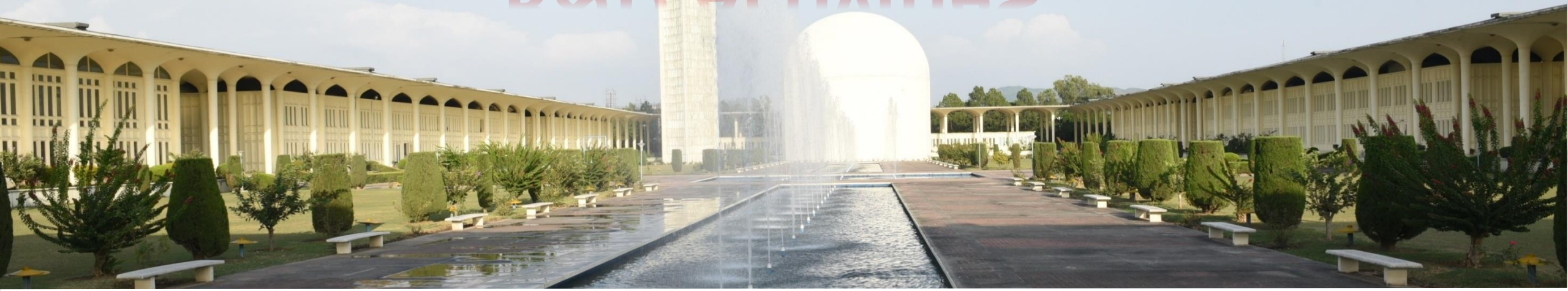
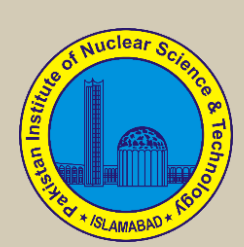


PINSTECH R&D Activities



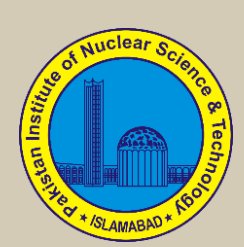
**CERN Task Force Review Meeting
April 19, 2022**



Outline



- PINSTECH: History and Organogram
- Major Facilities at PINSTECH
- Science Research at PINSTECH
- Technology Development and Technical Services at PINSTECH
- Scientific Collaborations and Quality Assurance at PINSTECH
- PINSTECH's Association with CERN



PINSTECH: Vision to Reality



PINSTECH Visionary Pioneers

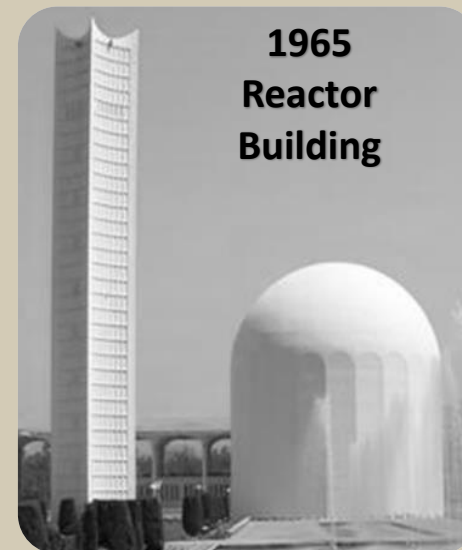
Conceived the vision of
establishing PINSTECH in 1960



Dr. Ishrat H. Usmani
Chairman, PAEC



Prof. Dr. Abdus Salam
Nobel Laureate

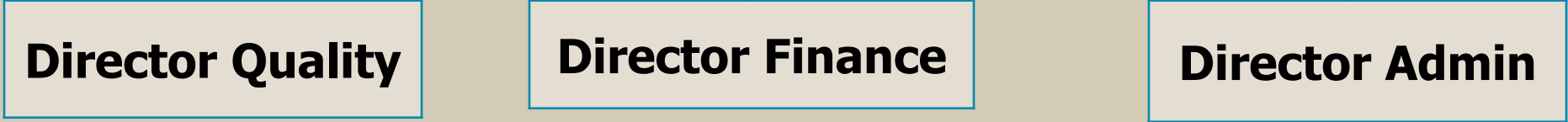
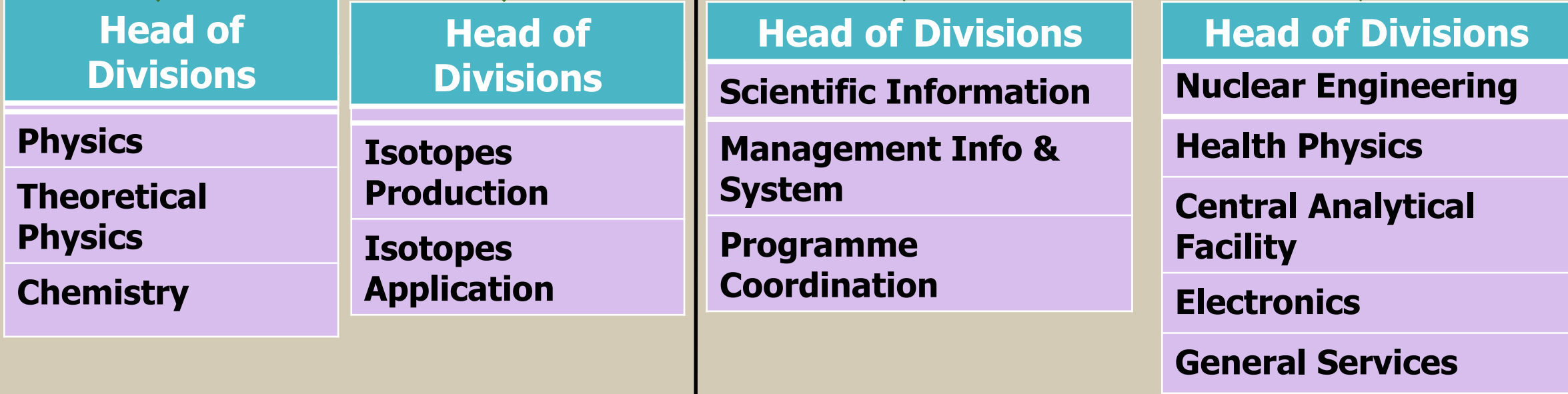


