

Update on Self-Seeding Studies

Shan Liu
on behalf of the HXRSS commissioning team

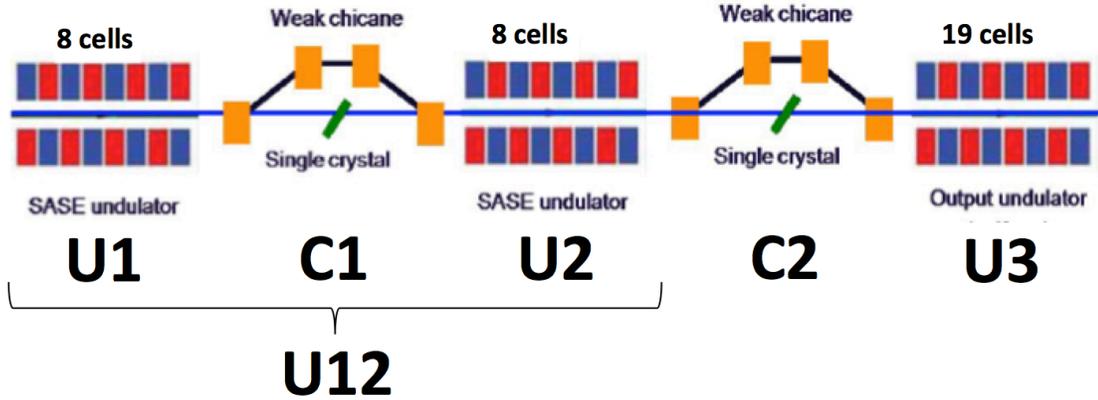
Beam dynamics meeting
Hamburg, 07.08.20



HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

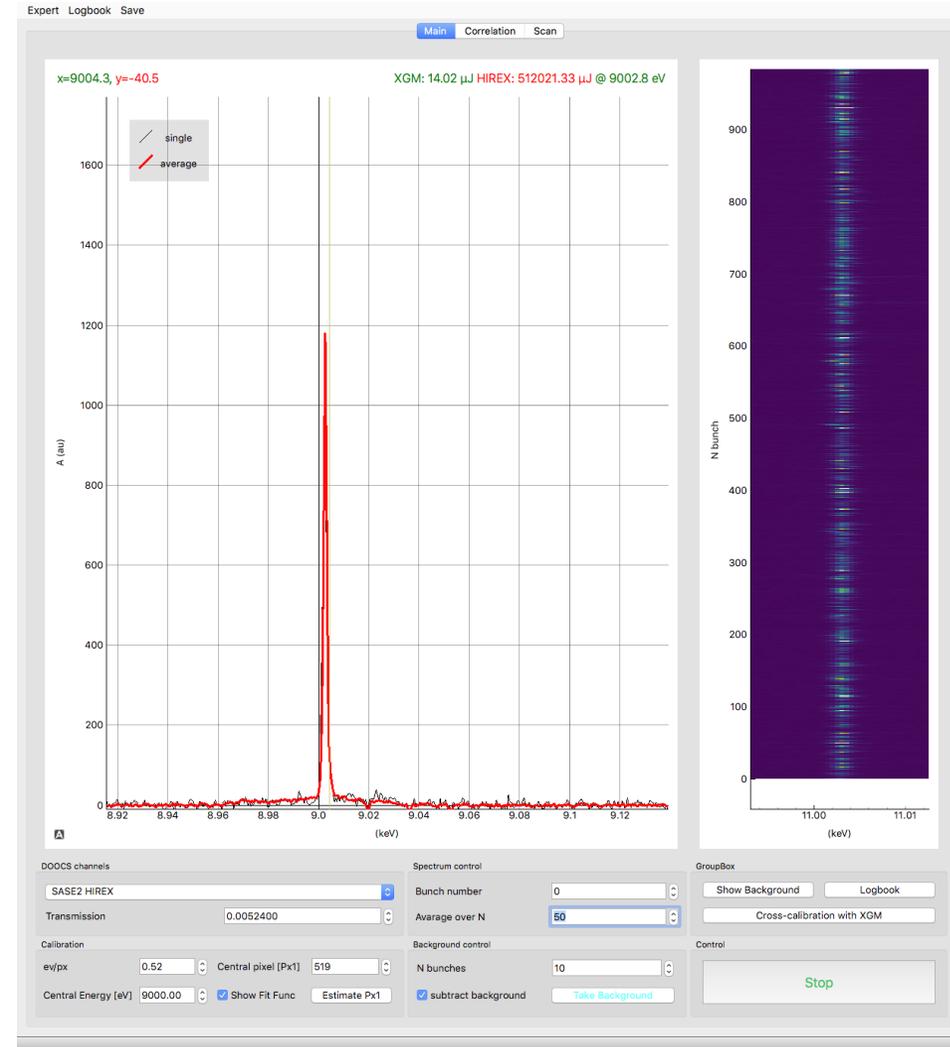


Seeding with 2 chicanes



HXRSS01		HXRSS02	
Energy	14000.00 MeV <input type="checkbox"/>	Energy	14000.00 MeV <input type="checkbox"/>
Angle	± 0.148 deg <input type="checkbox"/>	Angle	± 0.148 deg <input type="checkbox"/>
Angle	± 2.576 mrad <input type="checkbox"/> (Design: 0.00 mrad)	Angle	± 2.576 mrad <input type="checkbox"/> (Design: 0.00 mrad)
R ₅₆	± 18.952 um <input type="checkbox"/>	R ₅₆	± 18.952 um <input type="checkbox"/>
h _{BC}	± 3.957 mm <input type="checkbox"/>	h _{BC}	± 3.957 mm <input type="checkbox"/>
dt	± 34.000 fs <input type="checkbox"/>	dt	± 34.000 fs <input type="checkbox"/>
Gen. field	± 0.3711 T <input type="checkbox"/>	Gen. field	± 0.3711 T <input type="checkbox"/>

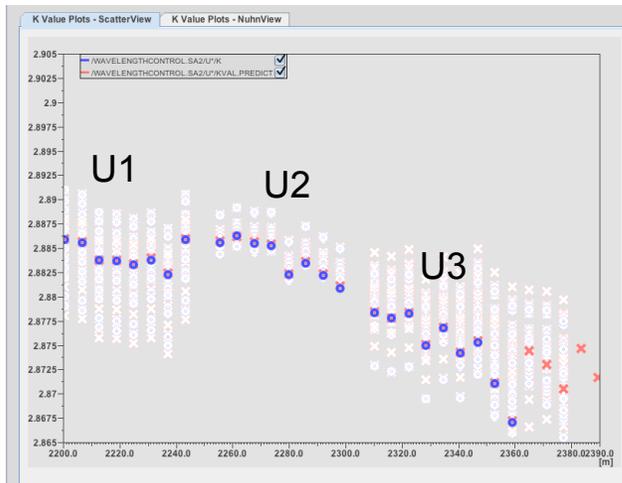
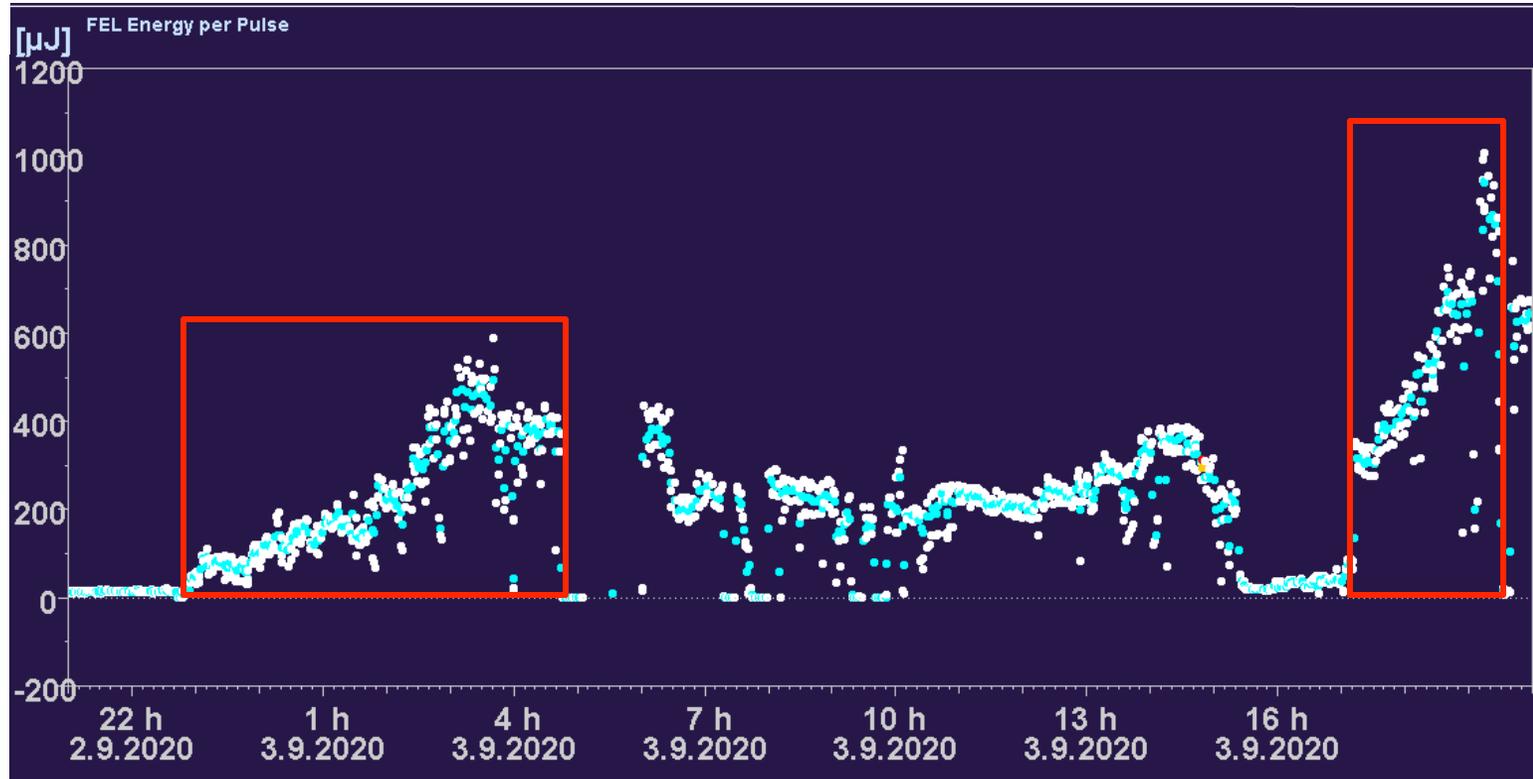
Optimized orbit in the first cells in U1



