

# Evolution of Control Systems for Large Telescopes and Accelerators : A Retrospective



Y. S. Mayya, OS and Head,  
Reactor Control Division  
Bhabha Atomic Research Centre,  
Mumbai – 400 085  
*ysmayya@barc.gov.in*

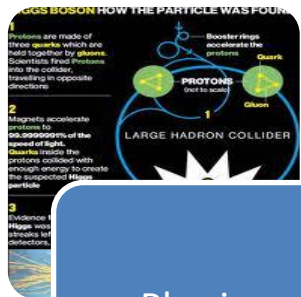
# Theme

Science and technology: The two way interchange

Mega Science: Industrial applications and takeaways

Technology accretion in Indian Industry : An assessment

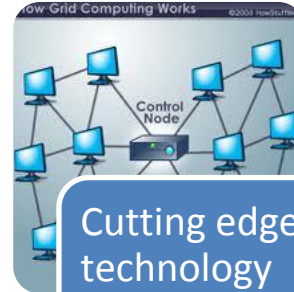
# Big science projects push technology frontiers



Physics  
Motivation

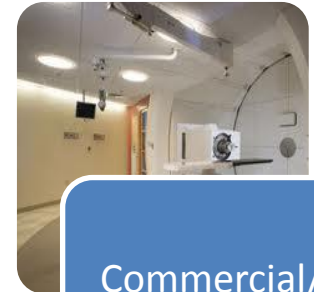


Big  
Instruments  
(Accelerators,  
telescopes)



Cutting edge  
technology

- Cryo, Magnets,  
detectors,  
computing

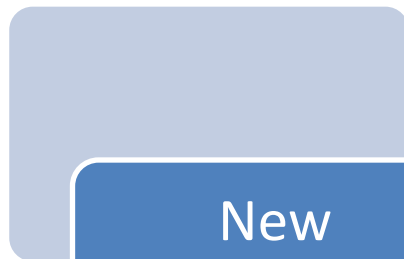


Commercial/  
industrial  
products

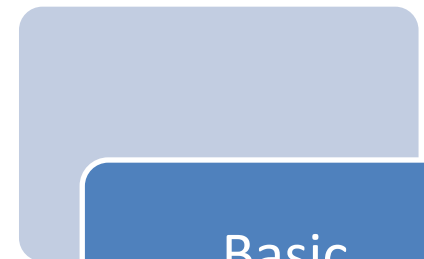
# Market demands spur Scientific research



Market  
demand



New  
technology,  
products

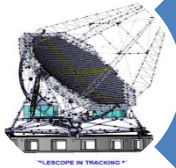


Basic  
research

# Telescopes and Accelerators



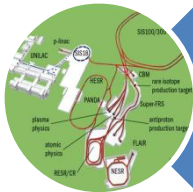
Giant metre-wave Radio Telescope  
(90's)



Multiple Atmospheric Cerenkov  
Emission telescope (MACE)

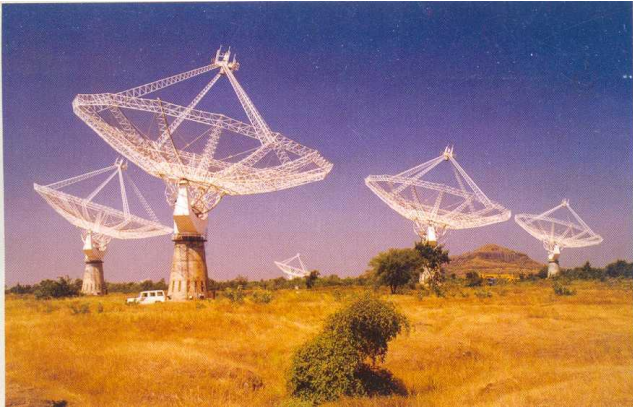


Large Hadron Collider (LHC)



Facility for Antiproton Ion Research  
(FAIR)

# Giant Metre-wave Radio Telescopes (90's)



- The Telescope
  - International facility for Radio-astronomy
  - Array of 30 Radio telescopes of 45 M diameter
  - Wire mesh construction, EL over AZ mount, fully steerable
  - Synthesized Radio-image equivalent to 25 Km telescope
  - Indigenous design- Low Cost, Shoe-string budget- frugal engineering
  - Remotely operated –optical fibre network

