

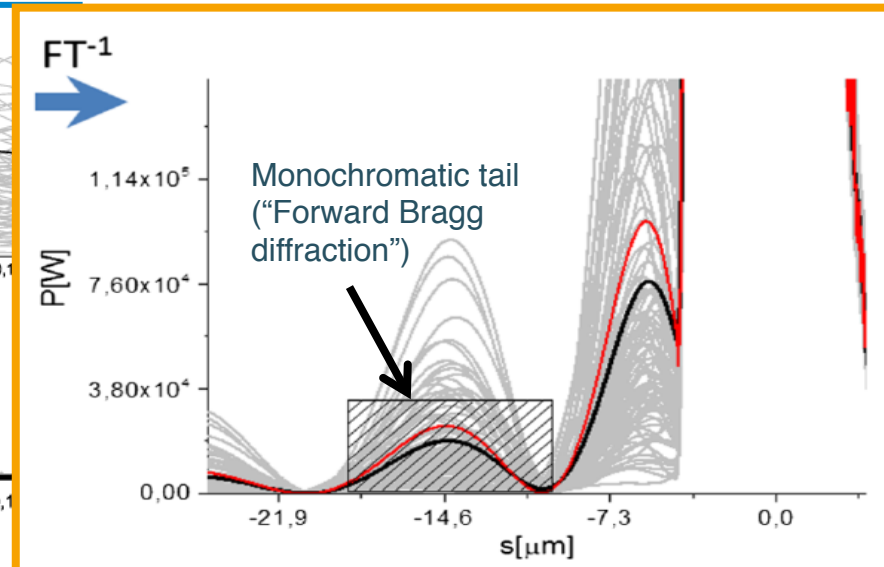
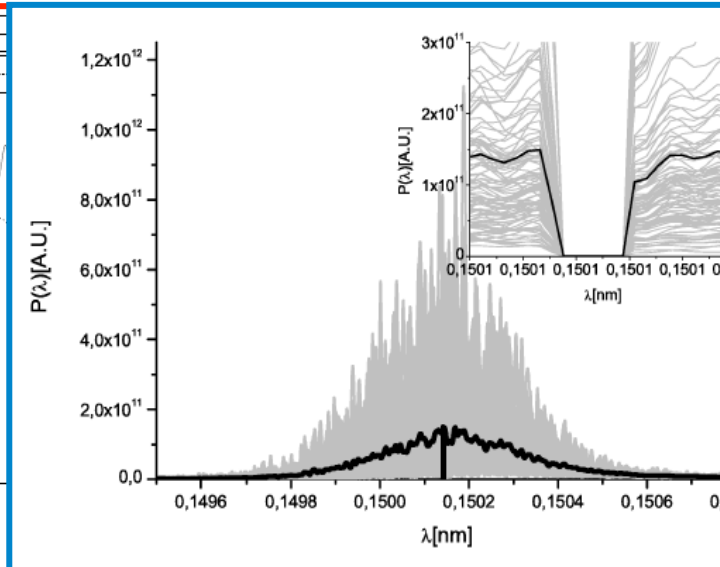
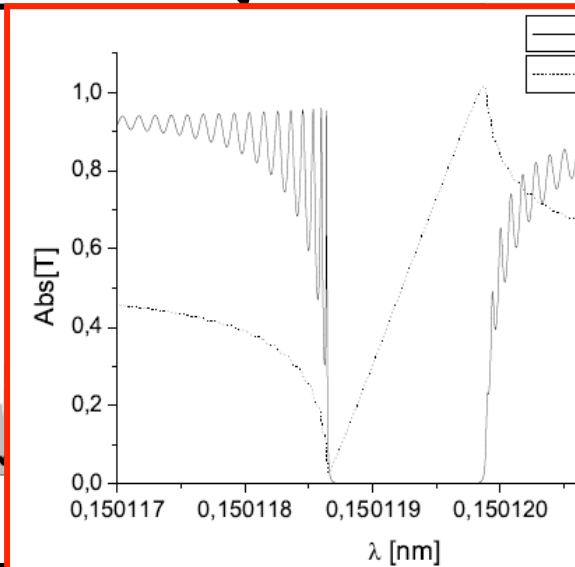
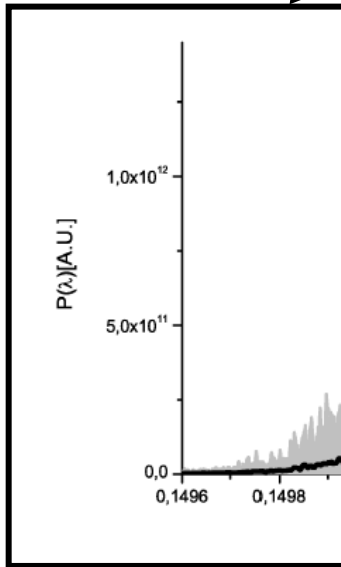
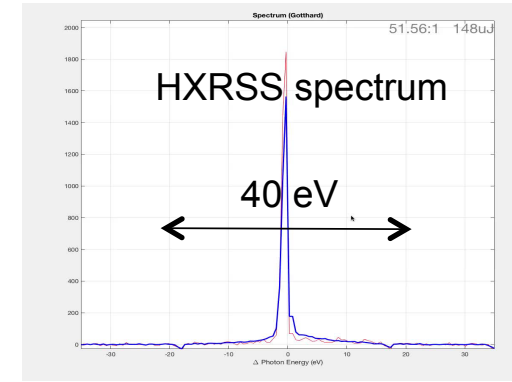
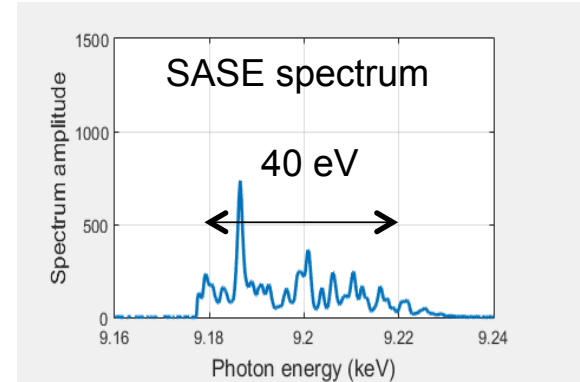
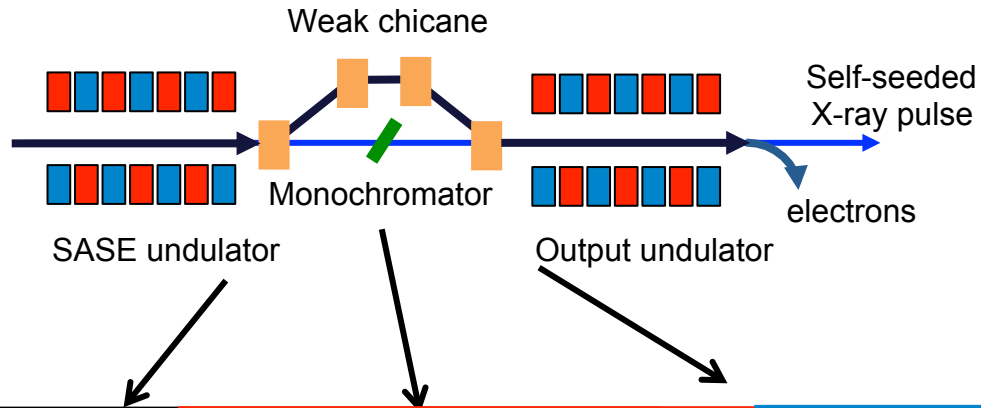
HXRSS user delivery experiences

Shan Liu
on behalf of the HXRSS team

Beam dynamics meeting
Hamburg, 16.11.2021



HXRSS principle



HXRSS and Monochromator panel

https://jddd-xfel.desy.de/jddd/XFEL/SASE/include/SASE2_HXRSS.xml XFEL.FEL//

Hard X-ray Self-seeding

Chicane Server

3 Color Controls

Common Orbit Display

SASE2 Orbit feedback

SASE22 Orbit feedback

SASE23 Orbit feedback

SA22 FB setup

CrystalGUI

MONO1 Control

MONO2 Control

MONO1....

pyHIREX

HIREX

SASE2 Undulator Launch

H CFX.2154.T1	H CEX.2196.T1
+0.0219 mrad	+0.1496 mrad
H CFY.2168.T1	H CNY.2196.T1
-0.0105 mrad	+0.1987 mrad

SASE22 Undulator Launch

H CBS.2248.SA2	H CBS.2251.SA2
+0.0000 mrad	+0.0000 mrad
H CAY.2241.S...	H CAY.2253.SA2
-0.0025 mrad	+0.0018 mrad

SASE23 Undulator Launch

H CBS.2303.SA2	H CBS.2306.SA2
+0.0015 mrad	-0.0025 mrad
H CBY.2300.S...	H CAY.2308.SA2
+0.0002 mrad	+0.0031 mrad

