

South Africa Activities in ALICE



ALICE

**Zinhle Buthelezi,
for SA-ALICE**

**First ASFAP Particle Physics Day,
African Strategy for Fundamental Physics & Applications
18 November 2021**



SA-CERN

- home to all CERN research in South Africa
- 6 universities + NRF-iThemba LABS
- more than 60 scientists

ALICE

- heavy-ion physics
- quark-gluon plasma
- 3 institutes



ALICE

ATLAS

- particle physics
- Higgs physics
- SUSY, BSM
- 4 institutes



ISOLDE

- rare isotope facility
- nuclear and atomic physics
- 4 institutes

ISOLDE

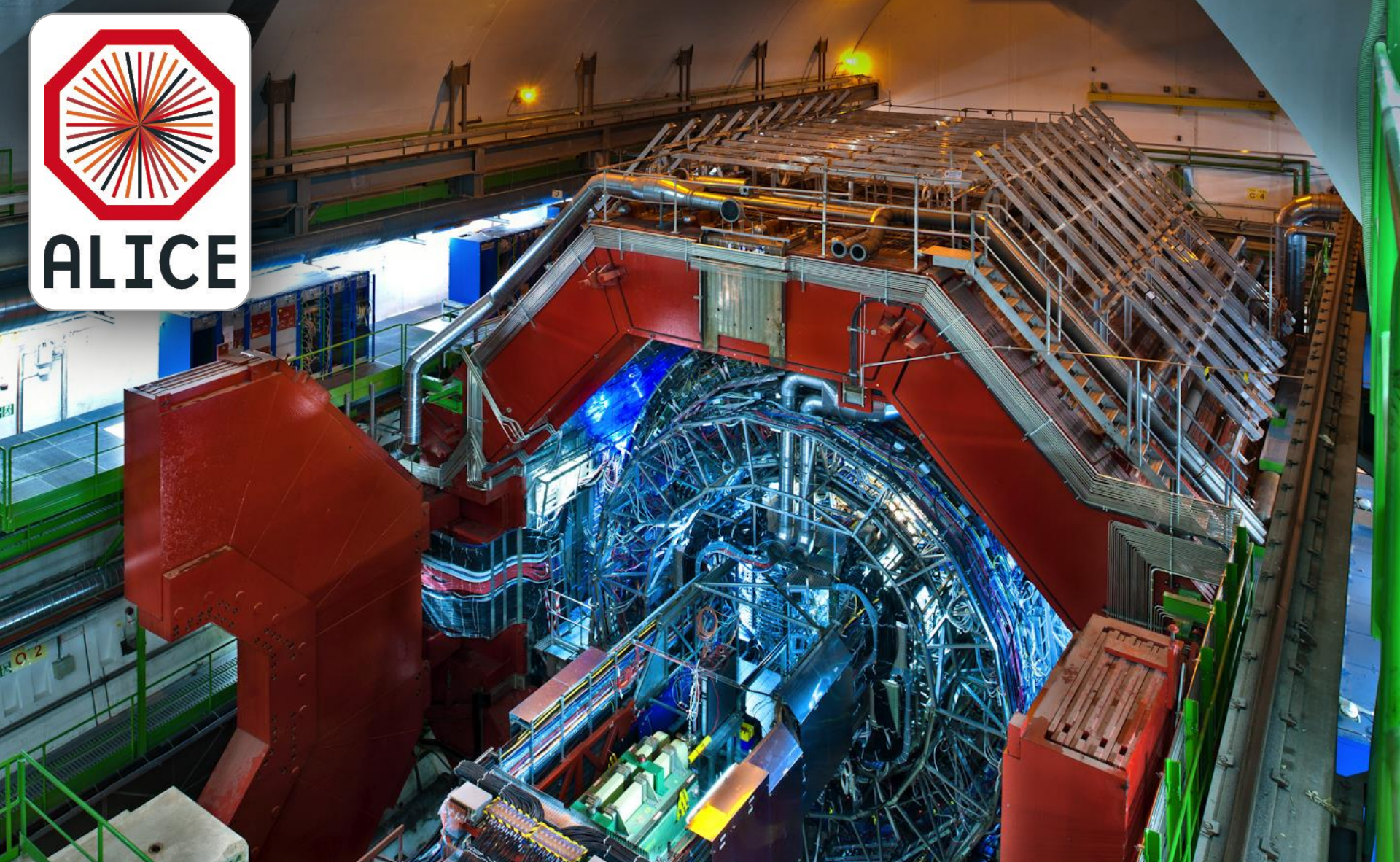
Theory

- particle, heavy-ion and nuclear physics
- 3 institutes





ALICE

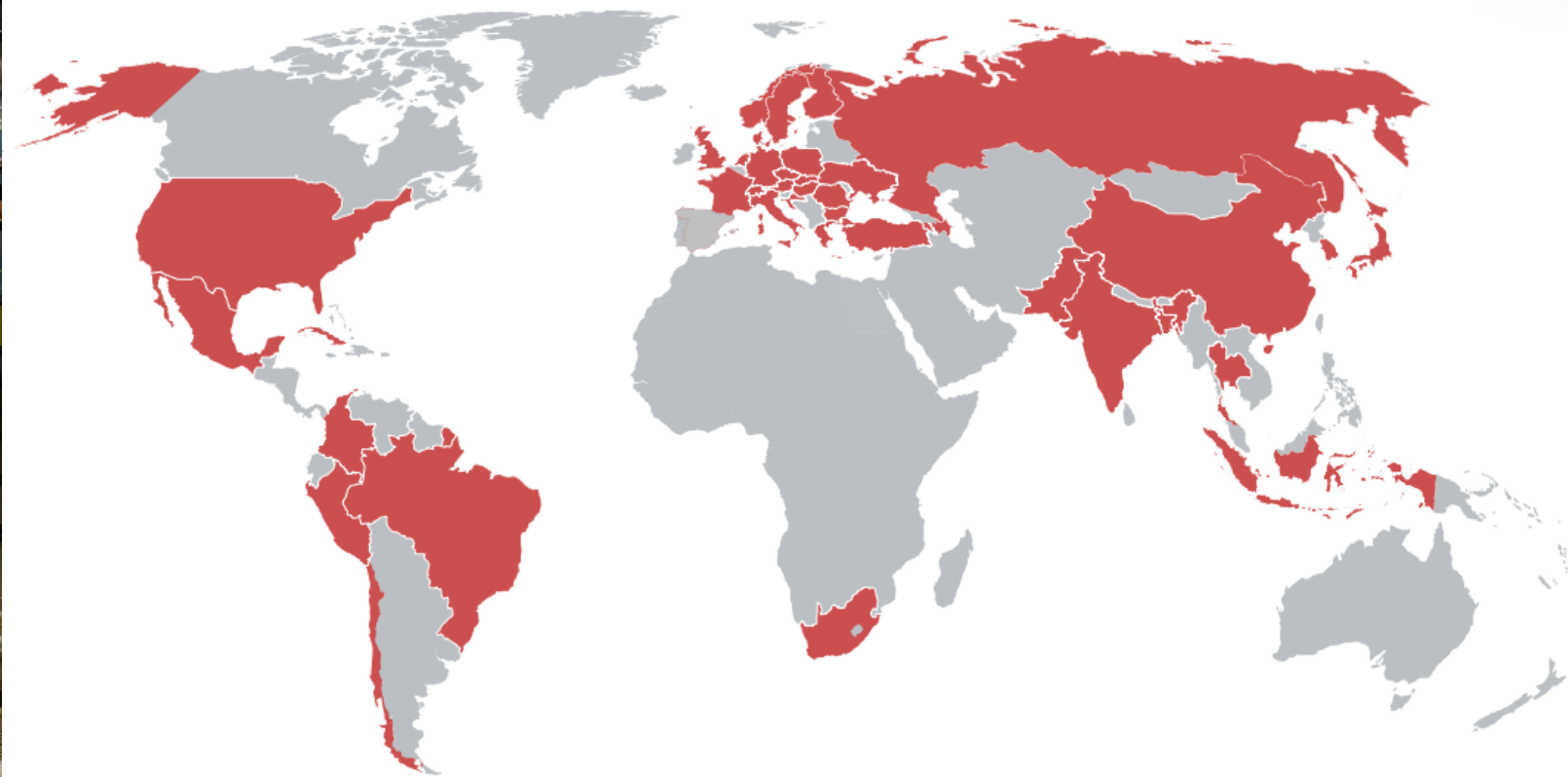


Dedicated heavy-ion experiment at the LHC
Study the Quark-Gluon Plasma created in heavy-ion collisions
Study also proton-proton and proton-lead

