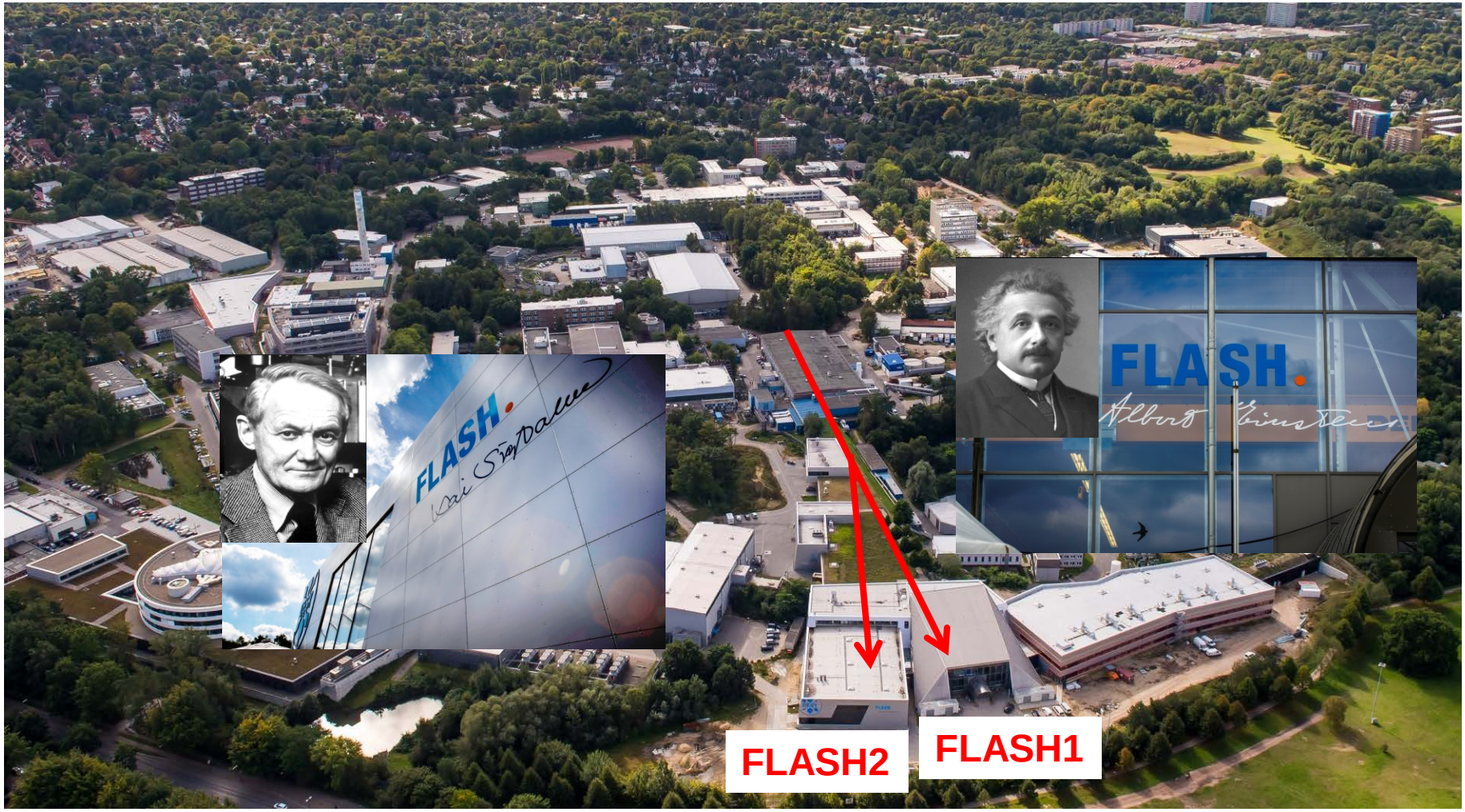
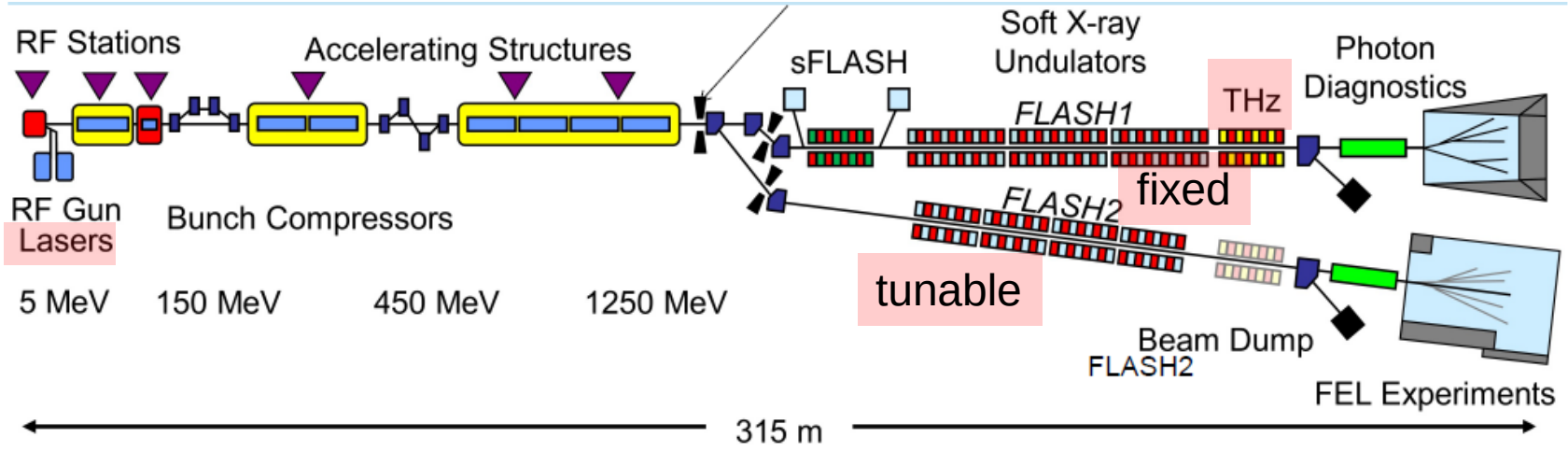
FLASH – the first XUV – Soft X-Ray Free-Electron Laser



