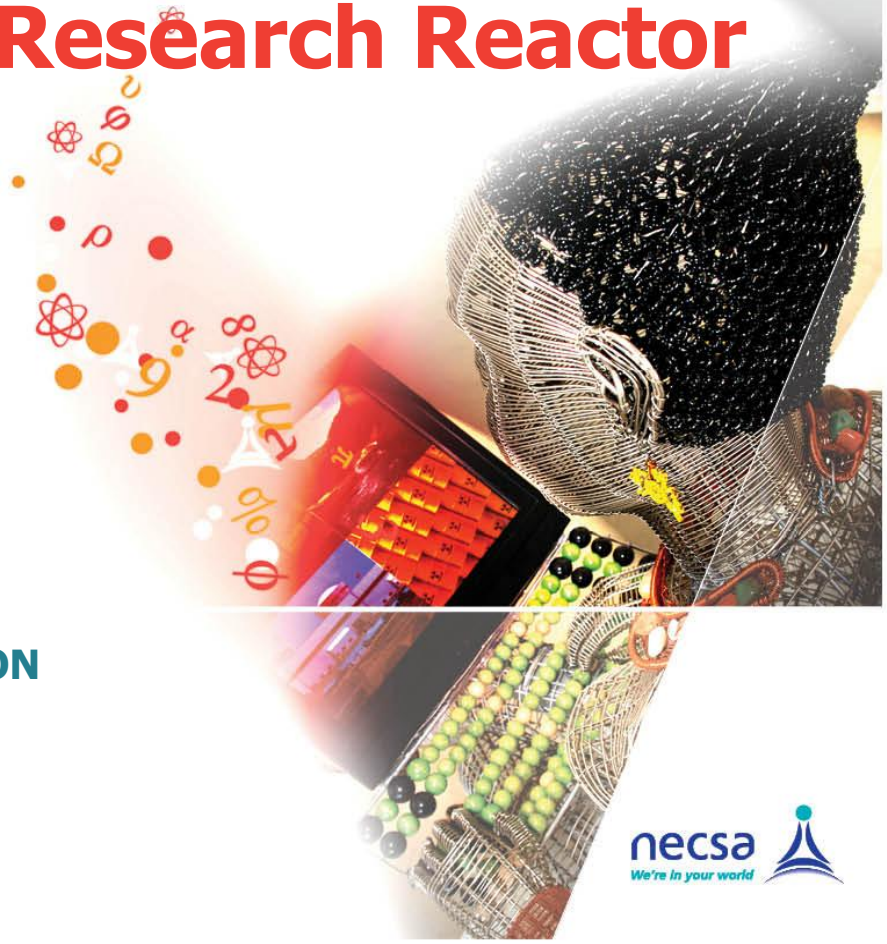
Utilisation and Upgrading of the Neutron Beam Lines Facilities at the SAFARI-1 Nuclear Research Reactor in South Africa

Frikkie de Beer

Section Head; Radiography/Tomography

R&D; Radiation Science; Necsa



CN-188 INTERNATIONAL CONFERENCE ON RESEARCH REACTORS: SAFE MANAGEMENT AND EFFECTIVE UTILIZATION

14 - 18 NOVEMBER 2011, RABAT, MOROCCO

necsa
We're in your world

Focus of talk

INTERNATIONAL CONFERENCE ON RESEARCH REACTORS:
SAFE MANAGEMENT
AND

EFFECTIVE UTILIZATION (Beam Lines)

Acknowledgement

- IAEA
  - Fellowships: Europe / Asia
  - Expert Missions to Necsa
  - Scientific Visits
    - Europe (Hungary / Germany / Switzerland / etc.)
    - Australia
    - Asia
  - CRP
  - TC

International Benchmarking of facilities

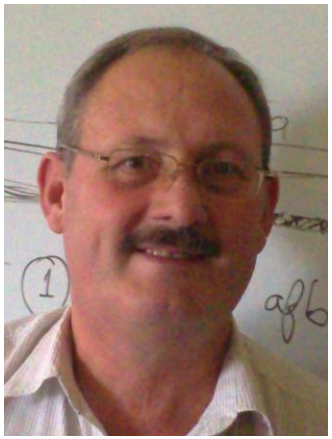
- Total upgrade of all 3 beam lines (Collaborations)
  - SANS
    - Hungary / Russia
  - NDIFF
    - ANSTO, Australia / IAEA
  - NRAD
    - Germany / Switzerland

Instrument Scientist on SAFARI-1 Beam Lines

BL-1: Small Angle Neutron Scattering
(Former PGNAA facility)
CHRIS FRANKLYN
& TSATJI TSEBANE

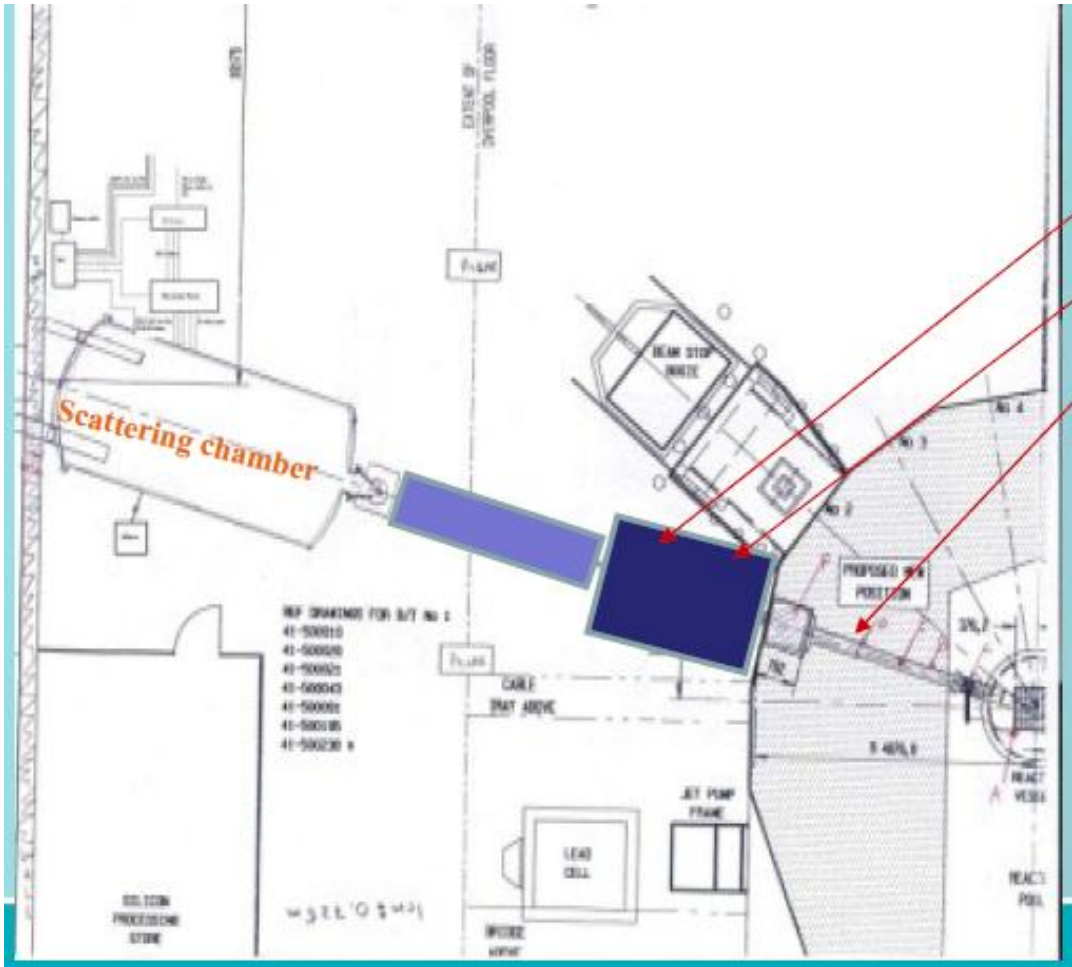
BL-5: Neutron Diffraction
- Powder diffraction
- Residual Stress

