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European XFEL

EuXFEL Laser Heater and Optical Replica Synthesizer

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EuXFEL Laser Heater

- Call by the Swedish Research Council for EuXFEL contributions in March 2008
- The group was triggered by the electron-laser theme
- Succesful bid, approved May 2008, but money was only released in October 2010!
- Swedish in-kind contribution to the EuXFEL
  - UU: Volker Ziemann, Mathias Hamberg, Gergana Angelova-Hamberg, Vitaliy Goryashko (from September)
- **So why does EuXFEL need one and what for?**

Why ...

- Electrons are born in the photo cathode with a very small momentum spread (~3 keV)
  - makes them susceptible to microbunching instability on their travel through the linear accelerator and bunching chicanes
- Solution: add decoherence in a well-controlled way to increase momentum spread
  - induce moderate momentum modulation by passing a laser over the electrons in an undulator
  - and smear out by coupling some of the angular spread into the longitudinal plane

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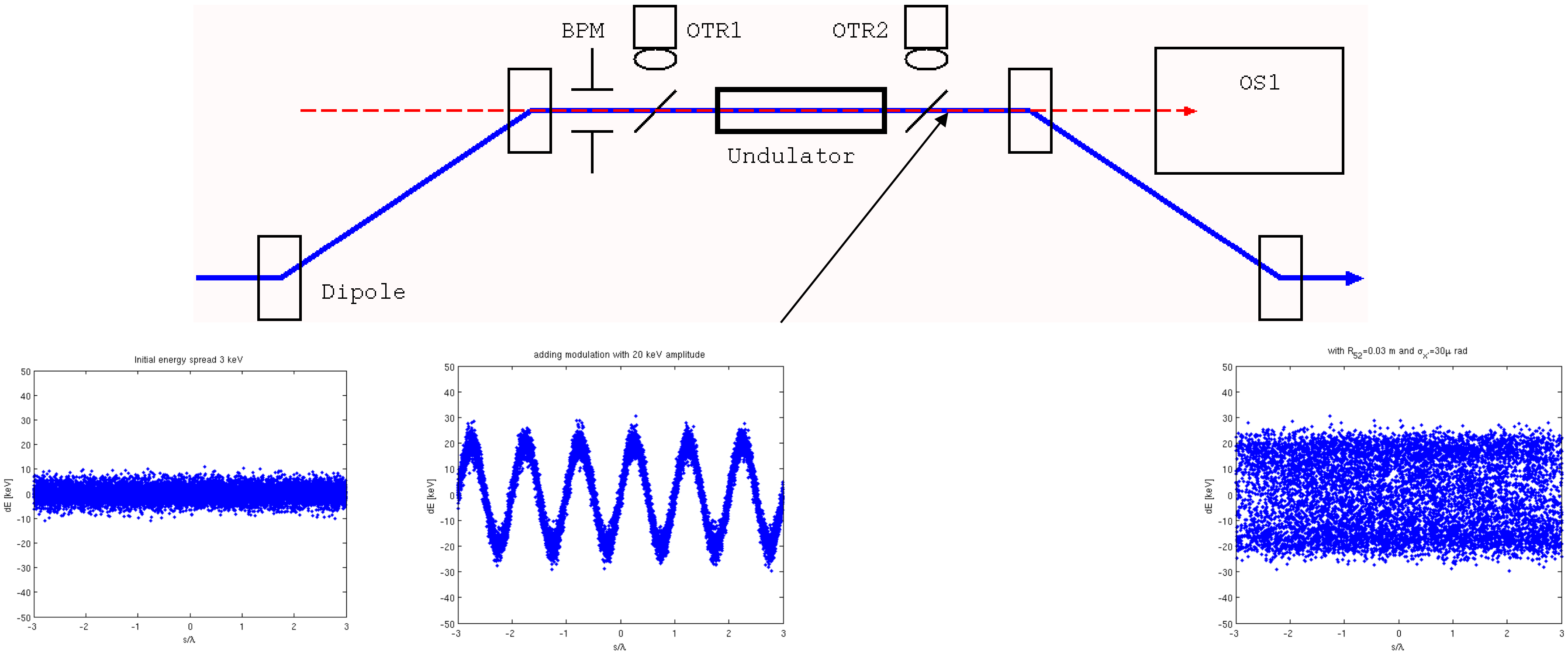
How ...