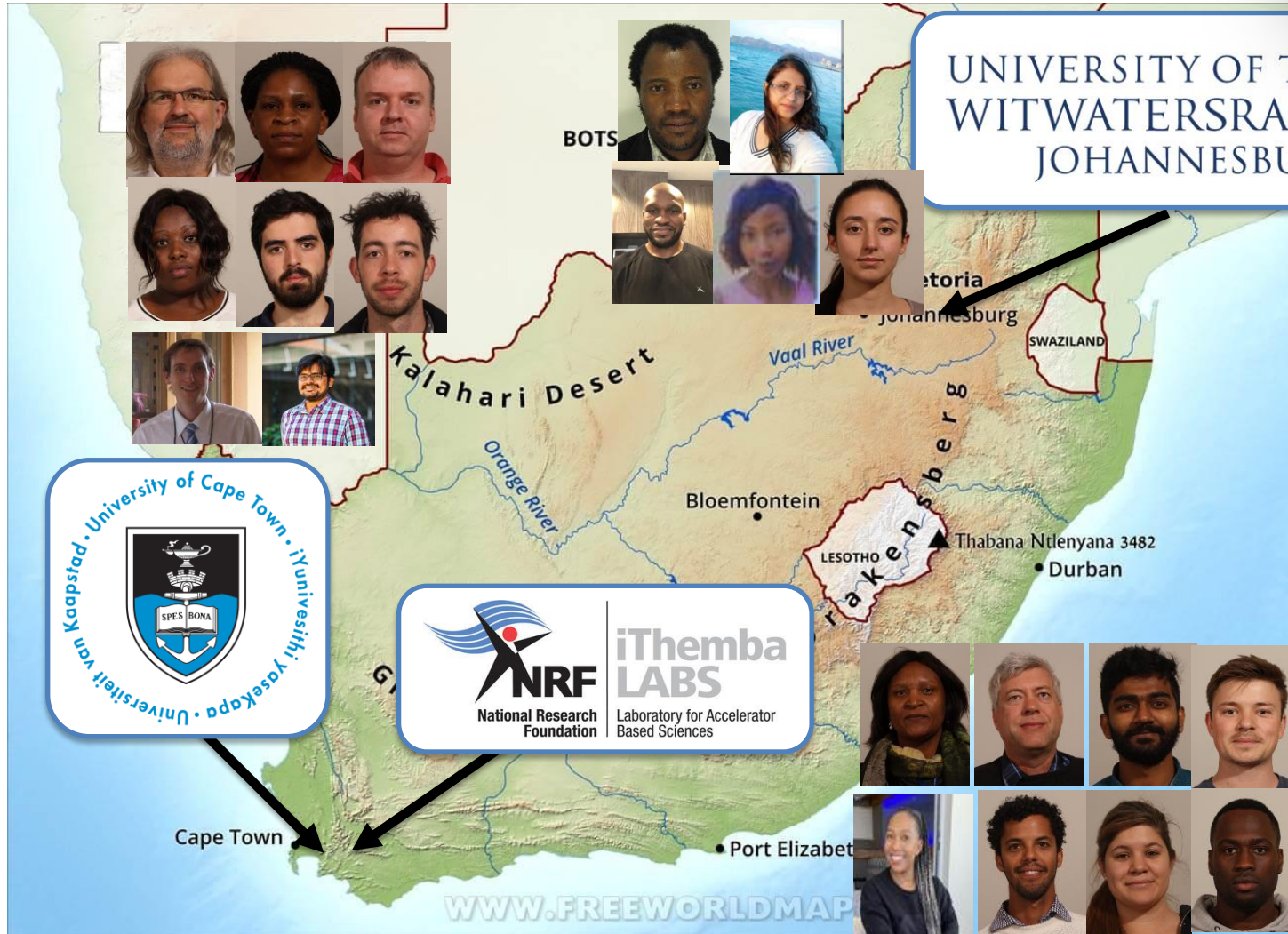
The ALICE Collaboration



41 Countries, 178 Institutes, 1981 Members



ALICE in South Africa



South Africa and ALICE

Transition Radiation Detector



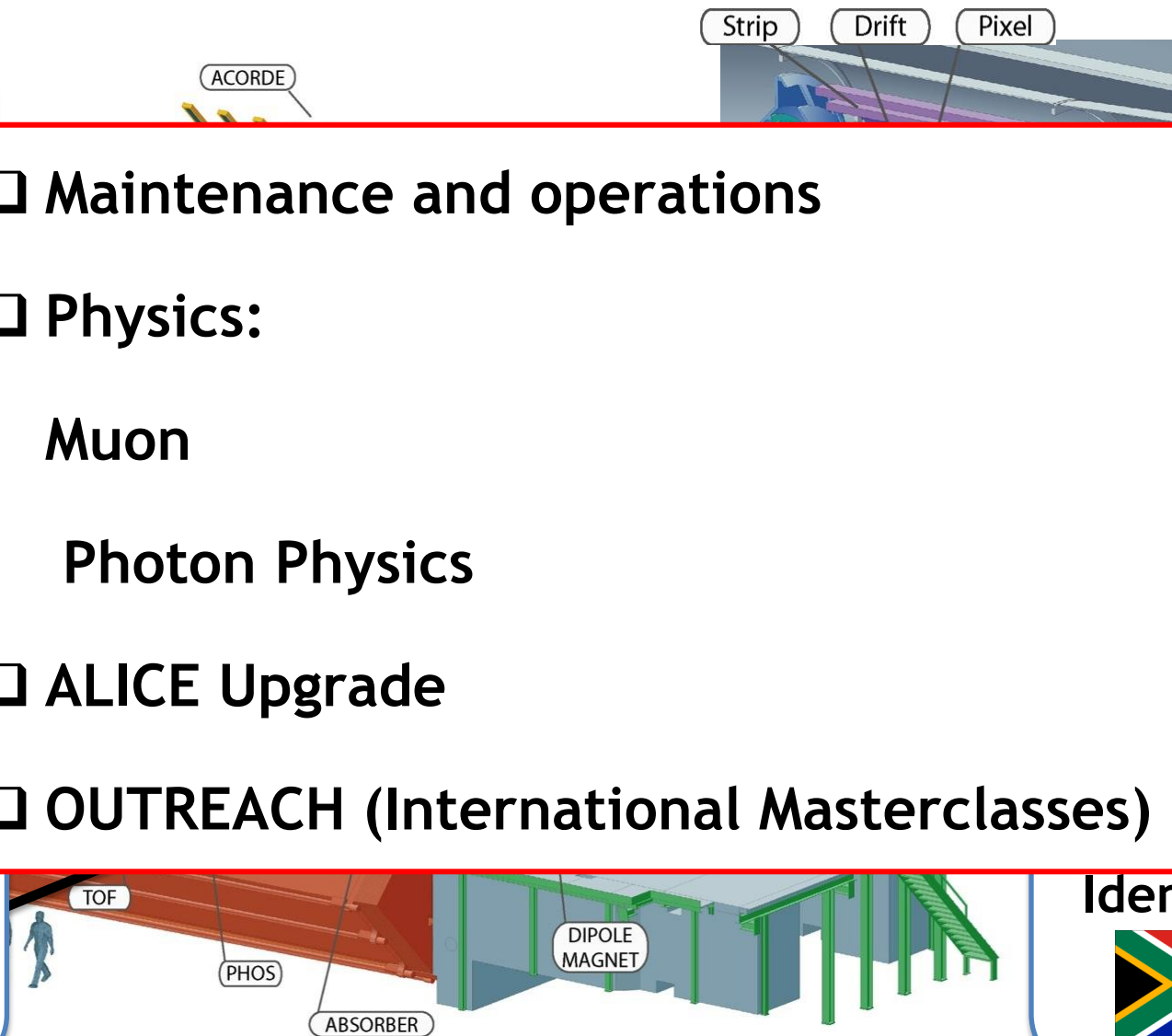
ZDC
~116m from I.P.

VO
TO

Muon Tracker



- Maintenance and operations
- Physics:
 - Muon
 - Photon Physics
- ALICE Upgrade
- OUTREACH (International Masterclasses)

