Activities of
Centre for Advanced Technology
Indore - 452 013

Presentation

to

Honourable Minister of State Shri Prithviraj Chavan

August 21, 2005

An Overview of the Activities of Centre for Advanced Technology (CAT)

CAT is the main R&D centre of DAE for Lasers and Accelerators, having branched off from BARC in early 80's. Its foundation stone was laid in 1984 and scientific activities got underway in 1986. Apart from accelerators, lasers and their applications, work is also going on laser materials, cryo-technology, low temperature physics etc.

Present focus of accelerators is on SRS & radiation related applications, while in lasers our interests are : solid-state lasers, gas lasers (CVL, COIL, CO_2 etc.), semiconductor lasers, as well as their applications, such as, in industry, medicine, laser cooling of atoms, spectroscopy etc.

First Office Order

Government of India
Department of Atomic Energy

C.S.M. Marg
Bombay-400 039

No. 25/34/83(BARC)-R

June 27, 1983.

OFFICE ORDER

Sub :- Centre for Advanced Technology at Indore, MP.

...

The Department of Atomic Energy has decided to set up a Research Centre for Advanced Technology at Indore. The Centre will initiate coordinated activities in the fields of inertially confined fusion research, plasma physics, advanced high energy accelerators, laser technology and other related areas such as laser isotope separation, industri... optical ... systems ...

I...

(...

(...

(...

Planning ... consisti...

1. Shri C. Ambasankaran, Director, E & I Group, BARC. .. Chairman

2. Dr. V.K. Moorthy, Director, Planning Cell, BARC. .. Member

...2

E1G-1492
1-7-83

The Department of Atomic Energy has decided to set up a Research Centre for Advanced Technology at Indore. The Centre will initiate coordinated activities in the fields of inertially confined fusion research, plasma physics, advanced high energy accelerators, laser technology and other related areas such as laser isotope separation, industrial lasers, cryogenics, ultra high vacuum technology, optical and X-ray instrumentation, nuclear detectors, RF systems and microelectronics, etc.

3. Dr. D.D. Bhawalkar, Head, Laser Section, BARC. .. Member

4. Shri A.D. Mathure, C & A Division, BARC. .. Member

5. Dr. V.K. Rohatgi, Head, Plasma Physics Divn., BARC. .. Member

6. Dr. N.S. Satyamurthy, Head, Nuclear Physics Division, BARC. .. Member

7. Shri R.C. A. Jain, Director, DAE. .. Member

8. Dr. G. Venkataraman, RRC. .. Member

9. Shri I.A. Lakshminarayanan, I.F.A., BARC. .. Member

...mber-
...cretary

...lowing :

...the

...keeping

...prepare
...quired
... the
...ntre.

...dget

e) To select personnel from within BARC and by recruitment, if necessary, through appropriate Committees, for forming the nuclii for the various activities at the Centre; and

f) All matters relevant and ancilliary to the implementation of this project.

The Committee will be responsible to and report to Director, BARC and Secretary to Government of Indial

Sd/-

(R. Ramanna)
Secretary to the Govt.of India

Foundation-Stone Laying Ceremony of CAT (Feb 19, 1984)

Inauguration of CAT by president Giani Zail Singh, Seen along with him (L to R) are – Dr. R. Ramanna, Chairman, Atomic Energy Commission: Shri P. C. Sethi, Union Home Minister; Shri Arjun Singh, Chief minister of M.P. , Shri Bhagwat Dayal Sharma, Governor of M. P.; Shri Shivraj Patil, Union Minister for Energy, Shri Rajnedra Dharkar, Mayor, Indore Municipal Corporation & Shri C. Ambasankaran, Chairman, P&IC, CAT

Our Synchrotron Radiation Sources

Indus-1 (450 MeV, 100 mA)

(Operational since 1999)

&

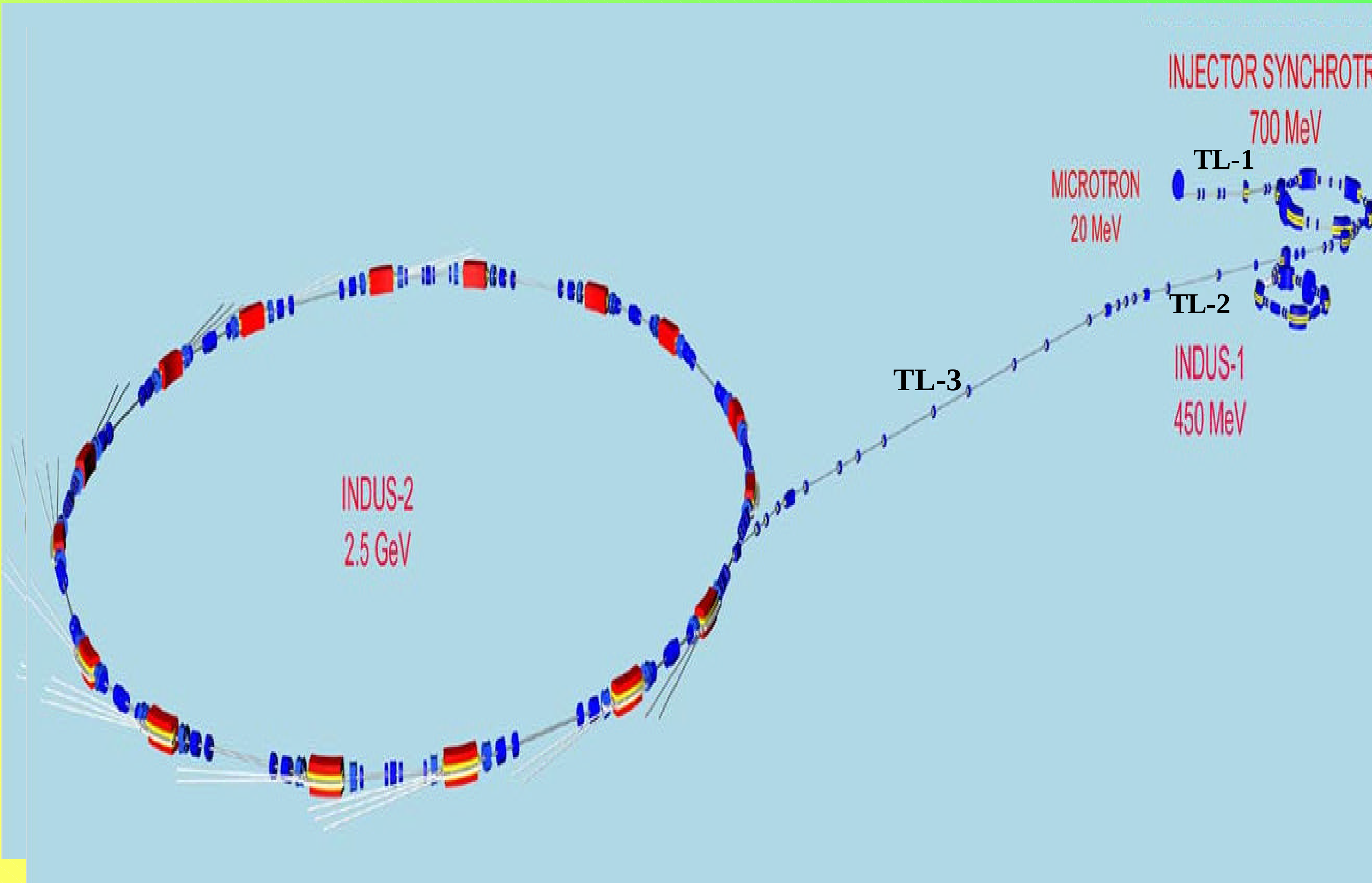
Indus-2 (2.5 GeV, 300 mA)

(Trials have begun to store the beam)

Sharing common injectors viz
a 20MeV Microtron & 700 MeV Booster

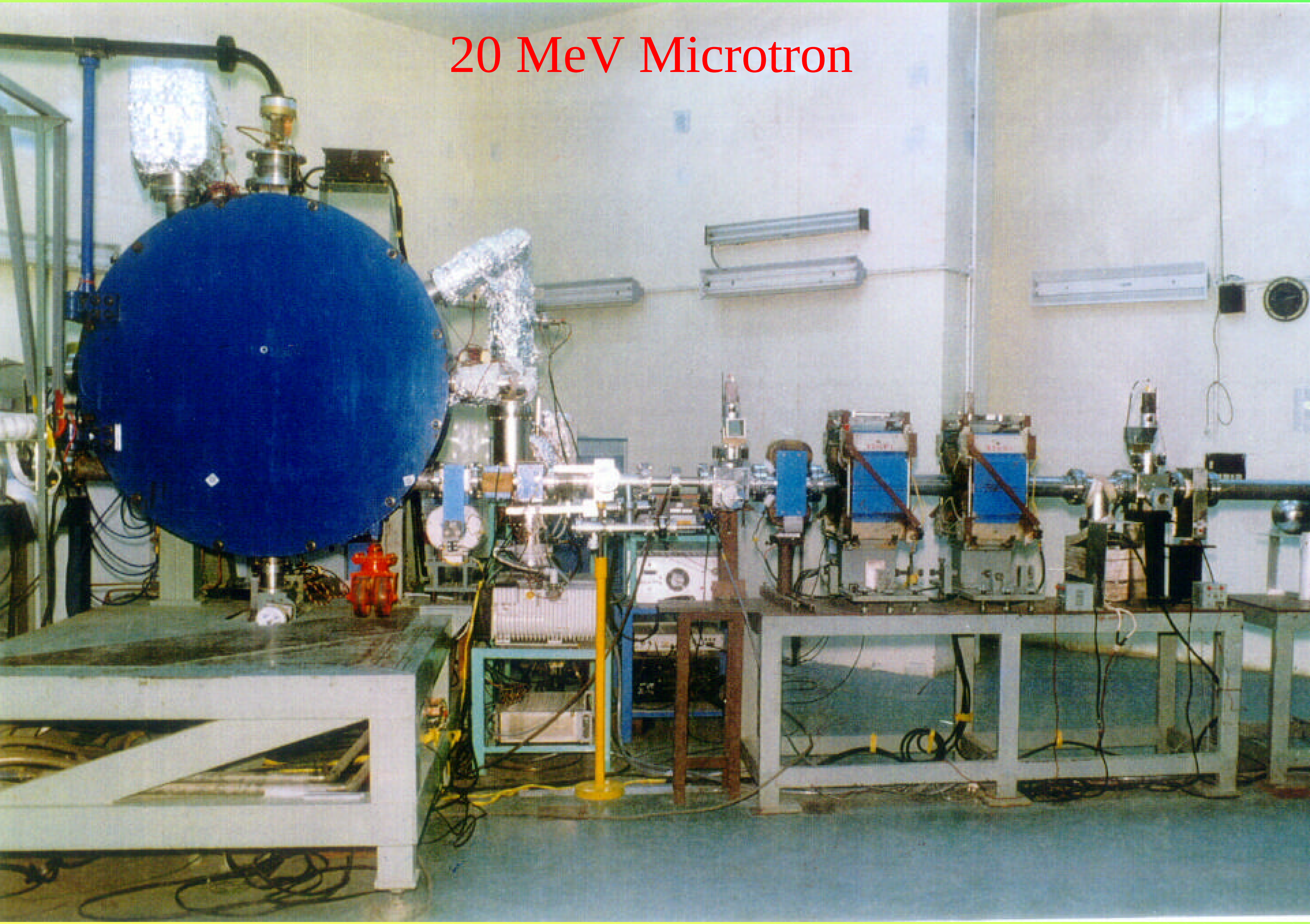
Hallmark of Our SRS Program is

- Intense focus on ***indigenous development & qualification*** of **most of the sub systems** through **home based efforts**.
- These include the magnets & their power supplies, vacuum chambers, ion pumps & gauges, beam diagnostic accessories, RF driver and control systems etc.
- Vendor development for many high quality components for these accelerators.

