# iThemba LABS: Accelerator-based research facility at the southern tip of Africa

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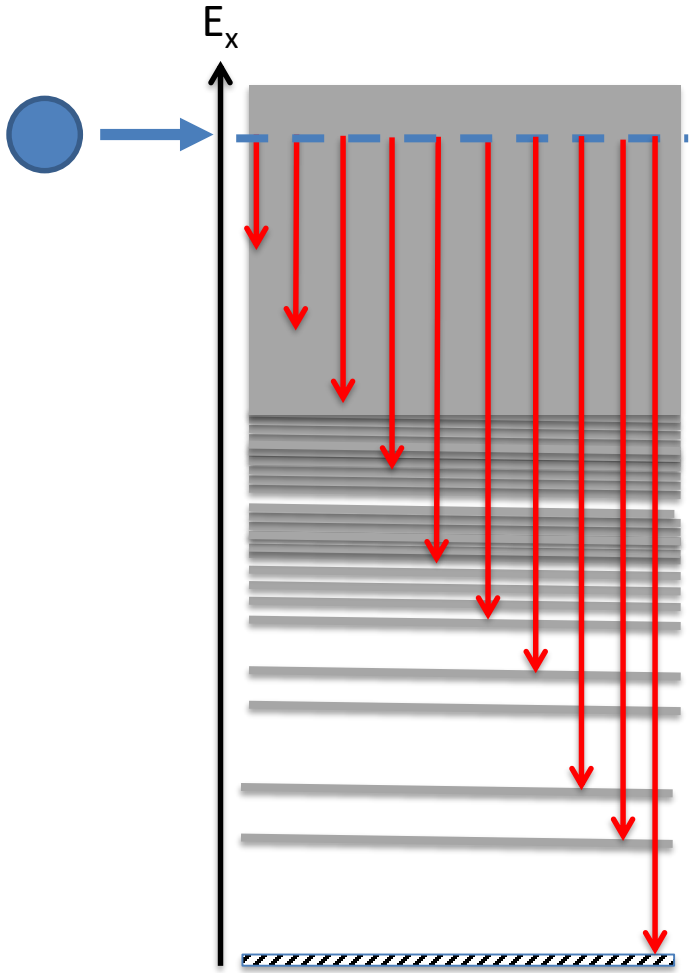
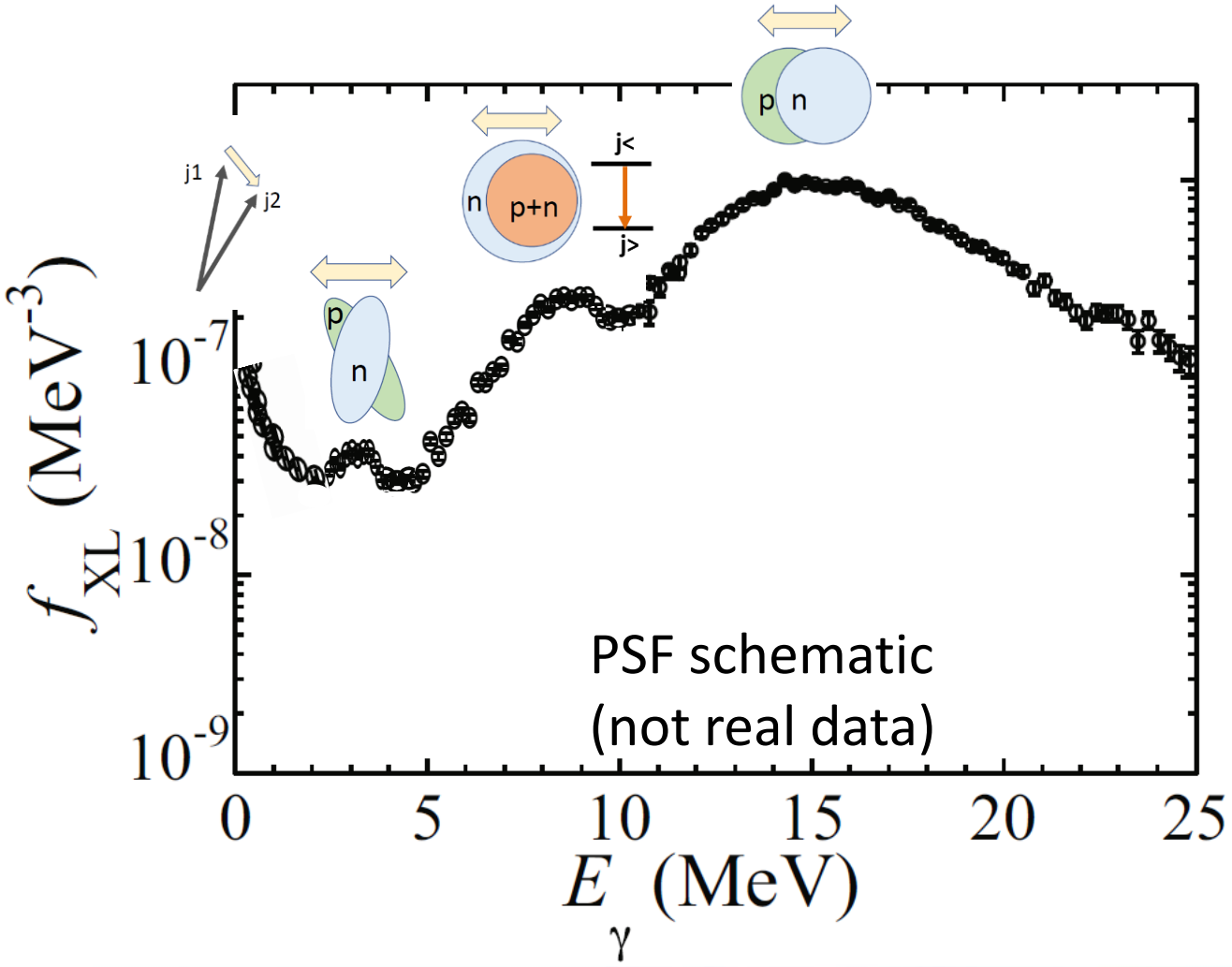
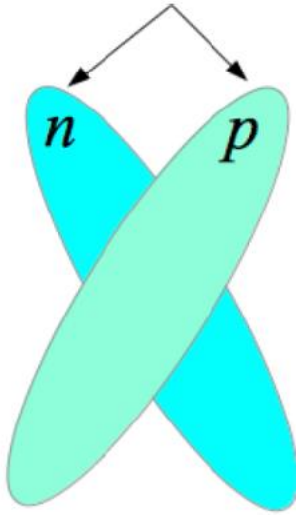
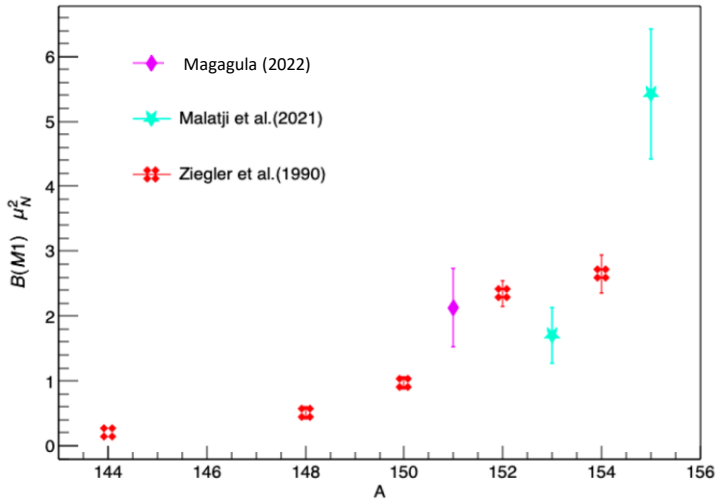
# Photon Strength Function



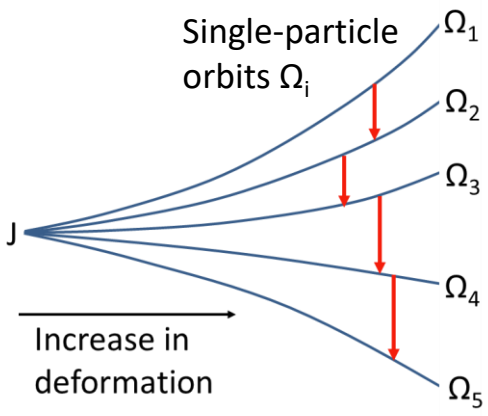



# Nuclear Structure from the PSF: Scissors Resonance




Malatji, Beckmann, MW *et al.*, Phys. Rev. C 103, 014309 (2021).
Magagula, MSc thesis, Wits (2022).



