

Das Machine Protection System (MPS) bei FLASH

- Warum ein MPS?
- Langsames Interlock – BIS
- Verlustmonitore – BLMs
- Undulatorschutz
- Schnelles Interlock – BICs
- Passiver Schutz: Kollimatoren

Warum Maschinenschutz?

Gun:

70 μs – 840 μs

Kalte Module (ACC1–6):

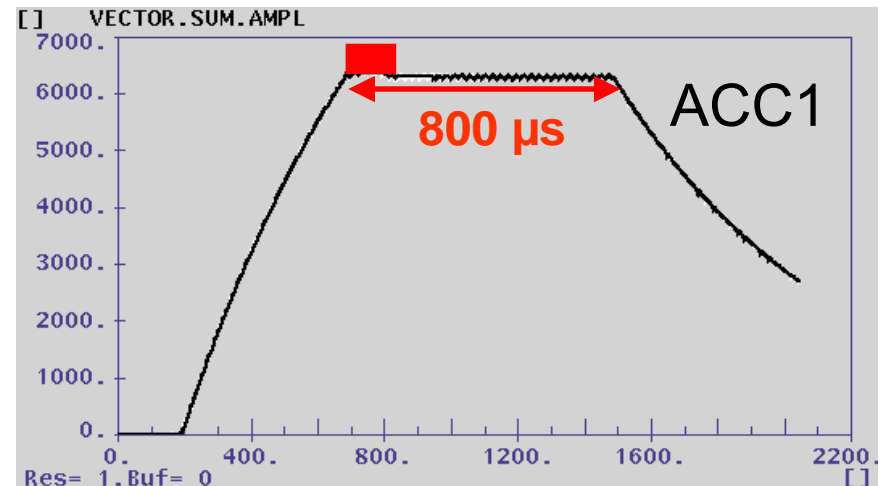
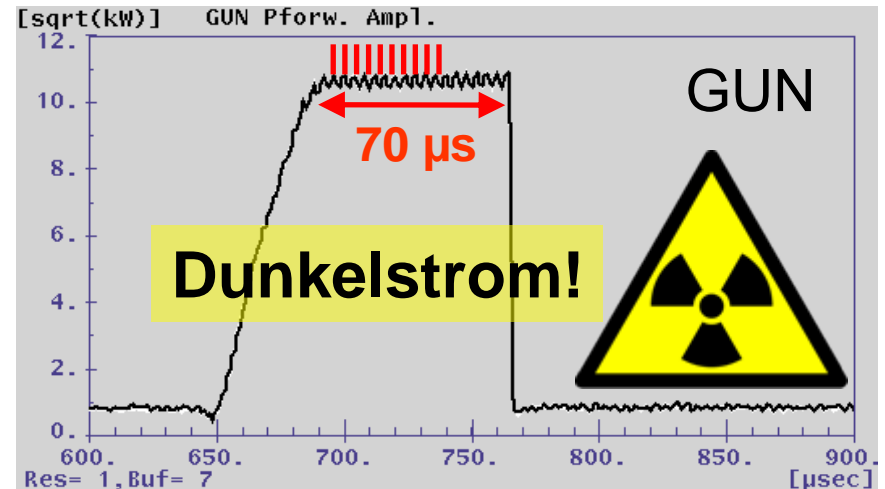
100 – 800 μs

Der Laser erzeugt max.

1 Bunch/ μs (1 MHz).

Der “flat top” hat Platz für

bis zu **800 Bunche.**

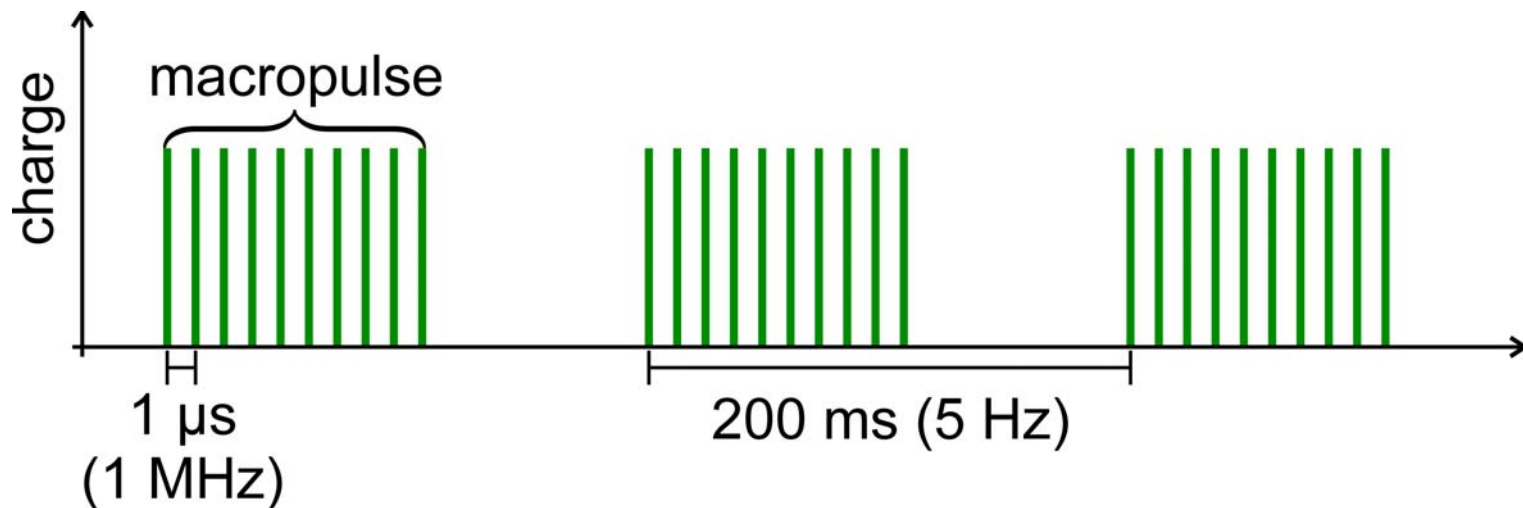


Wiederholrate (rep-rate):

1 Hz, 2 Hz, 2.5 Hz, **5 Hz**, 10 Hz

Bunch-Frequenz:

50 kHz, 100 kHz, 200 kHz, 250 kHz, 500 kHz, **1 MHz**, 9 MHz



Energie: bis zu **1 GeV**

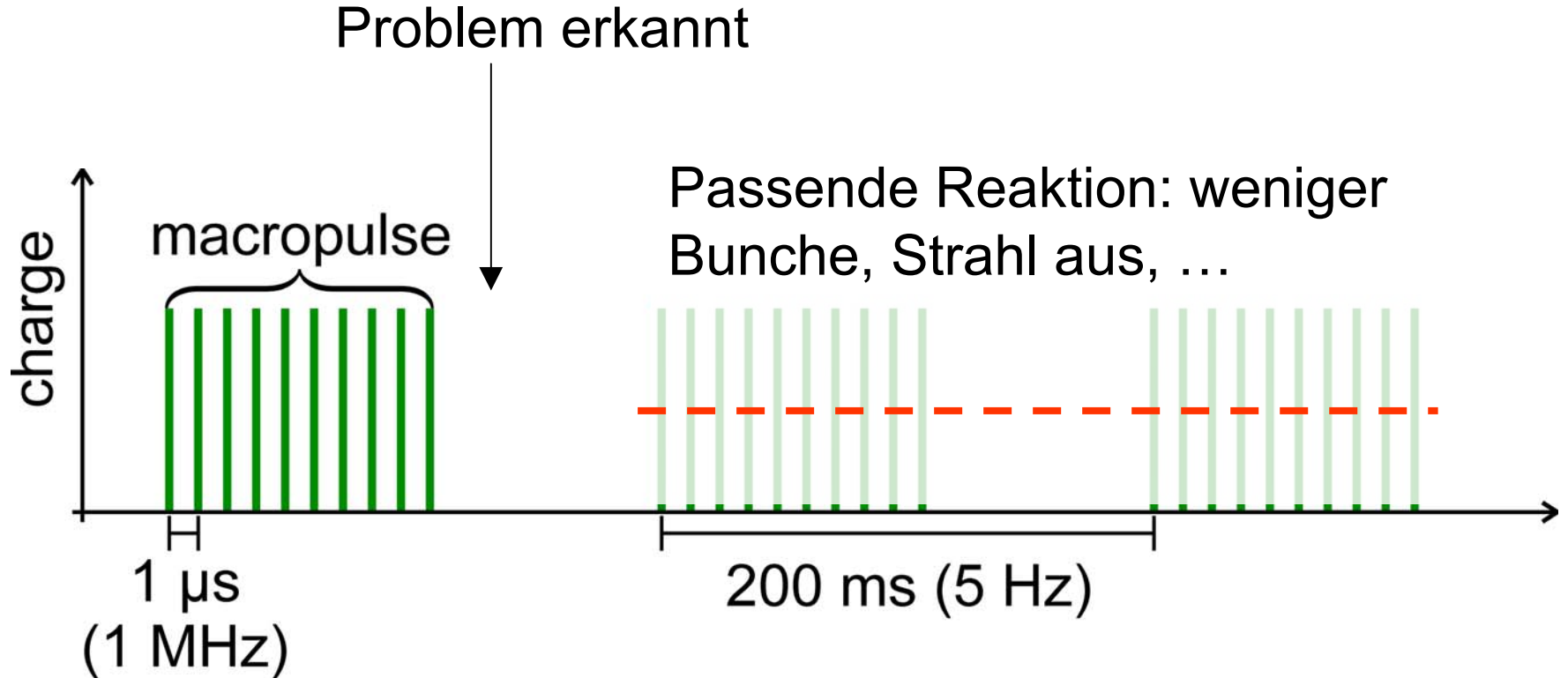
Ladung: **1 nC**

HF-Pulslänge: bis zu **800 μ s** plus Füll-/Abklingzeit

	1 Bunch	30 Bunche	800 Bunche	7200 Bunche
1 Hz	1 W	30 W	800 W	7.2 kW
5 Hz	5 W	150 W	4 kW	36 kW
10 Hz	10 W	300 W	8 kW	72 kW

Langsames Interlock – BIS

Beam Interlock System



Langsam: Reaktion zwischen Makropulsen (>1 ms)

Speicherprogrammierbare
Steuerung (SPS)

überwacht

- Magnet-Netzteile
- Schirme
- Vakuumventile
- Kühlwasser, Temperatur
- Verlust-Alarme
- etc.

BIS: „Gehirn“ des MPS.

Kann ausschalten:

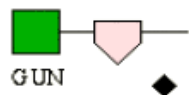
- Injektor-Laser
- Gun-HF
- ACC1-HF

Legt fest:

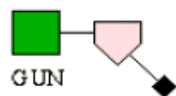
- Operation Mode
- Beam Mode

Der **Operation Mode** wird über den Zustand von Magneten und Ventilen festgelegt.

GUN Mode

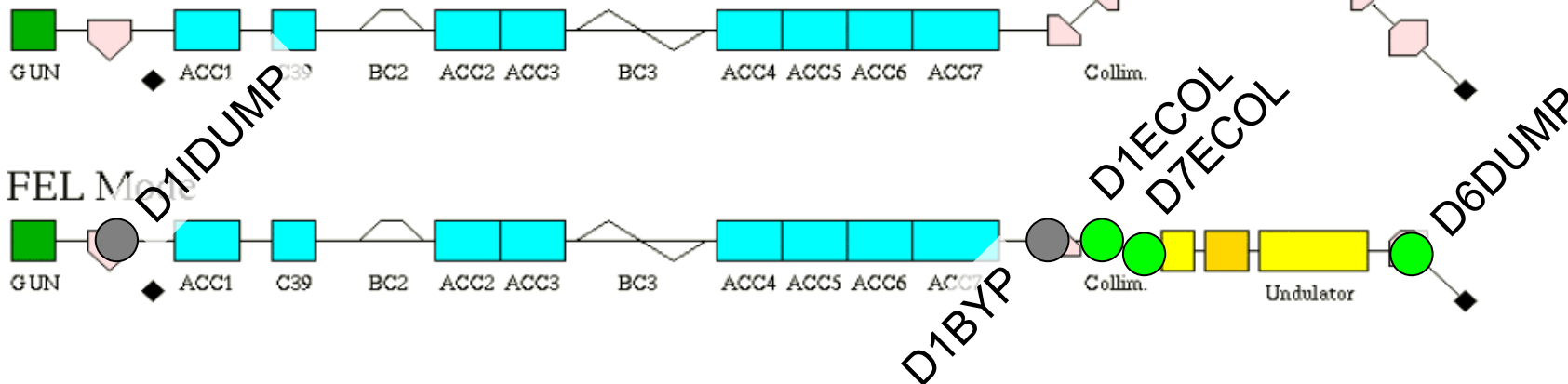


ANALYSIS Mode

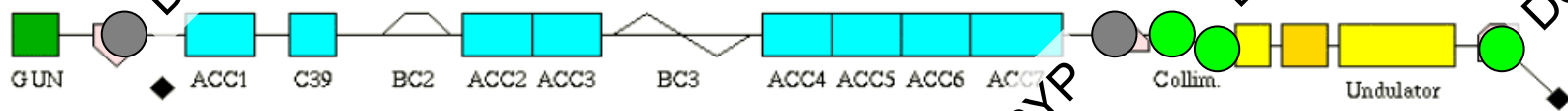


Grundregel:
Kein Operation Mode, kein Strahl.

