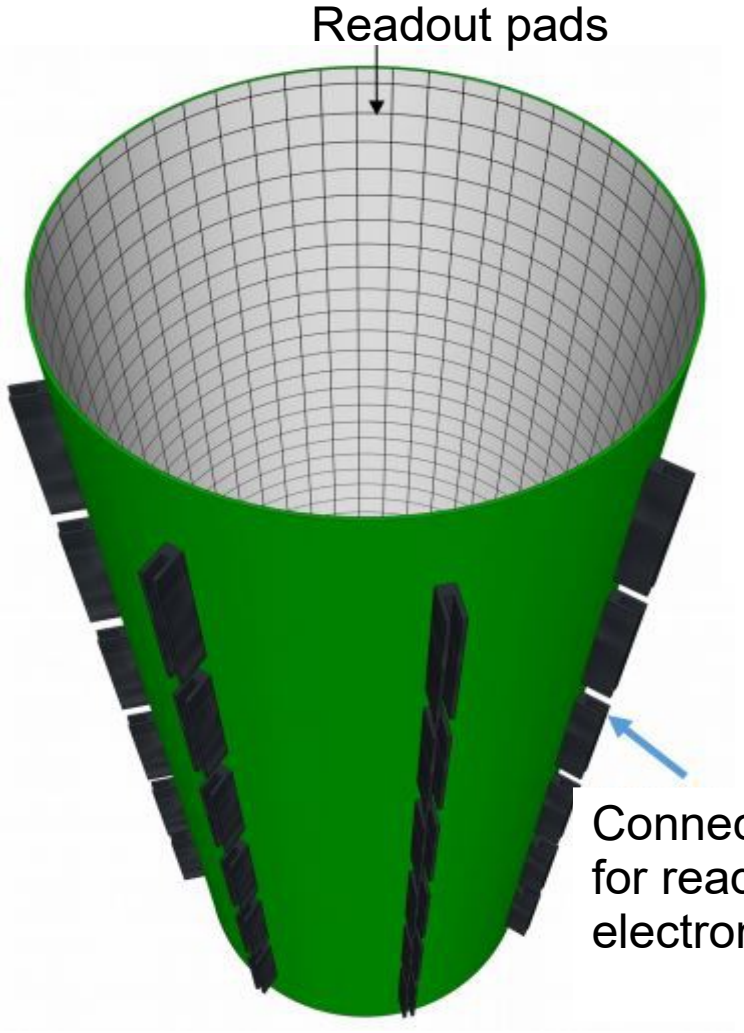
- Several tests were conducted to cut and wrap the 6 microns aluminum Mylar foil.

