Fast X-ray Detectors by X-Spectrum

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X-Spectrum

Founded 2014 out of the DESY Detector Group

Fast 2D detectors for X-rays

- **LAMBDA – based on MEDIPIX3 chip**
- **SPARTA – based on AGIPD chip**

Synchrotron customers worldwide

18 employees in Hamburg

EuXFEL Detector Vision

- Relying on availability of current detectors (AGIPD, LPD, DSSC) to 2030+ deemed too risky
  - ASIC manufacturing process obsolete
  - Availability of components unclear – will require redesign of critical components
- Idea: develop next generation detectors for use at the EuXFEL
  - Specifications similar (identical) to existing detectors but with smaller pixels
  - Fix known issues, improve reliability + performance
  - Ready for EuXFEL upgrade 2030+
- Specifications are not everything
  - Timeline
  - Integration
  - Calibration
  - Maintenance
  - Availability of components

	Target values	**Possible variant**
Sensitive Energy Range	5-13 keV[1] with Si 13-50 keV with high-Z	3-13 keV[1] with Si
Dynamic range in photons	> 5 x 10^3 12 keV ph./px	500 - 1000 12 keV ph./px, one gain
Noise (ENC)	< 300 el. rms. ~1keV photon in Silicon	
Frame rate	Burst mode, 1.1 MHz	Burst mode, 1.1 - 4.5 MHz
Sensor type	2D pixelated	
Pixel size	80 - 100 µm pitch	
Pixel count	Move away from fixed large detectors, modular approach, max 4 Mpix	
Operating pressure range	Both ambient and vacuum (below 10^{-3} mbar) versions needed	

Purpose of the Talk

What can X-Spectrum contribute to the EuXFEL detector vision?

Outline

- X-Spectrum
  - What we **can not** do
  - What we **can** do
- Past Developments
  - LAMBDA
  - SPARTA
- Future ideas