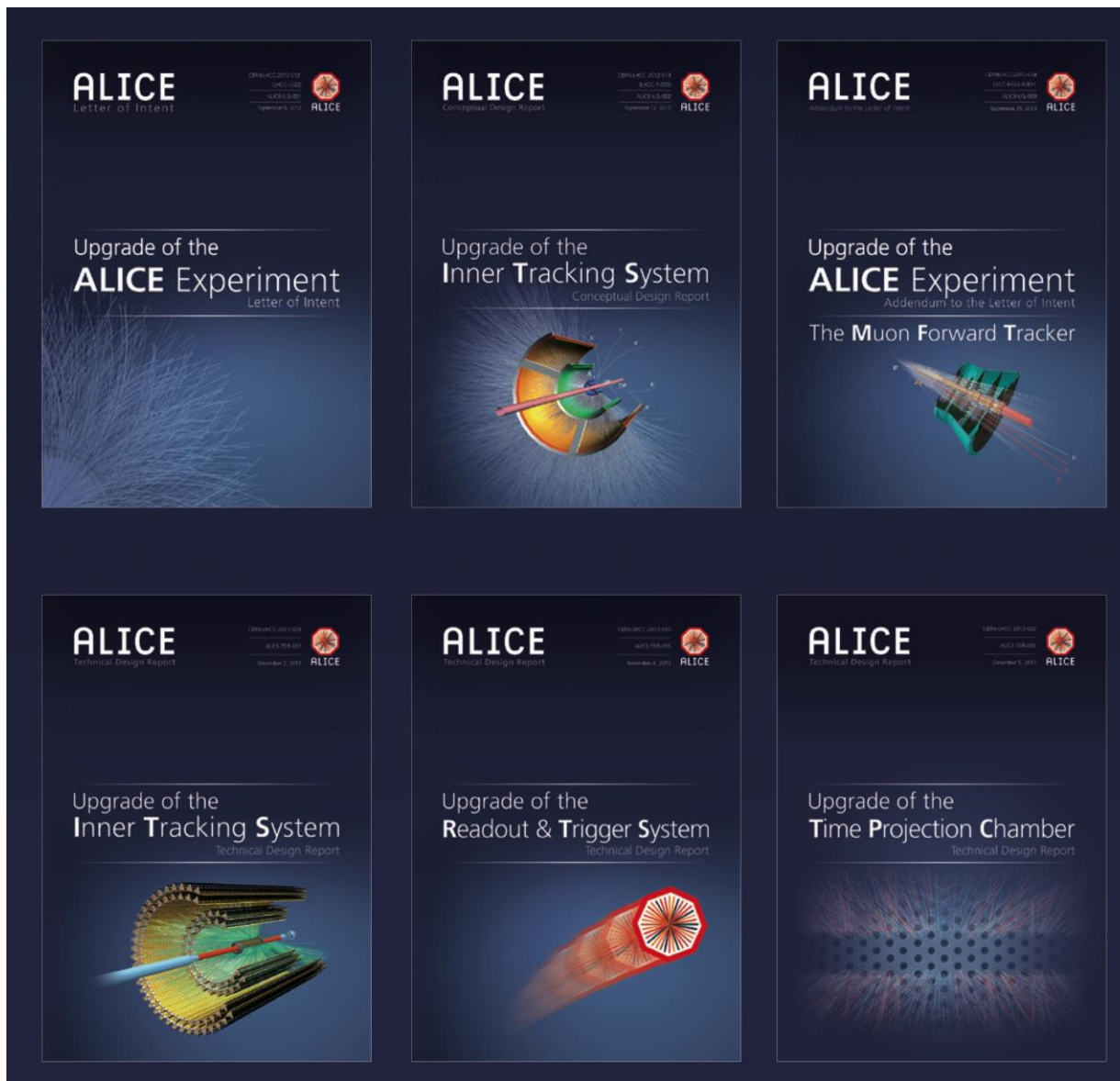


ALICE Collaboration

Identifier



ALICE Upgrade



Main Goal:

- 100x more collisions
- 50 kHz event rate
- all events recorded

Scheduled for
2019/21



ALICE

record all data seen by ALICE
1 timeframe 2ms@50kHz

expected data rate 3 TB/s
re-think readout, computing, analysis

Upgrade Projects



Muon Identifier: Common Readout Unit

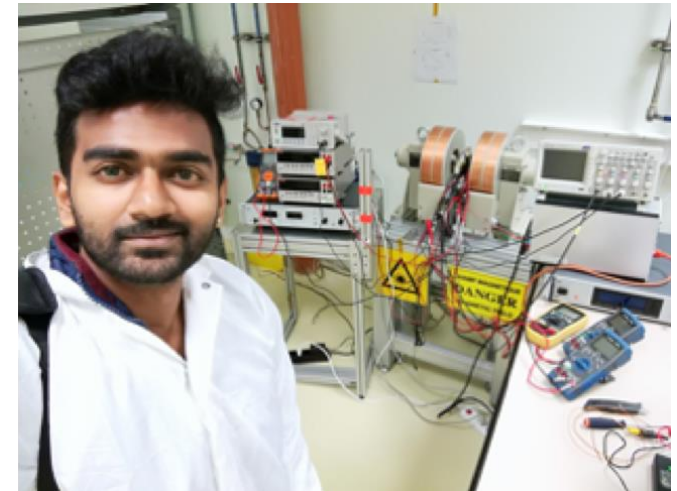
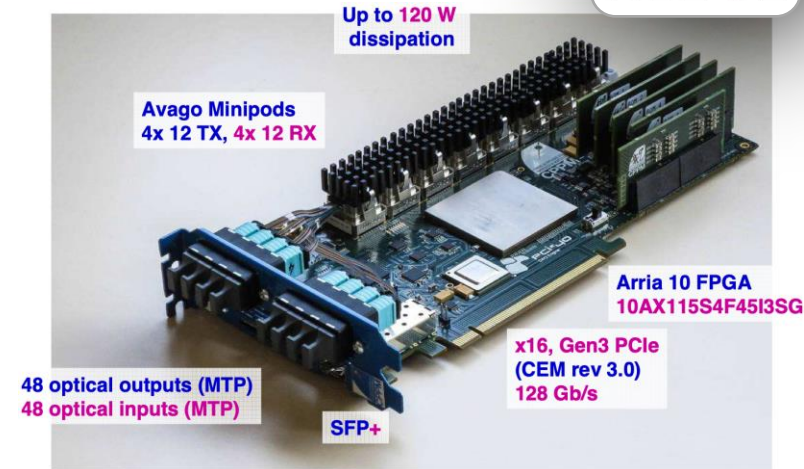
- VHDL firmware development
- Gen3 x16 PCIe card with Arria-10 FPGA and 48 optical inputs/outputs
- on-the-fly data conditioning @ 51.2Gb/s
- **Collaboration with French Labs: Subatech in Nantes & Clermont-Ferrand**

