JOHNS HOPKINS UNIVERSITY

Supported by NSTX

U.S. DEPARTMENT OF ENERGY | Office of Science

Prototype Multi-Energy Soft X-ray Diagnostic for EAST

presented by

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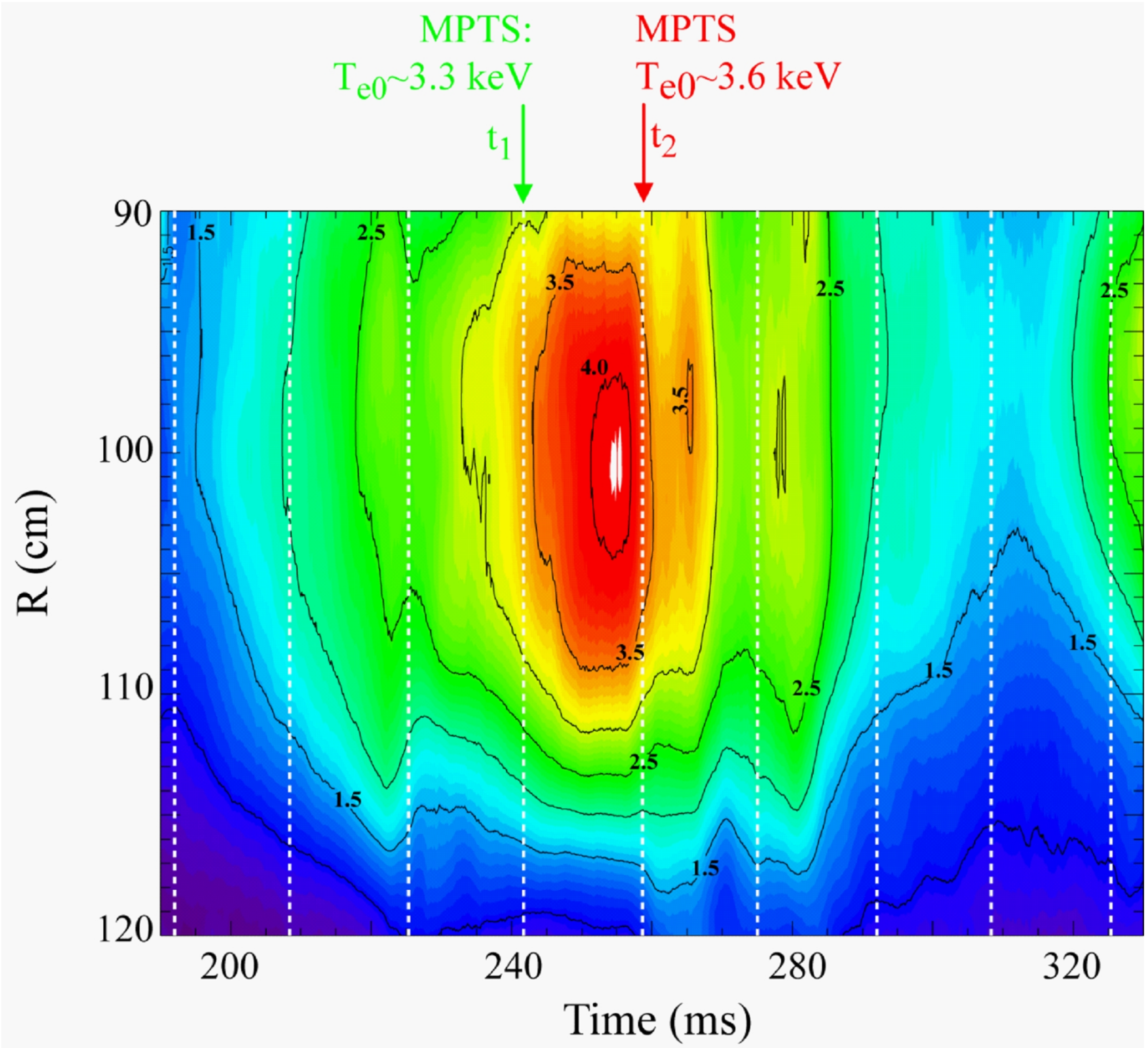
ME-SXR fast T_e technique used to reconstruct RF heated T_e profile between MPTS measurements

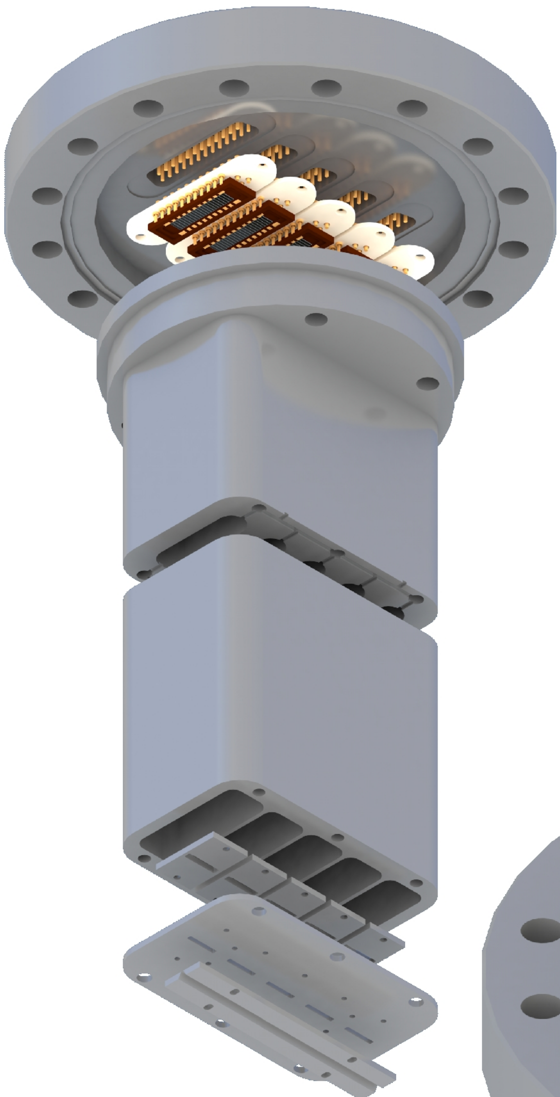


L. Delgado-Aparicio, et al., JAP, **102**, 073304 (2007).

L. Delgado-Aparicio, et al., PPCF, **49**, 1245 (2007).

- Reconstructed T_e shows peak >4keV, ~15% higher than MPTS measurement
- MPTS profiles used to cross-check ME-SXR reconstruction, provide normalization

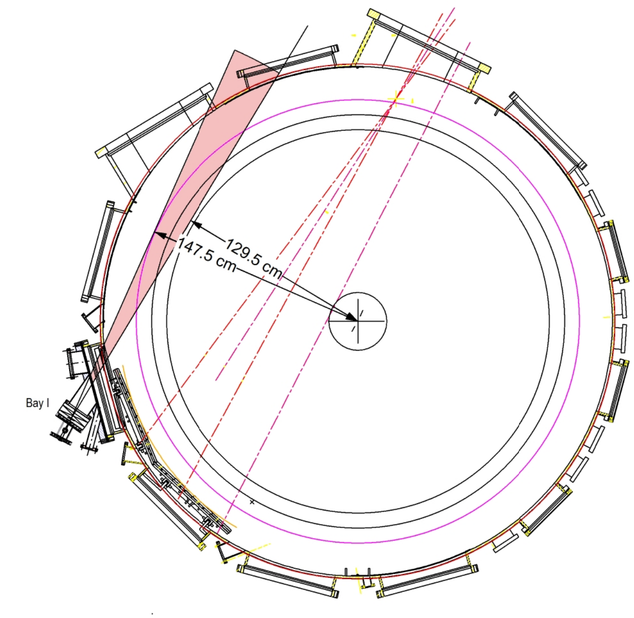
Original diode-based ME-SXR system operated on NSTX during 2010 run