What we can’t do

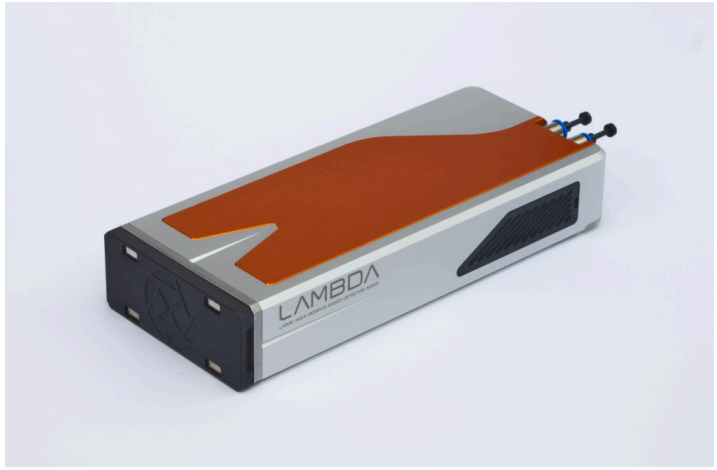
We are **not** chip developers

We **do not** have an XFEL

We can **not** provide a complete solution on our own

What we can do

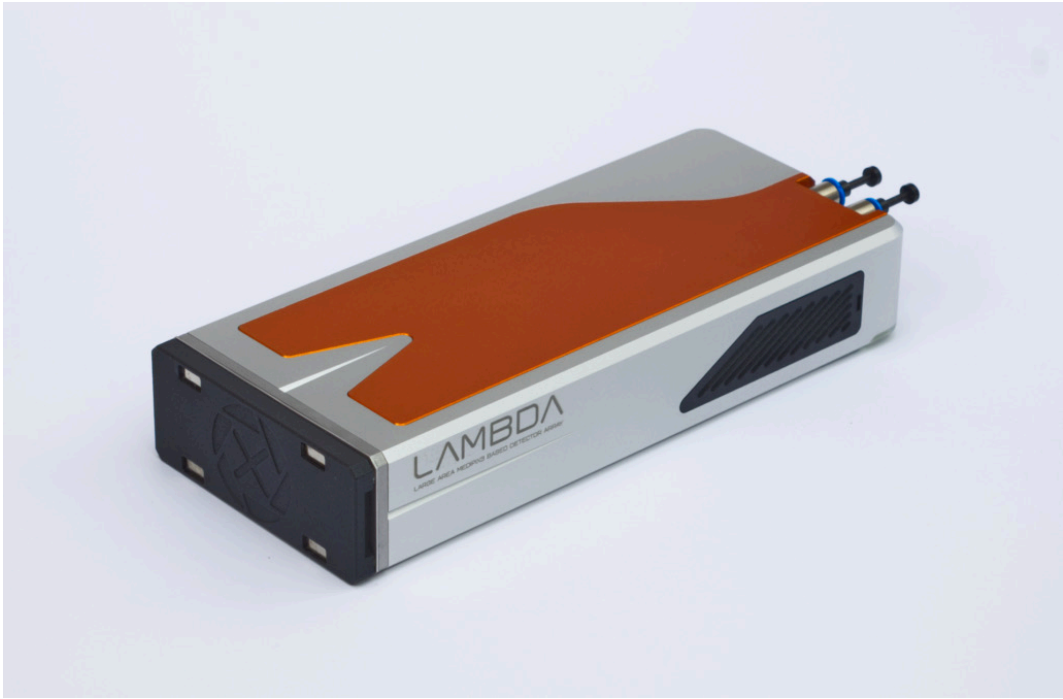
- We build **products** out of chips / prototype detectors
  - LAMBDA
    - Photon counting detector
    - Synchrotron applications
  - SPARTA
    - Based on AGIPD
- We **adapt** our systems to customer requirements
  - Custom detectors
    - LAMBDA windmill
    - LAMBDA flex
  - Sensor developments



Detector Development Process

Development Example: LAMBDA

- Based on Medipix3 chip
  - Developed by Medipix3 collaboration
    - CERN, DESY et al.
  - 55 µm pixels
  - Event counting (photons, electrons)
    - Not suitable for high intensities at EuXFEL
  - Fast
    - 24 kHz
  - Dual threshold
  - Charge summing
- Target application:
  - Synchrotron (hard) X-rays



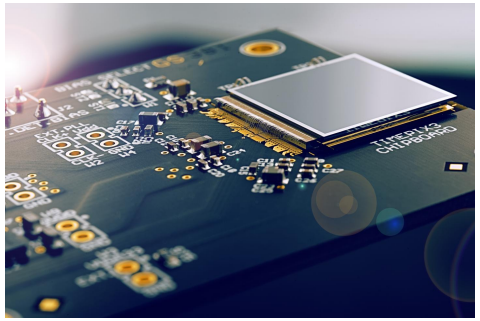
Development Example: LAMBDA

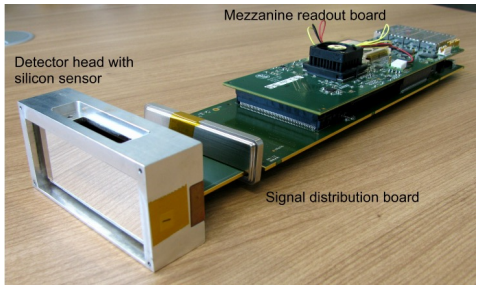
MPX3 Chip Development
- Medipix3 collaboration
- XSP: licensee, active part in the community

