sFLASH

First results from seeding at FLASH

FEL conference 2010

Malmö

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On behalf of the sFLASH team

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•Supported by BMBF under contract 05 ES7GU1
•DFG GrK 1355
•Joachim Herz Stiftung

Outline

- Introduction / Motivation
- sFLASH components
  - Seeding source
  - Injection beam line and diagnostics
  - FEL extraction beam line and diagnostics
- First Lasing Results
- Seeding Status
- Outlook

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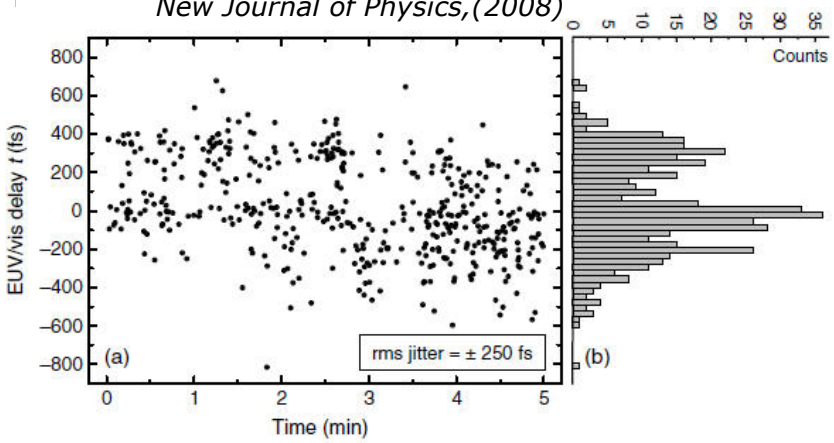
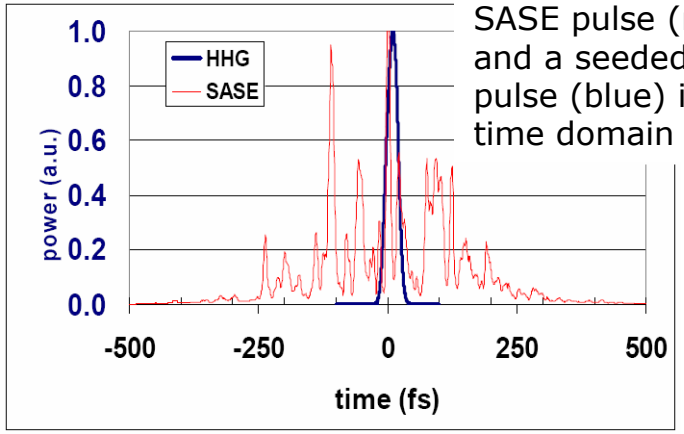
Introduction

- Demonstration of direct seeding with high harmonics (HHG) at wavelength below 40nm
- Temporal stability for pump-probe experiments in order of fs
- Improve the longitudinal coherence of the FEL in comparison to SASE radiation
- simultaneous operation of FLASH and sFLASH

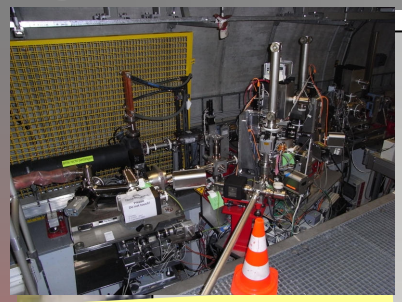
T. Maltezopoulos et al.,
New Journal of Physics,(2008)

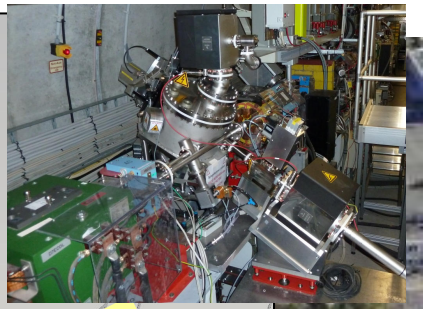


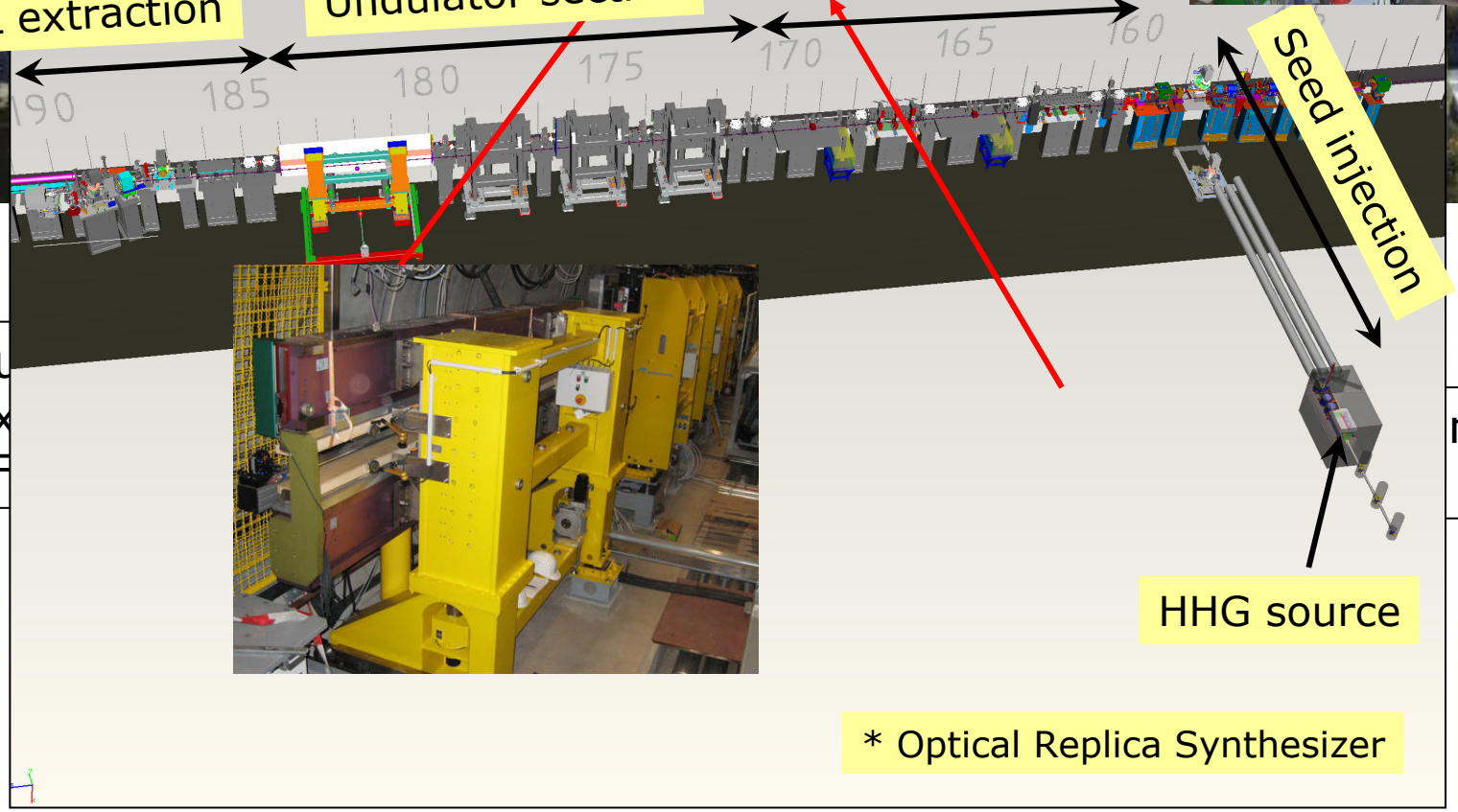


Comparison of a SASE pulse (red) and a seeded pulse (blue) in time domain

sFLASH Installation







* Optical Replica Synthesizer

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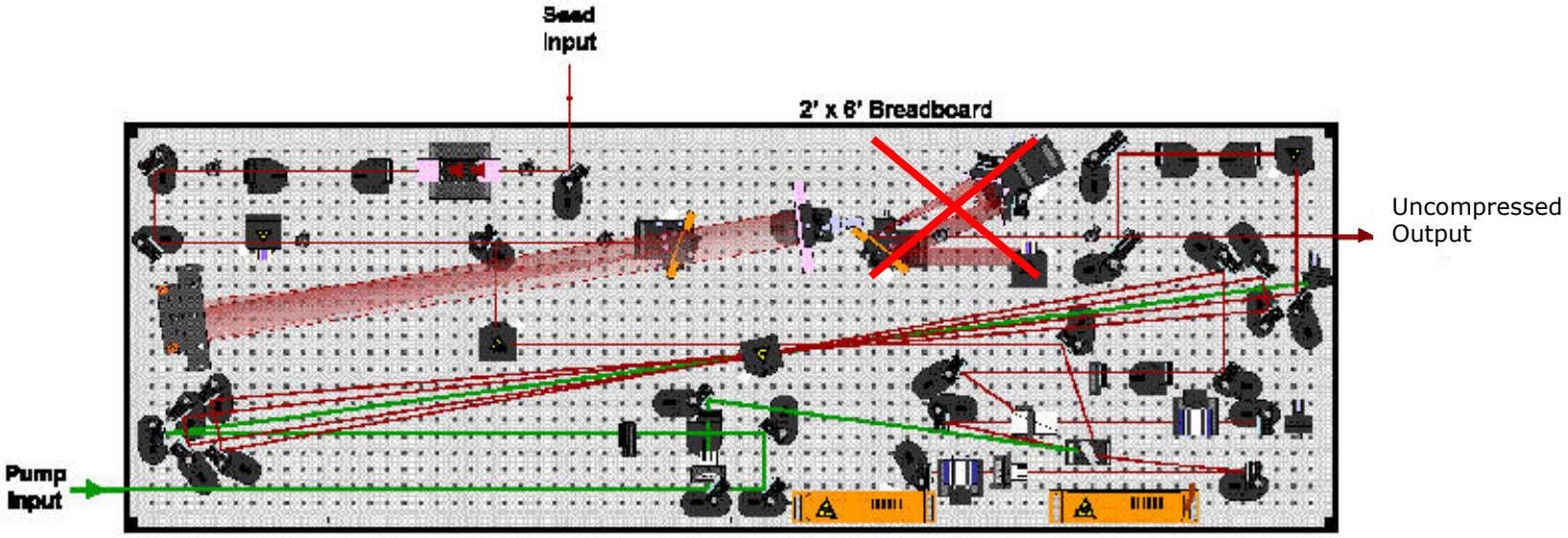
HHG laser system

- 81 MHz Ti:Sa oscillator, 0.5 mW output power
- CPA – reg. amplifier with 4x multi pass booster section

