



UNIVERSITY of the
WESTERN CAPE

The GAMKA spectrometer

GAMKA THE LION

$$d_{f_{\text{EL}}(\theta, \xi)} = \frac{4\pi r^2}{(2\lambda + 1)^2} \sum_{\xi} \left| r_{\text{EL}} \left(\begin{matrix} \pi \\ 2 \\ 0 \end{matrix} \right) \right|^2 \times |L_{\text{EL}}(\theta, \xi)|^2 \sin^2 \frac{\theta}{2}$$

$$\omega = \frac{v}{r} = \frac{qB}{m}$$

$$E^2 = (pc)^2 + (m_0c^2)^2$$

$$\frac{E_{\gamma}}{E_{\gamma 0}} = \frac{\sqrt{1 - \beta^2}}{1 - \beta \cos \vartheta_{\gamma}}$$

$$\sigma_{\text{EL}} = \left(\frac{Z_1 e}{\hbar v} \right)^2 a^{-2\lambda+2} B(\text{EL}) f_{\text{EL}}(\xi)$$

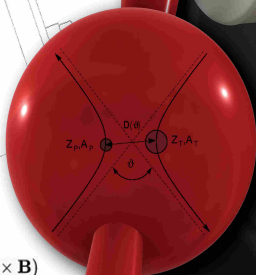
$$\mathcal{F} = NI$$

$$\frac{mv^2}{r} = qvB$$

$$\mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

$$\mathcal{F} = \oint \mathbf{H} \cdot d\mathbf{l}$$

$$\left(\frac{\Delta E_{\text{EL}}}{E_{\gamma 0}} \right)^2 = \left(\frac{\beta \sin \vartheta_{\gamma}}{1 - \beta \cos \vartheta_{\gamma}} \right)^2 \times (\Delta \vartheta_{\gamma})^2 + \left(\frac{\beta - \cos \vartheta_{\gamma}}{(1 - \beta^2)(1 - \beta \cos \vartheta_{\gamma})} \right)^2 \times \left(\frac{\Delta E_{\text{int}}}{E_{\gamma}} \right)^2$$



**Nico Orce
INTRANS 2024 WORKSHOP**





UNIVERSITY of the
WESTERN CAPE

GAMKA

THE LION

THE GAMMA-RAY SPECTROMETER FOR KNOWLEDGE IN AFRICA



First University for coloured people in South Africa (founded in 1960)



GAMKA

THE LION

THE GAMMA-RAY SPECTROMETER FOR KNOWLEDGE IN AFRICA

Largest single grant given by the NRF in a competitive call (+2M€) for a new γ -ray spectrometer
New funding instrument for Strategic Research Equipment (SRE). PI: Nico Orce

The House Of GAMKA (THE LION)

THE GAMMA-RAY SPECTROMETER FOR KNOWLEDGE IN AFRICA

DANDELION FRAME

A UWC-led Consortium of universities including: Stellenbosch University, University of Witwatersrand, University of Zululand, iThemba LABS
Funded By: National Research Foundation (NRF) • Hosted By: iThemba LABS • Designed and Manufactured by: CJ Dustraction Systems (Pty) Ltd.

UNIVERSITY of the WESTERN CAPE

Stellenbosch
UNIVERSITY
UNIVERSITHI
UNIVERSITEIT

NRF
National Research
Foundation

iThemba
LABS
Laboratory for Accelerator
Based Sciences

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

UNIVERSITY OF
ZULULAND

The name GAMKA (Lion in Khoisan language) was elected by the Physics Users in 2012.
A name that symbolized decolonization, SA pride and ownership



GAMKA

THE LION

THE GAMMA-RAY SPECTROMETER FOR KNOWLEDGE IN AFRICA

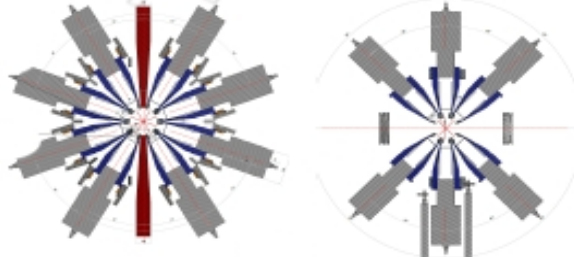
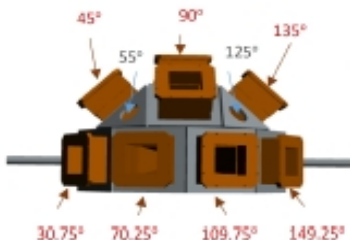
The Dandelion Frame : Inspired By Nature

Abstract

This research focuses on designing, engineering, and simulating structural frames for portable accelerator detectors, emphasizing pioneering mechanical design and systems research. In a collaboration with physicists led by the University of the Western Cape (UWC) our team explores innovative biomimetic methodologies and advanced simulations to allow for adjustable distances from the target chamber optimizing detector performance and precision resulting in a design inspired by nature.

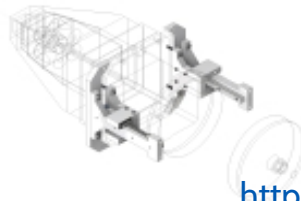
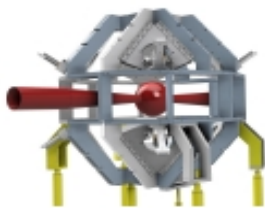
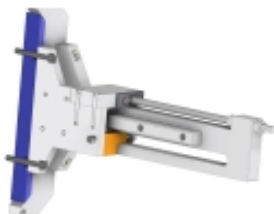
GEANT4 simulations

This work presents results from GEANT4 simulations of a new Dandelion frame for gamma-ray spectroscopy experiments. The work aims to optimize the performance of the gamma-ray array for different types of research such as: Charge particle detection, high-resolution gamma-ray spectroscopy, dipole resonances and gamma-ray strength functions.



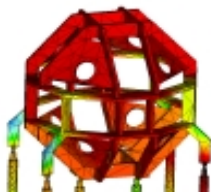
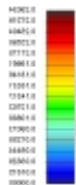
The Dandelion Frame Design

The Dandelion-frame setups include different combinations of detectors, placed at different distances. The aim is to provide a versatile frame, where different detectors can be mounted at different detector positions, and where the detector-target distance can be adjusted according to the needs of the experiment.

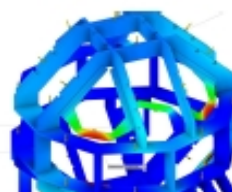
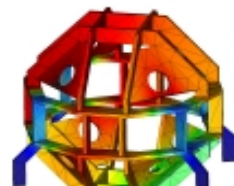


Finite Element Analysis

By harnessing the power of advanced simulations, we meticulously analyzed and optimized the intricate dandelion-inspired configurations. Through iterative design refinements, we ensured the frame's structural integrity, thermal efficiency, and durability.



Deflection Plot

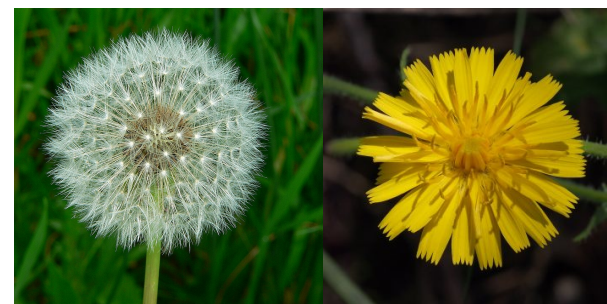


INTRANS 2024 Workshop
22-25 January 2024

Auditorium P. Lehmann - bldg 200



Design of the Dandelion ('dent de lion')
Frame: Poster by Shaun Hendricks



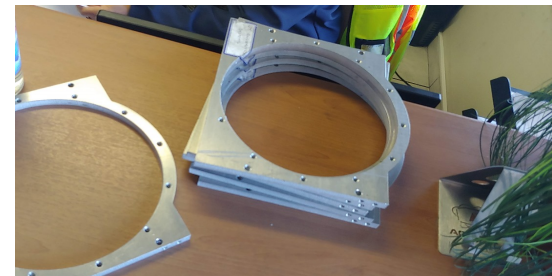
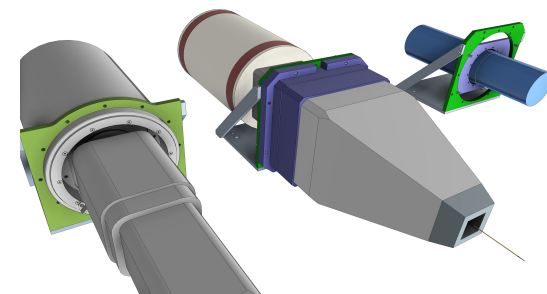
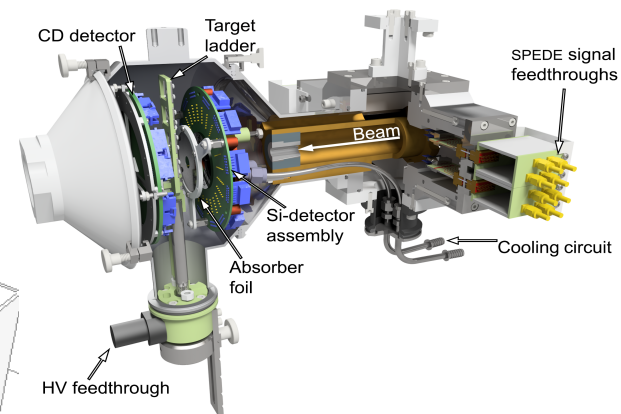
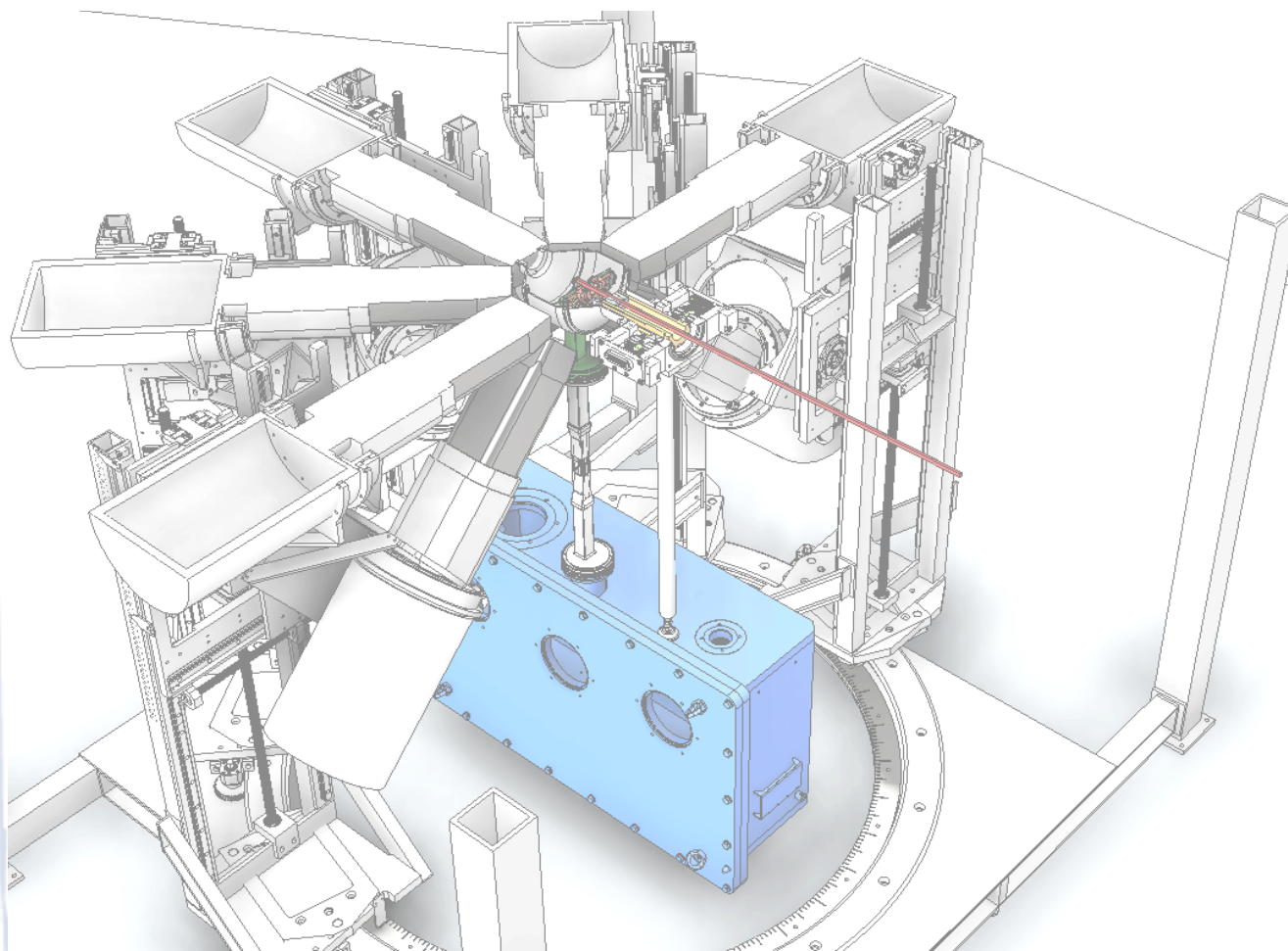
<https://www.youtube.com/watch?v=ucnQDrpNQk>

