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Optical Replica Synthesizer Experimental Shifts

The ORS Collaboration
prepared by
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Uppsala University

FLASH Seminar, 27. November 2007

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Overview

- Where did all the hours go?
  - things that go bump in the night
  - and making lots of ZZs
- Making transverse overlap
- And longitudinal overlap
- When all components worked simultaneously...
- Plans for next time

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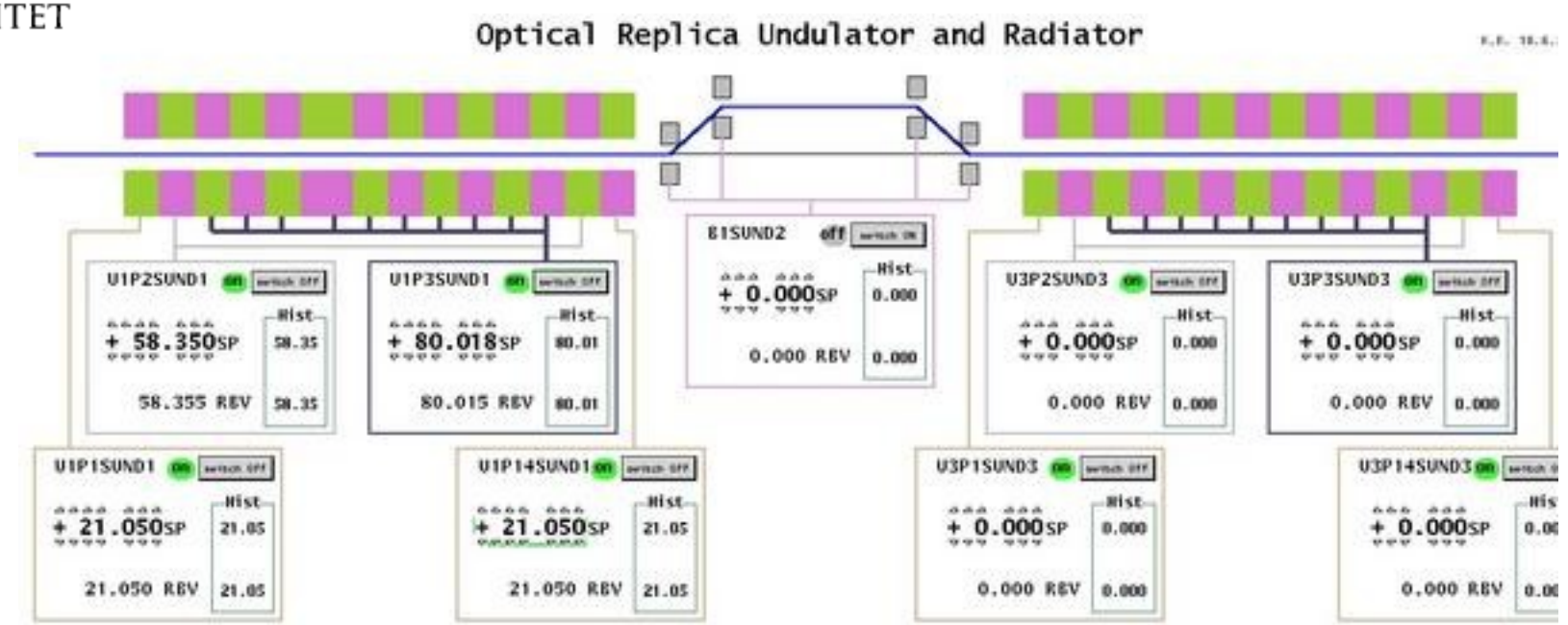
Undulators



- Worked almost out-of-the-box
  - did not affect SASE operation
- a little out-of-plane steering
  - just center the beam properly on-axis

Undulator control

- Calculate needed magnetic field for resonance
- Setting cycle or just incremental changes
  - uses the tables from Gergana's field measurements
- Turn them off (Cycle to Zero) → transparent

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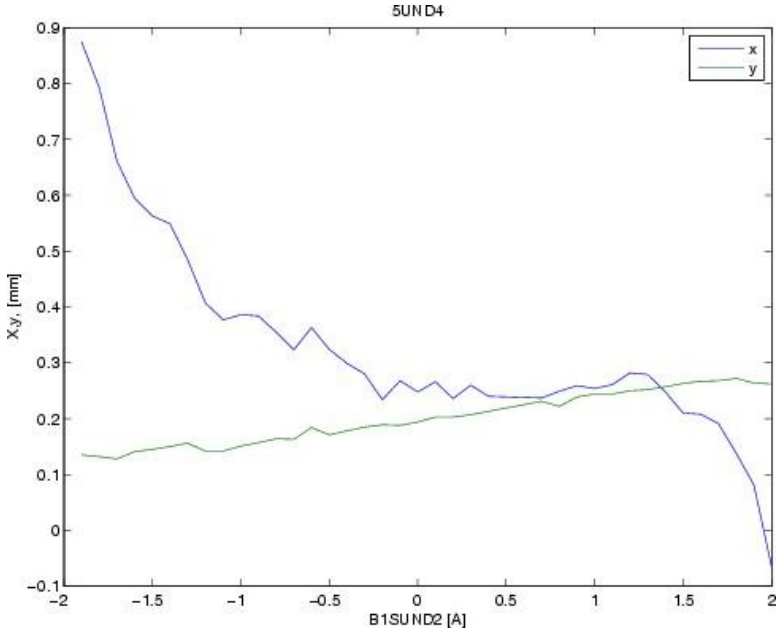
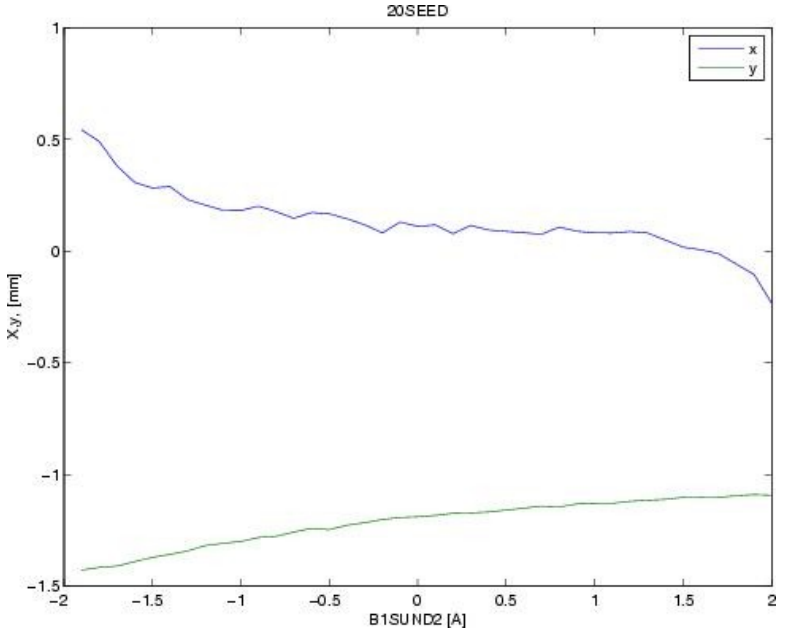
Chicane

- Chicane only well-closed for small excitations
  - extra windings and longitudinal movement
  - imbalance between steerers when excited >1 A





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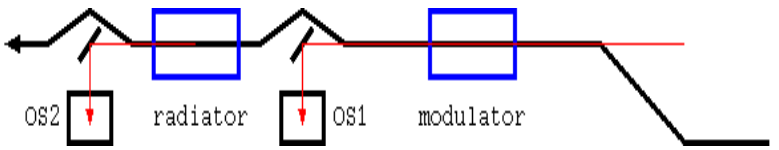
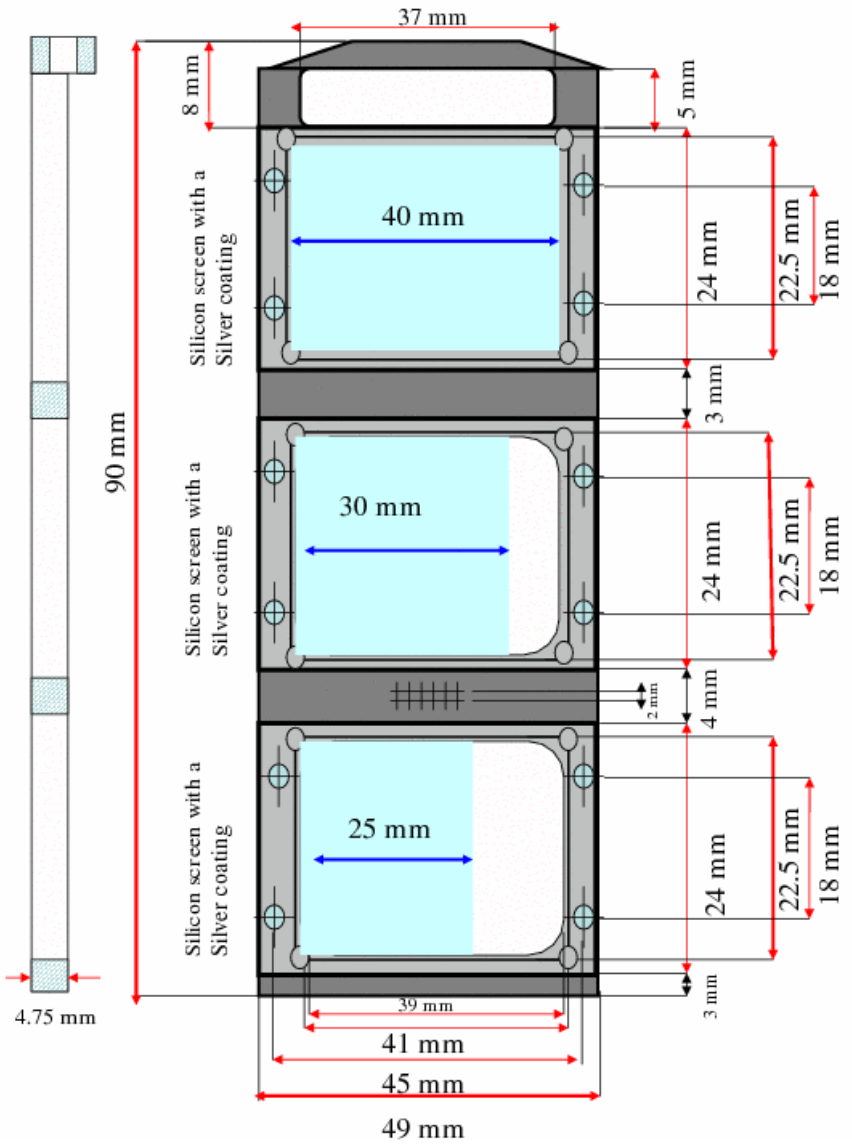
Optical station alignment

- Spent a lot of time on getting a properly focussed picture of the screens on the cameras both on optical station 1 and on optical station 2.
- Took a lot more time than anticipated
- Three optical stations
  - OS0 with the telescope
  - OS1 with seed laser extraction, camera, diodes, power meter
  - OS2 with Grenouille, camera, power meter



Alignment of the OTR pots



- The OTR chamber in OS1 and 2 were not aligned on the beam axis (off by up to 8 mm both horizontally and vertically)
  - Found out by driving local bumps and looking at downstream screens until we scraped on the OTR frames.

