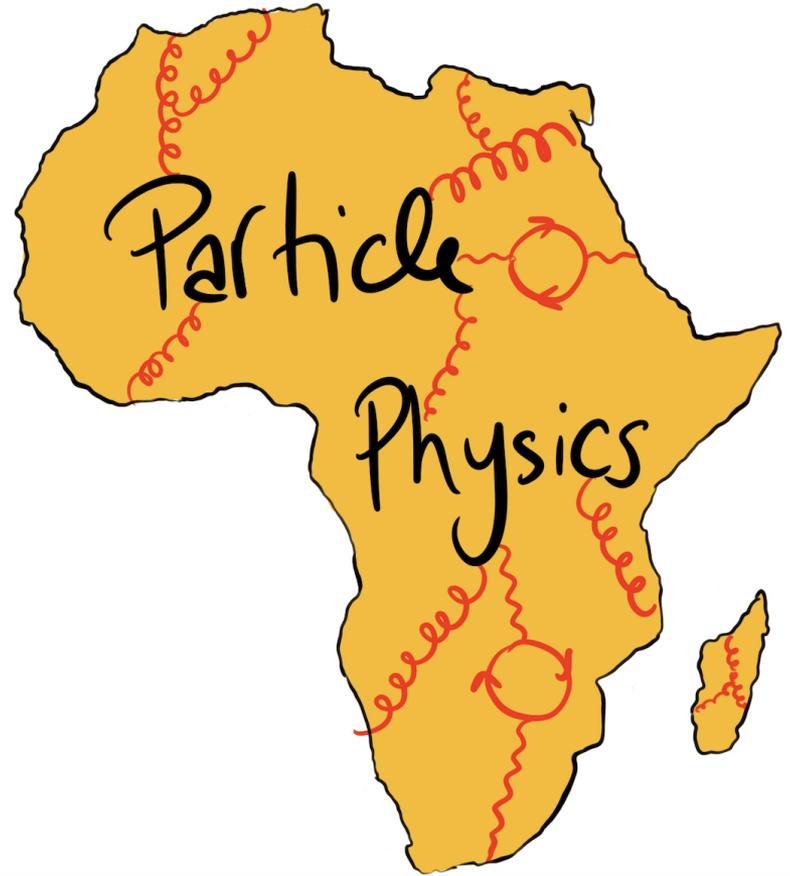


On Particle Physics, ASFAP, and Education in Africa: Status and Challenges

Mohamed Chabab

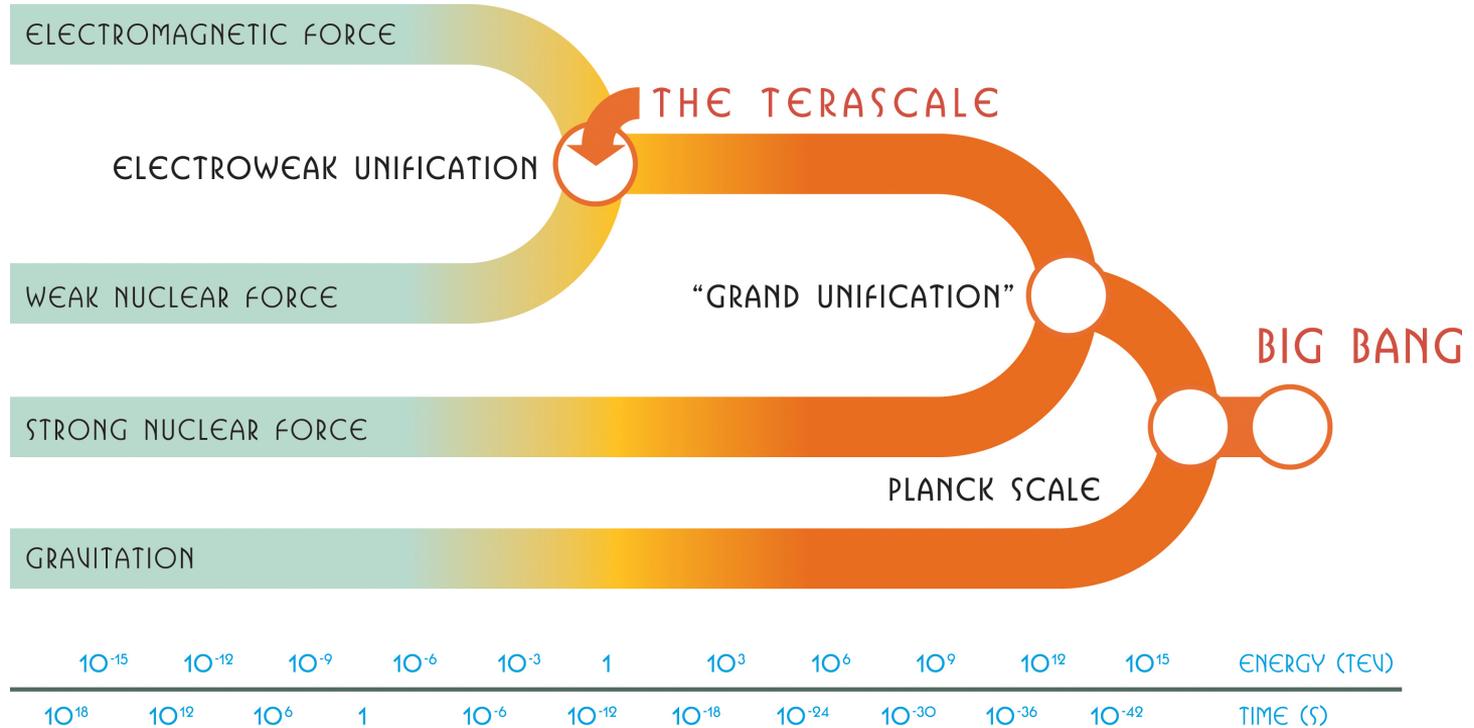
*in collaboration with
Yasmine Amhis and Zinhle Buthelezi*



