Lasing With Long Pulses

Driving FLASH with high duty cycle

- **Fast machine protection:** BIC system
- **Accelerator studies:** Lasing with up to 600 bunches
- **Tools** for operation in long pulse mode
- **Activation** of components and countermeasures

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M. Görler, P. Göttlicher, D. Nölle, S. Schreiber, M. Staack, M. Werner (DESY)

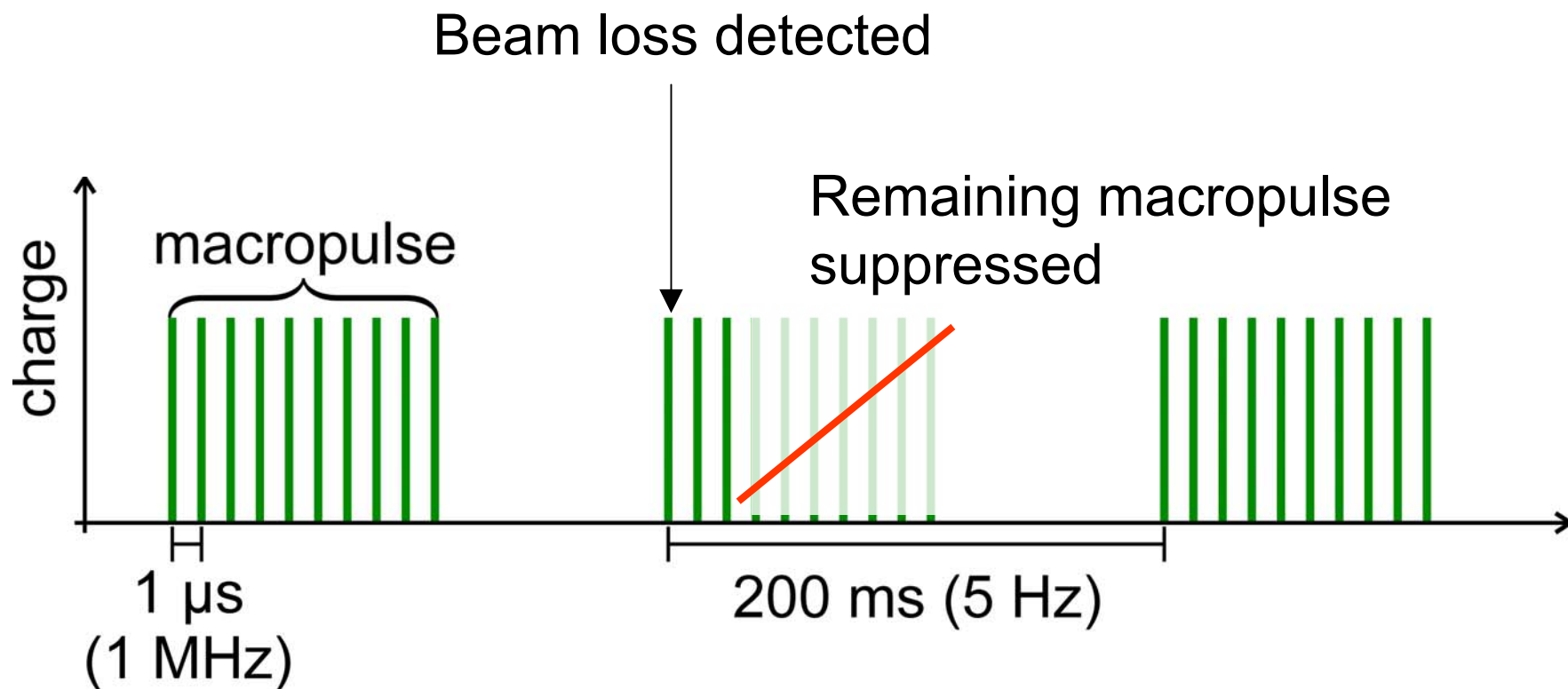A. Hamdi, M. Luong, J. Novo (CEA, Gif-sur-Yvette, France)

Fast Machine Protection

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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)