Seeding with 1st chicane

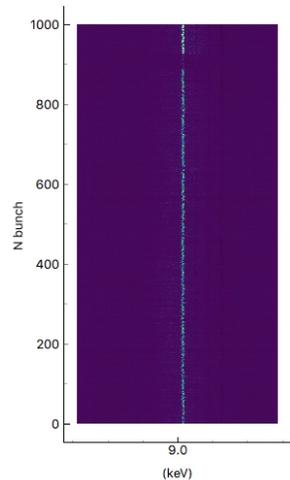
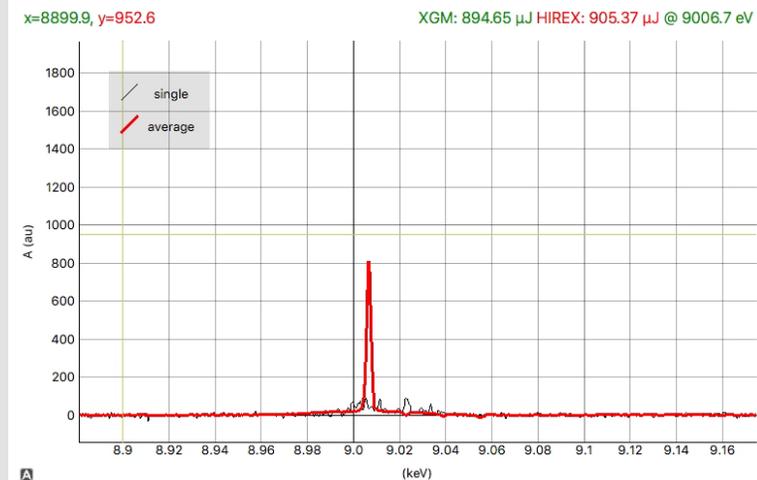
Day 1

- Removed 2nd crystal and try seeding with 1st chicane
- Got 60 uJ after **phase shifter** scan for cell 18 and 19
- Optimized **detune** for U2 and U3 separately, 70 uJ
- Quad. taper** in U3, 80 uJ, closed up to cell 27 ~100 uJ
- Launch optimization** with seeded signal, up to 180 uJ
- Phase shifter** scan (cells 24 now contributing)-> 200 uJ
- Change **detune** of U3 and linear taper for U2
- Adjusted **quad. taper** for U3 -> up to 250 uJ!
- Air coil, taper** -> 400-500 uJ



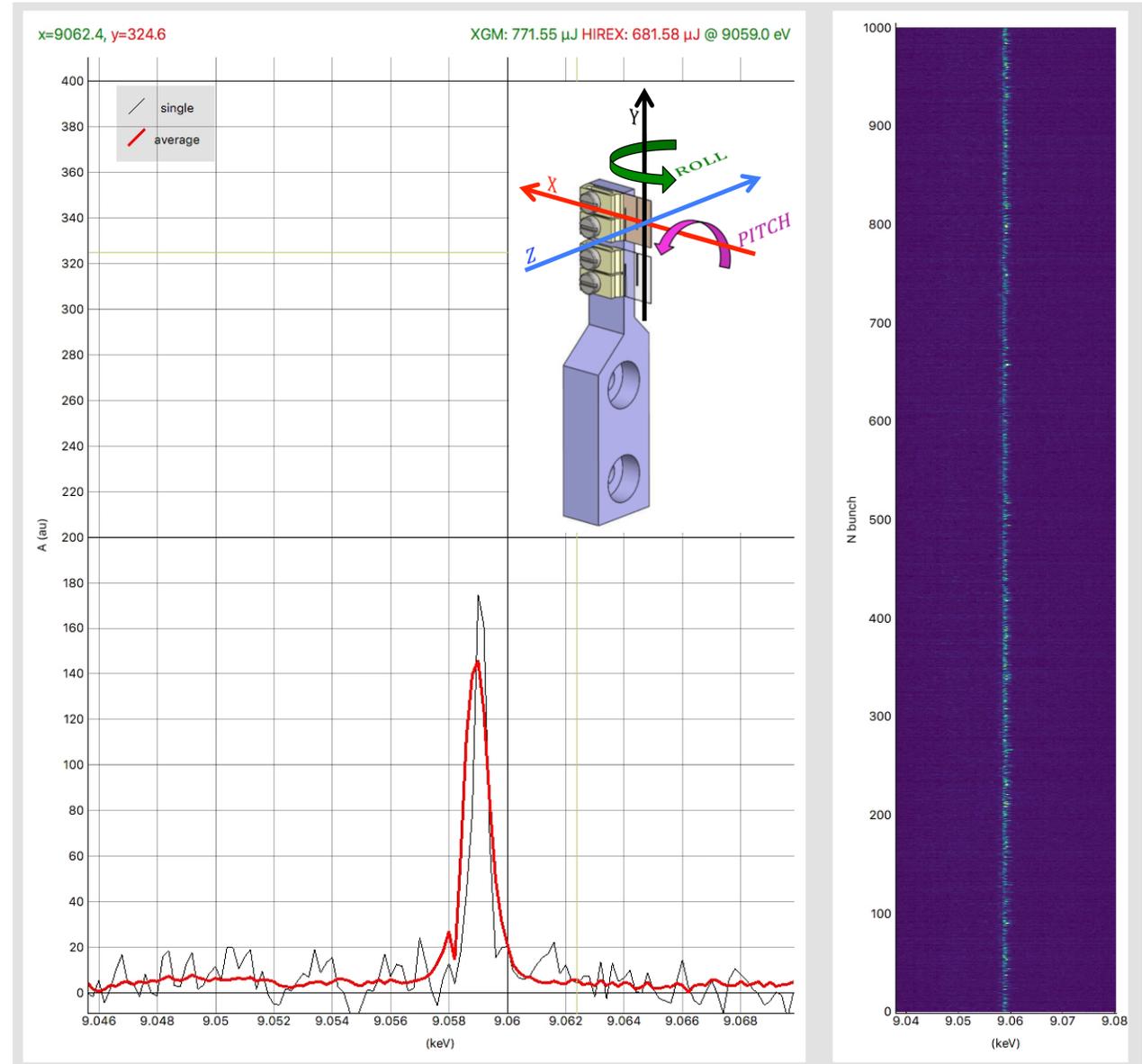
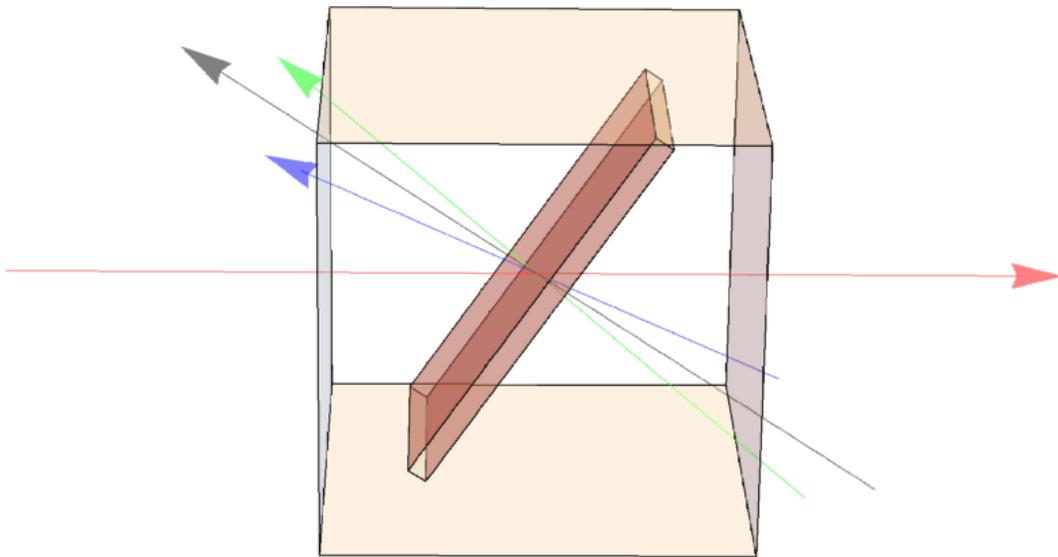
Day 2

