High-Level Dosimetry (HLD)

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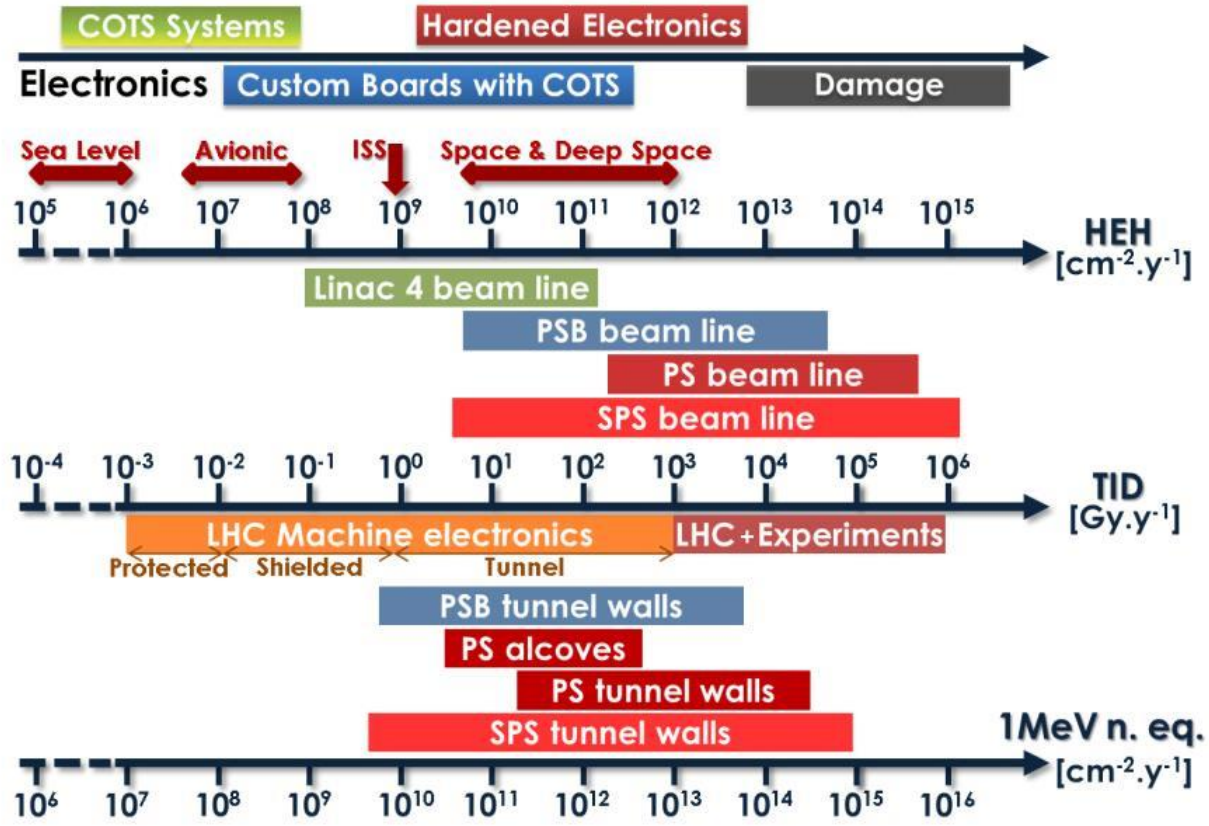
R2E Annual Meeting – 2-3 Feb, 2021
https://indico.cern.ch/event/971222/

CERN radiation environment

Accelerator complex presents a mixed radiation field in the tunnels and adjacent caverns

