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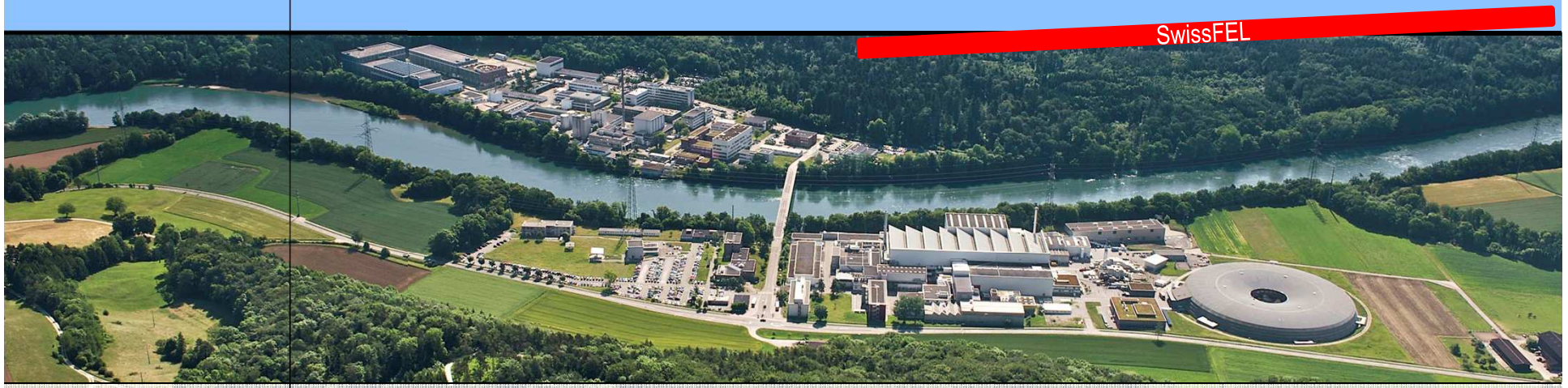


Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut

Status and Progress at SLS and SwissFEL

18.09.2013

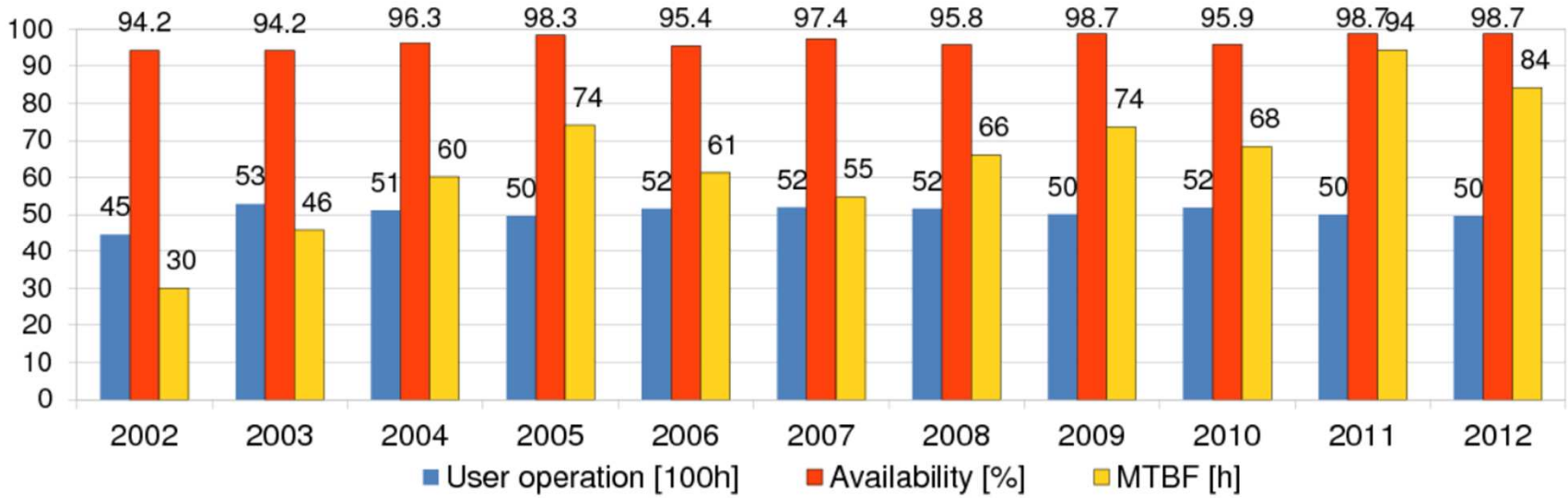
Paolo Craievich on behalf of RF group

17th ESLS-RF Workshop, Helmholtz Zentrum Berlin, 18-19 September 2013

Outline

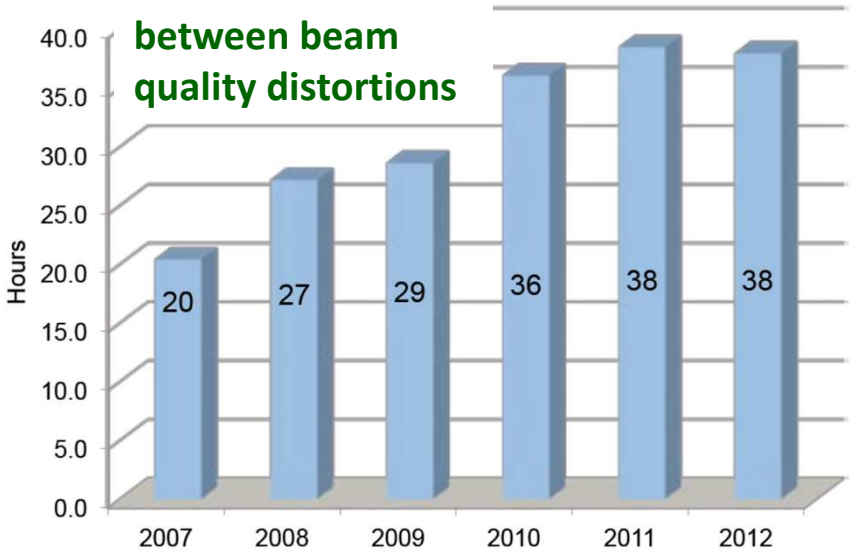
- **SLS operation statistics in 2012**
- **Major failures in 2012 and 2013**
- **SLS RF upgrade programs**
  - → 500 MHz test-stand
- **SLS extraction line**
- **SLS upgrade perspectives**
- **Status of RF for SwissFEL project**
  - → **Building site**
  - → **C-band test-stand**
  - → **Injector test facility**

SLS Operation Statistics



- The beam availability in 2012 again reached 98.7%
- **MTBF was 3.5 days**
- Number of "incident" about the same as in 2011
- Beam quality distortions that influence quality of experimental data: significantly improving over past sis years
- **More than 1.5 days between any of these beam distortions**