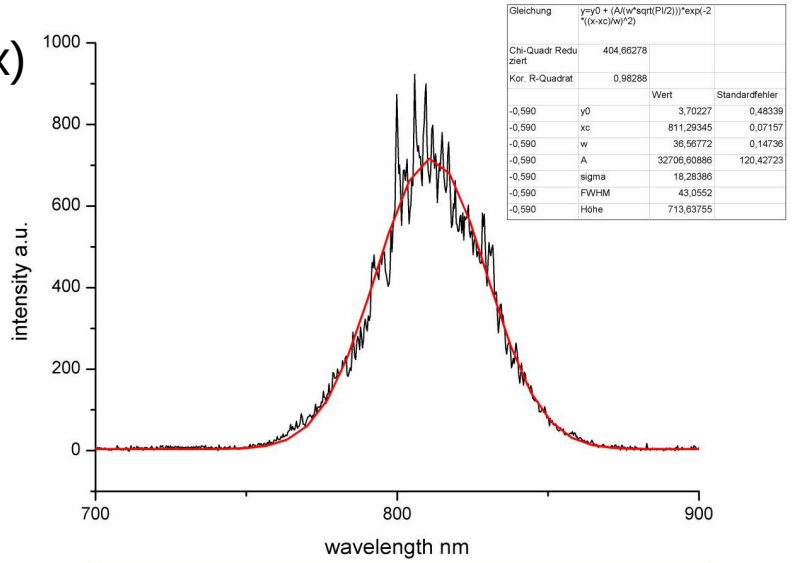


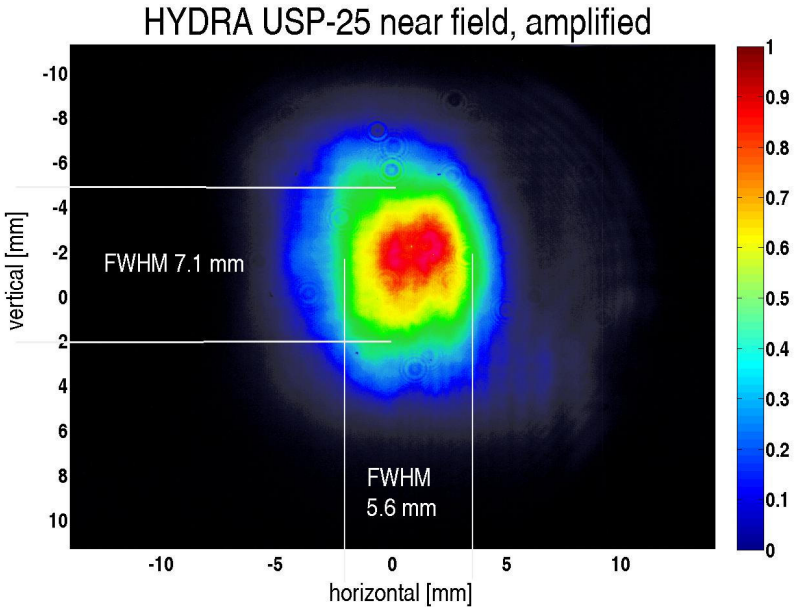
Hidra-25-USP
(4-pass configuration)

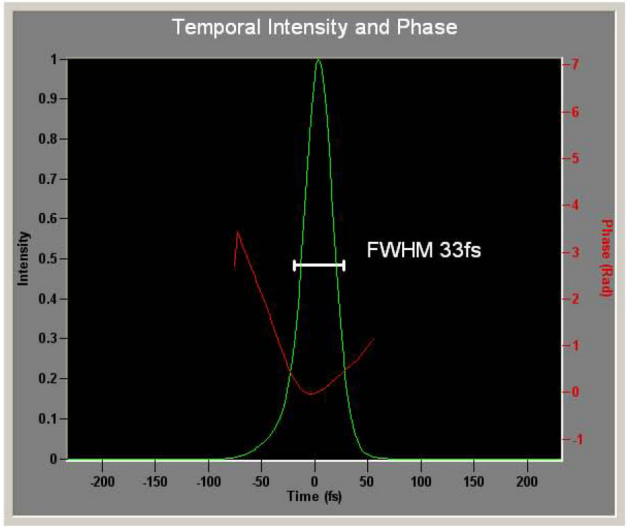
- Compressor is placed close to the HHG target chamber to avoid pulse distortions due to self focusing effects

HHG laser system

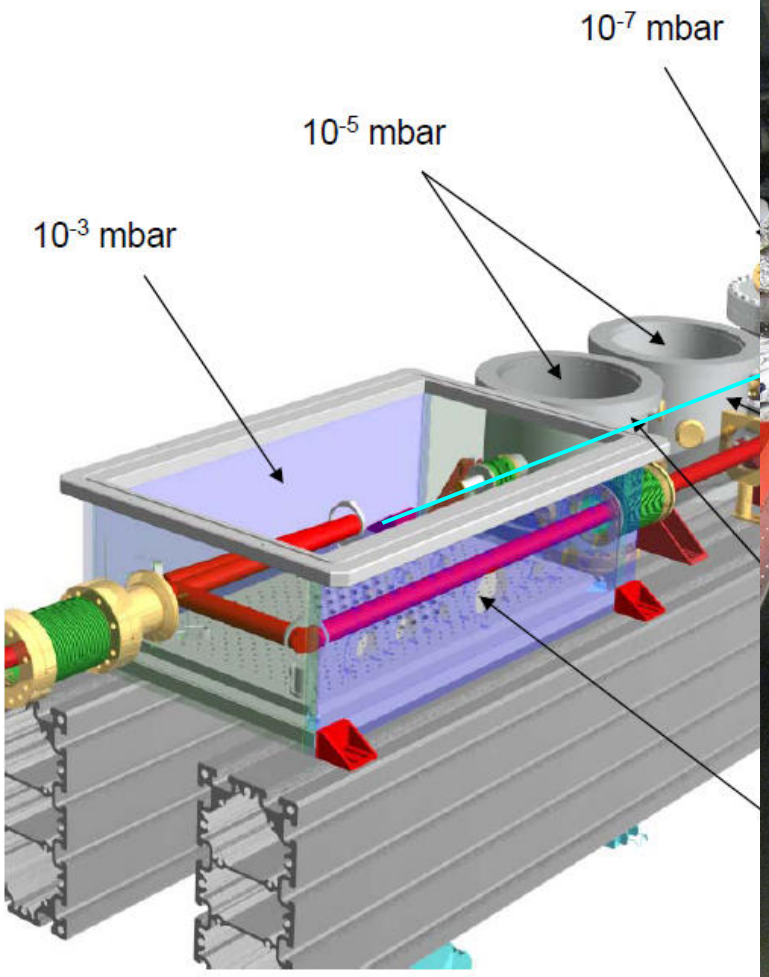
- Pulse energy: typ. 35 mJ (50 mJ max)
- Rep. rate: 10 Hz
- Energy stability: 4 % rms
- Bandwidth: 35 nm
- Pulse length: 33 fs (FWHM)
- $M^2 \leq 2.5$

