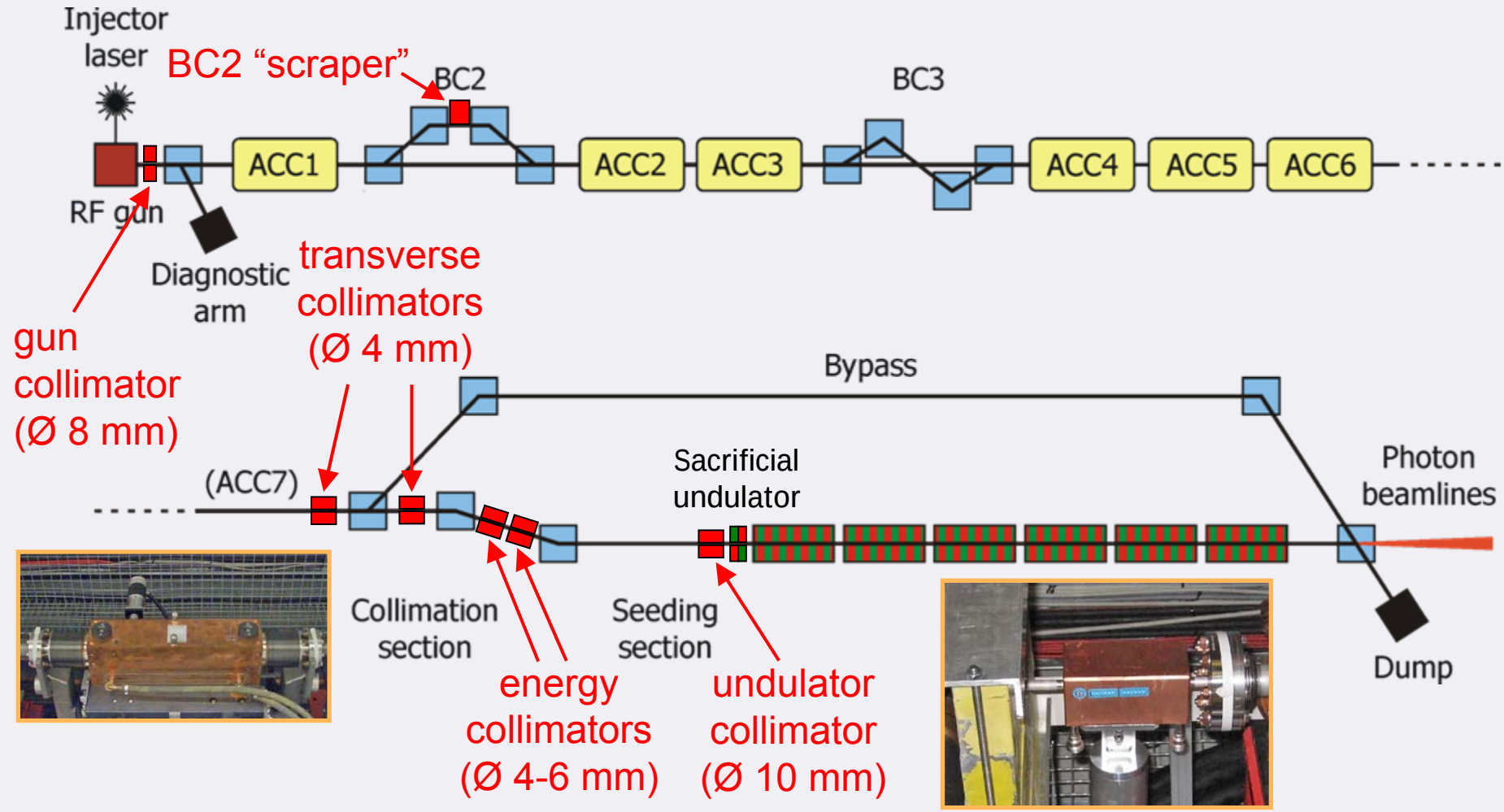
Undulator Protection for FLASH and for the European XFEL

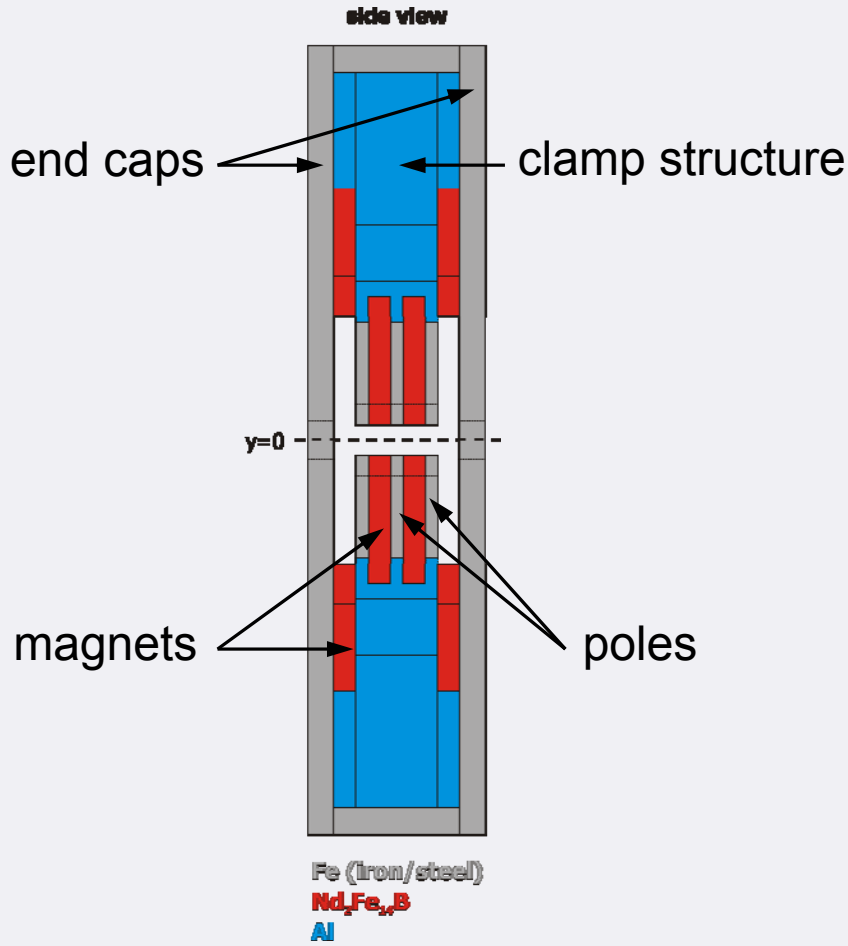
- FLASH sacrificial undulator: beam loss simulations
- FLASH BLM system
- XFEL plans

