

FIRE Diagnostics

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Workshop on Physics Issues for FIRE

PPPL

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Role for the Plasma Measurements

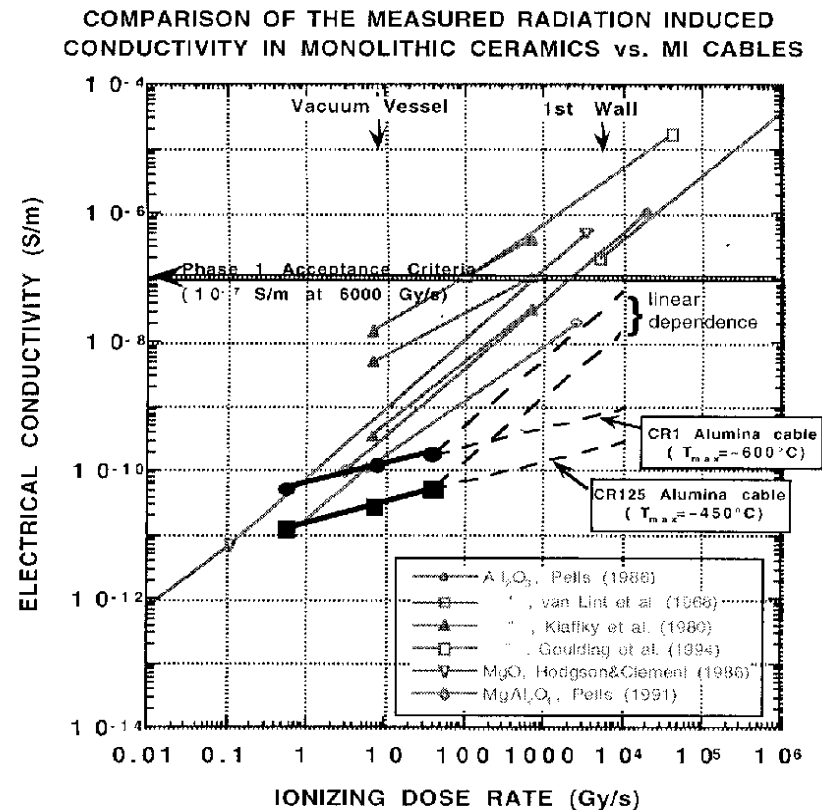
- 1) Provide data for physics studies for the evaluation of plasma performance in D,
- 2) Provide input for real-time plasma control systems,
- 3) Provide first evaluation of plasmas where alpha-particle heating dominates.

Simplified List of Measurements for Input to Control Systems

- Fast Plasma Shape and Position Control:
 - Magnetic diagnostics, IR camera, Thomson scattering
- Kinetic Profile Control, L→H Threshold:
 - Thomson scattering, interferometer, reflectometer, H_{α} -monitor, ECE, CXRS (T_i and He-ash), neutrons,
- Current Profile, Rotation Control:
 - Magnetic diagnostics, Thomson scattering, MSE, CXRS
- Optimized divertor operation:
 - Interferometry, IR camera, bolometry, spectroscopy
- Fueling control:
 - D,T monitoring (edge good enough?)
- Disruption prevention (First-wall/ divertor protection):
 - Magnetic diagnostics (β ; MHD), kinetic profile set

Magnetic Diagnostics: Issues

- Loops, coils, MI-cable must be inside vacuum vessel,
- Maximally unfriendly environment; RIC and RIEMF, temperature, neutral particles,
- No protection like ITER blanket.