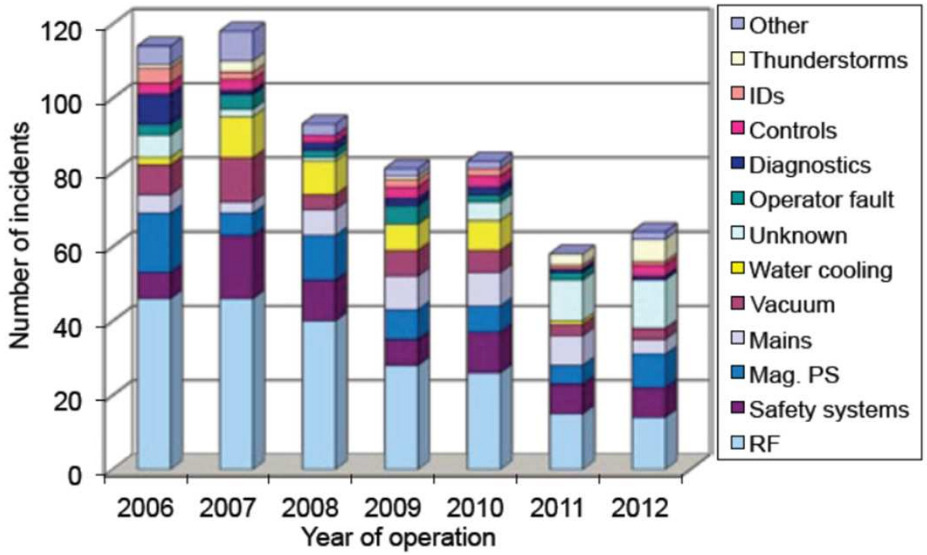
Mean time between beam quality distortions



Ref.: A.Lüdeke et al., PSI annual report 2012

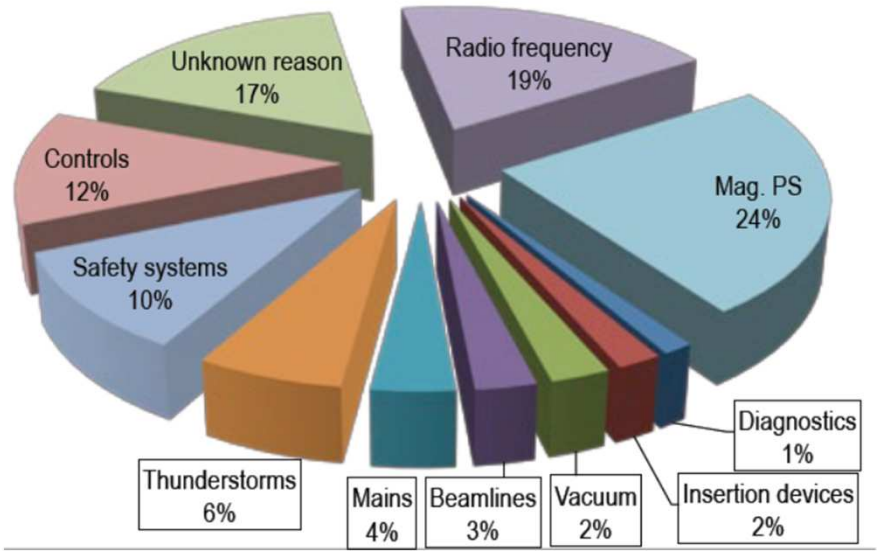
SLS Operation Statistics in 2012

Beam outage count per failure category



- New RF interlock system has helped improvement over last period

- The statistical increase in the number of beam losses by unknown sources was most likely the result of an **upgrade of the RF interlock systems**, which now avoids the false assignment of certain failures to the RF systems

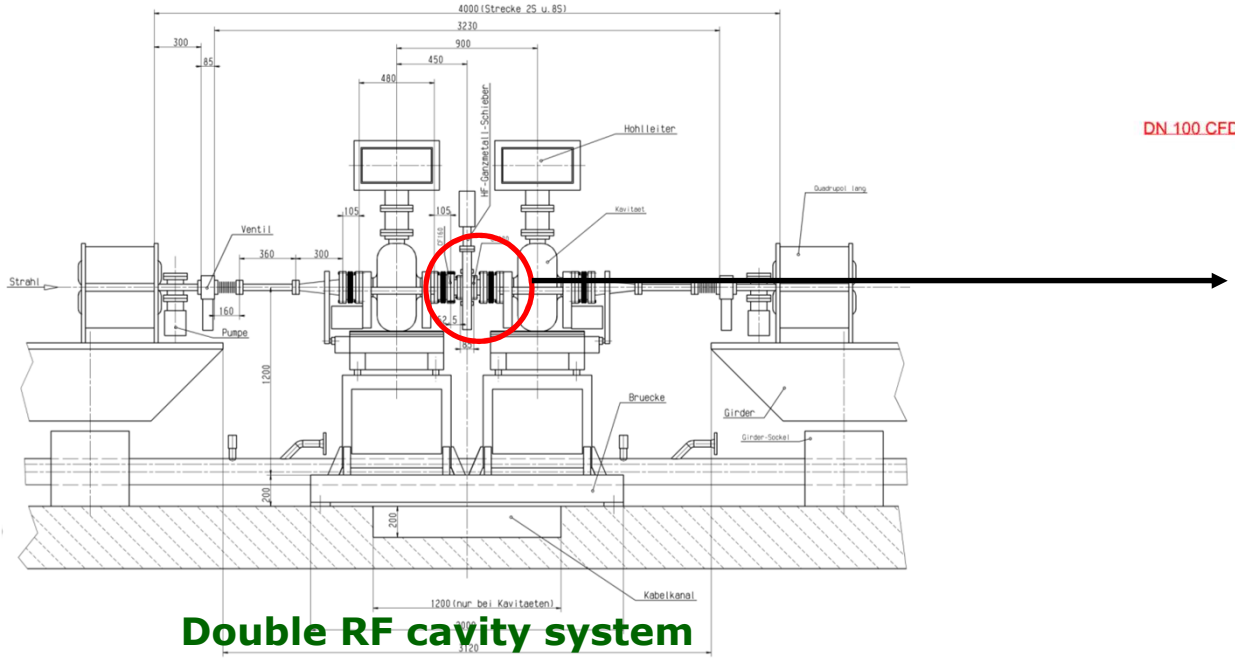


Ref.: A.Lüdeke et al., PSI annual report 2012

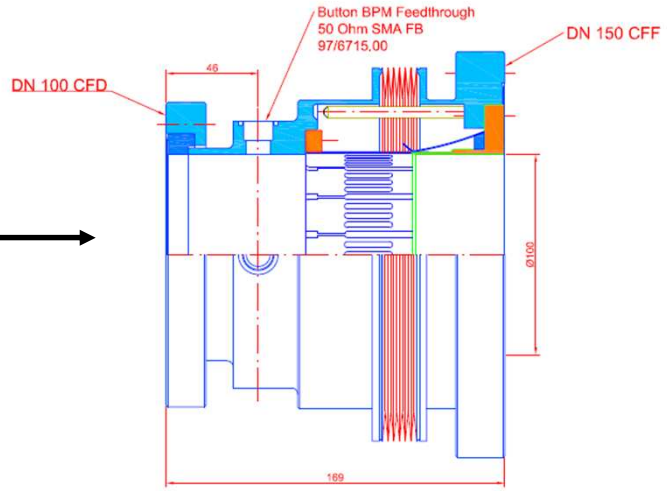
Beam outages per failure category in 2012

Major Failures in 2012 (1/2)

- **Reduced beam current of 350 mA** in the first 8 weeks due to coupled bunch mode (+71), causing beam instabilities and sudden beam losses
  - Several unsuccessful attempts were made to tune the higher order modes of the cavities
  - Problem seemed to be resolved by changing the RF frequency slightly
- **Two new tools for the investigation:** capacitive pickups in the input coupler (already installed) and BPM bellows with SMS feed-through



