UFSD update

Test beam results

Sensor design

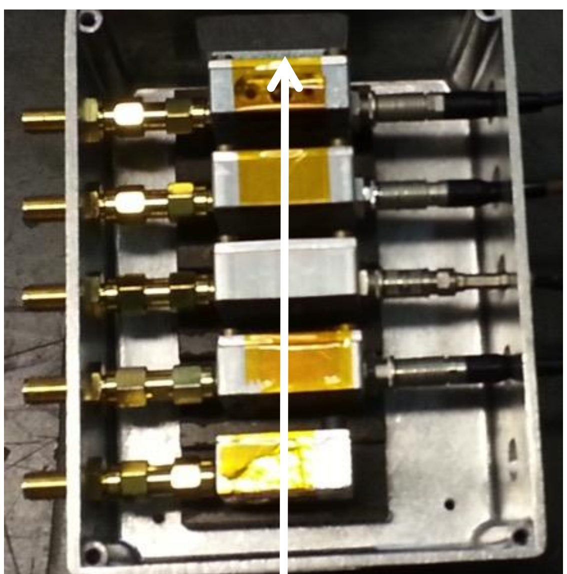
Board design

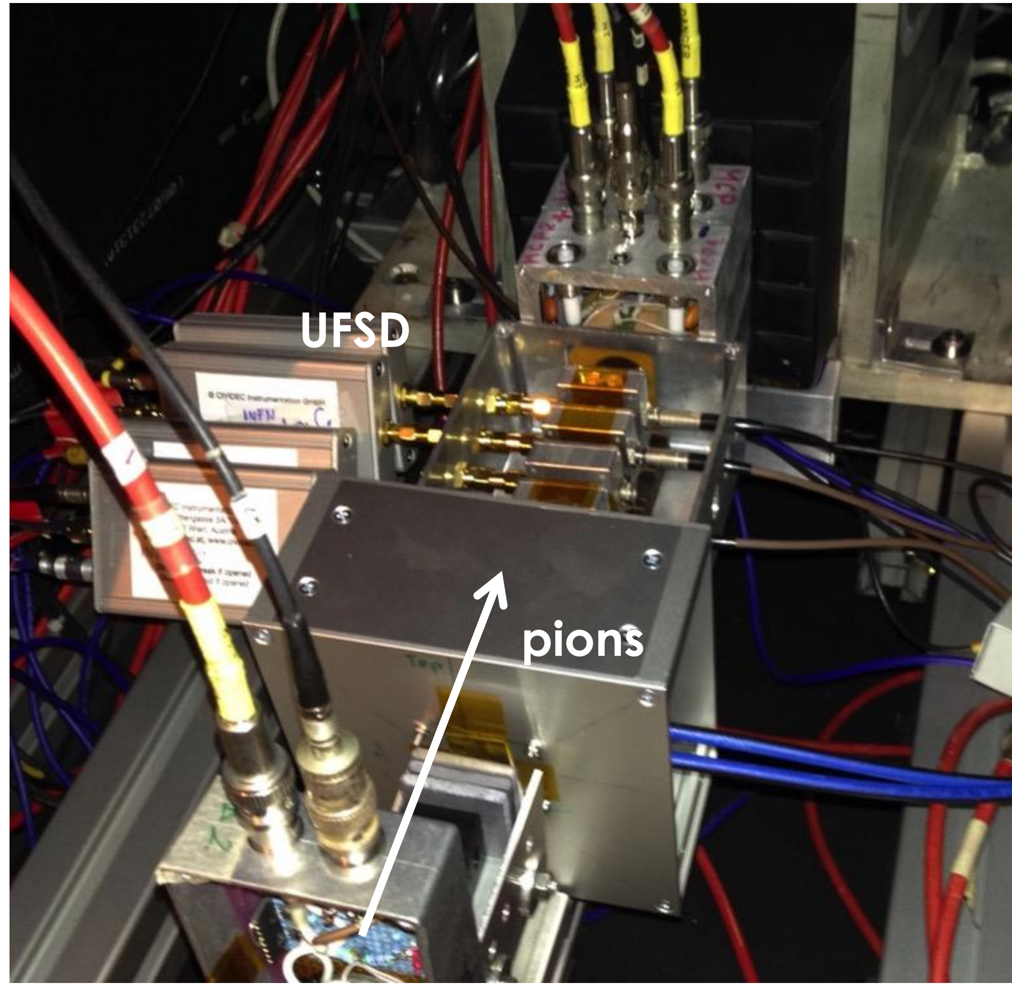
Timeline

INFN and Università di Torino, Università Piemonte Orientale

Testbeam Set-up

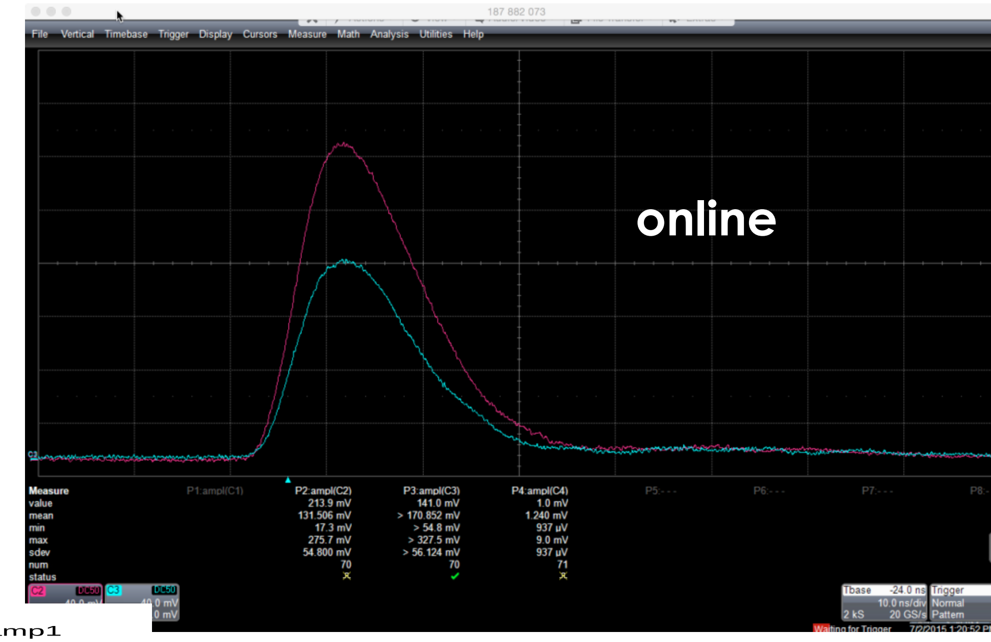
Testbeam part of the July CMS HGC