Start of user operation 2005

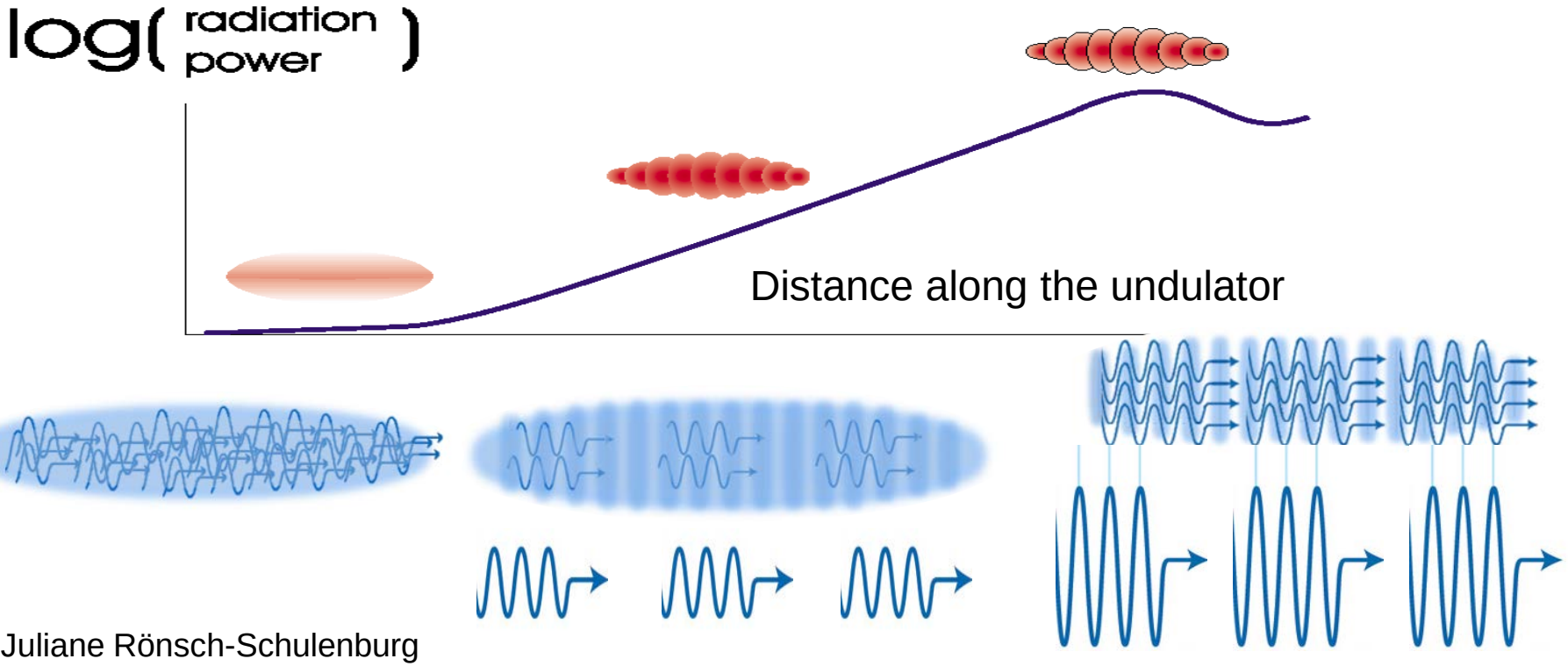
FLASH – FLASH1 and FLASH2



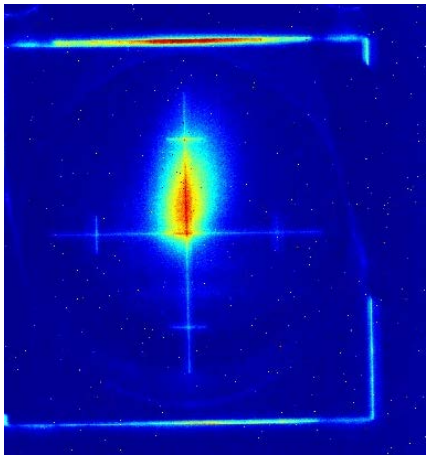
Photon energy range (1st Harmonic): 30-300eV tunable
up to 8000 pulses/s, pulse energy up to 500µJ

- **Only high repetition rate XUV and soft x-ray FEL world-wide**
- **Starting 2016 two independent FEL lines for users in parallel**
- **Very short FEL pulses (3fs-200fs)**
- **Fully optically synchronised**
- **Integrated THz sources**

