

South Africa – ALICE (SA-ALICE)

‘WHERE ARE WE NOW’



Zinhle Buthelezi



SA-CERN 15-year celebration
iThemba LABS, 20 January 2025





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?





Who is involved in ALICE in South Africa?

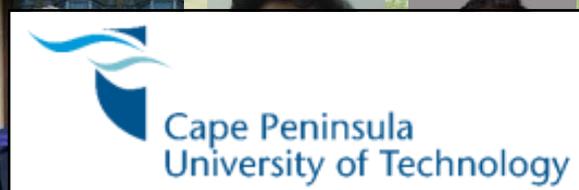
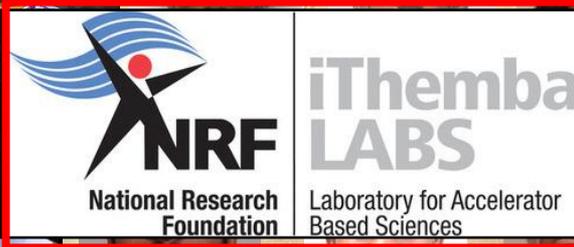
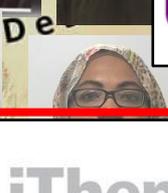
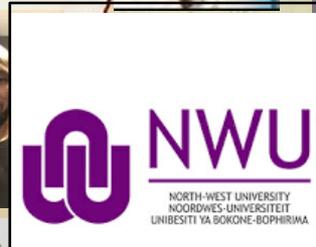




Who is involved in ALICE in South Africa?

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



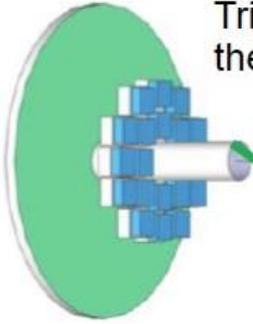
Dr Happy Sithole's talks tomorrow on "High-Performance Computing in South Africa".



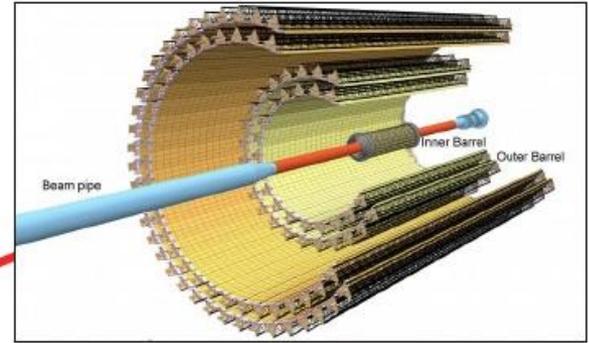
ALICE

LS2 Detector upgrades for RUN 3 (2019-2020)

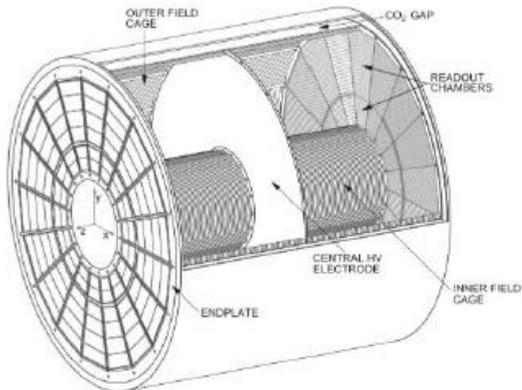
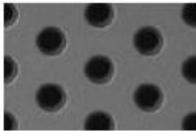
New Forward Interaction Trigger (FIT) to replace the V0 and T0 detectors



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

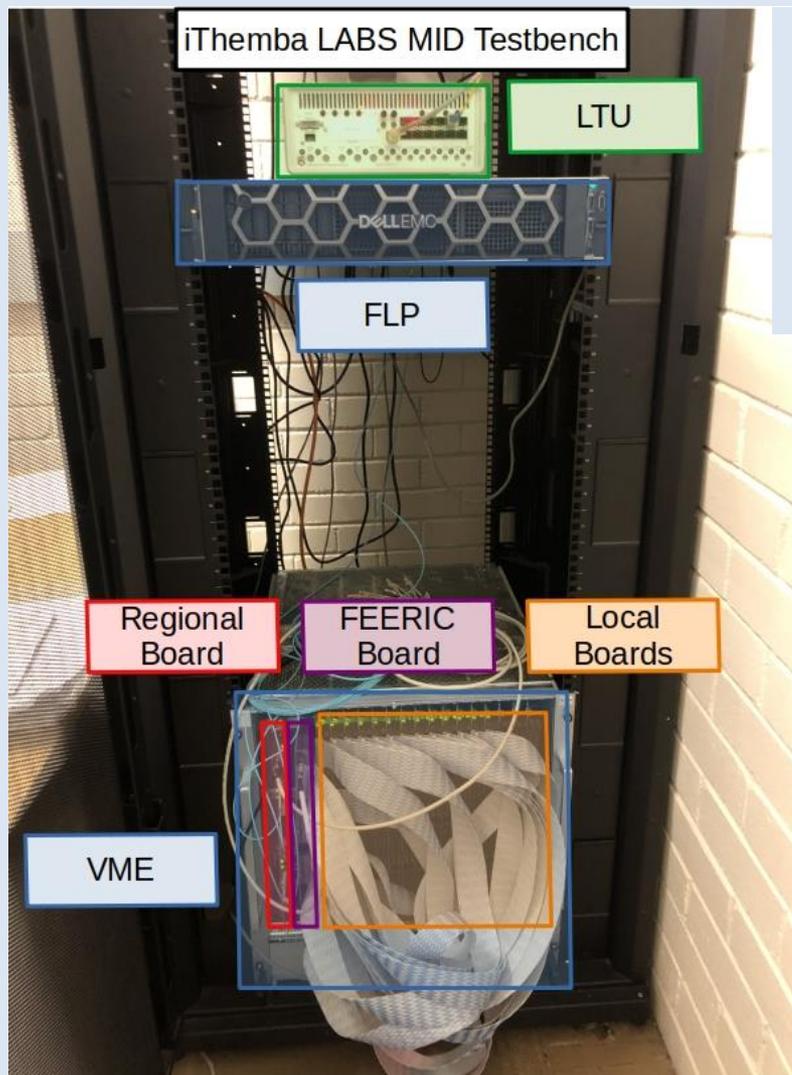


- ❑ System Run coordination
- ❑ Hardware/firmware/software activities
 - Transition Radiation detector (TRD)
 - Muon Tracking Chambers (MCH)
 - Muon Identifier (RPCs)





Readout firmware laboratory at iThemba LABS



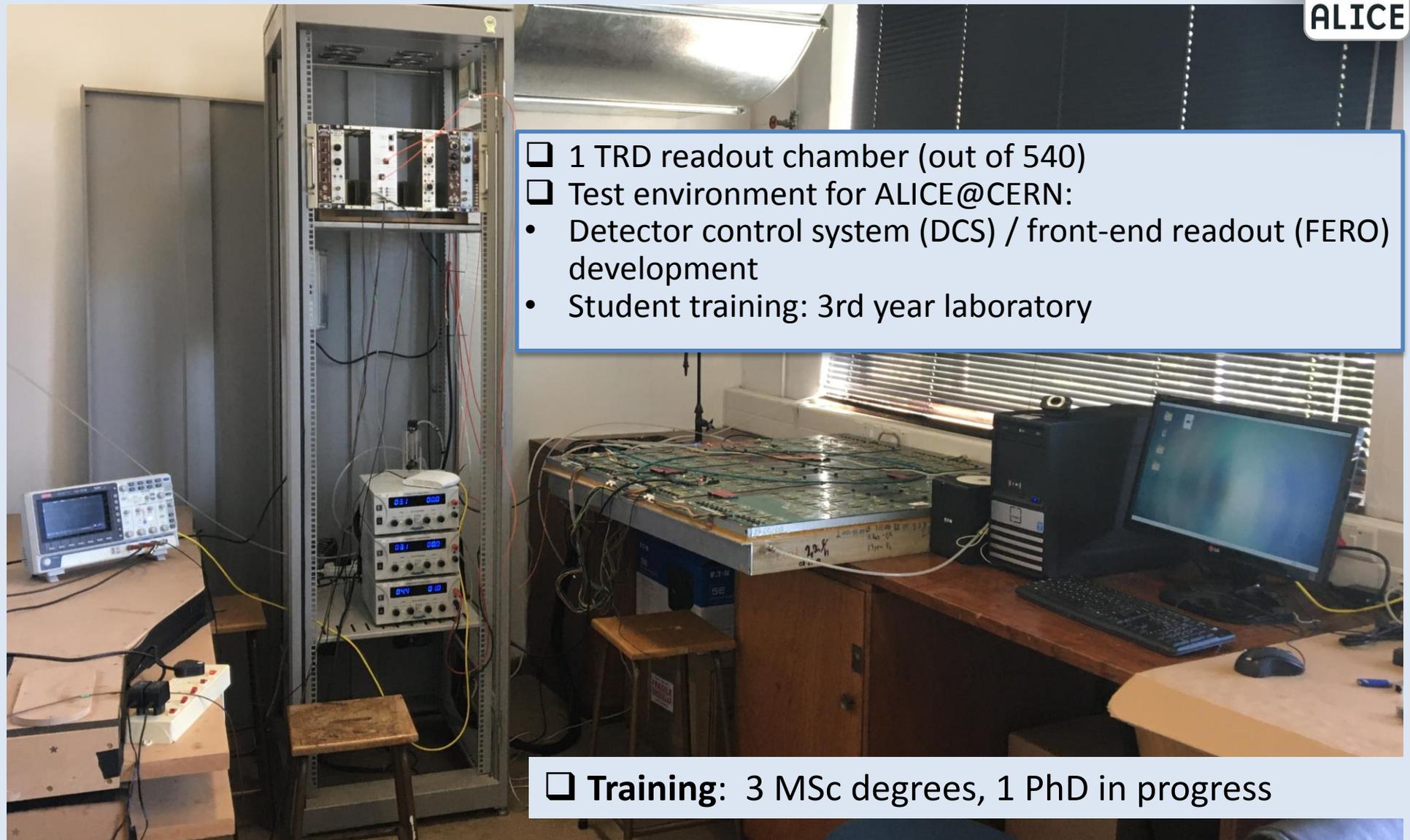
- ❑ Full setup of electronics, trigger, and data acquisition
- ❑ Test environment for MID:
 - FPGA/Firmware development
 - High-throughput electronics
 - Online-offline (O^2) development for Muon subdetector



