

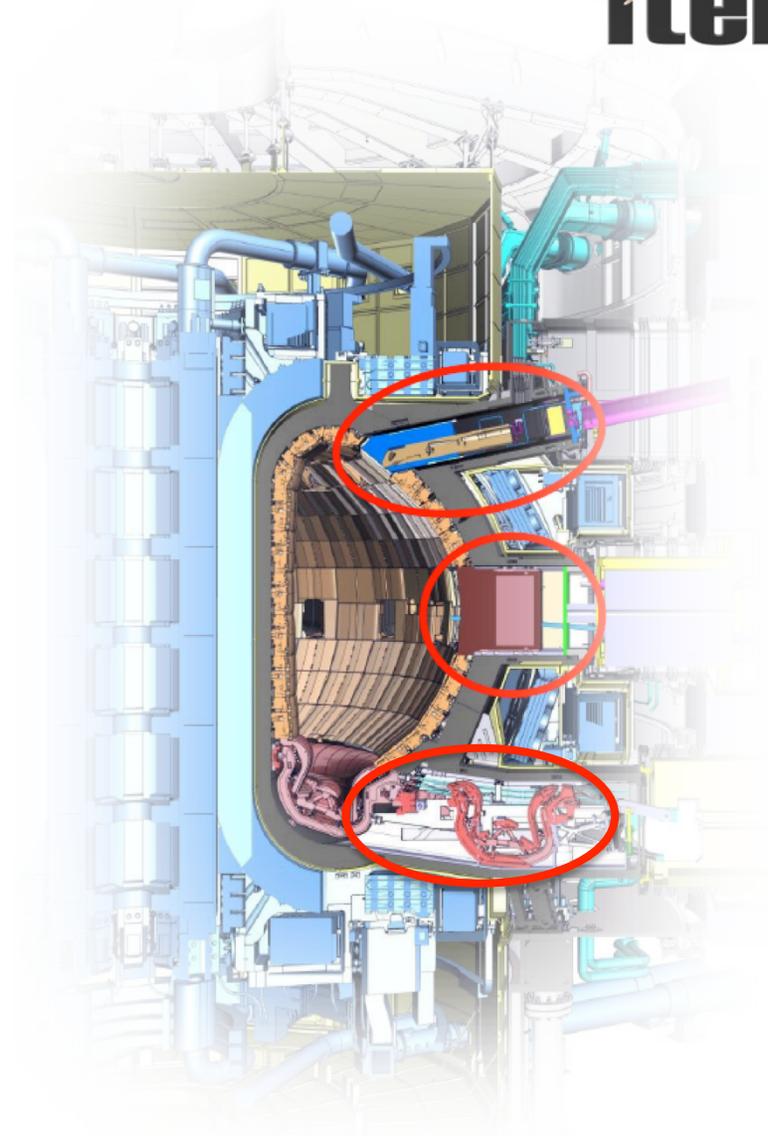
Status of US ITER Diagnostics

B. Stratton – PPPL

55th Annual Meeting of APS DPP

November 13, 2013

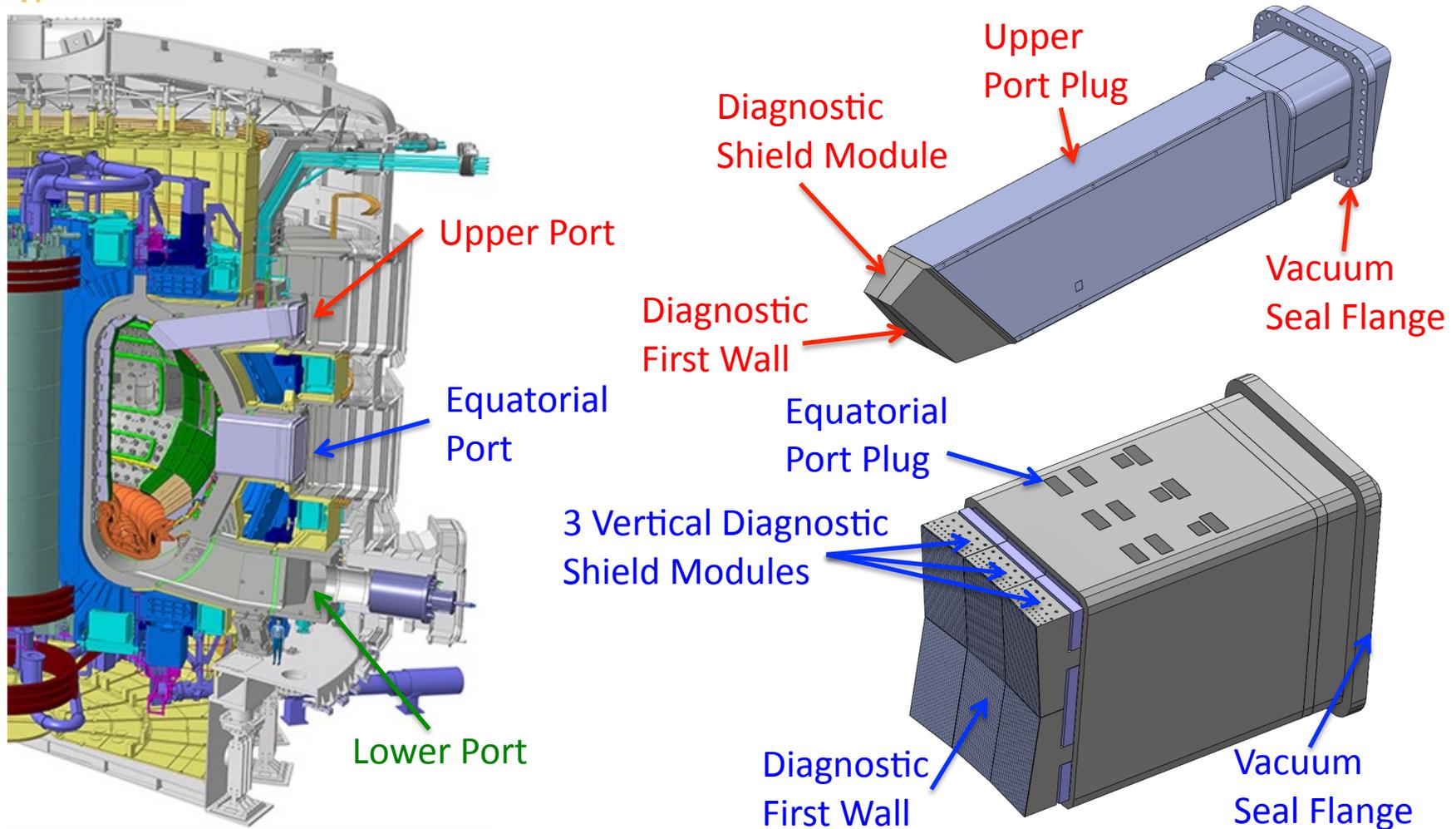
Denver, CO



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US Will