Bragg Angle Calculator

Reflection	1111	
Photon Energy	11.11	keV
Bragg Angle	NaN	deg

BPM I

BPM II

Monochromator Movement Expert Panel

CELL 18

Crystal Holder

Y Axis - Crystal Change

Actual Position: -2.4000 mm

Target Position (mm): -2.4000

Actual Speed: 0.000 mm/s

Speed Override (%): 50.0000

Max Speed: 0.50 mm/s

Status: Busy

Errors: Axis Error, Controller Error, Range Error, Negative Limit Switch, Positive Limit Switch, Homed, Axis Operational

Crystal Insert

Actual Position: 0.000 mm

Target Position (mm): -10.7900

Actual Speed: 0.000 mm/s

Speed Override (%): 80.0000

Max Speed: 0.50 mm/s

Status: Busy

Errors: Axis Error, Controller Error, Range Error, Negative Limit Switch, Positive Limit Switch, Homed, Axis Operational

Axis

Actual Position: 0.000 mm

Target Position (mm): -1.3502

Actual Speed: 0.000 mm/s

Speed Override (%): 33.5000

Max Speed: 0.50 mm/s

Status: Busy

Errors: Axis Error, Controller Error, Range Error, Negative Limit Switch, Positive Limit Switch, Homed, Axis Operational

Axis

Actual Position: 31.000 mm

Target Position (mm): 29.8800

Actual Speed: 0.000 mm/s

Speed Override (%): 100.0000

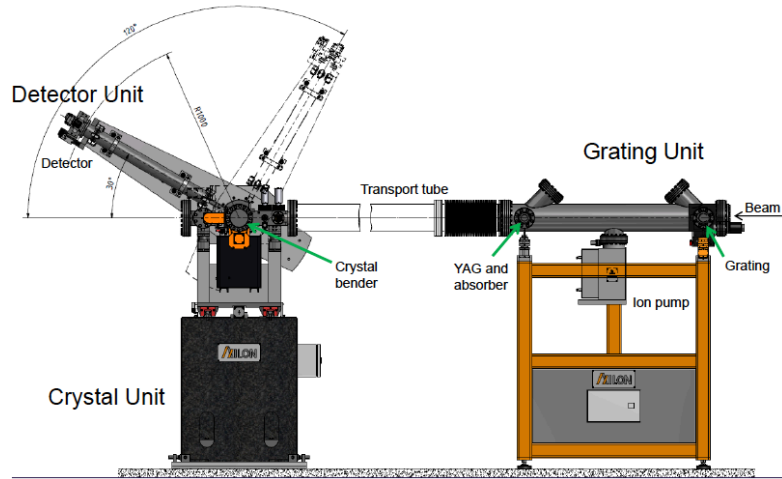
Max Speed: 0.90 mm/s

Status: Busy

Errors: Axis Error, Motor Overheat, Encoder, Range Error, Negative Limit Switch, Positive Limit Switch, Axis Operational

Motor Temperature: 45.6 °C

HIREX* diagnostic spectrometer



- Shot-resolved spectra of pulsed X-ray beams at MHz rates
- Covers hard x-ray range 5 - 20keV
- High resolving power of up to 40,000 (resolution 0.2 eV at 8 keV)
- Energy calibration by changing crystal pitch
- Gotthard detector signal processing (especially for multi bunches) will be improved by upgrading to Gotthard-II)

J. Grünert et al., JSR 26 (5), 1422 (2019)

* HIREX = High RESolution hard X-ray

SA2_HIREX_MAIN HIREX2_Location=350m(fromSource)

2D_Detector_Bragg MDL_Cal_spectrum 0 Hz
 ON Acquire Stop

Gotthard_Detector (Gotthard Should not exceed 3000)
 Gain lowgain lowgain
 ACQUIRING Start Stop Pulse resolve intensity

Expert-Panel C-Temp 27.200001
 Spectrum Gotthard

Motor_encoder
 CUx 90.49775
 CUy 170.49475
 Cx 95.01735
 CRx 35.099865
 DRx 64.495679
 Dx 282.99125

HIREX Filter's Out OUT

Self-seeding Studies USE ONLY SA2_XTD1_SOLIDATT
 Step1: INSERT ALL CVD +1mm of SOLID ATT (before starting)
 SOLIDATT
 Step2: Selected Photon energy (push the button)

ON	ON	CrystalSelection	9keV_C110
0.2eV/px	7.5keV_HXSS_C220	0.2eV/px	9keV_HXSS_Si440
0.25eV/px	8keV_HXSS_C220		
0.38eV/px	10keV_HXSS_C220		
0.3eV/px	12.9keV_HXSS_C440		
0.4eV/px	15keV_HXSS_C440		
1eV/px	15keV_HXSS_C220		

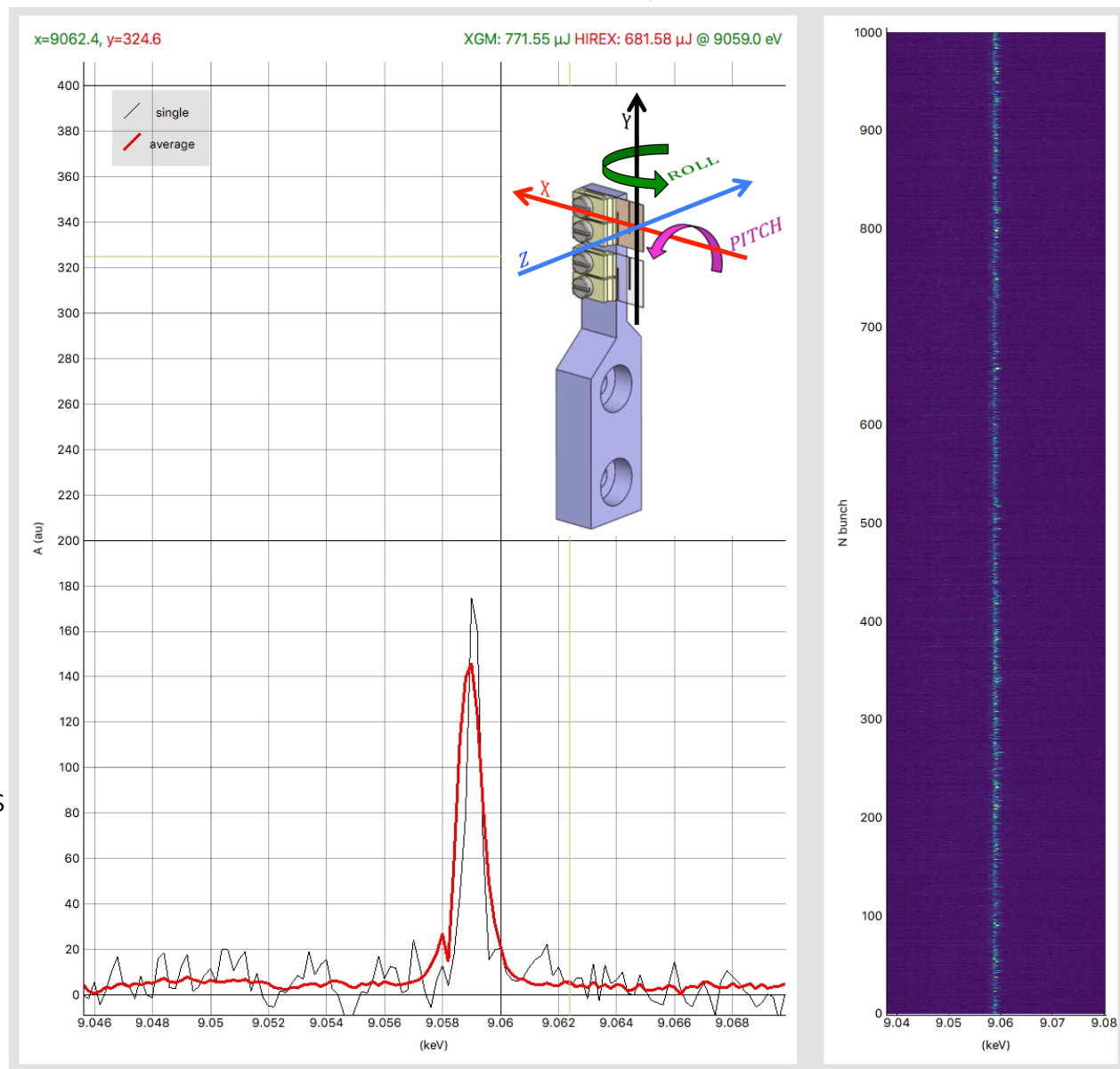
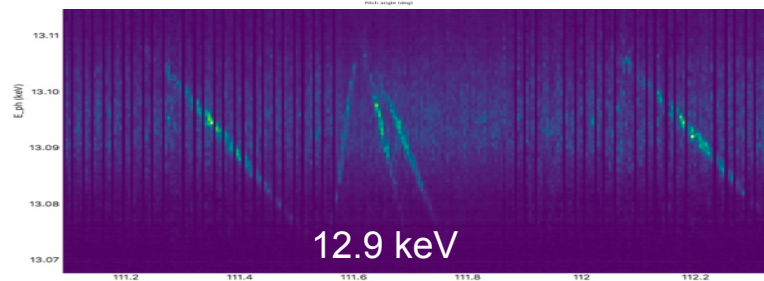
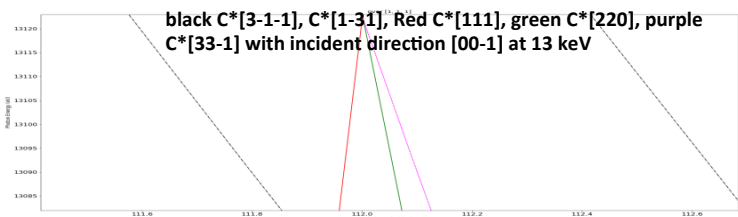
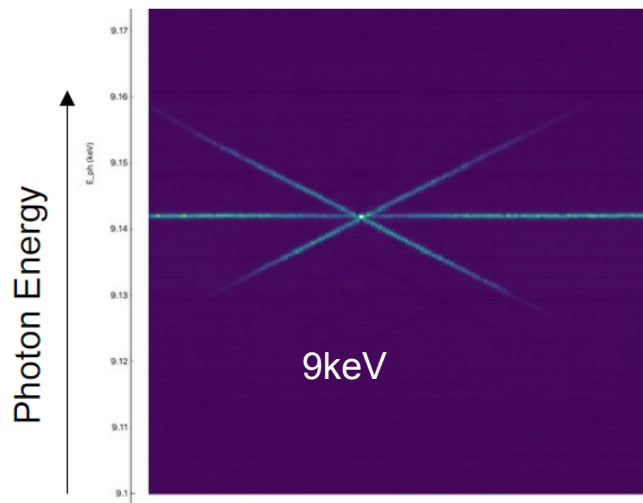
Single mode only

