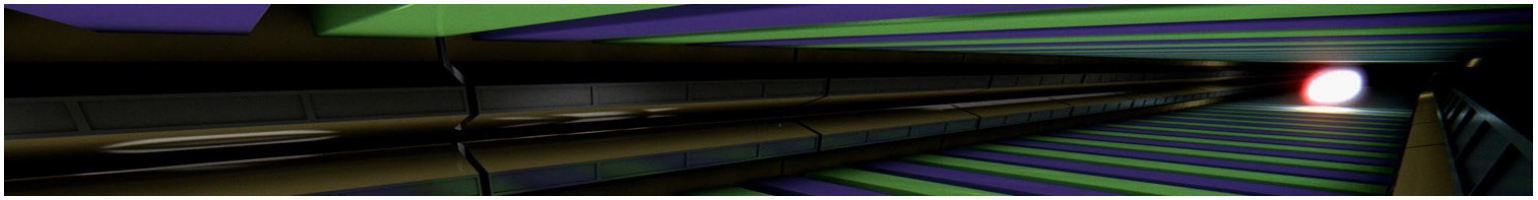


First operation of the Gun at XFEL … and the next steps

F.Brinker for the XFEL collaboration

Injector Tunnel (one year ago)

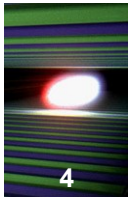
First operation of an accelerator at XFEL started December 2013

To make this happen a huge amount of work had to be done

After finalizing the construction work the infrastructure had to be installed in the complete injector building:

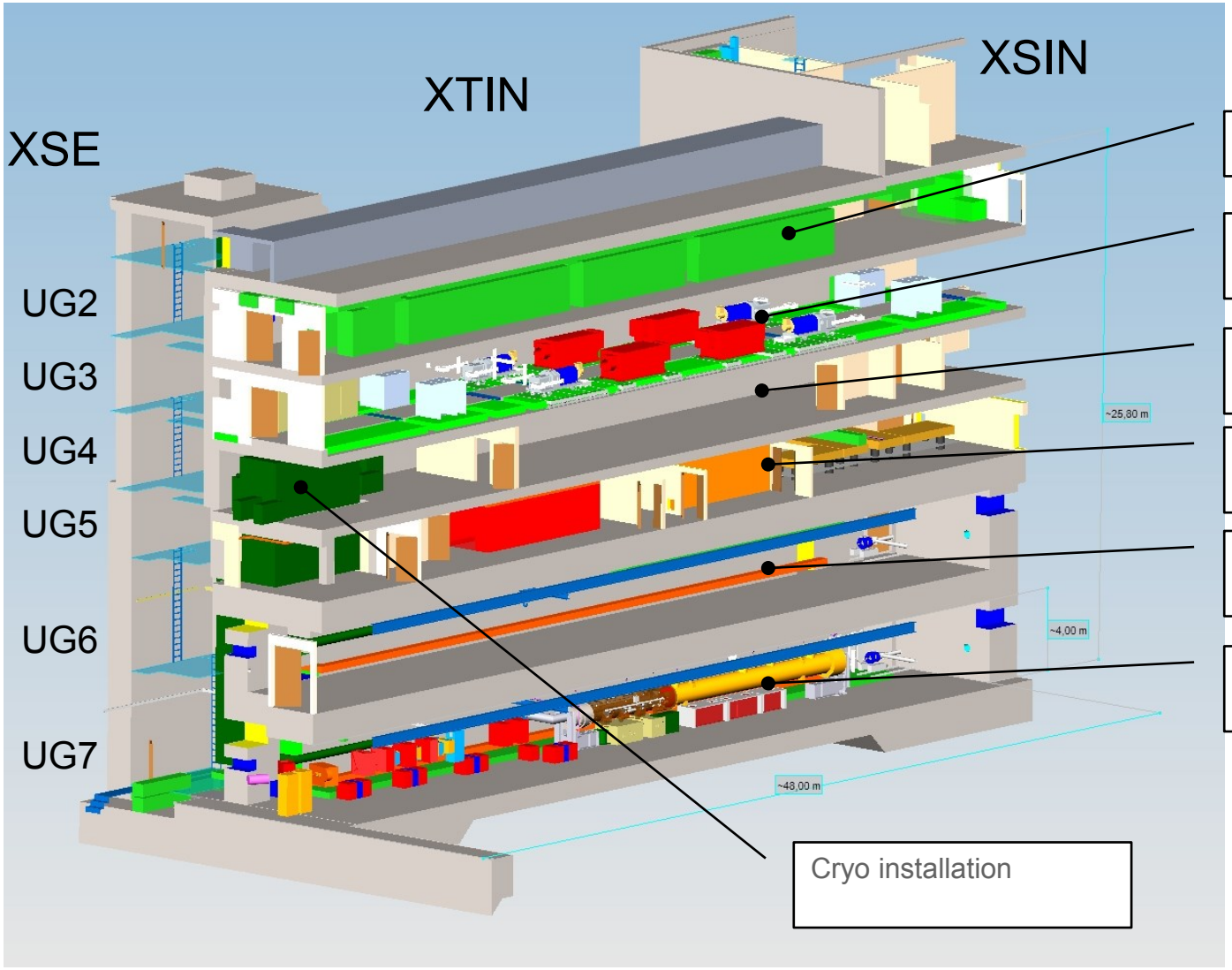
- Light
- Electric power
- Cooling water
- Air conditioning
- IT network
- Fire safety
- … things I forgot

We did the gun test during 4 weeks in December and learned a lot about the different systems involved



- the operation of the high power RF including modulator, transformer, klystron waveguides
- the gun with cathode, solenoids, vacuum system, input coupler and window
- the temperature regulation system
- the low level RF system
- the timing system the machine protection system
- the personal interlock system
- control system hard- and software

The location



Magnet power supplies

Klystron, puls-transformer, wave guides

Diagnostics, IT, MPS

Timing, Laser

Second Injector

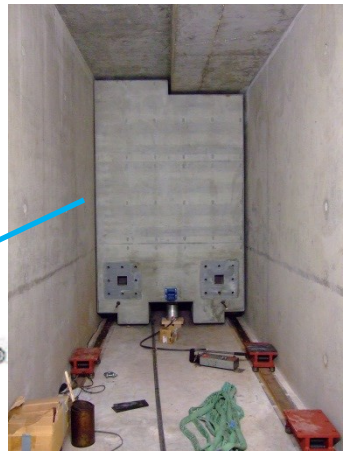
Gun, Gun cooling

Personal Interlock

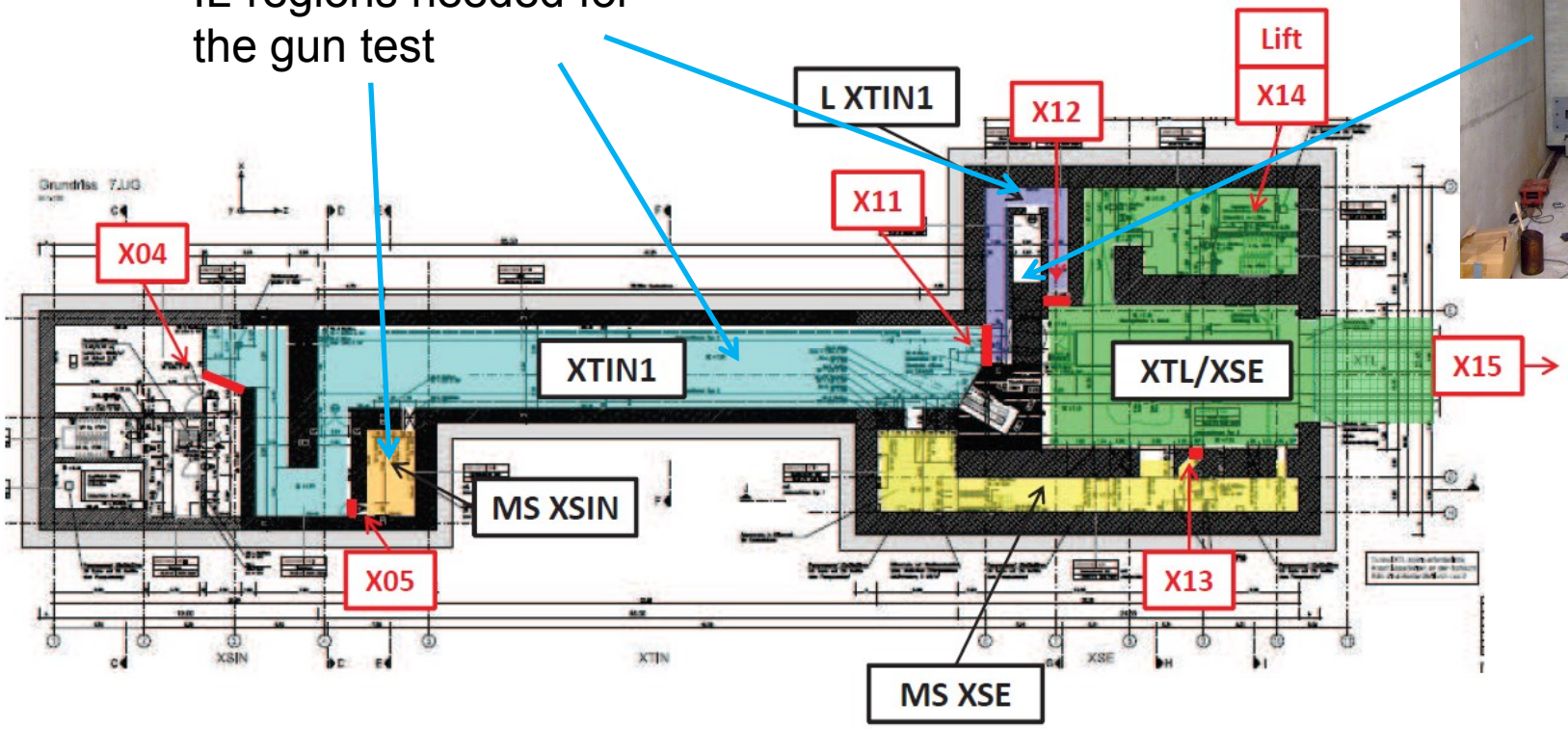
The 2 injectors and the main linac have to be independent

