Imaging clusters dynamics

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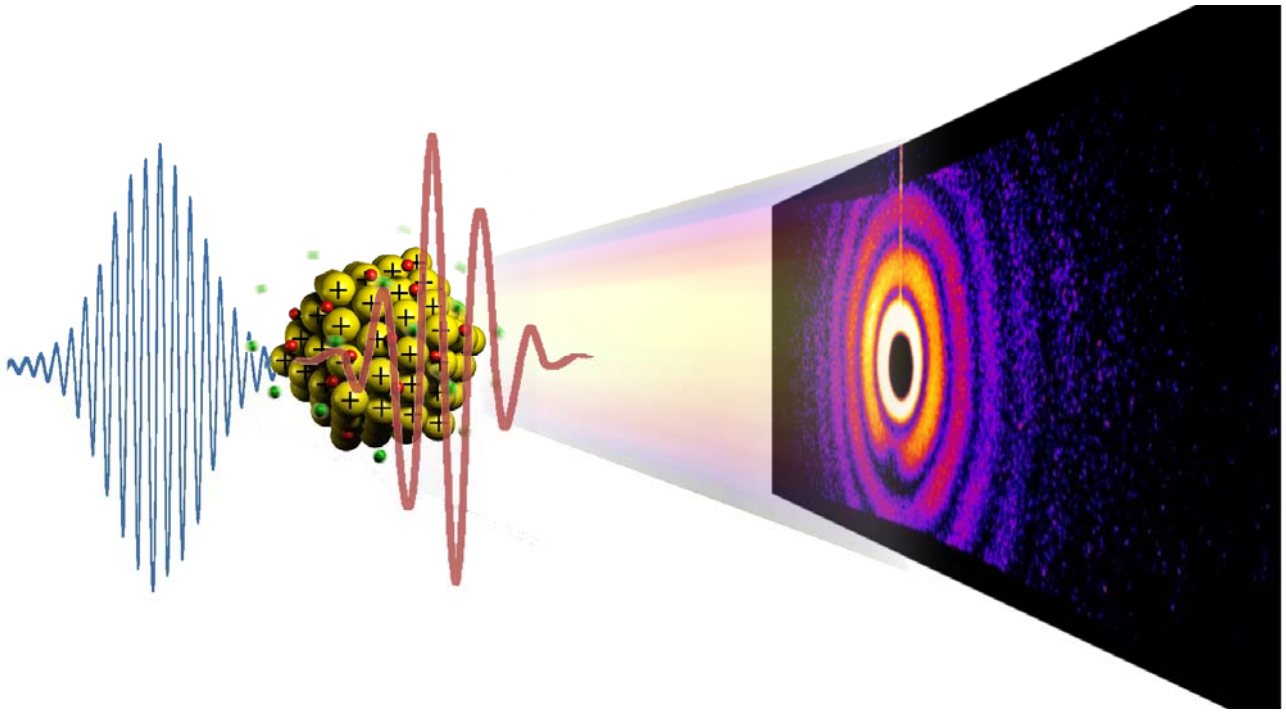
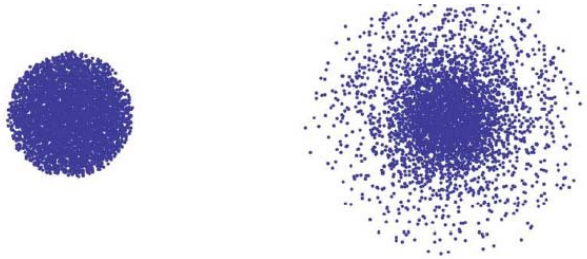
XFEL-XBSD workshop, Hamburg, January 30, 2014,

Light induced dynamic with X-ray pulses



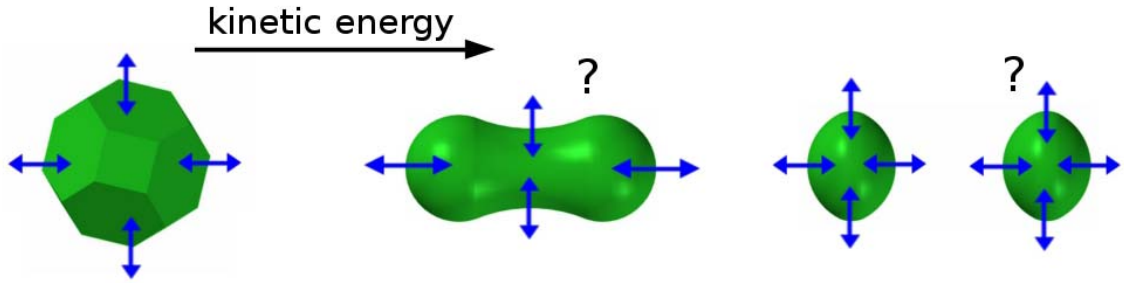
Two aspects

- **Light induced expansion dynamics**
  - **Short time scale, fs-ps,**
  - **Long time scale, ps- ns**