Developed by Naresh Kujala

Crystal calibration

Developed by S. Tomin, S. Serkez et al.

- Py-Hirex development (correlator 1D and 2D)
- One application: easier crystal calibration
- Had only preliminary calibration
- Tool used for a number of purposes



Energy Calibration Tool

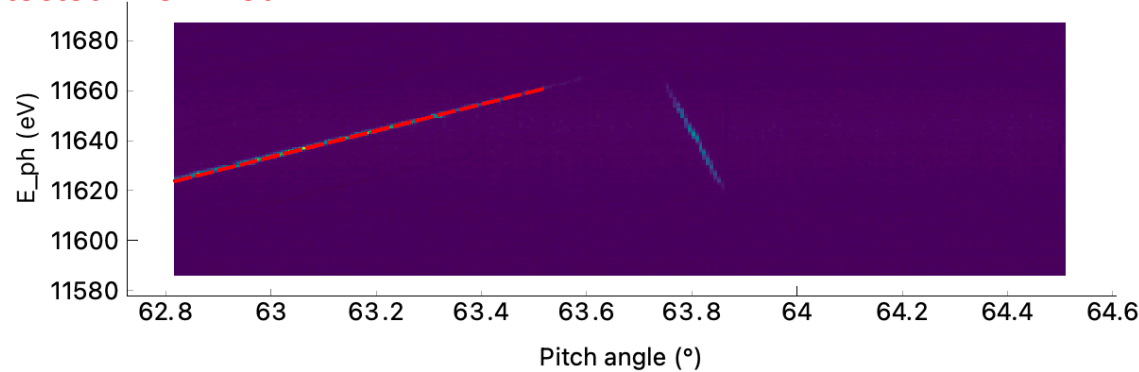
Developed by Christian Grech

Calculator

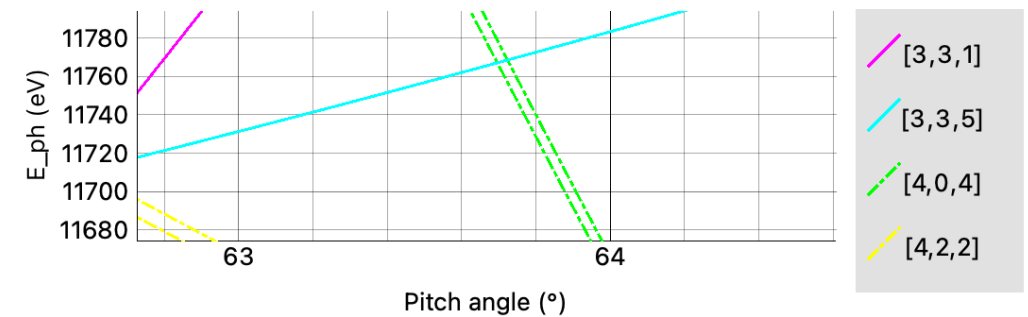
Measurement

Model

2. Detected line in red



5. Display of the model in the scanned area



3. ML classifier predicts that this line is [3, 3, 5]

1. Input image information

Calculate from file

File name:

Roll angle:

Monochromator 2 image found;
Machine status file found: roll angle=1.2677 deg

Logs

Image binarization complete
1 line(s) found
Id:[3,3,5] matched to line with centroid: 63.2 deg

	Parameter	Current value	Proposed val
1	[3,3,5] Eoff	-	97.5 eV
2	[3,3,5]ev/px	0.597	0.57
3	Avg.ev/px	-	0.57
4	Avg.Eoff	-	97.5 eV
5	Eo	11647.0 eV	11744.0 eV

6. Save info in DOOCS/ logbook

4. Calculated offset (Avg.Eoff), pixel calibration (Avg.ev/px) and new Central Energy (Eo).

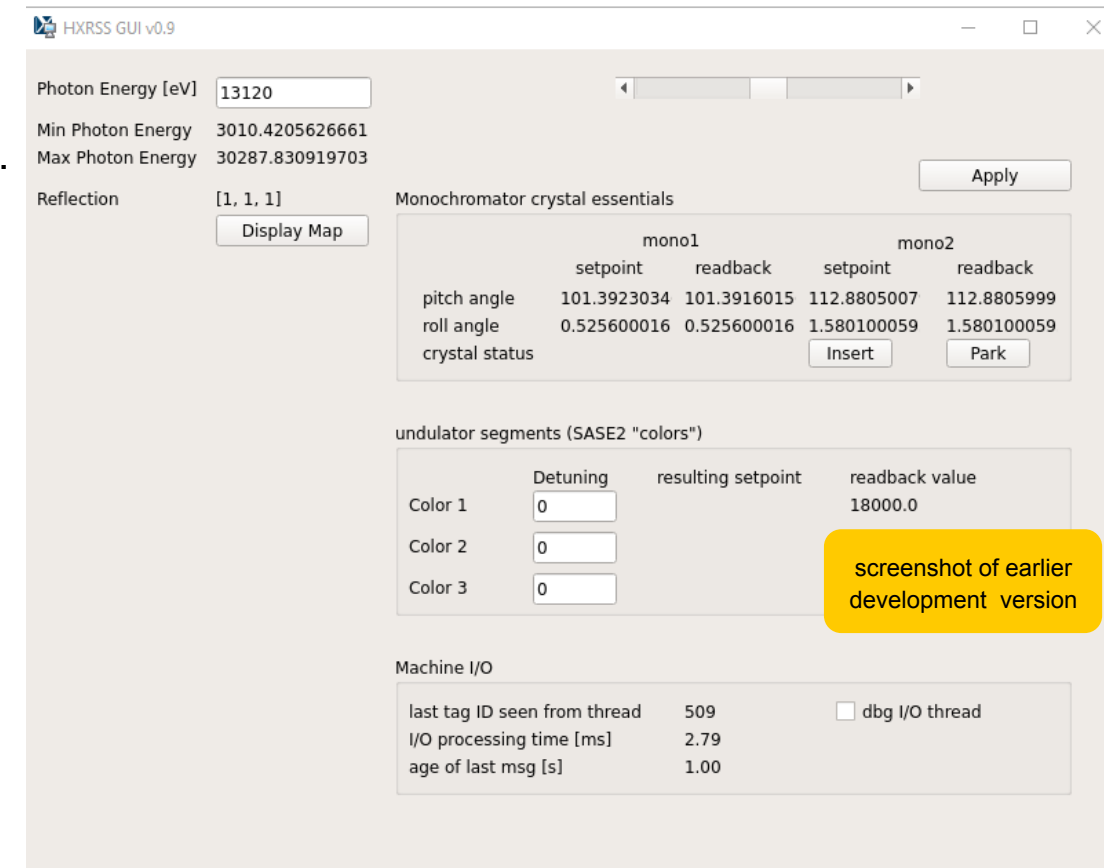
Software for HXRSS Crystal Control

- Challenges during HXRSS operation
 - Significant wavelength shifts require simultaneous adjustments of multiple devices: crystal motors, undulators, ...
 - Take into account imperfections of the system, for instance: corrections of setpoints due to imperfect crystal mounting

