Pakistan electron LINAC Project with CERN Support

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On Behalf of Pak-LINAC Team

Pakistan Atomic Energy Commission

Design Characteristics of a Novel Linear Accelerator for Challenging Environments: Improving global access to radiation therapy

Layout

- Pak-CERN Collaboration
- Motivation
- Project LINAC
- International Collaborations
- Progress so far

Pak-CERN Collaboration History

RPC for CMS

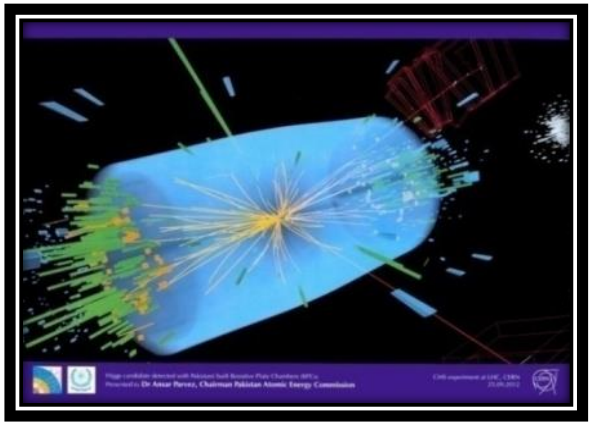
Shielding for CMS detector

CMS outer shielding

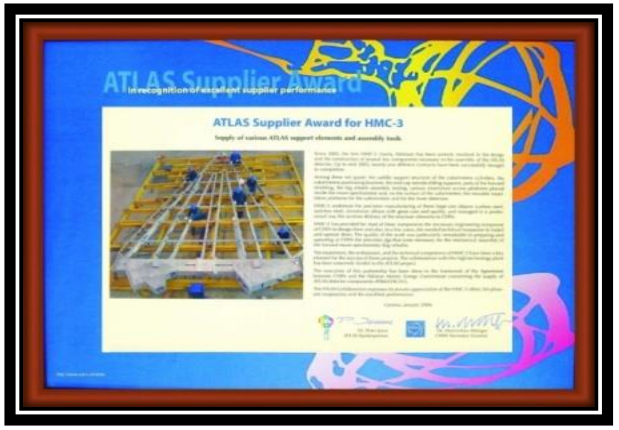
LHC consolidation

Quadrupole magnets in the I8 testing facility

CMS Crystal Award awarded to PAEC by CERN, 2014



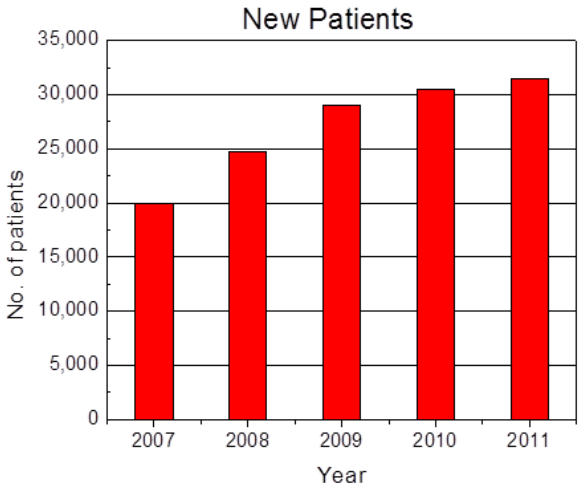
CMS Shield presented to Chairman PAEC by CERN, 2012

