

R2M studies of radiation effects on oils and greases

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<https://indico.cern.ch/event/971222/>



Agenda

1. Motivation for R2M studies on lubricants
2. Radiation effects on oils and greases
3. Application example
4. Experimental irradiation studies
5. Take-home message

1. Motivation for R2M studies on lubricants

Lubricants in high-radiation areas at CERN

MECHANISMS IN RADIATION AREAS

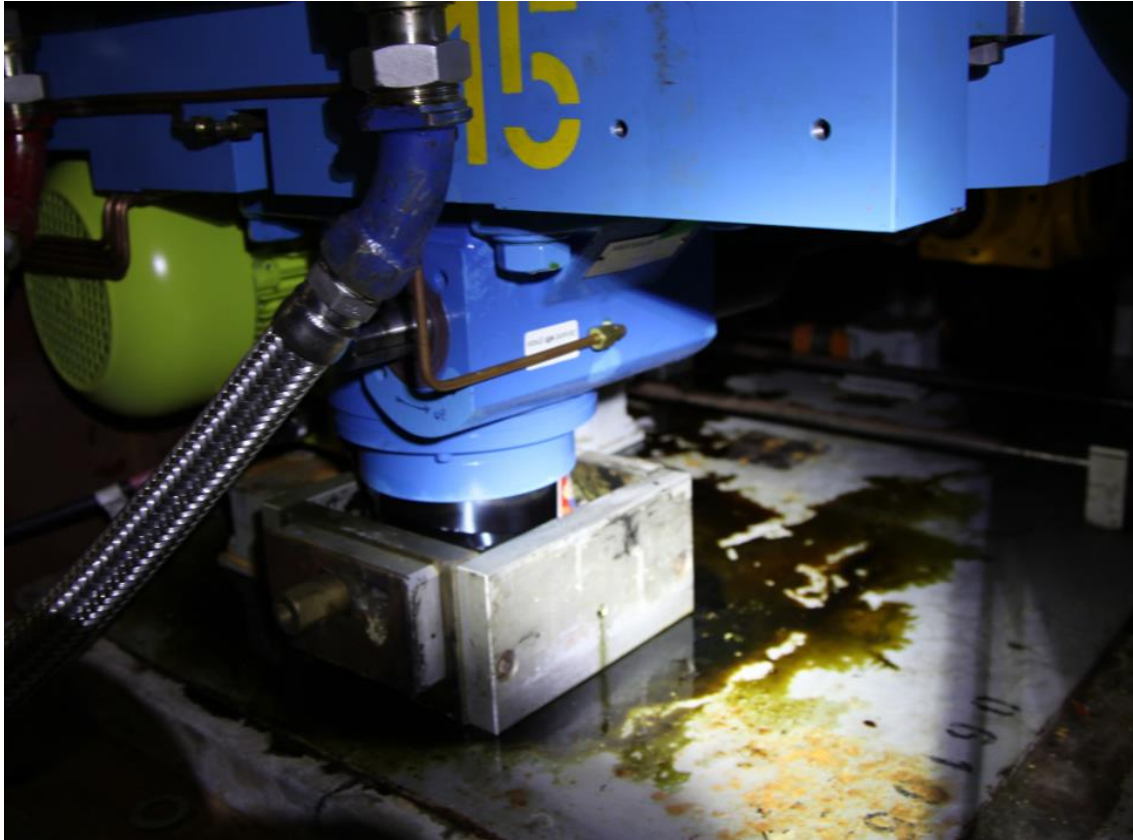
- ~MGy doses in mixed radiation fields
- Critical equipment with moving parts
- Lubricants sensitive to radiation
- Challenging maintenance

CORRECT LUBRICANT SELECTION IS CRUCIAL

Lubricated gearbox of stepper motor after irradiation
P. Gebolis et al. (TE-VSC), 2020, EDMS 2207213