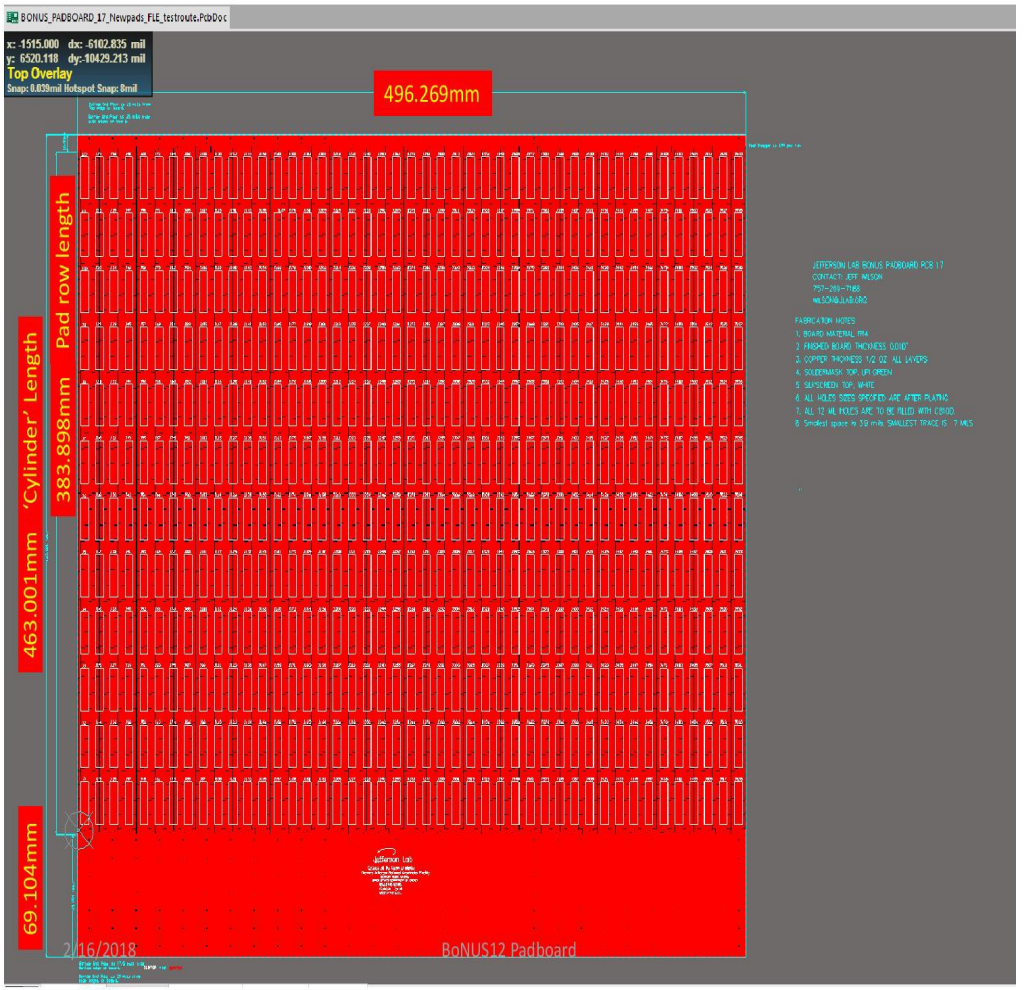




Readout board design

- 180 rows, 96 columns for total of 17280 pads.
- Pad board design by Jeff Wilson and C.Cuevas.

