PAUL SCHERRER INSTITUT

PSI

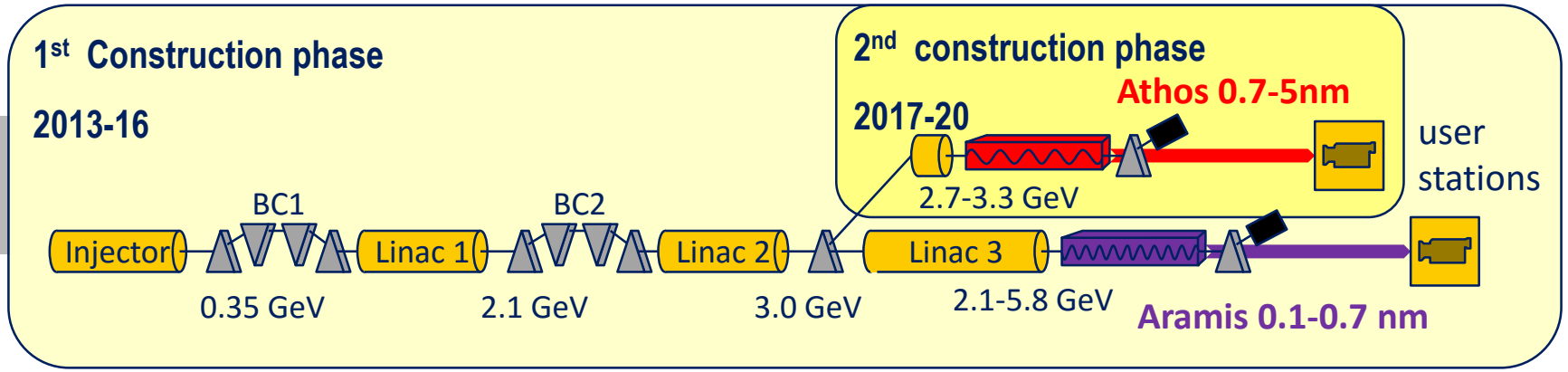
SwissFEL

Hans-H. Braun :: Paul Scherrer Institut

Facility update, SwissFEL

8th Hard X-ray FEL Collaboration meeting
PAL Pohang, 24-26 October 2016

SwissFEL in a nutshell



Aramis

Hard X-ray FEL, λ=0.1-0.7 nm

Linear polarization, variable gap, in-vacuum Undulators

First users 2017

Athos

Soft X-ray FEL, λ=0.65-5.0 nm

Variable polarization, Apple undulators

First users 2020

Main parameters

Wavelength from	1 Å - 70 Å
Photon energy	0.2-12 keV
Pulse duration	1 fs - 20 fs
e^- Energy	5.8 GeV
e^- Bunch charge	10-200 pC
Repetition rate	100 Hz