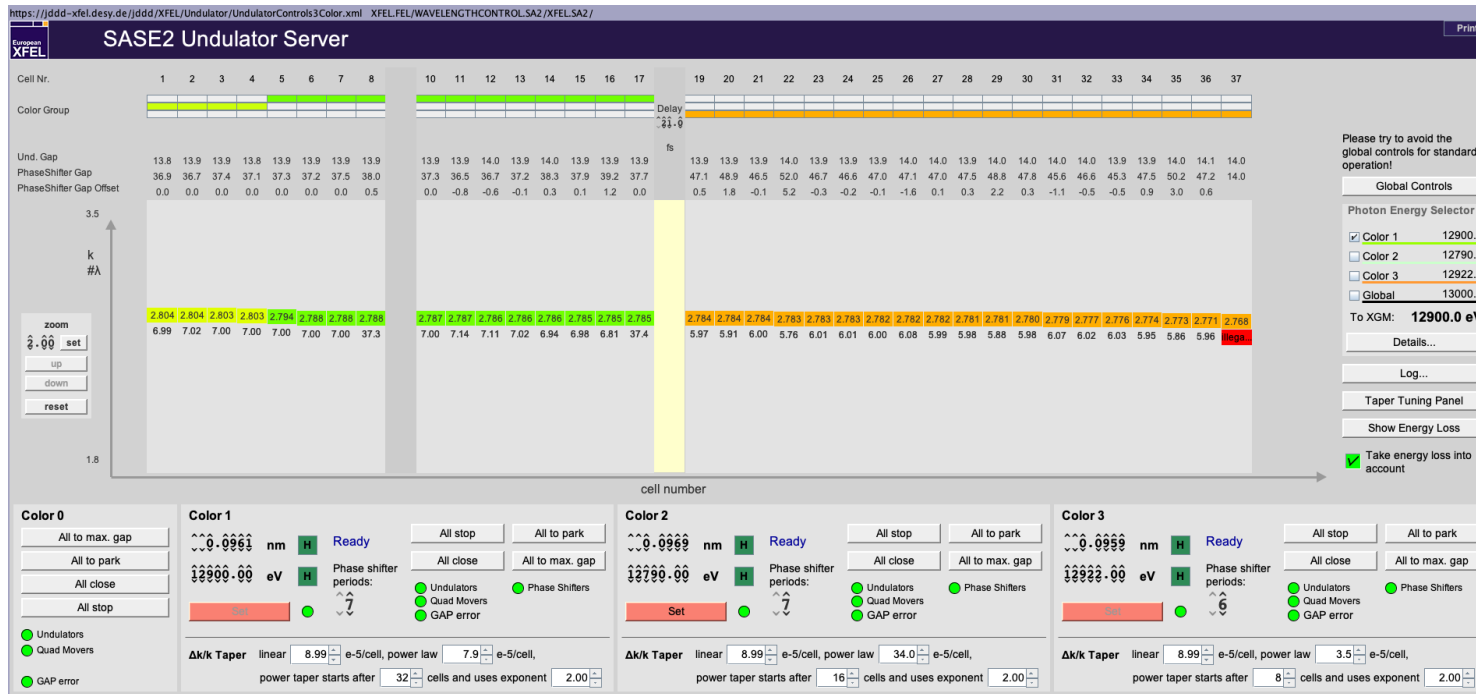
- Tool for HXRSS (crystal) operation is being developed
 - Key task: Translate desired photon energy into crystal orientation, following curve of desired crystal reflection
 - Apply correction parameters as determined by Christian Grech's analysis tool

- Ultimate goal: Produce tool for HXRSS routine operation
 - Implement features such as undulator gap control

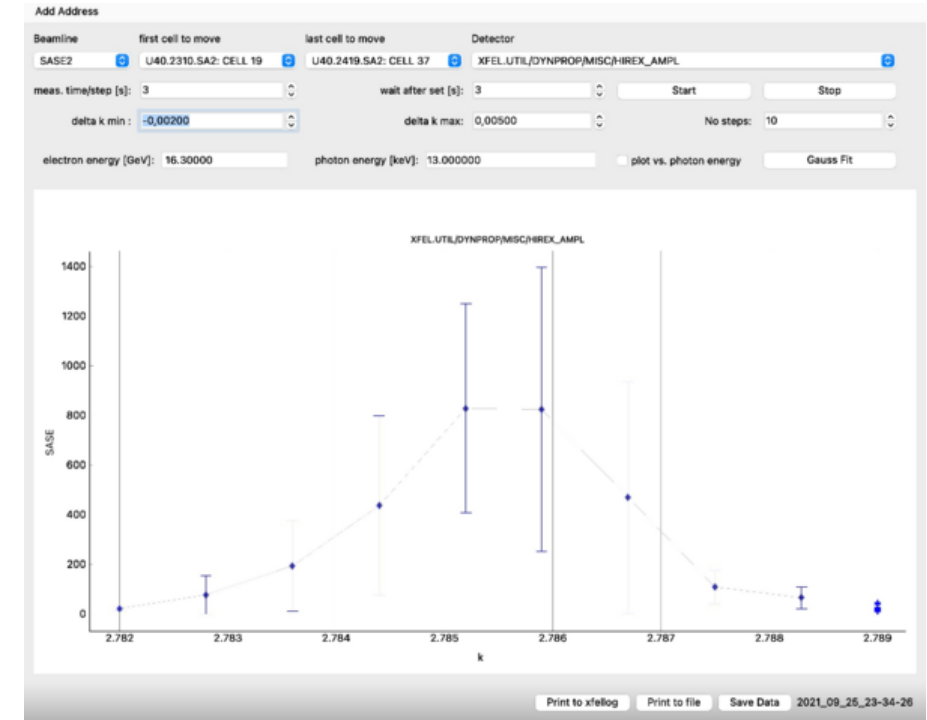
Development in progress by Christoph Lechner



Undulator panel and detune scan tool



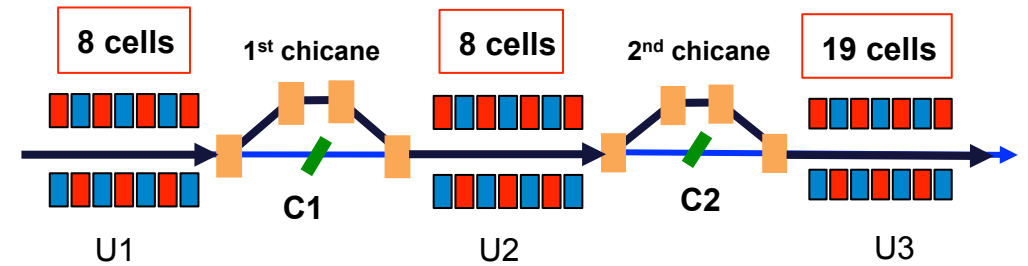
Developed by Olaf Hensler



Developed by Frank Brinker

HXRSS- User Runs in 2021

- 4 user runs in Sept.-Nov. with different photon energies
- Set-up time depends highly on the orbit



