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South African Nuclear Energy
Corporation SOC Limited

Imaging with X-rays and prospect of a cold neutron source at Necsa

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- Aim
- Beam Line Centre
- X-ray Imaging: Activities & Collaborations
- Prospect of a cold neutron source for imaging
- User office at BLC: X-ray Imaging

- Showcase the capabilities of imaging with radiation at Necsa with respect to instrumentation, software and methodology.
- Prospect of imaging with a cold neutron source at Necsa

BEAM LINE CENTRE

Located at Necsa (South African Nuclear Energy corporation SOC Limited)



CURRENT FACILITIES

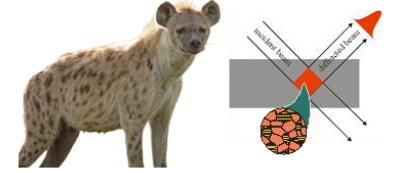
BEAM LINE CENTRE

IMAGING

DIFFRACTION

MPISI
(Neutron strain scanning)

Materials Probe for Internal Strain Investigations



Spotted hyena (isiZulu)

Micro focus X-ray

Neutron radiography



Neutron diffraction

XRD

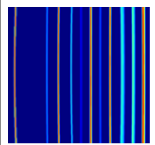


Talk of Today

Under refurbishment

PITSI (Neutron powder diffraction)

Instrument for Transition in Structure Investigations



Zebra (Sotho)

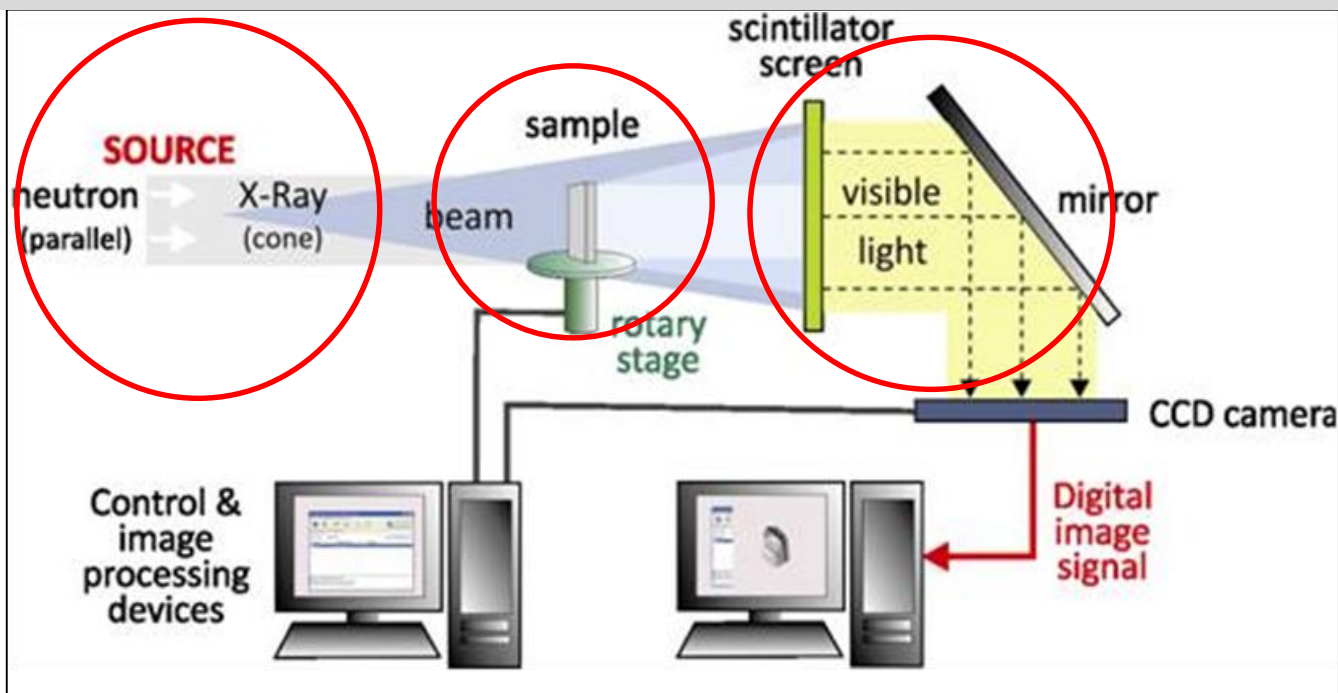
X-Ray diffraction analysis

information about the crystallographic structure, chemical composition, and physical properties of a material

