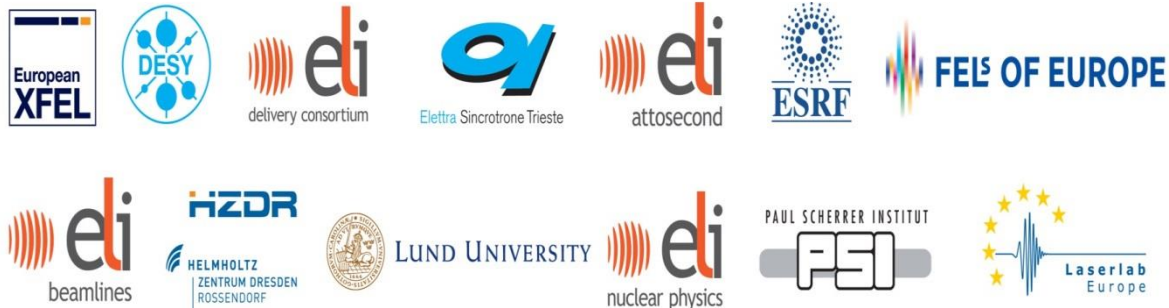


FPGA base data processing

Hamed Sotoudi Namin – European XFEL facility

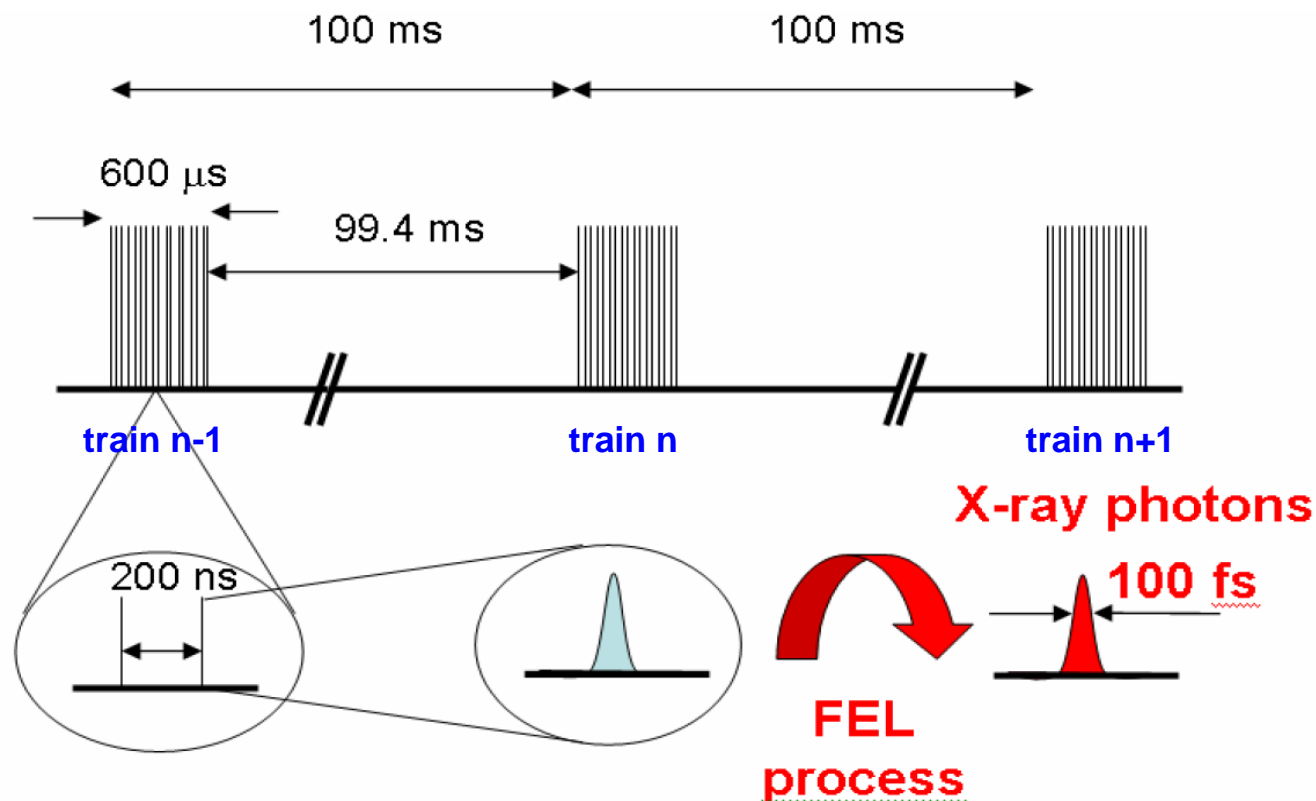


This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 654220

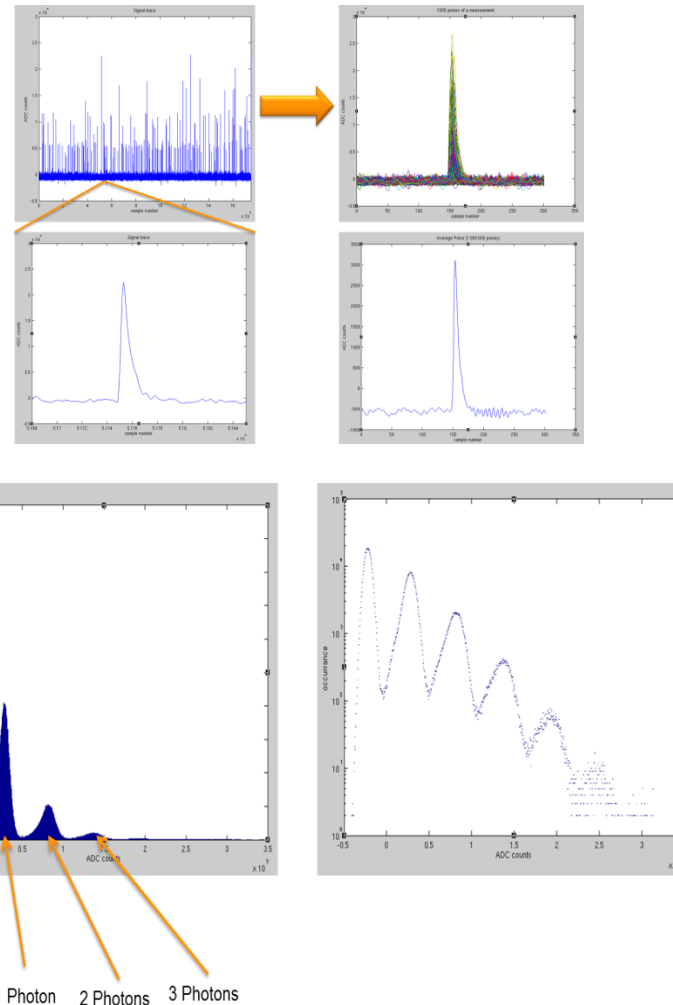
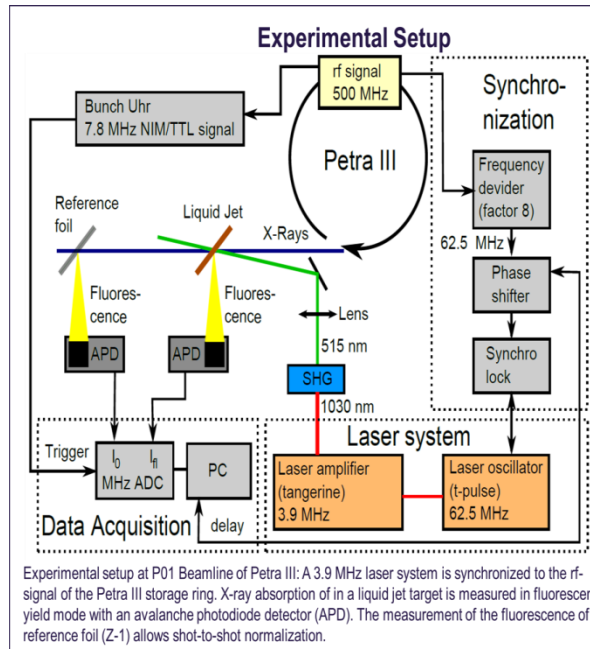


