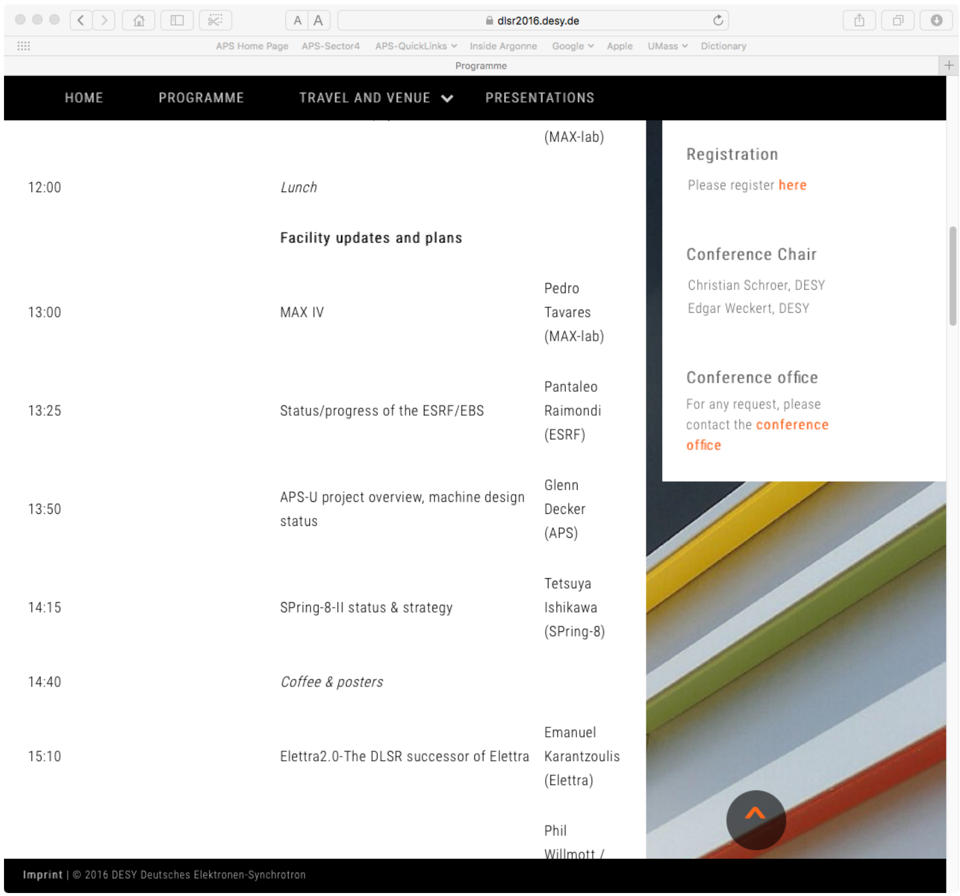
Highlights from the
5th Diffraction Limited Storage Ring workshop
DESY, Hamburg, Germany

Jonathan Lang
Advanced Photon Source
Argonne National Laboratory

APS-U Forum
March 24, 2016

5th DLSR – Workshop Program



Brought together:

- Facility operations
- Accelerator physics
- Beamline technologies
- DLSR scientific drivers

2011 - Cornell
2012 - Spring-8
2013 – Stanford/SLAC
2014 – Argonne/APS
2016 – DESY/Hamburg

~100 participants
~35 Talks over 2.5 days

DLSR – Workshop Program

Day 1

Keynotes:

- Harald Reichert (ESRF) – Science Opportunities at DLSRs
- Mikael Eriksson (MAX-IV) – DLSR Machine Physics