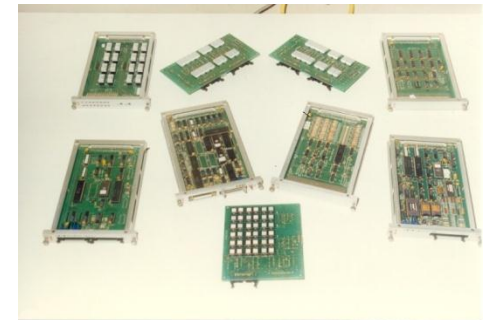
# GMRT: Controls

## Servo Control

- Brush DC + Thyristor Amplifier
- Position loop in Software + analog speed+ torque loops
- x86-No OS-local computer based servo control- 8086- fixed point-
- PASCAL – migrated to C-
- MDS as development platform- later migrated to PC

## Refurbishment plans

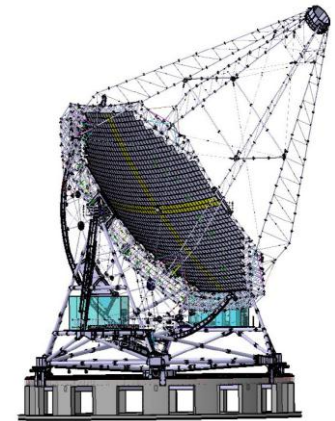
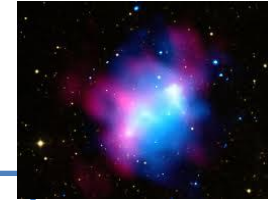
- PC 104 engines + RT Linux+TCP/ IP + C
- BLAC motor



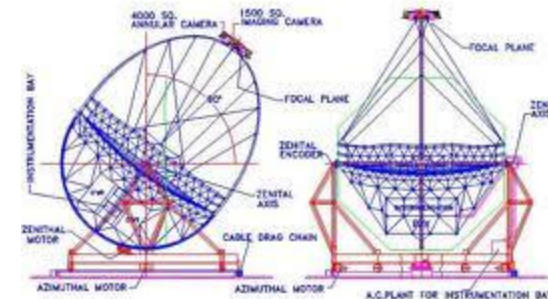
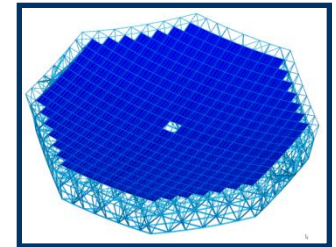
# MACE Telescope

## The Telescope

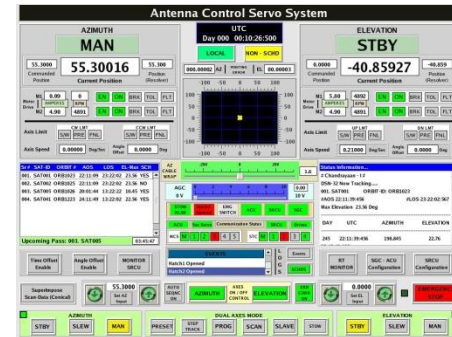
- 21M Telescope for Gamma Ray astronomy
- Being setup in Hanle (Leh) 4000Mtr ASL for BARC by ECIL
- Scheduled for 13-14 first light