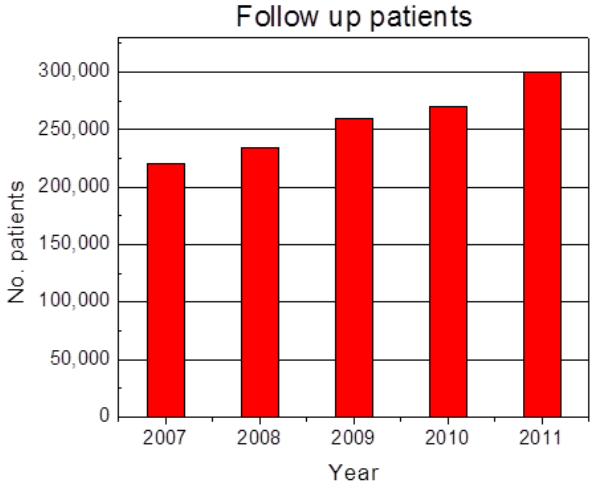


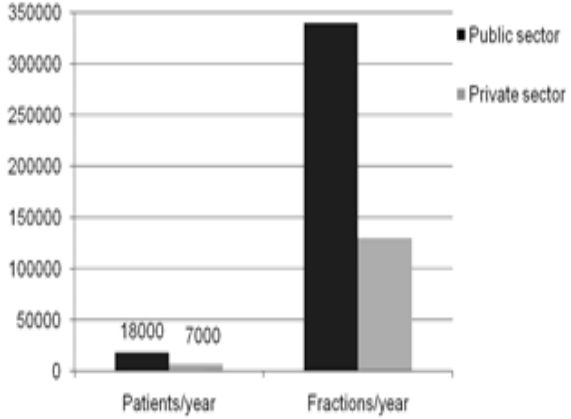
ATLAS Supplier Award presented to PAEC by CERN, 2006

Motivation

- WHO figured-by 2015 and beyond; 10 million cancer cases will be in the developing countries.
- Radiotherapy being an important health care.
- **Pakistan 8.2 million people /center**
- **30,000 new cancer cases every year…!**







Muthair et al., Pak J Med Res Jan ;49(4):134-7

Med. LINAC cost

- Capital cost of Med. LINAC (US$ 1.5-2 million)
- Annual service contract (US$ ≈ 20,000)
- Very high prices of spare parts
- Lack of maintenance expertise at medical centers

If indigenous production is started:

- We can have more medical LINACS
- Technical support group will be available
- Help in better maintenance of machine
- Affordable quality medical treatment

Accelerators in Pakistan

Electron accelerators

Medical Centers of PAEC : 22 (11-LINAC, 7-Functional)

Private sector medical centre having LINACS : 5

Cyclotron for isotope production (PET scanner) : 2

Not a single electron accelerator for academic/research (This year ; 2016 around 4 university Graduates had their First e-Beam for experimentation at LINAC Project)

Ion Accelerators

NCP, Islamabad (5 MeV Pelletron tandem, NEC, USA)

GCU, Lahore (2 MeV Pelletron tandem, NEC, USA)

GCU, Lahore (1.2 MeV Cockroft-Walton)

PINSTECH (250 keV locally developed)

Near Future Demands 3 times the present number

Medical LINAC Project

Vision: To make Pakistan self sufficient and capable of producing electron LINACs to cater the need of medical centers

Mission: To develop accelerator science and technology in Pakistan by developing the following.

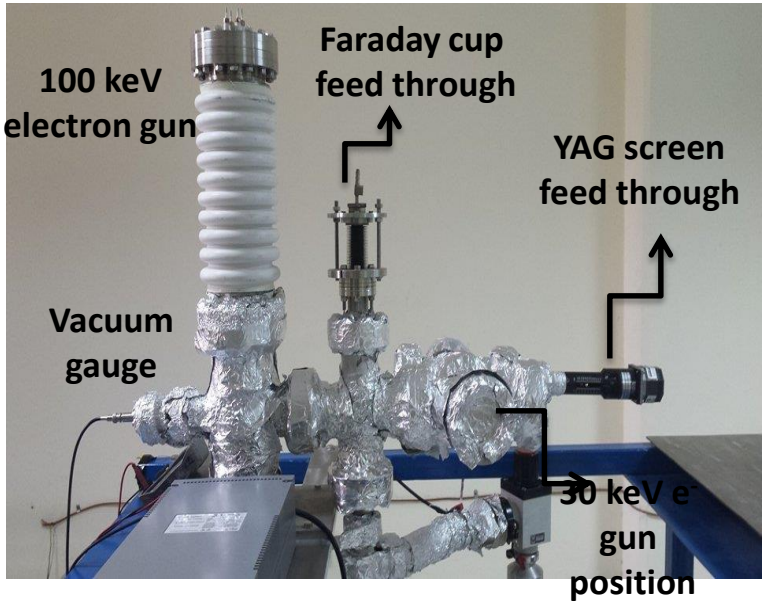
- ❑ RF – Technology (production, transport and delivery)
- ❑ Manufacturing of RF Accelerating Structures
- ❑ Power Electronics
- ❑ Control Systems
- ❑ Electron Beam Optics and Diagnostics