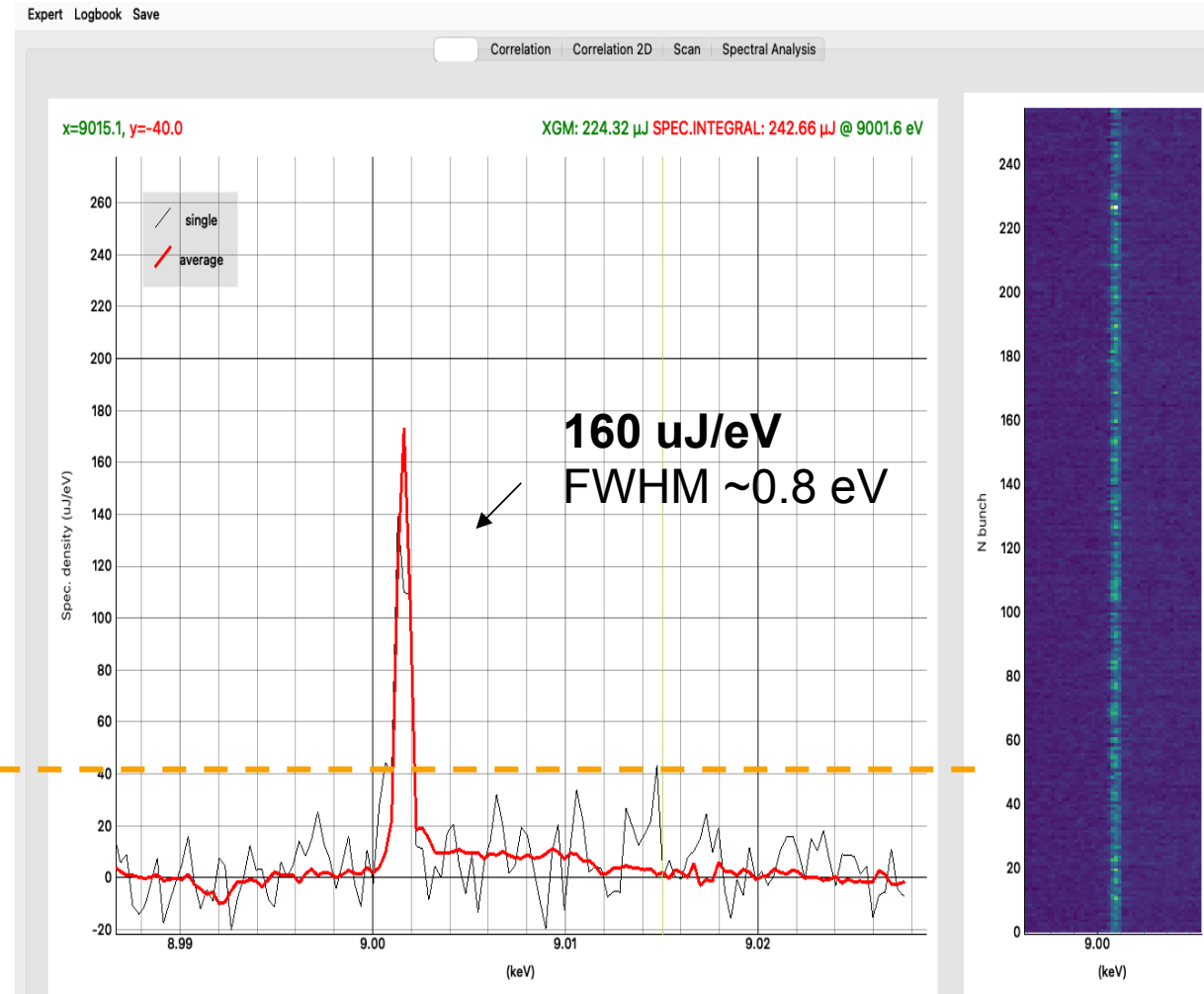
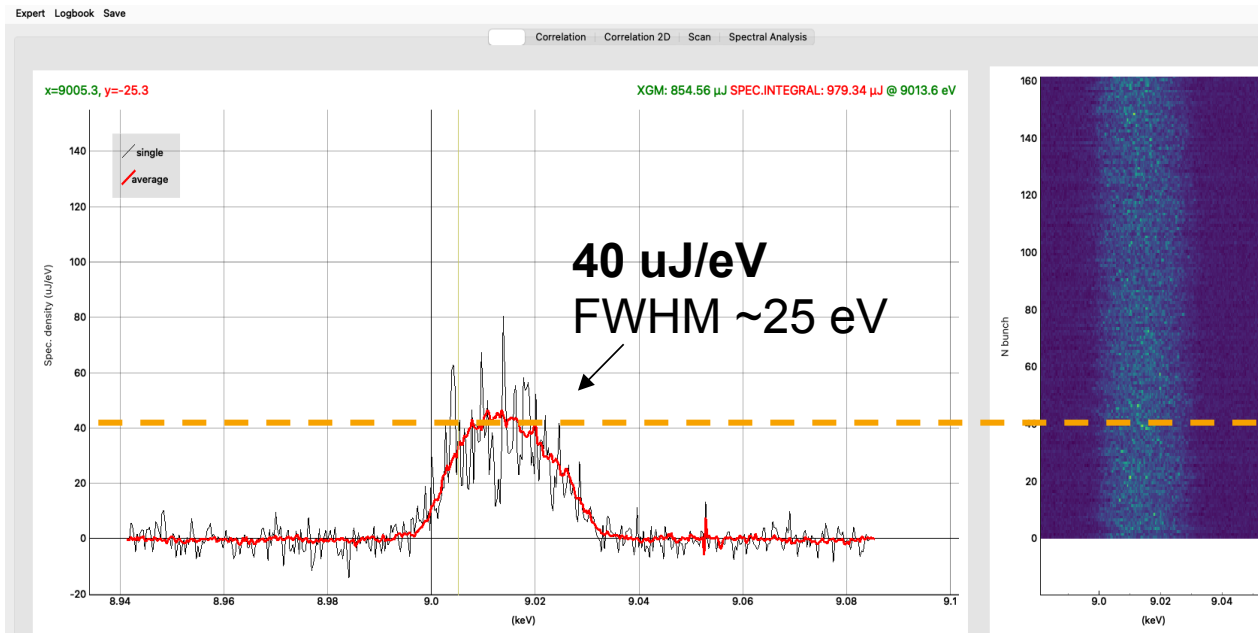
before BBA
(only 10 cells downstream 2nd chicane contribute)

after BBA
(18 cells downstream 2nd chicane contribute)

	7.5 keV (KW37, HED)	9 keV (KW36, MID)	11.5 keV (KW44, MID)	12.9 keV (KW40, HED)	18 keV (KW45, tested not delivered)
e- beam energy	11.5 GeV	11.5 GeV	16.5 GeV	16.5 GeV	16.5 GeV
SASE performance	1.5 mJ (140 uJ/eV)	1 mJ (40 uJ/eV)	2 mJ (60 uJ/eV)	2 mJ (100 uJ/eV)	1 mJ (60 uJ/eV)
Seeding with 2 nd chicane	-	250 uJ (160 uJ/eV)	700 uJ (300 uJ BG, up to 400 uJ/eV)	300-500 uJ (800 uJ/eV)	uJ level
Seeding with two chicanes	200 uJ (250 uJ/eV)	-	-	-	-
Seeding bandwidth (FWHM)	~0.6 eV	~0.8 eV	~0.7 eV	~0.6 eV	-

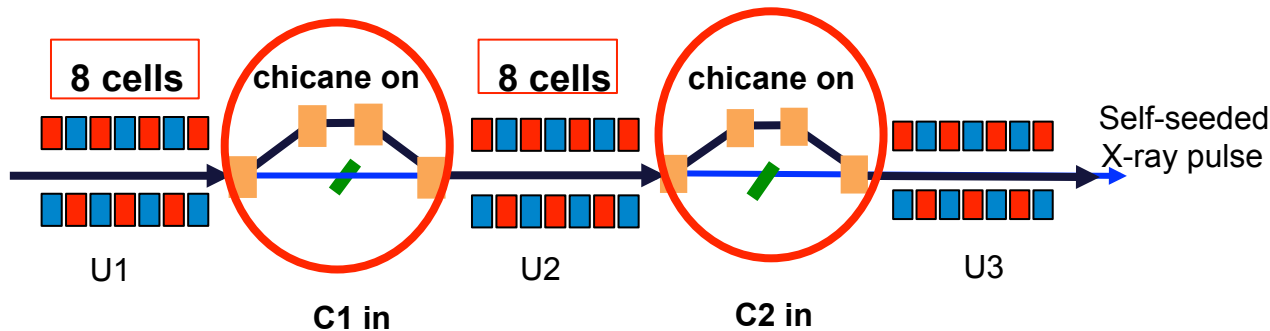
First user run at 9 keV

- 11.5 GeV, 250 pC e- beam @9 keV with 2.2 MHz
- Up to 1 mJ **SASE** with **40 uJ/eV** peak signal
- Up to 250 uJ **seeded** with up to **160 uJ/eV**
- Difficult to have cell 29+ lasing