<https://www.youtube.com/watch?v=wxLRLOtXwmM>

<https://github.com/UWCNuclear/>

<https://nuclear.uwc.ac.za/>

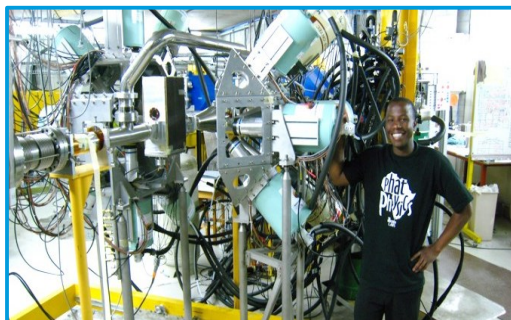
Shaun's further involvement @ IDS/CERN



Once upon a time

In October 2012 I was elected by the Physics Users @ iThemba LABS with the mandate to lead the design/building/funding of a new γ -ray spectrometer

AFRODITE ~20 years old



Needed a new array to be competitive worldwide

Powerful New Array at iThemba LABS
New Opportunities for Nuclear Physics and Astrophysics in South Africa

GAMKA - The LION

Gamma-ray Asymmetric spectrometer for the Knowledge of Africa
(The LION in Xhokhol language)

NUCLEAR STRUCTURE PHYSICS
Best Nuclear Chiral Structure found in ^{194}Tl
Paulus Mashego and Elena Lawrie
Lecturer (UI) and Researcher (iThemba LABS)

Searches for candidates for nuclear chiral structures have been carried out for more than a decade in many international laboratories all over the world. Recently the best case was discovered in the ^{194}Tl nucleus at iThemba LABS.

Chiral symmetry is linked to the presence of left-handed and right-handed objects. Such objects are a mirror image of one another, but they remain not completely identical, very much like our left and right hands. Examples of chiral objects are shown in Fig. 1 (a) and (b). It remains however to be established whether this symmetry can exist in such small objects as nuclei. If it does, it will be defined in the angular momentum space (Fig. 1(c)).

Chiral objects are very difficult to identify. Their most distinguishing feature is the observation of two rotational bands both of which consist of π spin transitions with very close spacing. Many nuclei were studied in great details in order to search for such new-deformation structures. The best cases found until recently were in ^{182}Pt [1] and ^{192}Pt [2] at iThemba LABS a pair of rotational bands with exceptionally good near-degeneracy and distinct identity [3]. The energies of the nuclear states belonging to the two chiral partners in the nuclear states found to differ by no more than 150 keV, which is considerably better than the best case known so far (Fig. 2). In addition all other measurable properties of these partner structures are nearly identical, confirming that a remarkable near-degeneracy is established, indicating the likely presence of chiral symmetry.

The newly proposed array allows a substantially improved sensitivity for nuclear chiral research!

Apart from near-degeneracy the nuclear chiral partners also exhibit specific behavior of the reduced transition probabilities. These can be detected by measuring the lifetime of the nuclear states and by measurements of the mixing ratios for the $M1 \pm 2$ transitions. Both the lifetime and the mixing ratios depend on the deflection angle. The proposed new asymmetric arrangement of the AFRODITE detectors has major advantages in respect to the present array. It is much more compact with the three detector angles in comparison with the three detector angles of the present array. This arrangement allows the simultaneous detection of the $M1 \pm 2$ transitions and also adds an additional power for accurate measurements of nuclei γ -ray multipolarities. These new abilities of the array will have a major impact on the chiral research.

[1] T. Kolbe et al., Phys. Rev. C 67, 044319 (2003).
[2] S. Zhu et al., Phys. Rev. Lett. 91, 132601 (2003).
[3] P. Mashego, E.A. Lawrie et al., Phys. Lett. B, 716, 123 (2012).

NUCLEAR ASTROPHYSICS
Shortest lifetimes in nuclei ($\sim 10^{-15}$ s) tell the age of oldest objects in Universe
Nico Guise
Associate Professor (University of the Western Cape)

What is the age of our universe? It is often said that one of the mainstays of modern astrophysics is the study of the oldest objects in the universe. In many respects this is the most basic of nuclear physics questions as it is the most fundamental question of the universe.

Consider clusters formed after the primordial cloud following the big bang and the oldest known stellar systems in our galaxy forming between 10 and 100,000 years after the big bang. The stars of any given age have a certain number of short-lived isotopes, which decay over time. The shorter the half-life, the more of these isotopes are present in the cluster. In the case of the oldest stars, which are thought to be 100 billion years old, the number of these isotopes is very small. The age of the cluster can be determined by measuring the number of these isotopes. The age of the cluster can be determined by measuring the number of these isotopes. The age of the cluster can be determined by measuring the number of these isotopes.

Planetary globular clusters can be older than the universe!

Figure 1: Left-handed and right-handed chiral systems in ^{194}Tl (a), (b) and (c) in ^{194}Tl .

Figure 2: Difference in the excitation energies of the nuclear states of the chiral partner bands in ^{194}Tl , ^{192}Pt and ^{182}Pt .

THE RADIOACTIVE ION BEAM PROJECT at iThemba LABS
Low-energy radioactive beams to test the Shell Model at N=82 and N=126

Robert Bark
Radioactive Beam Project Leader (iThemba LABS)

One of the major unanswered questions of nuclear structure physics and of nuclear astrophysics is whether or not the closed shell model is the dominant model of the nuclear shell. The shell model is the dominant model of the nuclear shell. The shell model is the dominant model of the nuclear shell.

In 1949 Hans Gessert Meier and I. Peter Jansen developed the nuclear shell model (SM) for which they later received the Nobel Prize. The nuclear shell model has played a central role in our understanding of the properties of atomic nuclei. For stable nuclei, it successfully predicts the observed magic numbers, which correspond to the filling energy of the nucleus, by including the spin-orbit interaction into the nuclear potential.

The question is: are there magic numbers still valid in very-massive nuclei? Will they be from the line of stability?

Recent theoretical and experimental work suggests they are not. In light nuclei, around the magic 20 region, the irregularities of a component of the nuclear shell that were included in the original shell model, are still present.

Recent theoretical and experimental work suggests they are not. In light nuclei, around the magic 20 region, the irregularities of a component of the nuclear shell that were included in the original shell model, are still present.

Elements heavier than iron are formed in astrophysical environments by the so-called r-process, the s-process that depends critically on the location of neutron shell gaps in the neutron-rich region. In the rapid process, an intense flux of neutrons, initially created in a supernova explosion, bombards nuclei during its evolution. This rapidly captures neutrons until the nuclei are so neutron-rich that they undergo β -decay. The final product is a neutron-rich nucleus. The final product is a neutron-rich nucleus. The final product is a neutron-rich nucleus.

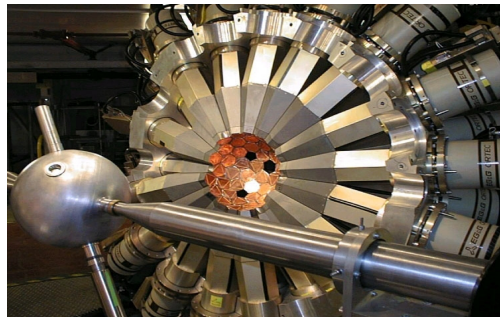
Figure 1: Upper part of the chart of the nuclides along the neutron drip line (red line) and the proton drip line (blue line). The shaded region indicates the region of stability. The shaded region indicates the region of stability. The shaded region indicates the region of stability.

Figure 2: Theoretical and experimental work suggests they are not. In light nuclei, around the magic 20 region, the irregularities of a component of the nuclear shell that were included in the original shell model, are still present.

