Lasers at Lightsources

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A User Perspective

Andreas Galler

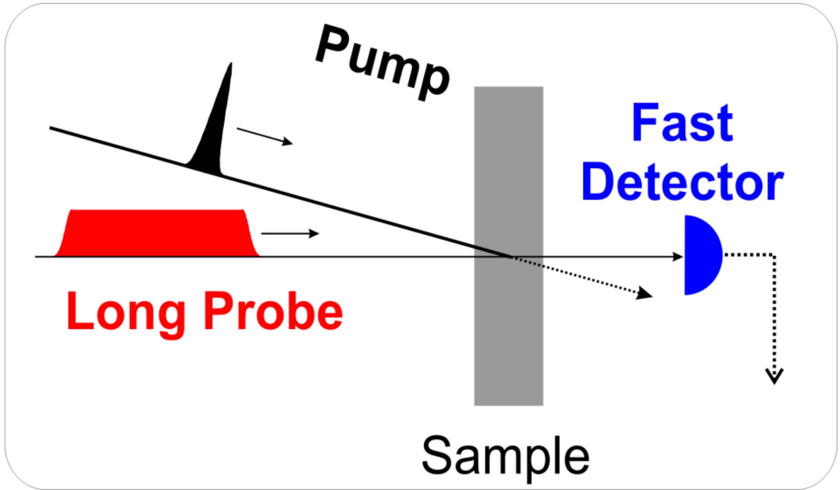
European XFEL (FXE), Hamburg

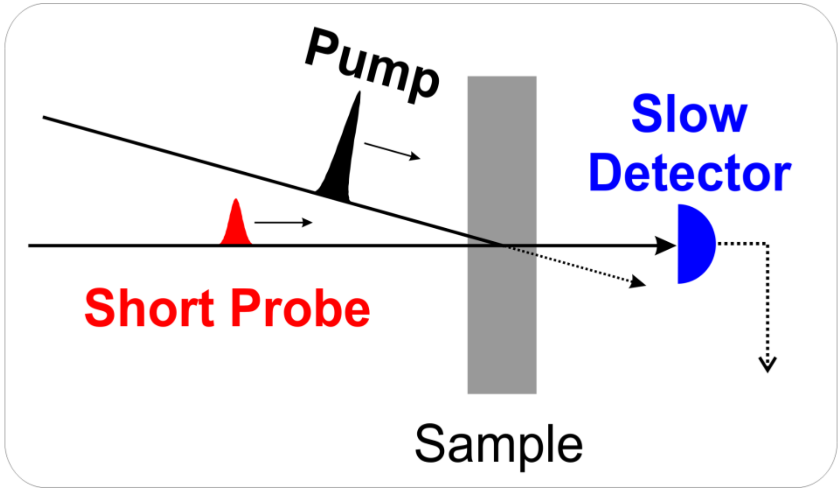
SwissFEL Pump-Probe Workshop

Outline

- Experiments at Lightsources (Synchrotrons & FEL)
  - kHz experiments
  - MHz experiments
  - FEL experiments
- Lasers at FXE
- Pulse Characterization at Sample Interaction Point

Towards Ultrafast Time Resolution





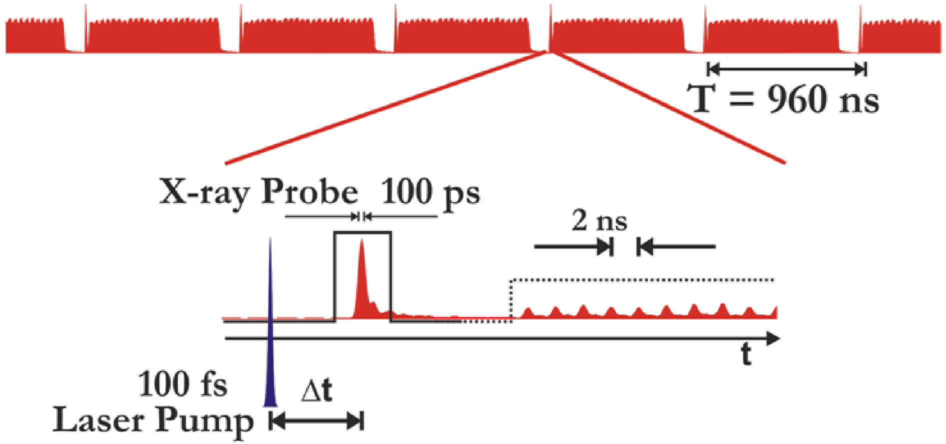
Femtosecond X-ray Streak Cameras

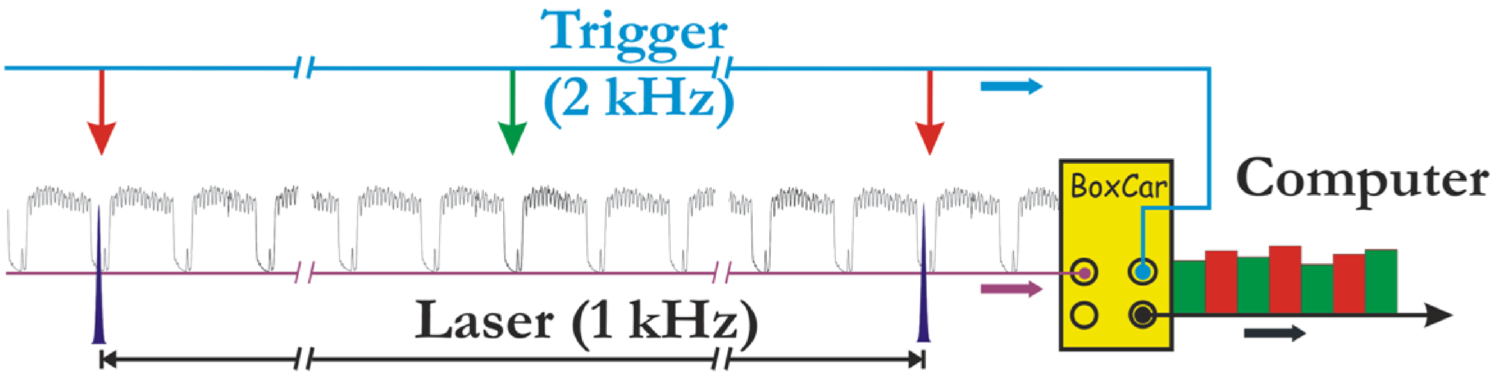
- ✓1-2 ps "routine" resolution
- ✓150-300 fs in lab

Femtosecond X-ray Sources

- ✓ Laser plasma sources (~100 fs)
- ✓3rd generation SR sources: Femtosecond electron bunch slicing
- ✓**X-Ray Free Electron Lasers**