Radiation damage

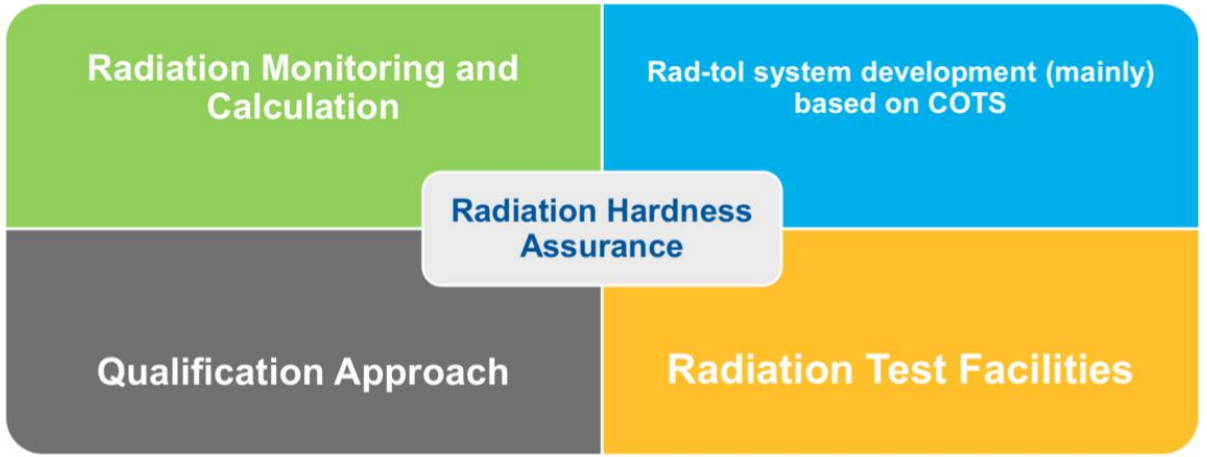
Impact on the lifetime of the equipment and it can lead to **machine downtime**



CERN-ACC-NOTE-2015-0042

Radiation Hardness Assurance (RHA)

The **monitoring and calculation of radiation levels** are a key element to develop a **Radiation Hardness Assurance (RHA)** procedure.



Mitigation approaches:
Rack relocations whenever possible, or implementation of extra shielding

Monitoring and Calculation Working Group (MCWG)

Analysis of the distribution and evolution of the radiation fields along the CERN's accelerator complex

- Radiation data based mainly on:
  - **Active dosimeters:** Beam Loss Monitor (BLM), RadMon, optical fibers;
    - New monitor installations are constrained to some infrastructure requirements
    - Large coverage but typically limited to dose levels up to 10kGy.
  - **Passive dosimeters:** RadFET, High-Level Dosimeters (HLD)
    - Easy of deployment → no infrastructure requirements
    - Small dimensions → can be placed next to equipment
    - Higher dose range → RPLs can reach up the MGy
- Fluka simulations → benchmark studies

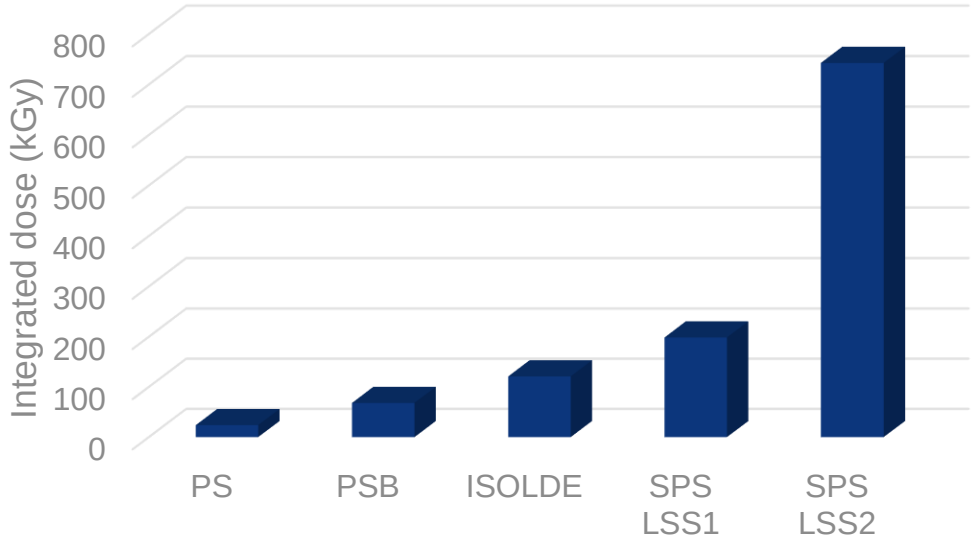
Applicability of the HLD service

- Synergy with the main activities in the MCWG
  - provides supplementary radiation level measurements where active dosimeters are not suitable.

