BKR training for X-ray Gas Monitors at European XFEL

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X-ray Photon Diagnostics (XPD)

Hamburg, 19.03.2019

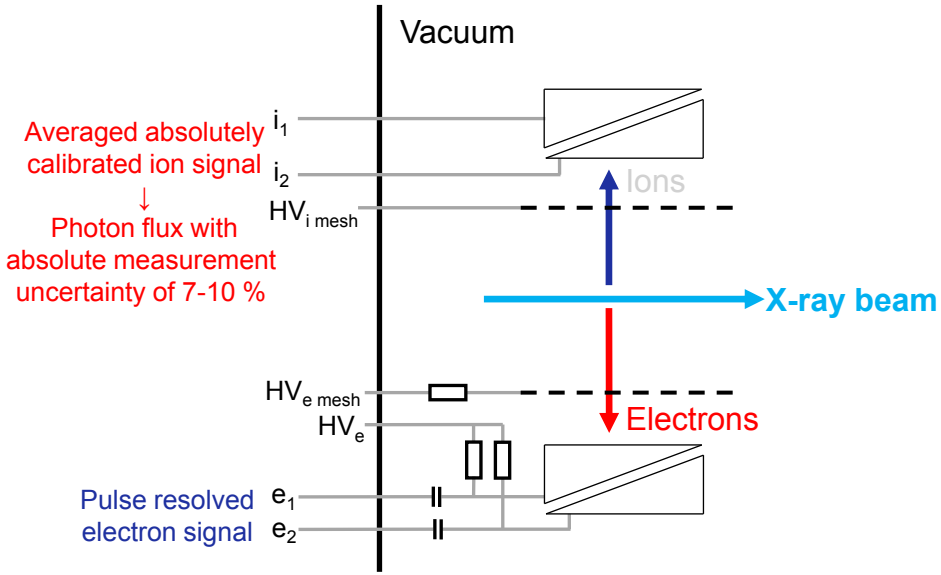
- Basic concept of XGM
- 24/7 operation
- Quick fixes

X-ray Gas Monitors (XGM) setup

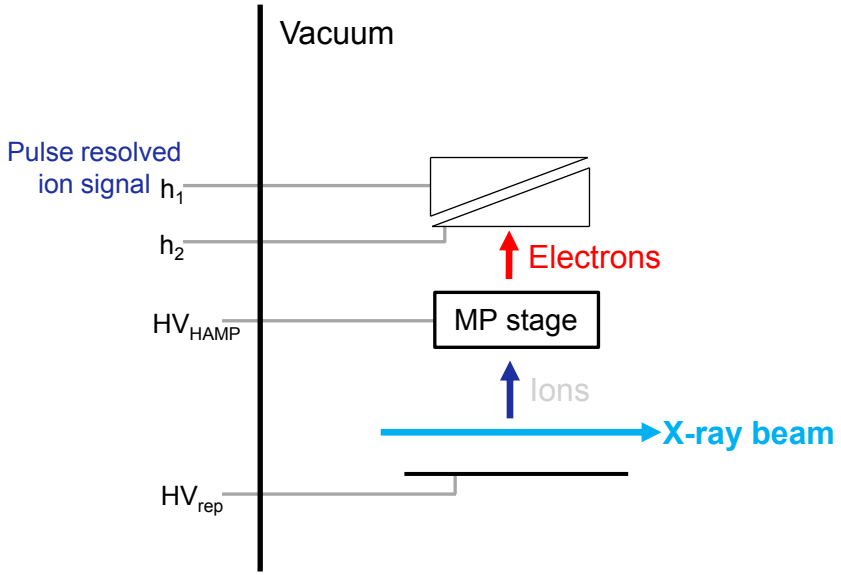
Single-shot non-invasive pulse energy measurement and average non-invasive beam position monitoring

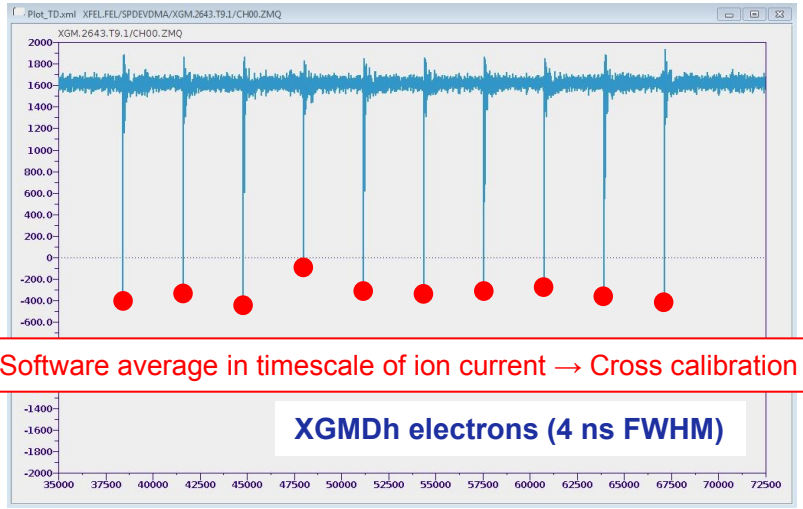
- Users
- Operators

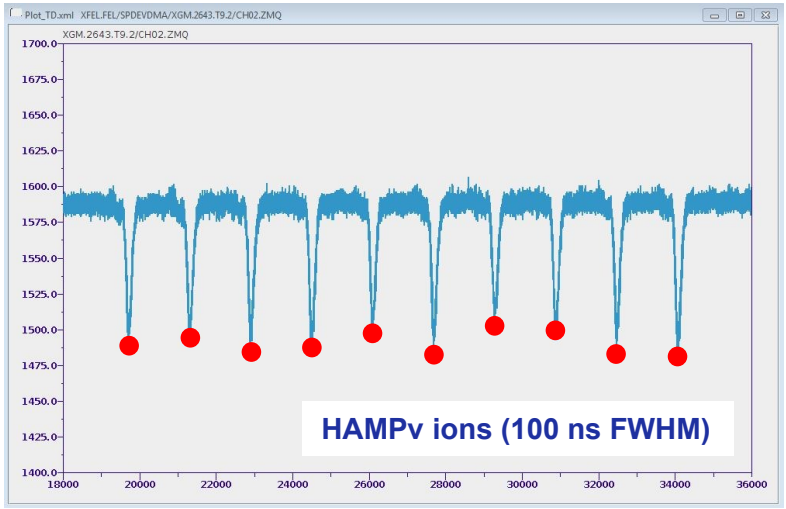
XGMD


Vacuum
Averaged absolutely calibrated ion signal
↓
Photon flux with absolute measurement uncertainty of 7-10 %
i1
i2
HVi mesh
Ions
X-ray beam
HVe mesh
HVe
Electrons
Pulse resolved electron signal
e1
e2

HAMP


Vacuum
Pulse resolved ion signal
h1
h2
Electrons
HVHAMP
MP stage
Ions
X-ray beam
HVrep


Plot_TD.xml XFEL.FEL/SPDEVDMA/XGM.2643.T9.1/CH00.ZMQ
XGM.2643.T9.1/CH00.ZMQ
Software average in timescale of ion current → Cross calibration
XGMDh electrons (4 ns FWHM)


Plot_TD.xml XFEL.FEL/SPDEVDMA/XGM.2643.T9.2/CH02.ZMQ
XGM.2643.T9.2/CH02.ZMQ
HAMPv ions (100 ns FWHM)

XGM equations

Number of ions created per pulse in the XGMD:

$$N_{ion} = \frac{N_{ph} * \sigma_{ph}(\hbar\omega) * z_{XGMD} * p_{atom}}{k * T}$$