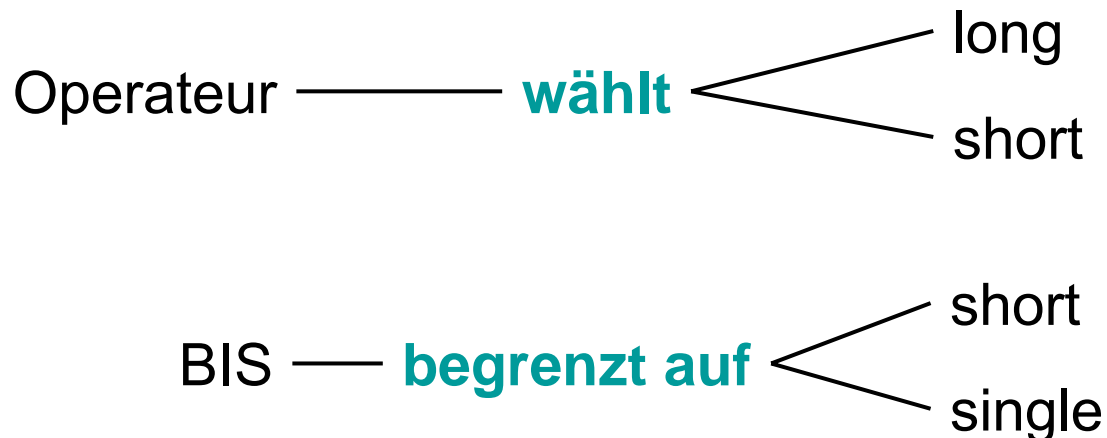
BYPASS Mode



FEL Mode

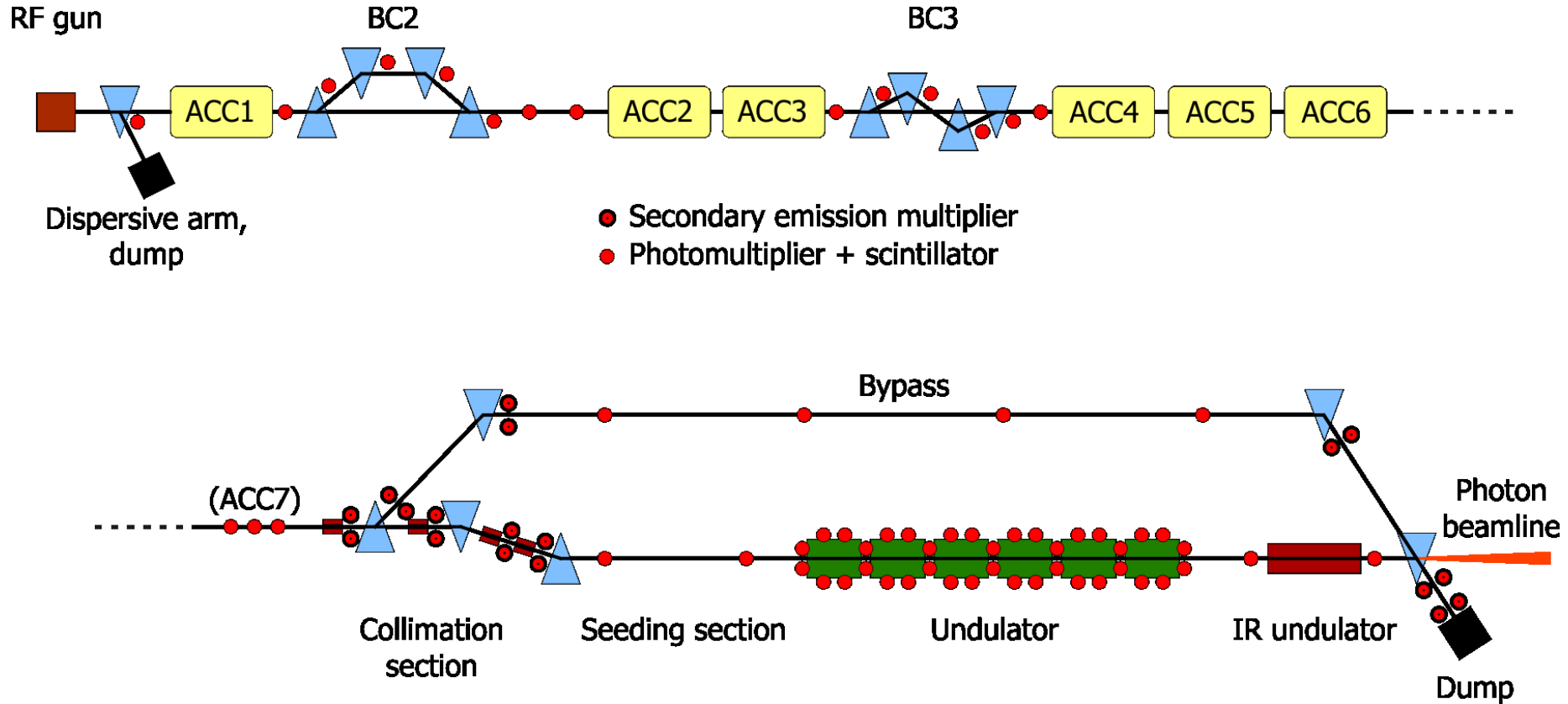


- **Single** pulse mode (bis zu **2** Bunche, schnelles System **aus**)
- **Short** pulse mode (bis zu **30** Bunche, schnelles System **aus**)
- **Long** pulse mode (**unbegrenzte** Bunchzahl, schnelles System **an**)