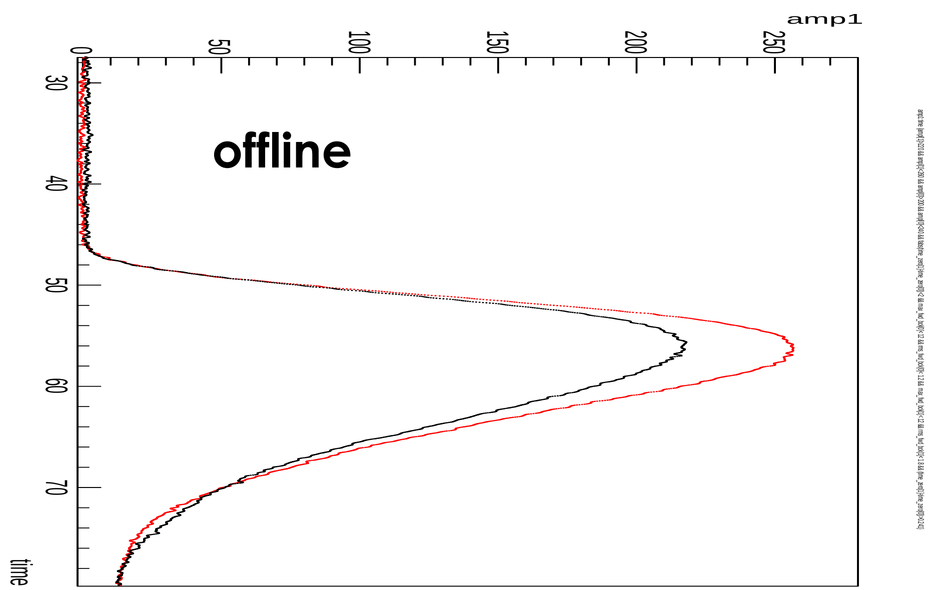


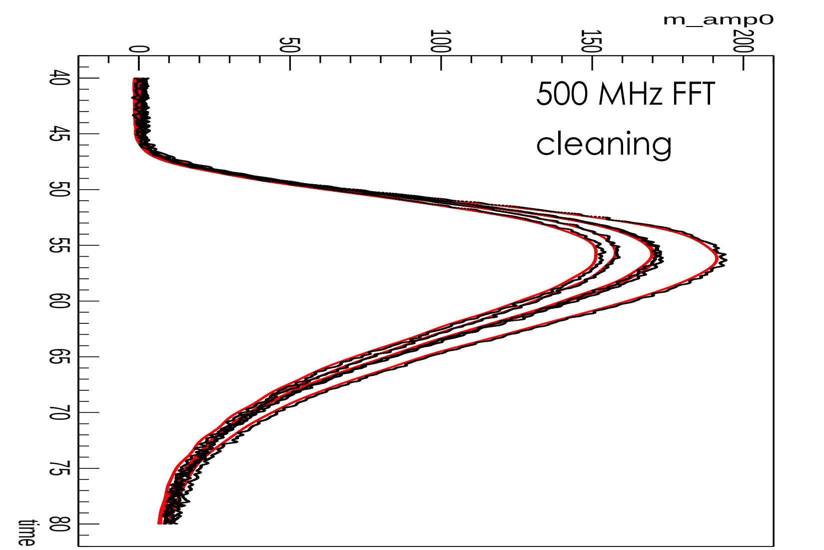


Testbeam: signal and noise

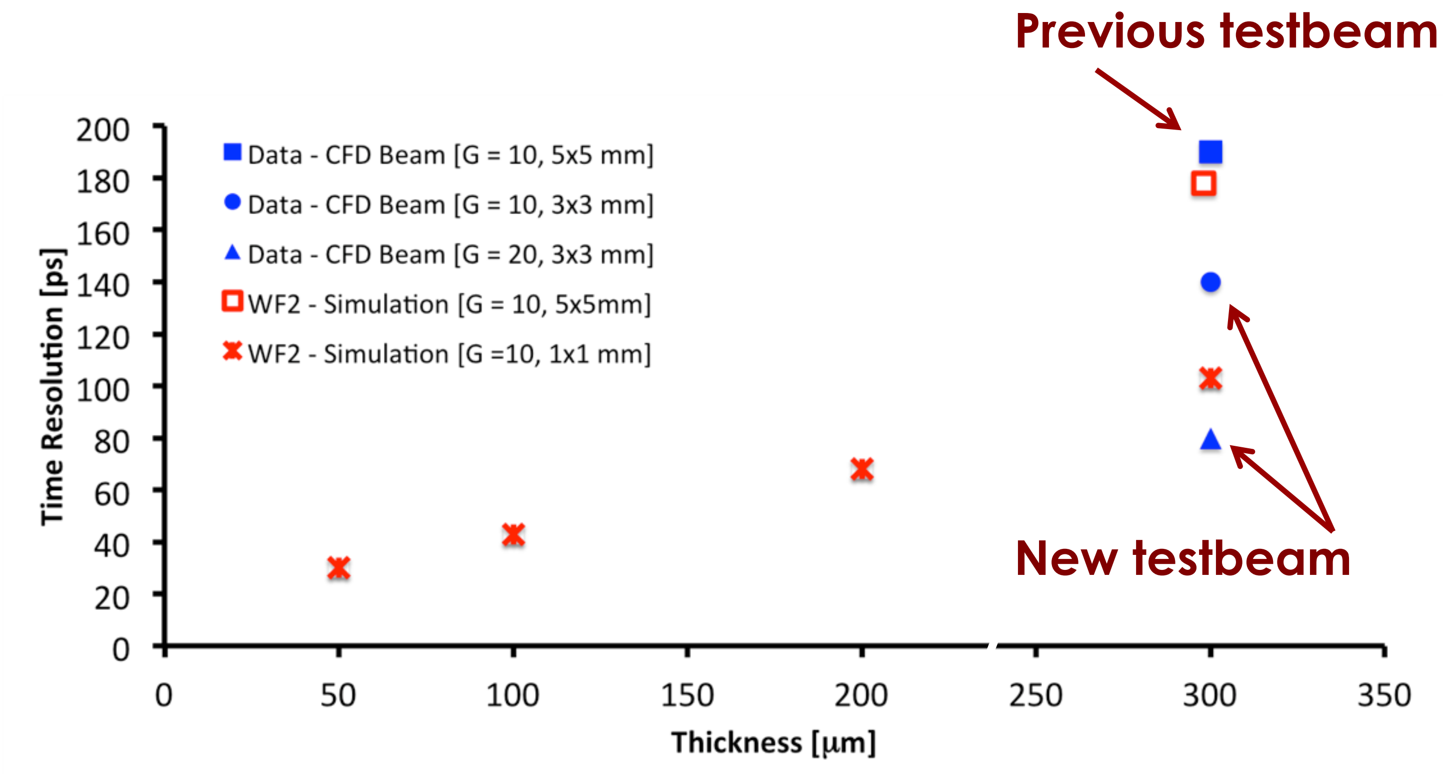
- Testbeam, very clean shape:
- 120 GeV muons
- Two UFSD, gain 10 and gain 20.
- Read-out with a CSA amplifier with a 4 ns integration time.
- Noise ~ 1 mV,