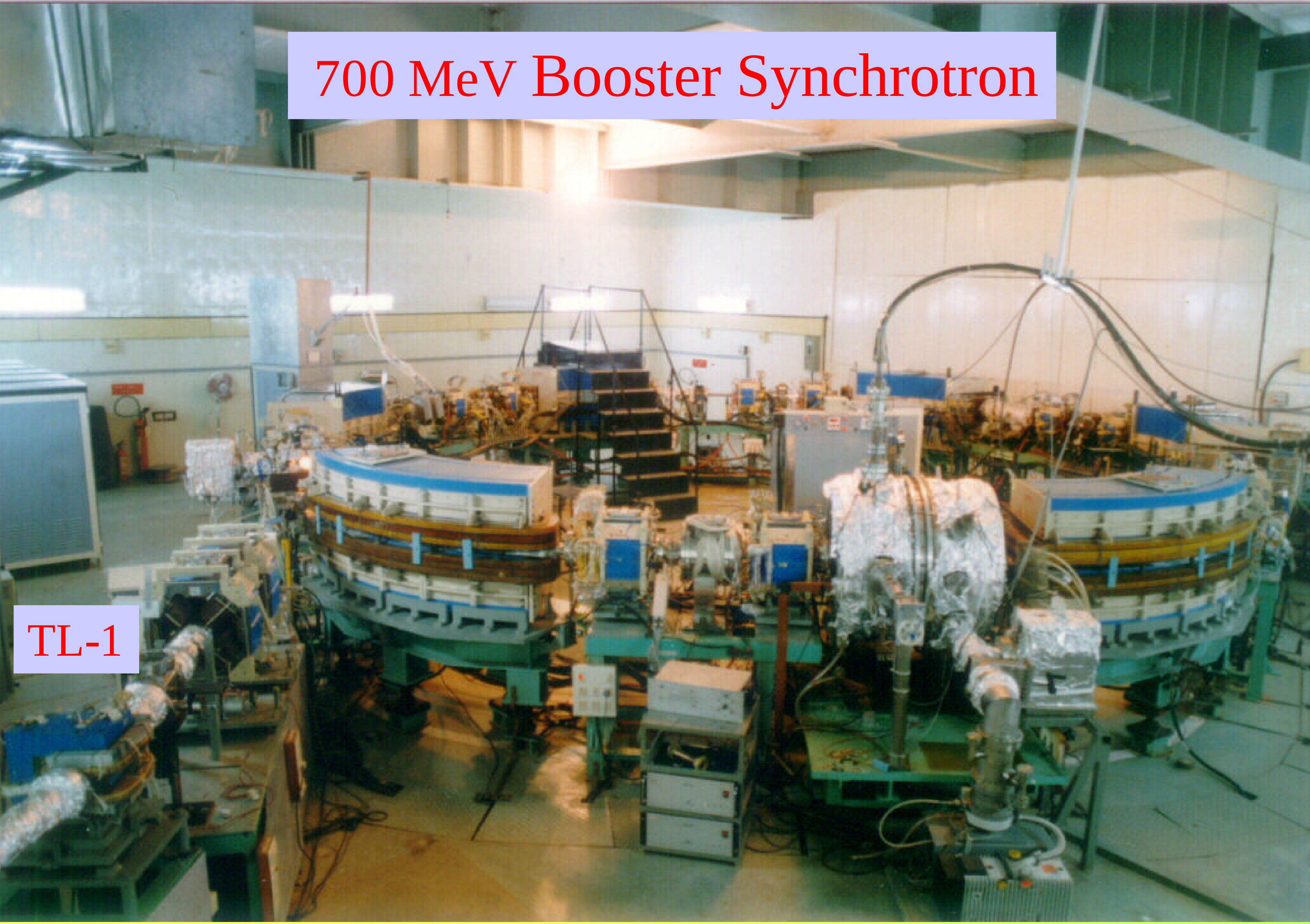


Schematic view of Indus Complex

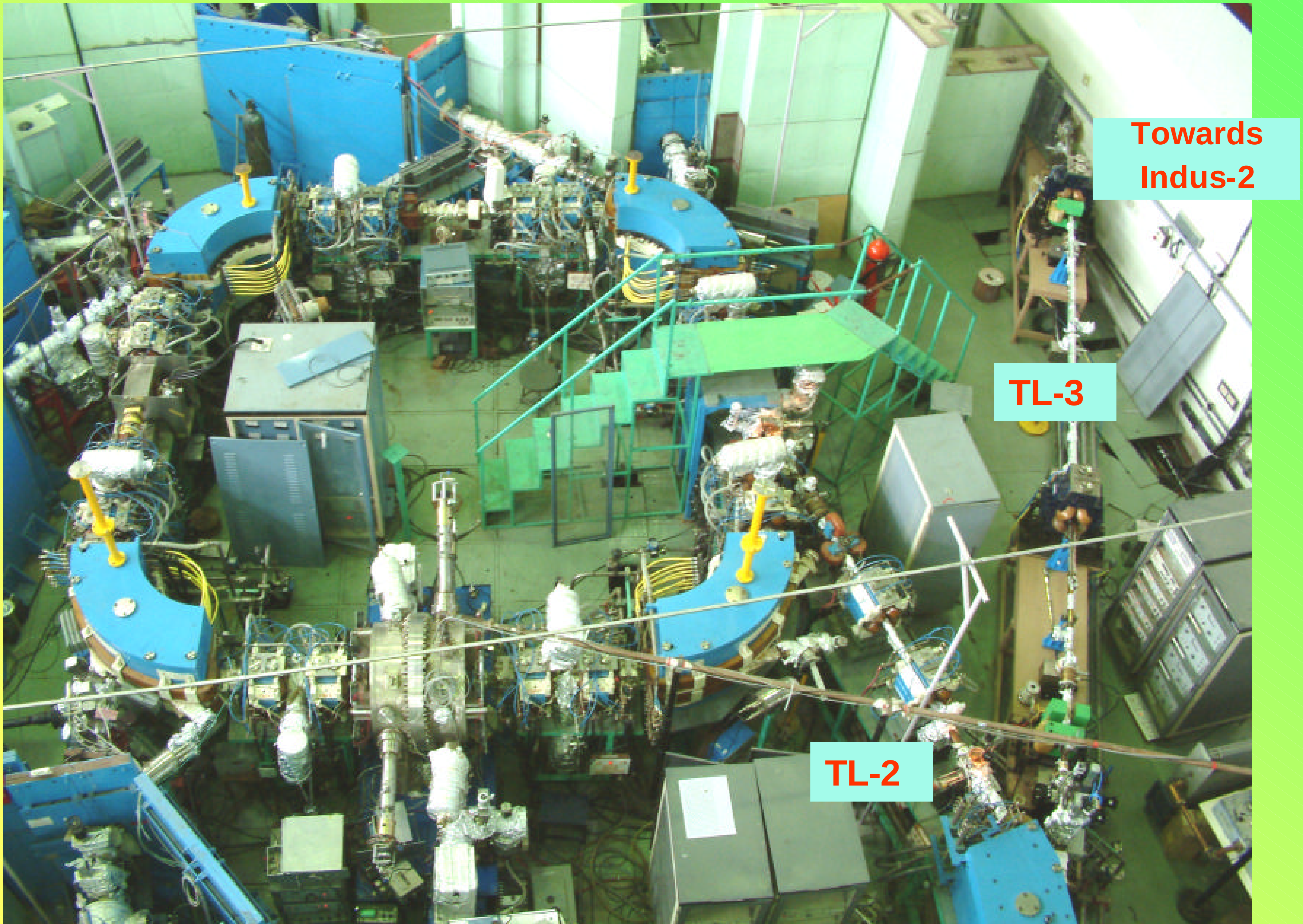
20 MeV Microtron



700 MeV Booster Synchrotron



Indus-1 Hall, Beam-lines, TL-2 & TL-3

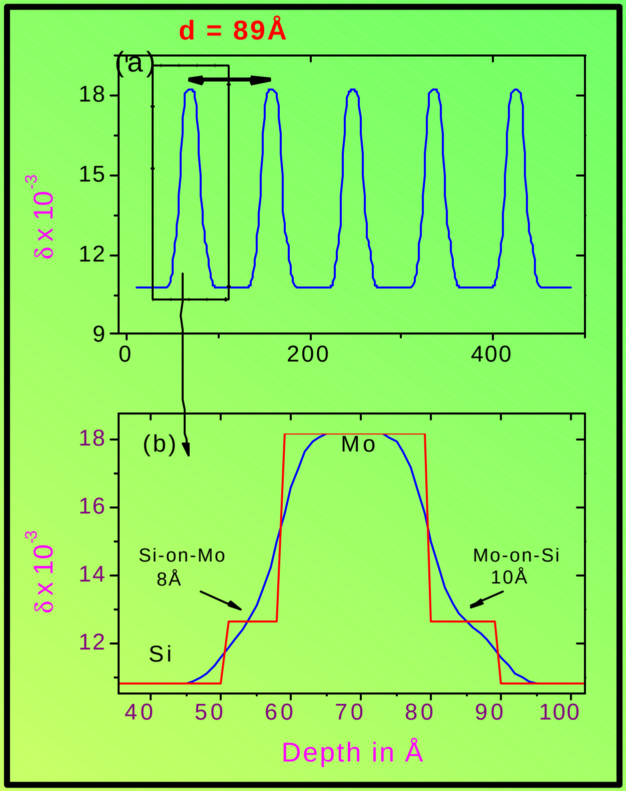


Indus-1 Beam-lines : Monochromators used & wave lengths covered (in A)

1. **Reflectivity – TGM (40 – 100A)**
2. **Photo physics – SN (500 – 2000A)**
3. **Angle resolved PES – TGM (40 – 1000A)**
4. **High resolution VUV Bl – RC (700 – 2000A)**
5. **Angle integrated PES – TGM (60 – 1600A)**
6. **Photoabsorption (PASS) – PGM (17 – 225A) $**

$ Under construction

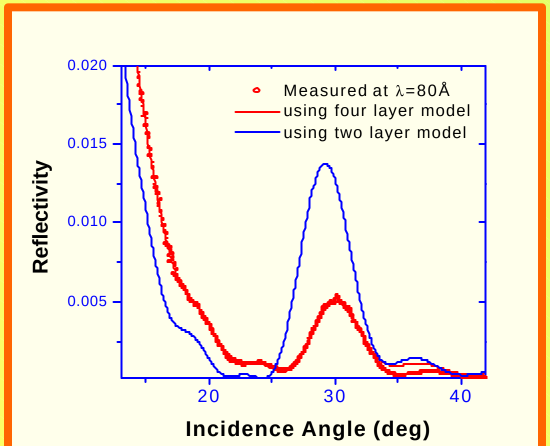
Reflectivity Beamline on Indus-1



Multilayer depth profile extracted from reflectivity data

Mo/Si multilayer: Interfacial studies

- Period 89Å (30Å Mo/ 59Å Si)$_5$
- Reflectivity Measurement @ λ=80Å



- Mo-on-Si Interface is thicker than the Si-on-Mo interface
- Interface asymmetry is due to large difference in thermal conductivities of M and Si

High Resolution VUV Beamline at Indus-1 (450 MeV) Synchrotron Source

for

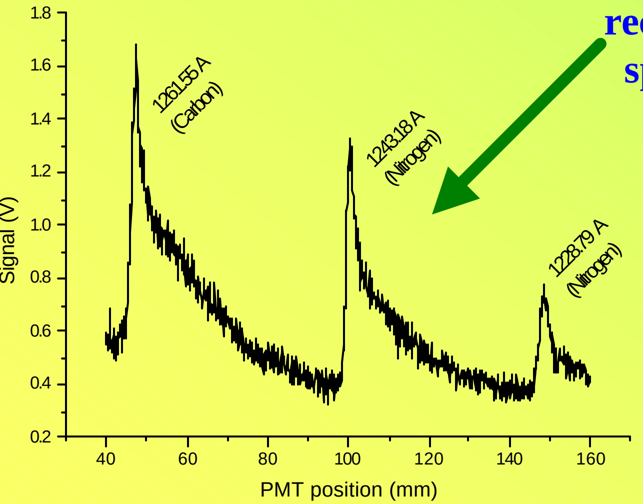
High Resolution studies of Atoms/Molecules for probing high-lying energy states

Identification of Rydberg states

Determination of ionisation potential of atoms/molecules

Measurement of photo-absorption cross-sections of individual and rotationally resolved absorption lines

Vacuum UV line of carbon and nitrogen recorded by the spectrometer



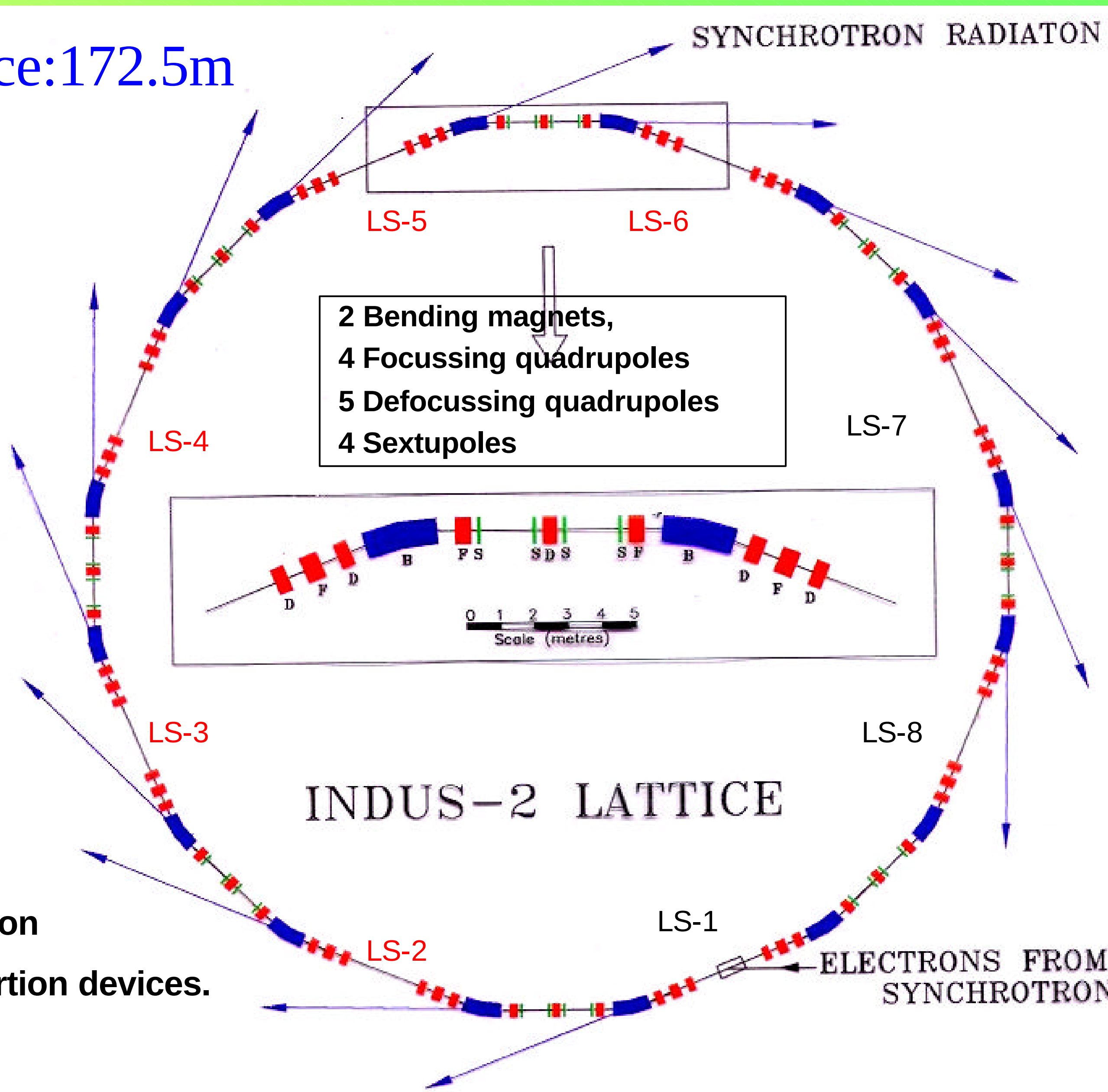
Wavelength Range: 700-2000 Å

Monochromator: Indigenous off-plane Eagle spectrometer

Resolution: 0.01 Å

Indus – 2 lattice & its components

Circumference:172.5m



S-1: used for injection

S-2 to LS-6: for insertion devices.

S-7: Unusable

S-8: for RF cavities

PARAMETERS OF Indus-2

Maximum energy		:	2.5 GeV
Maximum current		:	300 mA
Lattice type		:	Expanded Chasman Green
Superperiods		:	8
Circumference		:	172.4743 m
Bending field		:	1.502 T
Typical tune points		:	9.2, 5.2
Beam Emittance	ex	:	5.81×10^{-8} mrad
	ey	:	5.81×10^{-9} mrad
Available straight section for insertion devices		:	5
Maximum straight length available for insertion devices		:	4.5 m
Beam size	s x	:	0.234 mm
(Centre of bending magnet)	s y	:	0.237 mm
Beam envelope vacuum		:	$< 1 \times 10^{-9}$ mbar
Beam life time		:	15 Hrs
RF frequency		:	505.812 MHz
Critical wavelength		:	1.98 Å (Bending Magnet)
			0.596 Å (High Field Wiggler)
Power loss		:	186.6 kW (Bending magnet)

Magnets:

Dipoles : 16; Q'poles: 32 focusing & 40 defocusing type; S'poles: 32

Indus-2 OVERVIEW

1997 : Decision to make 2.5 GeV energy machine

1998- 2002 : Civil construction & infrastructure development, vendor identification, material procurement etc.

2000-2004 : Subsystem fabrication & evaluation phase.

2004 onwards: Subsystem installation & final commissioning.

Cost : 95 Crores (Cost of machine & building).

Indigenous Systems Developed : Vacuum chambers, magnets, power supplies, beam diagnostics and RF power system etc.

Imported Items: RF cavities & Klystrons.

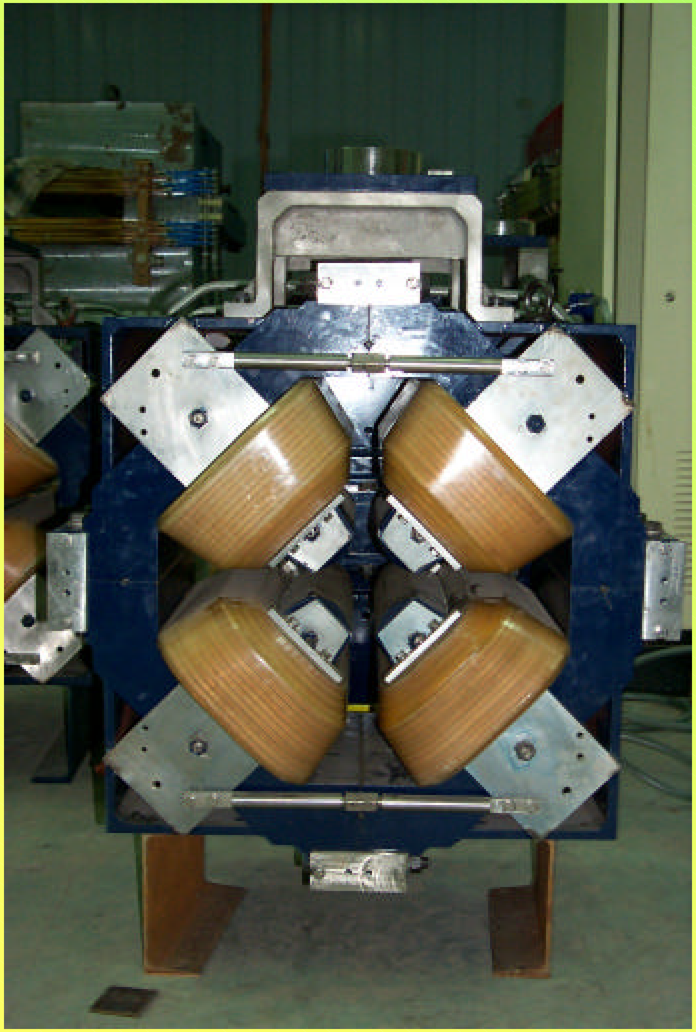
Main Dipole Magnet for Indus-2. Yoke made by Godrej, Mumbai;coils by CAT

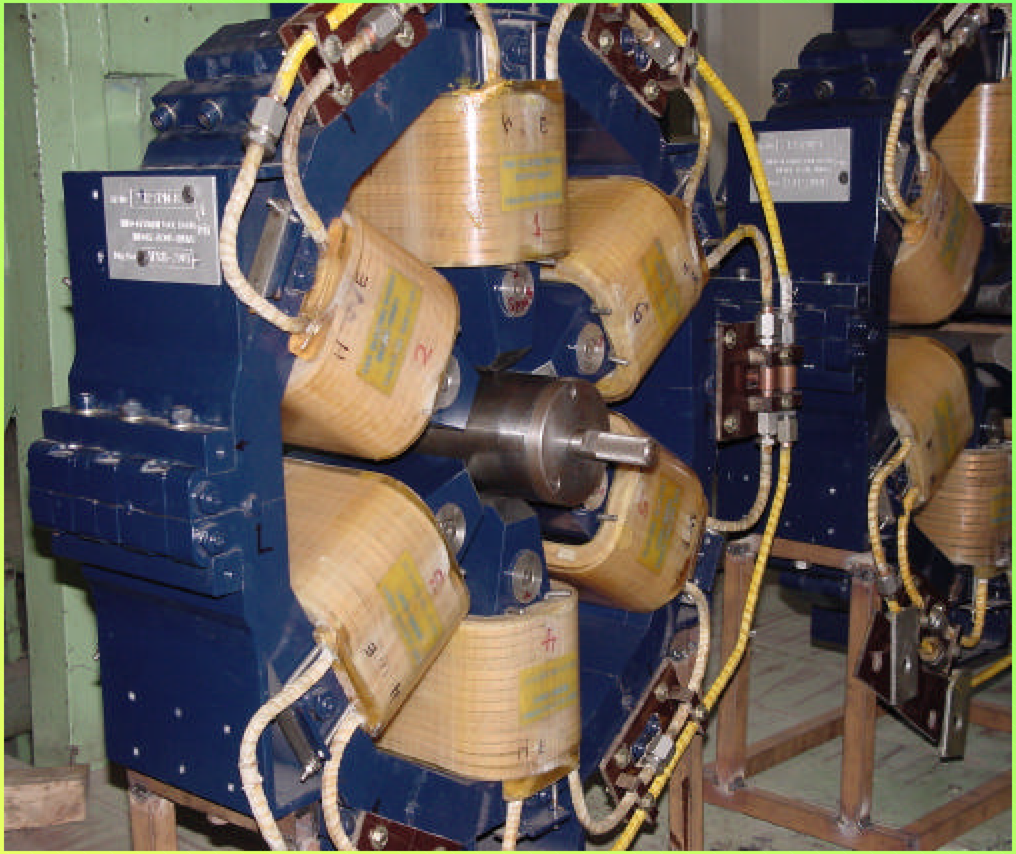
(Field: 1.5T; Gap: 50mm; NI: 70,000 Amp turns)

