Slovak activities in European XFEL

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European XFEL - built at scientific superhub

- DESY - German synchrotron center (budget blns €/year)
  - 50 years of photonics science
  - Petra III synchrotron (Petra IV in planning)
  - running breakthrough superconducting linac for XFEL
  - running electron injector for E-XFEL
- University Hamburg & UH Hospital
- EMBL , CFEL, CSSB, …
- scientific spinoffs & strong industrial ties
- strong political support at federal & local level

European XFEL

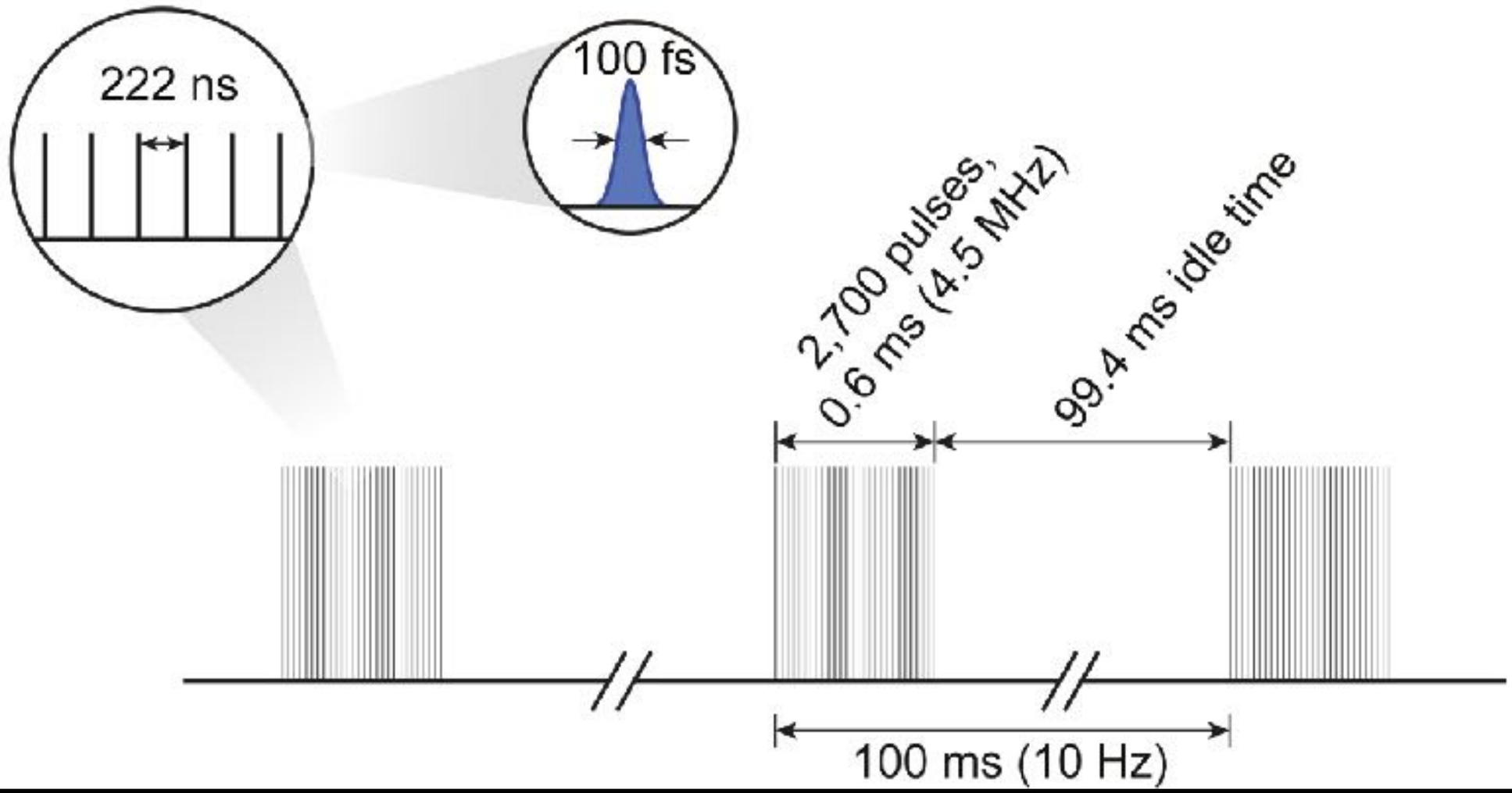
- flagship of ESFRI infrastructure
- Build for 1.25 bln € (in 2005 levels)
- free electron laser - X-ray
- supra-conductive linac technology
- ultrafast repetition rate
- first of its kind

SHAREHOLDERS

- The European XFEL is organized as a non-profit company with limited liability under German law (GmbH)
- New shareholders -
  - Great Britain (signed 2018 - before Brexit)
  - China, Czech Republic, - in talks

Present (bold) or likely future shareholder of the European XFEL GmbH		Country
DASTI (Danish Agency for Science, Technology and Innovation)		**Denmark**
CEA (Commissariat à l'énergie atomique et aux énergies alternatives) **CNRS (Centre national de la recherche scientifique)**		**France**
DESY (Deutsches Elektronen-Synchrotron)		**Germany**
NRDI Office (National Research, Development and Innovation Office)		**Hungary**
INFN (Istituto Nazionale di Fisica Nucleare) CNR (Consiglio Nazionale delle Ricerche)		Italy
NCBJ (National Centre for Nuclear Research)		**Poland**
NRC KI (National Research Centre "Kurchatov Institute")		**Russia**
Slovak Republic, represented by the Ministry of Education		**Slovakia**
Kingdom of Spain, represented by Ministerio de Economía y Competitividad		Spain
VR (Swedish Research Council)		**Sweden**
Swiss Confederation, represented by Staatsektretariat für Bildung und Forschung		**Switzerland**
Science and Technology Facilities Council		United Kingdom

European XFEL pulse train



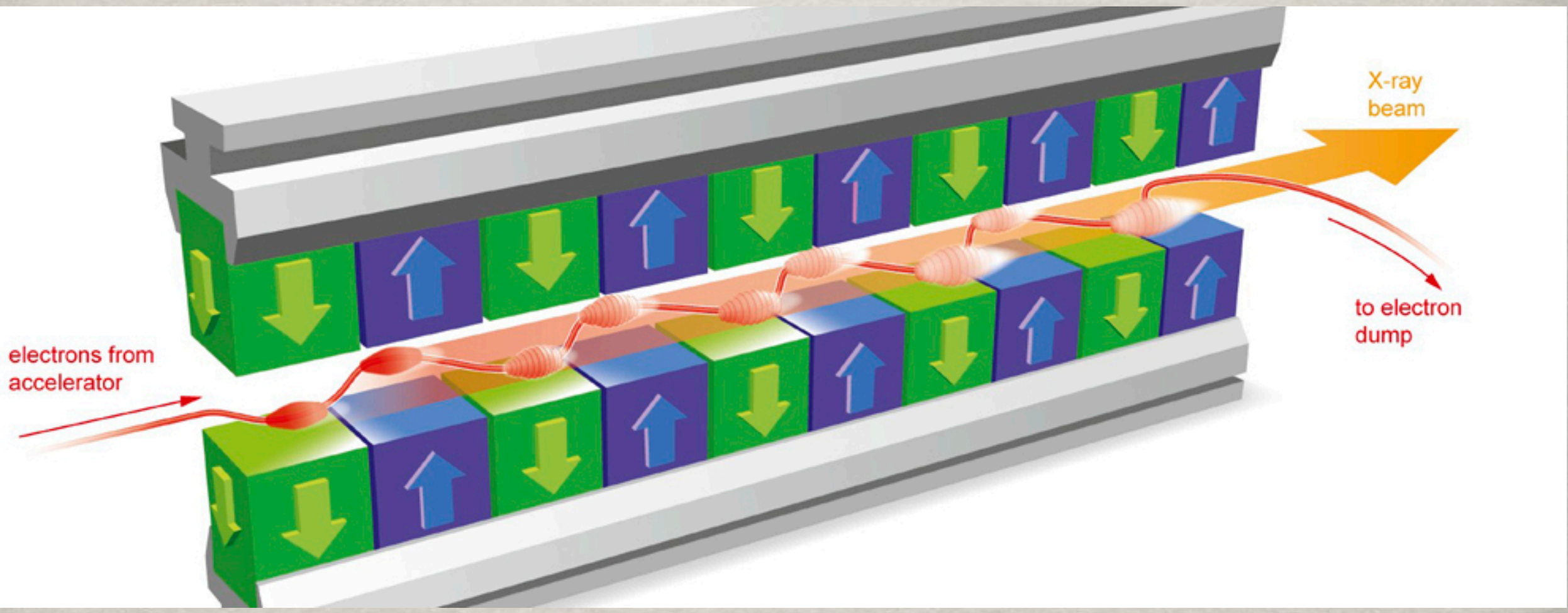
European XFEL - scientific superhub

- structural biology breakthroughts
- movies of chemical reactions
- extreme states of matter - early stages of universe (ultrahot ultradense plasma)
- material research (electronics, spintronics, smart materials)
- pushing a technological envelope (IT…)

European XFEL - scientific superhub

- record setting but not alone
- competition:
  - LCLS Stanford - USA
    - LCLS II
  - SACLA - Japan
  - Poang XFEL - South Korea
  - PSI SwissFEL - Switzerland
  - Shanghai XFEL

SASE principle
4th gen X-ray



WHY SLOVAK PARTICIPATION?