- Signal ~ 150-200 mV
- Rise time 20-80% ~ 5 ns







Testbeam Results



300 micron thick, ~ 4 pF sensor

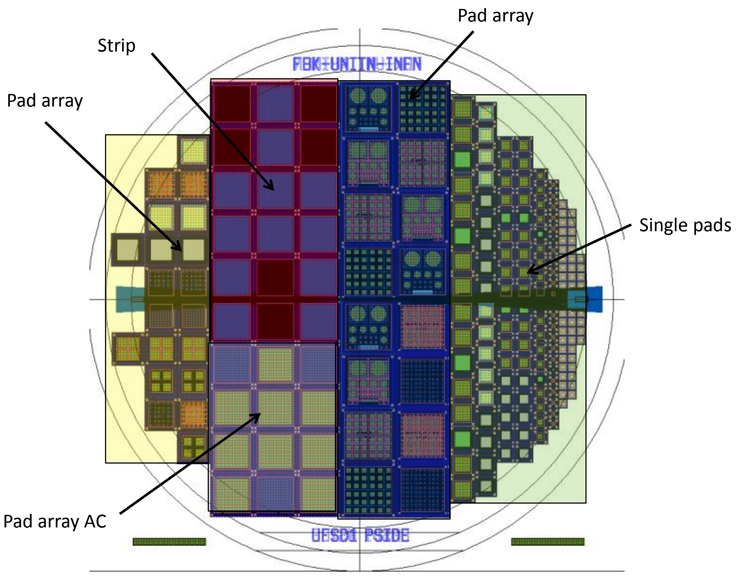
Gain 10 ➔ resolution ~ 145 ps

Gain 20 ➔ resolution ~ 85 ps

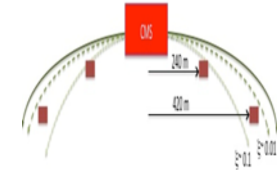
New productions: winter 2015

FBK: 300 micron, UFSD new production.