-> Separate regions are needed for the injectors, the main linac, the media shafts and the labyrinths

Concrete shielding door

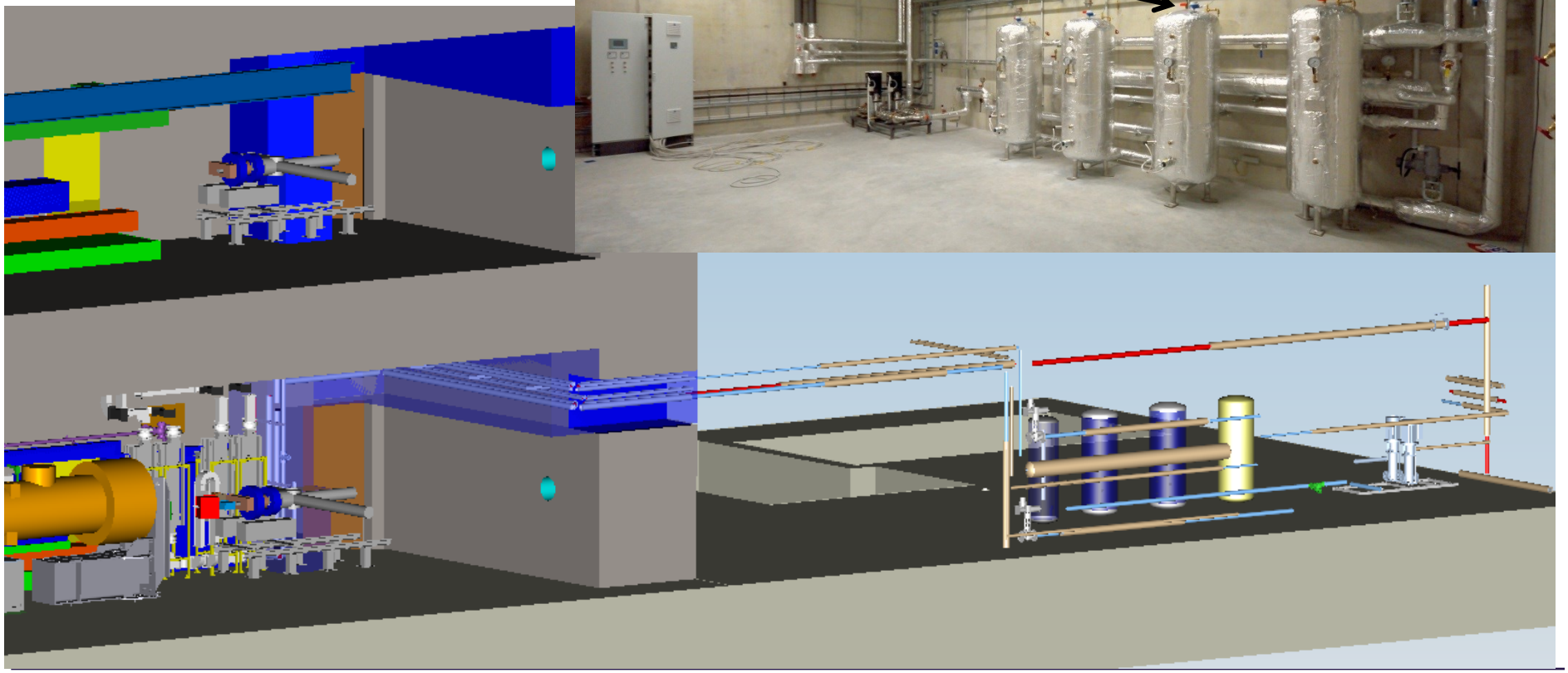


IL-regions needed for the gun test

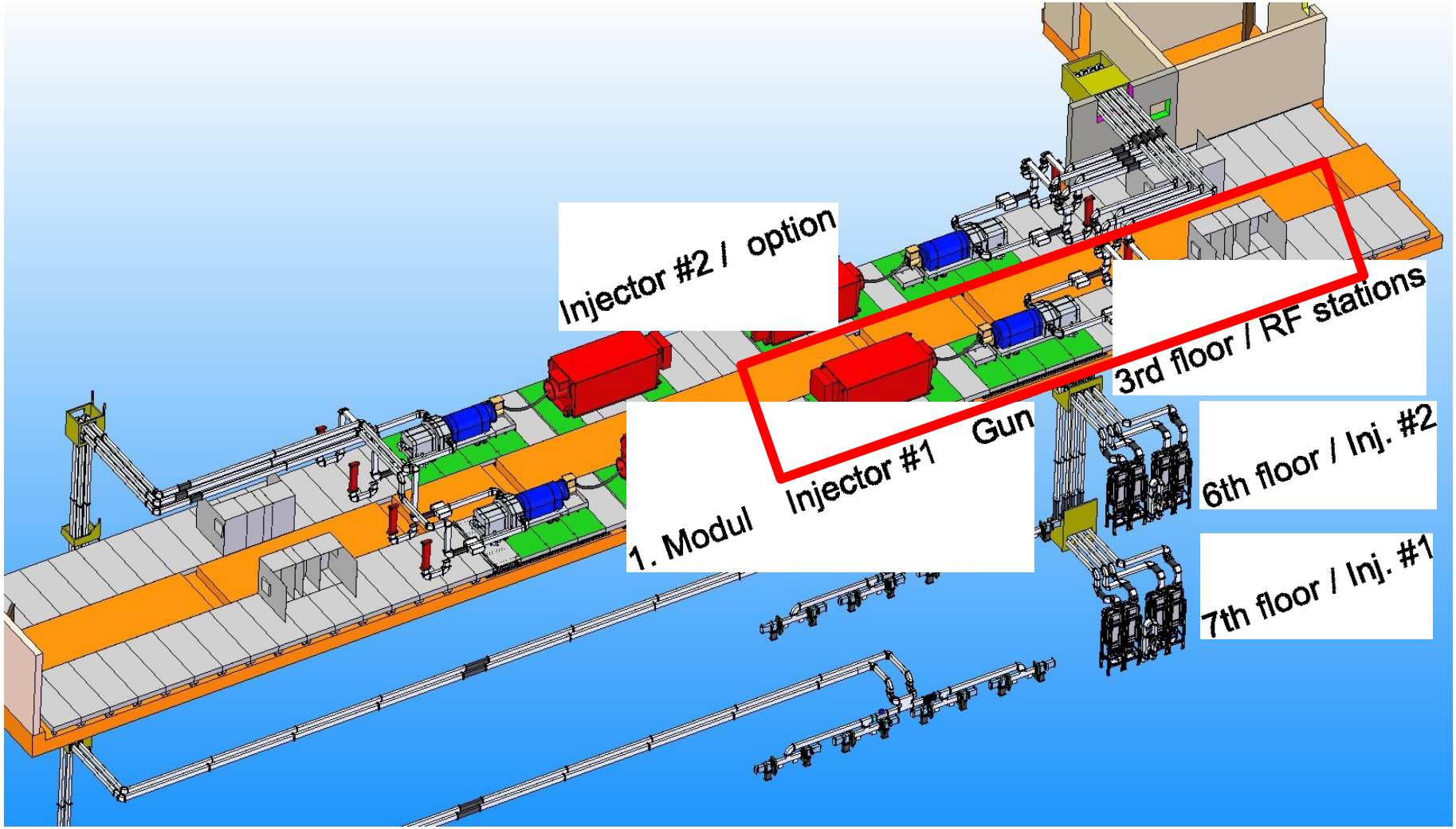


The gun cooling

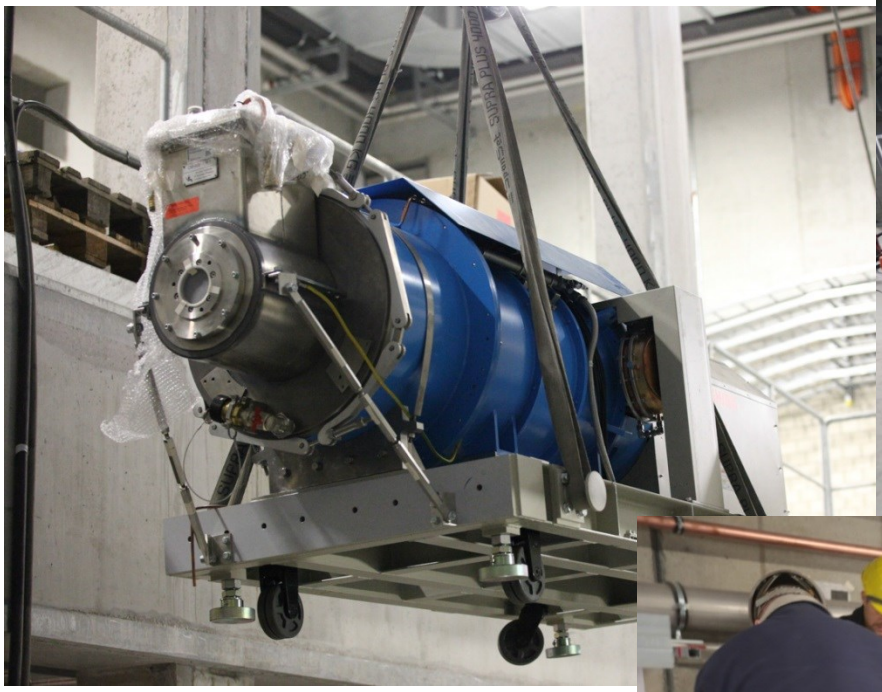
3 hot water reservoirs



RF Stations XTIN – UG3

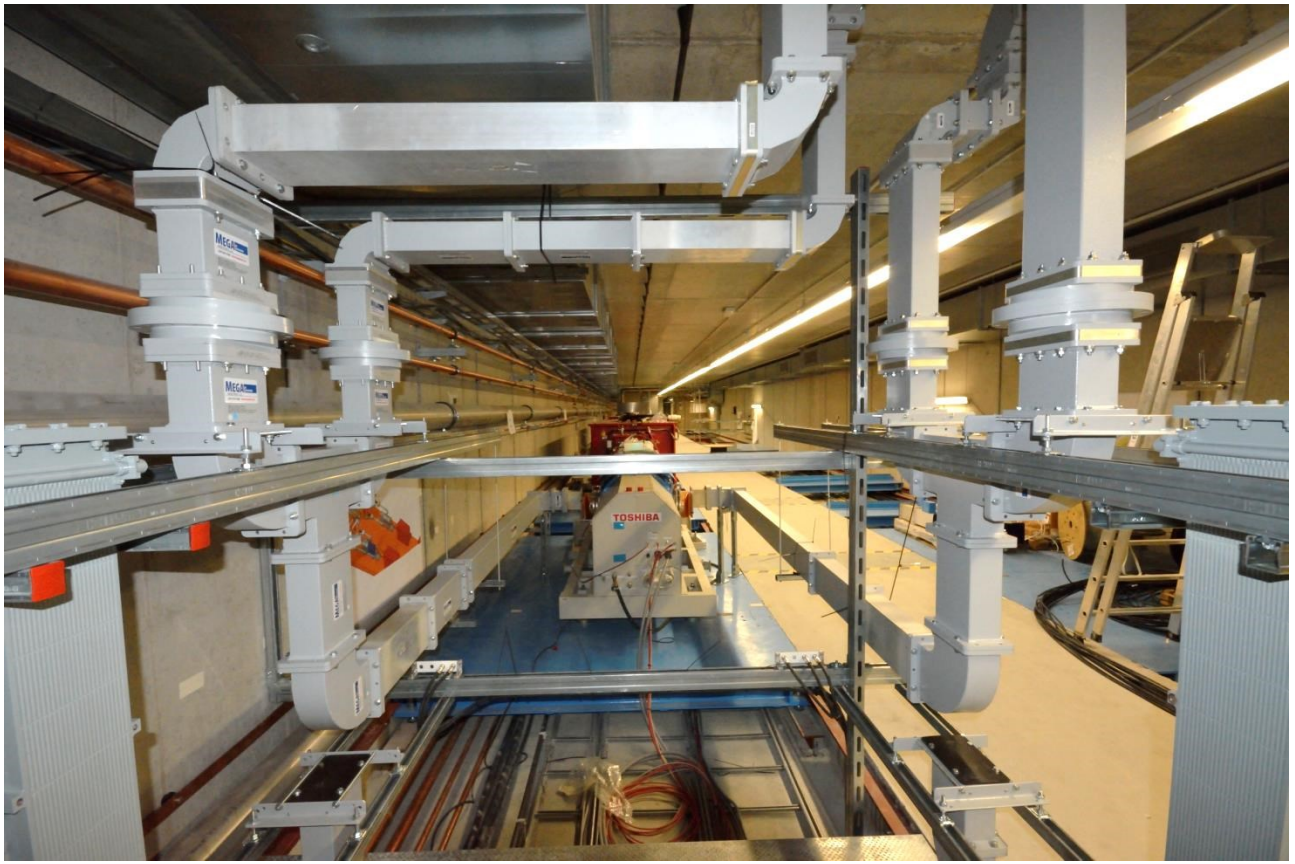


Arrival of the pulse transformers