- strategic interest of Slovakia to join selected ESFRI - because:

- way to join scientific superhubs

- too expensive for small countries (even for big ones)

- fostering ERA (European Research Area)

- raising competitiveness of EU

IN WHAT FORM?

- 1.1% shareholder (13+M€)
- SFX consortium (serial femtosecond crystallography and single particle imaging)
- XBI consortium (Biological laboratories for XFEL)

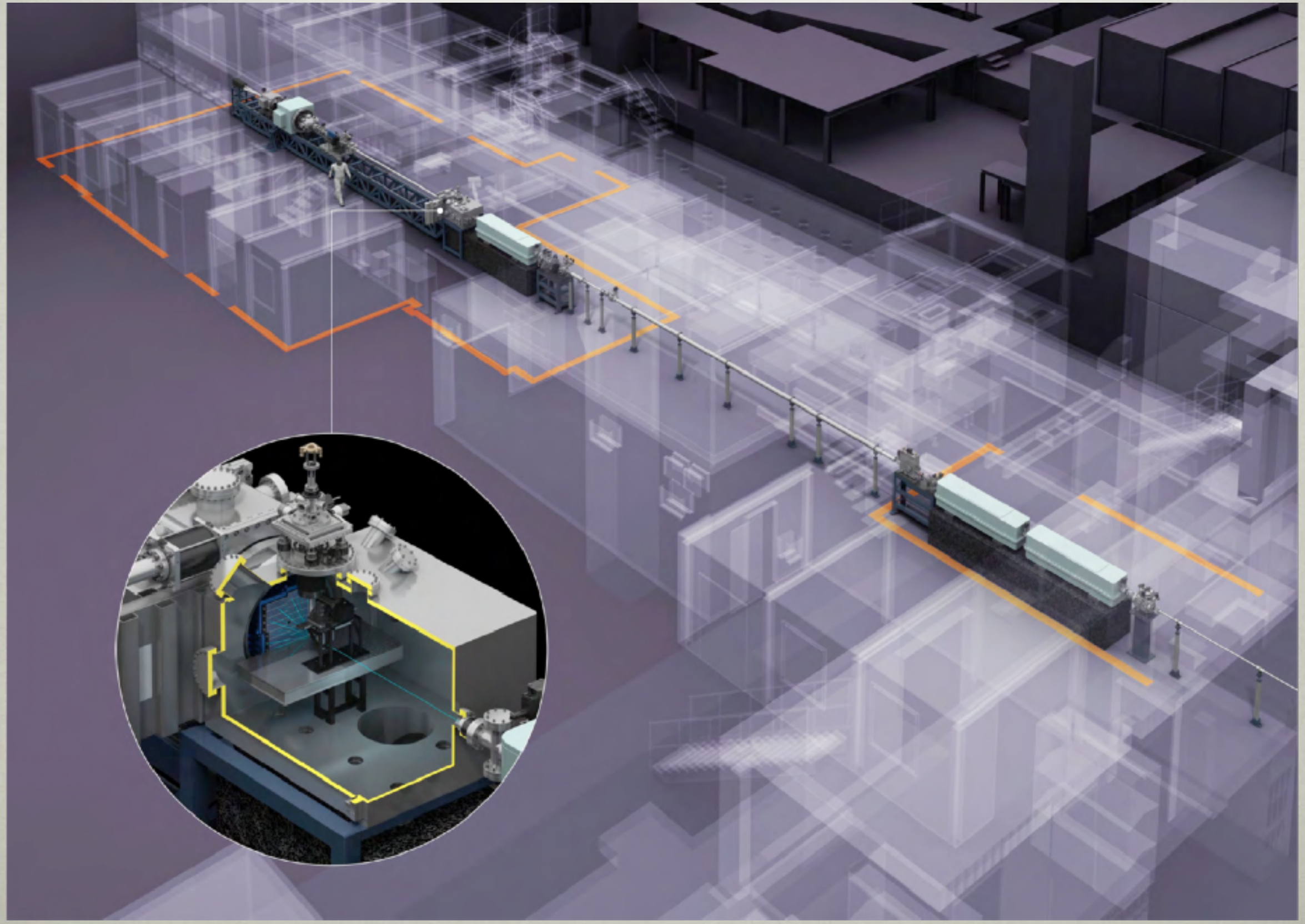
E-XFEL aerial view

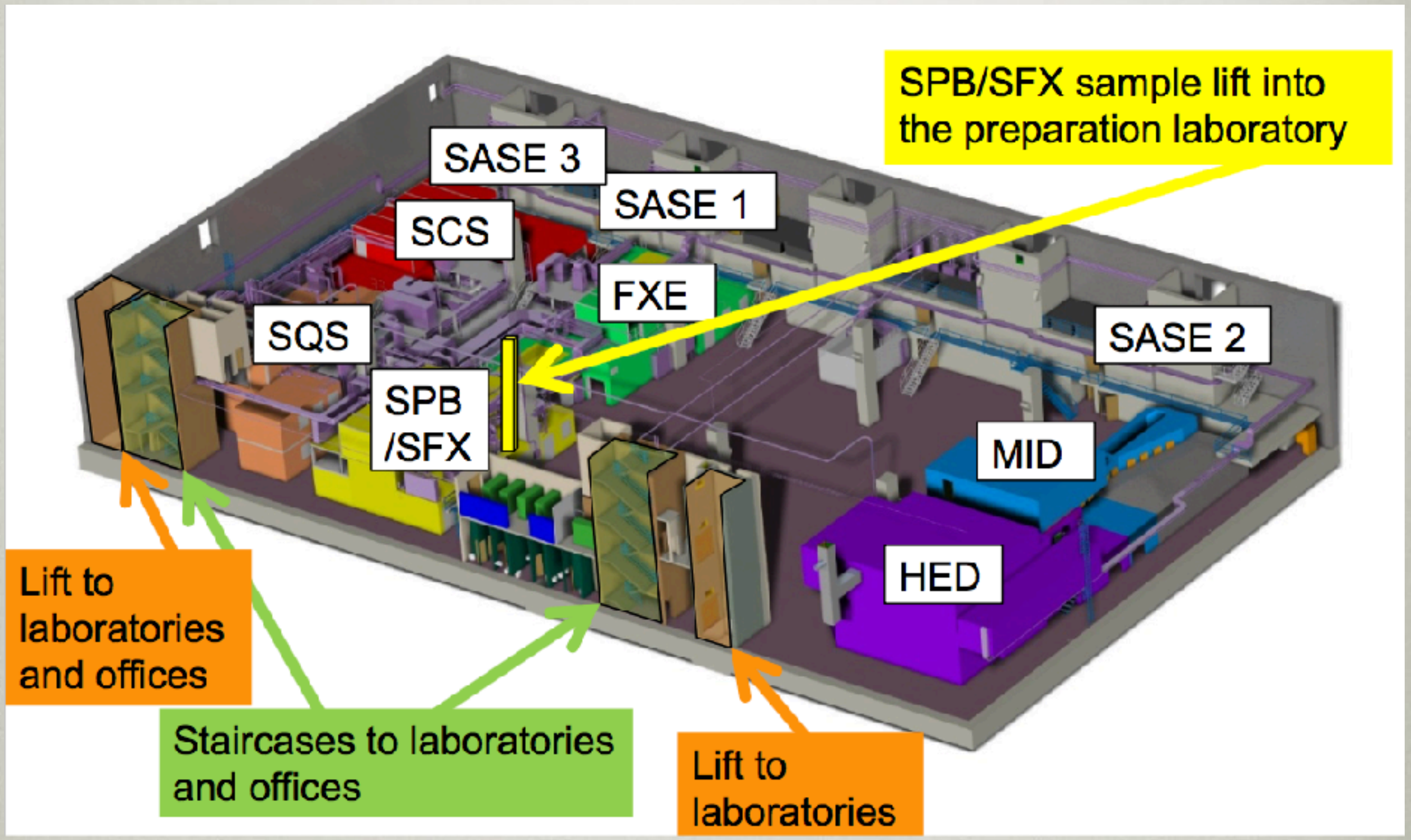
OFFICIALLY OPERATIONAL SINCE 1 SEPT 2017