Fast Machine Protection

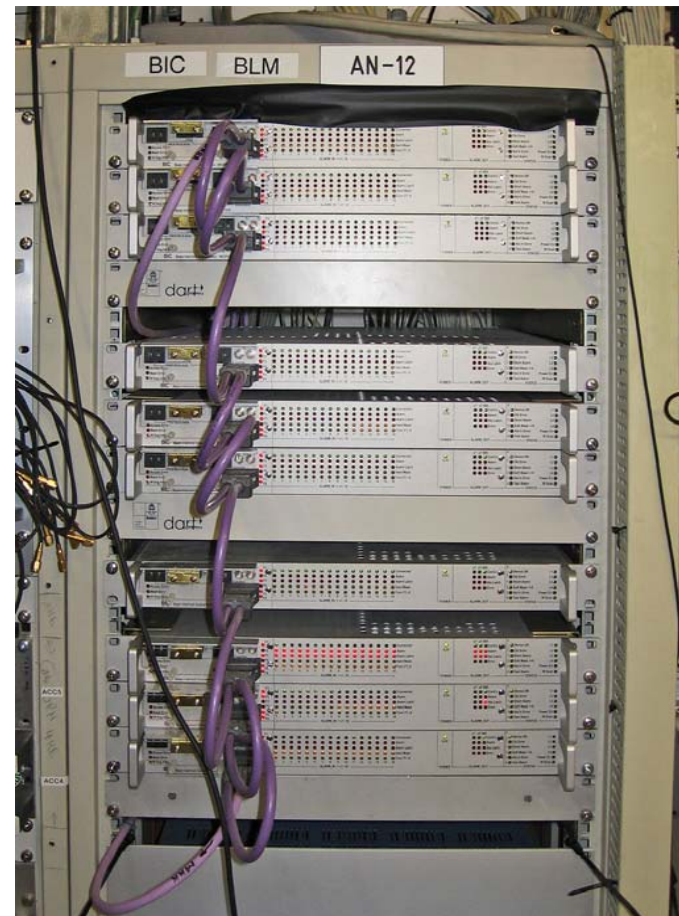Lars Fröhlich, MPY

Fast Beam Interlock
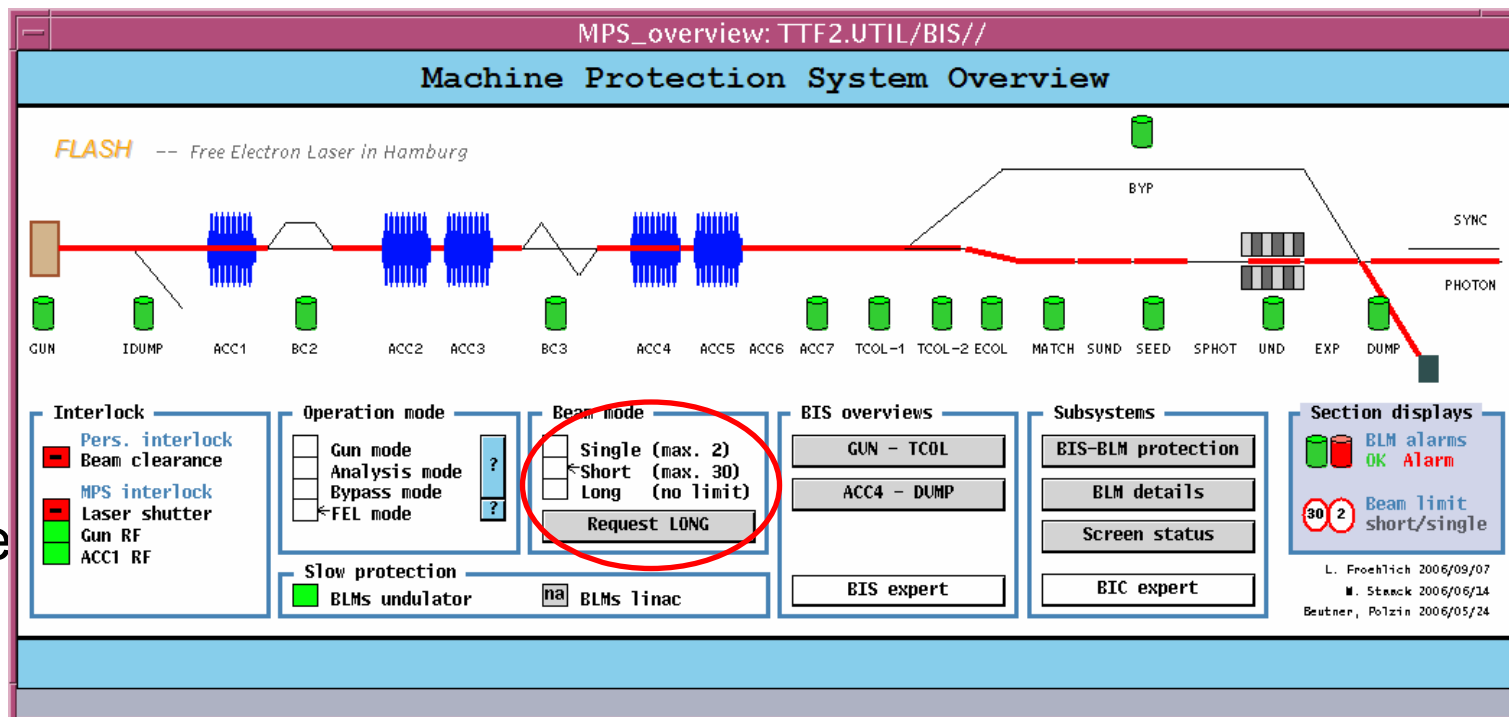
Fast: Stop bunch production for the remaining macropulse (2 – 4 μs)
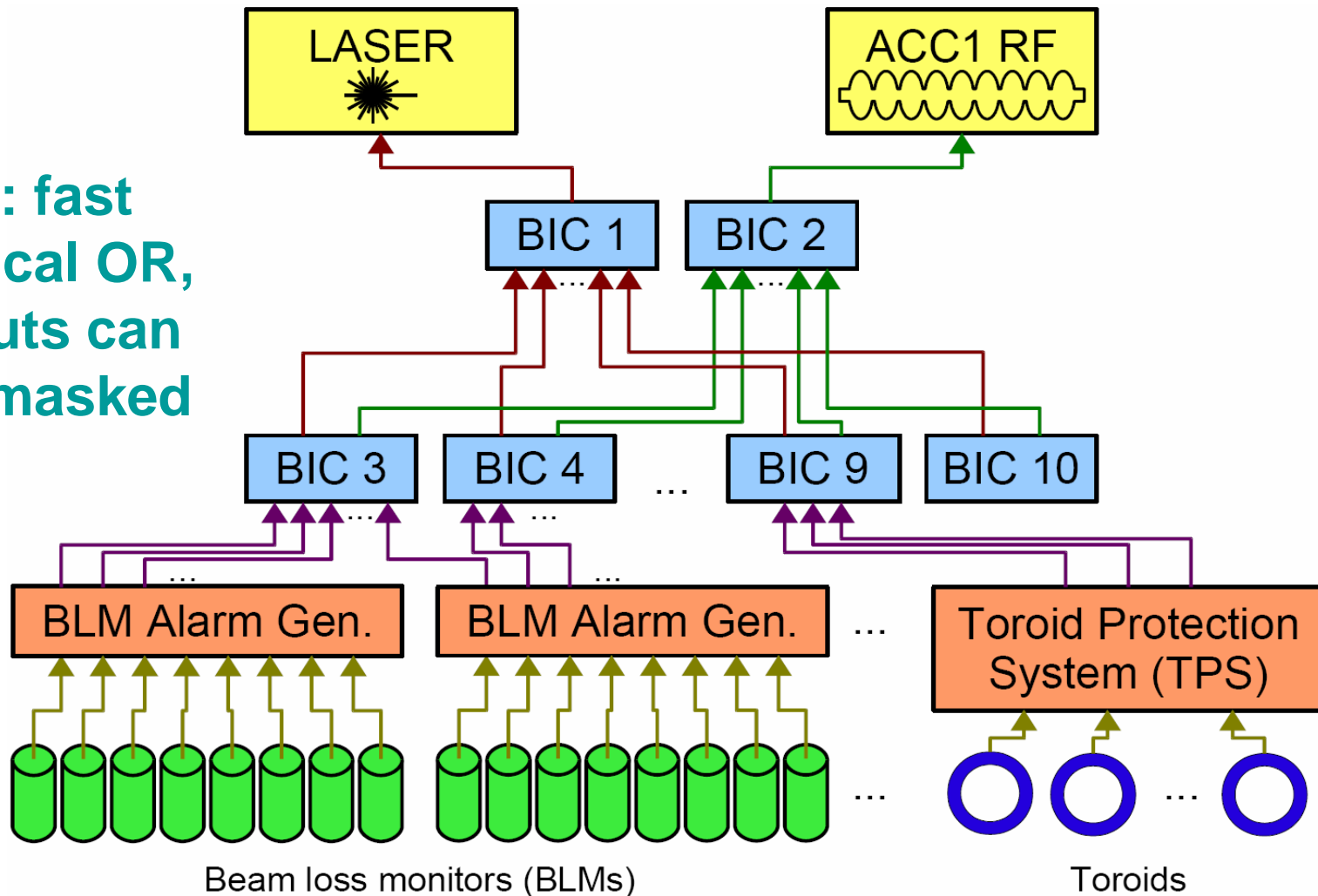
Beam Interlock Concentrators (BICs)