- Assessment of irradiation testing conditions
  - Only option for high-dose requirements in Radiation to Materials (R2M) experiments which irradiations can reach up to several MGy, for example.

High-Level Dosimetry (HLD) activity

- **HSE-RP:** annual report of accumulated dose is released roughly every 2 years
- More than 1700 dosimeters in the surveyed areas (around 400 in the PS complex, around 750 in the SPS complex and around 550 in the LHC complex)



Annual Report 2016, EDMS 2408778

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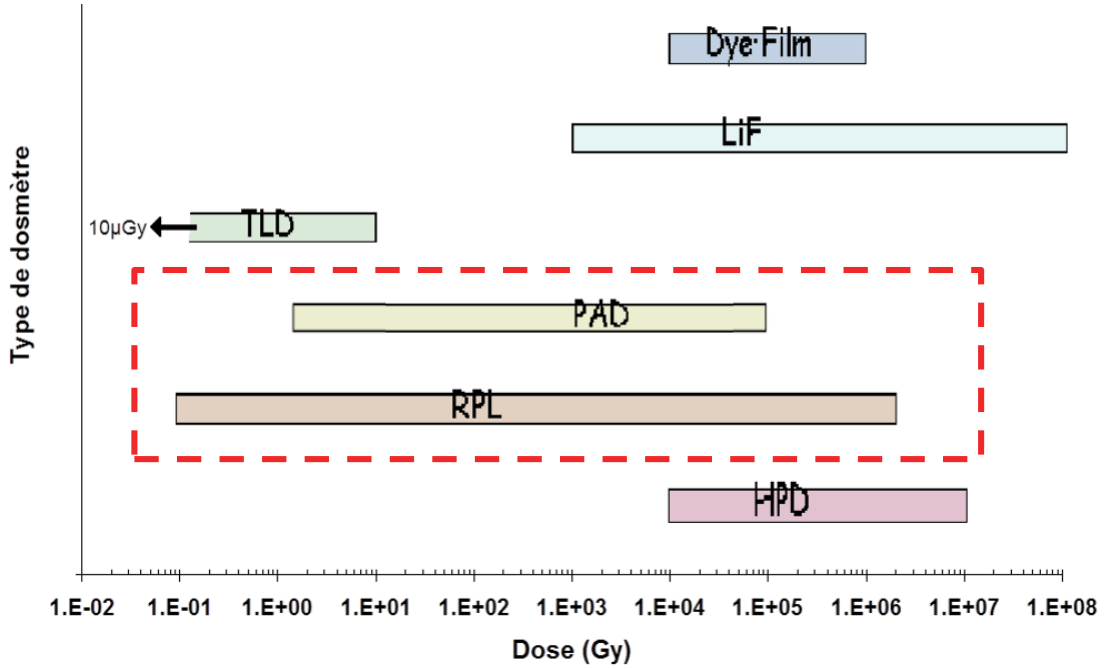
High-Level Dosimetry (HLD) activity

Monitoring of the accumulated dose is done using two passive dosimetry systems:



Polymer Alanine Dosimeter (PAD)

Radio-Photo-Luminescence Dosimeter (RPLD)

Main dosimeter system

Polymer Alanine Dosimeter (PAD)

Dosimeter composed of **alanine ($C_3H_7NO_2$)** and a polymer mixture

Cylinder (length: 2 cm, diameter: 0.4 cm)

Low dose **Mid dose** **High dose**

Irradiation of alanine creates free radicals → proportional to absorbed dose

Readout measurement based on the **Electro Spin Resonance (ESR)**

Dose range: 1 Gy – 100kGy

Radio-Photo-Luminescence Dosimeter (RPLD)

Cylinder: **Ag-activated metaphosphate glass**
(length: 8.5mm, diameter: 1.5mm)

