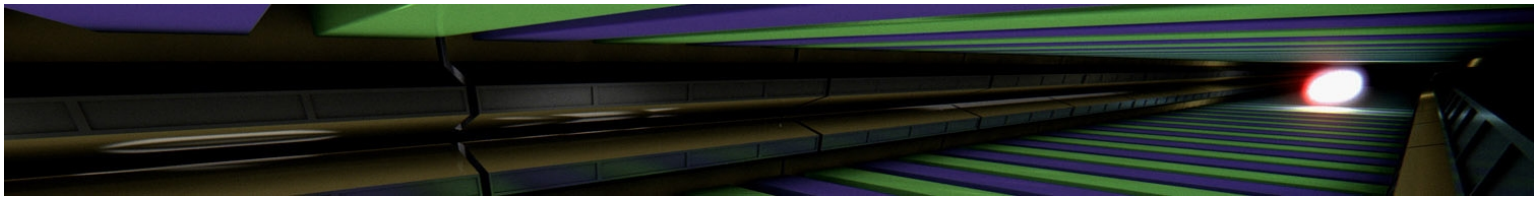


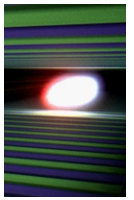
XFEL MPS

Machine Protection System
For European XFEL

Martin Staack, DESY

European XFEL

Requirements for the Machine protection System



- Protect accelerator components from damage
- Facilitate easy handling of machine
- Impair machine operation only if necessary
- Limit activation of accelerator components to preserve functionality and maintainability
- Beam time will be high in demand, the goal should be to limit downtimes to their necessary extent
- MPS should be highly reliable and “user-friendly”
- MPS should be as simple and flexible as possible
- Incorporate good experience from FLASH MPS
- Personal safety is not covered by MPS → separate system

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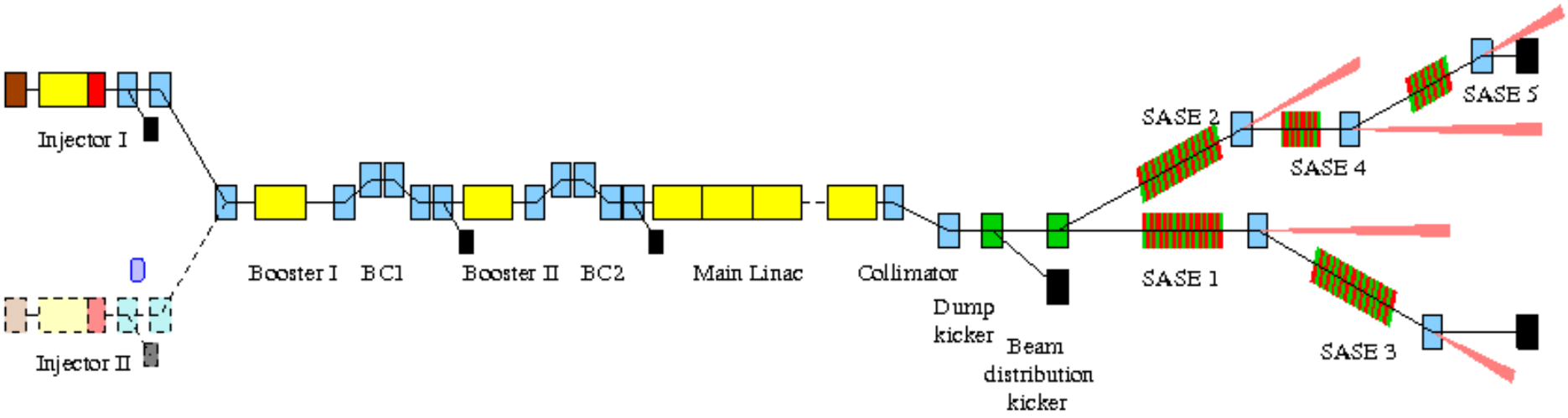
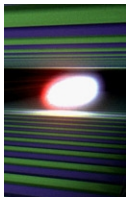
XFEL Architecture



- 2 independant Injectors
- Superconducting Linac with 2 Bunchcompressors
- 3 Electron Paths with Beamdumps
- 5 Photon Beamlines

Reaction times



Beam loss location	Distance from Injector	Distance from Dump	# of lost bunches
Injector	0 m	-1970 m	0
BC1	160 m	-1810 m	7
BC2	360 m	-1610 m	15
Linac center	1040 m	-930 m	44
Linac End	1650 m	-320 m	69
Beam distribution	2010 m	40 m	2
Last undulator	3010 m	1040 m	44

