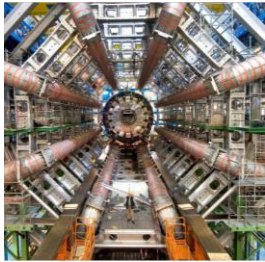


Pseudo-3D pixel detectors for powder diffraction

Martijn Fransen

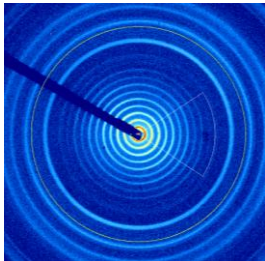
Agenda



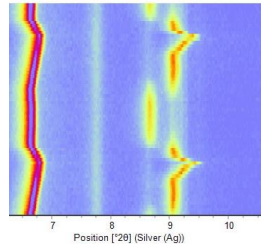
Solid state position-sensitive detectors @PANalytical



Dealing with polychromatic radiation



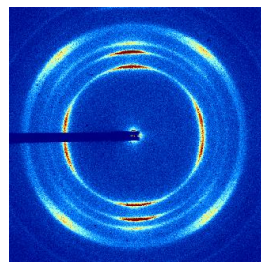
Spatial resolution ... in three dimensions



The challenges of non-Cu radiation

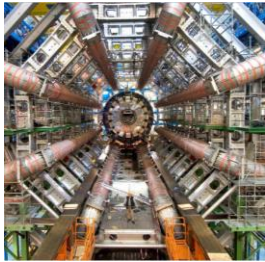


The importance of dynamic range



Conclusions

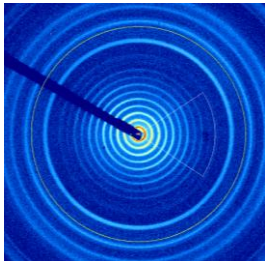
Agenda



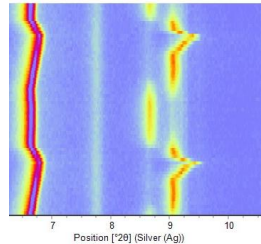
**Solid state position-sensitive detectors
@PANalytical**



Dealing with polychromatic radiation



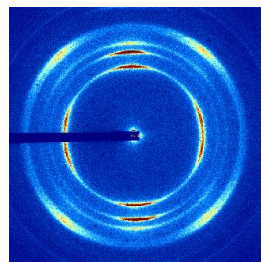
Spatial resolution ... in three dimensions



The challenges of non-Cu radiation



The importance of dynamic range



Conclusions

PANalytical: pioneer in solid-state position-sensitive detectors

- Around 1985 Philips started with position-sensitive detectors
- 2001: **X'Celerator**: the world's first solid state strip detector reducing measurement time for powder diffraction data from hours to minutes
- 2007: **PIXcel^{1D}**: a solid state strip detector with more and narrower channels and a highly improved dynamic range, based on **Medipix2** technology
- 2010: **PIXcel^{3D}**: the first solid-state hybrid pixel detector allowing 0D-1D-2D-3D experiments
- 2012: **PIXcel^{3D} 2x2**: enlarged angular coverage
- 2014: Introduction of **Medipix3** technology; enhanced wavelength coverage
- 2015: Introduction of **GaliPIX**: a new large solid-state 2D detector, optimized for hard radiation experiments

Philips Analytical

The Philips Solid State Position Sensitive Detector - SS-PSD

- Ultra high countrate over total detector
- Ultra high countrate per channel
- Extremely fast datacollection
- High spatial resolution



The Solid State Position Sensitive Detector (SS-PSD) is a revolutionary development in x-ray detector technology. Philips is the first to succeed in combining the advantages of Solid State technology with the benefits of simultaneous position sensitive x-ray detection, resulting in a unique detector with properties you have long been waiting for.

In fact, the SS-PSD is an array of 96 discrete and totally independent detectors, each with energy resolution and efficiency equivalent to a proportional counter, on one silicon chip. Integrated with the detector are 2 specially designed readout chips, forming a full custom device in a hybrid structure.

For the first time, simultaneous detection of two photons at two different positions on the detector is possible, giving the capability for position sensitivity at ultra high countrates. The parallel-processing of information opens up the possibility of very high speed data collection on strongly diffracting samples.