N_{ph}	number of photons per pulse
σ_{ph}	total photoionization cross section
z_{XGMD}	length of Faraday cup (27.8 cm)
p_{atom}	target gas pressure
k	Boltzmann constant
T	temperature

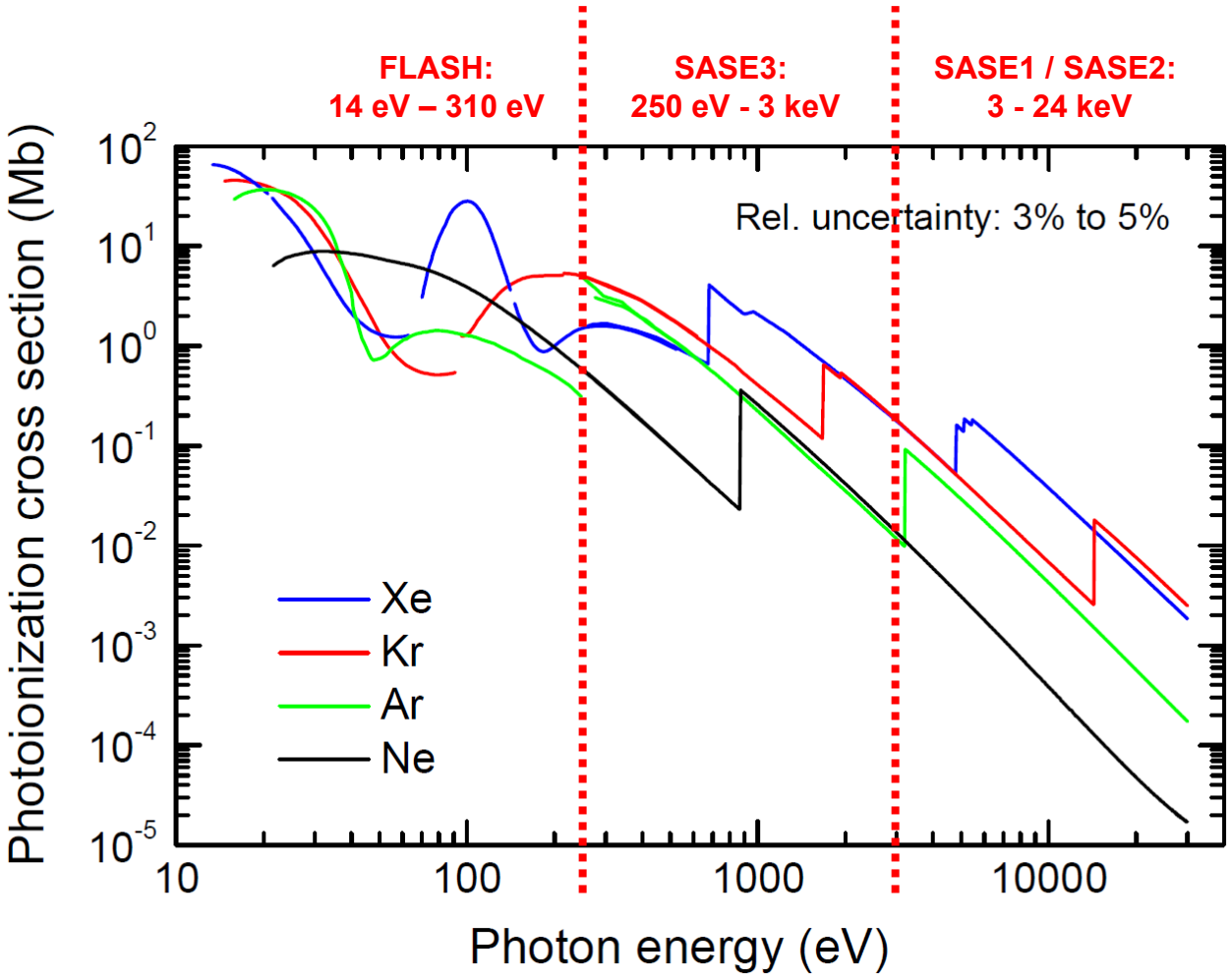
Ion current measured by Faraday cup of the XGMD:

$$I_{ion} = N_{ion} * T_{Ni} * q_{ph}(\hbar\omega) * N_{bunches} * R_{rep} * e$$

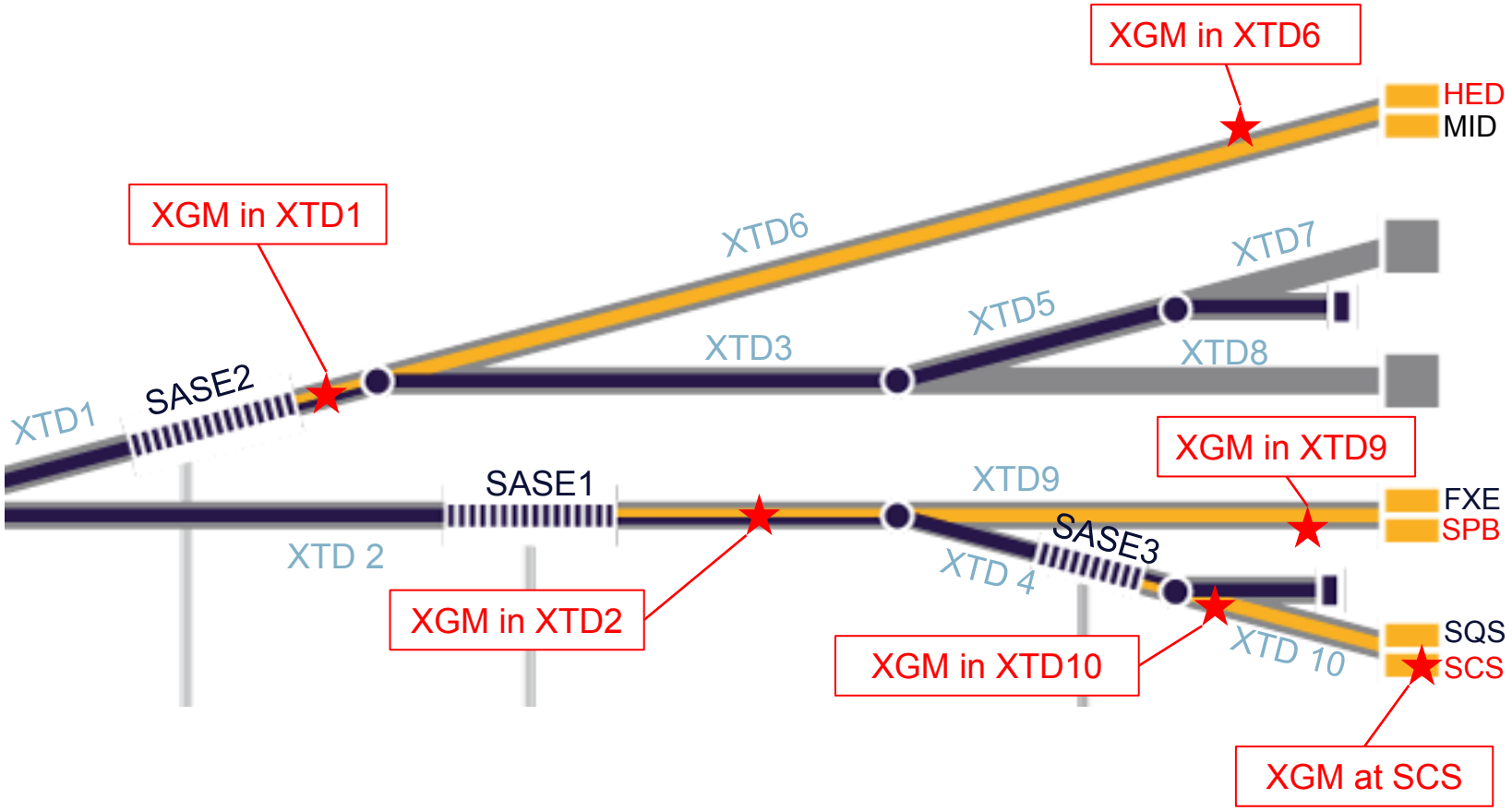
q_{ph}	ion mean charge
T_{Ni}	transmission of Ni mesh in front of the Faraday cup (80%)
N_{pulses}	number of pulses per train
R_{rep}	train repetition rate (10 Hz)
e	elementary charge

Courtesy from A. Sorokin and K. Tiedtke

Cross sections



Locations of XGMs in the tunnels



XGM installation

- Gas supply (N_2, Kr, Ne, and Xe)
- Differential pumping up- and downstream (vacuum group)
- Vacuum and gas controls under Karabo (photon system control)
- XGM measurement, controls, and data acquisition in DOOCS (accelerator system control)
- DOOCS to Karabo bridge
- Data acquisition in Karabo

24/7 operation

XGM has no "official" 24/7 support !!!