ANDREW VENTER



BL-2: Neutron Radiography / Tomography
FRIKKIE DE BEER
& MABUTI RADEBE

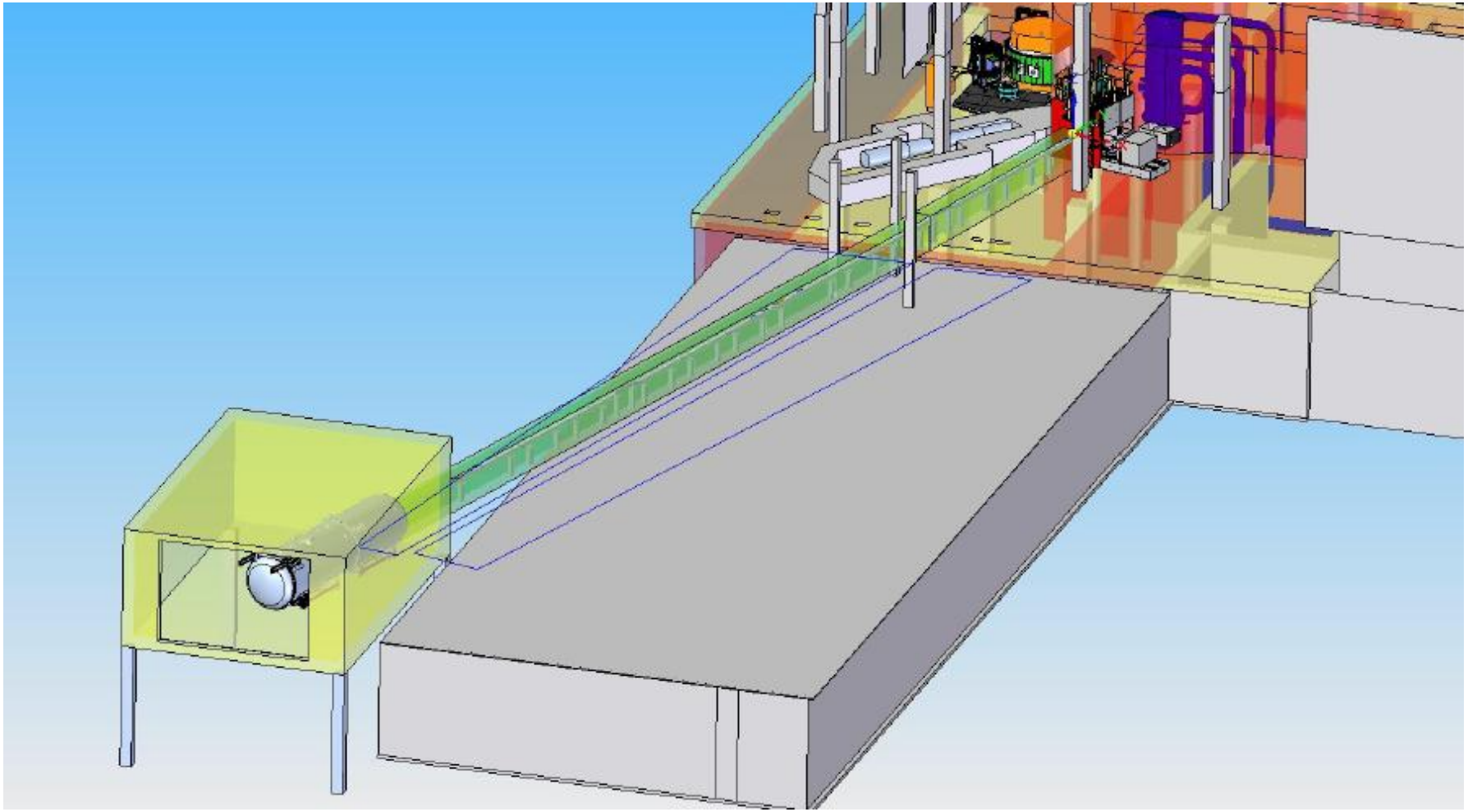
SANS UPGRADE (Phase-1)



Features

- Neutron Velocity Selector
- Be and Bi filters cooled to 70K
- 4x4 cm neutron guide within 7" steel sleeve
- 5m collimation tube
- Sample Changer
- 4.5 m long 2.3 m diameter scattering chamber
- Mobile detector system (60 x 60 cm PSD) and electronics
- Vacuum systems

SANS UPGRADE (Phase 2)



SANS UPGRADE

Detector system

- 60 x 1-D PSD each 60cm long
- Stacked configuration
- Position resolution < 2mm possible
- Efficiency at 6Å > 95%

SANS APPLICATIONS

Polymers

Electro-spun microfibres

Study of microfibres to see if there are semi-amorphous zones.

Co-polymer tail structure

Study of phase separation of co-polymer into 4nm micelles.

Core-shell structure

Study of core-shell structures in mini-emulsions of polybutyl acrylate in oil.
Study of core shell morphology of monodispersed polystyrene lattices.

UNESCO Centre for Macromolecular Chemisty
Department of Chemistry, University of Stellenbosch, South Africa

