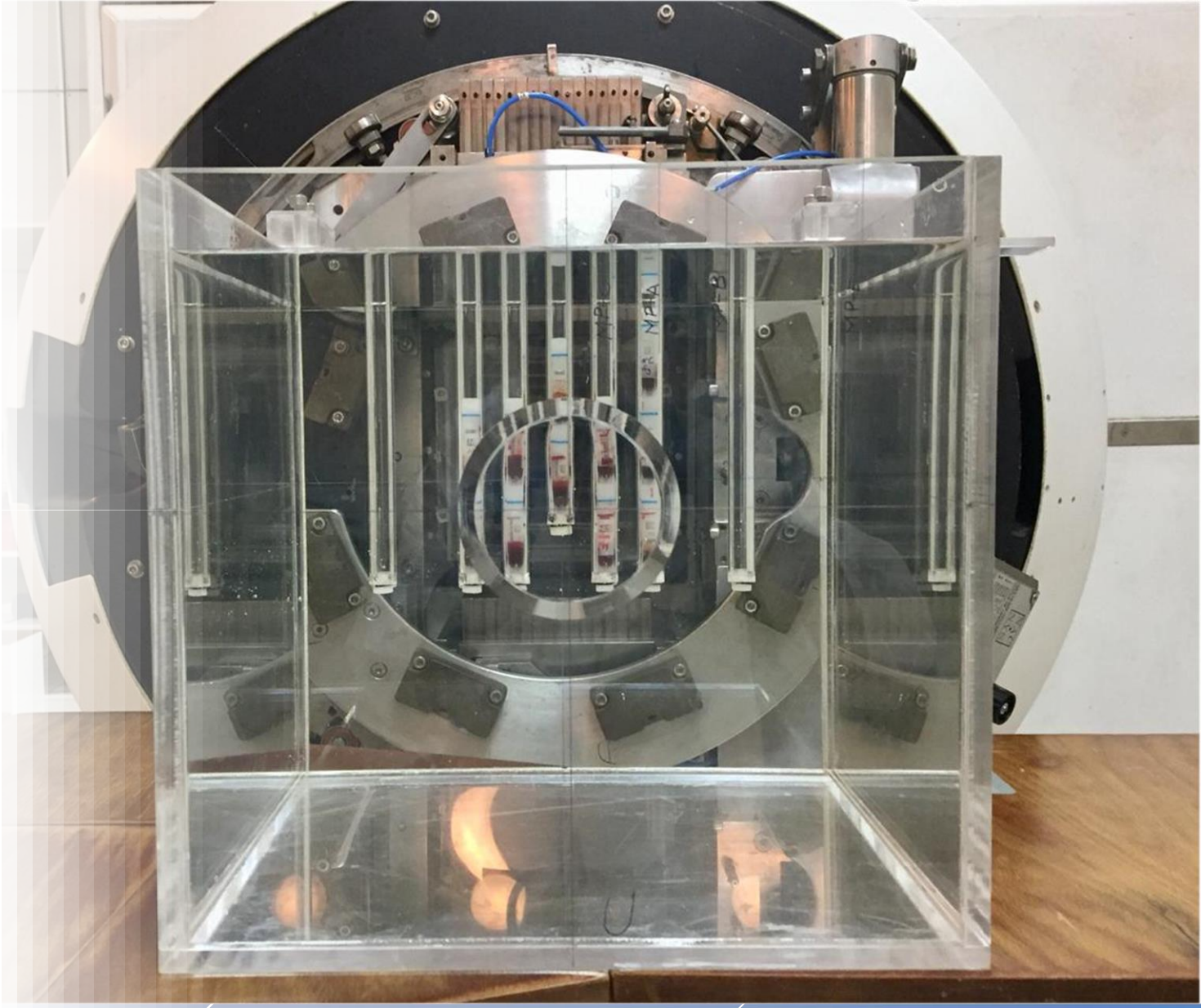
RADIATION BIOPHYSICS



A division of the Separated Sector Cyclotron Laboratory

NRF iThemba LABS

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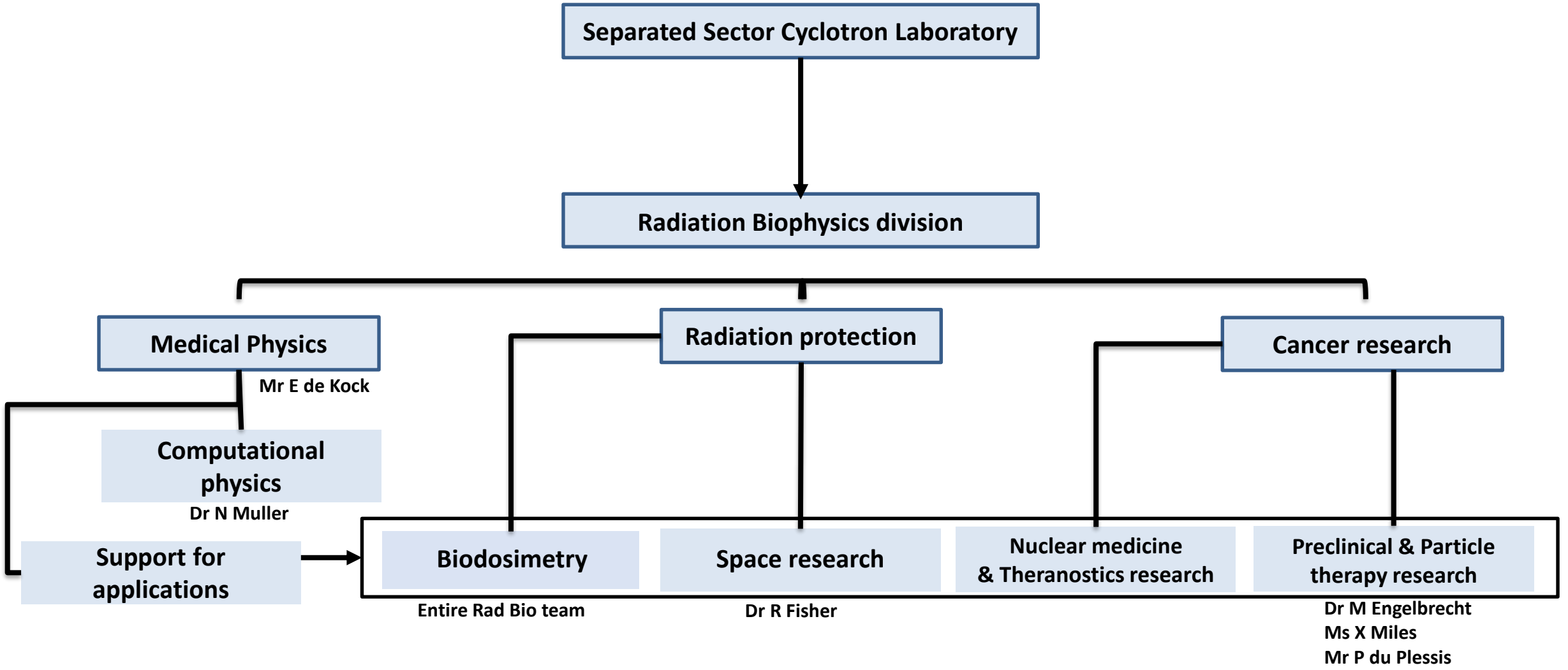
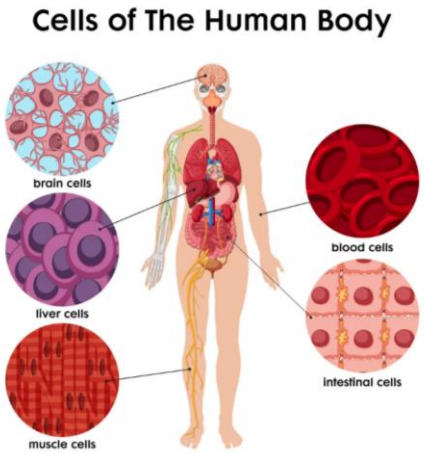
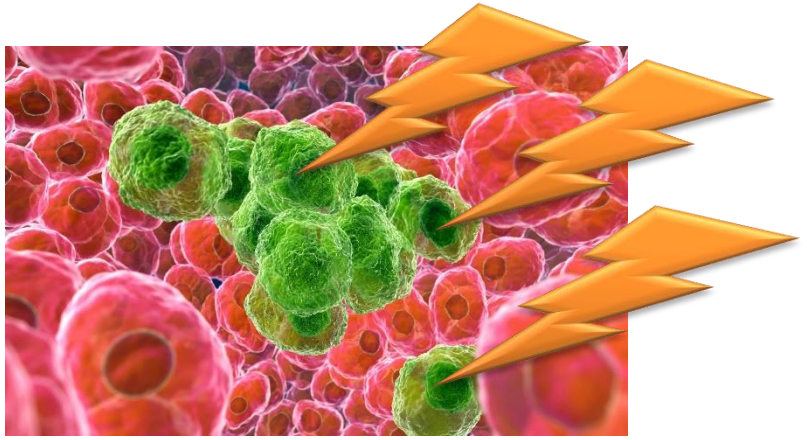
science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

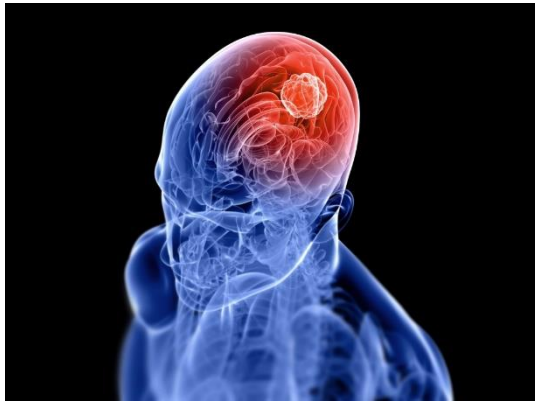
NRF National Research Foundation
iThemba LABS Laboratory for Accelerator Based Sciences


Separated Sector Cyclotron Laboratory
Radiation Biophysics division
Medical Physics
Mr E de Kock
Computational physics
Dr N Muller
Support for applications
Radiation protection
Biodosimetry
Entire Rad Bio team
Space research
Dr R Fisher
Cancer research
Nuclear medicine & Theranostics research
Preclinical & Particle therapy research
Dr M Engelbrecht
Ms X Miles
Mr P du Plessis

What is Radiobiology?