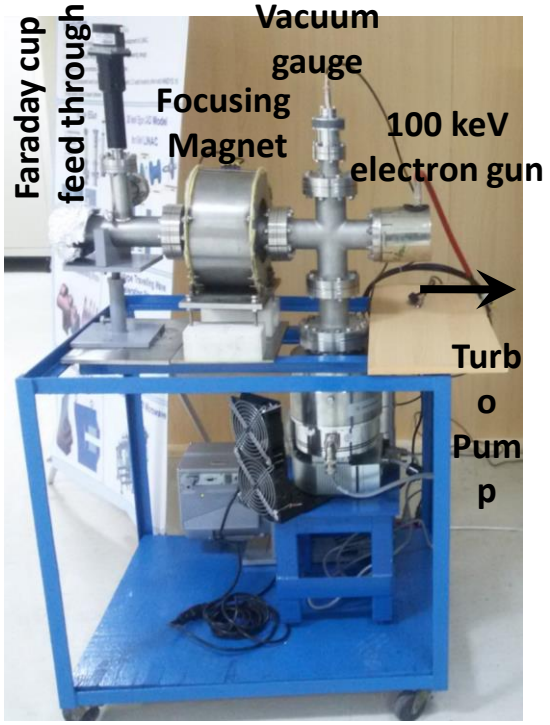
Project Schedule

Major Milestones for the development of 6 MeV LINAC	Target date
Development of 10 -100 keV electron gun	Completed (June, 2013)
Construction of waveguide assembly using components received from various non functional medical LINACs	Completed (Jan., 2014)
Beam dynamic calculation of 6 MeV LINAC	March, 2015
Designing of 6 MeV SW accelerating structure	April, 2015
High power test of 6 MeV SW accelerating structure	Dec., 2016 (In Progress)
Completion of 6 MeV electron LINAC	June, 2017 (In Progress)

Experimentation

- Design, fabrication and testing of Electron Gun (10-100 keV)

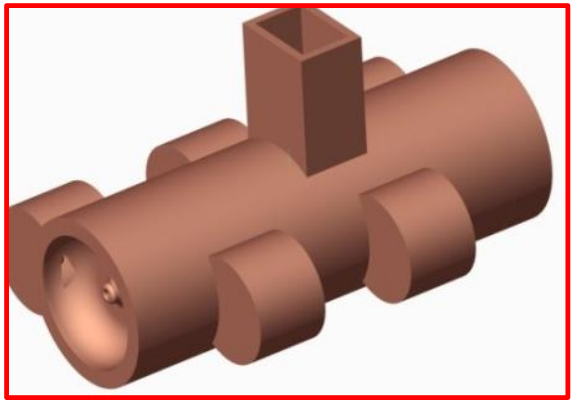




- 30keV and 100 keV Electron Gun setup has been established
- Ultra High Vacuum > 10^{-8}mbar
- High Voltage 10-100 keV
- Remote Control Handling

