South Africa – ALICE (SA-ALICE)
'WHERE ARE WE NOW'

Zinhle Buthelezi

SA-CERN 15-year celebration

iThemba LABS, 20 January 2025

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | iThemba LABS Laboratory for Accelerator Based Sciences

This talk

- **Introduction to South African ALICE members**

Reflection - launch from LS 2 upgrade activities

- Detector commissioning activities
- Human capital dev
- Training and skills

- **WHERE are we now?**
  - Physics data analysis activities
  - Service tasks and data taking
  - Upgrade R&D
  - Outputs
  - Stakeholder engagement
  - Outreach

- **Summary**

Who is involved in ALICE in South Africa?

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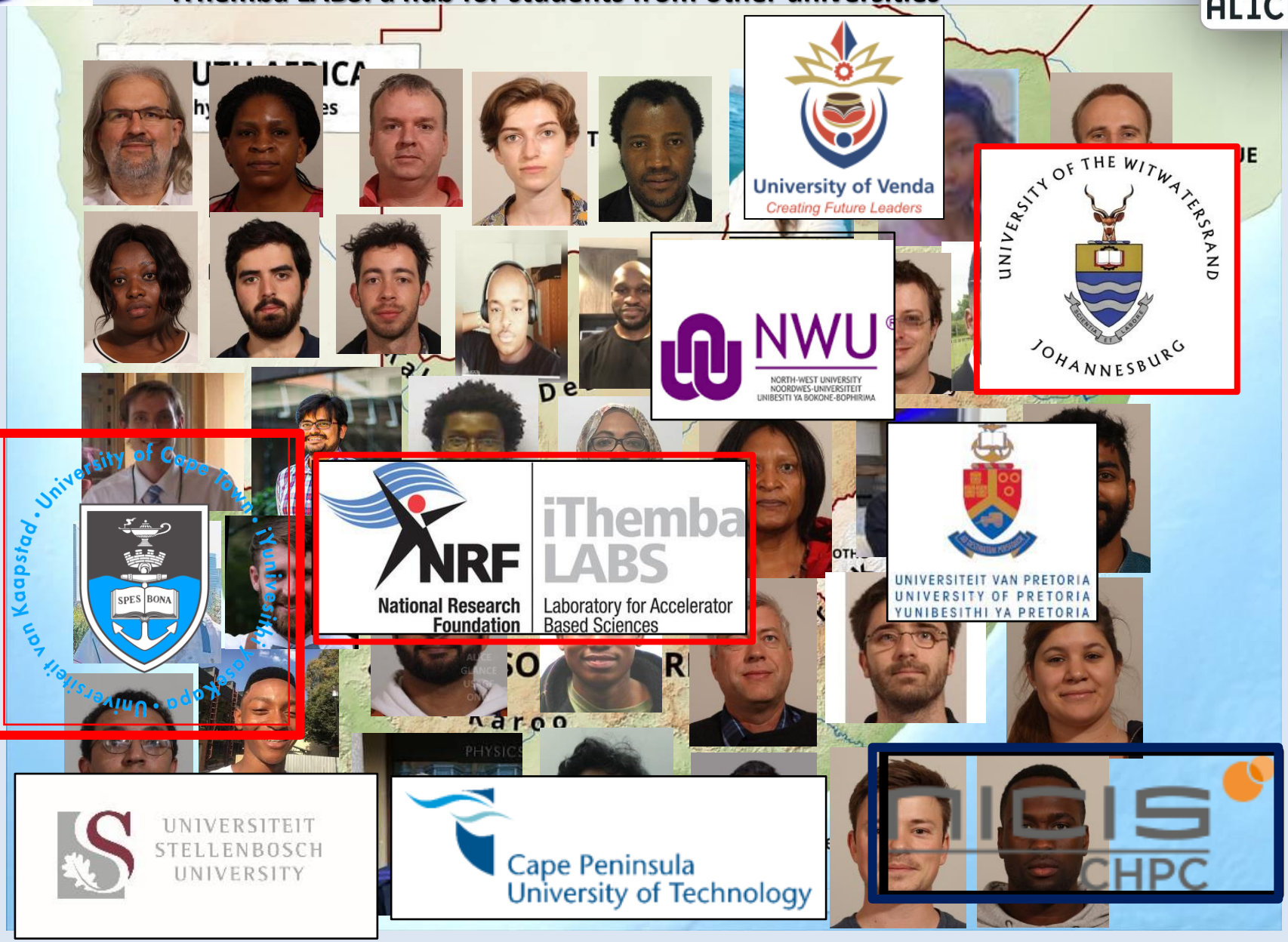
Cluster of full-member institutes & **Associate members**

iThemba LABS: a hub for students from other universities



Increasing footprint…

CSIR-CHPC ALICE Associate membership in 2024

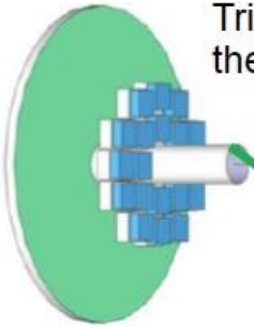
- Endorsement and MOU signing – March 2024
- Transition to ALICE: seminar series, Mr Mervyn Christoffels

- Integration of CHPC colleagues in ALICE

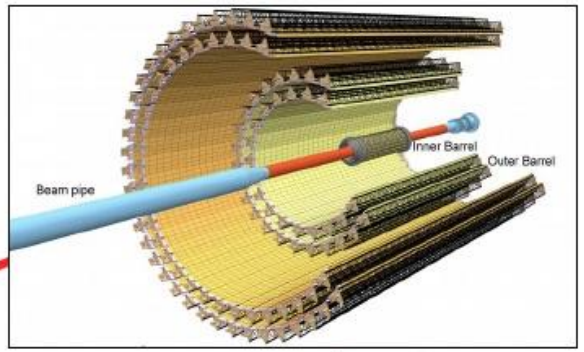
Dr Happy Sithole's talks tomorrow on "High-Performance Computing in South Africa".

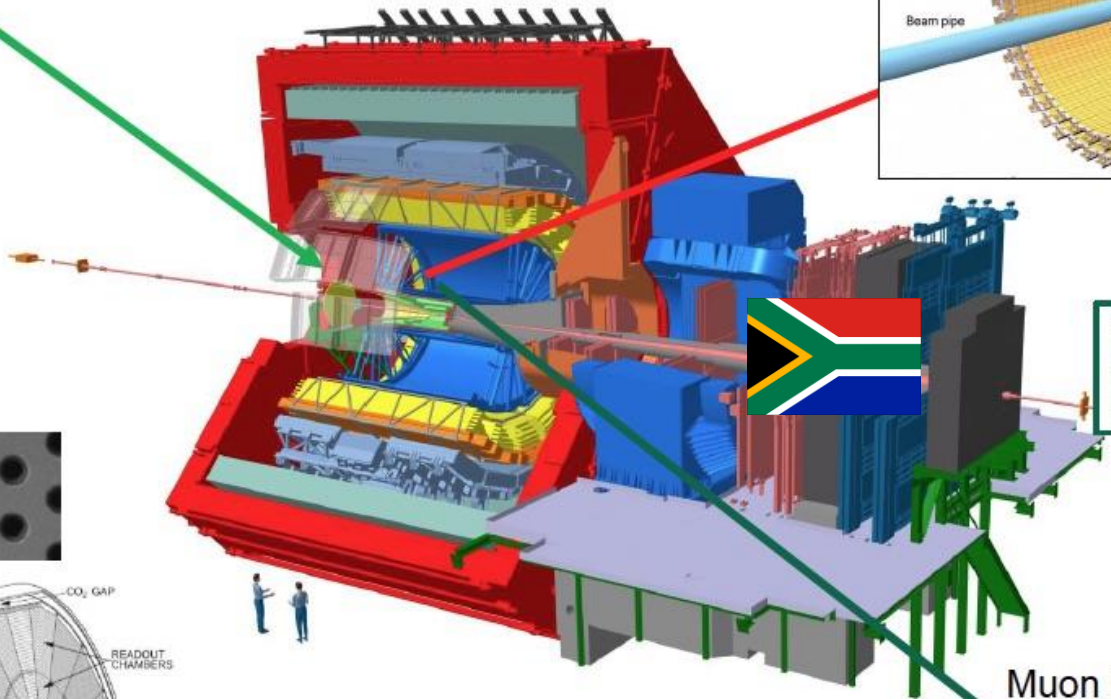
LS2 Detector upgrades for RUN 3 (2019-2020)

New Forward Interaction Trigger (FIT) to replace the V0 and T0 detectors

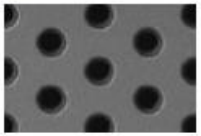


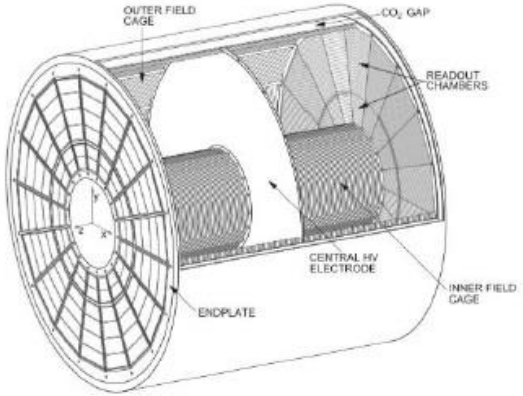
New Inner Tracking System (ITS)





TPC with GEM based readout



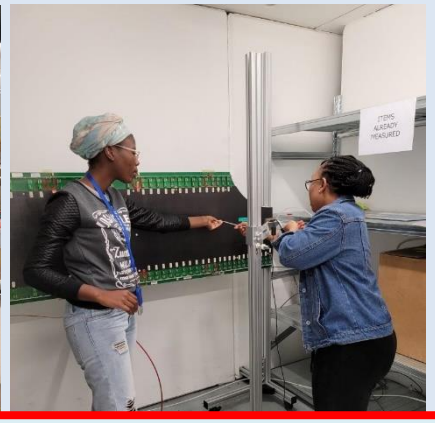


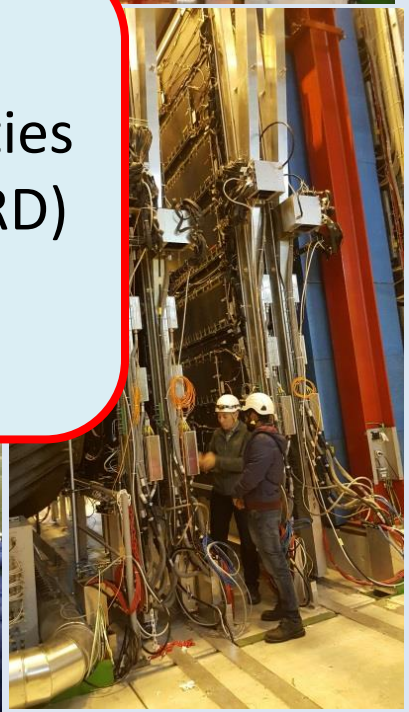
Both based on Monolithic Active Pixel Sensors (MAPS)

Muon Forward Tracker (MFT)

+ improved readout for TOF, ZDC, TRD, MUON ARM
+ new Central Trigger Processor
+ new DAQ/Offline architecture