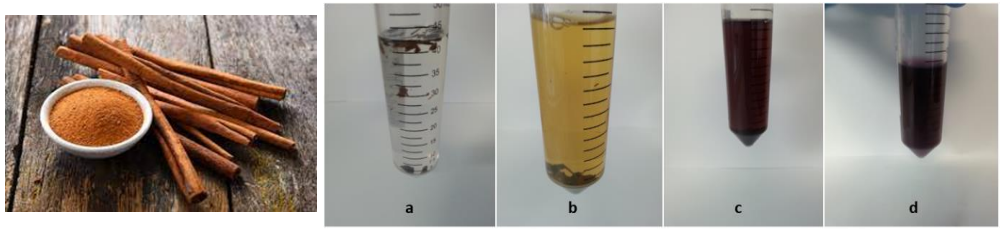
- Our projects investigate:
  - Using drugs to improve the recovery of normal cells or improve the killing of cancer cells
  - Different radiation types, what they do to cells and how they can be used to improve cancer therapy
  - The way that different radiation environments affect the human body and genetic cancer
  - New ways to identify and treat cancer with radioactive drugs
  - Genetic mechanisms of cancer resistance

RADIATION BIOPHYSICS

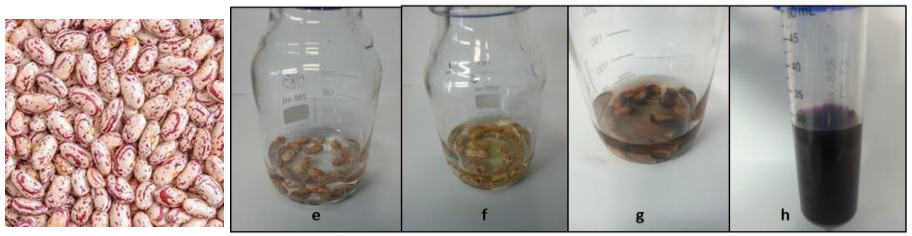
Current projects

Preclinical - Radiosensitisers

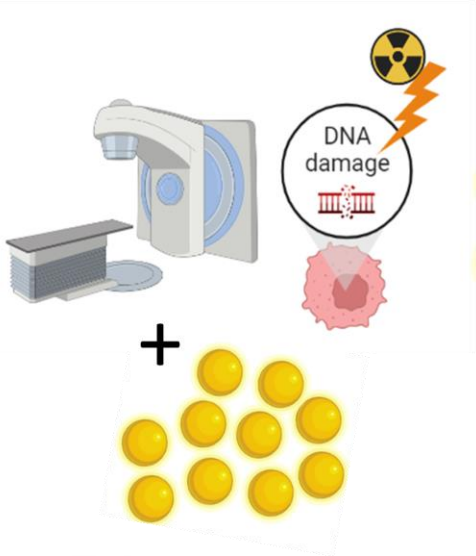
- Gold/Green NPs
- Radiosensitising drugs – AMG232, CUDC-101, Vorinostat (SAHA), Endostatin

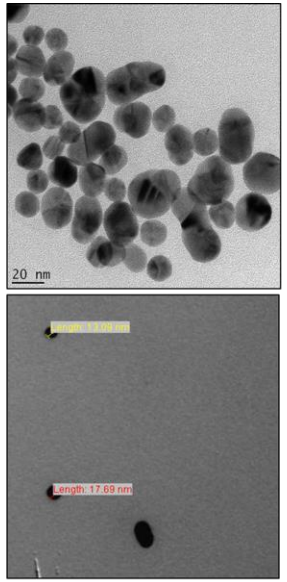


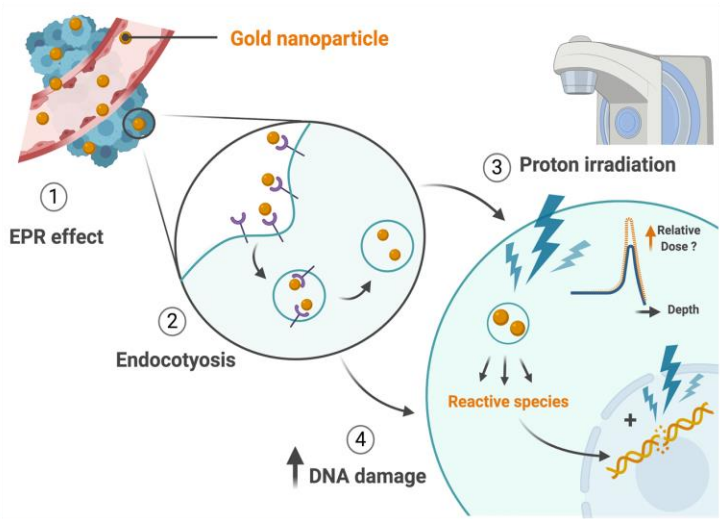
Cinnamon gold nanoparticles (Cin-AuNPs)

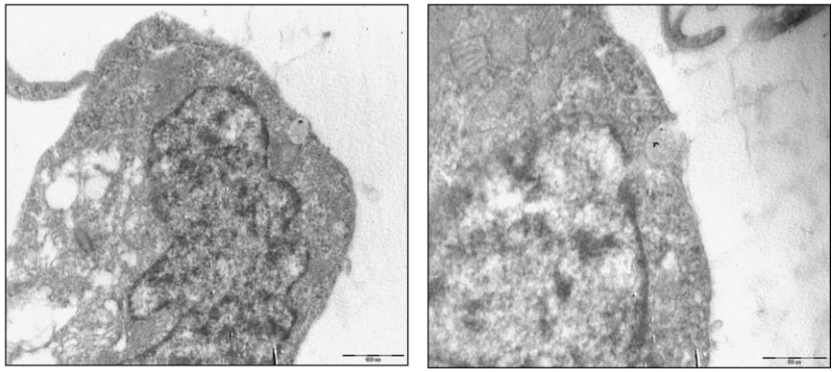


Red speckled beans gold nanoparticles (RSB-AuNPs)