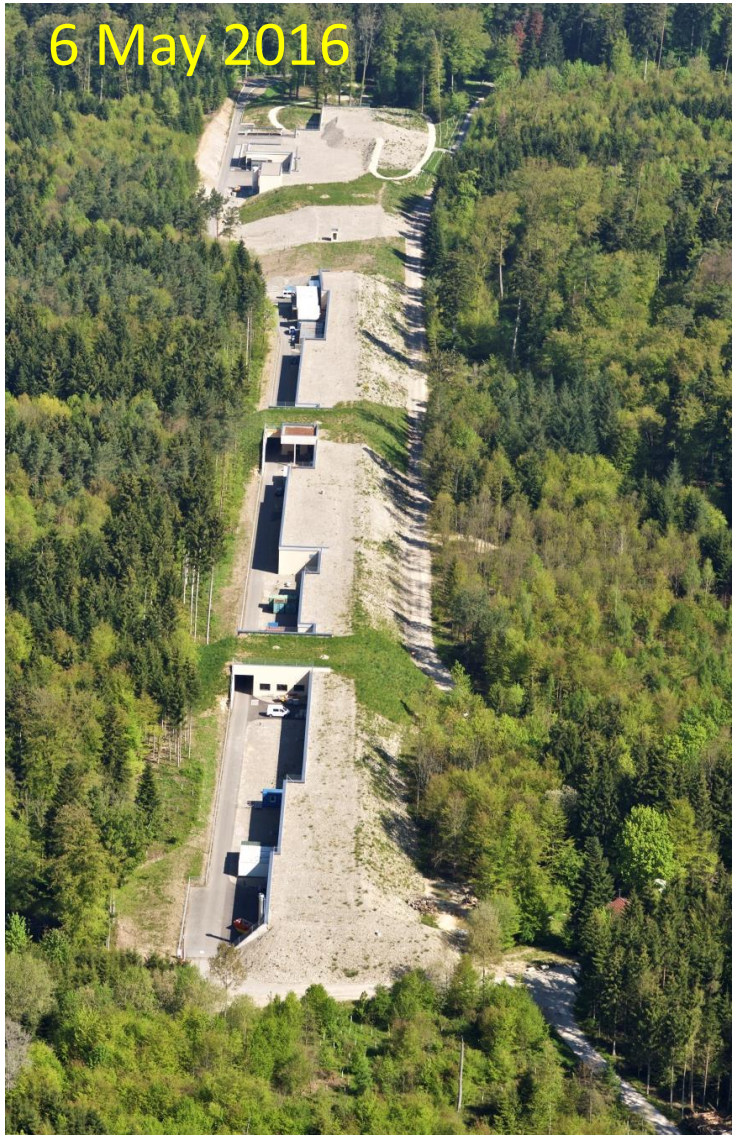
Building

The SwissFEL Building Site

Situation of SwissFEL next to PSI campus

PSI campus
Swiss Light Source 1
Central Control Room 2

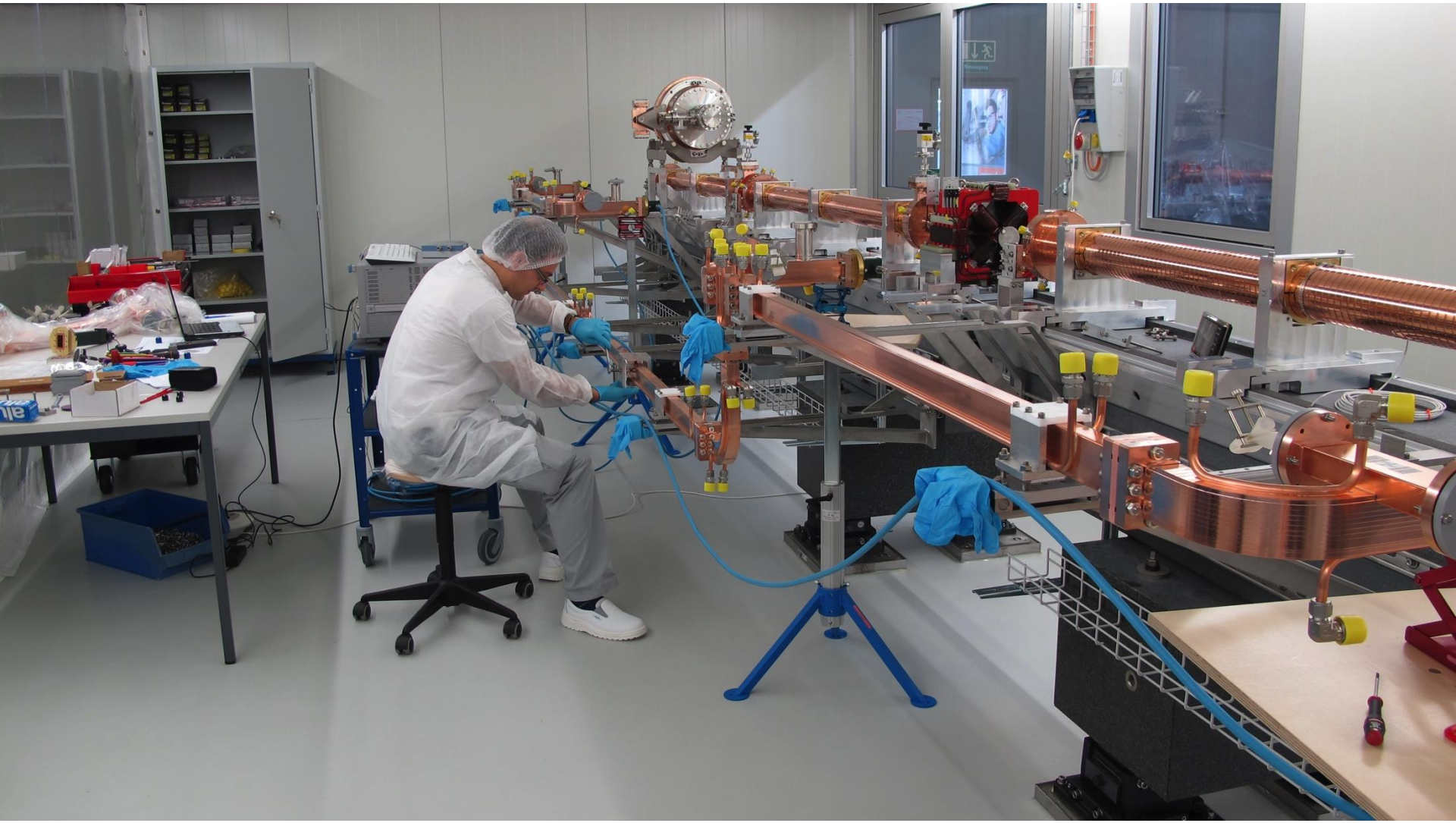
SwissFEL building evolution



Jan'16 first users of wild game crossing observed

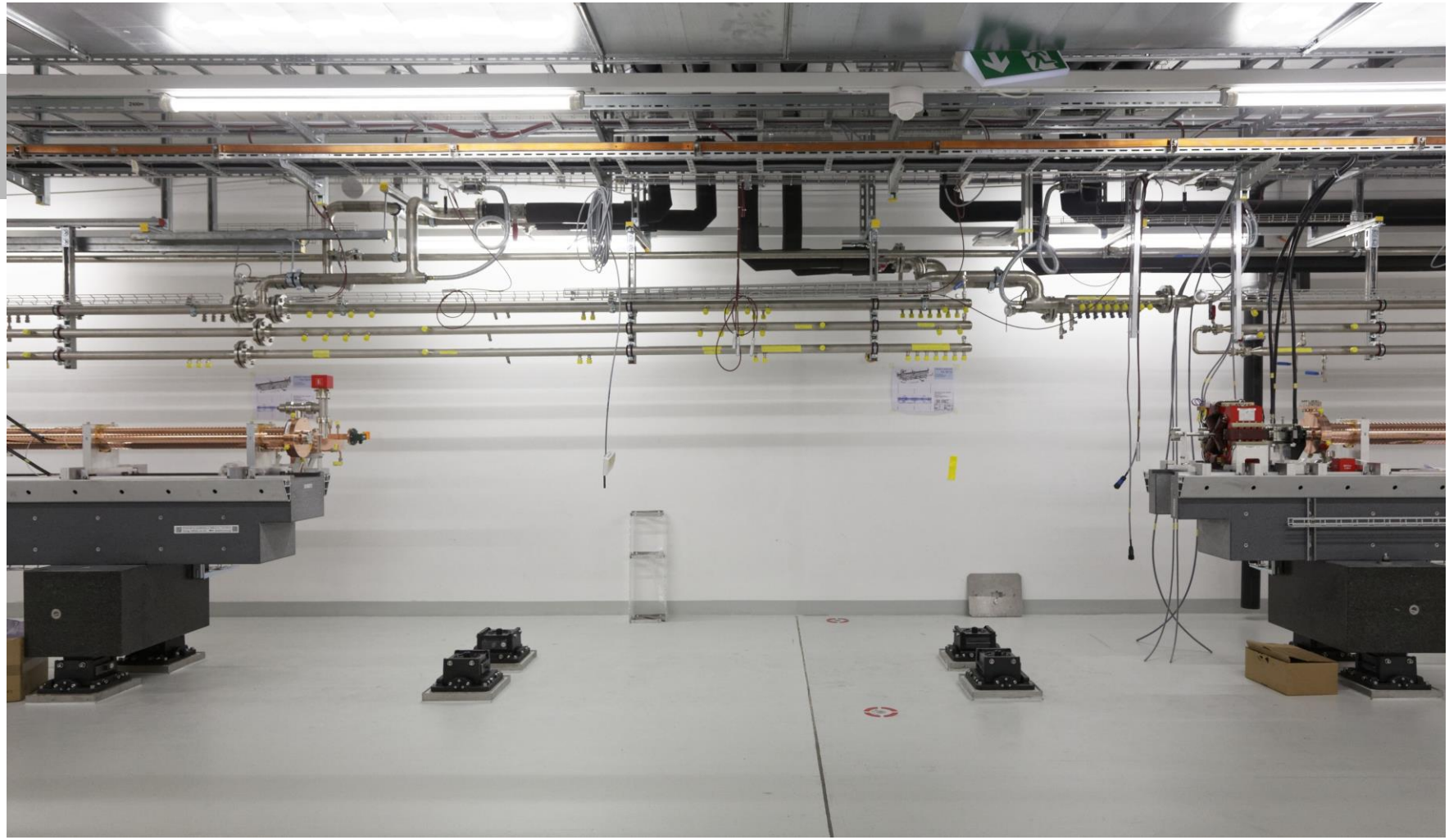
SwissFEL installation progress

C-band module assembly, now already history



Installation and tuning of waveguides (waveguides delivered from MHI-MS)

Installation of last Linac girder: Sept. 13, 2016



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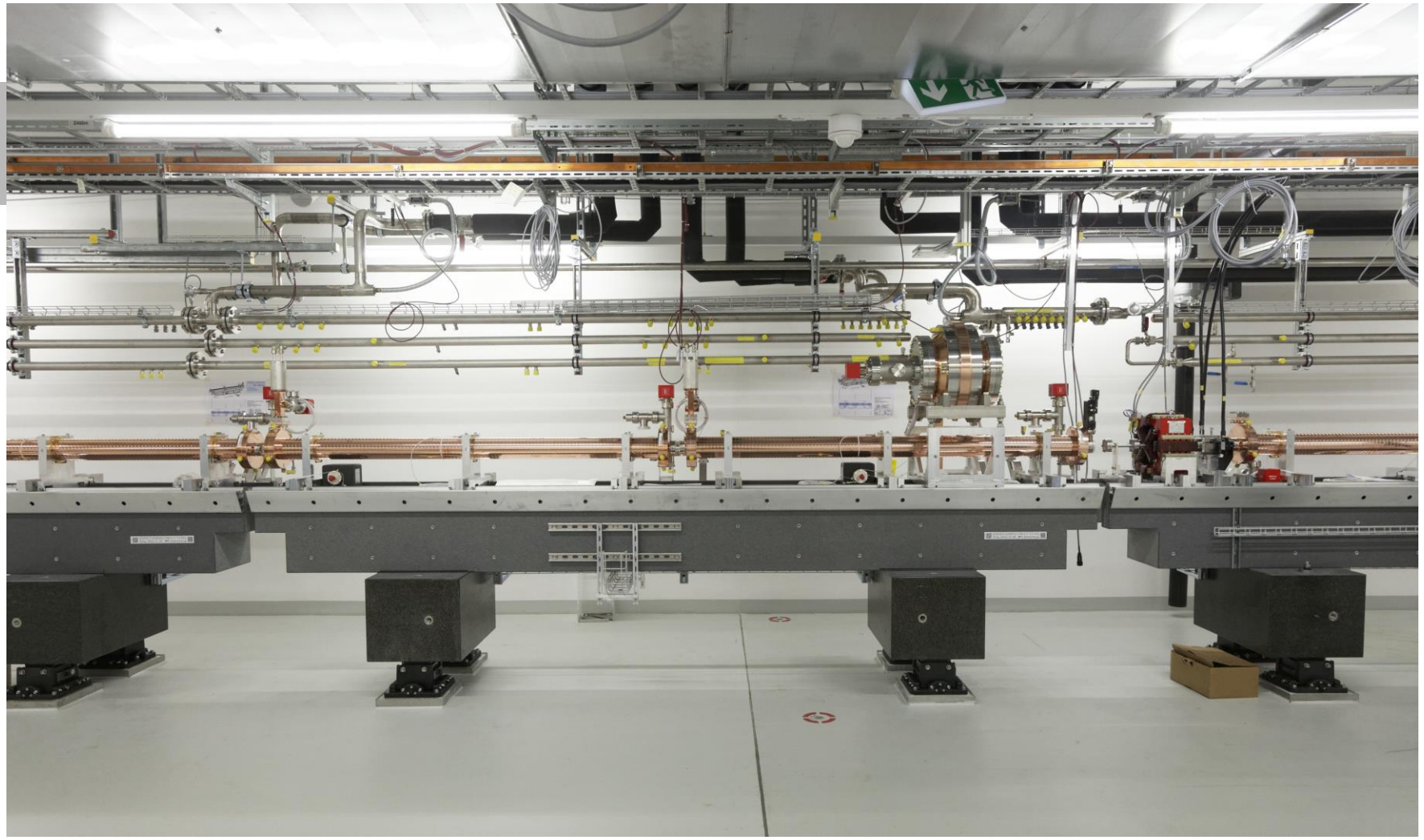
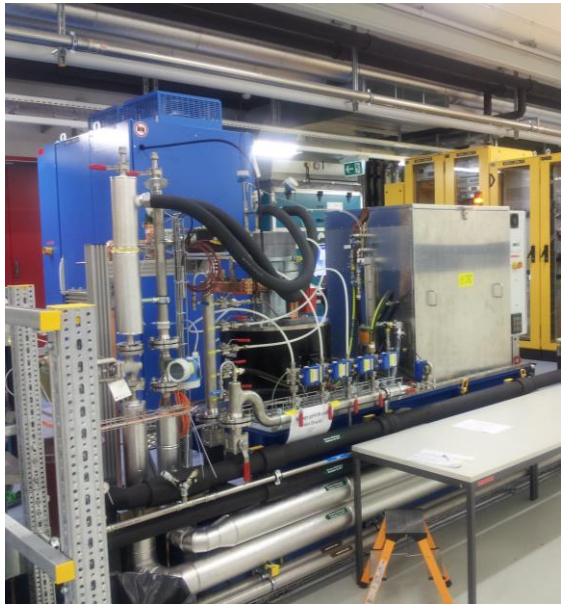


