TDIS mTPC design and prototyping

UVa GEM team

Nilanga Liyanage, Huong Nguyen and Kondo Gnanvo

Outline

- Overview - Nilanga
- Cylindrical GEM fabrication conceptual design – Huong.
- Pixelized strip readout for high rate operation. - Kondo

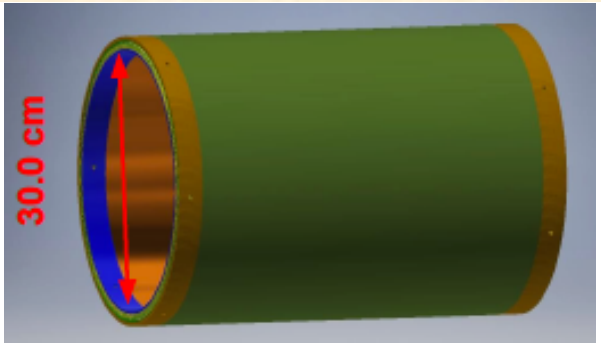
Status – MRI

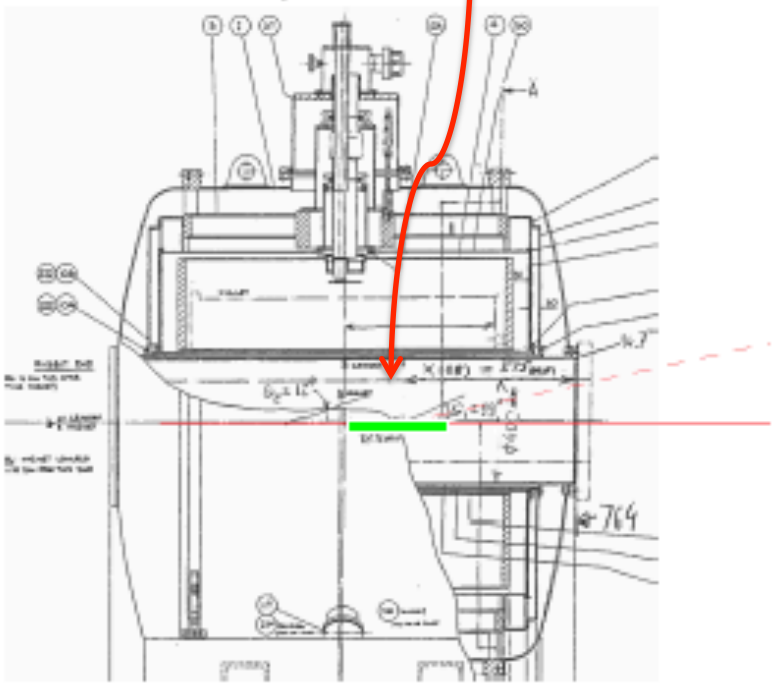
- The NSF Major Research Instrumentation (MRI) proposal developed and submitted on February 5.
- Consortium institutions: UVa and Hampton in collaboration with Jlab and TDIS collaboration institutions.
  - UVa portion:
    - mTPC development, prototyping and construction: $ 687 k
    - UVA contribution: $ 206 k
    - UVa NSF request: $ 481 k
  - Hampton Portion
    - Readout electronics and mTPC end-caps: $ 472 k
    - Electronics development at Jlab, Hampton will procure components and participate in assembly
    - HU NSF request: 472 k
  - Total NSF request: $ 953 k
  - Proposed project period: 08/2018 – 08/2020