Laser Pump X-ray Probe Strategy at the SLS

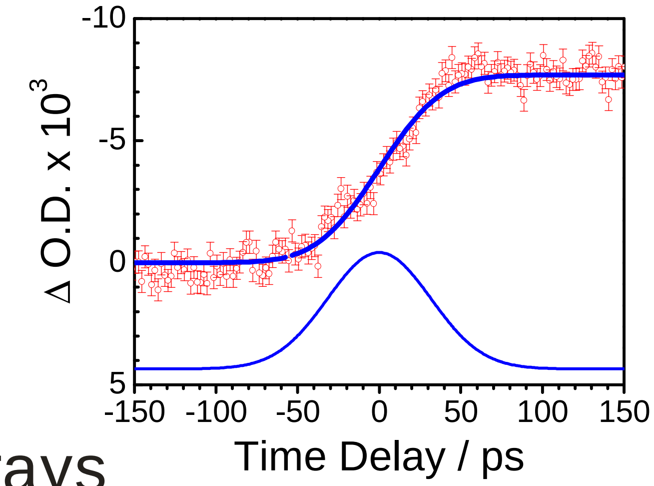


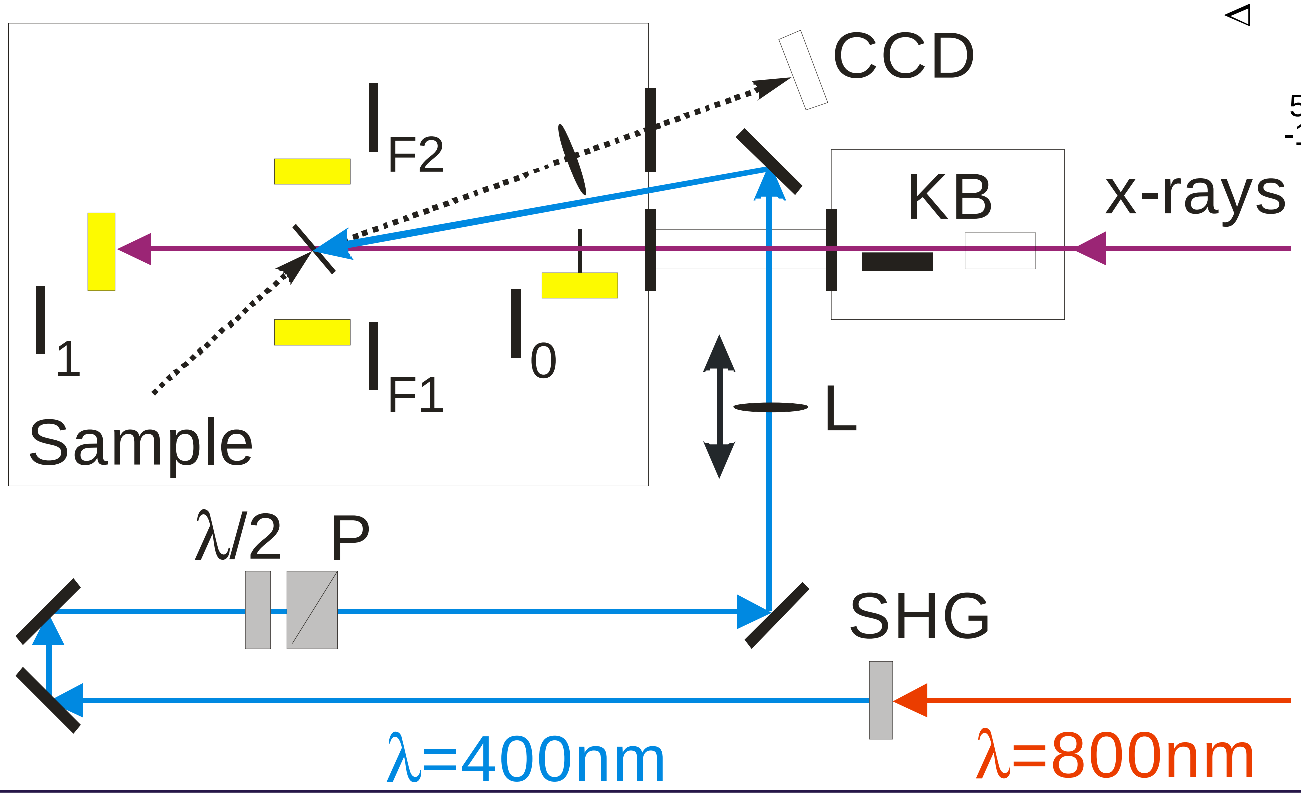


Laser pump X-ray probe setup at the SLS

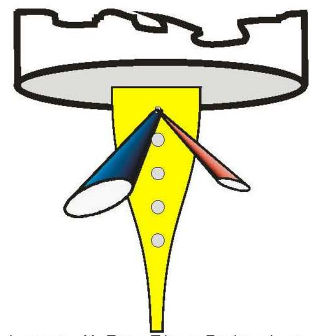
Work in disordered/dilute systems
Sample refreshed for each laser shot

Gawelda *et al.*,
AIP conf. proc. 881, 31 (2007)





liquid jet



- **Experiments at Lightsources (Synchrotrons & FEL)**
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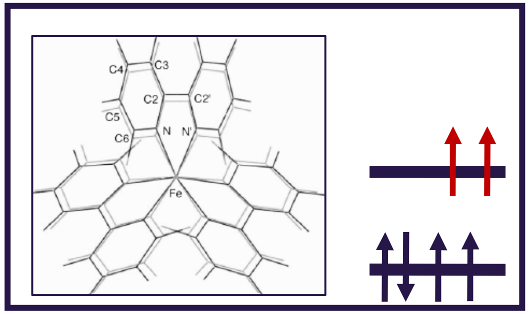
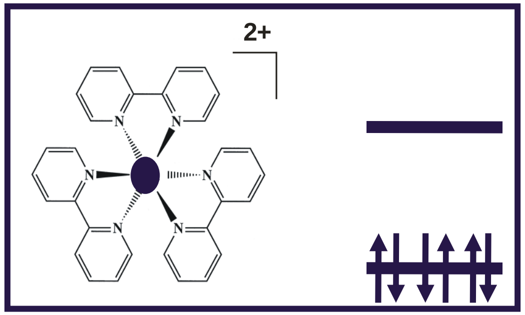
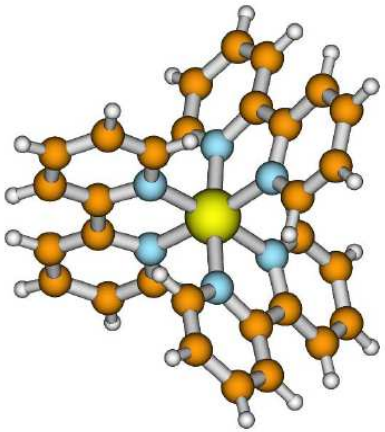
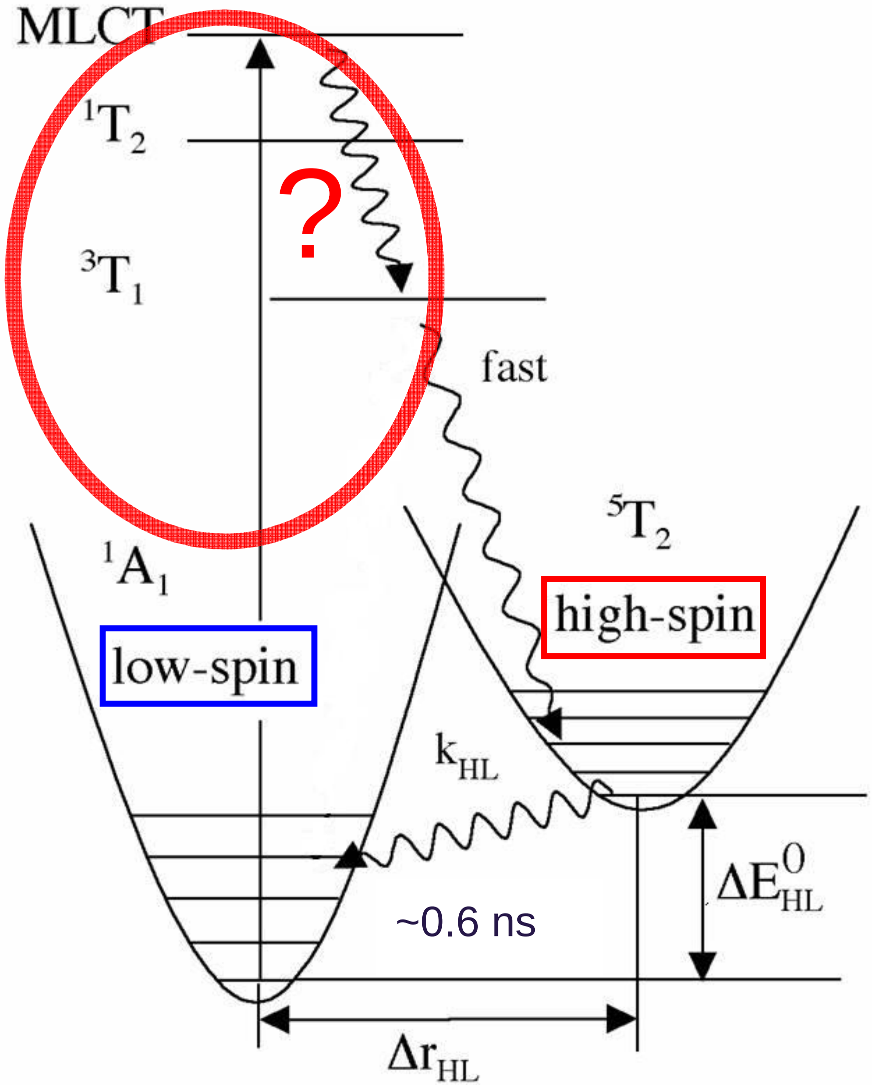
Light-induced low spin to high spin transition in $[Fe^{II}(bpy)_3]^{2+}$