Double RF cavity system

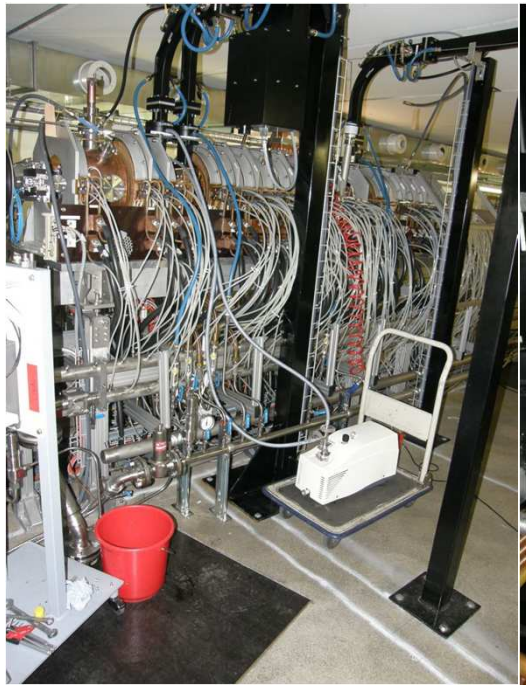


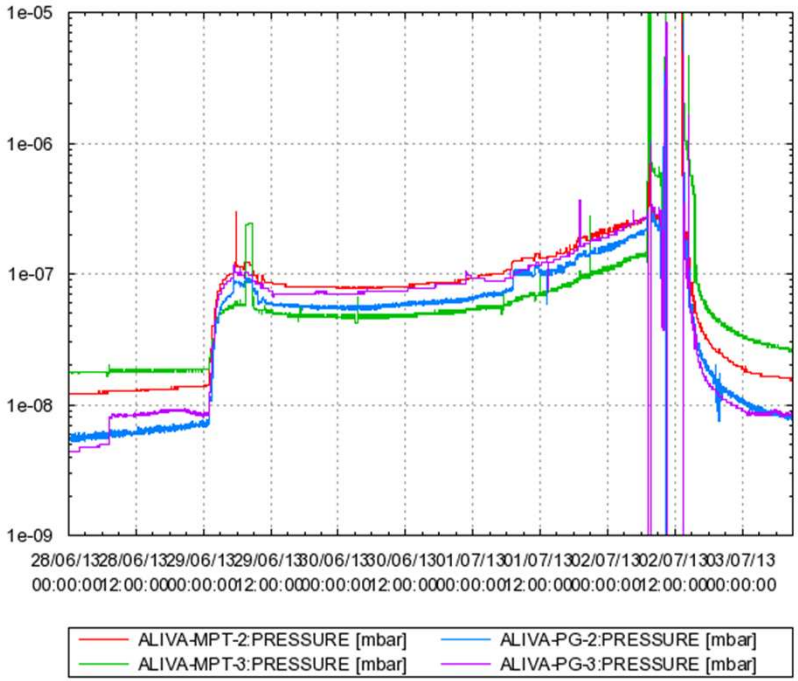
Major Failures in 2012 (2/2)

- **Shutdowns extensively used for preventive maintenance**
  - **Six water** leaks in the cavity cooling system were found and sealed during 2012 shutdowns, some leaks that had been sealed with glue several years ago had reopened.
  - One water leak came out just after a shutdown. The **48 hours needed to seal this leak** were spent during machine development time and *therefore do not show up in the downtime statistics.*
  - In 2008, such interruptions caused a total of **98 hours of downtime.**
- In order to achieve a permanent solution for the problem of recurring water leaks in the RF cavities, **it is planned to replace all cavities**
  - First one in January after RF conditioning in October
- Contamination of heat-exchanger in cryo-plant of S3HC (required warm-up and regeneration during October shutdown) – no downtime
- Problems with temperature measurement system of S3HC (5h+3h)

Major Failures in 2013

- **Accumulation issue still due to coupled bunch mode (+71)**
  - Partially solved by applying small phase modulation to the RF accelerating voltage
- **S3HC: replaced insulation vacuum pump due to defective Maxi Gauge controller (8h)**
- **Water leak in the RF window on the S-band pre-buncher**
  - Temporary solution: pre-vacuum in the cooling pipe
  - Reforming of the cathode
  - After replacement arcs in the sub harmonic pre-buncher





- **S3HC: 4 days downtime due to serious Helium contamination**

SLS RF Upgrade Programs

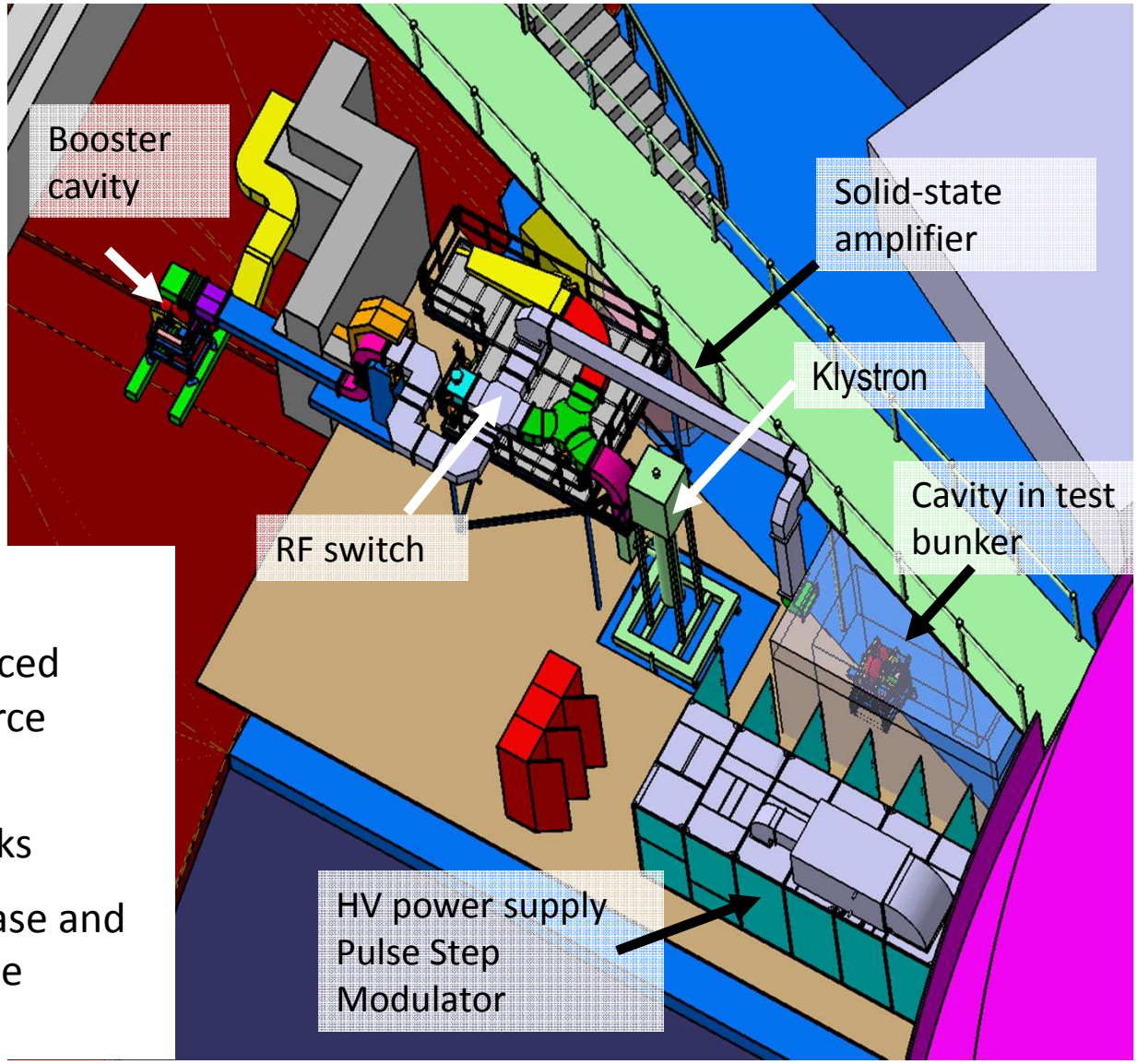
Accomplished

- Fire protection for LINAC modulators installed
- All storage-ring coincidence arc detectors installed
- Spare 500MHz RF cavities received from ELETTRA
- S3HC spare valve-box constructed at PSI workshop
- All Input Power Coupler replaced
- Bead-pull measurement on first RF cavity
- Support-frame for one Klystron was modified

