

# KALYPSO @ VLS

XUV Spectra at 1 MHz

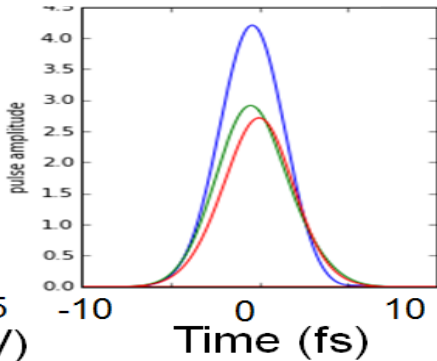
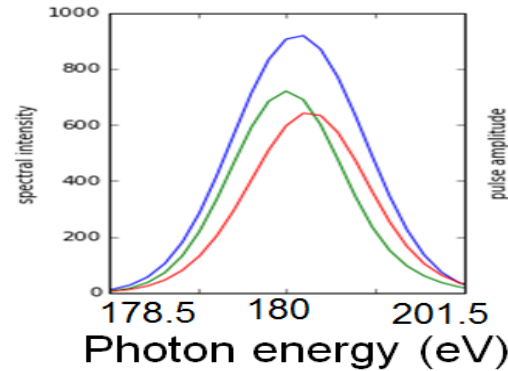
Stefan Düsterer for MSK (Sdiag) and FS-FLASH-D  
FLASH Seminar, DESY, 18.12.2018

# Outline

- **Motivation**
- **What is VLS and Kalypso ?**
- **Applications and results**
  
- **Outlook** next version
- Thanks ...

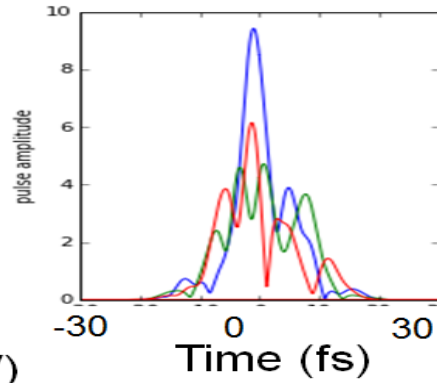
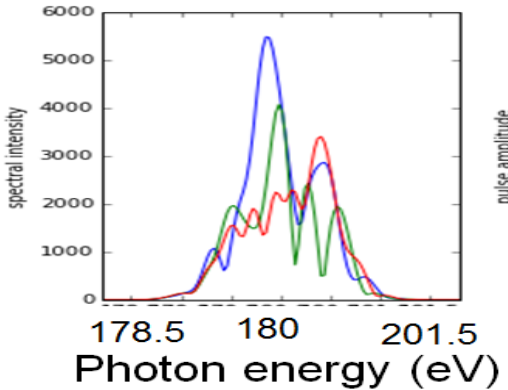
# SASE pulses (Self-Amplified Spontaneous Emission)

## Simulation

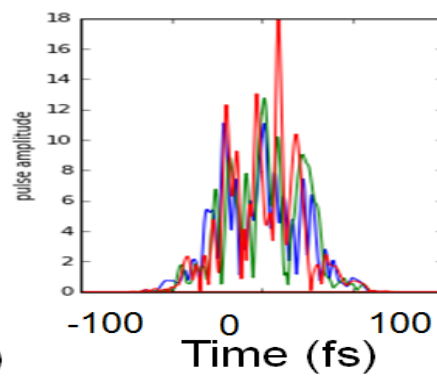
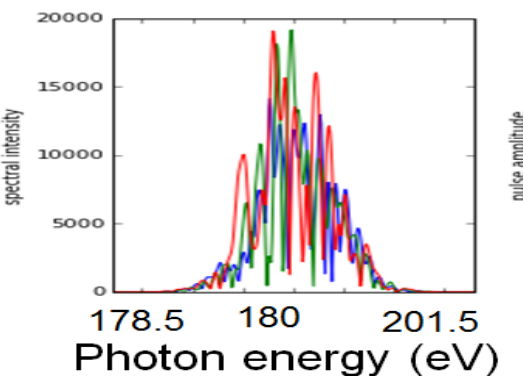


Single spike  
(currently) shortest  
SASE FEL pulses

**5-10 fs**

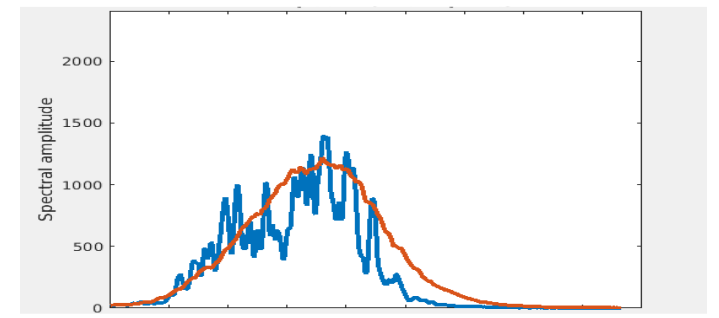
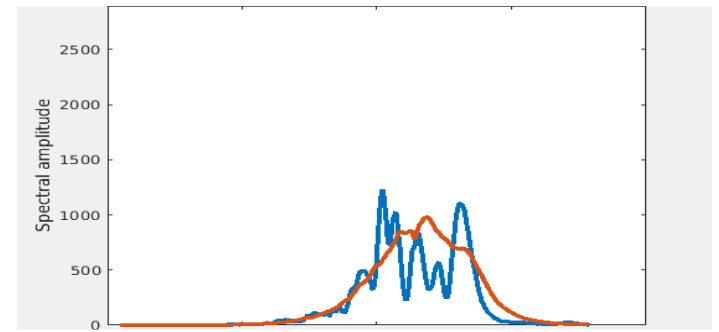
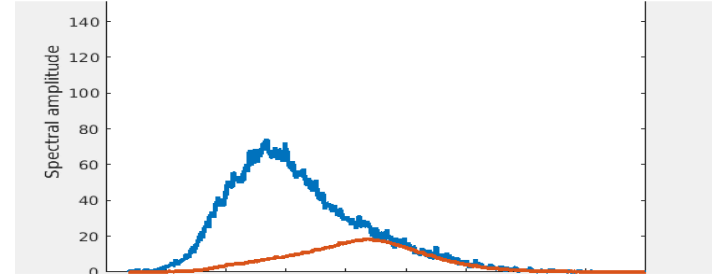


**~20 fs**



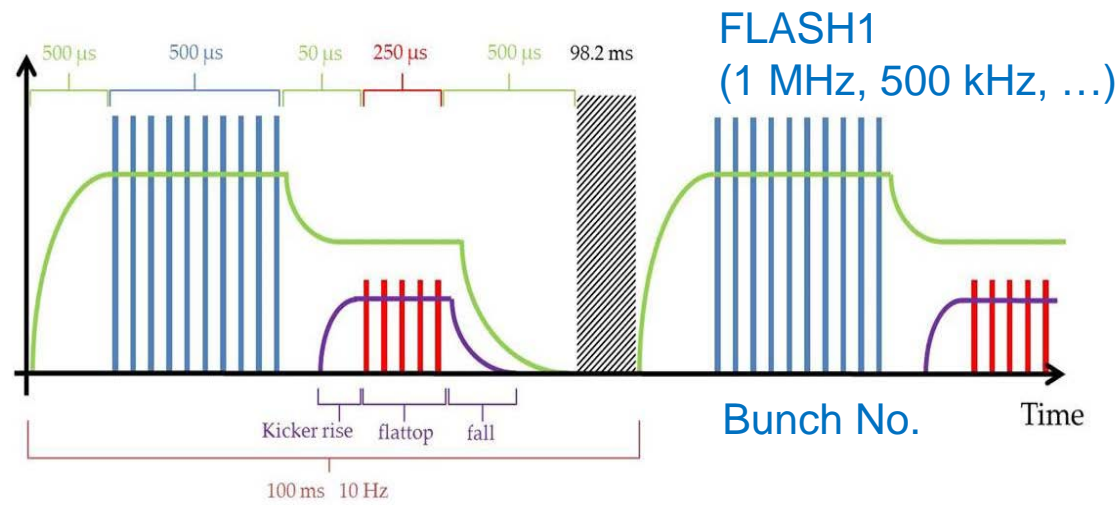
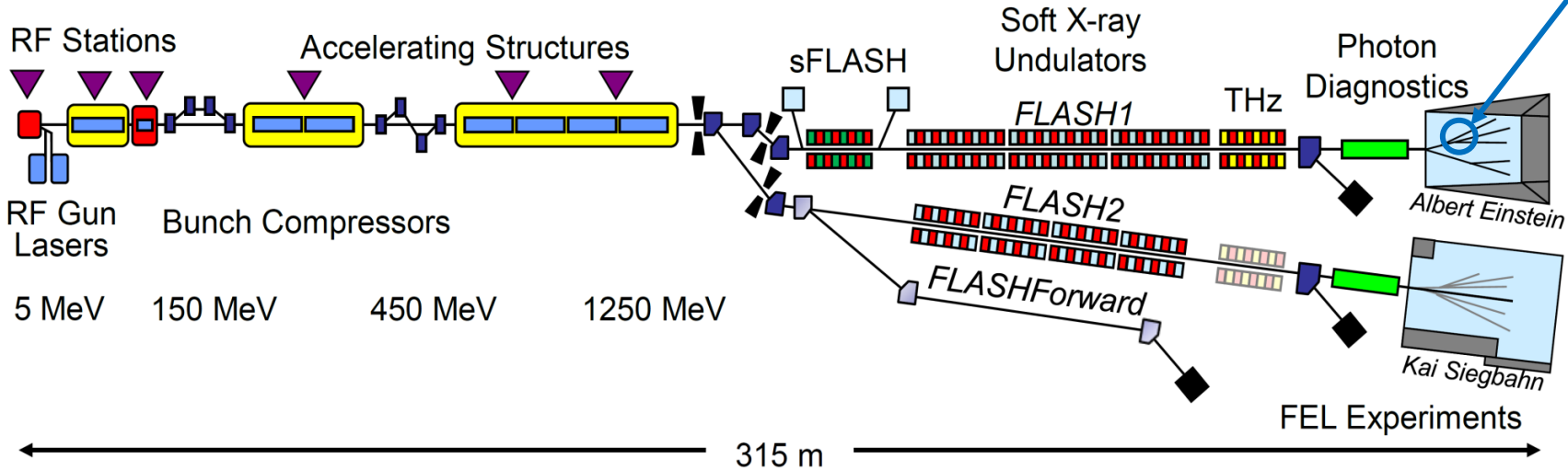
**~80 fs**