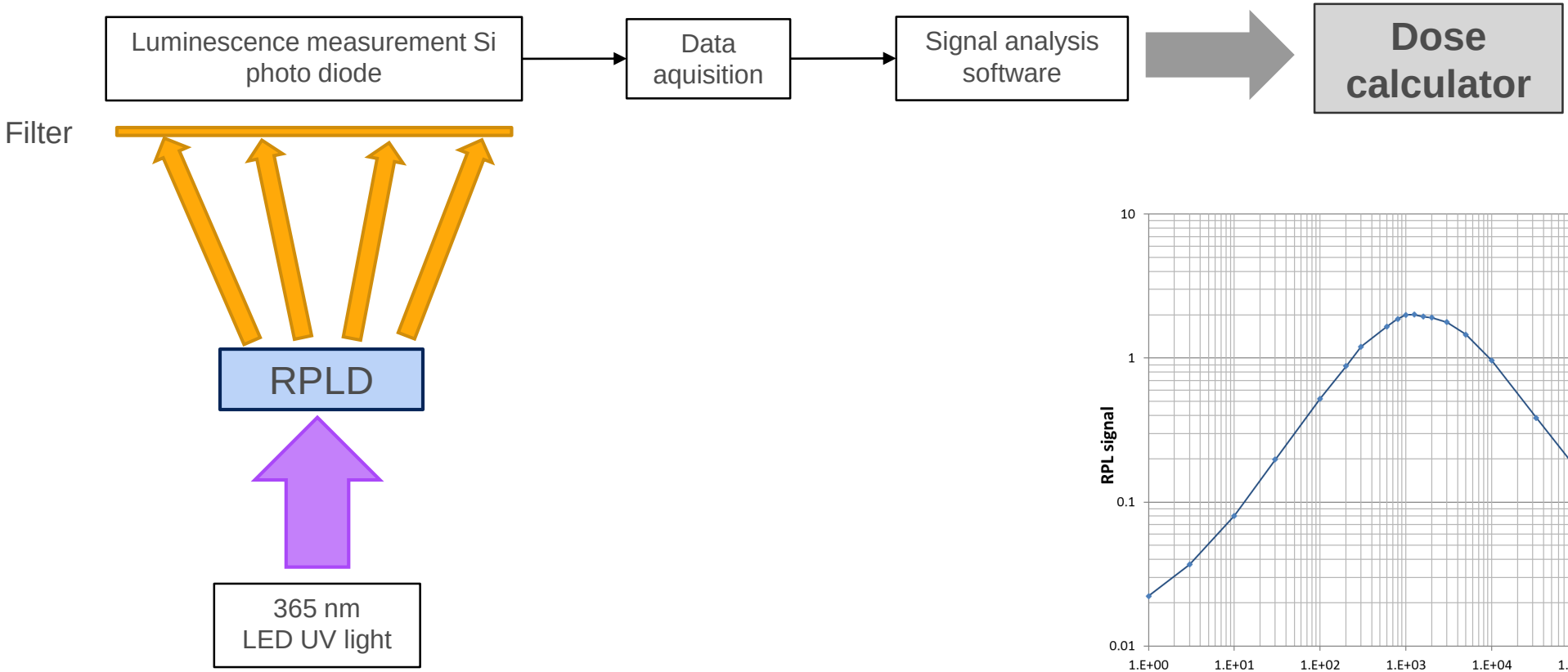
Irradiation creates **Radio-Photo-Luminescence (RPL)** and **colour centres**

