PAUL SCHERRER INSTITUT

Nicole Hiller

Diagnostics Collaborations with PSI Involvement

Diagnostics Collaborations with PSI Involvement

> Beam Position Monitors (DESY, PSI)

> Wire Scanners (PSI, FERMI)

> Bunch Compression Monitors (PSI, DESY)

> Fluorescence Screens (PSI, SLAC, PAL)

> Plasma-based diagnostic for characterizing high-field ultra-short FEL electron bunches (PSI, SLAC)

> Transverse Deflectors (CERN, DESY, PSI)

> Mini-Workshop Series on Longitudinal Diagnostics

Beam Position Monitors

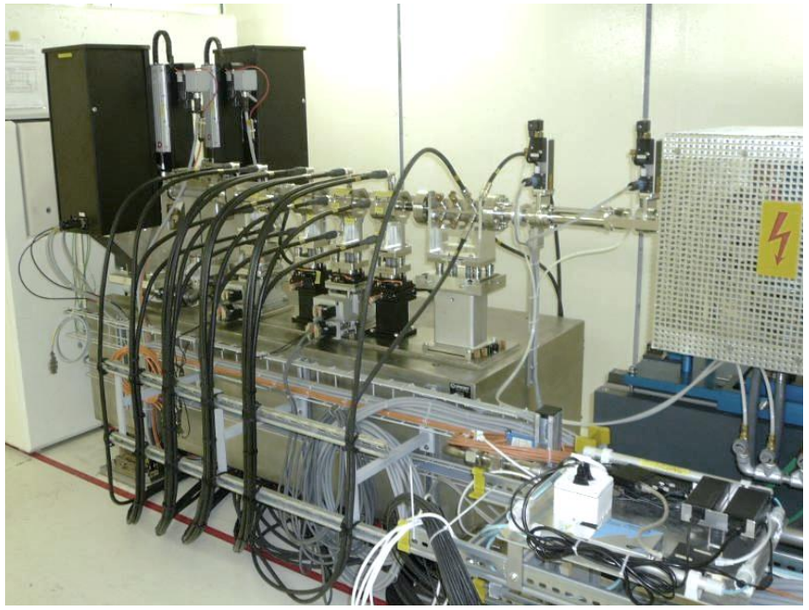
> The System

- > BPM Pickups (Cavity & Button) for SwissFEL & EU-XFEL
- > Modular Readout Electronics
- > Intra Bunch Train Feedback for EU-XFEL

Front-end electronics

> Collaboration

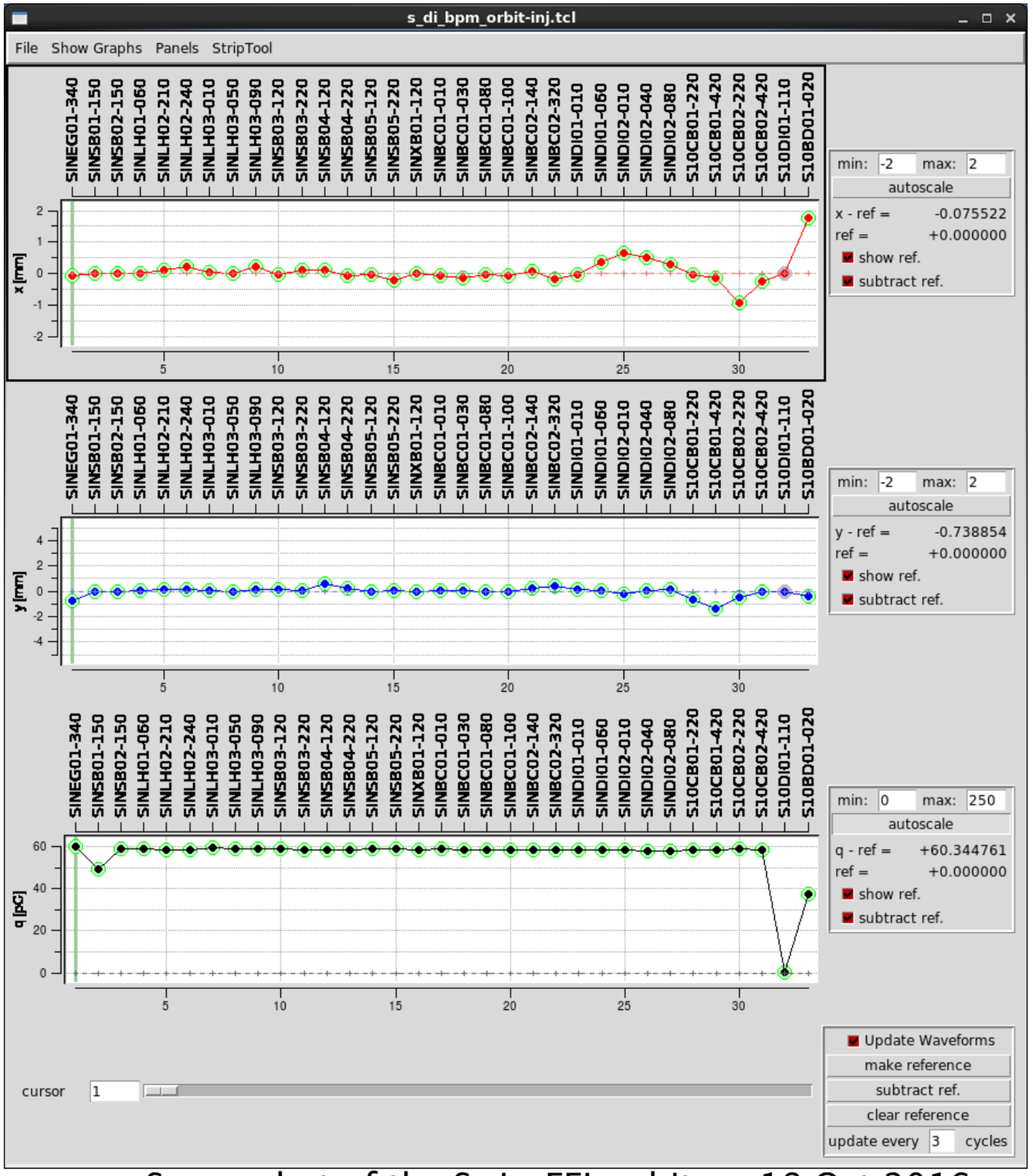
- > Original pickup design from SACLA, adapted by DESY
- > Front-End Electronics developed at PSI
- > PSI's contribution to the EU-XFEL
- > Final quality control and calibration measurements performed at PSI
- > System tests at the SITF



