Upgrades to the DIII-D Facility during the Long Torus Opening Activities Period in FY05-06

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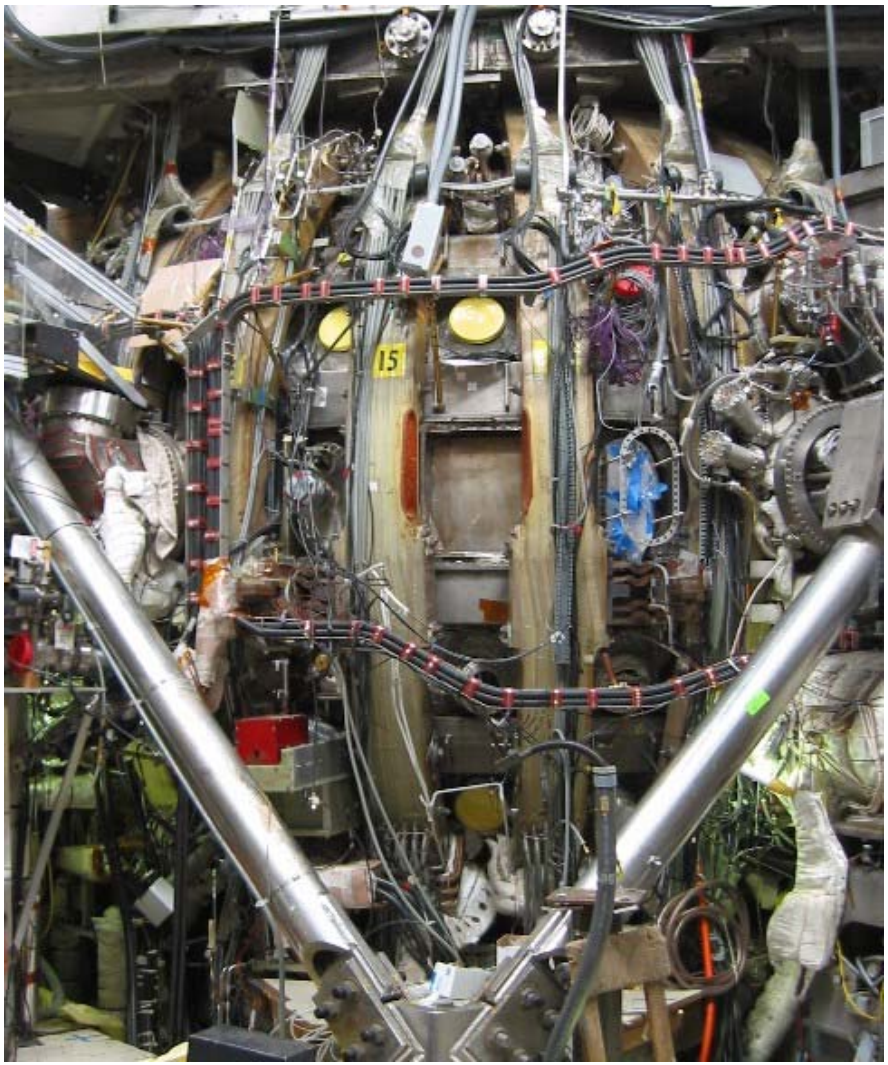
for the DIII-D Team



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Long Torus Opening Period Minimizes Impact on Physics Operation