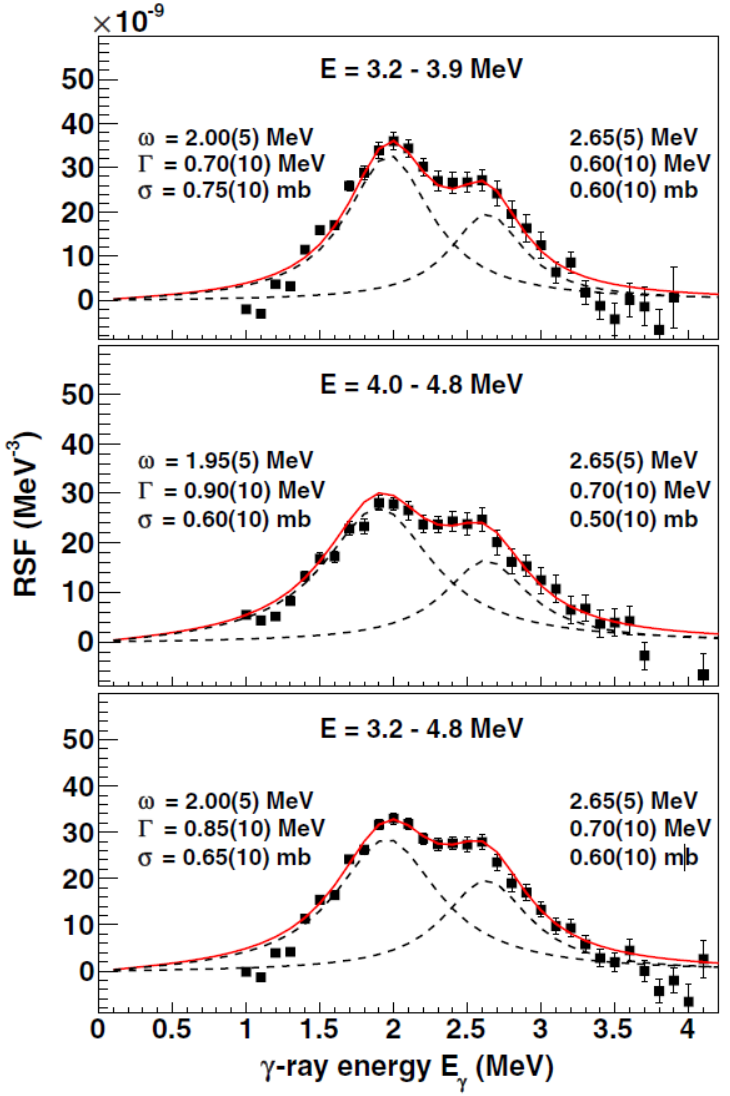

## Nature of splitting?

### i) Triaxiality

Iudice et al., Phys. Lett. B 161, 18 (1985).
Lipparini, Stringari, Phys. Rep. 175, 103 (1989).
F. Palumbo, Phys. Rev. C **99**, 034319 (2019).

### ii) Spin Scissors Mode

Balbutsev, Molodtsova, Schuck, Phys. Rev. C 88, 014306 (2013).
Balbutsev, Molodtsova, Schuck, Phys. Rev. C 97, 044316 (2018).
Balbutsev *et al.*, Phys. Rev. C 105, 044323 (2022).

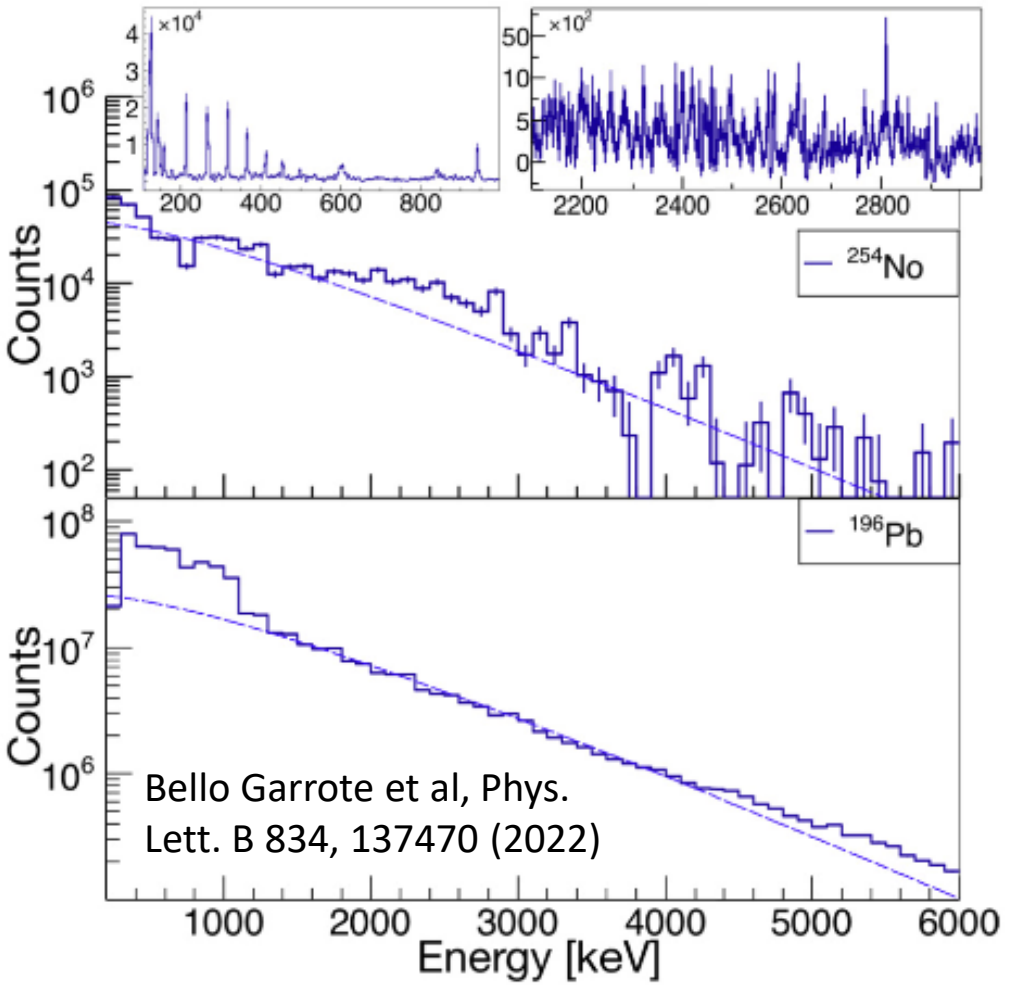



Guttormsen, Bernstein, Bürger *et al.*, Phys. Rev. Lett. 109, 162503 (2012).

# Nuclear Structure

- Discrete level spectroscopy (K-isomers) have been studied for Sg, No, Rf, Lr, etc.
- Significant detection efficiency increase.
- Opens up new possibilities for PSF studies to investigate resonances.
- Recent scissors resonance results in $^{254}$No from $^{208}$Pb($^{48}$Ca, 2nγ) reaction.

- New region of nuclear chart to measure the PSF and investigate resonances.
- Ideas for spectroscopic (or other) measurements welcome.



