

# RADIATION DAMAGE STUDIES ON LUBRICANTS

D. Senajova (SY-STI-TCD & Imperial College London)

## Acknowledgements

SY-STI: A-P. Bernardes, T. Giles, M. Ferrari, F-X. Nuiry, STI workshop and M. Calviani

HSE-RP: J-F. Gruber, F. Pozzi

BE-GM: A. Herty and M. Sosin

ICL: P. Cann, S. Bellingham, J. Zhang and D. Dini

LUBRILOG: J-L. Bossard, J-M. Navarro, M. Veron and F. Rouby-Giraud

MORESCO: Y. Hayashi and Y. Sakane

R2E Annual Meeting – 1-2 Mar, 2022

<https://indico.cern.ch/event/1116677/>



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# Agenda

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1. Motivation and context

2. Challenges

3. Investigation approach

4. Current status

5. Take-home message

# 1 MOTIVATION & CONTEXT

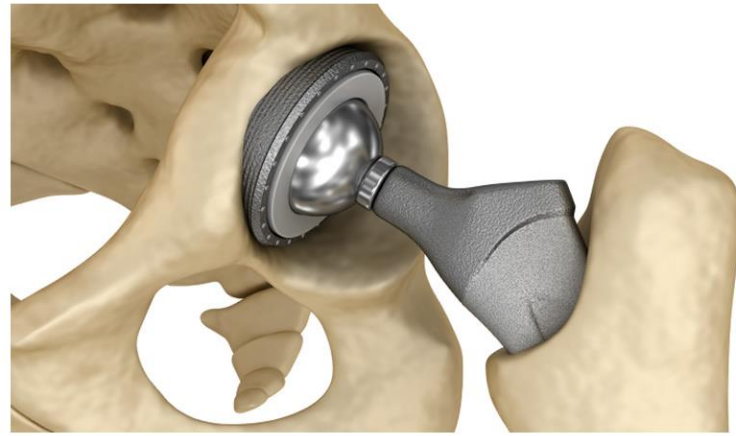
# Radiation damage studies on lubricants at CERN

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## MOTIVATION

- Improve reliability of lubricated devices in high-radiation areas
- Increase scientific **knowledge**: Tribology\* - Greases - Mixed fields

\*Tribology = science and technology of interacting surfaces in relative motion



# Radiation damage studies on lubricants at CERN

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## CONTEXT

- PhD (Tribology Group)
- Scientific collaborations

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**LUBRILOG**

**MORESCO**

For more details, see

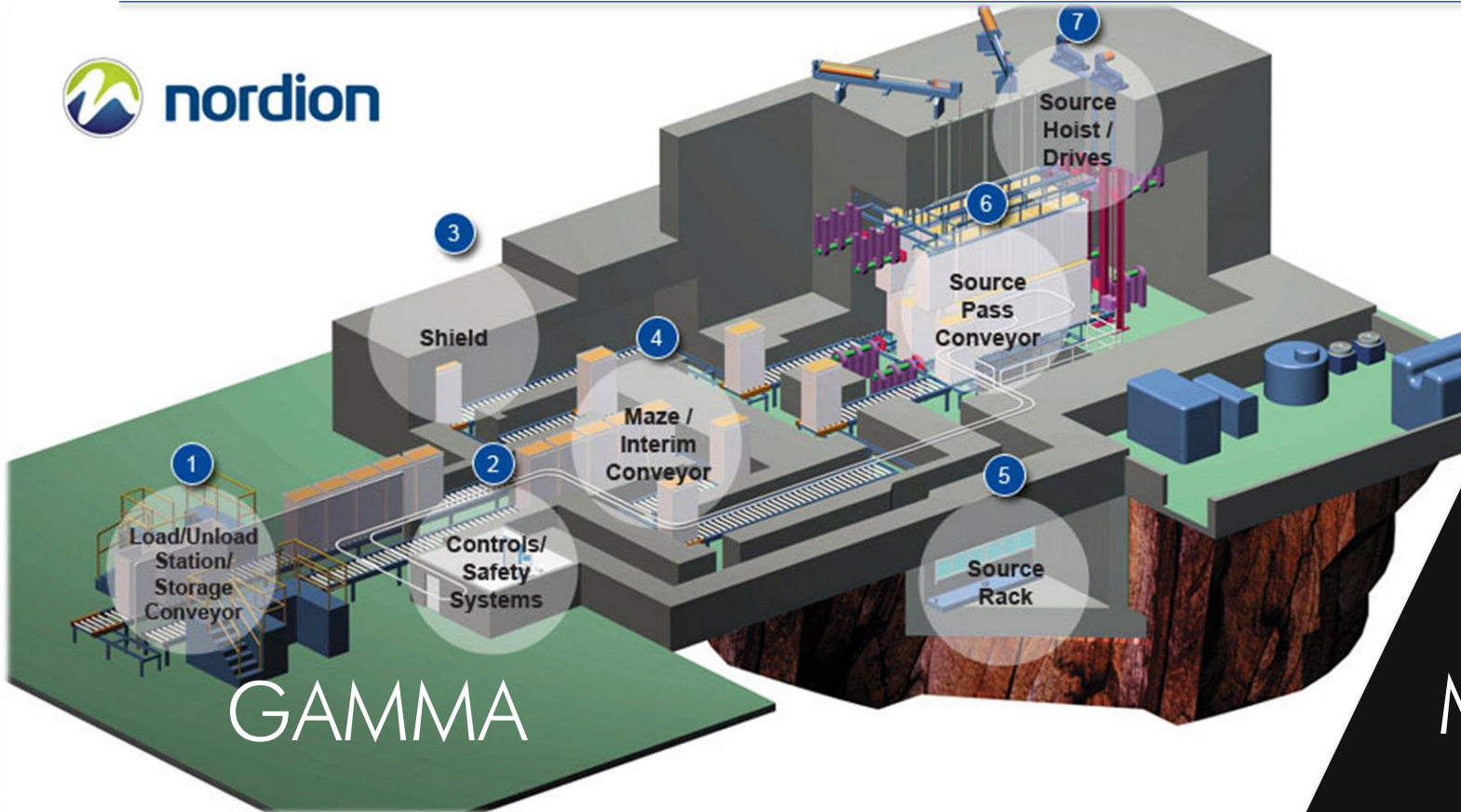
- [R2E Annual Meeting 2022 \(1-2 March 2022\): Radiation tolerance of EPDM O-rings used at CERN: recent results · Indico](#)
- [R2E Annual Meeting - 2021 \(2-3 February 2021\): R2M studies of radiation effects on oils and greases · Indico \(cern.ch\)](#)



# 2 CHALLENGES



# Challenge #1: Gamma vs. mixed fields



GAMMA

Quick

No material activation

How representative?

