Control and Instrumentation for Accelerators

C.K. Pithawa

DS and Head, Electronics Division, BARC, Trombay, Mumbai

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Instrumentation Development At BARC for National & International Projects

- Control System for Folded Tandem Ion Accelerator (FOTIA), BARC
- RF Electronics and Control System for TIFR-BARC LINAC
- RF control electronics for the super-conducting resonators of linacs at:
  - IUAC, New Delhi
  - Australian National University, Canberra
- RF Control Electronics for 400 KeV RFQ, BARC
- RF Control Electronics, BPM & Control system for Low Energy High Intensity Proton Accelerator (LEHIPA), BARC
- BPM Electronics for SPIRAL2, Ganil , France
- Advanced Multi-parameter Data Acquisition System (AMPS)
- Solid-state Particle Detectors

Control System for FOTIA

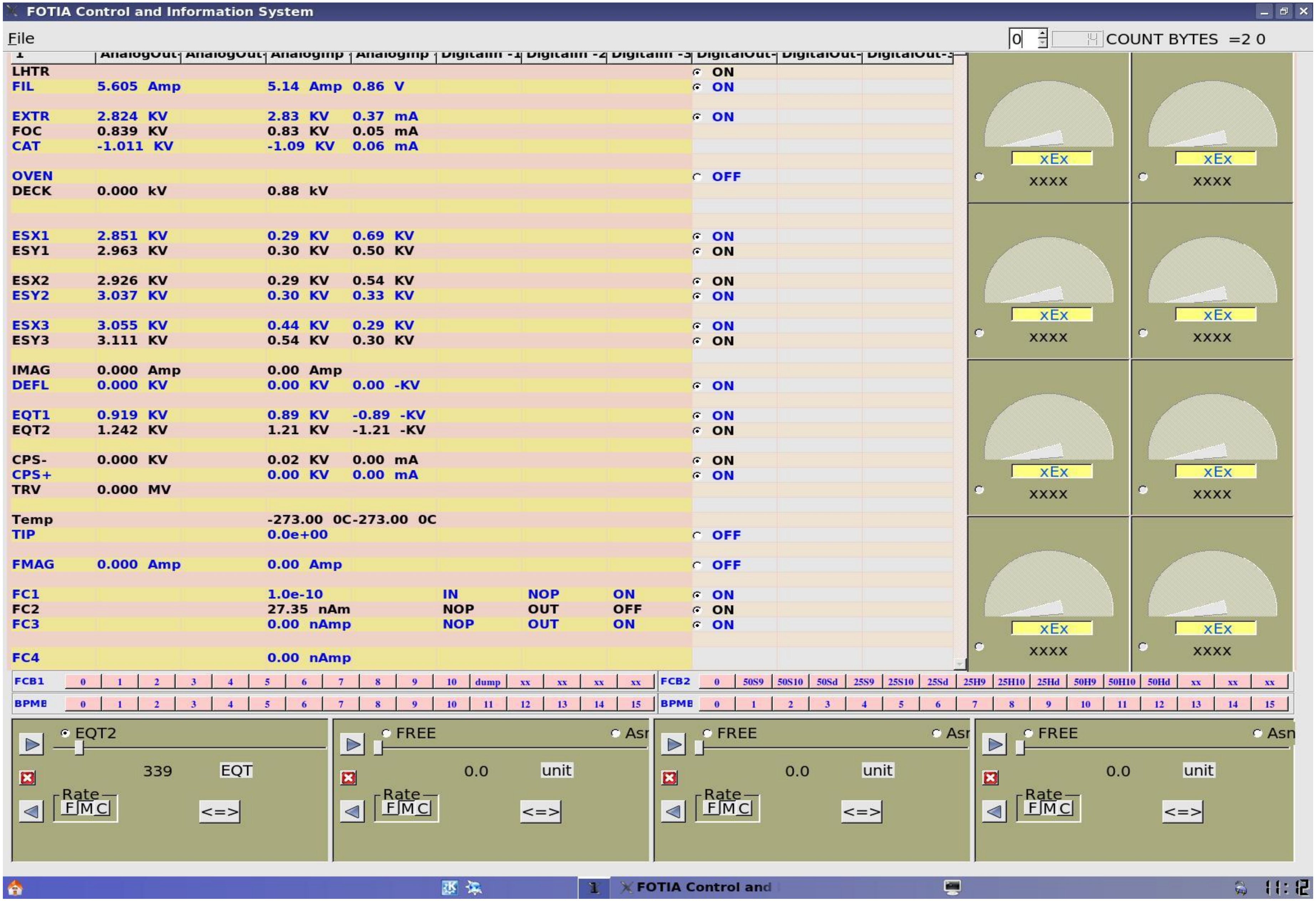
- CAMAC based Instrumentation
  - in house development
  - multiple crates
- Control & Information System
  - Linux Based Software

FOTIA Control and Information System (FOTIA-CIS)

Instrumentation Rack

Control Room

FOTIA & Pelletron UI



BARC-TIFR Super-conducting Linac
- RF sub-systems

1) RF Electronics for Super Conducting Resonators

   a) Resonator Controller : Based on Self-excited-Loop architecture.

   b) RF Power Amplifiers : Solid-state, 150 MHz, 150W.

2) RF Electronics for Normal Conducting Resonators

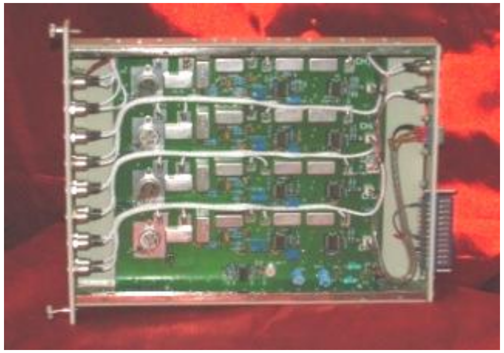
   a) Dynamic Phase Reference Generation: Provides stable Phase References to all the RF systems of the linac.

   b) Resonator Controller: Based on Generator Driven Resonator architecture

BARC-TIFR Super-conducting Linac

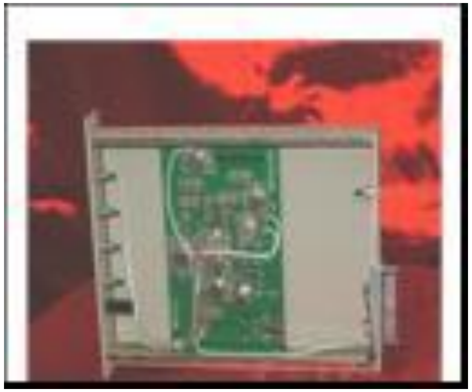
Some of the RF signal processing modules