# iThemba Laboratory for Accelerator Based Sciences

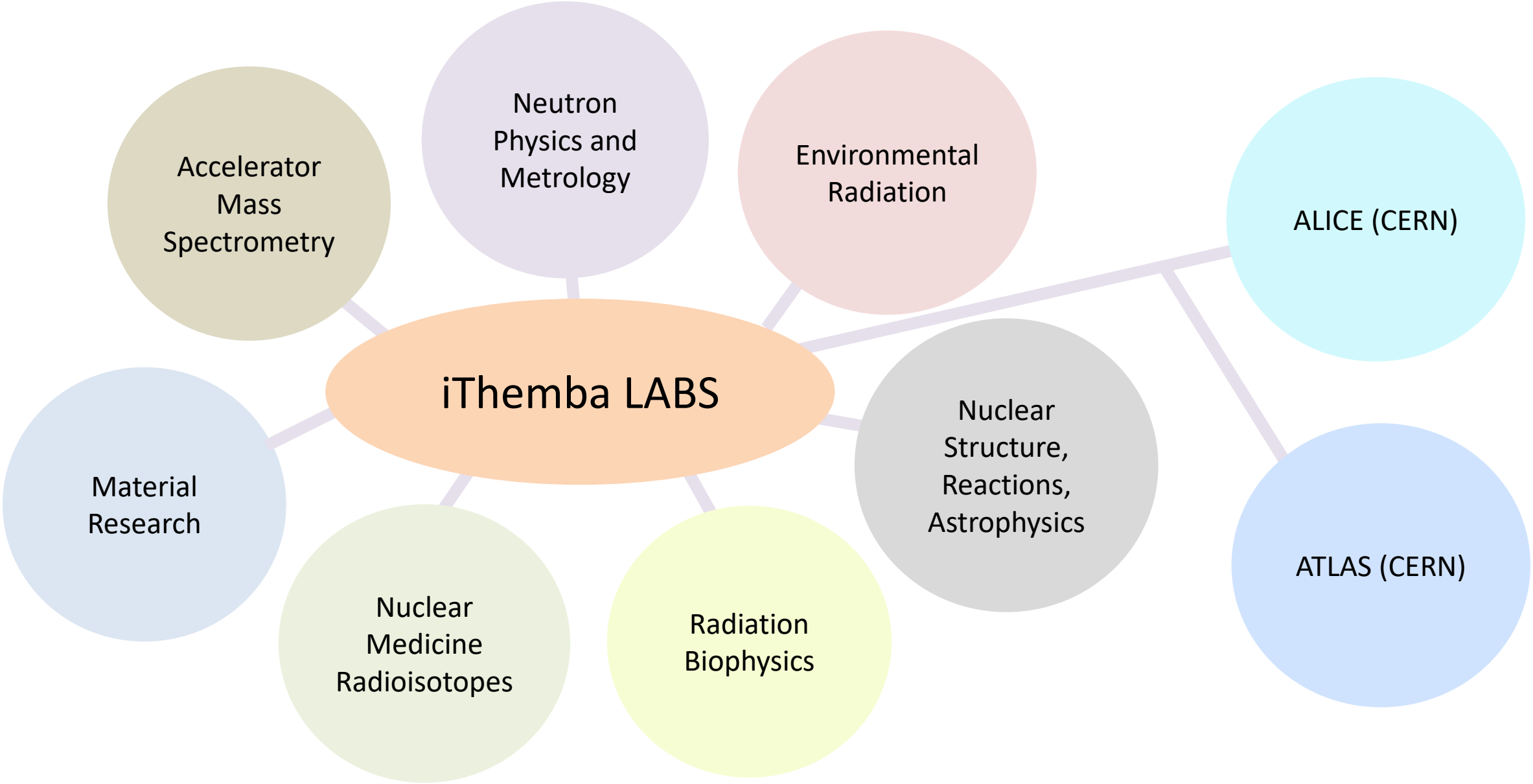
The iThemba Laboratories for Accelerator-Based Sciences is a group of multi-disciplinary research accelerator laboratories administered by the National Research Foundation of South Africa.


iThemba LABS Cape Town

iThemba LABS, TAMS

Largest National Research Facility in SA and the largest accelerator facility in the southern hemisphere:

- Facility for research, development and training in Accelerator Based Sciences
- More than half of the NRF budget for research facilities.
- ~250 staff
- ~150 users and students annually

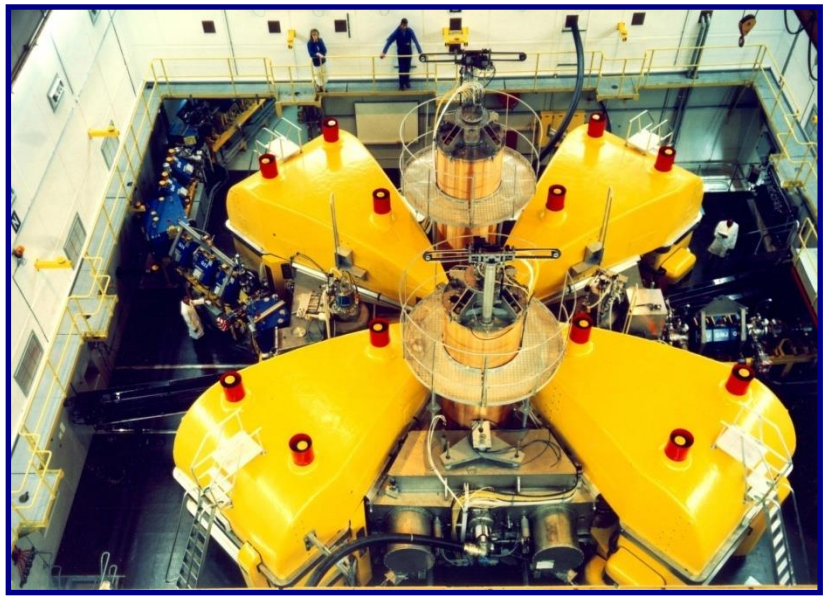

Accelerator Mass Spectrometry
Neutron Physics and Metrology
Environmental Radiation
ALICE (CERN)
iThemba LABS
Material Research
Nuclear Structure, Reactions, Astrophysics
ATLAS (CERN)
Nuclear Medicine Radioisotopes
Radiation Biophysics

