

Personnel interlock systems for protection against ionizing radiation produced by FEL beams and high power lasers

M. Dressel, B. Racky

DESY Hamburg

Germany

Outline

- > Very brief: from risk assessment to safety function in general
- > Multiple sources of ionizing radiation at the HED (High Energy Density Matter) of European XFEL
- > Simplified example requirement on safety function
- > Switching off LASERs with safe actuators

Risk assessment very brief (EN 1200)

> Risk assessment

- Define limits of facility, operation, system ...
- Identify possible hazards
- Estimate risks
- Possibly reduce risks

→ safety functions with required SIL performance

> We consider hazards due to ionizing radiation **only**

SIL safety function very brief (EN 62061)

> Systematic safety integrity

- Safety plan
- Quality of components
- Use within limits and according to specifications
- Verification, validation

> Hardware safety integrity

(Quantitative requirements on the probability of dangerous failure)

- Probability of Failure on Demand PFD_i (of partial system i):

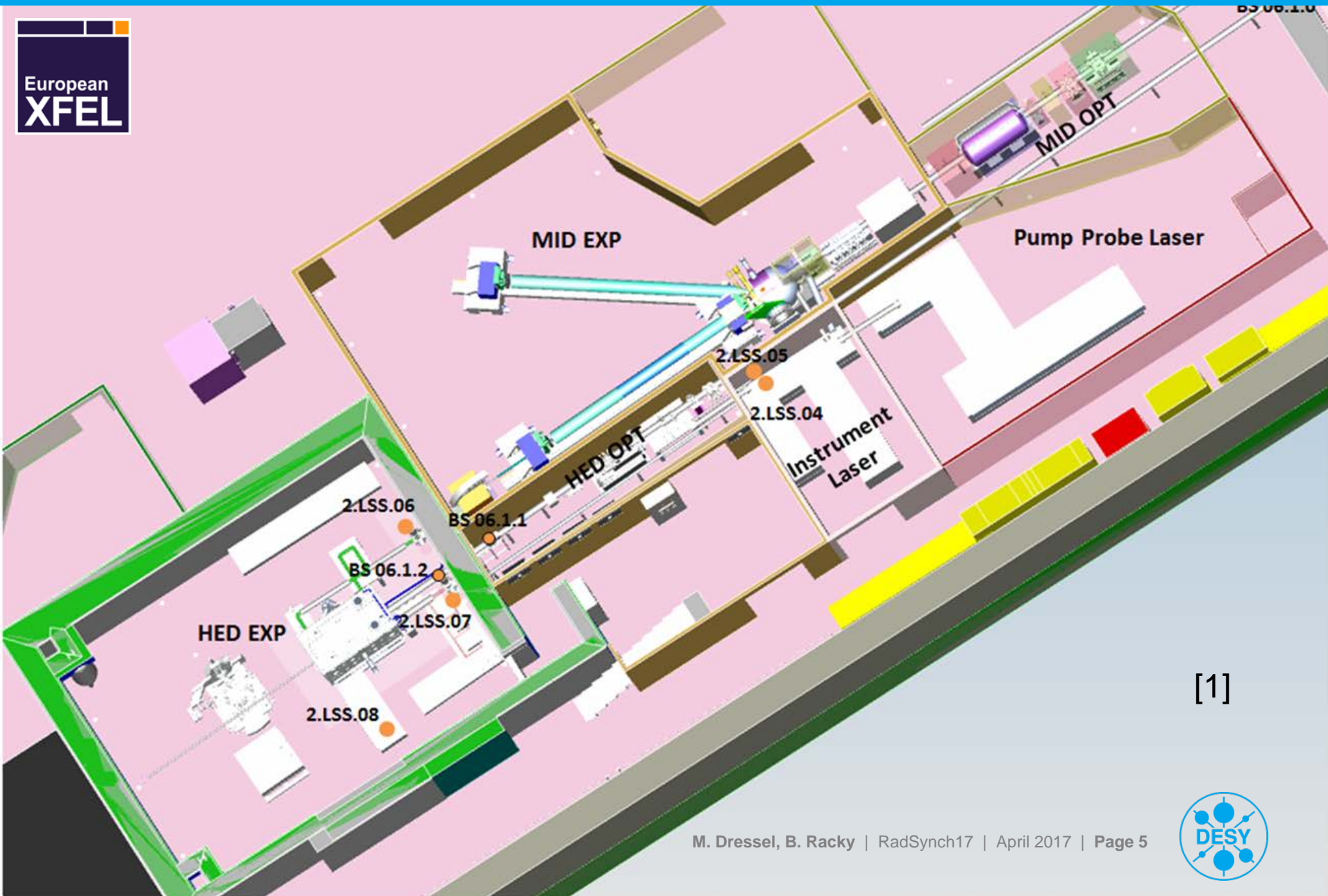
Probability of random failures

SFF

CCF

- Probability of Failure on Demand (PFD): Sum over PFD_i

XFEL SASE2 experiments overview



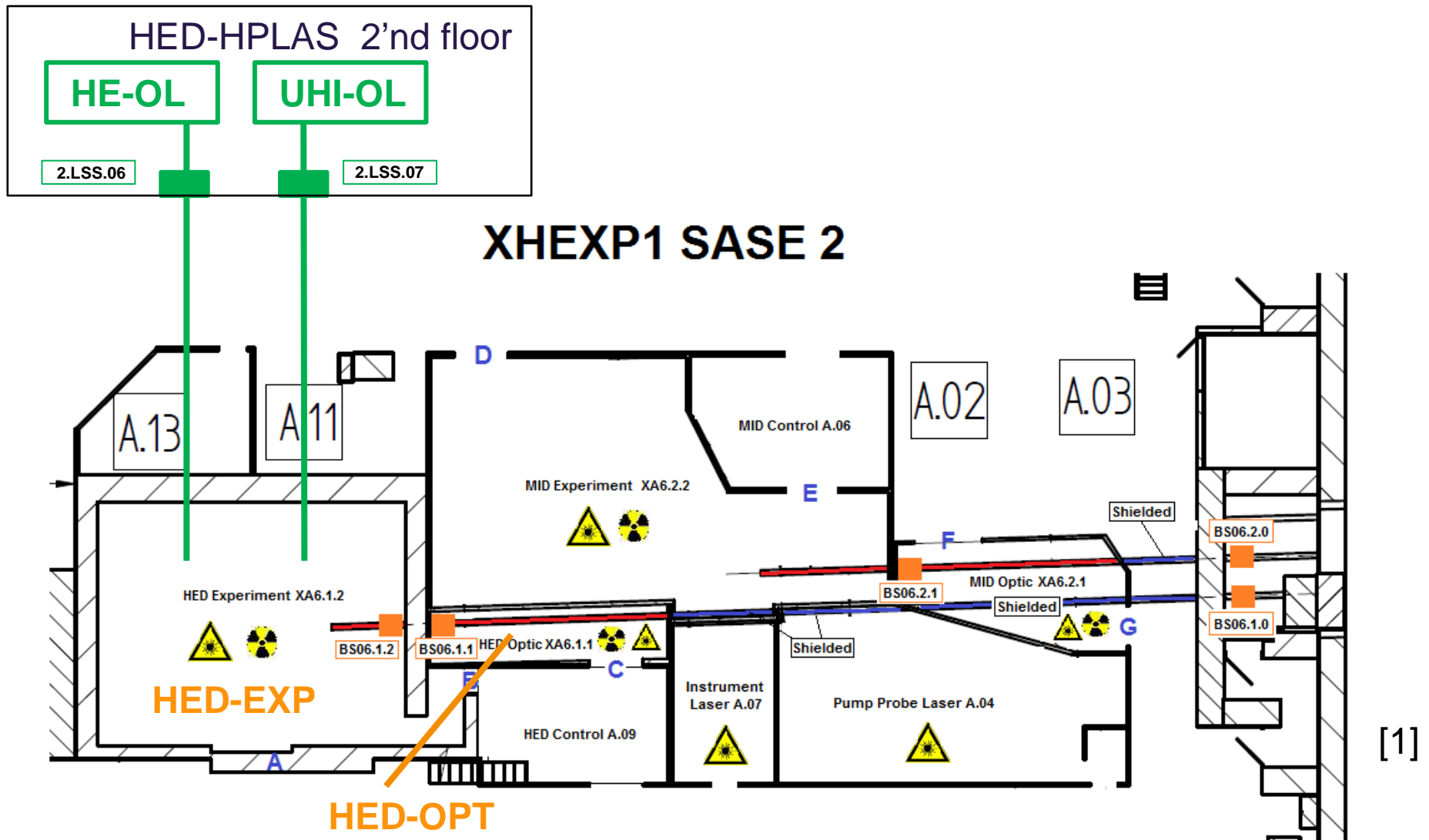
[1]