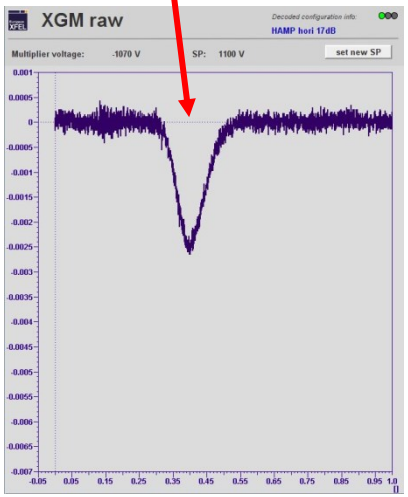
Number of bunches

Repetition rate

SASE1 photon energy

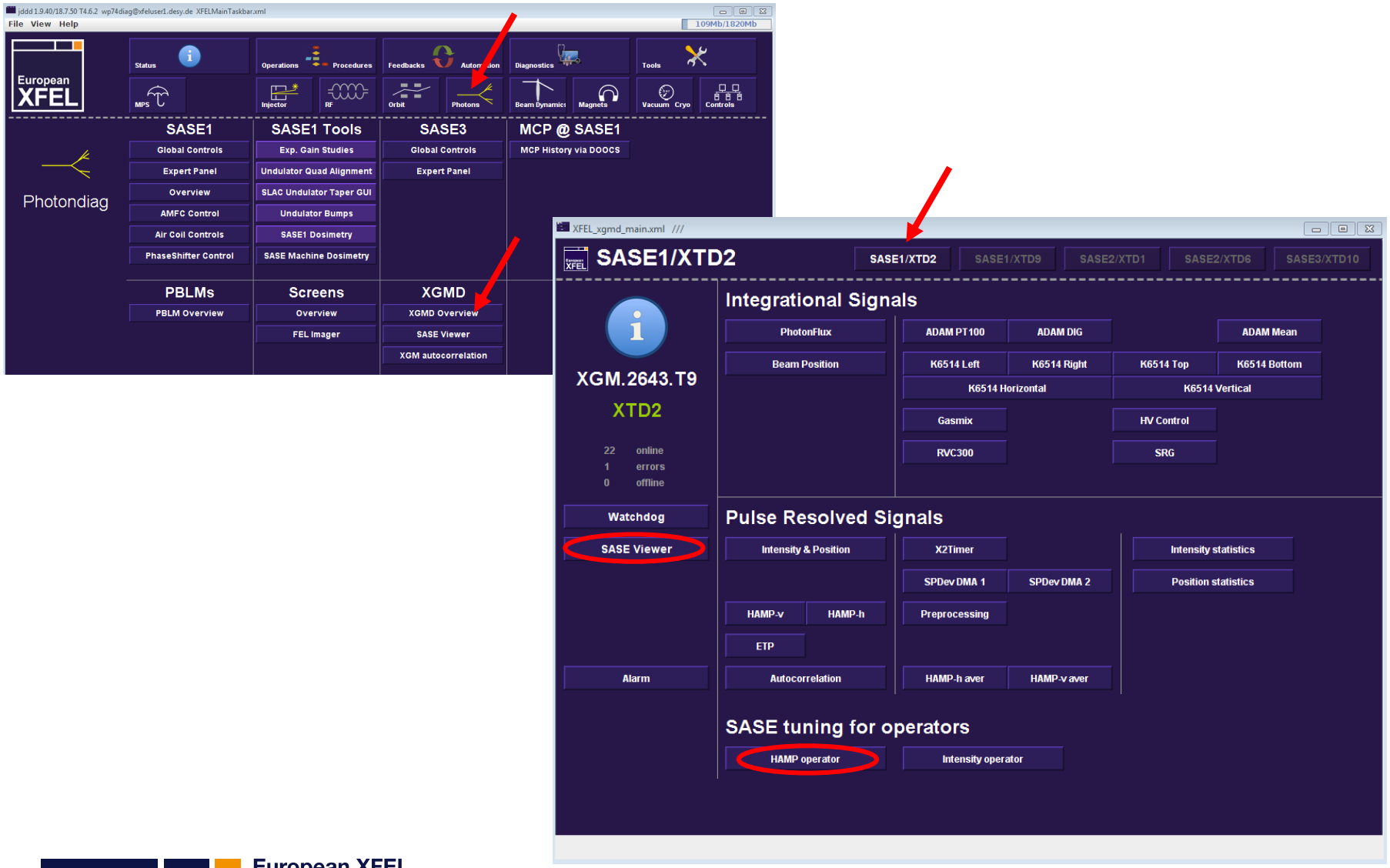
Pulse energy

SASE search with HAMP signal



- **Simultaneous operation SASE1, SASE2, and SASE3**
- **Fresh bunch …**
- **Alternating trains pattern …**

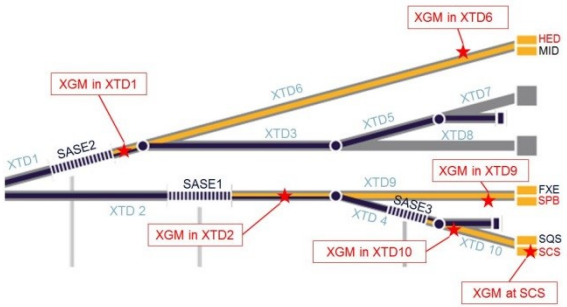
DOOCS


File View Help
European XFEL
Status
Operations
Procedures
Feedbacks
Diagnostics
Tools
MPS
Injector
RF
Orbit
Photons
Magnets
Vacuum
Cryo
Controls
Photondiag
SASE1
Global Controls
Expert Panel
Overview
AMFC Control
Air Coil Controls
PhaseShifter Control
SASE1 Tools
Exp. Gain Studies
Undulator Quad Alignment
SLAC Undulator Taper GUI
Undulator Bumps
SASE1 Dosimetry
SASE Machine Dosimetry
SASE3
Global Controls
Expert Panel
MCP @ SASE1
MCP History via DOOCS
PBLMs
PBLM Overview
Screens
Overview
FEL Imager
XGMD
XGMD Overview
SASE Viewer
XGM autocorrelation
SASE1/XTD2
SASE1/XTD2
SASE1/XTD9
SASE2/XTD1
SASE2/XTD6
SASE3/XTD10
XGM.2643.T9
XTD2
22 online
1 errors
0 offline
Watchdog
SASE Viewer
Alarm
Integrational Signals
PhotonFlux
ADAM PT100
ADAM DIG
ADAM Mean
Beam Position
K6514 Left
K6514 Right
K6514 Top
K6514 Bottom
K6514 Horizontal
K6514 Vertical
Gasmix
HV Control
RVC300
SRG
Pulse Resolved Signals
Intensity & Position
X2Timer
Intensity statistics
SPDev DMA 1
SPDev DMA 2
Position statistics
HAMP-v
HAMP-h
Preprocessing
ETP
Autocorrelation
HAMP-h aver
HAMP-v aver
SASE tuning for operators
HAMP operator
Intensity operator

