



Status WP17

WP17 Progress Meeting,
Online – 17.11.2020

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ARIES WP17: Objectives affected by COVID pandemic

- **Mainly experimental activities:**
 - **2nd irradiation campaign at GSI**
 - approved and initially planned for spring 2020- only half of the experiments which were scheduled as main beamtime were performed; secondary beamtime was cancelled
 - New proposals made for 2021- approved by PAC 2021,
 - Goal is to improve/extend findings of 2019 irradiation and test latest material grades
 - **Dynamic characterization tests at high temperature in POLITO**
 - Postponed due to the hard lockdown
 - The dedicated vacuum chamber was delivered
 - New timeline defined
 - **Shock experiments using high power laser beam experiments**
 - New proposal made for for experiments at the PHELIX laser at GSI in 2021 passed the technical board, approval by PAC pending
 - Workshop **“Extreme Beams meet Extreme Materials”** (MS62)
 - To be replaced by virtual workshop or by a a special issue in “Materials” open journal

Milestones

Milestone number ¹⁸	Milestone title	WP number ⁹	Lead beneficiary	Due Date (in months) ¹⁷	Means of verification
MS58	Organisation of PowerMat kick-off meeting (Task 17.1)	WP17	1 - CERN	6	Agenda, summary report
MS59	Irradiation campaigns at GSI for radiation hardness studies (Task 17.3)	WP17	23 - POLITO	27	Report to StCom
MS60	Irradiation effects analysis (Task 17.3)	WP17	1 - CERN	36	Report to StCom
MS61	Comparative compendium of materials developed (Task 17.2)	WP17	1 - CERN	40 M 43	Report to StCom
MS62	Dissemination of R&D results on novel materials for accelerator and societal applications (Task 17.5)	WP17	12 - GSI	46 M 51	Report to StCom

Deliverables

Deliverable Number ¹⁴	Deliverable Title	Lead beneficiary	Type ¹⁵	Dissemination level ¹⁶	Due Date (in months) ¹⁷
D17.1	Material characterization	1 - CERN	Report	Public	12
D17.2	Irradiation effect simulations	1 - CERN	Report	Public	44 M 50
D17.3	Irradiation test results	23 - POLITO	Report	Public	46 M 54

Task 17.1 – Status and Outlook

- Transnational Activities
 - Irradiation experiment at GSI UNILAC in March-April 2019
 - New irradiation campaign at GSI in March-Apr. 2021
 - Shock experiment on accelerator material at PHELIX laser at GSI approved for 2021

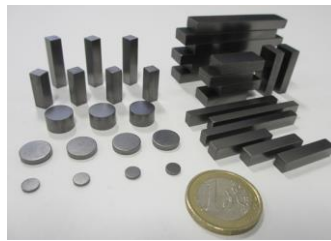
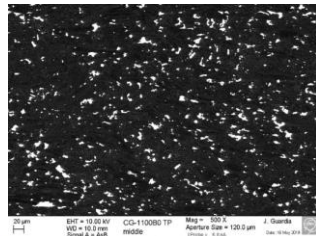
Task 17.2: *Materials development and characterization*

Molybdenum Carbide – Graphite (MoGr) from R&D to industrialization ...

- Large contract for the production of MoGr blocks for 5 primary and 10 secondary **HL-LHC collimators. Total of 380 blocks**
- **Main challenges highlighted by the industrial phase:** tight tolerances (require a multi-stage machining process) and UHV (high-precision control of the cycle parameters)
- **Material production completed in April 2020, first collimators already installed in the machine!**
- Blocks for secondary collimators **coated with molybdenum** layer to further **increase electrical conductivity**