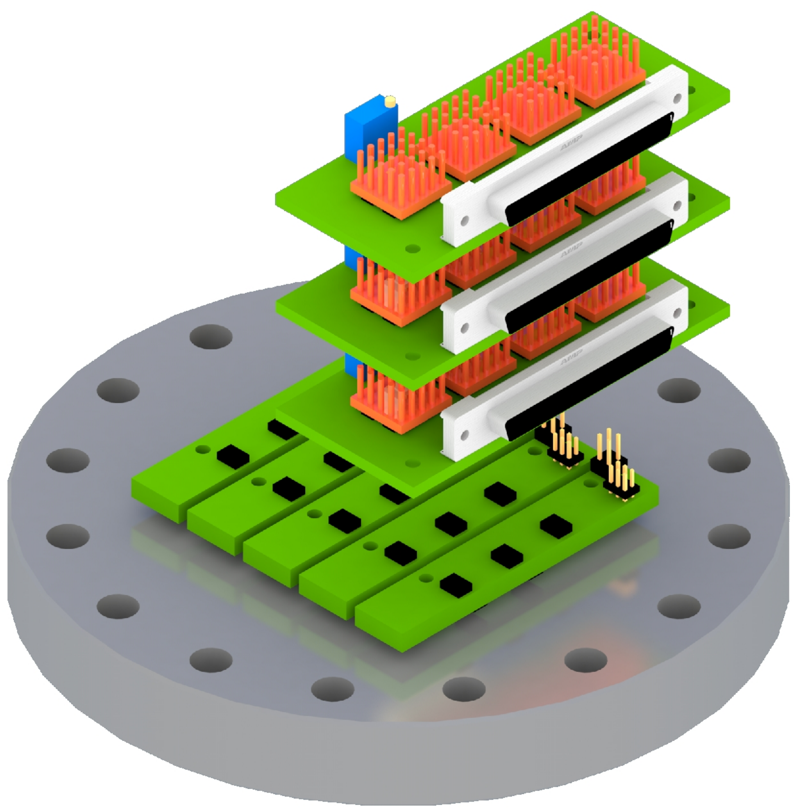


vacuum hardware mounted on 6" Conflat

attached to port-mounted gate valve

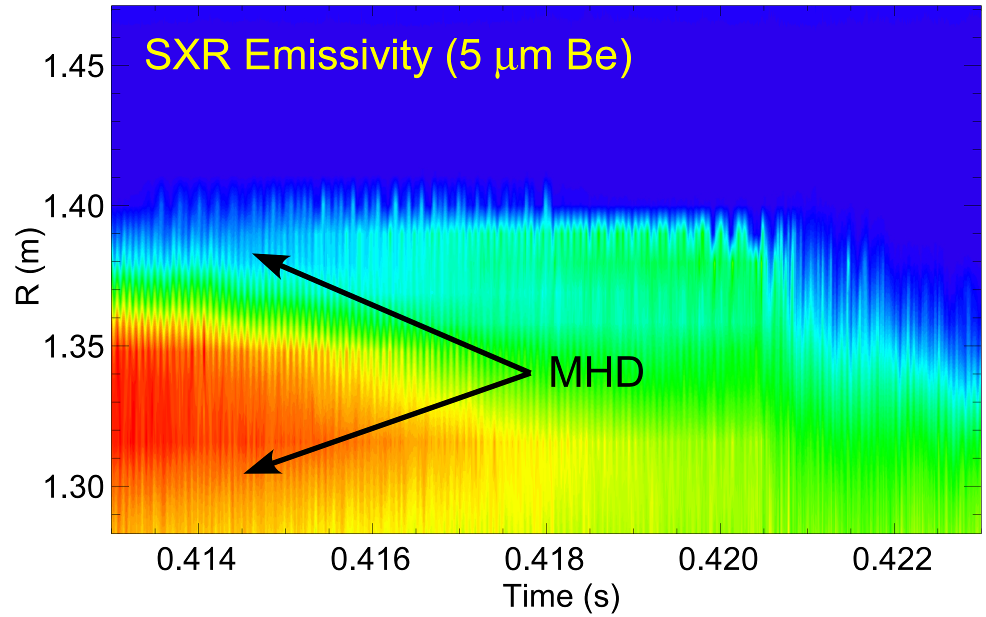
Edge ME-SXR tangential, mid-plane view on NSTX



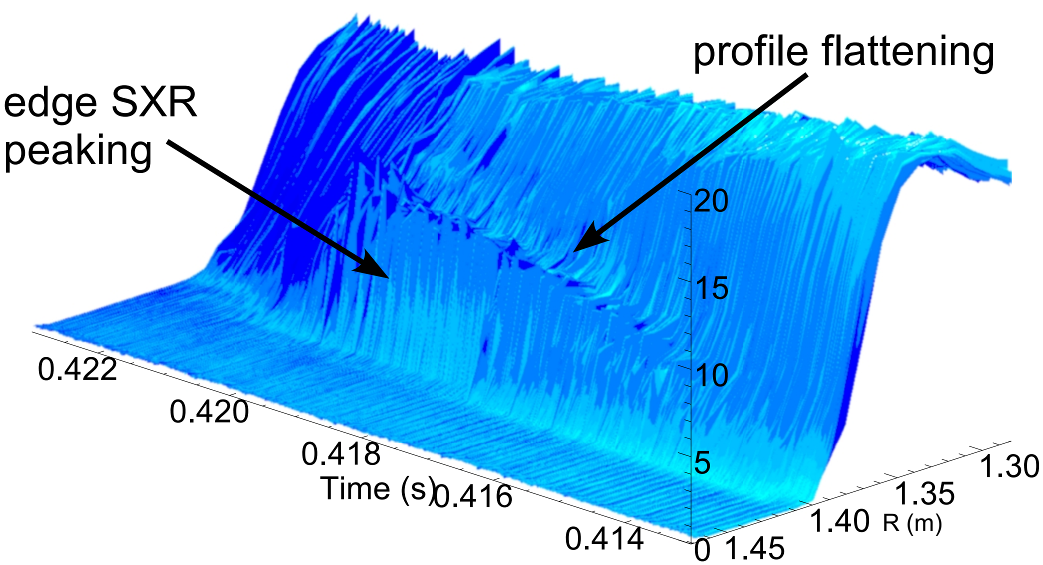


amplifiers mounted on back (atmoshpere-side) of Conflat flange

Abel inversion of tangential ME-SXR data shows detailed edge dynamics before profile crash

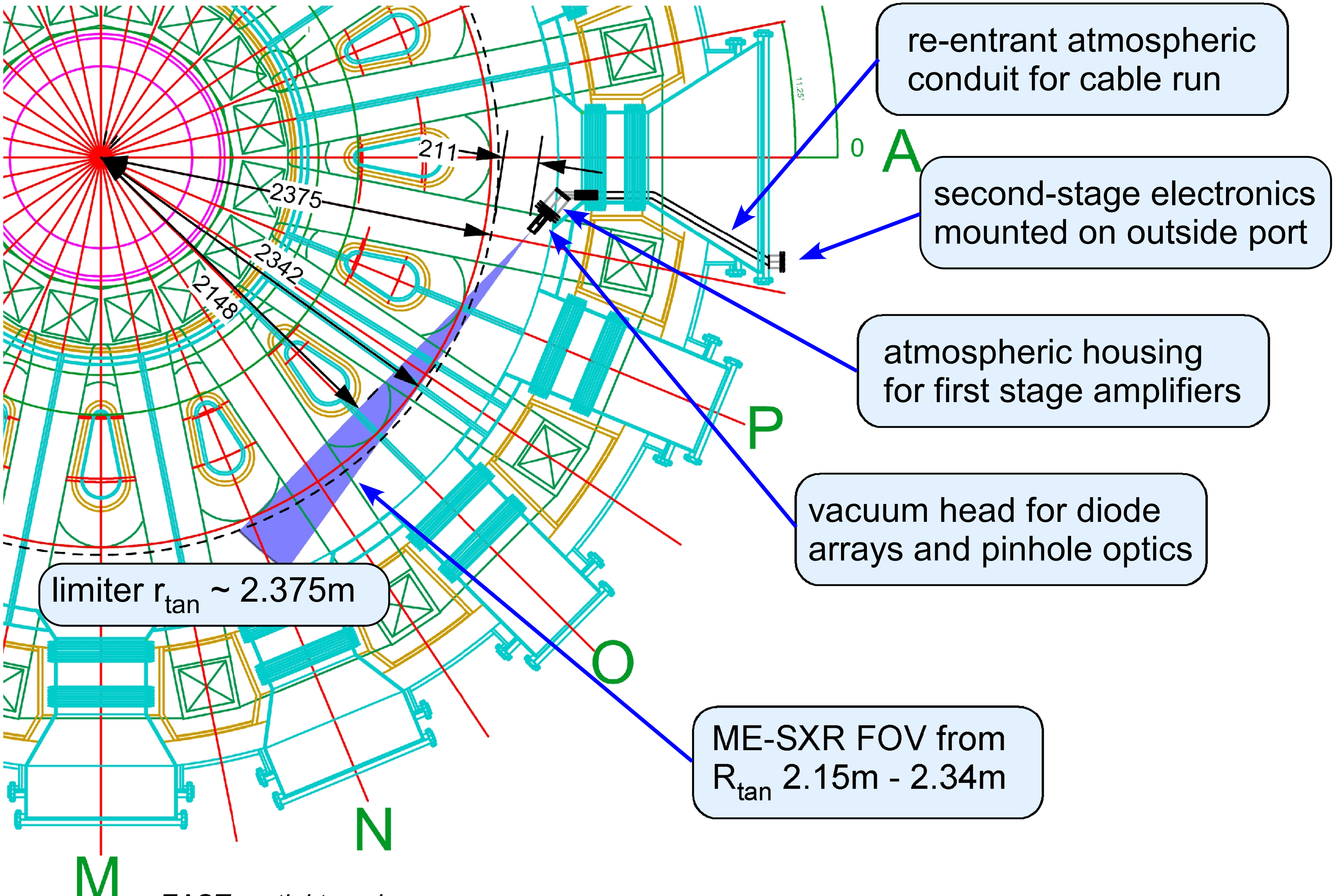


- 16 kHz internal MHD mode coupled to edge
- edge MHD slows prior to profile crash