Fresh bunch operation with old SASE viewers

SASE1 / XTD2 XGM

SASE3 / XTD10 XGM

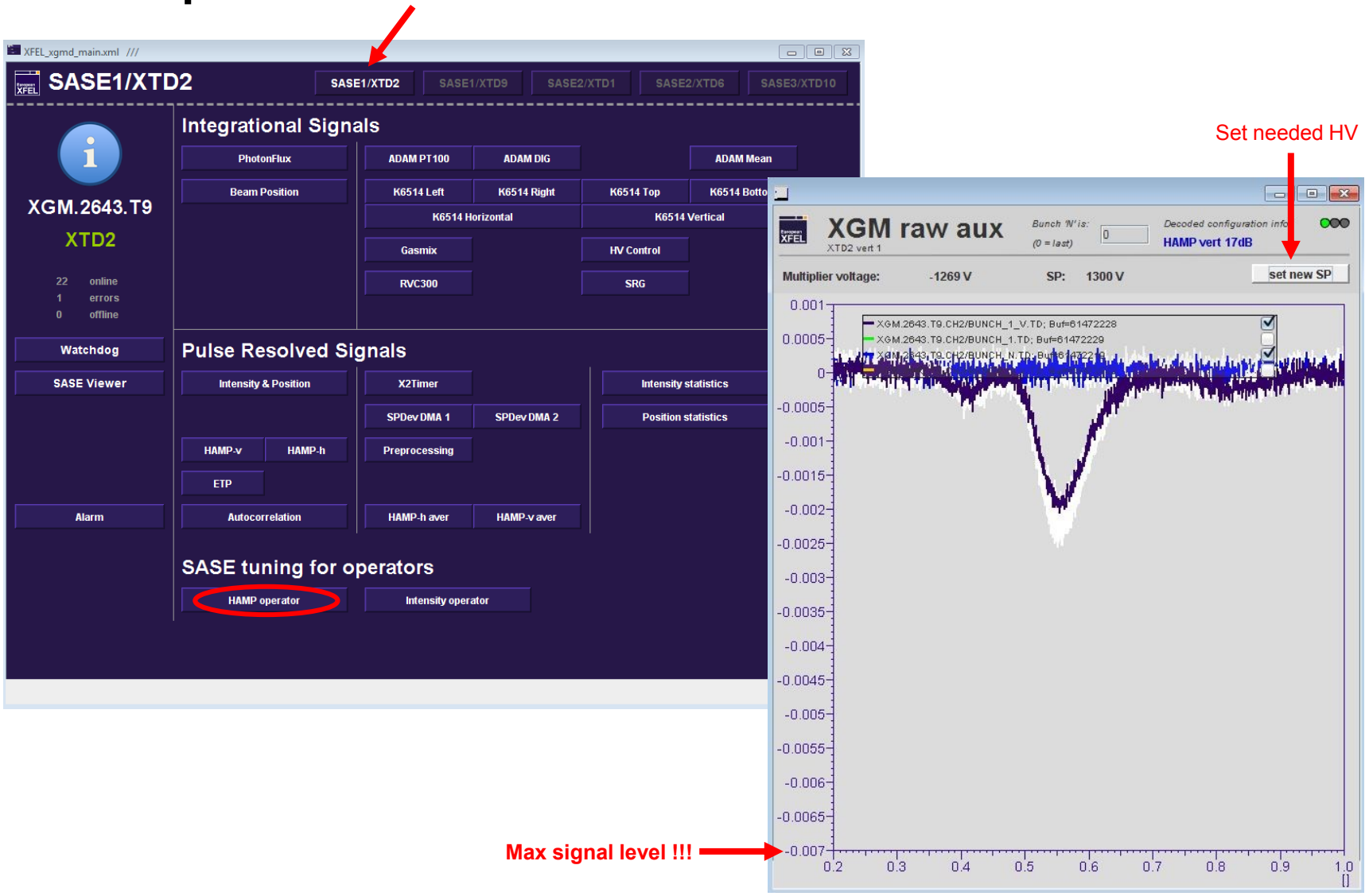


SASE1 XTD2 XGM with new viewer

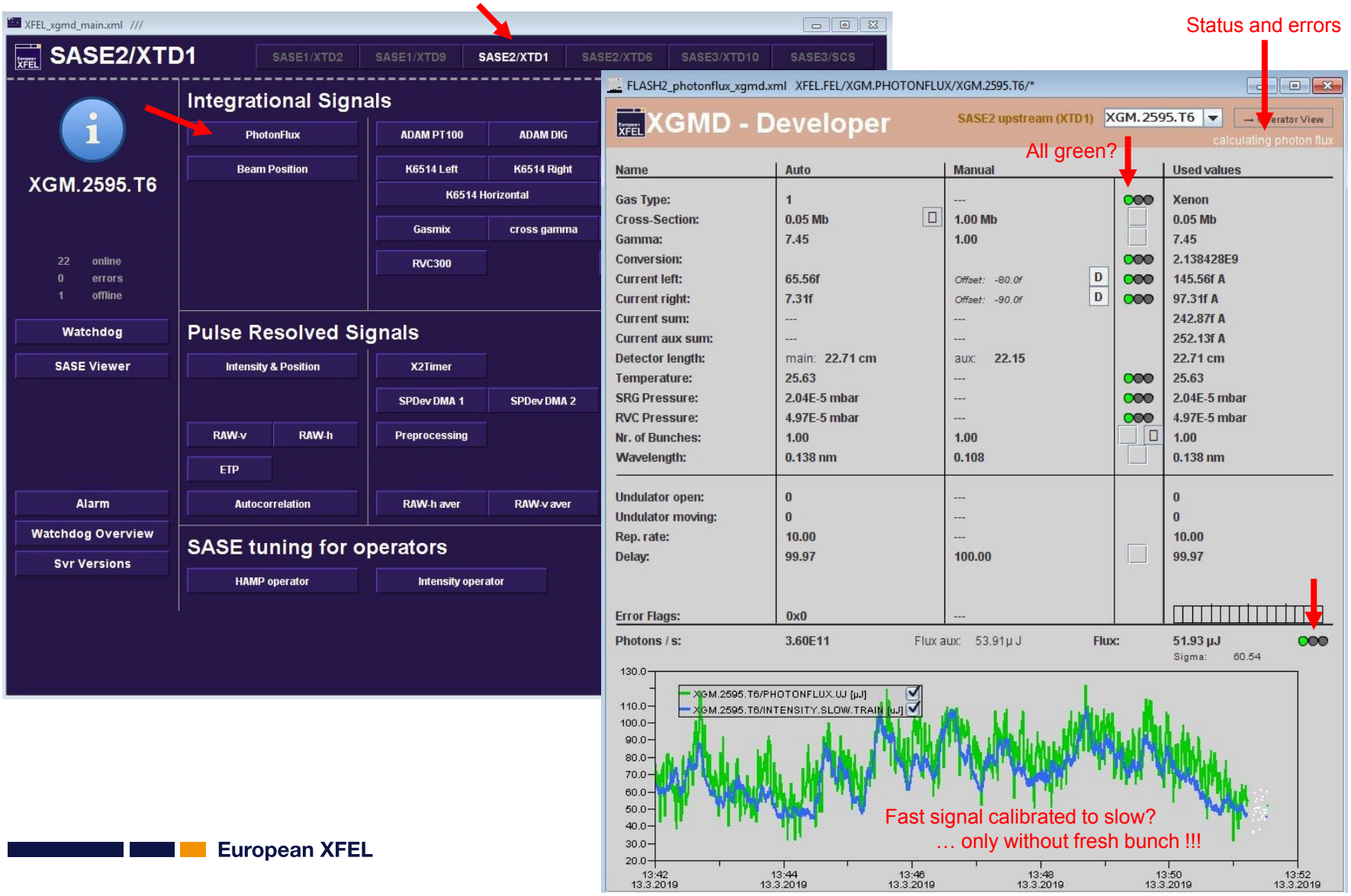
