



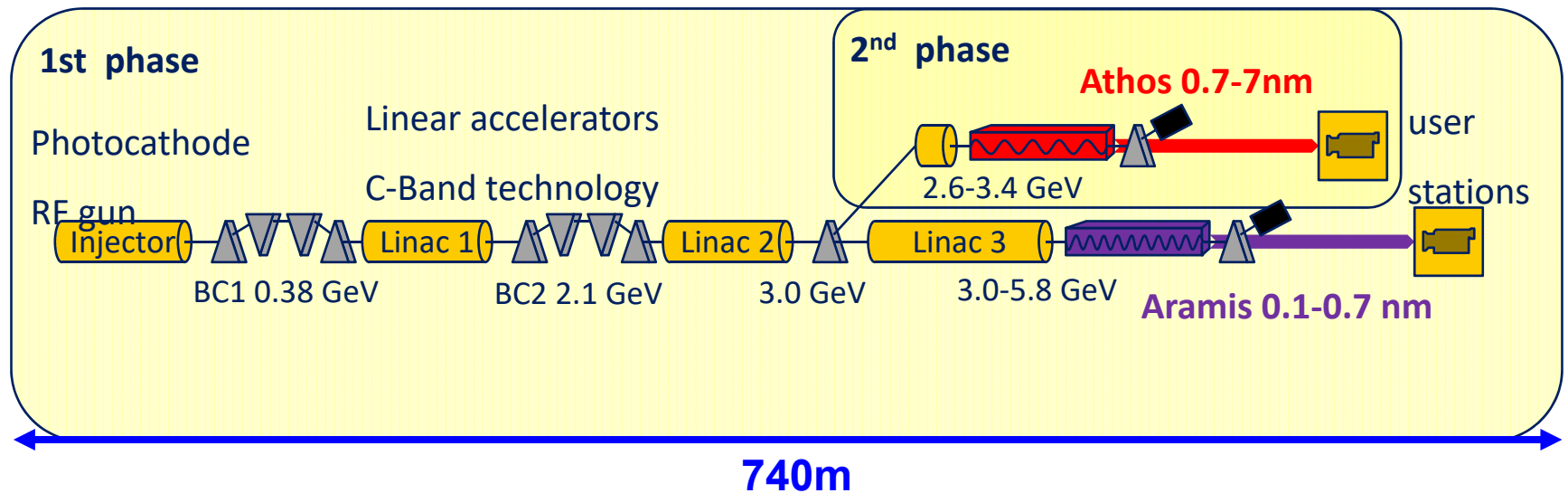
Babak Kalantari for Controls :: Paul Scherrer Institut