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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Accelerator Studies

10.8. - 14.8.

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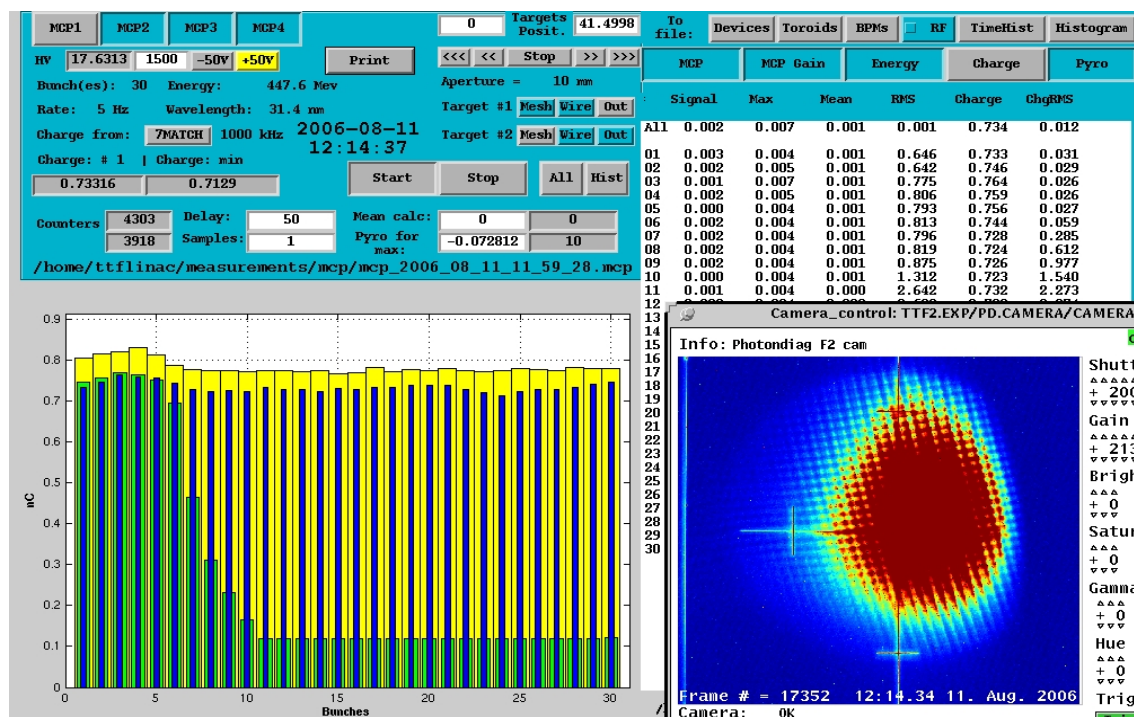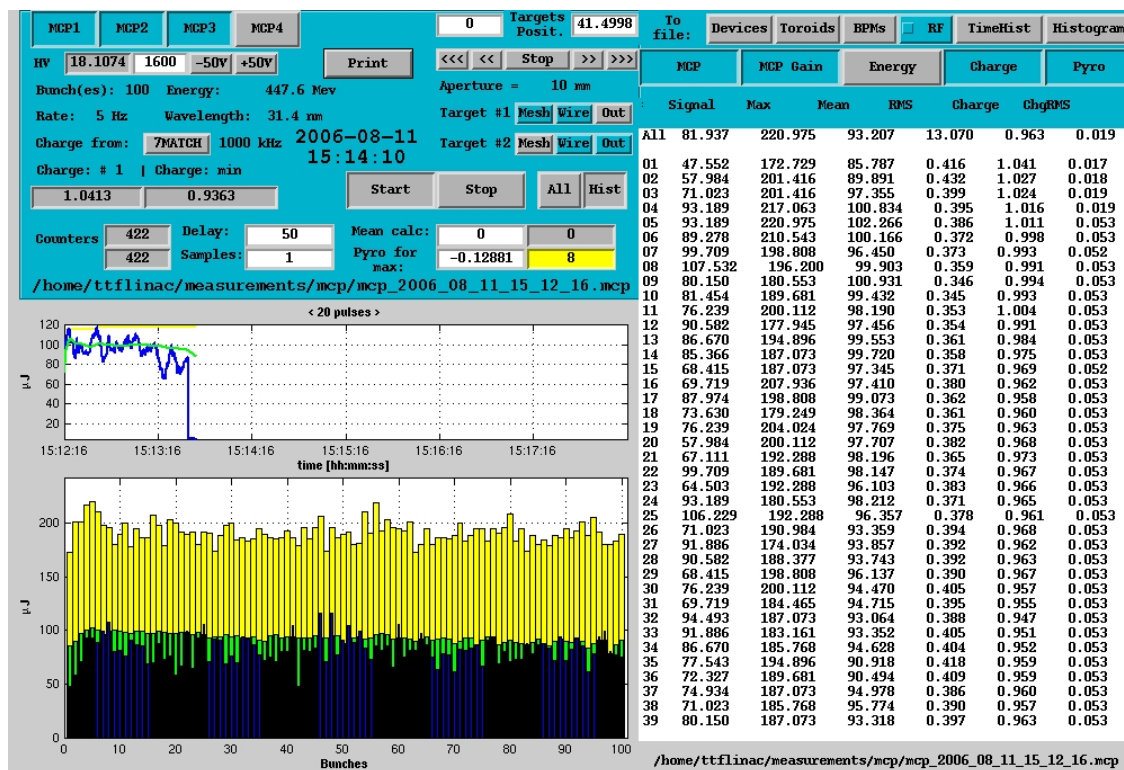## Thursday-Friday, August 10-11