Facility Updates

Day 2

Science opportunities

Challenges in DLSR machine physics

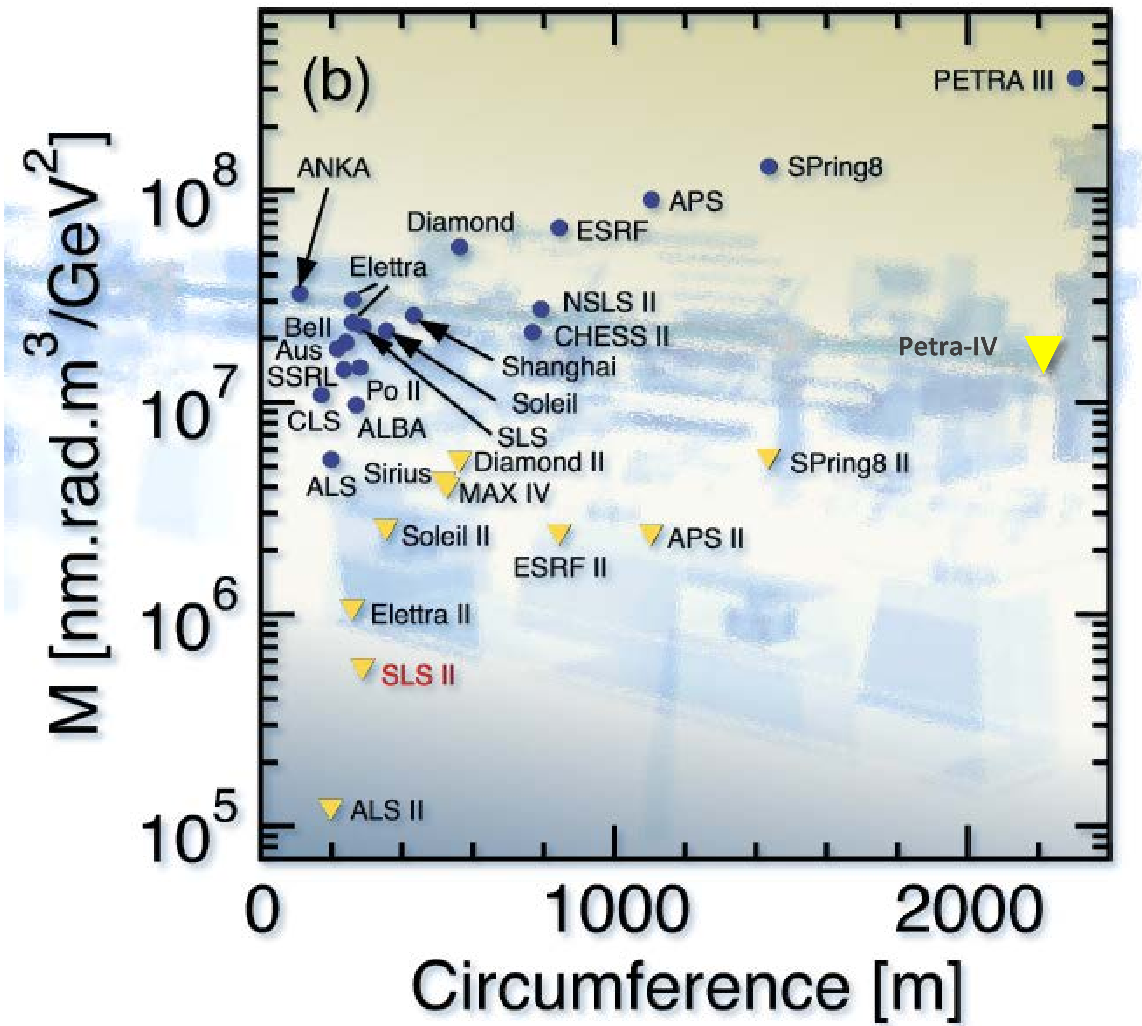
Day 3

Beamline technologies and instrumentation challenges

DLSR – Workshop Program - Facility Updates

$$M = \varepsilon C^3 / E^2$$

M. Borland, J.Phys. Conf. Ser. 425, 042016 (2013)



Courtesy P. Willmott (SLS)

DLSR - Facility Updates

Facility	Talk	E (GeV)	E (pm-rad)	Year
MAX-IV	P. Tavares	3	328	2016
SIRUS	H. Westfahl	3	236	2019
ESRF-II	P. Riamondi	6	140	2020
APS	G. Decker	6	47-68	2021
SLS-2	P. Wilmott	2.4	~150	2024
Spring-8-II	T. Ishikawa	6	190	2020s
Petra-IV	C. Shroer	5	20	2026+
Diamond-II	R. Bartolini	3	100-270	??
Elettra-II	E. Karantzoulis	2	~250	??
Soleil-II	A. Nadji	2.75	~200	??
ALS-U	R. Falcone	2	50	??

HEPS – China (5 GeV) ; SLiT-J – Japan (~3 GeV); ……

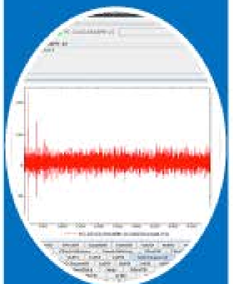
DLSR Facility Updates - Max IV

3 GeV Ring Commissioning Timeline

Beam in TR3

Aug 11

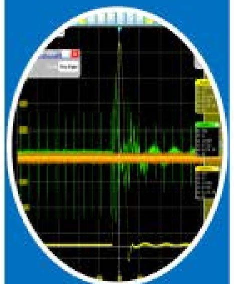
2015



First Turn

Aug 25

2015

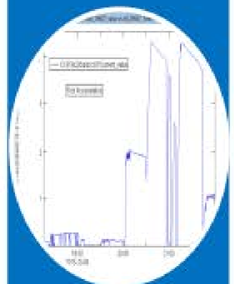


Stored Beam

0.1 mA

Sep 15

2015



Stacking

4 mA

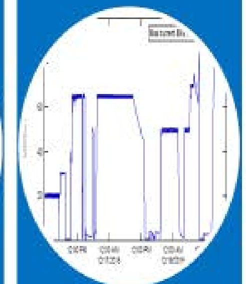
Oct 08

2015

First Light

Nov 2

2015



120 mA

Jan/31

2016

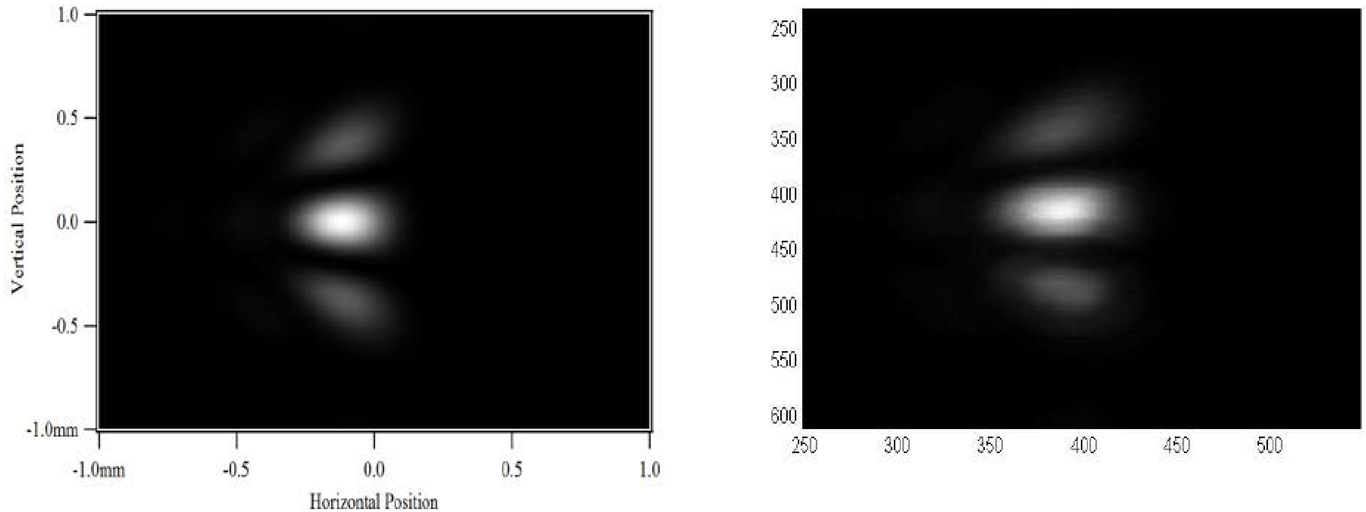
March 2016 DLSR Workshp 2016 MAX IV

Courtesy of Pedro Tavares

DLSR Facility Updates - Max IV

Emittance Measurement

Slide by J.Breulin



320 pm-rad

Sigma polarized SR, 632.8 nm, SRW calculation (left) and measured image (right). The simulation is done for ε_x = 320 pm rad, β_y = 1.5 m.
Both figures show a 2 x 2 mm^2 area of the image plane.
The fringe pattern is too weak to be visible.

