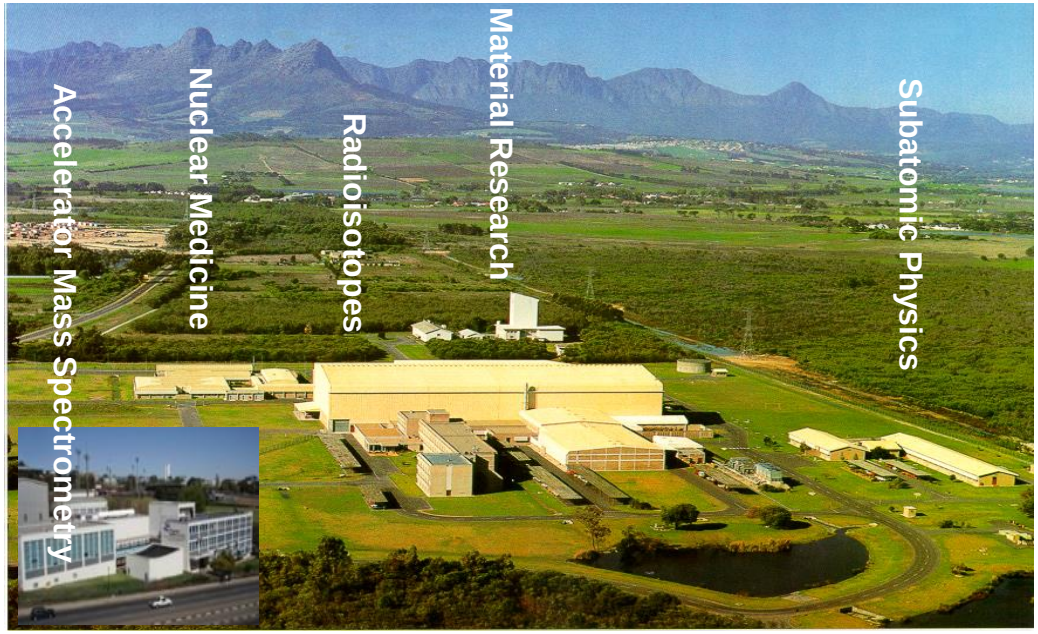
iThemba LABS: opportunities in nuclear science and applications

Mathis Wiedeking
Department of Subatomic Physics

- Facilities and developments
- Measurements – recent and future
- SAIF: Going neutron-rich