Resonator Controller



Input Module

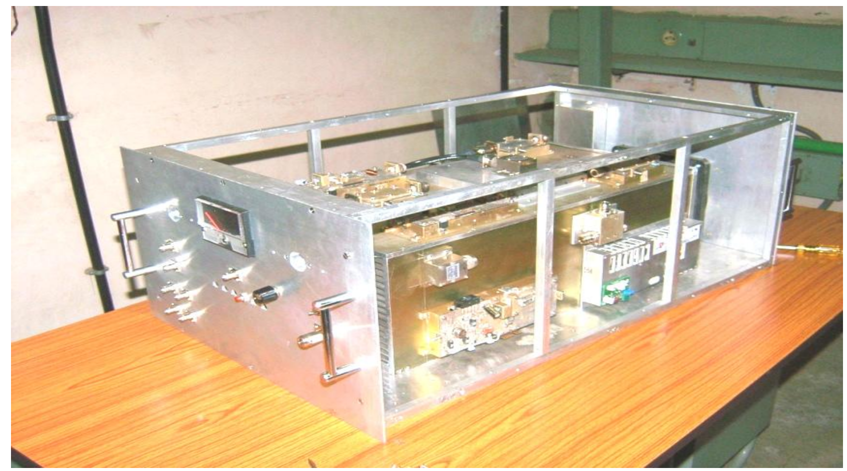
RF Multiplexer



Reference Splitter

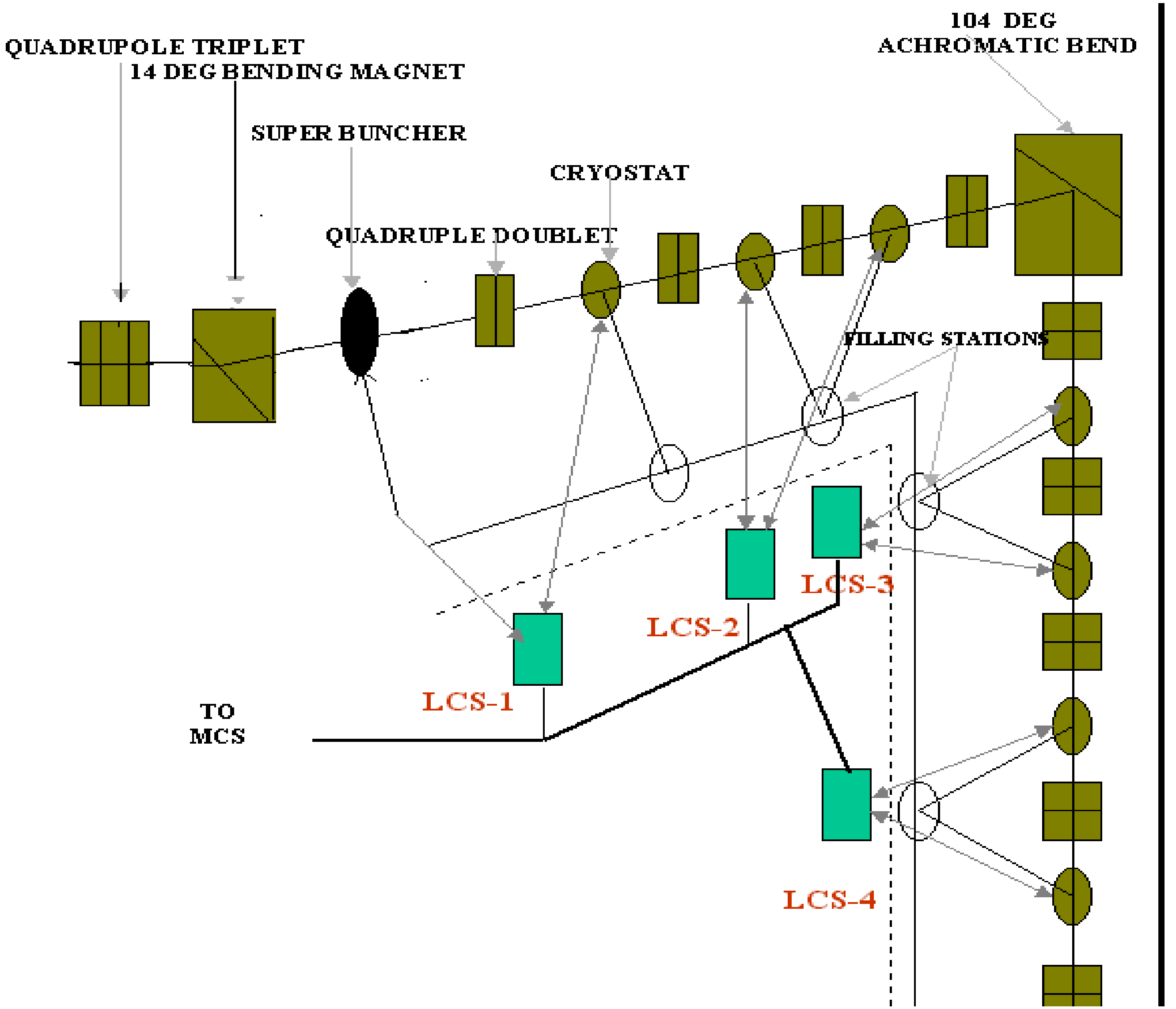
RF power amplifiers supplied to TIFR

Solid State, 150 W for normal operation



Solid State, 250 W for pulse conditioning

BARC-TIFR Linac - Beam Hall Layout



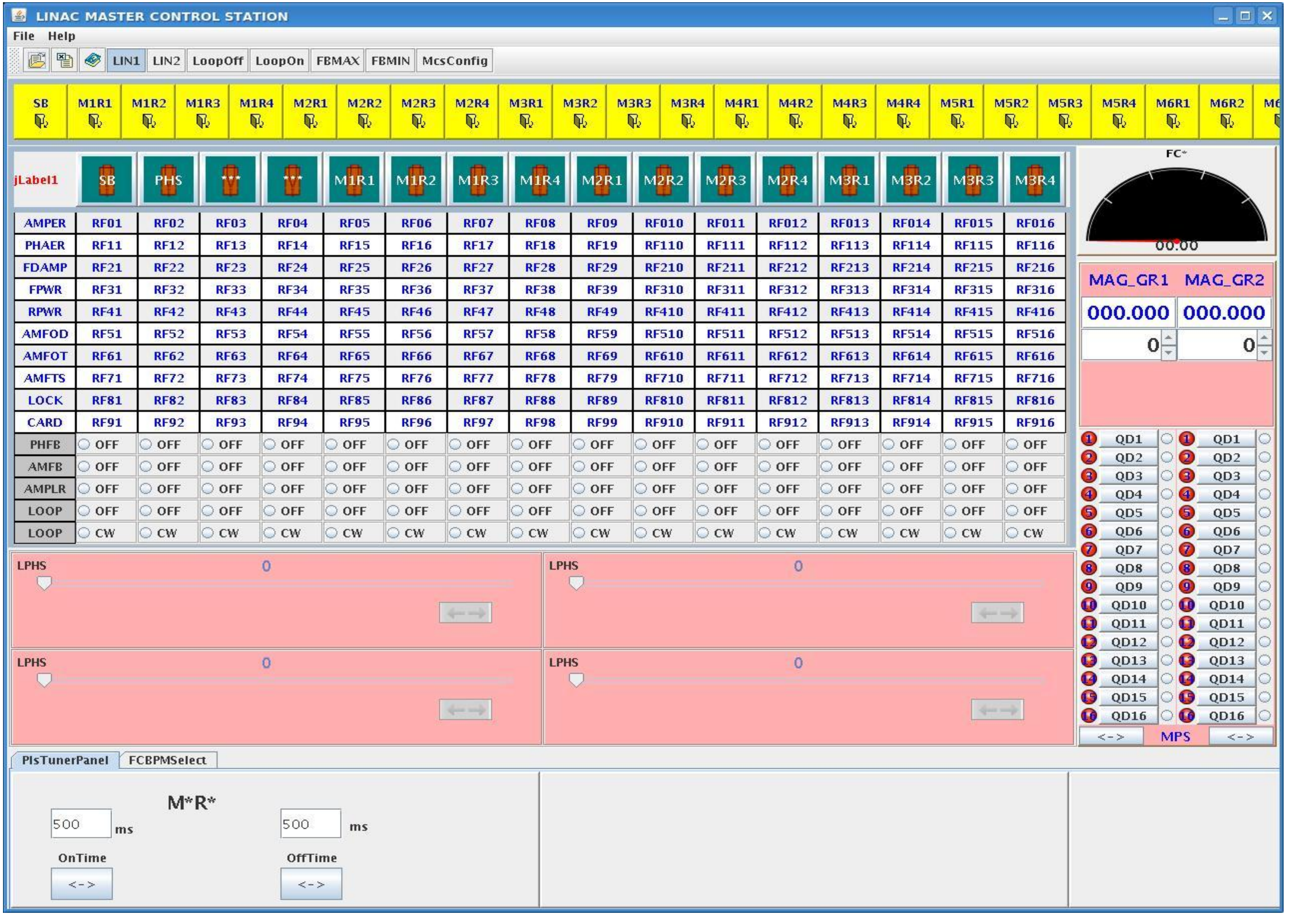
- Each LCS Controls two cryo-modules, each containing four resonators

LINAC Control System Software

- Distributed Control System
- Local Control Station (LCS) controls the Amplitude and Phase of 8 Resonator Cavities housed in two Cryostats.
- Each LCS is a LINUX machine. It has its own DAQ and Interlock application.
- JAVA applet for parameter monitoring and setting is hosted on individual web server of LCS node.
- Easily scalable with increase in the number of Cryostats with (cavity).