European XFEL

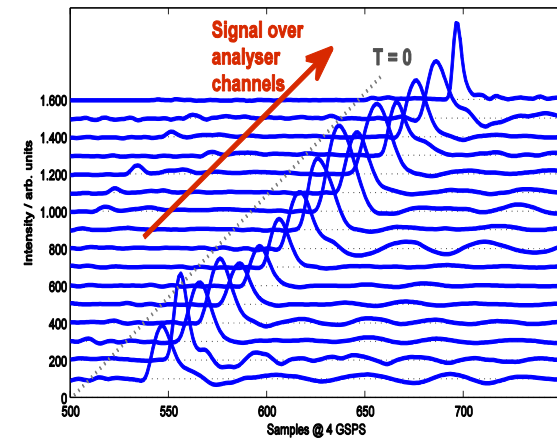
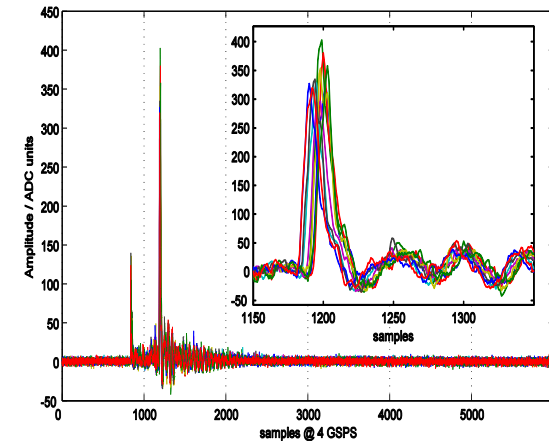
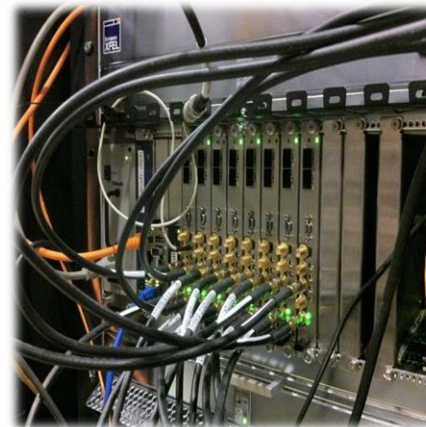
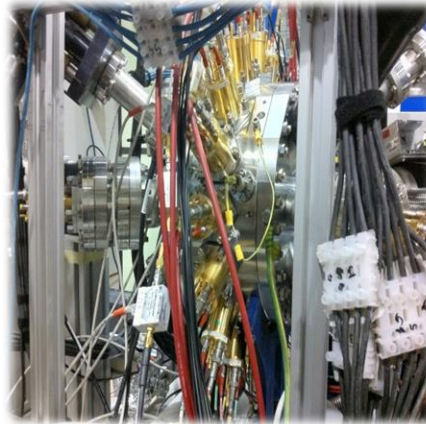
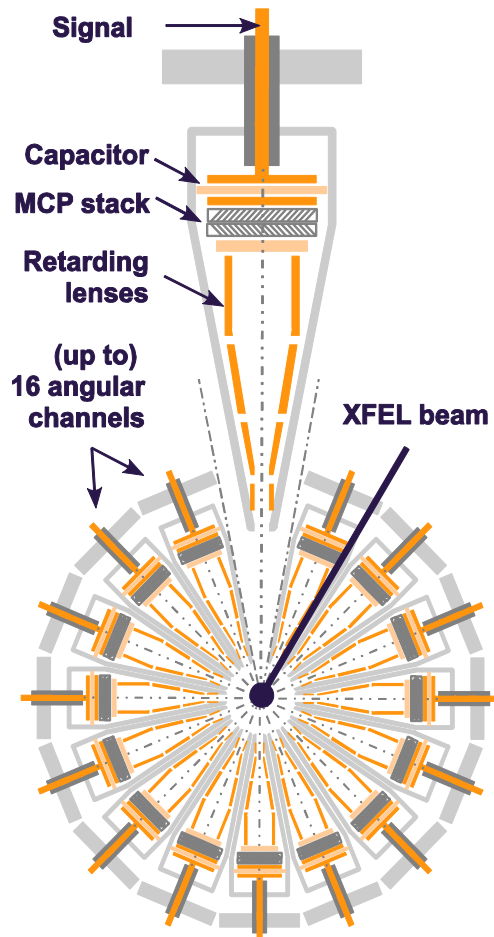
- With frequency of 10 Hz
- 2700 pulses



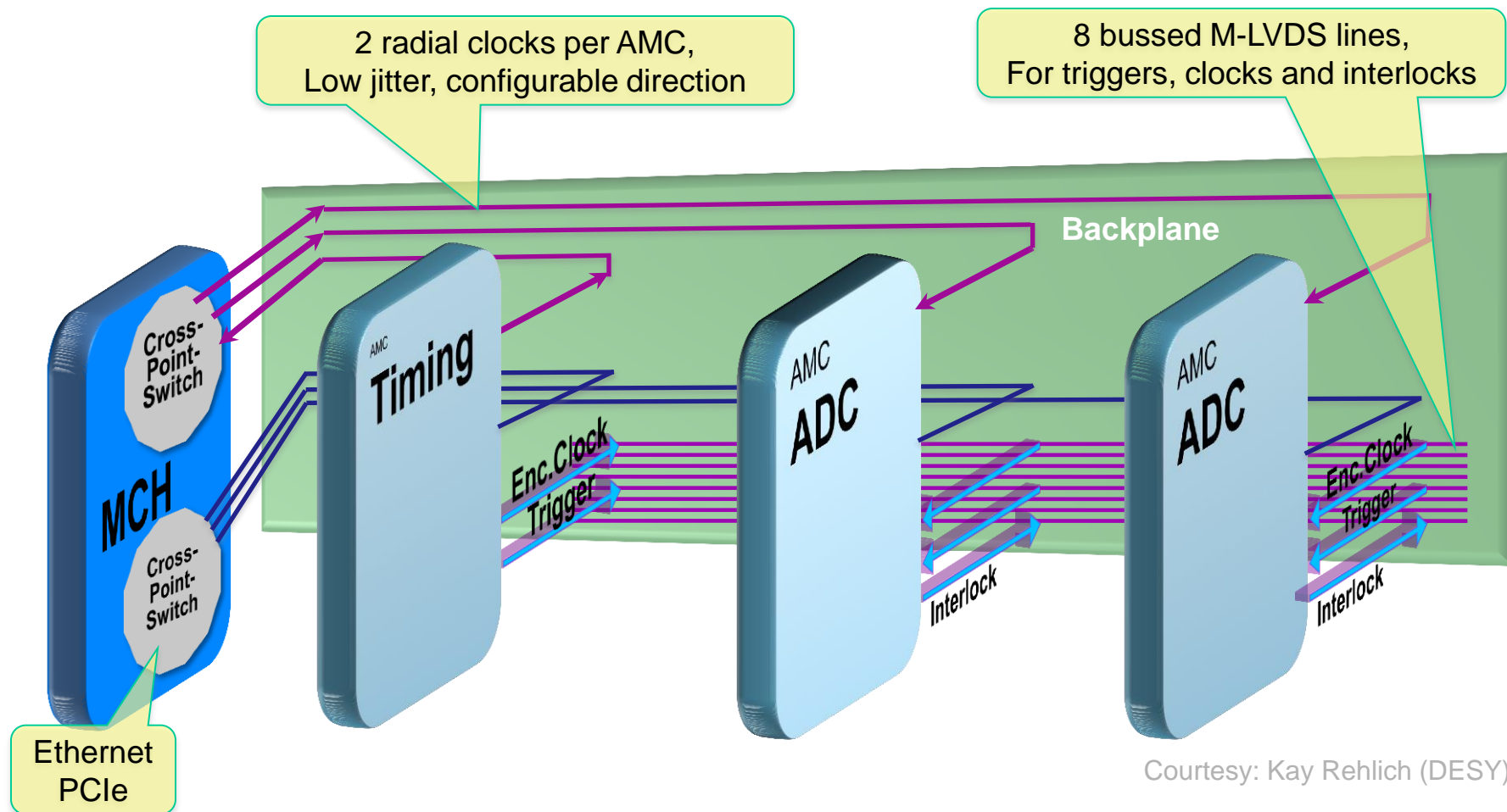
Application I – Energy detection with APD



Application II – Time of Flight (ToF) Spectrometer



MicroTCA - Overview



Courtesy: Kay Rehlich (DESY)

Micro TCA crate

- Example of micro TCA crate with digitizers
- Eight ADQ412
- Timing Module
- Processor
- MCH