Single-shot ADC data

Average ion current

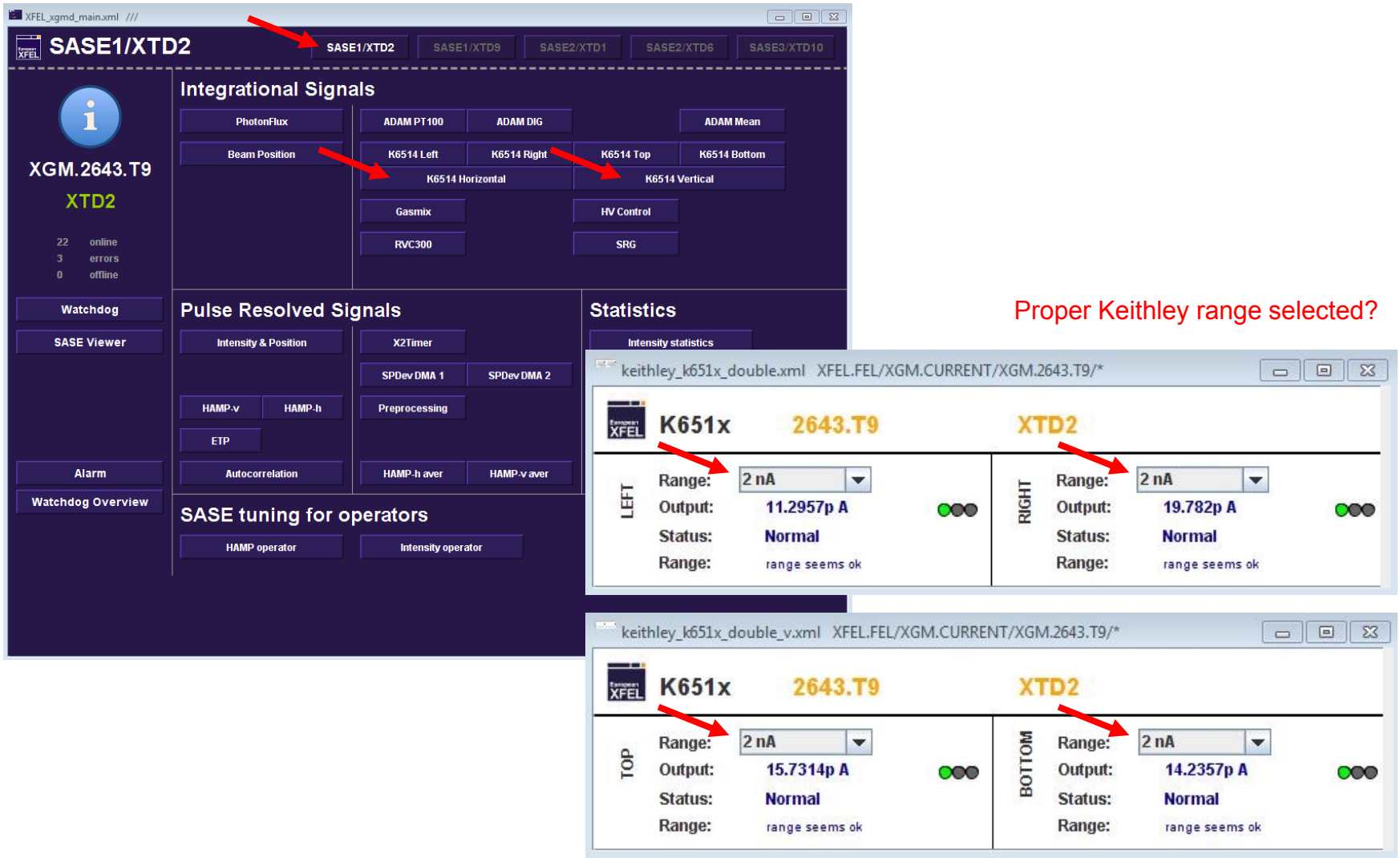
HAMP operator



Photonflux overview

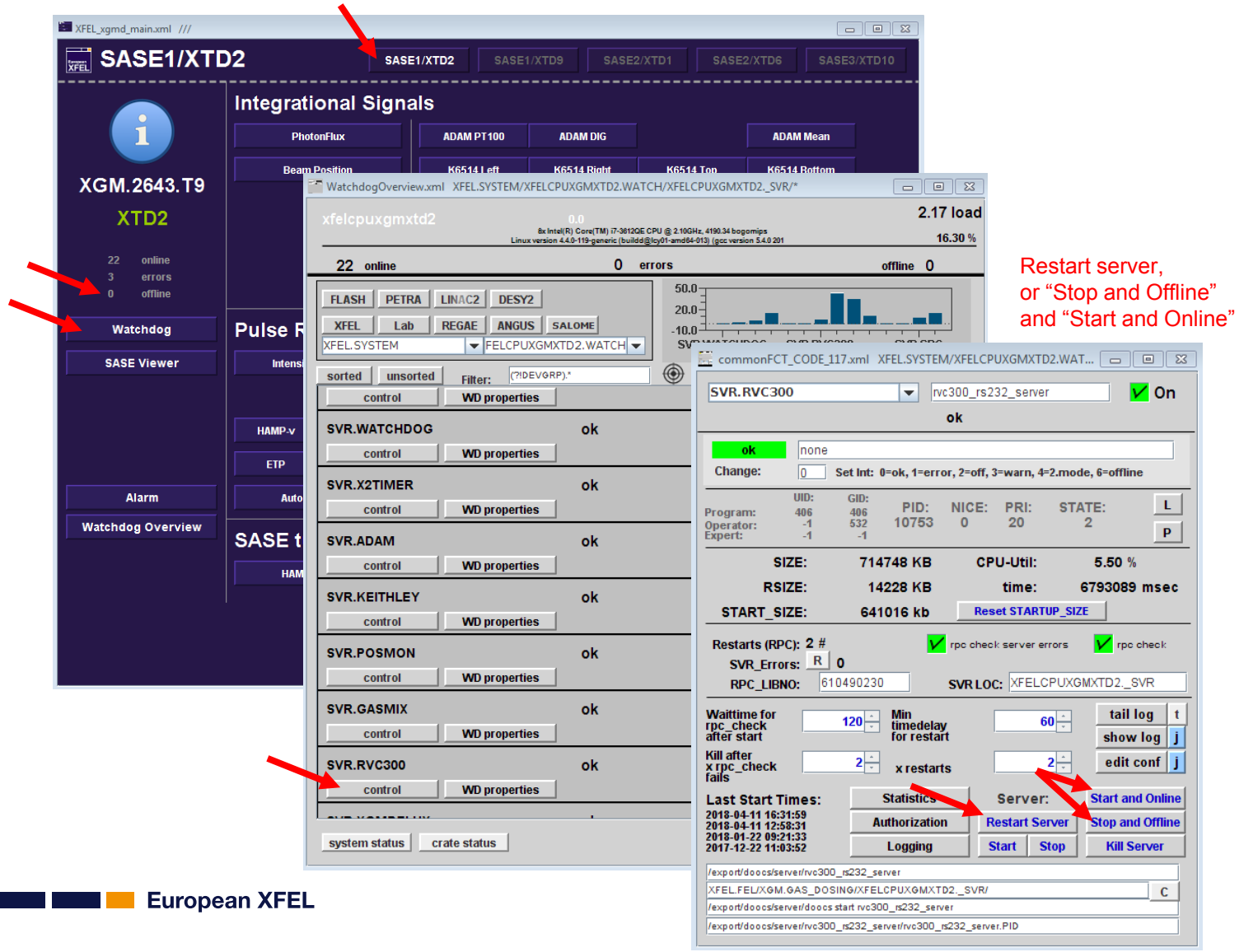


Keithley range

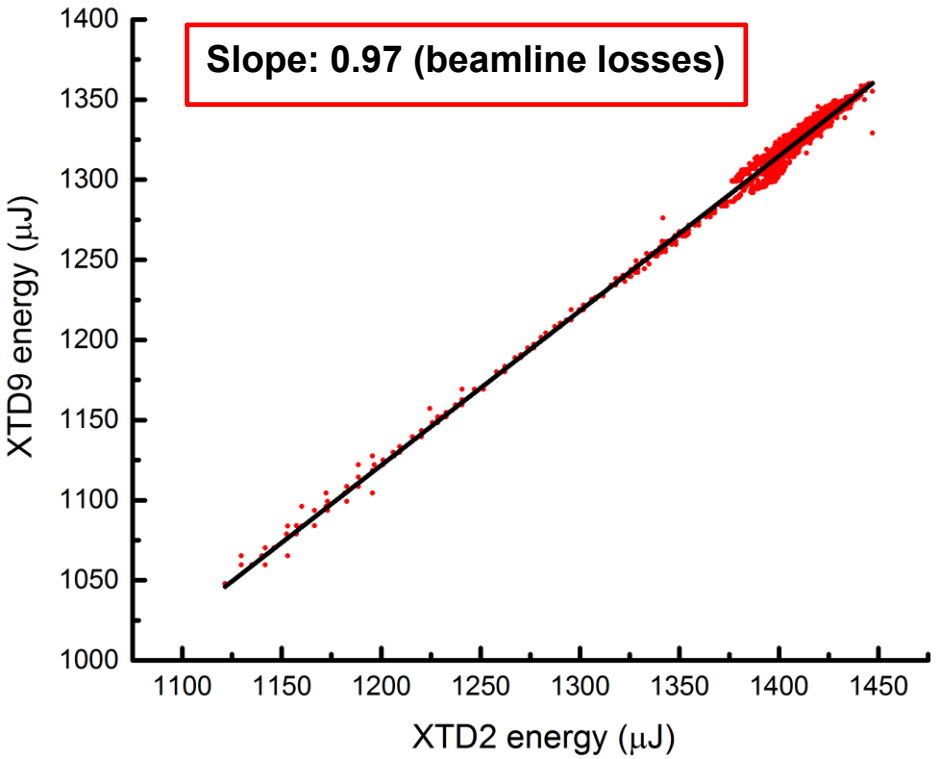


