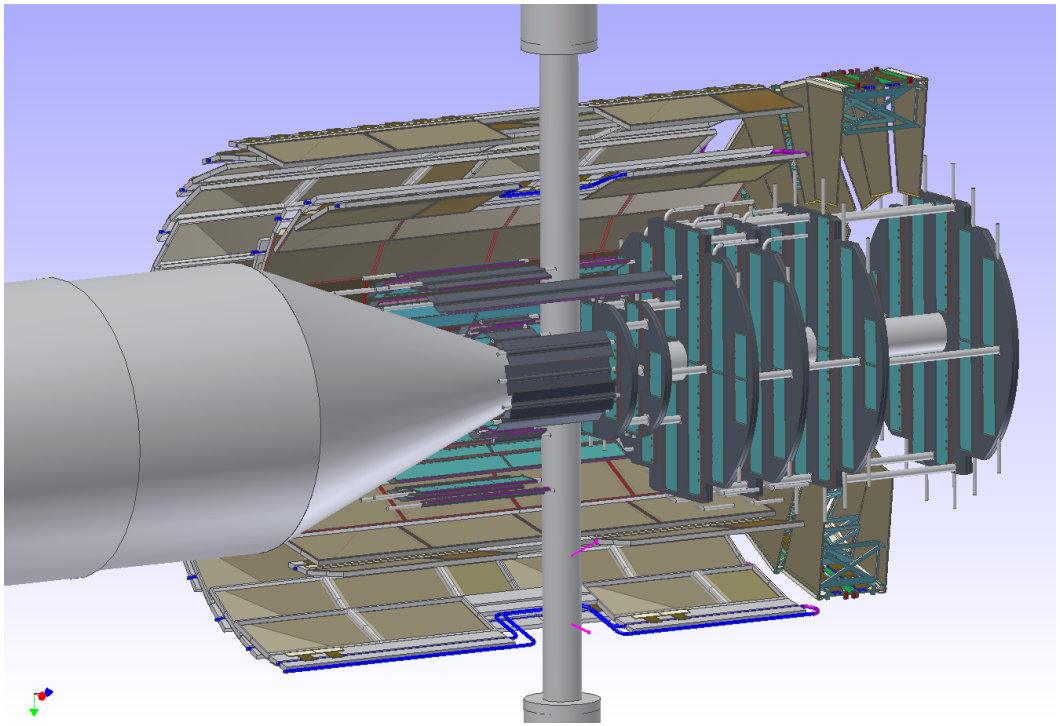
Pixel ibridi epitassiali e readout triggerless in tecnologia CMOS 130nm per il microvertice di Panda.



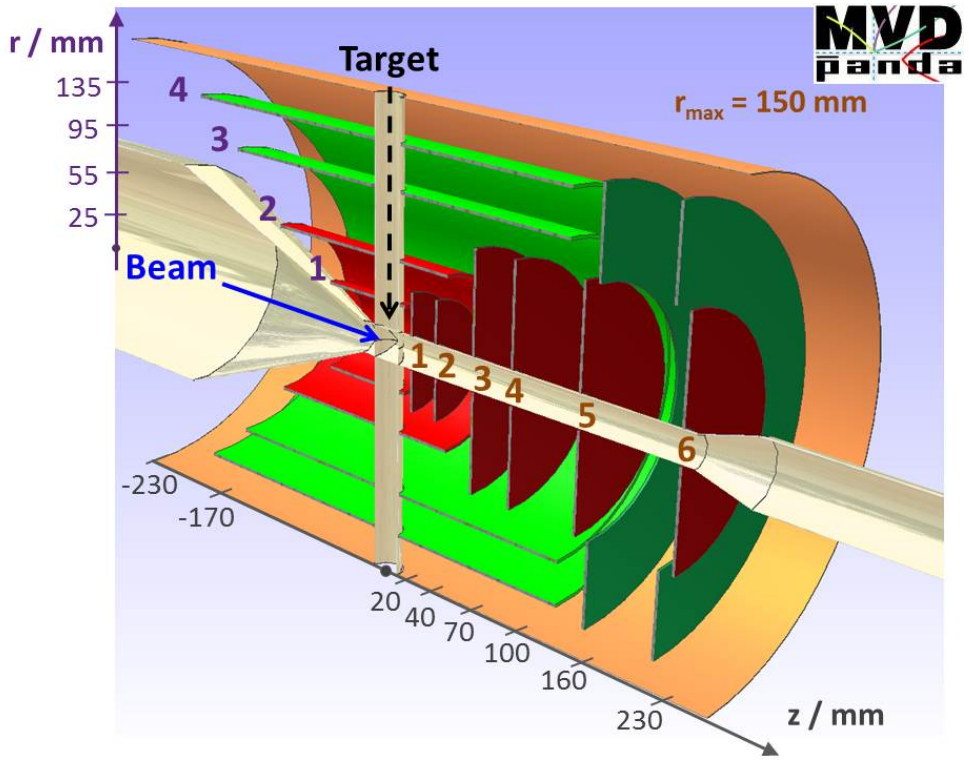
De Remigis (INFN Torino)

on behalf of the MVD group

IFAE, Perugia

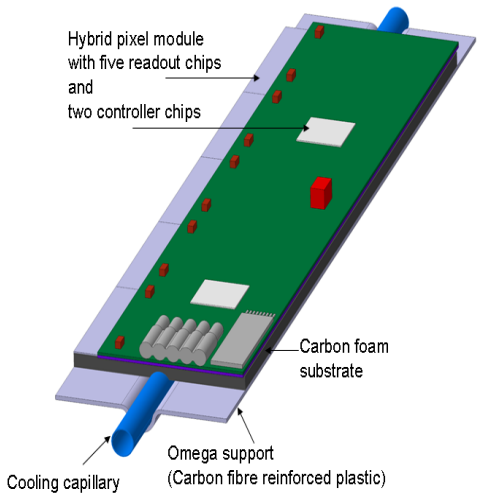
Universita', 2011

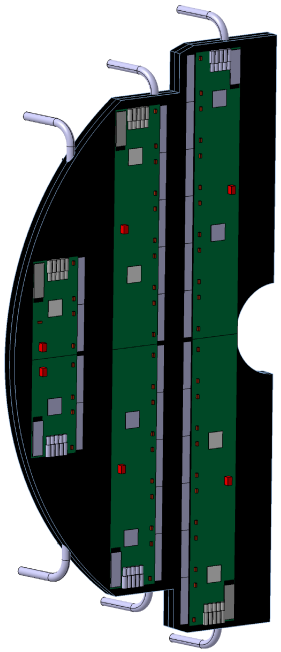
The Micro Vertex Detector (MVD).