Pakistan Research
Reactor-1 (PARR-1)

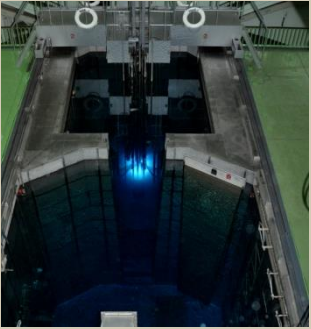


Criticality of PARR-1
21 December 1965

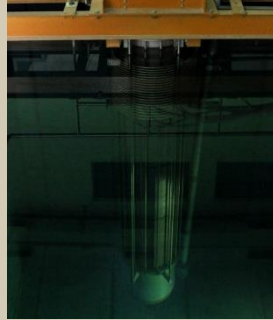
Director General



Major Facilities at PINSTECH



PARR-1



PARR-2



Mo-99 Production



Tc-99m Generator



**Iodine-131
Production**



Furnaces



XRD

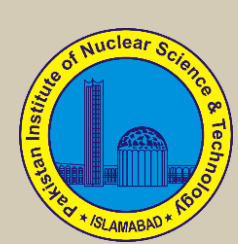


SEM



Optical Microscope + Heating Stage





Science Research at PINSTECH



PHYSICS

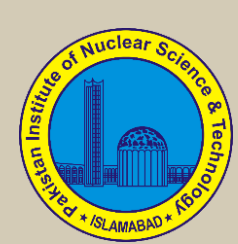
High Energy Physics

Atomic Physics

Plasma Physics

Condensed Matter Physics

- Study of Quark Gluon Plasma (QGP), to investigate the matter formed shortly after the Big Bang
- ALICE-CERN HEP Data Analysis, GEM Readout chambers for ALICE-TPC, Simulation studies for GEMs/ITS and high energy interactions
- Event vertex reconstruction of JUNO (JUNO-IHEP China)
- Entanglement properties of neutrino flavors in vacuum as well as in material medium (JUNO-IHEP China)
- Ion induced sputtering , atomic excitations and secondary electron emission studies, nanosecond pulsed electron beam and nanosecond pulsed X-rays generation
- Investigation of waves instabilities in both space and laboratory plasmas
- Nonlinear wave structures such as solitons, cnoidal and vortices in plasmas
- Wave-particle interaction in fusion plasmas
- Experimental condensed matter physics, Ferroelectric, Piezoelectric, Perovskite, Spinel structured materials



Science Research at PINSTECH



CHEMISTRY

Analytical Chemistry

Nuclear Chemistry

Materials Chemistry

Catalysis/
Electro-Chemistry

Separation Chemistry

- Analysis of diverse matrices for their elemental, radioisotope and organic content
- Preparation of electrodes and catalyst for renewable energy and environmental applications
- Preparation of reference materials for QA/QC
- Synthesis of different materials such as calcium hydroxyapatite (HAp) for decontamination of heavy metals/ radioactive waste
- Synthesis of resins and 2D materials for environmental remediation and extraction purposes

Materials Science

Nanomaterials

Functional Materials

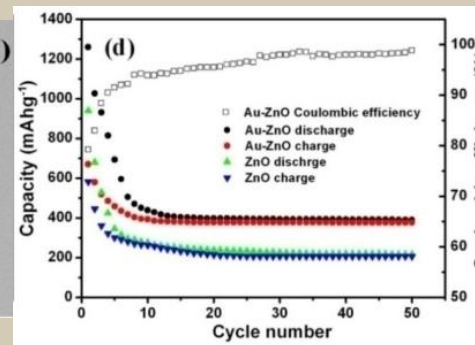
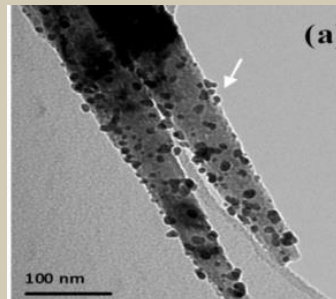
- Nanomaterials-based Li ion batteries (LiBs)
- Electrochemical biosensors
- Photocatalyst for environmental remediation
- Controlled synthesis of functional nanomaterials
- Development of SERS (Surface-Enhanced Raman Spectroscopy) technique
- Piezoelectric crystals of different compositions for different applications
- Synthesization of Mn-Zn Ferrite transformer cores



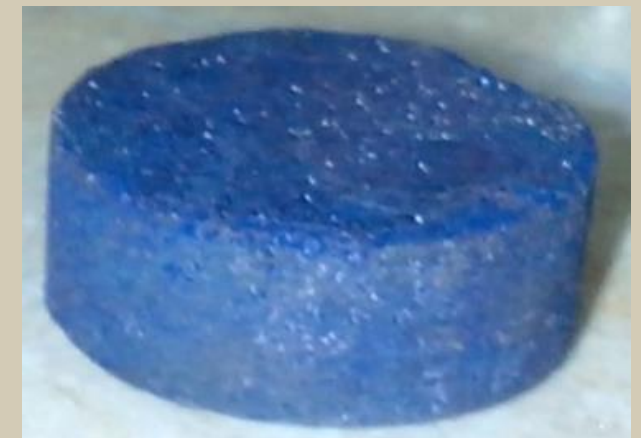
Scintillation Screen
for LINAC Project



Argon glove box for fabrication of coin cell batteries, Lithium ion coin cell batteries testing system



Au-ZnO hybrid structures, Charge Capacity of Au-ZnO based LiBs



CeB₆ Cathode for electron emission
for LINAC Project

Production of radioisotopes/radiopharmaceuticals in Research Reactor at PINSTECH

Isotopes: Mo-99/Tc-99m/I-131

- Fission Mo-99/ Tc-99m
~1300 generators/year
- Iodine-131
~1000 consignments/year
- Freeze Dried kits
Type of kits = 11
~ 30000 vials/year

