The European XFEL Beam Loss Monitor System

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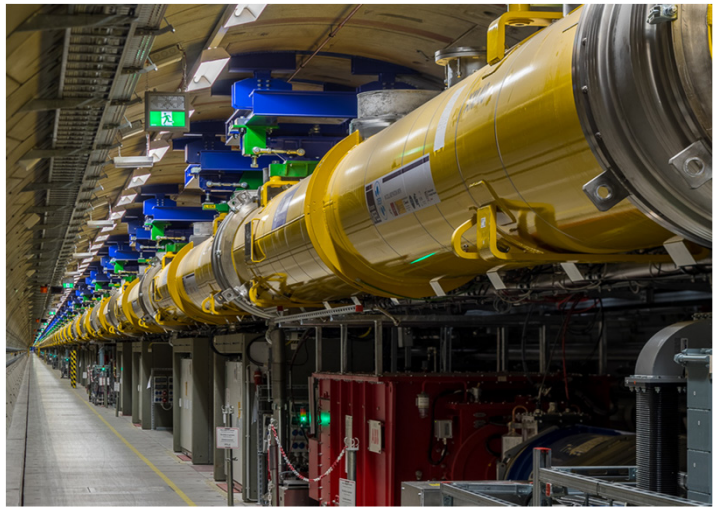
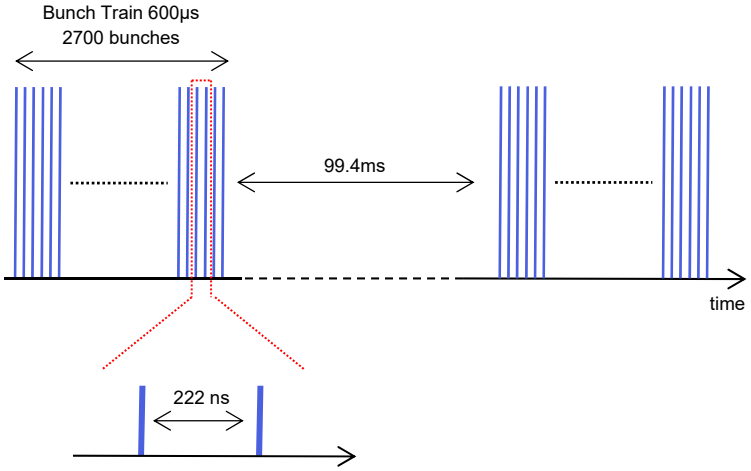


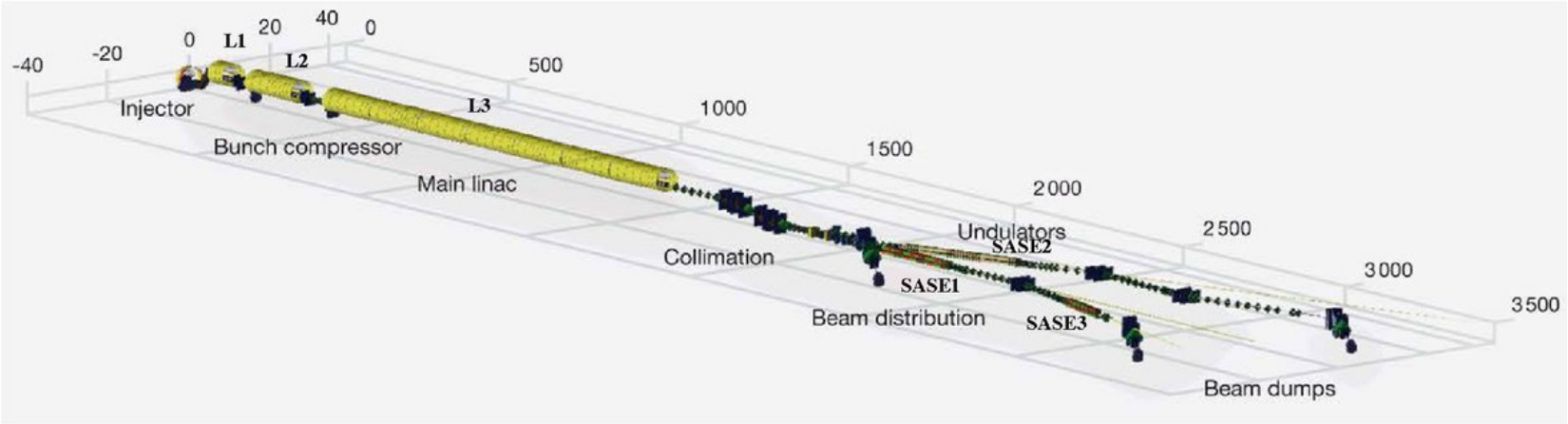
Outline

- European XFEL Goal Parameters
- BLM System Overview
  - Integration Examples
  - GUIs
  - Alarm Generation
    - Beam Based Alarms
    - Darkcurrent and Device Alarms
  - Calibration concept
- BLMs in Undulator intersection
- Conclusion

