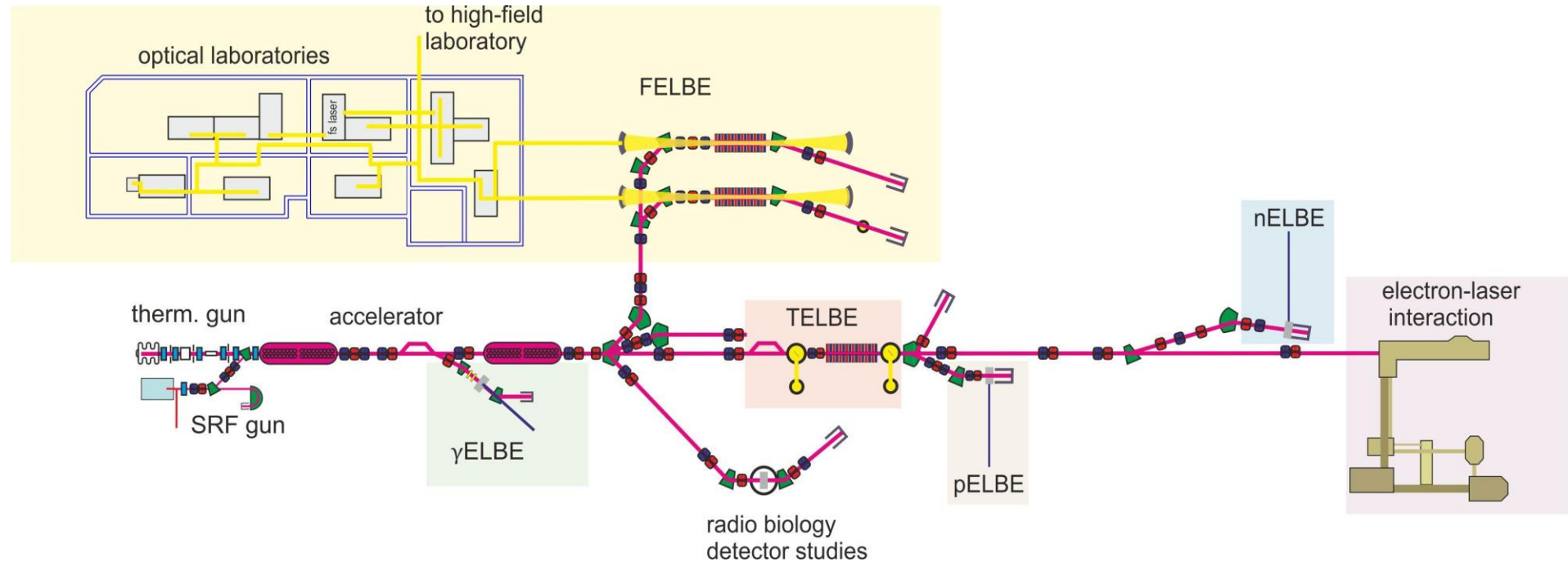
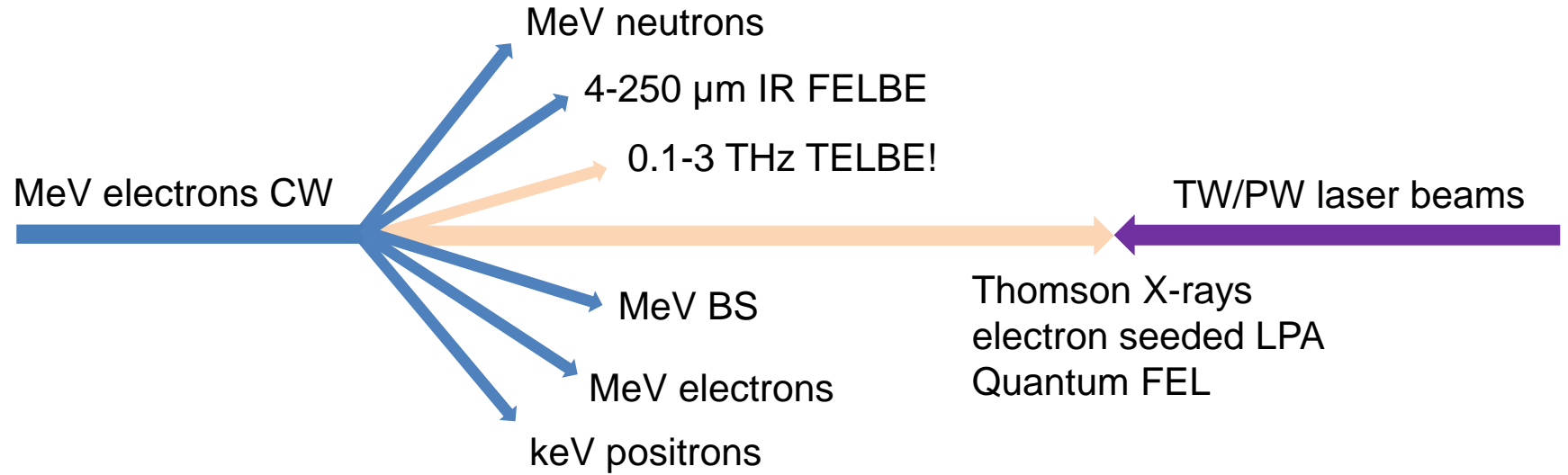


Arrival time and Intensity Binning at high quasi-cw repetition rates: the big data challenge