MIXED FIELD

Slow

Material activation

Closer to operation conditions



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# Challenge #2: Lack of centralised know-how



Radtest & NEAR  
coordination

Irradiations



Samples, lubricant testing



Samples, oil testing

# R2M

PhD

Contract  
coordination\*

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London**

Tribology expertise, laboratories



Gamma sources



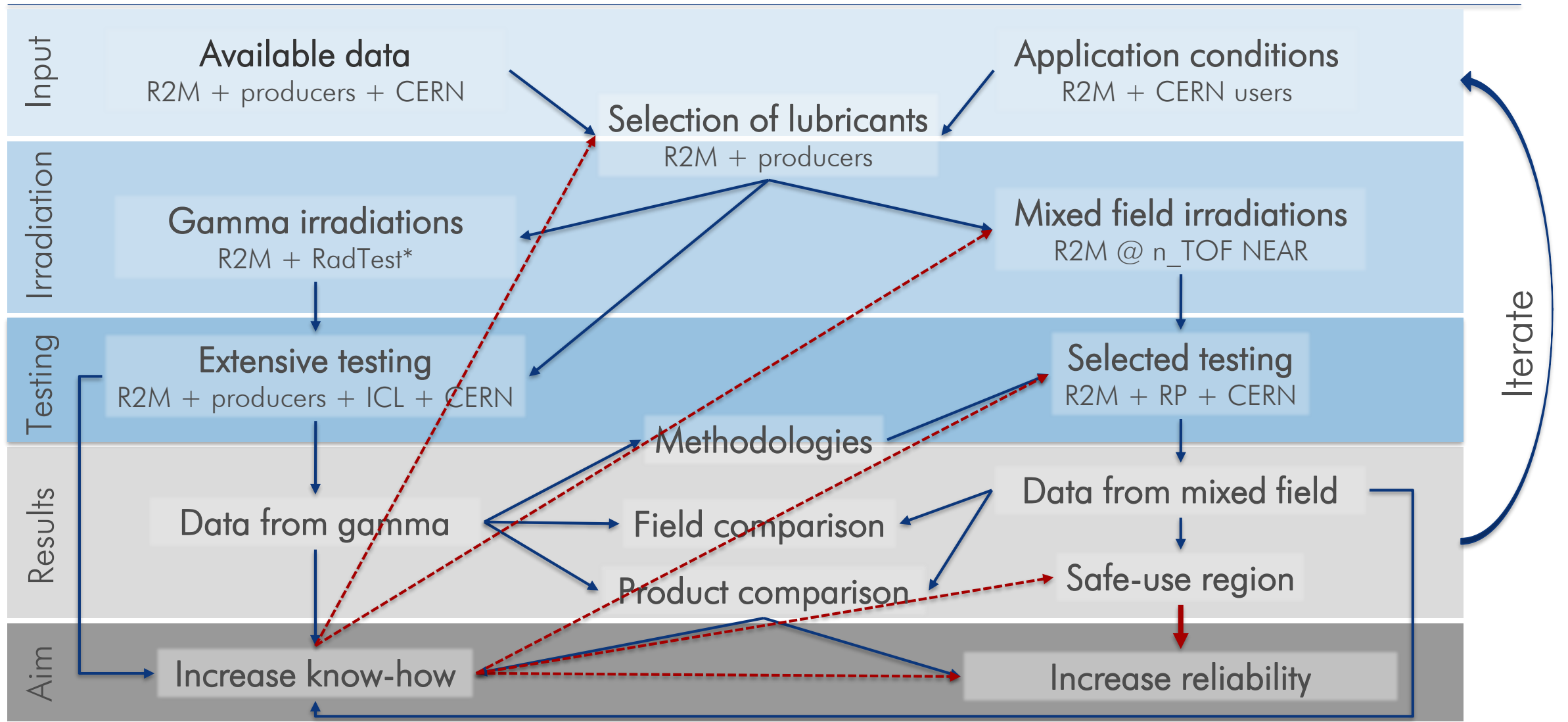
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# 3 INVESTIGATION APPROACH

# Investigation approach





# 4 CURRENT STATUS

# Current status : irradiations

## FINISHED

- ✓ Selection of materials
- ✓ Irradiation in mixed field n\_TOF NEAR (2021)

