

Experience from the commissioning of the FLASH machine protection system

- FLASH specifics
- Passive protection
- Fast active machine protection
- Slow active machine protection
- First operation with long macropulses

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H. Schlarb, S. Schreiber, M. Staack, M. Werner (DESY, Hamburg)

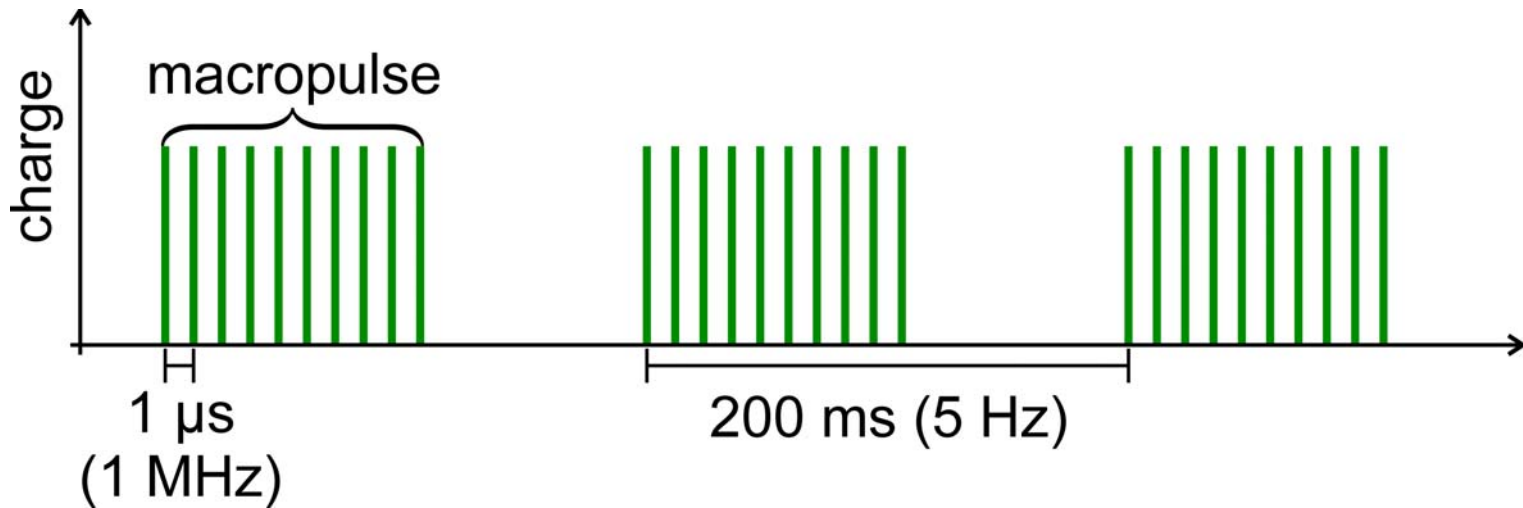
A. Hamdi, M. Luong, J. Novo (CEA, Gif-sur-Yvette)

Bunch frequency:

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

Repetition rate:

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



Beam power

Energy: **460 MeV**, 700 MeV, with additional modules >1 GeV?

Charge: **1 nC**

RF flat top: up to **800 μ s**

	1 bunch	30 bunches	800 bunches	7200 bunches
1 Hz	0.46 W	13.8 W	368 W	3.3 kW
5 Hz	2.3 W	69 W	1.8 kW	16.6 kW
10 Hz	4.6 W	138 W	3.7 kW	33.1 kW

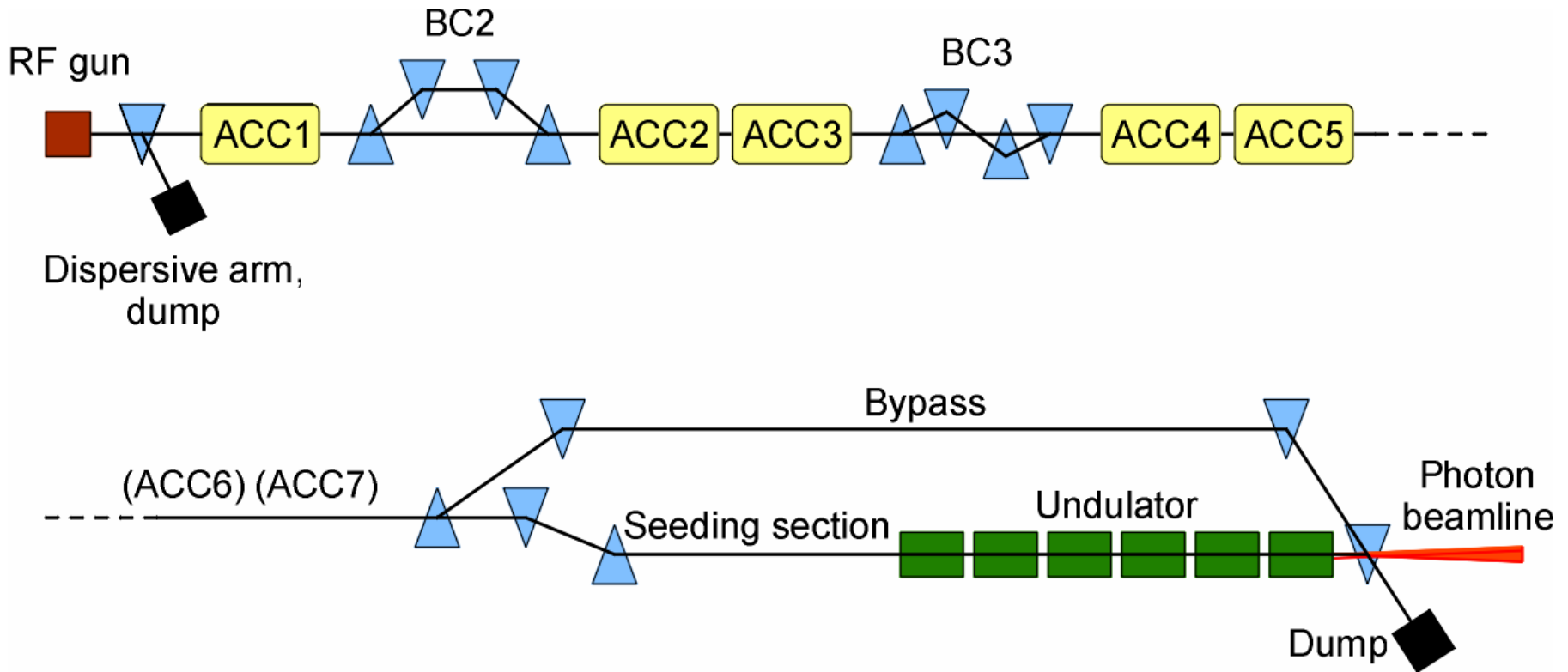
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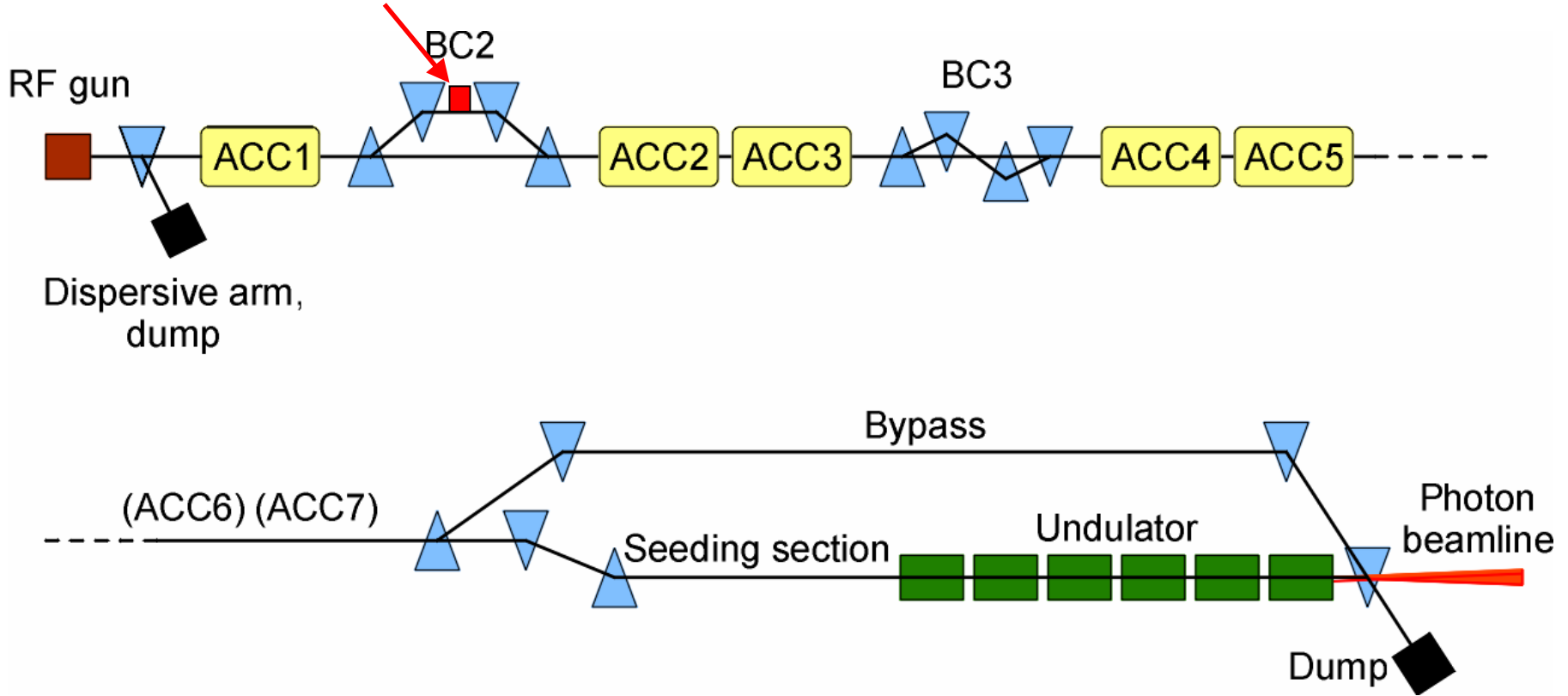
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Passive systems