FLASH sacrificial undulator

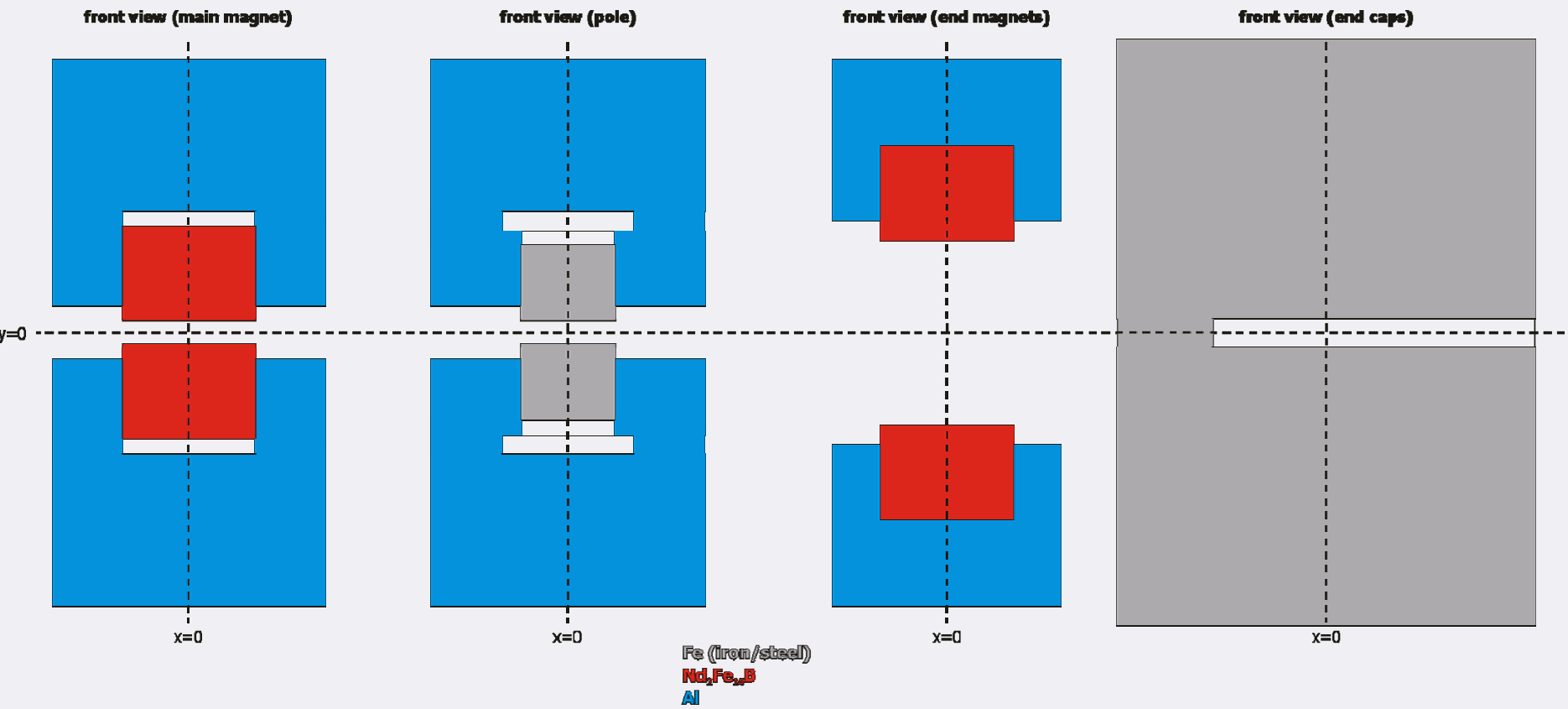
FLASH Collimators



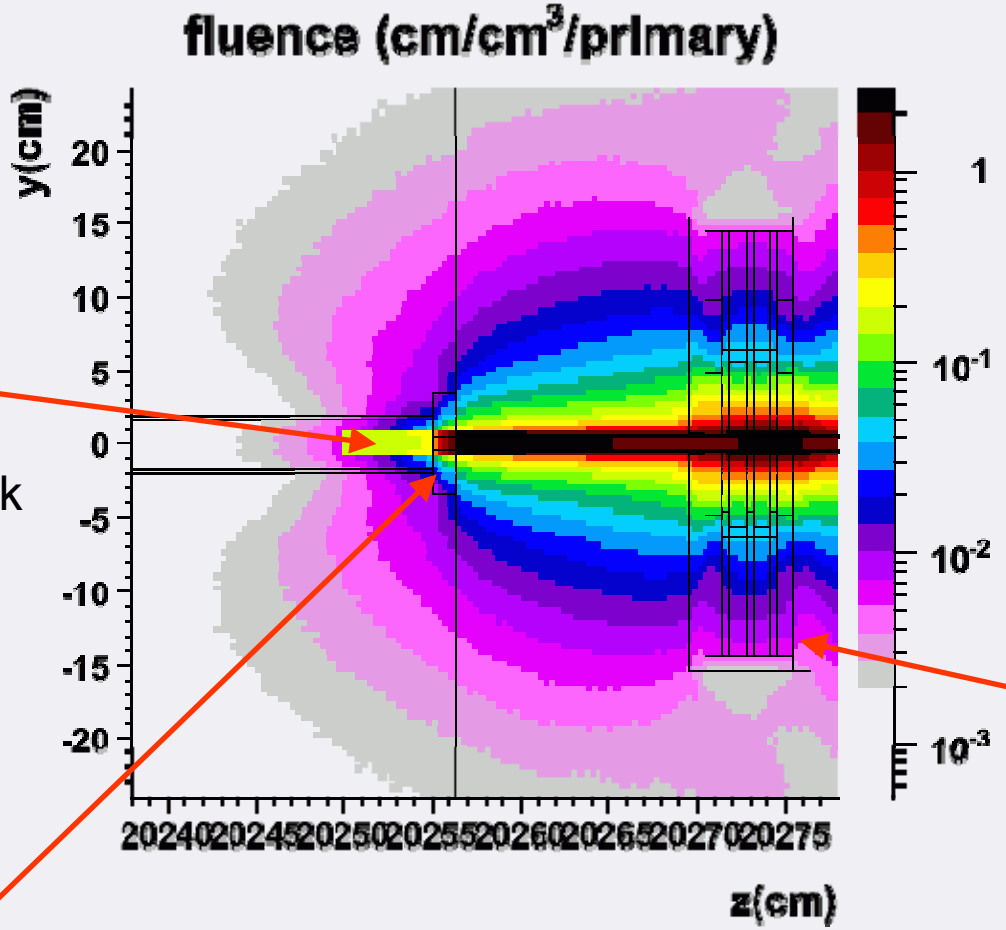
Sacrificial undulator



Sacrificial Undulator: Geometry



Simulation Setup

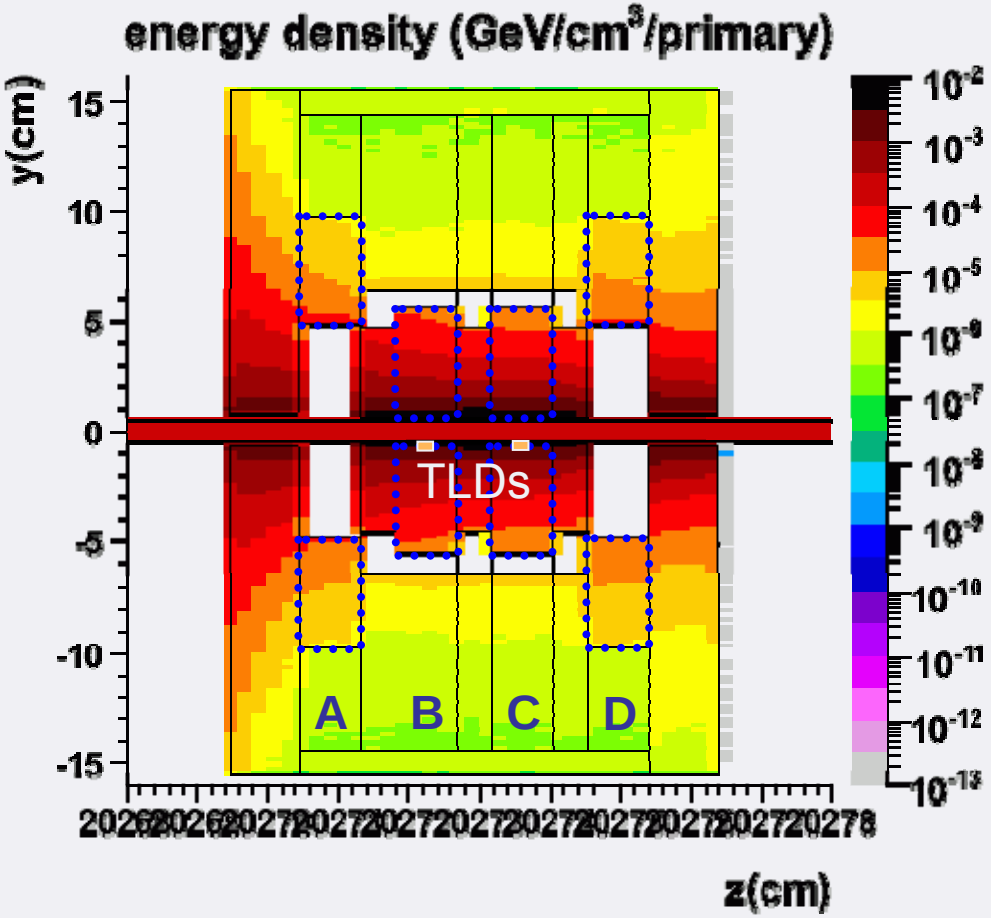


annular beam
(2 mm thick ring, simulates halo/dark current lost on aperture)

sacrificial undulator

flange 34 mm → 10 mm pipe Ø

Deposited Dose



absolute dose (Gy)

A	B	C	D
110	3600	3500	92
	TLD B	**TLD C**	
	86000	86000	

- dose measured by two TLDs: ~86 kGy (12/2004–5/2008)
- almost negligible dose in outer magnets (position unclear)

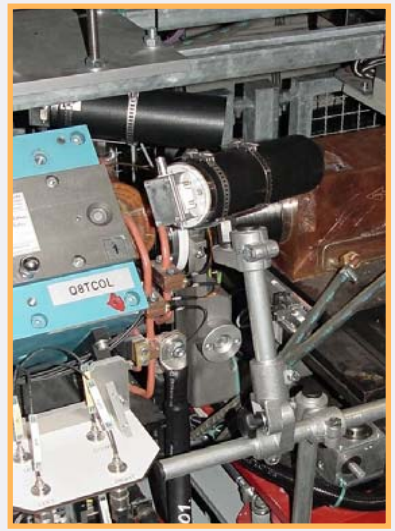