Gain foreseen ~ 10-20



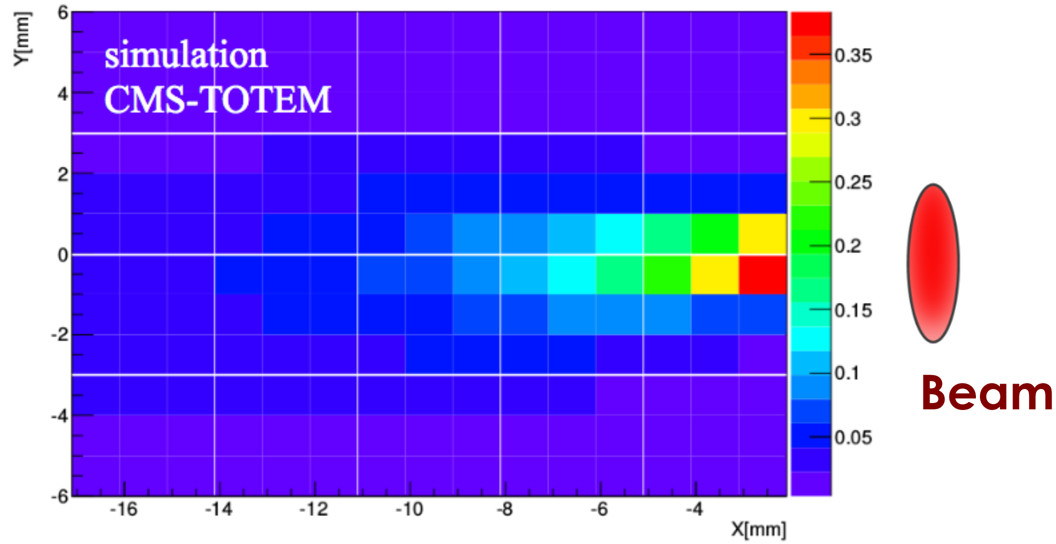
CNM: 50 and 100 micron thick silicon, with final PPS geometry ➔ next pages



Possible Coverage

Detector occupancy per mm^2 at pile-up = 50

Use as reference the Quartic coverage

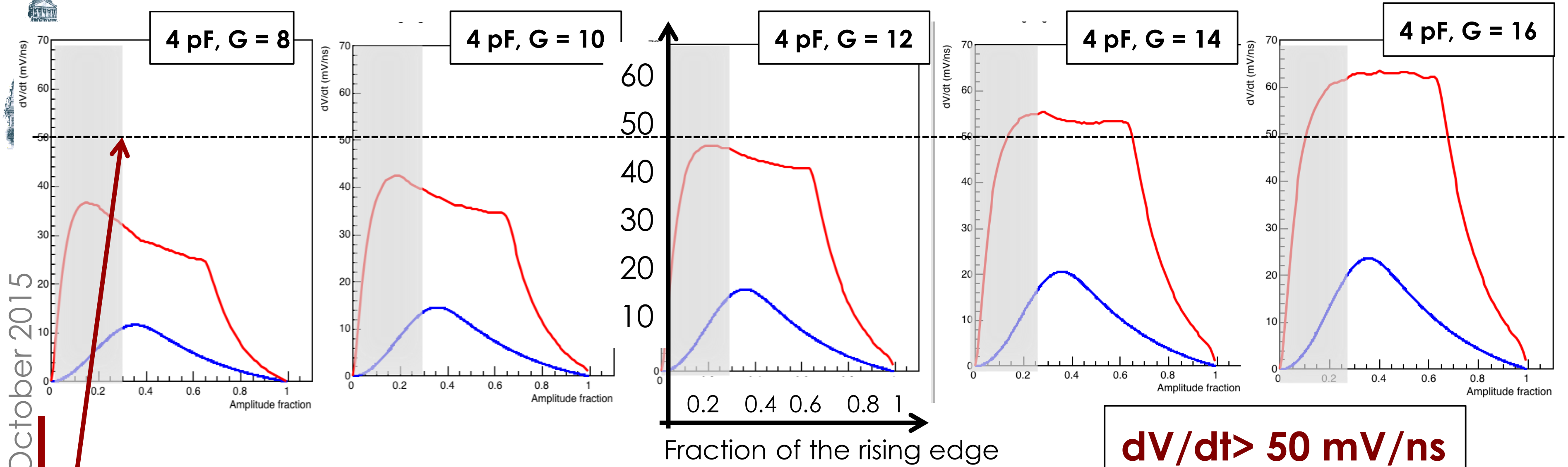


How large each pad can be?
1 mm^2 = 2 pF for 50 micron thick sensors
1 mm^2 = 1 pF for 100 micron thick sensors

Need to evaluate
- dV/dt vs area.
- How long each bond wire can be
- Electronic noise