Provide 4 Port Plugs & 7 Diagnostics

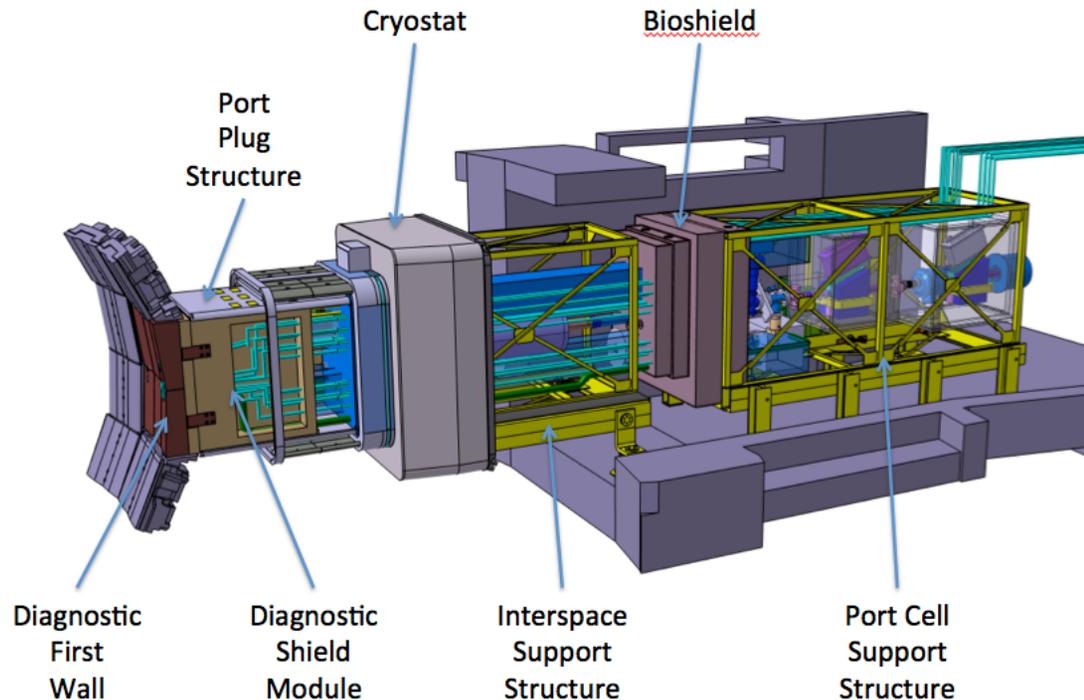


- Port Plugs provide vacuum boundary, shielding, and diagnostic support
- Vertical Drawers in Equatorial Port Plug simplify diagnostic integration and reduce disruption forces

