First results from a 4-channel charged fusion

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Introduction

- Determine the time dependent fusion rate profile
- Check of TRANSP simulations
- Study MHD instabilities: TAE, NTM, EPM, IRE
- Study effect of instabilities on fast ion redistribution and loss
- Probed ion distribution function weighted toward high energies, complements FIDA and ssNPA
- Expected to work well at high densities
- Cross check to total neutron rate measurements

Principle

Detect charged particles from:

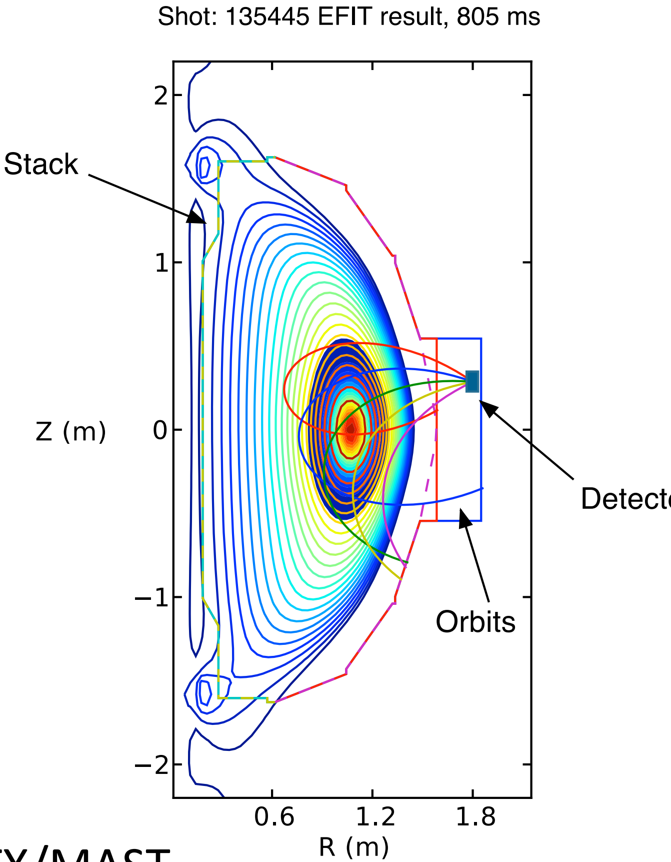
$$d + d \rightarrow p + {}^3H$$

$$d + d \rightarrow n + {}^3He$$

T_p = 3.02 MeV
T_T = 1.01 MeV

T_n = 2.45 MeV
T_{3He}= 0.82 MeV

dominated by neutral beam and plasma ion interactions



Advantage at NSTX and MAST:

- Proton/triton is not confined in the magnetic field of NSTX/MAST
- Proton/triton is quickly lost
- Trajectory similar to a view chord of neutral particle detection system
- observed particle rate is a measure of the integrated emissivity along the trajectory path

Proton measurements have been carried out previously:

- W.W.Heidbrink, J.D.Strachan, Rev. Sci. Instrum, **56**, 501 (1985)
- J.D. Strachan, Rev. Sci. Instrum., **57**, 1771 (1986)

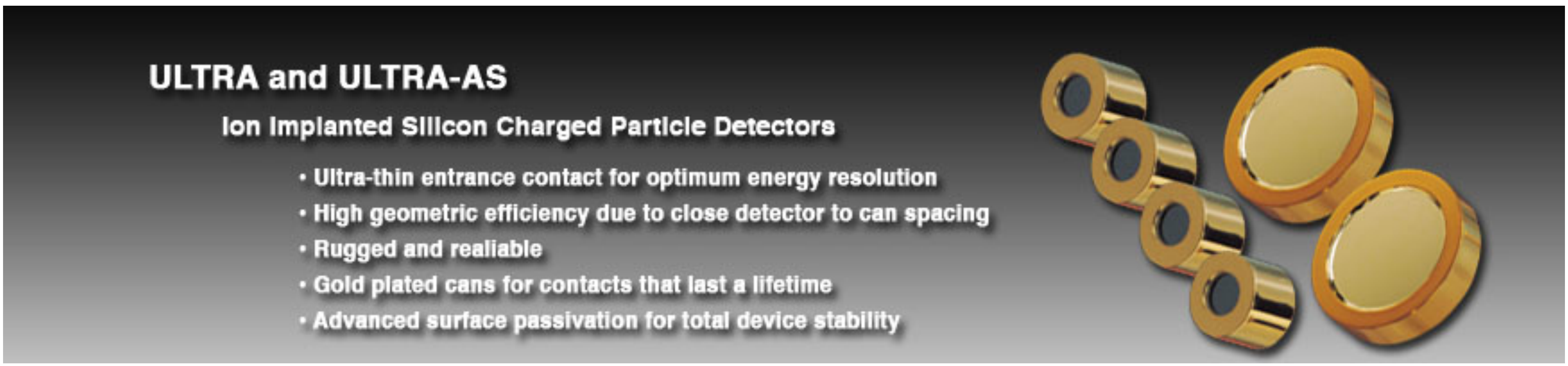
Particle Types:

- Protons
  - Highest energy (3MeV, p = 75 MeV/c, q = 1)
  - Easy to detector with surface barrier detectors
  - 100% efficient
  - Future: diamond detectors (less sensitive to radiation damage)
- Tritons:
  - Same orbit as protons (1 MeV, p = 75 MeV/c, q = 1)
  - More sensitive to electrical noise
  - Provide more statistics
- ^{3}He:
  - Lowest energy (0.82 MeV, p = 67.9 MeV/c, q = 2)
  - Different orbits than tritons and protons
  - Provide additional orbit data