European XFEL Goal Parameters

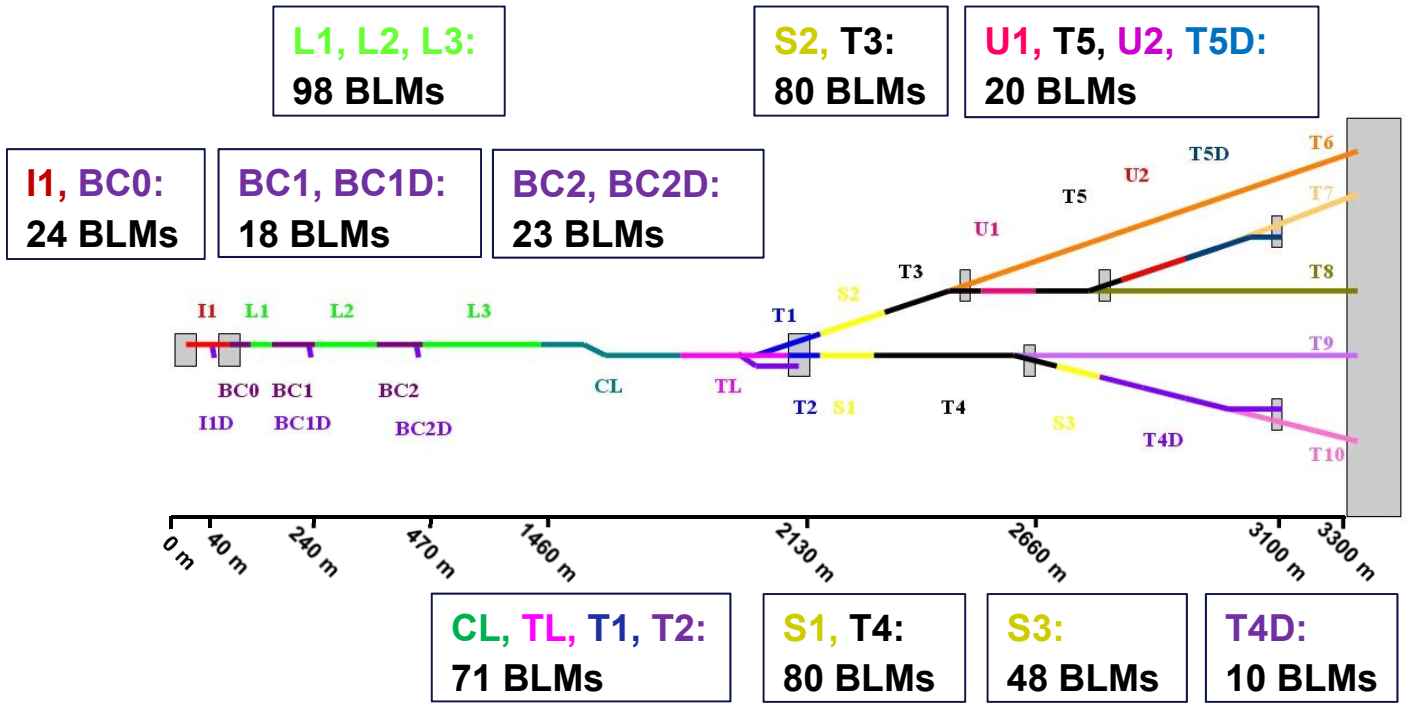
- Electron beam energy: ≤17.5 GeV
- Bunch charge: 0.02 – 1 nC
- Pulse repetition rate: 10 Hz
- Bunch repetition rate: 4.5 MHz
- Bunches per pulse: up to 2700
- Pulse length: 600 us





- Most electronics located in the tunnel

BLM System Overview

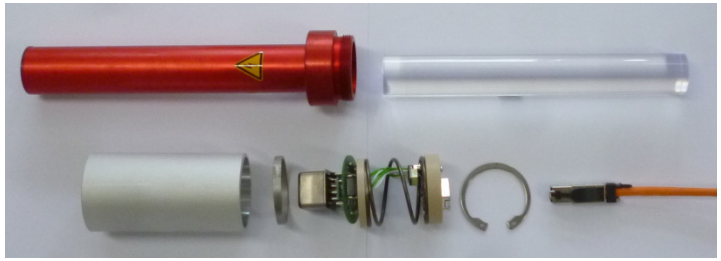


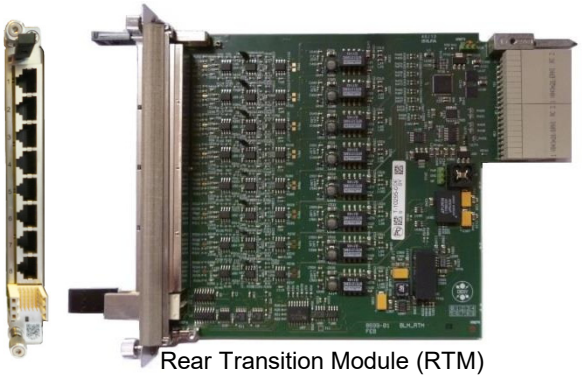
Explanation:

