BONUS 12
(BARELY OFF-SHELL NUCLEON STRUCTURE @ 12 GEV)
PROCEDURES AND STATUS

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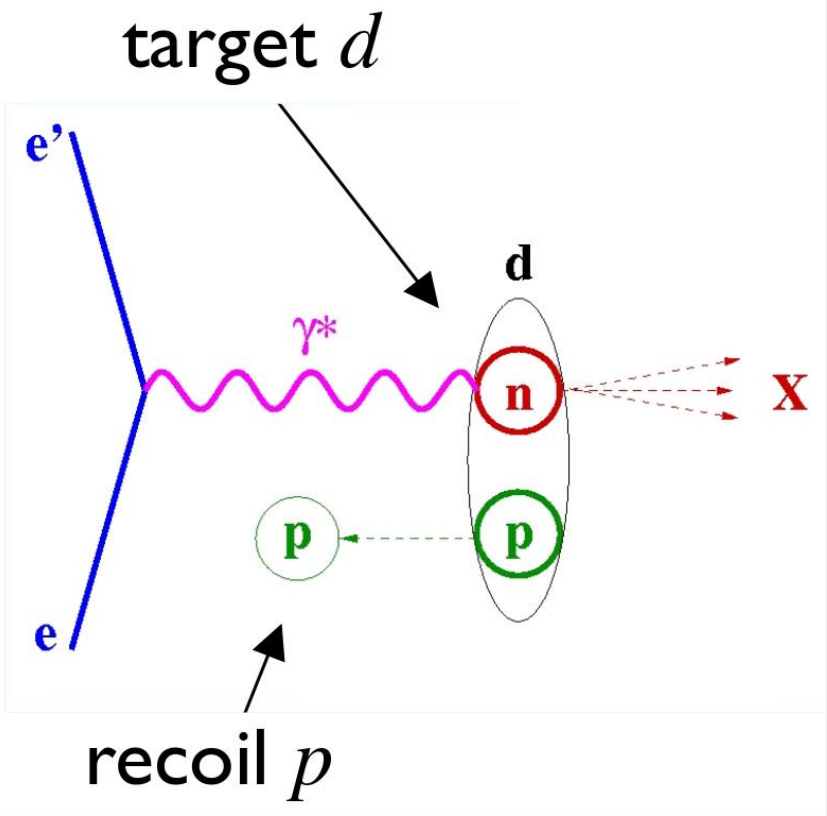
Hampton University

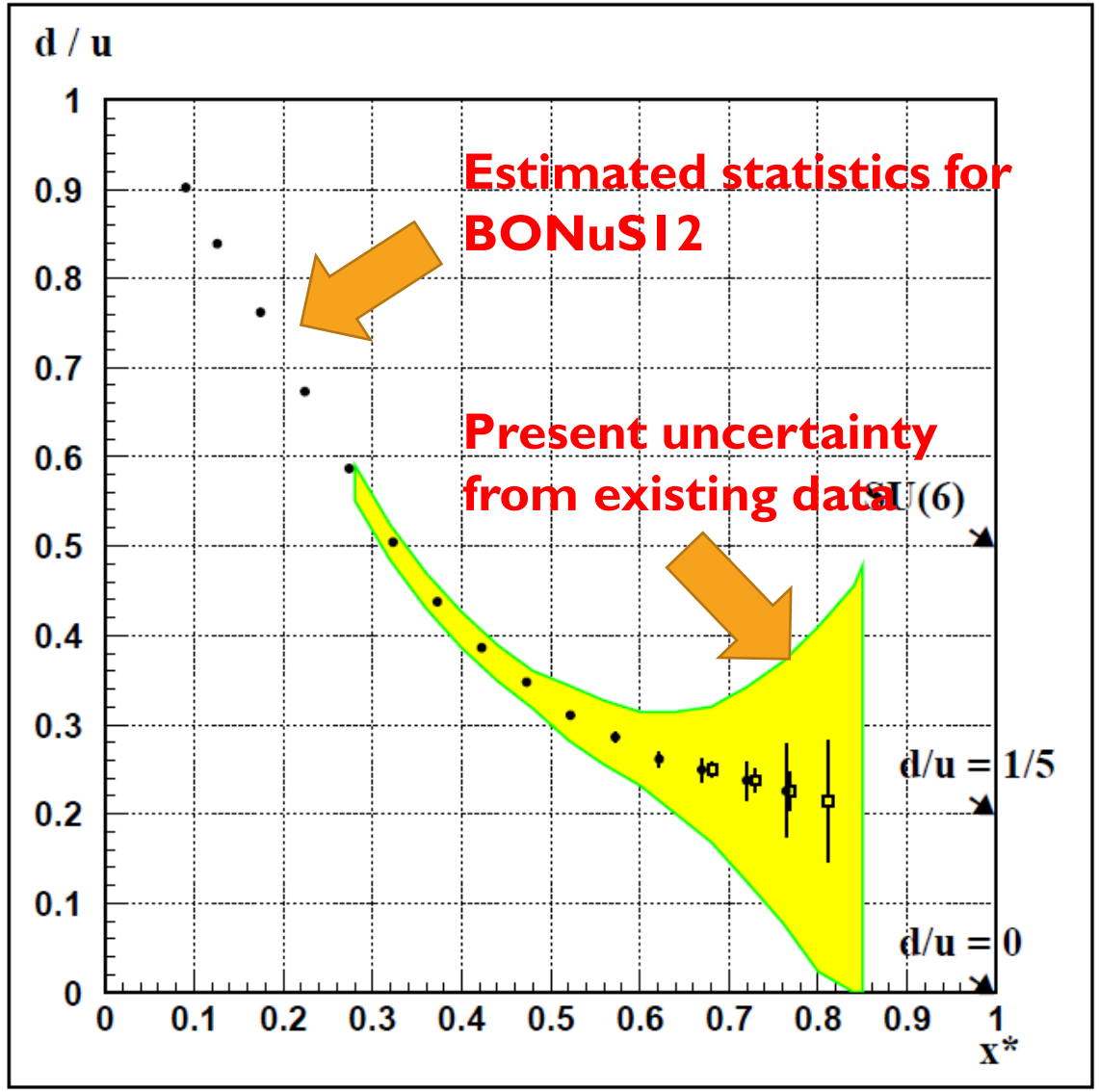
PHYSICS REVIEW

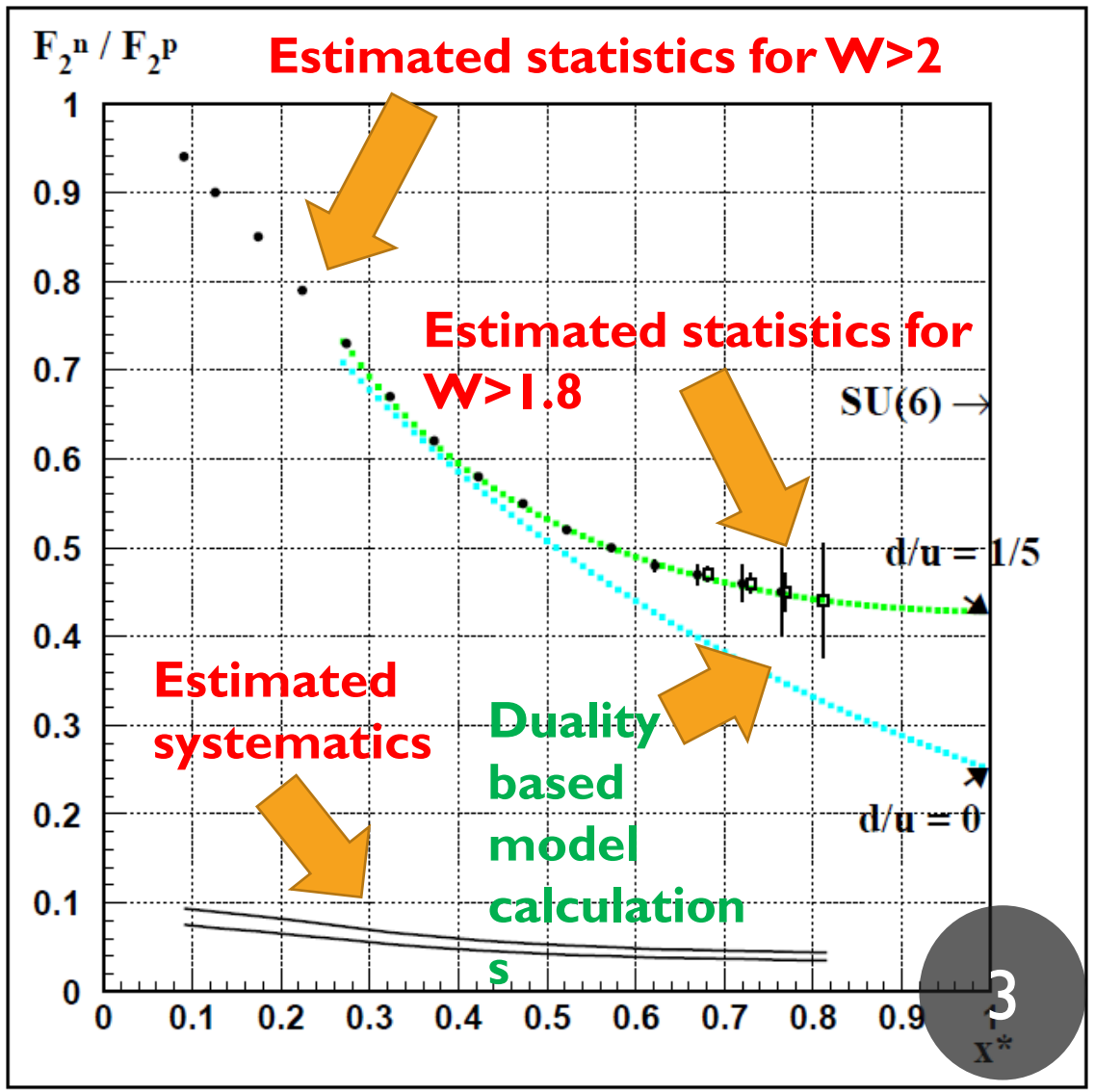
- Proton structure have been studied in great detail.
- Much less is know about neutron structure due to lack of free neutron target
- Neutron structure can be studied using DIS on deuteron target by tagging the recoiled proton using RTPC.
- The momentum of spectator proton is used to interpret initial 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



PHYSICS REVIEW

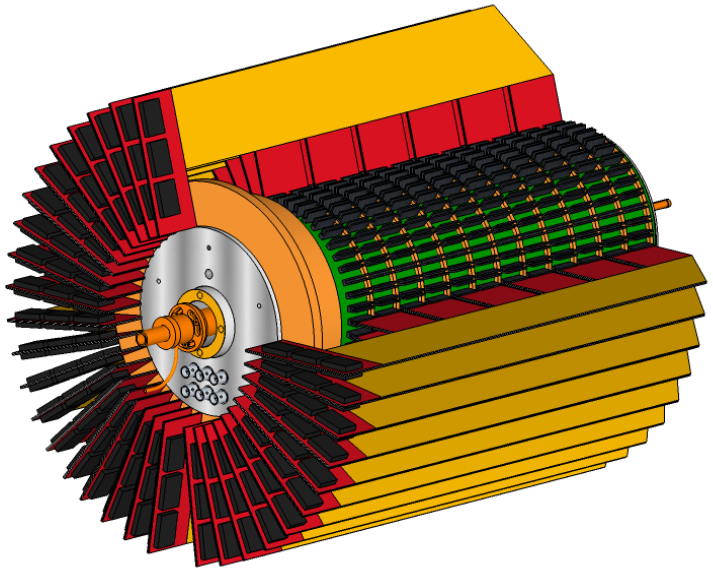
- BONuS12 expected results





PHYSICS REVIEW

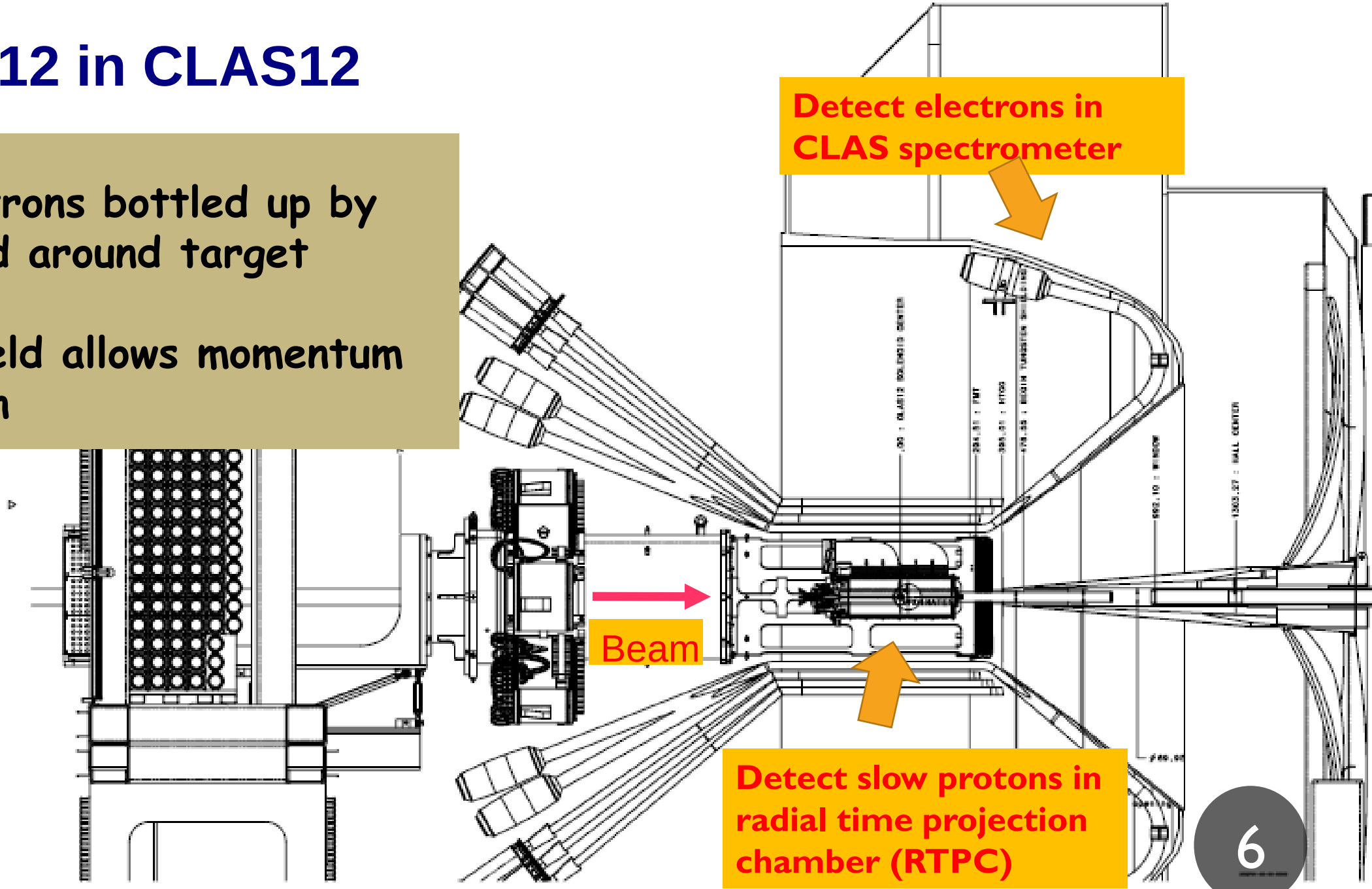
- **BONuS12 extends BONuS6:**
  - **Improved momentum resolution with Increased drift region from 3 cm to 4 cm**
  - **Improved W resolution with better momentum reconstruction**
  - **Increased gain**
  - **Reduce material and better reconstruction algorithm allowing lower threshold momentum of proton.**
  - **Better track sampling**
  - **Better acceptance in phi**
  - **Higher rates, higher statistics with increased detector length, increase luminosity to $2x10^{34}cm^{-2}s^{-1}$**