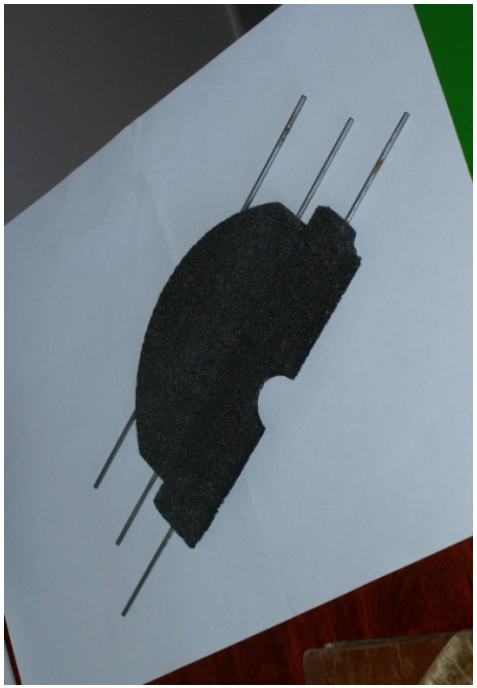


The MVD consist of 4 barrels in the central part (two layers of hybrid pixels, then two layers of silicon strips) and 6 disks along the forward direction (4 layers of pixels, then two layers mixed). Summarizing there are roughly 11M pixel cells and more than 200K strip readout channels.

The concept for the hybrid pixel module.

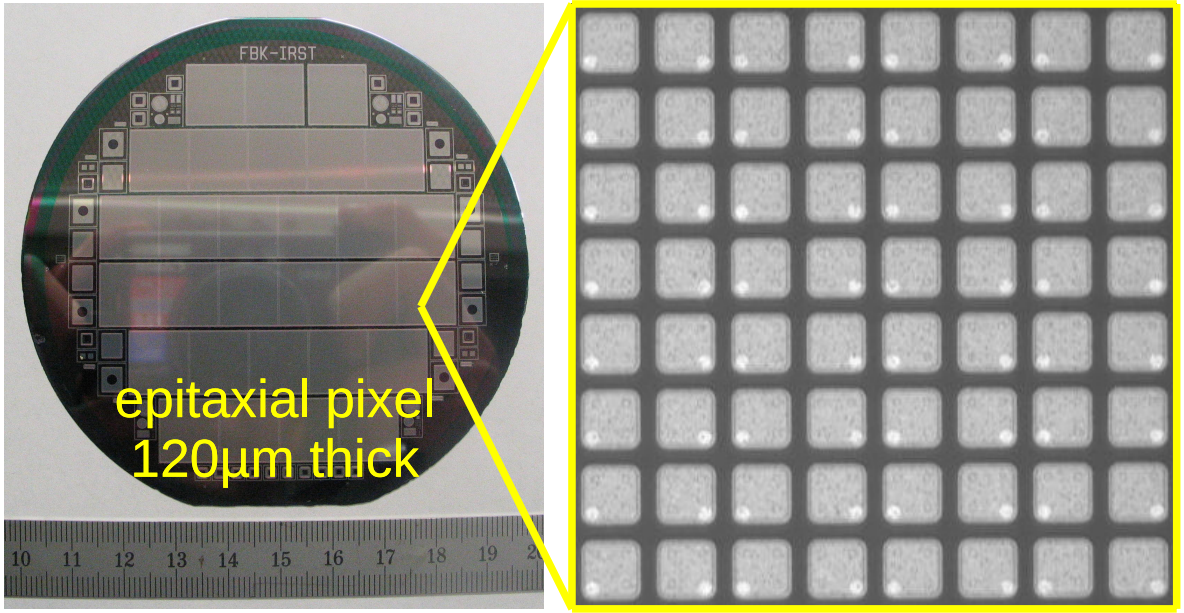


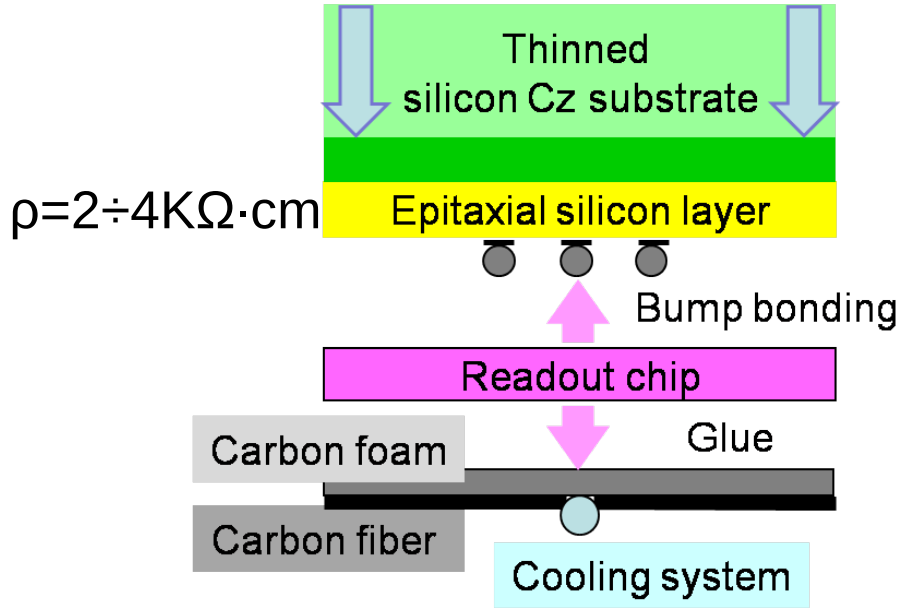




The epitaxial sensor is bump bonded over the readout chips, and the multilayer bus is added on the top. Then this structure is glued on a carbon foam to improve the thermal conductivity, while on the bottom there is the cooling pipe for the heat extraction.

