Detector Development strategy at European XFEL

Marco Ramilli
for the EuXFEL Detector Group

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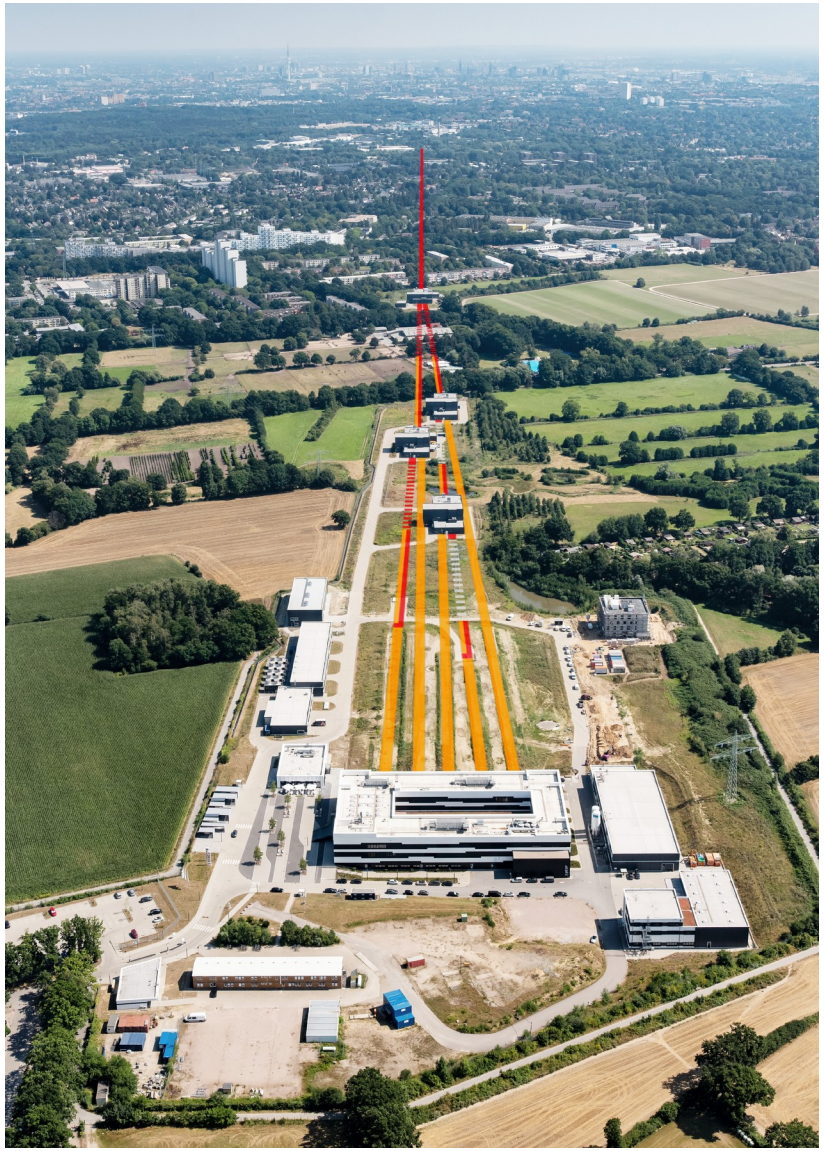
Outline

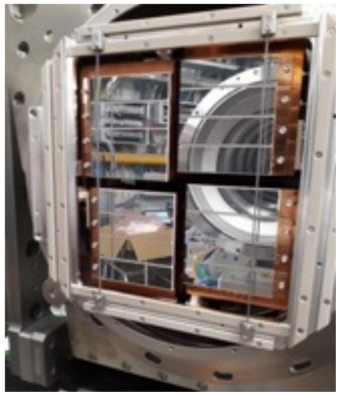
- Future detectors requirements
- Timeline and topics for development
- How we plan to be involved



