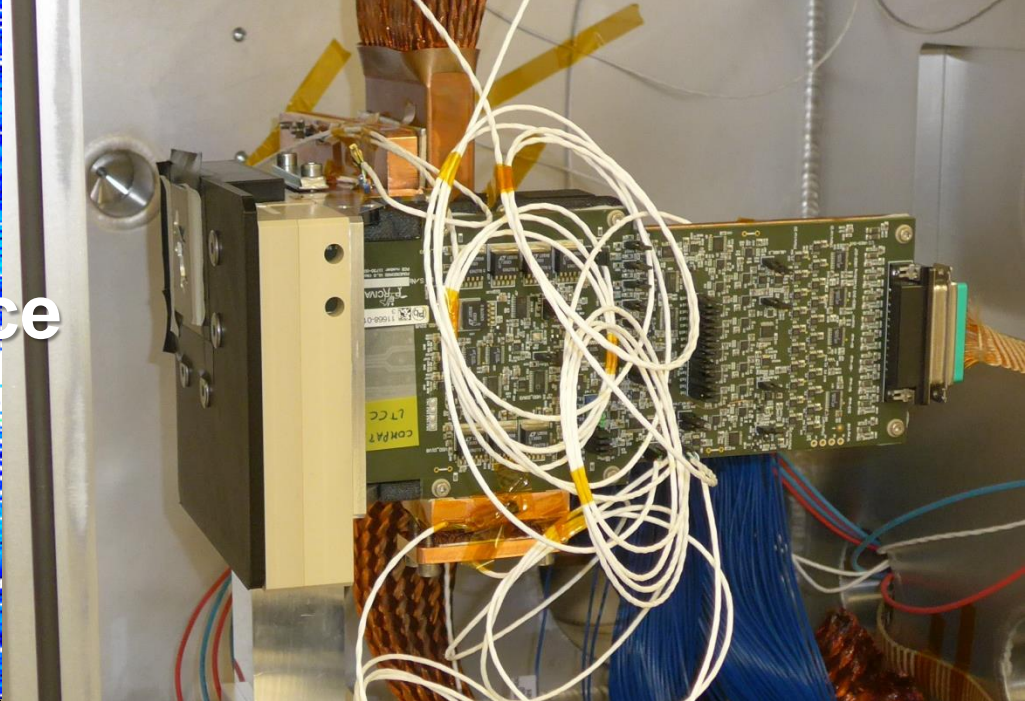
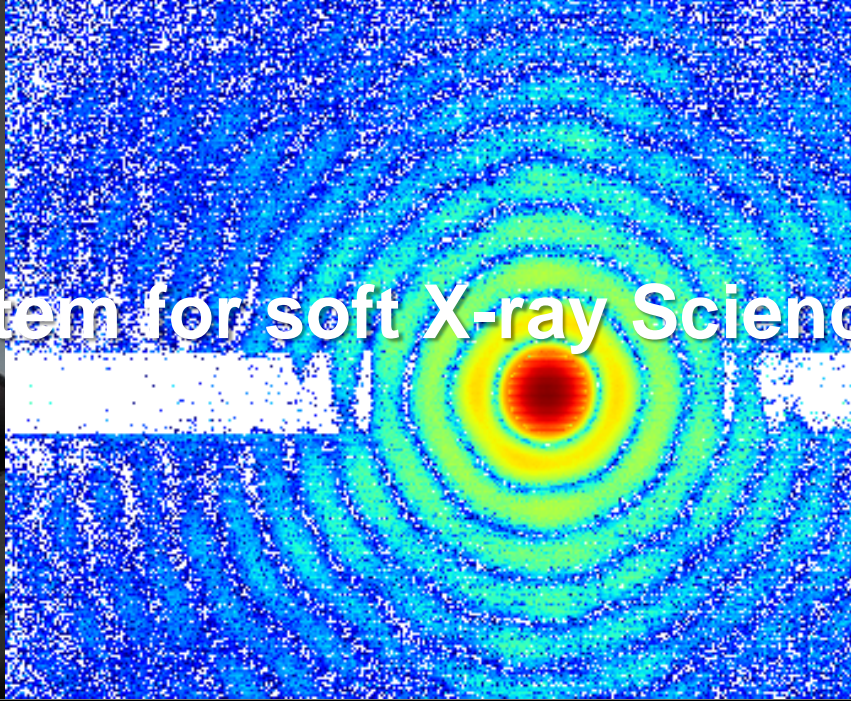


