

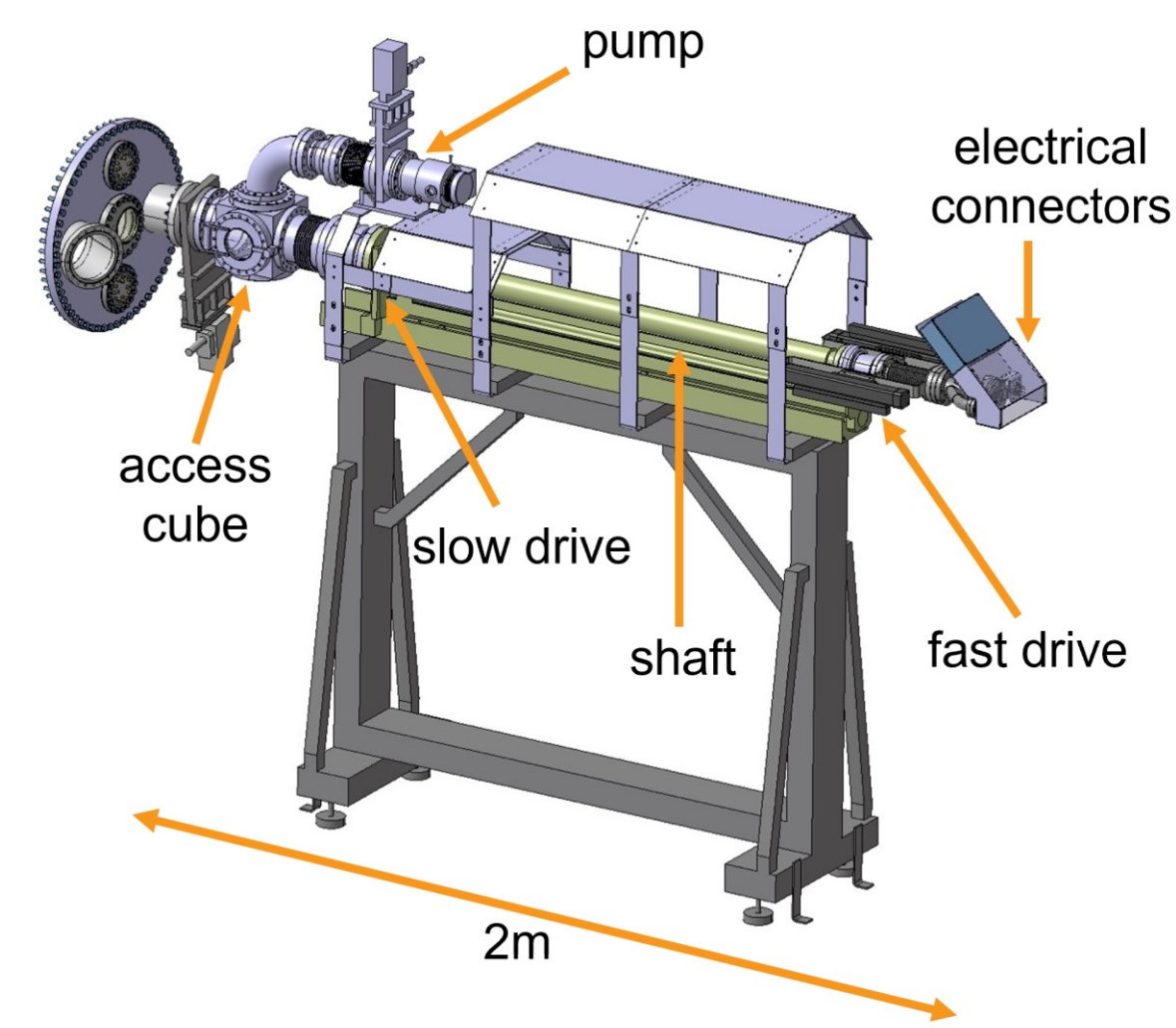
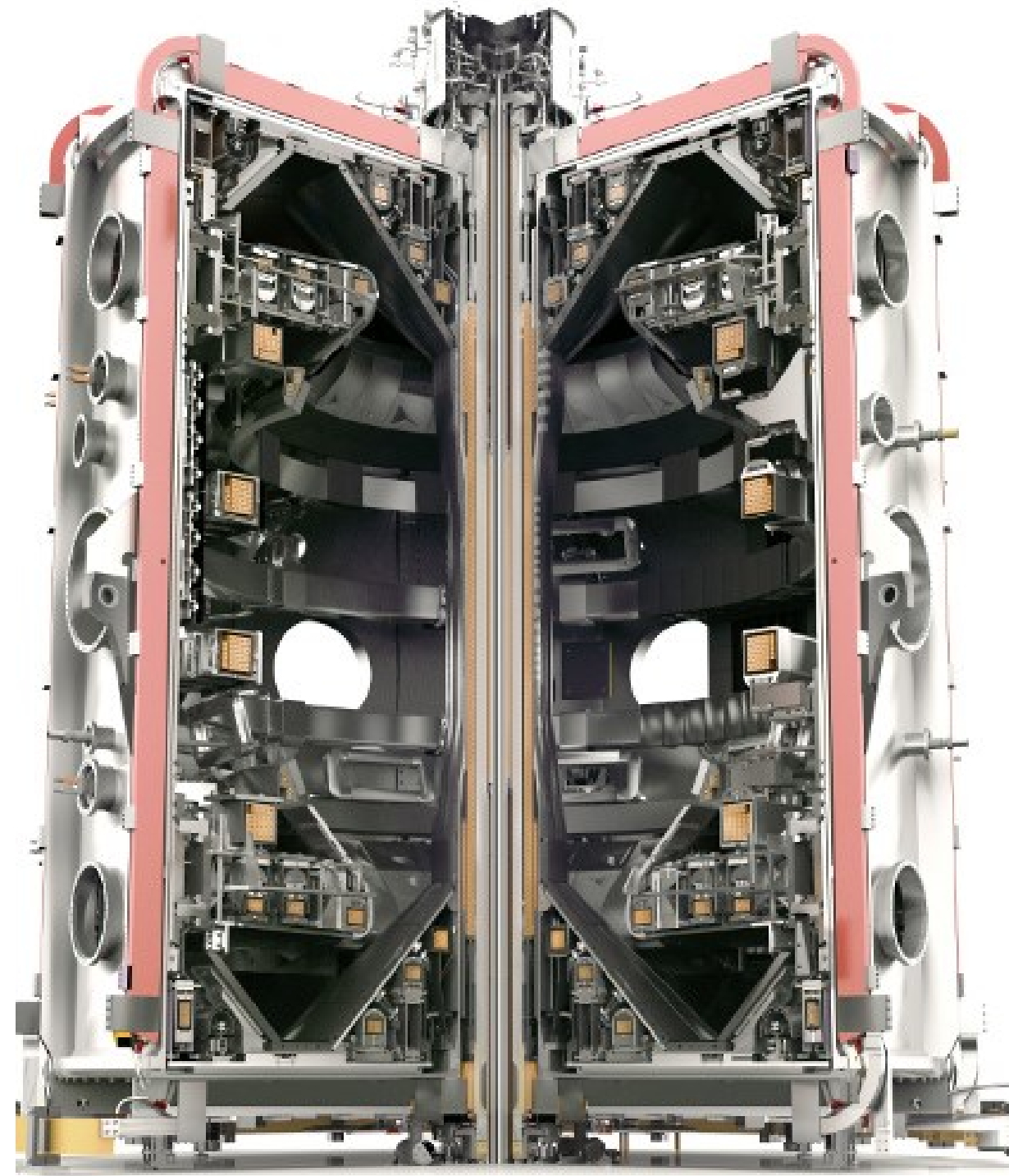
# Designing a Probe Head for Extreme Environments