Focus on protons

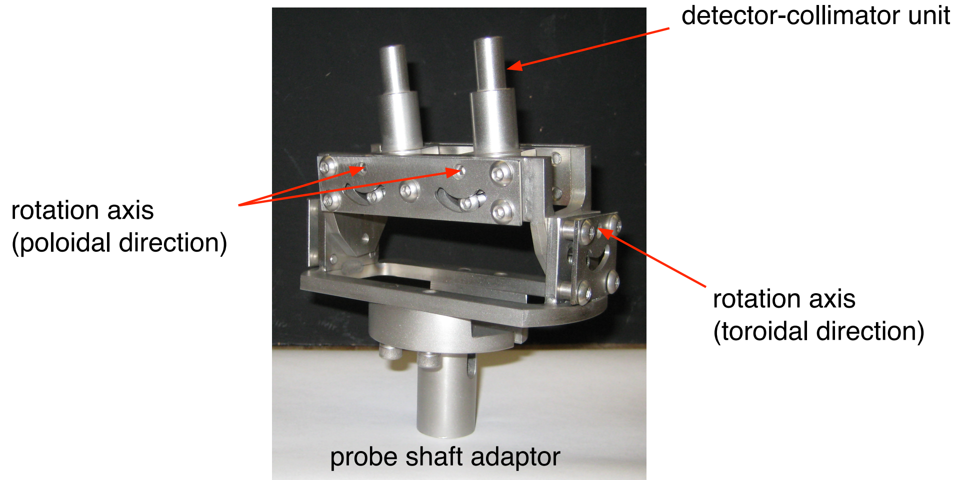
Surface Barrier Detectors

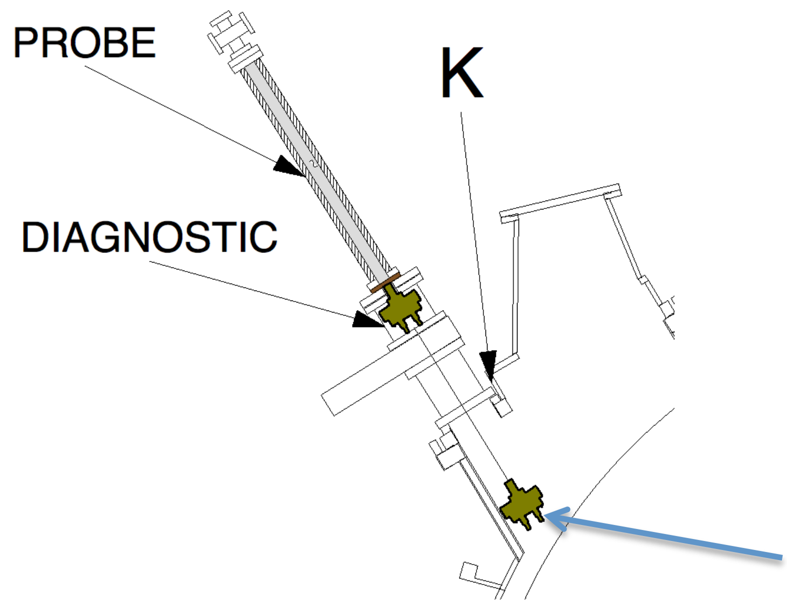
- Commercially available Ortec/Canberra
- Bakeable (up to 200 C)
- Can be operated in UHV
- Have been used previously
- Good energy resolution (1%)