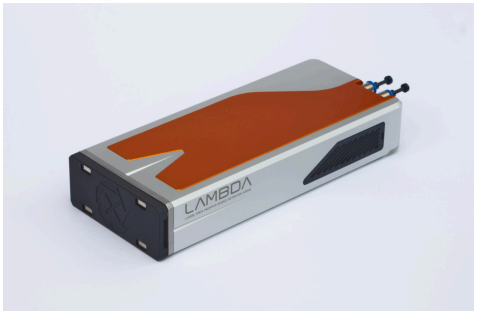
Prototype Detector
- DESY FS-DS

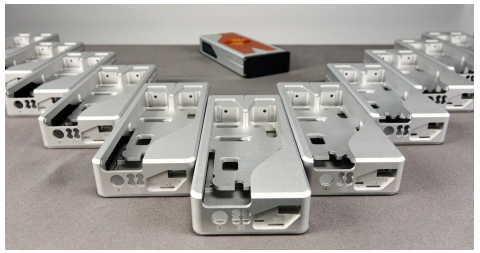
System Development
- X-Spectrum

Production
- X-Spectrum





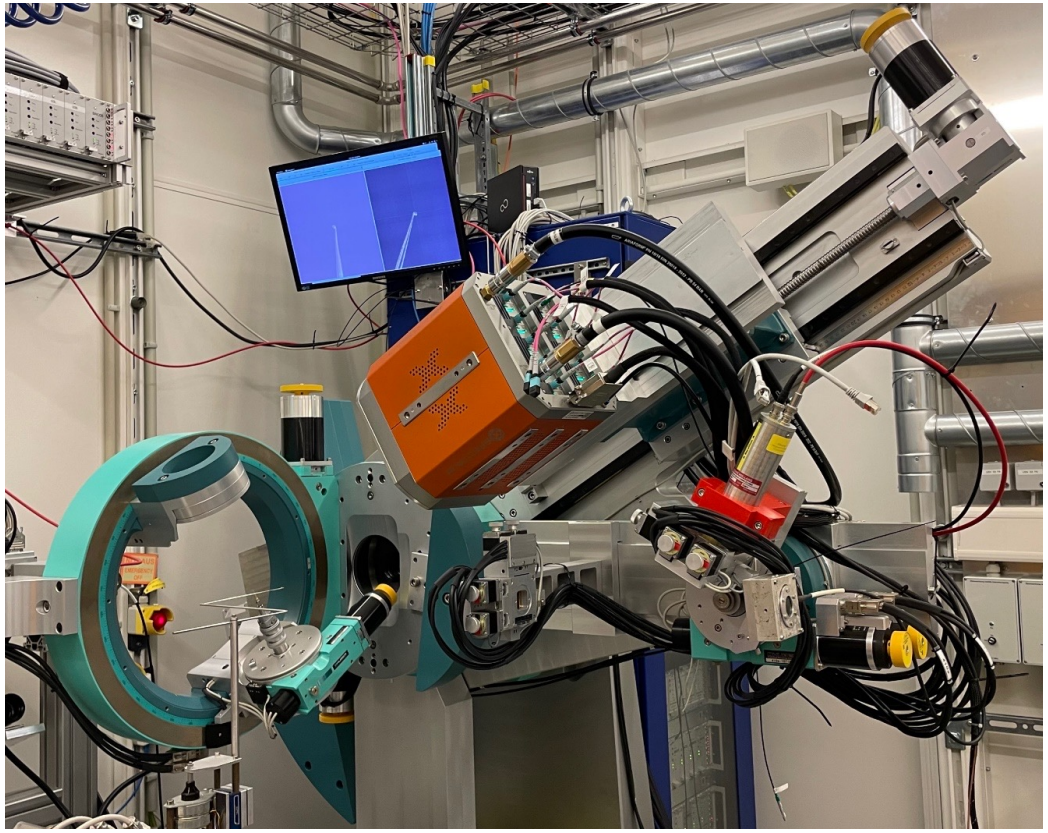




LAMBDA Detectors

- Requirements:
  - Various shapes and sizes
  - High performance regardless of size
  - Integratability
  - Easy to use
  - Servicable

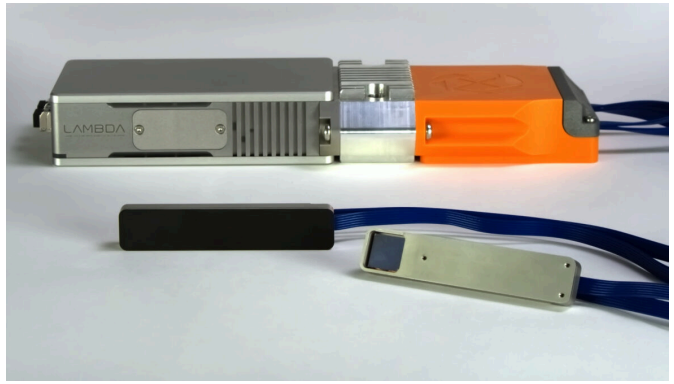
- Completely new design
  - Modular concept
  - New readout electronics
  - New on-board software + firmware
  - New software library and application tools
  - New cooling concept
  - New housing concept
  - New calibration and testing routines