Detectors for EuXFEL

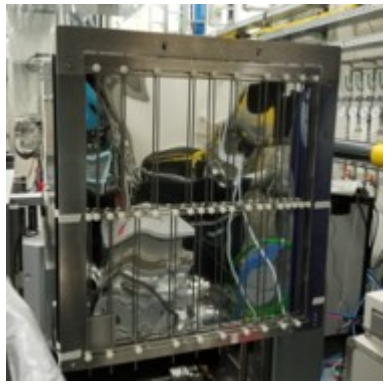
Gotthard-II

AGIPD (SPB/SFX, MID)



Noise: 350 e- (HG)
Dyn range: 10^4 12 keV ph

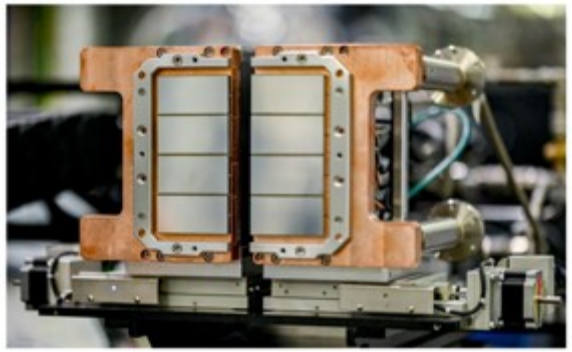
LPD (FXE)



Noise: 2010 e- (HG)
Dyn range: 10^5 12 keV ph

Noise: 50 e- (HG)
Dyn range: 100 8 keV ph

ePix100 (MID, HED)



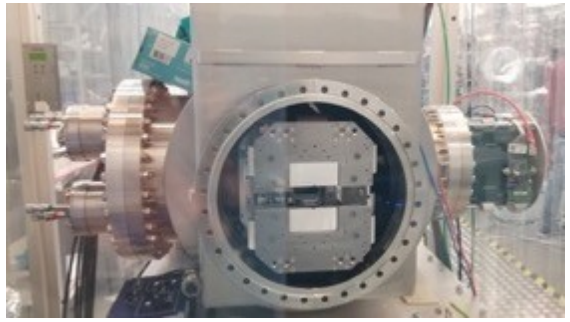
Jungfrau x 17 (all hard X-ray inst.)
Noise: 80 e- (HG)
Dyn range: 10^4 12 keV ph

Hard
X-rays
6-25 keV

X-ray energy

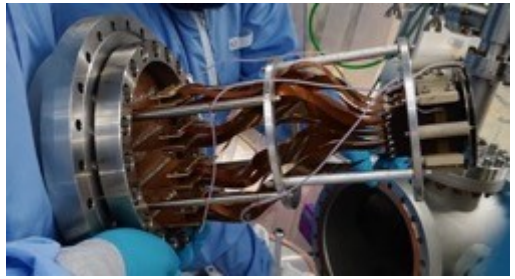
Soft
X-rays
0.5-3 keV

pnCCD (SQS)



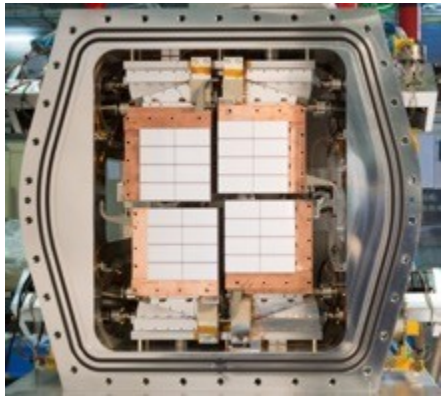
Noise: 3 e-
Dyn range: 1500-3000 1 keV ph

MCP + DLD (SQS, 2x SCS)



Single ph. sensitivity down to few hundred eV
Up to 50-60 ph/pulse

DSSC (SCS, SQS)



Noise: 60 e-
Dyn range:
N x 256 ph @ 4.5 Mhz –
N x 512 @ f≤2.2 MHz
N ≤ 1 for single ph sens.

