A Plan for Diagnostic Implementation and Diagnostic Interface Issues

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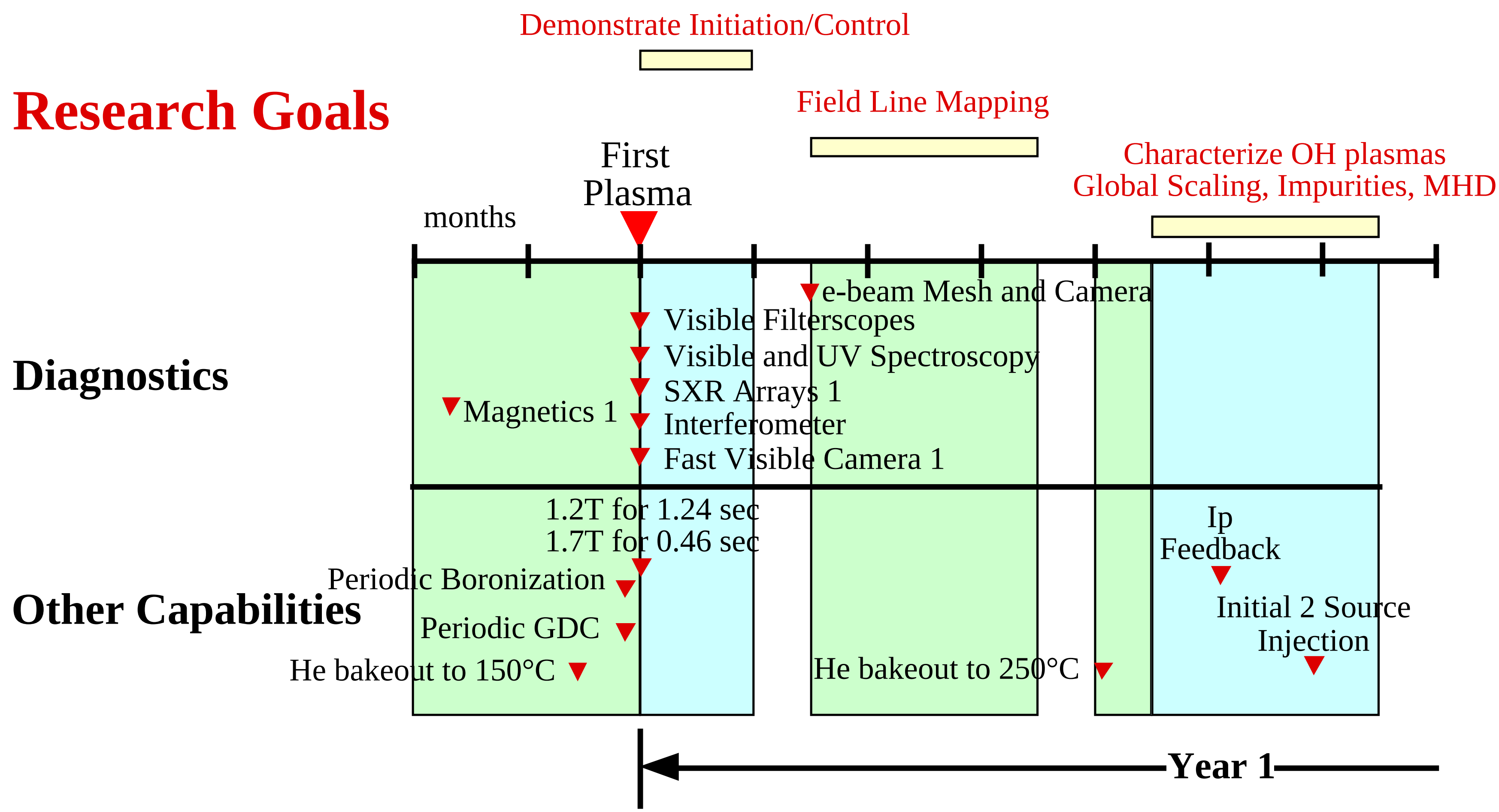
- A comprehensive set of plasma diagnostics is planned to support the NCSX research goals.
- Several interface issues have been identified for consideration in the conceptual design phase.
- Preliminary assessments of diagnostic access will be shown.
- The adequacy of diagnostic access in current NCSX design will be addressed.