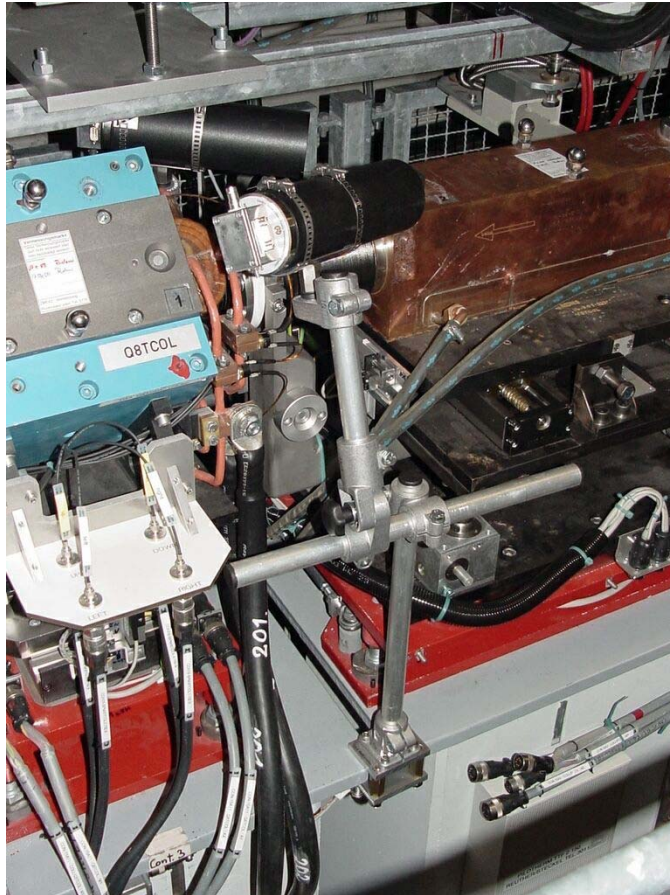


Verlustmonitore – BLMs

Beam Loss Monitors



18 Sekundärelektronen- Vervielfacher (SEVs)

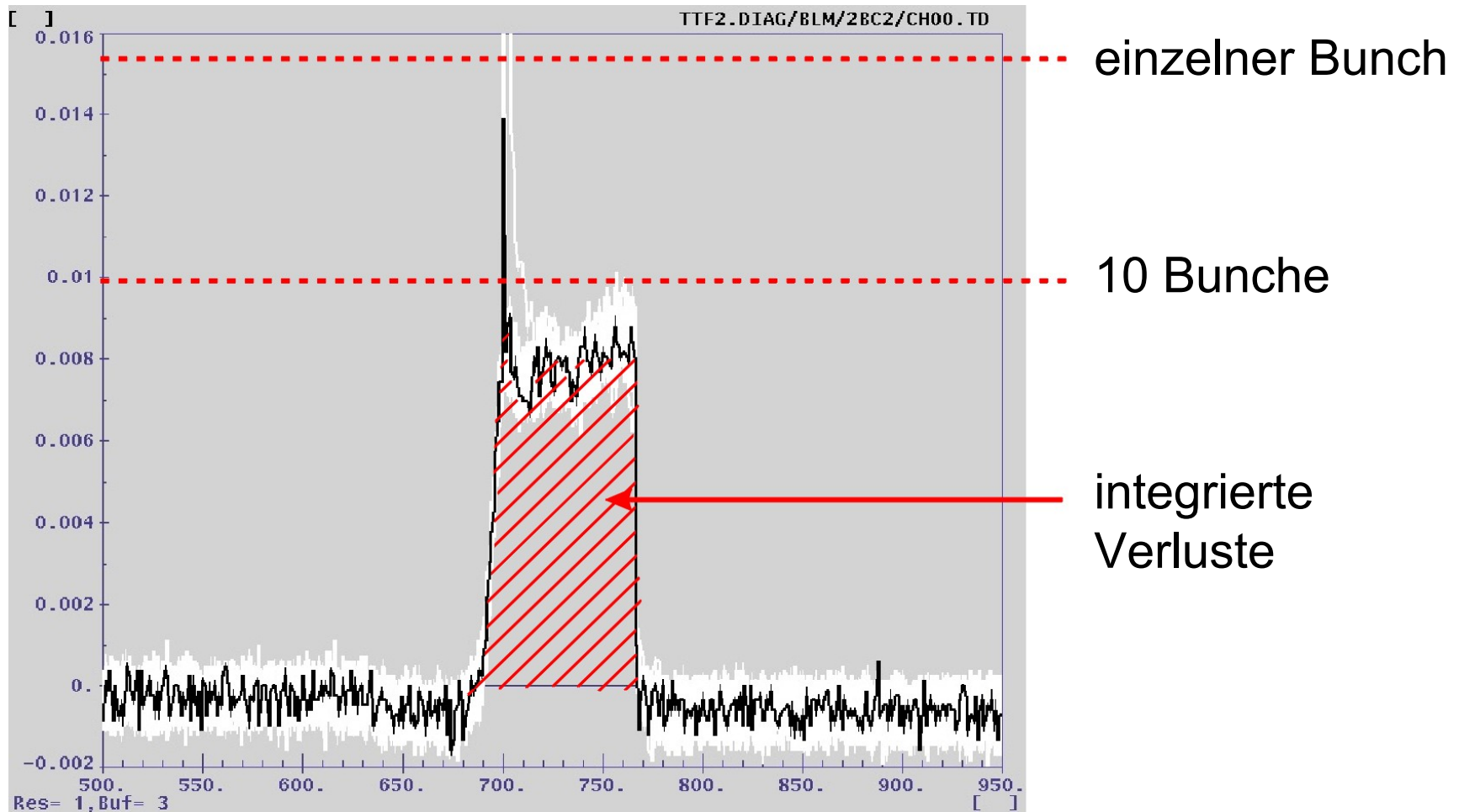


Schichtausbildung, 11. Okt. 2007

63 Photomultiplier mit Szintillator-Paddeln



Lars Fröhlich u. Martin Staack



diagnostics Expert

Diagnostics

Laser PT0 Beamline ADCs Scope VNC Energy Temperatures Manuals	BPMs sections INJ DBC2 ACC2&3 BC3 ACC4 to 7 Bypass Und. Seed misc. Diff Orbit Orbit Status list FEL BPMs Hist. Cav' BPMs Save & restore	Beam Loss Dose @ Und. Dose Rate BLM overview GUN - ACC2 ACC3 - ACC7 Bypass	Bunch Length BC2 - CSR TOSYLAB 9DBC2 - CDR Pyro 9DBC2 Diff' rad. BC3 - CDR Pyro 4DBC3 Diff' rad.	Screens OTR Cameras OTR Stations Active Image Grab Image status/resets Image Servers Manuals	Photon MCP MCP raw GMD Tool DAQ GMD Tool aux SASE history Correlations	Misc. Und. Temp. RF Cable Temp. Air Temp. 220V Mains Stretched wire HOM HOM Displays HOM Control Manuals F Cups FC 2GUN FC 3GUN FC IDUMP
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blm_overview_from_ACC3_to_ACC7: TTF2.DIAG/BLM//

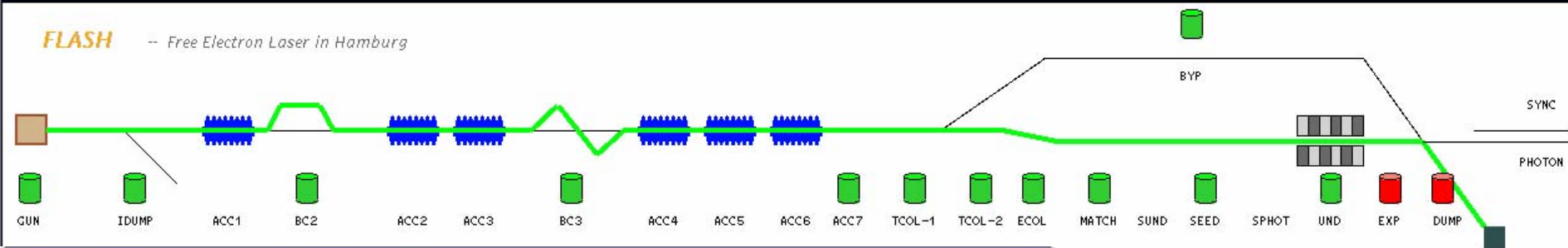
BLM overview ACC3 - ACC7

2UBC3 <p>Res= 1, Buf= 5</p>	1BC3 <p>Res= 1, Buf= 5</p>	5BC3 <p>Res= 1, Buf= 5</p>
11BC3 <p>Res= 1, Buf= 5</p>	14BC3 <p>Res= 1, Buf= 5</p>	2DBC3 <p>Res= 1, Buf= 5</p>