# Our Accelerators

Injector cyclotron 1

Injector cyclotron 2

Separated Sector Cyclotron



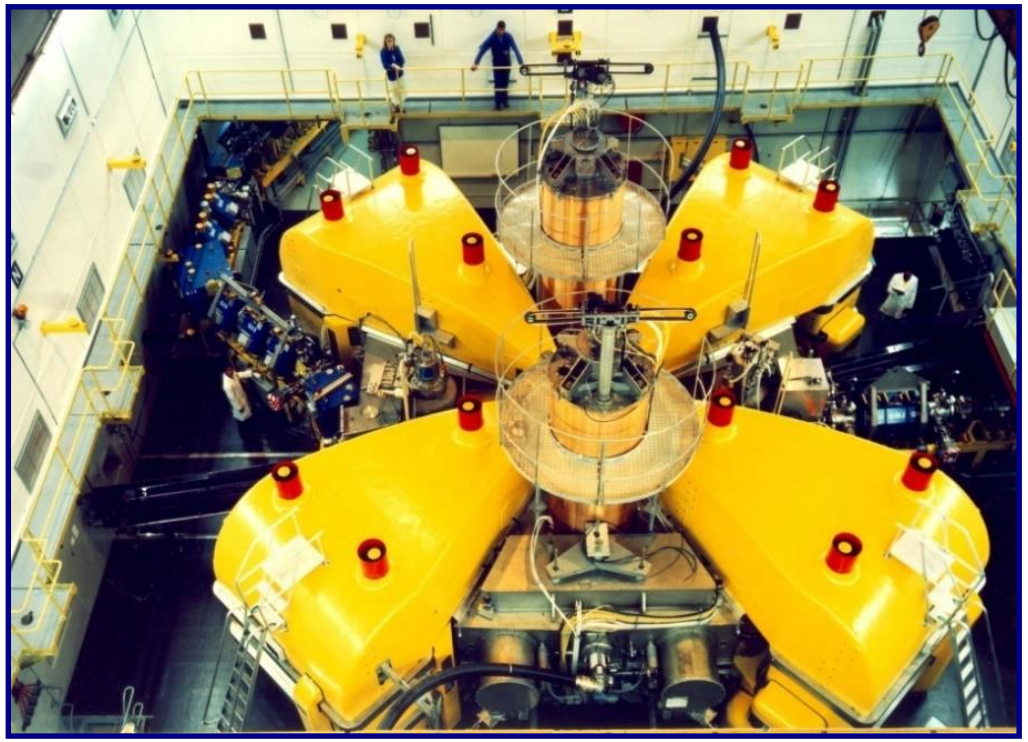
South African Isotope Facility: C70

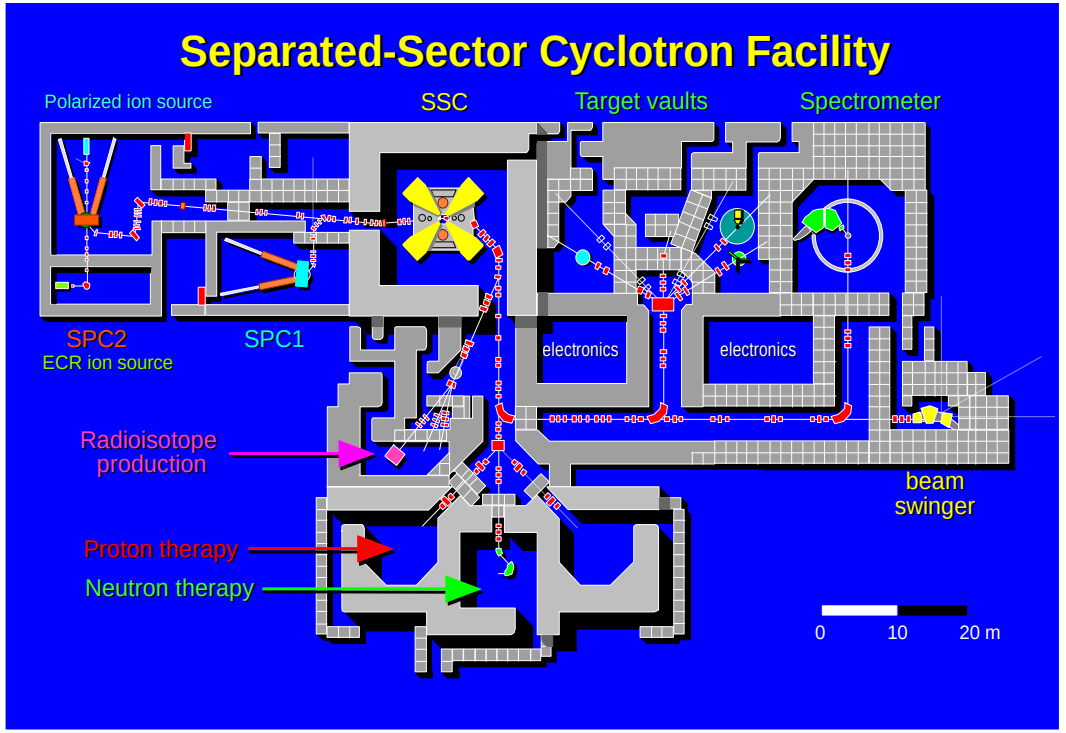
K11 Cyclotron

3MV Tandetron

6MV Tandem

# SSC Laboratory



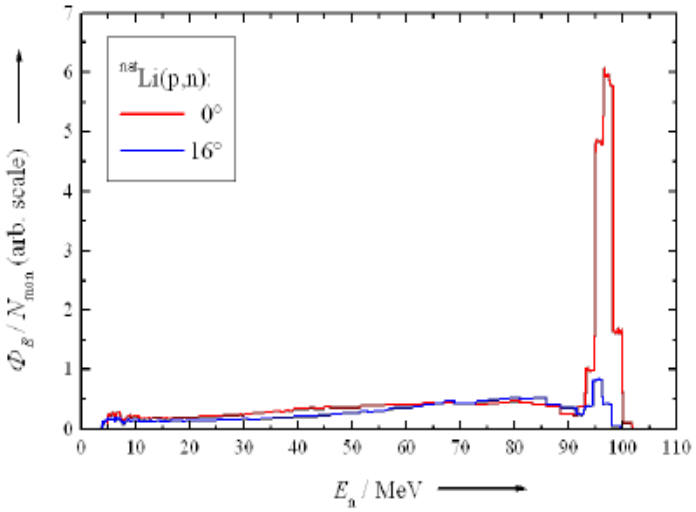


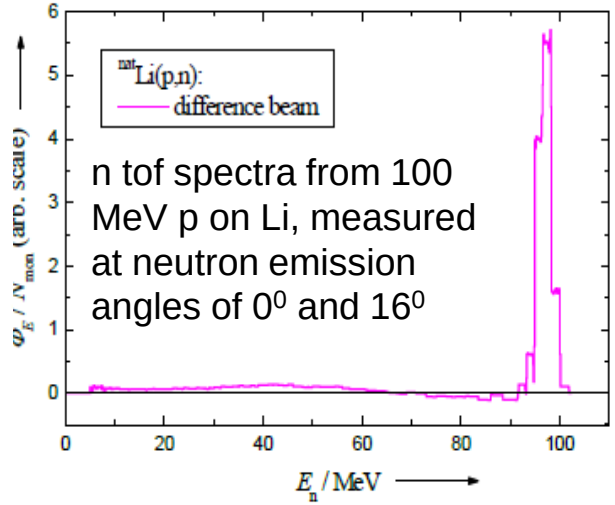

Subatomic Physics / Neutron Metrology / Radiation Biophysics / Nuclear Medicine / Radioisotope Production

**User facility: for local universities and for users from rest of the world.**

# Neutron beam facility

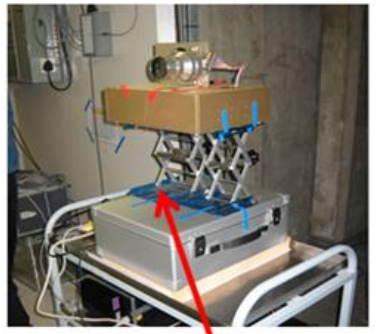
- Energies: 30 to 200 MeV
- Targets:
  - Li, Be: quasi-monoenergetic
  - C: quasi-white ('grey')
- Beam currents
  - 3-5 µA ($E_p$ < 100 MeV)
  - 300 nA ($E_p$ = 200 MeV)
- Pulse selection: 1/1 – 1/7
- Time resolution: ≈ 1 ns
- Flight paths:
  - 10 m (0°)
  - 13 m (16°)
- Fluence rate (1 mm Li): $j \approx 1 \cdot 10^3$ $cm^{-2}$ $\mu A^{-1}$ at 10 m




n tof spectra from 100 MeV p on Li, measured at neutron emission angles of $0^0$ and $16^0$