Radiation-induced lubrication failure



CONSEQUENCES

- Contamination
- Equipment damage
- Unplanned stops
- Complex repairs

**INCREASE KNOW-HOW TO
INCREASE RELIABILITY**

Radiation-liquefied grease leaking out of lifting equipment of XTAX tables

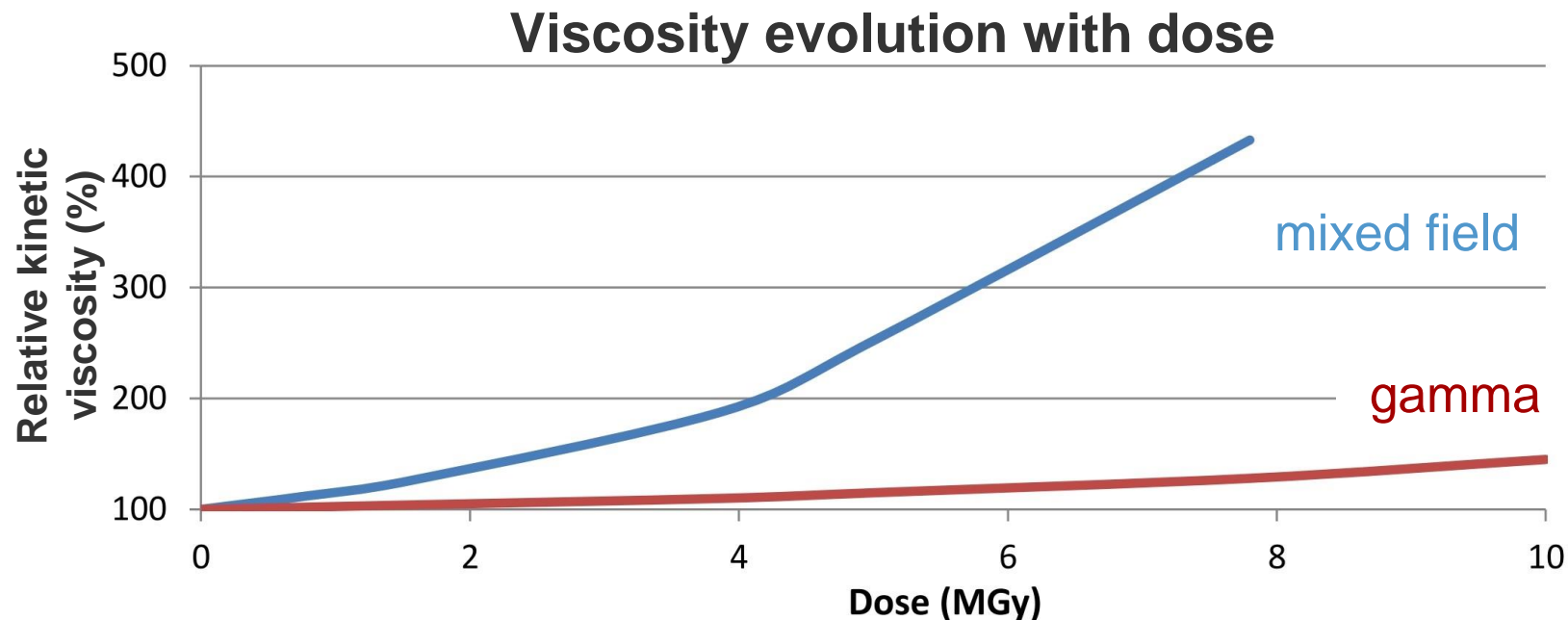
S. Girod (BE-EA)

2. Radiation effects on oils and greases

Radiation effects on oils

- MICRO : chain cleavage/cross-linking
- MACRO: viscosity decrease/increase

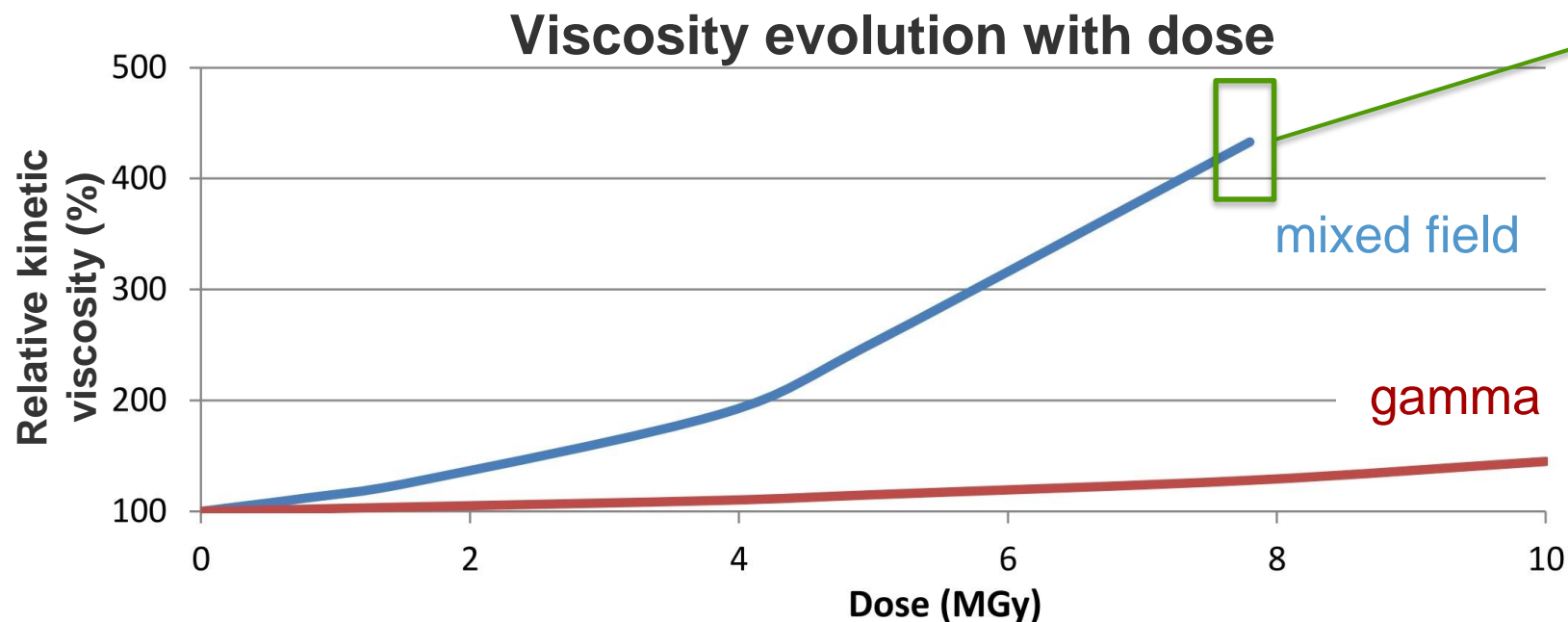
OIL = viscous fluid made of polymeric chains



Viscosity evolution of irradiated lubricating oil MORESCO RP-42R
M.Ferrari, Ph.D. Thesis (2020);
EDMS 2412825

Radiation effects on oils

- MICRO : chain cleavage/cross-linking
- MACRO: viscosity decrease/increase
- Other: gas evolution, acid production...



Aspect of MORESCO
RP-42R after irradiation
M.Ferrari, Ph.D. Thesis
(2020); EDMS 2412825

Radiation effects on greases



RG-42R-1



Petamo GHY 133N

GREASE = oil + thickener + additives

- Multiphase = more difficult
- All components affected
- Competing mechanisms

NEED SPECIFIC STUDIES ON COMMERCIAL GREASES

Selected greases before and after irradiation in reactor
M.Ferrari et al., Journal of Nuclear Materials (2021) [submitted].