Muon Tracking: Low-Voltage System

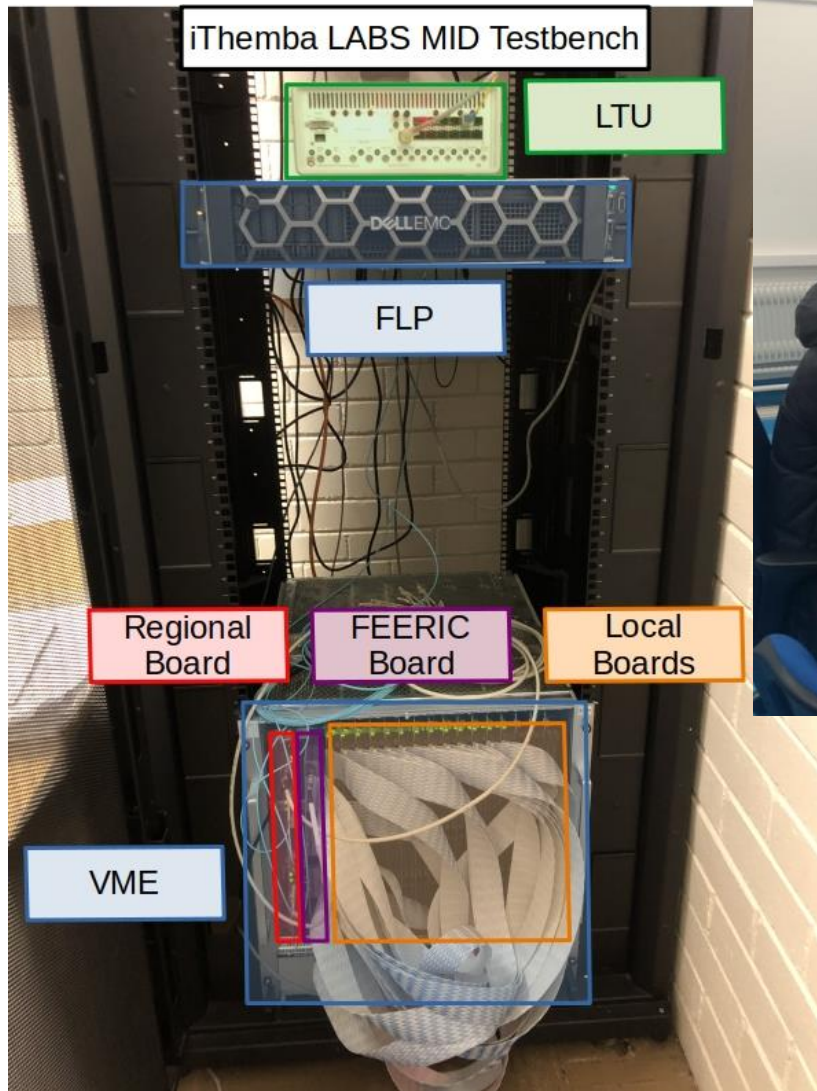
- challenges: high radiation, strong magnetic field
- circuit design, component selection, testing
- control system development
- **Collaboration with Italy (Cagliari) & France (Saclay and Orsay)**

Transition Radiation Detector: Online Data Processing

- simulation, calibration and reconstruction
- integrated in ALICE Online-Offline (O^2) upgrade
- distributed high-throughput computing @ 5GB/s
- **Collaboration with German institutes**



MID Readout Test Stand @ iThemba LABS



Muon Identifier (MID) Common Readout Unit (CRU)

- FPGA/VHDL CRU firmware development
- High-throughput electronics
- Full setup of MID electronics, trigger, DAQ

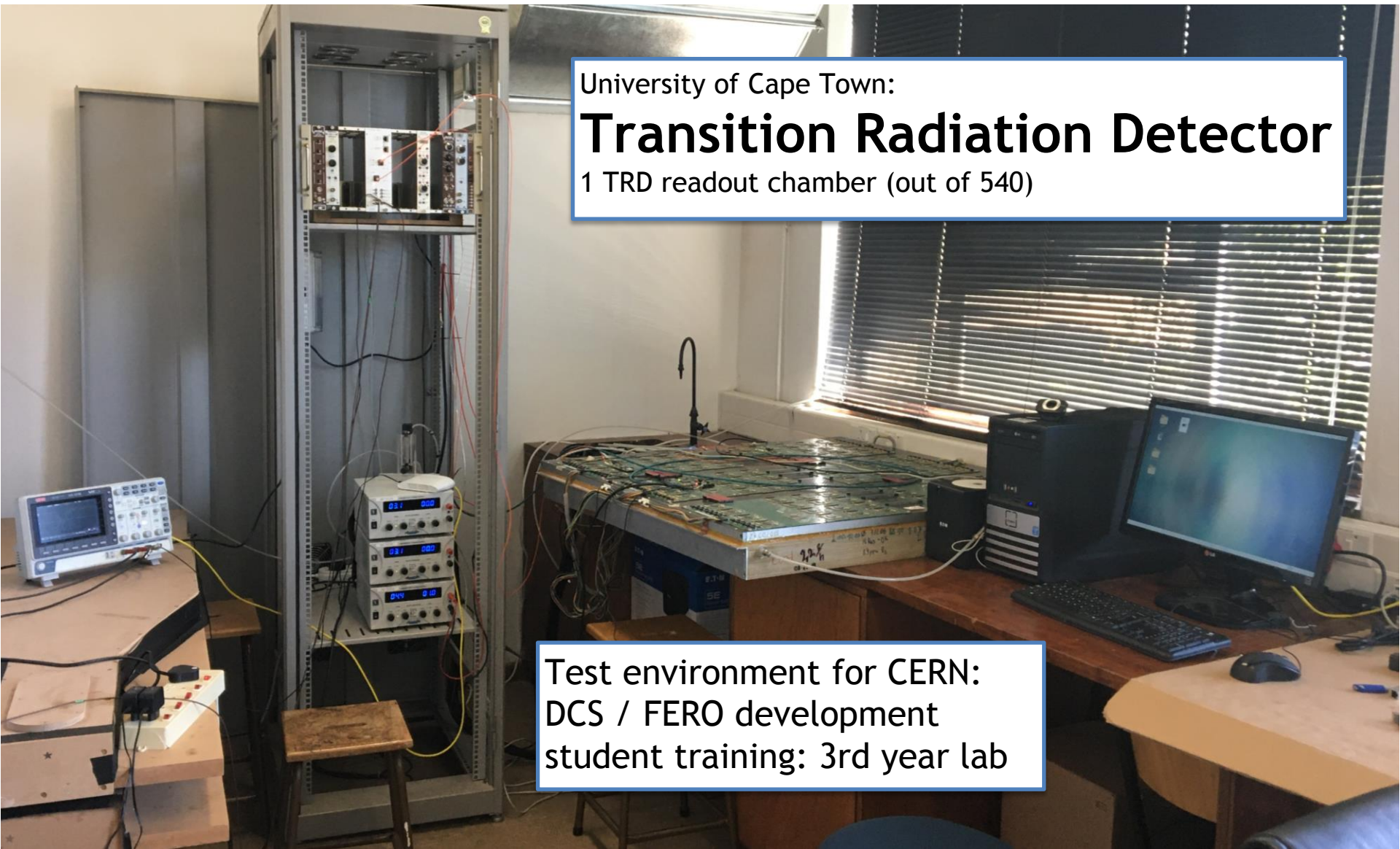
TRDlab @ UCT

University of Cape Town:

Transition Radiation Detector

1 TRD readout chamber (out of 540)

Test environment for CERN:
DCS / FERO development
student training: 3rd year lab



Remote Operation Site @ UCT



- Travel restrictions for many countries
- Limited availability of shifters at CERN in 2021
- Fall-back solution for 2022

Outreach: International Masterclasses



International programme led by CERN
“one day as a physicist”
up to 50 students from 25 schools
per year
Pandemic: Online masterclasses??