The hybrid pixel sensor.





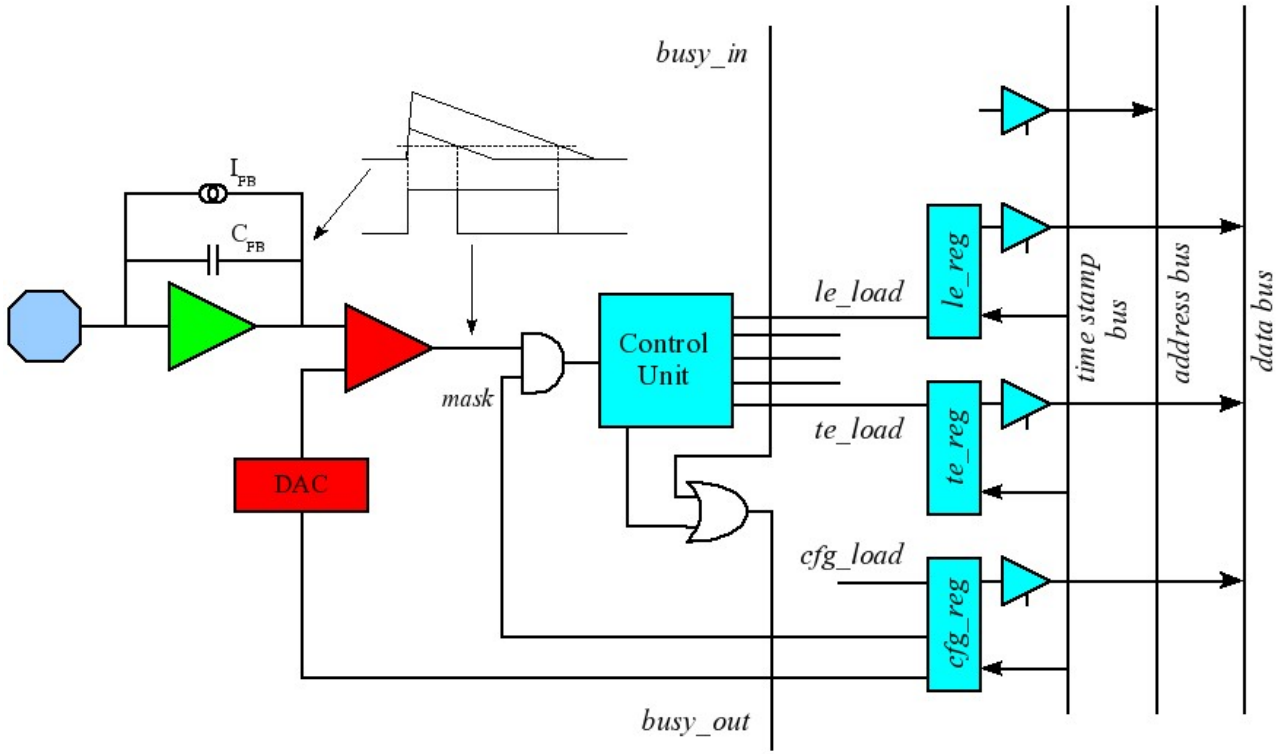
Each pixel is 100·100µm^2 large, and is implemented on an epitaxial layer deposited on a Czochralski substrate; it is connected to the readout chip by a bump bonding process. Some tests have been performed for the radiation damage, with the thickness in the range from 150 down to 100µm.

Specifications for the Topix readout chip.

pixel size	$100 \cdot 100 \mu m^2$
active area	$11.4 \cdot 11.6 mm^2$ (110·116 cells)
dE/dx measurement	TOT (12b range)
input charge	1÷50fC
noise floor	.032fC ($200e^-$)
system clock	155.5MHz
time resolution	6.41ns (1.85ns rms)
power consumption	$<500 mW/cm^2$
particle flux	$6.1 \cdot 10^6$ particles/$(s \cdot cm^2)$
total dose	100KGy

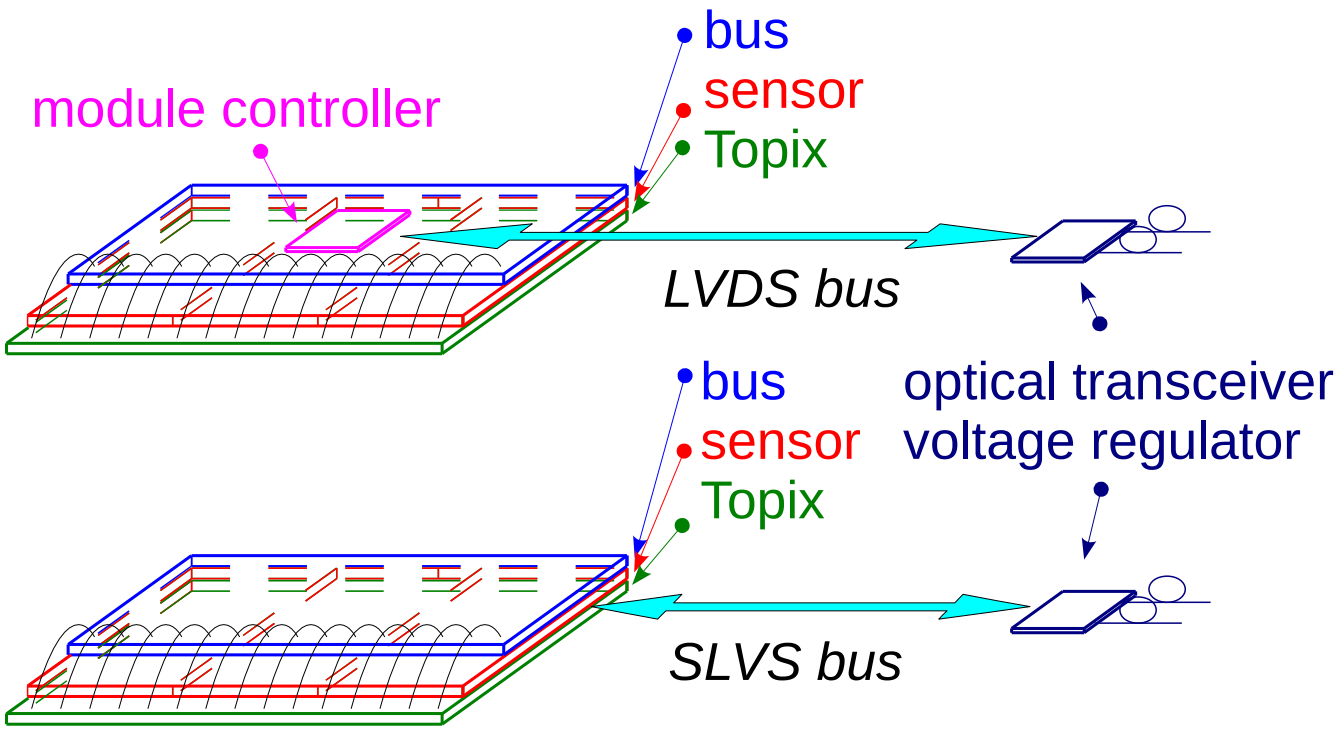
Since the system is triggerless, considering the constraints and a 50b word per hit due to the 8b/10b encoding, then a 400Mb/s data rate per chip is expected in the hottest region.