I1 - Injector 1
I1D - Injector Dump
L1 - Linac 1
BC1 - Bunch Compressor 1
BC1D - Bunch Compressor 1 Dump(Line)
L2 - Linac 2
BC2 - Bunch Compressor 2
BC2D - Bunch Compressor 2 Dump(Line)
L3 - Main Linac
CL - Collimation Section
SA1-3 - SASE Undulator Sections
UN1-2 - Spontaneous Radiation Undulator Sections (not equipped yet)
T5D - Main Dump(Line) in XTD5/XSDU1
T4D - Main Dump(Line) in XTD4/XSDU2
T1 - (straight) e-beam line
T2 - (straight) e-beam line
T3 - (straight) e-beam line
T4 - (straight) e-beam line
T5 - (straight) e-beam line
T6 - SASE-2 photon beam line
T7 - UN2 photon beam line
T8 - UN1 photon beam line
T9 - SASE-1 photon beam line
T10 - SASE-3 photon beam line

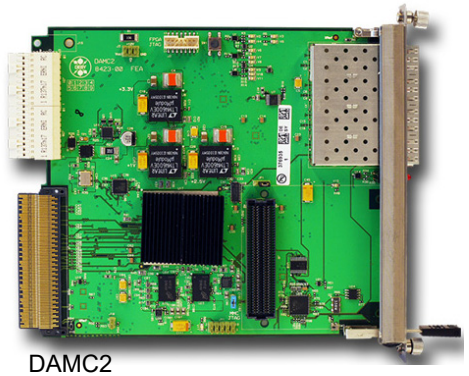
- Most BLMs in undulator area, each undulator intersection equipped with two BLMs
- A total of 472 BLMs are installed
- Cable-connected to 78 RTMs in 58 µTCA crates located in the tunnel
- All BLMs connected to the Machine Protection System (MPS)
  - Stops beam production at the photoinjector gun

BLM System Overview





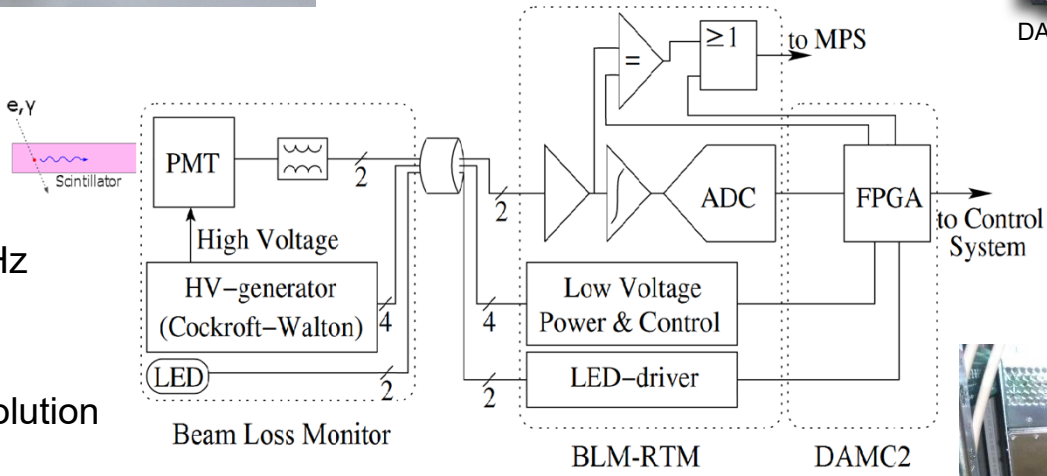
Rear Transition Module (RTM)

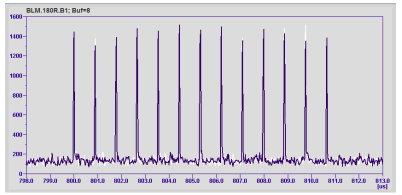


DAMC2

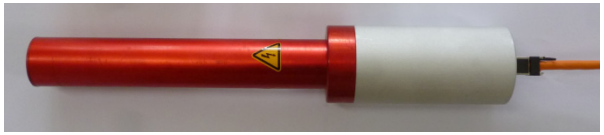
- Plastic scintillators
- HV: 0V – 900V
- 8 channels/RTM
- ADC: 14 bit @ 45MHz
- RJ-45 connectors

