PAUL SCHERRER INSTITUT

SWISS LIGHT SOURCE SLS + SwissFEL

SLS and SwissFEL Status

Andreas Streun
Paul Scherrer Institut, Villigen, Switzerland

News from the SLS

- Operation
- Optics corrections
- U14 CPMU operation
- Outlook

News from SwissFEL

- Layout & parameters
- Operation modes
- Accelerator design
- Prototype R&D
- Injector commissioning
- Summary

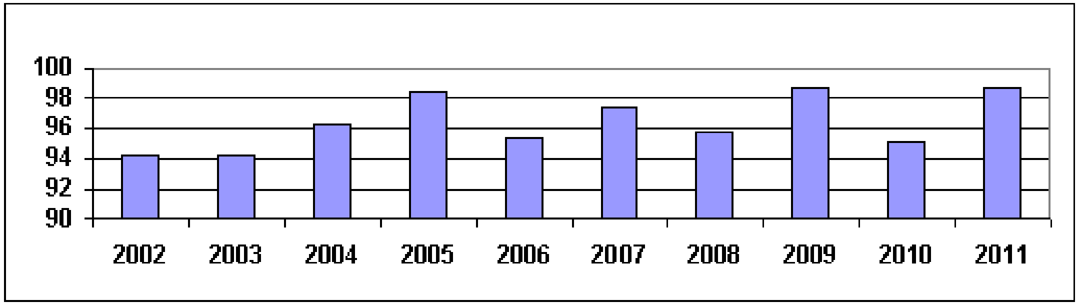
ESLS XIX meeting, Aarhus, Nov. 23-24, 2011

Operation

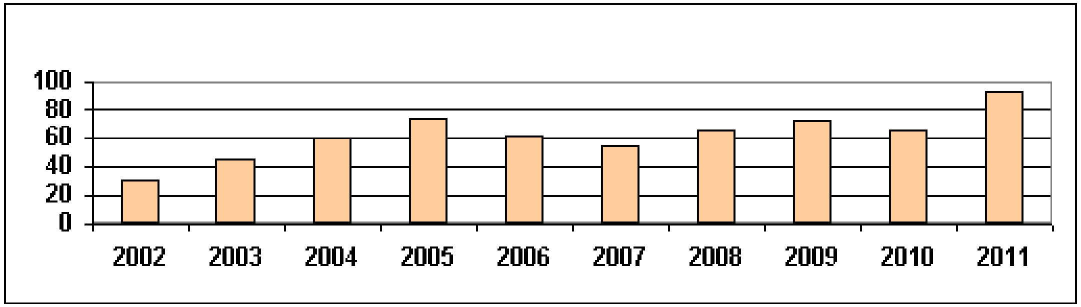
...SLS in 10th year of user operation: 18 beam lines

Performance

Availability 2011 98.7%



Mean time between failures: 92 h



Record: 325 hrs!

Coincidence arc detectors

⇒ no arc interlocks from RF anymore!

In 10 years we had 200 unnecessary beam losses due to fake arc alarms!

Optics correction

Comparative study

Results on beta beat correction (x / y, RMS)
(Measurement vs. design model)

QV (tune shift from quad variation)	4.0% / 3.2%
LOCO (fit to response matrix)	2.0% / 2.0%
TBT (turn by turn data)	1.4% / 3.6%

Required BPM synchronization upgrade and
data reconstruction to eliminate turn-to-turn crosstalk.

- M. Aiba, *Comparison of linear optics correction means at the SLS,* Proc. IPAC-2011 → subm. to PRSTAB IPAC Special Edition