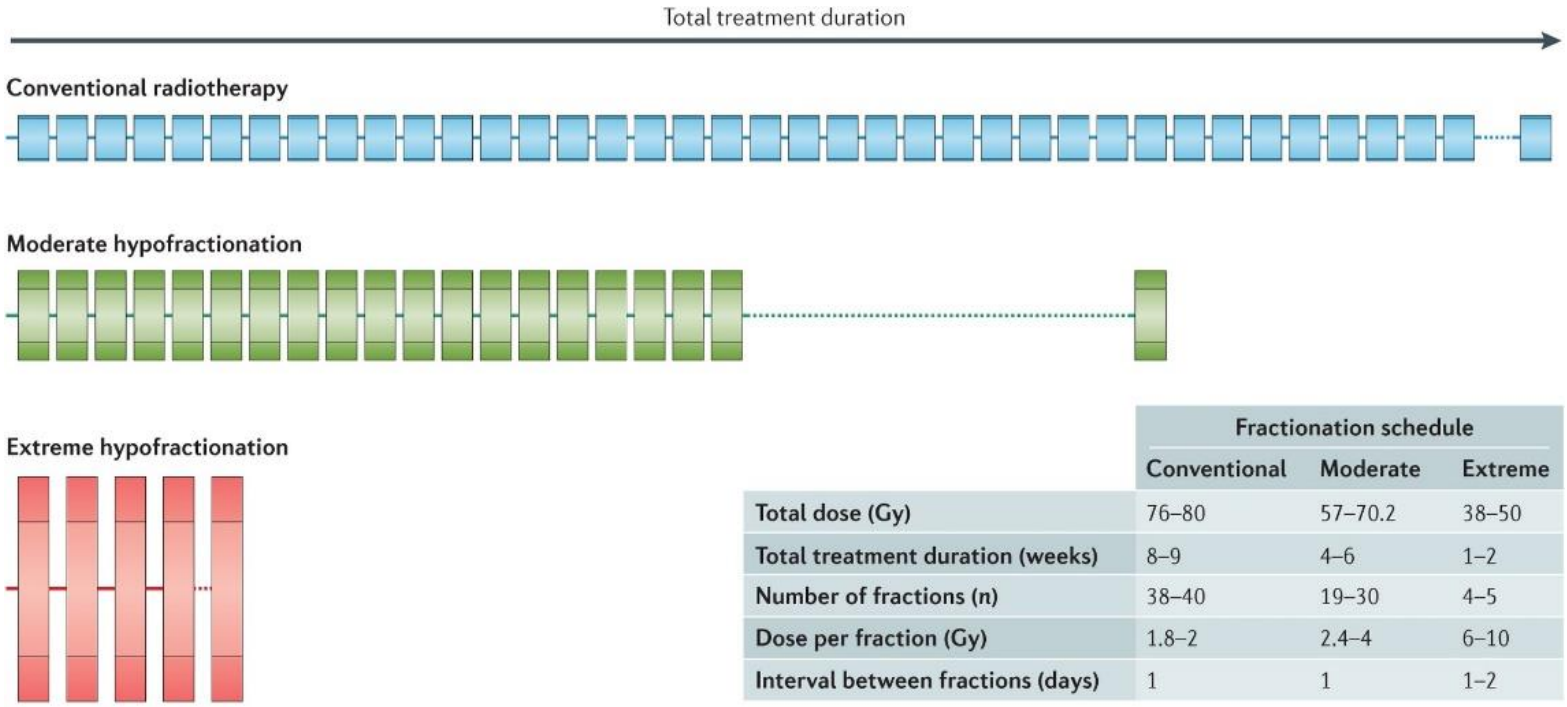




More effective therapy

Advancing knowledge. Transforming lives. Inspiring a nation.

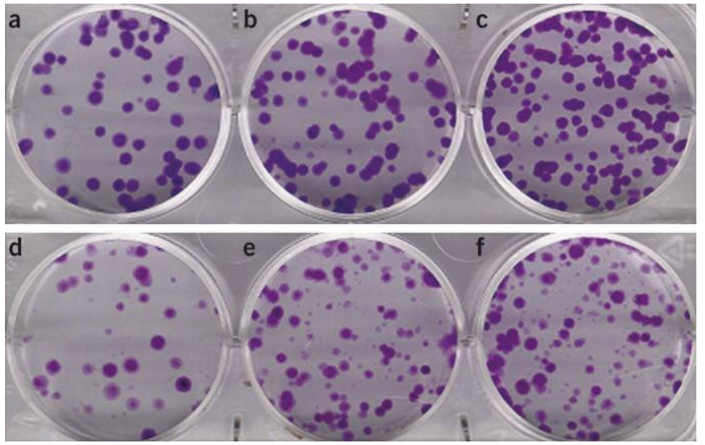
Preclinical – Hypofractionation



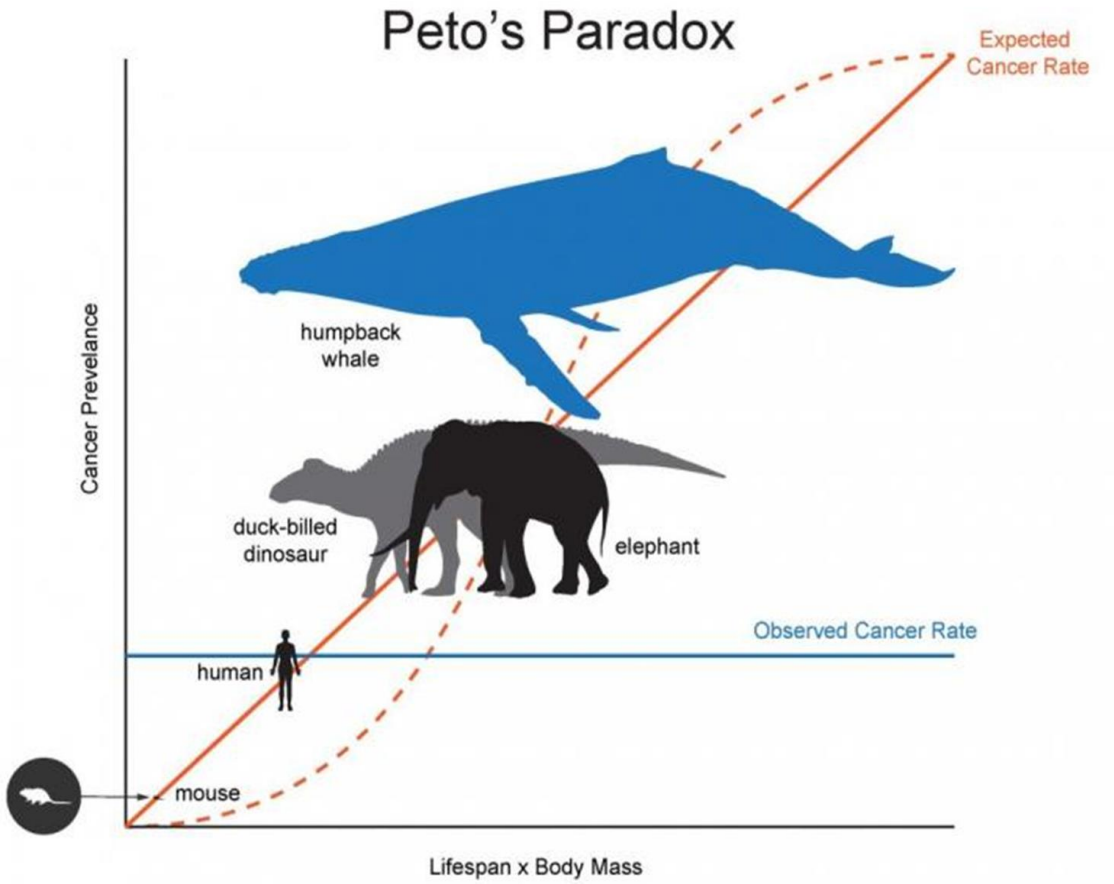
	Fractionation schedule		
	Conventional	Moderate	Extreme
Total dose (Gy)	76–80	57–70.2	38–50
Total treatment duration (weeks)	8–9	4–6	1–2
Number of fractions (n)	38–40	19–30	4–5
Dose per fraction (Gy)	1.8–2	2.4–4	6–10
Interval between fractions (days)	1	1	1–2

Nature Reviews | Urology

- Loss to follow-up in the clinic breeds resistance
- Hypofractionation should achieve a biological effective dose



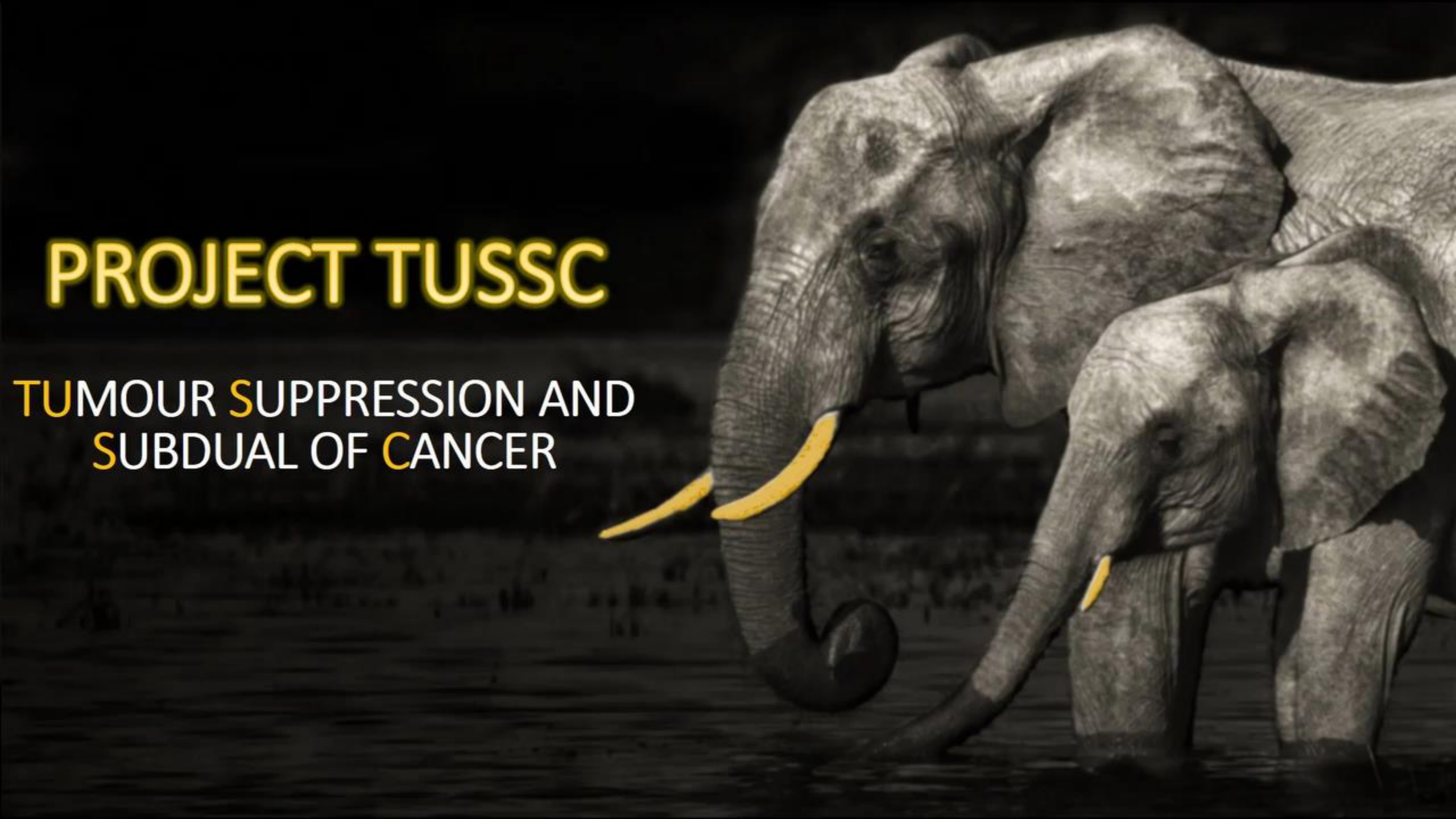
Preclinical - TUmour Suppression and Subdual of Cancer (TUSSC) in elephants: An *in vitro* study to shed light on Peto's Paradox