- Bunch by bunch resolution





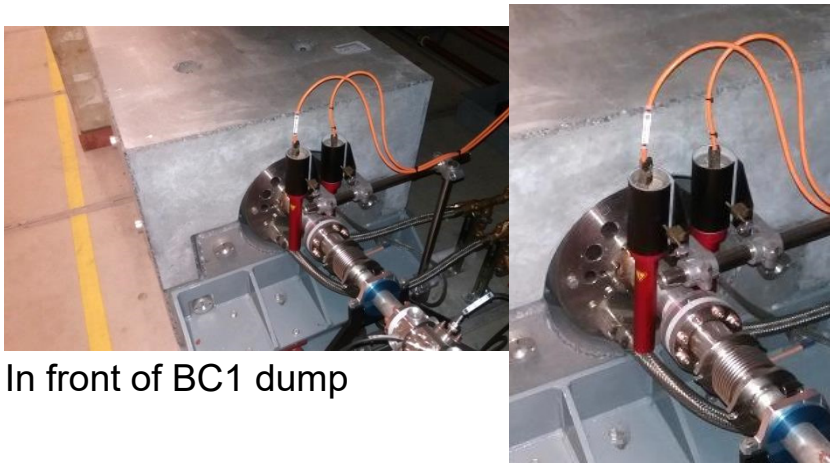
13 bunches @ 1.13MHz rep. rate



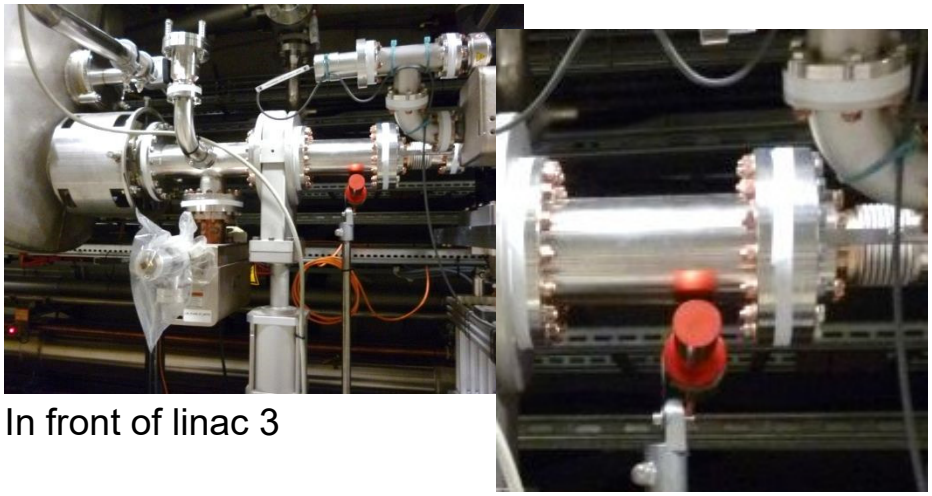
µTCA crate

HELMHOLTZ ASSOCIATION DESY.