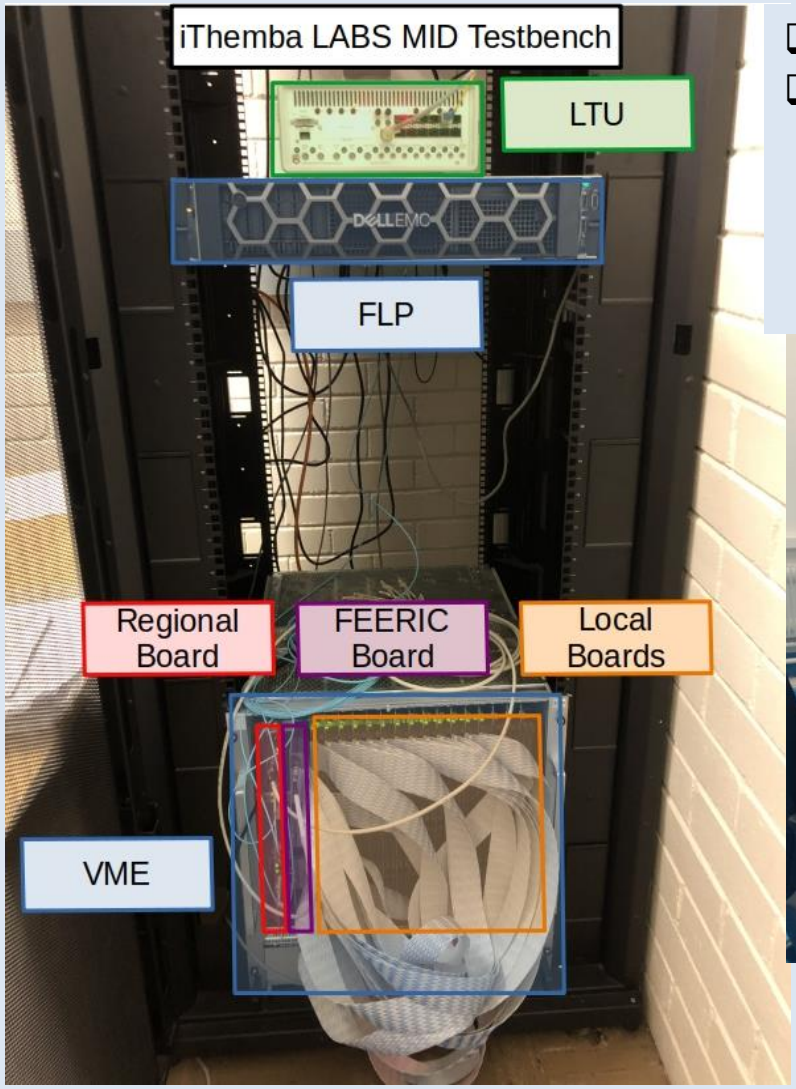
Detector commissioning activities

- System Run coordination
- Hardware/firmware/software activities
  - Transition Radiation detector (TRD)
  - Muon Tracking Chambers (MCH)
  - Muon Identifier (RPCs)

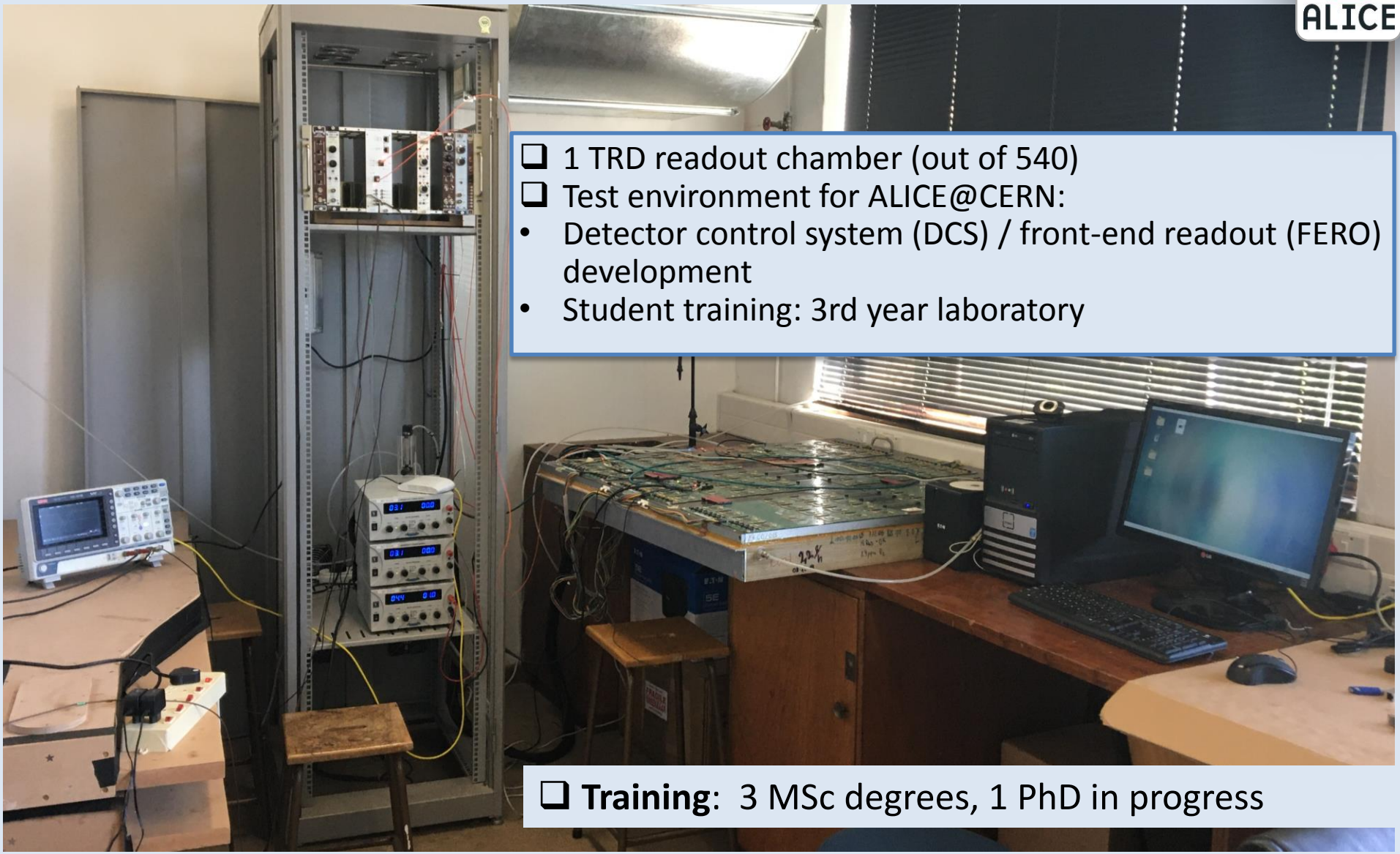
Readout firmware laboratory at iThemba LABS



- Full setup of electronics, trigger, and data acquisition
- Test environment for MID:
  - → FPGA/Firmware development
  - → High-throughput electronics
  - → Online-offline (O^2) development for Muon subdetector

- **Training**: 3 MSc degrees, 1 PhD in progress

Software development

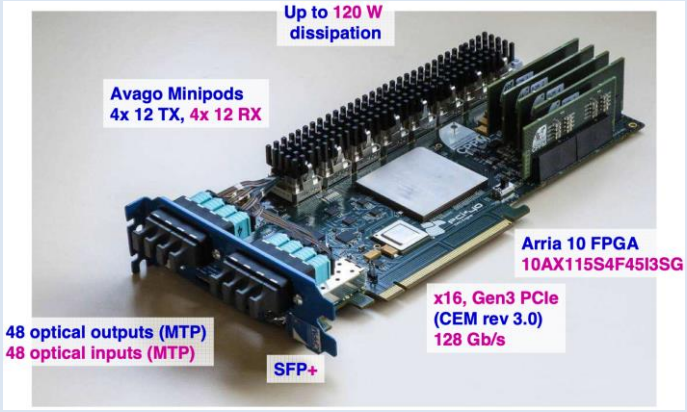


- ❑ 1 TRD readout chamber (out of 540)
- ❑ Test environment for ALICE@CERN:
  - Detector control system (DCS) / front-end readout (FERO) development
  - Student training: 3rd year laboratory

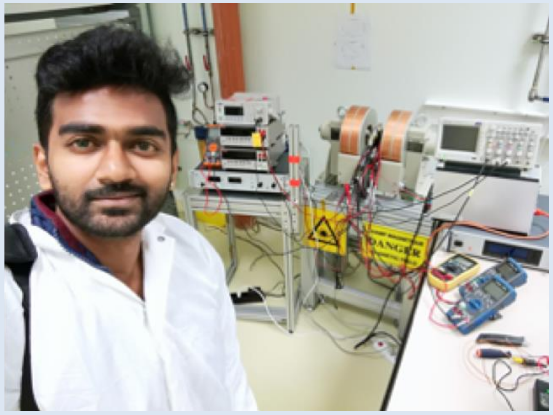
❑ **Training**: 3 MSc degrees, 1 PhD in progress

Human Capital Development

- Training and exposure
  - **Internship opportunities** with international partners in France (Saclay, Subatech, and Germany (Heidelberg)
  - **Hosting international technical associates/affiliates** → contribution to maintenance and operations (M&0)



- Skills/expertise:
  - FPGA programming - VHDL firmware development
  - Low-Voltage Power Supply (LVPS) + Detector Control System (DCS)
  - Software development and Data Processing
    - Simulation, calibration and reconstruction
    - Distributed high-throughput computing @ 5GB/s



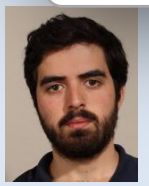
SA-ALICE: Where are we now?

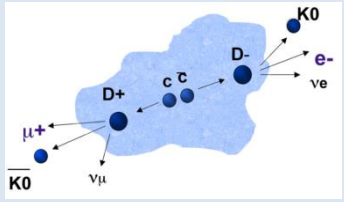
- ❑ Physics data analysis
- ❑ Maintenance and operations – Service works
- ❑ ALICE Upgrades R&D
- ❑ OUTREACH

Physics data analysis

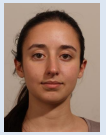
Exposure to complex analysis tools used in Big Data

- Photon measurements using the conversion into electron-positron pairs

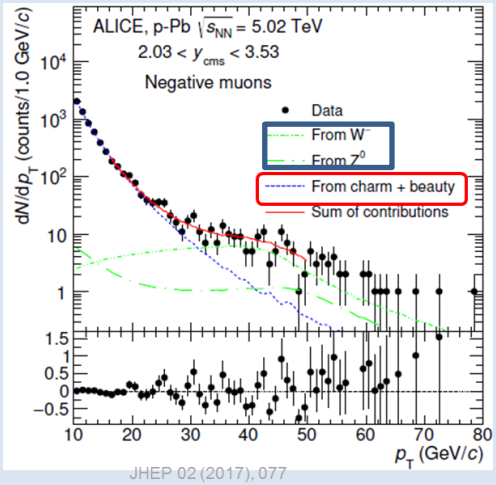




- Electron-muon correlation in pp collisions

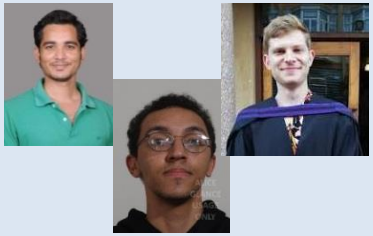


- "(multi-)Strange hadron production in pp collisions

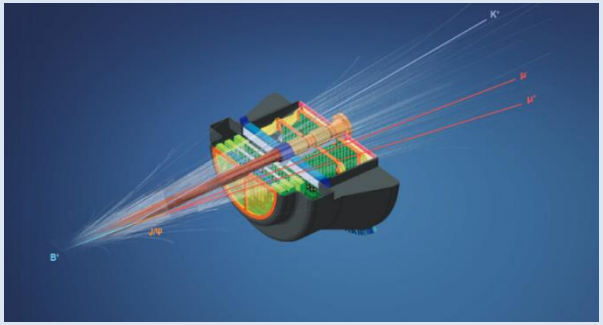


JHEP 02 (2017), 077

- Single muon measurements **ongoing**
  - Heavy- quark (charm and beauty)
  - Electroweak boson (W, Z)



- Use of Machine learning techniques in data analysis **ongoing**



Physics data analysis

Exposure to complex analysis tools used in Big Data

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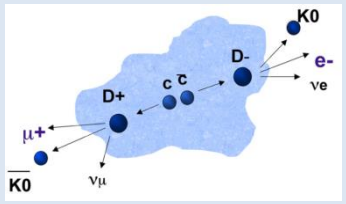

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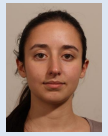

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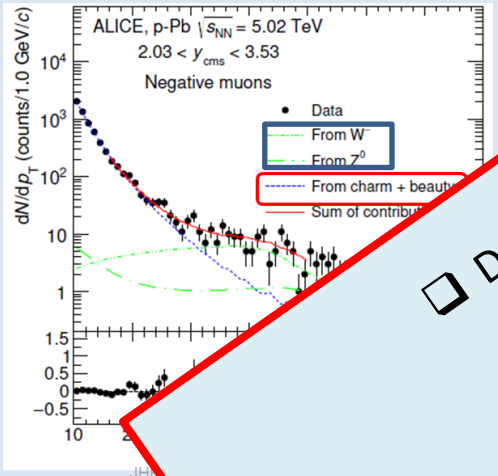
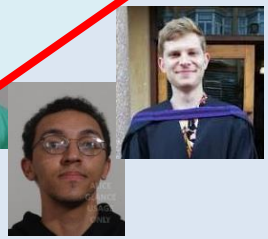
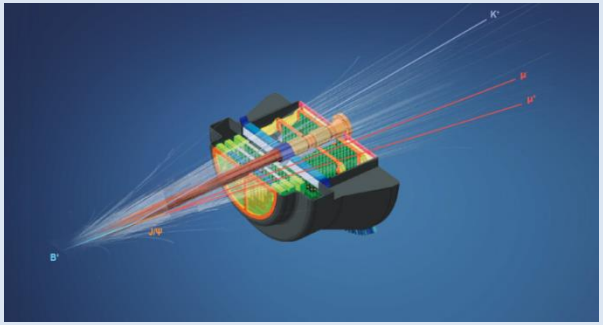


