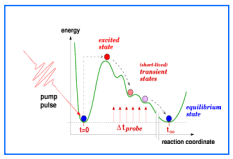
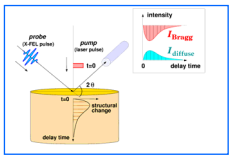
FEL-based pump-probe experiments

In collaboration with: MBI, BESSY, MAX-Lab, LURE, DCU

Examples of Pump-Probe Experiments



Investigation of transition states in a chemical reaction

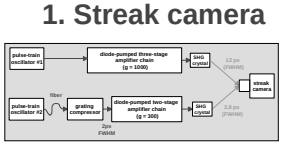


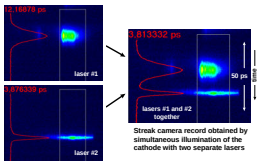
Investigation of melting of crystalline surfaces

Phase detection/control

1. **Standard Online Diagnostics:**
   Streak Camera
   → **Precision about 1-2ps**
2. **Direct, post-experiment Diagnostics:**
   e.g. Cross-correlation Ar and Single Shot Correlator
   → **Precision < 100 fs**
3. **Direct Online Diagnostics with feedback:**
   Electro-Optical Sampling (EOS)
   → **Precision < 100 fs**

1. Streak camera



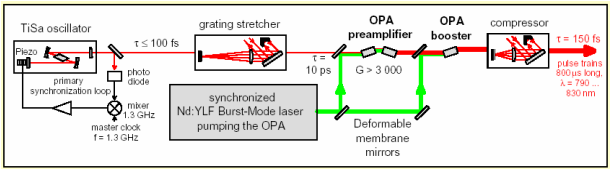


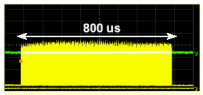
Streak camera record obtained by simultaneous illumination of the cathode with two separate lasers

Two- color pump-probe facility combining a FEL and a high-power optical laser

Funded by the 5th Framework Programme of the European Commission (HPRI-CT-1999-50009)

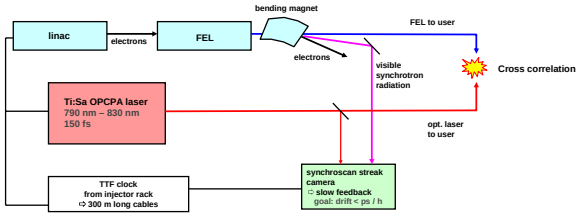
Layout of the optical laser system





Output pulse train of the OPA

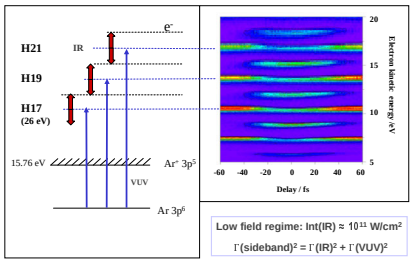
Synchronisation with the FEL



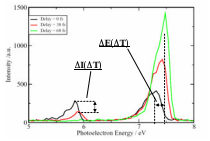
Goal:
Synchronization with FEL
⇨ 200 fs

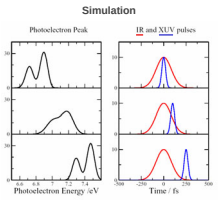
- HASYLAB/DESY (Coordinator)
- Research Centre Jülich / BESSY
- Max-Born-Institute, Berlin
- Dublin City University
- CNRS / LURE
- Lund Laser Centre / MAX-Lab

2. VUV-IR Cross-Correlation Experiments on Atomic Ar



Low field regime: Int(IR) ≈ 10^{11} W/cm²
Γ(sideband)² = Γ(IR)² + Γ(VUV)²



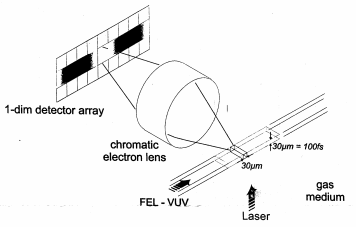


High field regime: Int (IR) ≈ 10^{13} W/cm²
$E_{kin} = \omega_{XUV} - IP - U_p$
U_p [eV] = α I [W/cm²]
α =9.33 x 10^{-14} λ² [µm²]

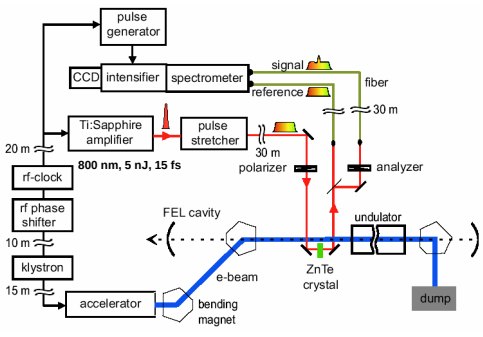
$$P(E) \propto \left| \int_{-\infty}^{\infty} E_{XUV}(t) e^{-i\left((\omega_{XUV} - I_P - E)t - \frac{1}{\omega_{IR}} \int_{-\infty}^{t} I_{IR}(t')dt'\right)} dt \right|^2$$

Single-shot cross correlator

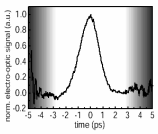
(Proposal by M. Drescher, Universität Bielefeld)



3. Electro-optical sampling



Single- shot chirped pulse spectrometer
G. Berden et al., Proc. DIPAC 2003, GSI, Mainz, Germany



Single- shot measurement of the electric field of an individual electron bunch at FELIX, pulse length ~ 1.7 ps FWHM)

EOS proposal for VUV FEL:
Use light from Ti:Sa oscillator (pump-probe laser system) with 50-100 m fibre link to EOS crystal for timing diagnostics

Plans for timing diagnostics and synchronisation

1. **Streak Camera, Cross-correlator, and EOS for determination of the time jitter on a shot-to-shot basis and corresponding sorting of the data.**
2. **Synchronise all lasers and accelerator RF to <10 fs using laser master oscillator and length-compensated fibre links**
3. **Investigate and improve accelerator induced time jitter**

→ **Prerequisite to seeding with fs harmonics**

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