Diagnostic Integration Challenges

Unique ITER Environment
[relative to Joint European
Torus (JET)]

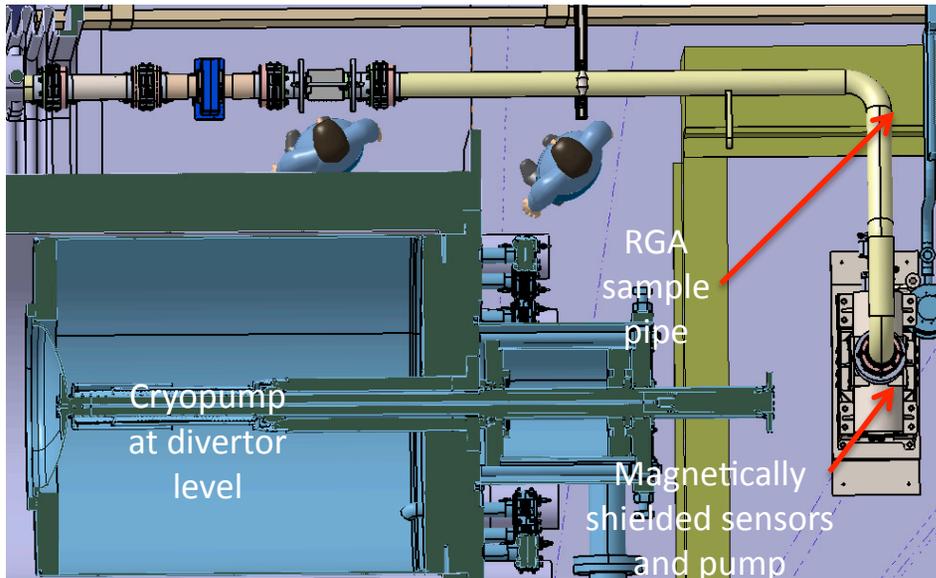
- Neutron and gamma fluxes (up to x10)
- Pulse length (up to x100)
- Neutron fluence ($>10^6$)
- Neutron heating (1MW/m^2) (essentially 0 on JET)
- Charge exchange (CX) neutral particles (up to x5)



For status of US diagnostic integration see Poster UP8.00012 Thursday afternoon

- Space constraints in Diagnostic Shield Module and on port plug closure plate
- Provision of adequate radiation shielding for diagnostic components and to meet shutdown dose rate requirements
- Compensation for vessel motion due to temperature changes and disruptions
- High reliability required with few opportunities for maintenance
- Maintenance strategies
- Design/qualification of shutters
- Design/qualification of windows (IO)
- Development of in situ calibration techniques
- Development of mirror cleaning techniques
- Mitigation of damage from stray microwave radiation

Residual Gas Analyzer (RGA)



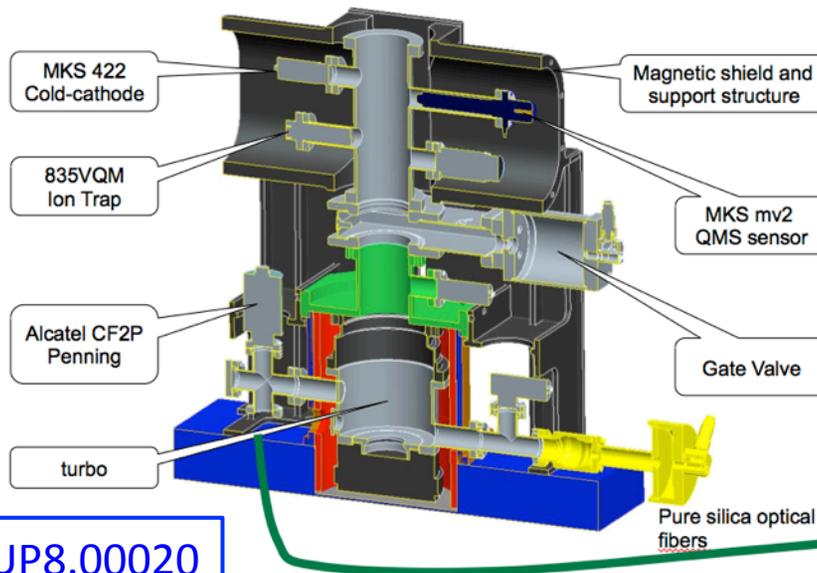
- Measures concentrations of H/D/T and higher mass species during discharge
- Samples gas from pumping ducts and equatorial port

