Status of Task 17.4-related activities

A. Lechner on behalf of Task 17.4 participants

2nd Annual WP17 meeting

ARIES is co-funded by the European Commission Grant Agreement number 73087

Task 4 description

Simulation of irradiation effects and mitigation methods

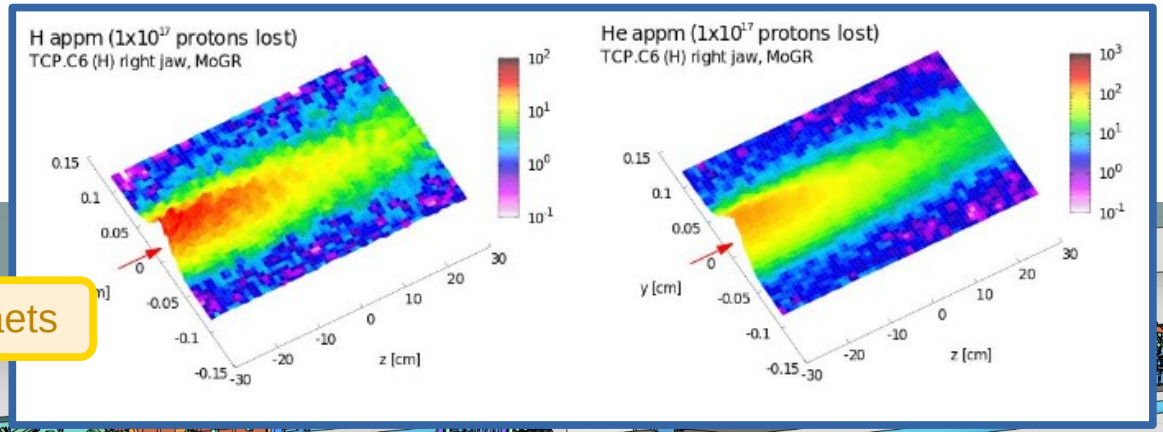
- Quantify Displacement Per Atom (DPA), gas production, nuclear transmutation for equipment in **complex accelerator environments**
- Provide a **relationship with irradiation experiments** at lower energies and/or with different particle species, in particular investigate and simulate the material damage induced by irradiation with protons and ions at various energies and fluences
- Ideally, relate radiation damage quantities (e.g. DPA) with **change of relevant macroscopic material properties**
- Assess annealing and temperature-related effects
- Open to **co-operate with other international collaborations** such as RaDIATE (Radiation Damage In Accelerator Target Environment)

Participants: CERN, GSI, POLIMI

ARIES

Simulation of rad. effects in HL collimators

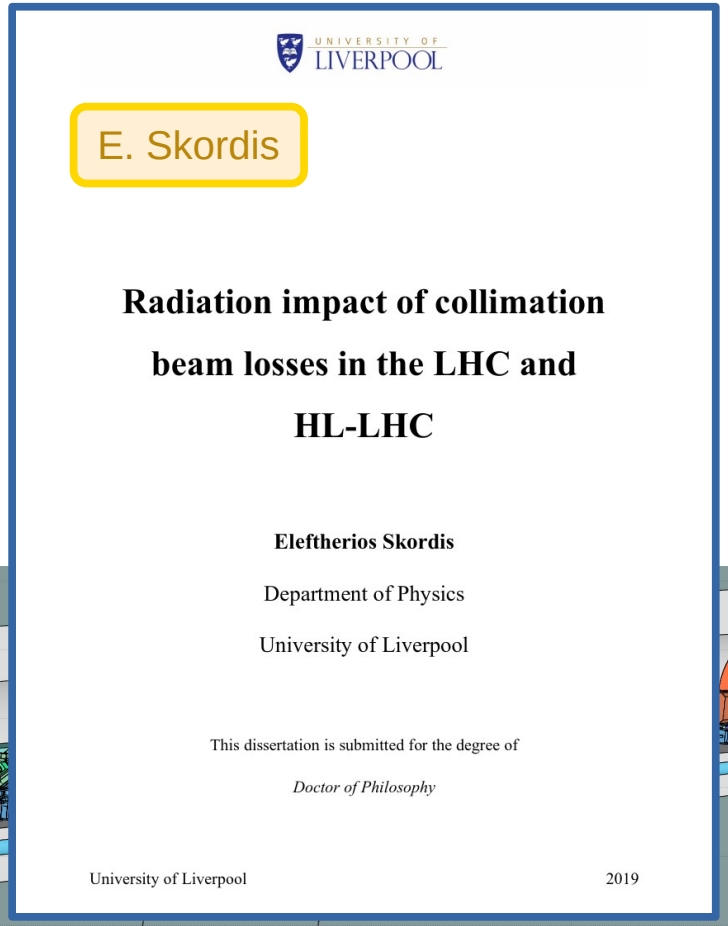
- The scoring functionality in the FLUKA simulation model was extended to calculate **gas production (H, He)** in collimators
- Obtained results for HL-LHC primary and secondary collimators (bulk and coatings) → important for comparing to irradiation experiments carried out with O(100 MeV) protons (BLIP)
- See talk by **A. Waets**