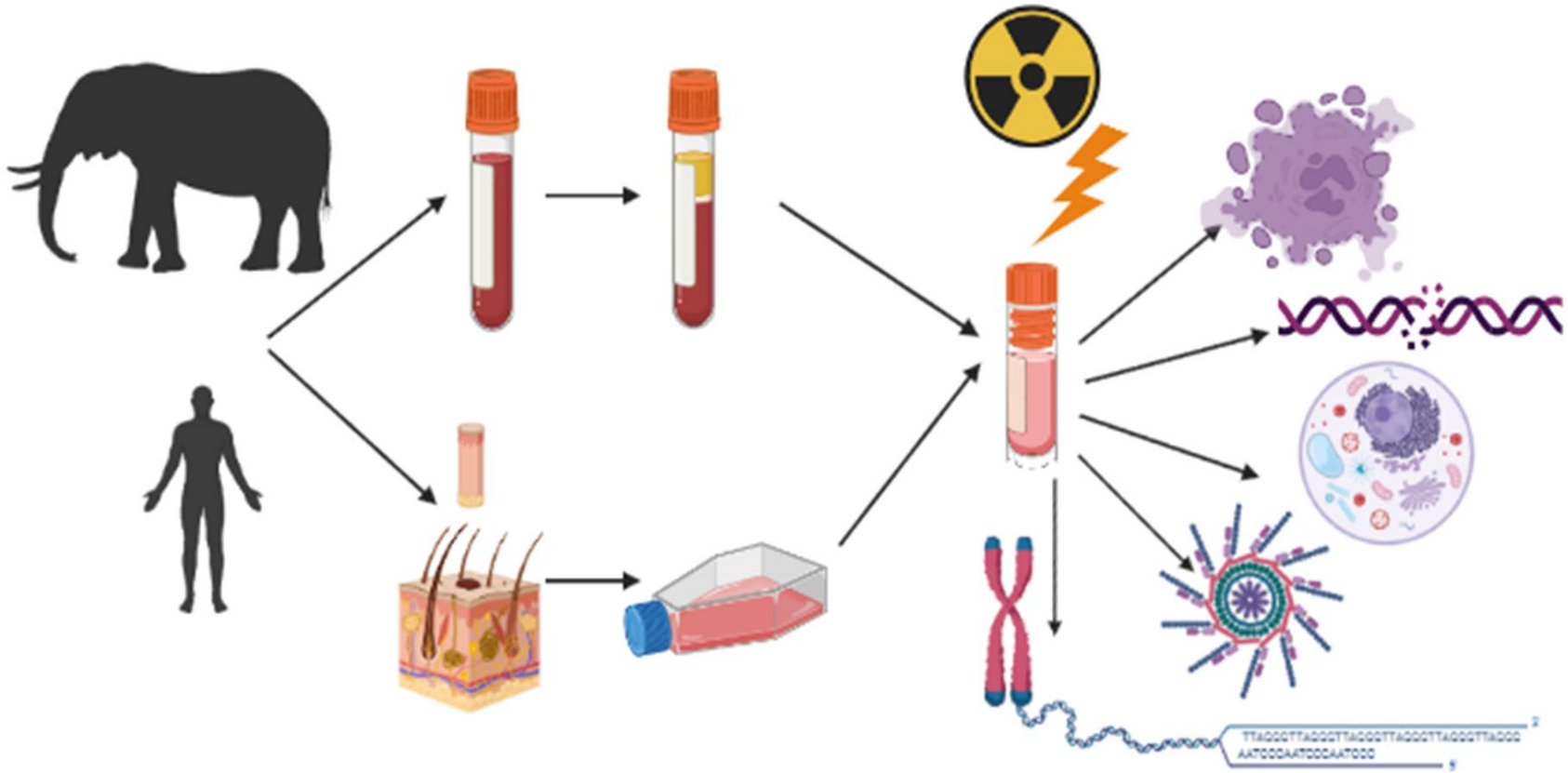
70 years	Average Life Span	>60 years
65 kg	Average weight	4800 kg
40 billion	Number of cells	40 trillion
25%	Cancer mortality	<5%
1	Copies of p53 gene	20