NASA's Curiosity Mars rover



Radiation Assessment Detector at iThemba LABS. n @100 MeV

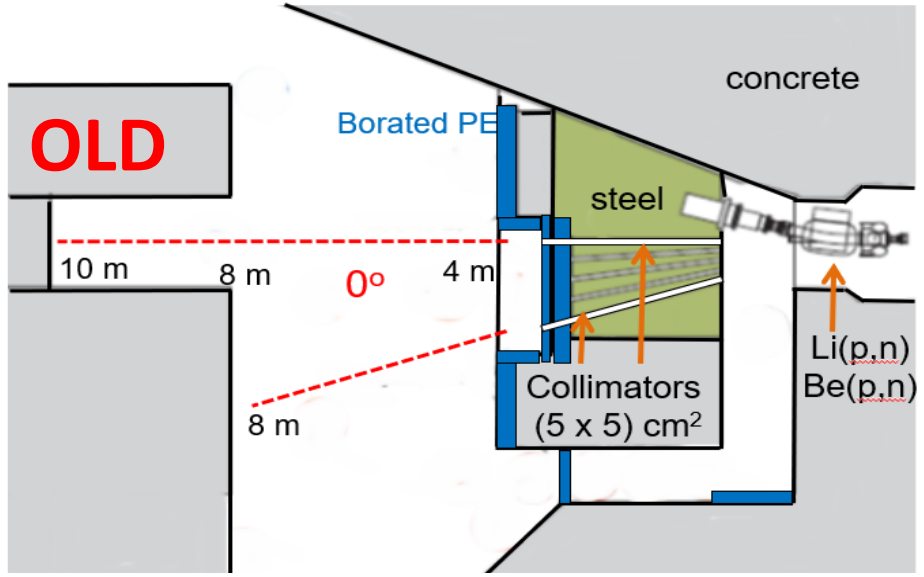
*Hassler et al., (2009) 40th Lunar & Planetary Science Conference;*

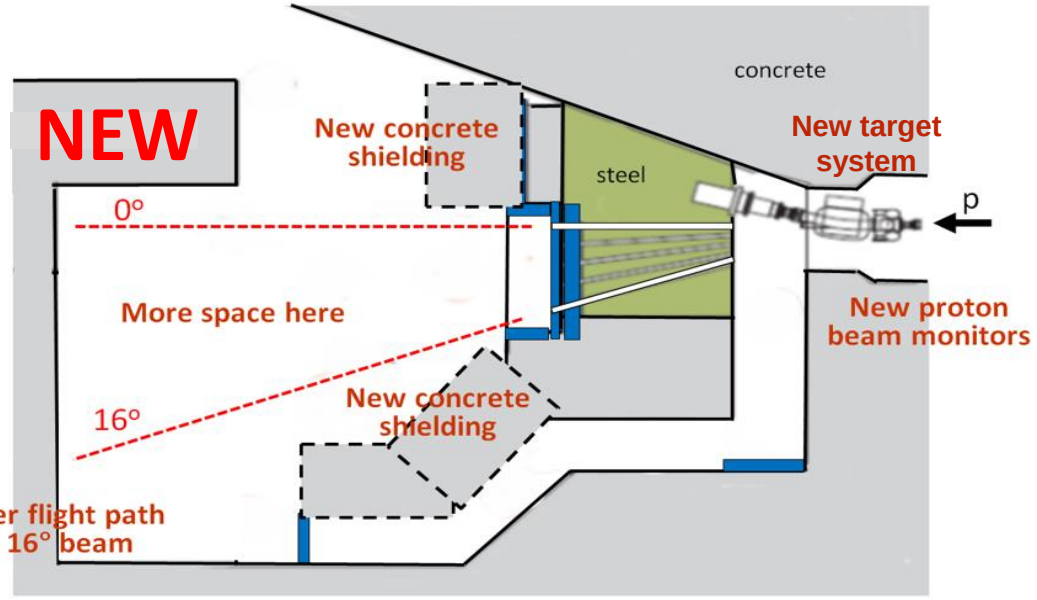
# Refurbished fast neutron beam facility

Reconstruction of neutron vault to meet requirements for high-energy neutron metrology facility.

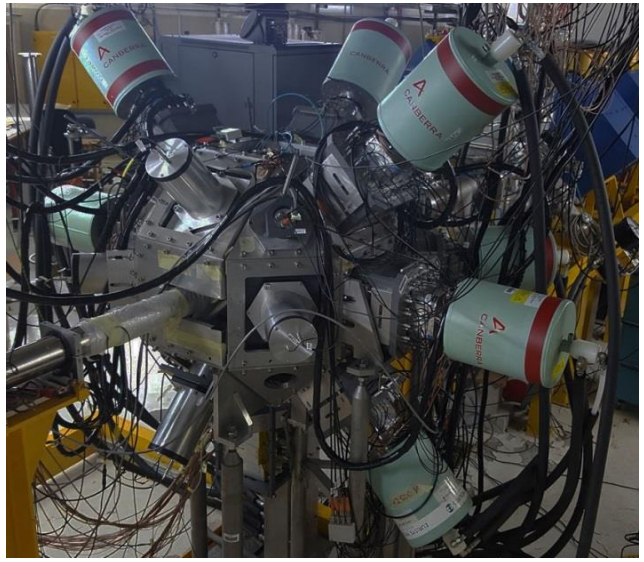
- Additional shielding
- Improved beam diagnostic
- Optimized beam stops
- Extended flight path at 16°
- New target system

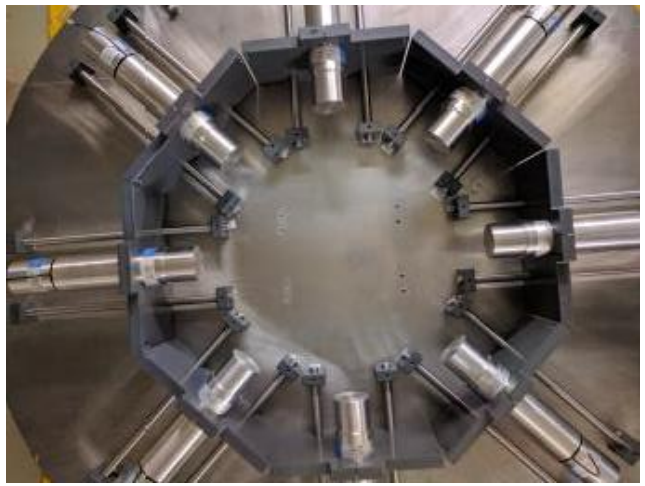
Ultimate goal is to achieve ISO accreditation, to be recognised as a ‘medium to high-energy’ neutron beam reference facility.



# Gamma-ray detectors





- 2017-2020: expanded detection capabilities
- ~4.5m Euro total investment.
- Fast-timing array: 2.5x2.5cm $LaBr_3$:Ce
- LEPS
- Segmented Clover detector.
- AFRODITE (Clover, BGO) doubled.
- African $LaBr_3$:Ce Array: ALBA 89x203mm $LaBr_3$:Ce
- Can be coupled to CSI, recoil det., silicon, solar cells, plunger, neutron wall, electron spectrometer, tape station.

# AFRODITE PLUS

Is an array of Compton suppressed (BGO) high-purity Germanium detectors (high resolution measurements). Total of 19 Clovers and 17 BGO


Until 2016: 9 Clover+BGO

2017 NRF grant to buy 5 BGOs and Clovers

2018 4 Clovers and 2 BGOs (GAMKA consortium)