FLASH undulator protection

FLASH Machine Protection System

- 83 BLMs
- differential charge monitoring ("Toroid Protection System")
- response time <4 µs incl. cables
- actuators:
  switch off photoinjector laser
  stop RF in ACC1

65
photomultipliers with scintillators

18
aluminum cathode electron multipliers



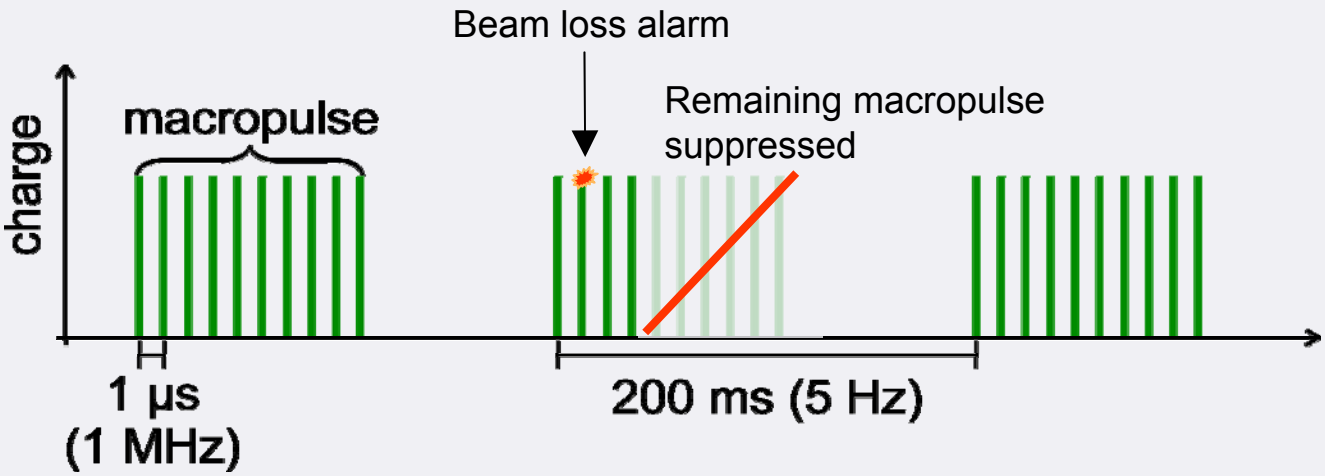
Beam Interlock Modes

Low current modes (max. 150 nA/180 W)

- very tolerant against losses in the linac
- only huge undulator losses stop machine operation → operators have to restart beam manually

High current mode (up to 72 µA/86 kW)