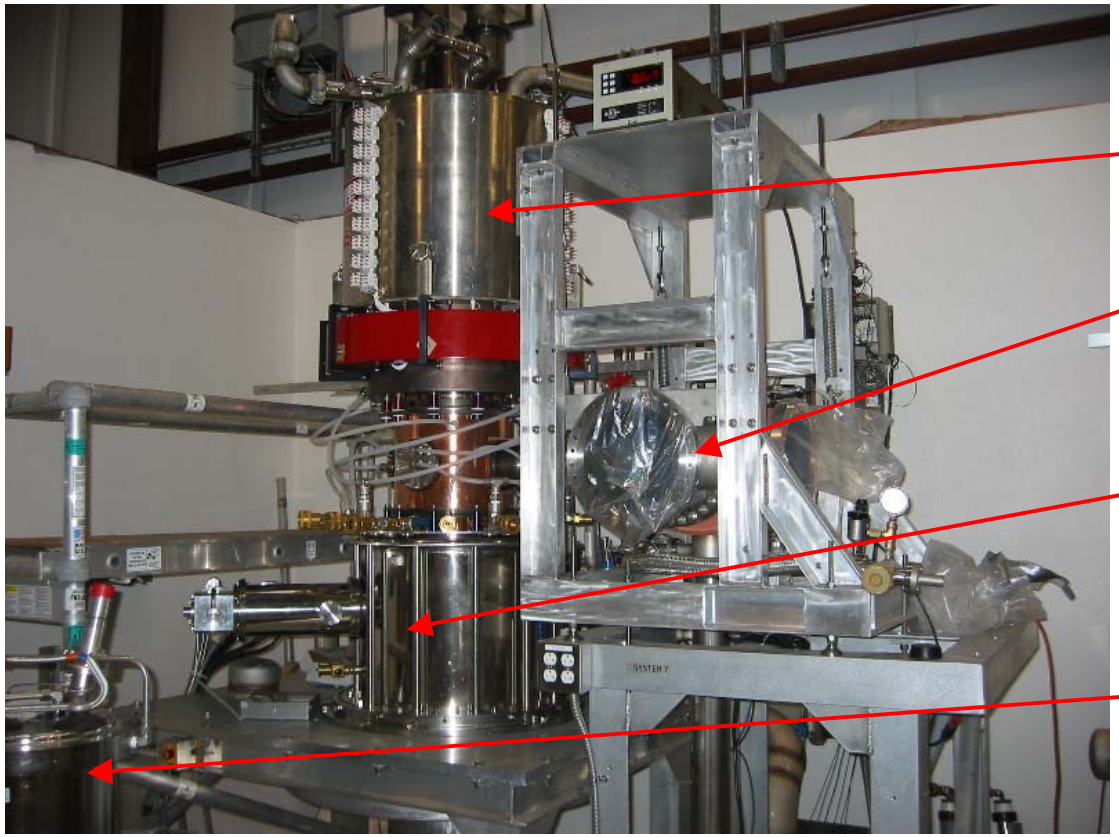
- **Completed 34 weeks of continuous operation during the physics campaigns of FY04 & FY05**
- **Extensive work both inside and outside the vessel is planned for the long torus opening period (4/19/05 – 3/31/06)**
- **Activities to be accomplished during torus opening**
  - Upgrade Electron Cyclotron System to six long-pulse gyrotrons
  - Install new lower divertor
  - Rotate one of four beamlines for counter injection
  - Upgrade diagnostics
  - Upgrade one of Fast Wave systems
  - Upgrade DIII-D water cooling system
  - Proceed with upgrades in coil cooling and in AC power towards ten-second operation
- **Schedule allows for 14 weeks of operation in second half of FY06**

Increases in EC System Power and Pulse-Length Enable New Physics Capability

- **Physics enabled**
  - Control current profile
  - Sustain high performance plasmas
  - Stabilize or avoid tearing mode
  - Perform transport barrier studies
  - Perform modulated transport and critical gradient studies
  - Perform electron heating

- **EC System had supported physics campaigns with**
  - Three 1 MW, 10 second gyrotrons from CPI
  - Three 0.75 MW, 2 second Russian gyrotrons
- **EC System will support FY06 physics campaign with**
  - Four to six 1 MW, 10 second gyrotrons from CPI
  - Developmental 1.2 MW depressed collector gyrotron could be available