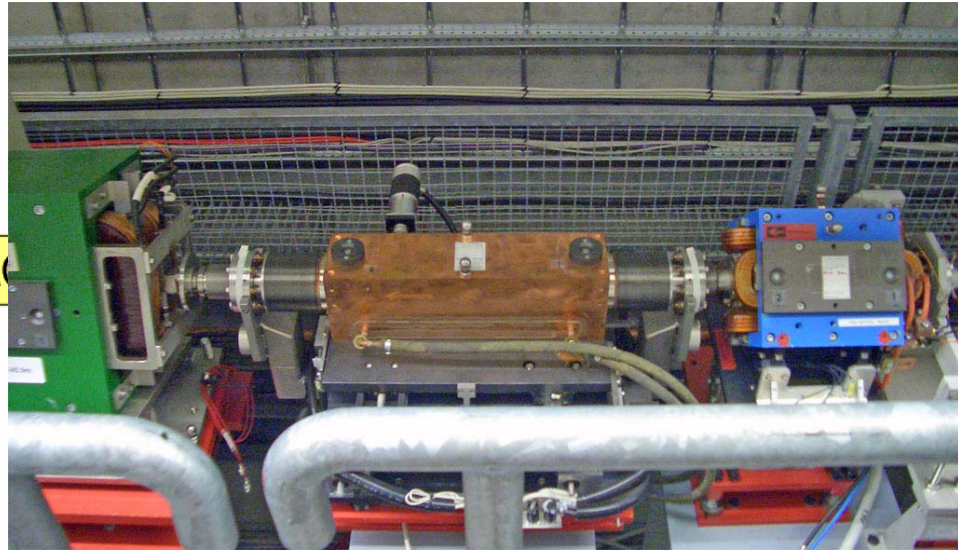
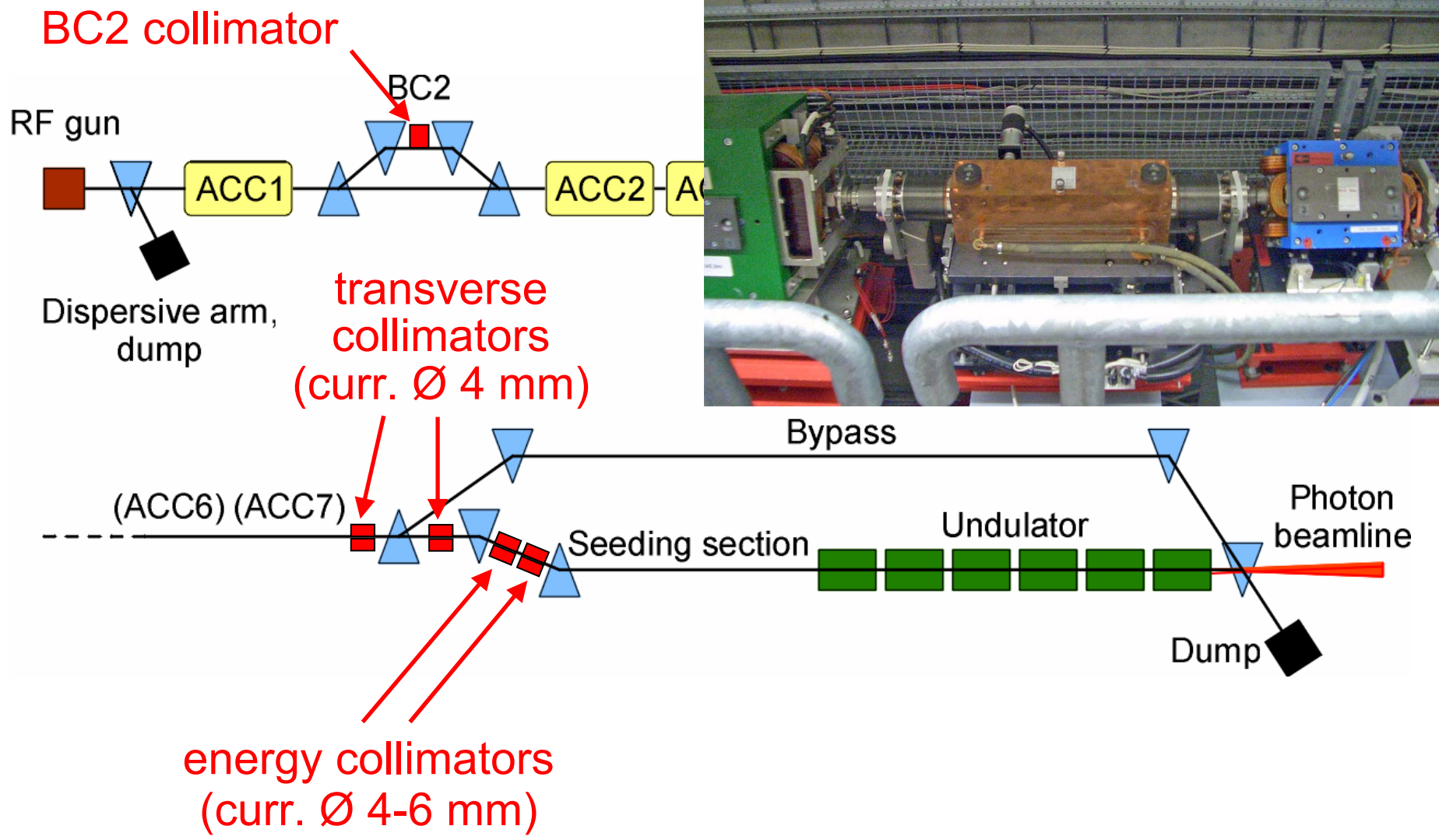


Passive systems

BC2 collimator



Passive systems



Fast: Stop bunch production for the remaining macropulse (2 – 4 μs)