SASE free-electron lasers

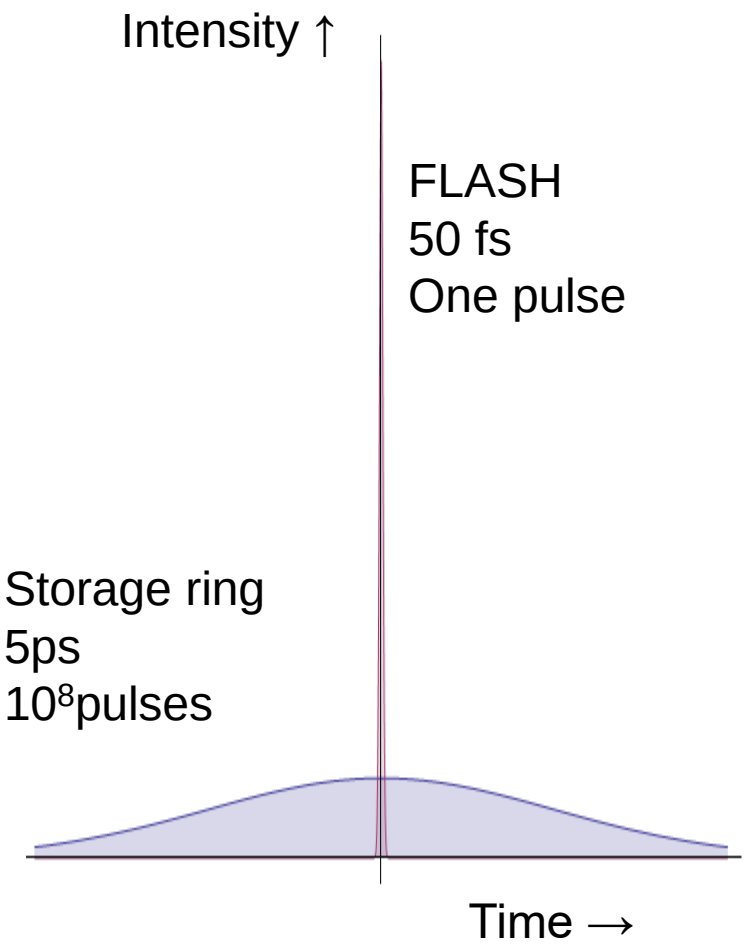


© Juliane Rönsch-Schulenburg



Self Amplified Spontaneous Emission = SASE

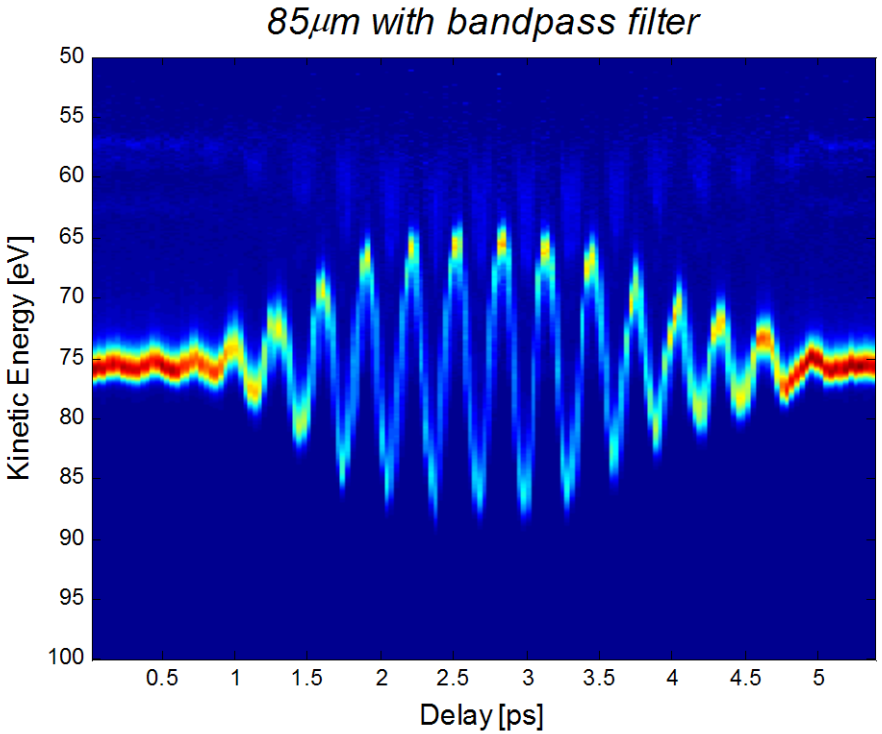
Extreme brillance – ultrashort pulses



Photon energy range: 30-300eV

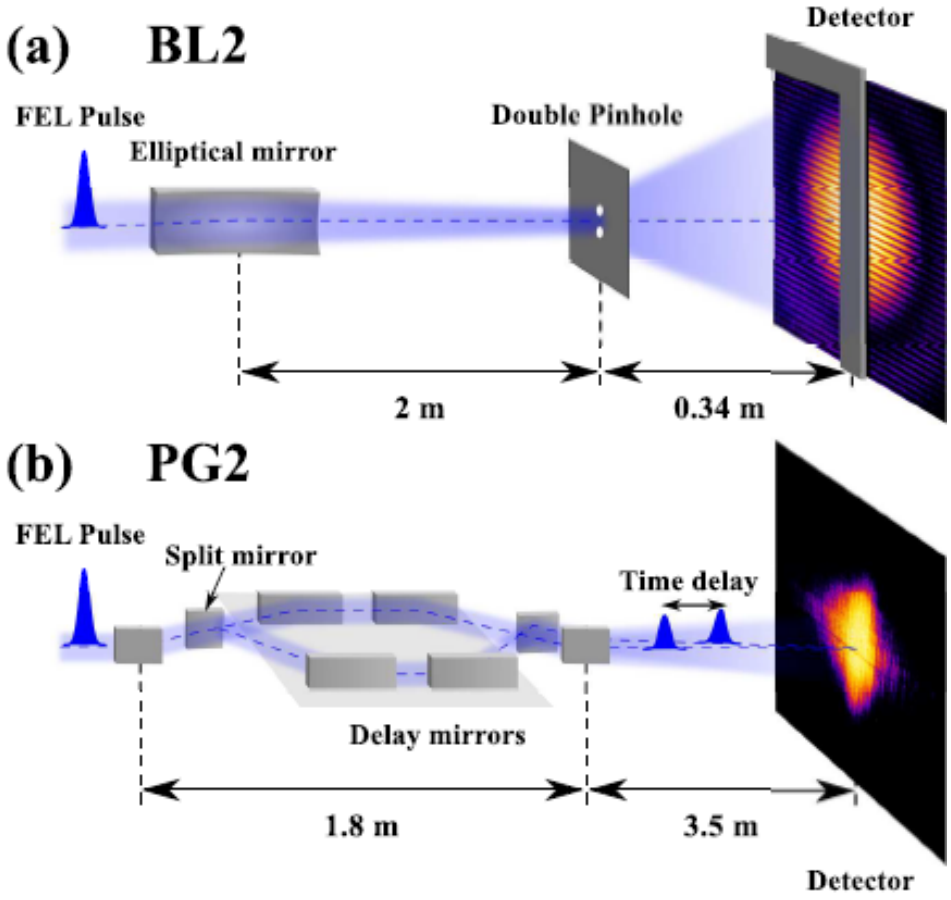
Photoelectron pulses image light fields

Krypton 4p photoelectrons emitted with 13.5nm FLASH pulses in a THz field

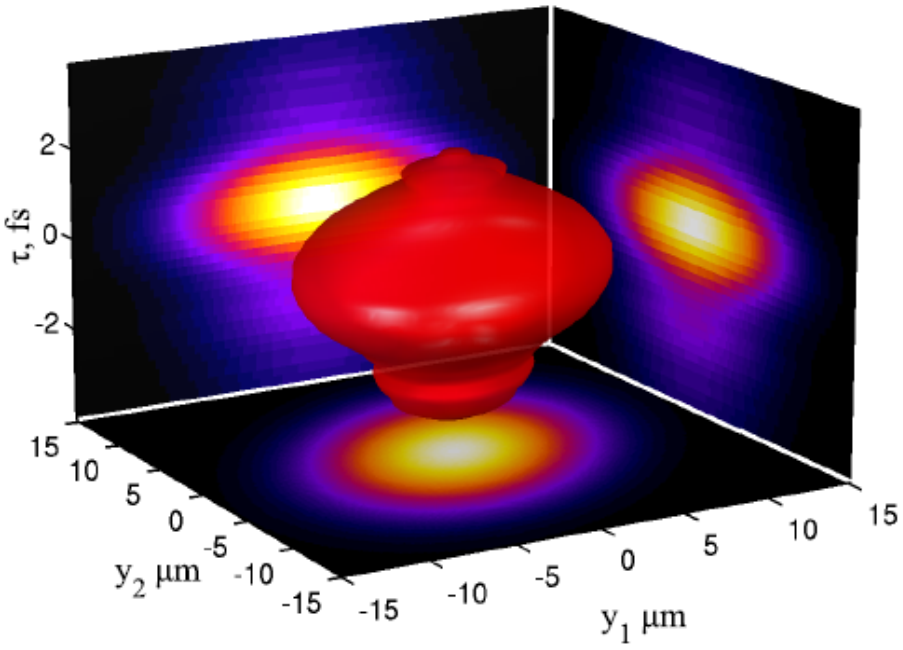


Ulrike Frühling et al.
Nat. Photonics 3, 523, (2009)

Coherence properties of FLASH



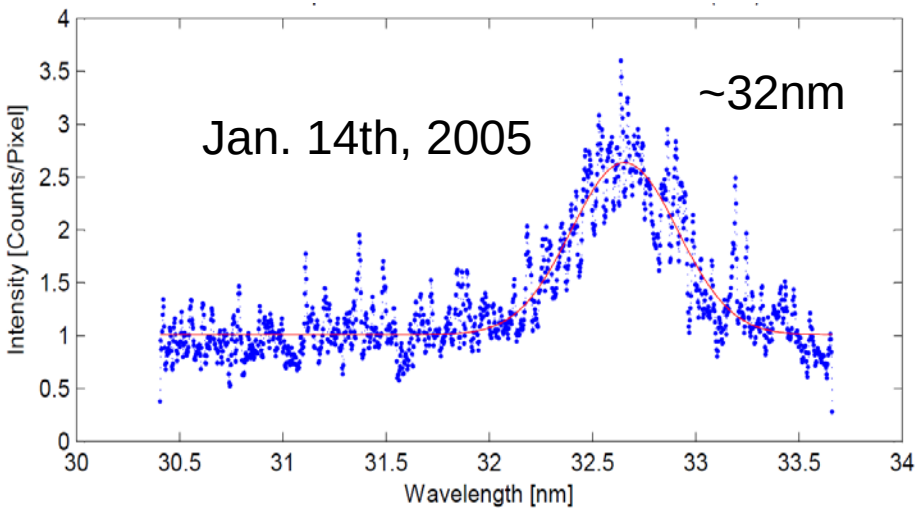
Mutual coherence function

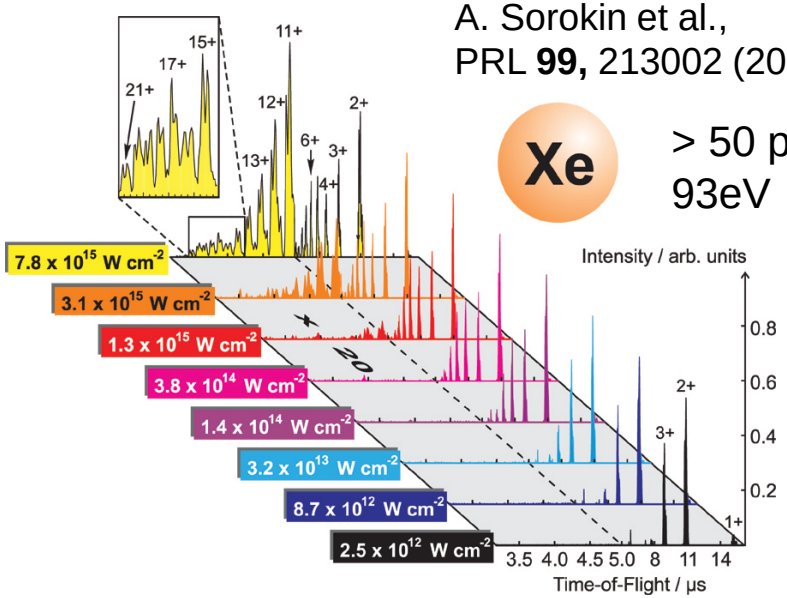


About 1% of total power in a single mode
~10^{10} photons

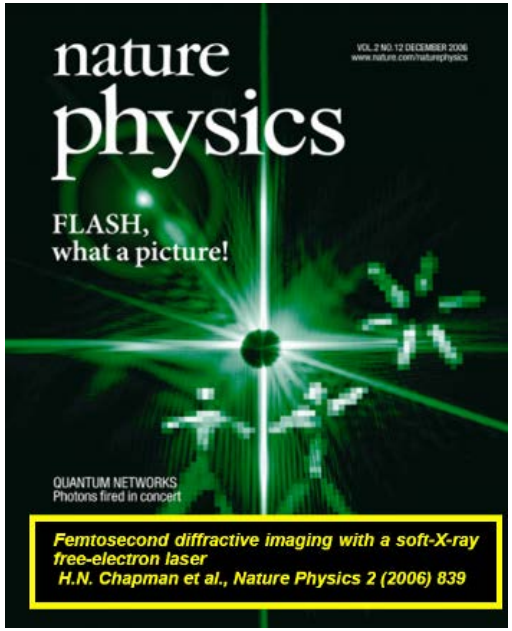
collaboration with the group of I.A. Vartanyants
A. Singer et al., Optics Express 16, 17480 (2012)