Example: PES System of WP74



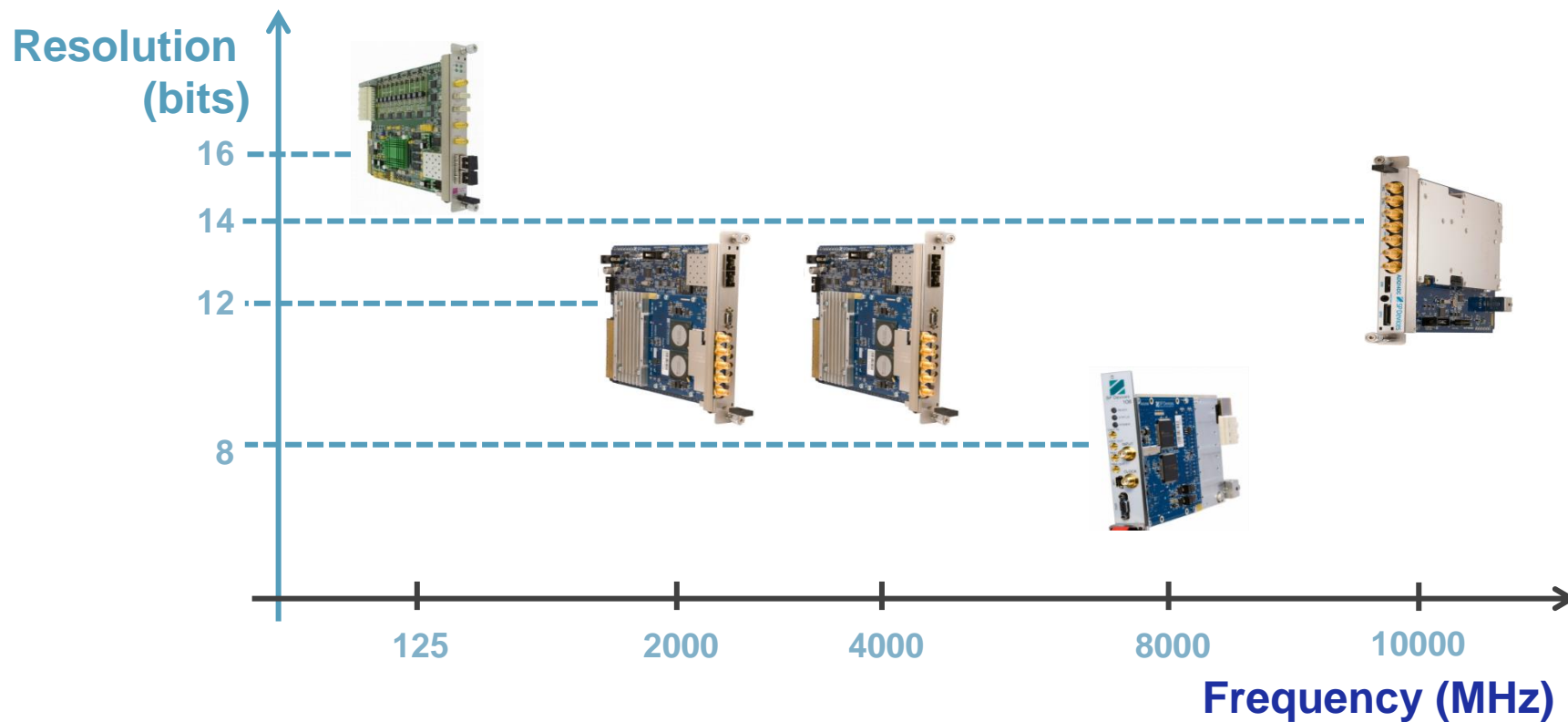
Tests done on beam times at FERMI and FLASH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654220

Hamed Sotoudi Namin, European XFEL, 10/04/2018
New concepts in ultra fast data acquisition, PSI



XFEL ADC Solutions

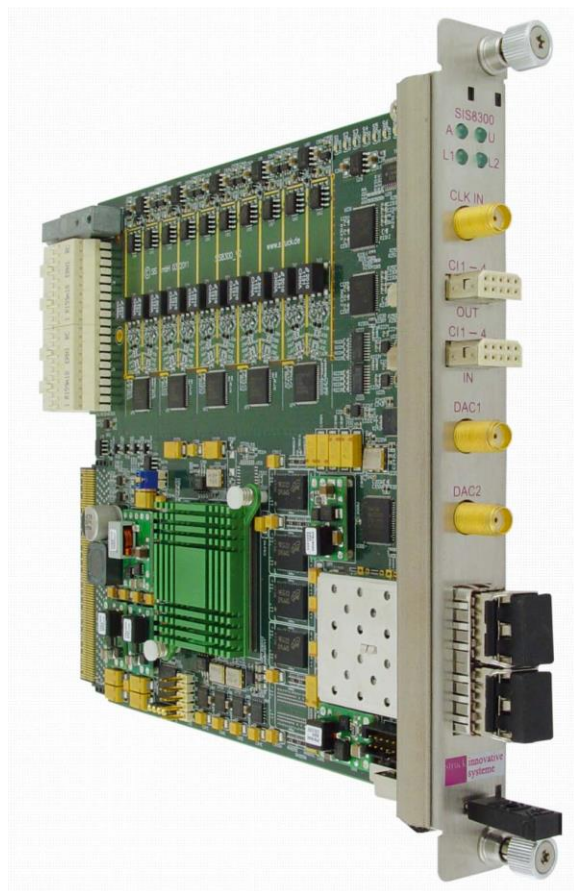


This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 654220

Hamed Sotoudi Namin, European XFEL, 10/04/2018
New concepts in ultra fast data acquisition, PSI



Fast ADC Board



SIS8300 uTCA for Physics Digitizer

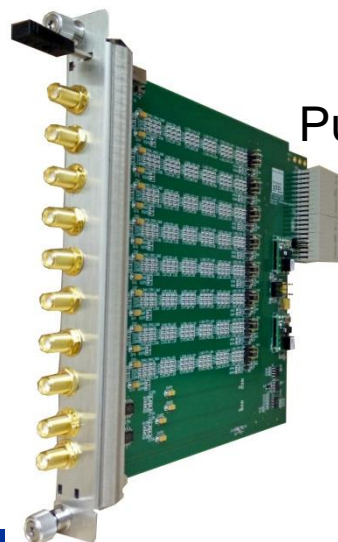
- 10 ADC 16bit @ 125MS/s
- 2 DAC Channels @ 250MS/s
- 4 Gb DDR2 Memory
- Dual SFP Card cage for High Speed optical communication (up to 2.5 Gb)
- FPGA Virtex-5

RTM Boards



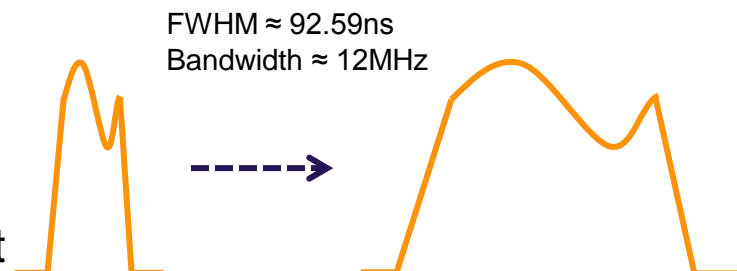
SIS8900 RTM

- 10 LEMO Connectors
- 50 ohm input impedance
- Default range -1V to +1V
- RJ 45 RTM clock