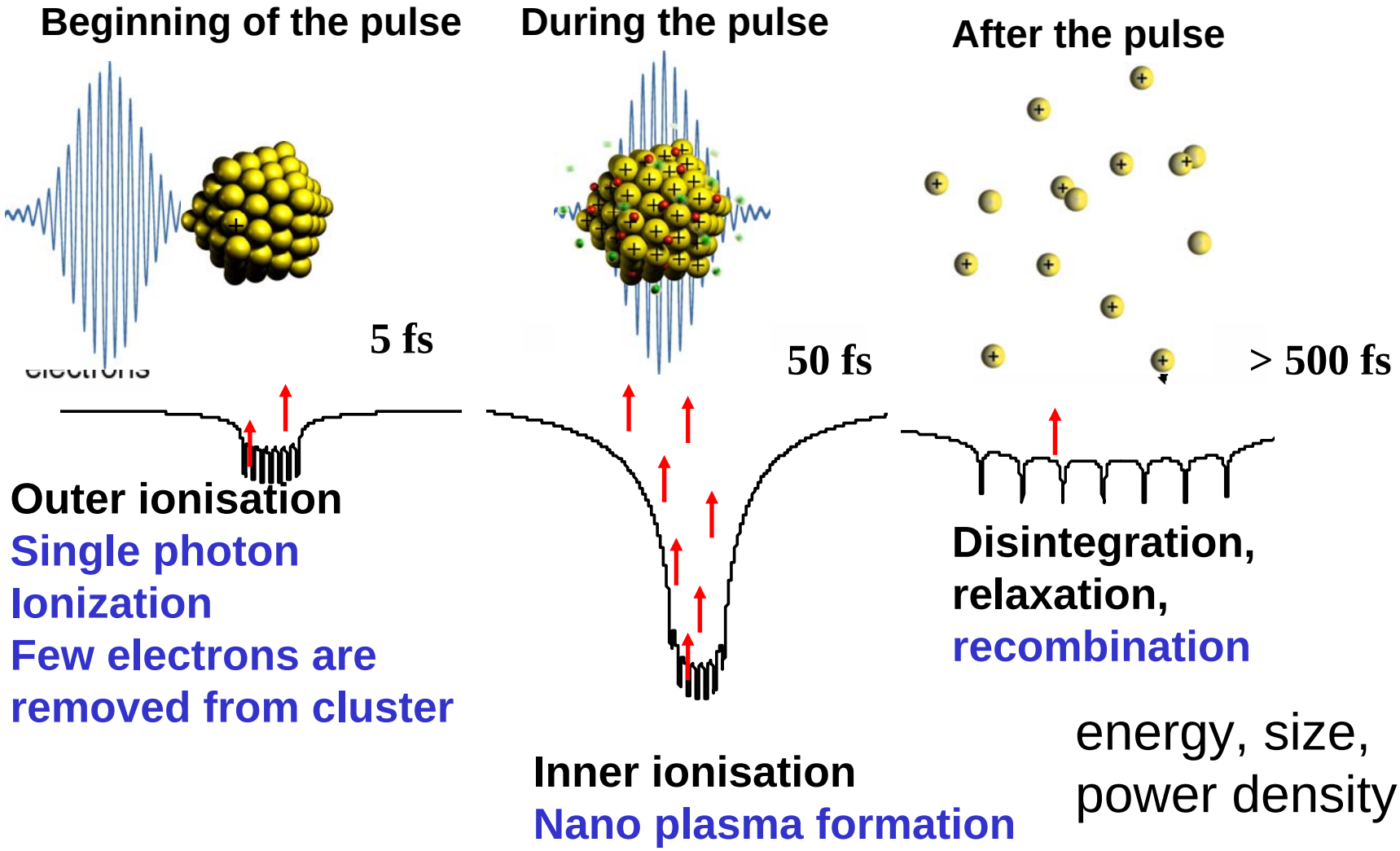
- **Collective cluster oscillations, fission, fs-ps time scale**