Solid-state modulators for C-band linac

Two prototypes were tested at PSI for evaluation of the series.

50 MW / 3µs RF, 370kV / 344A / <20 ppm voltage stability pulse to pulse @ 100 Hz

AMPEGON

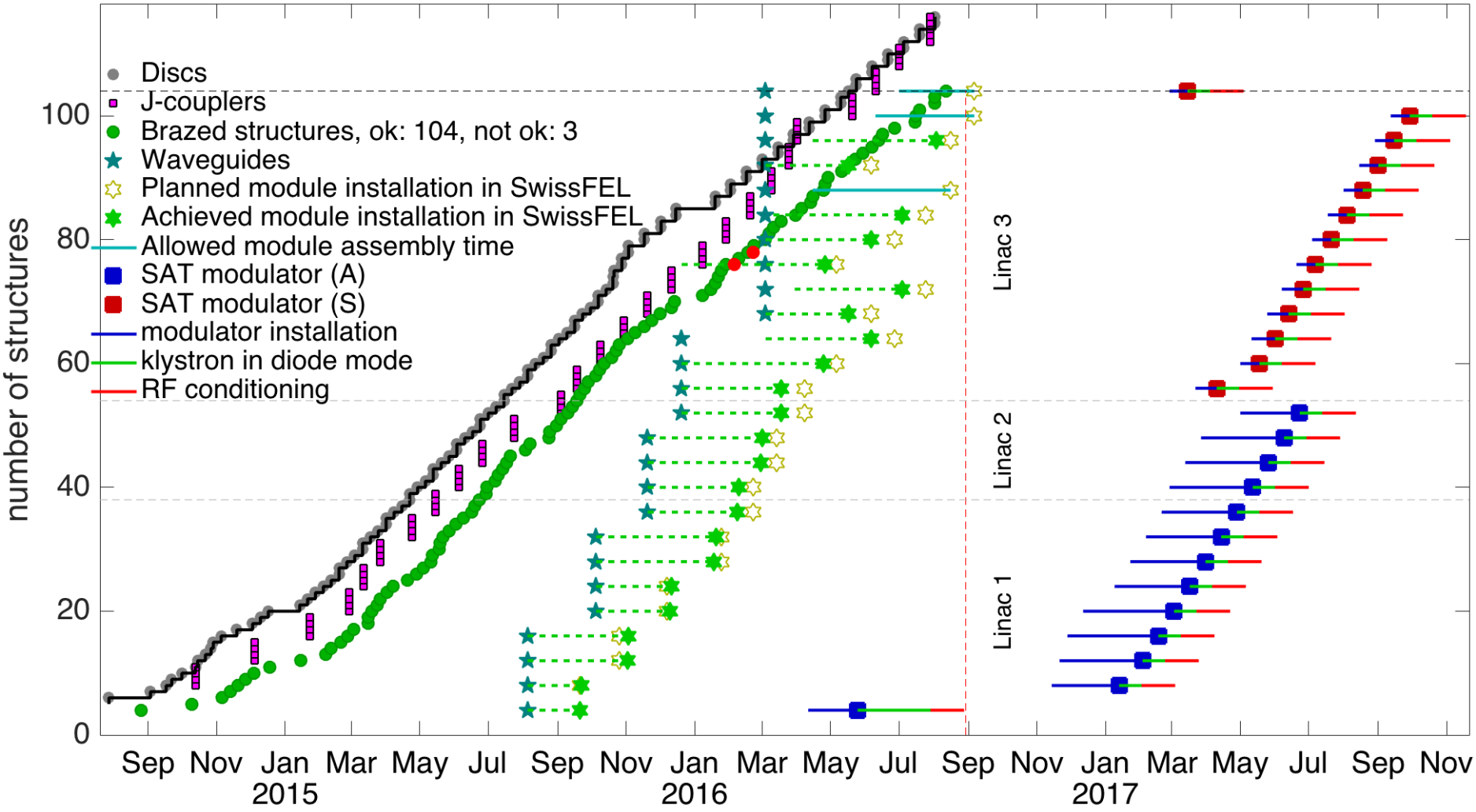


- 13 modulators (Linac 1, Linac 2)
- 1 installed
- others from Nov. 2016 – June 2017

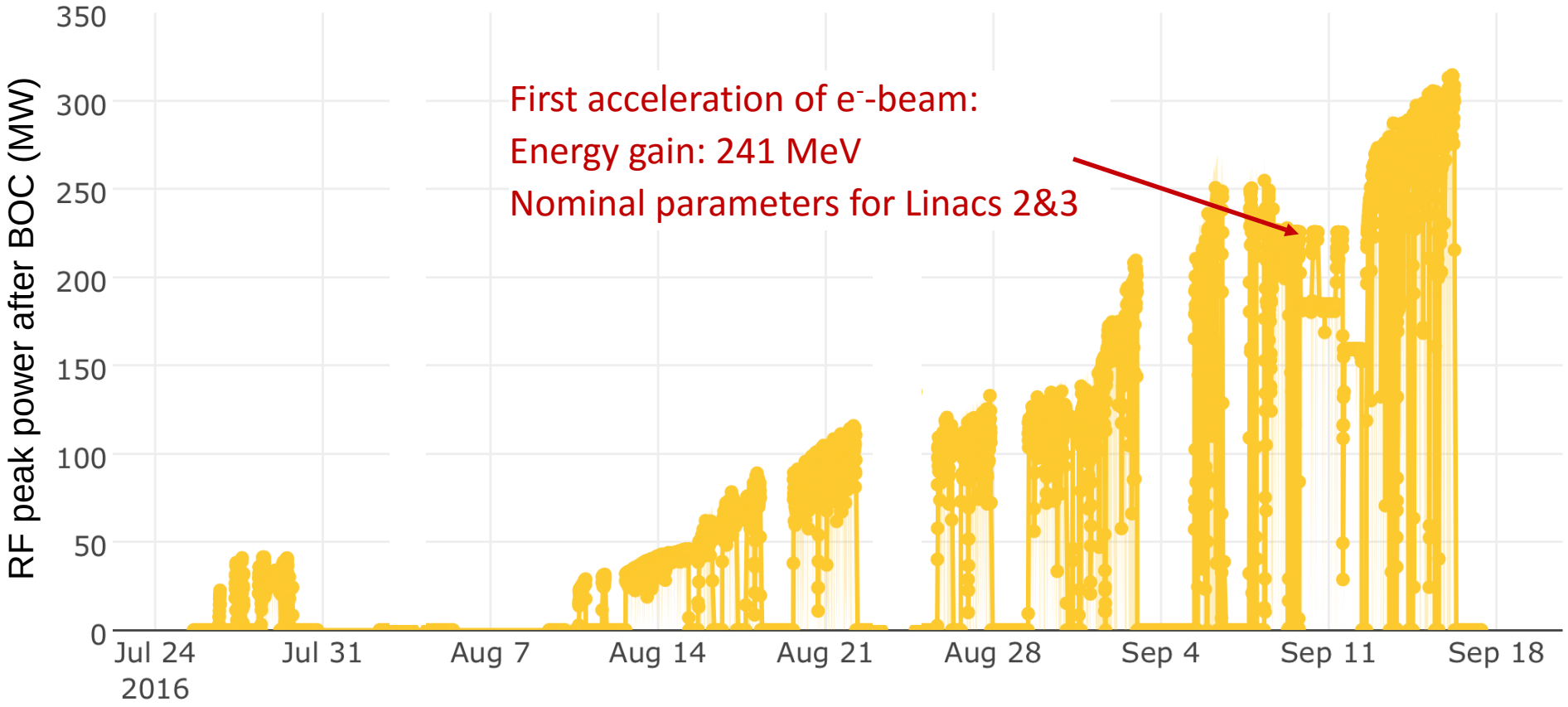
ScandiNova

- 13 modulators (Linac 3)
- Installation planned from March 2016 – Sep. 2017

Linac schedule 2016 & 2017



Conditioning of first C-band module



Module conditioning: Reached almost maximum available RF power (50 MW, 3 µs, full compression)