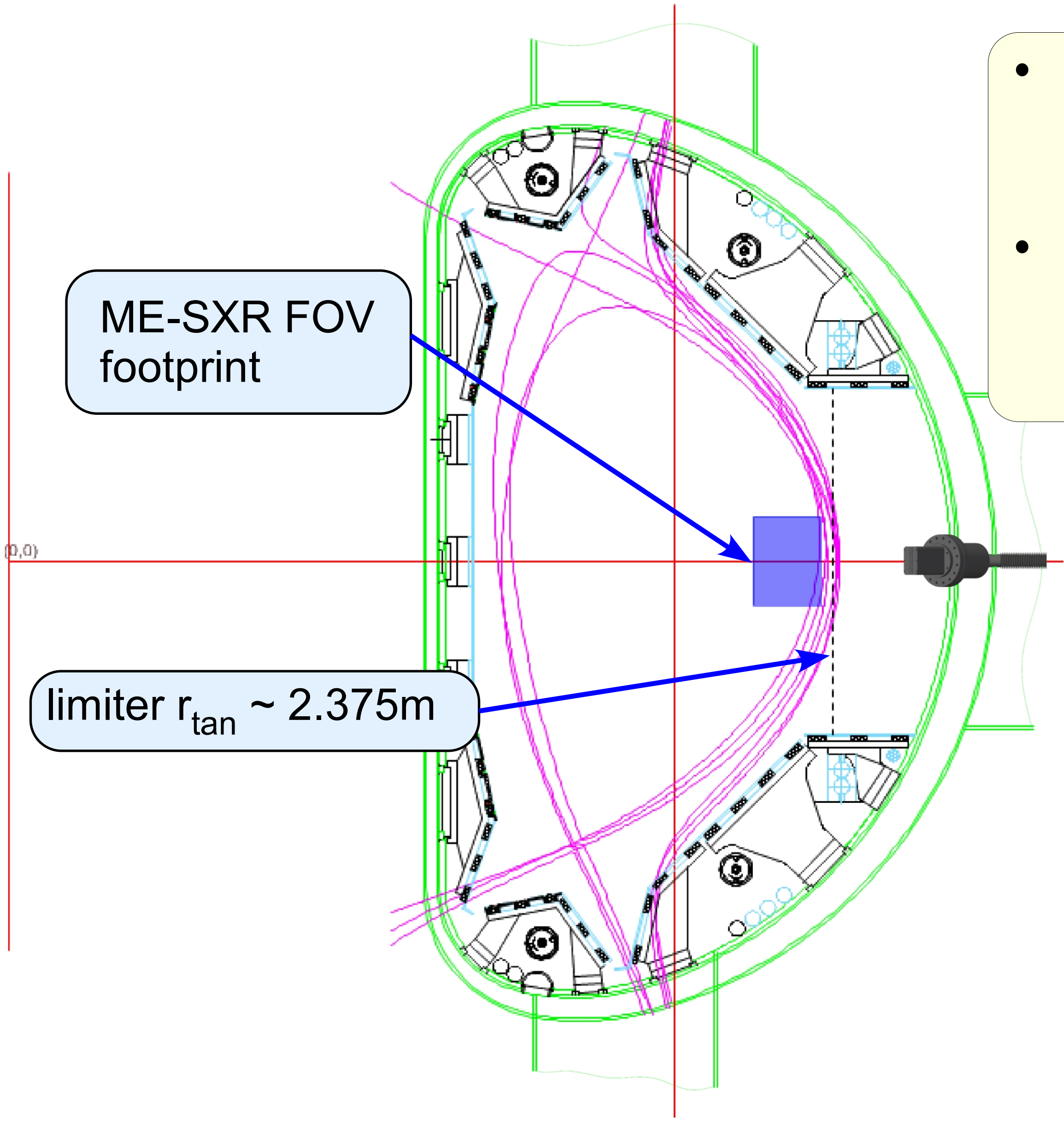
- SXR profile begins to flatten
- strong steepening of edge emission profile prior to crash (possible C accumulation?)

Atmospheric re-entrant ‘in-vessel’ design necessary to accommodate EAST port geometry



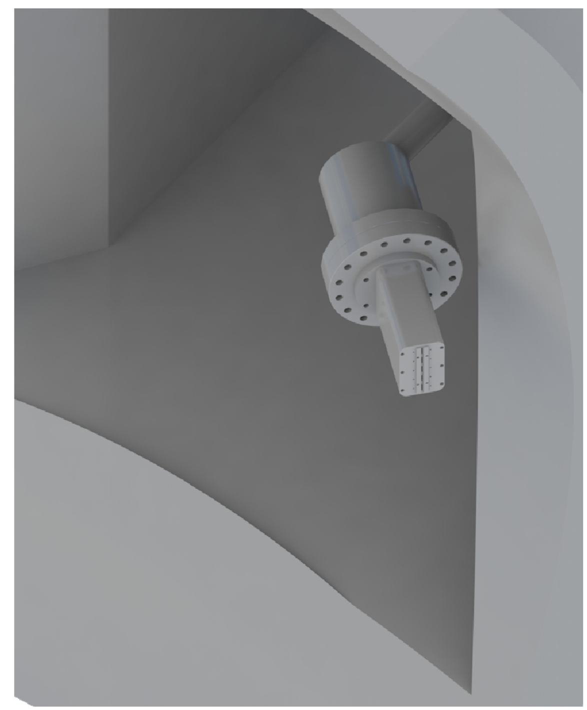
EAST partial top view

ME-SXR assembly to be mounted at mid-plane on port side wall



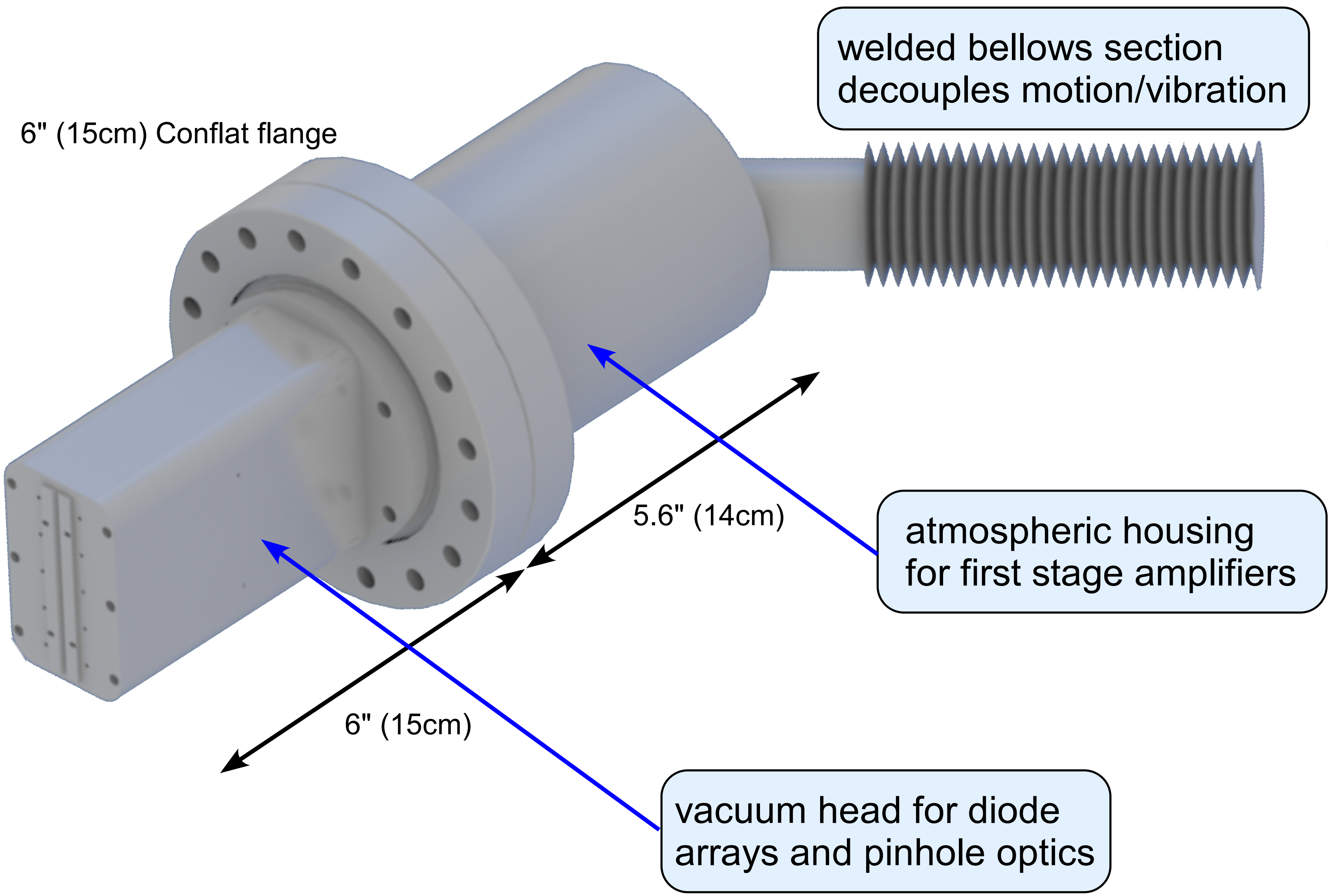
EAST side view

- ME-SXR provides coverage from edge to mid-radius
- FOV footprint in plasma can be adjusted by changing mounting position/angle