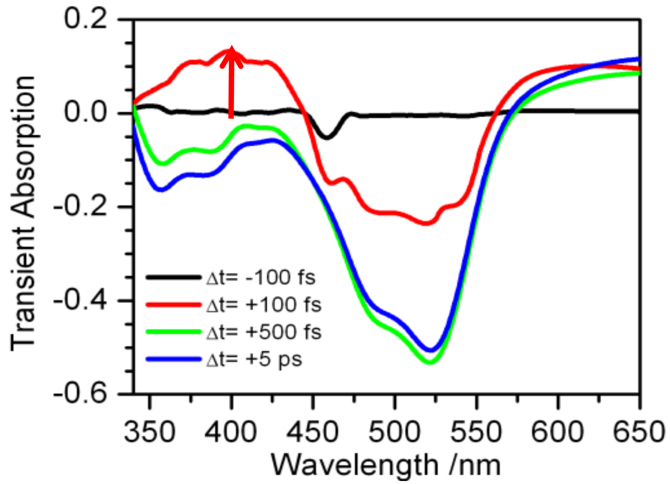




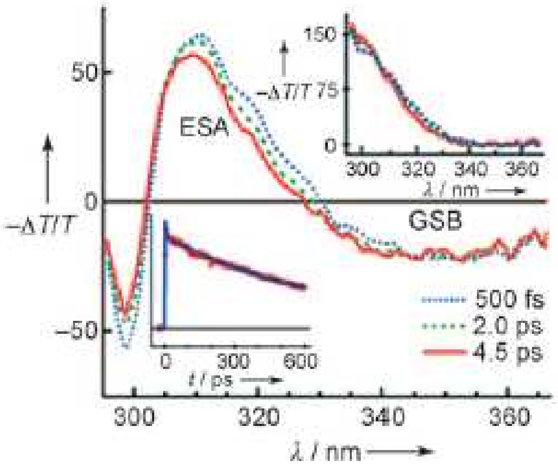




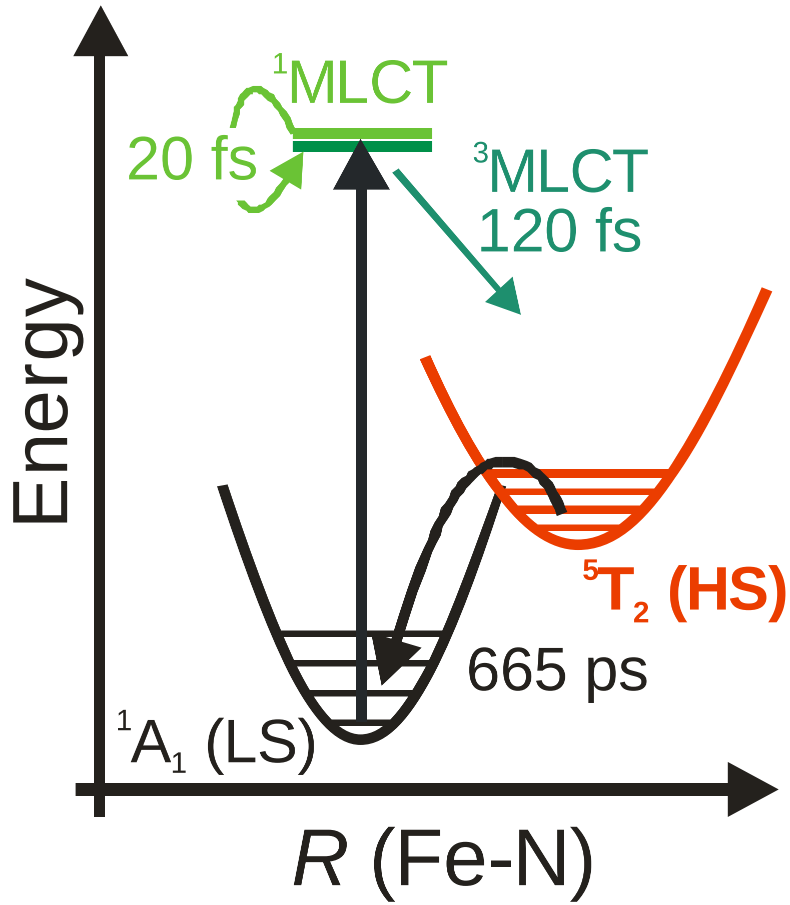
Iron-tris-bipyridine: what we actually know



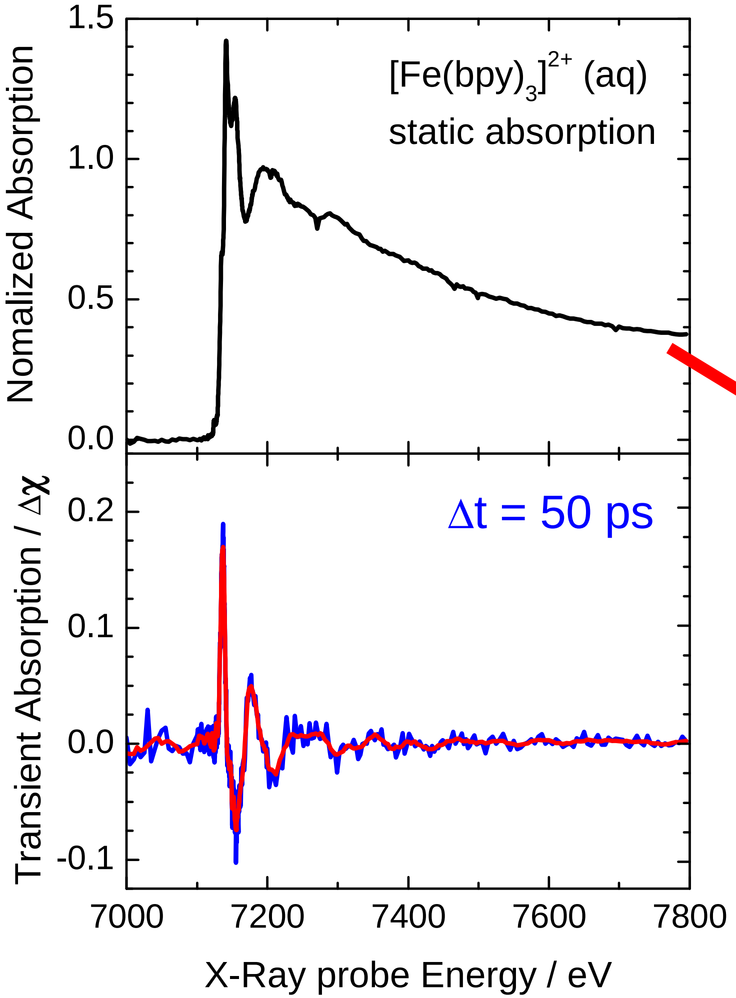
J. AM. CHEM. SOC. ■ VOL. 129, NO. 26, 2007