- ~50 bunches are in the accelerator
- Signal transport time of approximately 20 µs
- ~50 bunches generated before laser is blocked
- Beam distribution kicker used to dump stored beam

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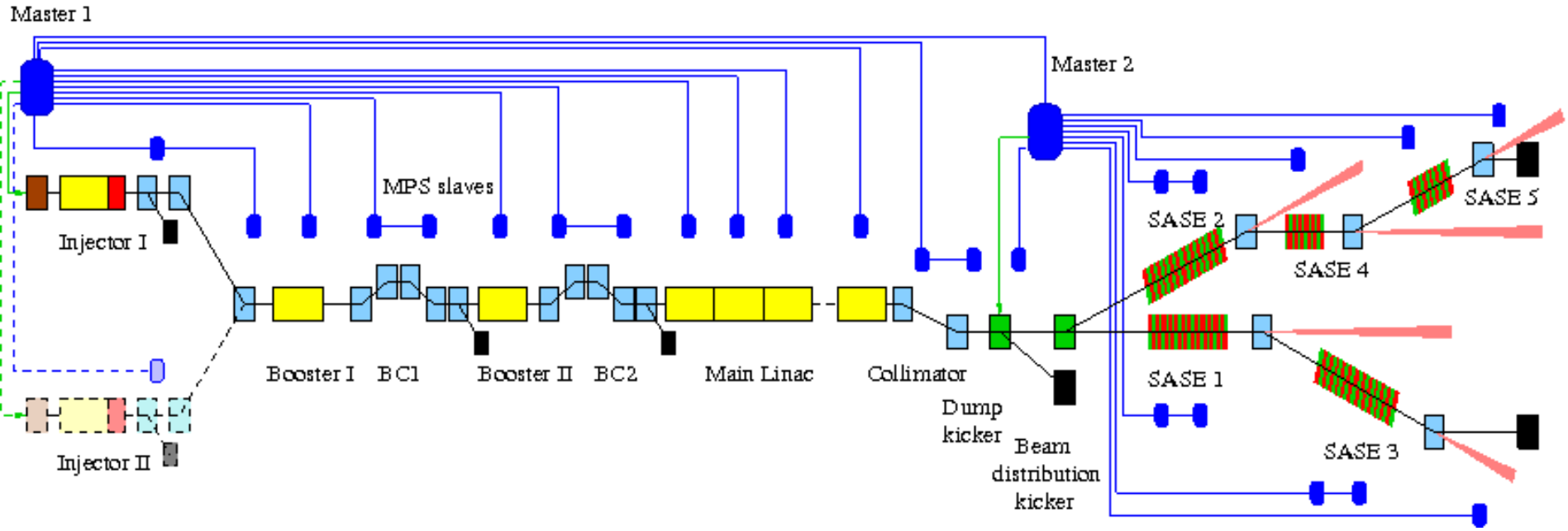
Machine Protection Architecture



- Distributed System with µTCA modules
- MPS Master Modules at Gun and Switchyard
- Optical fiber connections between MPS Modules
- MPS can act on Injector Lasers and Beam Switchyard