- 19 PAEC Cancer Hospitals
- 24 Public Sector Hospitals
- 16 Private Hospitals



Tc-99m Generator Production Facility



Weekly production of 40-45 generators ~ 300-600 mCi



Hot Cell-1
Heating and
Evaporation of I-131



Hot Cell 2
Dispensing of I-131 in container with computer
control measurement

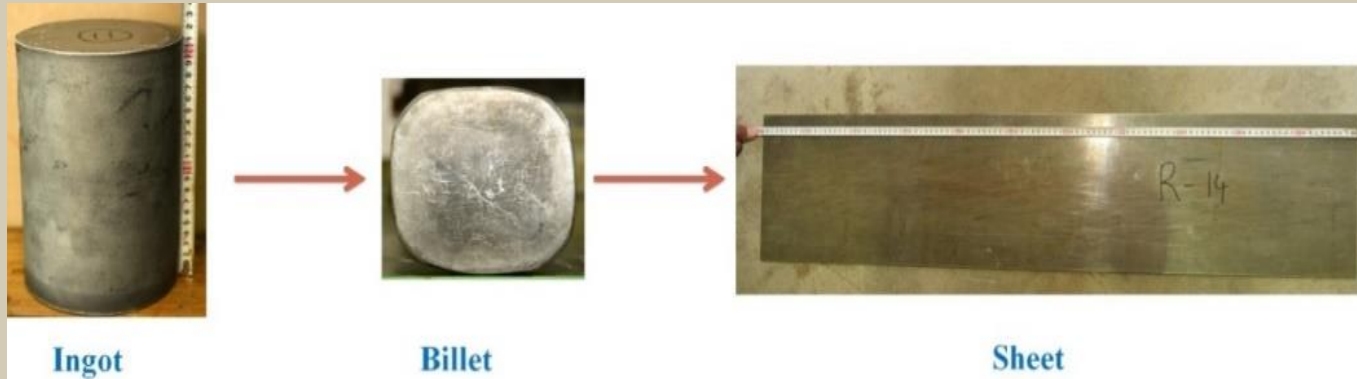


Composites

Al-B₄C

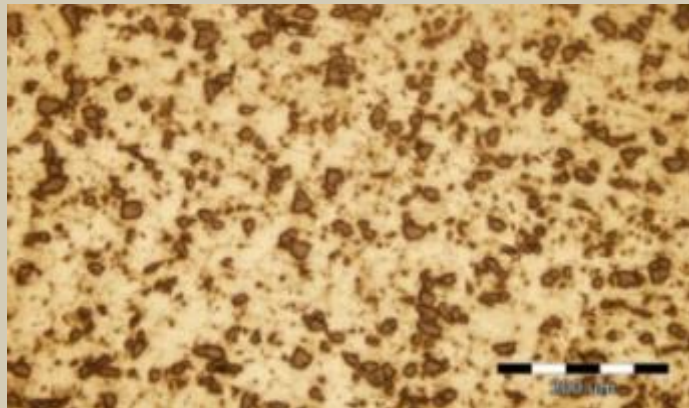
Lab. Scale Development

R & D on Al/B₄C plate was demonstrated on Lab. scale



Pilot Scale Development/Facilities

- **Objective:** To develop Al/B₄C composite plates for spent fuel storage racks and casks
- **Current Status:**
 - Pilot plant is in operation
 - Facility would be enough to cater current needs of PAEC power sector



LINAC

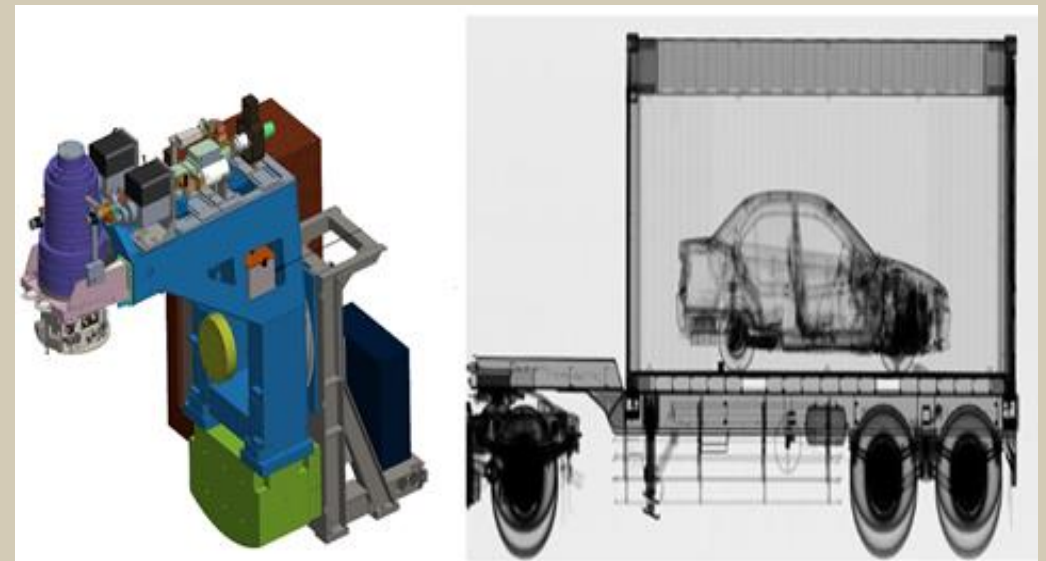
- 6 MeV LINAC for NDT (prototype developed)
- 6 MeV Medical LINAC by June 2022
- 6 MeV LINAC for Cargo scanning June 2023