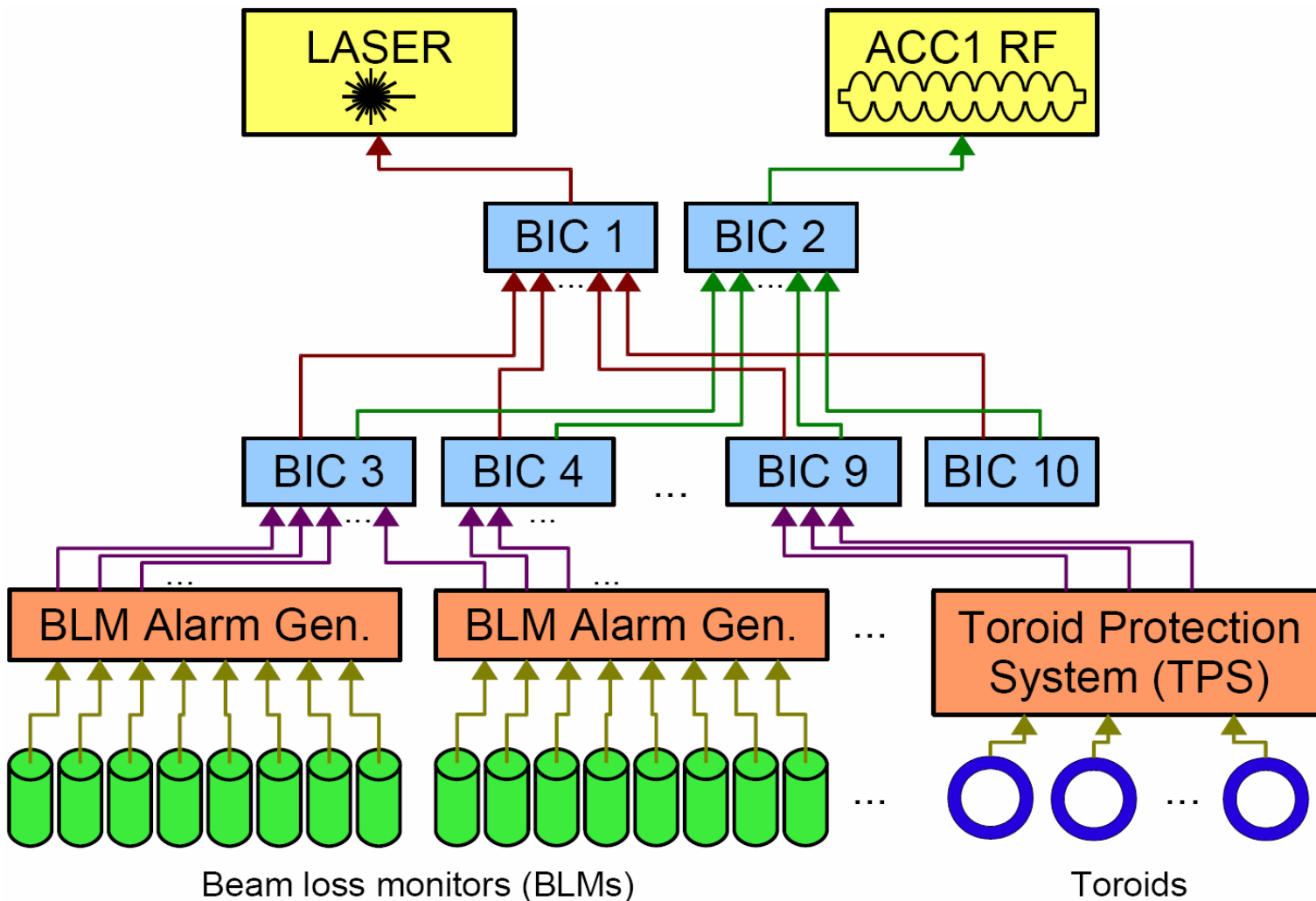
Beam Interlock Concentrators (BICs)

collect alarms from

- Beam Loss Monitors (BLMs):
Electromagnetic showers
- Toroid Protection System (TPS):
Charge loss
- Fast vacuum shutters
- LLRF quench detection



Fast beam interlock



Slow: Action between macropulses (>1 ms)

Programmable logic control
“Beam Interlock System” (BIS)

monitors

- Magnet power supplies
- Screens, diffraction radiators
- Vacuum valves
- Cooling water
- Status from fast system
- etc.



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“Beam Interlock System” (BIS)

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- etc.



The BIS is the brain of the machine protection.

It can switch off

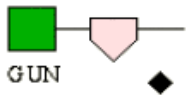
- injector laser
- gun RF
- ACC1-5 RF

and defines

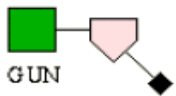
- operation mode
- beam mode

The **operation mode** is determined from the state of valves and magnets.

GUN Mode

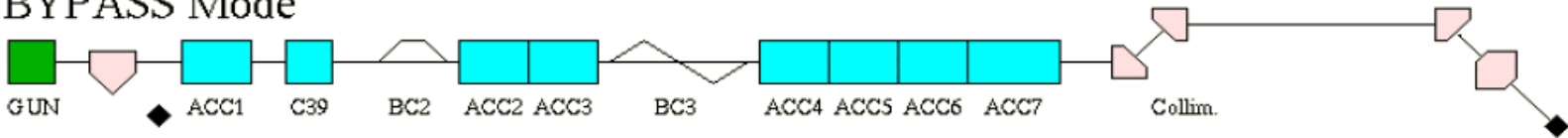


ANALYSIS Mode



Basic rule:
No operation mode, no beam.

BYPASS Mode



FEL Mode

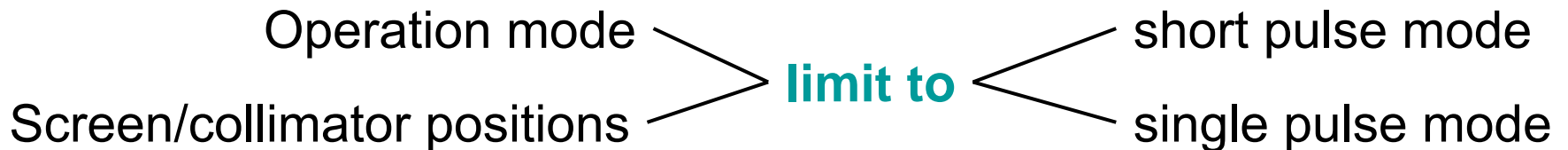



There are three beam modes:

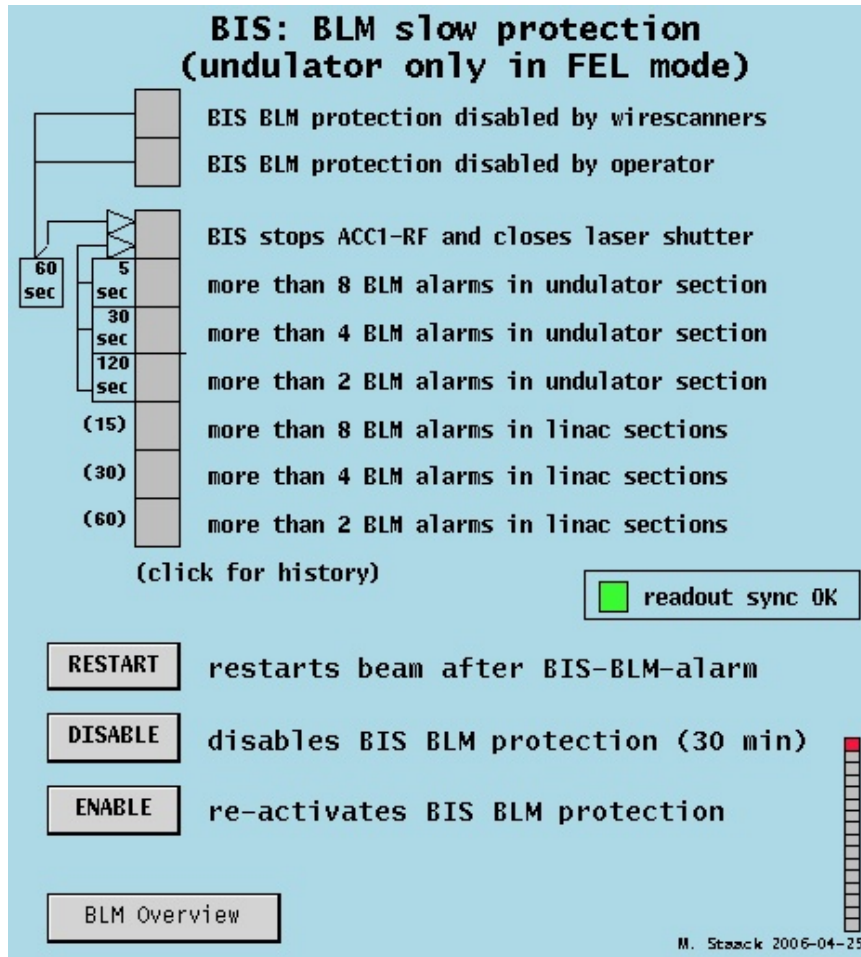
- **Single** pulse mode (up to **2** bunches, no fast protection)
- **Short** pulse mode (up to **30** bunches, no fast protection)
- **Long** pulse mode (**unlimited** bunches, fast protection)