- Pass IR laser over e-beam in undulator → modulate dE
- R_{52} of 2nd leg of chicane couples 'transverse heat' into the longitudinal plane and smears out the modulation

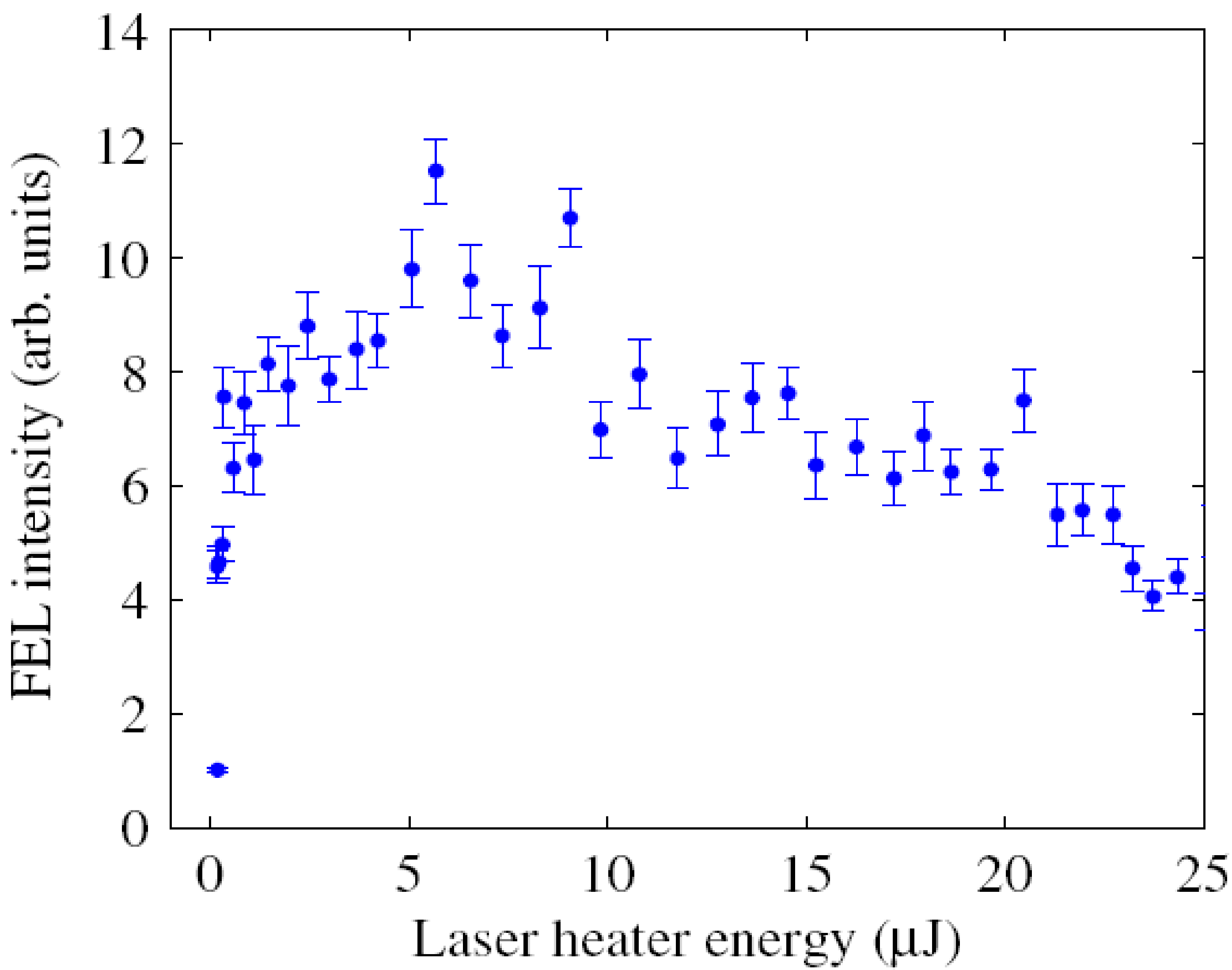


Parameters

- Will use 1030 nm photons
- Operate between 110 and 160 MeV
- Permanent magnet undulator with variable gap → B_0=0.11-0.27 T
- 8+2 periods of l=74 mm
- Chicane offset 30 mm
- Pulse energy up to 50 uJ (2.5 MW, 20ps)
- σ ~ 0.2 mm