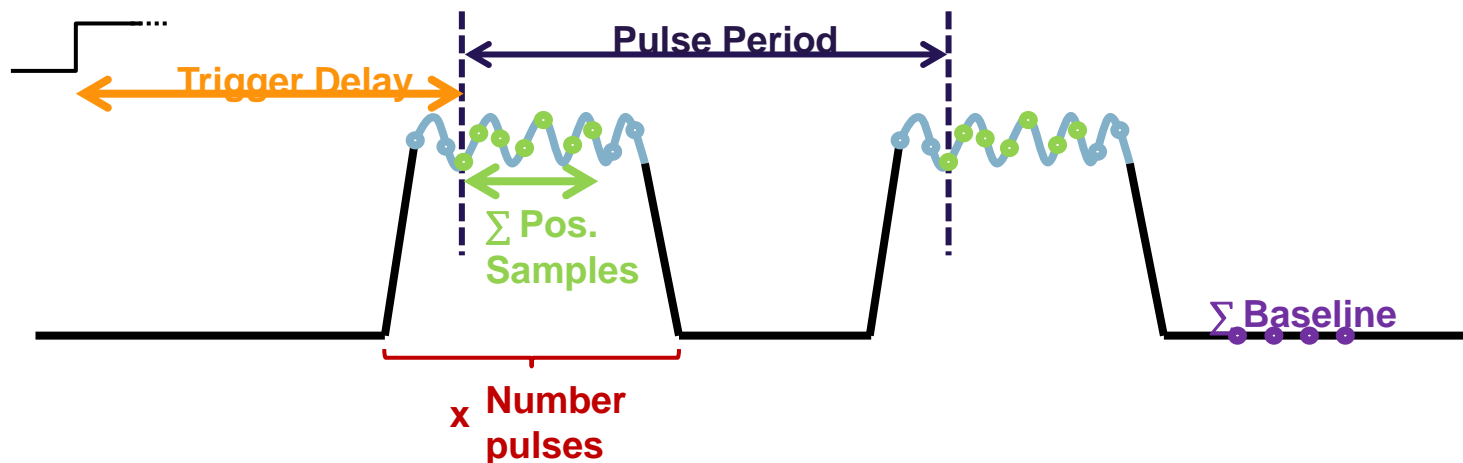
Pulse Stretcher RTM

- 10 SMA Connectors
- 2 Direct channels
- 8 Stretched channels
- Configurable DC Output
Open/+1.2V/-1.2V



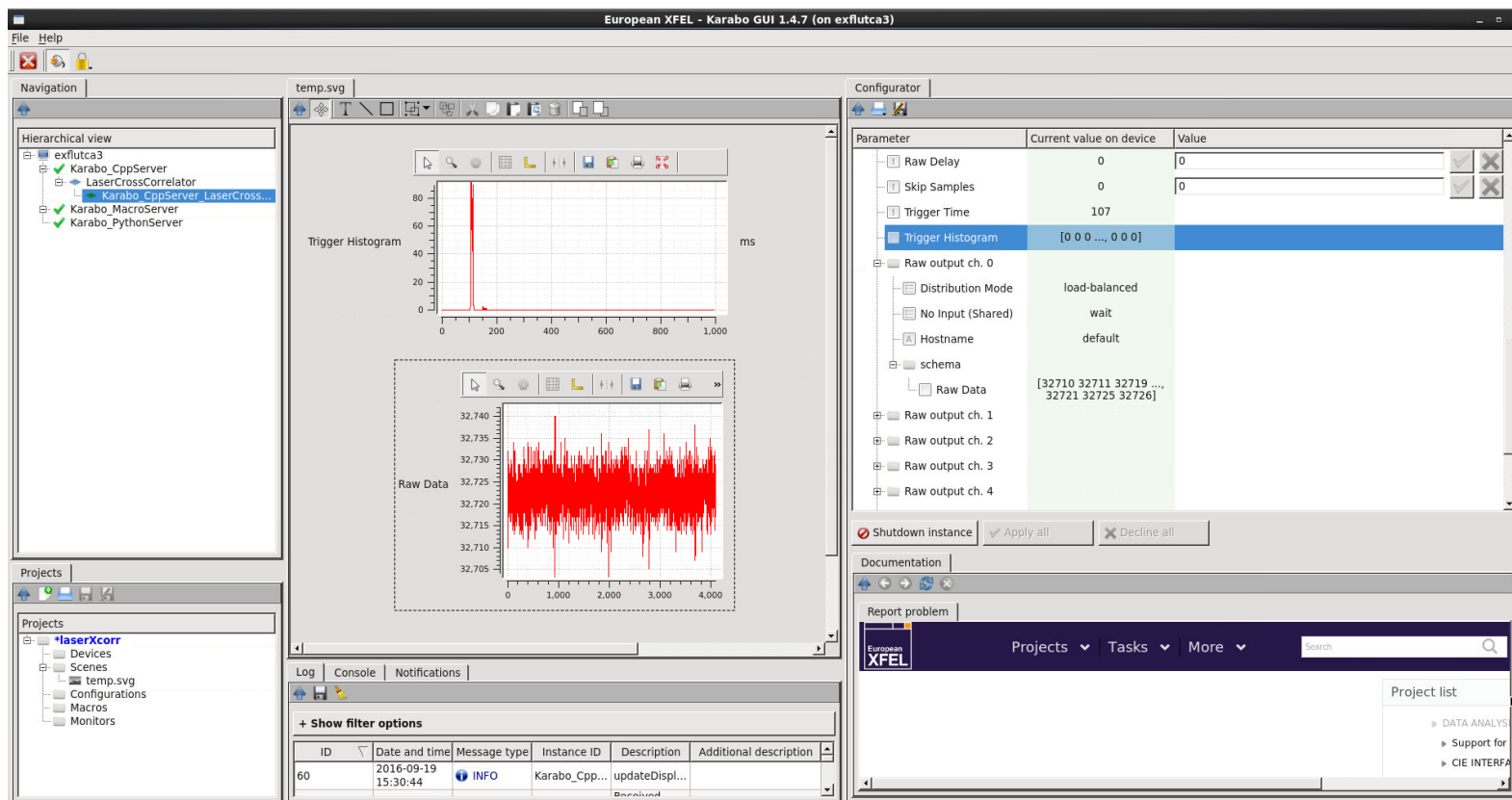
Fast ADC Firmware

- Firmware features
 - Pulse Integrator Algorithm (per ADC)
 - ▶ Per trigger, memory with sum of samples and baseline values are available (via **PCIe**)
 - Raw data is saved in DDR memory
 - ▶ all 10 ADC signals saved at the same time
 - ▶ 16 MSamples per ADC ($\sim 0.13\text{s}$ @ 125 MHz)