Q’poles & S’poles made at CMTI & CAT

(Q’p: Field:16T/m; Gap: 85 mm; NI:13,000 A turns)

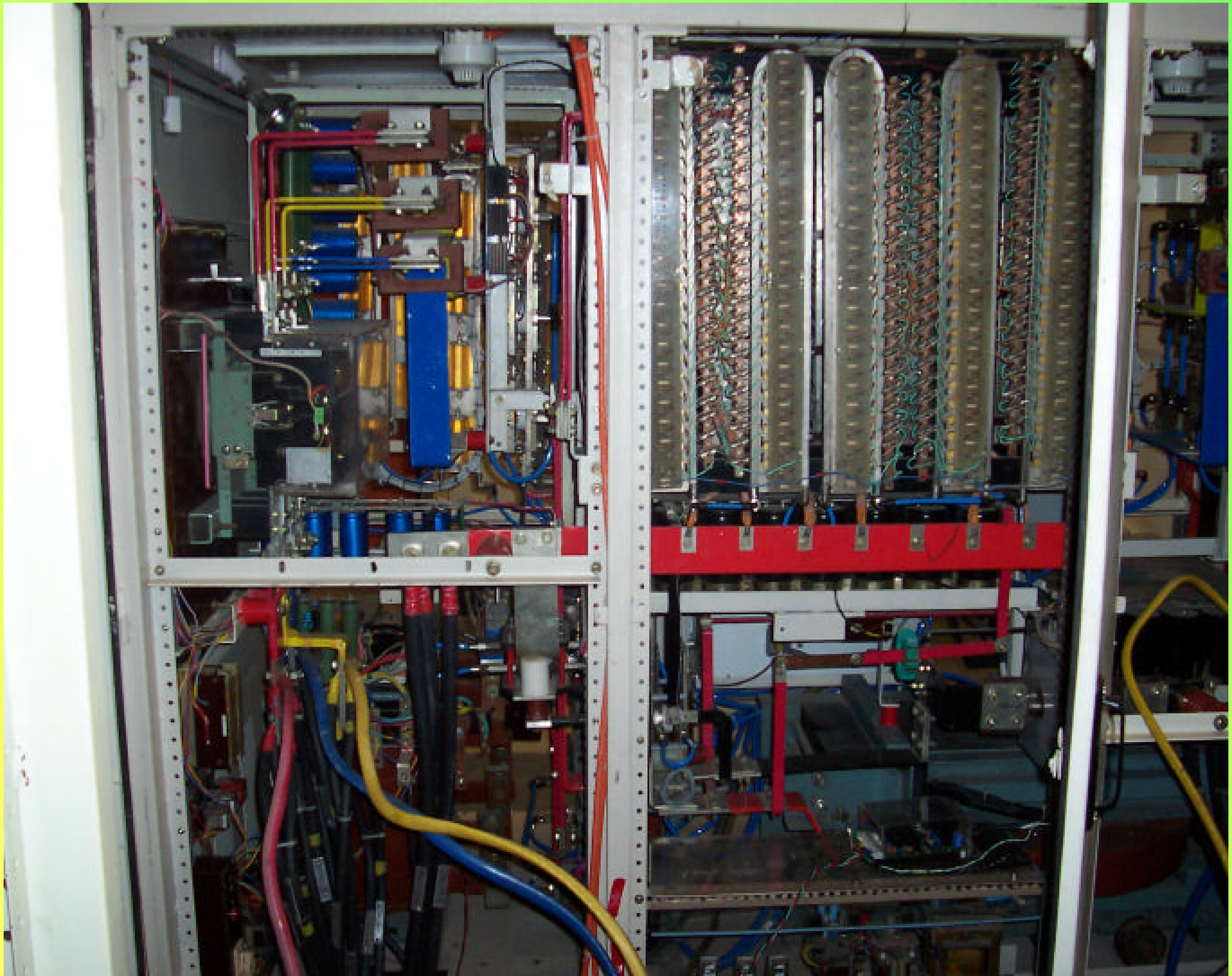
(S’p: Field: 400T/m2; Gap: 92 mm; NI: 5,700 A turns)





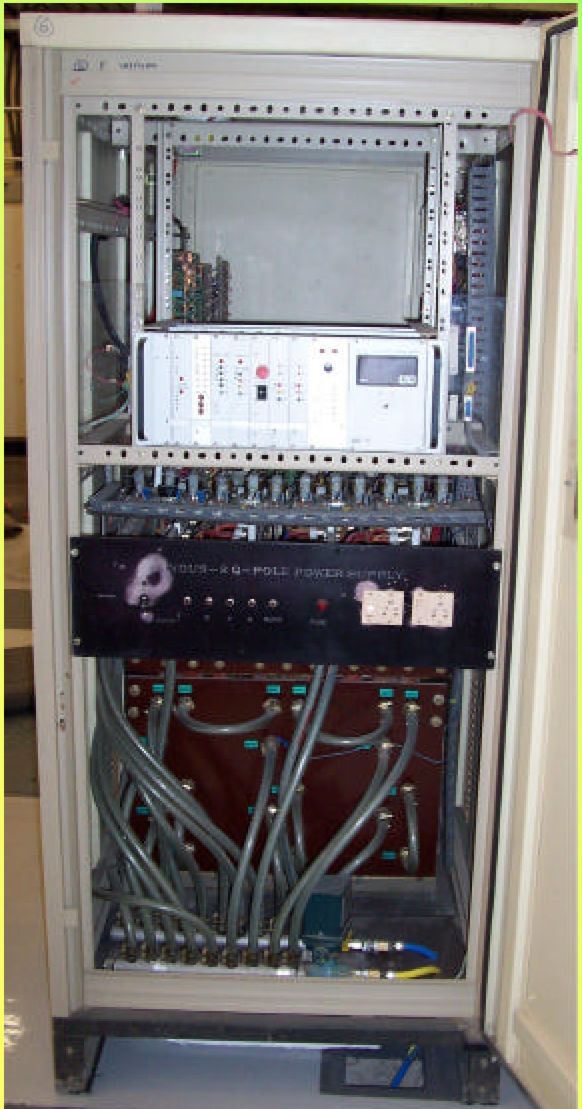
Indus-2 Dipole Power Supply

One P/S for 16+1 dipole magnets, Min - Max current 200-900 Amp, Max Voltage 680 Volts



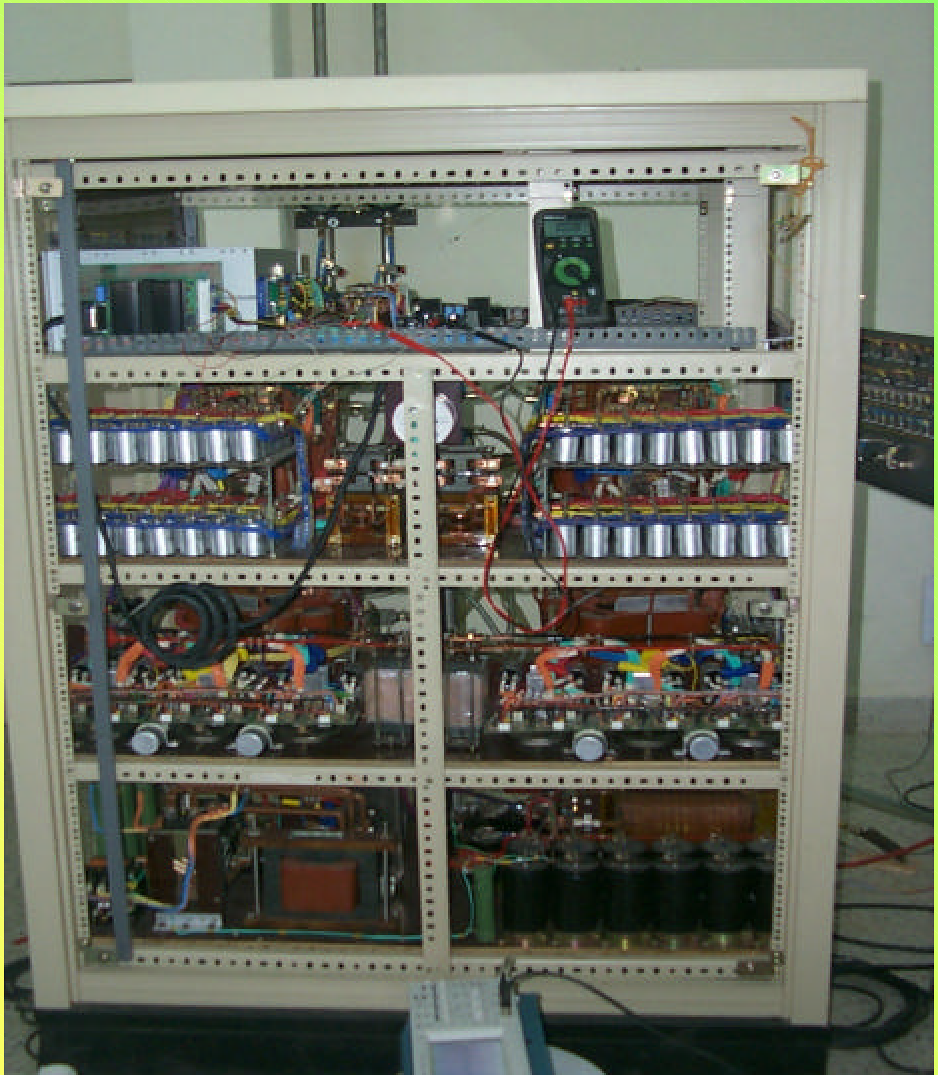
Indus-2 Q/P-1,2,3 Magnet P/S

8+8+8 P/S for Q-pole magnets, Min - Max current 30-180 Amp,
Max Voltage 87 - 119 Volts

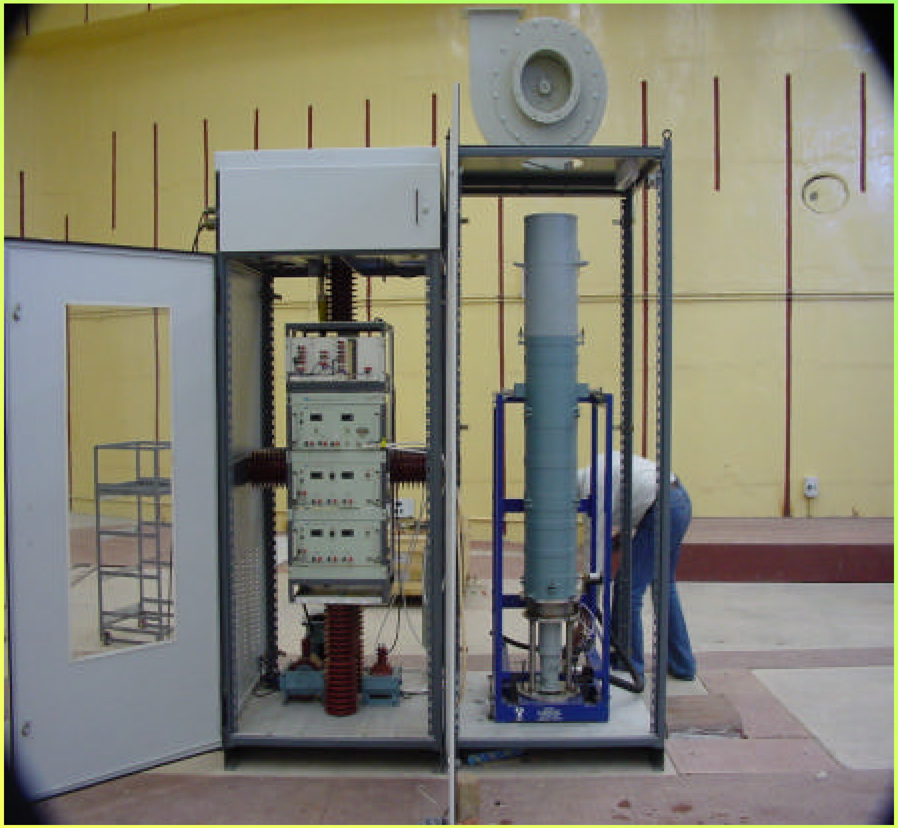


Indus-2 Sextupole Magnet P/S

Two P/S for 32 Sextupoles magnets, Min - Max current 40-230 Amp, Max Voltage 300 Volts



RF System



Klystron Tube & Auxiliary PS / Interlock

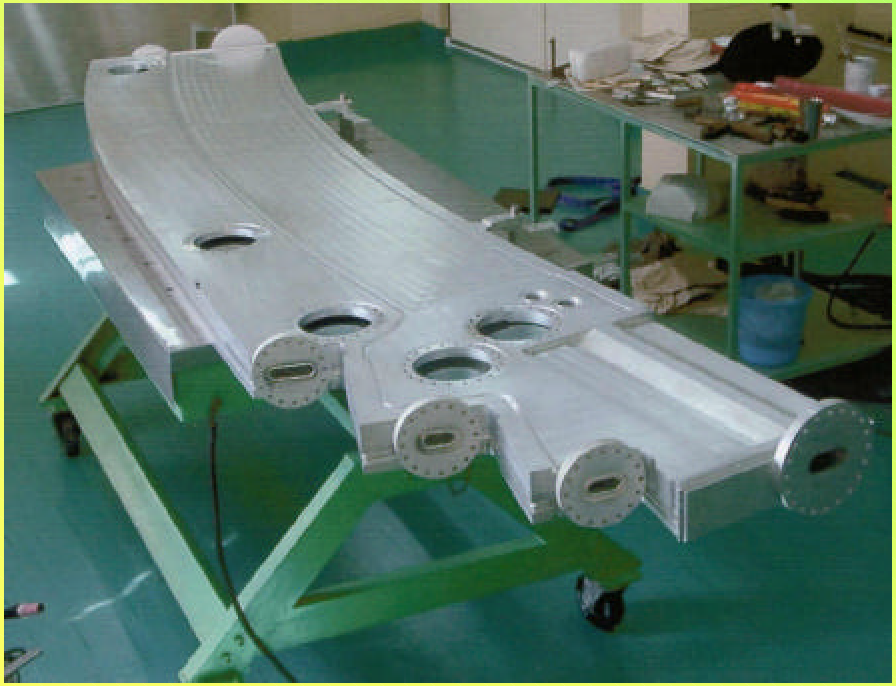
Co-axial Line, Circulator & Klystron

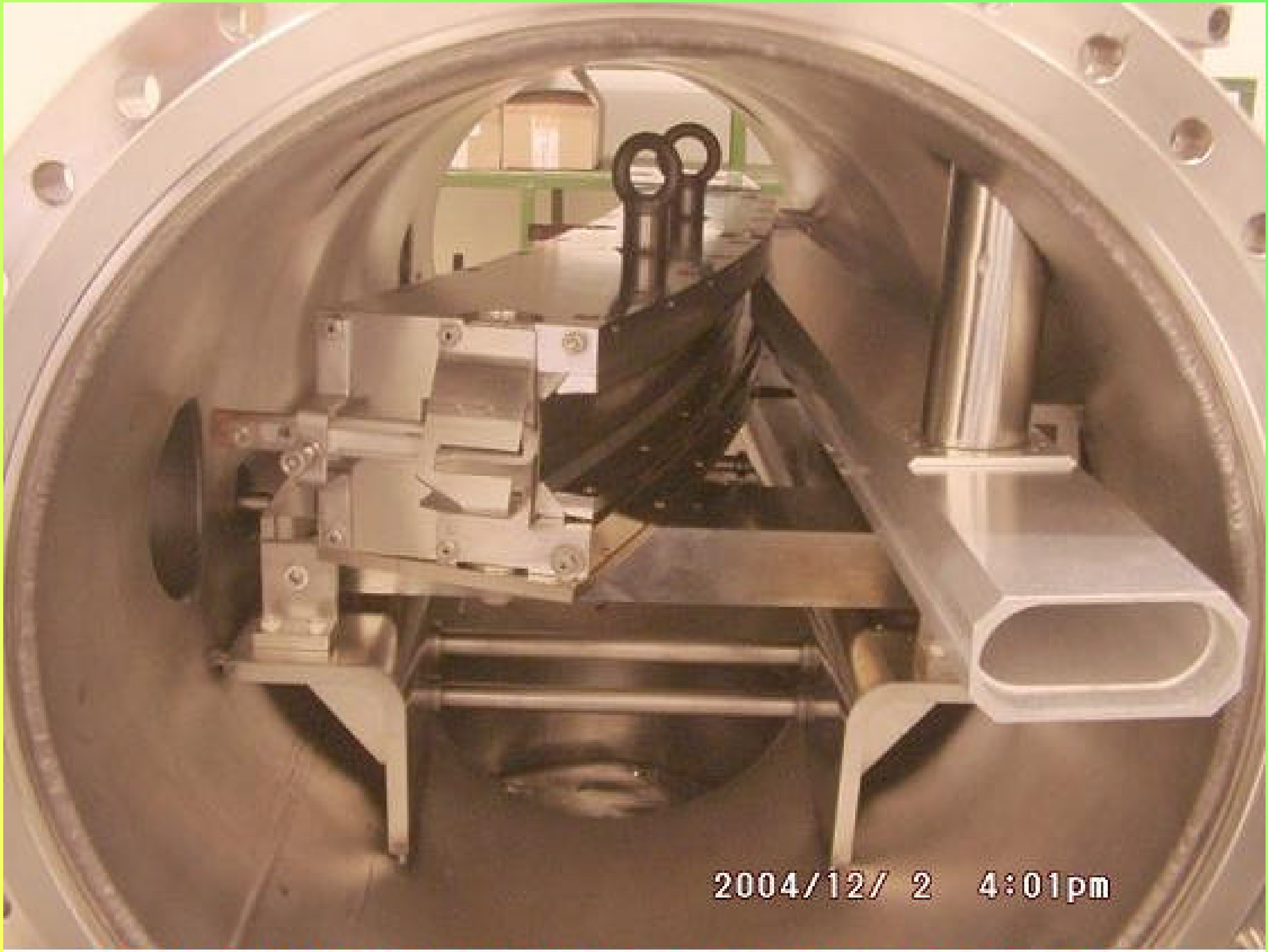
Solid-state Driver Amplifier

Indus –2 RF Power System

Dipole Chambers

- Material: Aluminium alloy A5083-H321 (Machining of 2 halves done by HAL; Welding plus leak checking etc. done at CAT)
- Two beam ports at 5^0 and 10^0 in each dipole chamber
- Additionally, port at 0^0 is also provided in five dipole chambers for insertion devices