Sources of ionizing radiation at HED experiment

- > XFEL beam:
 - Hard X-rays up to 25 keV, pulse energy ~mJ
- > Optical LASERs; Ionizing radiation via secondary interactions
 - HE-OL: High-energy optical-laser ~ 100 J / pulse
 - UHI-OL: Ultra-high-intensity optical-laser: ~ 100 TW

Shutters relevant to ionizing radiation



Requirements on FEL beam permission

> Safety of experiments areas:

The area and the following area has to be safe..

- The beam shutter is closed in front of the area
- Or the area is safe:
 - The beam permission for the area is granted
 - And the following area is safe

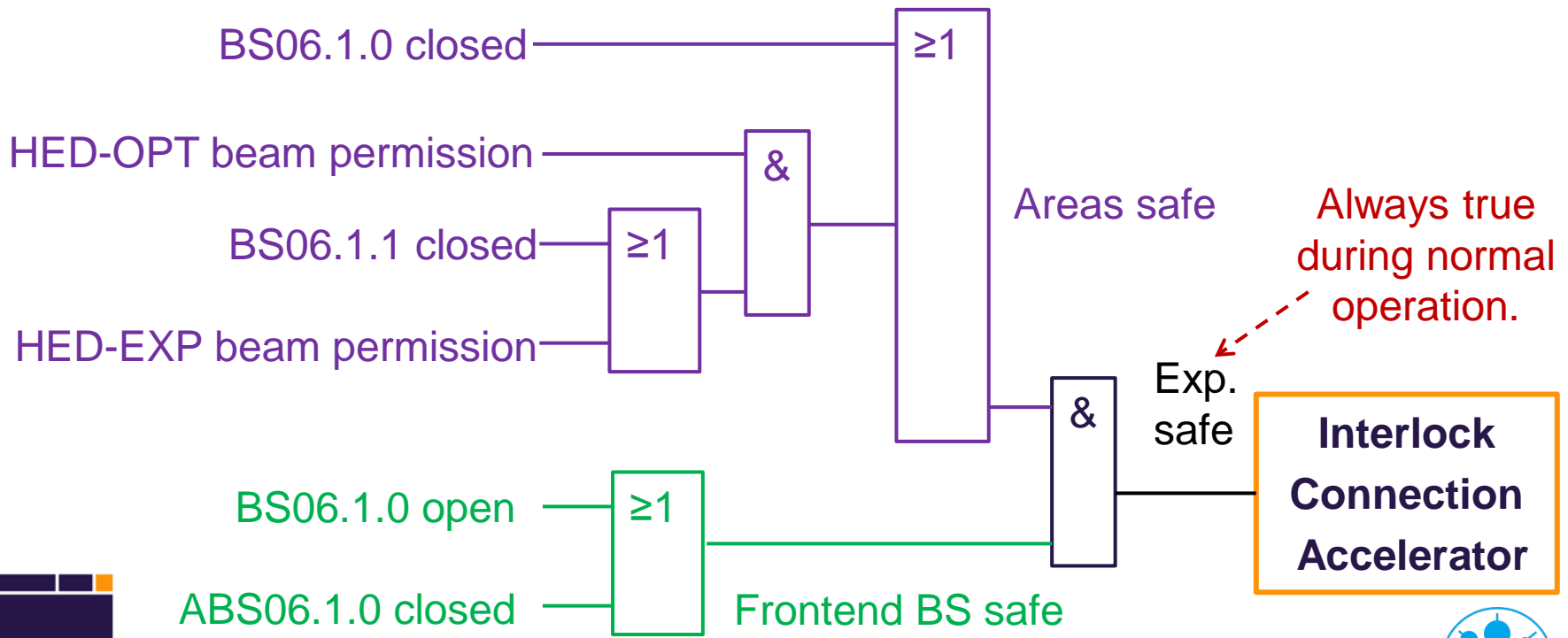
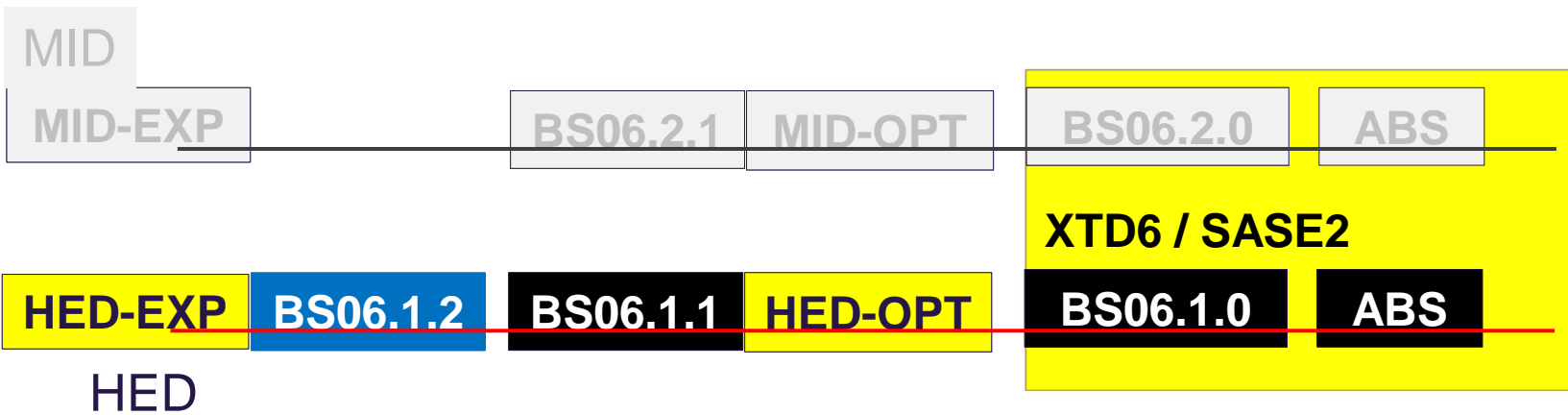