B. Green, S. Kovalev, J. Deinert, Z. Wang, N. Awari, M. Chen, S. Germanskiy, M. Gensch

Helmholtz Zentrum Dresden Rossendorf, Dresden, Germany





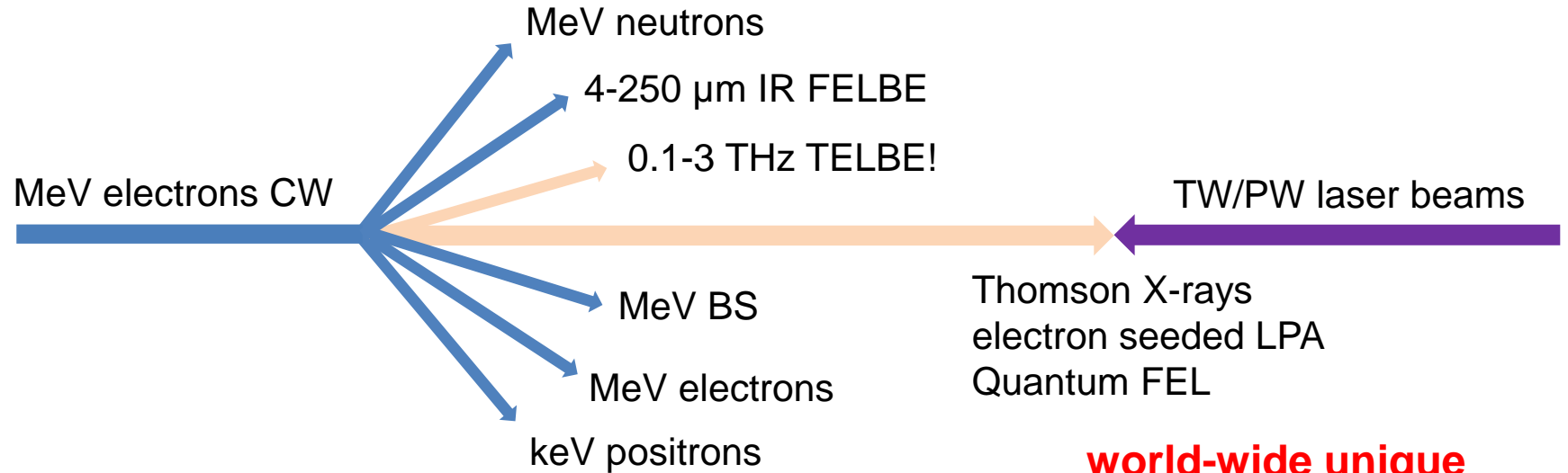
“high-fields @ high-rep-rates”

- CEP stable
- single cycle & multicycle (broad and narrowband)
- repetition rate adjustable
- few 10 fs time resolution

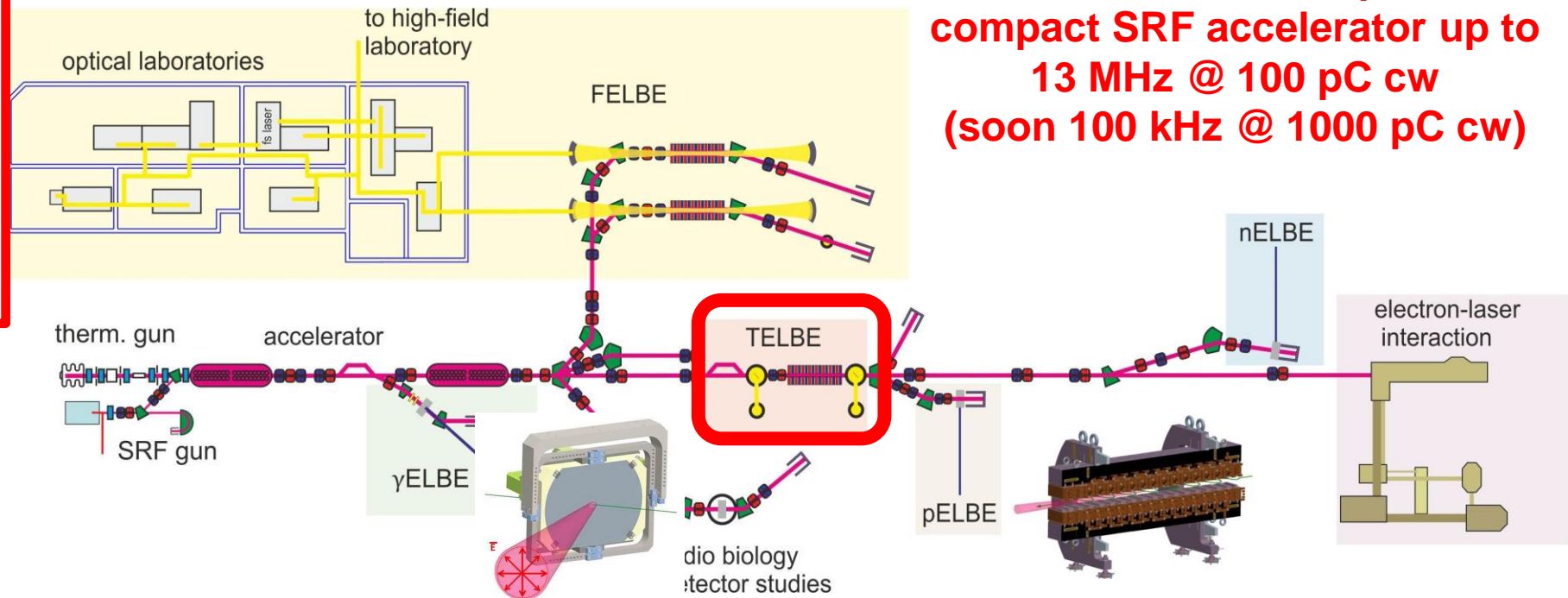
OPEN FOR PROPOSALS
 („Early stage operation“)
 since 07/2016

NOTE:

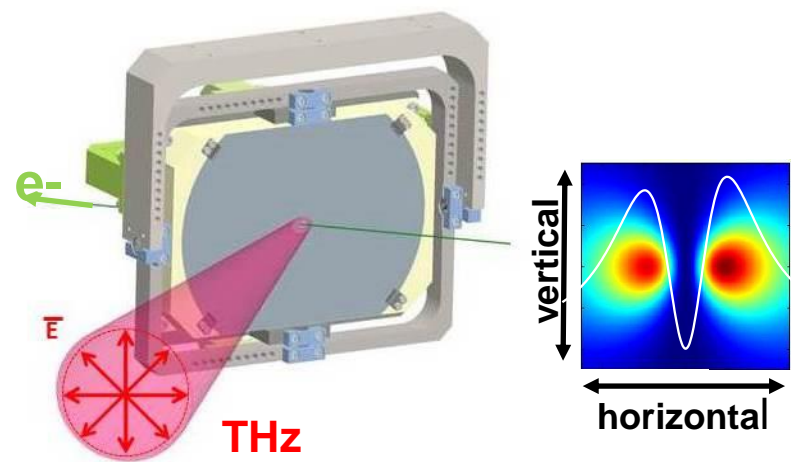
- TELBE is still under development
- factor of 100 below design param.
- operation ultimate challenge for accelerator department (long preparation, instable operation)



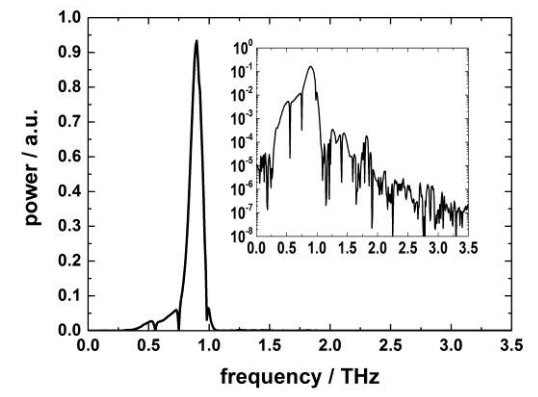
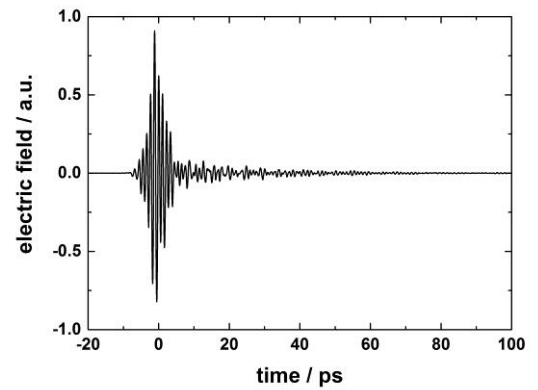
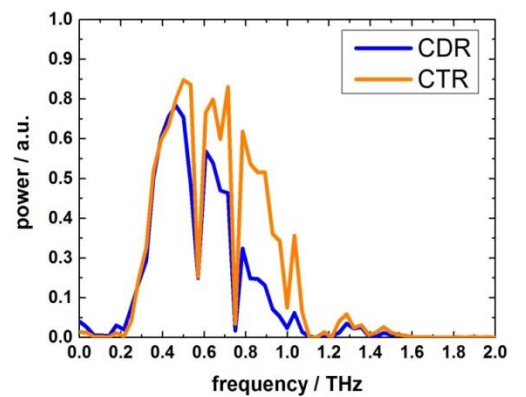
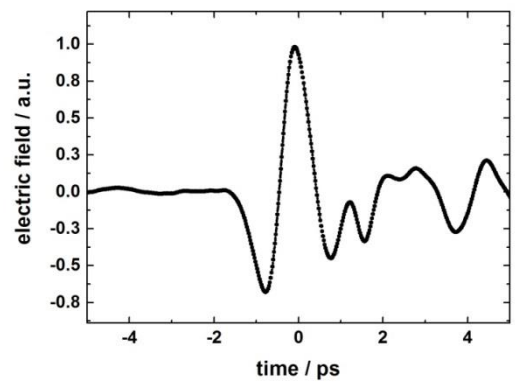
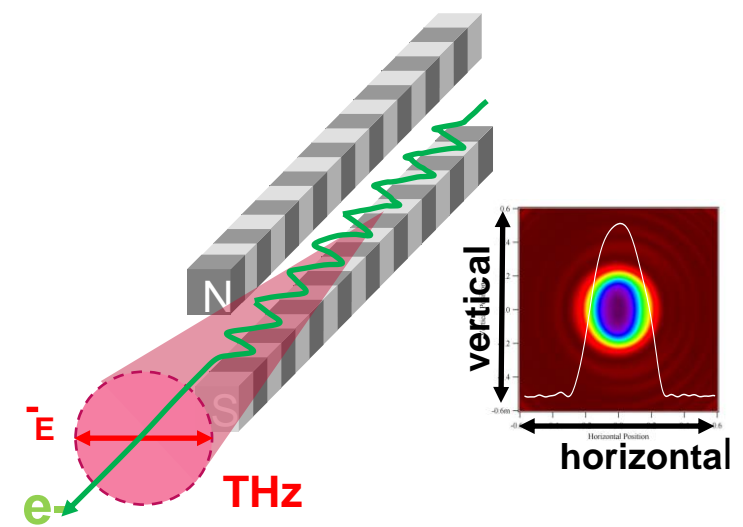
world-wide unique compact SRF accelerator up to 13 MHz @ 100 pC cw (soon 100 kHz @ 1000 pC cw)