- Sing ongoing
  - m and beauty)
  - son (W, Z)



- Details on physics activities covered in Poster presentations:
  - Salmaan Barday, Joshua Browne and Stephan Potgieter
  - Tebogo Shaba

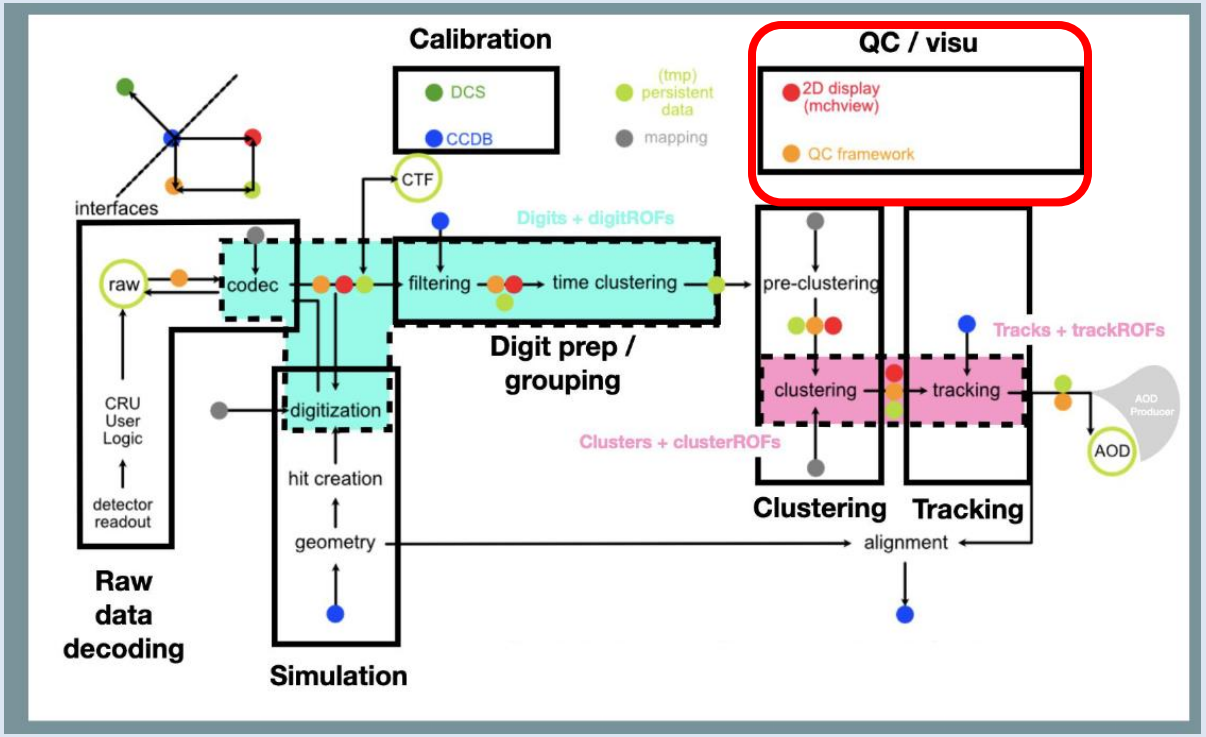
- Use of ng techniques in data analysis **ongoing**



Service task: MCH Quality Control (QC)

- MCH Asynchronous QC 2024 dataset

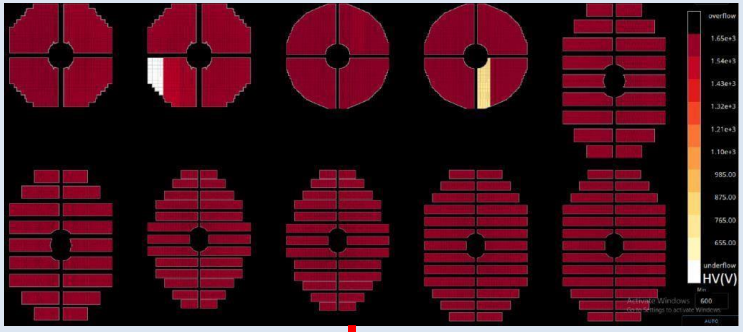
  Tebogo J Shaba, PhD (NWU ongoing)



- Global view of ALICE MCH reconstruction, showing the quality control (QC) in the red box. Figure taken from Dr L. Massacrier's "Muon software status in Run 3" talk at the DQ meeting, 18 June 2024, ALICE Mini-Week, https://indico.cern.ch/event/1427336/. The QC/vis denotes quality control/ visualization, and AOD denotes analysis data object.

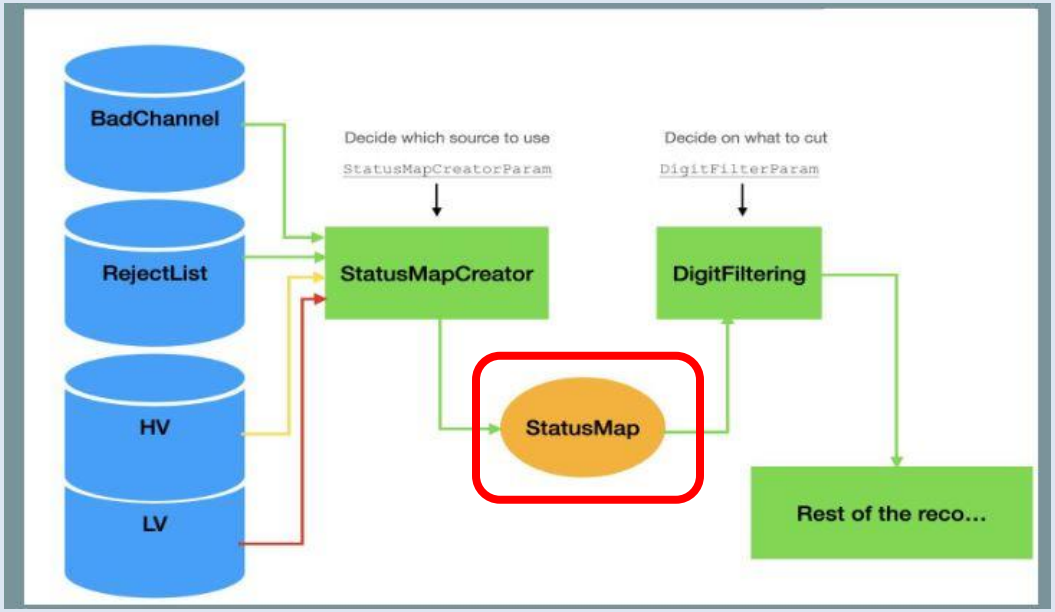
Service task: MCH reconstruction software

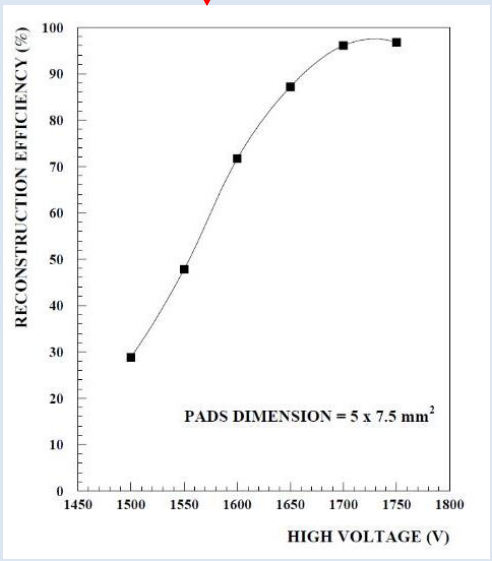
Stephan Potgieter, Senior MSc (UCT ongoing)



- Contribution to the algorithm which adds HV information to the StatusMap

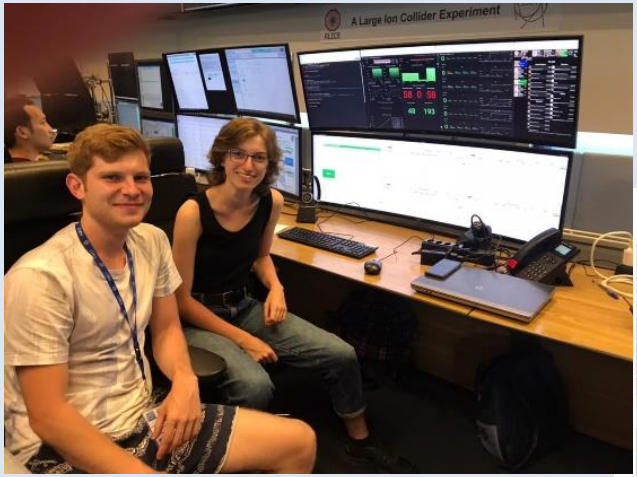
- Reconstruction efficiency as a function of the applied voltage



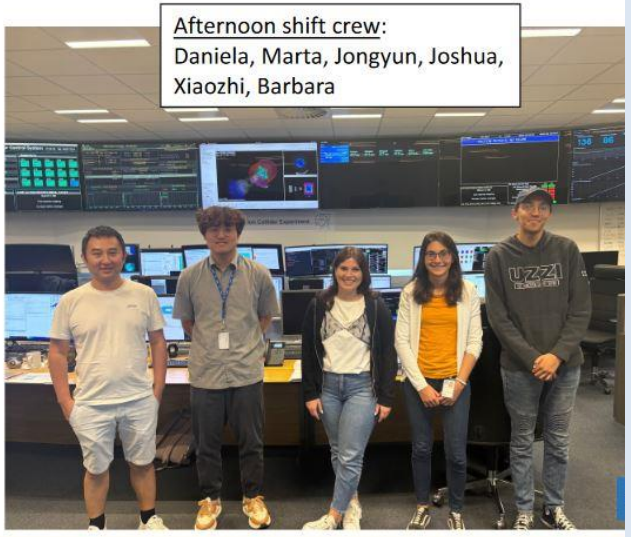


ALICE RUN 3 data taking

- ALICE Run Manager: Z Buthelezi (2022), B Naik (2023)



- Central shifts

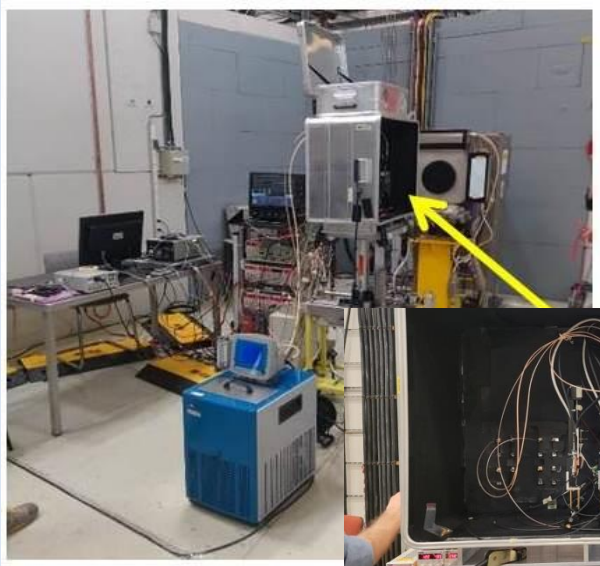


- Oncall shifts:
  TRD, MID, MCH

Leadership roles for young PhD and Postdocs:
Run Manager, System Run Coordinator, etc..