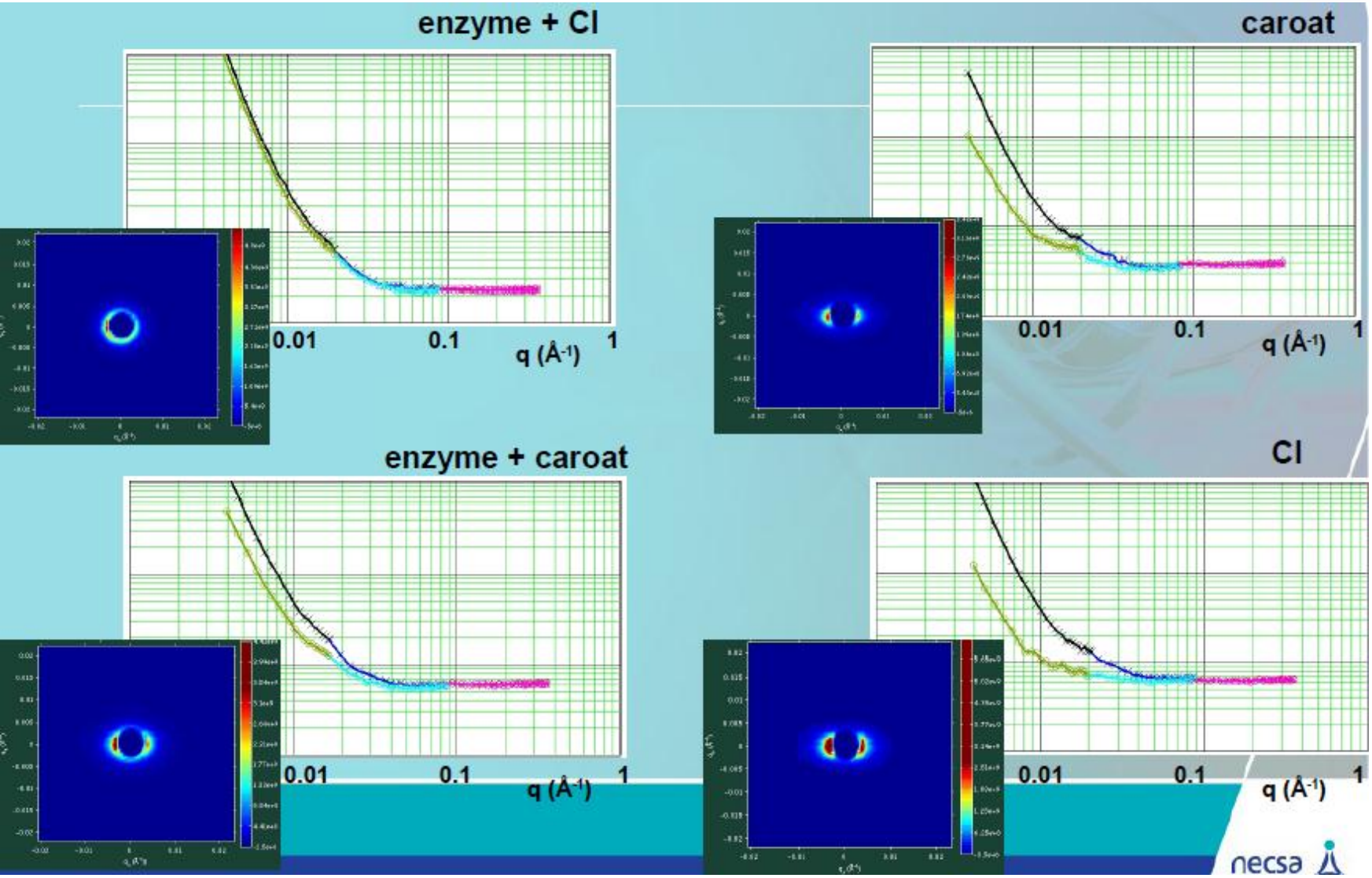
Nano-sciences

Sulphide nanostructures

Characterization of HgS, CdS and PbS nano-rods using SANS

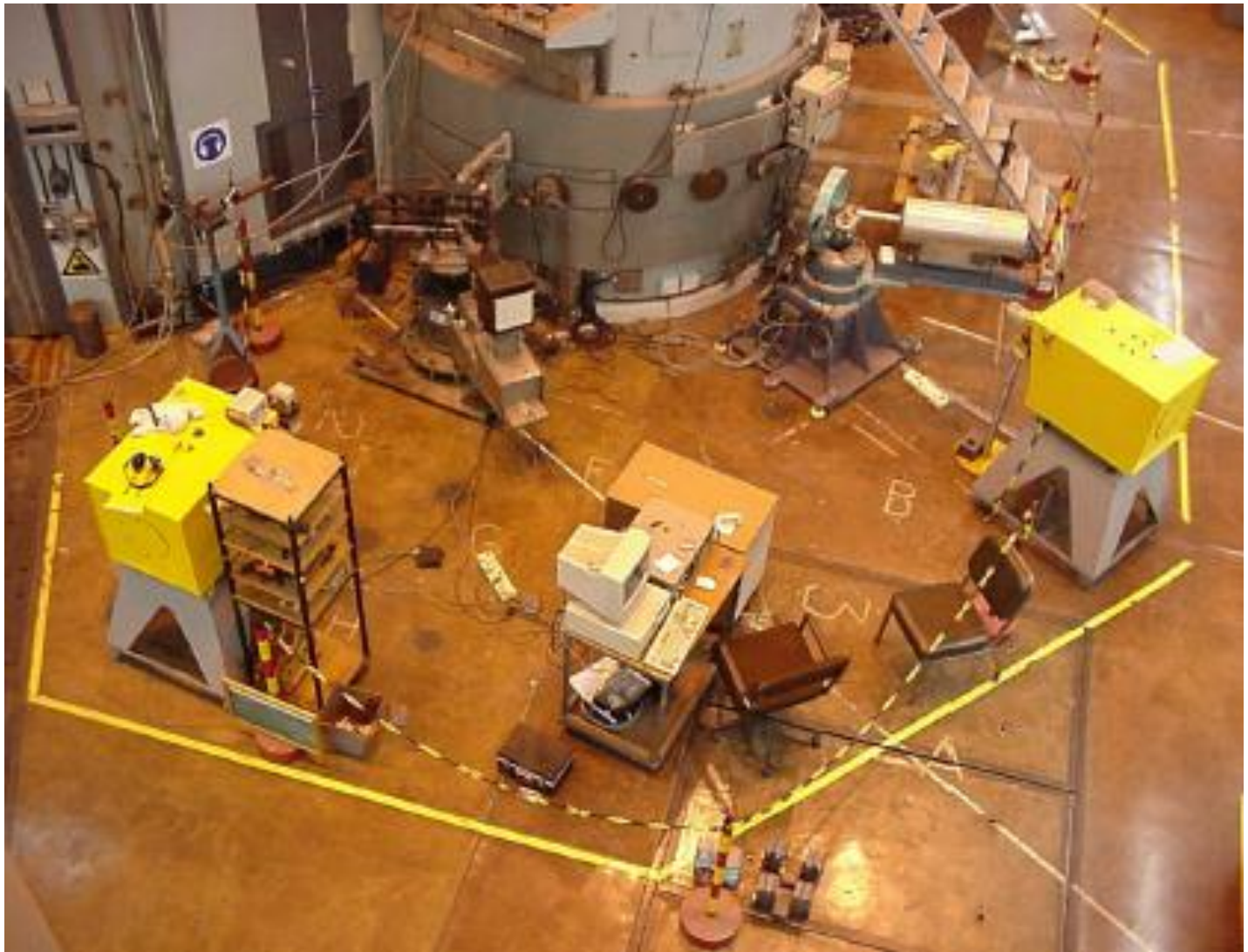
Department of Chemistry, University of Zululand and University of Witwatersrand, South Africa

