FLASH Machine Protection

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

L. Fröhlich, M. Görler, P. Göttlicher, D. Nölle, D. Pugachov,
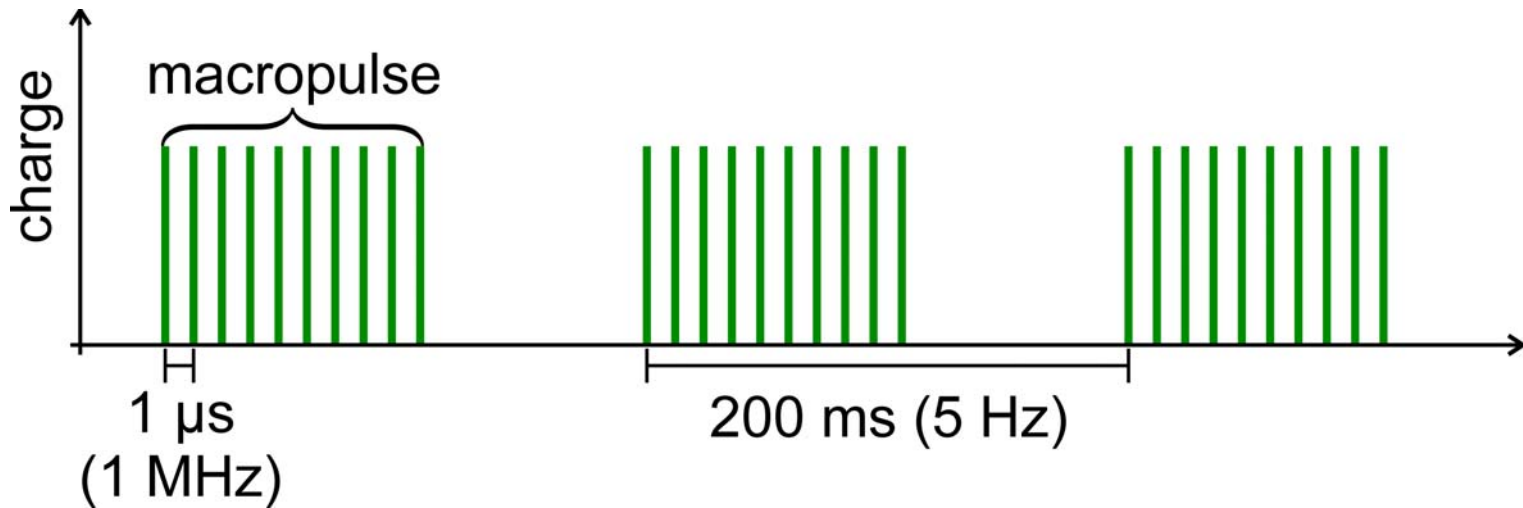H. Schlarb, S. Schreiber, M. Staack, M. Werner (DESY, Hamburg)

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

Temporal structure of the beam

Bunch frequency:

50 kHz, 100 kHz, 200 kHz, 250 kHz, 500 kHz, **1 MHz**, 9 MHz
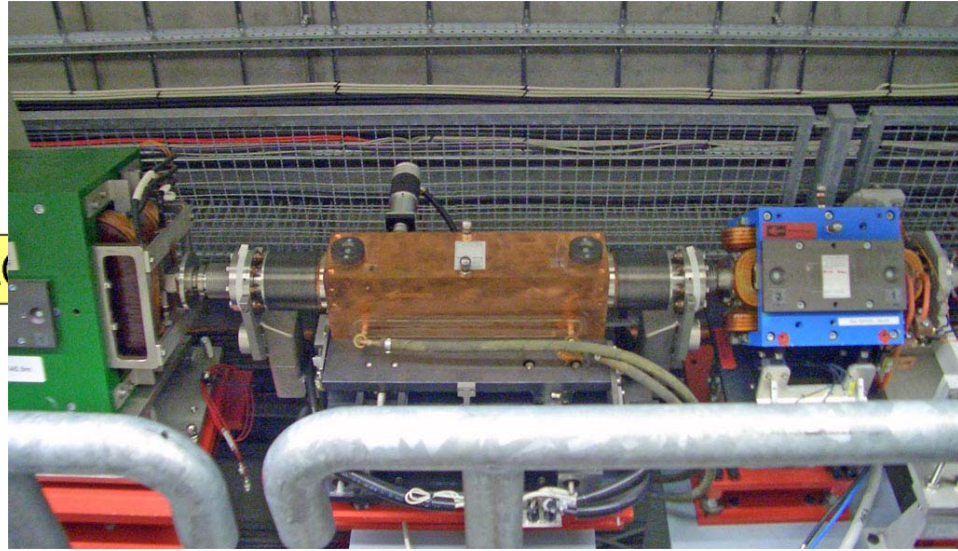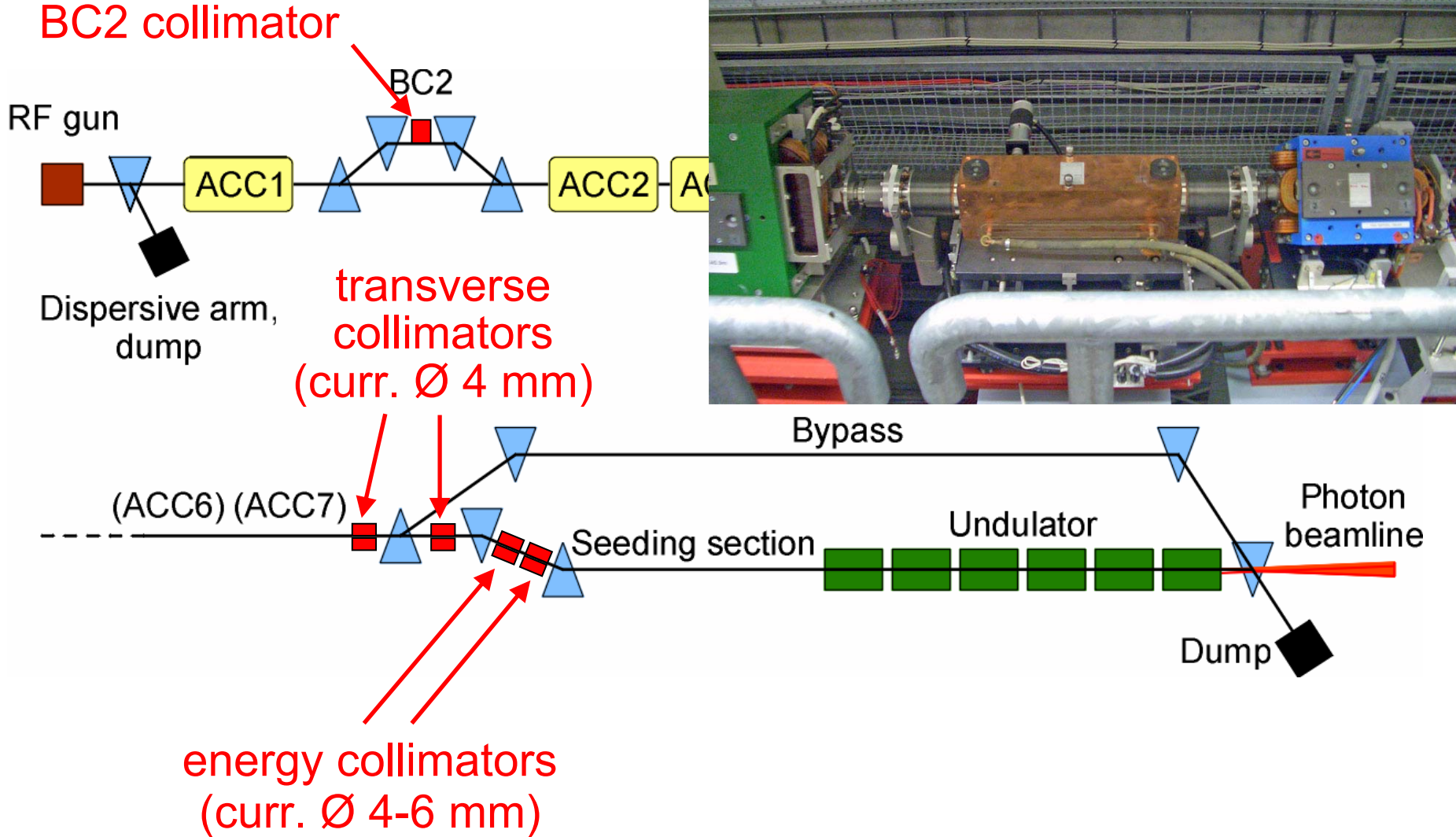
Repetition rate:

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

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Beam power

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

Charge: **1 nC**

RF flat top: up to **800 µs**

	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

Arc welding: ~10 kW Lars Fröhlich, DESY-MPY

Passive systems

BC2 collimator

RF gun

ACC1   BC2   ACC2   AC

Dispersive arm, dump

transverse collimators (curr. Ø 4 mm)

Bypass

(ACC6) (ACC7)

Seeding section   Undulator

Photon beamline

Dump

energy collimators (curr. Ø 4-6 mm)

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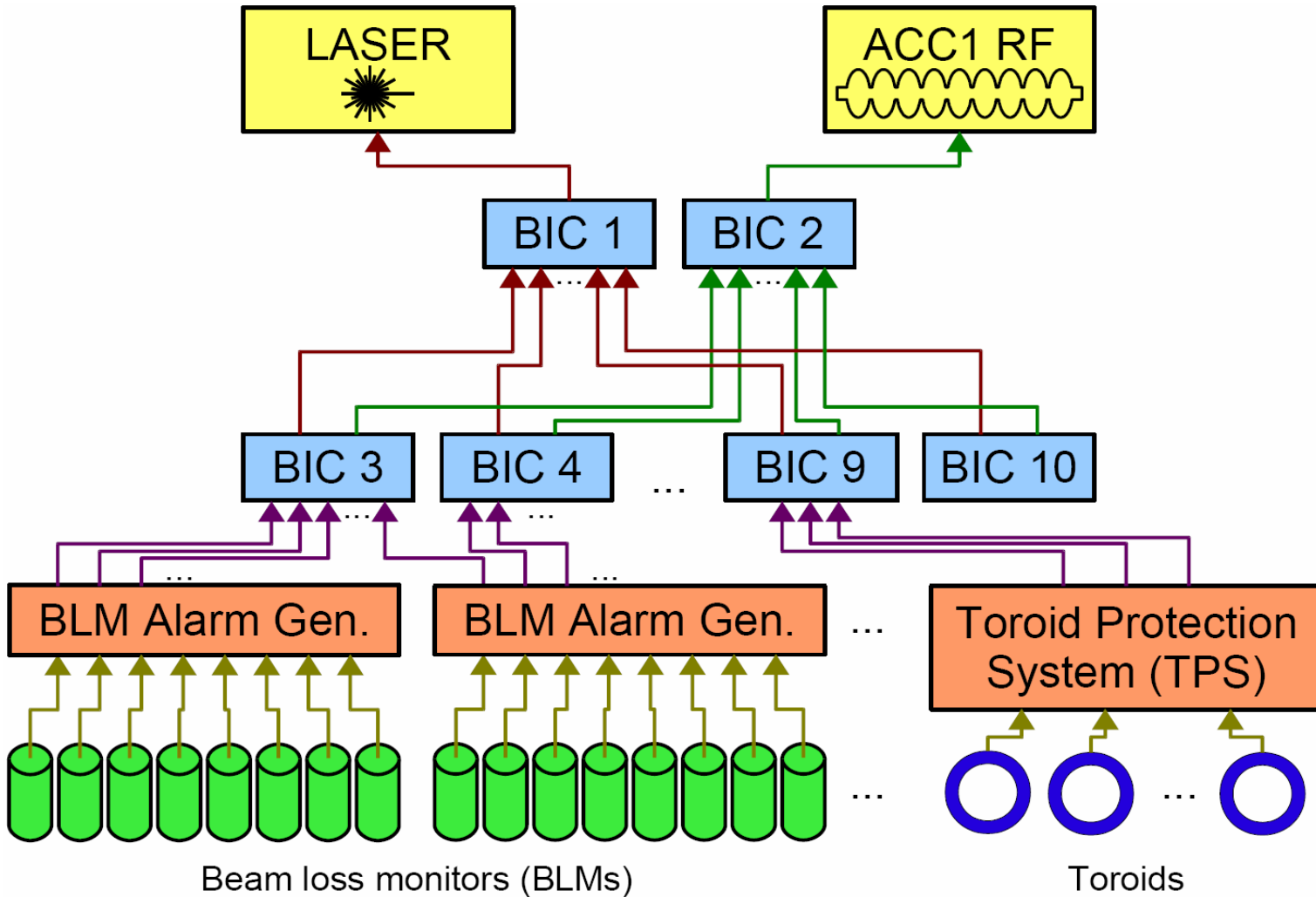
Fast: Stop bunch production for the remaining macropulse (2 – 4 µs)