- ❑ **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

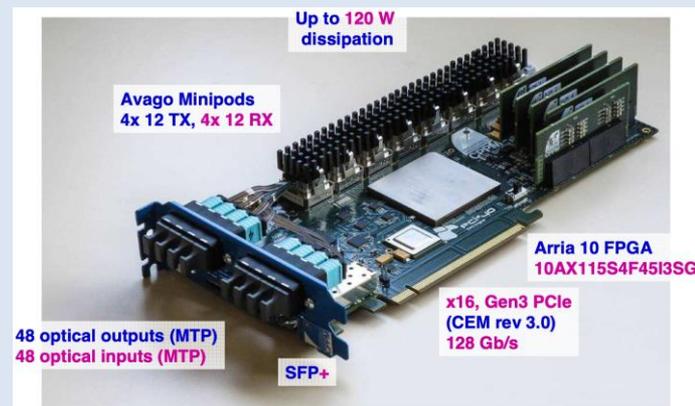


☐ Training and exposure

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

☐ 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

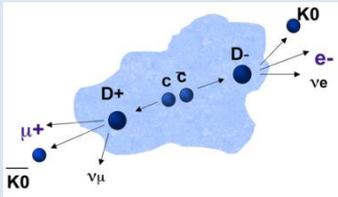


Physics data analysis



Exposure to complex analysis tools used in Big Data

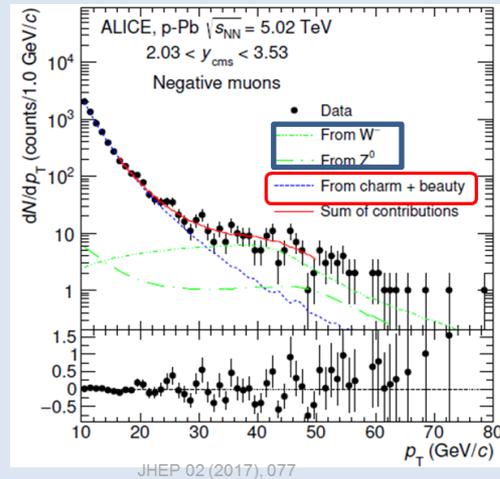
☐ Photon measurements using the conversion into electron-positron pairs



☐ Electron-muon correlation in pp collisions



☐ “(multi-)Strange hadron production in pp collisions

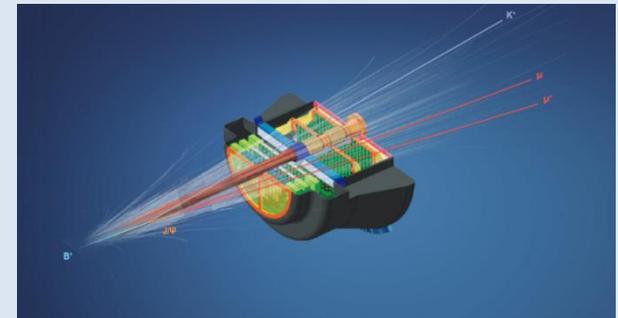


☐ Single muon measurements **ongoing**

- Heavy- quark (**charm** and **beauty**)
- Electroweak boson (**W, Z**)



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



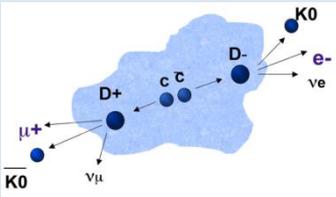


Physics data analysis



Exposure to complex analysis tools used in Big Data

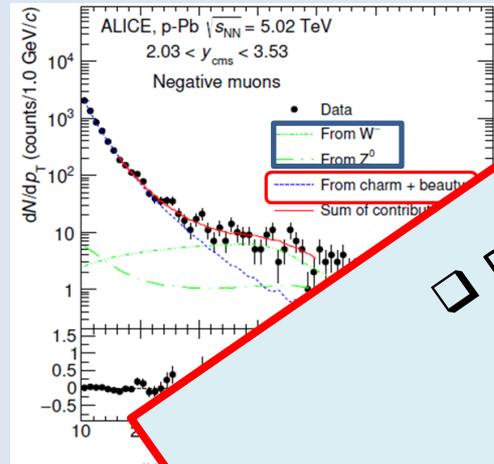
☐ Photon measurements using the conversion into electron-positron



☐ Electron-muon correlation in p



☐ "(multi-)Strange hadron production in pp



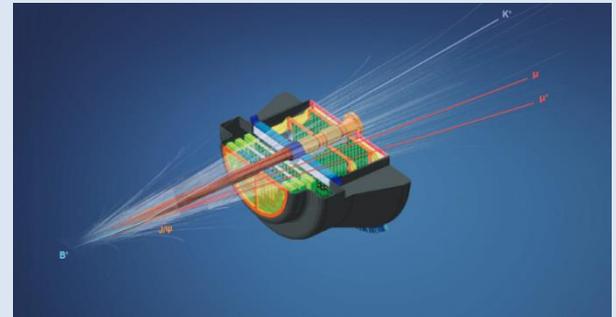
☐ Single

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

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



☐ Use of ... techniques in data analysis ongoing

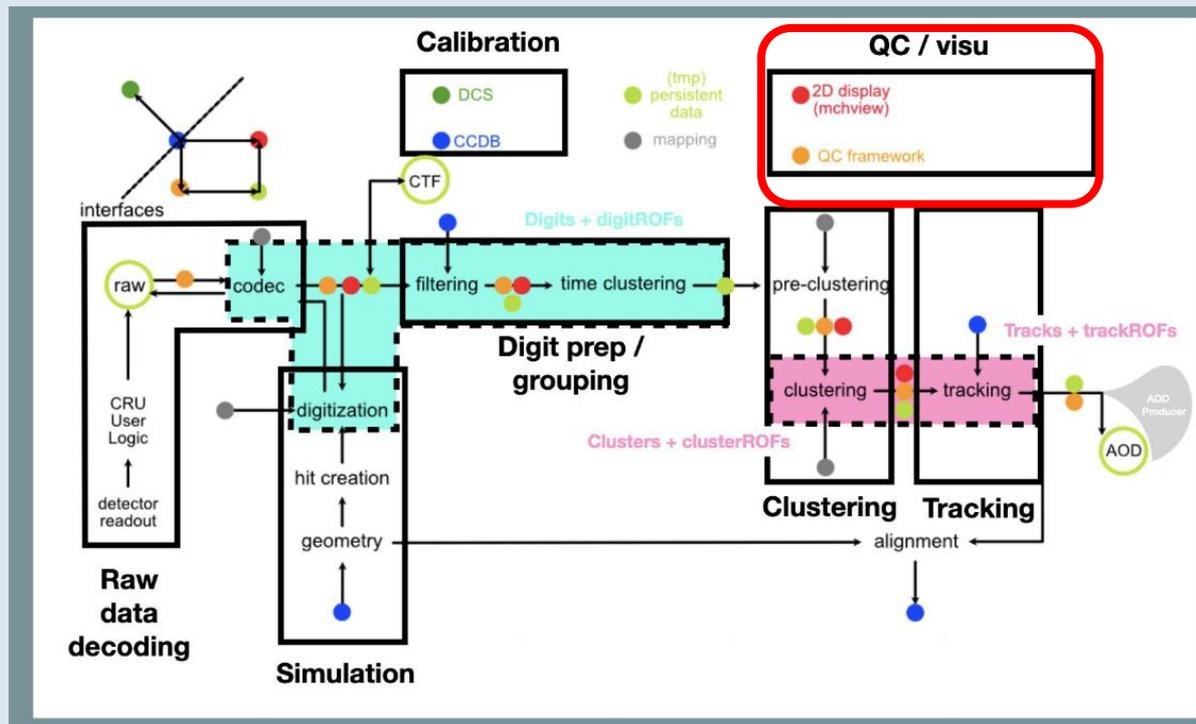




Service task: MCH Quality Control (QC)



- ❑ 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.