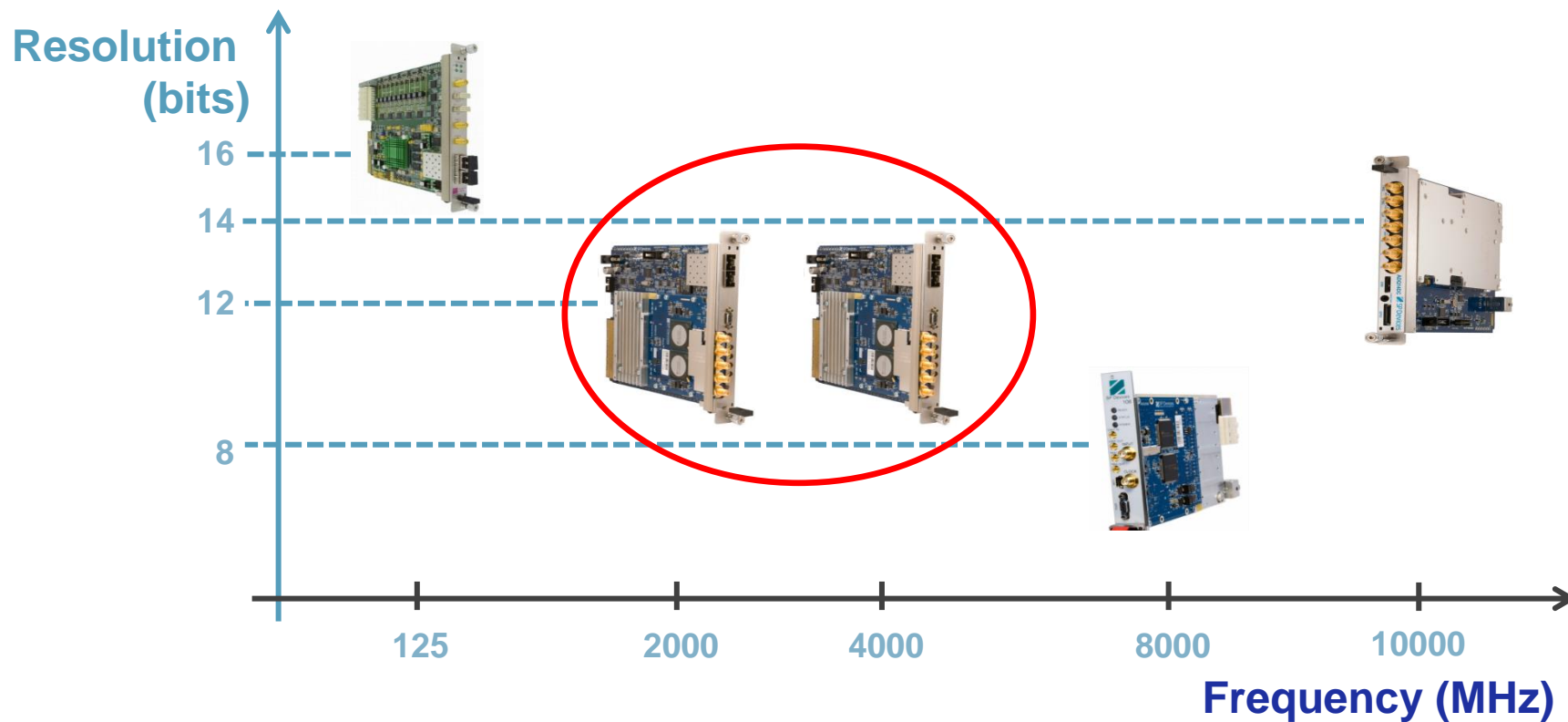


Fast ADC Karabo Device

- Karabo Device to control all firmware and board features



SP-Devices ADQ412

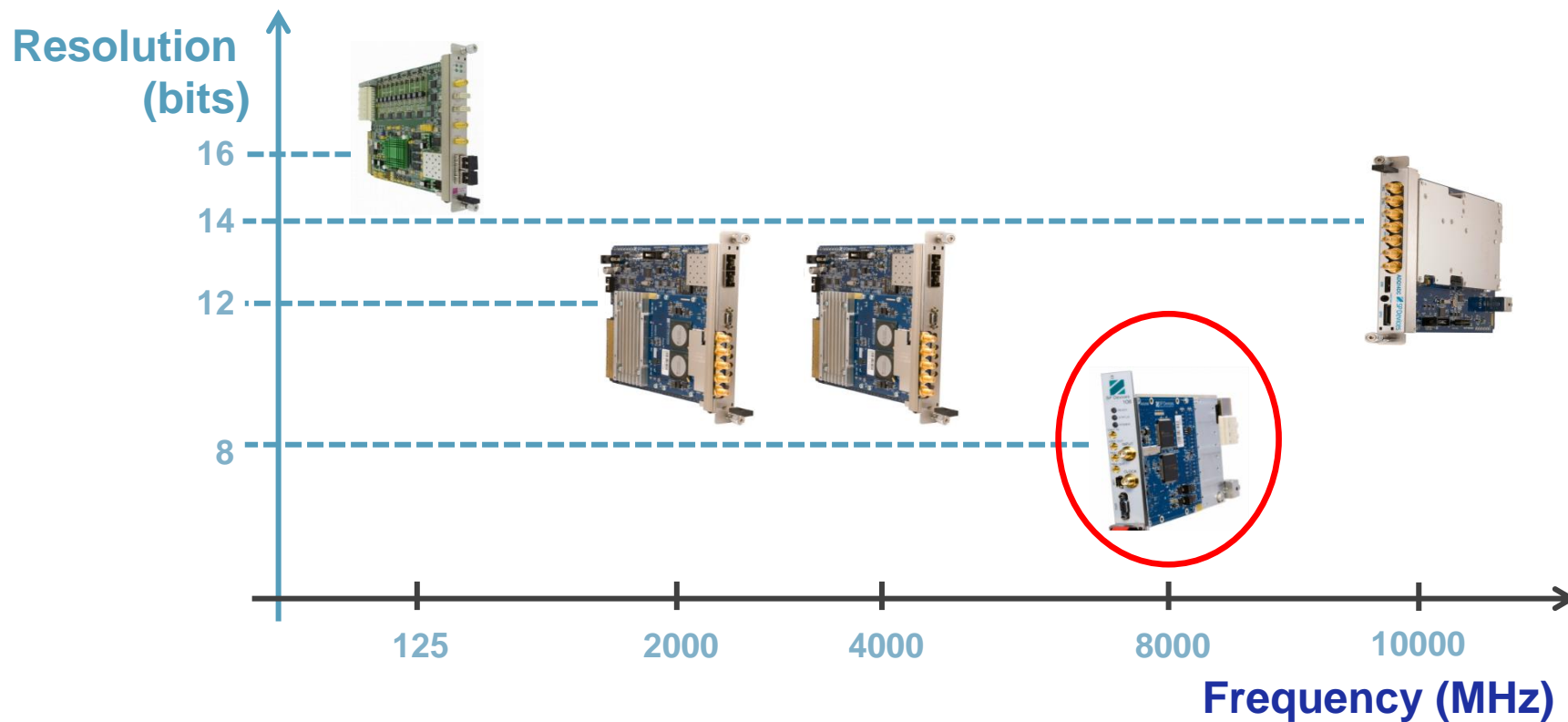


SP-Device ADQ412 Digitizer

SAMPLE RATE OPTIONS				
OPTION	STD.	-3G	-4G	
4 CHANNELS MODE				
Number of channels	4	4	4	
Sampling rate	1	1.8	2	GSPS
Analog bandwidth	2	2	2	GHz
SFDR @149MHz	63	63	63	dBc
SNR @149MHz	57	57	55	dB
2 CHANNELS MODE				
Number of channels	2	2	2	
Sampling rate	2	3.6	4	GSPS
Analog bandwidth	1.3	1.3	1.3	GHz
SFDR @149MHz	60	60	63	dBc
SNR @149MHz	55	55	55	dB



SP-Devices ADQ108



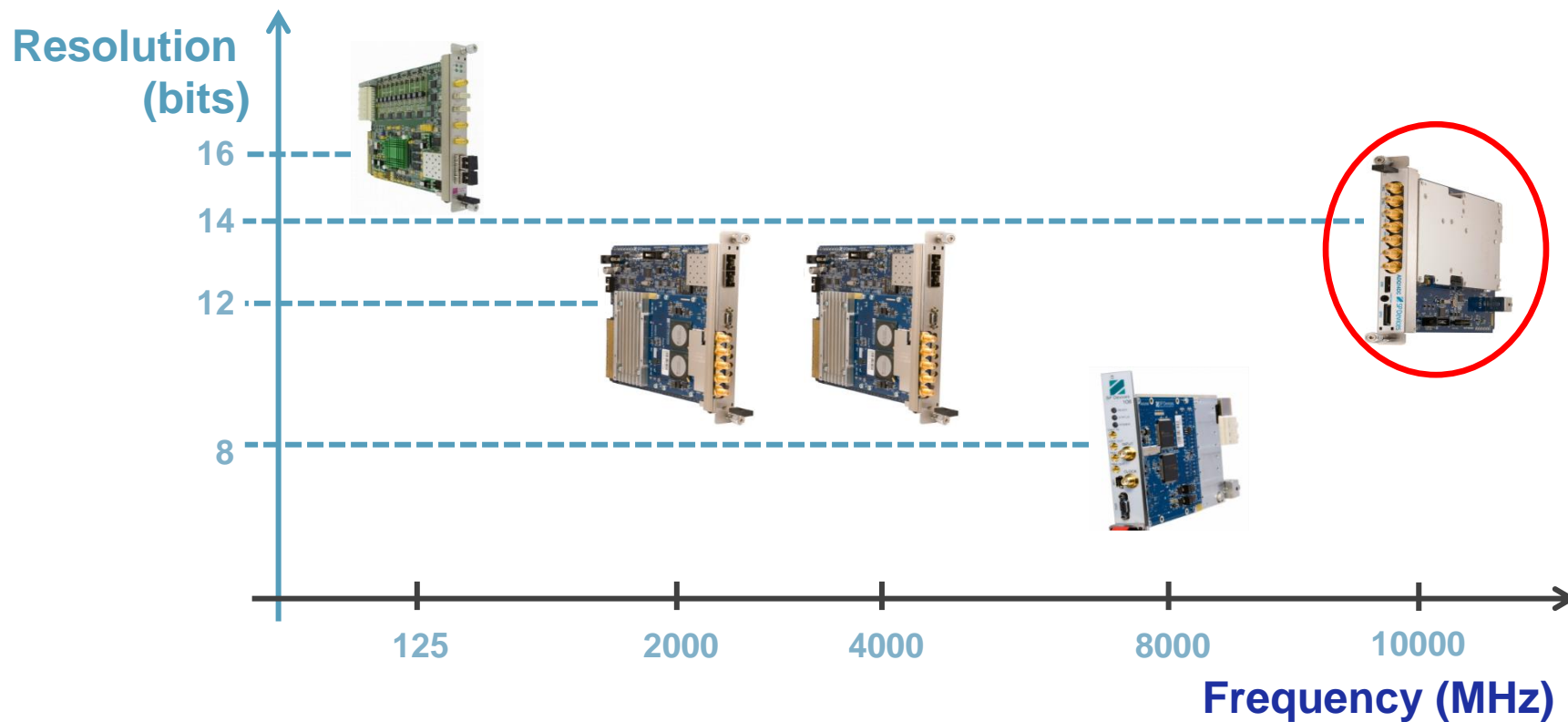
SP-Device ADQ108 Digitizer

KEY PARAMETERS

Number of channels	1
Digitizer Resolution	8
Sampling rate	7 / 6.4 / 6 GSPS
Clock reference	Internal / External / PXIe
Data memory	1 GSamples
Pre-trigger buffer	Up to batch size
Trigger hold off	2^{34} samples
Multi record batch size	1 to entire memory
Multi record max PRF	1.8 MHz
Trigger	Software / External / Level
Number of GPIOs	5
Front panel connectors	SMA/Micro-D Plug9w/MMCX