X-FEL BPM pickups installed at SITF

Beam Position Monitors

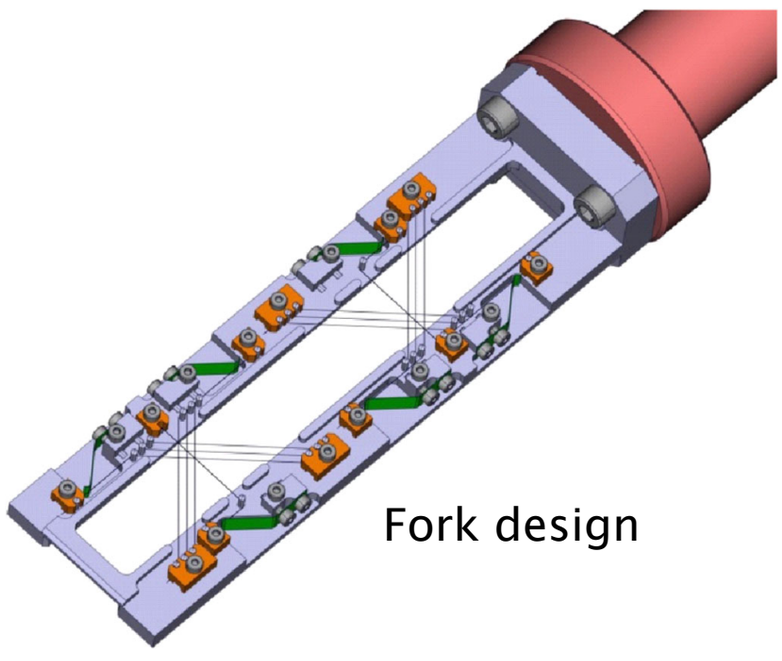
- **Status & Outcome**
  - Systems operational at EU-XFEL and SwissFEL injectors and installed in full machines
  - Commissioning in progress
  - Modular readout electronics are being used for different systems at PSI (e.g. THz detectors)
  - Applications by facilities outside the collaboration
    - FLASH2, SOLEIL, FLUTE (KIT), University of Hamburg, INFN



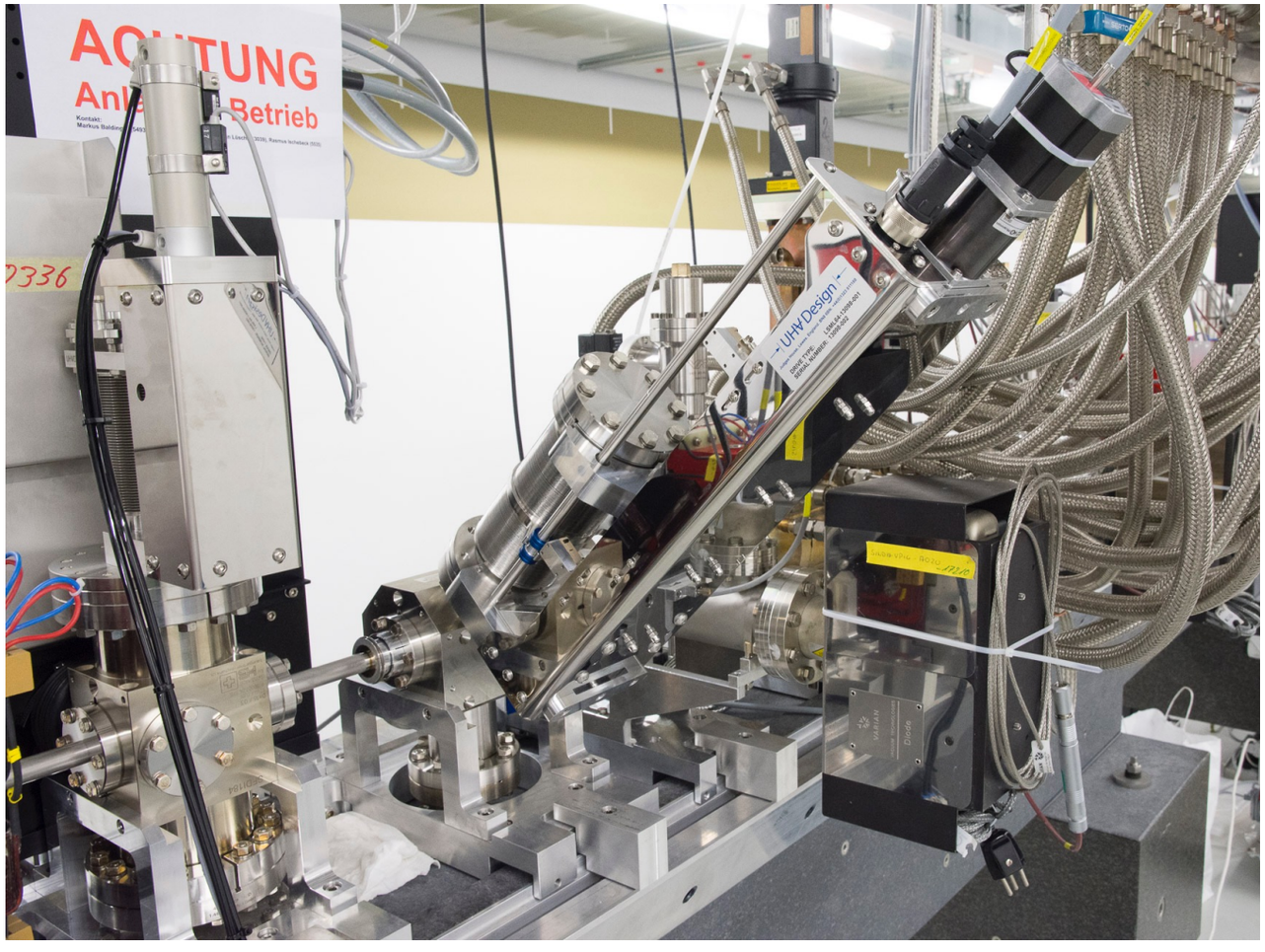
Screenshot of the SwissFEL orbit on 18 Oct 2016