- Setup machine for lasing at 32 nm

- No transmission of more than 5 bunches through BC3

- Triggered radiation interlock in hall 3 (!)

- Caused by darkcurrent kicker!

- DC kicker off →
30 bunches lasing

Friday, August 11

- Switch to long pulse mode

- One minute of glory (100 µJ with 100 bunches)

- 50 mW FEL output power

Saturday, August 12

- Quenches in modules 1-3 at RF pulse lengths >400 µs

- Attempt to reduce gradients

- Operation with 500 bunches possible with occasional quenches

- MCP limited to 100 bunches by ADC buffer, increased to 450

- Gun collimator tests

- Darkcurrent kicker tests

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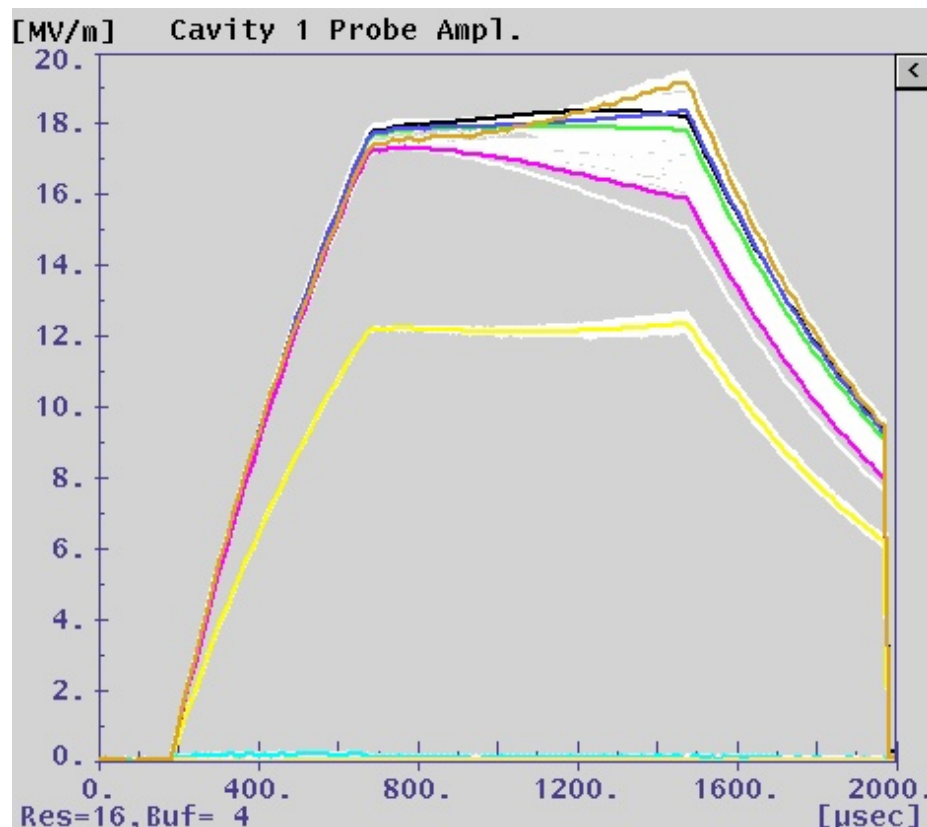
Sunday, August 13