The Topix cell structure.



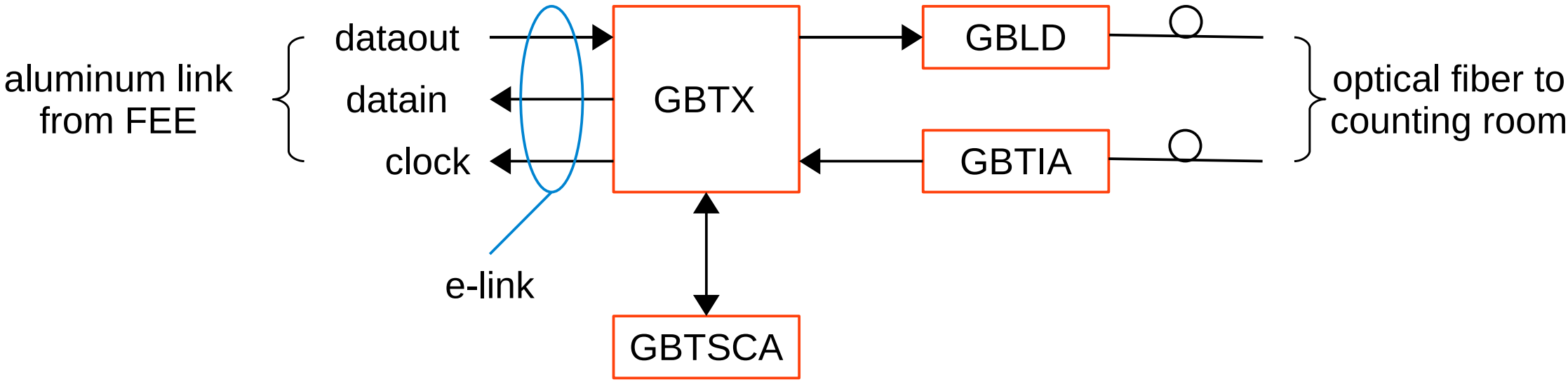
For each pixel cell there is a charge amplifier producing an output with a triangular shape, that is discriminated by a comparator indicating the leading and trailing time. This information is stored in the respective registers, latching the timestamps distributed to the chip.

Module alternatives.



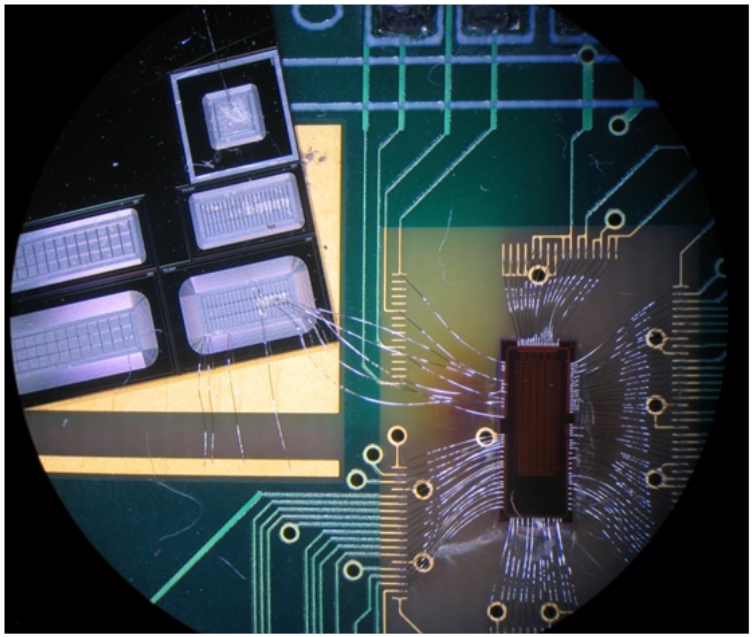
The design is progressing towards the last option because it does not require an extra chip, even though it could ask more electrical links. At present, the baseline solution for the serial ports needed for Topix comes from a CERN development.

The GBT interface towards the FEE.