Size selected clusters



together with B. von Issendorff, Freiburg

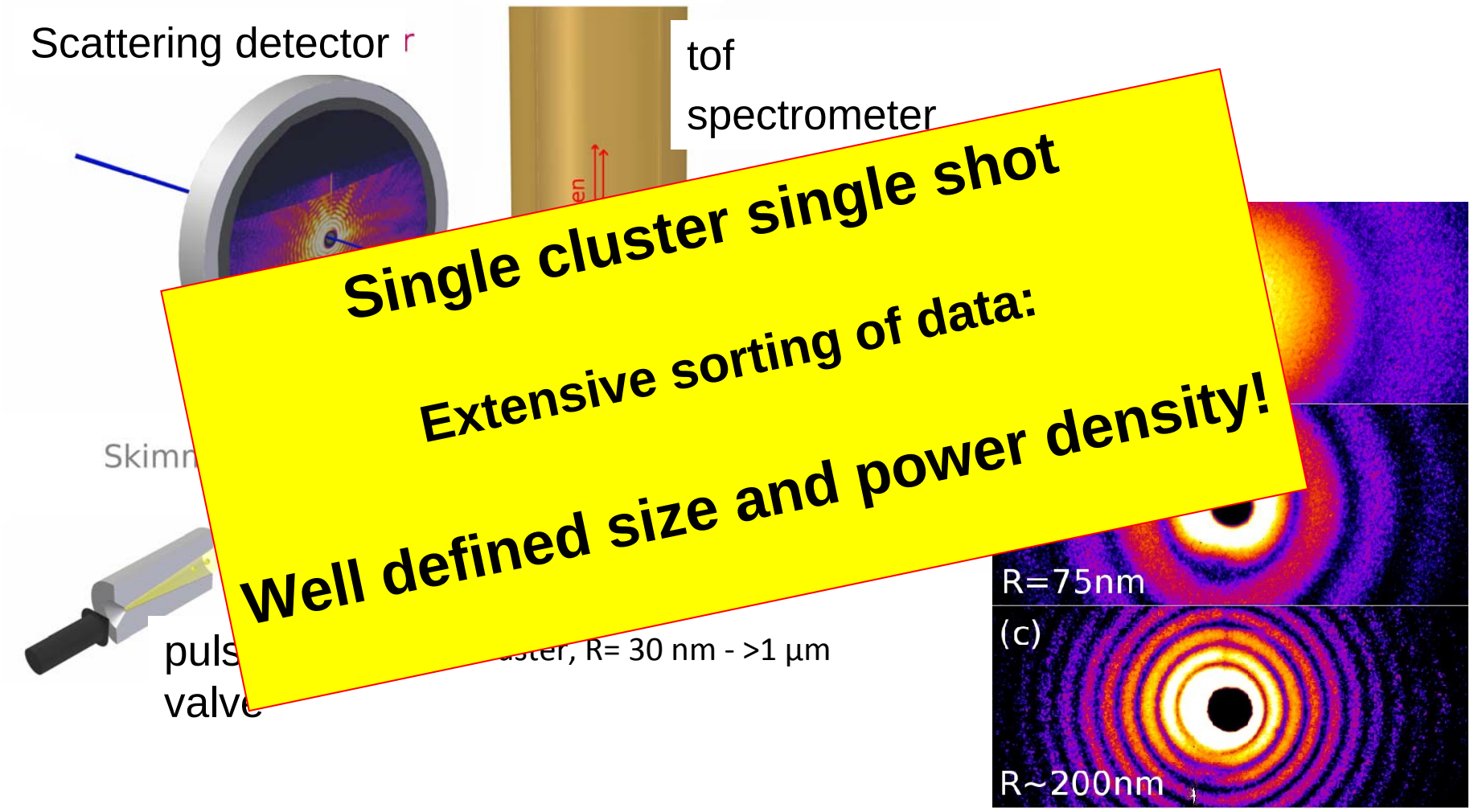
I. Cluster dynamics induced by intense x-ray pulses



Experiments Wabnitz et al, Nature 420, 482 , Laarmann et al, PRL 92, 143401, PRL 95, 063402(2005)

Theory R. Santra, PRL 91, 233401 (2003), Siedschlag, Rost, PRL 93, 43402 (2004), Ziaja, Phys. Rev. Lett. 102, 205002 (2009

Simultaneous light scattering and ion spectroscopy on individual clusters FLASH (DESY)



Single cluster single shot

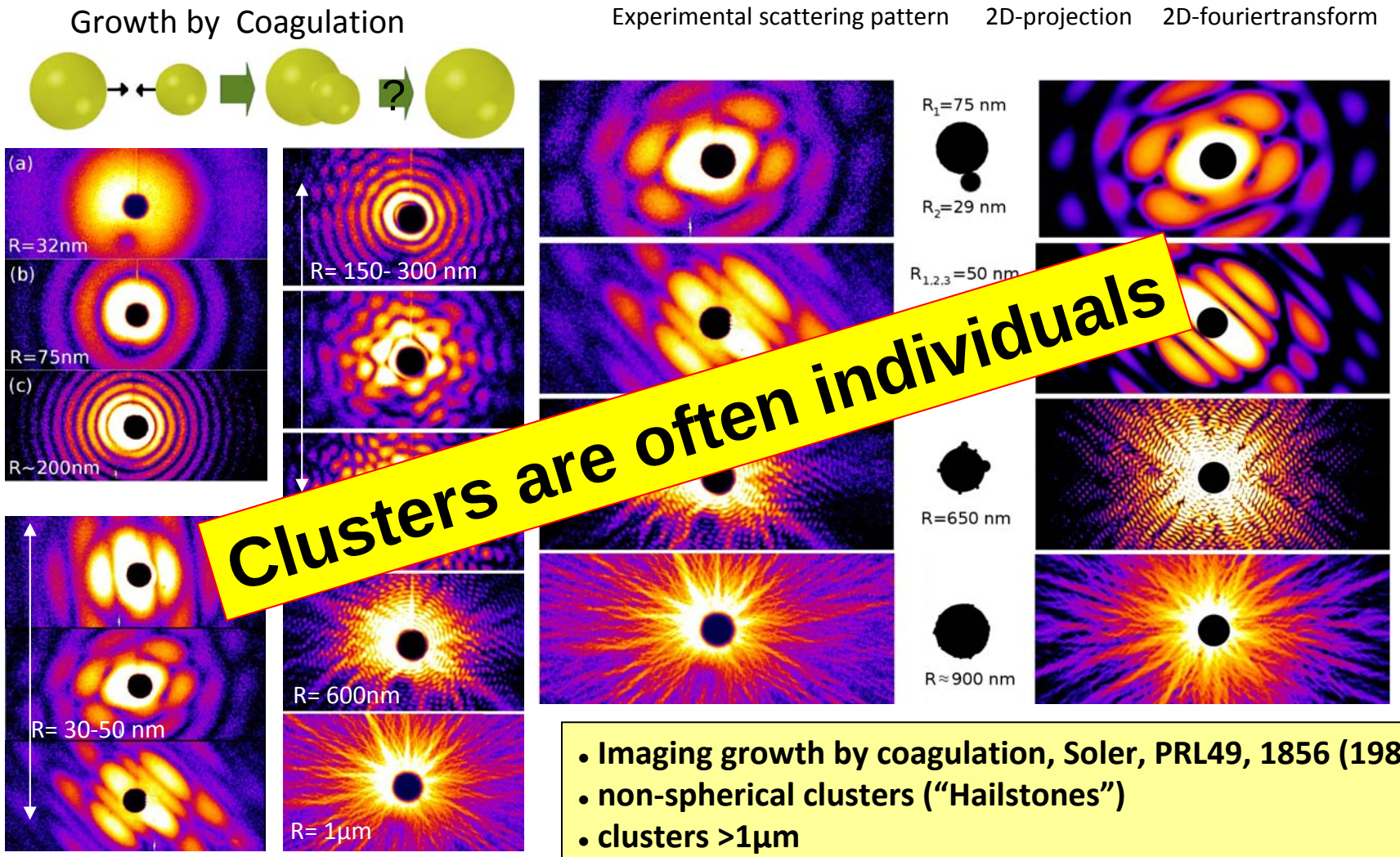
Extensive sorting of data:

Well defined size and power density!

Phys. Rev. Lett. 108, 093401 (2012)

Morphology of very large xenon cluster

Analysis with 2D-Fourietransform

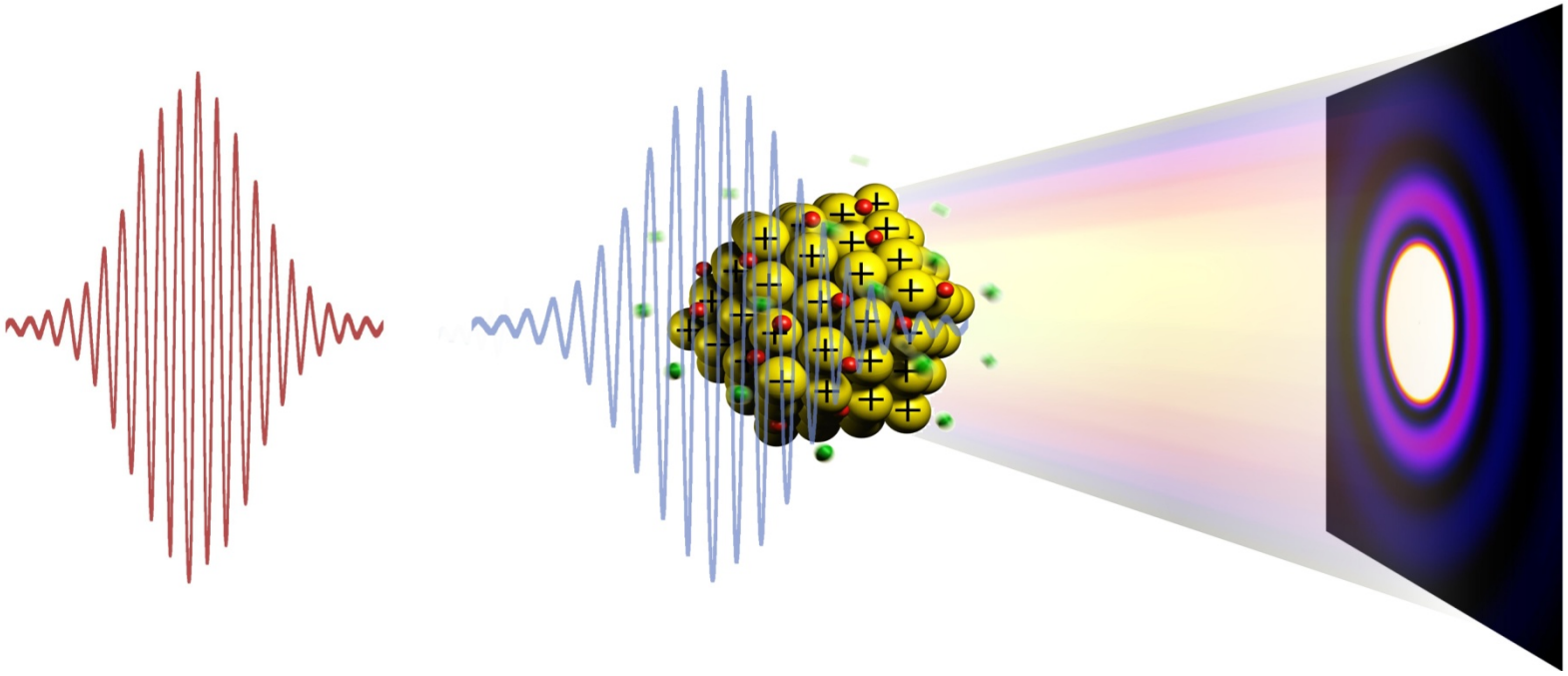


- **Imaging growth by coagulation, Soler, PRL49, 1856 (1982)**
- **non-spherical clusters ("Hailstones")**
- **clusters >1µm**