Lubricant samples before and after irradiation at nTOF NEAR

Acknowledgement: A-P. Bernardes, M. Ferrari, JF. Gruber

Moresco RP-42R



Lubrilog LX AGFA 2



Castrol Nucleol G121



0 MGy

0.4 – 0.8 MGy



# Current status: irradiations

## IN PROGRESS

- Irradiation in mixed field at n\_TOF NEAR (2022)
- Irradiations in gamma

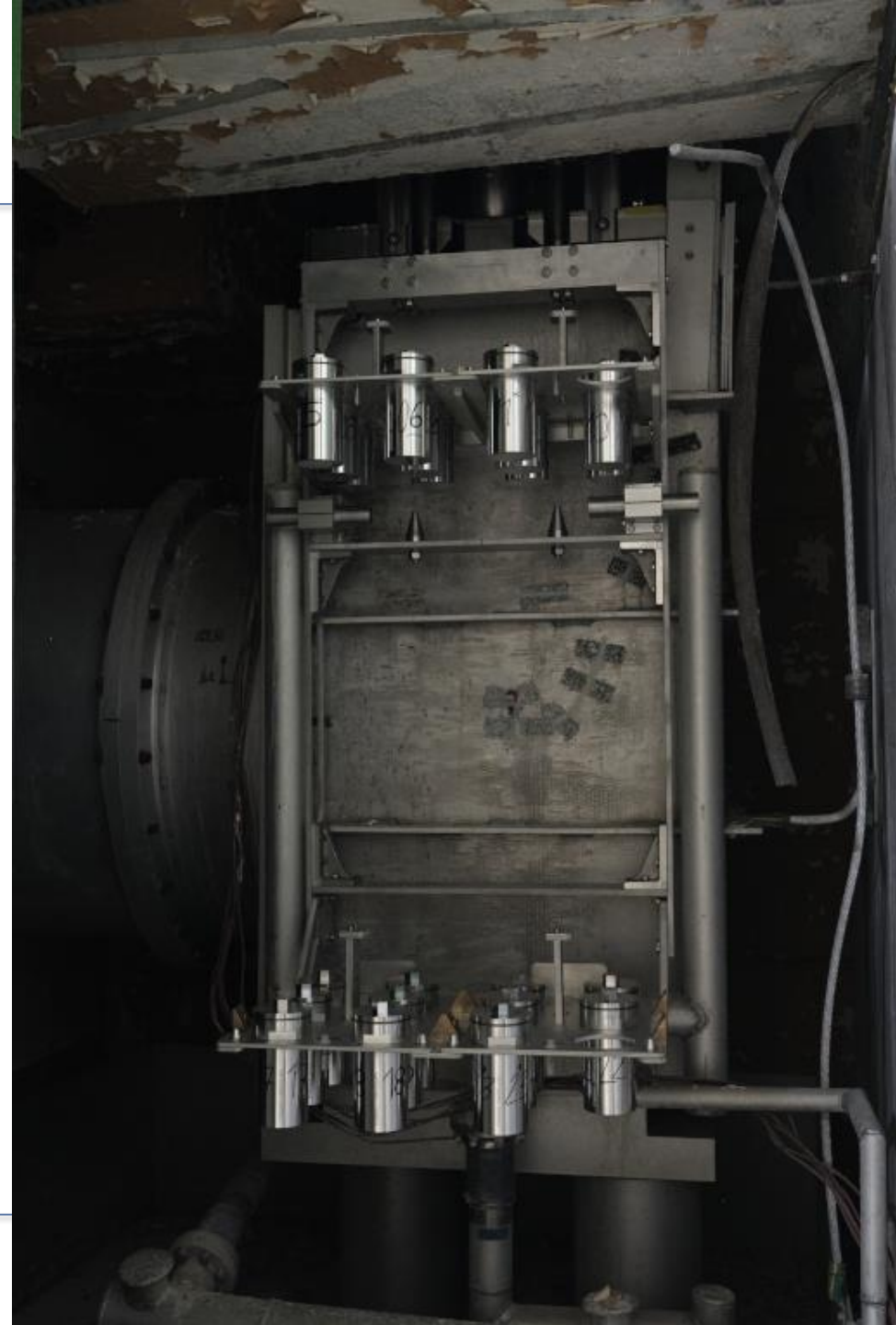
For more details, see

- [R2E Annual Meeting 2022 \(1-2 March 2022\): New NEAR irradiation station at n\\_TOF: design, implementation and first results · Indico \(cern.ch\)](#)

Lubricant samples installed at nTOF NEAR

M. Ferrari et al., arXiv 2202.12809 (2022) [preprint submitted]

CERN-PHOTO-202107-085-1



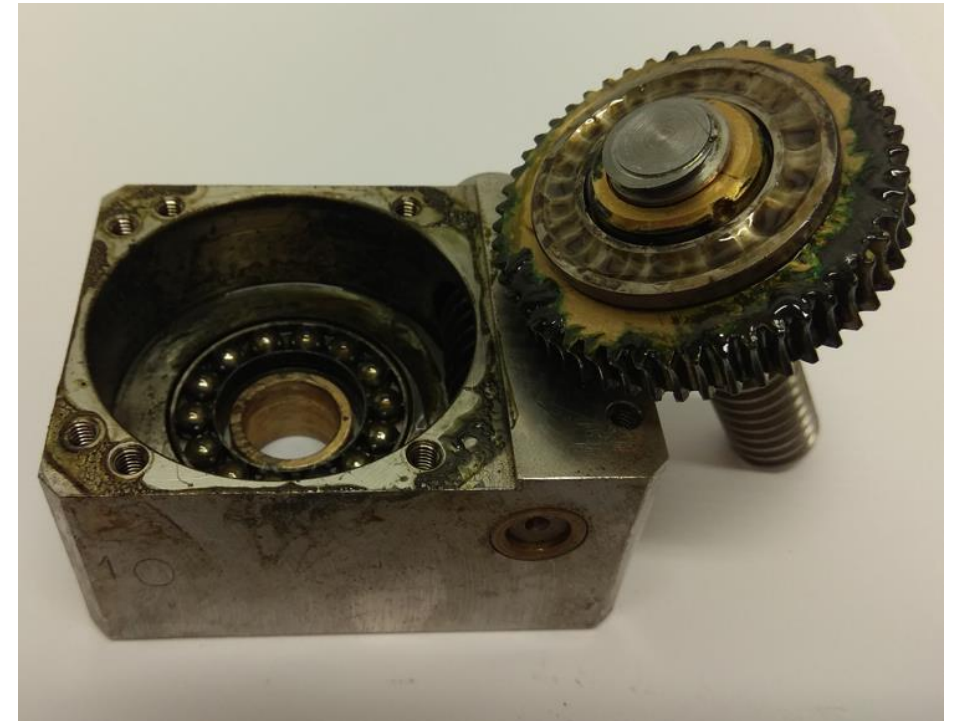


# Current status : irradiations

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## PLANNED STUDIES

- Lubricated components + lubricants
  - Collimator roller screws
  - UAP components



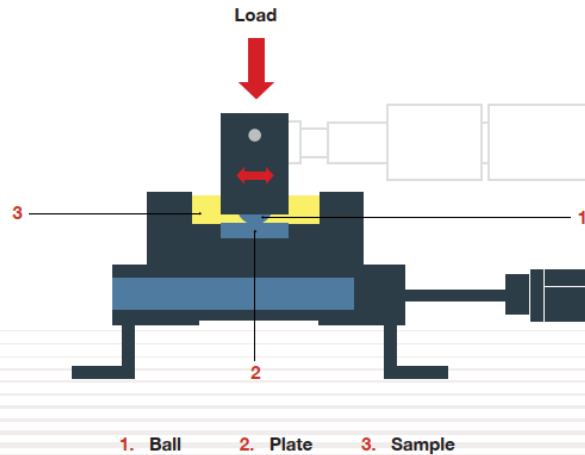
Vertical jig for UAP  
Irradiated up to 10 MGy in gamma