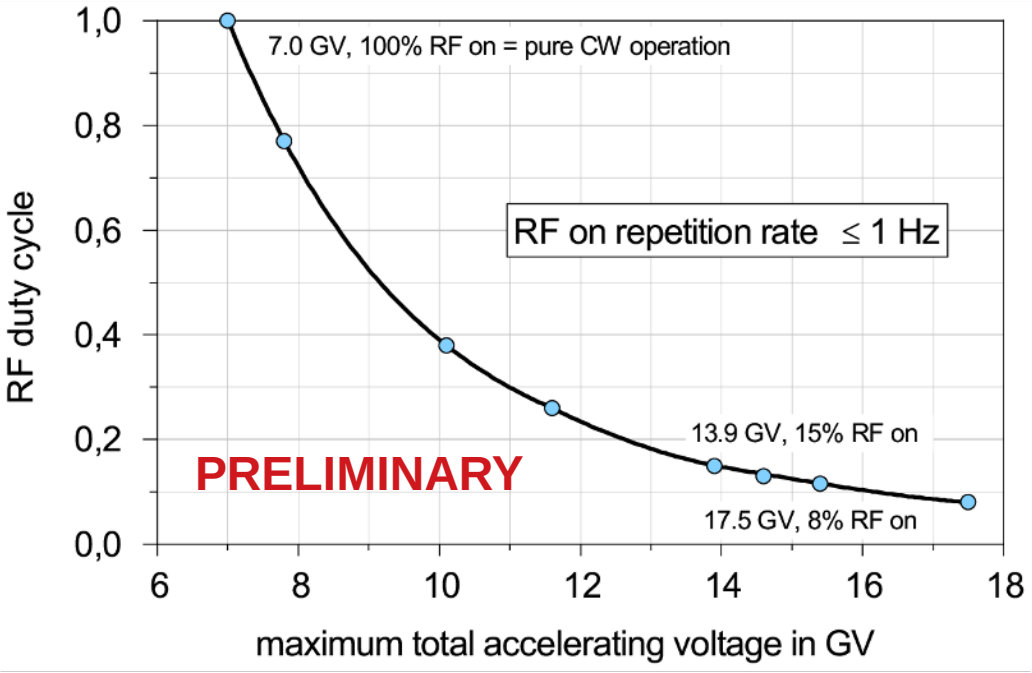
10 Hz

4.5 MHz

Rate

Facility developments: new time structure

Time structure not yet defined, some options under consideration



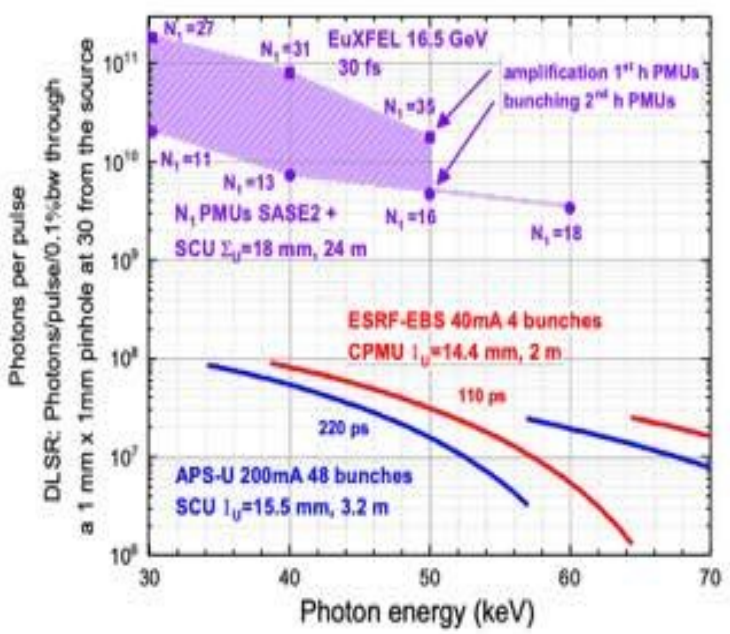
- Without major accelerator modifications
  - CW mode implies a max electron energy of 7 GeV (with respect to the 17.5 GeV of now)
  - energy can be gained by running in high duty-cycle mode, when RF is on for a fraction of time (the present burst mode corresponds to a duty cycle of 0.006)
- This choice impacts dramatically on detector design

