Gotthard: a charge integrating silicon strip detector for XFEL and Synchrotron applications.

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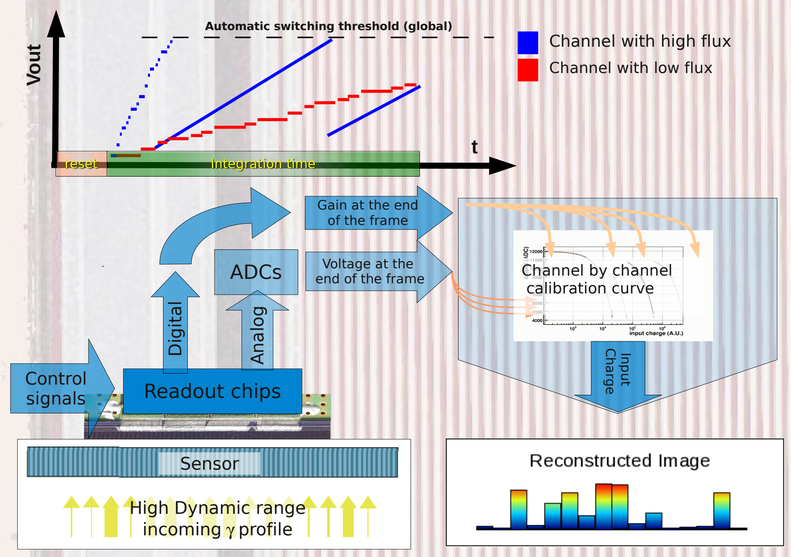
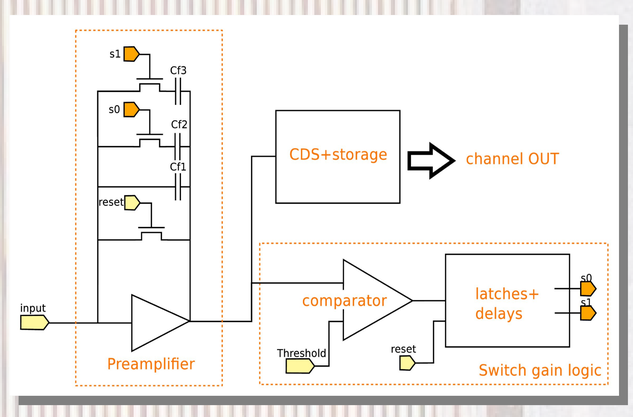
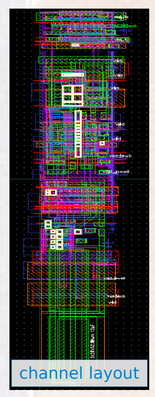


Automatic gain principle

Before the measurement the amplifier is in reset and the gain is set to high. When the reset is released the charge starts to be integrated on the feedback capacitor.
If the output of the amplifier reaches the threshold, a 2nd or 3rd capacitor is switched in, thus lowering the output. At the end of the measurement the analog an gain information are readout.
The switching works for an instantaneous charge release (e.g. XFEL pulse) as well.

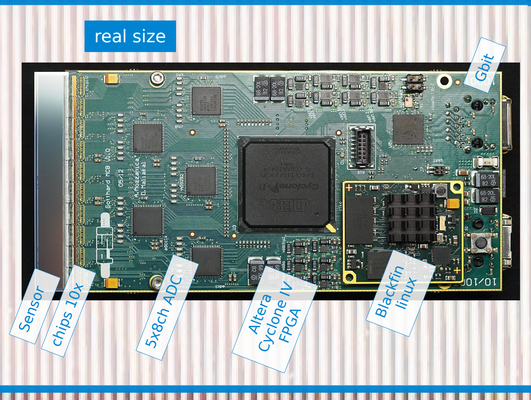
Channel Architecture





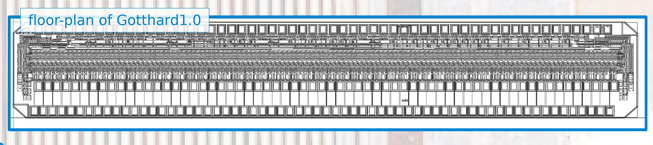
The detector module

The detector module consists of 10 readout ASICs for a total of 1280 channels at 50µm pitch. Each module is an independent unit with its own Gigabit link, for fast frame rates (60kHz continuous, 1MHz in bursts) and easy scalability.
Slow control is handled by a Blackfin embedded linux system.