New Journal of Physics **14** (2012) 055016

Time resolved imaging of exploding clusters

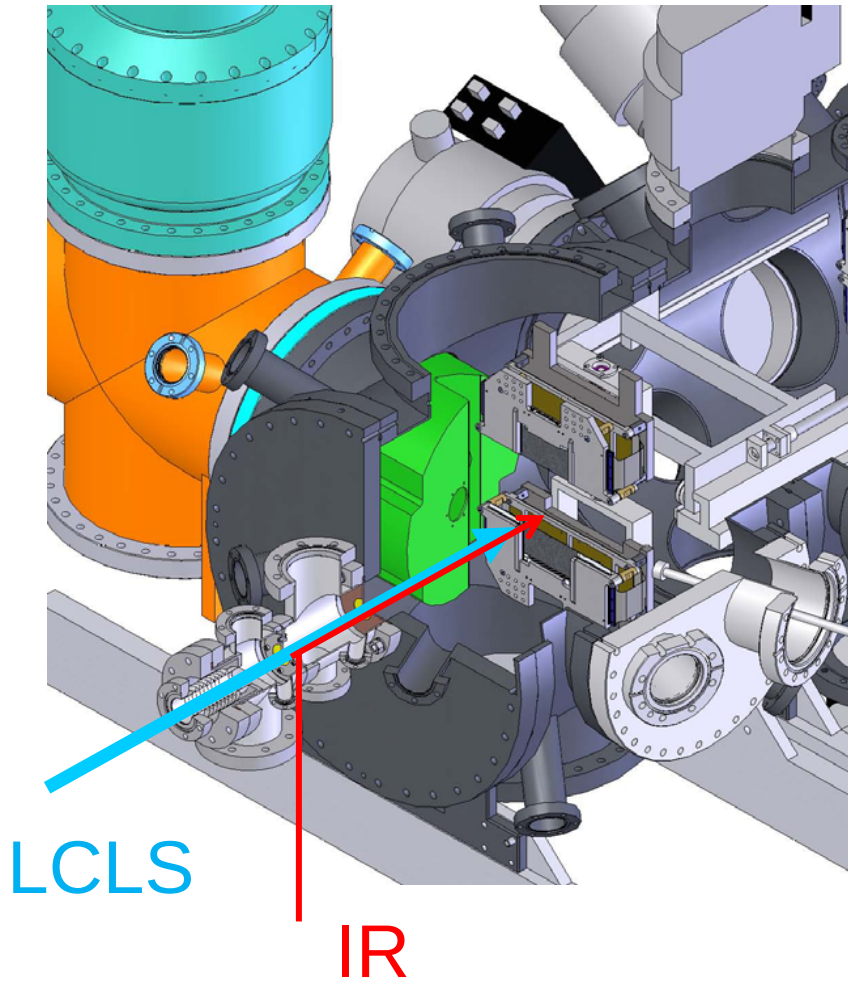
- Study how ultrafast ionization dynamics influence scattering process
- Scattering sensitive to both, changes in electronic and geometric structure