Work in progress:

- **500 MHz test-stand**
- 60 kW Solid-state amplifier
- Planned to replace one storage-ring cavity per year
- Fire detectors for storage-ring klystron power supplies
- Refurbish Klystrons, optimize efficiency and repair cooling circuit (on going) - CPI
- Spare solenoids for LINAC in construction (expected delivery by 2013)

500 MHz test-stand



Motivations:

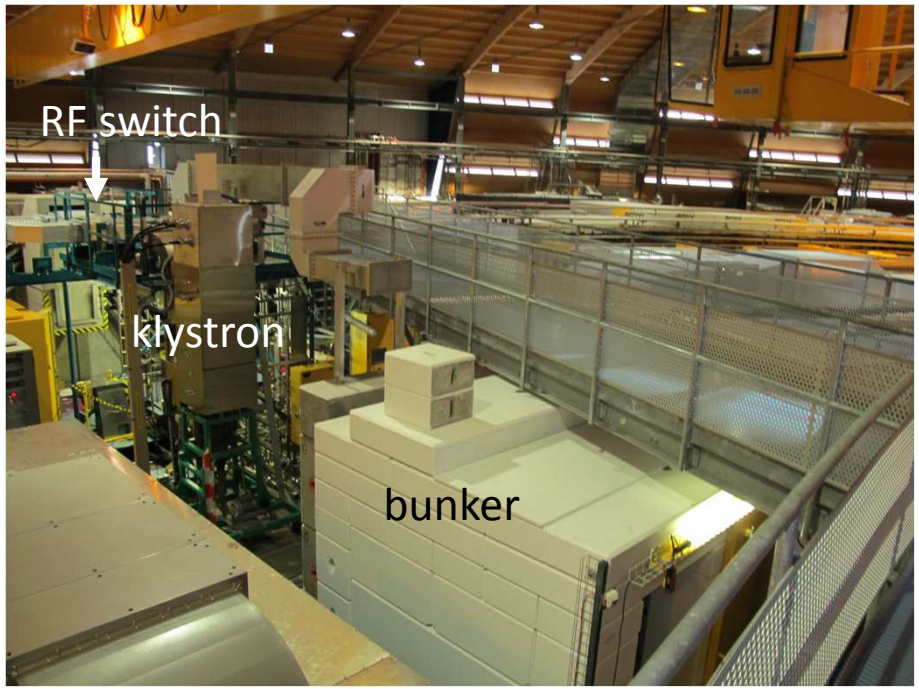
- Klystron by EEV is not produced anymore → test of new source
- Actual storage ring cavities continuously have water leaks
- Spare part of amplitude, phase and tuning loops are not available anymore

Ref.: L. Stingelin

500 MHz test-stand: status

Tasks in the test stand:

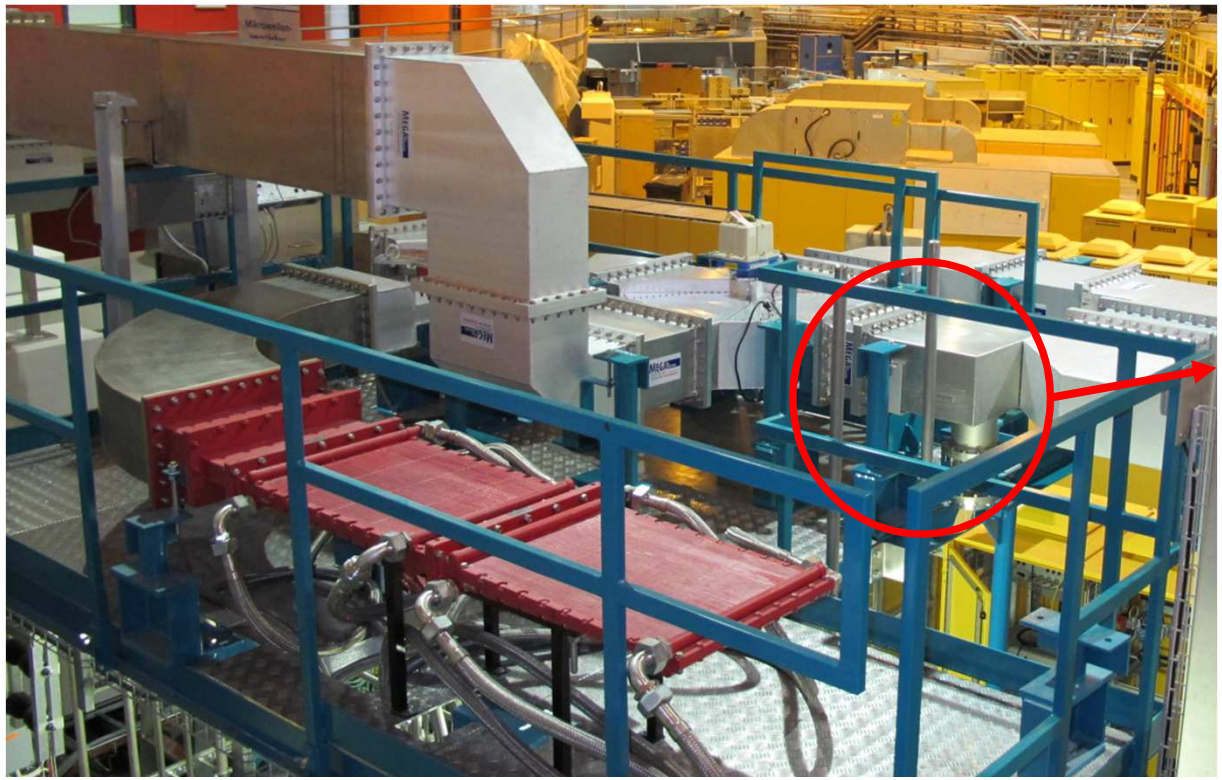
- Nov-Dec 2013: conditioning and test of new input coupler
- Nov-Dec 2013: conditioning of the first cavity
- Test of the solid-state amplifier from October 2013
- Test of the regenerated and repaired klystrons (2014)
- Test of amplitude, phase and tuning loops (2014)
- Training gym for picket group

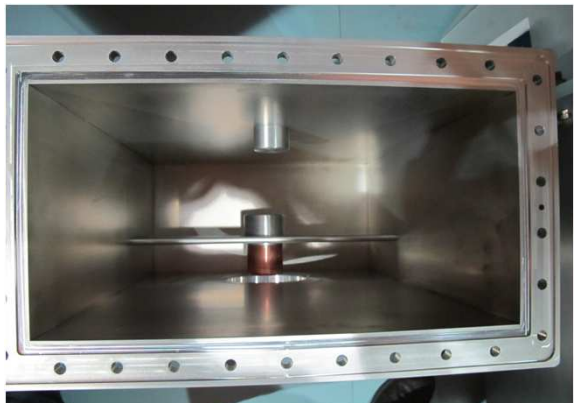


500 MHz test-stand: RF switch

SPX COMMUNICATION TECHNOLOGY Raymond, ME

- Standard Waveguide WR 1800 H-plane 4-Port Motorized Switch
- Impedance 50 Ω
- Average power ≤ 300kW, Peak power 124 MW
- Insertion losses ≤ 0.02B, VSWR ≤ 1.03, Isolation > 70 dB
- Switching time: 6 s