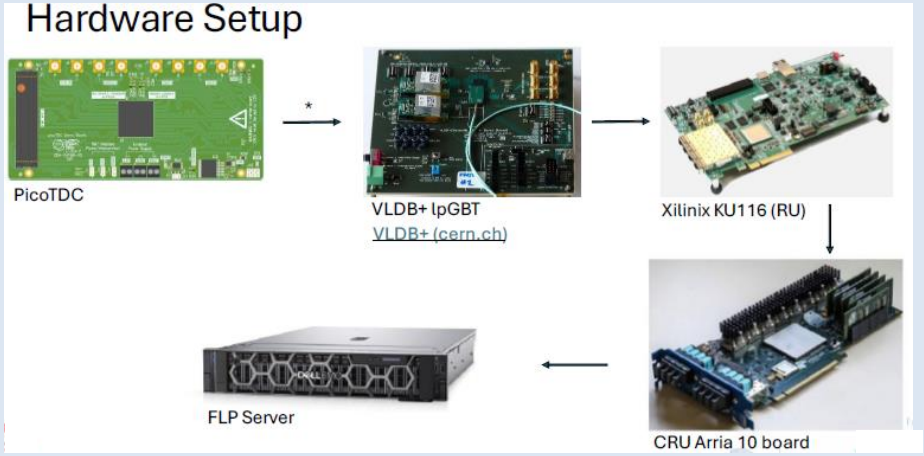
R&D towards the next ALICE Upgrade (ALICE 3)

- Involvement in ALICE 3 TOF test beam experiments at CERN PS: James Godhead (M Eng, UCT ongoing and Prof Simon Winberg (UCT Electrical Engineering)



The silicon (Si) sensor cards are located inside the black box and are positioned at various distances with respect to incoming beam of particles (mixture of hadrons and leptons) at the beam energy of ~10 GeV.

- Testbench development towards ALICE 3 Time-of-Flight (TOF) common readout unit (CRU) study



Institutes are encouraged to explore available opportunities. Contact us!!

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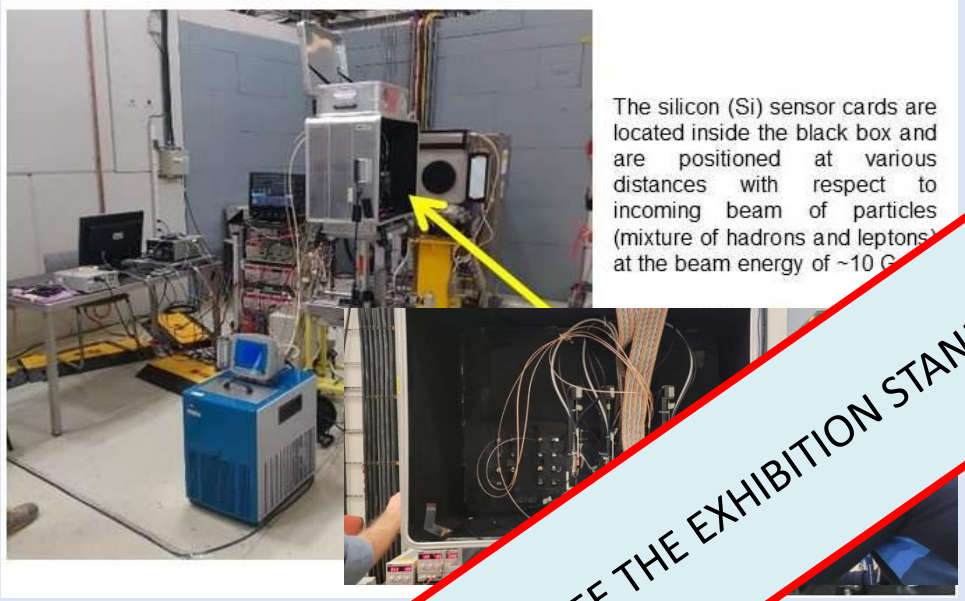
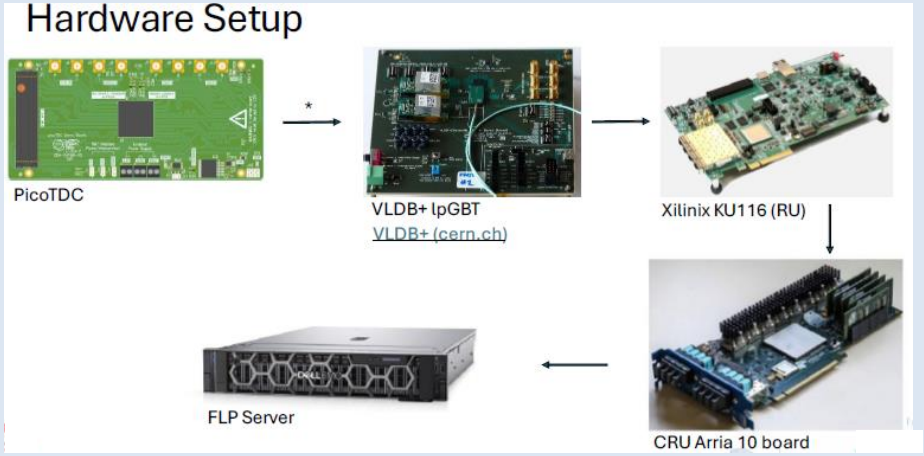


SEE THE EXHIBITION STAND and Poster presentations

- Testbench d… …rds ALICE 3 Time-of… …mon readout unit (CR…



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Summary: Benefits for SA in ALICE Upgrade R&D?

- ALICE 3 is at the **forefront of innovative advanced Silicon (Si) technology**

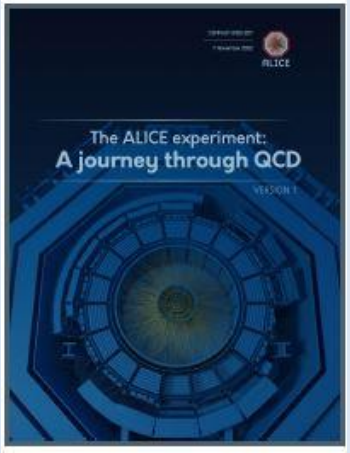
- **Human capital development**
  - Training and Skill transfer opportunities
    → pipeline for skilled workforce

- **Who can benefit from ALICE 3 involvement?**
  - → Technical postgraduates (Honors, Masters and PhD) and Interns
  - → **Involvement of local experts**: Engineers (electrical mechanical computing/software) and Technicians
  - → Institutional growth

Are you interested? Contact us!

Research Outputs

- South Africa contributes to authorship (data taking, paper reviews and service works/tasks) → appear in 265 ALICE papers from 2019 – 2024.



- Highlight publication of "*The ALICE experiment – a journey through QCD*", https://arxiv.org/abs/2211.04384
  → marks 407 ALICE papers on **2009-2018** data!

- Technical Contributions**: ALICE 2 upgrade paper** arXiv:2302.01238 – work during LHC Long Shutdown 2 (2019-2022)

- Local Contribution: Muon Spectrometer Low Voltage Power Supply (LVPS) + readout firmware (FPGA) -->
  - **9 Theses** (2019-2024)
  - **3 Technical Reports**: e-Prints: 2210.15278 [physics.ins-det] and 2104.05476 [physics.ins-det]

Stakeholder Engagement: High - profile visits

- ALICE Upgrade Coordinator, Dr Jochen Klein, visit to Cape Town, Dec 2022

- ALICE Spokesperson, Dr Marco van Leeuwen, visit to South Africa, 21-23 August 2023

- iThemba LABS MD & SA-CERN Chair visit to CERN, October 2023
- South African Parliamentary Portfolio visit to CERN

- DSTI Deputy Director General, Mr Patel's CERN Visit, April 2023

Outreach/Science Awareness



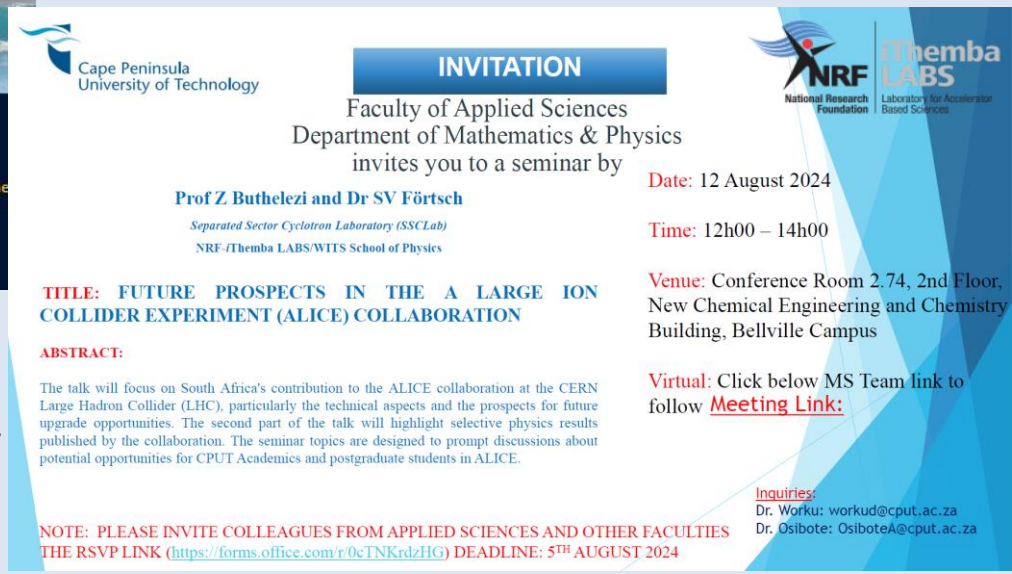
- International Masterclasses – hands-on particle physics
  - iThemba LABS – running for 11 years, ~100 learners p/a
    - Nelson Mandela University - since 2020, ~40 learners
    - University of Venda 2024
    - WITS 2025 (Dr Isobel Kolbè)
- UN International Day for Girls and Women in Science: ~40 learners



Outreach / Science Awareness: Local Seminars

- **NMU**, October 2024

- **CPUT**: virtual Sept 2023
  In person, August 2024

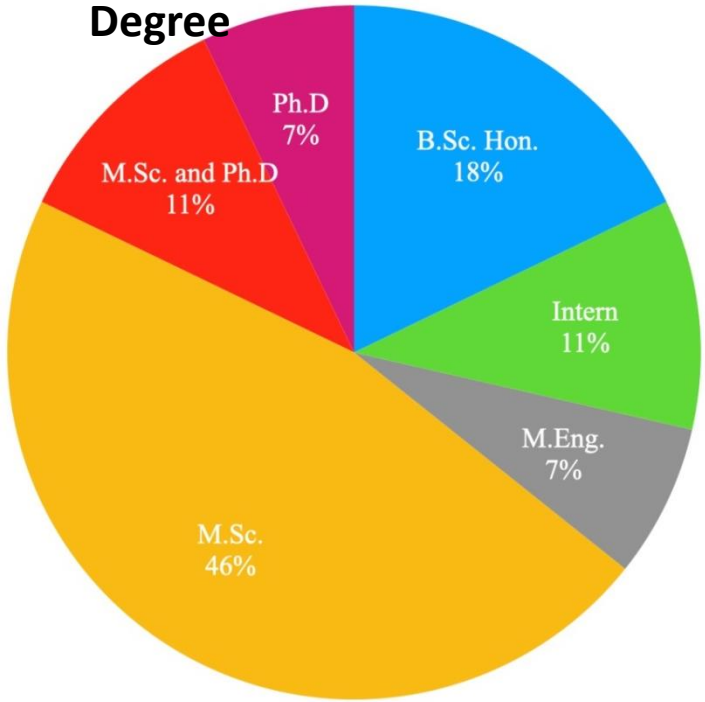


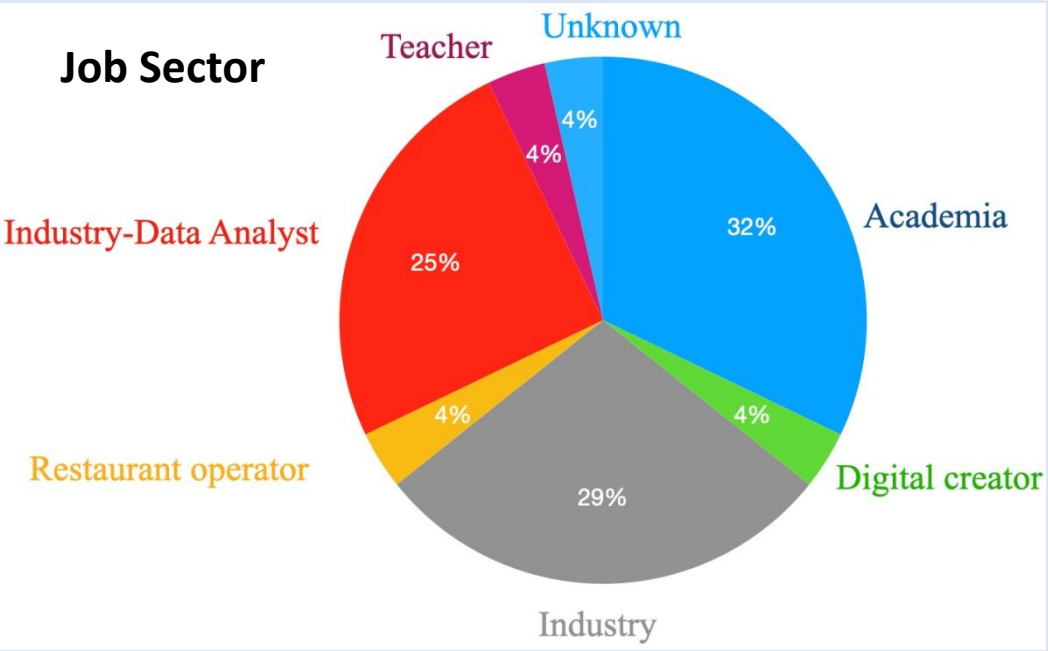
Virtual:

- UNIZULU Physics Department: Virtual July 2024
- UNIVENDA: September 2023
- NWU: September 2023

Summary

- Investment returns
  Local infrastructure/facility development
  Footprint
  Skills development and Human capital development
  33 completed MSc and PhD in Physics, Engineering, and Data Science





- **Opportunities exist within the ALICE 3 Upgrade.. Come and join us!**

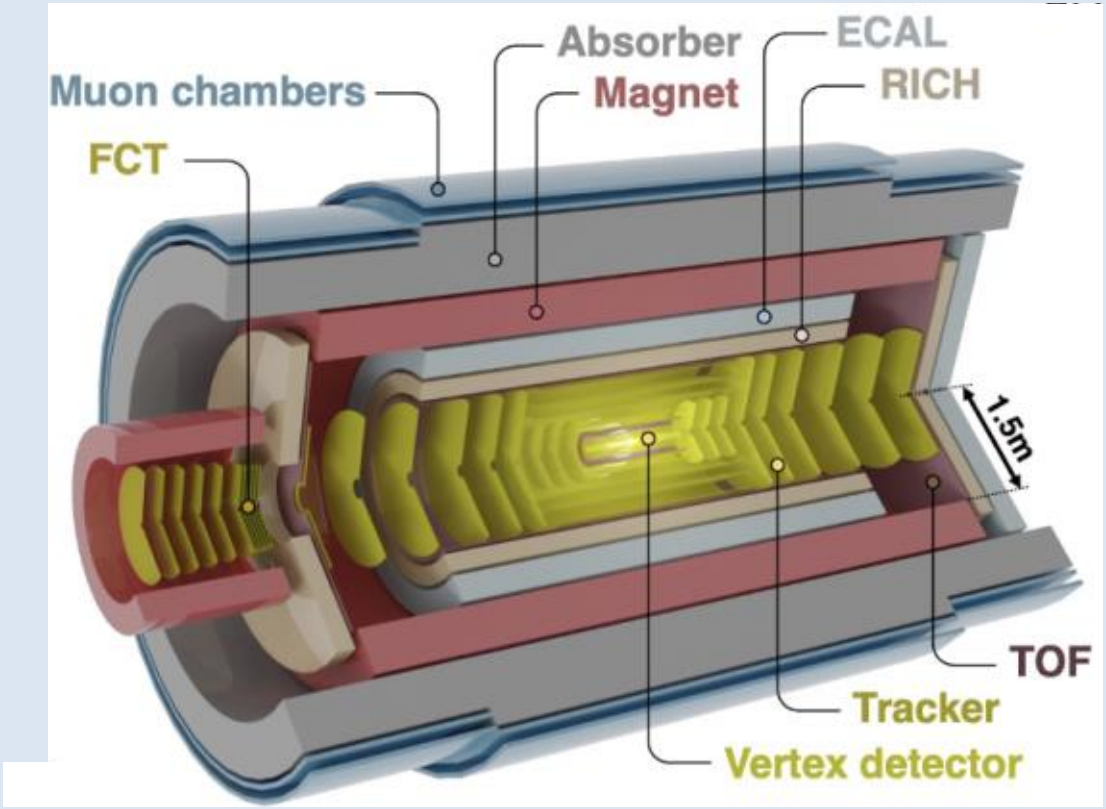
Thanks for listening

Backup

What's next for technology and innovation in ALICE?

ALICE 3 R&D

All systems will be based on **silicon technologies**, requiring integrated & parallel design of



- sensor,
- module,
- readout and control,
- powering,
- mechanics,
- cooling

ALICE 3 R&D

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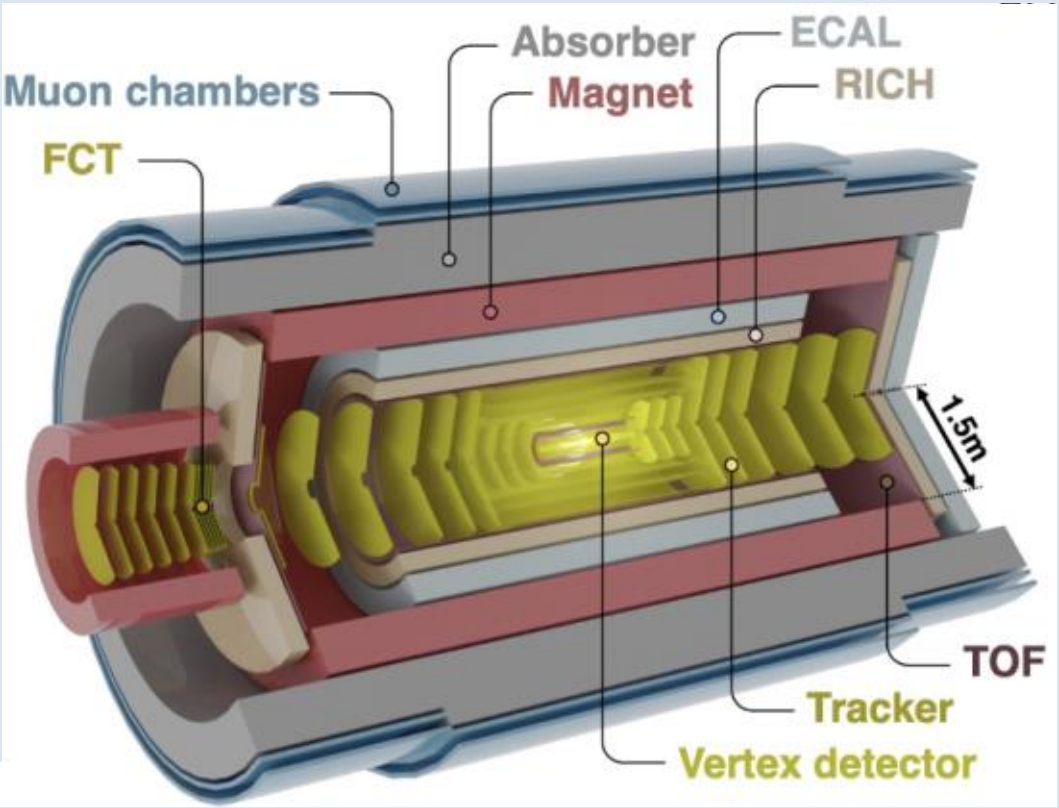


- sensor,
- module,
- readout and control,
- powering,
- mechanics,
- cooling

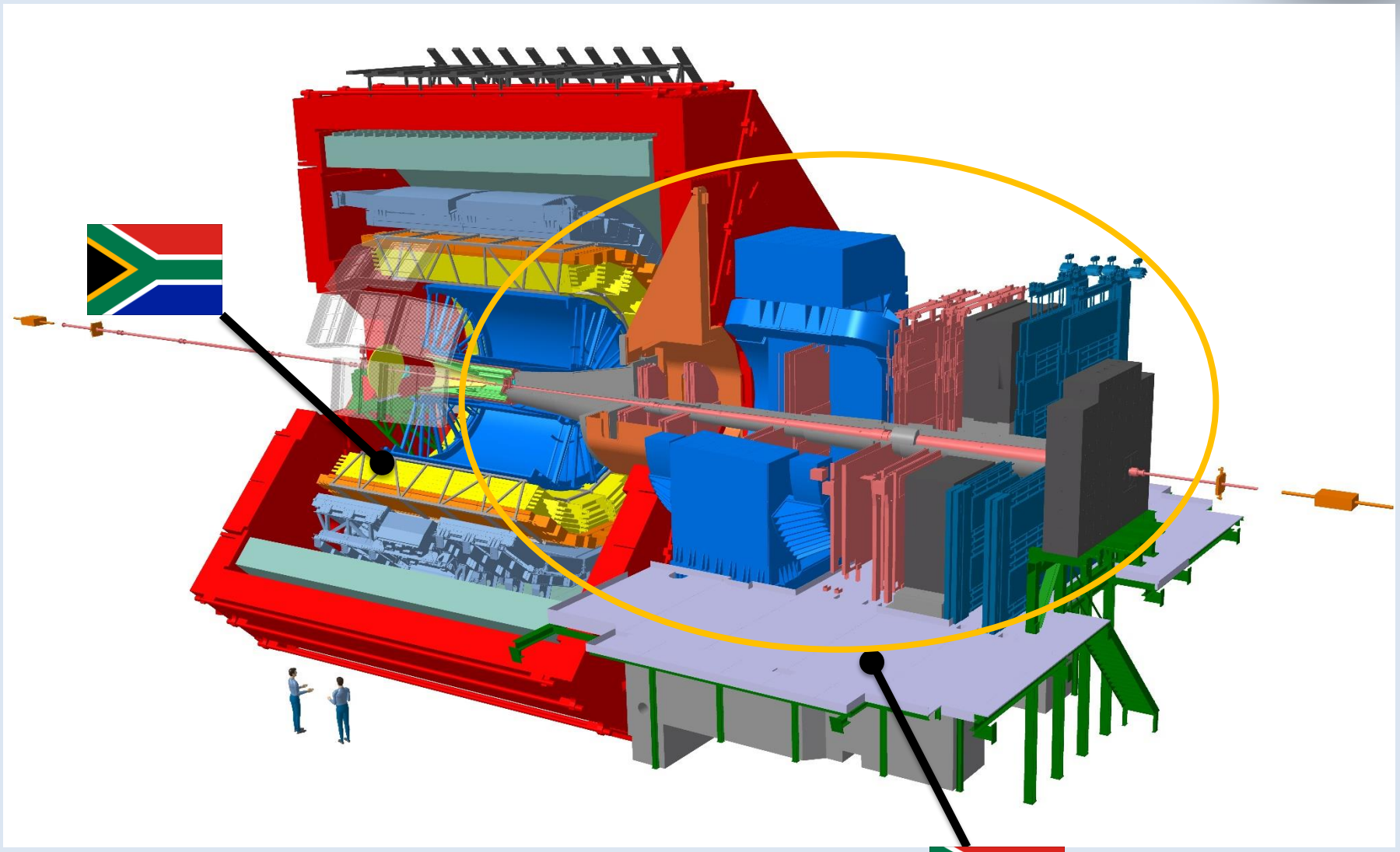
There are many R&D project opportunities → Technical manpower needed: mechanical, electrical and software engineering

Leadership roles

- Deputy Chair ALICE Collaboration Board (CB): SV Förtsch (2022 -2025 March)
- Secretary of ALICE CB: SV Förtsch (2020-2022)
- Run Manager: Z Buthelezi, B Naik
- Junior ALICE Ambassador for SA: Nina Nathanson (2022 – 2024 June)
  → Stephan Potgieter (since June 2024)
- ALICE Editorial Board member: Z Buthelezi (2020 – 2024 March)