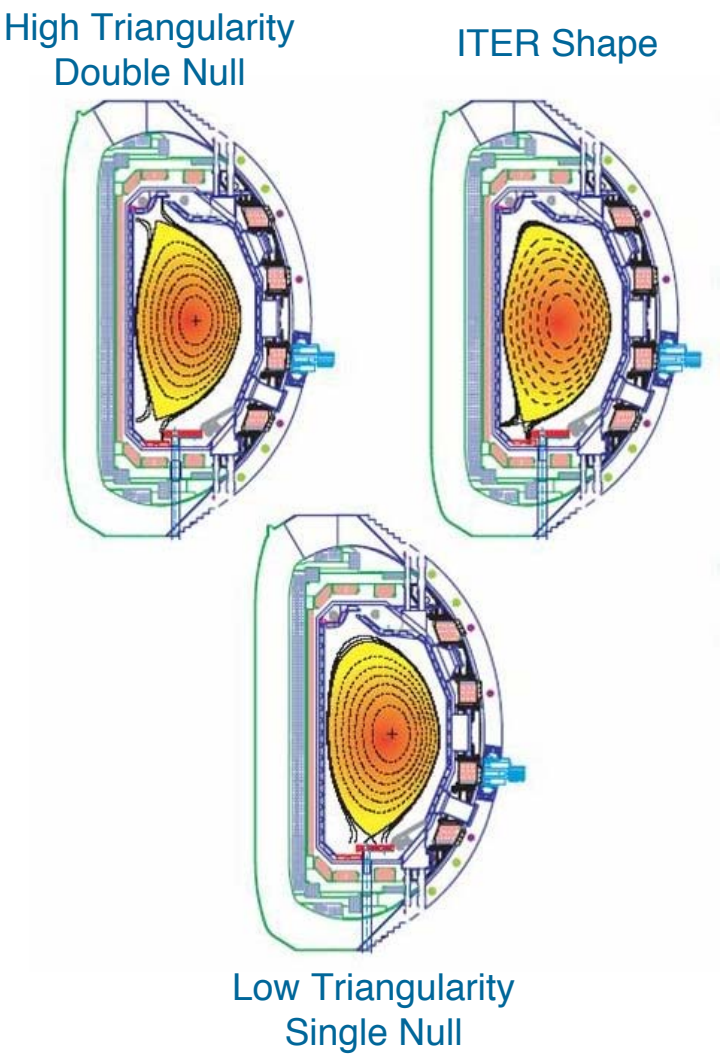
Installation of First Replacement Gyrotron Nears Completion



- Gyrotron
- Chamber for focusing mirror
- Superconducting magnet
- Dummy load

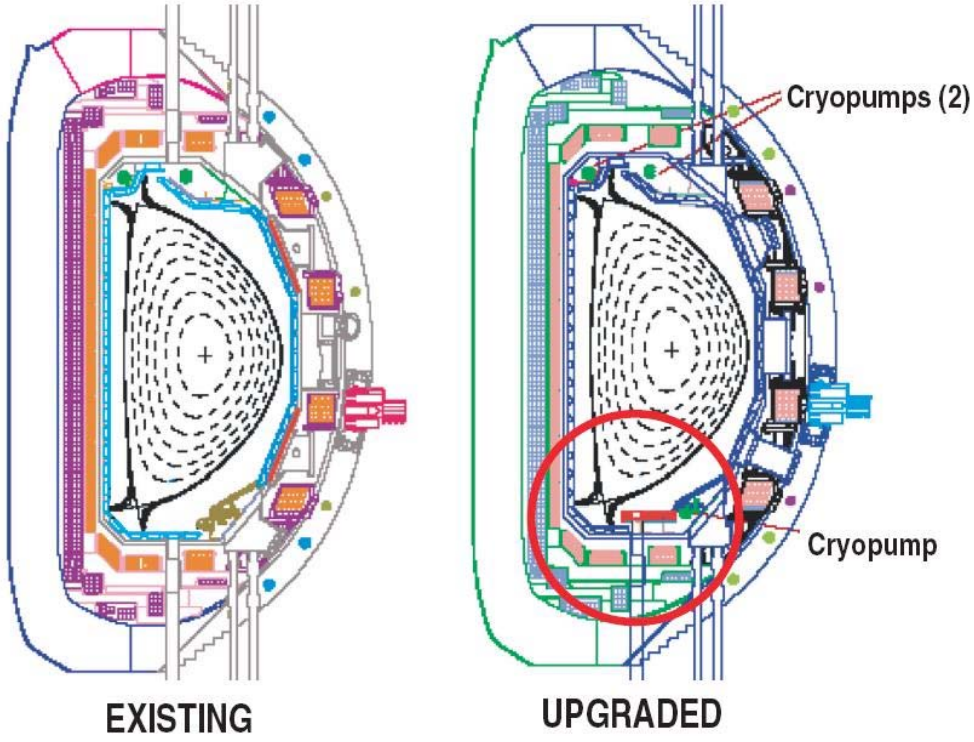
Installation of New Divertor Provides New Capability and Maintains Shape Flexibility