Instrumentation Racks at TIFR

LINAC UI



LINAC MASTER CONTROL STATION
File Help
LIN1 LIN2 LoopOff LoopOn FBMAX FBMIN McsConfig
SB M1R1 M1R2 M1R3 M1R4 M2R1 M2R2 M2R3 M2R4 M3R1 M3R2 M3R3 M3R4 M4R1 M4R2 M4R3 M4R4 M5R1 M5R2 M5R3 M5R4 M6R1 M6R2
jLabel1
SB PHS *** *** M1R1 M1R2 M1R3 M1R4 M2R1 M2R2 M2R3 M2R4 M3R1 M3R2 M3R3 M3R4
AMPER RF01 RF02 RF03 RF04 RF05 RF06 RF07 RF08 RF09 RF010 RF011 RF012 RF013 RF014 RF015 RF016
PHAER RF11 RF12 RF13 RF14 RF15 RF16 RF17 RF18 RF19 RF110 RF111 RF112 RF113 RF114 RF115 RF116
FDAMP RF21 RF22 RF23 RF24 RF25 RF26 RF27 RF28 RF29 RF210 RF211 RF212 RF213 RF214 RF215 RF216
FPWR RF31 RF32 RF33 RF34 RF35 RF36 RF37 RF38 RF39 RF310 RF311 RF312 RF313 RF314 RF315 RF316
RPWR RF41 RF42 RF43 RF44 RF45 RF46 RF47 RF48 RF49 RF410 RF411 RF412 RF413 RF414 RF415 RF416
AMFOD RF51 RF52 RF53 RF54 RF55 RF56 RF57 RF58 RF59 RF510 RF511 RF512 RF513 RF514 RF515 RF516
AMFOT RF61 RF62 RF63 RF64 RF65 RF66 RF67 RF68 RF69 RF610 RF611 RF612 RF613 RF614 RF615 RF616
AMFTS RF71 RF72 RF73 RF74 RF75 RF76 RF77 RF78 RF79 RF710 RF711 RF712 RF713 RF714 RF715 RF716
LOCK RF81 RF82 RF83 RF84 RF85 RF86 RF87 RF88 RF89 RF810 RF811 RF812 RF813 RF814 RF815 RF816
CARD RF91 RF92 RF93 RF94 RF95 RF96 RF97 RF98 RF99 RF910 RF911 RF912 RF913 RF914 RF915 RF916
PHFB OFF
AMFB OFF
AMPLR OFF
LOOP OFF
LOOP CW
FC*
00.00
MAG_GR1 MAG_GR2
000.000 000.000
0 0
QD1 QD2 QD3 QD4 QD5 QD6 QD7 QD8 QD9 QD10 QD11 QD12 QD13 QD14 QD15 QD16
MPS
LPHS 0
LPHS 0
LPHS 0
LPHS 0
PlsTunerPanel FCBPMSelect
M*R*
500 ms
500 ms
OnTime
OffTime

RF control electronics for IUAC and ANU

- IUAC, New Delhi
  - supplied RF control electronics for 97 MHz, thin walled, bulk niobium, Quarter-wave resonators
- ANU, Canberra
  - supplied RF control electronics for 150 MHz Split-loop and Quarter-wave resonators

Control electronics supplied to Australian National University, Canberra

RF Control for 400 keV RFQ

- Single cavity system

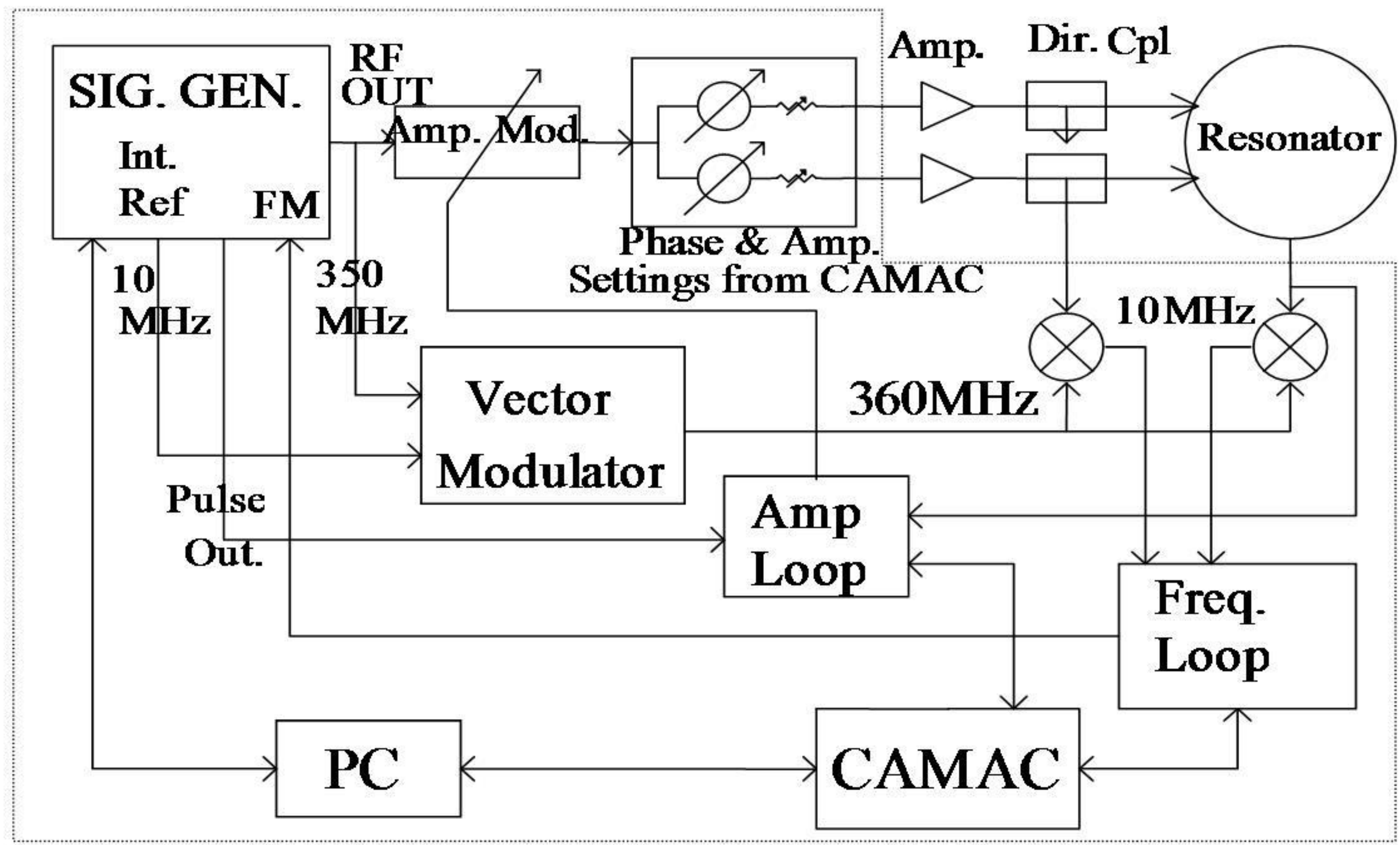
  Incorporates Amplitude Stabilization and Frequency Tracking

- Signal processing in analog domain

- Complete functionality divided over a number of simple signal processing modules

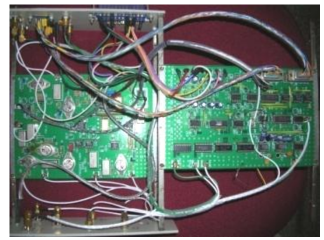
- Utilizes extensively the features available in a Signal Generator

Control Architecture of 400 keV RFQ



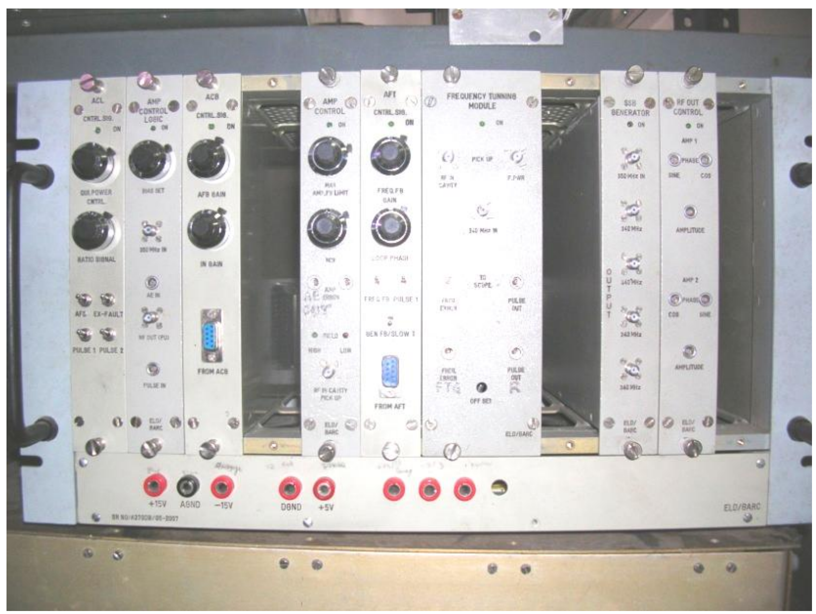
Modules for RF Control - 400 keV RFQ

Amplitude Control



Frequency Tracking

Output



Modules in the Bin

Instrumentation Program For LEHIPA

- RF Control based on digital technology
- Beam Position Monitor
- Integrated Control System for LEHIPA

RF Control based on Digital technology for 20 MeV Proton Linac (LEHIPA) and BARC-TIFR Linac

Development in stages:

- In the Initial Phase single channel system was developed
  - Has only one input and one output channel
  - Incorporates the main feedback algorithm of amplitude and phase control
  - Uses high speed, high density FPGA

System working

Single Channel RF Control System under test at BARC

Four Channel System: Digital Processing Card

Features:

High speed High Density FPGA

Fast ADC –14 bits,105 MSPS, 4 nos

.