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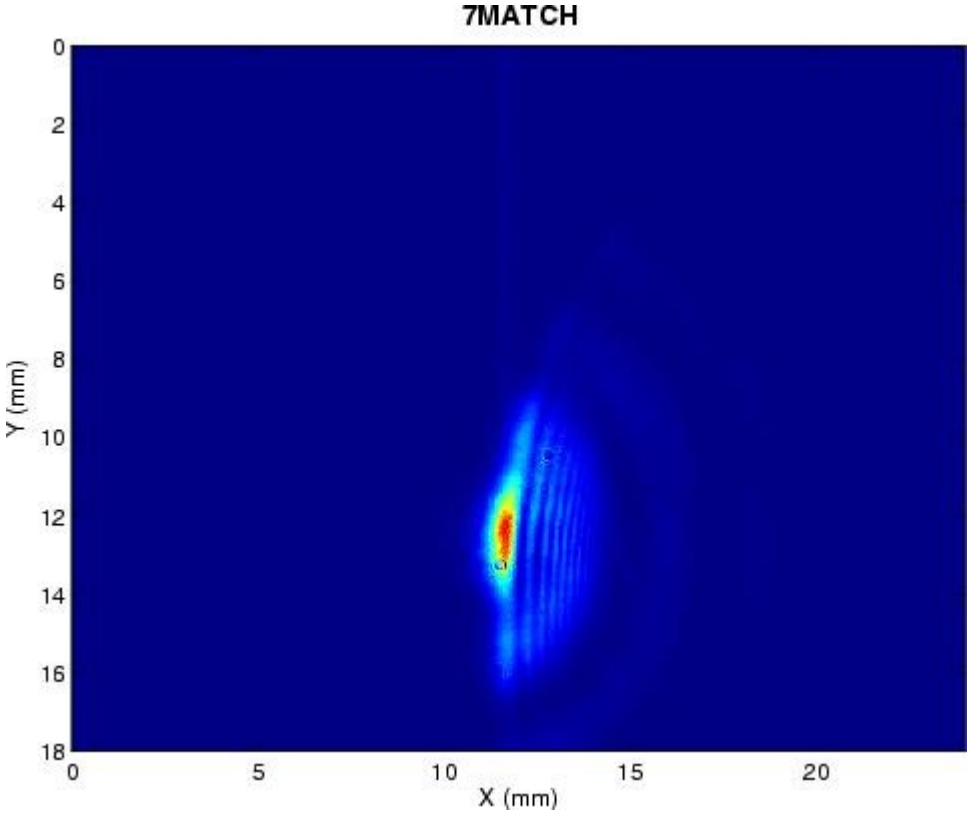
Laser alignment

Laser is reflected or hits edge of a mirror somewhere on its long way from the laser table to the screen immediately upstream of modulator (23.9)



- The alignment of the entire seed-laser transport system took several iterations after improvments
- Remotely controlled
- Weirdly mounted mirrors
- Got faster in the end

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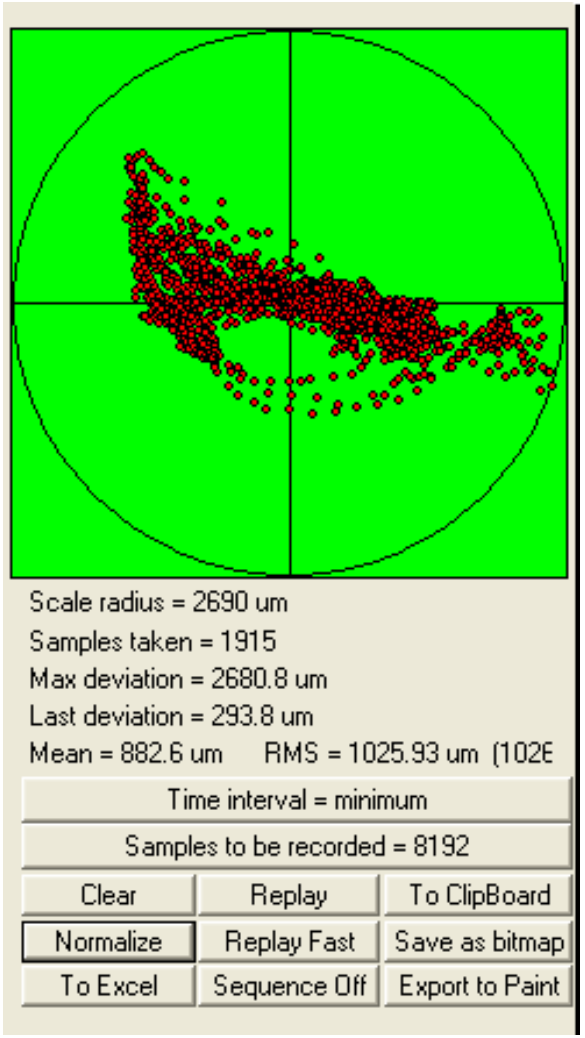
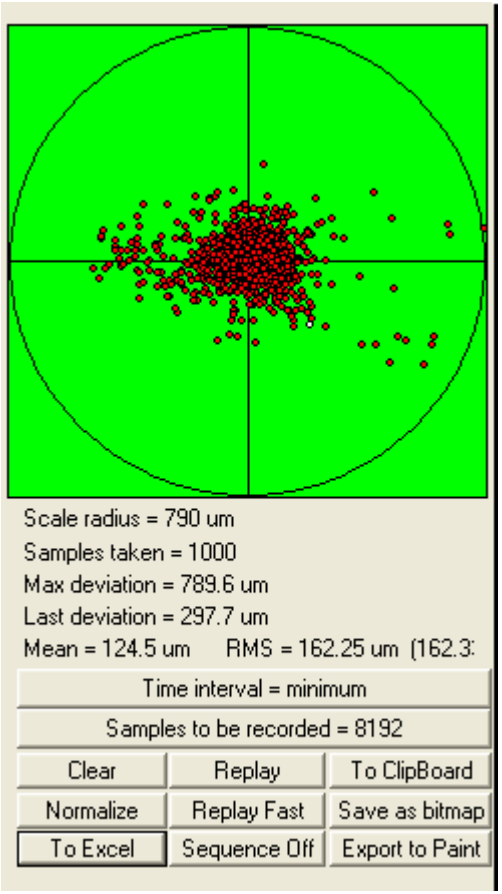
Laserbeam walkabout



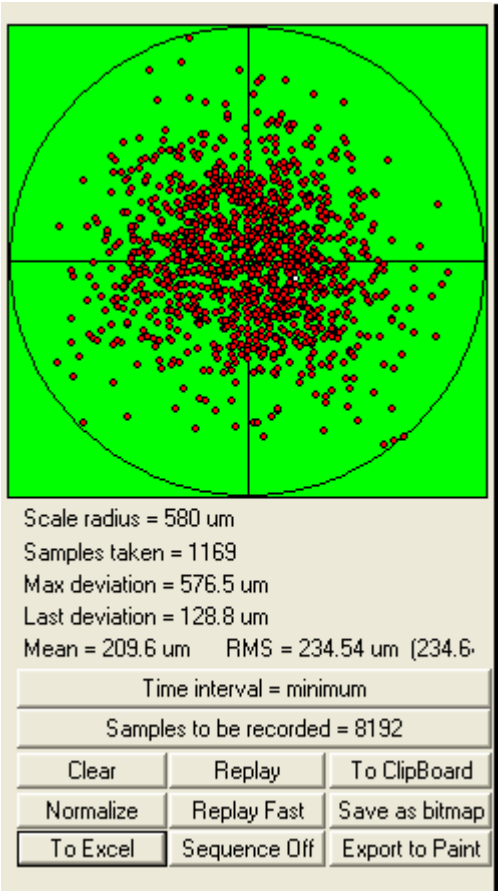
- Alignment laser into tunnel and back into laser hut onto table.
- Observe spot on camera
- Initially large amplitude (mm rms) wandering
- Fixed by
  - mechanical support under the telecope
  - windows to 'plug the hole'

0.2 mm after fixing

Alignment laser



CPA 2001



- Focussed beam on laser table in laser hut.
- Alignment laser and CPA beam wander now around 0.2 mm.
- CPA a little worse, we'll investigate
- Should be similar near waist inside modulator.

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Other stories to tell

- Mode lock of oscillator took a while
- RF lock worked rather quickly (Florian and Axel)
- Broken amplifier diode laser (Thorlabs driver fried the Peltier element)
- Broken optical fiber (Florian and Axel)
- Interlocks
  - personal protection in laser hut
  - machine protection
  - personal protection in experimental hall

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; >(Bloopers (<:

- Initially the polarization of the laser and the electron beam in the modulator were orthogonal to each other
- We planned to use the last pole of the radiator as the first part of the three-bump to steer around the replica extraction screen on OS2.
  - but by construction the magnet always had $\int B\,dl = 0$ because the flux always returns through the other poles.
  - had extra steerer H4SUND3 installed

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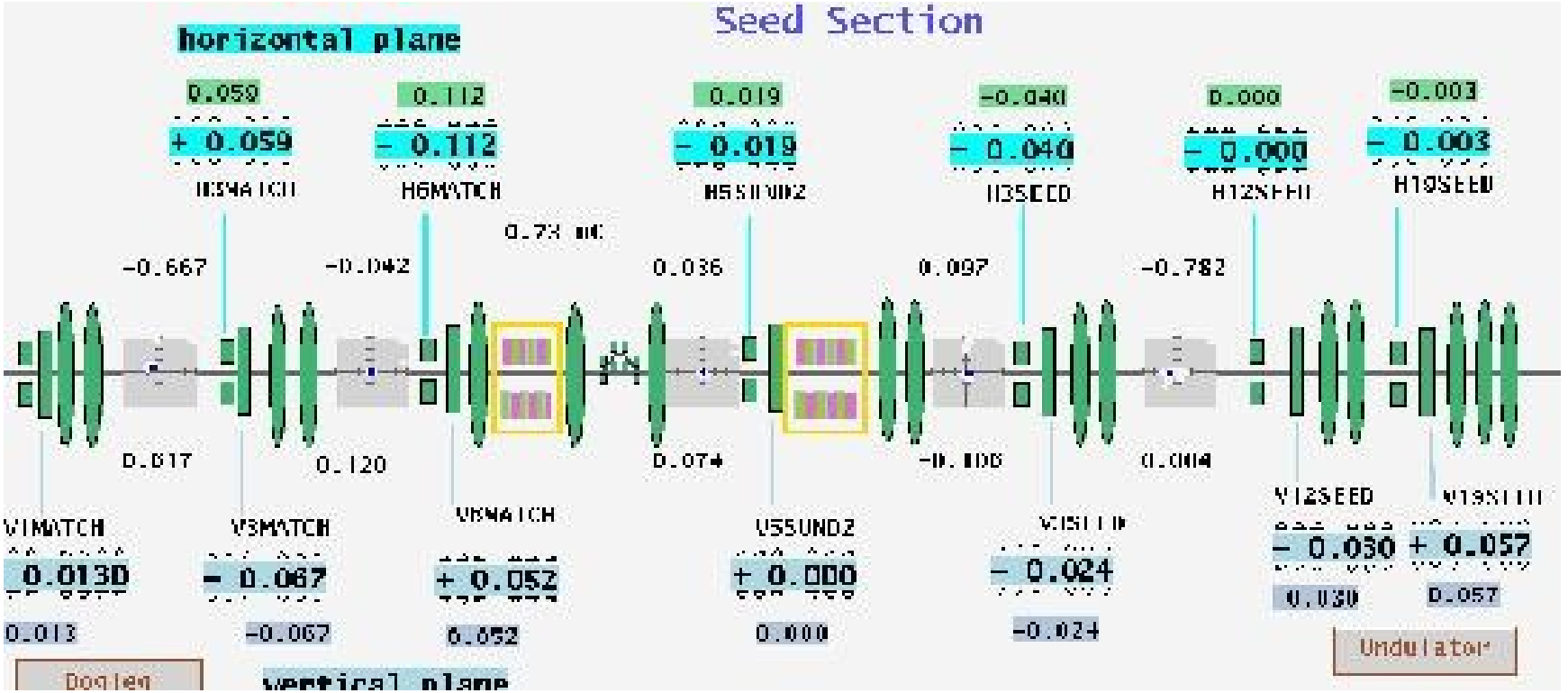
Start out with flat orbit