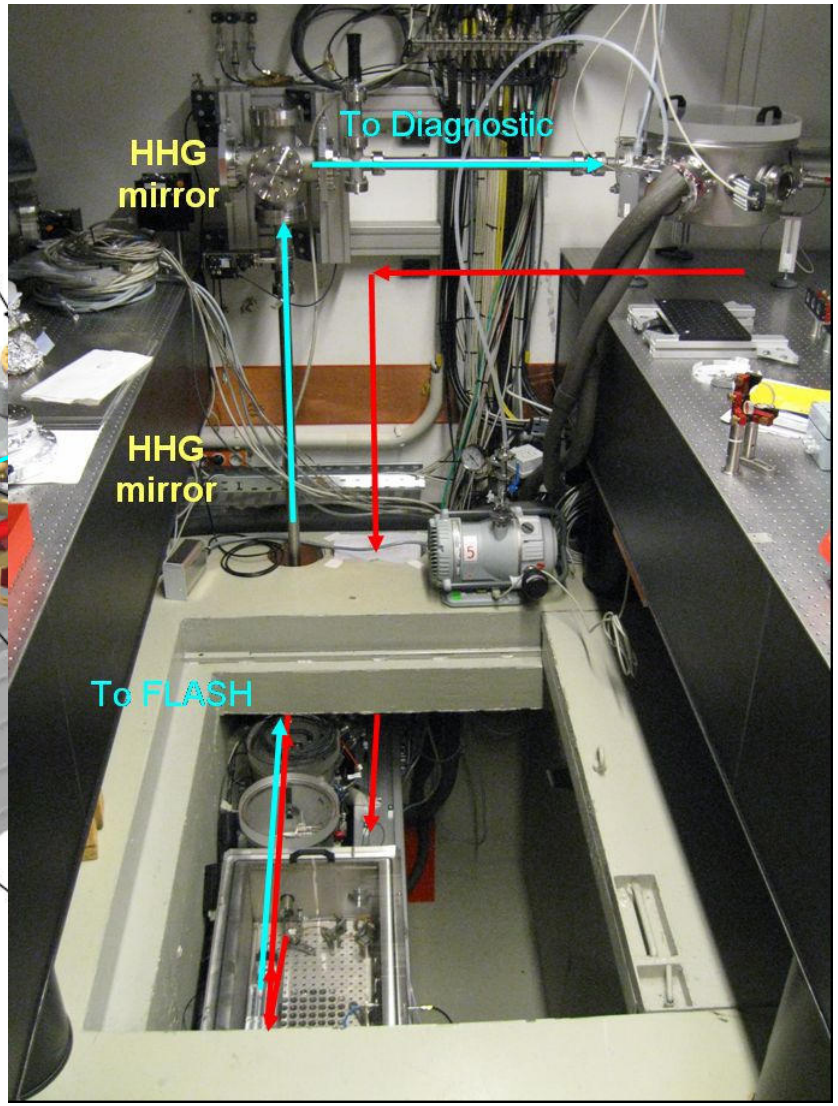






HHG Source


10^{-7} mbar
10^{-5} mbar
10^{-3} mbar


To Diagnostic
HHG mirror
HHG mirror
To FLASH

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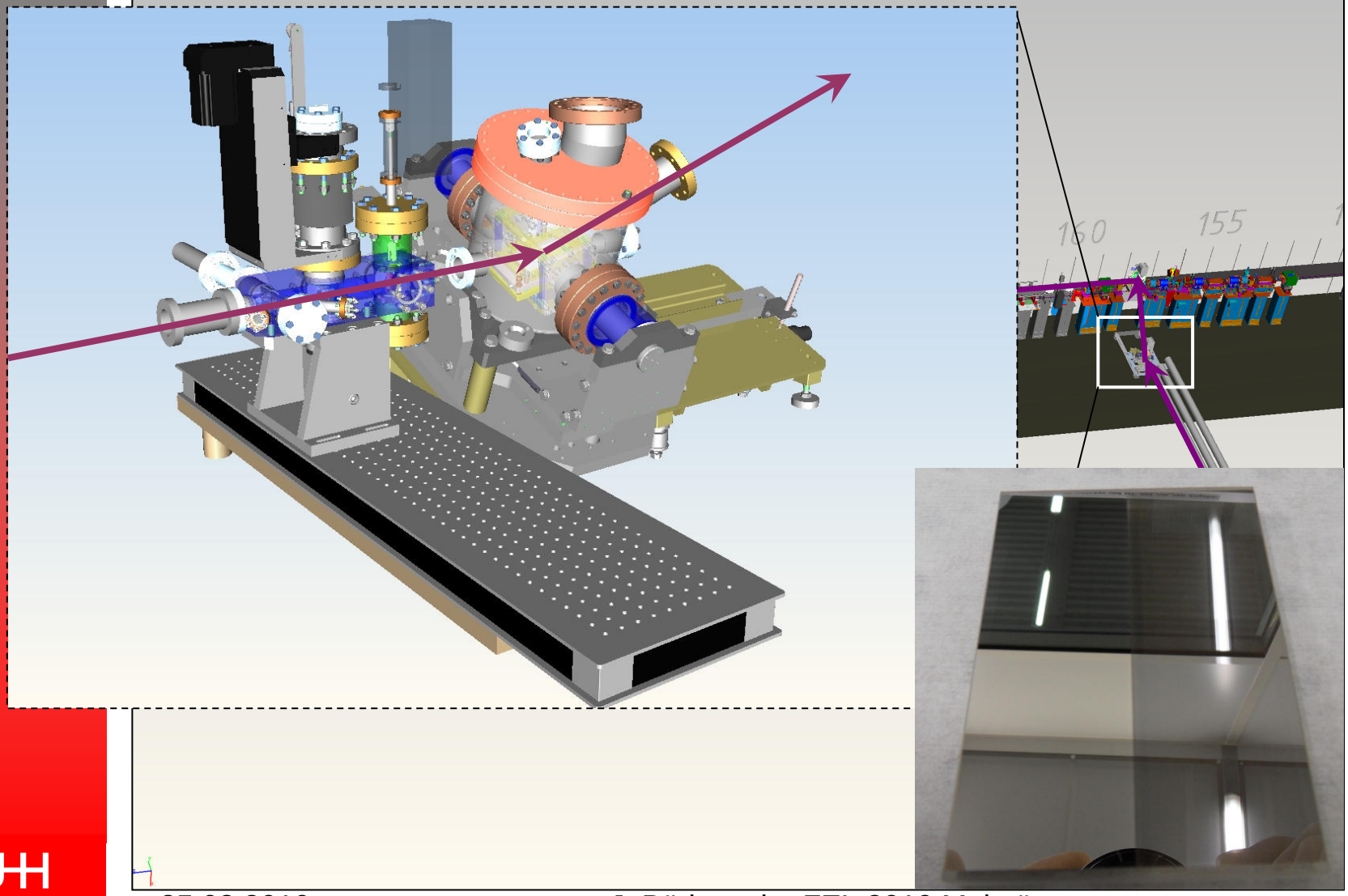
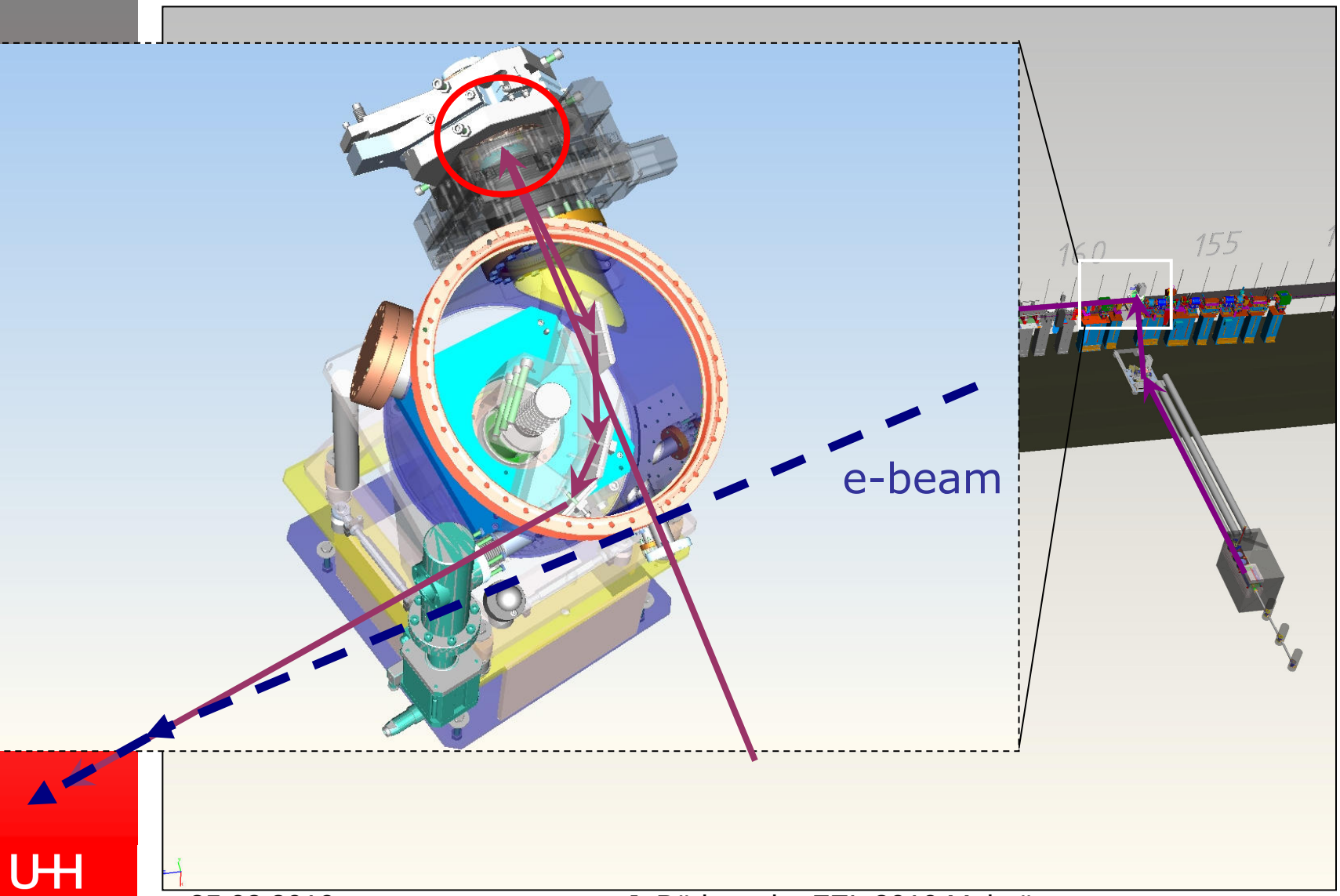
Injection beam line