- single BLM alarm cuts the macropulse

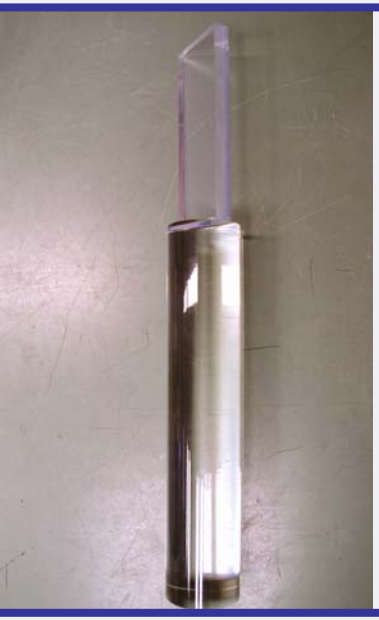


Scintillator Assembly

plastic scintillator
(NE110 or equivalent)

aluminum foil

black plastic foil



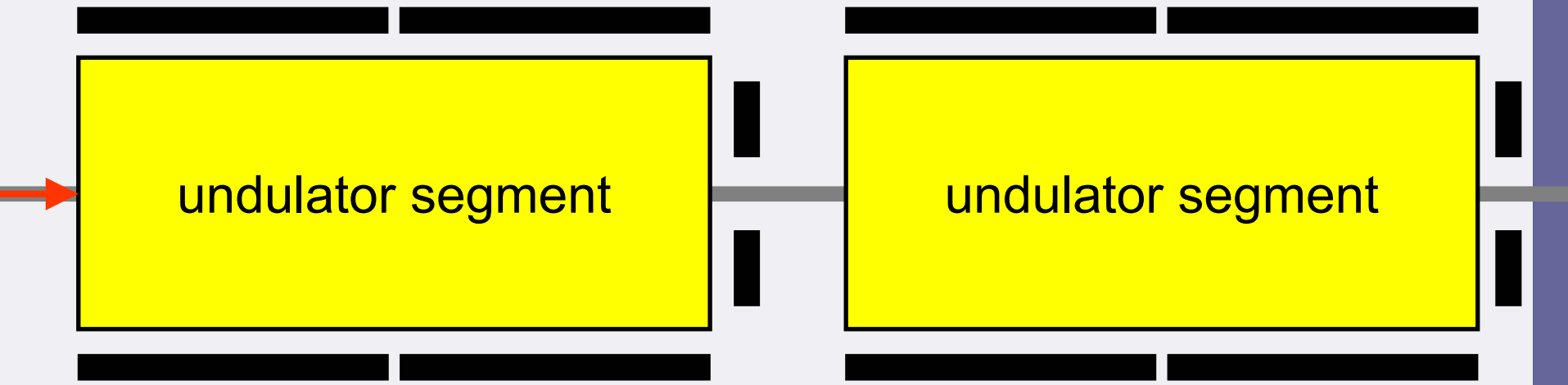
plexiglass light guide

test pulse LED

B. Michalek (DESY)

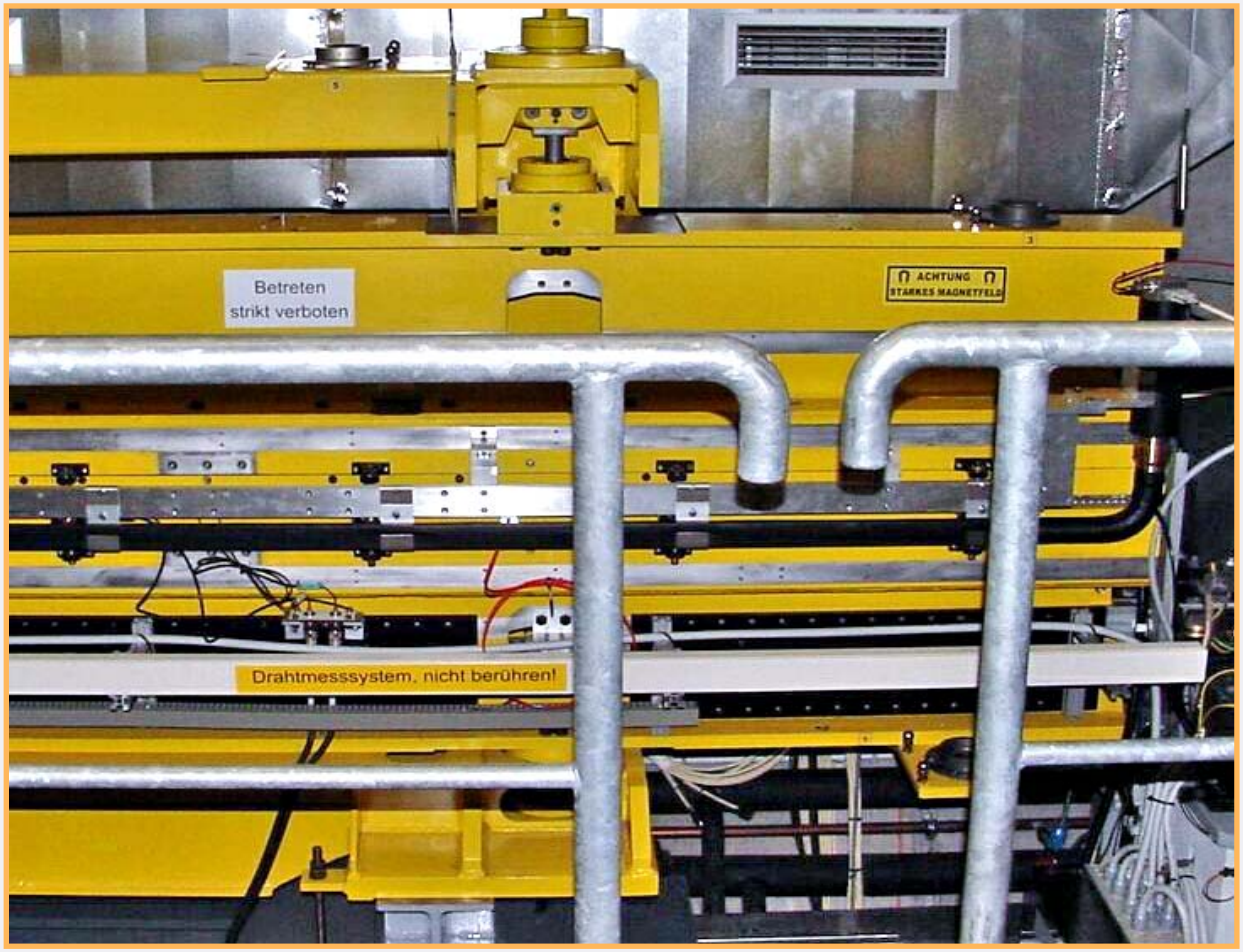
Undulator BLMs

- 6 scintillator panels (and PMTs) per undulator segment
- calibration vs. scattered charge with wirescans
- BLM thresholds adjusted manually to keep dose rate < 10 Gy/d
- dose measurements:
  - weekly exchanged TLDs
  - online fiber dosimetry system