xfel user meeting 2018

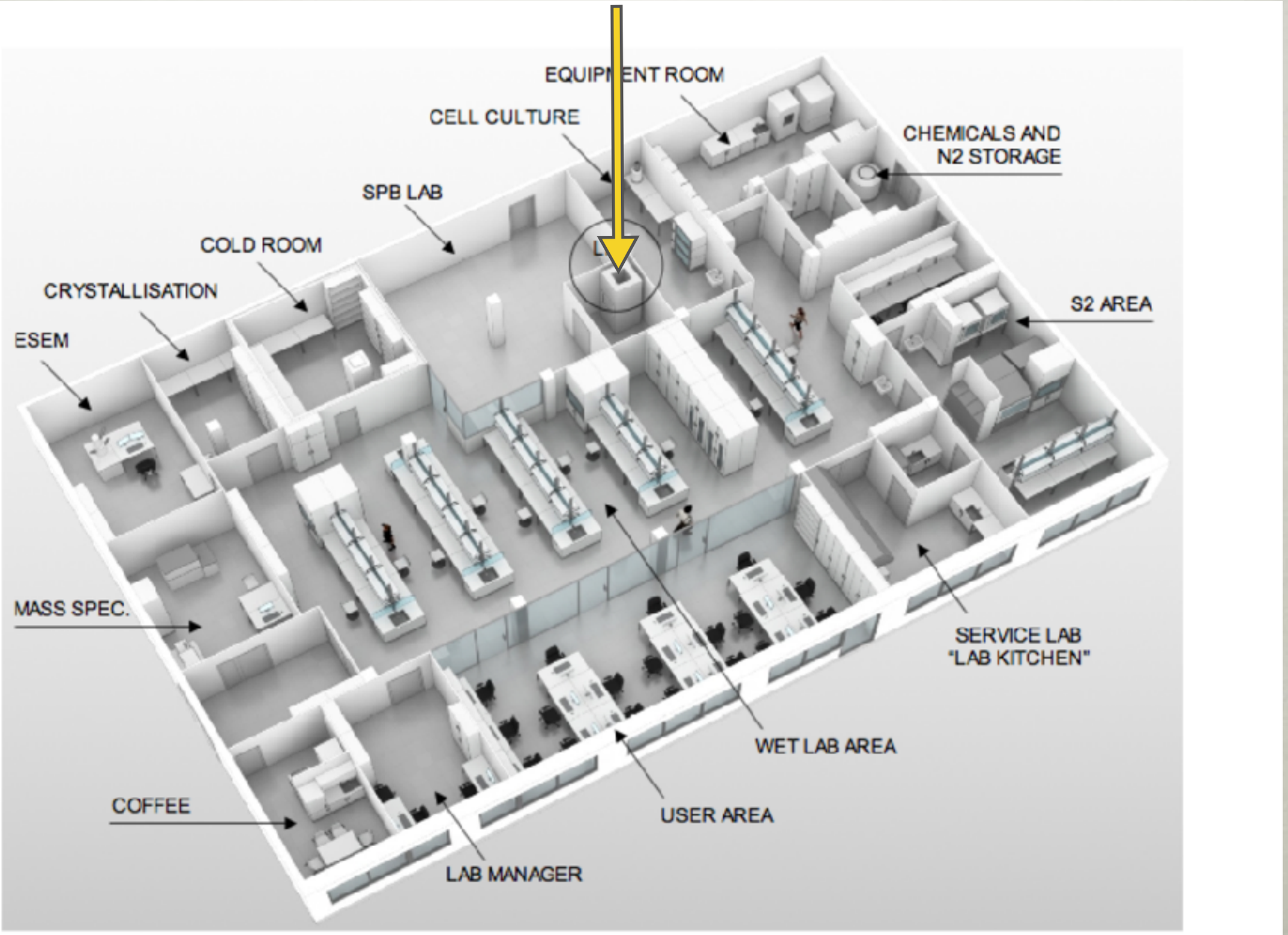
European XFEL XHQ

SPB/SFX at E-XFEL




SPB/SFX sample lift into the preparation laboratory
SASE 3
SASE 1
SCS
FXE
SQS
SPB /SFX
SASE 2
MID
HED
Lift to laboratories and offices
Staircases to laboratories and offices
Lift to laboratories