SANS APPLICATION: Wool treatments

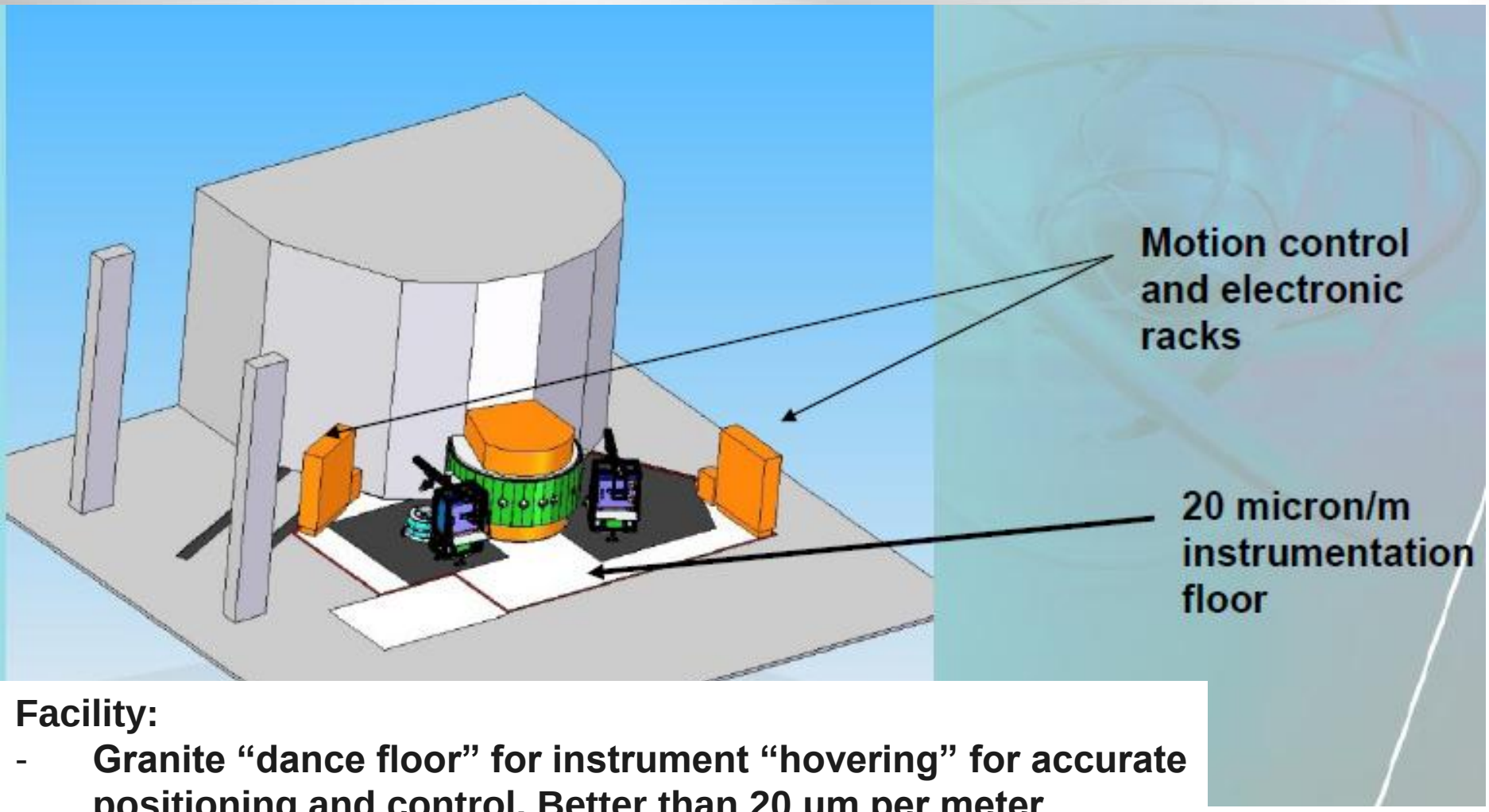


NDIFF UPGRADE

- FROM



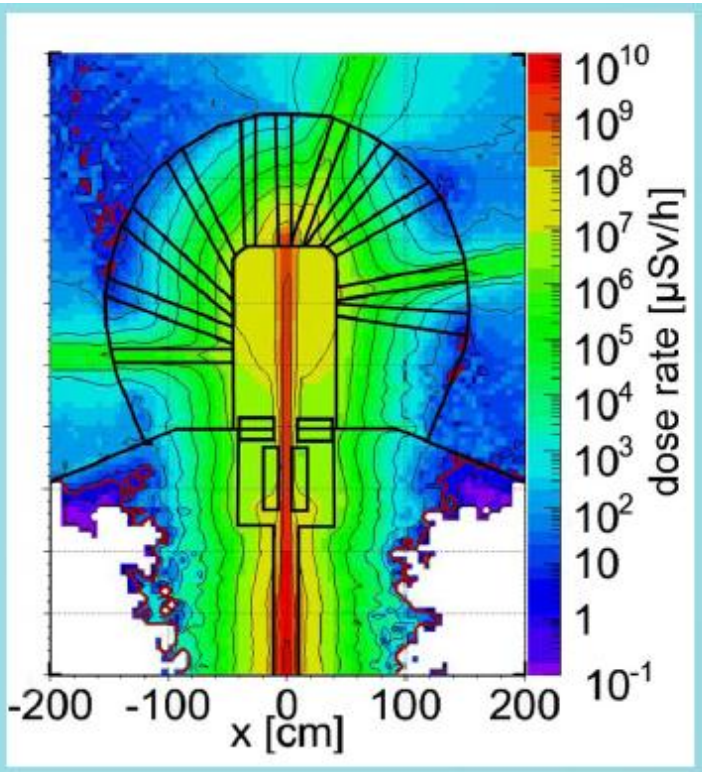
NDIFF UPGRADE



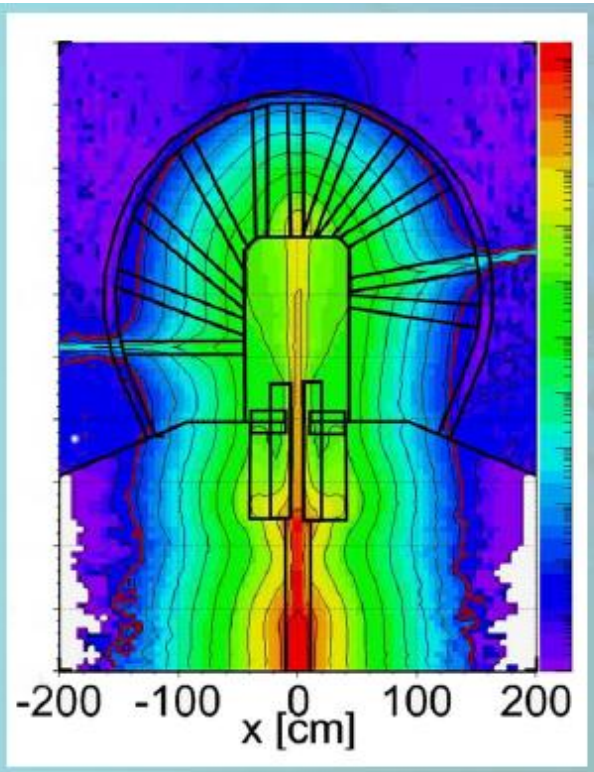
Facility:

- **Granite “dance floor” for instrument “hovering” for accurate positioning and control. Better than 20 µm per meter.**
- **Instrument control in conjunction with Gumtree / SICS (ANSTO).**

MCNP dose calculations for NDIFF facility



Original collimation configuration



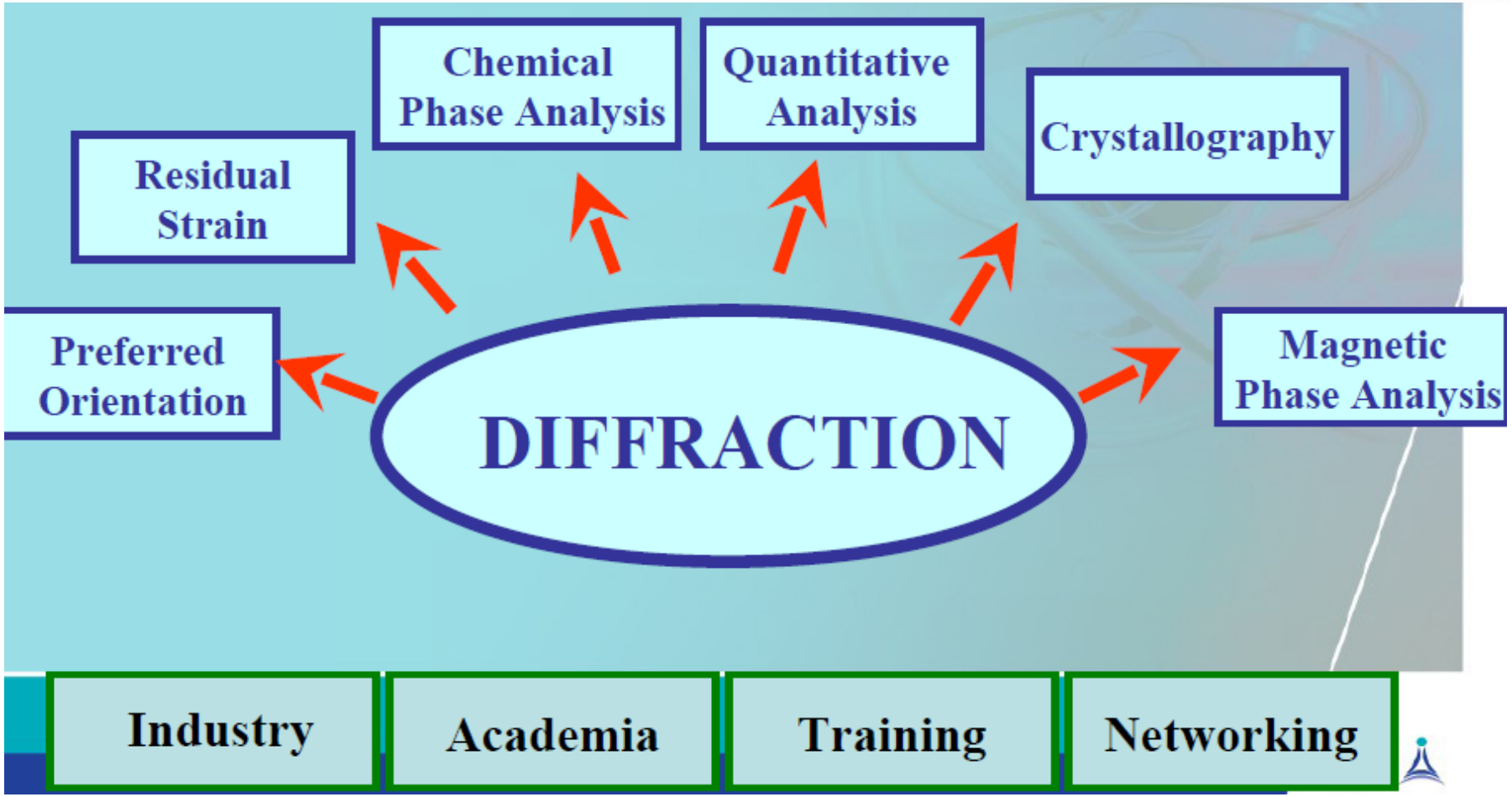
Improved collimation configuration

NDIFF UPGRADE

- **Powder diffraction:**
  - **State of the art goniometer, 0001o positional accuracy, integrated XYZ stage.**
  - **100 x data acquisition rate: Larger beam acceptance from 15 vertically stacked PSDs**
  - **Low temperature cryostat (3.5K)**
  - **Furnace (1500K)**

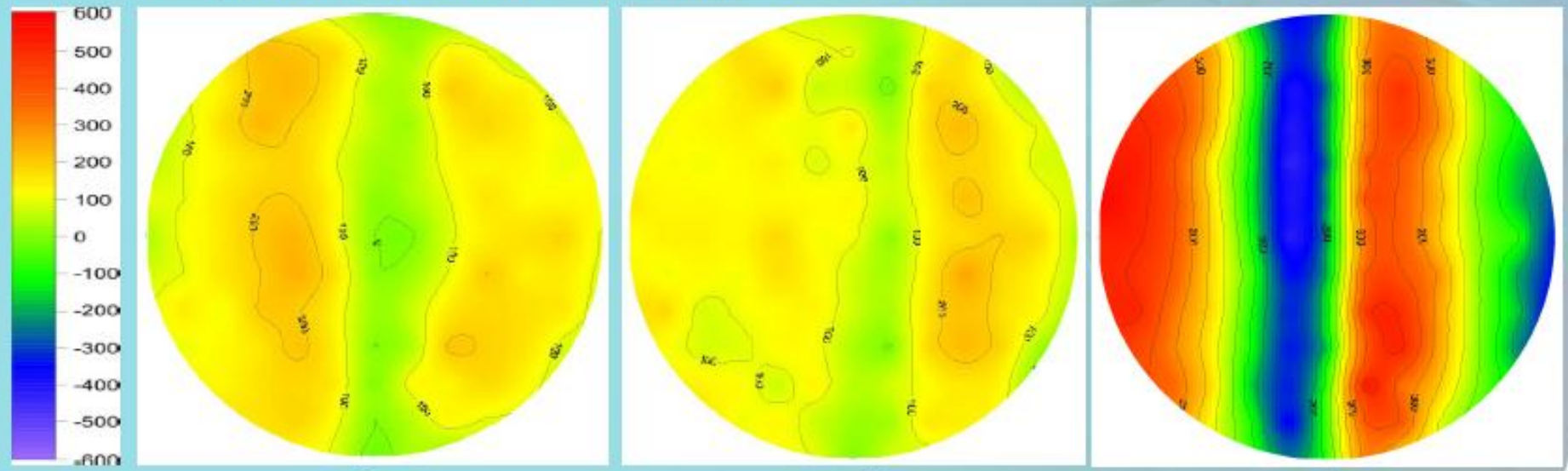
- **Strain scanner:**
  - **State of the art goniometer, 0001o positional accuracy, integrated XYZ stage.**
  - **Better sample positional accuracy (10 X) with no backlash.**
  - **Faster detection system (10 X)**
  - **Instrument alignment and calibration within 10µm.**

NDIFF APPLICATIONS



Residual stress mapping of helical coil springs

Primary driver: automotive industry



Two dimensional residual stress mapping through the interior of a 14 mm coil rod showing the stress components from the internal bore (left) to the external diameter: (a), Hoop; (b), Radial (along spring length); and (c), Axial (along the coil). The neutron strain scanning was done with a gauge volume of 1 mm^3.

