



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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Fast Machine Protection

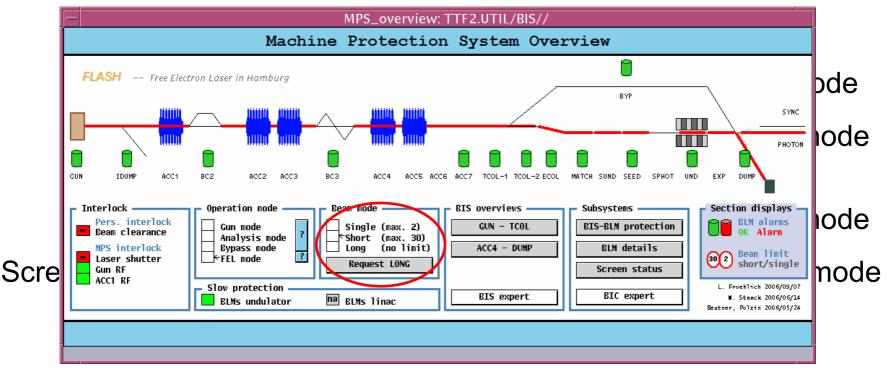
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There are three beam modes:

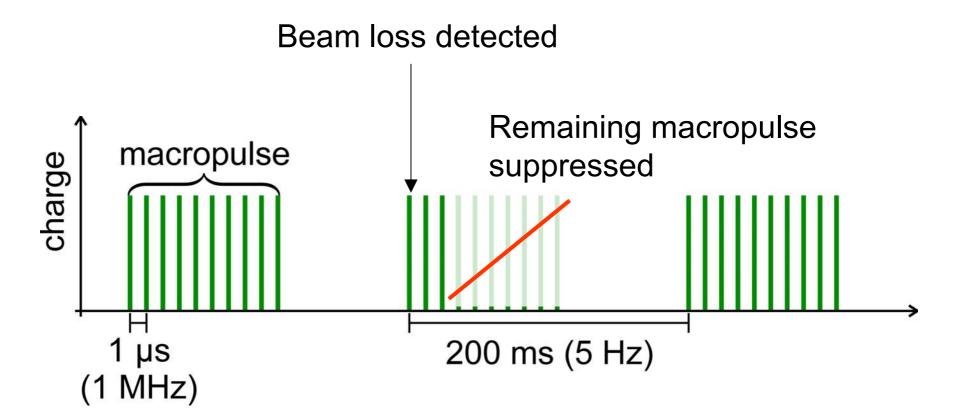
- Single pulse mode (up to 2 bunches, no fast protection)
- Short pulse mode (up to 30 bunches, no fast protection)
- Long pulse mode (unlimited bunches, fast protection)





Fast Machine Protection







Fast Beam Interlock



Fast: Stop bunch production for the remaining macropulse

(2 – 4 µs)

Beam Interlock Concentrators (BICs)

collect alarms from

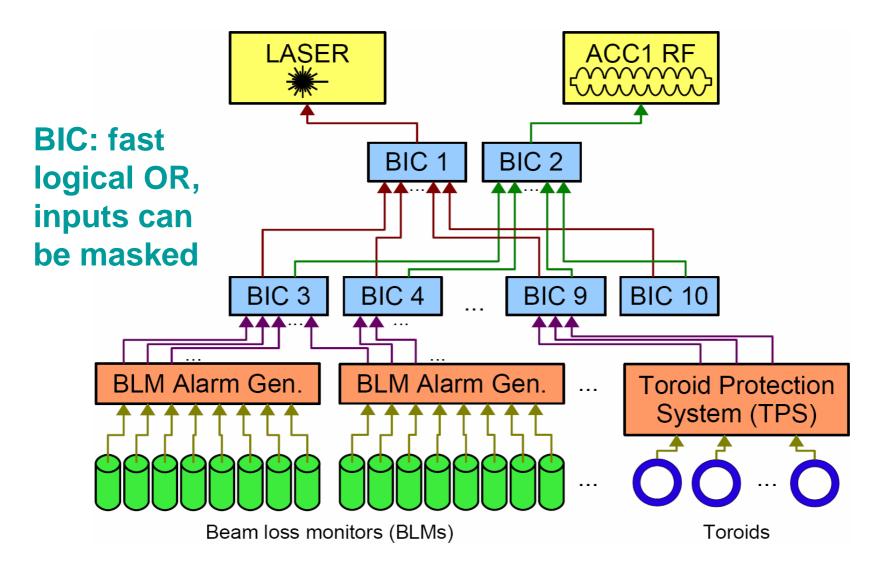
- Beam Loss Monitors (BLMs): Electromagnetic showers
- Toroid Protection System (TPS): Charge loss
- Fast vacuum shutters
- LLRF quench detection