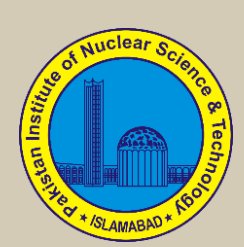


6 MeV LINAC

Future Development

- Enhancement of Energy up to 15 MeV
- Experimentation around LINAC



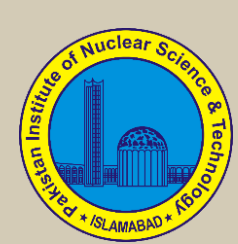


Technical Services at PINSTECH



Health Physics

- Radiation protection/ surveillance and technical support
- Personal dosimetry and standard calibration of dosimetry related systems used for the diagnostic of cancer patients and radiation workers
- Solid and liquid radioactive waste management
- R&D, teaching and training related to radiation, radiation protection and radiation emergency handling
- Radiological environmental monitoring country wide



Scientific Collaborations

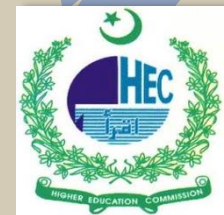


International

- IAEA
- Technical Cooperation Projects (TCP)
- Coordinated Research Projects (CRP)
- RCA (Regional /National)
- Establishment of Labs, Procurement of Equipment, Manpower Training, Expert Mission
- Pakistan is one of highest recipient of Technical Cooperation Program of IAEA
- CERN: Associate Membership, Trainings
- ICTP: Research, Training
- IHEP: Jiangmen Underground Neutrino Observatory (JUNO)

National

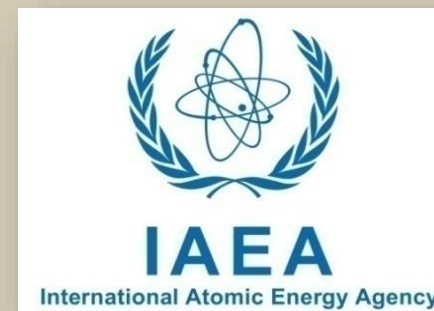
- Pakistan Science Foundation
- National Centre for Physics
- National Universities



Quality Assurance and Control

➤ Regional Resource Centers

- Isotope Hydrology
- Neutron Activation



➤ Certifications

- ISO (9001:2015) certification:
 - Isotope Production
 - Health Physics
 - Central Analytical Facility



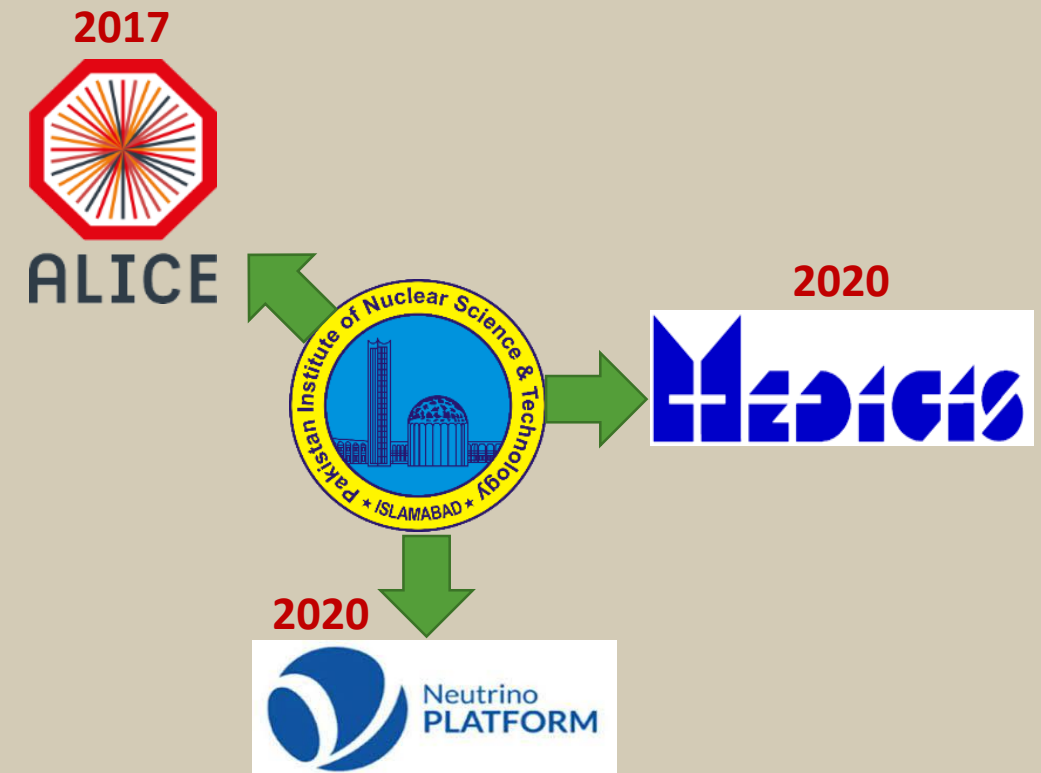
International
Organization for
Standardization

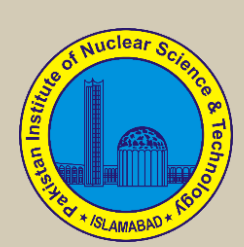


LAB 012
17025

PINSTECH's Association with CERN

- Pakistan became an Associate Member of CERN in 2015
- PINSTECH signed an MOU with ALICE Collaboration for an Associate Membership in 2017
- PINSTECH-Medicis (ISOLDE) started collaboration in 2018
- PINSTECH and CERN's Neutrino-platform signed a cooperation addendum in 2020
- PINSTECH became a Member of MEDICIS (ISOLDE) collaboration in 2020





PINSTECH-CERN Collaboration Areas



ALICE

- High energy heavy-ion physics (Data Analysis)
- GEM based detectors for ALICE TPC Upgrade
- Simulation studies for ALICE ITS

MEDICIS

- Radio-lanthanides separation process development
- Implantation foils material development
- Ba128/PtCl₂ production processes

Neutrino Platform

- CVN (Convolutional Visual Network) based data analysis
- Neutrino interaction classification
- Neutrino flavour identification