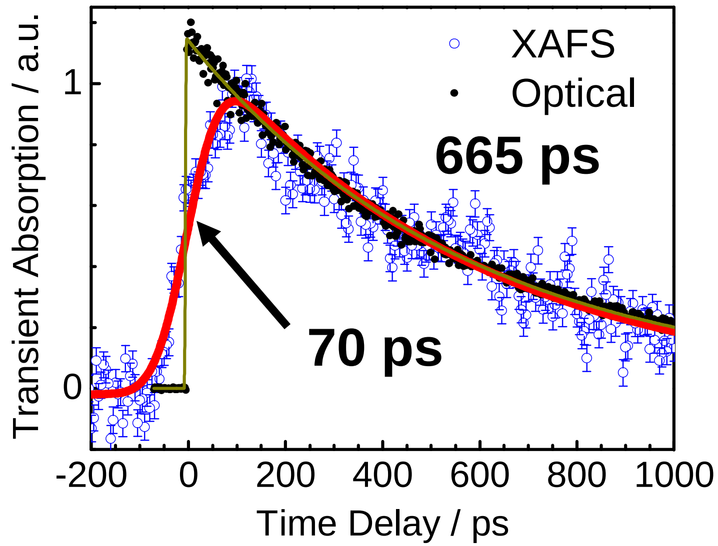


Angew. Chem. Int. Ed. 2009, 48, 7184–7187

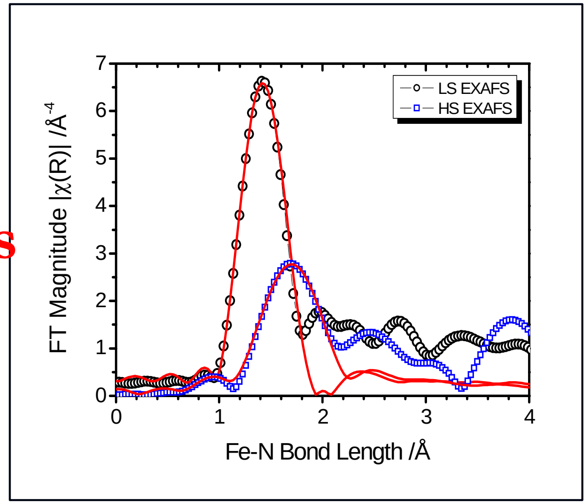


XAS Studies at kHz rates



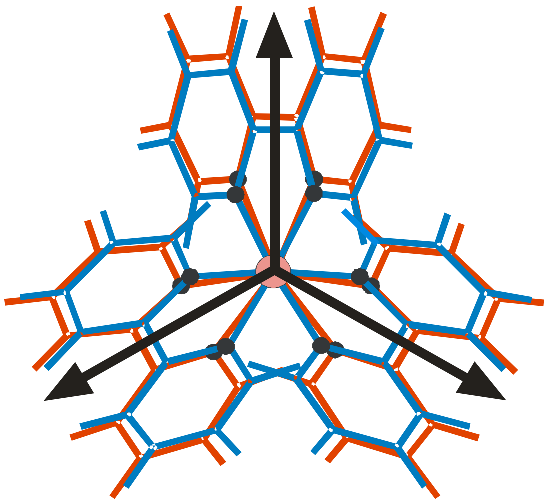


EXAFS analysis

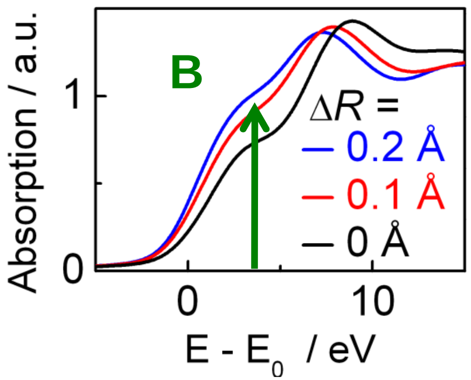


Gawelda *et al.*, Phys.Rev.Lett. 98, 057401 (2007)

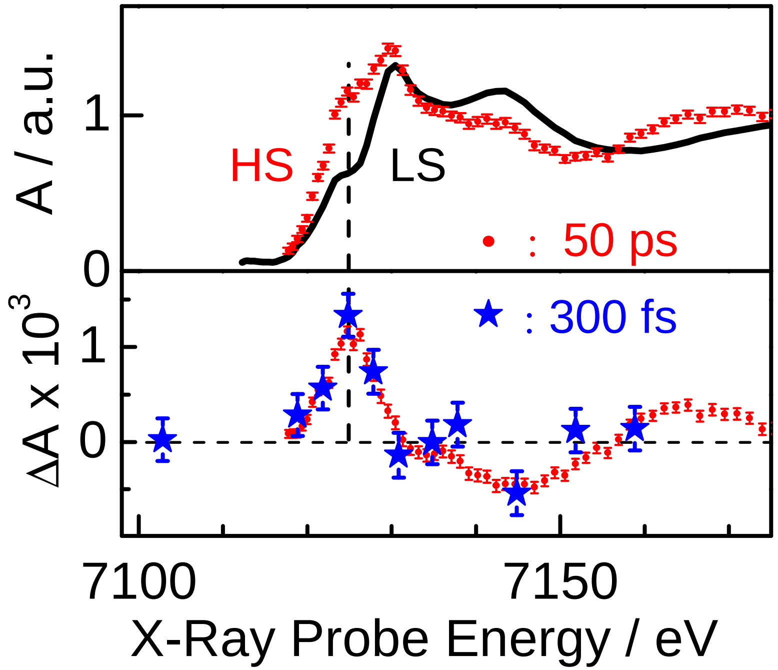
XAS Studies at kHz rates



M. Benfatto (INFN Rome)



C. Bressler *et al* .Science (2009)



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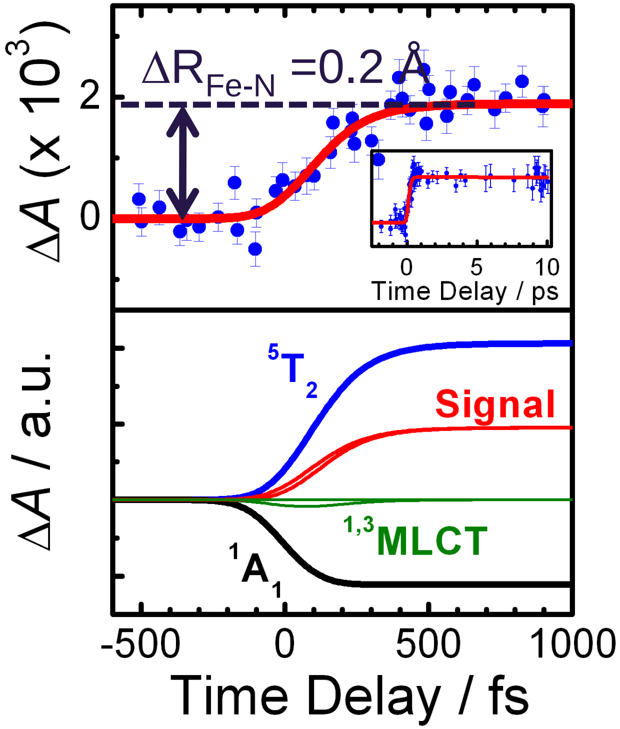
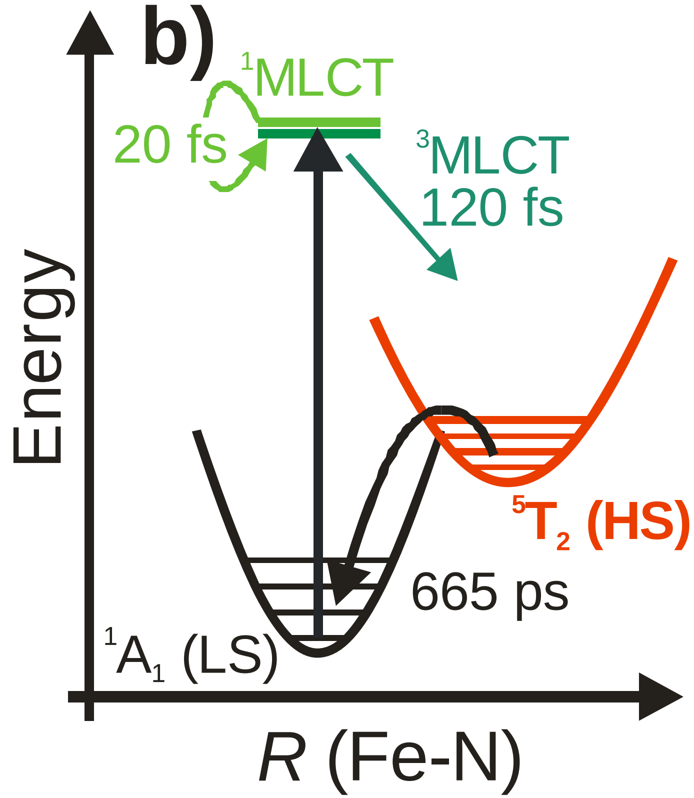