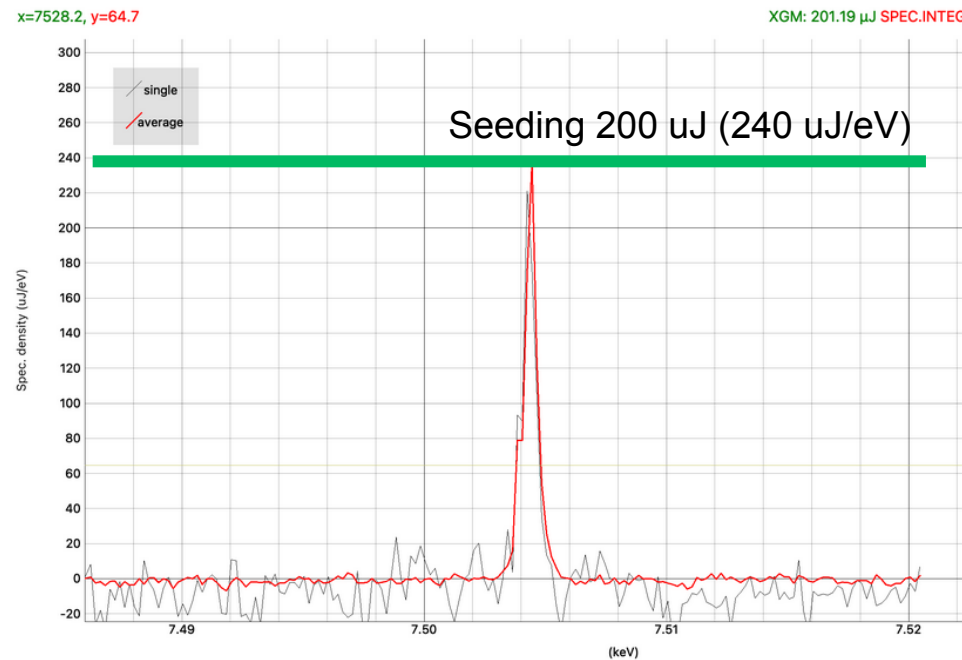
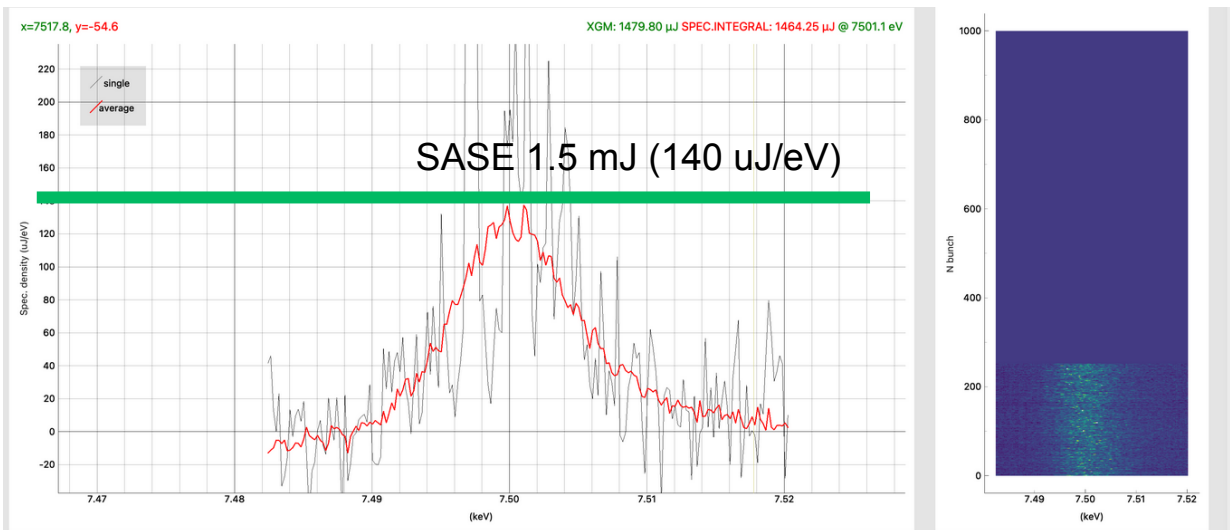


7.5 keV

- Went down in steps from 9keV
- Only up to cell 26-27 contributing with SASE
- Went to C1+C2 during the night (while seeding with C2 already) → much cleaner

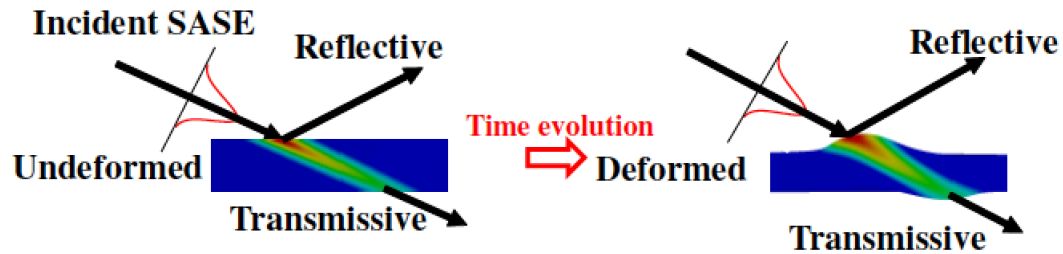


Cryo problem... back to seeding on Thu Sept 16th



By Friday 17th early morning delivery to HED

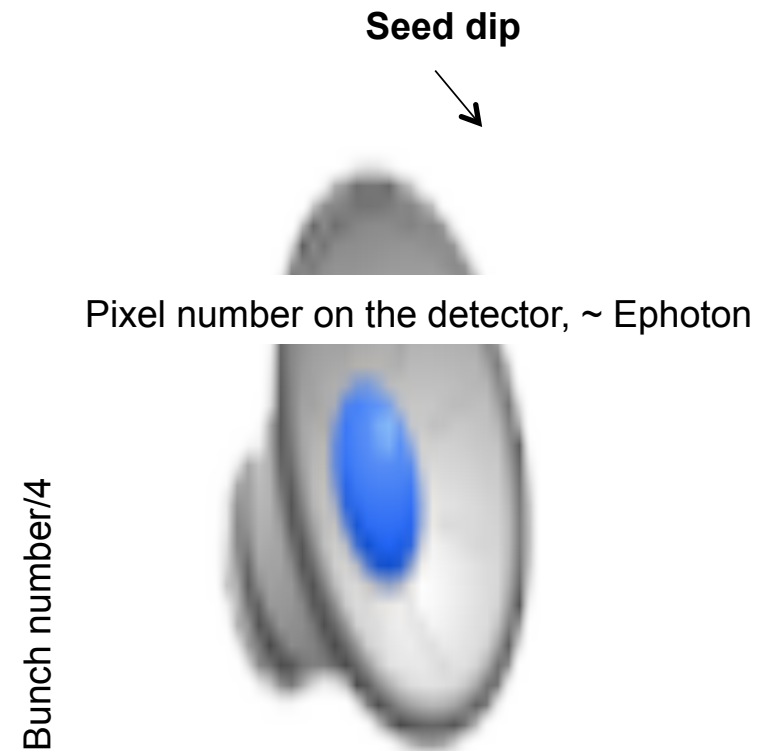
Heat load study at 7.5 keV



Qu, Zhengxian, et al., *NIMA* 969 (2020): 163936.

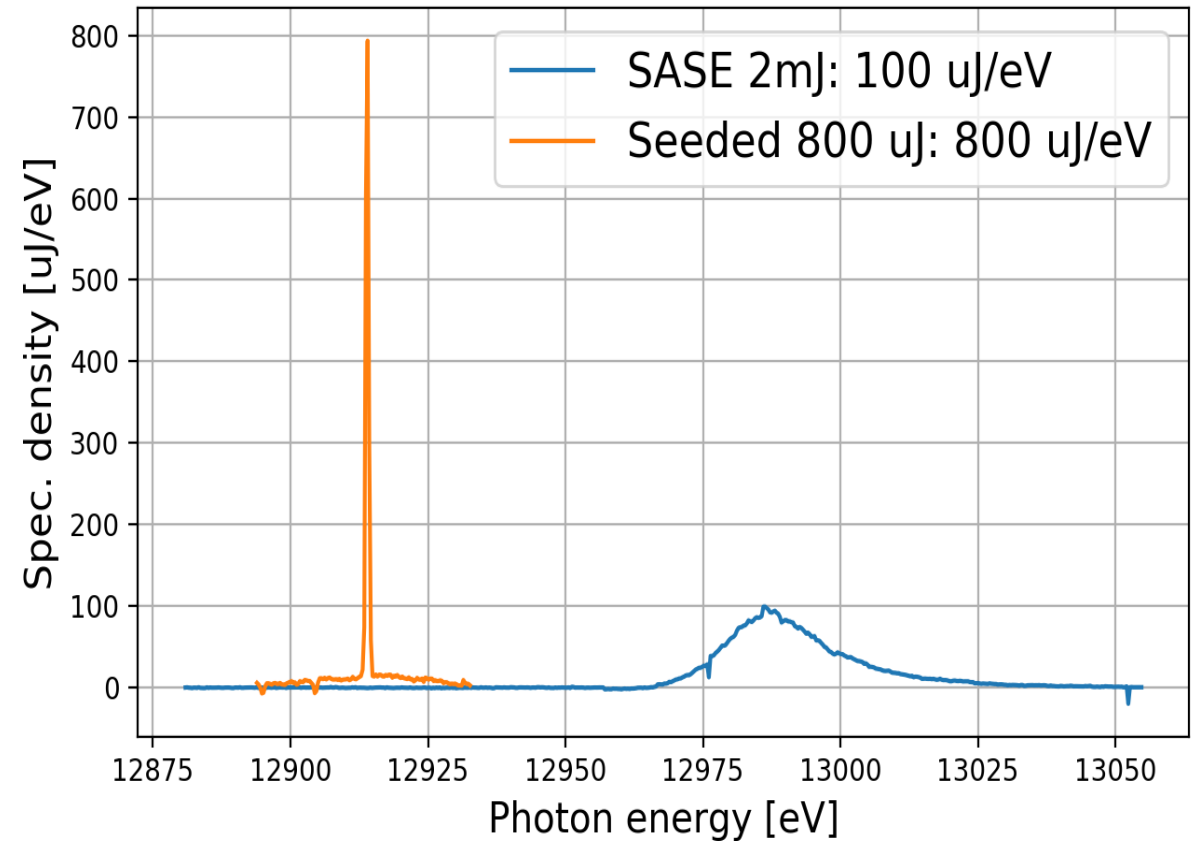
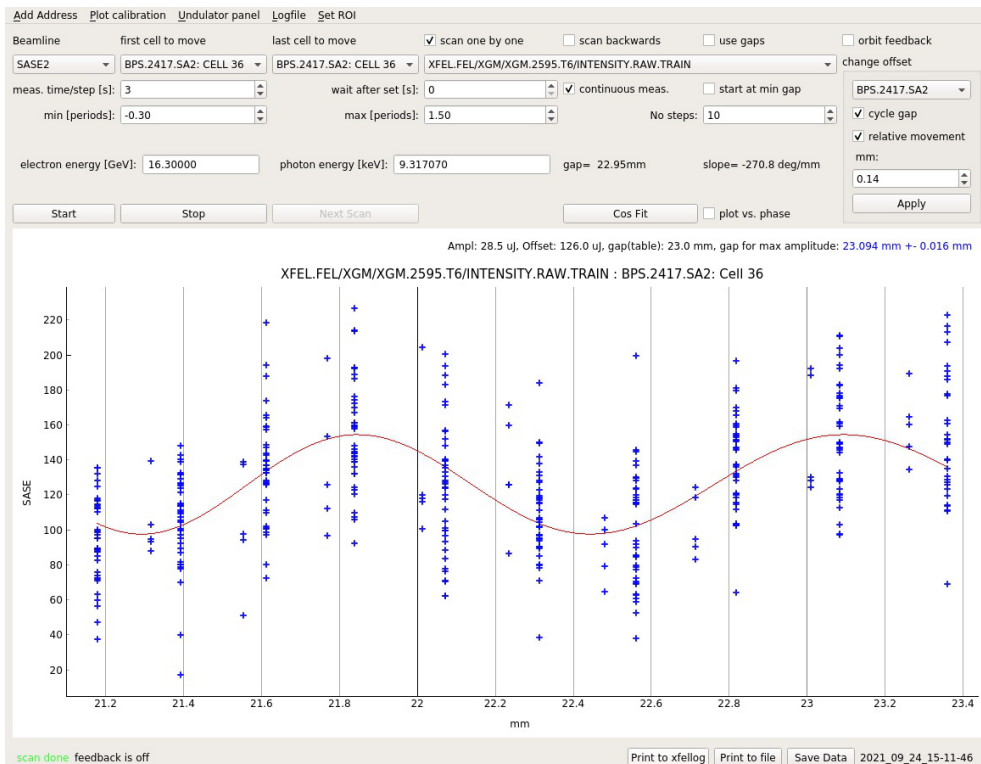
- Observed seeding wavelength shift (slope) along the bunch train for high impinging power (~40 uJ)
- Expect to have larger effect with lower photon energy
- 2 chicanes can help to reduce heat load -> data to be analyzed