- Added more cells
- Air coil, phase shifter, taper optimization
- Changed delay from 35 fs to 27 fs
- Up to 900 uJ achieved!



Crystal calibration

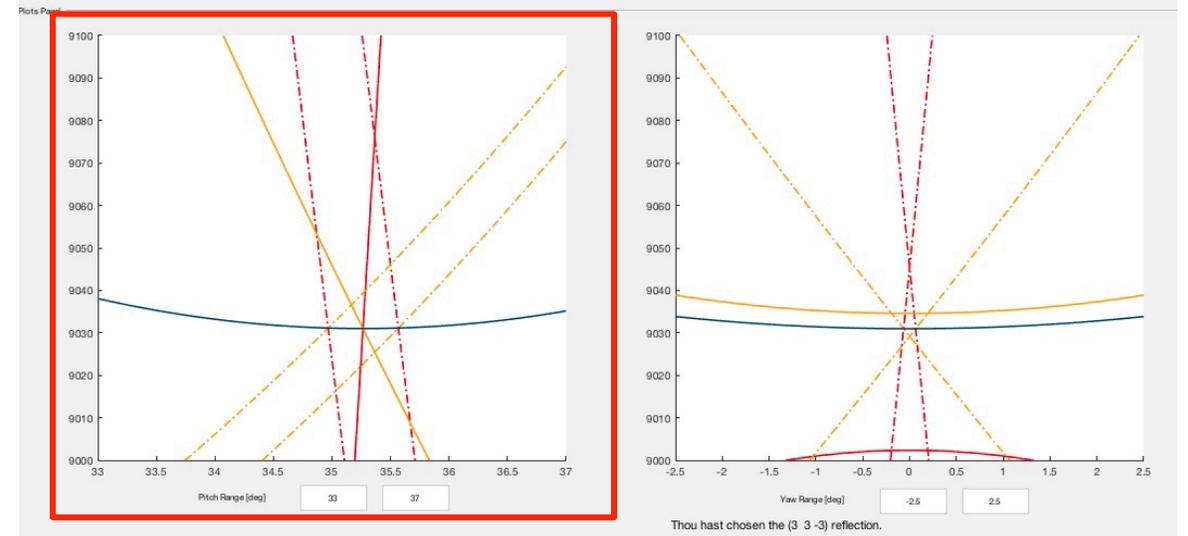
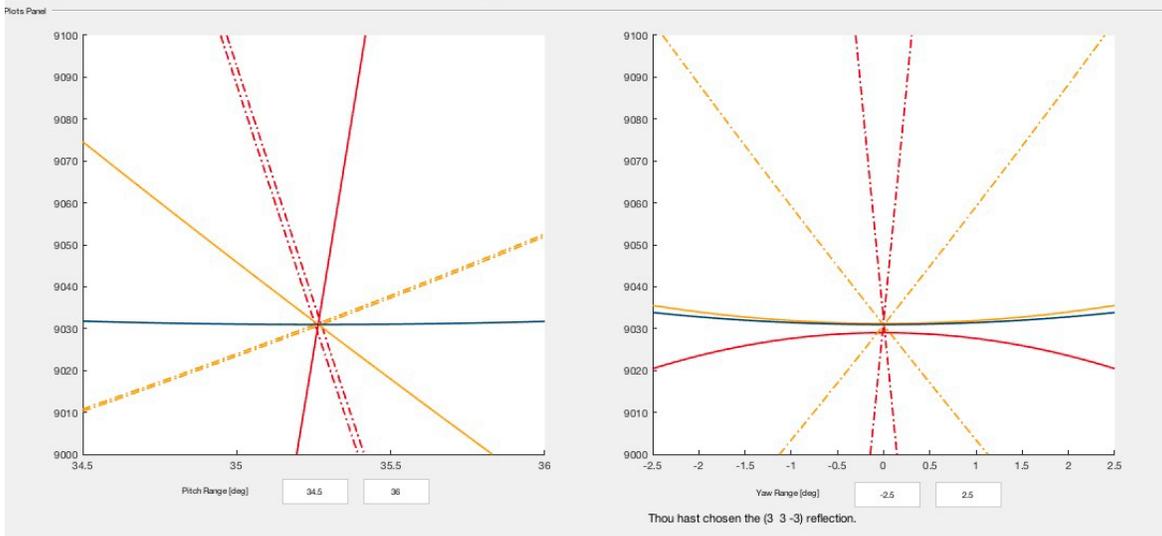
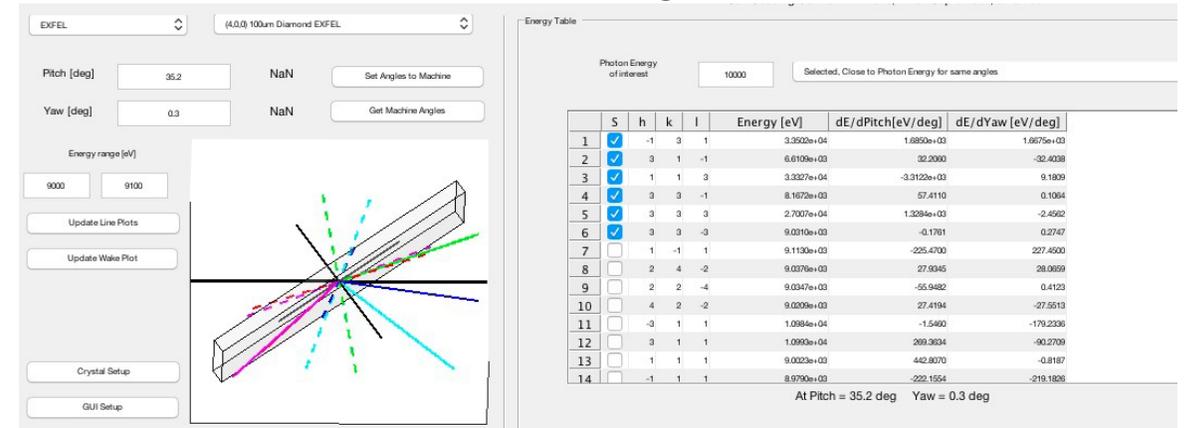
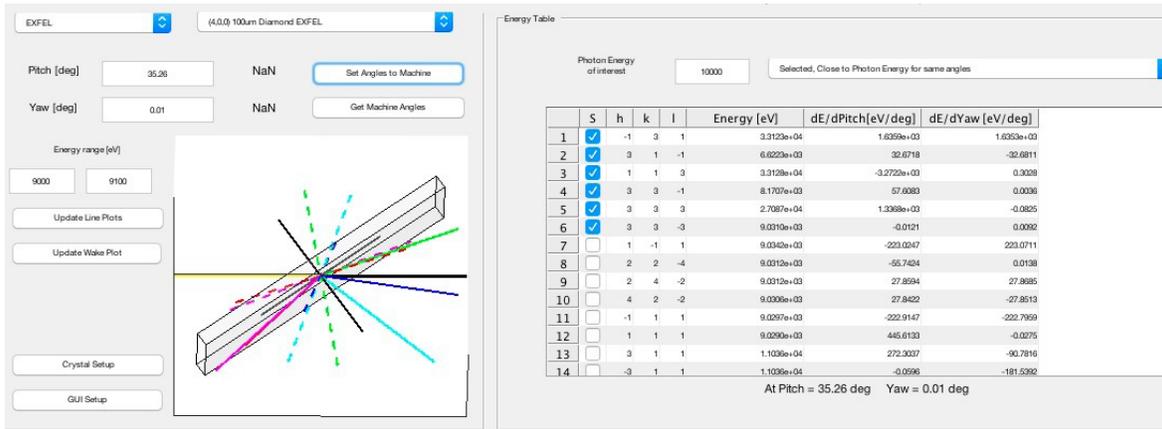
- Important for finding and using different reflections for seeding (including multi-color seeding scheme)
- Rough calibration by scanning pitch or roll to find the crossings
- Several crossings were scanned at around 9 keV