PROJECT TUSSC

TUMOUR SUPPRESSION AND
SUBDUAL OF CANCER

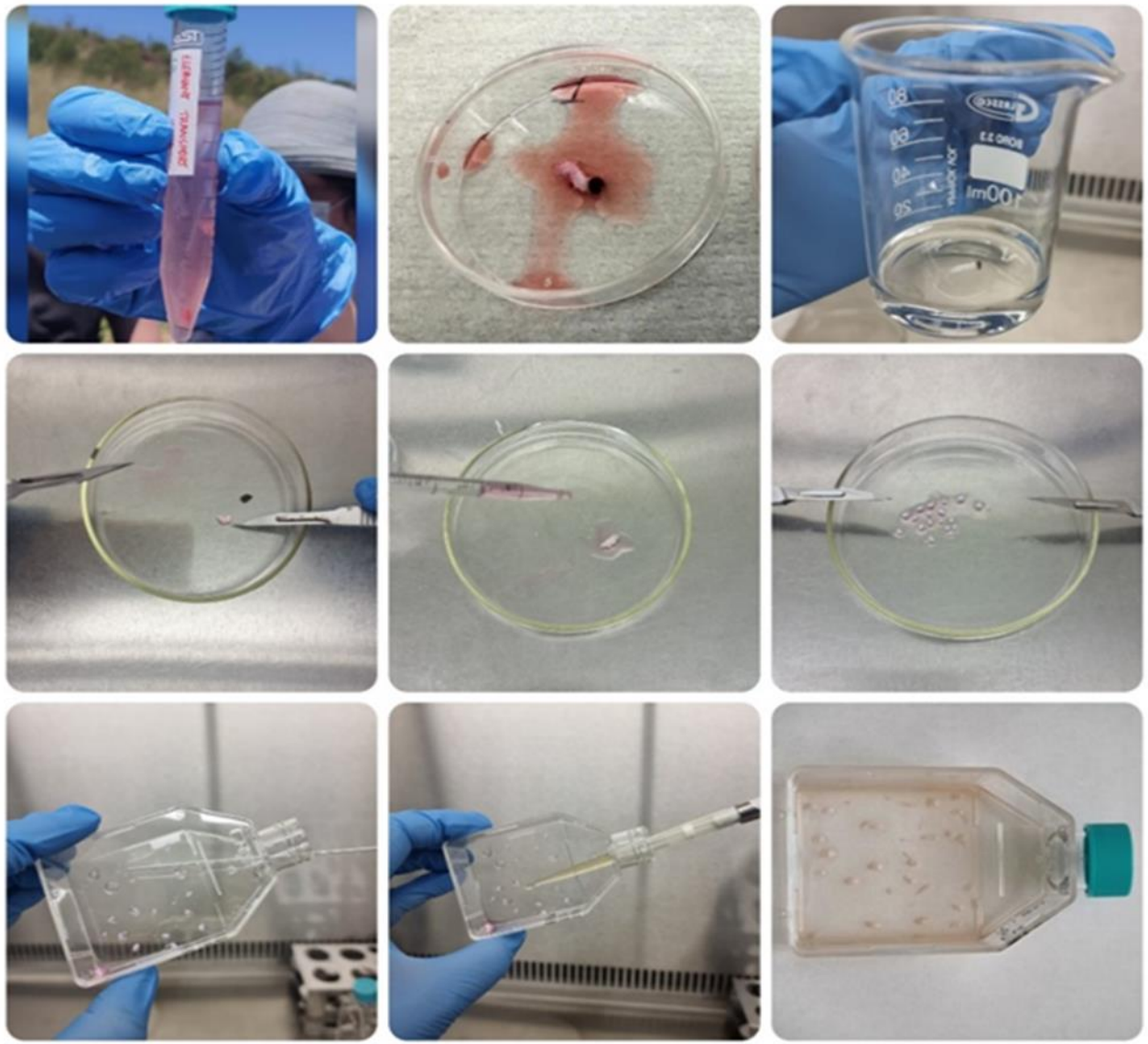


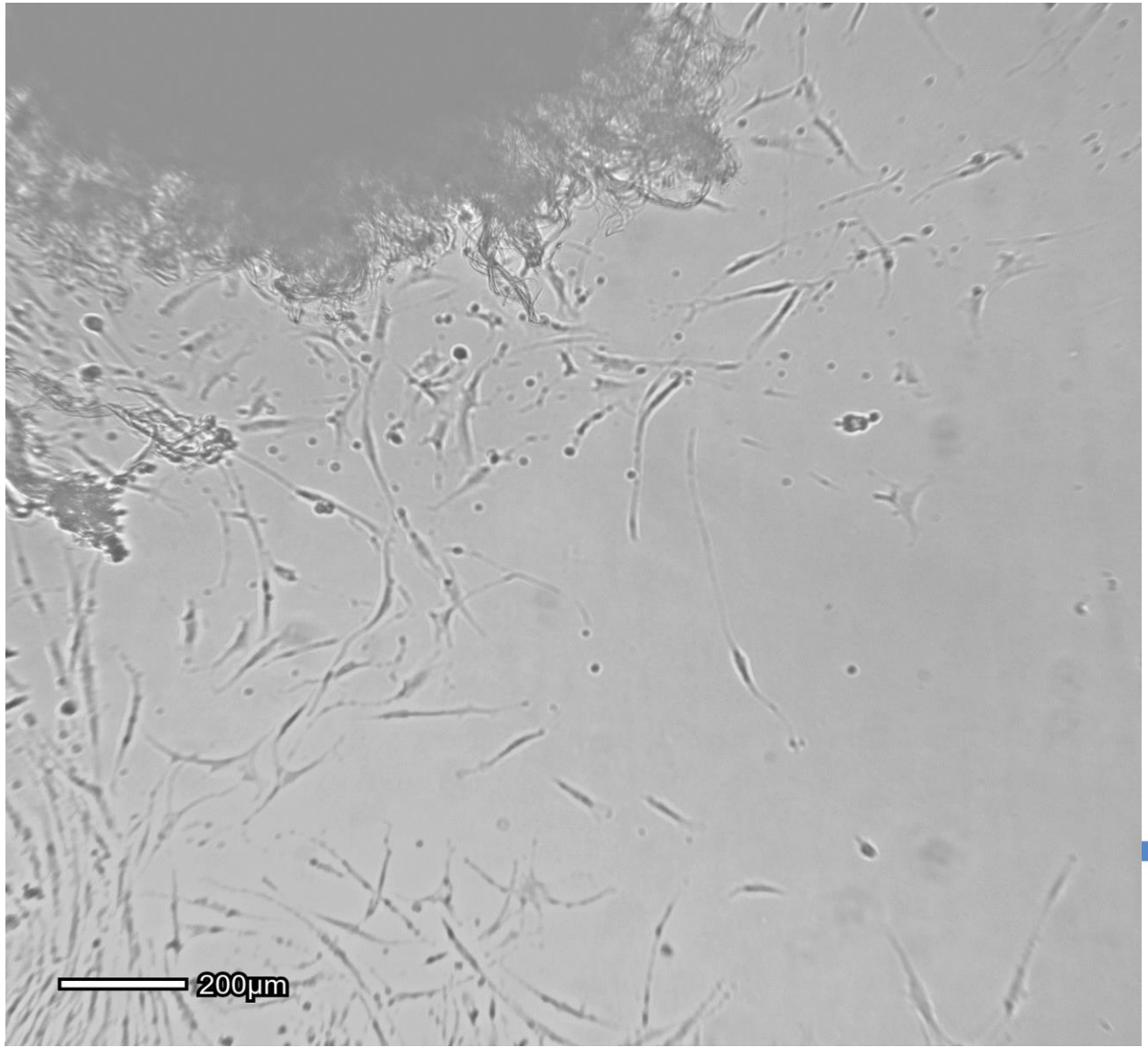
Preclinical - TUSSC Project



- Apoptosis
- DNA repair
- Metabolism status in the cancer suppression of elephants
- Inflammasome pathway of the immune system
- Role of telomere length and telomere shortening rate in Peto's paradox

Preclinical - TUSSC Project





Biodosimetry and Radioprotection – Spaceflight Radiobiology

- How to minimise the health risks induced by radiation exposure?

Space Radiation = Galactic Cosmic Rays and Solar Energetic Particles.

Extreme conditions: cosmic radiation, prolonged weightlessness and social isolation.

Causes stress, affect our eyesight, make bones more brittle.

Increase the risk of cancer and heart diseases.

Little known on the health effect of these space stress factors with psychological stress.

A space trip to Mars takes about two years.

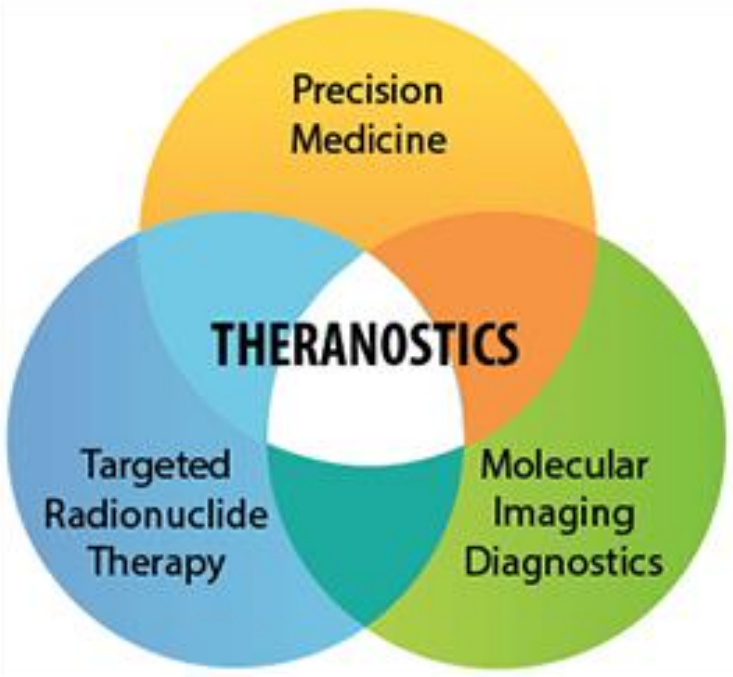
Biodosimetry and Radioprotection – Spaceflight Radiobiology