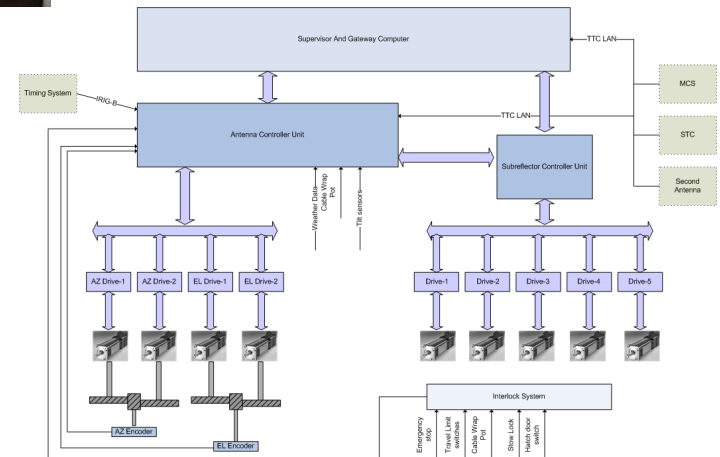
MACE TELESCOPE IN TRACKING MODE



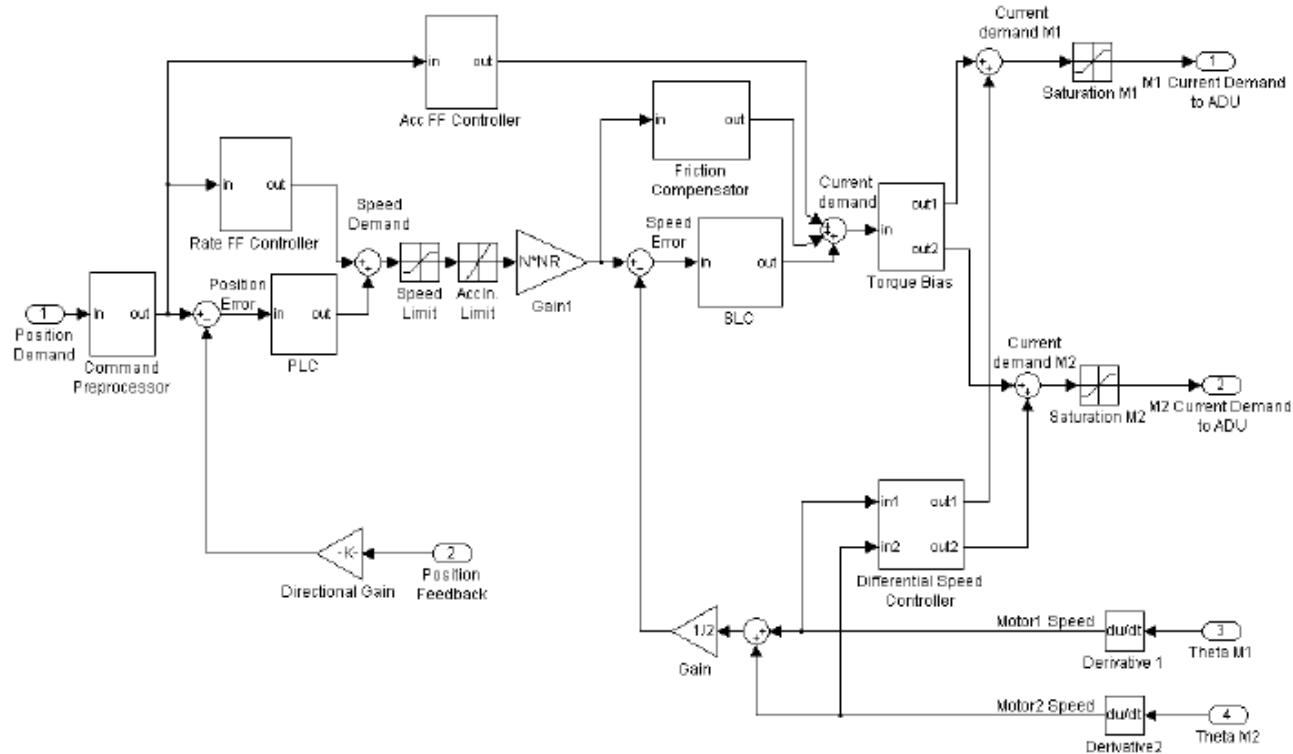
# MACE Servo System



- Derived from ACSS of IDSN32-
- cPCI- RTLINUX-Pentium, TCP-IP
- BLAC Motors, DSP/ IGBT based Vector Controlled Drive (CAN)
- Soft Consoles
- Configuration, diagnostics