iThemba LABS : National Facility for *research, development and training*

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



Injector cyclotron 1

Injector cyclotron 2

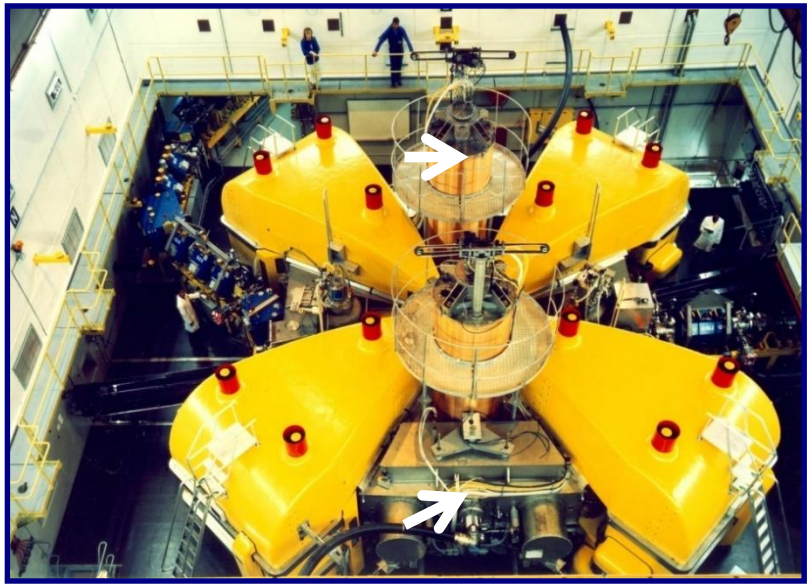
Separated sector cyclotron

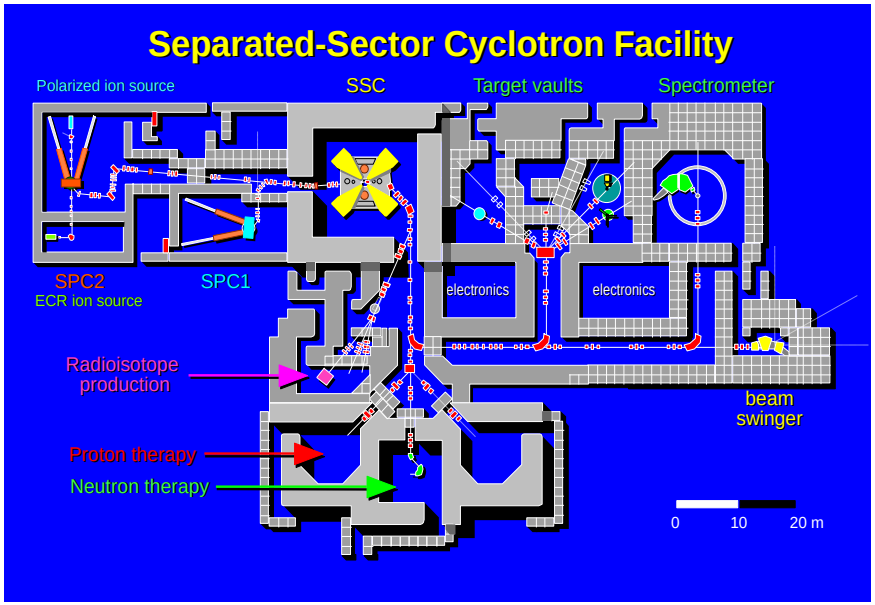
6MV Tandem

K11 Cyclotron

3MV Tandetron

iThemba LABS: SSC (Separated Sector Cyclotron)





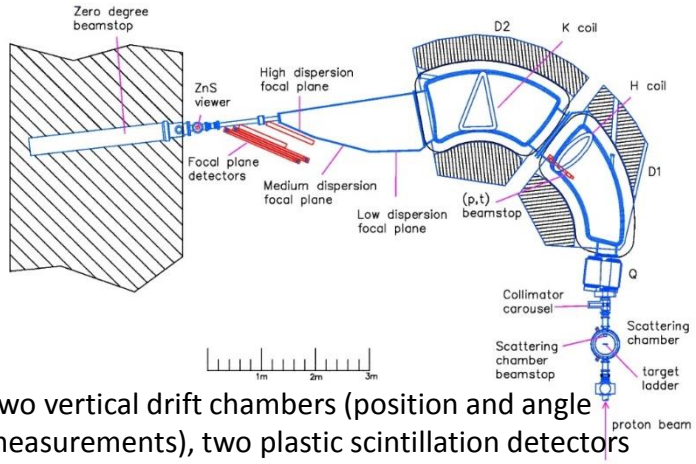
Subatomic Physics/ Nuclear Medicine / Radioisotope Production

Research is dependent on SSC accelerator:

- Operating 6000 h/year
- Physics beam not restricted any longer.

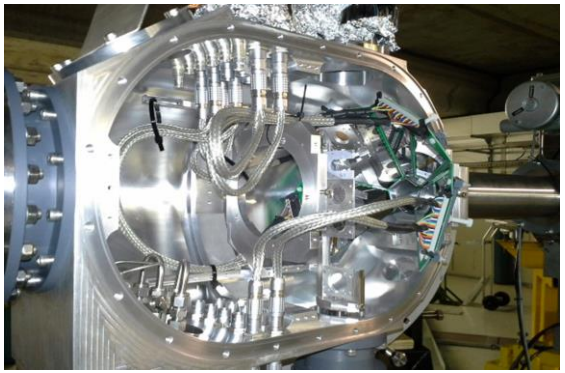
User facility: for local universities, but also for users from rest of the world.

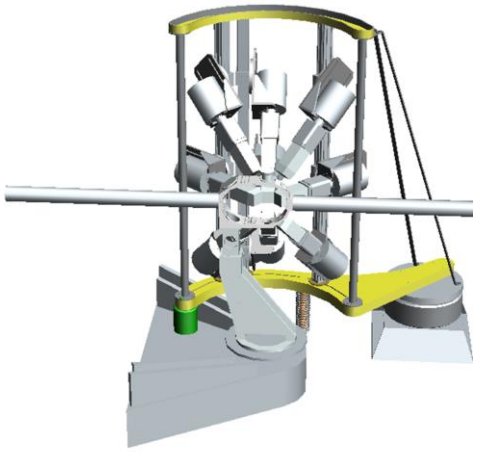
K=600 developments



Two vertical drift chambers (position and angle measurements), two plastic scintillation detectors (trigger and particle identification)
Full solid angle 3.5 msr and efficiency 80%