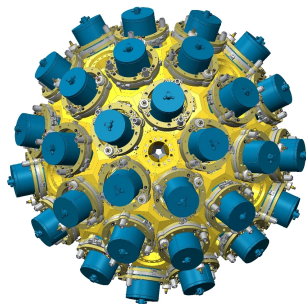
Combination of high-resolution + high-efficiency gamma detectors in flexible configurations to accommodate a wide range of nuclear physics and nuclear astrophysics phenomena: nuclear deformation and collectivity, high spin, short nuclear lifetimes, angular distributions, photon strength functions, nuclear polarizability and giant dipole resonances → NEP rejected (too much money!)

“Keep the dream alive”, late Danny Adams
(Chief Director: Basic Sciences & Infrastructure@ DSI)

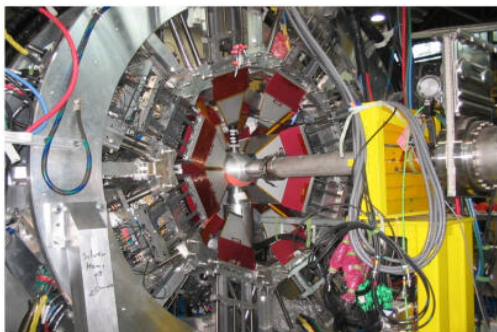
Gammasphere



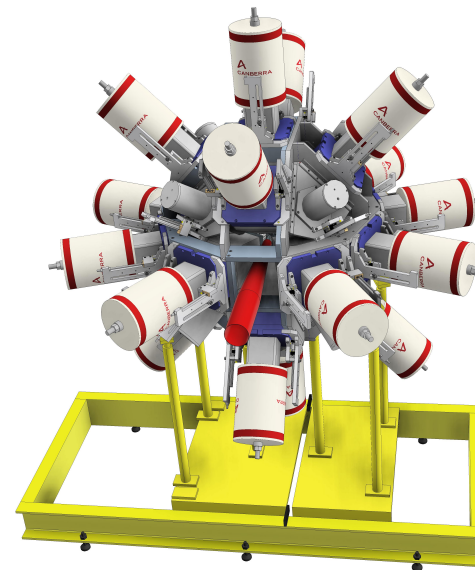
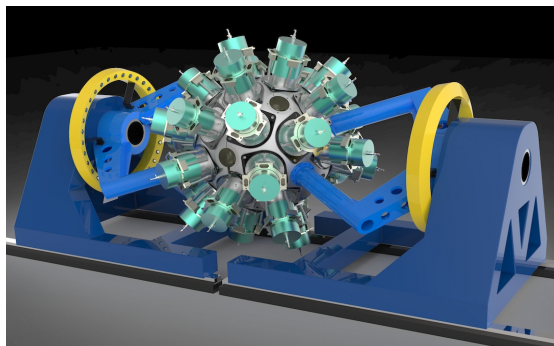
AGATA @ GANIL, LNL, GSI



TIGRESS



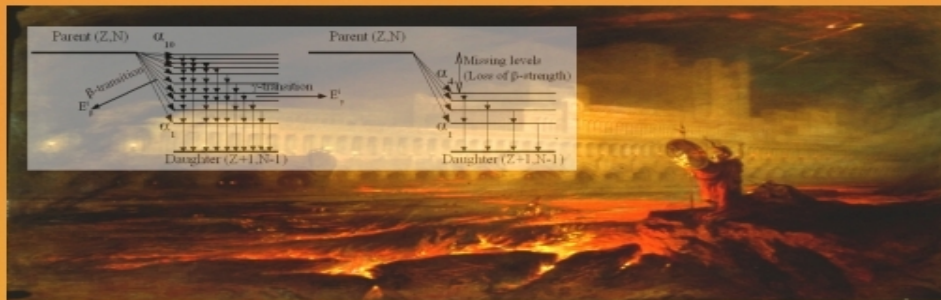
GRETA @ FRIB, ANL



GAMKA @ iThemba LABS

V Tastes of Nuclear Physics

November 4 - 6, 2015



Pandemonium: a place or scene of riotous uproar or utter chaos

New Physics with GAMMA [the Lion] and RBs

World-Class Lecturers

- Maria Garcia Borge (CERN, Switzerland)
- Alejandro Algora (Valencia, Spain)
- Paul Garrett (Guelph, Canada)
- Andreas Gørgen (Oslo, Norway)
- Emanuele Vardaci (Napoli, Italy)
- John Wood (Georgia Tech, USA)
- Steve Yates (Kentucky, USA)

With Special Talks By Our Own Students!

Timely Topics

- Mathematics for Advanced QM
- Beta Decay
- Coulomb Excitation
- Nuclear Lifetimes
- Statistical Model
- Physics @ ISOLDE (CERN)
- Physics with the 8pi (TRIUMF)
- Nuclear Astrophysics

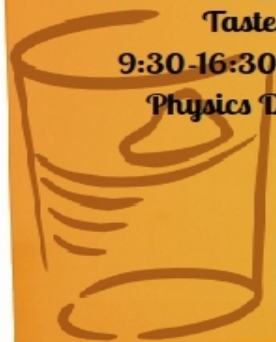
No Registration Fees

Free Coffee & Lunch

Tastes Braai

9:30-16:30 @ Room 1.35

Physics Dept @ UWC



Tastes of Nuclear Physics @ UWC/SU/UZ

John Wood, Steve Yates, Berta Rubio, Maria Garcia Borge, Alejandro Algora, Paul Garrett, Magda Zielinska, Dan Doherty, David Jenkins, Mark Riley, Paul-Henri Heenen, Kike Nacher, Peter Butler, Eric Norman, Emanuele Vardaci, John Sharpey-Schafer, Elena Lawrie, Nico Orce, Kobus Lawrie, Pawel Napiorkowski, Ale Pastore, Alexis Diaz Torres, Xavier Roca-Maza, Jorge Piekarewicz, Calors Bertulani, Adriana Banu, Krish Baruth-Ram, Mitch Allmond, Werner Richter, Paul Papka, Sifiso Ntshangase, our students and others



New GAMKA spectrometer: proposal

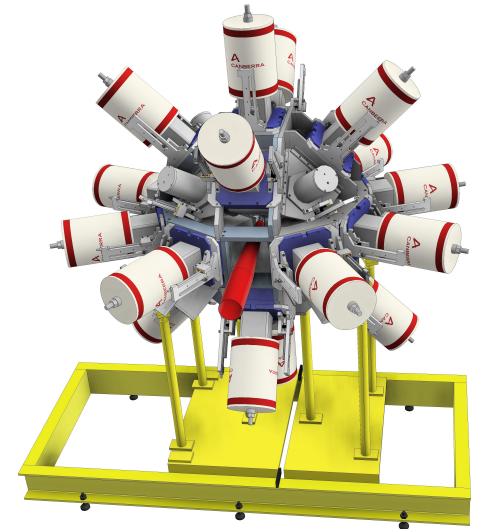
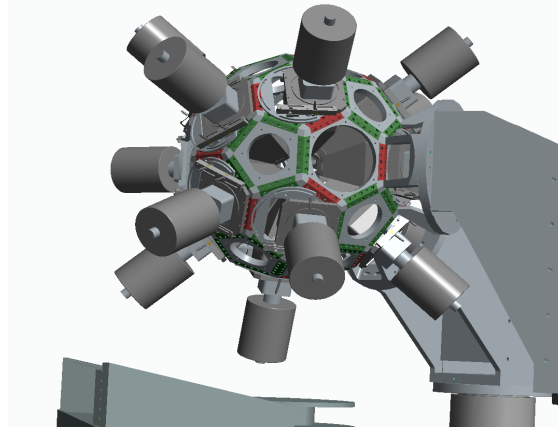
- 4 clovers and 3 BGO shield \rightarrow making up to 17 shielded clovers (including factory refurbishment of clovers)
- 17 large (89 mm diameter x 203 mm) LaBr_3 detectors \rightarrow making up to 23 LaBr_3
- 2 frames for two different beam lines: K600 line (Soccerball frame) and AFRODITE (Dandelion frame)
- XIA digital electronics (500 MHz)
- HV, LN2 liquefier system

Frames:

- versatile
- shielded (unshielded) clovers
- large LaBr_3 for efficiency
- small LaBr_3 for lifetimes
- LEPS (segmented Planar HPGe) for low-energy gammas
- optimized for clover efficiency, clover + LaBr_3 efficiency, number of independent angles, clover P/T

Target Chambers:

- smaller 170mm diameter for increased efficiency
- larger, 200mm diameter to hold Si detectors



GEANT4 Simulations (by Elena Lawrie, Walid Yahia-Cherif, Kobus Lawrie)

Aim: To optimize the performance of the gamma-ray array for different types of research.

Construct Geometry

different detectors

positions in space (for different combinations and angles)

Emit γ rays

γ rays at 1, 5 and 10 MeV

Isotropic sources (^{60}Co , ^{152}Eu)

coincident γ rays – cascades or sources (^{60}Co , ^{152}Eu)

with any given angular distribution

Track interaction in all materials

(Photo electric effect, Compton scattering, Pair formation)

Record energy deposition

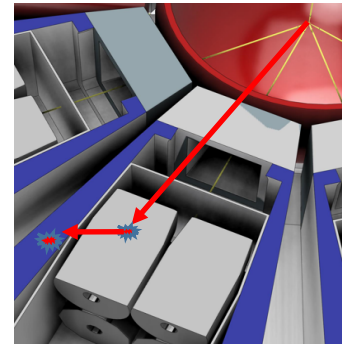
for each detector and for sum of all

clovers with or without Compton suppression

clovers with or without add-back

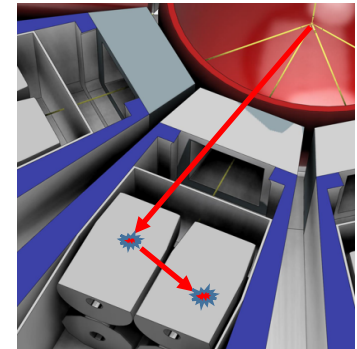
(add-back: summed energy over 4 crystals in a clover)