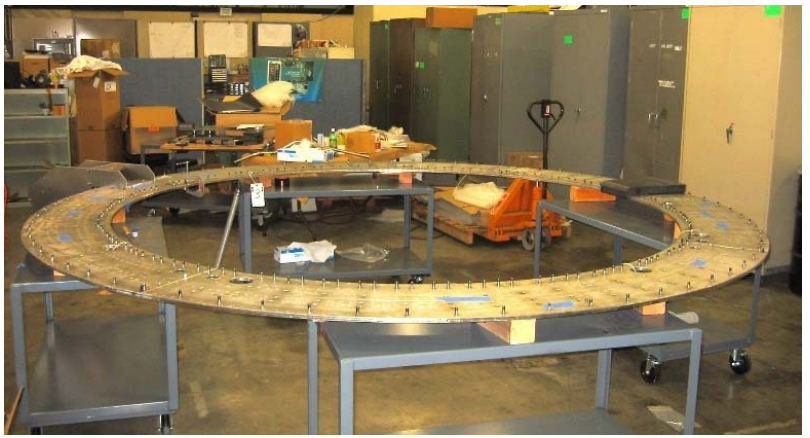
- **Motivation**
  - Density control in high triangularity, high performance
    - Single-Null and Double-Null Advanced Tokamak plasmas
    - QH-mode plasmas
  - Comparison of long duration Single-Null and Double-Null plasmas
  - Pedestal physics with range of collisionalities
  - Mass transport physics
  - Optical access to inner divertor leg
  - Detachment control via pumping