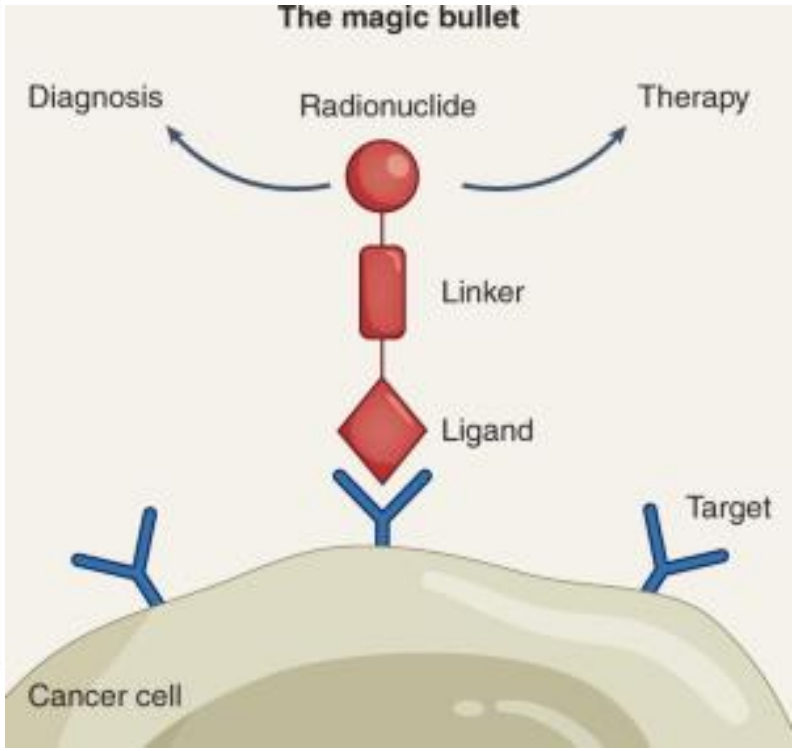
RADIATION BIOPHYSICS

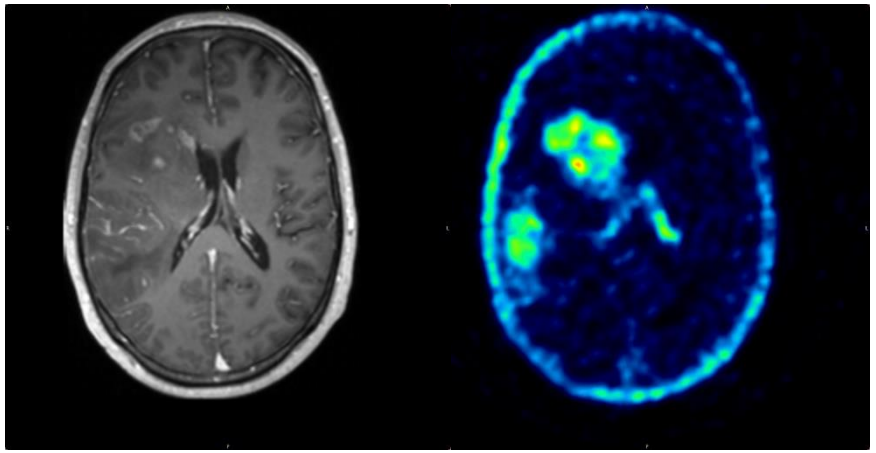
Future projects

Theranostics

= therapeutics + diagnostics





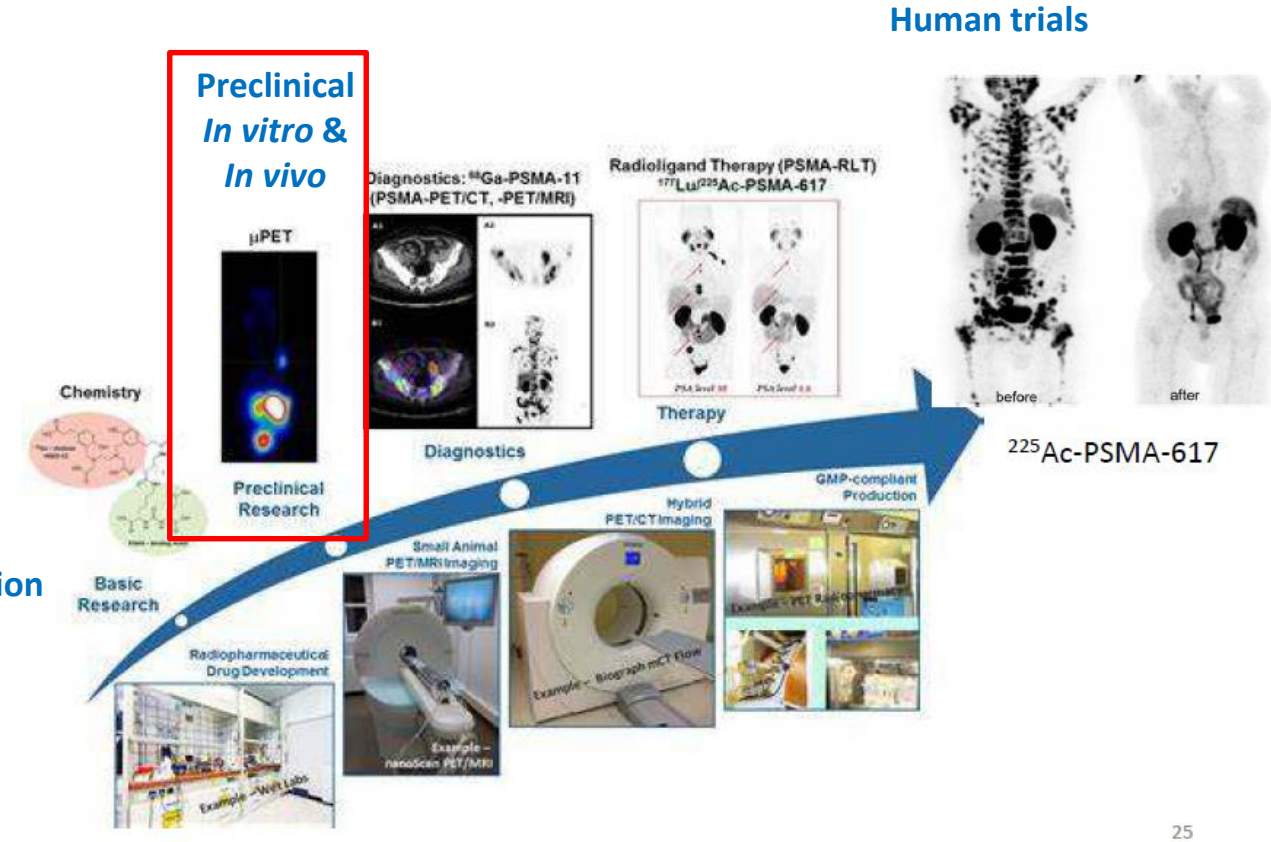


Pipeline for Theranostics research

Radiolabelling

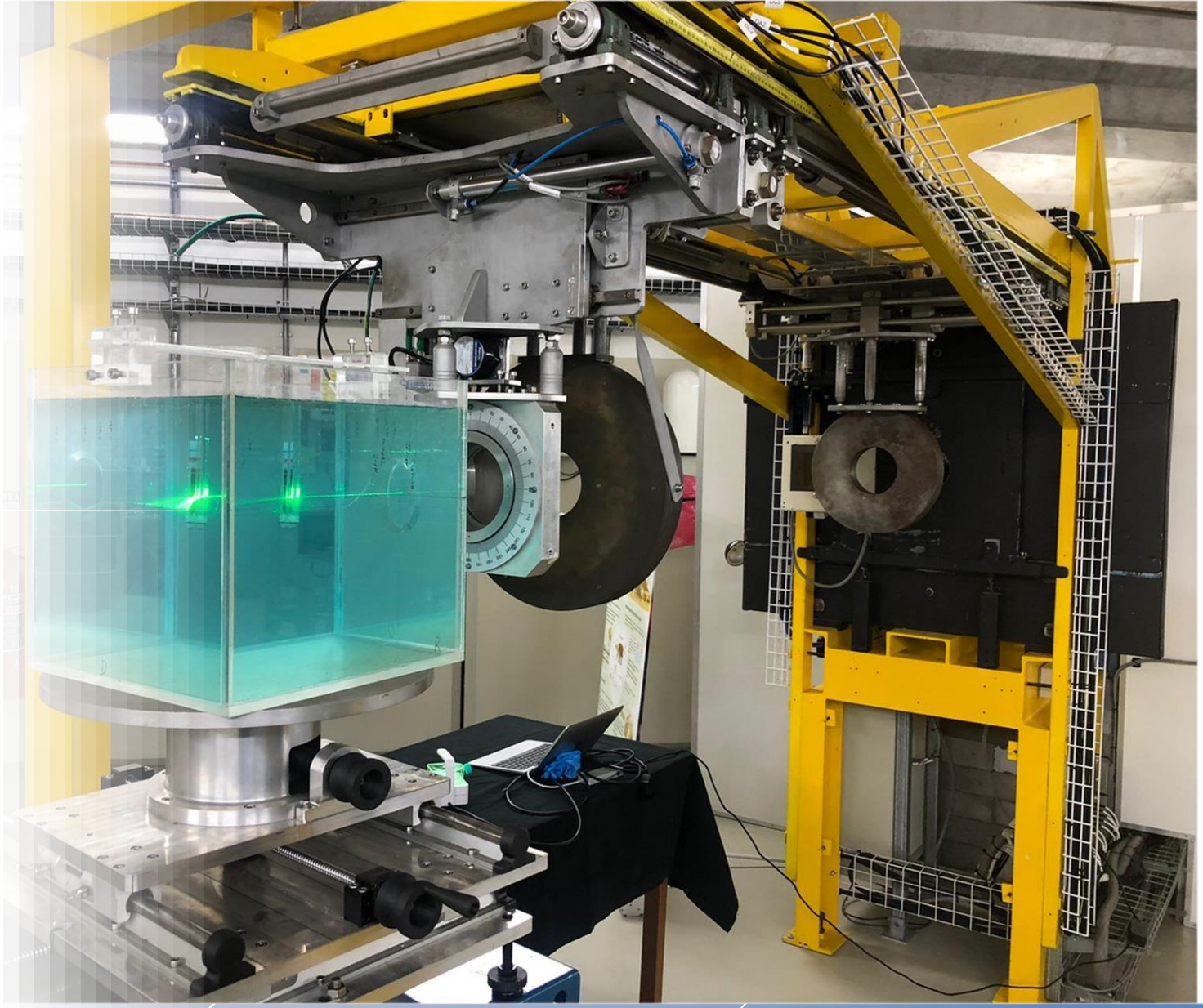
Chemical/Mass separation
E.g.: LERIB

Isotope production



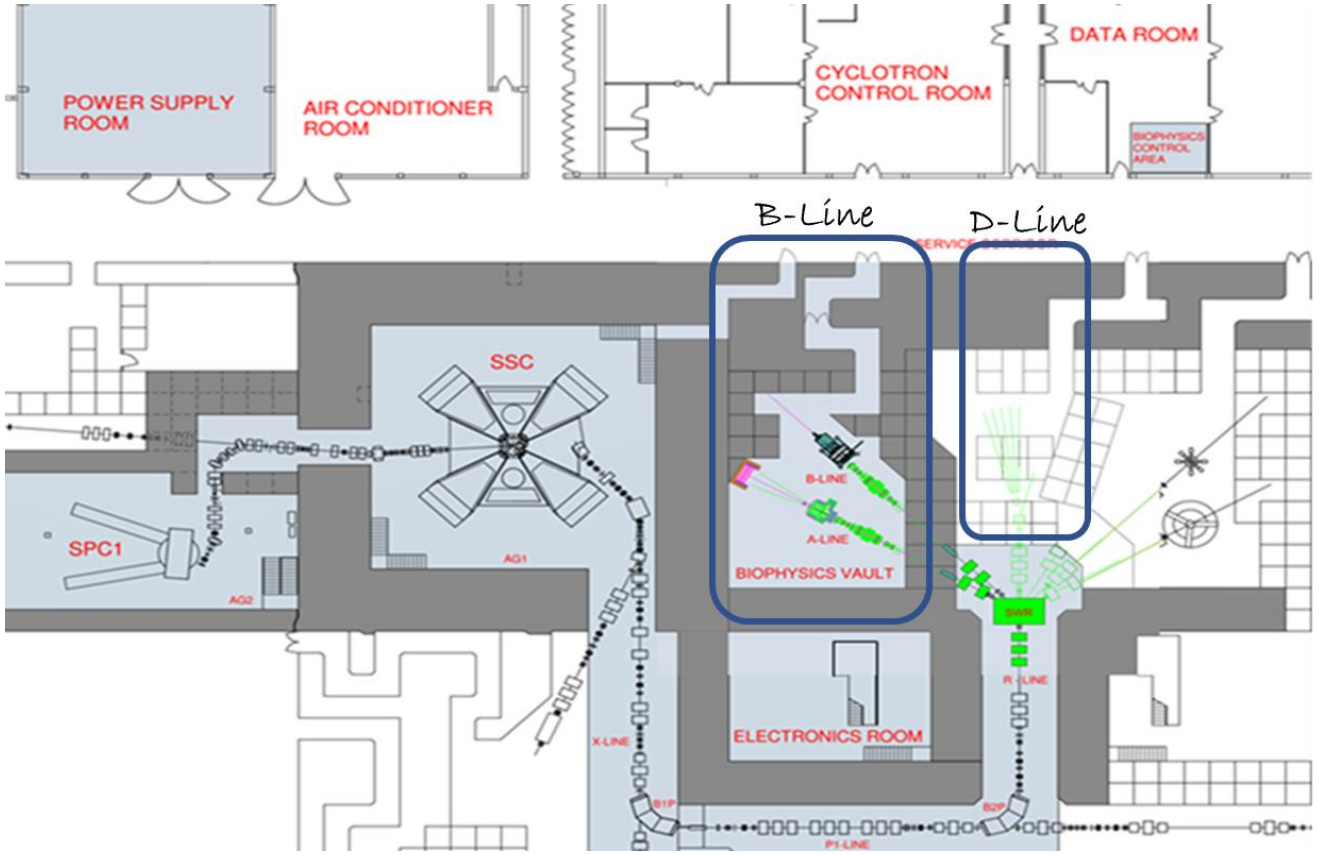
RADIATION BIOPHYSICS