and XBI Biological lab above it



Center for
Applied Structural
Discovery

Biodesign
Institute
Arizona State University

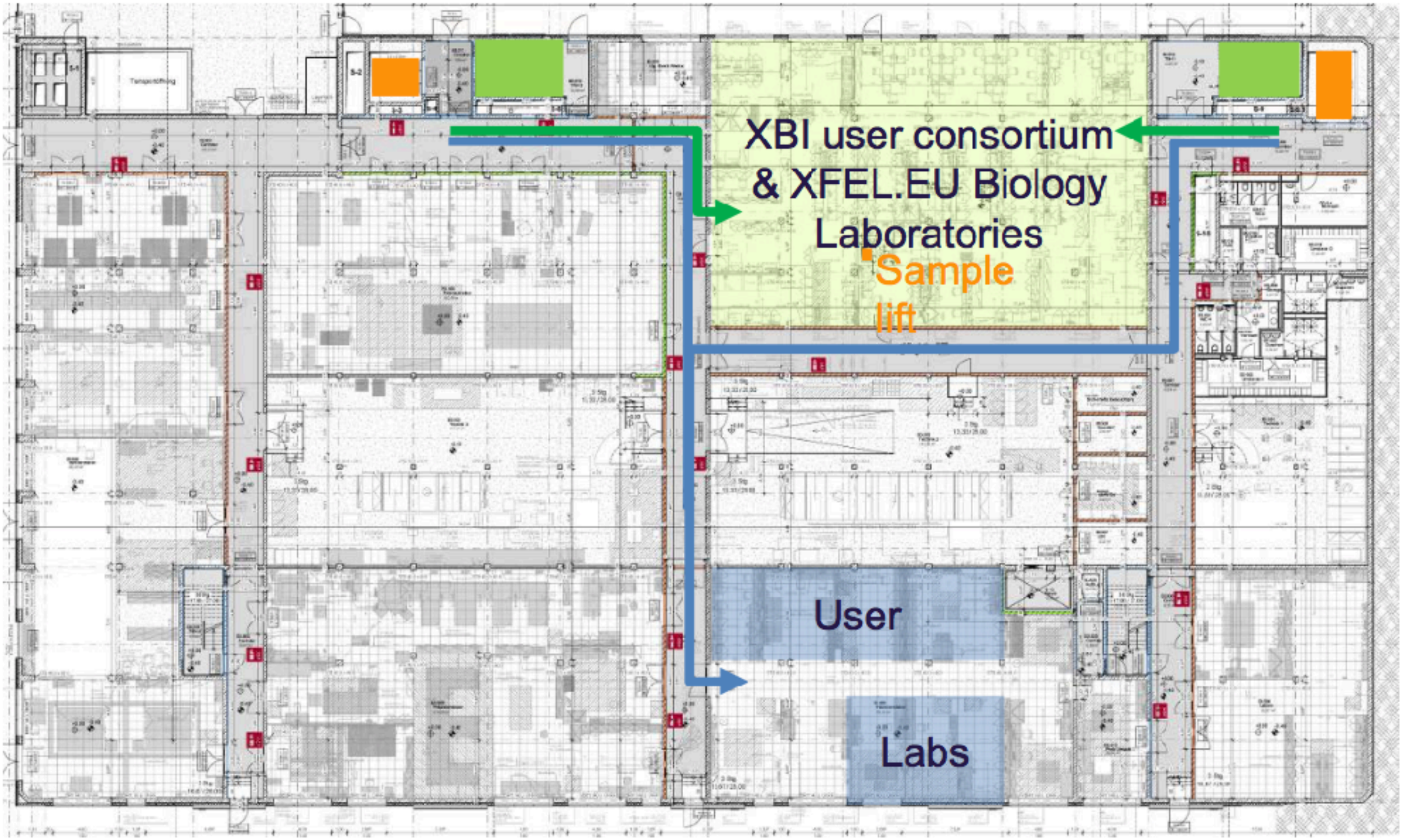
European
XFEL

EMBL

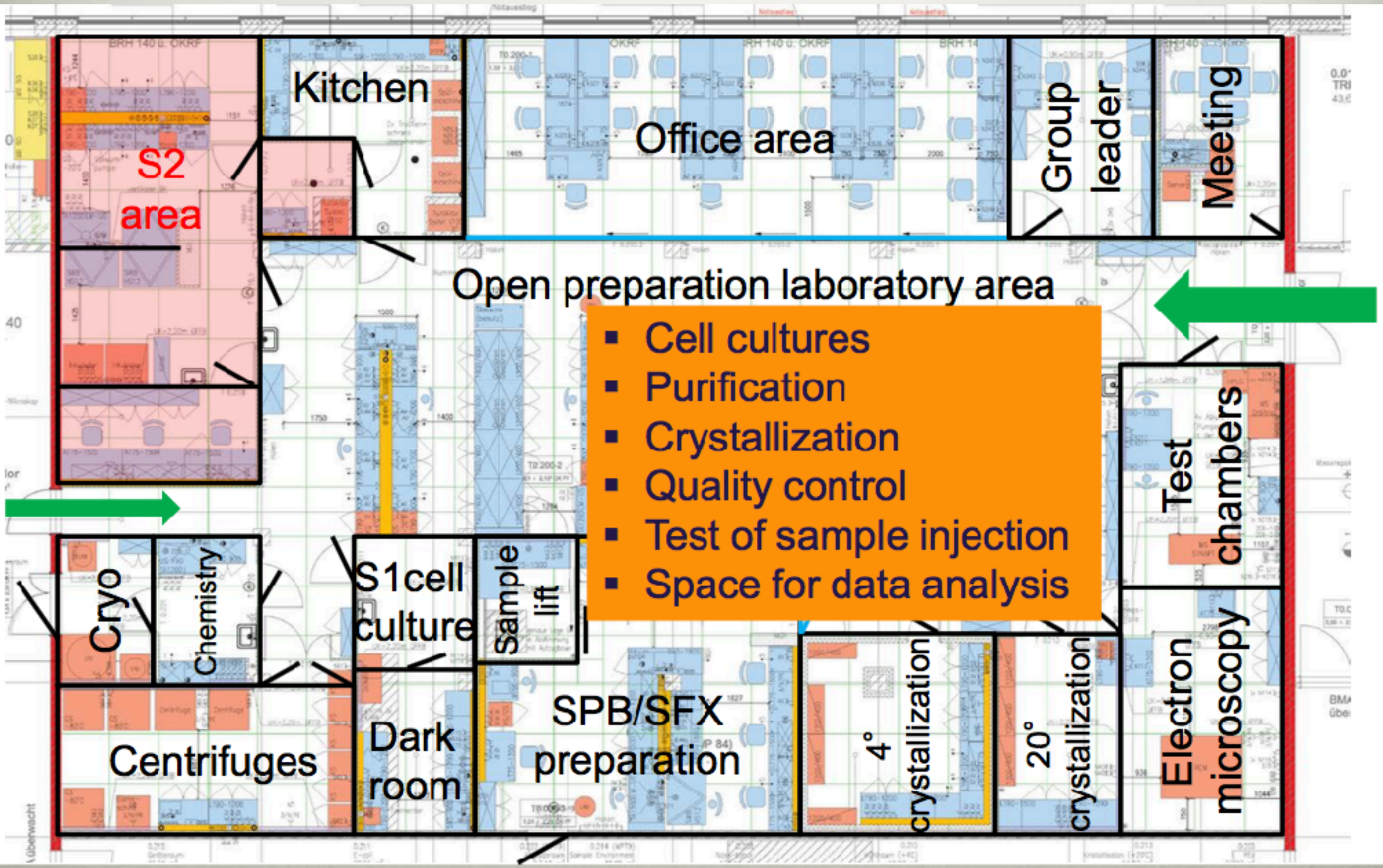
UNIVERSITY
OF OULU

UH UKE
HAMBURG

UPPSALA
UNIVERSITET


XBI user consortium
& XFEL.EU Biology
Laboratories
Sample
lift
User
Labs

LAB DISPOSITION



FXE experiment

WHAT WE PERSONALLY DO?

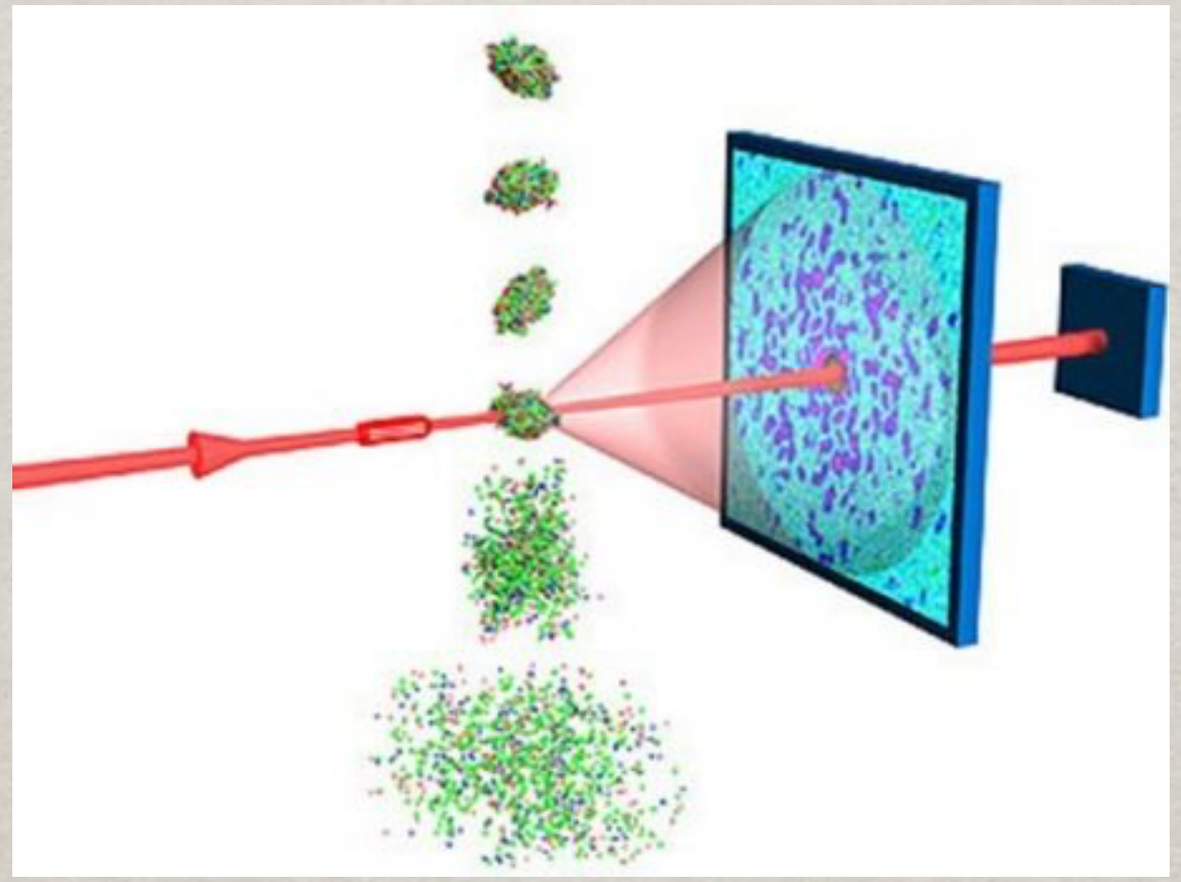
- sample delivery
- image processing
- fast imaging
- sample preparation
- DNA architecture