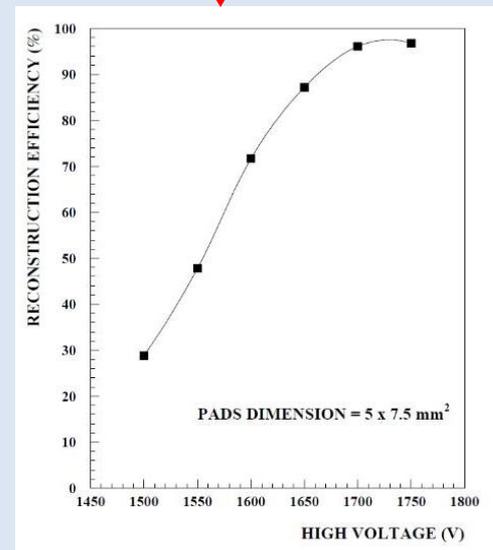
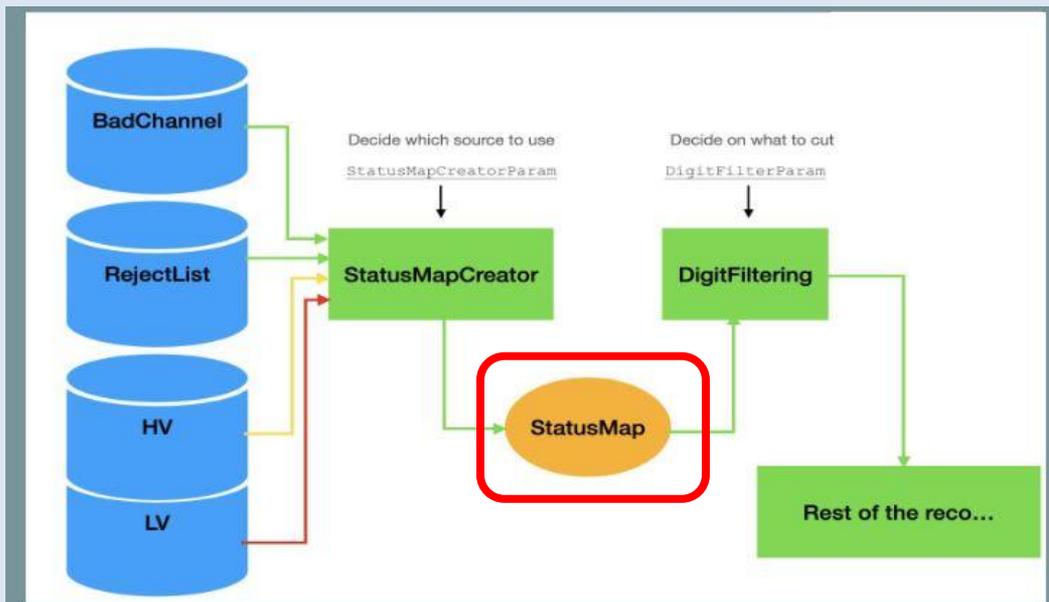
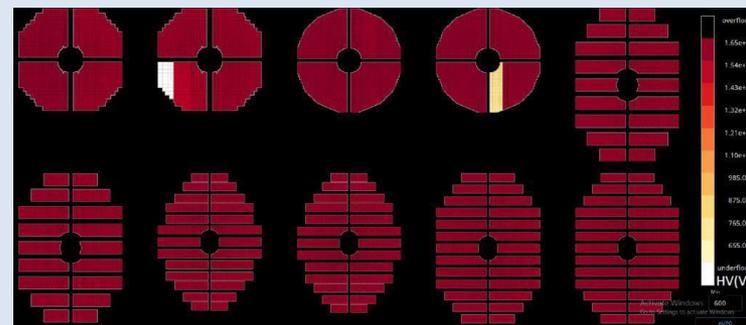
Service task: MCH reconstruction software



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





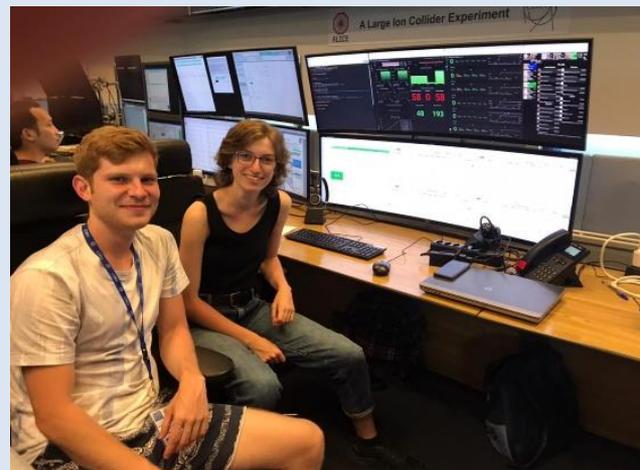
ALICE RUN 3 data taking



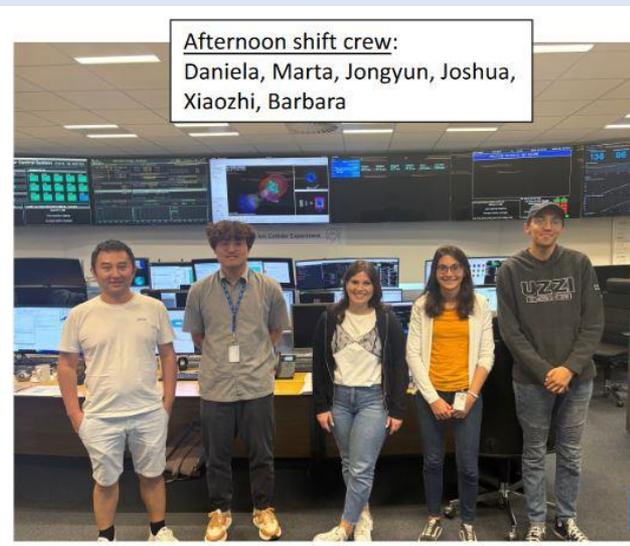
- ALICE Run Manager: Z Buthelezi (2022), B Naik (2023)



- Central shifts



Afternoon shift crew:
Daniela, Marta, Jongyun, Joshua,
Xiaozhi, Barbara



- Oncall shifts:
TRD, MID, MCH

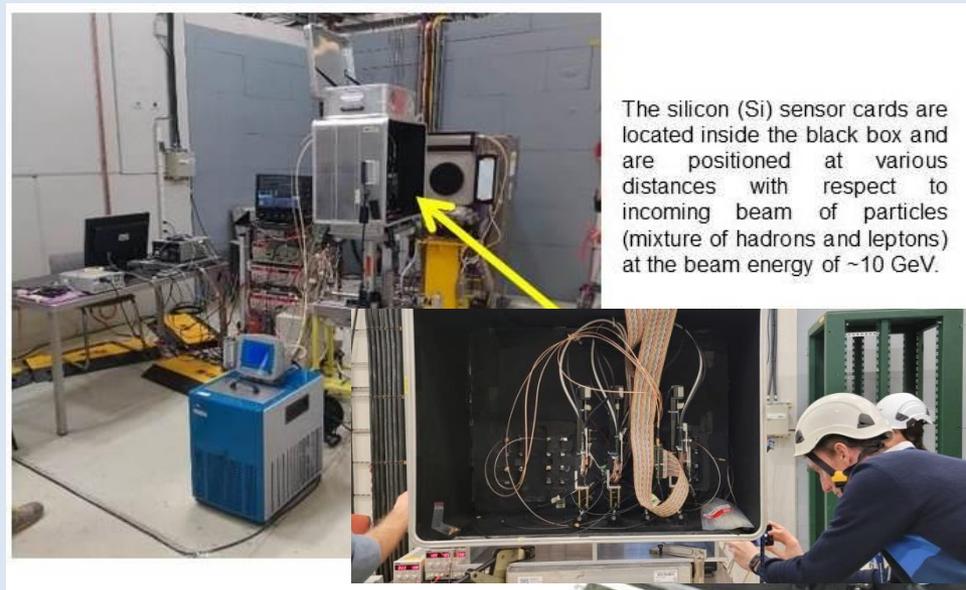
**Leadership roles for young PhD and Postdocs:
Run Manager, System Run Coordinator, etc..**



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

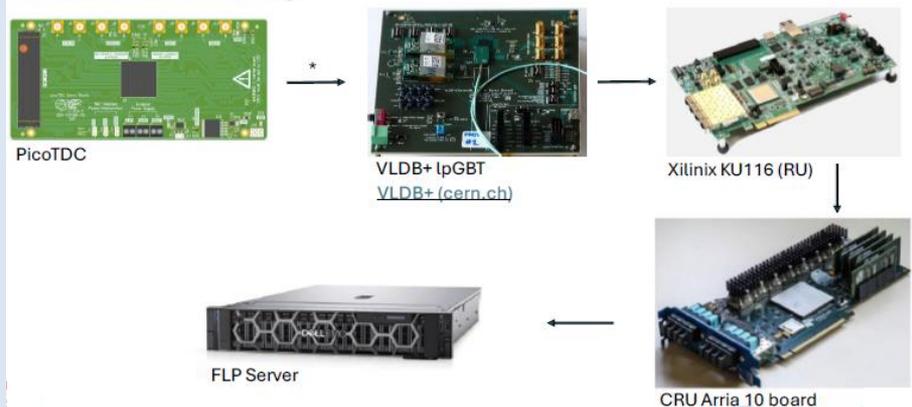


- ❑ Involvement in ALICE 3 TOF test beam experiments at CERN PS: James Godhead (M Eng, UCT ongoing and Prof Simon Winberg (UCT Electrical Engineering)



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

Hardware Setup



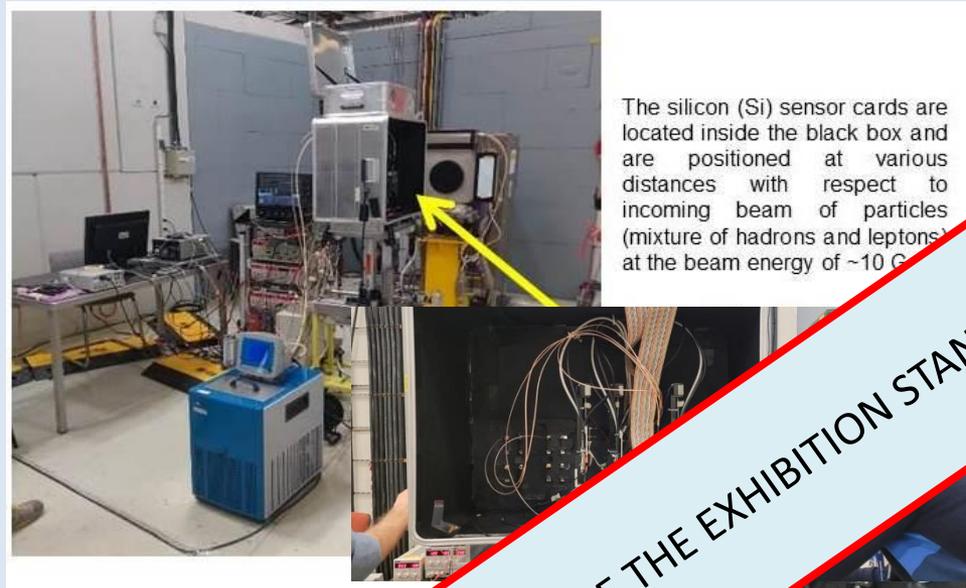
Institutes are encouraged to explore available opportunities. Contact us!!