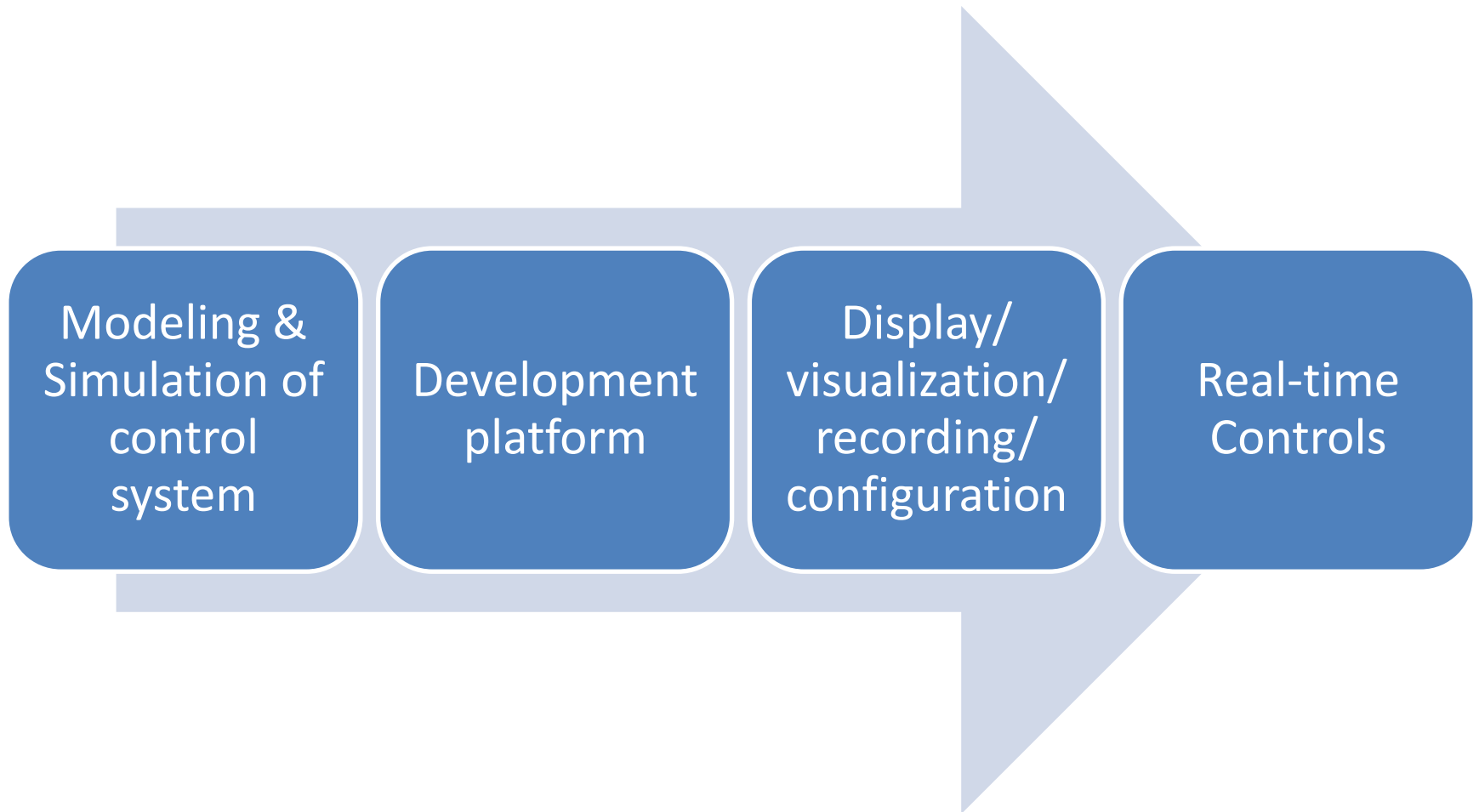


# MACE: Control Law



All software implementation of control loops  
Configurability: PC based tools  
Modeling & simulation

# Telescope Controls: Penetration of PC



# Controlling Telescopes: Spin-offs



Satellite Communication



UAV links



Active Radar Seekers



Airborne Radars



Weather Radars



Deep Space Network

# Optical & Radio telescopes: Enabling technologies

RF, Microwave

Digital Receivers

Signal processing,  
Image processing

Embedded real-time systems

Control engineering,  
Modeling,  
dynamic systems

Software, data base,  
SCADA HMI

Industrial Drives,  
HV

Precision clocks

Digital Communication,  
Networks

Structural design,  
analysis

# The common threads

	Signal & Image Processing	Drives	Controls	Digital Receivers
Weather Radar				
SAR				
Medical				
Industrial Drives				
Homeland security				
Defence				

# LHC Collaborations

## CORTEX (1994)

- Middleware for Experimental Information and control system
- OO data base- UML- CORBA- Solaris- / HP
- ESA Software Engineering Standards
- OMT/ UML
- DOORS