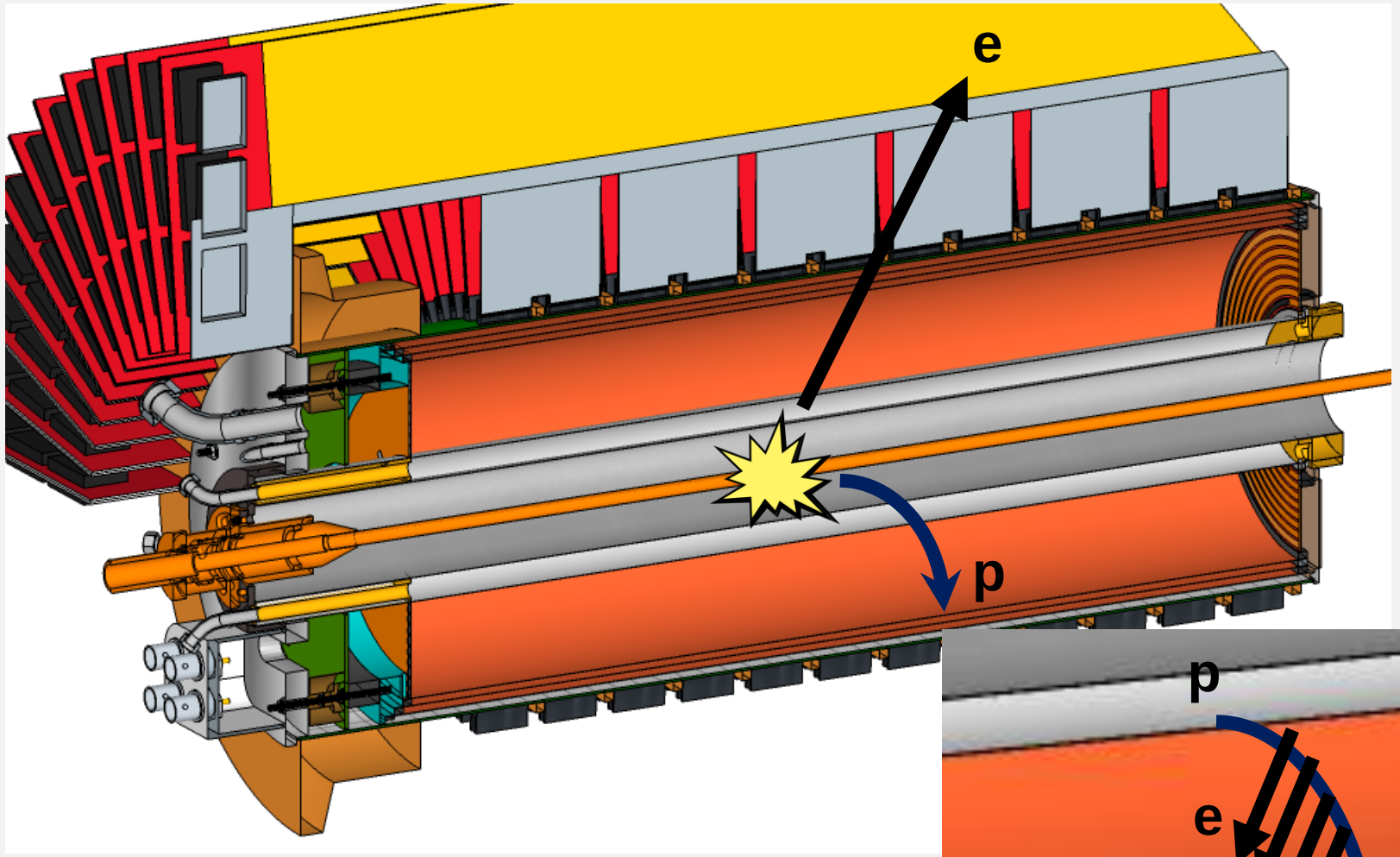


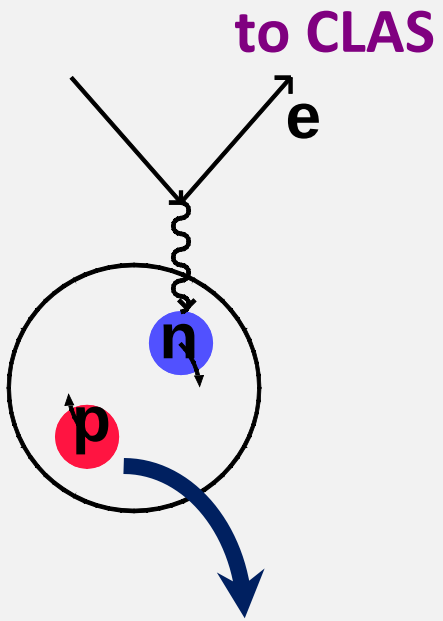
BONUS12 EXPERIMENTAL SETUP

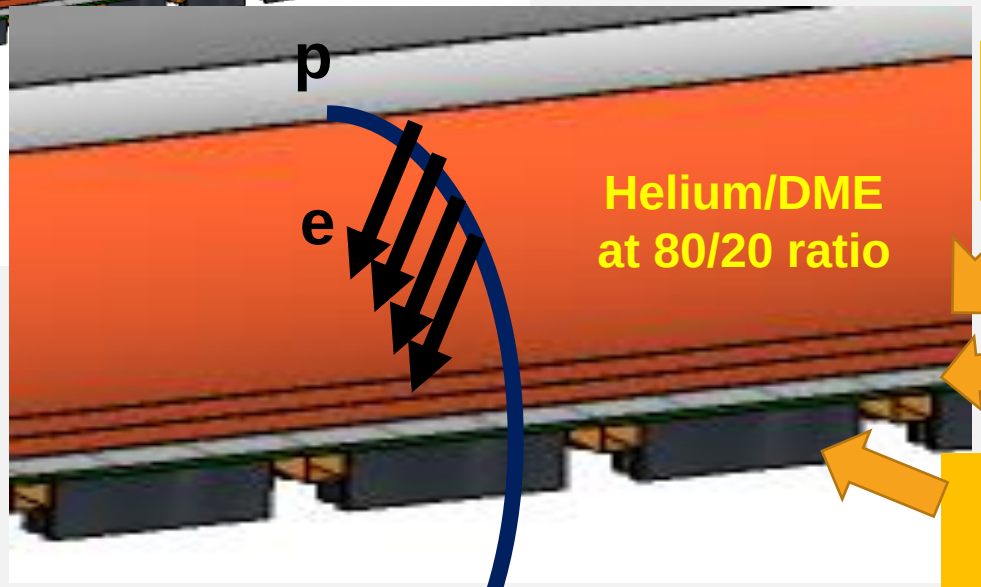
BONuS12 in CLAS12

- Moller electrons bottled up by Solenoid field around target
- Solenoid field allows momentum determination