Status – design and prototyping

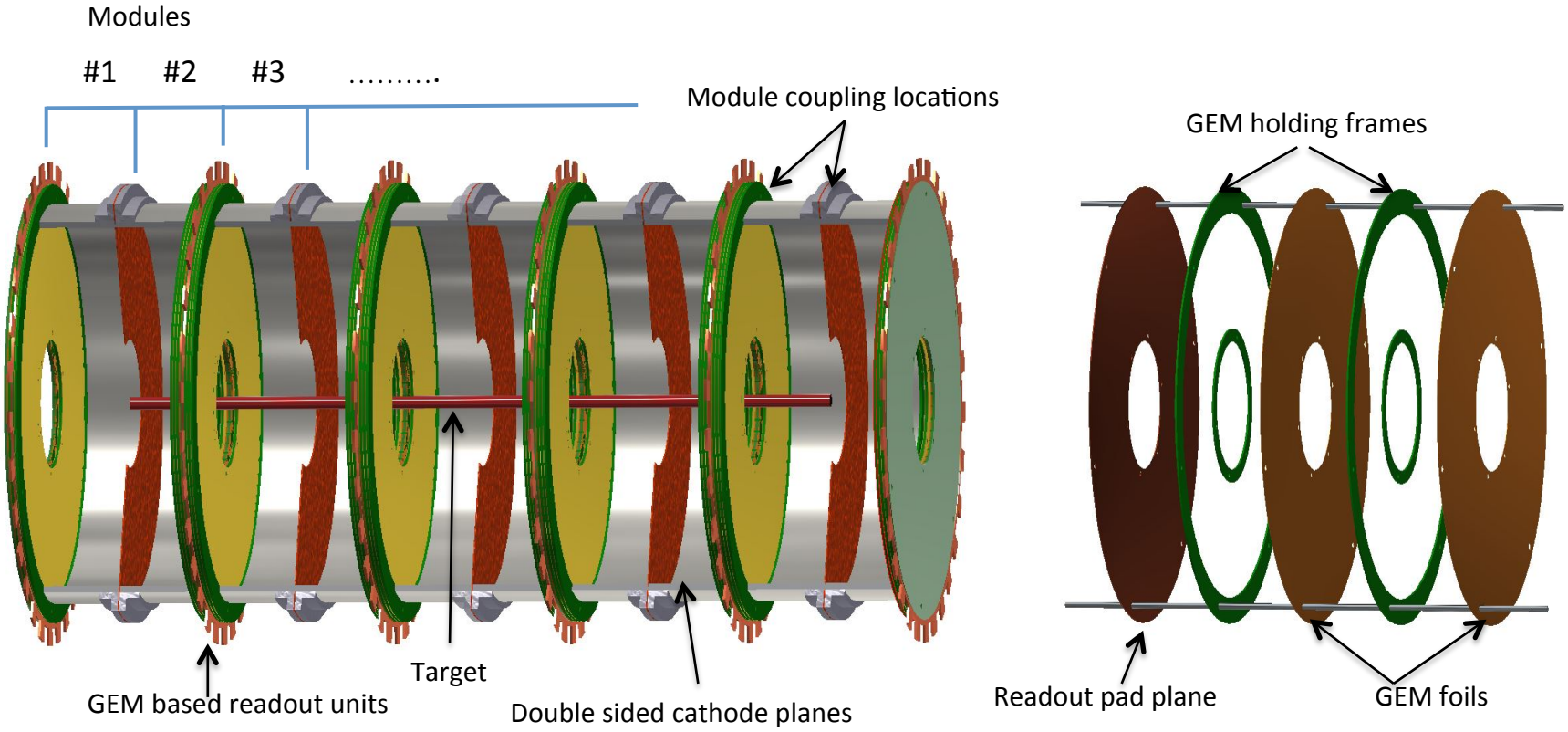
- Received a ~ $ 25 k UVa internal pilot grant (4-VA) for early design, prototyping and MRI proposal development.
- Design improved and optimized as part of the MRI proposal development
- Now we also have a design for the 0^{th} level prototype
- Expect to be able to complete this prototype before the expected start of the MRI project.