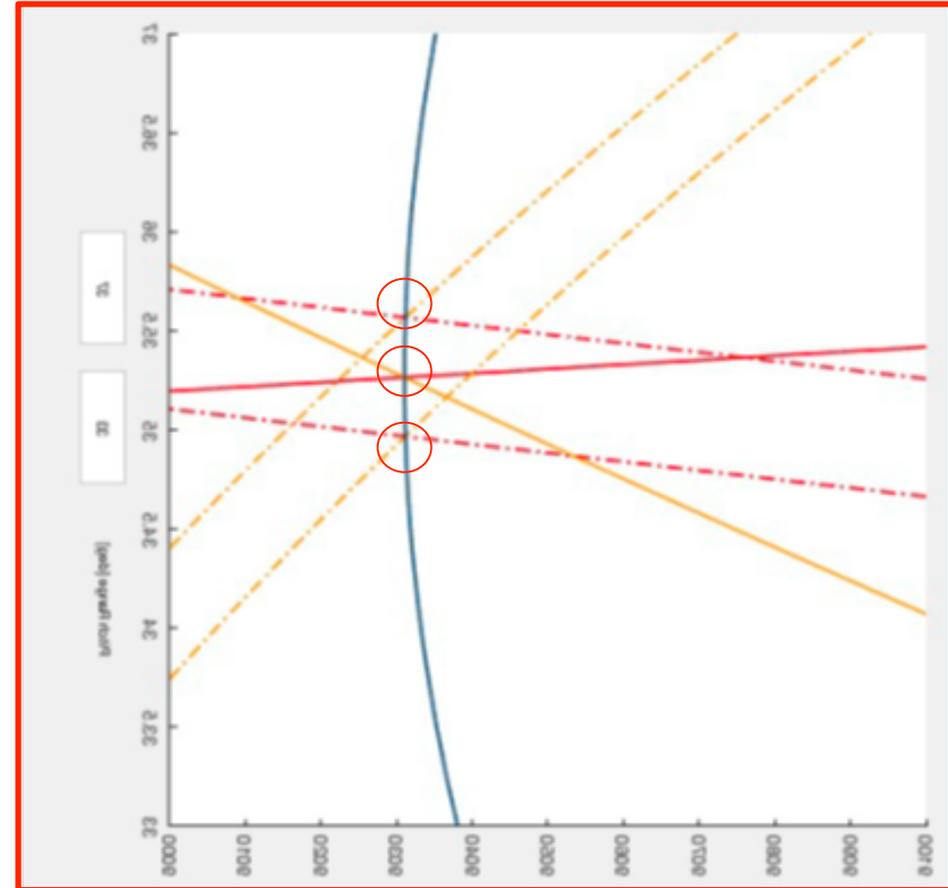
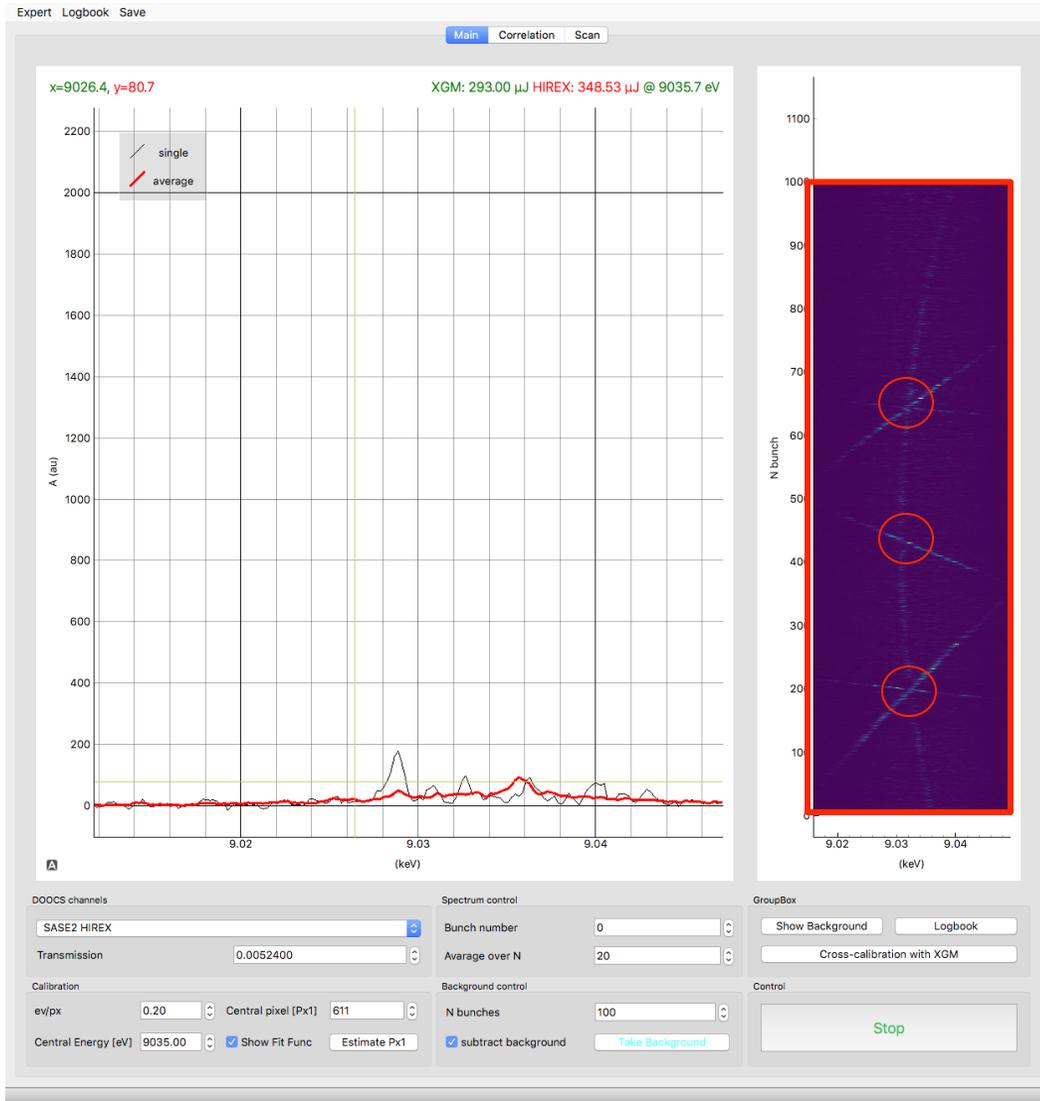
Example of crossings with (3,3,-3)