SAMPLE DELIVERY

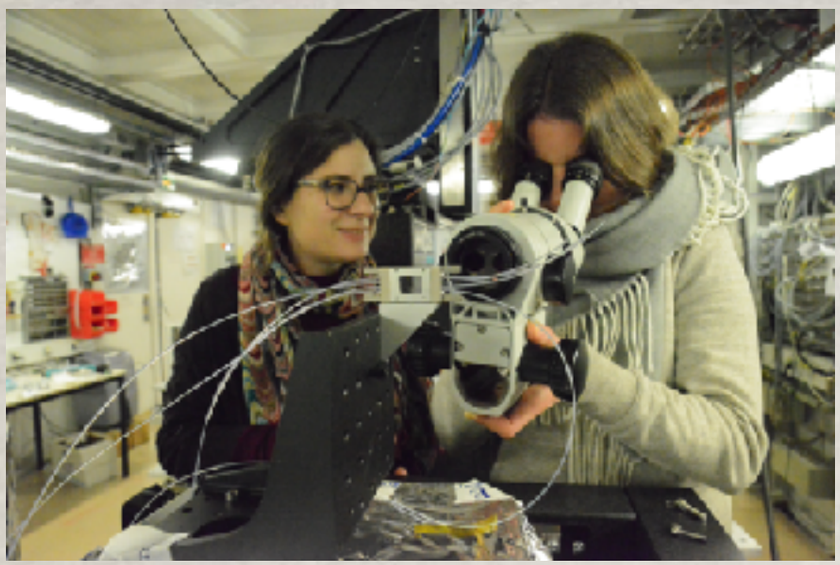
- 27 kHz sampling rate (4.5 MHz with gaps)
- liquid jet/aerosol ~400m/s
- not yet achieved (but major potential advantage)

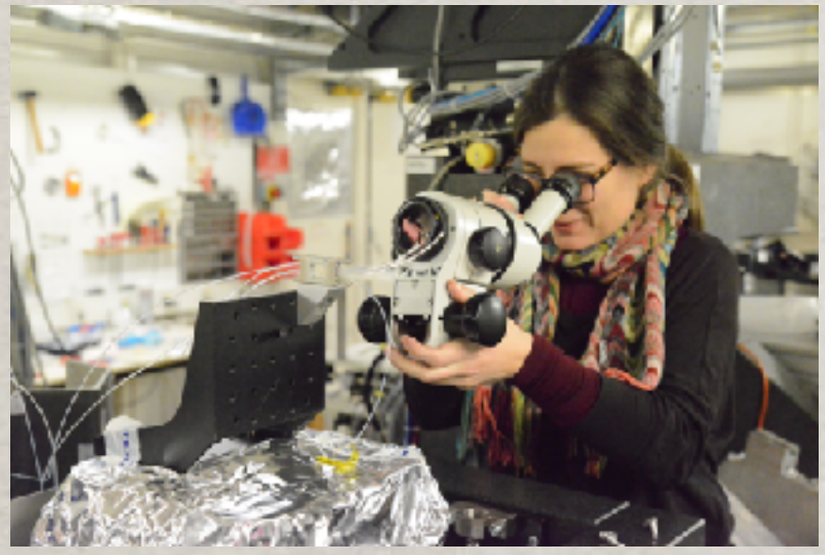
Rita Graceffa, Sample environment group of Joachim Schulz on official PR photo of E-XFEL

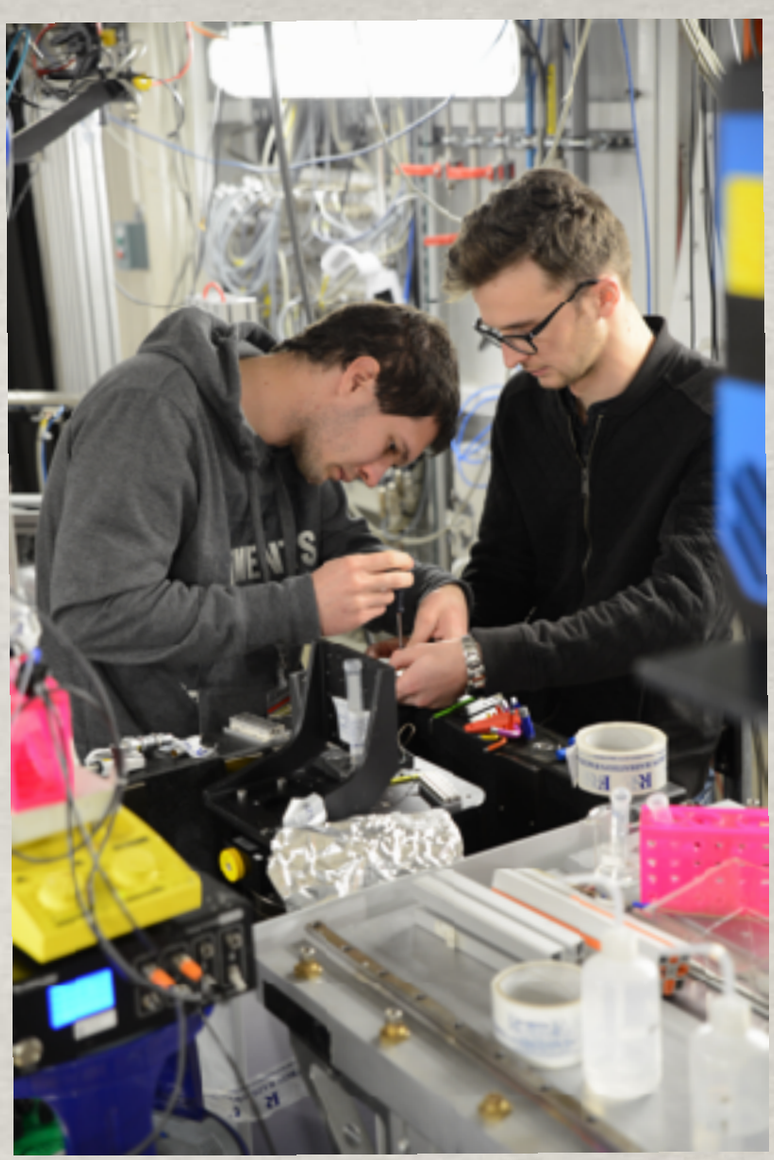
schematics of diffract-before-destroy experiment (SFX/SPB type)



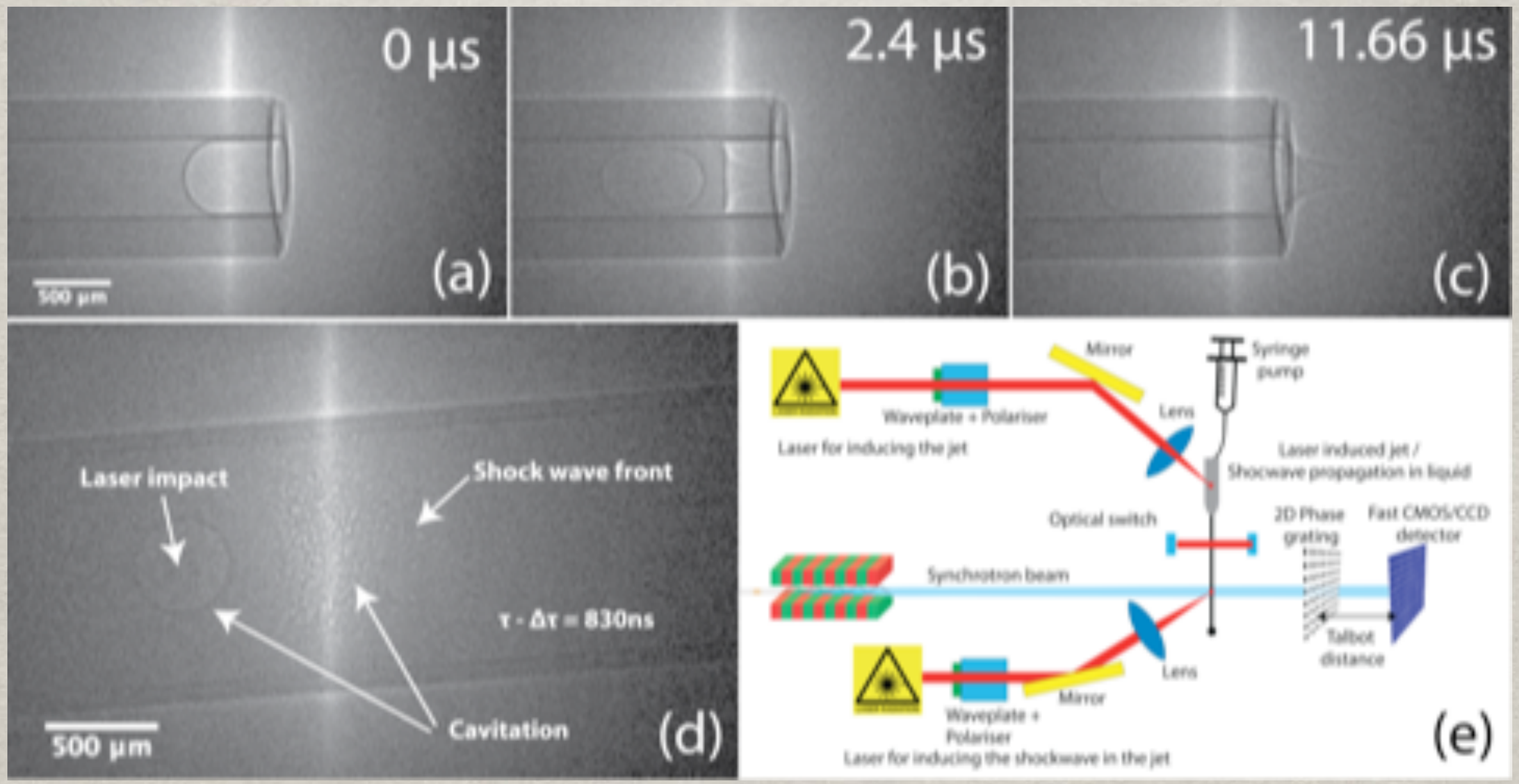
digital microfluidic part not attached yet…