U14 CPMU in operation

Jan 2011

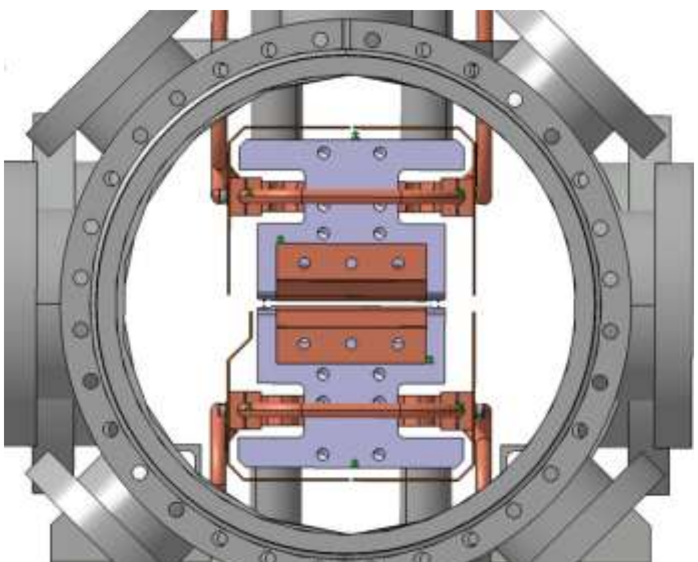
Cryogenic permanent magnet undulator

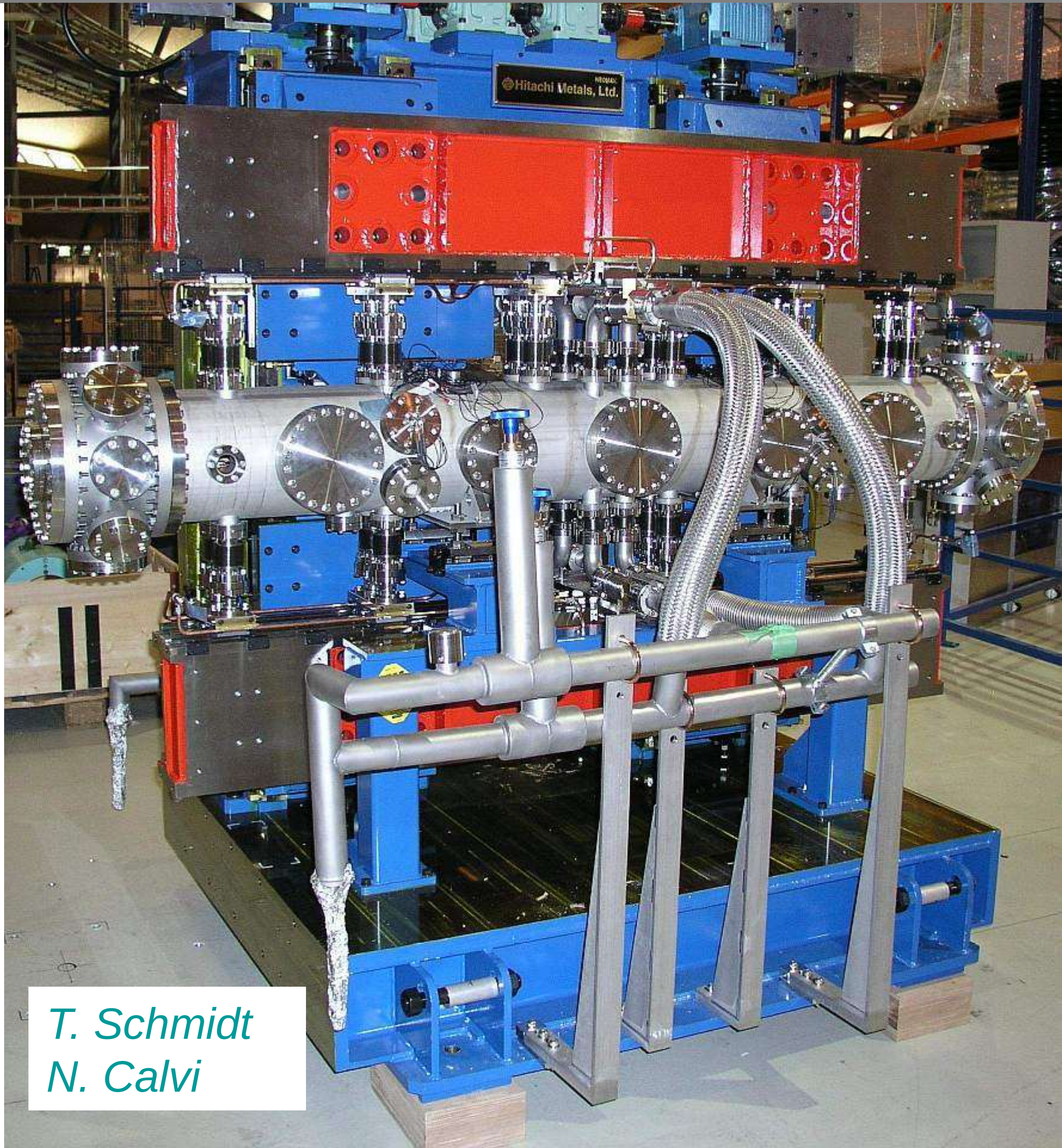
NdFeB at 135 K

Period 14 mm, Length 1.6 m

Minimum gap 3.5 mm
operational 4.0 mm

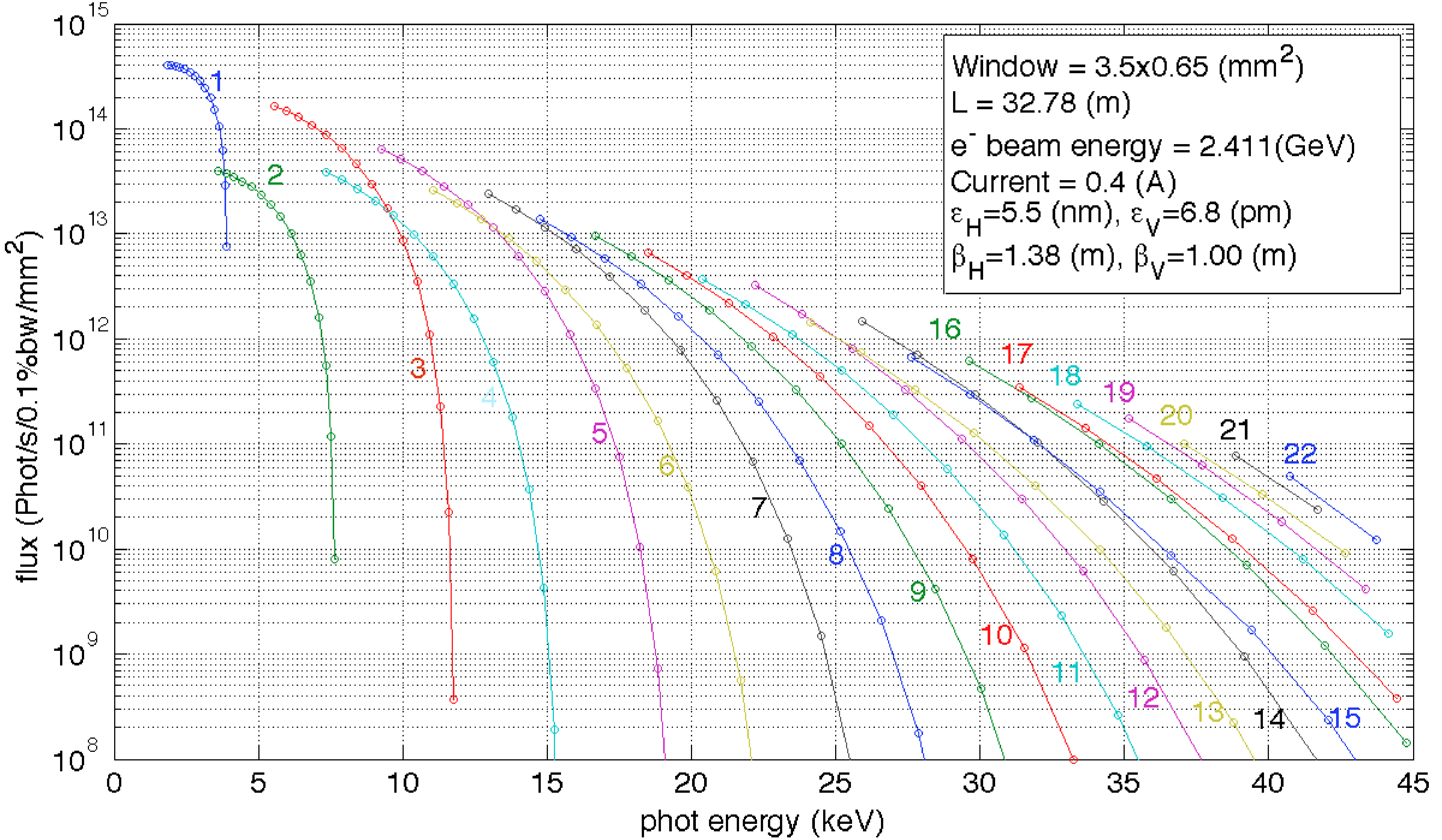
+ impedance optimized vertical collimator (Oct 2010)