Compton Scattering

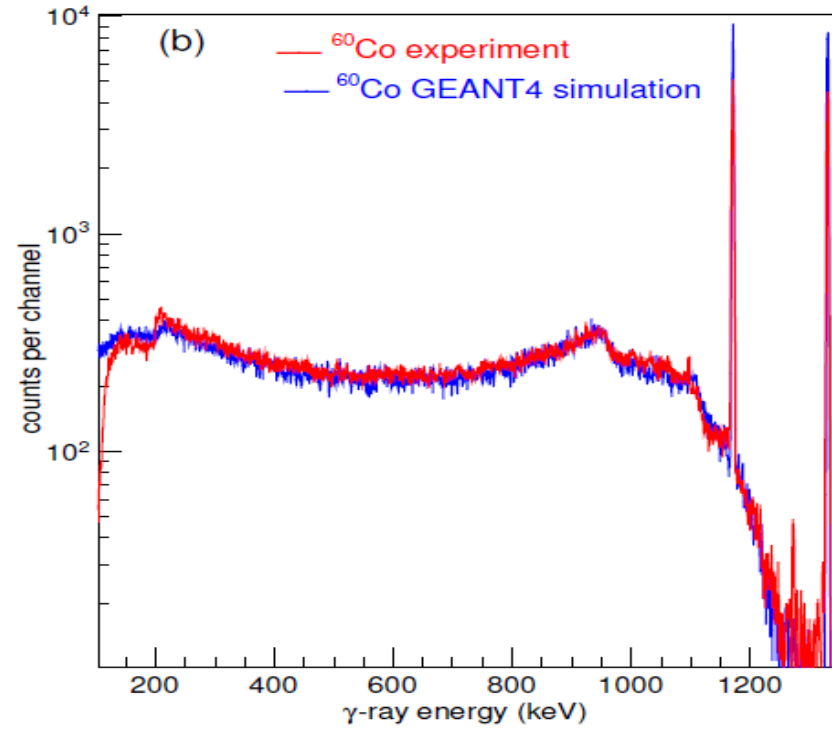
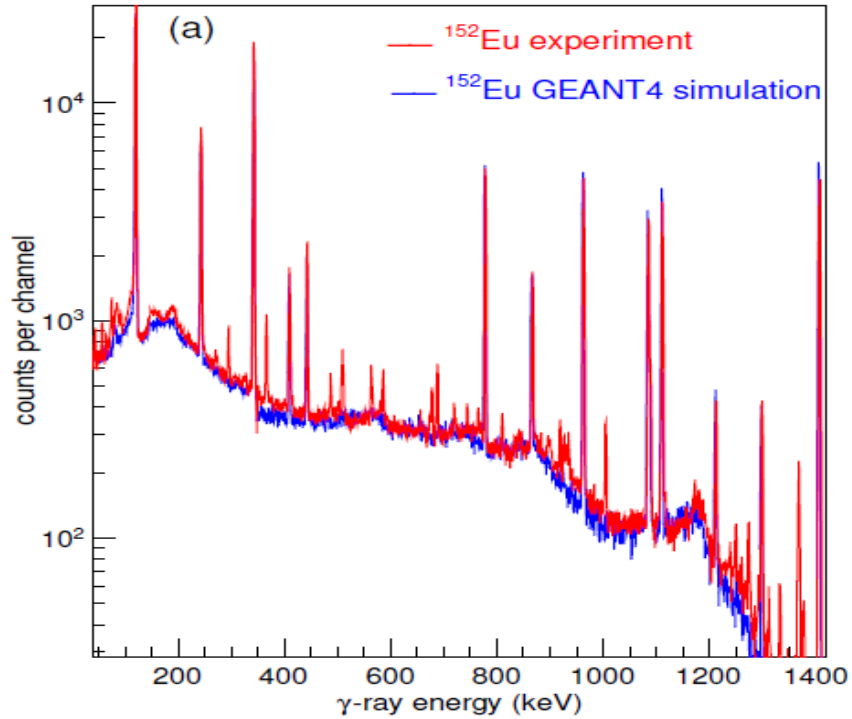


Escape
Suppression

Add-back



GEANT simulation of sources



Dandelion - option 1

Detectors:

- ✓ 18 suppressed clovers
- ✓ 8 large or small LaBr_3 or LEPS

Distances:

Clovers @ 194mm to crystal
(102mm to collimator)

Large LaBr_3 : at 183mm to cap

Small LaBr_3 : at 102mm to cap

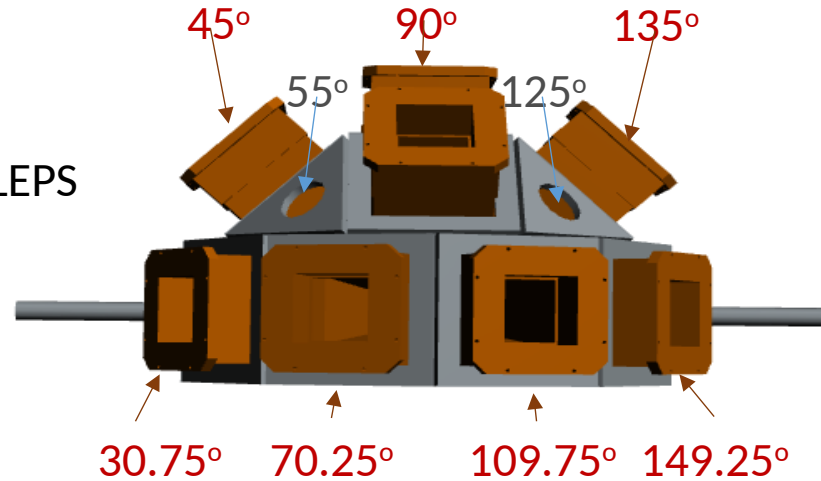
Chamber: 200mm diameter

Beam pipe: 40 mm diameter

Peak/Total at 1 MeV:

35x35mm Collimator 67.4%

40x40mm Collimator 66.7%



Physics:

- High-spins states, spins, parity, mixing ratios, matrix elements
- Clovers + S3 silicon detectors for Coulomb Excitation

| EFFICIENCY | 1 MeV | 5 MeV | 10 MeV |
|-------------------------|-------|-------|--------|
| 17 Clovers | | | |
| Collimator 35x35 | 4.85% | 1.32% | 0.56% |
| Collimator 40x40 | 5.59% | 1.47% | 0.59% |
| 8 Large LaBr_3 | 4.48% | 1.93% | 1.13% |
| 8 Small LaBr_3 | 1.92% | | |

Angular Distribution Simulation (by Elena Lawrie, Kobus Lawrie, Gugu Mtembu)

$$W(\theta) = a_0 + a_2 P_2(\cos \theta) + a_4 P_4(\cos \theta)$$

747 keV $17/2^- \rightarrow 15/2^-$ in ^{135}Pr

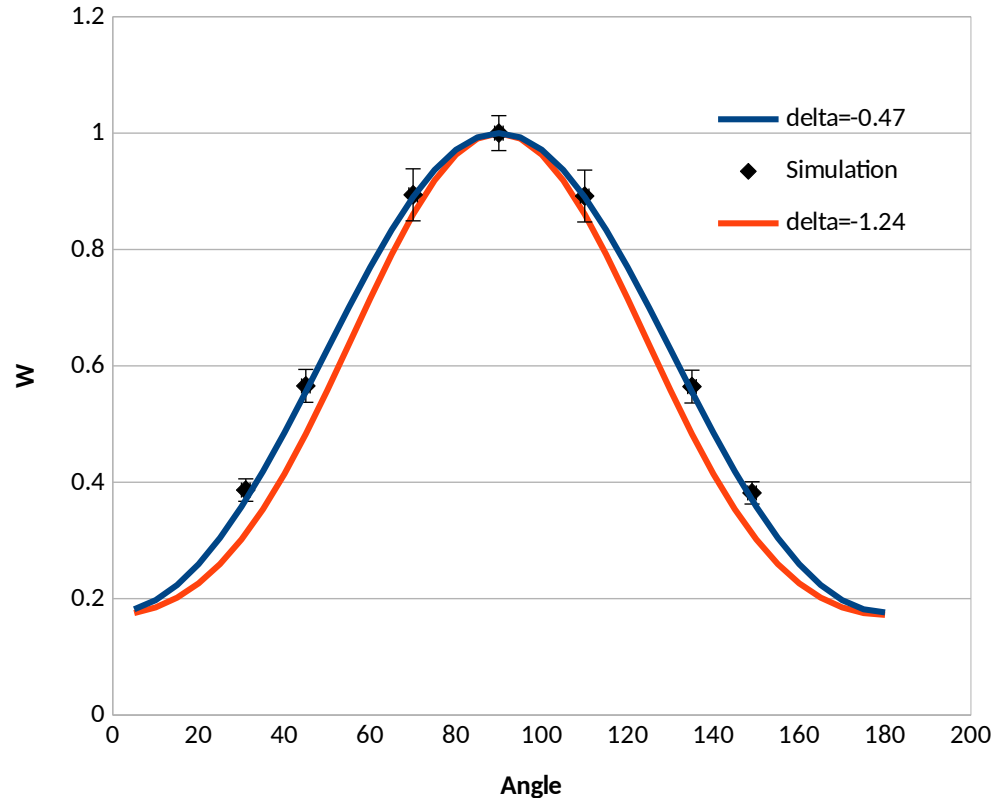
M1/E2 with $\delta = -0.47$ and -1.24

(two possible values that give different interpretations)

Calculated a_2 and a_4 for $\delta = -0.47$

Simulate emission with calculated $W(\theta)$ for 18 clovers in dandelion frame with 5% error

Compare with calculated $W(\theta)$ for $\delta = -0.47$ and -1.24



GAMKA Business Plan for Strategic Research Equipment (SRE)

100s of pages, thousands of files, sections, subsections, appendixes, various science cases, finances, steering, OC, NRF, UWC meetings, reports, NRF defense,..., many years of solid work.