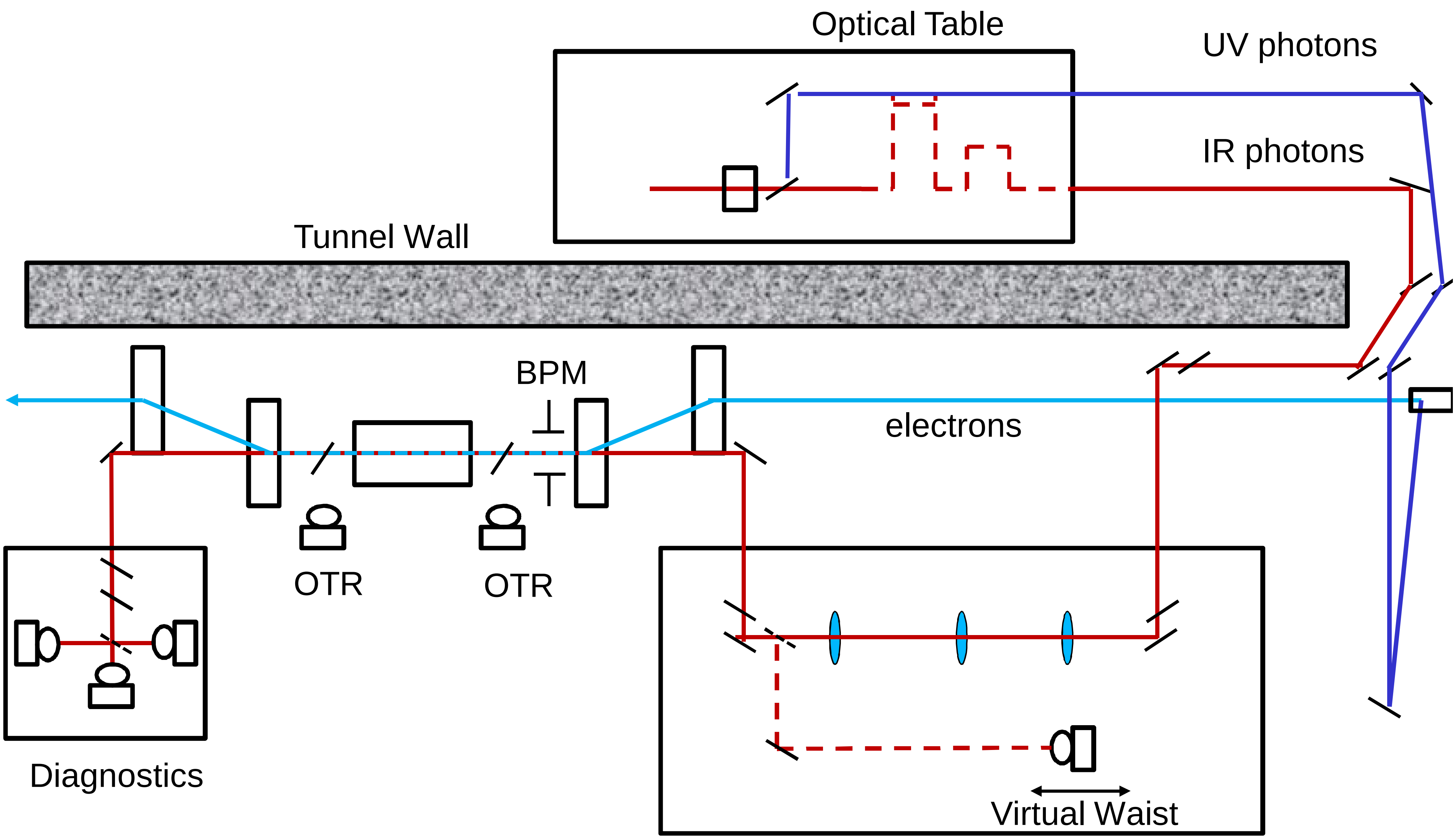
Experience from LCLS

Z. HUANG *et al.* Phys. Rev. ST Accel. Beams **13**, 020703 (2010)



- FEL intensity increases

Laser Heater Layout



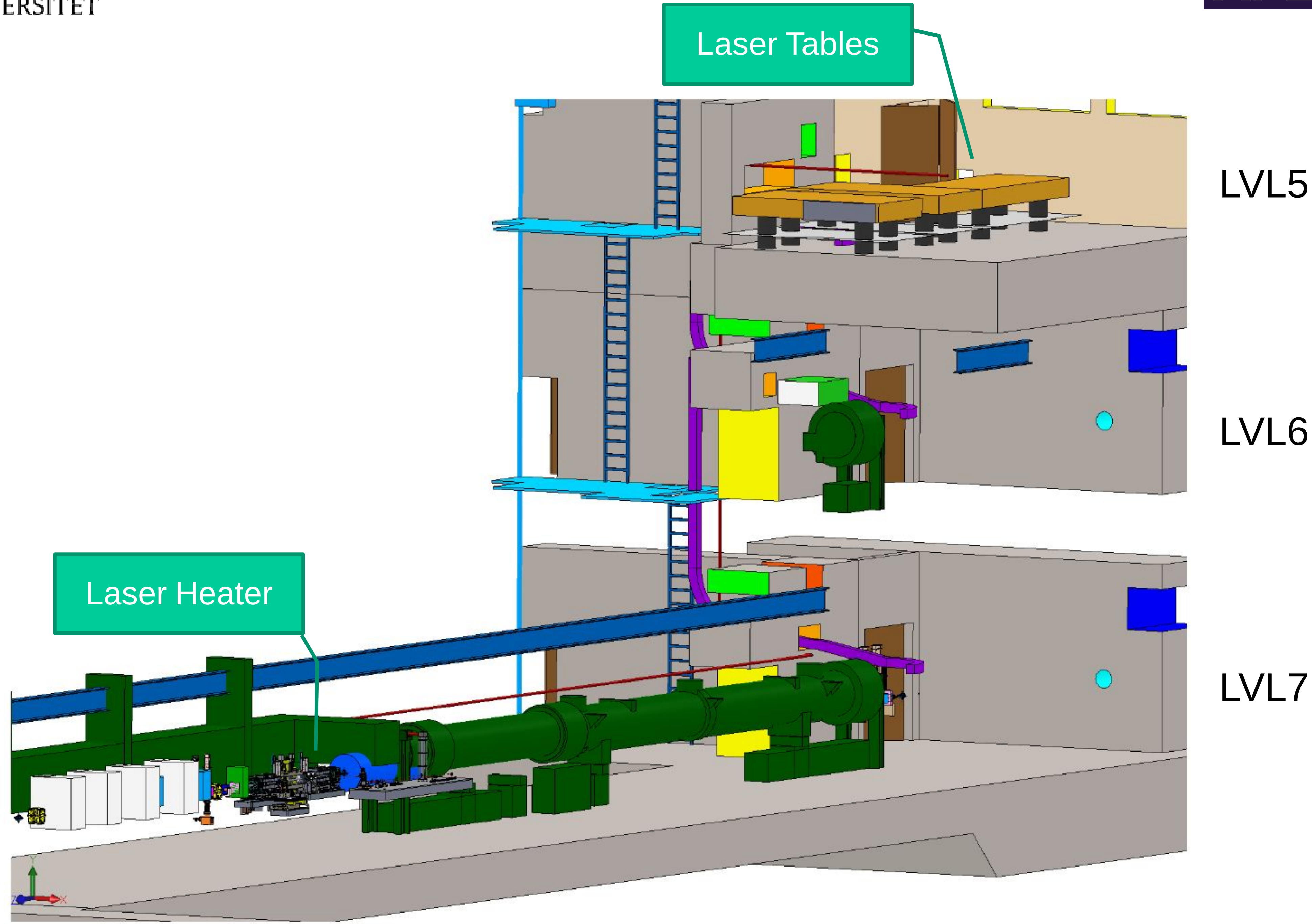
Obtaining 1030 nm Photons

- Use the non-converted "red" photons from the first frequency doubling (red2green) stage
  - Inherently locked in timing to the parent UV photons for the entire pulse train
  - Selective mirror to separate UV from IR
  - Intensity according to Ingo Will is 30 to max 50 µJ. This is adequate for routine operation, but for start-up and commissioning more is desirable (LCLS has 200 µJ available).
- Plan: study stability of photons (intensity, pointing, M2)