- Further reduction of ACC1 gradient
- Lasing with 600 (?) bunches at 45 µJ, occasional quenches
- ~140 mW FEL output power
- Tests with other bunch frequencies
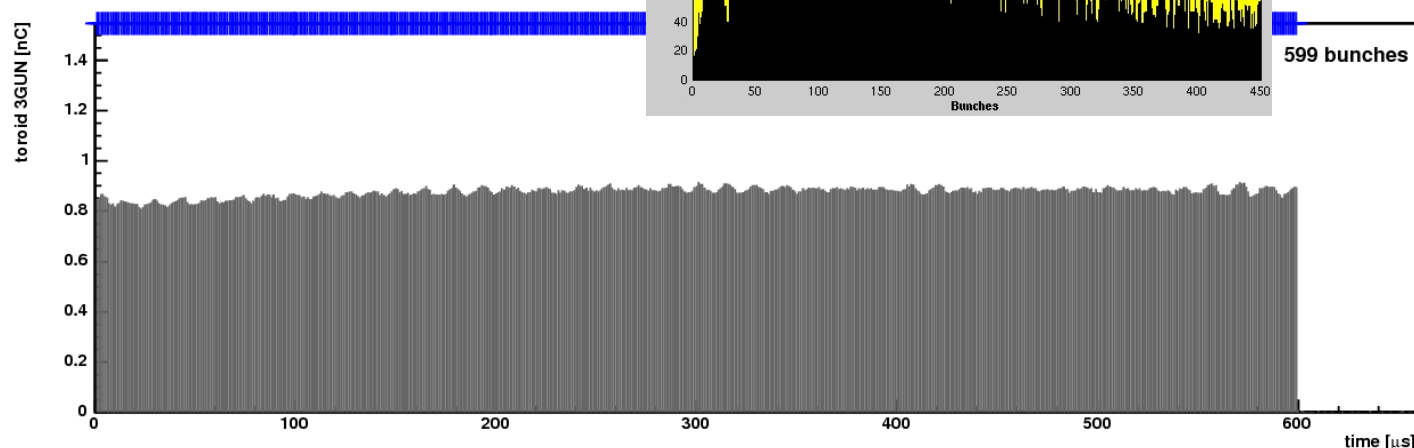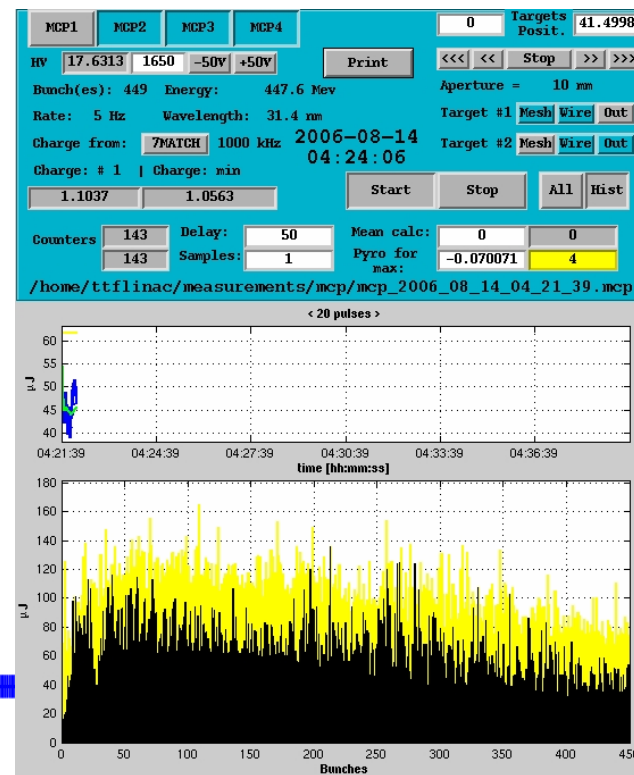
Monday, August 14

- Work on injector laser

- Tuning of cavities for 800 µs RF pulses

- Restart machine, re-tune SASE

- Long pulse mode at 1:20 (am)

- Lasing with 400 bunches, limited by losses in undulator

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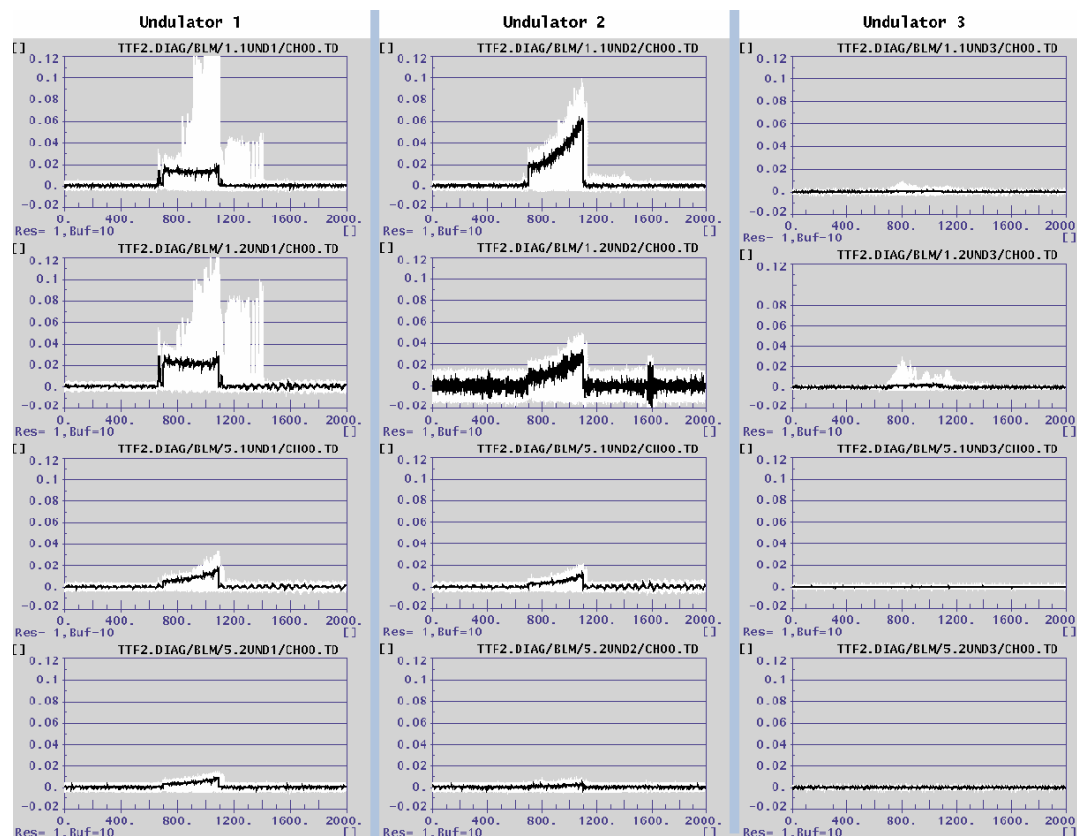
Tools