Outline

- ❑ Overview on Particle Physics: SM and beyond
- ❑ Status of PP activities in Africa
- ❑ ASFAP vision: PP Working group
- ❑ PP impacts on Education

Particle physics reveals the profound connections underlying all observed phenomena..From the smallest to the largest structures in our Universe.



Particle Physics in a nutshell

Standard Model of Elementary Particles

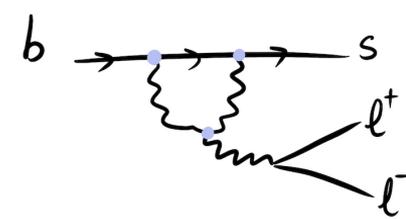
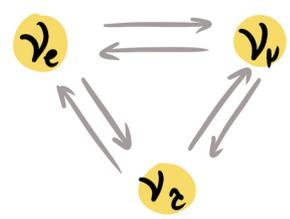
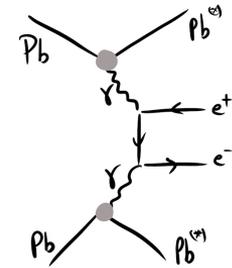
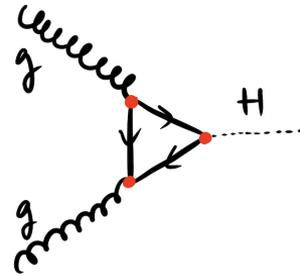
	three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III		
mass	=2.2 MeV/c ²	=1.28 GeV/c ²	=173.1 GeV/c ²	0	=124.97 GeV/c ²
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
	u up	c charm	t top	g gluon	H higgs
	d down	s strange	b bottom	γ photon	
	e electron	μ muon	τ tau	Z Z boson	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

QUARKS (left side of table)

LEPTONS (left side of table)

SCALAR BOSONS (right side of table)

GAUGE BOSONS VECTOR BOSONS (right side of table)



Standard Model Framework

Particle physics has a “Standard Model” of particles and their interactions: GSW



New York Times, July 5, 2012

Physicists Find Elusive Particle Seen as the Key to Universe

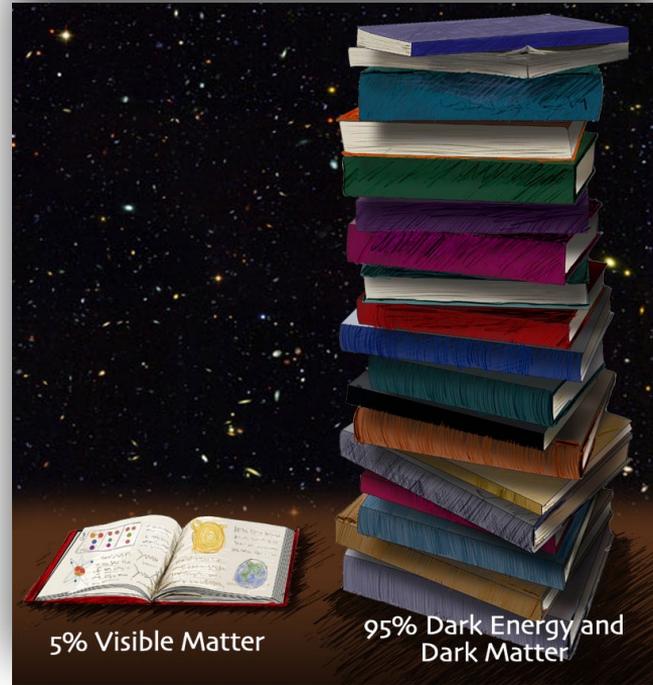


POOL PHOTO BY DORIS BALBUENA

Physicists in Geneva applauded the discovery of a subatomic particle that looks like the Higgs boson.

The SM cannot be complete

- It doesn't explain:
 - Neutrino masses
 - The pattern of fermion masses
 - Baryon asymmetry
 - Dark matter/energy



95% of the mass of the universe is **dark matter** and **dark energy** :
Not explained by the Higgs boson !