Maintenance and Operation

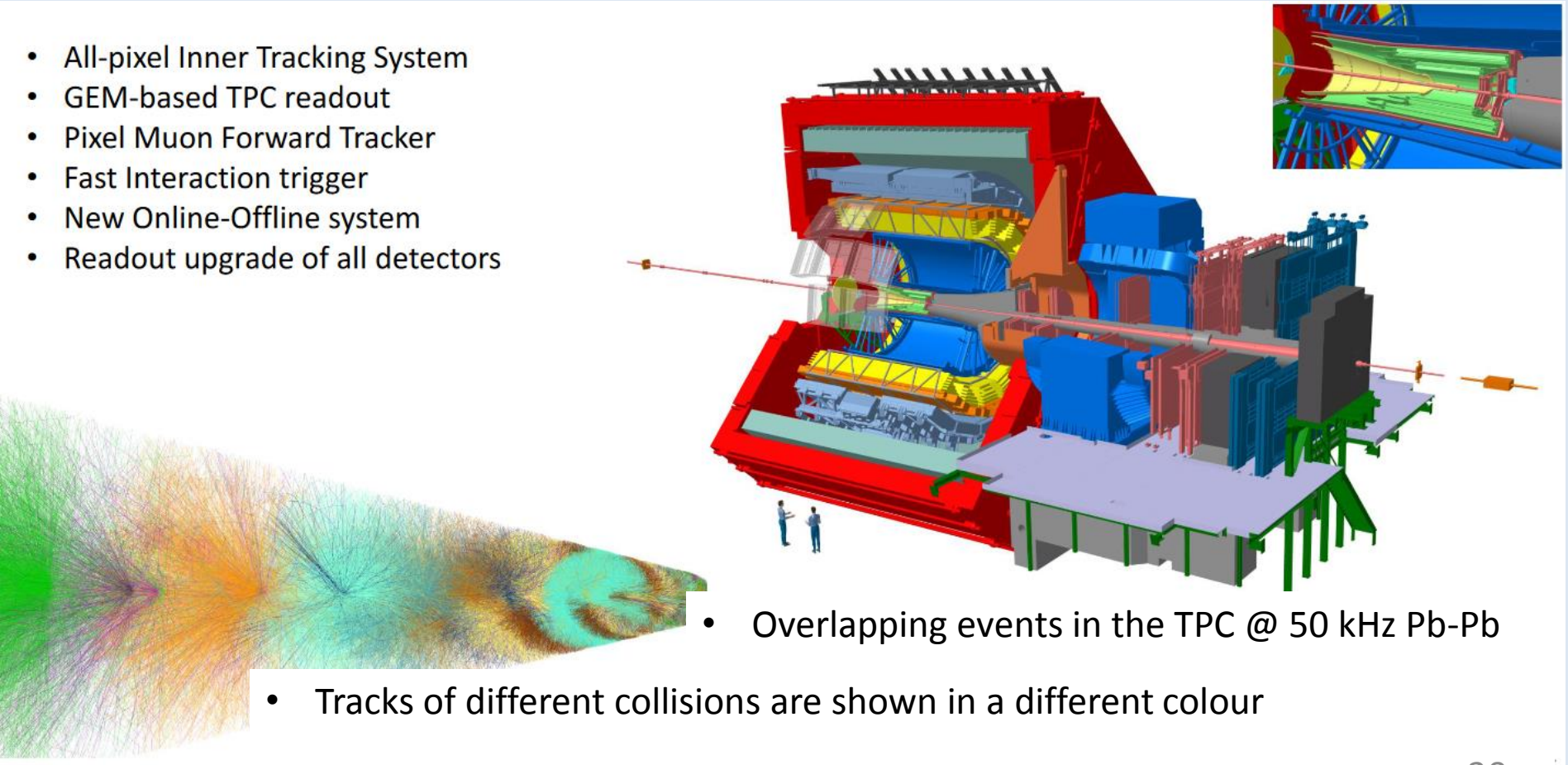
- ALICE detector in Run 3 (2020-mid2026)



ALICE in RUN 3 AIMS

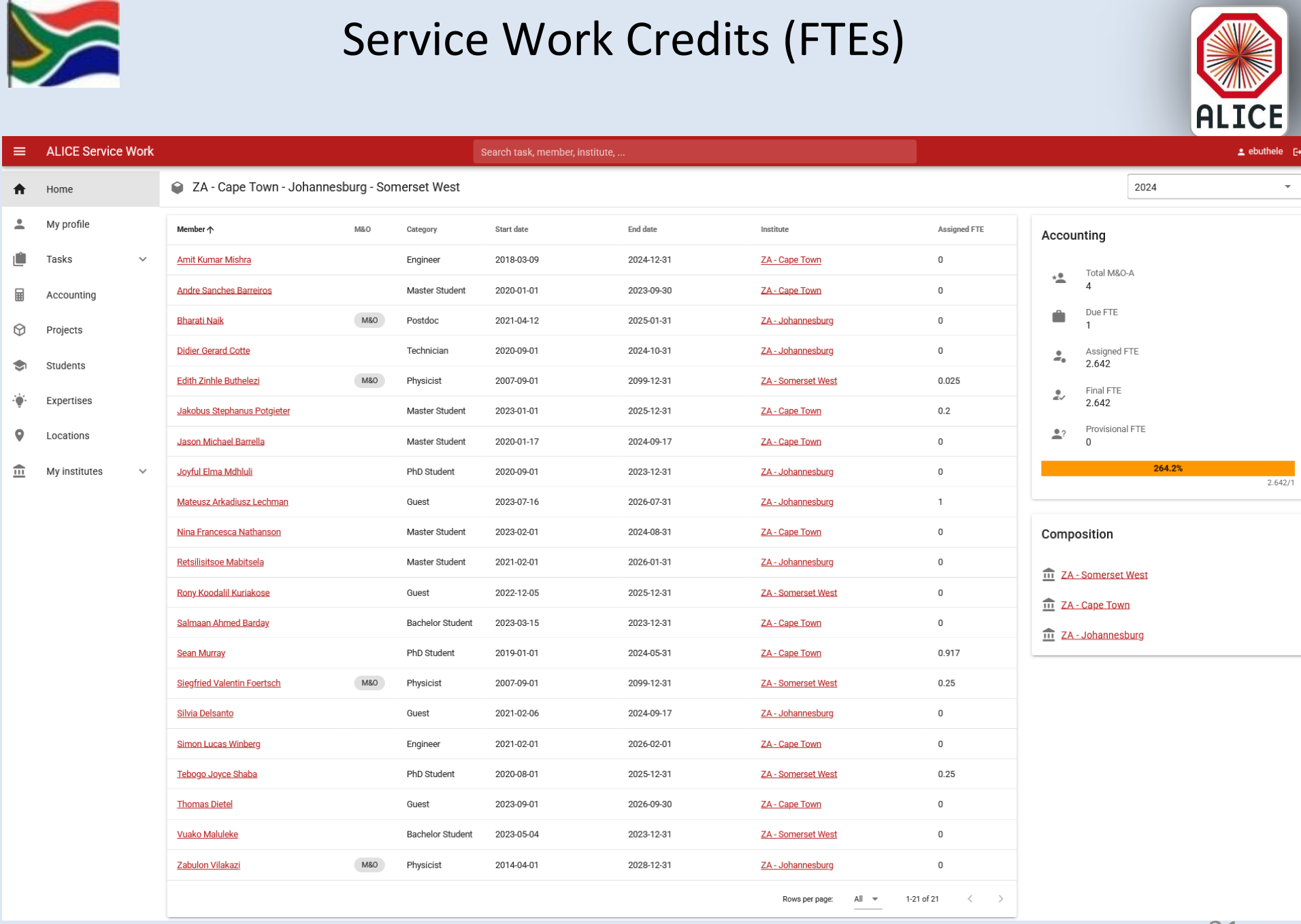
- Collect 13/nb in Run 3 and 4: (x100 larger minimum bias statistics)
- Improve tracking precision by a factor of 3-6

- All-pixel Inner Tracking System
- GEM-based TPC readout
- Pixel Muon Forward Tracker
- Fast Interaction trigger
- New Online-Offline system
- Readout upgrade of all detectors

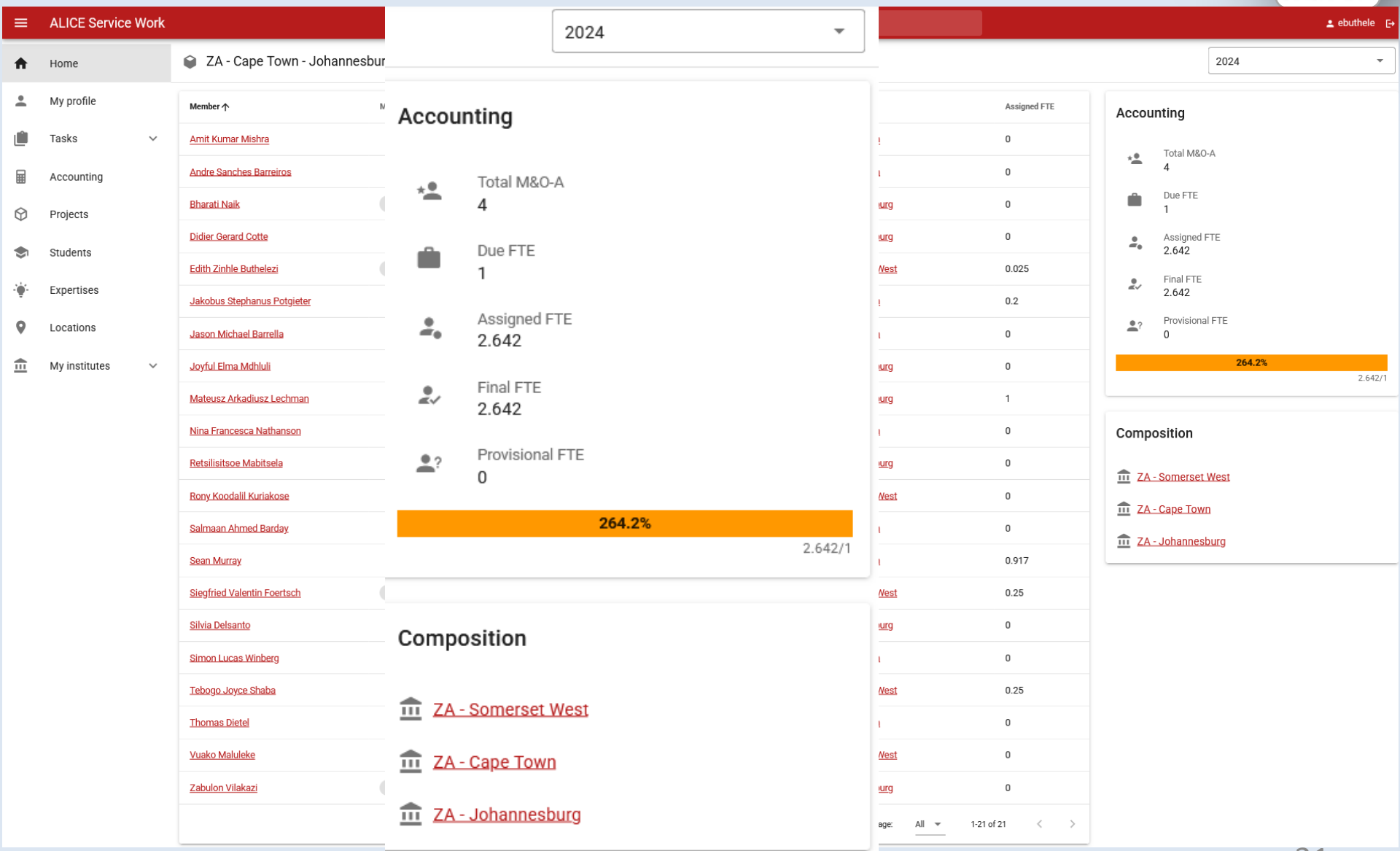


- Overlapping events in the TPC @ 50 kHz Pb-Pb
- Tracks of different collisions are shown in a different colour

Service Work Credits (FTEs)



Service Work Credits (FTEs)



Data-taking credits (FTEs)

- Due credit accounting for 2018-2024” fulfilled
  - Run Manager tasks, central shifts and detector oncall shifts

SAMS | Members, institutes, periods and detector... | ebuthele

ALICE › SAMS › Institutes › Details

Select Period

- Run 3
  - Data taking 2025
  - Data taking 2024
  - Data taking 2023
  - Data taking 2022
- Run 2
  - Data Taking 2018
  - Data taking 2017
  - Data Taking 2016
  - 2016
  - Commissioning-2014
- LS2 commissioning
  - commissioning in 2021
  - Commissioning 2020

Email Selected | Select All

Show 25 entries | Search:

	Member	Institute	Category	Start date	End date	Booked	Done
Profile	Salmaan Ahmed BARDAY	ZA - Cape Town	Bachelor Student	2023-03-15	2023-12-31		
Profile	Andre Sanches BARREIROS	ZA - Cape Town	Master Student	2020-01-01	2023-09-30		
Profile	Jason Michael BARRELLA	ZA - Cape Town	Master Student	2020-01-17	2024-09-17		
Profile	Edith Zinhle BUTHELEZI	ZA - Johannesburg	Physicist	2018-08-01	2025-12-31		
Profile	**Edith Zinhle BUTHELEZI** M&O	ZA - Somerset West	Physicist	2007-09-01		13.2	13.2
Profile	Didier Gerard COTTE	ZA - Johannesburg	Technician	2020-09-01	2024-10-31		
Profile	Silvia DELSANTO	ZA - Johannesburg	Guest	2021-02-06	2024-09-17		
Profile	Thomas DIETEL	ZA - Cape Town	Guest	2023-09-01	2026-09-30		
Profile	**Siegfried Valentin FOERTSCH** M&O	ZA - Somerset West	Physicist	2007-09-01		6.6	6.6
Profile	Rony Koodalil KURIAKOSE	ZA - Somerset West	Guest	2022-12-05	2025-12-31		
Profile	Mateusz Arkadiusz LECHMAN	ZA - Johannesburg	Guest	2023-07-16	2026-07-31	28	28
Profile	Retsilisitsoe MABITSELA	ZA - Johannesburg	Master Student	2021-02-01	2026-01-31		
Profile	Vuako MALULEKE	ZA - Somerset West	Bachelor Student	2023-05-04	2023-12-31		
Profile	Joyful Elma MDHLULI	ZA - Johannesburg	PhD Student	2020-09-01	2023-12-31		
Profile	Amit Kumar MISHRA	ZA - Cape Town	Engineer	2018-03-09	2024-12-31		
Profile	Sean MURRAY	ZA - Cape Town	PhD Student	2019-01-01	2024-05-31		
Profile	**Bharati NAIK** M&O	ZA - Johannesburg	Postdoc	2021-04-12	2025-04-30	6.6	6.6
Profile	Nina Francesca NATHANSON	ZA - Cape Town	Master Student	2023-02-01	2024-08-31	7	7
Profile	Jakobus Stephanus POTGIETER	ZA - Cape Town	Master Student	2023-01-01	2025-12-31		
Profile	Tebogo Joyce SHABA	ZA - Somerset West	PhD Student	2020-08-01	2025-12-31	6	6
Profile	**Zabulon VILAKAZI** M&O	ZA - Johannesburg	Physicist	2014-04-01	2028-12-31		
Profile	Simon Lucas WINBERG	ZA - Cape Town	Engineer	2021-02-01	2026-02-01		

Showing 1 to 22 of 22 entries | Previous 1 Next

overbooked

Booked/Due

176%

67.4 of 38.33

Done/Booked

100%

67.4 of 67.4

Institutes

- ZA - Somerset West
- ZA - Cape Town
- ZA - Johannesburg

CERN Accelerating science | The GLANCE Project | report an issue

Data-taking credits (FTEs)

- Due credit accounting for 2018-2024” fulfilled
  - Run Manager tasks, central shifts and detector oncall shifts

SAMS | Members, institutes, periods and detector... | ebuthele

ALICE › SAMS › Institutes › Details

Select Period

- Run 3
  - Data taking 2025
  - Data taking 2024
  - Data taking 2023
  - Data taking 2022
- Run 2
  - Data Taking 2018
  - Data taking 2017
  - Data Taking 2016
  - 2016
  - Commissioning-2014
- LS2 commissioning
  - commissioning in 2021
  - Commissioning 2020

Show 25 entries

	Member	Institute
Profile	Salmaan Ahmed BARDAY	ZA - Cape Town
Profile	Andre Sanches BARREIROS	ZA - Cape Town
Profile	Jason Michael BARRELLA	ZA - Cape Town
Profile	Edith Zinhle BUTHELEZI	ZA - Johannesburg
Profile	**Edith Zinhle BUTHELEZI** M&O	ZA - Somerset West
Profile	Didier Gerard COTTE	ZA - Johannesburg
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Profile	Tebogo Joyce SHABA	ZA - Somerset West
Profile	**Zabulon VILAKAZI** M&O	ZA - Johannesburg
Profile	Simon Lucas WINBERG	ZA - Cape Town

Showing 1 to 22 of 22 entries

Details *Data taking 2024*

Total M&O	4
Due credits	38.79
Carryover	0

overbooked

Booked/Due

108%

41.8 of 38.79

Done/Booked

100%

41.8 of 41.8

Institutes

- ZA - Somerset West
- ZA - Cape Town
- ZA - Johannesburg

Search:

Booked	Done
13.2	13.2
6.6	6.6
28	28
6.6	6.6
7	7
6	6

Previous 1 Next

overbooked

Booked/Due

176%

67.4 of 38.33

Done/Booked

100%

67.4 of 67.4

Institutes

- ZA - Somerset West
- ZA - Cape Town
- ZA - Johannesburg

CERN Accelerating science | The GLANCE Project | report an issue

High Energy Physics (HEP) and Innovation

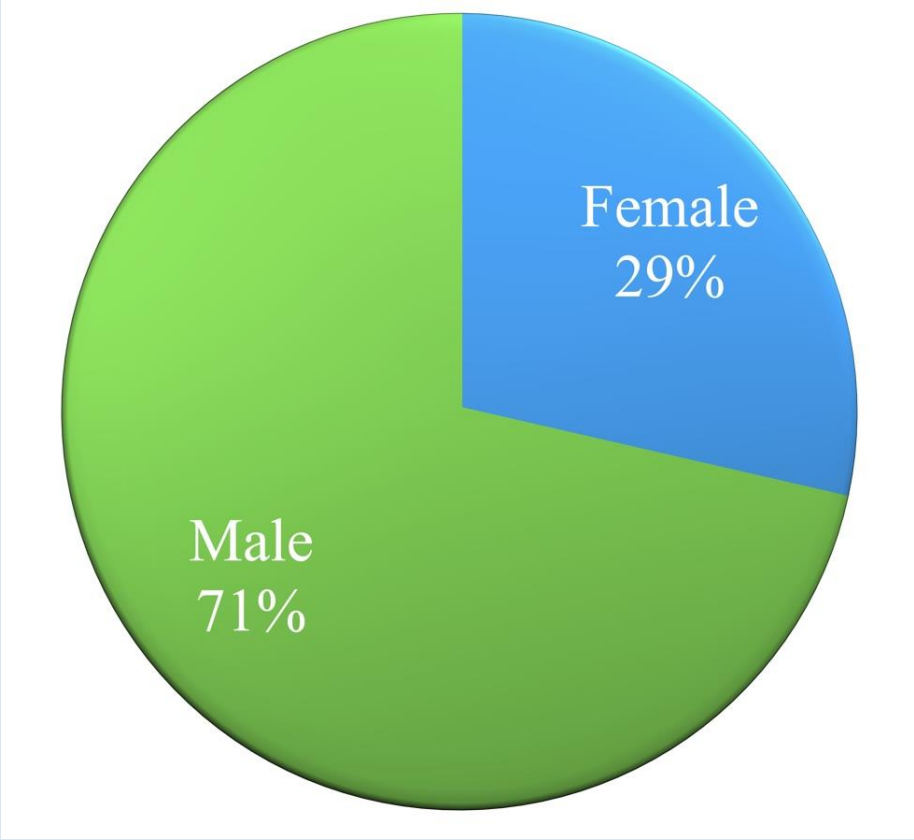
- Challenges around **detector upgrades** and multi-peta-byte datasets are ideal training environments for **physicists**, **engineers** and **data/computer scientists**

- **ALICE collaboration**: fully exploiting the physics potential of the detector upgrades

- Context of my talk:

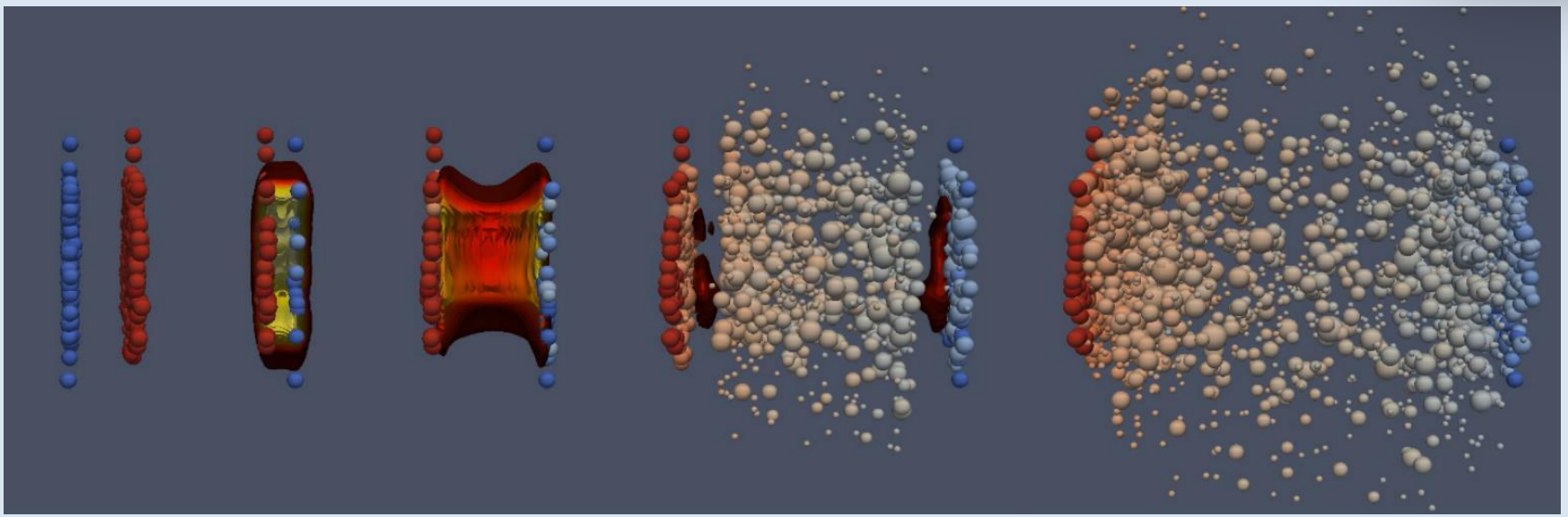
- Brief introduction
- Technical skills gained during the Long Shutdown 2 (LS2) upgrades
- Innovative new technologies emerging from R&D associated with next upgrades, i. e. the new heavy-ion experiment to replace the current RUN 3 detector, so-called **ALICE 3** in 2032