## Spectral measurements

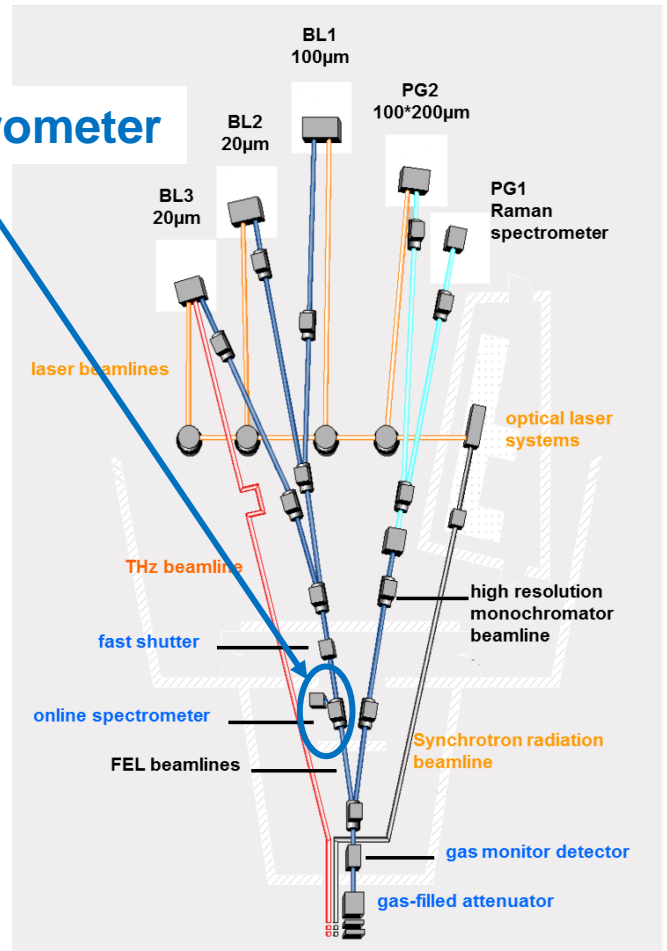


# VLS Spectrometer @ FLASH1

## FLASH1 and bunch repetition rate



## VLS spectrometer

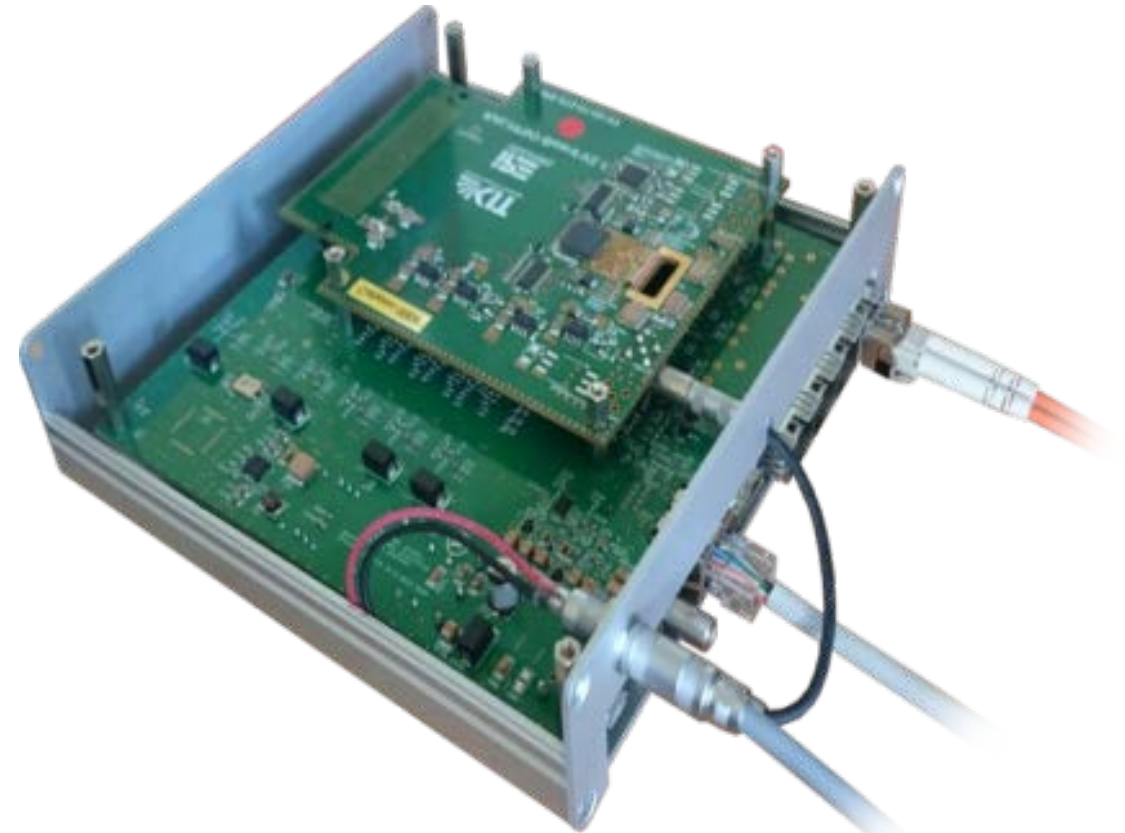


K. Tiedtke et al.,  
New journal of physics 11.2 (2009): 023029.

# KALYPSO

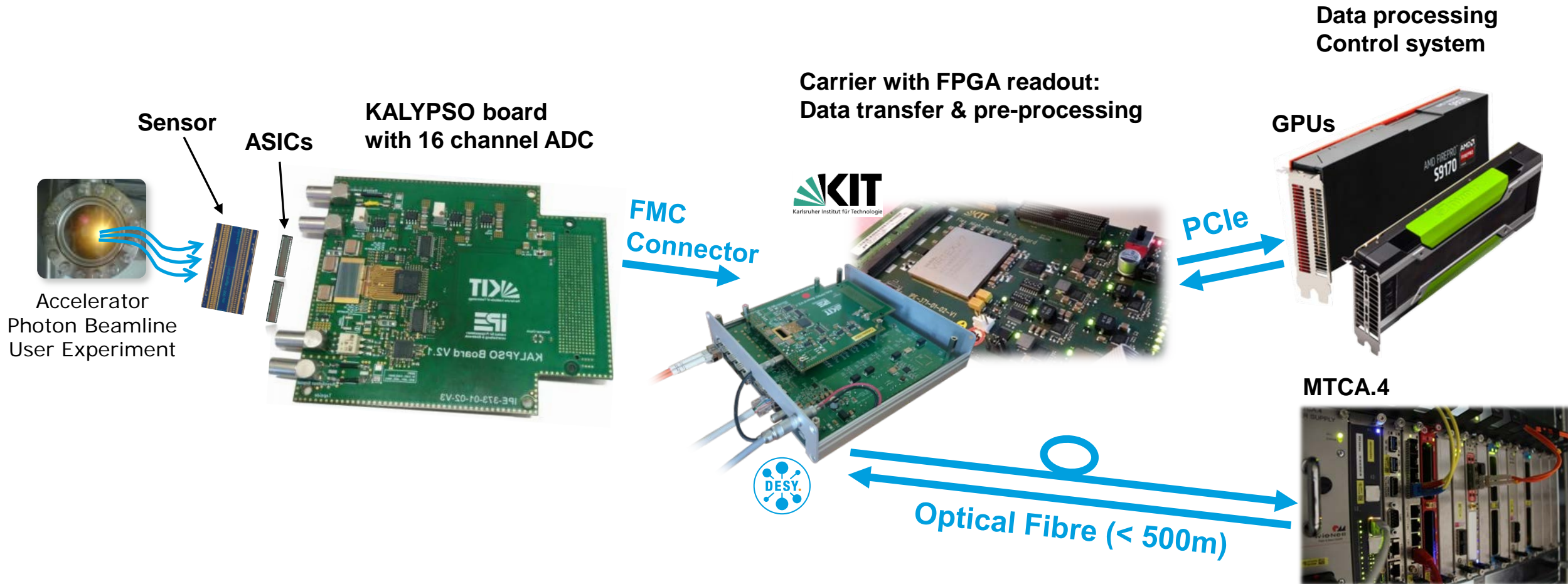
## KARlsruhe Linear arraY detector for MHz rePetition-rate SpectrOscopy