FLASH - 10 years of operation as a user facility

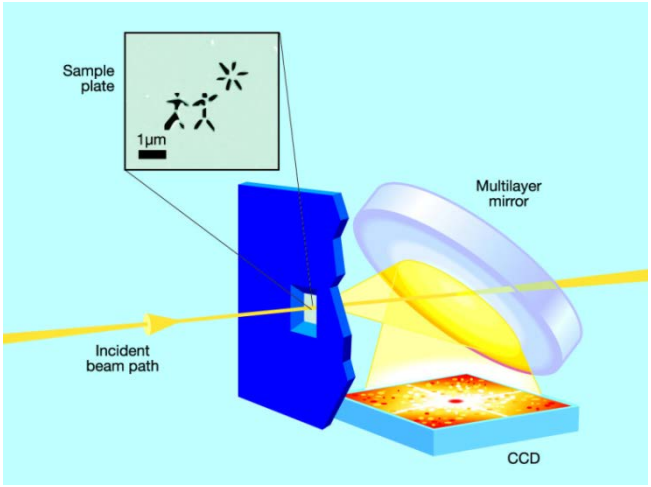




Nonlinear light-matter interaction



Single shot coherent diffractive imaging



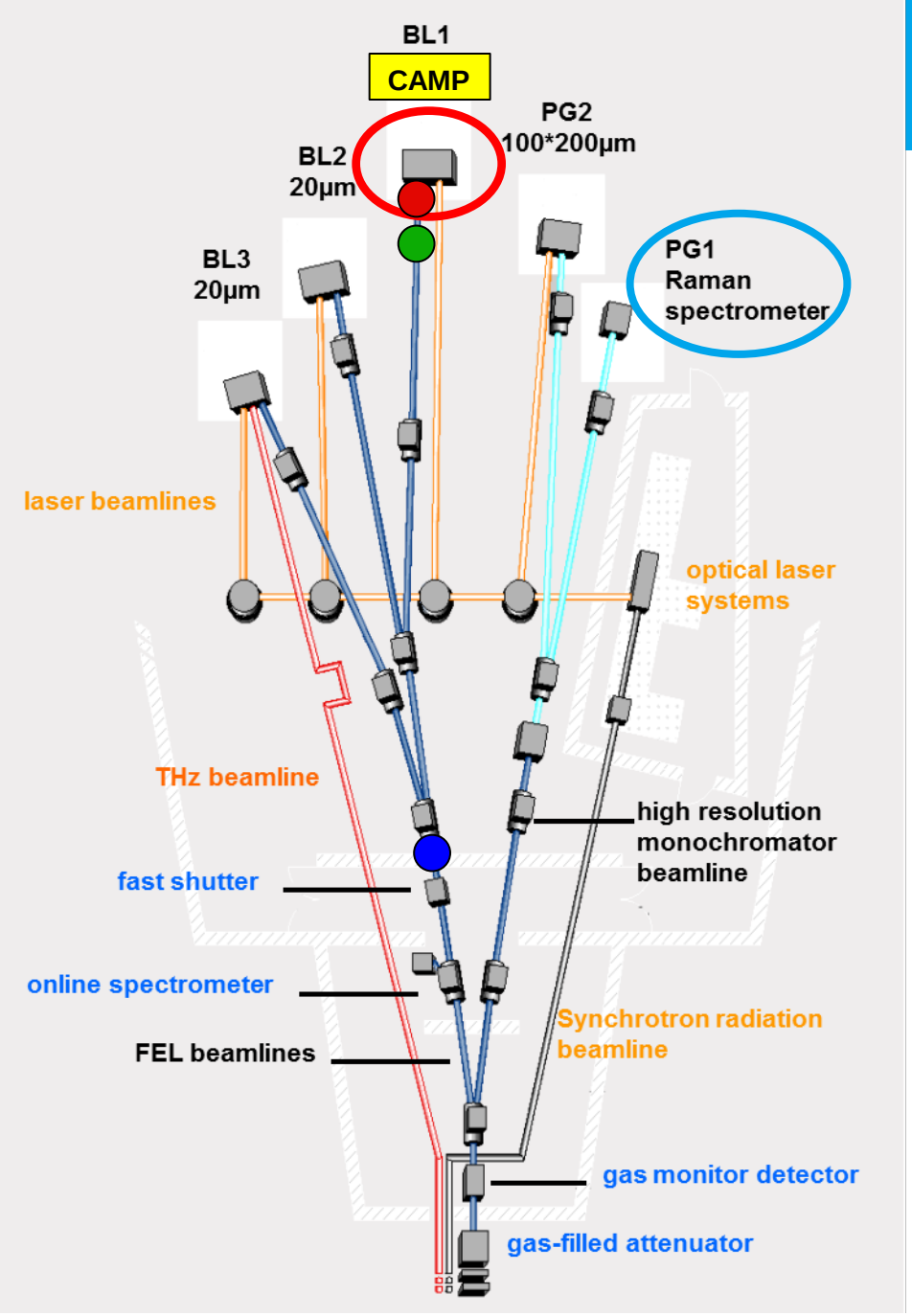
User runs

- **2 proposal rounds per year (https://door.desy.de/door/)**
  - **April 1st 2016** → beamtime **first half of 2017**
  - Oct. 1st 2016 → beamtime second half of 2017

- **Facility-operated (fixed) endstations**:
- CAMP@BL1
- Raman spectrometer@PG1
- TR-PhotoElectron Spectroscopy@PG2
- REactionMIcroscope@FLASH2

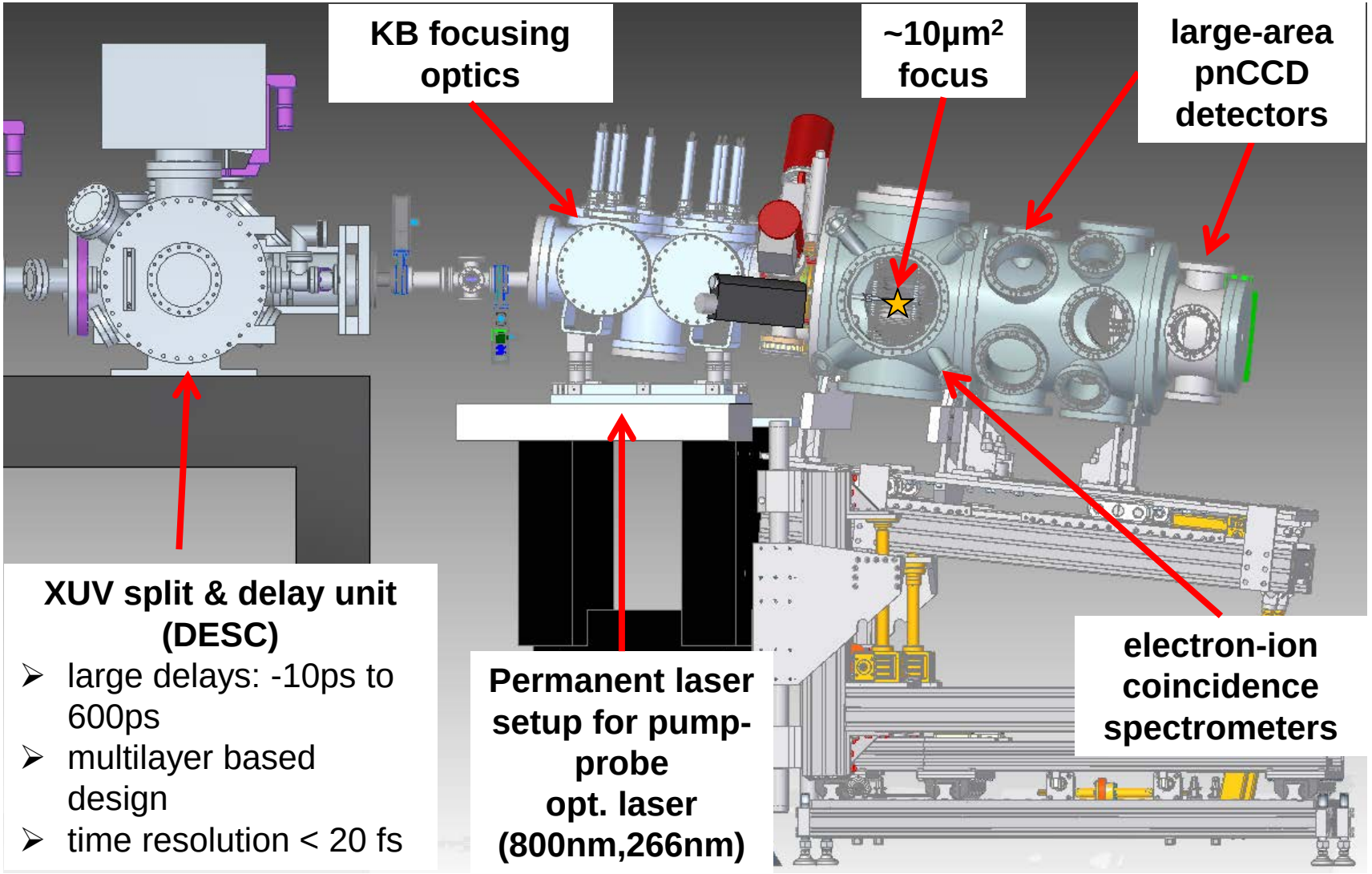
- **and flexible open ports**

FLASH1: Beamlines



http://photon-science.desy.de/facilities/flash/beamlines/index_eng.html

CAMP@FLASH:

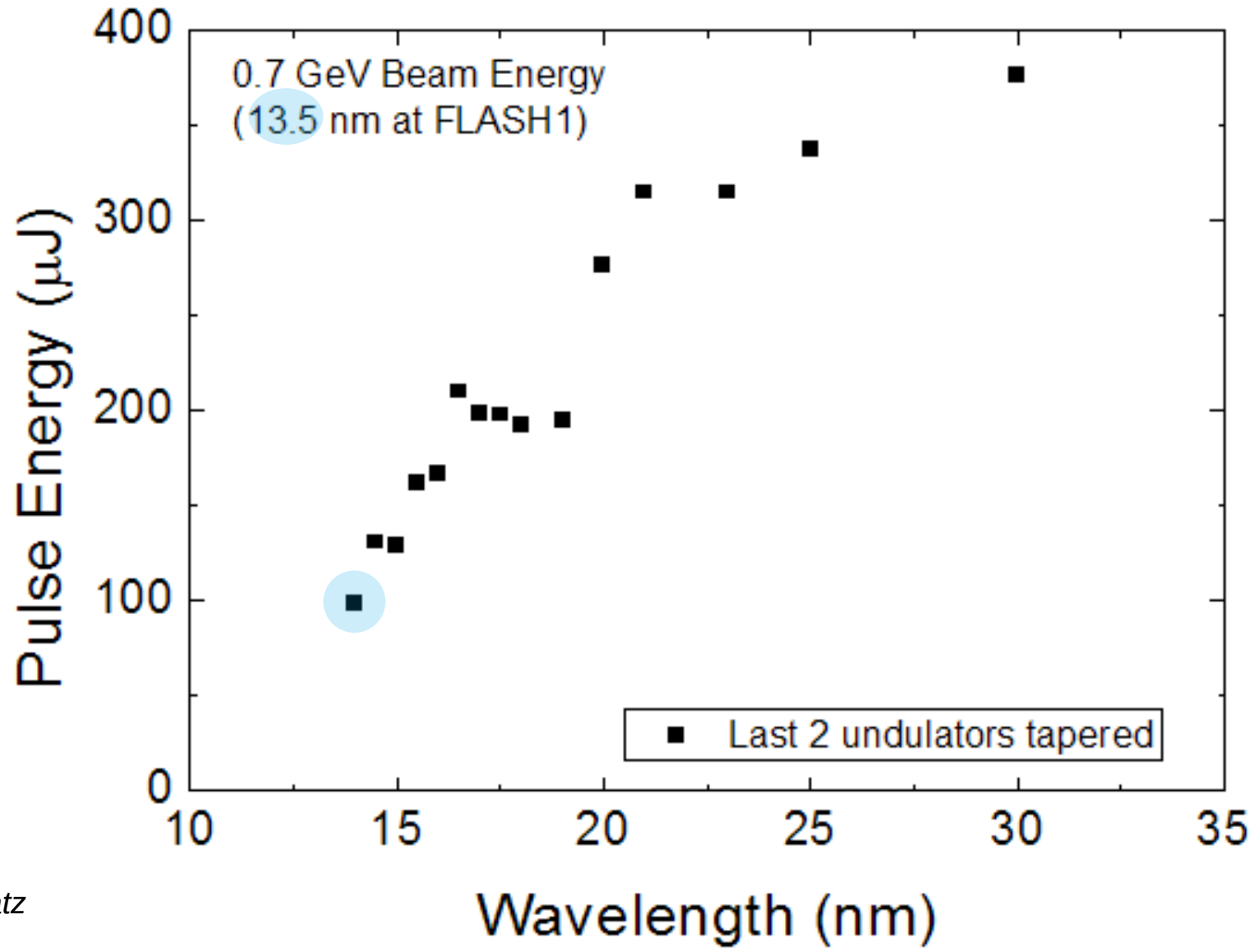


Benjamin Erk

FLASH2

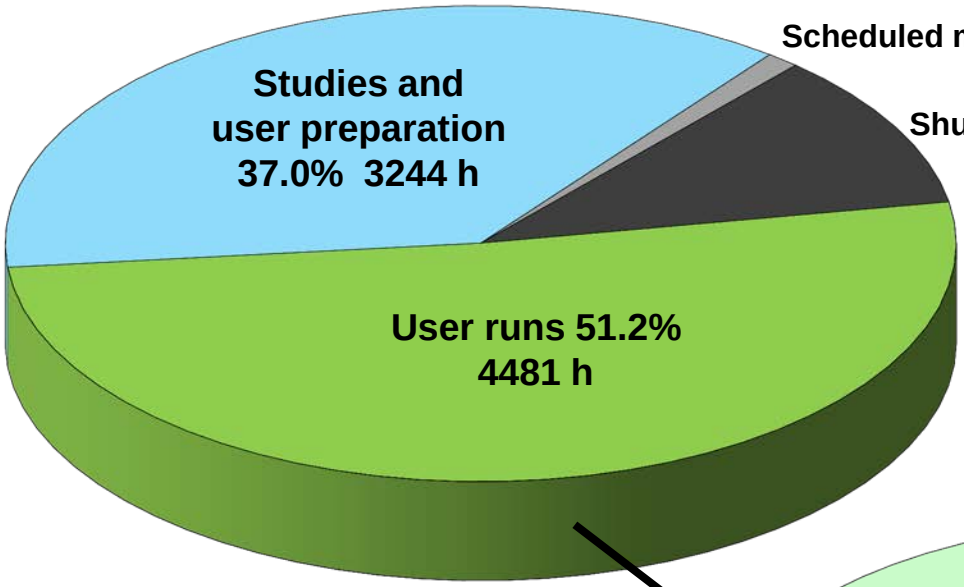
- First photons in Kai Siegbahn hall 11.06.2015
- Beamlines FL24 (open port) and FL26 (Reaction Microscope) close to finished
- Commissioning until 3/2016
- Tuning of wavelength in minutes
- First user experiments ~4/2016