T. Schmidt
N. Calvi

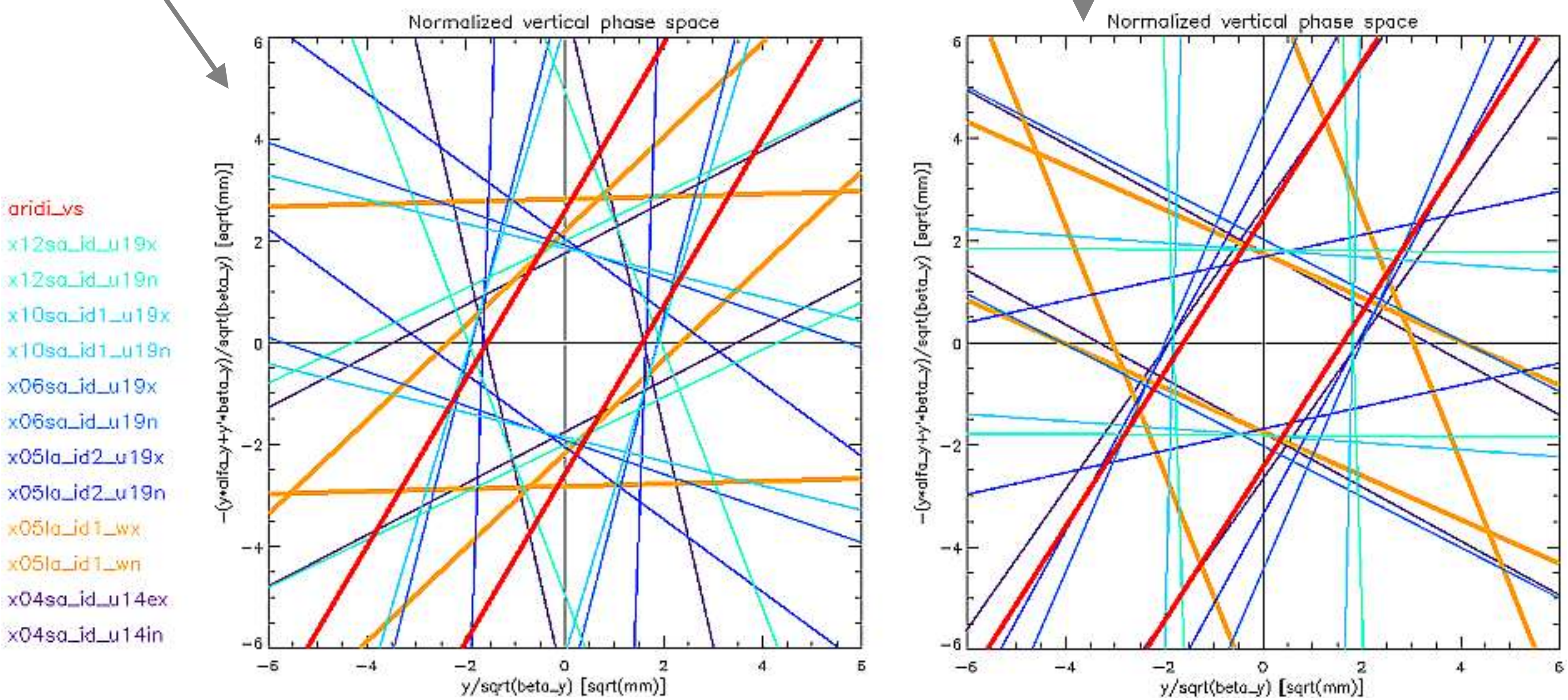
U14 flux curves



Phase error < 2.5° RMS for gap 4..6 mm ⇒ 50% at n = 19

Radiation and vertical acceptance

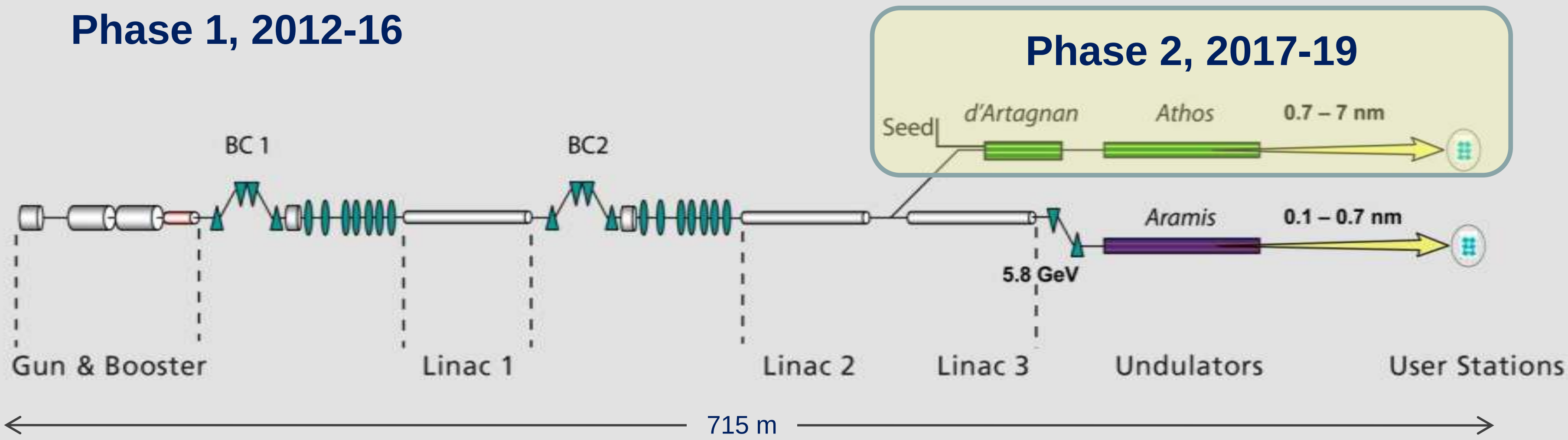
- **Radiation level at U14**
  compared to other in vacuum undulators (4.5 mm gap):
  U14 @ 4 mm gap: × **5...10**; @ 3.5 mm gap: × **25...50**
- **Acceptance definition**
  vertical collimator and FEMTO wiggler chamber
  not orthogonal ($\Delta\mu_y$=196º) at nominal tune Q_y=8.74
  ⇒ losses in **U14**. → would be better with Q_y=9.35 (NLD ☠)



SLS Outlook

- User operation
  - 2012: commissioning of 19^{th} (last?) beam line PEARL
- Evaluation “SLS 2020”
  - no major upgrade planned (e.g. lattice modification)
  - instead:
    optimize interfaces machine / beam line / experiment:
    - more work on photon BPMs:
      - blade XBPM integration in orbit feedback
      - development of residual gas based photon BPM
    - integrated models of machine & beam line
- Maintenance
  - replacement of all four RF cavities 2012
  - new BPM system 2014
- Beam dynamics
  - vertical emittance minimization → *tomorrow’s talk*

SwissFEL: layout & parameters



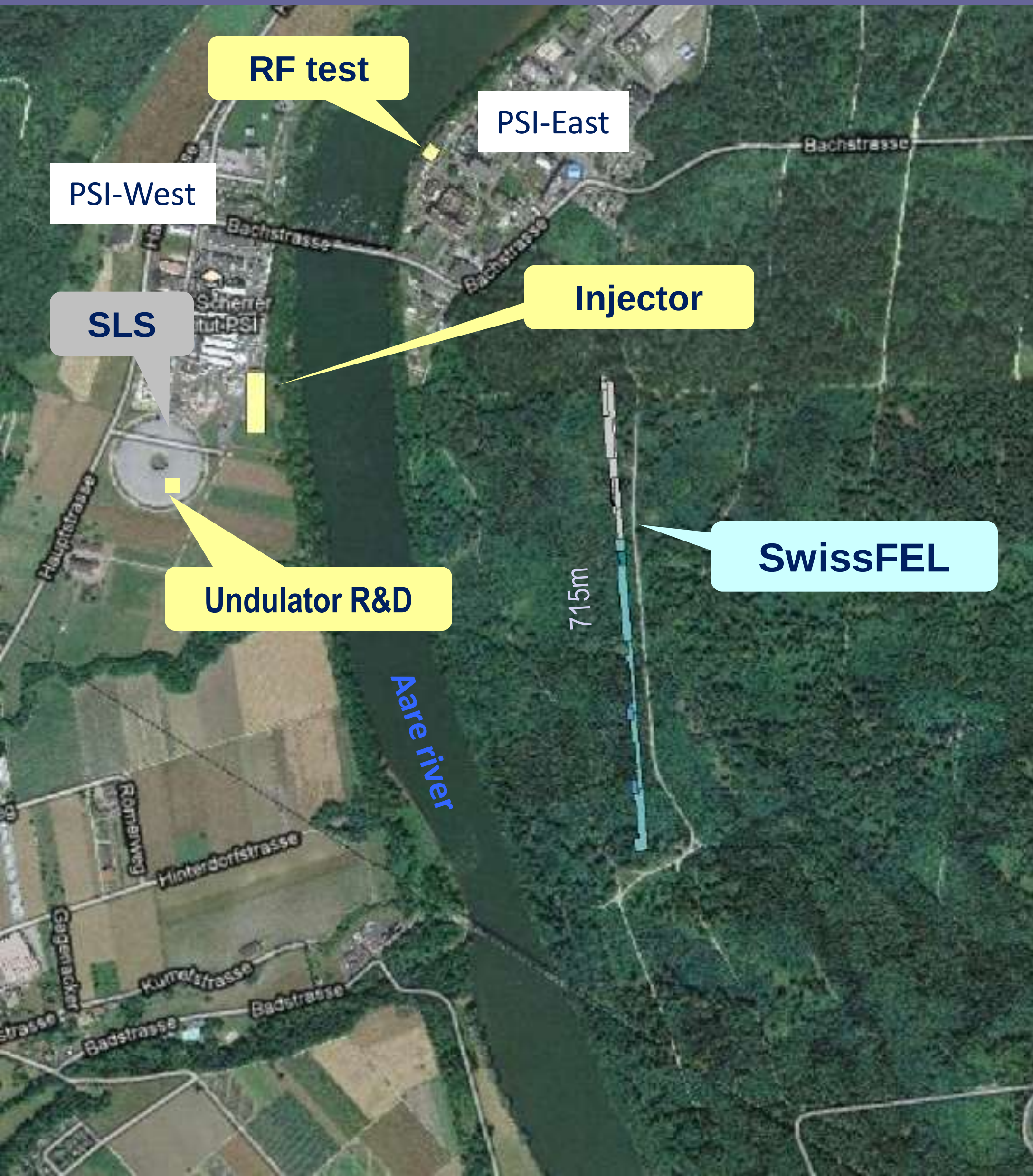
Aramis: 1-7 Å hard X-ray SASE FEL.
In-vacuum , planar 15 mm period undulators with variable gap.
User operation from mid 2017.