CLIC + CTF3 + LINAC4

- Control of DC electron gun for CTF3 drive beam
- Electronics of drive beam gun
- CTF3 beam operations

PINSTECH-CERN Timeline

2016

- High Energy Physics Group (HEPG) was established at PINSTECH
- LINAC (PINSTECH) scientists visited CERN for training



PINSTECH scientists in CERN

2017

- PINSTECH and ALICE Experiment signed an MOU for the Associate Membership
- Chairman PAEC visited CERN and ALICE Experiment



Chairman PAEC and Spokesperson ALICE in ALICE Control Room

2018

- Member (science) PAEC visited CERN, MEDICIS & ALICE
- A CERN delegate including Ms. Charlotte and Prof. Emmanuel visited PINSTECH



CERN delegate visited PINSTECH

PINSTECH-CERN Timeline

2019

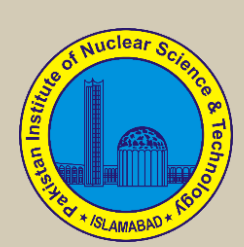
- A dedicated group for ALICE collaboration (ALICE-CERN Group) was established at PINSTECH
- DG PINSTECH represented PINSTECH in ALICE week at CERN



2020

- An addendum was signed between PINSTECH and CERN's Neutrino Platform
- PINSTECH became a member of CERN's MEDICIS (ISOLDE) Collaboration
- PINSTECH organized a webinar on "PINSTECH-CERN" Collaboration activities





Person-power Trainings



PINSTECH-CERN Trainings			
Sr.	Number of persons trained	CERN Collaboration	Project/Assignment
1.	05	ALICE	Physics Analysis, GEM based detectors, O2 Framework for Run3
2.	03	MEDICIS	Development of radioisotopes separation and purification processes
3.	06	CLIC + CTF3	Electronics of drive beam gun, CTF3 beam operations, Control of DC Electron Gun for CTF3

Scientific Output in Collaboration with CERN			
Sr.	Nature/Type	No. of articles	CERN Collaboration
1.	Research Papers	08	ALICE: 05 CLIC: 02 MEDICIS: 01
2.	CERN Analysis/Technical Notes	04	ALICE: 03 MEDICIS: 01
3.	Poster Presentations	02	ALICE: 02
4.	Conference Talks	05	ALICE: 03 CLIC: 02
5.	Student Theses	16	ALICE: 11 (completed) + 5(ongoing)



Scientific Output

➤ 07 Students/Researchers trained with CERN went on to PhD studies in Germany, Norway and China

ALICE: 01 CMS: 01 ATLAS: 02 STAR: 01 DESY: 02

PINSTECH-CERN Outreach Activities

Sr.	Webinar/ workshop	Year	No. of Participants
1.	Webinar on PINSTECH-CERN Collaboration	2020	235
2.	A Workshop on Computing with Python	2020	61
3.	Seminar on ALICE physics analysis and TPC upgrade	2019	43
4.	Seminar on ALICE physics analysis	2019	38
5.	Seminar on Heavy Ion Physics with ALICE at CERN	2019	25
6.	Symposium on Data Analysis for High Energy Physics	2018	75
7.	Workshop on Monte Carlo Simulations-Applications in Science and Technology	2017	67
8.	Two days seminar on Pakistan's Collaborations with CERN and SESAME	2016	176
9.	Two Weeks Seminar on Fluka and its Applications	2016	14



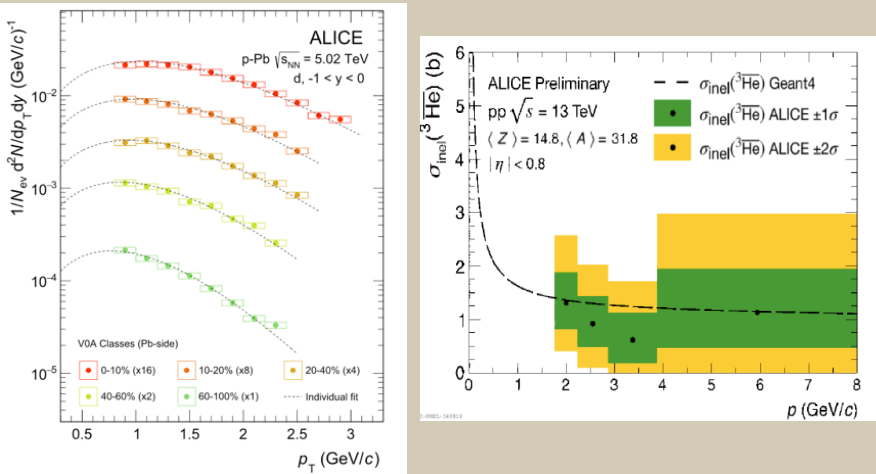
Two days seminar on Pakistan's Collaborations with CERN and SESAME, 2016



