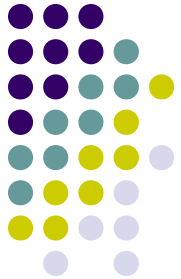
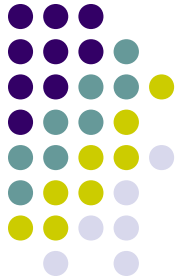
UHV ACTIVITIES
at
INSTITUTE FOR PLASMA RESEARCH

S. B. Bhatt



- Plasma Experimental Group started in 1972
- Electrojet Simulation Experimental System
- High Vacuum System
- Since then many high vacuum system were designed for different plasma experimental systems



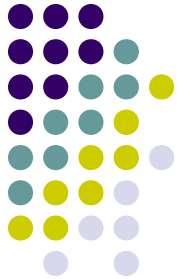
Plasma Physics Program started in 1982

To carry out high temperature plasma experiments

Design of First Indian Tokamak ADITYA started

In 1986, Plasma Physics Program transformed into Institute for Plasma Research (IPR)

Tokamak Vessel Requirement

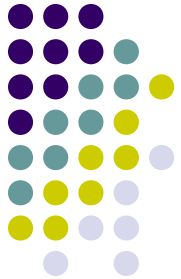


- Ultra High Vacuum compatibility
- Withstand Electromagnetic Forces
- Non-magnetic material
- Withstand bombardment of energetic particles

  Plasma-wall interaction
- Less Impurity introduction
- Lower Recycling

ADITYA TOKAMAK : A VIEW

SUB-SYSTEMS of ADITYA TOKAMAK



- Vacuum system
- Pulsed power system
- Magnetic field coils
- Data acquisition and control
- Diagnostics
- RF heating and current drive

ADITYA TOKAMAK PARAMETERS

chine Parameters:

or radius (R) : 75 cm

or radius (a) : 25 cm

oidal field : 0.75 – 1.0 T

k loop voltage : 20 – 25 V

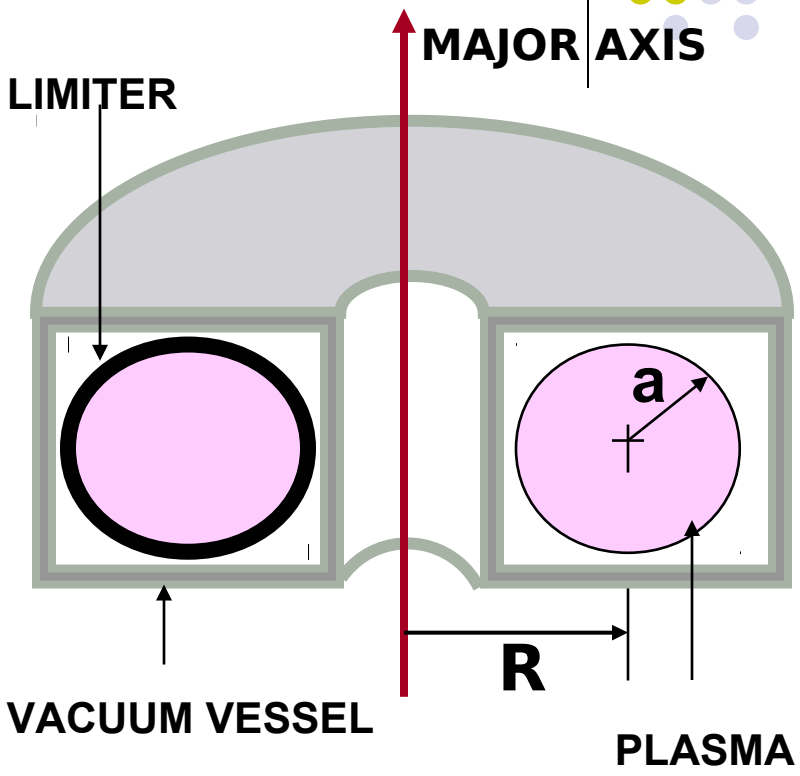
sma Parameters:

sma current : 70 – 150 kA

se duration : 100 – 200 ms

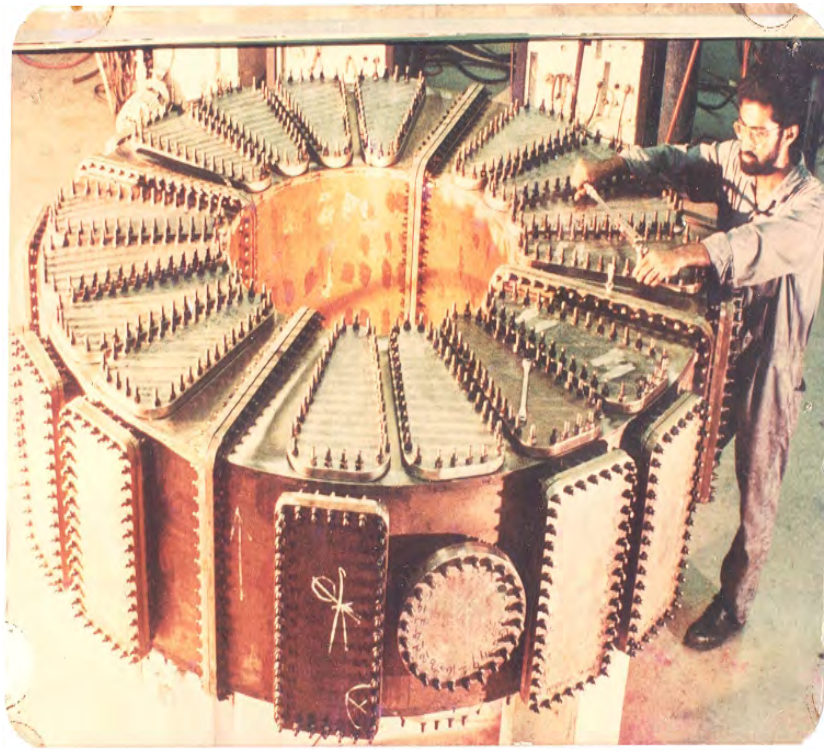
ctron density : ~ 1 x 10^{13} cm^{-3}

ctron Temp. : ~ 400 eV

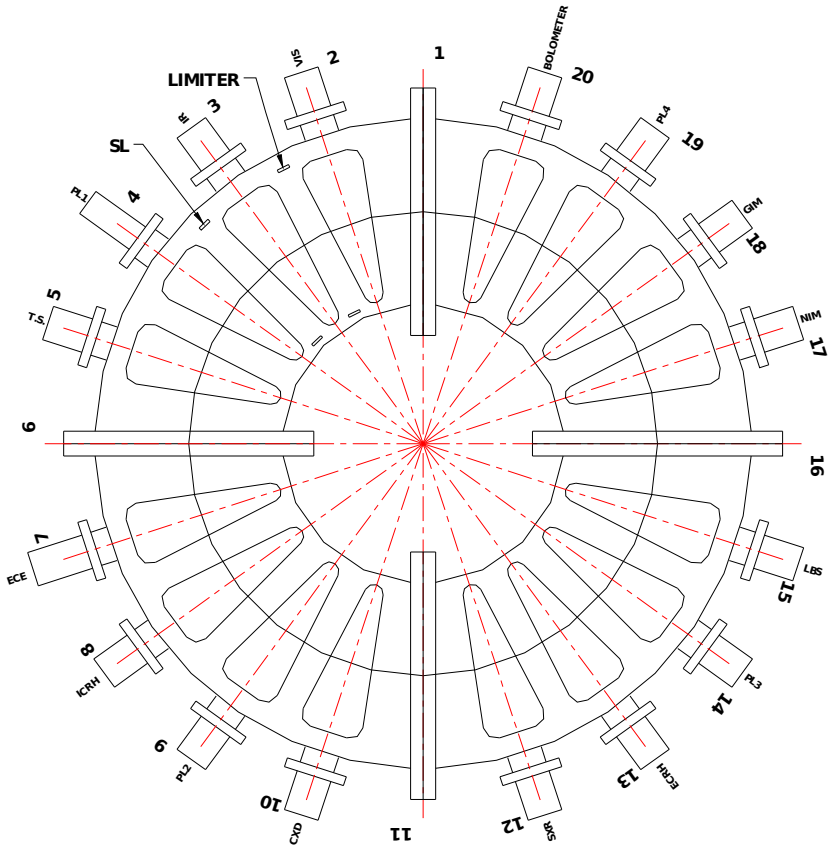


ADITYA TOKAMAK VACUUM SYSTEM

- Toroidal Chamber-Four Quadrants
- Rectangular cross-section of 0.6 m X 0.6 m
- Material : SS 304 L
- Minor Radius: 0.25 m
- Major Radius: 0.75 m
- 16 Top, Bottom & Radial Ports
- Volume ~ 2 m^3
- Surface Area ~ 20 m^2
- Pumping System: 4 UHV Lines
- 3 TMPs (2000 l/s each) &
- 1 Cryopump (2000 l/s)
- Pirani, B-A IG
- RGA
- He Leak Detectors
- Ultimate Vacuum: ~1 x 10^{-9} torr
- Base Pressure ~ 1 x 10^{-7} torr
- Working Pressure: 10^{-3}-10^{-5} torr