# Percival

## MAPS Imager System for soft X-ray Science



System and Status in a Nutshell  
First Friendly User Experiments



Cornelia Wunderer  
DESY Photon Science Detector Group  
IFDEPS Virtual Thursdays, 8. April 2021

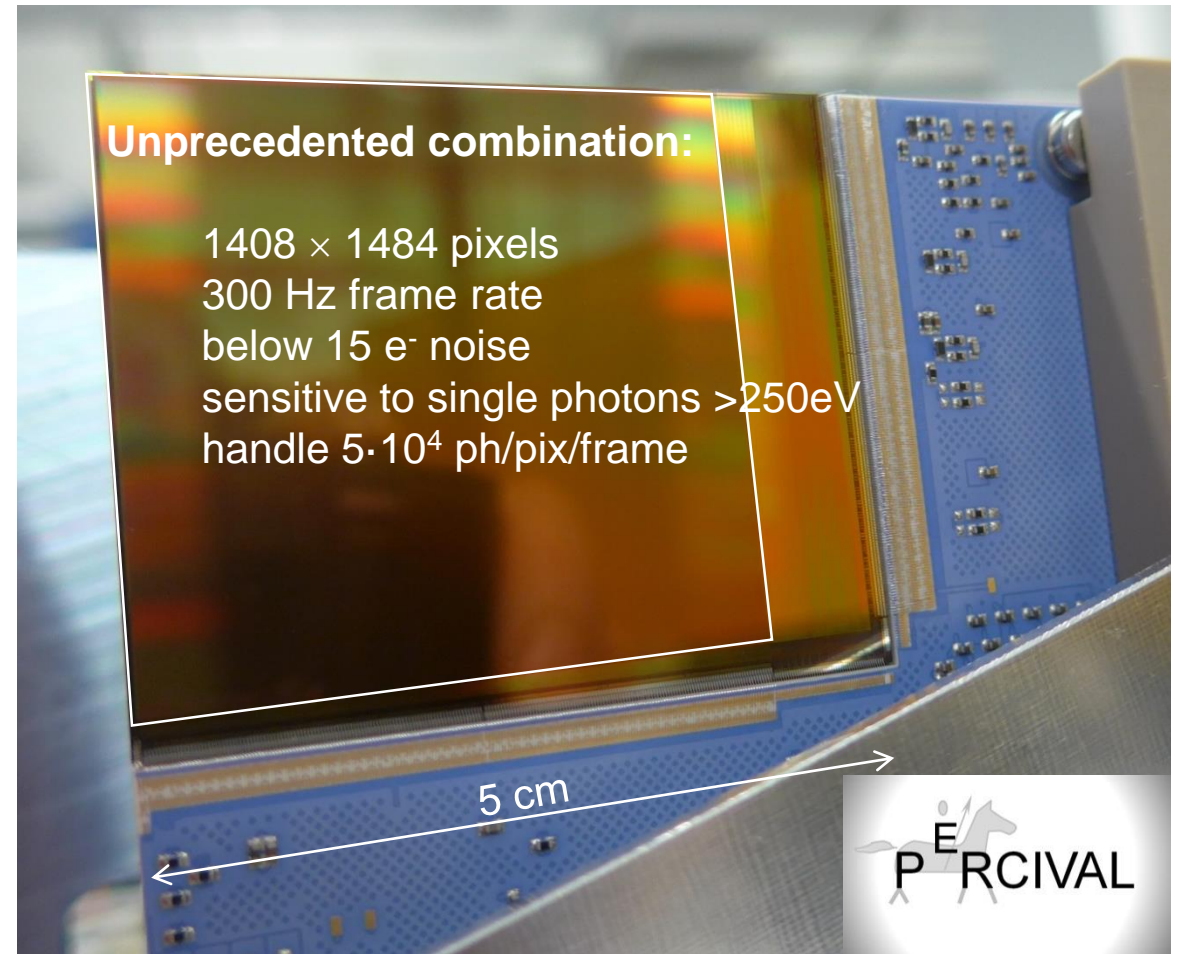
**HELMHOLTZ**  
RESEARCH FOR GRAND CHALLENGES