SwissFEL Timing System First Operational Experience

ICALEPCS'17, Barcelona

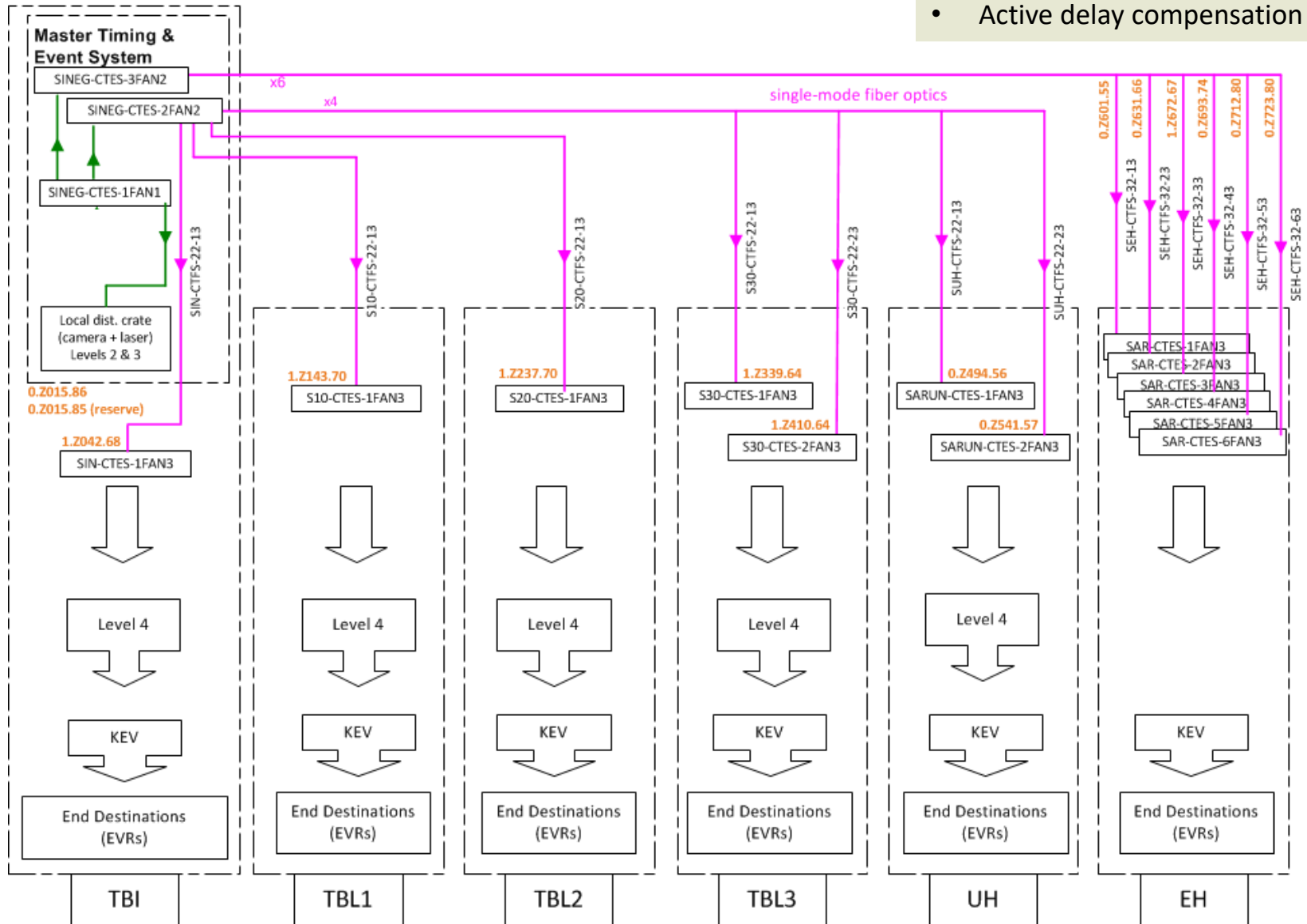
SwissFEL Timing Overview

- Provide precise triggering across the facility
- Rep- and beam rate controls
- Distribute operation-critical machine parameters
- Assist machine/beam synchronous DAQ and controls
- Assist Machine Protection System (MPS)



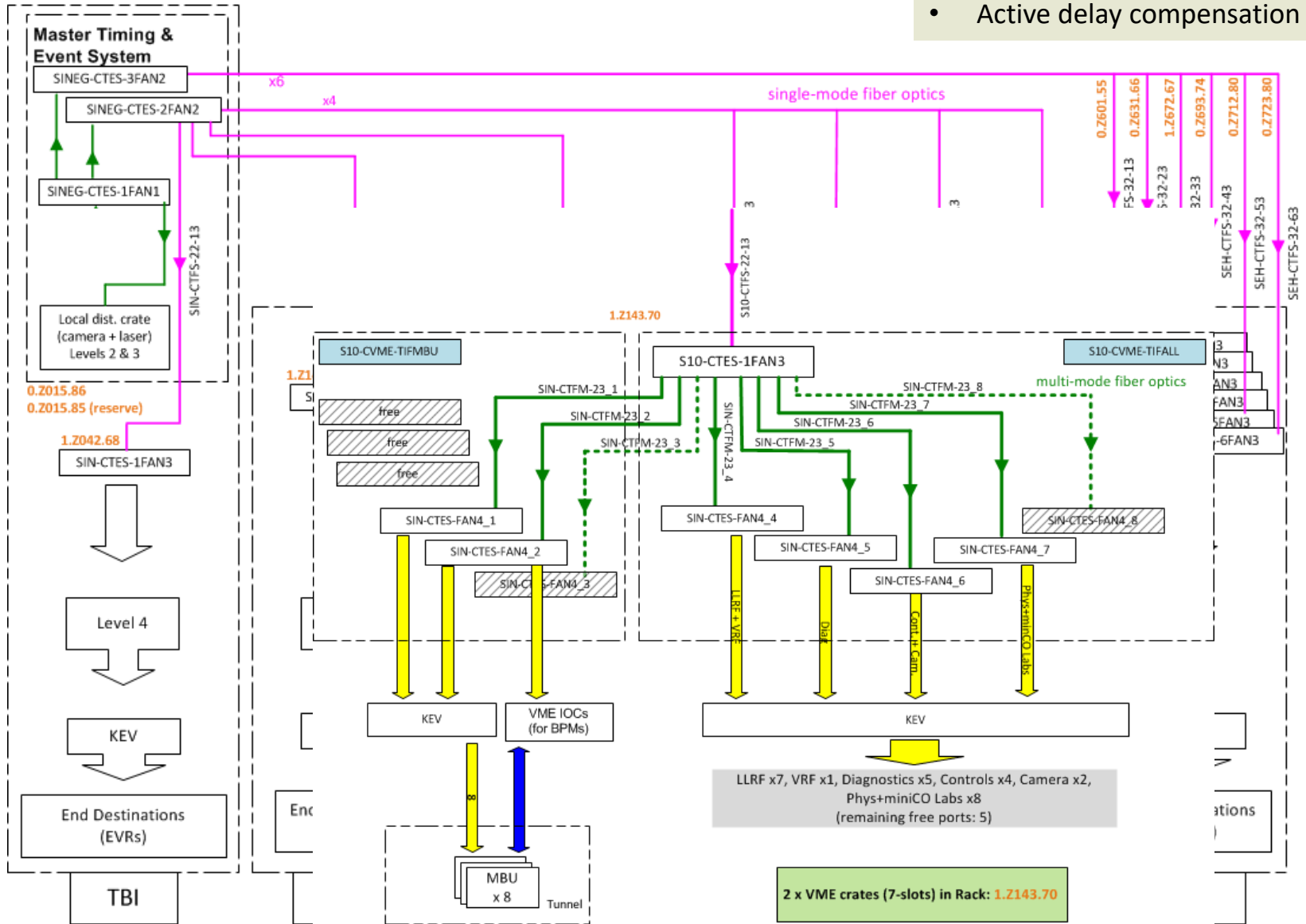
Timing System Overview

- Rep rate **100 Hz**
- Reference clock **142.8 MHz**
- Active delay compensation