Specific Technical Challenges

- Survivability of sensor electronics during DT
- Accommodating tritium line breaks for maintenance

Specific R&D Issues

- Qualification of ion trap sensor
- Validation of pressure range for optical Penning Gauge



Poster UP8.00020

Low Field Side Reflectometer (LFSR)

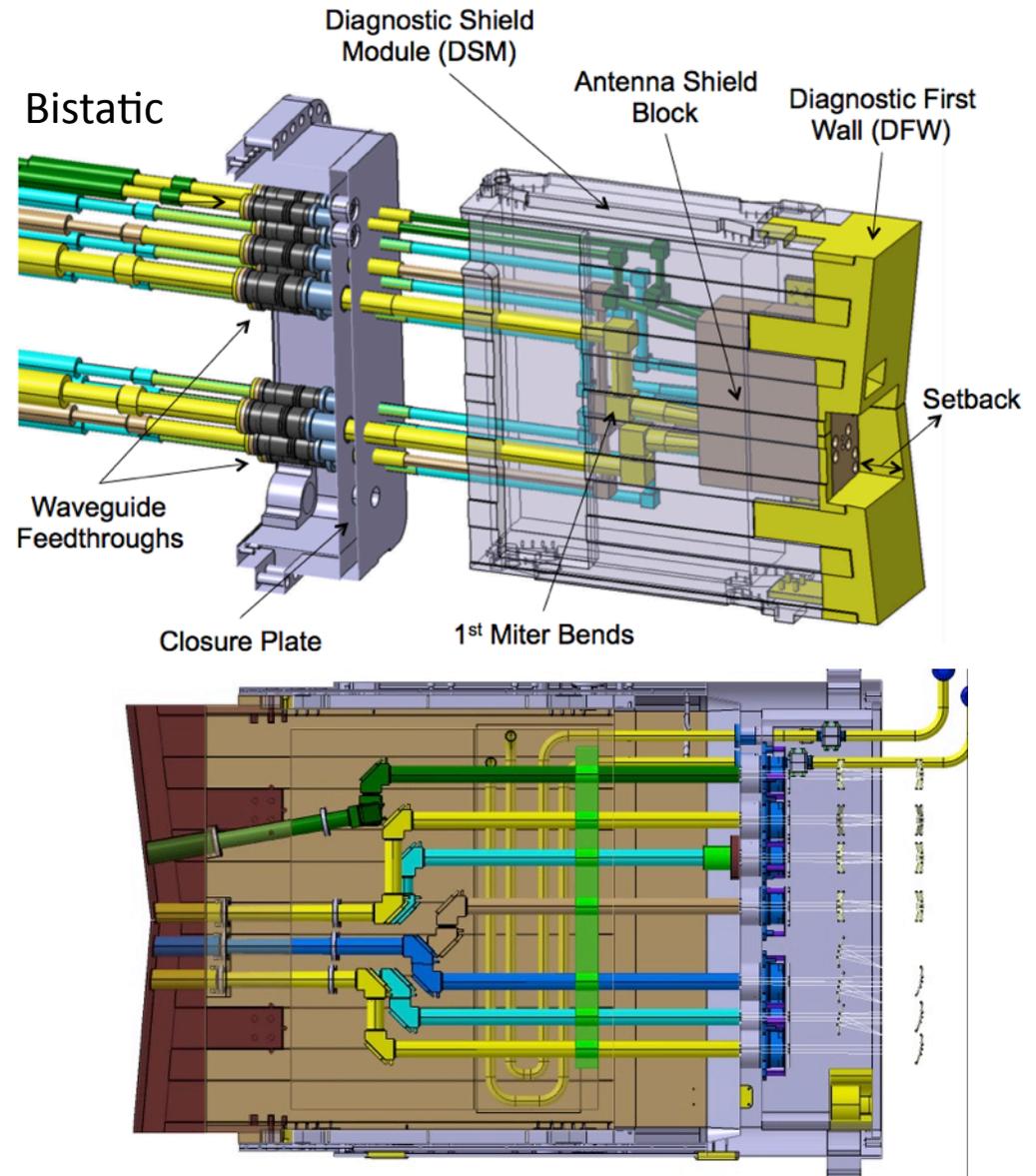
- Measures edge n_e profile and fluctuations
- Monostatic waveguide approach chosen – relieves crowding in port plug and adds capability

