



SA-ESRF 2019  
Synchrotron



# X-RAY AND NEUTRON RADIOGRAPHY / TOMOGRAPHY @ Necsa: A SUCCESS STORY

**Dr Frikkie de Beer**

**CHIEF SCIENTIST: Rad/Tom**



Success is no accident.  
It is hard work, perseverance,  
learning, studying, *sacrifice*,  
and MOST of all,  
*love of what you are doing.*

-Pele

## Allan McLeod Cormack

- South African-born American physicist who, with Godfrey Hounsfield, was awarded the 1979 Nobel Prize for Physiology or Medicine.
- For helping to invent CAT scan X-ray technology.





# Necsa Team



**Me**  
**31 years**



**Kobus  
Hoffman**  
**9 years**



**Lunga  
Bam**  
**11 years**



**Robert  
Nshimirimana**  
**10 years**

## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability

# Tools of the Trade

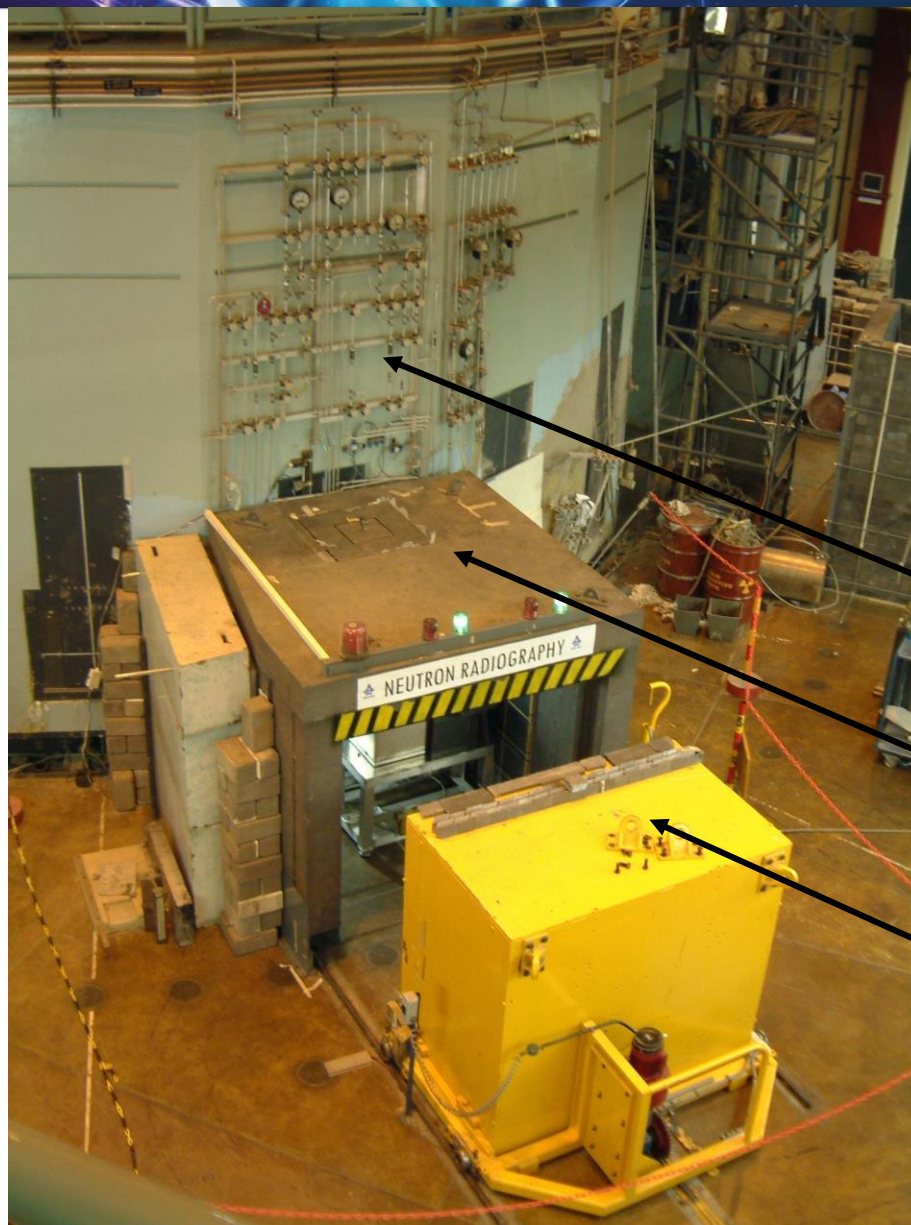




# NEUTRON CT FACILITY @ Necsa

**OPERATIONAL FROM  
1975 – 2013 (Thermal N)**

- **1975: Film**
- **1996: Digital**
- **2003: Tomography**



SAFARI-1  
reactor wall

Shielding

Beam stop /  
door

# NEUTRON CT FACILITY @ Necsa

IYNC 2008  
Interlaken, Switzerland, 20 – 26 September 2008  
Paper No. 460

Critical component.



Fig. 12(c): A neutron tomogram of the critical component of a helicopter engine lubricator.

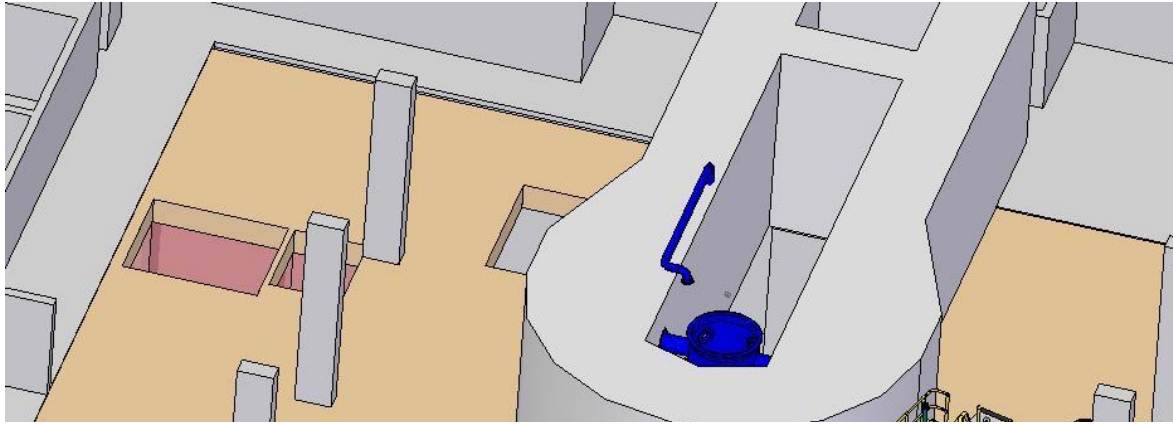
Oil blockage.



Fig. 12(d): A cutted into neutron tomogram of a of a helicopter engine lubricator revealing the blockage.



# NEUTRON CT FACILITIES



## Operational 2021

- Fast neutrons
- Thermal Neutrons
- Gamma-rays
- Dynamic imaging
- FOV: 350 x 350 mm<sup>2</sup>

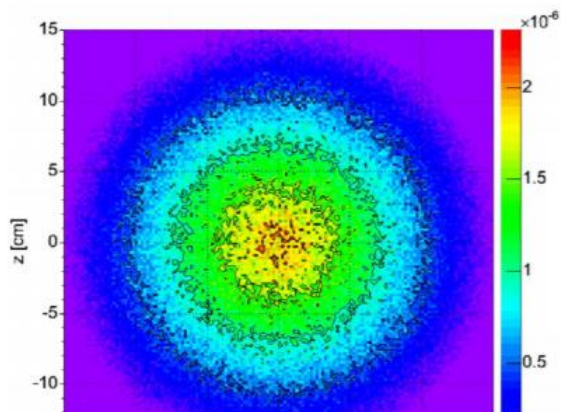


Fig. 6: Neutron beam flux at the detector plane resulting from the current collimation system.