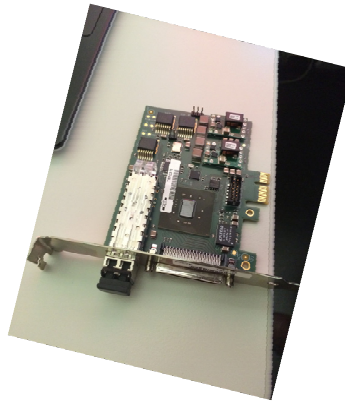
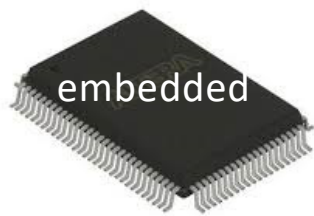
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Dealing with different form-factors

- VME, PCIe, embedded (FPGA)
- Provide same interface (software configuration, UI)
- Embedded EVR's increasing -> **non-standard interface must be managed!**



Timing device	VME-EVM	VME-EVR	PCIe-EVR	Embedded EVR
In operation 1 year ago	15	8	0	6
In operation today	67	142	45	152



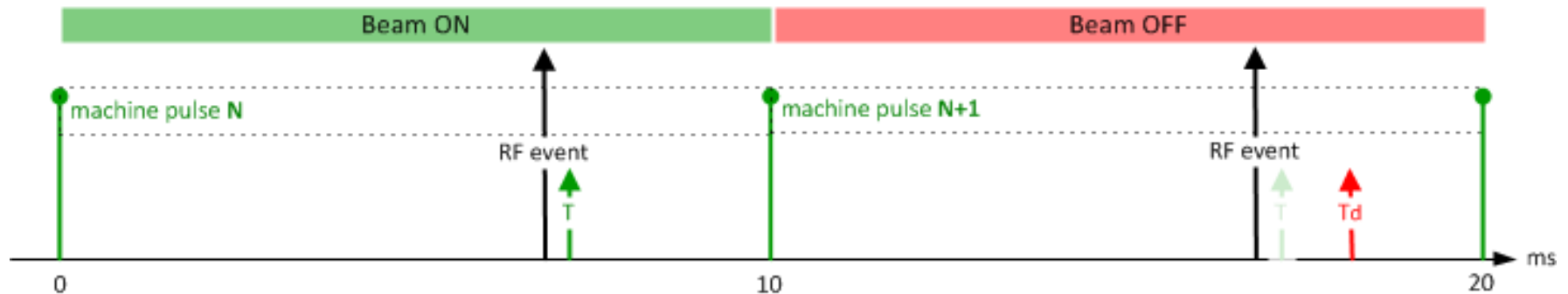
Beam Rate Control

- Event rep rate handling is a challenge -> flexible + independent + synchronous

Beam Rate Control

- **Green** is RF with normal trigger -> Acceleration -> Beam **ON**
- **Red** is RF trigger with delayed trigger -> No acceleration -> Beam **OFF**

➤ Continues triggering maintains stable subsystem operation (Laser, RF, etc.)

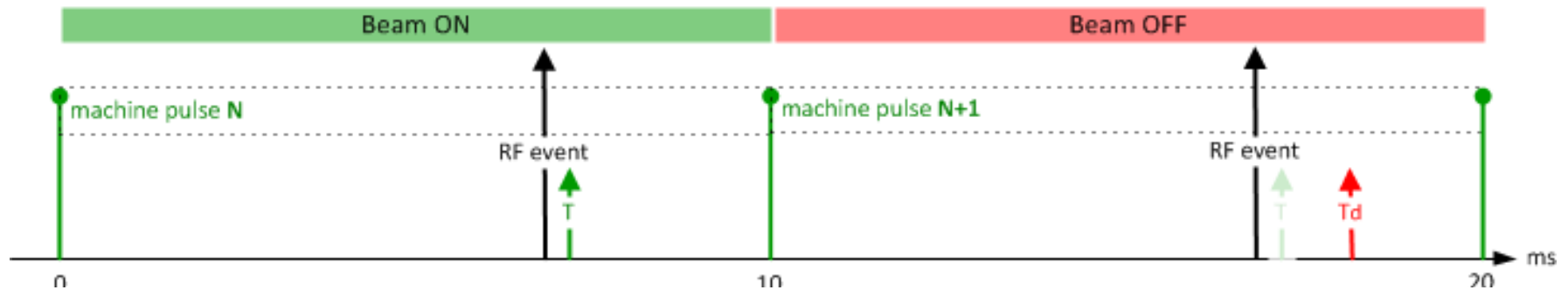


- Software controlled: operator's beam rate setting
- Hardware controlled: assist machine protection (beam stopper)