## String2 Supervision system

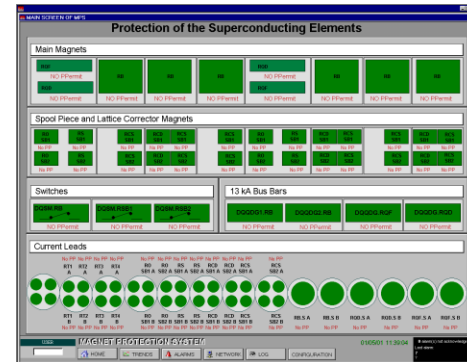
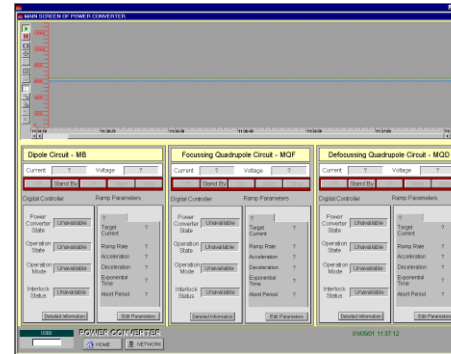
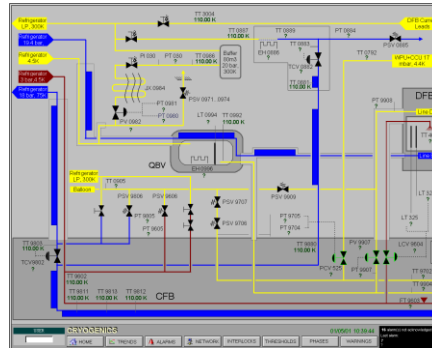
- String2 Magnet test facility
- Industrial PLC + PCView SCADA/ HMI + OPC

## Breaker electronics + Quench heater power supply

## Silicon strip detectors

# LHC collaborations

String2 supervision system for Cryogenics, Vacuum, Power converters, Magnet Protection & Interlocks



Breaker Control & Quench heater power supplies for LHC



# LHC Collaborations: takeaways

## Premature termination of CORTEX

- Need to take Users on board

## Lessons in Engineering large software systems

- Software engineering in practice
- Documentation
- Review processes
- Modeling
- Large international collaborations- collaborative development

# FAIR: Planned Indian in-kind contributions



Power  
Converters

Magnets

Detector  
Electronics

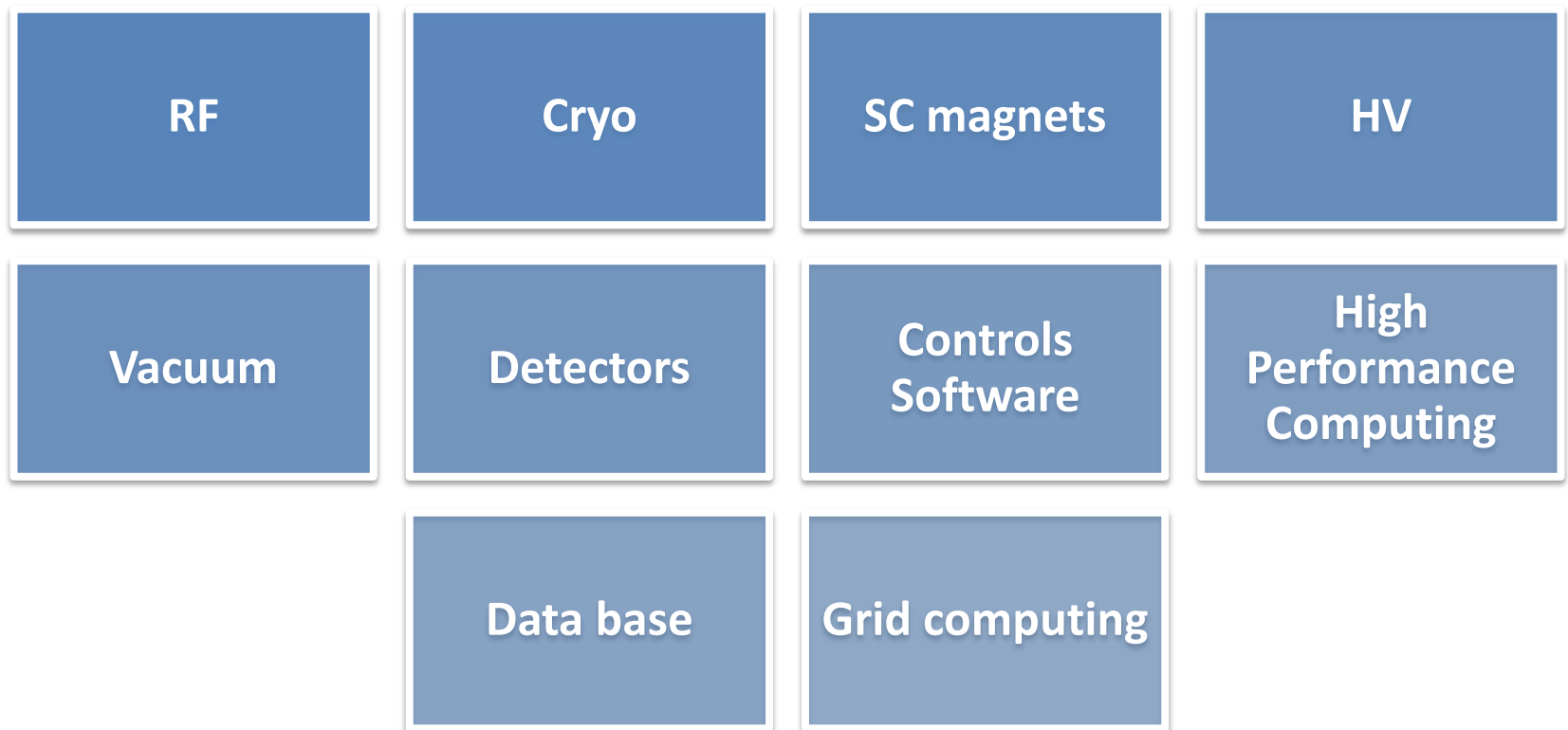
- Power Converters: ECIL-VECC-BARC-RRCAT Collaboration
- Quantities
  - SC magnets : 329
  - warm magnets : 204
  - Total : 533
- Experiments/Facilities
  - High Energy Beam Transport (HEBT)
  - Heavy Ion Synchrotron (SIS 100)
  - Super Fragment Separator (Super FRS)
  - Collector Ring (CR)