Session Accelerator C

Florian Loehl, "Experience with high power RF sources and RF conditioning"

October 6th, 12th Undulator installed

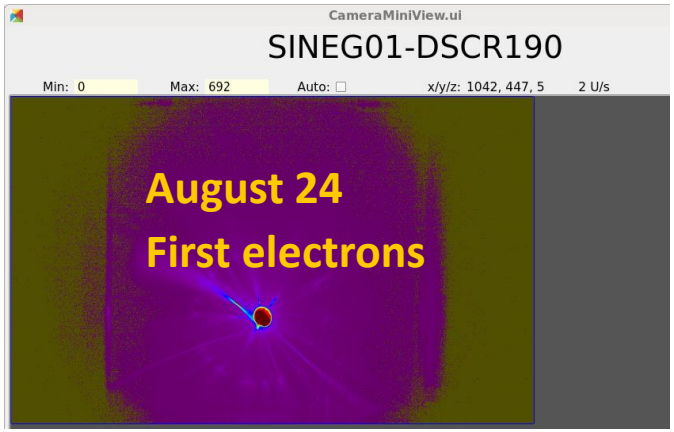
12 Undulator in Tunnel and under vacuum !

Gap control already under EPICS.

Mover control going on … .

Heilige List Name	Magnet Arrays Delivery (RI)	Undulator Frame at PSI	Inner I beam assembled	Optimization without Vacuum chamber	Vacuum Chamber Installed	Optimization with Vacuum chamber	Under vacuum	In Tunnel
SARUN15	May 2015	U15_41802						25.01.2016
SARUN14	July 2015	U15_41694		Phase = 6 deg at K=1.2		10.02.2016		26.02.2016
SARUN13	July 2015	U15_40679				02.03.2016		21.03.2016
SARUN12	October 2015	U15_41020		Phase = 1.8 deg at K=1.2		09.03.2016		11.04.2016
SARUN11	October 2015	U15_42287						02.05.2016
SARUN10	December 2015	U15_40971						20.05.2016
SARUN09	December 2015	U15_40101						13.06.2016
SARUN08	24.03.2016	U15_40046						27.07.2016
SARUN07	01.06.2016	U15_42292						22.08.2016
SARUN06	Mrz 16	U15_42718				start 11.08.2016		12.09.2016
SARUN05	Jun 16	U15_40730						03.10.2016
SARUN04	May2016	U15_38764						06.10.2016
SARUN03		U15_35159						01.01.2017

Recent Progress

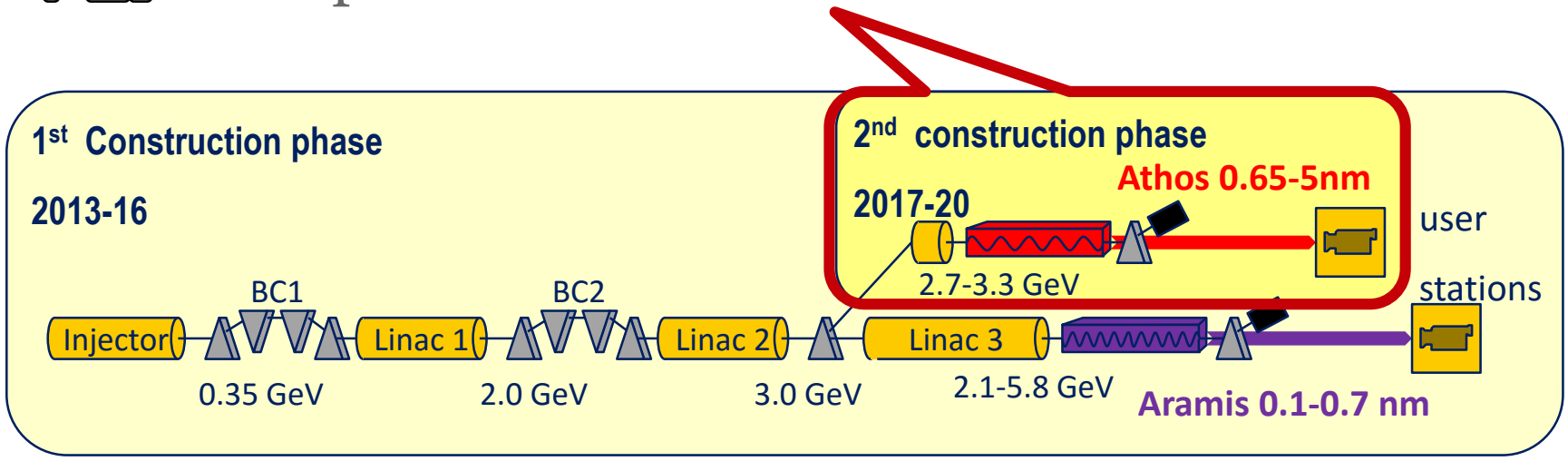


Date	achievement	active RF stations	$E_{electron}$	$Z_{Beam\ dump}$
August 24	First electrons from gun with 7.9MeV	1S	7.9 MeV	4 m
September 7	First electron to injector beam dump	3S	145 MeV	119 m
September 8	First acceleration with one C-band module	3S 1C	390 MeV	119 m
October 7	Beam line injector to main dump completed and under vacuum			
next goal	Beam transport through undulators to main dump	5S 1C	560 MeV	619 m

Challenges ahead

- Permits of radiation safety authorities for next phases
- 25 out of 33 RF modulators still to be delivered, installed and commissioned
- Radiation dose limiting system still to be delivered, installed and commissioned
- RF Conditioning of 25 C-band modules
- Setting up the electron beam for lasing