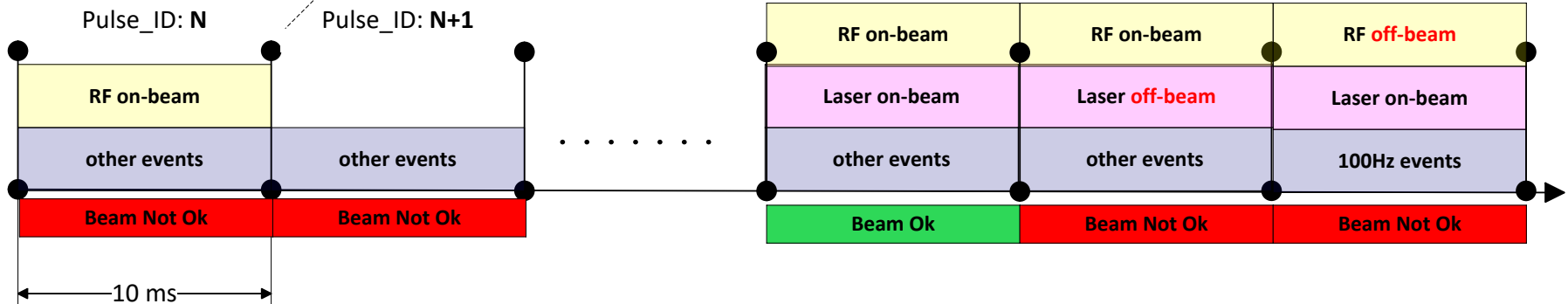
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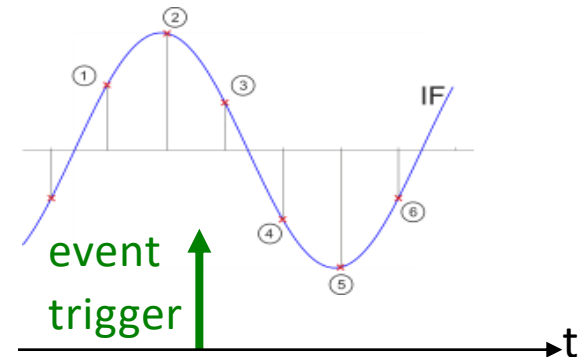
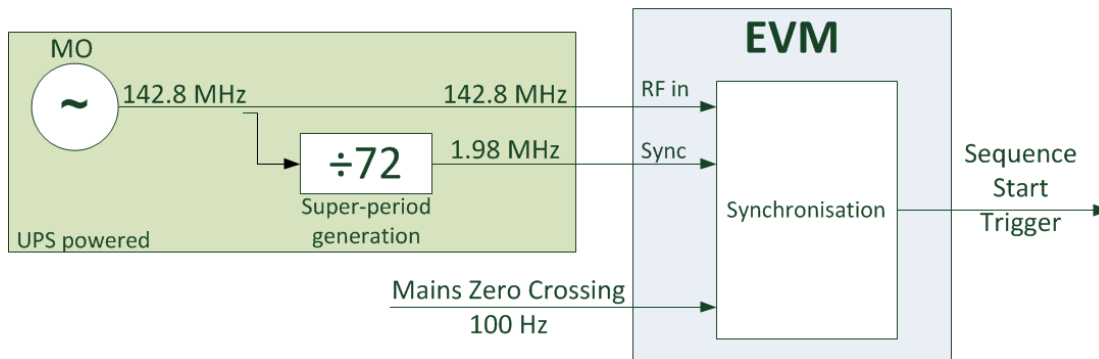
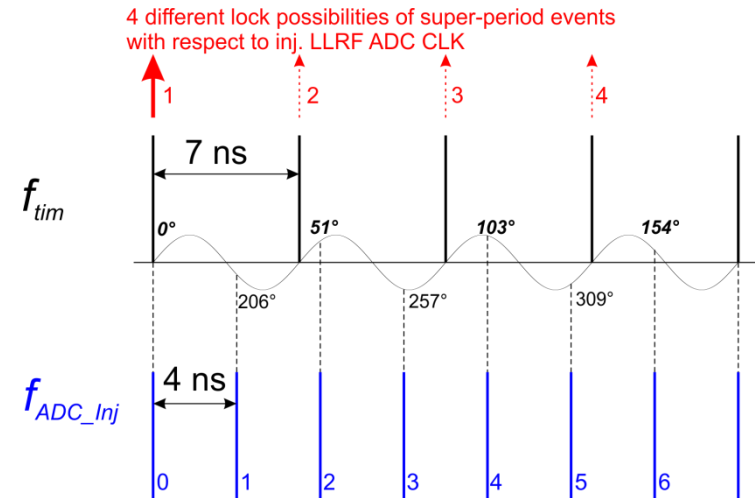
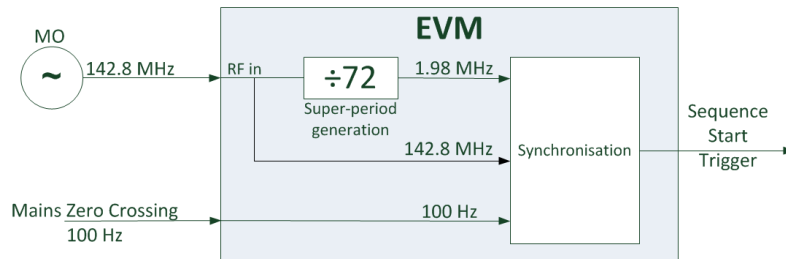