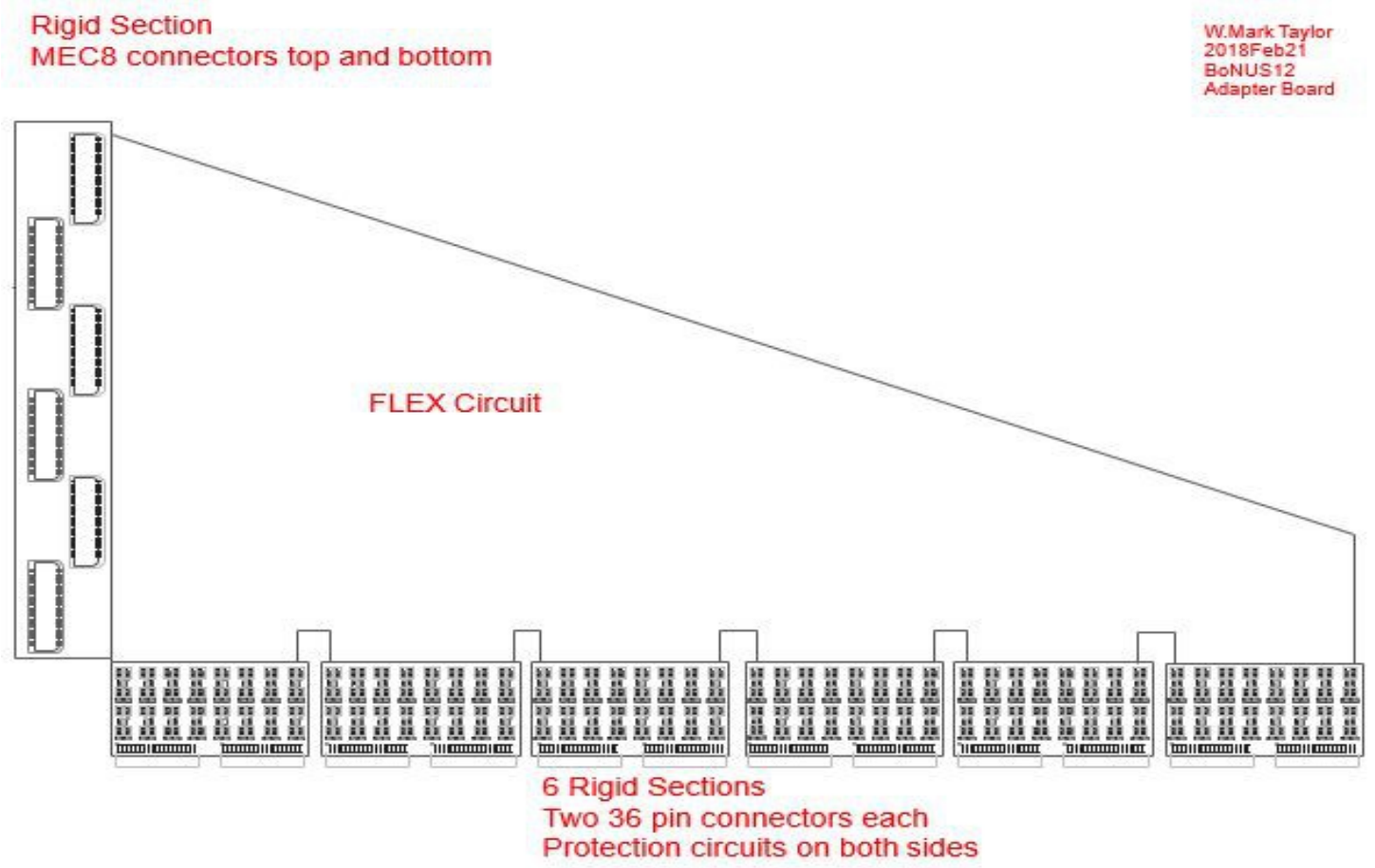




Adapter board design

- Adapter board protects the electronics from possible high current from the triple GEM foil due to a discharge.
- Connects to pad readout board. Out put cable adapter PCB board is shown.

  Three per each side.

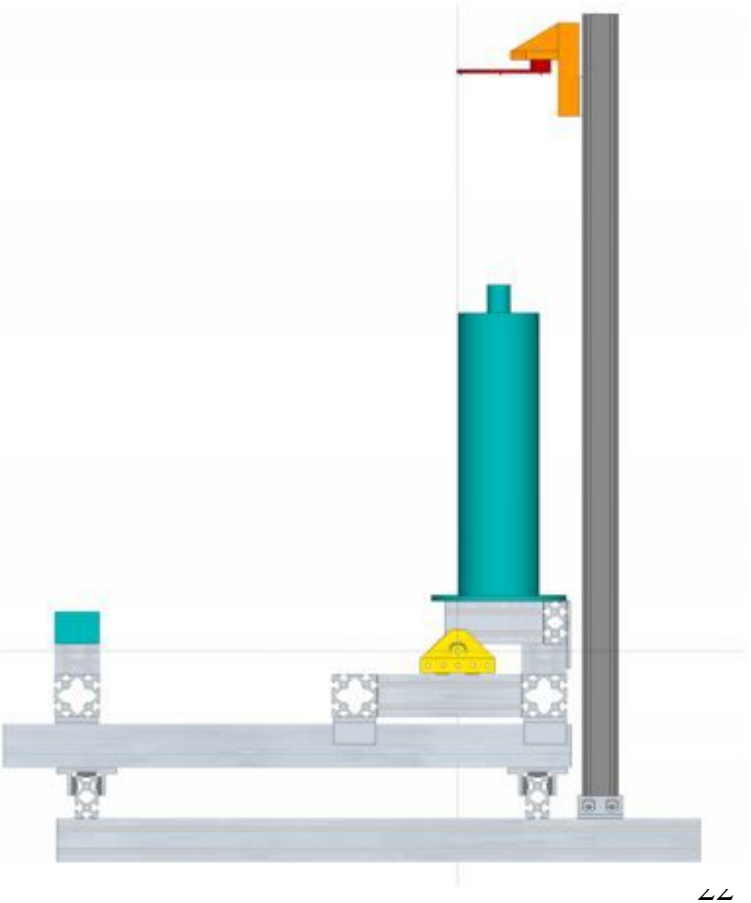


Future plans

- Build BONuS12 detector assembly tower.
- Finish the inner mandrel testings and finish the design of other two mandrels.
- Finish the detector construction by October

  2018.

Ready to run in 2019.