Fast Beam Interlock





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Accelerator Studies

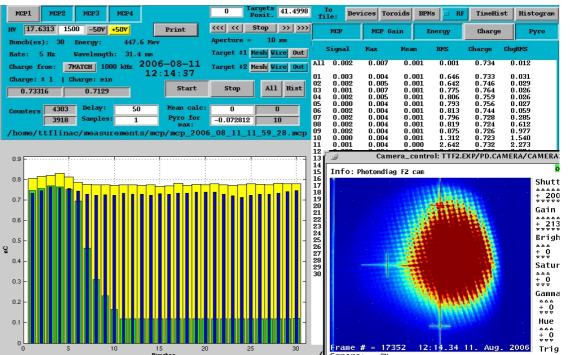
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HELMHOLTZ GEMEINSCHAFT Accelerator Studies 10.-14.8.



Thursday-Friday, August 10-11

- Setup machine for lasing at 32 nm
- No transmission of more than 5 bunches through BC3
- Triggered raditation interlock in hall 3 (!)
- Caused by darkcurrent kicker!
- DC kicker off →
 30 bunches lasing



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Friday, August 11

F

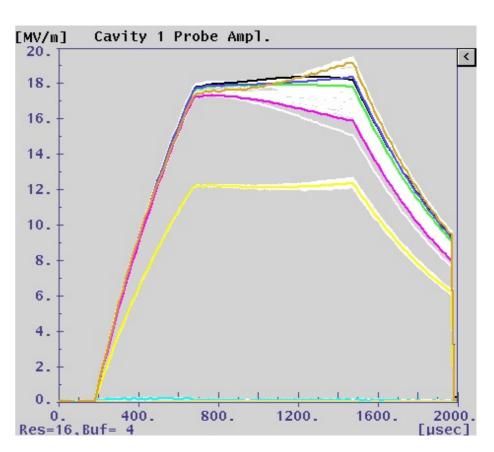
- Switch to long pulse mode
- One minute of glory (100 µJ with 100 bunches)
- 50 mW FEL output power

MCP1 MCP2 MCP3 MCP4	0 Targets Posit.	41.4998	To file	: Devi	.ces Toroids	BPMs	RF	TimeHist	Histogram
HV 18.1074 1600 -50V +50V Print	<<< <stop< th=""><th><u>>></u>>>></th><th>Þ</th><th>œ</th><th>MCP Gain</th><th>Energ</th><th>y I</th><th>Charge</th><th>Pyro</th></stop<>	<u>>></u> >>>	Þ	œ	MCP Gain	Energ	y I	Charge	Pyro
Bunch(es): 100 Energy: 447.6 Mev	Aperture = 10	mm							
Rate: 5 Hz Wavelength: 31.4 nm	Target #1 Mesh Wi	ire Out	51	gnal	Max Mea	n RMS	5 C	harge Ch	(RMS
Charge from: 7MATCH 1000 kHz 2006-08-11	Target #2 Mesh W	ire Out	A11 :	81.937	220.975	93.207	13.0	70 0.963	0.019
Charge: # 1 Charge: min 15:14:10				47.552	172.729	85.787	0.41		0.017
	Stop All			57.984	201.416	89.891	0.43		0.018
1.0413 0.9363 Start		. Juise		71.023 93.189	201.416 217.063	97.355 100.834	0.39		0.019
Comptane 422 Delay: 50 Mean calc:		D	05	93.189	220.975	102.266	0.3	86 1.011	0.053
Counters 422 50				89.278 99.709	210.543 198.808	100.166 96.450	0.3		0.053
422 Samples: 1 Pyro for max:	-0.12881	B		107.532	196.200	99.903	0.3		
/home/ttflinac/measurements/mcp/mcp_2006	i_08_11_15_12_	16.mcp		80.150	180.553	100.931	0.3		0.053
< 20 pulses >				81.454 76.239	$189.681 \\ 200.112$	99.432 98.190	0.34		0.053 0.053
120	1 1		12	90.582	177.945	97.456	0.35	4 0.991	0.053
	÷	· · · · · · · · -		86.670 85.366	194.896 187.073	99.553 99.720	0.36		0.053 0.053
80 - 1 N N N N N N N N N N N N N N N N N N	÷	•••••		68.415	187.073	97.345	0.35		0.053
3 60	÷	·····-		69.719	207.936	97.410	0.38		0.053
40	÷	·····-		87.974 73.630	198.808 179.249	99.073 98.364	0.36		0.053 0.053
20				76.239	204.024	97.769	0.30		0.053
15:12:16 15:13:16 15:14:16 15:15:16 15:	16:16 15:17:16		20	57.984	200.112	97.707	0.38	2 0.968	0.053
time [hh:mm:ss]	10.10 13.17.10			67.111 99.709	192.288 189.681	98.196	0.36		0.053 0.053
	1 1 1			59.709 64.503	192.288	98.147 96.103	0.37		0.053
			24	93.189	180.553	98.212	0.37	1 0.965	0.053
200				106.229	192.288	96.357	0.3		
	مطلطلال معما	d Hh ai		71.023 91.886	190.984 174.034	93.359 93.857	0.39		0.053 0.053
	111111111111111111111111111111111111111			90.582	188.377	93.743	0.39		0.053
150			29	68.415	198.808	96.137	0.39	0 0.967	0.053
				76.239	200.112	94.470	0.40		0.053
				69.719	184.465	94.715	0.39		0.053
				94.493	187.073	93.064	0.38		0.053
	a a sha a she a she a she			91.886	183.161	93.352	0.40		0.053
				86.670 77.543	185.768 194.896	94.628 90.918	0.40		0.053 0.053
كملكنا الالازي كمانا الأربيكيني الالاربي كا				72.327	189.681	90.494	0.40		0.053
50				74.934	187.073	94.978	0.38		0.053
			38	71.023	185.768	95.774	0.39		0.053
				80.150	187.073	93.318	0.39		0.053
0									
0 10 20 30 40 50 60 Bunches	70 80 90) 100	/how	ne/ttfli	nac/measureme	mts/mcn/r	nco 200	6 08 11 15	12 16.mm
Duncnes			,		,		-P_200		