TDIS Concept





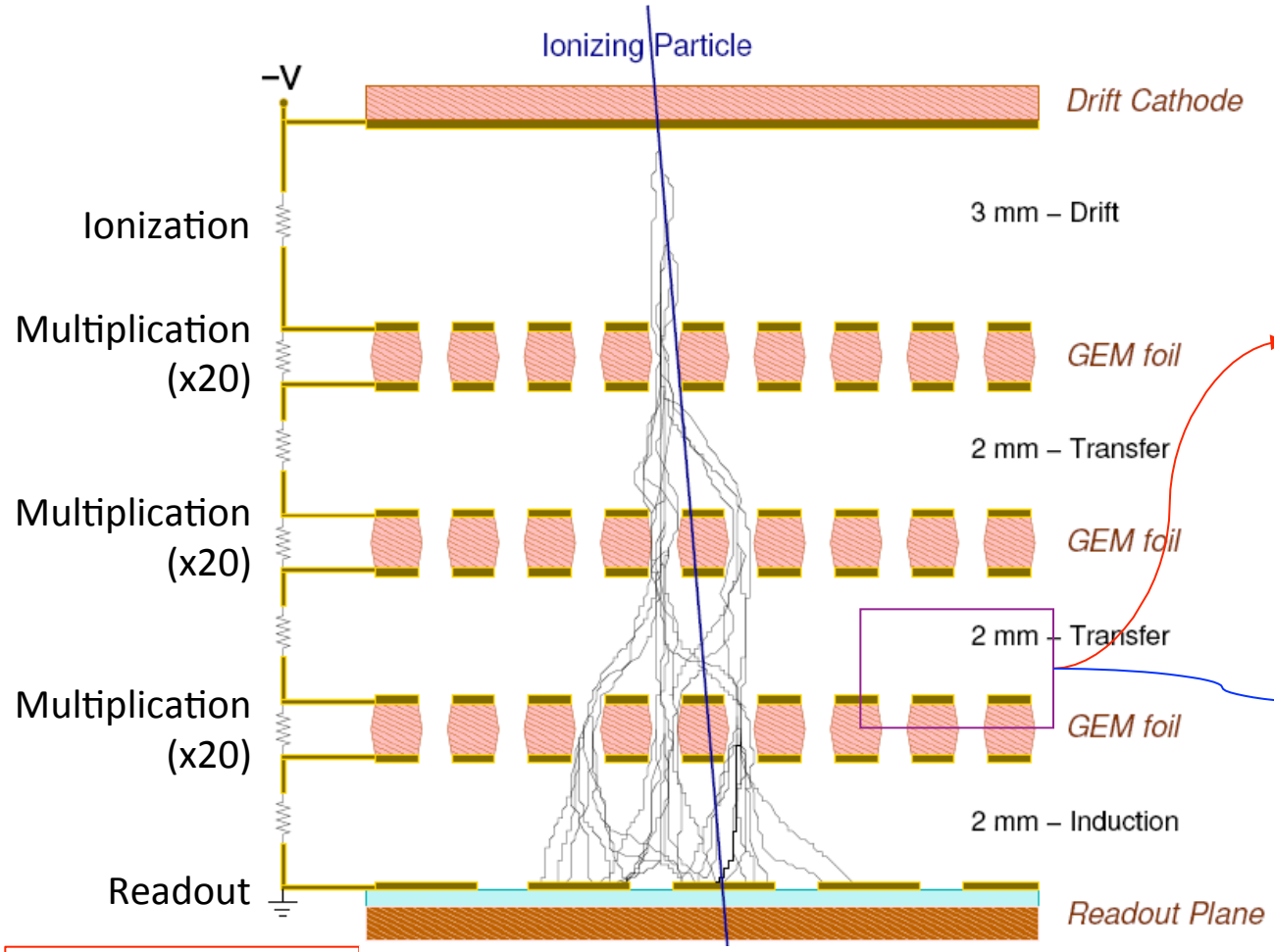
Design for the full mTPC



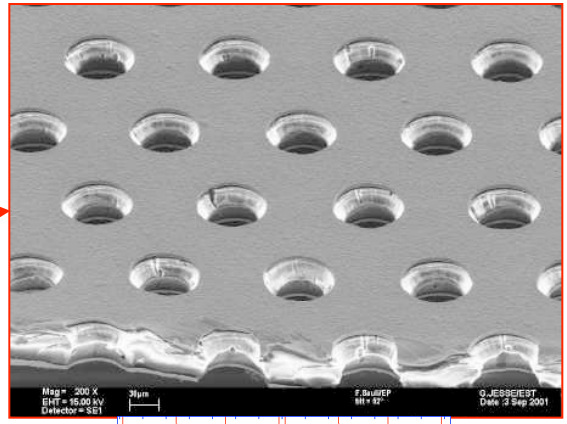
Things we can study with a prototype in pre R&D

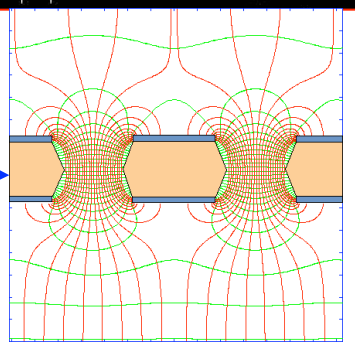
- Low pressure construction and operation
- Operation with He/CH4 mixtures
- Low temperature operation
- Ion feedback considerations
- mTPC construction techniques.
- Field case development and characterization
- Very thin inner field cage wall development
- High rate operation
- Provide a platform for testing and optimizing readout
- Benchmarking simulation
- …..
- ……

And many more things to learn



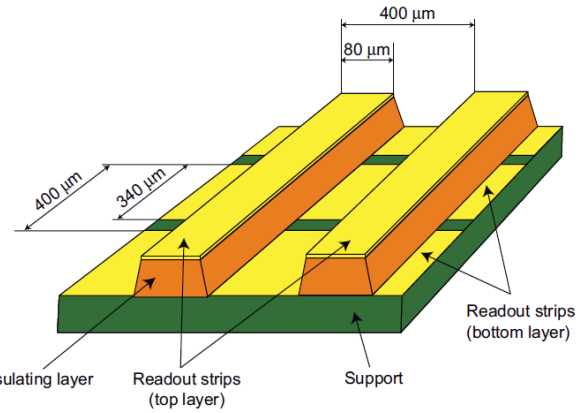
GEM foil: 50 μm Kapton + few μm copper on both sides with 70 μm holes, 140 μm pitch