Operator — **chooses** 

- long pulse mode
- short pulse mode

Operation mode 
Screen/collimator positions **limit to** 

- short pulse mode
- single pulse mode



Undulator protection

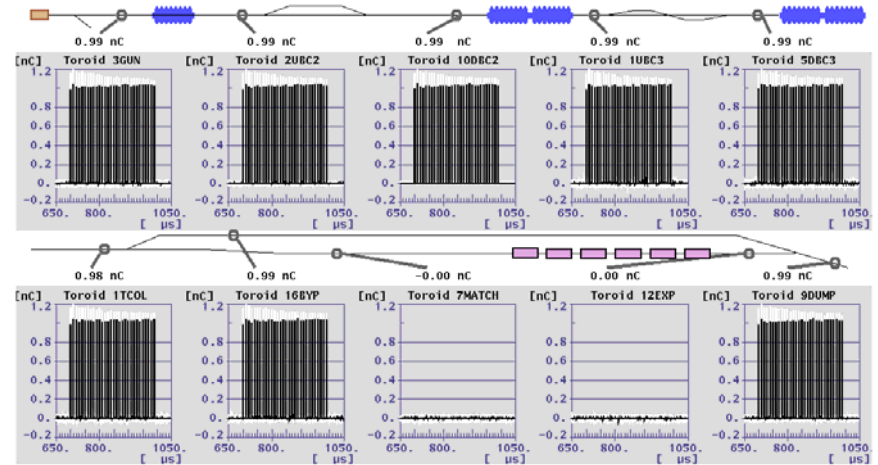
- loss alarms in undulator section: too many too long
→ laser/ACC1 off
- can be disabled for 30 min

Darkcurrent protection

- loss alarms in linac: too many too long
→ RF pulses shortened to 100 μ s
- can be disabled for 60 min