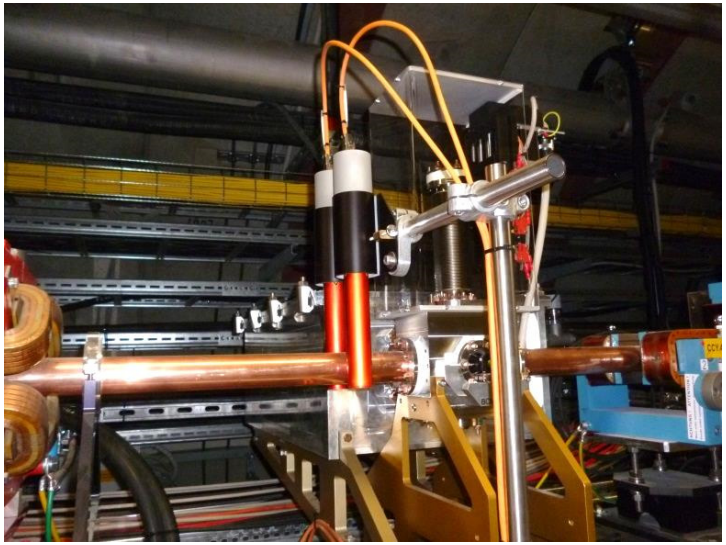
BLM Integration Examples



In front of BC1 dump



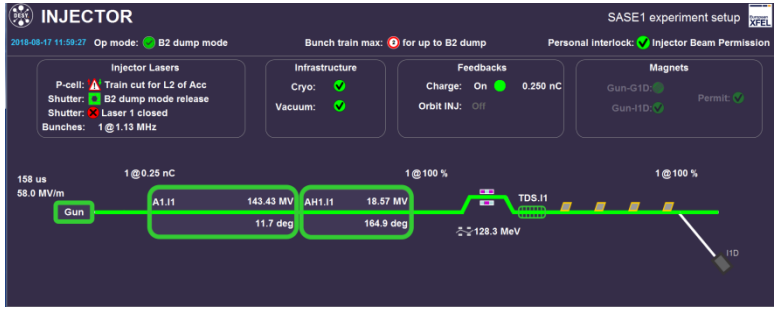
In front of linac 3

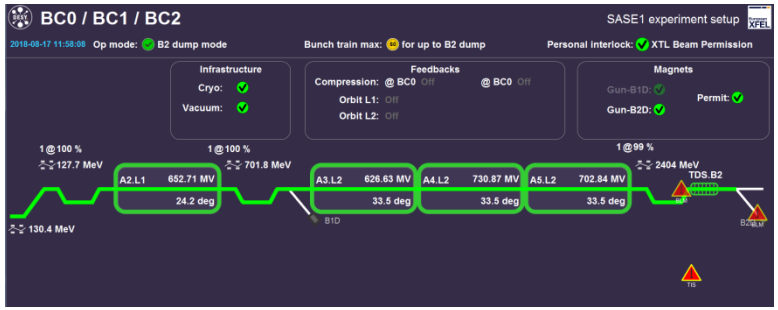


BC2 line

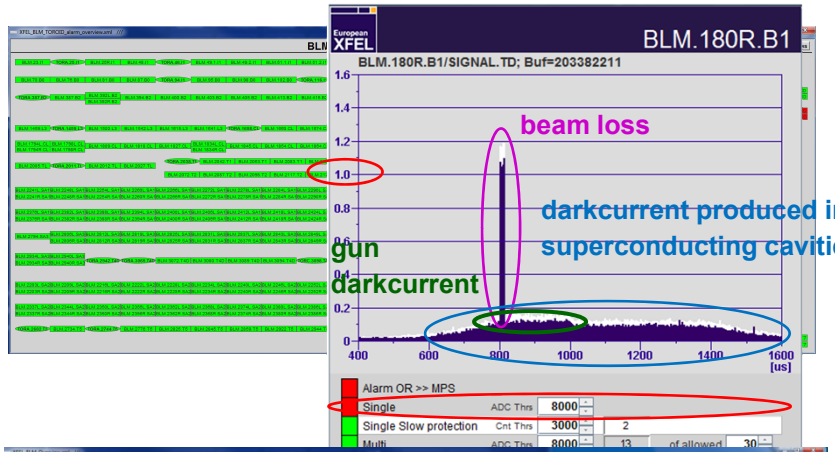
Undulator intersection

BLM GUIs





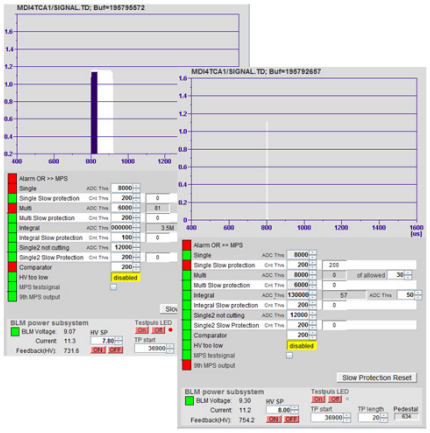
- Main Overview Panels
  - Alarms shown by section



- BLM & toroid Alarm Overview
  - Shows alarms from all BLMs and toroid (bunch charge monitor) based transmission Interlock
  - Each BLM selectable from this panel
- BLM Panel
  - Device settings (current consumption, HV readback)
  - Alarm thresholds
  - Y-axis normalized to single alarm threshold

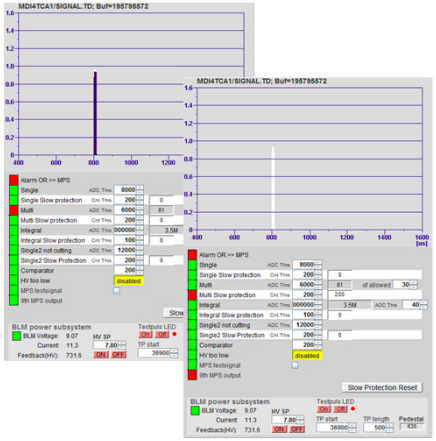
- XFEL BLM Overview
  - Shows maximum amplitude from each BLM
  - Fast overview of losses along the machine

BLM Alarm Generation: Beam Based Alarms



- Beam loss, alarm threshold exceeded, alarm active until end of bunchtrain
  - comparator alarm triggers additionally
- Latency: up to 28us → ~130 bunches @ 4.5 MHz run through

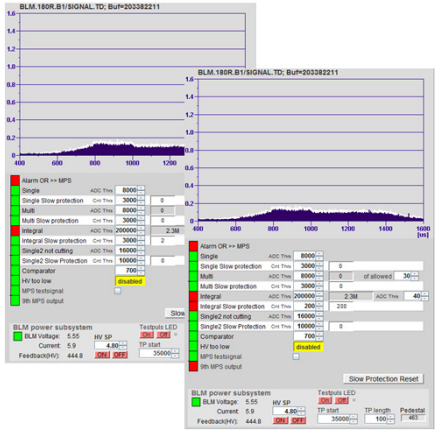
- Slow protection threshold reached, alarm active until reset
  - Slow protection counter started to increment by 1 per consecutive bunchtrain with loss
  - Beam switched off, reset necessary
- Slow protection prevents continously losses of consecutive bunchtrains with loss