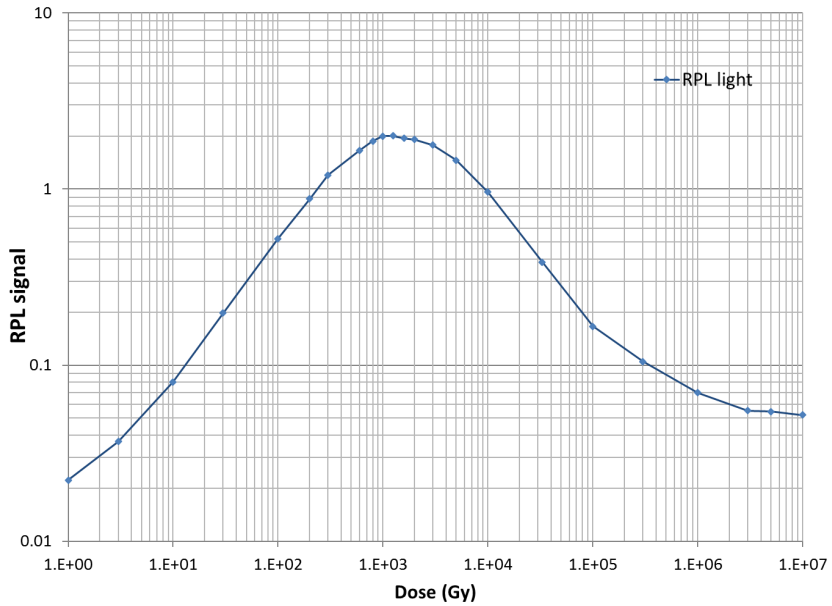
Readout measurement based on an in-house setup

Dose range: 1 Gy – MGy

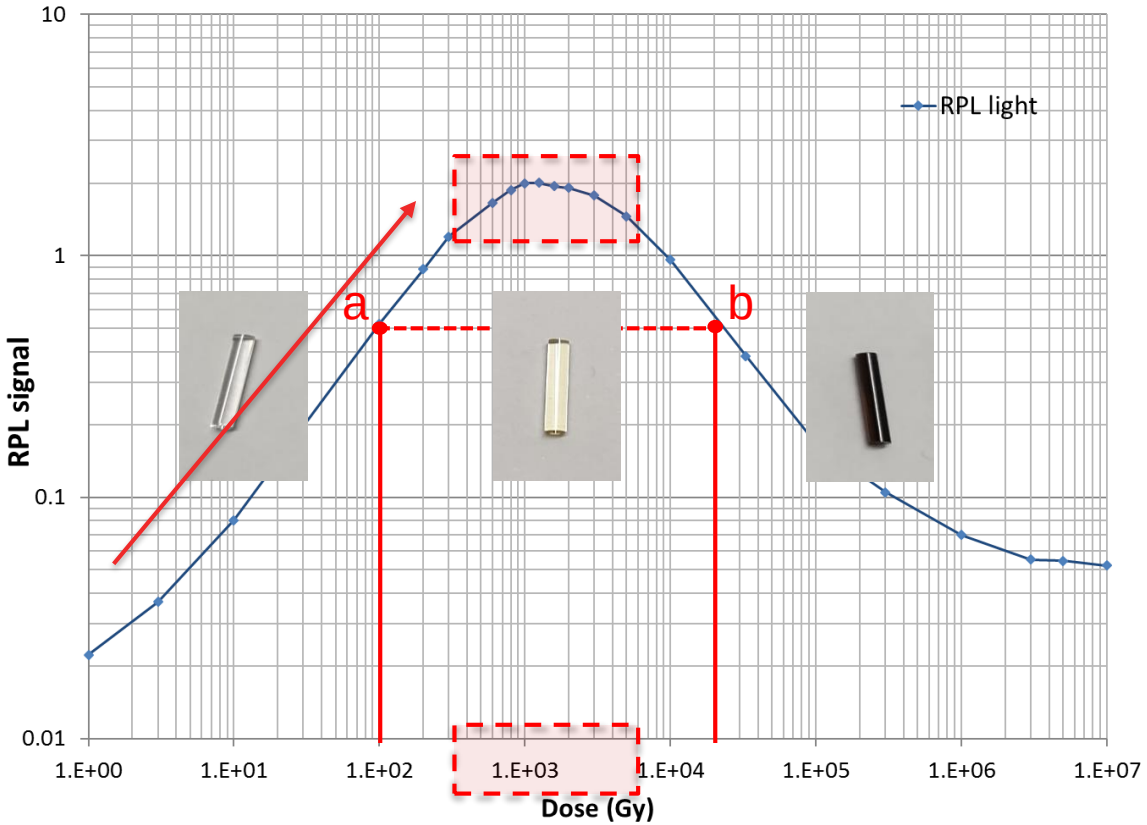
Irradiated RPL dosimeters when being illuminated with UV light