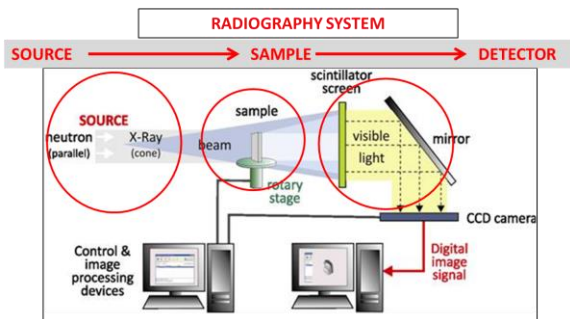
Imaging system

RADIOGRAPHY SYSTEM

SOURCE → SAMPLE → DETECTOR



Imaging system

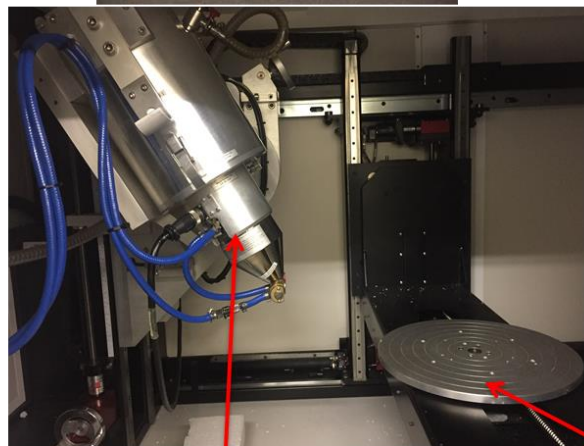


Voltage (kV)	30 -225
Pixel size resolution (μm)	3 -200
Detector size (cm)	40 x 40

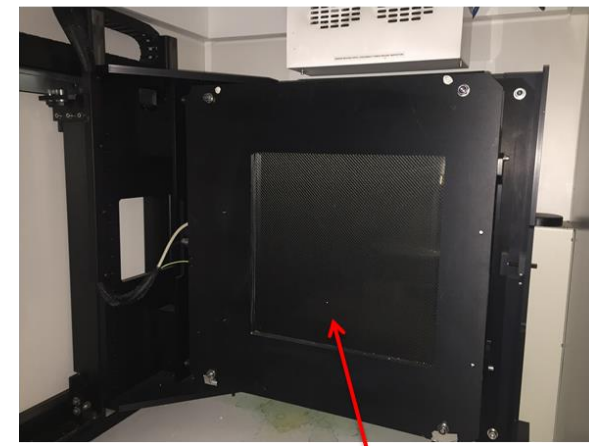
Micro focus X-ray machine



Nikon XTH 225 ST micro-focus X-ray tomography systems



X-ray source (spot size 1-3 μm)



Sample stage (50 kg)

X-ray Detector (direct conversion)

In operation since 2012

Service offered to clients (Students, Researchers, Private company):

- **Designing user experiments based on project requirements.**
- **Theoretical calculations to optimize experimental design.**
- **Executing experimental procedure and optimization for best possible results (Beam time). through the experience and scientific skill of the instrument scientists.**
- **Designing analytical procedures in 3D volume rendering and 3D image processing software which is different for each scientific project.**
- **Training on 3D data analysis procedures and capabilities of the 3D rendering software for the researcher to generate their own quantitative and qualitative analytical results. (Conduct all experiments, data analysis and interpretation as well as final report writing for commercial clients) .**
- **Assisting in the review of results and incorporating reviewer comments in scientific output such as peer reviewed scientific journals and conference proceedings, theses and dissertations.**

PARTNERS:

Museums

Collections at:

DITSONG (Natural & Cultural) (Pret)
WITS (Jhb)
NASMUS (Bloemf)
McGregor (Kimberley)
Mapungubwe (UP)

Medical Collection :

UP: Anatomy
WITS: Anatomical

RADTOM @ Necsa: SA-INSTITUTIONAL INTERACTIONS

HEI

Engaged in work:

DEPT: DST-NRF & DOE
SAHRA

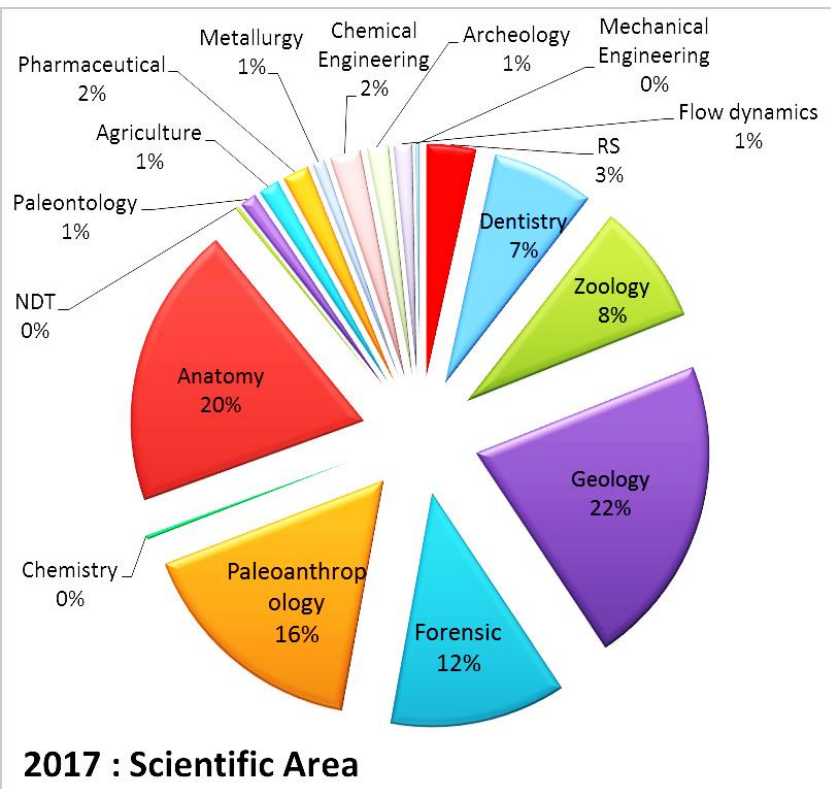
Gov

Local

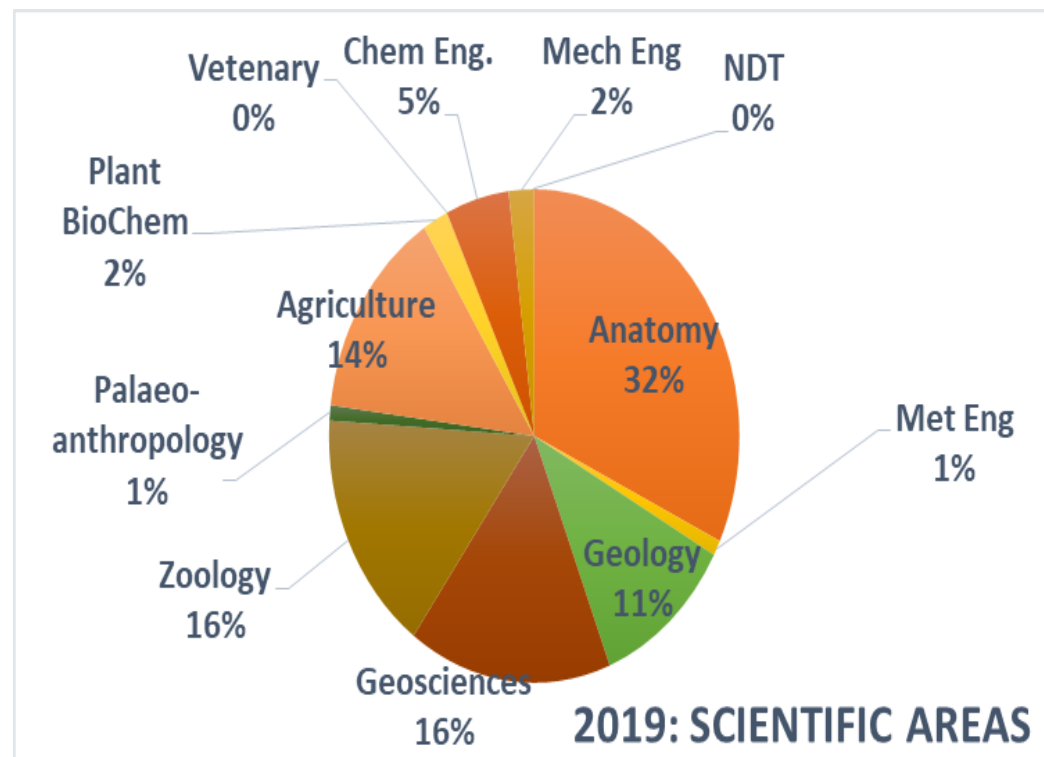
UJ ; UCT ; SUN ; Fort-Hare ;
Venda ; TUT ; UP ; WITS ;
NWU ; UL ;

International

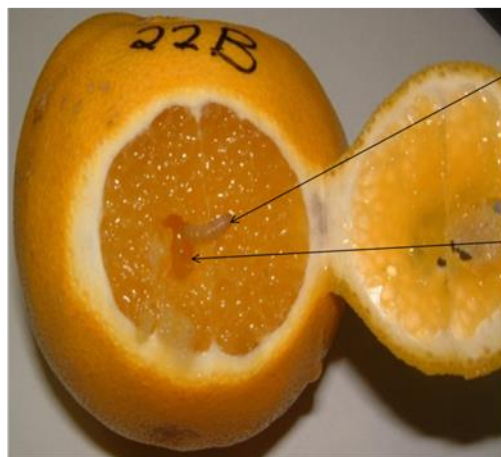
TUM (FRMII)
Univ. Toulouse (France);
Monash Univ (Austalia)
La Trobe Univ (Austalia)
Univ Missouri, (USA)
Maria Reactor (Poland)