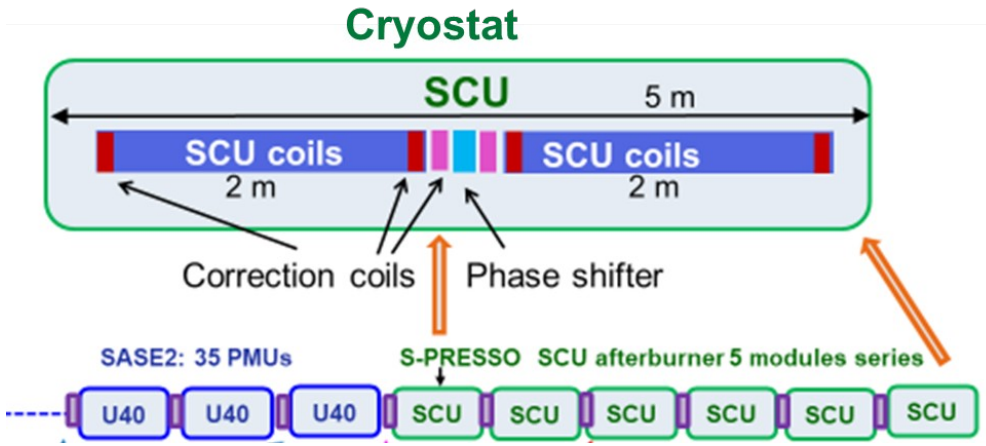
Thanks to the accelerator team, in particular J. Sekutowicz and E. Vogel

Facility developments: SCU system

- Electron beam energy > 16.5 GeV
- Estimated range of photons per pulse achievable by tuning the SCU afterburner to amplify
  - the output of the fundamental of the PMUs
  - the bunching of the second harmonic of the PMUs
- Peak flux ~100 x higher than HE diffraction-limited SR sources
- Large dynamic range detectors needed!

Normalized emittance	0.4 mm mrad	The simulations do not consider wake fields and tapering. A flat top 3 fs bunch is considered
Initial energy spread	3 MeV	
Current	5 kA	