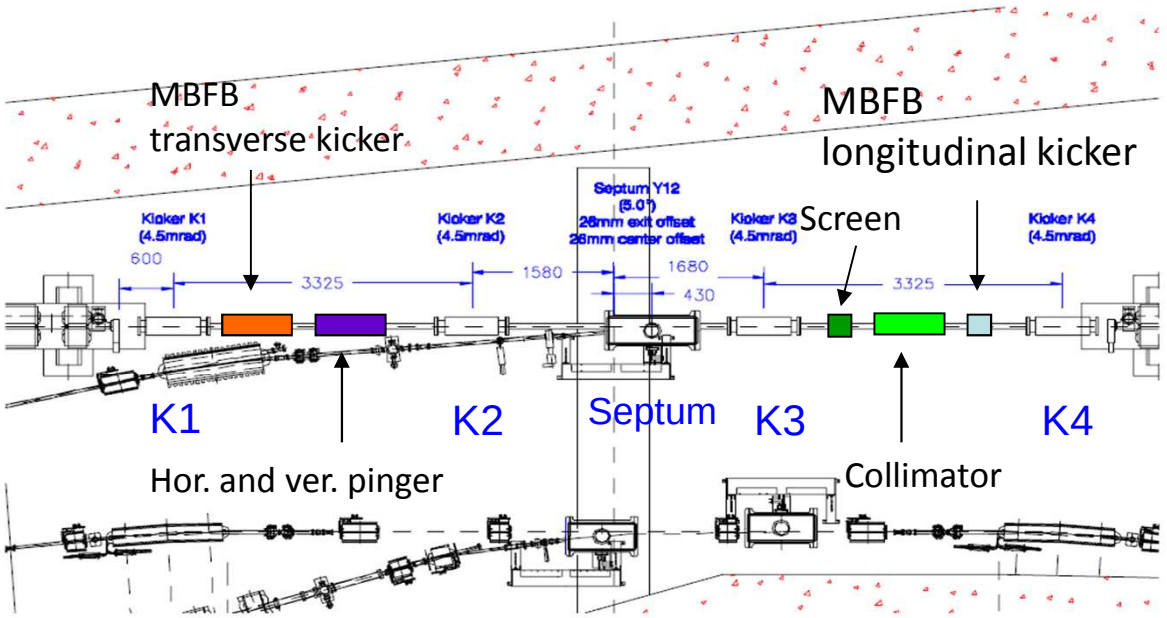


Coax-to-WG transition (MEGA)

SLS “extraction line”

Motivation

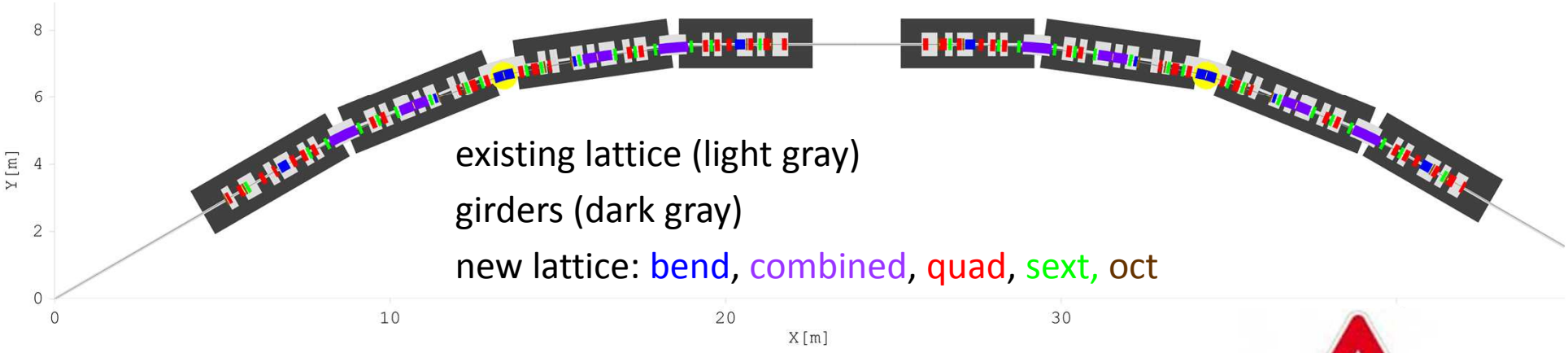
- Direct measurement of beam parameters
- Comparison with measurements in the storage ring
- Compact beam line to fit into the existing tunnel (with small extension)
- In-house experiences on beam measurements from SLS and SwissFEL injector linac



- Several options under study
- Need a fast horizontal or vertical kicker and septum
- Slowest raise time about 1 μs for 1 bunch
- Flat-top flatness not very important

Ref.: M. Aiba et al., Extraction beam line for light sources, IPAC 2013

SLS-2 upgrade dreams



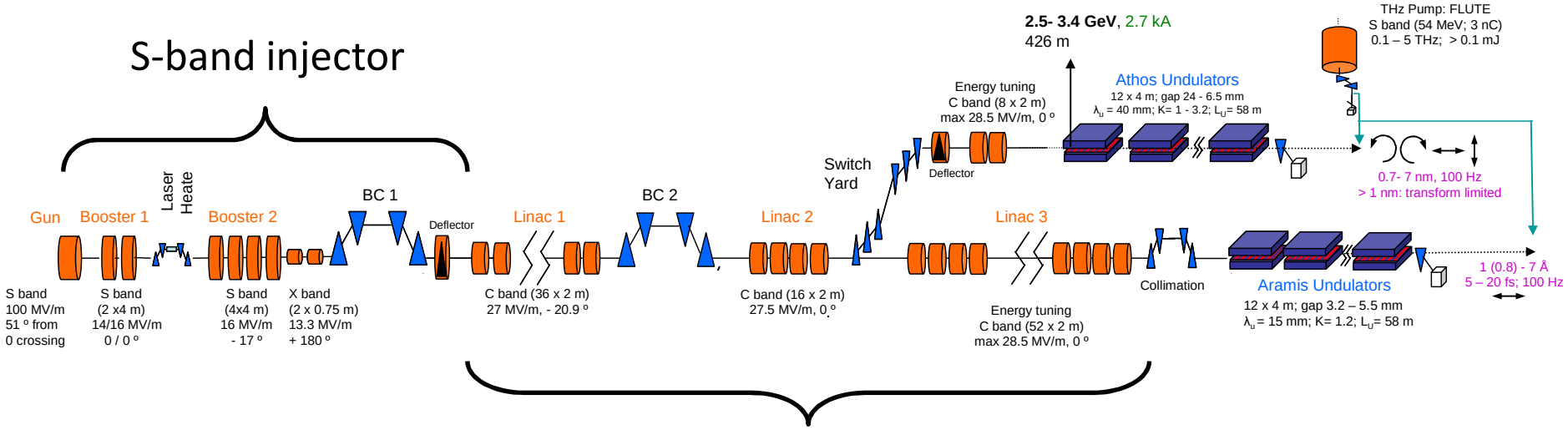
- **SLS** emittances : ε_x **= 5.5 nm** , ε_y ~ 1...10 pm
- Emittance for next generation: < 1 nm
- keep all beam lines (ID & bends)
- re-use girder system and injector complex
- **emittance 250...400 pm**

  @2.4 GeV, in 288 m circumference with 12 straights
- 5.7 T LGSB (*longitudinal gradient super bend*)
- small magnet bore Φ = 24 mm