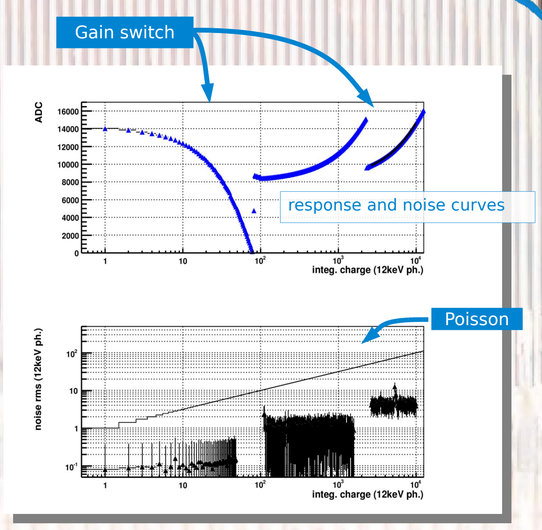
The readout ASIC

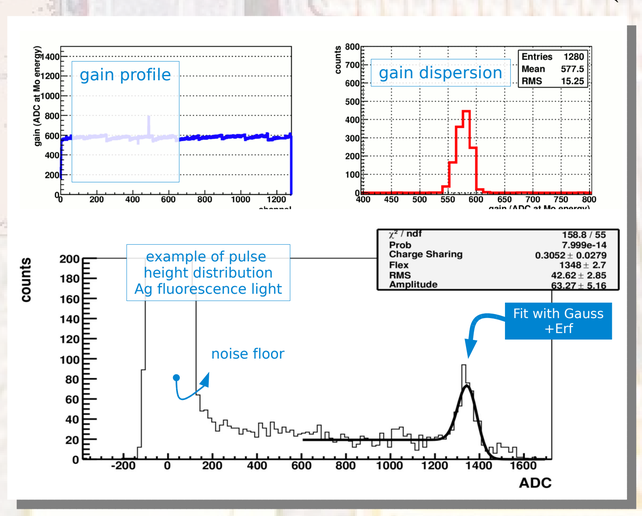
- IBM 130nm technology
- 6.3x1.4mm² - 128 channels - 50µm pitch
- 3 automatic gain stages + 1 High Gain mode
- Dead time free operation possible
- fast readout chain (off channel-off chip drivers), to sustain 32MHz readout with no cross-talk
- 4 differential analog outputs
- rad-hard design
- ~ 1mW/ch total consumption