SP-Devices ADQ7



This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 654220

Hamed Sotoudi Namin, European XFEL, 10/04/2018
New concepts in ultra fast data acquisition, PSI



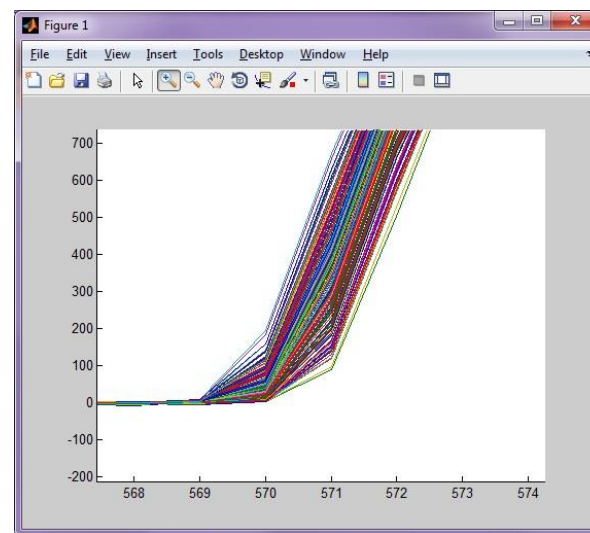
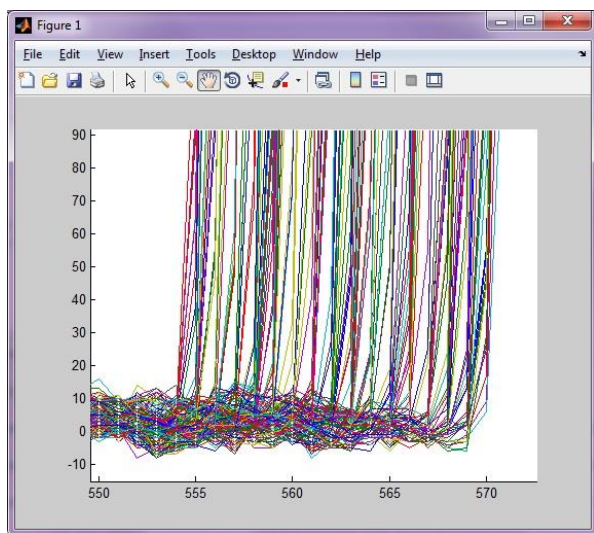
SP-Devices ADQ7 Digitizer

- 14 bit vertical resolution
- PCIe Gen3X8
- Pulse data front-end for low noise
 - DC-coupled
 - 1 / 2 channel @ 10 / 5 GSPS
 - ~ 3 GHz bandwidth
 - DBS – baseline stabilization
- RF signal front-end for high linearity



Time to Digital Converter (TDC)

- To solve uncertainty about Trigger and Clock
 - An open source TDC (Time to Digital Converter) has been used
 - Open source TDC core has been changed according to our application
 - Accuracy is about 42 PS



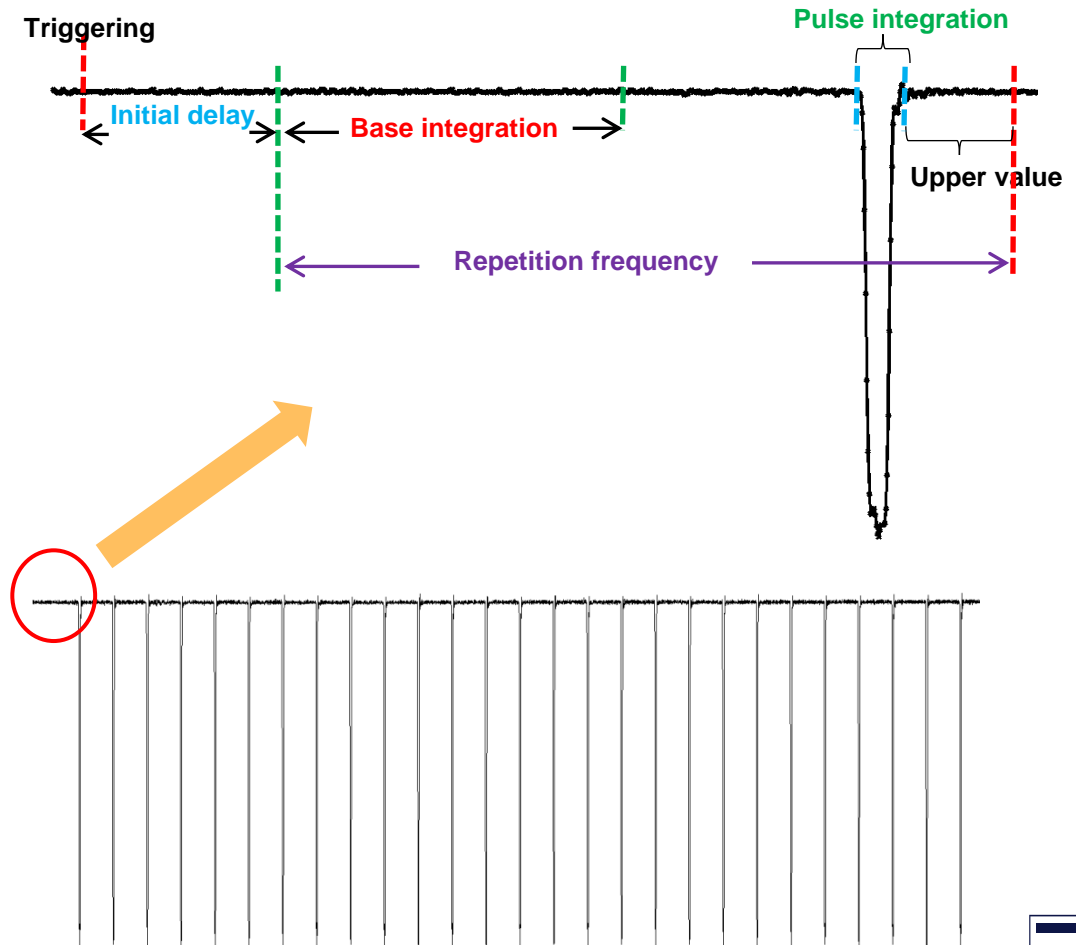
Available Algorithms

- Raw data
 - Sends in full data rate in stream and only samples
- Energy of pulse calculation
 - Calculates base line and pulse integration
- Zero suppression
 - Extracts pulses out of data and sends only pulse information
- Peak detection
 - Detects peak area and sends samples around with offset