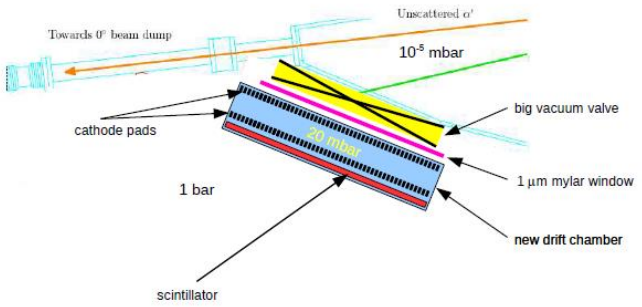
K600 is one of two facilities capable of high energy resolution (≤100 keV FWHM) measurements at zero degrees, with low background to the measured spectrum, for medium energy (E~50-200 MeV/A) light ions (p,d,t,He).





γ-ray array coupled to K600

New focal plane MICROMEGAS detector

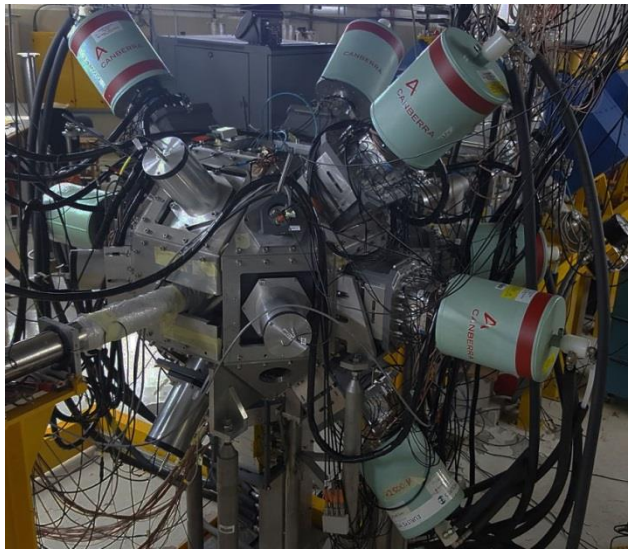


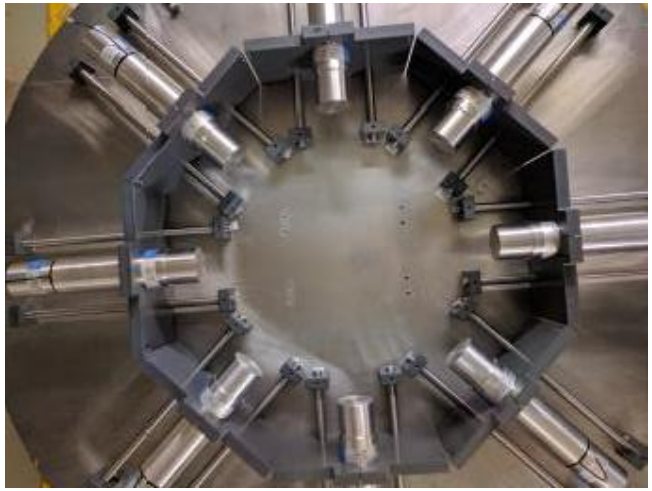
RS: R Neveling & R Smit

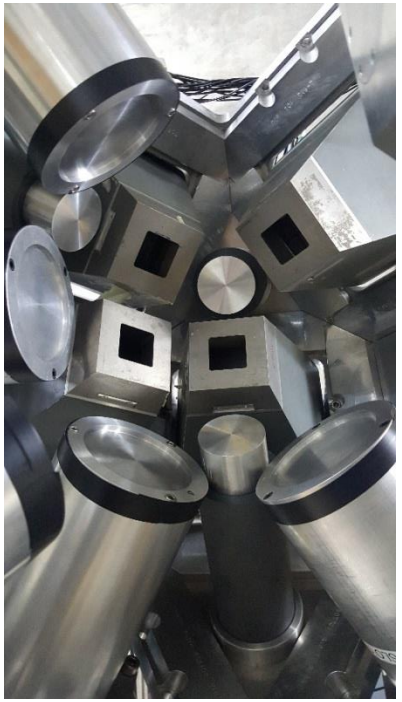
science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