- Within 0.1 mm and weak steerers
- Use 3/6MATCH to take out incoming orbit

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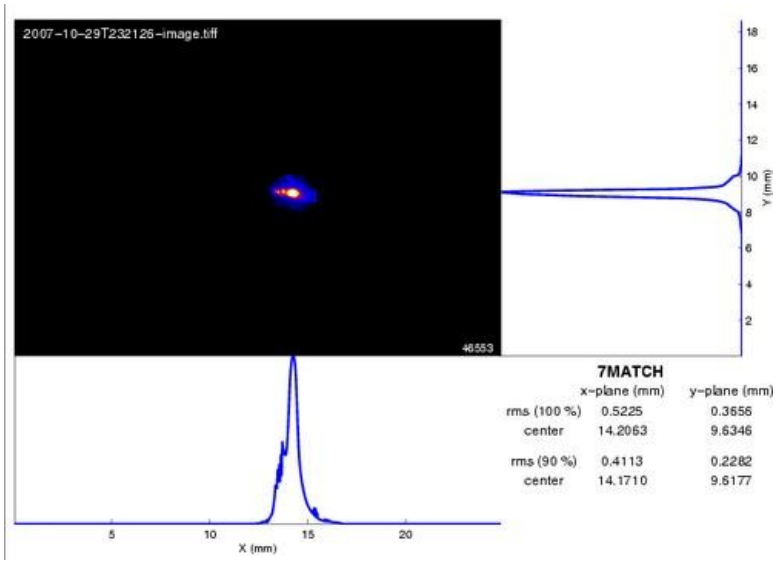
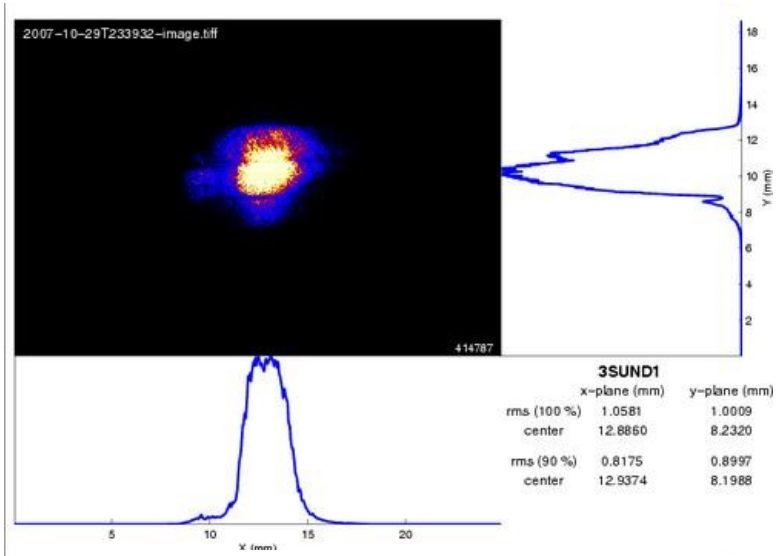
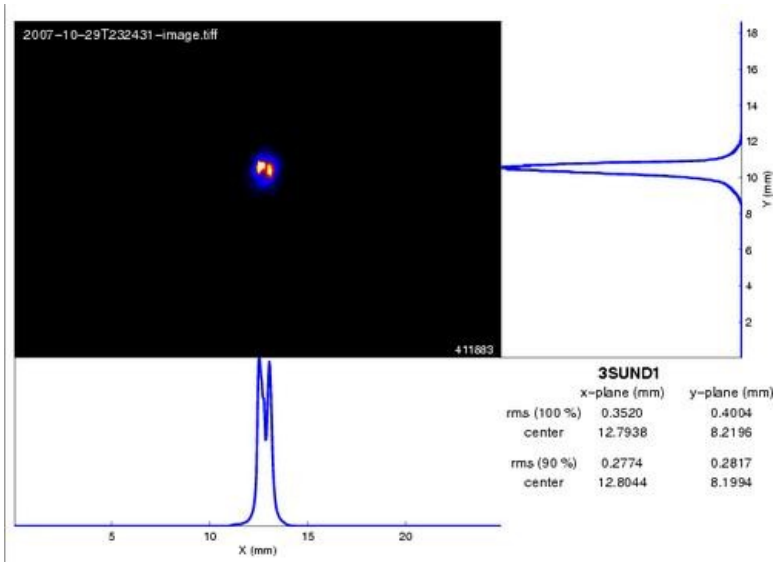
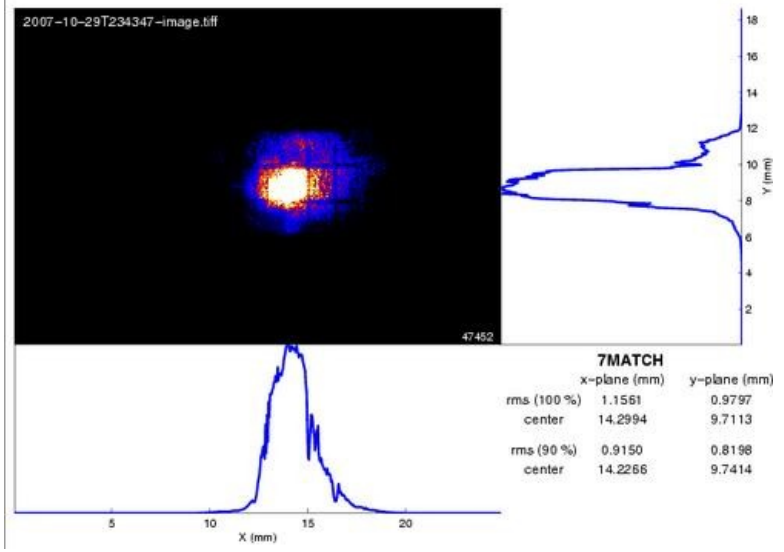
Transverse Overlap







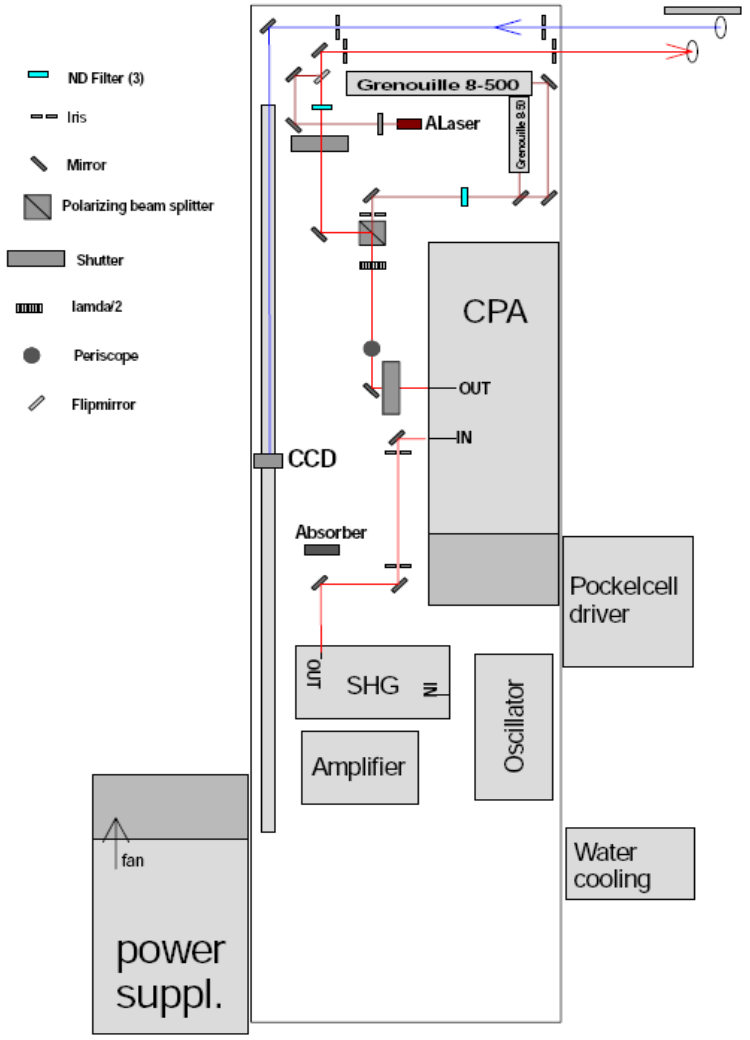


Rough temporal Overlap

- Remote 1 GHz scope
- Photo diode on OS1

- Signal from
  - attenuated seed laser
  - spontaneous synchrotron
  - radiation
- on photo diode
- good to ≈ 100s ps
- move relative timing with the phase shifter

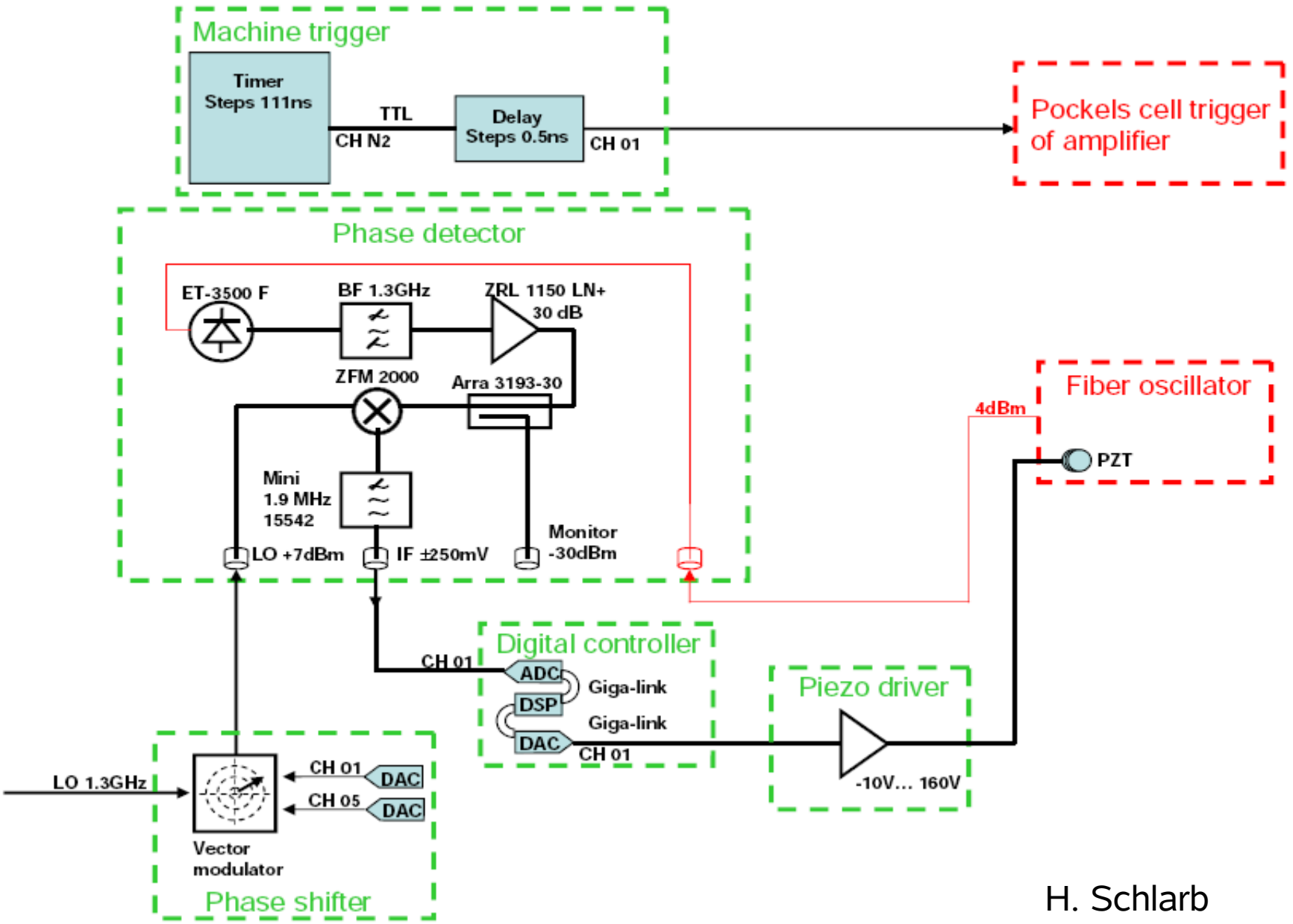
The Seed Laser



G. Angelova

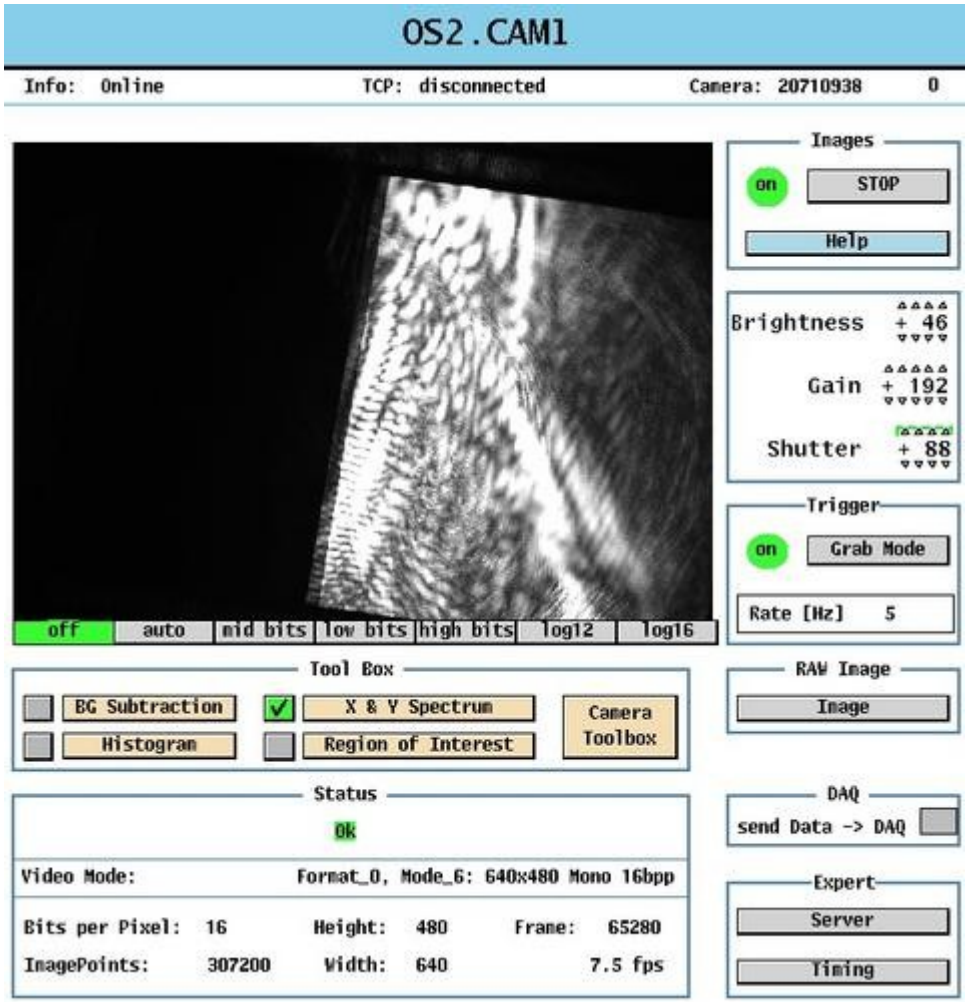
- Fiber-ring-oscillator is phase locked to RF (micro-timing)
- CPA is a regenerative amplifier
- Pockels cell fire to let the light pulse out (macro-timing)
- 1 mJ/pulse, 200 fs

