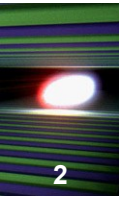




Online Photoemission Spectrometer for X-ray Photon Diagnostics at the European XFEL

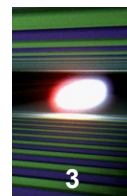
Jens Buck

European XFEL User Meeting 2012:
Satellite Meeting on Photon Beam Diagnostics
Jan 26, 2012



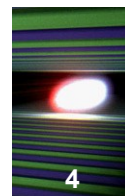
- Requirements
- Design
- Performance
- Data Handling

Device Requirements



SASE process		Shot-to-shot analysis
Online operation		Non-invasive
Any XFEL operation mode		High Tunability
XFEL Pulse Structure		Fast data acquisition
Input to other systems		Low latency

Capabilities of the spectrometer



4

Energy resolution		$\Delta E/E = 10^{-4*}$
Absolute energy calibration		
Linear Polarization	Direction	1 deg
	Degree	1 % **

* : from expected spectral width of XFEL

** : 0.1% by user demand

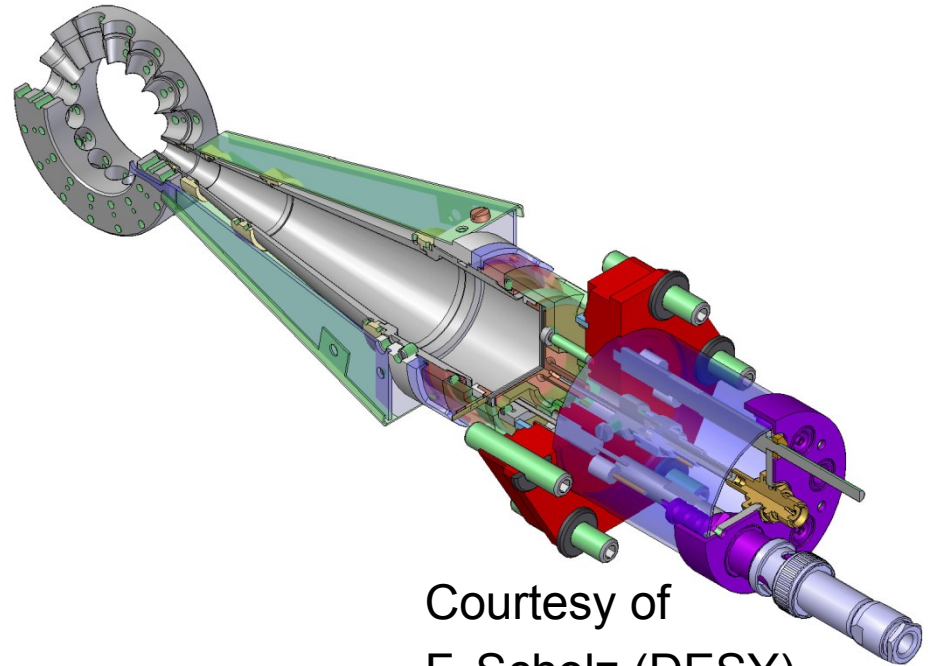
Agenda: Demonstrate how specifications can be met using gas-based photoemission