Master trigger (100Hz)



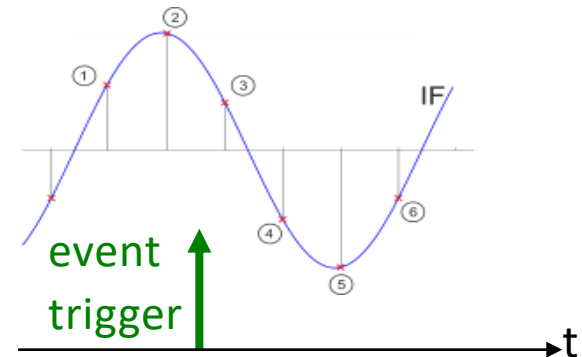
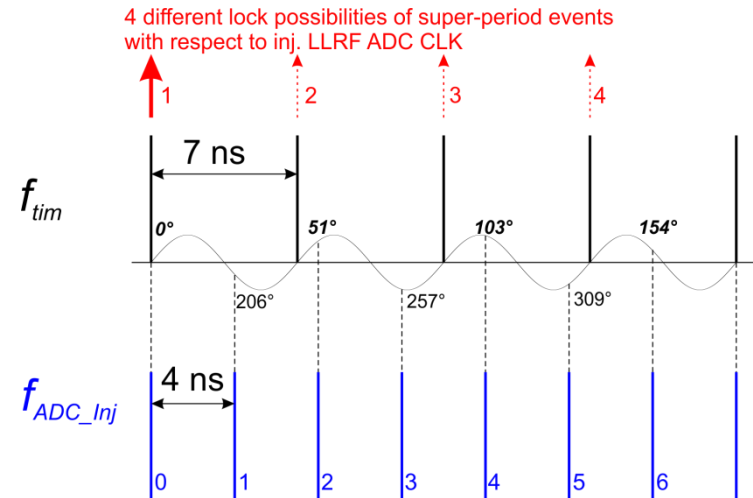
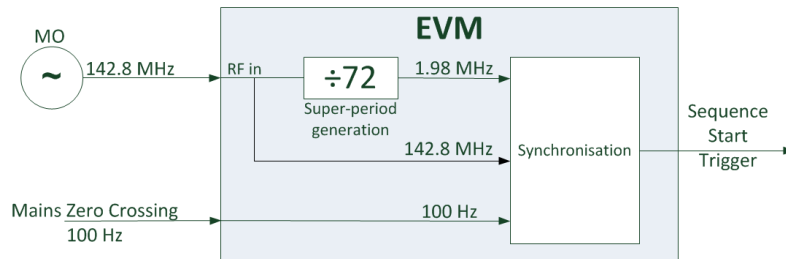
Master restart / power up

- Events are synced with internal super-period
- Relative phase of unrelated clocks across subsystems