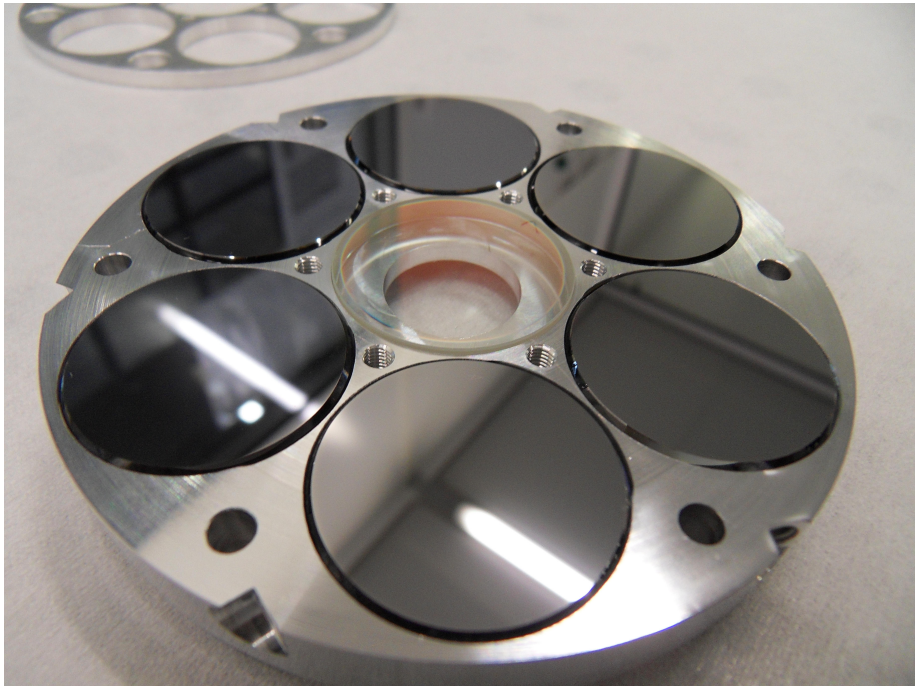


Injection beam line



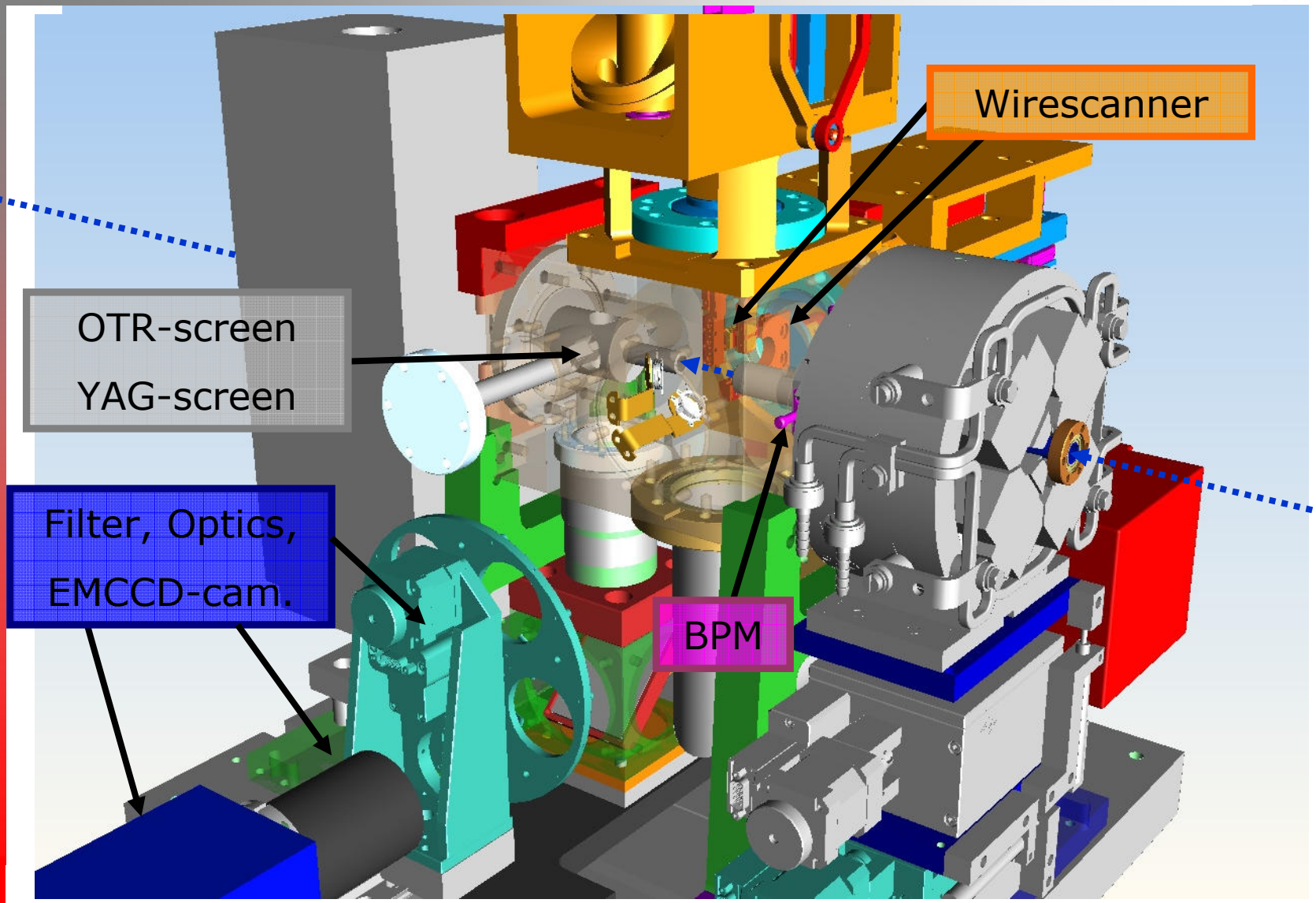
Focusing the XUV radiation

- To match the beam size of the XUV and the electron beam the seed source need to be imaged to the undulator
- sFLASH uses spherical mirrors with a multi layer coating for 38nm or 13nm. For each wavelength three focal length can be used (f: 6,25m ; 7m ; 8,5m)



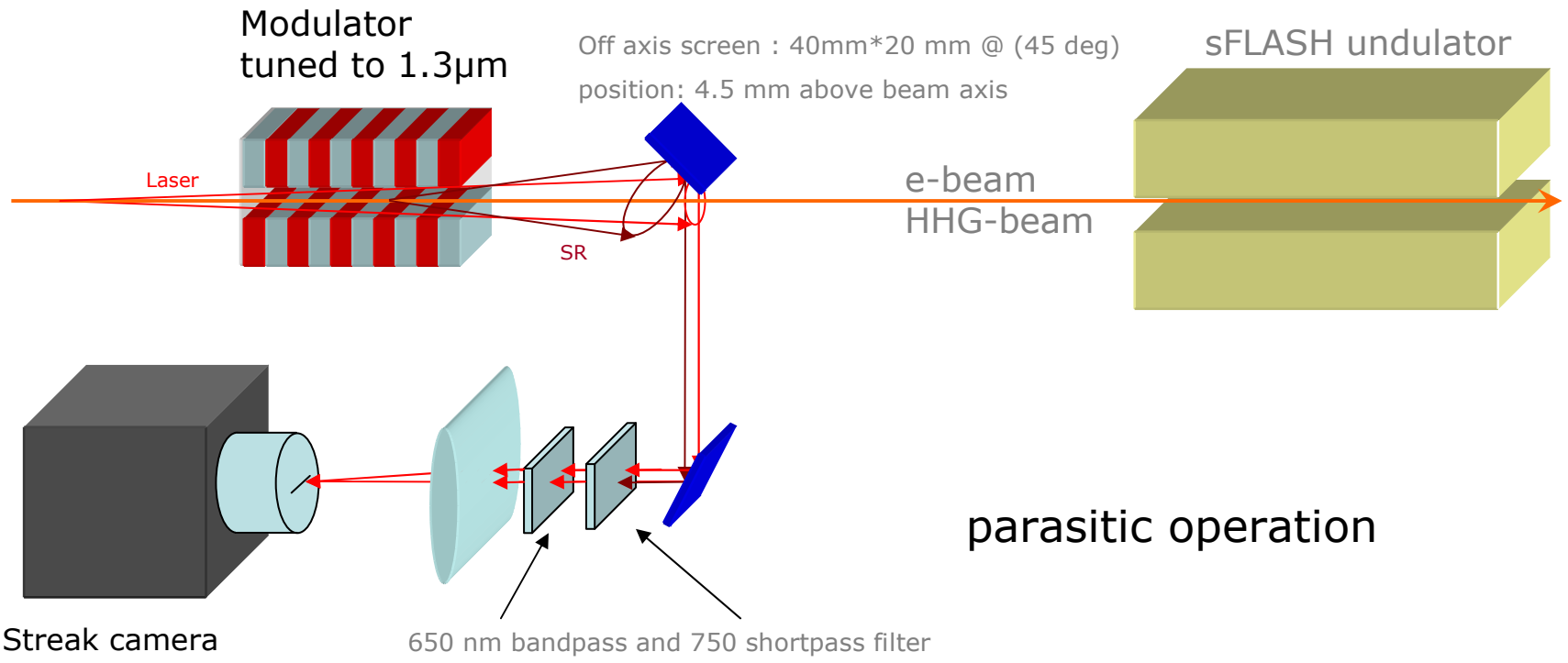
Poster: J. Bödewadt
TUPB22

Transverse overlap diagnostics



Longitudinal overlap diagnostics

- using synchrotron radiation from a short (N=5) electro-magnetic undulator together with 800nm laser pulses on a streak camera to find the temporal overlap



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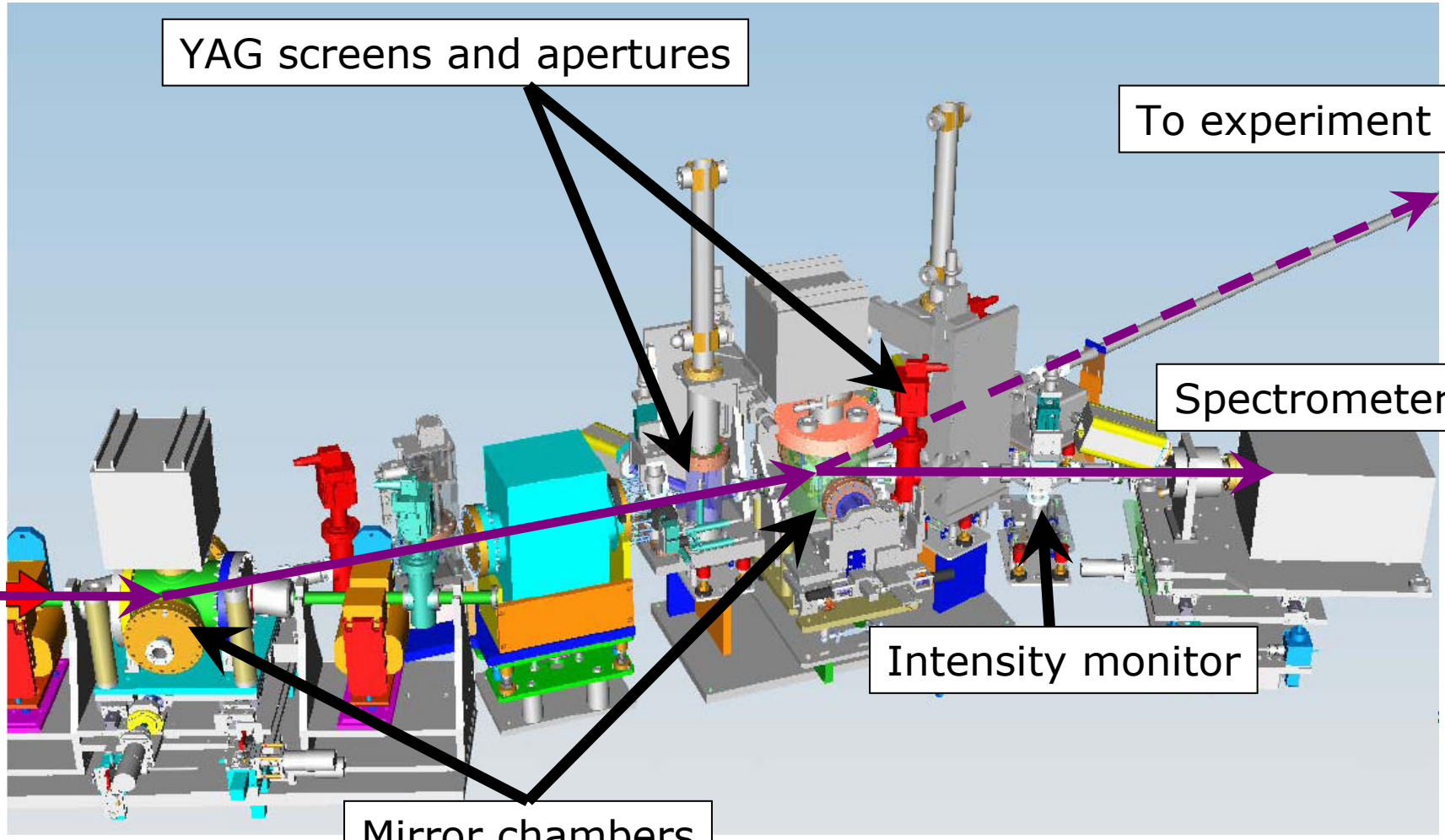
FEL extraction and diagnostics