Thanks to Sara Casalbuoni and UND group of EuXFEL

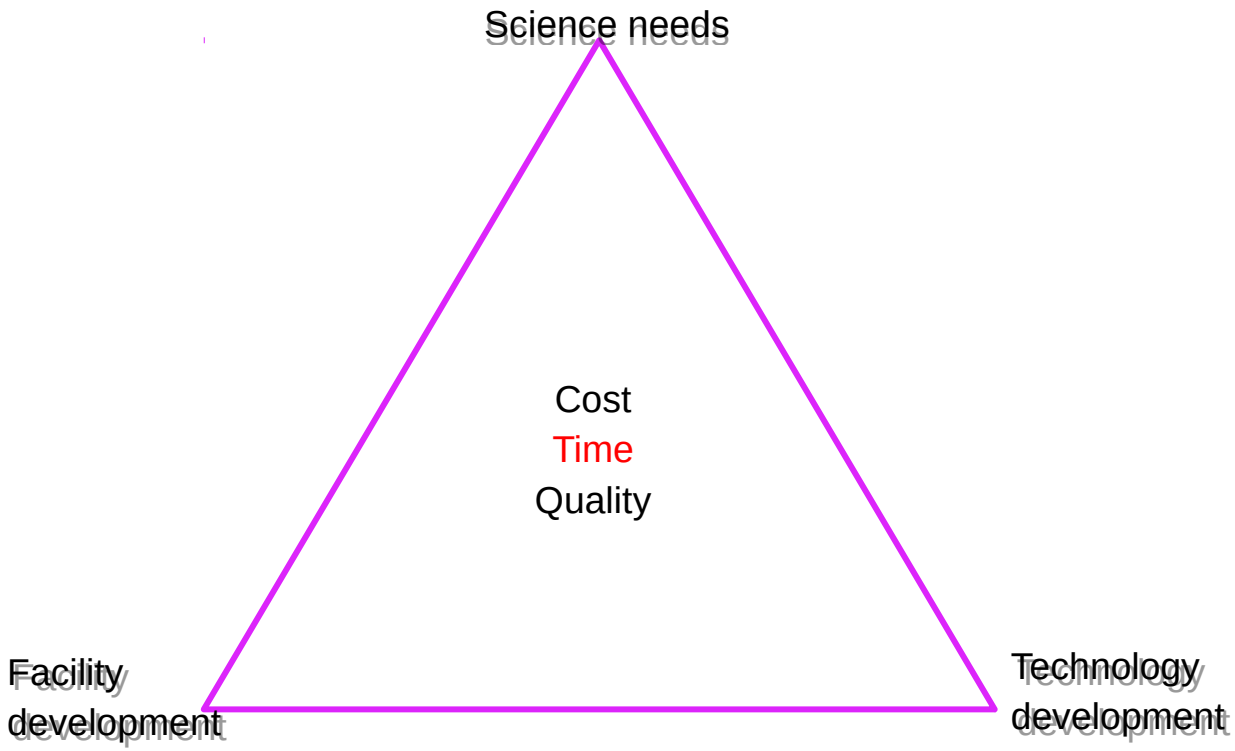
Preliminary requirements from Scientific Instruments

	Hard X-ray detector	Soft X-ray detector
Parameter	**Target values**	**Target values**
Sensitive Energy Range	3-13 keV with Si 13-50 keV with high-Z materials	0.25 - 3 keV, possibly higher
Dynamic range in photons	10^4 12 keV ph./pixel	10^4 1 keV ph./pixel
Noise (ENC)	< 300 el. rms.	< 30 el. rms.
Frame rate	4.5 MHz burst/long burst/CW?	4.5 MHz burst/long burst/CW?
Sensor type	2D pixelated	2D pixelated,
Pixel size	~ 100 x 100 µm²	~100 x 100 µm²
Pixel count	Modular detector, min. module size tbd. Able to build up several Mpixel full-size detector	Modular detector, min. module size tbd. Able to build up several Mpixel full-size detector
Number of modules	Tbd, depending on module size	Tbd, depending on module size
Operating pressure range	Ambient or below 10^{-3} mbar	< 10^{-6} mbar

How to get to the final requirements?

How do we get to the h/w definition and final requirements?

- Continue to evaluate scientific requirements
  - e.g. dyn. range at high energies
- Max repetition rate:
  - MHz rate is a must, continuous operation is not
  - duty cycle will be a machine parameter
- Fully integrate lessons learned from first systems in the new developments
  - Avoid multiple standards
  - Modular detectors
  - ...