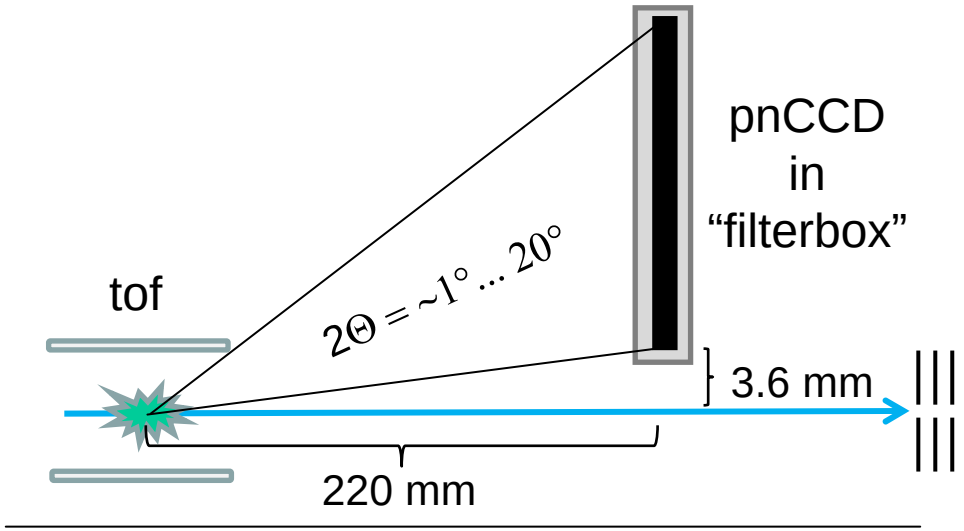


IR pump + FEL probe pulse (LCLS), CAMP

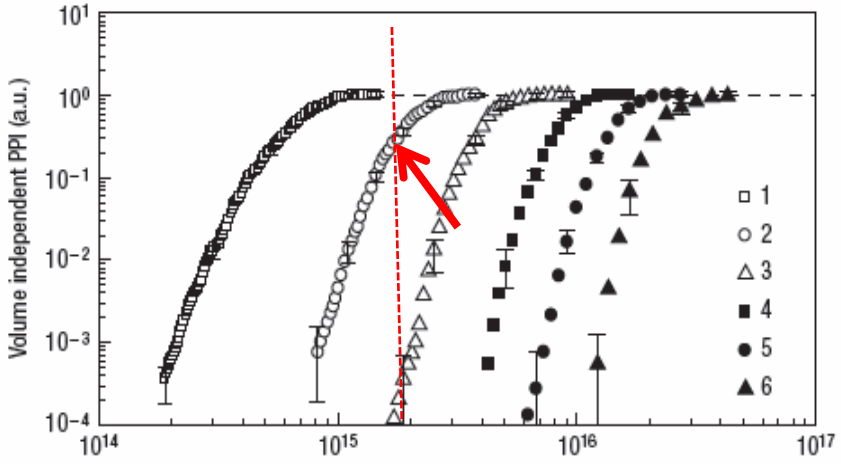
X-rays only Phys. Rev. Lett. 108, 245005 (2012)

Experimental layout





IR laser: 50 fsec, 2 mJ, $2 \cdot 10^{15}$ W/cm^2



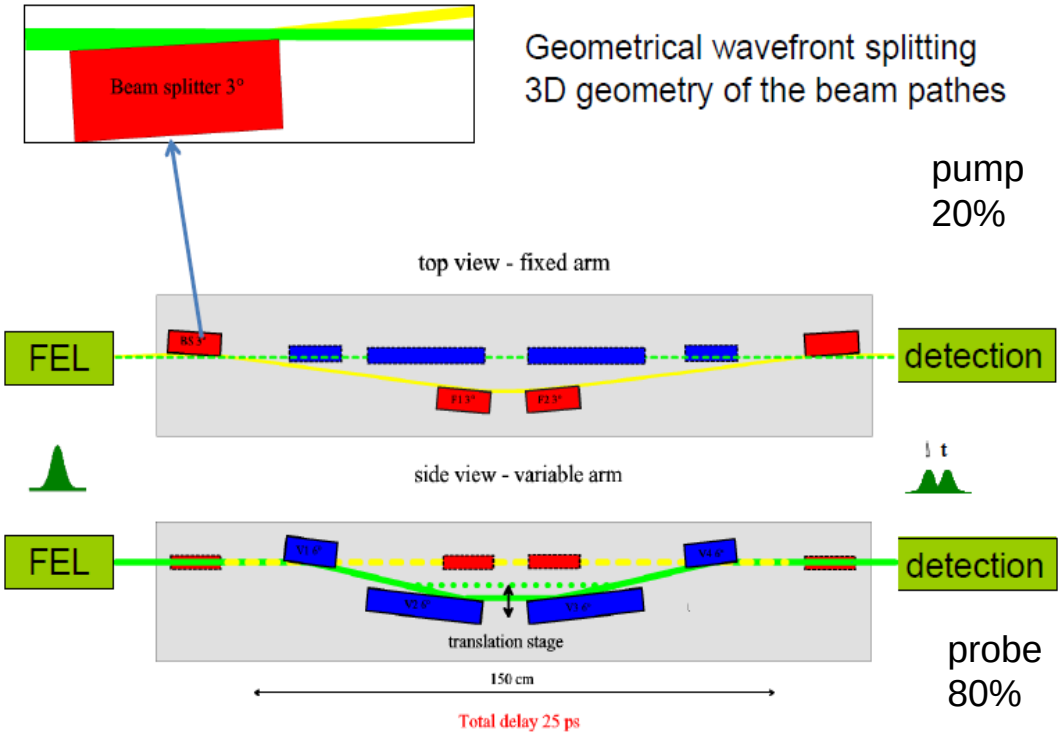
Bryan et al., Nature Physics 2, 379 (2006)

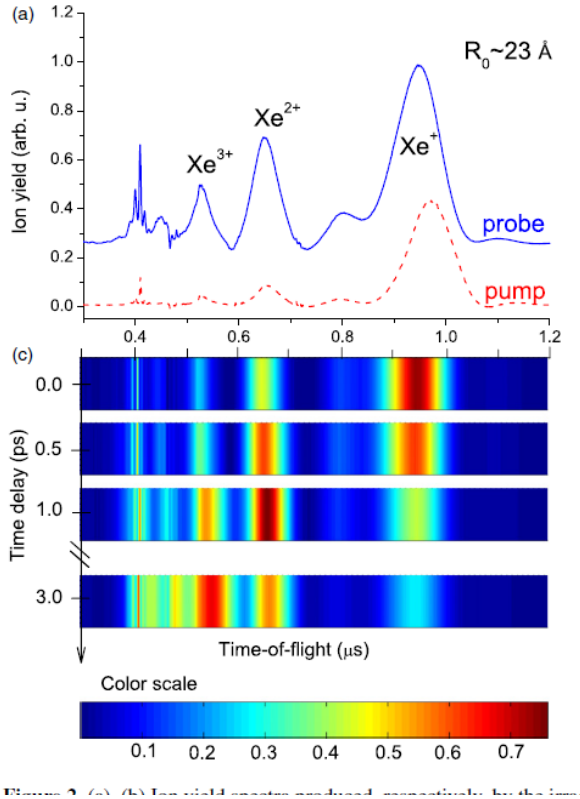
XUV pump XUV probe

FLASH, 93 eV

Delayline for soft x-rays (autocorrelator)