3 GEM Layers

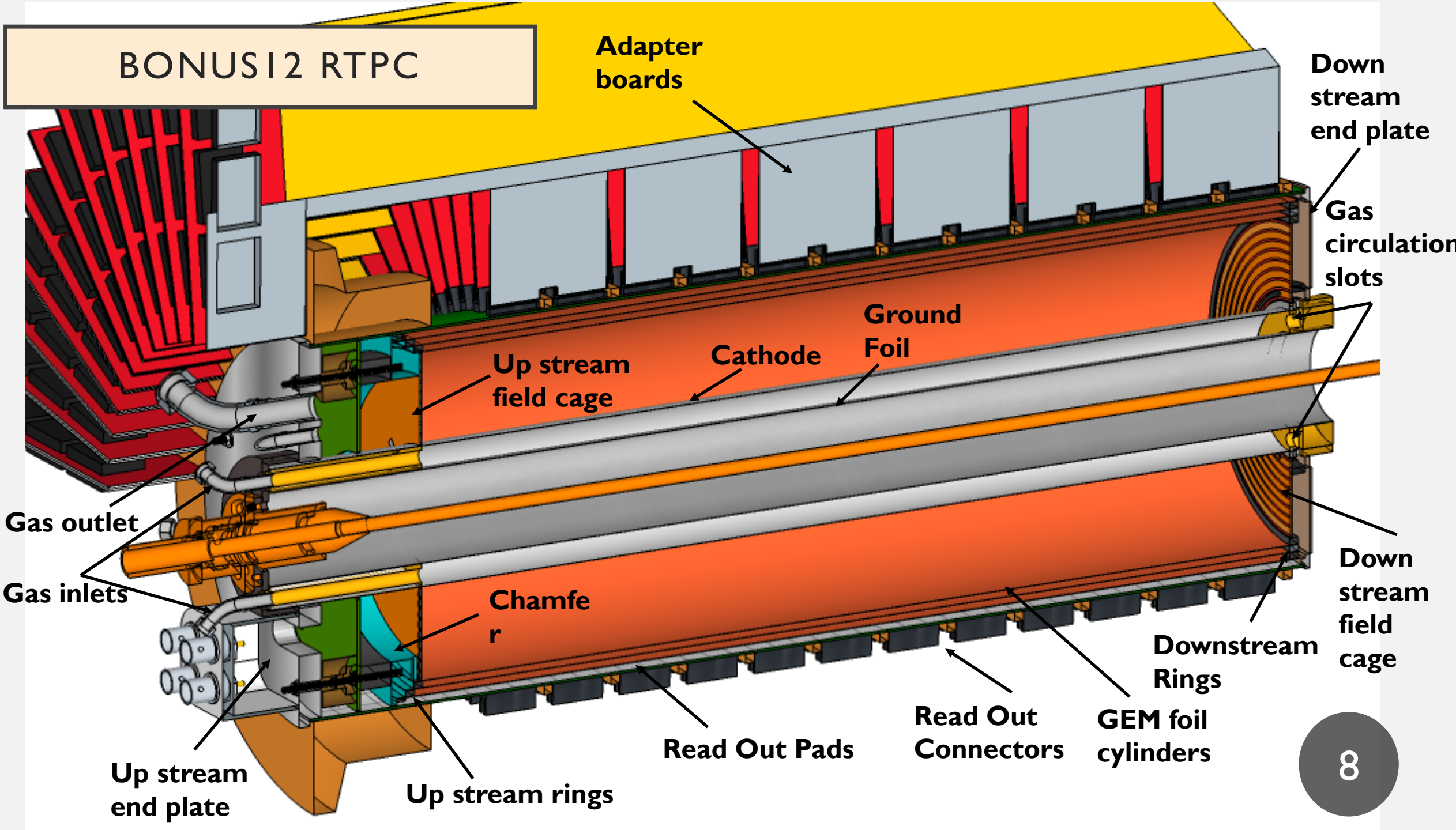
Gain Stage

Readout electrodes

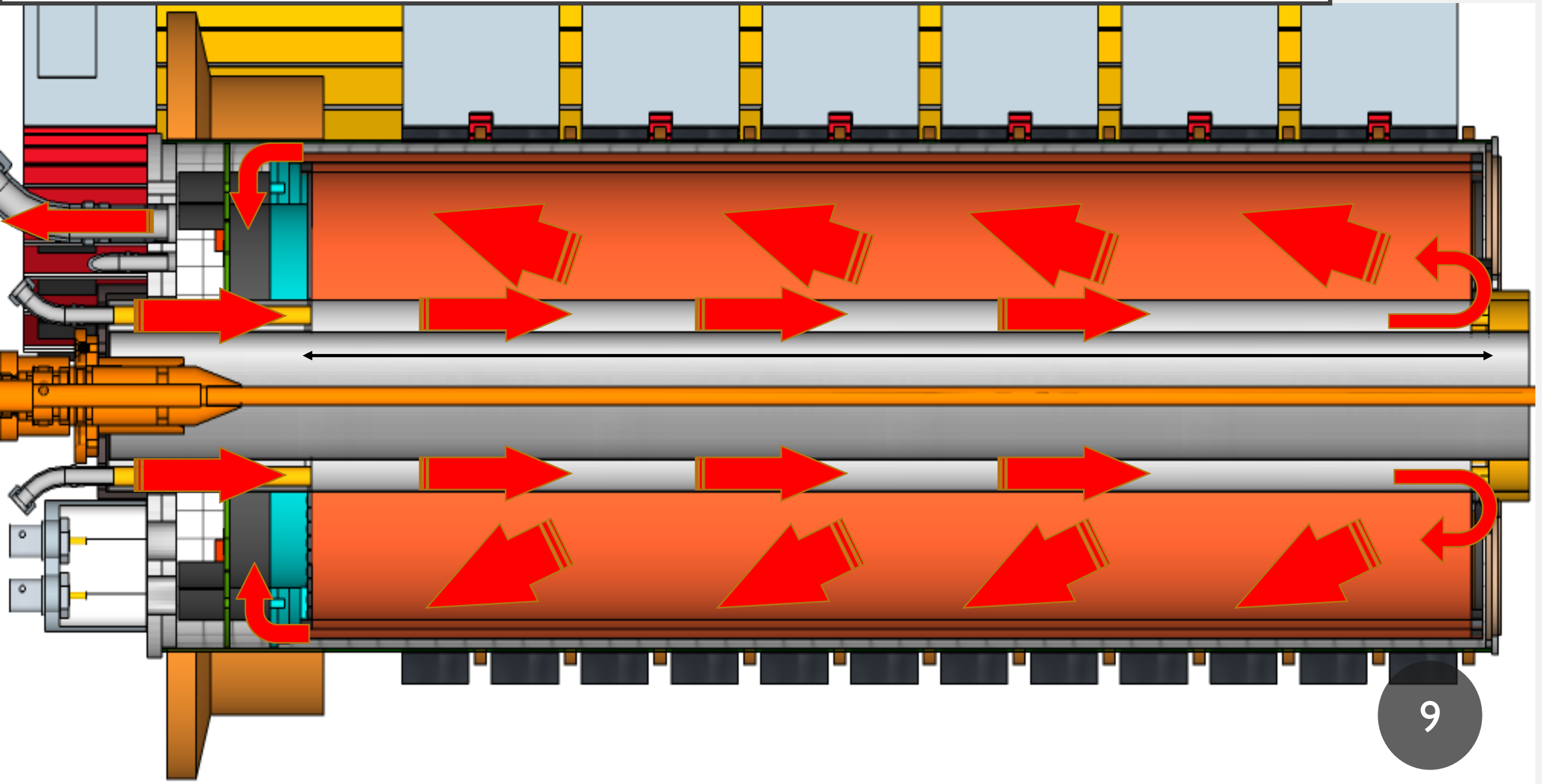
Readout connectors

BONUS12 RTPC

BONUS12 RTPC



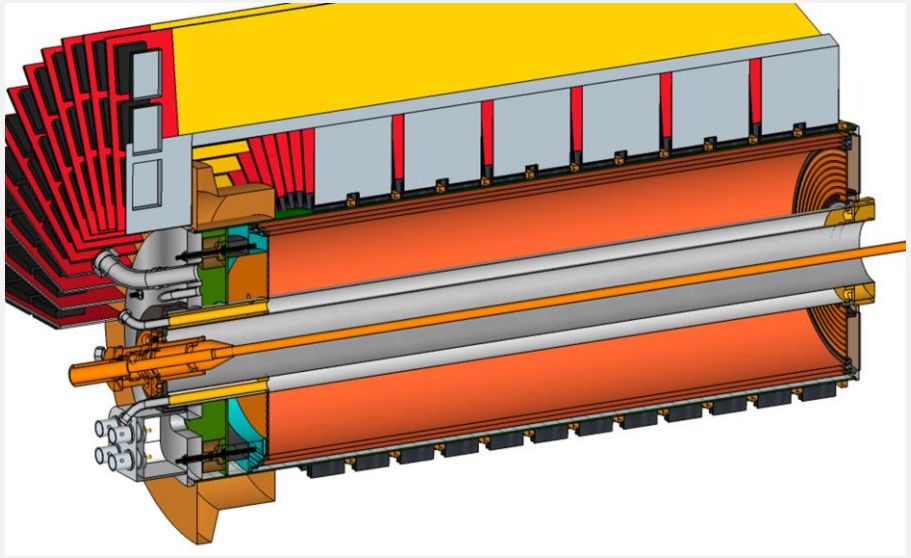
GAS CIRCULATION

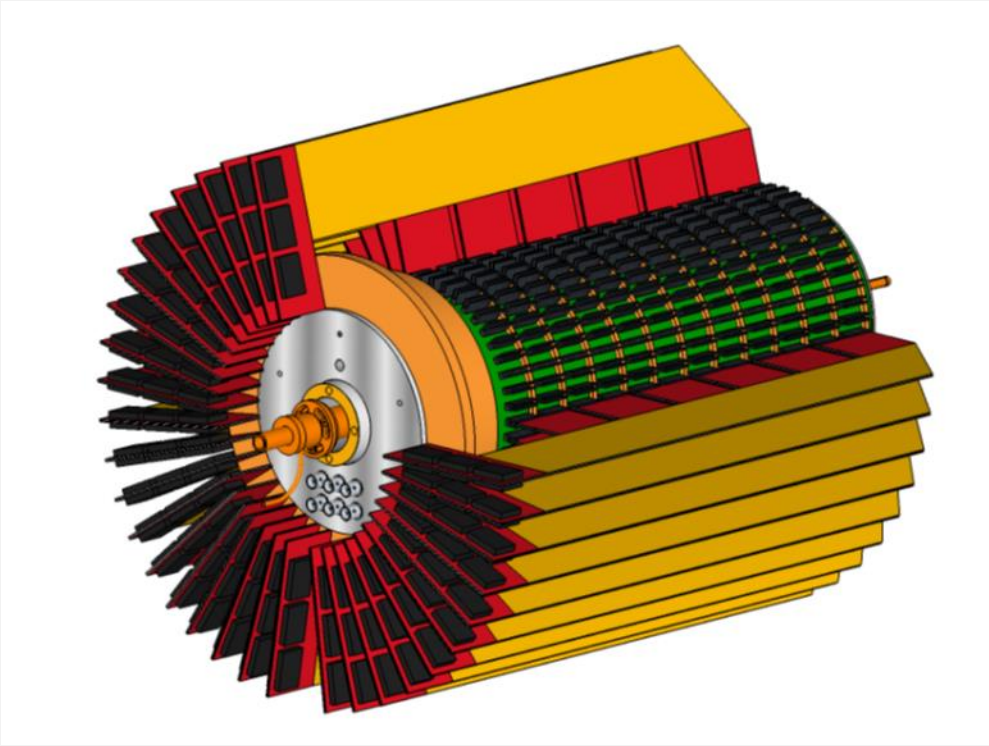


BONUS12 RTPC CONSTRUCTION

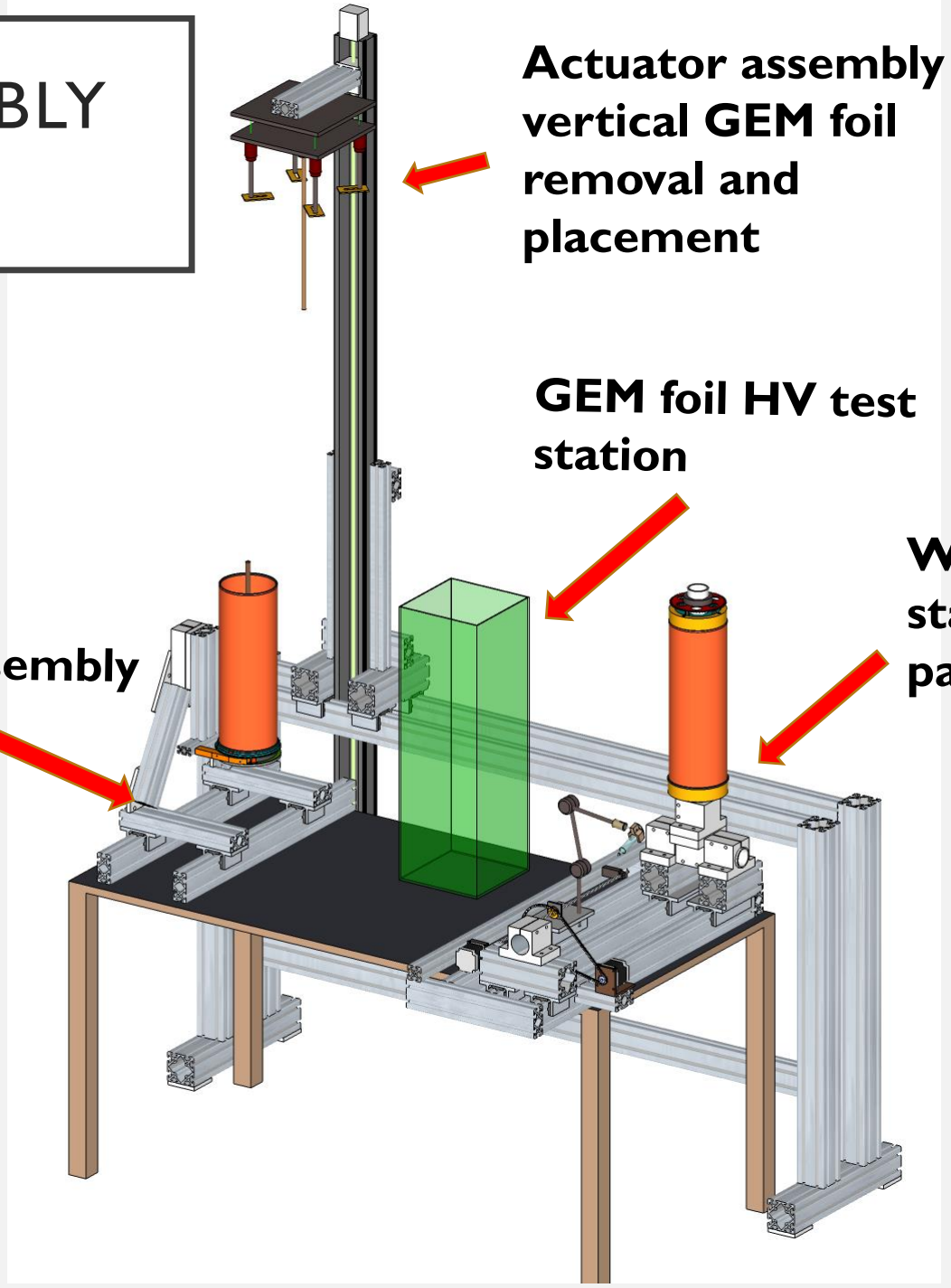
RTPC CONSTRUCTION

- Detector design is complete



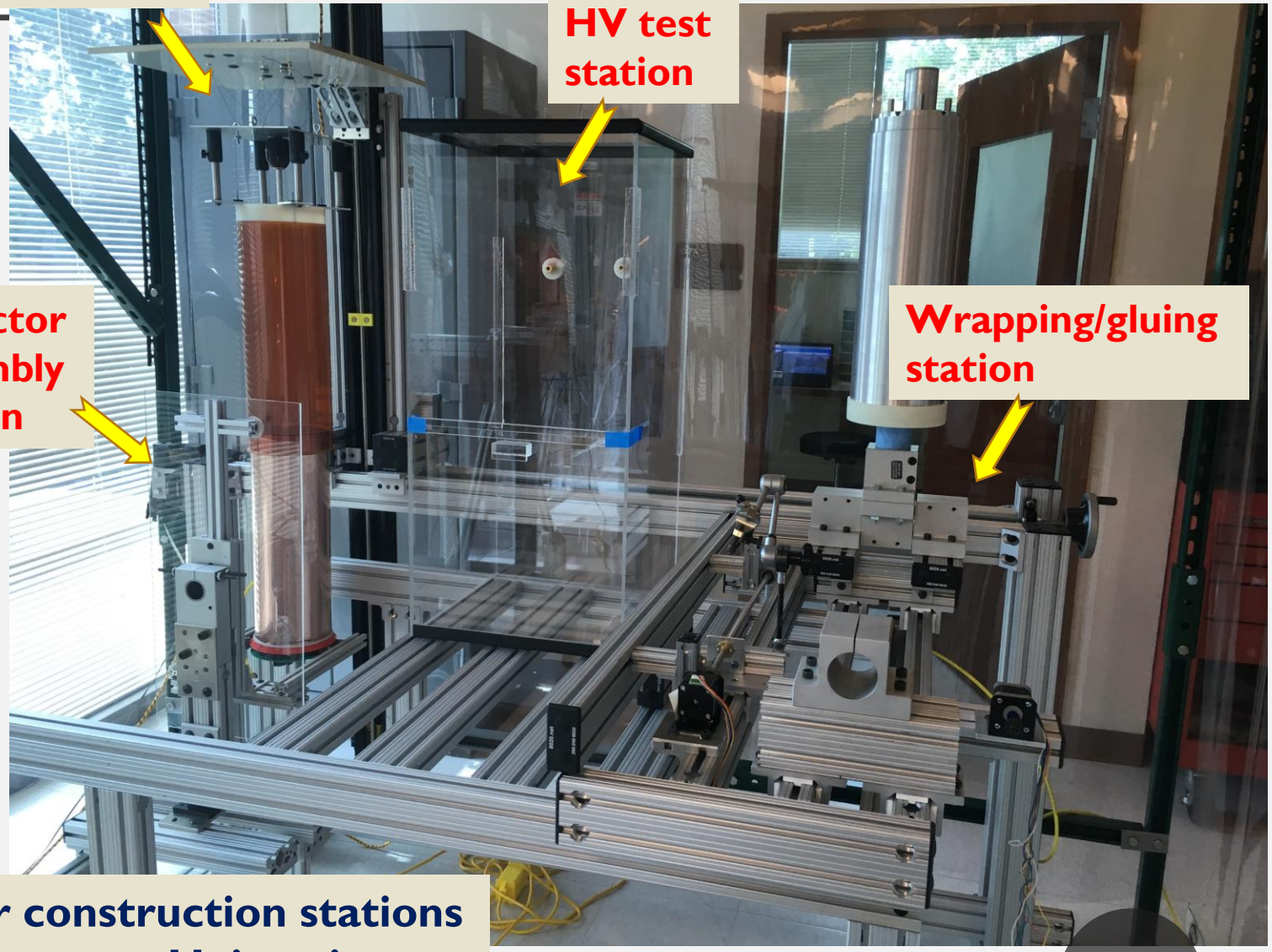


BONUS12 ASSEMBLY TOWER



RTPC CONSTRUCTION

- Ready to go:
  - Clean room environment
  - Automated wrapping/gluing station
  - Puller assembly
  - HV testing station
  - RTPC assembly station
  - Pad board surface uniformity scanner
  - Tested construction procedure



Detector construction stations at Hampton University

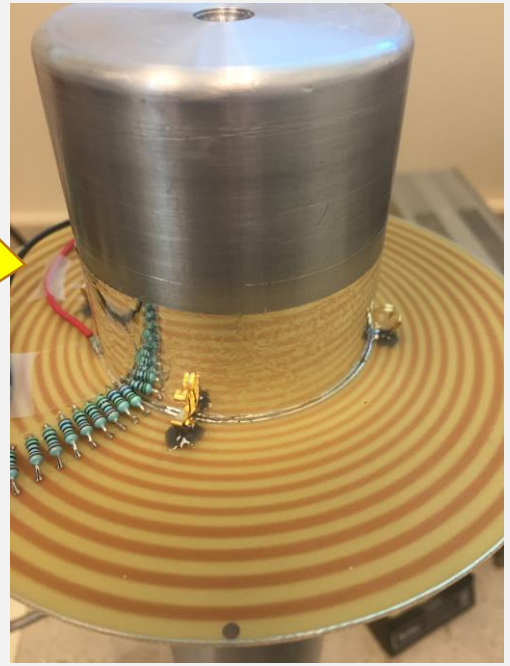
RTPC CONSTRUCTION

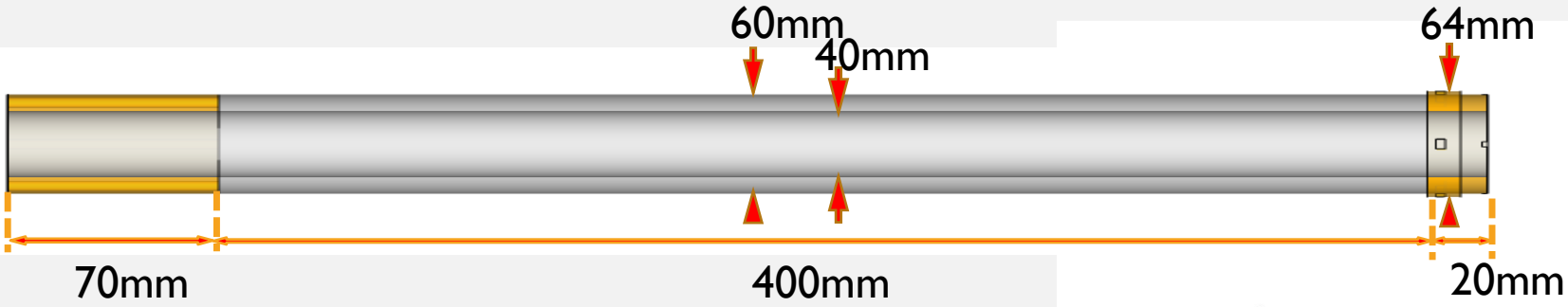
- **Tooling and procedures for wrapping cylinders well tested**
- **We completed a mechanical assembly test of a 3 layer GEM assembly, including connection to the HV board**
- **HV connection procedure, assembly of chamfer, US field cage, HV board, US plate mounting hardware complete**
- **Currently forming GEM cylinder layers and mounting on chamfer assembly**
- **First assembly including mounting of US endplate done by end of June in advance of padboard delivery.**

RTPC CONSTRUCTION

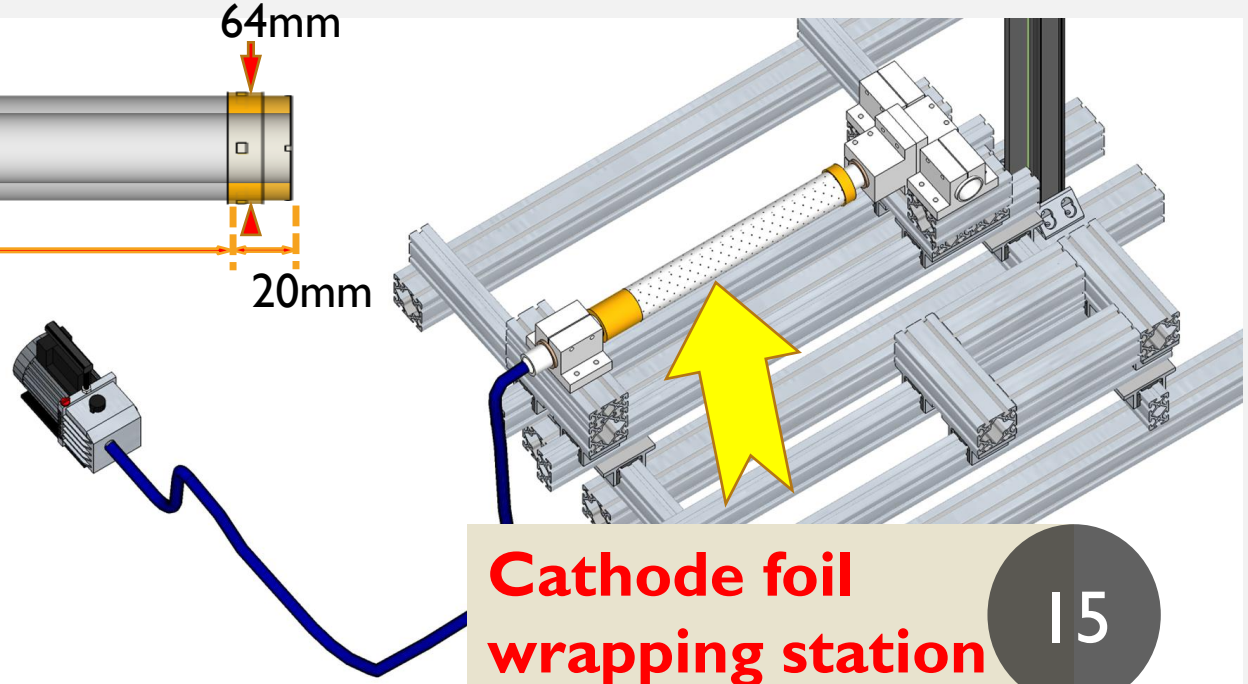
- **Cathode Assembly**
  - **Construction procedure tested**
  - **Assembly station is constructed**
  - **Complete construction by mid July**