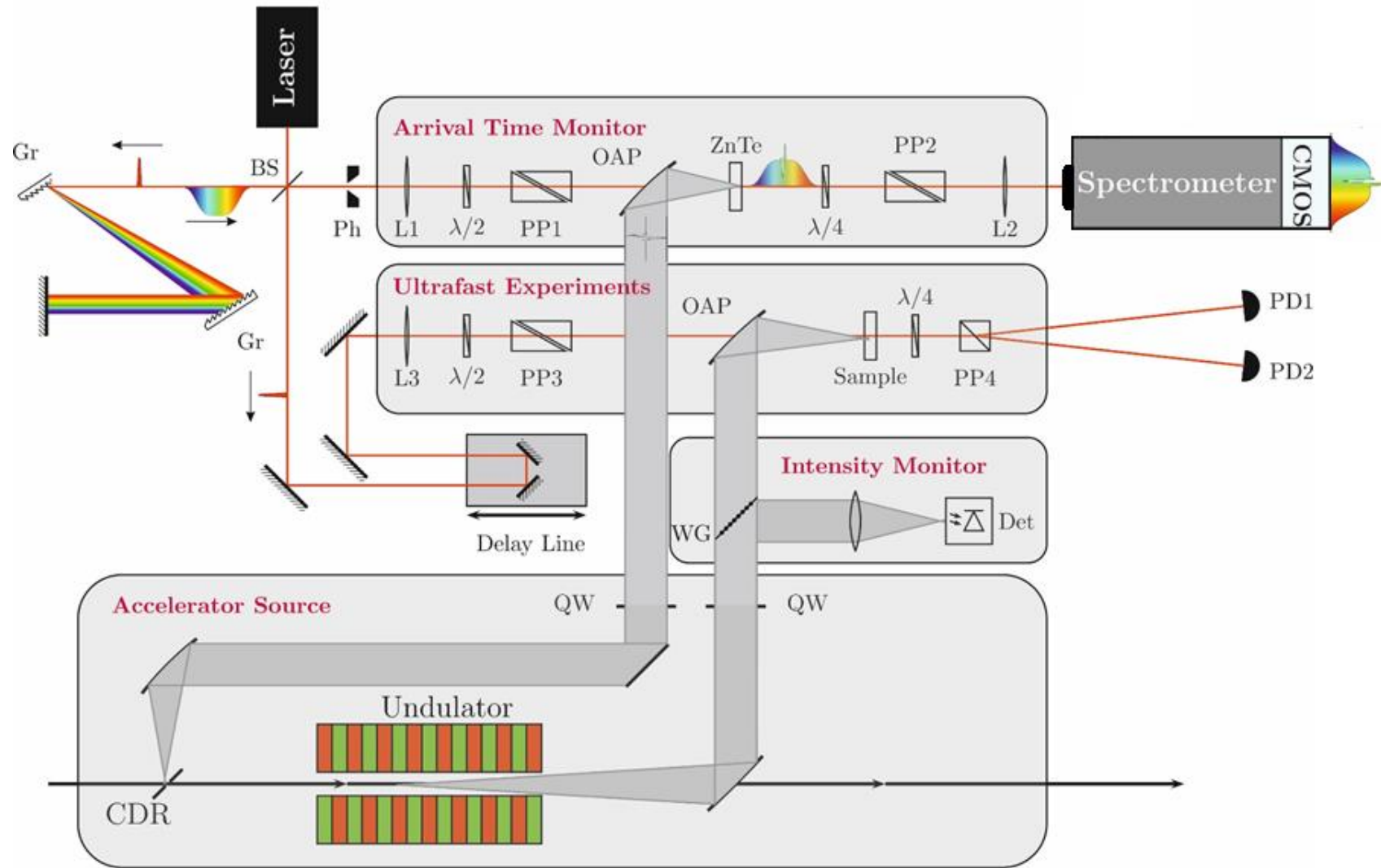


Coherent diffraction radiation:

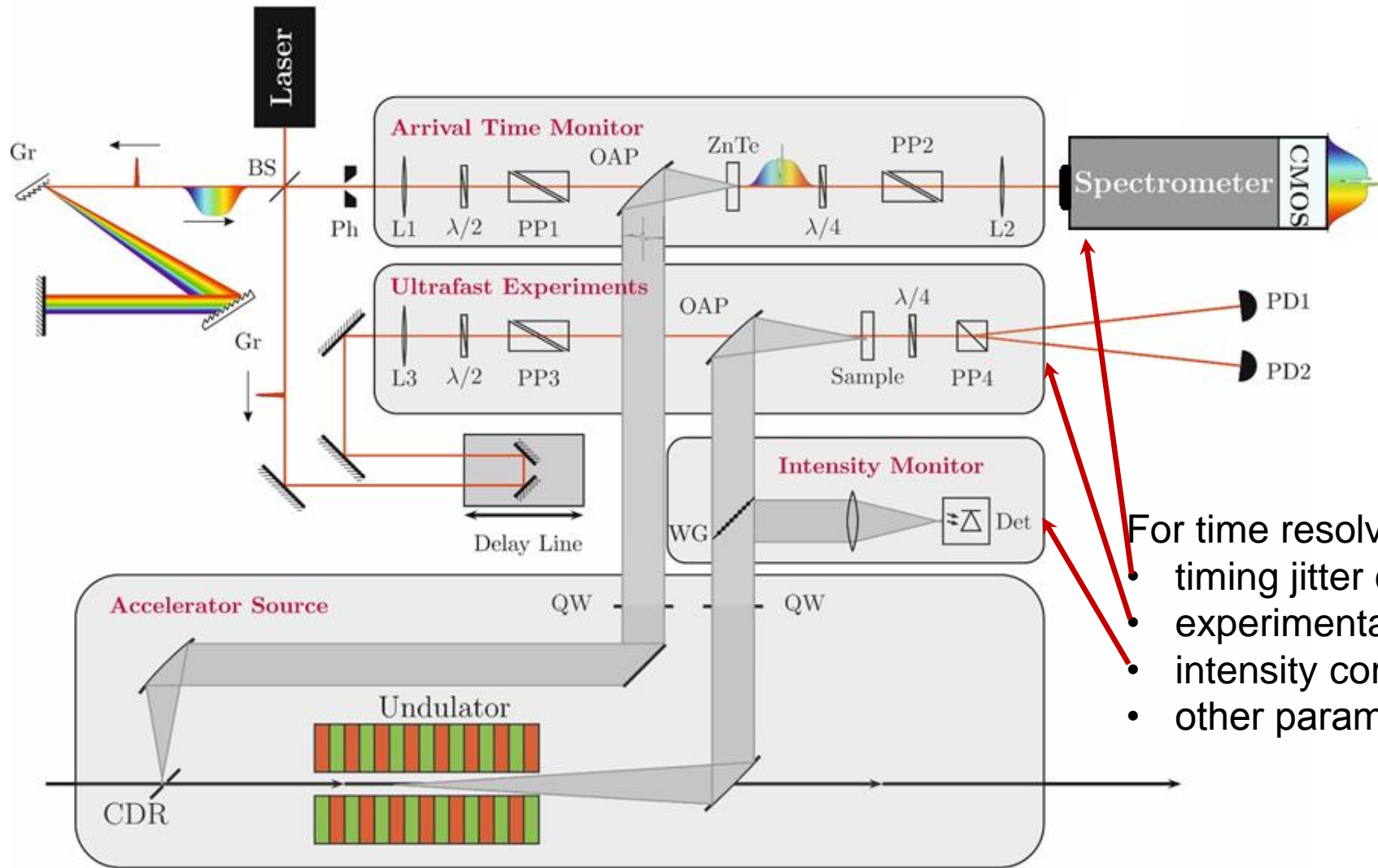


Undulator radiation:

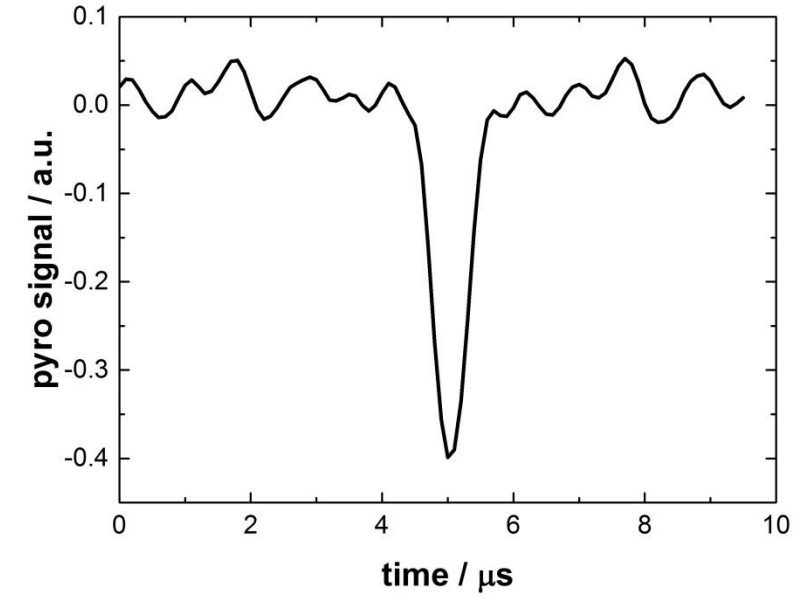
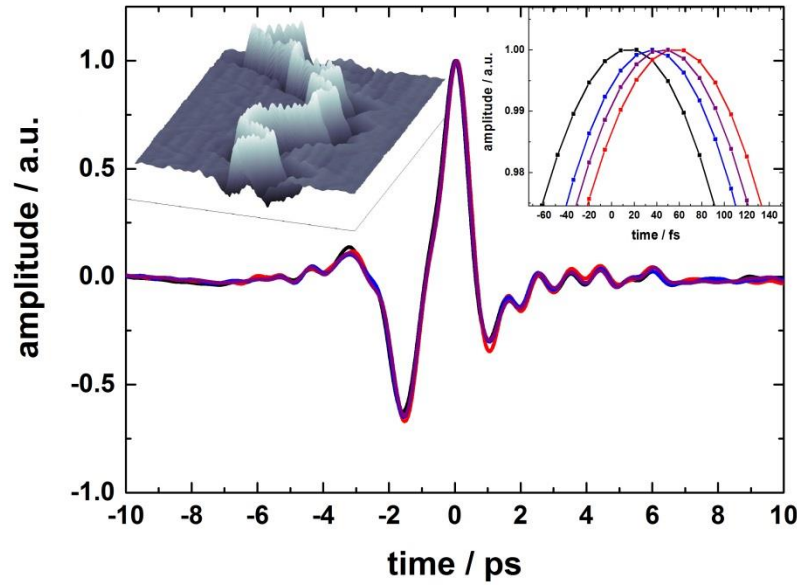
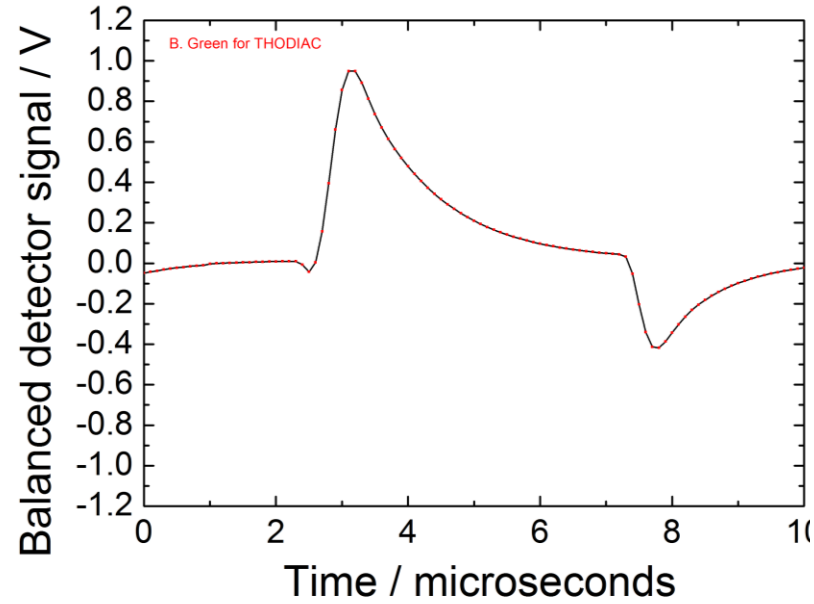