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



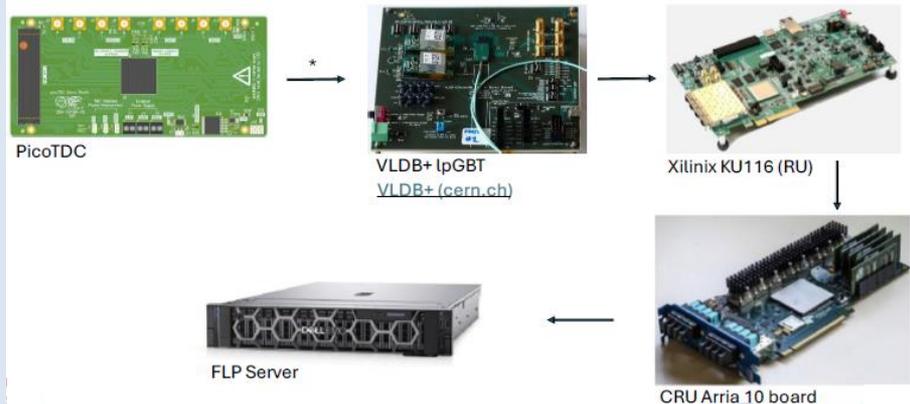
- Involvement in ALICE 3 TOF test beam experiments at CERN PS: James ... , UCT ... ongoing and Prof Simon Winberg (UCT Electrical Engineering)



SEE THE EXHIBITION STAND and Poster presentations

- Testbench d ... ds ALICE 3
Time-of ... ion readout unit
(CR ...)

Hardware Setup



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



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

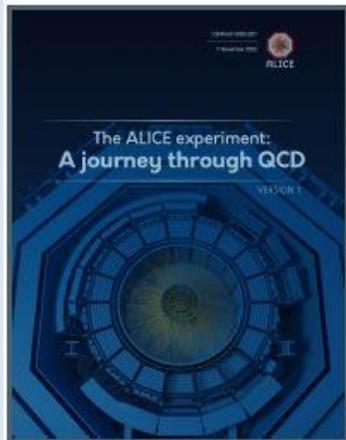
Are you interested? Contact us!



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!

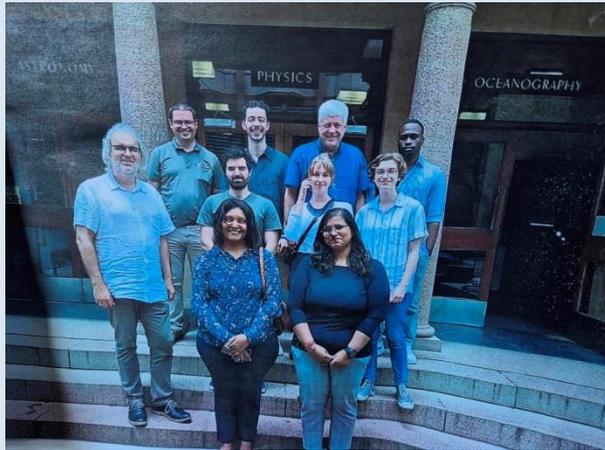
- Technical Contributions: **ALICE 2 upgrade paper** [arXiv:2302.01238](https://arxiv.org/abs/2302.01238) – work during LHC Long Shutdown 2 (2019-2022)

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

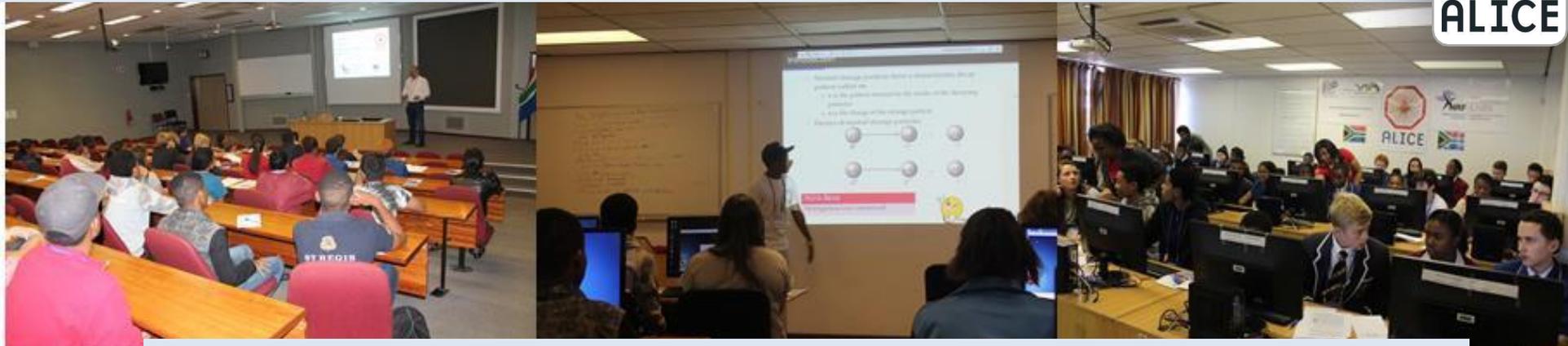
- iThemba LABS MD & SA-CERN Chair visit to CERN, October 2023
- South African Parliamentary Portfolio visit to CERN



- 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



NELSON MANDELA
UNIVERSITY
Departmental Seminar



Presentation by: Prof Z Buthelezi and Dr SV Förtsch

Title: ALICE Collaboration and Future Prospects

The talk will focus on South Africa's contribution to the ALICE collaboration at the CERN Large Hadron Collider (LHC), particularly the prospects for future upgrade opportunities and benefits of the ALICE masterclass outreach programme. The second part of the talk will highlight selective physics results published by the collaboration.

Date: 4 October 2024

Time: 11:00

Venue: Physics Seminar Room, 075

❑ **NMU, October 2024**

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

INVIATION

Cape Peninsula University of Technology
Faculty of Applied Sciences
Department of Mathematics & Physics
invites you to a seminar by

Prof Z Buthelezi and Dr SV Förtsch
*Separated Sector Cyclotron Laboratory (SSCLab)
NRF/Themba LABS/WITS School of Physics*

TITLE: FUTURE PROSPECTS IN THE A LARGE ION COLLIDER EXPERIMENT (ALICE) COLLABORATION

ABSTRACT:
The talk will focus on South Africa's contribution to the ALICE collaboration at the CERN Large Hadron Collider (LHC), particularly the technical aspects and the prospects for future upgrade opportunities. The second part of the talk will highlight selective physics results published by the collaboration. The seminar topics are designed to prompt discussions about potential opportunities for CPUT Academics and postgraduate students in ALICE.

Date: 12 August 2024
Time: 12h00 – 14h00
Venue: Conference Room 2.74, 2nd Floor, New Chemical Engineering and Chemistry Building, Bellville Campus

Virtual: Click below MS Team link to follow **Meeting Link:**

Inquiries:
Dr. Worku: workud@cput.ac.za
Dr. Osibote: OsiboteA@cput.ac.za

NOTE: PLEASE INVITE COLLEAGUES FROM APPLIED SCIENCES AND OTHER FACULTIES THE RSVP LINK (<https://forms.office.com/r/0cTNKrdzHG>) DEADLINE: 5TH AUGUST 2024

Virtual:

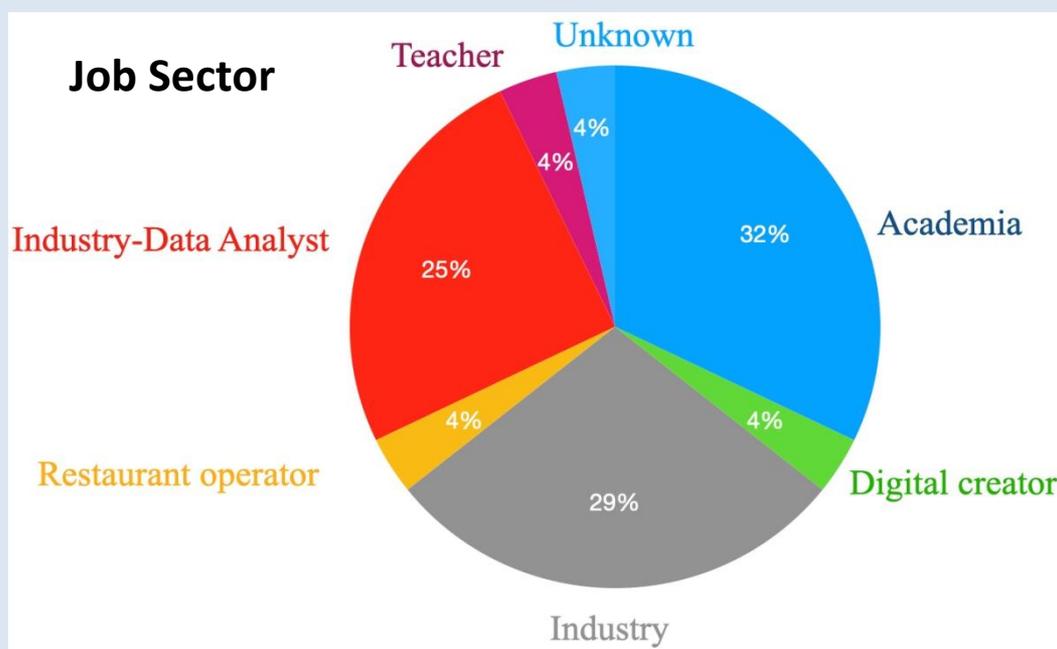
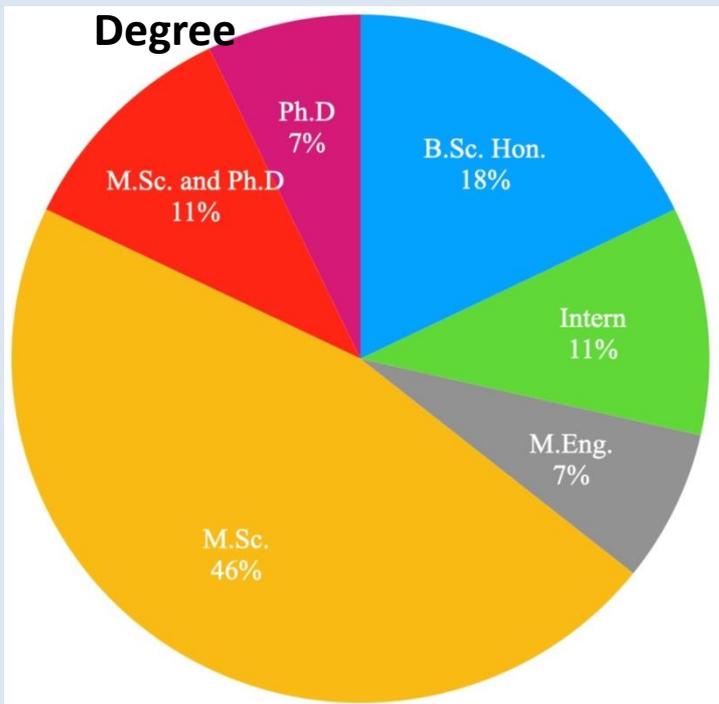
- ❑ UNIZULU Physics Department: Virtual July 2024
- ❑ UNIVENDA: September 2023
- ❑ NWU: September 2023



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



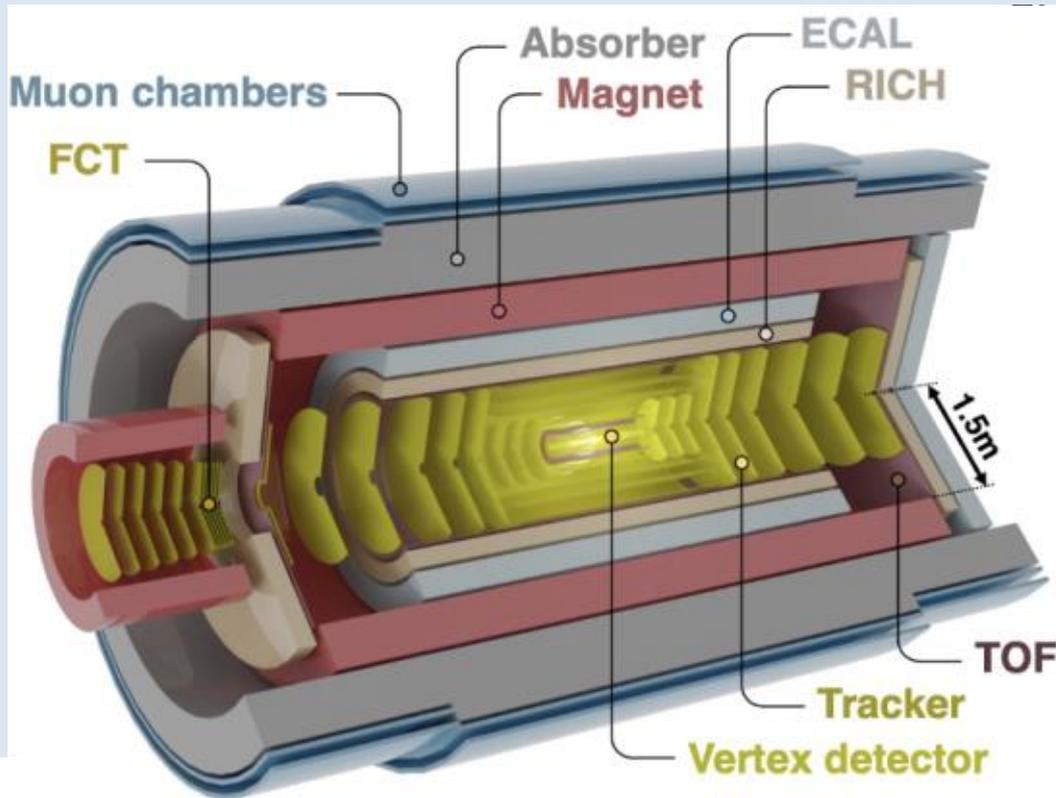
☐ Opportunities exist within the ALICE 3 Upgrade.. Come and join us!

Thanks for listening

Backup

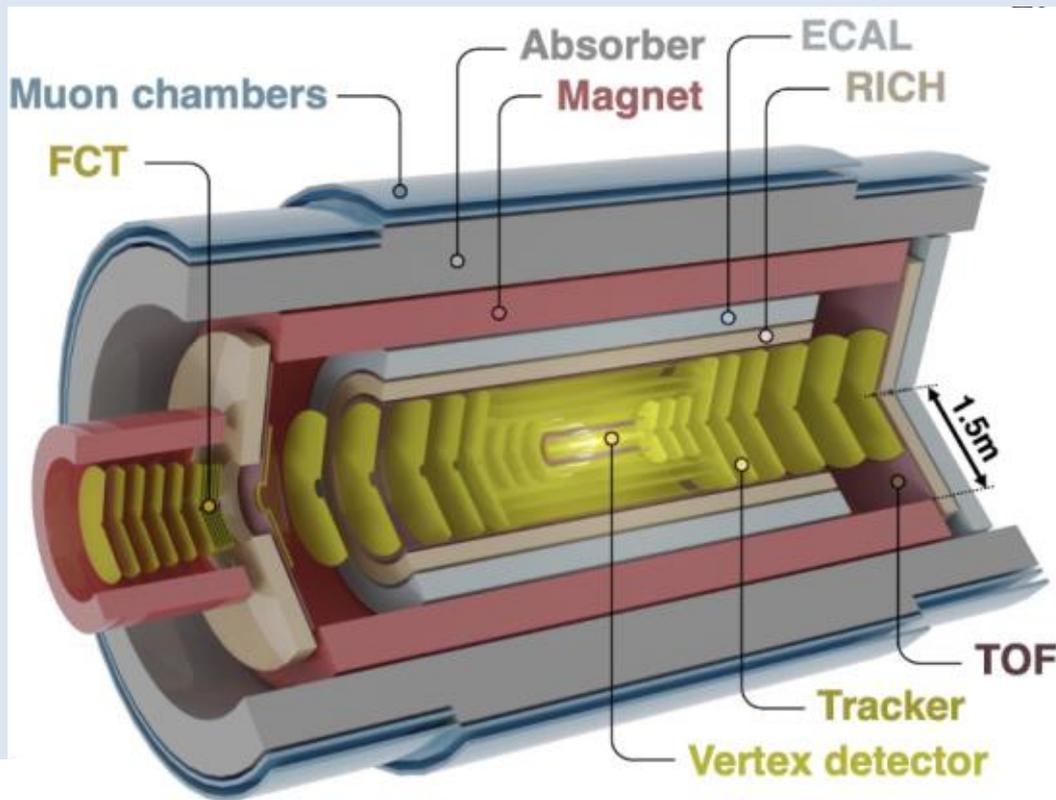
**What's next for technology
and innovation in ALICE?**