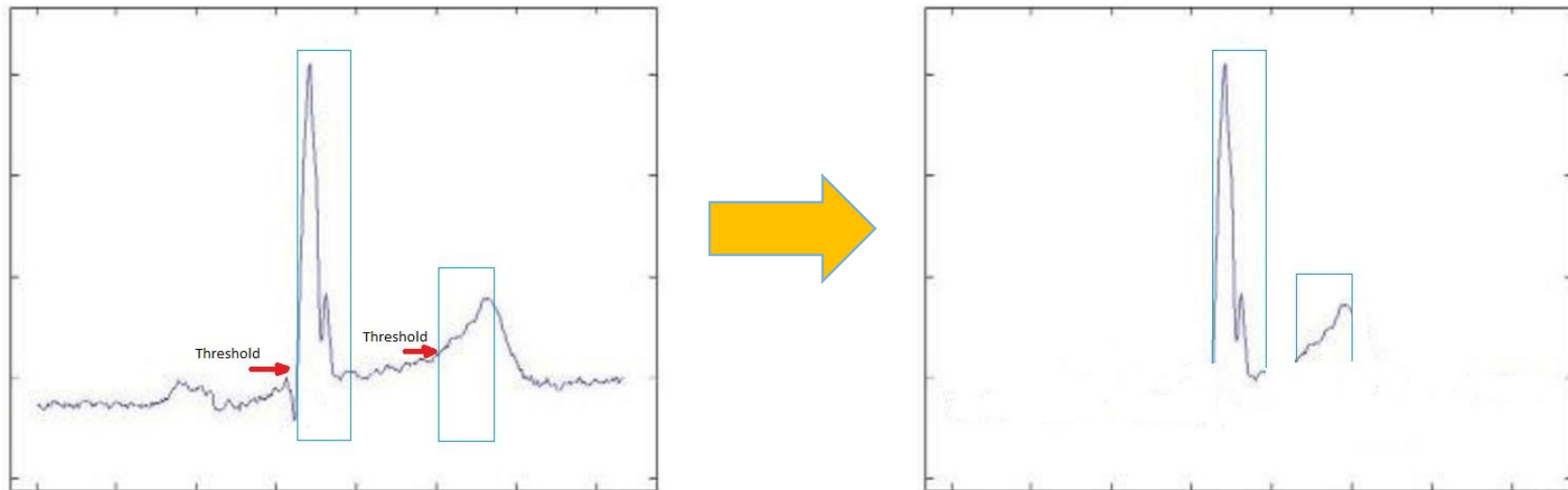
Calculating the energy of pulses

- Energy of pulse calculation
- Needs to calculate base line



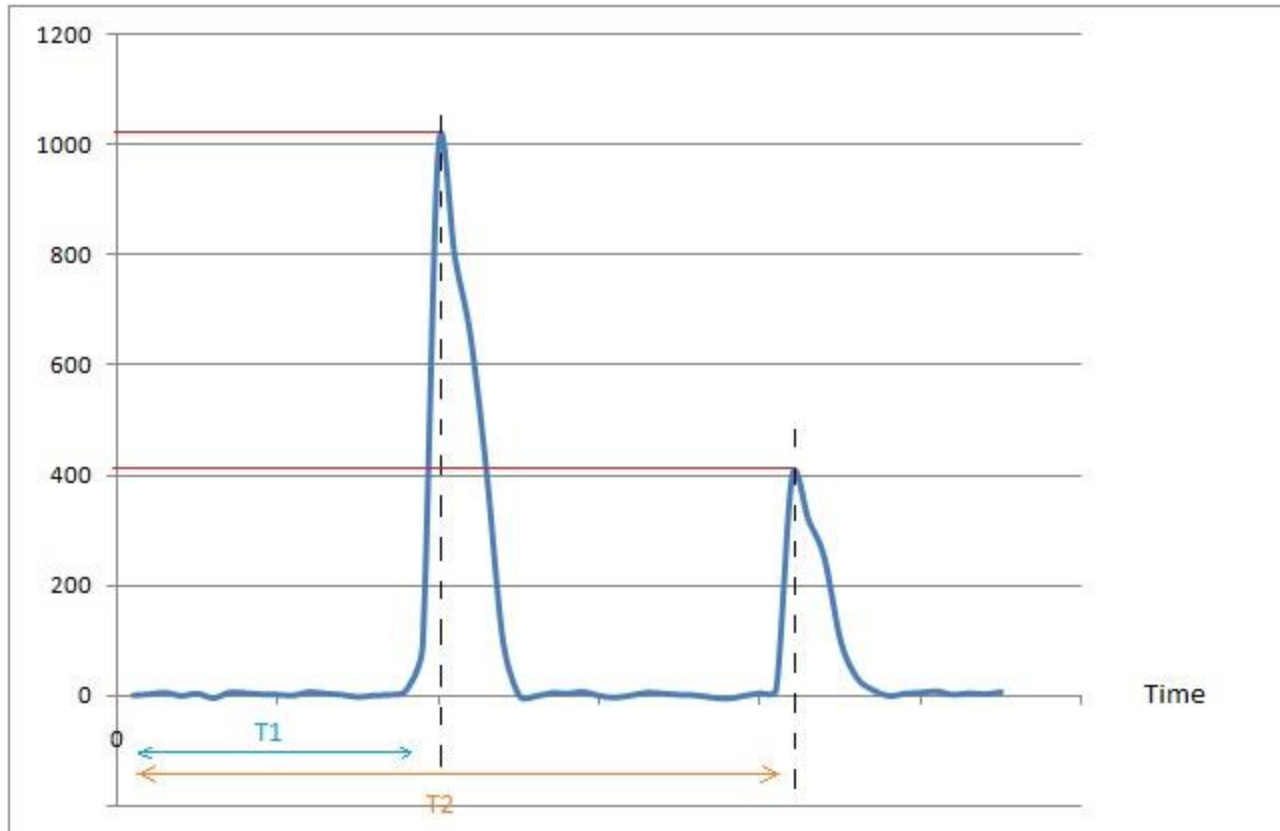
Zero Suppression

- Predefined window for number of pulses
- Adaptive Threshold to detect pulse or fixed threshold