RPLD readout setup





RPL signal



Increased photon absorption by the colour centres for mid and high dose range
→ **reduction in the RPL signal**

Need to identify the colour of the dosimeter → by **naked eyes**

Mid dose range (around 1kGy) is a critical area high uncertainties for the dose analysis

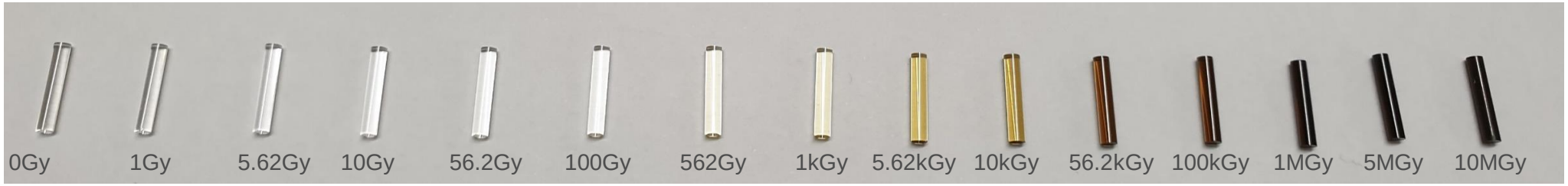
Point **a** and point **b** correspond to the same RPL signal but different absorved dose!