FLASH2 - tunability

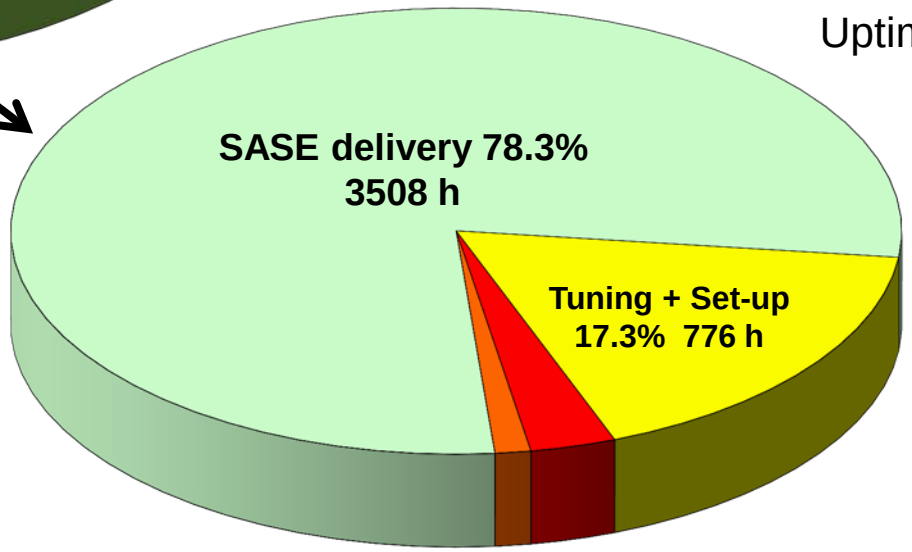


Bart Faatz

FLASH1 Operation Statistics 2015



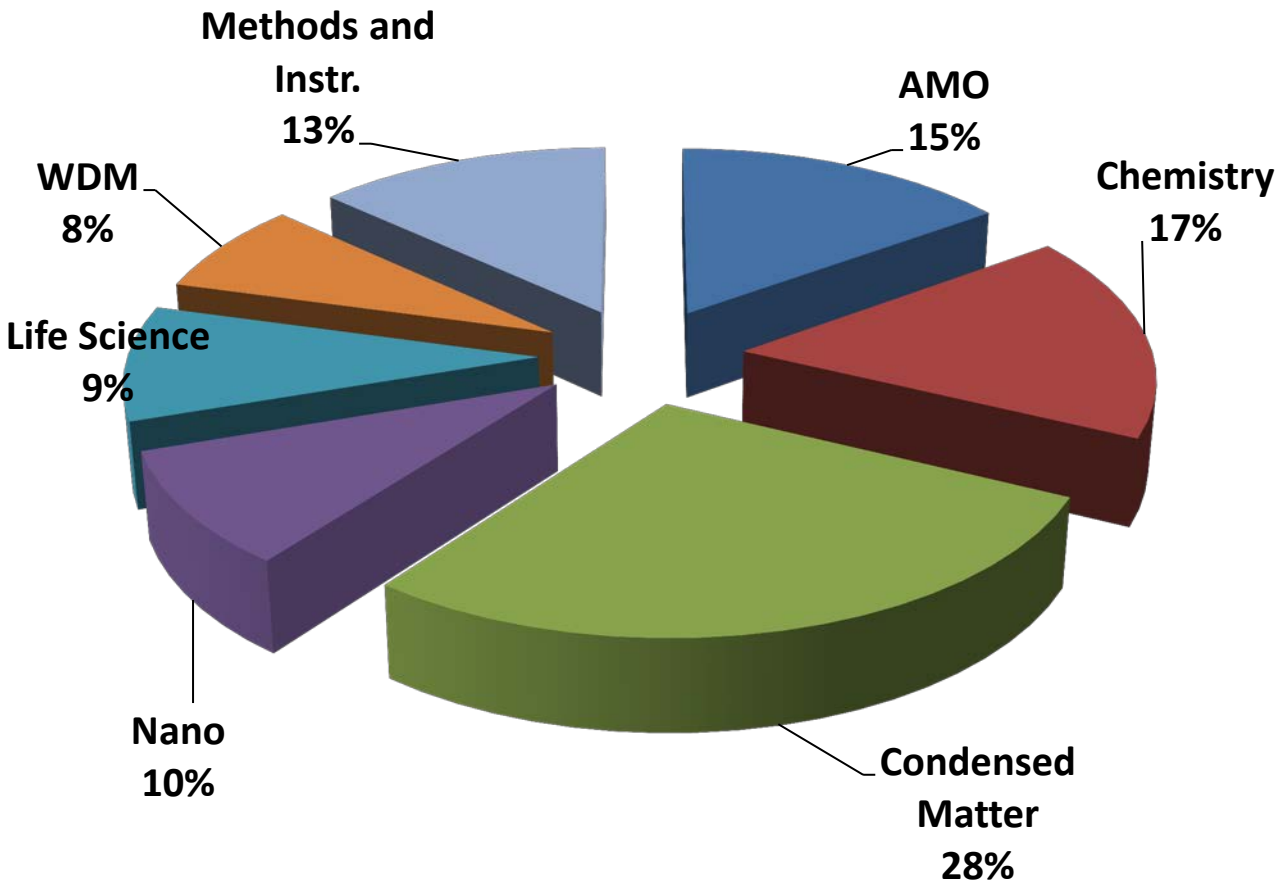
Uptime 95.6%



Katja Honkavaara

Science@FLASH

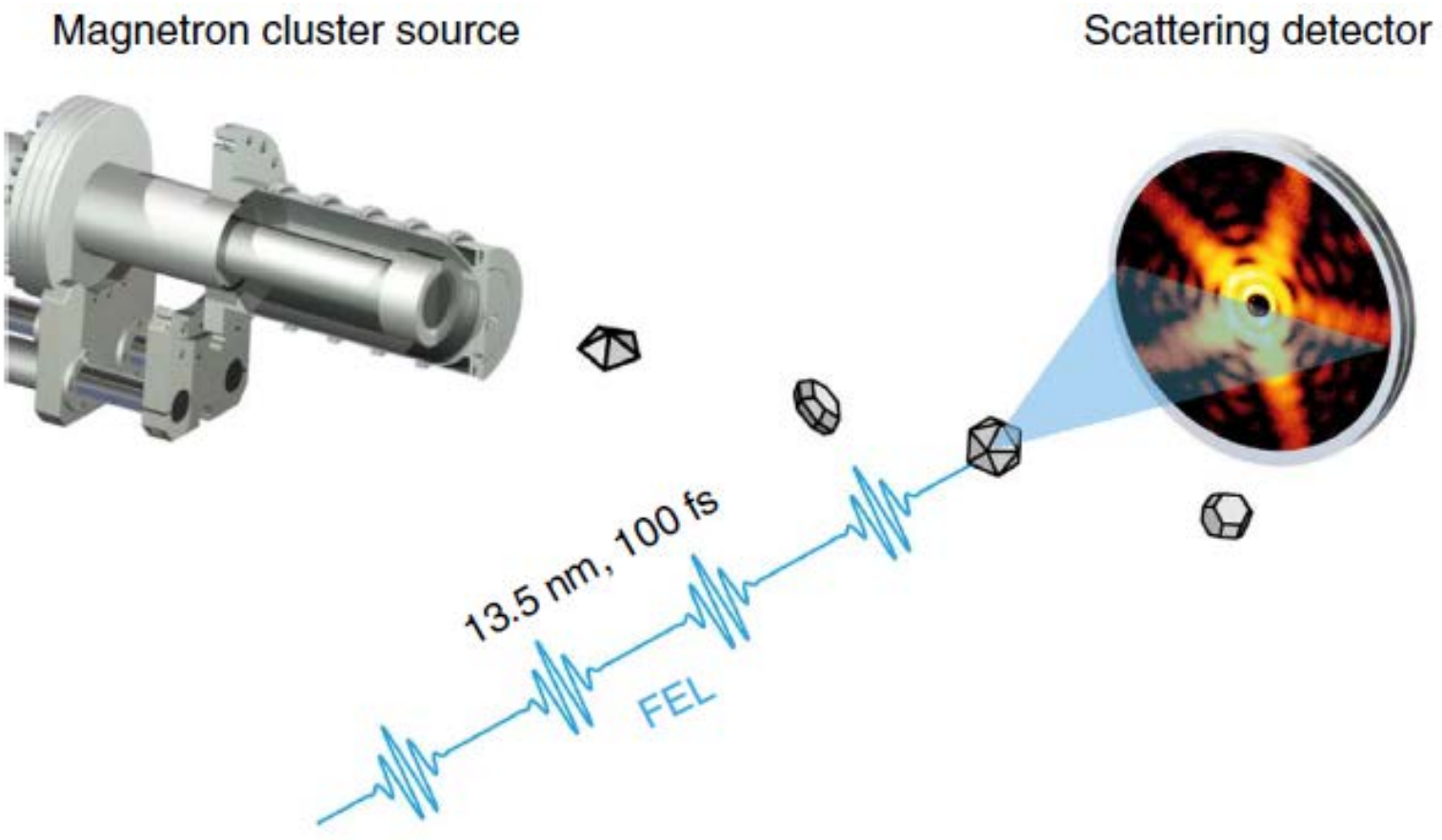
Average over last three calls



~80 % time-resolved (pump-probe) experiments

FLASH Recent Scientific Highlights

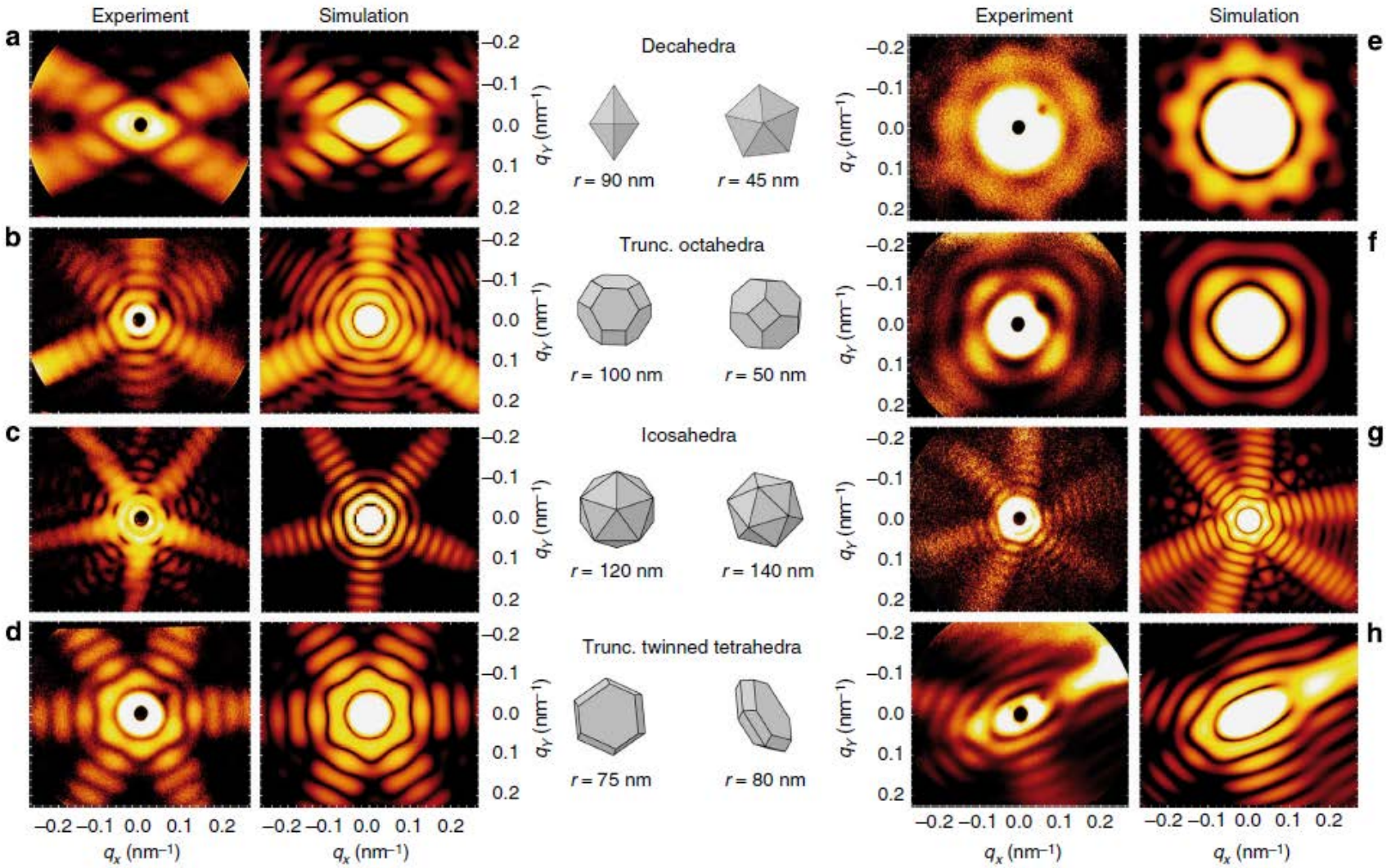
CAMP@FLASH: Single nanoparticle imaging



Single Shot Imaging

3D Imaging of Silver Nanoparticles

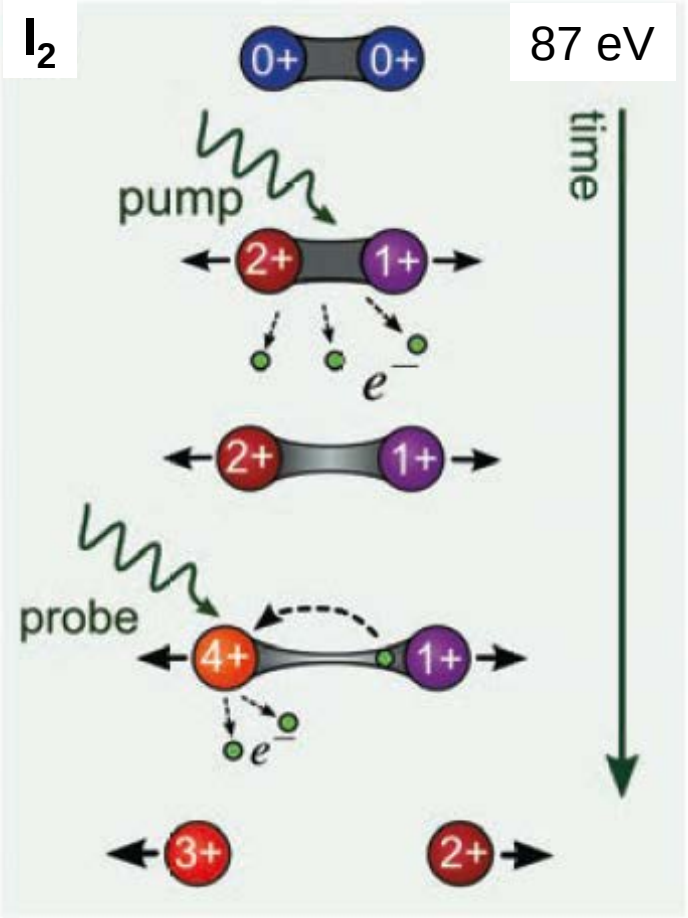
XUV pulses λ=13.5nm