Plan View


LIMITER
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PL1
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S.T.
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ICRH
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PL2
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CXD
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12
SXR
13
ECRH
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PL3
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LBS
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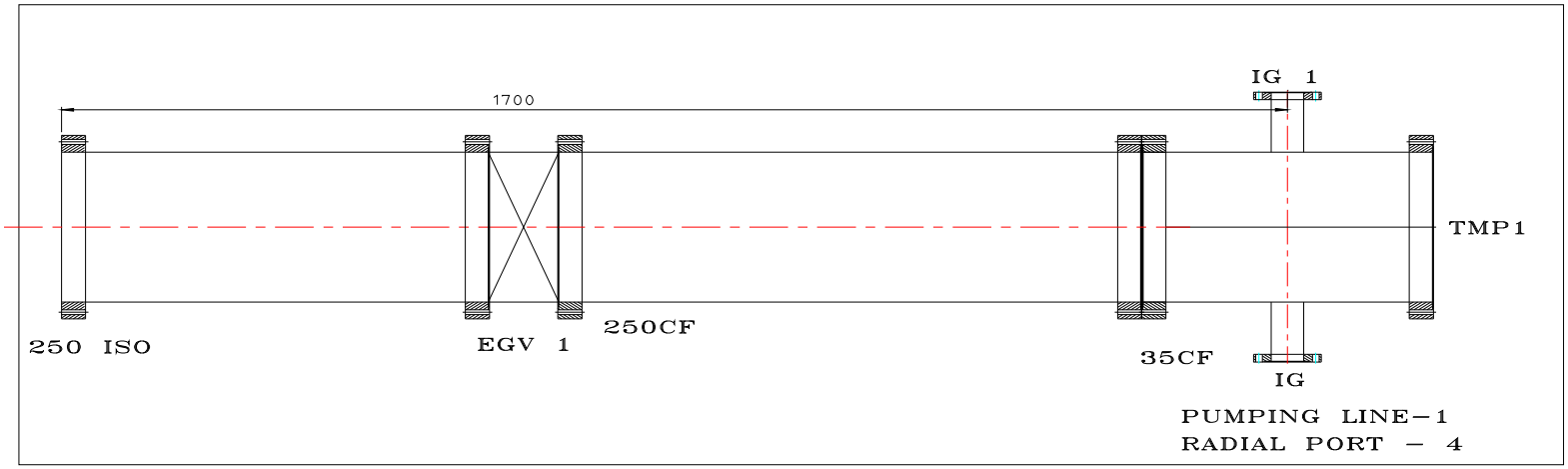
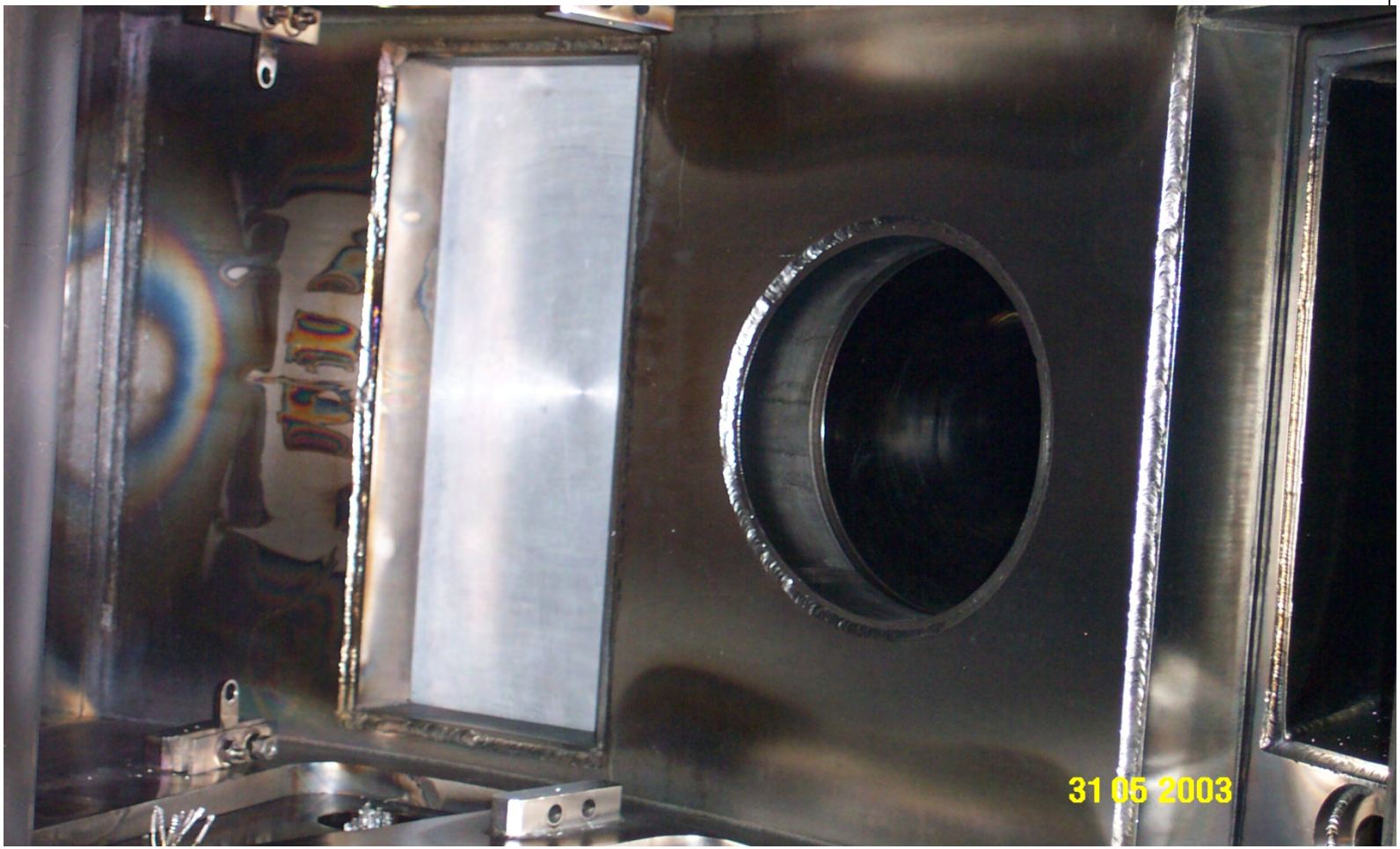
17
NIM
18
GIM
19
PL4
20
BOLOMETER