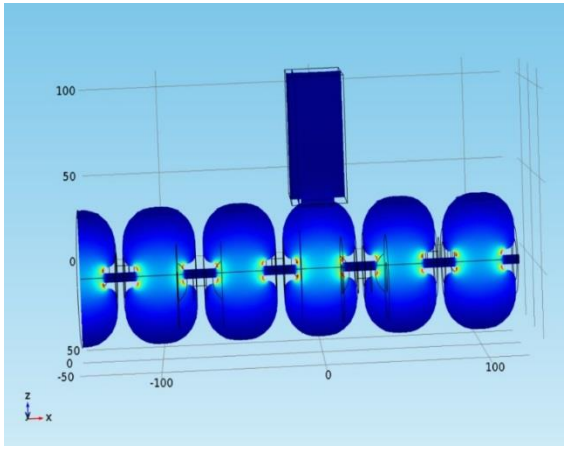
RF Structures

Indigenously developed Bead pull setup



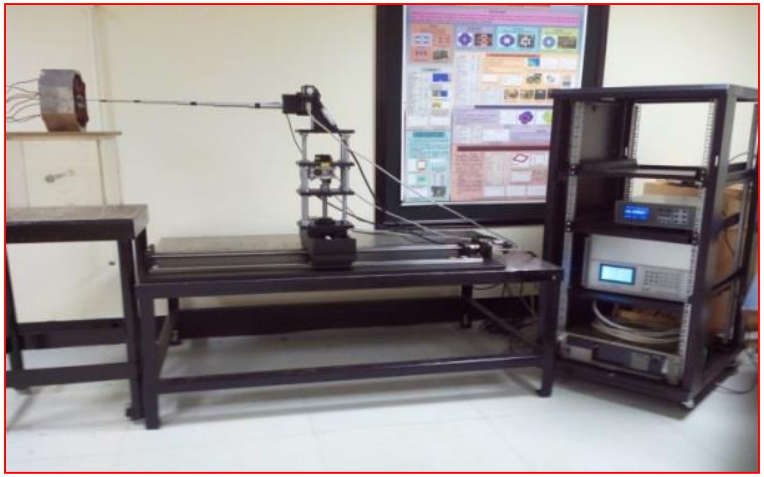
Standing Wave Accel. Structure

Traveling Wave Accel. Structure

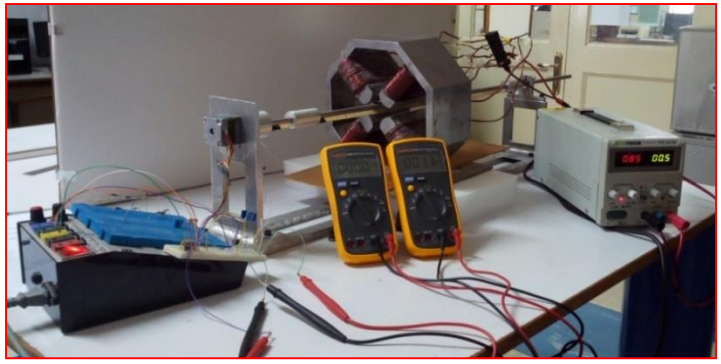


Standing Wave Accel. Structure

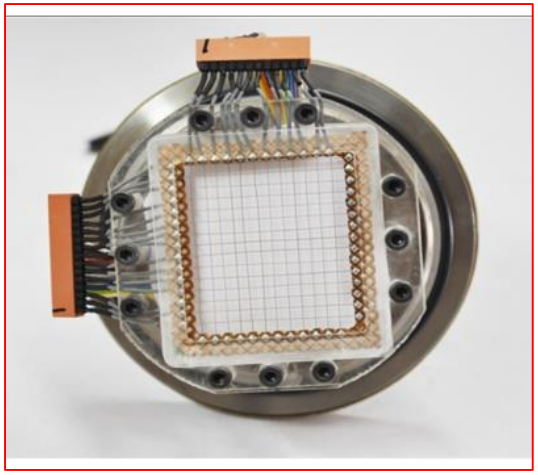
Magnets and Diagnostics



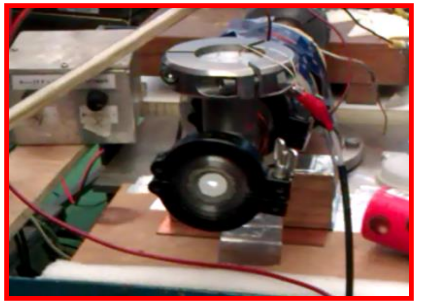
Hall Probe Magnetic Measurement System



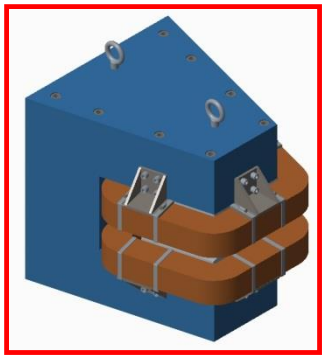
Rotating Coil Magnetic Measurement System



Indigenously Developed SEM Grid for beam profiling.