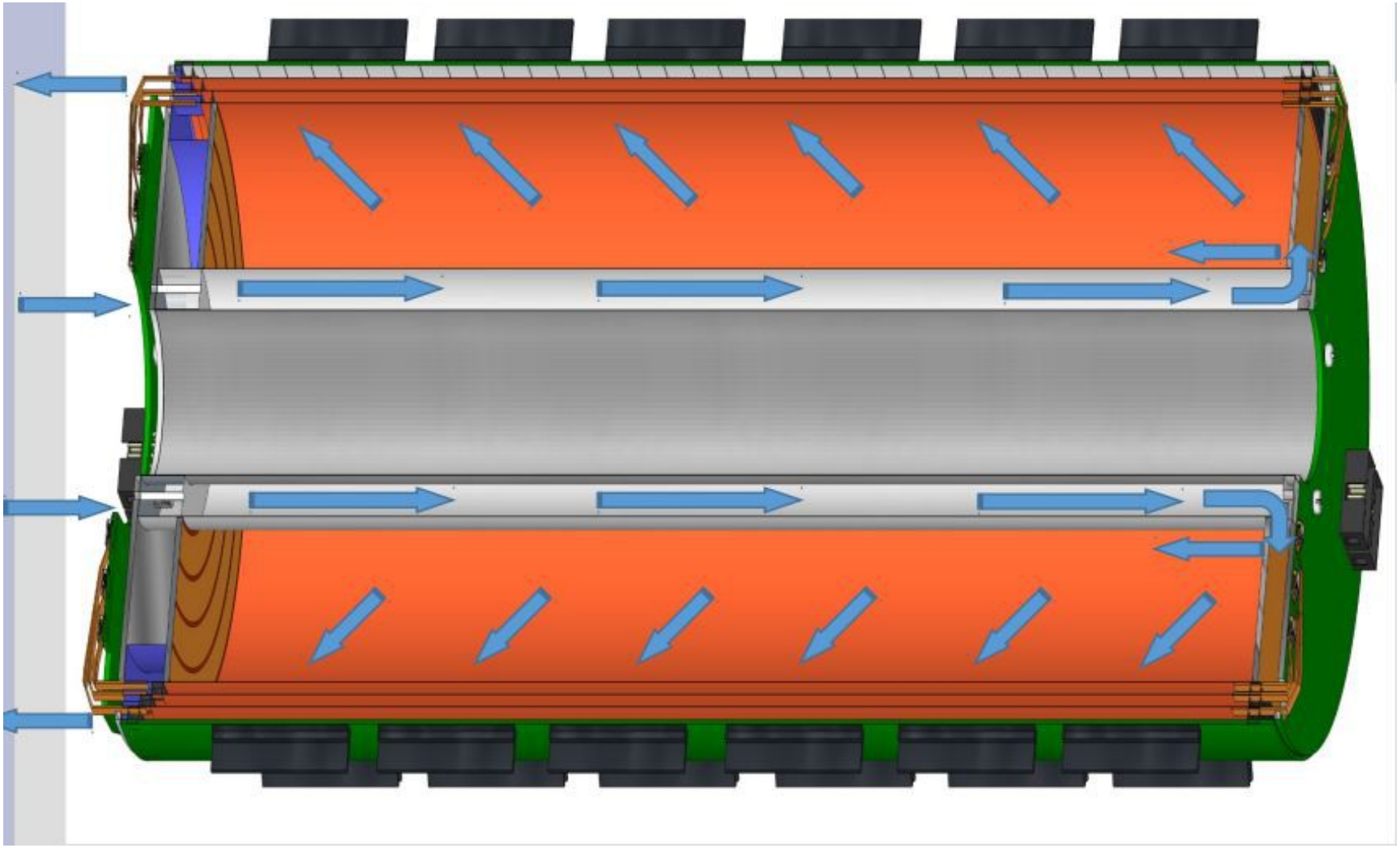


Summary

- Improvements implemented over BONuS6.
- Completed design with detailed parts.
- Mechanical tests for cylindrical 40 cm GEM foils success.