Strong electrostatic field in the GEM holes

Recent technology: F. Sauli, Nucl. Instrum. Methods A386(1997)531



Readout independent from ionization and multiplication stages

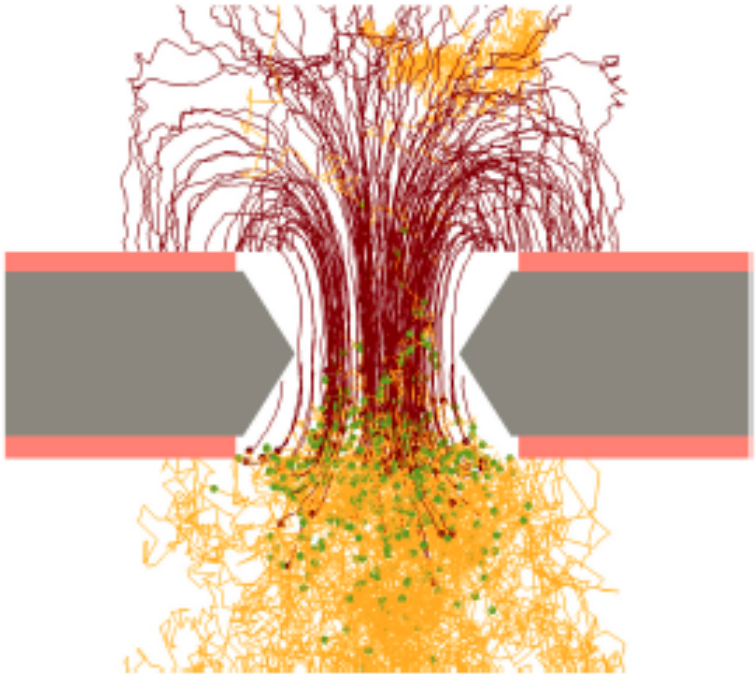
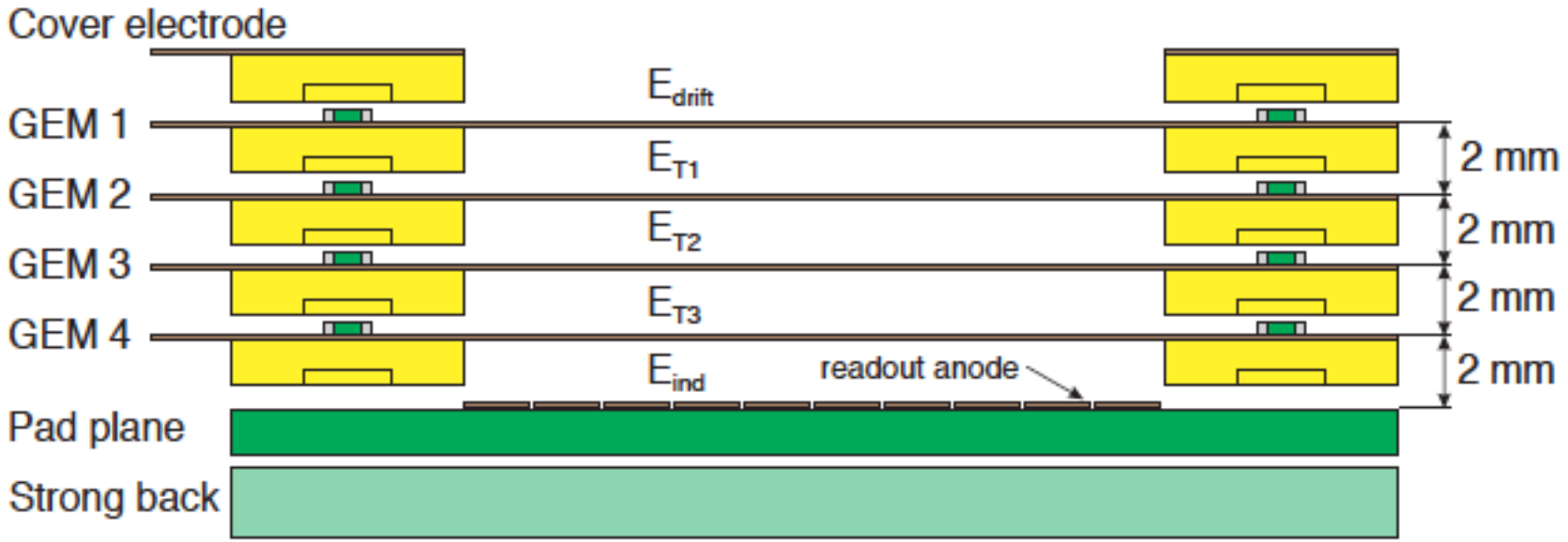
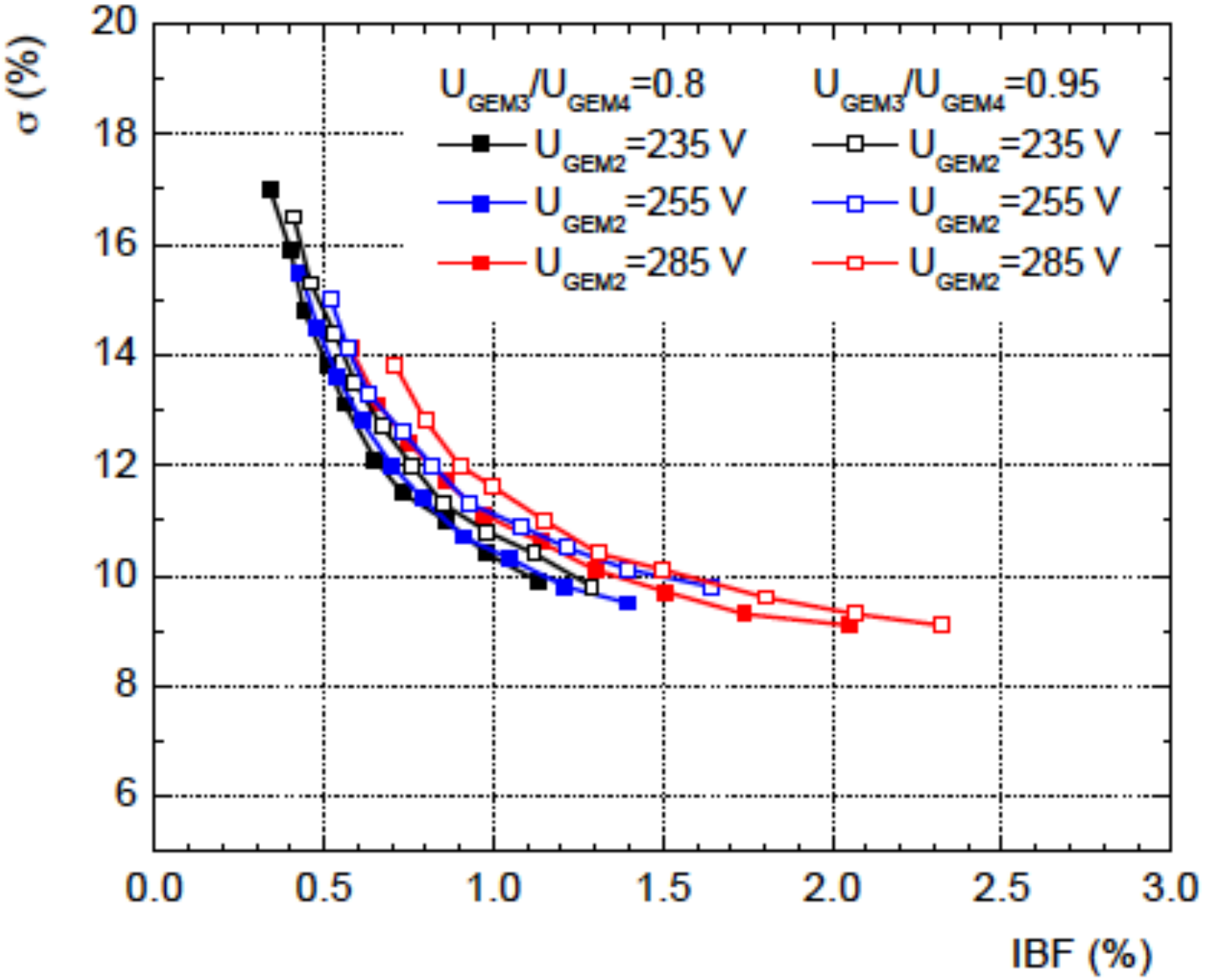