Unirradiated

> 10 MGy

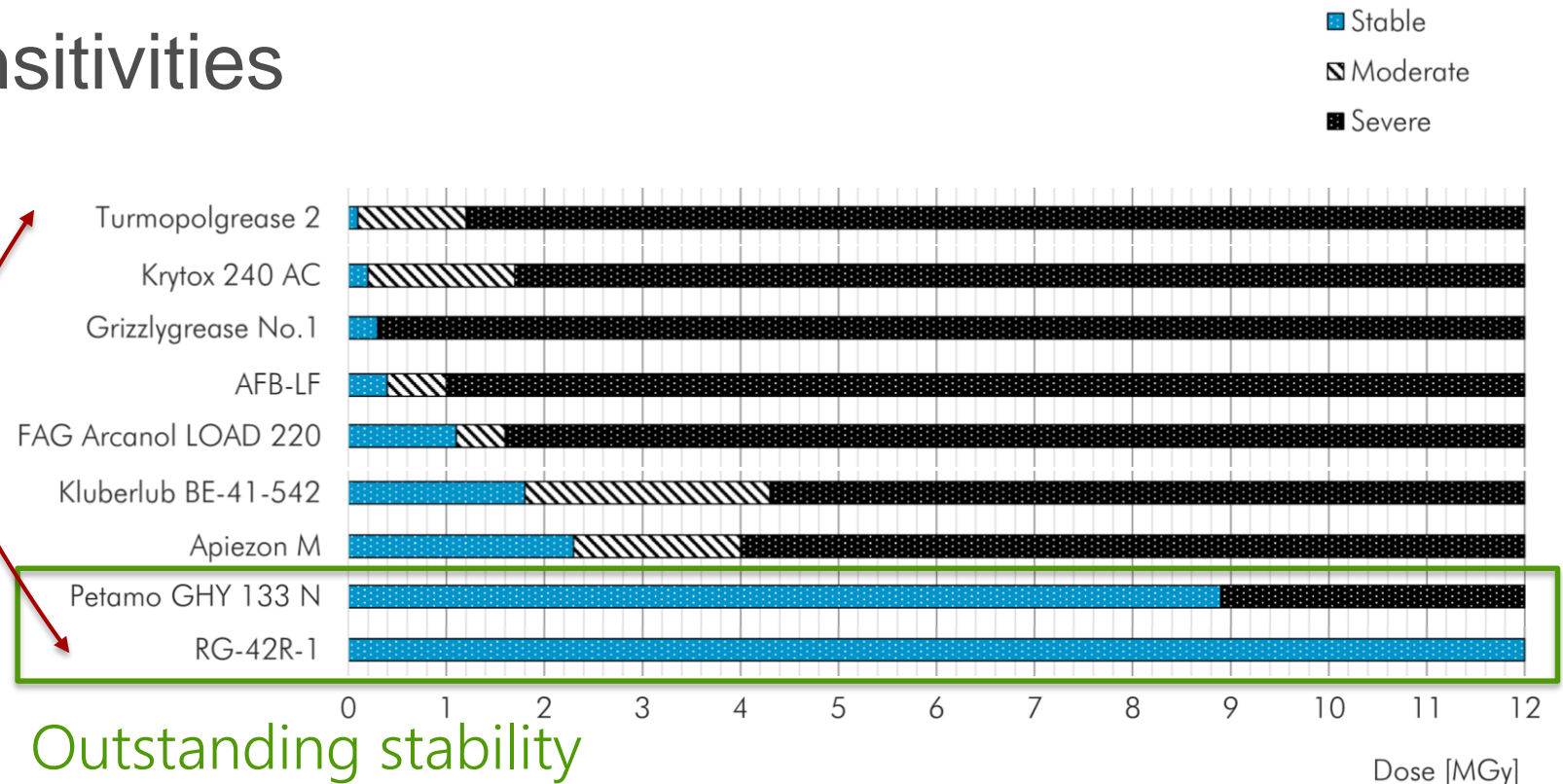
Recent irradiation studies on greases

- Commercial products in mixed radiation field (reactor)
- Studied property : grease consistency
- Wide range of sensitivities

Factor
100 !

Usability thresholds of selected greases

Adapted from M. Ferrari et al.,
Journal of Nuclear Materials (2021)
[submitted].



Outstanding stability

3. Application example: SPS beam dump support

SPS beam dump support (TIDVG 5)