Specific Technical Challenges

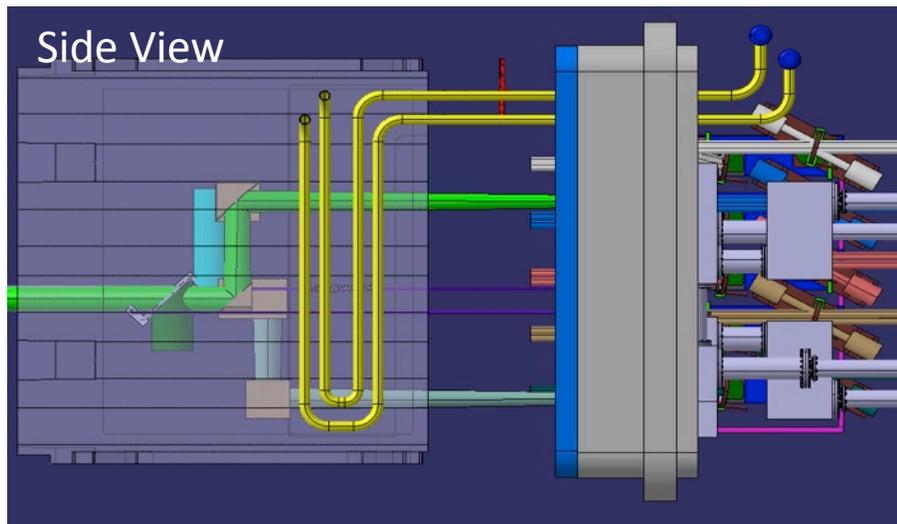
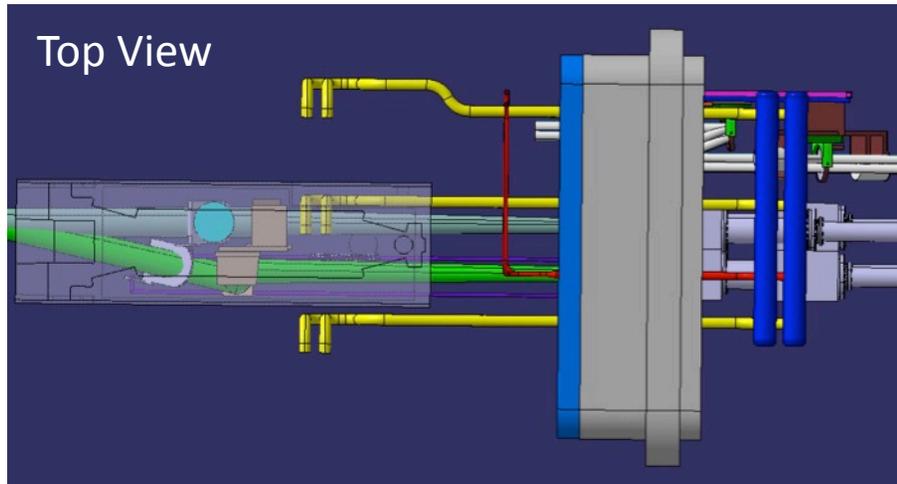
- Optimization of antenna geometry to maximize capability
- Transmission across vacuum boundary

Specific R&D Issues

- Qualification of waveguide corrugation design
- FPGA – based data acquisition/ analysis



