IRRADIATION OF LUMINESCENCE DOSIMETERS IN STRAY RADIATION FIELD IN LASER-DRIVEN ACCELERATORS

A. Cimmino[1], I. Ambrožová[2], R. Versaci[1], V. Olšovcová[1], V. Stránský[1], R. Truneček[1]

1) *ELI Beamlines, Institute of Physics, Academy of Sciences of the Czech Republic, Czech Republic*
2) *Dep. of Radiation Dosimetry, Nuclear Physics Institute, Czech Academy of Sciences, Czech Republic*

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Faculty Disclosure

X	No, nothing to disclose
	Yes, please specify:

UHDPulse: WP4-A4.2.1

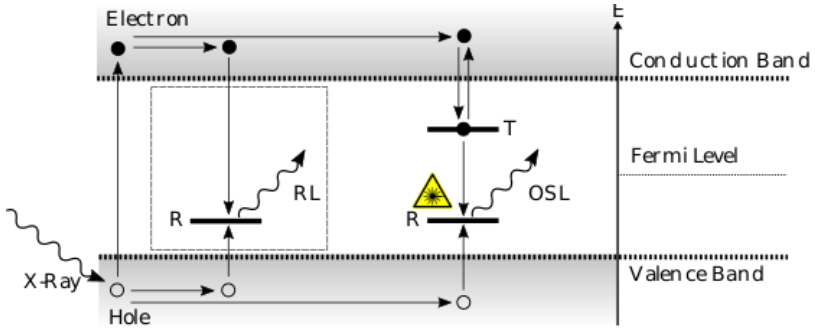
- UHDpulse project:
  - Work Package 4 – Activity 4.2.1: *Testing of luminescence dosimeters in stray radiation fields.*

- Stray radiation fields:
  - Are inevitably associated with all therapeutic beams
  - May cause damage to healthy tissue and organs outside the targeted area → need to characterized and understood
  - Have the same pulsed time structure of the primary beams → same metrological issues as primary field
  - Are mixed fields, i.e. composed of different types of particles with different energies → The various field components need to be identified.

- Solid state dosimeters are being investigated, in this context, by ELI Beamlines (https://www.eli-beams.eu/) and UJF CAS (http://www.ujf.cas.cz/en/)

Optically Stimulated Luminescence Detectors (OSLD)

- Optically Stimulated Luminescence:
  - is the emission of light from a previously irradiated material when stimulated with photons of a specific energy.



https://commons.wikimedia.org/wiki/File:Optically_Stimulated_Luminescence_Dosimeter_Energy_Diagram.svg

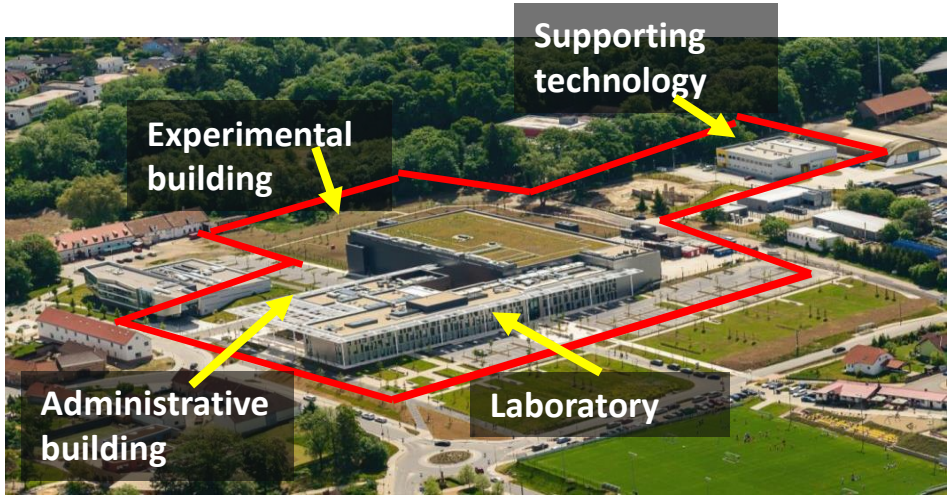
- The intensity of the emitted light is proportional to the absorbed energy

- BeO - OSLDs have good dosimetric properties:
  - High sensitivity to ionizing radiation
  - Wide linear response (~1µGy – few Gy)
  - Tissue equivalent (Z_{eff} = 7.2)
  - Sensitive to artificial and natural light

ELI Beamlines – International

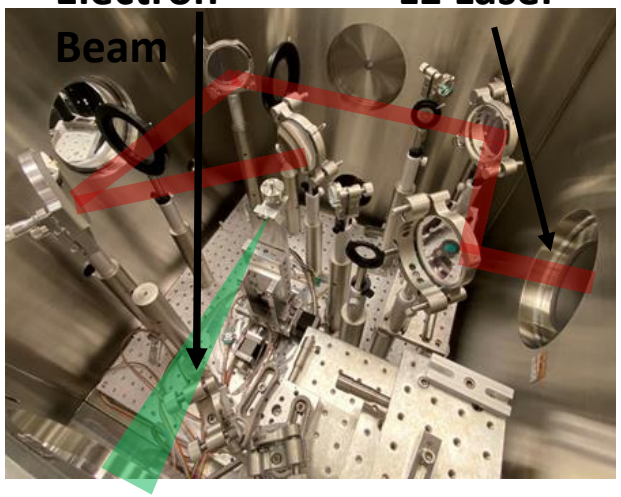
ELI (Extreme Light Infrastructure) Beamlines