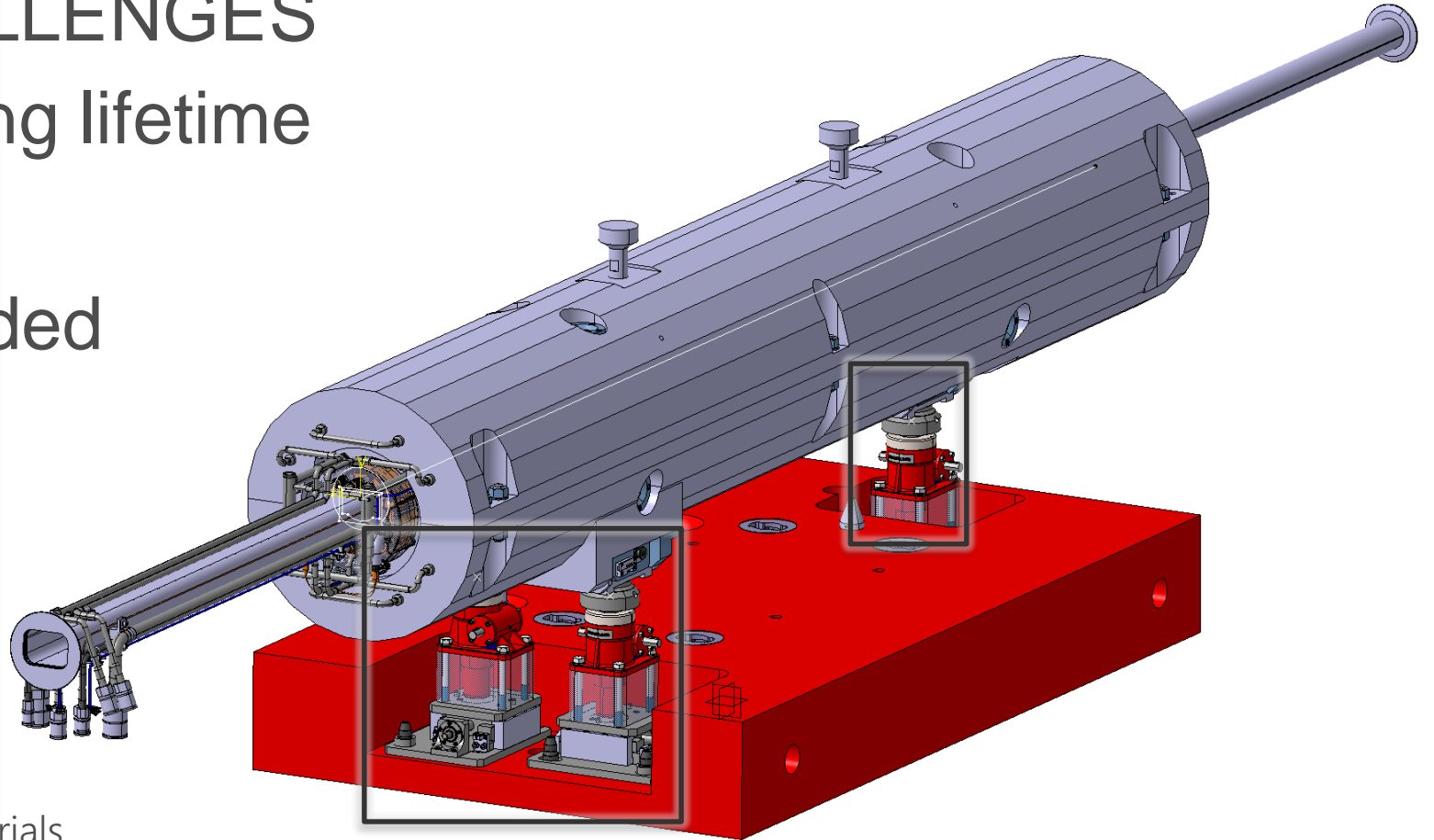
APPLICATION CHALLENGES

- Up to 10 MGy during lifetime
- No maintenance
- High reliability needed

EXTREMELY CHALLENGING FOR GREASES

SPS beam dump, isometric view

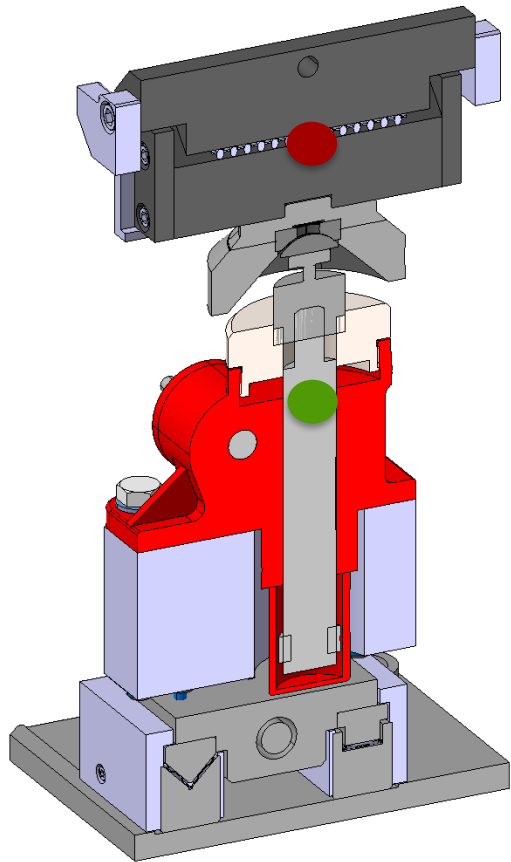
M. Ferrari et al., Journal of Nuclear Materials
(2021) [submitted].