2.2 MHz, 400 bunches

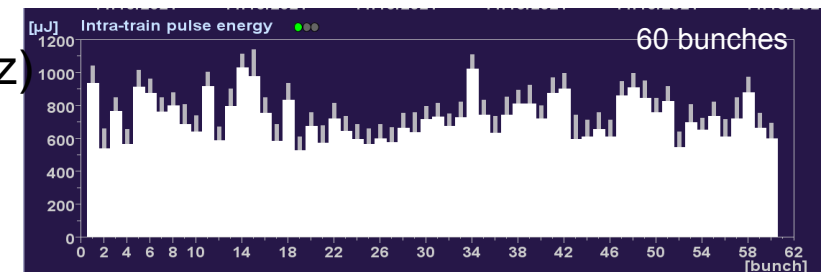


12.9 keV

After BBA (all cells contribute well)

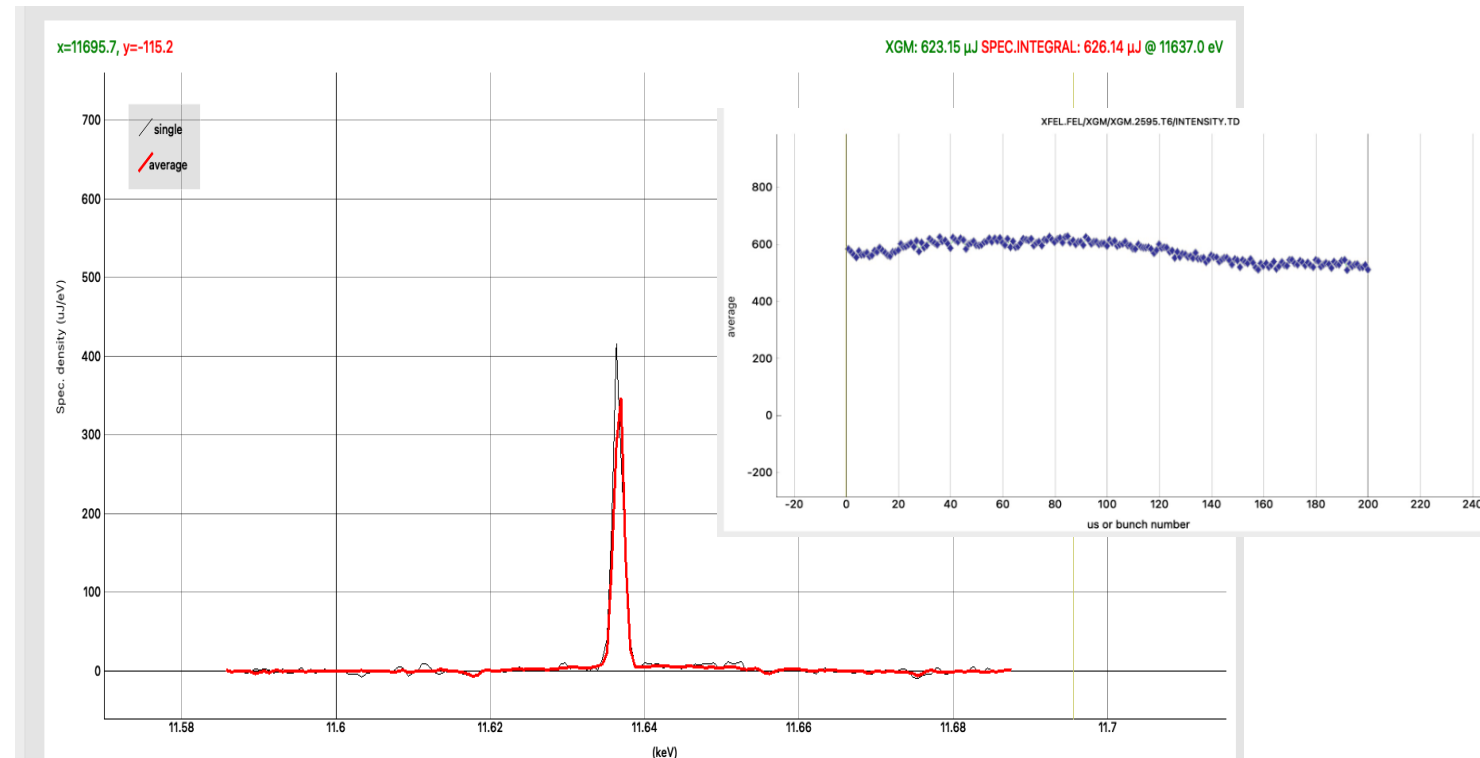
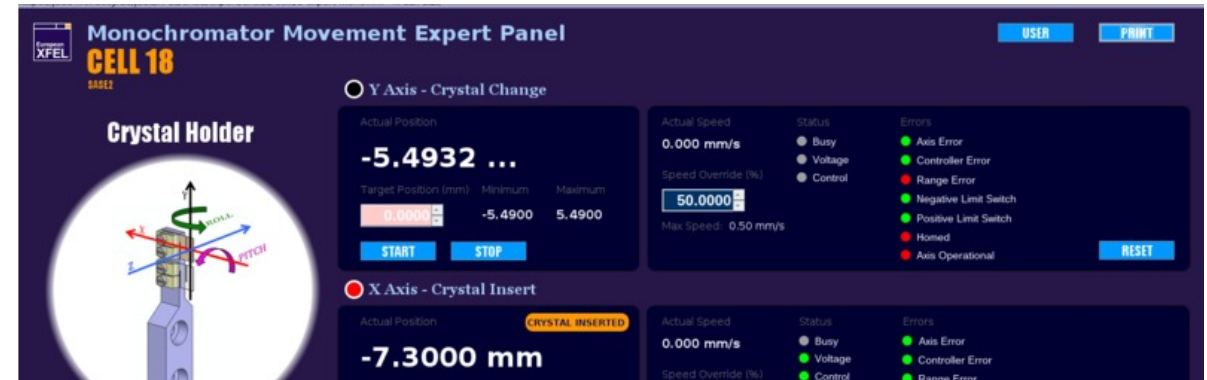