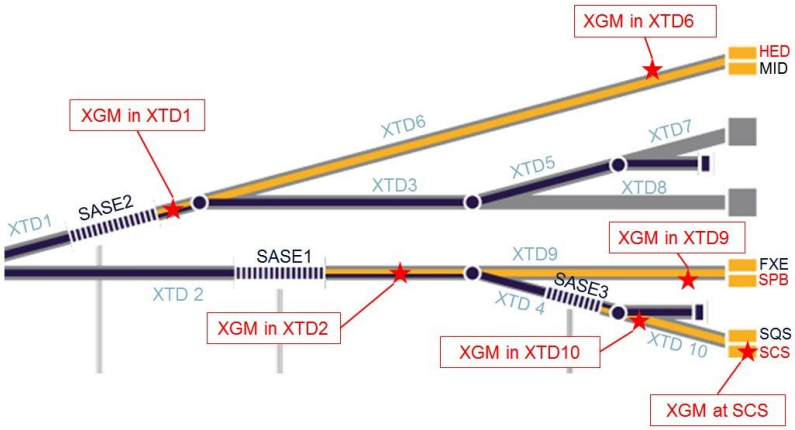
Proper Keithley range selected?

DOOCS server restart



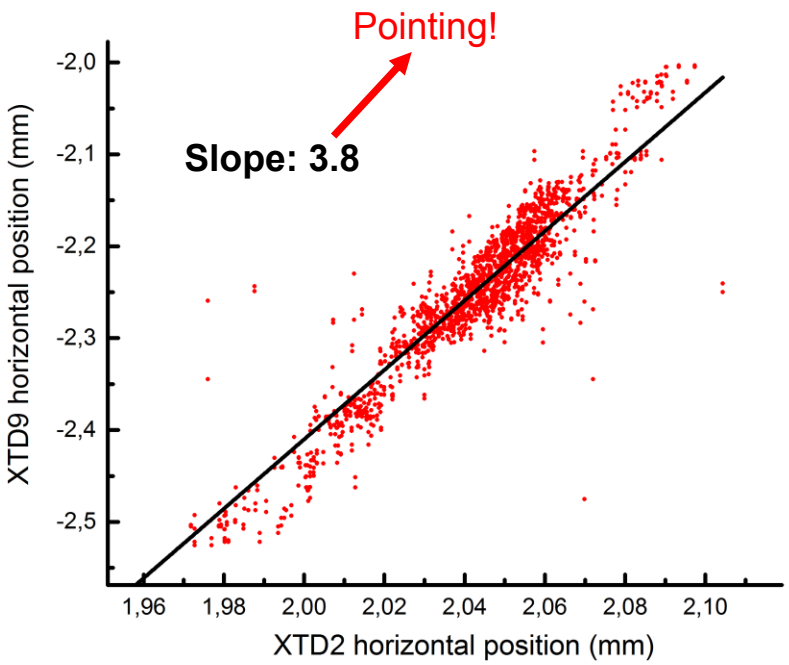
Averaged pulse energy: XTD2 versus XTD9 XGM