Divertor and Tile Configurations

Configurations for Lower Divertor



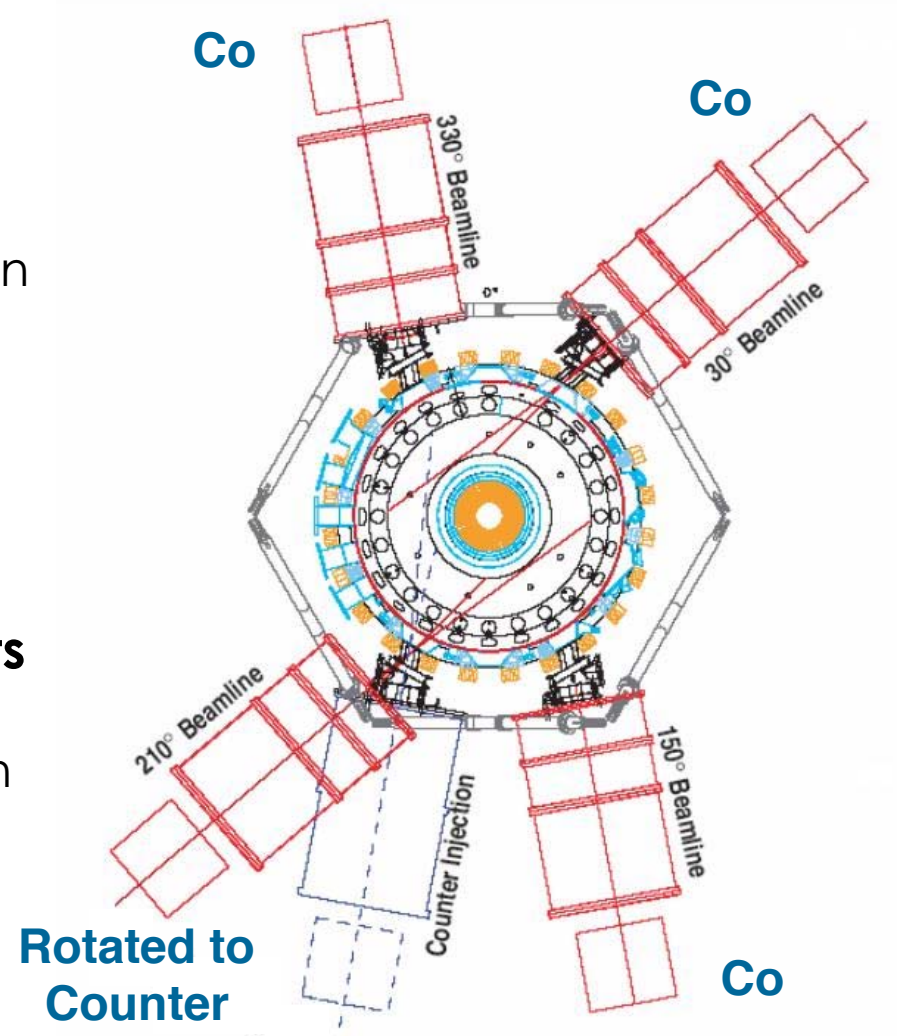


Preparing cooling plates for installation

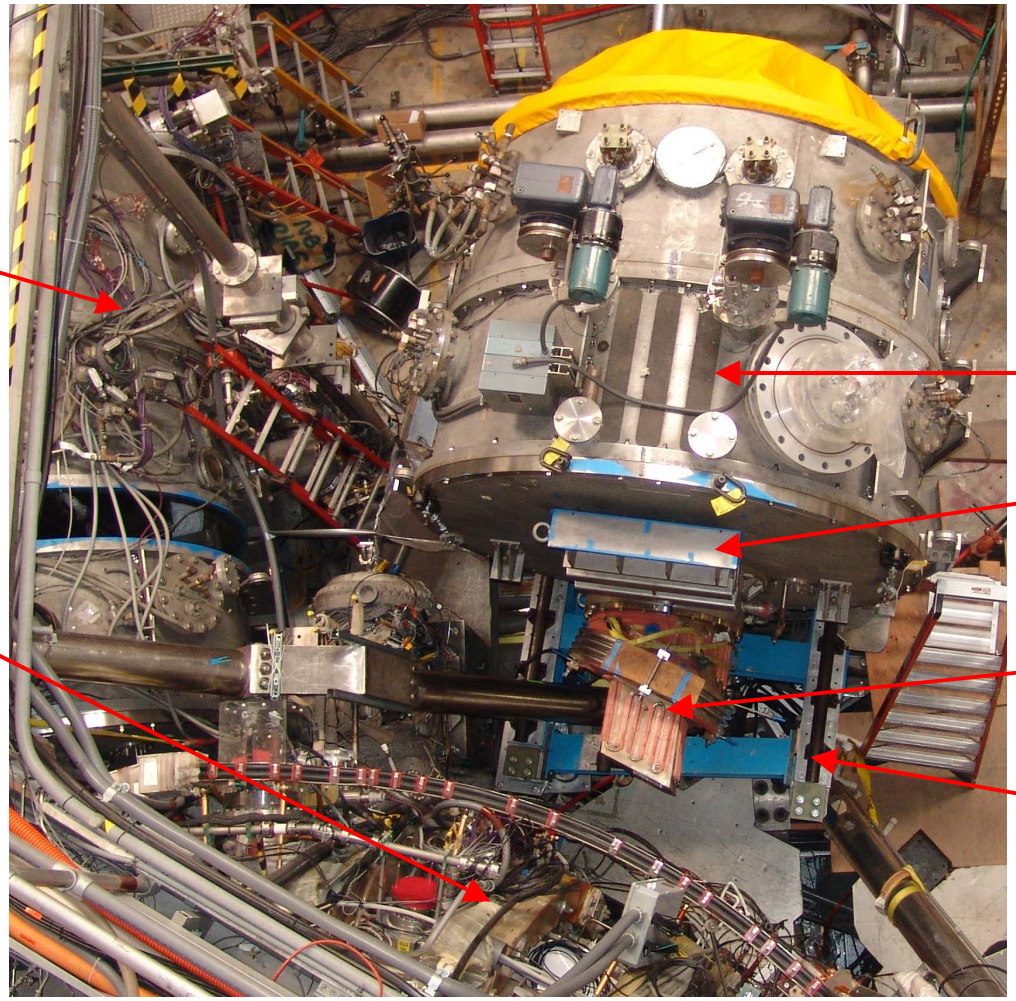
New tile mounting eliminates holes in regions of high heat flux

Rotation of 210 Beamline

- **Opens new areas for physics**
  - QH-mode ELM-free regime with central co-rotation
  - Understanding physics of rotation
  - RWM stability with low rotation
  - Transport barrier control
  - Fast ion physics
  - Understanding the physics of neutral beam current drive
- **Improved plasma measurements**
  - MSE measurement viewing counter beam allows separation of E_r and J
  - Co and counter Charge Exchange Recombination