ion spectra





R. Mitzner et.al., Proc. Of SPIE 59200D-1

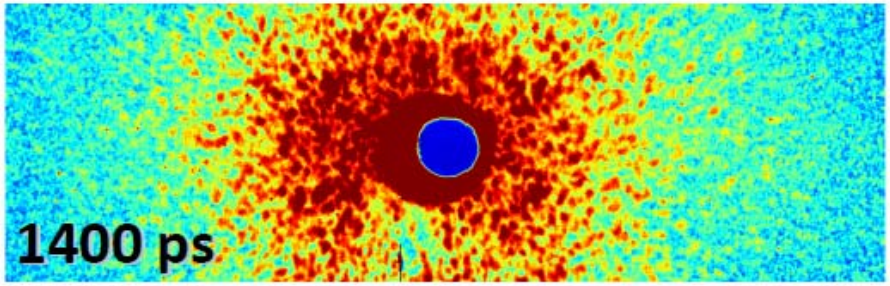
Universität Münster, Zacharias
BESSY

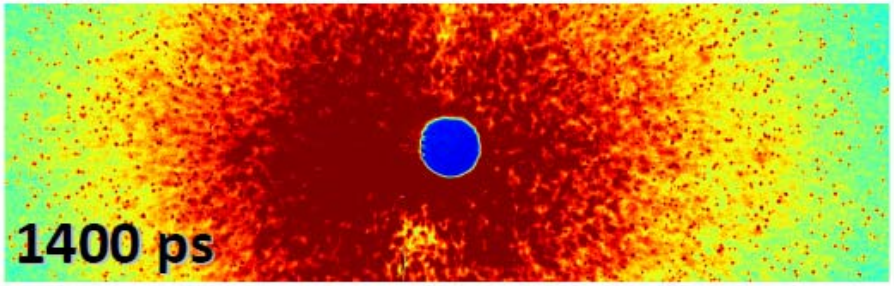
M. Krikunova, et al. J. Phys. B: At. Mol. Opt. Phys. **45** (2012) 105101

2 nm Xe clusters,
destroyed after ~2 ps

Very long delay: Results from FLASH 93 3V, Comparison with simulations

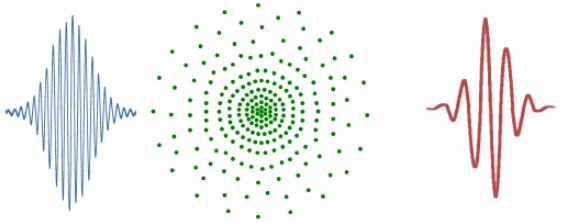
Timescale: 1000 – 1500 ps - moderate NIR intensities



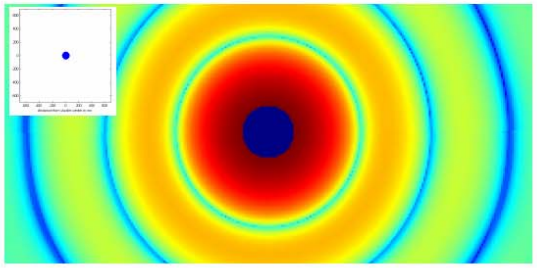


Simulation with Gunnier-aproach

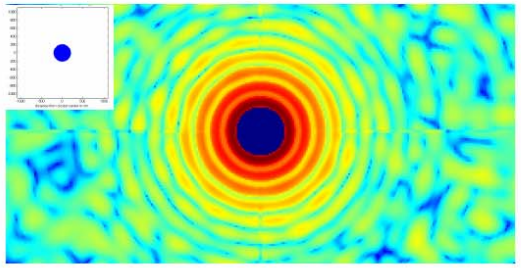
R. De Castro et al, J. Ele. Spectr. Rel. Phen. 166, 21 (2008)