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

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Fast beam interlock

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Slow 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.

The BIS is the brain of the machine protection.

It can switch off
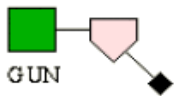- injector laser
- gun RF
- ACC1-5 RF
and defines
- operation mode
- beam mode

BIS: Operation Modes

The **operation mode** is determined from the state of valves and magnets.
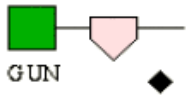
> Basic rule:
>
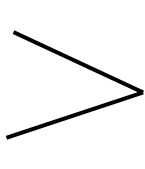> **No operation mode, no beam.**
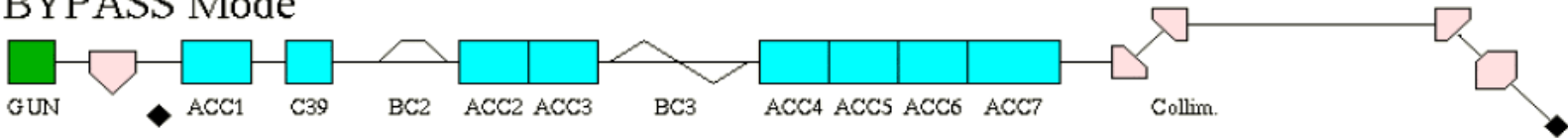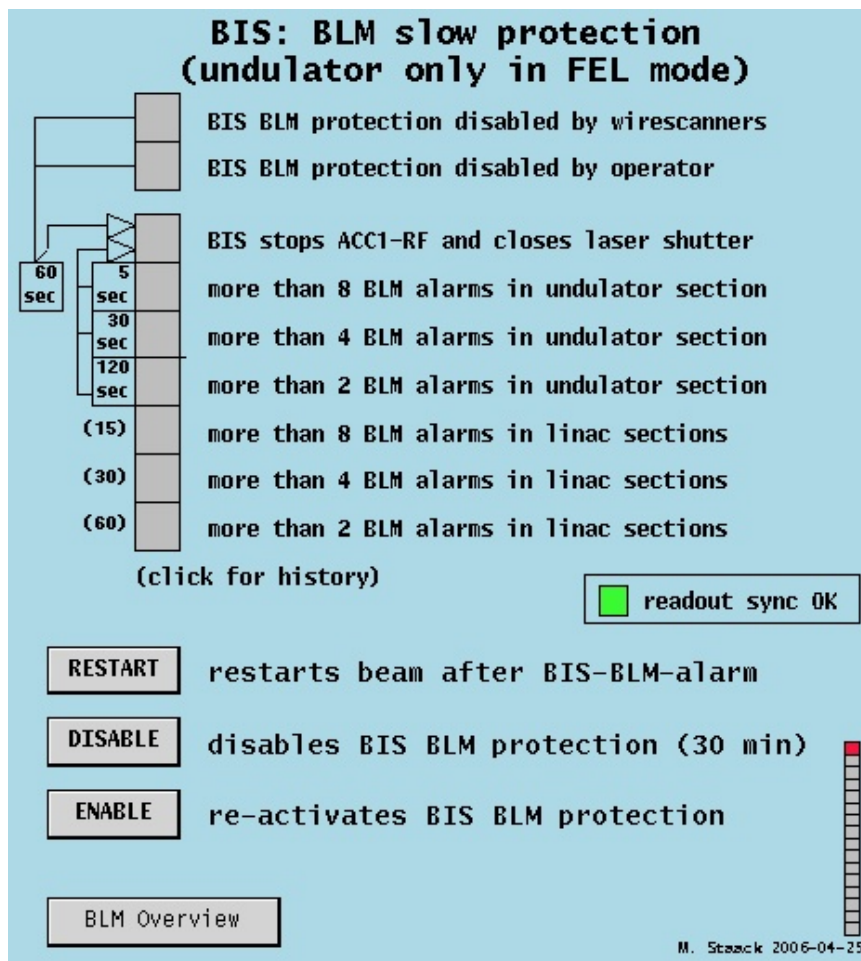
BIS: Beam Mode