DETAILED INSIDE VIEW OF SEPTUM CHAMBER

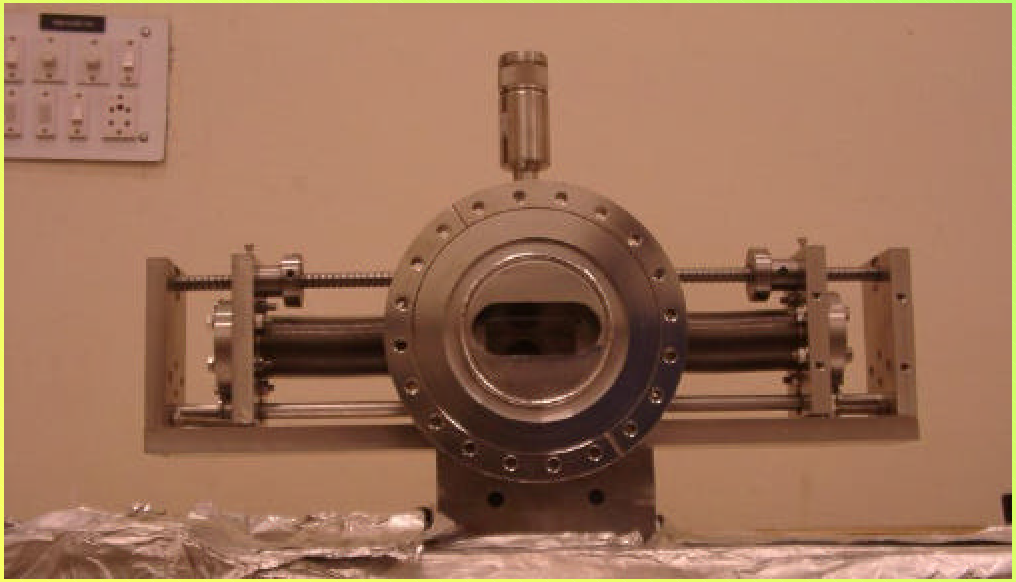
- Photon Absorber
  - To absorb unwanted photon x-ray radiation and protect the vacuum chambers
  - Material: OFHC Copper

Beam diagnostics

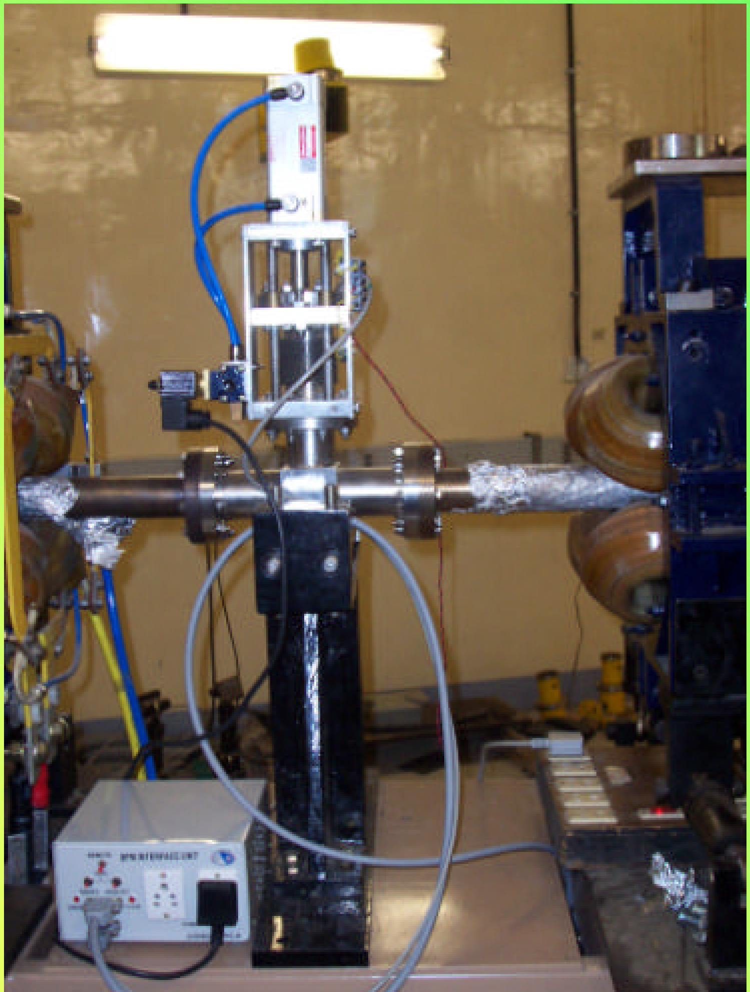
- Precision fabrication/ assembly
- Calibration, fast signal processing
- UHV compatibility
- Devices used: Beam Position Monitors (Electrostatic pick-up), Beam Profile Monitors, Stripline Monitors, DCCT, Beam Scrapers, Wall current monitors, Secondary emission wire monitors, Sighting Beamline, Visible / X-ray diagnostic beam line.

Beam Diagnostics …cont.

Horizontal Scraper during assembly



Beam profile monitor



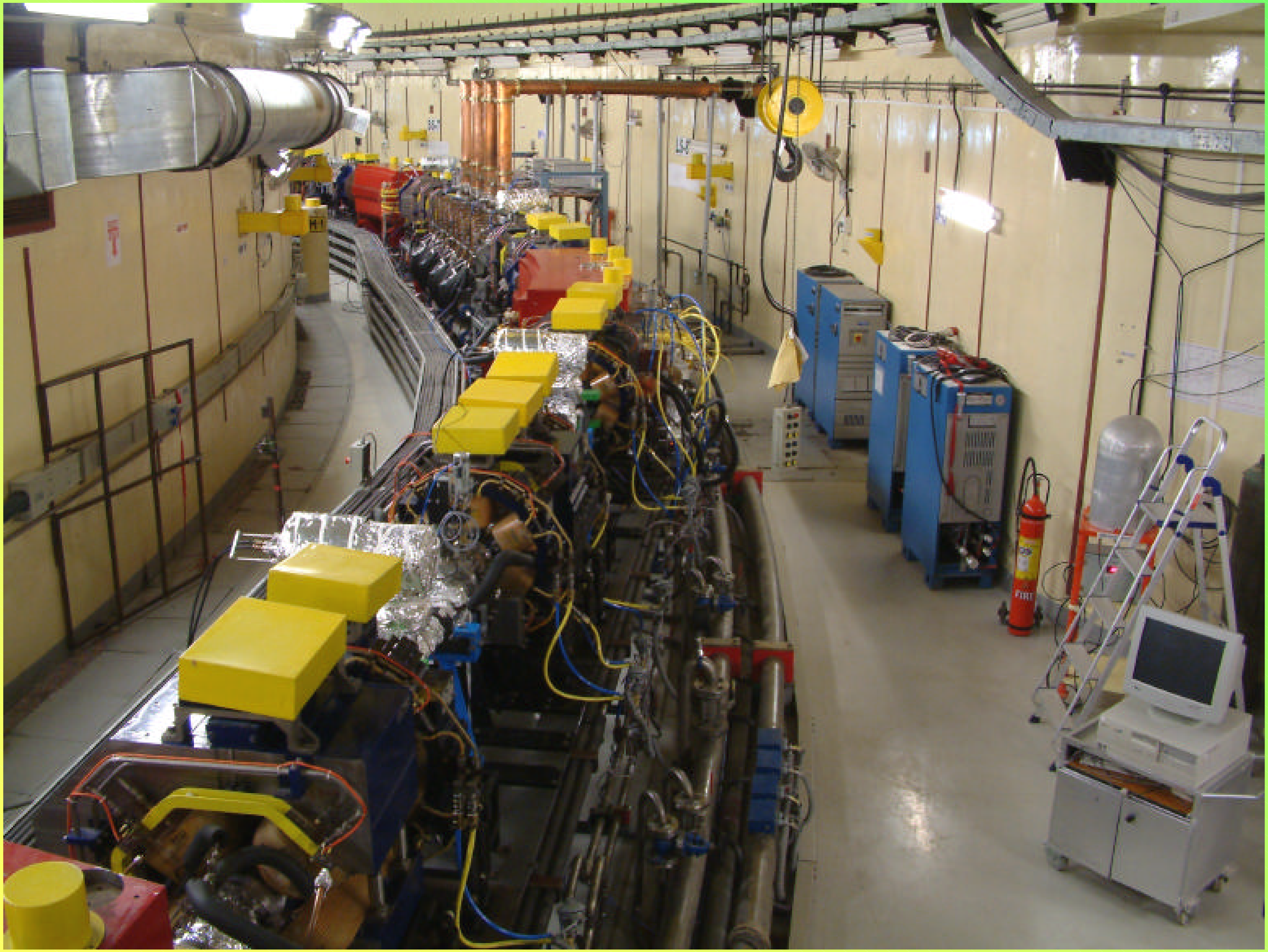
Control System … cont.

Control room for Indus-1 and 2

Subsystem Qualification and Installation Details

1. All vacuum chambers were baked to get ~10^{-9} mbar before assembling in the ring.
2. All p/s were tested with dummy loads.
3. Field mapping done on each magnet. Data was used **to optimize magnet locations ie "which one to place where"for best performance of ring**.
4. This optimization was arrived at using the simulated annealing algorithm.
5. All Transfer Line (TL-3) & Indus-2 components were installed after full qualification.

Assembly of Indus-2 Ring in the Tunnel



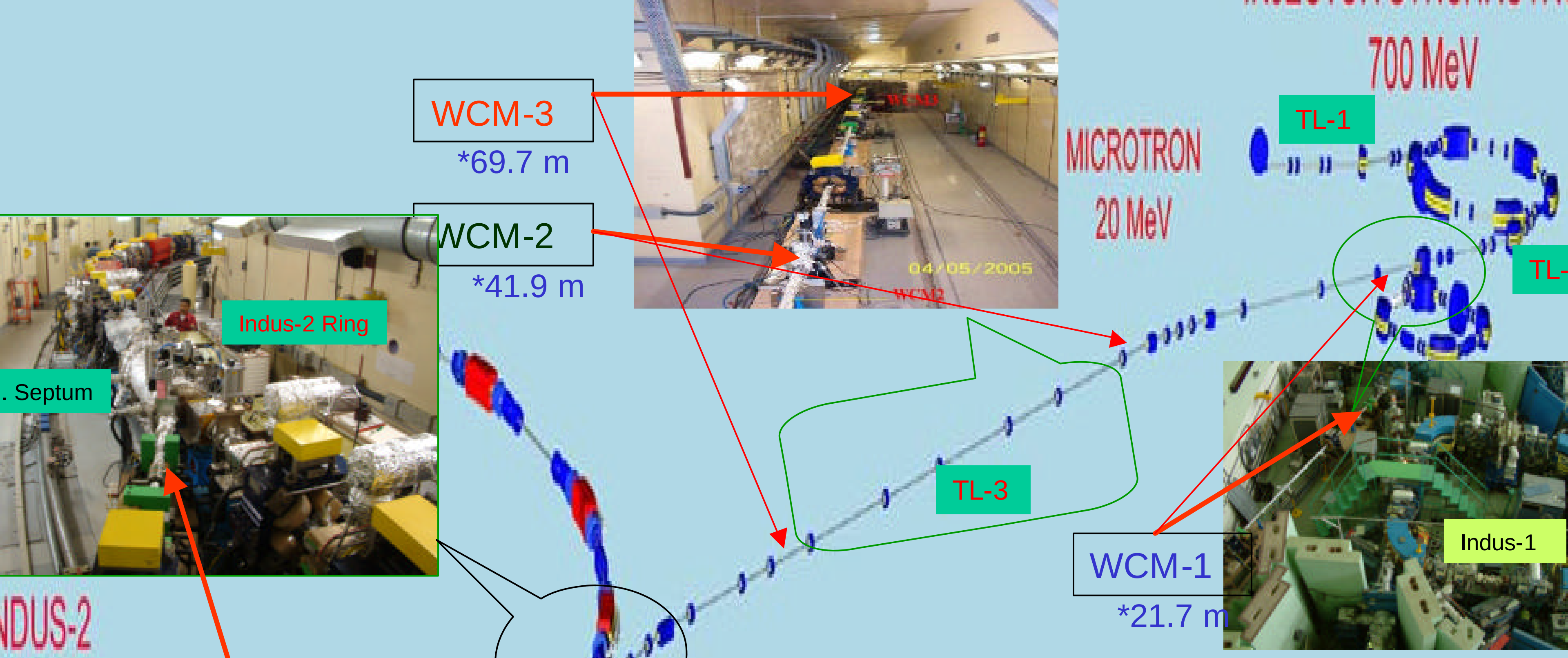
RF Cavities Commissioned in Indus-2 Ring

Long Straight Section LS-6 Assembly

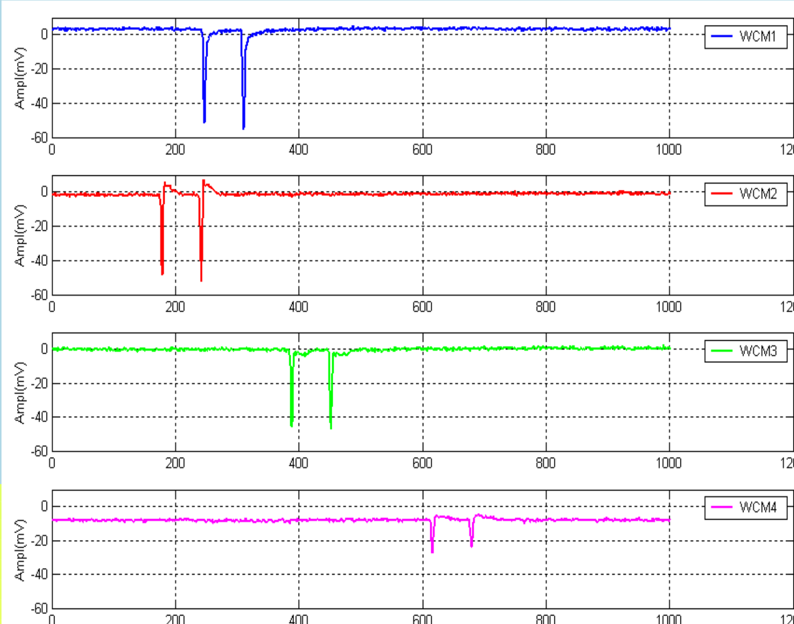
TL-3 Joining on to Indus-2

Status of Indus-2 as of August 20, 2005

- **Storage ring & TL-3 installation & evacuation completed.**
- **Booster synchrotron operated upto ~ 550 MeV.**
- **Dipole magnet P/S of Indus-2 connected and energized to a level so that ~ 700 MeV energy beam can be circulated.**
- **All main subsystems can be controlled from Control Room Consoles and final tests have been completed.**
- **On August 11, 2005 AERB gave consent to carry & inject up to 10 mA beam into Indus-*2* & raise its energy upto 2 GeV.**
- **Trial experiments to store beam in Indus-2 started. First runs with 450 MeV beam from booster to injection point on Indus-2 (via TL-2 and TL3) successfully completed ~ 8 pm on Aug 14, 2005.**
- **Beam quality improved & taken into the ring up to first BPM, (past kicker magnets K3 & K4) ~ 4:30 pm on August 20, 2005.**



Signals from Wall Current Monitors showing Beam Transmission through TL-3 on Aug 14, 2005



* Number designates the distance from extraction point
on Booster Synchrotron

Letter from Prof. Herman Winick from Stanford Linear Accelerator Centre, Stanford Synchrotron Radiation Laboratory, USA

ANFORD LINEAR ACCELERATOR CENTER
ANFORD SYNCHROTRON RADIATION LABORATORY
SSRL

fessor Anil Kakodkar
irman, Atomic Energy Commission and Secretary D.A.E.
.C.
mbai – 400 001

July 6, 2005

Email: chmn@dae.gov.in

r Professor Kakodkar

he recent US Particle Accelerator Conference (PAC05) in Knoxville Tennessee, I chaired a session which uded a talk by Professor Vinod Sahni on the Indus facilities following which Professor Sahni kindly invited me ome to India for a five day visit on my way to a meeting in Melbourne of the International Scientific Advisory nmittee (ISAC) for the Australian Light Source. I gladly accepted this invitation because I was eager to see the gress on the synchrotron radiation program at CAT since my previous visits there many years ago. From June 27 I spent two days at BARC and two days at CAT. I gave two talks at each laboratory and engaged in

As I am sure you know, Indus 2 has immense potential for basic and applied research, including biomedical and environmental studies of great relevance to developing strategies for dealing with societal issues that are of great importance to India and other countries in the region. In this regard it is very good that the energy of Indus 2 wa raised from 2 GeV to 2.5 GeV, bringing the facility into the class of new rings recently completed at my laborato at Stanford University and in Canada, and rings in construction in Australia, China, France, Spain and the UK. Th relatively small increase in electron beam energy greatly expands the scientific range of Indus 2, since at this ener it is possible to use recently developed undulator designs (such as in-vacuum, small gap, short period devices) to produce very high brightness x-ray beams up to about 15 keV, a spectral range of particular importance to structu molecular biology (including protein crystallography) and molecular environmental science. With an electron energy of 2.5 GeV Indus 2 can take advantage of these technological developments to achieve hard x-ray performance levels that are much closer to that of the very biggest third generation rings (the 6-8 GeV rings in Europe, Japan, and the US) than was previously expected.