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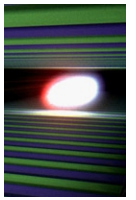
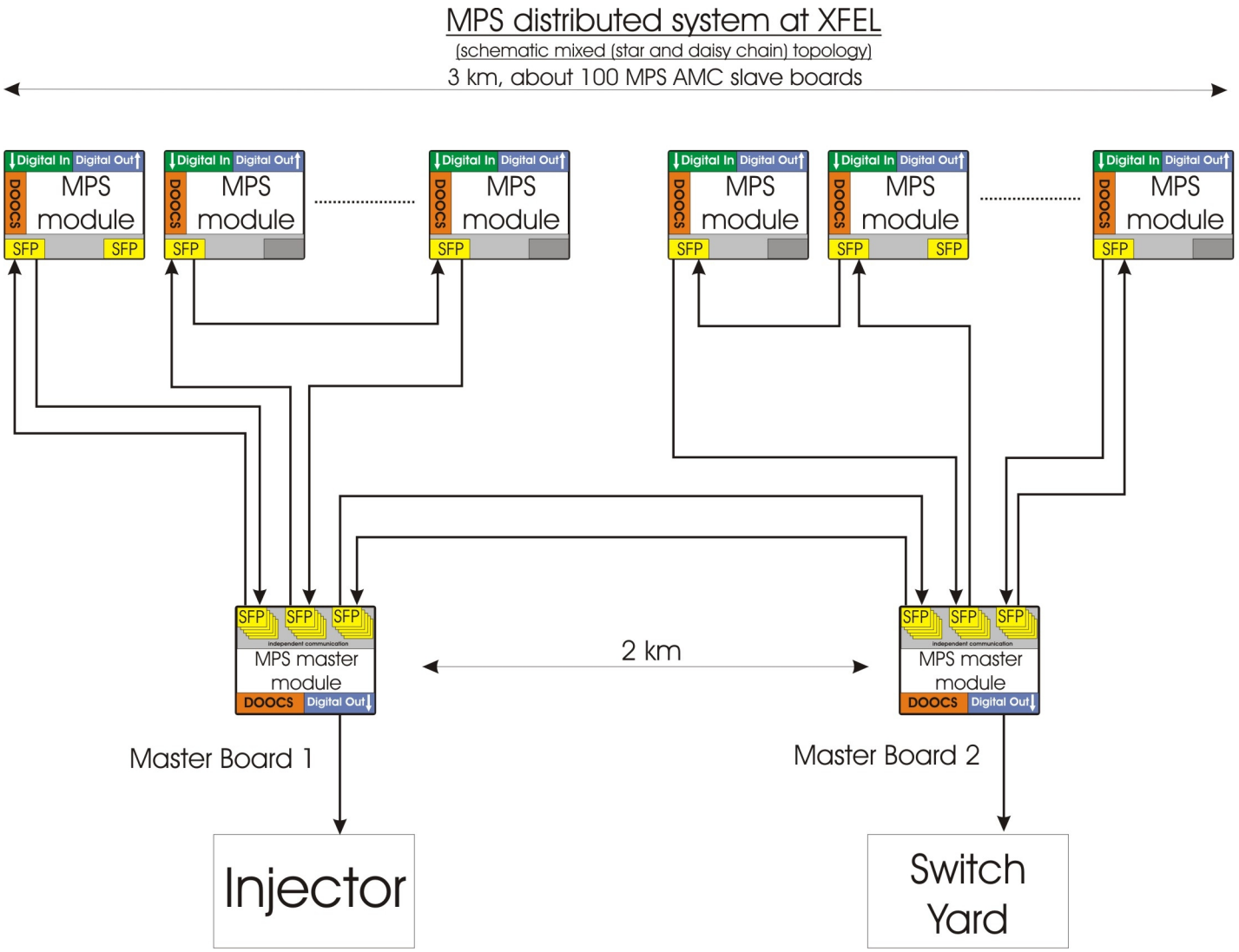
MPS topology





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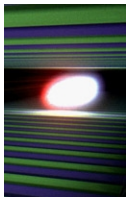
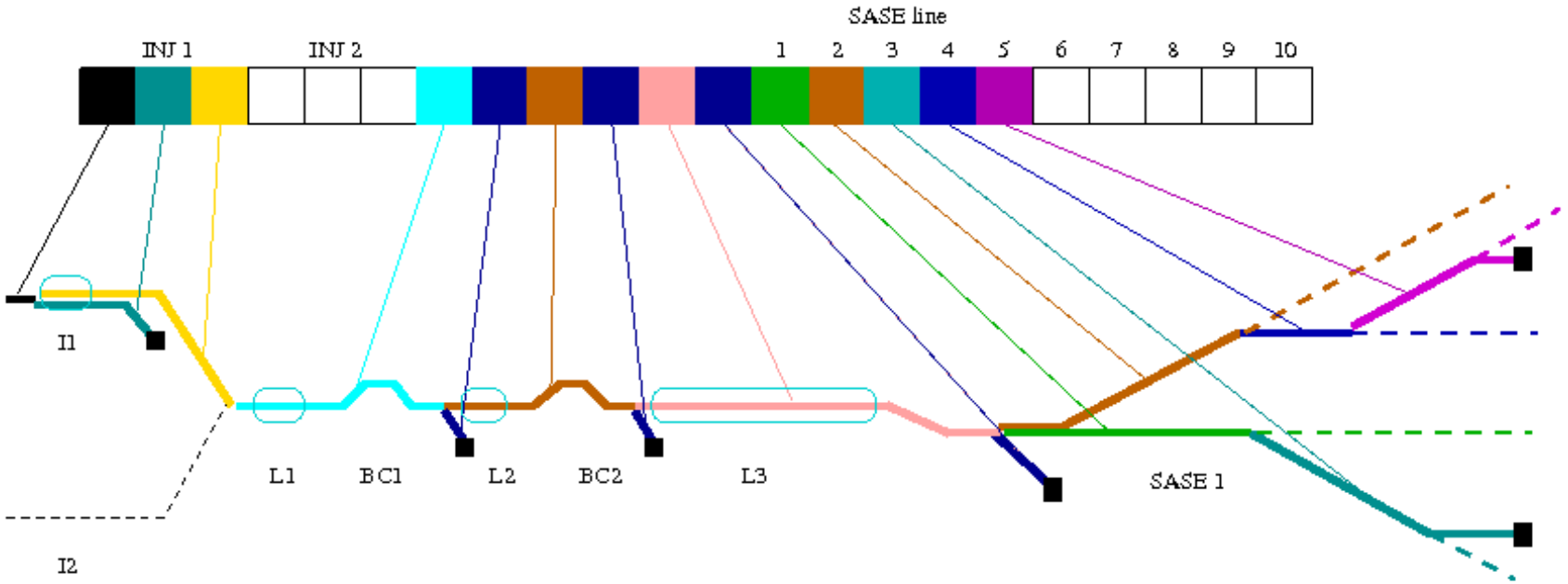
Operation Mode