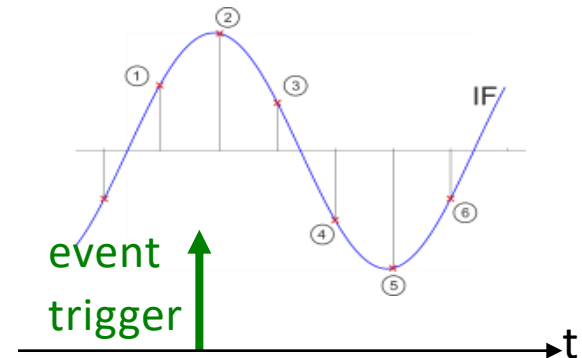
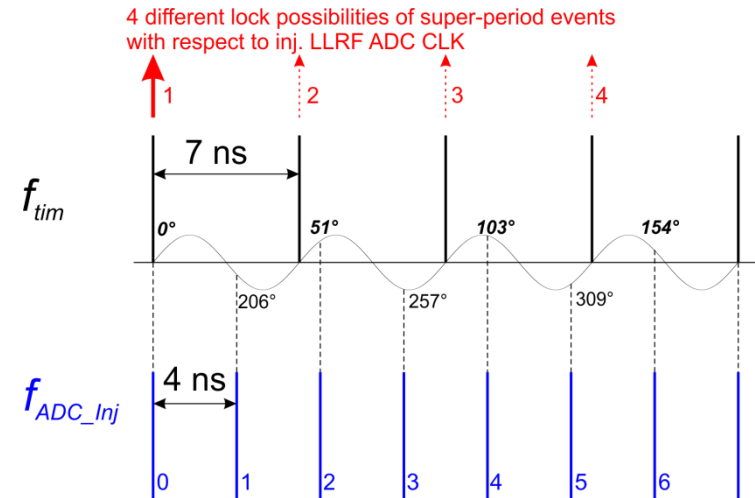
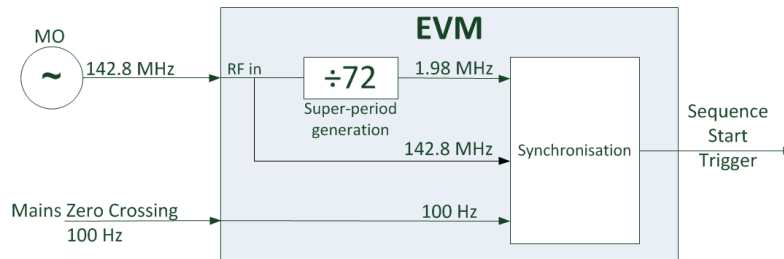
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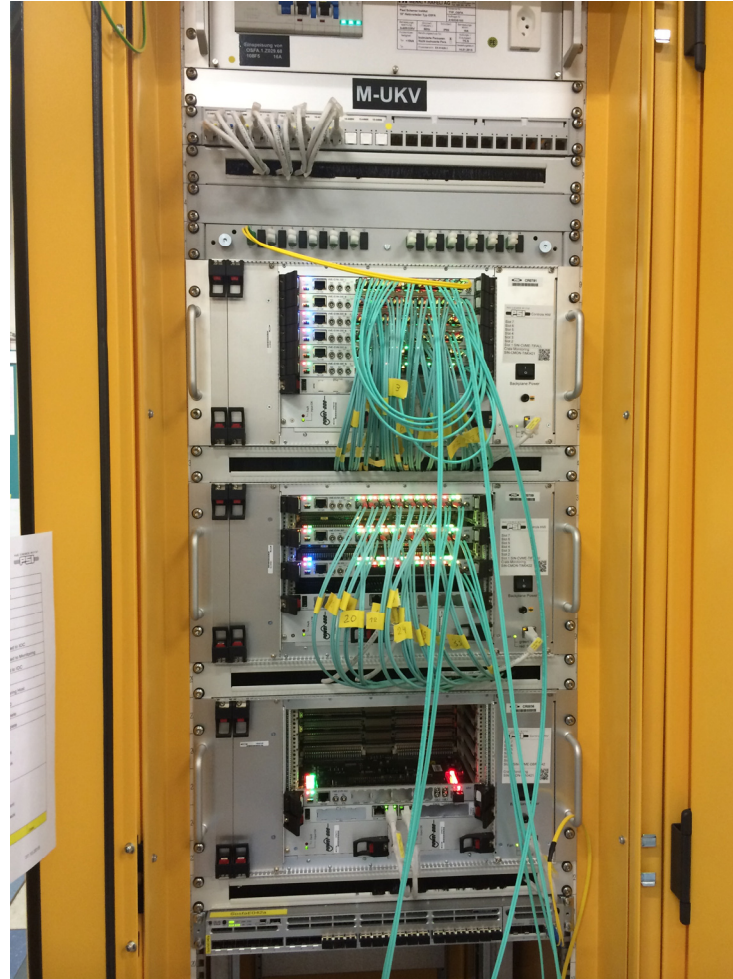
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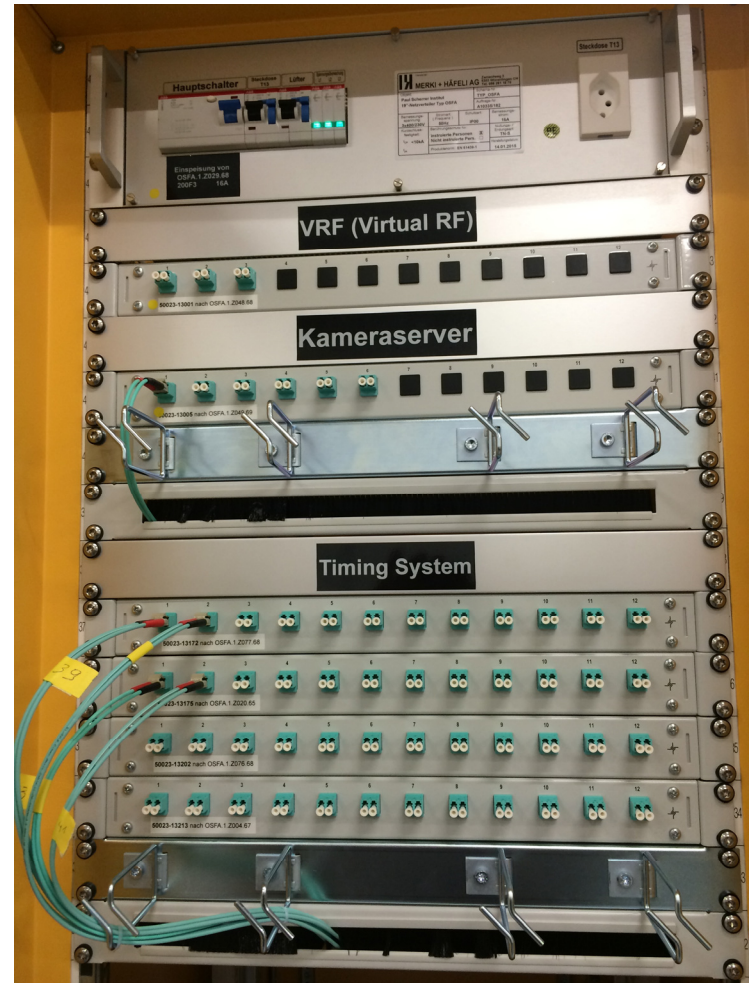
Timing Network Diagnostics

- Art of “spaghetti”



Timing Network Diagnostics

- Make it cleaner!
- will nice cabling and labeling help?