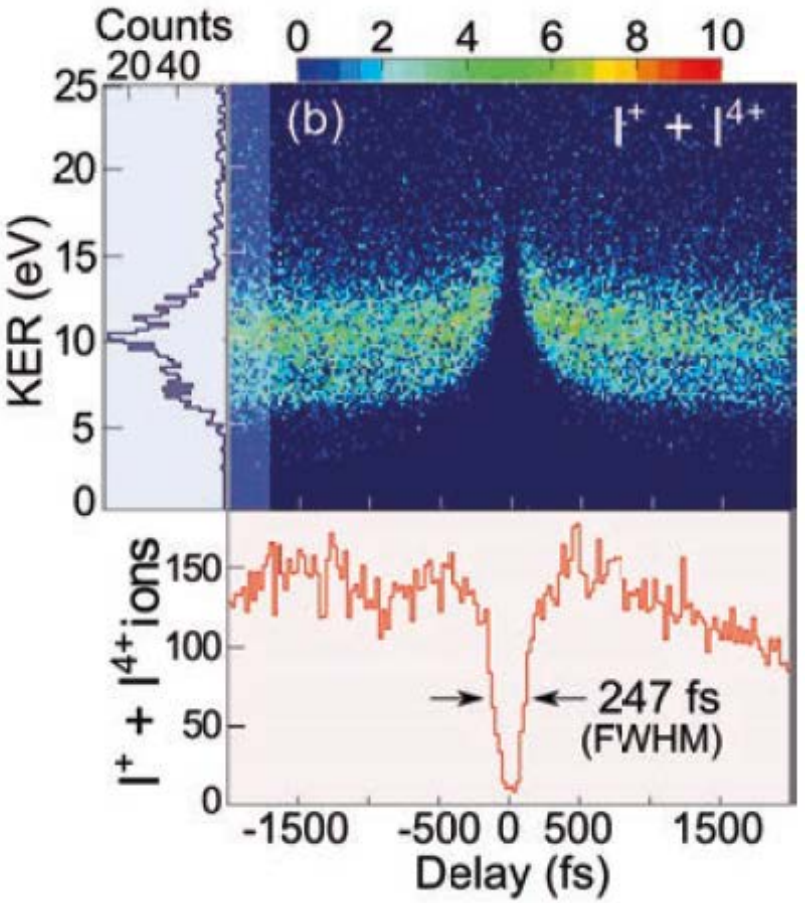


I. Barke et al., Nature Comm. Feb. 4th, 2015

AMO physics – XUV Pump – XUV probe

Electron rearrangement in dissociating molecules

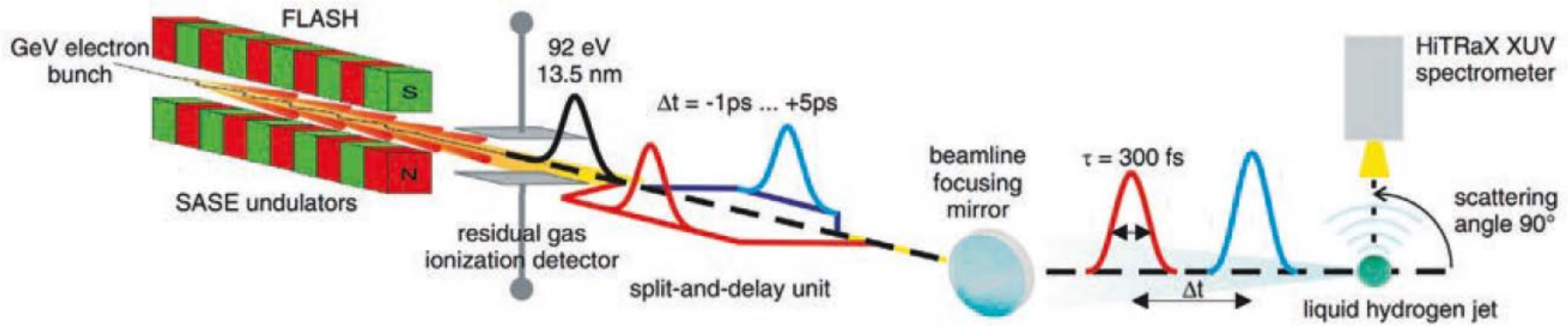


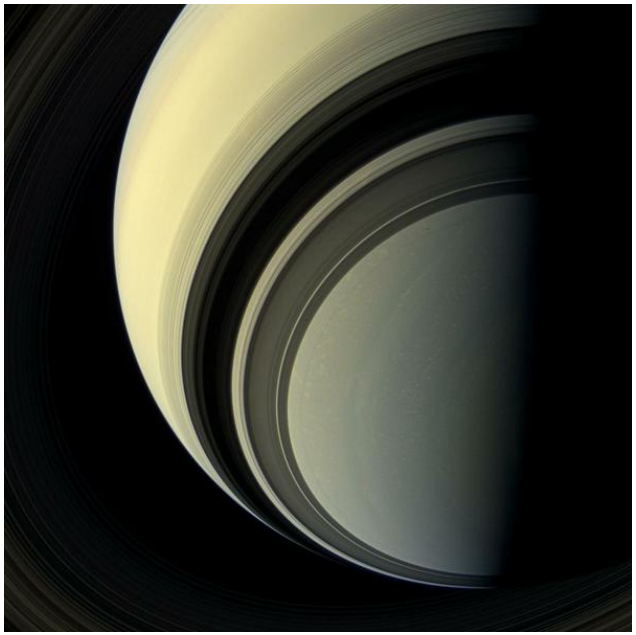


K. Schnorr et al. PRL 113, 073001 (2014)

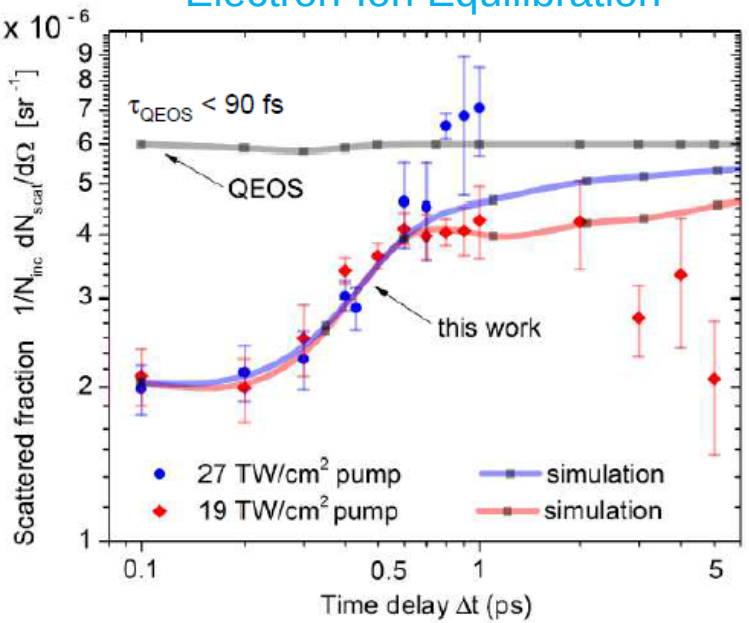
Extreme States of Matter – „Astrophysics in the Lab“

Ultrafast Heating of Dense Cryogenic Hydrogen





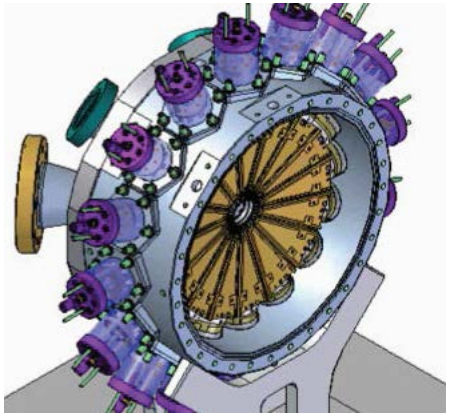
Electron-Ion Equilibration

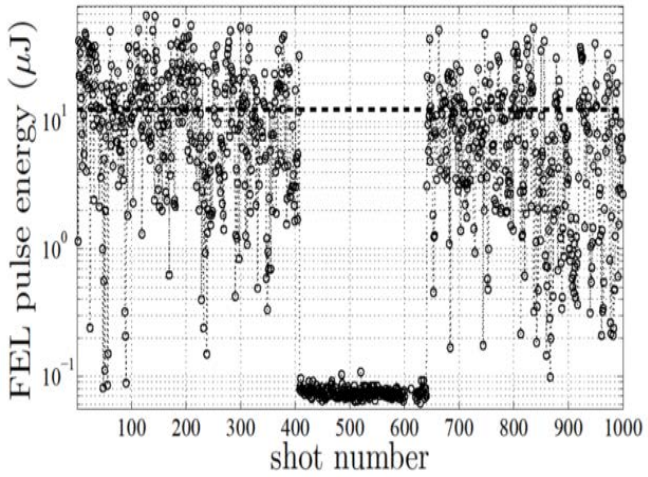


U. Zastrau et al., PRL 112, 105002 (2014)