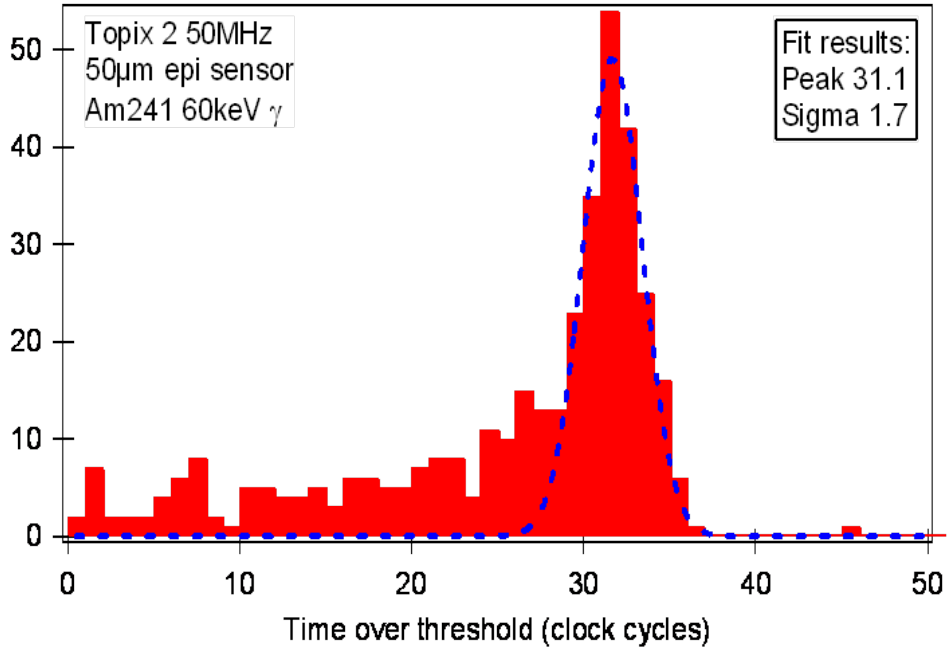


The GBT is the radiation hard chipset designed at CERN to provide an optical link for the next generation experiments and it consists of: a data transceiver (GBTX), a laser driver (GBLD), a transimpedance receiver (GBTIA) and a slow control (GBTSCA).

Topix test.