Detectors used : CU-014-050-100-S ULTRA by AMETEK/ORTEC

Original Prototype

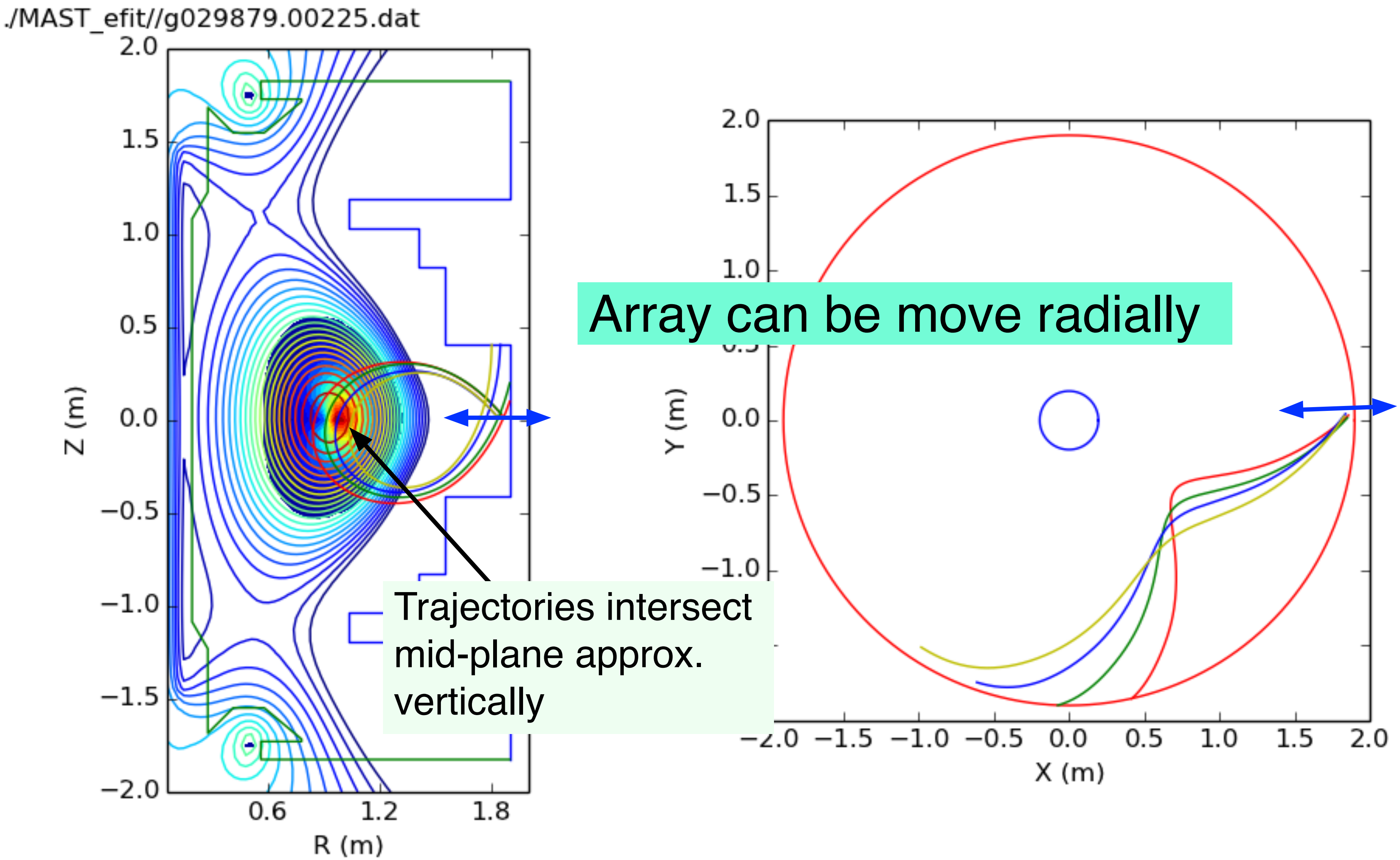




- Prototype: 2 detectors
- Flexible orientation around 3 axes
- Study signals and rates
- Optimize detector arrangement and location for full array of 8 detectors
- Location: Bay K
- Mounted on moveable probe shaft
- IN-position: R=1.7m, Z = 0.286m

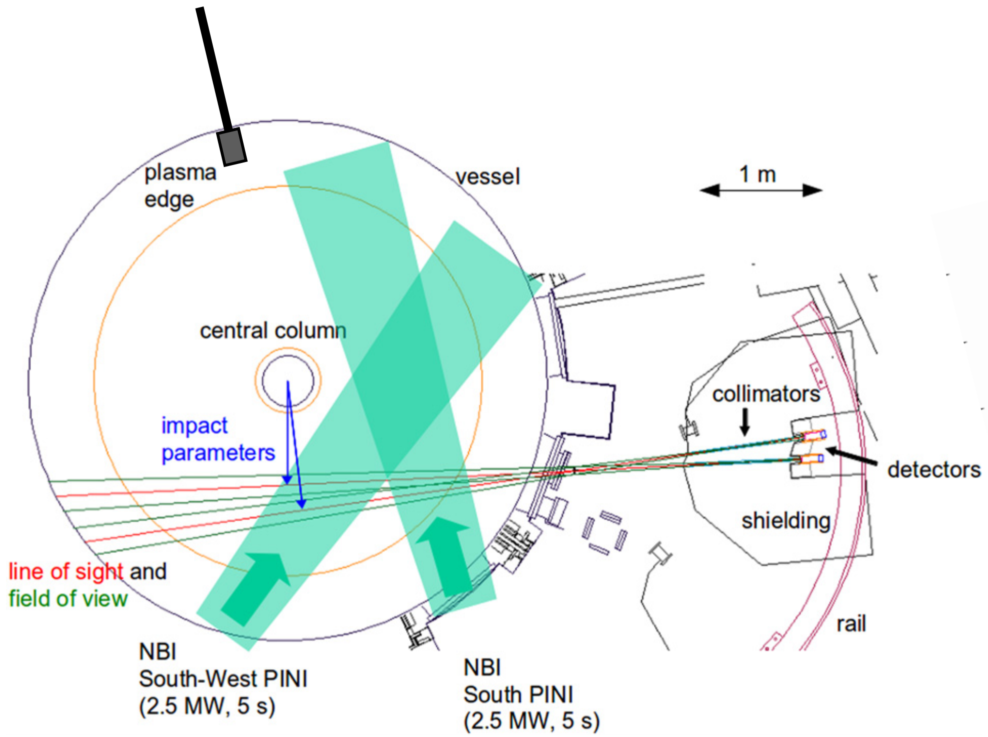
Could not be tested

MAST Design

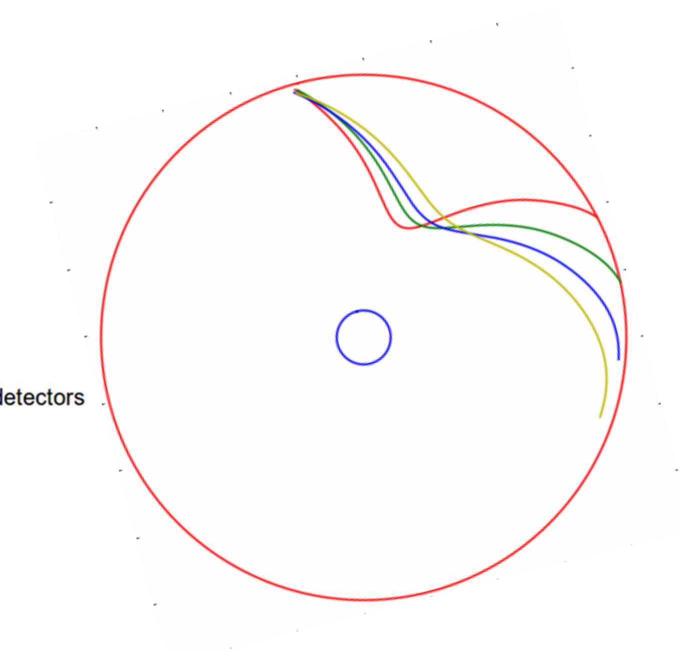


./MAST_efit//g029879.00225.dat
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
Z (m)
0.6
1.2
1.8
R (m)
Trajectories intersect mid-plane approx. vertically
Array can be move radially
2.0
1.5
1.0
0.0
−0.5
−1.0
Y (m)
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0
X (m)

