

ASFAP—Towards the final report

Nuclear Physics Working Group

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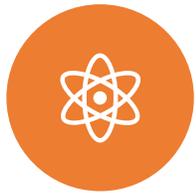
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Outline



**Nuclear Physics
Research
Facilities in
Africa**



**Synergies with
other Fields**



**Roles of African
Government
Policies**



Challenges



Recommendations

Nuclear Physics Research Facilities in Africa

Accelerators and Cyclotrons

- Accelerator-Based Neutron Sources: Blue (146 with **3** in Africa)
- Boron Neutron Capture Therapy (BNCT) facilities: Orange (29 with **0** in Africa)
- Electrostatic Accelerators: Red (322 with **7** in Africa)
- Synchrotron Light Sources: Light Blue (60 with **0** in Africa)
- X-ray Free Electron Laser Sources: Yellow (14 with **0** in Africa)

<https://nucleus.iaea.org/sites/accelerators/Pages/Interactive-Map-of-Accelerators.aspx>



Country	Facility	Category	Incident Particle	Target	CW Operation	Pulse Operation	Max. Neutron Energy (MeV)	Max. Source Strength (n/s)	Max. Current (A)	Max. Exp. Neutron Flux (n/s/cm ²)
South Africa	RFQ	CANS	d	D		Yes	5		0.03	1.00e+04
	SSC	CANS	p	Be, Li		Yes	200	1.00e+04	3e-07	
	van de Graaff	CANS	p, d		Yes		3.8		0.0001	

Research reactors

Nuclear Physics Research Facilities in Africa

- Heavy Water: ES-SALAM in Algeria
- Pool: ETRR-2 in Egypt
- MNSR: GHARR-1 in Ghana and NIRR-1 in Nigeria
- Critical Assembly: TNRC Critical Facility in Libya
- TRIGA MARK-II: MA-R1 in Morocco
- Tank in Pool: SAFARI-1 in South Africa

ES	ES-SALAM Type: HEAVY WATER	Algeria City: Djelfa	Operational
NI	NIRR-1 Type: MNSR	Nigeria City: Zaria	Operational
TC	TNRC Critical Facility Type: CRIT ASSEMBLY	Libya City: Tajoura	Operational
MA	MA-R1 Type: TRIGA MARK II	Morocco City: Rabat	Operational
GH	GHARR-1 Type: MNSR	Ghana City: Accra	Operational
SA	SAFARI-1 Type: TANK IN POOL	South Africa City: Pretoria	Operational
ET	ETRR-2 Type: POOL	Egypt City: Cairo	Operational

Out of 220 Operational Research Reactors in the world, **7** in Africa

Nuclear Physics Research Facilities in Africa

Neutron Beam Instrument

- Neutron Scattering Instrument: **4** in Africa Out of 370 worldwide
- Neutron Imaging Instruments: **4** in Africa out of 55 worldwide
- Cold neutron Source: **0** in Africa out of 26 worldwide
- Neutron Activation Analysis Facilities:

Industrial Irradiation Facilities

- Gamma Irradiators: **5** in Africa out of 184 worldwide
- E-Beam Irradiators: **1** in Africa out of 110 worldwide