Optical magnification of m=-2.28 is taken into account in the SRW model
Horizontal opening angle: 6 mrad
Vertical opening angle: 8 mrad
Exposure time: 2.9 ms

Courtesy of Pedro Tavares

DLSR Facilities updates Sirus

Building construction (~20% concluded – 03/2016)

Oscar Vigna (oscar.vigna@lnls.br)

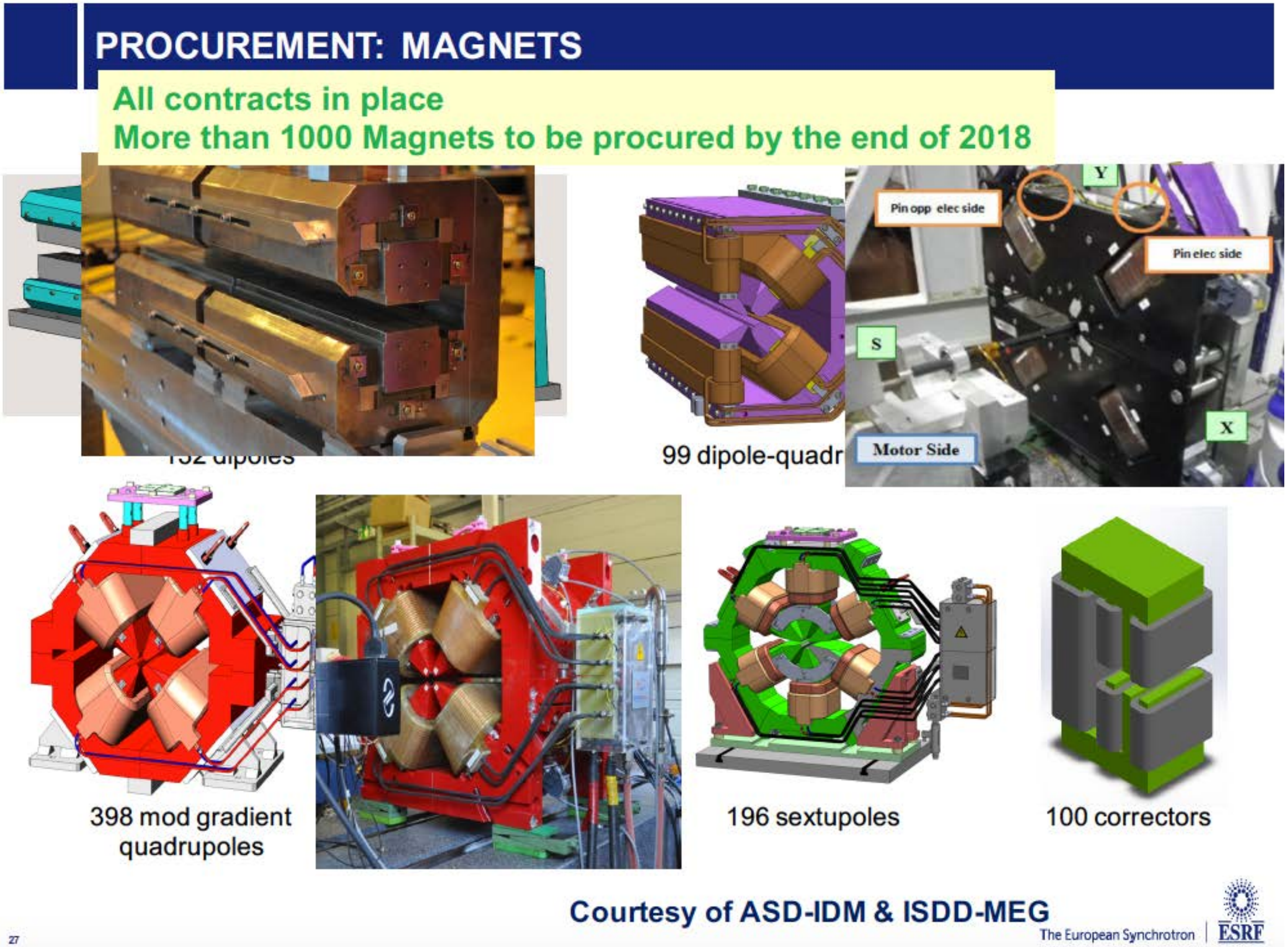
Diffraction Limited Storage Rings workshop
DESY, March 9th-11th, 2016.

Slide courtesy of Harry Westfahl

Expected first light/experiments early 2019

DLSR Facility Updates - ESRF

Design finalized; Currently procuring magnets

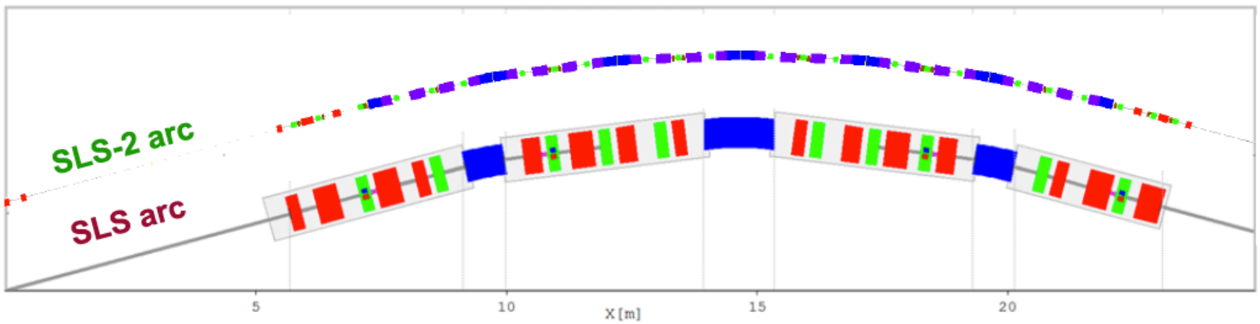


Slide courtesy of P. Riamondi

DLSR – Facility Updates – Swiss Light Source

Looking at designs with reverse bends (585˚ & 488˚)