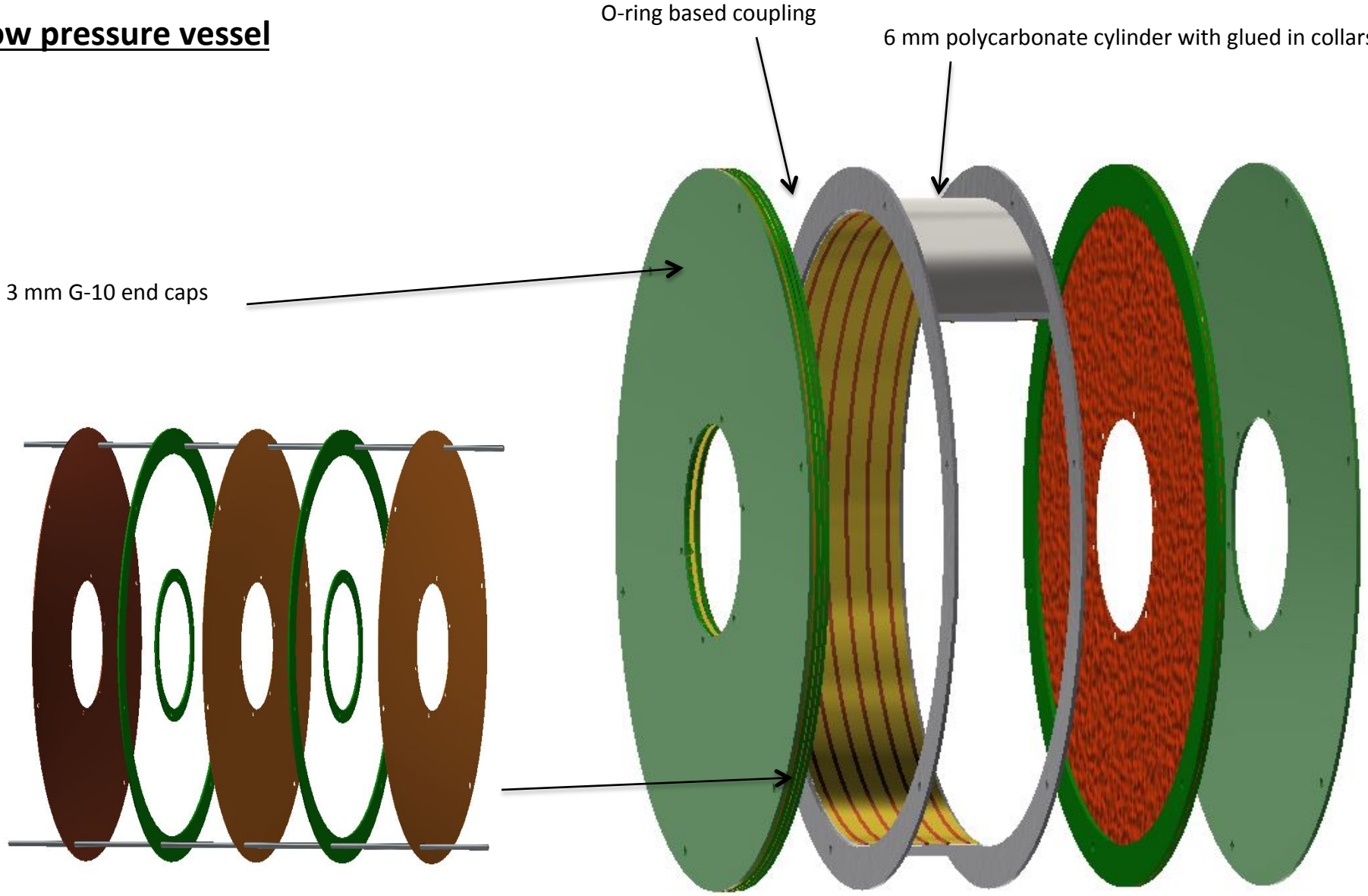
Figure 4.2: Garfield / Magboltz simulation of charge dynamics for electrons (two in this simulation) entering into a GEM hole [4]. Electron drift paths are shown as light lines, ion drift paths as dark lines. Dots mark places where ionization (multiplication) processes have occurred. The paths have been projected onto the cross section plane.