Laser	Energy [J]	Power [TW]	Rate [Hz]
L1 (ALLEGRA)			
(present)	0.03	1.5	10^3
(target)	0.1	5	10^3
L2 (AMOS)	2	10^3	50
L3 (HAPLS)			
(present)	30	333	3.3
(target)	30	10^3	10
L4 (ATON)	$2 \cdot 10^3$	10^4	0.1



- The **ALLEGRA** laser (design performance)
  - Developed in house by the ELI Beamlines laser team.
  - The laser system is designed to generate <20 fs pulses with
  - energy exceeding 100 mJ per pulse
  - high repetition rate (1 kHz).

ALFA Experiment - 2020



Courtesy of Dr. G.M Grittani & the ALFA Team

ALFA (Allegra Laser For Acceleration)

- Electron beam of energy up to 50 MeV with nominal laser parameters

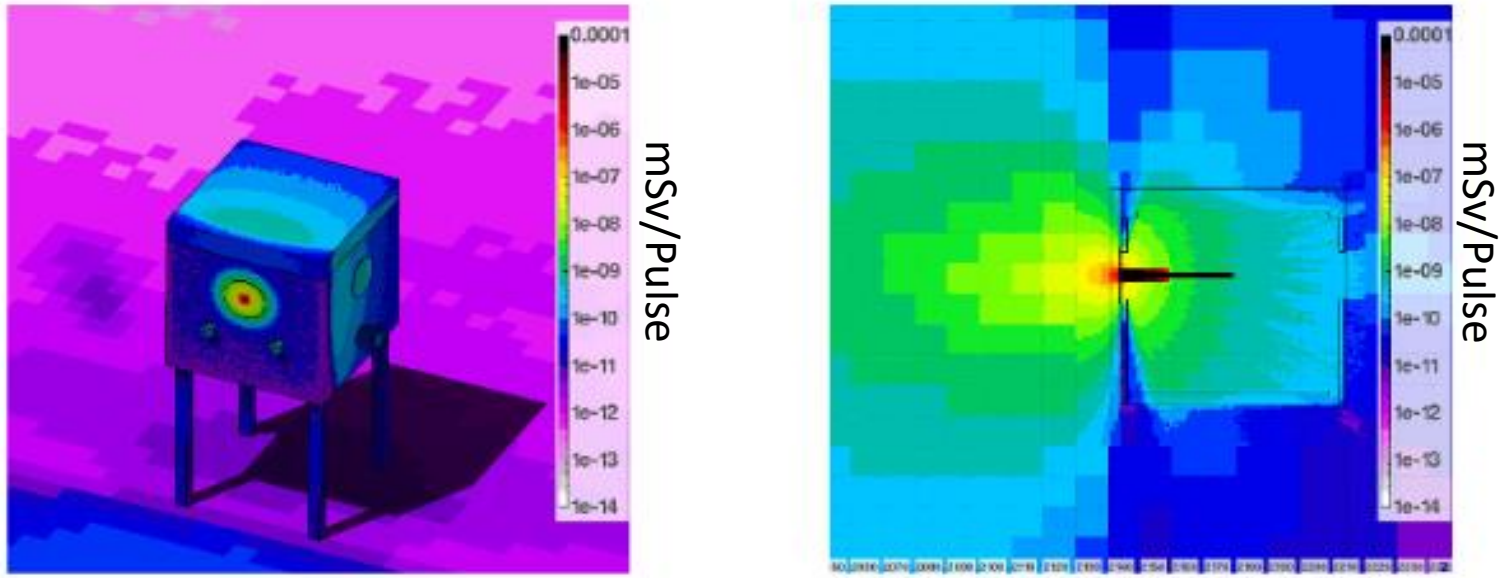
ALFA commissioning in Feb. 2021

- Laser is working at 1 kHz, but pulses were done by operating a mechanical shutter (minimum 2 sec)
- Plasma generation and acceleration was triggered at 1Hz
- Pulse burst were in : single, 20 msec and 100 msec mode
- ~ 8000 pulses at low energy (6 mJ) with very weak signal
- ~500 pulses at high energy (22 mJ)
- 2 minutes of continues operation
- Beam characteristics:
  - Few pulses >5-10 MeV
  - Energy > 0.5 MeV beam
  - Ang Distr. 90 mrad,
  - Charge 1 pC/pulse

FLUKA Monte Carlo

PARTICLE TYPE	
No of primaries/charge:	1 pC / shot electrons
Source size:	pointlike
Angular distribution:	250 mrad divergence, gaussian angular distribution
Energy spectrum:	Maxwellian distribution with 300 keV temperature

Courtesy of D. Horvath (ELI Beamlines RP Group)



H*(10) at contact with experimental chamber only [mSv per pulse].