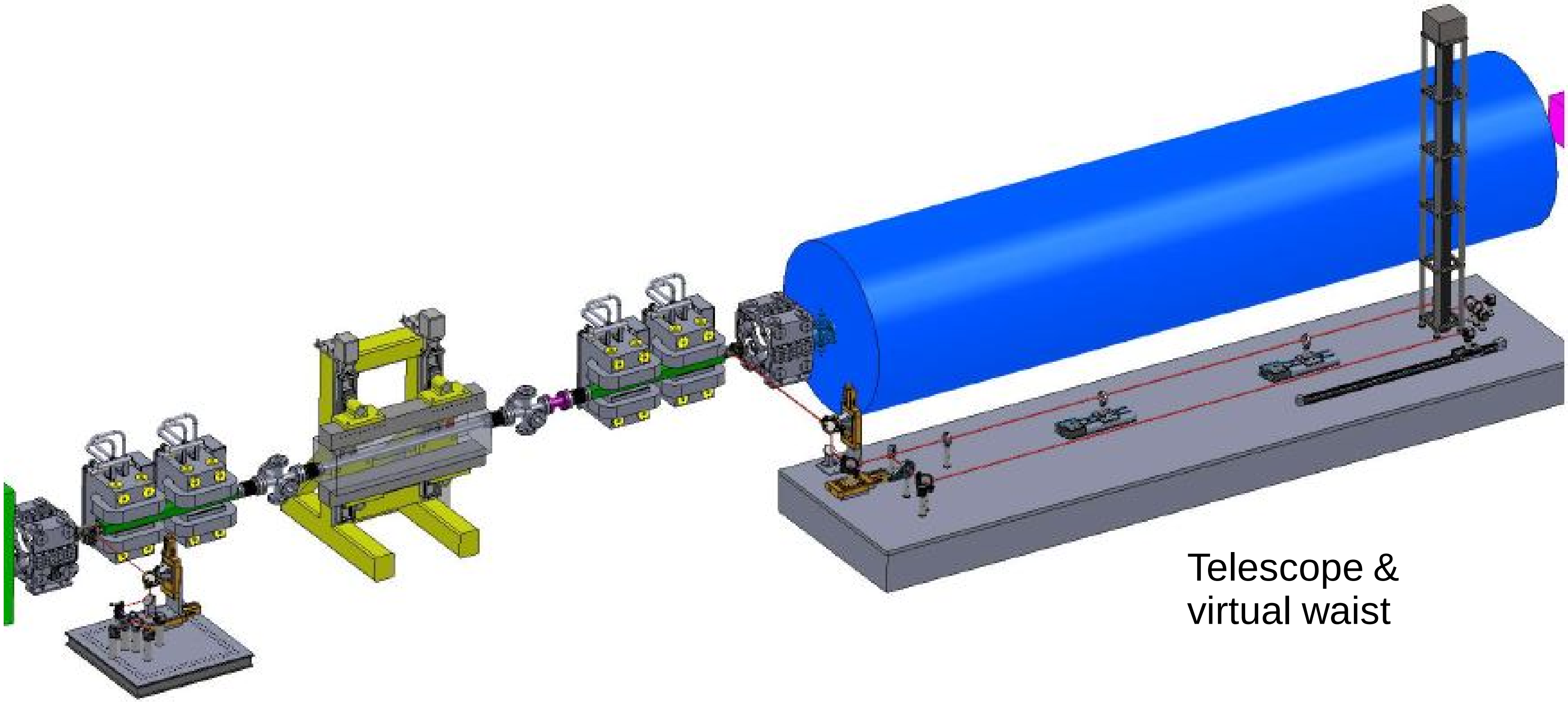
Transporting the photons

- Long (~50 m) transport path through 'hostile' environment such as the vertical shaft
- Evacuated pipe to avoid refractive index changes
  - moderate vacuum ok but will use ion pumps to avoid mechanical noise
- Mirror mounts and pointing stability
  - passive stability to counteract fast jitter
  - slow feedback near undulator to counteract drifts