Preparation for ATHOS



ATHOS

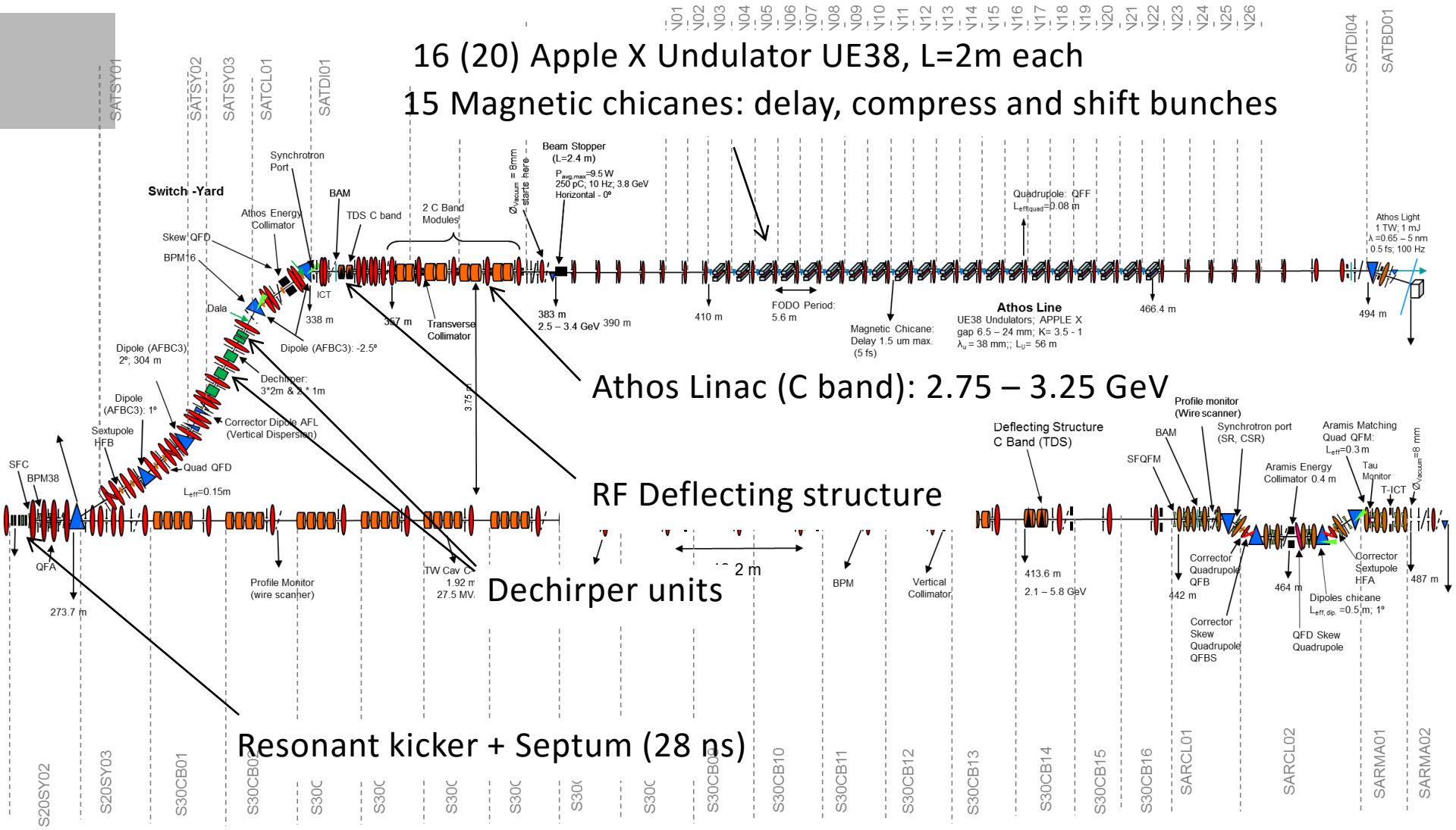
Soft X-ray FEL, λ=0.65-5.0 nm

full polarization control withU38 Apple-X Undulators

Switch Yard: already installed in phase 1

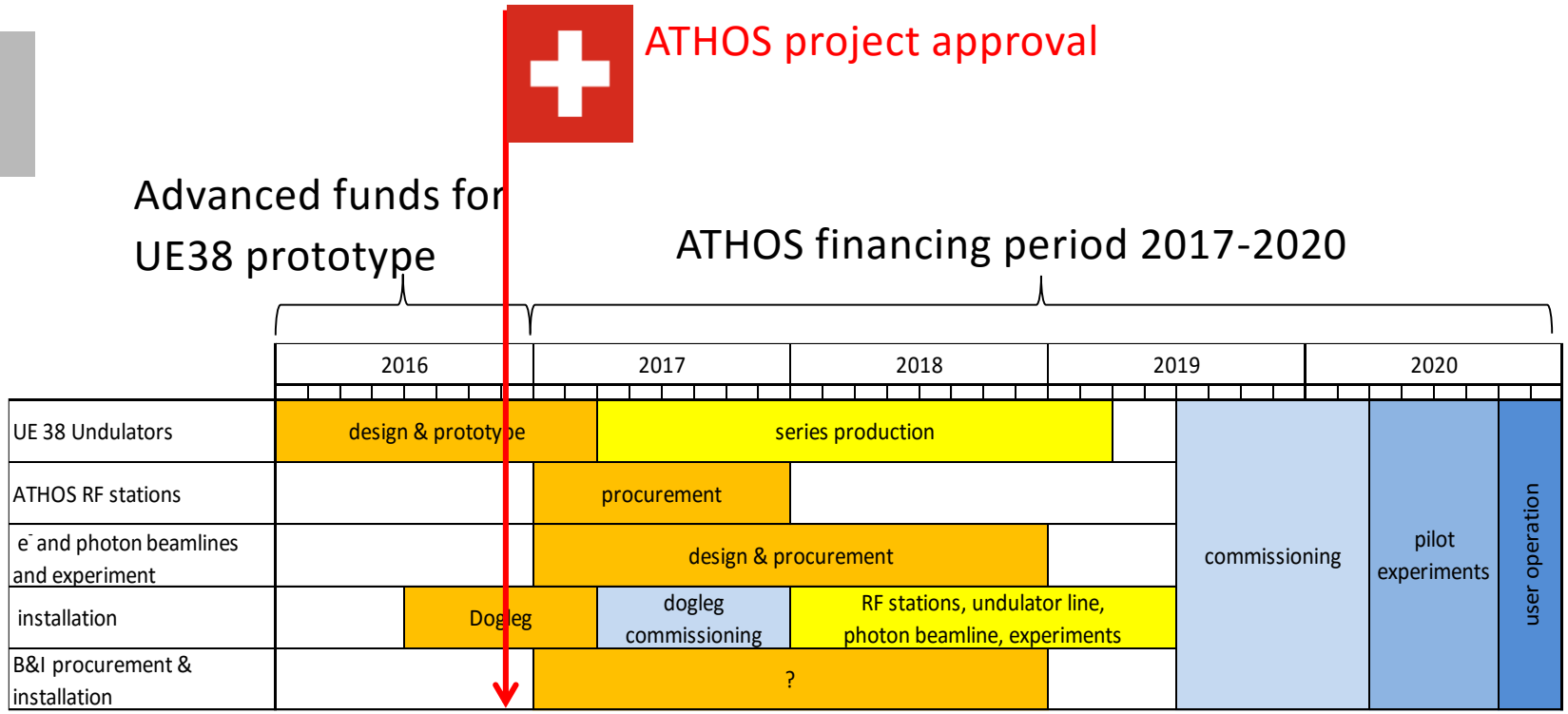
Extraction done at constant energy of 3 GeV

ATHOS, second SwissFEL Undulator Line L≈220m



Courtesy Romain Ganter

ATHOS overall time plan

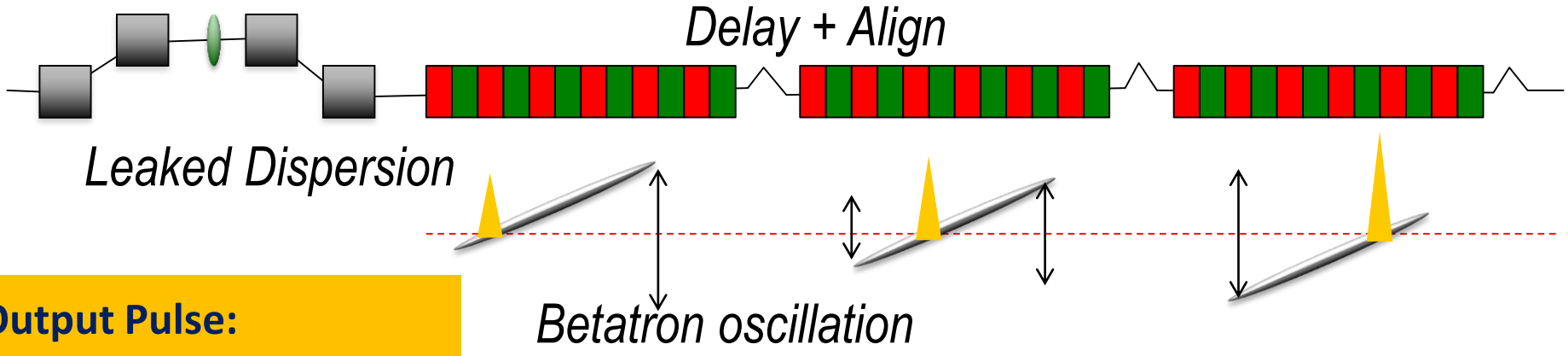


New configuration for ATHOS

[Eduard Prat and Sven Reiche PRL 114, 2448 (2015)]
[Eduard Prat, F. Löhl, S. Reiche, PRSTAB 18, 100701 (2015)]

Chic=**C***hicanes for* ***H****igh power and* ***I****mproved* ***C****oherence*

- Inject tilted beam to only drive FEL amplification in one slice.
- Delay bunch and align bunch slice, where radiation pulse overlaps with beam.
  - Superradiant amplification by fresh bunch slice
- Delay and align multiple times to supply continuously fresh bunch parameters



Output Pulse:

- **1.5 TW Peak Power**
- **4 fs Full Length**
- **1% FWHM Bandwidth**

Session Accelerator B

Sven Reiche, "Design strategies for Athos"