Athos : (2nd phase) 7-70 Å soft X-ray FEL for SASE & seeded operation .
APPLE II undulators with variable gap and full polarization control.
User operation end 2019.

Beam parameters:

$E_{max} = 5.8$ GeV	$\varepsilon_n = 0.35\ \mu m$	$\Delta E = 350$ keV
$Q = 10..200$ pC	$I_{peak} = 3$ kA	100 Hz rep.rate

SwissFEL: site & CDR



http://www.psi.ch/swissfel/

Operation Modes

Wakefield Limited ← **Charge** → Diagnostic Limit

- Standard operation
- 200 pC
- Maximum FEL pulse energy
- Longest FEL pulse length

- Lowest charge operation
- 10 pC
- Short FEL pulse length
- Single-spike in soft X-ray

Special Cases

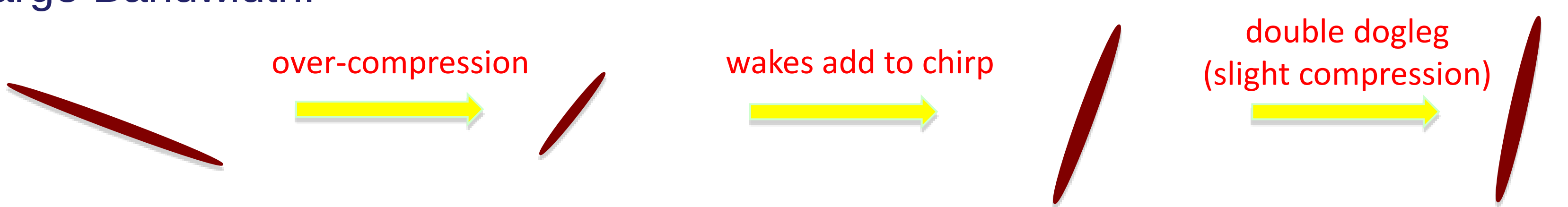
- Strong residual energy chirp
- 200 pC
- Large FEL Bandwidth (>1%) for single short absorption spectroscopy & Laue diffraction

- Attosecond FEL pulse
- 10 pC
- Strongest compression
- Single-spike in hard X-ray

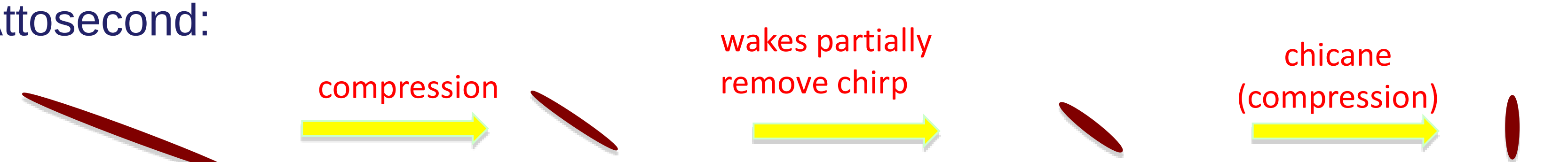
Compression Schemes

- *Normal*:

- Large Bandwidth:



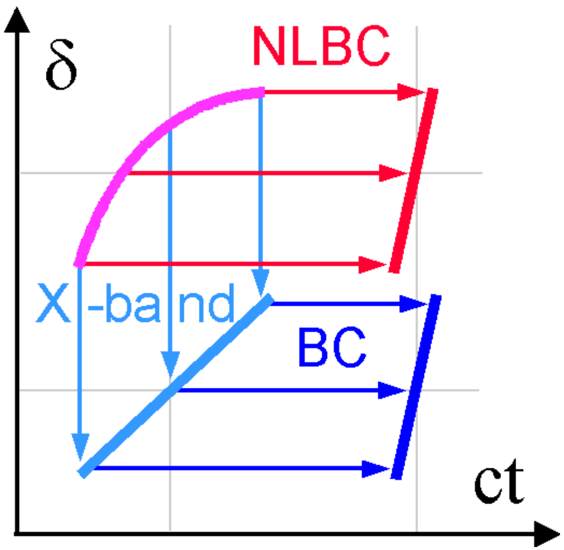
- Attosecond:

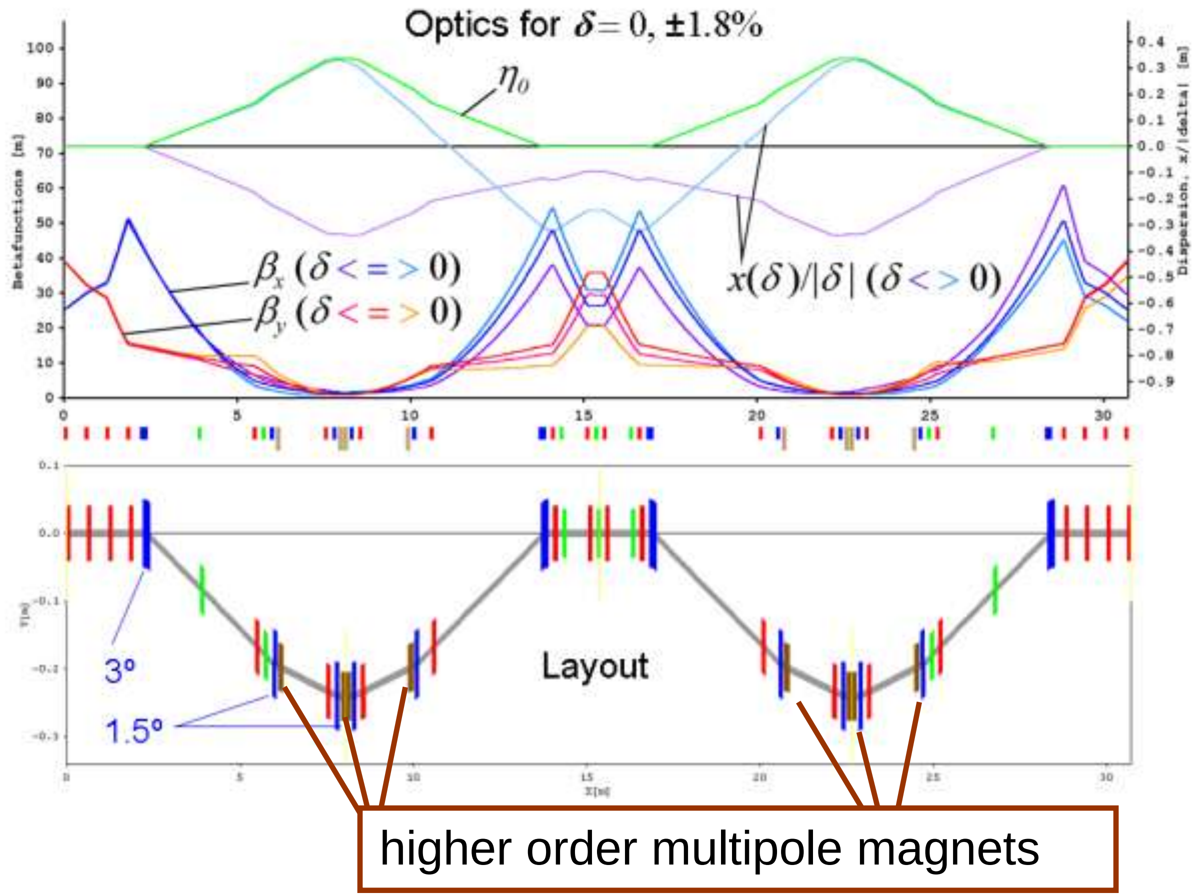


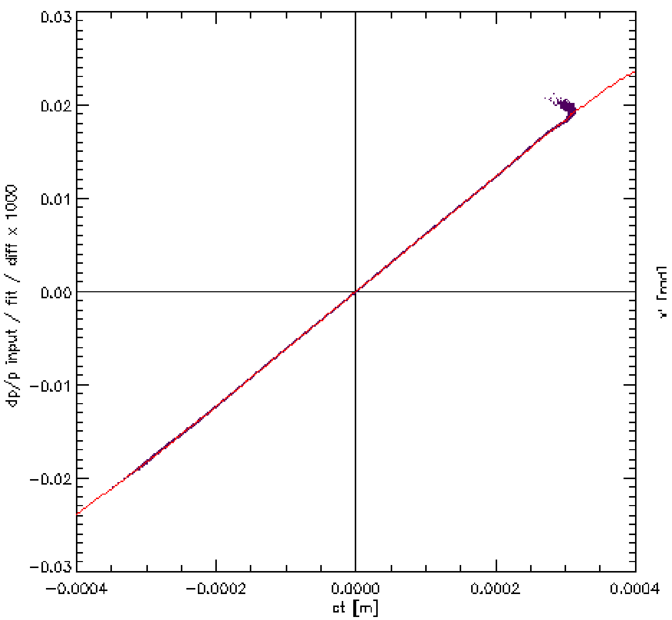
S. Reiche

Non-linear bunch compressor

Alternative to X-band cavity for longitudinal phase space linearization



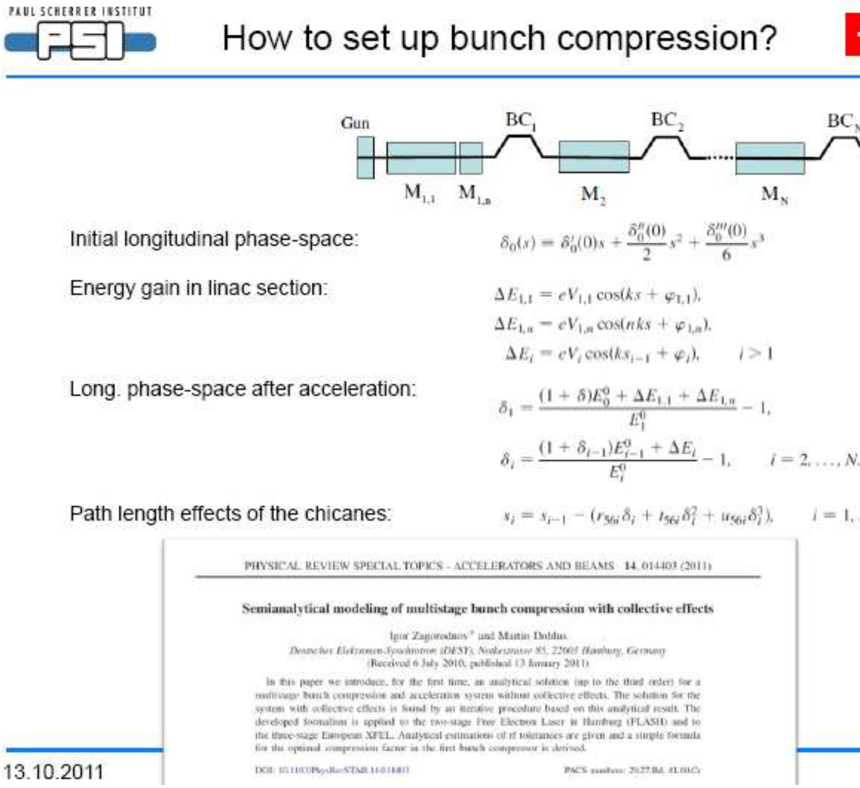


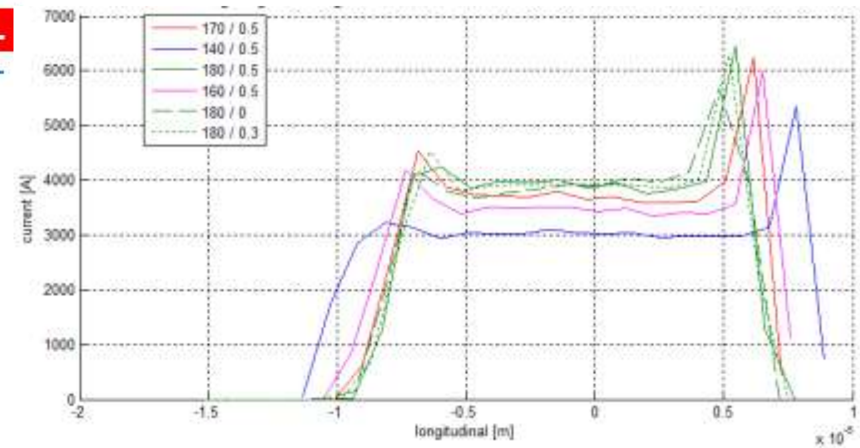


⇦ Linearization and partial (variable) compression

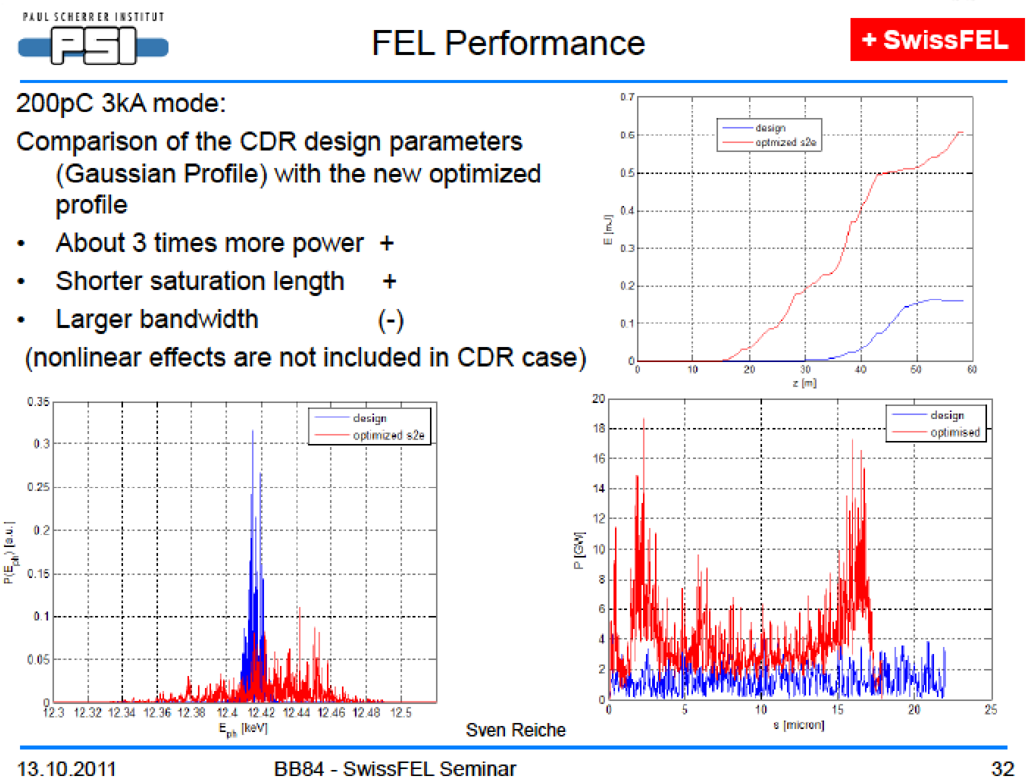
Challenges: tuning procedure & magnet design

Longitudinal optimization