A. Waets

Simulation of rad. effects in HL collimators

- **E. Skordis** completed PhD thesis on radiation impact in HL collimators
  - estimates of beam losses in HL-LHC collimation region
  - first DPA calculations for HL
  - thesis defense took place in March 2020.


UNIVERSITY OF LIVERPOOL

E. Skordis

Radiation impact of collimation beam losses in the LHC and HL-LHC

Eleftherios Skordis

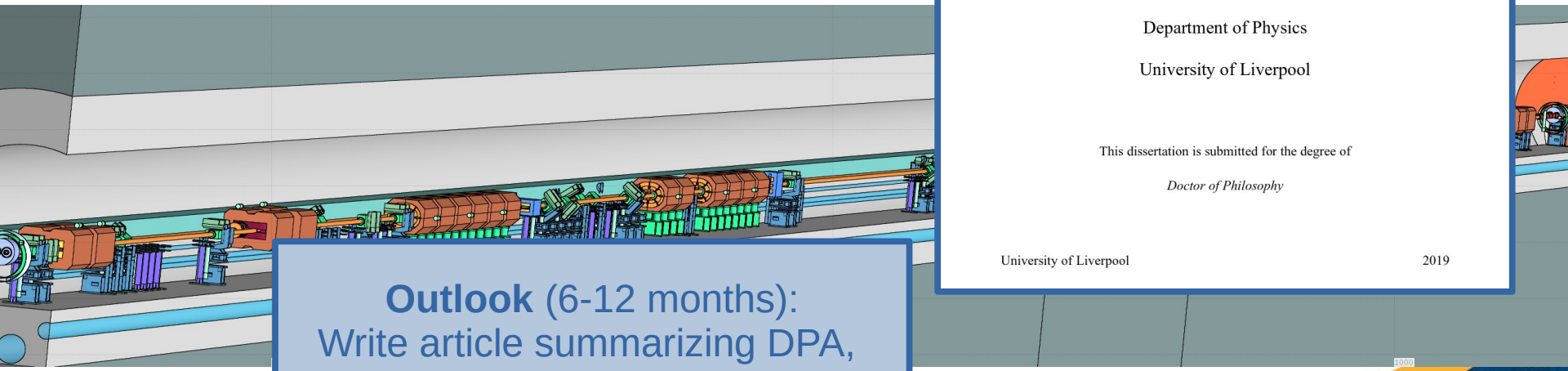
Department of Physics

University of Liverpool

This dissertation is submitted for the degree of

Doctor of Philosophy

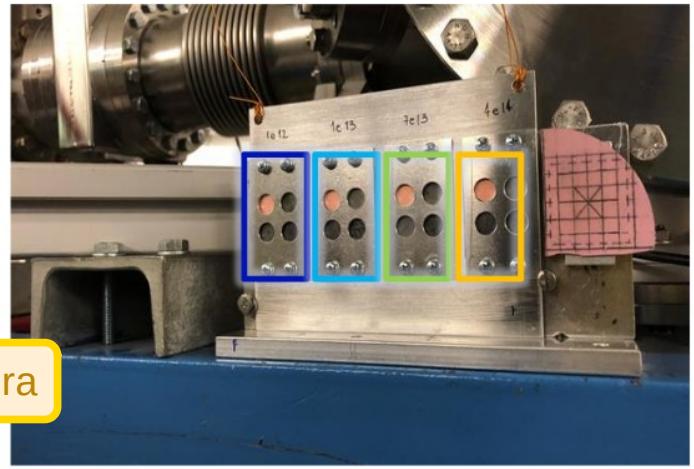
University of Liverpool 2019



Outlook (6-12 months):
Write article summarizing DPA, gas production in HL collimators

