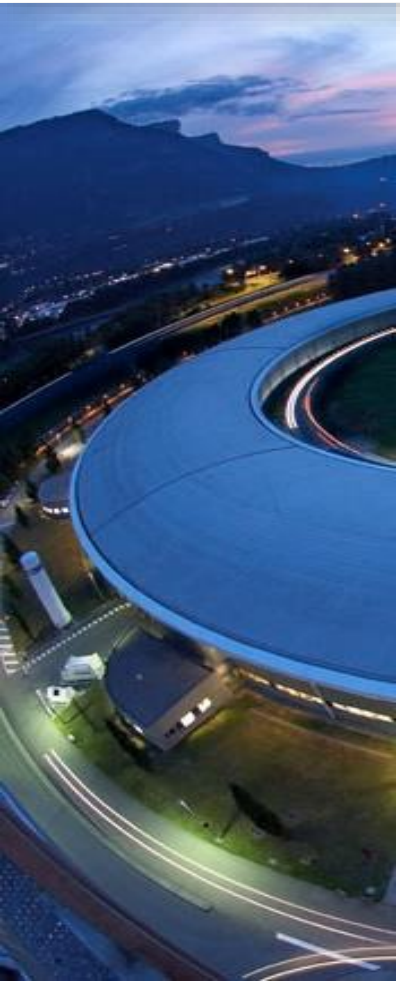
ESRF | The European Synchrotron

AGH University of Science and Technology



# SPHIRD:
## Small Pixel, High Rate Photon Counting Detector for Synchrotron Applications

D. Magalhães, P. Busca, P. Fajardo, P. Gryboś, R. Kleczek, P. Kmon, T. Martin, P. Otfinowski and M. Ruat

# SPHIRD PROJECT

## Motivation:

- Address the challenges of EBS and all the new 4$^{th}$ generation diffraction-limited synchrotron sources
- Optimal use of coherent scattering techniques

## Goals and Approach:

- Develop a new detector overcoming the present photon-counting detection systems, pushing the limits of count-rate capabilities and spatial resolution
- Collaboration between ESRF and AGH University of Science and Technology
- First phase (R&D Study) → final design to be launched in 2023

# SPECIFICATIONS AND TECHNICAL CHOICES

Key target specifications:

- High count rate capabilities: >15 Mcps per pixel (at 10% of pileup)
- Sensor pixel pitch ≤ 50 µm, desired target in the 30 to 40 µm range
- Optimized for 15 - 30 keV, usable in a wider range

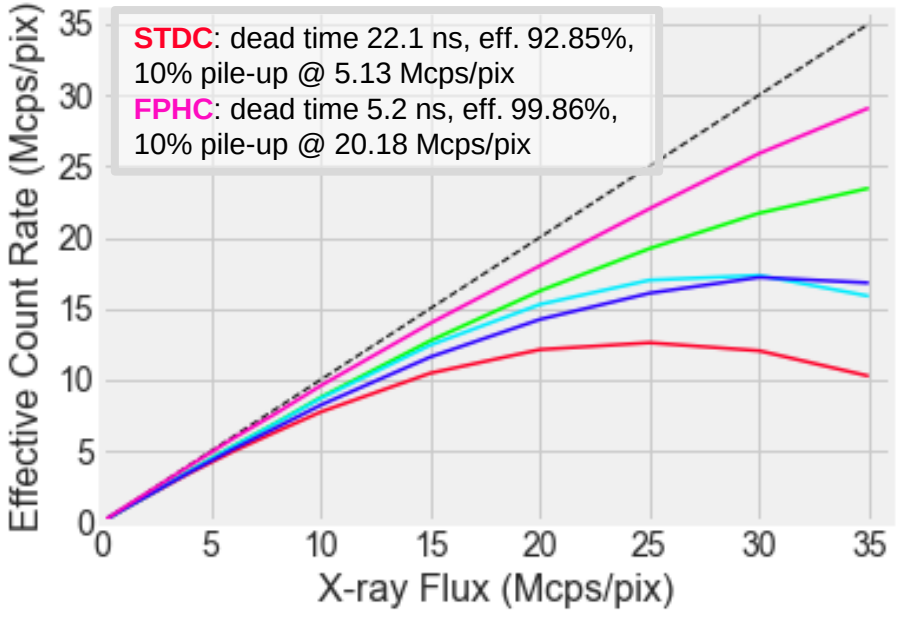
Main technical choices:

- Readout electronics designed for electron collection, Silicon and High-Z sensors
- TSMC 40 nm CMOS technology
- Fast Charge Sensitive Amplifier with short output pulses (R. Kleczek *et al*, http://10.1109/JSSC.2018.2851234)
- Pile-up compensation schemes and/or sub-pixel relocation embedded in the pixel logic

# SPECIAL METHODS: IN-PIXEL PILE-UP COMPENSATION

- Study and comparison of several pile-up compensation techniques
  - Amplitude based (pulse aggregation based on multiple discrimination)
  - Time based (fractional photon-counting, retriggering methods)

- Extract suitable figures of merit: dead time, detector efficiency, SNR
- Preliminary simulation results: (T. Johng-ay *et al.*, [http://10.1109/NSSMIC.2016.8069944](http://10.1109/NSSMIC.2016.8069944))




Simulation conditions:

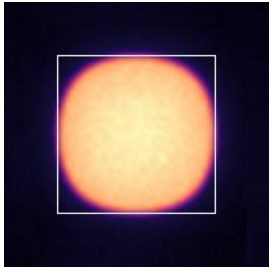
Sensor: CdTe, 500 µm, bias -300 V
Pixel pitch: 50 µm
Source: 20 keV, size 3x3 pixels
AC Coupling time constant: 200 ns
Noise: 200 e- rms
Shaper: Triangular pulses of 20 ns

# SPECIAL METHODS: PIXEL AND SUB-PIXEL RELOCATION

- Usage of the information from neighbors (charge-sharing) to relocate the hits:
  - Simple relocation using arbitration
  - 2x2 and 3x3 sub-pixel relocation (additional logic)

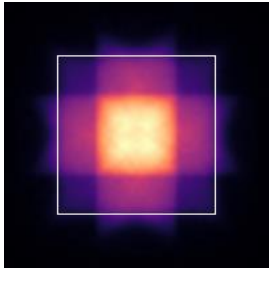
- Extract suitable figures of merit: PSF, effective size of the pixel (ESOP)
- Preliminary simulation results (30 µm pixel):

PSF Conventional photon counting

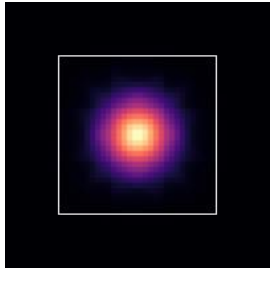


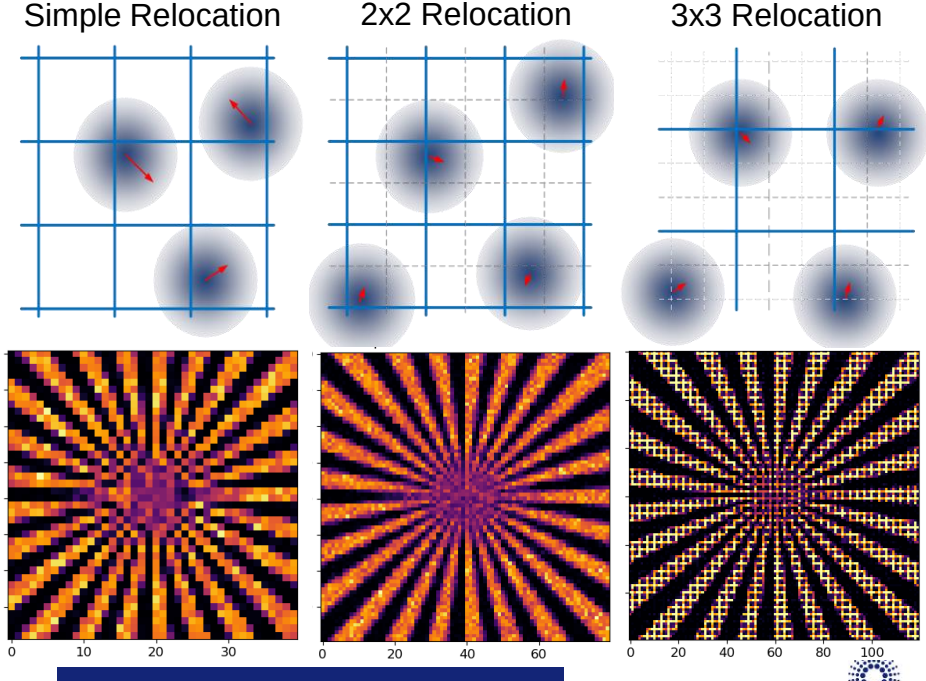
PSF Simple Relocation

PSF 2x2 Relocation



PSF 3x3 Relocation






**Thank you!**