Key Skills

Digital Electronics (Readout electronics)

- High speed optical networks
- Data formatting and filtering

Circuit Design (Low-voltage system)

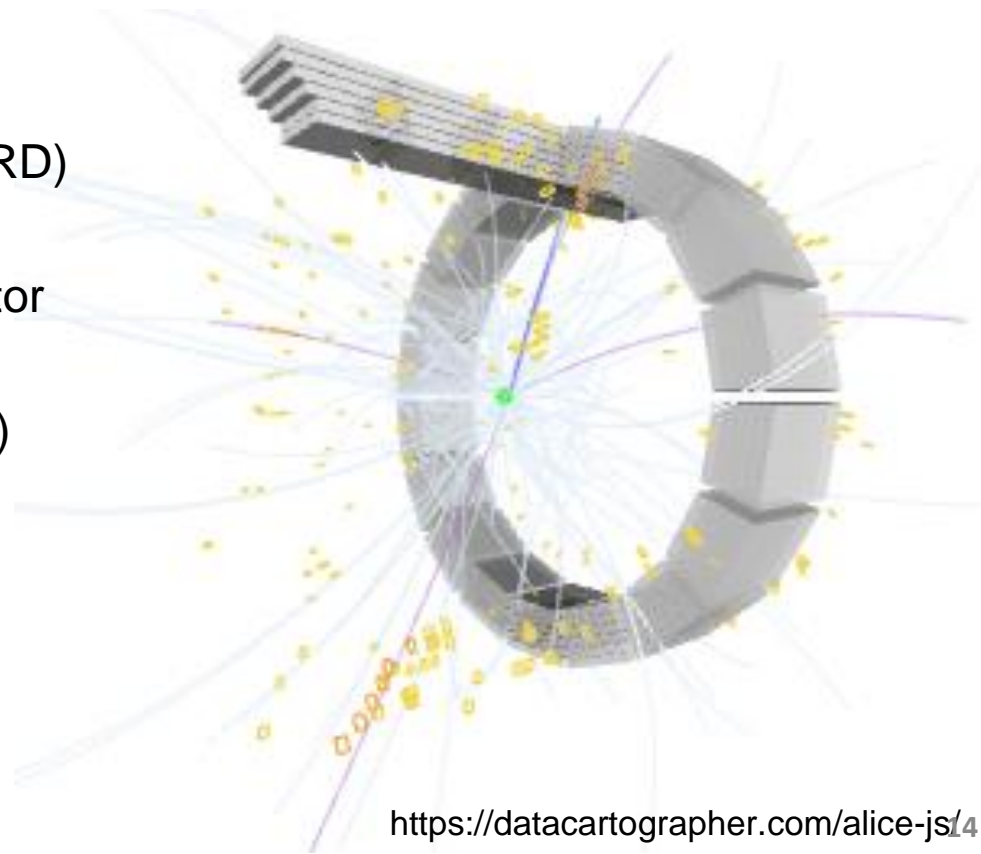
- PCB design and evaluation

Control Systems (DCS for muon LV, TRD)

- Siemens WinCC SCADA system
- Remote control of entire ALICE detector

Data Science (Online/offline processing)

- Data reconstruction & calibration



Challenges

Student Bursaries

- Limiting factor
- SA-CERN bursaries help
- Planning uncertainty

Post-Docs

- Important step towards academia
- Expansion of supervisory capacity

ALICE Students 2009-2020: Where are they now?

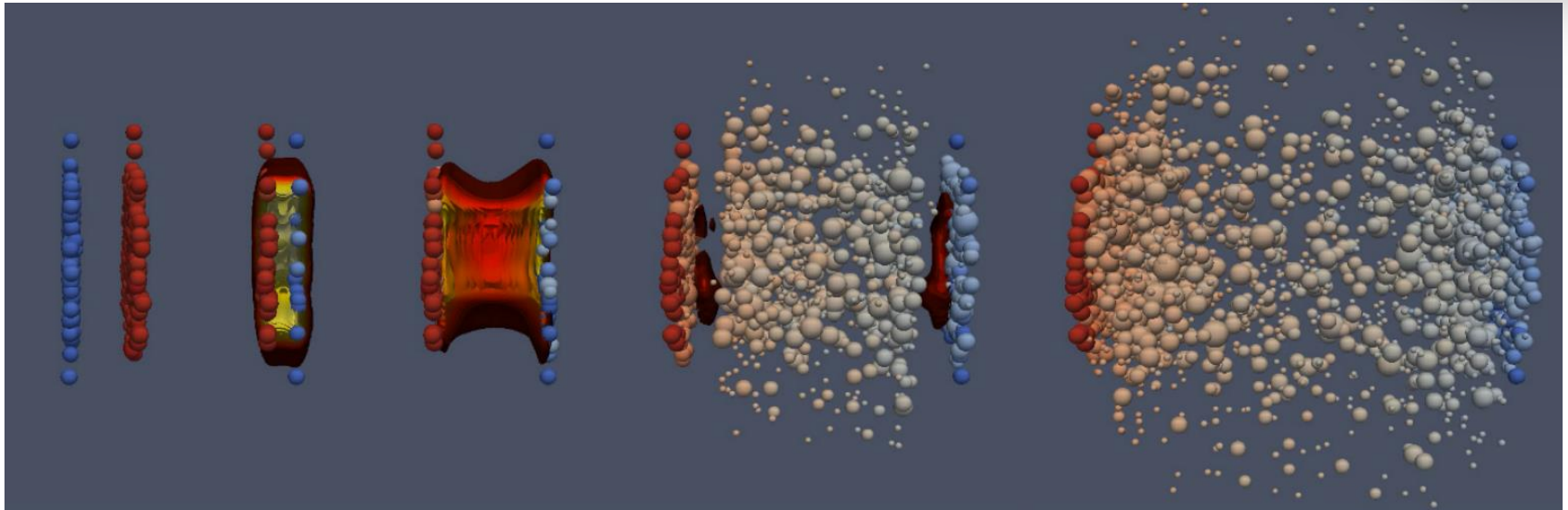


Johnson K Senosi	PhD (HEP)	Data Quality Analyst, FNB, Johannesburg
Sibalisio Mhlanga	PhD (HEP)	Post Doctoral fellow, iThemba/UCT
Silvia Delsanto	PhD (HEP)	Data Analyst, Stage Presso Avenada, Milan (Italy)
Christine Monteverdi	MSc (HEP)	Research Associate, Proclinical Group (Cape Town/Switzerland)
Pieter Du Toit	MSc (HEP)	Scientist - NMISA
Seforo Mohlalisi	M Eng - Muon Software	Lecturer, National University of Lesotho
Nathan Boyles	M Eng - MID readout	Firmware Engineer, Kutleng Dynamics Electronics Systems, Johannesburg
René Monteverdi	Intern - MID readout	Software developer, Cape Town
Fabrice Nininahazwe	Intern - HP Computing	IT - Hong Kong