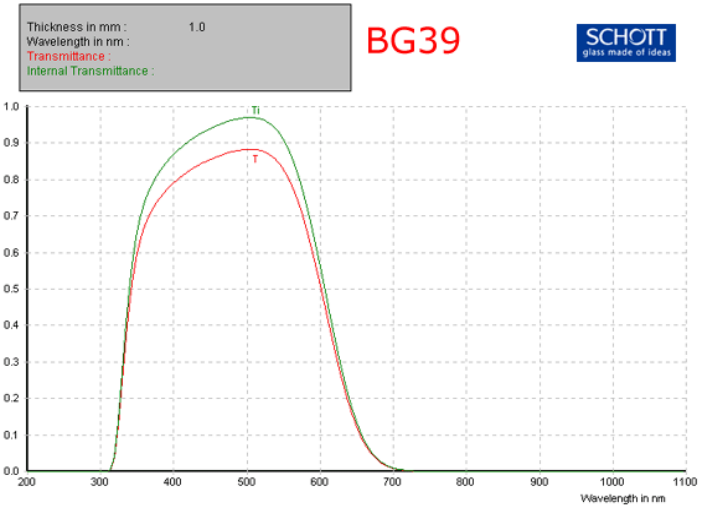
Scheme of the ORS synchronization & trigger system



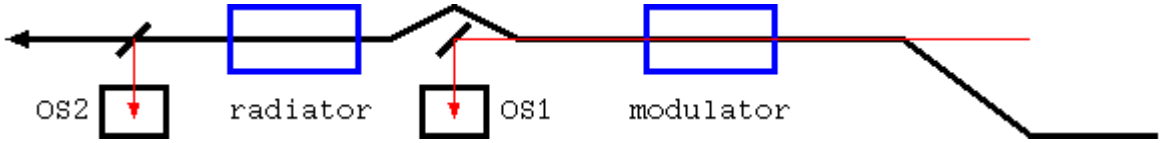
H. Schlarb

Problem with Seed laser leakage

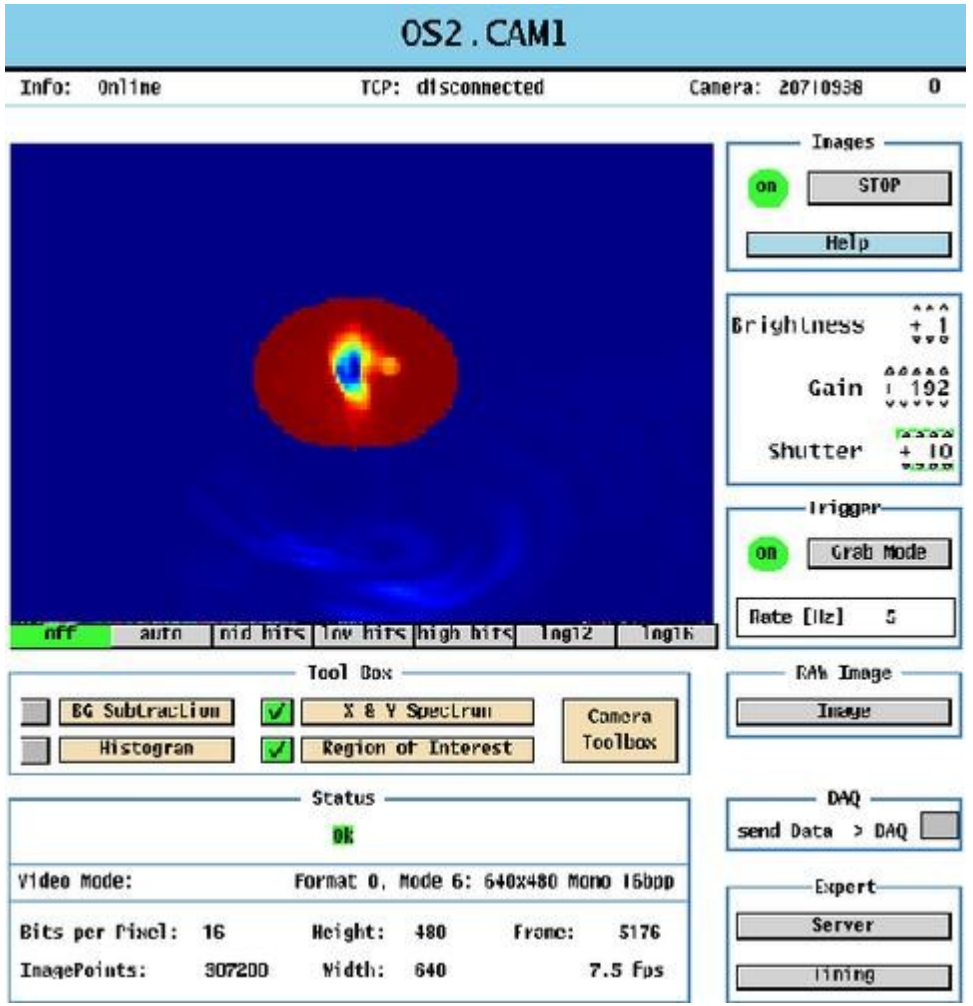




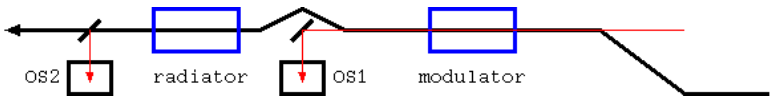
- Bunching also causes radiation at higher harmonics
- Insert 700nm filter



With Seed laser filtered



- OTR at 2nd harmonic
- Radiator OFF
- Need signal that identifies overlap
- Use average pixel value in *Region of interest*



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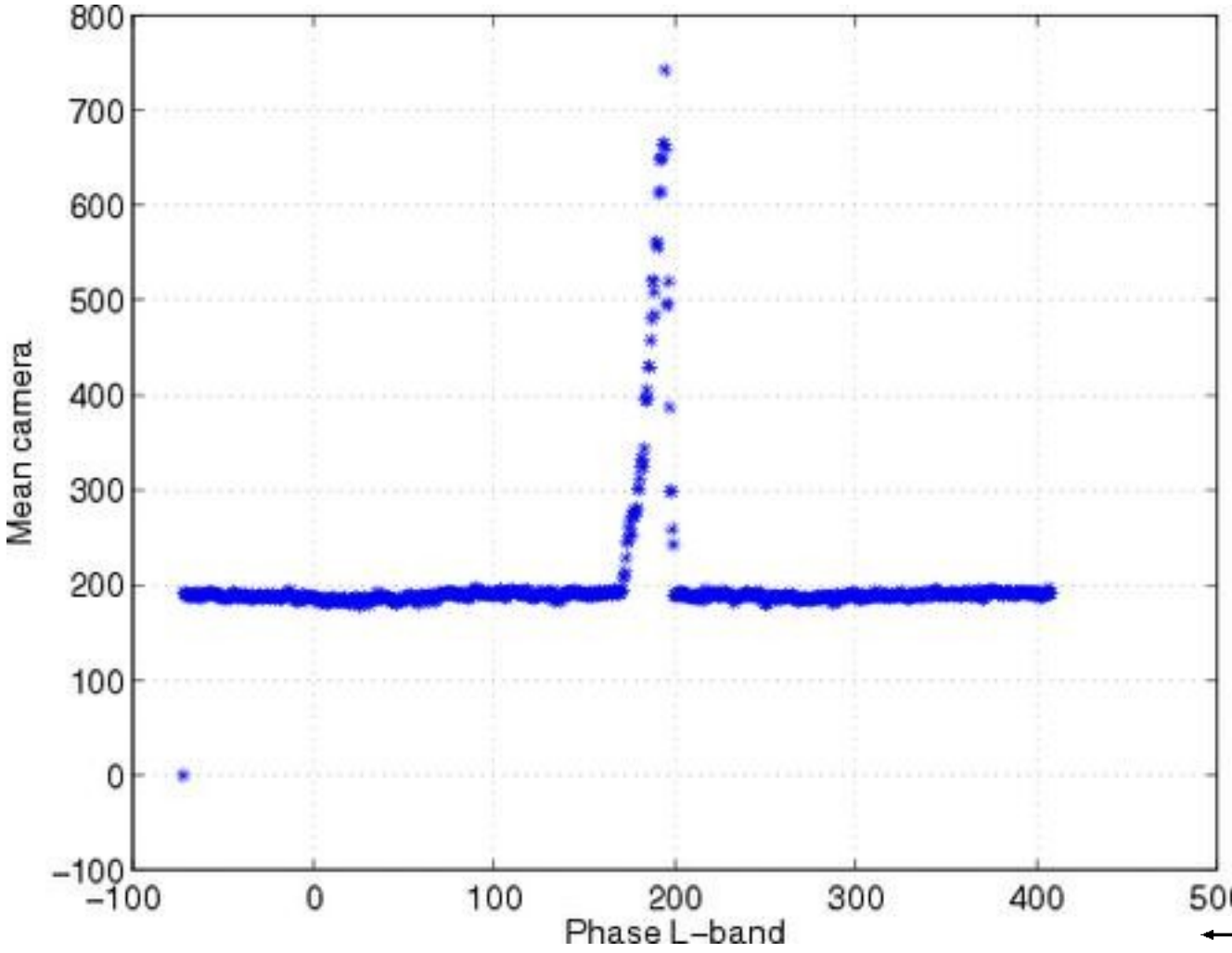
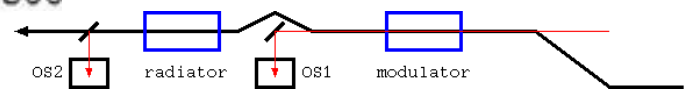
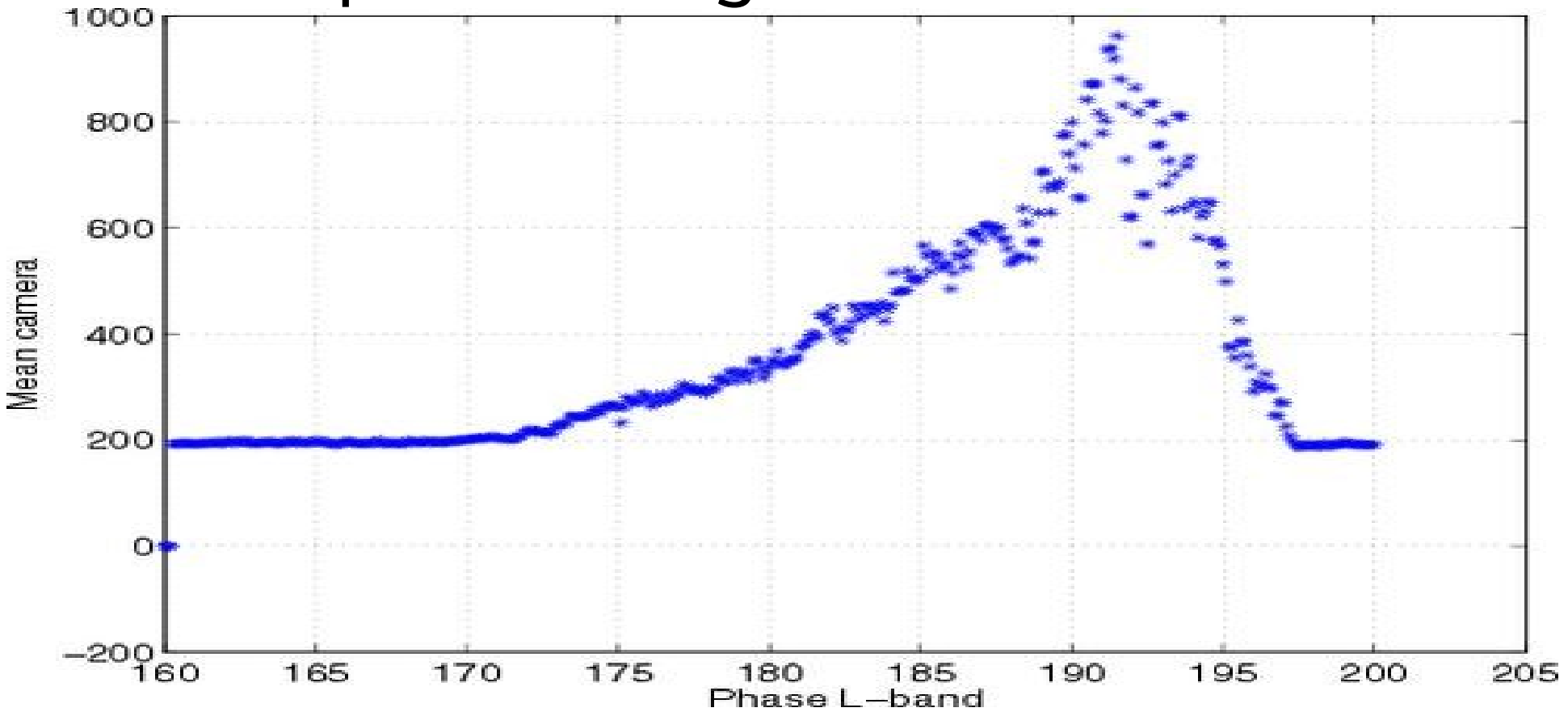
After some scanning...