2019 KVI donation of 1 BGO and Clover

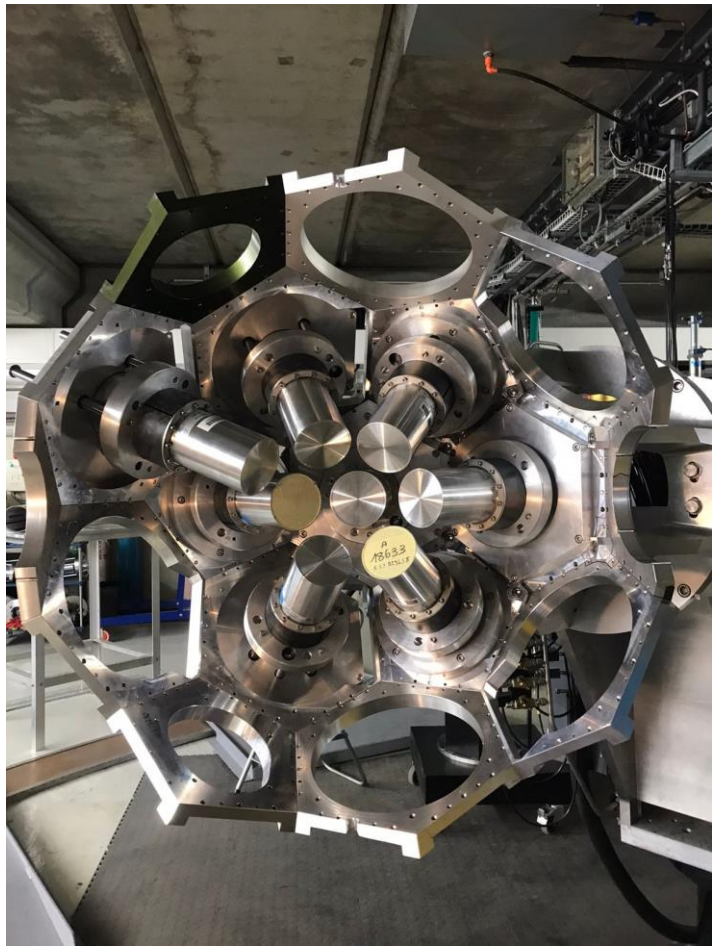
# ALBA: African LaBr Array

An array of 21 large-volume $LaBr_3$:Ce detectors (high efficiency at high energies).

2017 NRF grant for 6 $LaBr_3$:Ce

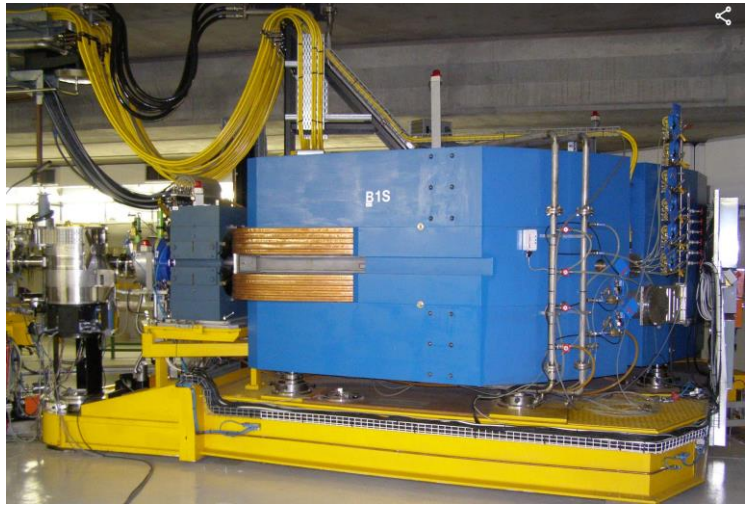
2018 15 $LaBr_3$:Ce through NRF GAMKA grant

2021 completion of ALBA with 21 $LaBr_3$:Ce detectors

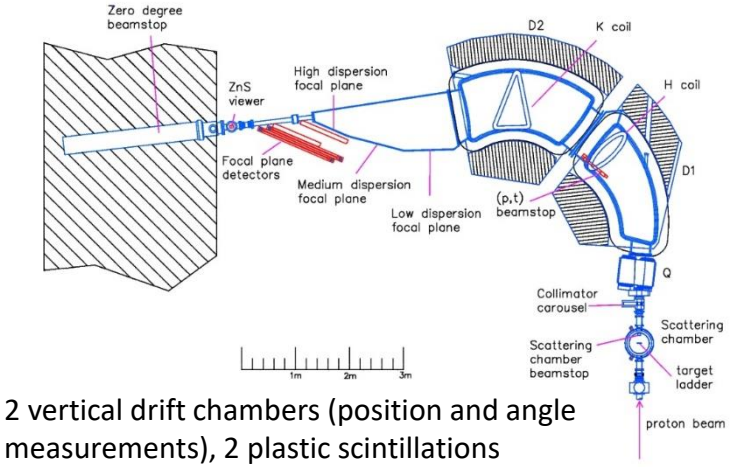


| Efficency 11cm from target | | | |
|---|---|---|---|
| **g-ray Energy (MeV)** | 1 $LaBr_3$:Ce (%) | 6 $LaBr_3$:Ce (%) | **21 $LaBr_3$:Ce (%)** |
| **1** | 1.2 | 7.1 | **25.2** |
| **5** | 0.5 | 2.9 | **10.5** |
| **10** | 0.3 | 1.7 | **6.3** |

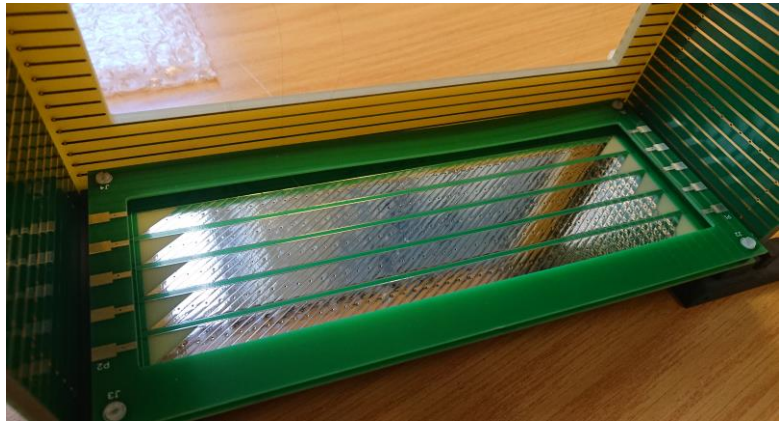
# K=600 Magnetic Spectrometer



K600 is one of two facilities capable of high energy resolution (≤100 keV FWHM) measurements at zero degrees, with low background to the measured spectrum, for medium energy (E~50-200 MeV/A) light ions (p,d,t,He).




2 vertical drift chambers (position and angle measurements), 2 plastic scintillations (trigger and particle id). Full solid angle 3.5 msr, efficiency 80%

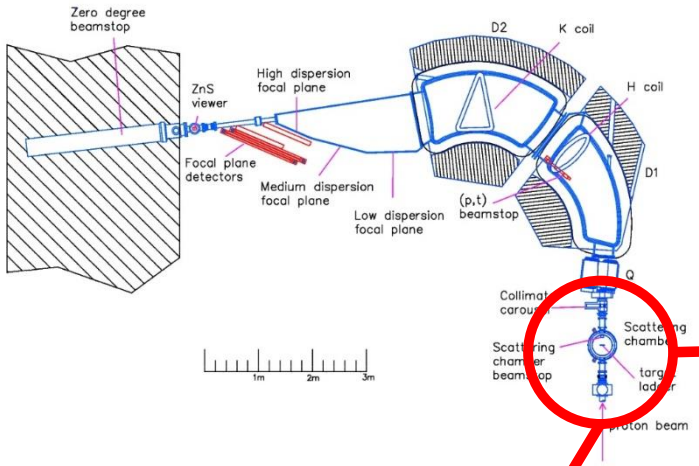


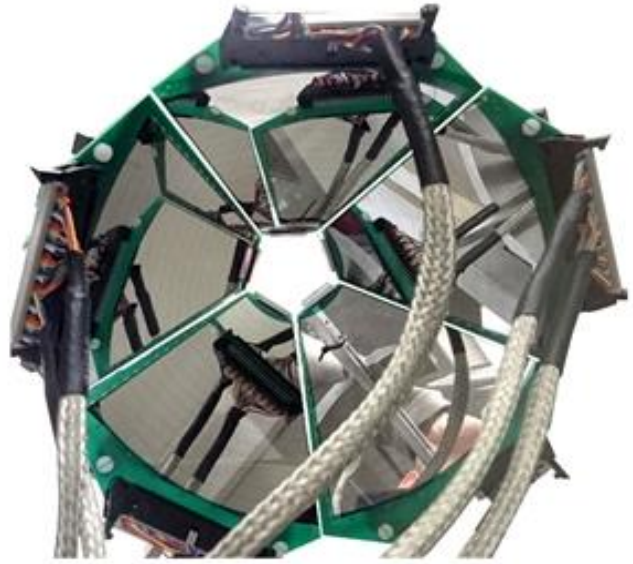
New FPD prototype:

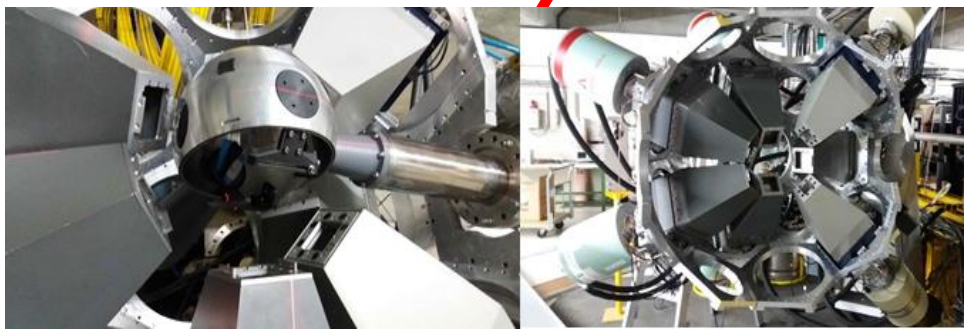
TPC-like detector: 200mm wide, 100mm deep (¼ size of full focal plane)

Segmented anode: 5 rows with 46 slanted pads each with 1 amplification wire per row. High density connectors

# K=600 Magnetic Spectrometer



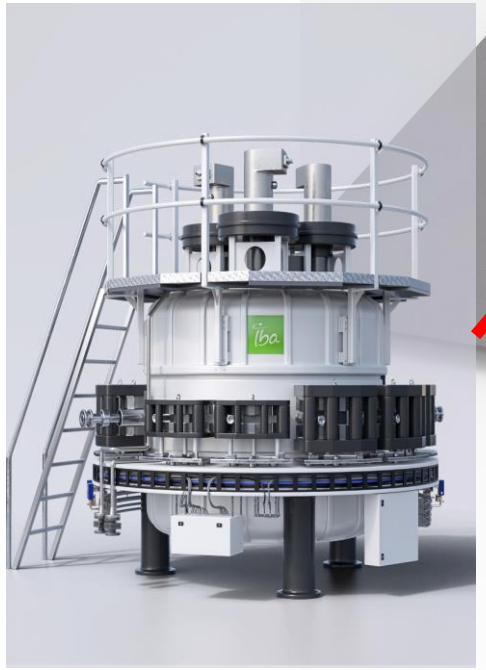


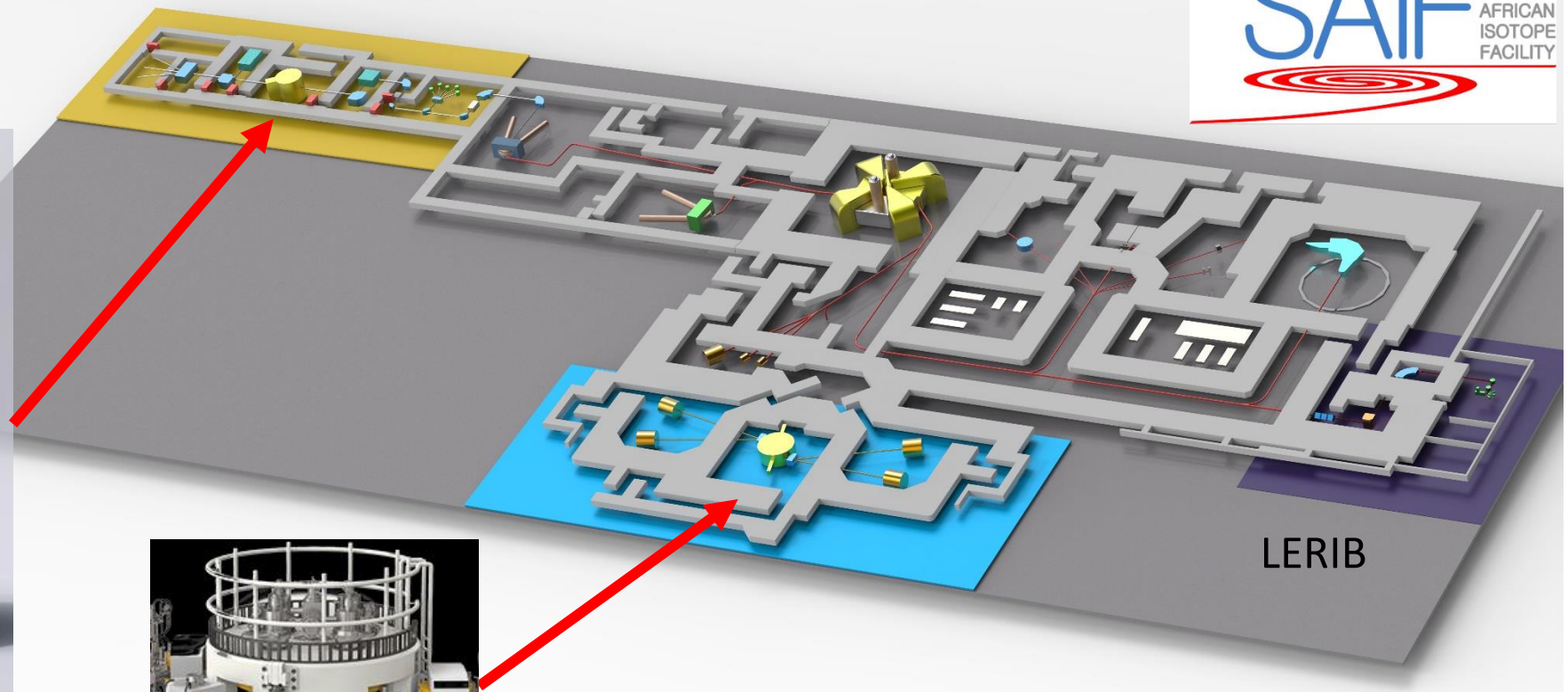
New gamma-ray detector array and chamber has been installed and commissioned in 2019.

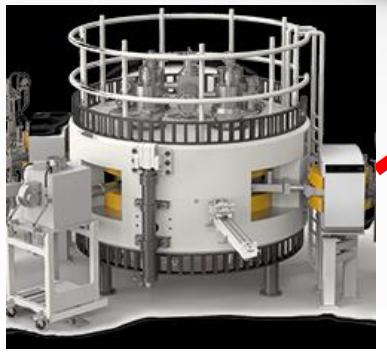
**C**oincidence **A**rray for **K**=600 **E**xperiments (CAKE). CAKE consists of five wedge-shaped double-sided silicon strip detectors, in a lampshade configuration.