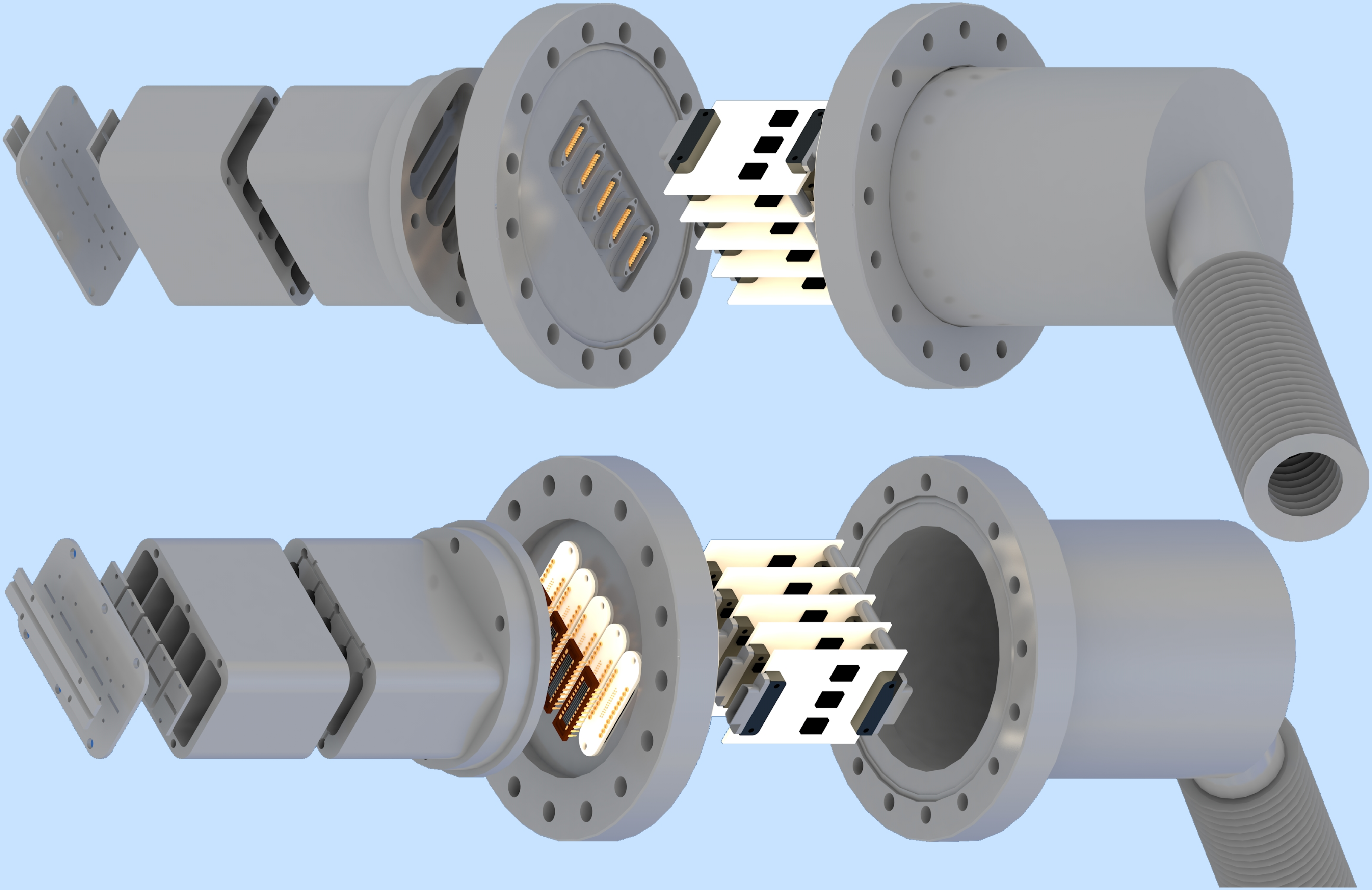


3D view of ME-SXR

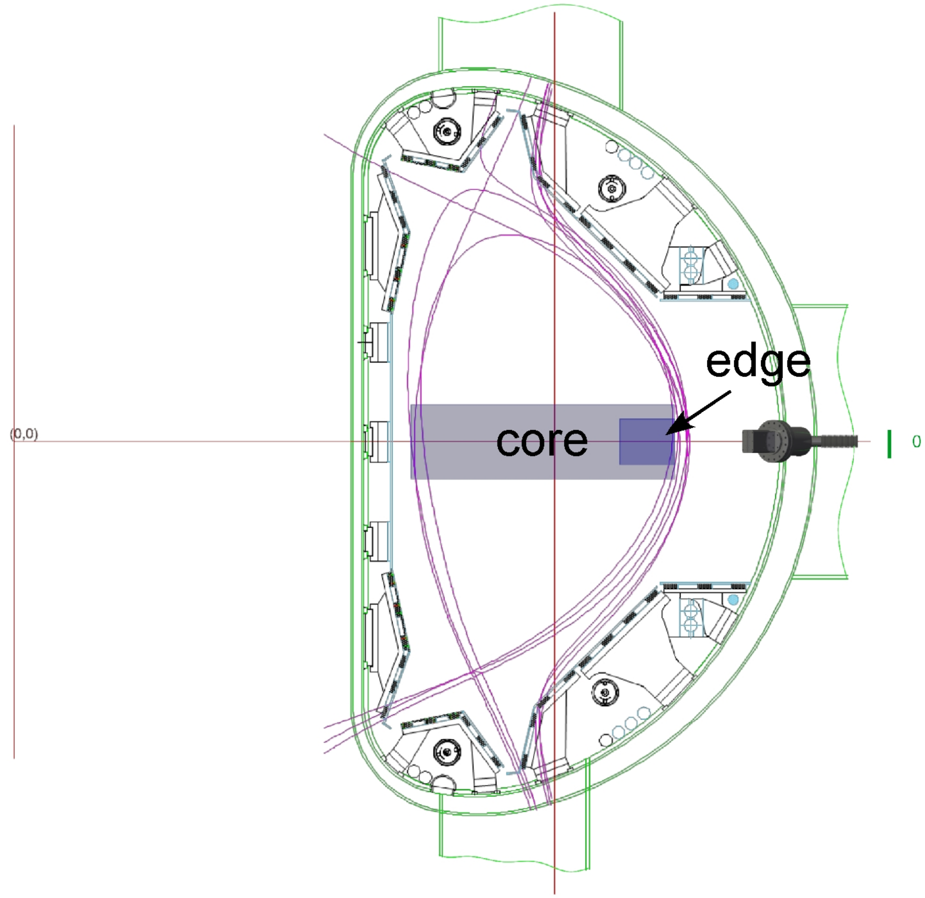
In-vessel housing provides compact system for ease of mounting

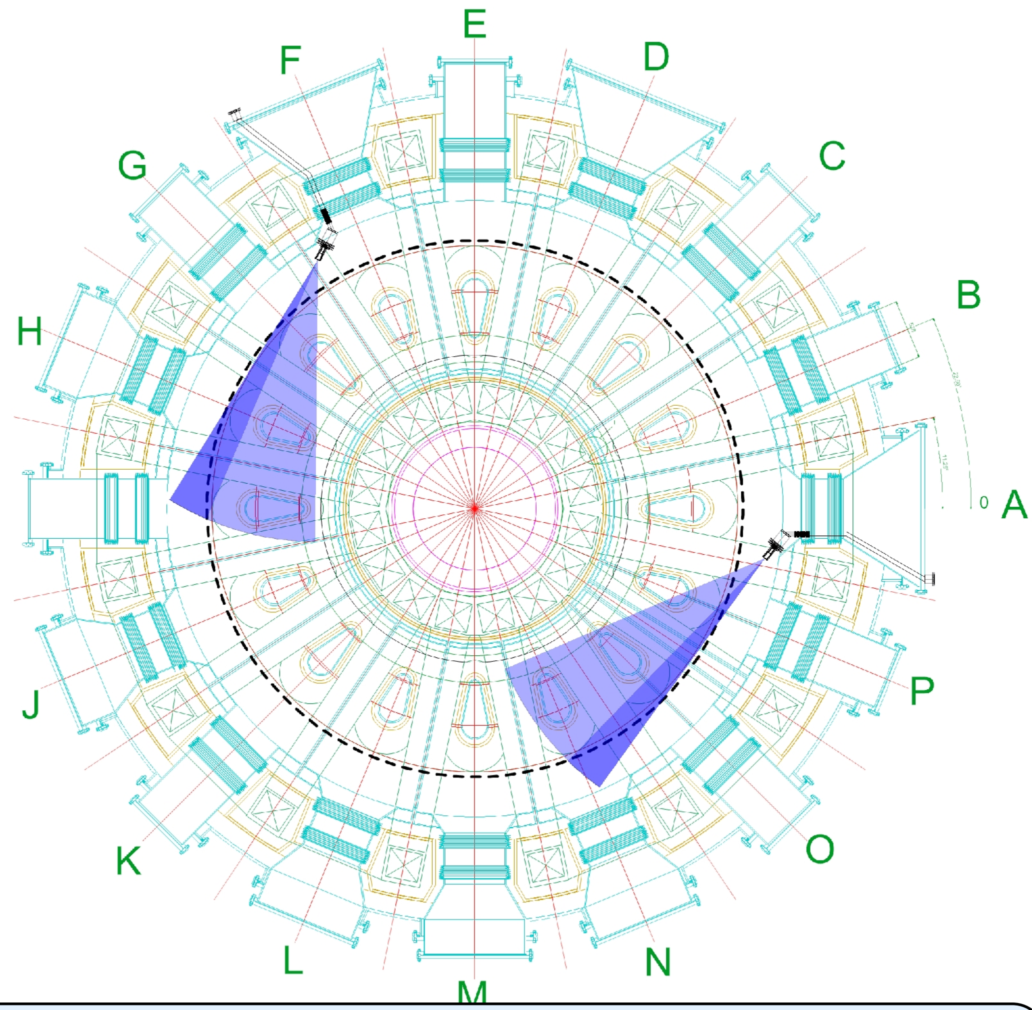


Expanded view of ME-SXR assembly



Toroidally-displaced core/edge ME-SXR systems currently proposed for EAST under DOE international solicitation