Human Capital development



Heavy-Ion Physics

Study of Matter at 2 Trillion (10^{12}) Degrees



Initial State

Gluon saturation

Colour-glass condensate

Quark-Gluon Plasma

EOS and hydrodynamic evolution

Quark & gluon energy loss / jet quenching

Heavy quark transport properties

Thermalisation

Deconfinement

Hadronisation

Statistical hadronisation

Quark (re-)combination

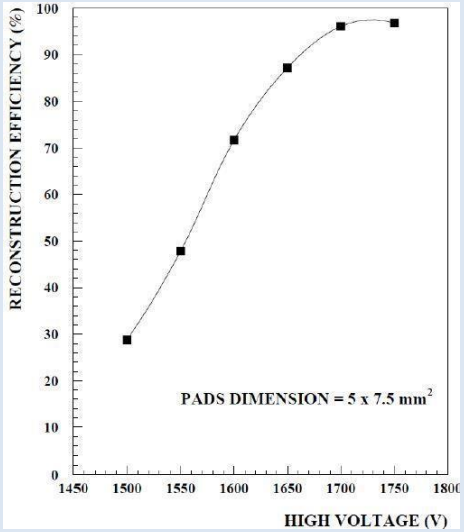
Hadron Gas

Resonance decays

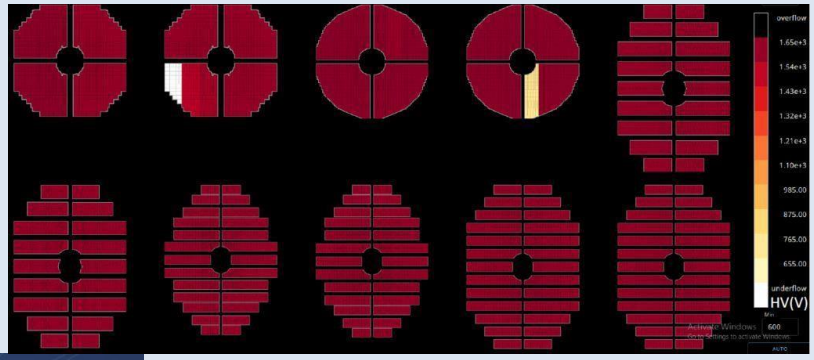
Hadron physics

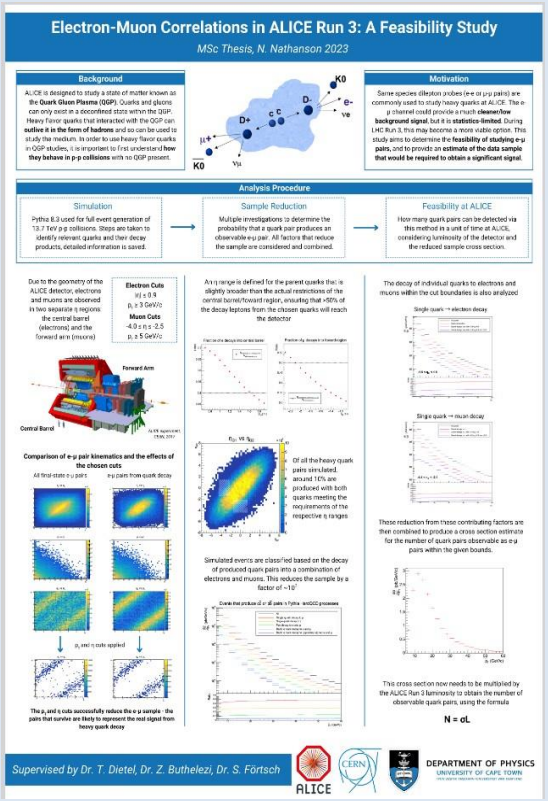
Physics Activities in Run 3

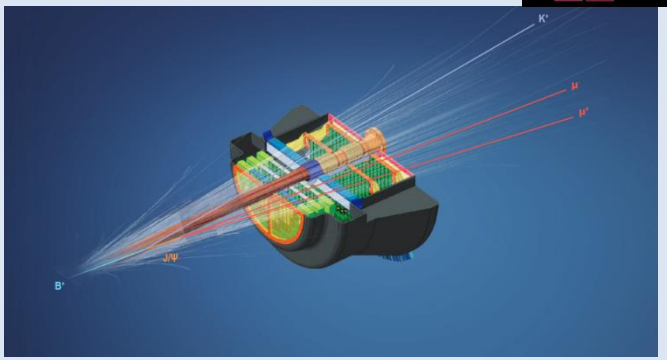
- Physics data analysis: experimental data and simulations
- **Detector Performance** studies in Run 3 pp and Pb-Pb



- **Software development**: Online-offline (O2) data processing







- **Machine Learning techniques in data analysis**
- **Readout project for ALICE 3 R&D**

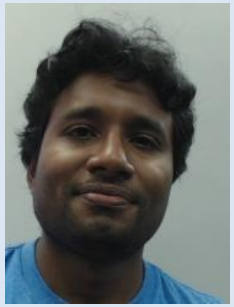
Other Outreach

- WIPISA documentaries: “Women in Physics Role Models available on Youtube, J Mdhluli https://youtube.com/watch?v=vGqYycRs9c4
- Dr B Naik SAIP mini documentary “Physics in everyday life” available on Youtube, https://youtu.be/68GPbav8NDE

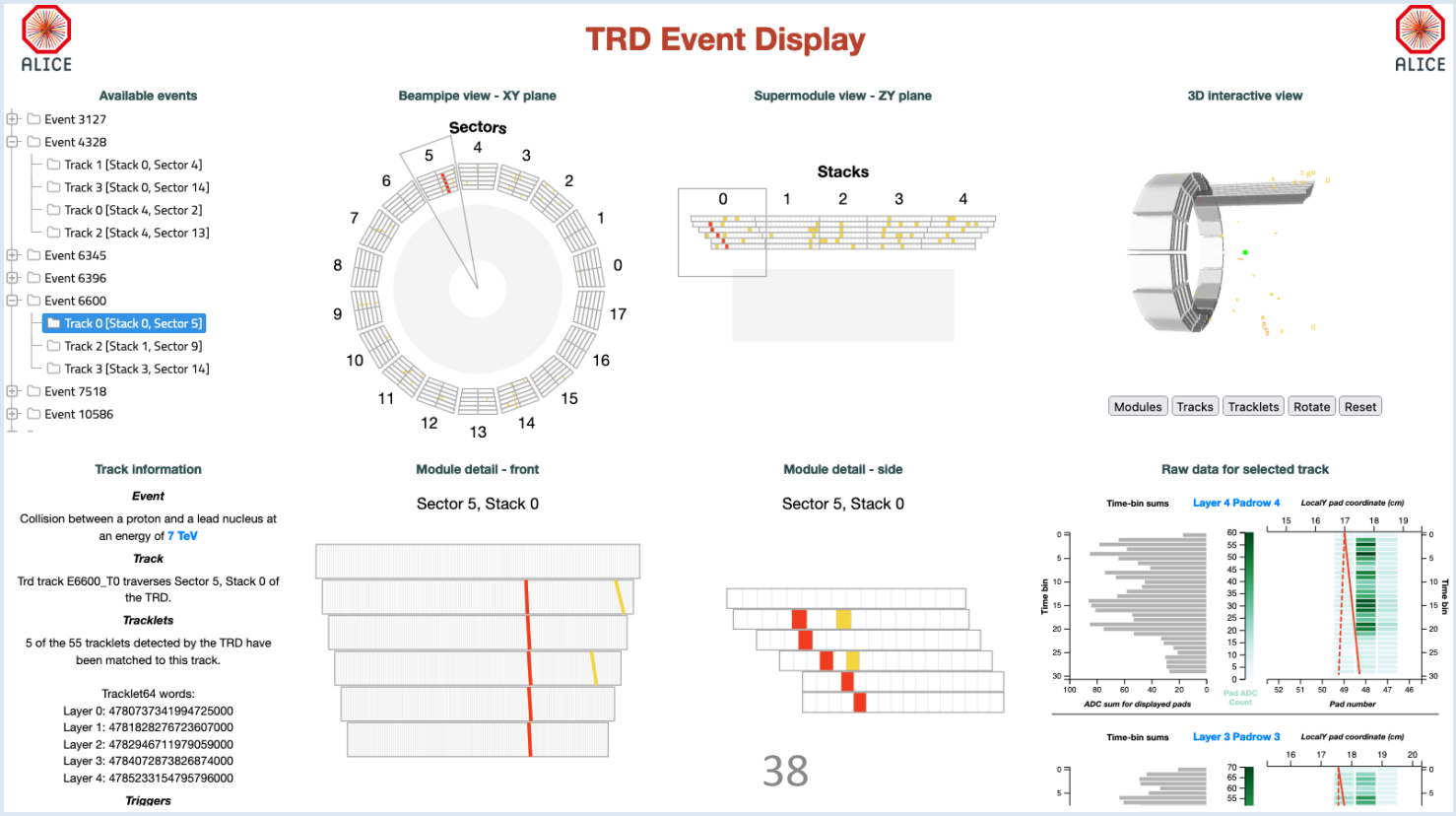
- ZB in BBC documentary about the 70 years of CERN, “***The Peace Particle***” shot at CERN from 17-24 June 2024

Transition Radiation Detector (TRD)

- **Development of the new reconstruction software** (vertical slice) within the new Online-Offline (O^2) software (2019 -2023) TRD



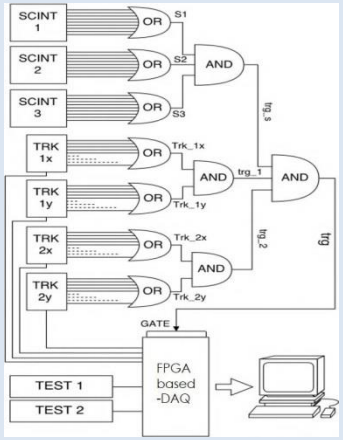
- Event Visualisation for TRD, Sameshan Perumal (MSc Data Science, UCT 2021)
- Design and Implementation of a Quality Control System for the ALICE TRD (Tokozani Mtetwa, UCT 2022)
- Calibration and DCS for the ALICE TRD, Jason Barrella (UCT MSc 2023)

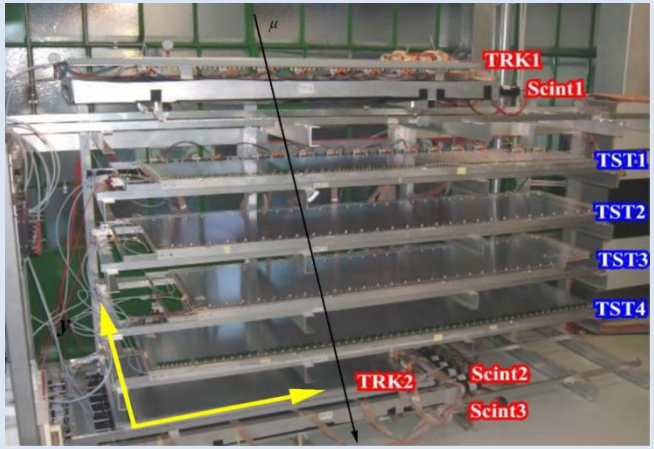


Muon Resistive Plate chambers (RPCs)

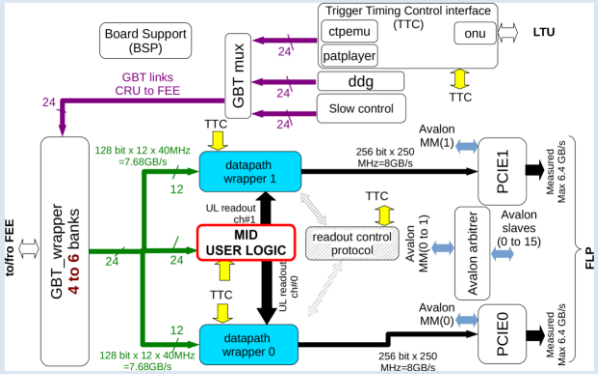
Silvia Delsanto, WITS/Turin,PhD 2018-2020)

- Characterisation of muon RPCs with new gas gaps in the Turin (Italy) laboratory for installation in the ALICE Cavern
- Trigger design to measure the efficiency





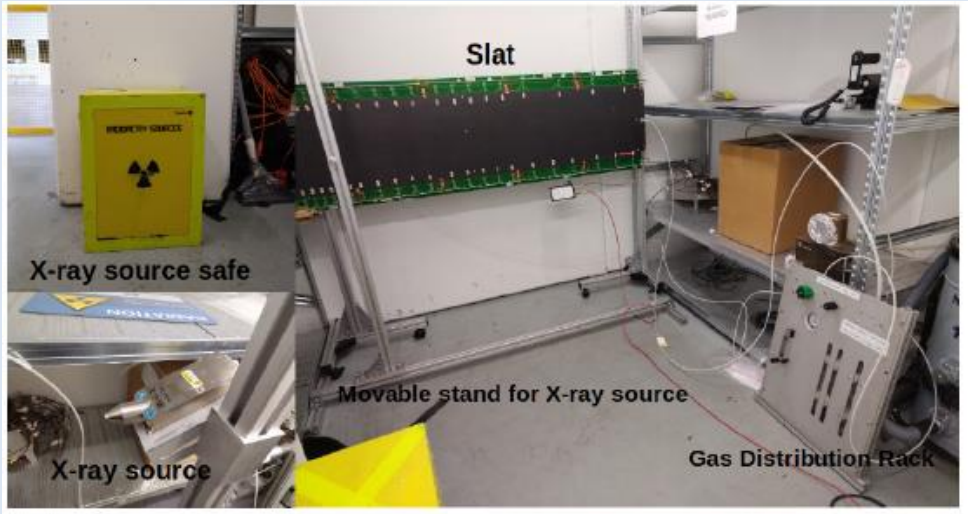
- Muon Common Readout Unit (CRU) firmware development for Run 3, Orcel Thys (M. Eng. CPUT 2022)



Muon tracking chambers (MCH) for Run 3

Joyful Mdhluli (PhD 2020-2023 WITS)

- Slat tests for Run 3 readiness at Point 2
- Implementation of the MCH visualisation of the front-end card (FEC)



- Implementation and integration of MCH LVPS on the DCS, Rony Kuriakose (Stellenbosch, M. Eng. 2022