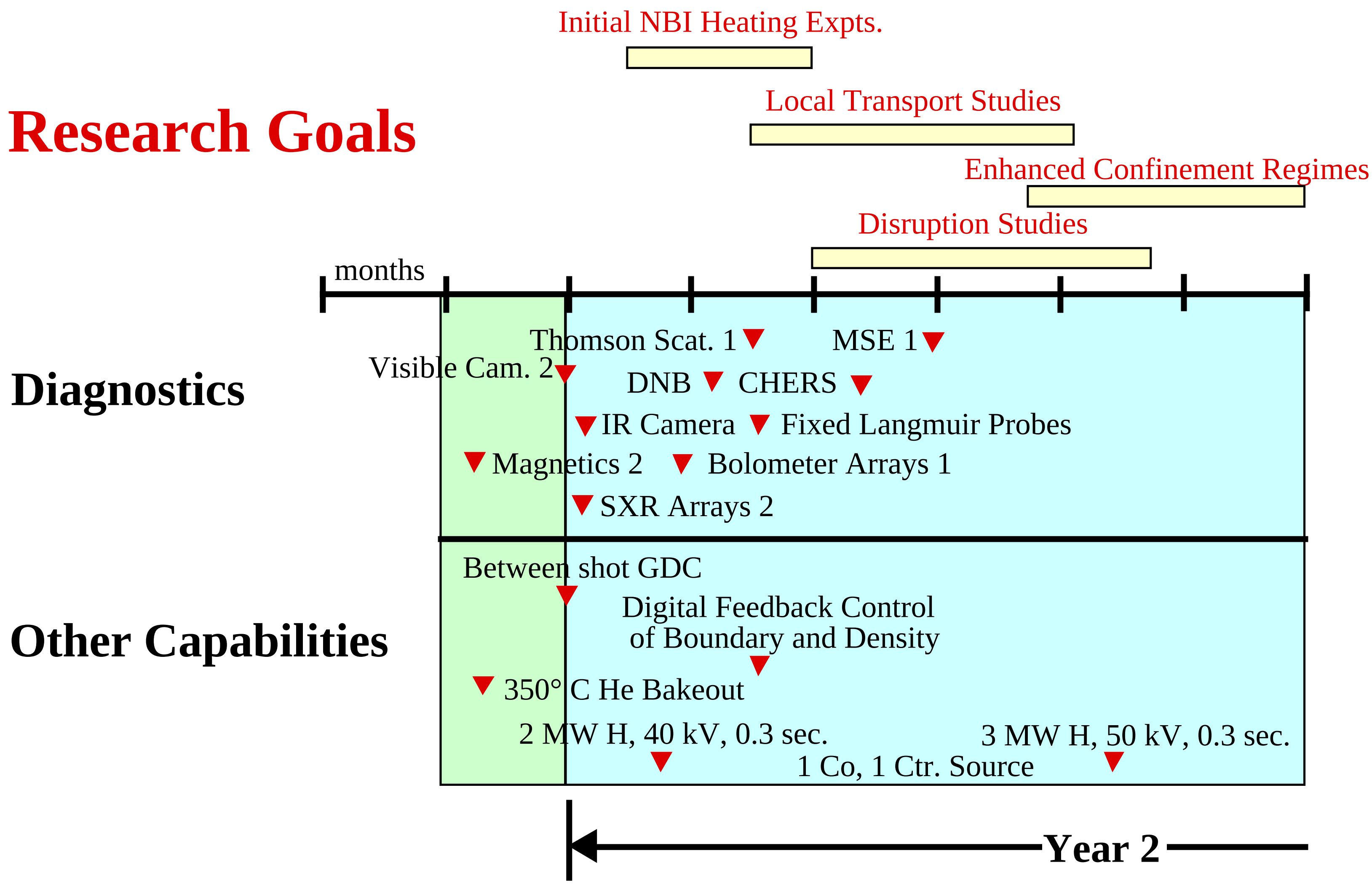
Research Plan Drives Choice of Diagnostics and Implementation Schedule

- One of the design goals for NCSX is to facilitate the diagnostic tools about to be described.
- A plan for implementing diagnostics on NCSX has been developed based on a preliminary ‘vision’ of the research plan described in the PVR document.
- Scenarios for the first 2 years are relatively clear. Later phases are less so.
- The plan is based on the presumption that roughly half of each year will be devoted to installation of upgrades.