Support jack assemblies

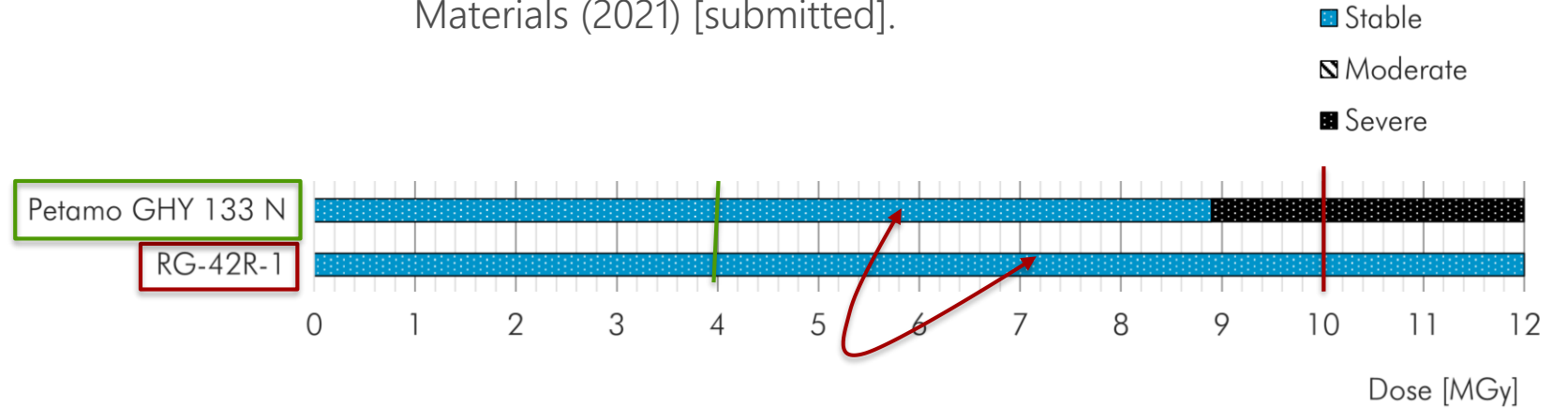
Support jack assemblies, isometric view

M. Ferrari et al., Journal of Nuclear Materials (2021) [submitted].



Usability thresholds of selected greases

Adapted from M. Ferrari et al., Journal of Nuclear Materials (2021) [submitted].



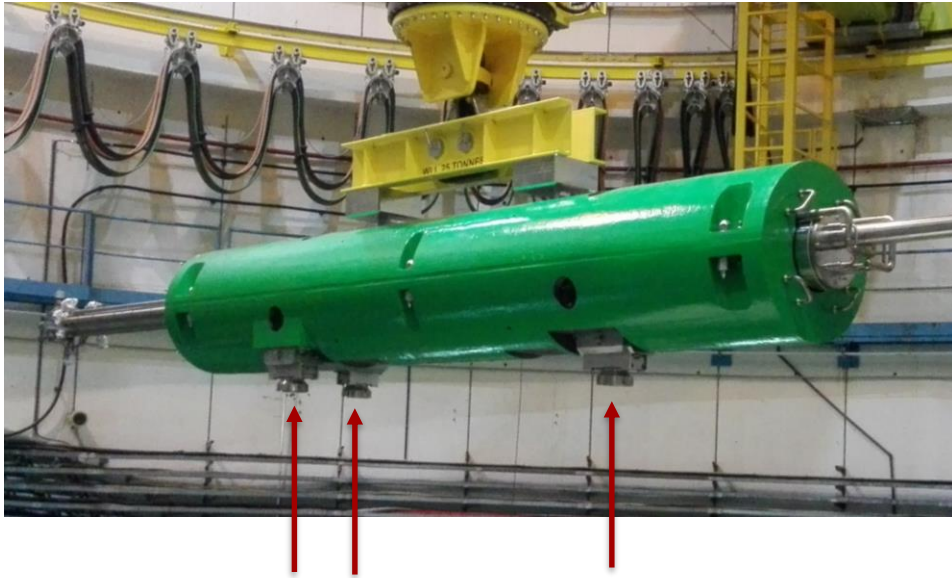
10 MGy
Roller bearings

4 MGy
Screw jack

Factor ~30 in price

RELIABLE LUBRICATION & COSTS OPTIMISATION

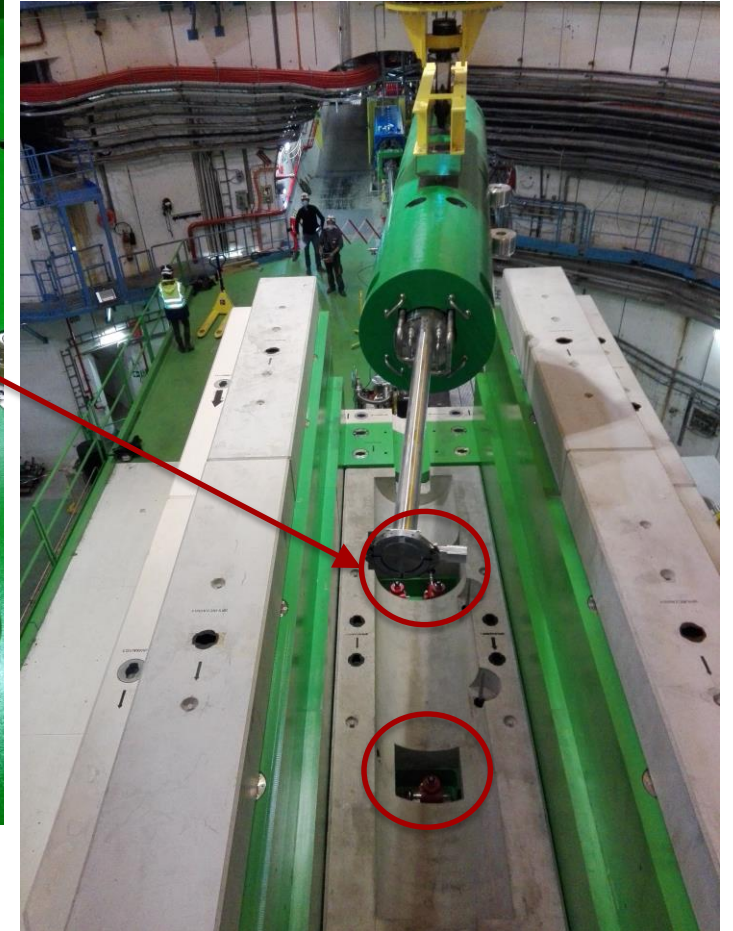
SPS beam dump installation



Support upper roller bearings fitted to dump
SY-STI, 2020.



Support jacks inside shielding
SY-STI, 2020.



Lowering dump into position
SY-STI, 2020.