Infrastructure



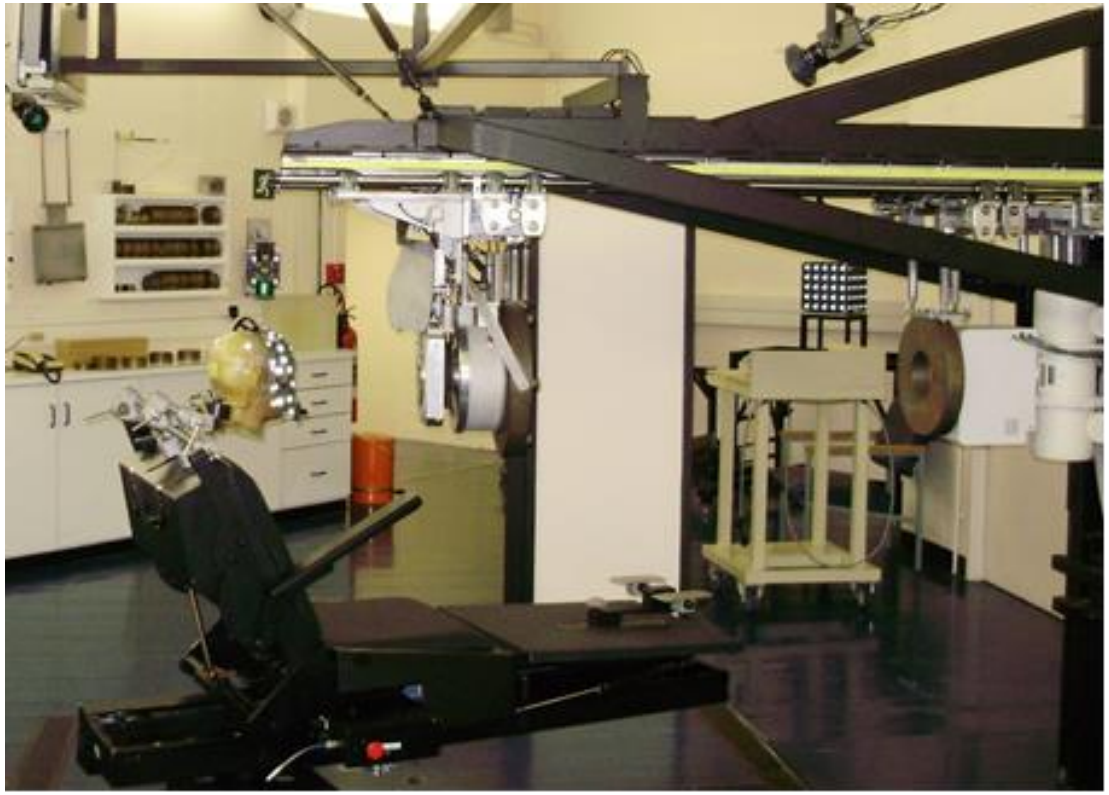
Infrastructure: Irradiation facilities

- Horizontal 200 MeV proton therapy beam delivery system in the B-line,
- A Quasi-mono energetic neutron beams produced in the D-line
- Self-contained biological X-ray irradiator (X-Rad320, Precision X-ray)
- Cobalt-60 source (from an older Theratron 780 teletherapy unit)
- The p(66)/Be isocentric neutron therapy unit is no longer available.