Flight tube

- Segmented electrodes for retardation

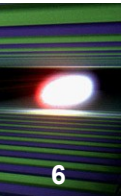
MCP detector

- Z-Stack
- $\approx 1''$ active area
- Integral signal output

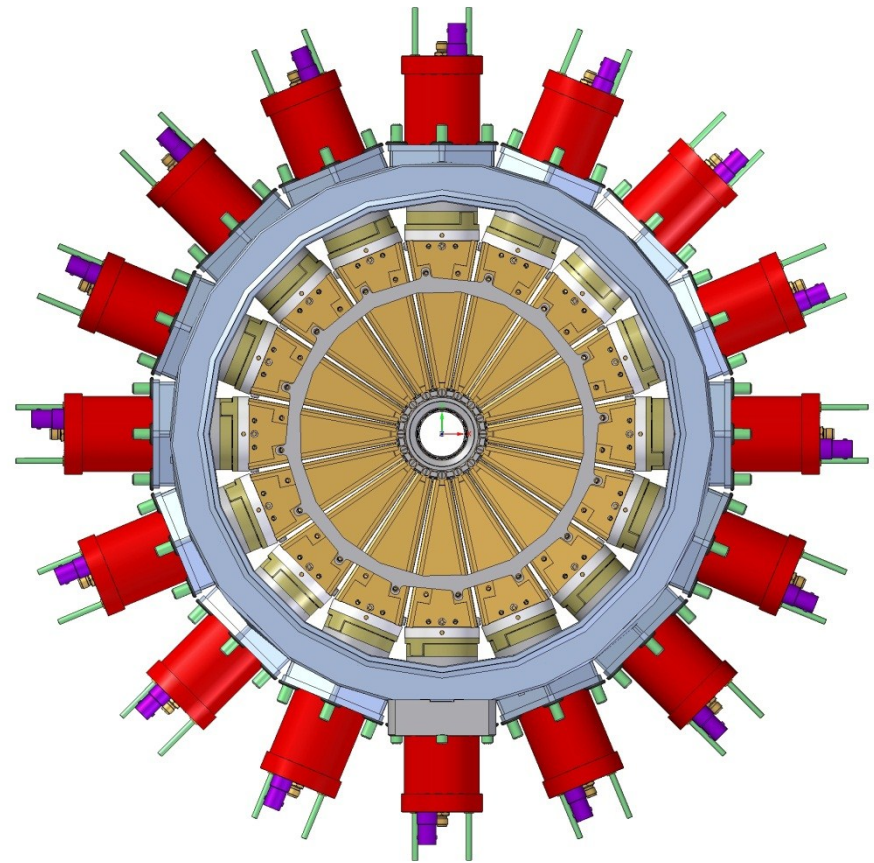
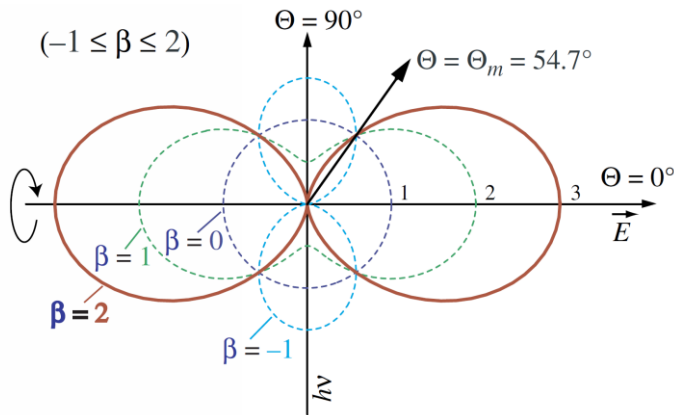


Courtesy of
F. Scholz (DESY)

Length	13.5 cm
Aperture	3.2 mm
Full Opening Angle	12.4 deg



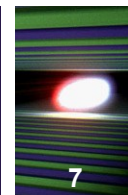
- 16 channels (max.)
⇒ angular resolution
- Independent operation