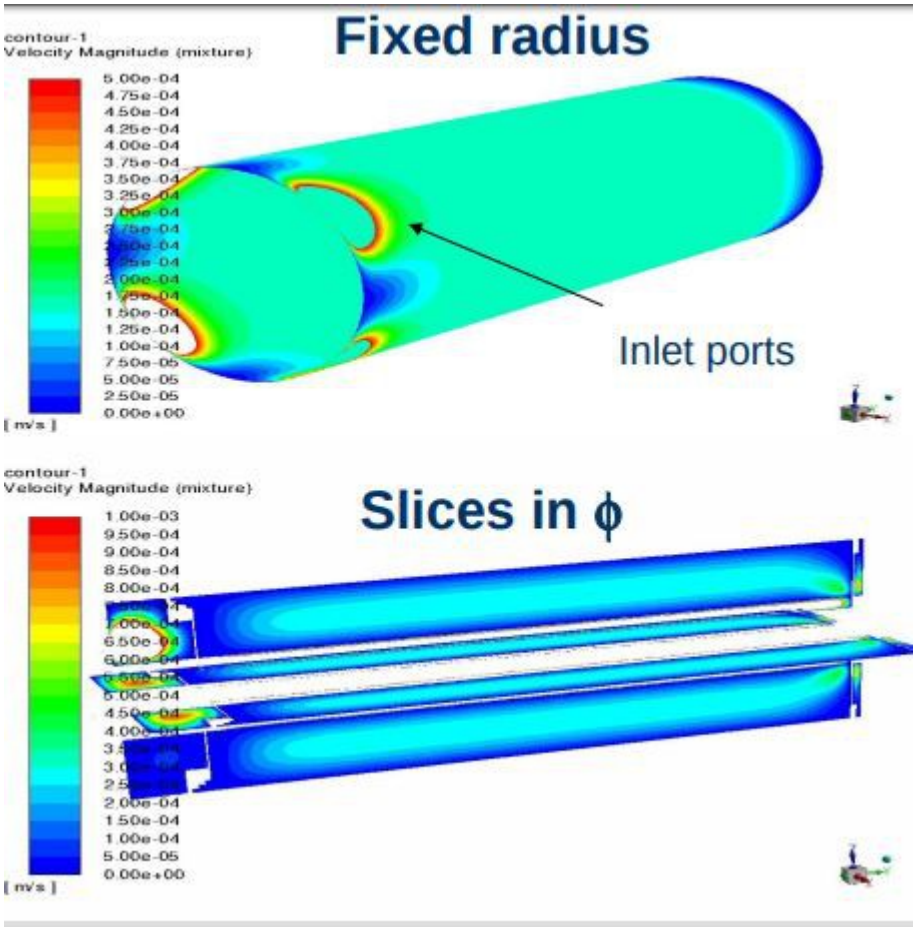
THANK YOU

Gas flow of RTPC

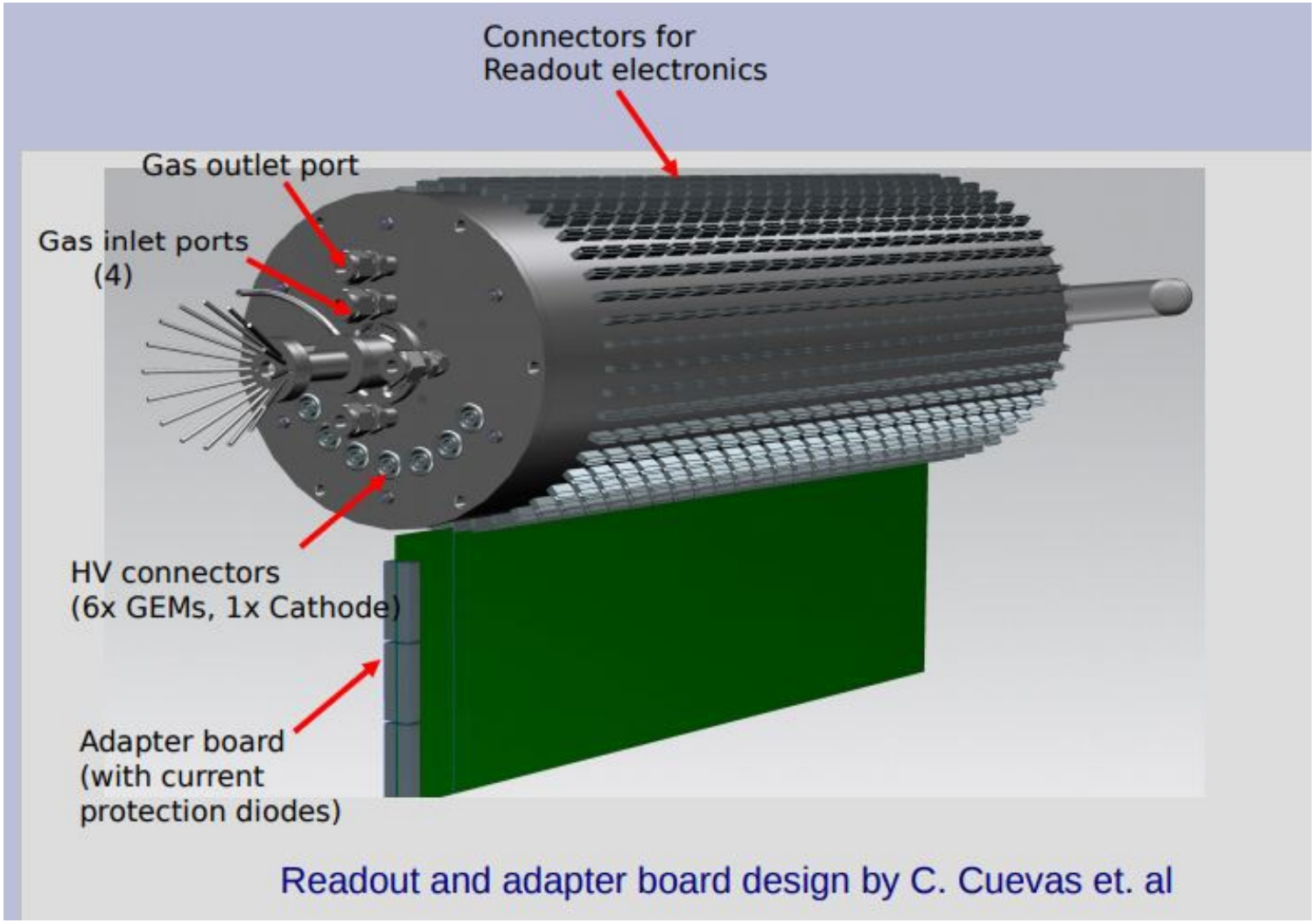


Velocity profile from CFD

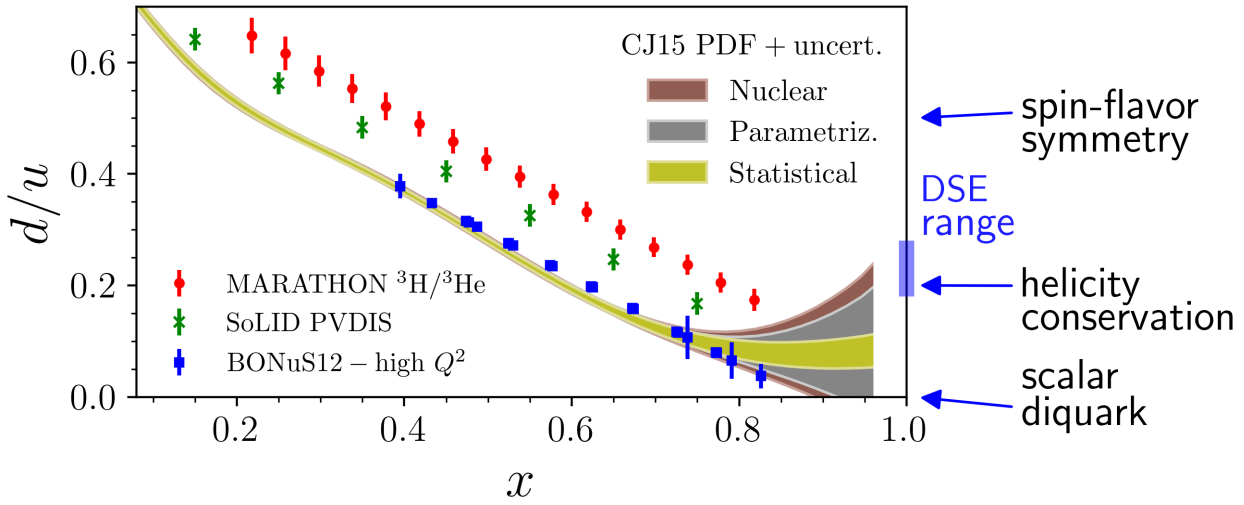
- Assumptions
- 0.2L/min, Premixed
- Current design shows relatively uniform flow.



Complete assembly



The neutron-to-proton F2 ratio. (with future JLab12 data for comparison)



The uncertainties are:

- * statistical: from the experimental data propagate into the fitted PDFs, and then into the calculated F2 n/p ratio
- * Parametrization: from the functional form used for fitting PDFs at large x
- * Nuclear: from using various deuteron wave functions (AV18, CD-Bonn, WJC2) when calculating F2(deuteron) needed in the PDF fits.