Funding Instrument: Strategic Research Equipment
Functional Domain: Human and Infrastructure Capacity Development
Type of Equipment: Multiple Complimentary Instruments
Document: ANNEXURE A: Revised Management Plan
Date: March 2018

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List of Acronyms

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APPENDIX A (Reproduced from Phase II Business Plan p 17-19)

Technical capabilities/applications

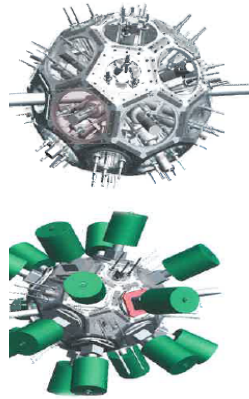
Technical capabilities

- The GAMKA gamma-ray spectrometer will be comprised of high-resolution clover-type HPGe detectors and high-efficient LaBr₃:Ce detectors. The technical capabilities and applications for the clover detectors were explained in our Phase 1 application.
- Four clover detectors will be used to complement the existing AFRODITE gammarray array. This will provide 16 detectors that constitutes the maximum number of detectors that can be accommodated in the present geometry and would give the largest possible coverage of the full 4pi solid angle. The expected efficiency at 1.3 MeV would be 2.72% with an energy resolution of 2.1 keV and a peak-to total ratio 40%. The increase from the present 9 detectors to 16 will increase the probability of detecting coincidences of more than 3 simultaneous gamma rays by a factor of 4, thus allowing much superior selectivity particularly where gamma transitions with similar energies exist in the same isotope or in contaminants isotopes.
- The 17 new large volume (89x203mm) and high-efficient LaBr₃:Ce detectors, that supplemented 6 identical detectors that have been ordered. These have an energy resolution of ~3% (40 keV at 1.3 MeV and 180 keV at 6 MeV). However the photopeak efficiency, particularly at high gamma energy, is much higher than that of Ge detectors as can be seen in the table below.
- The GAMKA array of high-resolution clover and high-efficiency LaBr₃:Ce detectors could be mounted in flexible configurations that makes provision for 30 detectors. Two possible configurations that could make up the GAMKA array are shown in Fig. 1. Additional electronics for data processing to supplement the existing system at iThemba LABS are included in this proposal.

| Gamma-Ray Energy (MeV) | Efficiency for one HPGe clover detector (%) | Efficiency of AFRODITE (nine Clovers) (%) | Efficiency for one LaBr ₃ :Ce detector (%) | Efficiency for 23 LaBr ₃ :Ce detectors (%) |
|------------------------|---|---|---|---|
| 1.3 | 0.20 | 1.9 | 0.38 | 8.74 |
| 6.0 | 0.05 | 0.45 | 0.16 | 3.68 |
| 10.0 | 0.03 | 0.27 | 0.10 | 2.30 |

- Coupled with other particle detection devices (such as the K800 spectrometer, silicon detectors, etc), GAMKA detectors will provide a unique combination with each detector

ifferent aspects of nuclear properties. As evident from the Br₂Ce detectors will provide a huge increase in efficiency at , thus allowing cutting edge science to be performed.



s of the GAMKA array comprising (top) 30 LaBr₃:Ce detectors and Ce detectors.SU

LaBr₃:Ce and clover detectors are delivered they will be available for experiments, an approach which utilizes the ability without delay and further commissioning.

, such as the study of resonances and strength functions, research projects, will benefit from the availability of large

- 2.3.1 all communications between the Consortium and the NRF as a point of contact;
- 2.3.2 submission to the NRF of an annual report, from date of grant award to ten (10) years post commissioning of the equipment under signature of the Chairperson of the Advisory Committee and the designated DvC from the lead institution (if different);
- 2.3.3 establishing the SRE as a national resource in leading the scientific and research themes of the Proposal and in the management of the day-to-day operational activities;
- 2.3.4 the development of the strategy;
- 2.3.5 the development of the Annual Business Plan;
- 2.3.6 Annual Progress Reports (APRs);
- 2.3.7 the financial management of the SRE Consortium funds; and
- 2.3.8 the preparation and provision of all other consolidated reports for submission to the NRF.

2.4 The provisions of this Agreement supersede any other related provisions contained in earlier Agreements between the Parties, which pertain to the management and operation of the DST - NRF SRE Consortium.

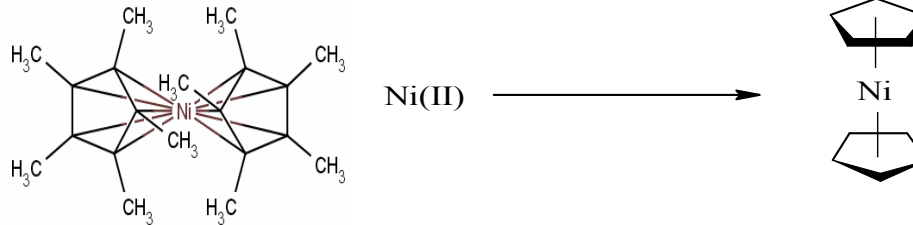
2.5 This Agreement will operate as from the Effective Date and will remain in force for a maximum period of ten (10) years, or until the winding up of the SRE Consortium as hereinafter provided, or as otherwise agreed between the Parties, or terminated in terms of the Clause 9, whichever occurs first, subject to the provisions of this Agreement.

GAMKA gantt chart – according to plan



Development of new beams @ iThemba LABS

Organometallic Chemistry using MIVOC method to accelerate exotic stable beams



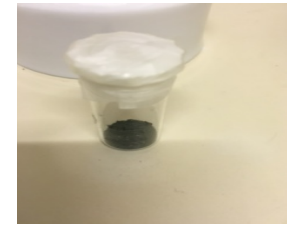
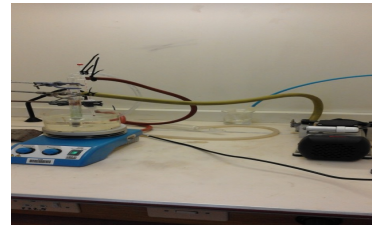
- Enriched isotopic material in powder form needed (Rainer Thomae)
- Organometallic chemistry (new chemistry lab available @ TLABS)
- Inject enriched compound into the new injection system of the HMI ECRIS4 ion source
- Lots of new beams (Ni, Ru, Pd, Pt, Sm, Mg, etc)
- New Physics (lifetimes in inverse kinematics, second-order effects in Coulomb excitation, strength functions, etc)



Ntombi Kheswa (PhD), Rainer Thomae and the Accelerator Group at iThemba LABS, Rudolph Nchodu (iThemba LABS), Salam Titinchi (Chemistry, UWC) and Nico Orce (UWC)

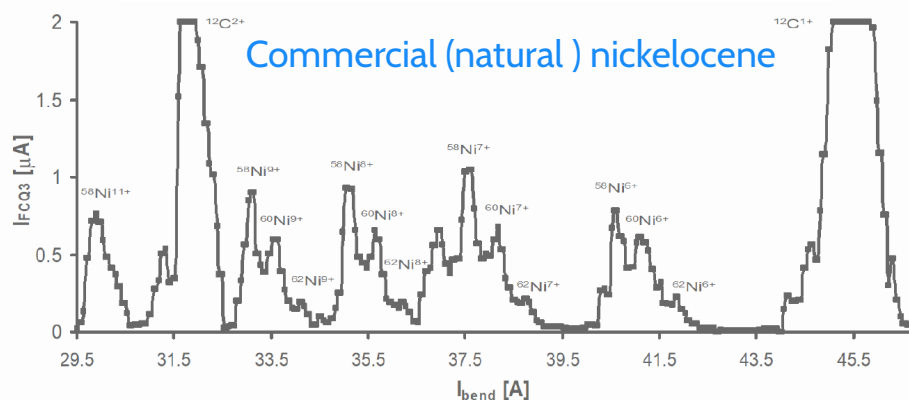
Chemistry lab @ TLABS (Ntombi's PhD)

Nickelocene step by step synthesis from Nickel Chloride to Hexaaminenickelchloride to nickelocene

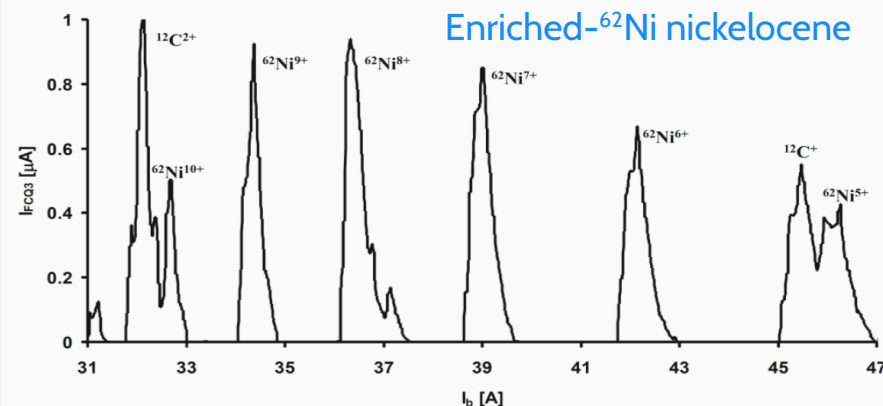


Synthesising samples characterised by investigating their crystal structure and bonding arrangements by X-ray diffraction (XRD), Fourier Transform Infrared (FT-IR) spectroscopy, and ^1H NMR

m/q spectrum



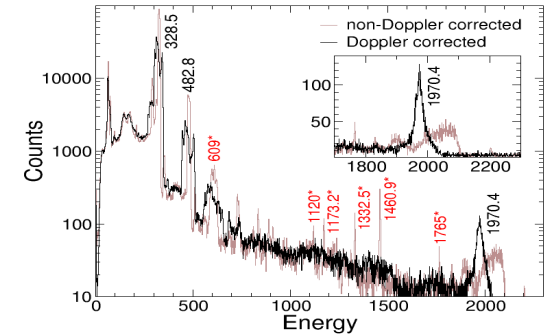
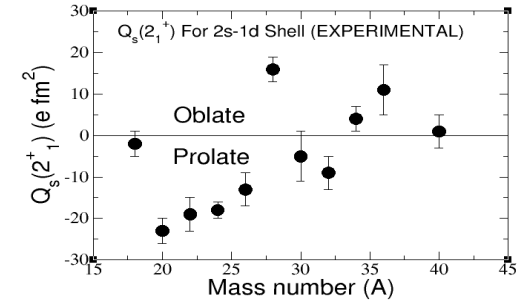
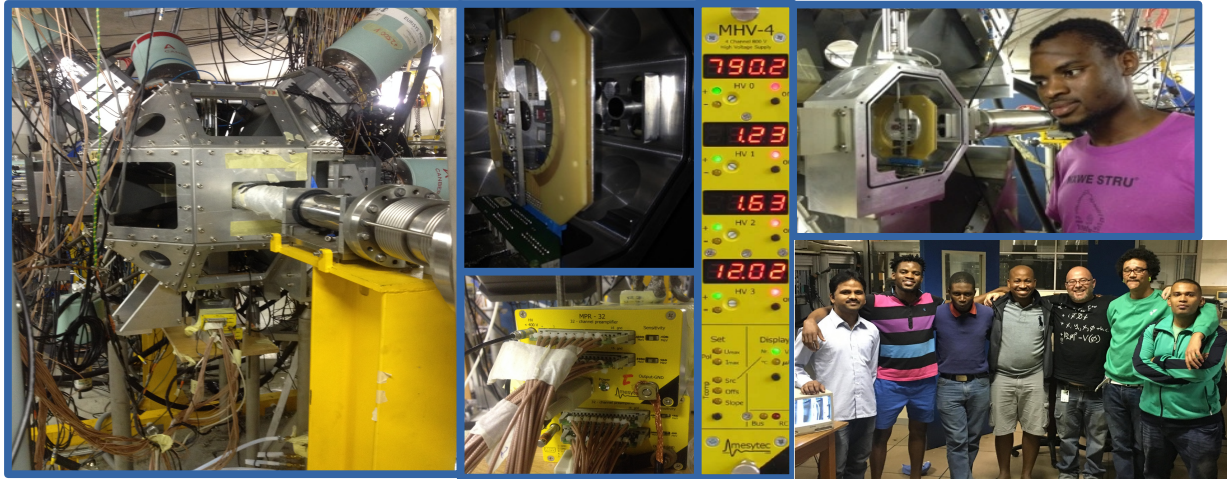
^{62}Ni -Ocene: $U_{ex}=10\text{kV}$, $V_{MV}=770\text{sc}$, $I_{ex}=1.0\text{mA}$, $U_{pl}=-70\text{V}$, $I_{pl}=0.2\text{mA}$, $P_r=150\text{W}$, $p_1=1.7\cdot 10^{-6}\text{mbar}$, $I_{inj}=650\text{A}$, $I_{ext}=580\text{A}$, $I_{col}=174\text{A}$, $U_{elrx}=4.2\text{kV}$, $SLX=1\text{mm}$, $SLY=30\text{mm}$



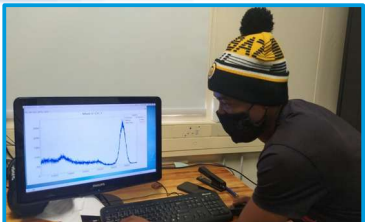
Beam currents $\sim 30 \mu\text{A}$ for both ^{60}Ni and ^{62}Ni \rightarrow optimum for physics measurements!