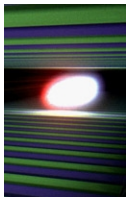


Operation mode, sent to timing master



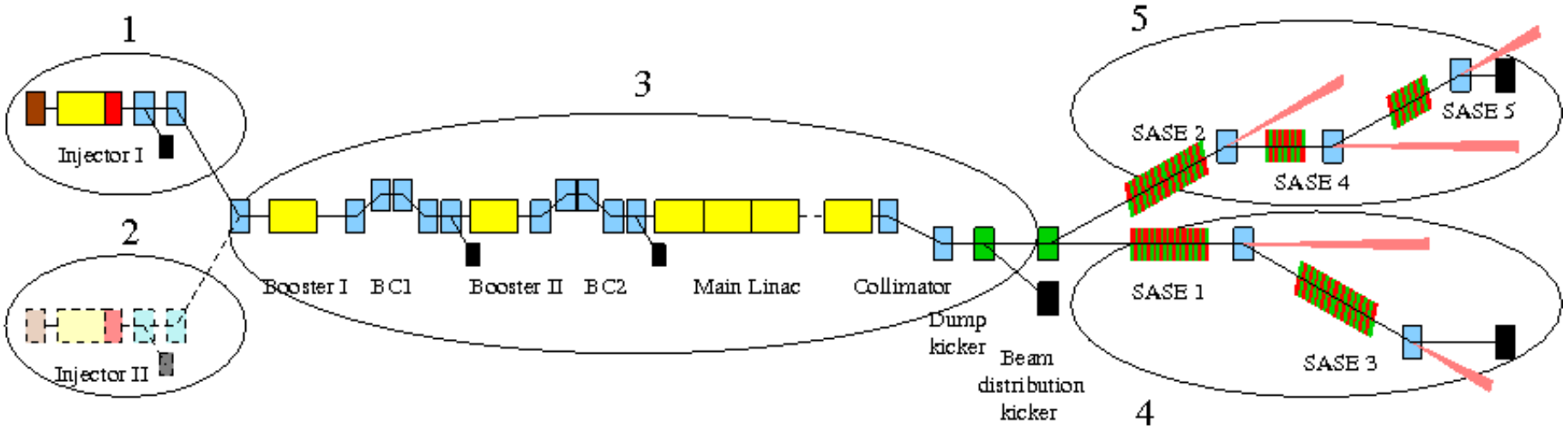
- Operation Mode is determined from magnet currents, vacuum valves and photon beamline status
- Operation Mode describes paths electrons can take
- Status is sent to Timing System

Beam Modes (1)