■ LCLS Crystal GUI, roll 0.01 degree

■ Roll 0.3 degree

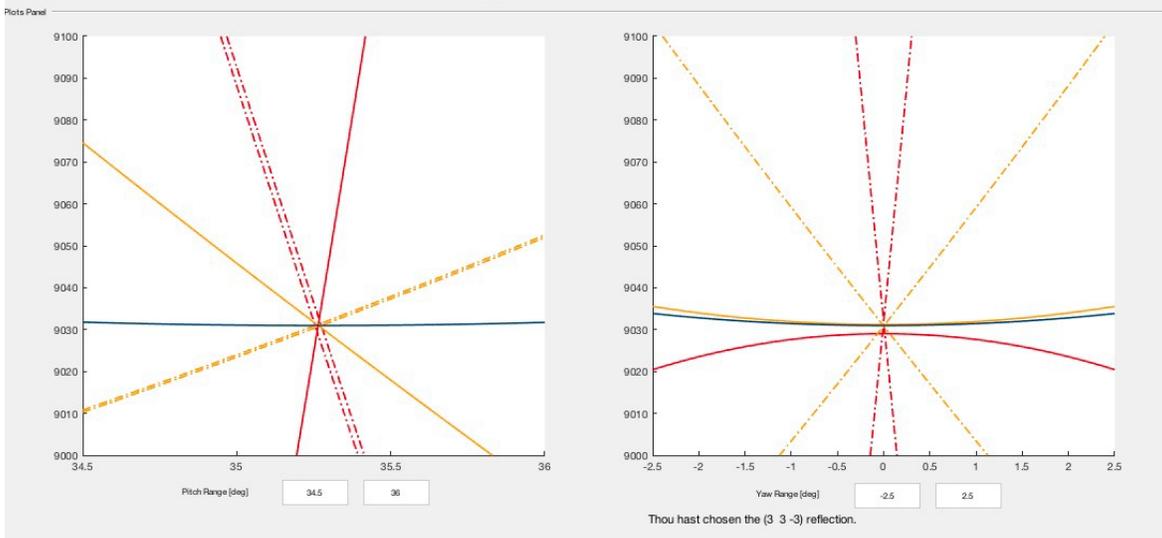
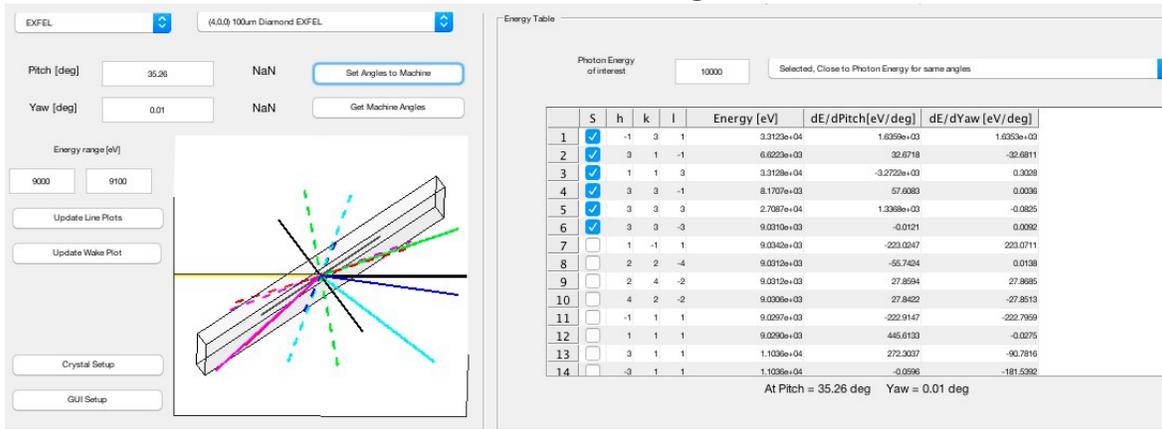


Pitch scan

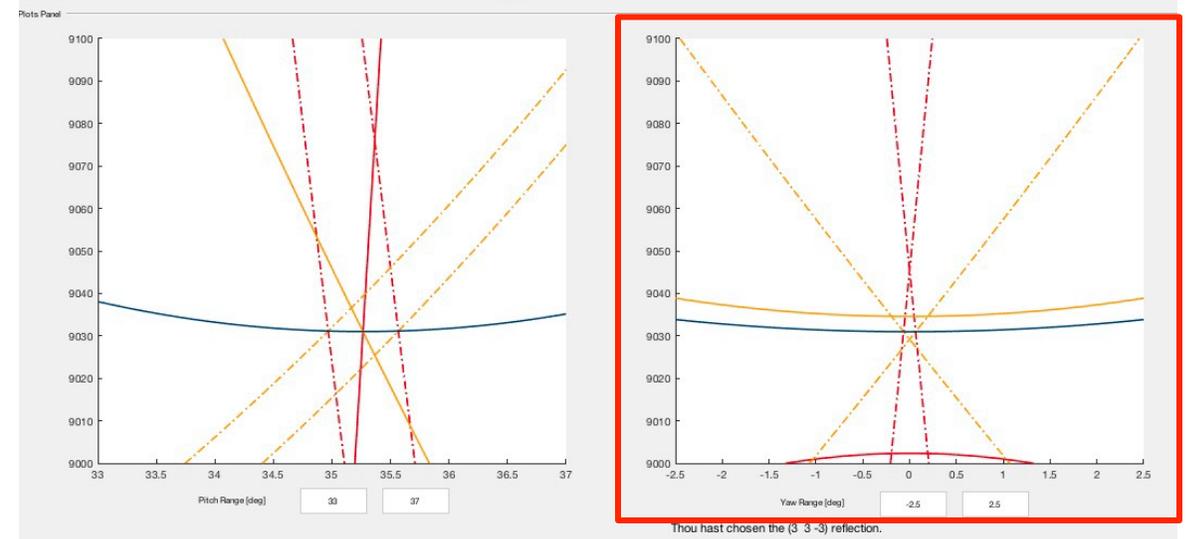
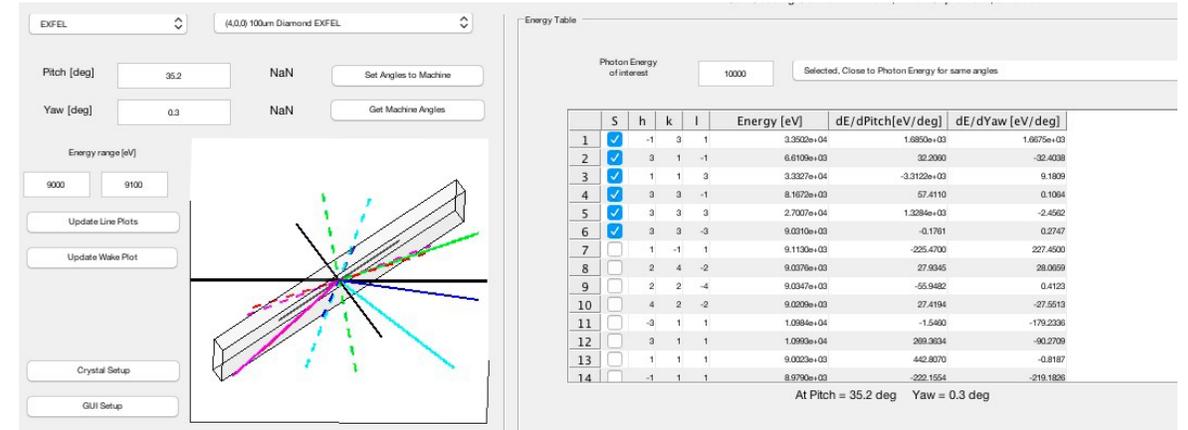


Example of crossings with (3,3,-3)