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



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

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



Leadership roles

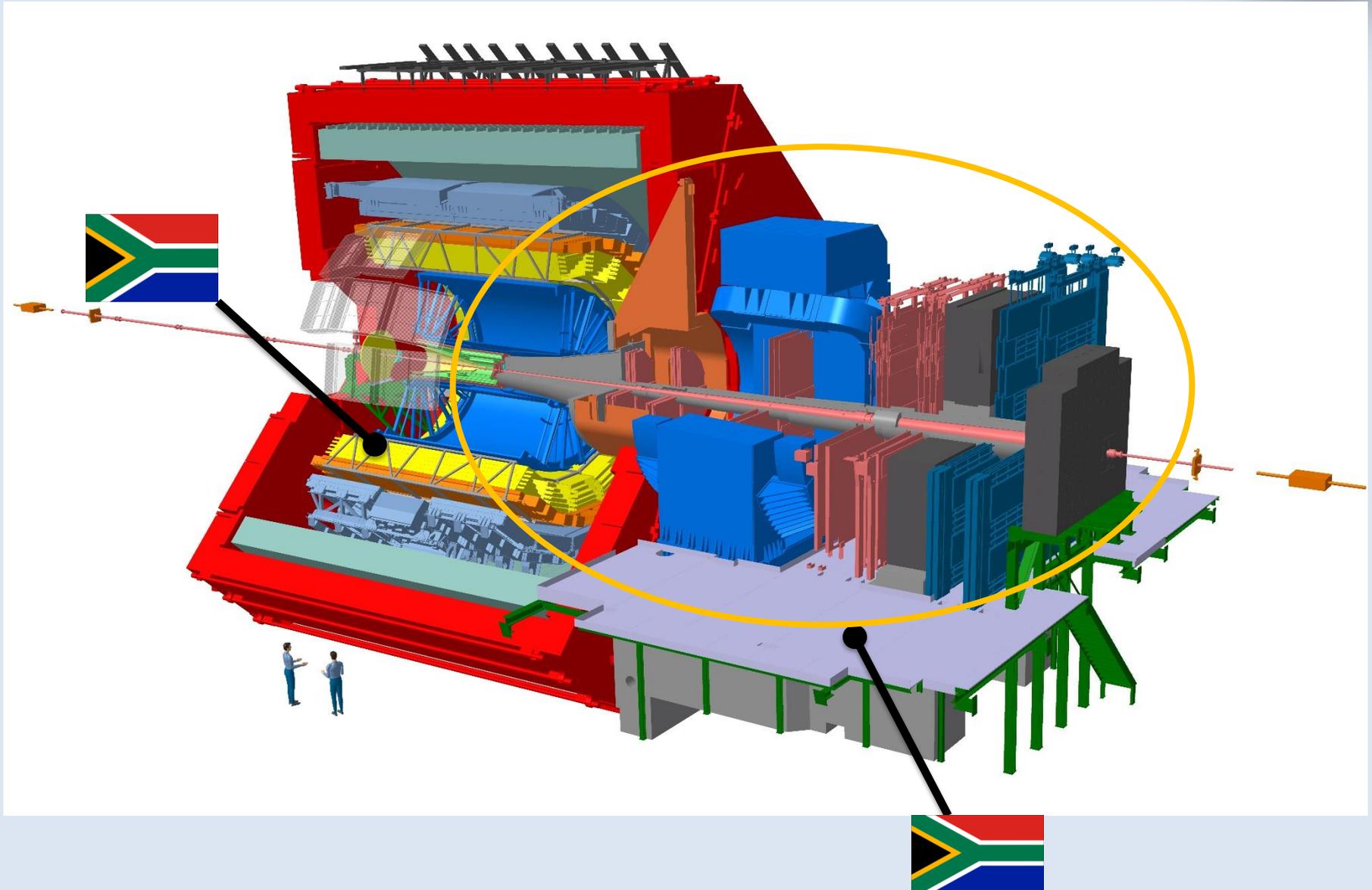


- ❑ Deputy Chair ALICE Collaboration Board (CB): SV Förtsch (2022 -2025 March)
- ❑ Secretary of ALICE CB: SV Förtsch (2020-2022)
- ❑ Run Manager: Z Buthelezi, B Naik
- ❑ Junior ALICE Ambassador for SA: Nina Nathanson (2022 – 2024 June)
→ Stephan Potgieter (since June 2024)
- ❑ ALICE Editorial Board member: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

Maintenance and Operation



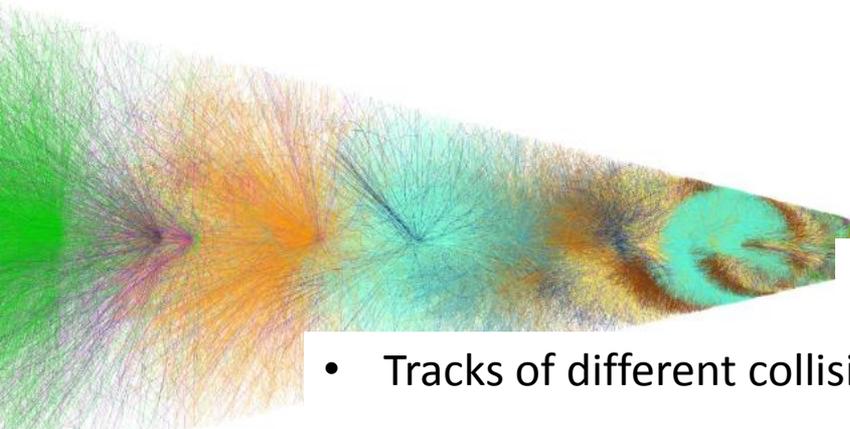
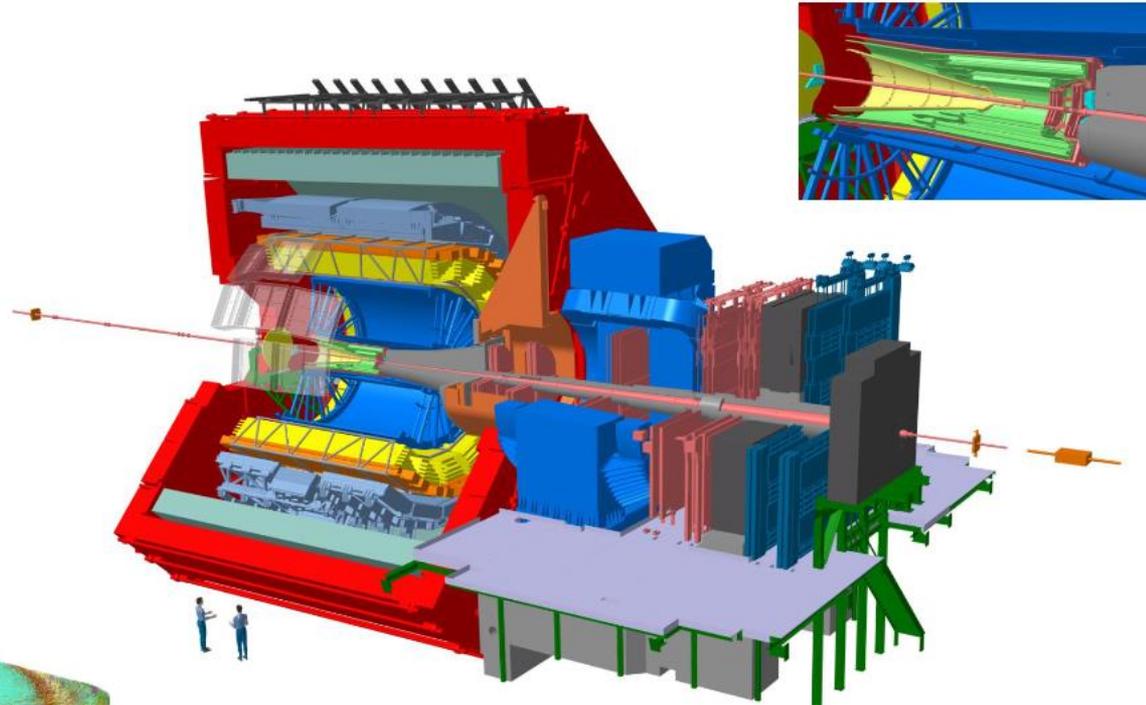
□ ALICE detector in Run 3 (2020-mid2026)



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)



- Home
- My profile
- Tasks
- Accounting
- Projects
- Students
- Expertises
- Locations
- My institutes

ZA - Cape Town - Johannesburg - Somerset West 2024

Member ↑	M&O	Category	Start date	End date	Institute	Assigned FTE
Amit Kumar Mishra		Engineer	2018-03-09	2024-12-31	ZA - Cape Town	0
Andre Sanches Barreiros		Master Student	2020-01-01	2023-09-30	ZA - Cape Town	0
Bharati Naik	M&O	Postdoc	2021-04-12	2025-01-31	ZA - Johannesburg	0
Didier Gerard Cotte		Technician	2020-09-01	2024-10-31	ZA - Johannesburg	0
Edith Zinhele Buthelezi	M&O	Physicist	2007-09-01	2099-12-31	ZA - Somerset West	0.025
Jakobus Stephanus Potgieter		Master Student	2023-01-01	2025-12-31	ZA - Cape Town	0.2
Jason Michael Barrella		Master Student	2020-01-17	2024-09-17	ZA - Cape Town	0
Joyful Elma Mdhululi		PhD Student	2020-09-01	2023-12-31	ZA - Johannesburg	0
Mateusz Arkadiusz Lechman		Guest	2023-07-16	2026-07-31	ZA - Johannesburg	1
Nina Francesca Nathanson		Master Student	2023-02-01	2024-08-31	ZA - Cape Town	0
Retsilisitsoe Mabitsela		Master Student	2021-02-01	2026-01-31	ZA - Johannesburg	0
Rony Koodalil Kuriakose		Guest	2022-12-05	2025-12-31	ZA - Somerset West	0
Salmaan Ahmed Barday		Bachelor Student	2023-03-15	2023-12-31	ZA - Cape Town	0
Sean Murray		PhD Student	2019-01-01	2024-05-31	ZA - Cape Town	0.917
Siegfried Valentin Foertsch	M&O	Physicist	2007-09-01	2099-12-31	ZA - Somerset West	0.25
Silvia Delsanto		Guest	2021-02-06	2024-09-17	ZA - Johannesburg	0
Simon Lucas Winberg		Engineer	2021-02-01	2026-02-01	ZA - Cape Town	0
Tebogo Joyce Shaba		PhD Student	2020-08-01	2025-12-31	ZA - Somerset West	0.25
Thomas Dietel		Guest	2023-09-01	2026-09-30	ZA - Cape Town	0
Vuako Maluleke		Bachelor Student	2023-05-04	2023-12-31	ZA - Somerset West	0
Zabulon Vilakazi	M&O	Physicist	2014-04-01	2028-12-31	ZA - Johannesburg	0