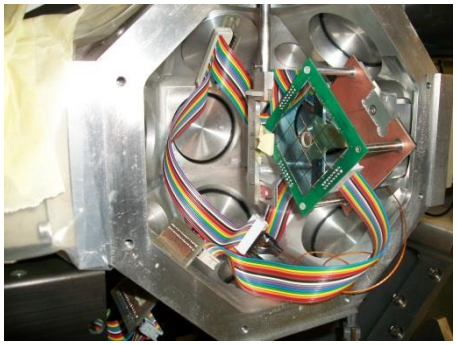
NRF National Research Foundation
iThemba LABS Laboratory for Accelerator Based Sciences

Gamma-ray array(s) developments





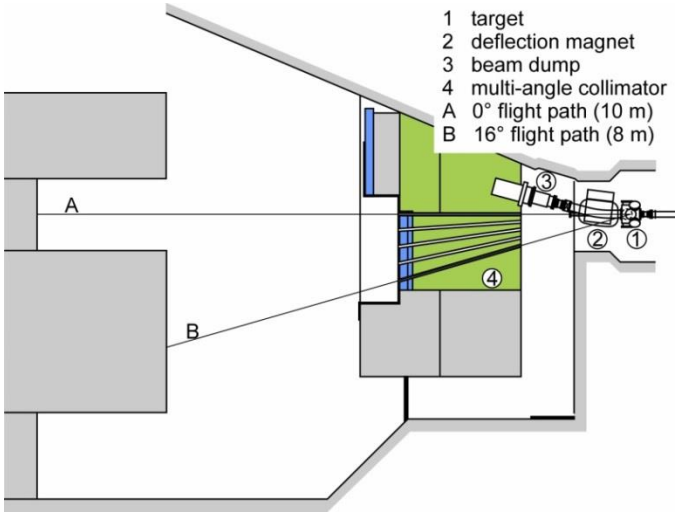


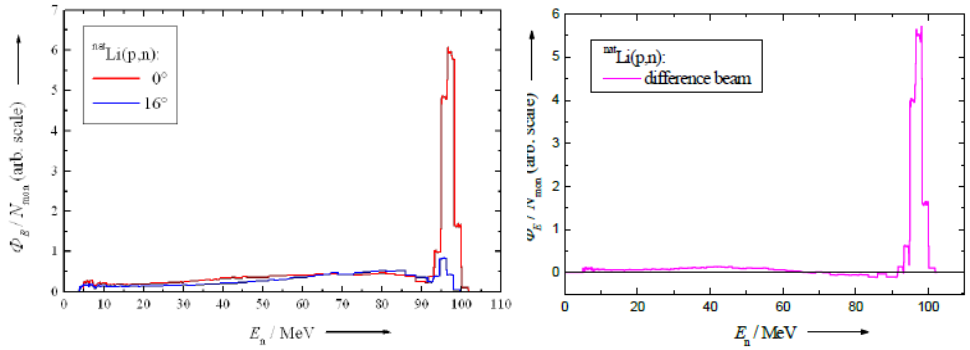


- iThemba LABS embarked on mission to expand capabilities ~4.5M Euro total investment.
- AFRODITE (Clover, BGO and LEPS) to be doubled.
- Fast-timing array: 2.5x2.5cm LaBr3:Ce
- Segmented Clover detector.
- African LaBr Array: ALBA 89x203mm LaBr3:Ce (L Pellegri, Talk Friday 9:40)
- Coupled to CSI, recoil det., silicon, solar cells, plunger, neutron wall.
- Digital electronics (XIA).

RS: P Jones, E Lawrie, L Pellegri, M Wiedeking

Neutron beam facility developments





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

- 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°)
  - 8 m (16°)
- Fluence rate (1 mm Li): $j \approx 1 \cdot 10^3$ cm^{-2} µA^{-1} at 10 m

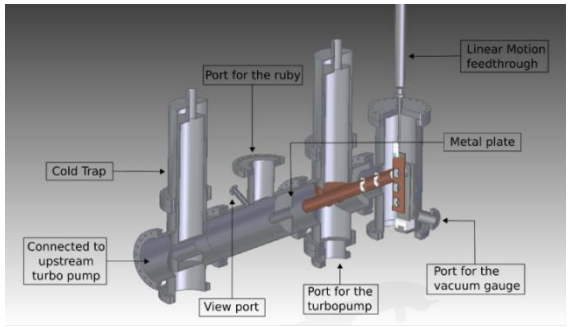
2018: Reconstruction of the neutron vault to meet requirements for high-energy neutron metrology facility.