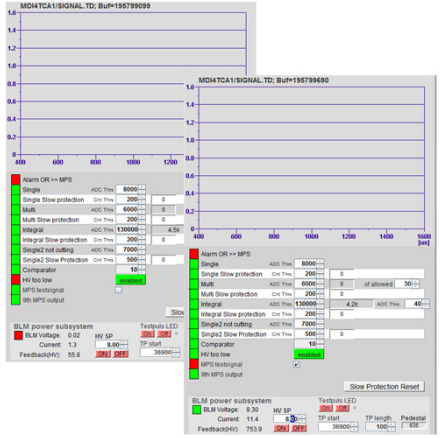
- Beam loss, alarm thresholds exceeded
  - Two terms to trigger alarm
    1. Signal exceeds threshold
    2. Number of allowed bunches over threshold reached
  - Slow protection counter increments
- Slow protection threshold reached
  - Beam switched off, reset necessary

- Expected single loss events during destructive measurements will be masked automatically

BLM Alarm Generation: Darkcurrent Alarms, Device Alarms

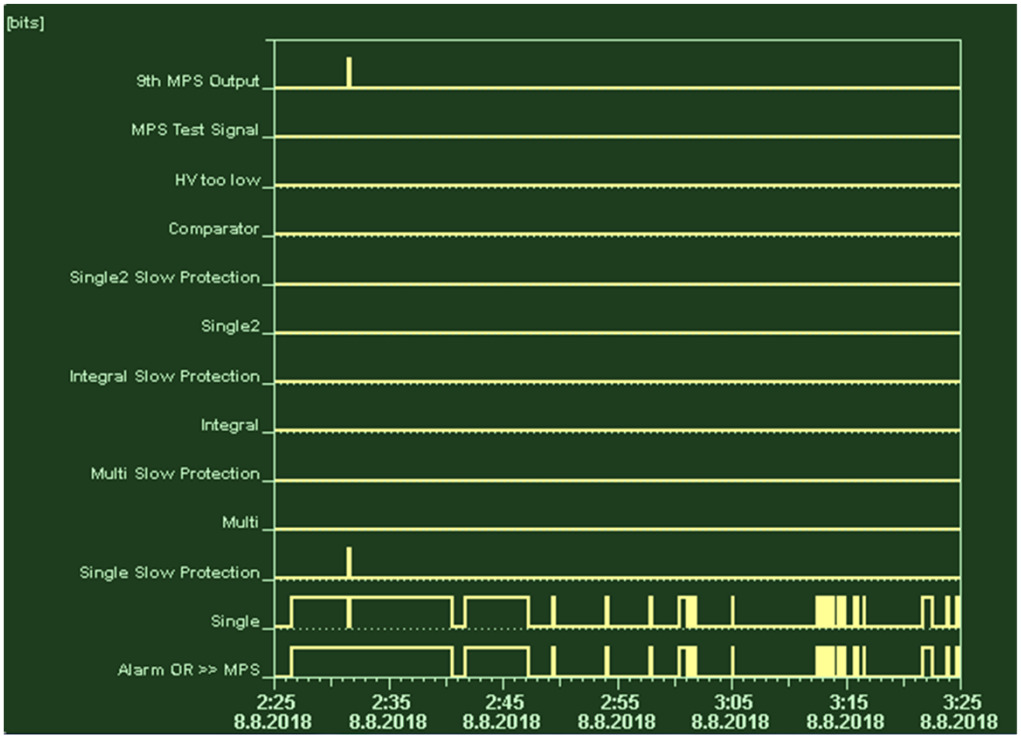


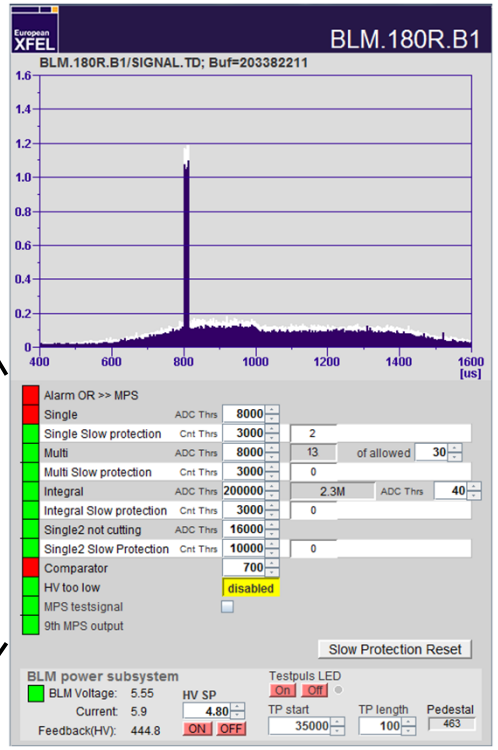
- Integral alarm due to darkcurrent, alarm threshold exceeded
  - Slow protection counter increments
- Slow protection counter reached threshold
  - Alarm still there since it is not a beam based loss
  - Additional alarm output triggers to activate Dark Current Supression (by shifting timing of RF station in Injector), not implemented yet
  - Reset necessary