Accounting

- Total M&O-A: 4
- Due FTE: 1
- Assigned FTE: 2.642
- Final FTE: 2.642
- Provisional FTE: 0

264.2% 2.642/1

Composition

- [ZA - Somerset West](#)
- [ZA - Cape Town](#)
- [ZA - Johannesburg](#)



Service Work Credits (FTEs)



ALICE Service Work | 2024 | ebuthele

Home | ZA - Cape Town - Johannesburg | 2024

Member ↑

- [Amit Kumar Mishra](#)
- [Andre Sanches Barreiros](#)
- [Bharati Naik](#)
- [Didier Gerard Cotte](#)
- [Edith Zinhle Buthelezi](#)
- [Jakobus Stephanus Potgieter](#)
- [Jason Michael Barrella](#)
- [Joyful Elma Mdhululi](#)
- [Mateusz Arkadiusz Lechman](#)
- [Nina Francesca Nathanson](#)
- [Retsilisitsoe Mabitsele](#)
- [Rony Koodalil Kuriakose](#)
- [Salmaan Ahmed Barday](#)
- [Sean Murray](#)
- [Siegfried Valentin Foertsch](#)
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264.2%

2.642/1

Composition

- [ZA - Somerset West](#)
- [ZA - Cape Town](#)
- [ZA - Johannesburg](#)

	Assigned FTE
!	0
l	0
urg	0
urg	0
West	0.025
l	0.2
l	0
urg	0
urg	1
l	0
urg	0
West	0
l	0
l	0.917
West	0.25
urg	0
l	0
West	0.25
l	0
West	0
urg	0

page: All 1-21 of 21

Accounting

- Total M&O-A: 4
- Due FTE: 1
- Assigned FTE: 2.642
- Final FTE: 2.642
- Provisional FTE: 0

264.2%

2.642/1

Composition

- [ZA - Somerset West](#)
- [ZA - Cape Town](#)
- [ZA - Johannesburg](#)



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... Q

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

Email Selected Select All

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	Jas on 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 <small>M&O</small>	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 <small>M&O</small>	ZA - Somerset West	Physicist	2007-09-01		6.6	6.6
Profile	Rony Koodalili 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 <small>M&O</small>	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 <small>M&O</small>	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



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... Q

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
Salmaan Ahmed BARDAY	ZA - Cape Town
Andre Sanches BARREIROS	ZA - Cape Town
Jas on Michael BARRELLA	ZA - Cape Town
Edith Zinhle BUTHELEZI	ZA - Johannesburg
Edith Zinhle BUTHELEZI	ZA - Somerset West
Didier Gerard COTTE	ZA - Johannesburg
Silvia DELSANTO	ZA - Johannesburg
Thomas DIETEL	ZA - Cape Town
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Rony Koodalili KURIAKOSE	ZA - Somerset West
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Retsilisitsoe MABITSELA	ZA - Johannesburg
Vuako MALULEKE	ZA - Somerset West
Joyful Elma MDHLULI	ZA - Johannesburg
Amit Kumar MISHRA	ZA - Cape Town
Sean MURRAY	ZA - Cape Town
Bharati NAIK	ZA - Johannesburg
Nina Francesca NATHANSON	ZA - Cape Town
Jakobus Stephanus POTGIETER	ZA - Cape Town
Tebogo Joyce SHABA	ZA - Somerset West
Zabulon VILAKAZI	ZA - Johannesburg
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

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

Previous 1 Next

High Energy Physics (HEP) and Innovation

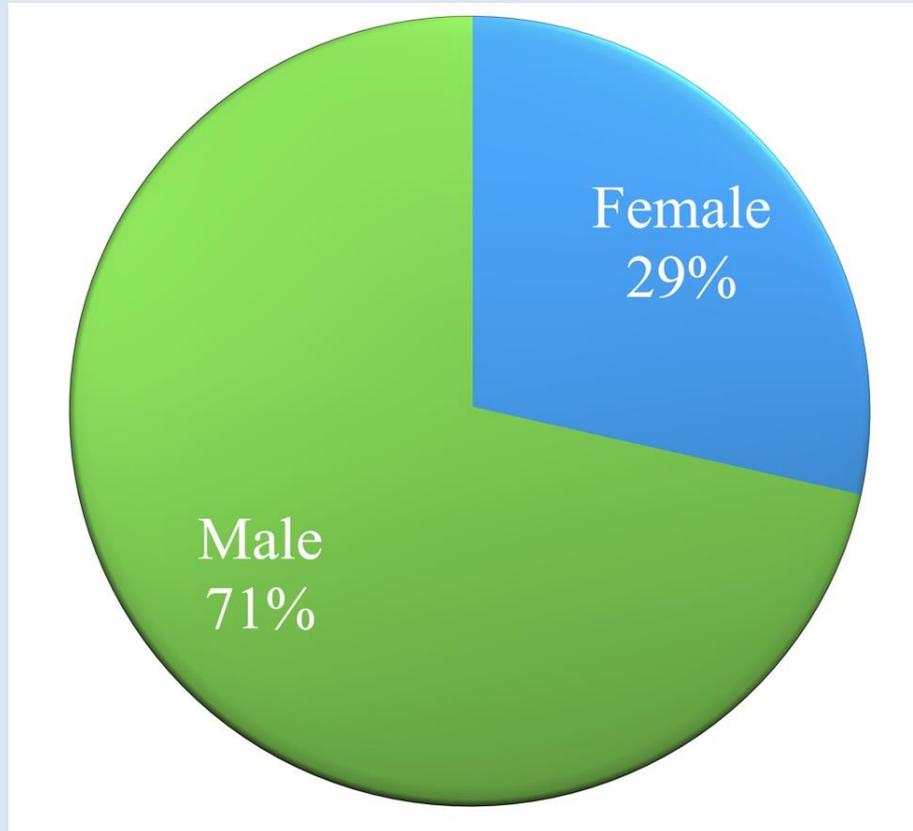
- ❑ Challenges around **detector upgrades** and multi-peta-byte datasets are ideal training environments for **physicists, engineers** and **data/computer scientists**

- ❑ **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



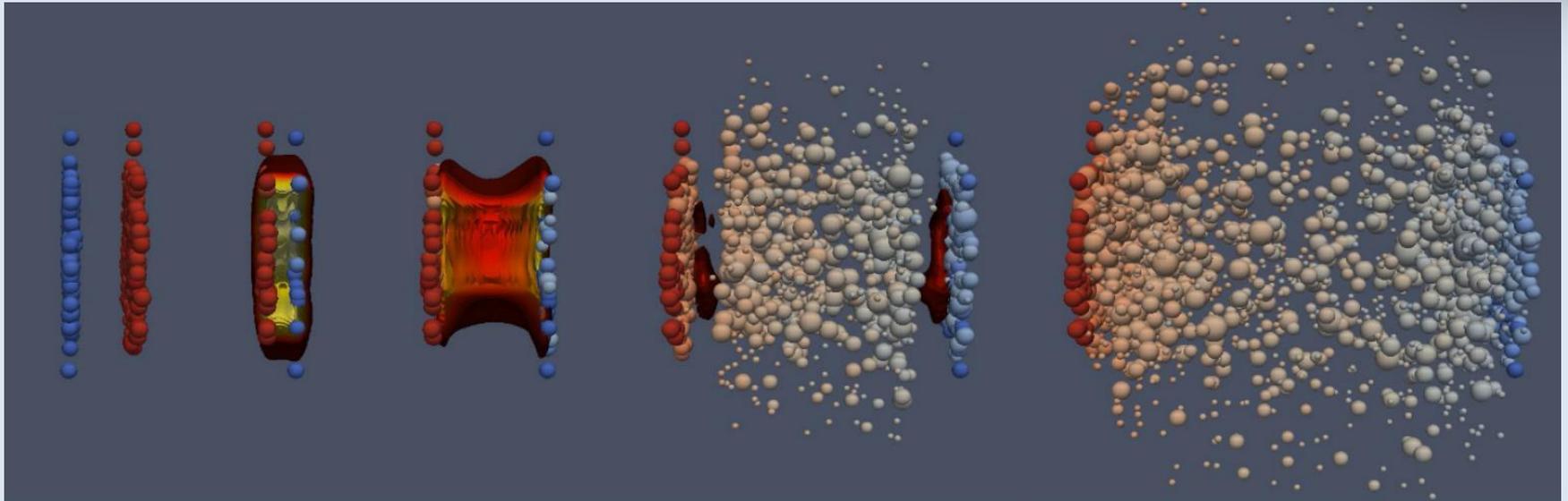
Human Capital development



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

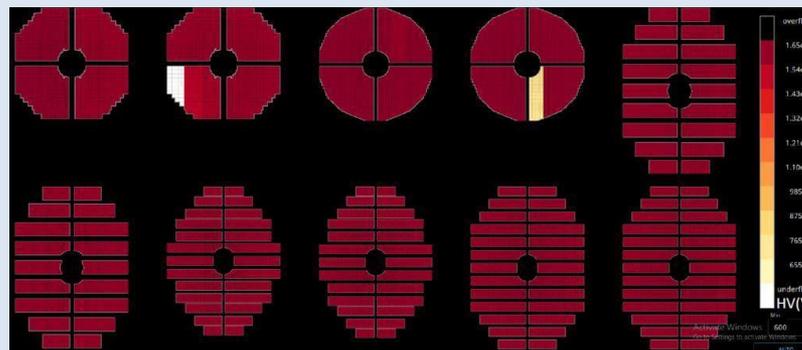
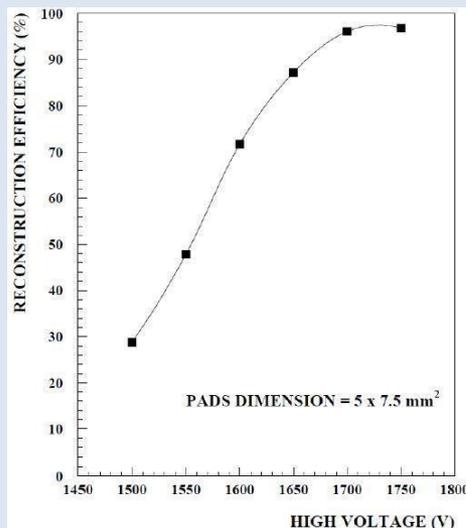
Hadron physics