ESRF Grenoble December 2017
Rita, Laco, Jožo, Marie-Christina

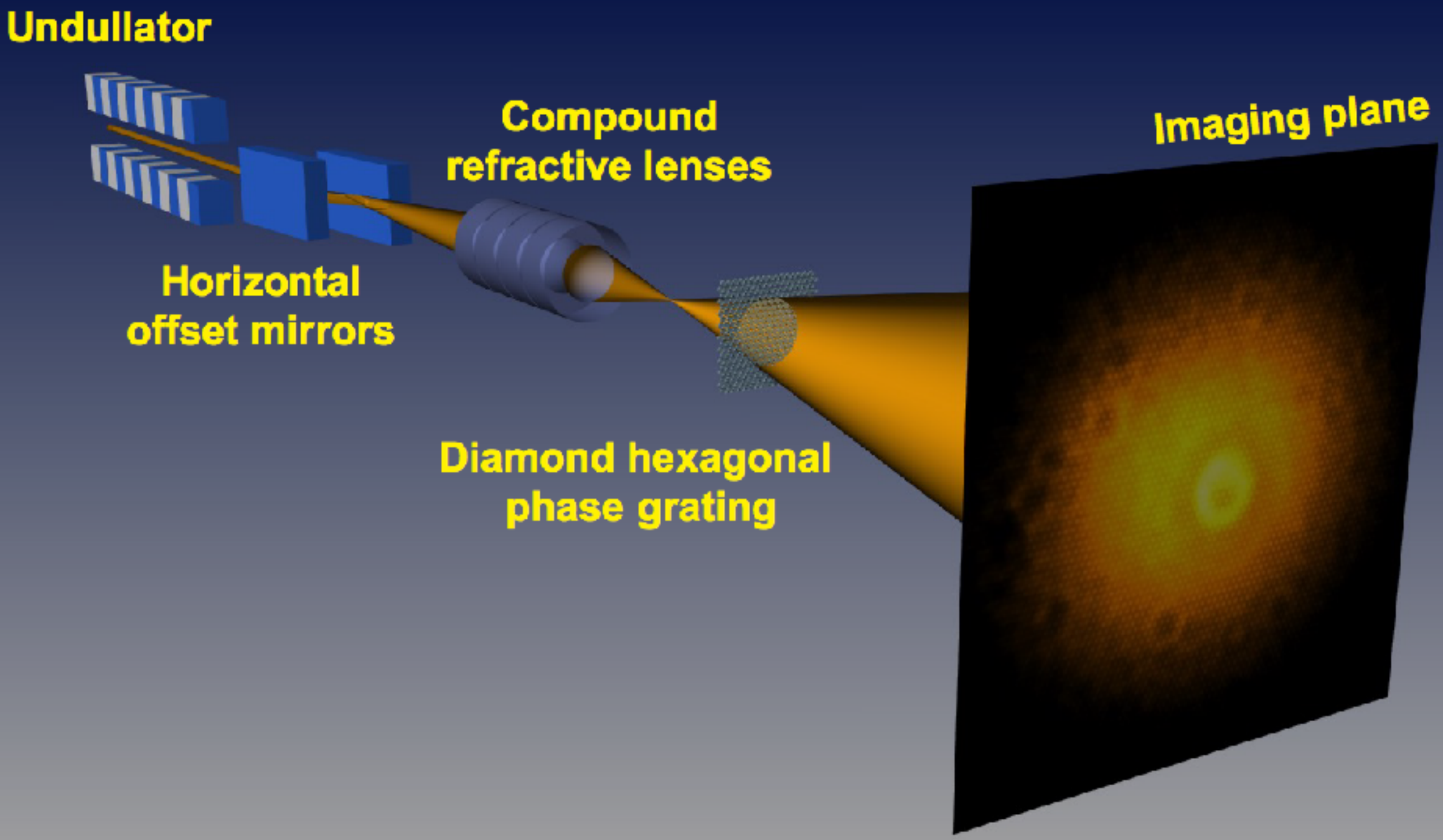

0 µs
2.4 µs
11.66 µs
500 µm
(a)
(b)
(c)
Laser impact
Shock wave front
τ - Δτ = 830ns
Cavitation
500 µm
(d)
Mirror
Syringe pump
Waveplate + Polariser
Lens
Laser for inducing the jet
Laser induced jet / Shocwave propagation in liquid
Optical switch
2D Phase grating
Fast CMOS/CCD detector
Synchrotron beam
Talbot distance
Lens
Mirror
Waveplate + Polariser
Laser for inducing the shockwave in the jet
(e)

