Adaptive gain charge integrating detectors for SwissFEL

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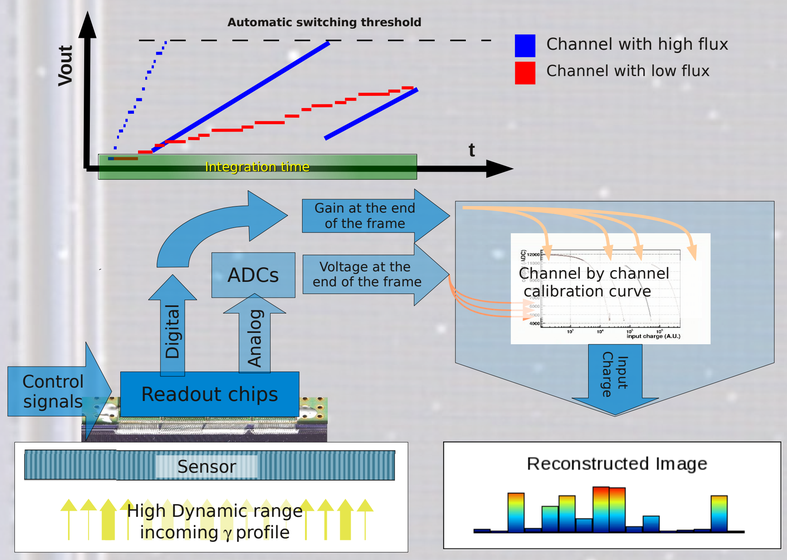
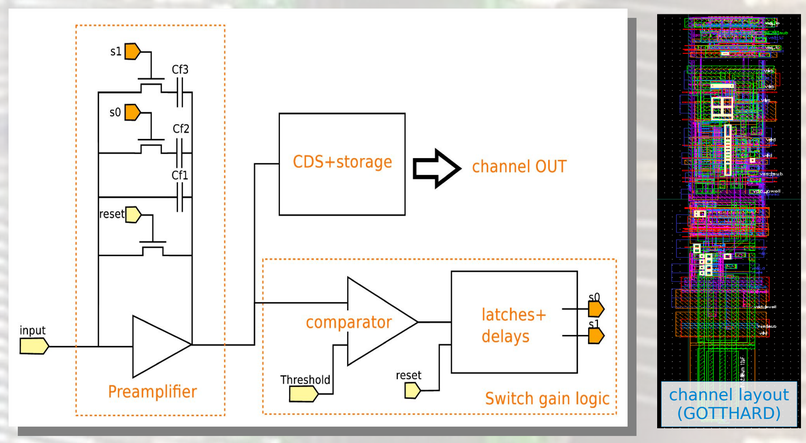
SwissFEL

Automatic gain principle



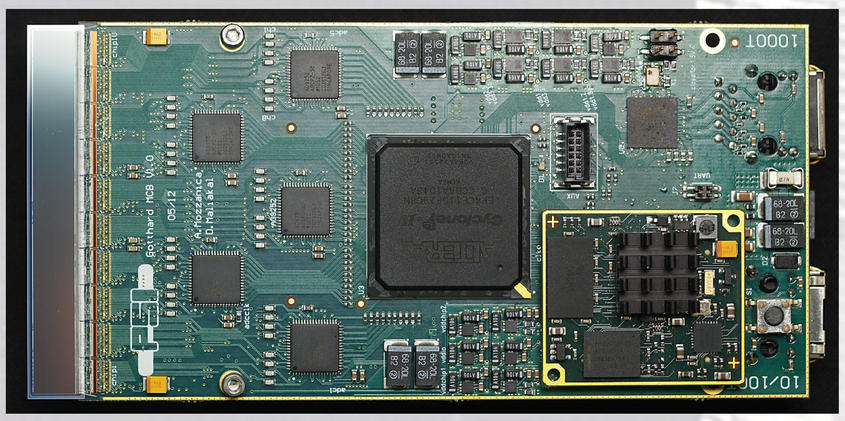
Before the measurement the amplifier is in reset and the gain is set to high. When the reset is released the charge starts to be integrated on the feedback capacitor. If the output of the amplifier reaches the threshold, a 2nd or 3rd capacitor is switched in, thus lowering the output. At the end of the measurement the analog an gain information are readout.

Channel Architecture



The GOTTHARD 1D detector

The first strip detector modules with 1280 channels at 50µm pitch have been produced and are now in the commissioning phase. Each module is an independent unit with its own Gigabit link, for fast frame rates (100kHz continuous, 1MHz in bursts) and high scalability. The readout chip has 3 gains in automatic mode plus a fix high gain mode.