Wire Scanners

- **Measurement principle**
  - Scan a thin wire through the beam and synchronously observe the losses downstream
  - Fast, accurate and only slightly invasive measurement technique to record the transverse beam profiles
- **Crucial points**
  - Wire material
  - Balance between losses and resolution



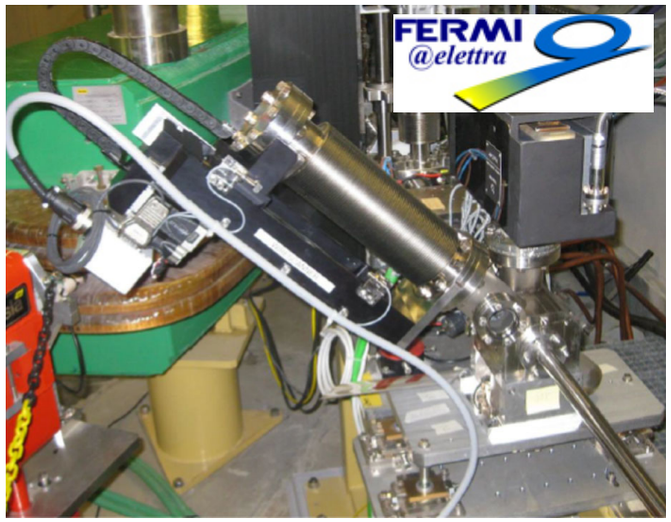
Fork design

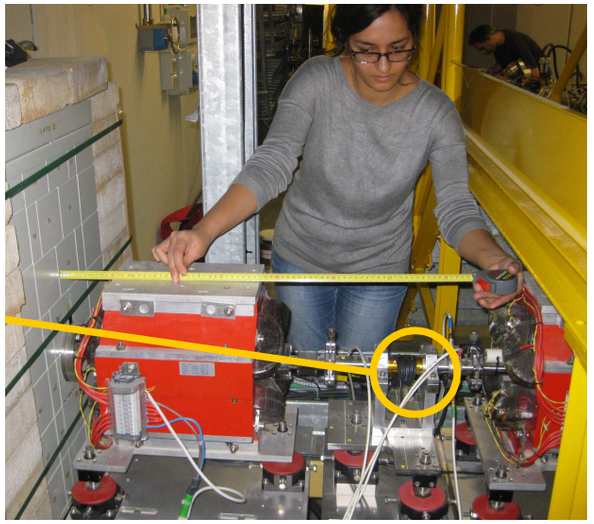


Wire scanner system installed at SwissFEL (about to be commissioned)