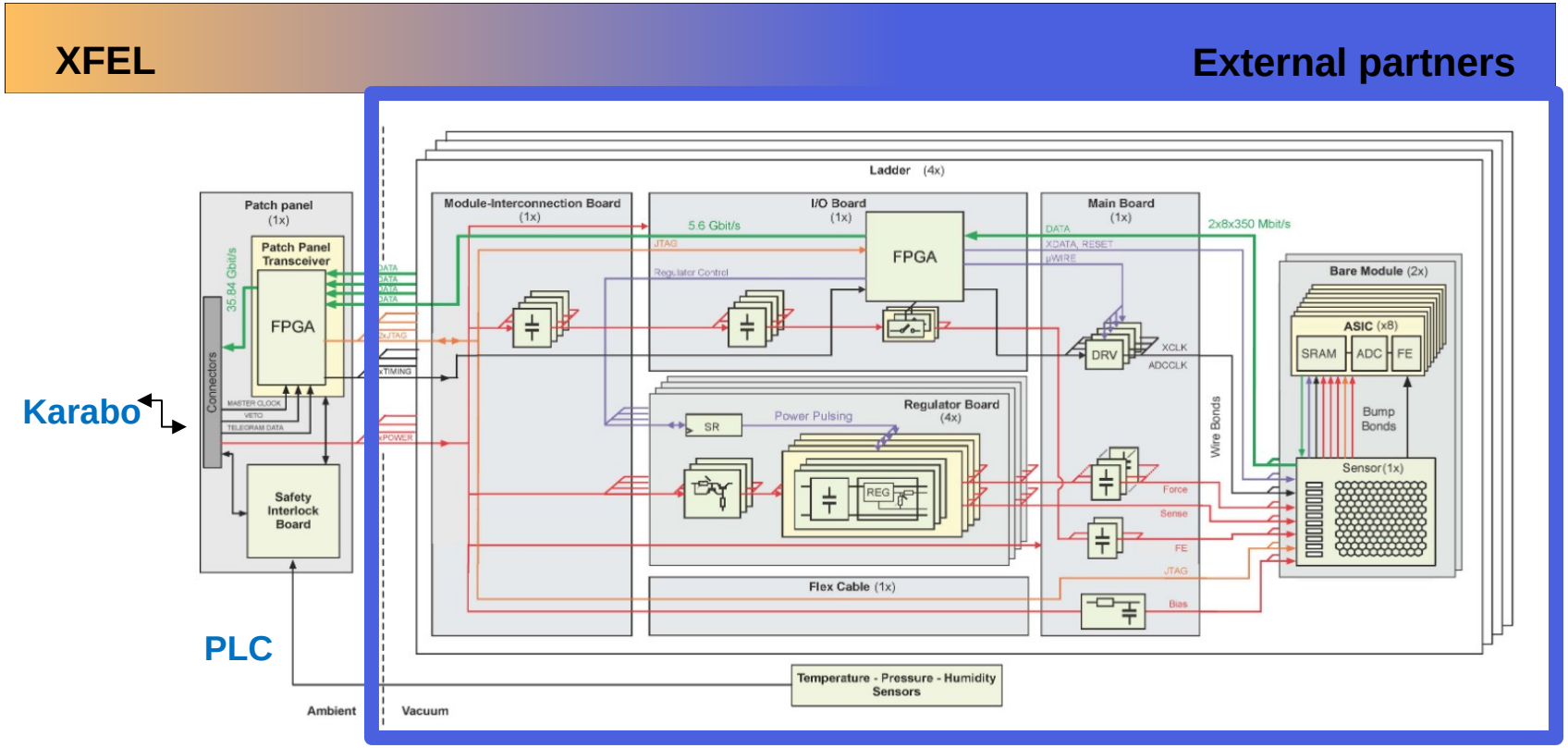
Detector development

Goal: 2nd generation of Large Area Pixel Detectors 2028-2030

- **Phase I 2023 – 2025 (budget established to cover four areas of investigation)**
  - Investigate candidate technologies
  - Work with external partners to establish clear areas of expertise
  - Identify areas of strategic collaboration and funding opportunities
  - Areas of investigation:
    - System integration, backend electronics
    - System integration, mechanics and cooling
    - High-Z materials
    - Sensor and ASIC
- **Phase II 2024 – 2030**
  - Establish concrete projects to build 2nd Generation detectors
  - Prototyping of selected technologies
  - Final designs
  - Construction and commissioning at Scientific Instruments

How we plan to be involved

- Our main expertise are in calibration, system integration and some part of mechanics
- Take a leading role concerning mechanics and backend
- Take a more active role for the front-end development (ASIC and sensor)
  - Need to retain know-how in house
    - ► Small number of people with overview of the systems developed



Conclusions

- Detector requirements are being defined
- Detector development funding has been established at the EuXFEL and first steps have been done to allocate it.
- Phase 1 of the development will serve to increase EuXFEL expertise in certain fields and to define collaboration with external partners in specific topics (ASICs, sensors…)