SAMPLE JET

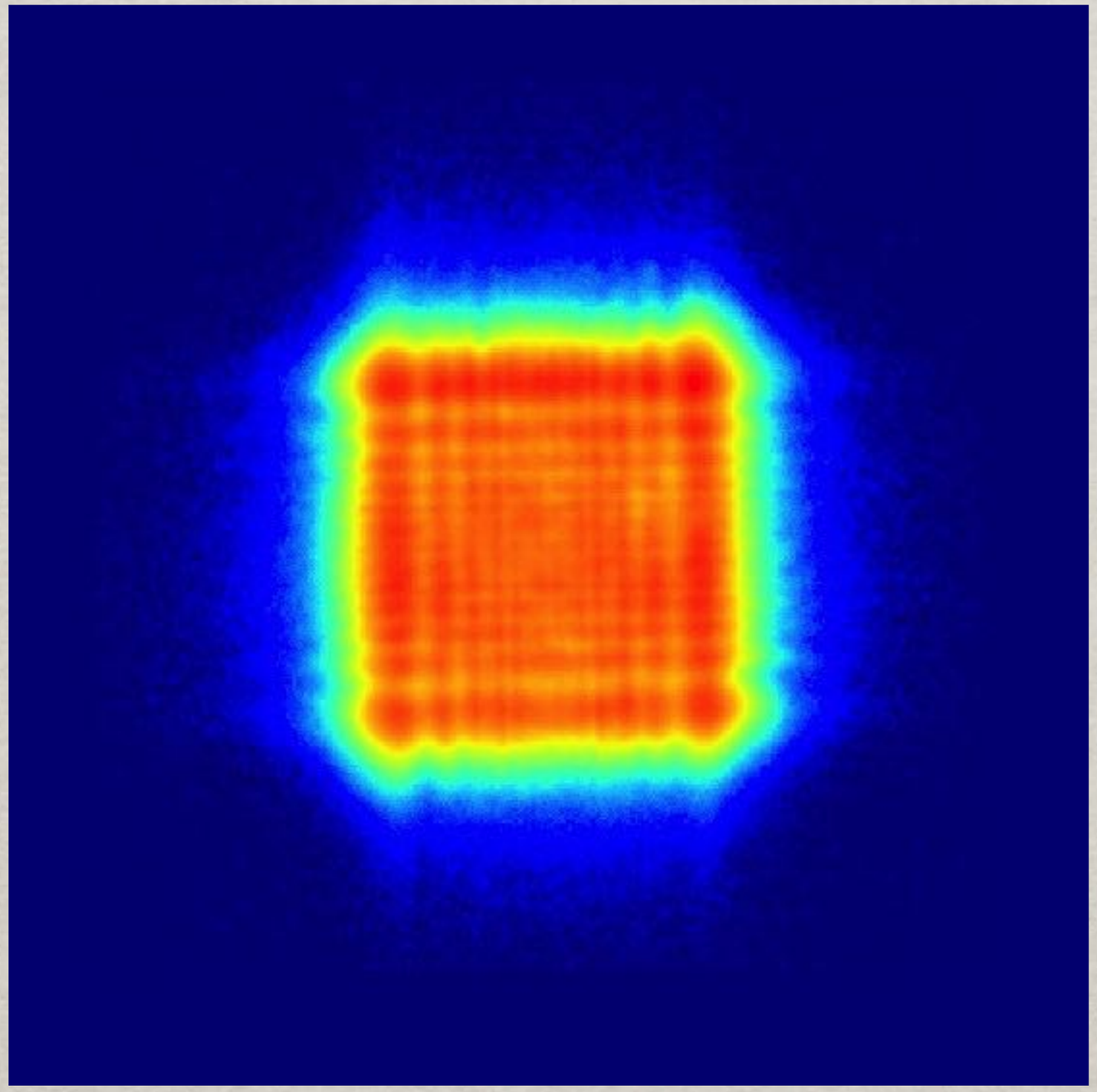
- H. Chapman (private communication)
  - for narrow liquid jet (70 m/s) sample rate est. up to 1.1 MHz
- still: 4.5 MHz out of reach
- rare samples: how to get hit rate > 10%?
- very difficult to prepare, 1:9 work cycle