Set as goal 1 mV noise ➔ dV/dt ~ 50 mV/ns to obtain 20 ps resolution

dV/dt vs Signal fraction for C = 4, 6 pF and gain = 8, 10, 12, 14, 16



dV/dt> 50 mV/ns

Gain = 14-16

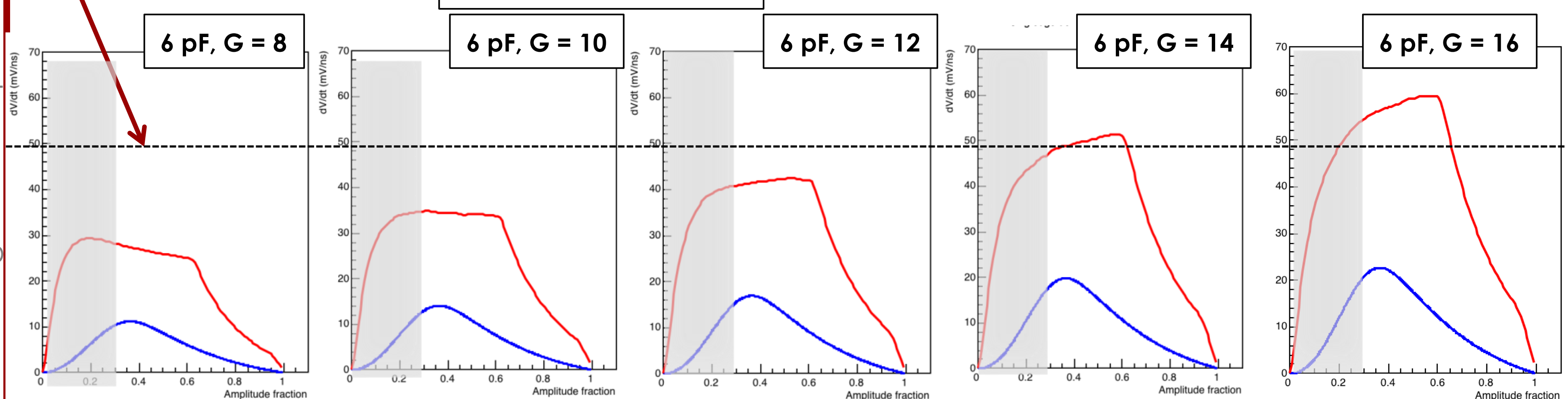
C = 4-6 pF

dV/dt = 50 mV/ns

BB amplifier, 40 db,

R input = 50 Ohm,

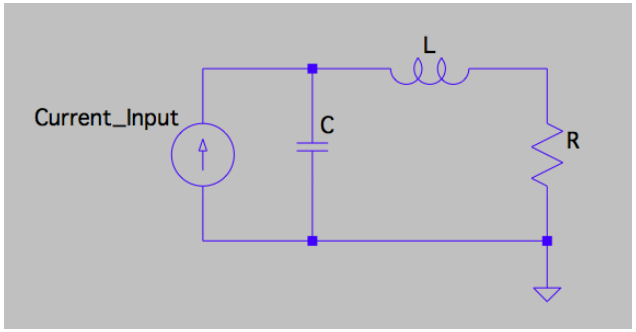