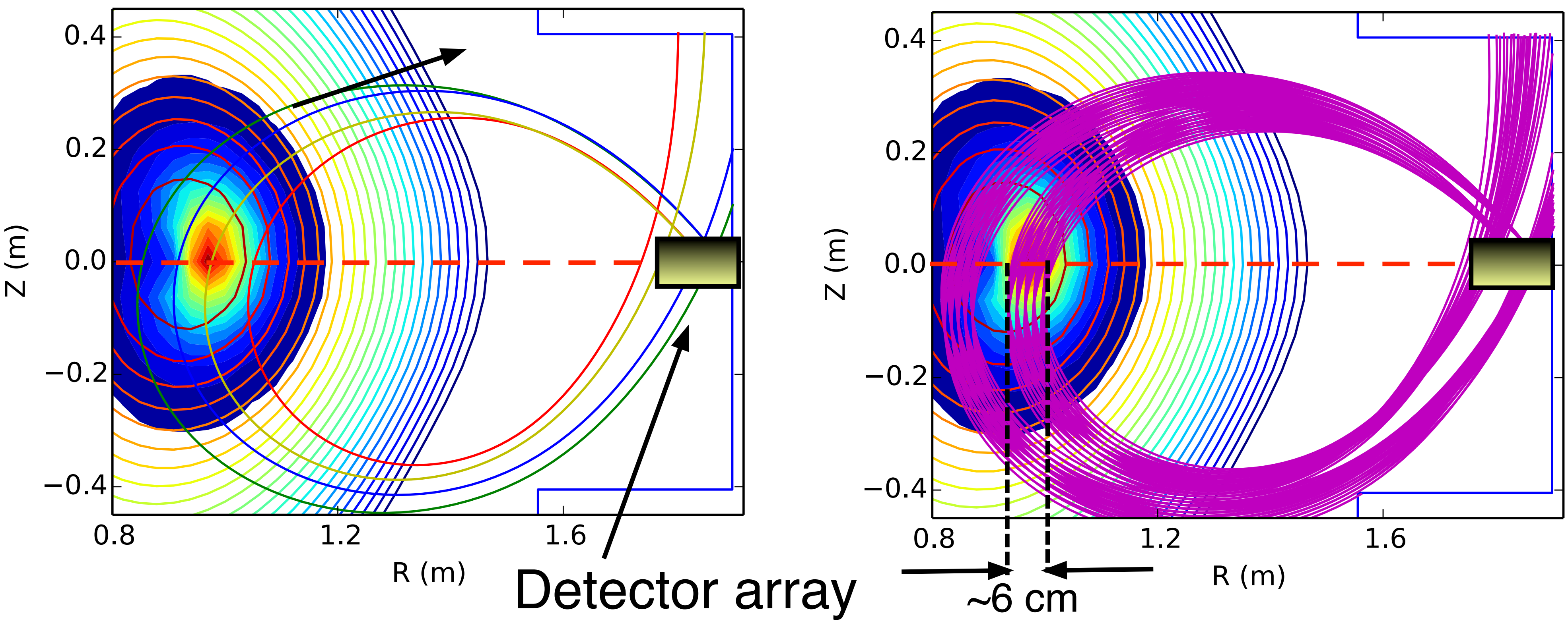
Approx. location of probe arm



Central Orbits



Acceptance: Poloidal

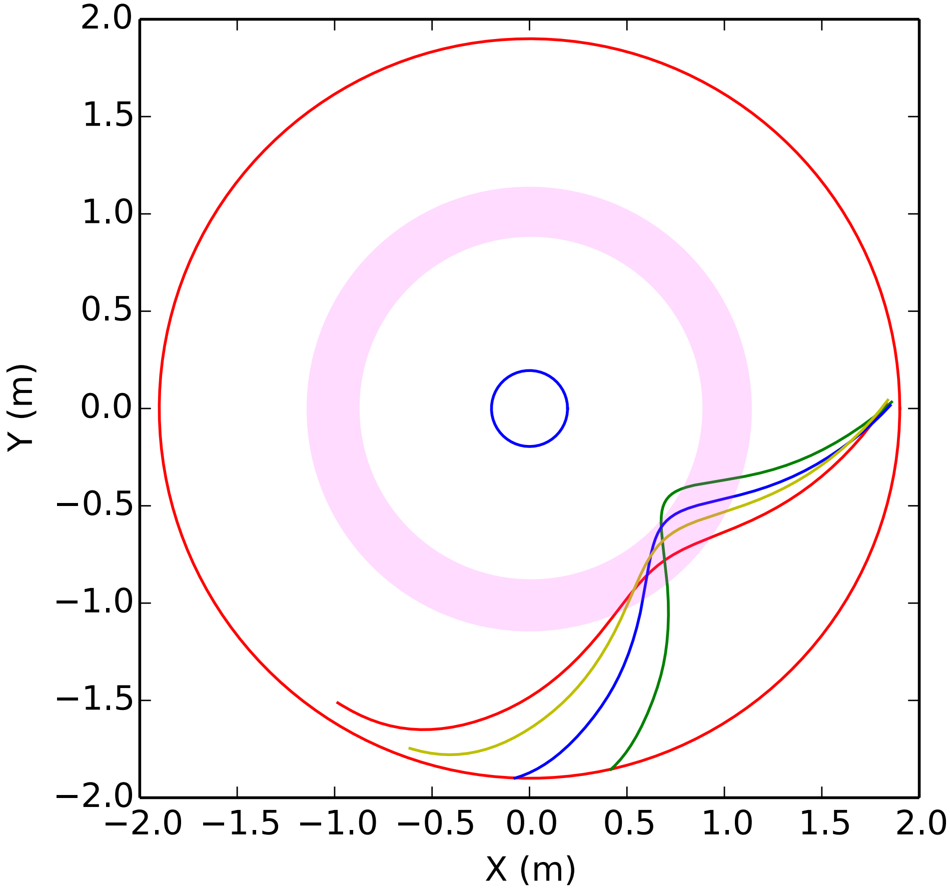