SCIENTIFIC AREAS



Examples: infestation detection



Larva and the infested region inside the orange fruit

Larva

Infested region

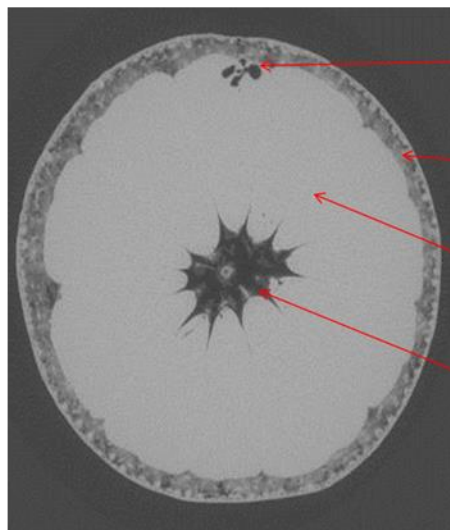
False codling moth



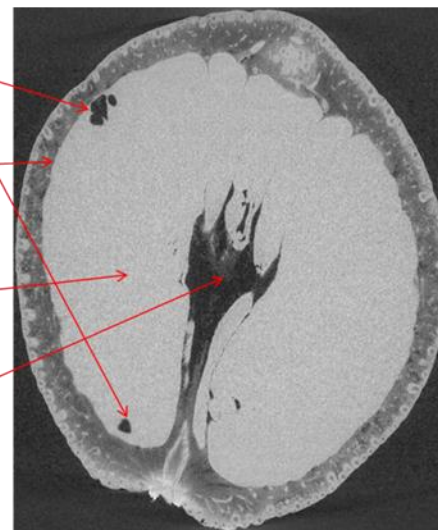
Orange fruit



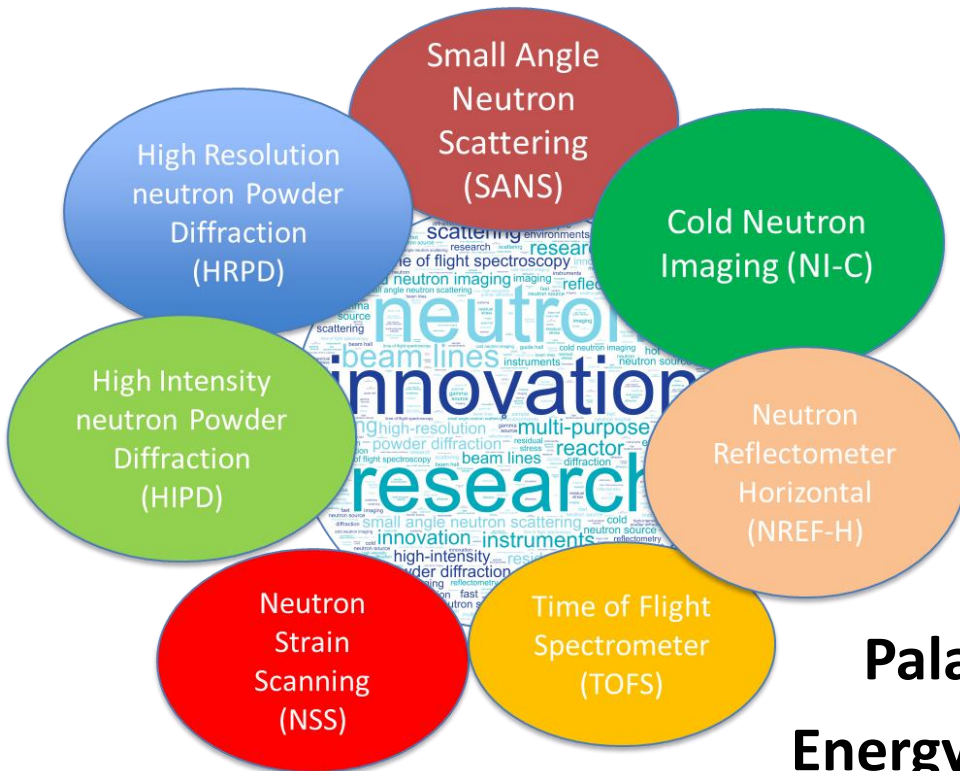
False codling moth: *Thaumatotibia leucotreta*



Infested region
The rind
Segments region
Core region



PHASE ONE INSTRUMENTS FOR NBLC



Agriculture
Magnetism
Geosciences
Nanomaterial
Engineering applications
Crystallography: Organic chemistry
Palaeontology and heritage sciences
Energy storage and conversion materials

Use of Law of radiation attenuation (Beer-Lambert law)