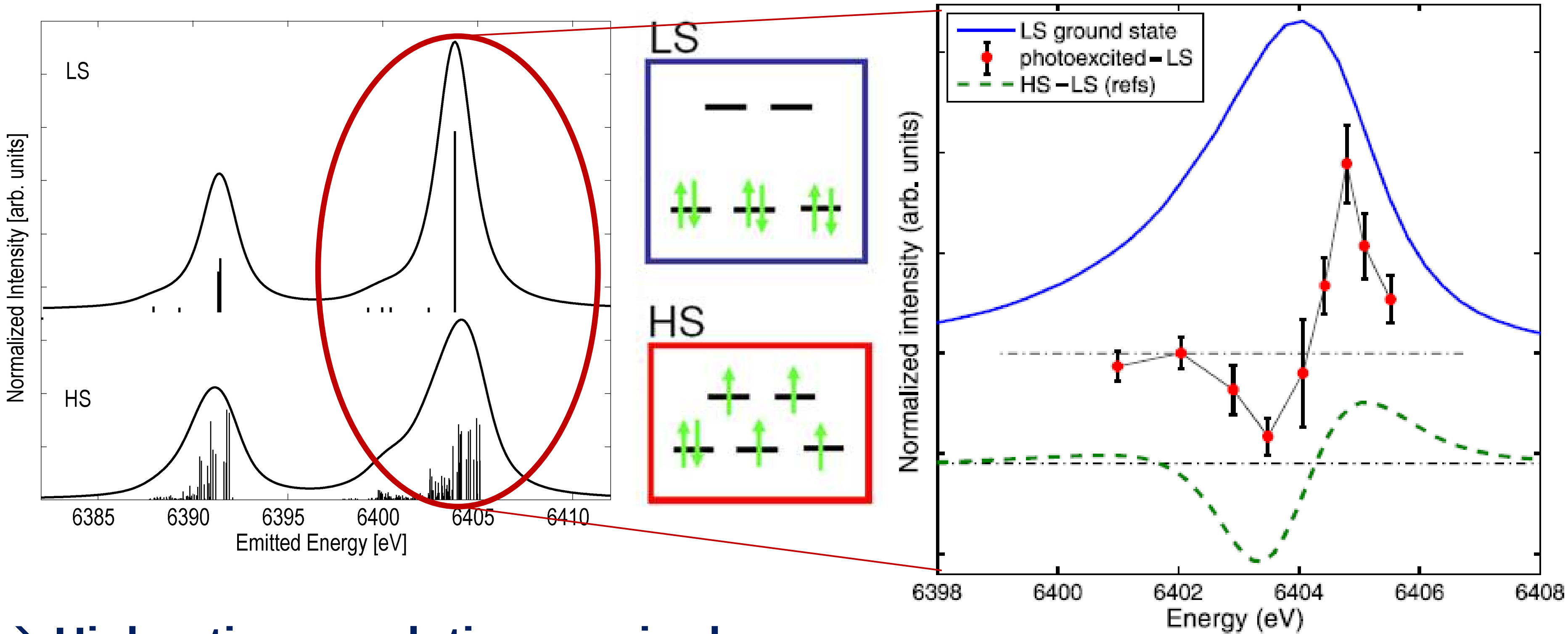
250 fs (instrument response):

140(30) fs hard x-ray pulse
115(10) fs laser pulse
<100(30) fs time zero drifts

10-12 photons/pulse (2 kHz, 2 eV BW)

XES studies at kHz rates

60 ps delay between laser and x-ray pulse



Direct measurement of change of Fe spin state.

→ **Higher time resolution required**
→ **Ideally suited for single wavelength XFEL experiments**

G. Vankó et al Angew. Chem. Int. Ed. **2010**, 49

Lessons learned

- **Lasers have become widely available at synchrotrons**
- **Synchronization is not a problem anymore**
- **Tunability is required for optimal sample exciation**
- **User access to laser beam is favorable**

- **Experiments at Lightsources (Synchrotrons & FEL)**
  - **kHz experiments**
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- **Lasers at FXE**

- **Pulse Characterization at Sample Interaction Point**

MHz studies

MHz studies

Time Resolved RIXS becomes feasible

Lessons learned

- **MHz lasers make much better use of the storage ring**
- **Synchronization has become very reliable**
- **MHz lasers can be portable → Users can bring their own laser**

- Experiments at Lightsources (Synchrotrons & FEL)
  - kHz experiments
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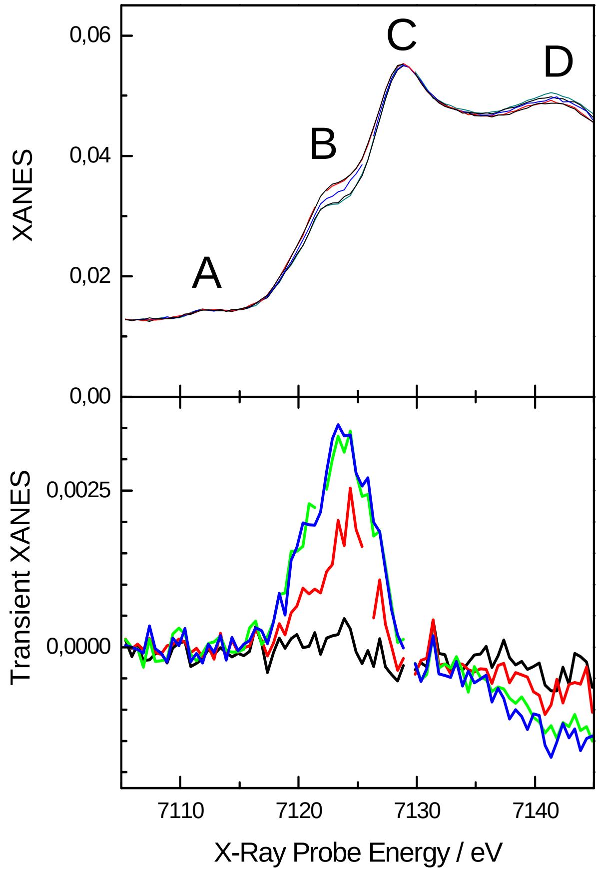
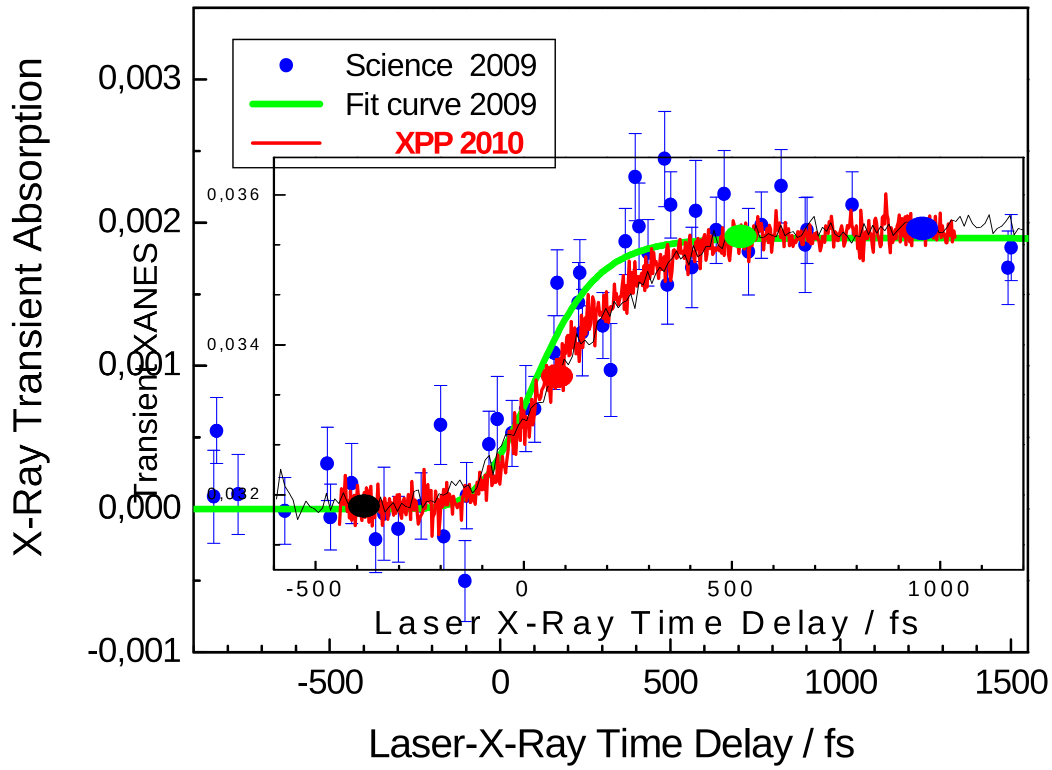
TR-XAS $[Fe(bpy)_3]^{2+}$ at XPP/LCLS