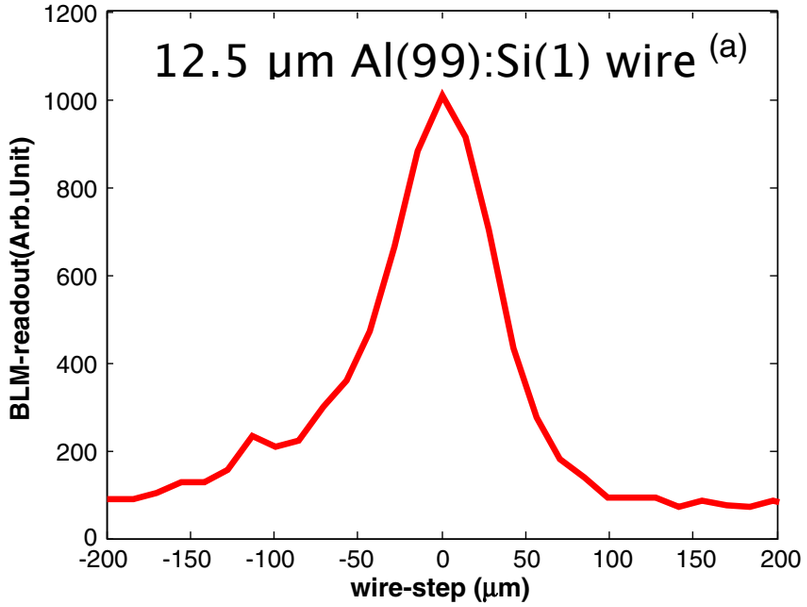
Wire Scanners

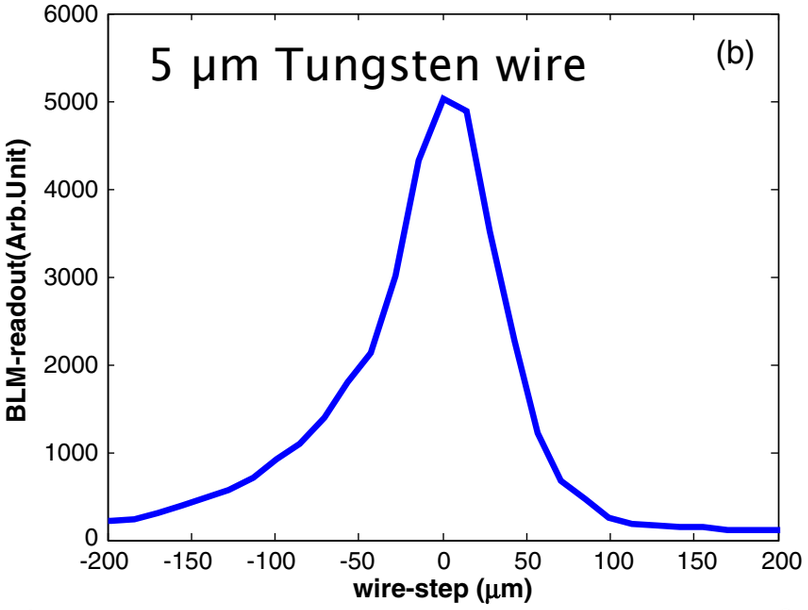
- **Collaboration**
  - PSI developed wire scanners and beam loss monitors for SwissFEL and tested them at the SITF with a 250 MeV beam
  - G.L. Orlandi presented a poster at FEL'13
  - Interest of colleagues from FERMI (M. Ferianis & G. Penco)
  - Jan 2015: First measurements at FERMI with a complete prototype setup from PSI (5 and 13 µm tungsten wires) revealed significant losses at 1.5 GeV beam energy
  - Search for a better wire material -> Al(99):Si(1)
  - 2nd round of tests at FERMI in Oct 2015
- **Outcome**
  - FERMI quickly got a wire scanner prototype installed to use for emittance measurements
  - PSI got to test the SwissFEL system at higher energies and could optimize it
- **Next steps**
  - FERMI is implementing more wire scanners
  - PSI will now commission the system at SwissFEL





Joint Measurements at FERMI in 2015

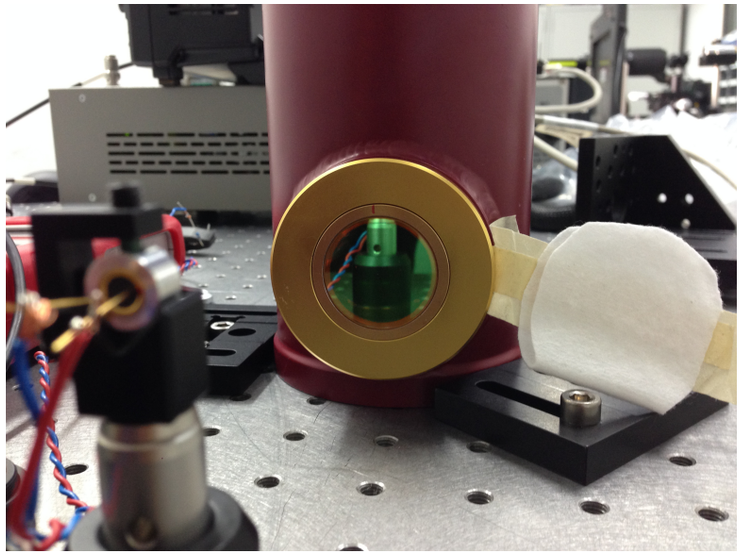




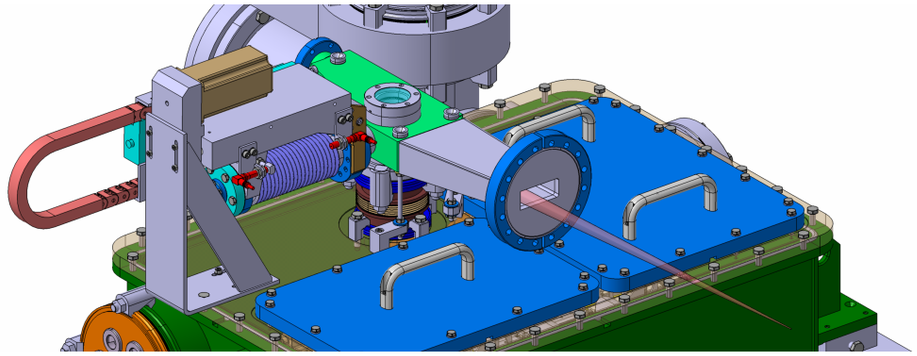
Design and experimental tests of free electron laser wire scanners
G. L. Orlandi, P. Heimgartner, R. Ischebeck, C. Ozkan Loch, S. Trovati, P. Valitutti, V. Schlott, M. Ferianis, and G. Penco
Phys. Rev. Accel. Beams **19**, 092802 – Published 16 September 2016