- **Parameters for current version 2.1**
  - **256 pixels, 50  $\mu\text{m}$  pitch**
  - **14 bit ADC, 2.7 Mfps**
- Burst mode -> few 1000 “line images” per 10 Hz
- cw operation (for storage rings or cw FELs)
  - Continuous data stream out
  - Low latency for fast feedback
- First demonstration
  - ANKA/KARA: 2.7 MHz
  - E-XFEL: 2.25 MHz
  - FLASH: 1 MHz



# KALYPSO

## Overview: Building Blocks of the Detector System



# Applications of KALYPSO

## Different applications

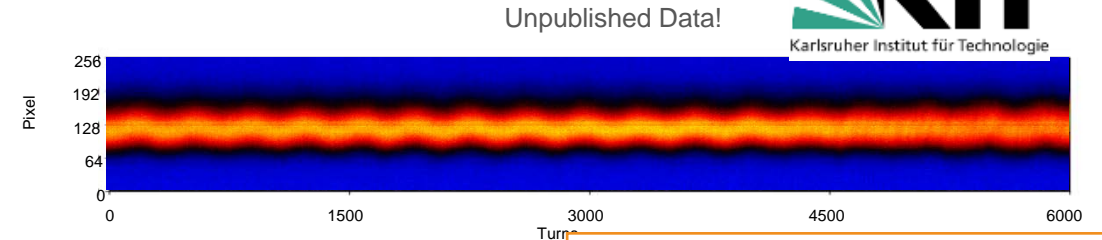
- Synchrotron:
  - KALYPSO installed at visible synchrotron radiation port
  - Measure horizontal bunch position and profile
  - Single-shot (turn-by-turn) with 2.7 MHz
  - Continuous data taking => 1.4 GB/s
  - Horizontal synchrotron motion in low-alpha mode

- XFEL

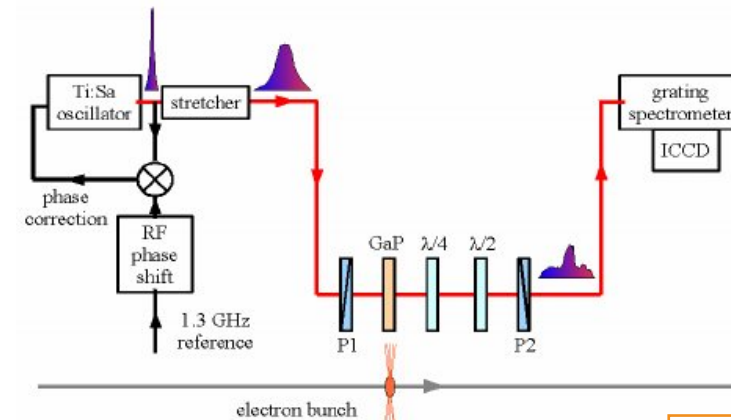
- Electron bunch Diagnostic: EOS (Bernd Steffen)

- FLASH:

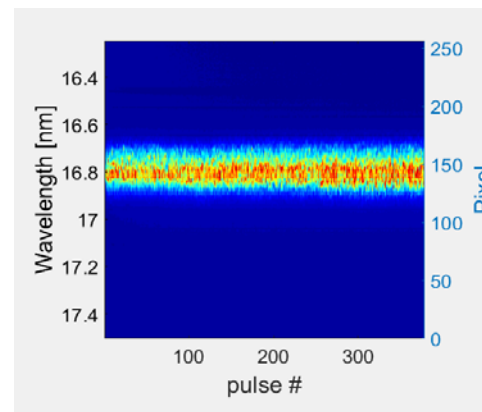
- XUV spectrometer



Preliminary,  
courtesy of B. Kehrer and S. Funkner



By B. Steffen



# KALYPSO --> DOOCS / DAQ

## Graphical user interface

The screenshot displays the KALYPSO graphical user interface (GUI) with several key components:

- Top Panel:** Includes the FLASH logo, the text "KALYPSO", and tabs for "User" and "Expert".
- Control Panel (Left):** Features "Kalypto control" buttons (Start, Stop, Restart, Board Reset), Gain (1/4), Exposure (8), and a "Data is saved" indicator.
- Output data (Top Left):** A 2D heatmap plot showing intensity as a function of wavelength (A in nm) and frames.
- Center of mass (Top Right):** A line plot showing the center of mass of bunches over time.
- Line profile (Bottom Left):** A plot showing the signal profile for a selected line (109).
- Mean values (Bottom Right):** A plot showing the mean values of the signal over time.
- Background mean (Bottom Right):** A plot showing the background mean values over time.
- Parameters and Controls (Right):** Includes a "Selection parameters" section with "Started" and "Finished" times, a "Channels" list, and various control buttons like "Get Channels/Files", "Start Display", "X2 Timer", "MHz Trigger", "10 Hz Trigger", "Temp.", "HV", "LV", "Hold EOD PROCserver", "HoldDMA server", and "KalypsoServer Watchdog".
- Data Show Window (Overlaid):** A smaller window titled "Data Show" displaying a zoomed-in view of the output data plot.



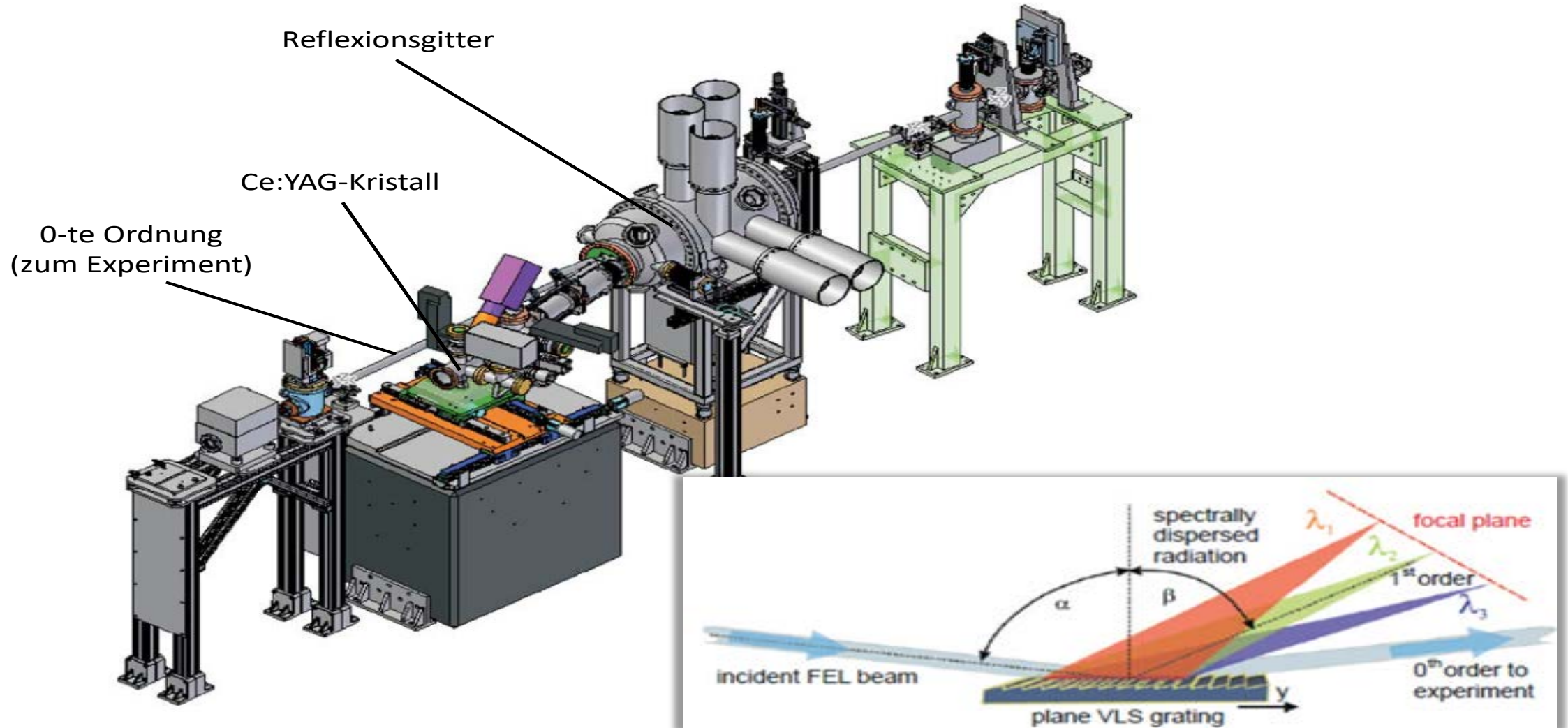
# How to get to KALYPSO

The image displays the FLASH control interface, which is organized into several sections:

- Top Navigation Bar:** Contains icons for Status, Operations, Feedbacks, Diagnostics, and Tools. Below this are icons for MPS, Injector, RF/LLRF, Orbit, Photons, Magnets, Vacuum, Cryo, and Controls. The 'Photons' and 'Magnets' icons are circled in red.
- Left Panel (Photondiag):** Includes a 'Photondiag' logo and buttons for 'Diag. tunnel', 'Link to FL2 Vacuum SPS', 'Link to Vacuum panel', 'Phone numbers in the hall', and 'Manuals'. Below these are 'Spectrometer' and 'Experimental hall' sections. The 'VLS spectr /KALYPSO' button in the Spectrometer section is circled in red.
- Right Panel (Main Control):** Features a URL bar, tabs for 'User / S1 screen / CO', 'Kalypso / line detector', 'VLS spectrometer', 'Advanced', and 'Expert'. The 'Kalypso / line detector' tab is circled in red. It contains:
  - Output data:** A heatmap showing detector data with a circular arrow indicating a scan. A red oval highlights the text 'Data is NOT saved'.
  - Center of mass:** A plot of  $\lambda$  (nm) vs. position, showing a rising trend.
  - Line profile:** A plot of signal intensity vs.  $\lambda$  (nm) showing a dip at 8.60 nm.
  - Mean values:** A plot of mean values vs. position, showing a sharp peak at 8.60 nm.

# VLS – Variable-Line-Spacing spectrometer

## Setup

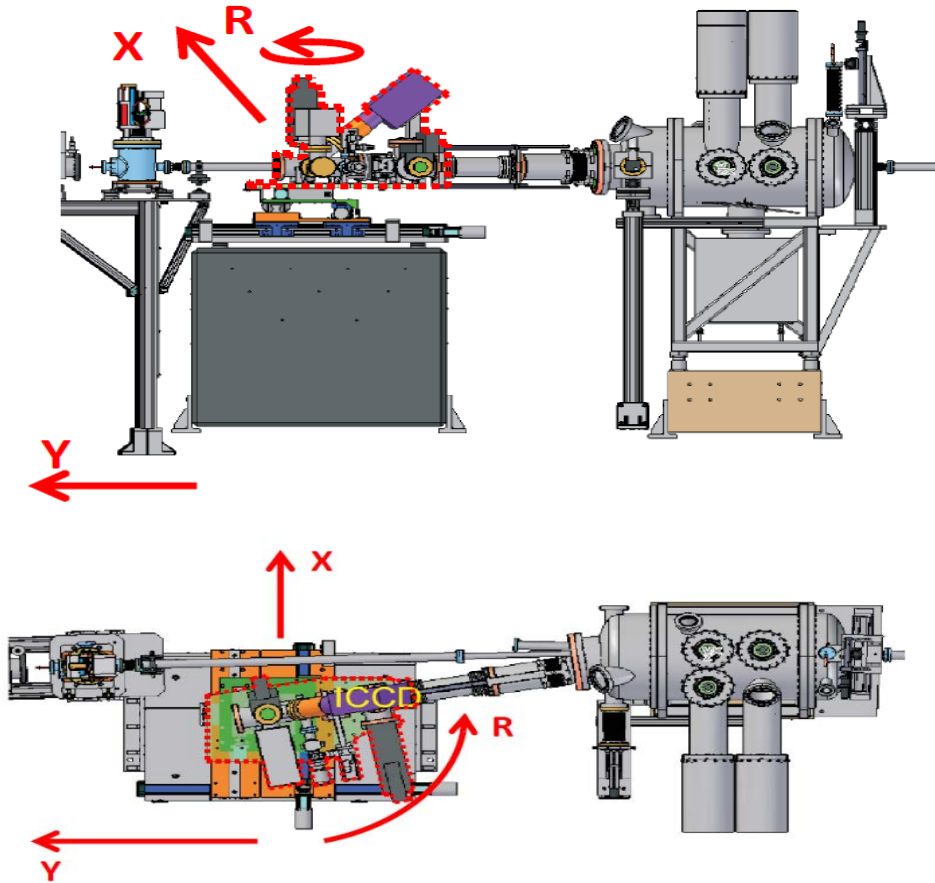


# Automatic movement of the VLS detector

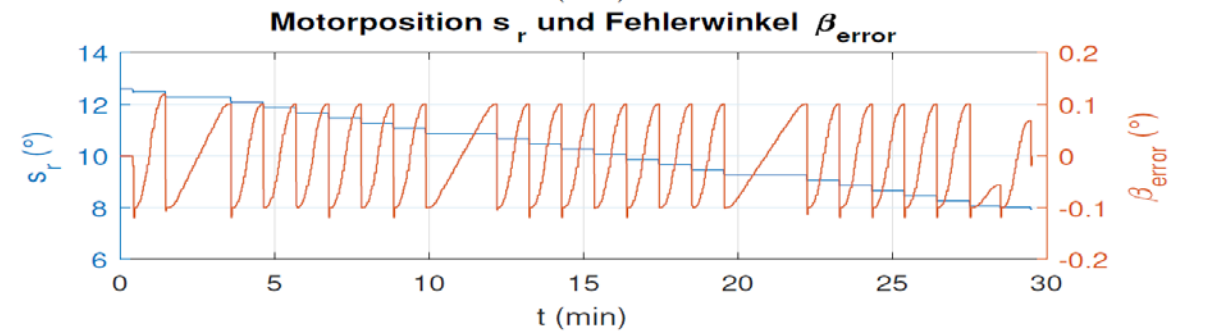
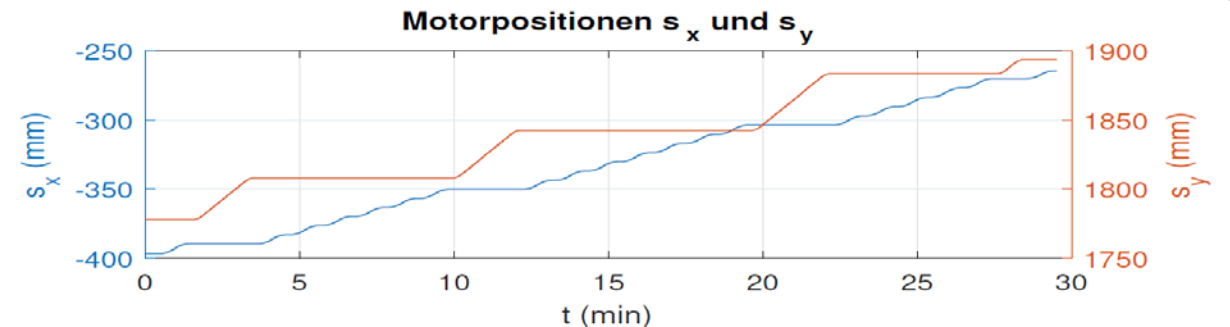
## 3 motor movement

Detector unit

Optics chamber



G. Brenner et al.,  
Nucl. Instr. and Meth A **635**, 99–103 (2011).



# VLS Spectrometer @ FLASH1

## VLS Spectrometer

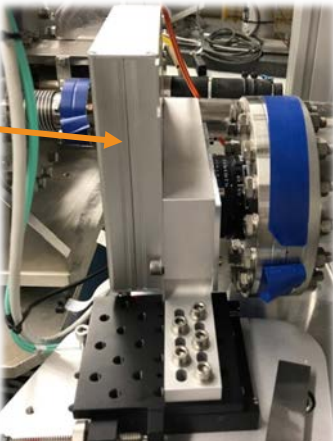
0<sup>th</sup> order  
(to experiment)