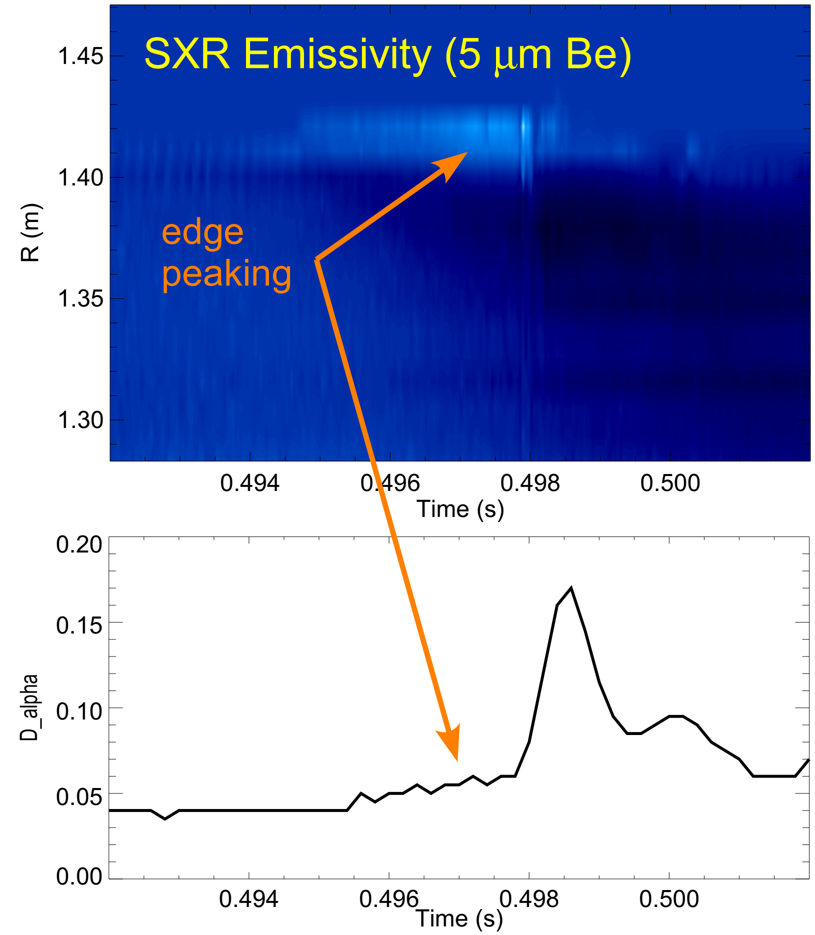


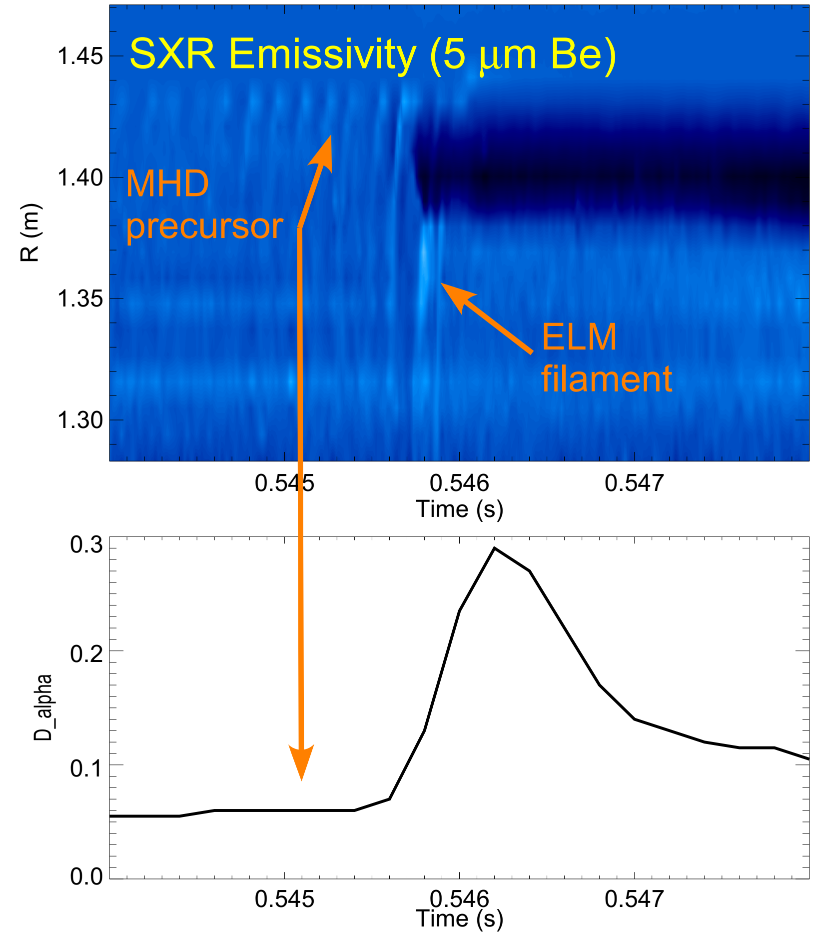
- ME-SXR proposed in "International collaboration to advance the three dimensional science of stability and control for long-pulse, high-performance tokamaks" Gates/Sabbagh

- System designed to study lithium effects on ELM and MHD/NTM behavior, disruption pre-cursors and thermal quench, and positioned to study effects of planned 3D coils on plasma

Thank You

Time/spatial resolution of ME-SXR allows investigation of different ELM cycle dynamics



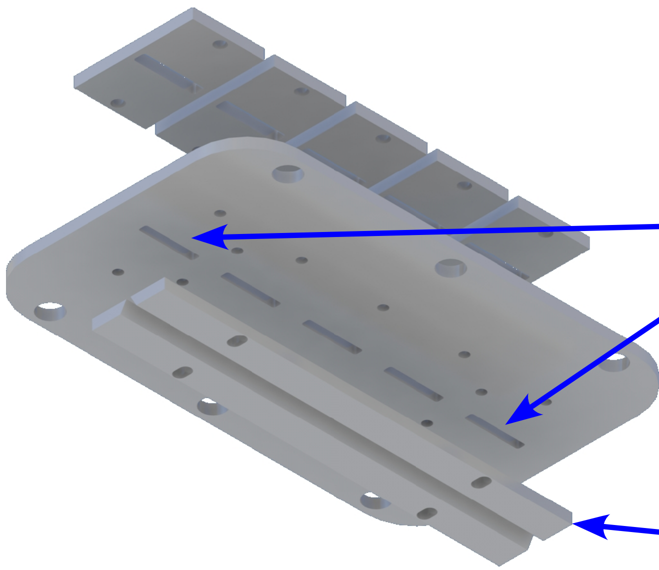


- MHD precursor leads to profile flattening, edge peaking of SXR
- ELM causes broad profile crash

- MHD precursor leads to large ELM filament
- ELM crash limited to edge

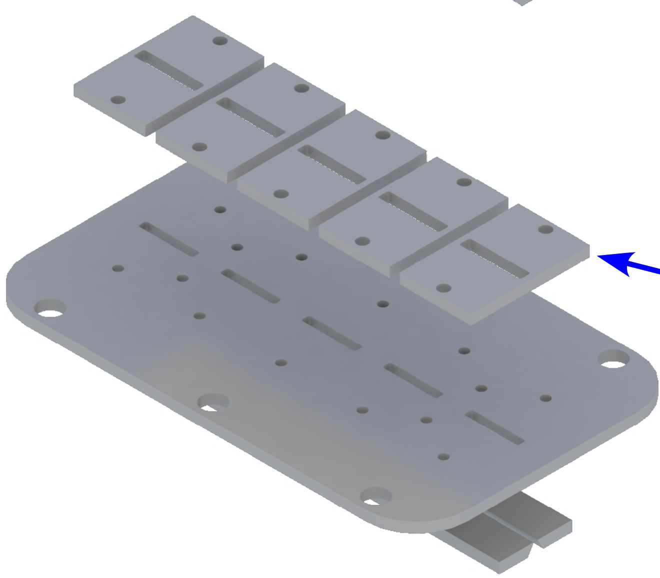
Pinhole assembly provides separate apertures for each diode array

material: 303/304 Stainless Steel



5 pinhole apertures
1.5mm x 10mm

rails with knife edge allows
adjustable widths (0.5-1.5mm)