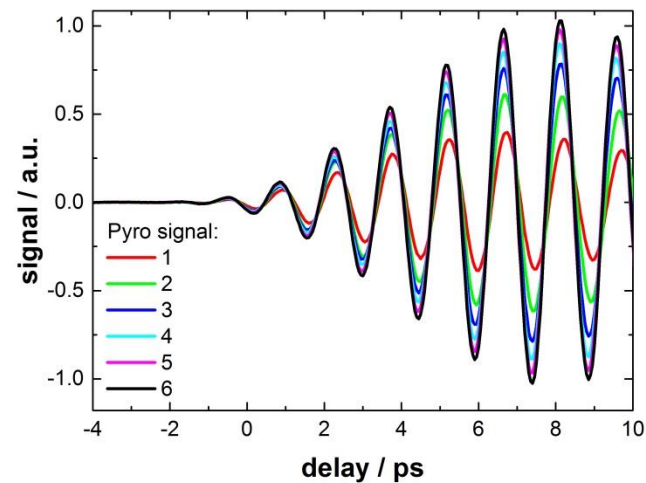
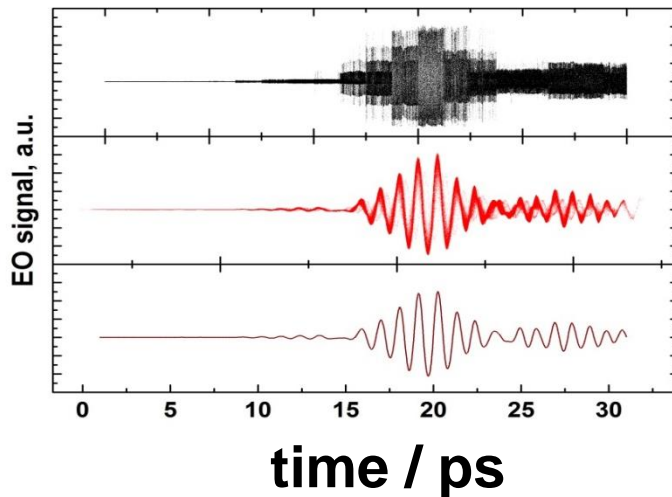
S. Kovalev et al. Probing ultra-fast processes with high dynamic range at 4th-generation light sources. *Struct. Dyn.*, 4:024301, 2017.



- For time resolved experiments:
- timing jitter correction;
 - experimental data;
 - intensity correction;
 - other parameters...