Lattice layout



- 12×TBA ⇨ 12×7BA lattice: ½ + 5 + ½ cells of LGB/AB type
- Circumference 288.00 m ⇨ 287.25 m
  - in order to keep undulator positions (source points)
- Periodicy 3: 12 arcs and 3 different straight types:
  - 6 × 4 m ⇨ 6 × 2.9 m 3 × 7 m ⇨ 3 × 5.1 m
  - split long straights: 3 × 11.5 m ⇨ 6 × 5.1 m
- beam pipe: 64 mm x 32 mm ⇨ ∅ 20 mm
  ⇨ magnet aperture ∅ 26 mm

A. Streun, PSI Swiss Light Source Upgrade SLS-2 5th DLSR workshop, March 9-11, 2016, DESY Hamburg 18

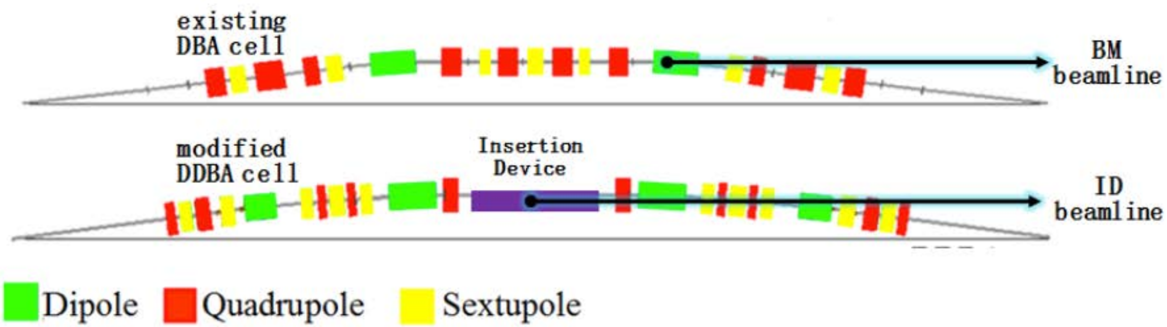
Slide courtesy of Andreas Streun

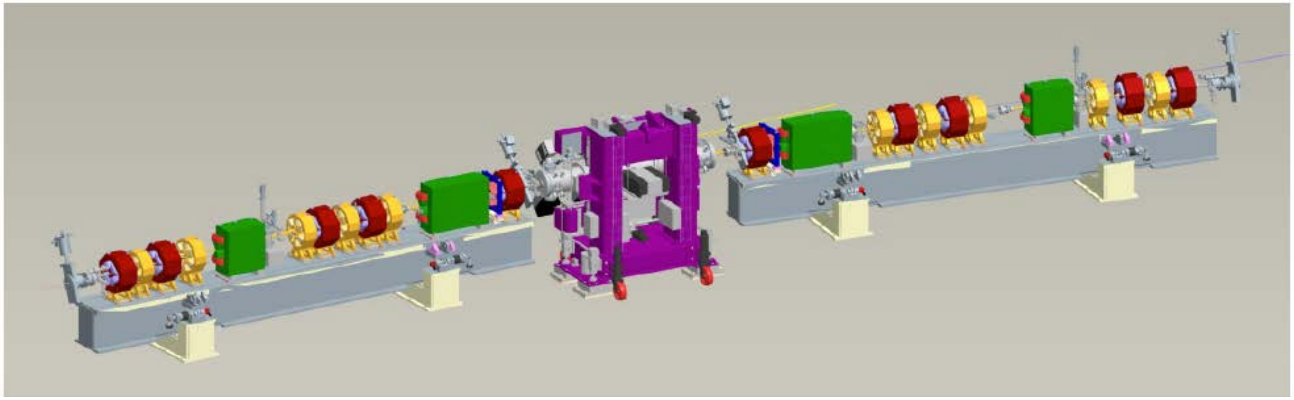
DLSR – Facility Updates – Diamond-II

Use 4BA (or 6 BA) to convert BM to ID ~3m

One DDBA cell in the existing lattice

One DDBA cell is going to be installed in the existing lattice in order to have one more beamline (no significant gain in emittance)