- Additional shielding
- Optimized beam stops
- Extended flight path at 16°

RS: P Maleka

Other developments

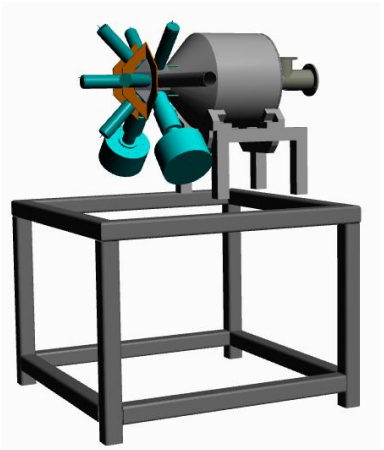
DSAM setup for half-lives of astrophysical important nuclei.



A new DSAM lifetime measurement setup for half-lives of astrophysical important nuclei.
Very sensitive and able to measure lifetimes to ~10fs.
Commissioning run April 2018.

RS: S Triambak

Electron Spectrometer



Refurbish (Siegbahn-Kleinheinz, Orsay). B_{max} ~0.15T, Si(Li) 5-6mm.
conversion e spectroscopy
Internal Pair Spectroscopy
E0 decays
Couple to K600
Commissioning run July 2018.

RS: P Jones

Tape station for beta-decay studies.

Metallic tape delivers implants ~2m from target.

SiLi and plastic detectors

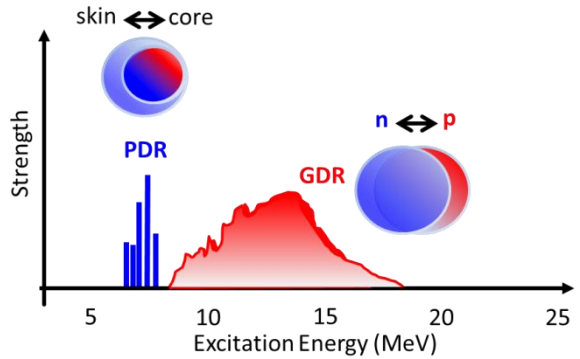
Currently up to 4 Clover detectors.

Commissioning run April 2018.

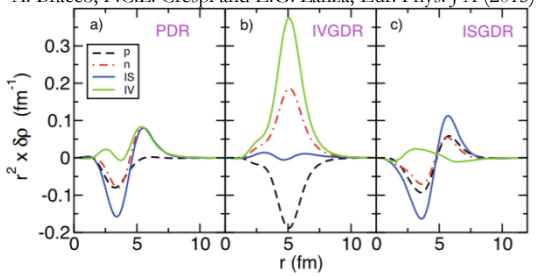
RS: RA Bark

Physics case: PDR and SR

Pygmy Dipole Resonance (PDR)

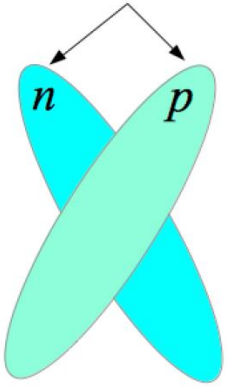


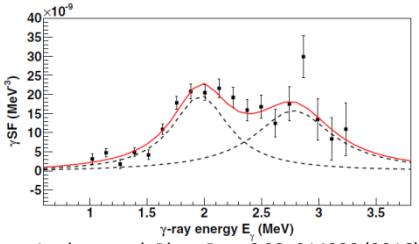
A. Bracco, F.C.L. Crespi and E.G. Lanza, Eur. Phys. J A (2015) 51



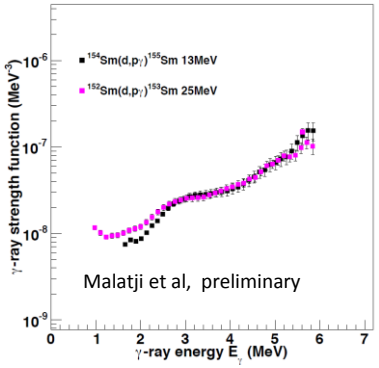
- Observed in several neutron-rich nuclei
- Astrophysical implications: r-process nucleosynthesis and EoS
- Systematic measurements in deformed and spherical nuclei

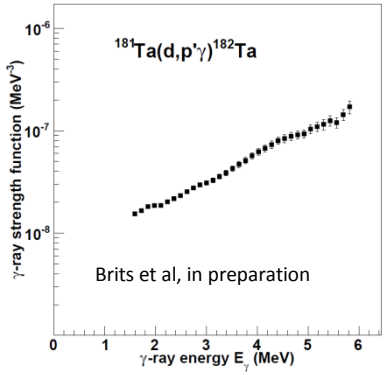
Scissors Resonance (SR)