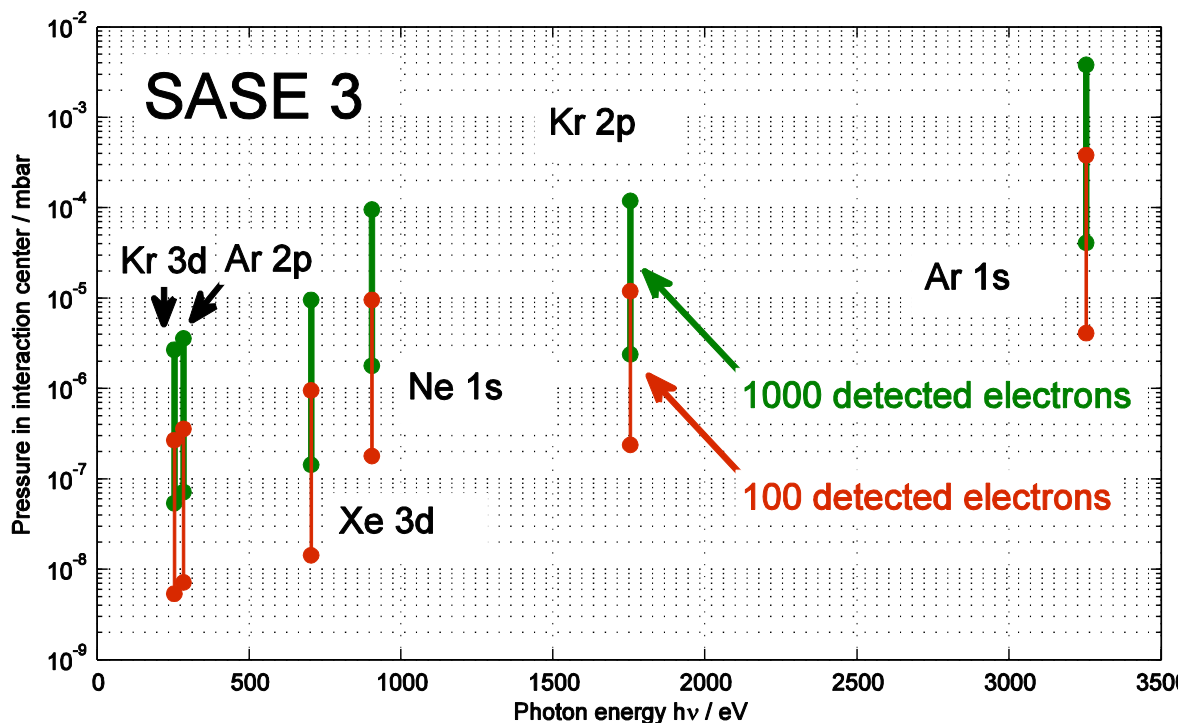
Courtesy of J. Viefhaus (DESY)

Courtesy of F. Scholz (DESY)

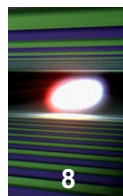
Expected signal at SASE 3



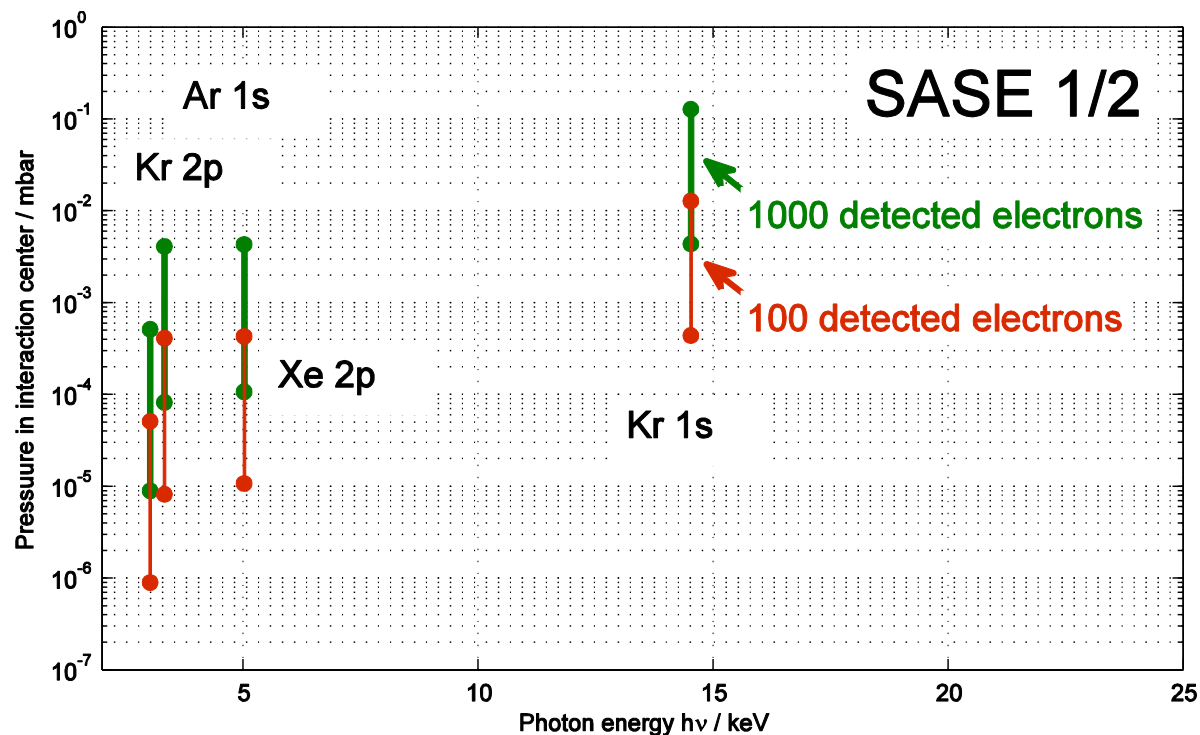
- Neon, Argon, Krypton
- Intensities by Schneidmiller&Yurkov, Transmission estimated
- Isotropic emission
- Well-known photoionization cross-sections (NIST)