BSM: plethora of Models

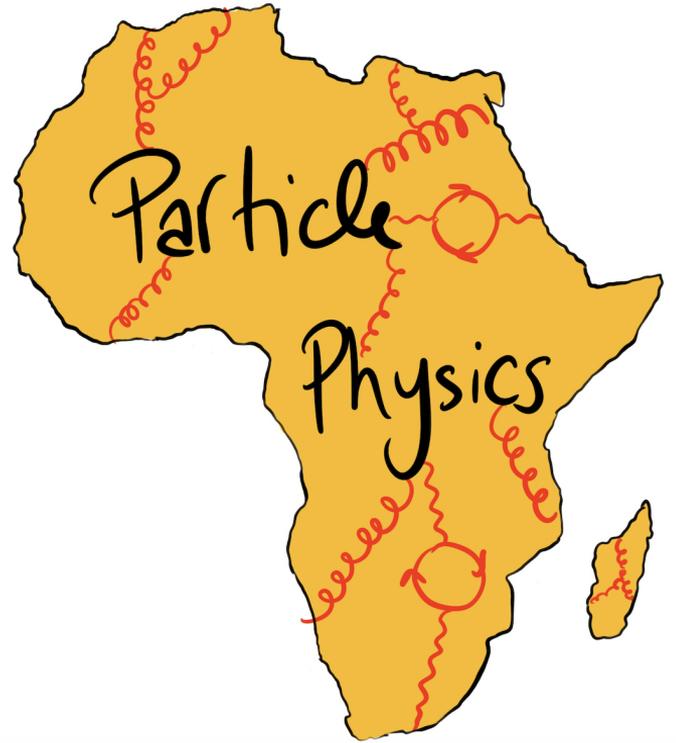
Supersymmetric Models:

- MSSM
- NMSSM
-

Multi-Higgs Models:

- 2HDM
- SM + Triplet (Type II seesaw models)
- SM + 2 triplets (Georgi-Machacek Model)
- 2HDM + Singlet, Triplet
- 3HDM
-

Status of PP activities in Africa



Presence at CERN

Non-Member States, Territories and Regions Collaborating with CERN

Albania	Algeria	Argentina	Armenia	Australia	Azerbaijan
Bahrain	Bangladesh	Belarus	Bolivia	Brazil	Canada
Chile	China	Colombia	Costa Rica	Cuba	Ecuador
Egypt	Georgia	Ghana	Hong Kong	Iceland	Indonesia
Iran	Ireland	Jordan	Kazakhstan	Korea	Kuwait
Latvia	Lebanon	Madagascar	Malaysia	Malta	Mexico
Mongolia	Montenegro	Morocco	Mozambique	Nepal	New Zealand
North Macedonia	Oman	Palestine	Paraguay	Peru	Philippines
Qatar	Rwanda	Saudi Arabia	Singapore	South Africa	Sri Lanka
Taiwan	Thailand	Tunisia	United Arab Emirates	Uzbekistan	Vietnam

Involvement in experiments either full members or associate:

ATLAS

CMS

Alice

Training opportunities for example in LHCb.

Computing Tier 3 WLCG



South Africa

SA-CERN programme

ATLAS, ALICE, ISOLDE, CERN



science & innovation

Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



iThemba LABS
Laboratory for Accelerator
Based Sciences



NELSON MANDELA
UNIVERSITY



Participating institutions : 1 National Facility (iThemba LABS) and 10 Universities



	ATLAS	ALICE	ISOLDE	Theory	Total
PhD	6	5	6	8	25
MSc	19	4	7	15	45
Accad Staff	8	6	6	7	27
Tech Staff	3	2	4		9
Post Docs	5	2	2	2	11

2020 numbers, increasing trajectory

Slides courtesy of Simon Connell, UJ

- SA has a long history in High Energy Physics, eg : 1st neutrino discovered and studied in nature 1965
 - Long history at CERN, BNL, JLAB, JINR, others
 - Also a long history of theoretical contributions
- **SA-CERN Co-operation Agreement 1992**
- Now formal participation at CERN and JINR

Most HEP now in the SA-CERN and JINR Programmes

*Decades of
"ad hoc"
participation*

- ALICE since 2001
- ATLAS since 2010
- ISOLDE since 2017
- Theory
- JINR since 2005