In discussions with Professor Sahni during this visit I learned of his intention to make the Indus rings available t scientists from other countries, including Pakistan, and to offer the expertise and experience gained with designi building, and commissioning the Indus rings to assist nascent projects such as SESAME in Jordan and CANDLE

In a detailed tour around the Indus 2 ring the high quality of the engineering and fabrication that has gone into the technical components (magnets, vacuum system, rf system, etc.) was apparent. This is equal to standards in storage rings in the most developed countries. It is particularly noteworthy that most of this equipment was built in India, significantly expanding India's high-tech capacity. Indus 2 is very close to completion and injection trials should

ign specifications and that offer state-of-the-art beam lines and user-support. Also, the injection system is not able and does not meet its design specifications. This also should be fixed since a more reliable and higher formance injection system will greatly aid commissioning of Indus 2 and the operational efficiency of both rings.

a detailed tour around the Indus 2 ring the high quality of the engineering and fabrication that has gone into the inical components (magnets, vacuum system, rf system, etc.) was apparent. This is equal to standards in storage gs in the most developed countries. It is particularly noteworthy that most of this equipment was built in India, nificantly expanding India's high-tech capacity. Indus 2 is very close to completion and injection trials should t within a few months. An important milestone was recently achieved with the successful transport of the ctron beam from the injector all the way down the long transfer line to Indus 2, so that injection trials can start as n as the last few components of Indus 2 are installed. This is indeed an exciting time and the staff is eager to in injection to the ring.

ent several hours with the machine staff, particularly the very important beam dynamics group which is ponsible for the basic design of the machine, including the specification of tolerances, diagnostics, rumentation and controls, application programs, etc. I was very impressed with the thoroughness and fessional level of their work. The next challenge will be commissioning the ring. Based on my observations and ailed discussion with the staff, I expect that commissioning will go well. Two reasons for this are the excellent ay of diagnostic instrumentation, and the careful study of a relaxed optics that could facilitate commissioning in early stages. I was so impressed with the quality of this work that I urged them to start commissioning using the re demanding final optics, since I believe that there is a good chance they can achieve a stored beam in this figuration within a week or so of first injection trials.

d not make as thorough an evaluation of the status of work on the beam lines and experimental program, ough there is clearly much activity underway at BARC and particularly at CAT, where I met with several entists working on the design and construction of beam lines and planning the experimental programs on Indus 2. ould have liked to see more beam line equipment on the experimental floor since the storage ring will very likely able to offer some stored beam within a few months. Although it will take several more months to reach the ign level of stored beam current, stability and lifetime, I expect that very soon there will be enough to start nmissioning and characterizing beam lines and in fact doing the first experiments.

teams designing and using Indus beam lines. At the PAC05 meeting in Knoxville, I arranged for Prof. Sahni to discuss this with Dr. Gaetano Vignola, the Technical Director of SESAME. While in India I suggested to Prof. Sahni that he might discuss these possibilities with Prof. Herwig Schopper, President of the SESAME Council a former Director-General of CERN when he visited CERN during the week of June 27. I was happy to hear from Prof. Schopper that he had a very positive discussion with Prof. Sahni about this.

It may be of interest to you to know that I have developed strong connections with scientists in Pakistan, initially through their participation in SESAME. In the summer of 2004 I gave a series of lectures on synchrotron radiat sources and research at the Nathiagali Summer College in Pakistan. I was pleased to be asked by Prof. Riazuddin join the International Advisory Scientific Council (IASC) of the National Centre for Physics (NCP) of Pakistan o which he is the director. Prof. Riazuddin would be the best person in Pakistan with whom to discuss India/Pakis cooperation in synchrotron radiation science.

While in Pakistan, and also at several SESAME meetings, I met with Pakistani scientists who are effectively promoting synchrotron radiation science and technology in Pakistan, including plans for designing and building world-class soft x-ray spectroscopy beam line for SESAME and eventually constructing a national synchrotron radiation facility in Pakistan. The scientist leading the design of the beam line project is Dr. Zahid Hussain, a se scientist from Pakistan who is now at the Advanced Light Source at the Lawrence Berkeley National Laboratory worked with him in the early 1980's in commissioning the first permanent magnet undulator and have great resp for him as a scientist and as a person eager to promote science and technology in the developing world. The bea line that is being designed for the 2.5 GeV SESAME ring would also be very appropriate for Indus 2. If a cooperative agreement between India and Pakistan could be worked out I could imagine that two identical beam lines could be built, at considerable savings, one for SESAME and one for Indus 2. This is but one example of possible scientific and technical cooperation between India and Pakistan.

My interest in international scientific activities has led me to run (successfully) for election as Vice Chair of the Forum on International Physics (FIP) of the American Physical Society (APS). I will move on to chair FIP in 20 In these positions I will work with others in the APS and the US government to assist India and other countries as those in the Middle East, Africa and elsewhere to make progress in the development of scientific research in their countries, with particular emphasis on the role of synchrotron radiation.

As I am sure you know, Indus 2 has immense potential for basic and applied research, including biomedical and environmental studies of great relevance to developing strategies for dealing with societal issues that are of great importance to India and other countries in the region. In this regard it is very good that the energy of Indus 2 was raised from 2 GeV to 2.5 GeV, bringing the facility into the class of new rings recently completed at my laboratory at Stanford University and in Canada, and rings in construction in Australia, China, France, Spain and the UK. This

Herman Winick

Herman Winick

Assistant Director and Professor (research), Emeritus
Stanford Synchrotron Radiation Laboratory Division of the
Stanford Linear Accelerator Center (www-ssrl.slac.stanford.edu)
Professor (research), Emeritus; Applied Physics Dept, Stanford University

SSRL/SLAC MS 69; bldg 137, room 316; 2575 Sand Hill Road, Menlo Park CA
94025-7015 USA; Office Phone: (650)926-3155; Office FAX: (650)926-4100;
Email:winick@slac.stanford.edu; Home Ph:(650)493-1900; home FAX:(650)856-2840
http://www-ssrl.slac.stanford.edu/faculty/faculty_research.html#Winick
[EOB]

Indus – 2 Team

Prototype Front-end of Indus-2 Beam-line

List of Beam-lines being built/designed/planned

	Range (KeV)	Groups
Being built		
XRD powder diffraction	5 – 25	CAT
XRF-microprobe	2 – 20	CAT
Energy Dispersive – XRD	10 – 70	BARC
EXAFS	5 – 20	BARC + UGC-DAE-CSR
Grazing incidence mag scattering	5 – 15	SINP, Kolkatta
PES	.08 - 15	BARC
Small angle X-ray scattering (SAXS)	8 - 16	BARC + UGC-DAE-CSR
Being designed		
Protein Crystallography	6 – 25	BARC + UGC-DAE-CSR
White-beam lithography	1 – 10	CAT
MCD / PES on bending magnet	0.03 – 4	UGC-DAE-CSR
Medical imaging beam-line	10 – 35	BARC
Planned		
IR-beam-line	2 – 100 mm	BARC
Undulator-MCD	0.1 – 1.5	CAT
Imaging beam-line	15 – 35	UGC-DAE-CSR
Multipurpose white-EDXRD	5 – 40	UGC-DAE-CSR
X-ray beam diagnostics	6.2	CAT
Visible beam diagnostics	Visible	CAT

Assembly of X-Ray Diffraction Beam Line BL-12

10MeV, 10kW Electron LINAC for food & medical product irradiation

Other Accelerators for Radiation Processing Applications

1. Home Built DC Accelerator 500-750 KeV, 10 kW

   (Operational since 2003)

2. 2.5 MeV, 100 kW DC Accelerator

   (Under development)

12 MeV Microtron Given to Mangalore University

DEVELOPMENT OF INDUSTRIAL & MEDICAL LASERS :

- **INDUSTRIAL Nd:YAG LASERS WITH FIBER OPTIC BEAM DELIVERY SYSTEM FOR INDUSTRIAL APPLICATIONS**

- **HIGH PEAK POWER Nd:YAG LASERS**

- **SURGICAL CARBON DI-OXIDE LASER WITH BEAM DELIVERY SYSTEM**

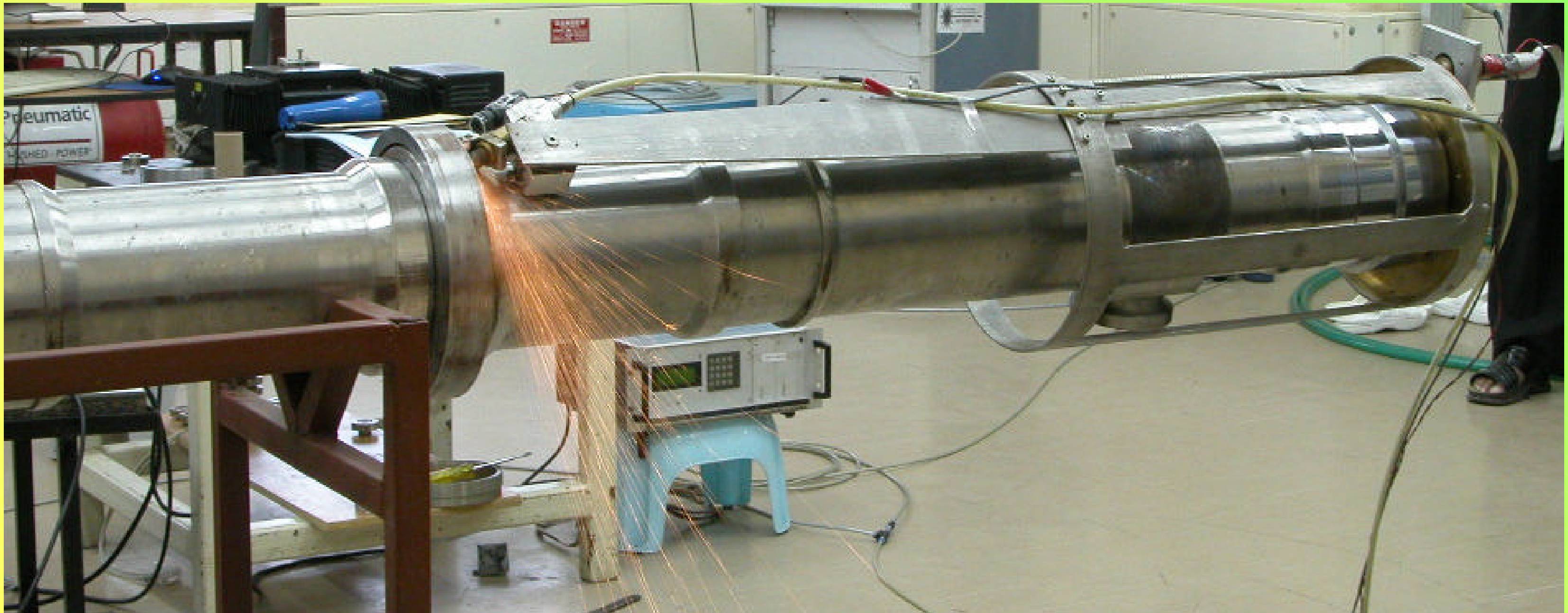
Industrial YAG Laser

Laser based cutting and welding of coolant channel bellow lips for en-masse coolant channel replacement (EMCCR) in Pressurized Heavy Water Reactors (PHWR)

- Nd:YAG laser with fiber optic beam delivery and motorized fixture motion from E-face of coolant channel

- Cutting time for one bellow lip is typically 5minutes welding of the bellow lip takes about 8minutes

- This will bring down radiation dose by over a factor of 50 compared to standard cutting techniques



Diode-pumped High Power CW IR Laser

Geometry – Gold-coated Flow tube
Diode stacks – Linear, 3x50W (TM Polarized)
Pump Module – 3x Diode stacks
120 °(Angular separation)

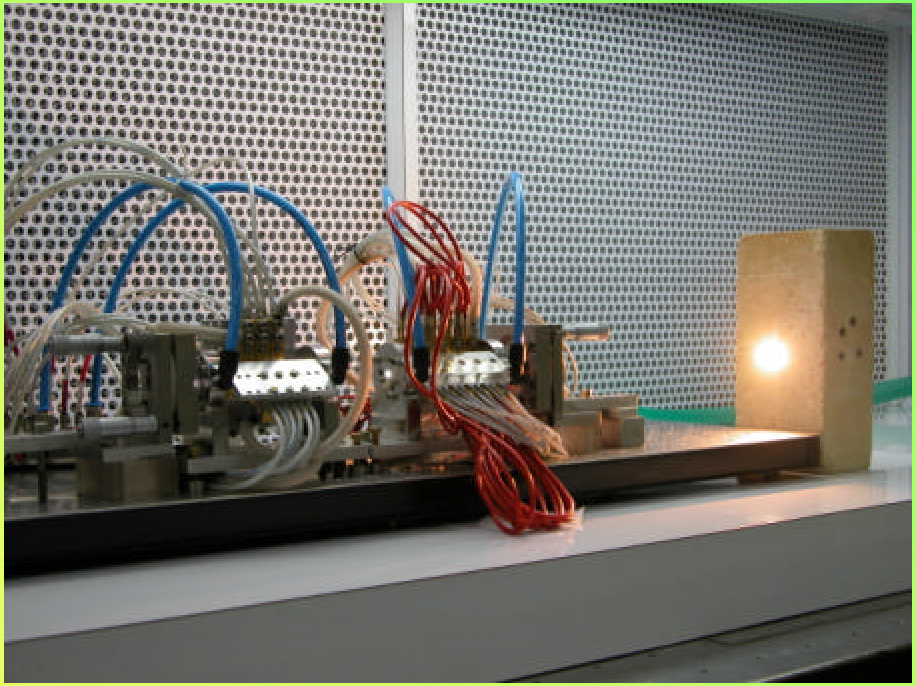
Laser Type : Nd:YAG/1064nm

Laser output : 200W, Multimode

Diode pump power : 430W

Optical-to-optical eff. : 46%

Electrical-to-optical eff. : 23%(Highest reported)