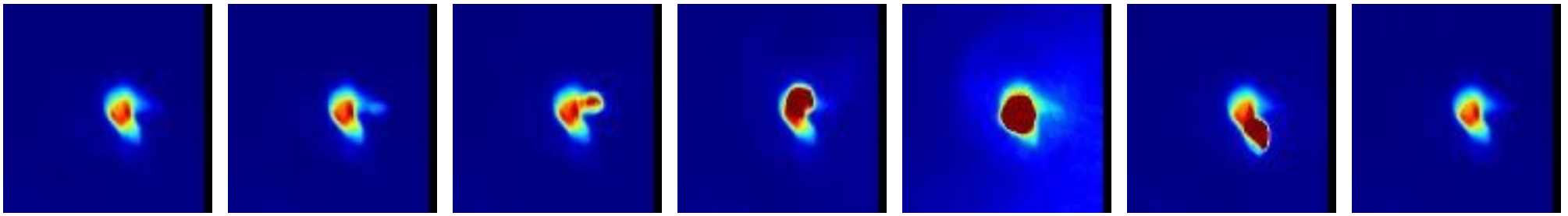


It's femto-slicing, right?

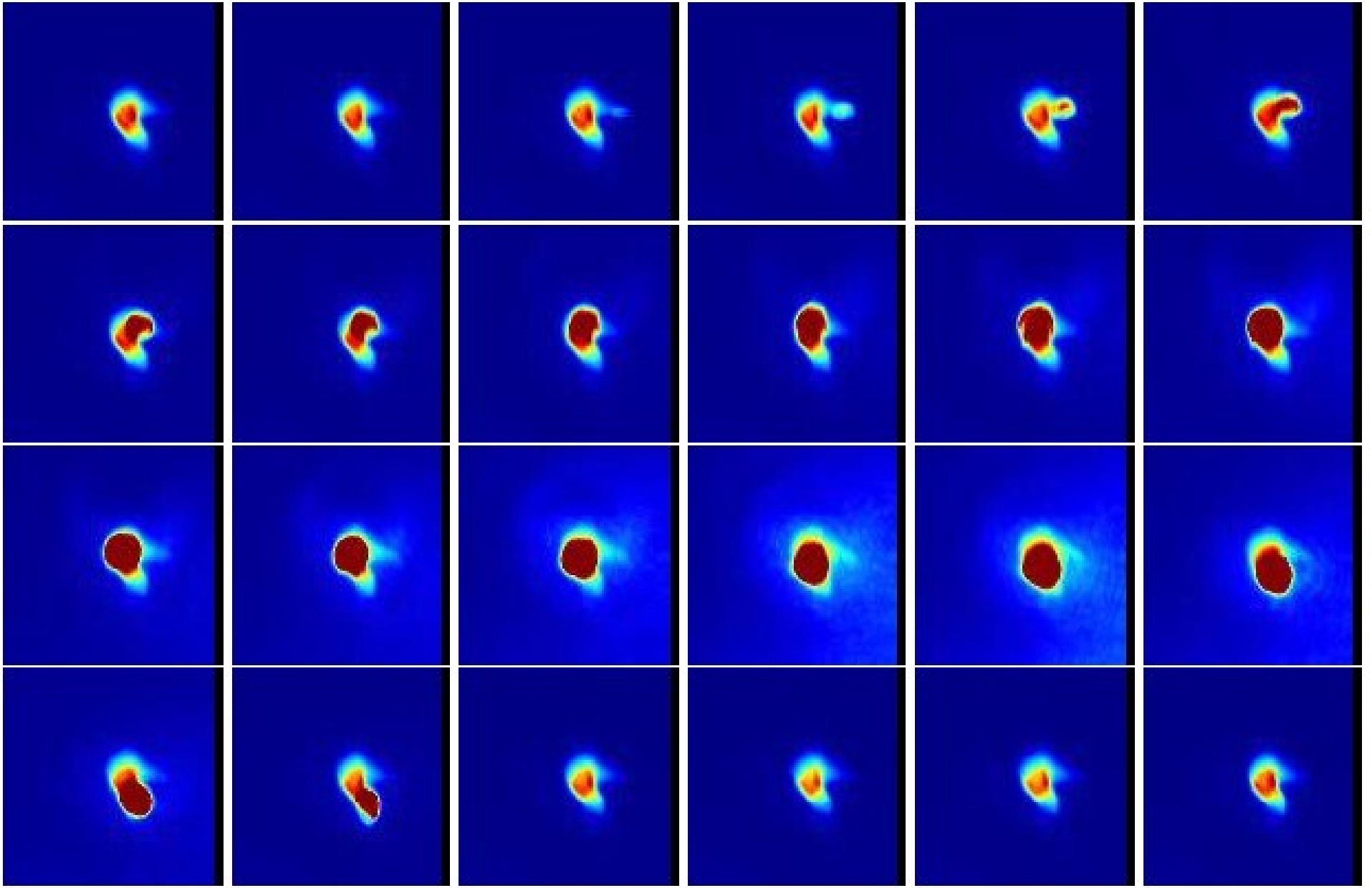


CTR on screen 1SEED while passing a 200 fs laser pulse through an electron bunch

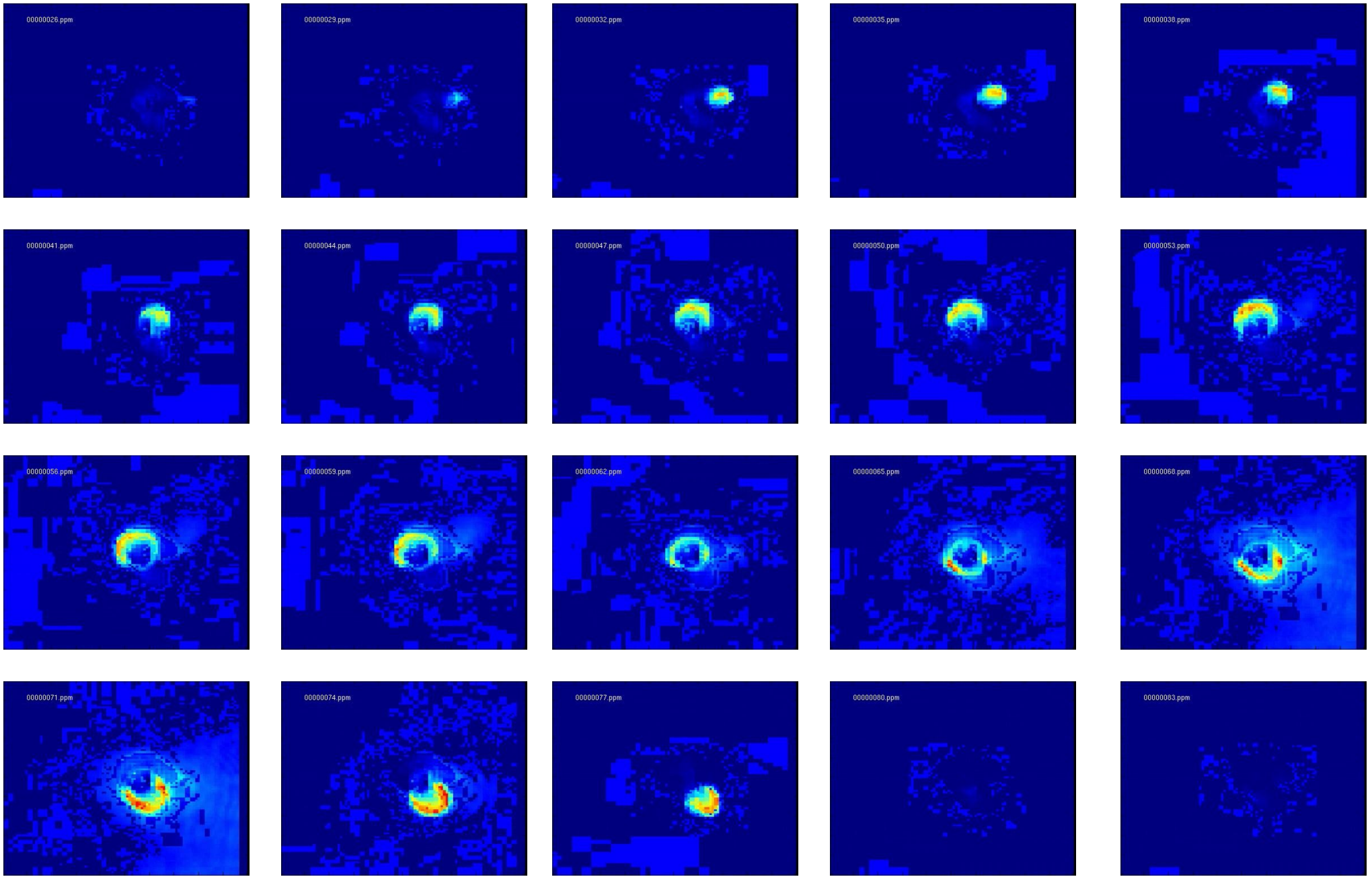




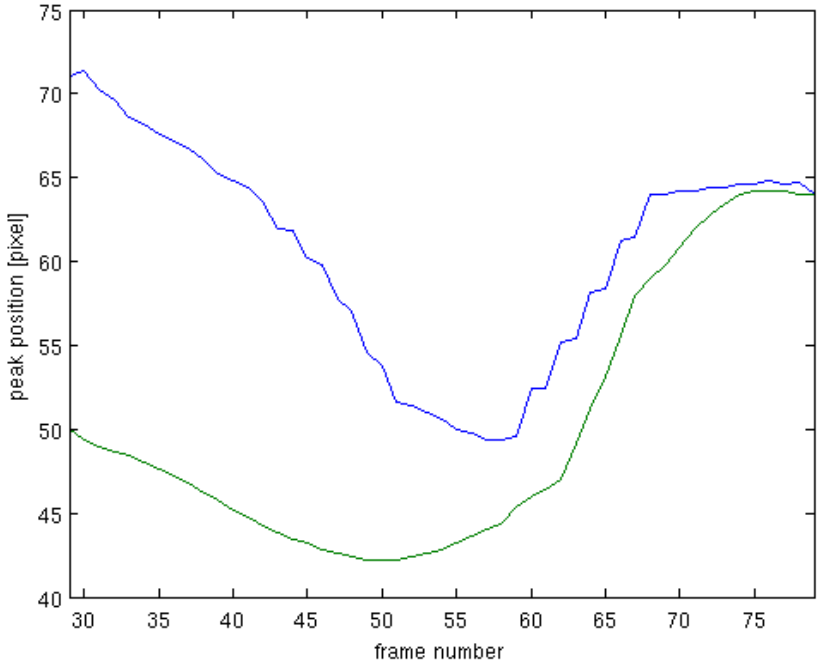
Every third frame

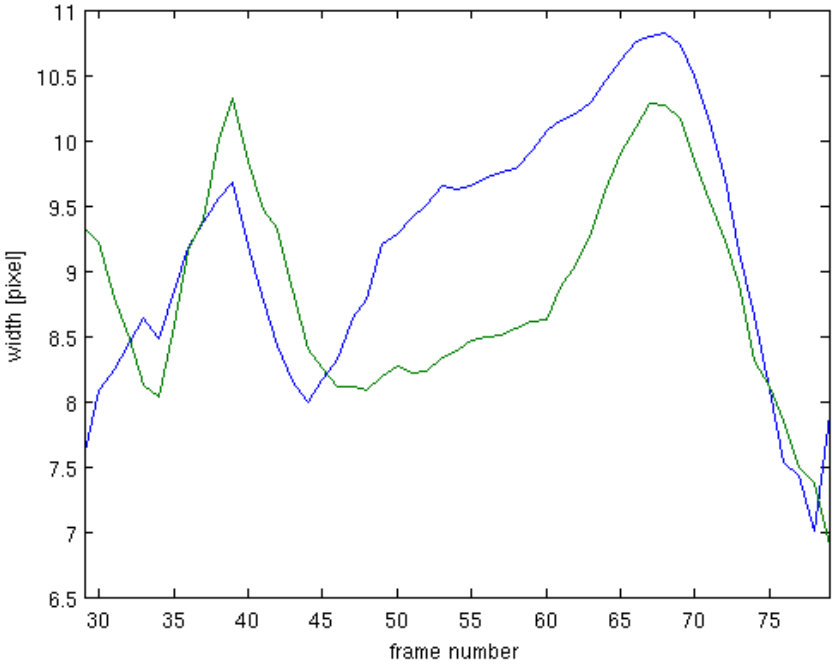


with the incoherent spot computer-graphically removed, saturation at center