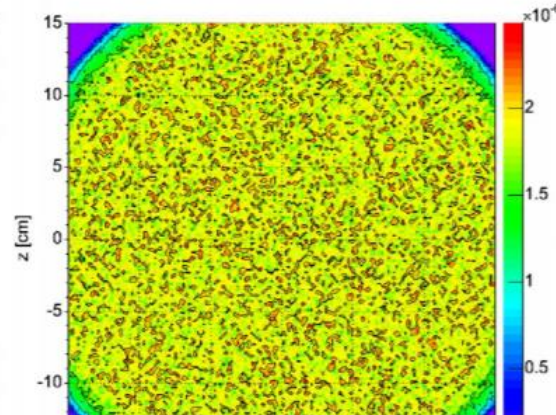
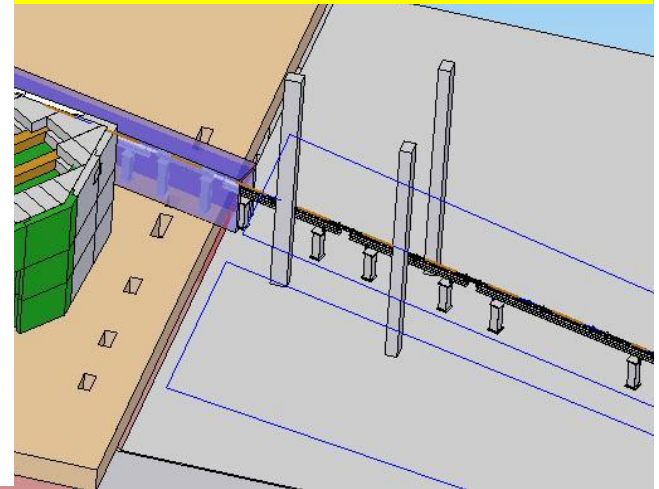


Fig. 7: Neutron beam flux at the detector plane simulated for the new facility.



**NDIFF: Operational**

**NRAD: Upgrade Phase**

## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)

# $\mu$ XCT FACILITY @ Necsa



COMMISSIONED IN  
July 2011

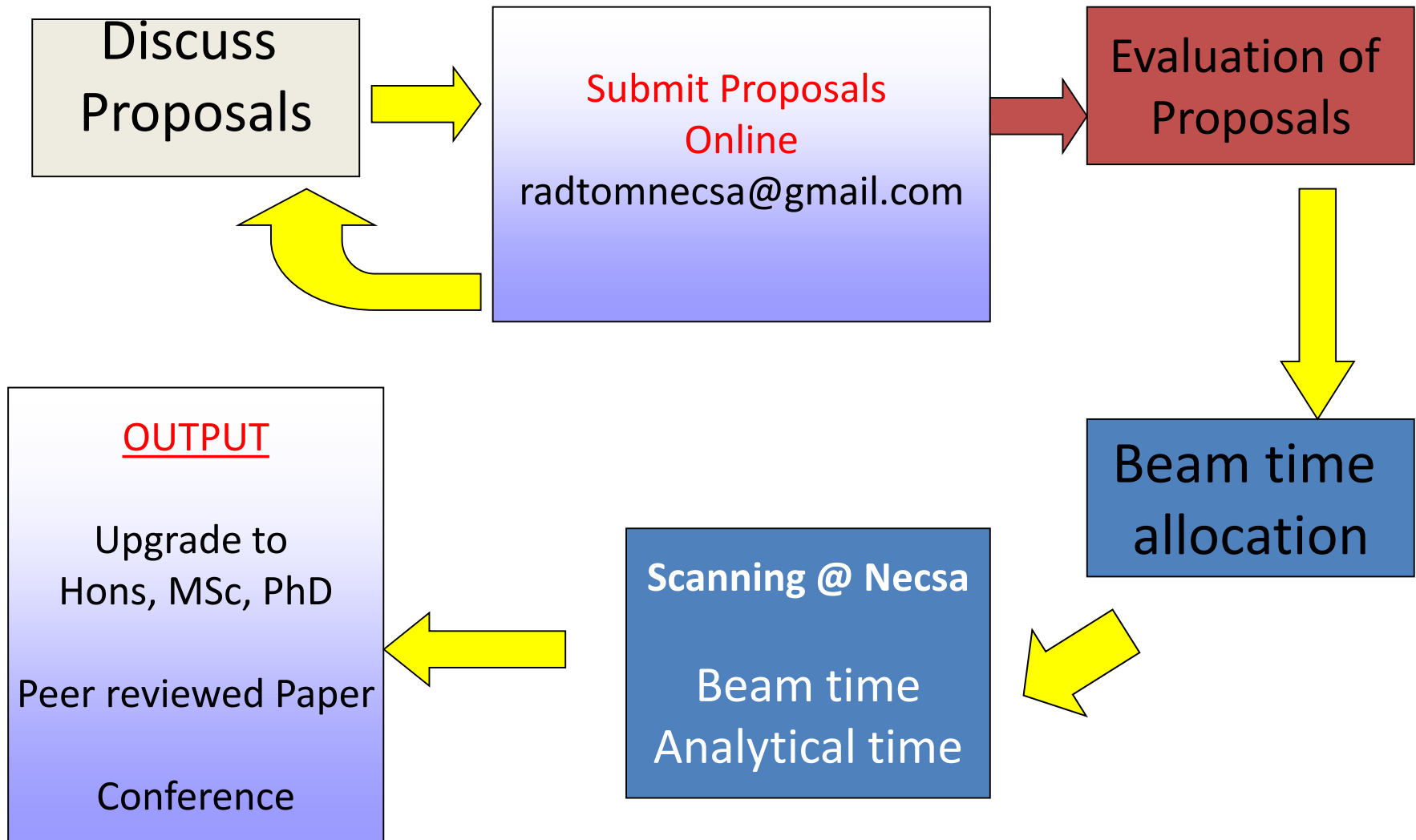


National  
Research  
Foundation



## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program



# USER PROGRAM

## 2019 Calendar

Period 1

January						
S	M	T	W	T	F	S
			2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

February						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		

March						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

April						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18		20
21		23	24	25	26	27
28	29	30				

Period 2

May						
S	M	T	W	T	F	S
				2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

June						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26		28	29
30						

July						
S	M	T	W	T	F	S
						6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

August						
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8		10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Period 3

September						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15		17	18	19	20	21
22	23	24	25	26	27	28
29	30					

October						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

November						
S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

December						
S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15		17	18	19	20	21
Holidays						

215 days beam time available per annum



## POST GRAD STUDENTS & RESEARCHERS

- Beam time Rates (Subject to change):
  - Normal:

	Once off Registration Fee per Project	Cost per day
Researchers & Post Graduate Students	R1000	R500

- Beam time on special request is available on Saturday's and Sunday's:

	Once off Registration Fee per Project	Cost per day
Researchers & Post Graduate Students	R1000	R5000

## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program

## ■ **SUCCESS OF HUMAN CAPITAL DEVELOPMENT**

- ▶ Necsa Employees (Instrument Scientists)

### **CAPACITY BUILDING:**

- 3 x MSc
- 1 x PhD (2 currently unrolled & Submitted)

### **RECOGNITION: NATIONAL**

- 1 x DSI-NRF C3 rated researcher:
- 2 x Associated Researchers @ HEI
- 1 x Lecturer for Honors & MSc
- 1 x Host of National Conference (IMGRAD)

### **RECOGNITION: INTERNATIONAL**

- 1 x Board Member of Scientific Society (President)
- Reviewing Beam line proposals / Peer reviewed Journals
- 1 x Host of International Conference
- IAEA : TC; CRP; Specialist; Host of Scientific mission.



## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program

## ■ **SUCCESS OF HUMAN CAPITAL DEVELOPMENT**

- ▶ Necsa Employees (Instrument Scientists)
- ▶ Number of scientific visitors to Necsa's CT Labs (Local & Intl)

2017: 438

2018: 389

2019: 412

## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program

## ■ **SUCCESS OF HUMAN CAPITAL DEVELOPMENT**

- ▶ Necsa Employees (Instrument Scientists)
- ▶ Number of scientific visitors to Necsa's CT Labs (Local & Intl)
- ▶ Number of Proposals submitted

2017: 38

2018: 42

2019: 39

## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

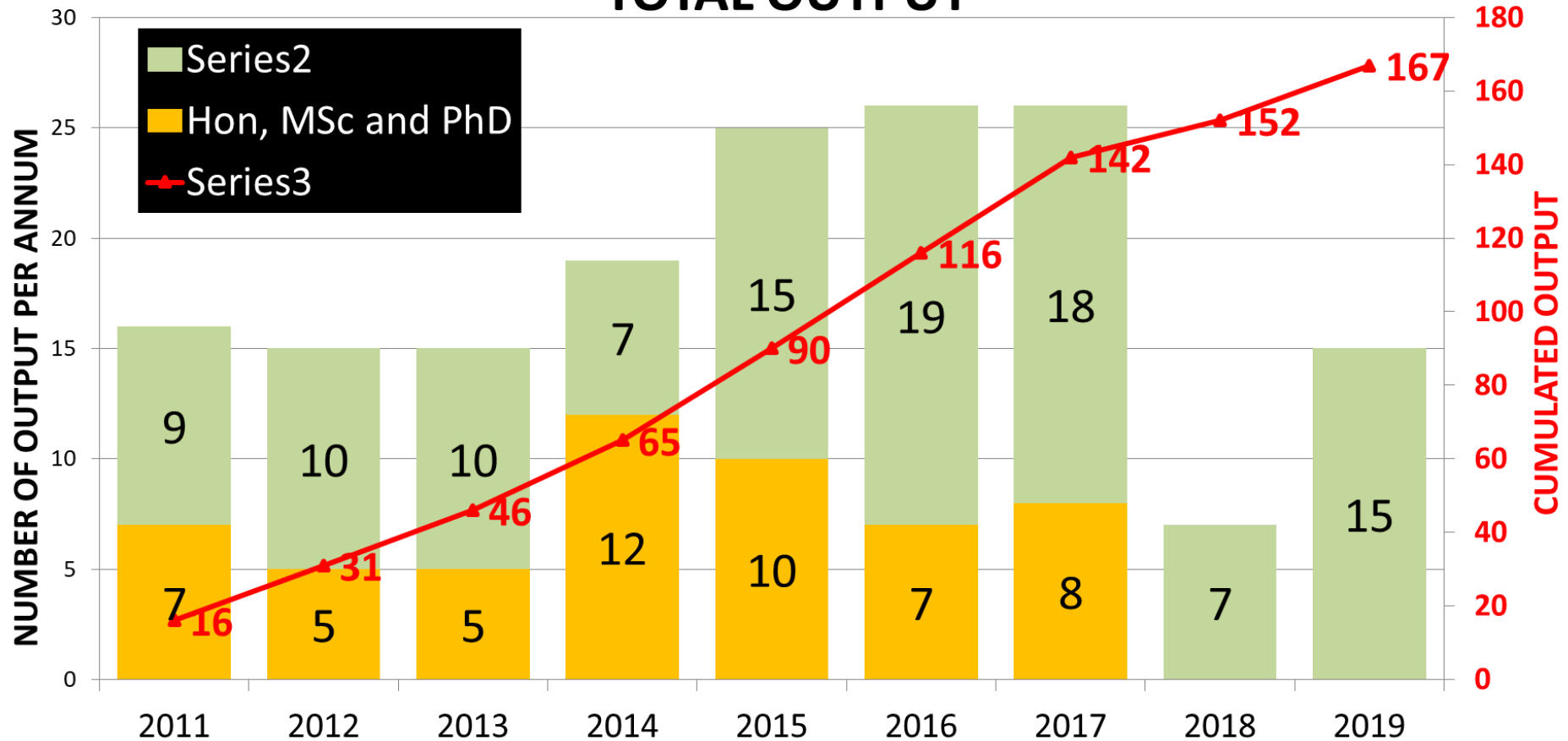
- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program

## ■ **SUCCESS OF HUMAN CAPITAL DEVELOPMENT**

- ▶ Necsa Employees (Instrument Scientists)
- ▶ Number of scientific visitors to Necsa's CT Labs (Local & Intl)
- ▶ Number of Proposals submitted
- ▶ Number of Peer reviewed papers (Aware of)
- ▶ Number of higher educational degrees (Aware of)

# OUTPUT

## TOTAL OUTPUT





## ■ **SUCCESS IN THE ESTABLISHMENT OF:**

- ▶ A Neutron CT & X-CT capability
- ▶ A Micro-focus XCT capability (1 / 4 for Academia)
- ▶ A Sustainable USER program

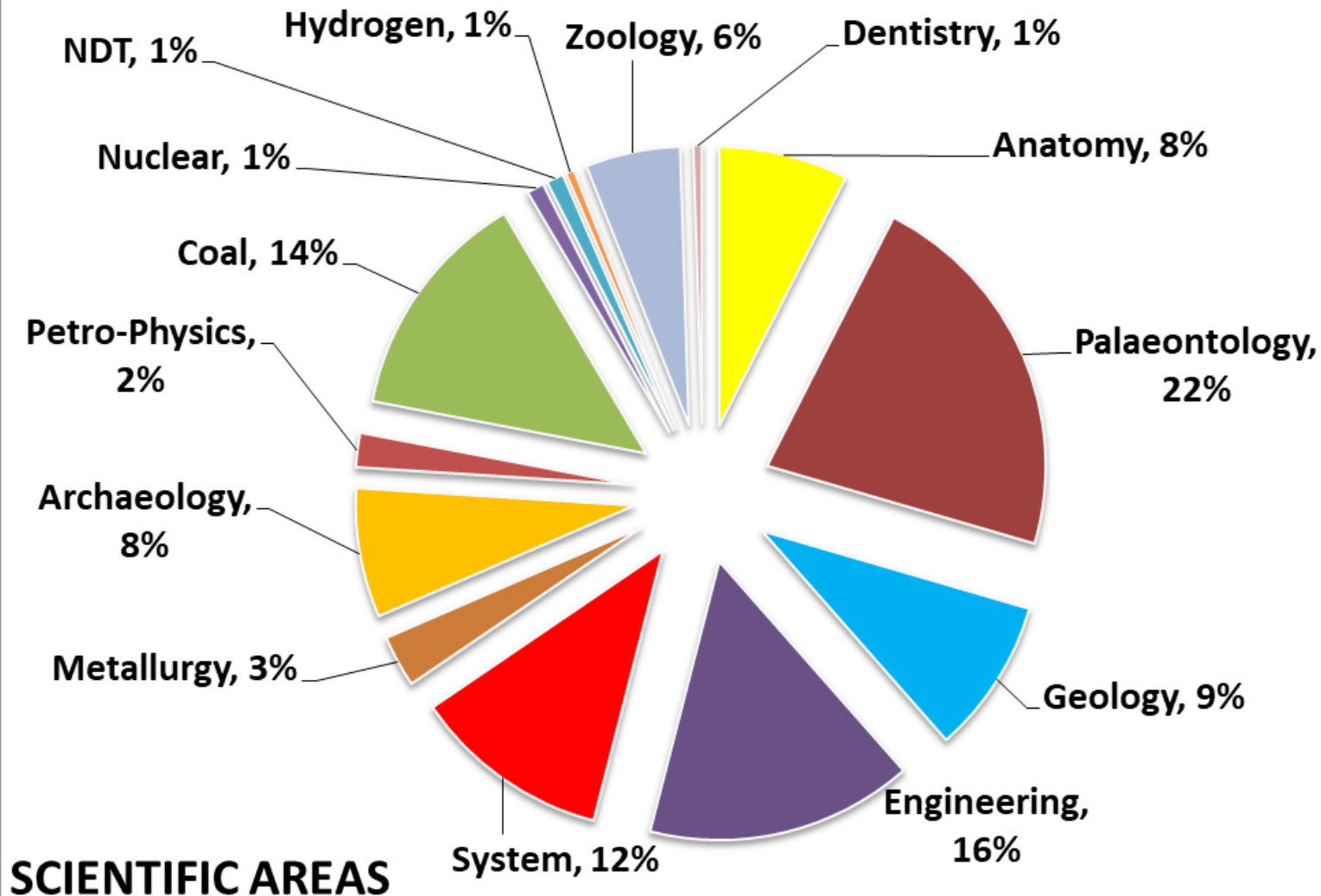
## ■ **SUCCESS OF HUMAN CAPITAL DEVELOPMENT**