> Safety of frontend beam shutter:

The front beam shutter has to be protected by the absorber.

- The absorber is closed
- Or the beam shutter is open

FEL beam permission beamline 6.1



Requirements on laser operation in HED-EXP

> Safety of HED experiment area HED-EXP:

The lasers HE-OL and UHI-OL may only be operated in **high power** mode if the experiments hutch is safe.

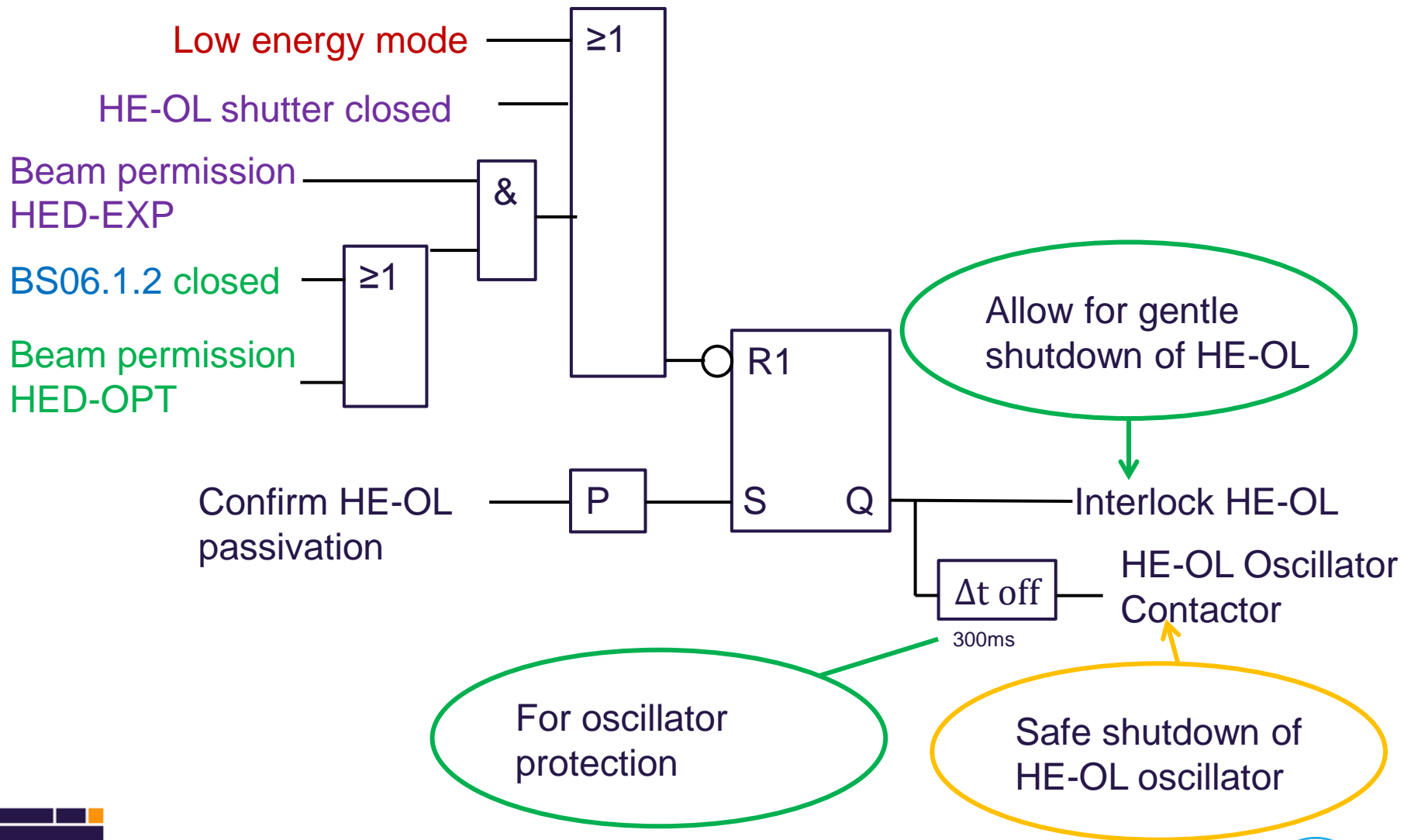
- The appropriate laser shutters to HE-OL / UHI-OL are closed
- Or the HED-EXP is safe:
 - The beam permission for HED-EXP is granted
 - And the optics hutch HED-OPT is safe