# Soft X-ray CMOS Imager for FELs and bright Storage Rings

## CMOS imager to meet the combination of challenges

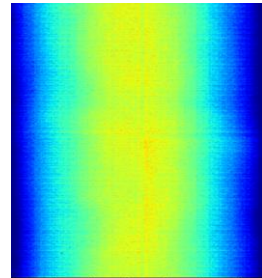
- Novel imager meeting key FEL challenges simultaneously, in the soft X-ray regime:
  - (at least) Megapixels in a single sensor (avoid dead area)
  - fast enough for “shot by shot” science @ today’s FELs
  - dynamically adjust to single photons & large signals
- Project initiated by DESY
- Actively invited collaboration from the community  
-> today five light sources plus RAL/STFC, DESY lead
- Sensor CMOS design at RAL
- System overall design by DESY, with contributions from partners
- Project kickoff 2011



# “Dry Numbers” – Achieved vs Aims, today



- **Frame rate today: 66 Hz**
  - Limited by today's readout periphery
  - Work in progress ...
- **Dynamic range**
  - 14e<sup>-</sup> noise for part of pixels today, 24e<sup>-</sup> for all (expect ~ 14e<sup>-</sup> for all pixels with revised firmware)
  - 3Me<sup>-</sup> with dynamic gain & overflow, 3.6Me<sup>-</sup> if fixed
- Today's system has significant **performance variations over chip area** (dynamic range per gain level, noise, ...)
- **Soft X-ray QE**
  - We have seen 250eV photons without evidence of higher harmonics at P04, same for 92eV at FLASH
  - No QE numbers yet for P2M full-size chip



- **Design: 300 Hz, proportionally faster for partial readout**
- **Design dynamic range:**
  - single photons at 250eV / <15e<sup>-</sup>,
  - 50k Photons at 250eV (3.5Me<sup>-</sup> for 100% CCE)
- **Uniformity to be addressed in respin** (improved grounding)
- **Soft X-ray QE:** using NASA JPL's delta-doping BSI process for ultrathin entrance windows (~ 5nm) and soft X-ray QE > 85%

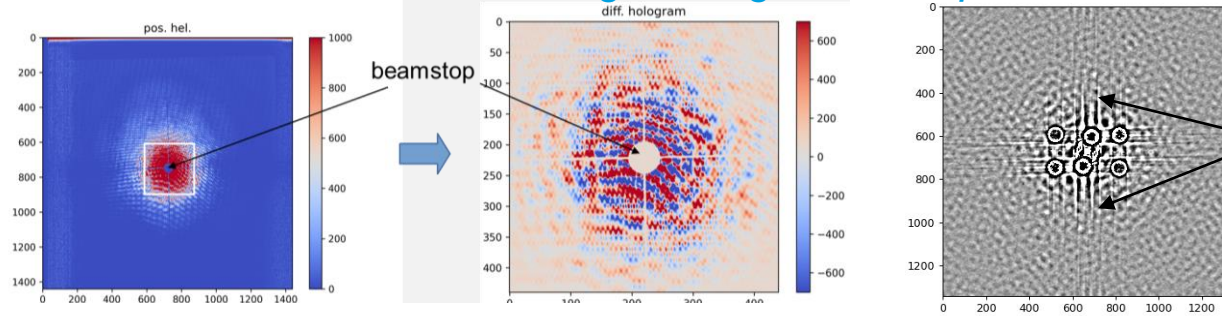
# Holography at Petra III

## Imaging magnetic domains



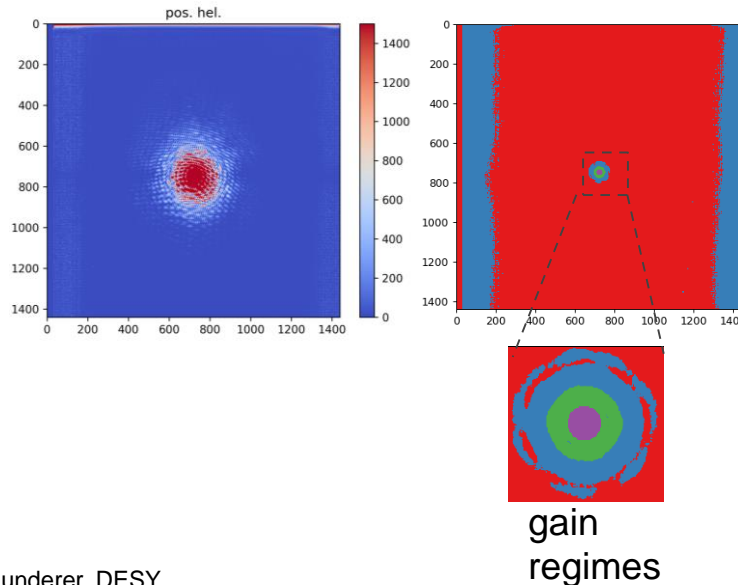
- 780eV
- Percival offers high frame rate, very large dynamic range
- Usual measurements combine many beam intensities, beam stops, absorbers
- Percival: reduced complexity & (beam) time
- Next:
  - 2<sup>nd</sup> “pilot experiment”
  - better-integrated experiment
- Thanks to the groups of F. Buettner (HZB) and B. Pfau (MBI)