$$I(r, E) = I_0 \exp^{-\mu(E)x_r}$$

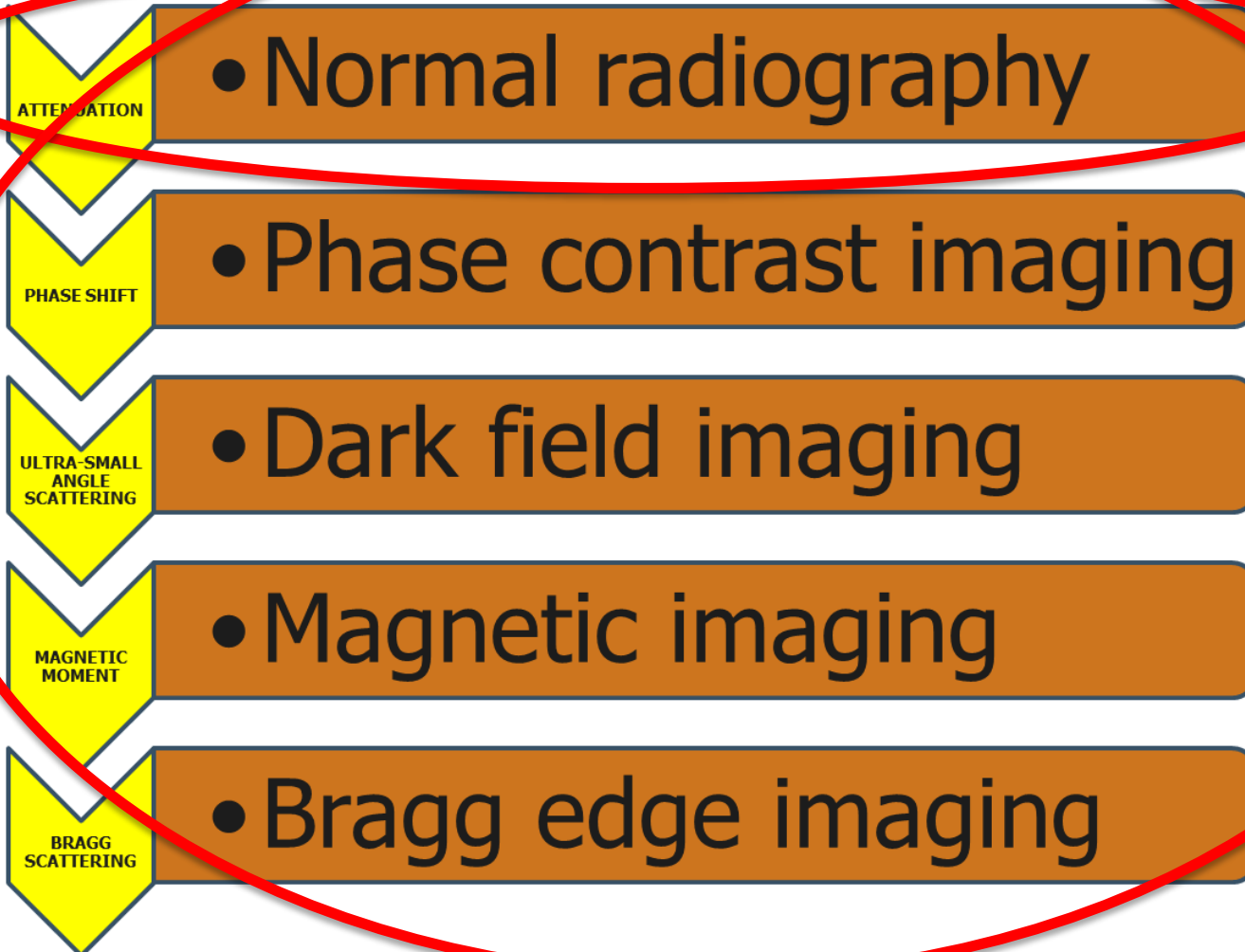
Fast (1–20 MeV)
Thermal (0.025–0.4 eV)
Cold (< 0.025 eV)