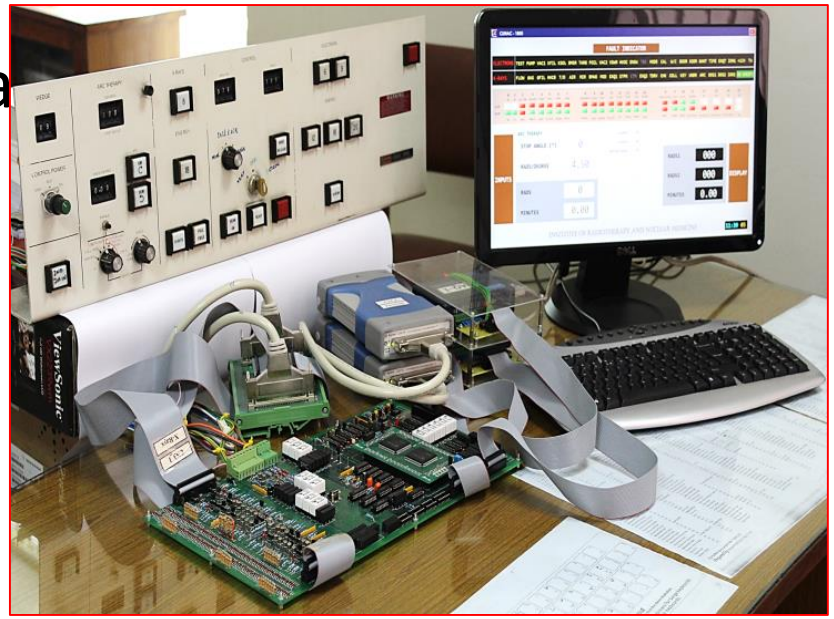
e- beam image on Zn-Sulphide fluorescent screen



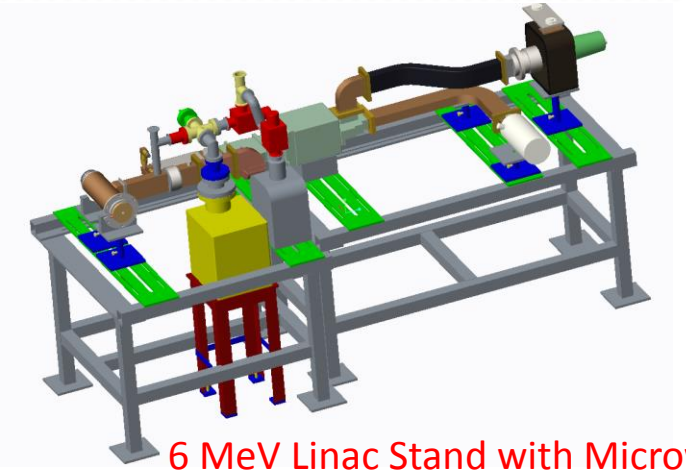
Dipole Magnet

Repairs of Existing LINACs

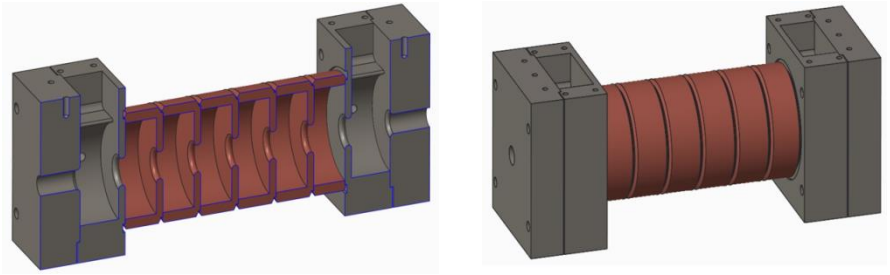
- Two existing LINACs were made operational after:
  - Replacement of control electronics.
  - Inter lock updates.
  - Cooling loop and vacuum repa
  - Software updates
  - Replacement of parts.