New pipeline for Coulomb-excitation measurements using particle-gamma coincidences @ iThemba LABS

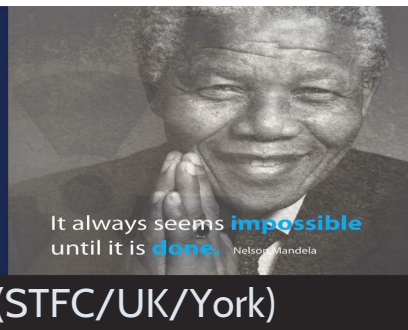
First successful measurements in April-May 2016
Orce et al., PRC 104, L061305 (2021) → Proof of Principle



3xS3 detectors + adapters, 6xMPR-32 preamps, 1xMHV-4, feedthrough cables, computers, sorting and Coulomb-excitation codes, GEANT, GOSIA, ²⁰Ne, ^{36,40}Ar, ³²S, ^{60,62}Ni experiments, 4 postdocs, flexible chamber+ extension + feedthroughs, new beam development (⁶⁰⁻⁶²Ni, ¹⁰²Ru), PIXIE-16, DAQ digital system, +15 completed MSc+PhD theses (machine learning, big data, academia,...)



Modern African Nuclear DETector Laboratory



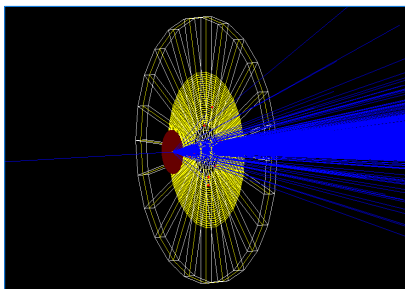
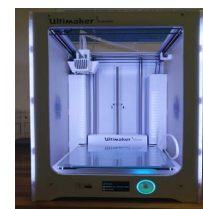
Global Challenge Research Funds (STFC/UK/York)

Modern nuclear laboratories built @ UWC and UZ

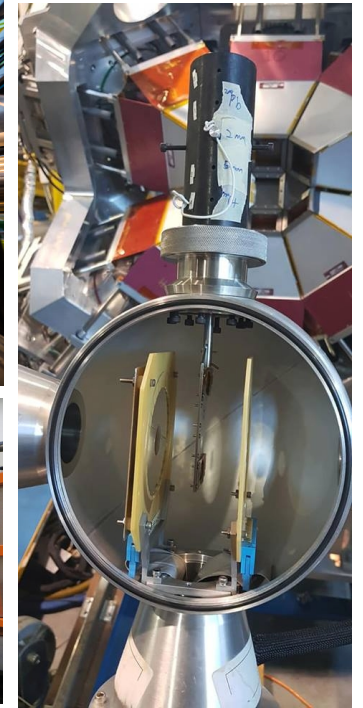
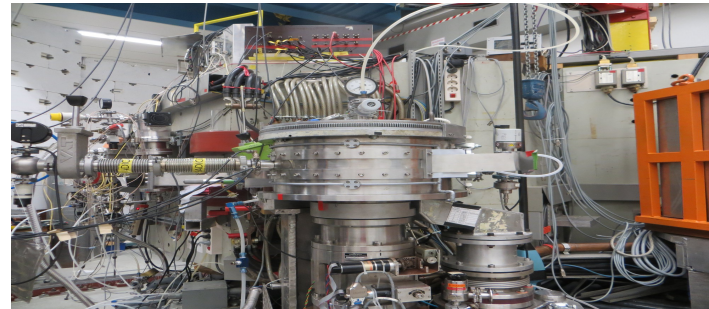
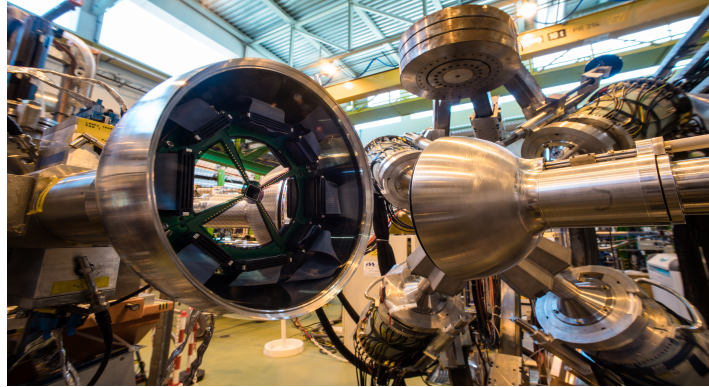
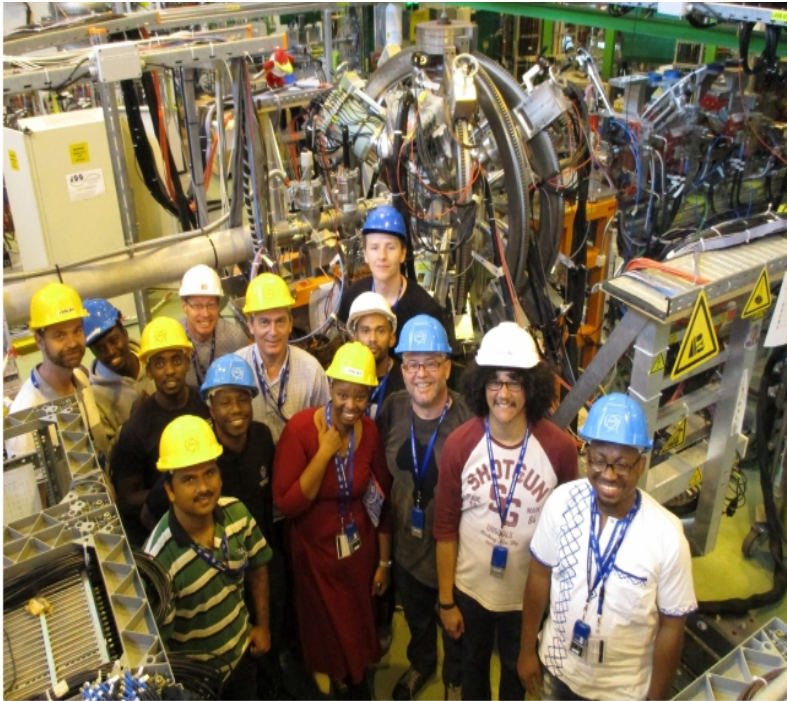


MANDELA partly to support GAMKA-based research

- Digitizers: XIA Pixie-16 250 MHz 12bit,
- CAEN DT5730S 500 MS/s, DT5742 5 GS/s
- Ionization chamber (beam purity, beam energy loss)
- PET scanners for nuclear imaging
- GEANT on the Cloud
- CsI array @ forward angles
- Segmented SiC detectors



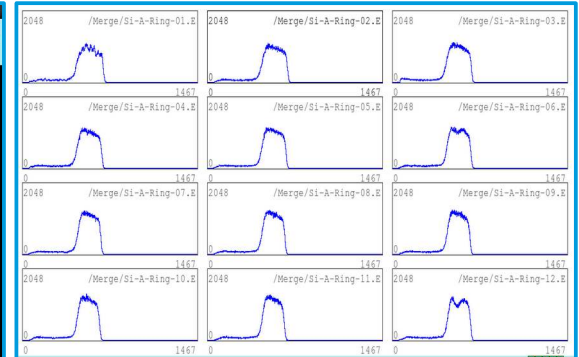
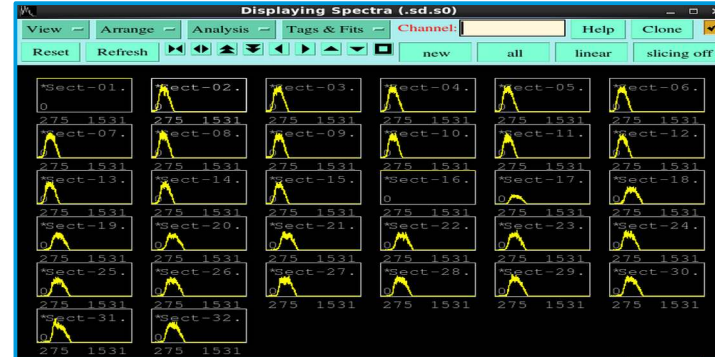
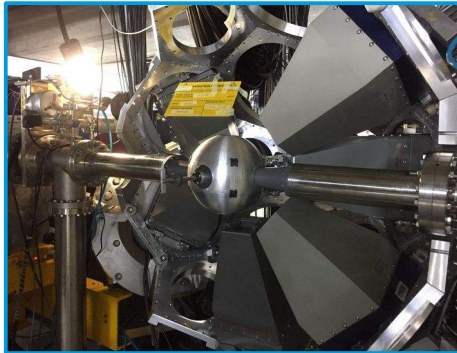
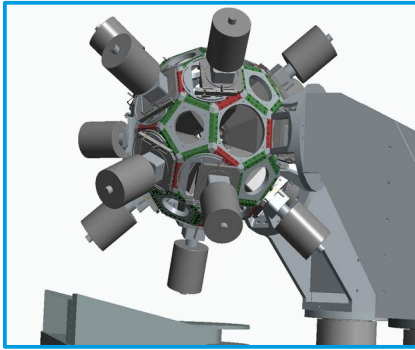
Other Coulomb-excitation measurements @ HIE-ISOLDE, TRIUMF, MLL