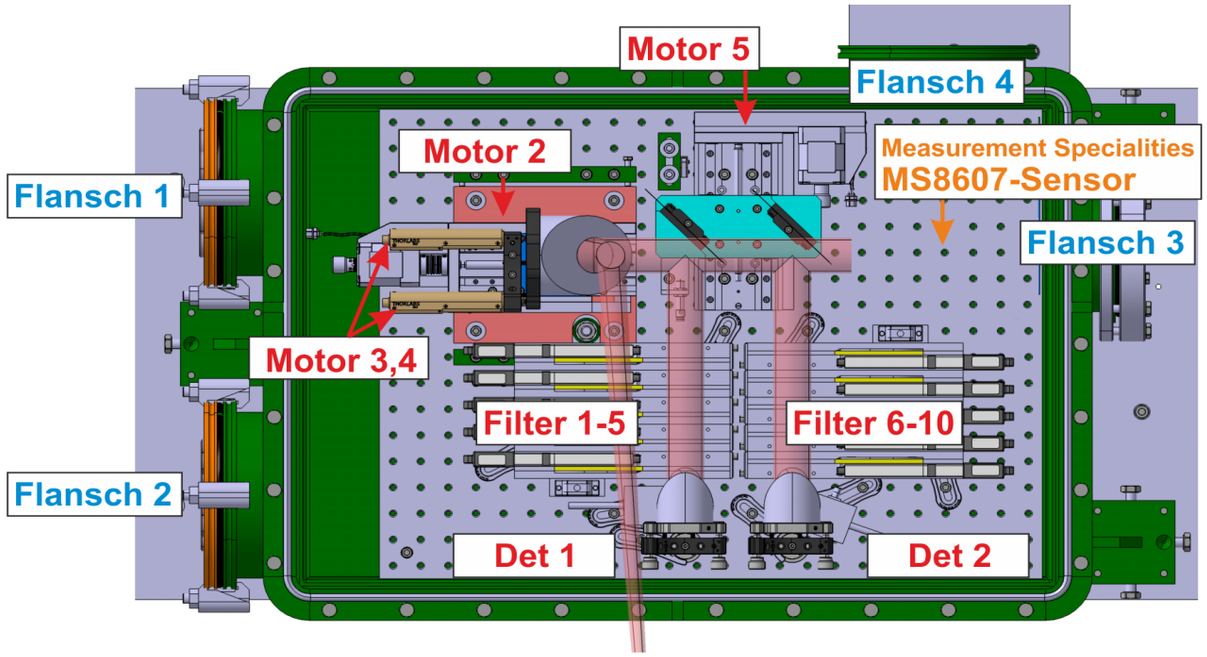
Bunch Compression Monitors

- **Crucial points**
  - Choice of suitable detector for desired bunch length and thus wavelength range
  - Choice of polarizers and filters
  - Implementation of system into beam feedbacks
- **Collaboration**
  - Comparison and tests of different detectors and filters
  - Evaluation of newly developed detectors (e.g. when Schottky-Diodes became available and Ultra-fast YBCO detectors
  - Joint measurements
  - Discussion of results and general issues when implementing systems into accelerator environments