- High Voltage (HV) alarm, PMT cannot work, BLM not functional
  - No beam possible
  - Can be disabled
- MPS testsignal, can be switched on to check BLM alarm response

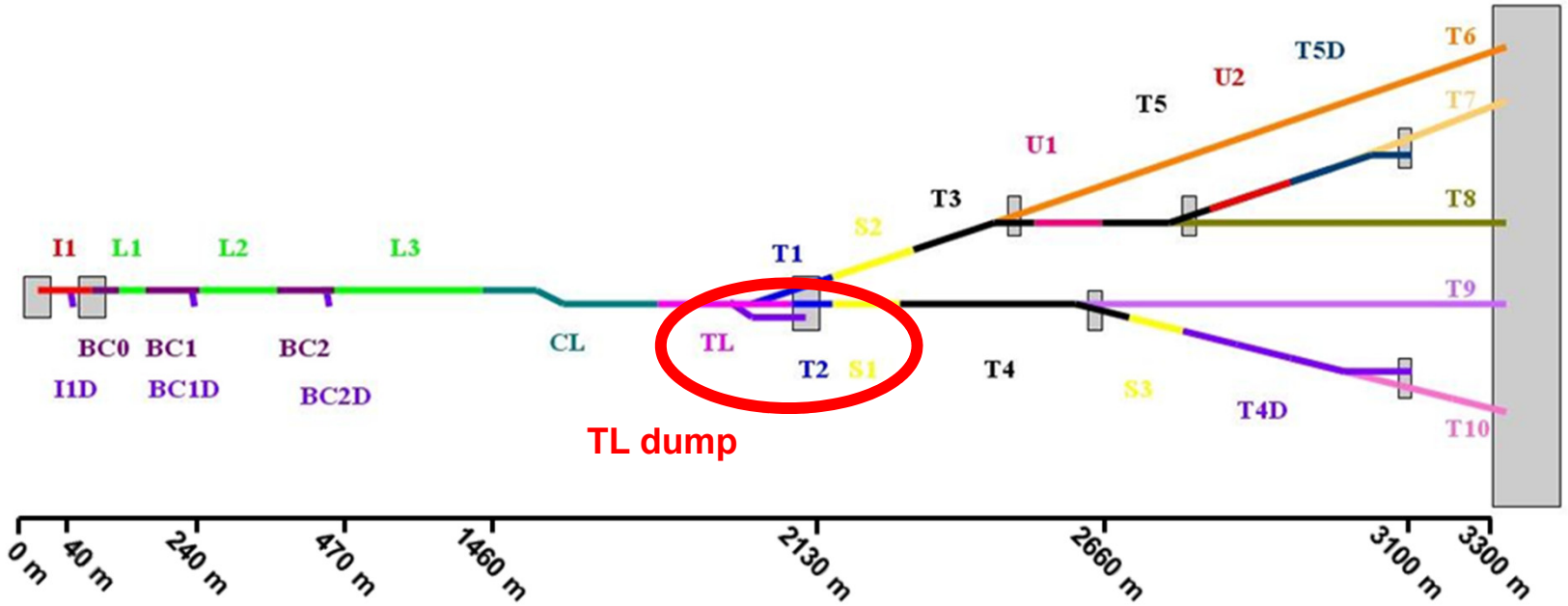
BLM Alarm History Plot





- Alarm history plot for each BLM
  - Kind of alarms traceable (alarm order reversed)

BLM Alarm Latency Decrease



- BLM Alarm in one of the SASE branch
  - Bunchtrain redirected to TL dump
  - Decreases cut latency to 7us

BLM calibration concept

- No absolute calibration
- Get activation results from
  - Measurements from radiation department: Activation profile of the machine
  - Additional information from RadFet dosimetry system
  - Thermoluminescent dosimeter (TLDs)
- Strategy for the warm beamline
  - Use activation profile, look for non tolerable increase and tighten BLM threshold or step up PMT voltage at these positions

1499m	QB 1499. L3	0,1	0,1	
	bis			
1650m	QF 1650. L3	0,2	0,2	
1685,8m	COLS.1685.CL	0,5	2,0	Kollimator
1690,1m	COLM.1690.CL	2,0	17,0	Kollimator
1691-1695m	Div.	2,0	0,3	
1721,8m	COLS.1721.CL	0,2	0,3	Kollimator
1726,1m	COLM.1726.CL	2,0	12,0	Kollimator