Slide courtesy of R. Bartolini

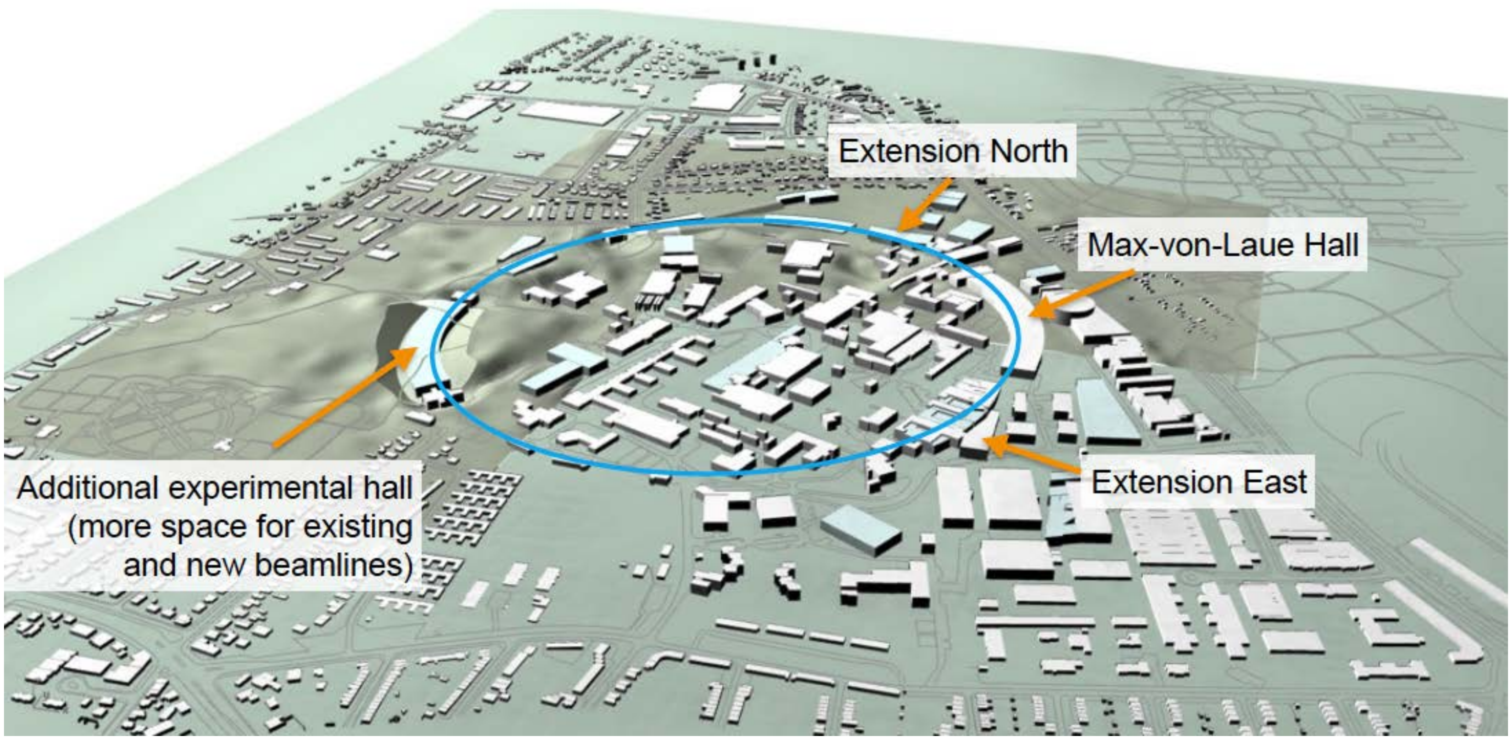
DLSR – Facility updates – Petra-IV

Circumference 2300m ---> ~20 pm-rad

PETRA IV at DESY in Hamburg

Transform PETRA into ultra-low emittance ring

Starting: 2026



Slide courtesy of Christian Schroer

DLSR – Facility Updates - Bending Magnets

What about bending magnets?

ESRF CONTEXT

ESRF today has DBA 6 GeV lattice

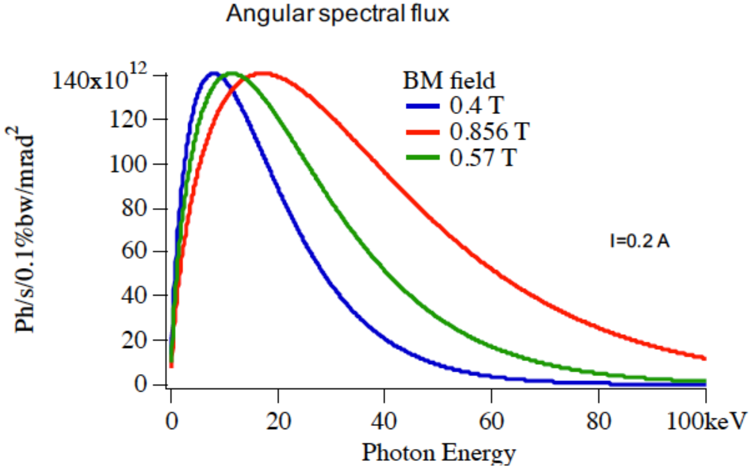
BM beamlines use X-ray from

- 0.856 T dipole E_c=20.5 kev, 6 mrad max
- 0.4 T soft end E_c=9.5 keV, 6 mrad max
- Very productive Beamlines

ESRF II will be 7BA 6 GeV lattice

Available BM field for Beamlines:

- 0.39 T dipoles E_c=9.3 kev , **2** mrad max
- 0.57 T soft end E_c=13.6 keV, **2** mrad max



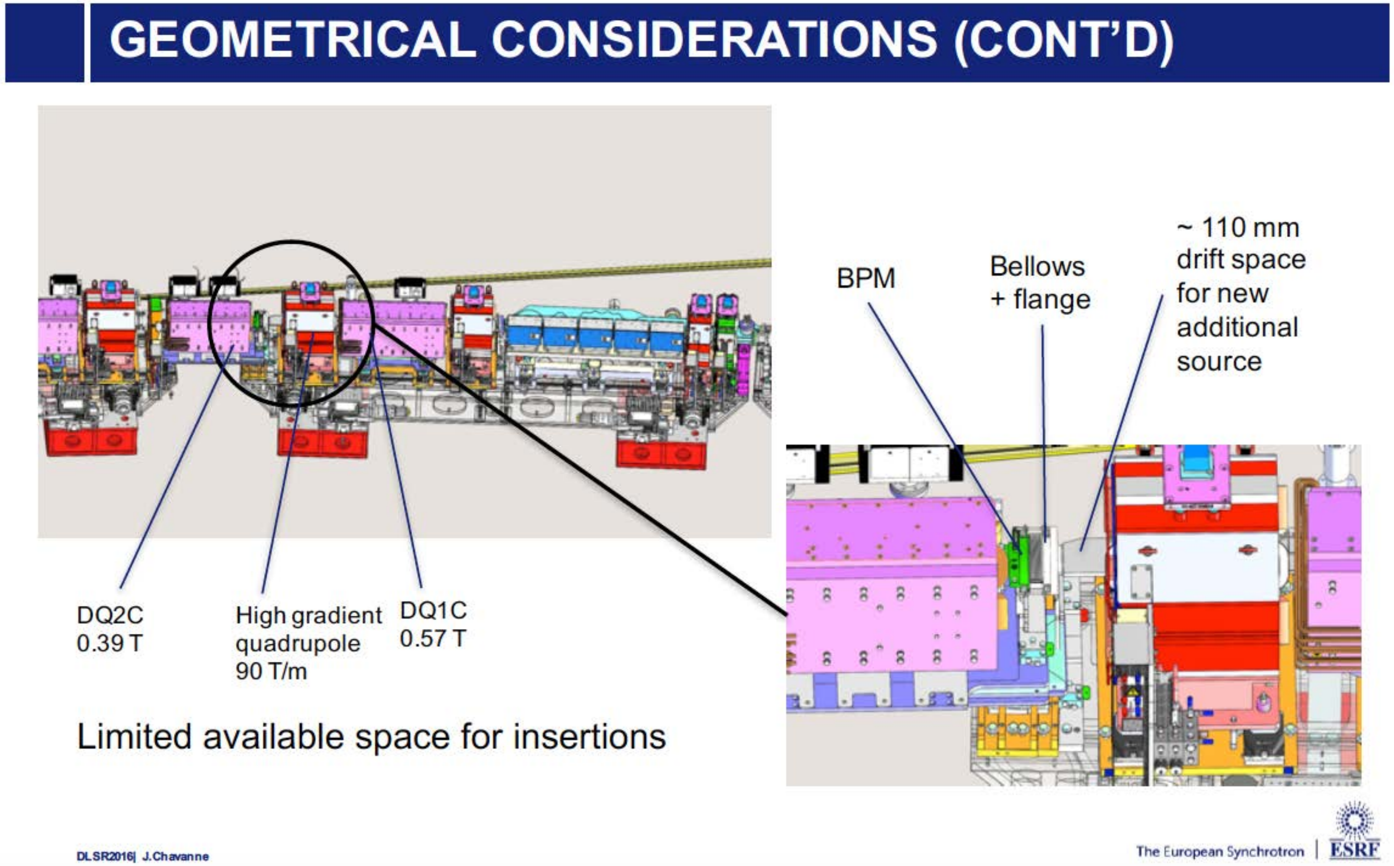
The European Synchrotron | ESRF

Slide courtesy of Joel Chavanne (ESRF)