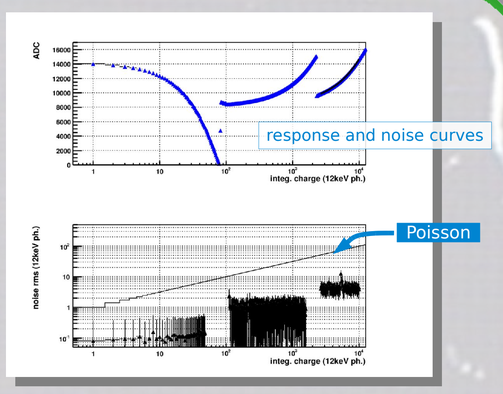
GOTTHARD specifications

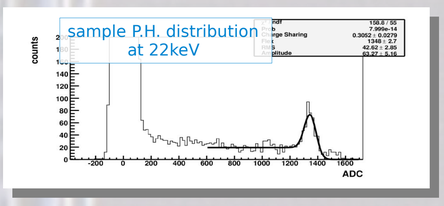
ASIC technology	IBM 130nm
module size	6.7x12.5cm^2
sensitive area	64x10mm^2
sensor thickness	320-500 µm
pitch	50 µm
noise r.m.s.	160 e.n.c.
dynamic range	10^4 12keV photons
min Energy	<3.5 keV
linearity	better than 0.5%
point spread function	O(pitch)
min int. time	80ns
dead time	<50ns
cooling	air
readout time = 1 / frame rate	100kHz continuos 1MHz burst

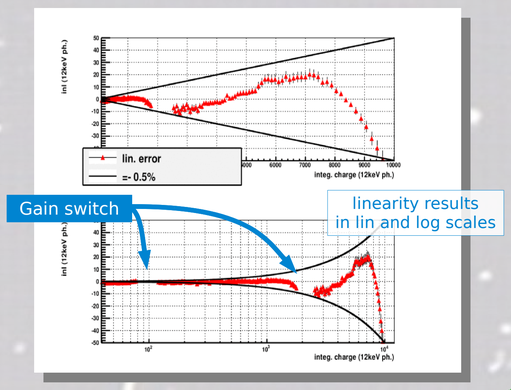
GOTTHARD test results

Single chip GOTTHARD systems have been tested with X-Ray flourescence light.

- Noise ~160 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
- Gain variation better than 1.5%
- Linearity within 0.5%



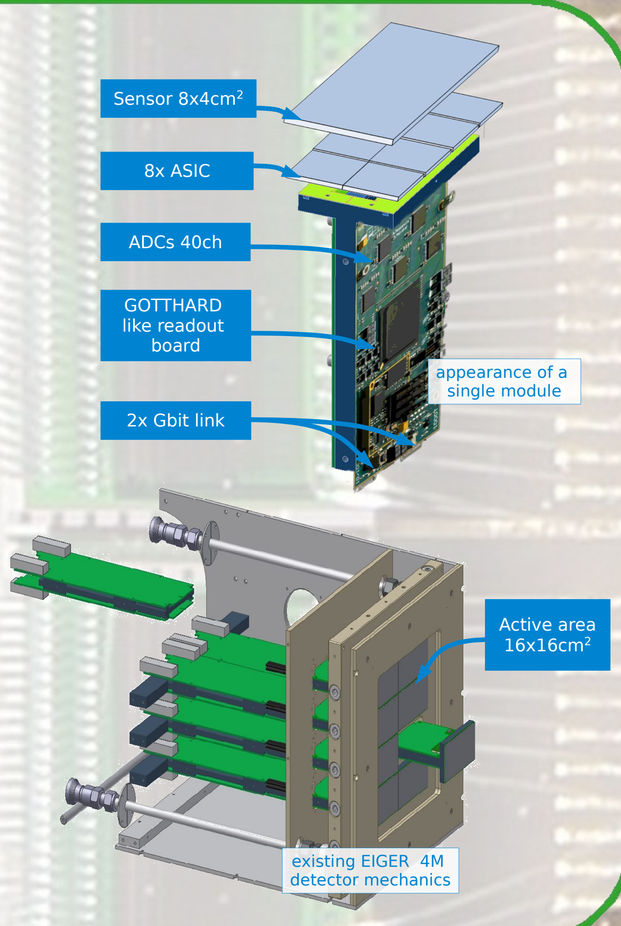




2D detector design

- Pixel size 75x75µm^2
- ASIC design based on GOTTHARD
- ASIC and module dimension based on EIGER:
  - chip size 1.9x1.9cm^2
  - 65kpixel per chip
  - 8 chip per module
  - 0.5 Mpixel per module
- Readout board based on GOTTHARD, with 2 Gigabit links per module.
- Mechanics and cooling based on EIGER

A 4Mpixel detector will be available at first.
Bigger system (9M and 16M) can be requested.



2D detector module specifications

The 75µm pixel detector is expected to have marginally better noise and reduced dynamic range with respect to GOTTHARD.
The system will be noise free (i.e. photon counting detector data quality) for photon energies greater than 3-4 keV.
The detector is expected to be available in 2014.

ASIC technology	UMC110nm
mudule pixel count	525k
mudule size	80x40 mm^2
sensor thickness	320-500 µm
pixel size	75x75 mm^2
dynamic range	up to 10^4 12keV photons
noise r.m.s.	<150 e.n.c.
min Energy	<3 keV
linearity	better than 1%
point spread function	1 pixel
dead time	<50ns
cooling	liquid
readout time = 1 / frame rate	400Hz

Options for future 2D detectors

50µm pitch pixel detector:

2 gain stages
automatic gain switching
dynamic range ~2000 12keV photons
active area similar to the 75µm one

25µm pitch pixel detector:

1 gain stage
dynamic range ~200 12keV photons
smaller active area but with similar pixel counts

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