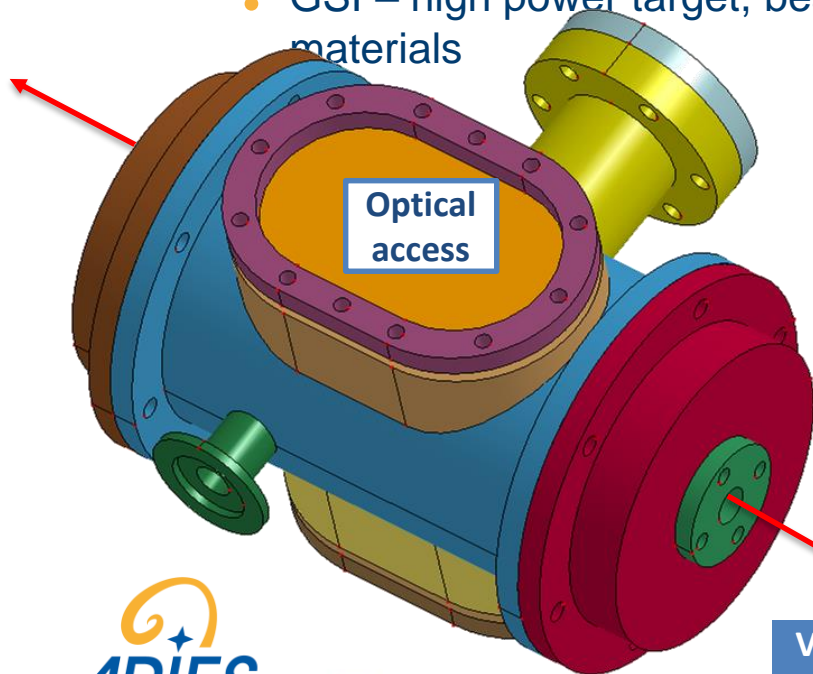
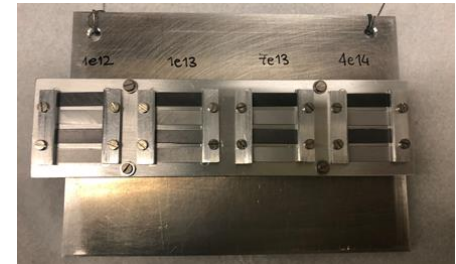
Novel **Chromium – Graphite** (CrGr) composite under development as **lower cost** alternative to MoGr

- 4 different CrGr grades, produced by Brevetti Bizz, investigated
- Thermo-physical analyses and microstructural characterization -performed
- **Record high thermal conductivity** - $739 \text{ Wm}^{-1}\text{K}^{-1}$ at 20°C



Task 17.3: Dynamic Testing and Online Monitoring

- Continuation of analysis of data from irradiation campaign at GSI and from HiRadMat
- Fracture mechanics and high strain-rate tests. POLITO
 - Tests expected in coming months. Some delay in delivery of on-sample furnace for ad-hoc test bench
 - Benefiting experiments / materials:
 - CERN – collimator and beam absorber materials
 - GSI – high power target, beam dumps / catchers, luminescence screen materials