Cathode foil field cage electrical connectivity test





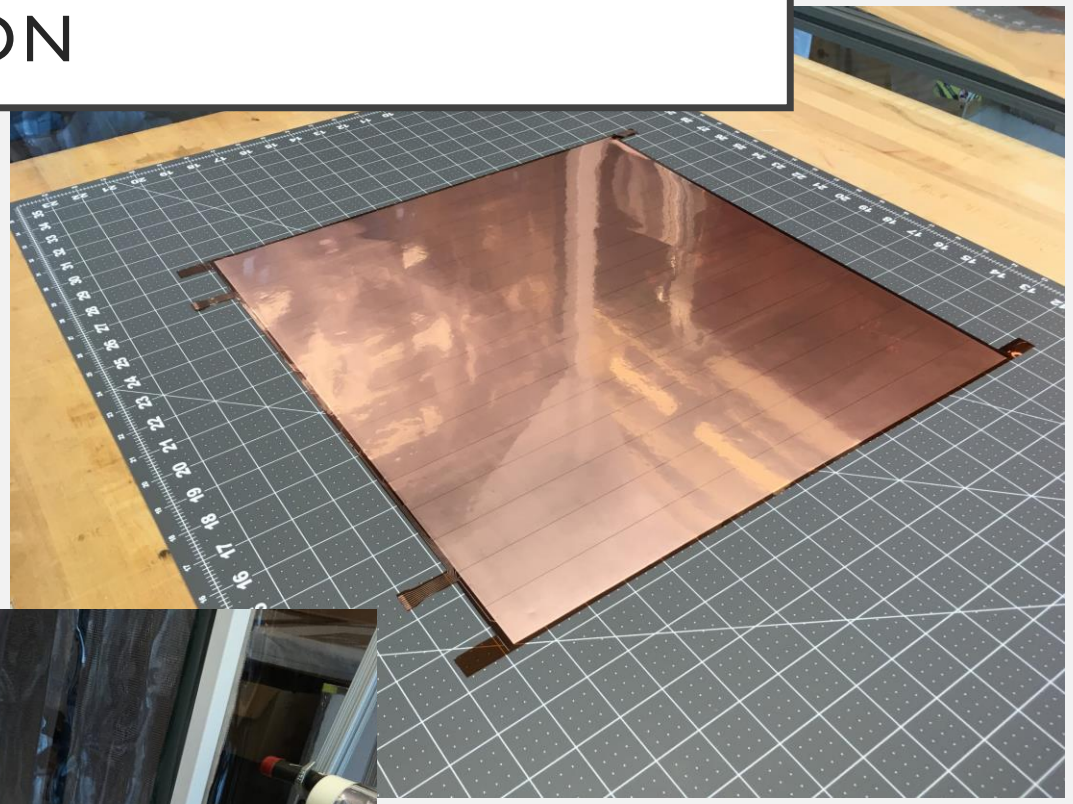
Cathode and ground foil assembly

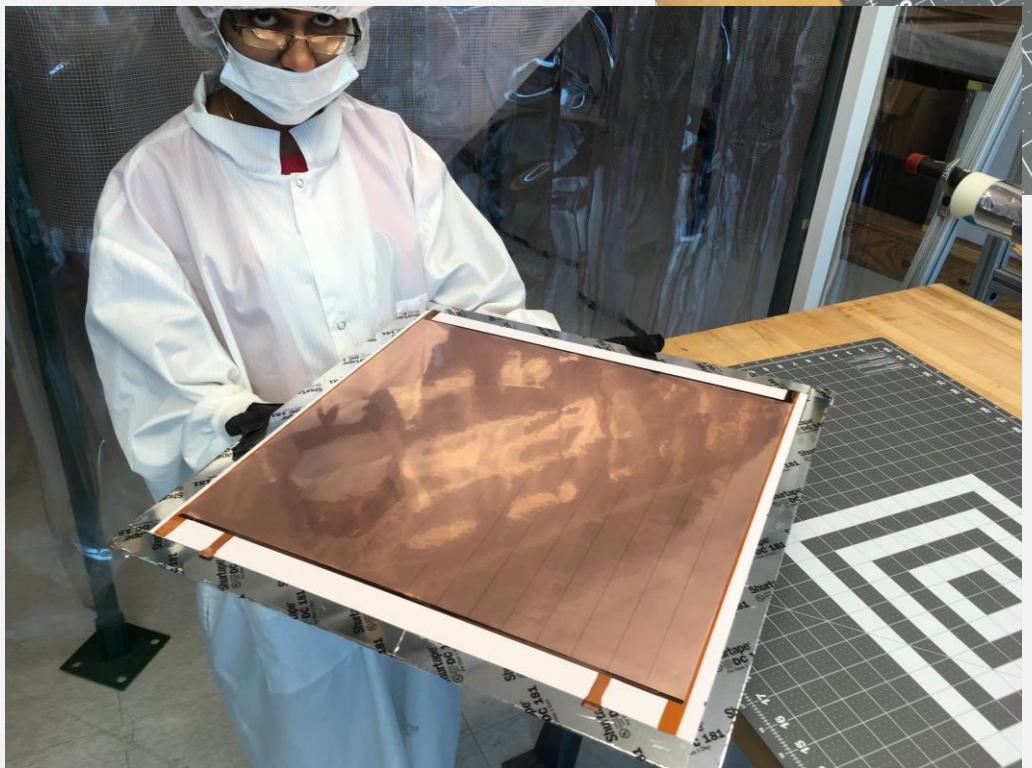


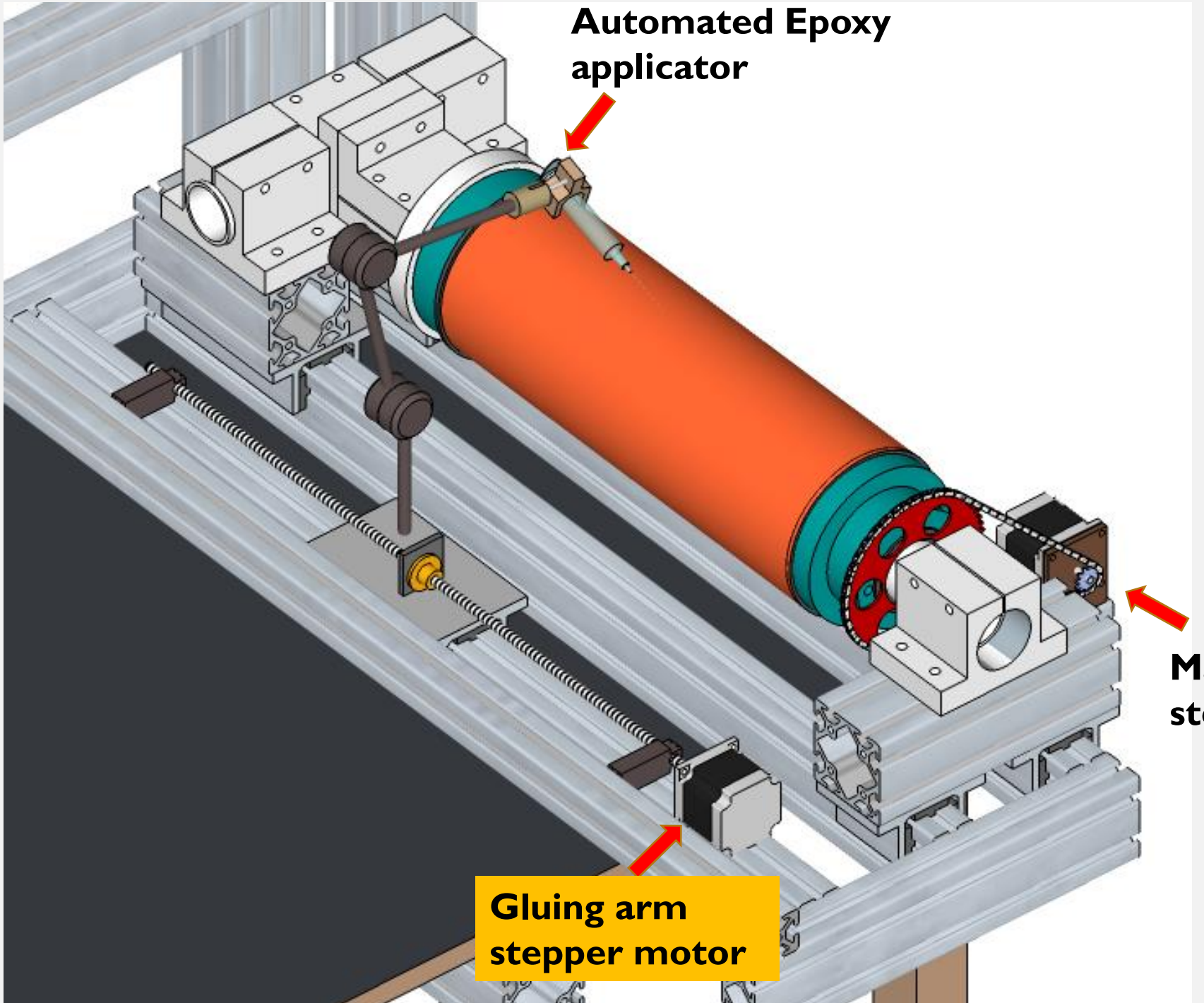
Cathode foil wrapping station

RTPC CONSTRUCTION

- GEM foils, read out board, cathode assembly, Wrapping/gluing



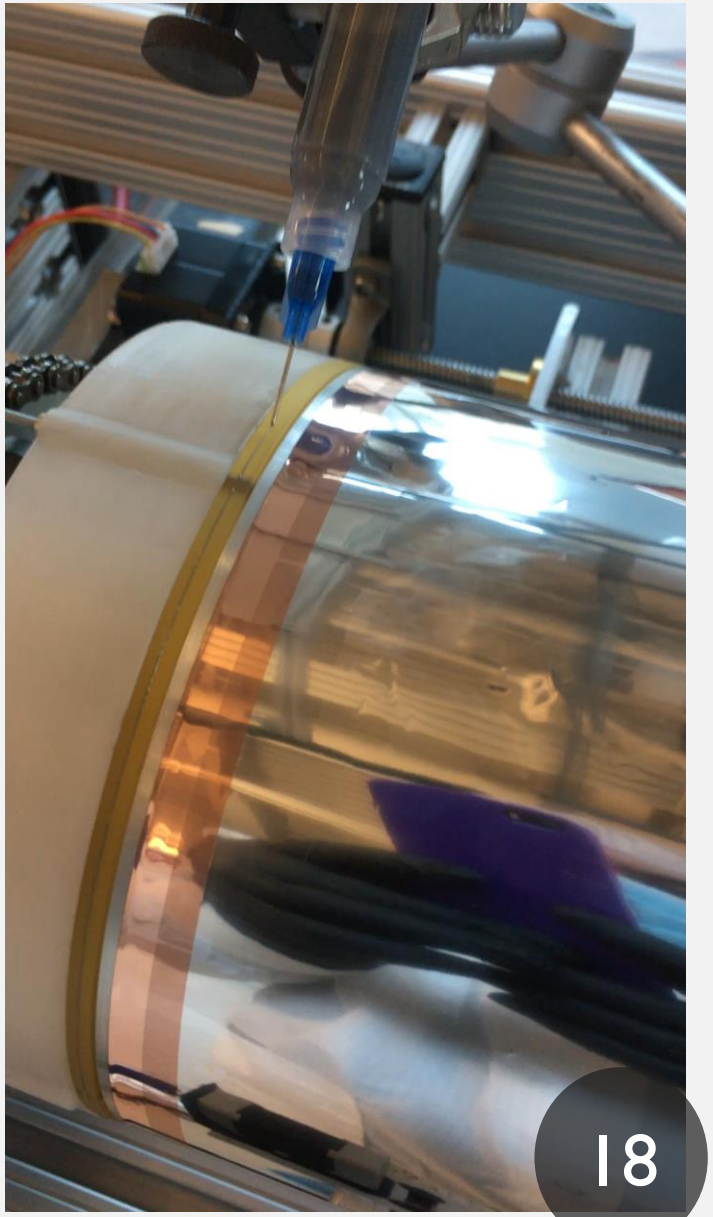



Automated Epoxy applicator
Mandrel rotation stepper motor
Gluing arm stepper motor