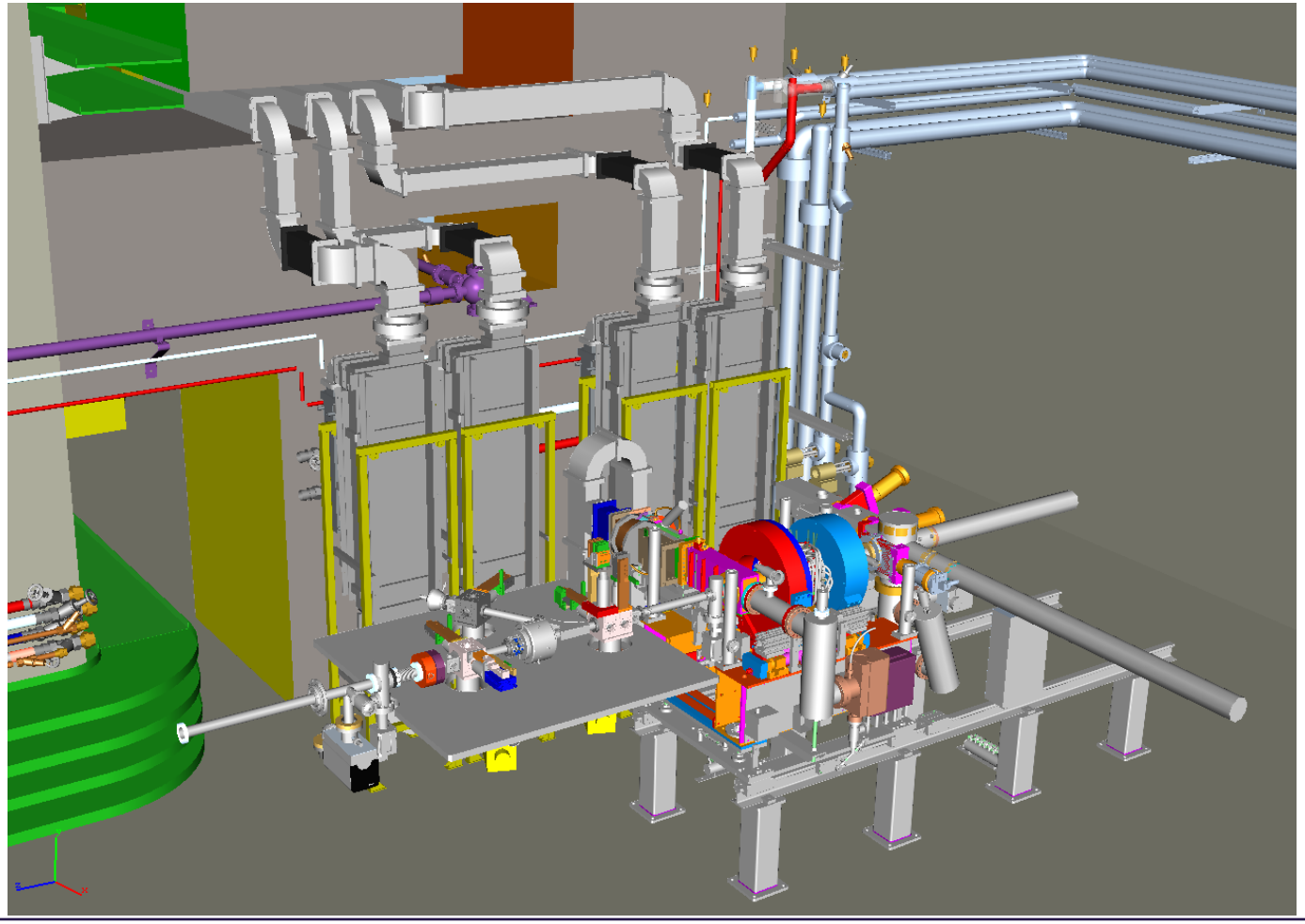
and klystrons

Waveguides – the power is distributed over 4 waveguides and recombined before the gun



Already getting tight …

From model …



… to reality

Gun conditioned at DESY-Zeuthen with up to 6MW

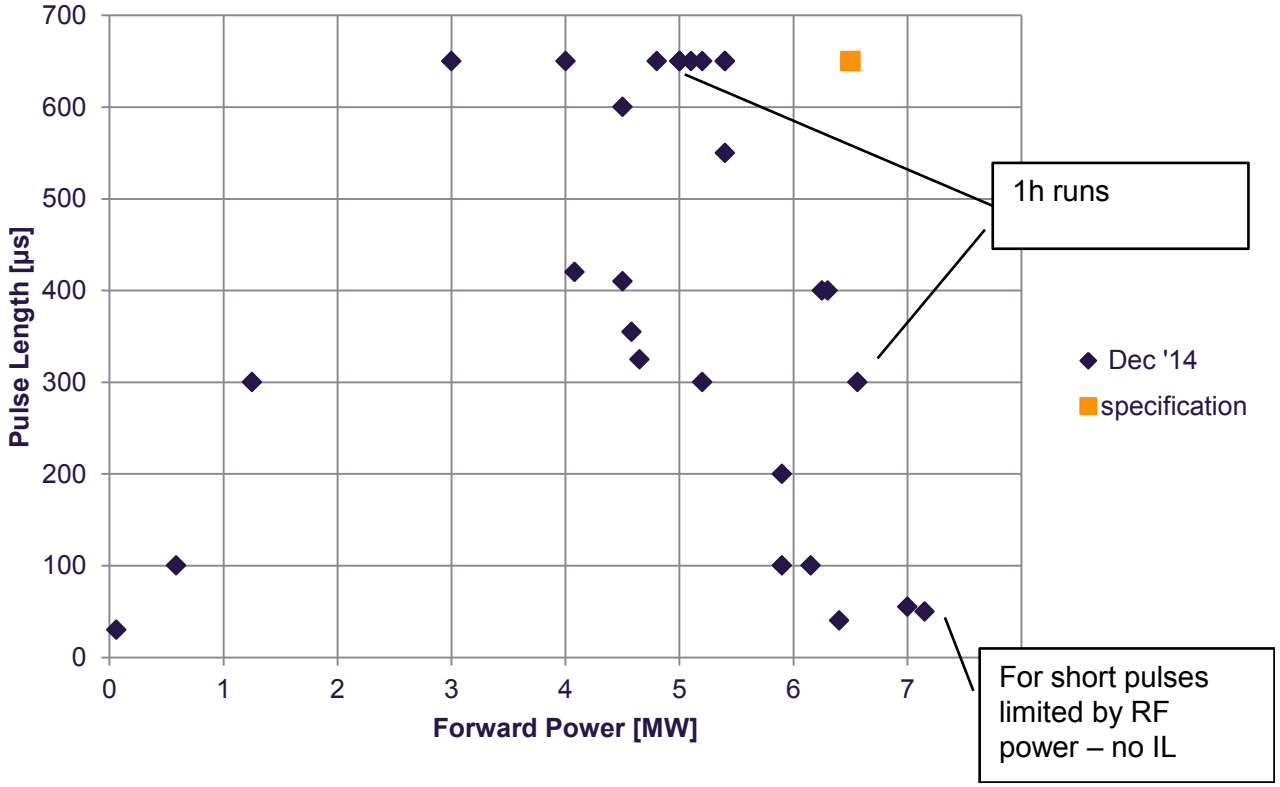
Intentionally limited to this value to avoid risk of failures (RF-window)

Operational experiences – Thanks a lot for the good preparation !