I. Zagorodnov and M. Dohlus, PRST-AB 14, 014403 (2011)



Pulse energy optimization:
200 μJ (CDR) ⇒ >500 μJ
for 200 pC mode

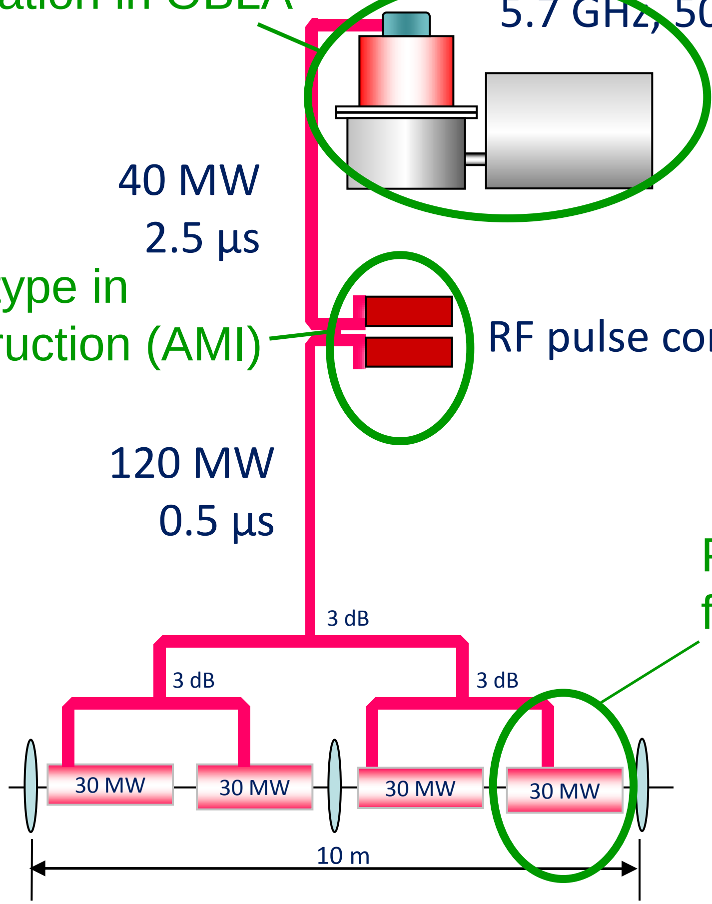
B. Beutner & S. Reiche

C-band RF system & linac

RF amplifier in operation in OBLA

C-band- Klystron
5.7 GHz, 50 MW, 2.5 µs, 100 Hz

Prototype in construction (AMI)

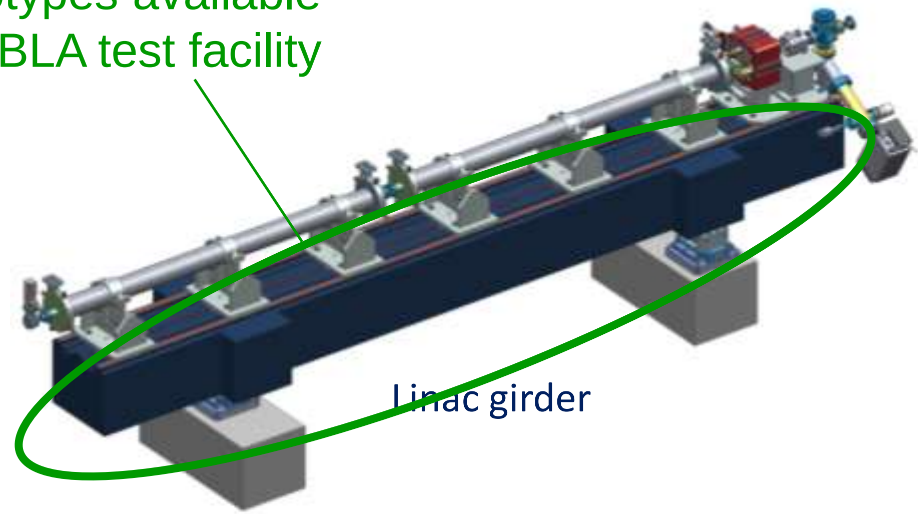


four 2 m long C-band structures, 30 MV/m

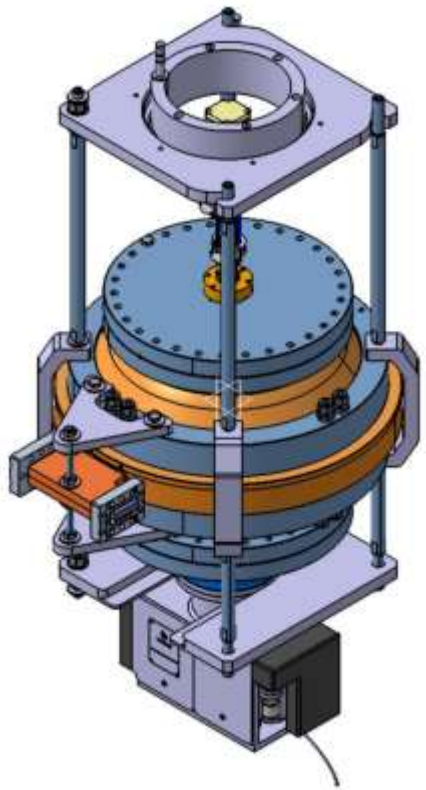
H. R. Fitze et al.