4. Experimental irradiation studies

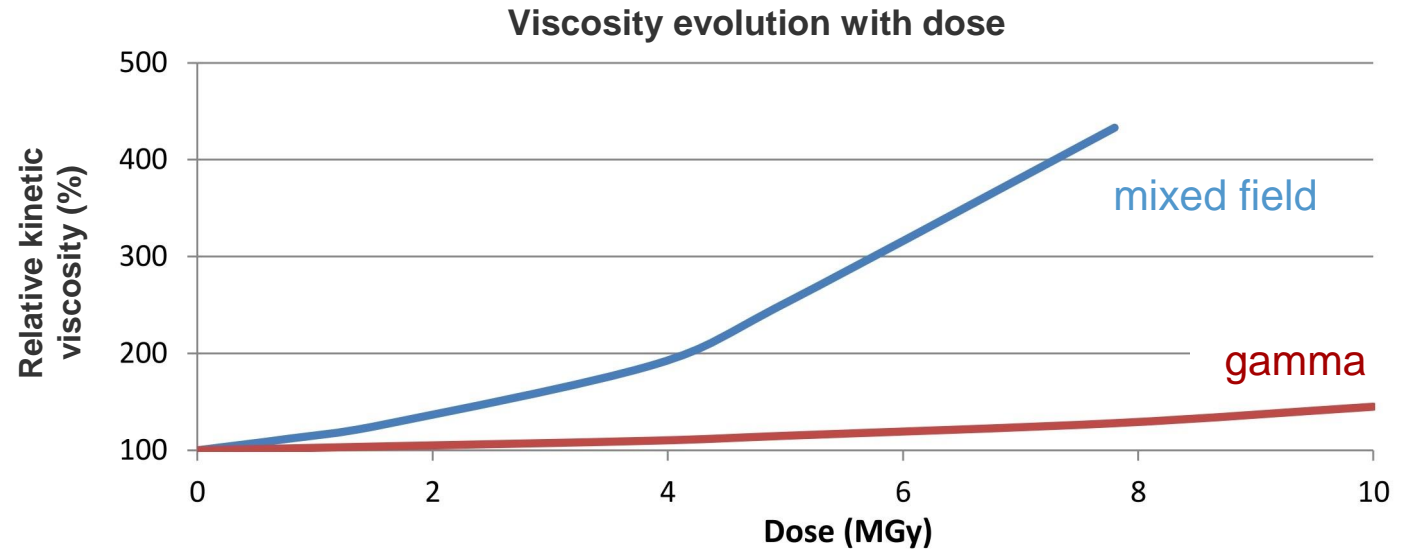
Limitations of available data

Particles/gamma : different energy deposition mechanisms

➤ **Equal dose \neq equal effect**

Insufficient data on

- Influence of irradiation conditions (field, T, O₂...)
- New/other products
- Evolution of other relevant parameters



Viscosity evolution of irradiated lubricating oil MORESCO RP-42R
M.Ferrari, Ph.D. Thesis (2020); EDMS 2412825

NEED FURTHER R2M STUDIES

Ongoing studies with gamma radiation

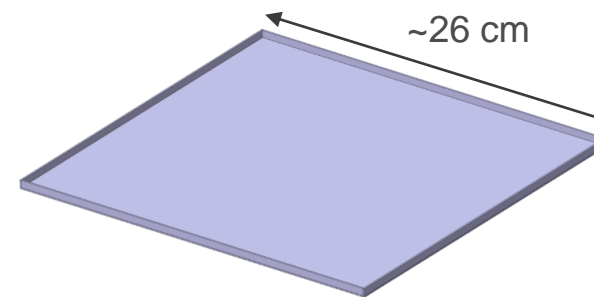
- Research collaboration agreements
- Promising products – PPE
- Specific irradiation conditions
1-10 MGy / Temperature / Atmosphere
- Irradiation containers design
- Multi-scale post-irradiation characterization
Rheological / Chemical / Operational