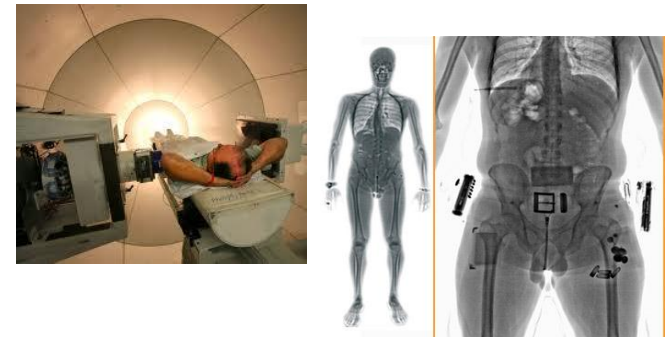
# Power Converters : prototype plan

S No	Experiment	No of quadrants	Flat Top Voltage (V)	Rated Current (A)	Max. Power (KW)	Stability (ppm)
1	SIS 100	Four	7	295	4.9	100
2	Super FRS	Four	7	292	29	100
3	SIS 100	Four	9	270	4.9	100
4	HEBT	Two	70	271	34	100
5	HEBT	Four	27	93	3.1	100
6	HEBT	Two	41	455	50	100
7	HEBT	One	2	292	55	100
8	HEBT	Four	200	535	134	100