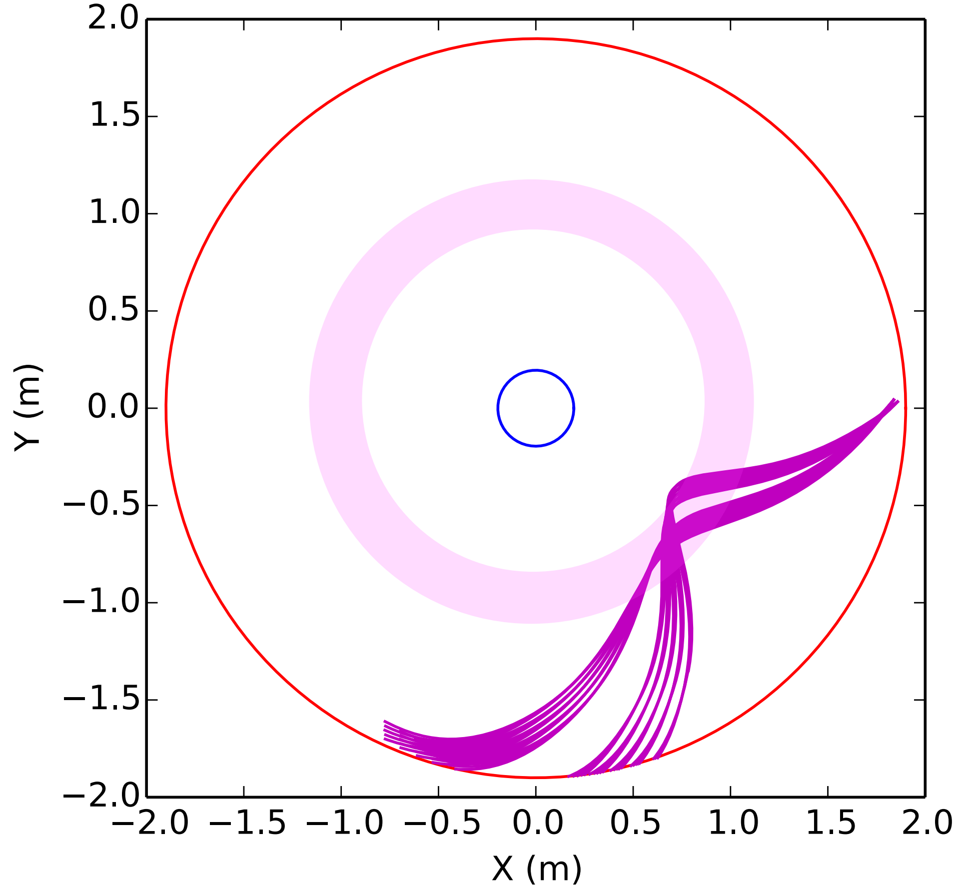
Central orbits

Radial Positions: +/- 3cm

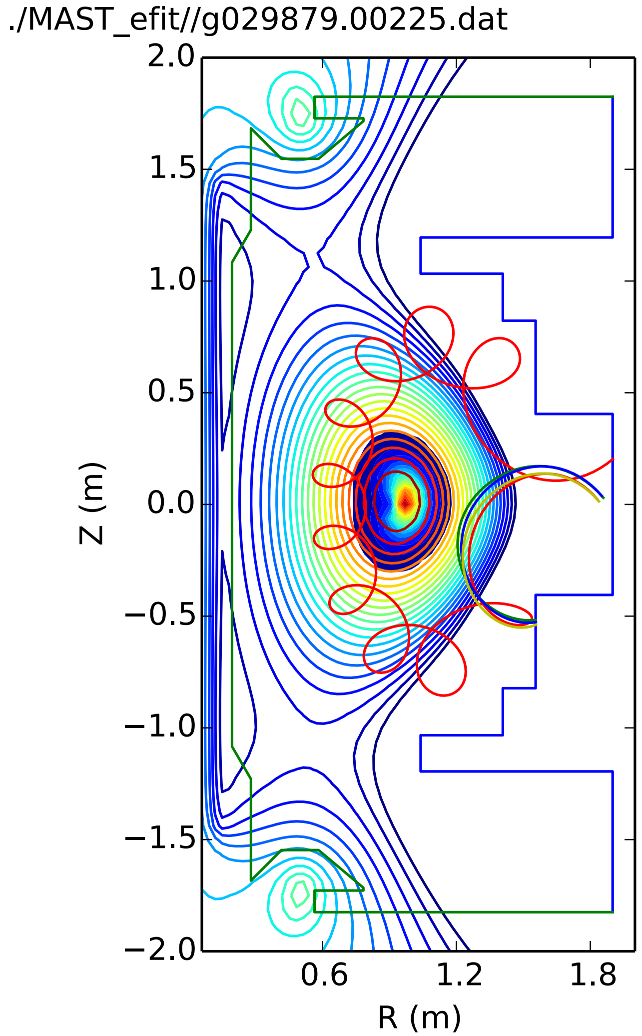
Integration region (not weighted by acceptance)