> Safety of HED optics hutch HED-OPT:

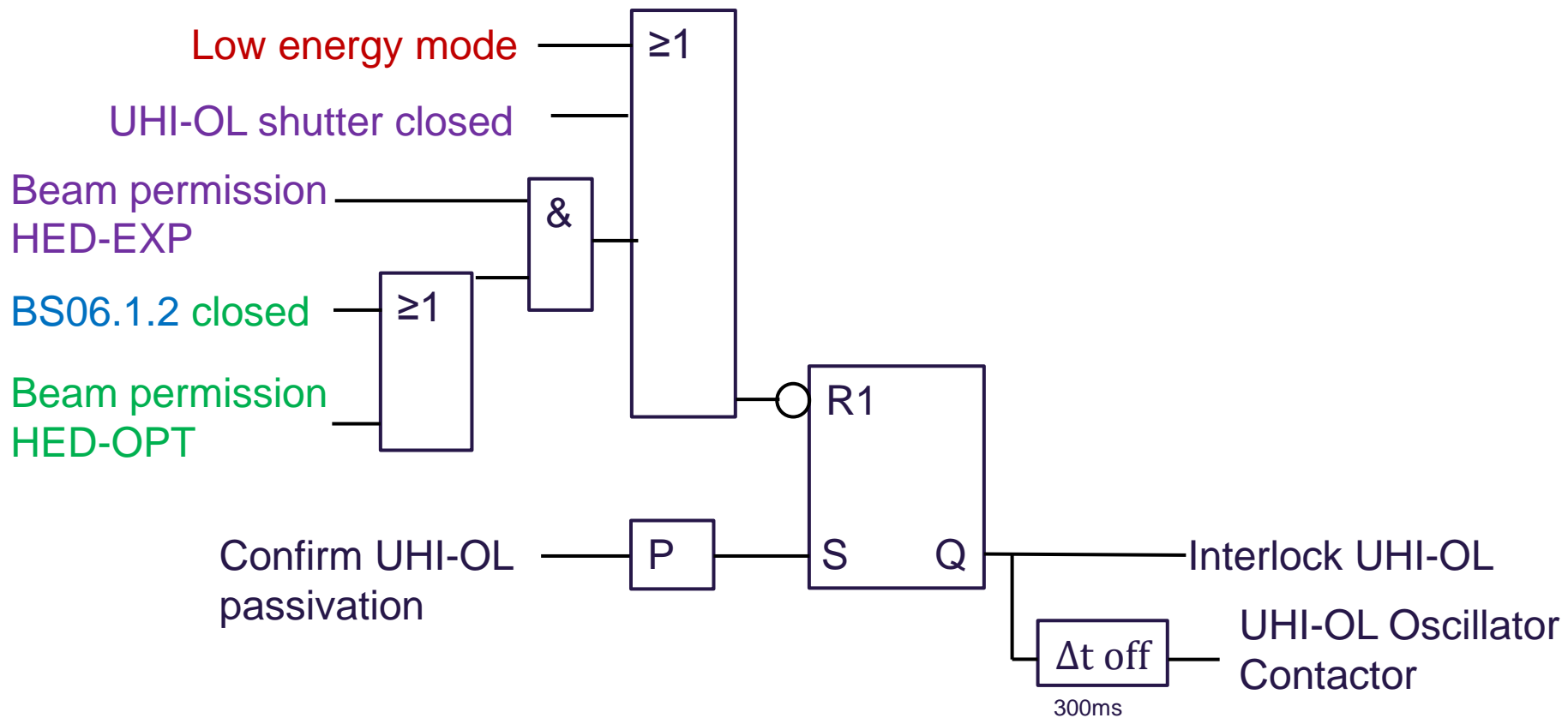
The lasers HE-OL and UHI-OL may only be operated in **high power** mode if the optics hutch is safe.