- ▶ Necsa Employees (Instrument Scientists)
- ▶ Number of scientific visitors to Necsa's CT Labs (Local & Intl)
- ▶ Number of Proposals submitted
- ▶ Number of Peer reviewed papers (Aware of)
- ▶ Number of higher educational degrees (Aware of)

## ■ **SUCCESS IN # OF SCIENTIFIC FIELDS SERVED**

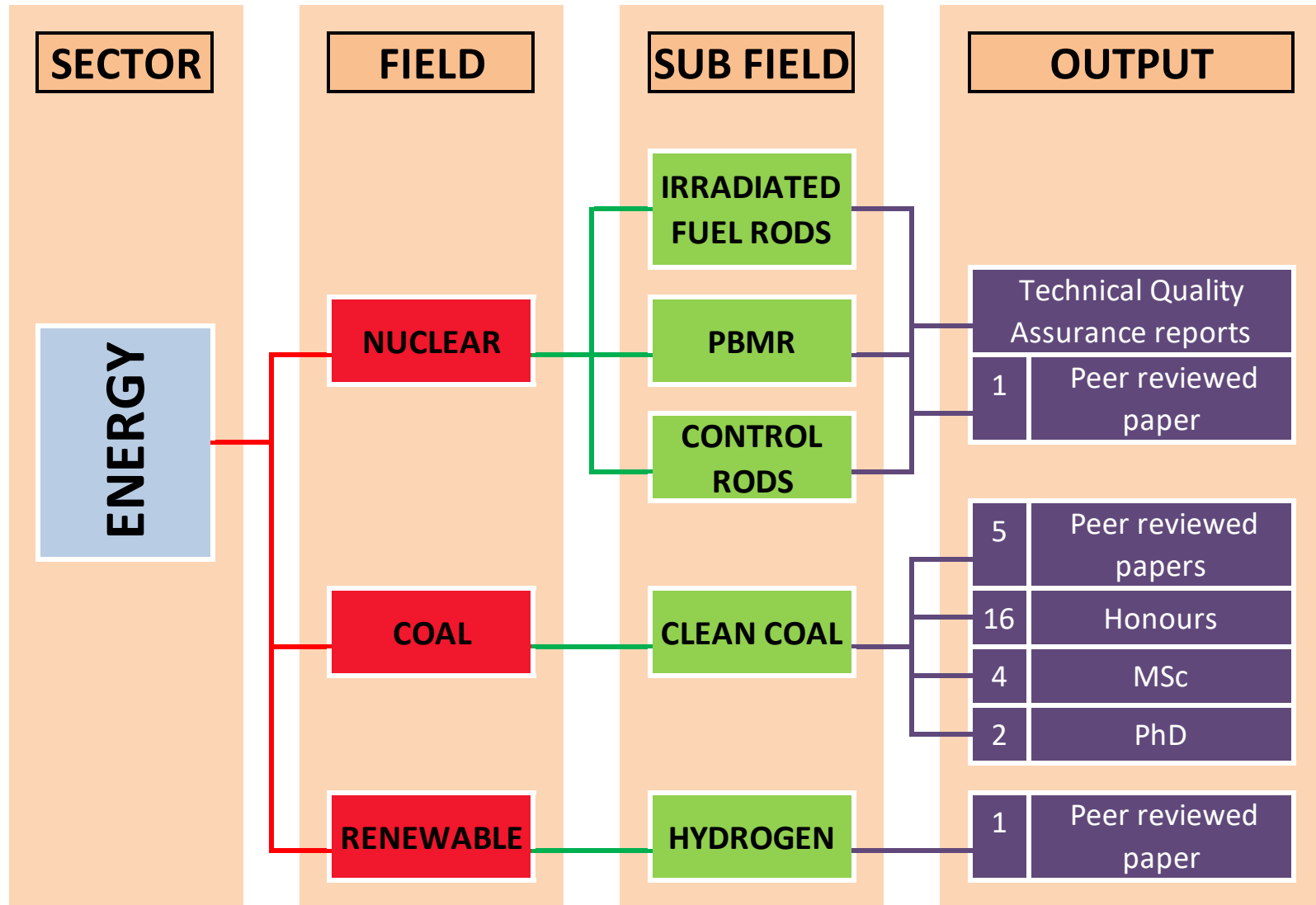
- ▶ Number of scientific fields

# SCIENTIFIC FIELDS



**SCIENTIFIC AREAS**

# SCIENTIFIC FIELDS



# FUEL CELLS

CATHODE ANODE

Hydrogen outlet

Channel Size:  
2 mm x 2 mm

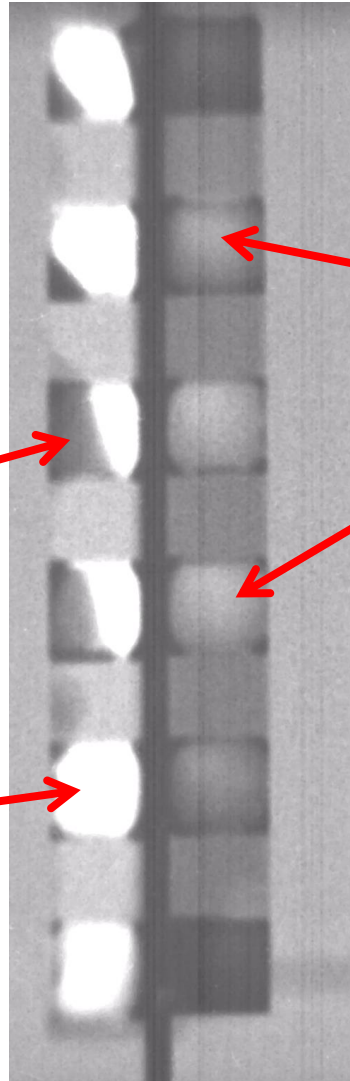
Cross over  
Water: Black

Hydrogen:  
White

- Management of Water in an electrolyzer.