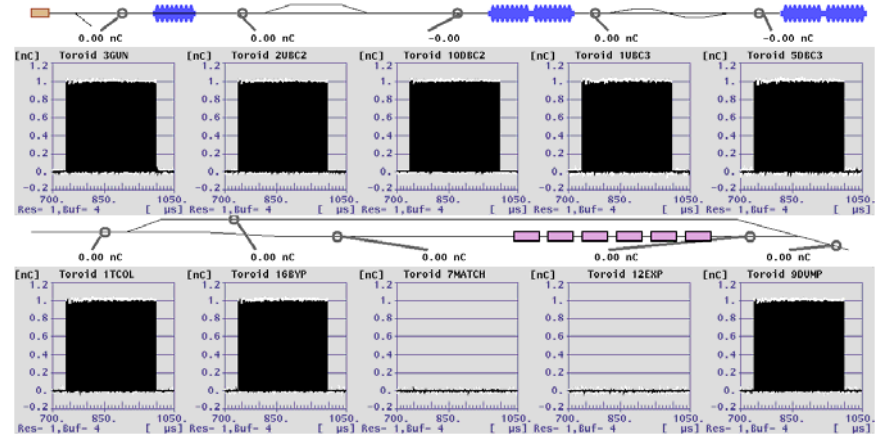
Up to March 2006

max. 30 bunches/macropulse

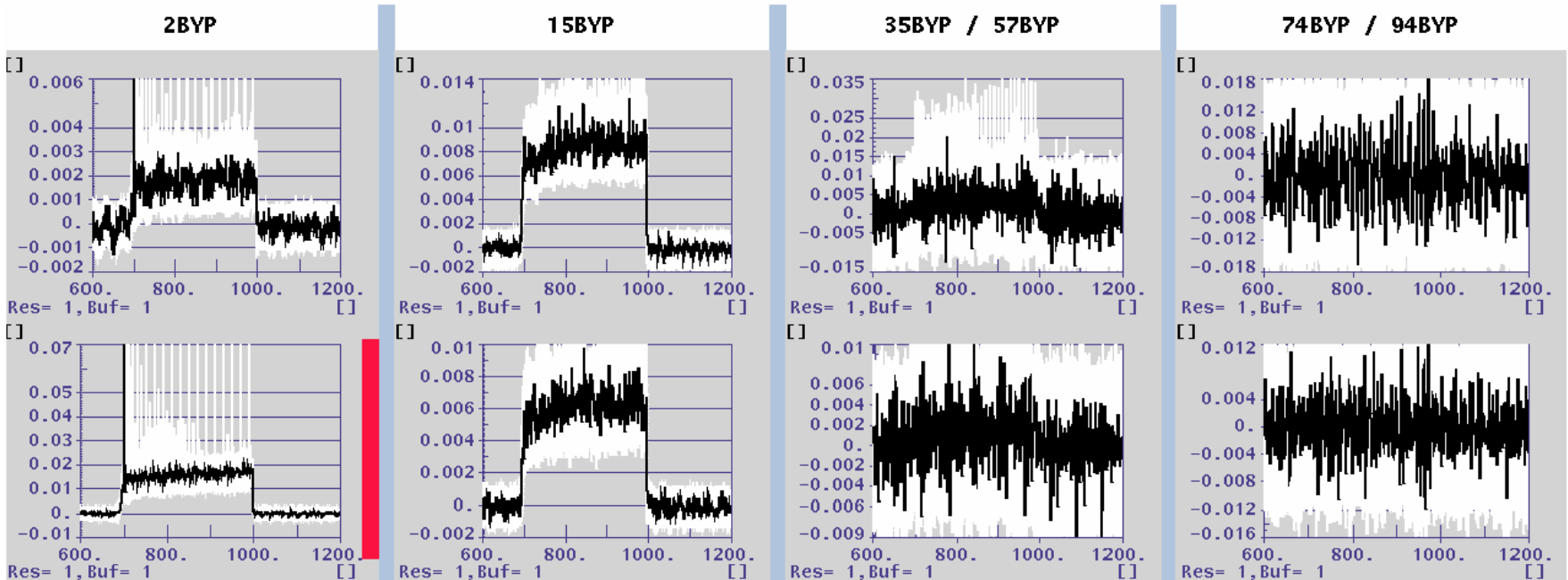


18–20 March 2006

300 bunches/macropulse in bypass line

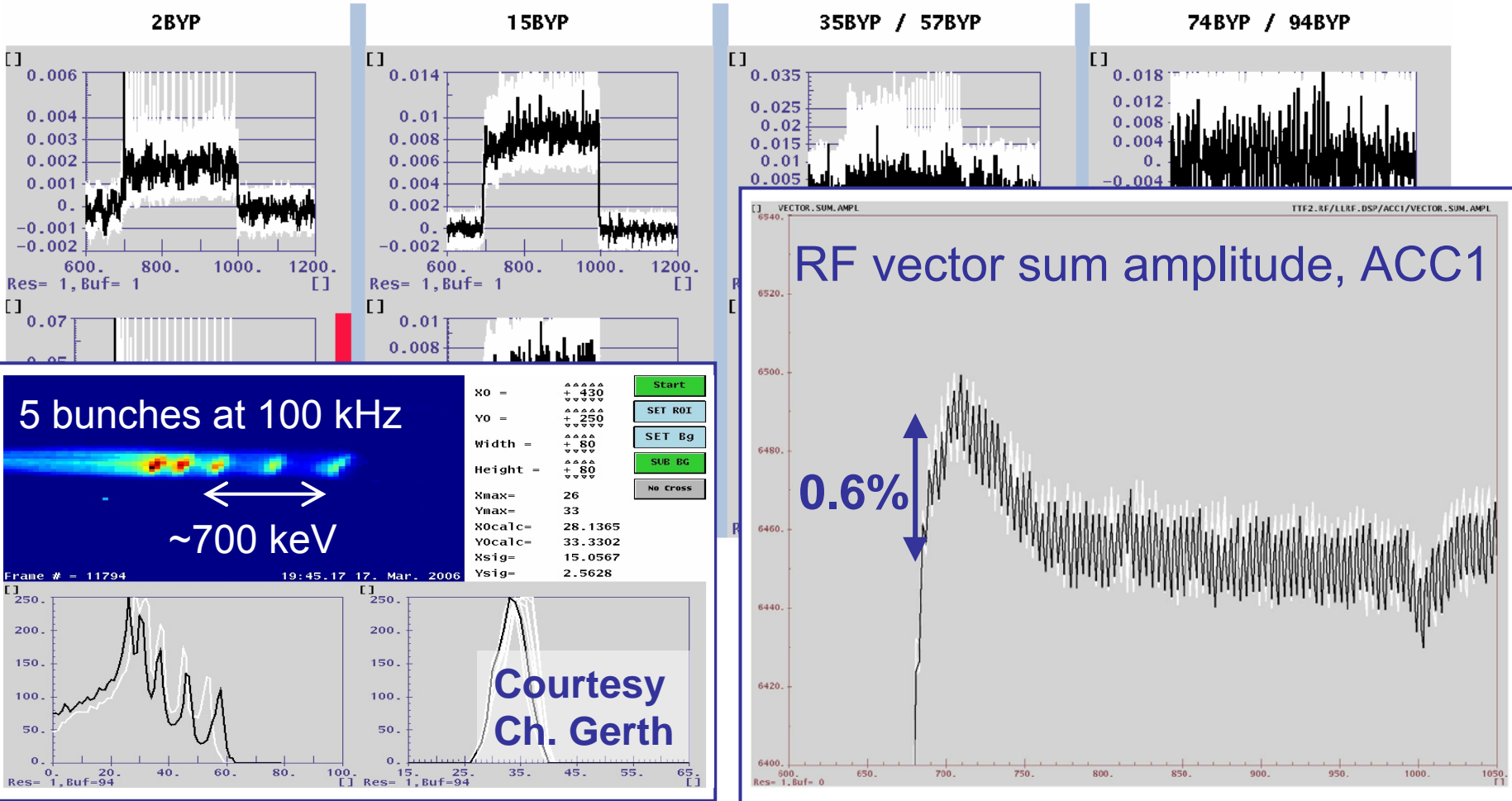


Main problem: Losses in first 50 μ s of the macropulse



Transmission problems

Main problem: Losses in first 50 μ s of the macropulse



Fast beam stops seen on a BPM (induced by quenching cavity)

warn

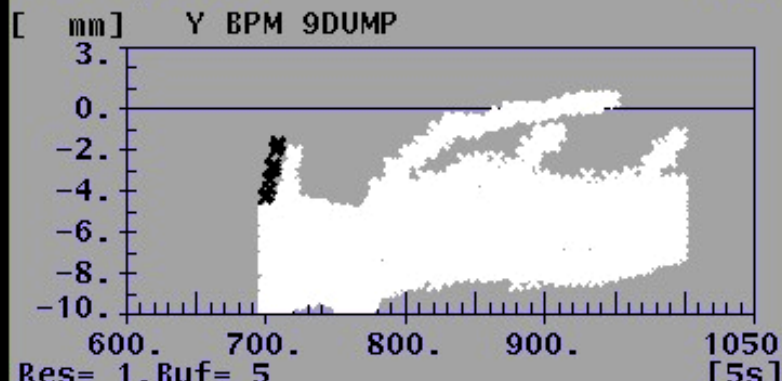
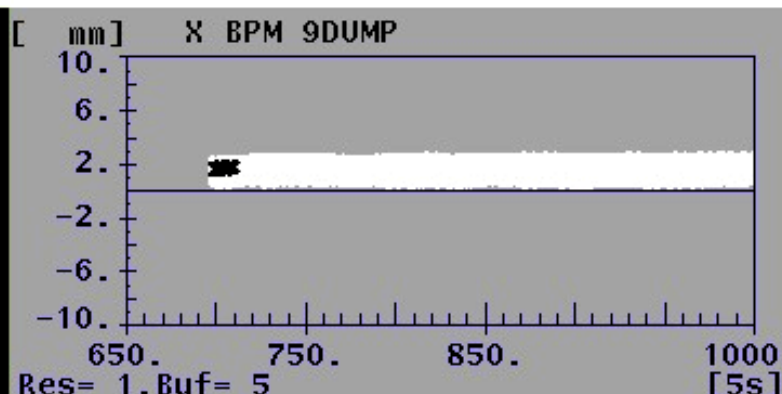
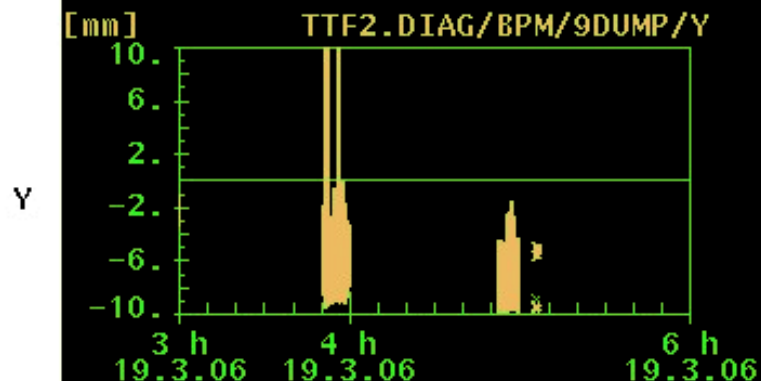
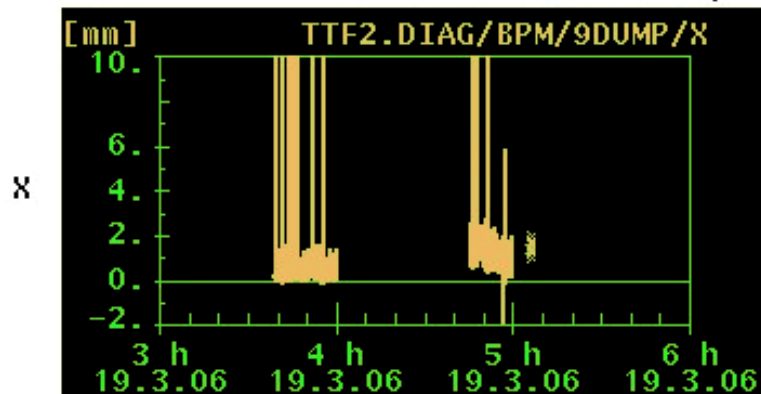
cal splitter y, could not cal x-same par as y NB JLN 27feb06

X BPM 9DUMP

x= 1.683

y= -4.244

z= 249.12 m



Past

- Frequently >100 Gy/shift in undulator
- Several false alarms of the fast system (photomultiplier HV failure detection), but mostly fixed

Present

- Undulator protection accepted by operators, dose rates mostly below detection limit
- Slow system (BIS) well-tried
- Fast machine protection system operational, not yet accepted

Future

- Tight tolerances on beam losses may be relaxed
- Make operation with long pulses the default
- Lasing with long pulses (August 2006)