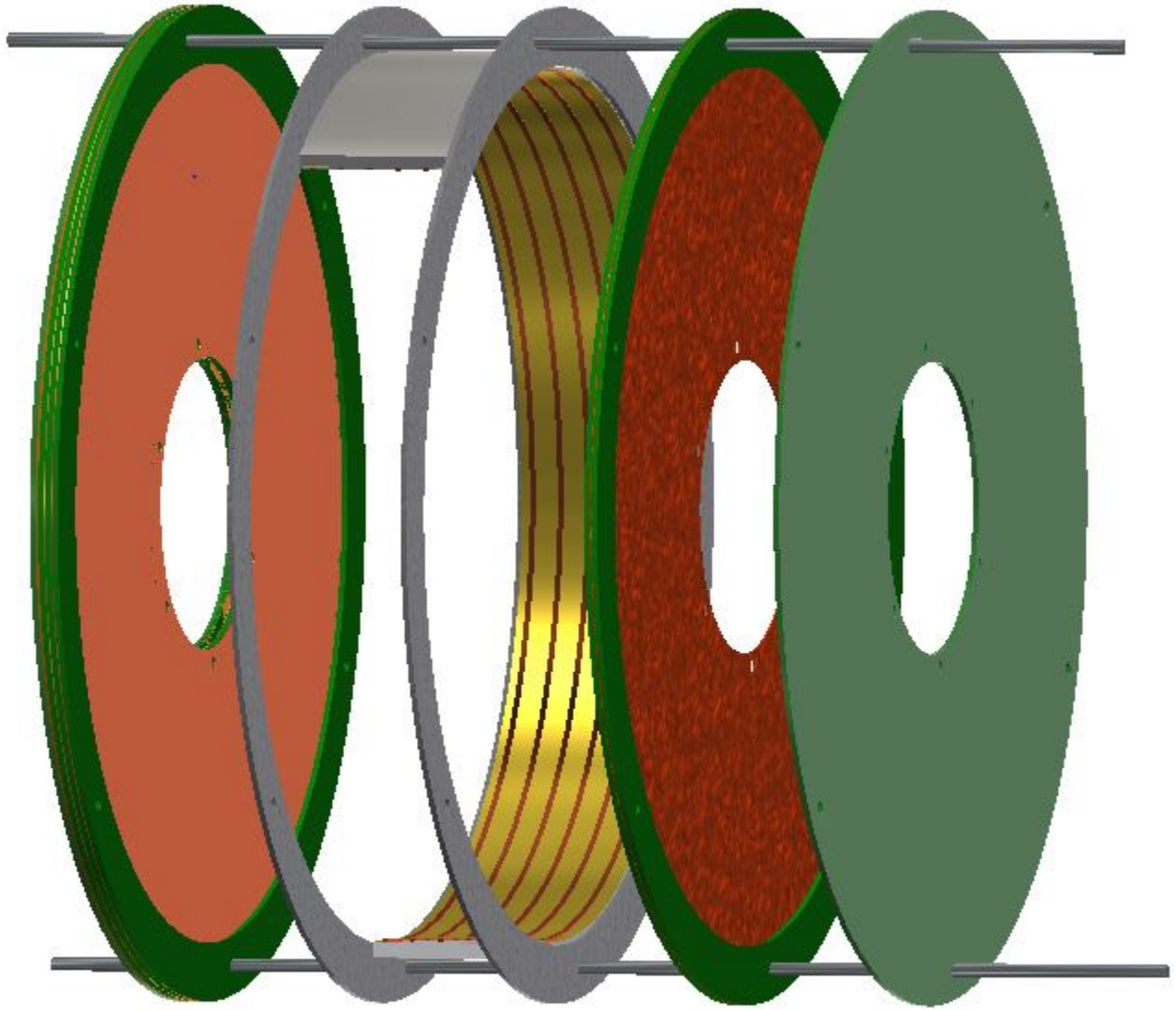

σ (%)
20
18
16
14
12
10
8
6
0.0
0.5
1.0
1.5
2.0
2.5
3.0
IBF (%)
U_GEM3/U_GEM4=0.8
U_GEM2=235 V
U_GEM2=255 V
U_GEM2=285 V
U_GEM3/U_GEM4=0.95
U_GEM2=235 V
U_GEM2=255 V
U_GEM2=285 V

A single module Prototype as pre-R&D (i.e now)