SS-PSD solves another of the well known limitations of gas-filled Position Sensitive Detectors, their poor spatial and angular resolution. The SS-PSD's unique combination of silicon (in place of gas) and the detector dimensions results in excellent resolution performance. The absorption depth of an x-ray photon in silicon is 100 times smaller than in gas. This eliminates parallax errors for obliquely incident photons.

Furthermore, the length of the detector is purposely kept short, to reduce the defocusing effects at the detector ends. The high scan speed makes it possible to cover a large angular range in a short time. An added benefit of scanning compared to static measurements is that the detector resolution remains constant over the entire scan range.

The SS-PSD is designed to study all sorts of applications: from applications where a PSD is traditionally applied (phase transitions at high or low temperatures, faint reflections from low crystallinity samples) to fast quantitative and qualitative phase analysis. The detector can give you up to 96 times more counts (better statistical group) to 96 times shorter measurement times with the same number of counts of one position, compared to a "normal" single-channel detector.

The SS-PSD is fully compatible with the Philips X'Pert range of x-ray diffractometers.

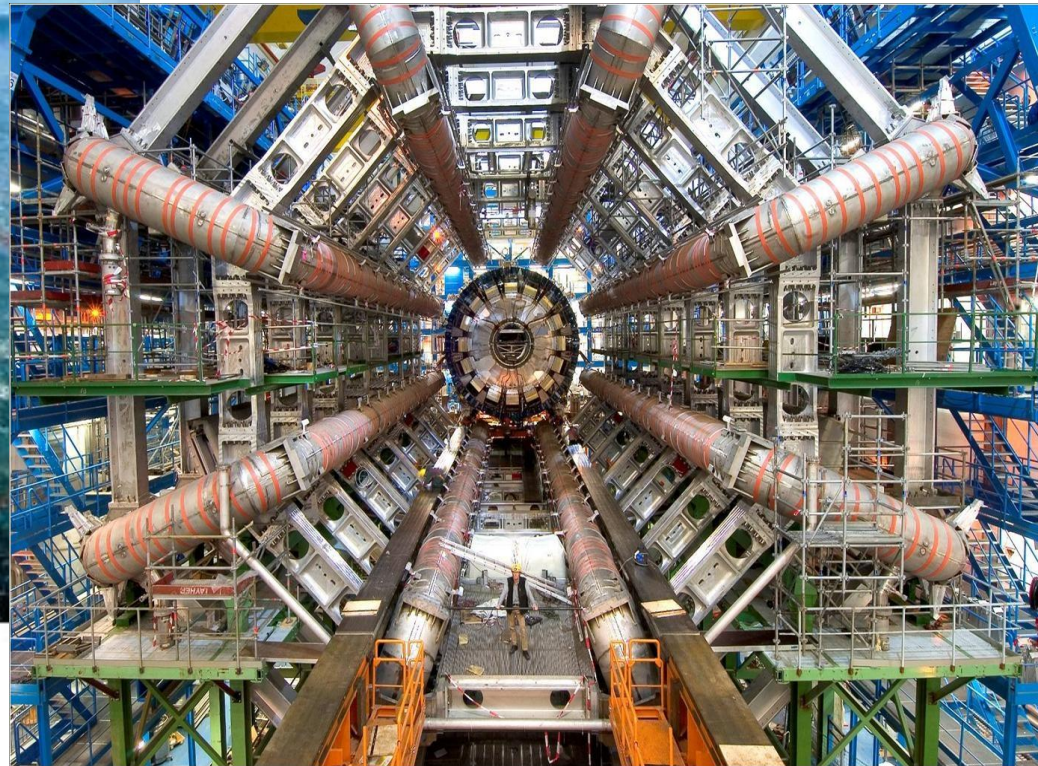
The SS-PSD, really something new!

Specifications SS-PSD

Detector material	High ohmic n-conductive silicon
Active thickness	350 µm
Active dimensions	15x7 mm
Number of detector channels	96
Spatial resolution	70 µm
Maximum countrate	40,000 counts/s per channel 2,000,000 counts/s total

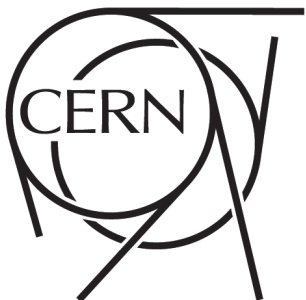


The origin of Medipix technology



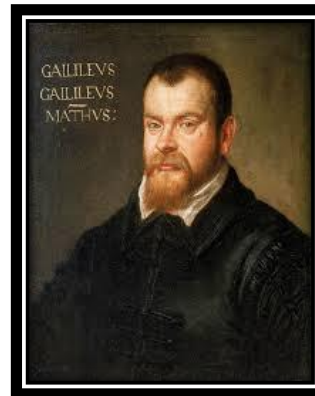
From the huge Atlas detector...