SA participates in Physics, Upgrade activities, Engineering, Outreach



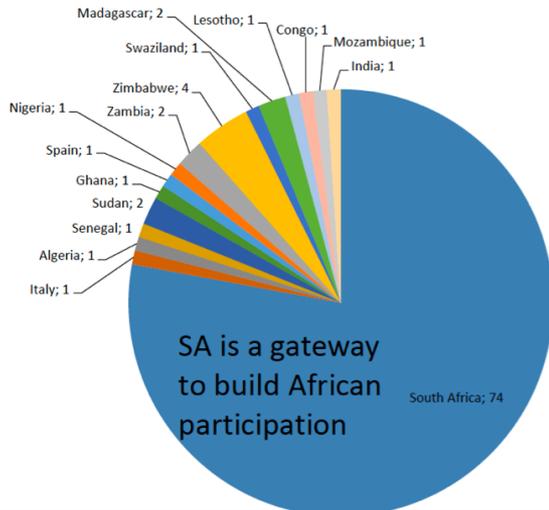
Some of the SA-CERN group



Staff and students at ALICE



Testing modules developed in SA for ATLAS



Staff and students at ISOLDE

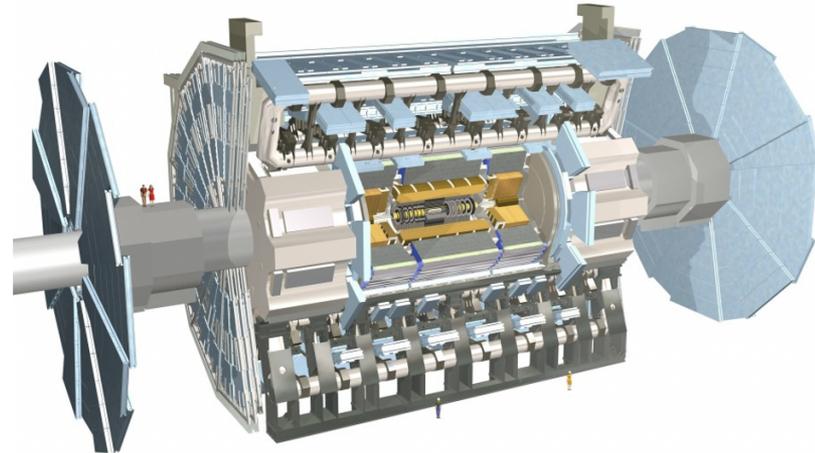


Slides courtesy of Simon Connell, UJ

Particle Physics in Morocco : History



- Morocco has an internationally high-quality research in theoretical and experimental high-energy physics
- Morocco started its research in experimental particle physics with CERN in **1996** as a member of the ATLAS collaboration
- The scientific collaboration with CERN was boosted thanks to the foundation of the High Energy Physics framework (**RUPHE**)
- **RUPHE is formed of 5 Universities:**
 - Hassan II University in Casablanca;
 - Mohammed V University in Rabat;
 - Cadi Ayyad University in Marrakech;
 - Mohammed 1st University in Oujda;
 - Ibn-Tofail University in Kenitra



ATLAS Morocco group at a glance



- **Current ATLAS People :**
 - **52 members:**
 - 20 physicists
 - 32 PhD Students
 - 12 defended PhD thesis
 - **Research Program includes the topics:**
- **1) Physics analyses:**
 - Measurements: Standard Model (SM) and Higgs
 - Searches: Beyond the SM and Exotic new physics
 - Higgs boson and dark matter
- **2) Detector performance:**
 - Jets & Missing Transverse Energy reconstruction
 - Lepton reconstruction
- **3) Detector Operation:**
 - Inner detector Offline Commissioning,
 - Performance & Optimization
- **4) Upgrade:**
 - ATLAS High Granularity Timing Detector
- **5) Computing:**
 - Grid Data Processing & Analysis
 - Deep Machine Learning
 - High Performance Computing
- **4) Theory and Phenomenology**
 - Multi Higgs models building
 - Colliders Phenomenology

ATLAS-computing@Algeria

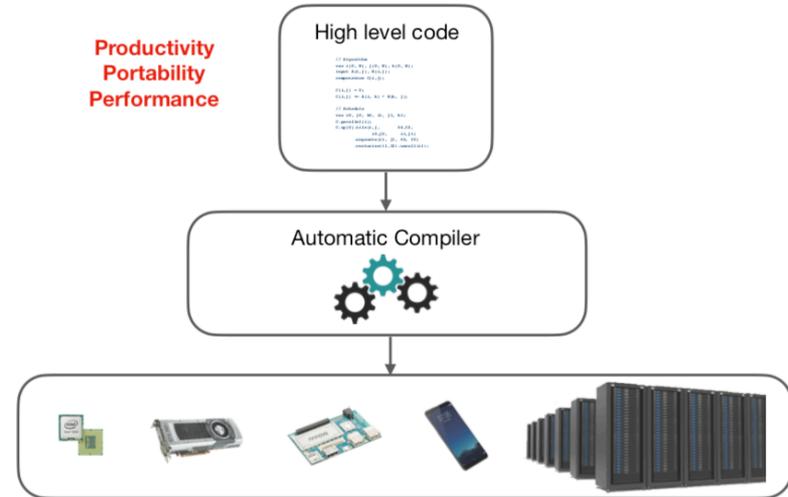
Monitoring of conditions database access

- Researchers are accessing the ATLAS experiment databases via ATLAS Distributed Computing systems (ADC systems)
- Many distributed agents have been set up to produce valuable information and metadata on the health and operation of ADC systems
- **Objective:** produce a general service capable of gathering difference pieces of information including logging, monitoring and performance information in order to analyse it, improve the operation of systems and detect any anomaly in these systems
- *Si Amer Mellissa Master Intern worked on this topic. She developed a platform based on elastic search to detect anomalies in database access*

Results

- We built a model that achieves state-of-the-art results
- Accuracy: 92%
- Paper
 - "Deep Learning and Classical Machine Learning for code mapping in Heterogeneous Platforms", 5th International Conference on Networking and Advanced Systems (ICNAS 2021), Annaba, Algeria, Nov. 2021

Goal: Enable Compilers to Automatically Optimize Code

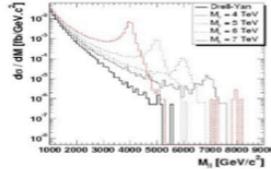
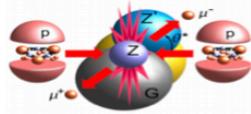


CMS @ Egypt

- Search for new heavy resonant and non-resonant phenomena in dilepton channels

contact person Dr. Sherif Elgammal (BUE)

Z prime models (BSM)



Kaluza Klien excitation from Extra-dimensions



- To explain $b \rightarrow s l^+ l^-$ anomalies at the LHC

<https://arxiv.org/abs/1805.11402>

- High pt correlated tests of lepton universality in lepton(s) + jet(s) processes; EFT analysis

<https://arxiv.org/abs/2005.06457>

- ATLAS published this analysis in

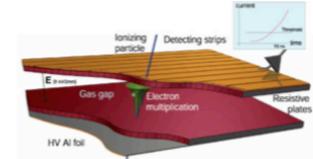
<https://inspirehep.net/literature/1853941>