ACC1 (Simcon): Toroid-based beam loading compensation works well
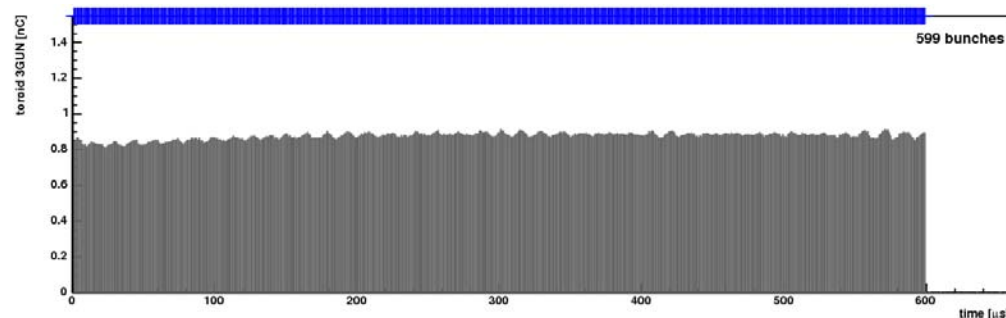
ACC2-5 (DSP): Adaptive feedforward by FSM works well, but has some nasty problems:

- Instability: Eliminated by reducing lowpass frequency

- Keeps adapting when no bunches are present

beam loading compensation

Tools: Diagnostics
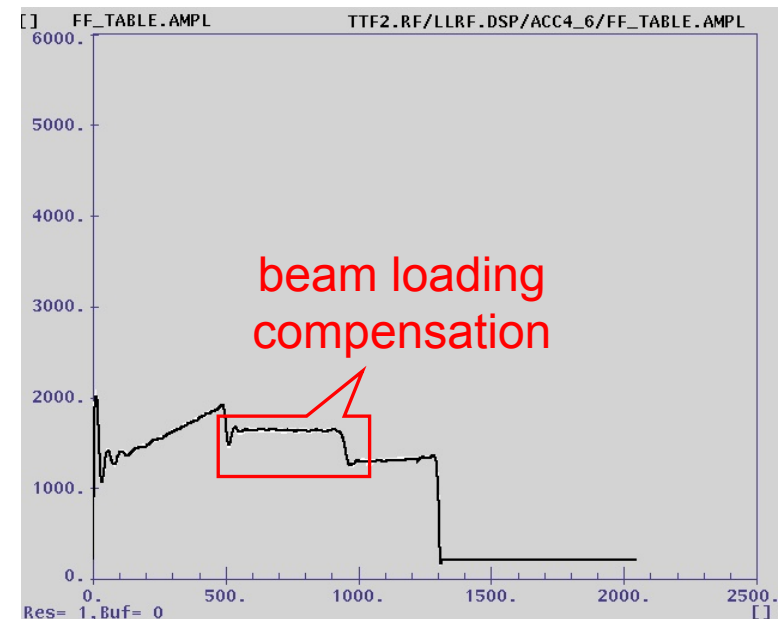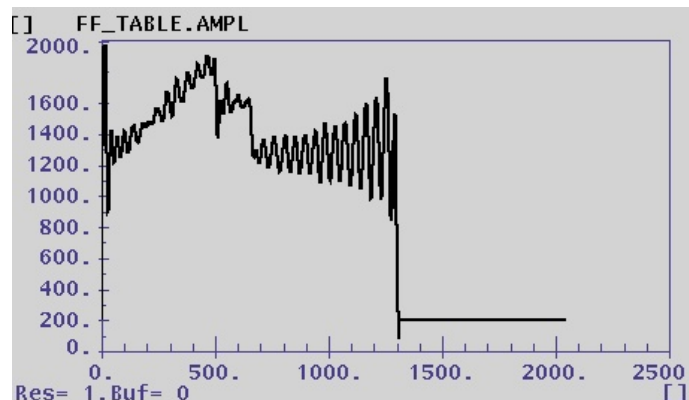
Charge:

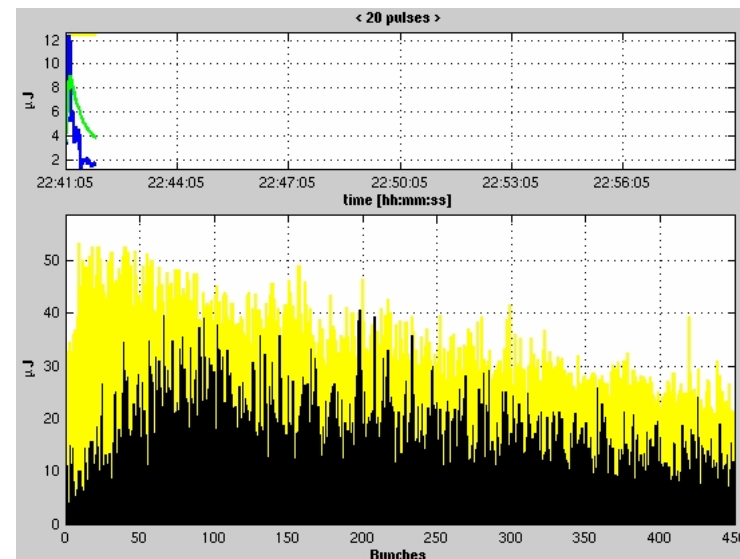- Nice new display mode in P. Castro's tool

MCP:

- no saturation effects of MCP hardware observed
- limited to 450 bunches by ADC, now solved (?)
- MCP tool history drops dramatically when 1 macropulse is shortened
- MCP tool very slow with >100 bunches

GMD:

- tools crash with >100 bunches, problem with ADC buffer length?