## Turbulence Probe Design Considerations

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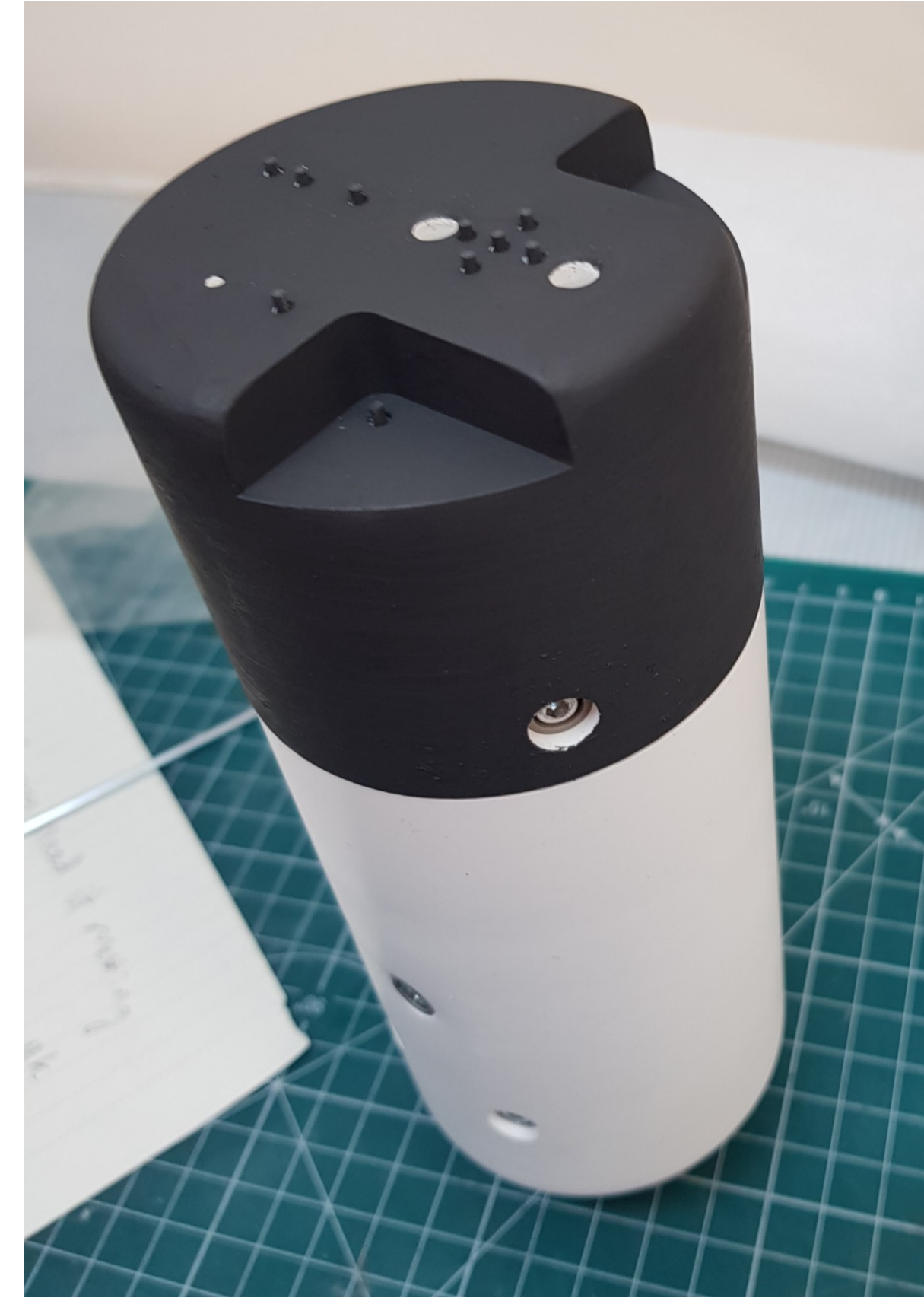


### MAST-U

- Spherical Tokamak
- Core temperatures up to 3keV (34 million °C)