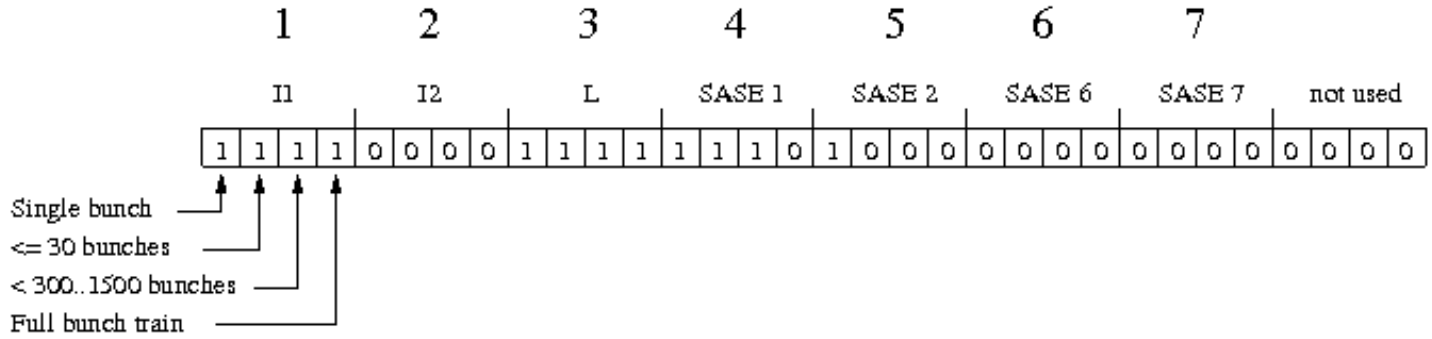
- MPS collects limitation signals from accelerator components
- BC beam dumps allow only few bunches
- Inserting screens into course of beam → limit to single bunch operation
- Experiments and photon beamlines have to inform MPS about limitations → how many bunches allowed?
- MPS will not calculate µJ into number of bunches
- MPC forwards this information to the timing system
- Timing system processes this information and distributes bunch patterns to injector lasers, LLRF, TPS, TDS, beam switchyard and other important systems

Beam Modes (2)



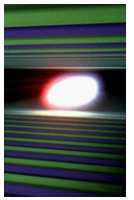
6: SASE 6 et al (future)
7: SASE 7 et al (future)

Beam mode (32 bit vector):



European XFEL

Signals to MPS from accelerator



Devices	Inputs	Outputs
Cold Magnets	200	
PS Master	50	
Modulator	25	
Klystron	25	25
LLRF	25	50
Cryo / Vacuum	25	
Coupler interlock	120	120
OTR screens	160	
Wirescanner	80	20
Toroid protection	160	
BPM	120	
BLM	350	
Laser / Switchyard	20	20

and additional:

- Dump
- Watercooling
- Collimator temp
- …

- ~2000 alarm signals are collected, RS422 technology

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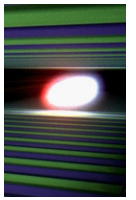
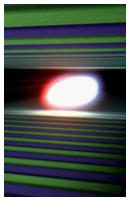
MPS modules in cold section