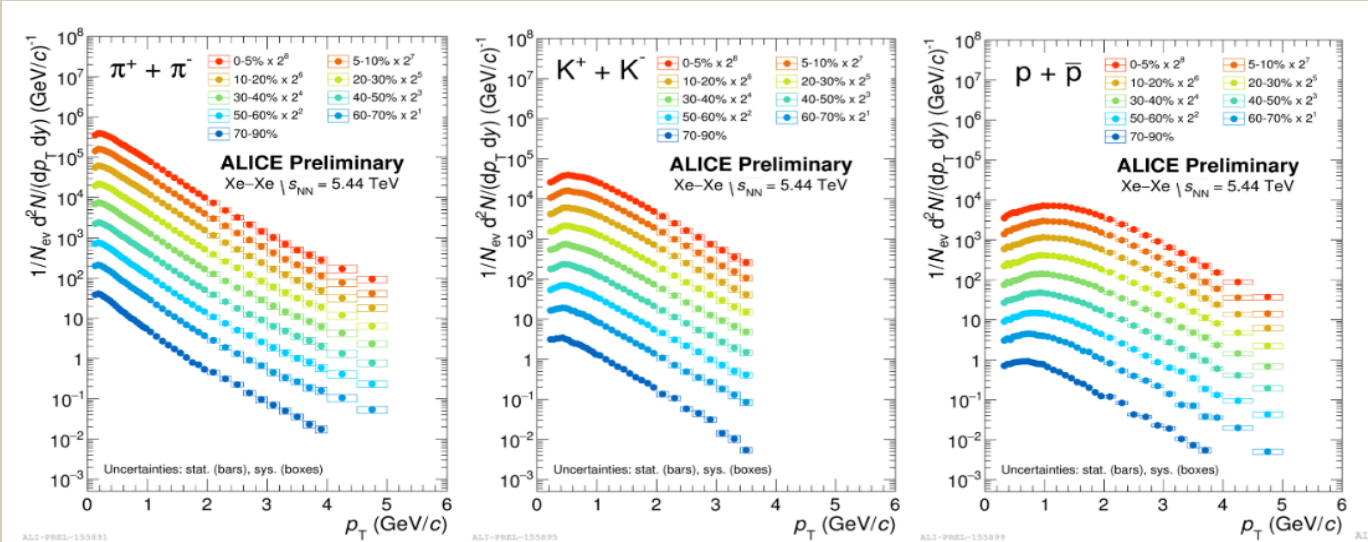
Workshop on Monte Carlo Simulations-Applications in Science and Technology, 2017

ALICE Physics Analysis

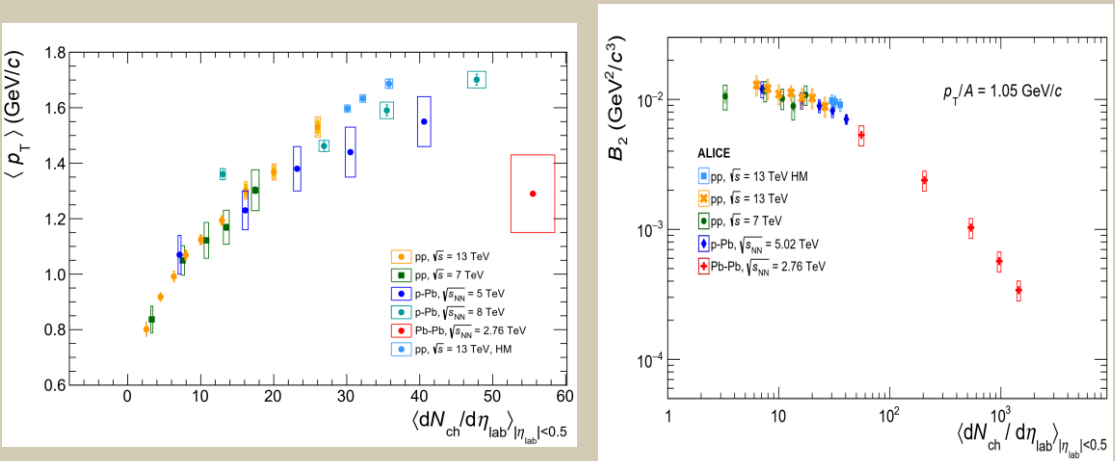
- (Anti-)deuteron spectra and absorption study in the detector material of ALICE for p-Pb collisions
- Production of (anti-)deuterons in pp collisions at $\sqrt{s} = 13$ TeV
- Pi/K/p production in Xe-Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV



Transverse momentum distributions of deuterons (left) and constraints (right) on the inelastic cross section of ³He as a function of momentum in pp at 13TeV (Published)



Spectra of pi/K/p in Xe-Xe collisions at 5.44 TeV (Published)

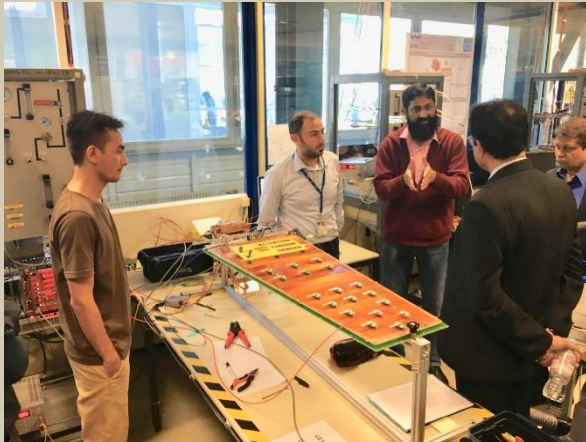


Average mean transverse momentum as a function of transverse multiplicity (left) B_2 (coalescence parameter on right) at $p_T/A = 1.05$ GeV as a function of charged particle multiplicity (Published)

PINSTECH-CERN Projects (completed)

ALICE TPC GEM Upgrade

- Preparation and Installation of GEM based chambers on the ALICE TPC (Time Projection Chamber)
- GEM foils QA for ALICE TPC
- Assembly and testing of GEM chambers for *CMS muon system upgrade*
- Simulation studies of secondary discharges in GEM structures



CMS GEM upgrade lab
and a GEM detector

ALICE Clean room with TPC



Dear All,

The GEM has landed.

Both sides are upgraded with GEMs and we are all looking forward to the fascinating time of commissioning.

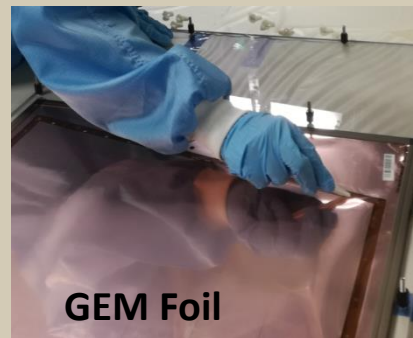
Many thanks to all of you!

Special thanks go to **GEM ROC preparation team(s)**: Renato, Daiki, Michael, Berkin, Esther, Sohaib, Sebastian, Jerome, Christian, Chilo

If you are around, join us at P2.