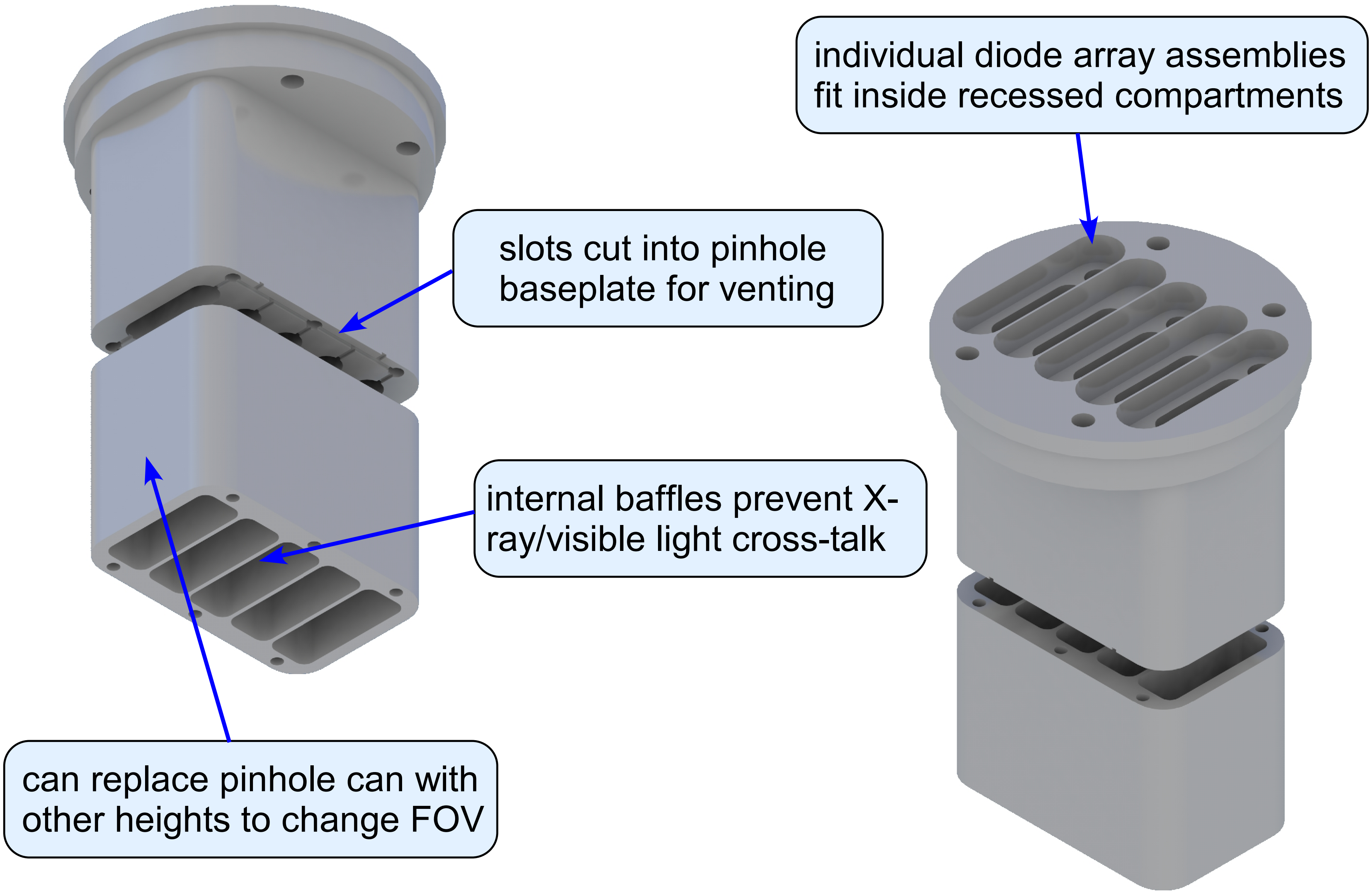


filter plates can sandwich metal foils
or use directly deposited filters
(preferred, Lebow Co.)

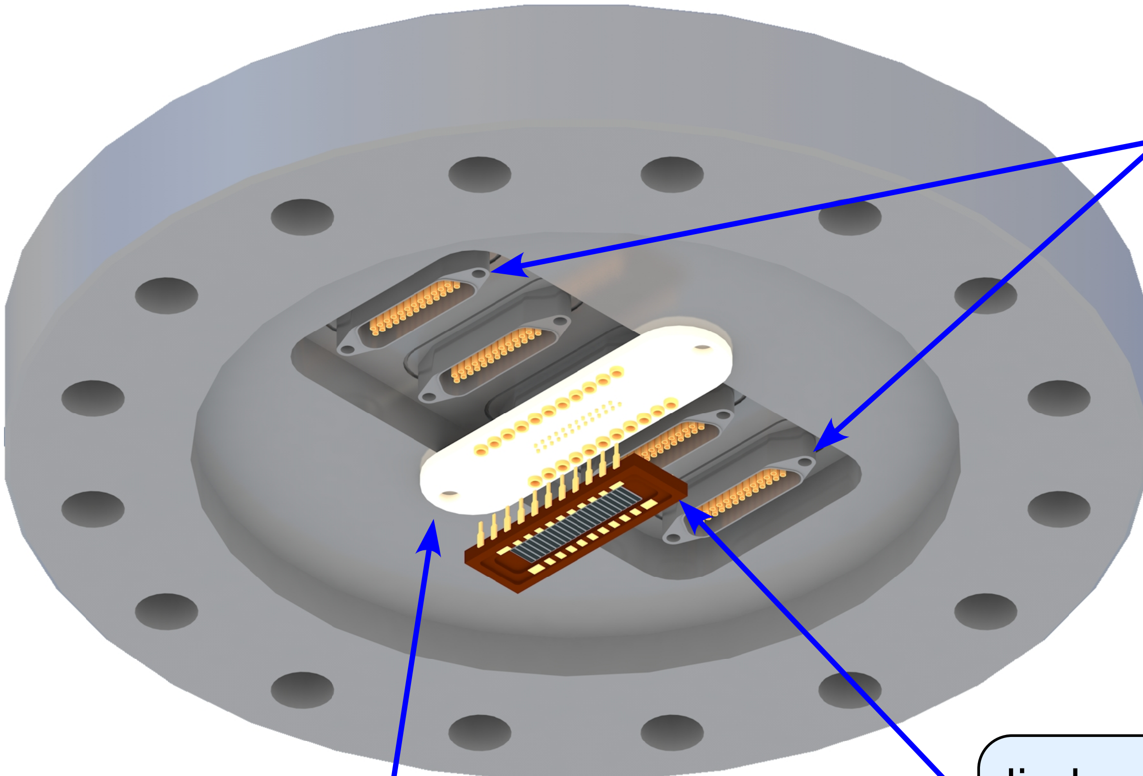
sample filters:
0.3 μm Ti
5 μm Be
15 μm Be
50 μm Be

Pinhole can assembly uses separate compartments to eliminate cross-talk between arrays

material: 303/304 Stainless Steel



Conflat flange uses 25 pin MicroD vacuum feedthroughs

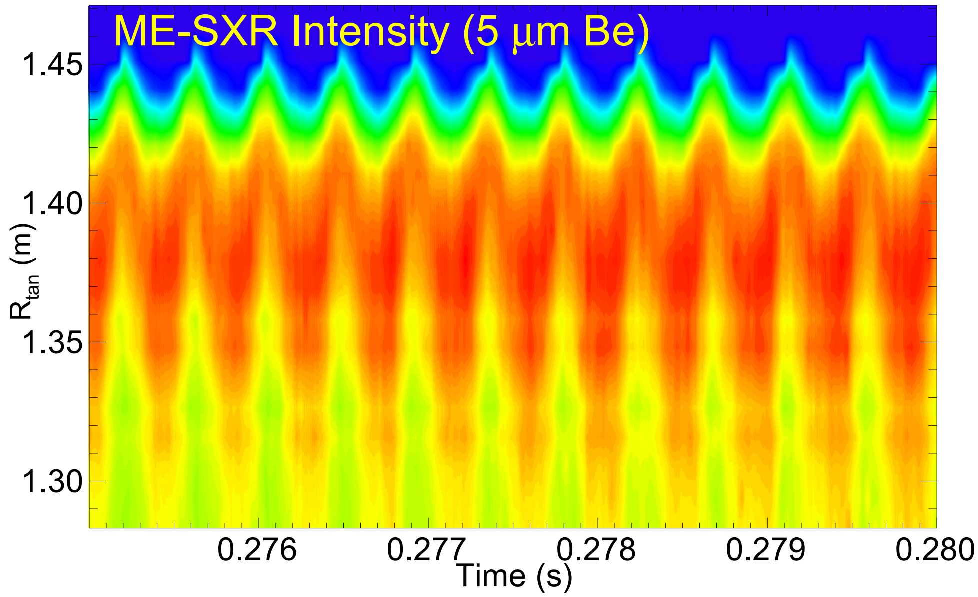


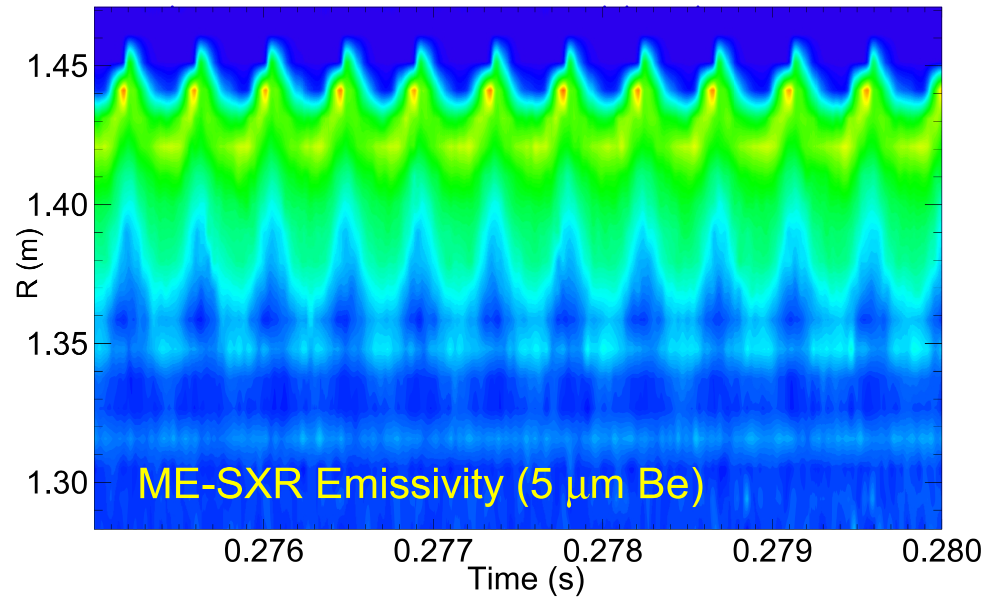
5x 25 pin MicroD feedthroughs for mounting diode array PCB assembly