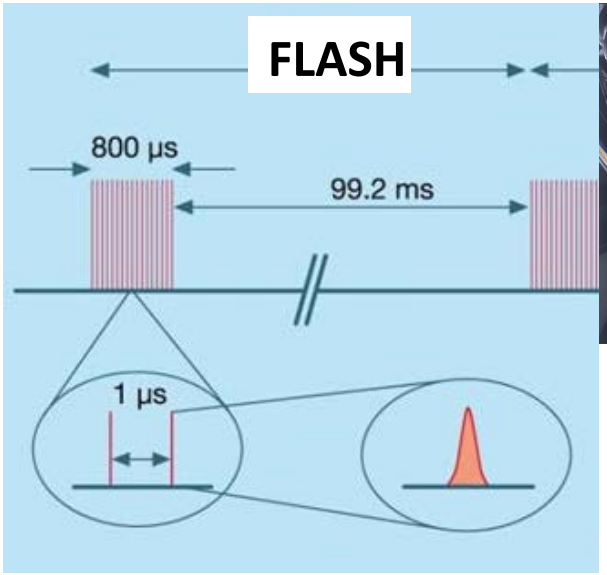
FLASH Mid term upgrade plans

- Variable gap undulators for FLASH1
- variable polarization
- external seeding FLASH2 up to 100kHz



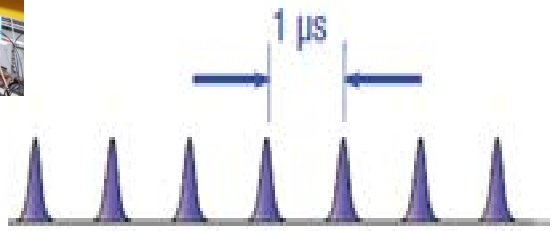


FLASH2020 – The Future



Gain x 125

FLASH2020



- CW operation with up to 1MHz repetition rate
- Extended energy range ~30-550eV 1st harmonic (chemistry and biology driven: C-, N-,O-K edges, “water window”)
  - complementary to XFEL
- up to 1keV 2nd harmonic (materials science driven: 3d transition metals)
- operation of multiple FEL lines with 100kHz