Roll 0.01 degree

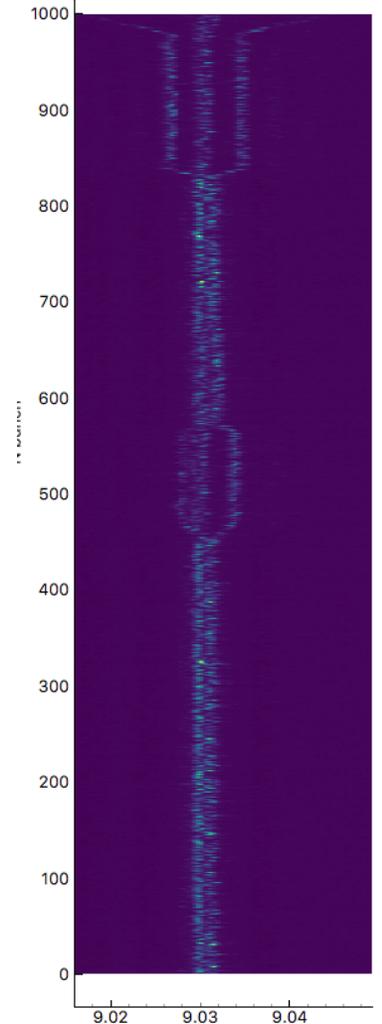
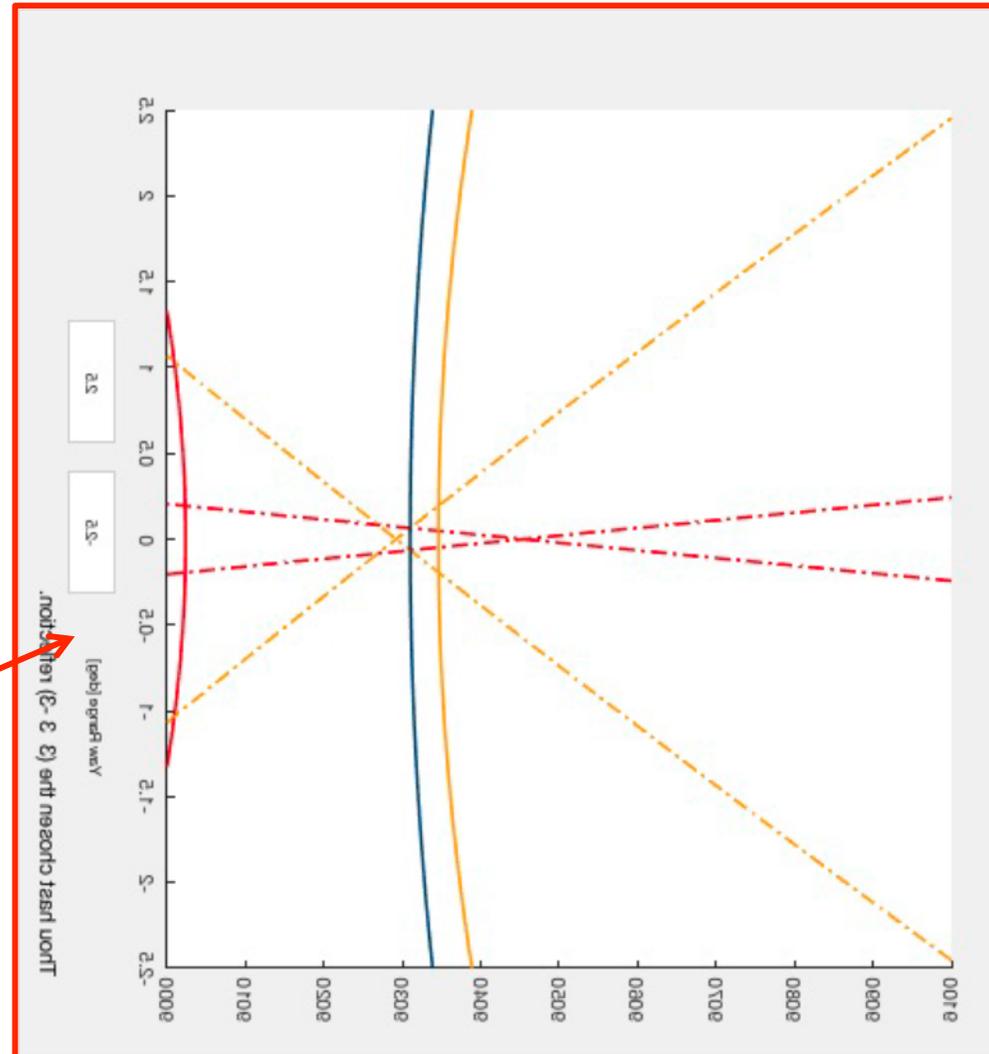
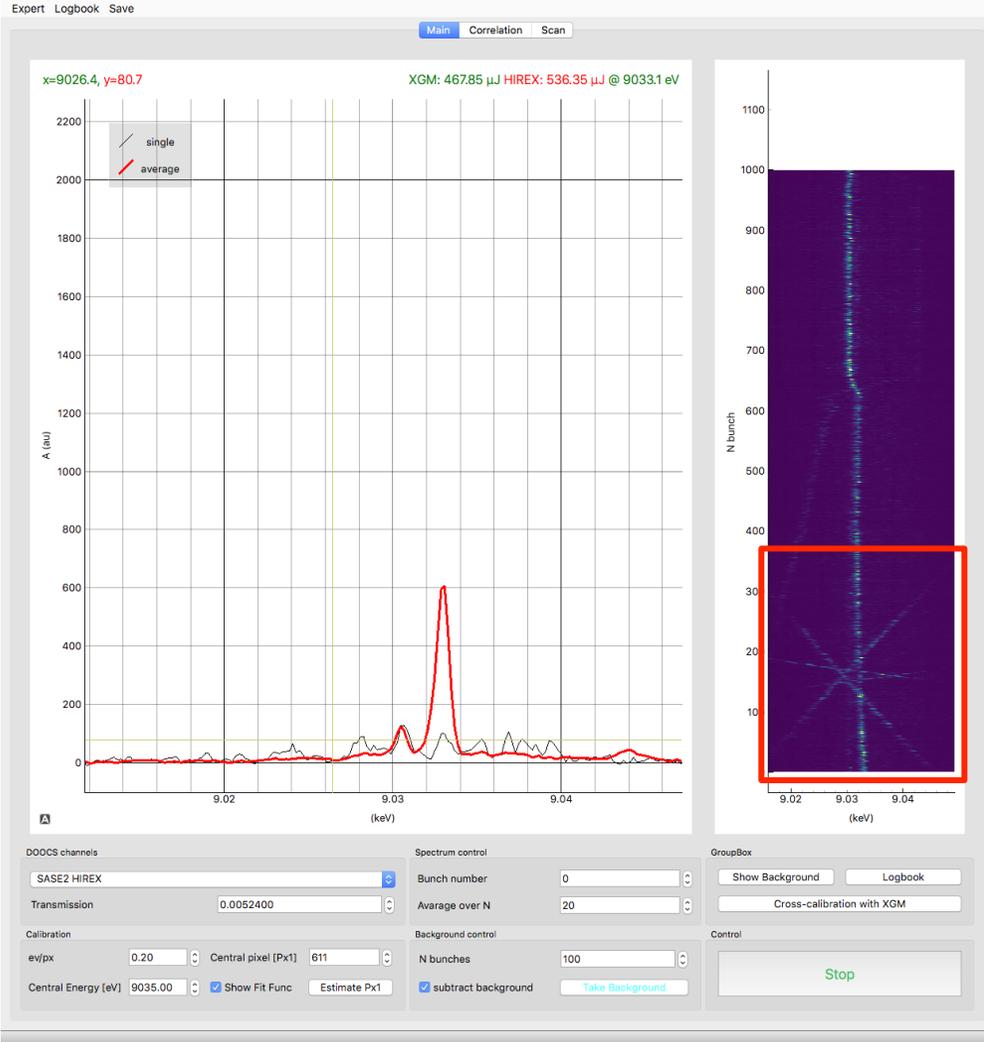


Roll 0.3 degree



Roll scan with pitch at ~35 degree

Bring the central two lines together by adjusting roll angle



Rough calibration summary

1st crystal (1,0,0)

offset errors at the geometrical point (4,0,0) :