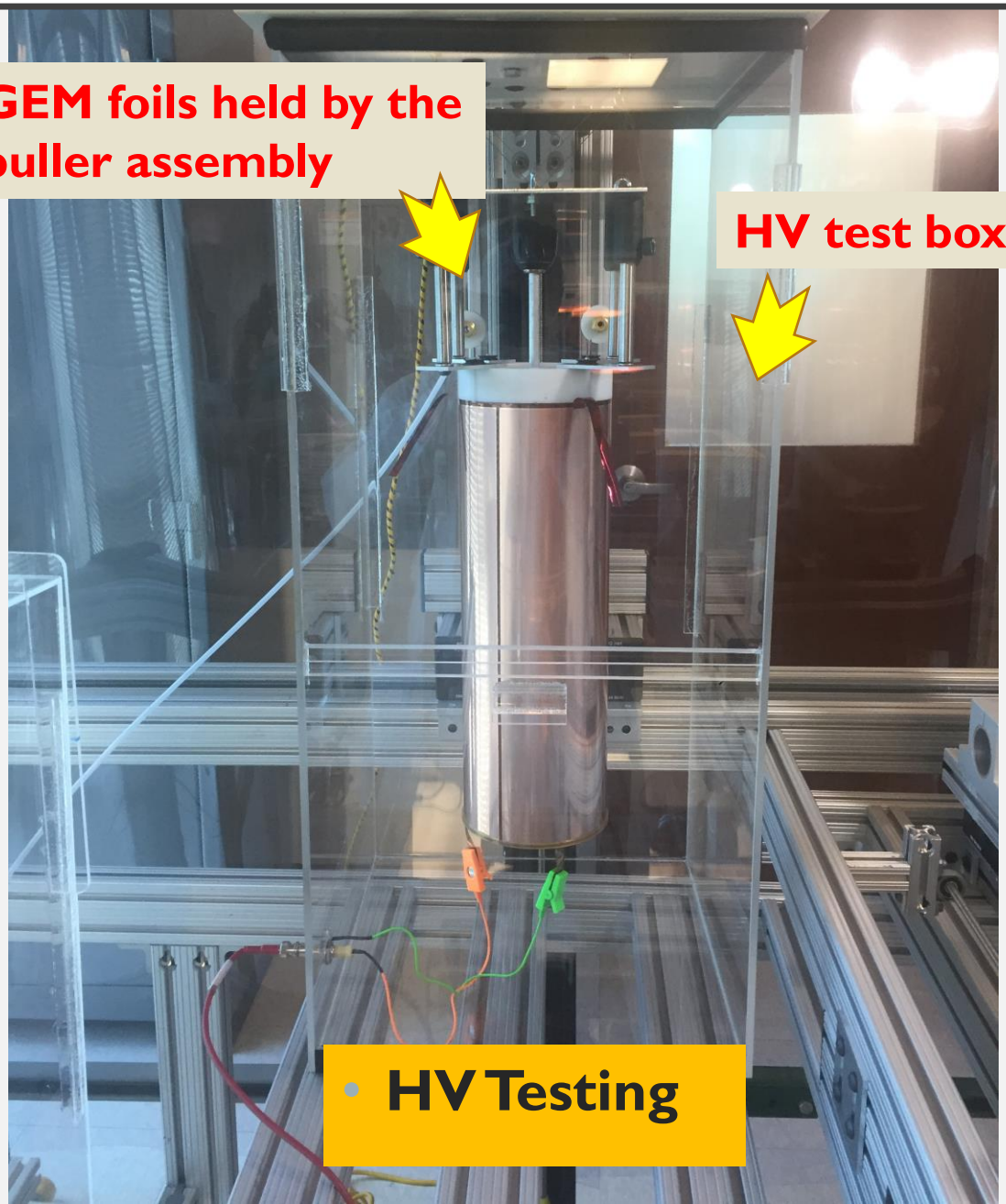
RTPC CONSTRUCTION

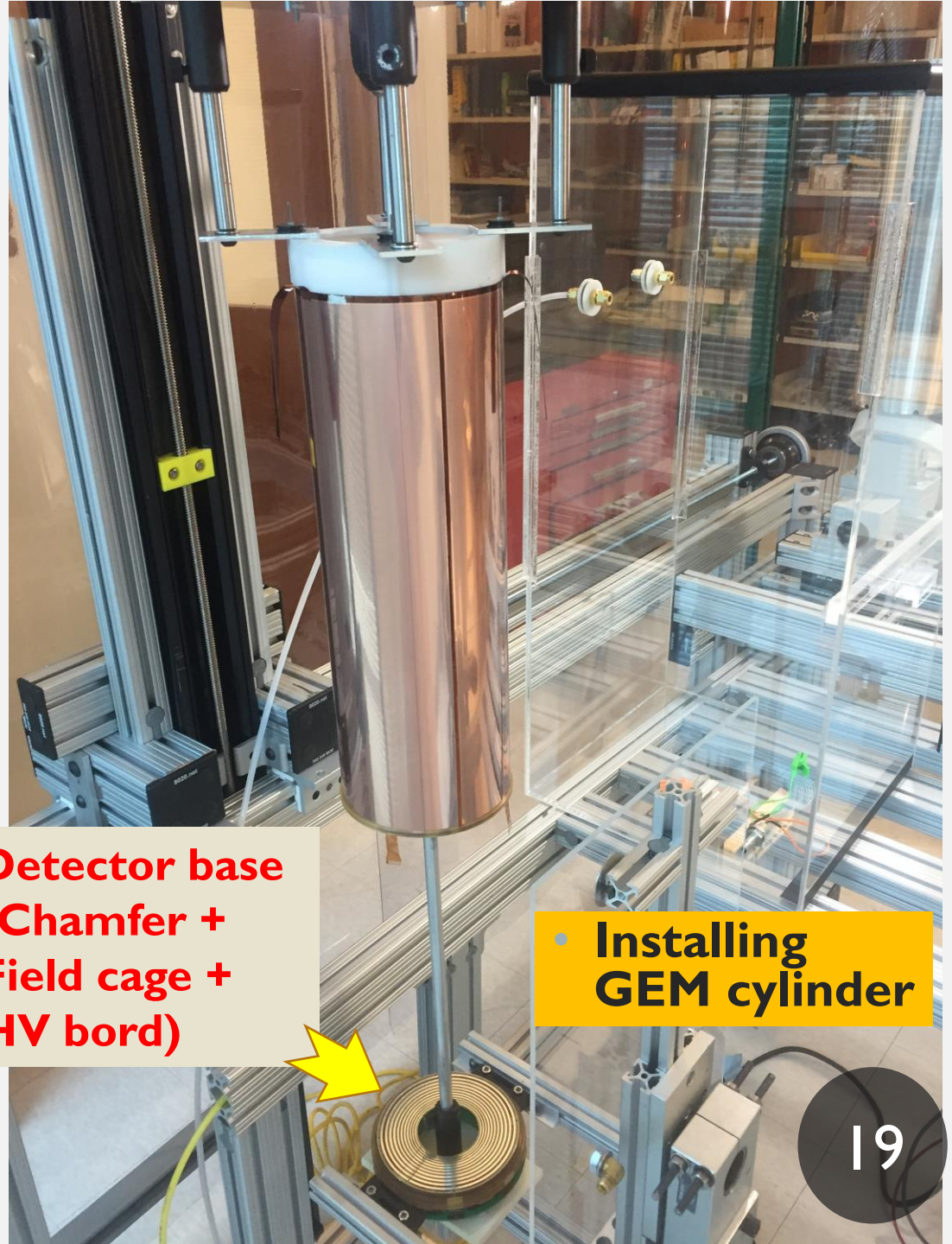
Automated epoxy application

GEM foil wrapping and gluing



RTPC CONSTRUCTION

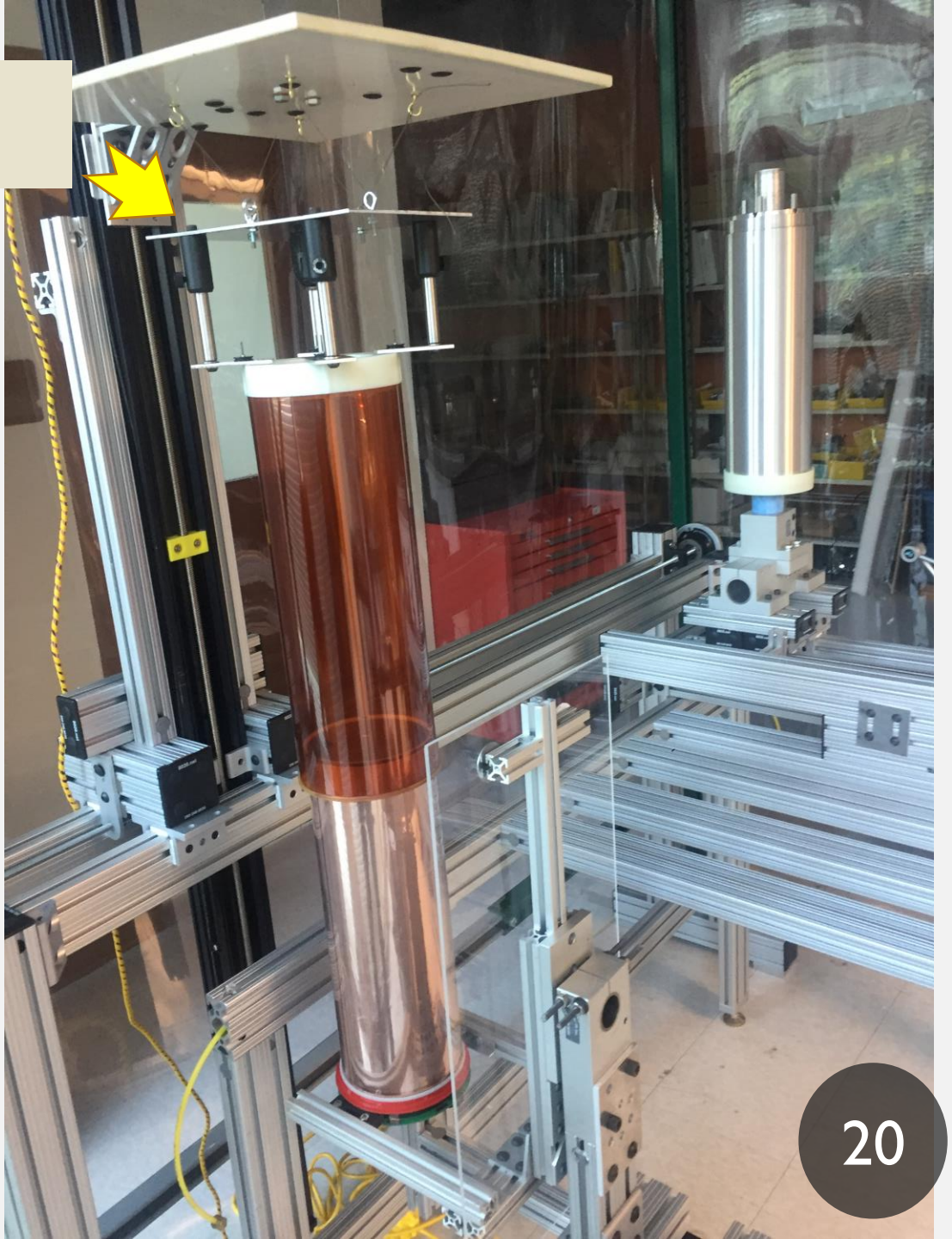




RTPC CONSTRUCTION

Removal of glued capton cylinder using puller mechanism

Self aligning puller assembly

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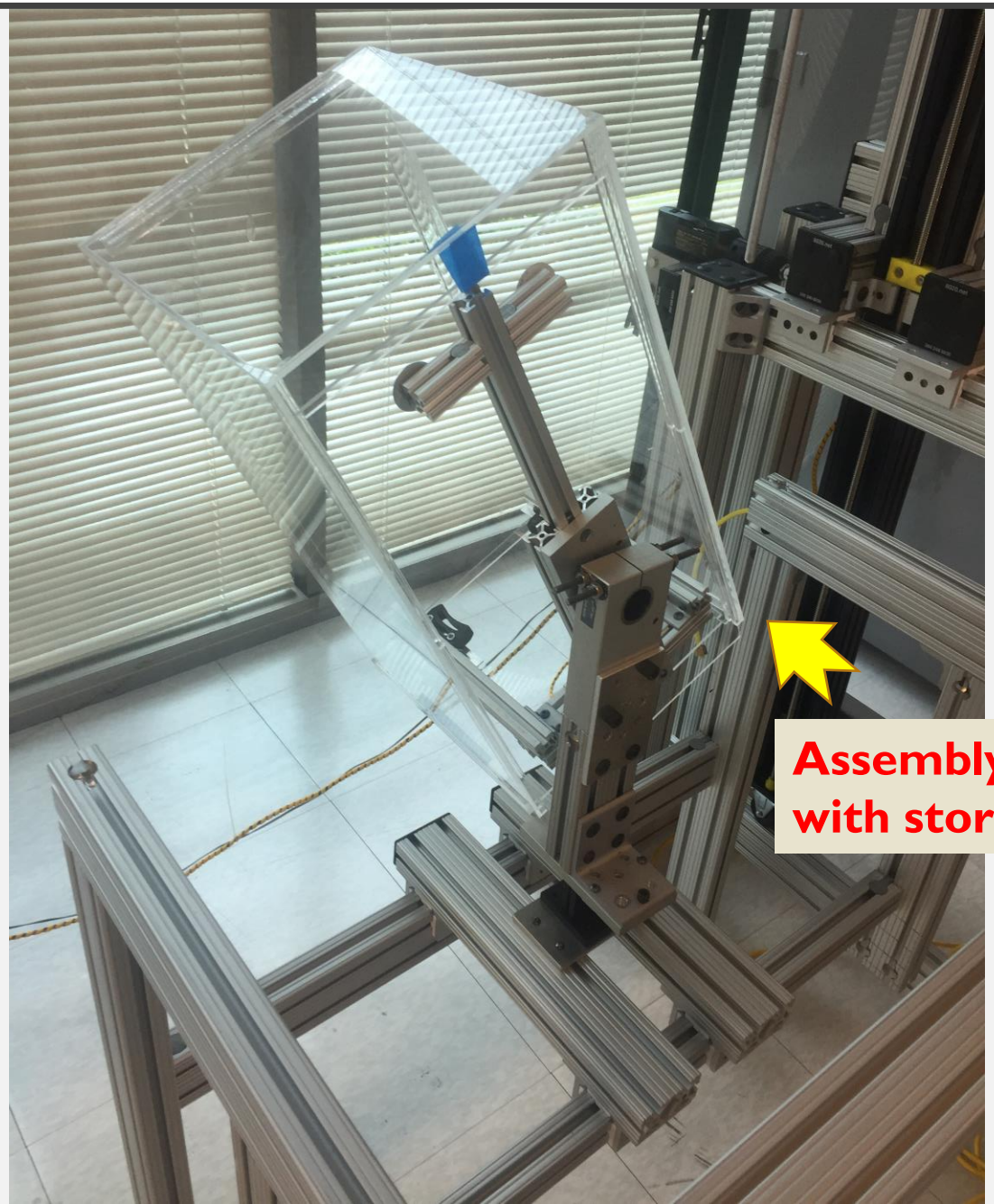
RTPC CONSTRUCTION

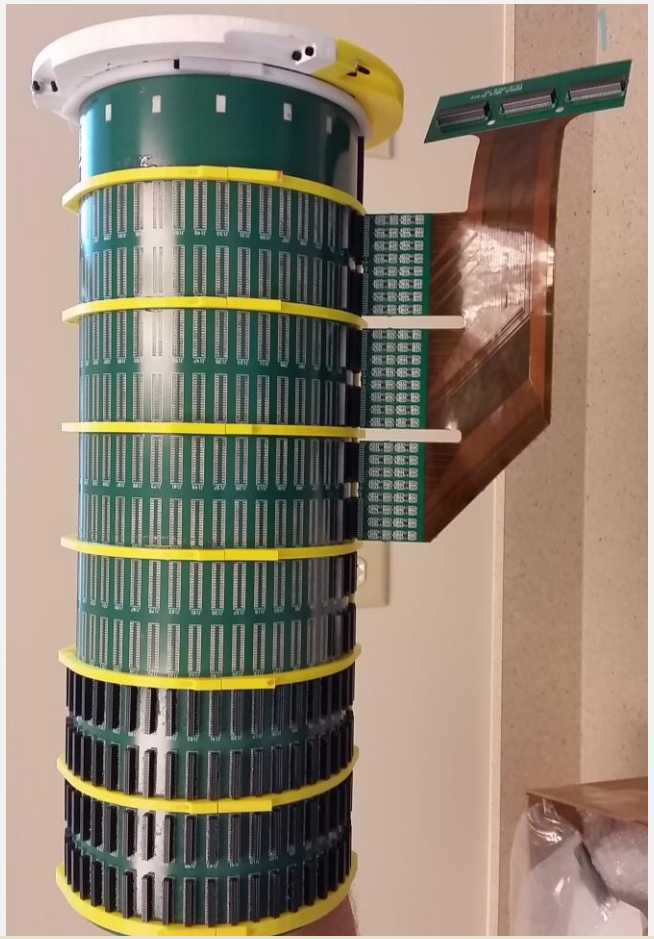


Assembly Station with storage box

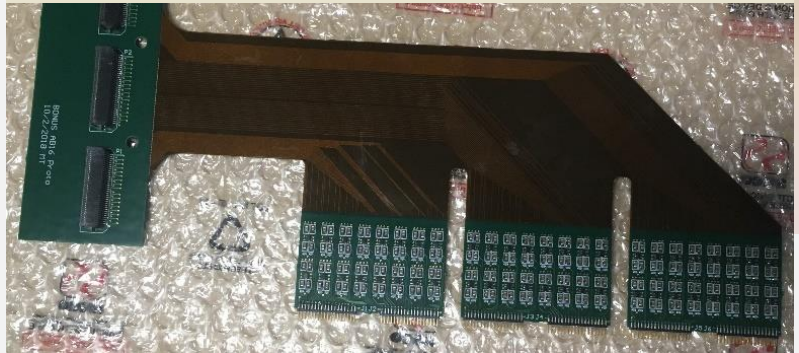
Can rotate around two axes and moves in one dimension

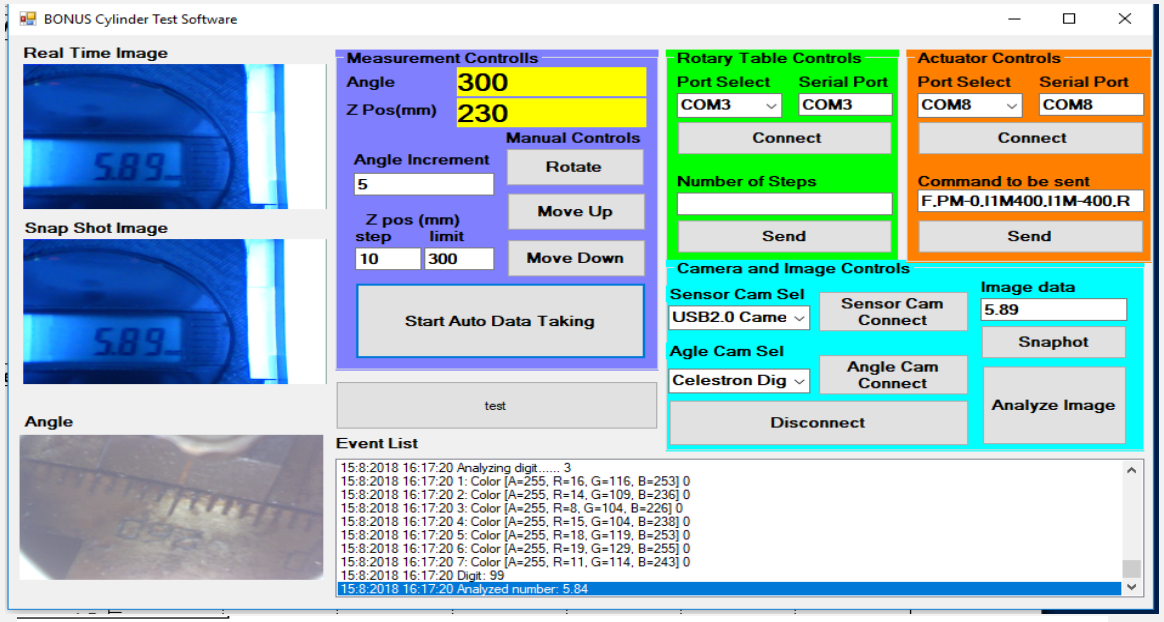
RTPC CONSTRUCTION

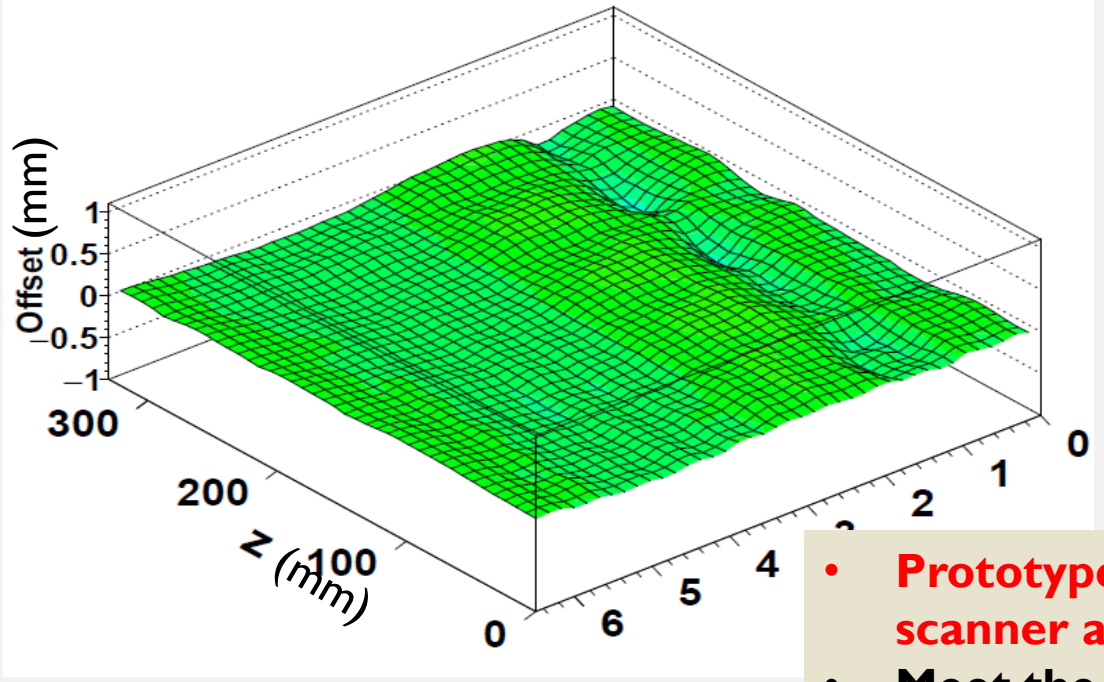
- **Readout 'padboard'**
  - **Fabricated, delivered, tested for continuity and shorts. We have electrical connectivity after wrapping for better than >99.5%. of the pads all the way to the end of the adapter boards**
  - **Successfully tested wrapping into cylindrical geometry (next slide).**
  - **Currently having surface connectors mounted**
  - **Expect complete board beginning of July**
  - **Wrap first detector board and mount installation ring in early July**
- **Current limiting adapter boards**
  - **Design completed.**
  - **Prototype of short board received and tested for continuity and shorts**
  - **Checked that board inserts easily into padboard without distorting shape and remains firmly connected.**