Irradiation of HL collimators materials @GSI

- Was performed in March 2019 at the M-Branch of the UNILAC accelerator at the GSI (**4.8 MeV/u Ca** ions, **113 h** of beam time)
- Different coated (Mo, Cu) and uncoated **MoGR**, **CfC** and **Graphite** samples included in the setup
- Samples were exposed to four different fluences (**10^{12}-4*10^{14} ions/cm^2**) → evaluate degradation vs DPA
- Maximum obtained DPA value equivalent to HL-LHC era



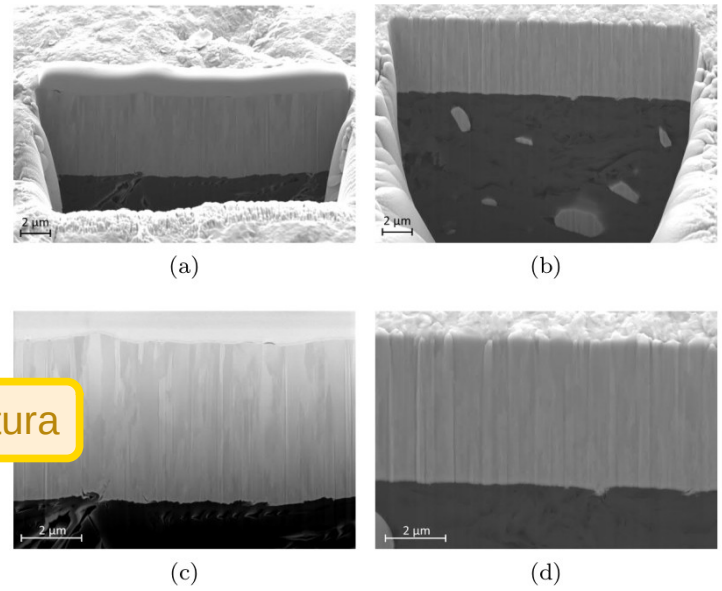
C. Accettura

	Peak DPA collimator HL-LHC life
Mo coating	$1 \div 3 \cdot 10^{-3}$
MoGr secondary	$4 \cdot 10^{-4}$
MoGr primary	0.3 *(in a small points, to be averaged)*

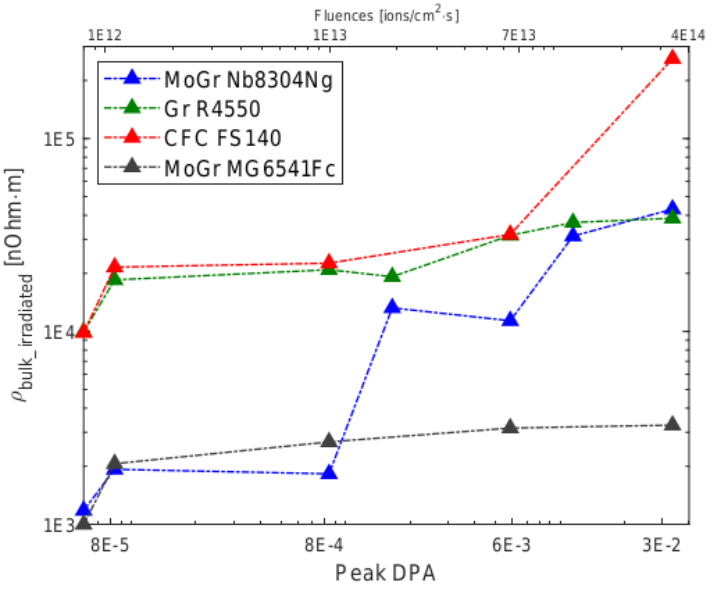
Fluences [ions/cm^2]	Peak DPA coating	Peak DPA bulk
$1 \cdot 10^{12}$	$\sim 2.8 \cdot 10^{-6}$	$\sim 1.1 \cdot 10^{-4}$
$1 \cdot 10^{13}$	$\sim 2.8 \cdot 10^{-5}$	$\sim 1.1 \cdot 10^{-3}$
$7 \cdot 10^{13}$	$\sim 1.9 \cdot 10^{-4}$	$\sim 7.8 \cdot 10^{-3}$
$4 \cdot 10^{14}$	$\sim 1.1 \cdot 10^{-3}$	$\sim 4.4 \cdot 10^{-2}$