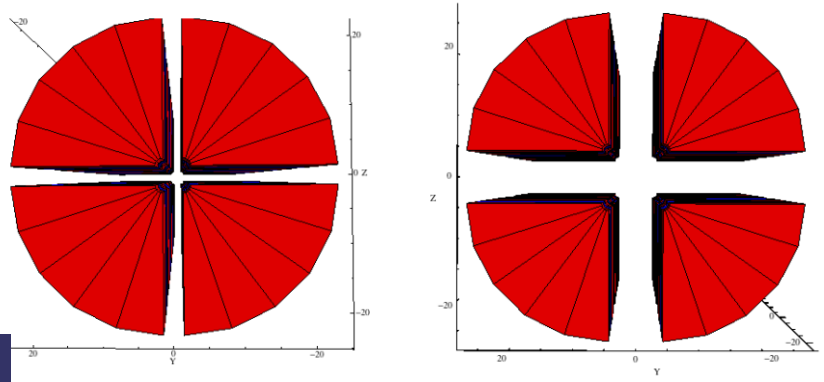
UE38 Magnet Design

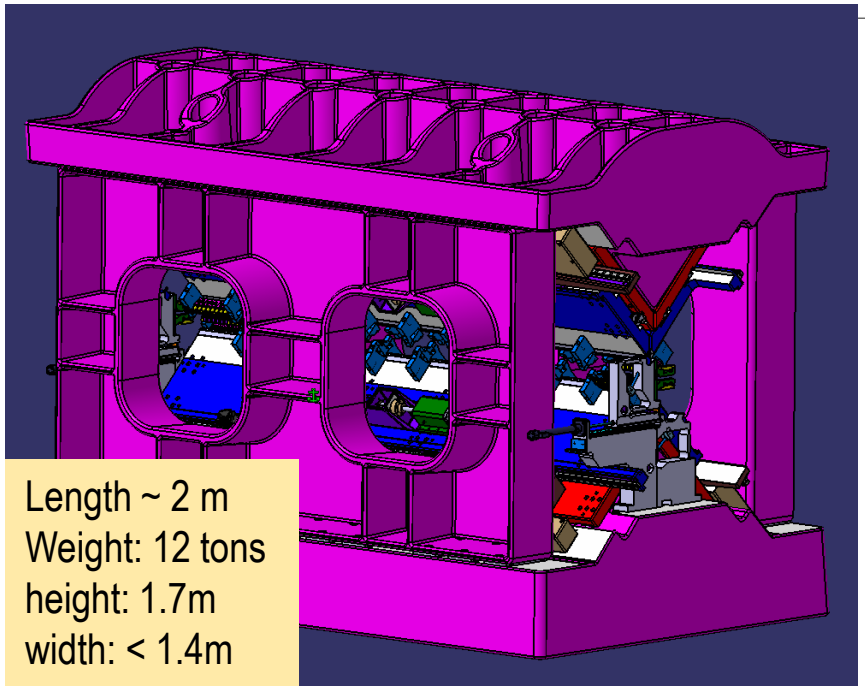
APPLE – X configuration

highest flexibility

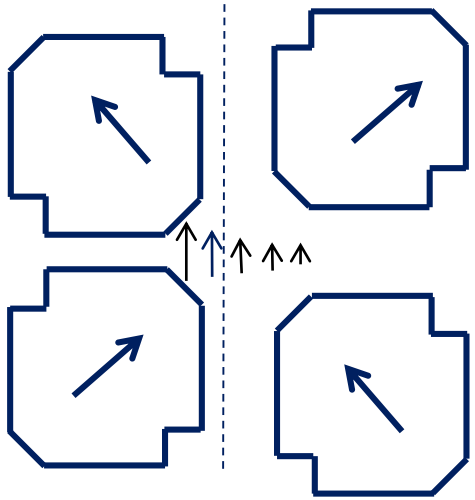
⇒ adjustable gradient

(i.e. for ultra high bandwidth mode)





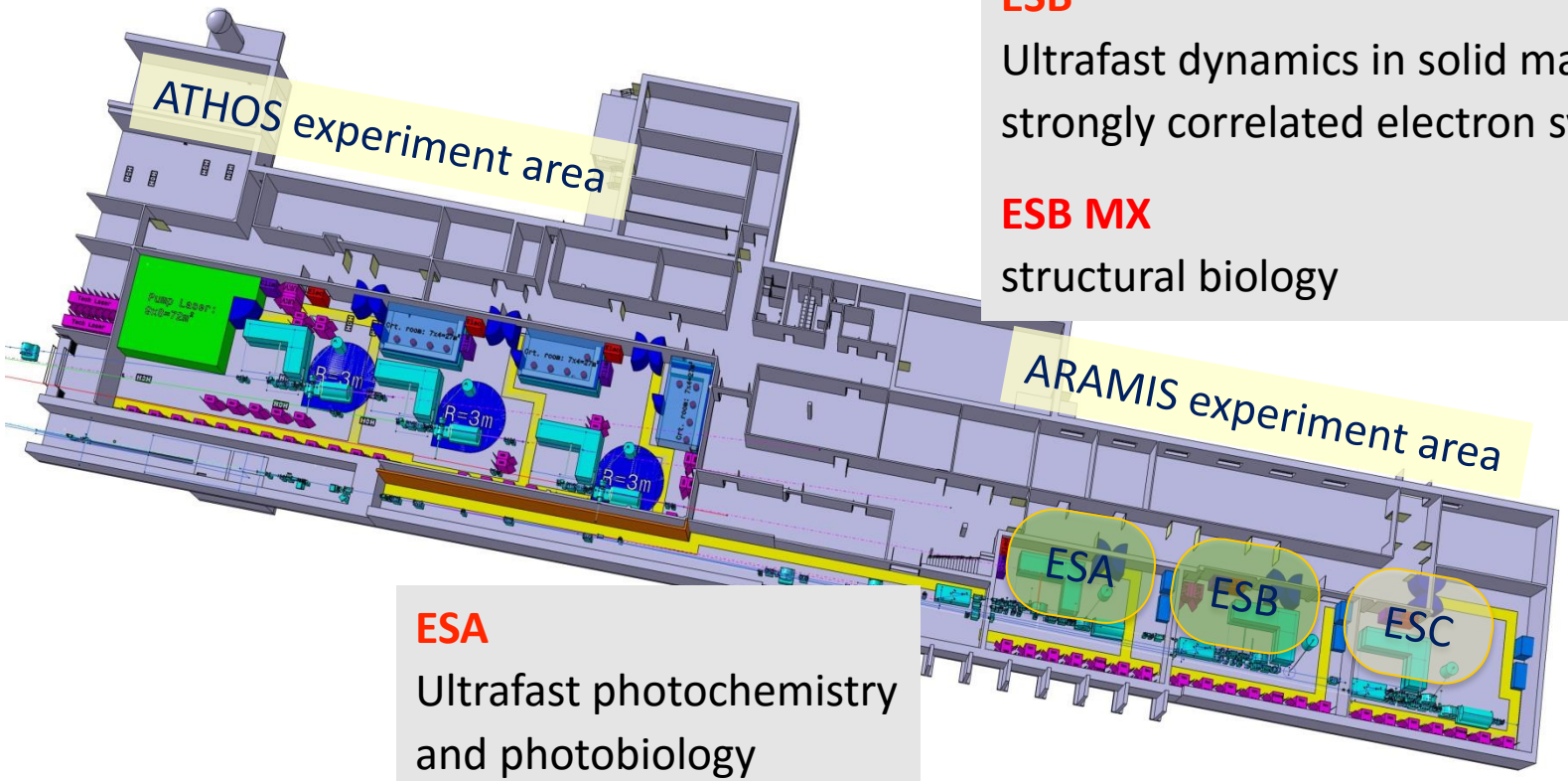
Length ~ 2 m
Weight: 12 tons
height: 1.7m
width: < 1.4m



Session Accelerator B

Thomas Schmidt, Apple-X undulator for Athos and EU-XFEL (SASE 3)