Gotthard-I replaced  
by KALYPSO

60nm

6nm

1<sup>st</sup> order



CeYAG scintillator screen  
imaged by tandem optics

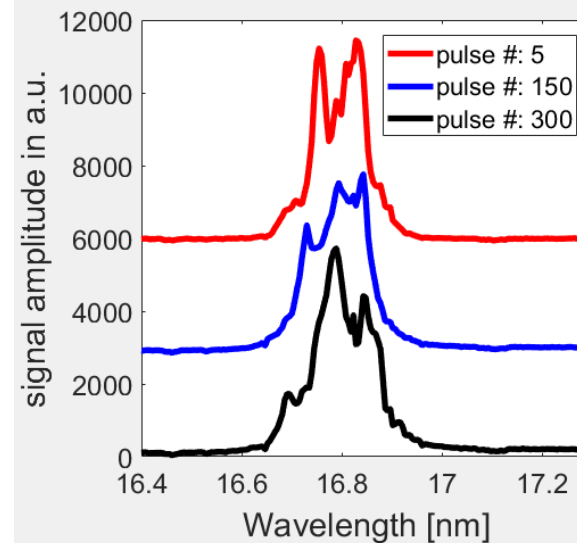
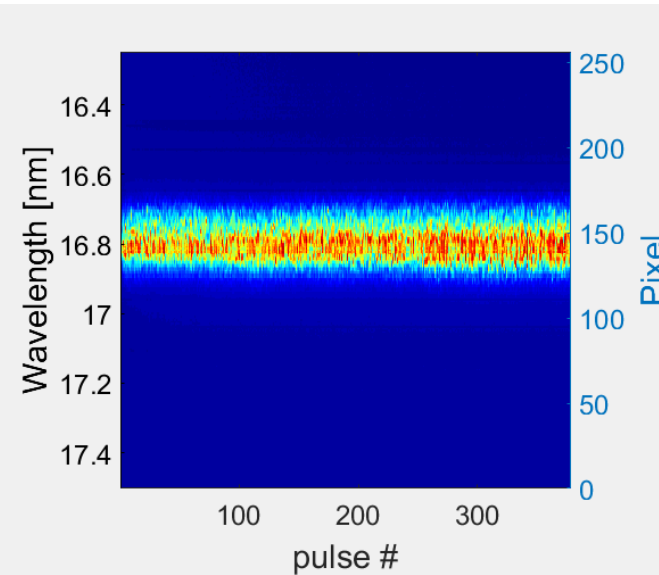
VLS grating

Working range: 5.8 – 60 nm  
Efficiency: 1 – 10 %  
Resolving power:  $\sim 2\text{-}3 \cdot 10^3$

FEL beam

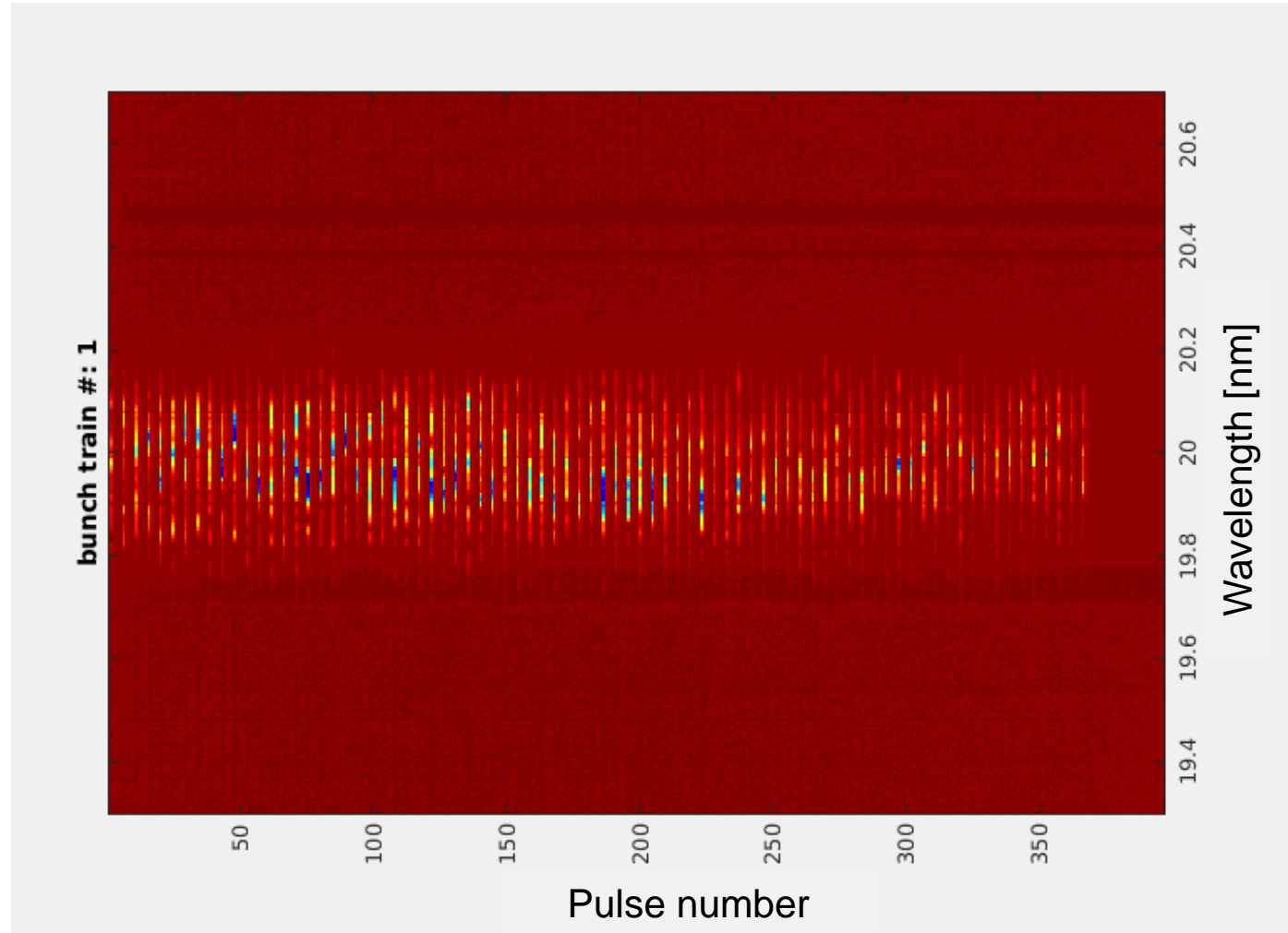
G. Brenner et al.,  
Nucl. Instr. and Meth A **635**, 99–103 (2011).