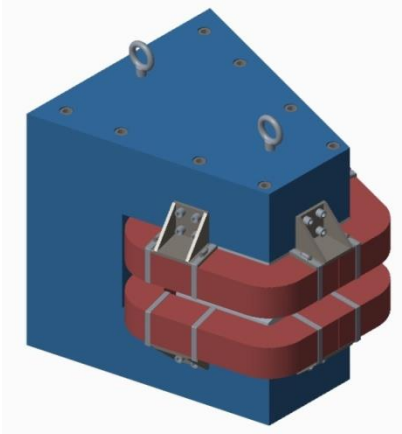
Mechanical Engineering

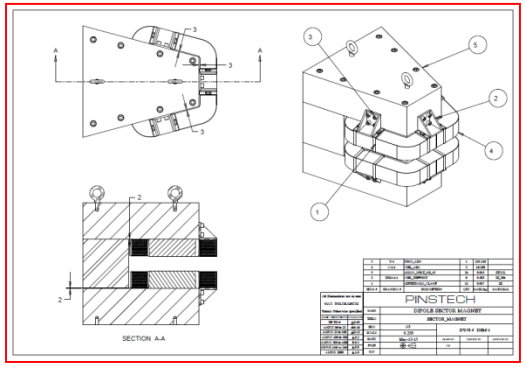


6 MeV Linac Stand with Microwave Assembly

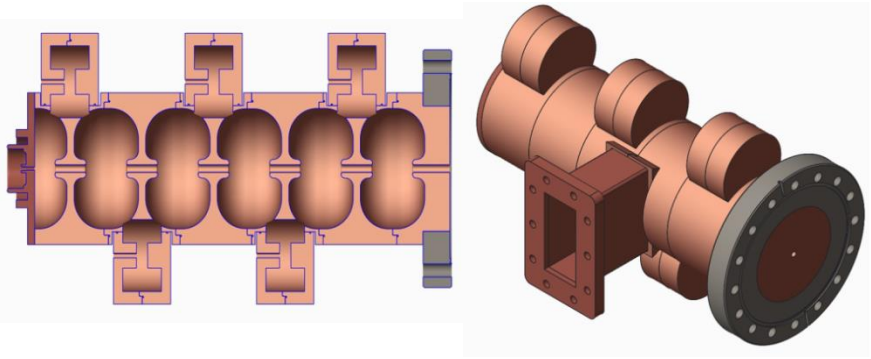


Prototype Travelling Wave Accelerating Structure





3-D view of magnet and Detailed Mechanical Drawing



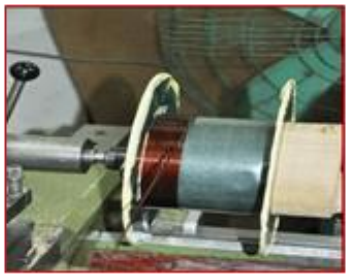
6 MeV Side-coupled Standing Wave Accelerating Structure

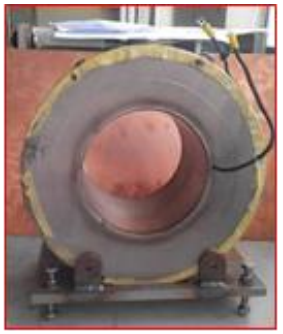
Collaboration with CERN

- CERN is major Collaborator with the Project.
- CERN provided trainings in areas:
  - Accelerator Physics and Accelerator Operations,
  - Magnets, Simulation,
  - RF Systems and Controls.
  - Mechanical
- Lectures delivered by CERN officials at Int. Nathiagali Summer College, Pakistan.
- Visits and technical feed back.