TTF VUV-FEL - PRESENT STATUS, V1.0

File Help

~~TTF VUV-FEL~~ STATUS

Sun. 19.Mar.2006 03:24:49

Charge/Bunch at Gun

0.92 nC

Total Transmission

100 %

Bunches/Macrop. at Gun

298

End-Energy/Electron

0.47 GeV

Macrop. Rep.-Rate

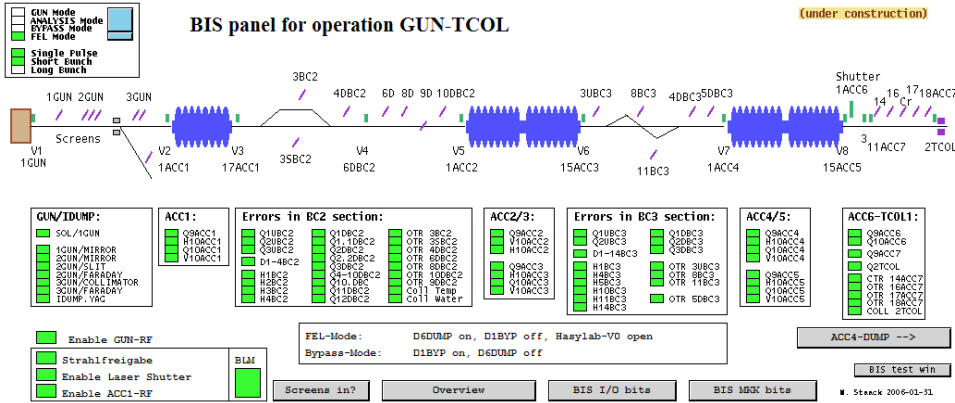
5 Hz

Beam Power at Dump

0.64 kW

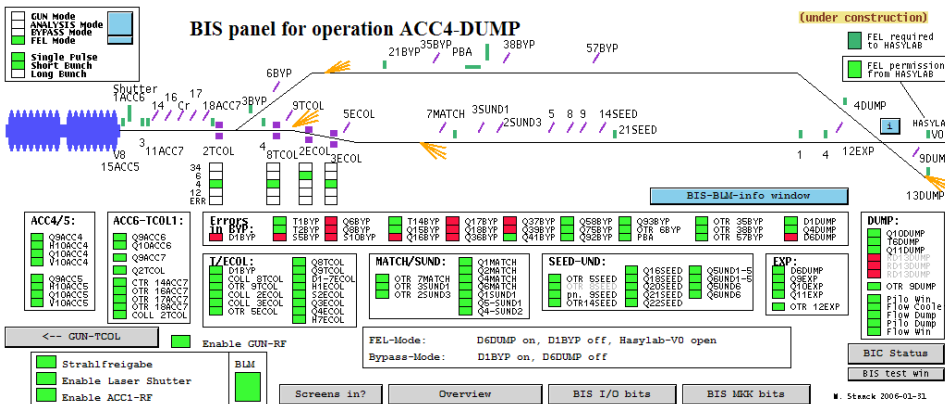
Thanks for your attention.

The BIS is the brain of the MPS.

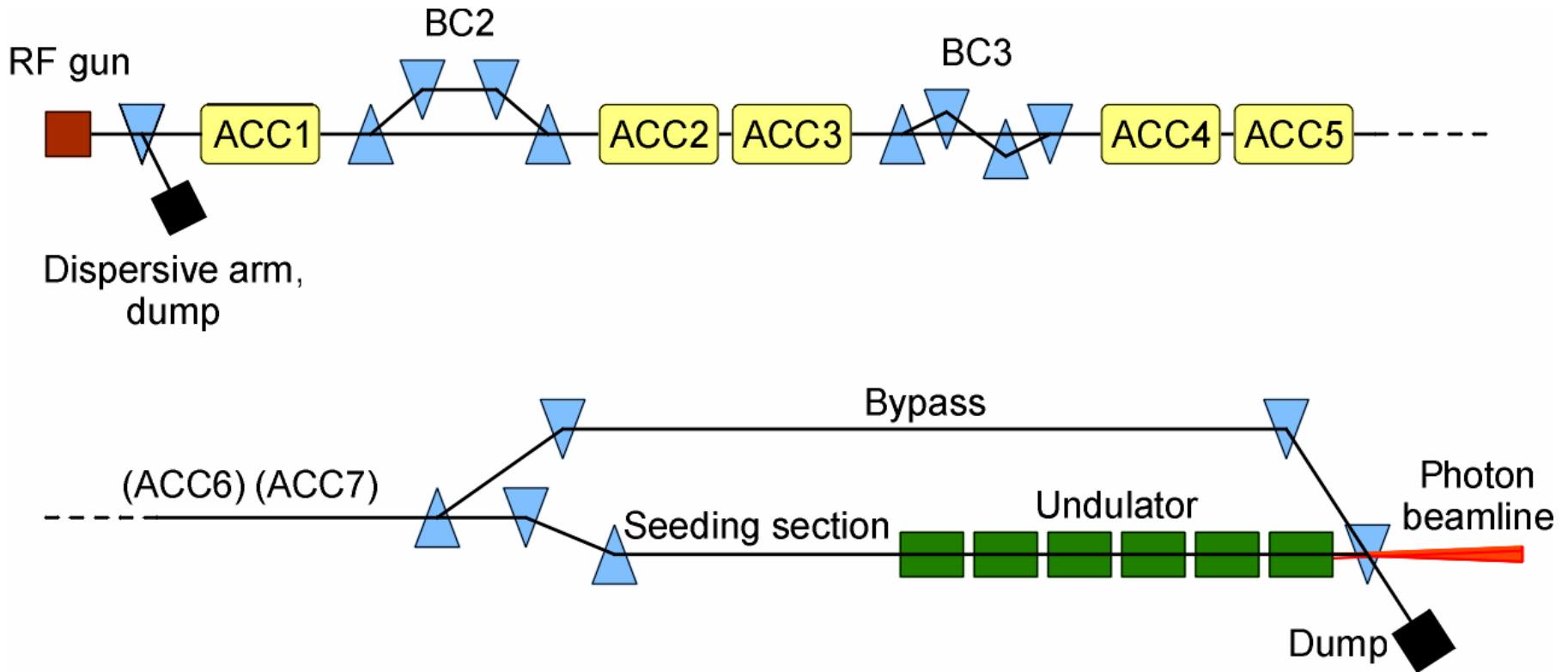


Outputs:

- Laser shutter
- Laser pulse controller
- Gun RF inhibit
- ACC1-5 RF inhibit
- Configuration of the fast system (masking)
- Operation Mode
- Beam Mode
- etc.



FLASH overview



Gun:

70 μ s – 800 μ s

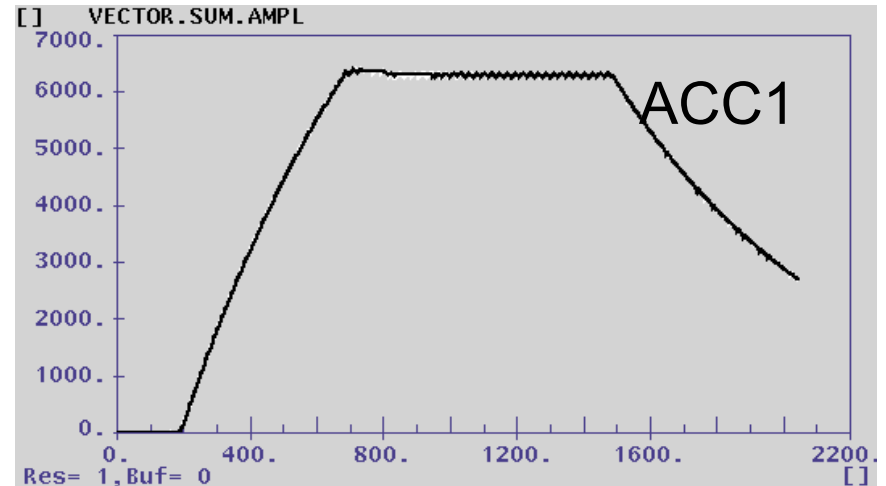
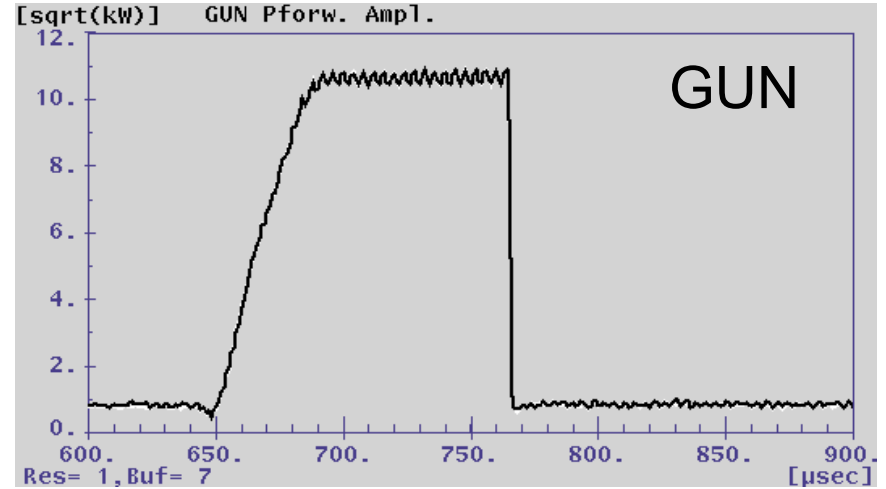
Kurze Pulslängen
reduzieren
Dunkelstrom!