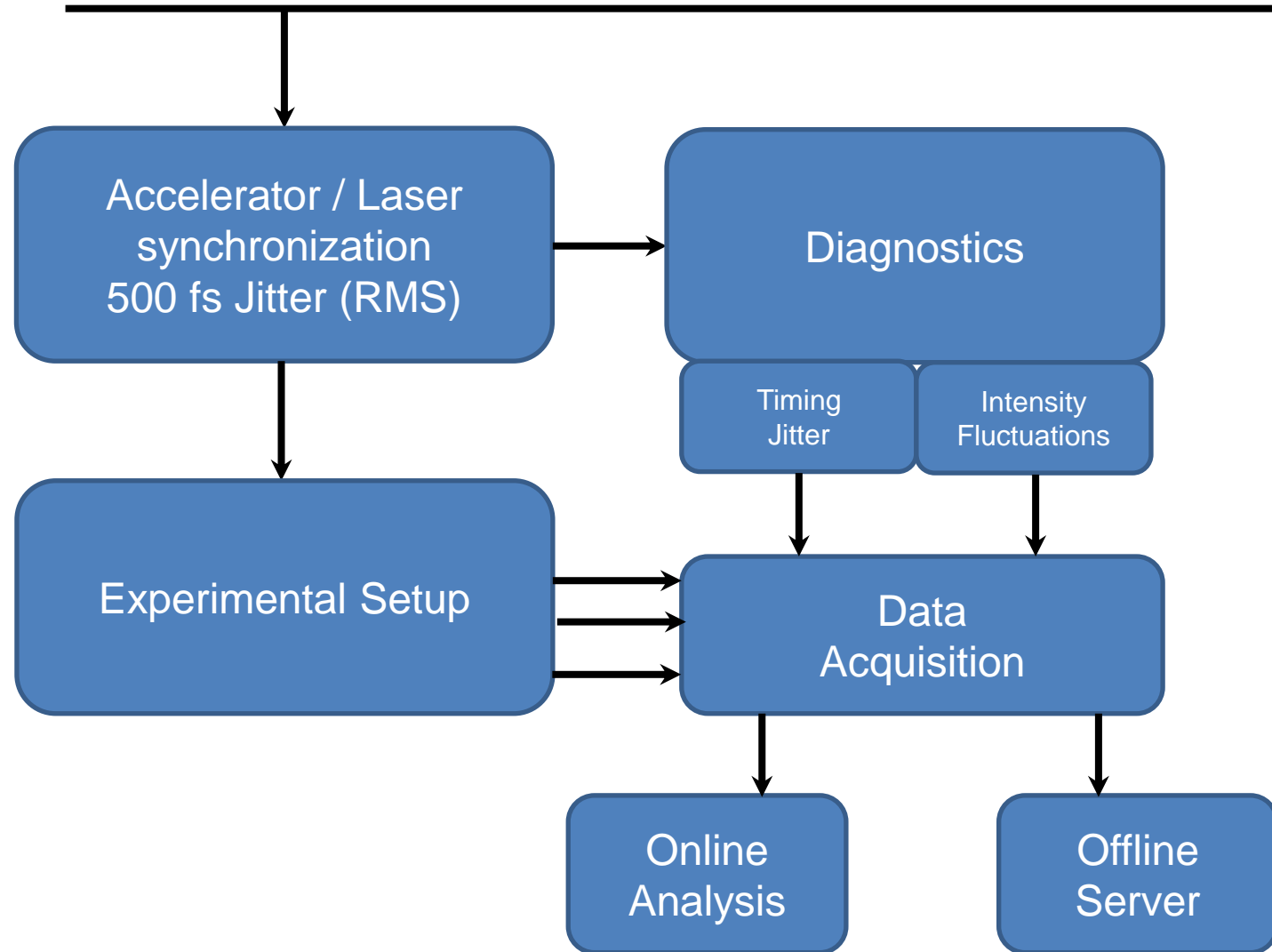


Timing jitter suppression to 30 fs



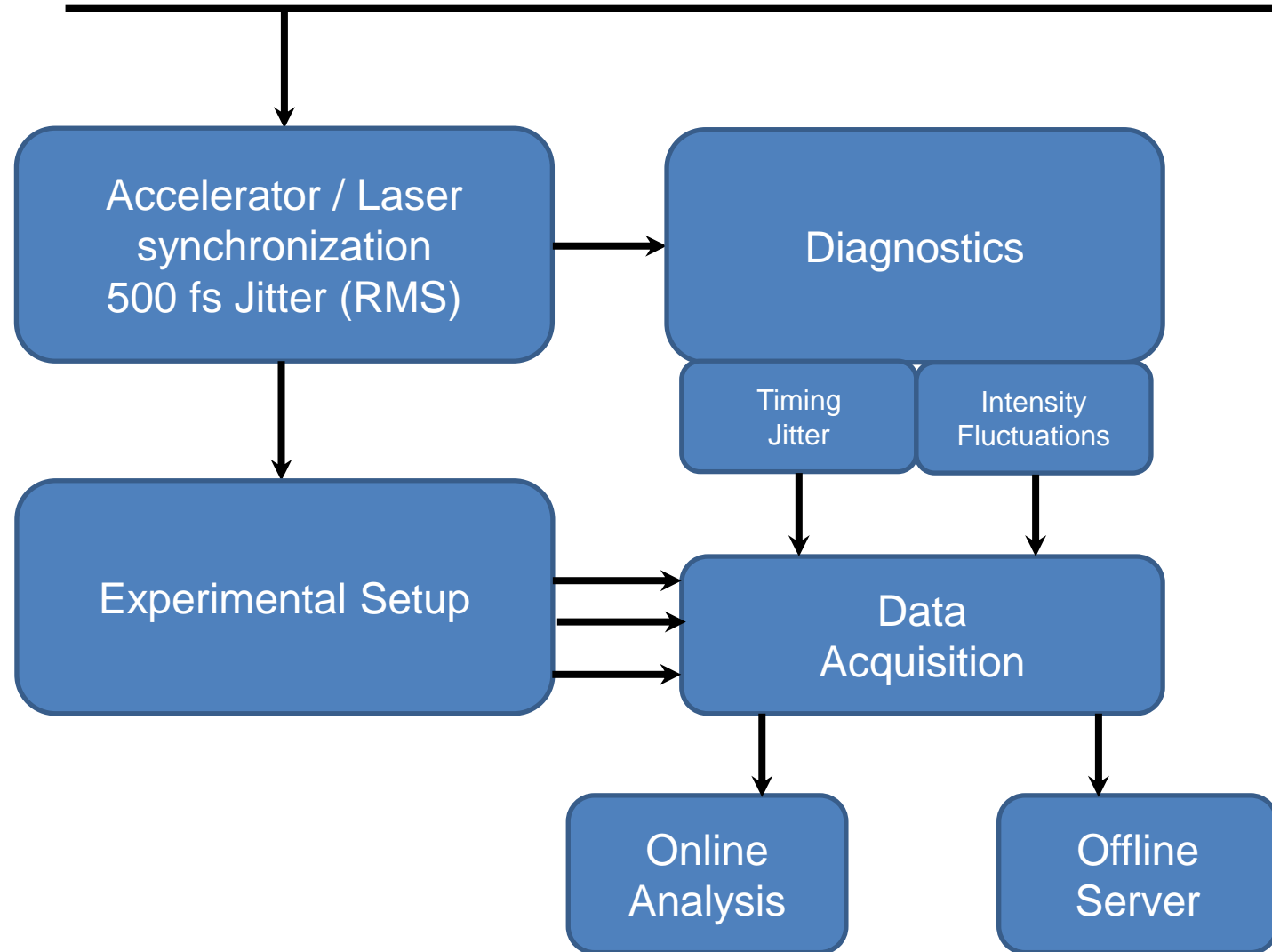
Intensity fluctuations suppressed to few %





before we used network with 1 Gb bandwidth // limits our duty cycle to 25%

Our capacity was limited by local storage – 50TB,



Now we are using:

- network with 10 Gb bandwidth
- local and online storage with 125 TB capacity
- resulted in the increased duty cycle and we are able to run the measurements with up to 3 days



How long should data be saved?

How can the user access it?



What is the best way to analyze it?