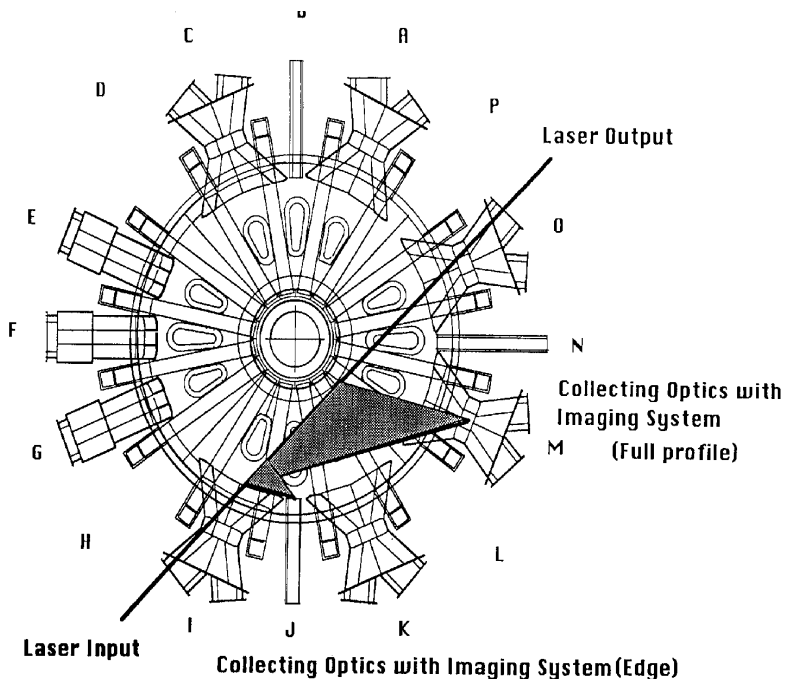


Radiation Effects on Optical Systems

- Radiation discolors/blackens optical components,
- Hence must use reflective optics in high-radiation areas.
- Optical fibers suffer from:
 - Prompt luminescence,
 - Prompt absorption,
 - Long - term absorption damage,
 - Effective change in numerical aperture.
- Running fibers hot only affects the long-term absorption.
- Great disparity in radiation effects on nominally identical fibers.

Thomson Scattering: Issues

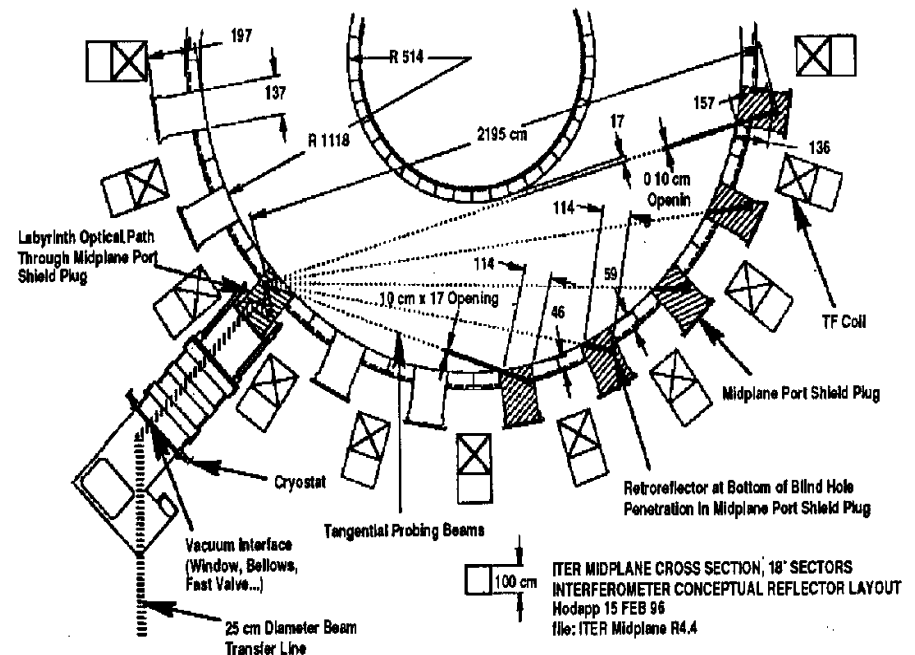
- Imaging system required for spatial resolution (cannot use LIDAR),
- Optical systems need shielding,
- Difficult sightline arrangement; will have to use tangential laser beam, view from nearby port, with close front-end mirror.