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

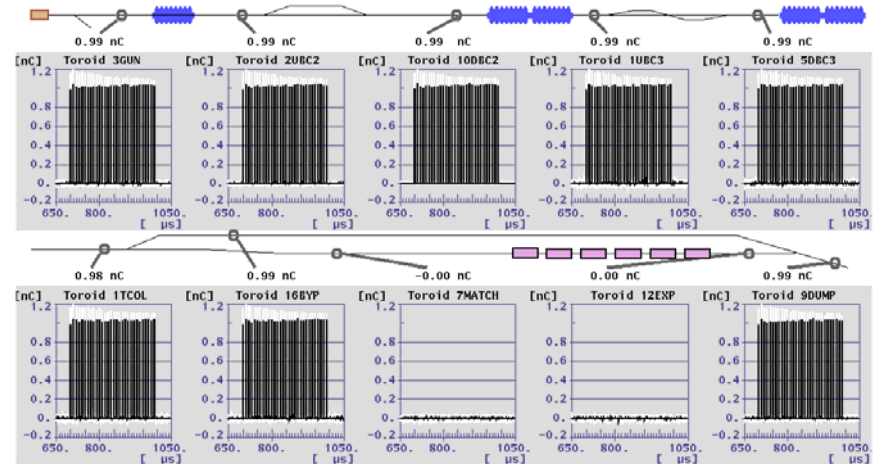# Slow beam loss protection

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

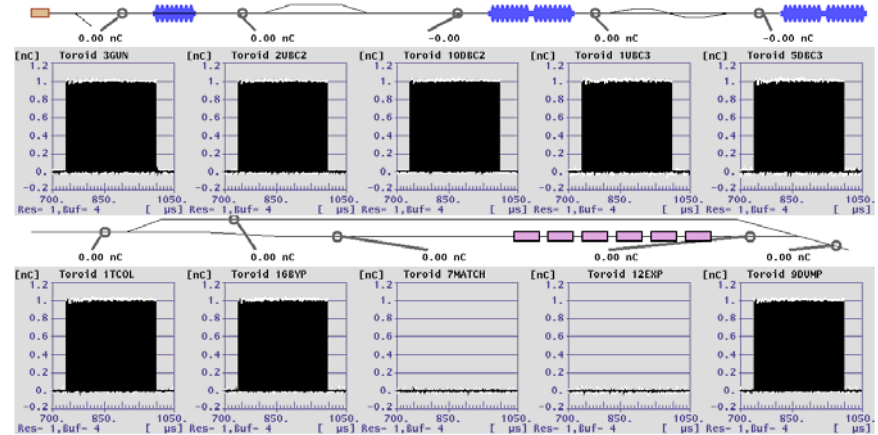   →RF pulses shortened to 100 µs

- can be disabled for 60 min

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Long pulse operation

Up to March 2006

max. 30 bunches/macropulse