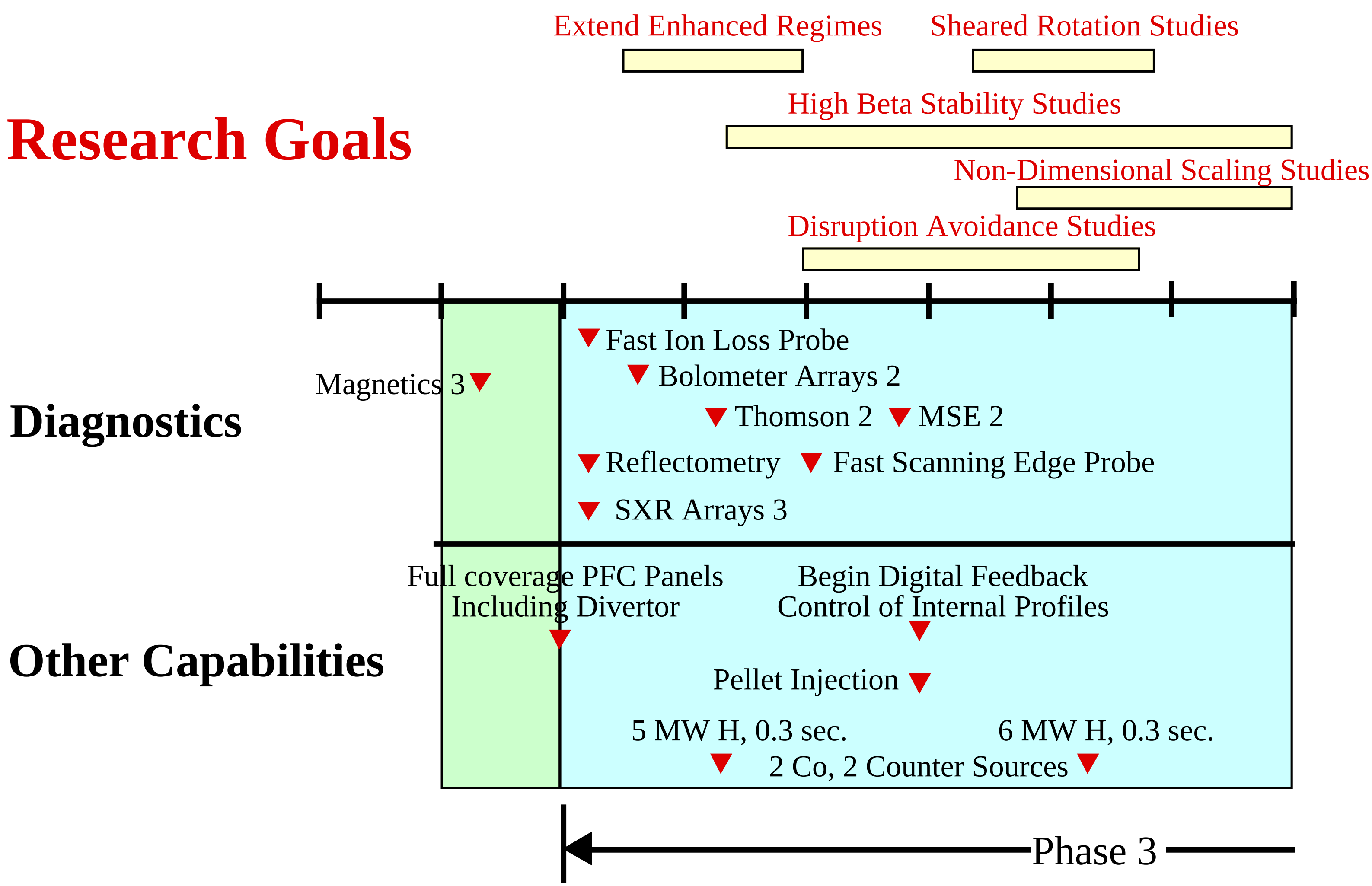
First Plasma, Field Mapping, and OH Studies