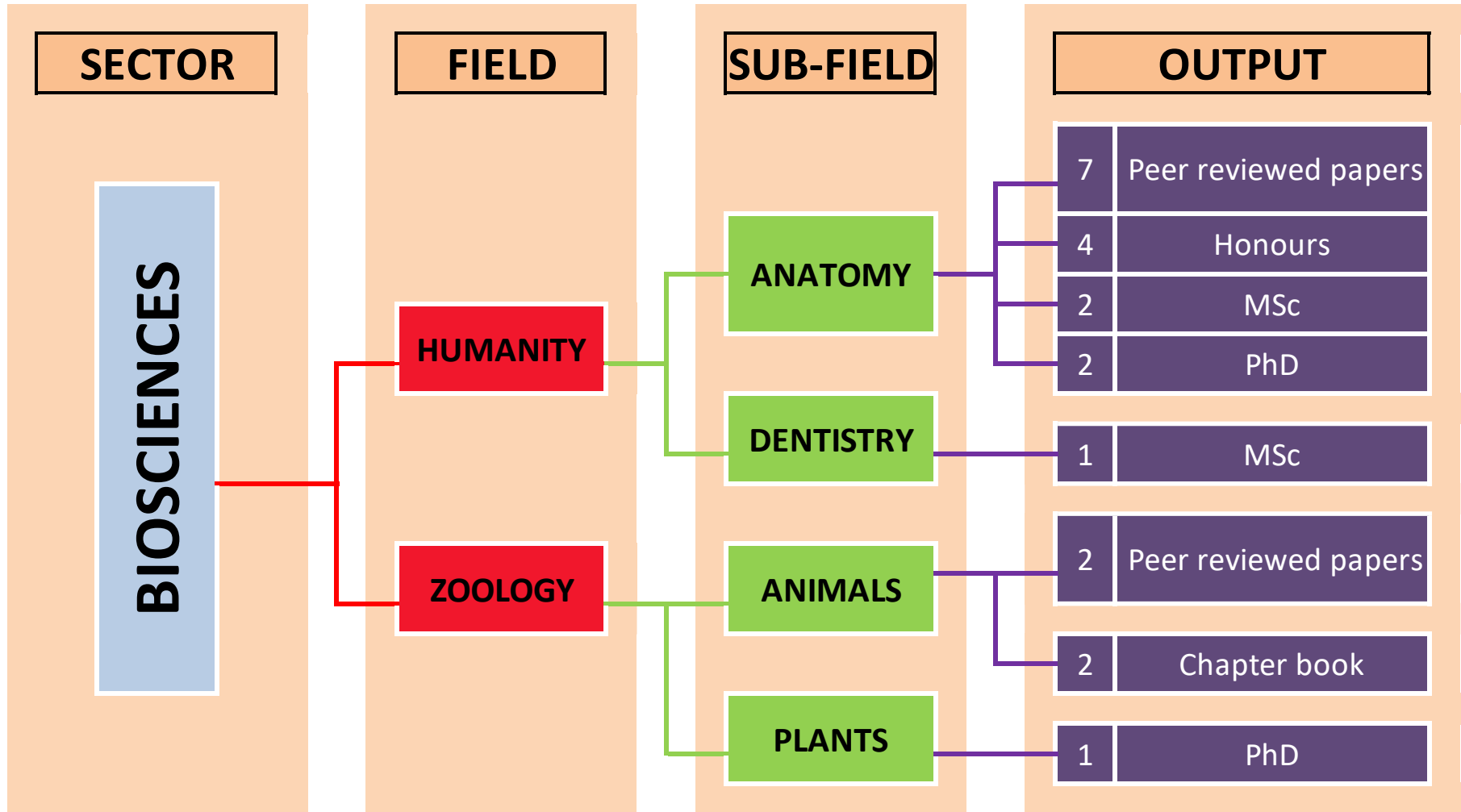
Combination of  
Water and Oxygen

Water supply IN





# SCIENTIFIC FIELDS



## DIGITAL SKELETAL REPOSITORY

Co-funded by the  
Erasmus+ Programme  
of the European Union



University of  
Pretoria



Sefakho Makgatho  
Health Sciences  
University



Stellenbosch  
University



South African  
Nuclear Energy  
Corporation



University of  
Bordeaux

université  
de BORDEAUX

University of  
Coimbra



Katholieke  
Universiteit Leuven



**The use of digital imaging is the way of  
the future for teaching and research at  
Higher Education Institutions.**

## DIGITAL SKELETAL REPOSITORY

Co-funded by the  
Erasmus+ Programme  
of the European Union



(2019 – 2021)  
This project is the first of its kind to amalgamate a large digital archive of microfocus scanning (Micro-XCT), Lodox Statscan, and CBCT scans from known deceased South African and comparative specimens and to make them internationally accessible.