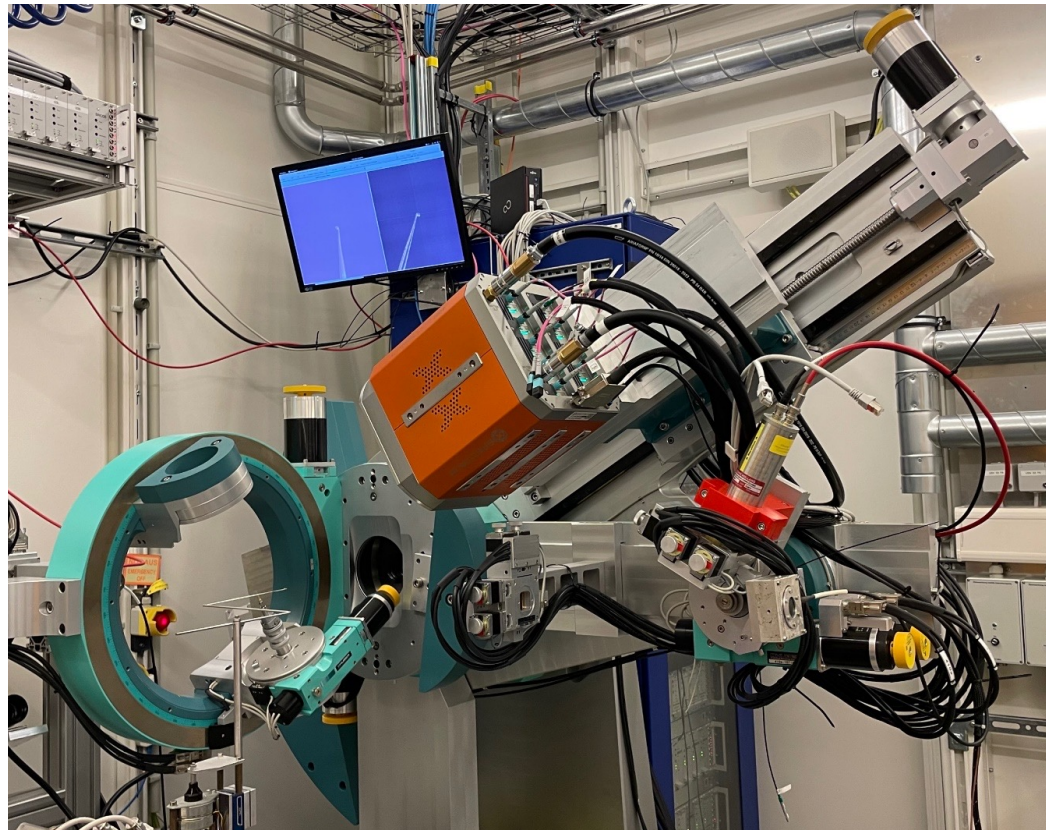


LAMBDA Detectors

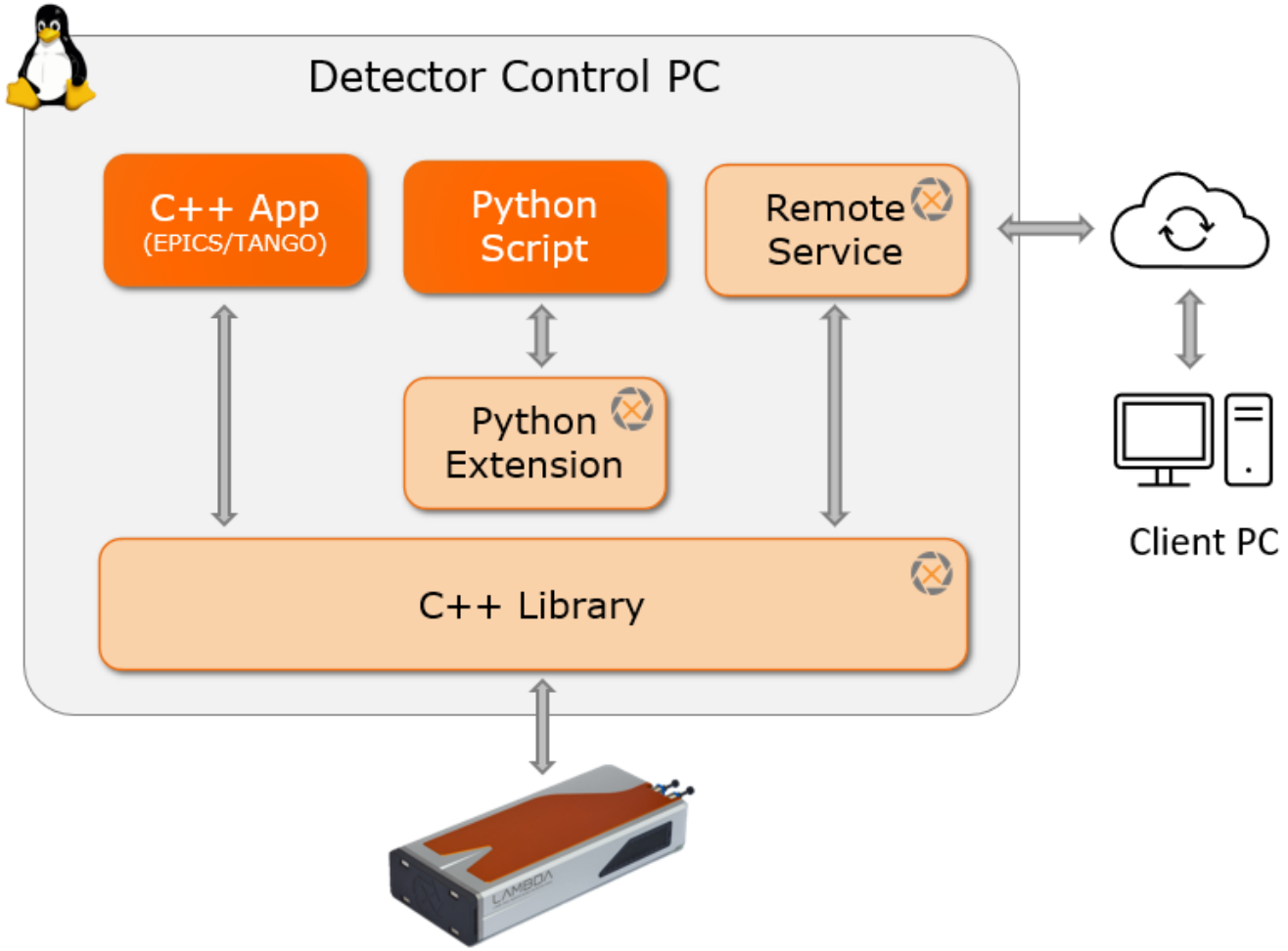
- Requirements:
  - Various shapes and sizes
  - High performance regardless of size
  - Integratability
  - Easy to use
  - Servicable

- Completely new design 2
  - Small and flexible via cables
  - New readout electronics
  - New housing





Software Concept



LAMBDA Detectors

- Large variety of sizes and configurations
- Customer-oriented development
- Reliable supply chain
  - Quality checks essential
- All different, but completely modular
  - Same software
  - Same firmware

Size	Detector pixels	Sensor area (mm²)
Up to 4x 60k	256 x 256 per sensor	14 x 14 per sensor
60k **250k**	256 x 256 512 x 512	14 x 14 28 x 28
350k **750k**	512 x 768 512 x 1536	28 x 42 28 x 85
2M	1536 x 1536	85 x 100
7.5M	3072 x 2560	170 x 170
10M	4608 x 2560	260 x 175

LAMBDA Application Example – Custom Detector

3M detector (4 modules)