- Magnet power supplies : used for solenoids , OK
- Cooling water : OK, minor water temperature issues during the first days at pulse transformer (power too low)
- Modulator : OK beside a single server failure
- Pulse transformer, Klystron : OK
- Waveguides, circulators directional couplers … : OK
- Personal interlock : OK, no failures – operation without temporary access
- Timing : OK – some reboots necessary (unstable power ?)
- LLRF : (no feedbacks used) no failures but some measurements need further checks
- Machine protection : OK, no failures observed
- Gun cooling : OK – works very stable under steady state or ramping conditions. Further improvements needed (and foreseen) for fast power changes like trips.
- Control system : OK – operation completely from BKR (control room bldg. 30), no high level applications yet

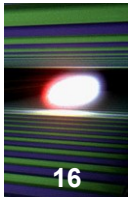
Achieved RF Parameters in December Run

- Gun has been conditioned at Zeuthen to 6MW – no “Gun” interlocks observed (no vacuum break out or reflected power ILs)



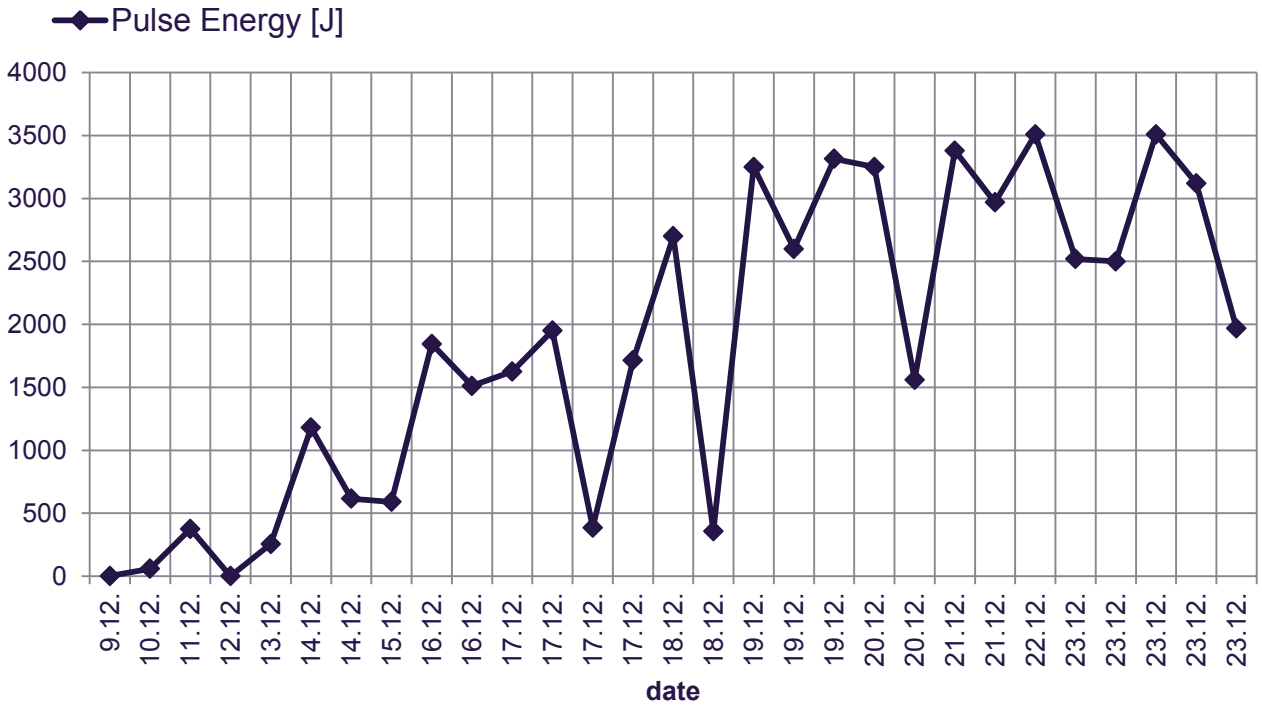
RF Run from 9th to 23rd of Dec.

Development of pulse energy over time

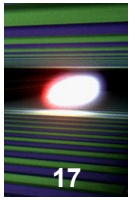


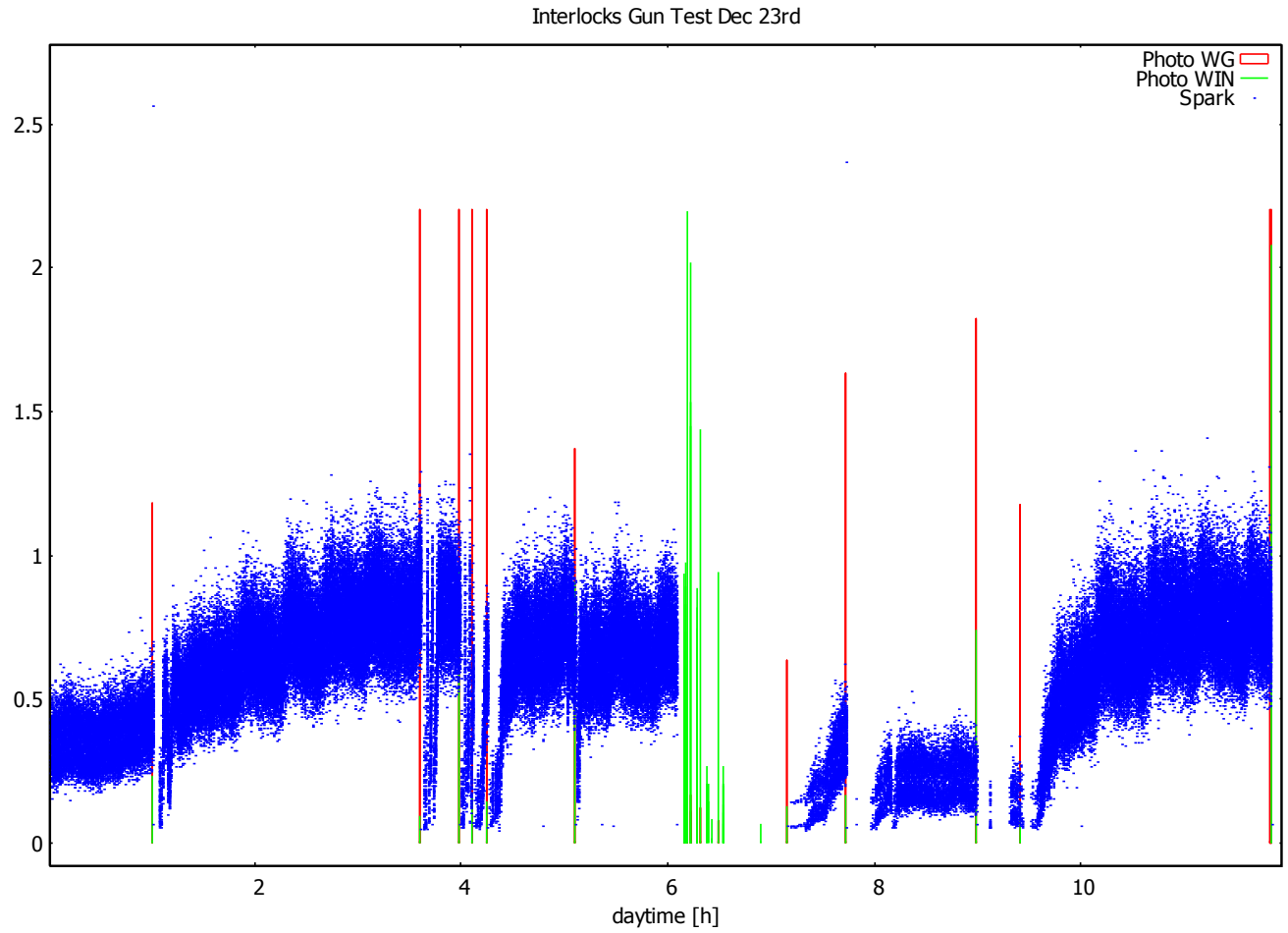
- Goal :

6.5MW · 650µs = 4.2 kJ



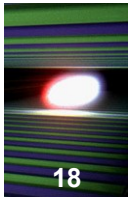
So, what limited the power / pulse length ?
→ Interlocks only from light sensors at RF window





- Signal from photodiode on air side (Spark) increases slowly with pulse energy
- Photomultipliers on vacuum side detect only high spikes together with spark det.
- One exception only after 6:10, Dec 23rd for about 1h with light on vacuum side

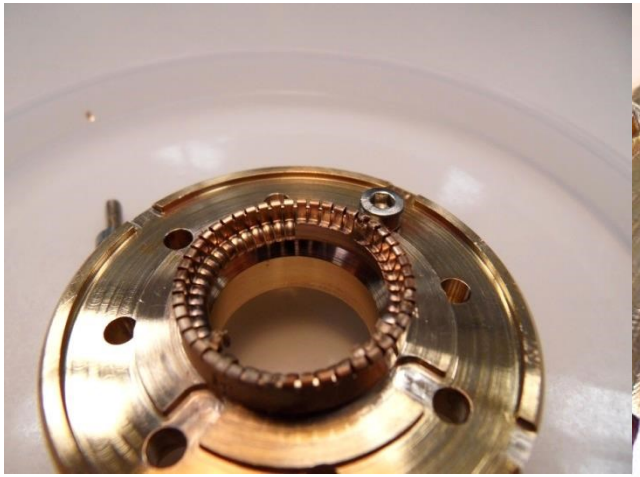
Hint to problems with RF spring:

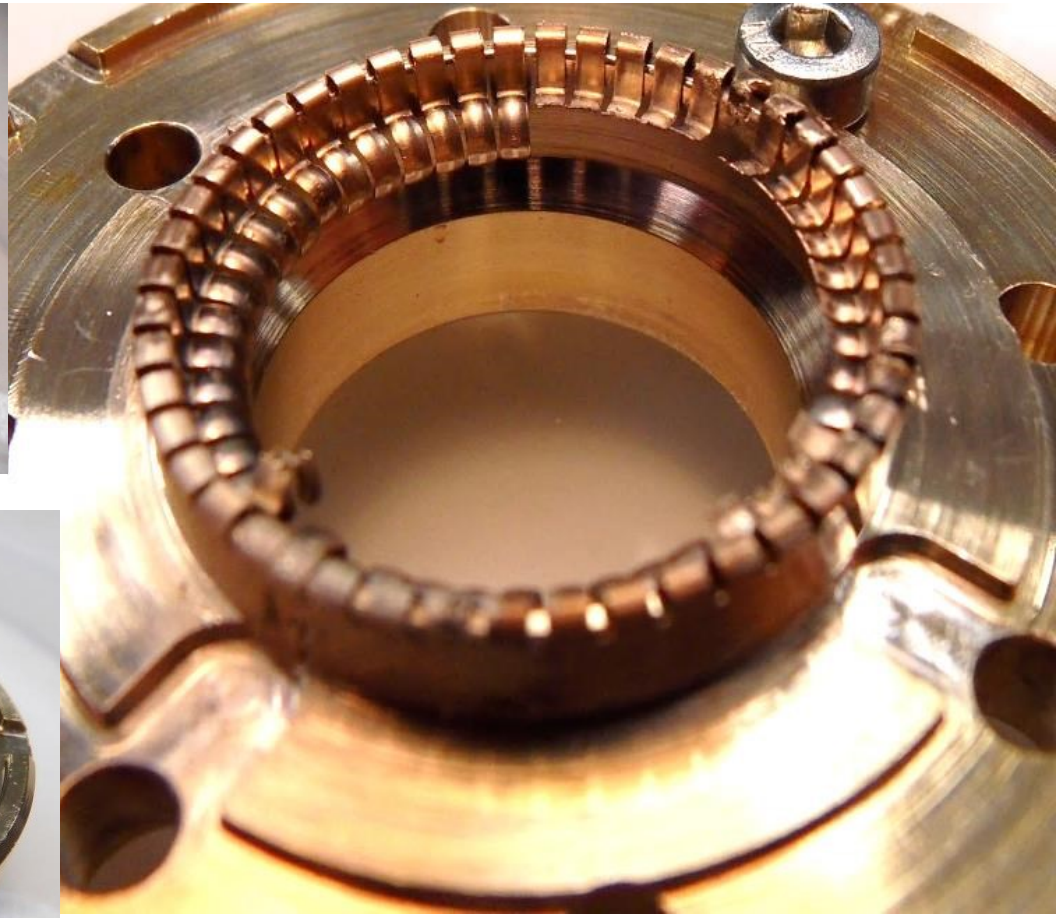


- Strong vacuum activity behind the cathode – no activity seen within the gun
- Same behavior when changing the magnetic field. Ramping up the solenoids with RF-power without any problems – beside pressure increase in the cathode chamber
- No interlocks !

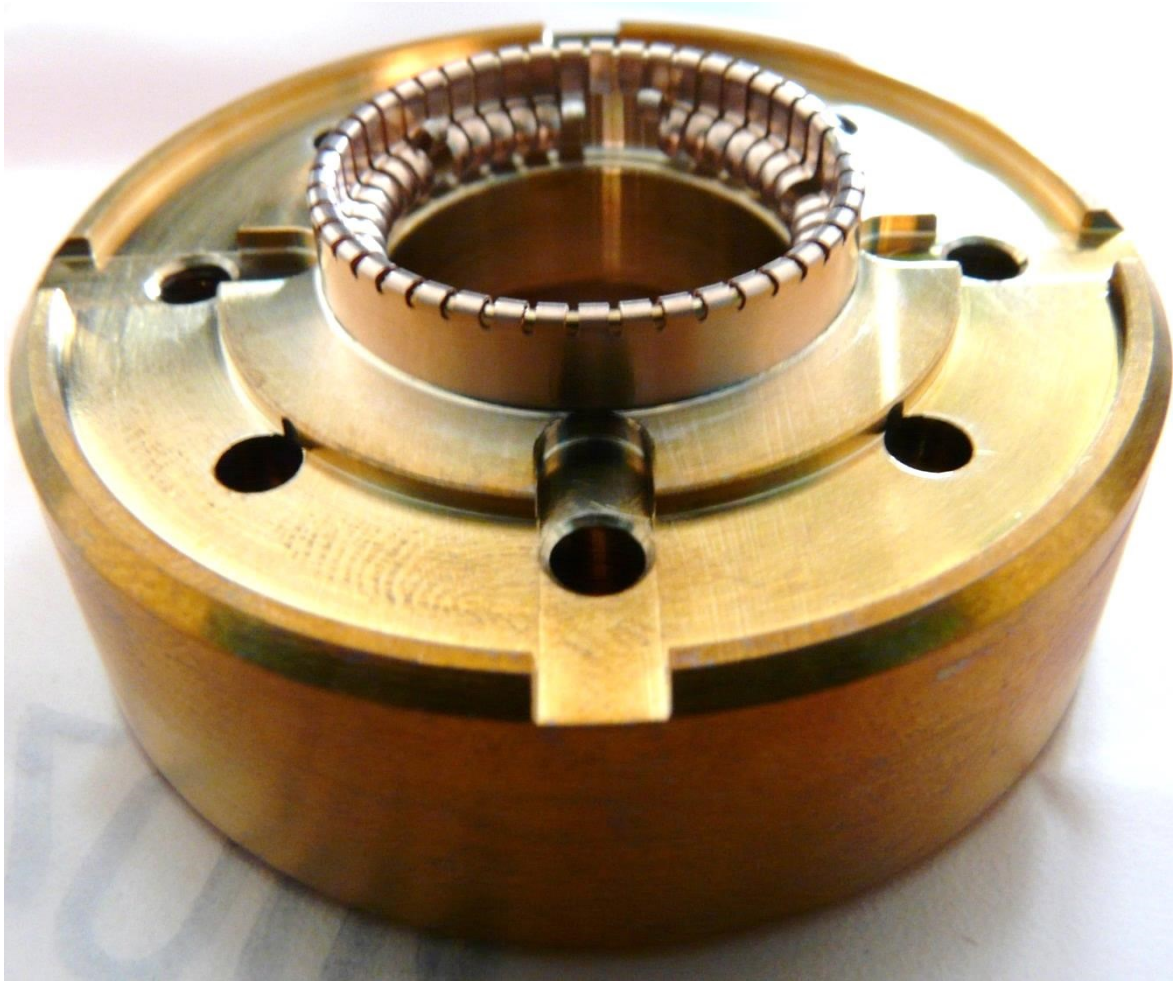
- After the test the gun was opened to examine the cathode holder
- The holder is a new design after damages have been observed at the gun backplane at FLASH

Massive damages of Cathode spring after operation





Improvement seen at the next gun at Zeuthen

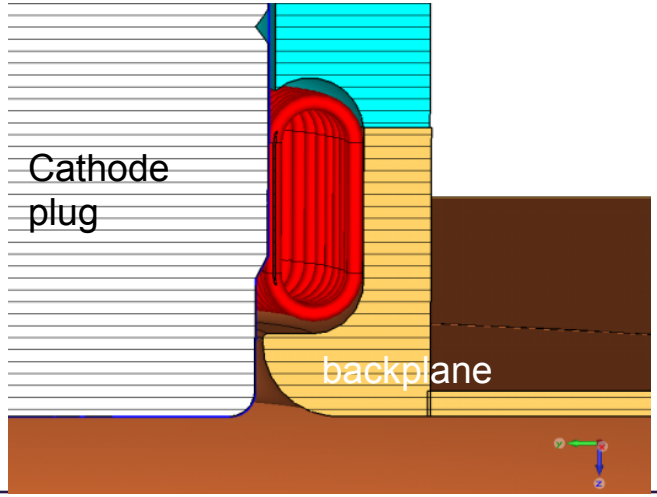


- The gun 4.4 has been opened after operation at Zeuthen last week
- Cathode spring in much better condition
- No melting
- Nevertheless 3 broken fingers

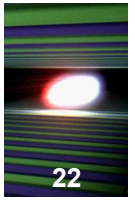
Plan for improvements:

- Improvement of surfaces (test in Zeuthen starts now):
  - Cathode holder have been gold plated
  - Spring has been rhodium and gold coated
  - Cathode plugs have been electro polished

- In parallel : modification of the geometry
  - A different spring geometry (“watchband design” used at FLASH) is in preparation for this autumn



Attacking the window problem



- The light emission seen at the window is a hint for RF-induced discharges
- These can be reduced by ultra high vacuum in the waveguides, fillings of SF6 or increasing the air pressure
  - SF6 is practically excluded due to safety reasons
  - For UHV operation waveguide components like in-vacuum T-combiner and directional couplers are needed – these are presently under tests at Zeuthen
  - At XFEL the waveguides will be prepared for higher air pressure of up to 3 bar for the next run