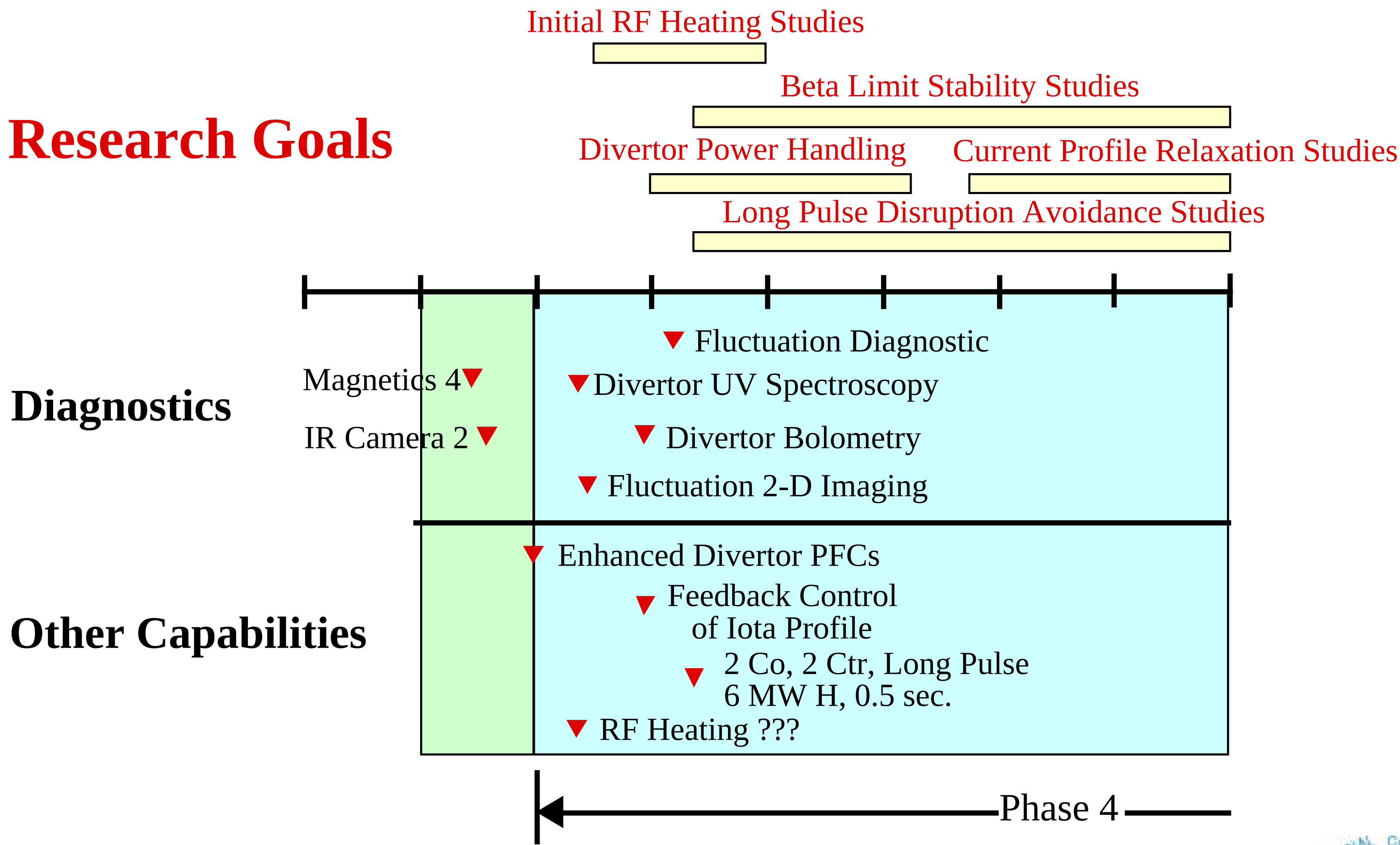
Initial Plasma Heating and Transport



Optimize Confinement and Beta



Sustainment at High Beta

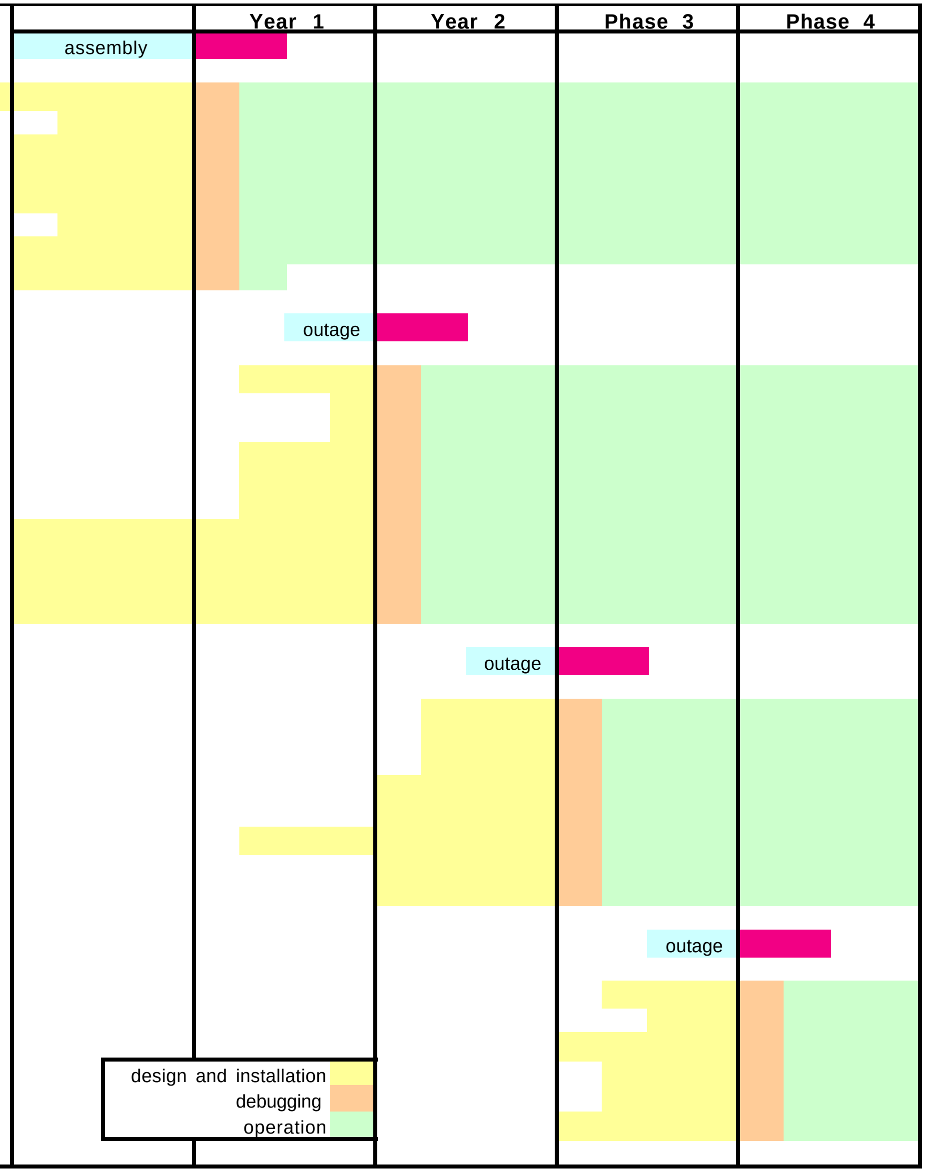


Diagnostic Implementation Strategy

- Baseline Diagnostics will provide:
  - Magnetics needed for plasma initiation and control, and to derive stored energy for assessment of global confinement. Also will serve as primary input to equilibrium reconstruction code.
  - Spectroscopic assessment of impurities
  - Fast camera views of plasma edge to observe plasma wall interaction.
  - Line average density measurements.
  - Initial indications of MHD activity
- Upgrade Strategy
  - Initial emphasis will be on profile diagnostics (MPTS, CHERS, MSE) for local transport studies.
  - Continuing evolution and expanded capability in magnetics, x-ray tomography, bolometry, and fast ion diagnostics
  - Divertor and turbulence diagnostics come later in plan