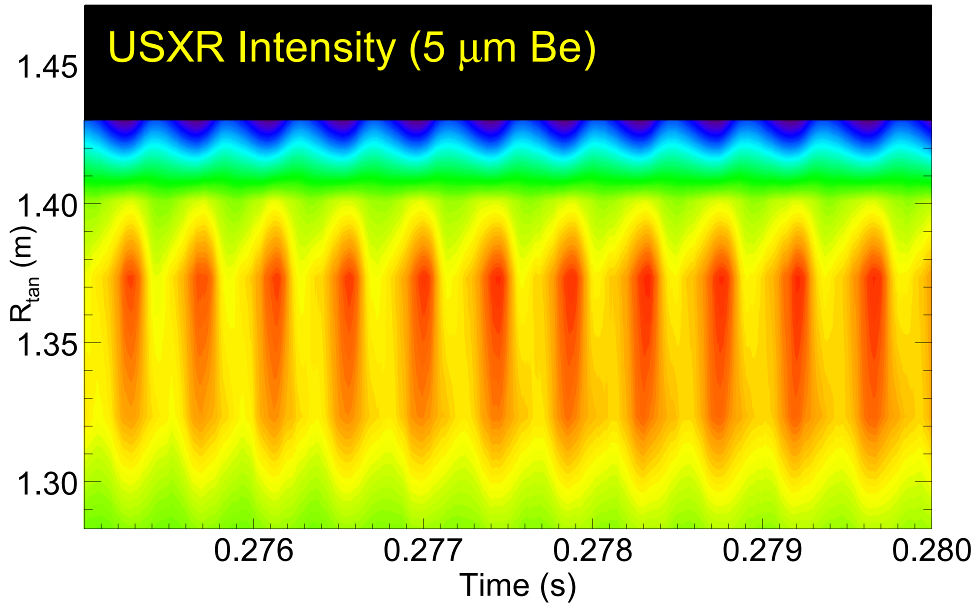
diode arrays plug into DIP socket of PCB adapter

elevated area provides mounting surface for PCB adapter

High spatial resolution measures strong localization of emission during edge MHD activity



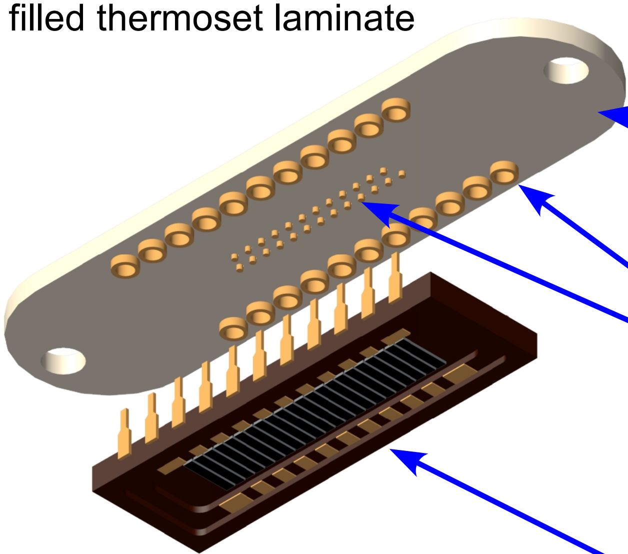




- Inversion shows highly localized MHD, Δr~1cm SXR emission near edge (possible carbon accumulation?)
- High spatial resolution and Abel inversion provide advantages over poloidal USXR system

PCB diode adapter uses low-outgassing laminate material

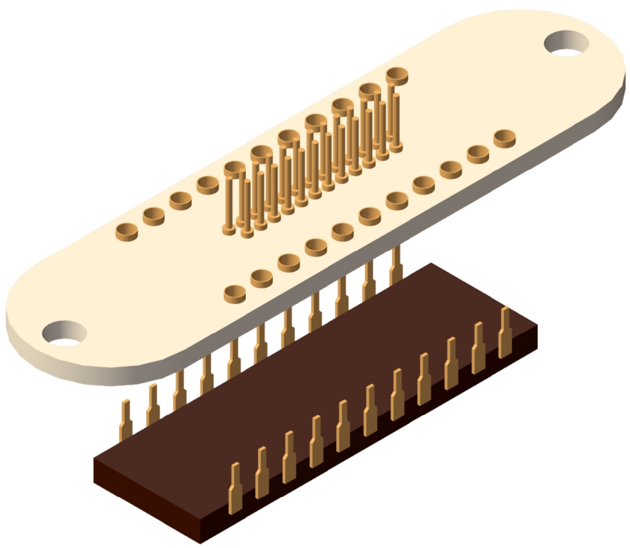
RO4003 glass woven/ceramic
filled thermoset laminate



custom PCB adapter uses Rogers 4003 laminate (RO3003 used in NSTX, RO4003 used in LTX)

Mill-Max pin/sockets used for DIP22 to MicroD25 adapter layout

AXUV20 diode array from OptoDiode (formerly IRD Inc.) 20x 0.75mm x 4mm elements



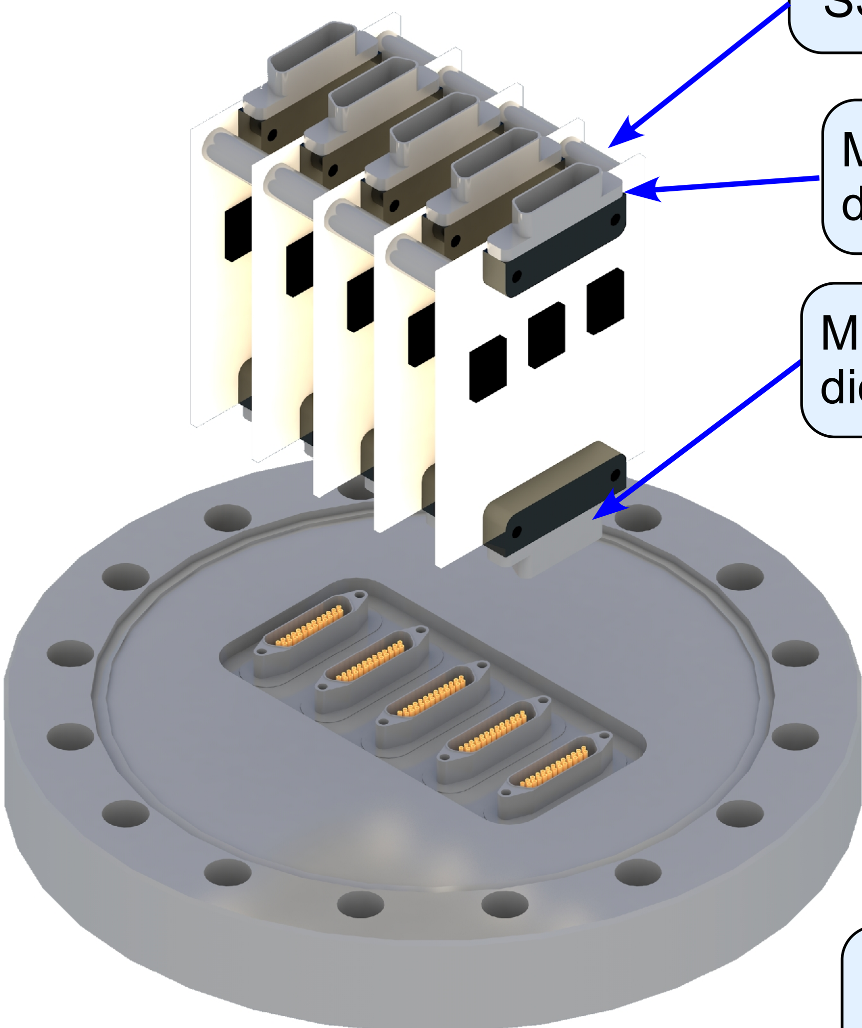
system bakeable up to 125-150 °C

Materials outgassing comparison (NASA)

Material	%TML	%CVCM	%WVR
RO4003	0.06	0.00	0.02
Vespel	1.0	0.00	0.40
PEEK	0.14	0.00	0.05
FR4	0.3	0.01	0.1
LCP	0.06	0.01	0.01

TML = total mass loss
CVCM = collected volatile condensable materials
WVR = water vapor regained

Switch to MicroD connectors allows compact stacking of first stage amplifier boards