MPS_overview: TTF2.UTIL/BIS//

Machine Protection System Overview

FLASH -- Free Electron Laser in Hamburg



BLM_overview: TTF2.DIAG/BLM.ALARM//

Beam Loss Monitors

1GUN	11BC3	8.1TCOL	2.1BYP	6.1DUMP
17ACC1	14BC3	8.2TCOL	2.2BYP	6.2DUMP
1BC2	2DBC3	2.1ECOL	15.1BYP	13.1DUMP
2BC2	2ACC7	2.2ECOL	15.2BYP	13.2DUMP
3BC2	10ACC7	3.1ECOL	36BYP	
4BC2		3.2ECOL	59BYP	
4DBC2		7MATCH	74BYP	
8DBC2		17SEED	92BYP	
12DBC2		2EXP	1.1DUMP	
2UBC3		10EXP	1.2DUMP	
1BC3	2.1TCOL			
5BC3	2.2TCOL			
Inj .. Acc5		Acc6 .. Dump		

Hardware configuration
1GUN - 3BC2
4BC2 - 2DBC3
1ACC7 - 36BYP
59BYP - 2.1ECOL
2ECOL - 17SEED
22L.SEED - 1R.UND3
1UND3 - 5UND4
1UND5 - 5UND6
1R.UND*, 3R.UND*
1DUMP - 13DUMP

- BLM audio warning
- BIS-BLM protection
- Save & Restore
- BIC status
- Expert tools
- Developments
- Status