Nine well-trained SA students came to CERN in July 2017 to run what CERN called the Ubuntu experiment. PhD awarded to Kenzo Abrahams (2021)

<https://home.cern/news/news/experiments/ubuntu-powerful-motto-important-experiment>

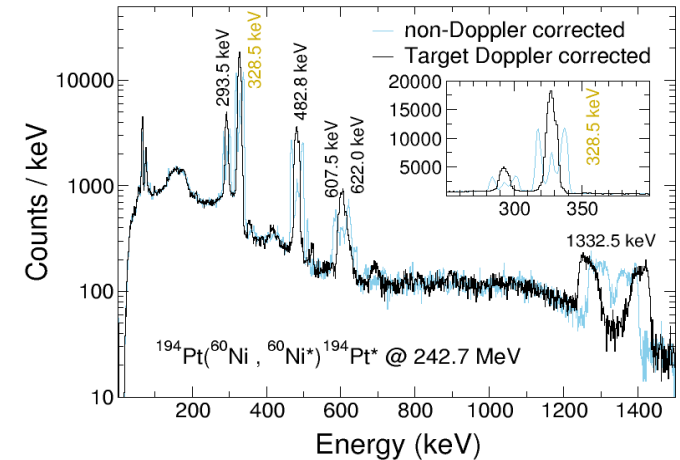
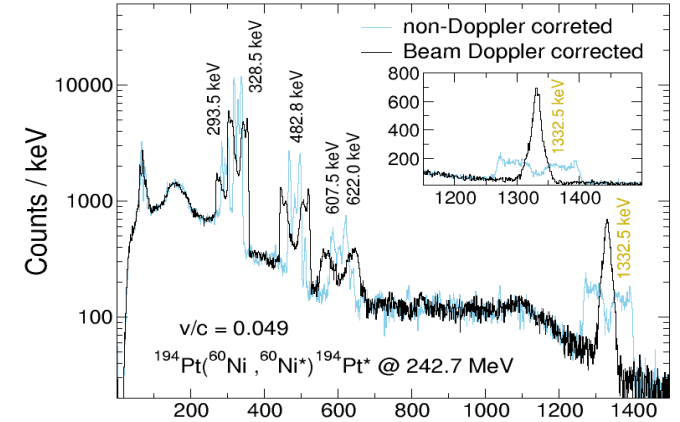
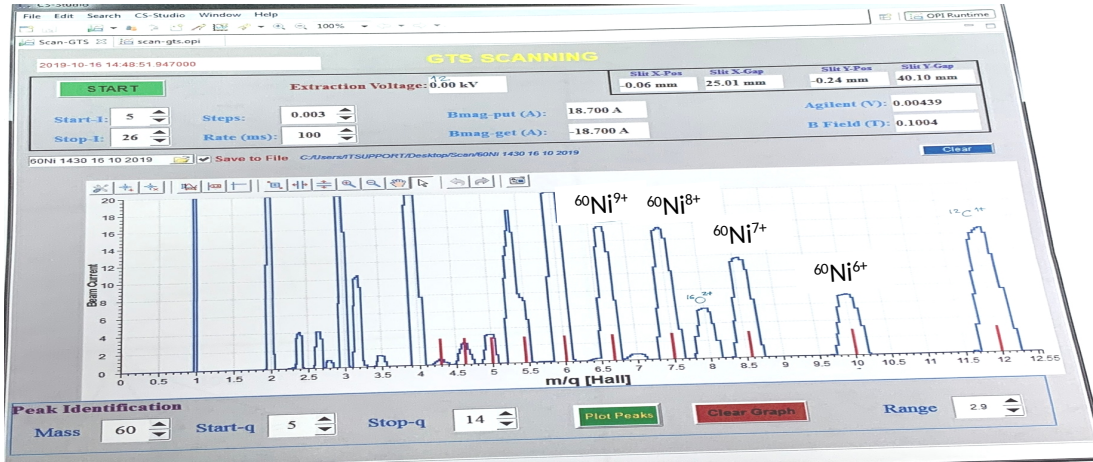
First Pre-GAMKA experiments with the soccerball frame designed by Paul Papka and manufactured @ SAAO



SEARCH FOR THE LOSS PARADIGM OF SURFACE VIBRATIONS.
Spokesperson: Nico Orce

Successful delivery of enriched $^{60-62}\text{Ni}$ beams in October-November 2019

Search for the loss paradigm of surface vibrations in the Ni isotopes



More data analysis

Paradigm of Surface Vibrations in ^{62}Ni

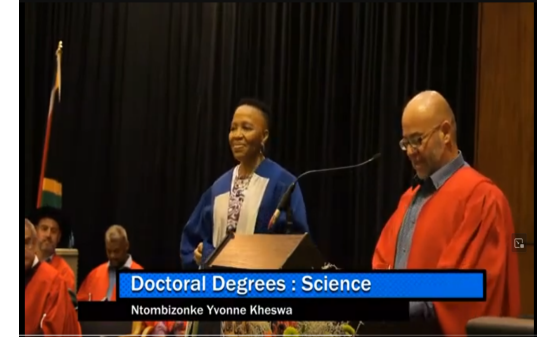
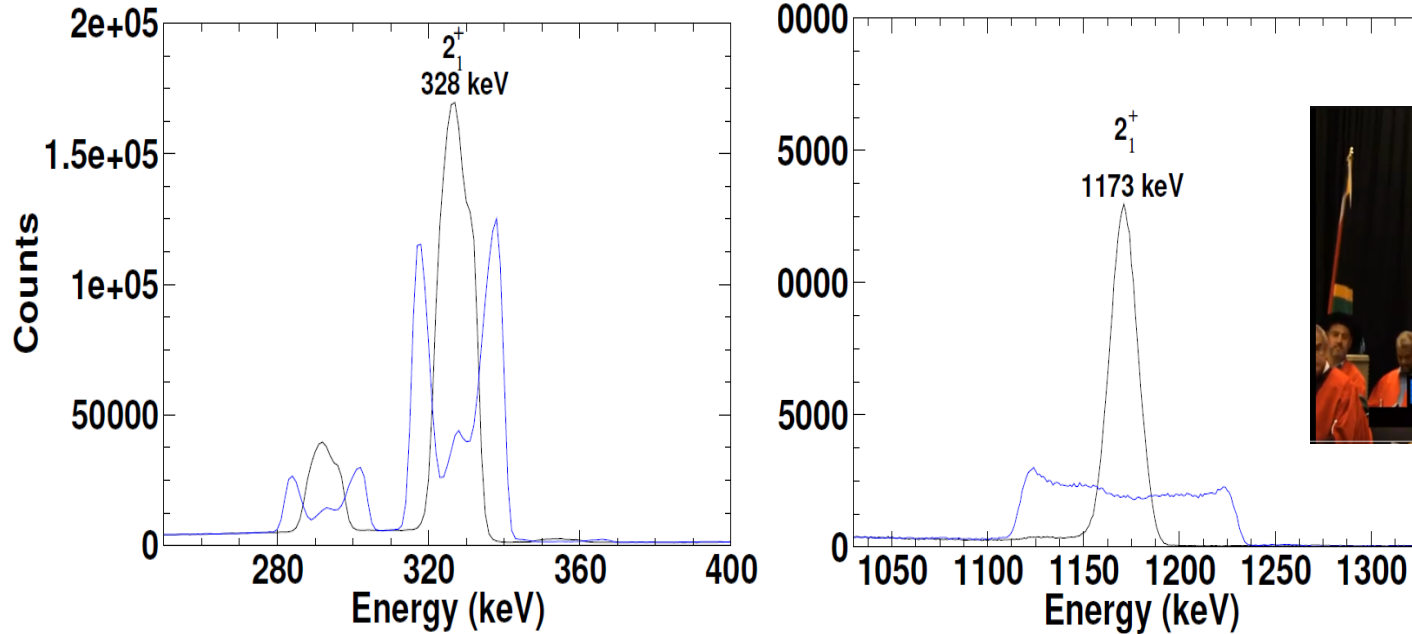
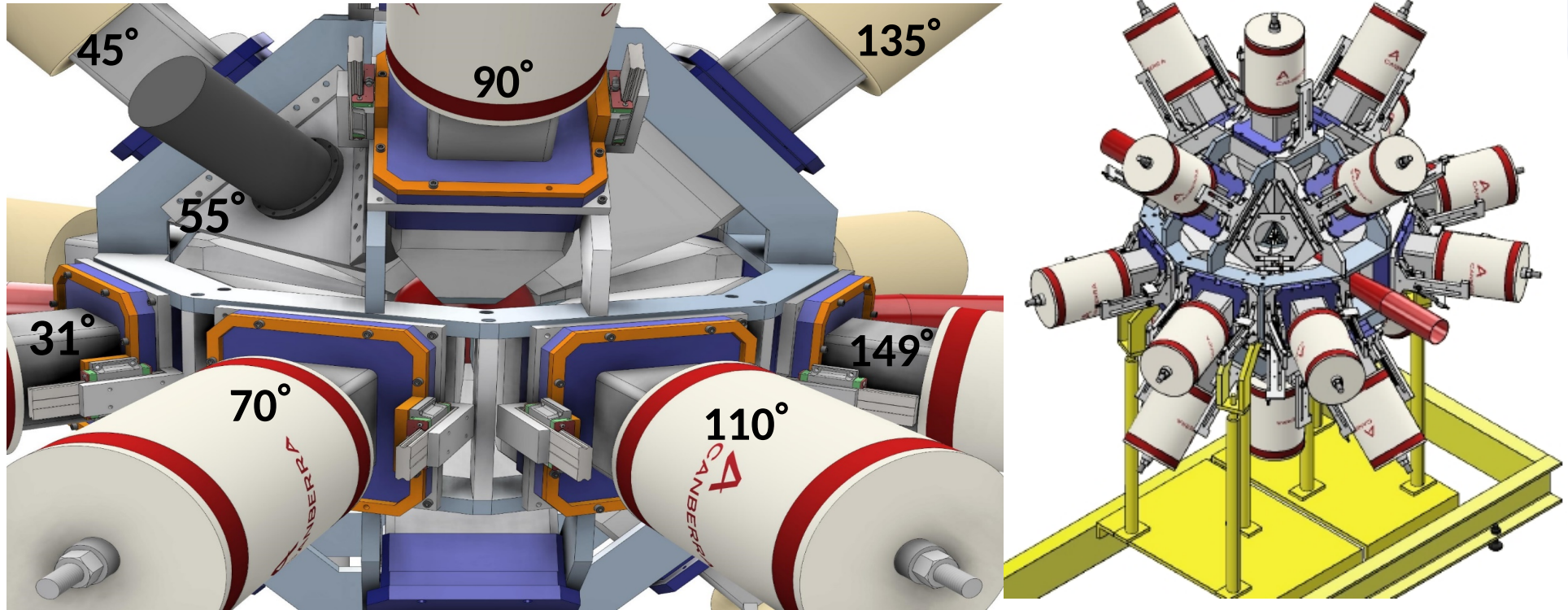