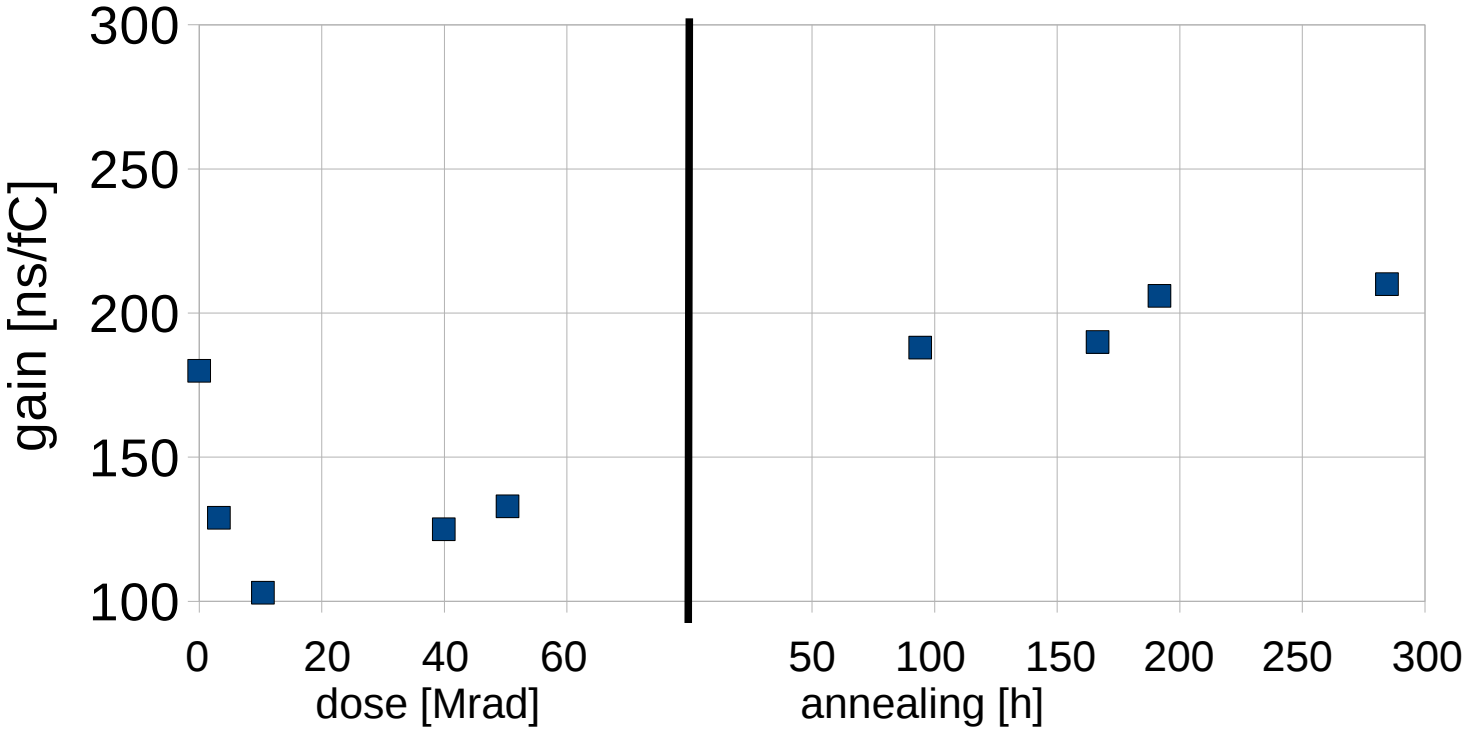
ToPix + epitaxial sensor



TOT calibration

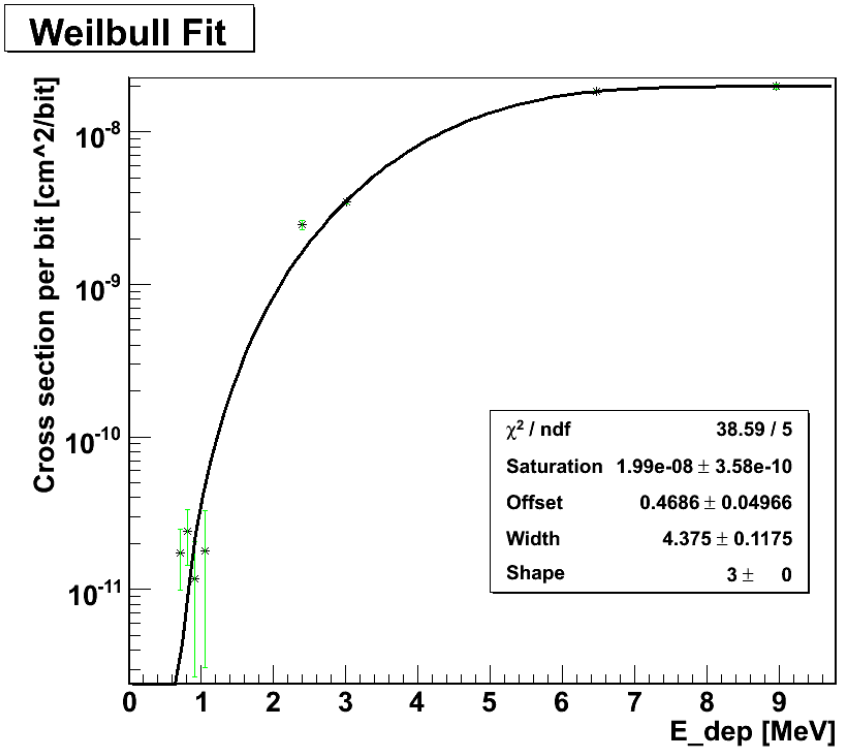
The Topix prototype test has been performed with good results: the TOT gain is around 160ns/fC, there is a good linearity over the input range, the threshold dispersion has to improve but it can be compensated by the DAC present in each cell.

Test for Total Ionizing Dose.



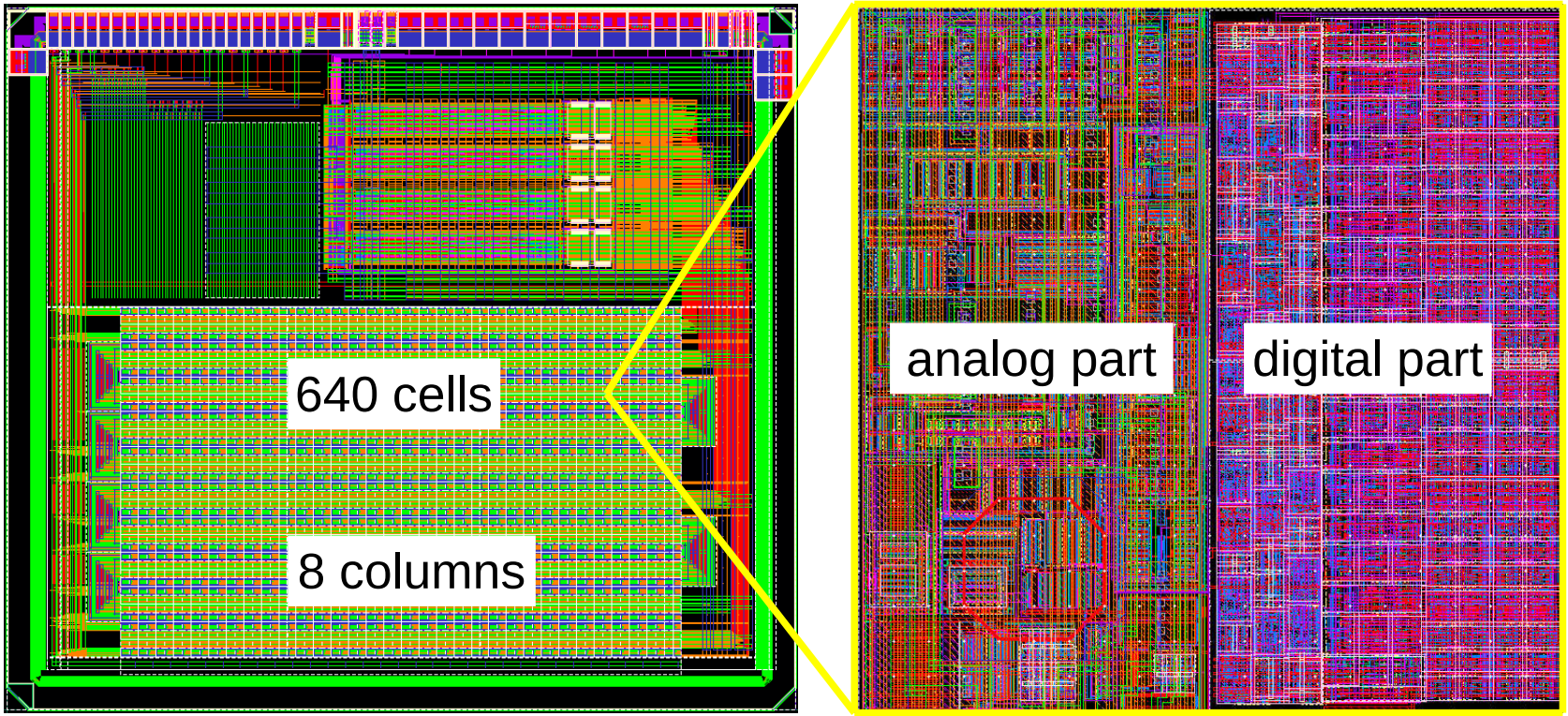
From the test for TID a variation of roughly 40% in the TOT gain has been pointed out; for this reason the circuit inducing this behaviour has been redesigned to improve the radiation tolerance. The changes, for all the other parameters, are below the 10%.

Test for Single Event Upset.