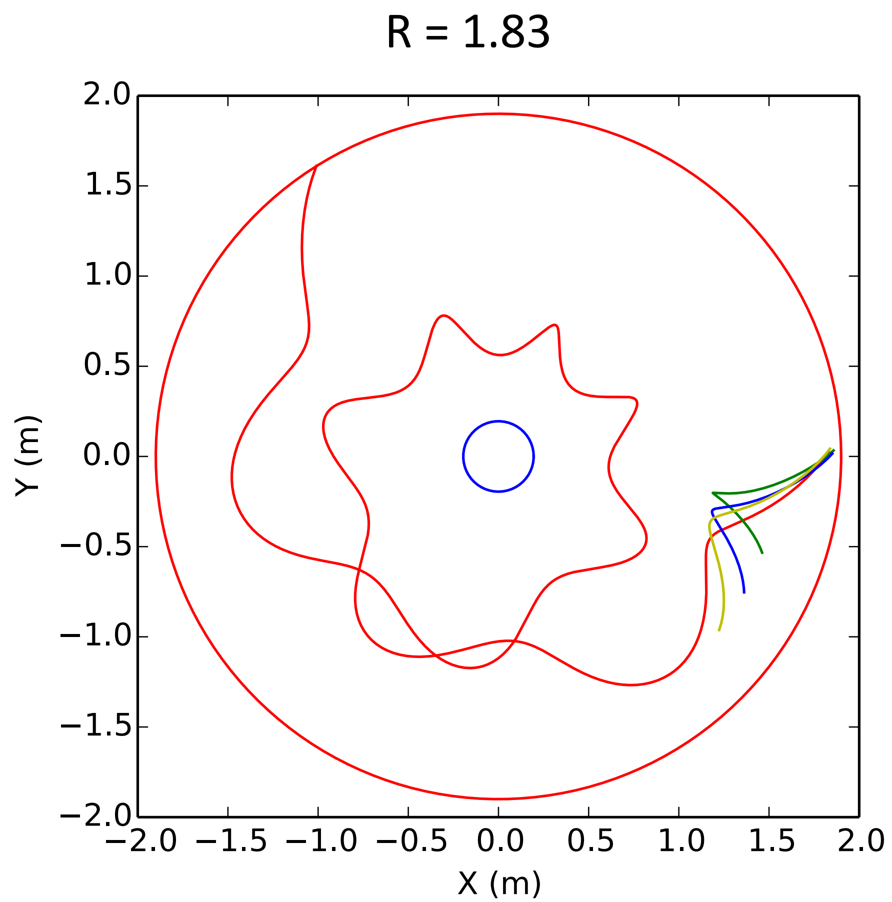
Acceptance: Toroidal View



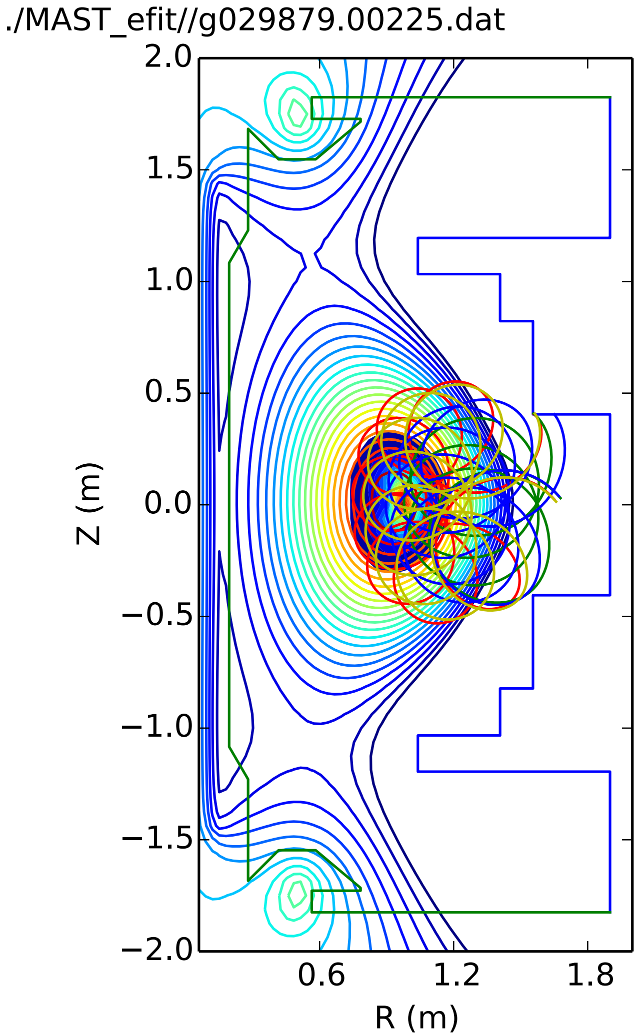


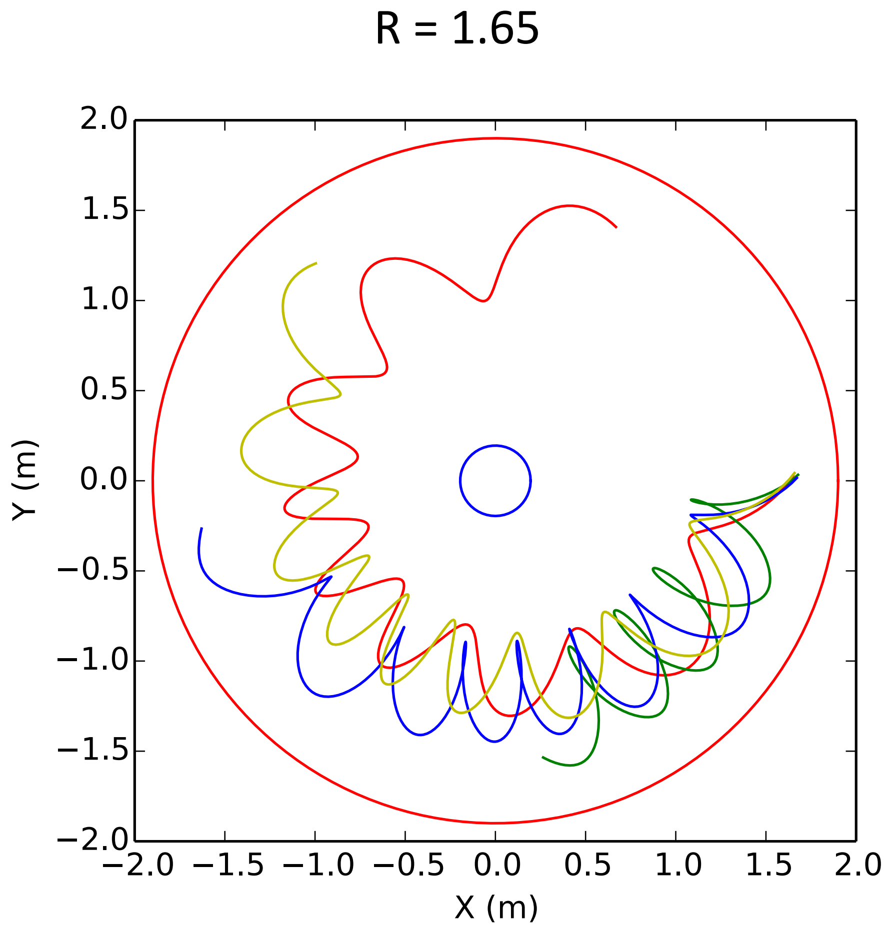
^{3}He Orbits