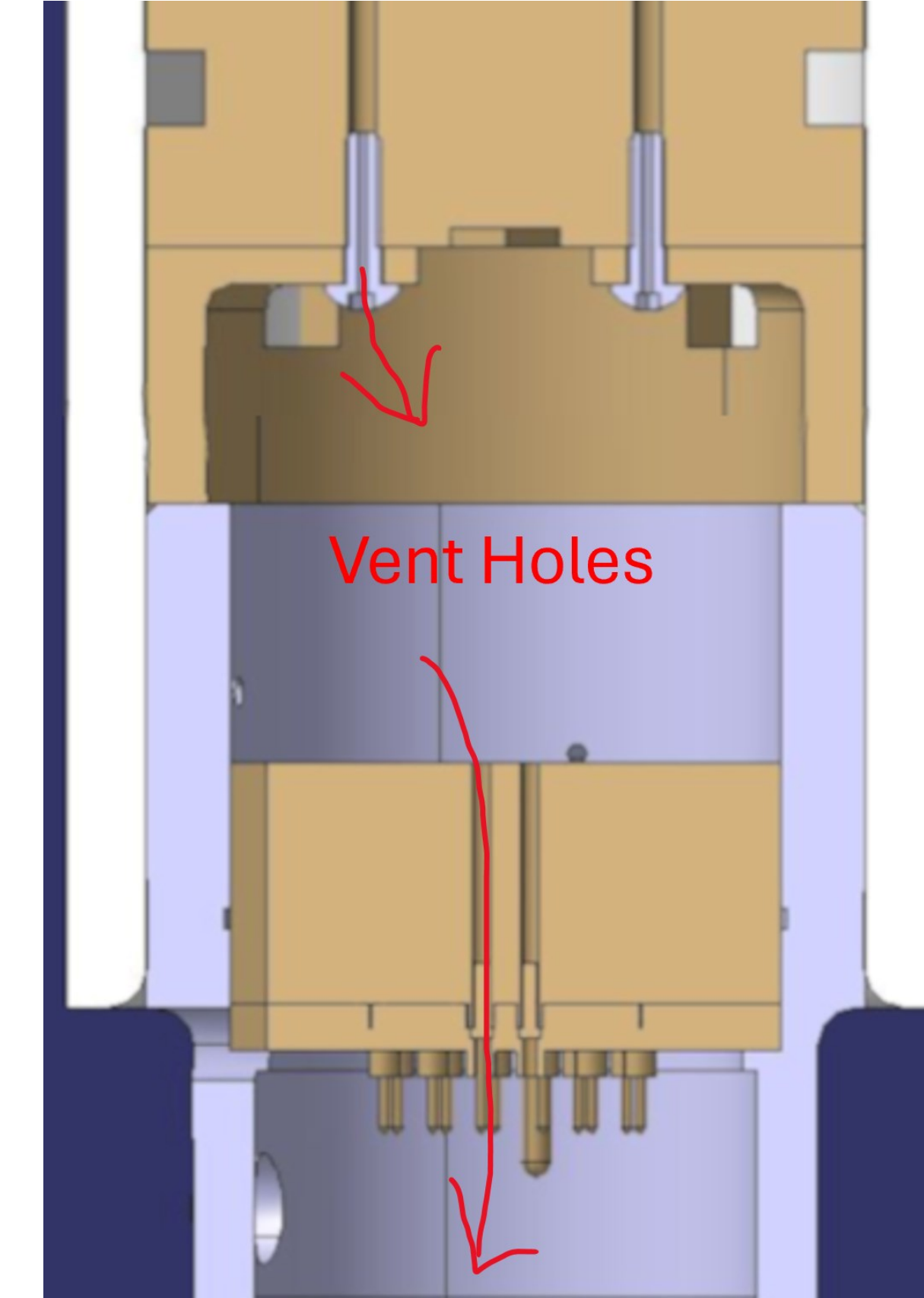
### Reciprocating Probe system

- Stepper motor slow drive to start position
- Pneumatically driven