# Current status : analyses

## FINISHED

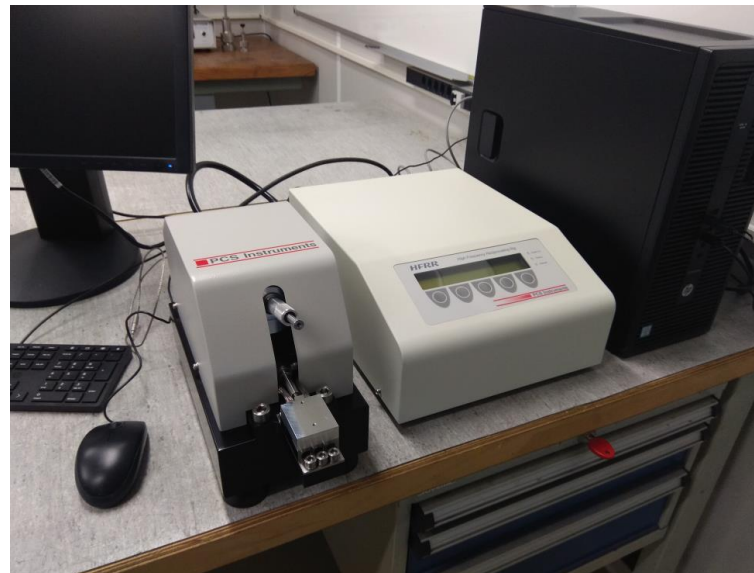
- ✓ Identification of critical tests (ex: High Frequency Reciprocating Rig)
- ✓ HFRR instrument at CERN
- ✓ Penetrometer at CERN

### Test Area Schematic:



### HFRR principle

PCS, HFRR brochure



HFRR instrument in the R2M lab



Penetrometer in the R2M lab

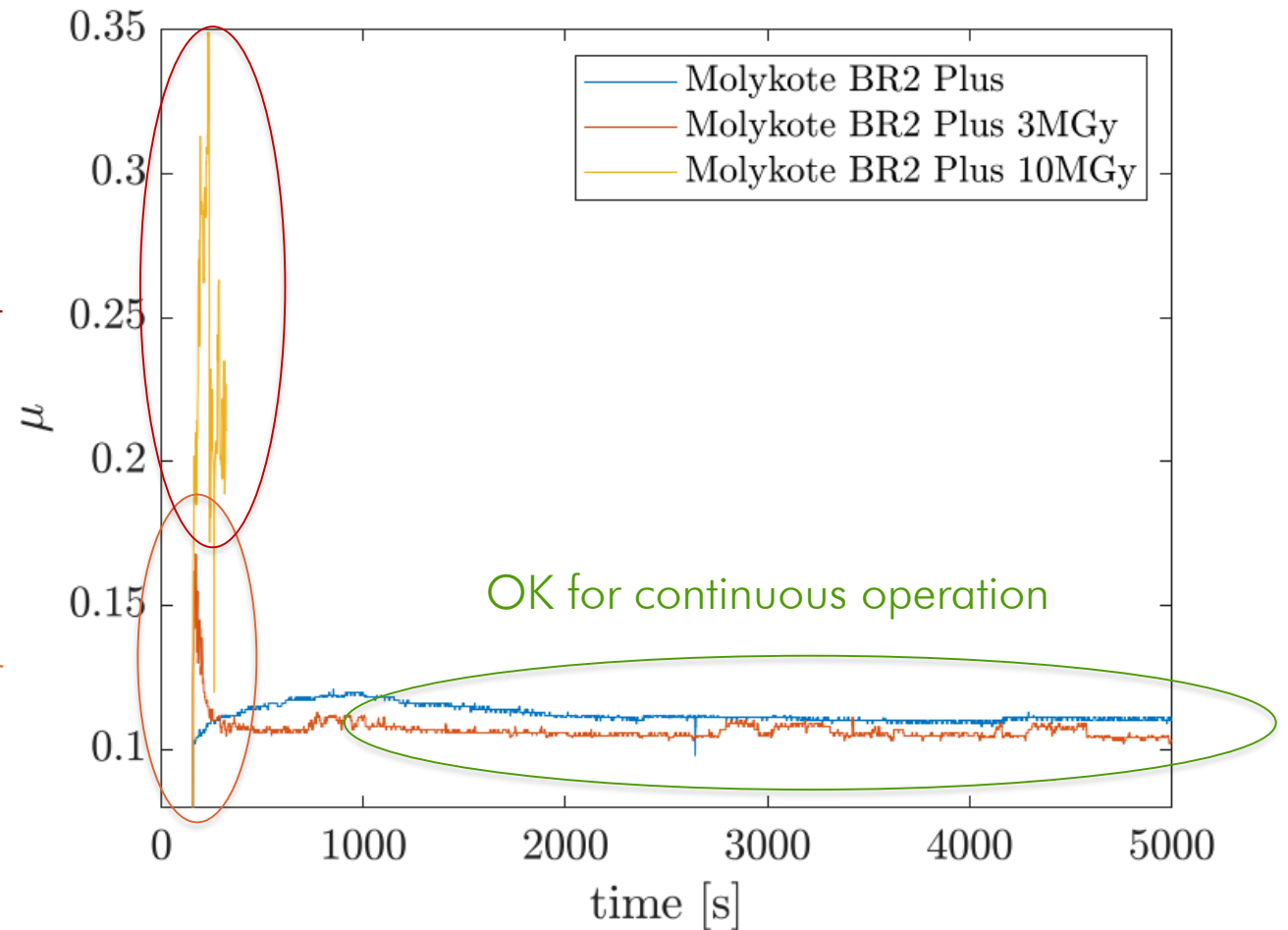
# Current status : analyses

## FINISHED

- ✓ HFRR training
- ✓ Pilot test campaign

Not efficient

Static friction  
Potentially problematic for  
intermittent motion

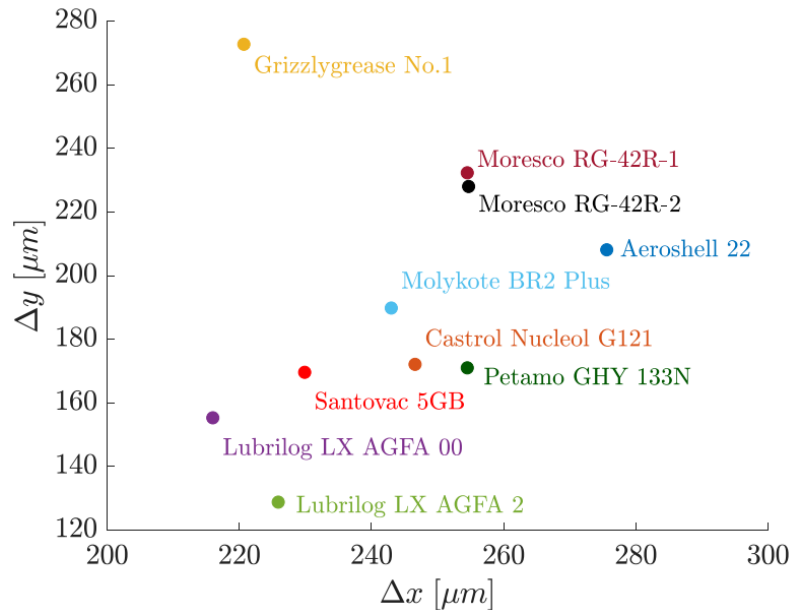


Coefficients of friction during HFRR test at  
25°C, 1kg load, 100k strokes of 0.25mm