Gain = 8 - 16

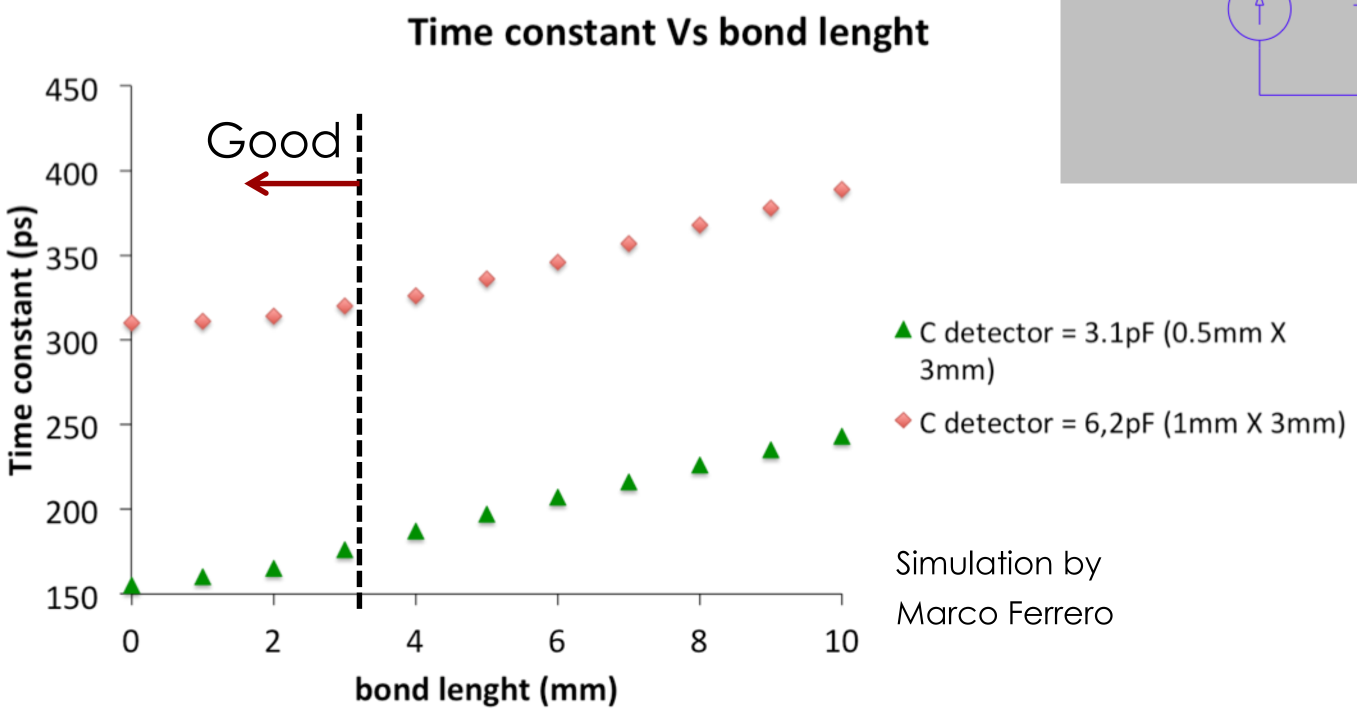


Bond wire

The geometry of the sensor has to take into account the bond-wire length

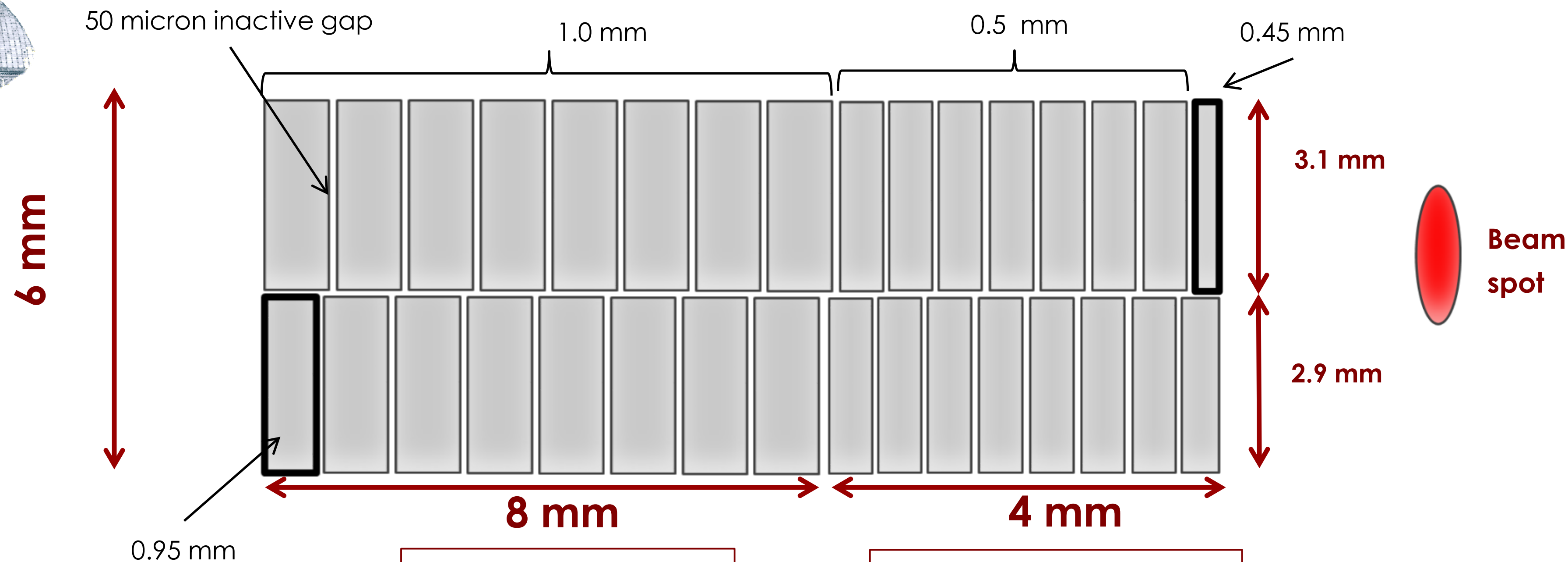
A bond wire act as an inductor of 0.8 nH/mm placed in between the detector capacitance C and the amplifier input resistance R