Solution: Transmission Light

Measurement of the **transmission light** for a blue LED light emission

→correlates to the density of colour centres

→no need for the identification of the dosimeter colour by naked eyes analysis



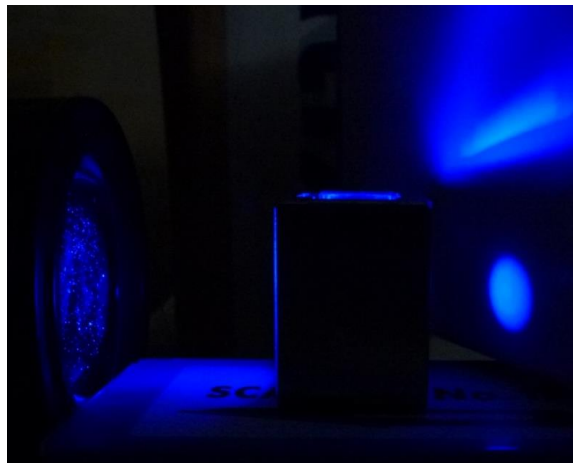
Increase of colour centres

Solution: Transmission Light

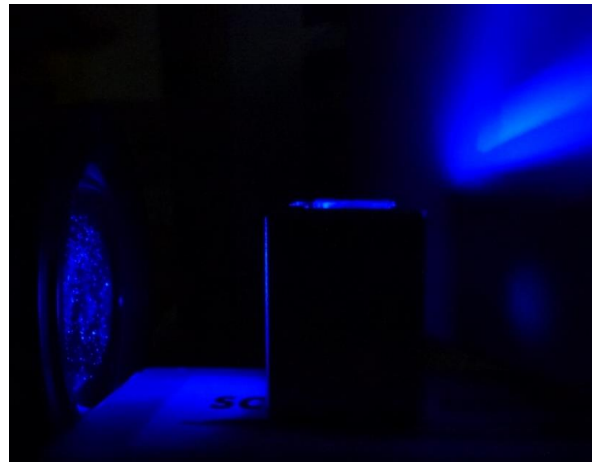
440 nm LED light

Low dose

Mid dose

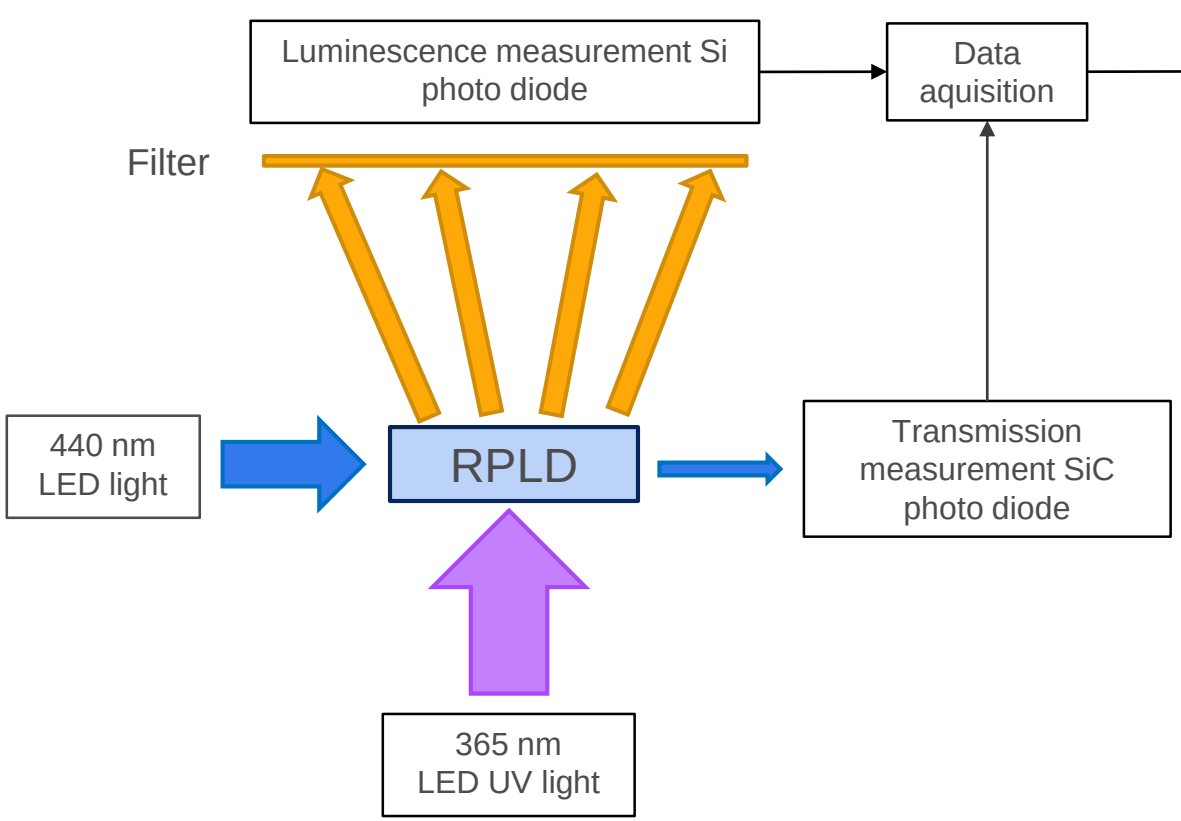


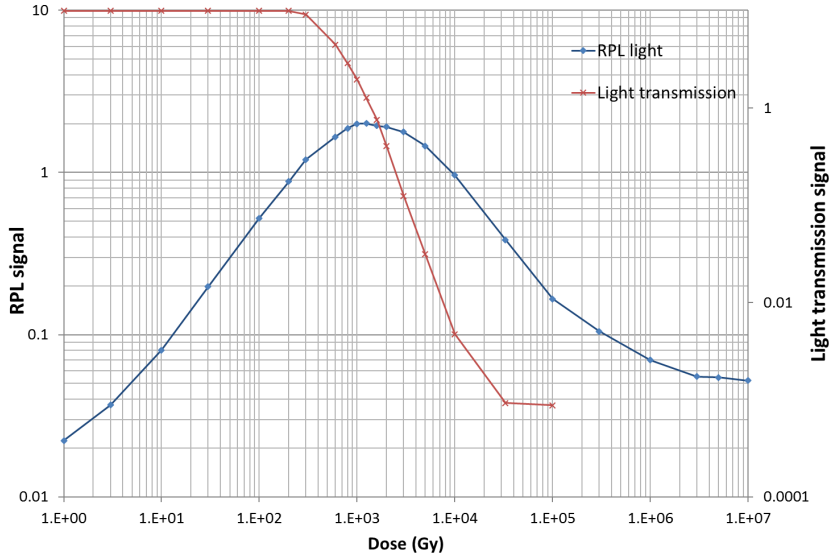
High dose



Increase of colour centres

RPLD readout (RPL and transmission light)