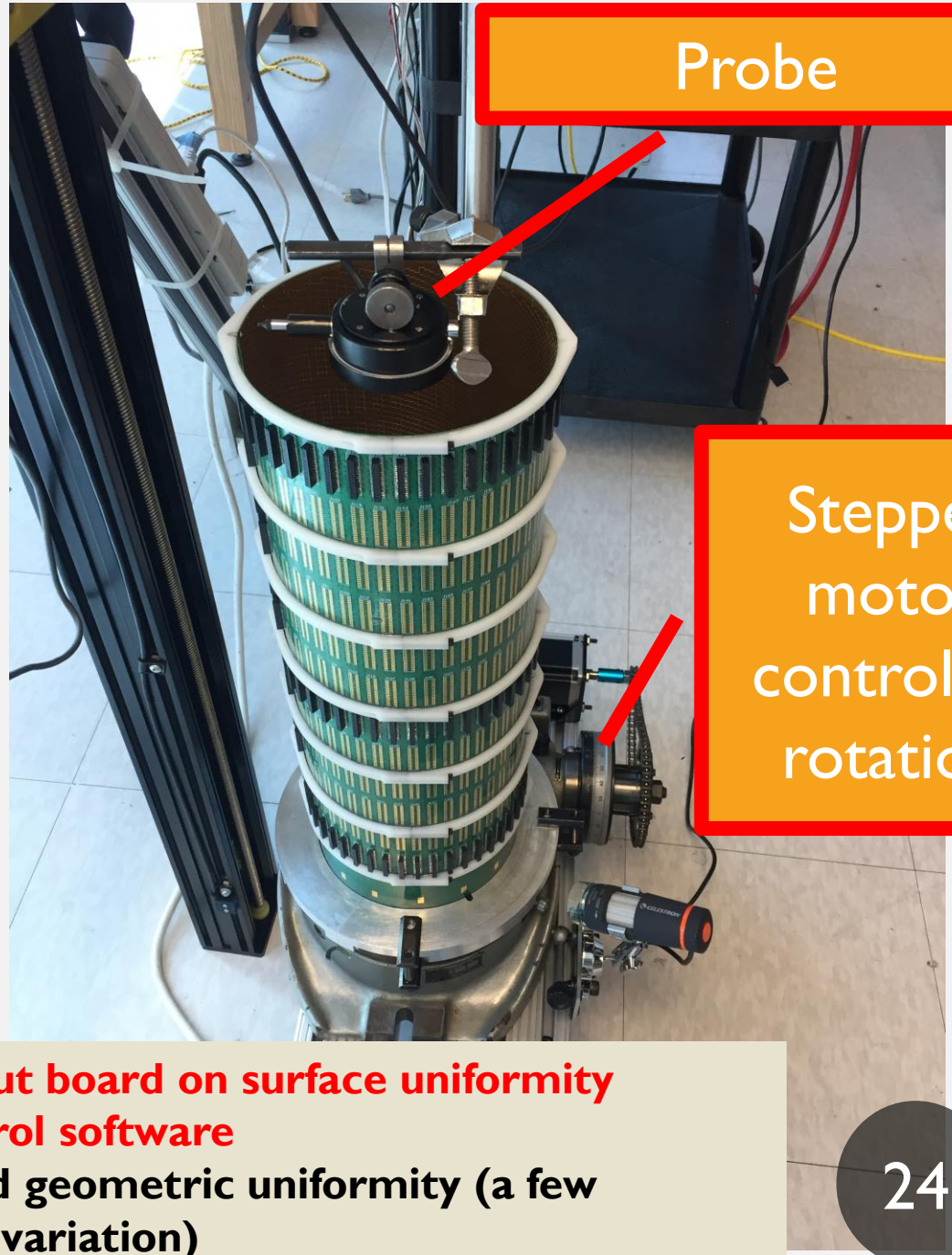


Readout adapter board with current limiting circuitry



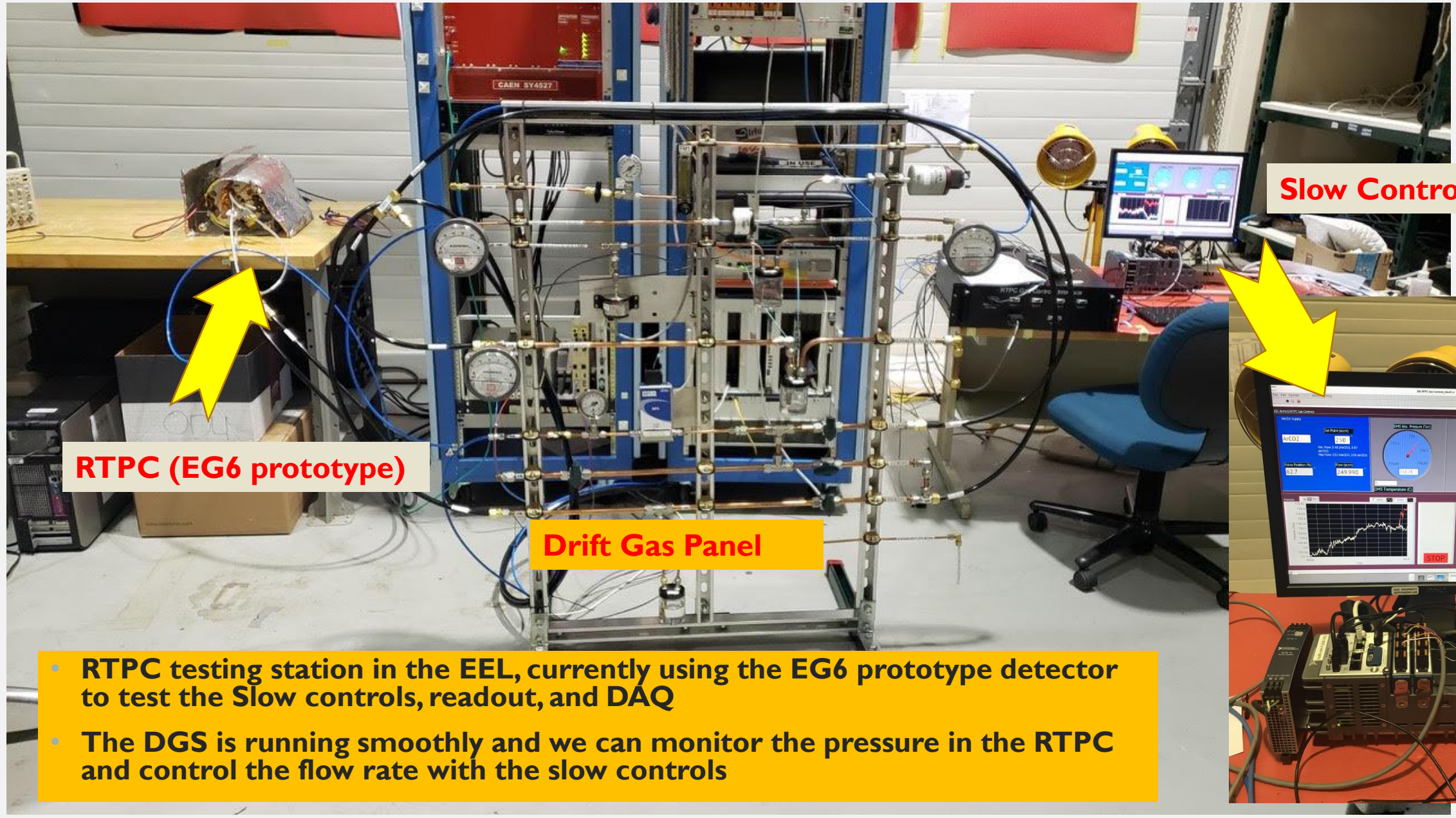






- **Prototype read out board on surface uniformity scanner and control software**
- **Meet the required geometric uniformity (a few hundred microns variation)**

RTPC TEST SETUP IN EEL



Slow Controls Software

- RTPC testing station in the EEL, currently using the EG6 prototype detector to test the Slow controls, readout, and DAQ
- The DGS is running smoothly and we can monitor the pressure in the RTPC and control the flow rate with the slow controls

DAQ AND RECONSTRUCTION SOFTWARE

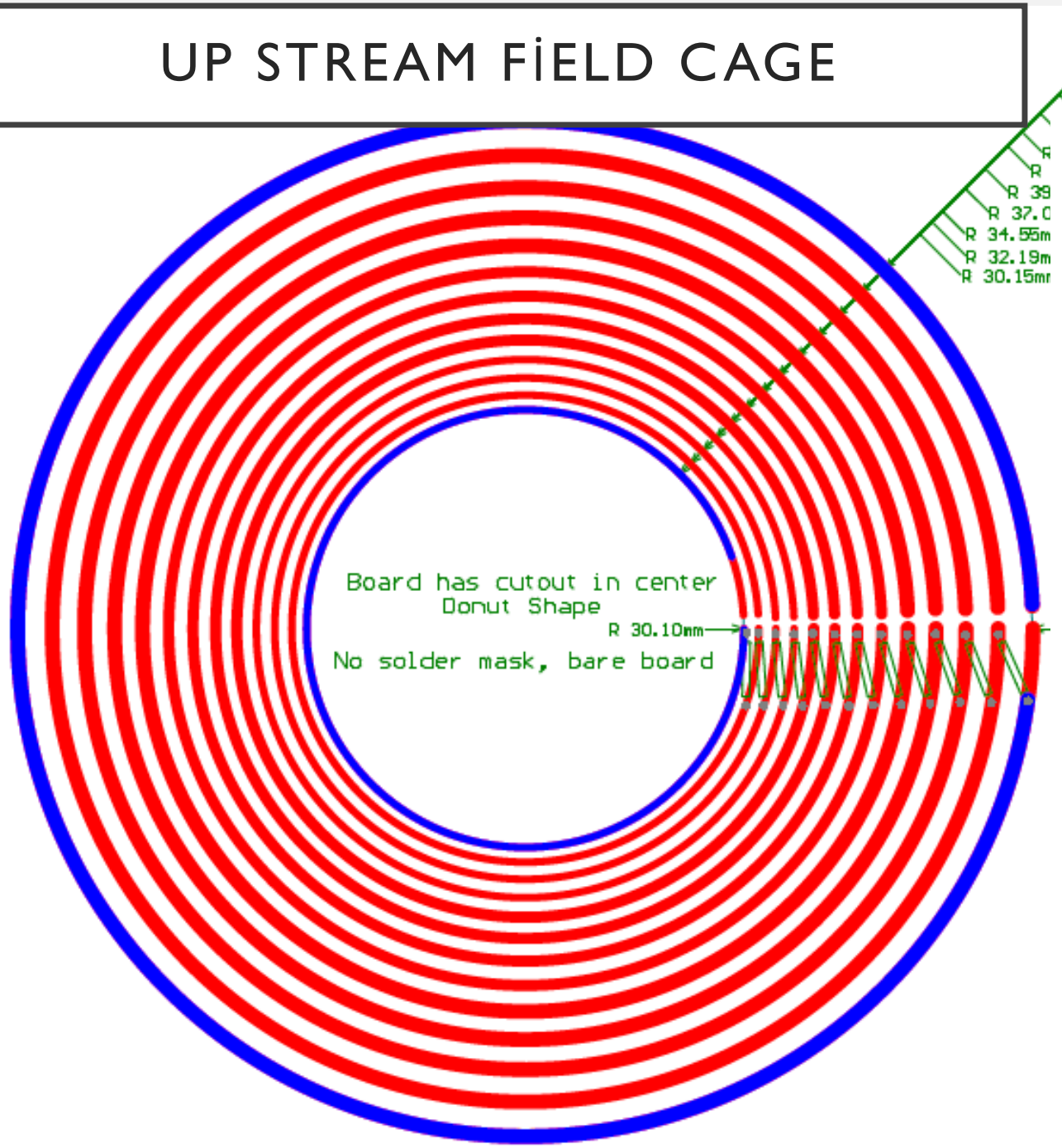
- **We are working with Saclay (Irakli Mandjavidze) on completing the update on FEU and BEU firmware to accommodate simultaneous readout of the RTPC and the FMT.**
- **We will be doing extensive tests of the whole DAQ chain in the EEL, initially with the EG6 prototype and starting in mid-July with the "real" RTPC. We will use both cosmic rays and sources, and look for reconstructed tracks.**
- **The data analysis software is close to complete - pattern recognition and helix fitter work and are fast enough for our expected data set. We are ironing out some small remaining compatibility issues and expect to integrate the software into the official CLAS12 coatjava release later this summer.**
- **First round of simulations is done; will repeat with higher statistics and more realistic detector soon.**

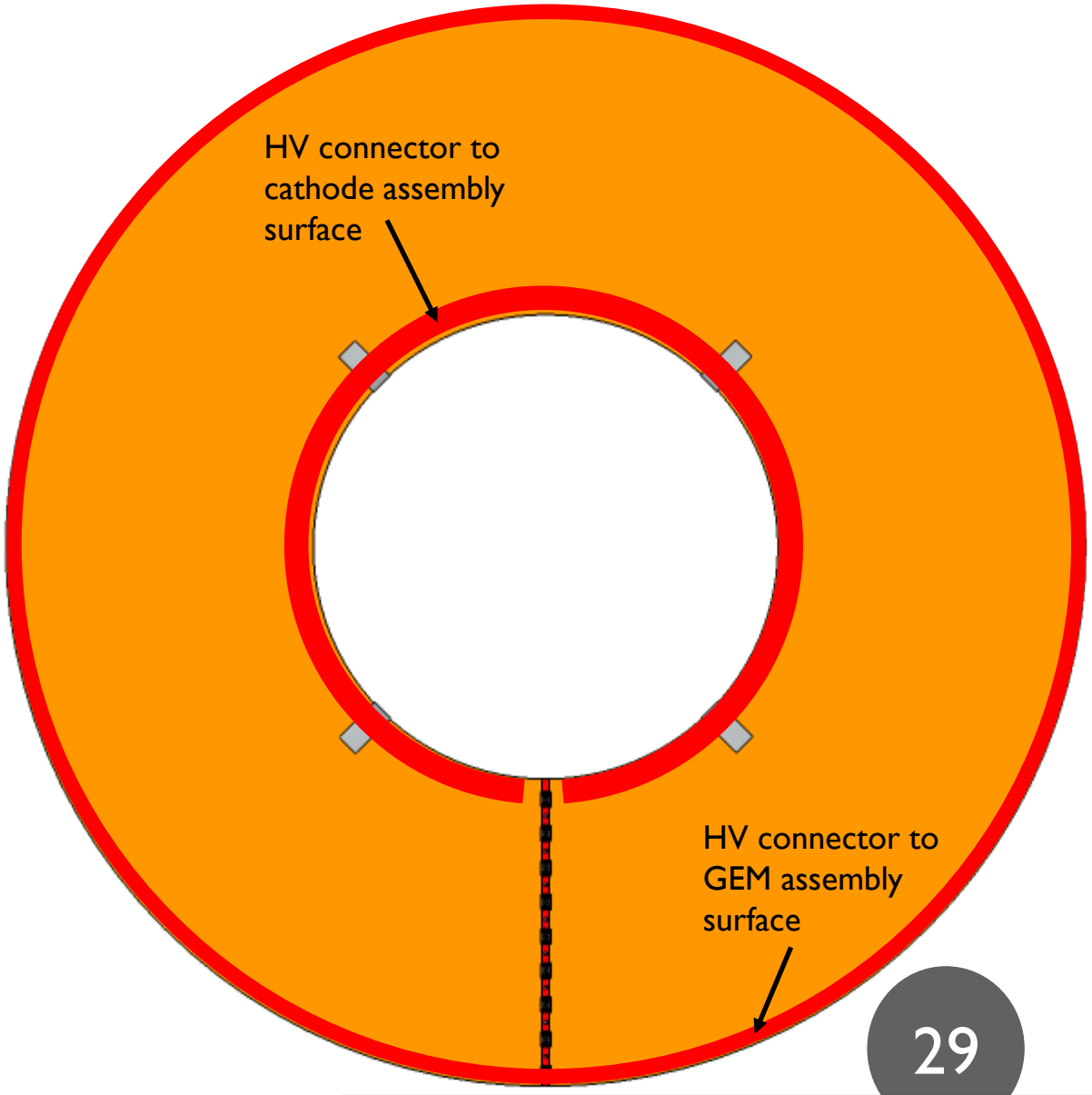
SUMMARY

- **Real BONuS12 RTPC construction has started:**
  - **Construction of the Inner core of the detector (GEMs+Chamfer+HV assembly) has started and will be ready by the end of the month**
  - **Final Padboard + Readout adapter boards will be ready by the end of the month**
  - **Cathode assembly will be ready early next month**
  - **Gas panel, slow controls, HV and DAQ in the EEL are being tested with the EG6 prototype**
  - **The BONuS12 RTPC is expected to be ready to be tested in mid July**