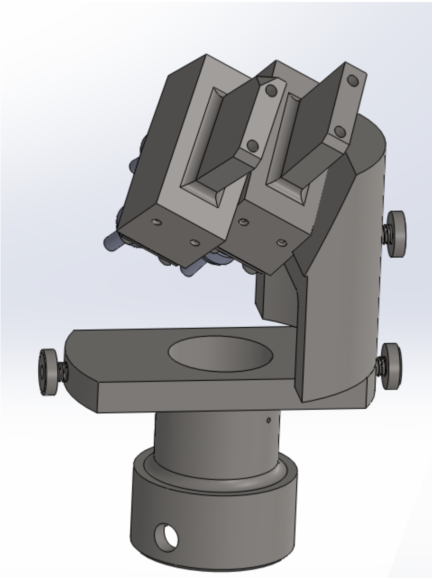
very small ^{3}He rate



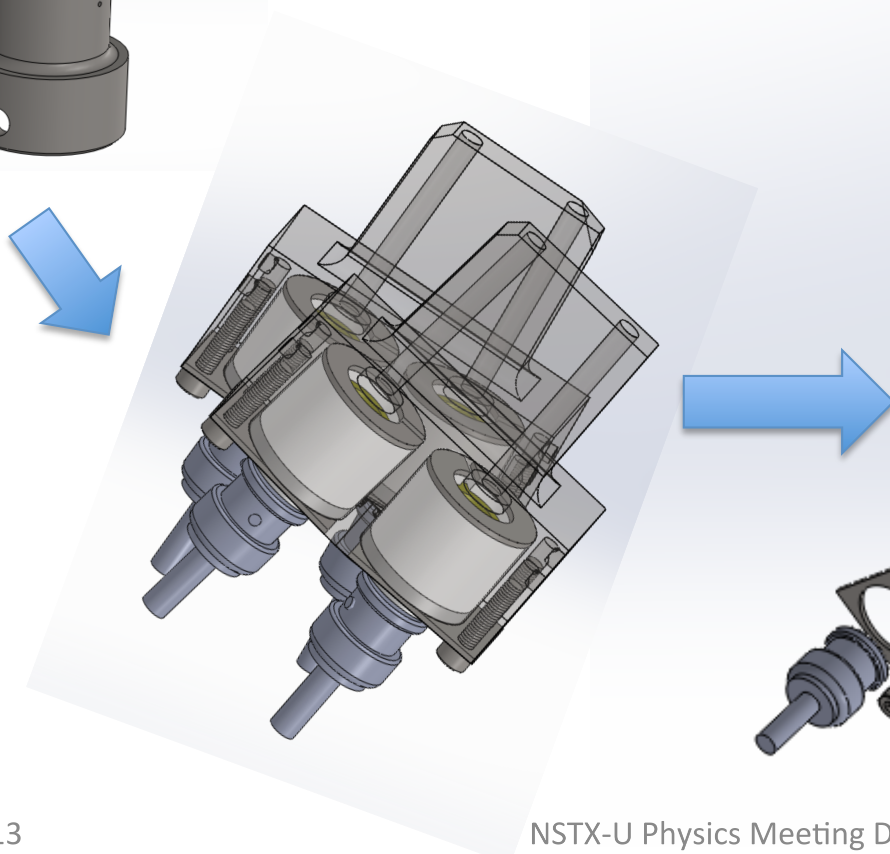


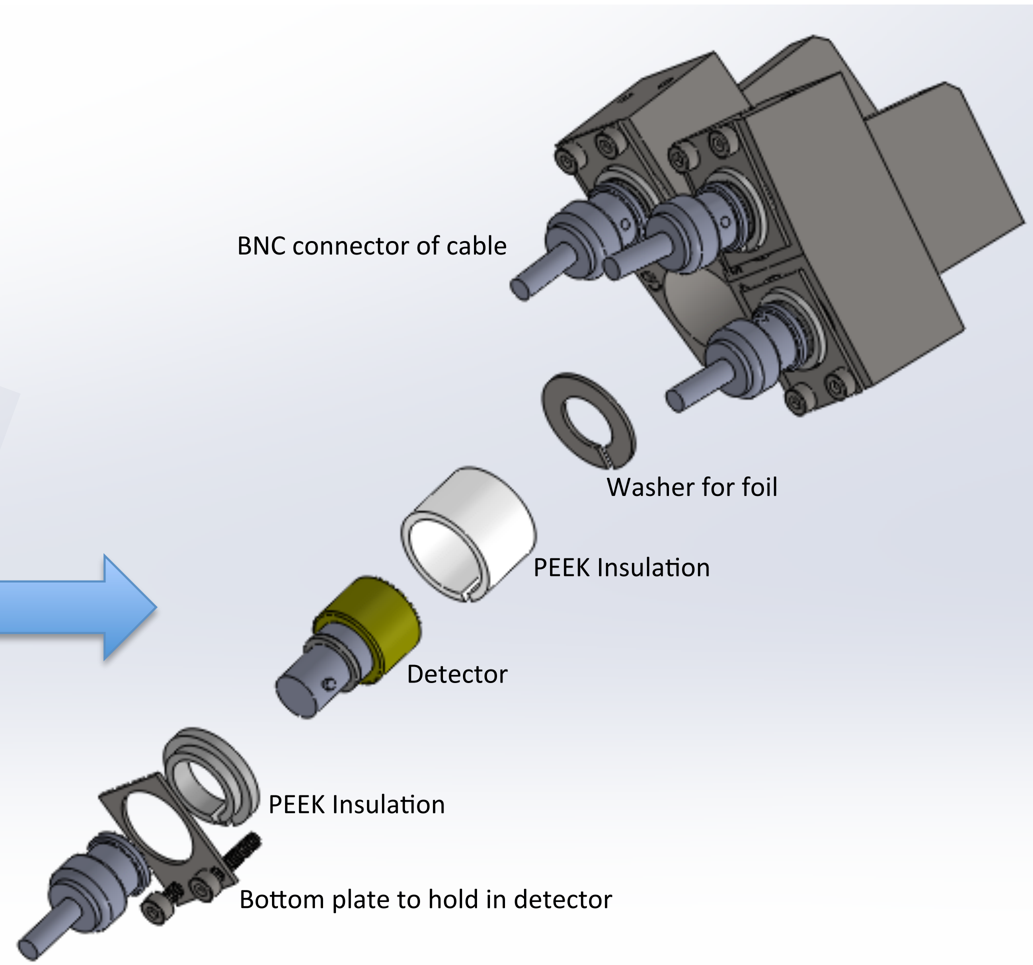
^{3}He rate about 3 – 10 times higher than proton/triton rate