Imaging techniques with a cold neutron source

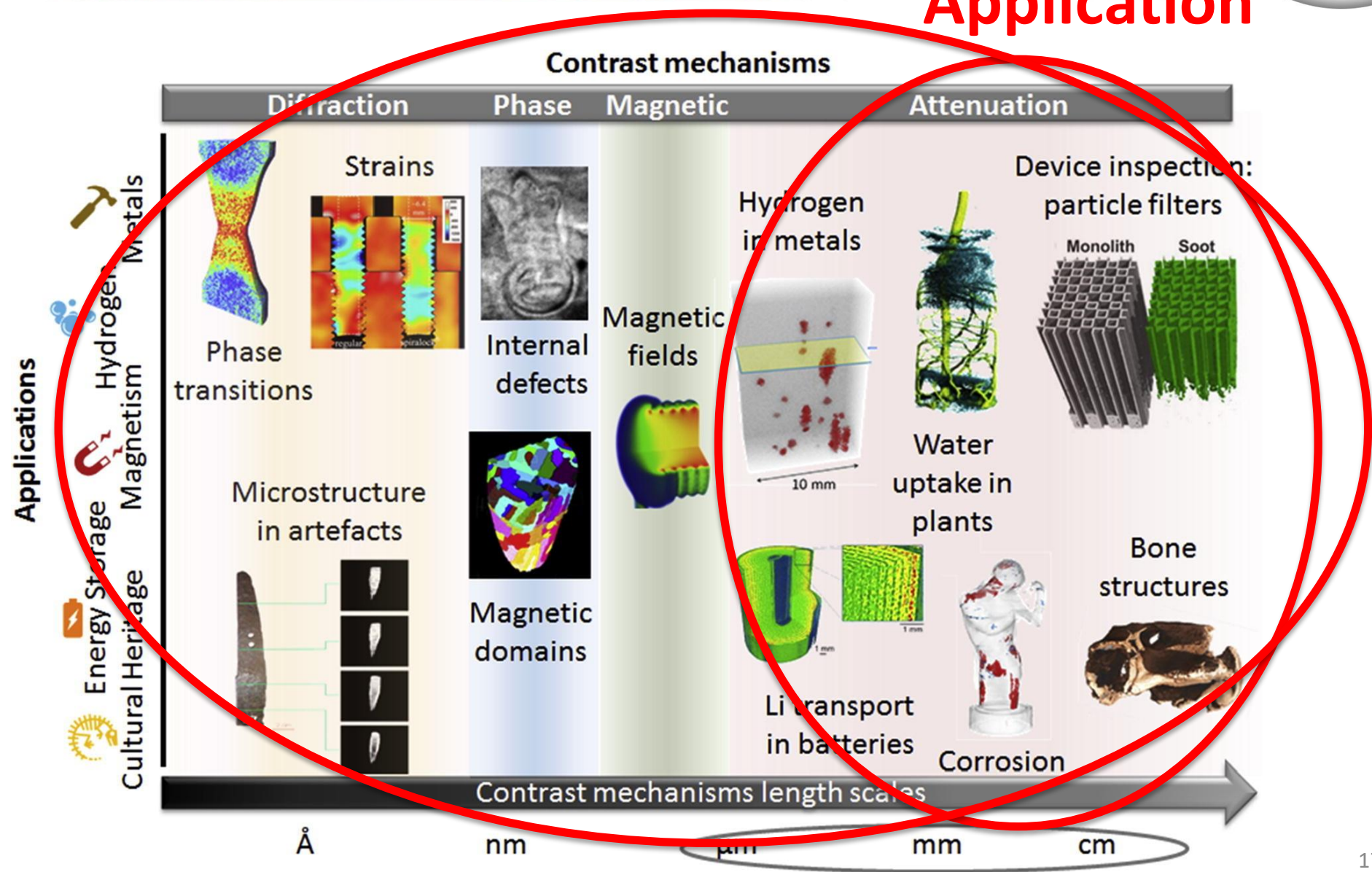
$$I(r, E) = I_0 \exp^{-\mu(E)x_r}$$

Fast (1–20 MeV)
Thermal (0.025–0.4 eV)
Cold (< 0.025 eV)

NEUTRON BEHAVIOUR AND PROPERTIES



Application



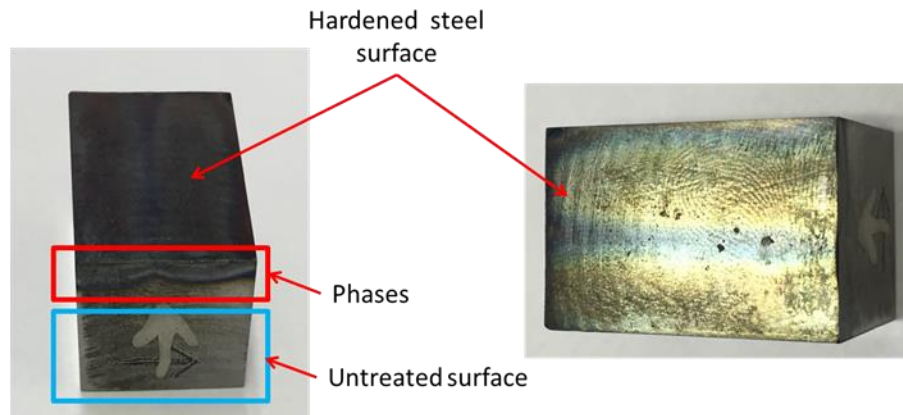
AREA OF RESEARCH

- ✓ **Materials science & engineering:** new materials, welds, cracks, stress, texture, etc.
- ✓ **Electrochemistry:** batteries, fuel cells, etc.
- ✓ **Concrete, rocks and porous media:** porous media, porosity, permeability.
- ✓ **Nuclear materials and fuels:** fuel, structural materials, moderators, etc.
- ✓ **Solid state physics & magnetism:** bulk and magnetic materials.
- ✓ **Hydrogen & processes:** hydrogen storage, processes involving fluids.
- ✓ **Cultural heritage, Art, Conservation & Archaeometry:** study and conservation of cultural heritage.
- ✓ **Botanic, wood science and technology:** plants physiology, wood study and conservation.
- ✓ **Palaeontology:** fossils and evolution.

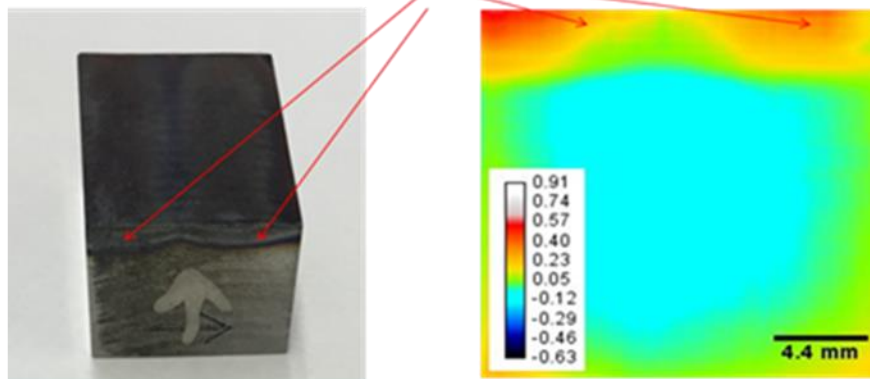
Example of application

Strain and stress mapping

Differential depth-resolved strain map of the laser treated steel. The map shows the magnitude and distribution of strain.