Kalte Module (ACC1–5):

800 μ s

Der „flat top“ bietet Platz für

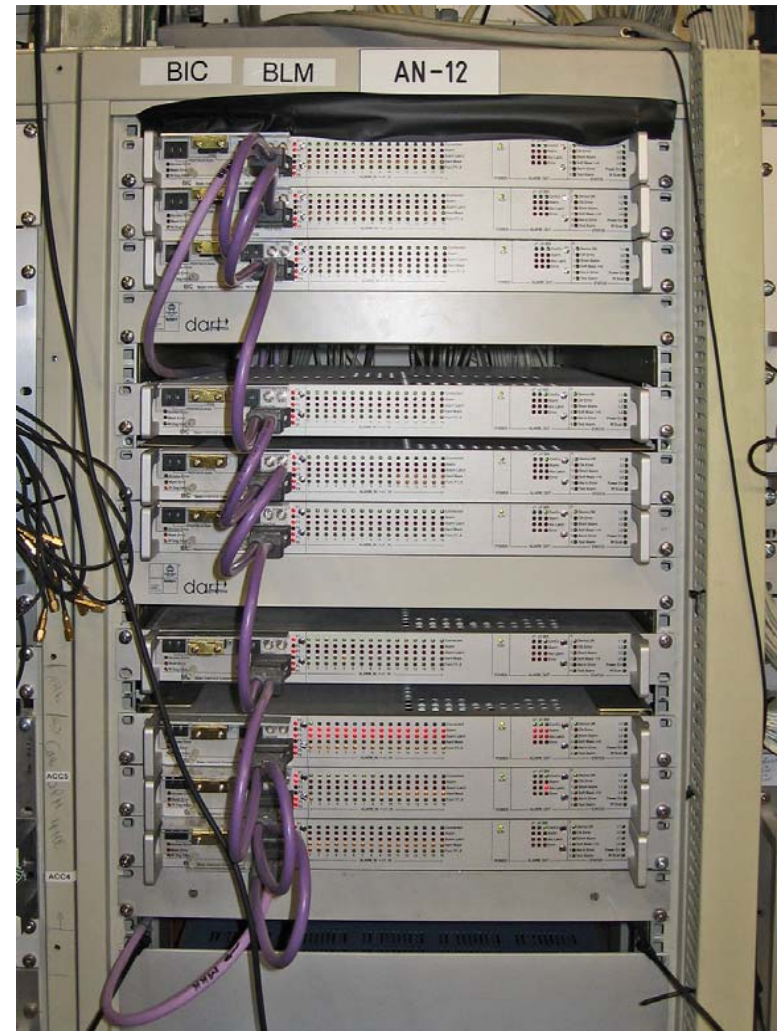
- bis zu 800 Bunche (1 MHz)
- bis zu 7200 Bunche (9 MHz)



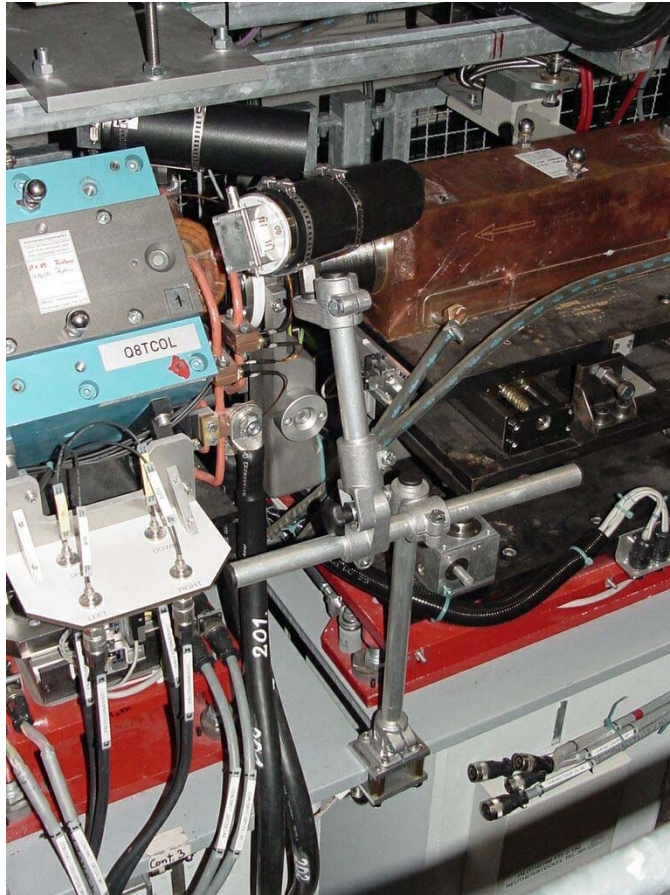
Ein BIC ist ein logisches „ODER“ mit Zusatzfunktionen.

- Je 16 Eingänge (RS-422, galvanisch isoliert)
- Je 2 Ausgänge (RS-422)
- Eingänge maskierbar
- $< 3 \mu\text{s}$ Reaktionszeit (inkl. Laufzeiten im Kabel)
- Auslese u. Steuerung per Profibus
- Redundanz durch FPGA + diskrete Logik