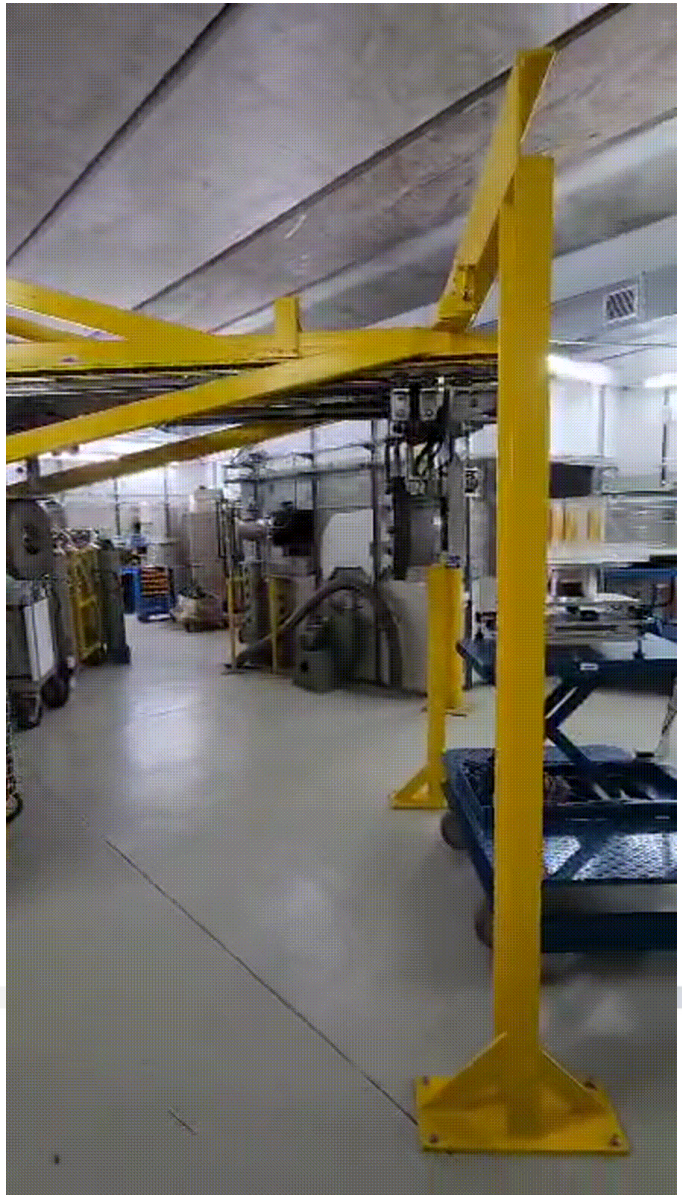


Infrastructure: Irradiation facilities

Horizontal 200 MeV proton therapy beam delivery system in the B-line



Infrastructure: Irradiation facilities

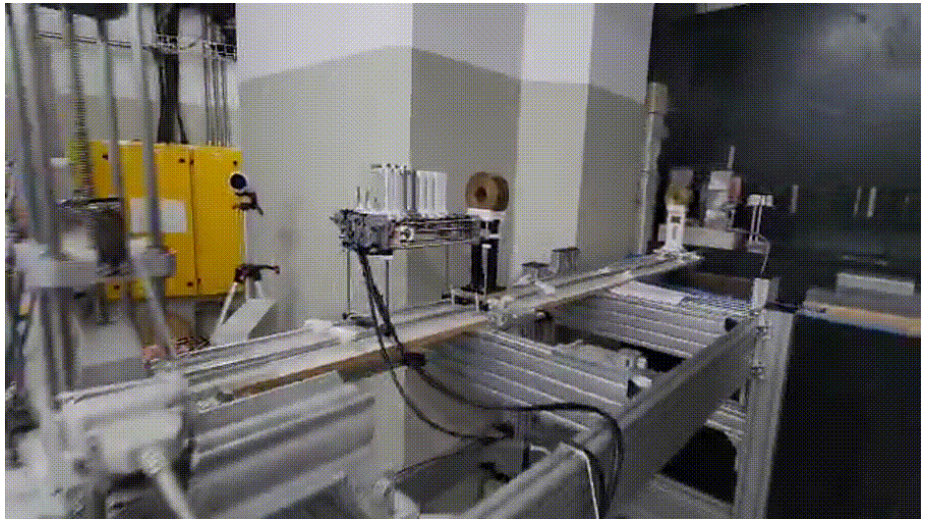


Horizontal 200 MeV proton therapy beam delivery system in the B-line

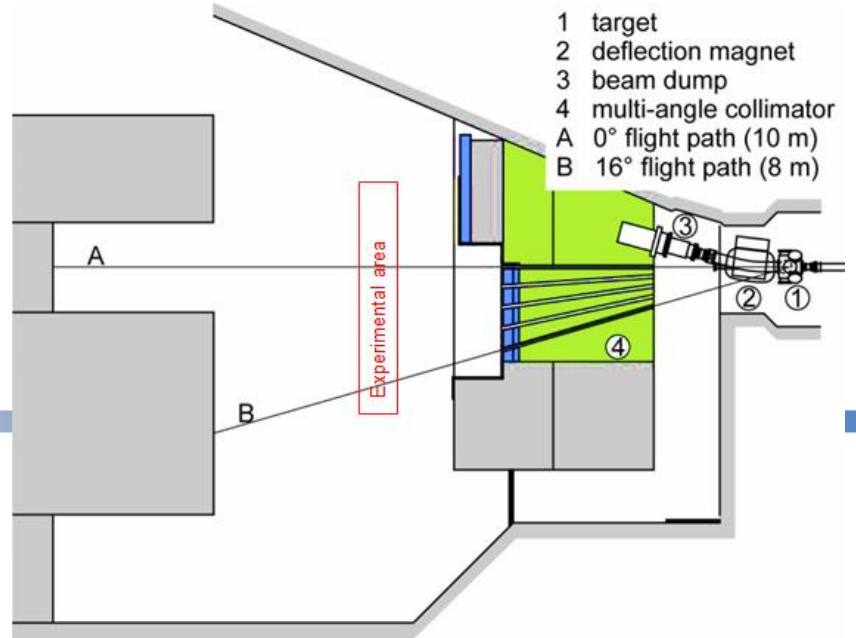
- A passive double scattered and occluding ring system is used to spread and flatten the beam.
- Graphite-wedge flattening filters.
- Maximum field of 10 cm in diameter.
- The reference beam used for absolute dose calibrations have dose rate of 3.5 Gy/min at depth of 3 cm in water.
- Incident proton beam current of 20 nA – 100 nA.
- FLASH dose rates (>40 Gy/sec)

Infrastructure: Irradiation facilities

Quasi-mono energetic neutron beams produced in the D-line



- Medium- to high-energy neutron metrology facility
  - Quasi-monoenergetic neutron beams with energies 30 – 200 MeV, using (p,n) reaction on thin Li and Be targets
- Collaboration with UCT MeASURe group
  - 5x5 cm field at 0°, 4°, 8°, 12° and 16°
  - Dose rate 0.04 Gy/hour (1.2µA) to max 0.7 Gy/hour
  - These beams are useful for the characterisation of dosimetry detectors (neutron energies up to 200 MeV). Future developments are planned to cater for *in vitro* radiobiology.



Infrastructure: Irradiation facilities

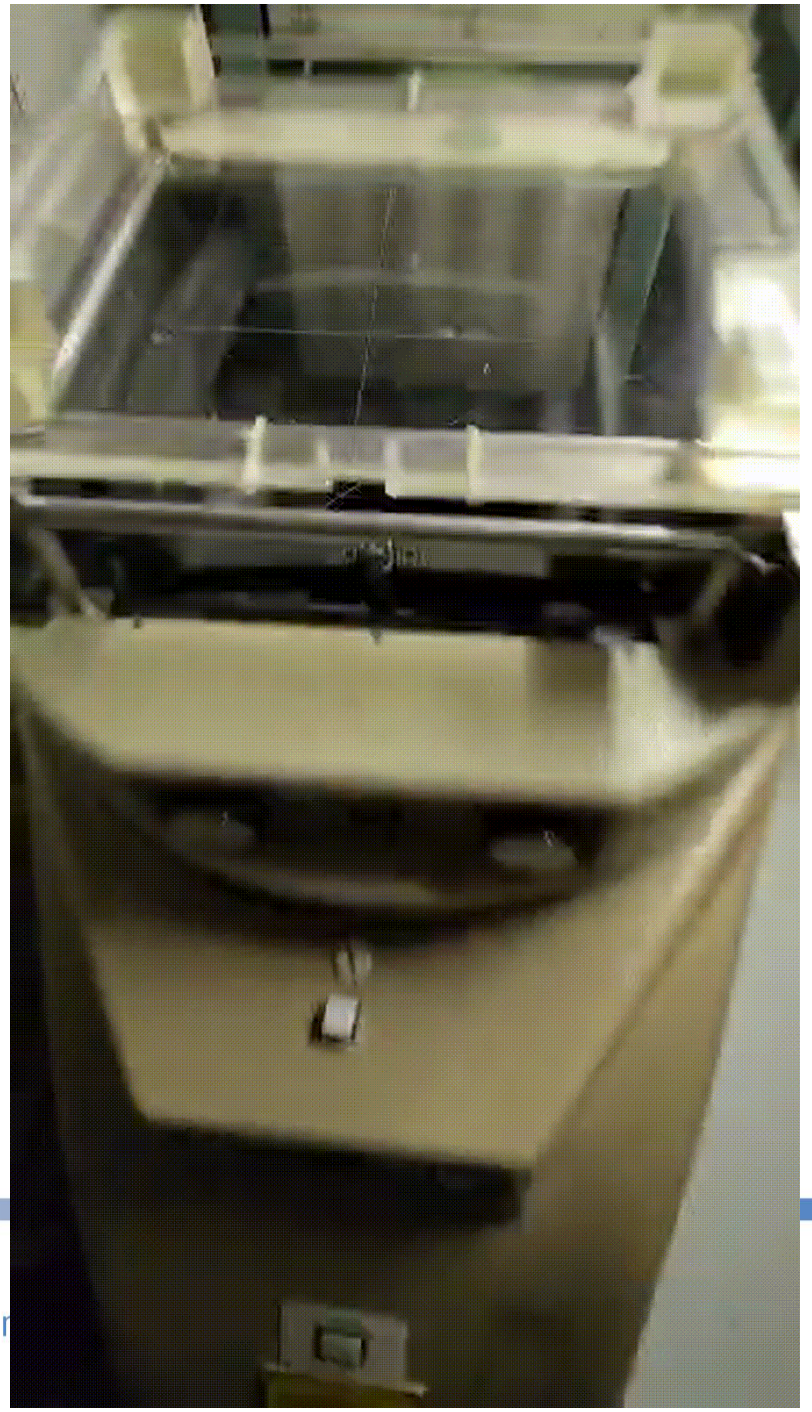
Self-contained biological X-ray irradiator (X-Rad320, Precision X-ray)

- In close proximity to the cell culture facilities.
- 250 kV commissioned for four cell culture receptacles (TG-69 protocol)
  - H-series filtering (3.5mm Be, 4mm Al, 3mm Cu)
- 5 energy ranges: 100 kV to 300 kV
- Field size set as 19 cm × 19 cm at a SSD of 50 cm.
- The average dose rate for the T25 flask (for the standard setup in the 250 kVp beam) is 0.685 Gy/min for a tube current of 16 mA. 5 energy ranges (100 to 300 kV)

Infrastructure: Irradiation facilities

Cobalt-60 source (from an older Theratron 780 teletherapy unit):

- Reference beam for *in vitro* studies
- Detector cross calibration
- ~1.25MeV
- SSD – 600 mm
- Dose rate of 0.22 Gy/min for a 27 × 27 cm^2 field size.



Infrastructure: Irradiation facilities

- Sterile cell culturing facilities.
- Microscopy infrastructure:
  - Two Metafer automatic scanning and imaging platforms (Metasystems)
  - Zeiss Axioscope fluorescent microscope
  - Live cell imaging system (Lonza Cytosmart)
- Flow cytometry (BD Accuri C6 flow cytometer)
- Fluorescent in situ hybridization (FISH) for chromosomal aberration analysis
- Radiochemical synthesis and validation of radiolabelled compounds:
  - Radiosynthesis laboratory
  - Rotary evaporator
  - Scintillation counter
  - High-performance liquid chromatographer
- UV-VIS spectrophotometer

Thank you for your attention!

IAEA International Atomic Energy Agency

BOTLIERSKOP Private Game Reserve

UNIVERSITY of the WESTERN CAPE

UNIVERSITEIT STELLENBOSCH UNIVERSITY

AWCF AFRICAN WILDLIFE CONSERVATION FOUNDATION

Cape Peninsula University of Technology

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

NWU NORTH-WEST UNIVERSITY NOORDWES-UNIVERSITEIT YUNIBESITI YA BOKONE-BOPHIRIMA

NUCLEAR MEDICINE RESEARCH INFRASTRUCTURE NuMeRI

necsa We're in your world

MeASURe Metrological and Applied Sciences University Research Unit

GSI Helmholtzzentrum für Schwerionenforschung

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UNIVERSITEIT VAN PRETORIA UNIVERSITY OF PRETORIA YUNIBESITHI YA PRETORIA

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