Region of interest



The introduction and implementation of a USER OFFICE principle by the Team for the management of project applications in order to apply for XCT beam time at the facility contributes to the human resource development as it is an international standard practice to apply for “beam time” at similar overseas facilities.

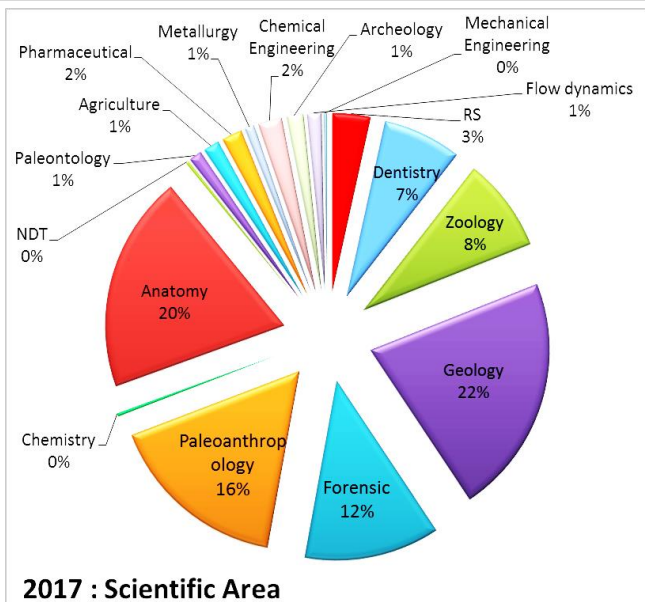
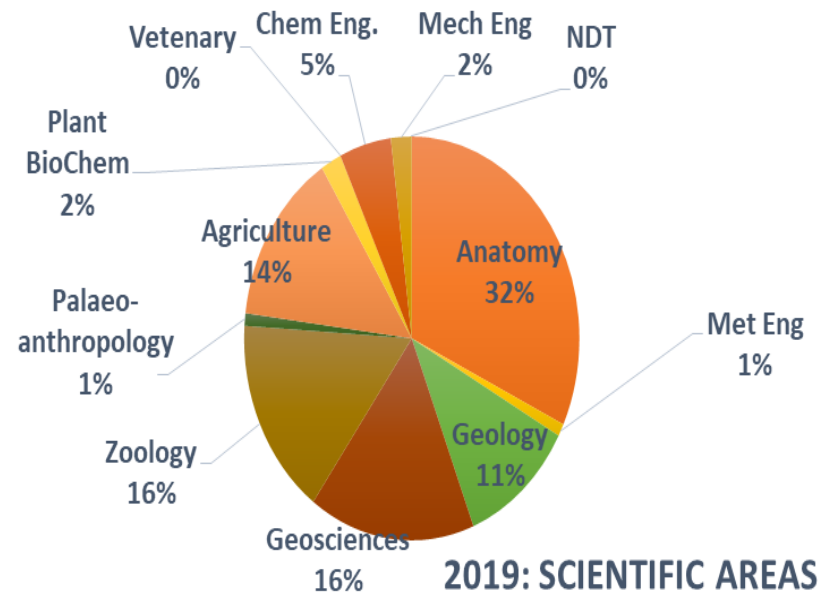
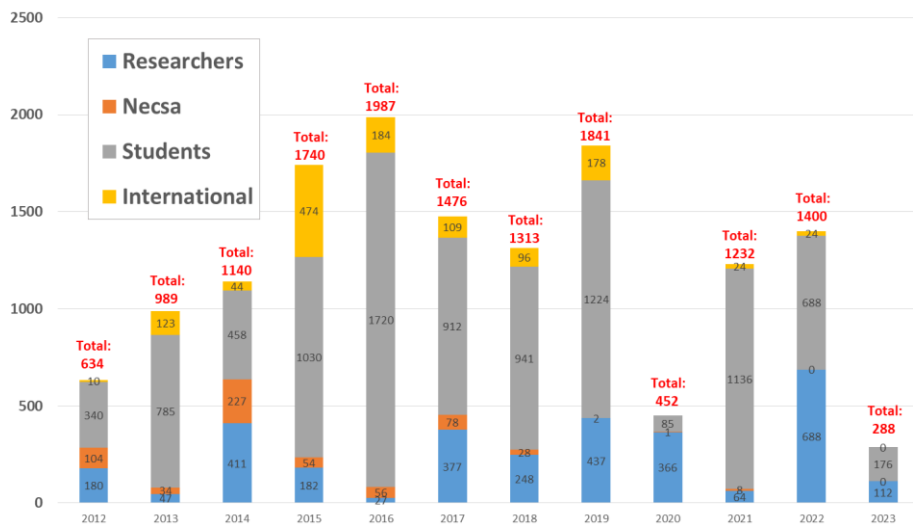
The functional USER OFFICE streamlines the process of proposal applications, allocation of beam time as well as the monitoring and feedback of the potential and completed output e.g. dissertations, thesis's, peer reviewed articles and conference output by the users