FIRST RESULTS MID 2021

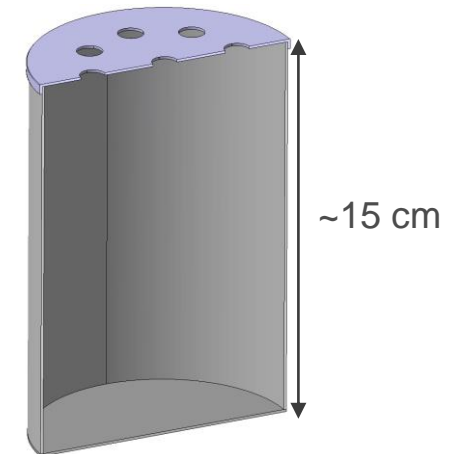
MORESCO

LUBRILOG

Irradiation in thin layer –
oxygenated conditions

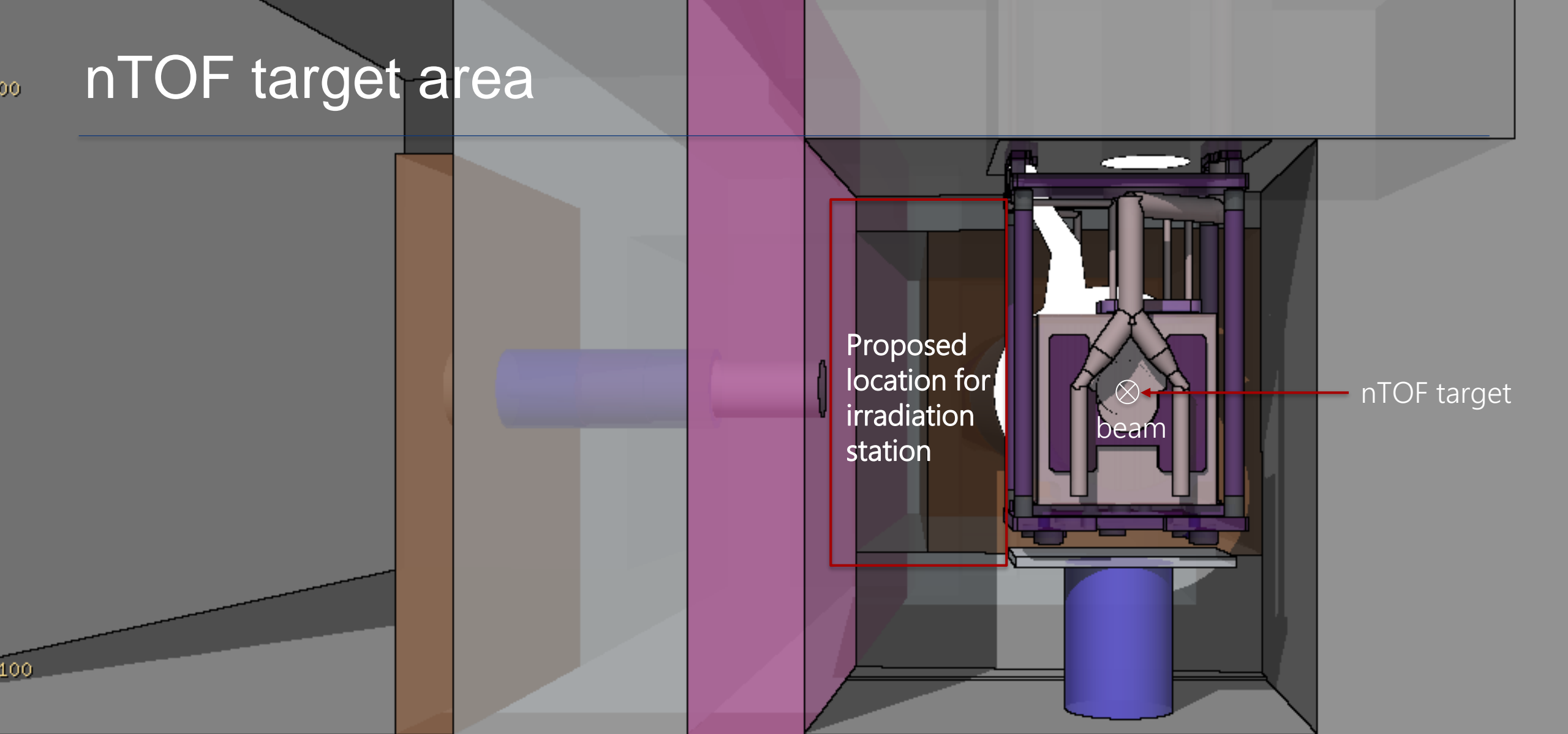


Irradiation in bulk



Containers for irradiation of lubricants, design proposal
S. Sorlut (SY-STI-TCD), Dec 2020.

nTOF target area



nTOF NEAR irradiation station, proposed location
M. Barbagallo (EP-SME), Jan 2021