Simulation by Marco Ferrero

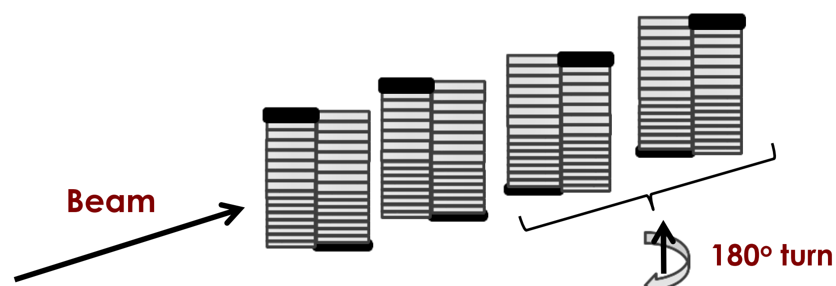
CT-PPS proposed sensor geometry



16 Pixel ~ 3 mm^2
Cap. Pixel ~ 6 pF

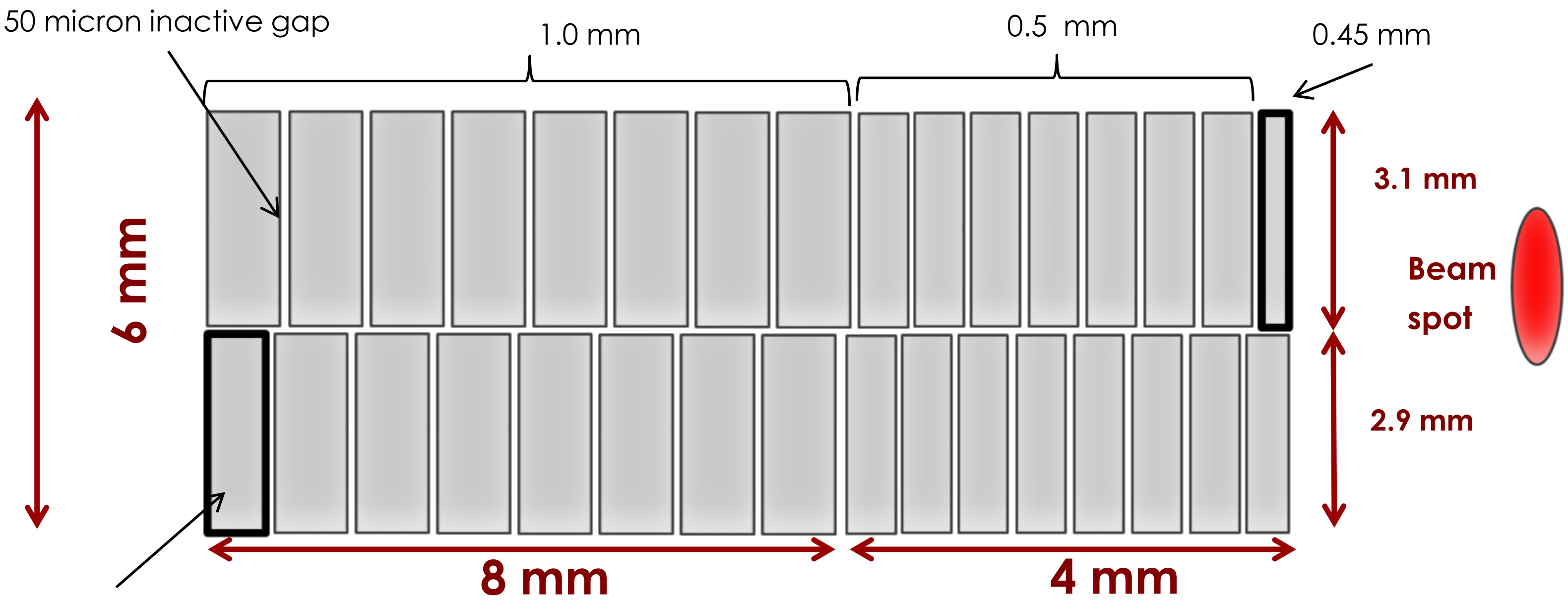
16 Pixel ~ 2 mm^2
Cap. Pixel ~ 4 pF

Asymmetric designed
Area = 12mmX6mm;
Thickness = 50 um;
# of pixels = 32



No cracks aligned: 2 (3) planes facing the beam, and 2 (3) turned by 180°

CT-PPS proposed sensor geometry



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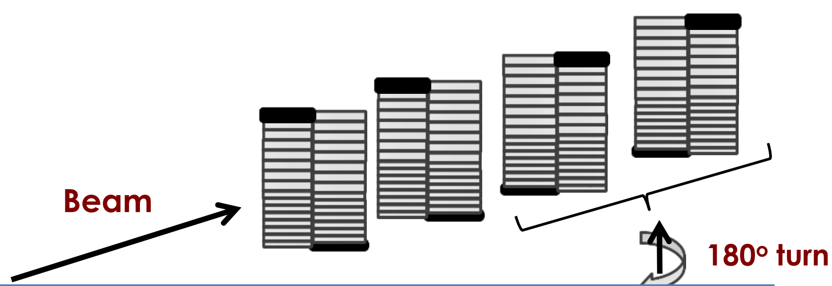


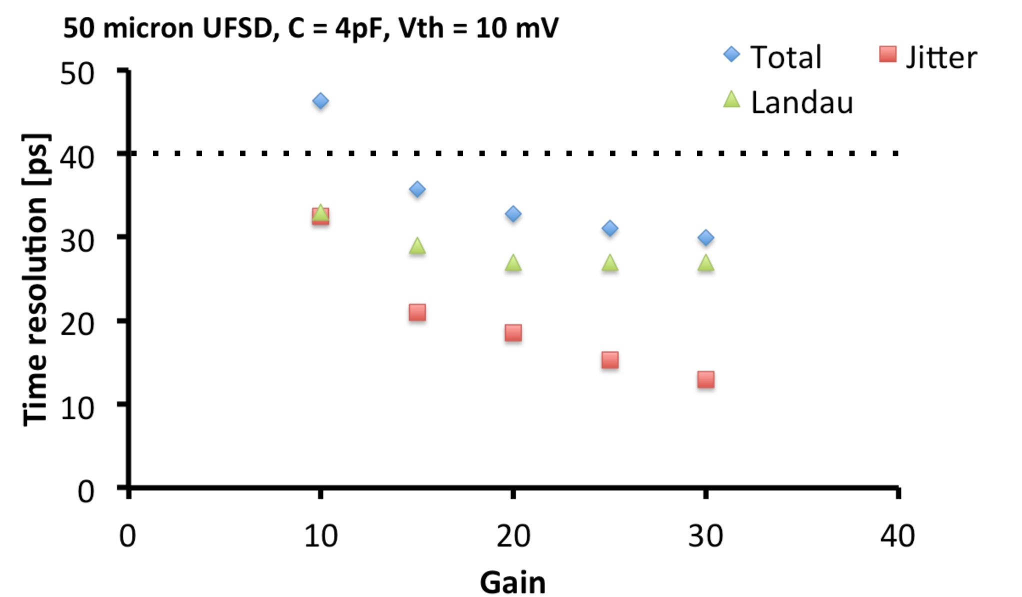
No cracks aligned: 2 (3) planes facing the beam, and 2 (3) turned by 180°

UFSD expected time resolution

What resolution per plane can we expect?