Need for time arrival detector

- **Experiments at Lightsources (Synchrotrons & FEL)**
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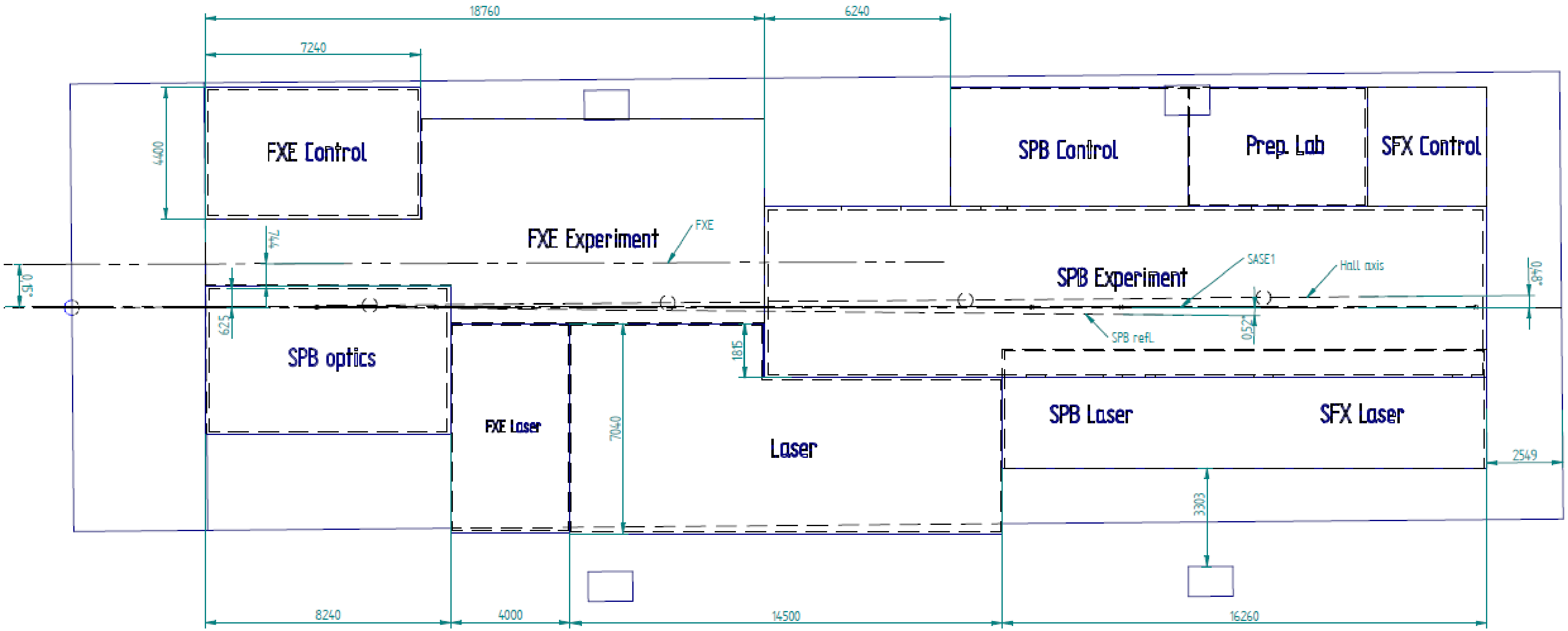
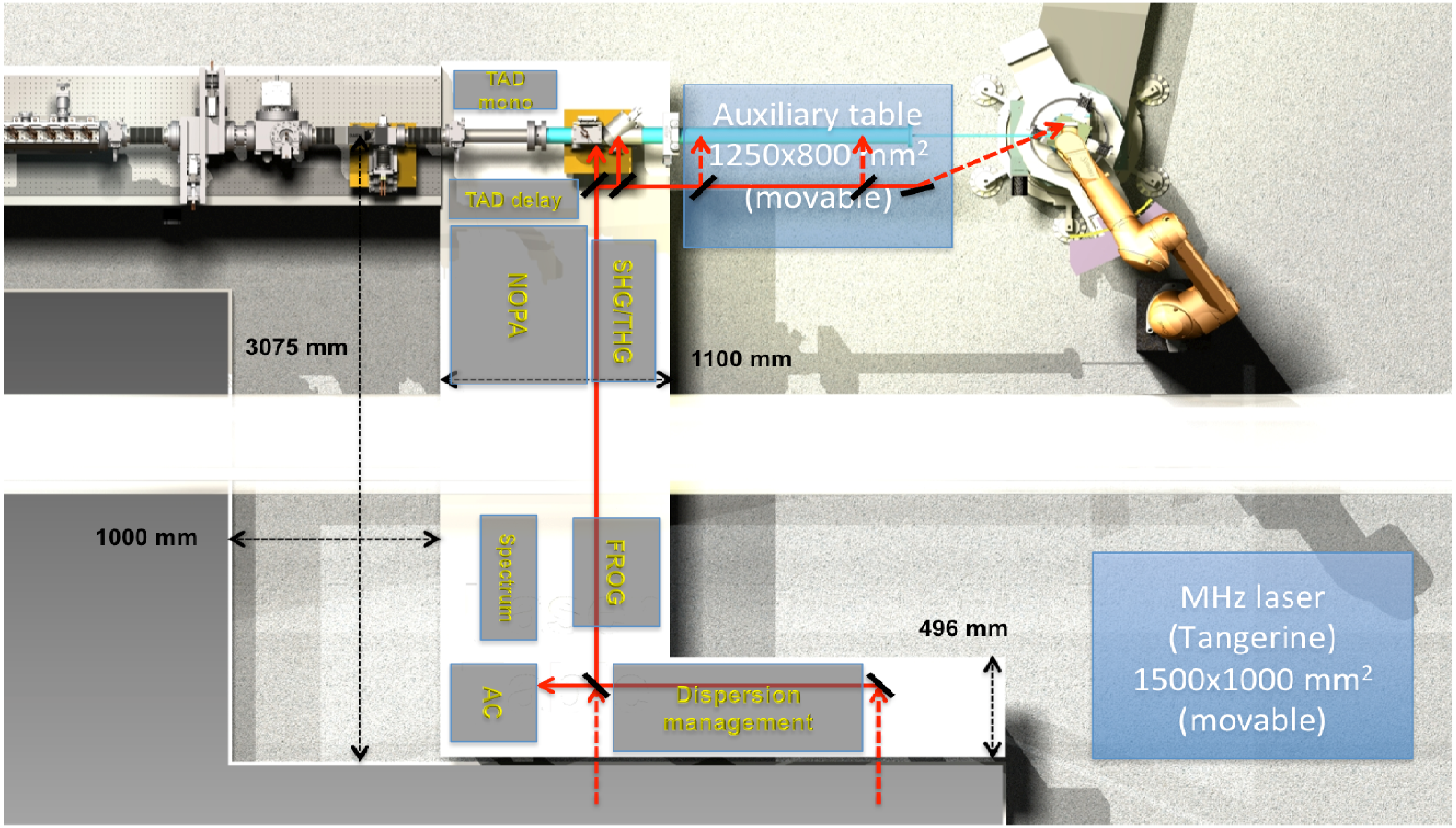
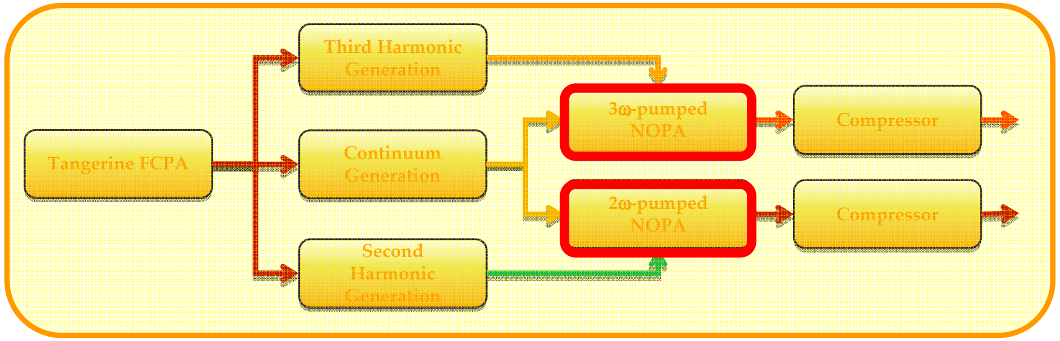
Lasers at FXE