... to the PIXcel detector family that fits a lab diffractometer

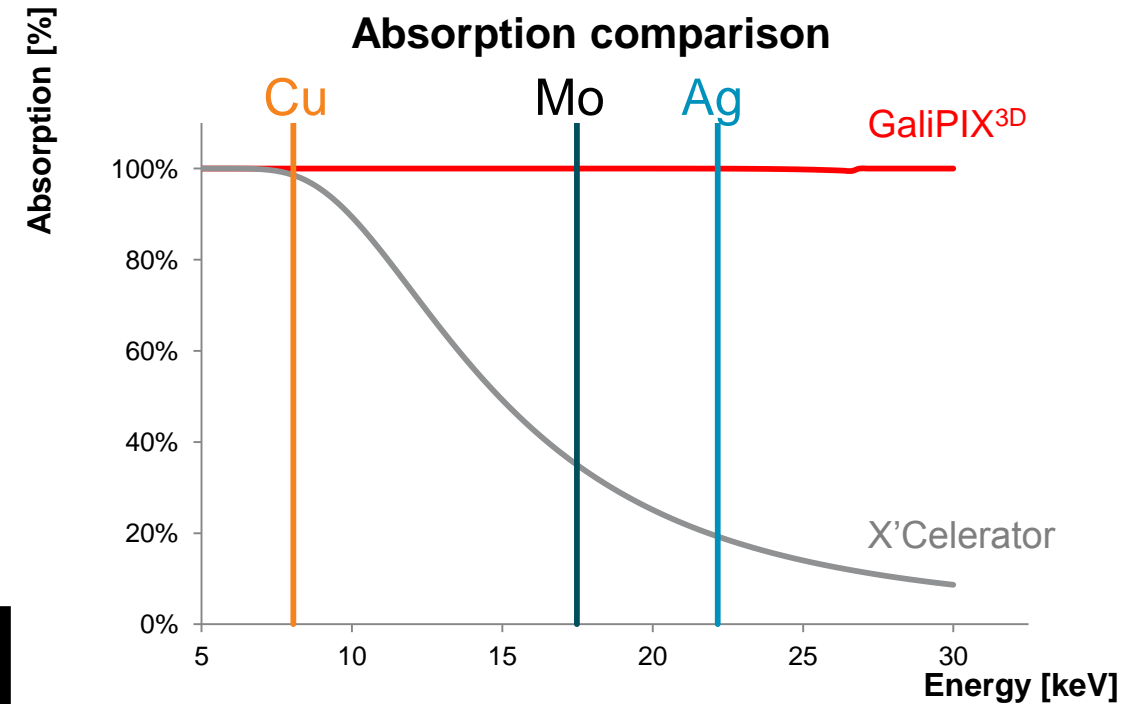


The latest addition: GaliPIX^{3D}

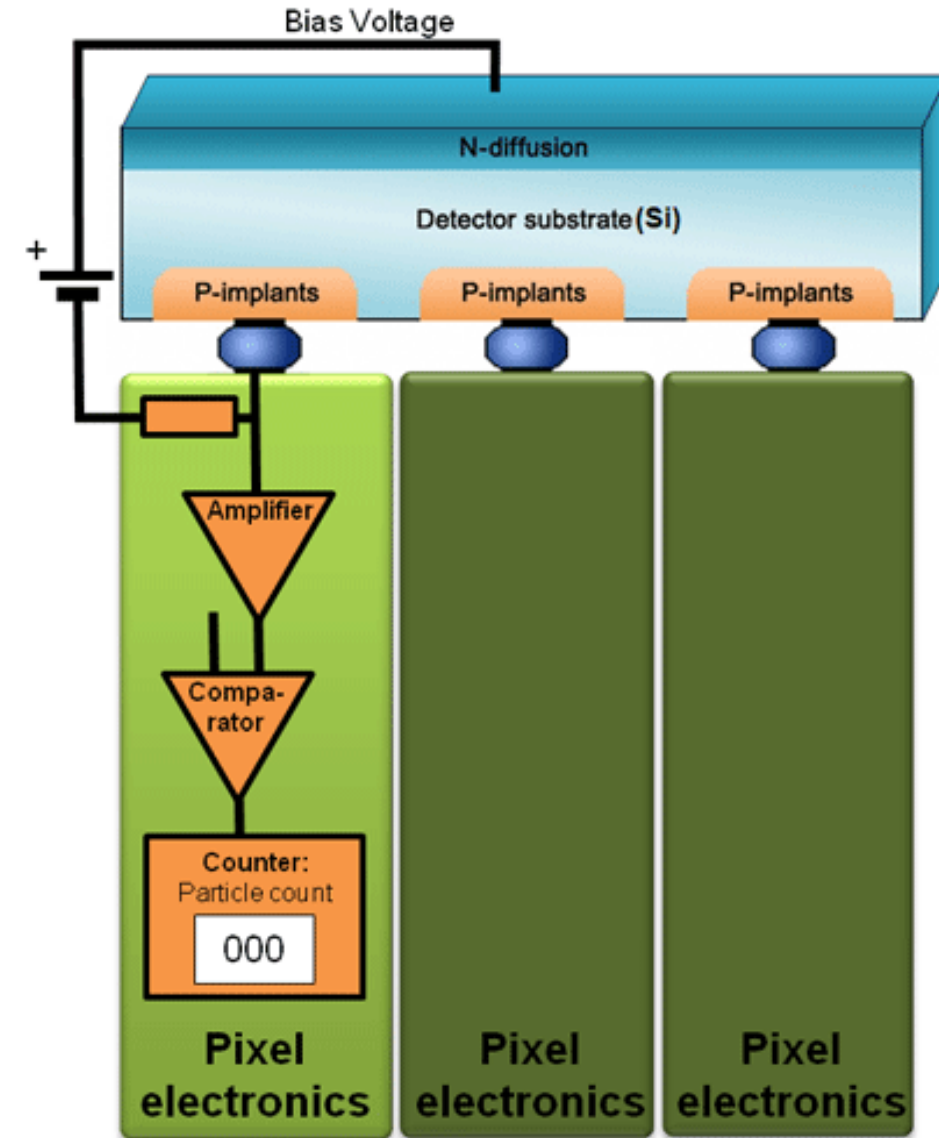
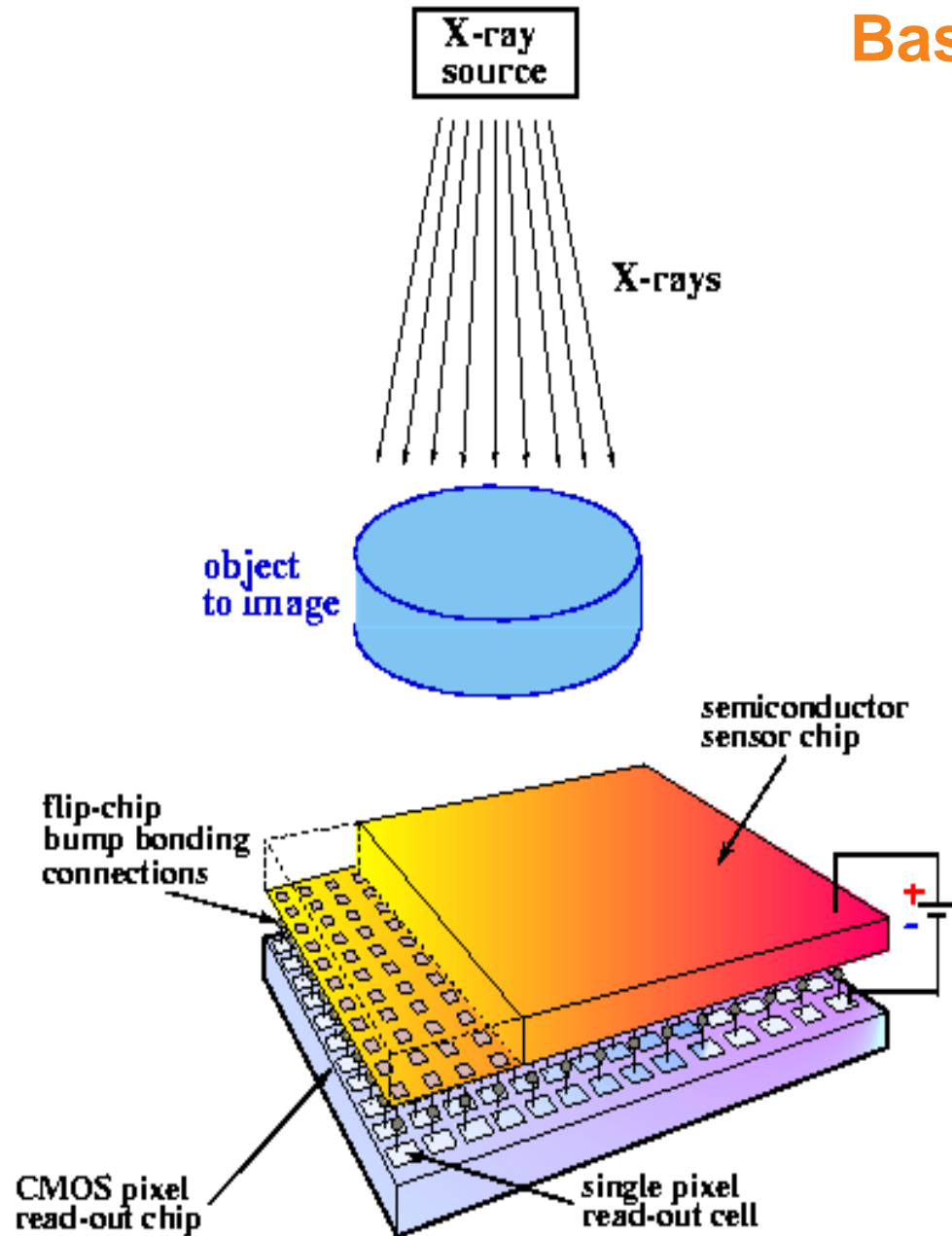
- Developed by Pixirad, an INFN spin-off
- High-quality sensor material
 - Large stopping power of Cd and Te
 - 100% absorption efficiency @ 25 keV
- High resolution
 - Pixel size 60 μm
- Large field of view
 - Active area 31 x 25 mm²