Laplace et al, Phys. Rev. C 93, 014323 (2016)

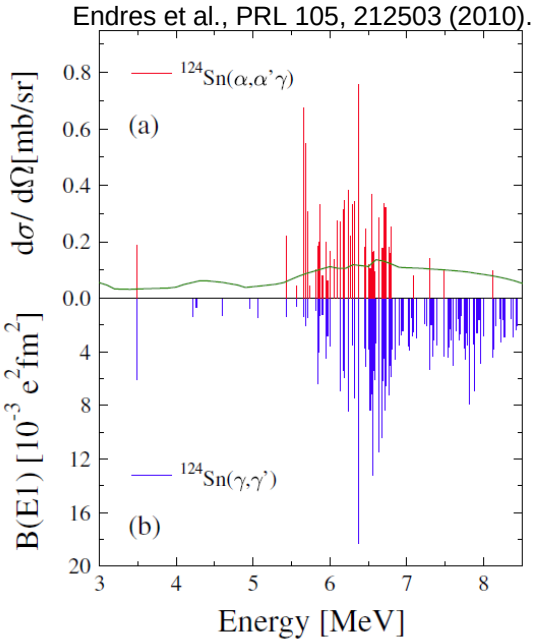




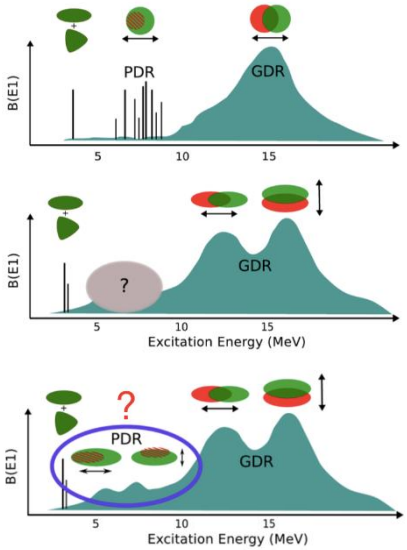
- Observed in several deformed nuclei.
- Can be significantly fragmented
- Measurements to investigate splitting of SR and relationship to low-energy enhancement.
- Need new K600 focal plane detector.

K600+Gamma-ray detectors: PDR studies

Endres et al., PRL 105, 212503 (2010).

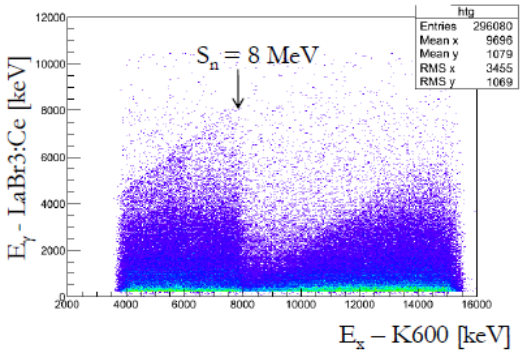


Typical: 1) IS-IV mixed states at low energies 2) relatively pure IV states at higher energies.

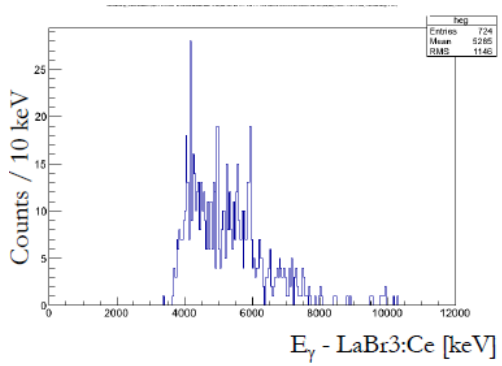


Possible interpretation:
Deformed proton-neutron saturated core, oscillating against a neutron skin along two different axes