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

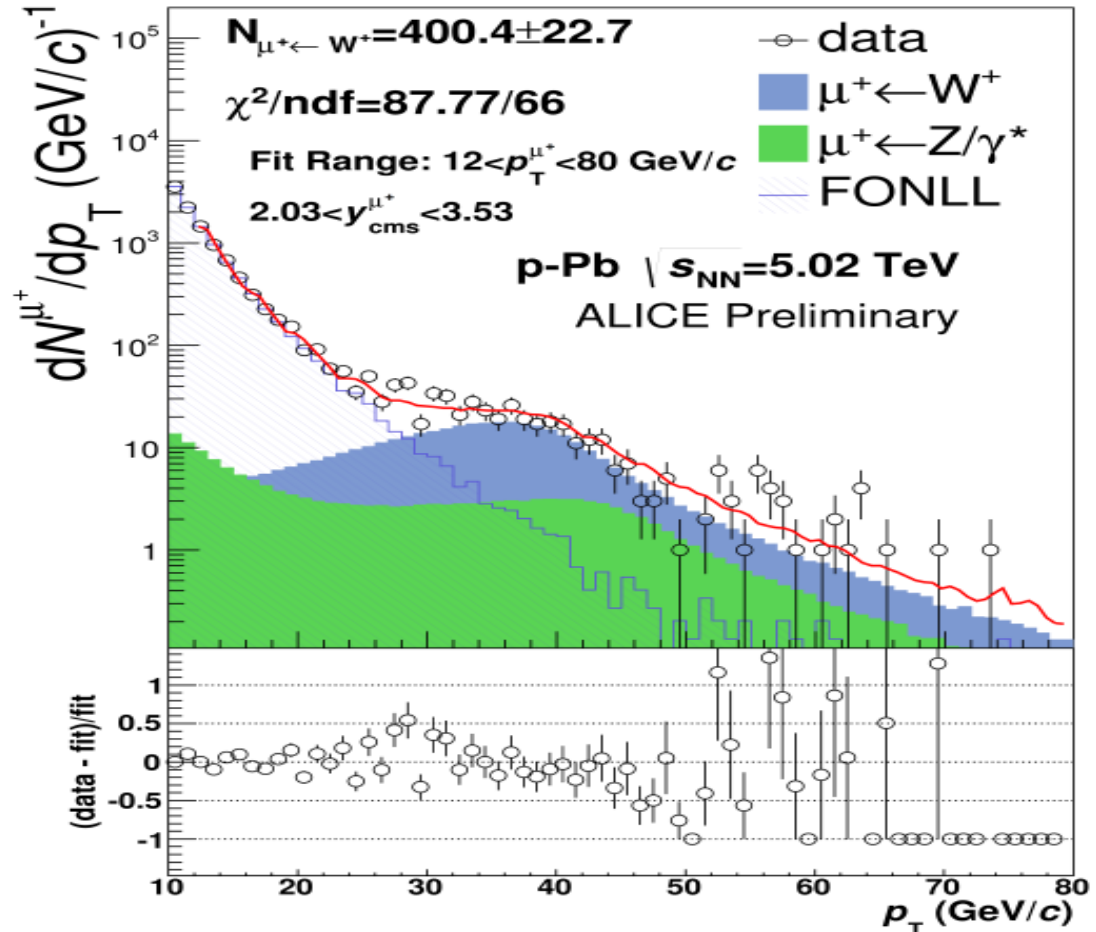
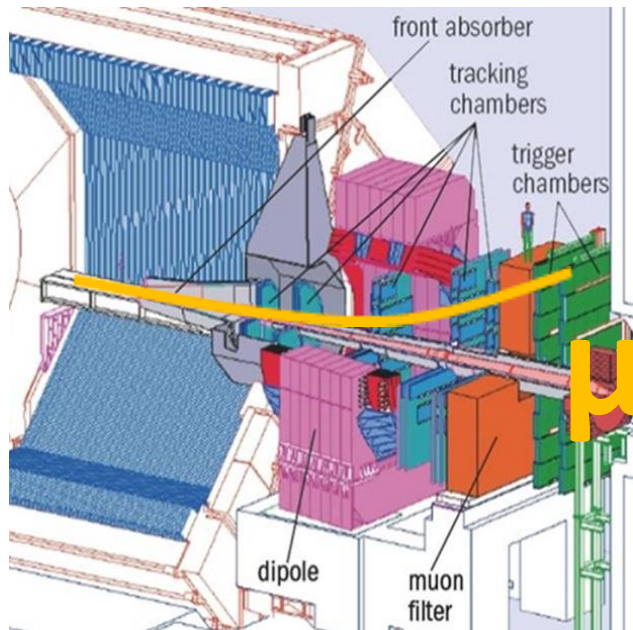
Hadron physics

W-Boson – Standard Model Test

pp: PDFs at large Q²

p-Pb: Cold Nuclear Matter (CNM) effects, nuclear PDFs

Pb-Pb: binary collision/ N_{coll} scaling of hard processes



ALI-PREL-82168

Work done in collaboration with Subatech (France) and Wuhan (China)