Bird's Eye View during Installation of Rotated 210 Beamline



DIII-D will Resume Operations in FY06 with Enhanced Diagnostic Capability

- Additional MSE system with view of the counter beam
- Additional CER system with view of the counter beam
- Quartz-microbalances in new lower divertor
- Additional optical (filterscope and spectrometer) views in lower divertor
- Upgraded and relocated scattering diagnostic
- Upgraded BES system with additional high efficiency channels
- New poloidal Soft X-Ray system (2 arrays)
- Improved ECE radiometer spatial resolution
- Improved Divertor Thomson scattering system
- Upgraded midplane scanning probe (airlock capability)

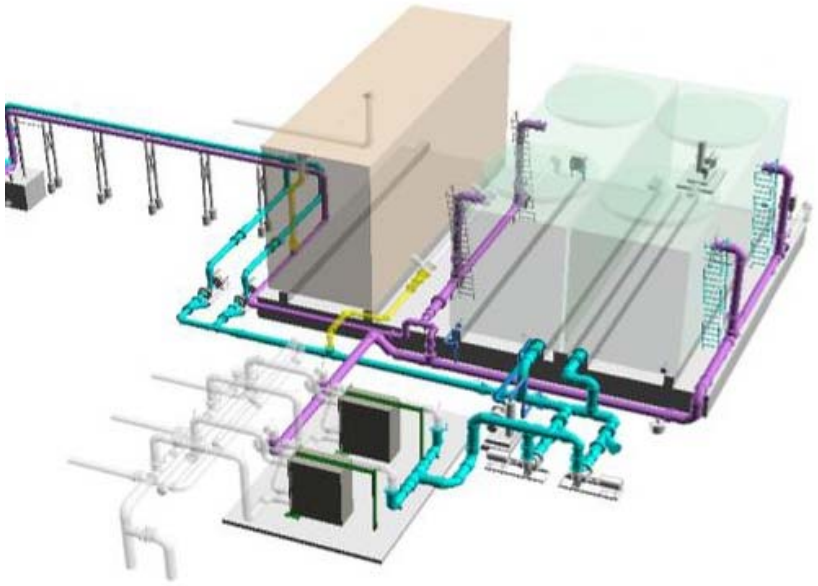
- For more details see Poster CP1.002, R.L. Boivin

Other Activities During Long Torus Opening (Partial List)

- **Fast Wave**
  - Refurbish 285/300 FMIT antenna
  - Convert ABB #1 transmitter to EIMAC tube
- **RWM**
  - Six additional high bandwidth amplifiers for I-coils (6 _12)
- **ECH**
  - Long-pulse launcher with fast steering
- **Pellet Injector for ELM pacemaking**
- **Plasma Control System**
  - Control algorithm improvements
  - Hardware upgrades
- **Maintenance**
  - Motor generator bearing inspection and balancing
  - General maintenance

Increase Capability of DIII-D Water Cooling System

- **Upgrade two cooling towers with capacity for future heat loads**
- **Upgrade heat-exchanger and pumps in ECH cooling loop to improve heat rejection**



Layout of new cooling towers

Installation of new ECH heat exchanger

Upgrades Progressing Towards 10-Second Operation

- **Improve cooling of toroidal coil return bus**
  - Adding water-cooled plates to bus in 24 locations (48 required)
  - Addressing locations with difficult access first
- **AC power for auxiliary heating systems**
  - Existing transformer rated at 84 MVA for one second
    - Sized in 1979 for eight _ second neutral beams
  - Replacement transformer rated at 110 MVA for 10 seconds enables simultaneous operation of
    - Eight neutral beams for 5 seconds
    - Six 1 MW and two 1.5 MW gyrotrons for 10 seconds
    - Three 2 MW fast wave systems for 10 seconds

Return to Physics Operation in 2006

- **Complete installation of lower divertor by end of Jan 2006**
- **Complete installation of counter beamline by Mar 2006**
- **Perform diagnostic calibrations**
- **Close DIII-D vessel on or before 3/31/06**
- **System check-out and start-up – six to eight weeks**
- **Start plasma physics operation in mid May2006**
  - Neutral beam should be ready with seven sources
  - ECH should be ready with four to six gyrotrons
  - Fast Wave should be ready with three transmitters
- **Schedule allows for 14 weeks of operation in FY06**

Conclusion

- **As a result of the upgrades DIII-D is well positioned to do advanced tokamak research over the next decade**