## Kalypso



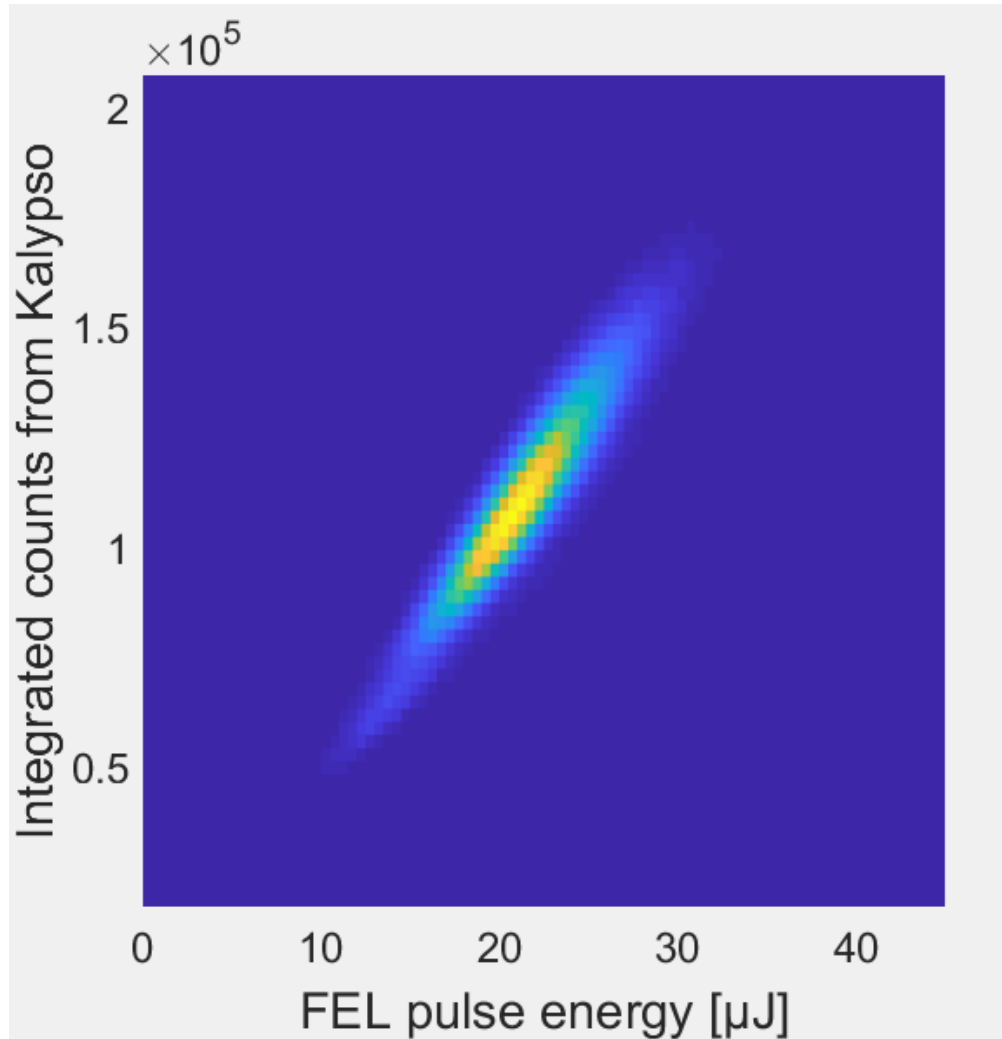
# Applications

## KALYPSO and VLS



# First tests KALYPSO

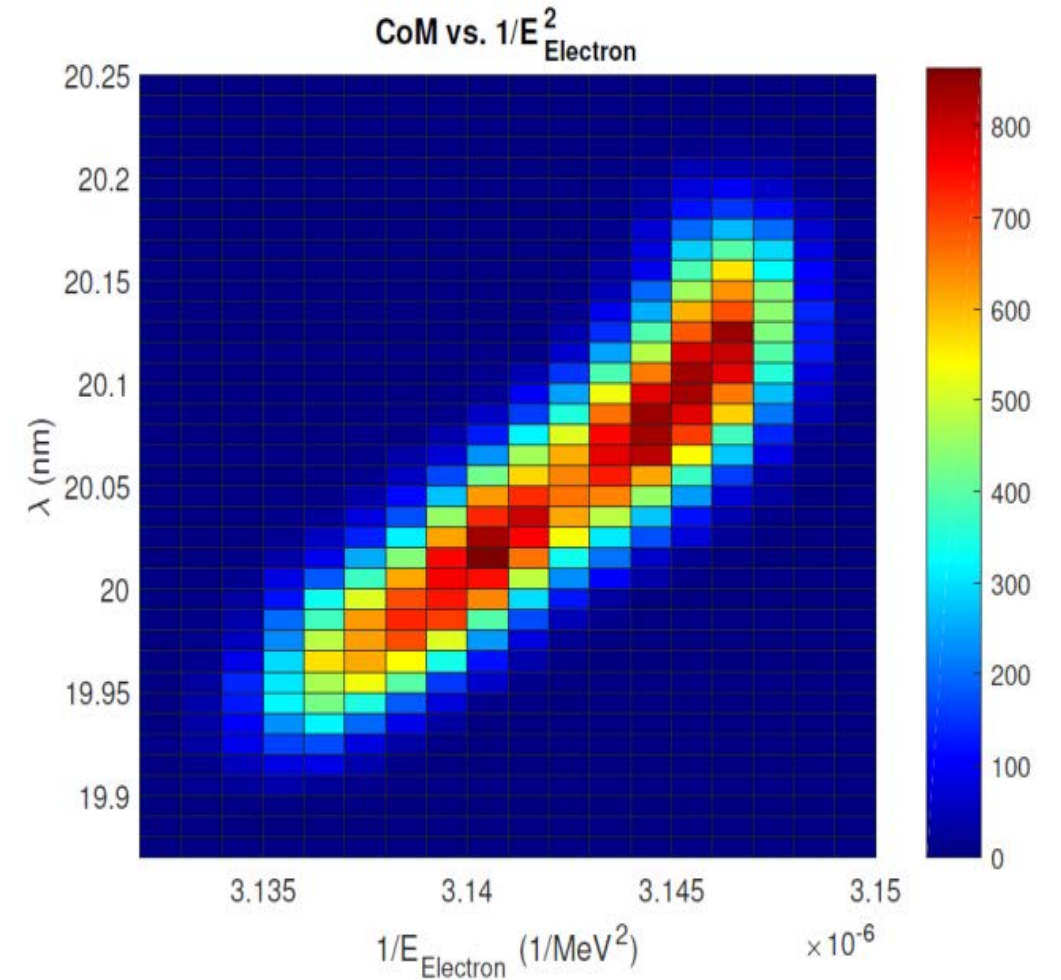
Korrelation with GMD



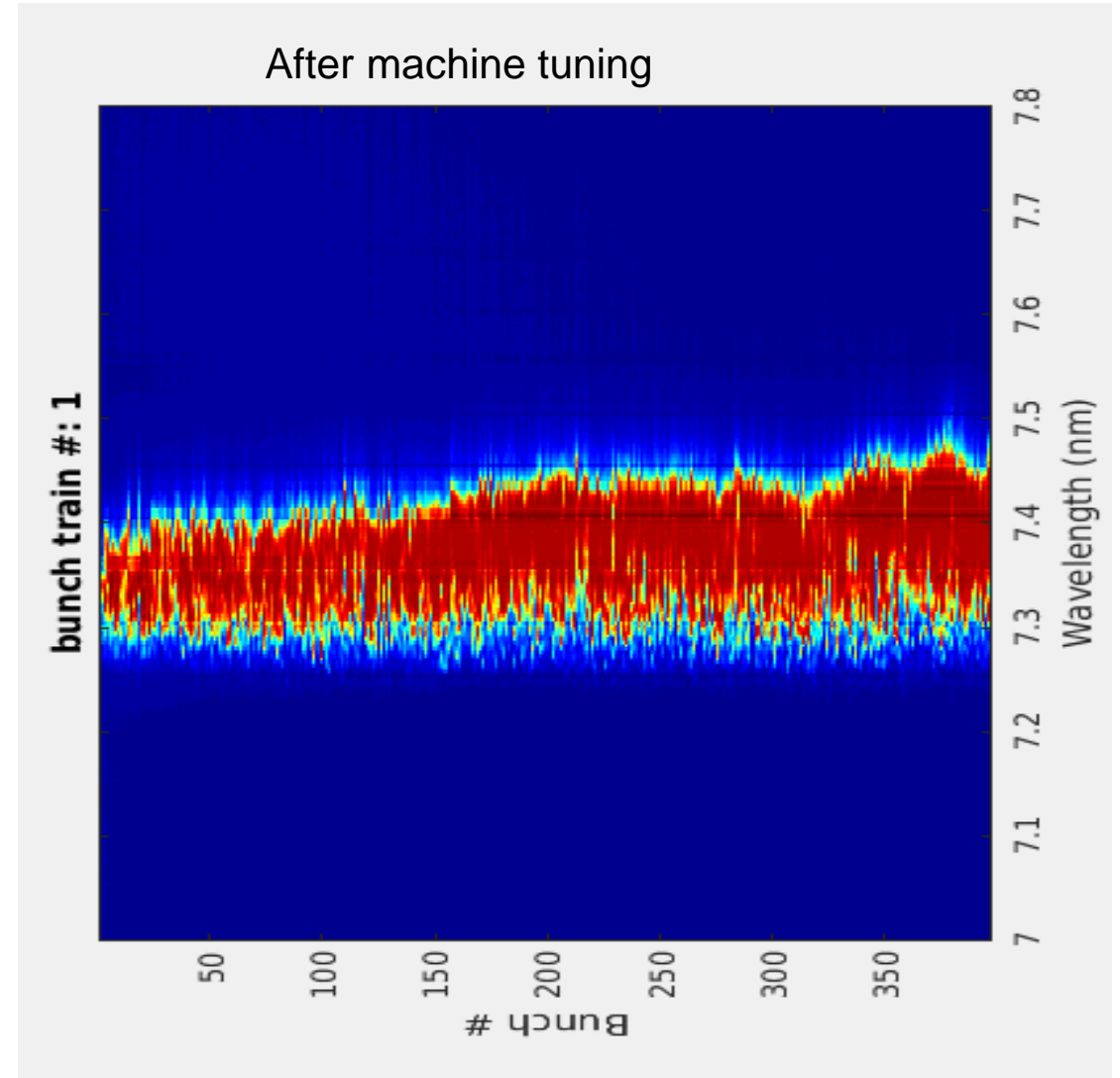
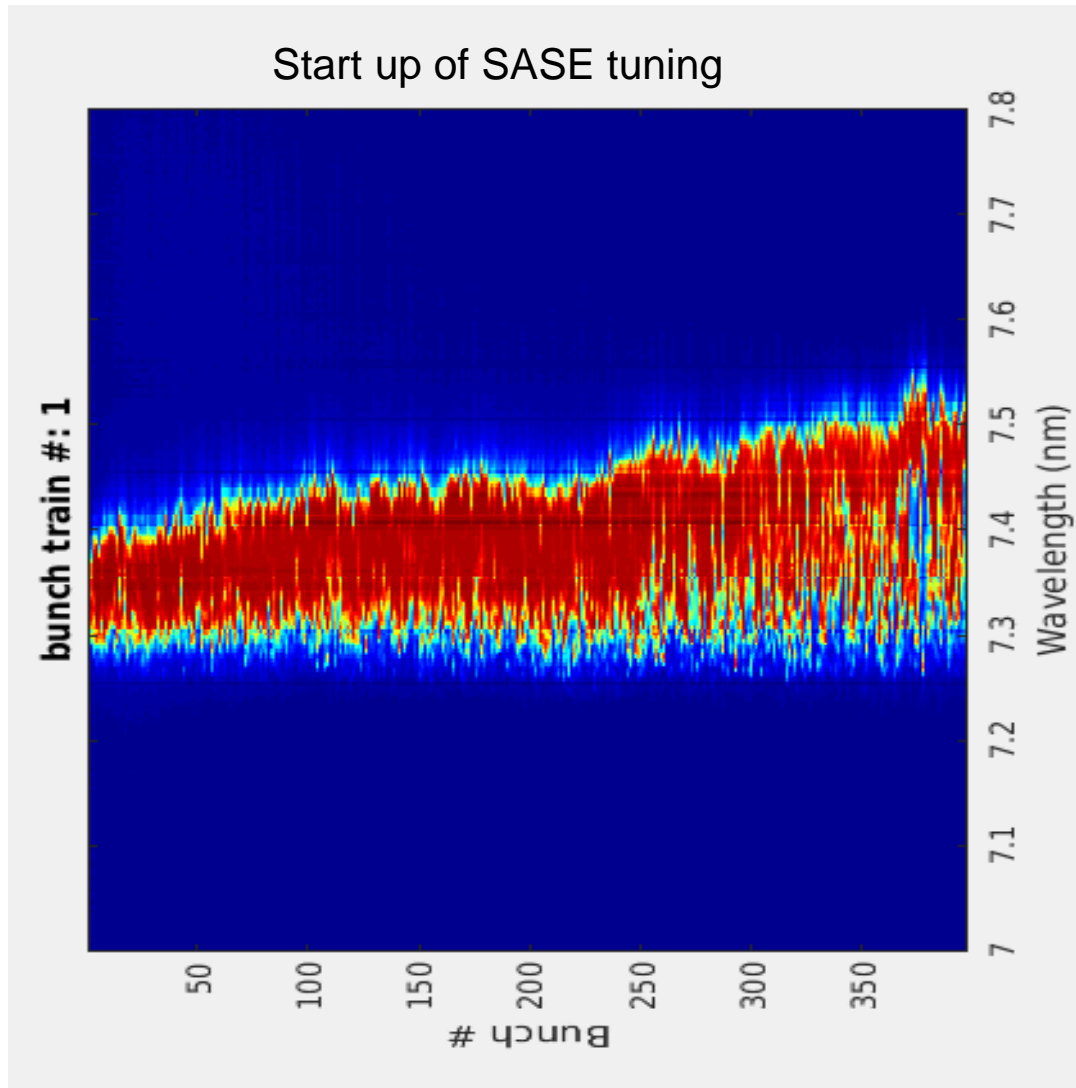
Correlation with 600.000 FEL pulses