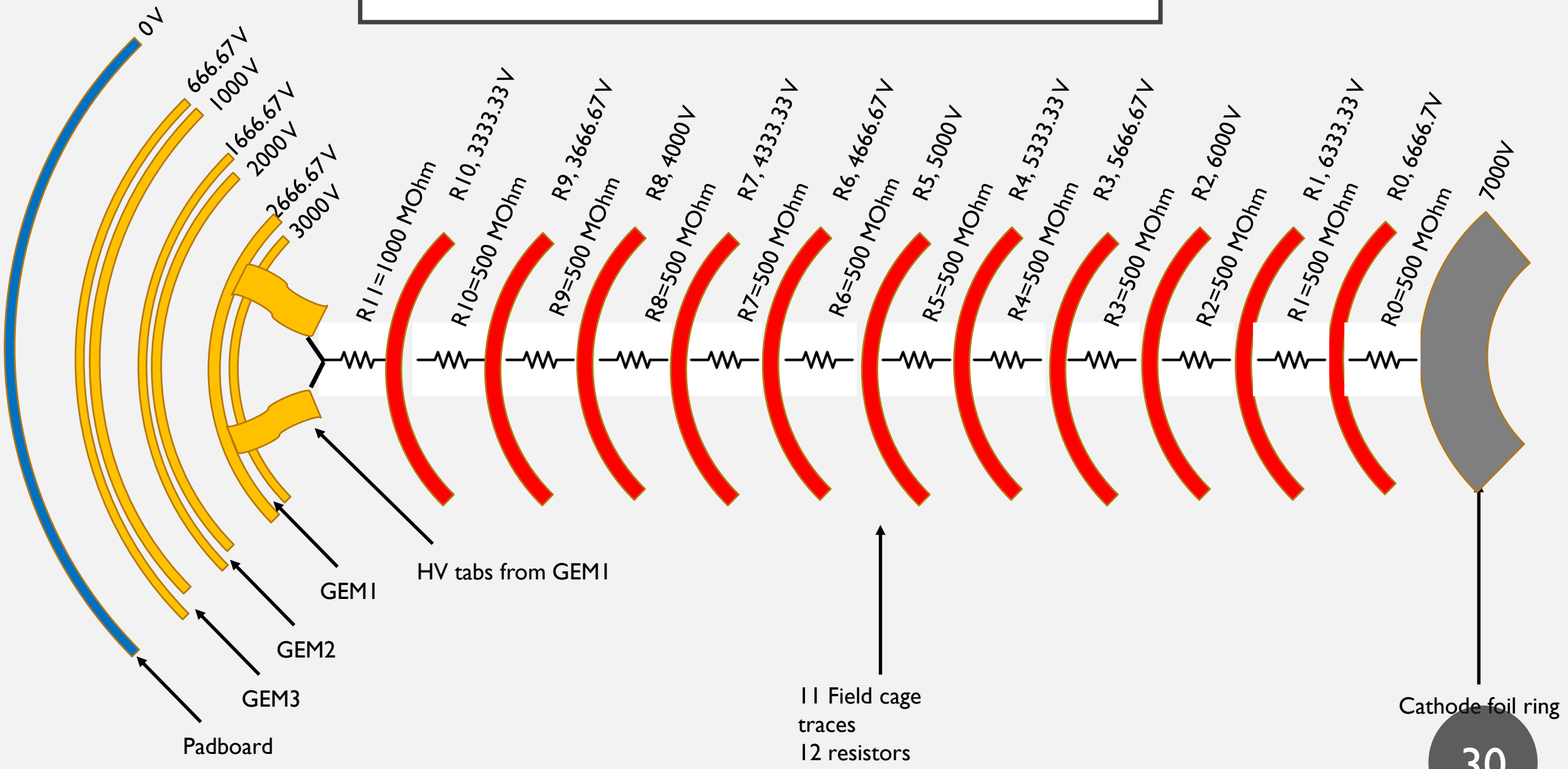
BACK UP SLIDES

UP STREAM FIELD CAGE





DOWN STREAM FİELD CAGE



PHYSICS REVIEW

- BONuS6 measured neutron SFs ratio: F_2^N/F_2^P

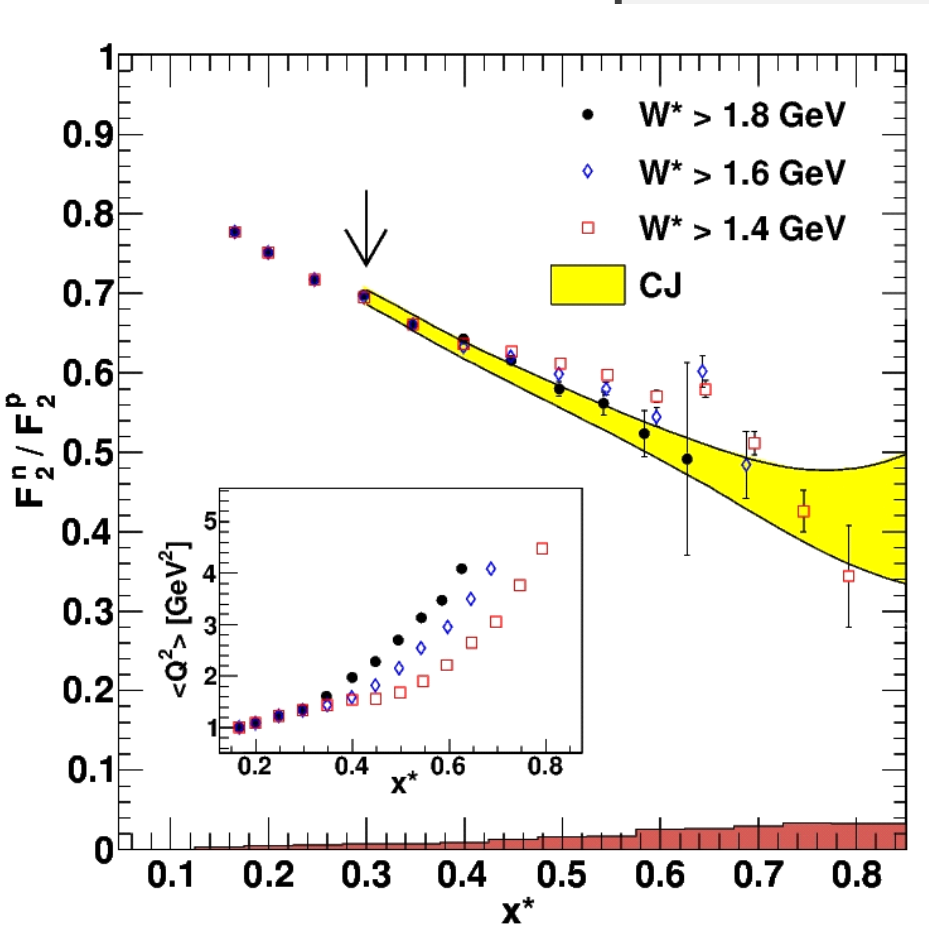
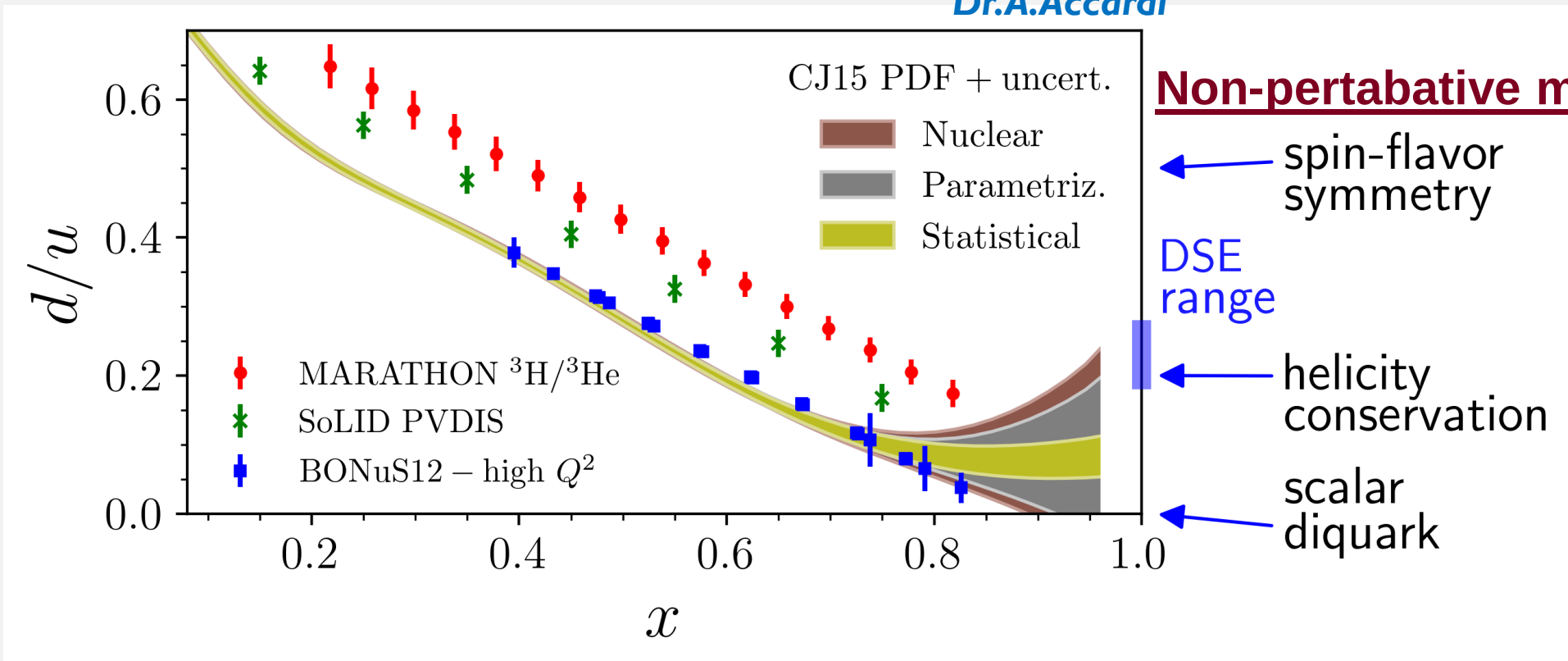


Figure: N.Baillie et al.,PRL 108(2012)199902

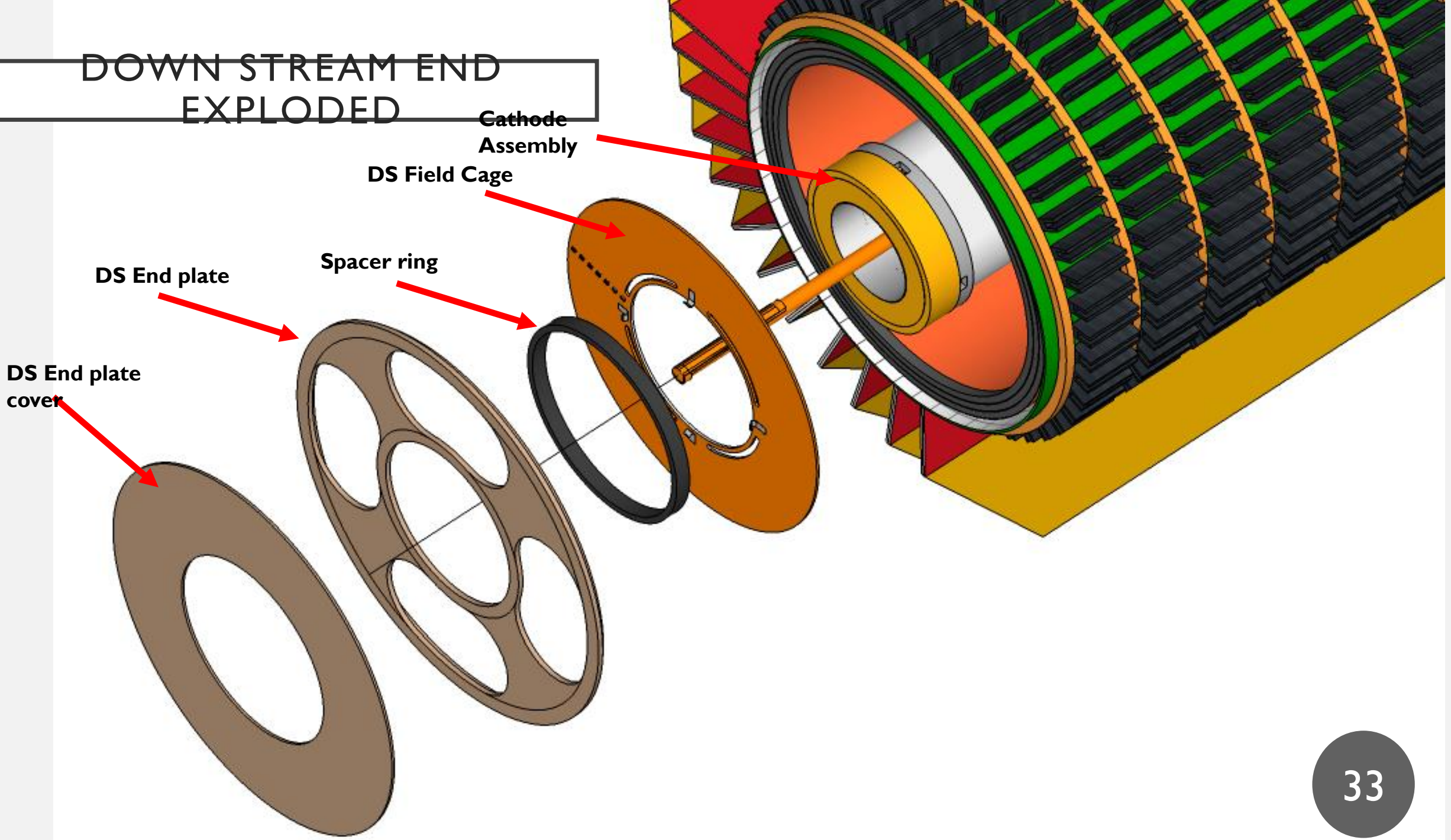
PHYSICS REVIEW

- Direct measurement of neutron would lead to a better understanding of:
  - Neutron SFs
  - Test the predictions for d/u when x -> 1
    - SU(6), spin flavor symmetry ½
    - Hard gluon exchange, helicity conservation 1/5
    - Scalar diquark dominance 0

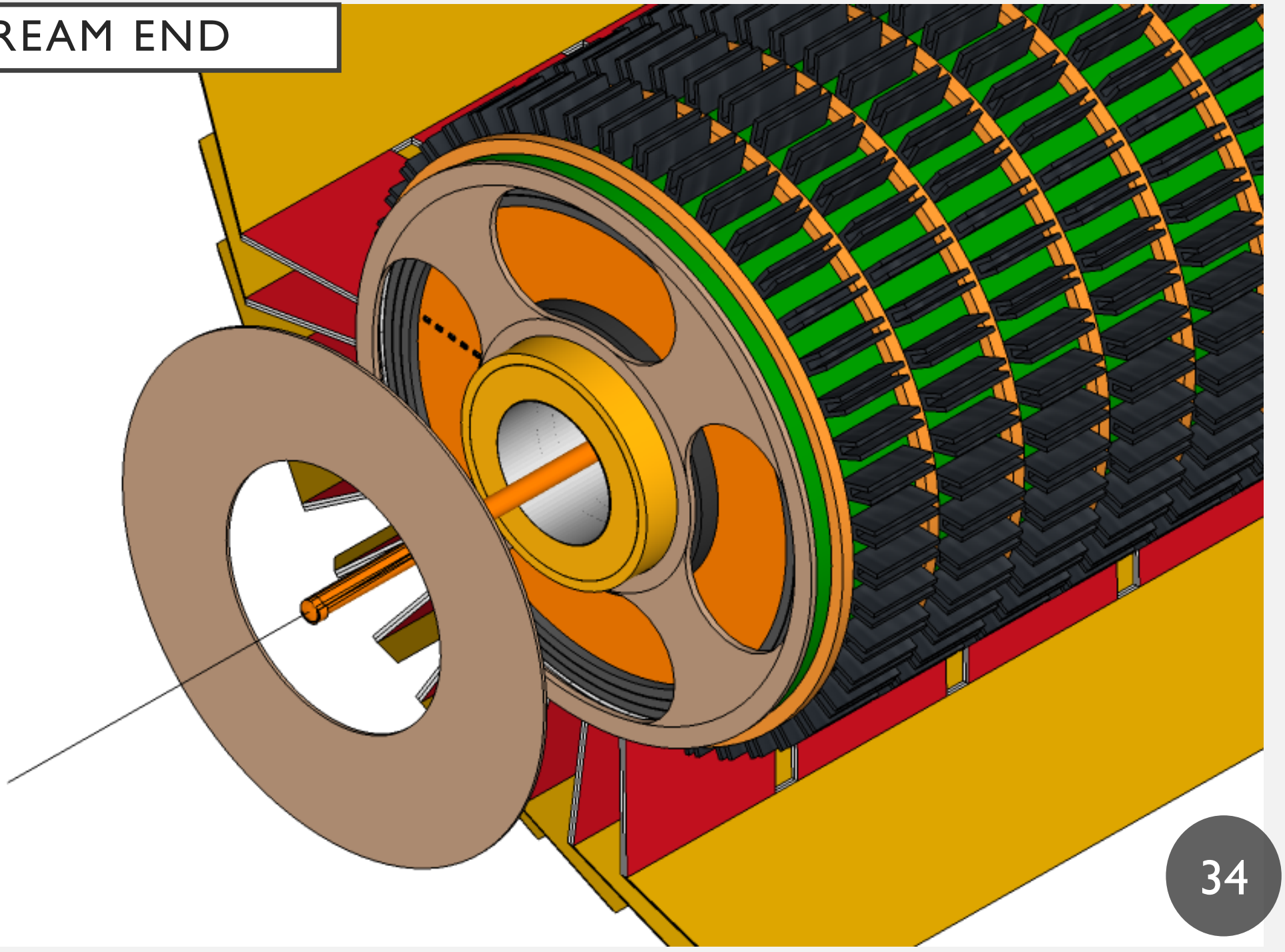
Figure: The figure of projected 12 GeV u/d ratio extractions comparison by Dr.A.Accardi