Timing Network Diagnostics

- Screw it up!
- only swap a patch and forget!



Dynamic Topology Survey

- Each node gets its topology id from its parent
- Each parent sends its own id plus ports number to the connected child
- Topology id is updated dynamically

G_EVG_main.ui (on sf-cons-02)

SIN-CVME-TIFGUN-EVG1

Enabled

Firmware version 0x22010204

Driver version 2.7.13

Timestamp

DBus status 0x0

Event clock 142.800 MHz

Delay compensation

Enable ☐ Disabled ☒ Enabled ☐

Beacon ☐ Disabled ☒ Enabled ☐

Soft / manual event

Set Event ☒ RB ☐

0 0

DBus Input Output Triggers MXC AC Event clock Soft Sequences FCT

Data compensation delay

Upstream 382.544 ns Receive FIFO 45.015 ns FCT internal datapath 89.177 ns

Port	Loop delay	Link status	Link violation
Port 1	791.971 ns		
Port 2	783.963 ns		
Port 3	499.311 ns		
Port 4	496.430 ns		
Port 5	497.404 ns		
Port 6	486.647 ns		
Port 7	497.912 ns		
Port 8	500.065 ns		

SFP	Temperature	TX Power	RX Power
SFP 0	39.0 C	368.7 uW	367.5 uW
SFP 1	36.2 C	277.8 uW	364.2 uW
SFP 2	36.9 C	435.0 uW	328.5 uW
SFP 3	36.7 C	372.3 uW	0.0 uW
SFP 4	37.1 C	400.6 uW	0.0 uW
SFP 5	38.9 C	435.6 uW	0.0 uW
SFP 6	40.8 C	418.8 uW	0.0 uW
SFP 7	40.0 C	325.3 uW	0.0 uW
SFP 8	39.6 C	324.8 uW	0.0 uW

SwissFEL event timing overview (on sf-lc6a-64-03)

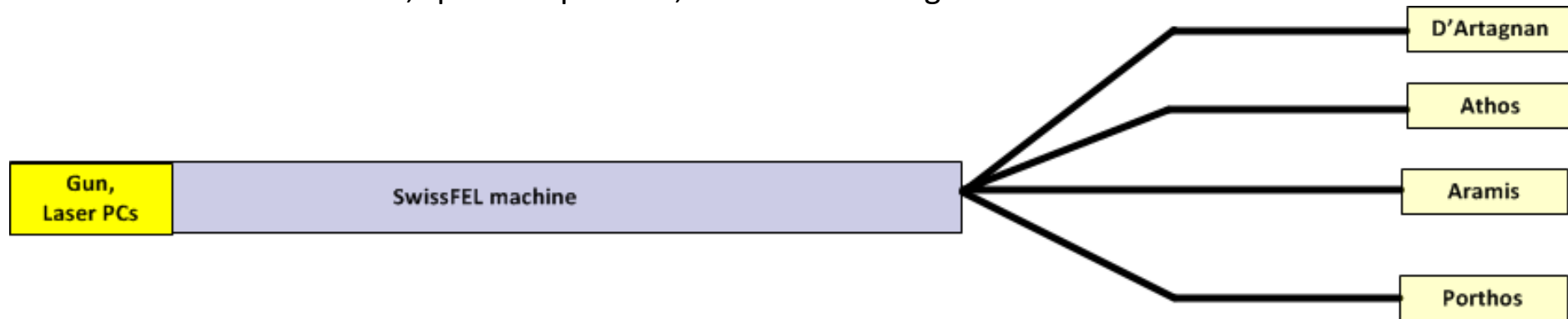
File View

Filter:

Name	Status	TopoID[stored/actual]	Link Violation
SIN-TIMAST-EVG0:	OK	None/0	4 5 6 7 8
SIN-TIMAST-EVG2:	OK	1/1	4 5 6 7 8
SIN-TIMAST-EVG1:	OK	2/2	8
SIN-CVME-TIFALL-EVG0:	OK	21/21	
S10-CVME-TIFALL-EVG0:	OK	22/22	7 8
S20-CVME-TIFALL-EVG0:	OK	23/23	6 7 8
S20-CVME-TIFALL-EVG1:	OK	231/231	3 4 5 6 7
S20CB01-EVR0:	OK	2311/2311	
S20CB02-EVR0:	OK	2312/2312	
S20CB03-EVR0:	Link error	2313/None	
S20CB04-EVR0:	Disconnected	2314/None	
S20-CVME-TIFALL-EVG2:	OK	232/232	1 2 3 7
S20-CVME-TIFALL-EVG3:	OK	233/233	2 3 4 5 6 7 8
S20-CVME-TIFMBU-EVG0:	OK	234/234	
S20-CVME-TIFMBU-EVG1:	OK	235/235	1 2 3 4 5 6 7 8
S30-CVME-TIFALL1-EVG0:	OK	24/24	8
S30-CVME-TIFALL2-EVG0:	OK	25/25	7 8
S30-CVME-TIFALL2-EVG1:	OK	251/251	2 3 4 5 6 8
S30-CVME-TIFALL2-EVG2:	OK	252/252	1 2 3 4 6
S30CB13-EVR0:	OK	2525/2525	
S30CB10-DBLM381-EVR0:	OK	2527/2527	
S30CB14-DBLM417-EVR0:	OK	2528/2528	
S30-CVME-TIFALL2-EVG3:	OK	253/253	4 5 6 7 8
S30-CVME-TIFMBU2-EVG0:	OK	254/254	5 6
S30-CVME-TIFMBU2-EVG1:	OK	255/255	1 2 3 6
S30-CVME-TIFMBU2-EVG2:	OK	256/256	1 2 3 4 5 6 7 8
SARUN-CVME-TIFALL1-EVG0:	OK	26/26	6 7 8
SARUN-CVME-TIFALL2-EVG0:	OK	27/27	5 6 7 8
SIN-CVME-TIFGUN-EVG0:	OK	3/3	3 4 5 6 7
UNSORTED	OK		