Proton Detector (PD)



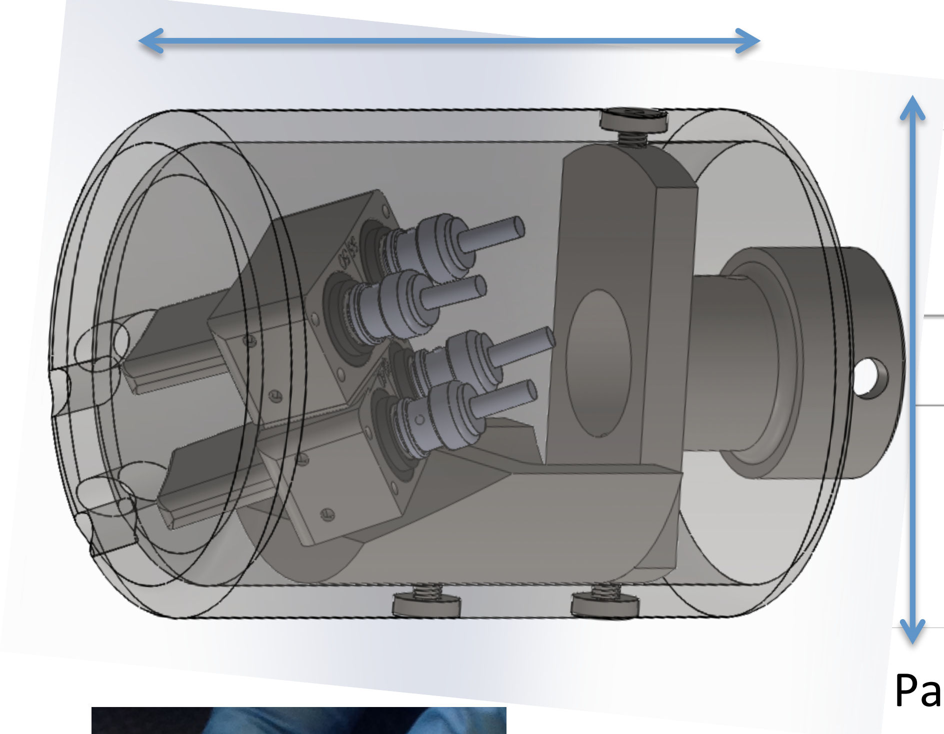
4-channel system, each channel having a unique angular orientation.





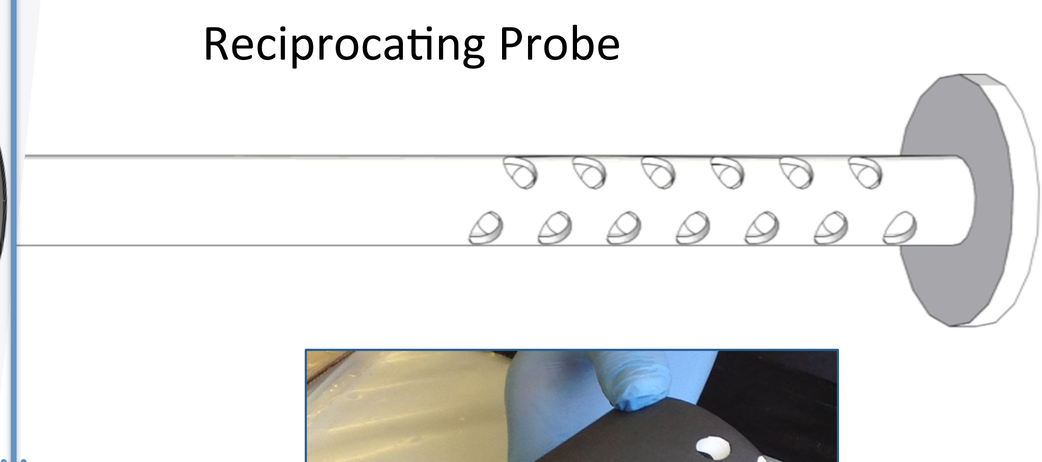
PD Assembly

185 mm

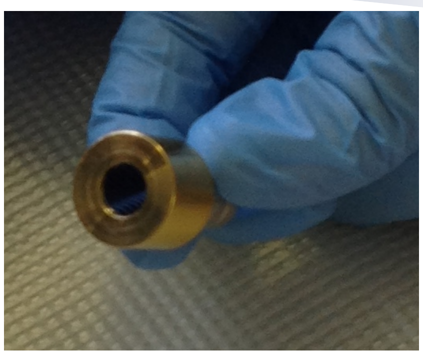


110 mm

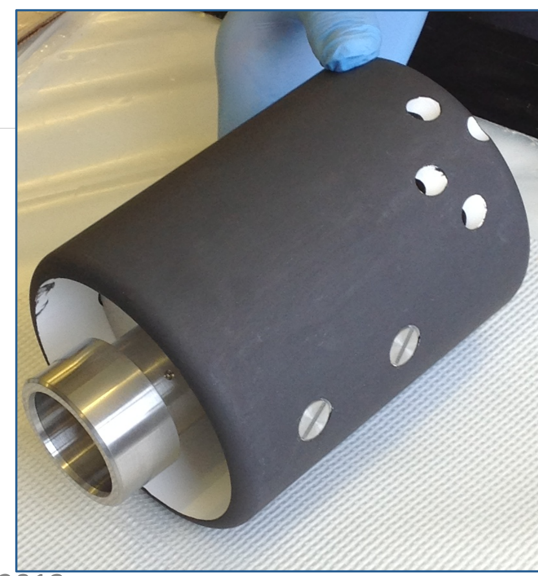
Reciprocating Probe



Particles



Detector with BN shield on



Cross-Sectional View