and

Energy server

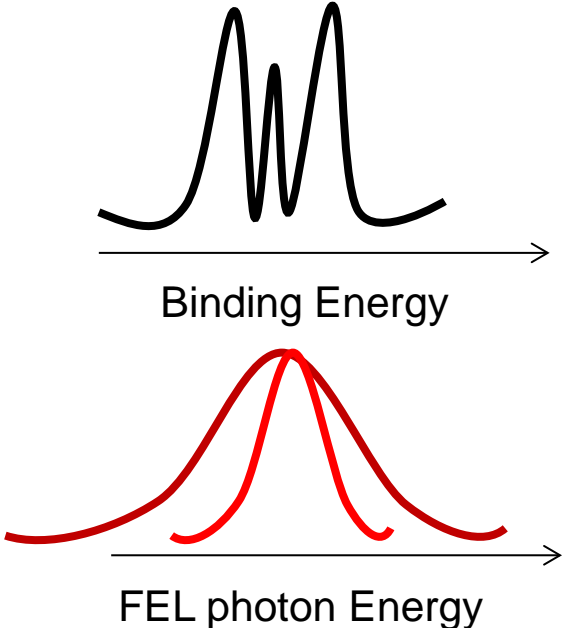
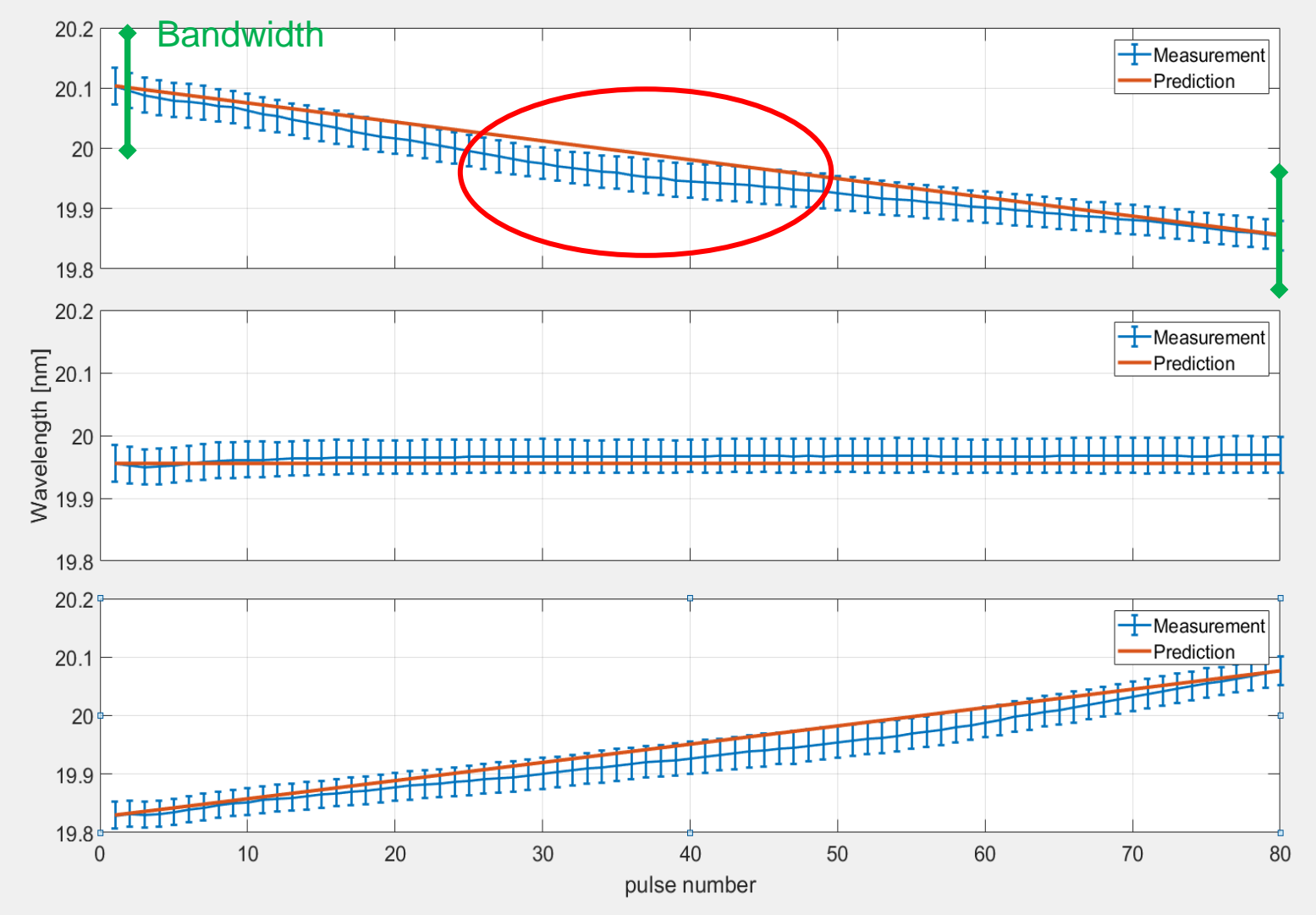