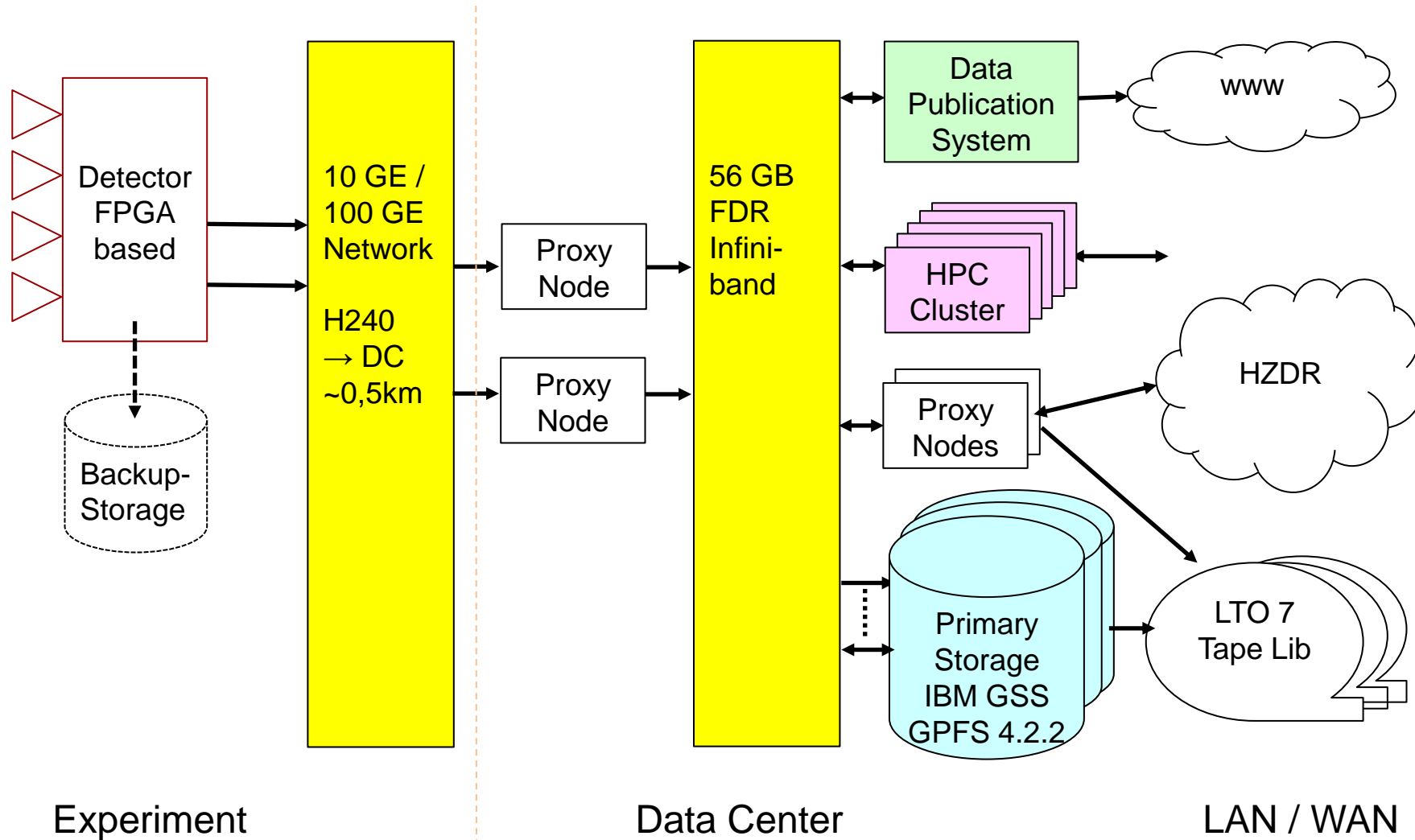


TELBE data generation	
Repetition rate	101 kHz
ADC specifications	10 MS/s 14 bit 8 channels
Camera specifications	2048 pixels 14 bit
Data generation rate	505 MB/s
Data for 30 shifts (15 days)	654 TB

later up to 13 MHz cw!

- 12/2016 Workflow concept of DAQ and data management
- 02/2017 Round table discussion with TELBE/DALI user community about requirements for 101 kHz DAQ and data management
- 03/2017 Specification of data network and storage for operation of the light-house facility TELBE @ 101 kHz
- 09/2017 Specification and Procurement of HW TELBE Phase 1 (~1 Pbyte / 0.5 GByte/s)
- 06/2018 Real-time Transfer to Data Center and Analysis at 101 kHz with 100% duty cycle operational
- 07/2018: **mid term review**
- 12/2018 Benchmarking of TELBE DAQ and data management at 101 kHz over 20+10 shifts
- 02/2019* Round table discussion with TELBE/DALI user community about experiences with 101 kHz DAQ / data management and requirements for increase in repetition rate towards 4.5 MHz and 13 MHz.
- 06/2019 Based on the results of * -> Design of DAQ and data management for TELBE at 4.5 MHz and 13 MHz
- 02/2020 ** Round table discussion with TELBE/DALI user community about DAQ and data management requirements for DALI
- 03/2020 Specification and Procurement of HW TELBE Phase 2 (maximum ~15 Pbyte / 10 Gbyte/s)
- 06/2020: **final report** (incl.: concept for DALI DAQ and data managem. based on **)

Architecture:



Experiment

Data Center

LAN / WAN

Repetition rate	Camera	ADC 14 bits 8 channels	Data rate	Storage needed for 30 shifts of 12 hours each
101 kHz	Commercial	10 MS/s	505 MB/s	654 TB
101 kHz*	Commercial	10 MS/s	143 MB/s	185 TB
4.5 MHz	KALYPSO	5 GS/s	10.3 GB/s	13.3 PB
4.5 MHz*	KALYPSO	5 GS/s	6.3 GB/s	8.2 PB
13 MHz	TBD	15 GS/s	29.8 GB/s	38.6 PB
13 MHz*	TBD	15 GS/s	18.2 GB/s	23.6 PB
DALI 2025				
10x100 kHz	Commercial?	10 MS/s 14 bits	5 GB/s	6.54 PB
10x100 kHz	Commercial?	100 MS/s 16 bits	19.7 GB/s	25.6 PB

Project goal: Operate for 30 shifts, 12 hours each

- TELBE could be an ideal benchmark facility for pulse-resolved DAQ and data management at a high rep rate photon science user facility
- the topics:
 - > pulse resolved DAQ at high-rep-rate
 - > Data management at high-rep-rate (photon science) user facilities
 - > european wide standard procedures to cope with the huge amount of data in user-lab interaction are highly timely!

B. Green et al, *High-Field High-Repetition-Rate Sources for the Coherent THz control of Matter*, Sci. Rep. **6** (2016), 22256.

S. Kovalev et al, *Probing ultra-fast processes with high dynamic range at 4th generation light sources: arrivaltime and intensity binning at unprecedented repetition rates*, Struct. Dyn. 2017, submitted.

B. Green, *Superradiant Terahertz Sources and their Applications*, PhD thesis, KIT 2017.