Galileo Galilei
(1564 – 1642)



Basic working principles

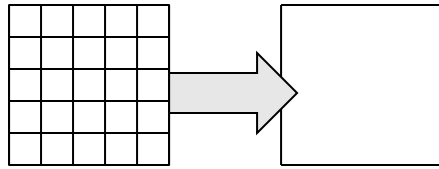


Key specifications

	PIXcel ^{3D}	PIXcel ^{3D} 2x2	GaliPIX ^{3D}
Detector size (pixels)	256 x 256 pixels	516 x 516 pixels	512 * 476 pixels
Detector size (mm)	14.1 mm * 14.1 mm	28.4 mm * 28.4 mm	30.1 mm * 24.2 mm
Pixel size	55 μm * 55 μm		60 μm * 51 μm
Point spread function	1 pixel		
99 % linearity range	0 - 6.5 x 10 ⁹ cps - Overall	0 - 5.2 x 10 ⁹ cps - Overall	0 - 3.9 x 10 ⁹ cps - Overall
	0 - 25 x 10 ⁶ cps - Column	0 - 1 x 10 ⁷ cps - Column	0 - 7.8 x 10 ⁶ cps - Column
Background noise (whole detector)	< 0.5 counts / s	< 2 counts / s	< 6 counts / s
Dynamic range	> 10 ⁹		
Energy discrimination	Two level discriminator (user adjustable)		
Calibration by user	None		
Exchange of detection medium	None (solid state technology)		

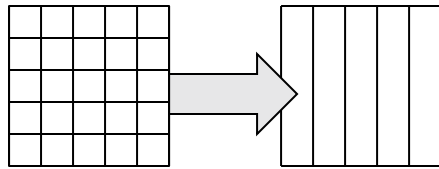
Hybrid pixel detectors: four modes of operation

0D



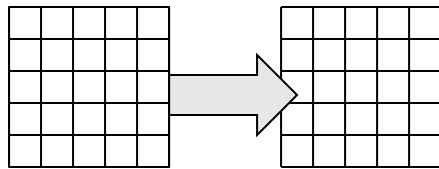
The signal from all pixels is added up to lead one value as a function of detector position

1D



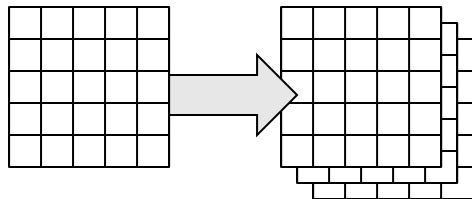
The signal from each column is added up, creating a static or scanning 1D detector