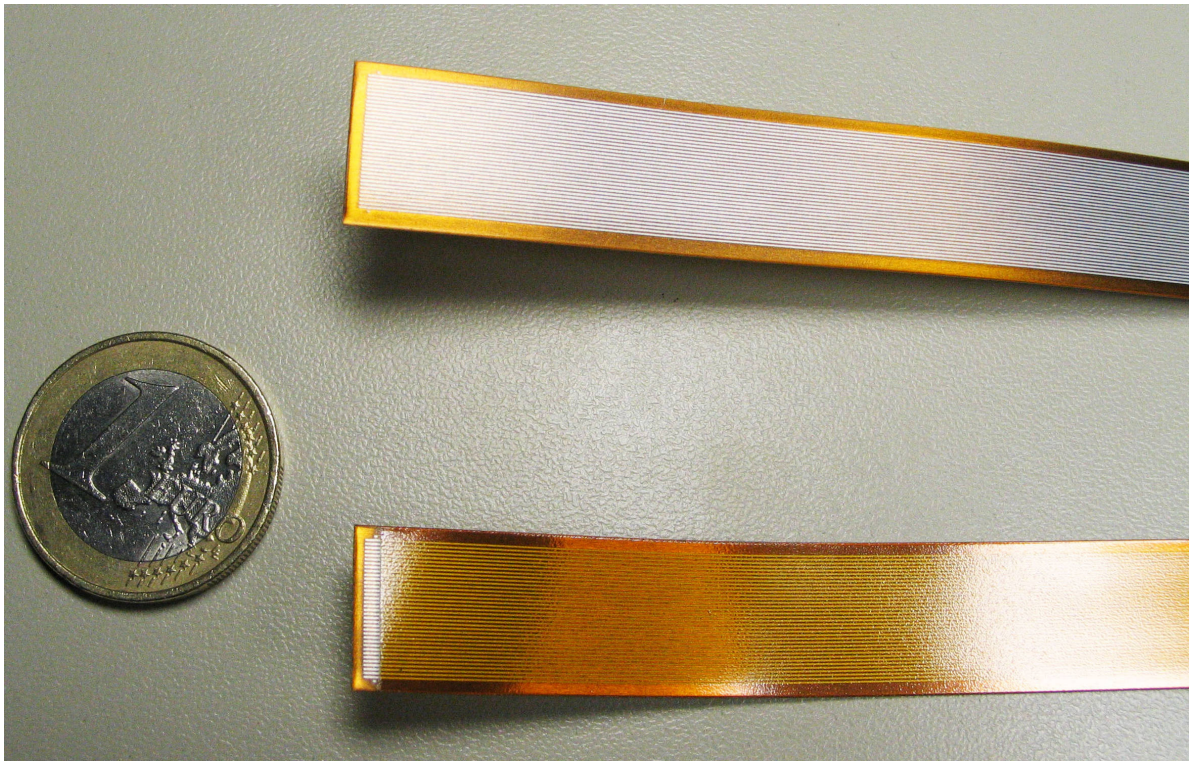
The test has been performed at Laboratori Nazionali di Legnaro (INFN) with several heavy ions to evaluate the cross section and energy threshold. Taking into account the Panda environment this result leads to an expected value of 2.3SEU/(chip·h): that asks for a better radiation hardness.

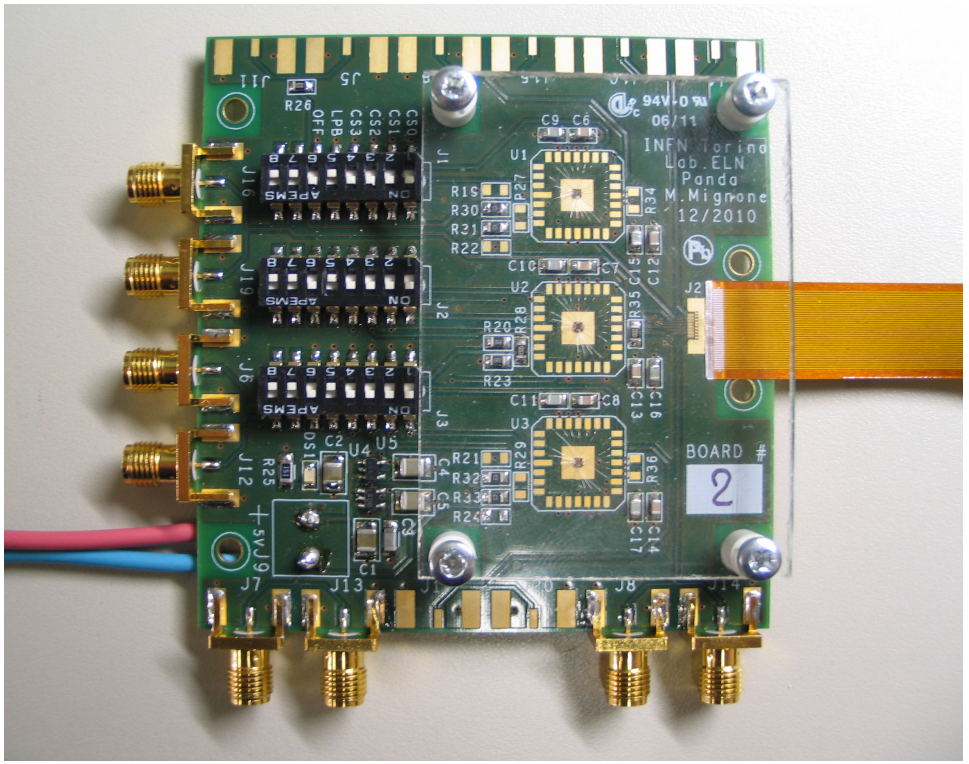
New Topix prototype.



The new prototype takes up an area of $4.5 \cdot 4mm^2$ and it features: 640 cells arranged on 8 columns, registers implemented with triple redundancy, a serial output to match with the GBT chipset and pads for bump bonding to test a complete hybrid.