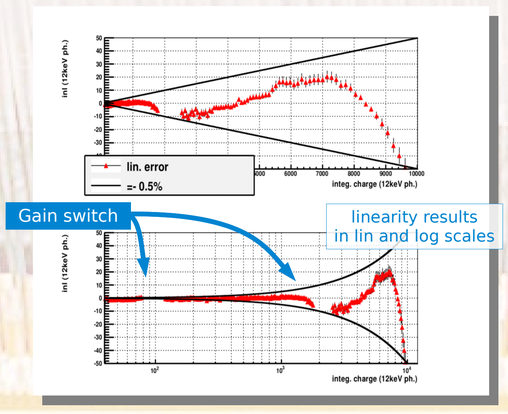


Test results

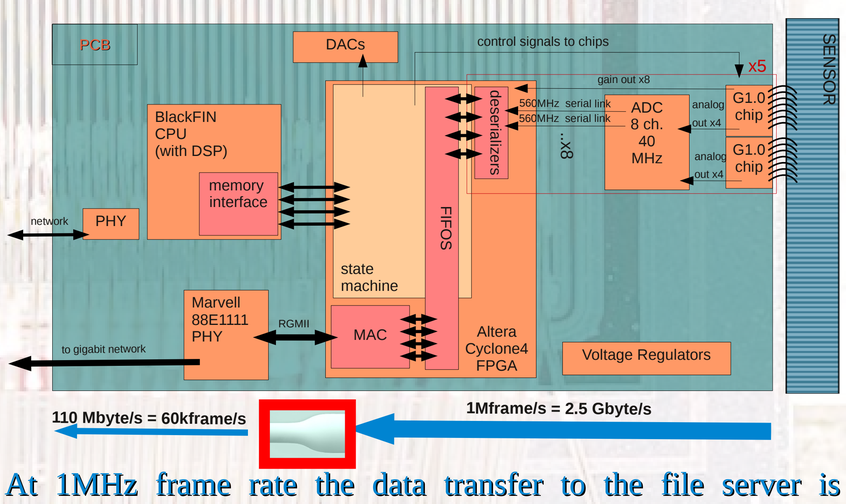
GOTTHARD systems have been tested with X-Ray fluorescence light and at Synchrotron sources.
- Noise ~200 e.n.c. (r.m.s.) for High Gain mode
- Noise ~300 e.n.c. for the 1st gain of gain switching mode
- Noise at low gains ~10 times smaller than Poisson fluctuations
- Saturation at 10^4 photons
- Gain variation better than 1.5%
- Linearity within 0.5%





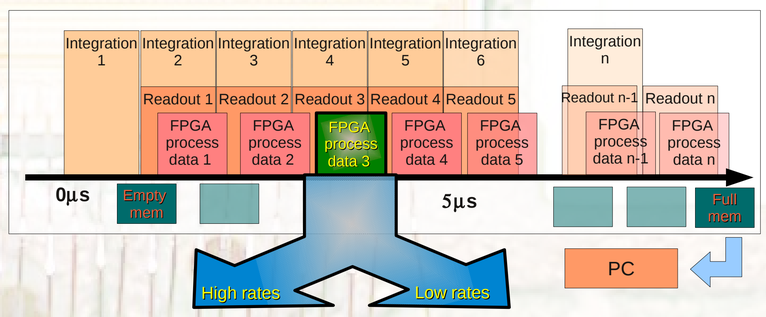


Board architecture and data flow



At 1MHz frame rate the data transfer to the file server is not possible. Depending on the application, two solutions are available.
- EU-XFEL or fast pump probe experiment: burst mode with local storage, ~350 frames on the FPGA
- Synchrotron: FPGA data processing

Operation modes for Synchrotron applications

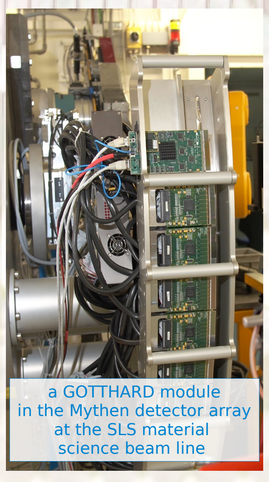


Loop on channels, for each one:
- Subtract dark frame
- Divide ACD out by single photon peak =>number of photons in the integration time
- Add this number of photons to the channel counter
- Position interpolation
- Window discrimination
- Per channel energy binning
- Zero suppression

GOTTHARD specifications

ASIC technology	IBM 130nm
module size	6.7x12.5cm²
sensitive area	64x8mm²
sensor thickness	320-500 µm
pitch	50 µm
noise r.m.s.	~200 e.n.c.
dynamic range	10^4 12keV photons
min Energy	<3.5 keV
linearity	better than 0.5%
point spread function	O(pitch)
min int. time	80ns
dead time	<50ns
cooling	air
readout time = 1 / frame rate	60kHz continuos 1MHz burst

Applications


a GOTTHARD module in the Mythen detector array at the SLS material science beam line

XFELs:
- powder diffraction
- XES/XAS (with energy dispersive optics)
- diagnostics

Synchrotrons:
- diffraction experiments very high photon rates
- pump and probe experiments in 10kHz-1MHz rep. rate range
- profile monitors, diagnostics

International Workshop on Semiconductor Pixel Detectors for Particles and Imaging, Inawashiro, Japan 2–7 September 2012