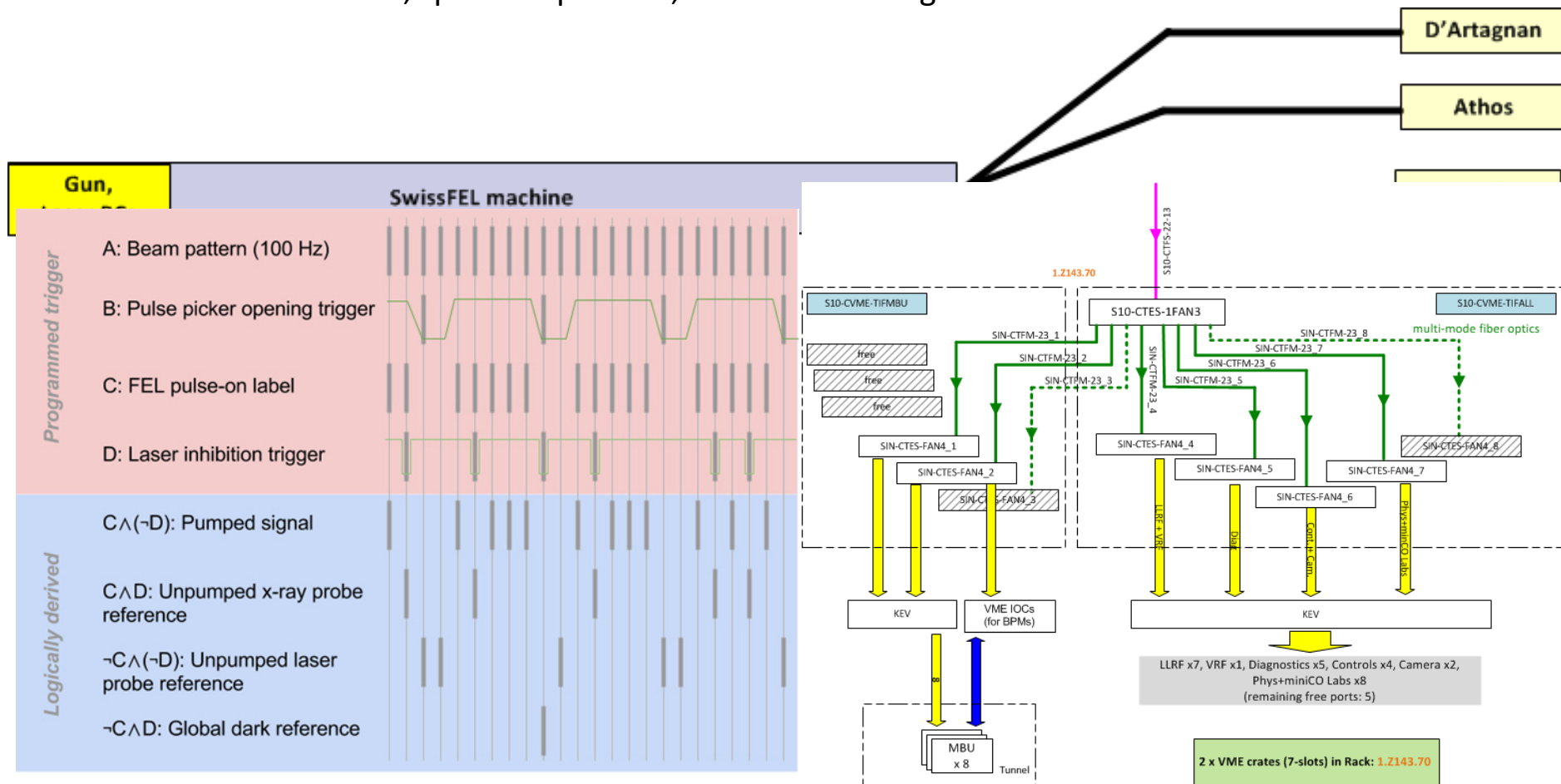
Complex Triggering Application (CTA)

- Generate flexible trigger-and-acquisition patterns (e.g. pump-probe)
- Independent CTA for each end-station -> CTA runs locally + forwards global events
- Upload desired trigger pattern; start pattern playing upon:
 - user's demand, specified pulse ID, occurrence of a global event



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My thanks go to

- GFA Controls
- Expert groups: LLRF, DI, Laser, ...
- MRF
- Cosylab