→ M. Werner

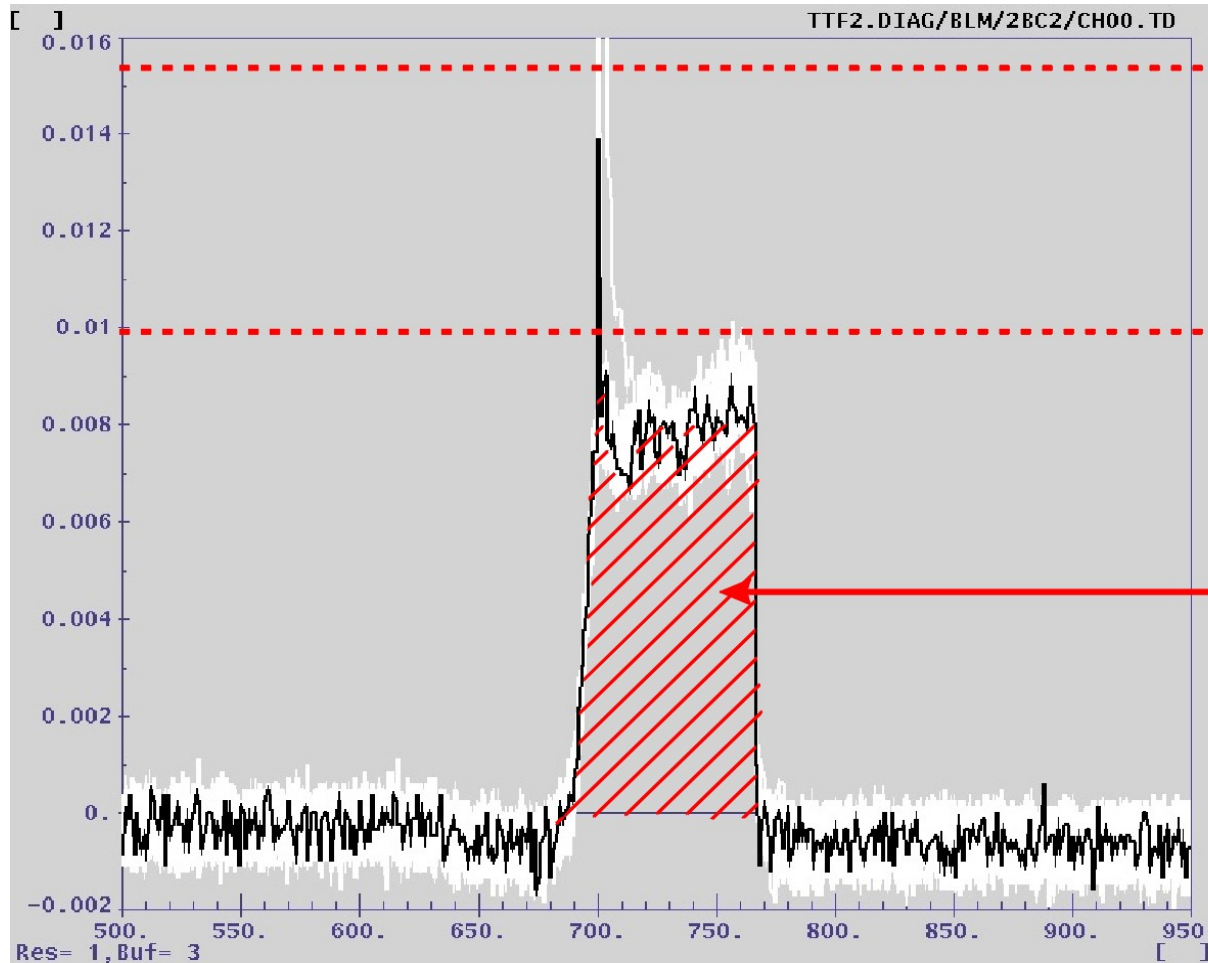


18 Sekundäremissions-Multiplier (SEMs)



49 Photomultiplier (PMs) mit Szintillator-Panels



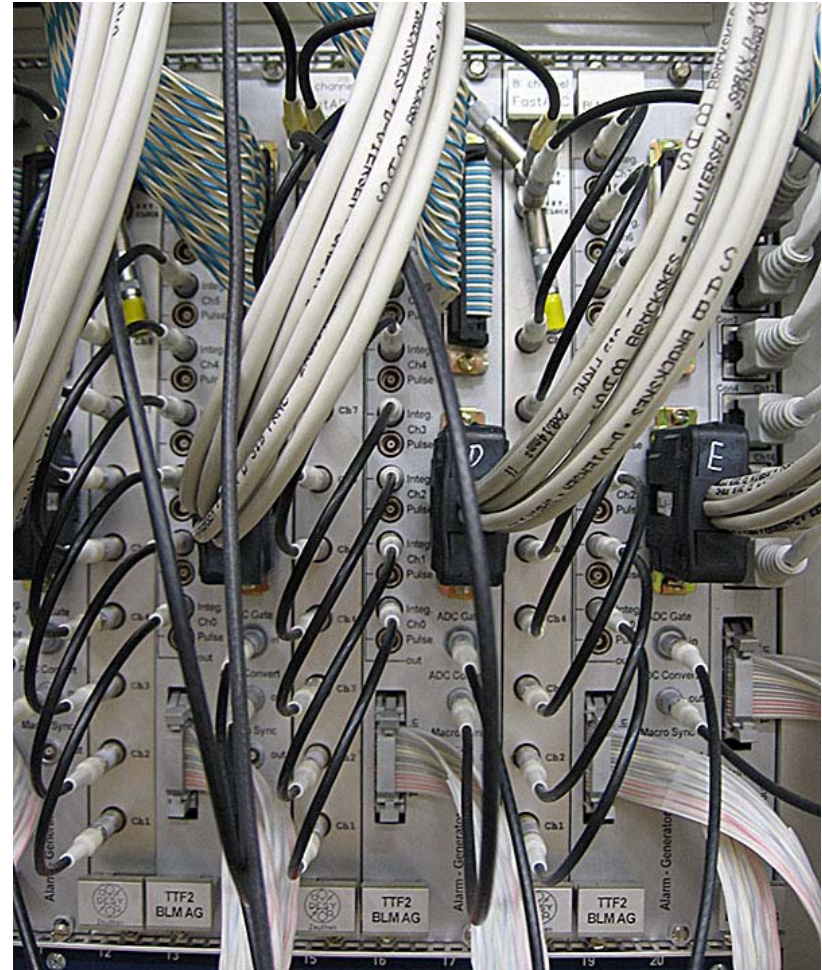


“fast high” threshold
(single bunch)

“fast low” threshold
(several bunches)

integration threshold
(over RF gate)

- 9 VME-Karten in Gebrauch
 - Je 8 Eingänge für BLM-Anodensignale
 - Je 8 Alarm-Ausgänge (RS-422)
 - Je 8 Ausgänge zum Anschluss von ADCs
 - Verschiedene Alarmtypen
 - Über VME-CPU direkte Anbindung ans DOOCS
 - Timingmodule und Testpulsgeber als VME-Karten vorhanden
- P. Göttlicher, M. Reinecke (FEB)



Überwacht Ladungsverlust im Linac durch Auslese von Toroid-Paaren

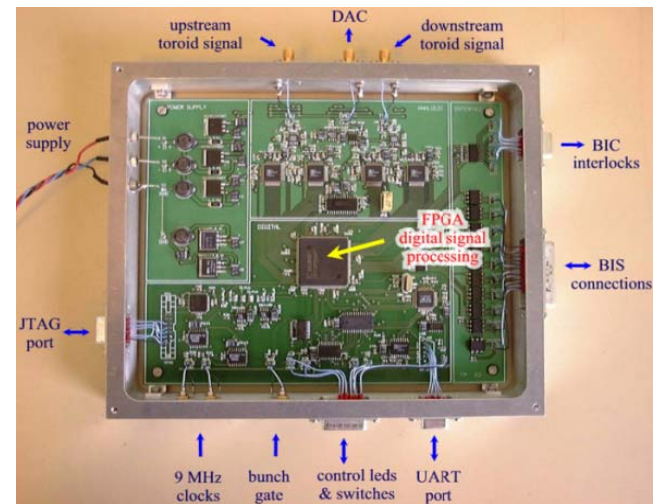
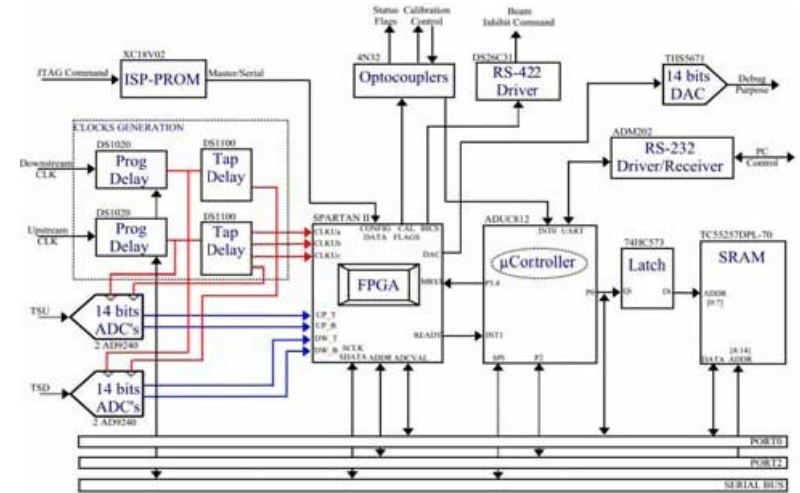
Alarmtypen:

- charge validation (Erster Toroid < 0.05 nC)
- single bunch mode (Transmission < 75 % für 1 Bunch)
- slice mode (Transmission < 99 % für 100 Bunche)
- integration mode (Verlorene Ladung > 10 nC)

→ A. Hamdi, J. Novo (CEA/Saclay)



- Toroid-Signale werden mit 14-Bit-ADCs abgetastet
- FPGA zur schnellen Alarmerzeugung
- 4 RS-422-Alarmausgänge
- Statusbits zum BIS über Optokoppler
- Mikrocontroller für Kalibration, RS-232
- Einstellung von Alarmschwellen über RS-232



Das BIS ist das „Gehirn“ des MPS.

- SPS
- 192 Eingänge
- 32 Ausgänge
- 256 dezentrale Eingänge
- Auslese u. Steuerung der BICs über Profibus
- Ethernet-Anbindung
- Zykluszeit 1.2 ms
- Modularer Aufbau

→ M. Staack (MVP)