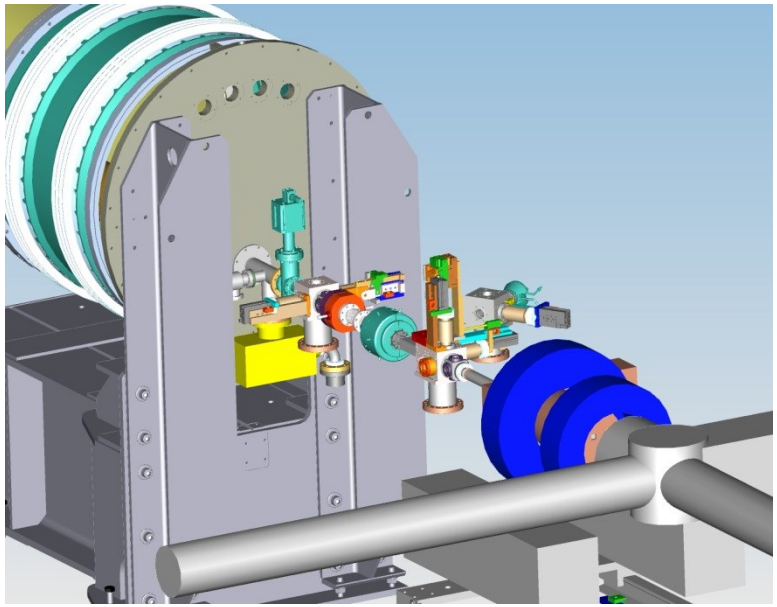
Further installations until mid ‘14

- Add dispersive arm and diagnostics to the gun
- Major part of the warm beamline
- Injector dump
- Cryo installations for injector
- Laser system

Installation of Cryo transfer lines

Installation of Cryo-Module supports

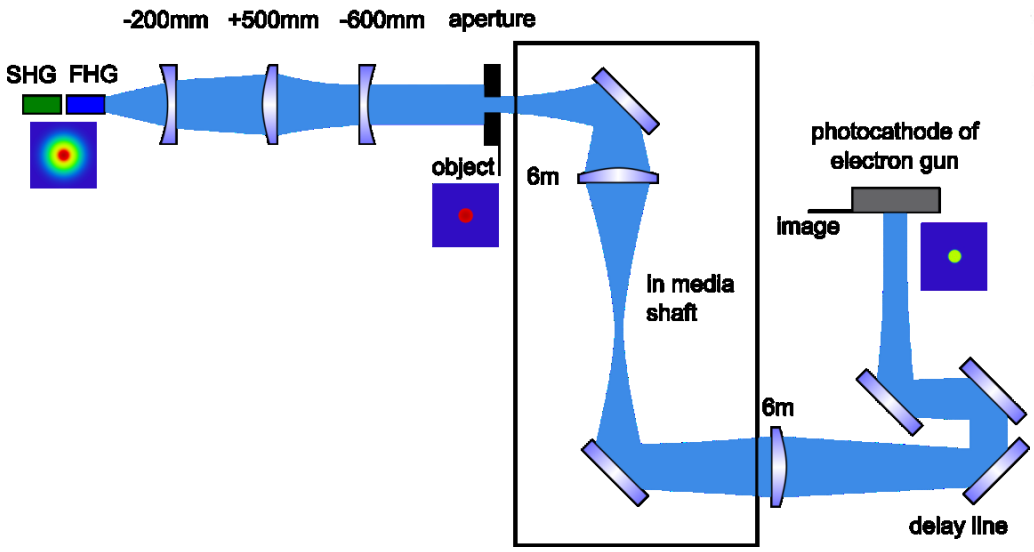
next : Gun Section



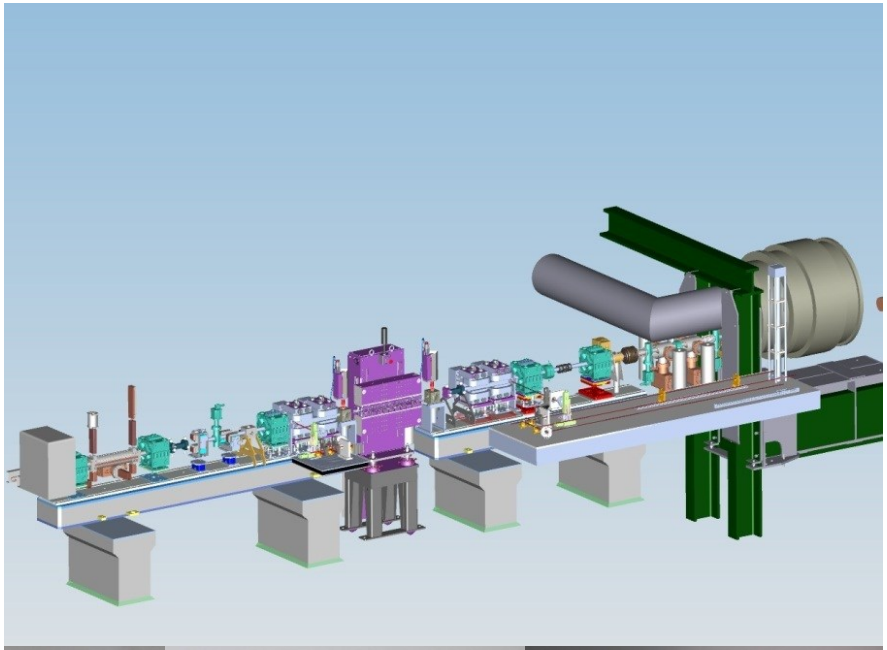
- Charge
  - Toroid
  - Dark current monitor
  - Faraday Cup
  - Integrated Faraday Cup
- Position
  - BPM
- Beam shape
  - Screens
- Energy
  - Spectrometer magnet
  - Screen

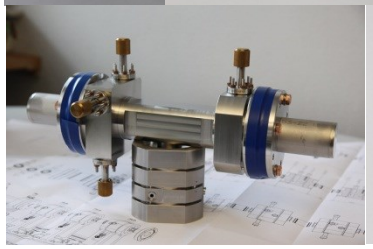
UV-Laser (MBI) installation in UG5 started, beamline design ready

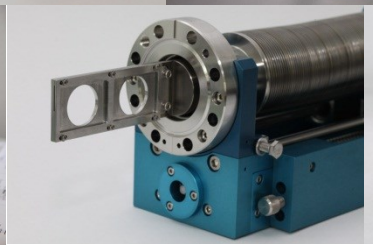
XFEL UV laser beamline concept (FS-LA)



Diagnostics : Part 1

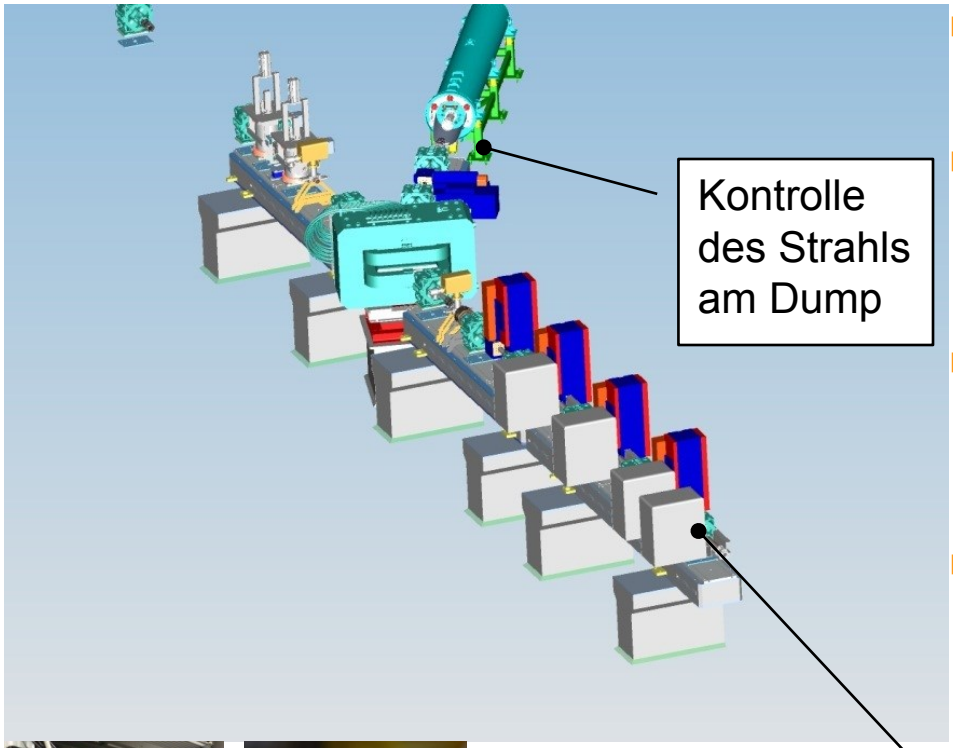




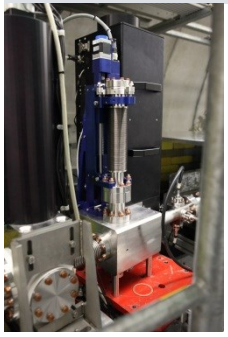


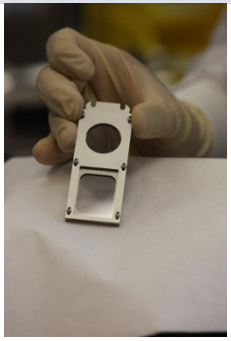
- Charge
  - Toroid:
  - DCM:
- Position
  - BPMC/R:
  - BPMA:
  - BPMF:
- Beam Shape
  - OTRL:
    - → Mover + Screen:
    - → Chamber: to be delivered by Uni Upsala
  - Loss monitors:
    - → BLM:
- TDS will come later in 2014

Diagnostics Part 2



- Charge
  - Toroid:
- Position
  - BPMA:
  - BPMD:
- Beamshape
  - OTRC:
  - OTRD:
- Losses
  - Loss monitors