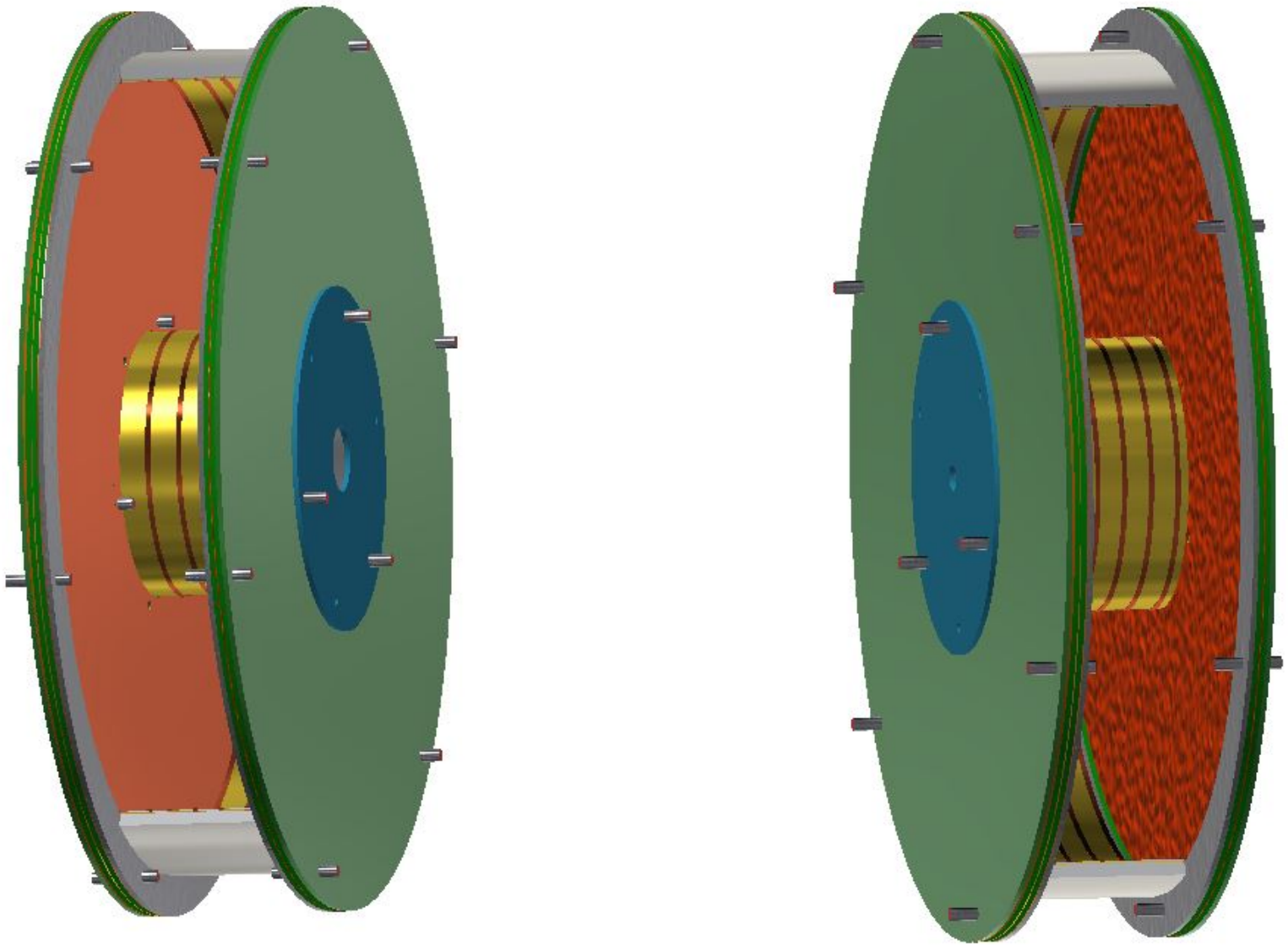
Low pressure vessel



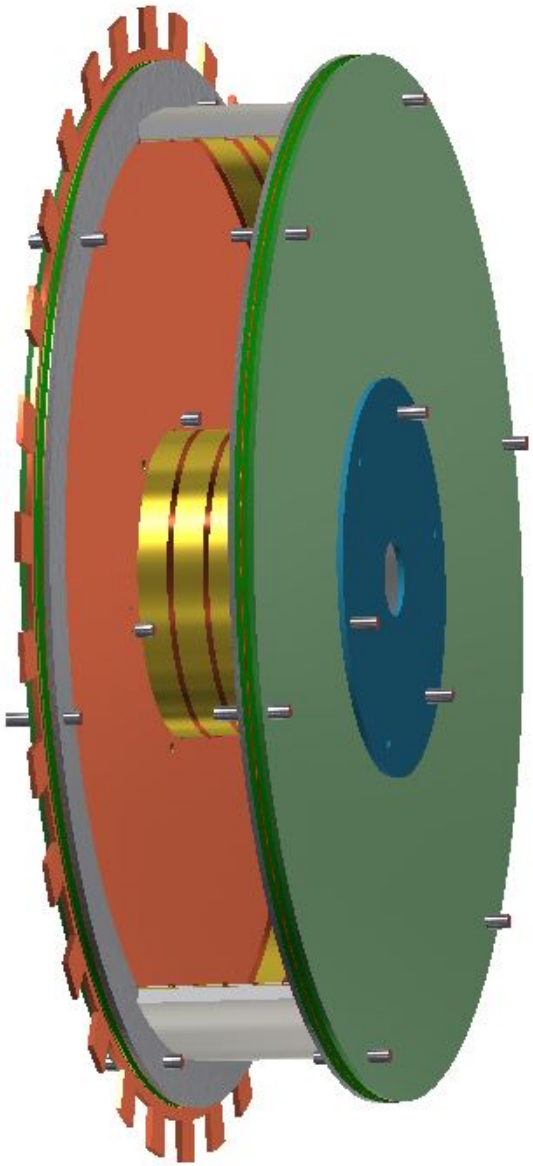
A single module Prototype as pre-R&D (i.e now)