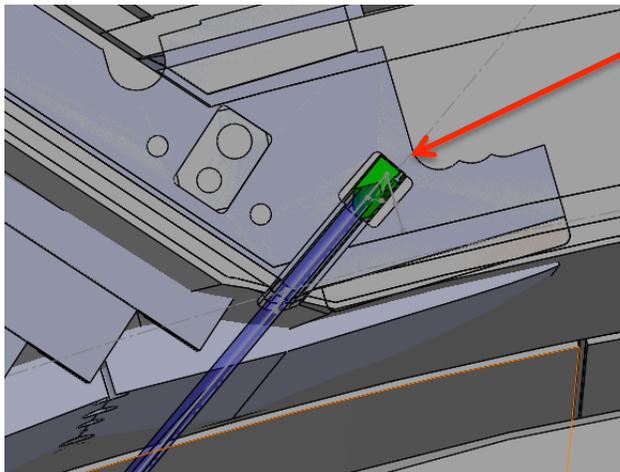
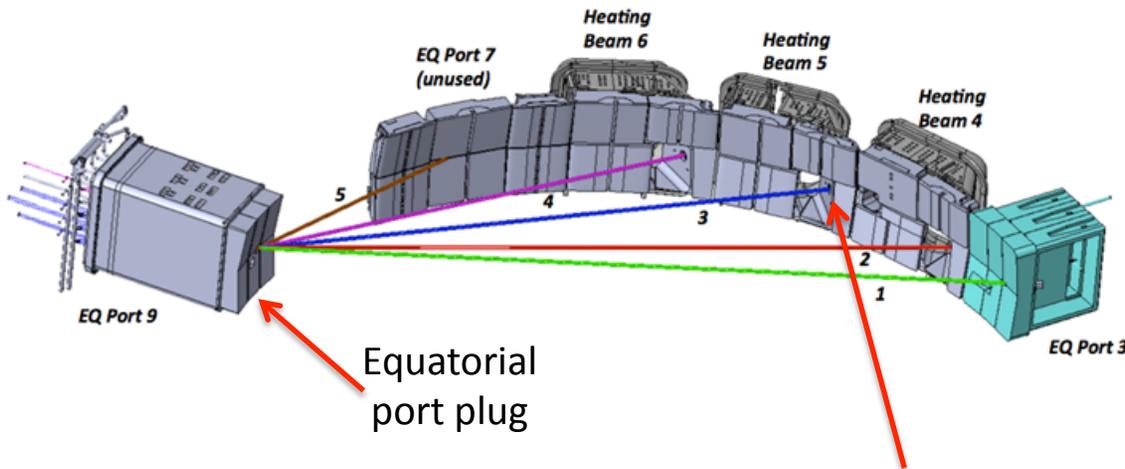
Electron Cyclotron Emission (ECE)



- Measures core T_e profile
- Diagnostic scope shared with India
- O-mode radiometer (IN), O-mode Michelson interferometer (IN), and X-mode radiometer (US)
- US provides diagnostic front-end

Specific R&D Issues

- Qualification of calibration hot source (US)
- Qualification of transmission line for wide bandwidth (IN)



Retroreflector in pocket in beam duct blanket – passively cooled to facilitate remote handling

- Two-color system with 5 toroidal chords in midplane measures line average n_e

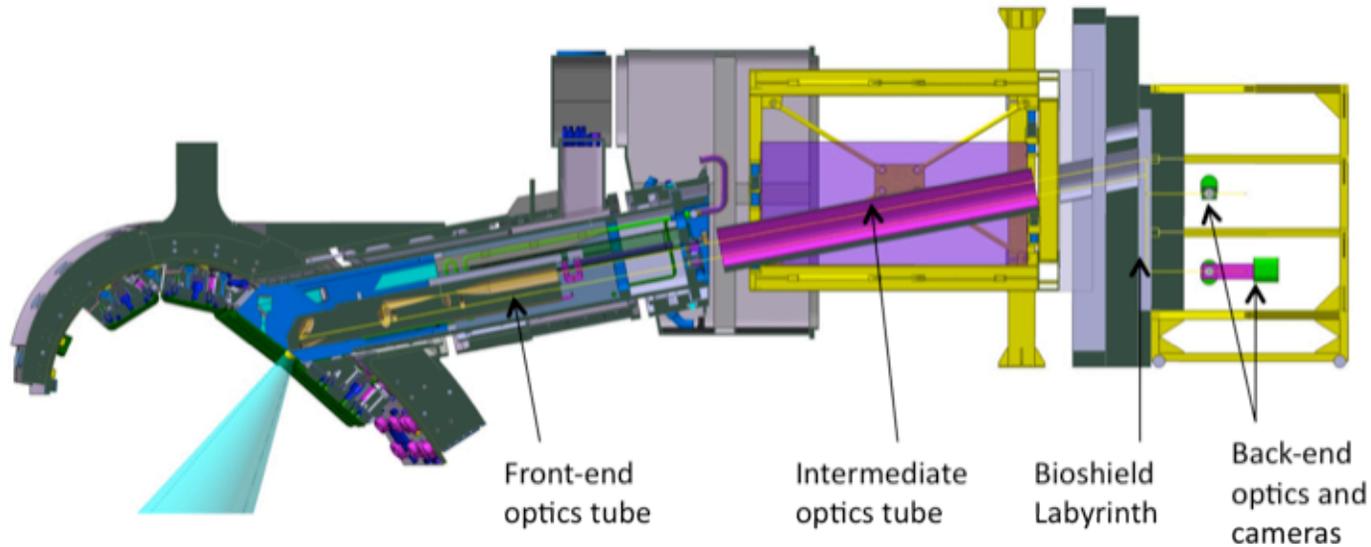
Specific Technical Challenges

- Minimizing optical distortion for plasma-facing optics
- Complex interfaces with blankets for retroreflectors