# The South African Isotope Facility

Phase 2



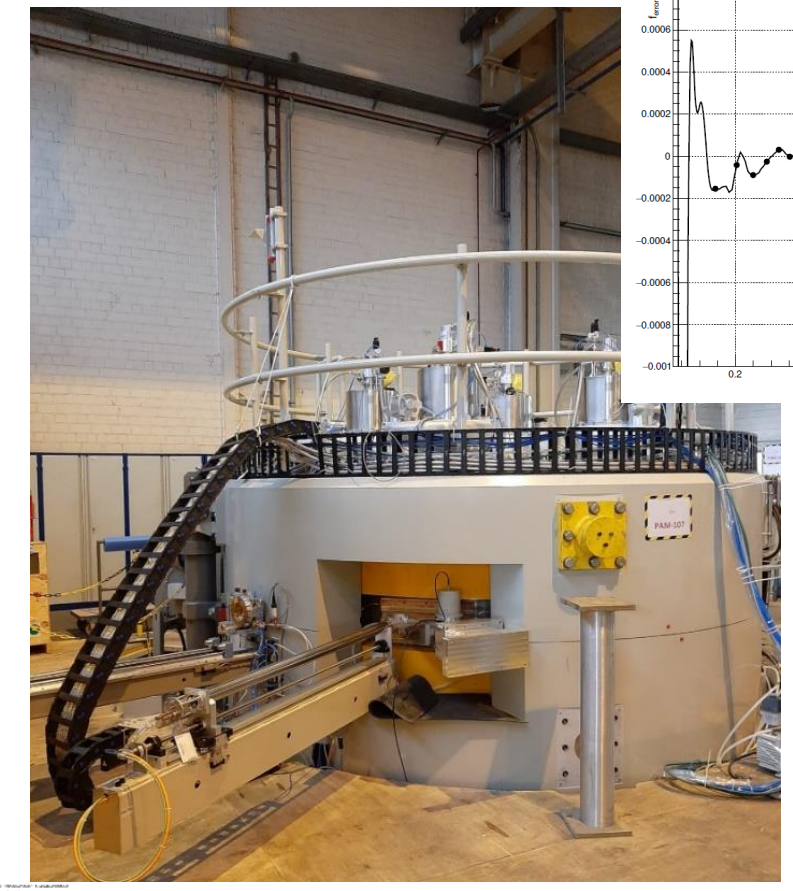


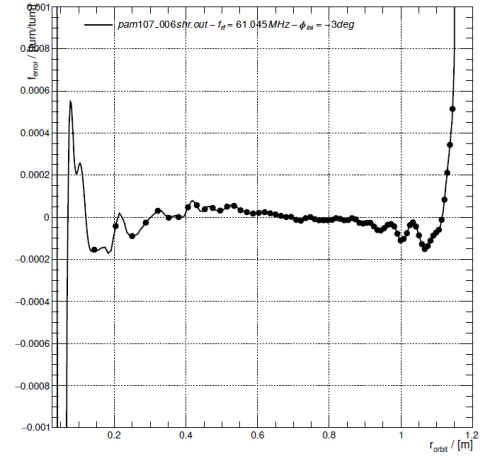



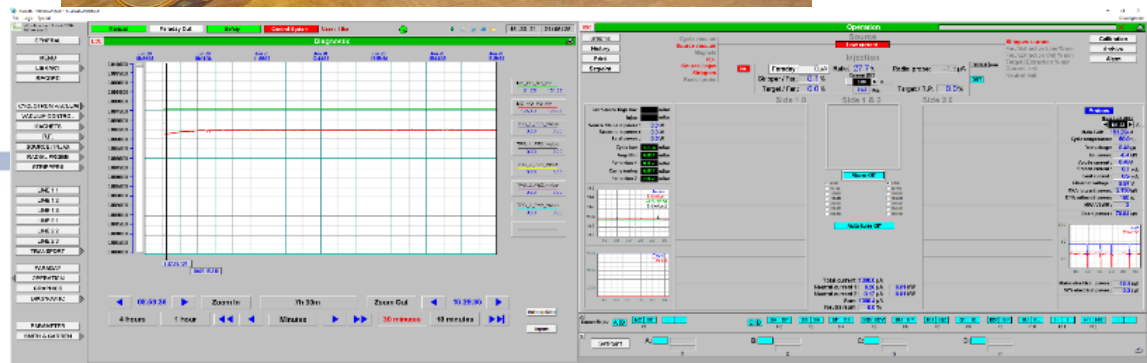
Phase 1

# South African Isotope Facility: 70MeV cyclotron

- Cyclone 70P supplied by IBA Radiopharma Solutions
- Variable energy proton beams (30 – 70 MeV).
- Multicusp ion source with 10 mA injected H- current.
- High-intensity p beams up to 375 µA per extraction port.
- Dual extraction ports for simultaneous beam delivery.
- 4 beam transport lines with beam diagnostics, Faraday cups and neutron shutters.



- Implementation started Sept. 2019
- Ion source commissioned Feb 2023.
- First internal beam March 2023 at 70 MeV with 966,9 µA on radial probe in the cyclotron.
- April 2023 first proton beam extracted at 20µA.



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# Summary

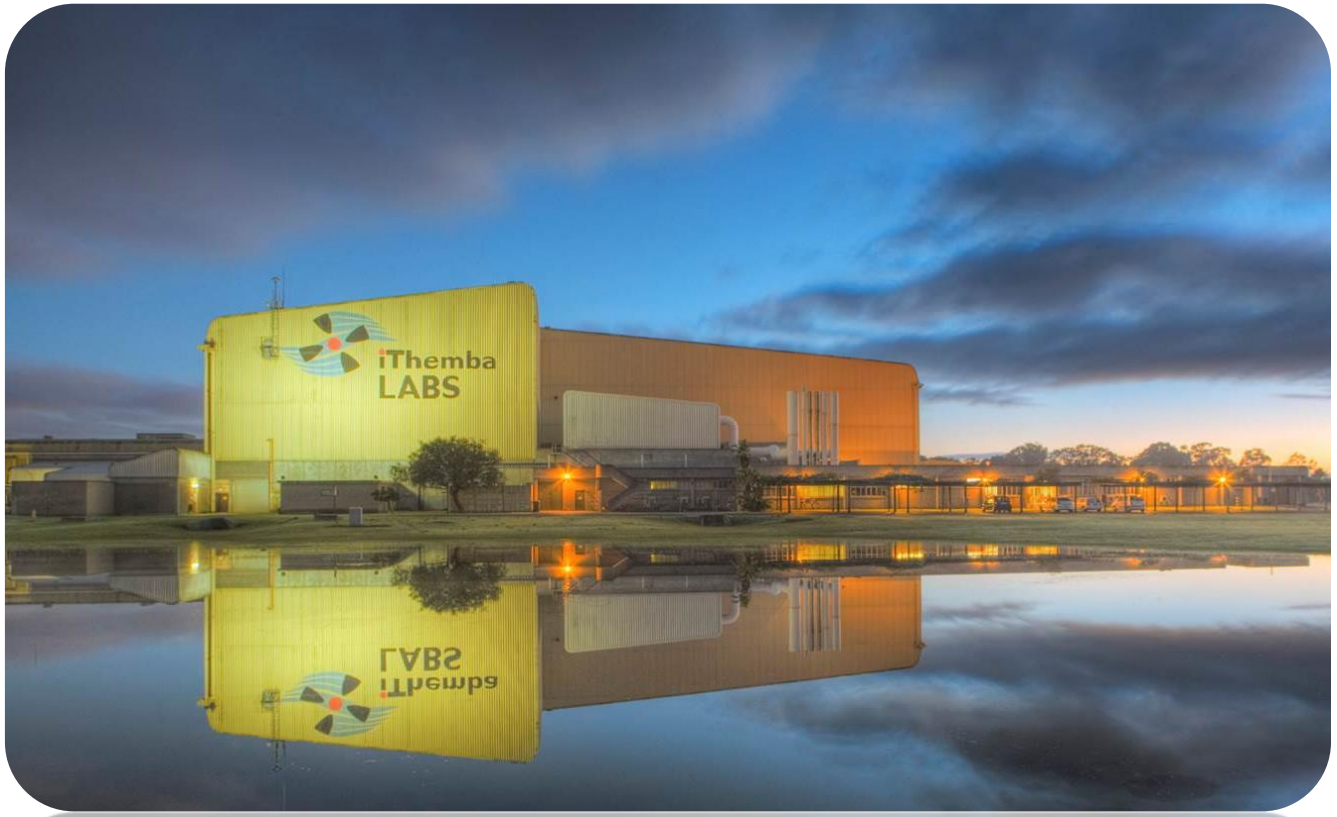
Opportune time to extend PSF/resonance studies to heaviest nuclei.

SSC Laboratory

- AFRODITE
- ALBA
- K600
- Neutrons

SAIF (i.e. no beam time constraints)

Ideas for measurements welcome




Thank you!