Section	Building	Room	Z [m]	ACC	Racktype	IT	IT	MPS	RTM	Patch	Timing	IN	OUT-B	OUT					
I1	XSE	UG04-02	0		DIAG		F	2	2		1	53			ContrSys WP28	1xBPM	BLM: 2x4	2xOTR: 11x4	
I1	XTIN		30	1	LLRF Master	HV	F	1	1		3	7	1	8	ContrSys WP28	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 5In/6Out	
I1	XTIN		33	1	RF		F								Klystron 1In/1Out				
I1	XTIN		36	1	LLRF Slave		F	1	1		2	2	1	7	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out		
I1	XTIN		47		DIAG		F	1	1		1	25			ContrSys WP28	1xBPM	BLM: 2x4	TPS: 4x4	
I1	XTL		100		DIAG		F	1	1		1	42			ContrSys WP28	2xBPM	OTR: 2x4	BLM: 4x4	TPS: 2x4
L1	XTL		117		PS / Vac		F			1					8xMagnet	GP & TSP			
L1	XTL		123	2	Cryo / Vac		F								Iso & Schieber	2xBPM	Kryogenik	2xCouplerMot	
L1	XTL		127	2	LLRF Master		F	1	1		1	1	1	1	PinDiode 1 Out	LLRF 1In/1Out			
L1	XTL		131	2	LLRF Master	HV	F+O	1	1		3	7	1	8	ContrSys WP28	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 5In/6Out	
L1	XTL		138	2	RF		F								Klystron 1In/1Out				
L1	XTL		160	2	LLRF Slave		F	1	1		2	3	1	7	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out		
L1	XTL		163	2	LLRF Slave		F	1	1		1	1	1	1	PinDiode 1 Out	LLRF 1In/1Out			
L1	XTL		167	2	Cryo / Vac		F								Cryo	Iso & Schieber			
B1	XTL		177		DIAG		F	1	1		1	14			ContrSys WP17	2xBPM	TPS: 1x4	BLM: 2x4	
B1	XTL		179		SDIAG		F								BAM1	EOD1			
B1	XTL		188		SDIAG										E-BPM	SRM			
B1	XTL		204		SDIAG		F				1				ContrSys WP18	BAM2	EOD2	IT/Patch	
B1	XTL		206		DIAG		F	1	1		1	26			ContrSys WP17	2xBPM	TPS: 1x4	BLM: 2x4	OTR: 3x4
B1	XTL		211		SDIAG		F								Pyro	TDS			
B1	XTL		213		Vacuum		F								GP & TSP	Iso & Shutter			
B1	XTL		216		DIAG		F	1	1		1	33		4	ContrSys WP17	1xBPM	WS:4x2In/1Out	BLM: 2x4	OTR: 4x4
B1	XTL		218		KICK	HV	F				1				ContrSys WP28	Kicker			
B1	XTL		221		DIAG		F	1	1		1	25		8	ContrSys WP17	1xBPM	WS: 8x2In/1Out	OTR: 2x4	
B1	XTL		223		DIAG		F								CRD				
L2	XTL		239	3	Cryo / DIAG		F	1	1		1	14			ContrSys WP17	2xBPM	TPS: 1x4	BLM: 2x4	Cryo
L2	XTL		244	3	Vacuum		F								GP & TSP				
L2	XTL		246	3	LLRF-Master	HV	F+O	1	1		3	7	1	8	ContrSys WP28	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 5In/6Out	
L2	XTL		253	3	RF		F								Klystron 1In/1Out				
L2	XTL		276	3	LLFR-Slave		F	1	1		2	3	1	7	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out		
L2	XTL		280	3	Spare														
L2	XTL		283	3	PS / Vac		F			1					8xMagnet	GP & TSP			
L2	XTL		294	4	LLRF-Master	HV	F	1	1		3	12	1	8	ContrSys WP28	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out	
L2	XTL		302	4	RF		F								Klystron 1In/1Out				
L2	XTL		324	4	LLFR-Slave		F	1	1		2	11	1	7	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out		
L2	XTL		331	4	PS		F			1					8xMagnet				
L2	XTL		334	4	PS		F			1					8xMagnet				
L2	XTL		342	5	LLRF-Master	HV	F	1	1		3	12	1	8	ContrSys WP28	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out	
L2	XTL		350	5	RF		F								Klystron 1In/1Out				
L2	XTL		372	5	LLFR-Slave		F	1	1		2	3	1	7	PinDiode 1 Out	LLRF 1In/1Out	Coupler-Int 2In/6Out		
L2	XTL		379	5	Cryo / Vac		F								Cryo	Iso & Schieber			
B2	XTL		388		DIAG		F	1	1		1	14			ContrSys WP17	2xBPM	TPS: 1x4	BLM: 2x4	
B2	XTL		390		SDIAG		F								BAM1				

- MPS modules modules in LLRF Master and Slave Racks

MPS in undulator sections



SASE2	XTD1		2217		Rack													
SASE2	XTD1		2223		DIAG			1	1		1	17			ContrSys WP17	1xBPM	BLM: 4x4	
SASE2	XTD1		2229		Vacuum													
SASE2	XTD1		2235		DIAG										MBU BPM			
SASE2	XTD1		2242		IT		F								Patch			
SASE2	XTD1		2248		DIAG										MBU BPM			
SASE2	XTD1		2254		Vacuum													
SASE2	XTD1		2260		DIAG										MBU BPM			
SASE2	XTD1		2266		Rack													
SASE2	XTD1		2272		DIAG			1	1		1	17			ContrSys WP17	1xBPM	BLM: 4x4	
SASE2	XTD1		2278		Vacuum													
SASE2	XTD1		2284		DIAG										MBU BPM			
SASE2	XTD1		2290		Rack													
SASE2	XTD1		2296		DIAG										MBU BPM			
SASE2	XTD1		2303		Vacuum													
SASE2	XTD1		2309		DIAG										MBU BPM			
SASE2	XTD1		2315		IT		F								Patch			
SASE2	XTD1		2321		DIAG			1	1		1	17			ContrSys WP17	1xBPM	BLM: 4x4	
SASE2	XTD1		2327		Vacuum													
SASE2	XTD1		2333		DIAG										MBU BPM			
SASE2	XTD1		2339		Rack													
SASE2	XTD1		2345		DIAG										MBU BPM			
SASE2	XTD1		2351		Vacuum													

- SASE undulator section: MPS modules are hosted by diagnostic crates with BLM, TPS and BPM electronics