- Dielectric mirrors, use "spill" for target practice

Injector building



Optical Table(s)



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Diagnostics on Laser Table

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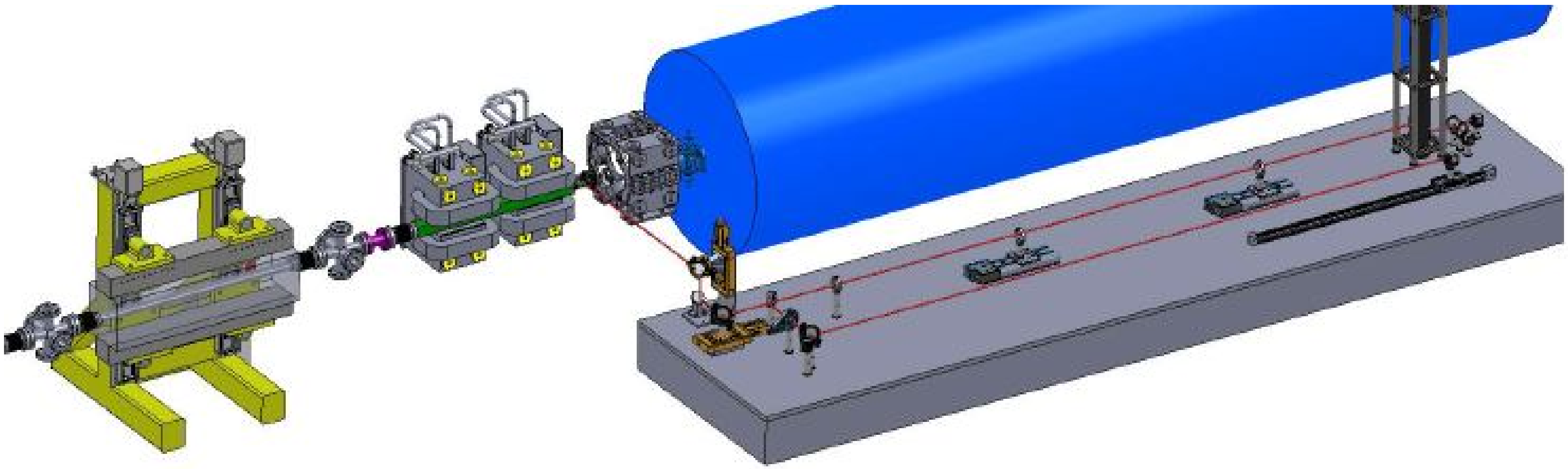
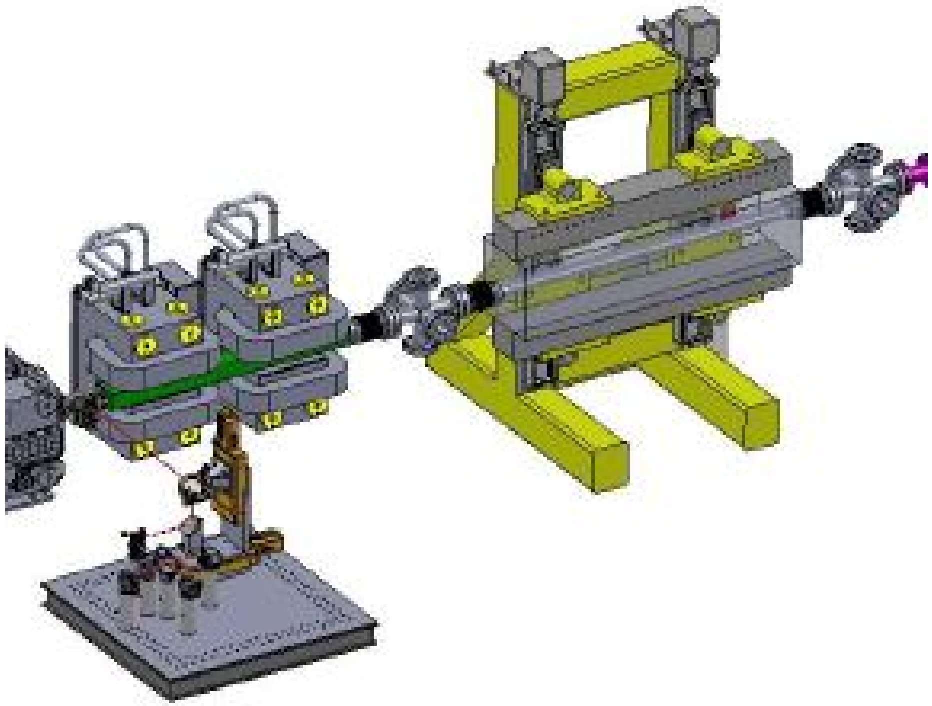
- **First table**
  - Telescope
  - photon waist size and position
  - control transverse position
- **Laser Stabilization system**