Lasers at FXE

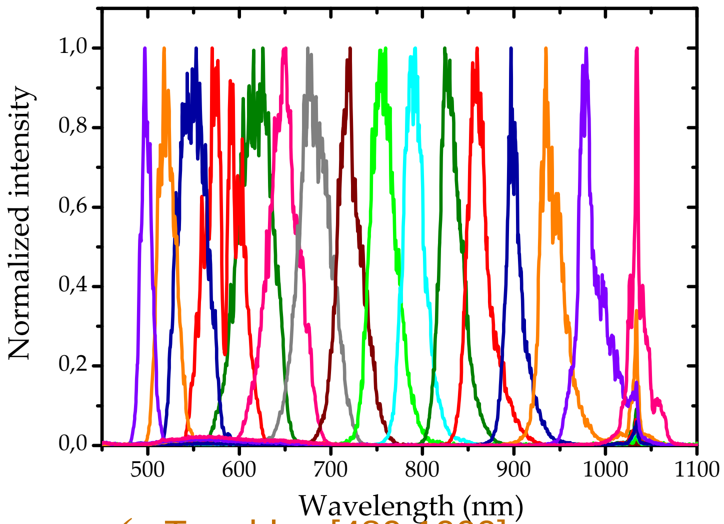


MHz NOPA… on the road, reached 500 kHz



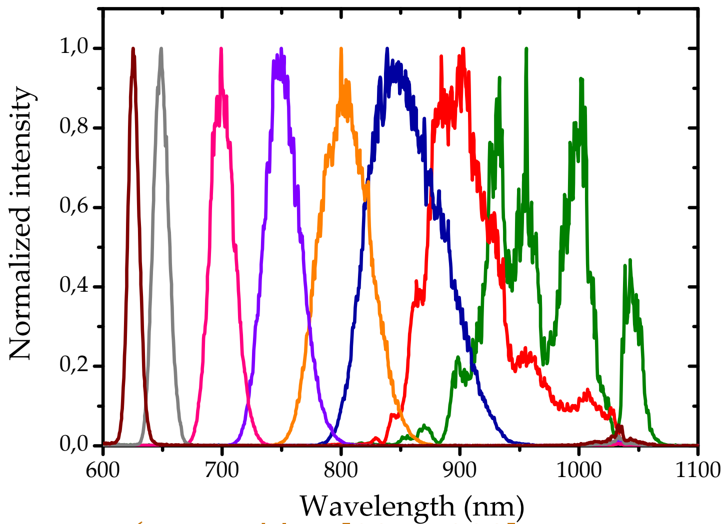
- ✓ Type I BBO crystals
- ✓ Noncollinear geometry

NOPA 3ω



- ✓ Tunable : [480-1000] nm

NOPA 2ω



- ✓ Tunable : [625-1000] nm

courtesy of J. Nillon

MHz NOPA next steps

What is available :

NOPA 3ω

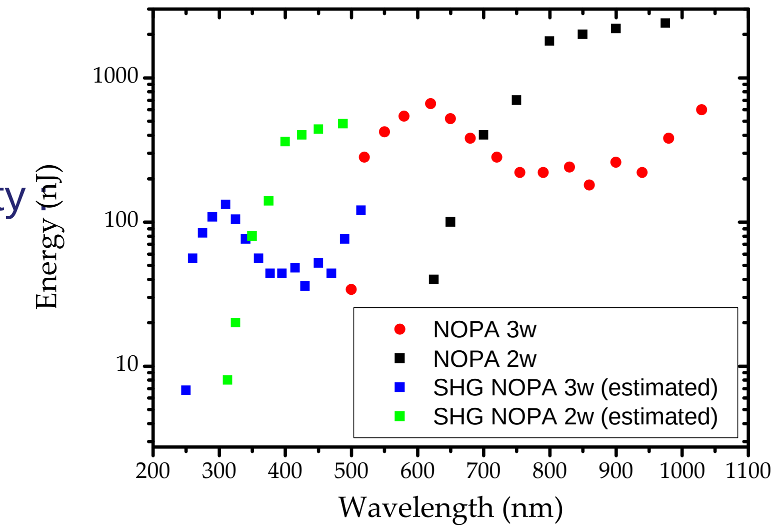
✓Repetition rate : 0-500 kHz
✓Tunable : [480-1000] nm
✓E > 200 nJ for λ∈[510-1000] nm
✓E_{max} = 700 nJ @ 620 nm
✓Δt < 20 fs for λ∈[510-700] nm

NOPA 2ω

✓Repetition rate : 0-500 kHz
✓Tunable : [625-1000] nm
✓E > 500 nJ for λ∈[700-1000] nm
✓E_{max} = 2,2 µJ @ 900 nm
✓Δt < 30 fs for λ∈[700-1000] nm

What as to be done :

- ✓ Increase the repetition rate to 2 MHz
- ✓ Compression of the pulses
- ✓ SHG of amplified pulses for extended UV-Vis tunability
  - [250-350] SHG NOPA 3ω
  - [350-500] SHG NOPA 2ω
  - [500-700] NOPA 2ω
  - [700-1000] NOPA 2ω
- ✓ Transfer to the industry for product development (collaboration with Amplitude Systèmes)



courtesy of J. Nillon

European XFEL

Lasers at FXE

- **keep laser paths as short as possible**
- **Realize as much tunability as possible (HG, NOPA)**
- **keep laser paths as short as possible**
- **Details on the Laser system will be presented by Max Lederer**