South African  
Nuclear Energy  
Corporation

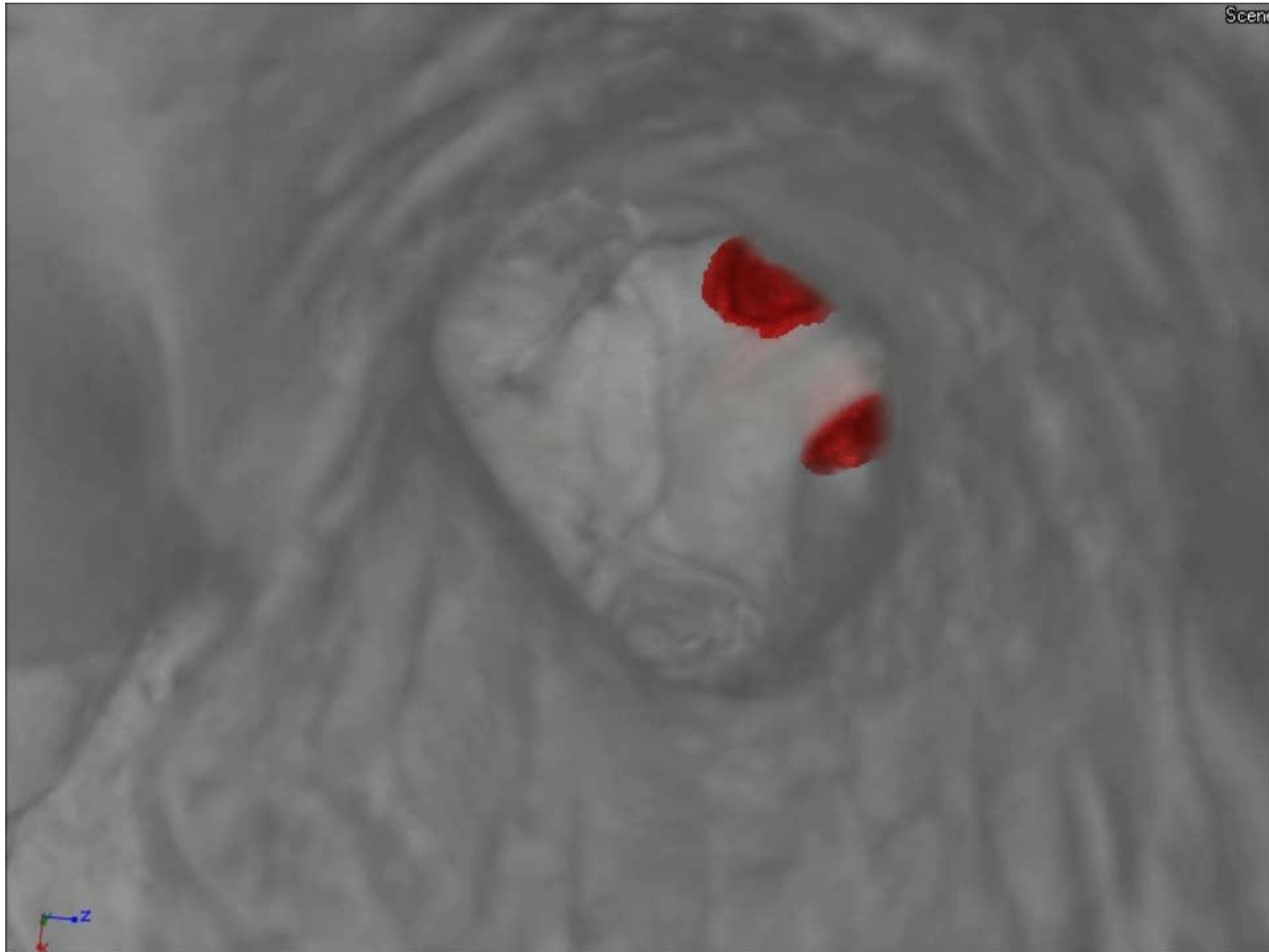


Katholieke  
Universiteit Leuven



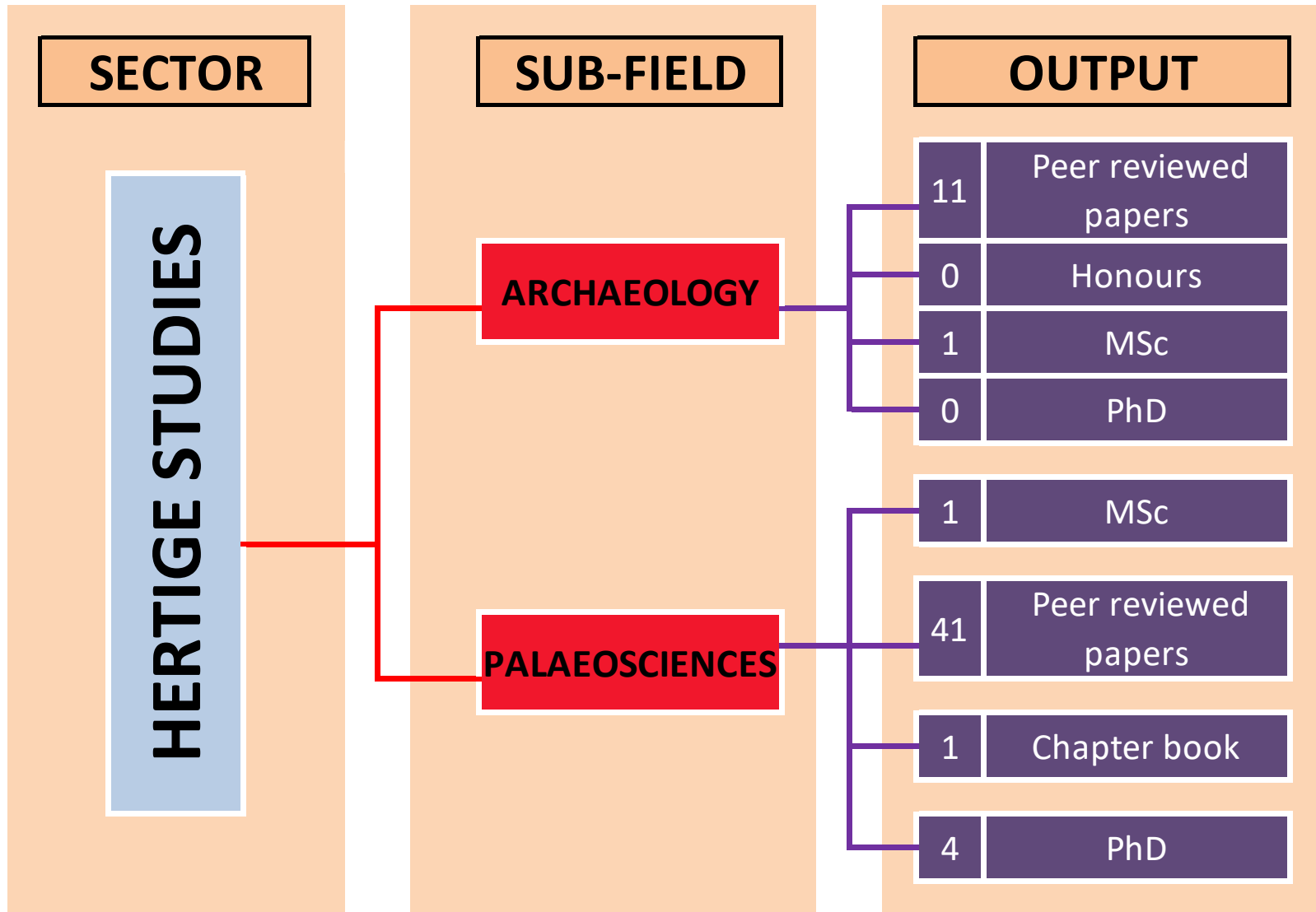
**The use of digital imaging is the way of the future for teaching and research at Higher Education Institutions.**

# ROTATING SKULL





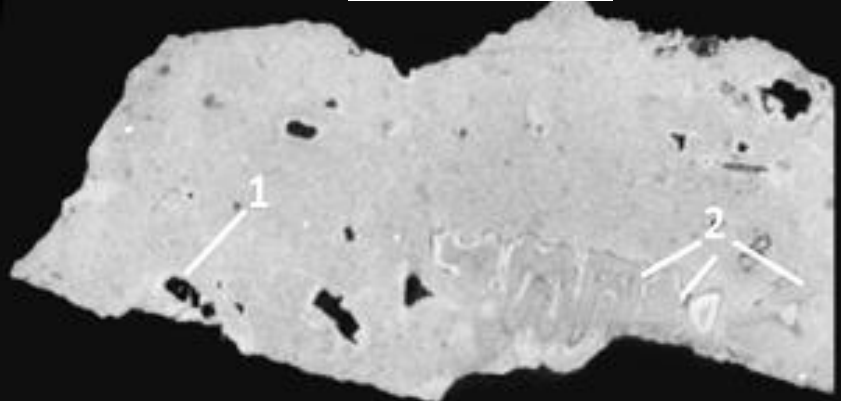
# SCIENTIFIC FIELDS



Neutrons

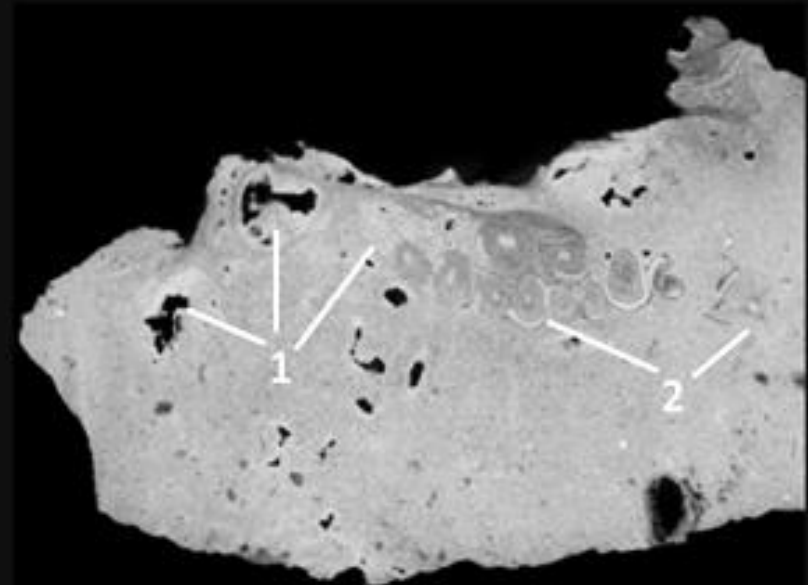
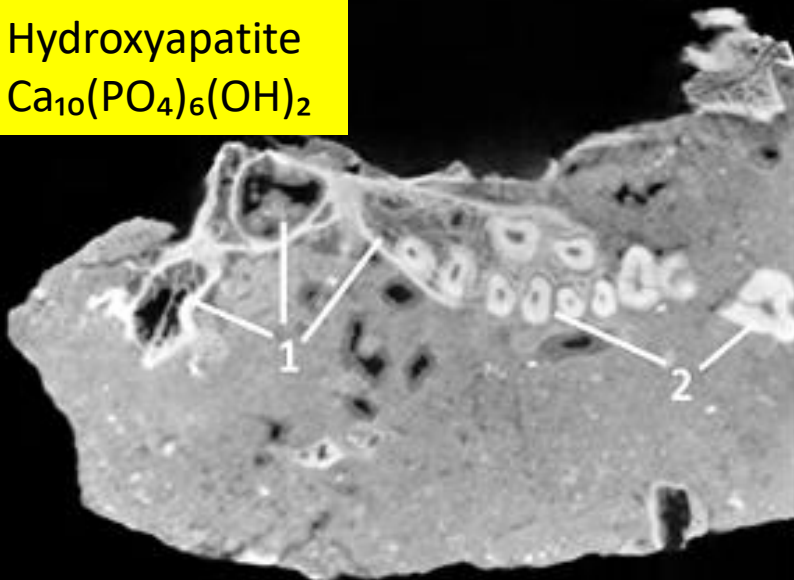
X-RAYS