MCT detector array for spectral measurements





Bunch compression monitor at SwissFEL

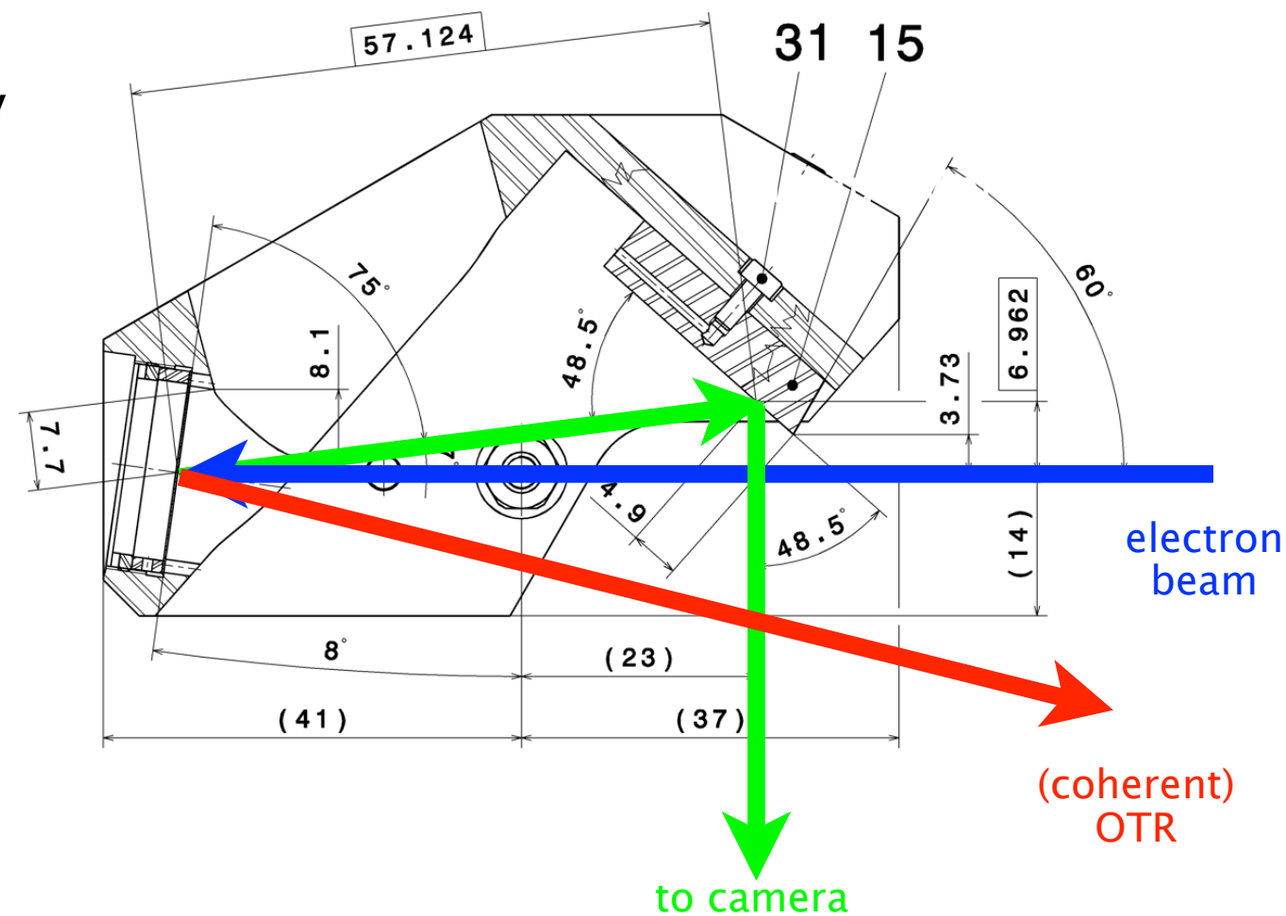
Fluorescence Screens

> **Measurement principle**

> Fluorescence screen material is inserted into beam and imaged onto a camera

> **Problem** (found by LCLS) – COTR for ultra-short electron beams saturates and even damages cameras

> **Solution** – change in geometry to observe screen under an angle



Fluorescence Screens

> **The Collaborative activities**

> When the problem was observed at LCLS, PSI was deciding upon the design of the screens for SwissFEL and could implement this change

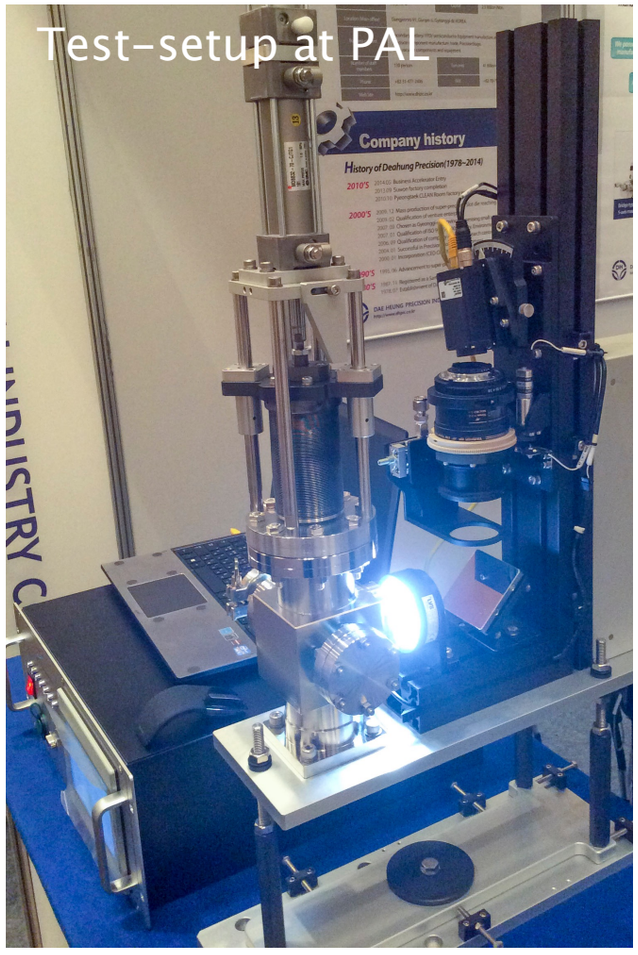
> Tested new design at LCLS in 2013

> Finalized designs for several geometries for the SwissFEL screens

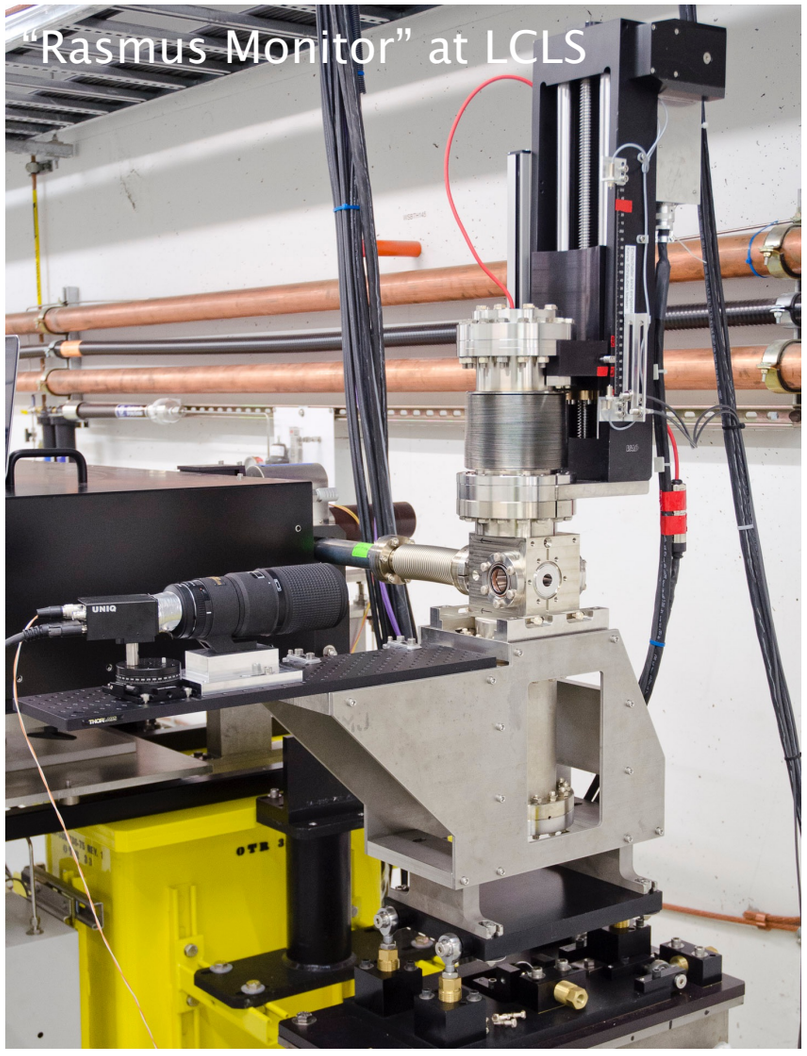
> PAL has received the design and implemented it