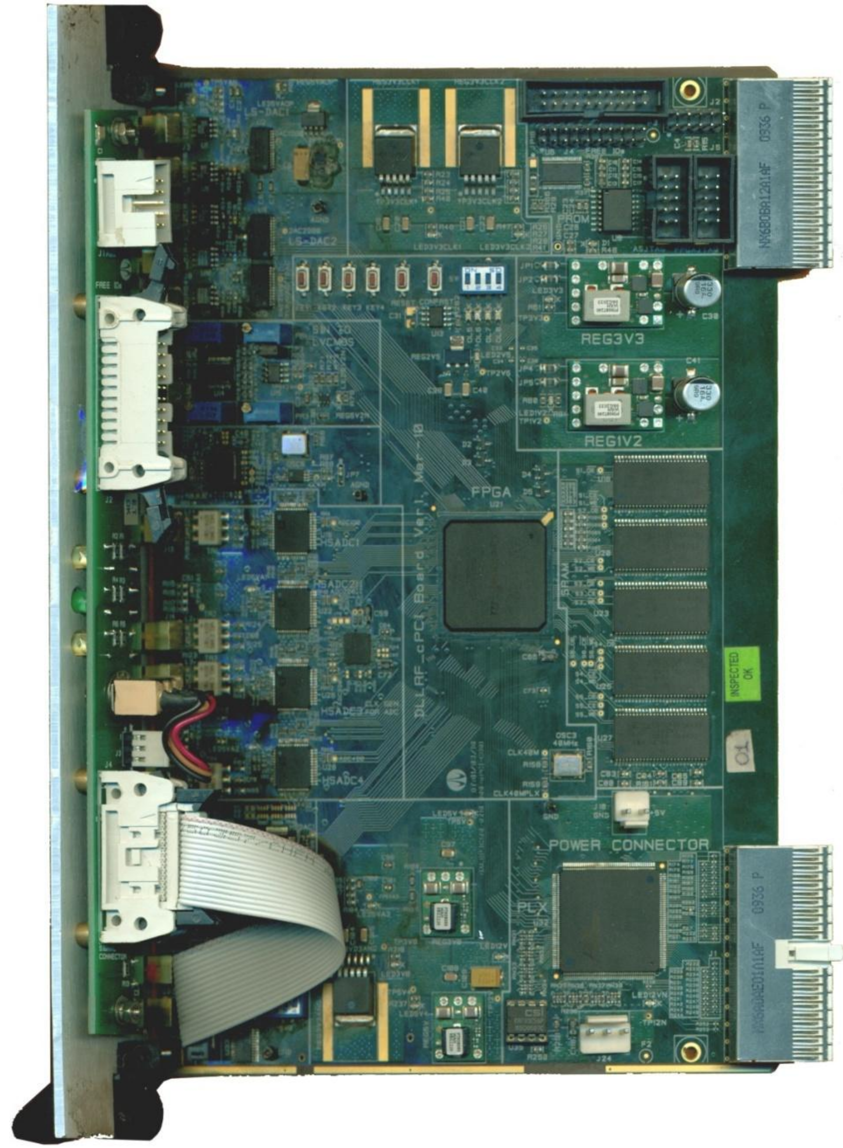
Fast DACs –14 bits, 300 MSPS, 2 nos

Slow DACs –Dual,40 MSPS,10 bits,
3 nos.

Clock Generation – PLL synthesizer

Memory – 1 MB, 6 nos.

cPCI Interface



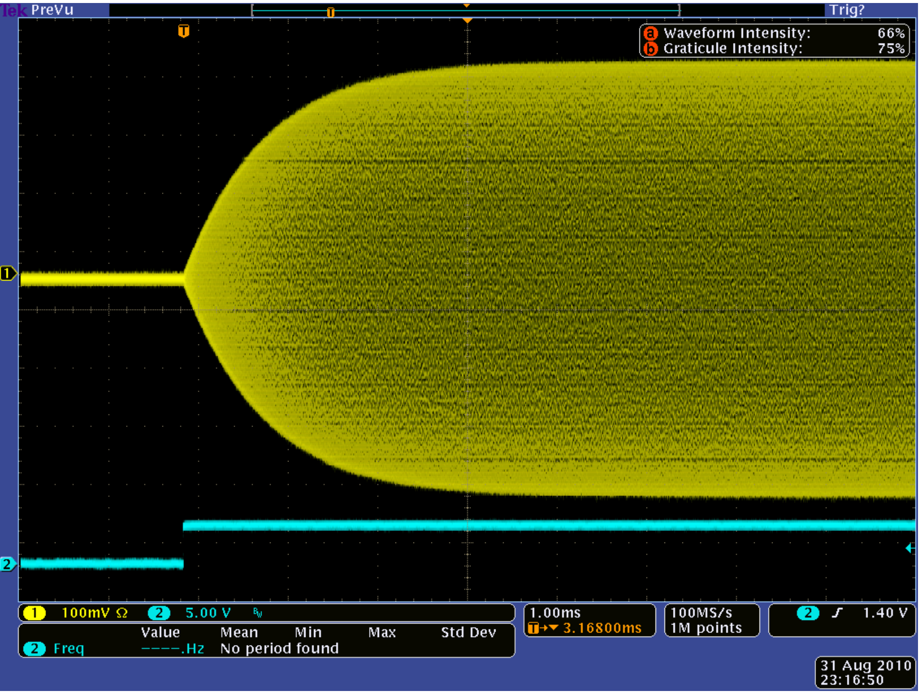
Four Channel DLLRF Card in Compact PCI chassis

Testing of four channel RF Control Card at TIFR – free running Digital SEL

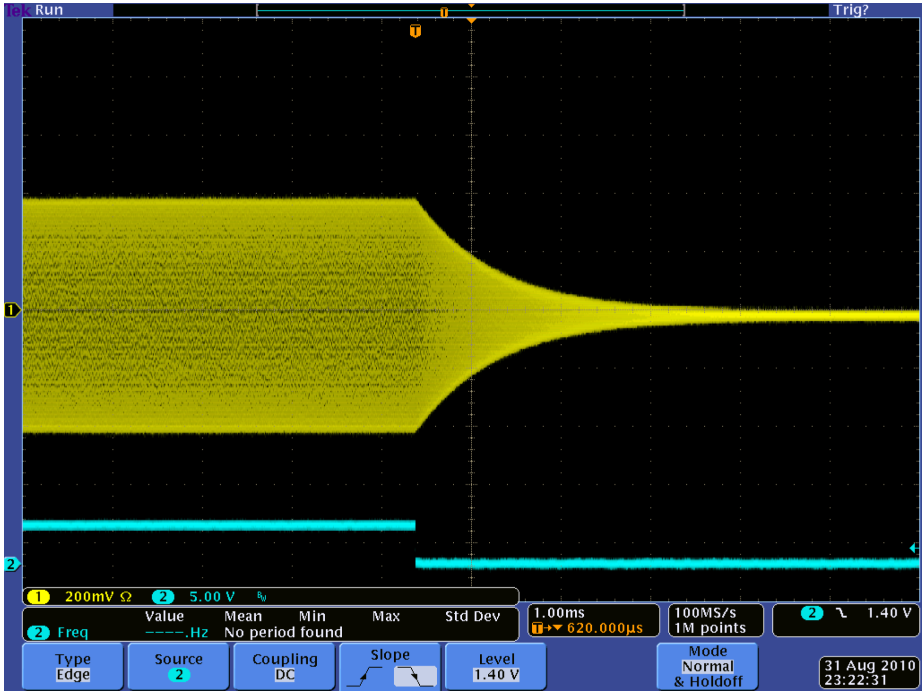
Operating quality factor: $5x10^5$, Low Field Operation