Consulting with researcher to determine micro-focus X-ray tomography application goals, objectives and foreseen outcomes of the engagement. This entails the engagement in advance, prior to visiting Necsa, through a proper proposal application, for beam time (access to the instruments) which is based on internationally accepted protocol.

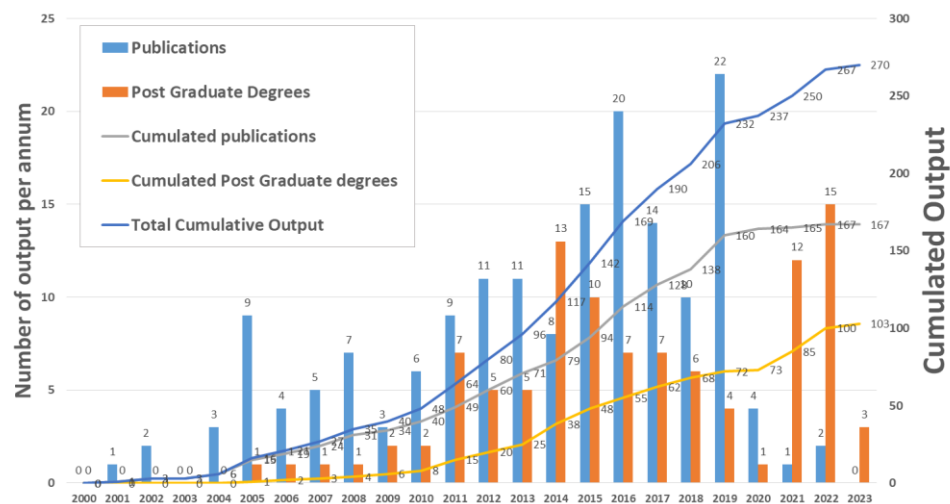
Period /Year	Beam time application for period:	Call open on:	Proposal deadline	Final Allocated beam time:
1/YY	1 Jan – 30 April	1 Aug previous year	30 October previous year	30 Nov previous year
2/YY	1 May – 31 Aug	1 Dec previous year	30 February	30 March
3/YY	1 Sept – 31 Dec	1 April	30 June	31 July

User office at BLC: X-ray Imaging

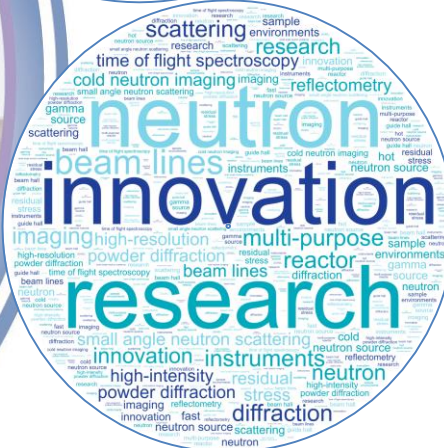
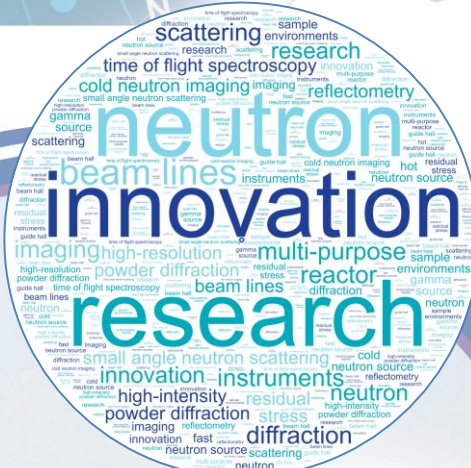
MIXRAD: Total number of CT Scans conducted



Radiation Imaging Total Output 2000 - 2023



QUESTIONS



TEAM MEMBER	Mr Robert Nshimimana	Mr Jakobus Hoffman	Dr Lunga Bam	Mr Evens Moraba
Research Focus	Group Leader (Neutron & XCT): <ul style="list-style-type: none"> Instrument scientist Instrument design Simulations Software development 	Instrument Scientist (XCT): <ul style="list-style-type: none"> Instrument scientist Coal sciences Geosciences Analysis applications 	Instrument Scientist (XCT): <ul style="list-style-type: none"> Instrument scientist Geosciences Analysis applications 	Technologist: <ul style="list-style-type: none"> Instrumentation & Software Design Analysis applications

Senior Secretary: Mrs Linda Reyneke (User office)

Use office email: RadTom@necsa.co.za