Applications: R&D, Medical and Industrial

High Average Power Green Laser

Power : 75W at 30kHz

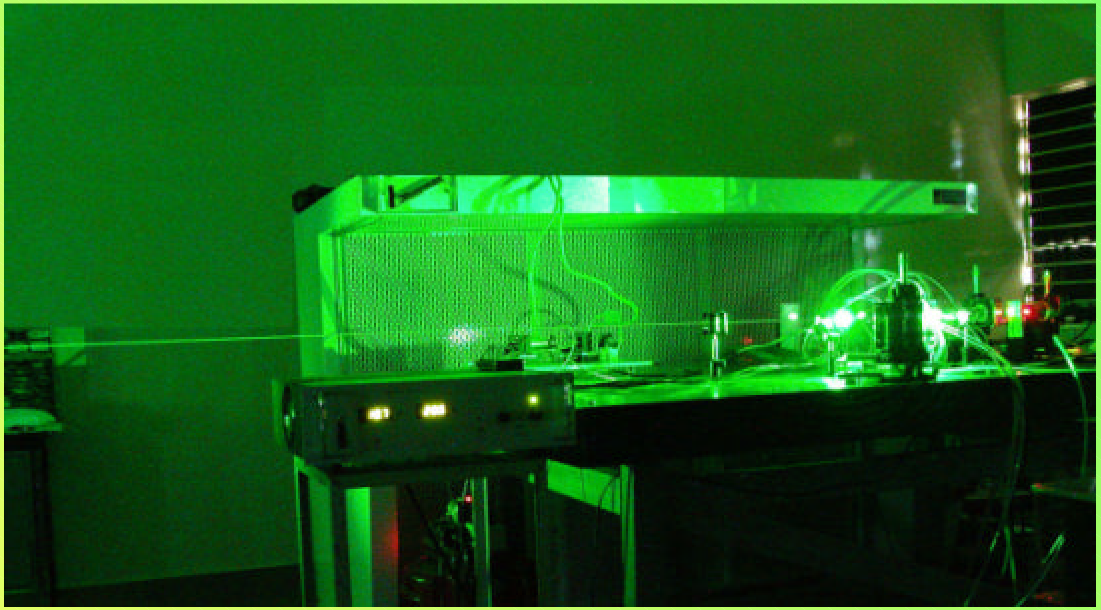
Wavelength : 532nm

pulse width : 200nsec

power stability <2%

optical conversion eff >20%

Beam quality M^2 <30



Applications:
Pumping of Dye laser, Ti:sapphire laser

Ophthalmic Green Laser

Diode-pumped frequency doubled Nd:YVO_4 system

- **Transpupillary retinal photocoagulation**
- **Laser trabeculoplasty**

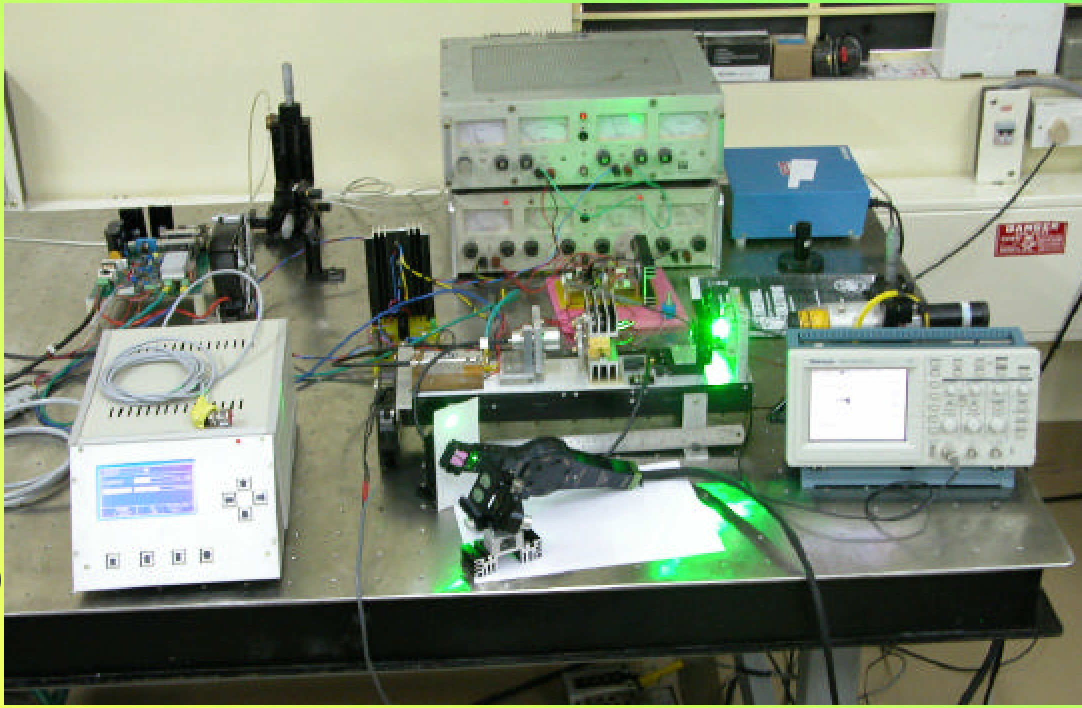
Power : 0-1000mW

Mode : True CW

Wavelength: 532nm

Pulse duration : 50ms to 1000ms

Repeat interval : Variable (<50% duty)



SURGICAL MODEL C-40 CO_2 LASER

Power	:	40Watts
Modes	:	CW
		Pulsed
		Chopped
Beam Delivery	:	7 Joint Articulated Arm
Aiming Beam	:	He-Ne
Surgical Modalities	:	ENT
		Plastic Surgery
		General Surgery
		Gynecology
		Dermatology

Industrial Nd:YAG Lasers supplied by CAT to various DAE Units

Supplied to	End use
Fuel PIE Section, P.I.E. Division, BARC	**For end plate cutting of nuclear fuel bundles**
Remote Application Section, Back End Technology Development Division, Nuclear Recycle Group, BARC	**For Nuclear waste management**
NRG(P), BARC	**For cutting and welding in hot cell**
BRIT, Mumbai	**For brachytherapy and radiography capsule welding**
PIRS, DPEND, IGCAR, Kalpakkam	**For cutting of spent fuel bundles**
IDEAS, IGCAR, Kalpakkam	**For cutting and welding in hot cell**
NFC, Hyderabad	**For cutting of fuel pins to extract fuel pellets**
CED, IGCAR, Kalpakkam:	**For thermal diffusivity measurement of materials**
CED, IGCAR	**250 Watt fiber coupled CW Nd:YAG for surface treatment**

Home Built High Power CO2 Lasers

3.5 kW CW CO2 Laser with CNC Workstation

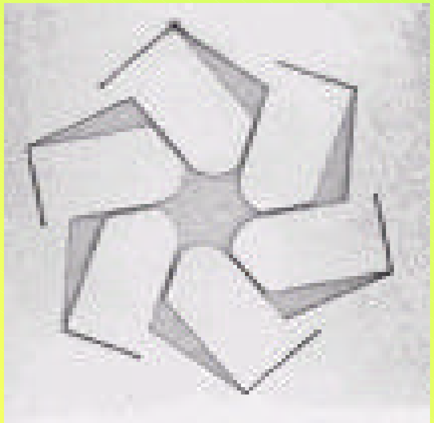
High Rep. Rate TEA CO_2 Laser

20 kW CW CO_2 Laser

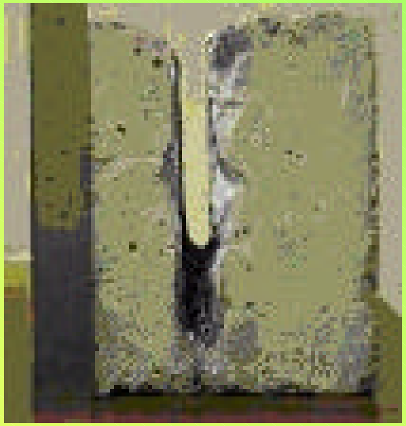
Applications of these High Power CO2 Lasers

Laser Cutting

Template for Accelerator Magnet: Iron Sheet



Profile-cut Titanium sheet

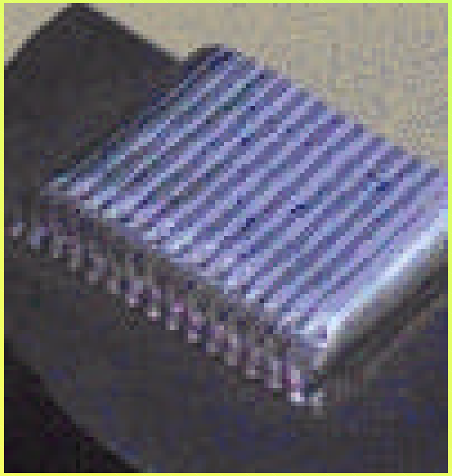


Laser cut 6” thick concrete block

Contd…

Laser welded gear assembly

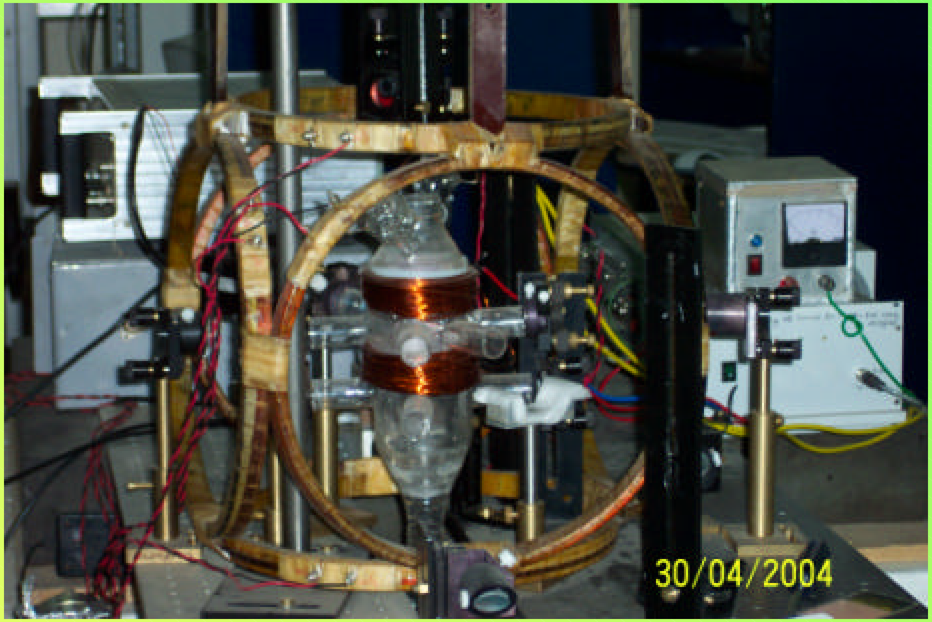
Laser cladding



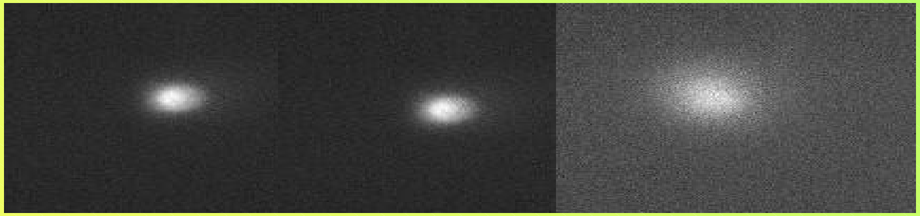
Multi-layer cladded sample

Laser cut souvenir

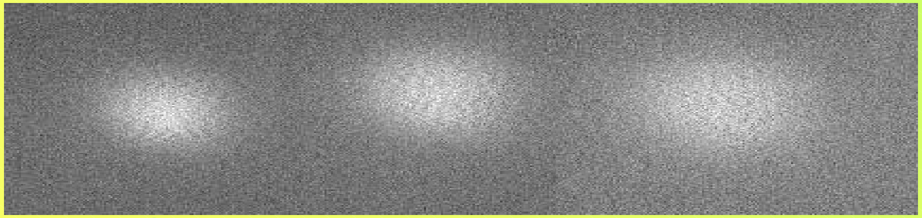
Laser Cooling and Trapping of Atoms



Magneto-optic Trap for Rb atoms



t=0 ms 1 ms 2 ms



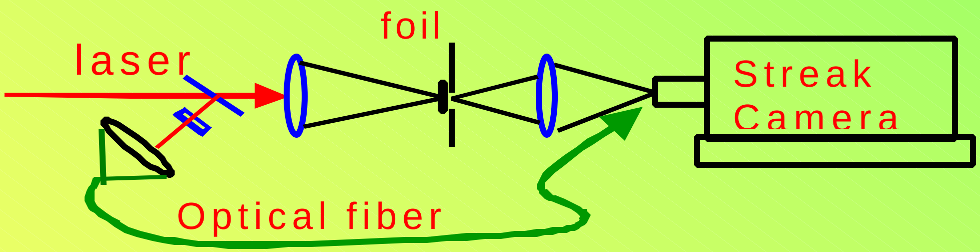
t=3 ms 4 ms 5 ms

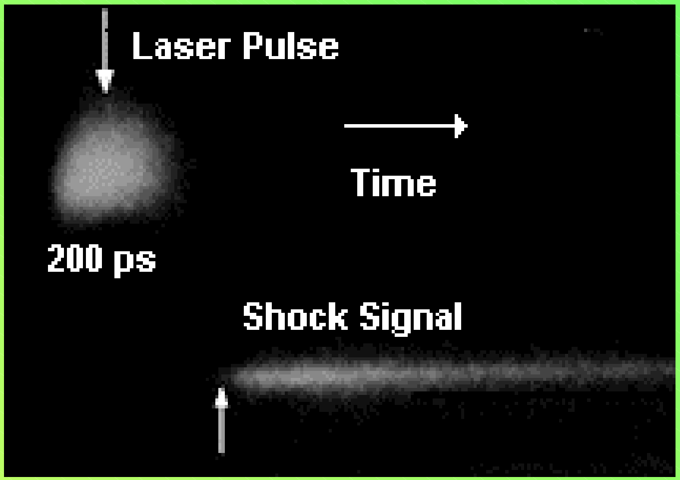
Laser Plasma Interaction Studies

Table- Top Terawatt laser

High power Nd:glass laser system

Laser driven shock wave studies

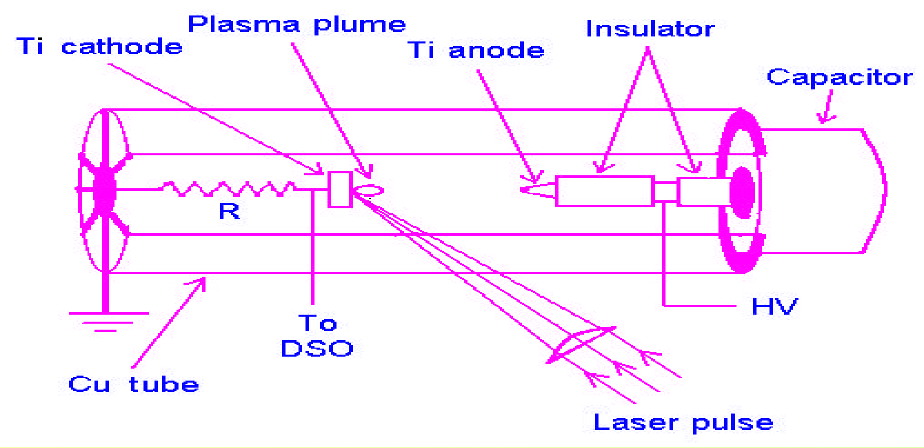


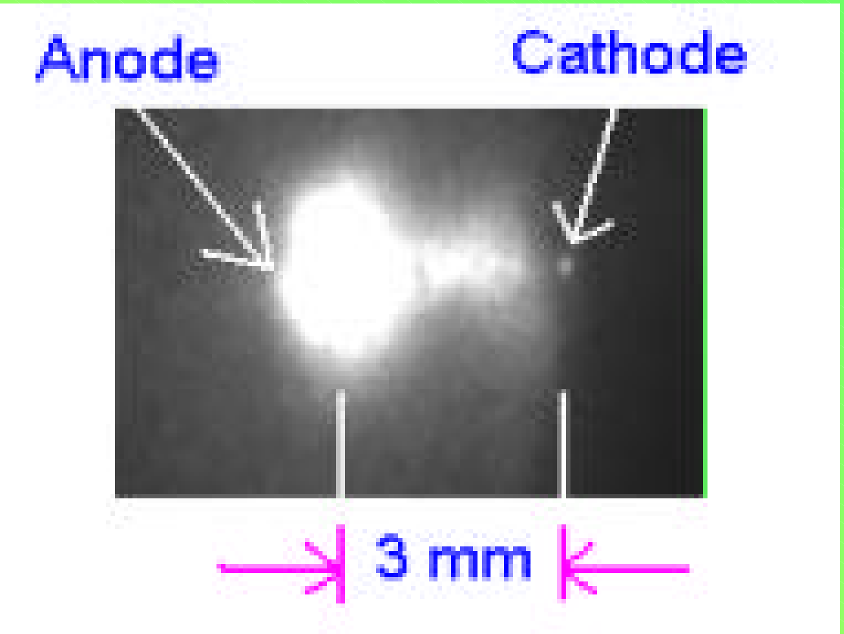


Experimental set-up for
laser driven shock studies

Streak camera signals

Laser based X-Ray sources





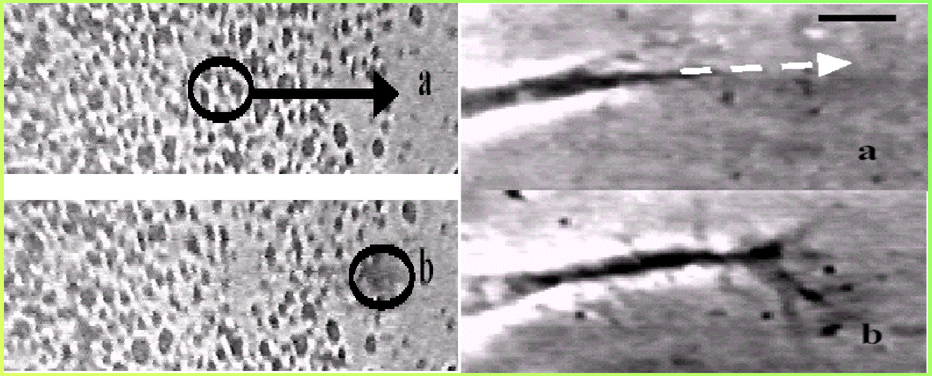
Intense x ray generation in laser triggered vacuum discharge