KSTAR Concept for TS

Use of Access Ports

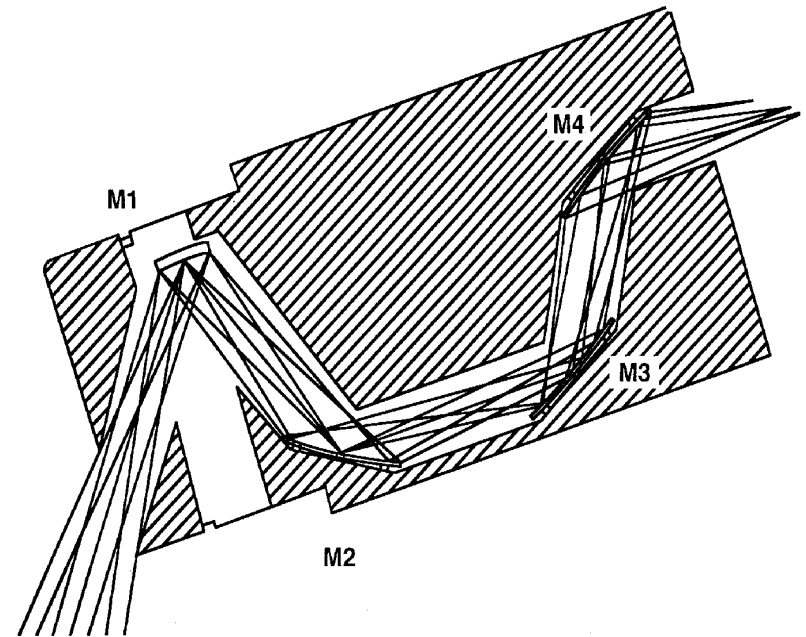
- Extremely good radial access (with shielding),
- Very limited access top and bottom,
- Use top and bottom outer ports for viewing divertors, bolometers, light arrays,
- Use tangential arrangements for interferometry, TS, etc.



CONCEPT FOR
INTERFEROMETER/POLARIMETER FOR ITER

Measurements which presently need a Neutral Beam

- $T_i(r)$, $v_\phi(r)$, $v_\theta(r)$, $q(r)$, $n_{\text{HE-ash}}(r)$, $(E_r(r))$,
- Good poloidal rotation needs opposing views; not possible,
- Diagnostic beam near-radial; penetration at $\sim 100\text{keV/amu}$ problematic,
- Diode beam, $5 \times 10^9\text{W}$ for $< 1\text{ms}$ for CXRS?
- MSE prefers 3 - 400 keV/amu.