> DESY Zeuthen also uses the design now

18 systems installed in SwissFEL more to follow in Jan/Feb'17

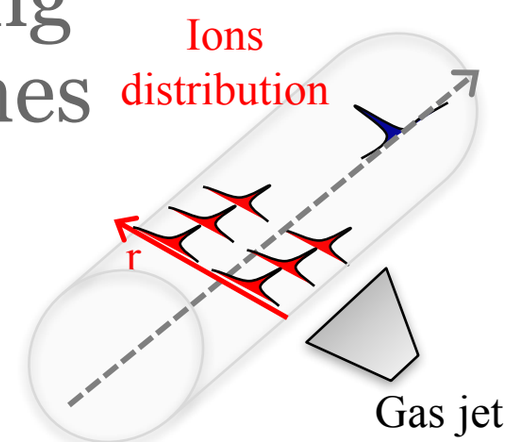


Test-setup at PAL

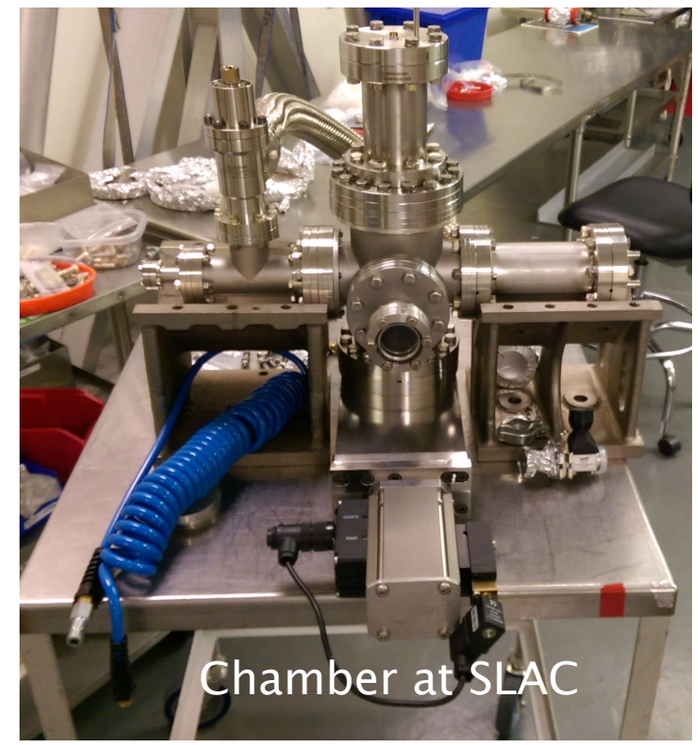


"Rasmus Monitor" at LCLS

Plasma-based diagnostic for characterizing high-field ultra-short FEL electron bunches



- **Concept**
  - Electron bunch is sent through gas jet –> tunnel ionization occurs
  - Number of ions depends greatly on bunch density
- **Collaboration**
  - Measured Xenon jet density and divergence by Schlieren interferometry at PSI (Semester Thesis, B. Hermann)
  - Proof of principle measurement planned at LCLS LTU beamline in 2017
  - Possible transverse-size monitor for BELLA (Berkley) driven electron bunches
  - Potential interest within EuPRAXIA



Roxana. Tarkeshian, Rasmus. Ischebeck, Volker. Schlott, T. Garvey (PSI)
Patrick. Krejcick (SLAC)
Remi Lehe, Jean-Luc Vay, Wim P. Leemans (LBNL)

Transverse Deflectors for European X-Band

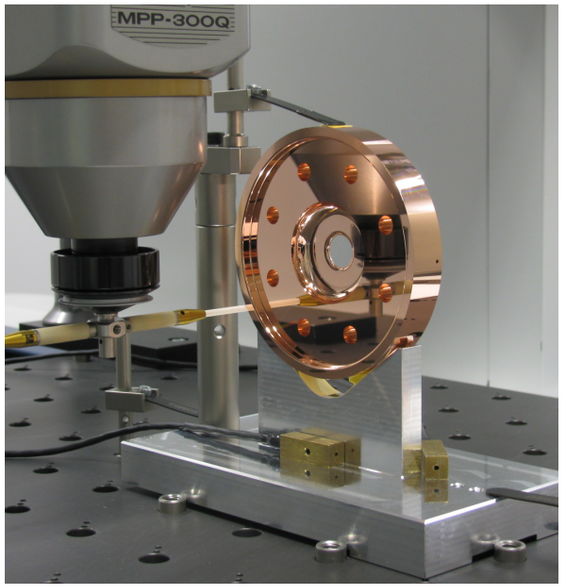
> **Idea**

- > Inspired by LCLS's TCAV
- > Goal – Develop a transverse deflector with variable polarization at European X-band frequencies that can achieve 1 fs resolution
- > Facilities (so far): SINBAD, FLASH2 & Forward, SwissFEL (Athos)