18–20 March 2006

300 bunches/macropulse in bypass line

Transmission problems

Main problem: Losses in first 50 μs of the macropulse

5 bunches at 100 kHz

~700 keV

Courtesy
Ch. Gerth

RF vector sum amplitude, ACC1

0.6%

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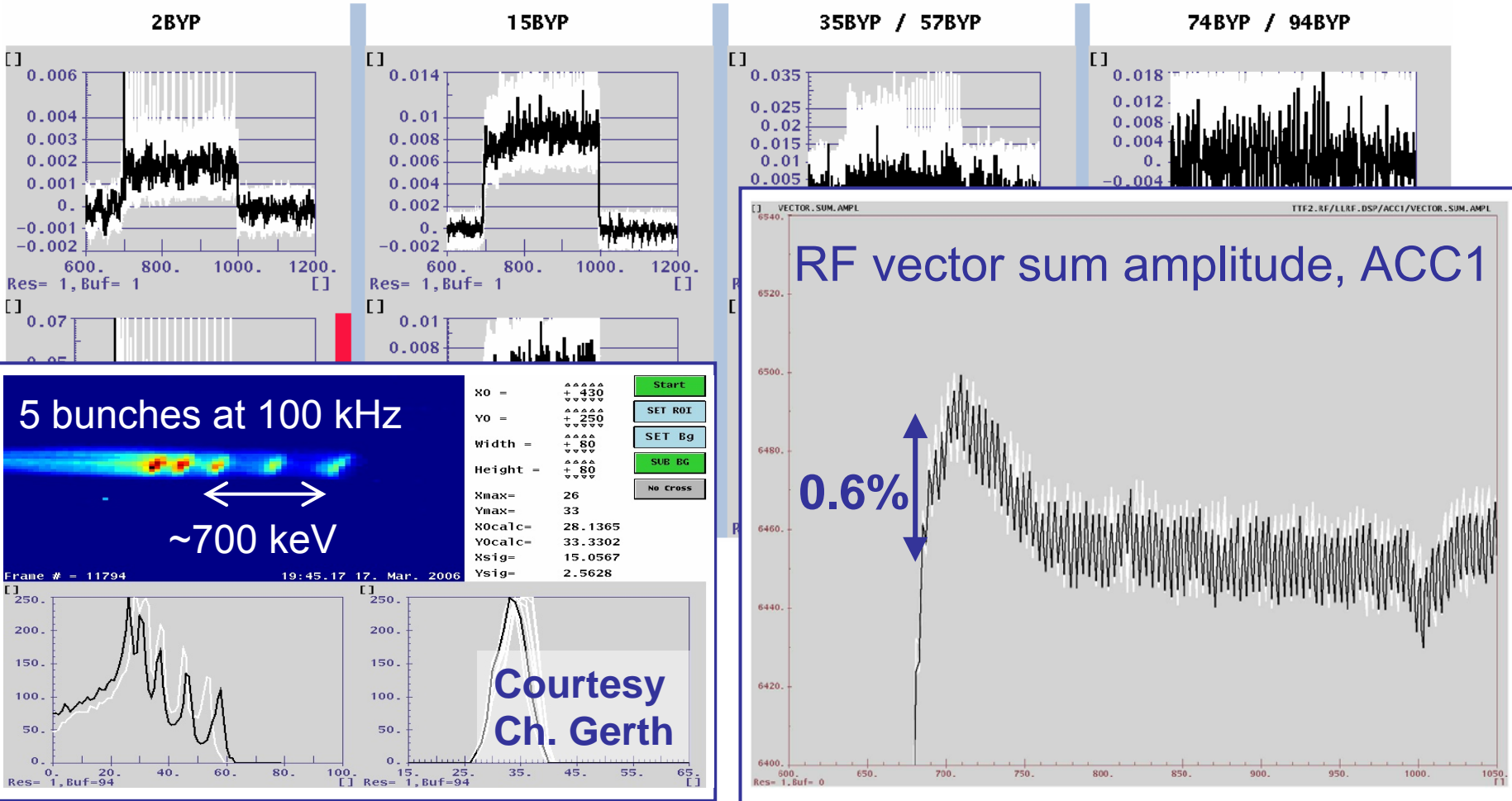
Fast beam stops seen on a BPM (induced by quenching cavity)