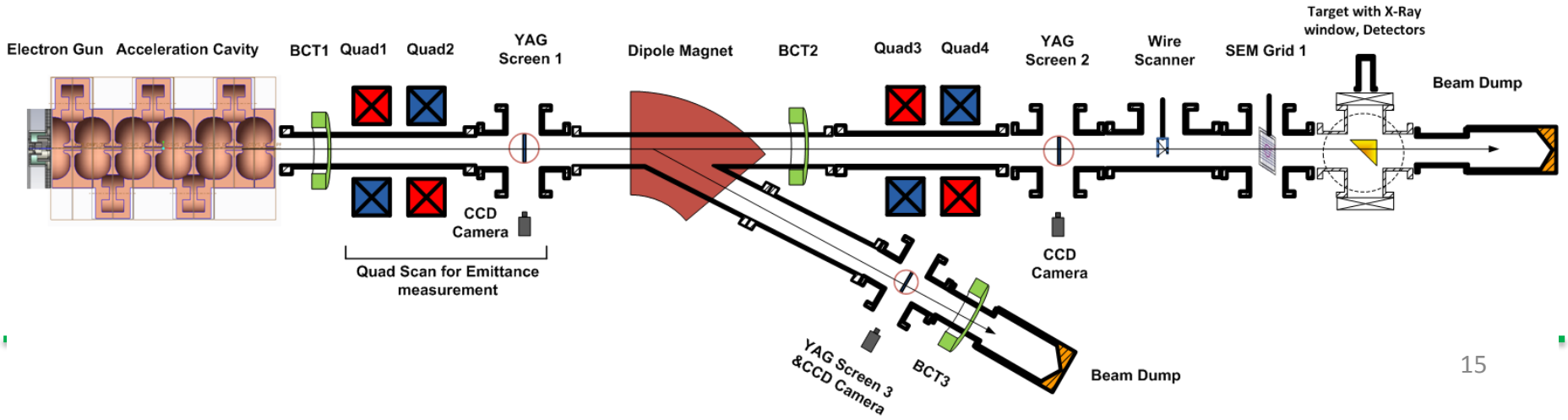
Post Training Achievements

- Development of Magnetic Structure lab.



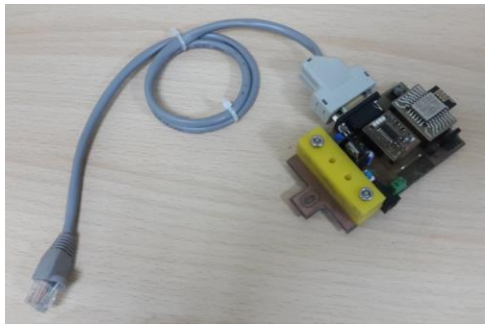


- Beam Dynamics calculations of 6 MeV accelerator

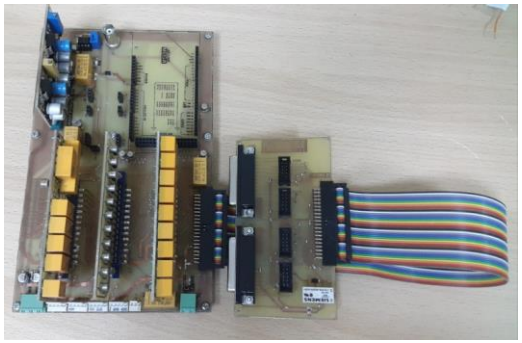


Post Training Achievements….

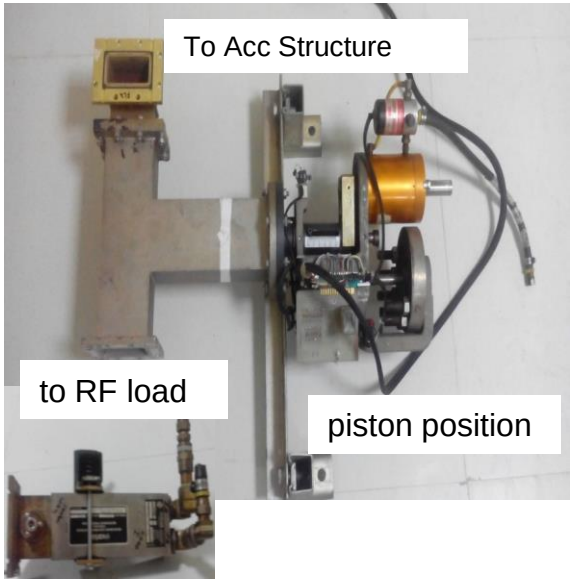
- RF handling expertise
- Electronics and controls related to accelerator operations.