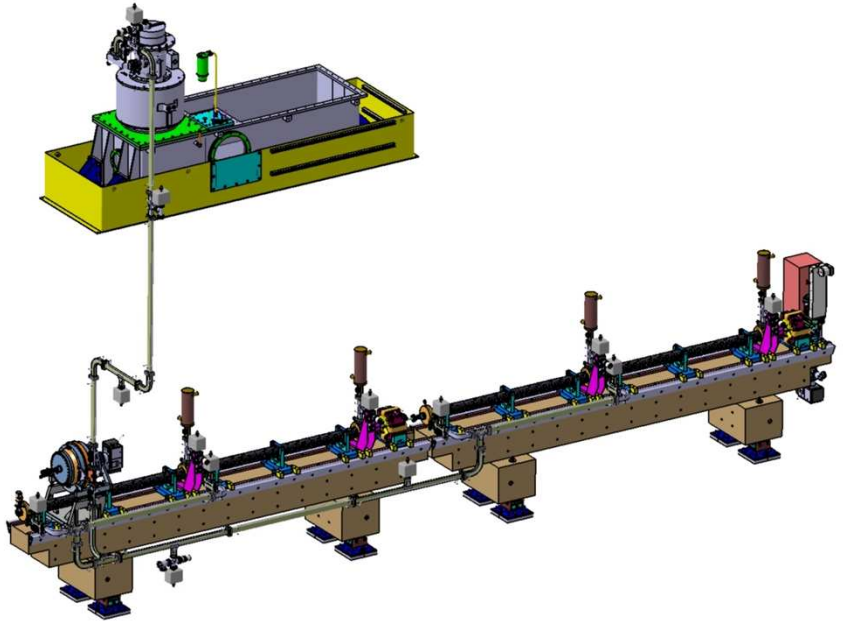
! DRAFT ! feasibility to be still verified

Ref.: A. Struen

SwissFEL project

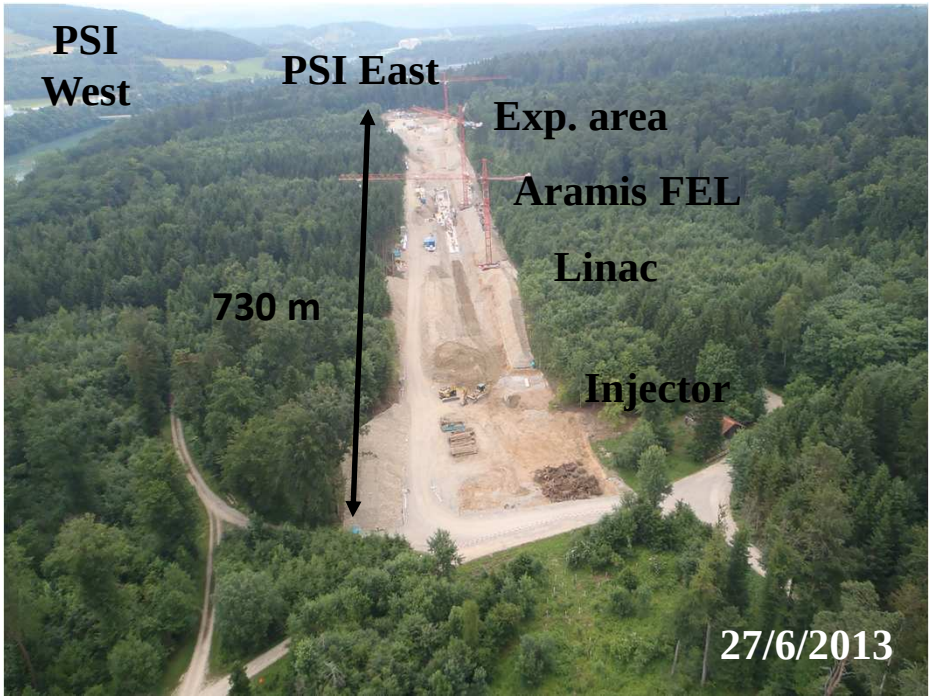


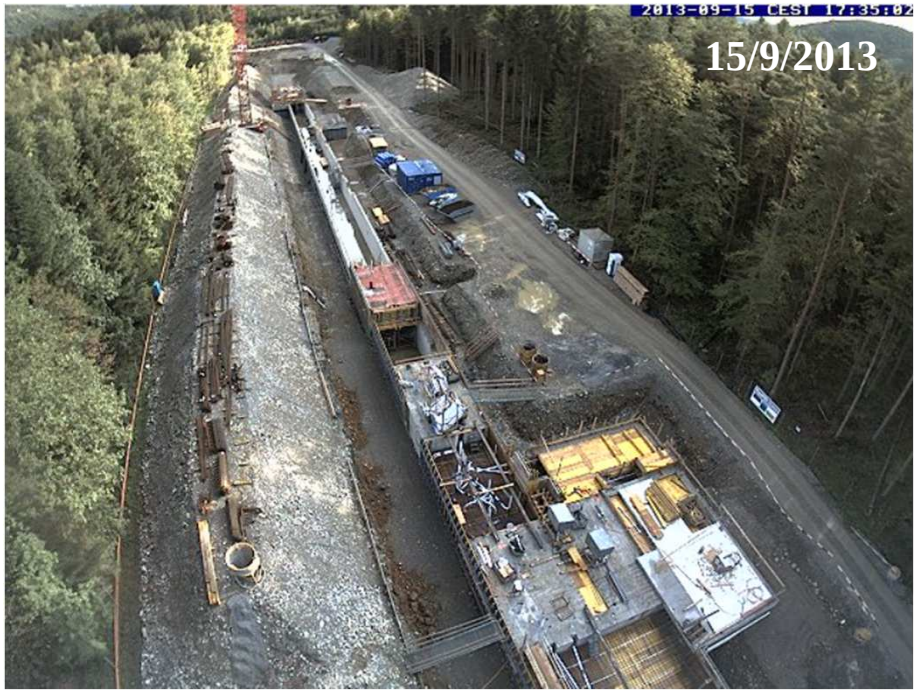
Key parameters		
Wavelength	1-70	Å
Pulse duration	3-20	fs
Beam Energy	5.8	GeV
Bunch charge	10-200	pC
Repetition rate	100	Hz
Slice emittance (design)	0.18 (10 pC) 0.43 (200 pC)	µm
Slice energy spread	250-350	keV
Saturation length	<50	m