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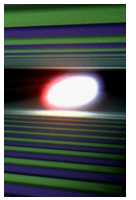
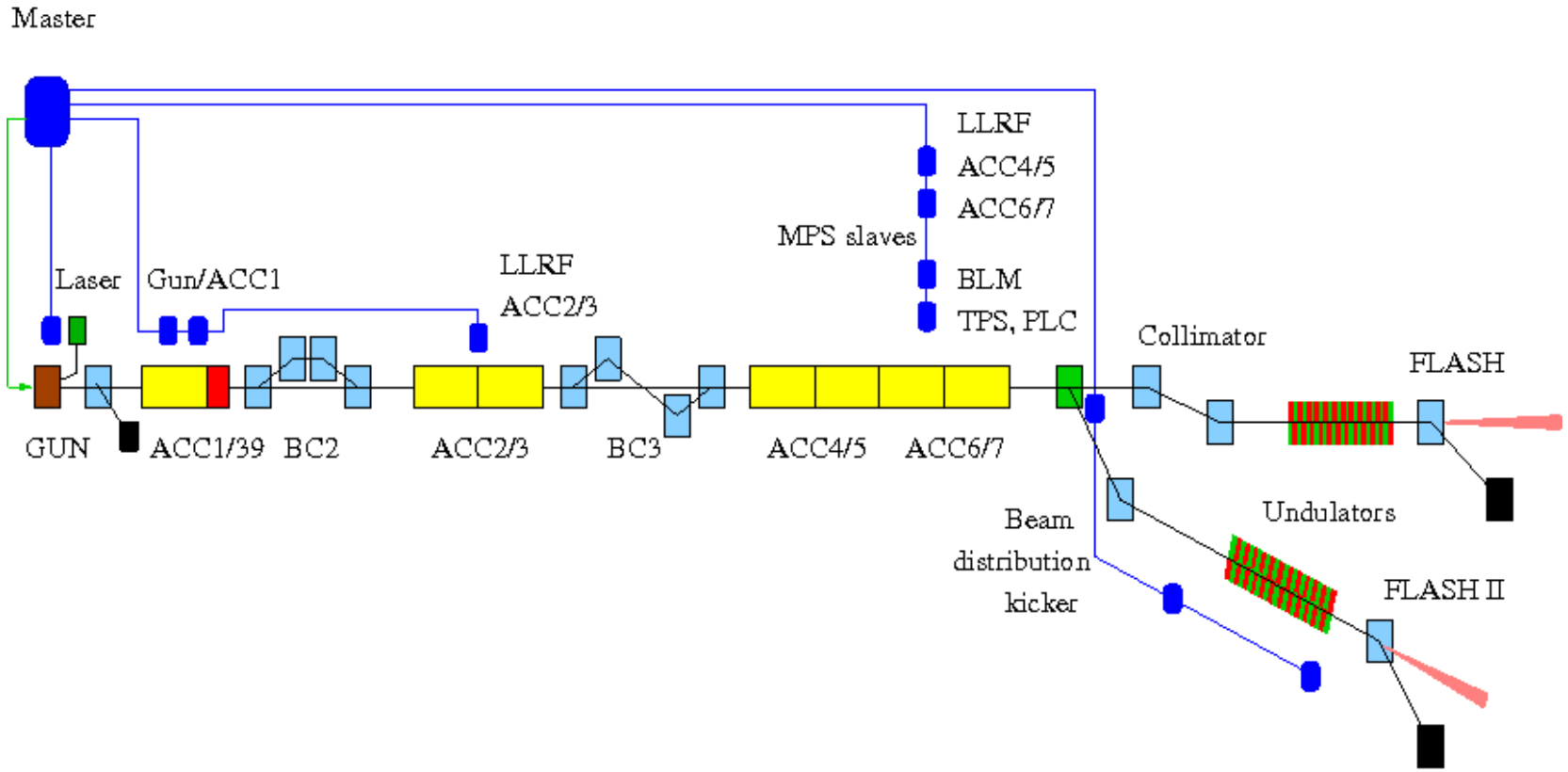
XFEL MPS for FLASH II





- XFEL MPS modules take care of new beamline and LLRF, Laser
- “Old” FLASH sections are checked by PLC
- XFEL MPS will be master of the system