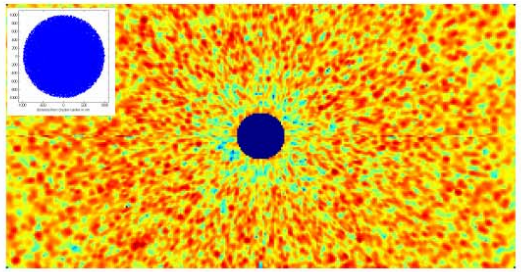
Atom distance = 2.5 nm



Atom distance = 10 nm



Atom distance = 100 nm



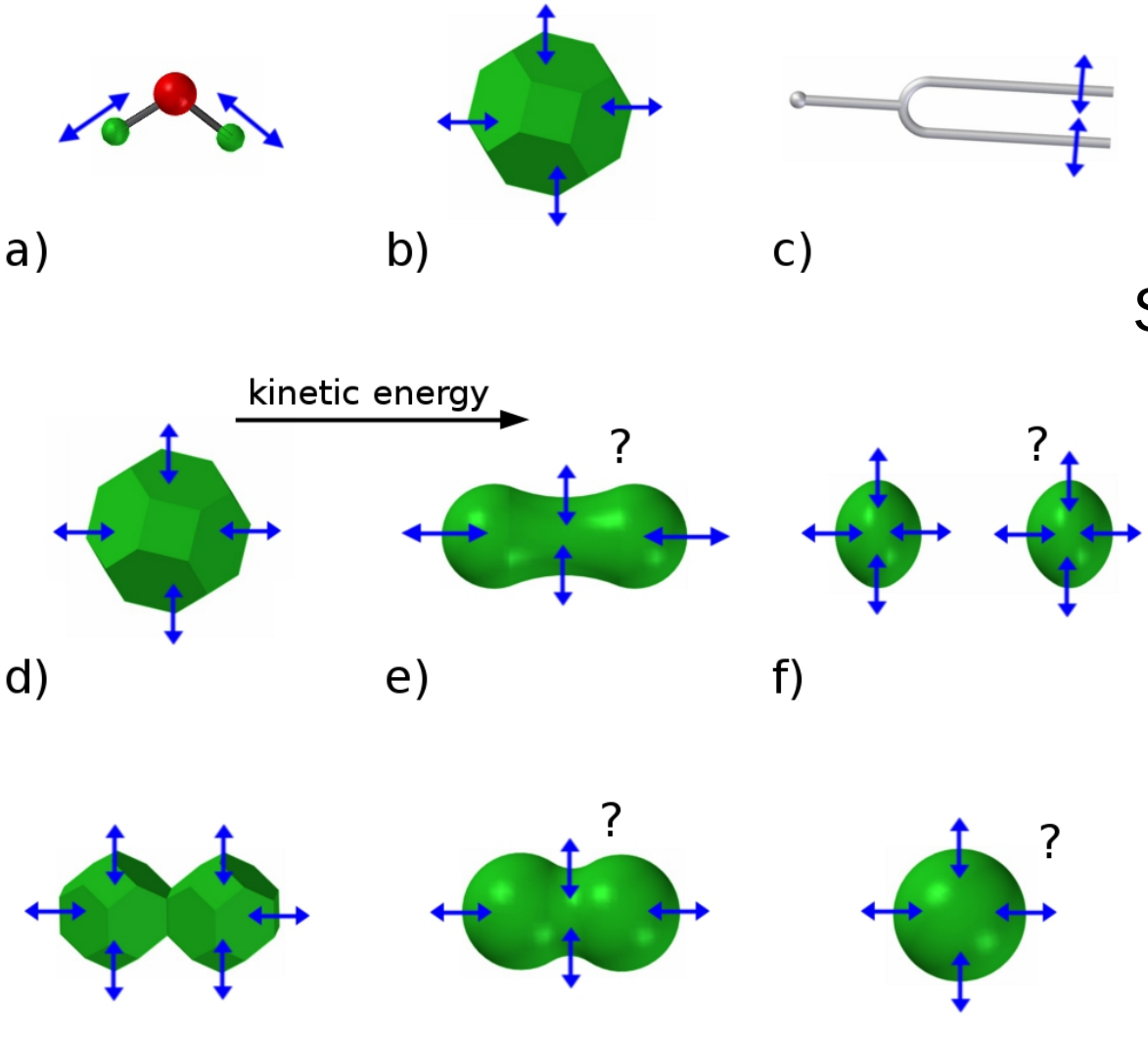
Density fluctuations in an expanding nanoplasma?

With two X-rays pulses at SQS

- First (weak) puls shape of initial cluster
- Second pulse imaging of the cluster dynamics

- surface melting and explosion, fs-time scale
- Cluster expansion, ps time scale

Collective oscillations/dynamics in nanoparticles



Approved DFG project
with B. von Issendorff

Size selected nanoparticles and two/three light pulses

- first (very weak) X-ray pulse
- IR pulse induces vibration by heating

- second X-ray pulse, imaging as a function of delay
- Two x-ray pulses, inital shape of clusters

New regime of cluster dynamics
Damping on the nanoscale

Parameters wish list

	Day 0	Nice to have
Experimental techniques	Scattering / spectroscopy	
Source properties		
Energy range	500	500 eV- 2000 eV
Pulse duration	50 fs or less	< 30 fs
bandwidth		
Device properties		
Maximum Temporal delay	5 ps	30 ps or more
Pulse intensity ratio	1:3	1:1- 1:50
2 Colors		yes
Symmetric delay around t=0		no
Spatial separation behind sample		
Add your suggestions	Small focal spot, good overlap	

Acknowledgement

Funding by BMBF and DFG

TU Berlin + MPHIl @ FLASH

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And thank you for your attention!

CAMP @ LCLS