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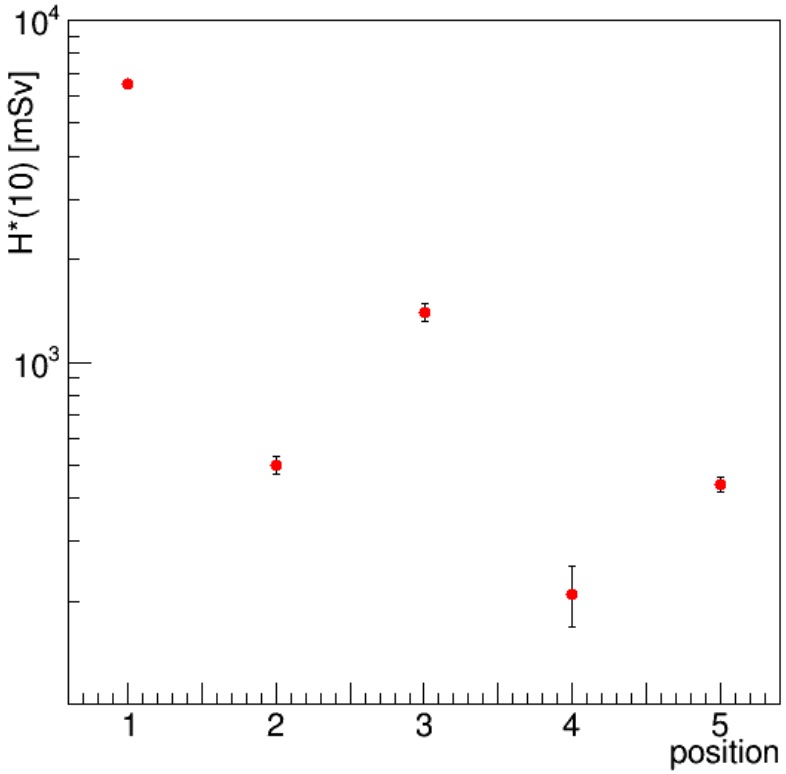
BeO- OSLDs: Results



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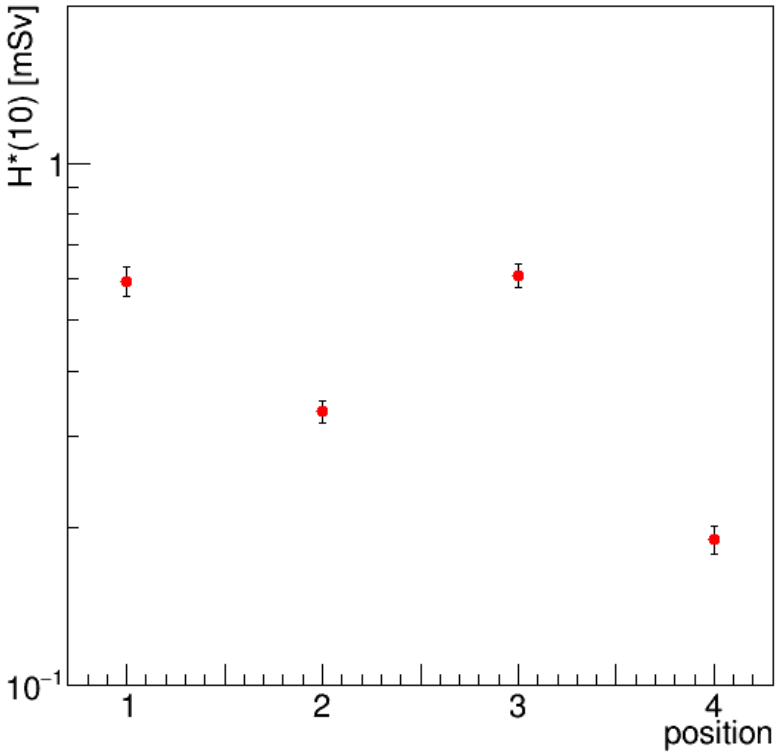

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Conclusions

- UHDPulse - Work Package 4 - Activity 4.2.1: *Testing of luminescence dosimeters in stray radiation fields*:
  - BeO – OSLDs were irradiated in a stray radiation field, using a laser-driven electron beam @ ELI Beamlines.
  - Preliminary results were presented.
  - Laser-driven radiation fields are complex and not well characterized as those produced in conventional accelerators.
  - The discrepancy data/Monte Carlo can be attributed to unknown geometrical features of the beam and uncertainties of the source term.

- Future plans :
  - Repeat measurements using laser driven proton beams
  - Add different detector technologies with different sensitivities to different particles
    - Thermoluminescence dosimeters:
    - Electron and proton laser-driven beams

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