- Work still on going using CMS run 2

Egypt involved in the following CMS R&D projects

- Resistive Plate Chamber (RPC)

- Prof. Elsayed Salama (BUE)
- Dr. Yasser Assran (BUE) contact person
- Shereen Aly (HU)
- Asmaa Fawzi (HU)
- Fatma Abdelkawy (AU)
- Tahany Elhussieny (AU)

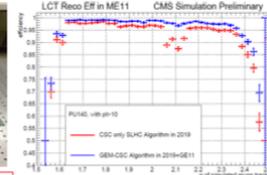
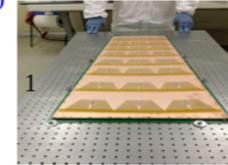


Egyptian groups participate in
 * Assembling of RPC detector
 * Efficiency tests

- Gas Electron Multiplier (GEM)

- Dr. Ahmed Abdelalim (ZC)
- Dr. Shima Abuzeid (AU)
- Dr. Hassan Abdalla (CU)
- Salwa Mohamed (AU)
- Mohamed Elhoseny (CU)
- Aya Beshr (AU)
- Basma Elmahdy (BUE)

contact person



Advantage of GEM

- * Combine triggering and tracking functions.
- * Enhance and optimize the readout (η, ϕ) granularity by improve rate capability.

Egyptian groups participate in
 * Simulation of GEM detector
 * Efficiency tests

- Search for mono-Z' + DM:

contact person Dr. Sherif Elgammal (BUE)

<https://arxiv.org/pdf/2013.04326.pdf>

- Search for mono-Higgs + DM:

contact person Dr. Sherif Elgammal (BUE)

<https://link.springer.com/article/10.1007%2FJHEP03%282020%29025>

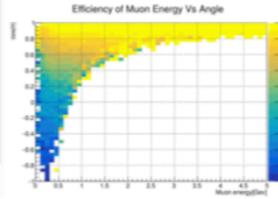
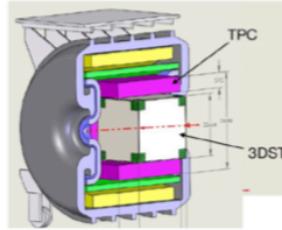
- Search for mono-Z + DM:

contact person Prof. Shaaban Khalil (ZC)

Dune@Madagascar

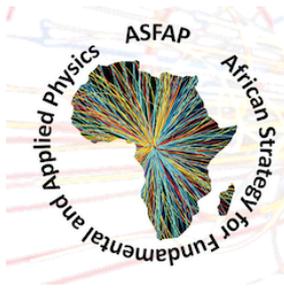
Our contribution:
Near Detector

- Near Detector Conceptual Design Report-
- SAND-System for on-Axis Neutrino Detection
 - Figure 5.15 from the CDR Report made by our students
 - The efficiency to reconstruct muons generated by neutrino interactions in the 3DST that escape and enter into the TPCs

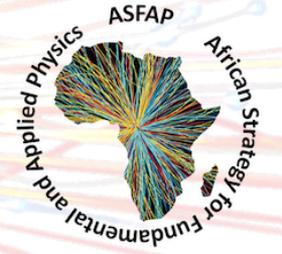


Outcome of
our
contribution

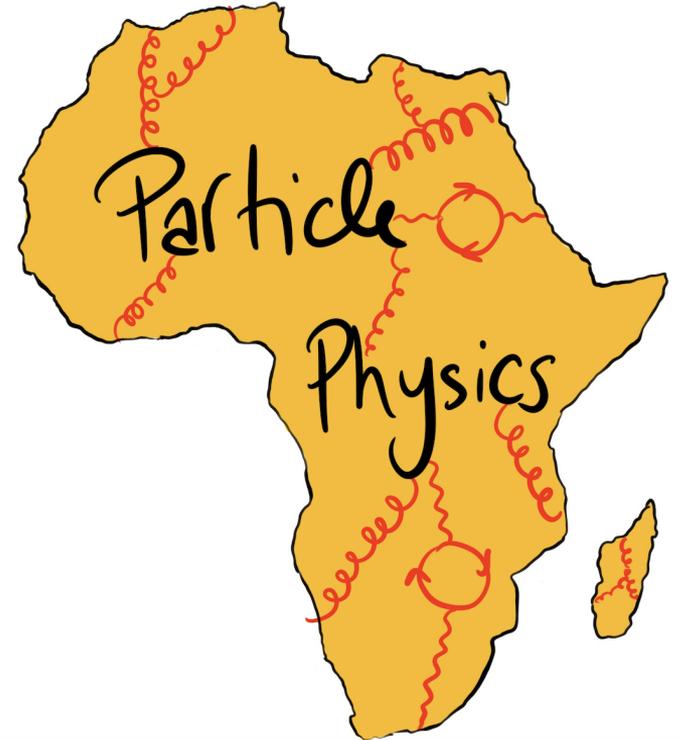
- Joining DUNE is a tremendous opportunity
- Learning collaborative works
- 4 defended Masters thesis since 2016
- 1 PHD candidate at the University of Antananarivo
- 3 graduate students research in training focusing on the near detector
- All 4 graduates has obtained PHD position due to outstanding performance during their masters
 - Manoa Andriamirado- PhD candidate at IIT
 - Sitraka Andriasetta-PhD candidate in South Dakota
 - Miriama Rajaoalisoa- (ASP 2016) PhD candidate at the University of Cincinnati
 - Herilala Razafinime- PhD candidate at the University of Cincinnati



African Strategy for Fundamental and Applied Physics



ASFAP vision: PP Working group



Challenge of PP research in Africa

- Gaps in human capital
- Infrastructural deficits
- Weaker support systems for research
- Barriers to international mobility and collaboration.
- Small presence of African developing countries in world wide PP community
- Scientific collaboration among African countries is still below expectations

These factors have limited the contributions of the physics community to translate skills and expertise to a potential factor for development.