Pumping Line (Cross-sectional View)



ADITYA Pumping Line with TMP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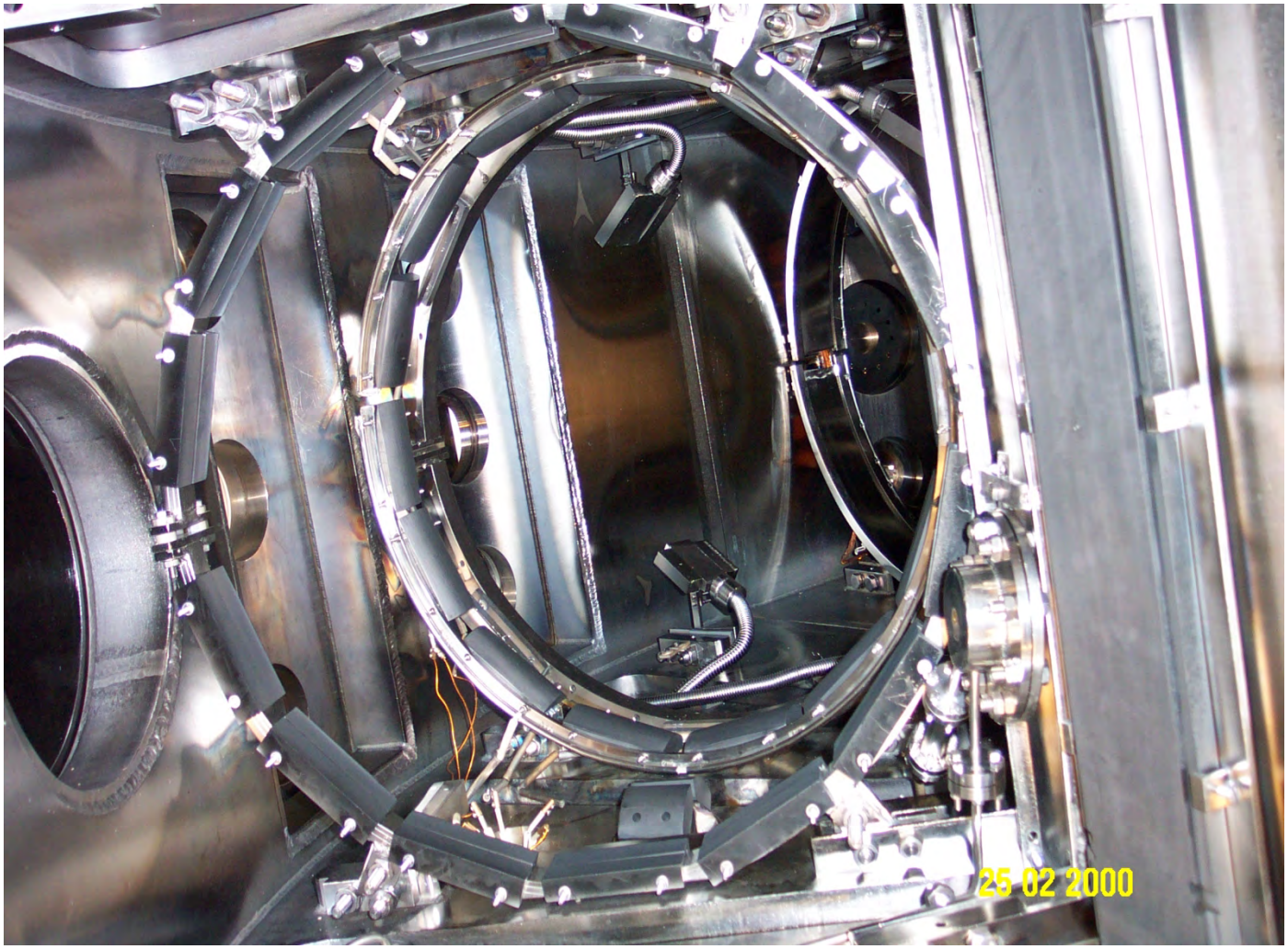
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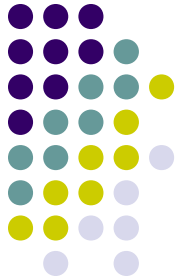


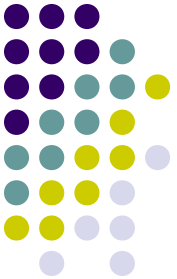
Pre-treatment Procedures

- Cleaning with acid solution, Detergent solution
- Washing with water
- Electropolishing
- Ultrasonic Cleaning

In-Situ Treatments

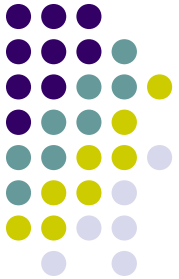
- Baking at 120 C
- Wall Conditioning by discharge Cleaning
- Wall Coating

WALL CONDITIONING SYSTEMS



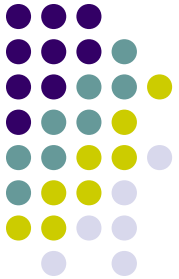
- Automated Glow Discharge Cleaning System
- Pulse Discharge Cleaning System
- ECR Discharge Cleaning System
- Lithium Coating