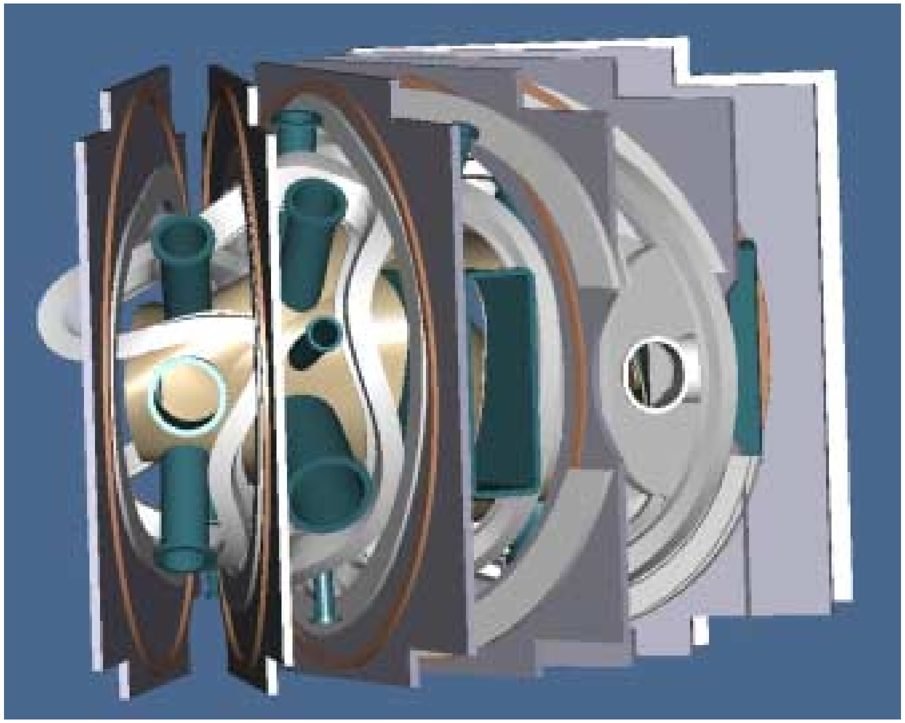
Diagnostic Implementation Plan

Diagnostic	Description	ports
1st Plasma, Field Mapping, and OH Studies		
Magnetics 1	100 channels	12
Visible Cameras 1	3 views, 1 fast, 2 slow	3
Interferometer	single chord, 1mm	1
UV Spectroscopy	single sightline	1
Visible Spectroscopy	direct+several fibers	1
Visible Filterscopes 1	3 views, 10 sightlines	3
SXR Arrays 1	1 compact array	1
e-Beam Field Mapping	probe, mesh, CCD	2
Initial Plasma Heating and Transport		
Magnetics 2	50 additional channels	6
Visible Cameras 2	2 add. fast cameras	
SXR Arrays 2	2 additional arrays	2
Bolometer Arrays 1	2 arrays	2
Fixed Langmuir Probes	20 probes	5
IR Camera	1 camera, multi. wind.	3
Thomson Scattering 1	100 Hz, 15 pos.	4
CHERS	50 ch system, 5 msec.	2
MSE 1	1 view, 10 channels	1
Diagnostic Neutral Beam	???	1
Optimize Confinement and Beta		
Magnetics 3	50 additional channels	
SXR Arrays 3	3 add. arrays,	3
Bolometer Arrays 2	2 add. arrays	2
Reflectometry	multiple scanning	1
Thomson Scattering 2	200 Hz, 30 chns.	
MSE 2	2nd view, 10 chns.	2
Fast Ion Loss Probe	fixed probe	1
Fast Scanning Edge Probe	1 pos.	1
Sustainment at High Beta		
Magnetics 4	additional channels	
IR Camera 2	additional camera	
Fluctuation Imaging	2-D imaging system	1
Divertor Bolometer	2 high res. Arrays	2
Divertor UV Spectrometer	scannable instrument	1
Fluctuation Diagnostic	undetermined	1
	total	65



Conceptual Design Will Address Several Access Issues

- No access presently available at symmetry planes, which are optimum locations for many diagnostics. As machine design evolves, will look for opportunities to improve this access.
- Interface ports are at the end of rather long vacuum extensions. Thus wide angle views will require re-entrant diagnostic assemblies.
- The difficulty of personnel access inside the vacuum vessel will complicate diagnostic installation and maintenance/calibration.



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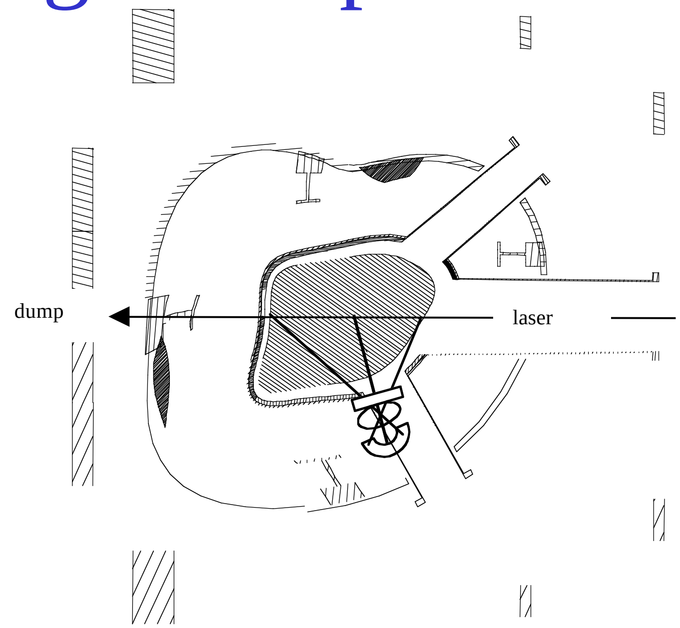
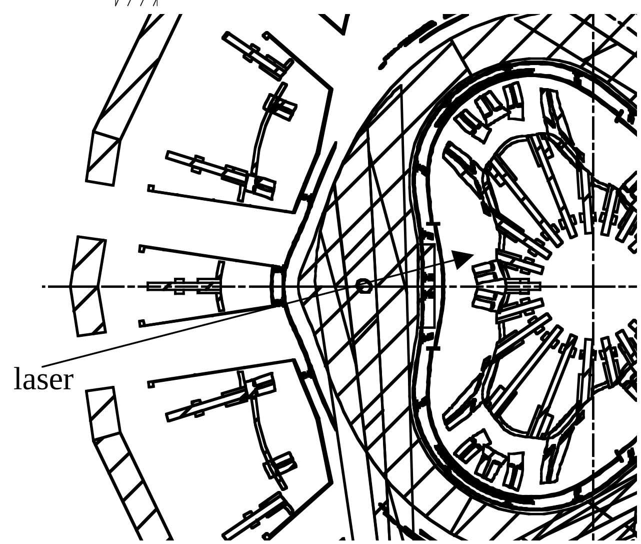
Thomson Scattering Example