MoGr, CC, 3D CFC samples for quasi-static and dynamic tests at high temperature

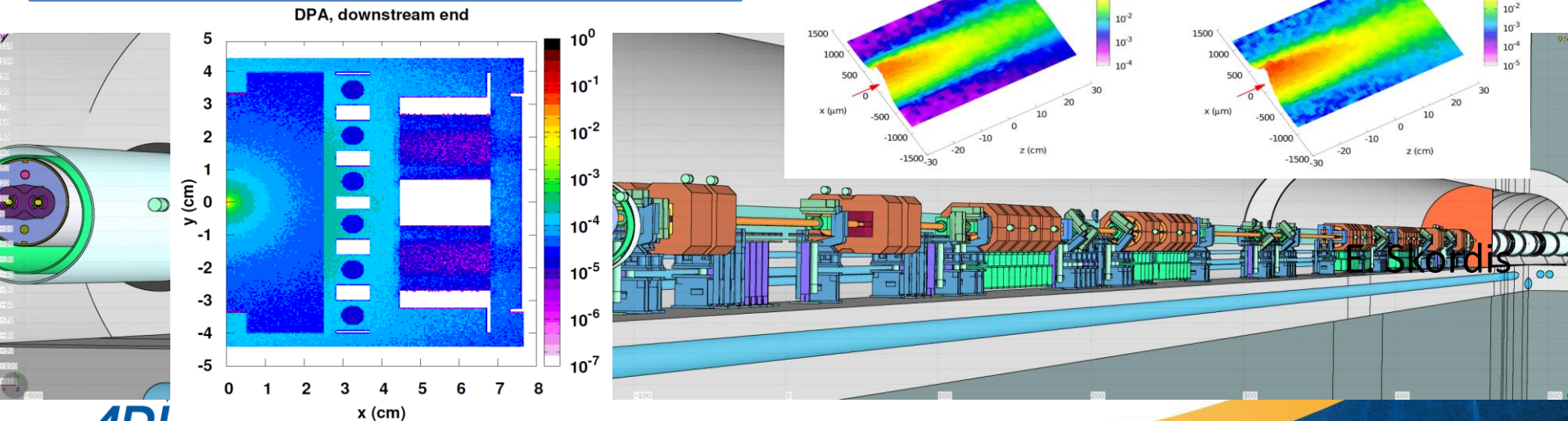


Vacuum chamber for Hopkinson bar apparatus delivered

Task 17.4 – Simulation of radiation effects

- Assessment of long-term radiation damage in HL-LHC collimators
 - Finalized **displacement damage** predictions for collimator bulk materials and coatings through complex shower simulations
 - Obtained estimates of **H/He gas production** in primary and secondary MoGR/CfC collimators
 - Confirm that appm/DPA ratio is of the same order as achieved in the BLIP irradiation
- Upcoming studies: assessment of long-term radiation damage in future GSI and CERN facilities

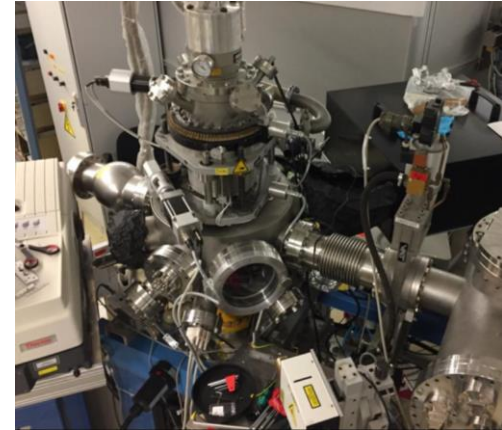
Displacement Per Atom (DPA) in HL-LHC
(1×10^{17} protons lost in collimation system)