2nd crystal (1,1,1)

final adjustments for crystal#2
at ~90 degrees

Roll Angle Axis

Actual Angle
0.6660 °

Target Angle Minimum Maximum
0.6660 -1.7942 0.8931

START STOP

Pitch Angle Axis

Actual Angle
64.5679 °

Target Angle Minimum Maximum
64.5677 29.9500 120.1300

START STOP

pitch -0.1926
roll +0.666
Eph -118 eV

Roll Angle Axis

Actual Angle
-1.4640 °

Target Angle Minimum Maximum
-1.4640 -1.7942 0.8931

START STOP

Pitch Angle Axis

Actual Angle
89.3924 °

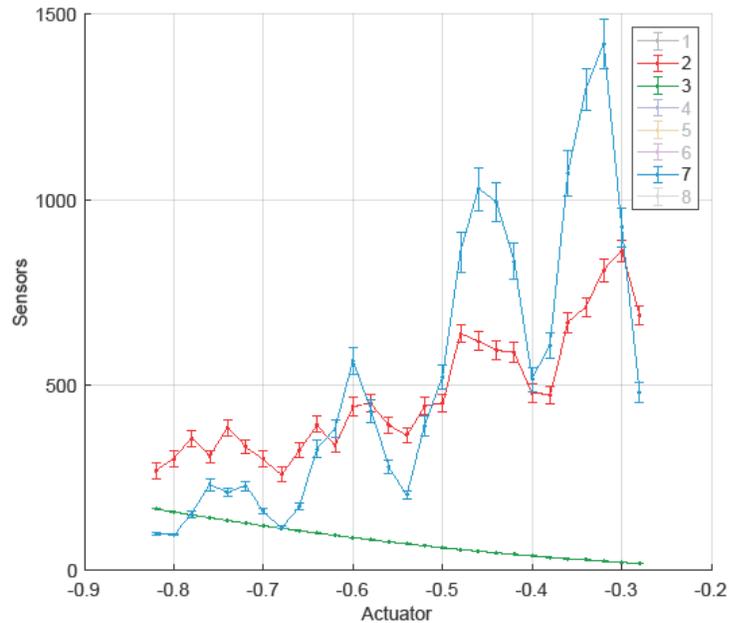
Target Angle Minimum Maximum
89.3930 29.9500 120.1300

START STOP

pitch -0.6076
roll -1.4640



Scan of delay

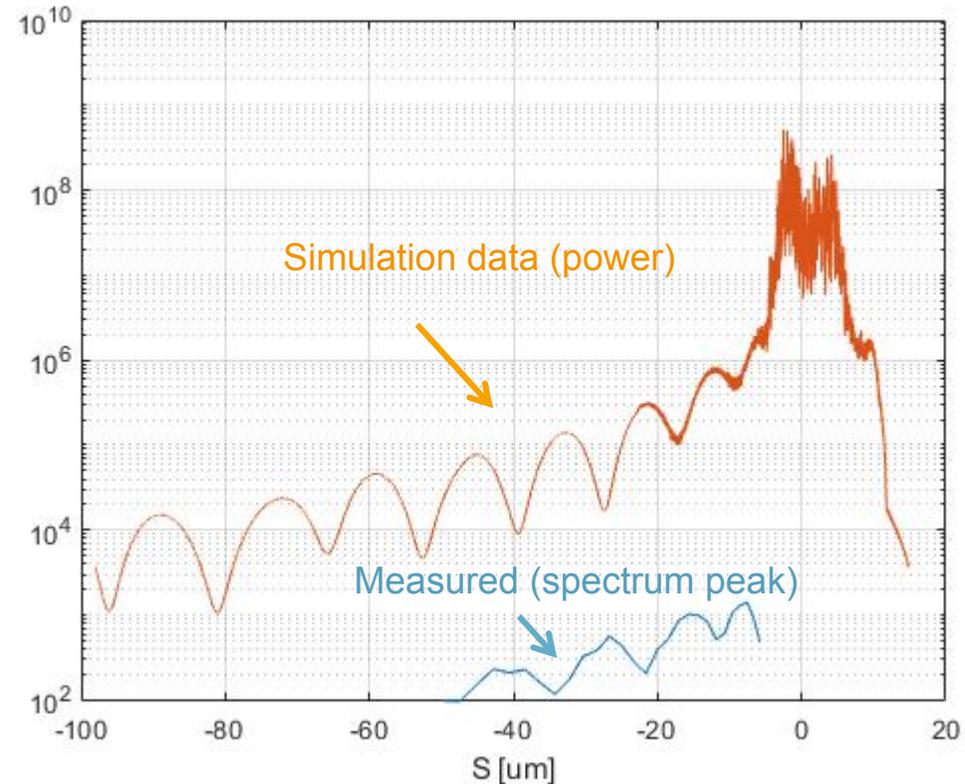


scan undulator gap using GMD fast signal

File: /home/xfeloper/data/scantool/2020-09-04T053216.mat
 Duration: 2020-09-04 05:32:23 - 05:40:42
 Samples/point: 100
 Scan from: Scan Tool version 2019-01-25

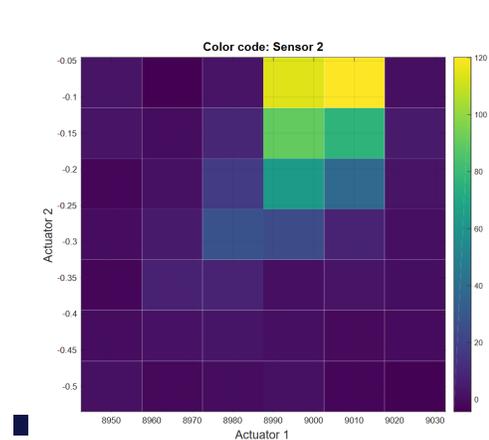
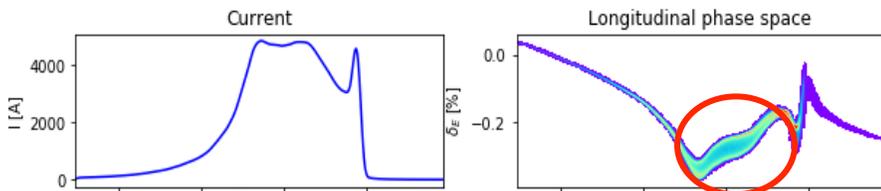
Actuator: XFEL.MAGNETS/MAGNET.ML/BS.2247.SA2/FIELD.SP
 Sensor 1: abs(min(y1)) (calculation)
 y1 = XFEL.FEL/XGM.PREPROCESSING/XGM.2643.T9.CH0/BUNCH_1.TD
 Sensor 2: XFEL.UTIL/DYNPROP/MISC/HIREX_INTEG
 Sensor 3: y1*1000 (calculation)
 y1 = XFEL.MAGNETS/CHICANE/HXRSS01/DT
 Sensor 4: XFEL.FEL/UNDULATOR.SASE2/U40.2255.SA2/K
 Sensor 5: XFEL.FEL/UNDULATOR.SASE2/U40.2261.SA2/K
 Sensor 6: XFEL.FEL/UNDULATOR.SASE2/U40.2267.SA2/K
 Sensor 7: XFEL.UTIL/DYNPROP/MISC/HIREX_AMPL
 Sensor 8: XFEL.FEL/XGM/XGM.2595.T6/INTENSITY.RAW.TRAIN

- The bump position is a convolution between SASE and input response function
- Bump position and length depends on the length of photon pulse (lasing window)
- Our lasing window is shorter than in the simulation (shorter delay)