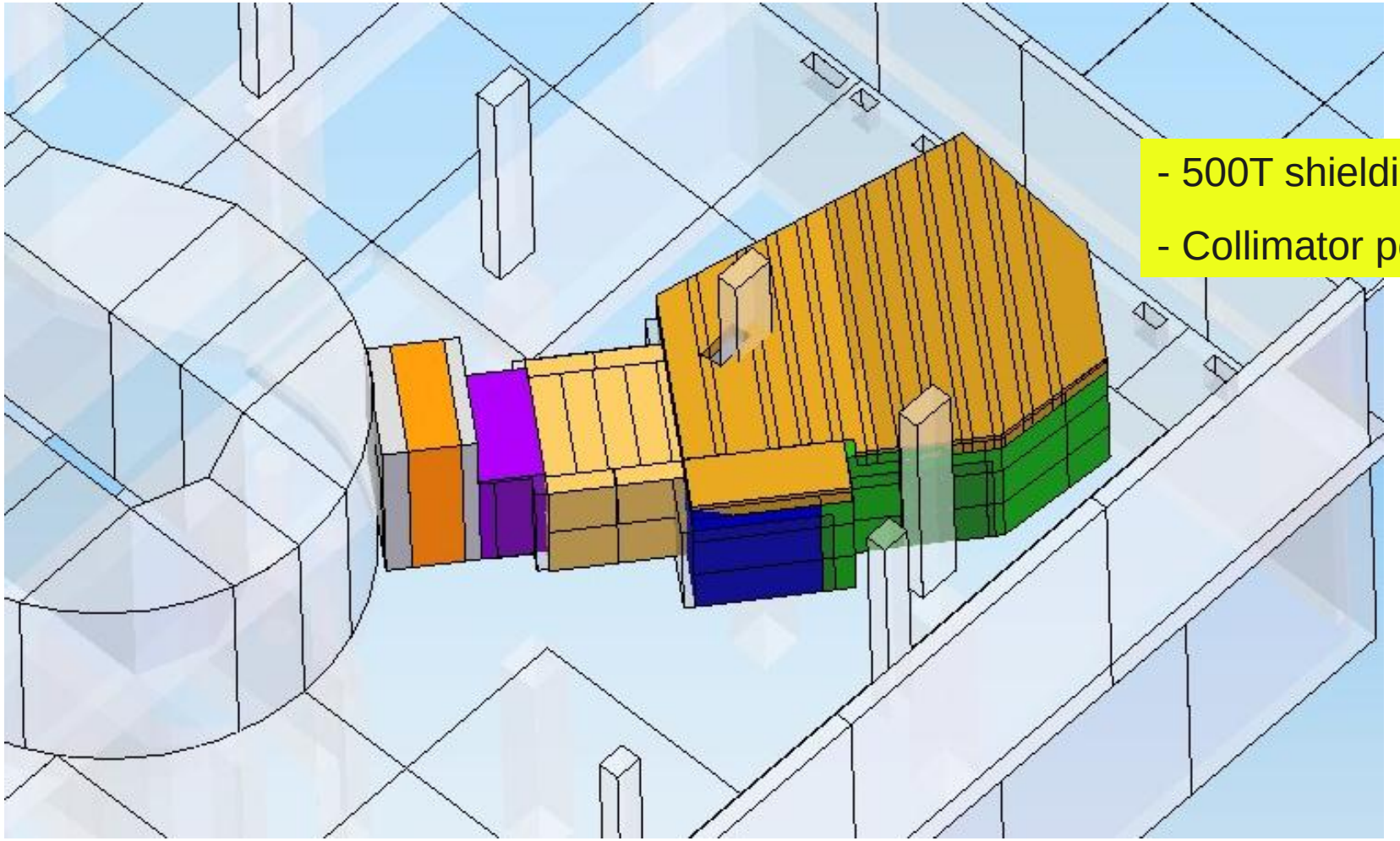
NRAD UPGRADE

- From

- Inadequate shielding
  - Safety
- Collimator position
  - Corrosion
  - Not facing full reactor core
  - Neutron profile in beam