# Current status : analyses

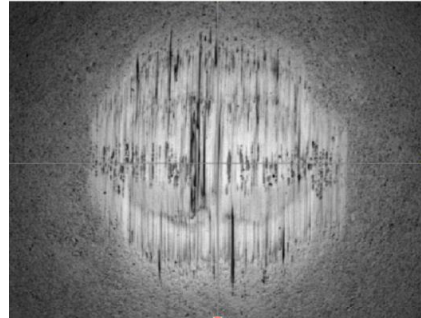
## IN PROGRESS

- Microscopy training

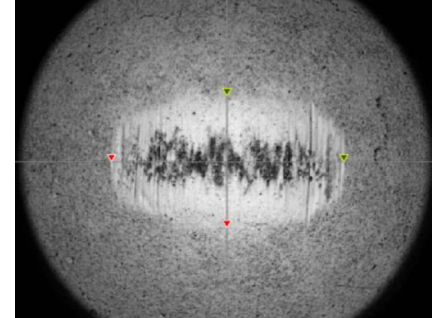


Wear scar size after HFRR test  
at 25°C, 1kg load, 100k strokes of 0.25mm

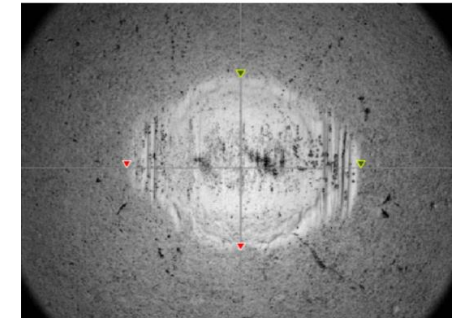
Moresco RG-42R-2



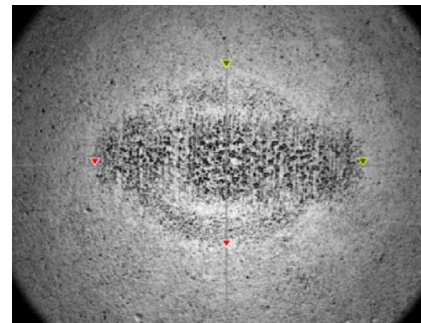
Lubrilog X AGFA 2



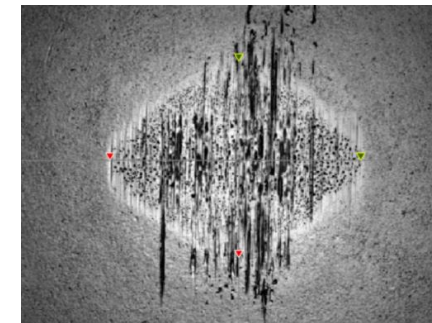
Santovac 5 GB



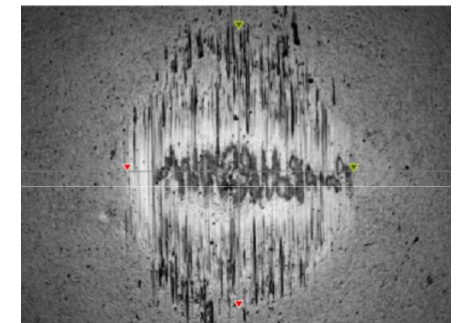
Petamo GHY 133N



Molykote BR2 Plus



Grizzlygrease No. 1



Wear scars on ball specimen after HFRR testing  
at 25°C, 1kg load, 100k strokes of 0.25mm

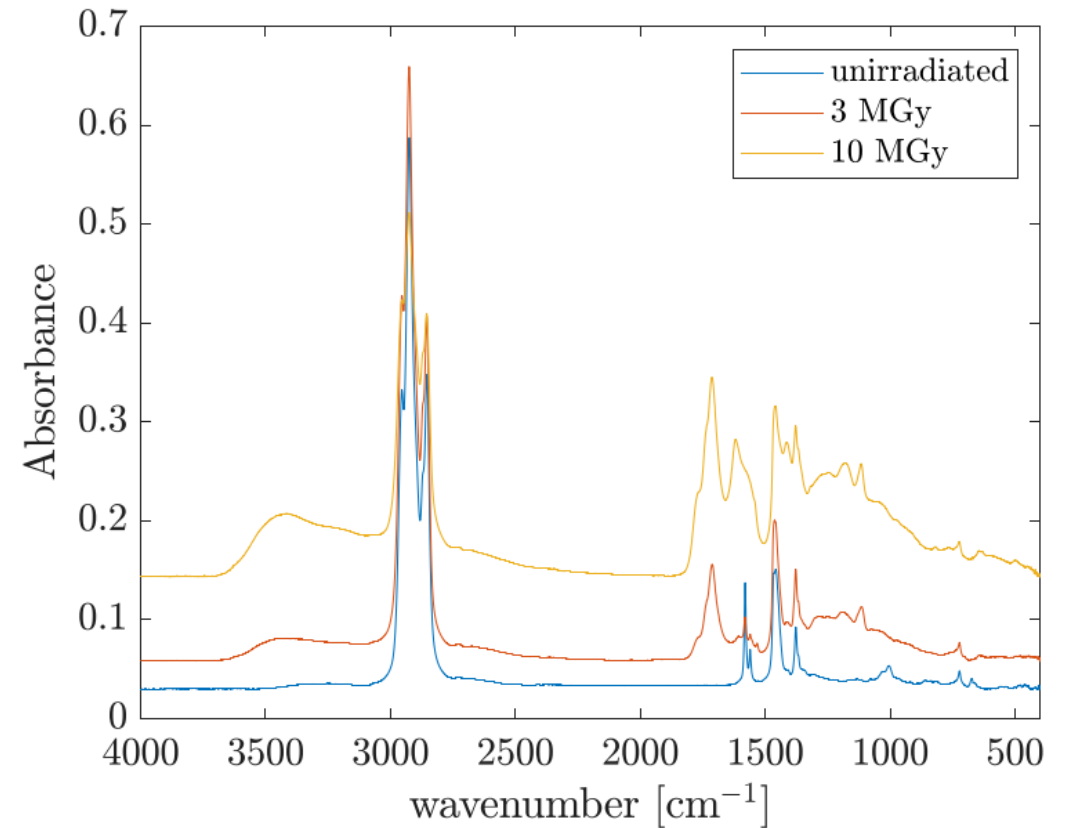
# Current status : analyses

## IN PROGRESS

- FTIR training

## PLANNED

- Additional trainings  
(rheometer, TAN, MTM...)