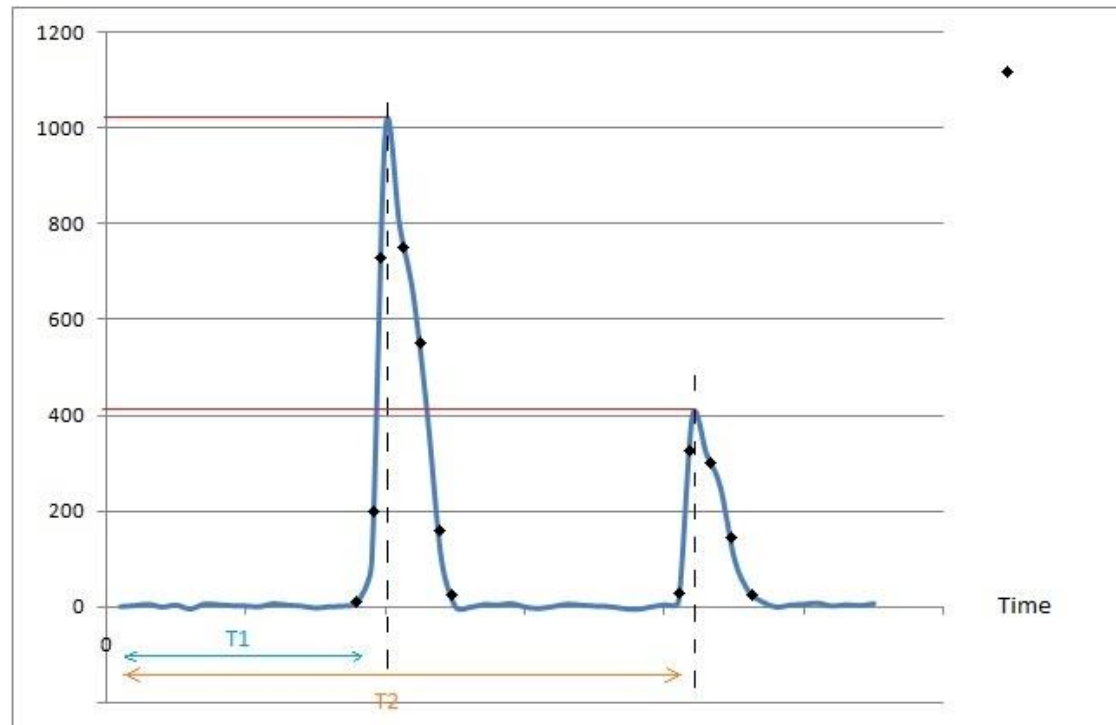
Analog pulses and Peak Information

- Precise time and value is required

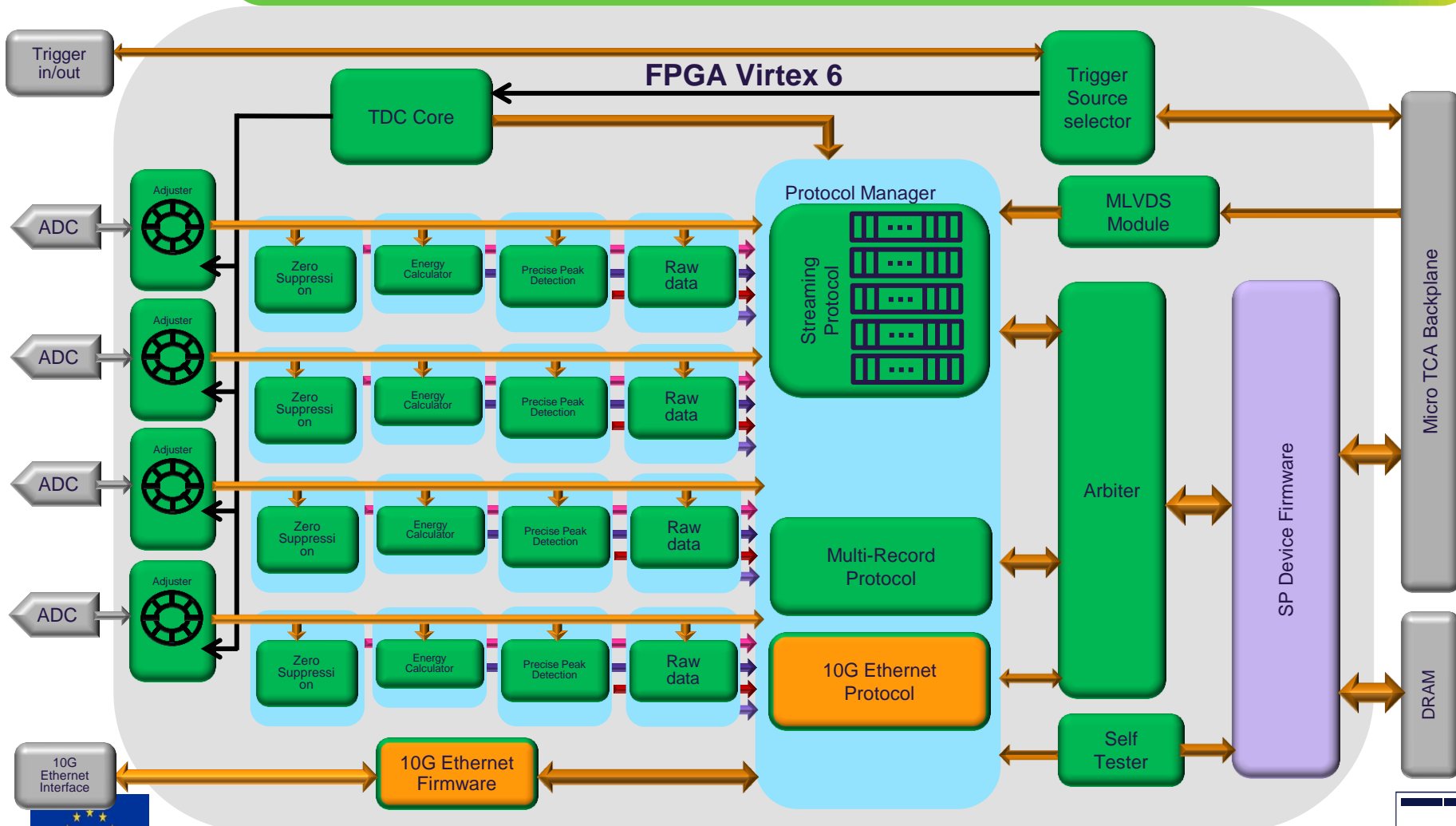


Digital values for Peak detection

- Less samples for pulse are available
- Interpolation is done in software



Firmware Block Diagram

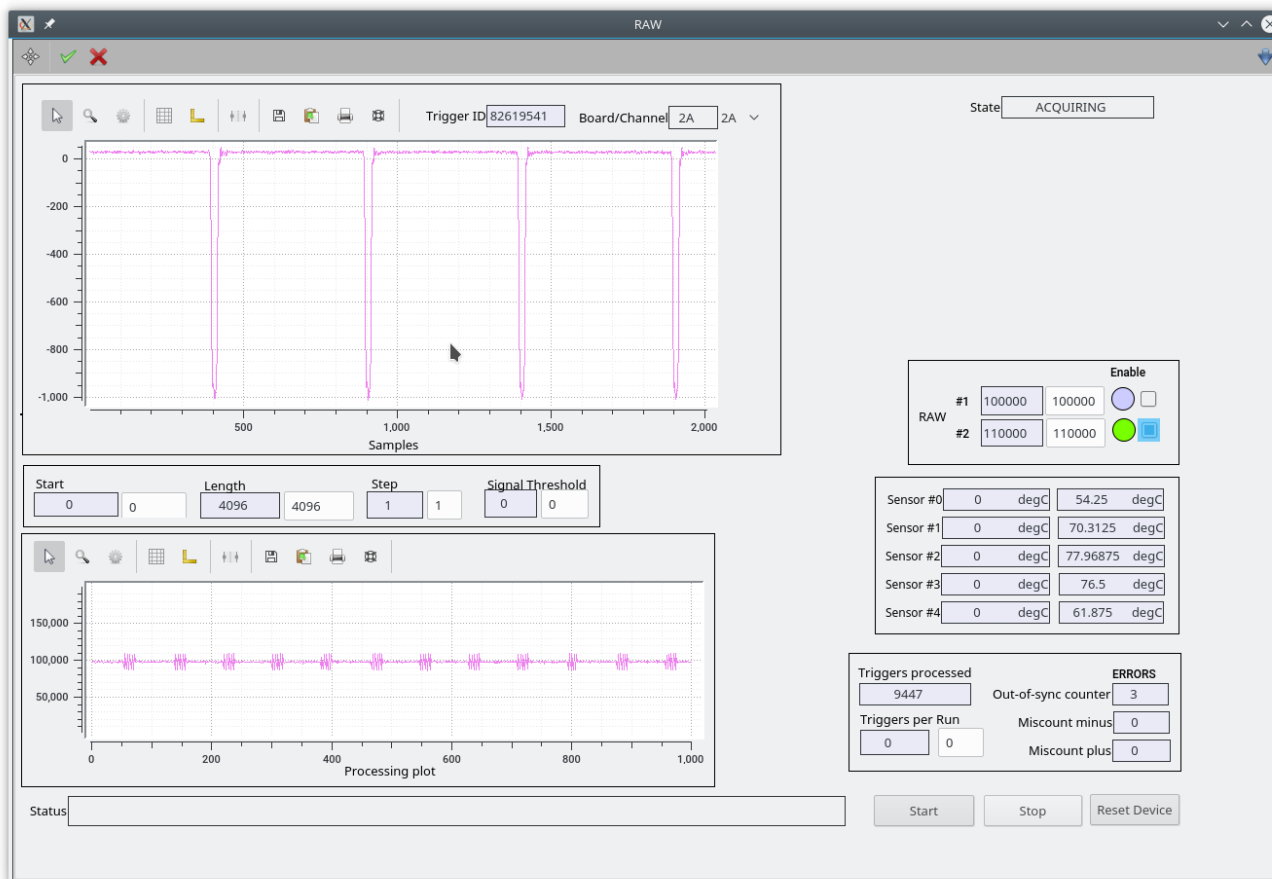


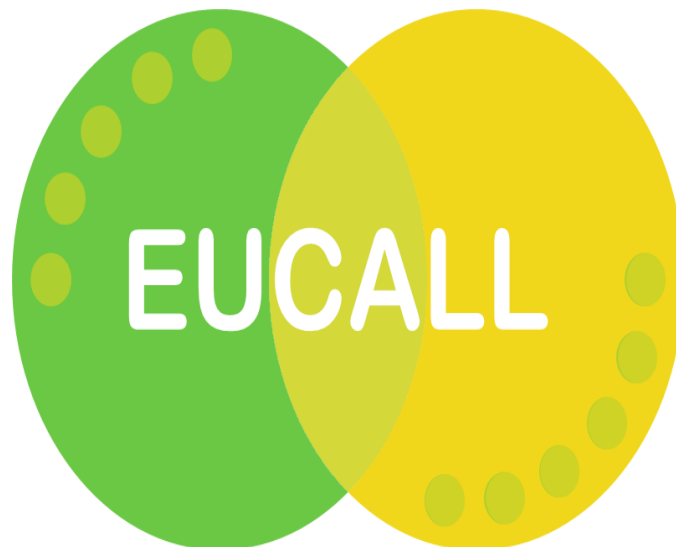
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654220

Hamed Sotoudi Namin, European XFEL, 10/04/2018
New concepts in ultra fast data acquisition, PSI



Karabo GUI using Digitizer





Thank you for your attention



LUND UNIVERSITY



PAUL SCHERRER INSTITUT



This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 654220