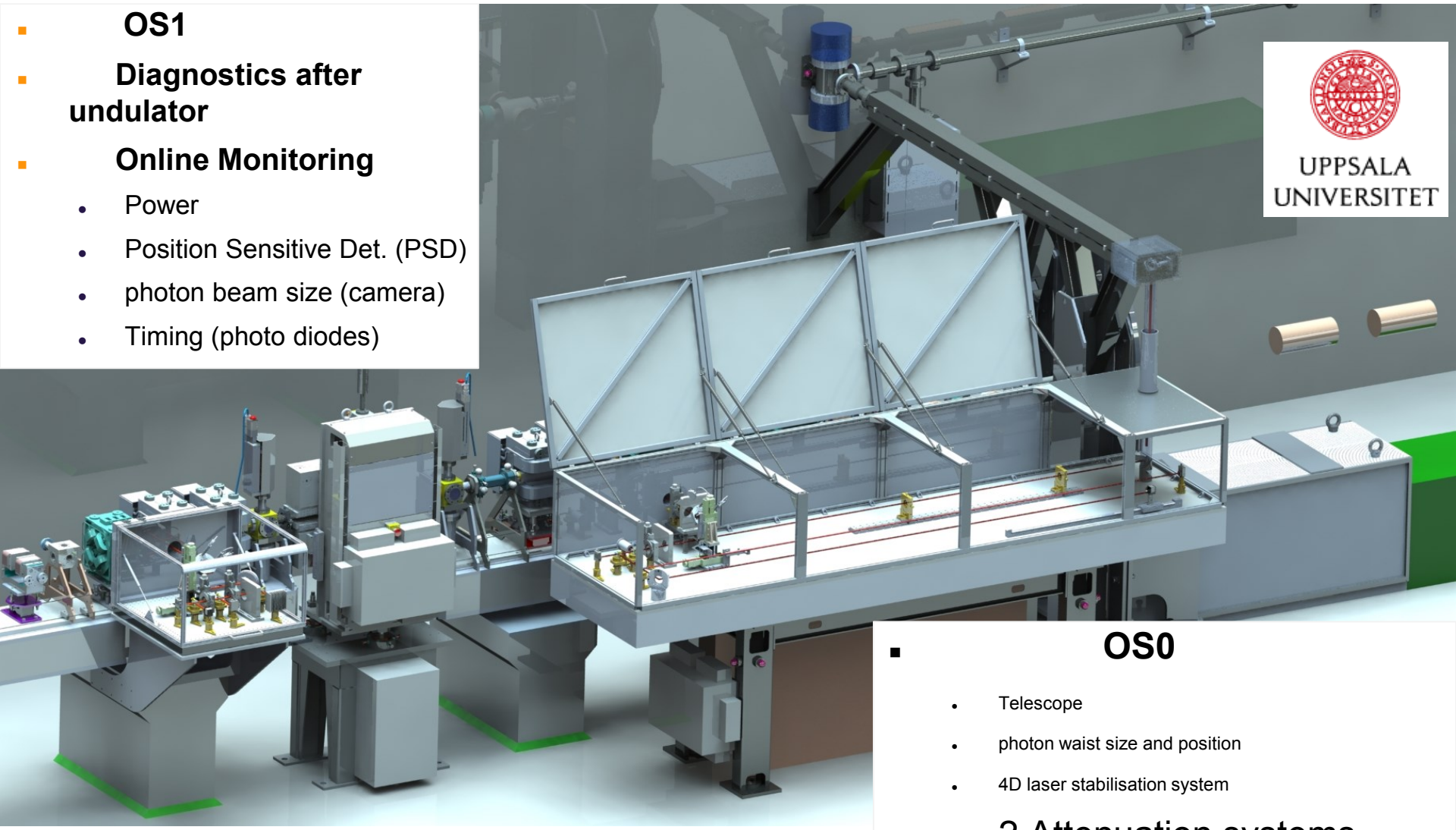




Fast Kicker allow the selection of bunches for diagnostics

Laser Heater system with undulator and infrared Laser

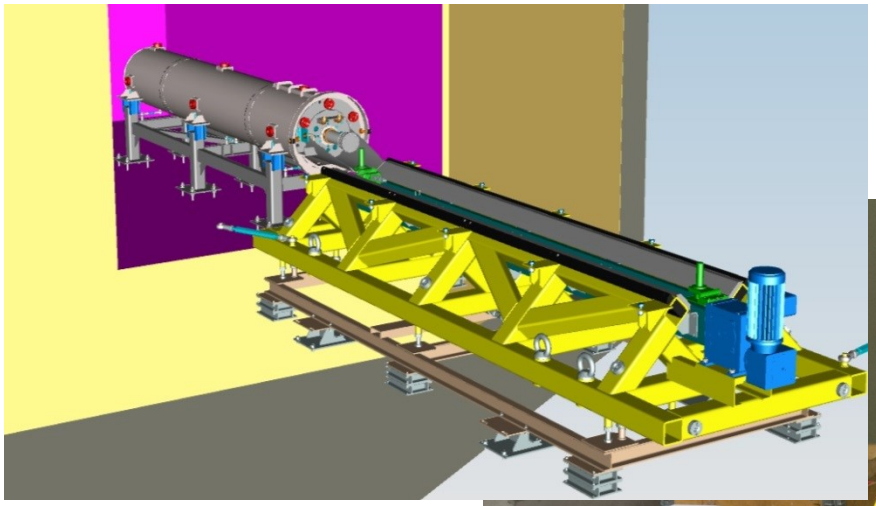
- **OS1**
- **Diagnostics after undulator**
- **Online Monitoring**
  - Power
  - Position Sensitive Det. (PSD)
  - photon beam size (camera)
  - Timing (photo diodes)

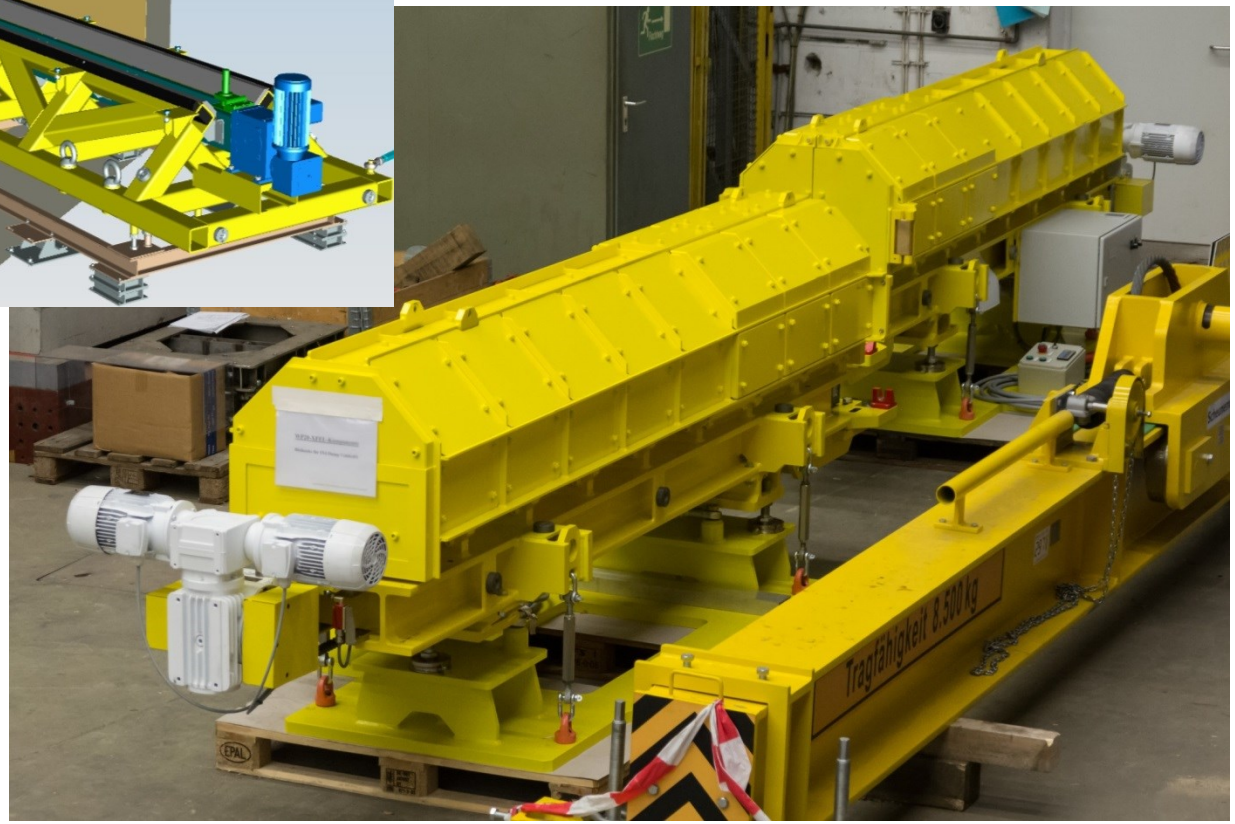


- **OS0**
  - Telescope
  - photon waist size and position
  - 4D laser stabilisation system
  - 2 Attenuation systems