- The beam shutter BS06.1.2 is closed
- Or beam permission for HED-OPT is granted.

Conditions for HE-OL permission



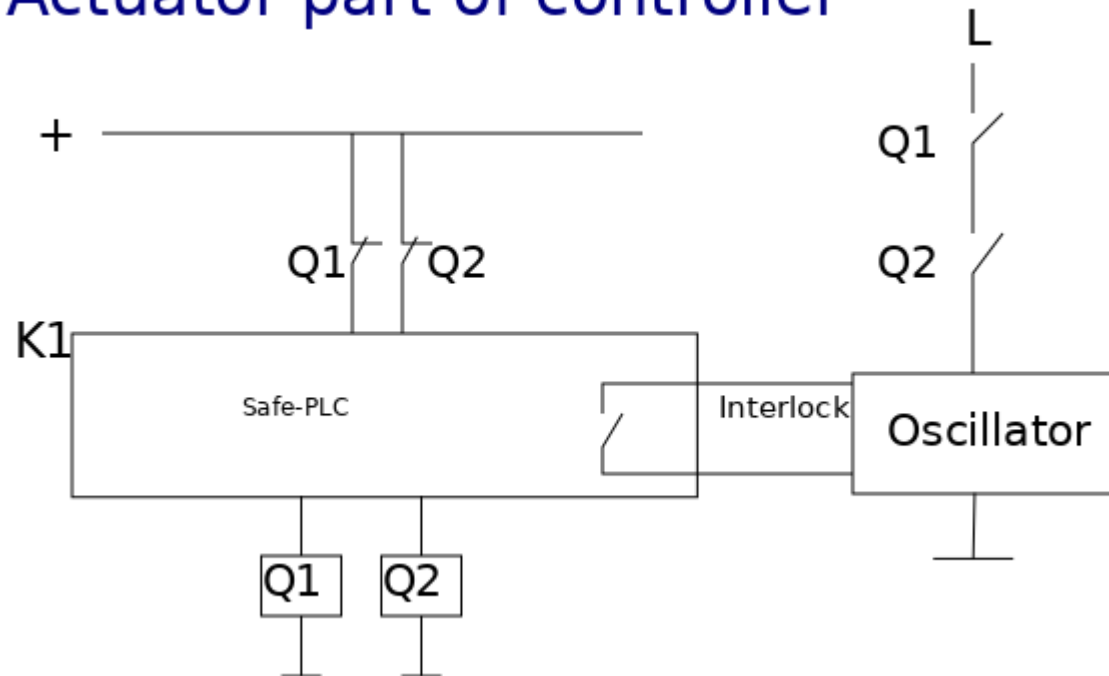
Conditions for UHI-OL permission



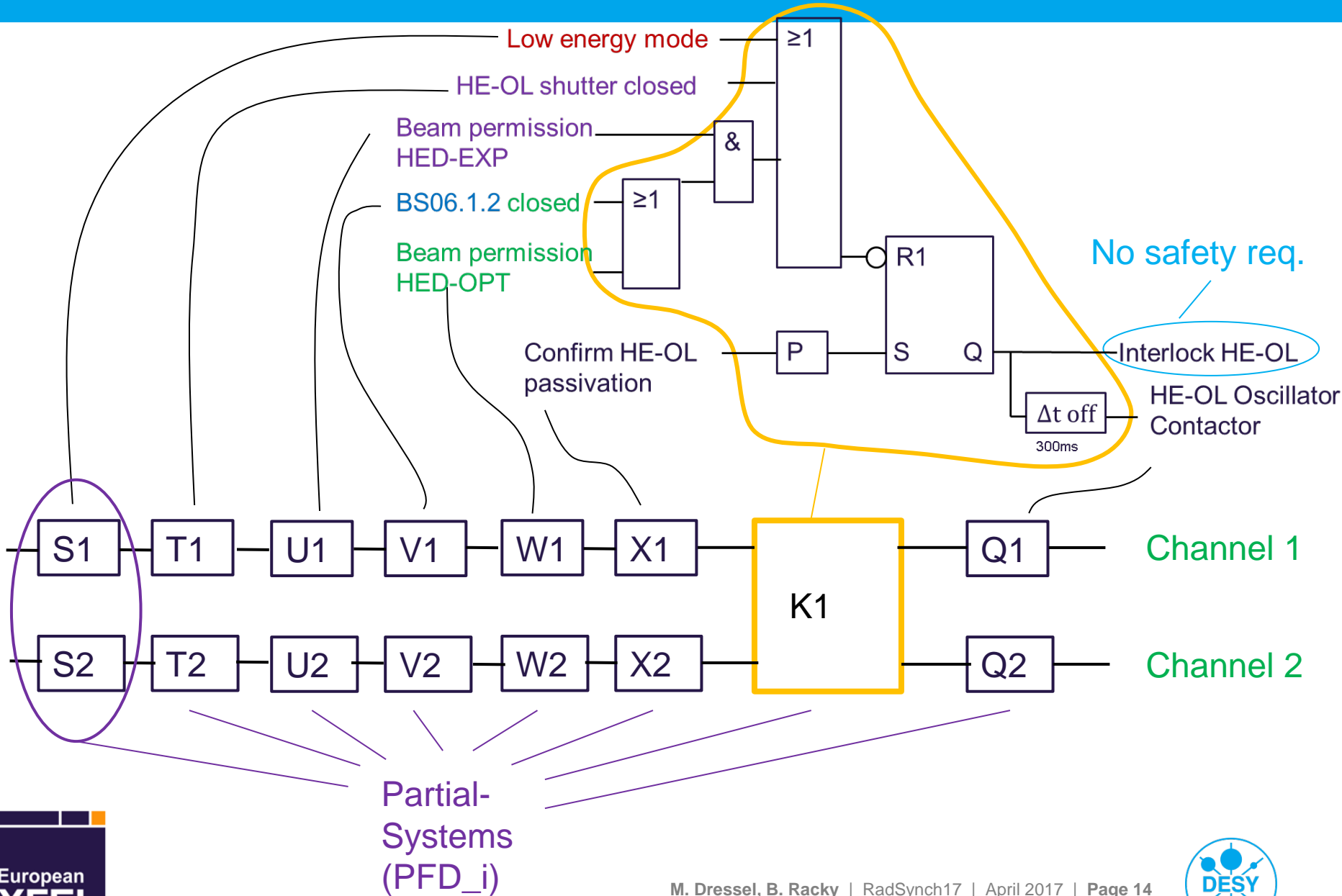
Contactors for safe LASER off

- > Two contactors (Q1, Q2) to oscillators power supply

Actuator part of controller



Safety related block diagram



SIL for safety function

- > PFD for the example has to be less or equal to required PFD_r

$$PFD = \sum_{i=S,\dots,X,K,Q} PFD_i \leq PFD_r$$

- > Fulfill requirements for systematic safety integrity
- > Verification/Validation

→SIL of safety function

Summary

- > HEDs three sources of ionizing radiation
- > Logic of an exemplary safety function
- > Dedicated actuators for safely switching of optical LASERs

References

[1]

Technical Design Report

Interlock Concept for Experimental Area

SASE 2 in XHEXP1

August 2015

E. Boyd and S. Kozielski

for Safety and Radiation Protection (SRP)

at the European XFEL