Poster: F. Curbis TUPB21

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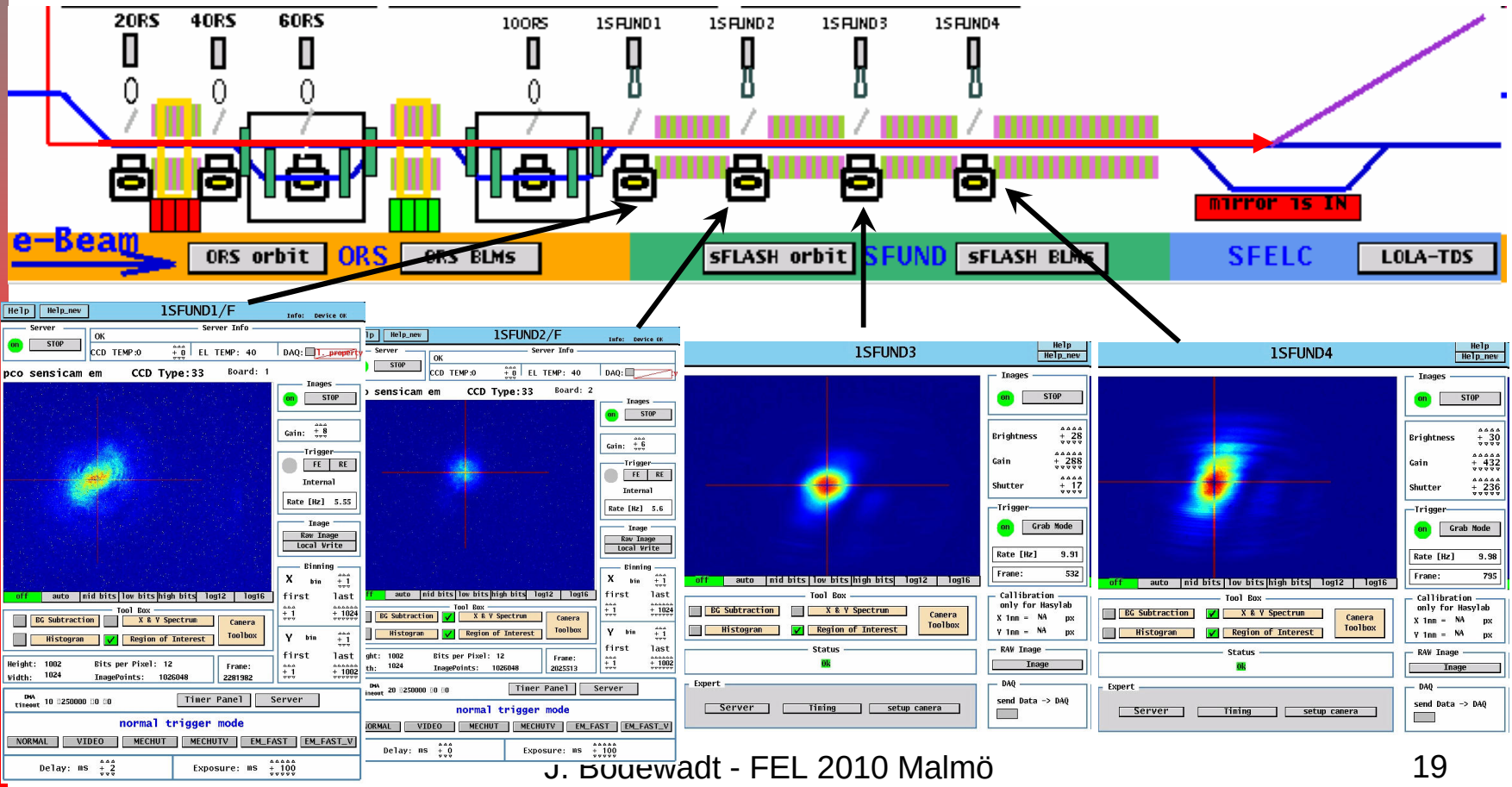
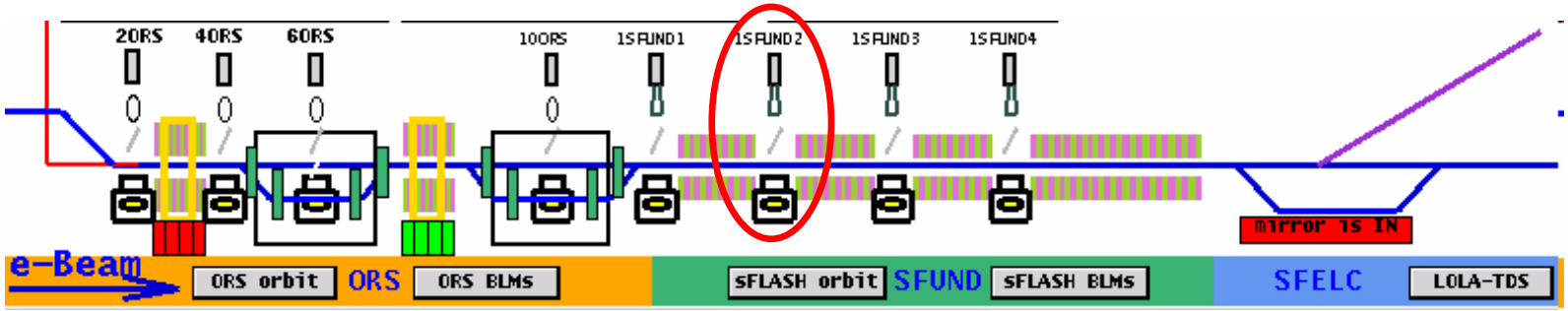
straightening the orbit

- using the laser as the orbit reference
- setting the electron beam on the straight laser line
- applying the slow orbit feedback



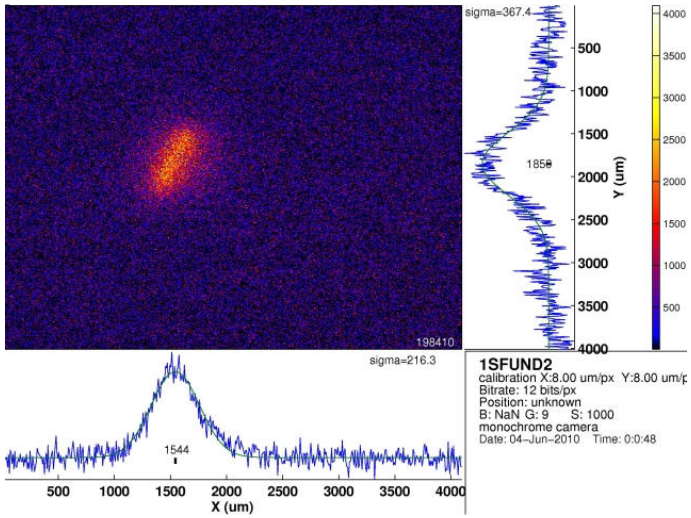
Transverse overlap

- detectors for HHG beam

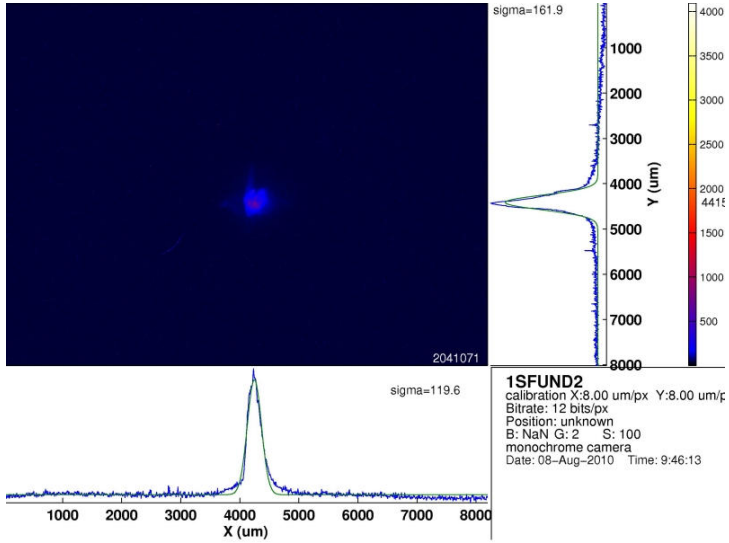


e.g. after the first sFLASH undulator module

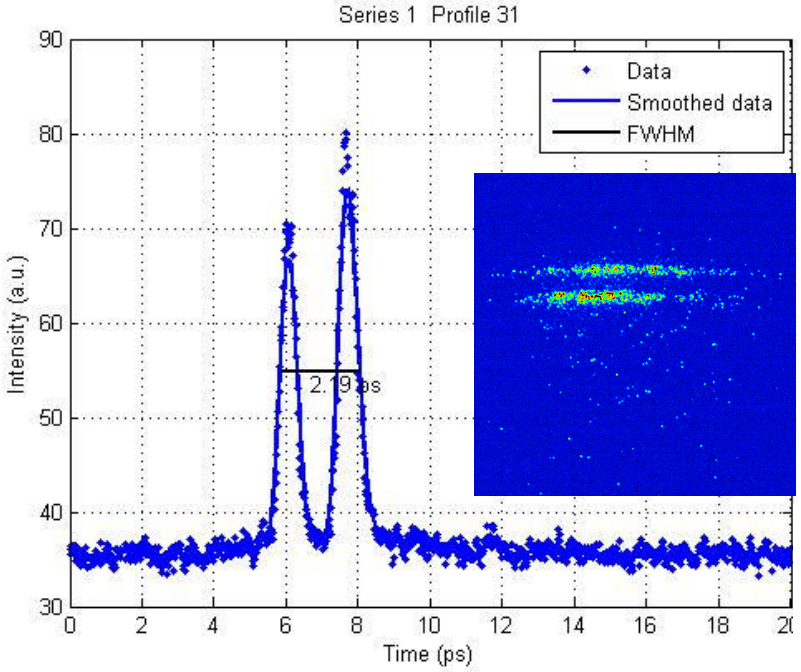
HHG-beam on YAG



e-beam OTR

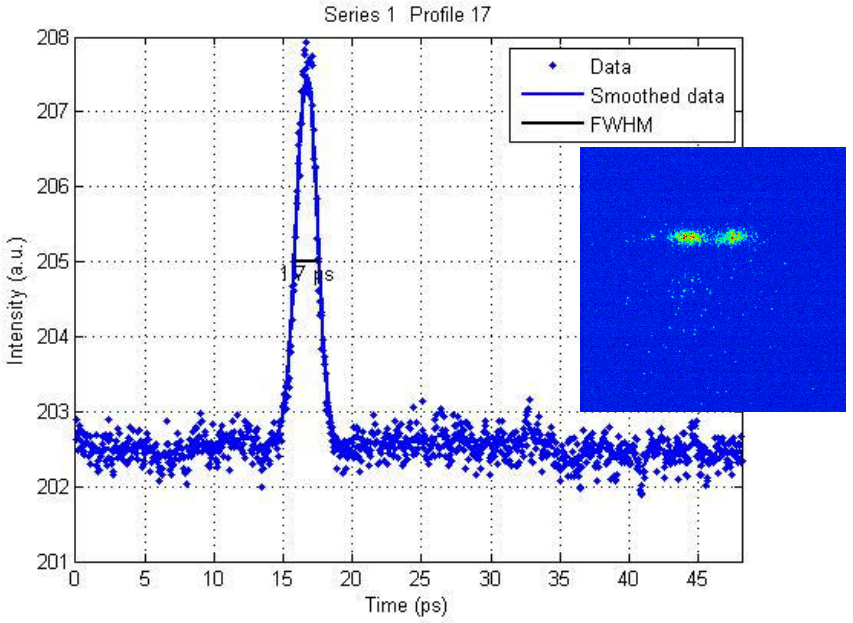


Longitudinal overlap („coarse“)