Position and Width of the 'Spot'





- Clear indication of the centroid moving transversely

- Width dubious
  - generation process
  - difficult to measure in noisy saturaed backg.

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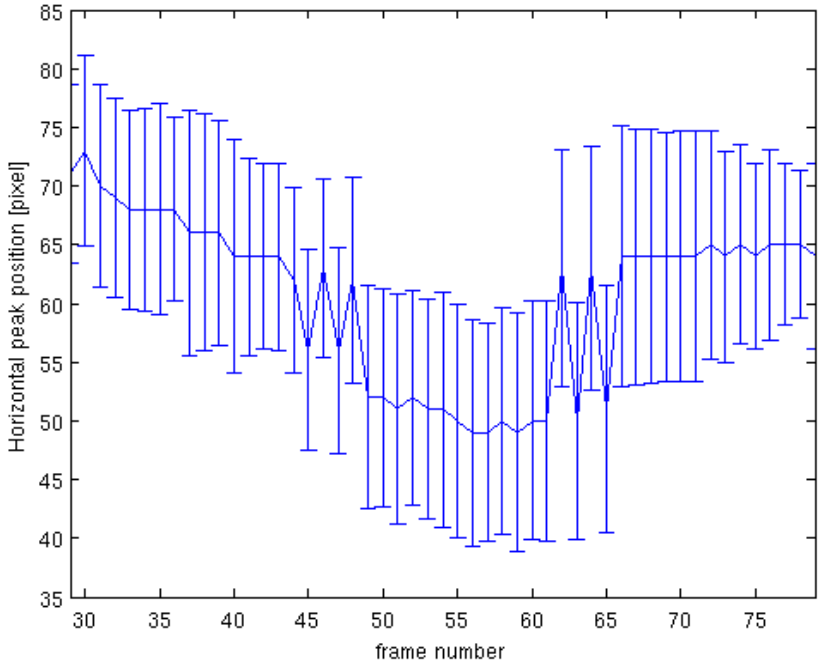
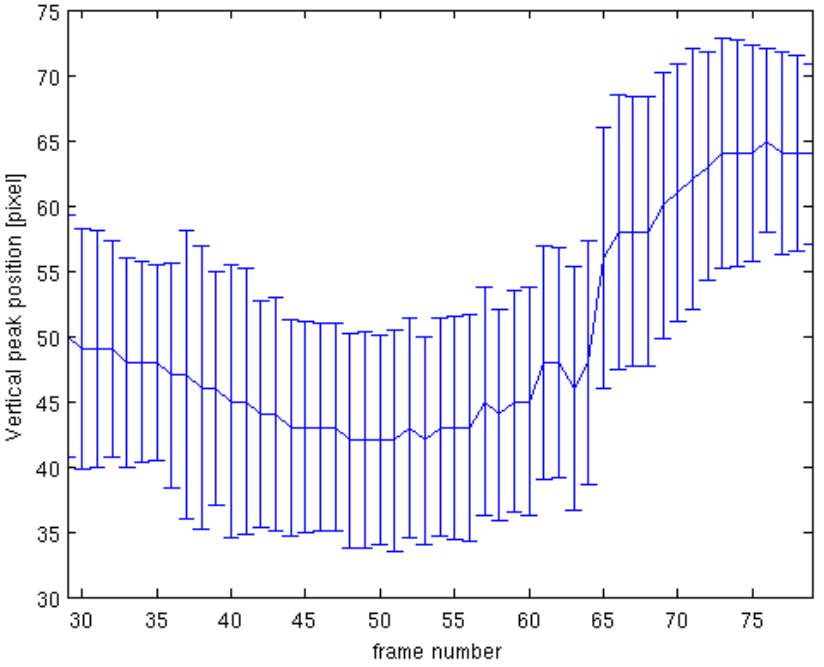
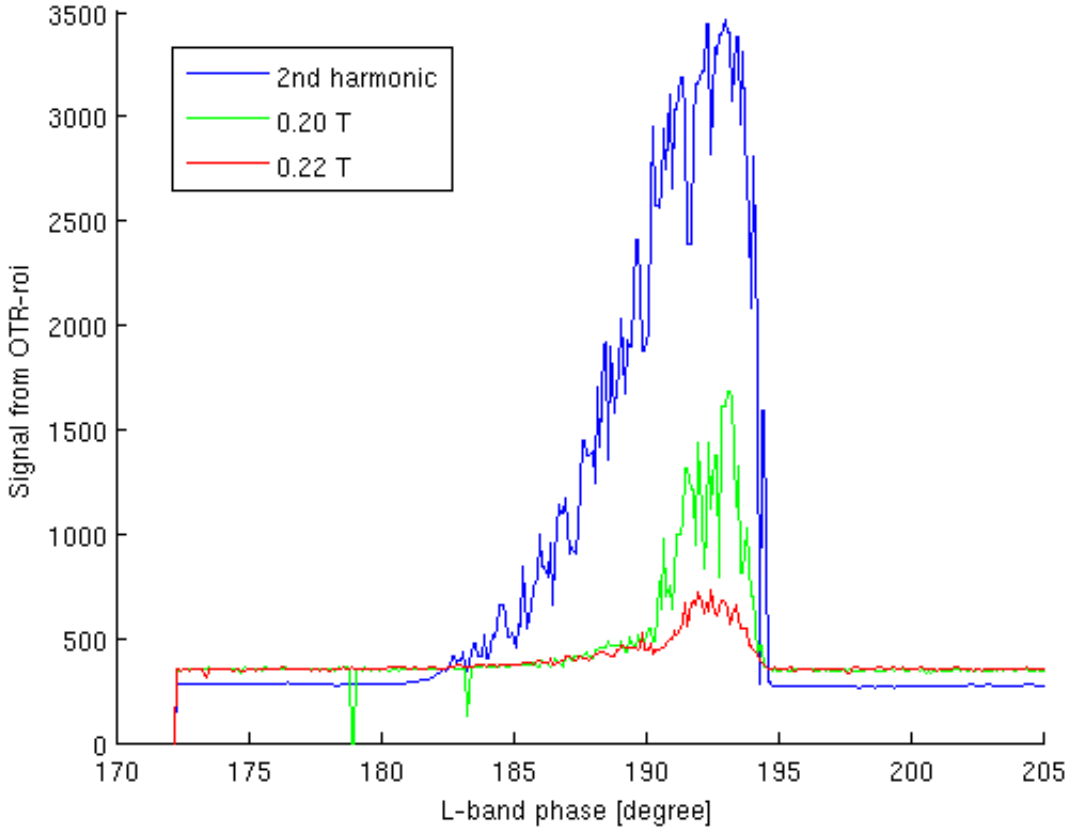
Horizontal and vertical