Magnets are in house and RFI
Girder pre-installation started

Dump vehicles ready and tested

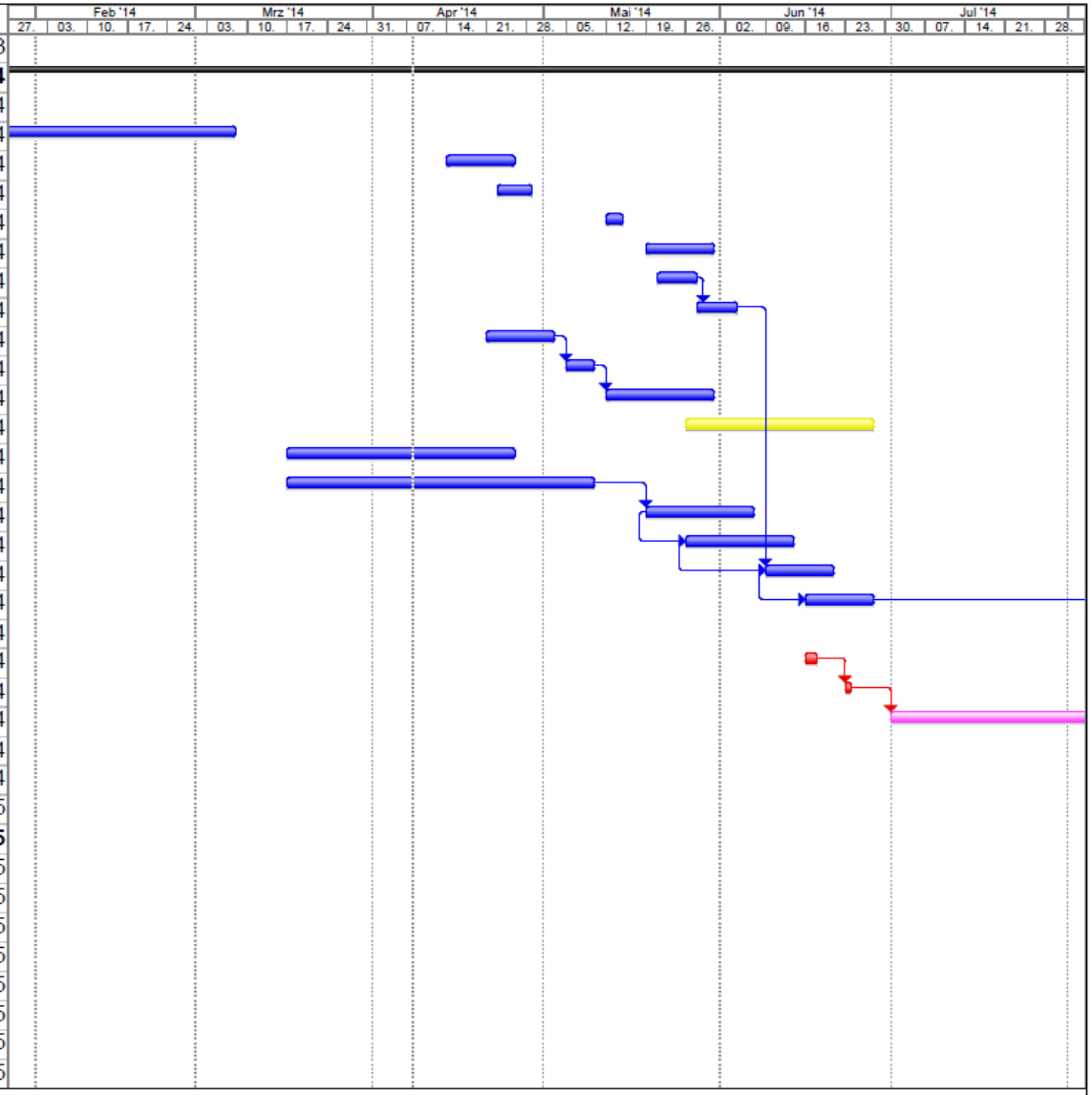




European XFEL

Schedule for the next steps

Nr.	Vorgangsname	Dauer	Anfang
1	Guntest	21 Tage	Mo 25.11.13
2	**Installationen1**	**203 Tage**	**Do 02.01.14**
3	Kühlwasserdemontage f. Cryo	7 Tage	Do 02.01.14
4	Cryoinstallation	2 Monate	Mo 13.01.14
5	Cryoinstallation-Ventilboxen	2 Wochen	Mo 14.04.14
6	Dump vergiessen	4 Tage	Mi 23.04.14
7	Dump Installation	3 Tage	Mo 12.05.14
8	Aufbau Laufgang	2 Wochen	Mo 19.05.14
9	Lieferung Poller	1 Woche	Mi 21.05.14
10	Pollereinbau XTIN	1 Woche	Mi 28.05.14
11	Aufbau Guntisch	2 Wochen	Mo 21.04.14
12	Einbau Guntisch XTIN	1 Woche	Mo 05.05.14
13	Verkabelung Guntisch	3 Wochen	Mo 12.05.14
14	Einbau Laserbeamline	5 Wochen	Mo 26.05.14
15	Lieferung Girder	6 Wochen	Mo 17.03.14
16	Vormontage Girder (Halle 1)	8 Wochen	Mo 17.03.14
17	Girder Reinraummont.	3 Wochen	Mo 19.05.14
18	Endmontage Girder (Halle1)	3 Wochen	Mo 26.05.14
19	Girderinstallation XTIN	2 Wochen	Mo 09.06.14
20	Vakuum Installation	2 Wochen	Mo 16.06.14
21	Verkabelung etc.	4 Wochen	Di 16.09.14
22	Interlockvorprüfung	2 Tage	Mo 16.06.14
23	Interlockprüfung	1 Tag	Mo 23.06.14
24	Gun 4.3 Commissioning mit Laser	11 Wochen	Di 01.07.14
25	Umbau auf Gun 4.x	4 Wochen	Di 16.09.14
26	Gun 4.x Commissioning mit Laser	10 Wochen	Di 14.10.14
27	3.9GHz fertig	0 Tage	Mo 16.02.15
28	**Installationen2**	**45 Tage**	**Mo 19.01.15**
29	Installation module racks,electronic	3 Wochen	Mo 19.01.15
30	Installation kalte Module	2 Wochen	Mo 09.02.15
31	LLRF cabling	3 Wochen	Mo 16.02.15
32	LLRF commissioning	2 Wochen	Mo 09.03.15
33	Kaltfahren	1 Woche	Mo 23.03.15
34	Modulkommissioning	3 Wochen	Mo 30.03.15
35	Interlockprüfung	1 Woche	Mo 30.03.15
36	Injektorinbetriebnahme	9 Monate	Mo 06.04.15



Projekt: InjektorUebersicht
Datum: Di 08.04.14

Vorgang | In Arbeit | Sammelvorgang | Externe Vorgänge | Stichtag
Unterbrechung | Meilenstein | Projektsammelvorgang | Externer Meilenstein

European XFEL

Longer perspective until mid of 2015

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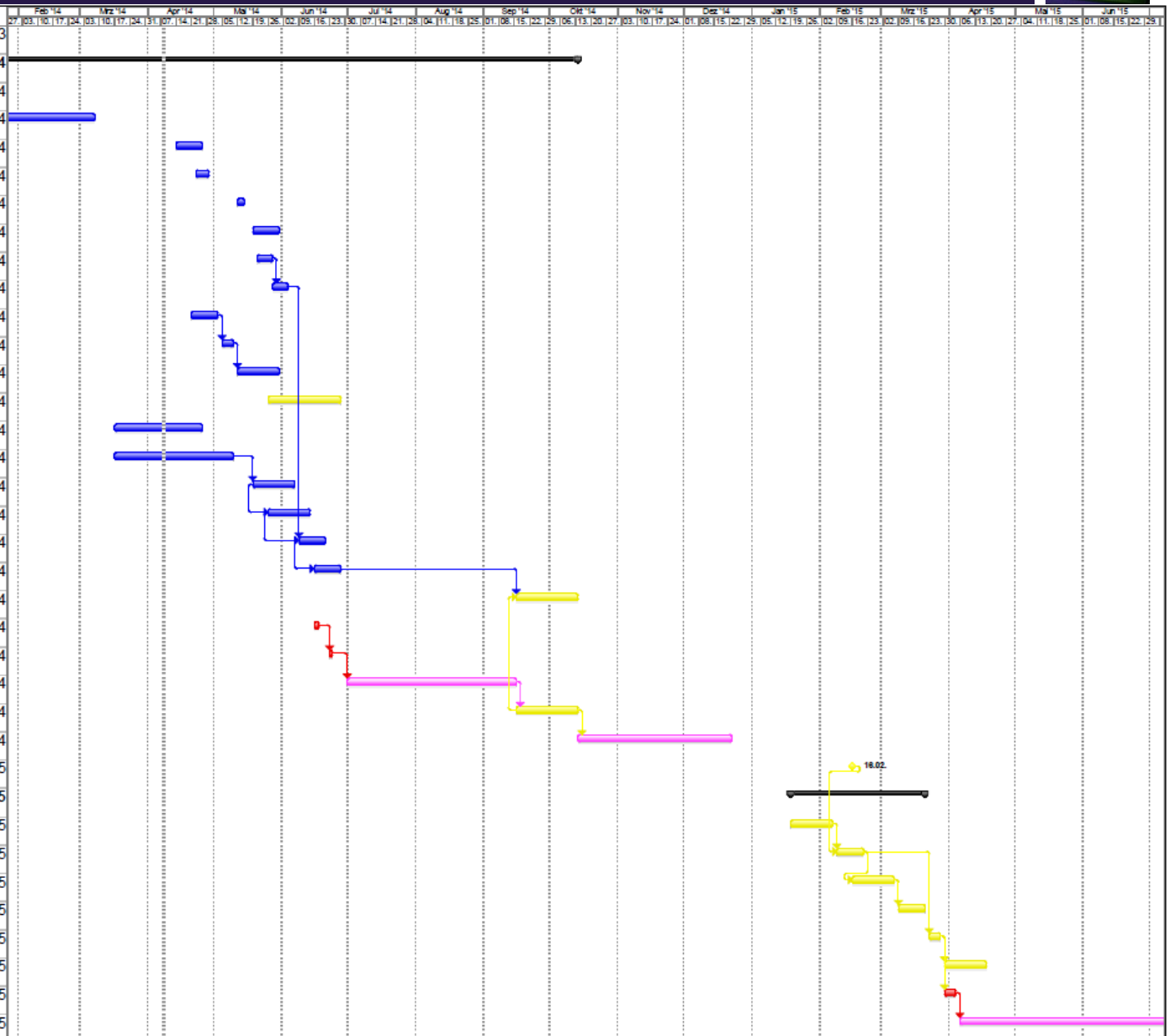

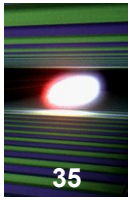

Thank You !