Task 17.5 - Broader accelerator and societal applications

Diamond and diamond-metal matrix composites for luminescence applications

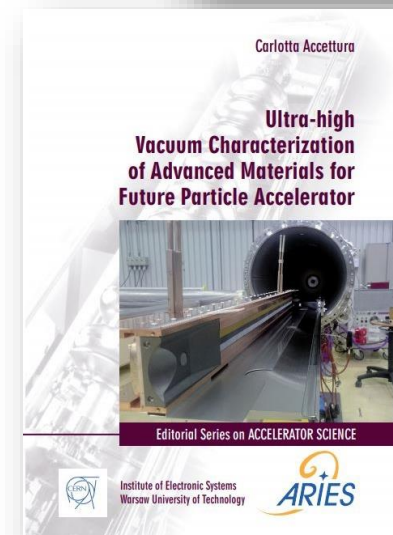
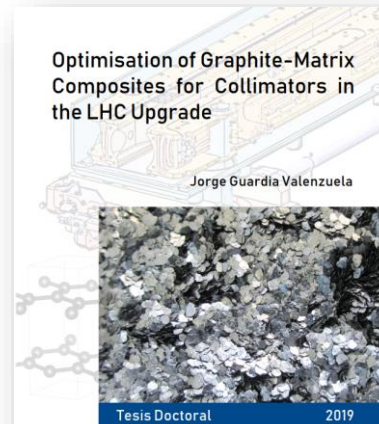
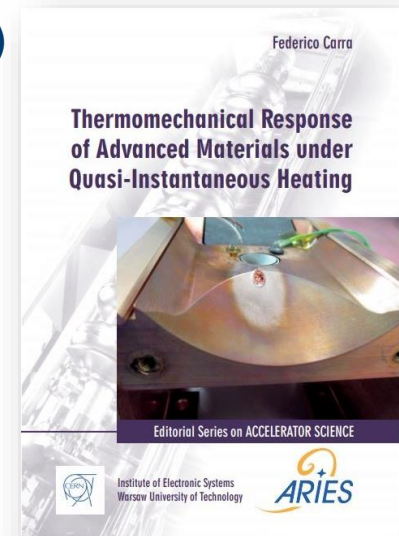
- Evaluation of the results from 2019 beamtime at GSI
 - Ion species / energy: Ca, Sn, Au / 4.8 MeV/u
 - Irradiated samples:
 - CuCD (1 & 10 μm),
 - TiCD (45 μm)
 - Single-crystalline HPHT Diamond
 - Experiments:
 - In-situ Raman & FT-IR spectroscopy
 - On-line iono-luminescence
 - Results:
 - For diamond composites - small diamond grids graphitize during production → negative impact on luminescence
 - 3H color center (503.4 nm, dual split-interstitial) identified as main contributor to luminescence
 - No observation of nitrogen-related defects in iono-luminescence
 - In-situ Raman shows significant creation of nitrogen vacancies
 - *Performed during beamtime in February 2020:*
 - Cryogenic in-situ UV/c absorption spectroscopy
 - Cryogenic on-line iono-luminescence



M3-branch at UNILAC: Multi-purpose UHV chamber with cryogenic sample holder and various spectrometers.

WP17 Outreach: Publications

- 10 PowerMat-related **Articles** and 2 **Theses** (PhD and Master) uploaded in **Zenodo**
- 2 additional **PhD theses** including one with **IP-sensitive** content with deferred publication
- **Open Access** articles in **Carbon** and **Acta Materialia** journals
- Two volumes in **ARIES** monographs published by WUT
- 5 articles on **Structural and Wave Propagation Effects in High-Energy Particle Impacts** submitted to open access journal - **Shock and Vibration**



What's next - IFAST - approved

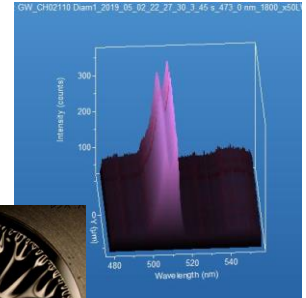
WP4.3

- **Task 4.3. - GRAPH&BEAWIN**

Beam windows for high-power accelerator applications. Suspended graphenic membrane beam windows for next generation accelerators

Originating in activities in task 17.5. on materials for broader accelerator applications

- **Participants:** CERN, GSI, WWU Münster, RHP
- **EC contribution: 100 k€ / Duration: 32 months**



Raman spectra of GM



graphenic membrane (GM)

- **Task 4.4.– “Large scale Carbide-Carbon Materials for multipurpose applications”** naturally follows the R&D and industrialization phases for the carbide-carbon materials.

- Aim is to **decrease the production costs** to broaden the industrial use, by two methods:

- **Participants:** CERN, Nanoker (ES)
- **EC contribution: 120 k€ / Duration: 4 years**



Overview and Outlook

- Significant progresses in materials development, characterization, testing, and simulation in all WP tasks.
- ARIES greatly contributed to have some of these materials qualified, produced in series and installed in HL-LHC Collimators for LS2.
- All deliverable and MS achieved so far. Substantial outreach, including articles, theses and workshops.
- WP activity continuing (at smaller scale) as tasks 3 and 4 in WP4 of I-FAST
- COVID-19 pandemic has jeopardized a number of activities planned for end of year and year 4:
 - Additional TNA irradiation experiment at GSI
 - Dynamic characterization of materials in POLITO with new high temperature set-up
 - Preparation of first high power laser beam experiments
 - Dissemination activities through joint workshop with WP6
 - Extension of WP by 8 months, postponing of deliverables and milestones requested