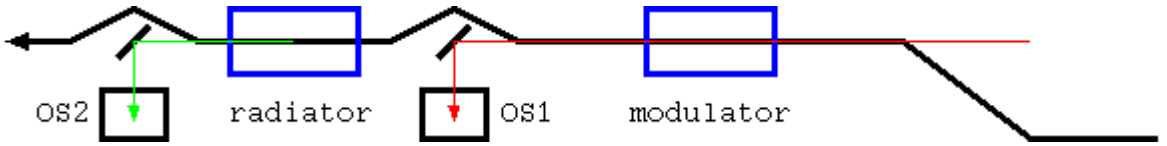


- as I said: dubious

Tune Radiator to 2nd harmonic



- Harmonic Generation
- Tune away from resonance and signal goes down



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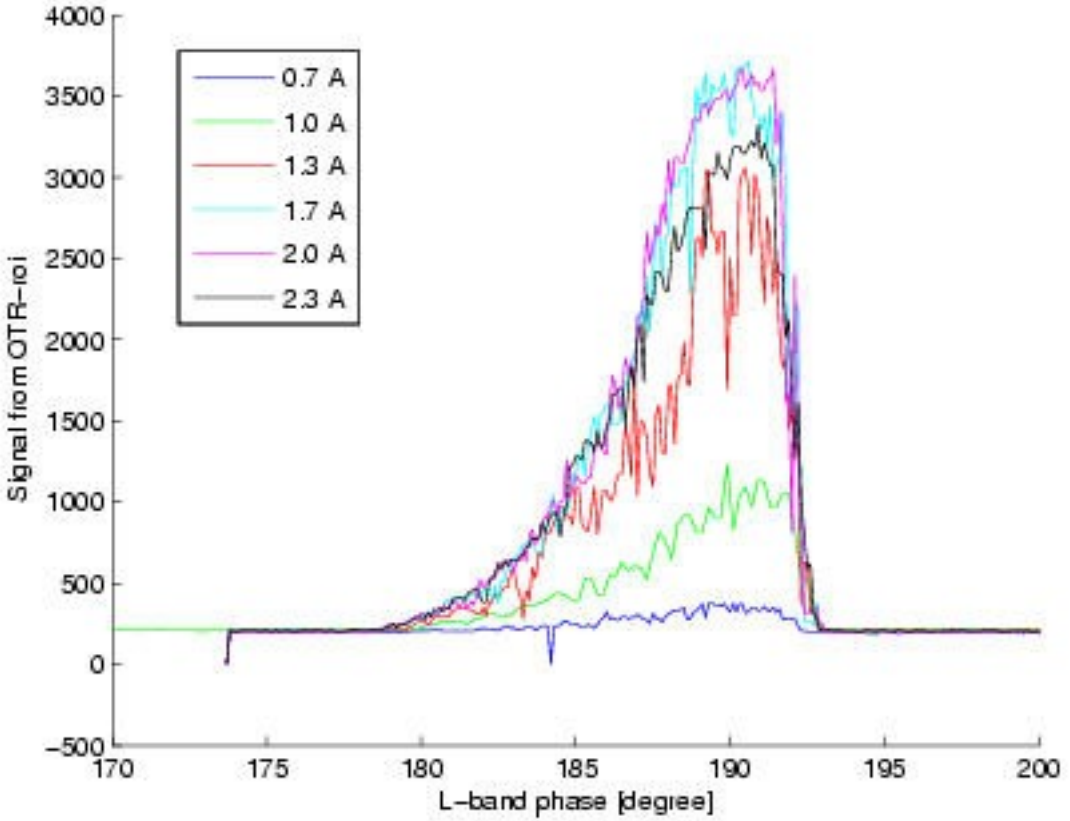
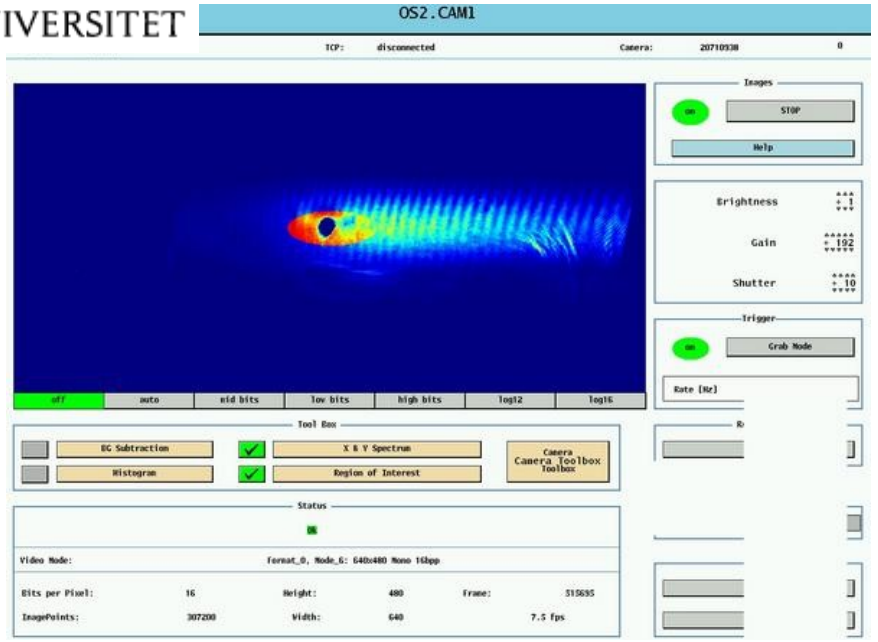
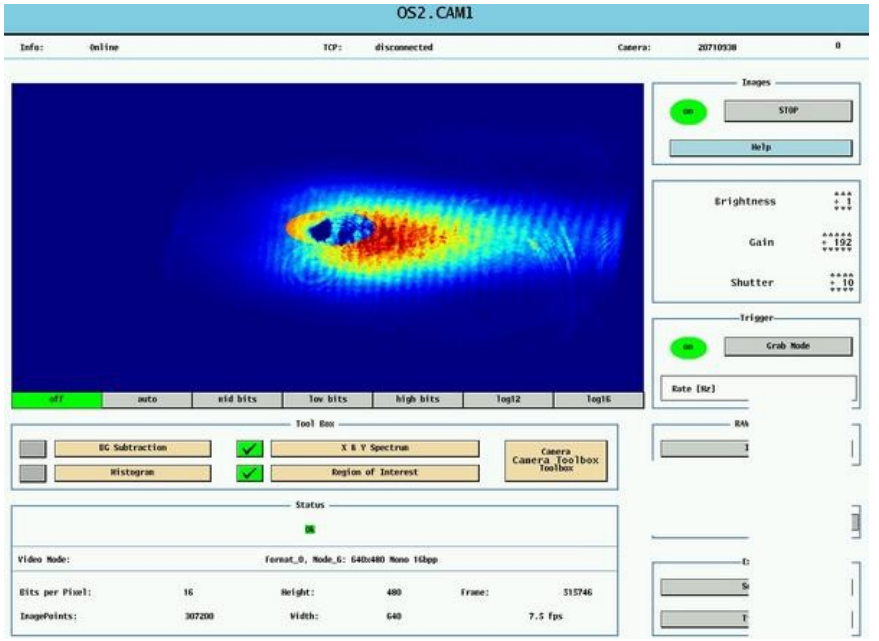
Scanning the chicane excitation



- There is a maximum bunching
- between 1.7 and 2.0 A

Coherent synchrotron radiation





- Maximum, when max overlap
- Likely from the last chicane magnet
- Only on second night, when the alignment of mirrors on optical station 2 had changed.
- Everything lights up once overlap is achieved, had to choke laser

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We're not done yet

- and applied for more shifts in January and March
  - Systematic studies with short (200 fs) laser pulse
  - Scan radiator field through harmonics
  - Decode longitudinal centroid (wake-field tail)
  - Place laser on steep edge of ebeam → timing jitter
  - Recover overlap with short electron bunches and long (2 ps) laser beam
  - Make optical replica and observe it in GRENOUILLE
  - Emergence of CTR with increasing modulation

Conclusions

- We were extremely well-treated by all@DESY
- We got 15 shifts and could actually use them
- Made most of the hardware work simultaneously
- Developed the procedure to achieve overlap
  - Femto-slicing, sort of
  - Second harmonic generation
  - Longitudinal centroid bunch shape
- We'll be back (hopefully).
  - Systematic studies
  - Short bunches and long laser pulse
  - Replica pulse on to the Grenouille

Extra Slides

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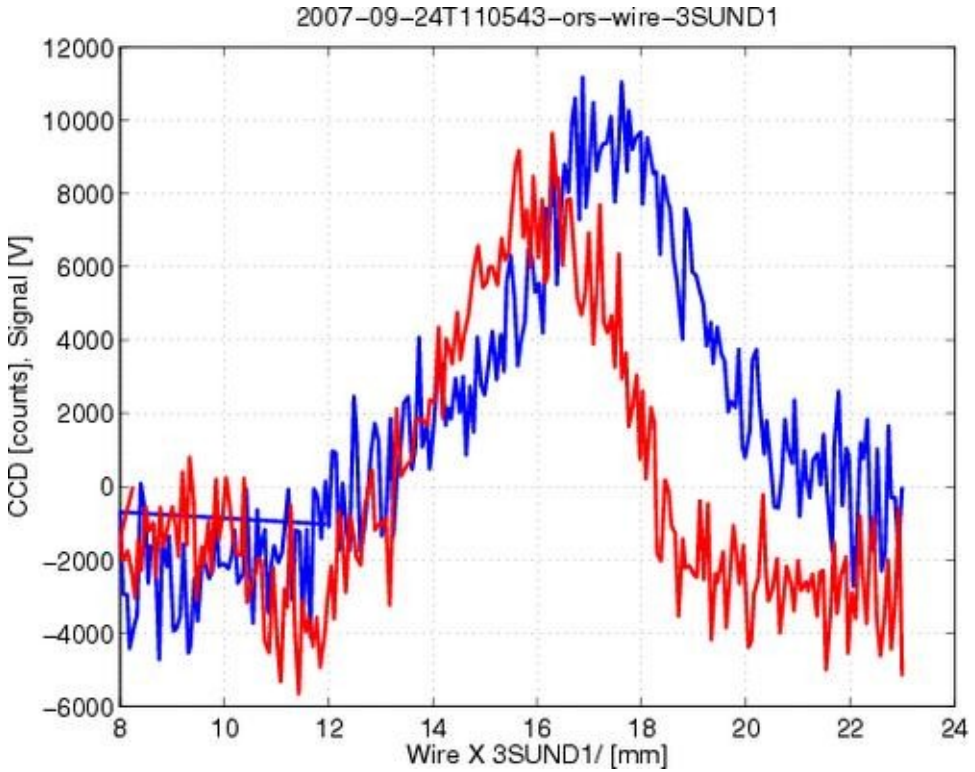
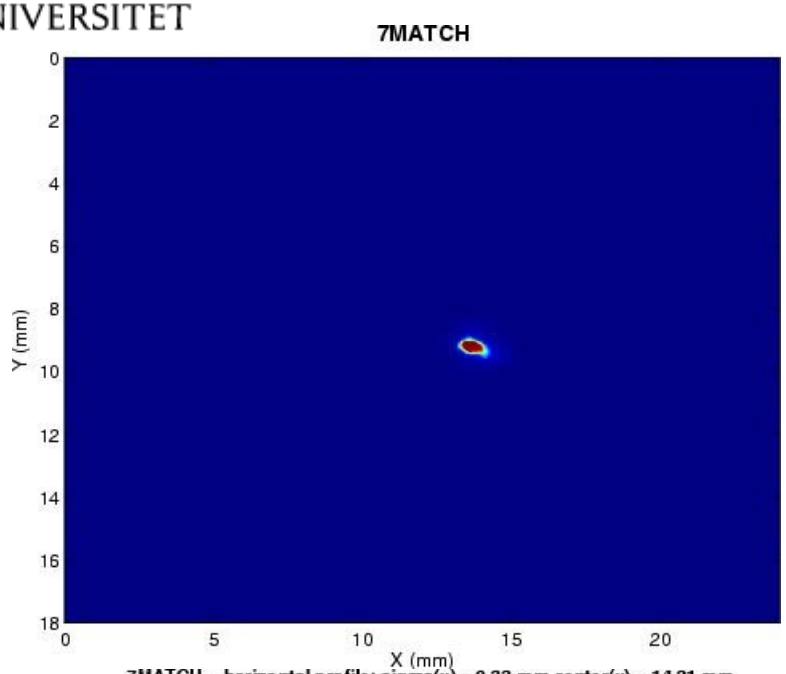
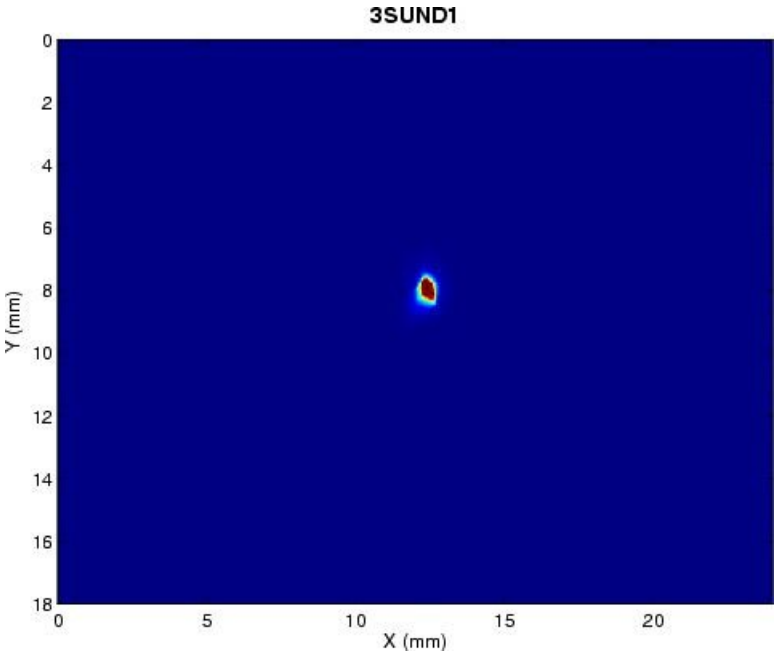
Alignment Laser on Wires

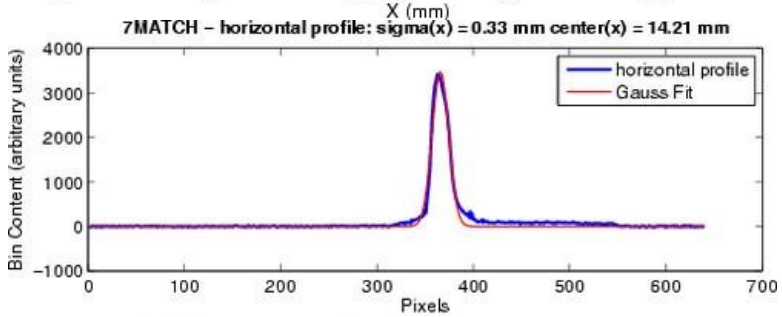


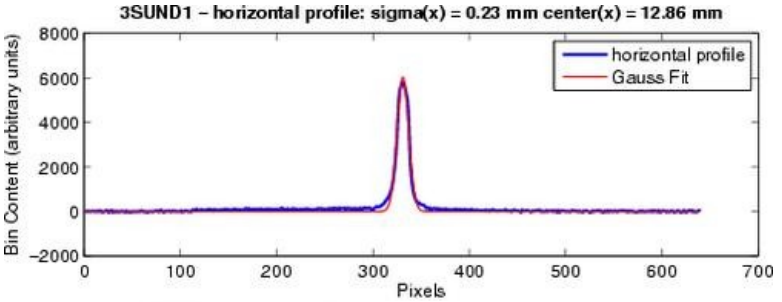
- As backup for 'laser-on-screen' we (mostly Holger) tested to get a signal from the align-ment laser on the wire scanners
- works
-