# Accelerators: Pushing technology frontiers



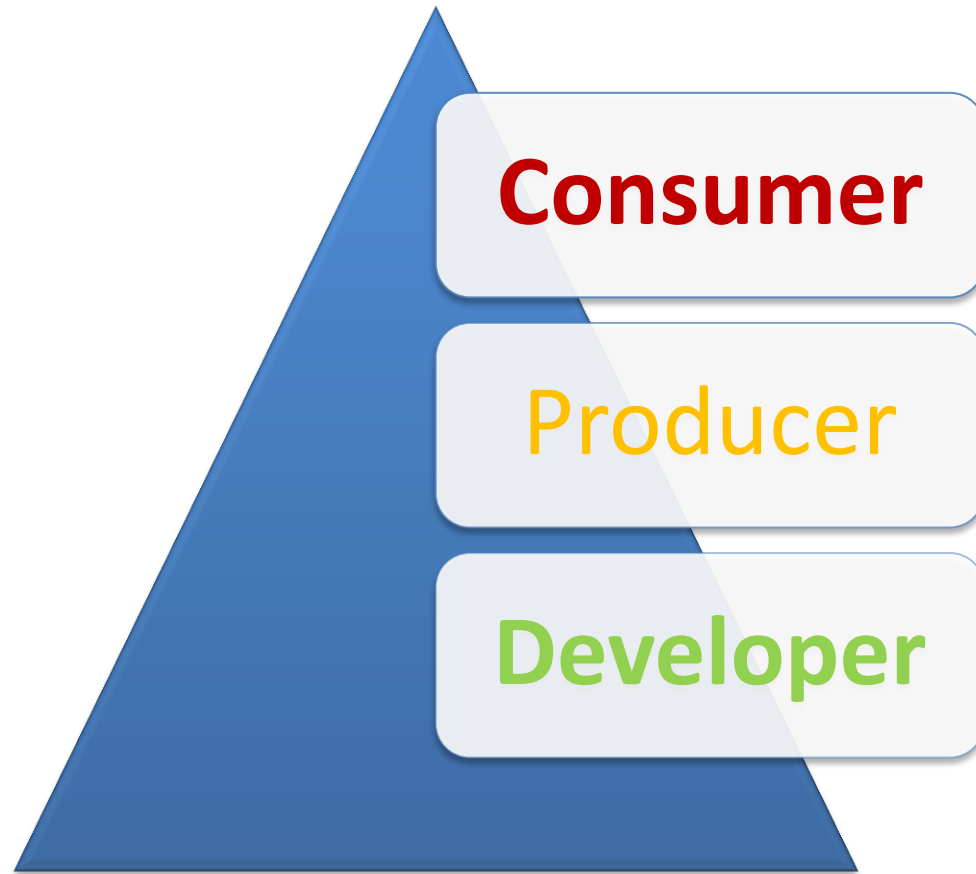
# Accelerators: Industrial applications



Cancer therapy  
Irradiation  
Industrial radiography  
Ion implantation  
Baggage/ cargo scanning



# Degree of technology penetration



# Indian Electronics Industry: Technology base

ECIL in all Nuclear Reactors

KAPS 1&2  
RAPS 1 to 6  
KGS 1 to 4  
KKNPP 1&2  
NAPS 1 & 2  
TAPS 3 & 4  
MAPS 1 & 2

Tools

Systems

Subsystems

Components

Jammer Station HF  
View of RDFS  
Jammer Station - VIUF

5 DEC 2012, VECC

Tools

Systems

Subsystems

Components

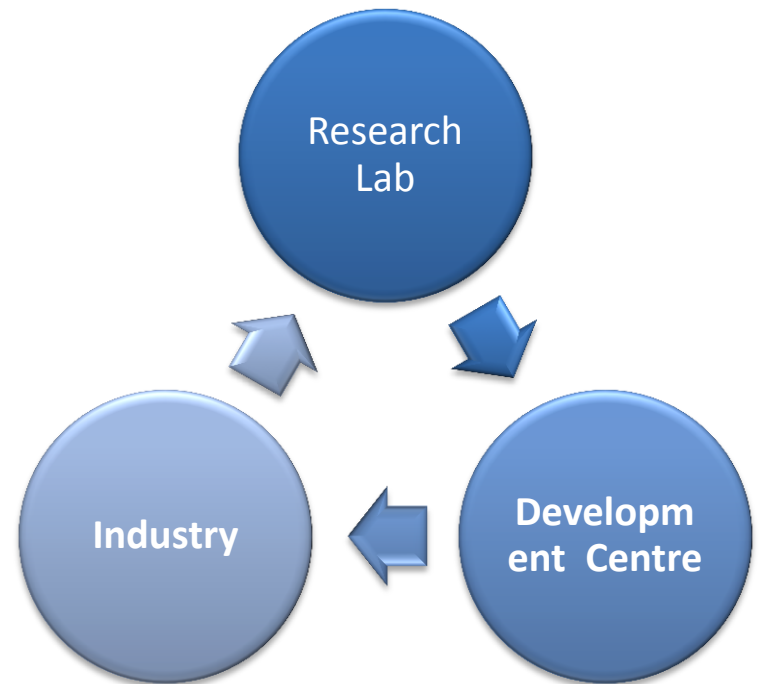
22

# Needed.. Better Synergy

Not this



This



# Needed .. Effective means of Transfer of technology