NRAD UPGRADE

- New



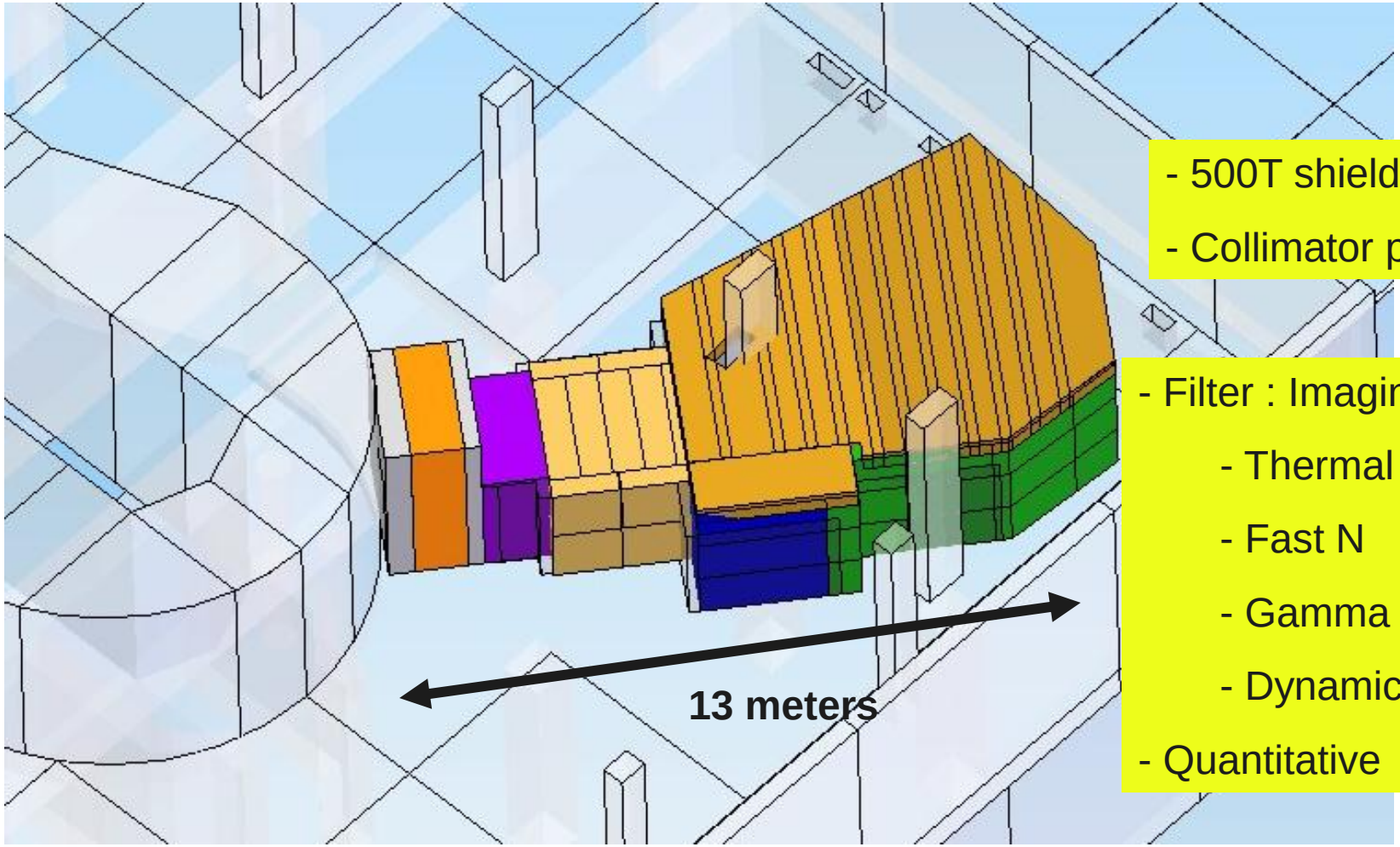
NRAD UPGRADE

- From

- Inadequate shielding
  - Safety
- Collimator position
  - Corrosion
  - Not facing full reactor core
  - Neutron profile in beam
- Filtering (Neutrons & gammas)
  - Versatile
  - Scattering – quantitative measurements

NRAD UPGRADE

- New



- 500T shielding
- Collimator position

- Filter : Imaging
  - Thermal N
  - Fast N
  - Gamma Ray
  - Dynamic studies
- Quantitative

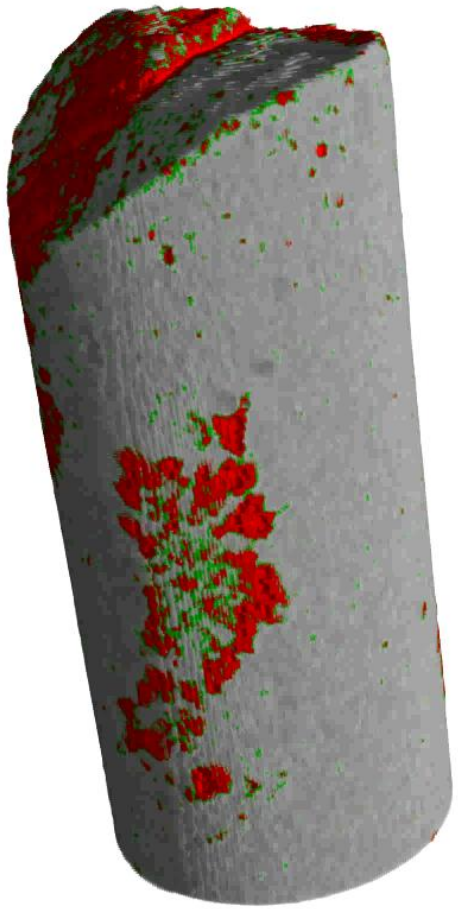
Neutron tomography: Geosciences

ADVANTAGE
Thin sectioning

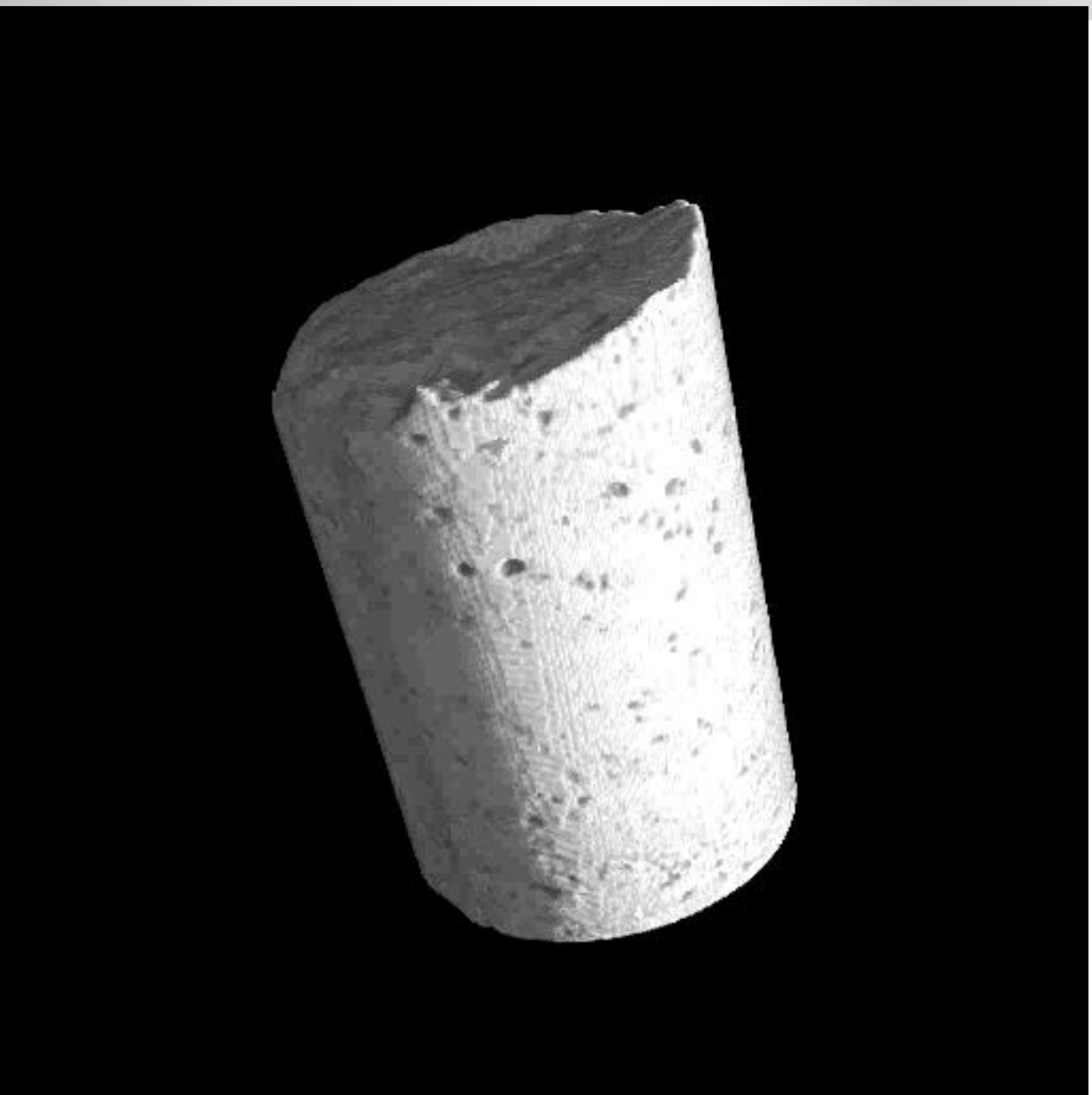
Mineral distribution

Plagioclase matrix

Pyroxenes
(Ortho / Clino)