fast drive to plunge in/out of plasma at  $0.45\text{ms}^{-1}$  over 9cm



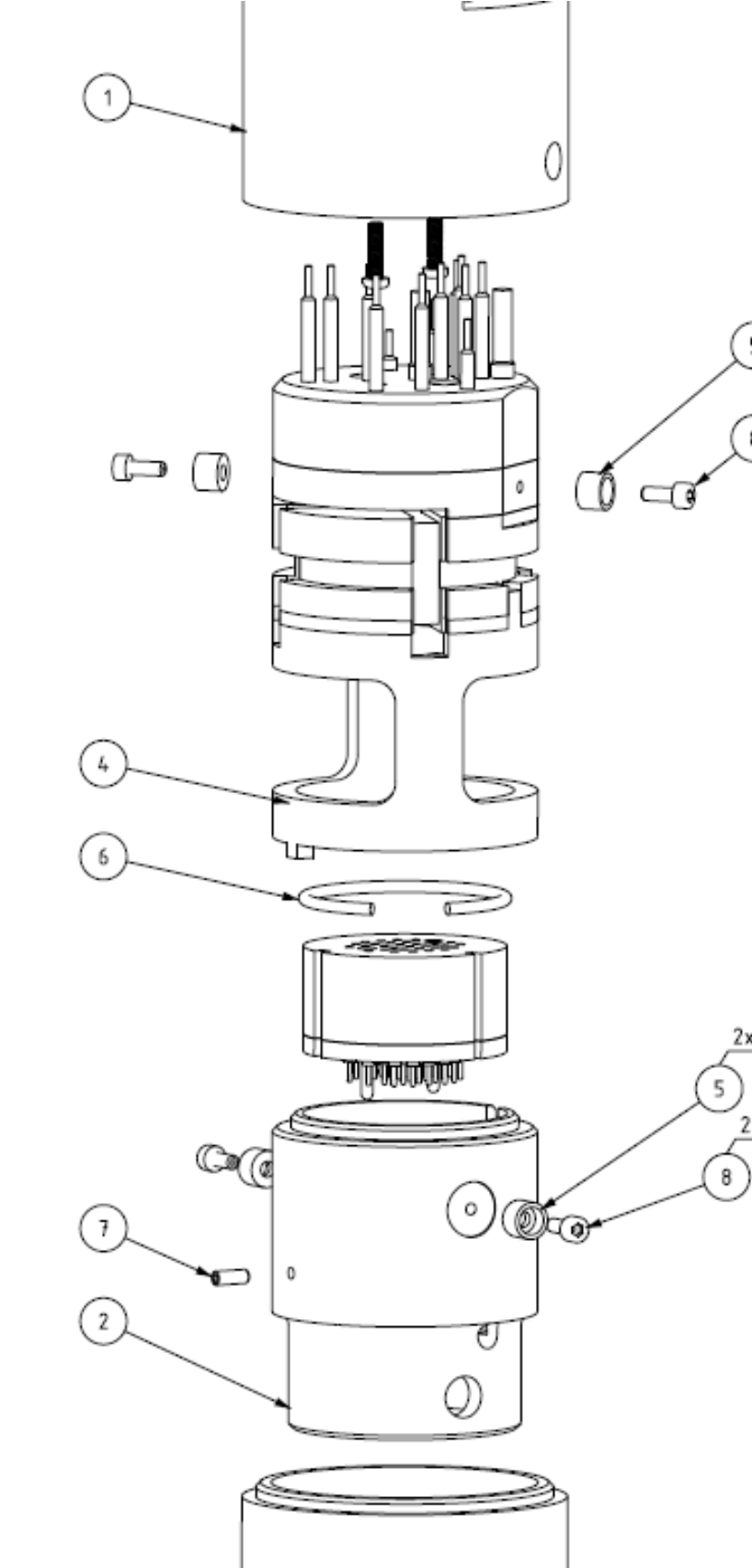
### Material Choices:

- Graphite – Probes
- Boron Nitride – Ceramic Shell
- PEEK – Internals
- Stainless Steel – Plug Housing, Screws



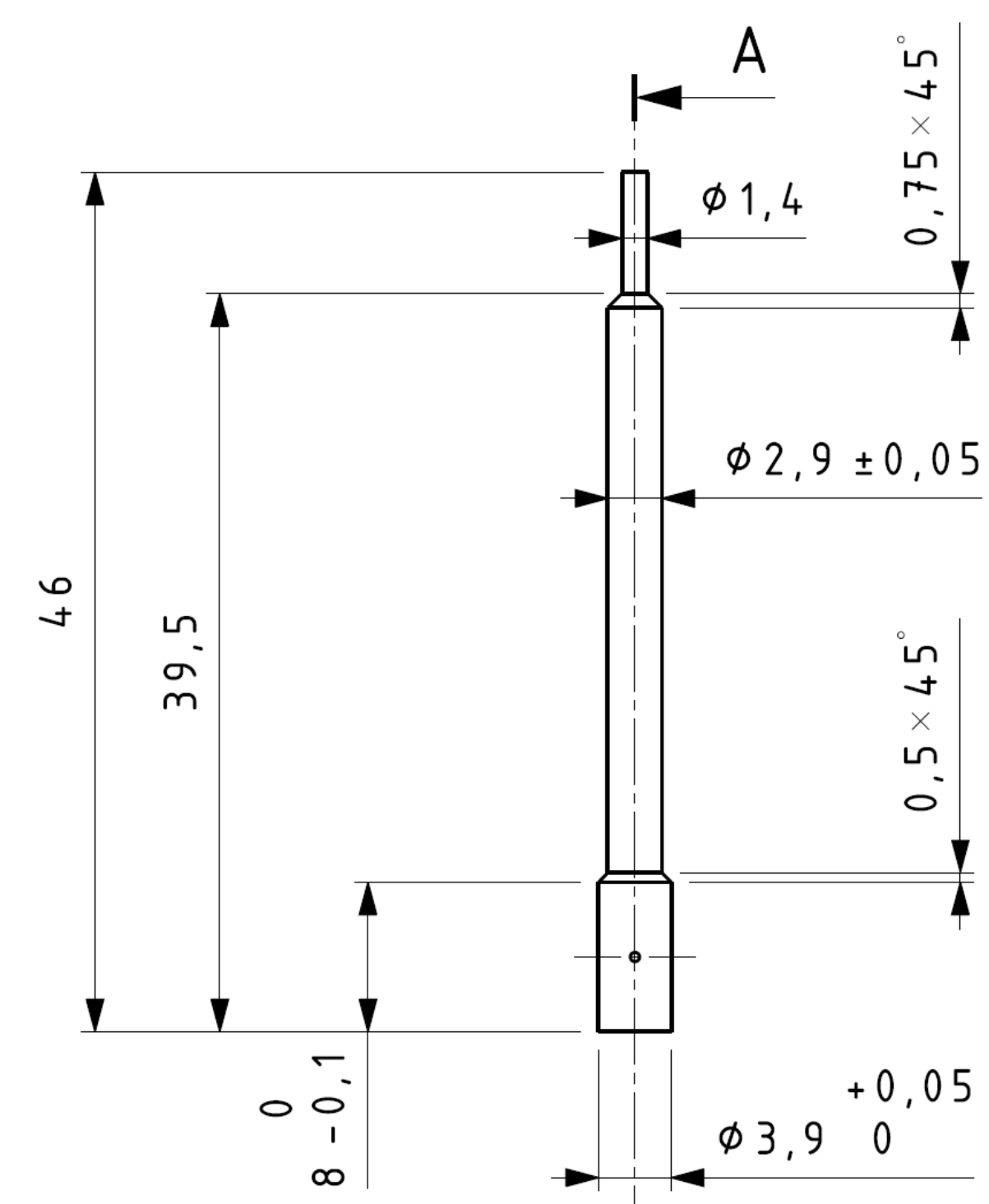
### Vacuum Considerations:

- Void Breaking
- Vent Holes
- Pumping Pathways



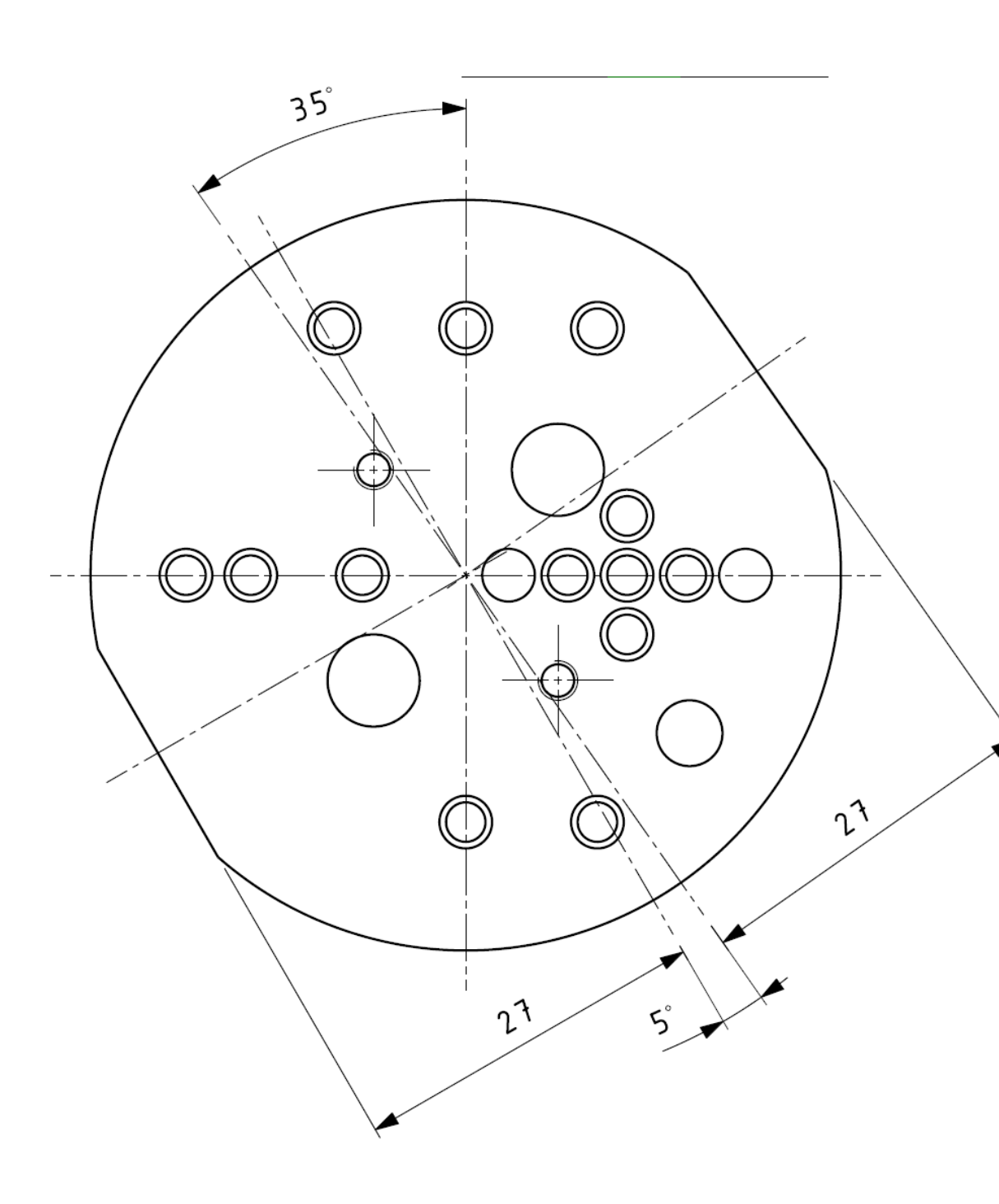
### Internal stack

- Mostly PEEK
- Bolted together
- Notches to stop rotation

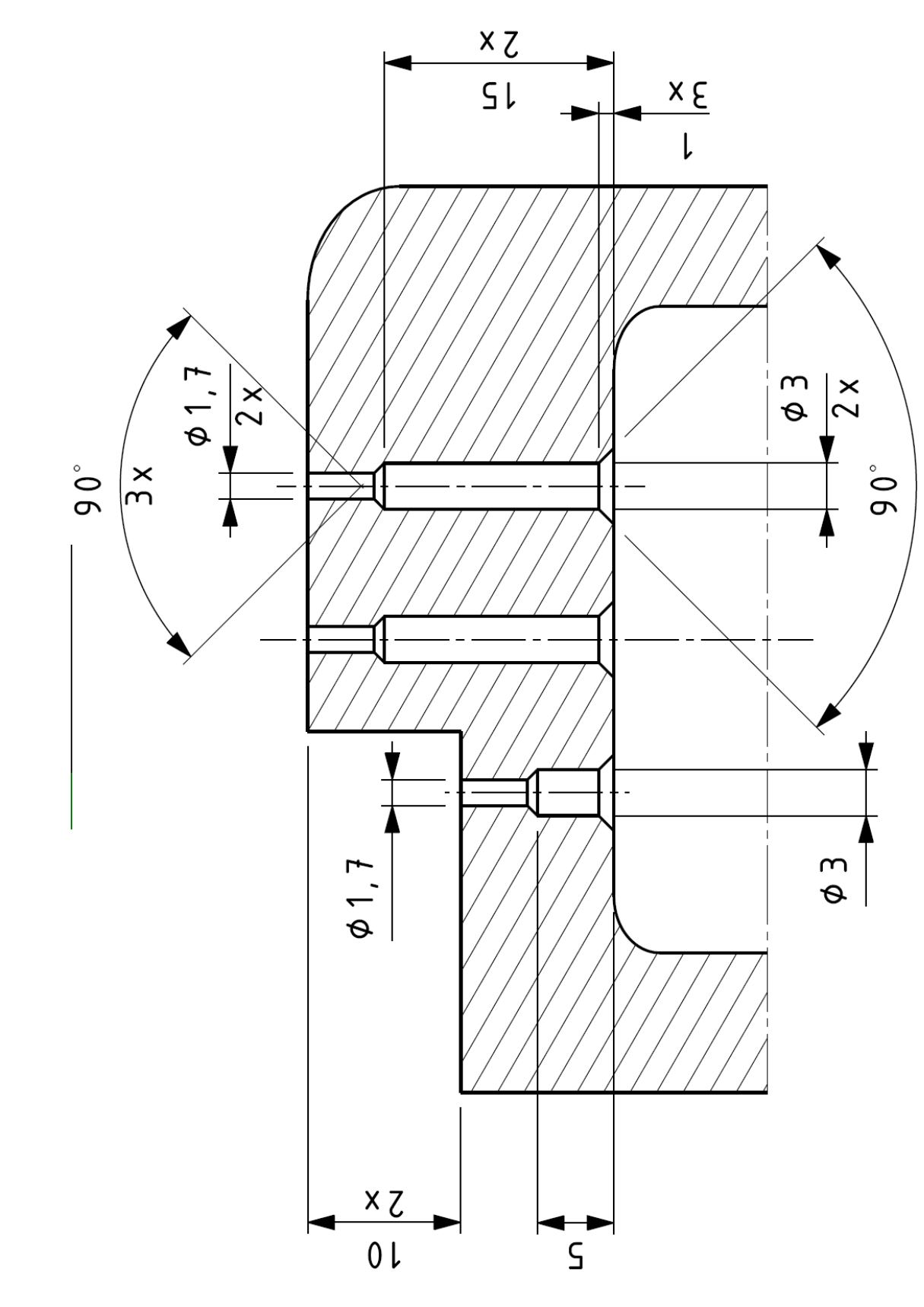


- Cabling routed in coil winding channels
- Kapton insulation between coils and cables
- Common earthed shield for cables
- Spacer gives room for wiring

- Thick probe until near the tip
- increase strength
- reduce breakages
- Vent hole