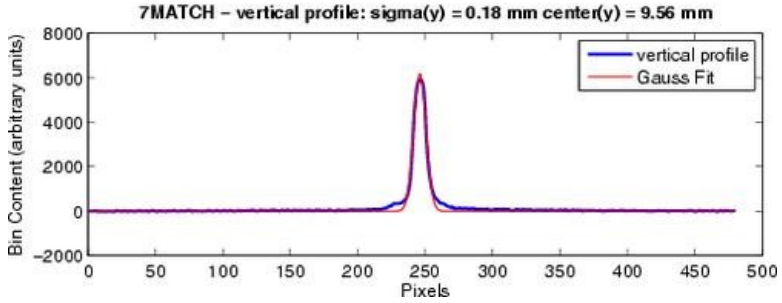
Electron Beam Alignment

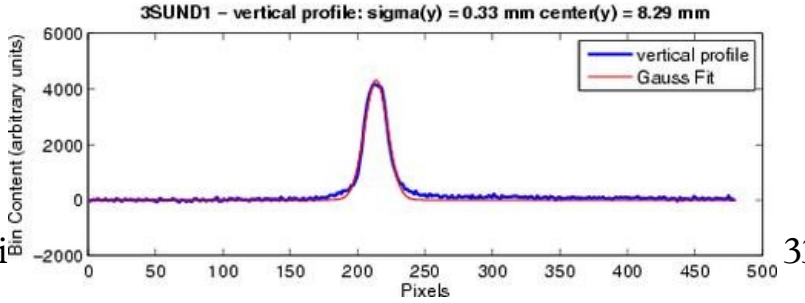




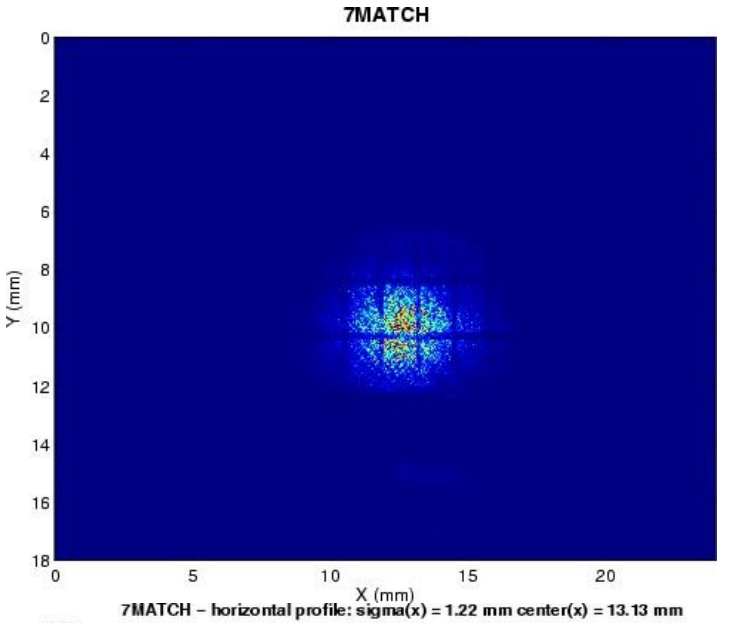


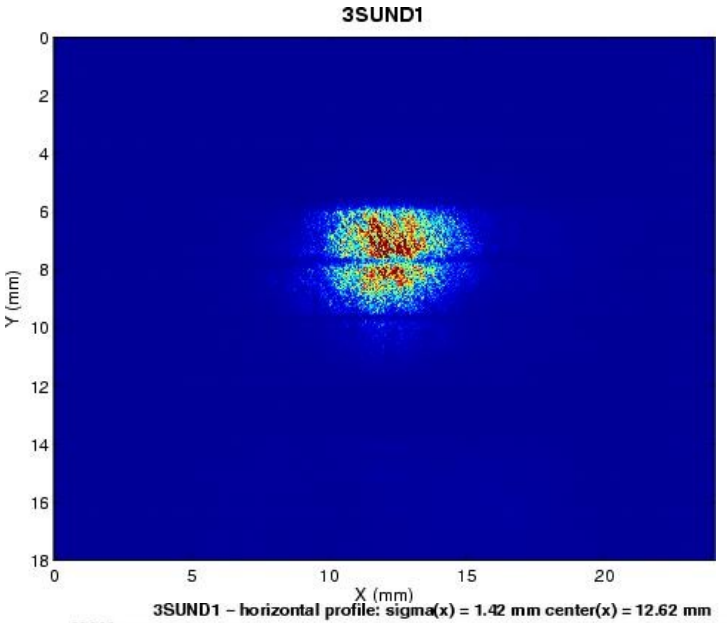


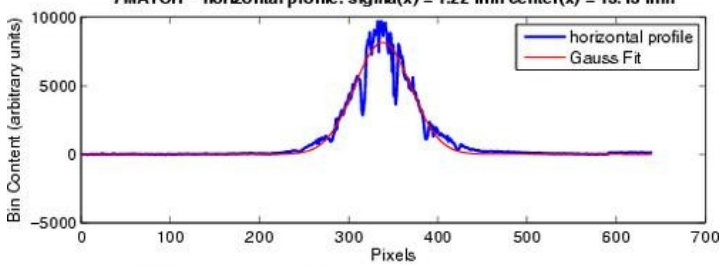


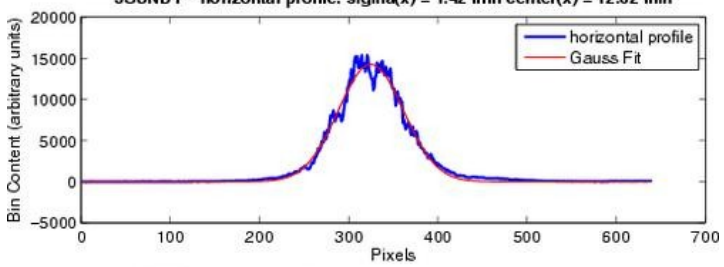


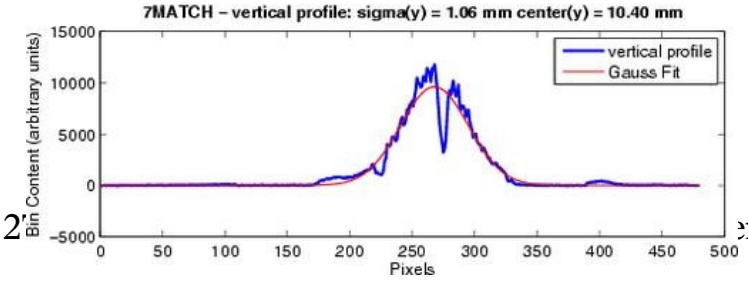
Transverse Laser Alignment on Calibration Screens, 1st try

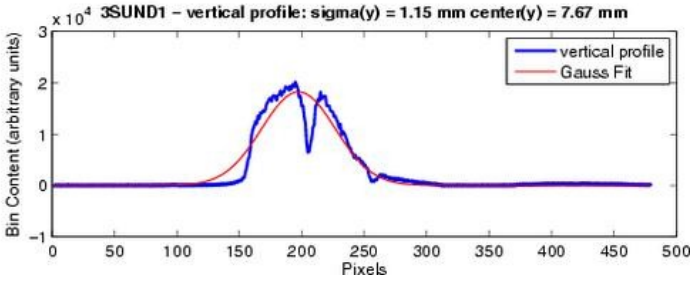












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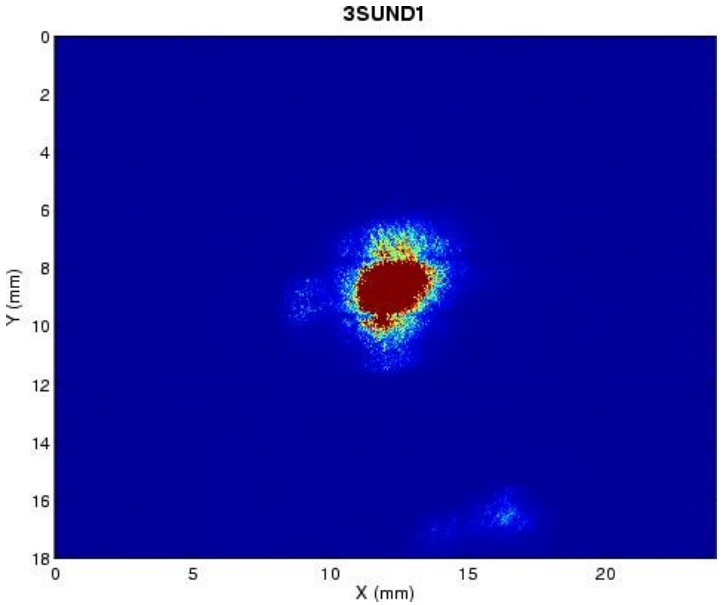
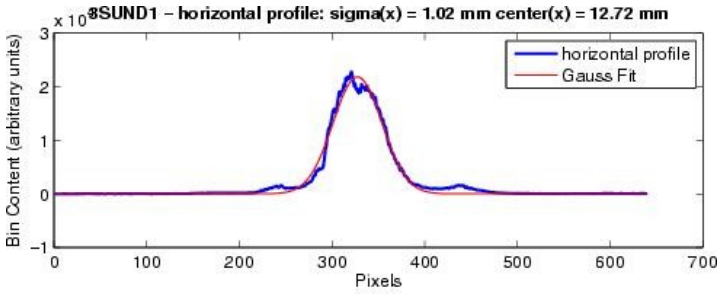
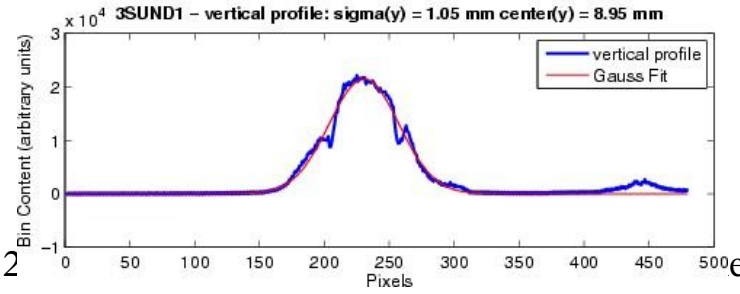
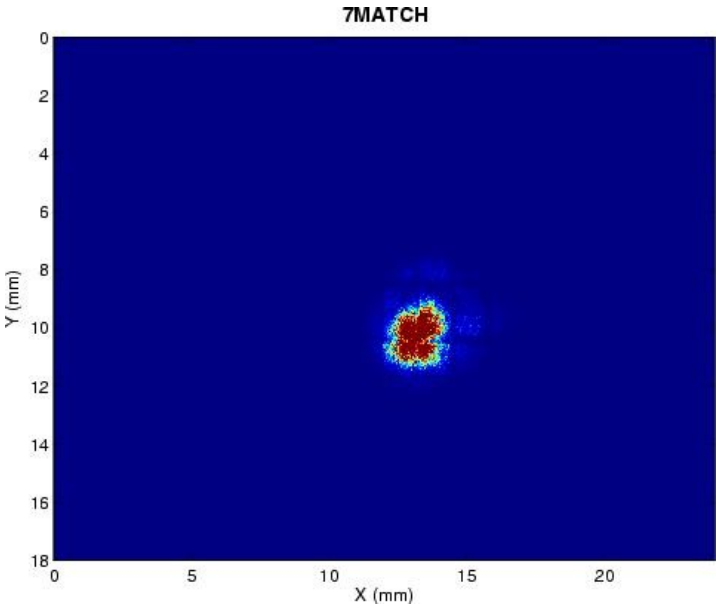
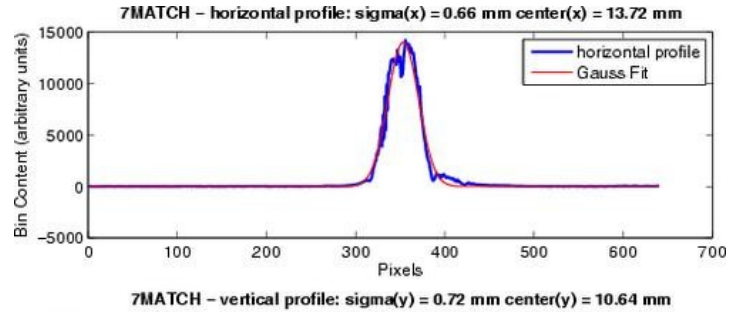
2nd try, focussing and alignment

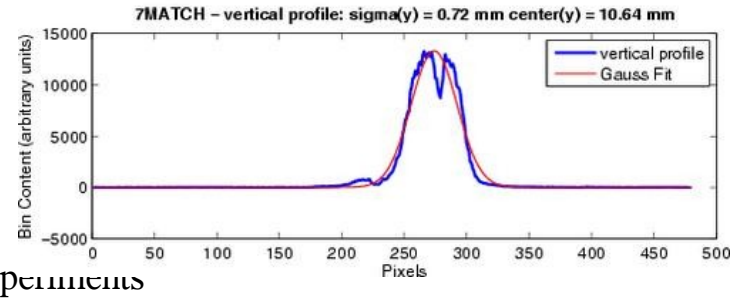












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Electrons, 2nd try, 20:50