Diagnostic Table(s)

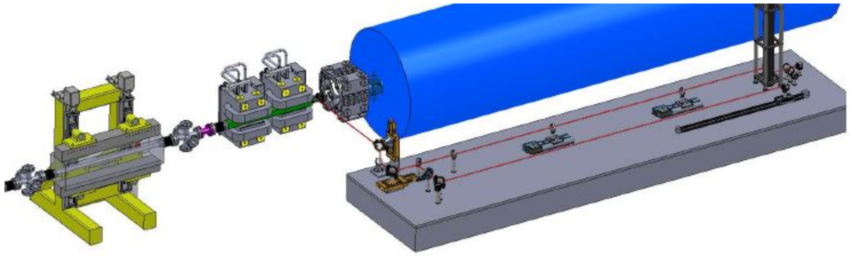
- **Diagnostics after undulator**

  Online Monitoring
  - photon beam position (4Q)
  - photon beam size (camera)
  - Timing (photo diode)

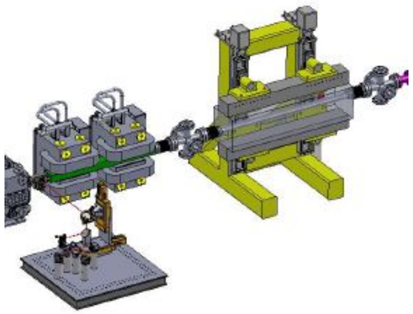


Overlap diagnostics

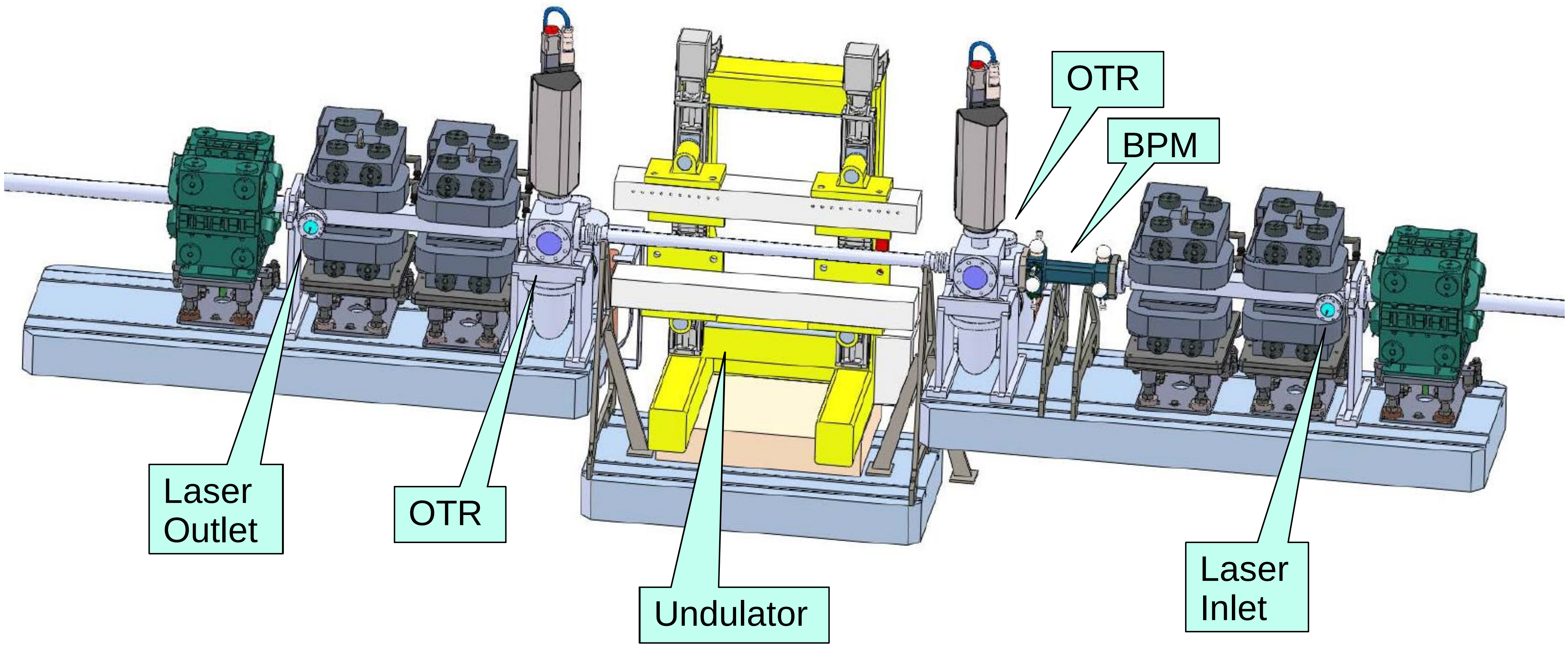
- **Transverse overlap**
  - OTR Screens before and after the undulator
  - XY-Control: in periscope