DLSR – Facility Updates – Bending Magnets

ESRF considering super-bend, 2,3,4,5 pole wigglers (similar to most facilities)

- Some designs need to cant quads



Slide courtesy of Joel Chavanne (ESRF)

DLSR – Beamline/Instrumentation Challenges

Nano – Positioning

- Accurracy, speed, and stability
- Experimental and optics (monochromators)
- Vibration reduction

Optics/Coherence

- Measure and preserve wave fronts

Detectors

- Faster detectors for higher energy

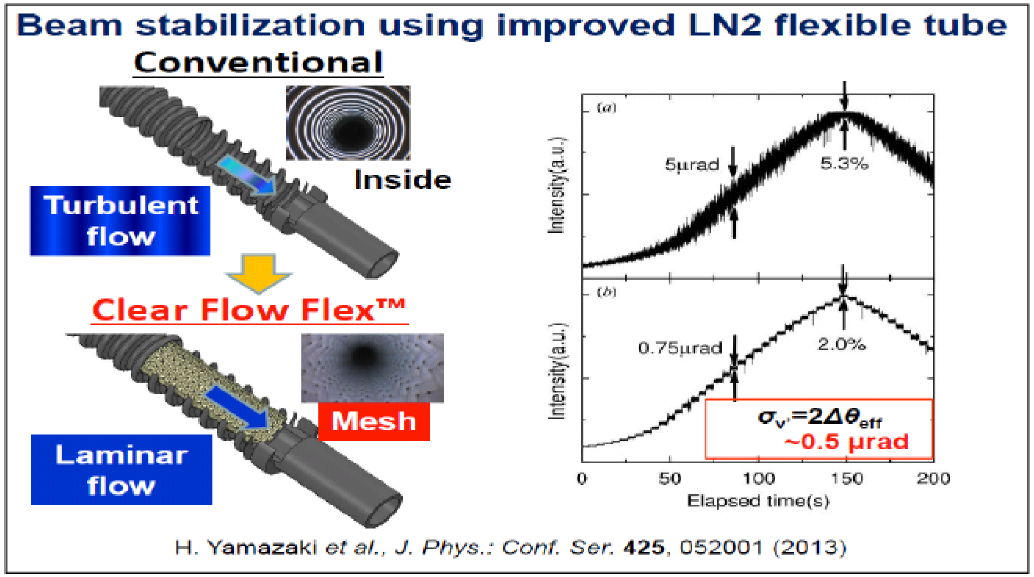
Velociprobe
C. Priessner et al. (APS)

DLSR – Beamline/Instrumentation Challenges

Stability of monochromators -> Coffee break discussions

Reduction of vibration in LN-cooled DCM

1) Improvement of conventional DCM: reduction of vibration with cooling; stabilization of mechanics



5 μrad to 0.5 μrad

Need much larger (x10) improvements

2) New optical scheme

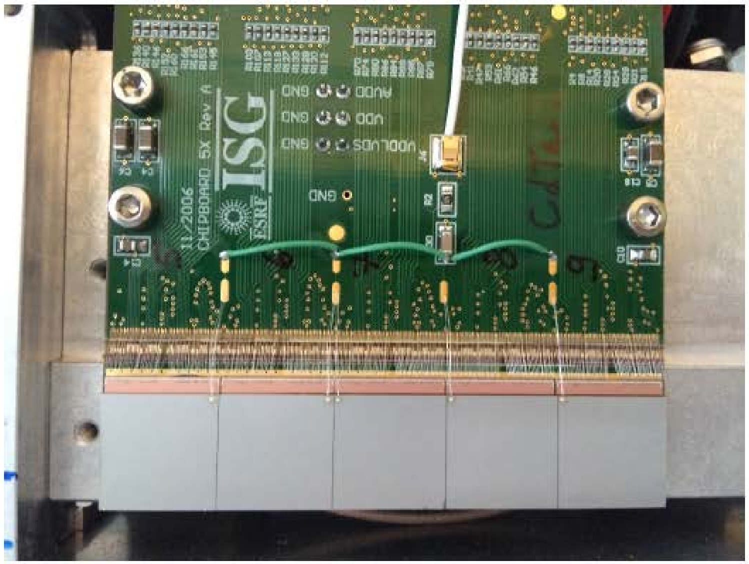
10

Courtesy of M. Yabashi (Spring-8)