# Tuning well defined pulse trains



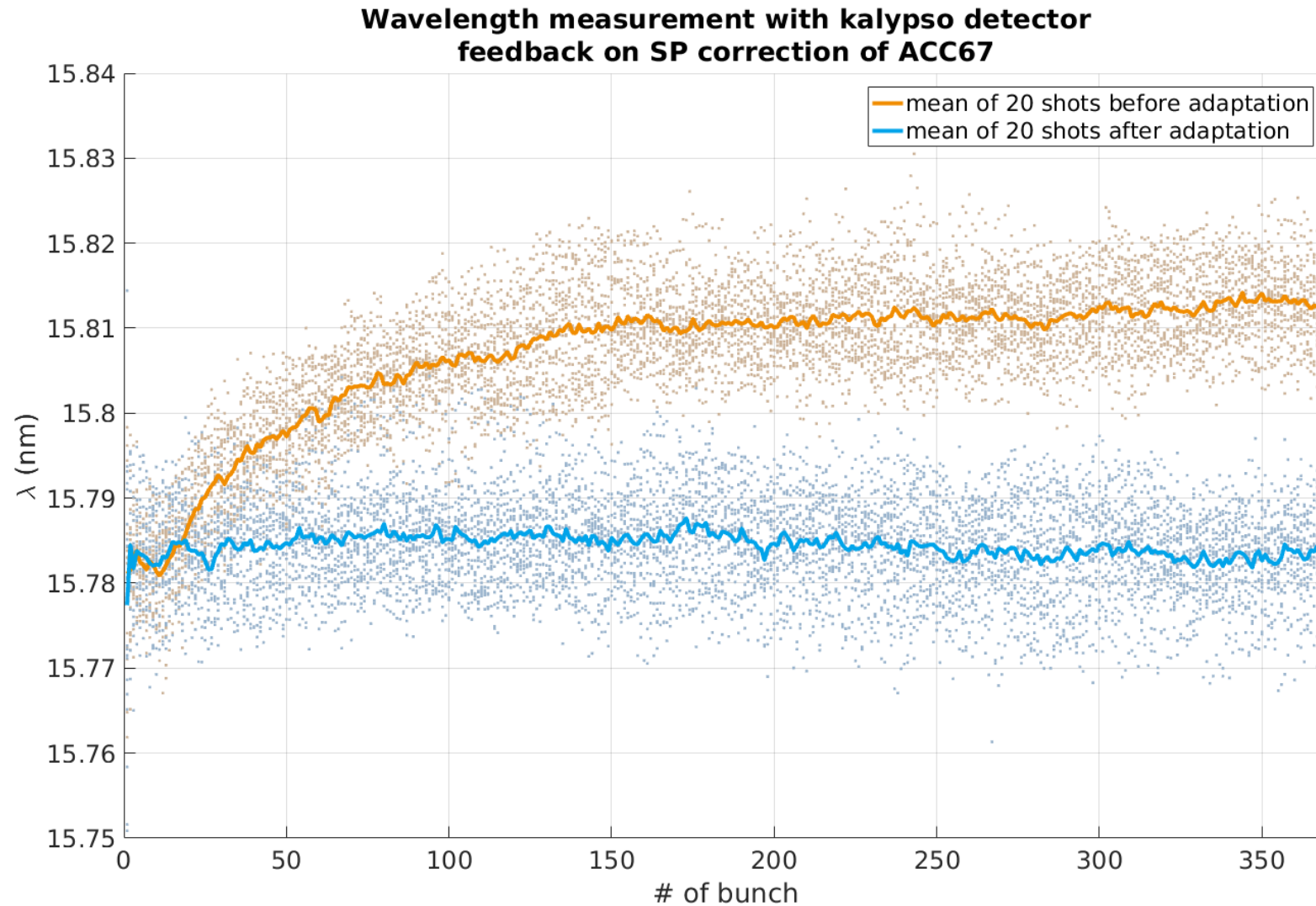
# Defined slopes

e.g. for Absorption spectroscopy



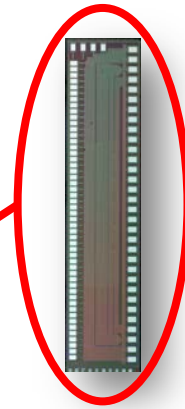
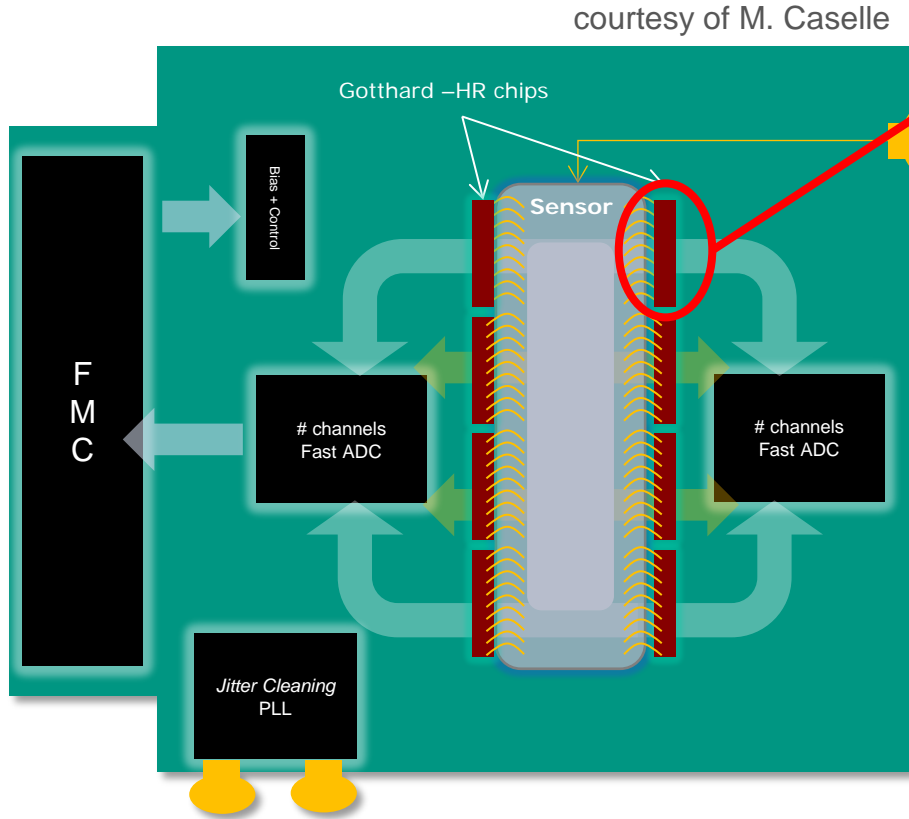


# Intra bunchtrain energy correction

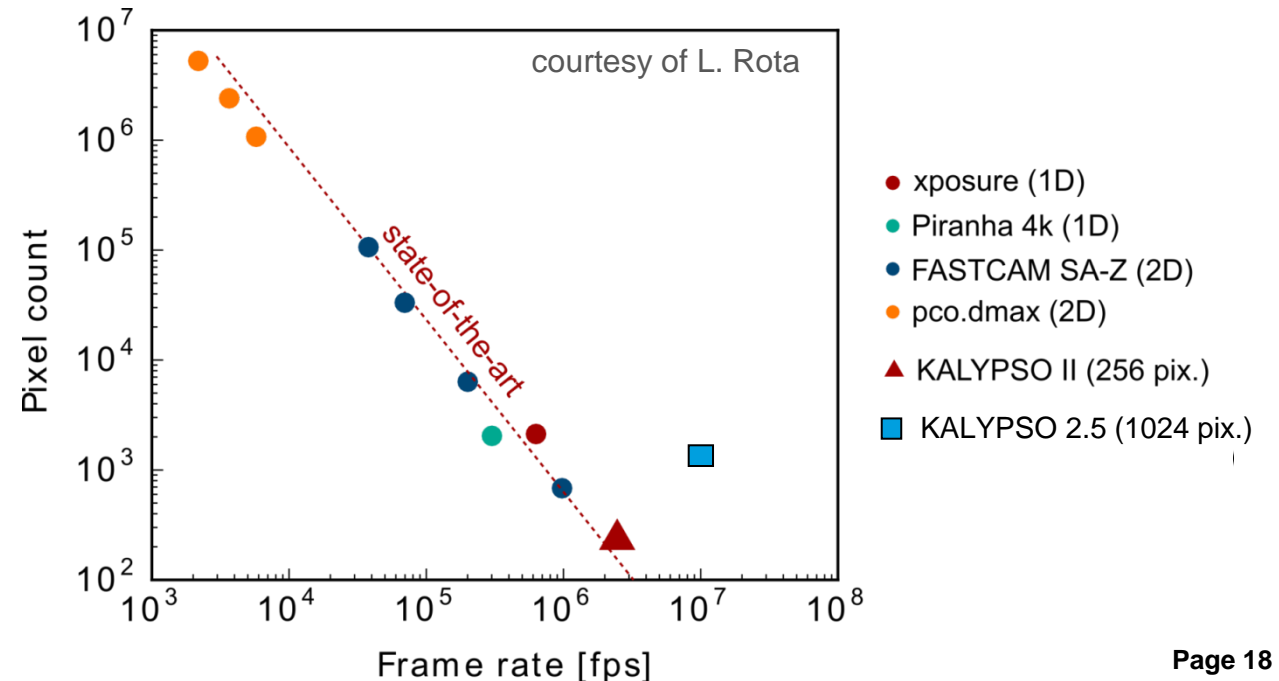


# Outlook

## KALYPSO v2.5



- **ASICs:**
  - From 2x Gotthard 1.6 to 8x Gotthard-HR10 (2017)
  - Technology: UMC CMOS 110 nm
- **HIGH spatial resolution:**
  - 1024 pixels @ 25  $\mu\text{m}$  or 512 pixels @ 50  $\mu\text{m}$
  - 25 mm field of view => standard optics
- **HIGH frame rate:**
  - Goal: increase frame rate to 10 MHz
  - 20 GB/s => "big data" and data reduction



# Summary

## MHz line detector at an XUV online spectrometer

- KALYPSO MHz linear array detector
  - Use for visible / IR light for bursts and cw MHz repeats
  - Fully integrated in DOOCS / DAQ
- Kalypso + online XUV spectrometer
  - Helpful for tuning (either constant or tilted wavelength distribution over pulse train)
  - Important for many experiments (save the data for analysis)
  - First attempts to use (LLRF) feedback to get desired wavelength pattern

# Acknowledgements

## Collaborations

- Karlsruhe Institute of Technology KIT
  - KALYPSO Board Design
  - Board assembly and Bonding
- Paul Scherrer Institut PSI
  - Gotthard ASIC – A. Mozzanica, B. Schmitt
- DMCS, Lodz University of Technology
  - Design KALYPSO Carrier
  - Firmware Programming
- DESY
  - DOOCS server: Vladimir Rybnikov (MCS4)
  - KALYPSO operation: Bernd Steffen, **Christopher Gerth**, **Christian Schmidt** (MSK)
  - VLS @ FLASH1: Stefan Düsterer, **Günter Brenner**, **Daniel Haack**, Kai Tiedtke (FS-FLASH-D)

Michele Caselle



Lorenzo Rota  
(now at SLAC)

Dariusz Makowski



Aleksander Mielczarek

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Thank you.