Juro Kroška
3D printed
microfluidic mixer

IMAGING - STRUCTURED ILLUMINATION SCHEME

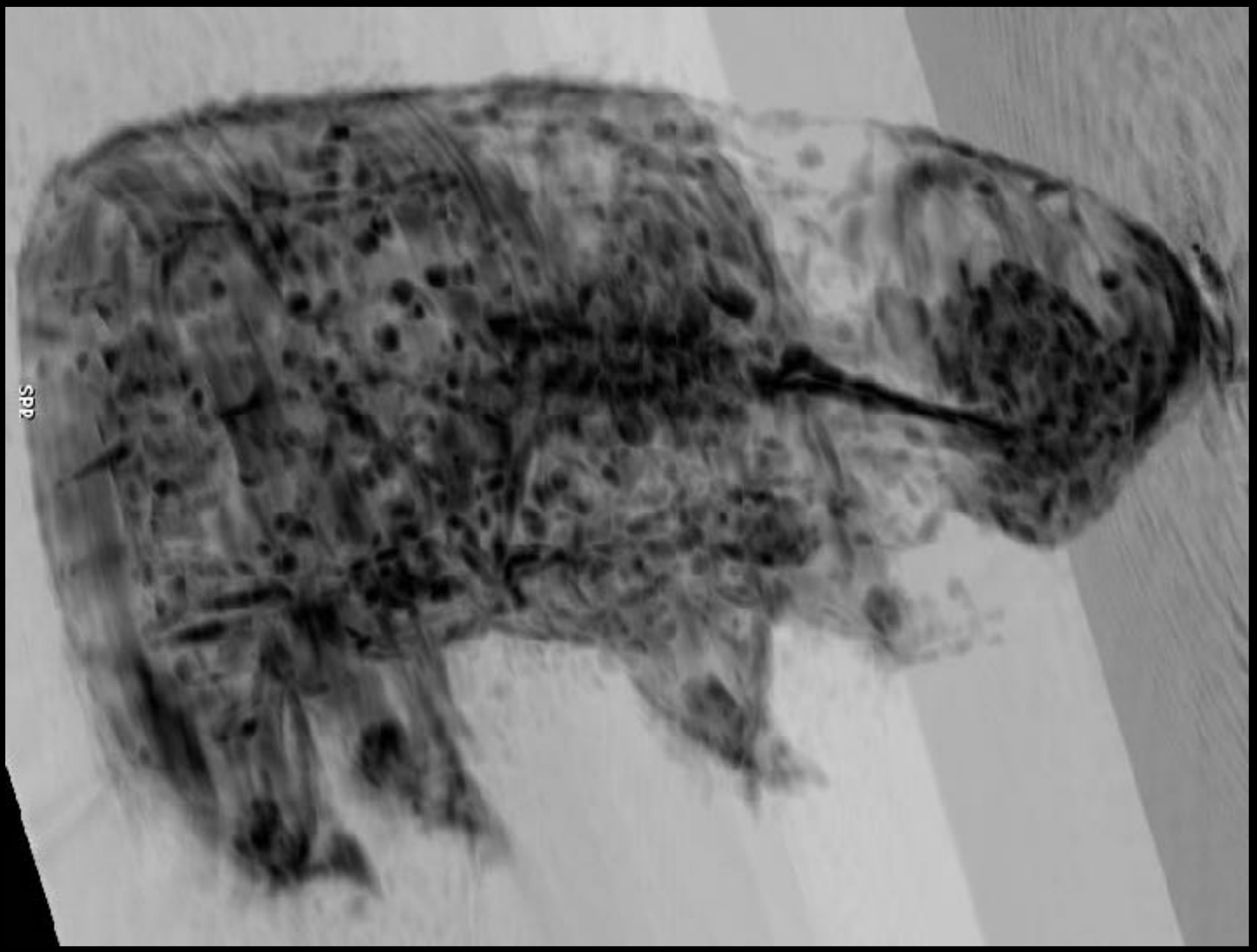


real world quality of E-XFEL beam hologram

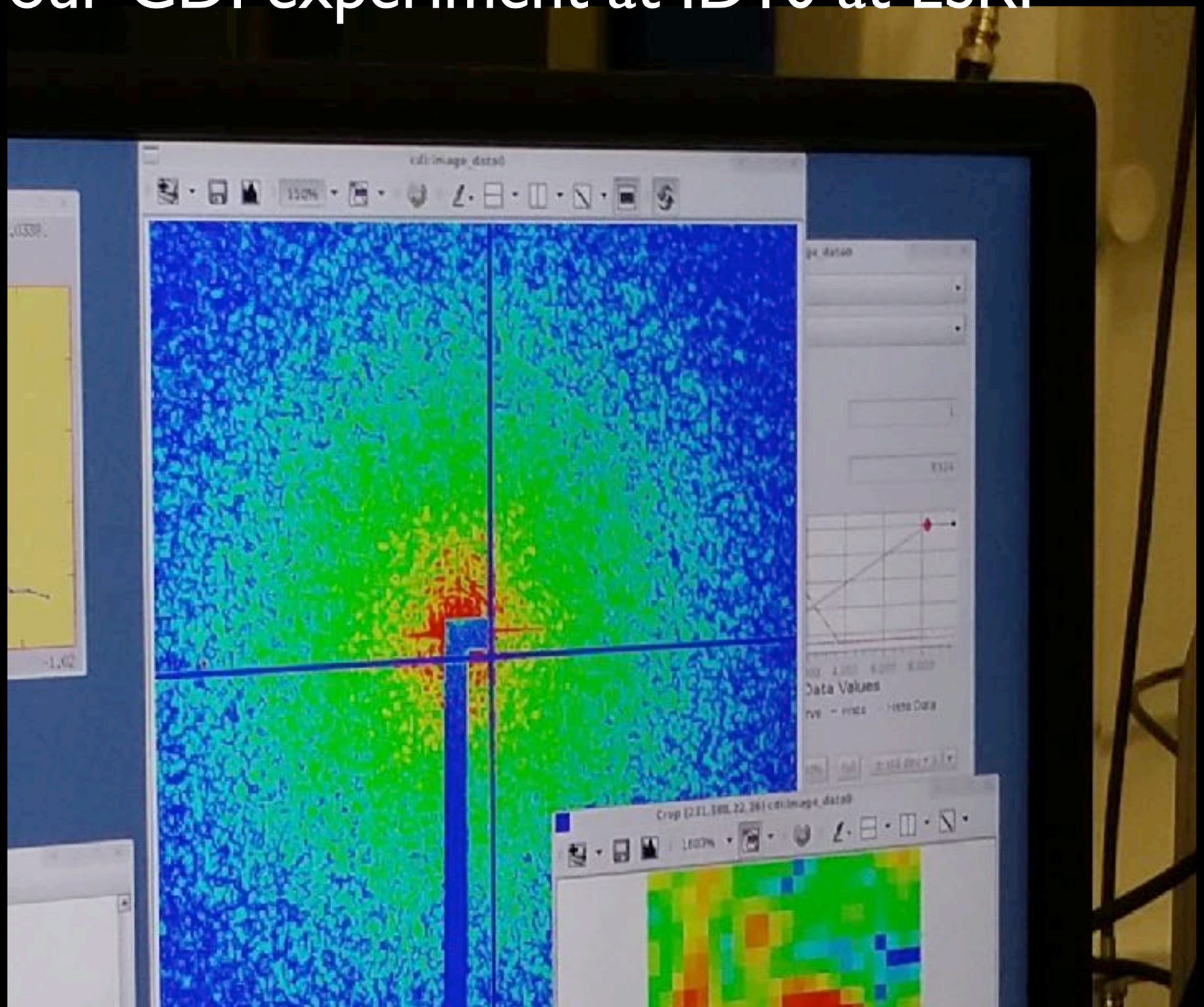


SPB experiment at XFEL - diffract before destroy limits

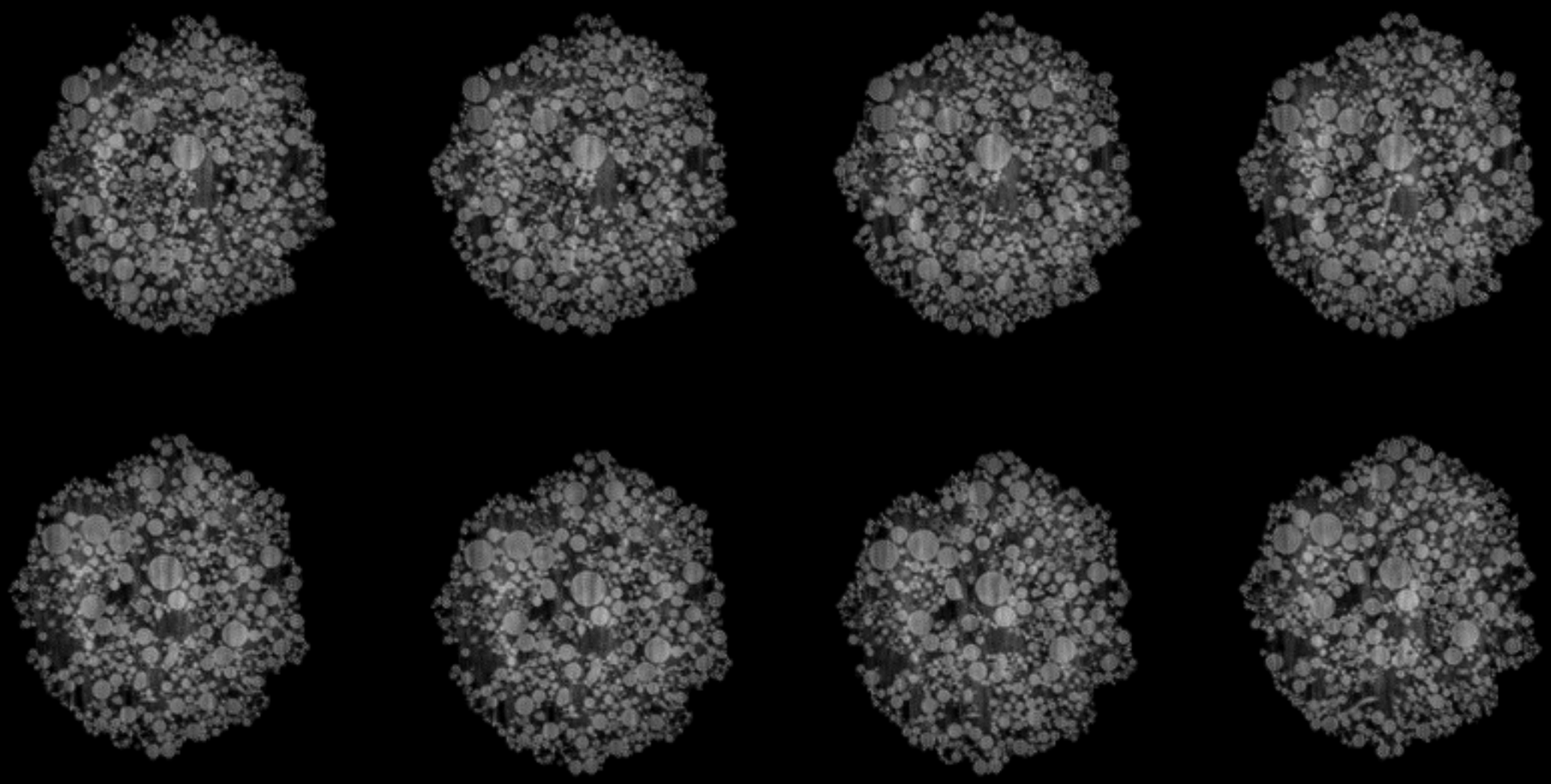
	Reproducible single particles (SPR)	**Nano-crystallography (NX)**	**Non-reproducible single particles (SPnR)**
Typical samples from biological sciences	Macromolecules, viruses	Protein nanocrystals	Viruses, organelles, bacteria, small eukaryotes
Photon energy	ca. 3–6 keV	ca. 8–16 keV	ca. 3–6 keV
Sample size	ca. 10 nm – 500 nm	ca. 100 nm – 2 μm	ca. 100 nm – 3 μm
Images per dataset	On the order of 100 000 – 1 000 000 and more	On the order of 10 000	1
Dimensionality of reconstruction	3	3	2
Single photon sensitivity	Critical	No	Beneficial, but not critical
Dominant signal levels in one measured pattern/pixel	0–10 photons	ca. 10^2–10^4 photons and more	0–10^8 photons and more
Sampling / number of pixels	Detector linear extent (pixels) ≅ 4 × number of resolution elements required (allows for adequate sampling of speckles); higher sampling favored	Detector linear extent (pixels) ≅ 10 × number of resolution elements required (i.e. ∼ 10 pixels between Bragg peaks)	Detector linear extent (pixels) ≅ 4 × number of resolution elements required (allows for adequate sampling of speckles)
Sensitivity to missing data regions	Sensitive, low-q information critical, many images benefitial	Not sensitive, low-q information not needed	Very sensitive, can prohibit unique reconstruction



imaging experiments:
our CDI experiment at ID10 at ESRF



so far - 27 nm imaging
prospect 5-6 nm



SCHOOL OF XFEL AND SYNCHROTRON RADIATION USERS "SFEL2018"

5th International Scientific School, May 27th – 31st 2018, Hotel SOREA MÁJ – Liptovský Ján, Slovakia

ABOUT THE „SFEL2018“

Pavol Jozef Šafárik University in Košice under the auspices of Ministry of Education, Science, Research and Sport of the Slovak Republic and European X-Ray Free-Electron Laser Facility GmbH in Hamburg organizes School of XFEL and Synchrotron Radiation Users 2018. The school is continuation of the Winter Schools of Synchrotron radiation held in 2011, 2012, 2014 and 2017.

European XFEL & Slovakia

- European XFEL - most brilliant coherent X-ray source driven by superconducting LINAC (build & maintained by DESY)
- Slovakia is regular shareholder of E-XFEL (1%+ share), covered from Slovak ESFRI budget
- Slovak application focus - mainly in structural dynamics studies of biomedical interest (proteins and bio particles including cells) - SFX and XBI user consortia at E-XFEL, SPB experimental workstation
- material research (MID) in future
- opportunities for next generation of Slovak scientists to join world-class research groups
- (semi)regular SFEL schools (80+ people) coorganised with E-XFEL