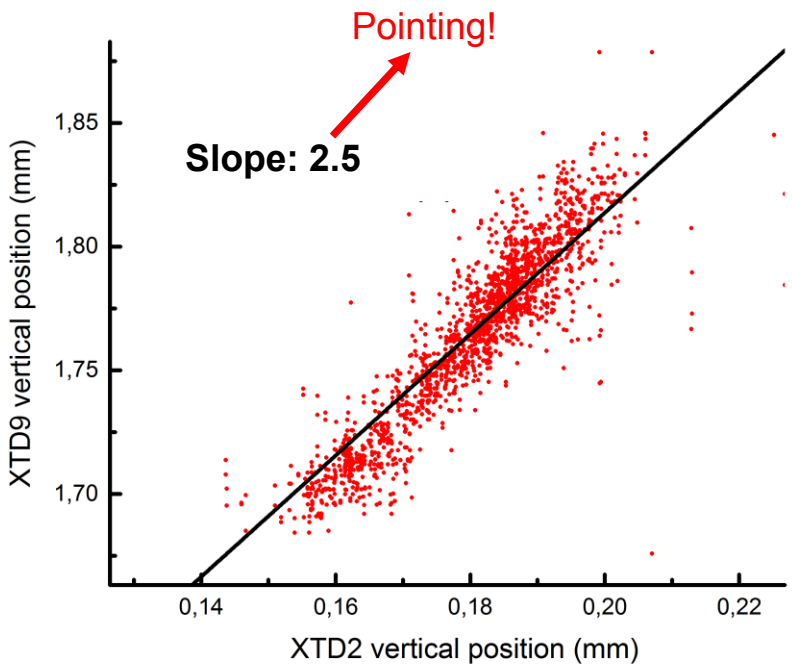




15.06.2018
0.134 nm, 60 bunches, slow ion signal
both XGMs with Xe, Run 149

Averaged beam position: XTD2 versus XTD9 XGM



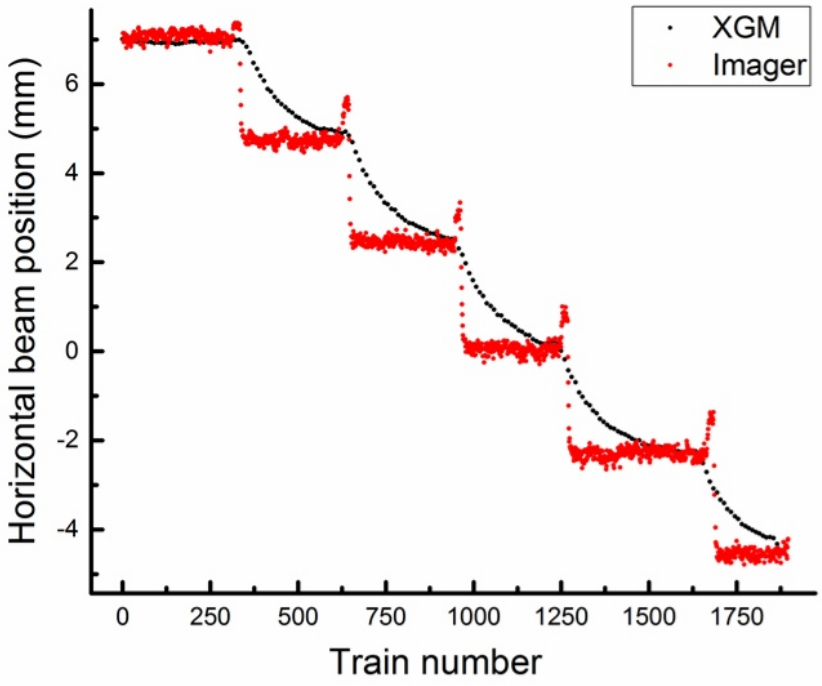


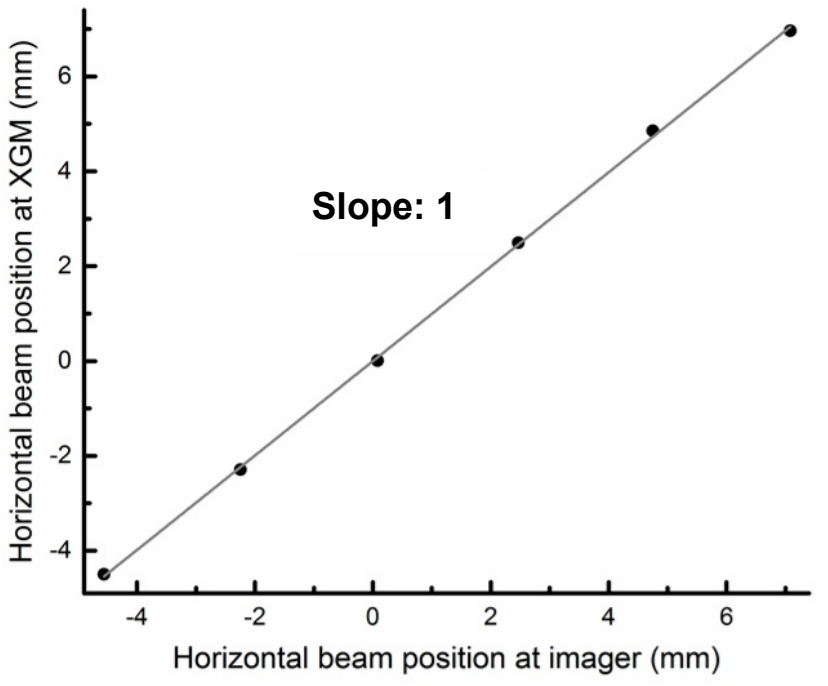
- Distance SASE1 source to XGM@XTD2: 209 m
- Distance SASE1 source to XGM@XTD9: 878 m, therefore: 0.4 mm / 878 m correspond to 0.5 μrad

→ Can be used for future active feedback

15.06.2018
0.134 nm, 60 bunches, slow ion signal
both XGMs with Xe, Run 149

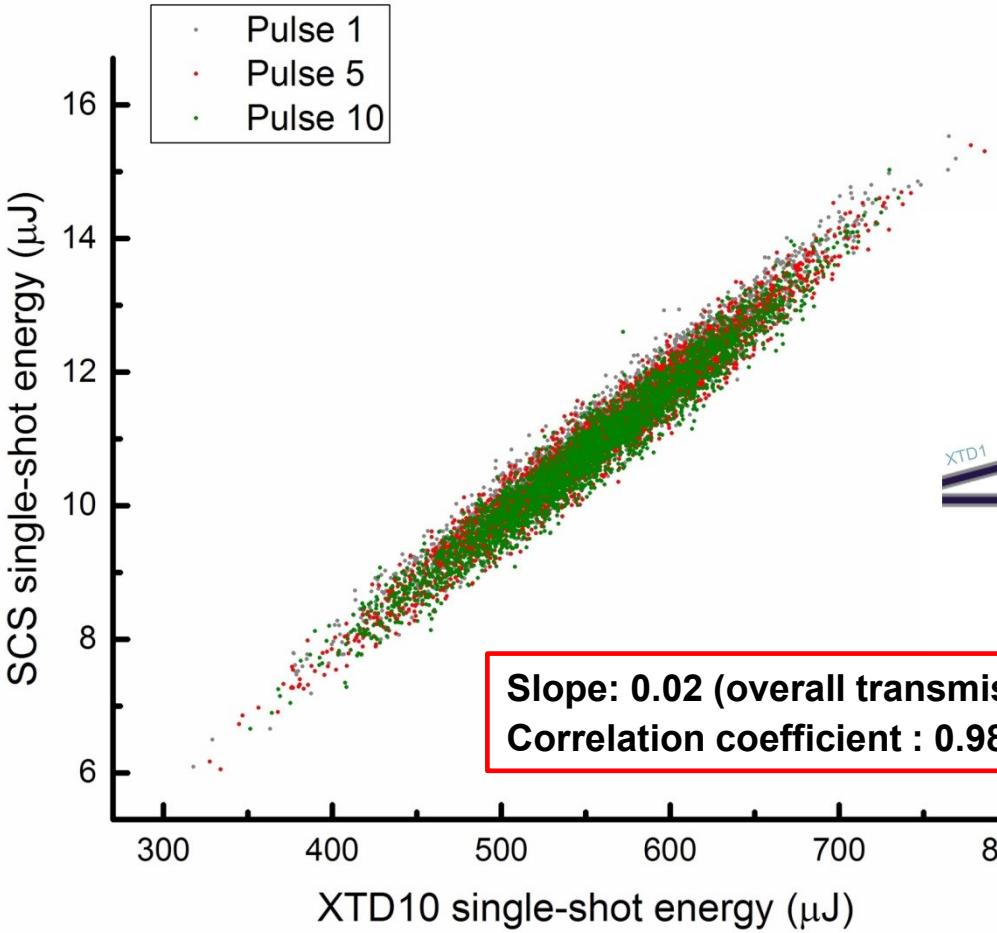
Position correlation: XGM versus Imager

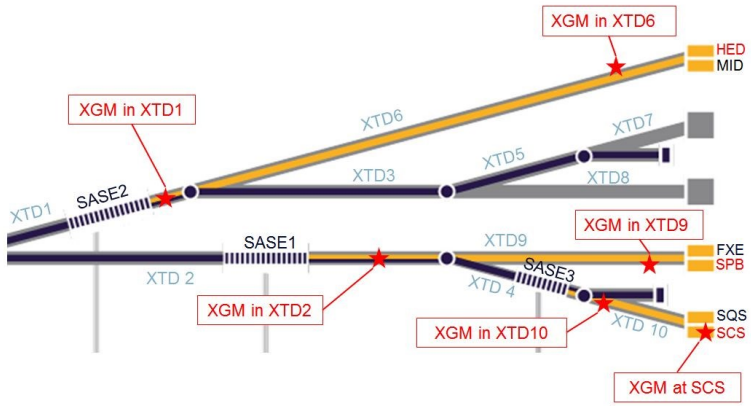




24.08.2017
0.136 nm, 60 bunches, slow ion signal
XTD9 XGM with Xe, Imager pop-in type I

Single-shot pulse energy: XTD10 versus SCS XGM





Slope: 0.02 (overall transmission)
Correlation coefficient : 0.98

11.11.2018
1.127 nm, 120 bunches, run r0183,
gas attenuator set to 5.5 % transmission
XTD10 XGM with Kr, SCS XGM with Xe

Acknowledgments

People@DESY … 15 years of experience!