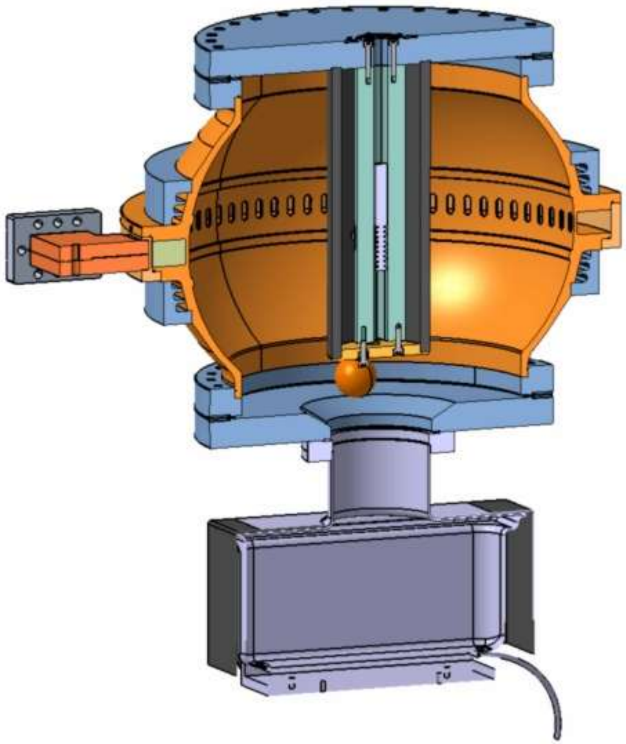
Main LINAC	#
LINAC modules	26
Modulator	26
Klystron	26
Pulse compressor	26
Accelerating structures	104
Waveguide splitter	78
Waveguide loads	104

Prototypes available for OBLA test facility



C-band pulse compressor

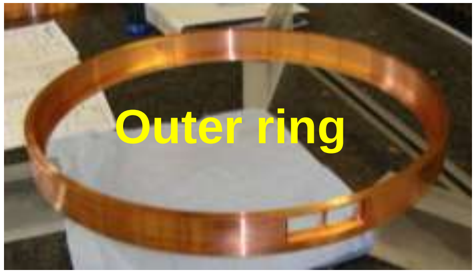




BOC (barrel-open cavity) for pulse compression and power enhancement.

Status:
First BOC prototype in production

Goal:
Prototype ready for summer 2012



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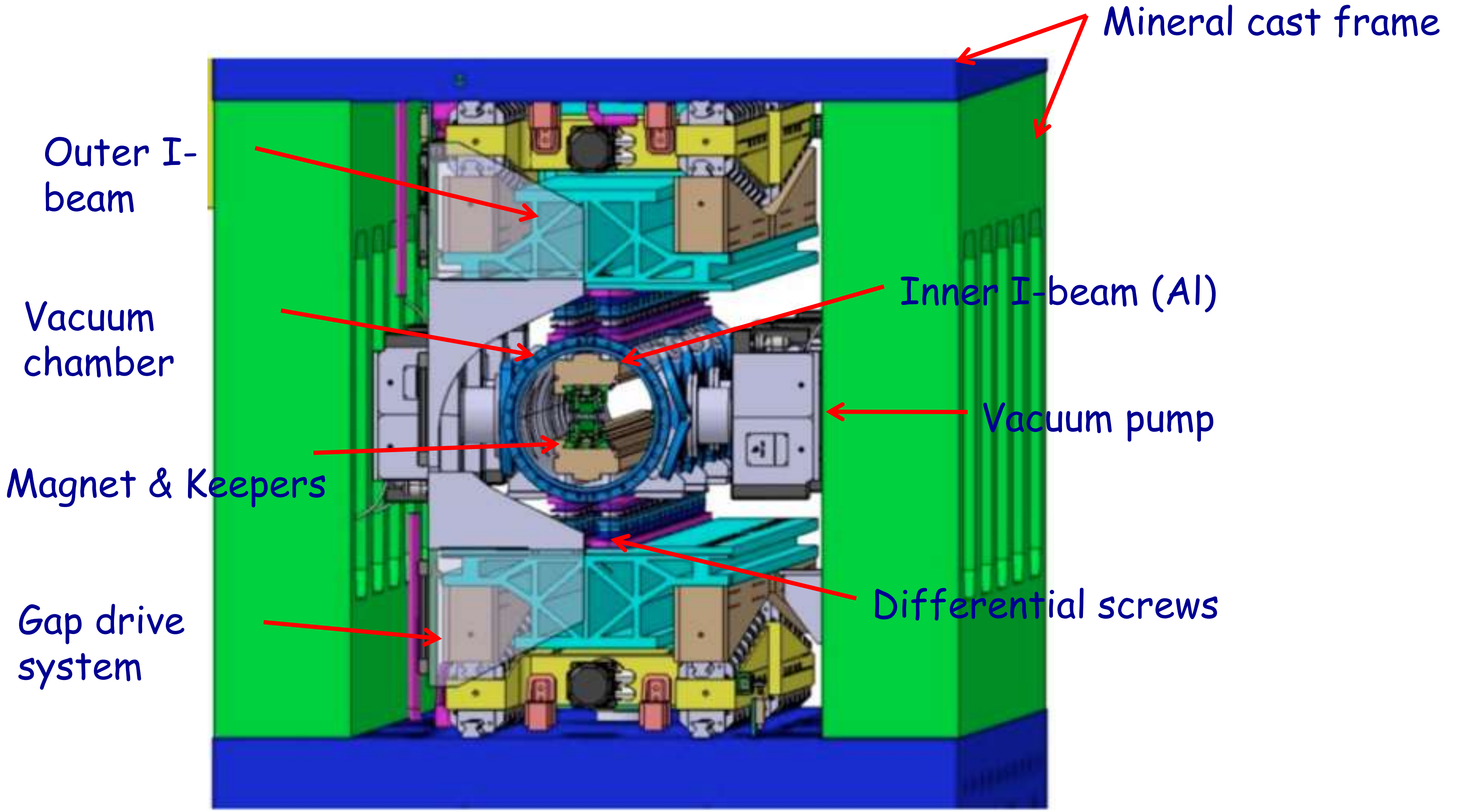
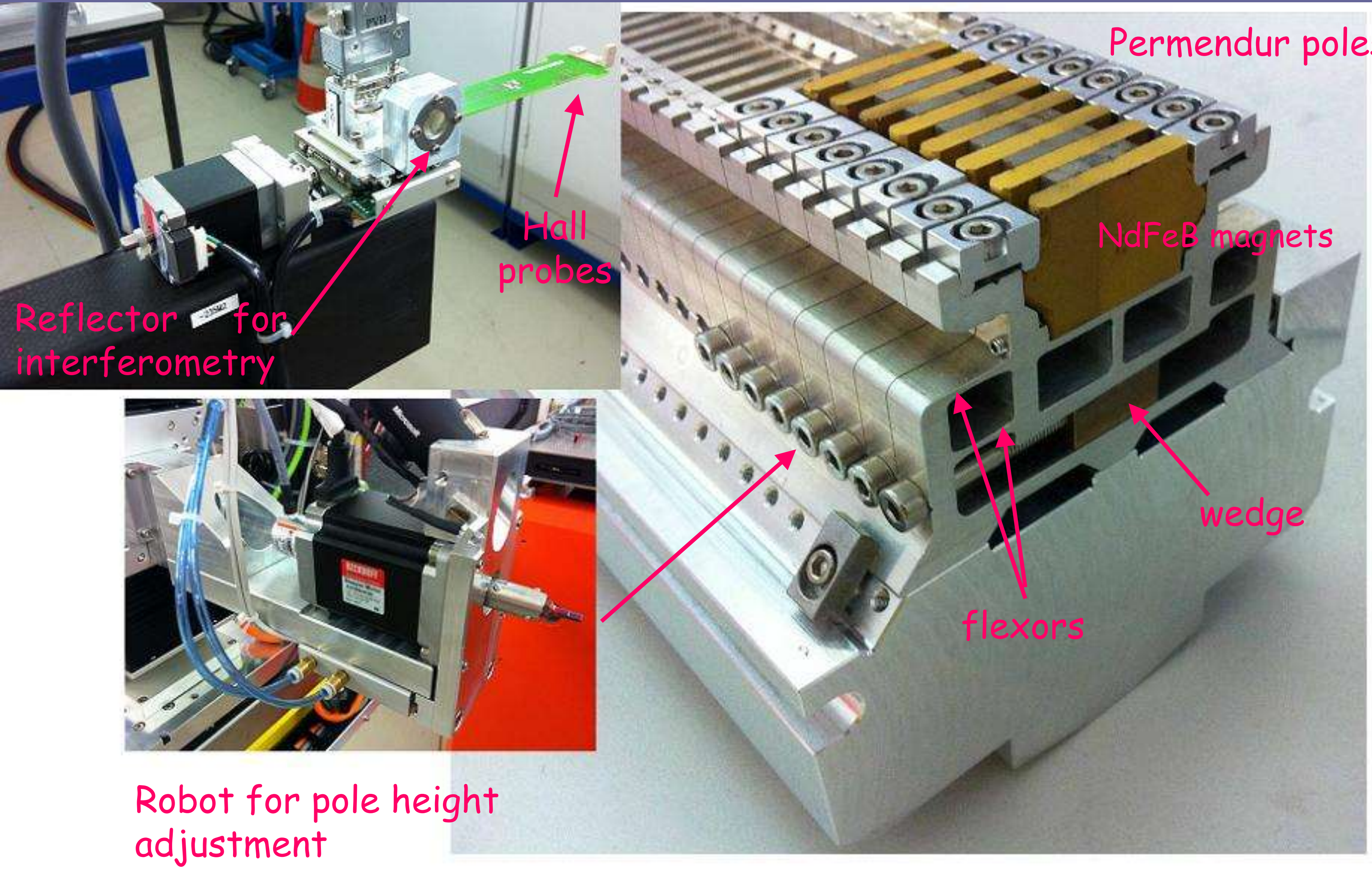
Undulator R&D (1)