Subsystems

- BIS-BLM protection
- BLM overview**
- BIS: GUN-TCOL
- BIS: ACC4-DUMP

Expert views

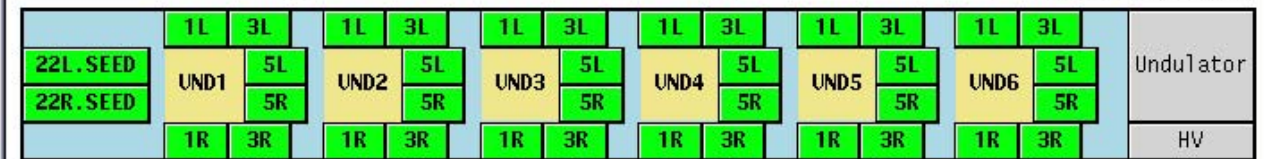
- BIS
- BIC

Section displays

- BLM alarms green: OK red: alarm
- Beam limit short/single

30 2

L. Froehlich 2007-08-09
M. Staack 2007-08-08

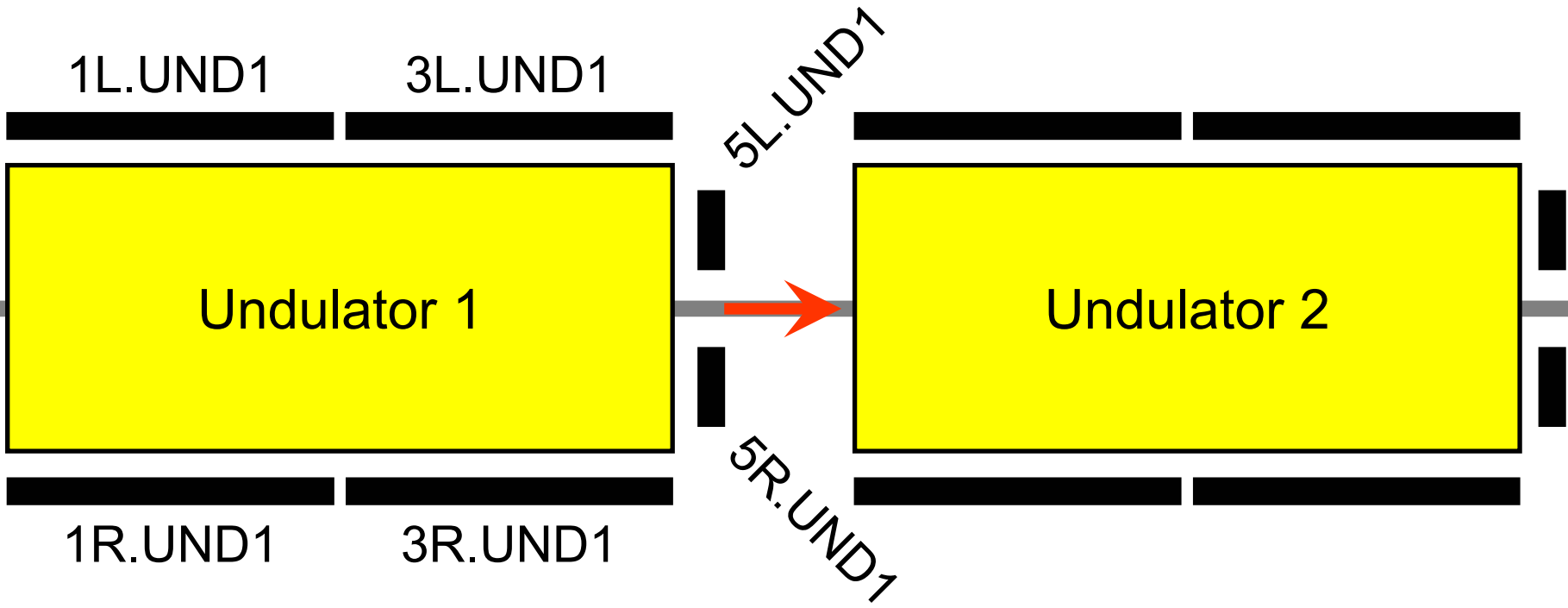


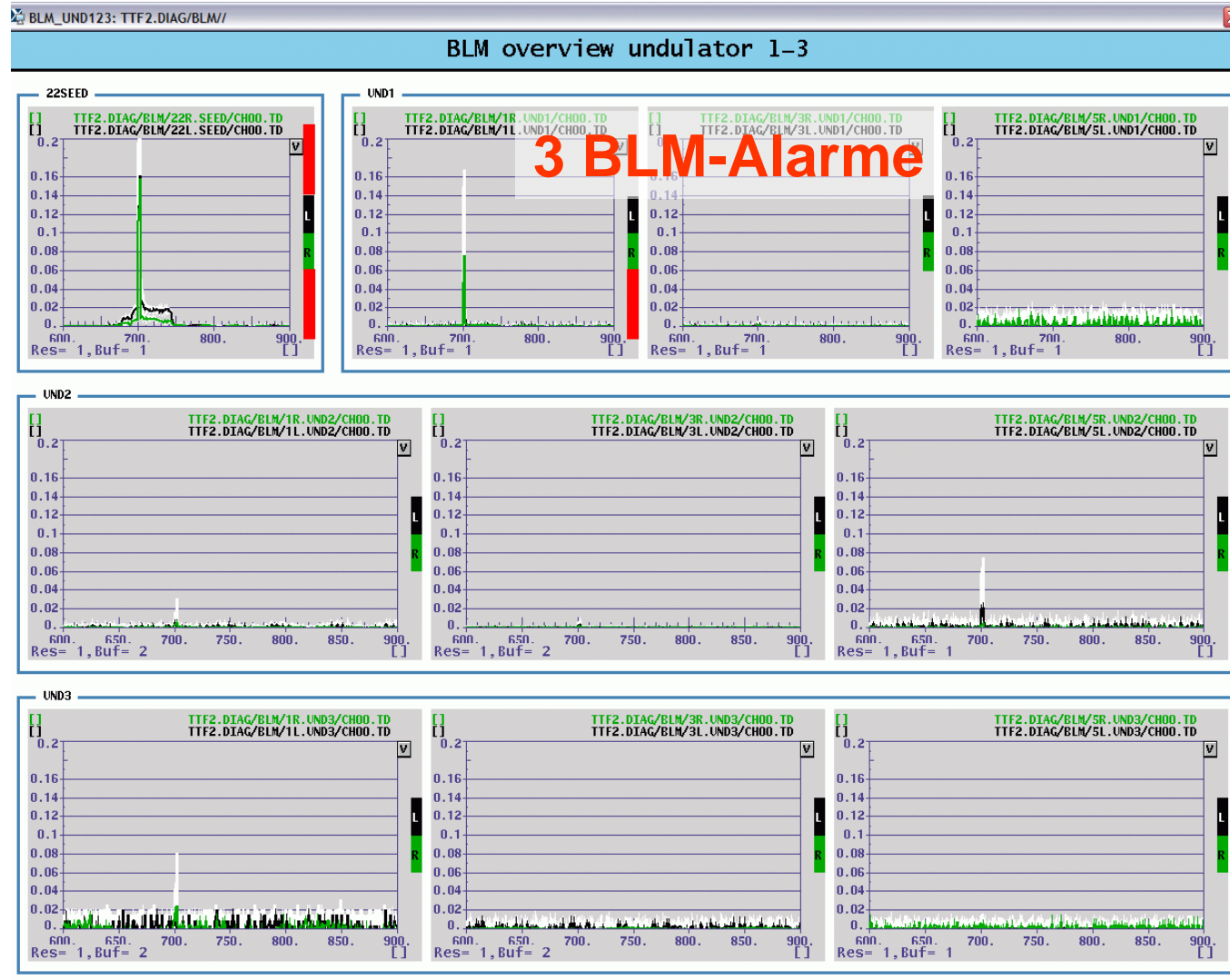
Undulatorschutz

BIS-BLM protection

Undulator-BLMs

6 BLMs pro Undulator-Segment (Draufsicht)





Zu viele Alarme im Undulator

→ Abschaltung von Laser und ACC1-HF

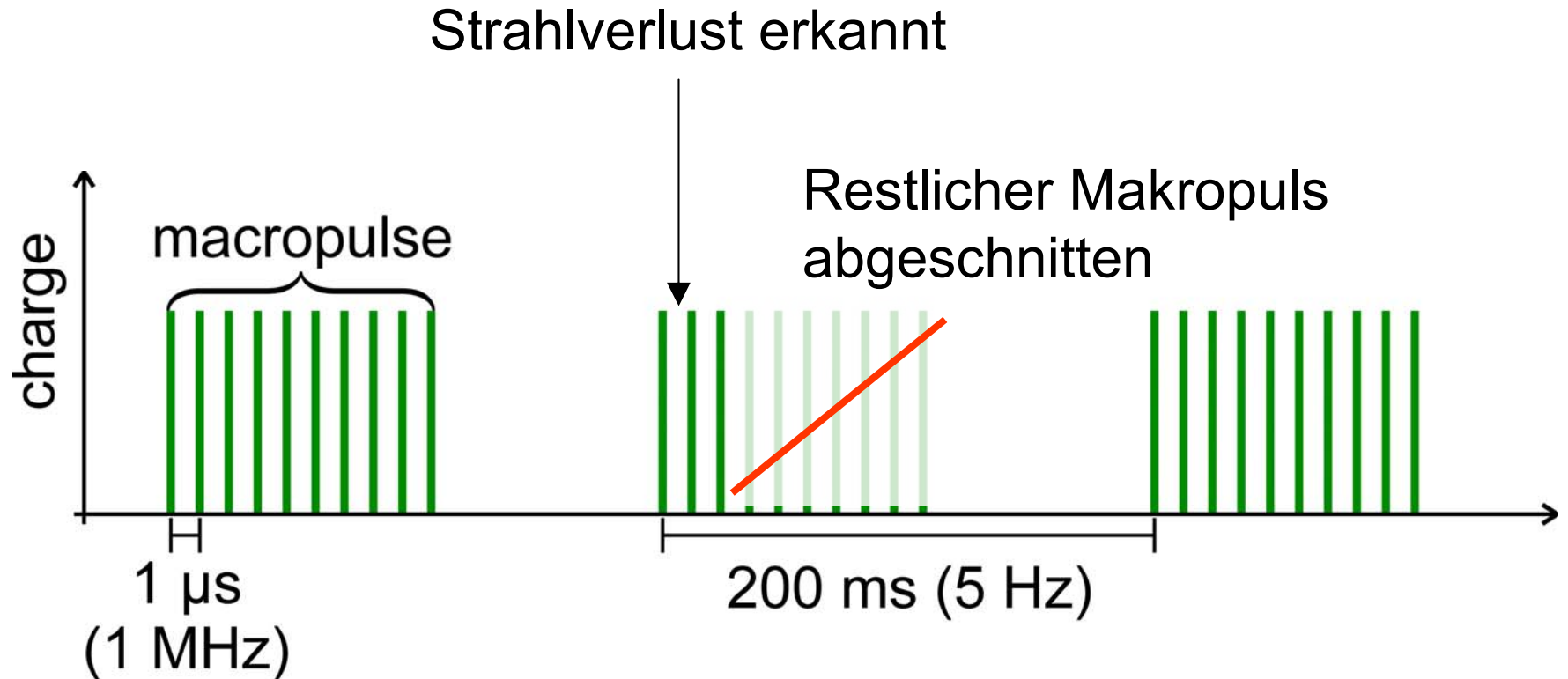
BLM-Alarme	Toleriert für
2	120 s
4	30 s
8	5 s

Kann zeitweise abgeschaltet werden, aber:

Bei 8 BLM-Alarmen stoppt die Maschine trotzdem!