Full speed – up to 24 kHz

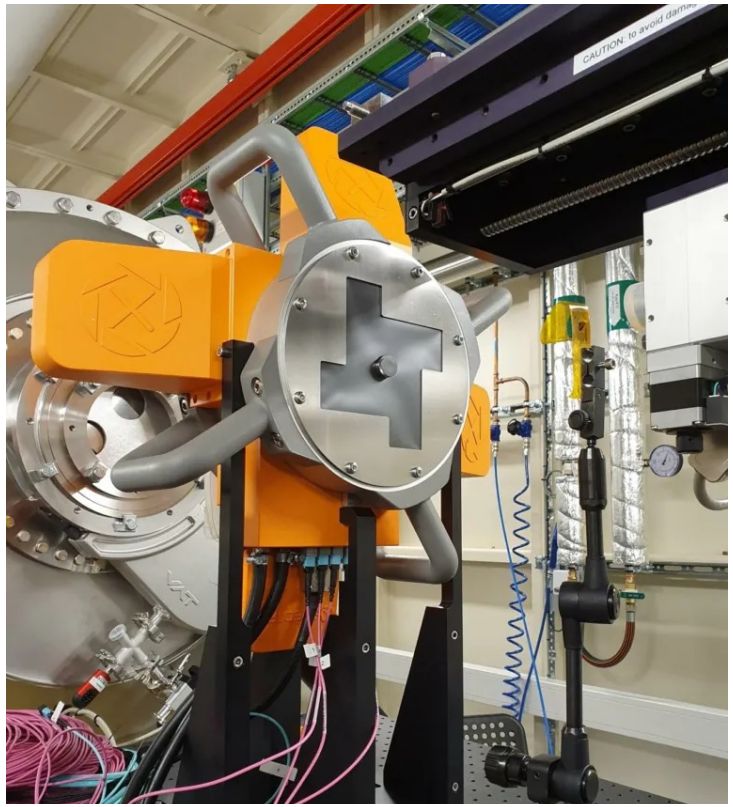
ForMAX beamline – MAX IV, Lund, Sweden

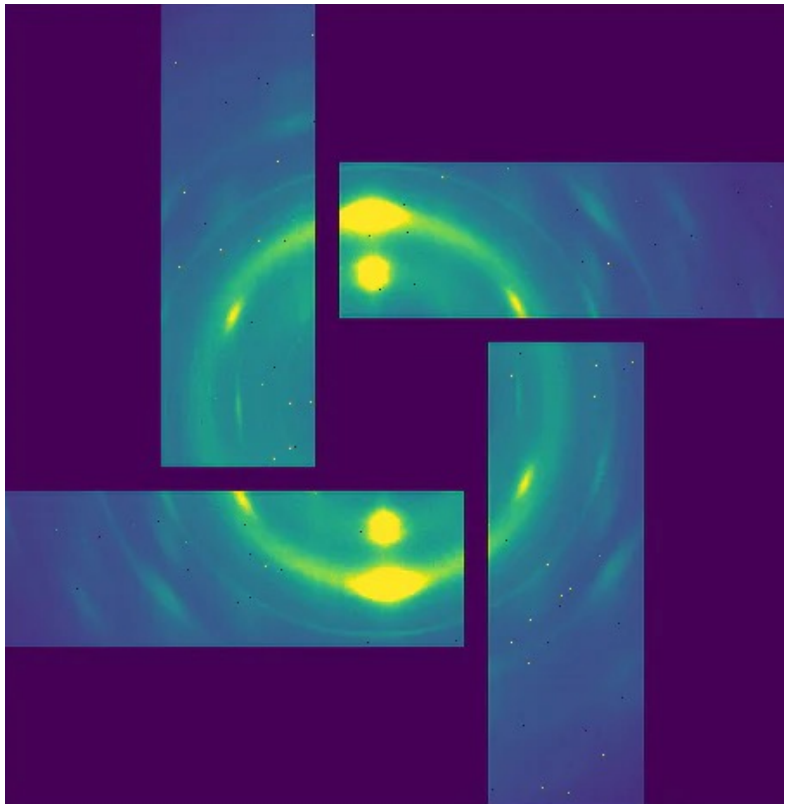
Simultaneous SAXS + WAXS

Detector with hole (like SPB/SFX AGIPD 1M)