W Boson Paper



PUBLISHED FOR SISSA BY SPRINGER

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ACCEPTED: February 4, 2017

PUBLISHED: February 15, 2017

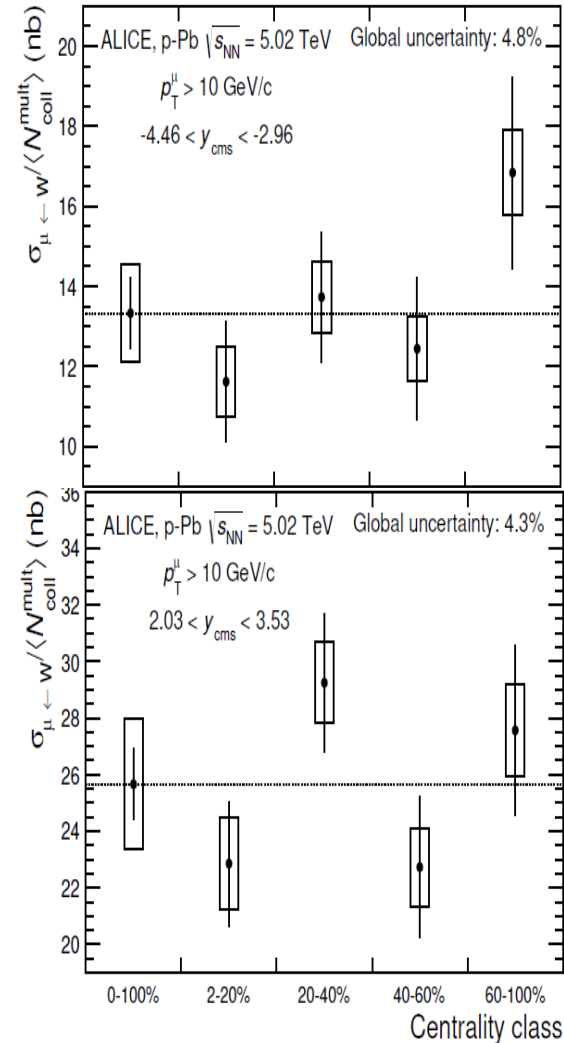
W and Z boson production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV



ALICE
The ALICE collaboration

E-mail: ALICE-publications@cern.ch

ABSTRACT: The W and Z boson production was measured via the muonic decay channel in proton-lead collisions at $\sqrt{s_{NN}} = 5.02$ TeV at the Large Hadron Collider with the ALICE detector. The measurement covers backward ($-4.46 < y_{cms} < -2.96$) and forward ($2.03 < y_{cms} < 3.53$) rapidity regions, corresponding to Pb-going and p-going directions, respectively. The Z-boson production cross section, with dimuon invariant mass of $60 < m_{\mu\mu} < 120$ GeV/ c^2 and muon transverse momentum (p_T^μ) larger than 20 GeV/ c is



Cross sections measured at backward and forward rapidities normalised by the average number of binary collisions are.

The results are independent of collision centrality → consistent with expectations

JHEP 1103 (2011) 071

JHEP02 (2017) 077

Heavy-quark production vs multiplicity – since 2014

Differential measurements, e.g. multiplicity-dependence, correlation, etc. are currently “hot” topics at the LHC --> provide insight into mechanisms influencing particle production

Heavy quarks: charm and beauty (also called heavy flavour)

- Produced in the early stages of a collision via hard scattering processes
- They probe the evolution of the collision
- Large amounts of heavy quarks are produced at the LHC

...their production

- In **pp** collisions: Test pQCD theories and use as a reference for

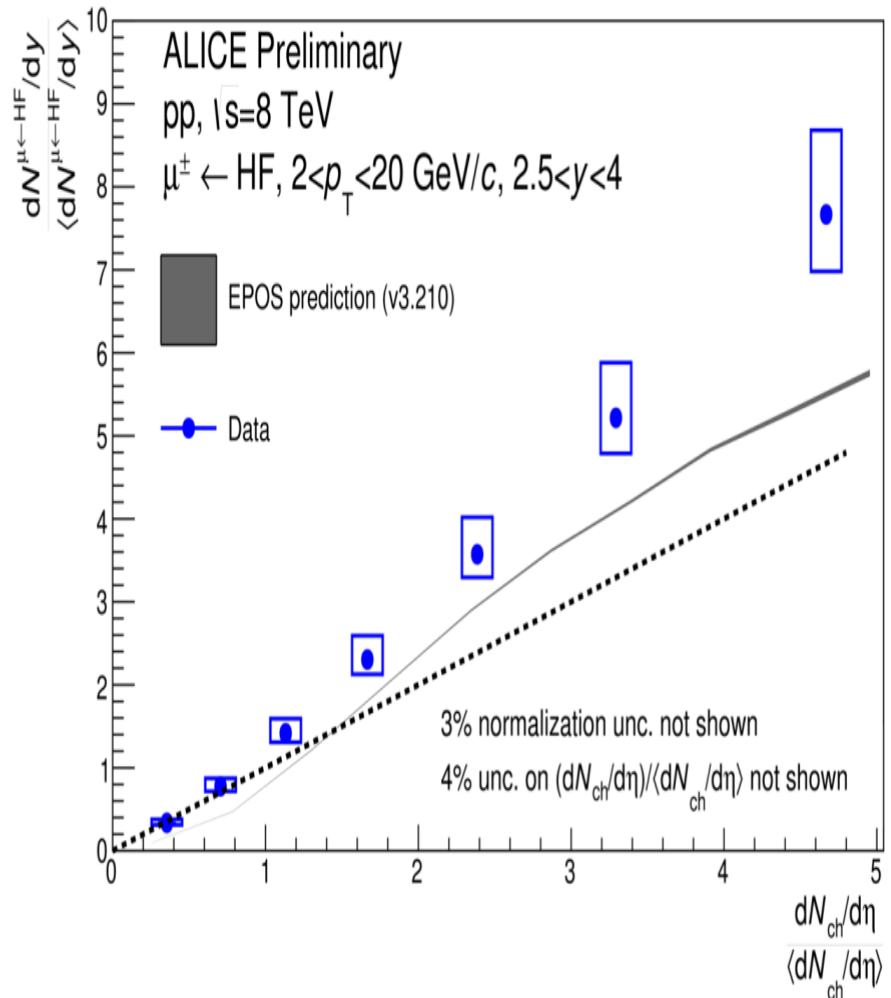
p-Pb and Pb-Pb collisions

- In **p-Pb** collisions: Investigate CNM effects
- In **Pb-Pb** collisions: Study the properties of the QGP

Heavy-quark production vs multiplicity...

- Key observable for multi-parton interactions (MPI)
- Test pQCD-based models of particle production
- Investigate contribution of **hard** and **soft** processes in the production of particles

Work done in collaboration with Lyon (France)



Detectors: Muon Spectrometer and TRD