Specific R&D Issues

- Finite-offset vs zero-offset beams
- Prototype real-time alignment
- Prototype retroreflectors

Upper Visible/IR Cameras



- Measures divertor temperature
- Views divertor from 5 upper ports

Specific R&D Issues

- Real-time image analysis capability
- Sensor development

Motional Stark Effect (MSE)

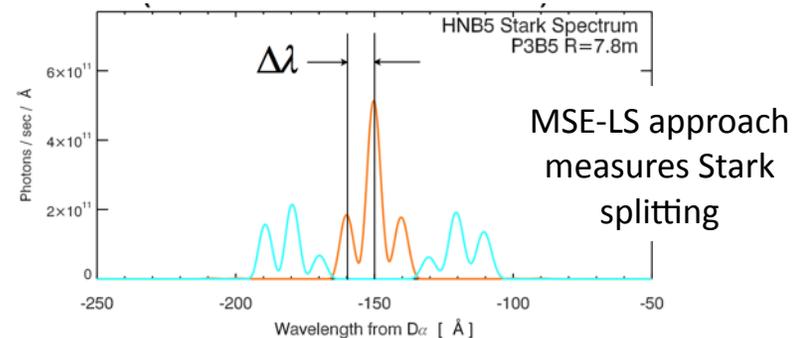
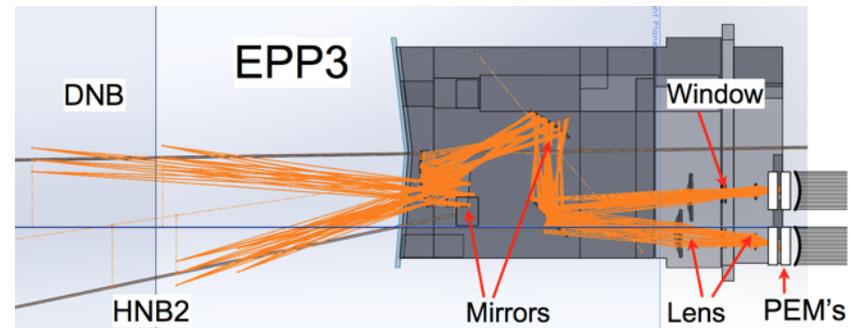
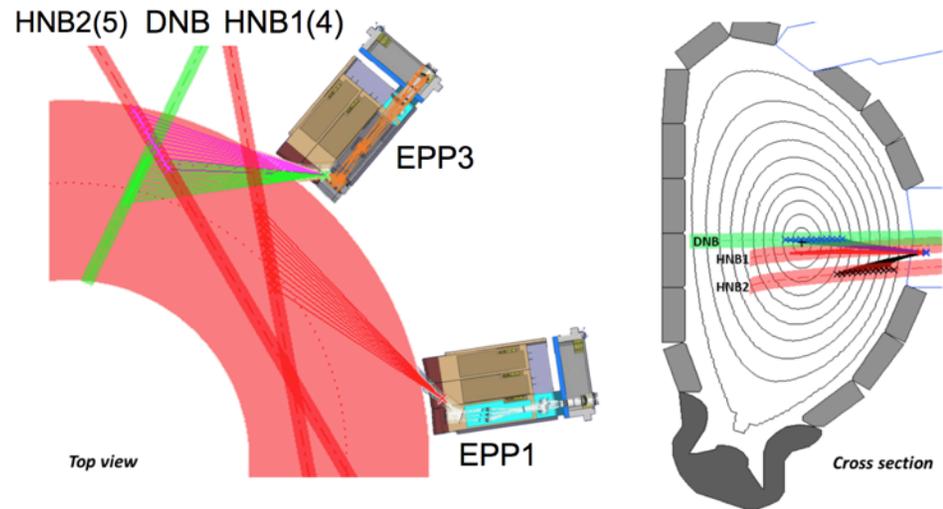
- Polarimetry measurement of pitch angle (MSE-LP) & line shift measurement of $|\mathbf{B}|$ (MSE-LS)
- Views from 2 equatorial ports provide good spatial resolution