Very smooth operation

Oscillations initiate from the noise in the circuit

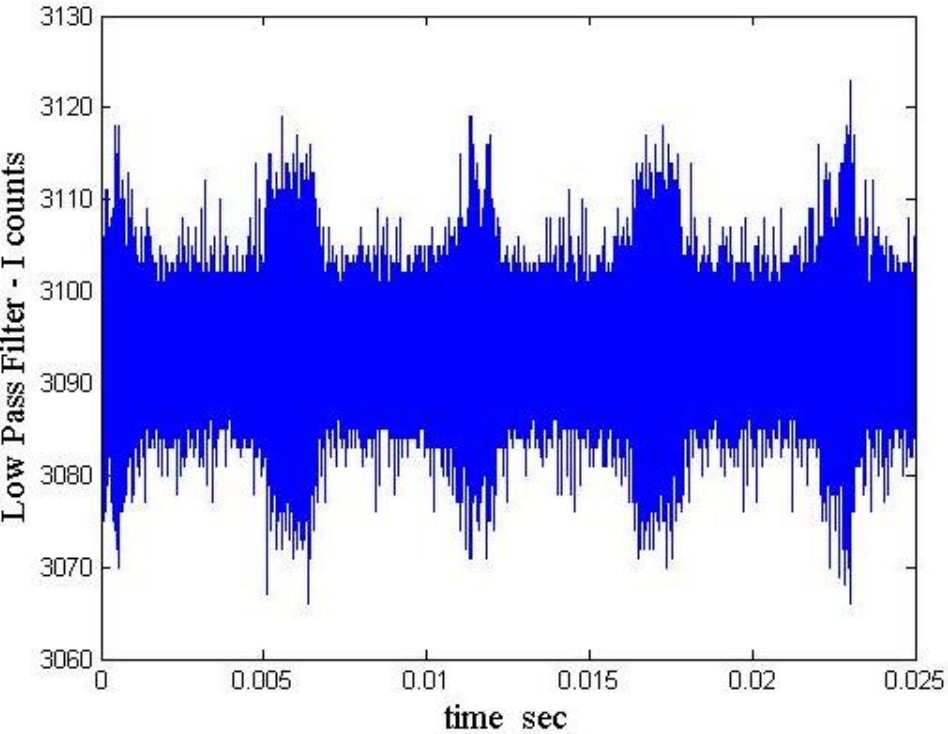


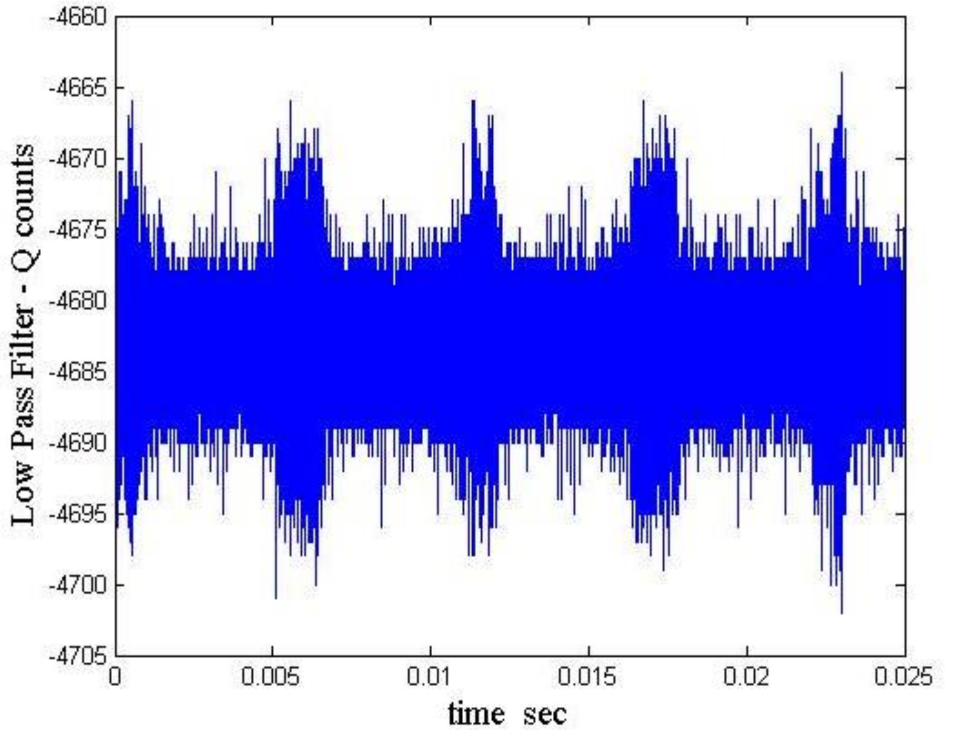
Turn-on transient



Turn-off transient

Testing at TIFR – SEL under Locks





Resonator Pick-up

Amplitude Jitter (rms) - 0.07 percent

Phase Jitter (rms) - 0.14 degree

Encouraging Results – system under study

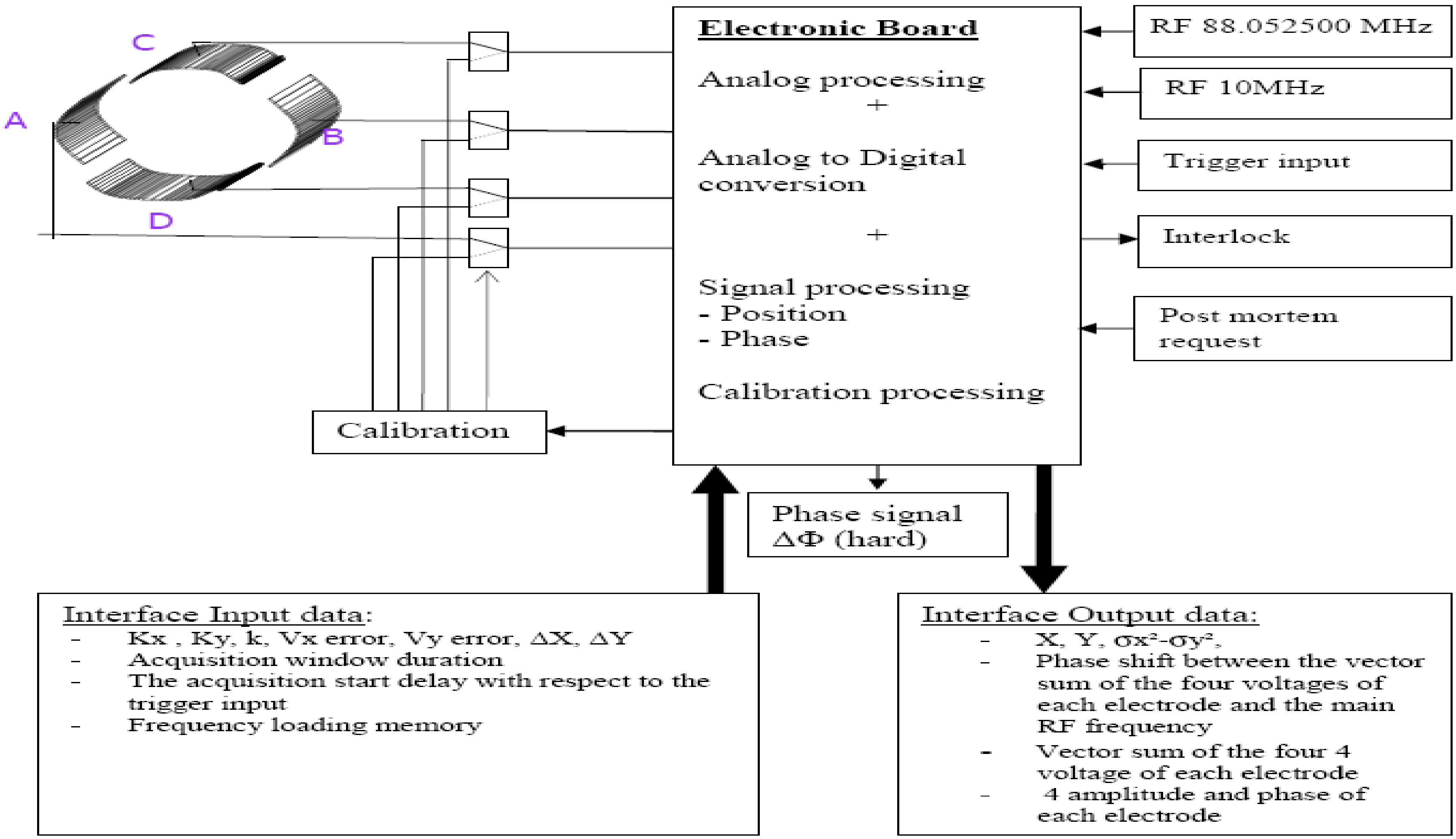
Beam Position Monitor (BPM)