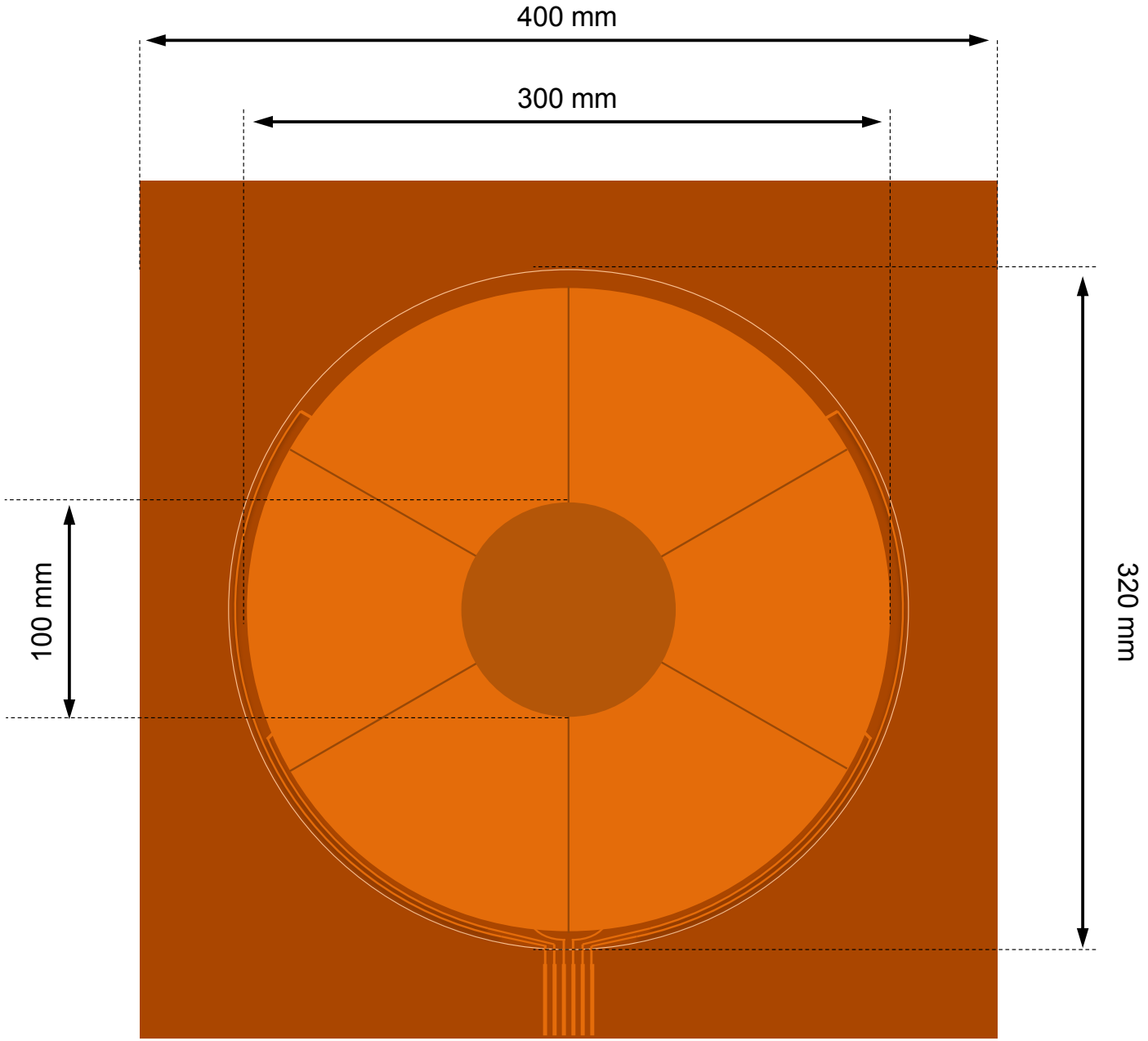
A single module Prototype as pre-R&D (i.e now)



A single module Prototype as pre-R&D (i.e now)



A single module Prototype as pre-R&D (i.e now)



Testing the prototype

- With cosmics at UVa – cosmic track determined by other GEMs, and scintillator trigger.
- Can use x-ray source to create high ionization conditions
- Other ideas: ?
  - Use a powerful alpha-source inside the drift volume to mimic low energy proton tracks
- Design allows coupling with a target/beam line. This will allow us to benefit from beam tests
  - Jlab
  - Fermilab
  - TUNL

Some important points

- Need some help from Robyn and/or a Jlab designer to ensure that our low pressure vessel design is adequate.
- Need to coordinate with Ed and the electronics designers to make sure connector for readout compatible with the cards
- Need to work closely with Rachel and Marco on simulations (Geant4/ Garfield/Magboltz) to get the field cages design, gas mixture etc. optimized