Irradiation of HL collimators materials @GSI

- Samples were shipped to CERN after two month (dose rate <0.1 µSv/h)
- Post-irradiation examinations carried out since then:
  - electrical conductivity measurements of bulk and coatings
  - microscopic inspection with SEM-FIB
- See talk of **C. Accettura** for details on methods and results (publication under preparation)

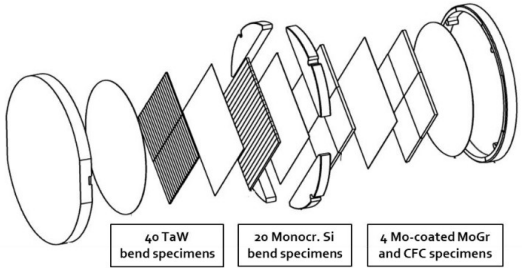


C. Accettura

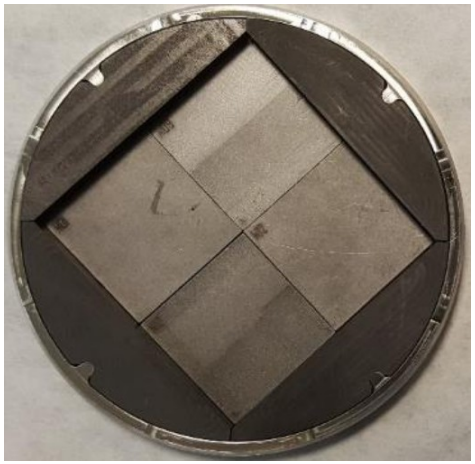


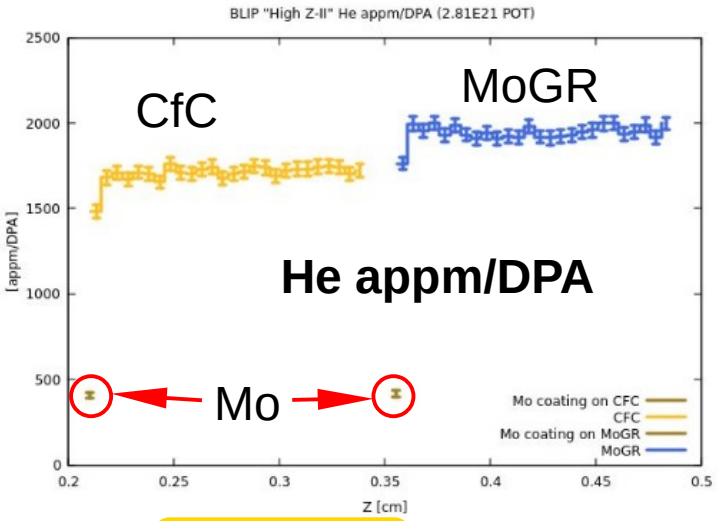
Irradiation of HL collimators materials @BLIP

- Irradiation carried out by **RaADIATE collaboration** (**M. Calviani et al.**)
- **MoGR** and **CfC** samples irradiated in RaDIATE target box (CERN2 capsule) in 2018 → in total 2.81×10^{21} protons on target
- Proton beam with 181 MeV: sizable H/He production → appm/DPA in the same ballpark as in future HL collimators
- Was confirmed in **updated FLUKA simulations in 2019**