DLSR – Beamline/Instrumentation Challenges

ESRF working on high-Z sensors (CdTe, GaAs, …) for pixel array detectors

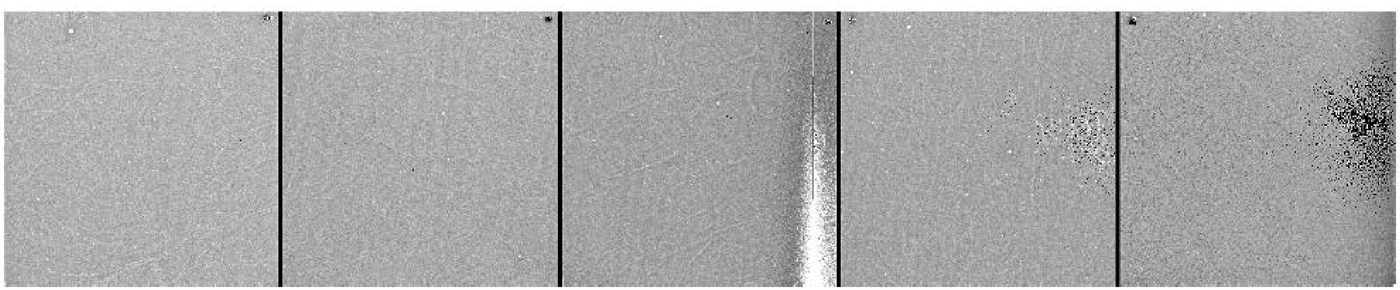
FIRST 5X1 CDTE DETECTOR



1280 x 256 pixels
75 mm x 15 mm field of view

Slim edge sensors (100 um)
30 um gap in between modules

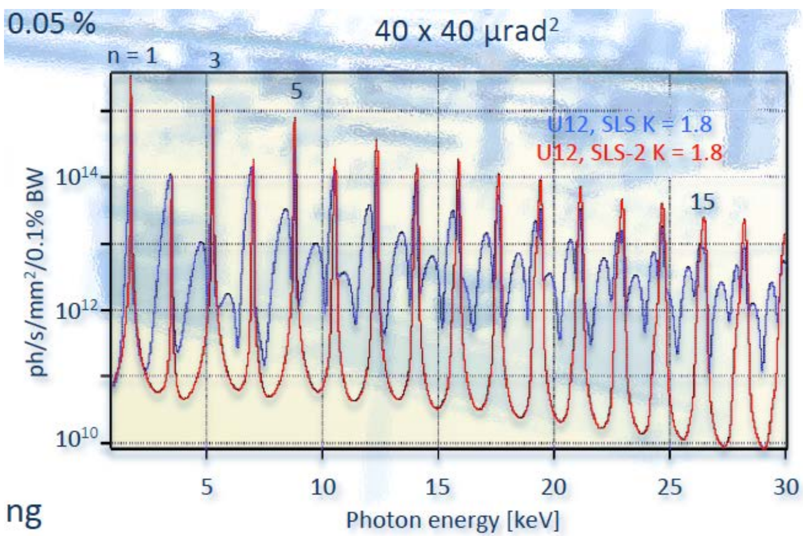
Alignment precision < 1 pixel over the whole width



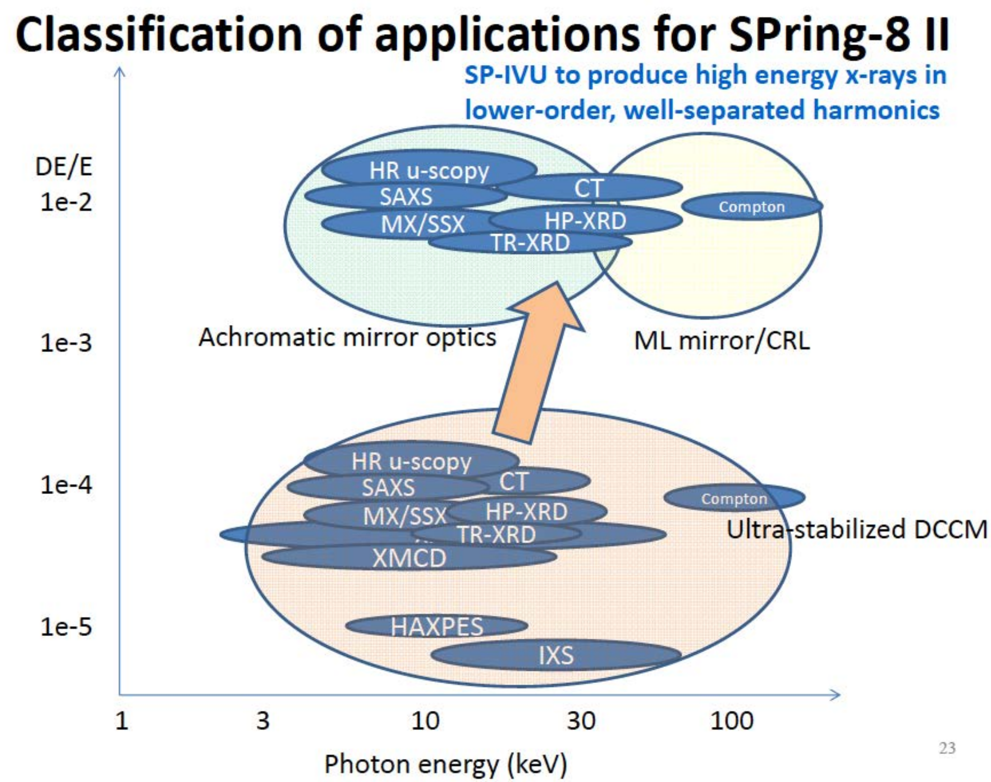
Slide courtesy of Marie Ruat (ESRF)

DLSR – Beamline/Instrumentation Challenges

- Spring-8 working on wide band-pass optics to take advantage of suppressed off harmonic intensity (SLS)
- Not all techniques need energy resolution of Si/C mono



Courtesy of P. Willmott (SLS)



Courtesy of M. Yabashi (Spring-8)

DLSR – Science Opportunities

Nano-focusing

- "The ultimate 3D microscope"
- "Taking flux starved techniques into the nano-world"
  - ✓ High-pressure
  - ✓ RIXS

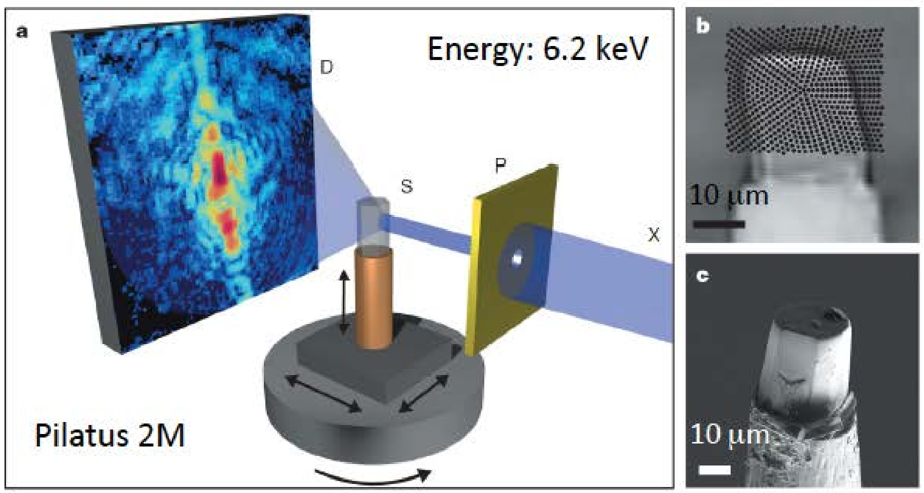
- Serial MX (SLS, ESRF, DESY, ….)
- Looking at materials processes in-situ at ultra-fast time-scales (additive manufacturing)