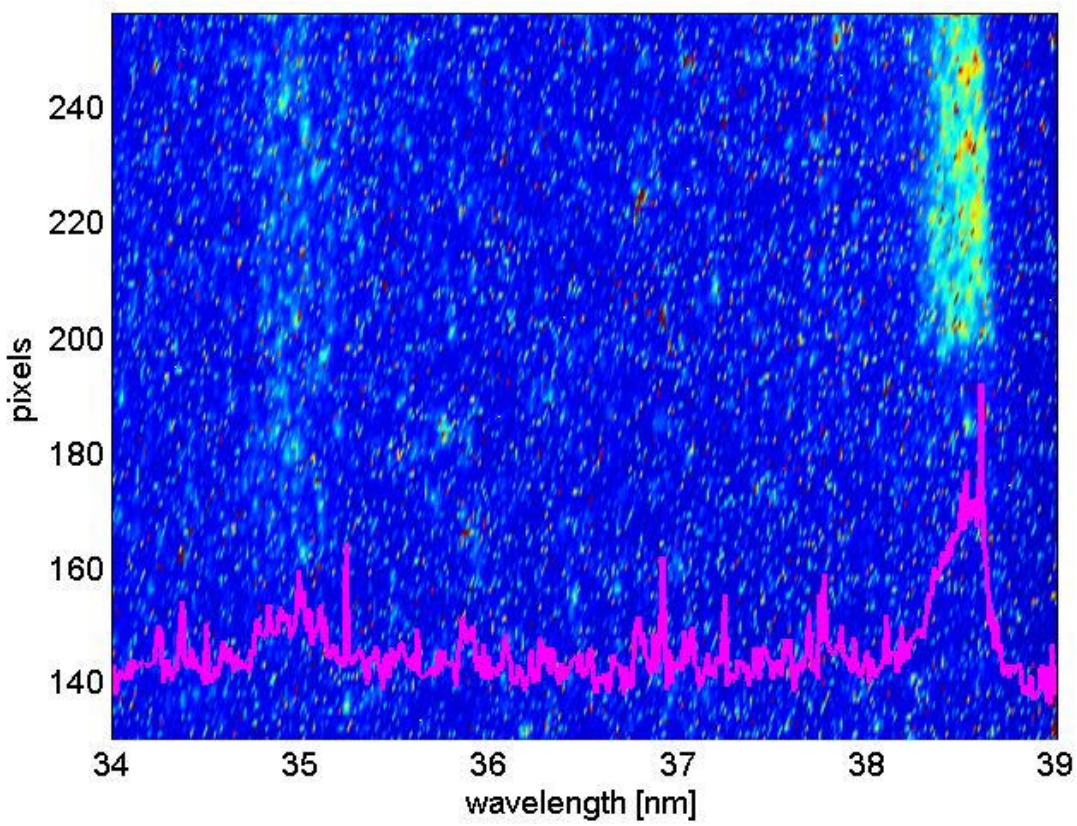
laser and electron beam are seperated in time by ~2 ps

laser and electron beam are overlapped within ~ 1ps



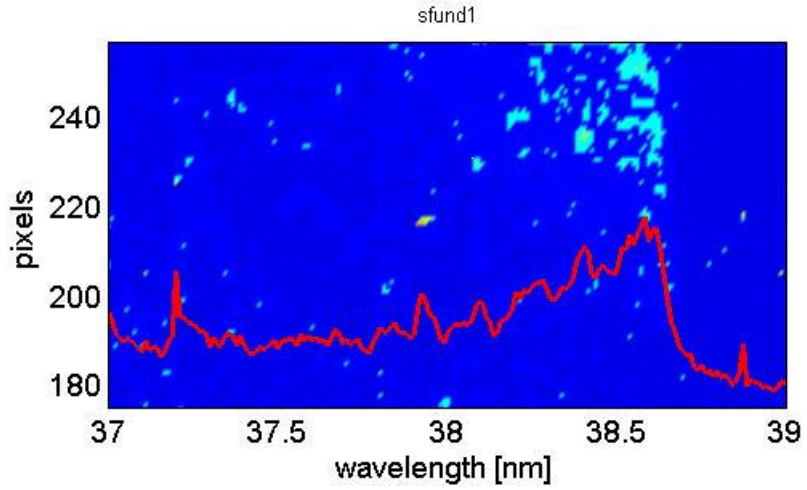
Seed laser spectrum

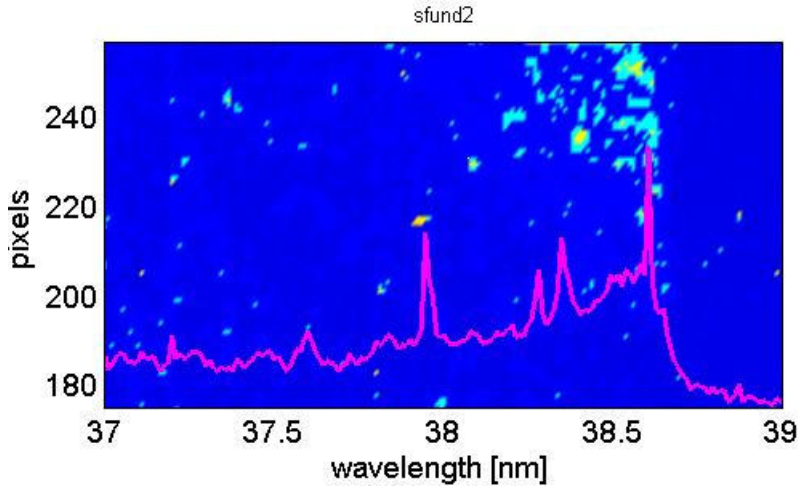
- 21st harmonic at the FEL XUV-spectrometer