Percival-recorded image, using beam stop

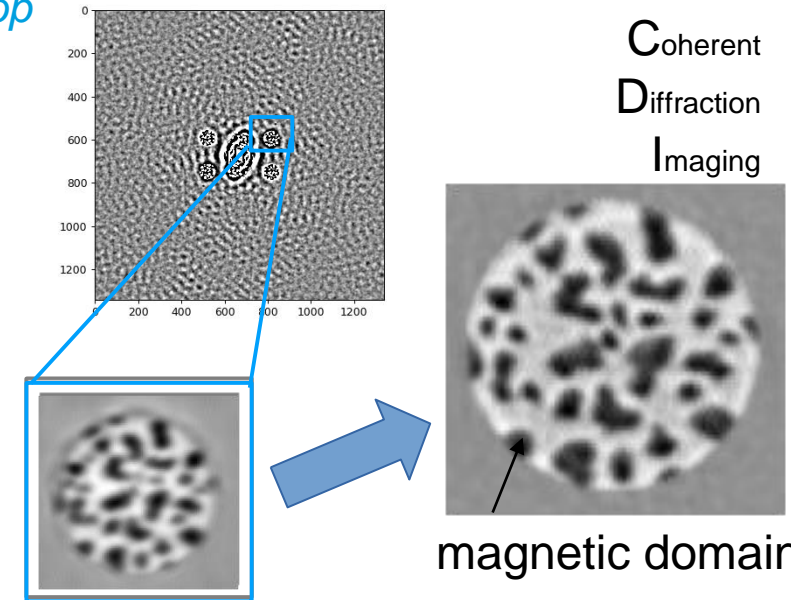


note beam stop causes artefacts in FTH image (“stripes”)

Percival-recorded image, no beam stop



Fourier Transform Holography



Coherent Diffraction Imaging

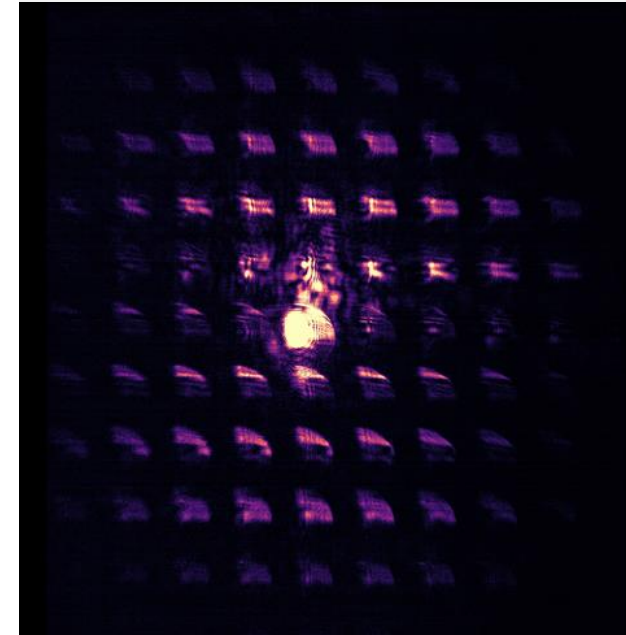
magnetic domain

# Ptychography at FLASH2

At 92 – 466 eV (fundamentals and 3<sup>rd</sup> harmonic of 13.5nm and 8nm)



- Single-shot Ptychography raw data
- Analysis of this Nov 2020 beamtime is currently ongoing



- 92 eV images
  - Left: highest-gain image of a single-shot user sample scatter pattern (detail).
  - Right: illustration of the achievable dynamic range pinhole “Airy” Pattern of a single FEL shot