SS spacers provide rigidity to amplifier stack

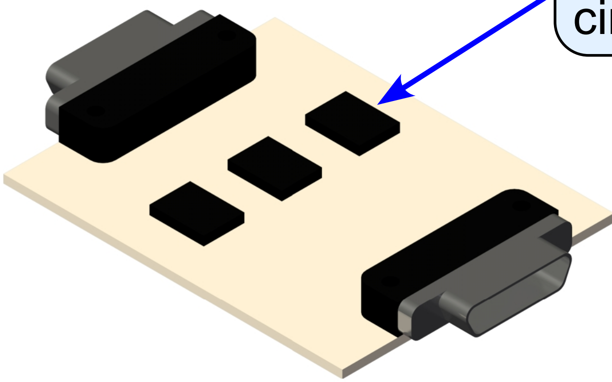
MicroD cable connection carries V+, ground, diode bias, gain control (x3), 20 amplified signals

MicroD feedthrough connection carries ground, diode bias, signals from diode array (x20)

diagnostic ground from connector shield isolated from machine ground on feedthrough shield

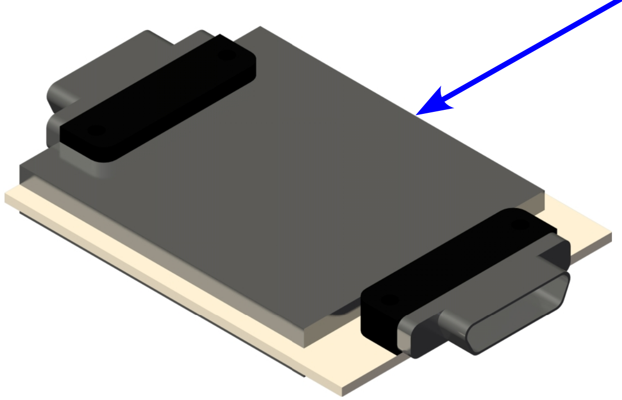
use low-outgassing materials in case leak requires evacuation of ME-SXR system (RO4003 PCB, LCP/SS MicroD connectors)

Initial amplifier system similar to NSTX/LTX circuit design



larger board layout provides room for enhanced power circuitry and MicroD connectors for robust mating

multi-channel variable gain transimpedance amplifiers provide signal flexibility

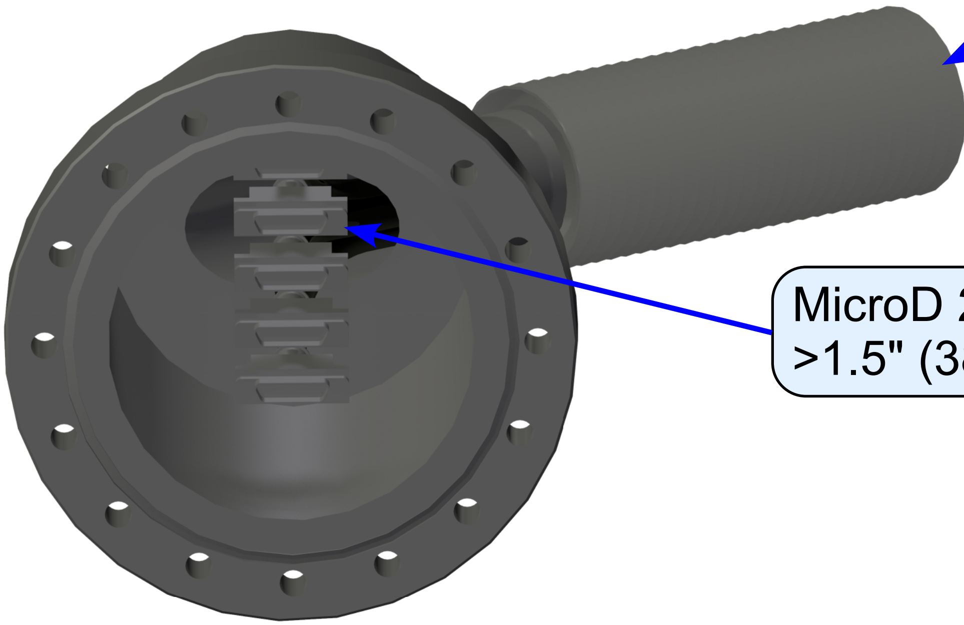


option for EMI shielding of first stage amplifier circuits under consideration

Two other modifications under development

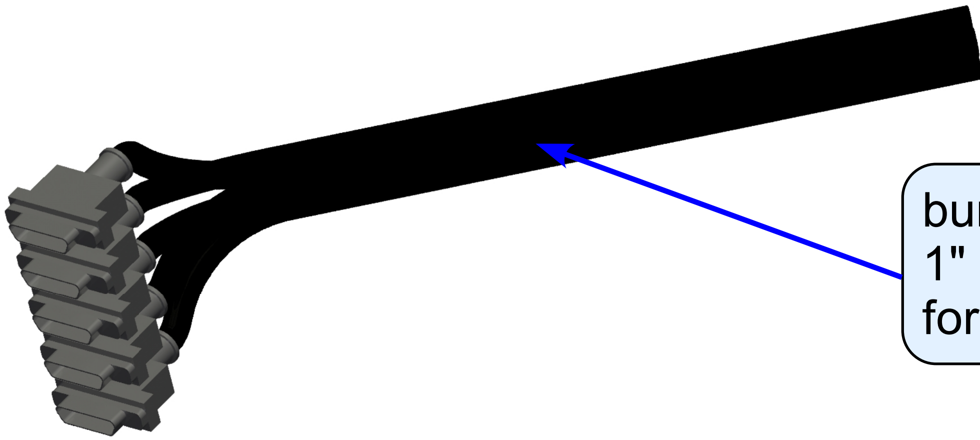
- on-board ADC: convert to serial output
  5x MicroD 25 cables $\Rightarrow$ 1x MicroD 31
- use UHV ICs and connectors for first-stage, in-vacuum amplification (requires cooling)

5x MicroD 25 cabling carry amplified signals to second stage electronics



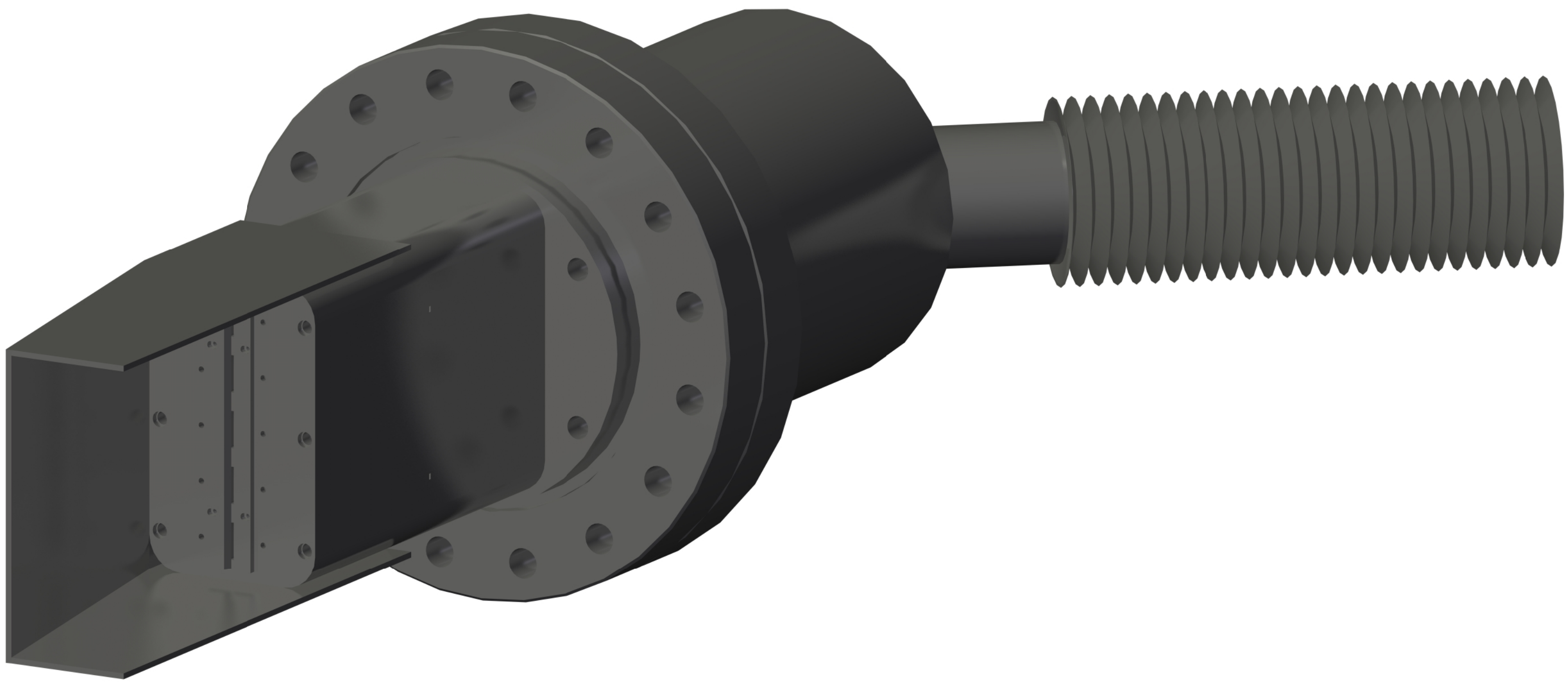
welded bellows needed to retract housing for cable to PCB assembly

MicroD 25 cable connectors require >1.5" (38mm) dia. conduit for clearance



bundle of 5x MicroD 25 cables fit within 1" (25mm) I.D. conduit with clearance for compressed air line for cooling

Line-of-sight shielding protects filters from lithium deposition and sputtering



complete shuttering of view would be preferable though may be difficult given port access