Delivery with high repetition rate (2.2 MHz) and multi-bunches



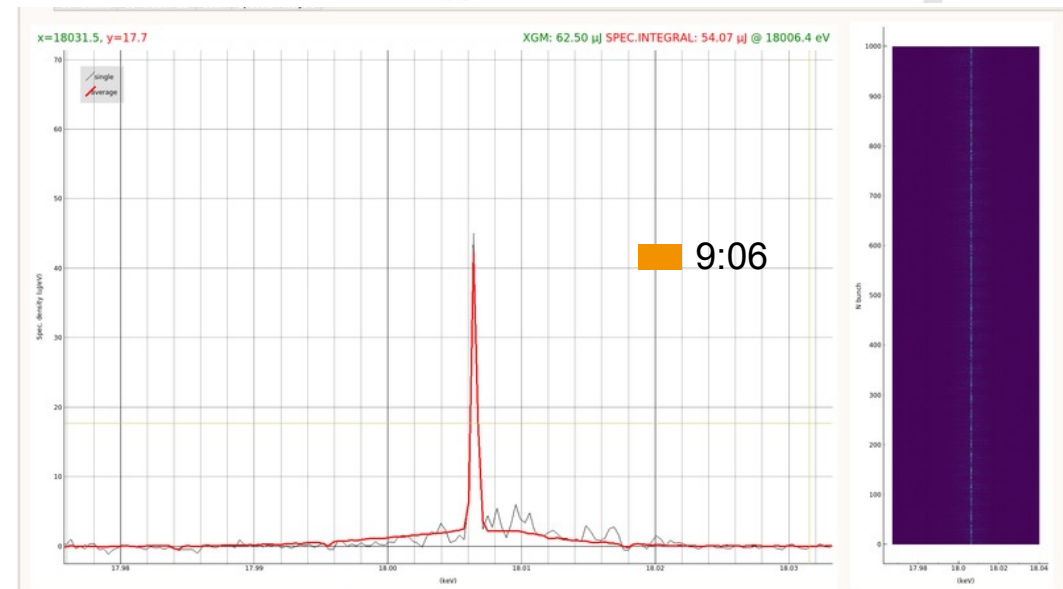
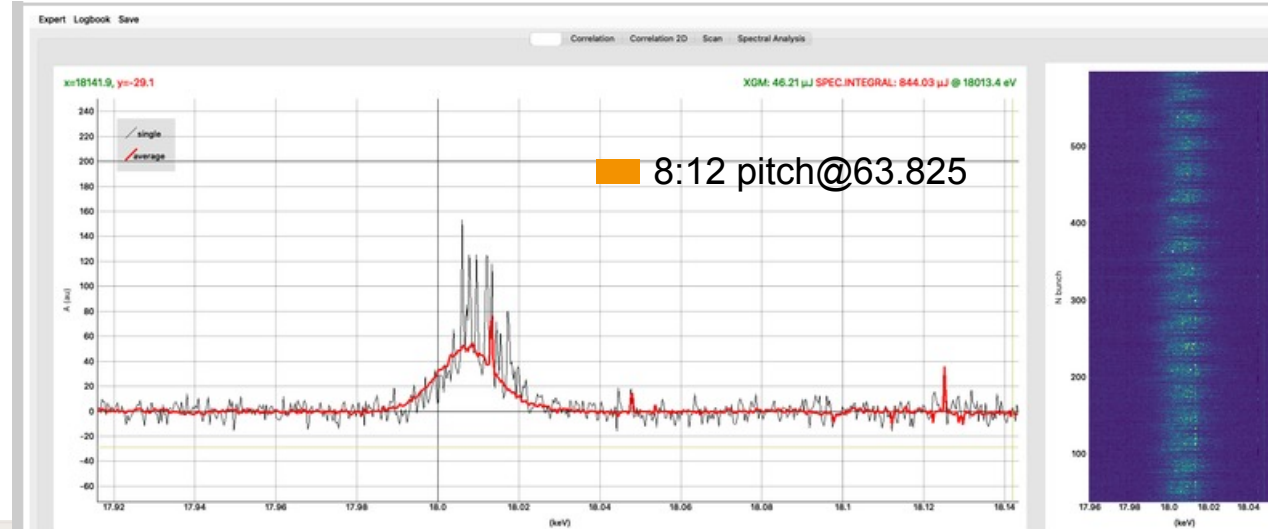
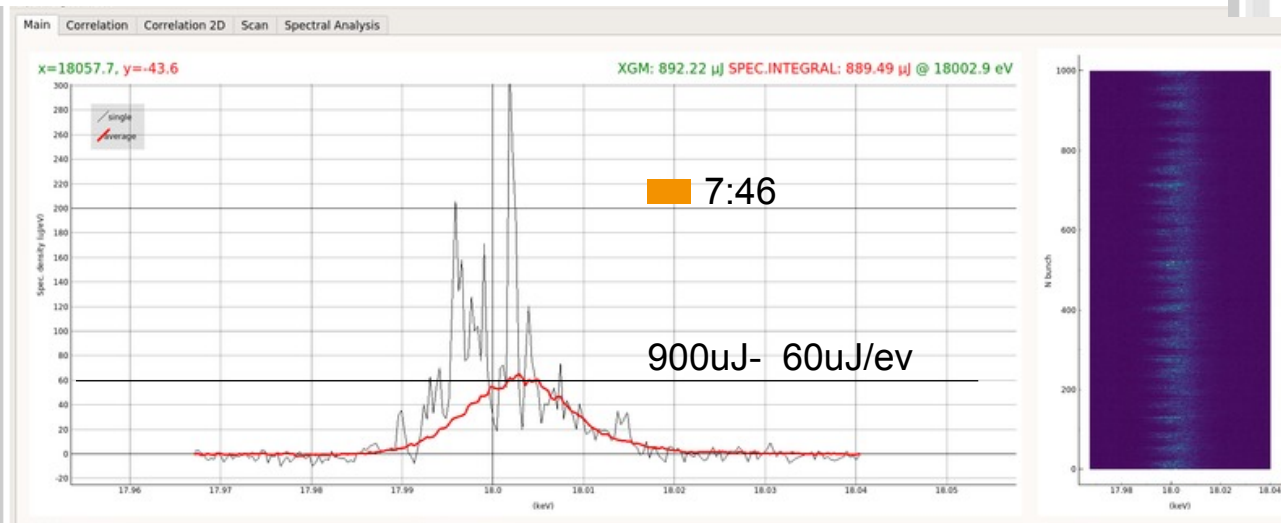
11.5 keV

- The piezo stage encoder "Crystal Change (Y-axis)" has got damaged. The main assumption is due to the radiation damage. Could find a solution to manually center the crystal to the beam.
- Seeding found quickly and optimized up to 400 uJ/eV comparing with 60 uJ/eV SASE (2mJ) in 2 shifts.
- User delivery with 200 bunches at 2.2 MHz, 640 uJ with 300 uJ background.



18 keV

- Easily found seeded signal and could optimize to several uJ level with good contrast on HIREX



DOOCS channels: SASE2, Bunch Number: 1, Transmission override: 1.0000000

Calibration: ev/px: 0.35, Central Energy [eV]: 18000.00, Central pixel [Px1]: 444, Show Fit Func: , Estimate Px1:

Display control: Px first: 350, Px last: -720, Average over N bunches: 200, Cross-calibration with XGM: uJ/eV scale

Display: Sigma Av [eV]: 0.21, TextLabel: TextLabel

Background control: Take Background: , subtract background: , Show Background: , Hide Average:

Misc: Logbook: Logbook with data: Open Logger: DOOCS: Send Data: Control:

Plan for next year

- Transfer set-up procedure to operators and minimize set-up time
- 4 user requests for the 1st half of year
- User interests also at lower photon energy (6.457 keV)
- Try 2nd harmonic at 7.5 and 9 keV
- Advanced operation schemes (two color, fresh slice seeding etc.)

Confluence Spaces People Create ... Search

Bunch Compression Setup Procedure

Change the call forwarding of the RC mobile phone

Communication between cryo-operation and XFEL BKR team

Pages / XFEL Operations / Procedures for EuXFEL

HXRSS set-up procedure

	9 keV (KW10)	14.4 keV (KW20)	8.9 keV (KW 22)	9 keV (KW24)
e- beam energy	11.5 GeV	16.3 GeV	16.3 GeV	16.3 GeV

Draft European XFEL Operation Schedule 2022		X-ray delivery	4176
Version 25.06.2021	Winni Decking	X-ray set-up	288
		Development	864
		Access, set-up, tuning	1872
		Scheduled Down	1248
		IL test	312

2022	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Jan	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon
Feb	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon			
Mar	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu
Apr	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	
May	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun		
Jun	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	

Roles and responsibilities

Role	Responsibility
Run coordinators	Plan for HXRSS shifts and schedules

Thank you!

Special thanks to the HXRSS set-up team!!!