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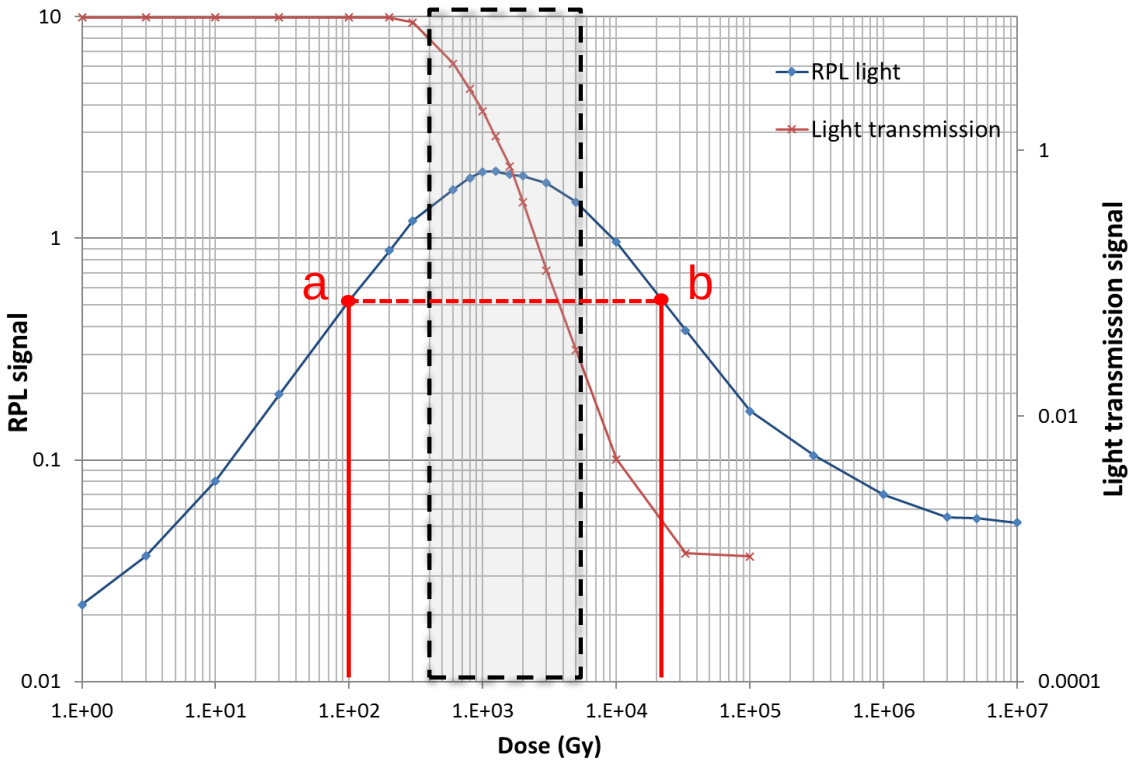

Transmission light is used to:

1) differentiate automatically between transparent and brown region

- Transmission signal in point a is different from the signal in point b

2) analyse problematic dose range with **higher accuracy**

More information: Technical Note EDMS **2275199**

System developed by HSE-RP and patented by CERN
WO 2014/161732 A1

Conclusions

Monitoring and Calculation of radiation levels are essential to increase the performance and availability of systems

→ Mitigation approaches

→ RHA methodologies

High-Level Dosimetry (HLD) provides information on accumulated dose in a wide range → from Gy to MGy

PAD/RPLs can be placed next to the machines where other dosimeters might not be suitable due to their size or to specific infrastructure requirements

HLD service is **entirely** provided at CERN, including the readout measurement of the dosimeters.

Thank you for
your attention!

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