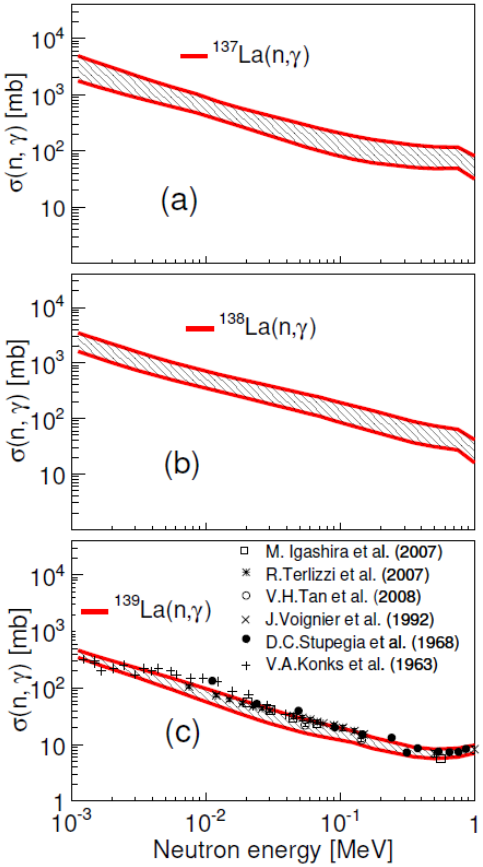
^{154}Sm(α,α'γ) @ 120MeV
Preliminary results



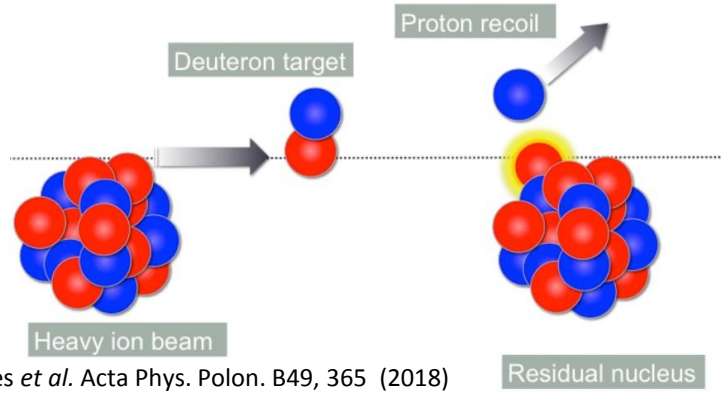
GATES: PID & Y1 plane & Gamma Time



Physics case:NLD and PSF – inverse kinematic



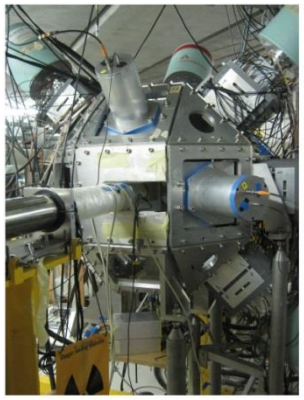
Kheswa, PLB 744, 268 (2015)
Kheswa, PRC 95, 045805 (2017)



Jones *et al.* Acta Phys. Polon. B49, 365 (2018)

- NLD and PSF reproduce (n,g) cross sections.
- May be easier to measure than direct approaches.
- Oslo Method and Beta-Oslo Method have limits.
- Inverse kinematics method can fill the gaps.
- Applicable to stable and radioactive beam facilities.
- Obtain capture cross sections when targets cannot be manufactured.
- Opens up great opportunities to get astrophysical relevant cross sections.
- Complementary to Oslo Method, Beta-Oslo (Guttormsen Friday 9am).

Silicon telescopes+Clovers+$LaBr_3$:Ce



300MeV ^{86}Kr beam, deuterated polyethylene & polystyrene targets. AFRODITE + 2 $LaBr_3$(Ce) + Silicon telescopes. 2016

^{87}Kr: VW Ingeberg, MSc thesis, UiO, 2016

Ingeberg Talk Thursday 14:45

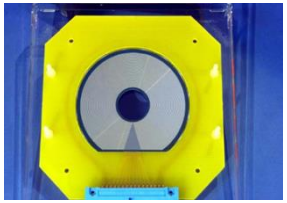
HIE-ISOLDE: PSF and NLD from ^{67}Ni 2016

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Statistical properties of warm nuclei:
Investigating the low-energy enhancement in the gamma strength function of neutron-rich nuclei

S.Siem[1], M. Wiedeking[2], F.L.Bello Garrote[1], L. Bernstein[3], D. Bleuel[3], P.A.Butler[4], T.Eriksen[1], F.Giacoppo[1], A.Görgen[1], M.S.Guttormsen[1], T.W.Hagen[1], P.Hoff[1], B.V.Kheswa[2], M.Klintfjord[1], A.C. Larsen[1], D. Negi[2], H.T. Nyhus[1], J.Rekstad[1], S. Rose[1], E. Sahin[1], G.M.Tveten[1], and A. Voinov[4], J. Wilson[6]