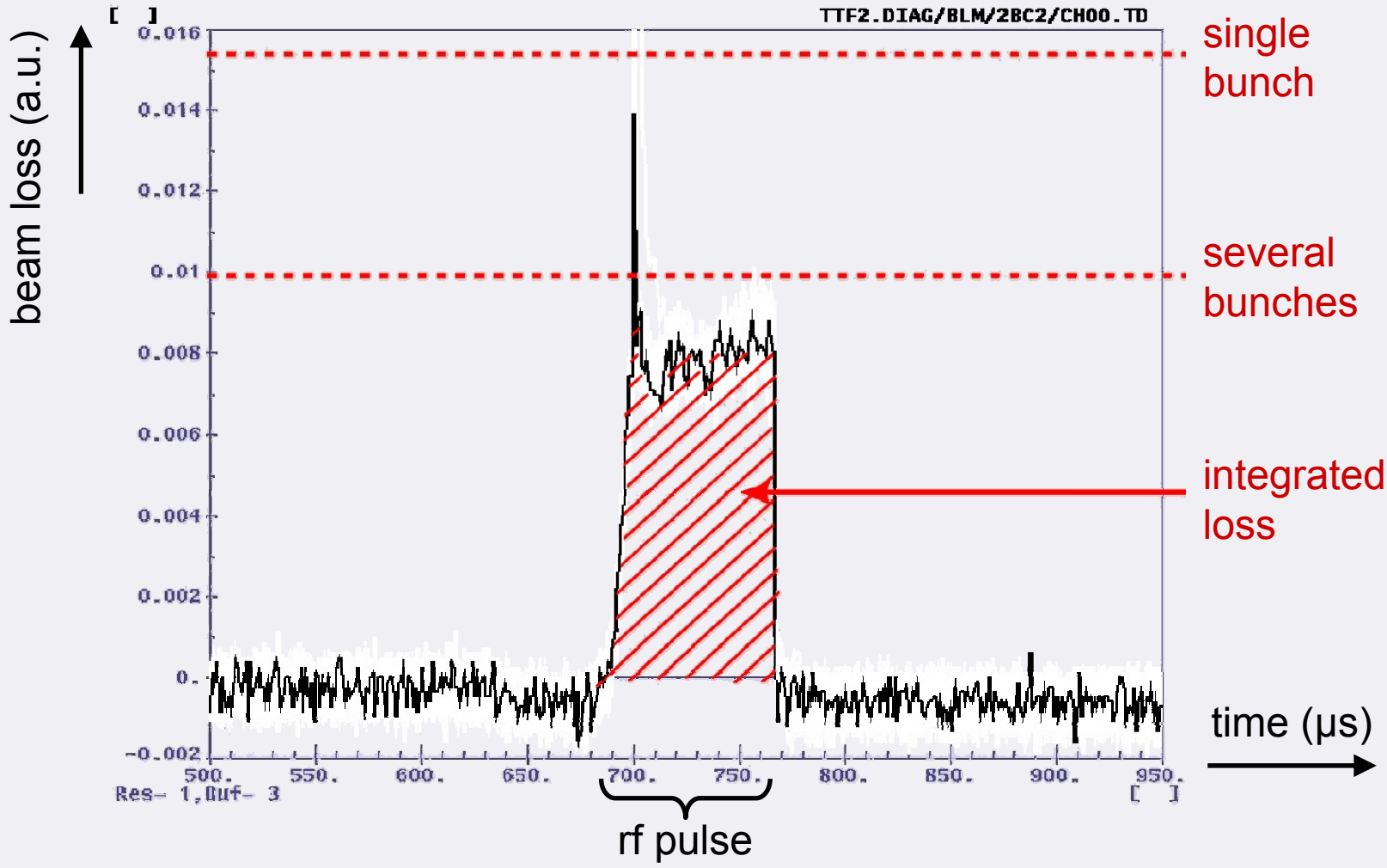


(top view)

