PERCIVAL characterization software framework

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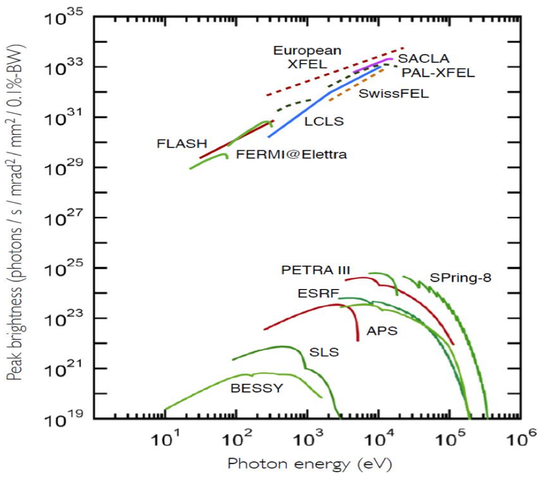
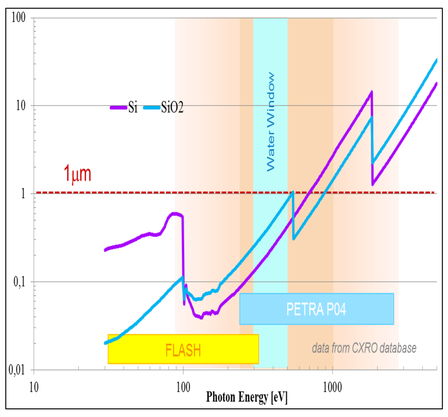
b DESY.
c
d Elettra Sincrotrone Trieste
e
f PAL
g CFEL SCIENCE

Scientific motivations

Fast readout pixelated detector for Soft X-rays experiments



Brilliance of photon sources increases requiring new detectors:
- **high dynamic range**
- **single-photon discrimination**



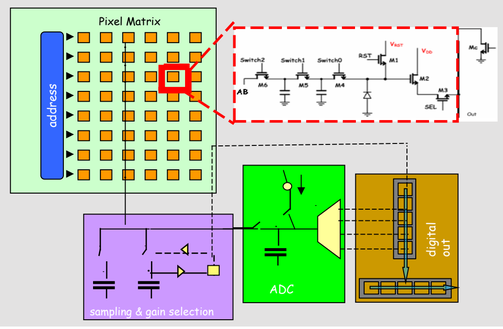
- Water window detection: sub-µm absorption lengths for Si and SiO_2
- Entrance window needs to be minimized

PERCIVAL features

PERCIVAL (DESY, STFC, ELETTRA, DLS, PAL and SOLEIL):
Monolithic Active Pixel Sensor CMOS

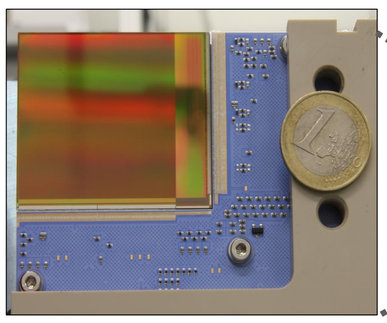
- Primary energy range: < 250 eV to 1 keV
- Single photon sensitivity
- High dynamic range (3.5 Me- (50k photons @ 250 eV)
- 100 % fill factor (back-illuminated, back-thinned)
- High and uniform QE
- Multi-Megapixel, small pixels (27 µm)

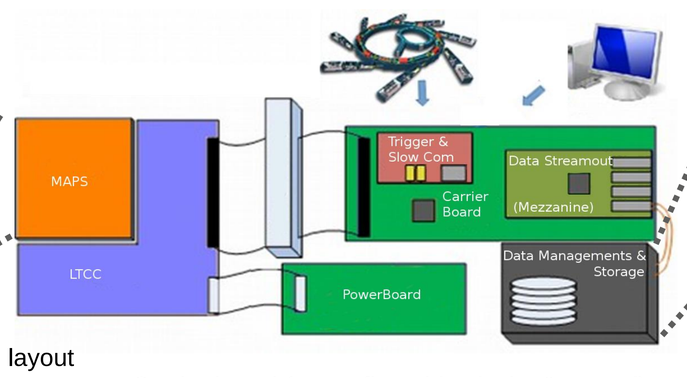
Matrix and pixel architecture



- Pixel: 3T structure + switches and capacitors in parallel
- Adapting pixel detection to the photon flux
- 7 (+1) ADCs per column
- Three gain levels: high, medium and low
- 15 bits output per pixel
- Correlated Double/Multiple Sampling (CDS/CMS)
- Wafer back-thinned and post-processed for minimizing entrance window

Detector Chain

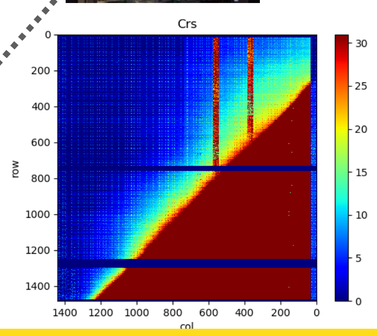




- 2 Megapixels (~ 4x4 cm^2 imaging area, layout stitching)
- 27 µm pixel pitch
- Auto-adaptive gain to incoming flux, per pixel, real time
- 2-side buttable: cloverleaf arrangement of 4 modules possible
- Up to 300 frames/s (tested to date up to 100 f/s)