Cathode plasma jet pinching

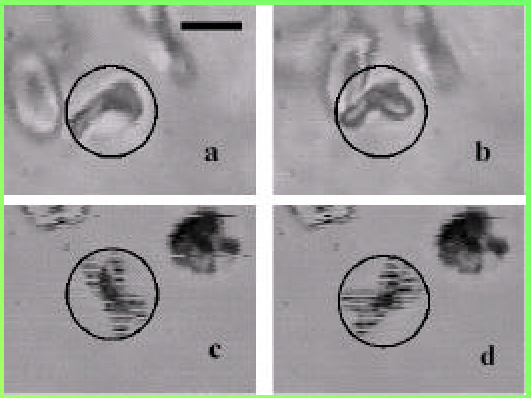
BIOMEDICAL APPLICATIONS OF LASERS

- OPTICAL MICROMANIPULATION
- OPTICAL IMAGING
- OPTICAL DIAGNOSIS OF CANCER
- NARROW BANDWITH LIGHT EFFECTS ON CELLULAR CULTURES / ANIMAL MODELS

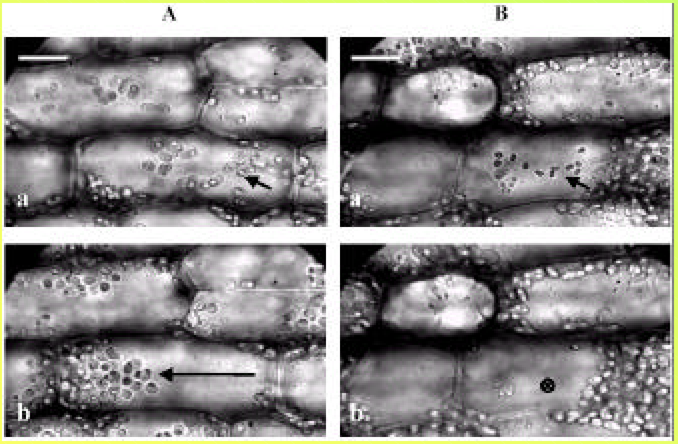
Optical micromanipulation



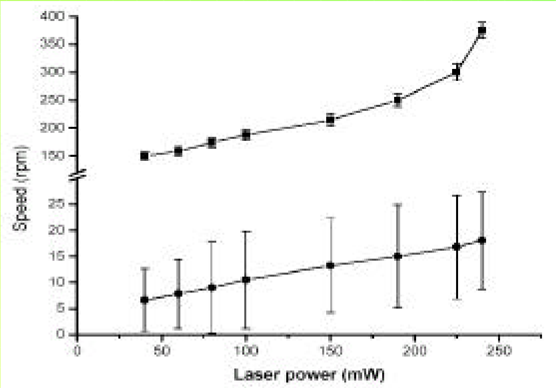
Use of an asymmetric beam profile elliptic laser tweezers developed at BMAS



Self-rotation of a normal RBC trapped by optical tweezers

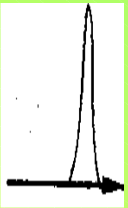


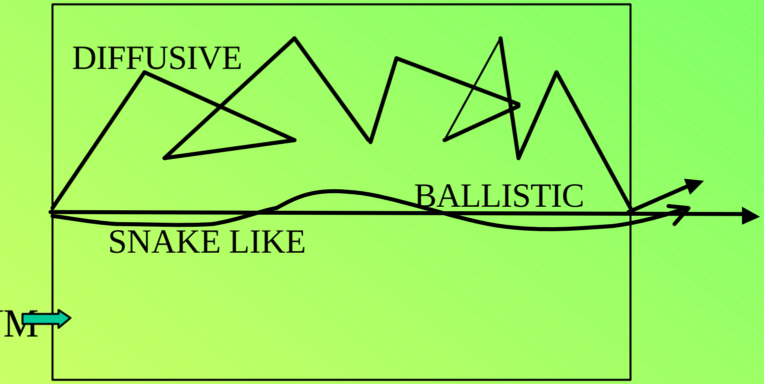
Intracellular trapping and displacement of chloroplasts in *E. densa* with a CW 1064 nm laser.

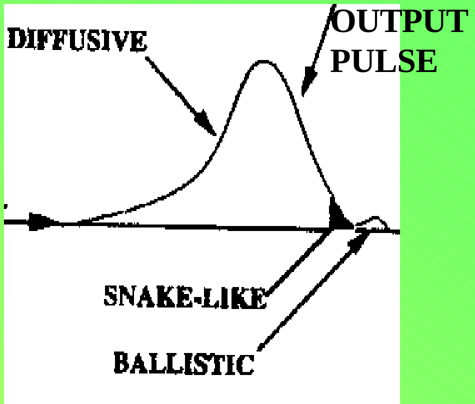


The difference in rotational speed of RBCs from healthy volunteer and malaria affected patient

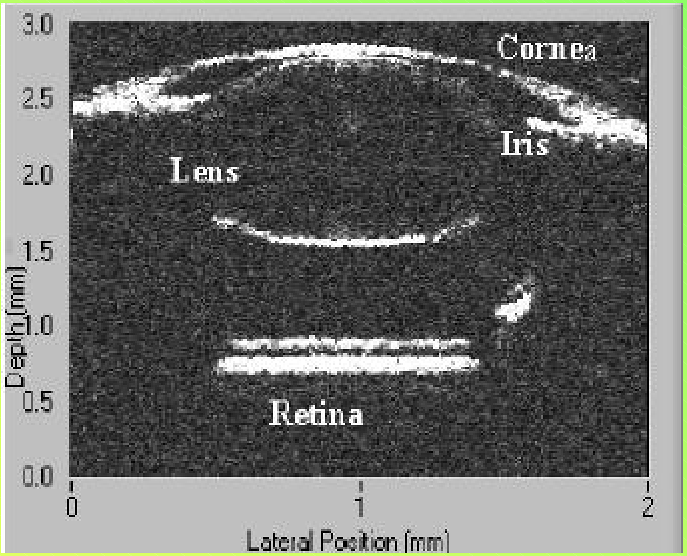
OPTICAL IMAGING



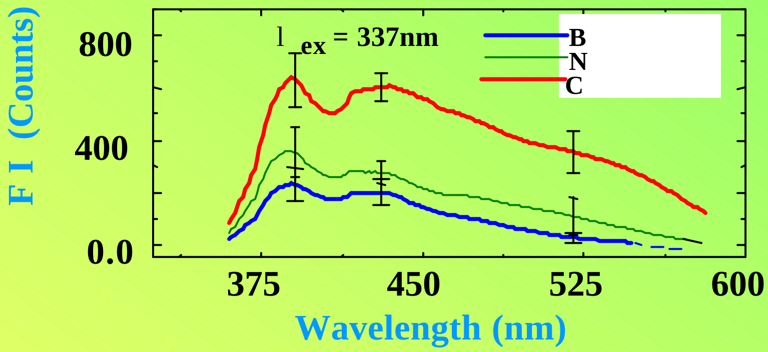


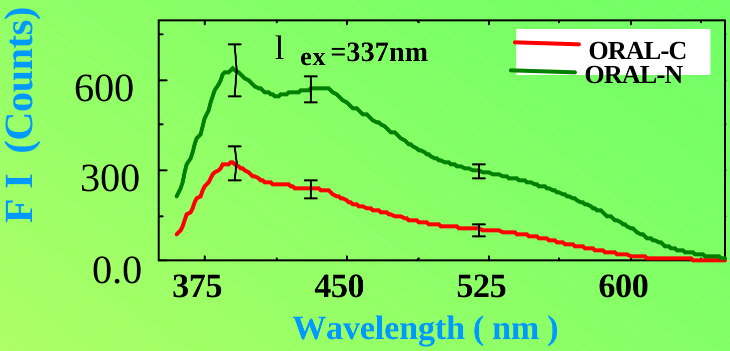


	DEPTH	RESOLUTION
BALLISTIC	FEW mm	~ µm
BALLISTIC + SNAKE	FEW cm	~100µm
DIFFUSE	SEVERAL cms	~ mm



OPTICAL DIAGNOSIS OF CANCER- STUDIES ON RESECTED TISSUES



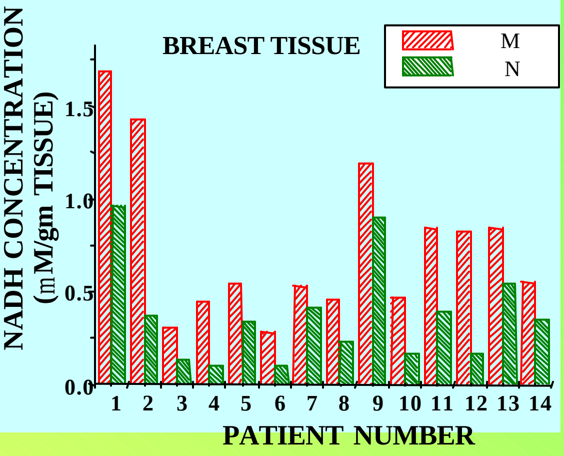


SIGNIFICANT VARIATION IN FLUOROPHORE CONCENTRATION

$[C]_{NADH} > [N]_{NADH}$ & $[B]_{NADH}$	BREAST TISSUES	*Lasers Life Sci.,8, 249- 264, 1999*
$[N]_{NADH} > [C]_{NADH}$	ORAL TISSUES	*Lasers Life Sci., 8, 211- 227, 1999*

ENZYMATIC MEASUREMENTS OF NADH CONSISTENT WITH SPECTROSCOPIC INFERENCE

Biotech. Appl. Biochem., 37, 45-50, 2003



TIME RESOLVED STUDIES, DEPOLARISATION OF FLUORESCENCE, ..

IN-VIVO STUDIES

Newsdesk

Indian group develops tools for oral cancer diagnosis

A research group at the Centre for Advanced Technology (CAT, Indore, India) has developed autofluorescence techniques for diagnosing cancers of the oral cavity, breast and cervix, using nitrogen-based lasers.

The group has developed a nitrogen-laser-based portable fluorimeter, consisting of a sealed-off nitrogen laser, a spectrograph coupled to a gateable intensified CCD (ICCD) camera, and a fibre optic probe to excite and collect fluorescence from the tissue. Both *in vitro* and *in vivo* studies have been carried out using prototype units.

Nitrogen-laser-based system for oral cancer diagnosis developed at Center for Advanced Technology, Indore, India

While *in vitro* studies used tissues from the oral cavity, breast and uterus, *in vivo* studies were conducted on oral cavity and uterine cervix tissues. The *in vitro* studies show that while the sites of malignant breast tissue were considerably more fluorescent than benign tumour and normal tissue sites, the reverse was the case with tissue from the oral cavity.

A pilot study involving 25 patients with histopathologically confirmed squamous-cell carcinoma of the oral cavity has also been completed. The prototype unit has been installed at the Government Cancer Hospital, Indore, to enable a detailed clinical evaluation of technique for oral cancer diagnosis.

"Very little appears to have been done on the *in vivo* use of autofluorescence spectroscopy for diagnosis of cancer of oral cavity", says Pradeep Kumar Gupta (Biomedical Applications Section, CAT). "The system used by us is conventional and similar systems have been used for studies on cancer of uterine cervix. Elsewhere such systems use commercially available lasers and other accessories, but we have manufactured everything except the ICCD detector and the spectrograph."

The discrimination algorithm, developed to analyse autofluorescence spectra, could differentiate the squamous-cell carcinoma of the oral cavity from normal squamous tissue with a sensitivity and specificity

towards cancer of 86% and 63%, respectively. "The reason for the quite low specificity values appears to be the fact that most of the patients who participated in this study had advanced stage malignant disease", says Gupta.

Various measurements on tissue fluorescence suggest a significant variation in the concentration of the

fluorophores in different tissue types. While concentration of NADH (reduced nicotinamide adenine dinucleotide) is higher in malignant breast tissue compared with benign tumour and normal breast tissue, the reverse is true for tissues from the oral cavity where NADH concentration is higher than in normal oral tissues. These results have been confirmed by enzymatic measurements of NADH concentration in malignant and normal tissues from

In India and other South Asian countries, oral cancers are some of the most common types of cancer, and a high consumption of chewing tobacco means that incidence levels are rising. Optical techniques hold considerable promise for *in situ*, near real-time, and early diagnosis of cancer. Researchers say there will be considerable demand for optical diagnosis techniques once they are clinically established.

Dinesh C Sharma

STUDIES ON NEOPLASM OF UTERINE CERVIX & ORAL CAVITY

NON-LINEAR DIAGNOSTIC ALGORITHMS DEVELOPED

SENSITIVITY : 95%

SPECIFICITY : 96%

Current Science, 79, 1089-1094 (2000)
The Lancet Oncology, 2, 258, 2001
Lasers in Surgery and Medicine, 33, 48-56 (2003).
J. Biomed. Opt. (In Press)

THE LANCET Oncology, Vol. 2, May 2001

SELF ROTATION OF RBC-DIAGNOSIS OF MALARIA

Normal RBC

Malaria-infected

Analysis of cells in a micro-flow

Biotechnology Letters, 26, 971-974 (2004).

BURN WOUND INFECTED WITH PSEUDOMONAS RESISTANT TO ALL DRUGS

WOUND AFTER 5 DAYS OF EXPOSURE TO 3mW AVERAGE POWER N_2 LASER. CULTURE SHOWS INSIGNIFICANT GROWTH OF BACTERIA

Land Leveler Unit

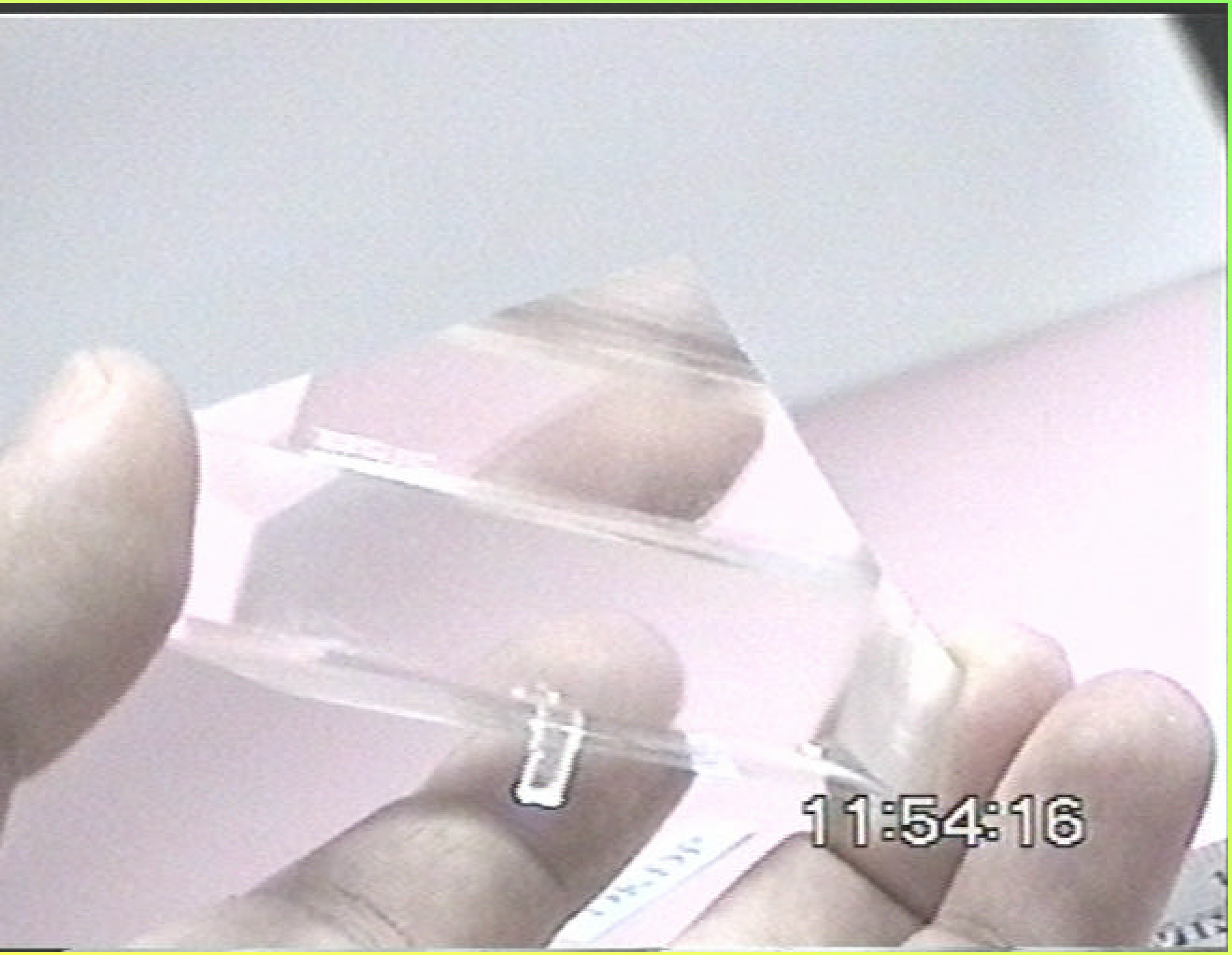
- The unit is useful to flatten ~300m diameter ground to within a cm.
- Technology was developed as per request from MoA.
- Successful trial conducted by PUSA Institute, Delhi.
- Technology Transferred to OSAW, Ambala and would be integrated with tractors.
- Other applications are also possible.