Power Supply Remote Controller



Modulator Remote Controller

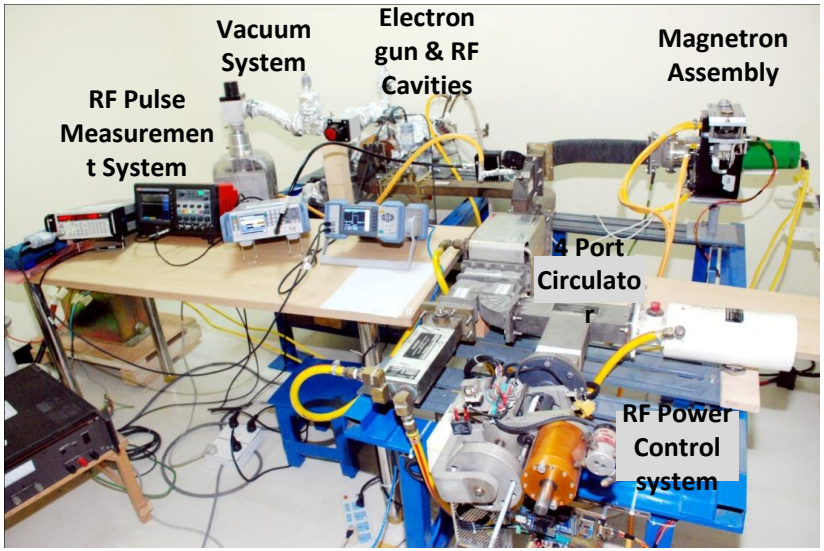


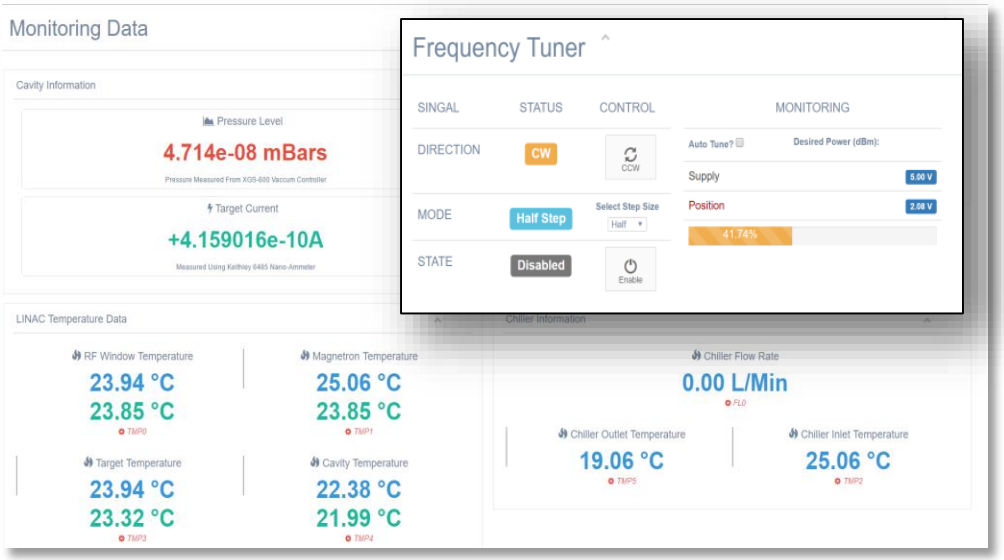
(B) 4-port Circulator (under test)

Future at CERN

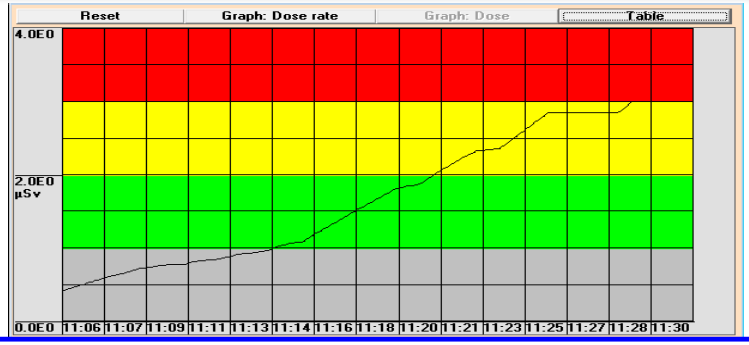
- CERN's contributions are promising and there are a lot of grounds where Pakistani scientists and engineers can get training.
  - RF Structure designs, Fabrication and Testing
  - Commissioning of Accelerators
  - Control and Operation
- Contribution in establishment of accelerator test facility and experimentation.

Some Recent Results





Dose Rate: 0.2 cGy/min @ 670kW RF Power Injection



Accumulated dose at 200-280kW Power injection

Acknowledgements

- All members of LINAC Team (Pakistan)
- CERN (Switzerland)

شکریہ Thank you