- **Longitudinal overlap**
  - Diagnostic: fast photo-diode and oscilloscope (20 ps pulses) laser and synchrotron light
  - Control: delay stage in laser hut



Laser Heater Overview



Transverse Overlap with OTR

- Need to determine
  - the position and
  - the beam size of laser and electrons

- Reqested accuracy is about 10-15% of beam size or at least 20 to 30 µm in both planes
  - because a ten precent size mismatch between laser and e-beam becomes visible in the momentum distribution.

Laser Heater Conclusions

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- Laser heater is a Swedish in-kind contribution to the EuXFEL project done by Uppsala University.
- Started for real early 2011.
- We are working on engineering solutions (Mathias Hamberg, Niklas Johansson, Masih Noor)
- Simulations and tolerance calculations are in progress. (Martin Dohlus and Vitaliy Goryashko)
- Undulator parameters are fixed and draft of tender is in the works.

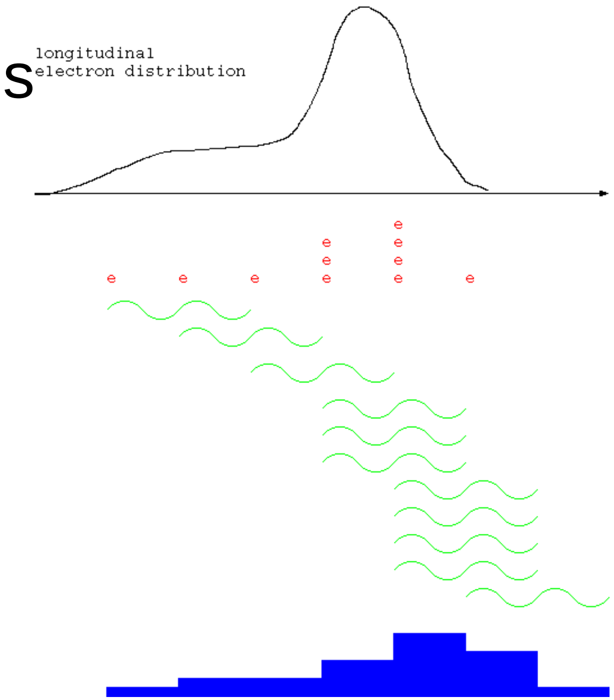
Optical Replica Synthesizer in FLASH

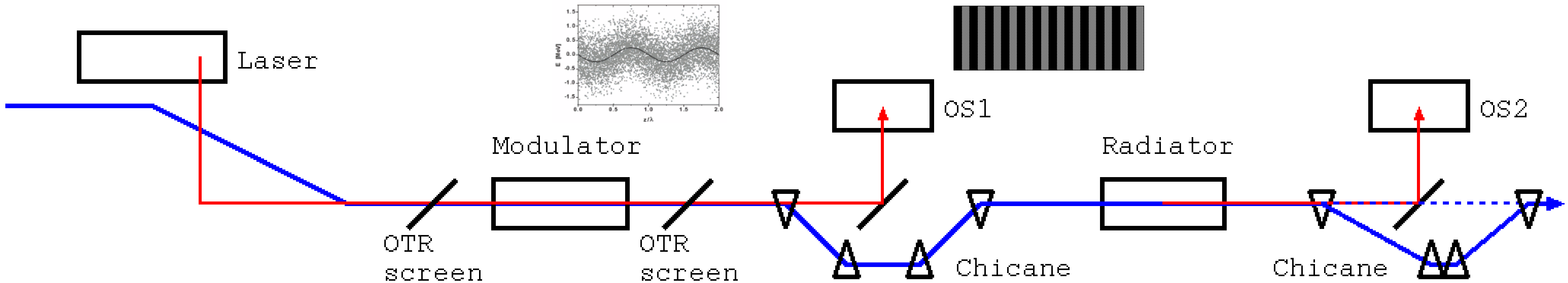
The original ORS collaboration:

G. Angelova, VZ, *Uppsala University*
P. van der Meulen, P. Salén, M. Larsson, *Stockholm University*
H. Schlarb, J. Bödewadt,E. Saldin, E. Schneidmiller,
M. Yurkov, F. Löhl, A. Winter, DESY
S. Khan, *DELTA, TU Dortmund*
A. Meseck, *BESSY*

The Idea behind the ORS

- Problem: measure ultra-short bunches in the 10's of fs range:
  - too fast for electronics (10 Gs/s, 100 ps)
  - but laser folks know (autocorrelation, FROG)
- Solution: make an optical copy of the electron bunch and analyze that with laser methods.