SwissFEL building site

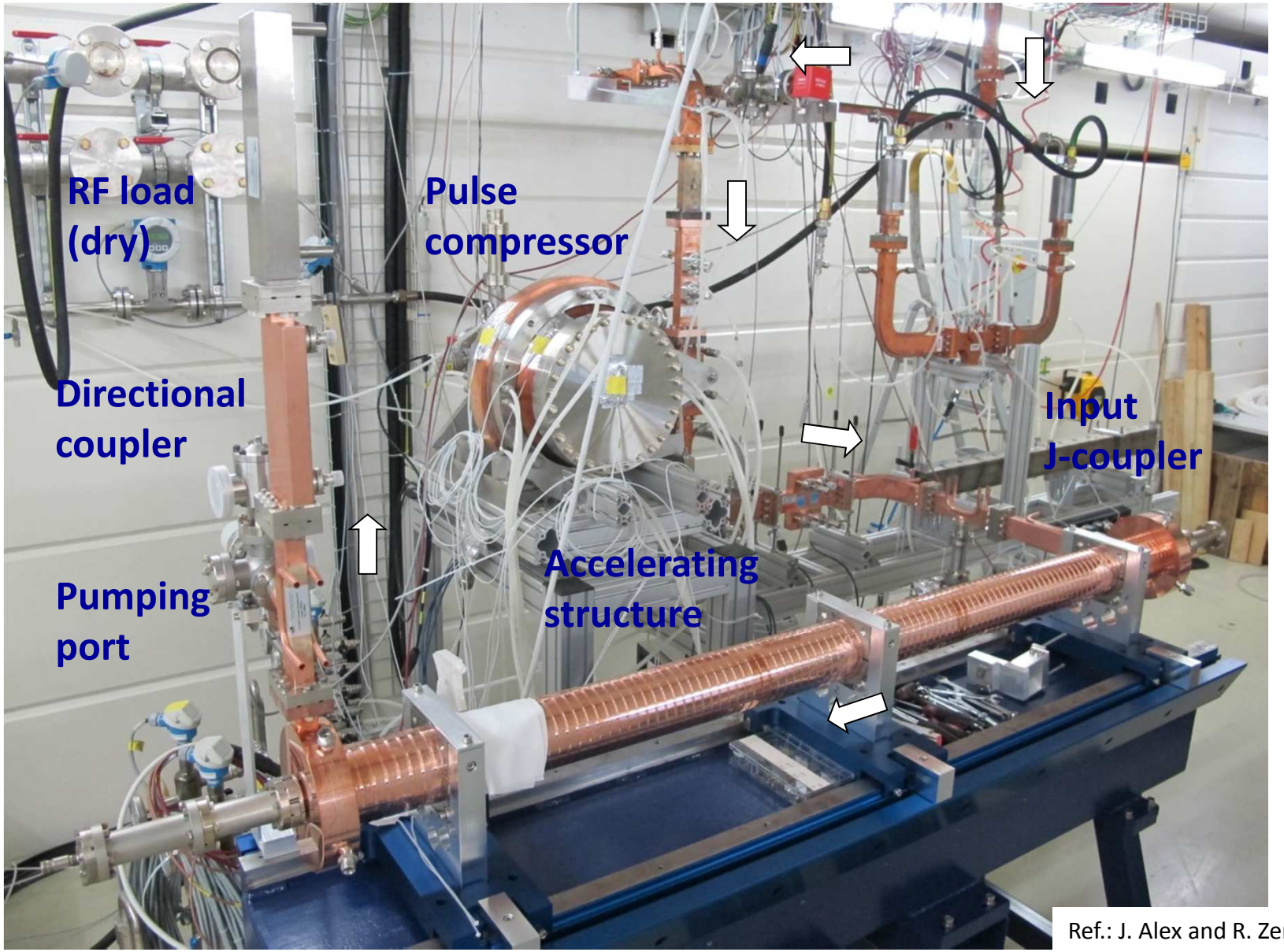
- Construction started in 2013
- Ground breaking in April 2013
- Laying of the foundation stone on July 3rd
- Building handover in December 2014





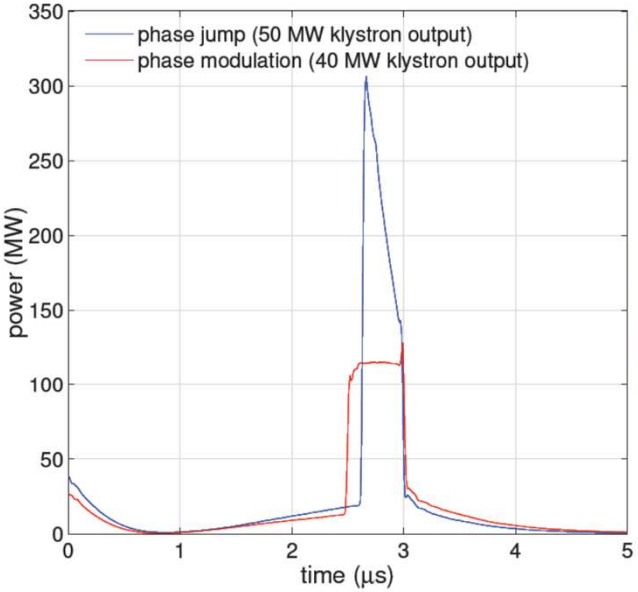
- Commissioning planned to start in 2015
- User operation for Aramis planned in 2017
- Athos line planned for 2019

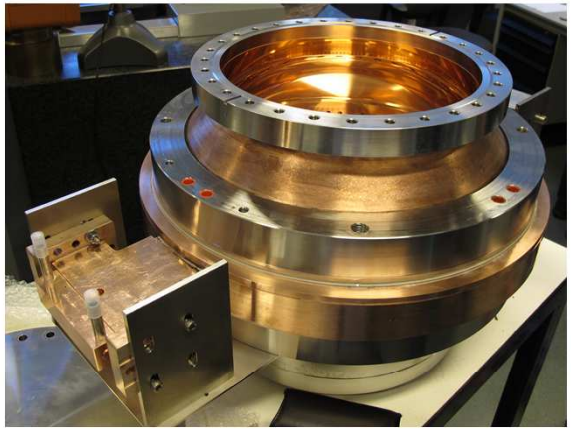
SwissFEL C-band test-stand



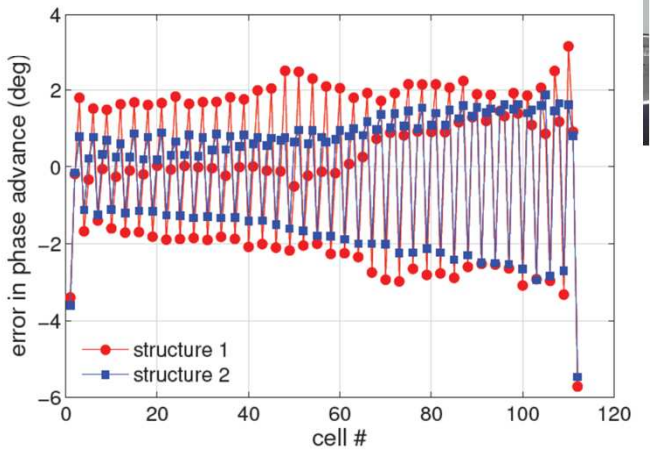
Ref.: J. Alex and R. Zennaro

SwissFEL C-band test-stand: achievements

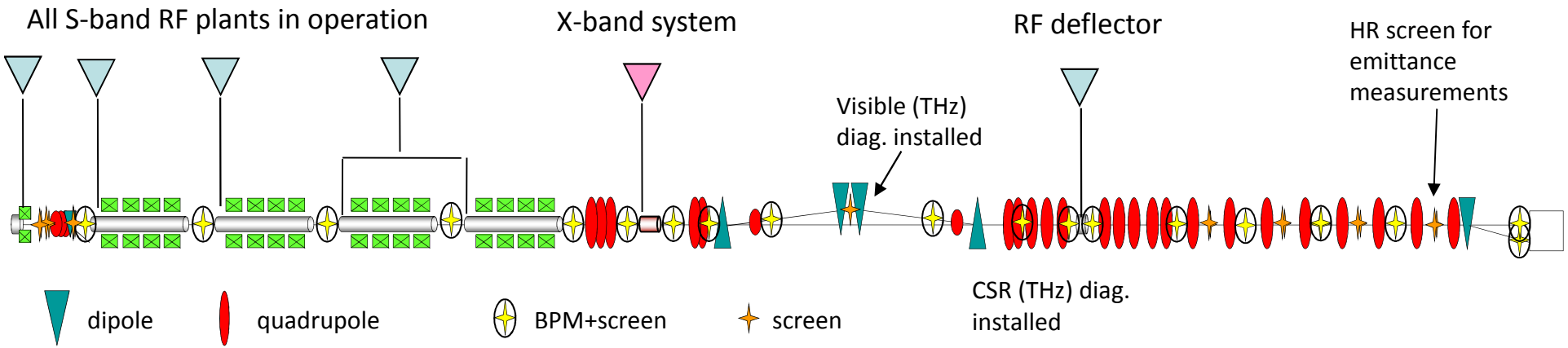




- SwissFEL energy gain requires 28 MV/m @100Hz
- Actually we have on the first accelerating structure >28 MV/m @ 100 Hz with both phase jump and phase modulation and BDR<1e-6
- Next step: conditioning of the full C-band module (4 RF structures with pulse compressor).