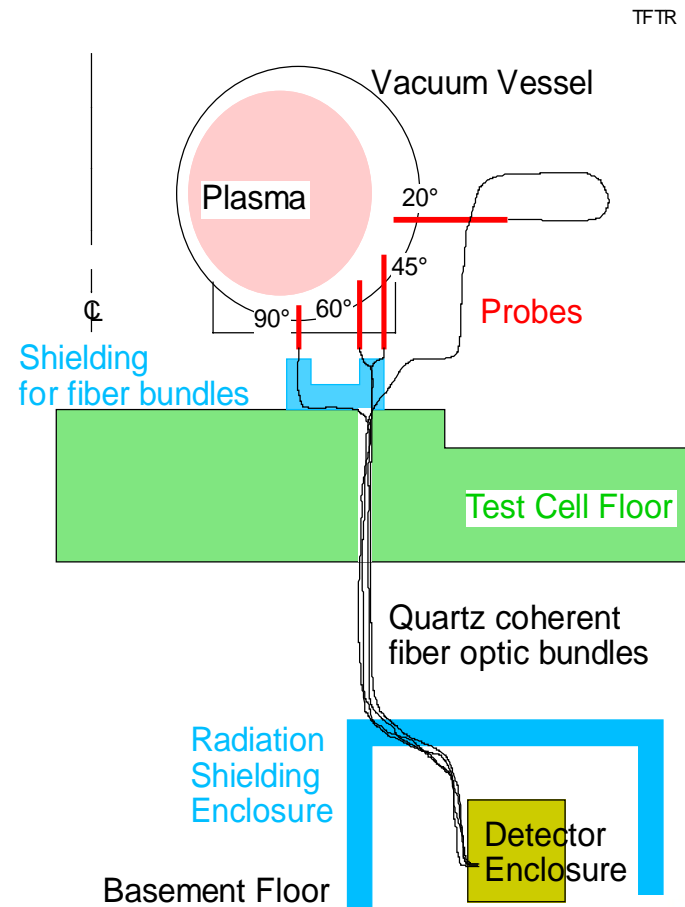


CONCEPT FOR MSE OPTICS LABYRINTH FOR ITER

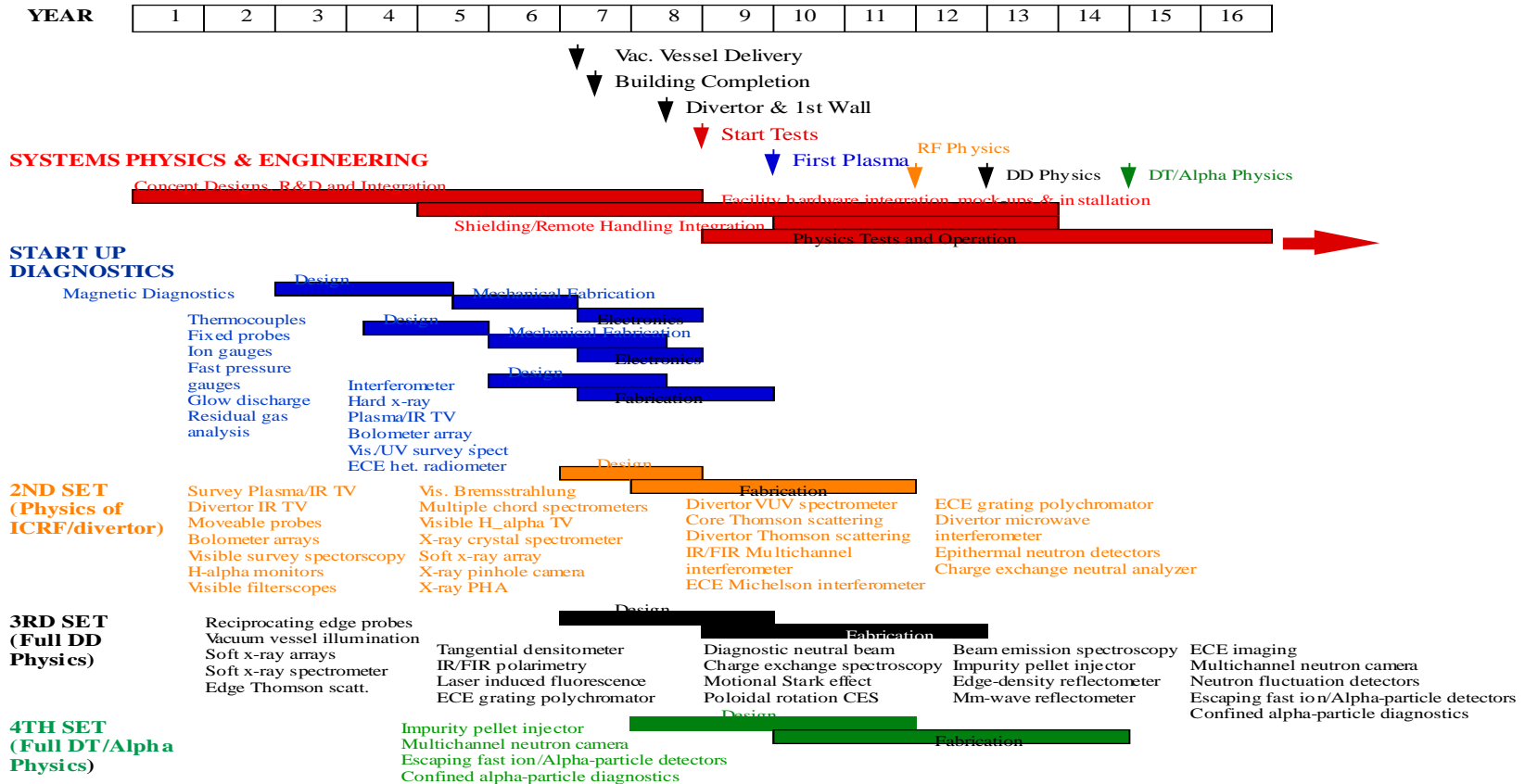
Diagnosics for Alpha-Particle Physics

- Lost fast-ion detectors and IR camera,
- α -CHERS,
- Li-pellet, fast neutral particle analyzer,
- Collective scattering ($\text{CO}_2?$),
- Knock-on neutron,
- New confined- α detector?
- High-frequency Mirnov coils, reflectometry.

TFTR Escaping Alpha Diagnostic



FIRE: Diagnostics Schedule



FIRE DIAGNOSTICS SCHEDULE: REVISION 0

1 SEPTEMBER 1999

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R&D Concerns

- What are impacts of high-field, highly shaped, high- n_e , high radiation, RF-only on diagnostics selection and development?
 - Reliability of magnetic diagnostics?
 - Lifetime of plasma-facing mirrors, other optical elements?
 - ECE overlap?
 - Interferometry refraction/wavelength?
 - Functionality of x-ray systems?
 - CXRS and MSE techniques; capability for diagnostic neutral beam(s)?
 - Inside-launch reflectometry?
 - Confined alpha-particles?

Provisional List of Diagnostics (1)

- Magnetic Measurements
 - Rogowski Coils, Flux/voltage loops, Discrete Br, Bz coils, Saddle coils, Diamagnetic loops, Halo current sensors, Hall effect sensors
- Current Density Profiles
 - Motional Stark effect with DNB, Infrared polarimetry
- Electron Density and Temperature
 - Thomson Scattering, ECE Heterodyne Radiometer, FIR interferometer, Multichannel Interferometer, ECE Michelson interferometer, ECE Grating Polychromator, Millimeter-wave Reflectometer