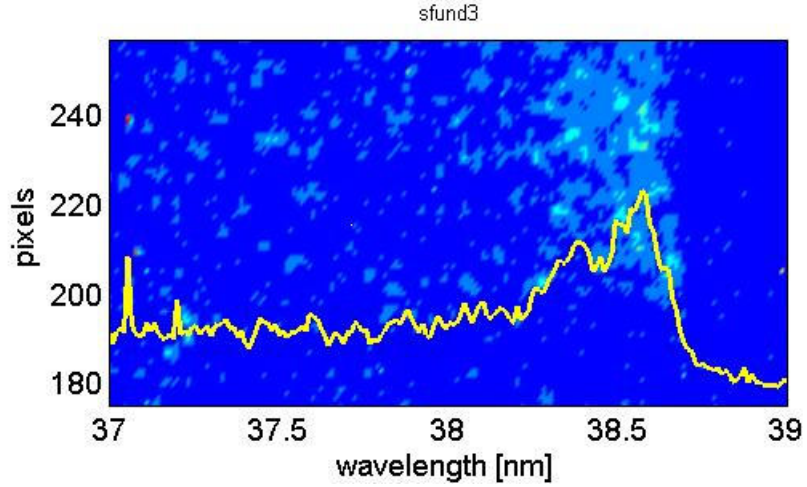
spectral overlap

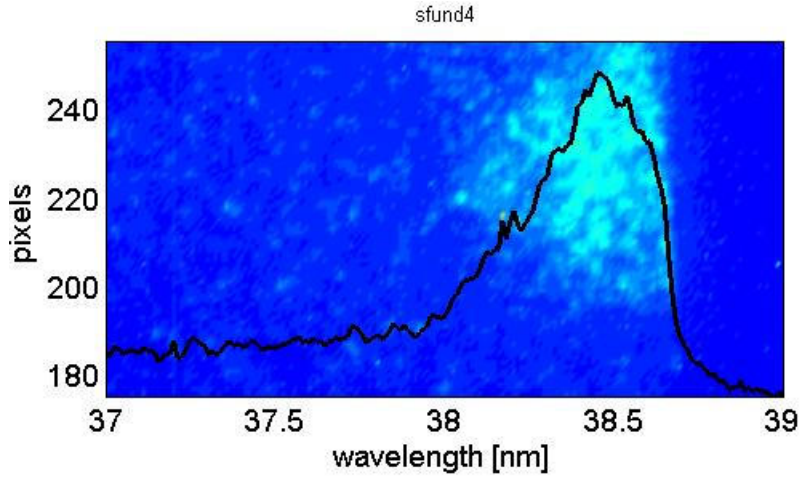
tuning each undulator gap separately





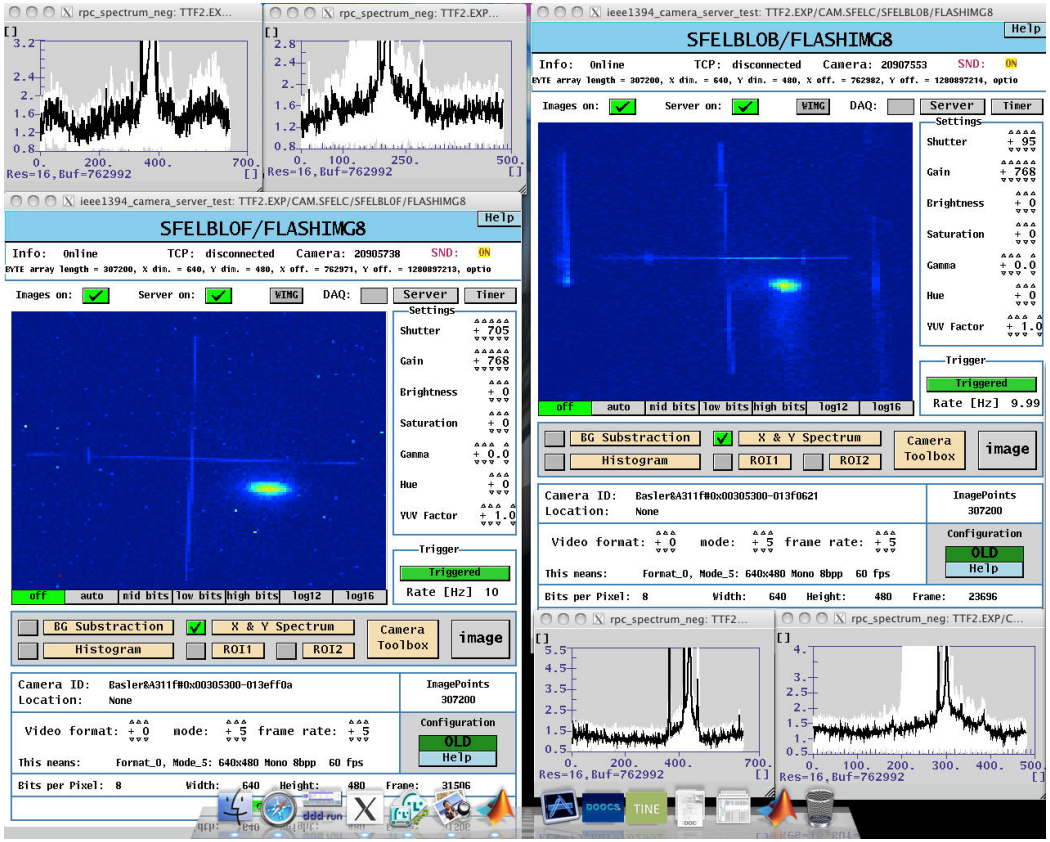
Exposure 1 s, Slits 500µm





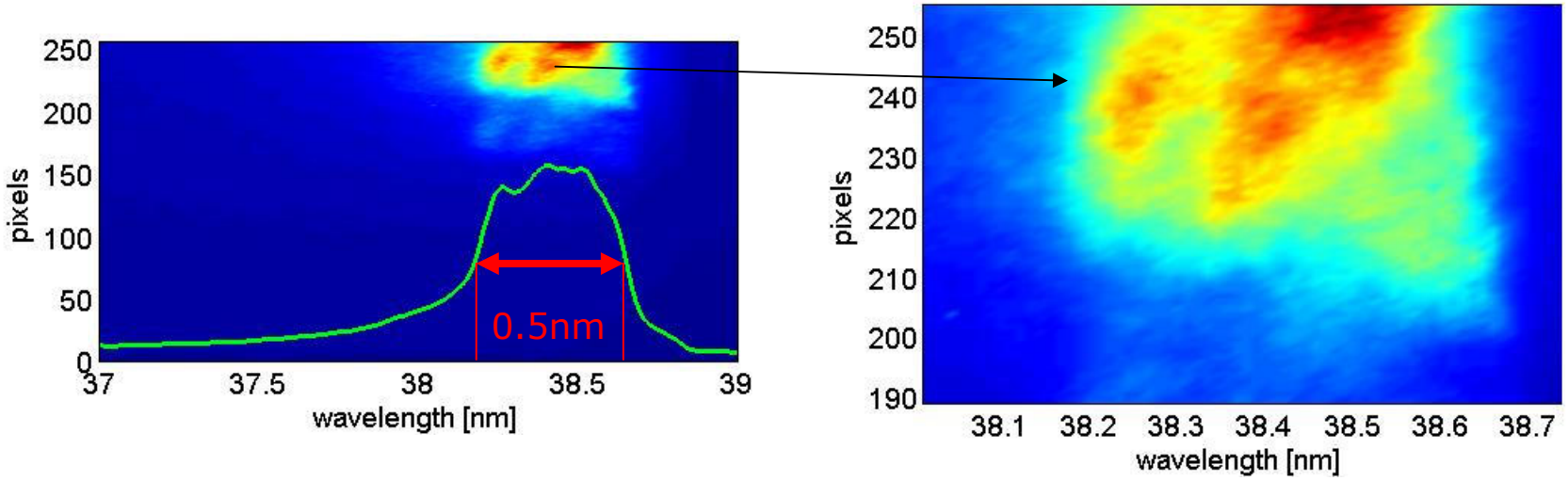
sFLASH SASE

- Close all undulator modules
- The slow feedback keeps the orbit constant
- On 8. August first electron beam through the undulator