Single crystal growth Programme

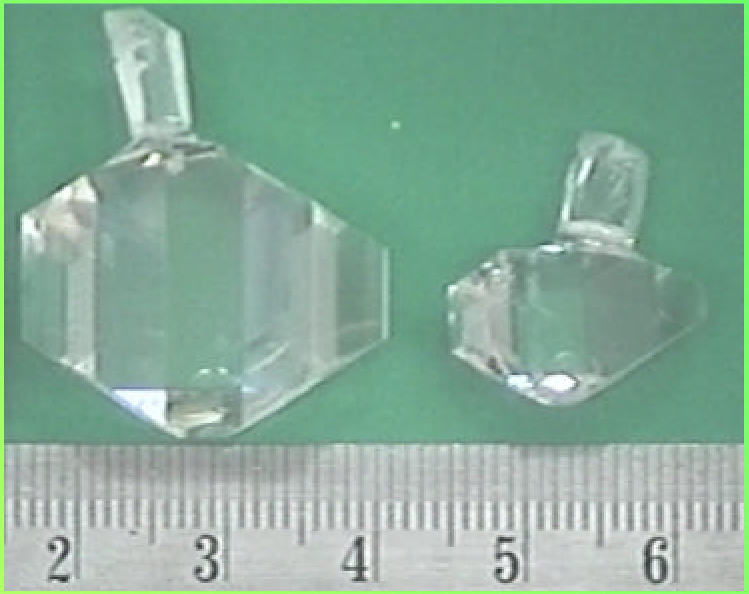
DKDP crystal
(Application in Pockels cells)

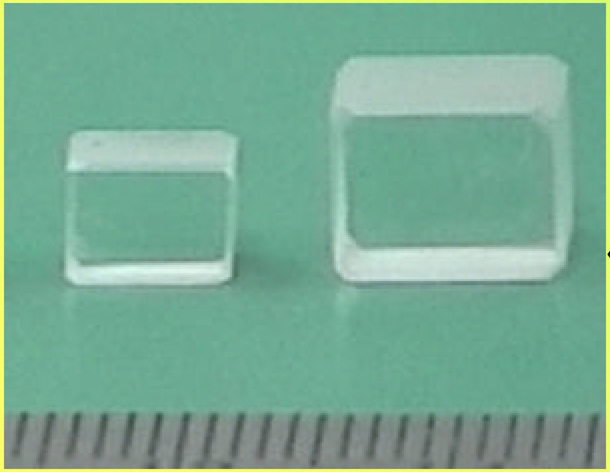


Deuteration level: >98%

KTP crystals

Single crystals of **potassium titanyl phosphate (KTP),** grown by TSSG technique





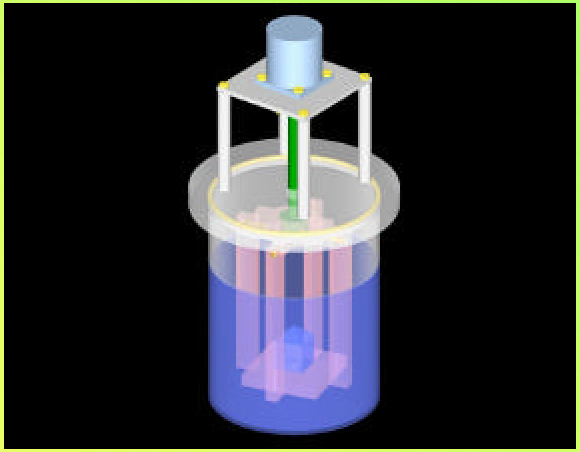
SHG elements

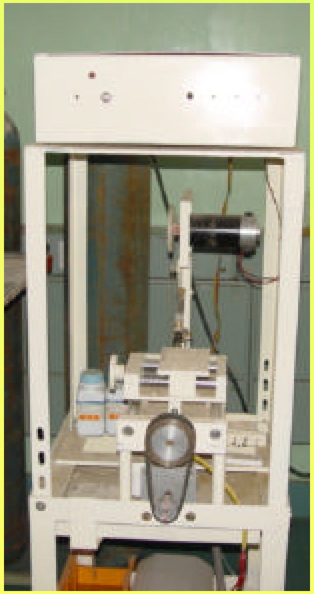
Laser used: electro-optically Q-switched pulsed Nd:YAG laser in an extra-cavity configuration, with a pulse duration of 8-9 ns.

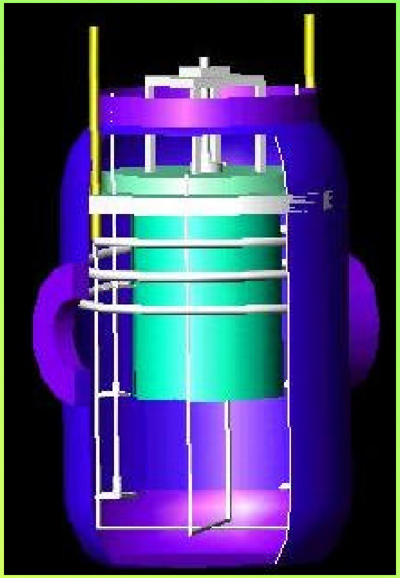
The maximum intensity incident on the KTP element of 6 mm interaction length was approximately 207 MW/cm^2.

Conversion efficiency 62% without accounting for Fresnel losses.

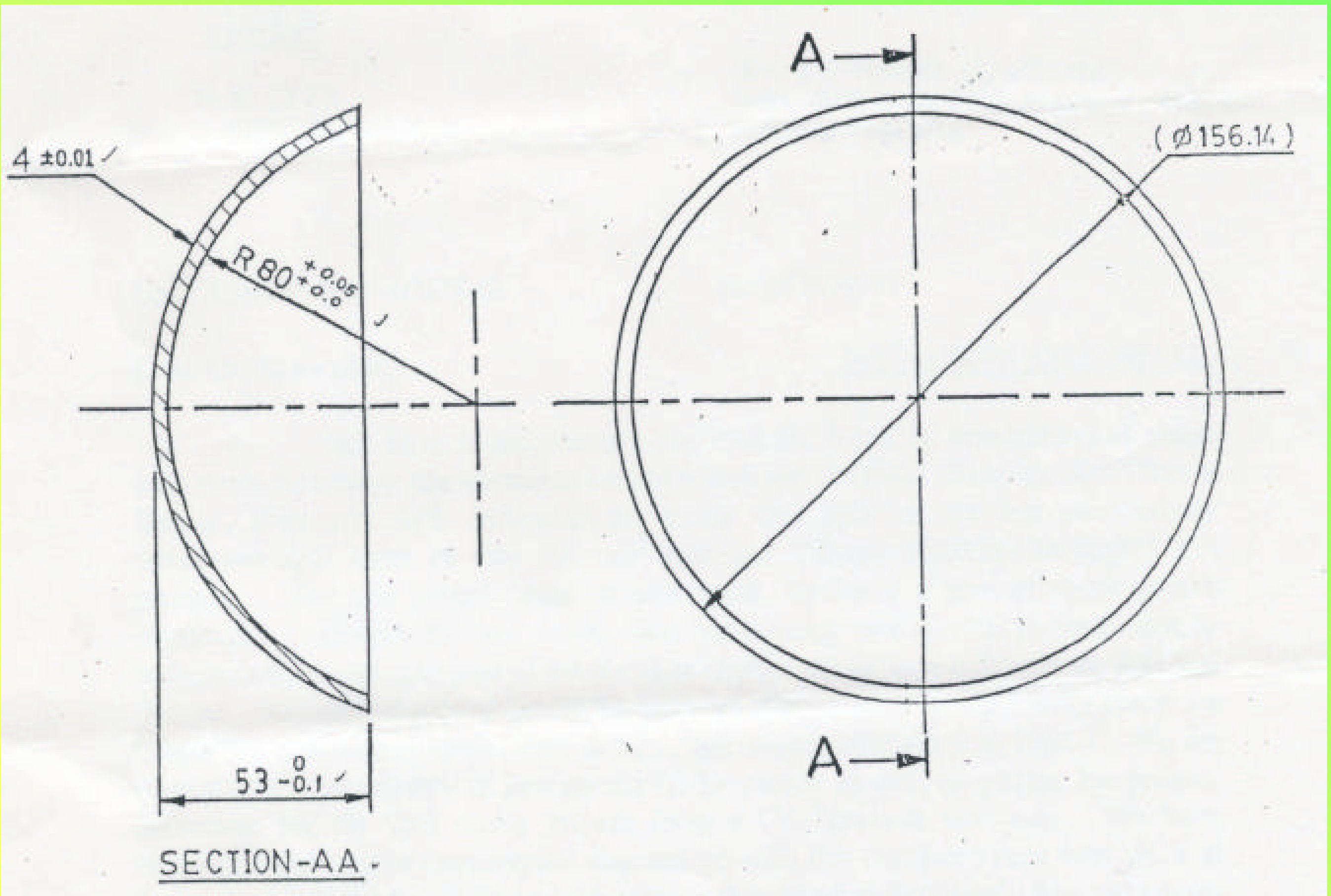
Systems developed

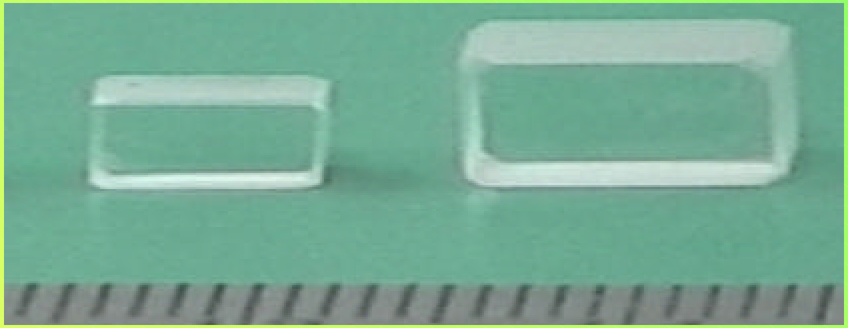






ZnS Dome for Seeker Missile *'Nag'*





Production of large sized transparent ceramics is going on

DAE-CERN COLLABORATION

1991: DAE-CERN Cooperation agreement

1996 : Decision to contribute to LHC

India has joined LHC project under a DAE-CERN cooperation agreement, with DAE Centres, like, CAT, BARC, ECIL etc., and many other agencies contributing to its construction.

By now our in kind contribution is ~40 MCHF, covering delivery of a variety of components and subsystems for LHC and providing skilled manpower support for magnetic tests and measurements at CERN.

Details of Indian contribution to LHC

Participation in accelerator construction: delivering sub-systems e.g. ***PMPS Jacks***, SC Corrector Magnets, QHPS,QDE, Circuit Breakers etc;

Participation in CMS and ALICE detector R&D and also installation of HO & ECAL (for CMS) etc., PMD & MUON Chamber (for ALICE).

Contribution to GRID computing software development; setting up a Regional Tier 2 Centre

Requirements of the PMPS Jacks (being entirely made by India) to support full LHC, all along the 27 Km tunnel

- ✓ Precise alignment of ~ 1250 Numbers of 32 Ton, 15 meter Superconducting magnets of the LHC collider with a setting resolution of 50 micron,
- ✓ **This is equivalent to moving the weight of eight elephants by the breadth of a human hair.**
- ✓ **Numbers Required ~ 6800 jacks.**
- ✓ The Jacks were **Designed & Developed by a team from Centre for Advanced Technology.** Mass produced by **AAL & IGTR** and supplied under responsibility of CAT, as part of CERN-DAE collaboration agreement.

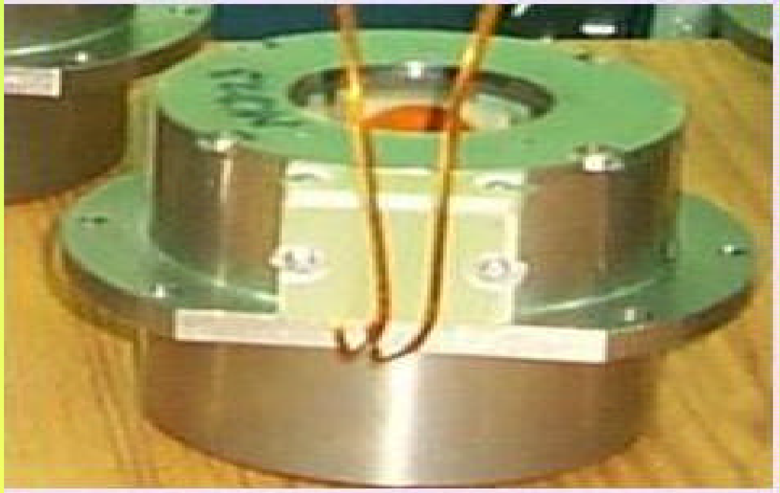
Precision alignment JACKS for LHC cryomagnets (weighing 32 Tons)

Test Set-up to demonstrate setting resolution of 0.02 mm

Cryo-magnet installation in the LHC tunnel on the Indian made jacks

Cryogenic test facility at CAT, Indore

Warm magnet measurement setup at CAT

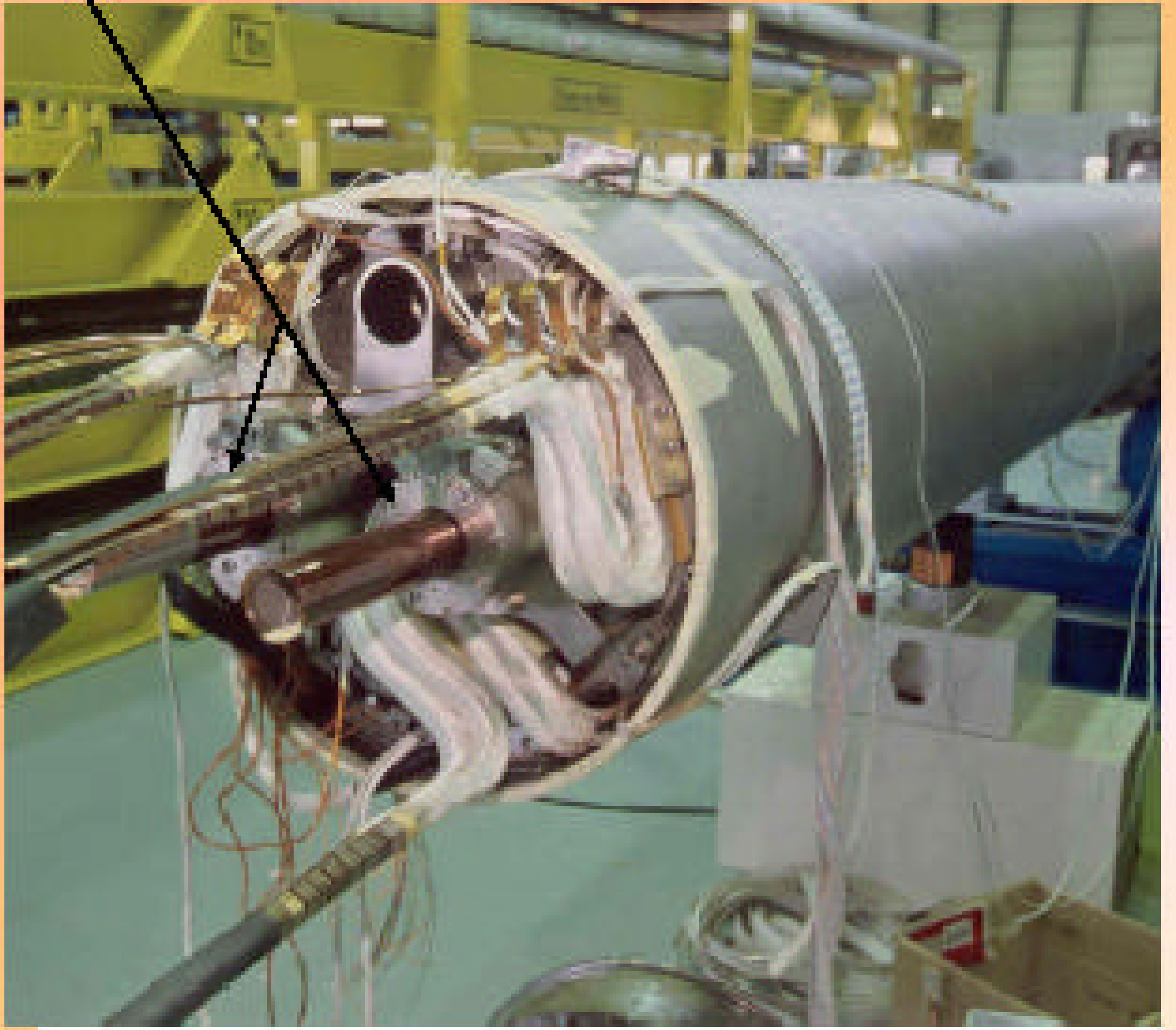


Decapole & Octupole corrector
magnet assembly

Correcter Magnets for LHC Diploes

MCS & MCDO Corrector Magnet on main dipole magnet

- To correct the systematic field errors of the LHC Main Dipole
- They Share the same cryostat as that of Main Dipole
- Their proper functioning is as important as Main Dipole



End view of the LHC main Dipole


SC Magnet Test Hall
SM18-CERN
Cryogenic Integrity
Electrical integrity
Field Quality
Axis and Alignment
Protection checks

Cryocoolers

Indigenous Development of Turbo Molecular Pump

Thank you