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Activation Of Components

Dose rates (µSv/h)	2006/08/01	2006/08/15
Darkcurrent kicker	297	410
D1BC2	8210	10000
D1BC3	695	4400
Transverse collimator	83	800
Transverse collimator	22	130
Energy collimator	10	20
Energy collimator	7	8
Dump toroid	157	40
Dump entry	1780	1200

Contact dose rates measured
by Hartz/Tesch/Leuschner, D3

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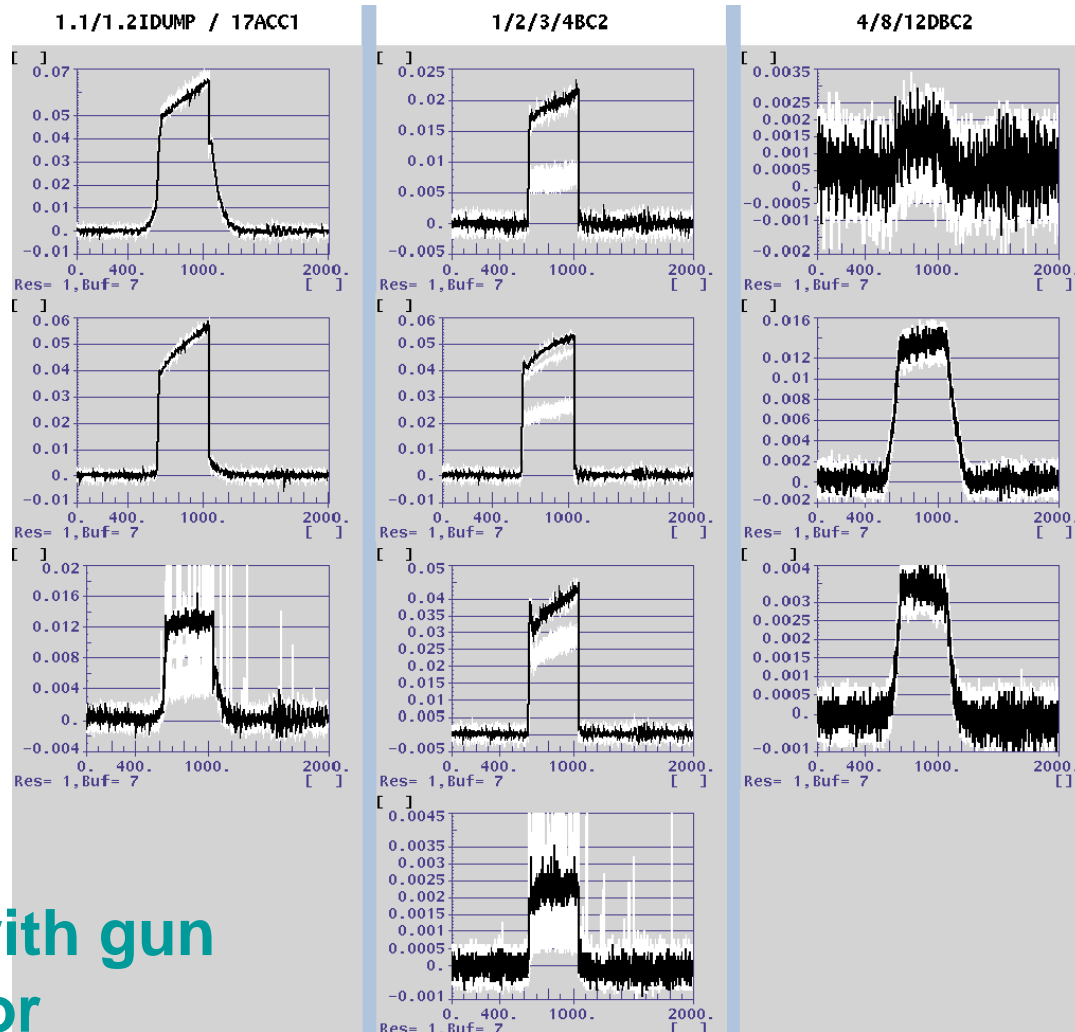
Countermeasures

BC2 scraper

- essential for operation with long pulses
- no room for improvements (already very near the beam)

Darkcurrent kicker

- not usable in the current state, needs work on timing
- increases BC2 dose

Gun collimator

- reduces darkcurrent losses in BC2 by 50%
- ... while reducing transmission to 80%

**white:
losses with gun
collimator**

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Final Remarks

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Conclusion

- FLASH MPS (almost) fully operational
- Allows to operate linac safely with 800 instead of 30 bunches/macropulse (> 25x duty factor)
- Lasing with long bunch trains successfully demonstrated
- Output power reached: 140 mW (600 bunches, 45 µJ)

- Tools need to be improved
- Activation by darkcurrent is a problem, we need a working gun collimator.

- Long pulse mode will be available to user experiments soon.