- $p = 10^{-5}$ mbar still safe for MCPs
- Tune signal strength by gas pressure
- 100 ... 1000 *detected* electrons per shot sufficient

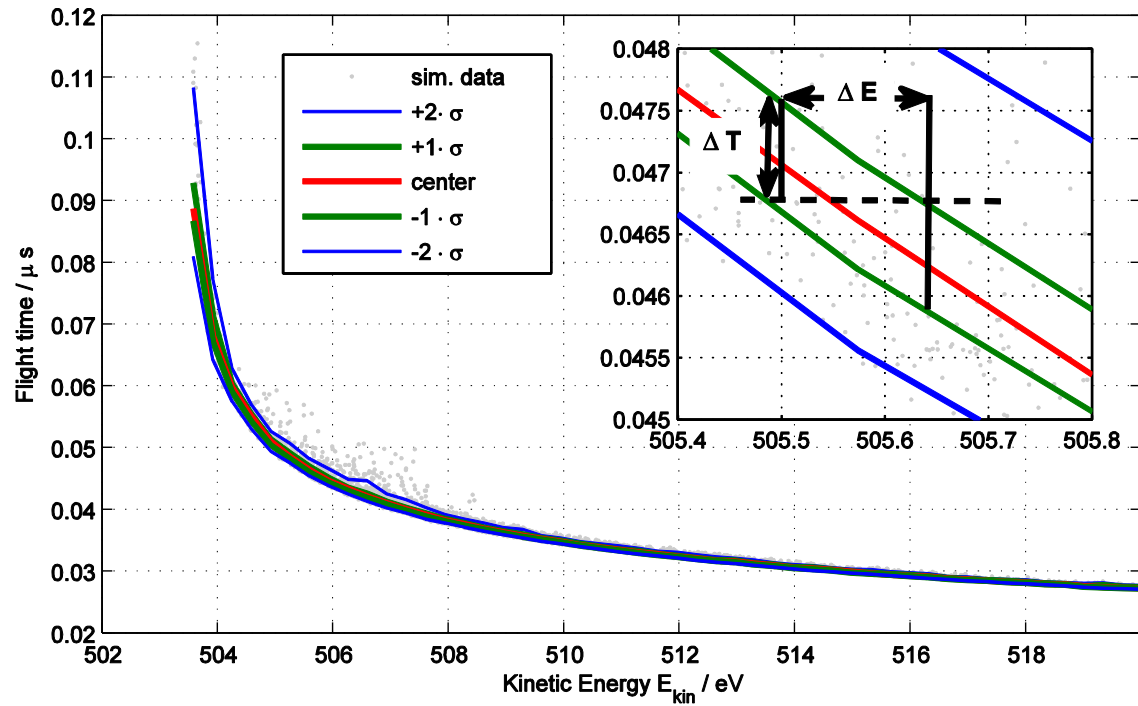


- Argon, Xenon, Krypton
- Higher pressure in interaction region required
- Higher kinetic energies (up to 10 keV)