Schnelles Interlock – BICs

Beam Interlock Concentrators

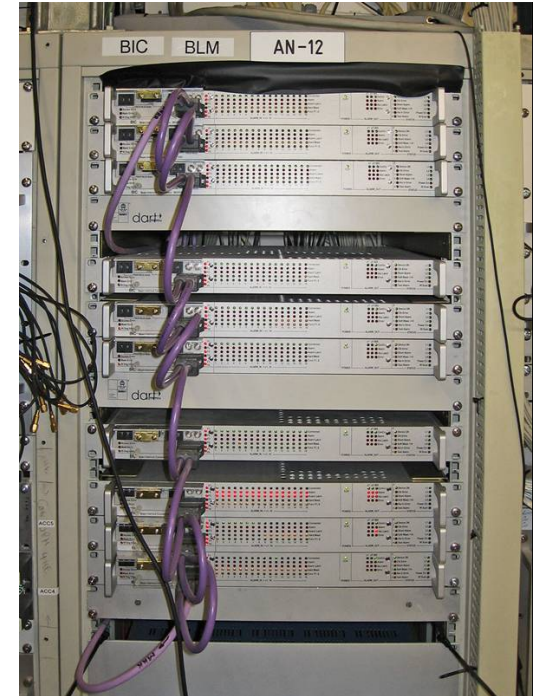


Schnell: Stopp des verbleibenden Makropulses (2 – 3 μ s)

Beam Interlock Concentrators (BICs)

sammeln Alarme von

- allen Verlustmonitoren (BLMs)
- Toroid Protection System (TPS):
Ladungsverlust zwischen 2 Toroiden



Nur aktiv im Long Pulse Mode (für mehr als 30 Bunche)

The TPS monitors the charge difference between two points in the machine.

Inputs

- 9 MHz machine clock
- bunch gate
- 2x analog toroid signal

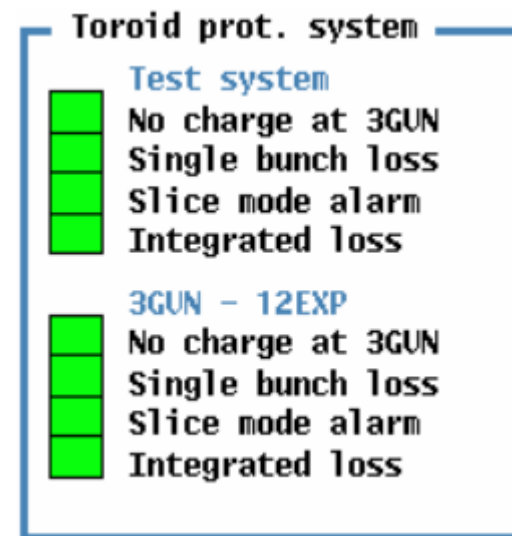


Features

- fully digital signal processing
- response time $\ll 1 \mu\text{s}$
- independent of control system

The TPS generates 4 types of alarms:

- **Charge validation:**
There is no charge on the upstream toroid.
- **Single bunch:**
One bunch has lost more than 25% of its charge.
- **Slice mode:**
More than 6% loss over a sliding window of 30 bunches
- **Integration mode:**
Total loss of more than 20 nC



Four independent crates planned:

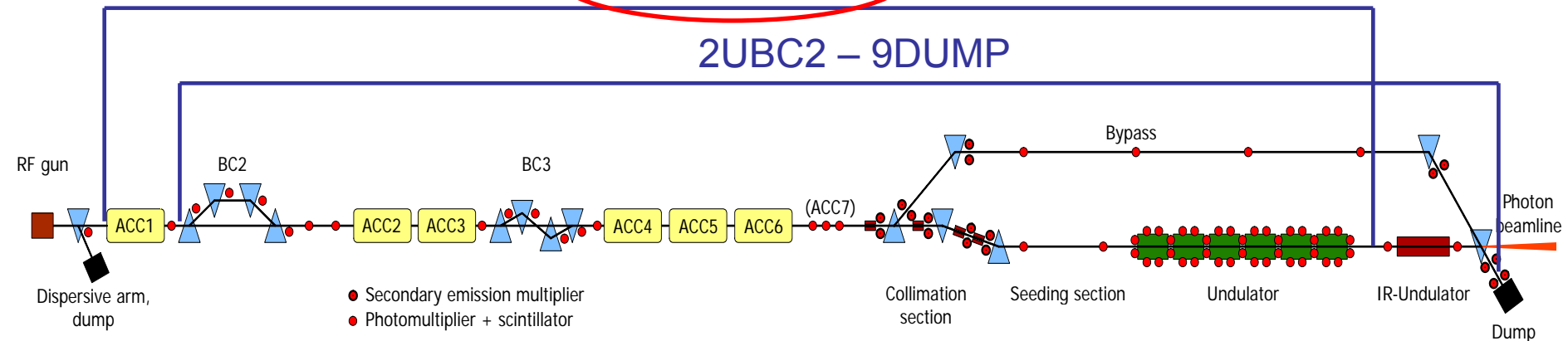
Two for **FEL mode**

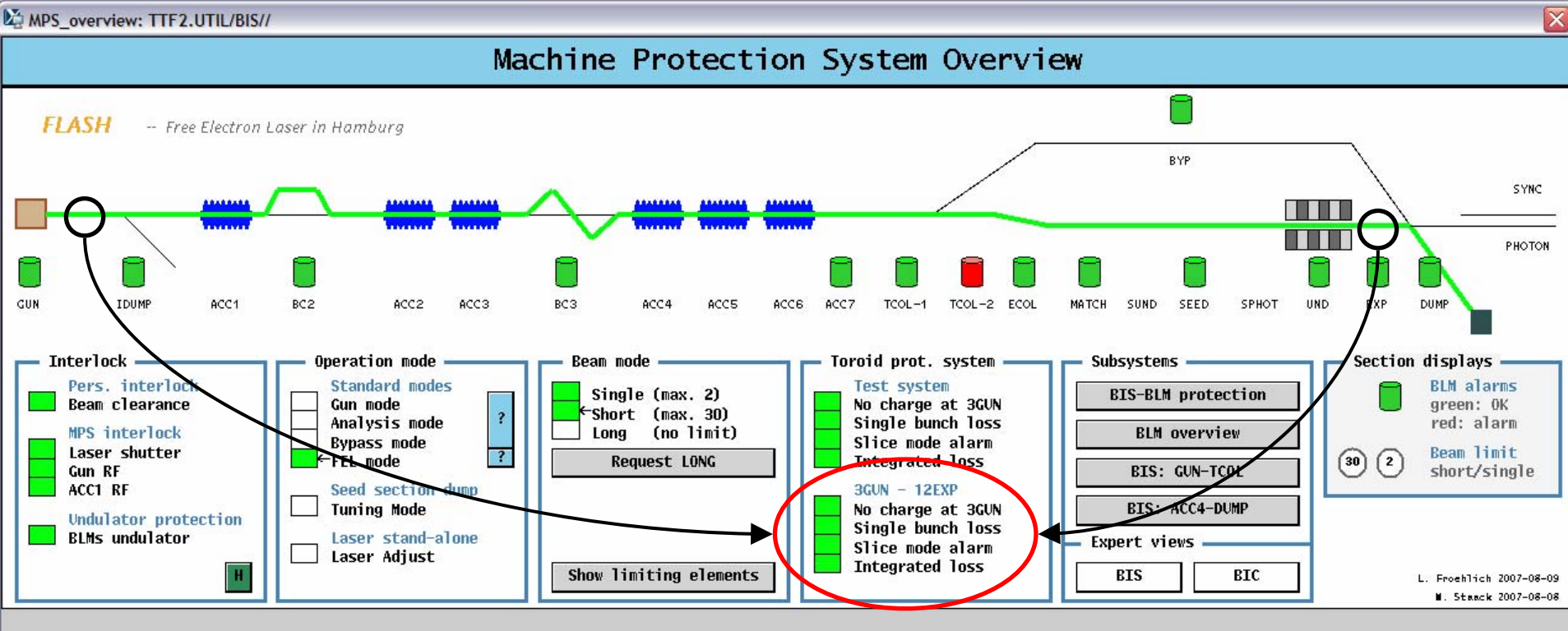
Two for **bypass mode**

Tested and active by default

3GUN – 12EXP

2UBC2 – 9DUMP

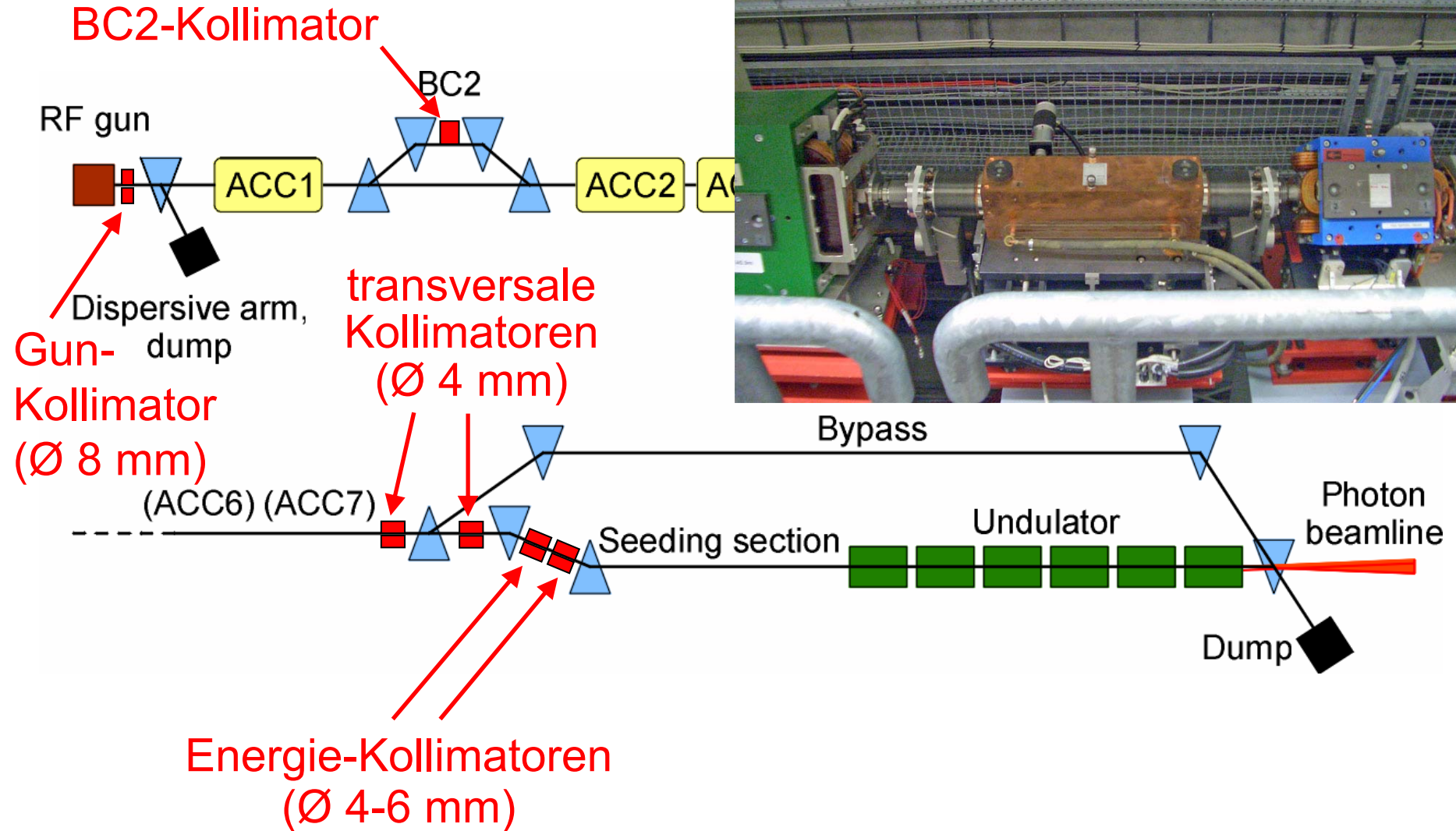




Toroid Protection System:
Vergleicht Ladung vorne und hinten

Passiver Schutz – Kollimatoren

Schutz gegen Dunkelstrom



The screenshot displays the TTF2_injector control interface. The main window shows a beamline layout with components like GUN, ACC1, UBC2, BC2, and DBC2. A red circle highlights the 'Gun Actu.' component. A secondary window, 'bc2_collimator_win: TTF2.DIAG/SR.MOTOR/2BC2.COLL/', shows the 'BC2 Collimator' status, including position/microsteps (0) and position/mm (0.000). A third window, 'gun_actuators: TTF2.DIAG/ACTUATOR/', shows a detailed diagram of the gun actuators, including the collimator, slits, and mirrors. A red circle highlights the 'Collimator' status, showing 'out' and 'in' indicators. A warning box indicates 'Caution! watch vacuum when IN'. The interface also shows various status indicators like 'Kly 3', 'Klystron 5', and 'ACC2 .. ACC5 -->'.