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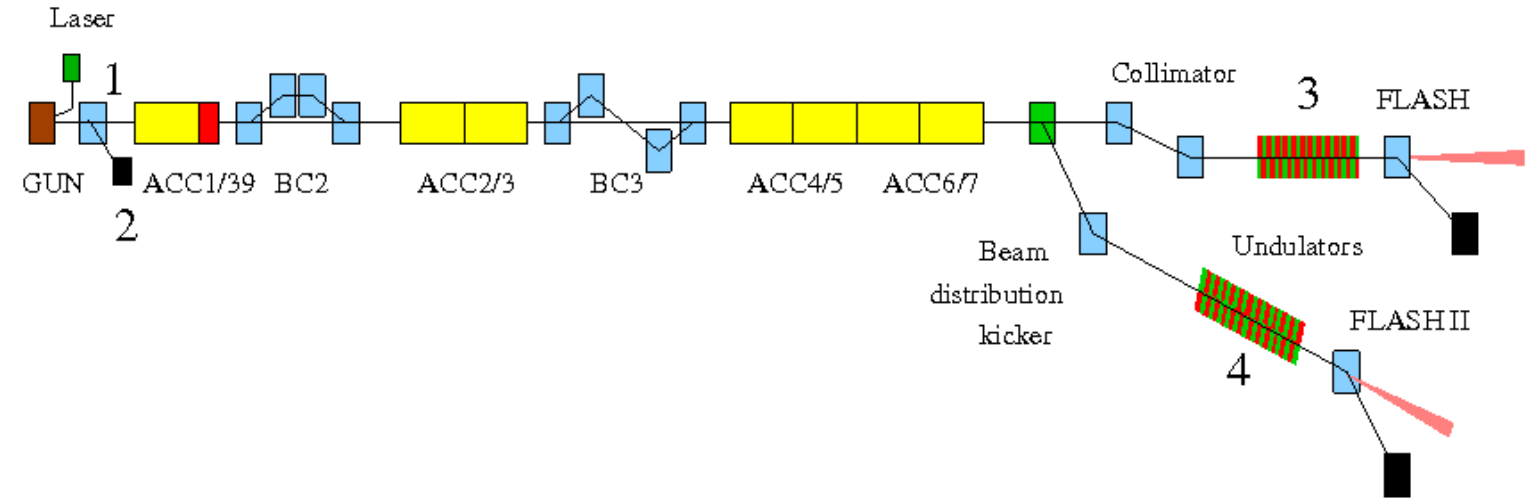
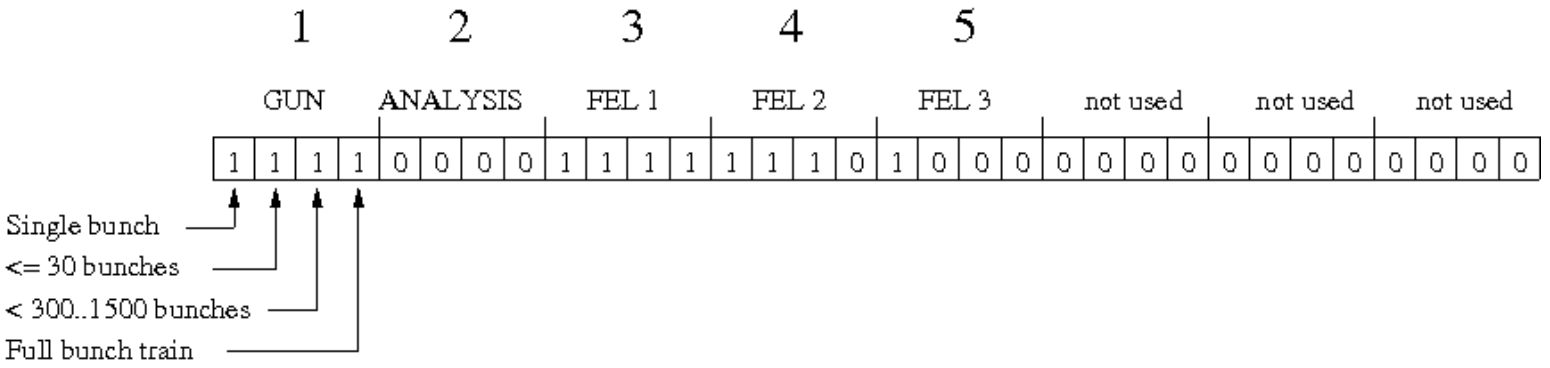
Beam Modes for FLASH II

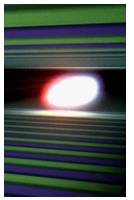


Beam mode (32 bit vector):



- Beam Modes similar to XFEL → only 1 system to be maintained

Conclusions



- MPS for XFEL is a distributed system
- ~130 MPS slave modules are distributed over accelerator, photon beam lines, experiments and halls
- Master modules act on injector laser and distribution kicker
- MPS modules will host radiation monitoring (separate talk)
- MPS has a simple and flexible structure
- We profit from long, good experience at FLASH
- XFEL MPS will be tested at FLASH and go into operation at FLASH II in 2013
- Installation at XFEL injector end of 2013
- Installation at XFEL in 2014