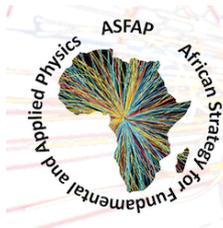
However, despite these challenges, Africa has produced a vibrant research PP communities with enormous potential.

ASFAP: Scope of PP-WG

Define the particle physics community's direction for the current decade
Identify and prioritize the actions / activities in the coming years.

- Contribute to building a network of Particle Physicists in Africa.
- Push forward the ongoing activities and foster cooperations between African researchers for both Experimental and Theoretical physics.
- Address the possibilities of evolution and expansion of involvements and drive future endeavors.
- Collect scientific inputs from African PP community: written contributions (LoI): Provide a shared roadmap for the field: **White paper**²⁰





African Strategy for Fundamental and Applied Physics



Particle Physics Conveners



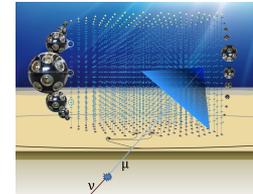
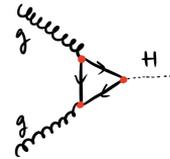
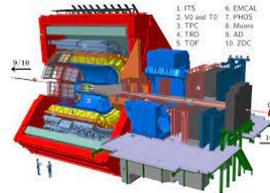
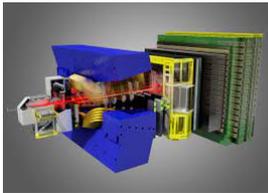
Yasmine Amhis (France)



Zinhle Buthezi (SA)



Mohamed Chabab (Morocco)



Proposed subgroups:

- **subWG I “Fundamental constituents & forces” :**

- Higgs physics.
- Electroweak and BSM physics.
- Direct searches.

- **subWG II “Symmetries and composite structures”:**

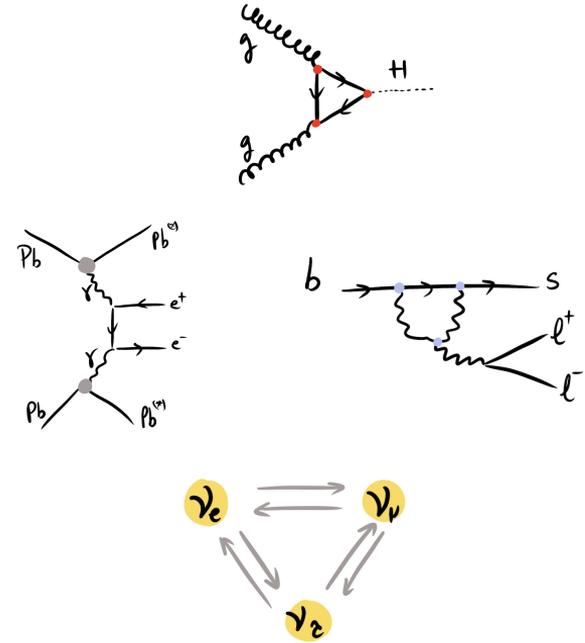
- Flavour physics, CP violation.
- Strong interaction, hadron physics, heavy ions.
- Indirect searches.
- nEDM.

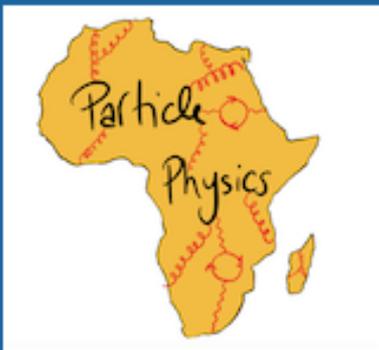
- **subWG III “Light messengers” :**

- Neutrino Physics : neutrino parameters, CP violation, BSM.

- **subWG IV “Infrastructures” .**

Note: Two conveners for each, an experimentalist and a theorist.