Fusion Devises

- Out of 96 operating worldwide
- LIBTOR: Libya
- EGYPTOR Tokamak: Egypt

Nuclear Physics Research Area in South Africa

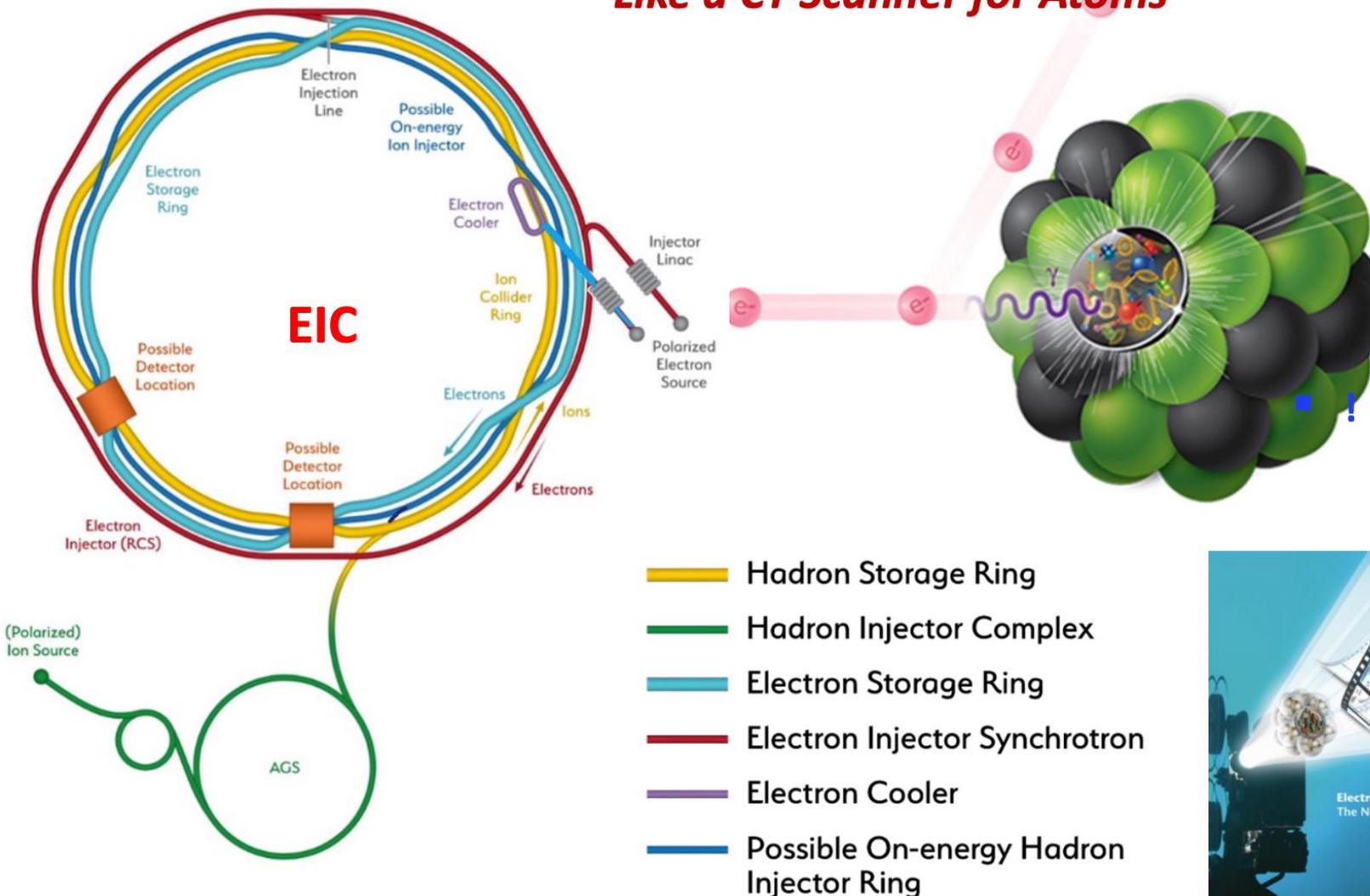
- **Experimental Nuclear Structure:** Light-ion induced medium-energy reactions with investigations ranging from Nuclear structure, Nuclear reactions, Nuclear cluster and Nuclear astrophysics using K600 Magnetic Spectrometer, Nuclear Chirality and superdeformation using AFRODITE, Electron Spectrometer, GAMKA Detectors, and High-energy Neutron experimental Facility at iThemba LABS.
- **Accelerator Mass Spectrometer (AMS) and South African Isotope Facility (SAIF) Projects** at iThemba LABS.
- **Theoretical Nuclear Physics:** Nuclear Few-Body system
- **Applied Nuclear Physics:** Environmental Radiation in collaboration with Centre for Nuclear Safety and Security (CNSS) at NNR, Nuclear Forensics, Medical Physics and Nuclear Medicine (NuMeRi).
- **Reactor Physics:** Reactor Safety Analysis using MCNP, SCALE-VI, OSCAR5, GEANT4, Reactor Thermal-hydraulic Analysis using RELAP5 at NECSA.
- Nuclear Material Research using SAFARI-1 Reactor Neutron Activation Analysis (NAA) at NECSA.

African Contributions To Electron Ion Collider (EIC)

<https://www.bnl.gov/eic>

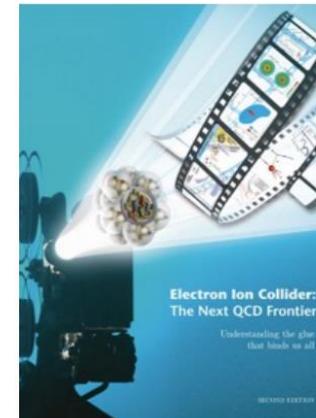
A machine that will unlock the secrets of the strongest force in Nature

Like a CT Scanner for Atoms



Basic Tech Requirements

- Center of Mass Energies:
20 GeV – 141 GeV
- Required Luminosity:
 $10^{33} - 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- Hadron Beam Polarization:
80%
- Electron Beam Polarization:
80%
- Ion Species Range:
p to Uranium
- Number of interaction regions:
up to two



Synergies with other Fields

- Foundational knowledge generated through nuclear research have interdisciplinary/multidisciplinary applications in other fields such as
 - Materials science,
 - High energy physics.
 - Theoretical physics,
 - Astrophysics,
 - Medical physics,
 - Engineering, etc

Roles of African Government Science Policies

- Government supports and funding towards Nuclear Education, Training and Research- From Policy Making to Implementation
- Human capacity developments in science, technology and innovation
- Role of IAEA, AFCONE, AFRA-NEST, AU and NGOs
- Enabling environment for research and development
- Research to Innovation supports

Challenges

- Lack of experimental setups in many African countries
- Problems of maintenance due to lack/absence of technical services
- Affordability to purchase new equipment
- Bureaucracy in laboratory governance and management
- No funds to support students (MSc and PhD) and postdocs
- Students are not trained during their Bachelor/Master to use the experimental equipment
- Difficulty in accessing equipment in other institutions in the same country
- Acquisition of equipment is subjected to time-consuming bureaucratic procedure

Challenges

- Lack of high-performance computing centres for theoretical projects
- Problems with internet connection to use HPC in other institutes
- Lack of affordable and powerful workstations
- Lack of commercial software licenses for nuclear physics simulations
- No training within organized schools and workshops
- Lack of suitable student exchange programs /projects among African countries
- Shortage of skilled scientists and personnel who are trained in nuclear physics, specifically in areas related to the EIC.

Recommendations

- Increase Funding
- Strengthen Collaborations
- Develop Infrastructure
- Enhance Education and Training
- Promote Networking
- Engage the Youth
- Interdisciplinary approaches
- Public engagements

Thank you