- Machine operators
- Transport group, Survey and alignment group
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- Johannes Risch
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- CAS
- ITDM
- Vacuum group
- SCS, SPB, HED
- E-plan team
- TS
- … and many more

Summary

- Basic concept of XGM
- Position of XGMs in the tunnels
- Simultaneous 24/7 operation of XGMs
- Quick fixes
- Cross-correlation results

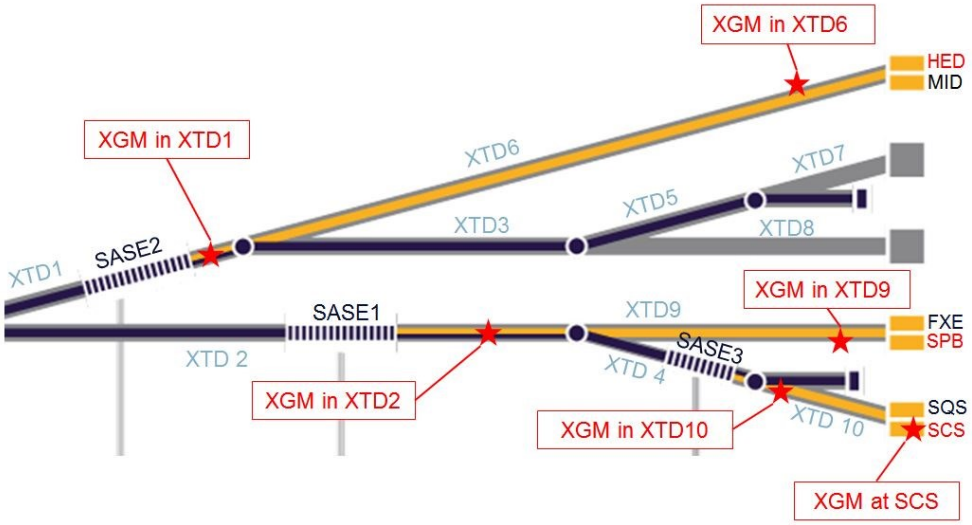
Two new publications soon available:

- A. A. Sorokin JSR 2019 “XGM for FELs”
- Th. Maltezopoulos JSR 2019 “Operation of XGMs at Eu.XFEL”

Thank you for your attention !!!

Change of gas: Xe versus Kr

29.06.2017 - 2 bunches at 0.15 nm



$$\frac{I_{XTD2,Xe}}{I_{XTD9,Xe}} = \frac{I_{XTD2,Xe}}{I_{XTD9,Kr}}$$

… gives same pulse energy ☺

From synchrotron measurements:
< 10% for absolute pulse energy
< 20 μm for absolute beam position

24.11.2017

550 μJ, single bunch mode, at 0.136 nm

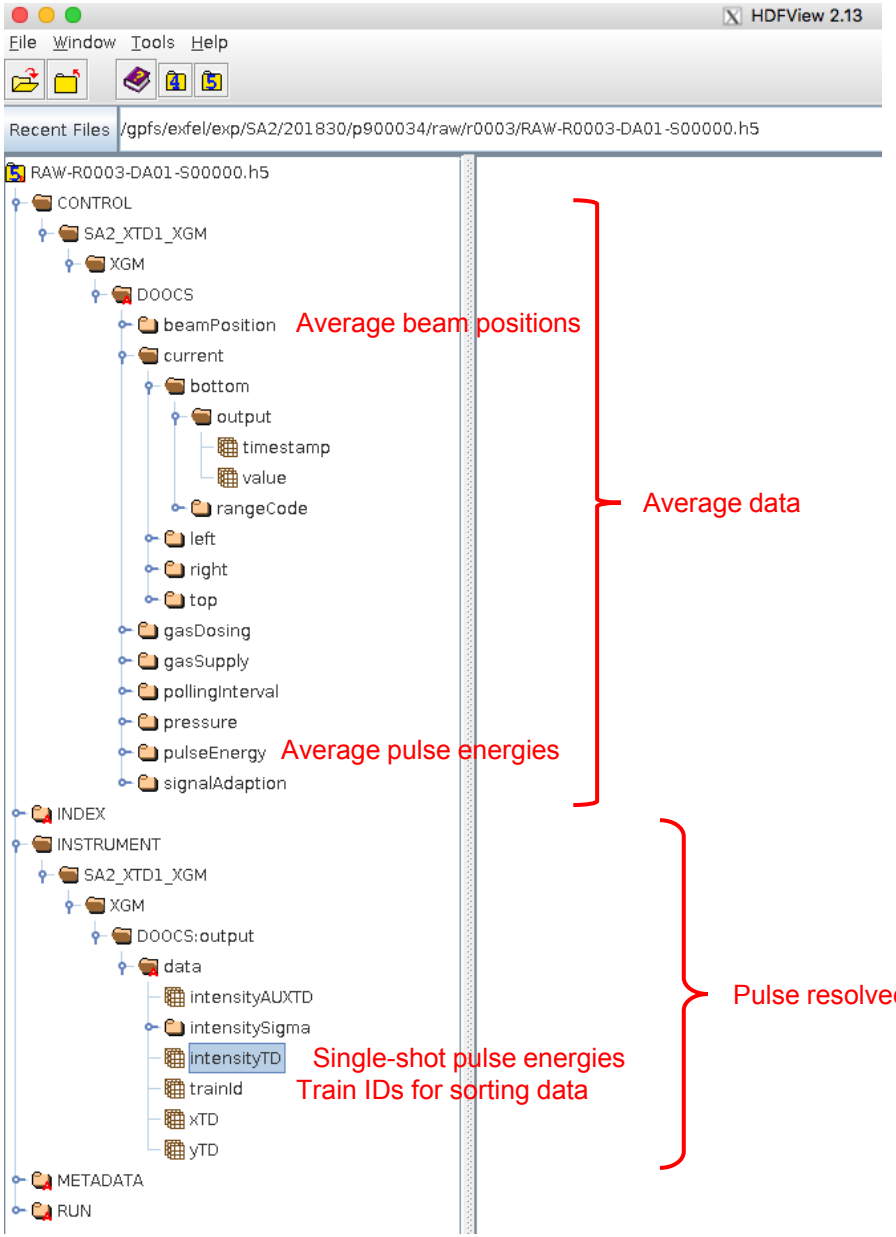
Absolute measurement uncertainty …
… with Xe (XTD2): 39 μJ sigma (7%)
… with Kr (XTD9): 176 μJ sigma (32%)

10.11.2017

350 μJ, 2 bunches, at 0.133 nm

Absolute measurement uncertainty …
… with Xe (XTD2): 20 μJ sigma (6%)
… with Kr (XTD9): 90 μJ sigma (26%)

How to get XGM DAQ data



XGM Karabo scene