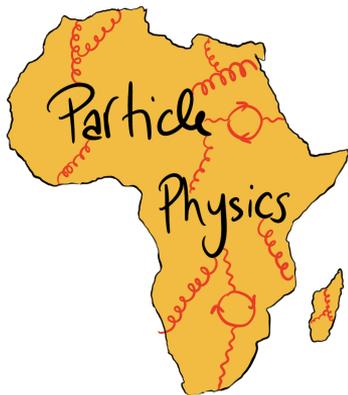




First ASFAP Particle Physics Day

18 November 2021
Online
Europe/Paris timezone

<https://indico.cern.ch/event/1080353/>



Second ASFAP Particle Physics Day PhD' students and postdocs

31 March 2022
Online

<https://indico.cern.ch/event/1126310/>

LoIs related to Particle Physics

- [Searching for subtle signs of new physics via novel top quark measurements](#) (*University of Cape Town (RSA) and IFIC Valencia ATLAS groups that commenced in 2020*), Concerns the electroweak couplings of the top quark as they pertain to the search for new physics and comprises analyses of data within the ATLAS collaboration and reinterpretation of published LHC data outside experimental collaborations. The aim is to highlight the importance of a thematic long-term research programme in enriching the African particle physics community and maximising its impact on the field's most prominent research questions.
- [Searches for heavy resonances decaying to top quarks with the ATLAS detector at LHC](#) (*Mohammed V University, Morocco*), A search for new resonances that decay into top-quark pairs ($t\bar{t}$ invariant mass distribution) using data collected in 2015 to 2018 by the ATLAS experiment in pp collisions at $\sqrt{s} = 13$ TeV at the LHC.
- [Jet energy scale and resolution in the High-Granularity Timing Detector in ATLAS upgrades at HL-LHC](#) (*Mohammed V University, Morocco*), Large increase of pileup is one of the main experimental challenges for the High Luminosity-Large Hadron Collider (HL-LHC) physics program. HL-LHC is expected to start in 2027 and will provide an integrated luminosity of 3000 fb⁻¹ in ten years, a factor 10 more than what will be collected by 2023. A powerful new way to address this challenge is to exploit the time spread of the interactions to distinguish between collisions occurring very close in space but well separated in time. A High-Granularity Timing Detector (HGTD, low-gain avalanche detector technology), is proposed for the ATLAS Phase-II upgrade. The impact of HGTD in reducing pileup track contamination in the jets reconstruction in the forward region is investigated
- [Higgs portal vector dark matter interpretation: review of Effective Field Theory approach and ultraviolet complete models](#) (*Mohammed V University (Morocco), BNL (USA), University of Johannesburg (RSA)*):- The Higgs portal-vector dark matter interpretation of the spin-independent dark-matter nucleon elastic scattering cross section, using the invisible Higgs decay width measured at the LHC, is presented. The Effective Field Theory approach and ultraviolet complete models have been used and details description are discussed. Hence, the inclusion of these theoretical scenarios in LHC public results in comparison with direct detection results is proposed. We investigate the dark matter in the sub-GeV mass range as well.

Where to find us?

<https://twiki.cern.ch/twiki/bin/view/AfricanStrategy/AfParticlePhysics>

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Observers Committee members

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Please reach us if you are interested !

Education and PP impacts

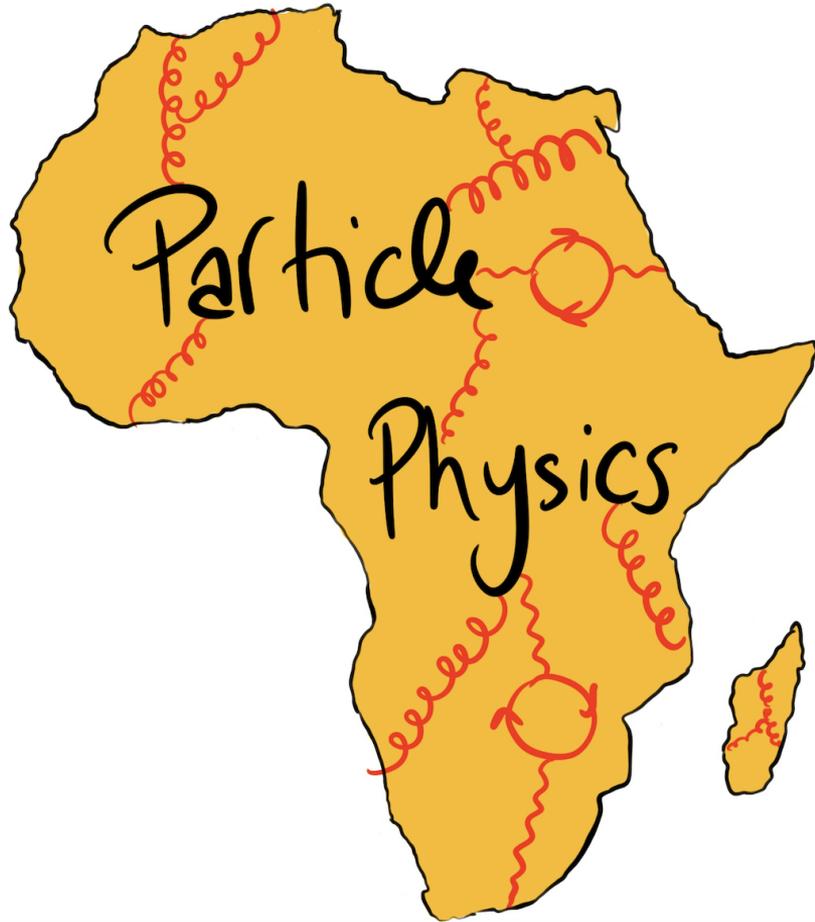
Many activities in particle physics for education and outreach to:

- Support, motivate learners and educate students
- Demonstrate the impact of particle physics research
- Build support among policy makers and opinion leaders
- Build public appreciation for particle physics
- Promote inclusion and diversity

Particle Physics educational programs can be used to:

- Create knowledge
- Develop coordination and capacity building
- Prepare educated, engaged, students / citizens
- Create a scientific consciousness

- Particle Physics Lessons
- e-learning portal (LifeLongLearning)
- Masterclasses
- More Centres of excellence: AIMS, EIFP,..
- More Meetings for PP: ASP, ACP,...