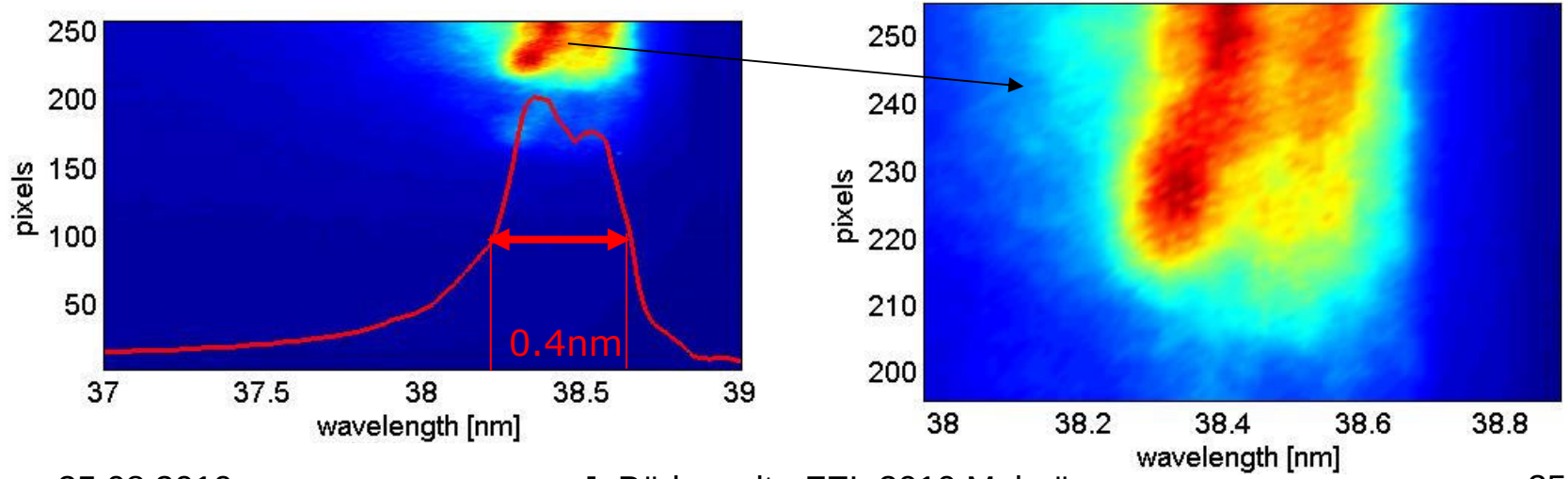


First beam through the tuned undulator

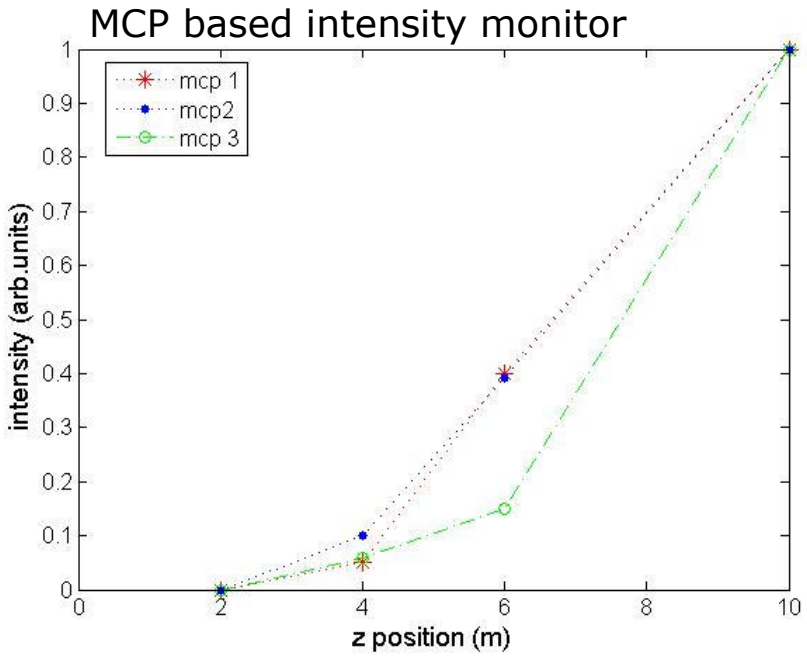
Single shot SASE spectra



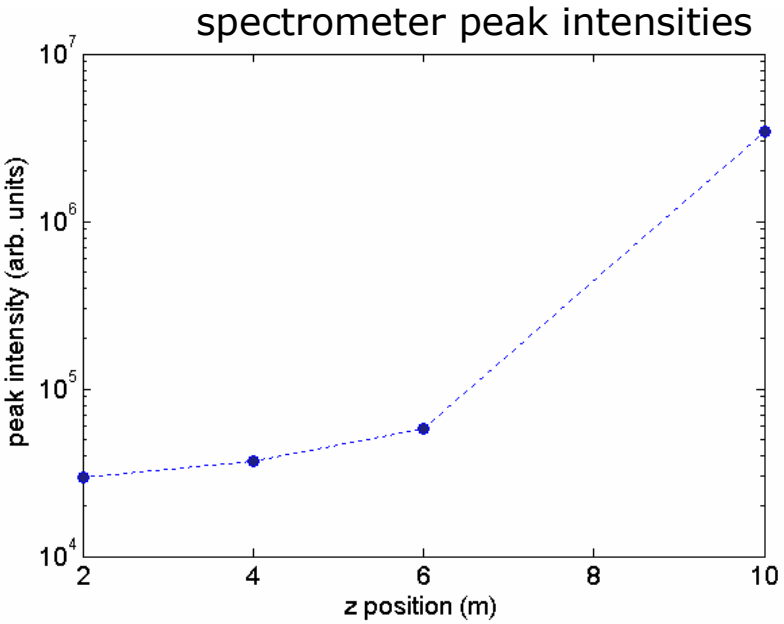
Single shot spectra at around 38.4 nm



Gain curve

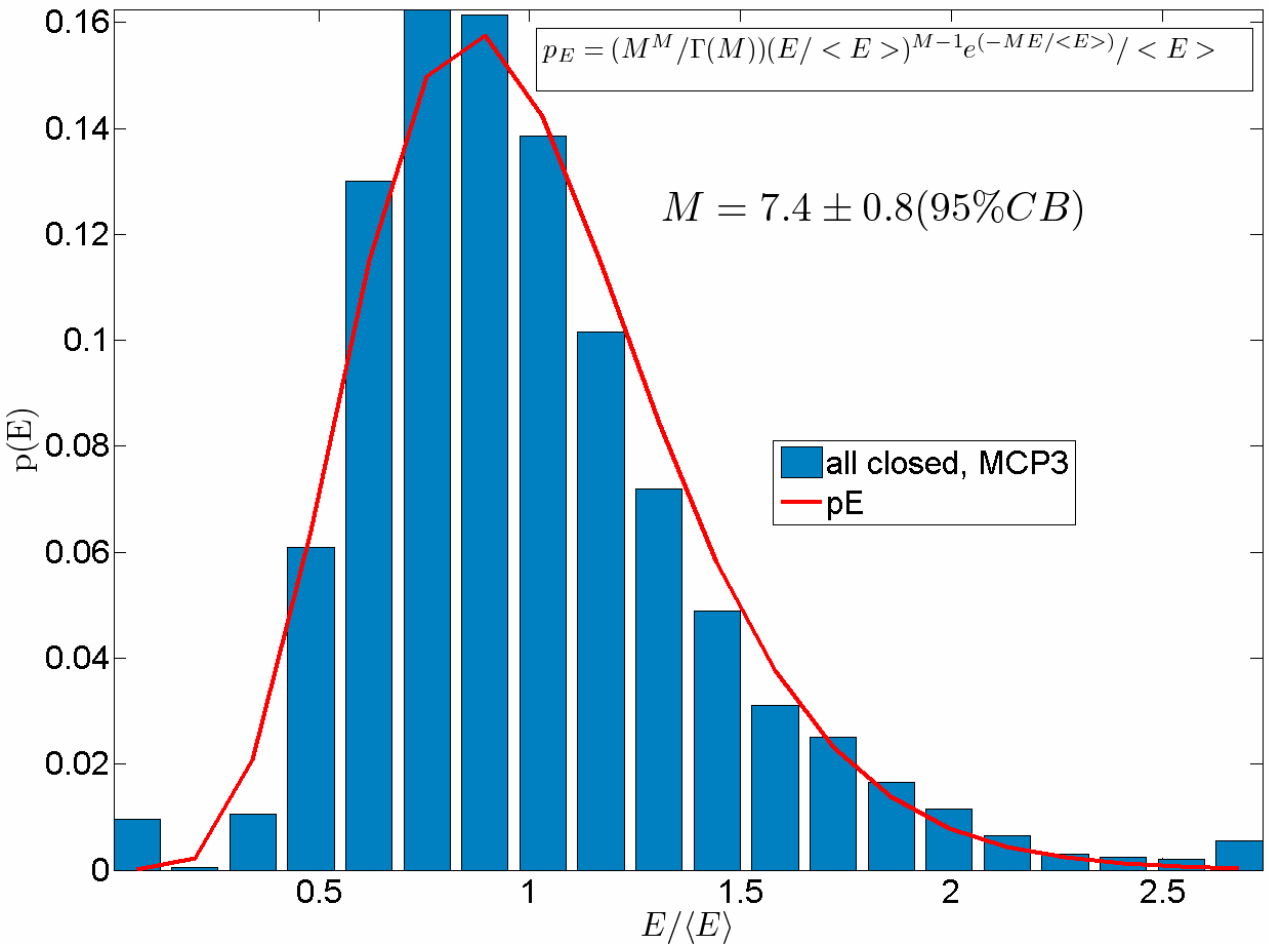


- SASE energy ~200 nJ
- amplification of about 100
- Power Gain Length ~ 1.7 m



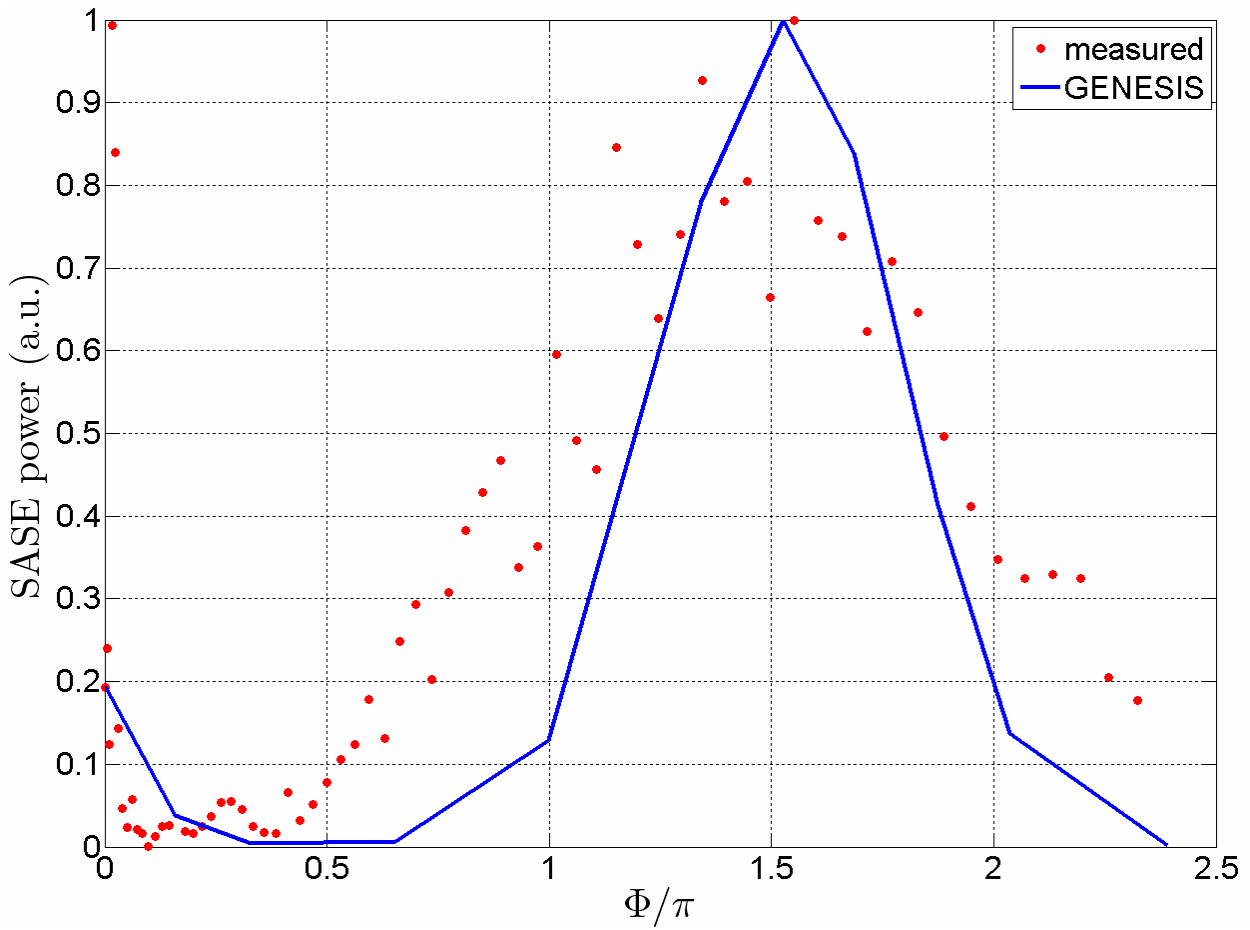
SASE statistics

- Intensity fluctuation from MCP monitor



Phase shifter

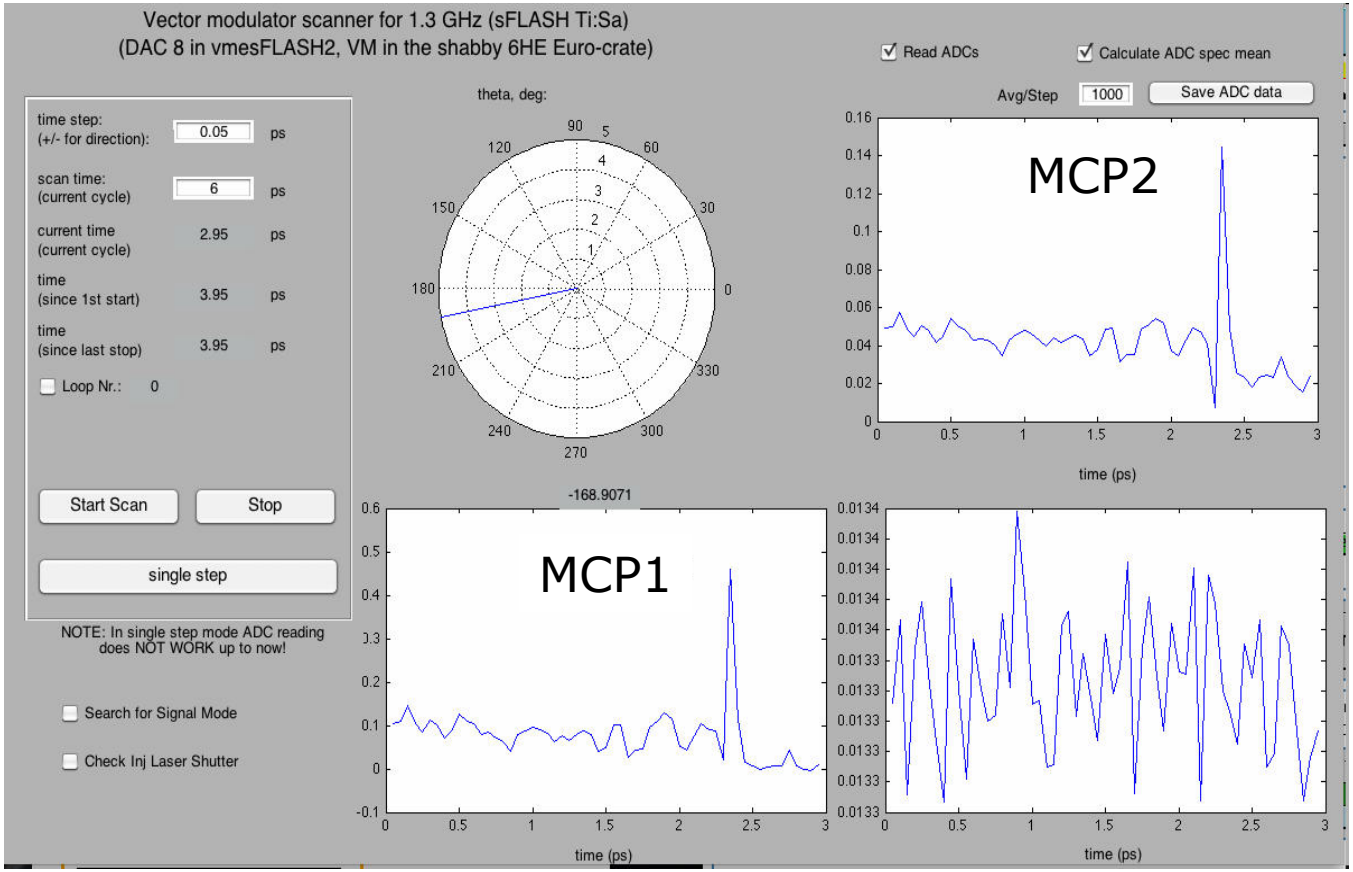
- Scan of the phase shifter



And what about seeding?

Temporal overlap fine scan

- using an electronically delay for the laser trigger the seed pulse is scanned with 25 fs step size with resp. to the electron bunches



First seeding? The status

- seed parameters:
  - Seed energy within the undulator is probably less than 1nJ
  - XUV focusing not yet optimal
  - Synchronization of HHG laser with FLASH MO will be improved (Talk by M. Felber THOA3)
- electron beam parameters has to be improved during the sFLASH shifts
  - longer current distribution with a few 100 fs pulse duration
  - Matched electron beam in sFLASH undulator
  - Stabilization of the bunch arrival time (Talk by W. Koprek THOAI2)

Summary and outlook

- New hardware for direct seeding at FLASH was installed during the FLASH shutdown 2009/2010
- All components were commissioned and are ready for operation
- Procedures to find six-dimensional overlap were tested
- First SASE with sFLASH at 38nm

- Dedicated shifts for first seeding at 38nm are planned during the FEL studies end of September 2010
- characterization of seeded FEL pulses in the pump-probe lab are in preparation

On behalf of the sFLASH team

Thank you for your attention

Armin Azima, Jörn Bödewadt, Francesca Curbis, Hossein Delsim-Hashemi, Markus Drescher, Stefan Düsterer, Josef Gonschior, Katja Honkavaara, Rasmus Ischebeck, Shaukat Khan, Tim Laarmann, Theophilos Maltezopoulos, Atoosa Meseck, Nils Mildner, Velizar Miltchev, Manuel Mittenzwey, Heinrich Münch, Otto Peters, Benjamin Polzin, Jörg Rossbach, Ernst-Otto Saemann, Holger Schlarb, Sebastian Schultz, Michael Schulz, Angad Swiderski, Roxana Tarkeshian, Markus Tischer, Antonio de Zubiaurre Wagner, Marek Wieland, Torsten Wohlenberg, and others