SwissFEL Injector Test Facility (SITF)



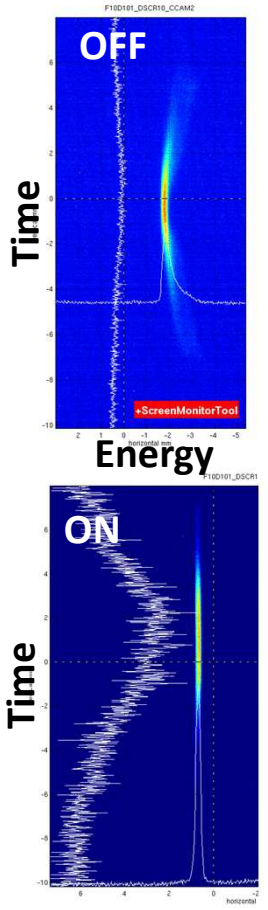
- Maximum beam energy 270 MeV
- Emittance after a full optimization:

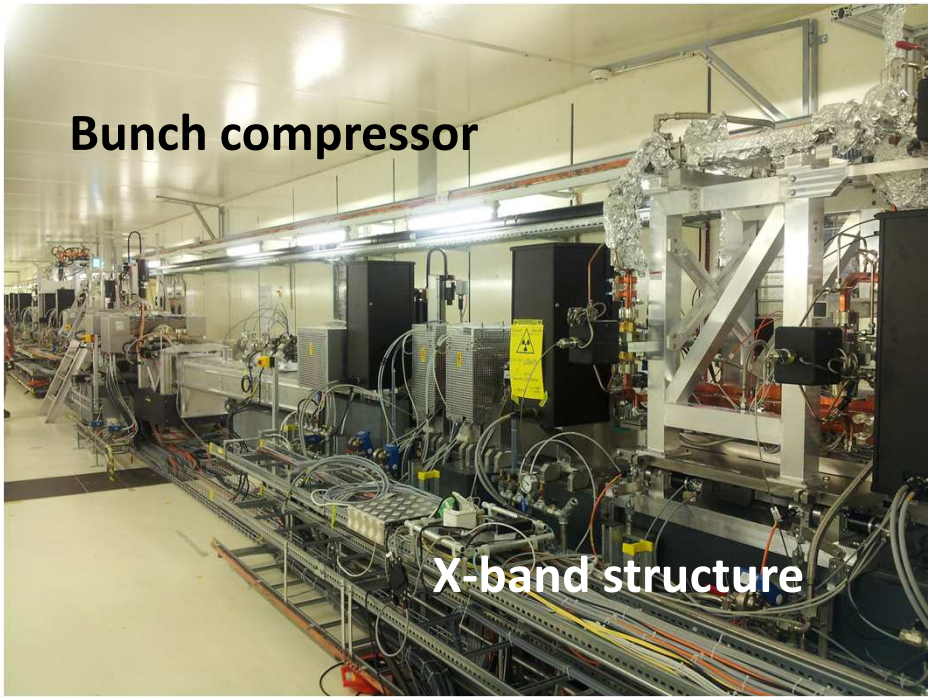
	200 pC	10pC	Unit
Projected emittance	~0.30	~0.15	μm
Slice emittance	~0.20	~0.10	μm

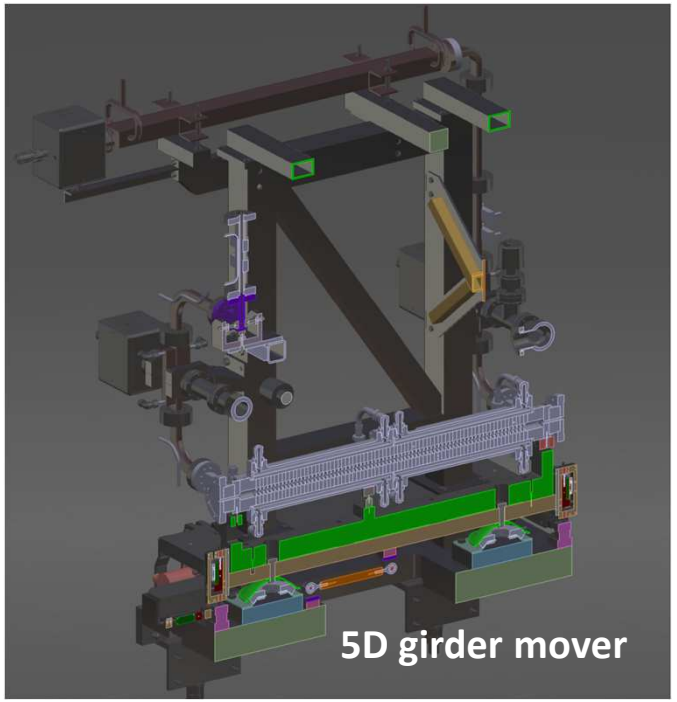
- These emittance values fulfill the SwissFEL requirements for uncompressed beam
- X-band system available from April 2013 (**21MV @18MW and 10Hz**)
- Installation of the new PSI RF gun and undulator experiment in November 2013

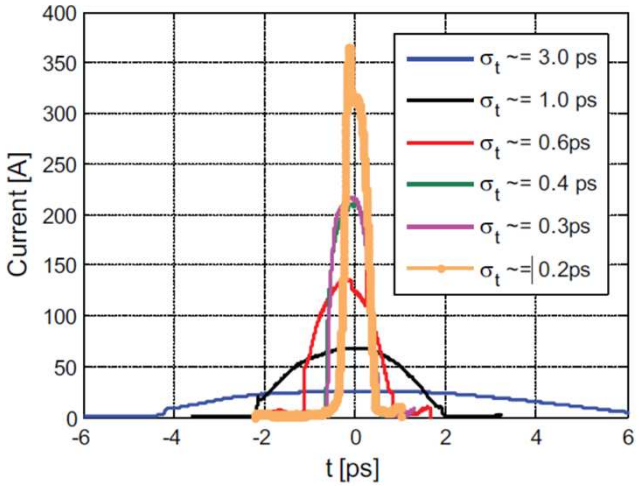
Ref.: IPAC 2012 and FEL 2013

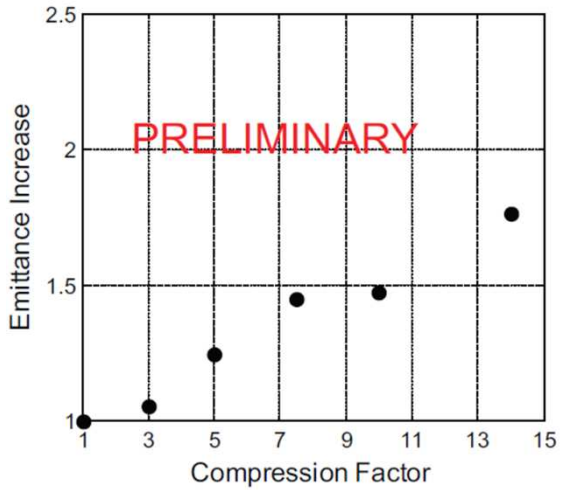
SITF: X-band and linearized compression











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Thanks for your attention