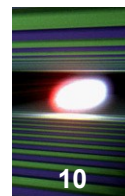


Simulated Dispersion Relation

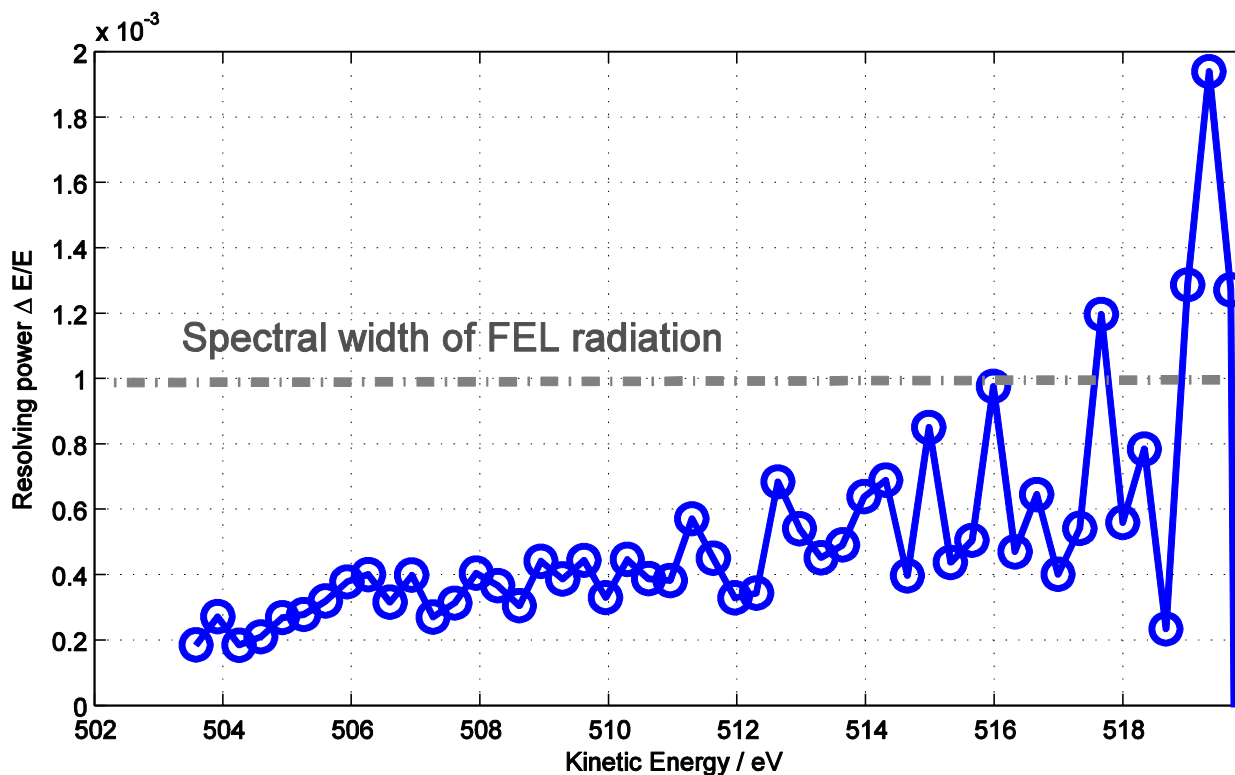
- Representative sample from complete accepted phase space volume
- Spread from optical aberration
- To be validated during experiments