- Used primarily for determining position of bunched beam in the accelerator
- Can provide several other parameters – phase, intensity, energy
- BPM under development at BARC for:
  - Our own accelerator programs – LEHIPA
  - SPIRAL2, GANIL, France
  - Project X, Fermilab

BPM for the SPIRAL2 LINAC

GANIL (Grand Accelerateur National d'Ions Lourds) in Caen, France

- Frequency 88 MHz
- BPM Electronics based on VME Board (22 units to be supplied)
- MVME5500 , VxWorks6.8 , Spiral2 EPICS IOC, EDM GUI



Software Development for BPM of SPIRAL2 GANIL

- Instrument Front End :
  - VME with MVME 5500CPU
- Software Environment at Instrument front-End:
  - EPICS IOC on VxWorks
- Operator Front End:
  - EPICS over Linux, EPICS Extendible Display Manager (EDM) GUI
- Epics Client Access server on VxWorks to access VME Hardware
- Epics Client Access:
  - client on Linux to read the data from VME

BPM for LEHIPA

- Frequency – 352 MHz
- Architecturally similar to GANIL BPM–except additional down-conversion
- Presently under design phase

Integrated Control System for LEHIPA

Integrates the Local Control Systems of -

- Low Level RF Control
- RF Power System
- Beam Diagnostic Instrumentation (Beam Position Monitor, Beam Profile Monitor, Wall Current Monitor)
- Low Conductivity Water Control System
- Ion Source Control System

Collaboration with Fermilab for Project X

- Beam Position Monitor
- Low Level RF Control System
- RF Protection Interlock System
- Unified Control System (Software Development)
- Integrated C&I for CMTF

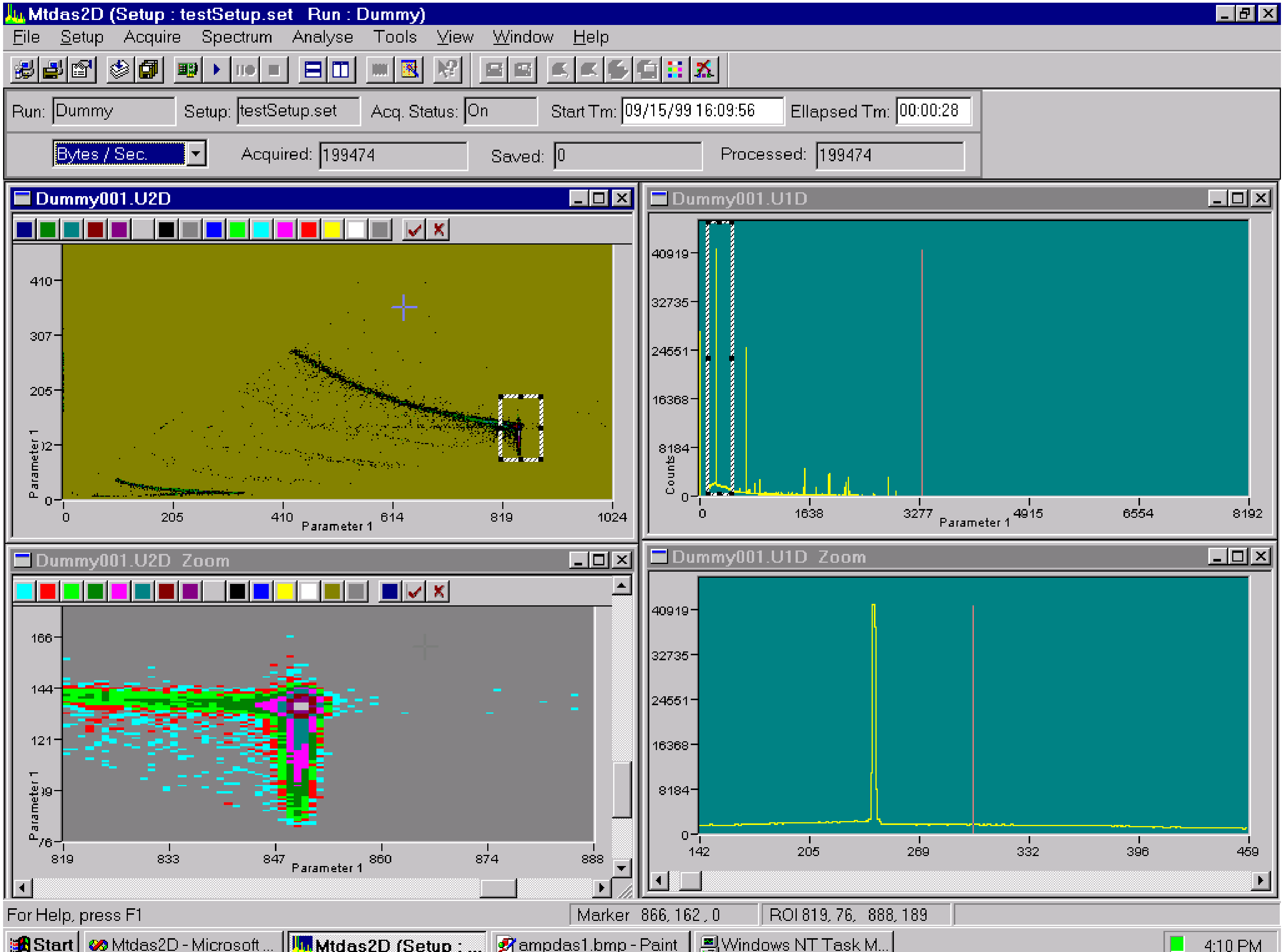
Advanced Multi-Parameter Data Acquisition System(AMPS)

- Spectrum Analysis
  - ROI Selection, Gate Specification, Peak find (Mariscotti search algorithm)
  - Peak Fit with reanalysis (Gaussian peak fit), Area calculation.
  - Energy Calibration (up to fourth order)
- ID Spectra: Spectrum Display Options
  - Overlapping of multiple spectra ,Nested Zooming, Scaling Options Auto, Log/Linear
- 2D Spectra: Spectrum Display Options:
  - Definition of Rectangular ROI / Banana gates with Projections along X / Y Axis

Advanced Multi-Parameter Data Acquisition System(AMPS)- contd…

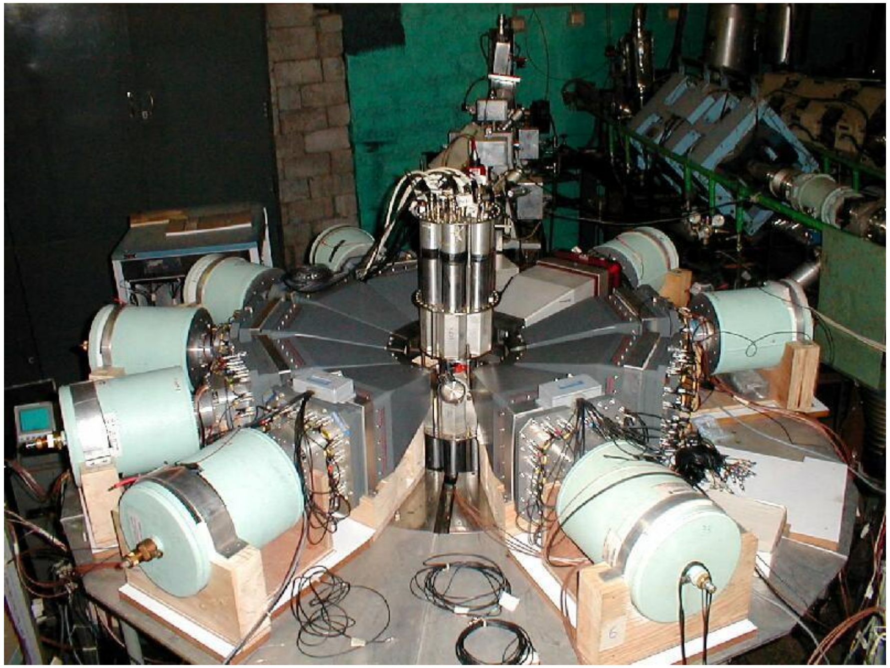
- Event Data File Storage:
  - Support for Multiple Formats, List file Compression using Zero Suppression
- Configuration of Experimental setup:
  - Logical Grouping of setup items in hierarchical property pages
  - Automatic Integrity and Consistency checks of interrelated setup items
- Single Version for Online / offline analysis
- Pseudo Computation :
  - Support for commonly used Expressions, Support for User defined routines
- Scalable Architecture:
  - Multi-Threaded Architecture to exploit the continuous advances in PC Technology