Lasers at FXE

FXE will also have an in-house laser lab

→ **kHz laser system**

→ **transient absorption setup**

→ **fluorescence upconversion setup**

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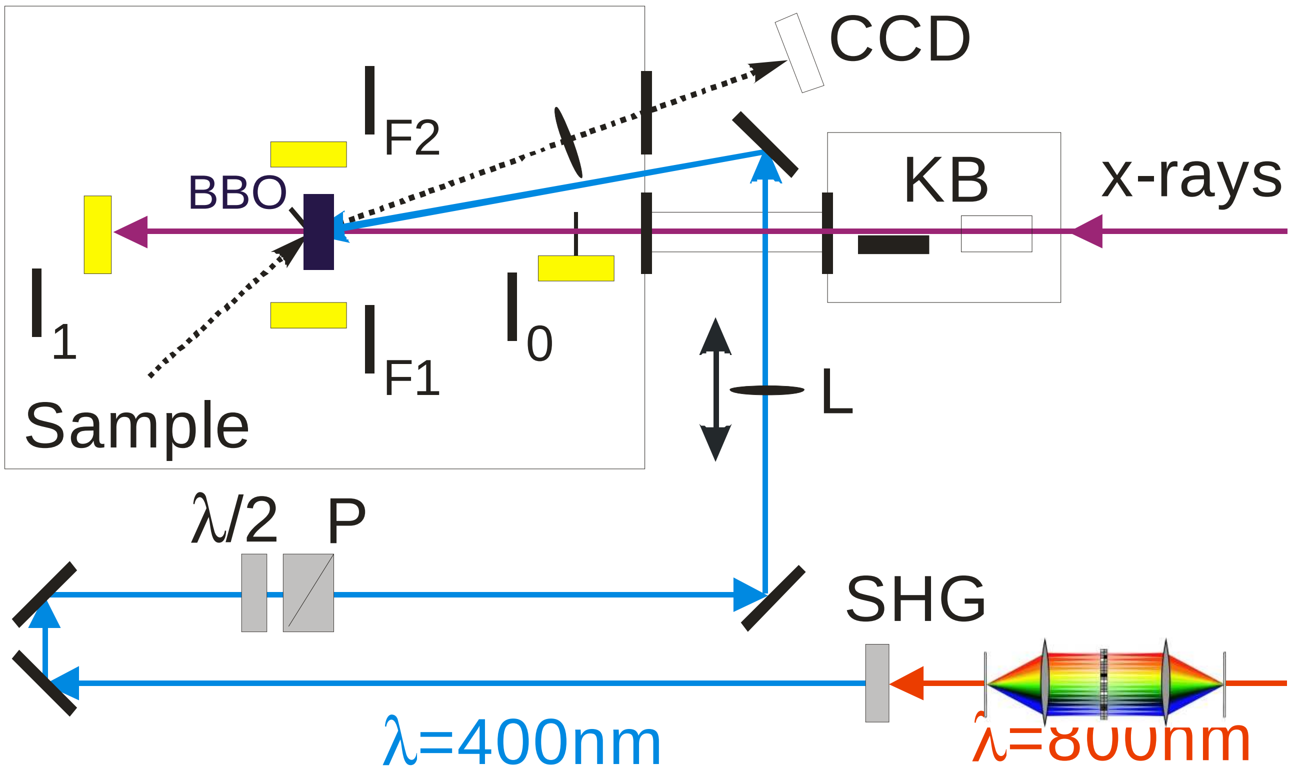
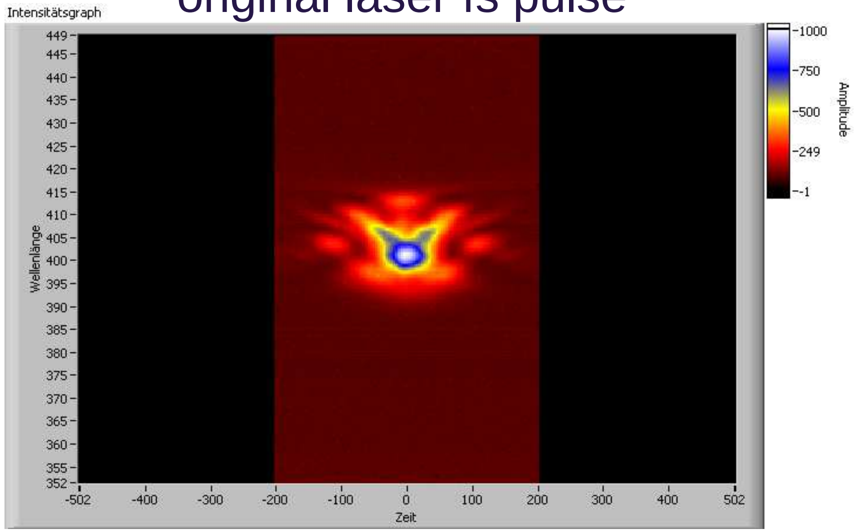
Pulse Characterization at Interaction Point

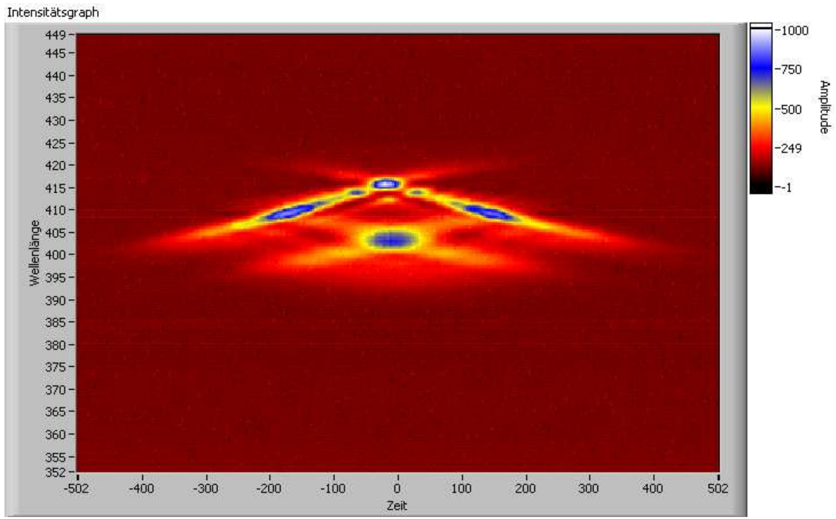


Pulse Characterization at Interaction Point

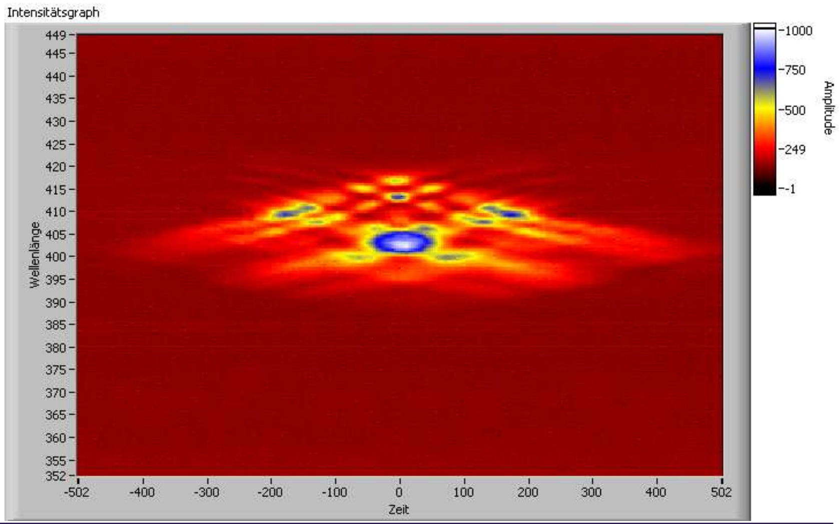
original laser fs pulse



pulse propagated through 5cm of SQ1 glass

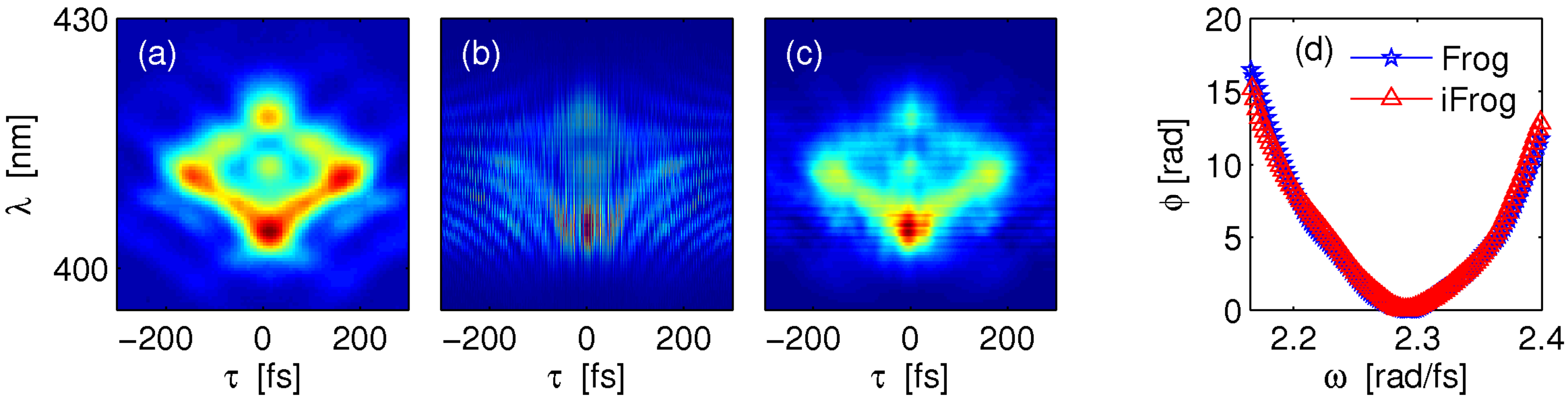


a GVD of 3500 fs^2 was imposed to pulse



Pulse Characterization at Interaction Point

FROG vs iFROG



A. Galler and T.Feurer, Appl. Phys. B 90, 427-430 (2008)

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