> **Collaboration partners**

- > **CERN** – proposed RF design; X-band waveguides
  - > Alexej Grudiev, N. Catalan Lasheras
- > **PSI** – experience in the fabrication of tuning-free C-band structures that can be adapted to X-band
  - > Paolo Craievich, Marco Pedrozzi
- > **DESY** – test and use
  - > Barbara Marchetti, Richard D'Arcy, Mathias Vogt, Florian Christie

> **Status** – Collaboration forming



C-Band structure manufactured by VDL with the process designed by PSI

Collaboration meeting on Xband TDS

DESY- Hamburg, 21st September 2016 – SR1 CFEL Building.

Workshop Series on Longitudinal Diagnostics

- > Series of mini-workshops between DESY, KIT, PSI, and STFC
  - > Started in 2013, hosted the workshops at DESY, PSI, KIT and STFC
- > Guests from Universities of Bern, Berlin, Dortmund, Dresden, Dundee, Lille, Lodsz, and Maxlab
- > Target participants: students, post-docs
- > Show and discuss mainly unpublished results & “problems” and plan joint measurements, but also brainstorming about new techniques/ideas

Next workshop: June’17 at PSI

Interested in joining? Contact me!

Science & Technology Facilities Council ASTeC

6th Workshop on Longitudinal Diagnostics for Free Electron Lasers

20-21 October 2016
The Cockcroft Institute

- Mar 2013 PSI
- Nov 2013 DESY
- July 2014 KIT
- Jan 2015 PSI
- Nov 2015 DESY
- Oct 2016 STFC
- Jun 2017 PSI

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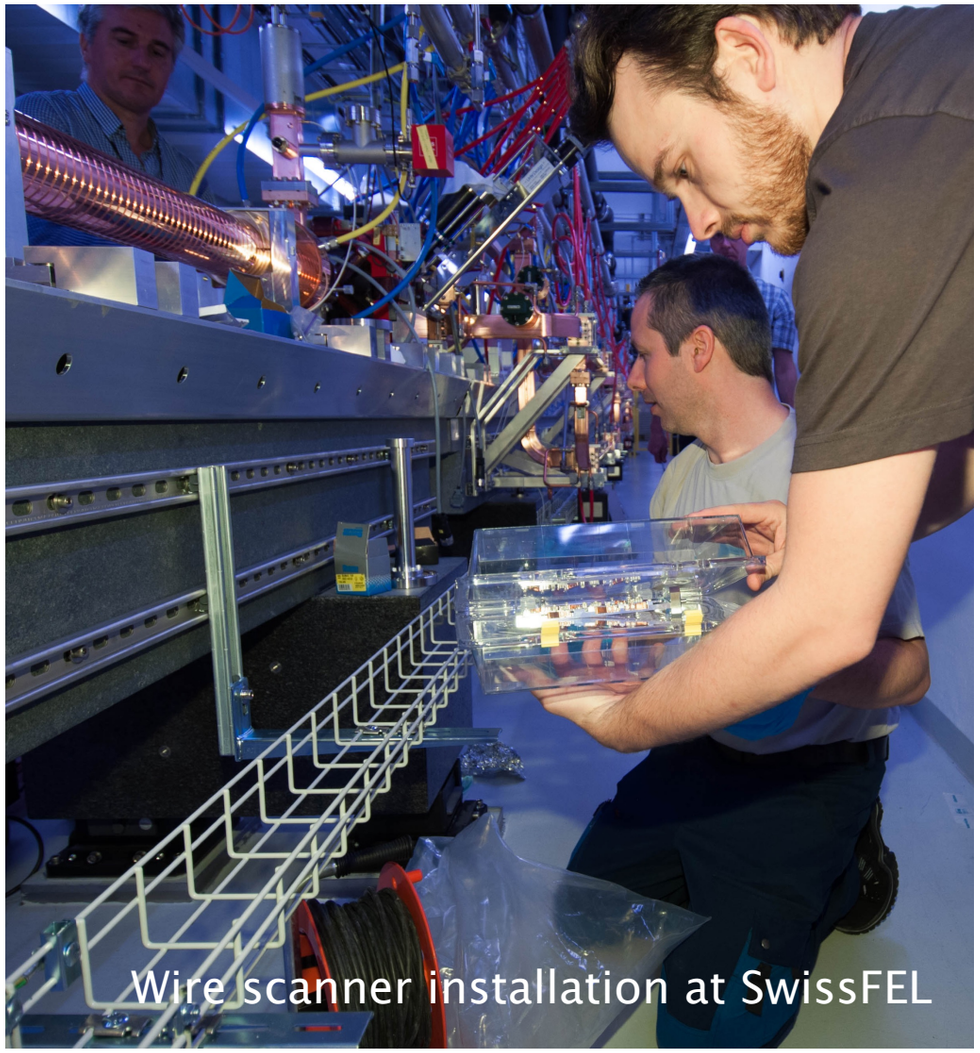
Did I miss any ongoing collaborations? Where can we work together in the future?


Wire scanner installation at SwissFEL

Acknowledgements

Thanks to all the colleagues who supplied me with material and information, especially
B. Keil, G.L. Orlandi, C. Ozkan, F. Frei,
P. Craievich, R. Tarkeshian & R. Ischebeck