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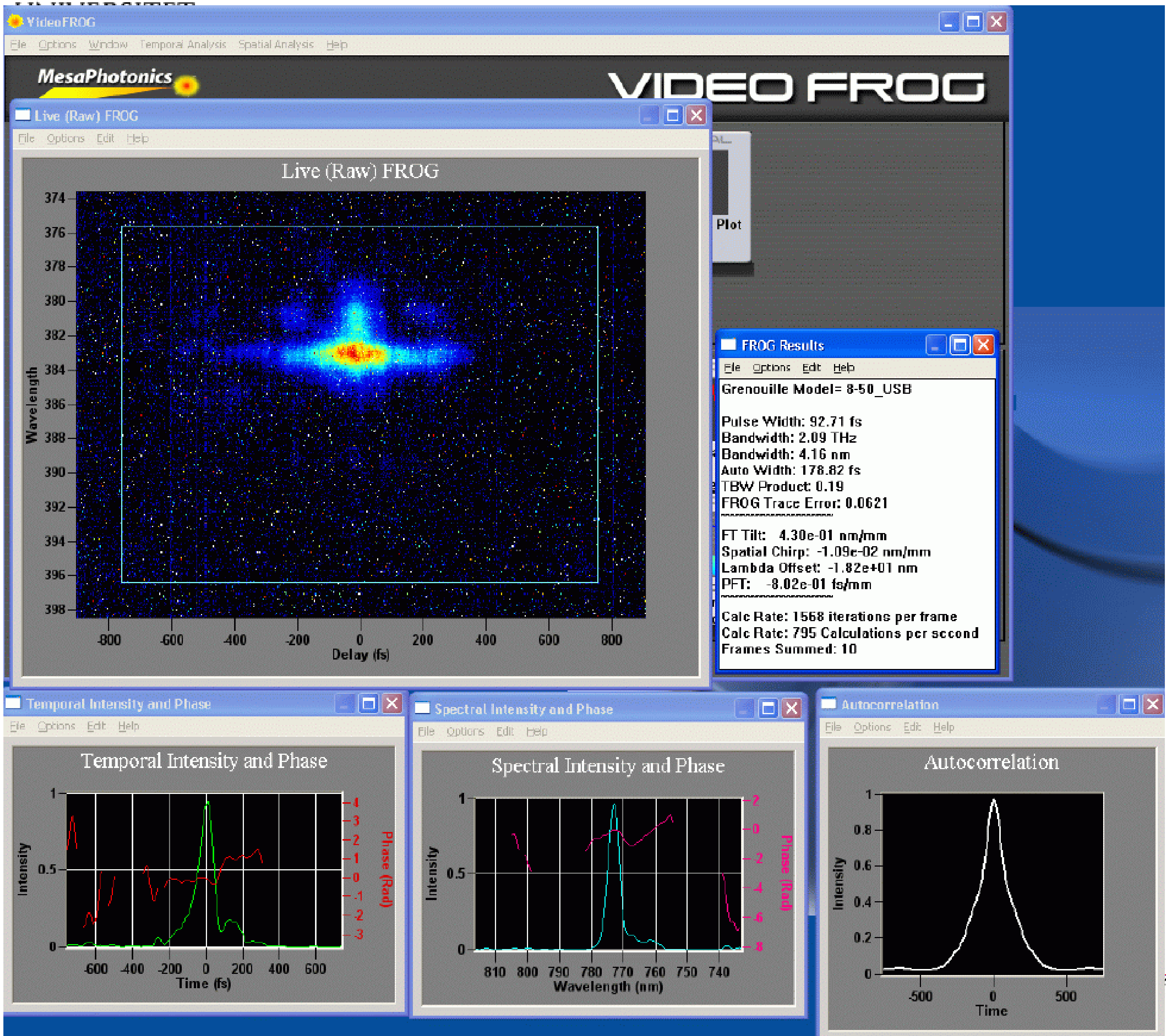
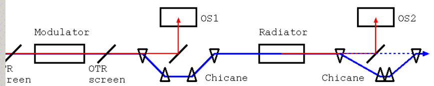
...finally: Single-shot FROGs

Optical Replica



From radiator (HILDA)



ORS Conclusions

- Installed and commissioned the optical replica synthesizer in FLASH since fall 2007

- We managed to hit the electron bunch with laser

- Eventually recorded online FROG traces from the short-pulse GRENOUILLE

Thank you for you attention!