Neutron tomography: Petrophysics

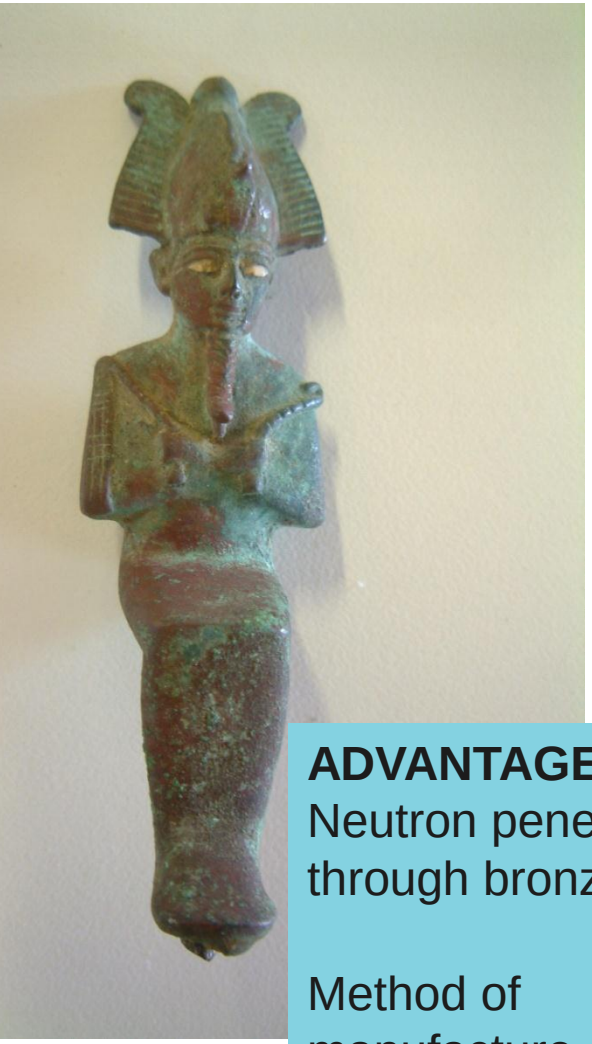


Oil bearing Sandstone
Diameter 7cm

Empty pores
5.5 ± 1.1%

Oil filled pores
4.7 ± 0.9%

NRAD-Applications: Archaeology



ADVANTAGE
Neutron penetration through bronze

Method of manufacture

Authenticity

Neutron radiography: Achievement 2010

WCNR-9

2010

9th World Conference on Neutron Radiography

3 - 8 October 2010, Kwa Maritane, South Africa

BIG FIVE ON

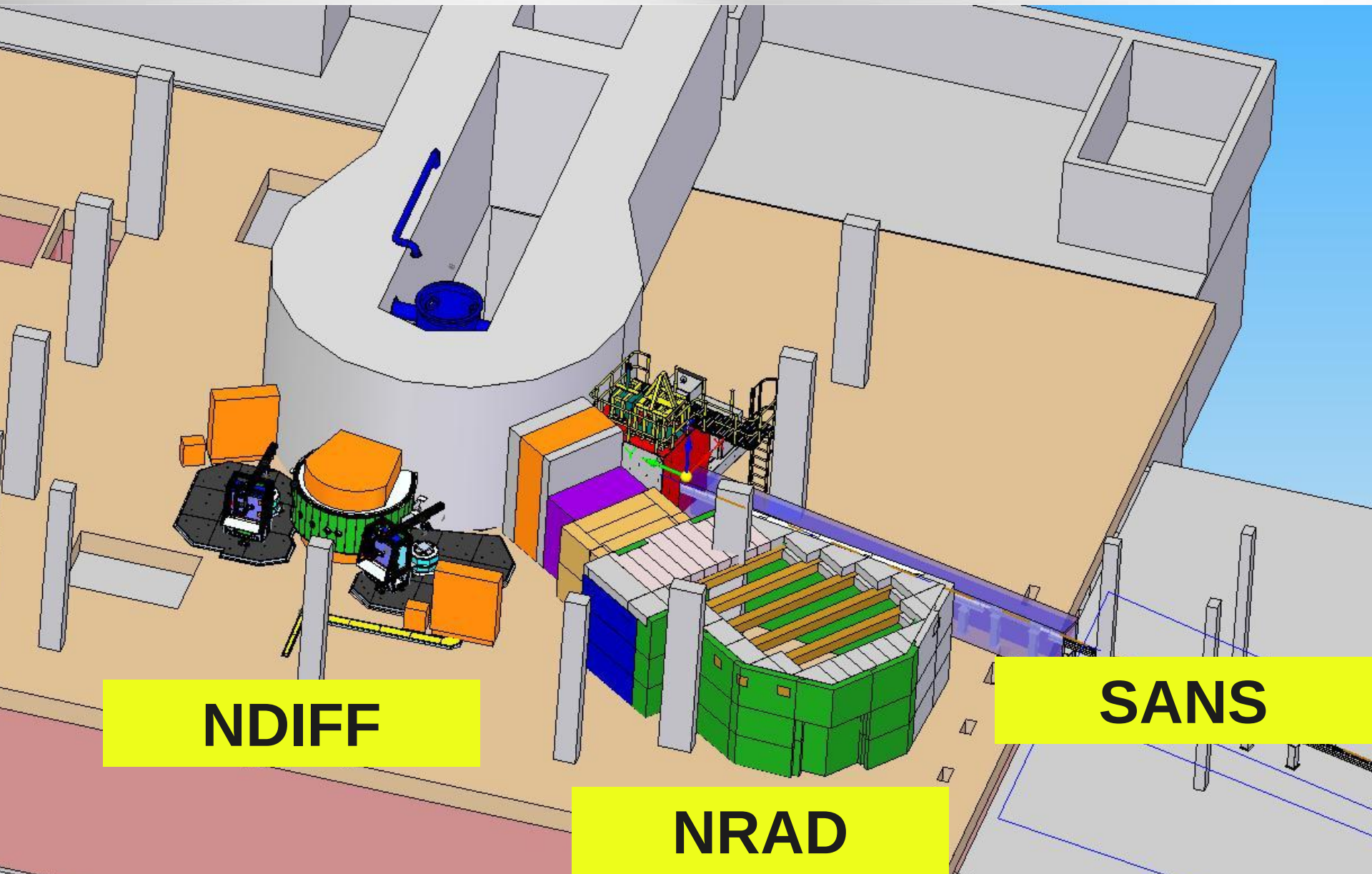
NEUTRON RADIOGRAPHY

NEW NEUTRON BEAM LINE FACILITIES

- USER OFFICE
  - Online
- www.necsa.co.za/research/beam lines/

- Beam line facility characteristics
- Terms and conditions to perform research
- Proposals
- Safety

SUMMARY




Thank you