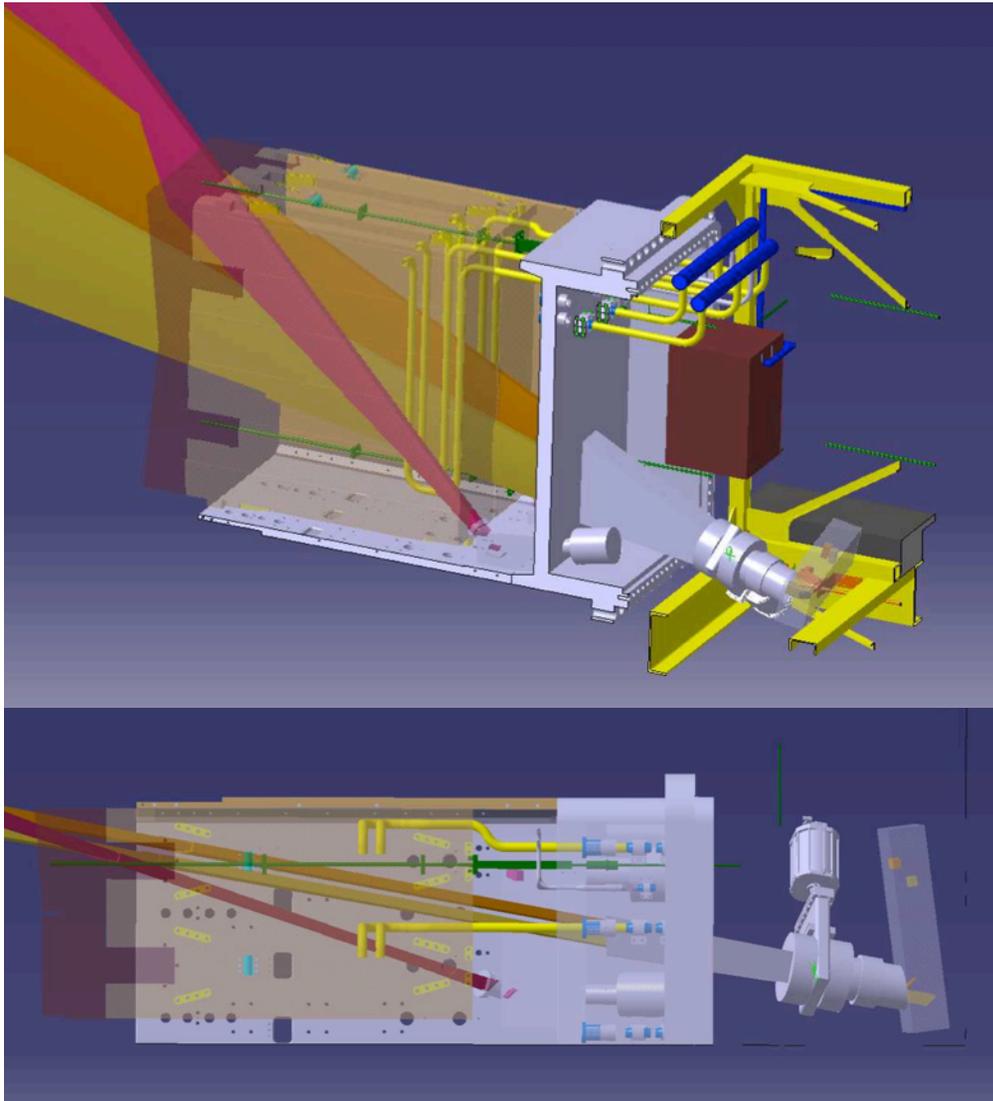
Specific Technical Challenges

- High stray background emission
- Uncertainty regarding drifts in energy distribution of beamlets

Specific R&D Issues

- Calibration of MSE-LP
- Qualification of MSE-LS approach on existing device





- T_i and velocity profiles out to $r/a \sim 0.8$ measured by spectrometers inside and outside port plug

Specific Technical Challenges

- Survivability of internal detector
- Uncertainty of intrinsic impurity levels
- Temperature control of crystals

Specific R&D Issue

- Radiation hardened detectors

Good Progress is Being Made

- PPPL is responsible for delivering US ITER Diagnostics and port plug integration

Port Plugs	CDR or SIR	PA	PDR	Provider or Design & Fabrication Subcontract Award Target
Upper Port 11	x	x	Apr-15	
Upper Port 14	x	x	Apr-15	
Equatorial Port E3	x	Jan-14	Oct-15	
Equatorial Port E9	x	x	Aug-14	
Diagnostics				
Residual Gas Analyzer	x	x	x	ORNL
Low Field Side Reflectometry	x	x	Mar-15	Nov-13
Electron Cyclotron Emission	x	x	Oct-15	Feb-14
Toroidal Interferometer/Polarimeter	x	x	Nov-15	Mar-14
Upper IR/Visible Cameras	x	x	Sep-15	Feb-14
Motional Stark Effect	x	Jan-14	Jul-15	Aug-14
Core Imaging X-ray Spectrometer	x	Jan-14	Jun-15	PPPL

- R&D needs and technical challenges are well understood.
- Work is ongoing in many areas, focused primarily on front-end design.