Undulator BLMs

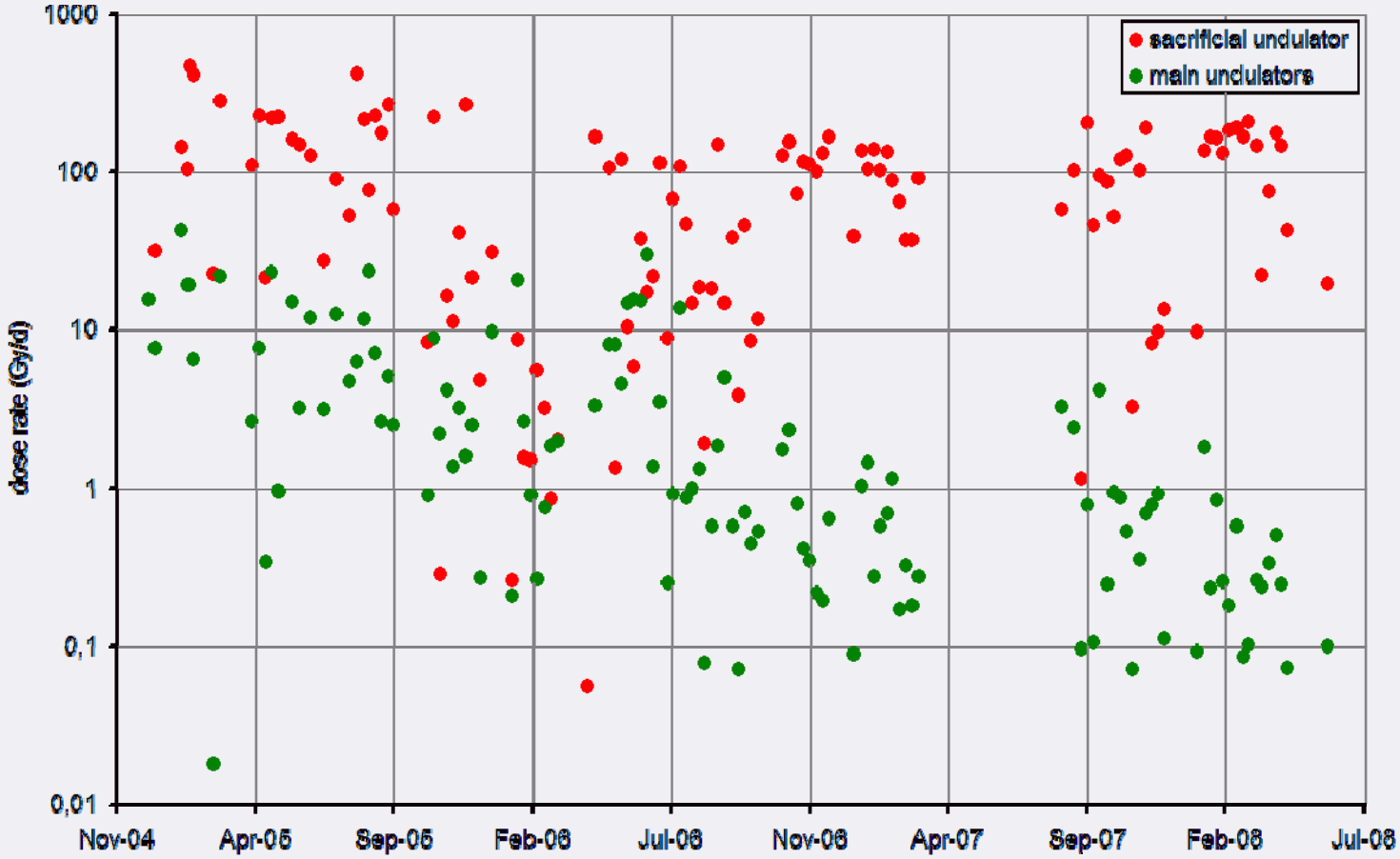


BLM Thresholds



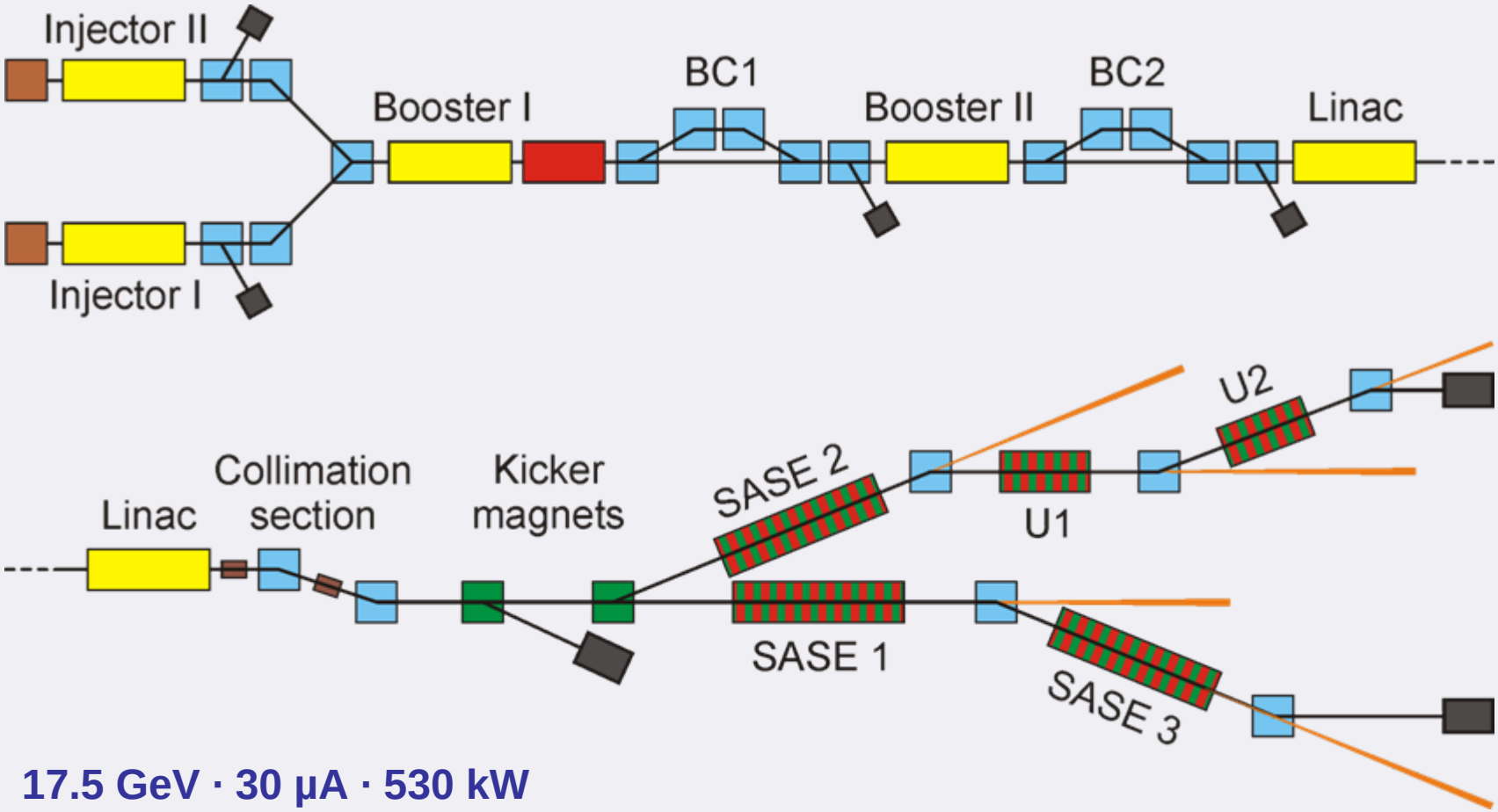
Undulator Dose Rate (TLD Measurements)

Courtesy T. Vielitz (HASYLAB)



XFEL undulator protection

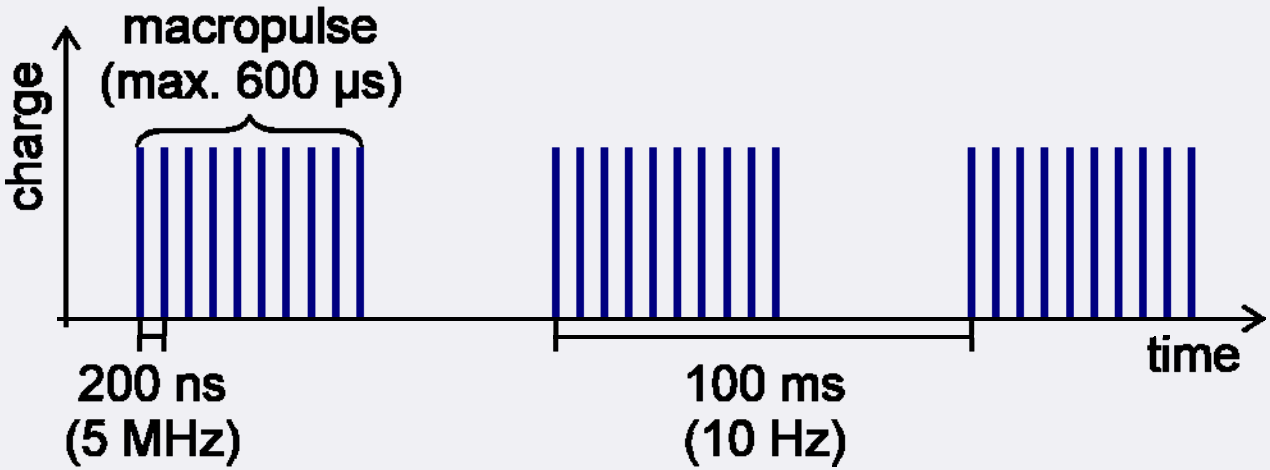
The European X-Ray Free Electron Laser



17.5 GeV · 30 µA · 530 kW

Beam Structure

- RF system pulsed at 10 Hz
- Electron bunches (1 nC) grouped in macropulses
- Up to 3000 bunches/macropulse in arbitrary pattern