Best

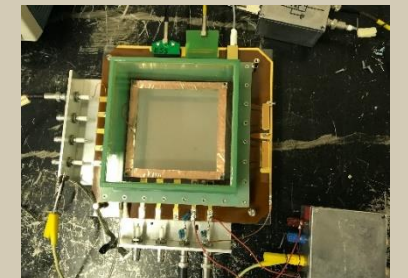
ALICE TPCU Installation Team
(Bernd, Jörg, Stefan, Thomas, Piotr)



GEM Foil



GEM Foil under microscope

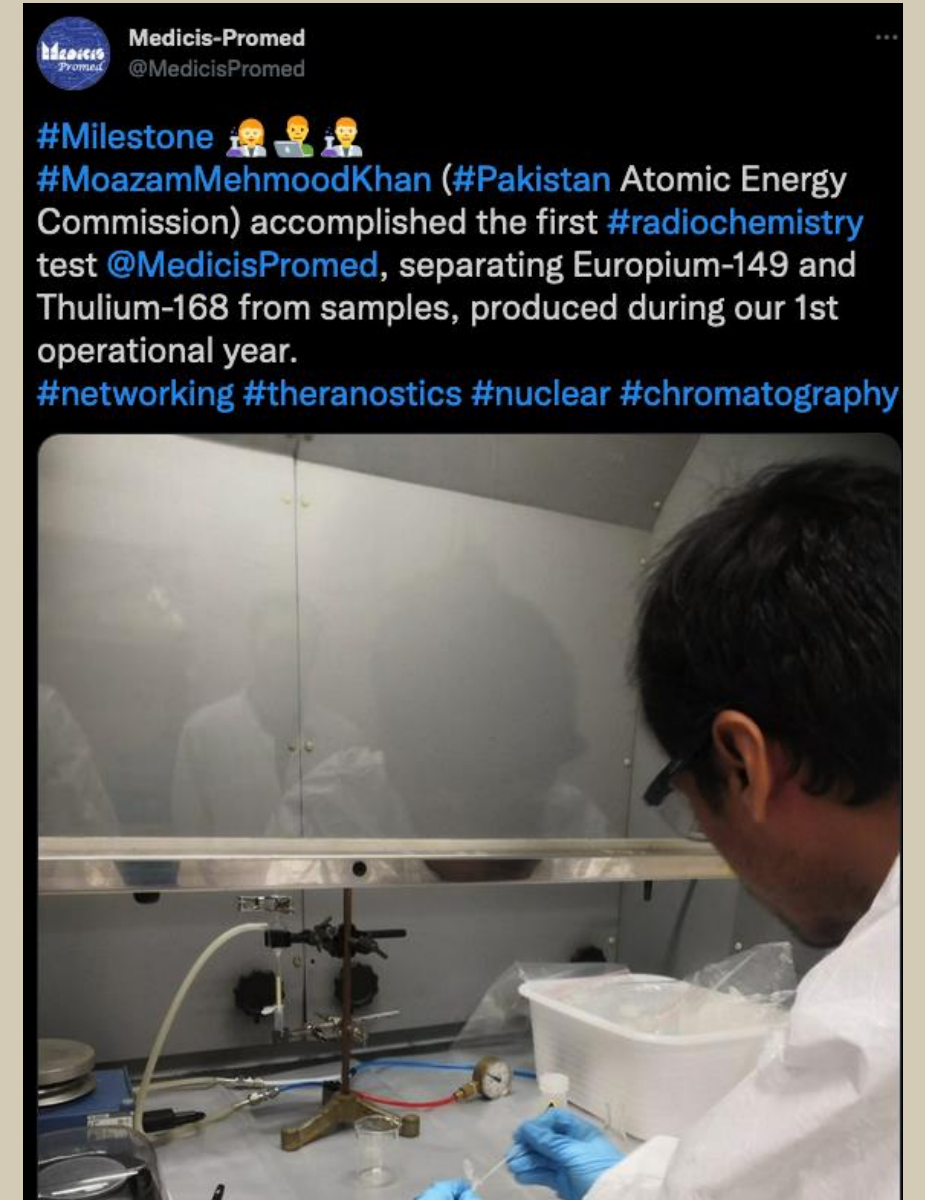


GEM setup for discharge study

PINSTECH-CERN Projects (completed)

PINSTECH-MEDICIS

- Carrier Added Radio lanthanides Separation Process Development
- Non Carrier Added Radio lanthanides Separation Process Development
- Implantation Foils Material Development
- Ba128 and PtCl₂ Production Processes



PINSTECH-CERN Projects (completed)

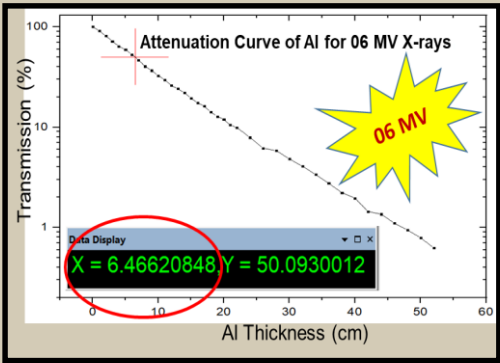
LINAC at PINSTECH Design & Operational Parameters		
1	Max Energy	06 MeV
2	Input Power	2.5 MW
3	Pulse Repetition Freq.	50 Hz
4	RF Pulse Width	4 μ s
5	Operation frequency	2998.2 MHz
6	Output current	80 mA
7	X-ray Dose Rate (@ 100cm)	0.54 Gy/min

Trainings at CERN played an important role in development of indigenous LINAC technology at PINSTECH

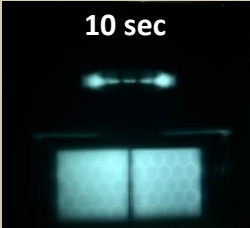
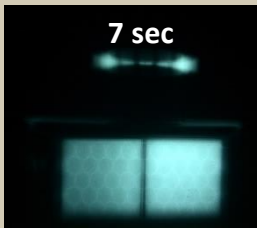
- Radiography (NDT)
- Electron Gun and Beam Optics
- RF Accelerator Design and Development
- HV Pulsed Modulators
- EPICS based Control System of LINAC