A



B

Fossilized bone:  
Hydroxyapatite  
 $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$



## Palaeosciences

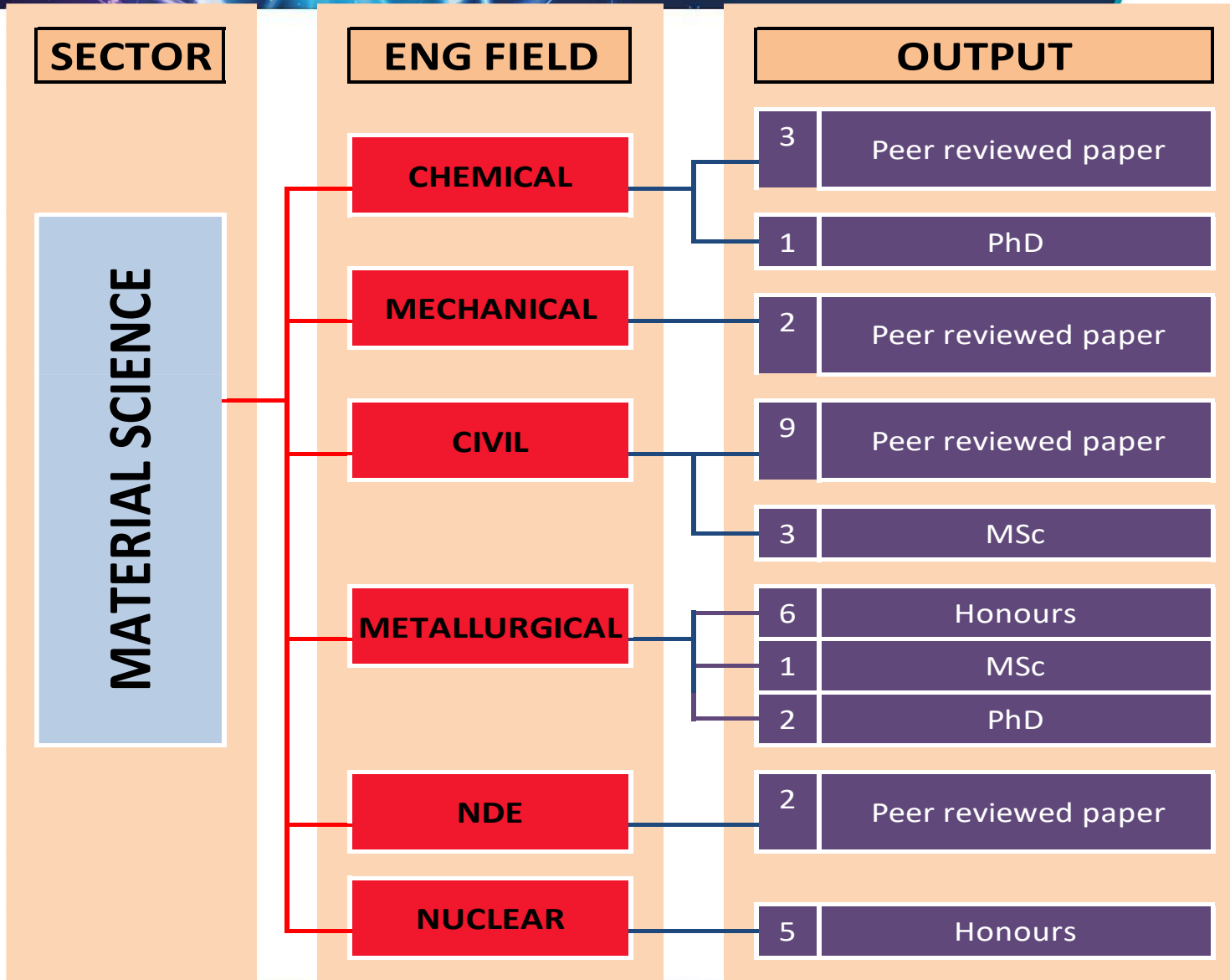
Fossil materials in dense Breccia matrix

### Materials in:

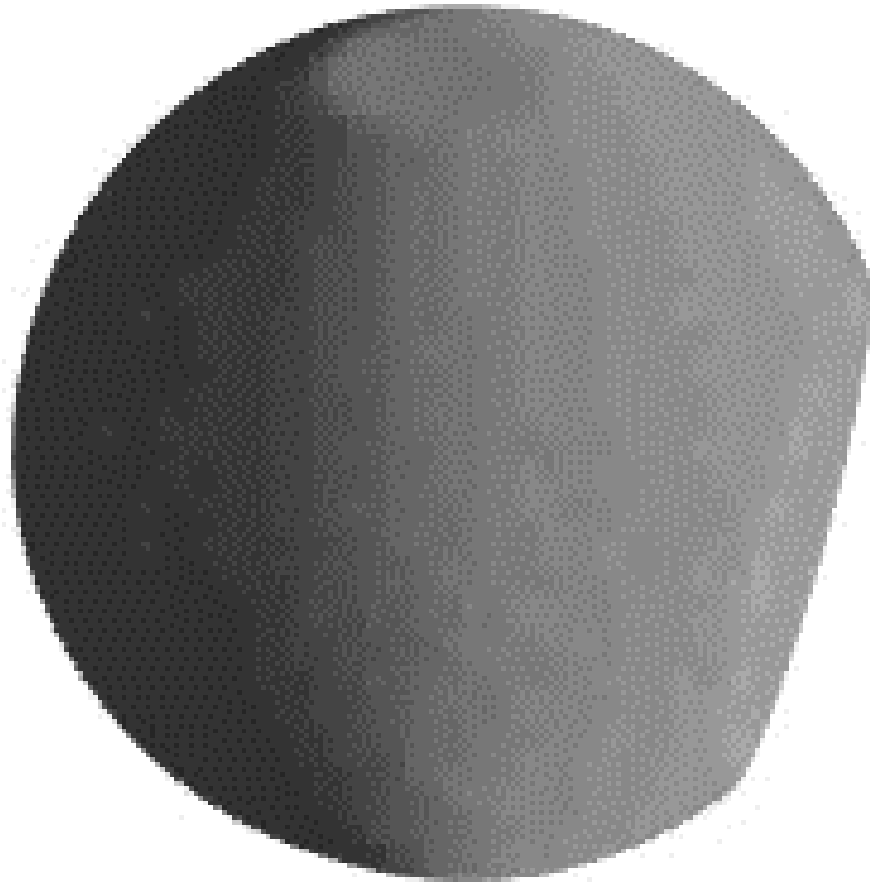
- Nuclear Sector
- Energy Sector
- Aircraft Industry
- Motor Industry
- Civil Eng
- Geosciences
- Archaeology
- **Palaeosciences**