Thank you

Major collaborations



SAHAL YACOB

ATLAS@UCT



UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

ATLAS Activities in Morocco

D. Benchekroun
Hassan II University of Casablanca
On behalf the ATLAS Moroccan Group

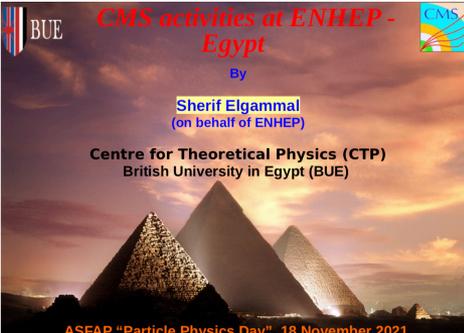
18/11/2021 D. Benchekroun, ASFAP Particle Physics Day 1

South Africa Activities in ALICE



Zinhle Buthelezi,
for SA-ALICE

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



BUE **CMS activities at ENHEP - Egypt** CMS

By
Sherif Elgammal
(on behalf of ENHEP)

Centre for Theoretical Physics (CTP)
British University in Egypt (BUE)

ASFAP "Particle Physics Day", 18 November 2021.

Contribution to ATLAS Computing in Algeria

Ecole Nationale Supérieure d'Informatique (ESI)

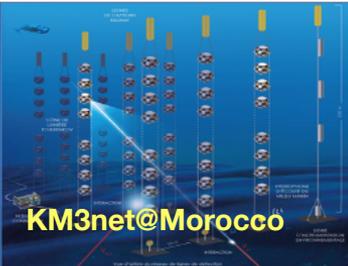


18/11/2021 D. Benchekroun, ASFAP Particle Physics Day 1

The UJ-ATLAS and Associated Innovation Group + UNISA + UWC

- Staff**
 - Simon Cornell (Prof)
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 - Leon Truong (Associate Visiting Prof)
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- Past Docs**
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 - MSc: Chris Lee
- Associate sub-institute**
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 - Robin Moko (Dr UNISA)
 - Mantle Lelaka (Prof UNISA)
- Visiting Associates**
 - Dr Graham Smith, Dr Ozamen Mwanande, Eric Chonka, Lintia Buthelezi
- Research Associates**
 - Dr Martin Cook (SMA UJ)
 - Dr Sergio Bellecchio (SMA UJ)
 - Tim Brooks (SMA UJ)

18/11/2021 UJ-ATLAS 1



KM3net@Morocco




First ASFAP Particle Physics Day
DEEP UNDERGROUND NEUTRINO EXPERIMENT
and
UNIVERSITY OF ANTANANARIVO
MADAGASCAR
Nov. 18th 2021

Laza Rakotondravochitra PhD
Université d'Antananarivo
GenesisCare USA/ Duke University Medical Center

HEP in Madagascar

D. Rabearivony,
on behalf of the
Institute of High Energy Physics of Madagascar, Univ. Antananarivo (MG)



The Institute for Collider Particle Physics

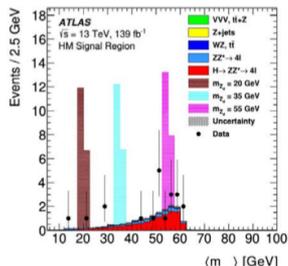
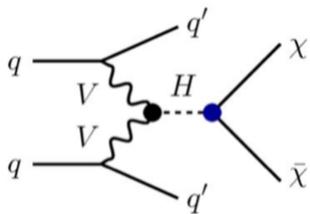
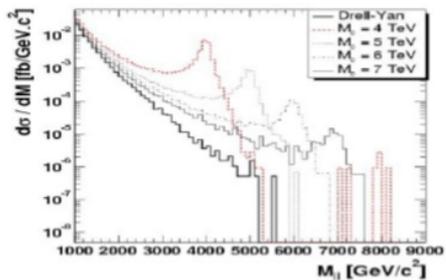
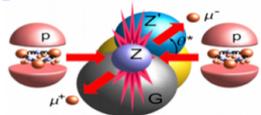


UNIVERSITY OF ZULULAND
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MRF
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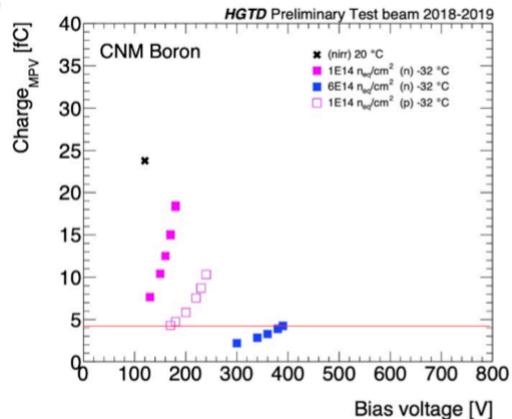
A few highlights

Physics analyses

Z prime models (BSM)



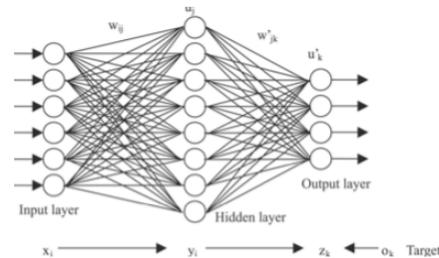
Beam tests



Electronics development



Machine learning



Remote operations