N. Solieri,
M. Calviani et al.

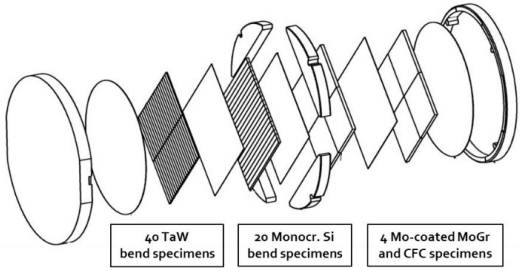




A. Waets

Irradiation of HL collimators materials @BLIP

- Activation > than for GSI tests → PIE needs to be carried out in industry
- Contract awarded to Framatome Gmbh last year (for visual inspection with a digital microscope, coating adherence tests + other options)
- Shipping to Germany originally planned earlier this year, but was postponed due to COVID-19 (should take place soon)
- See talk of **N. Solieri**



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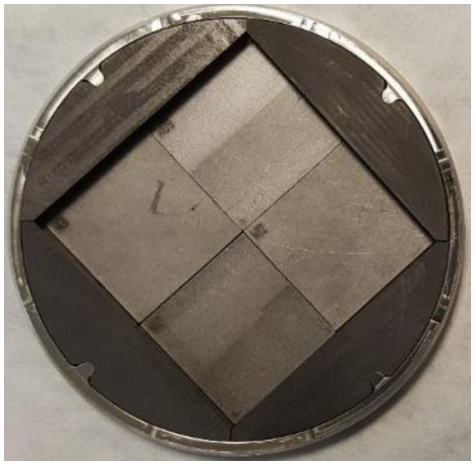

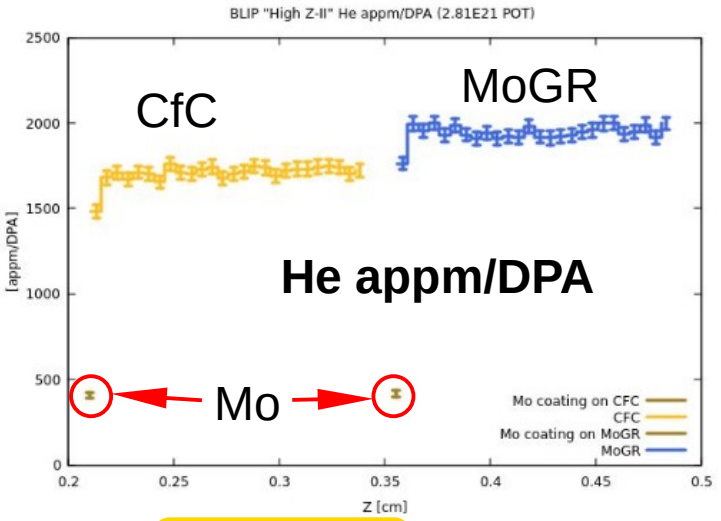

A. Waets

Upcoming tests (@GSI and @BLIP)

- Plan is to test new grade of MoGr (Nb8404Ng) with new powders (Mo coated), but also Graphite R7550 → same grades in both tests
- **GSI test (by CERN/GSI):**
  - Proposal submitted, awaiting approval by Scientific Committee
  - Goal is to assess dose rate effect

Talk of C. Accettura

- **BLIP test (by RaDIATE Collaboration):**
  - CERN3 capsule with CERN/Fermilab specimens, including the coated MoGR and Graphite samples
  - Irradiation test delayed due to COVID-19, but will probably still take place this year
  - FLUKA simulations have already been carried out

Talk of N. Solieri,

This session

Status task 17.4	*Anton Lechner*
376/1-020, CERN	13:30 - 13:50
Radiation damage and gas production simulations for HL-LHC collimators	*Andreas Waets*
376/1-020, CERN	13:50 - 14:10
GSI irradiation tests results and future test plans	*Carlotta Accettura*
376/1-020, CERN	14:10 - 14:30
Modelling of defects in graphite	*Marco Beghi*
376/1-020, CERN	14:30 - 14:50
Update on BLIP irradiation tests and RaDIATE activities	*Nicola Soleri*
376/1-020, CERN	14:50 - 15:10

Deliverables & Milestones

- **Deliverables:**
  - The task has one deliverable: “Report on simulations on irradiation effects [month 44]”
- **Milestones:**
  - No milestones are foreseen for Task 17.4