Conclusion and outlook
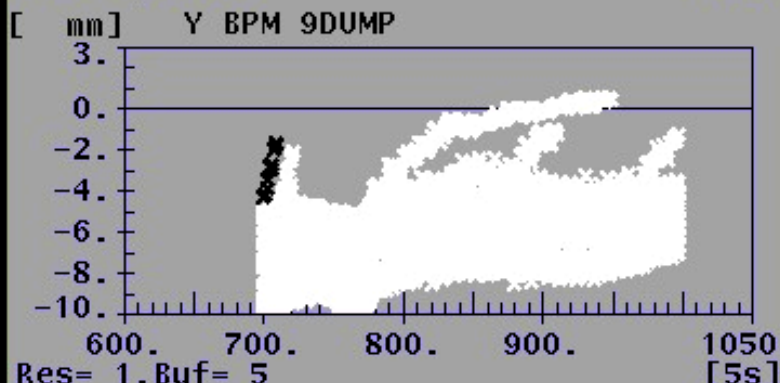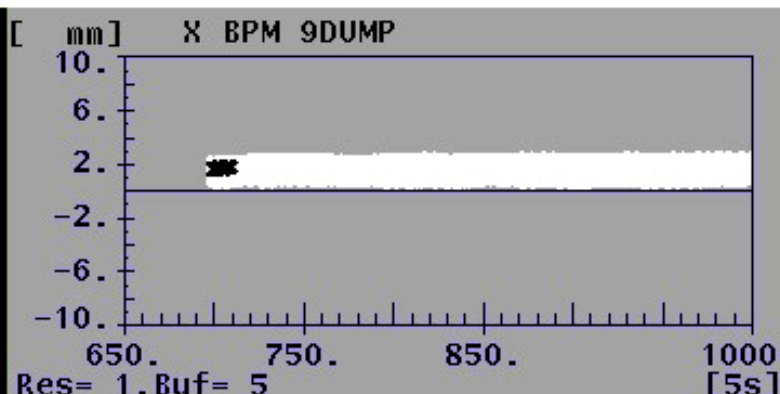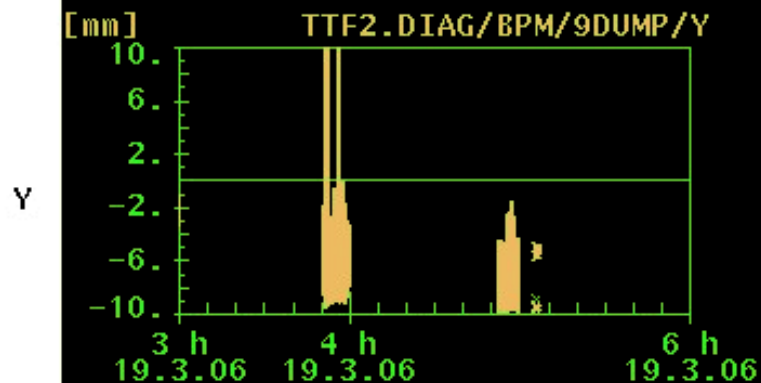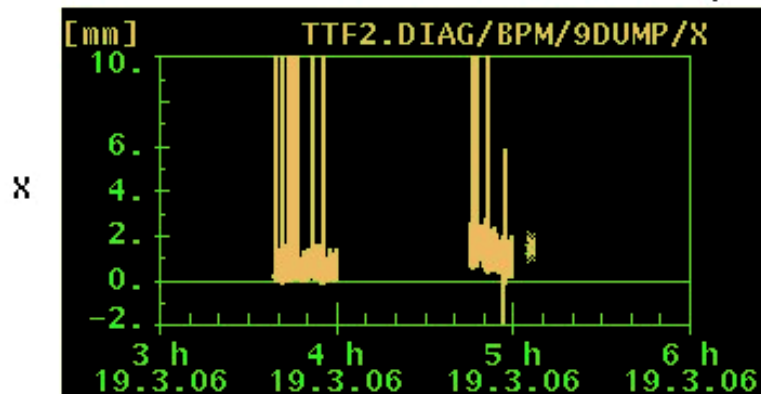
Past

- 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)

Thanks for your attention.