Photon Beamlines and Experiments



ESB

Ultrafast dynamics in solid matter, strongly correlated electron systems

ESB MX

structural biology

ESA

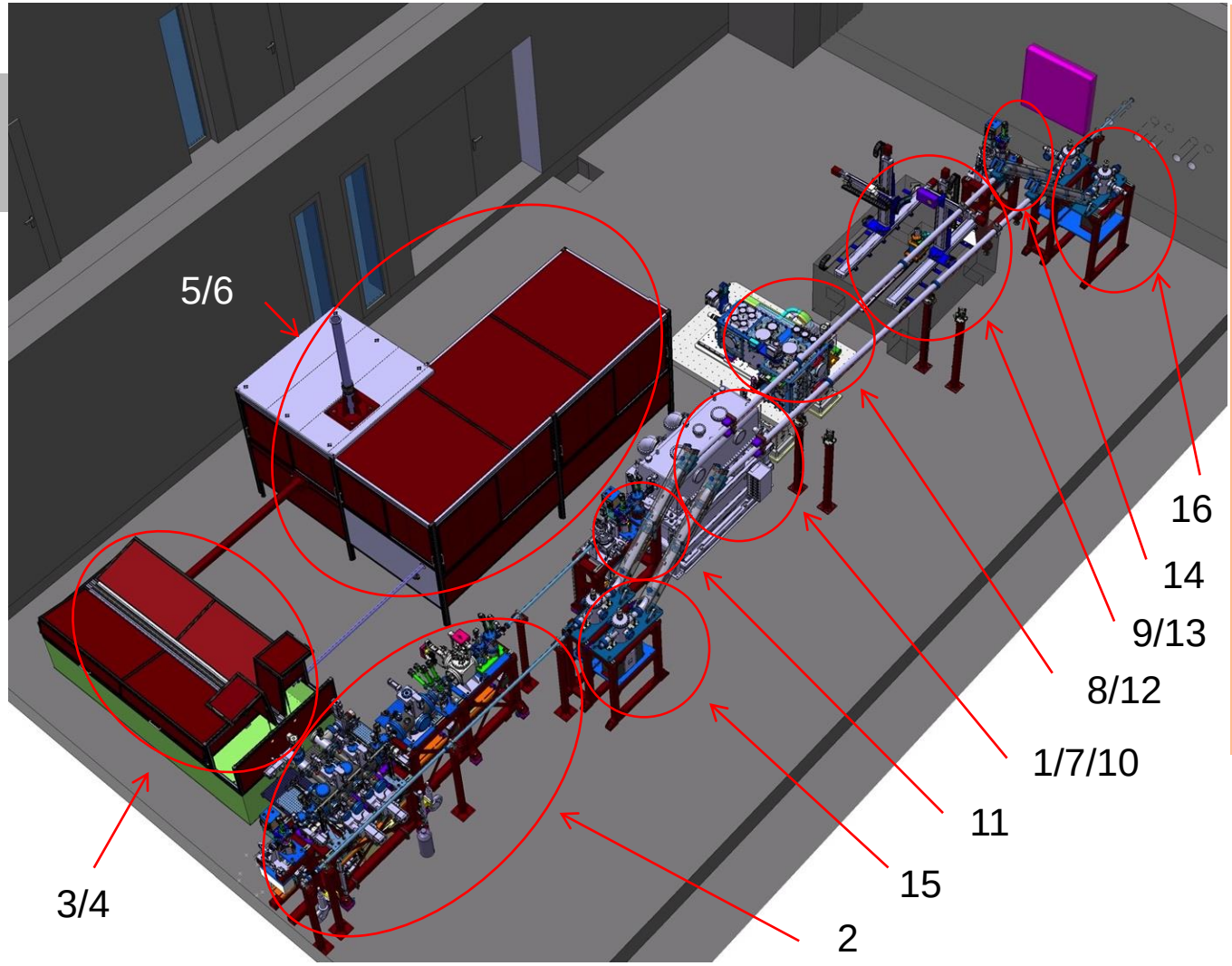
Ultrafast photochemistry and photobiology

Session Photonics A

Uwe Flechsig, "Status of the SwissFEL optics"

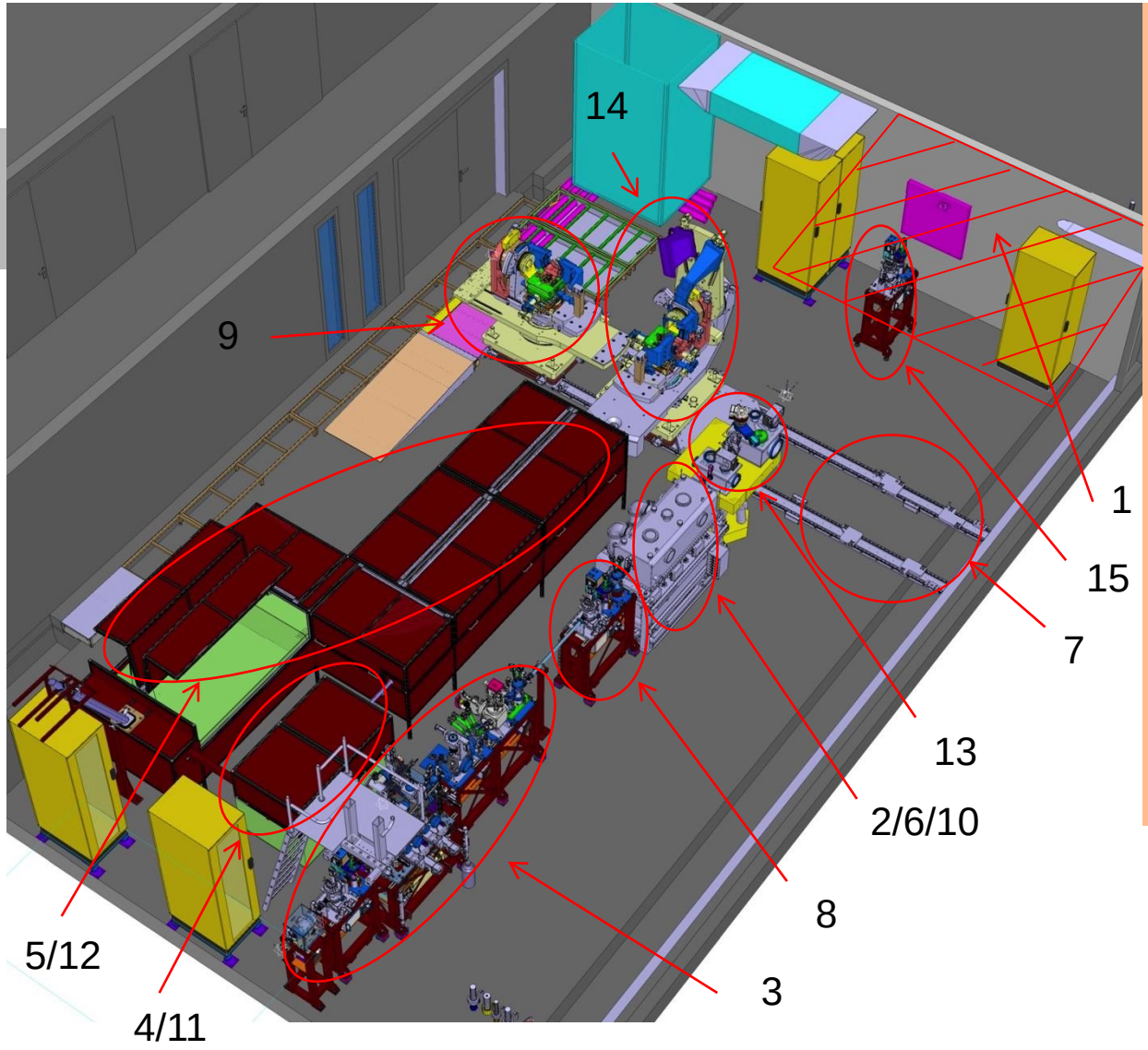
Paul Beaud, "Laser timing and jitter diagnostics tools for SwissFEL experimental stations"

ESA hutch: work in progress



Installationen		Monat
-	Ankerbohrungen	09.16
1	KB Bodenplatte setzen	09.16
2	Palm und PSEN inkl. Zub.	10.16
3	Grundplatte Laser Diagn.	10.16
4	Laser Diagn.	10.16
5	Grundplatte Laser Exp.	10.16
6	Laser Exp.	10.16
7	KB Basis und Kammer	10.16
8	Support ESA Prime	11.16
9	Support ESA Flex	11.16
10	KB-Spiegel	11.16
11	PBPS und PPRM	11.16
12	ESA-Prime	12.16
13	ESA-Flex	12.16
14	PBPS und PPRM	04.17
15	Schikane	05.17
16	Schikane	05.17
-	Laser Transferl. LHx-ESA	05.17