XFEL Machine Protection System Inputs

Beam loss monitoring

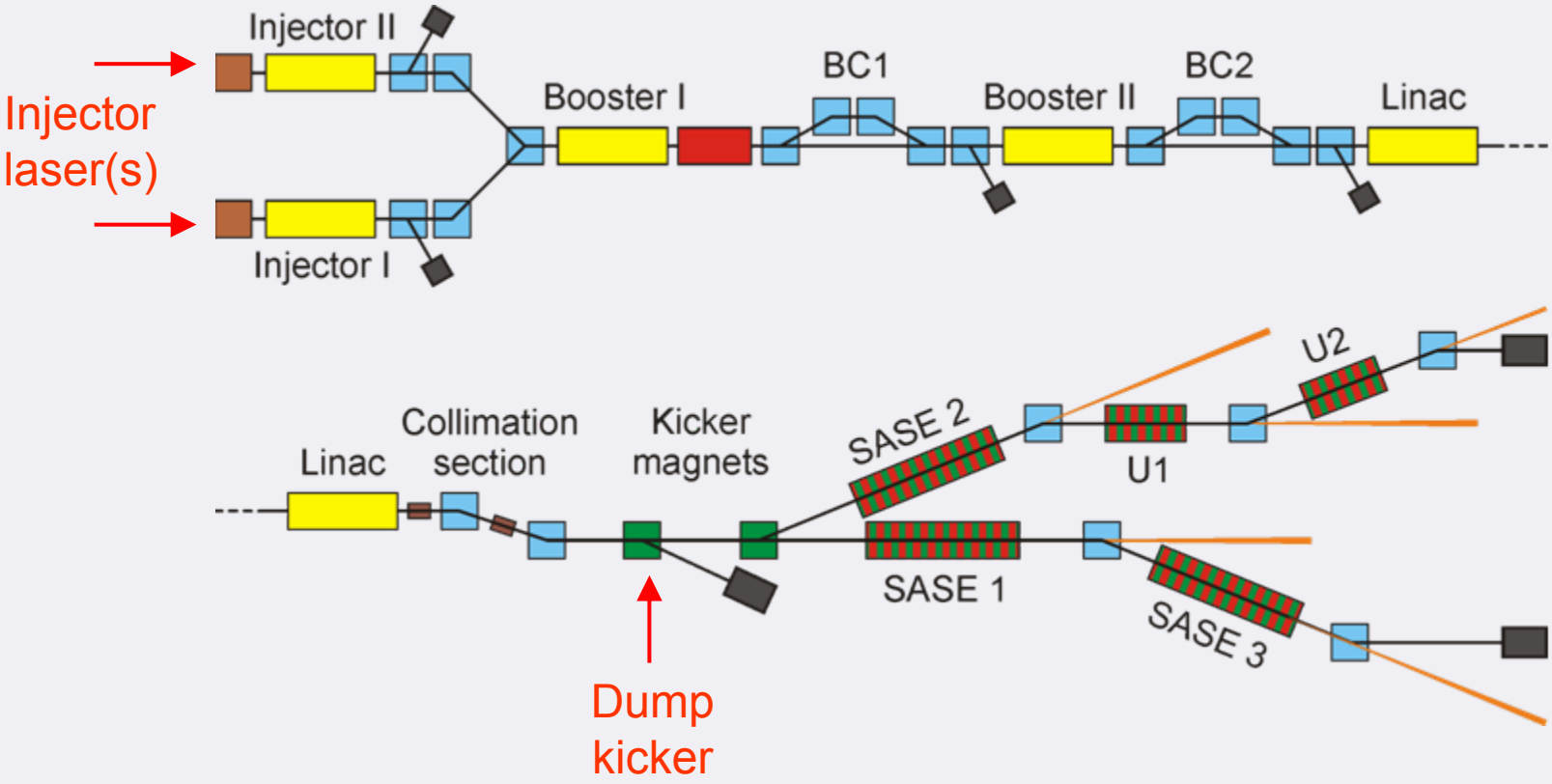
- Beam Loss Monitors (BLMs)
  - Undulator sections: Photomultipliers + plastic scintillators
  - Linac and high radiation areas: Ionization chambers or other systems (Čerenkov fibers, sLIONs, PIN diodes, ...)
- Multiple differential charge measurements

Precautionary monitoring

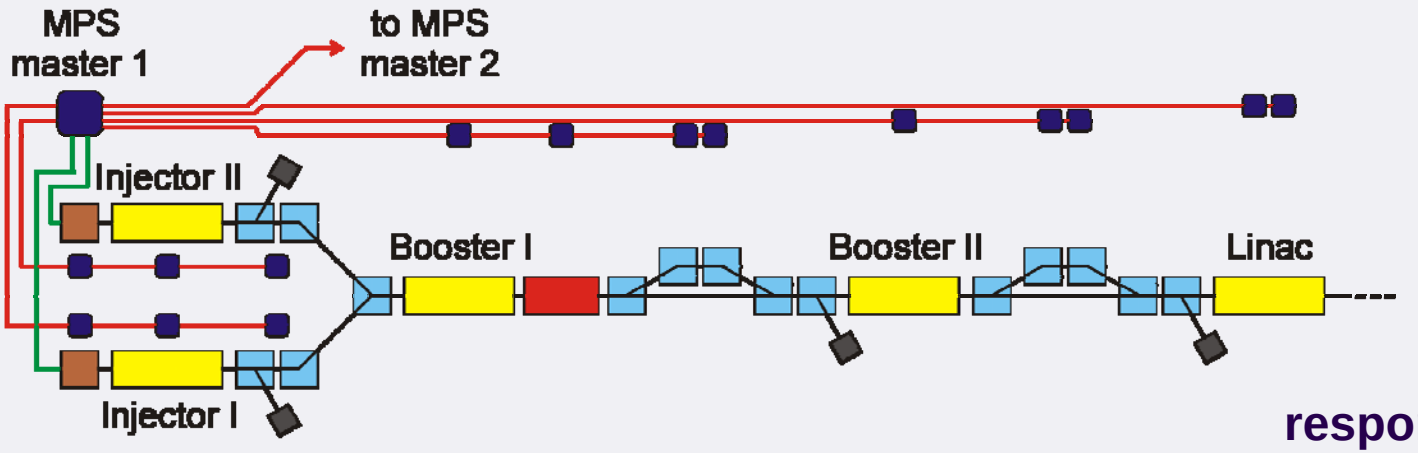
- Magnet power supplies
- LLRF exceptions, quench detection
- Valves, screens, wire scanners, temperatures, water flow, ...
- Beam position

MPS Topology I

Only two points for intra-macropulse beam stops:

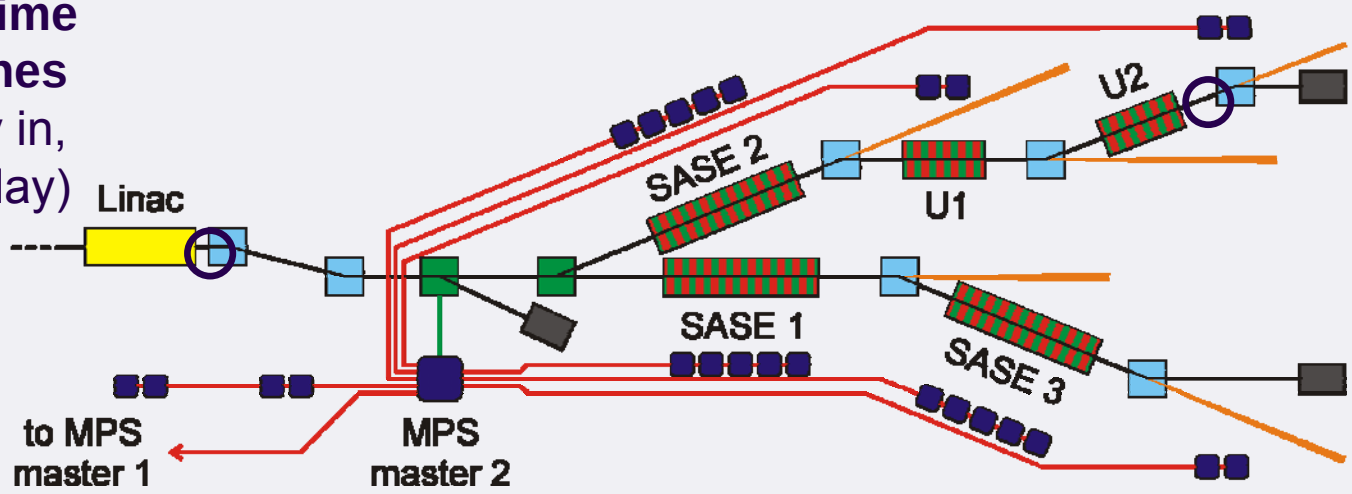


MPS Topology II



response time
> 50 bunches

response time
> 83 bunches
(33 already in,
50 cable delay)



Functionality

Operation modes

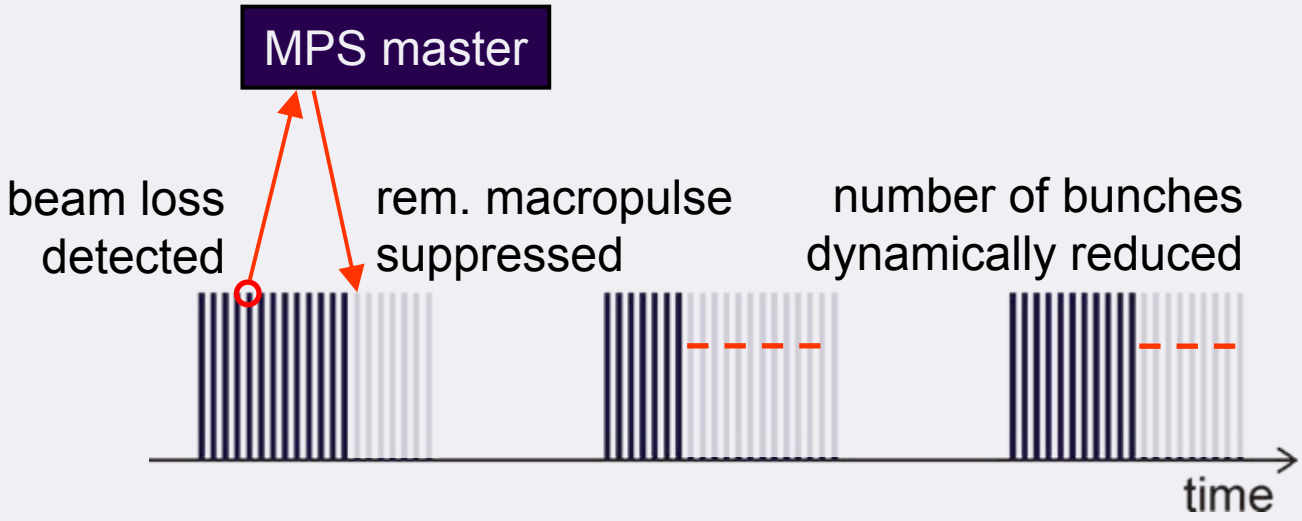
- Valves and dipoles are set right to guide the beam to a dump

Power limits

- Limit the number of bunches for startup, to protect screens, ...

Alarm cutoffs

- Immediate reaction in case of beam loss



Undulator BLMs

Scintillator panels in the space between undulator segments

Undulator option a)

two scintillator rods

242 photomultipliers

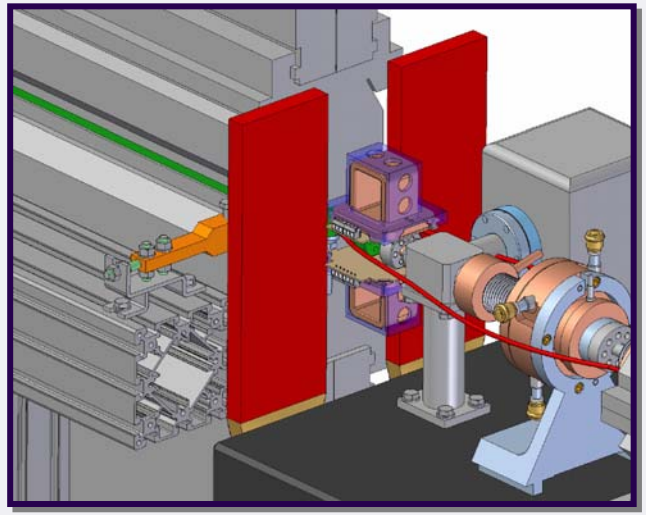
high redundancy

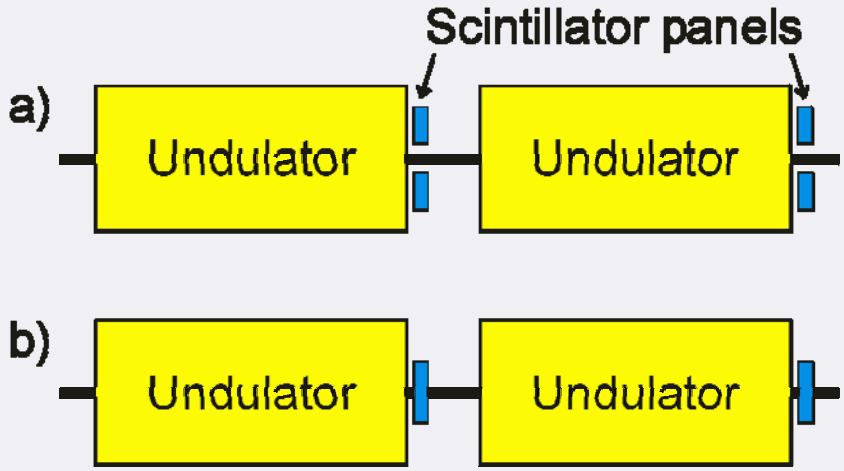
Undulator option b)

one scintillator panel with gap for beam pipe

121 photomultipliers

limited redundancy





People (actively) involved

FLASH MPS

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XFEL MPS

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