FIGURE 4.7: Non-Doppler corrected (blue) and Doppler corrected (black) spectra for ^{194}Pt using $\beta = \frac{v}{c} = 0.032$ FIGURE 4.8: Non-Doppler corrected (blue) and Doppler corrected (black) spectra for ^{62}Ni using $\beta = \frac{v}{c} = 0.047$

Successful delivery of enriched $^{60-62}\text{Ni}$ beams in October-November 2019
Proof of Principle (PhD awarded to Ntombi Kheswa)

Dandelion frame design & construction

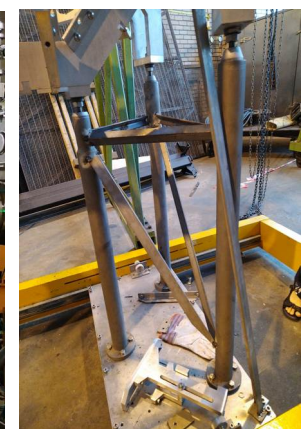
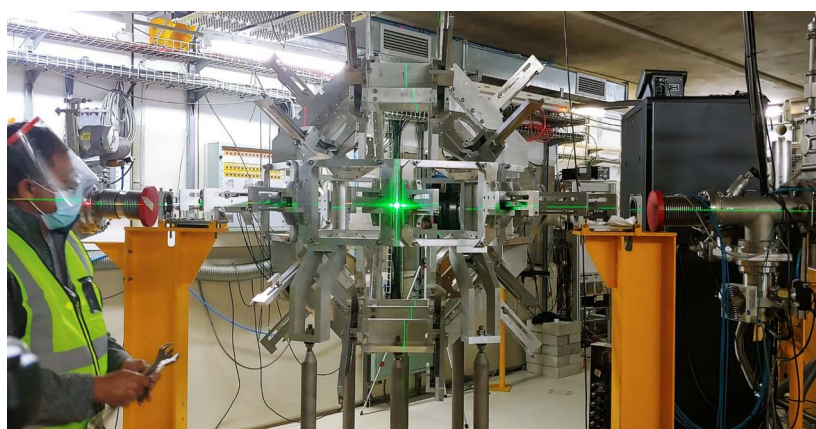
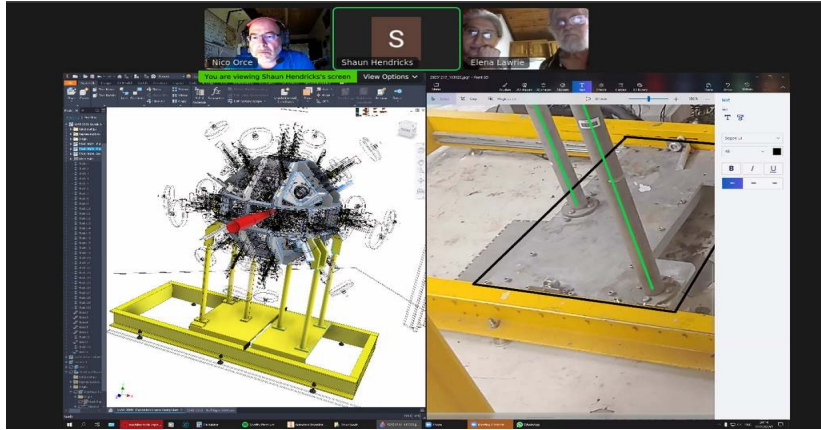


Design: Shaun Hendricks

Construction: **CJ** Dustraction SYSTEMS
ENVIRONMENTAL SOLUTIONS (Pty) Ltd.

Commissioned in May 2021

Currently fixing the base and pillars



“the notable progress of the NRF-funded GAMKA project”

NRF-funded GAMKA Project makes South Africa potential world leader in nuclear physics research

Original source: University of the Western Cape

<https://nuclear.uwc.ac.za/index.php/gamka>

When UWC was awarded the single largest grant given by the NRF in a competitive call for a new nuclear spectrometer called the Gamma Ray Spectrometer for Knowledge in Africa (GAMKA), many people doubted if the project would ever see the light of day. But UWC ensured that the project was completed with great aplomb; bolstering the country's ability to perform cutting-edge nuclear research and attracting more world-class projects in the process.

The project was composed of a consortium led by Professor Nico Orce from the Department of Physics and Astronomy at UWC, and consisted of four South African universities – UWC, Stellenbosch University, the University of the Witwatersrand and the University of Zululand – as well as NRF-iThemba LABS operating as the final host of GAMKA. It also included enormous support from NRF officials, the review from experts and letters of support from SKA and CERN. The NRF awarded UWC a R35 million grant through the Strategic Research Equipment Programme to address the ageing of detection equipment; to become competitive worldwide; and enhance human capital development in South Africa.

GAMKA provides state-of-the-art equipment that will allow not only the consortium members, but also

other researchers across the country and worldwide, to study a wide range of nuclear properties and phenomena. This month, the final pieces - the liquifier and the dandelion-shaped frame, which houses the GAMKA detectors and, as a whole, forms the GAMKA spectrometer - have been completed after two years of extensive and vigorous work on the design and manufacturing. The first GAMKA experiment is scheduled to run in June.

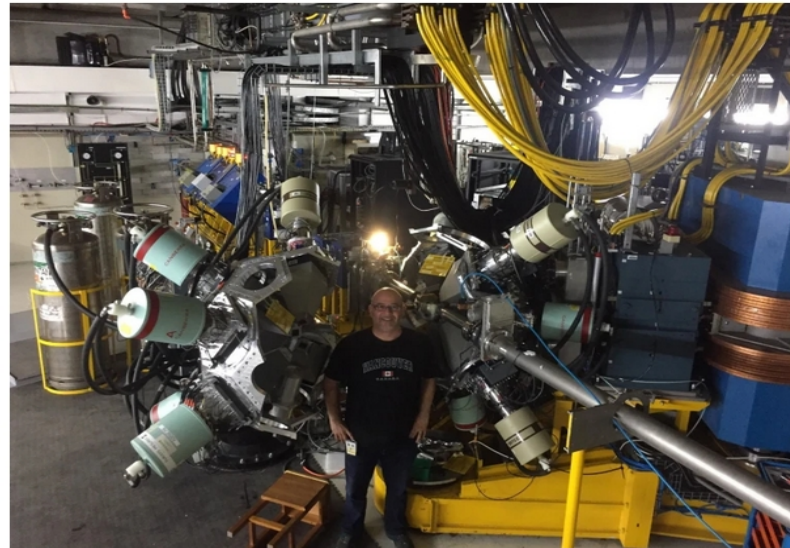


According to Prof Orce, the GAMKA frames, now housed at NRF-iThemba LABS, were manufactured locally by SAAO and CJ Dustraction Systems in Kuils River, which has garnered international recognition. “Not only made in South Africa, but in one of the communities feeding UWC, too,” **Read full article here.**

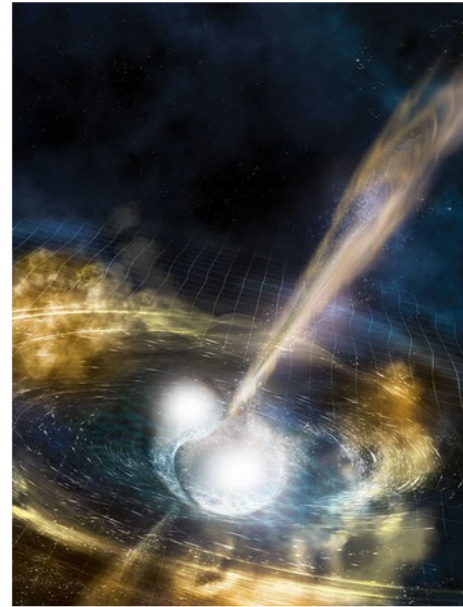
Understanding the universality of heavy elements

Groundbreaking research sheds light on scientific mystery.

[Morgan Morris](#) 



As more neutrons are added to the nucleus, symmetry energy has a counterbalancing effect on the binding energy that holds the nucleus together. In this case, the greater the symmetry energy, the smaller the binding energy.



Artist's illustration of two merging neutron stars. The rippling space-time grid represents gravitational waves that travel out from the collision, while the narrow beams show the bursts of gamma rays that are shot out just seconds after the gravitational waves. Swirling clouds of material ejected from the merging stars are also depicted. The clouds glow with visible and other wavelengths of light. Credit: NSF/LIGO/Sonoma State University/A. Simonnet

The rise in symmetry energy found by the researchers is ascribed to a slight increase in the energy of giant dipole resonances (GDR). GDRs are the result of the collective 'excitation' – a specific type of jump in energy – of protons and neutrons oscillating out of phase, meaning that their waves are out of step with each other.

As such, GDRs represent the main contribution to the absorption and emission – the attraction and release – of electromagnetic radiation in a nucleus.

The jump in symmetry energy, the scientists argue, shrinks the 'neutron drip line', the boundary at which nuclei eventually become unbound. At this point, nuclei break up into their constituent neutrons and protons.

"It tells us we can't go too far capturing neutrons during the 'cooking' of elements," explains Orce.

Ultimately, the rise in symmetry energy impacts on the r-process. The r-process is responsible for the 'cooking' or nucleosynthesis of heavy elements. It is a set of nuclear reactions believed to create

around half the known elements in the universe with an atomic weight heavier than iron.

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JOURNAL ARTICLE

Enhanced symmetry energy may bear universality of r-process abundances

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José Nicolás Orce ✉, Balaram Dey ✉, Cebo Ngwetsheni, Srijit Bhattacharya, Deepak Pandit ✉, Brenden Lesch, Andile Zulu

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[/10.1093/mnras/stad2539](https://doi.org/10.1093/mnras/stad2539)

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VIEWS



ALTMETRIC



More metrics information



GAMKA

THE LION

THE GAMMA-RAY SPECTROMETER FOR KNOWLEDGE IN AFRICA

Acknowledgments

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