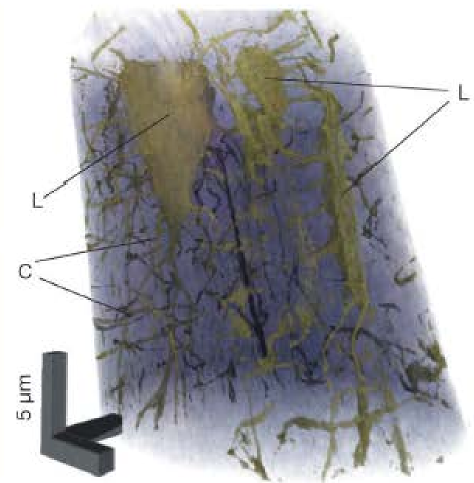
Coherence

- "Atomic scale dynamics down to nano-seconds"
- 10^{4-6} speed-up in dynamics for XPCS
- XPCS in complex environments
- CDI on nano-particles undergoing chemical reactions

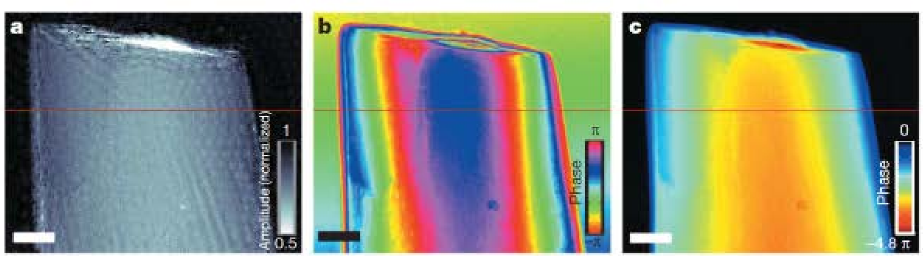
DLSR – Science opportunities

X-ray ptychographic tomography





Mouse bone specimen



Voxel size: 65 nm
Resolution: 120 nm
Dose: 2MGy

M. Dierolf *et al.*, **467** Nature (2010) 436

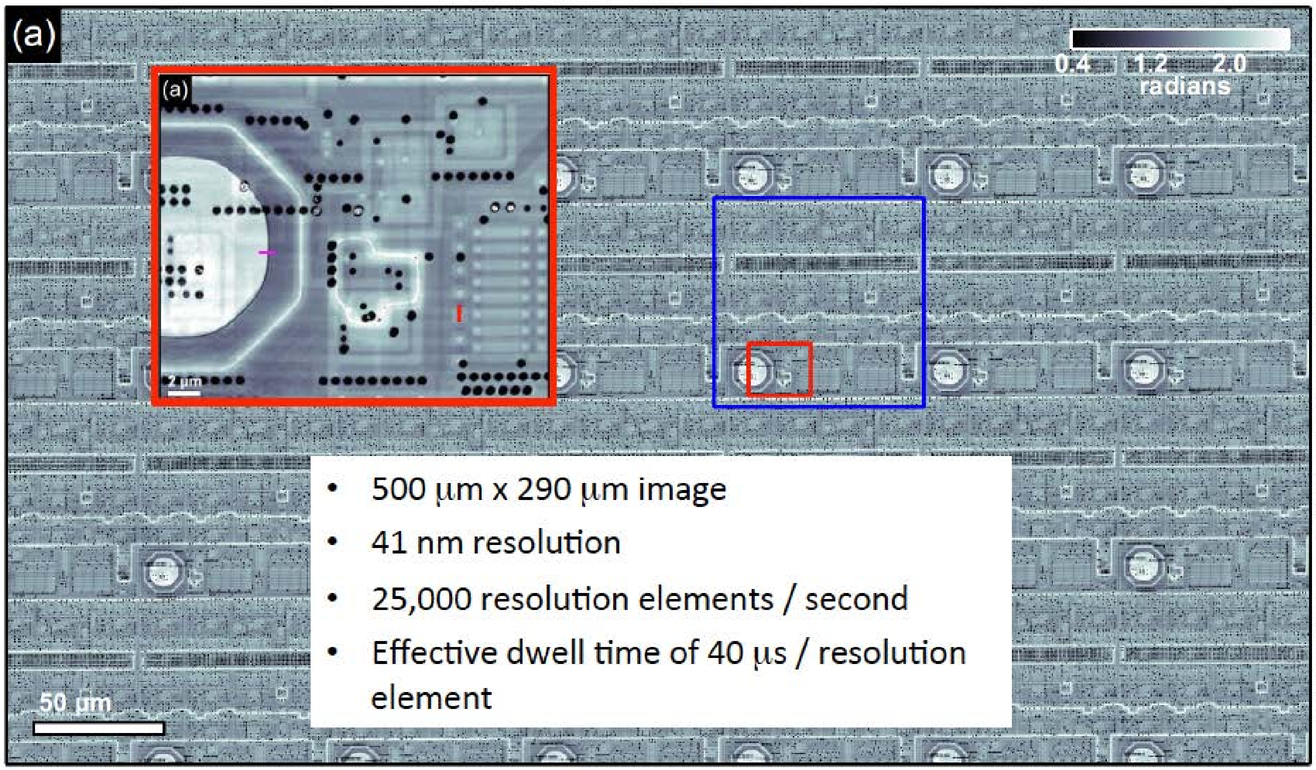
Slide courtesy of Ana Diaz (SLS)

DLSR – Science opportunities

Hierarchical imaging using ptychography

PAUL SCHERRER INSTITUT PSI High throughput ptychography

The EIGER "selfie" M. Guizar-Sicairos *et al*., Opt. Express **22** (2014) 14859



Slide courtesy of Ana Diaz (SLS)

DLSR - Safety

Altoona Hospital Room 1015A

Safety doesn't end at the lab gate

Watch out for ice even on travel

Hamburg in March (rain + cold)