2D



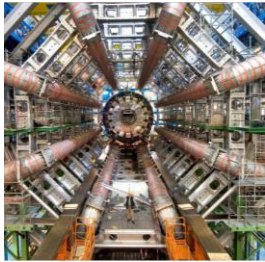
The signal from each pixel is stored individually, the detector is used static or scanning. In scanning mode, a 'strip file' is created which resembles a Debye-Scherrer film

3D



The signal from each pixel is stored individually, the sample is rotated in order to get multiple radiographs for 3D reconstruction

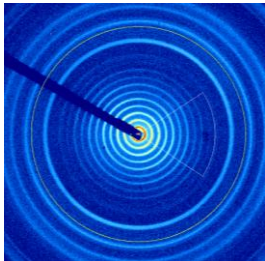
Agenda



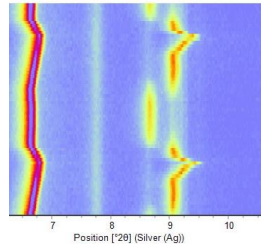
Solid state position-sensitive detectors @PANalytical



Dealing with polychromatic radiation



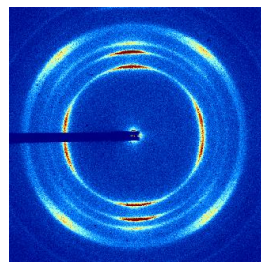
Spatial resolution ... in three dimensions



The challenges of non-Cu radiation

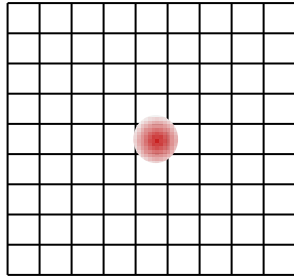


The importance of dynamic range

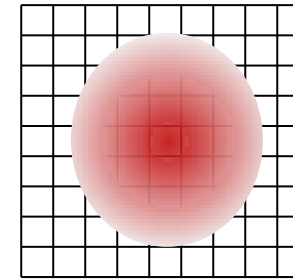


Conclusions

Point spread function (PSF)



Hybrid pixel technology



Other technology

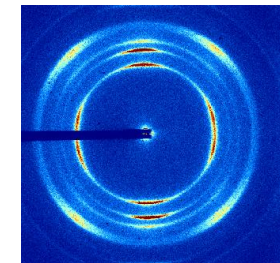
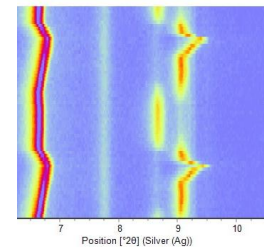
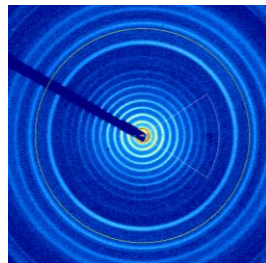
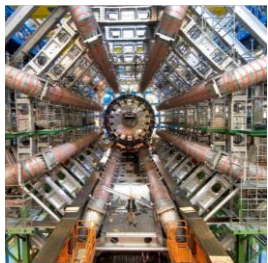
- The point spread function (PDF) describes the spread of one event (an incoming photon) over its neighbors
- With hybrid pixel technology, this effect is virtually absent: the PSF has a width of 1 pixel

Want to see the full presentation?

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I'll send you the full version
martijn.fransen@panalytical.com

Summary

- Hybrid pixel detectors are the state-of-the-art in X-ray detection
- Key detector parameters for the powder lab:
 - **Spatial resolution** in x, y and z, angular coverage
 - **Dynamic range** and low noise
 - **2-level energy discrimination** to deal with the tube-sample spectrum
 - Ability to deal also with **non-Cu radiation**





- The PANalytical award recognizes and praises groundbreaking research that required the use of a laboratory X-ray diffraction, X-ray fluorescence or X-ray scattering instrument as the primary analytical technique.
- As such, recipients will not be limited to any brand of instrument, but rather to research that utilised an X-ray source to reach their conclusions.

- The annual award consists of a € 5 000 cash prize, a trophy and a certificate.
- <http://www.panalytical.com/Events-overview/The-PANalytical-Award.htm>
- Submissions for the PANalytical Award will be accepted until and including 1 December 2016. The full application form is to be completed by the first author of the journal article. Questions may be directed to award@panalytical.com