- Asymmetric con-flats ensure one way to fit the shell cap
- Middle space raised for central pin
  - Needs to peak above the rest of the array
  - Allows for same pin dimensions reducing unique parts

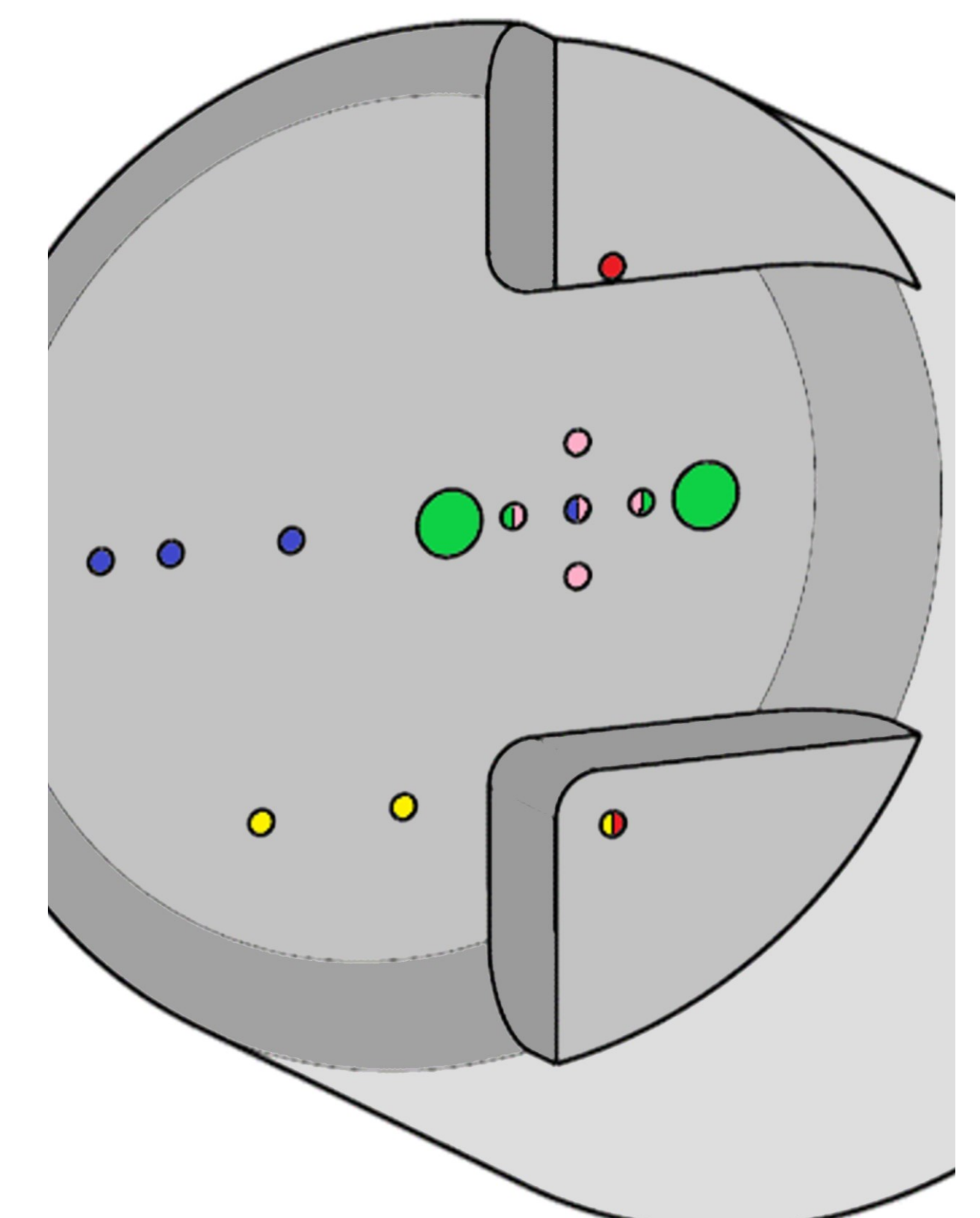


- Wide countersink for centring pins
- Stepped to match pins prevent plasma leakage



### Thermal Expansion:

- Clearance of 0.4mm
- PEEK expanded by 0.7mm
- Clearance of 1.4mm for new design



### Multifunctional Probe Arrays:

- Blue – Log-spaced for cross-correlations
- Green – Ball-Pen Probes  $\Phi_{\text{Plasma}}, T_e$
- Pink – 5-pin balanced probe  $n_e, T_e$
- Yellow – Linear array filament stats
- Red – Parallel Mach number