New mixed field irradiation station: nTOF NEAR

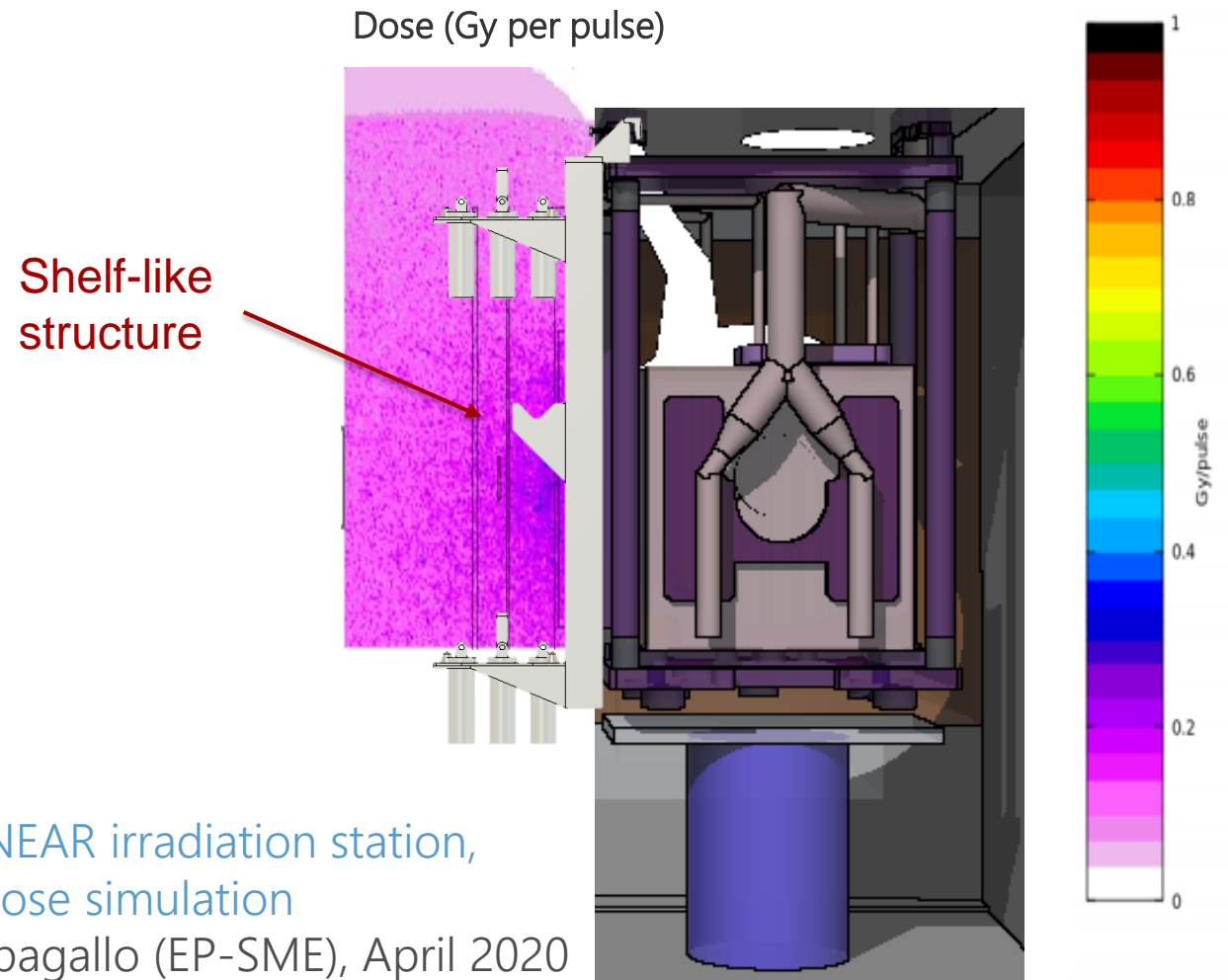
FEATURES

- Homogeneous field
- Neutron-dominated
- ~1 MGy/year
- Access 2-3 times per year

COMPATIBLE WITH R2M STUDIES

Sample holder design proposal
M. Maeder (SY-STI), Jan 2021

nTOF NEAR irradiation station,
Total dose simulation
M. Barbagallo (EP-SME), April 2020



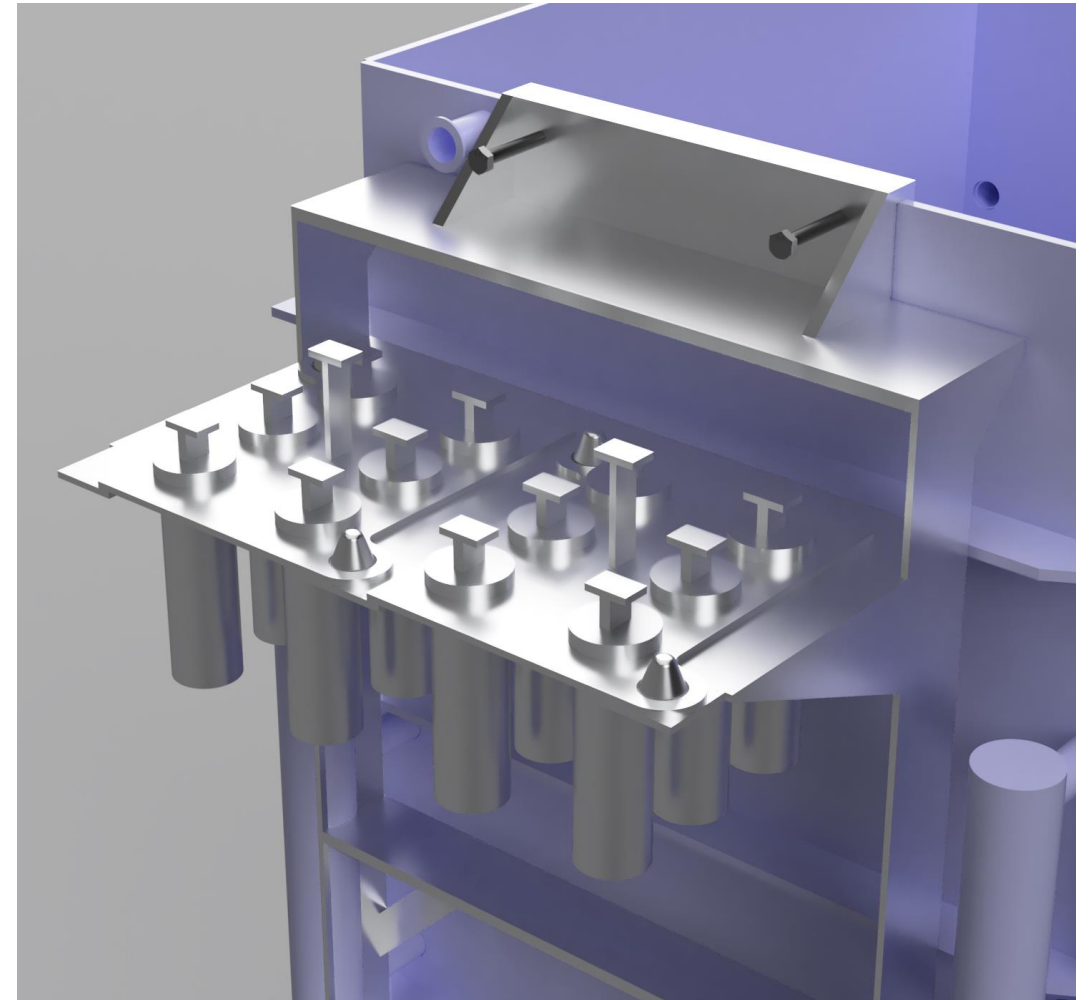
nTOF NEAR development status

CONTAINERS AND SUPPORT

- Minimal impact on the nTOF experiment
- Chemical compatibility
- RP considerations
 - low activation
 - low contamination risk
- Remote handling-compatible

FIRST RESULTS IN 2022

nTOF NEAR irradiation station, Design proposal
M. Maeder et al. (SY-STI), Jan 2021.



6. Take-home message

Take-home message

- Lubricants are sensitive to radiation
- An informed lubricant selection is crucial
- Limitations on previous work
- R2M studies on lubricants are needed for evolving conditions
- Studies in different irradiation conditions are complementary
- On-going in-house studies

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Thank you for
your attention!