GLOW DISCHARGE CLEANING SYSTEM



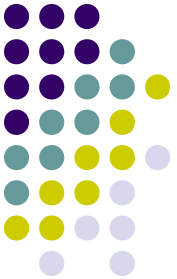
- Discharge Current : ~ 3.5 ampere
- Discharge Voltage : 350 Volts
- Fill Pressure : ~ 8 X 10-4 Torr
- Fuel Gas : Hydrogen
- Duration : Automated (12 Hours)
- No magnetic field

PULSE DISCHARGE CLEANING SYSTEM



- Ohmic Voltage : ~ 5.0 KV
- Toroidal Magnetic Field : ~ 0.09 T
- Pressure : ~ 3 X 10-5 torr
- Fuel Gas : Hydrogen
- Pulse duration : 4 ms
- Pulse Repetition Rate : 900 Pulses/ Hour

ECR DISCHARGE CLEANING SYSTEM



- Frequency : 2.45 GHz
- Toroidal Magnetic Field : ~ 0.05 T
- Pressure : ~ 3 X 10-5 torr
- Fuel Gas : Hydrogen
- Power : ~ 750 Watt

LITHIUM Coating

- Expose solid lithium during glow discharge Cleaning for more than 10 hours.

After lithiumization, Observed Reduction in

- visible continuum,
- Oxygen
- Carbon
- Hœ

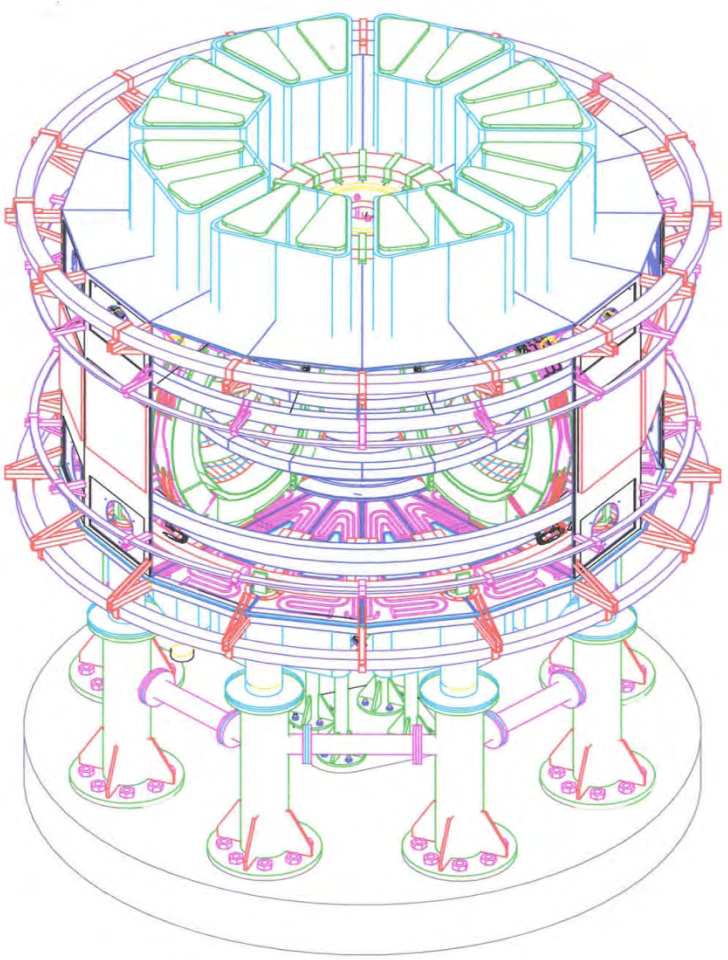
& Increase in Plasma Current Rise rate

GAS FEED SYSTEM

Piezoelectric Gas Leak Valves - Operated in

- Continuous and/ Or
- pulsed Mode

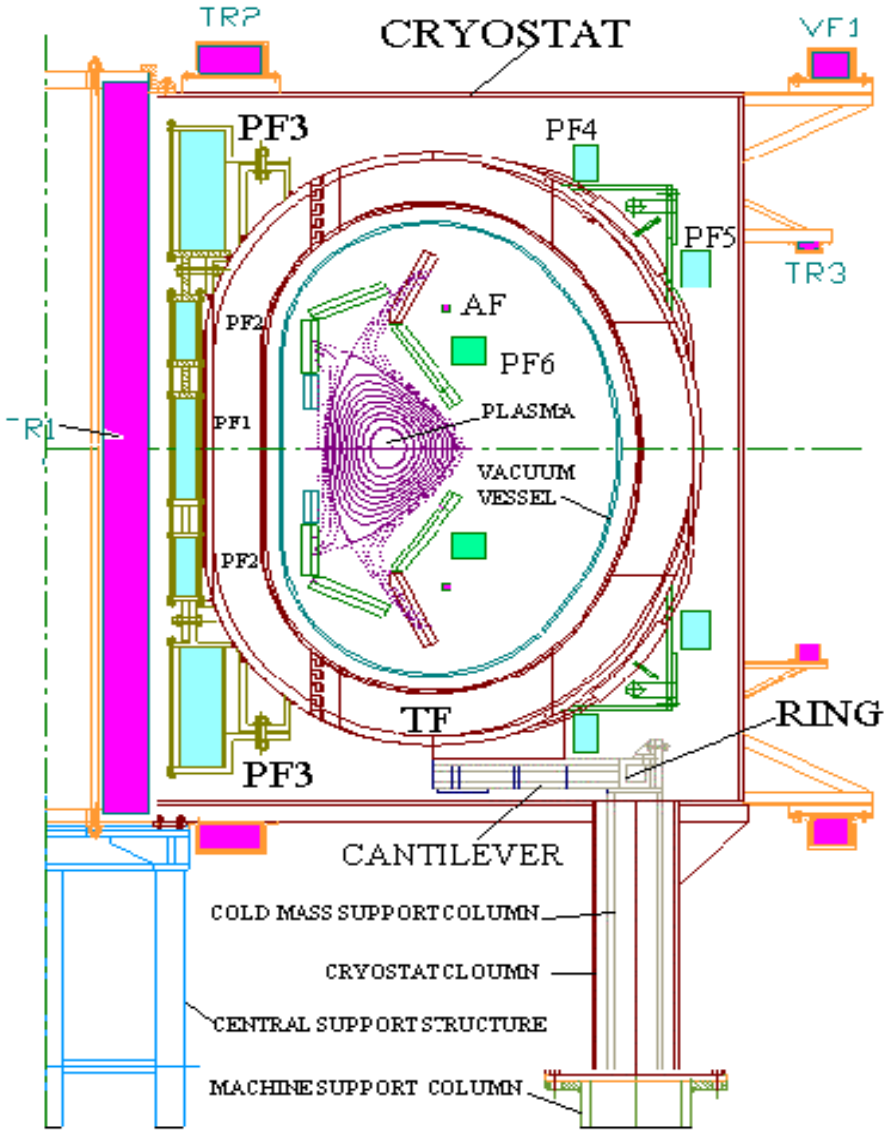
SST 1 TOKAMAK



SST1 TOKAMAK PARAMETERS

MAJOR RADIUS : 1.1M
MINOR RADIUS : 0.2 M
ELONGATION : 1.7-2
TRIANGULARITY : 0.4-0.7
TOROIDAL FIELD : 3T
PLASMA CURRENT : 220 kA.
ASPECT RATI : 5.2
SAFETY FACTOR : 3
AVERAGE DENSITY : 1X $10^{13} cm^{-3}$
AVERAGE TEMP. : 1.5 keV
PULSE LENGTH : 1000 s