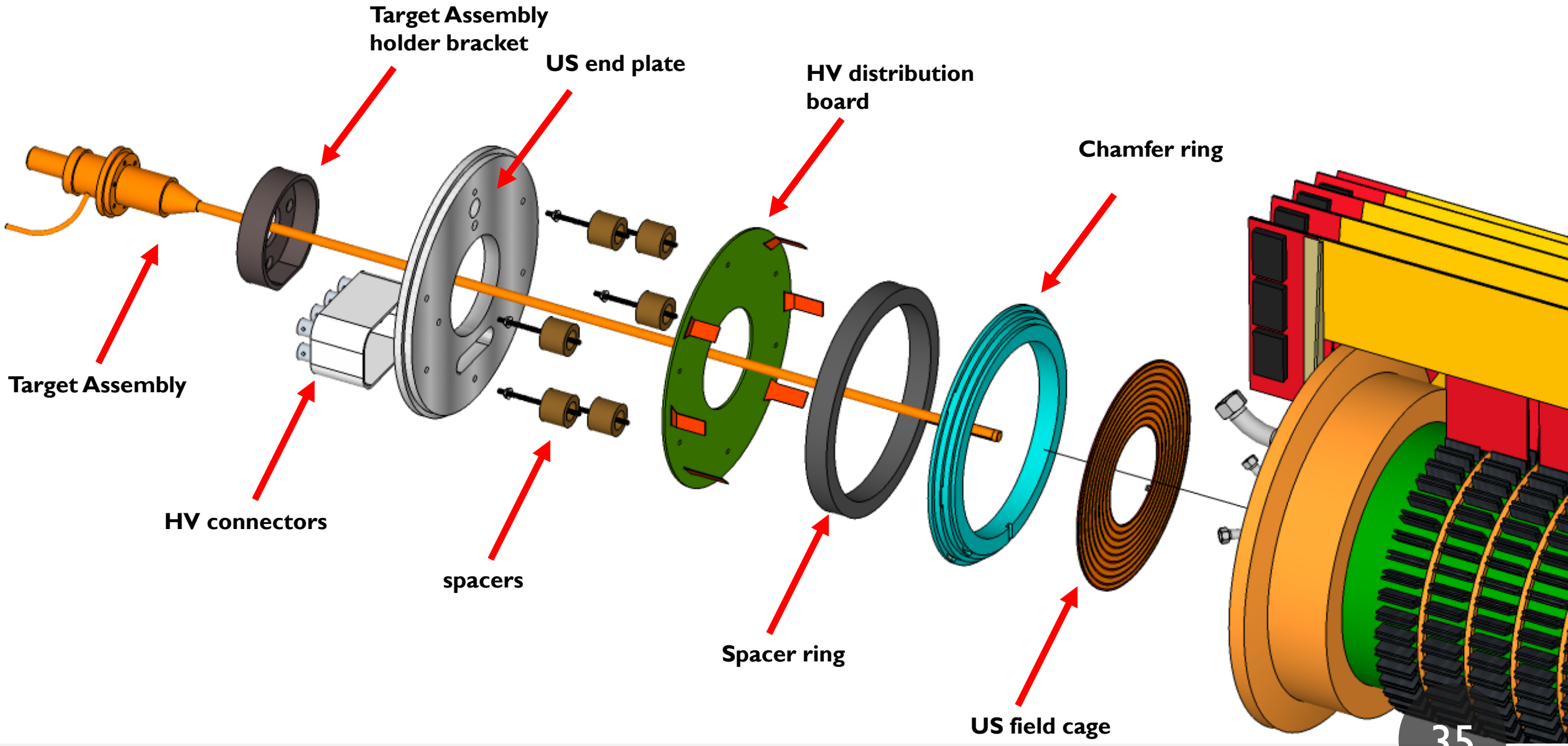
DOWN STREAM END EXPLODED



DOWN STREAM END



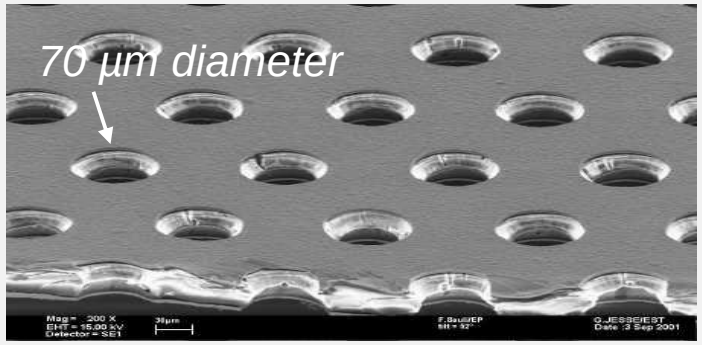
UP STREAM END EXPLODED

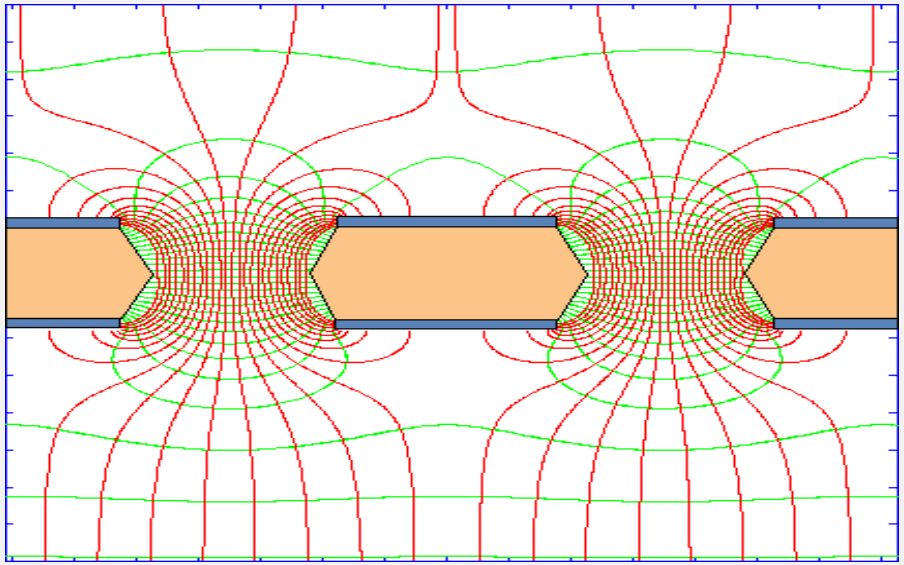


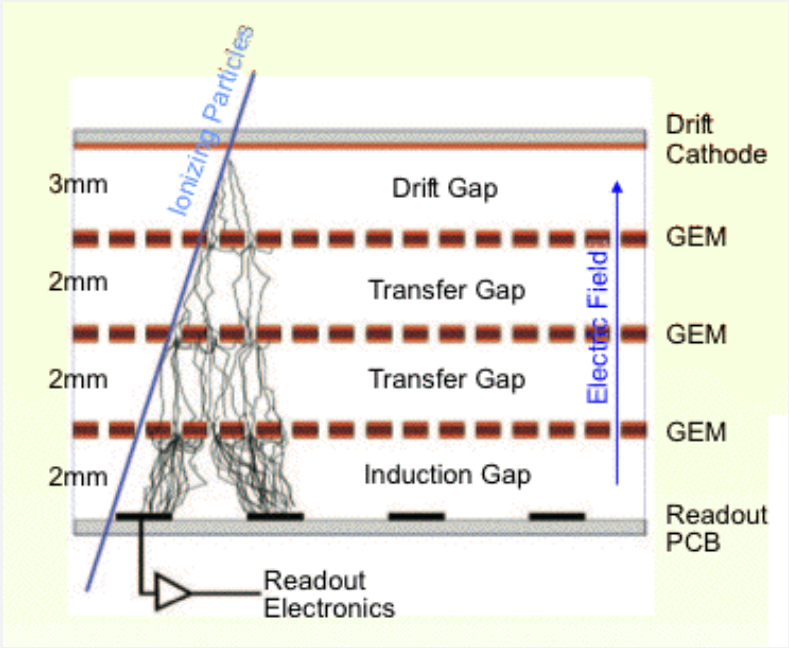
Gas Electron Multipliers (GEMs)

F. Sauli et al., NIMA 386 (1997) 531

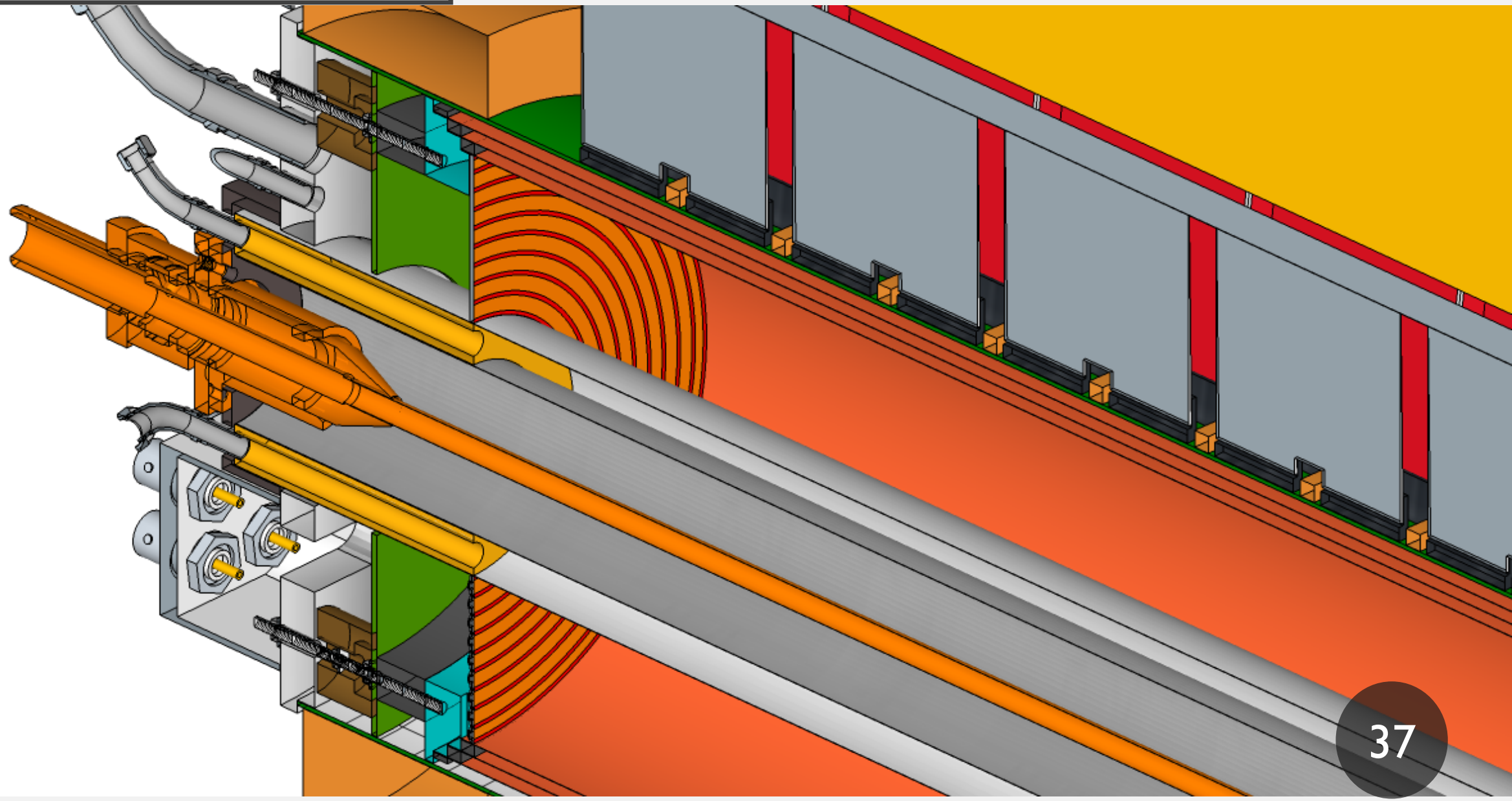
→ Holes chemically etched in kapton layered front and back with copper.
→ Gas amplification due to large local field in holes.
→ More amplification from more GEM layers.
→ Can operate at very high rates.
→ Can conform to curved geometries
→ Configurable charge collection (strips vs pads)



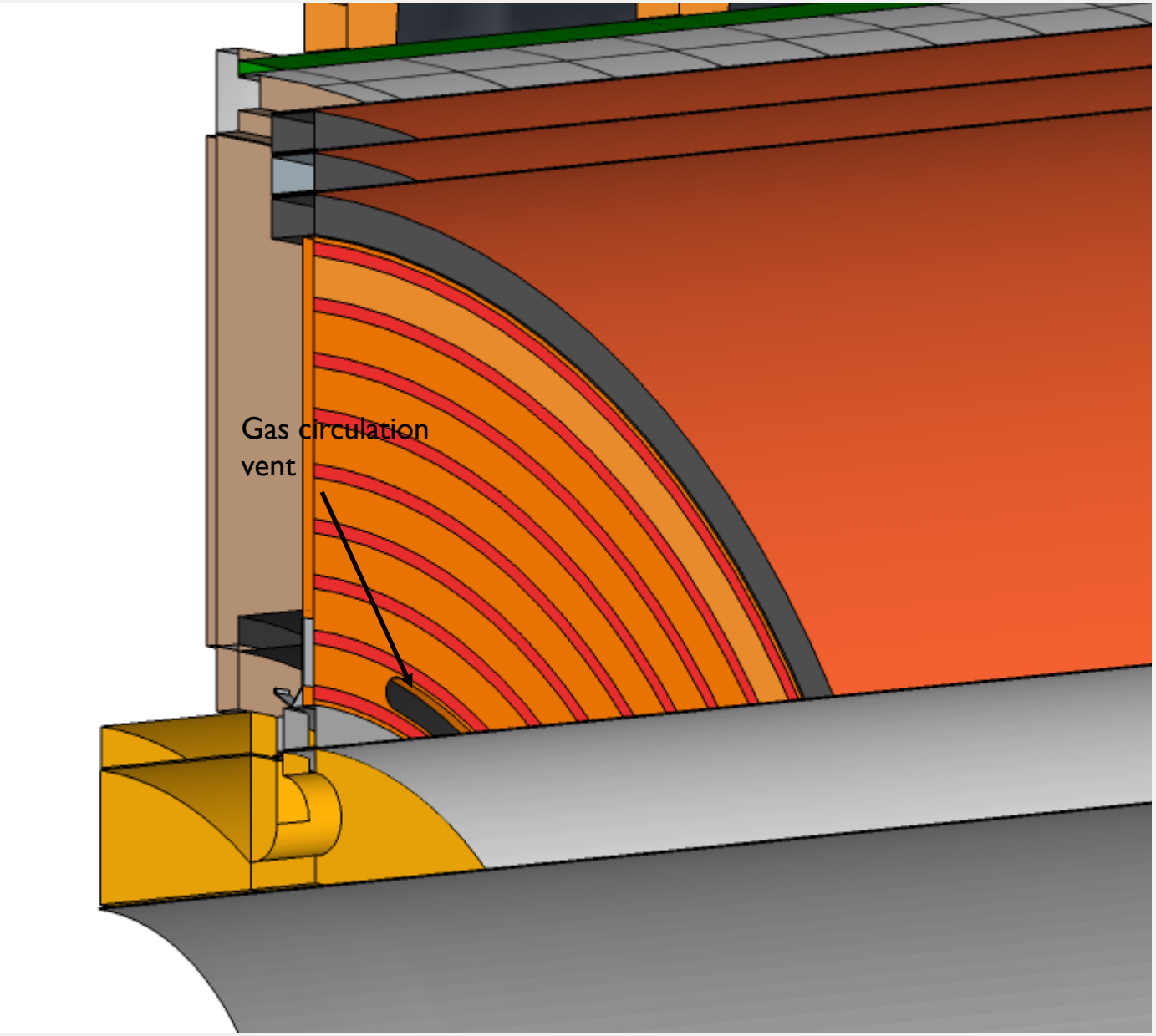


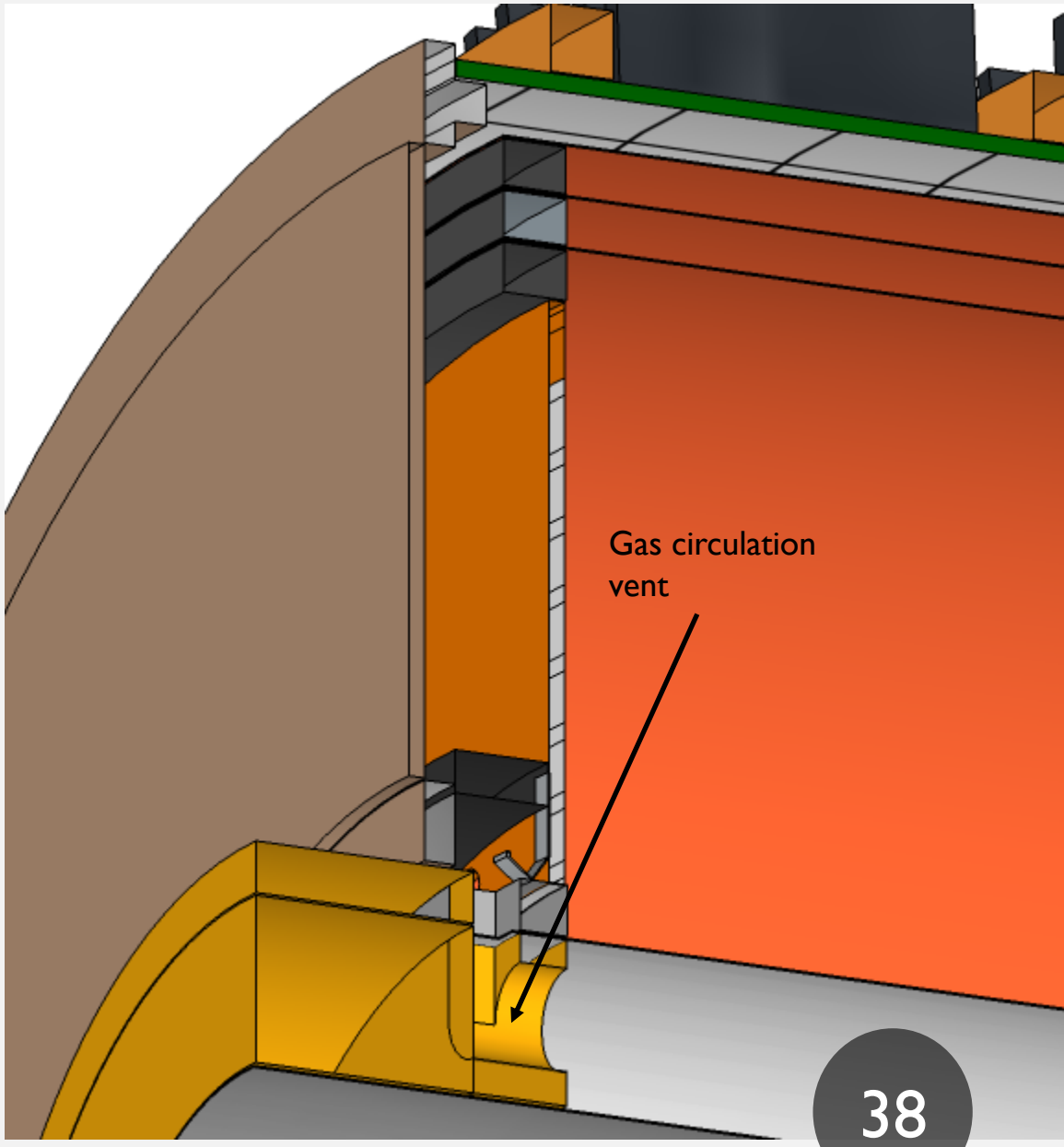


UP STREAM END



DOWN STREAM END





PADBOARD SURFACE UNIFORMITY TESTS