- Ion Temperature
 - Charge Exchange Spectroscopy with DNB, X-Ray Crystal Spectrometer, Charge Exchange Neutral Analyzer (edge)
- Visible and Total Radiation
 - Visible Survey Spectrometer, Visible Filterscopes, Visible Bremsstrahlung Array, Bolometer Arrays, Plasma TV and Infrared TV
- Ultra Violet and X-Ray Radiation
 - UV Survey Spectrometer, Hard X-ray detectors, Soft x-ray Spectrometer, X-ray pulse height analysis

Provisional List of Diagnostics (2)

- MHD and Fluctuations
 - Mirnov Coils, Locked-mode coils, Soft x-ray array, Beam emission spectroscopy, Millimeter wave reflectometer, Collective scattering
- Particle Measurements and Diagnostic Neutral Beam
 - Epithermal Neutron detectors, Multichannel Neutron Collimator, Neutron Fluctuation detectors, Diagnostic Neutral Beam
- Charged Fusion Products
 - Escaping Alpha Particle detectors, IR TV (shared with total radiation), Collective Scattering (CO₂?), α -CXRS, Knock-on neutron detectors
- Divertor Diagnostics
 - Divertor IR TV, Visible H α TV, UV Spectrometer, Divertor Bolometer Arrays, Multichord visible spectrometer, Divertor H α monitors, ASDEX-type Neutral Pressure Gauges, Divertor Thomson Scattering, Penning Spectroscopy, Divertor reflectometer
- Plasma Edge and Vacuum Diagnostics
 - Thermocouples, Fixed Edge Probes, Fast Movable Edge Probes, Torus Ion Gauges, Residual Gas Analyzers, Glow Discharge Probes, Vacuum Vessel Illumination