# SCIENTIFIC FIELDS







PBMR Fuel Sphere

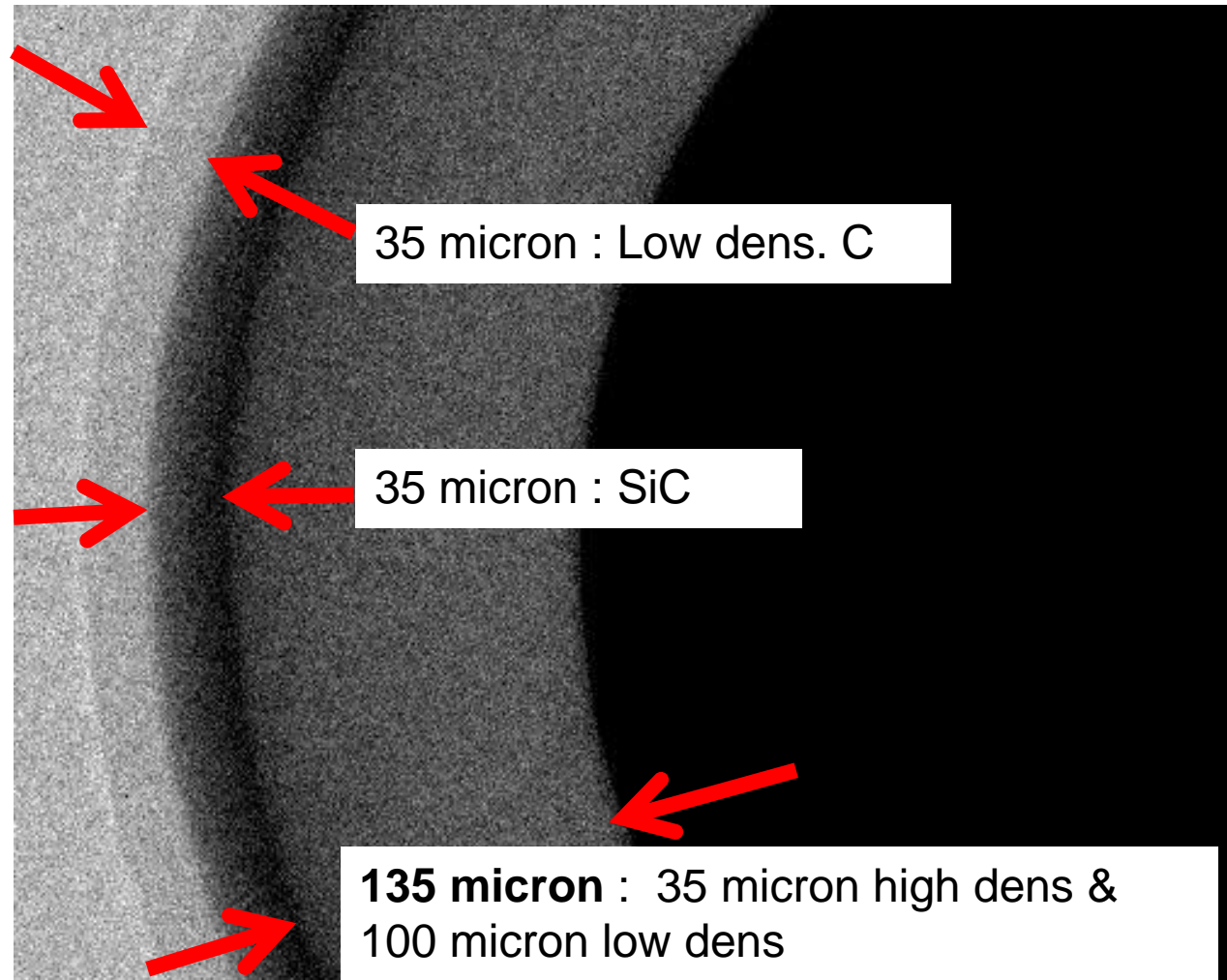
6 cm diameter

Carbon matrix

20000 Triso particles

# 2D VISUALISATION: Nano XCT

## ■ TRISO PARTICLES (1mm diameter) QUANTIFICATION



### Sample:

1mm diameter TRISO  
fuel kernel

### Parameters:

Cr - target

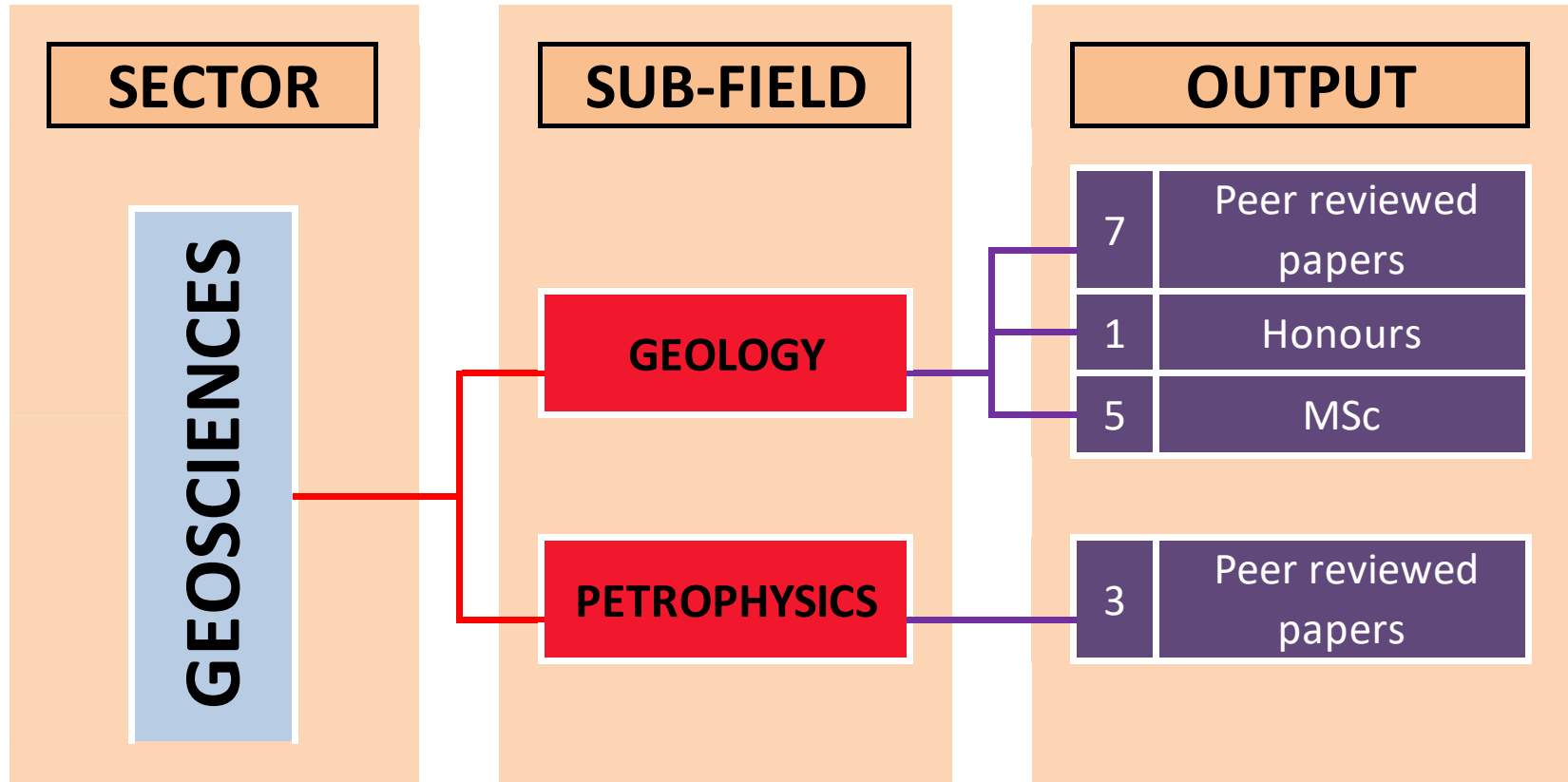
X-ray: 40kV ; 30mA

Time = 12 min

### Equipment:

Micro-focus X-ray  
system & A-Si detector  
University Ghent;  
Belgium

# SCIENTIFIC FIELDS



# EVOLUTION OF X-RAY TOMO





- **State owned Company**
- **In terms of Section 13 of the Nuclear Energy Act, No. 46 of 1999, Necsa is mandated to:**
  - ▶ **Undertake and promote research and development (R & D) in the field of** nuclear energy and **radiation sciences and technology** and, subject to the Safeguards Agreement, to make these generally available.
  - ▶ Process source material, .... and nuclear material; and
  - ▶ **Co-operate with any person or institution in matters falling within these functions**, subject to the approval of the Minister.



Questions?