- Carrier board (re-configurable clocks & control)
- LTCC board
- PowerBoard (bias & monitoring)
- Mezzanine board (stream-out data // 10Gb ports)
- Data Management & Storage

<u>20Gb/s data out, (or x4 if cloverleaf):</u>
- DAQ interface (deep switch & multiple DELL R630)
- VirtualHDF5 dataset data organization (presenting data as a simplified array to the user)
- Calibration procedure (tested in prototype)



<u>First in-lab tests using mask</u>
- Acquisition of 660 nm light with P2M-FSI demonstrator
- Sensor fully reacting *(blue horizontal lines coming from missing files during acquisition and vertical ones a hardware problem – not from sensor)*

GOALS:
- Shared framework between all partners avoiding multiple software solutions
- Easy expandability and interchangeability of method
- Minimizing error sources when comparing results
- Providing tools for calibration, characterization and data-viewing

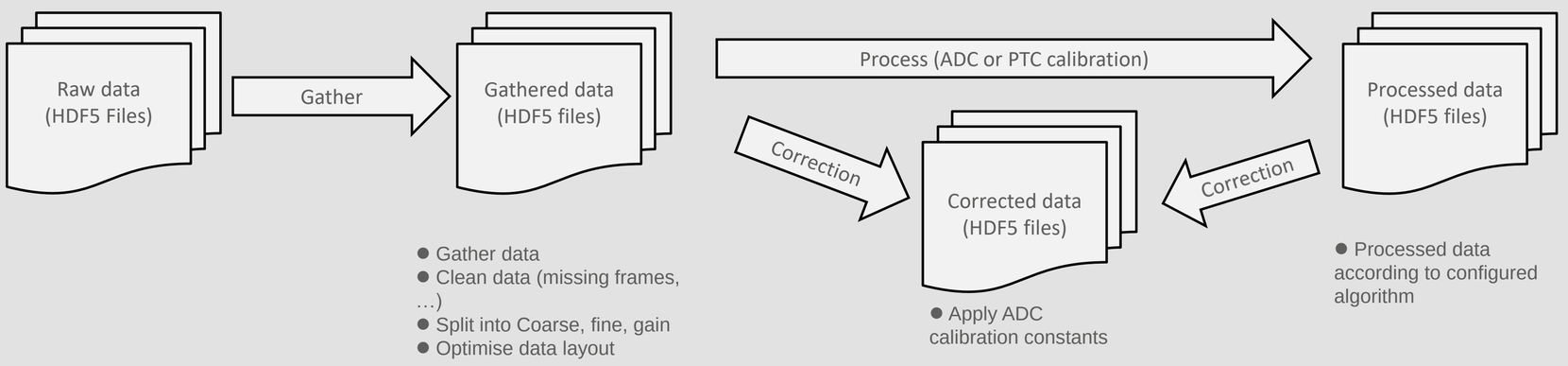
PERCIVAL characterization software framework

PURPOSES
- Calibration: generation of calibration constants (ADC calibration, PTC calibration)
- Correction: applying calibration constants
- Characterization: noise, MTF, clustering, CCE, INL/DNL, …
- Written in Python3 for treating HDF5 files format

Algorithm development:

- Users define algorithms using a provided scaffold architecture
  - Derive from a base class to include a set of methods for the analysis (fit, error bars,…)
  - Selection of algorithm to use via command line arguments or a configuration file
- Users create a set of files to contain the algorithms
  - Files are put into predefined folder (to contain all existing algorithms)
  - Commits only to this predefined folder
  - One 'file' per algorithm
- Different generations of algorithms at the same time
  - Need to be in different files
  - Default algorithm is defined in global configuration

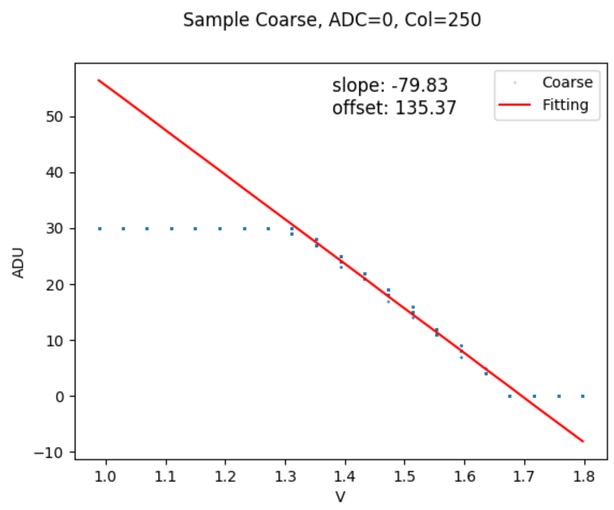
Principle of calibration:



- Gather data
- Clean data (missing frames, …)
- Split into Coarse, fine, gain
- Optimise data layout

- Apply ADC calibration constants

- Processed data according to configured algorithm



- Simulated data of 210 pixels for one column
- Pre-step for ADC calibration
- Linear fitting of coarse part

Summary and perspectives

- P2M-Front-Side-Illuminated demonstrator is fully working: tests in laboratory are ongoing for complete performances validation
- Demonstrator with specific back-side process will be delivered soon for tests
- Software framework for calibration and characterization tools is being developed

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