- An optimal geometry for Thomson scattering is a horizontal beam at the bullet symmetry plane.
- Always sees the peak and has the longest scattering length.
- One could approach this geometry by adding a small port on the inside of the machine, and with minor modifications to a lower viewing port.
- At the low TF fields and densities expected on NCSX, plasmas are overdense for ECE radiometry. Thus, Thomson scattering be relied upon for T_e profiles.





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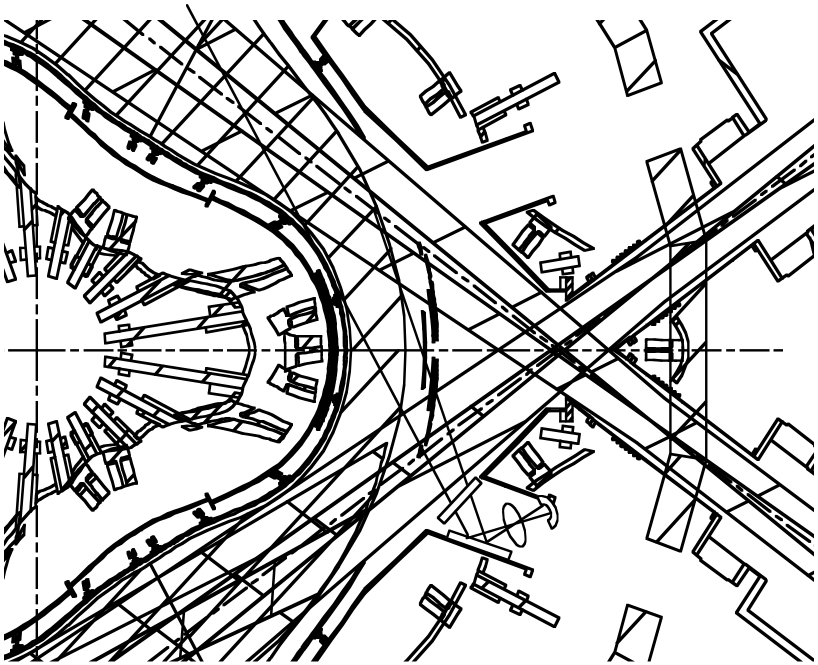
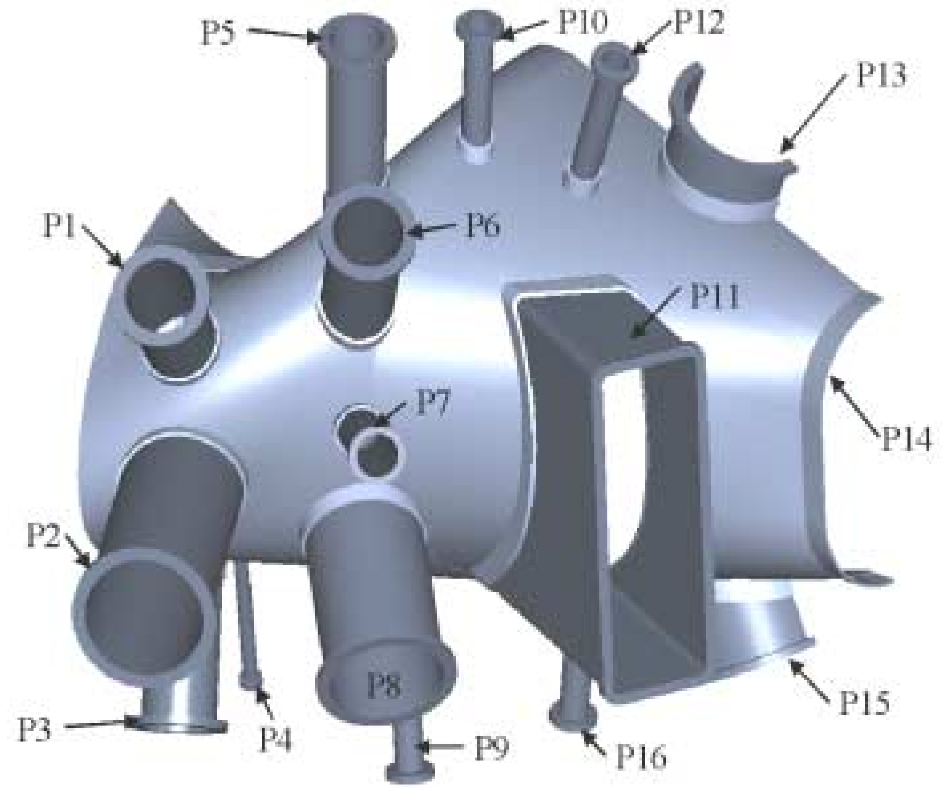
Beam-Based Diagnostics

