Designing a Probe Head for Extreme Environments

Turbulence Probe Design Considerations

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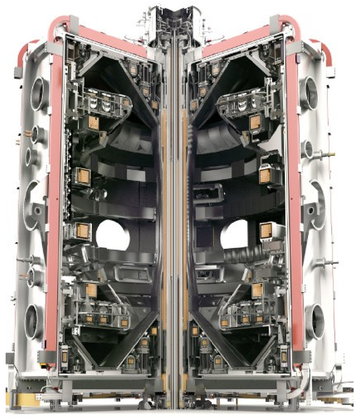
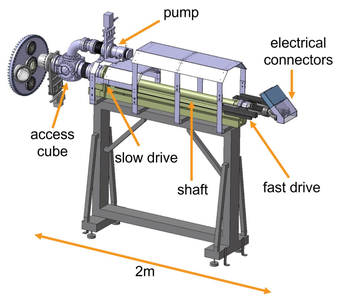
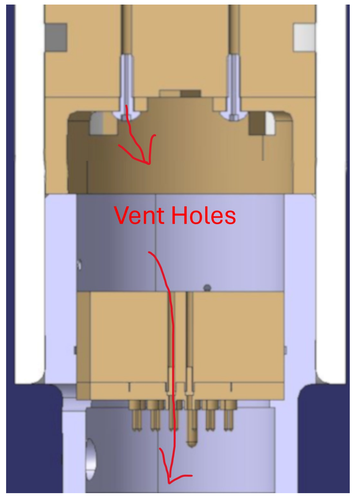


MAST-U
- Spherical Tokamak
- Core temperatures up to 3keV (34 million °C)

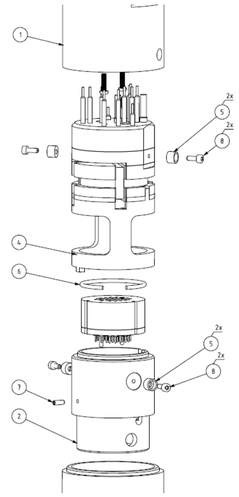


Reciprocating Probe system
- Stepper motor slow drive to start position
- Pneumatically driven fast drive to plunge in/out of plasma at 4.5ms^{-1} over 9cm

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

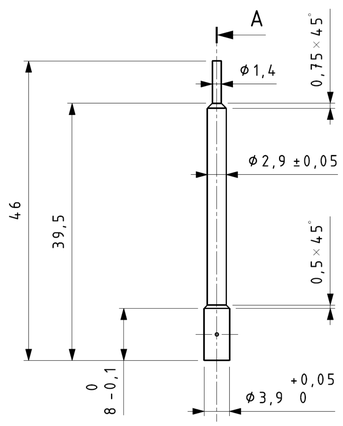


Vacuum Considerations:
- Void Breaking
- Vent Holes
- Pumping Pathways

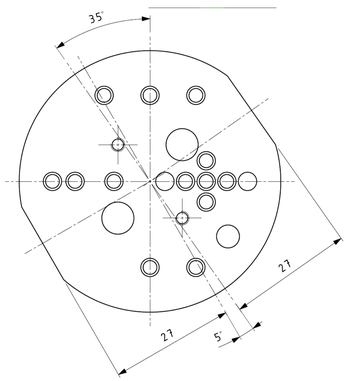


Internal stack
- Mostly PEEK
- Bolted together
- Notches to stop rotation

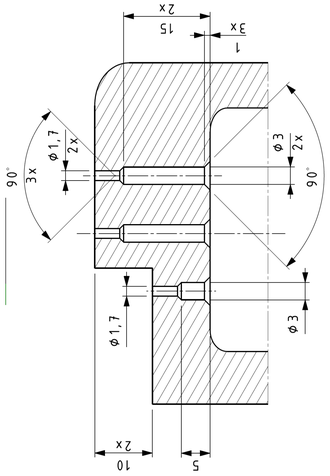
- Cabling routed in coil winding channels
- Kapton insulation between coils and cables
- Common earthed shield for cables
- Spacer gives room for wiring



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

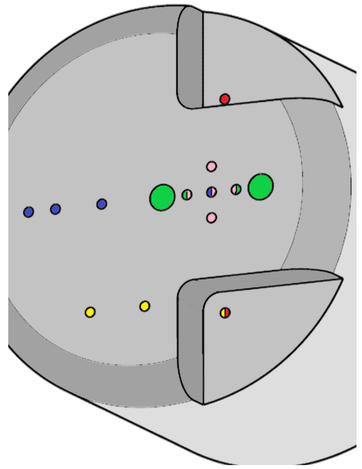


- Asymmetric con-flats ensure one way to fit the shell cap
- Middle space raised for central pin
  - Needs to peak above the rest of the array
  - Allows for same pin dimensions reducing unique parts



- 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 $\Phi_{\mathrm{Plasma}}, T_{\mathrm{e}}$
Pink – 5-pin balanced probe $n_{\mathrm{e}}, T_{\mathrm{e}}$
Yellow – Linear array filament stats
Red – Parallel Mach number