AMPS-UI

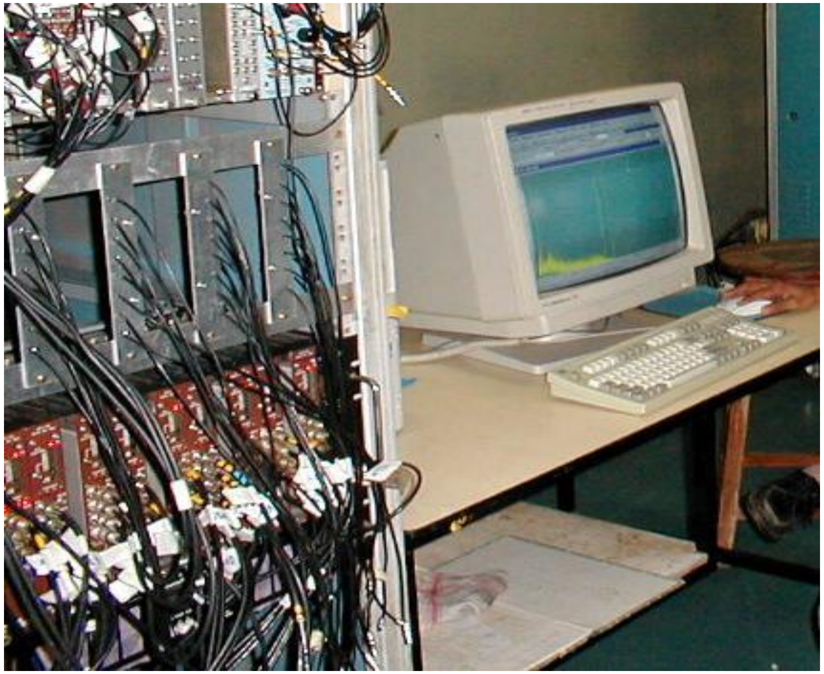


Mtdas2D (Setup : testSetup.set Run : Dummy)
File Setup Acquire Spectrum Analyse Tools View Window Help
Run: Dummy Setup: testSetup.set Acq. Status: On Start Tm: 09/15/99 16:09:56 Ellapsed Tm: 00:00:28
Bytes / Sec. Acquired: 199474 Saved: 0 Processed: 199474
Dummy001.U2D
Dummy001.U1D
Dummy001.U2D Zoom
Dummy001.U1D Zoom
Parameter 1
Counts
For Help, press F1
Marker 866, 162, 0
ROI 819, 76, 888, 189
Start
Mtdas2D - Microsoft ...
Mtdas2D (Setup : ...
ampdas1.bmp - Paint
Windows NT Task M...
4:10 PM

AMPS-Experimental setup at TIFR



In this experiment there were 40 parameters (8x4 energy signals from each segment of Clover Detectors and 8 time signals common from each clover detector).



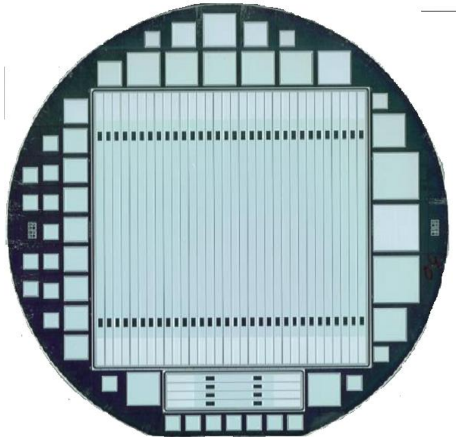
INGA Collaboration (Indian National Gamma Array an all India collaboration with participation from VECC, SINP, NSC, IUCC, Punjab University, Mumbai University etc.

Semiconductor Detectors

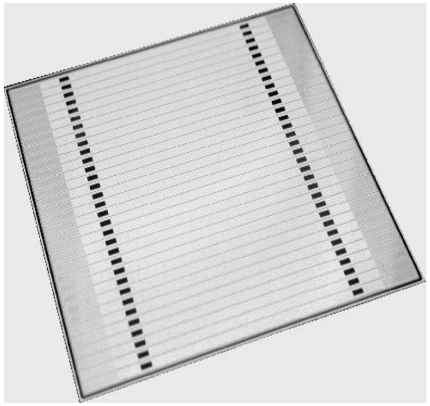
Compact Muon Solenoid (CMS) Preshower Detector

BARC has delivered ~ 1500 detectors for the CMS preshower

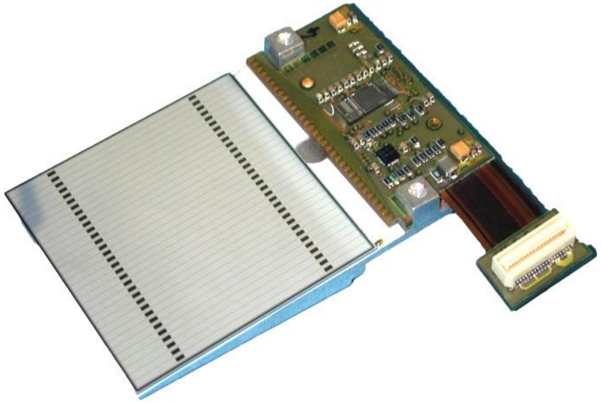
4" Wafer



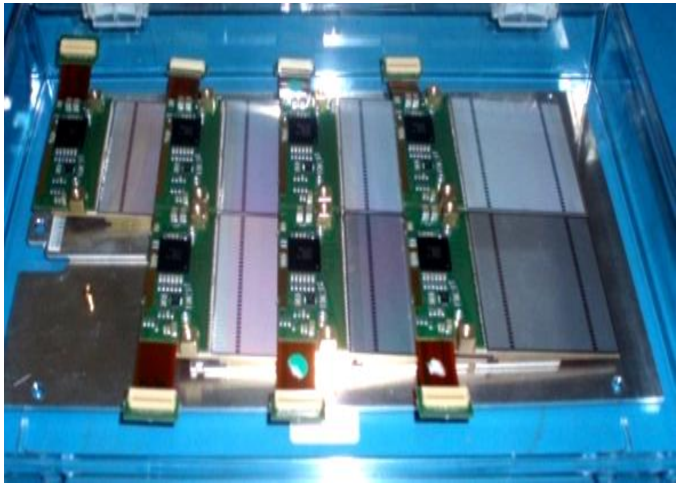
32-strip Silicon strip detector



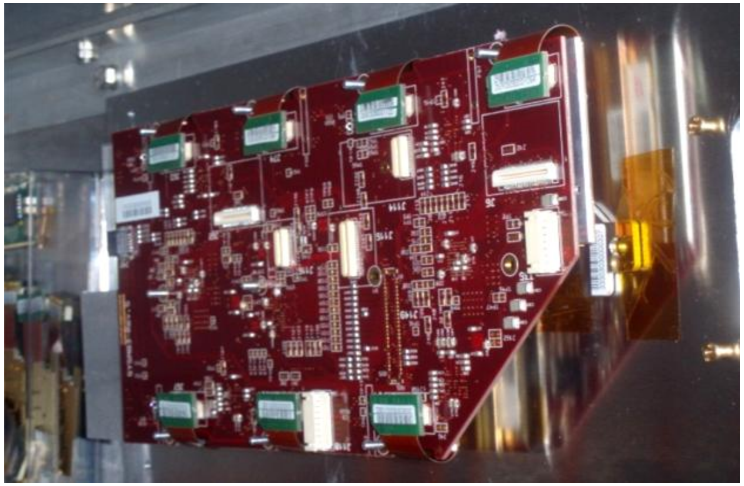
Silicon detector integrated with CERN front end hybrid



Detector micromodule ladder

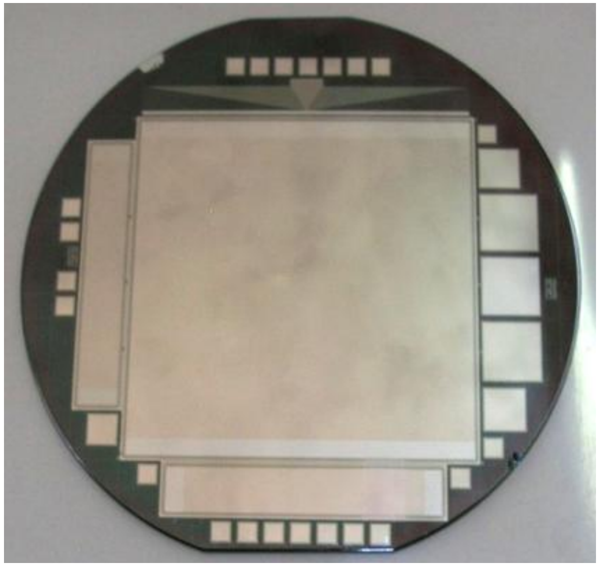


Detector ladder with motherboard



Micro strip sensors for the FOCAL (Forward Calorimeter) prototype, PHENIX Experiment at BNL, USA

4” Wafer showing microstrip sensor & pitch adapter



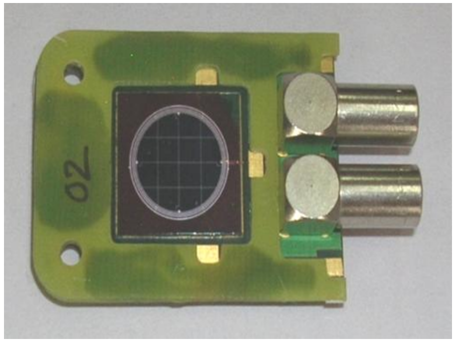
Microstrip sensor, Geometry - 62mmx62mm, 128 strips with separation of 15 µm

The sensors are being assembled at BNL with the SVX4 readout hybrid to make a micromodule. There is a requirement of ~400 microstrip sensors.