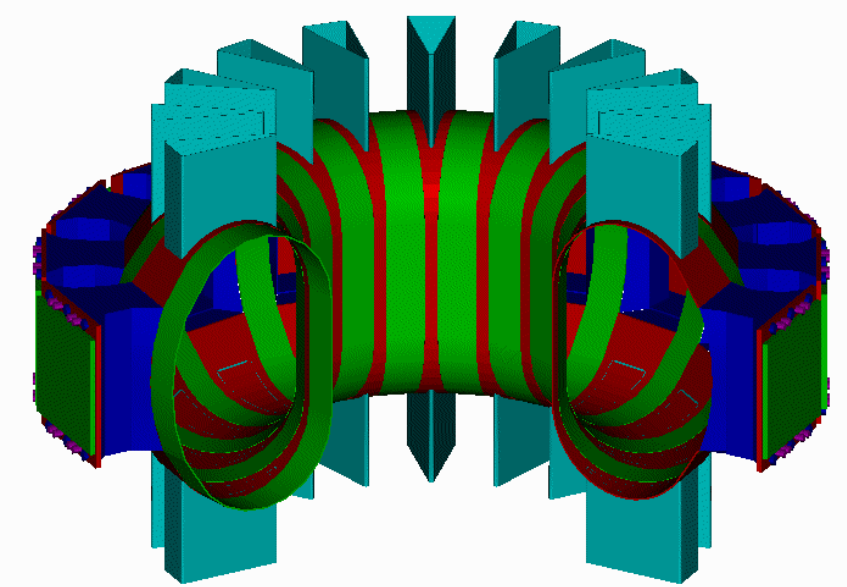
SST 1 Tokamak

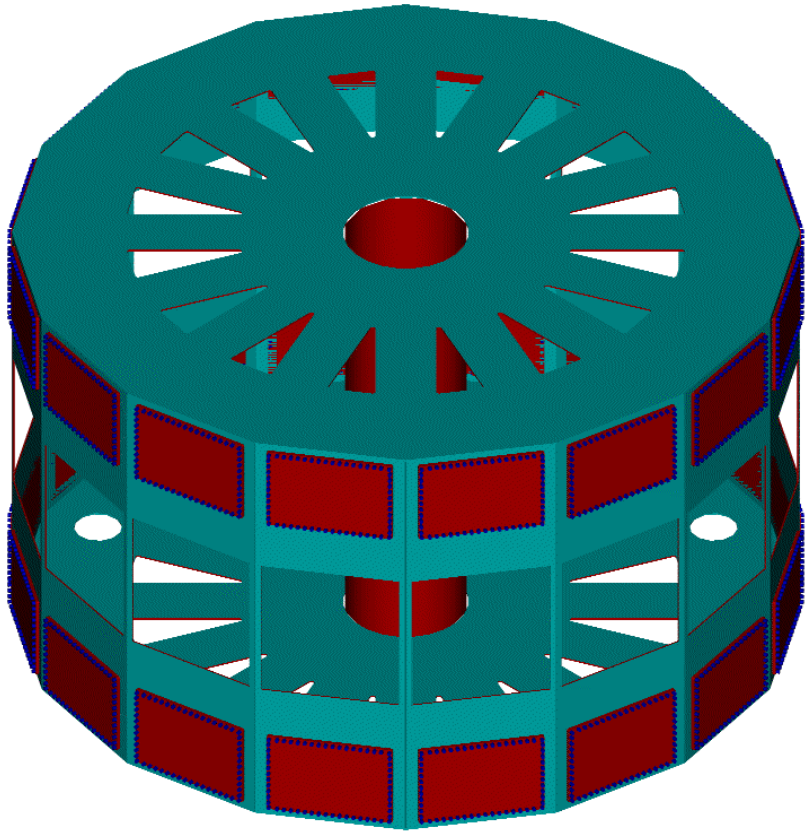


- Material : SS 304 L
- Major Radius : 1.3 m
- Vertical Semi-axis : 0.8 m
- Radial Semi-axis : 0.5 m
- 16 Top, Bottom & Radial Ports
- Volume : ~ 16 m^3
- Surface Area : ~ 68 m^2
- Pumping System : UHV Lines
- 16 TMPs (5000 l/s each)
- Ultimate Vacuum : ~1 x 10^{-9} torr
- Base Pressure :~ 1 x 10^{-7} torr
- Working Pressure : 10^{-3}-10^{-5} torr

Cryostat

- Height : 2.6 m
- Mid plane width : 4.4 m
- Volume : ~ 40 m^3
- Surface Area : ~ 72 m^2