^{67}Ni: VW Ingeberg, PhD project, UiO



300MeV ^{84}Kr beam, and 530 MeV ^{132}Xe beam, on deuterated polyethylene targets. AFRODITE + 6 $LaBr_3$(Ce) + Silicon telescopes. 2017

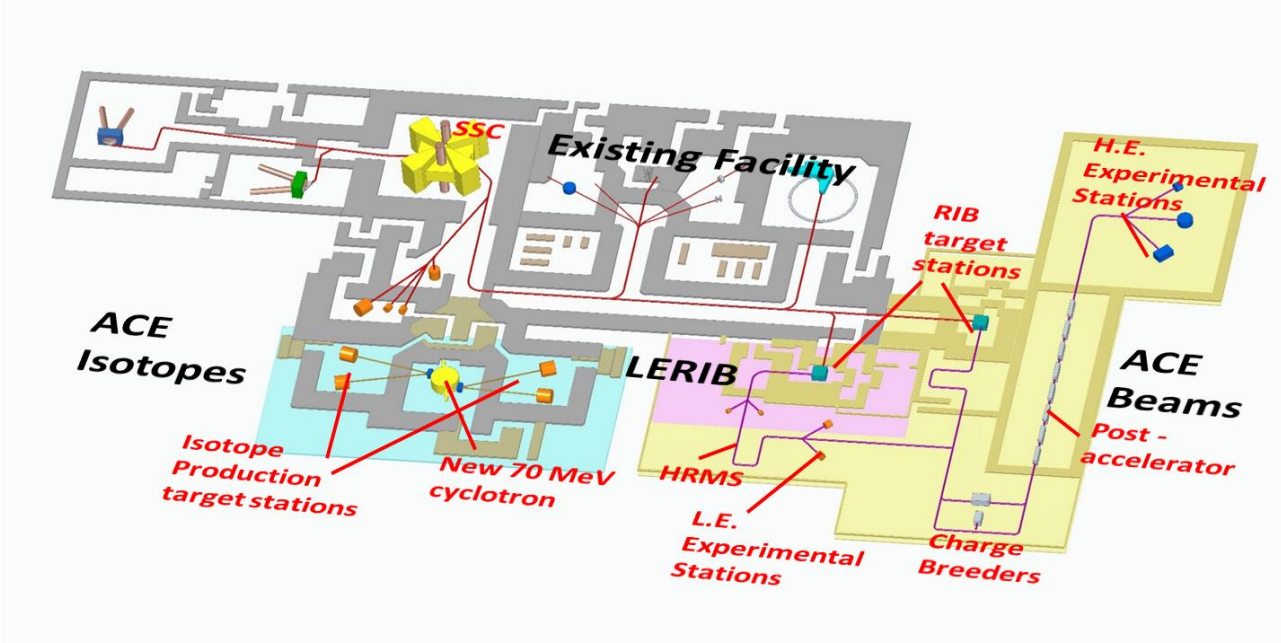
^{133}Xe: H Berg, MSc project, UiO

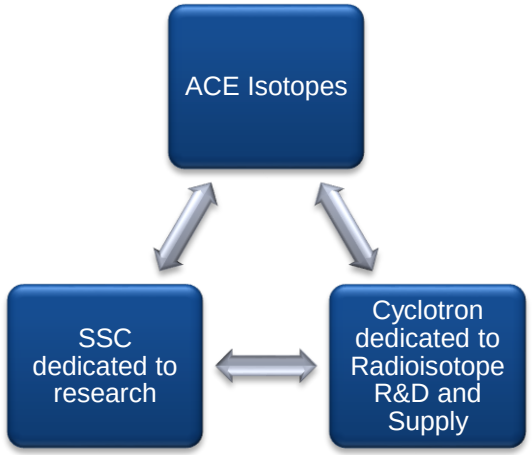
Poster

^{85}Kr: T Seakamela, PhD project, UJ

And many other ideas…

South African Isotope Facility (SAIF)





Phase I: ACE Isotopes and LeRIB

- 70MeV cyclotron: dedicated to the production of isotopes.
- SSC: dedicated to beams for research (stable and LeRIB).
- Timeline - 4 years to operations

Phase 2: ACE Beams

- SSC: dedicated to beams for research (stable and radioactive).
- Post-accelerated radioactive beams.
- Timeline - 8 years to operations

Summary

- Overview of facilities
  - K600, Gamma-ray arrays, n-beam line,...
- Physics cases:
  - PDR and SR
  - Gamma-decay from GR
  - PSF and NLD
- SAIF

Thank you!