- The geometry of the heating beams on NCSX makes localization very difficult for CHarge Exchange Recombination Spectroscopy (CHERS - T_i and v_ϕ) and impossible for Motional Stark Effect polarimetry (MSE - J and E_r) for core measurements.
- A Diagnostic Neutral Beam will be needed, particularly for MSE. Nova Photonics has developed a suitable DNB for MSE measurements on NSTX.



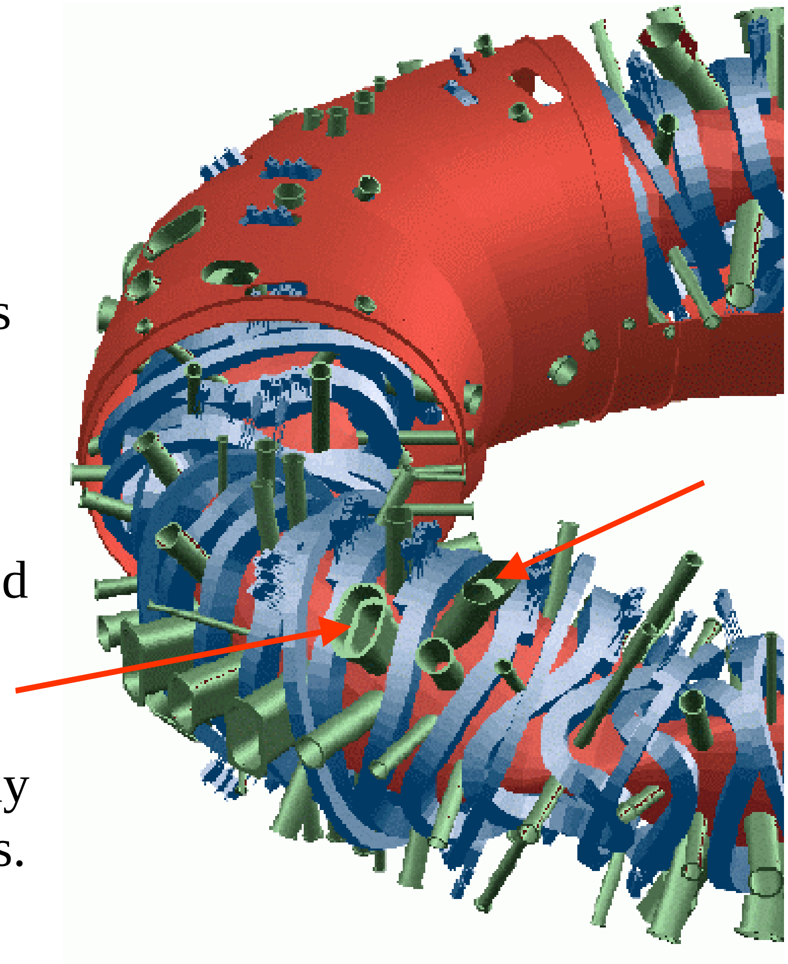
Adequacy of Diagnostic Access

- Planned diagnostics need ~ 65 ports. Current vessel design has 87 ports for all systems.
- A concept has been developed for Thomson scattering which looks feasible with some port modifications.
- Access concepts for all of the diagnostics listed will be developed as a priority in the conceptual design.
- Diagnostic integration is an explicit part of the project plan.
- At this point, diagnostic access appears adequate for measurement needs, if available space is used optimally for specific views.



W7-X Port Configuration

- W7-X design has a total of 309 ports for heating, diagnostics and other systems.
- Relation of modular coils and ports looks much like the NCSX model, excluding the TF coils and shell support plates.
- On W7-X, ports are often elongated and angled to optimize specific plasma views.
- NCSX conceptual design will likely result in similar port configurations.



Summary

- A preliminary plan for implementing diagnostics has been developed, based on the NCSX research goals.
- Based on this plan, estimates of the port access needed for the diagnostics has begun.
- Localization is a problem for beam-based spectroscopy (CHERS and MSE), and a DNB will be needed.
- At this point, it appears that the port space available for diagnostic access is adequate.
- Optimizing port shapes and orientations for specific diagnostic needs will be a priority task for the conceptual design phase.