FTIR spectra of Molykote BR2 plus  
Irradiated up to 3 and 10 MGy in gamma



# 5 TAKE-HOME MESSAGE

# Take-home message

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- Radiation damage studies are **critical**, but **challenging**
- New techniques implemented at CERN
- First results available
  - Differences between fresh lubricants
  - Modifications with irradiation
- Ongoing studies

# Picture references

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- Slide 4: Power Point stock/<https://dx.doi.org/10.13005/bpj/1717/> Power Point stock
- Slide 5: Imperial College website/Lubrilog website/Moresco website
- Slide 7: Nordion website/CERN-PHOTO-202107-085-1
- Slide 8: CERN website/Imperial College website/Lubrilog website/Moresco website/Radtest website
- Slide 12: M. Ferrari, A-P. Bernardes
- Slide 13: CERN-PHOTO-202107-085-1

Thank you for your attention!



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# BACK-UP SLIDES



# Grease structure in non-polarized light

## Lithium soap

Grizzlygrease  
No.1



Molykote BR2 Plus

0 MGy



3 MGy



10 MGy

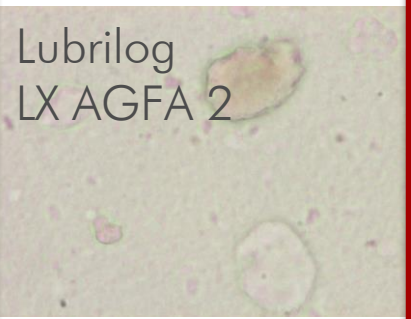


## Silica gel

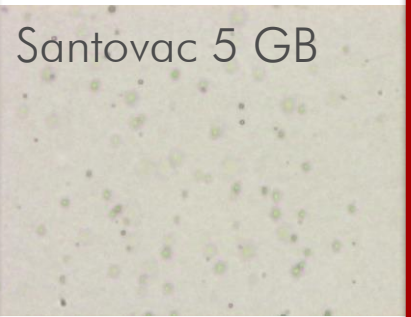
Lubrilog  
LX AGFA 00



Lubrilog  
LX AGFA 2

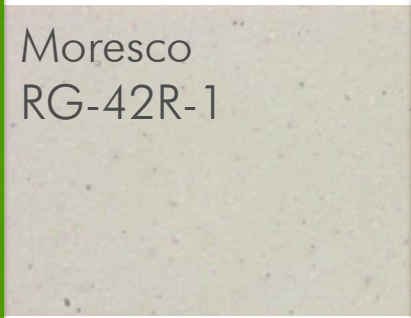


Santovac 5 GB

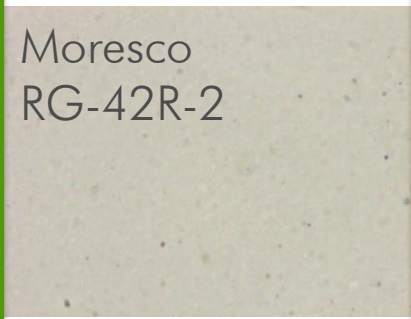


## Bentonite

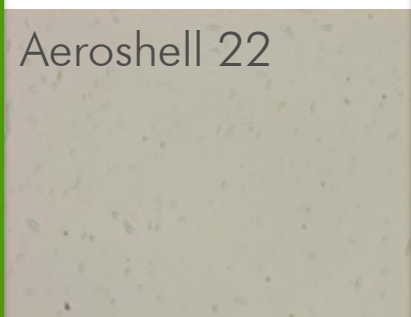
Moresco  
RG-42R-1



Moresco  
RG-42R-2

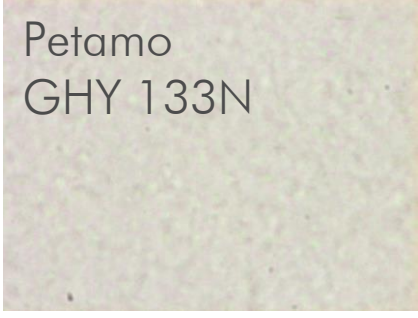


Aeroshell 22



## Inorganic


Petamo  
GHY 133N



Elaskon SK-DL

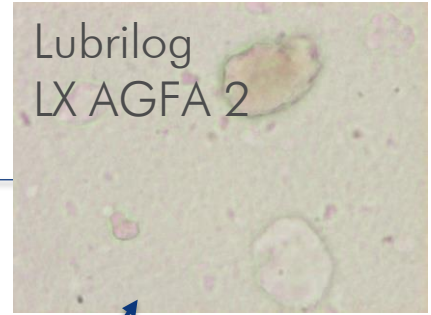


Castrol Nucleol  
G121

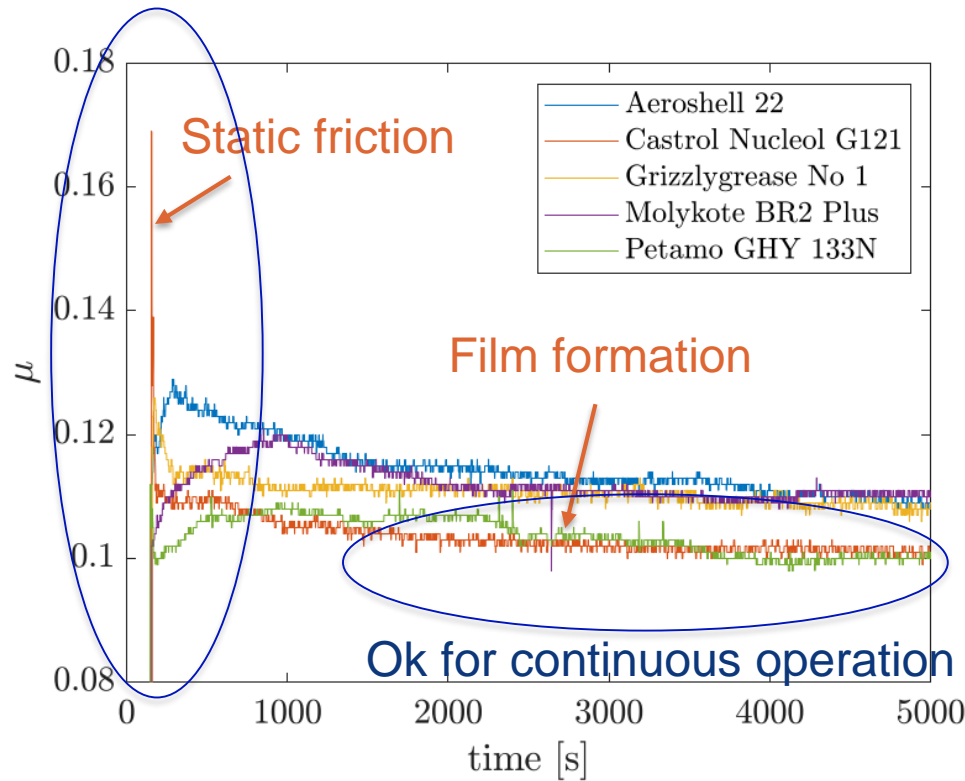


# HFRR results – fresh samples

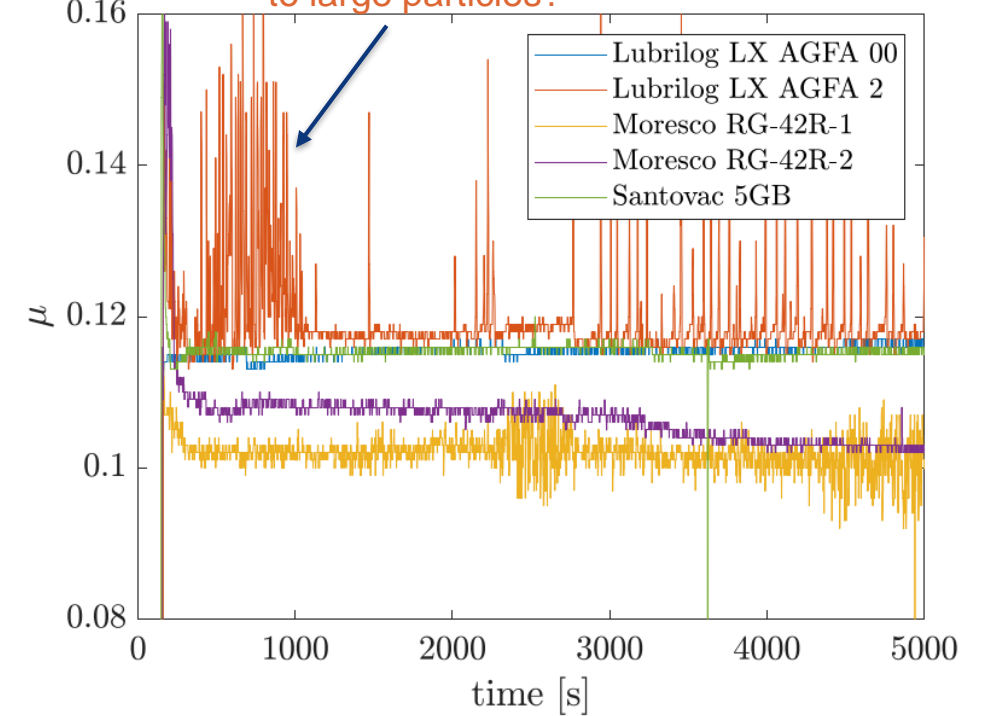
Coefficients of friction during HFRR test  
at 25°C, 1 kg load, 100k strokes of 0.25mm



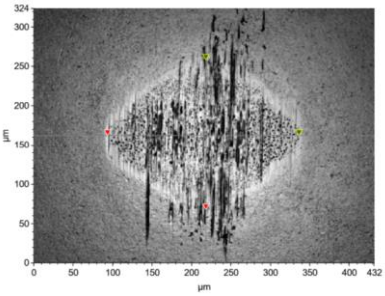
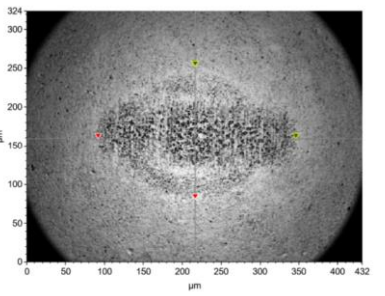
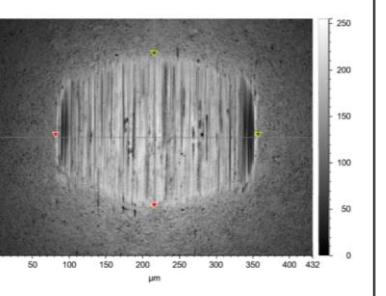
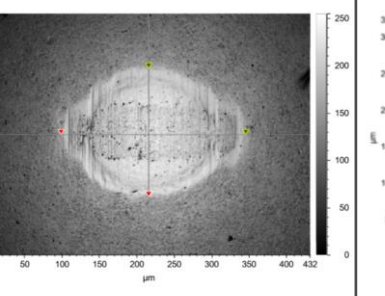
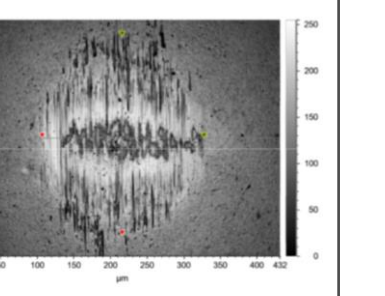
Potentially problematic for intermittent motion



Peaks of friction due to large particles?