Fabrication of SST1 Vacuum vessel and Cryostat

TF Coil Vessel Sector Assemly Mock Up


2. 4. 2004

Vacuum Chamber for NBI System

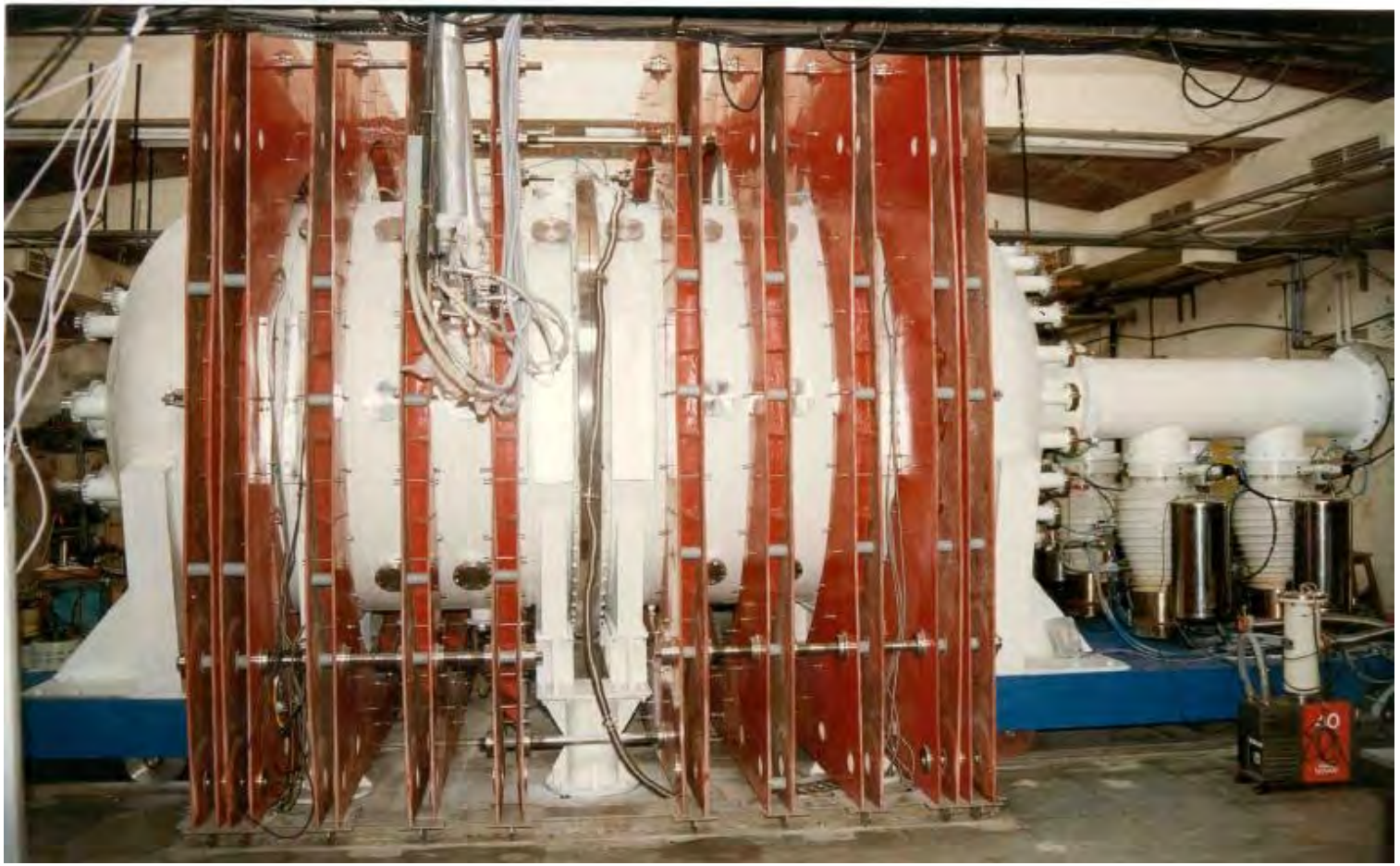
2.4 m (l) x
2.2 m (w) x
3.3 m (h),

V = 20 m3,

A = 50 m2,

Mfg. by
Godrej, 2002

The Large Volume Plasma Device



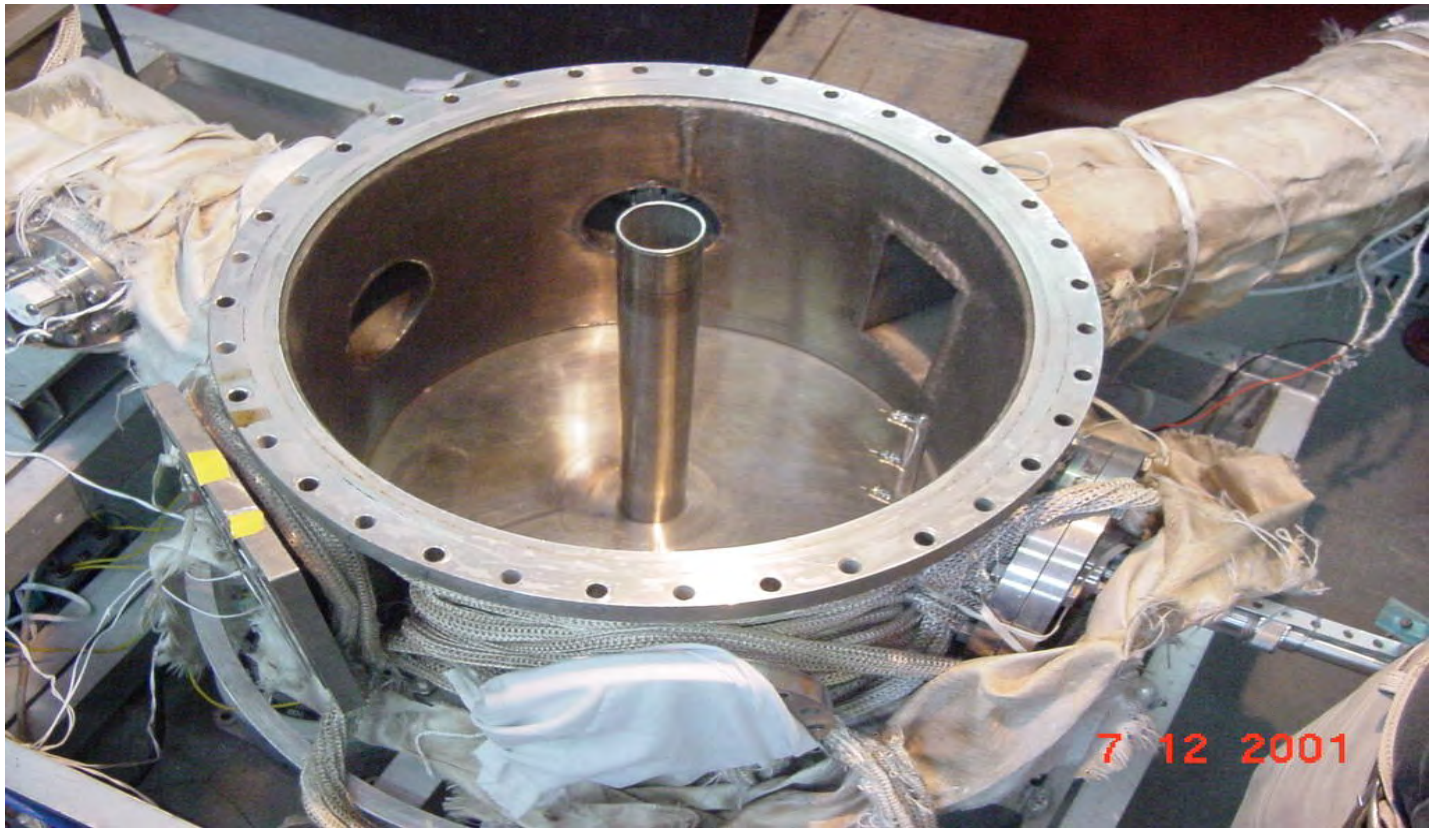
R = 2 m, L = 3 m, V = 9 m3, A = 40 m2 Double wall, Water cooled, Number of ports = 94

Mfg. by HHV, 2000

- Rotary Pumps (3 nos.) 42 m^3/h
- Roots pump (1 no) 1750 m^3/h
- Diffusion pump (3 nos.) 6100 m^3/h (each)
- Ultimate base pressure 1×10^{-7} mbar

BETA

Non Neutral Plasma Chamber



At IPR,

we have designed UHV vessels and pumping lines for ADITYA tokamak, SST1 Tokamak and other experimental systems. We have developed the pre-treatment procedures for UHV components, wire seals, different types of gas feed systems, UHV compatible Wilson feedthrough, in-situ coating etc..

THANK YOU