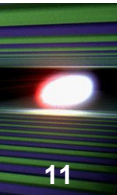
Simulated Energy Resolution



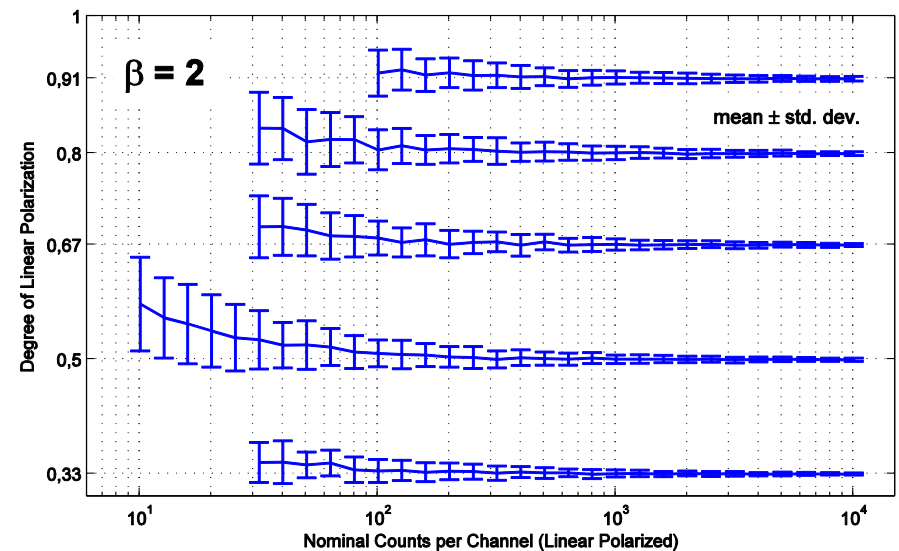
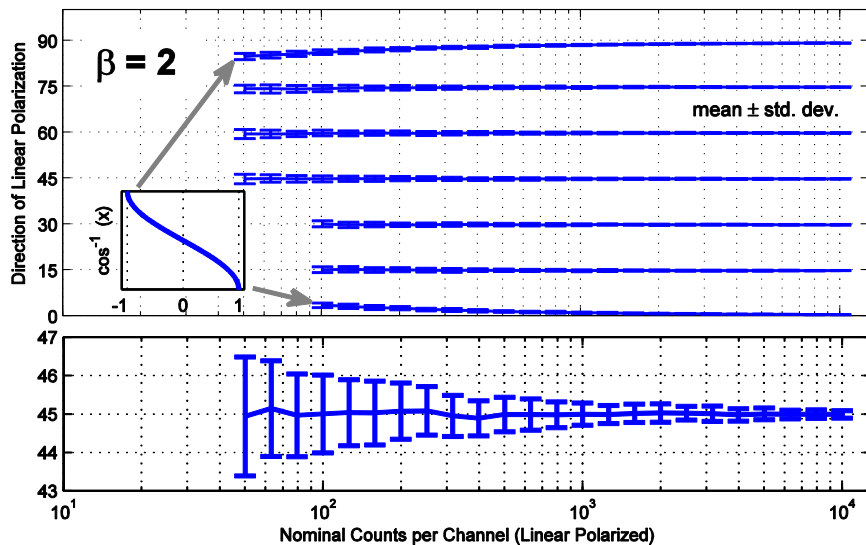
- Resolution close to specification of 10^{-4}
- Range: few % of kinetic energy (at least)



Polarization Analysis



- Degree and orientation of linear polarization
- 100 ... 1000 electrons/shot already give good results
- Single-shot capability
- NO curve fitting: FPGA- implementation possible



- Sample analog signal (16 x 1D data)
- Estimation of data rate:

- 5 GS/s
- 12 Bit resolution
- 220 ns per
TOF-spectrum
- (Up to) 16 channels

Raw data rate per channel*

1100	Samples / shot
56.5	MB / s
4.65	TB / d
1.66	PB / y

*Assuming 16 bit integer numbers
and 24/7 operation

⇒ **Data reduction needed!**

- Representation of data in low-dimensional basis

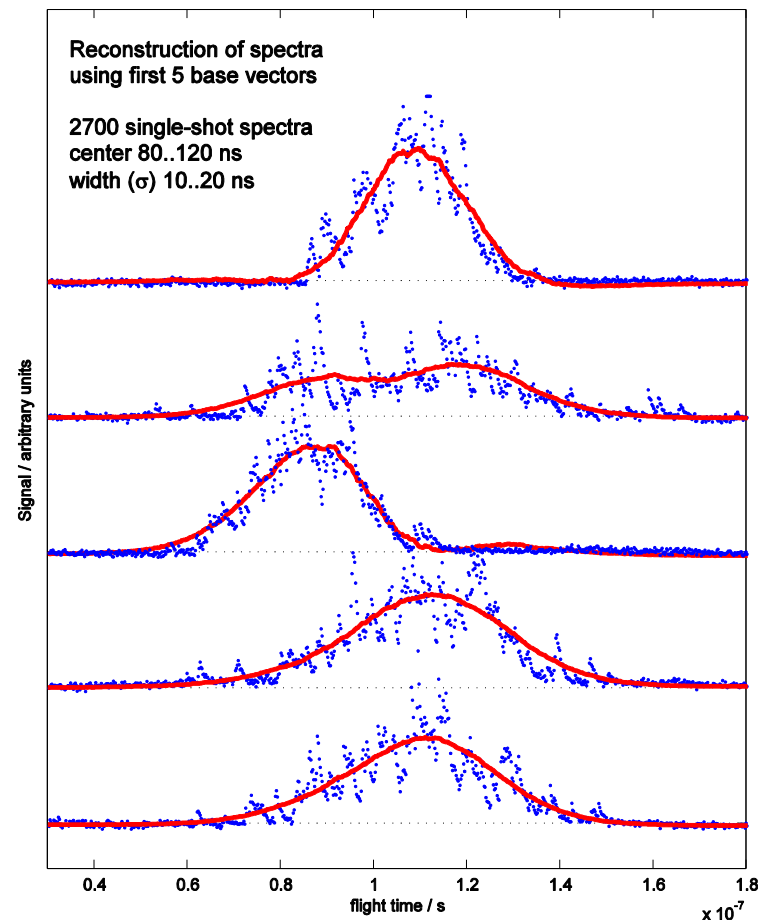
$$S = s_0 + \sum_{k=1}^N \beta_k \cdot s_k$$

- Basis determined from actual data
- Separation / Removal of Noise
- Implementation on FPGA / PC

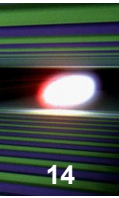
- Scalability between extremes:

100% Detail \Leftrightarrow **Compression down to 1.8 %**

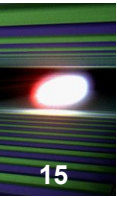
- Demo with artificial data:



Summary of the current status



- Mature mechanical design and detectors available
- First simulations of device performance for SASE 3 promising
- Hardware and software for online processing outlined
- Conceptual Design has been reviewed recently



- Conceptual Design documents in preparation, publication planned until end of Mar 2012
- Development for SASE 1/2-version going on
- Prototype for SASE 3 to be built soon
- Digitizer/FPGA hardware to be ordered
- Beamtime for test measurements scheduled 1st semester 2012

WP-74

- Jan Grünert
- Wolfgang Freund
- Cigdem Ozkan
- Bin Li

P04 group@PETRA III

- Jens Viefhaus
- Leif Glaser
- Frank Scholz
- Markus Ilchen
- Peter Walter
- Sascha Deinert
- Jörn Seltmann

XFEL.EU

- Serguei Molodtsov
- Tobias Haas
- Michael Meyer
- Harald Sinn
- Christopher Youngman
- Patrick Geßler

FLASH@DESY

- Markus Braune

University of Hamburg

- Michael Martins

- Thank you for your attention!
- Visit our posters on photon diagnostics in the poster session on Friday.