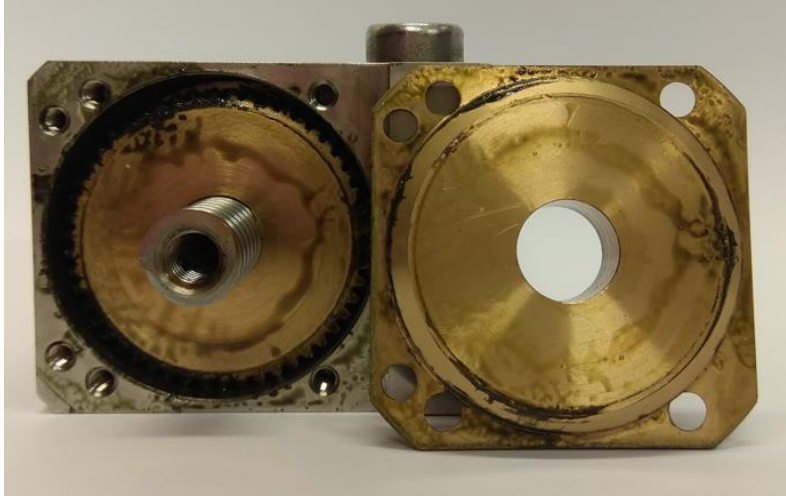
# Wear scars – fresh samples

Name	Molykote BR2 Plus	Petamo GHY 133N	Aeroshell 22	Castrol Nucleol G121	Grizzlygrease No. 1
Picture					
$\Delta x$ [ $\mu m$ ]	243.0	254.5	275.6	246.6	220.7
$\Delta y$ [ $\mu m$ ]	189.8	171.0	208.1	172.1	272.7

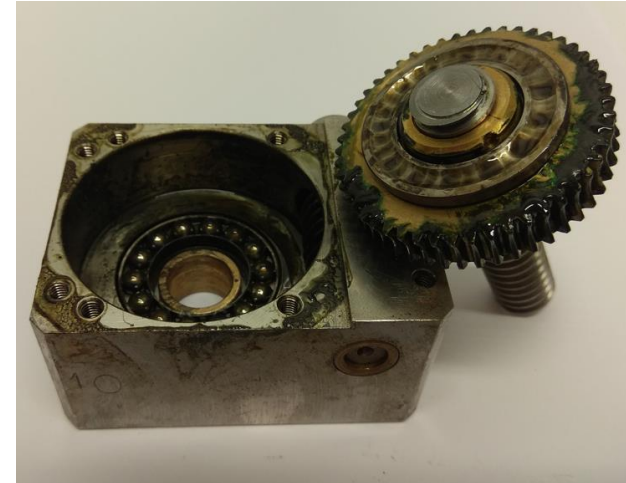


# Vertical jigs - visual inspection


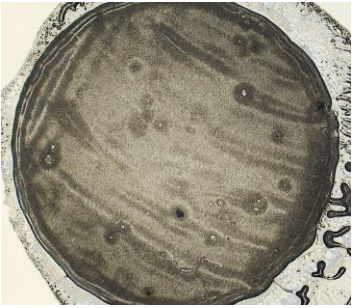


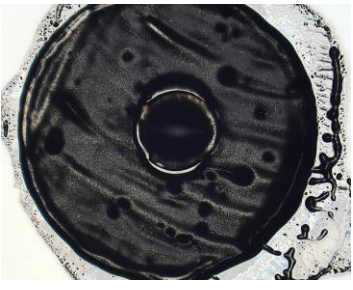

3 MGy



10 MGy

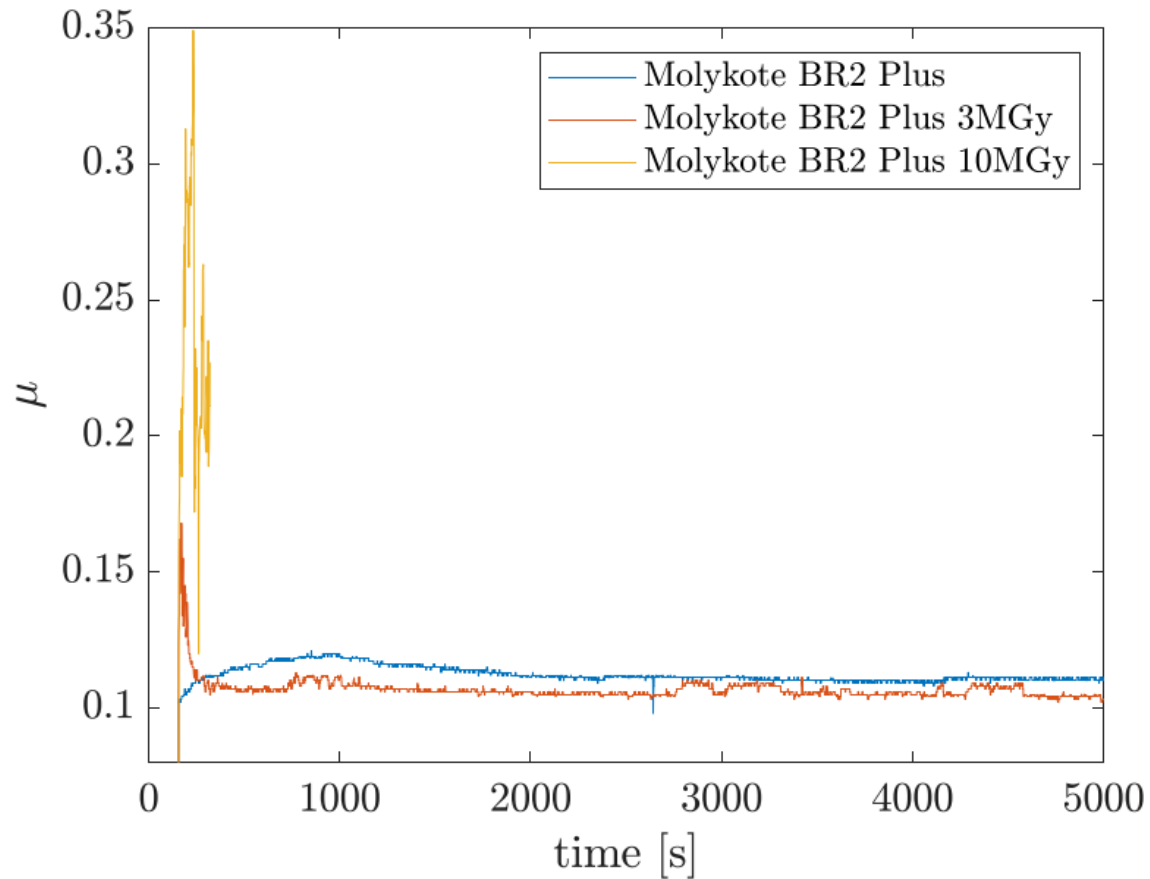


# GREASE ASPECT – Molykote BR2 Plus

Name	0 MGy	3 MGy	10 MGy
Before HFRR			
After HFRR			

Scale bar, no 3D  
– to be repeated

# HFRR results



Dose	0 MGy	3 MGy
Picture		
$\Delta x$ [ $\mu\text{m}$ ]	243.0	223.0
$\Delta y$ [ $\mu\text{m}$ ]	189.8	208.4

Comparison of coefficients of friction during HFRR test at 25°C, 1kg load, 100k strokes of 0.25mm



# FTIR results