Control Room



Energy Measurement



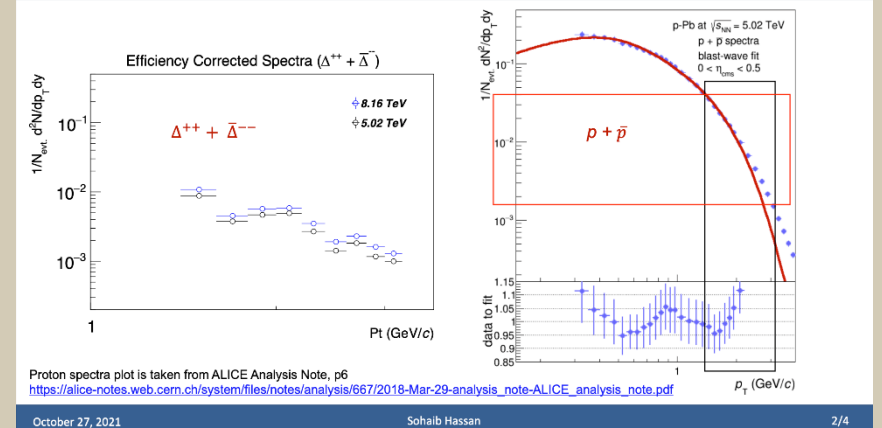
Radiograph of Ion Pump (136 mm thick) Revealing Honey Comb diode structure exposed for 10s and 7s



ALICE Physics Analysis + ITS Simulations

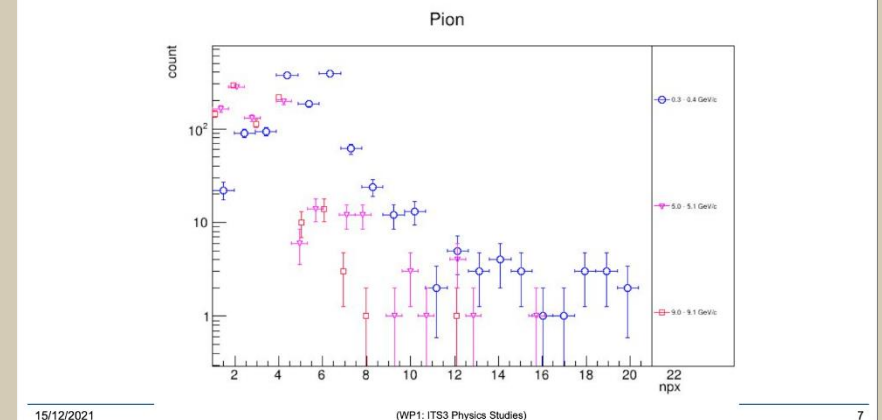
- Delta ($\Delta^{++}/\bar{\Delta}^{--}$) resonances production In p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ & 8.16 TeV
- High multiplicity pi/K/p production in pp collisions using O2 framework
- Particle identification based on cluster size using inner tracking system (ITS) detector
- Simulation modelling of particle production in HEP interactions

Comparison with protons



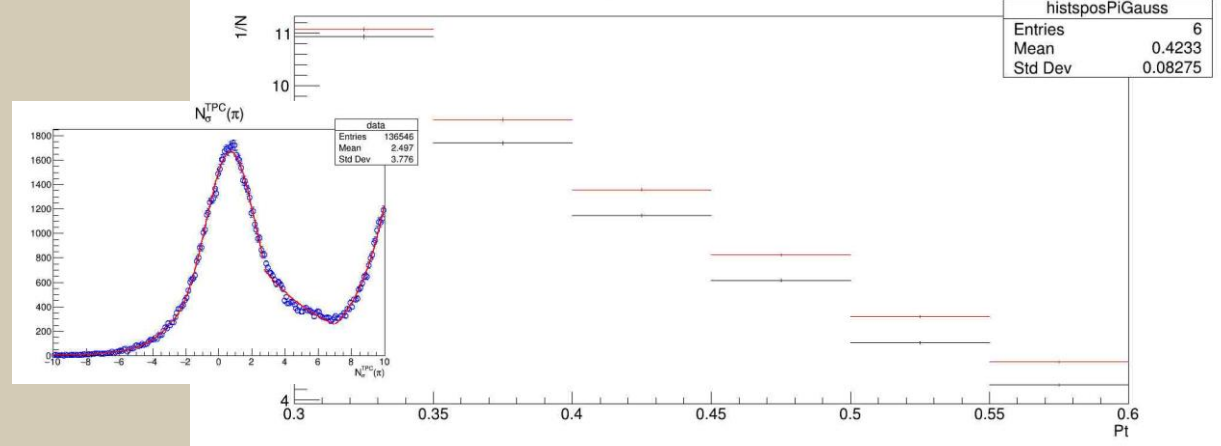
Presented in ALICE Resonance PAG meeting October 27, 2021 <https://indico.cern.ch/event/1090765/>

Cluster size distribution for pion (π^+)



Presented in ALICE WP1: ITS3 Physics Studies meeting December 15, 2021 <https://indico.cern.ch/event/1106640/>

Spectra of posPi Gauss



The Raw yield of π^+ in pp collisions at 13 TeV using O2 Physics environment

PINSTECH-CERN Projects (Ongoing)

PINSTECH-MEDICIS

- Parameters Optimisation For Non Carrier/Carrier Added Production of Radio lanthanides
- Exchange of medical research isotopes between PINSTECH and CERN
- Automatic Setup For Large Scale Isotopes Production at CERN



PINSTECH-Neutrino Platform & Accelerator Research

- Development of medical LINAC
- Accelerator based Neutrino Physics and its Implications (with DUNE-CERN)



Thanks