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Thanks for your attention.
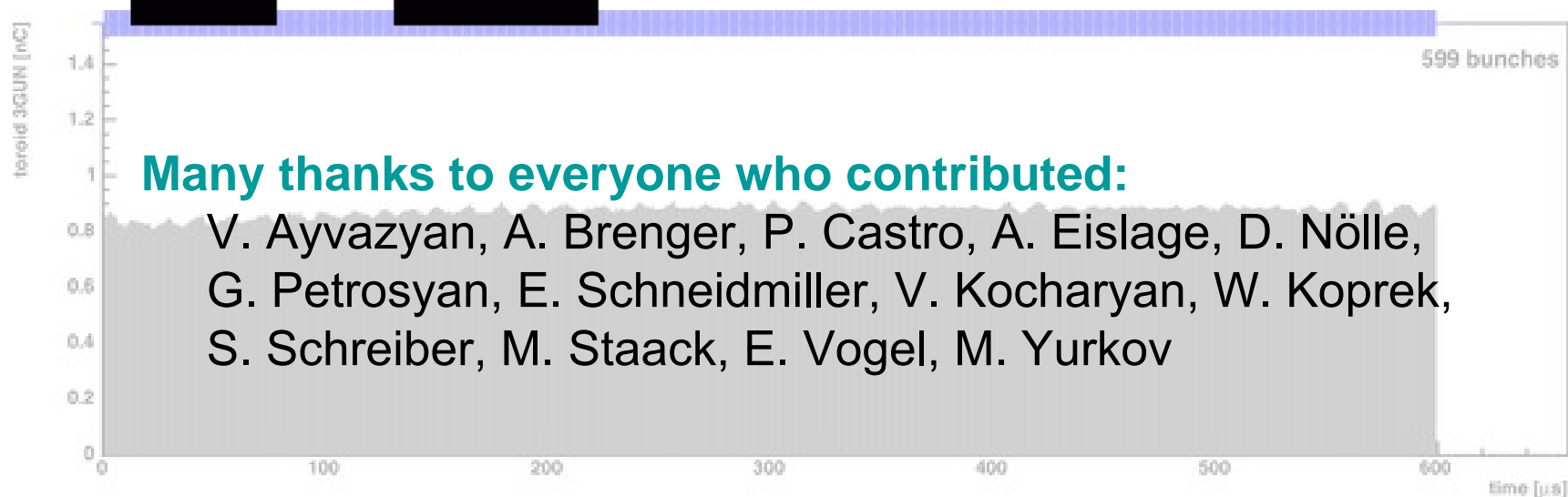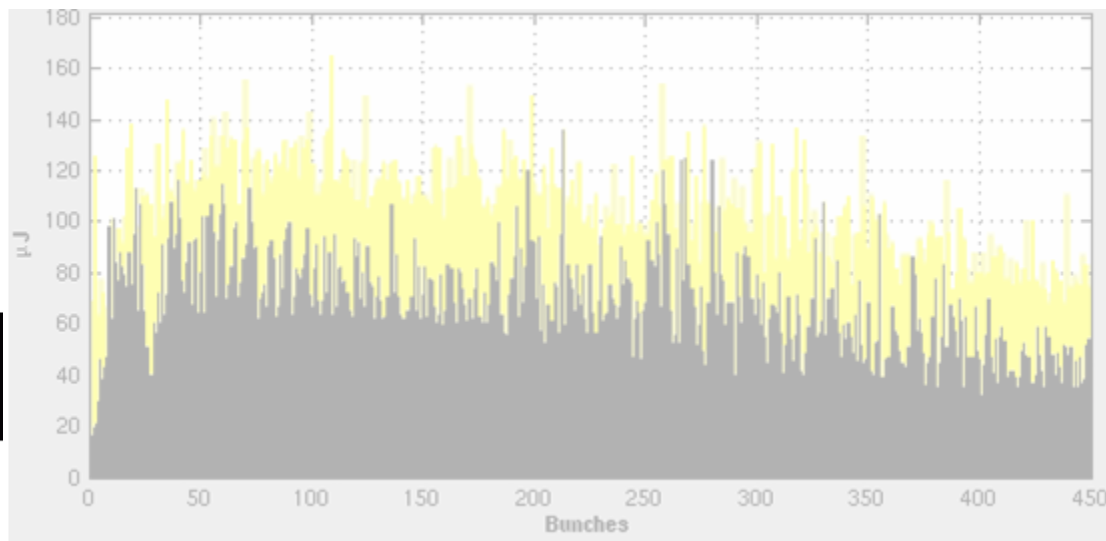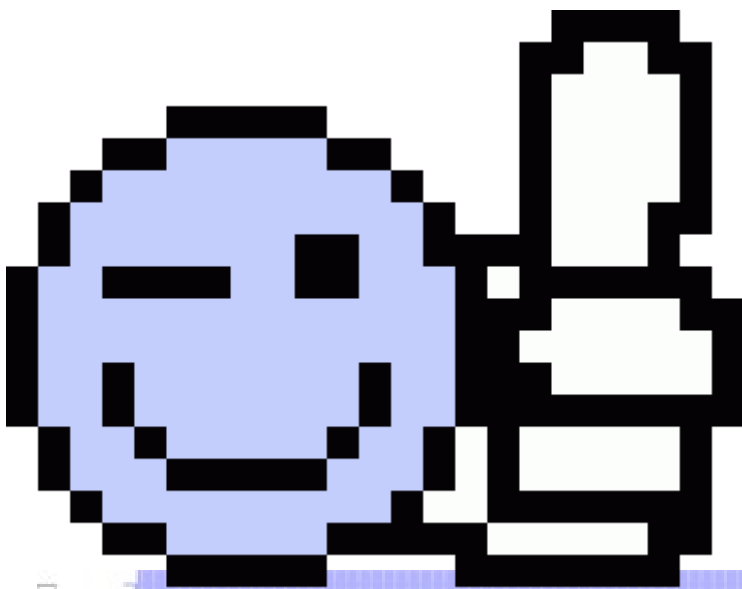
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