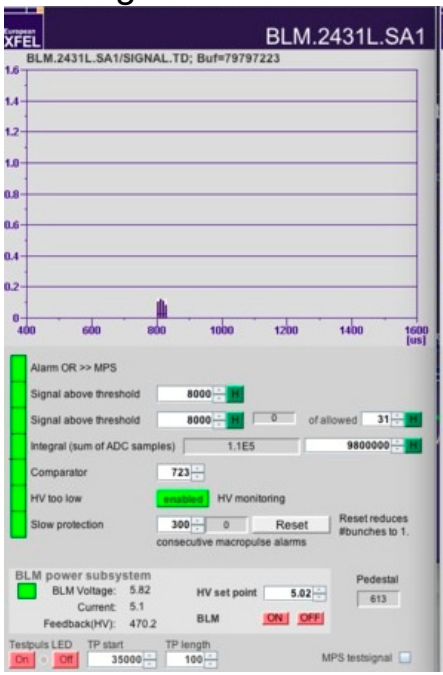
Messprotokoll zum Ausmessen von Stellen mit erhöhter Radioaktivität bei XTL bis XS 1

Datum:	04.04.2018
Zeit:	07:15
Beschleuniger:	XTL bis XS 1
gemessen von:	Hartz / Hartz
Messgerät:	6150AD2
Bemerkung:	

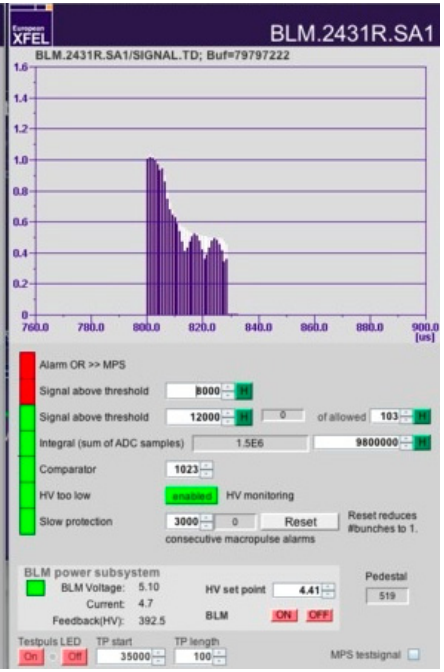
Messort	Bezeichnung	Dosisleistung in 30cm [µSv/h]	Dosisleistung Oberfläche [µSv/h]	Bemerkung
467m	BG 467 B2D	0,2	0,2	
473m	BC2. 473	0,3	1,0	
475m	XM 7	0,1	0,2	
	bis			
660m	XM 14	0,2	0,3	rechts
783m	XM 56	3,0	8,0	
917m	XM 49	0,5	2,0	
1002m	XM 81	0,3	3,0	bis XS 15 Tür
	XM 75	0,1	0,2	
	XM2 XM 79 Verbindung	0,2	0,5	
1457m	XM 98	0,2	0,5	
1457,7m	VCST78T40.1457.L3	0,5	2,0	Sprung nach Linac
1459m	L3_01 DS	0,2	0,2	
	bis			
1499m	QB 1499. L3	0,1	0,1	
	bis			
1650m	QF 1650. L3	0,2	0,2	
1685,8m	COLS.1685.CL	0,5	2,0	Kollimator
1690,1m	COLM.1690.CL	2,0	17,0	Kollimator
1691-1695m	Div.	2,0	0,3	
1721,8m	COLS.1721.CL	0,2	0,3	Kollimator
1726,1m	COLM.1726.CL	2,0	12,0	Kollimator
1793,8m	COLS.1793.CL	0,2	0,2	Kollimator
1798,1m	COLM.1798.CL	0,5	2,0	Kollimator
1798-1800m	Div.	0,2	0,4	
1834,1m	COLM.1834.CL	0,4	5,0	Kollimator
1940,1m	VCST40T30.1940.TL	0,2	0,2	Kicker
1979,5m	VCABSA.1979.TL	2,0	20,0	Absorber vor Septum zum Dump
1982m	QK1982.TL	0,2	0,5	
1986m	BZ1986. TLD	0,2	0,3	
2016m	SA2016. TLD	0,2	0,2	links
2024,5m	VCABSA.2024.TL	0,2	0,3	Absorber vor Septum zum T1
2027m	QK2027.TL	0,2	0,3	links
2066m	BD2066.TLD	0,2	0,2	
2086m	BV2087. TLD	0,2	0,2	links
2095m	QK2095. TLD	0,2	0,2	links
2096m	SK2096. TLD	0,2	0,2	rechts
2098m	CNY2098. TLD	0,2	0,2	bis Wand

BLMs in Undulator intersection

Quartzglass



Plastic scintillator



- Scintillators sensitive to (spontanous) synchrotron radiation
  - Gets blind to electron beamlosses in the undulator section
- Use Cherenkov effect (not sensitive for synchrotron radiation) and switch to quartzglass in the undulator intersections (currently being implemented)

Conclusion

- 472 BLMs installed
- 78 RTMs in 58 MTCA Crates
- Different independent configurable alarm thresholds
- Slow protection prevents permanent high losses
- Dump kicker decreases bunchtrain cut latency
- BLM threshold adjusted to activation profile of the machine
- Change scintillators to quartzglass in undulator section

Thank you for your attention