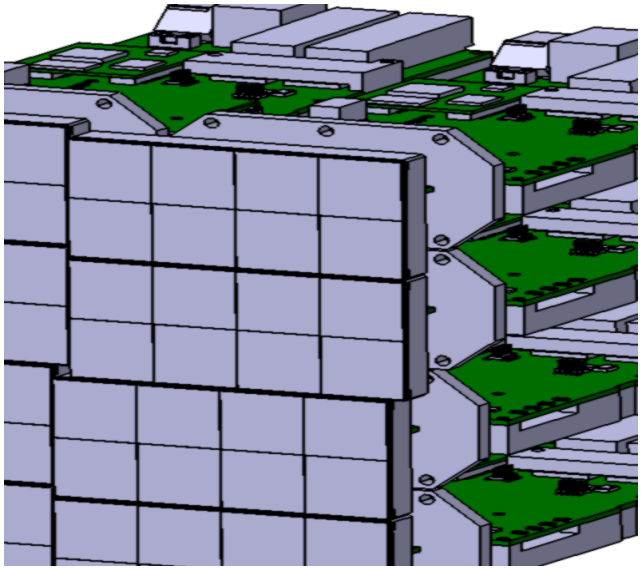
ESB hutch: work in progress



Installationen		Monat
-	Laser Transferl. LHx-ESC	07.16
-	Laser Transferl. LHx-ESB	08.16
-	Ankerbohrungen	07-09.16
1	Montage Gestell Decke	09.16
-	Mont. Support Schikane	09.16
2	KB Bodenplatte setzen	10.16
3	Palm und Zubehör	10.16
4	Grundplatte Laser Diagn.	10.16
5	Grundplatte Laser Exp.	10.16
6	KB Basis und Kammer	10.16
7	Schiene Montage Boden	11.16
8	PBPS und PPRM	11.16
9	ESB-GPS	11.16
10	KB Spiegel	11.16
11	Laser Diagnostic	02.17
12	Laser Experiment	02.17
13	Coupling Mirror	03.17
-	Roboterarm Q1.17	
14	ESB-Diff.	05.17
14	PBPS–PPRM	05.17

The Jungfrau 2D detector

courtesy Aldo Mozzanica

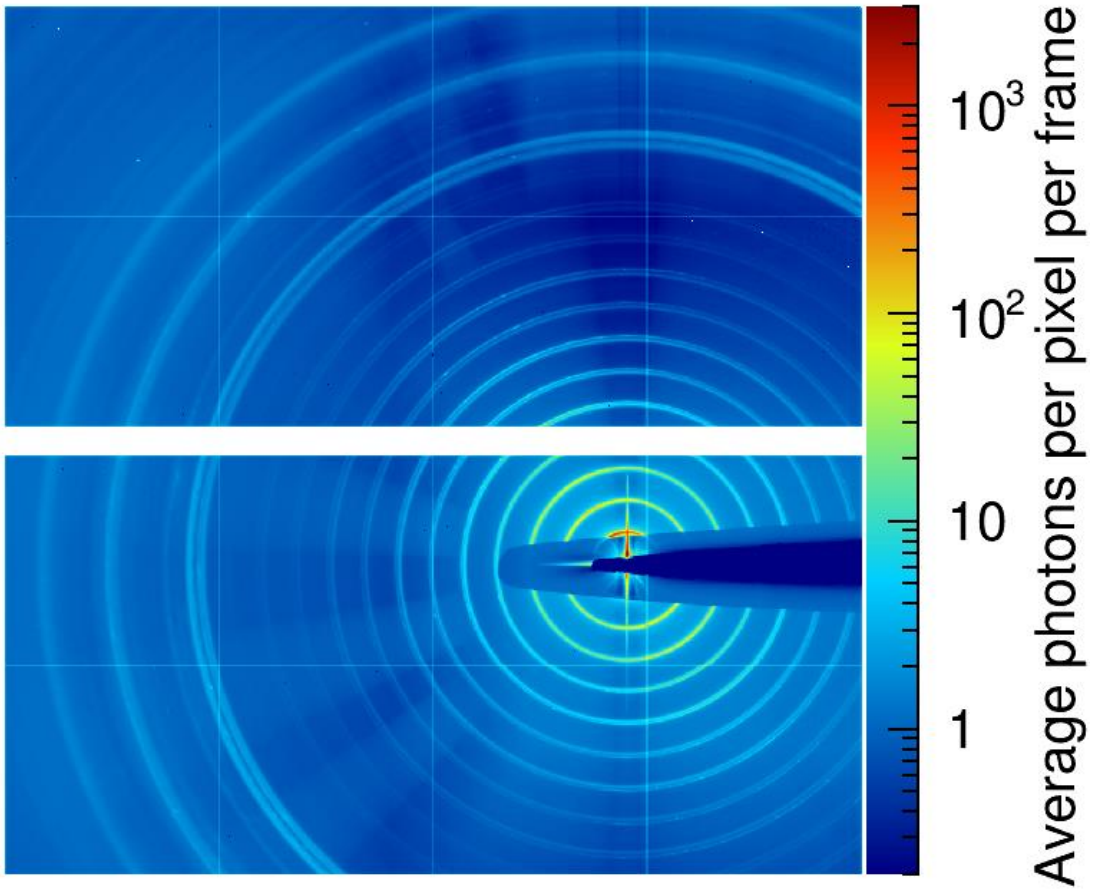


- Specifically developed for SwissFEL applications
- Charge integrating detector with dynamic gain switching, with:
  - Front end electronics similar to AGIPD and GOTTHARD
  - Dimensions, sensor and mechanics similar to the EIGER project: 75x75 mm^2 pixel size, 4x8 cm^2 module area.

- 500k (one module), 1M (2 modules), 4M and 16M (ESA-ESB main instruments, 32 modules) systems are foreseen
- Horizontal gaps very small (8px)
- compact (20-25cm) in the Z direction
- Vacuum compatible option

JUNGFRAU 0.1: A. Mozzanica et al., JINST, 9, C05010, 2014
JUNGFRAU 0.2: J. H. Jungmann-Smith et al., JINST, 9, P12013, 2014
JUNGFRAU Technical Design Report, J.H. Smith et al.,SwissFEL website, 2015

First Tests@ LCLS



Two modules
(500k Pixels each)

Silver Behenate
Single cristalls
Average over 1000 shots

Users Operation: Considerations

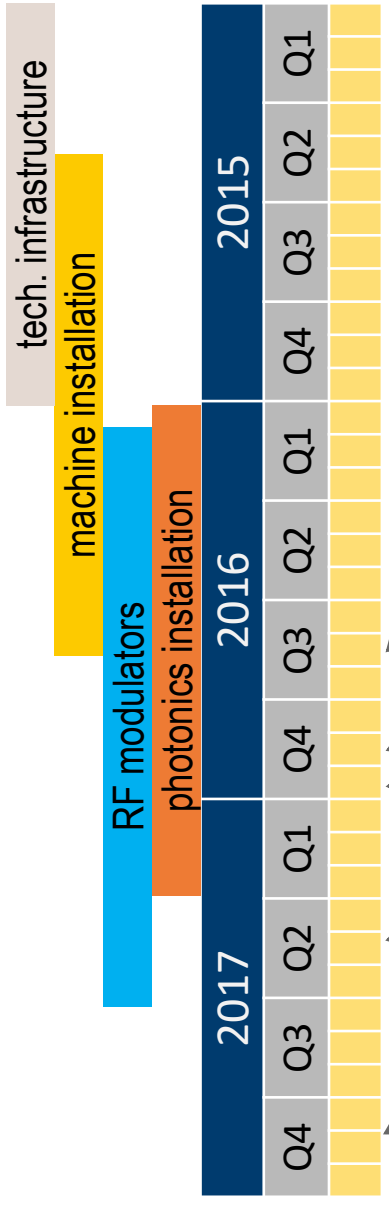
The first years of user operation at SwissFEL are driven by:

- Improving the performance of ARAMIS accelerator, beamlines and stations
- Installation and commissioning of ATHOS
- Building up operation and exploitation experience

Session Photon B

Luc Patthey, First experiments and user operation at SwissFEL

ARAMIS Next milestones



Start injector commissioning

First beam through Aramis undulator

December 5th, inauguration ceremony
December 6th, first user meeting

First lasing

Start first experiments with E_{ph}=3.4 KeV

Start first experiments with E_{ph}=12.4 KeV

SwissFEL presentations

Subject	Presenter	Session
Overview of collaborations for beam diagnostics with PSI involvement	Nicole Hiller	Accelerator A
Status of the SwissFEL optics	Uwe Flechsig	Photon A
Laser timing and jitter diagnostics tools for SwissFEL experimental stations	Paul Beaud	Photon A
First experiments and user operation at SwissFEL	Luc Patthey	Photon B
Design strategies for Athos	Sven Reiche	Accelerator B
Apple-X undulator for Athos and EU-XFEL (SASE 3)	Thomas Schmidt	Accelerator B
Experience with high power RF sources and RF conditioning	Florian Loehl	Accelerator C

Facility filled and under pressure !