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



Electron-Muon Correlations in ALICE Run 3: A Feasibility Study

MSc Thesis, N. Nathanson 2023

Background

ALICE is designed to study a state of matter known as the Quark Gluon Plasma (QGP). Quarks and gluons can only exist in a deconfined state when the QGP. Heavy flavor quarks that interact with the QGP can realize in the form of hadrons and can be used to study the medium. In order to use heavy flavor quarks in QGP studies, it is important to first understand how they behave in pp collisions with no QGP present.

Motivation

Some species (electron probes (e or μ pairs)) are commonly used to study heavy quarks at ALICE. The μ pair channel could provide a much cleaner low background signal, but it is statistically limited. During LHC Run 3, this may become a more viable option. This study aims to determine the feasibility of studying e - μ pairs, and to provide an estimate of the data sample that would be required to obtain a significant signal.

Simulation

Pythia 8.3 used for full event generation of $\sqrt{s} = 2.76$ TeV pp collisions. Steps are taken to identify resonant quarks and their decay products, detailed information is saved.

Sample Reduction

Multiple investigations to determine the probability that a quark pair produces an observable e - μ pair. All factors that reduce the sample are considered and combined.

Feasibility at ALICE

How many quark pairs can be detected via this method is a unit of time at ALICE, considering luminosity of the detector and the reduced sample cross sections.

Forward Arm

Due to the geometry of the ALICE detector, electrons and muons are observed in two separate regions: the central barrel (electrons) and the forward arm (muons).

Electron Cuts

$|y| < 0.5$
 $p_T > 2 \text{ GeV}/c$
Muon Cuts
 $-4.0 < y < -2.5$
 $p_T > 0.5 \text{ GeV}/c$

Analysis Procedure

An η range is defined for the parent quarks that is slightly smaller than the cut of resonances of the central barrel/forward region, ensuring that $\sim 50\%$ of the decay leptons from the chosen quarks will reach the detector.

Comparison of e - μ pair kinematics and the effects of the chosen cuts

All final state e - μ pairs (left) and e - μ pairs from quark decay (right).

Single quark - electron decay

Single quark - muon decay

Of all the heavy quark pairs simulated around 10% are produced with both quarks meeting the requirements of the respective η ranges.

Simulated events are classified based on the decay of produced quark pairs into a combination of electrons and muons. This reduces the sample by a factor of $\sim 10^3$.

Supervised by Dr. T. Dietel, Dr. Z. Buthelez, Dr. S. Fortsch

☐ 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 Mdhuli
<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





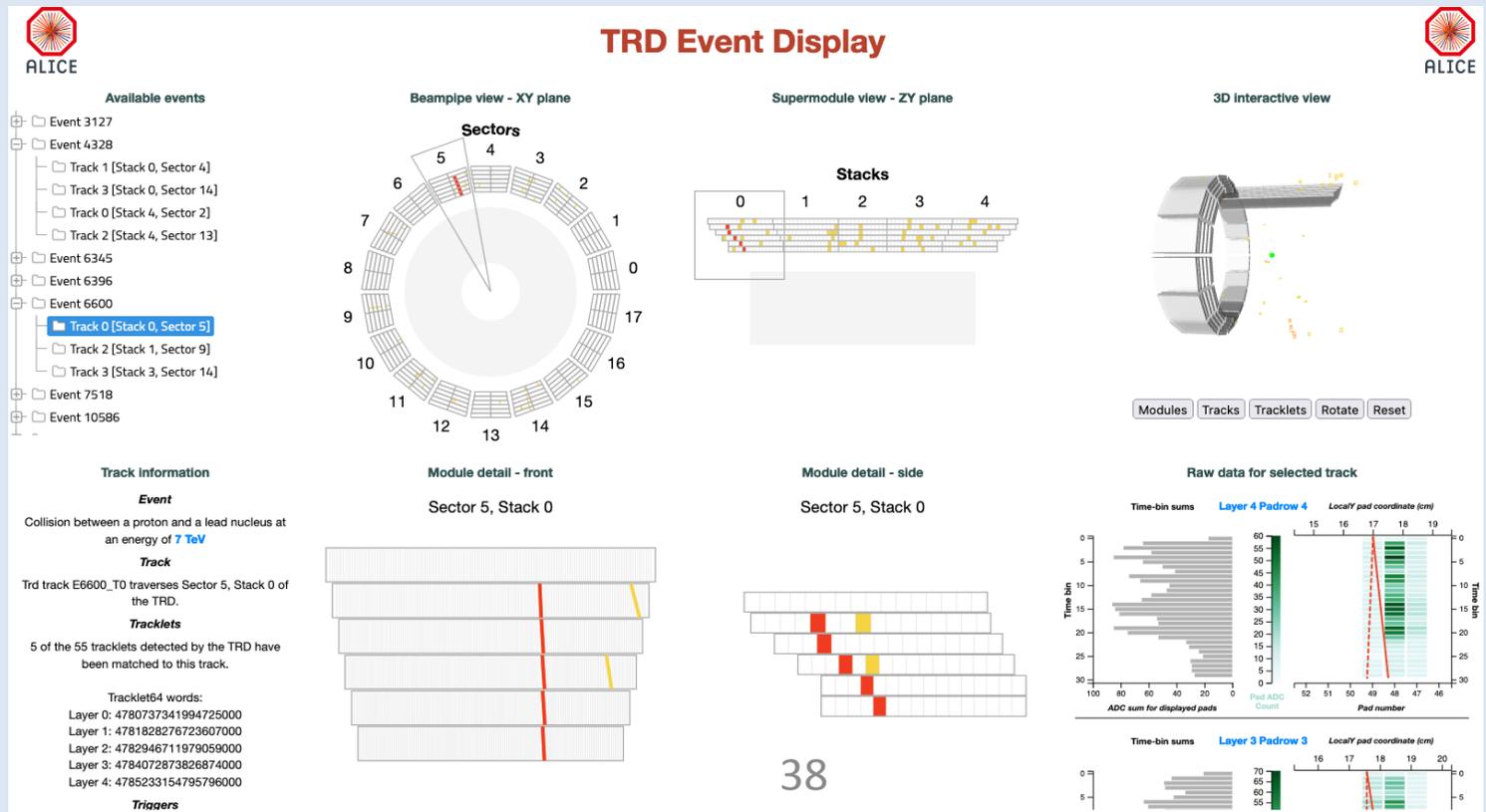
Transition Radiation Detector (TRD)



Development of the new reconstruction software (vertical slice) within the new Online-Offline (O²) 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)



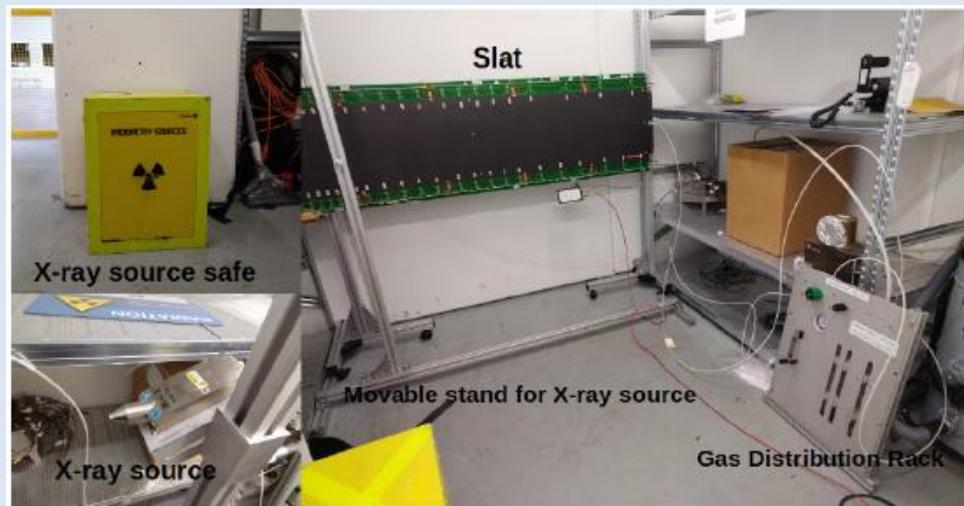


Muon tracking chambers (MCH) for Run 3



Joyful Mdhuli (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)



Visualization of FEC

	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10
LEFT	0/894	1/901	1/883	1/883	1/603	3/611	0/860	0/860	0/950	0/950
RIGHT	5/897	0/902	1/883	11/873	0/604	4/610	7/853	111/749	1/949	1/949

EXIT