Period: 15 mm

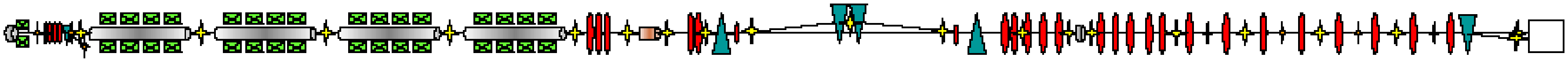
T.Schmidt et al.

Undulator R&D (2)



250 MeV test injector

- **Phase 3: The full machine**



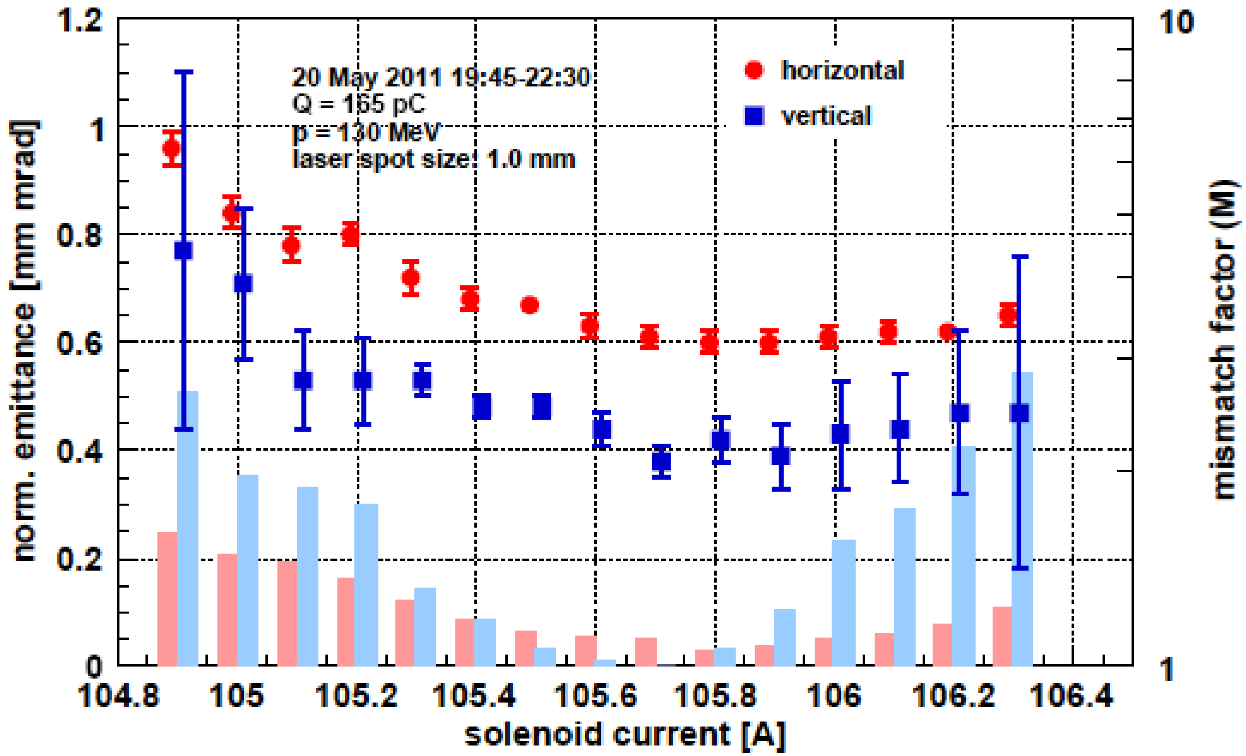
Test injector
in operation since
March 2010

Design parameters	Long Pulses	Short Pulses
Charge per bunch (pC)	200	10
Core slice emittance (mm.mrad)	0.43	0.18
Projected emittance (mm.mrad)	0.65	0.25

Phase 3:

August 2011:
Bunch compressor
⇩
early 2012
X-band cavity

Emittance measurement ⇨



Ref.: T. Schietinger et al.,
proc. of IPAC'11

SwissFEL summary

- SwissFEL will be an unique facility
  - Compact: 1 Å laser at 5.8 GeV electron energy
  - Two bunch operation
    to provide soft and hard X-ray simultaneously
- Intensive R&D activities
  - Accelerator design
  - Prototyping key components:
    C-band RF and undulators.
  - 250 MeV test injector commissioning in progress.
- Time schedule
  - Approval expected June 2012
  - Start of commissioning July 2017