Lars Fröhlich, MPY

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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Targets Posit.

<<< | << | Stop | >> | >>>

10 m

#2 Mesh Wire Out

Mesh Wire Out

All || Hist

0

Target

Ston

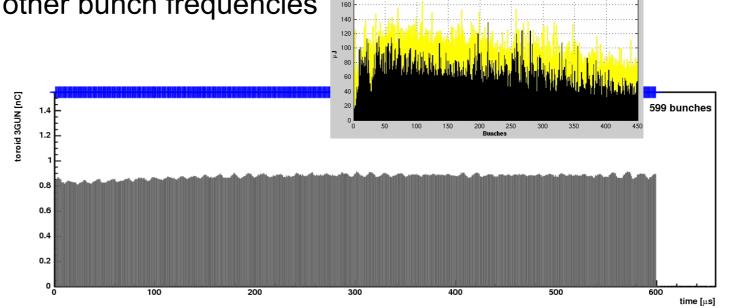
-0.070071

04:33:39

41.4998

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



MCP3

-50%

1.0563

1650

143

04:24:39

7MATCH

17.6313

1.1037

55 3 50

45 40 40

180

MCP4

447.6 Mev 31.4 nm

+50V

Print

2006-08-14

tflinac/measurements/mcp/mcp_2006_08_14_04_21 <20 pulses >

04:30:39

time [hh:mm:ss]

24:06

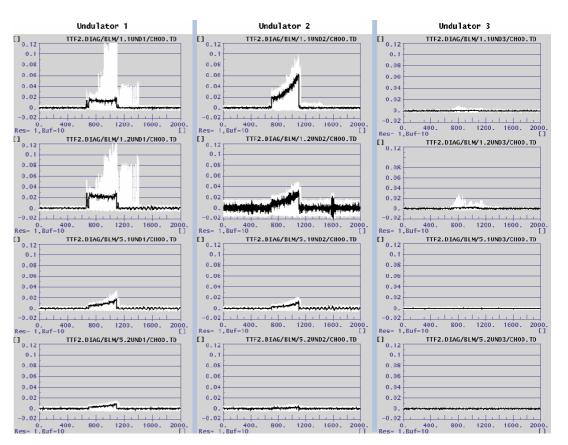
Start

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Monday, August 14

- Work on injector laser
- Tuning of cavities for 800 µs RF pulses
- Restart machine, retune SASE
- Long pulse mode at 1:20 (am)
- Lasing with 400 bunches, limited by losses in undulator



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Tools

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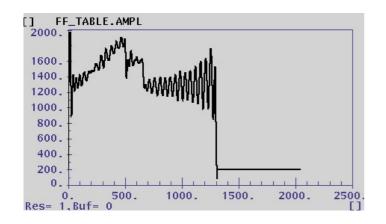
Tools: LLRF

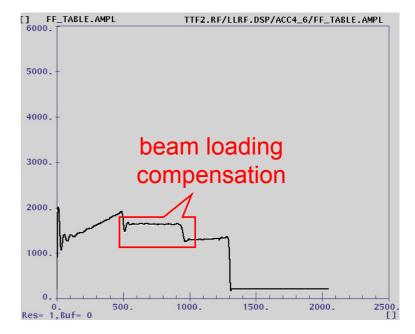


ACC1 (Simcon): Toroid-based beam loading compensation works well

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





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Charge:

MEINSCHAFT

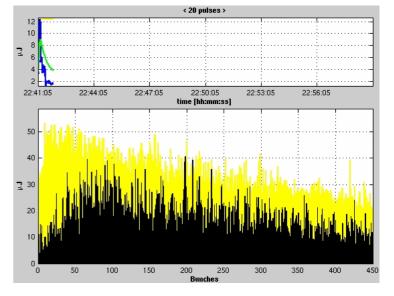
Nice new display mode in P. Castro's tool

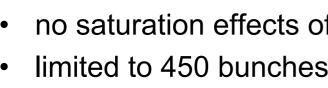
MCP:

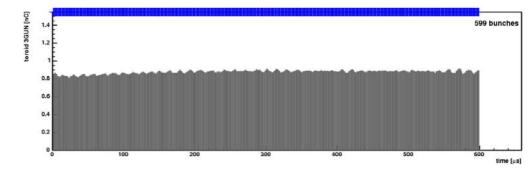
- no saturation effects of MCP hardware observed
- limited to 450 bunches by ADC, now solved (?)
- MCP tool history drops dramatically when 1 macropulse is shortened
- MCP tool very slow with >100 bunches

GMD:

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









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

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by Hartz/Tesch/Leuschner, D3



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

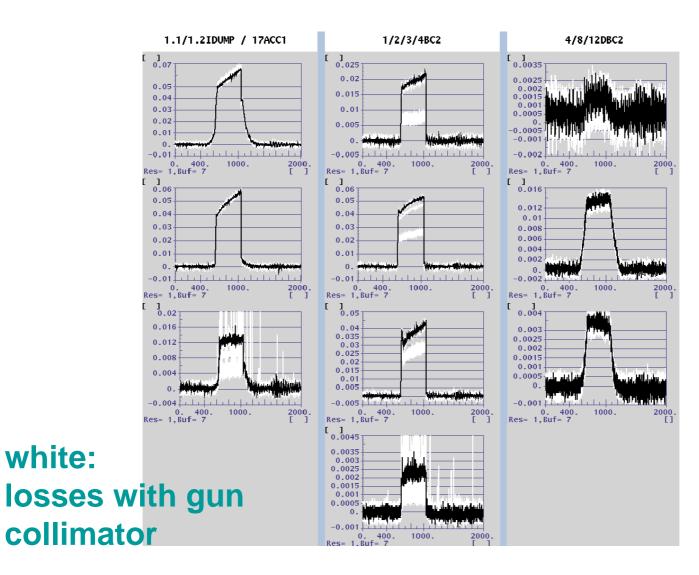
Gun collimator

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



Countermeasures









Final Remarks

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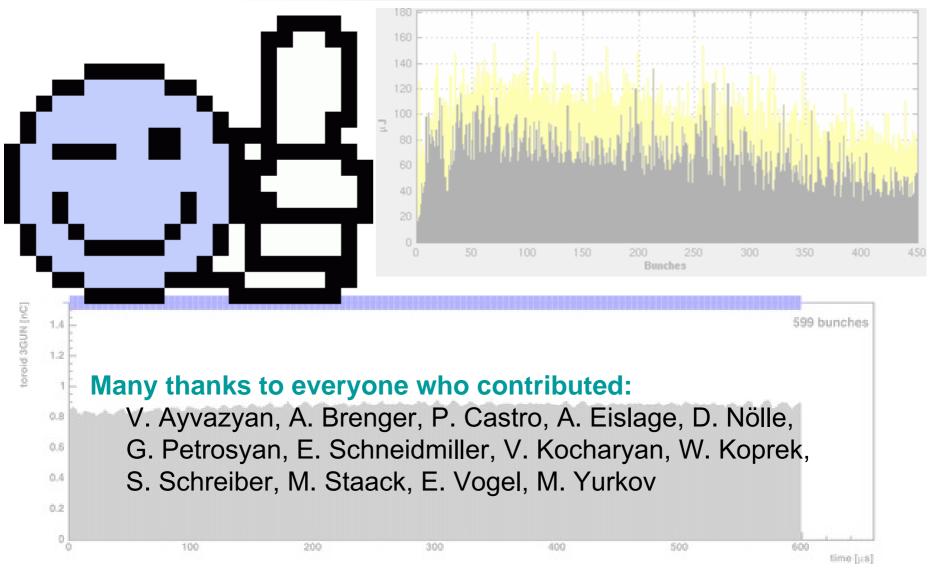
Conclusion



- 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.

Thanks for your attention.





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