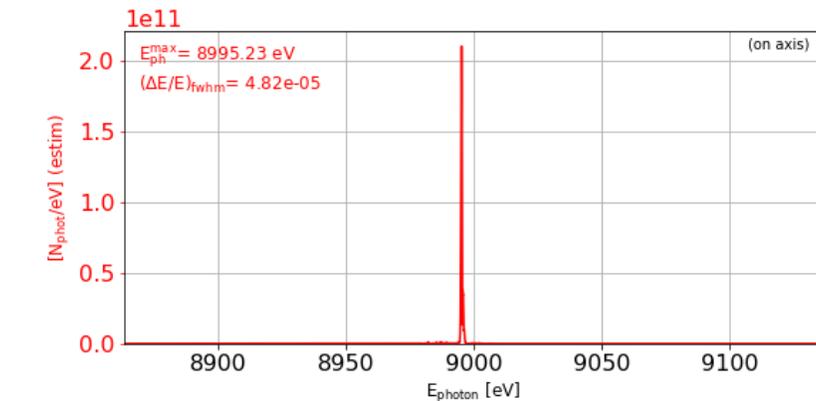
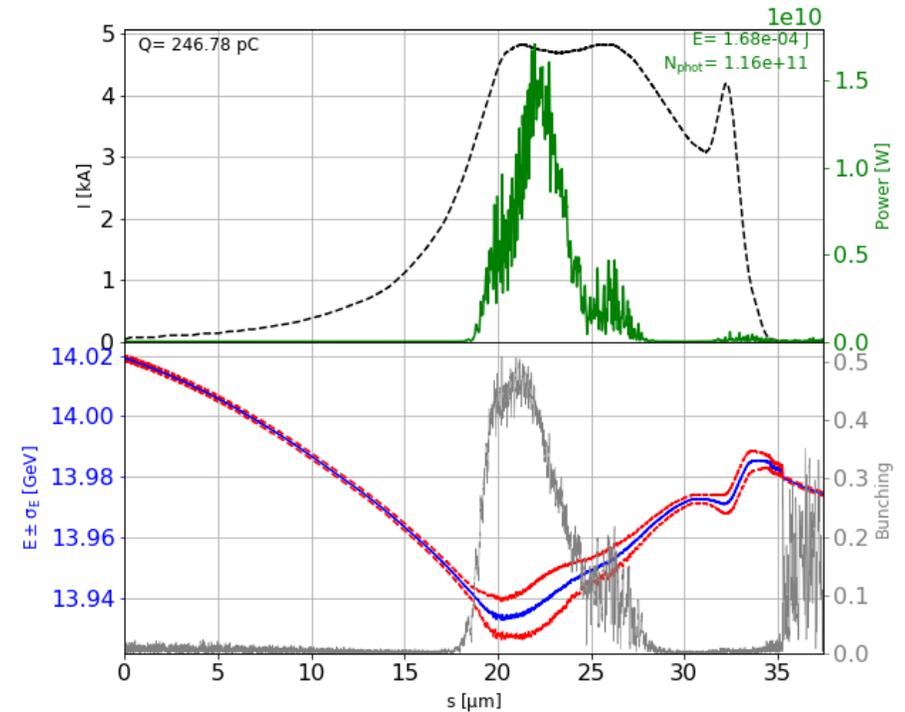


Simulation

- Input from S2E simulation (Ye, Igor)
- Seeing with ~ 40 fs delay
- With 10 cells after 1st chicane and some detune \rightarrow 170 μ J
- Comparable chirp as measured by DD scan



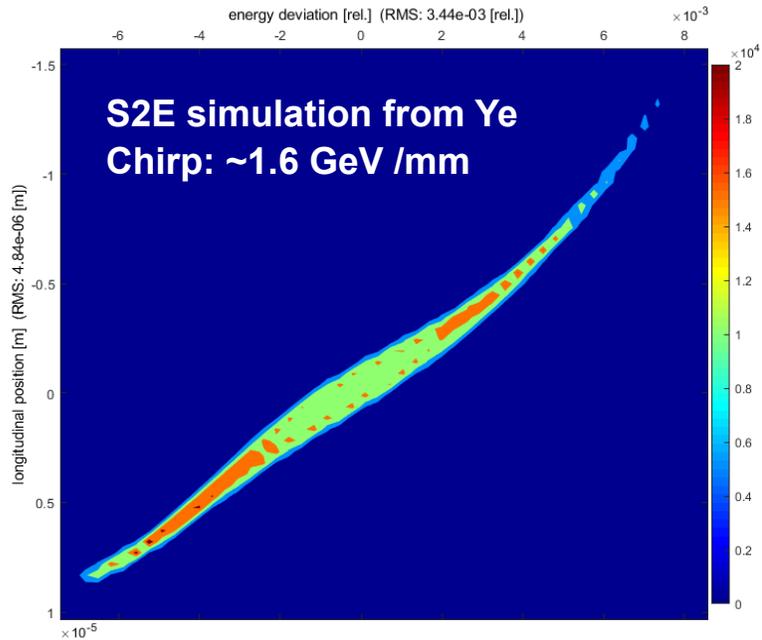
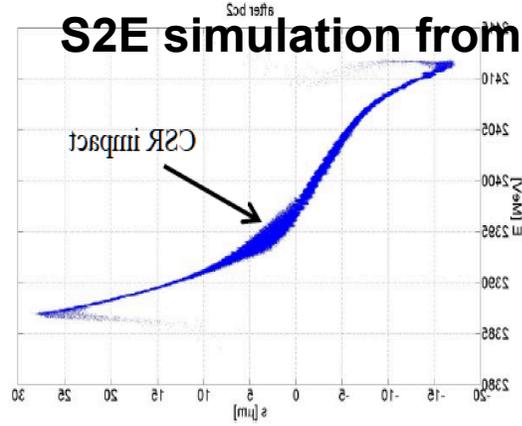
- Measured chirp ~ 2 e-4/fs
- Chirp in simulation 0.5-1 e-4/fs



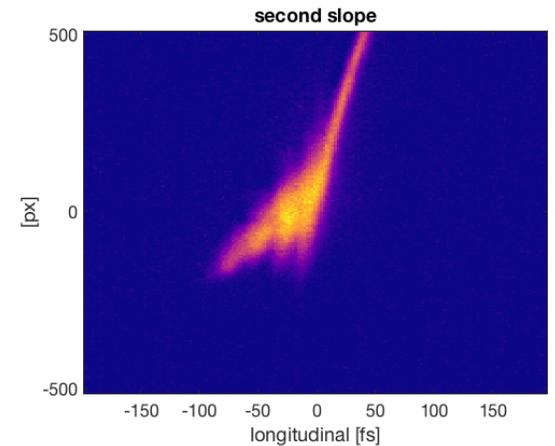
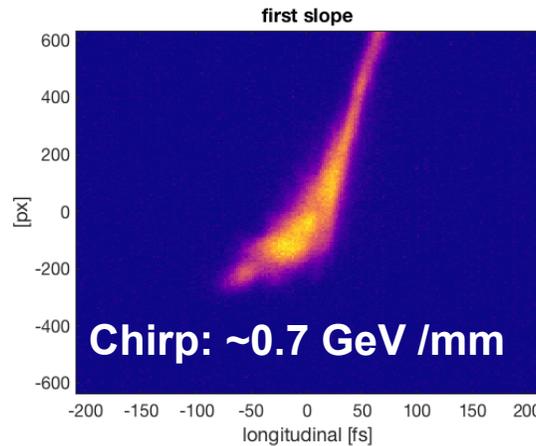
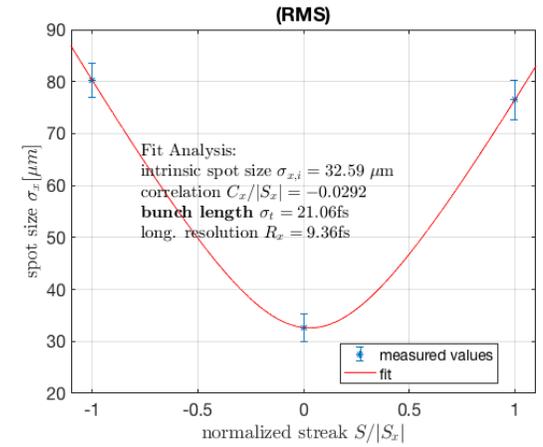
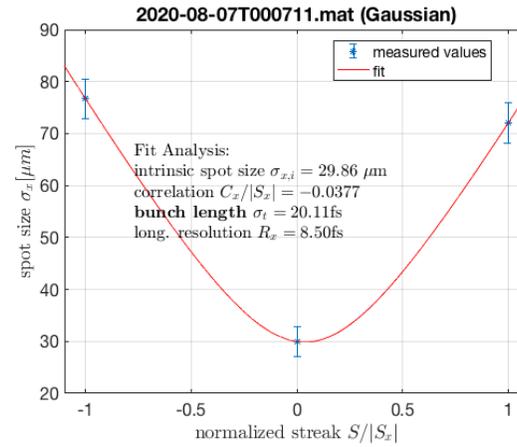
Longitudinal phase space comparison after BC2

Comparable slope

Different shape?



TDS measured profile at B2D



Future plans

- Data analysis to be continued ...
- Reproducibility and reliability (regular beam time on Monday?)
- Automization for set-up procedures and for crystal calibration
- High repetition rate operation (with 2 chicanes)
- Cross check between experiments and simulations

Thank you!

Special thanks to **Gianluca, Svitozar, Marc, Frank, Naresh and Sergey**, who participated in the last shifts!!!