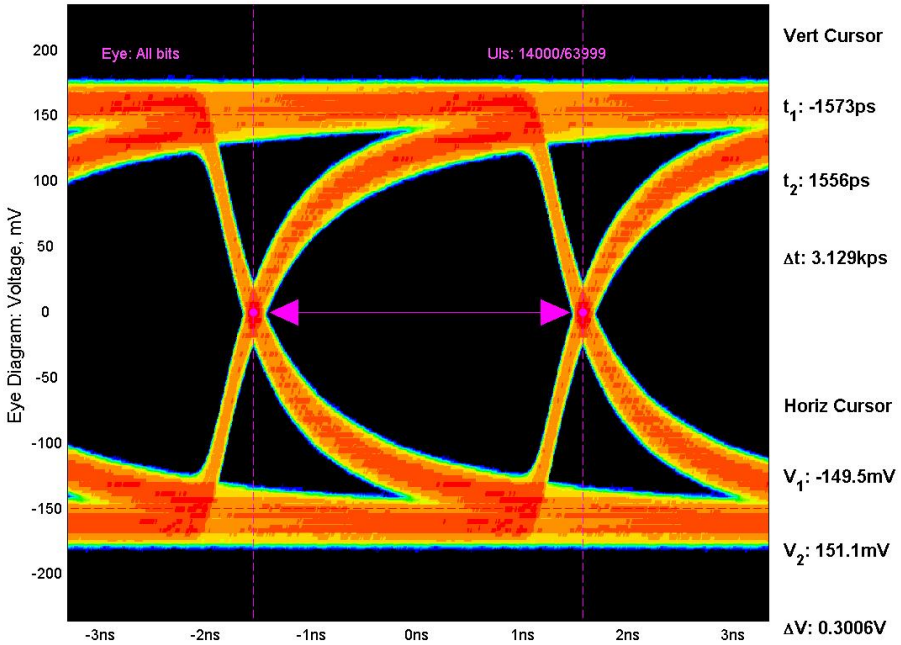
Tests on the aluminium cable.

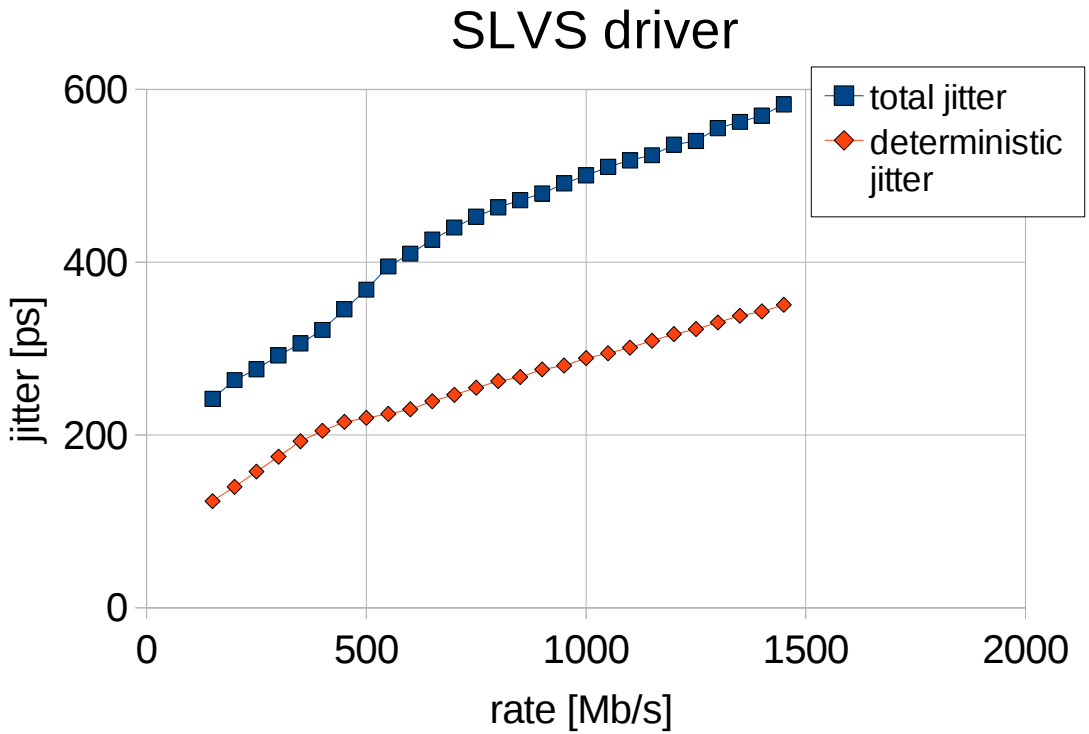




Some tests are in progress for the evaluation of the microstrip cables, made by a laminated sheet of aluminium over polyimide. The current prototypes present 36 tracks, that have a width of 100 and 150μm, for a differential impedance of 100Ω and a total length of 1m.

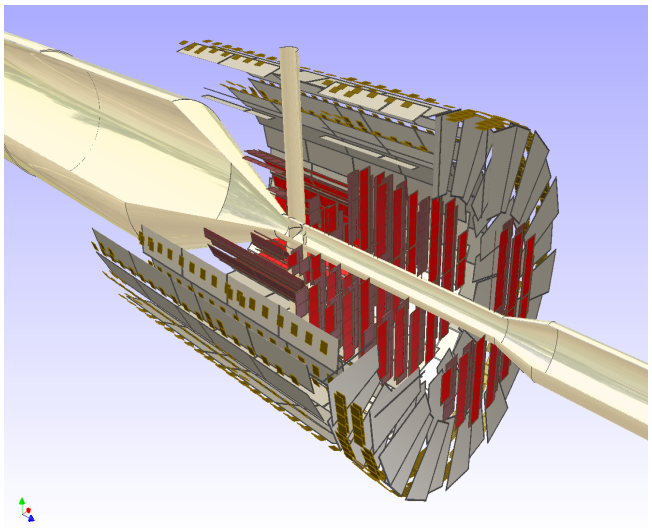
Total jitter for aluminium cable.





At present, the measurement on the static parameters, and the test of the behaviour with the actual SLVS transceivers are underway. Due to the stray capacitance on the overall length, the aluminium microstrips work well, with an acceptable jitter, up to a data rate greater than 700Mb/s.

Short summary.



- The sensor has been thinned successfully, and tested for radiation damage.
- The Topix test led to satisfying results, with some advices for the radiation hardness.
- A new prototype is going to be delivered, with a serial data output.
- It features the bump bonding pads, to match with the thinned pixel sensor.
- The tests on the aluminium microstrips are ongoing, to find the best tradeoff between layout and performances.