Strict space requirements

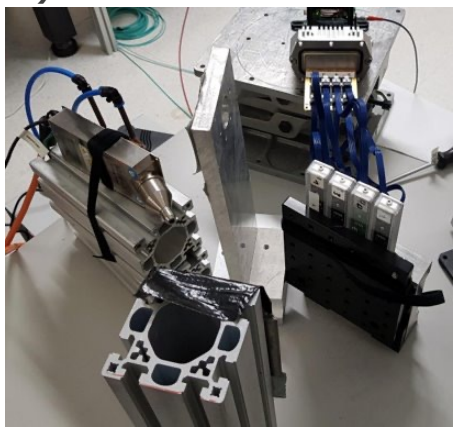
Vacuum tube integration

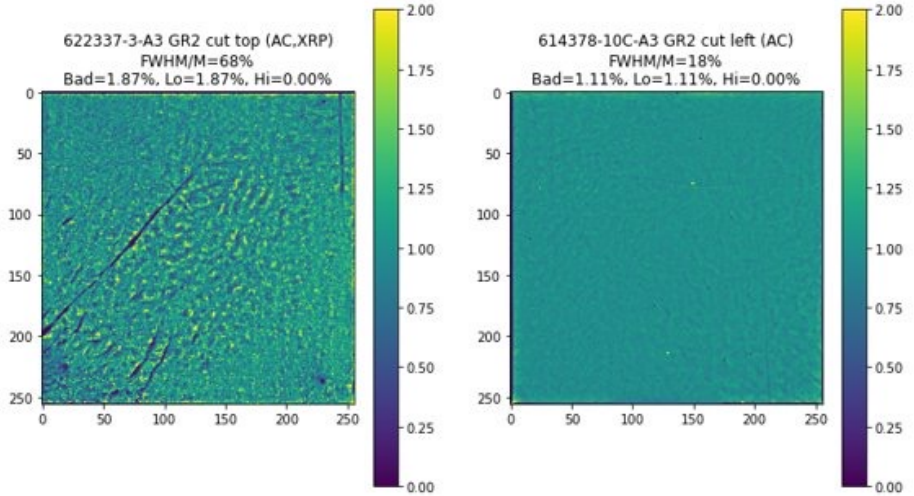




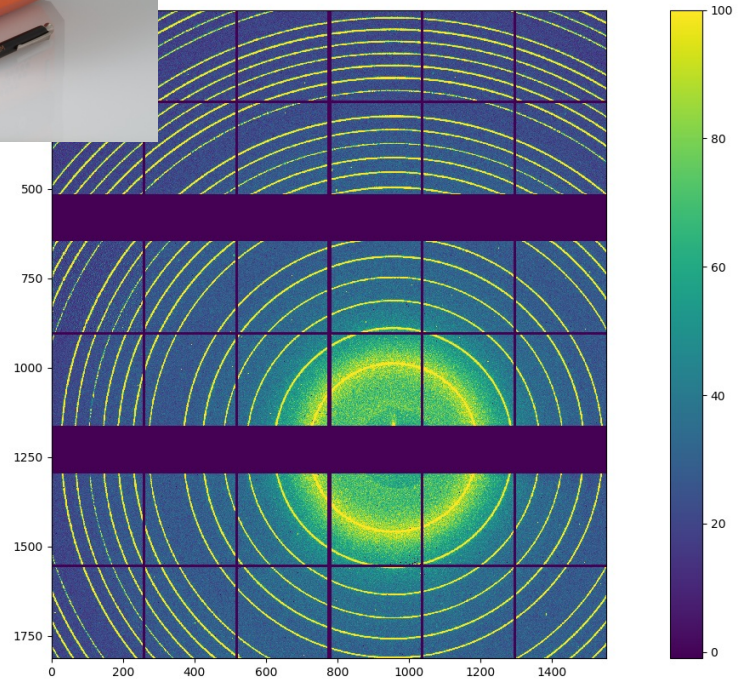
LAMBDA High Z - GaAs

Sensor development: Materials testing platform (QA/QC)





Product: LAMBDA 2M GaAs



SPARTA 60k – Small AGIPD Module

- X-Spectrum has (some) experience with charge-integrating detectors!
- Same as HED/HIBEF AGIPD 500K ‘Mini-Half’ but single module
- Stand-alone operation also possible using X-Spectrum control library
- First sale to non-XFEL user

How to move Forward?

- Building new detectors is an incredibly complex task, many risky steps, extremely demanding technology
  - EuXFEL detectors are unique
- Step-wise approach would be extremely prudent
  - Start small
- Possible X-Spectrum involvement:
  - Hardware design
  - Electronics design
  - FW design
  - SW control library
  - Sensor characterisation
  - Production
  - Supply chain
  - Spare part + service guarantees