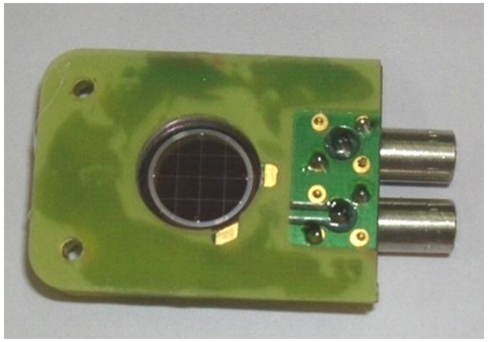
Also, there is a plan to participate in PHENIX decadal upgrade plan which will need a few thousand sensors on 6” wafers.

Detectors for Nuclear Physics Experiments in India

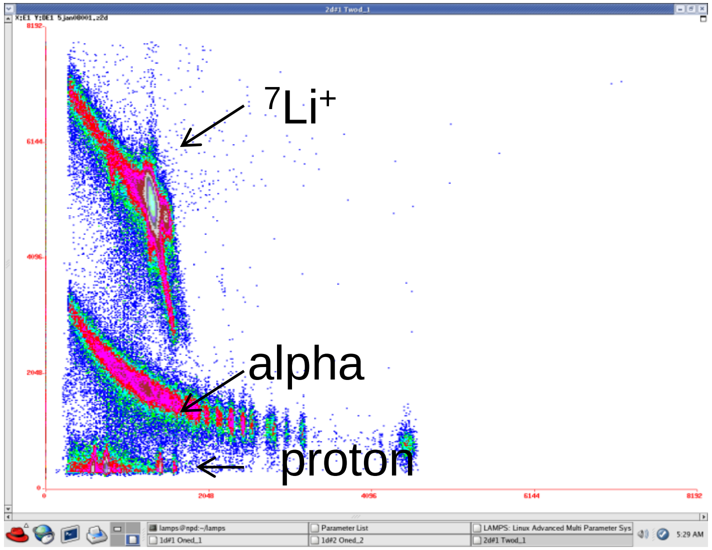
Double sided, integrated ΔE/E detector telescope for particle Identification and energy measurement



Front side Δ E detector
10 μm thick



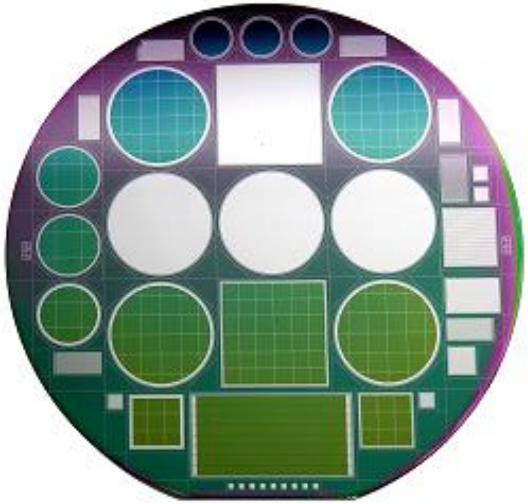
Back side E detector
300 μm thick

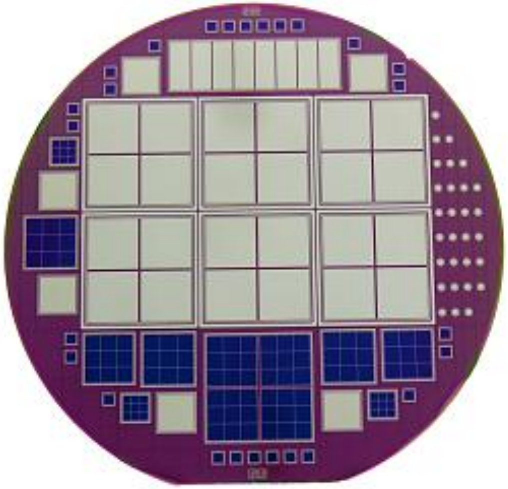


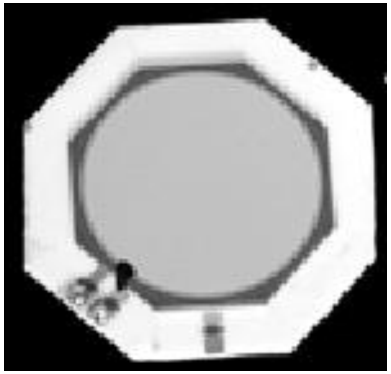
- Novel concept of integrating two detectors (Δ E and E) in one chip for particle identification and energy measurement
- Double sided wafer processing technology with electrically active devices on both sides developed for the first time in India

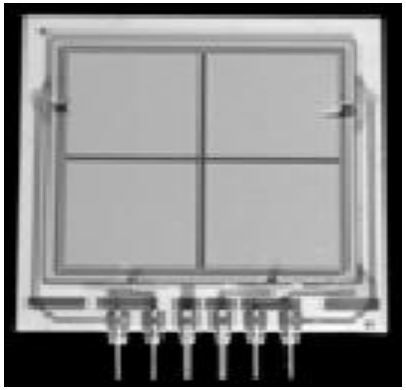
2D spectrum obtained by plotting ΔE signal on Y axis and E signal on X axis (Experiment carried out in FOTIA, BARC)

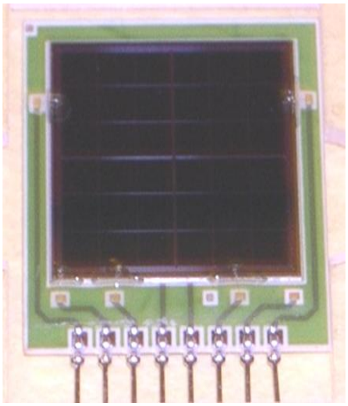
Various types of high energy resolution detectors fabricated in a 4" line for nuclear physics experiments

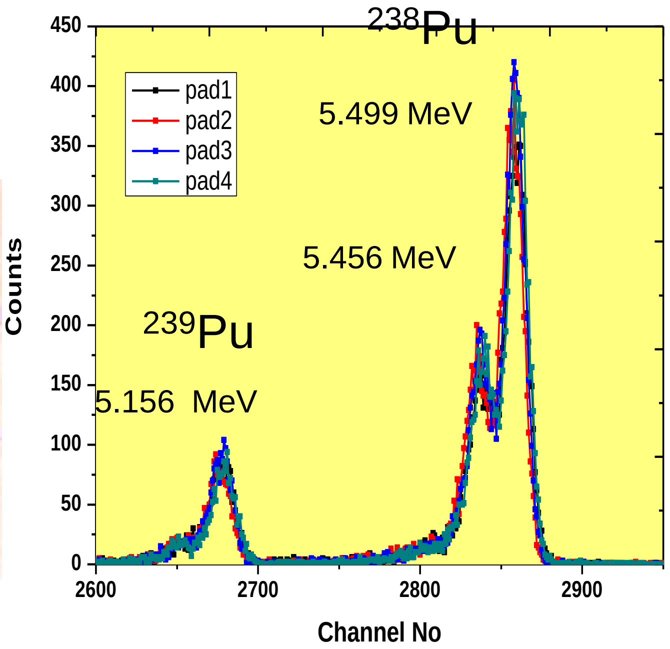












Single element Detector (300mm^2)

Pad detectors, 2x2 matrix

Pulse height spectrum for 4 pads of pad detector for ^{239}Pu and ^{238}Pu alpha particles

Thank You