There are 2 known main contributions:

Noise ➔ jitter (from current electronics and testbeam)
Landau fluctuations ➔ additional time spread (from simulation)



For gain >~15 ➔ σ < 40 ps

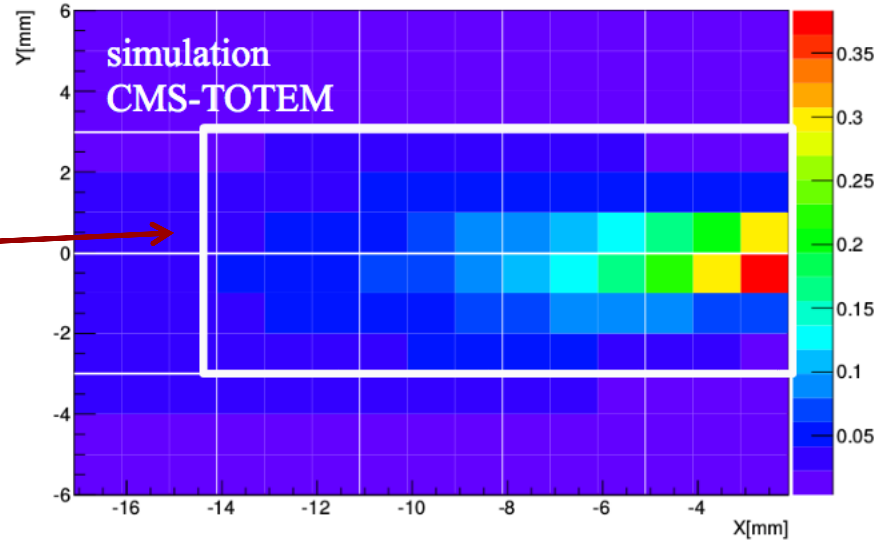
Note we remain below 40 ps even assuming an un-accounted for additional time spread of 20 ps.

Nicolo Cartiglia, UFSD update, CT-PPS -October 2015

Comparison with Quartic

Detector occupancy per mm^2 at pile-up = 50

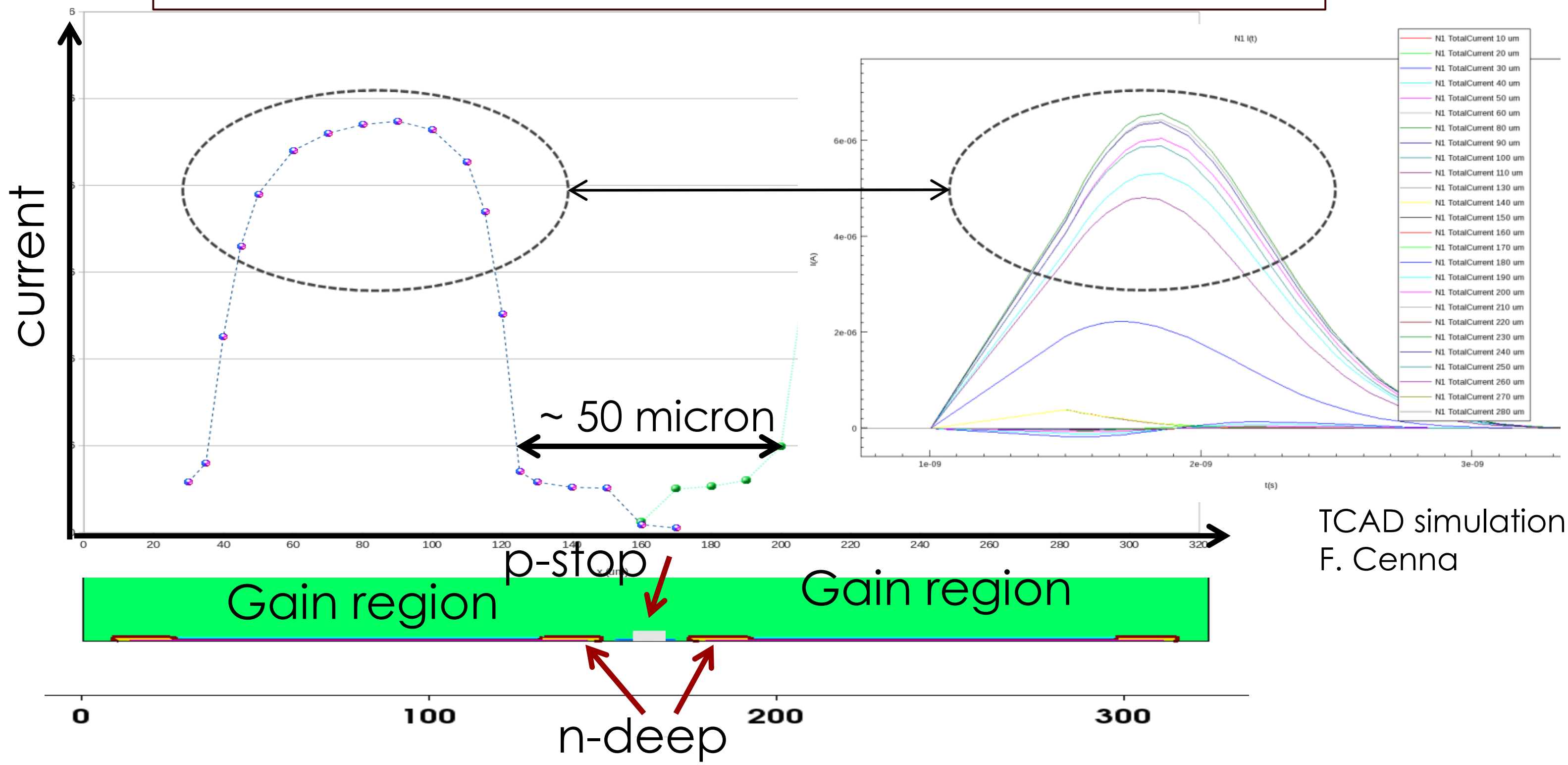
6 x 12 mm coverage,
to have 32 ch per plane



Beam

Lateral collector ring and sensor fill factor

No multiplication for particles hitting in between pads



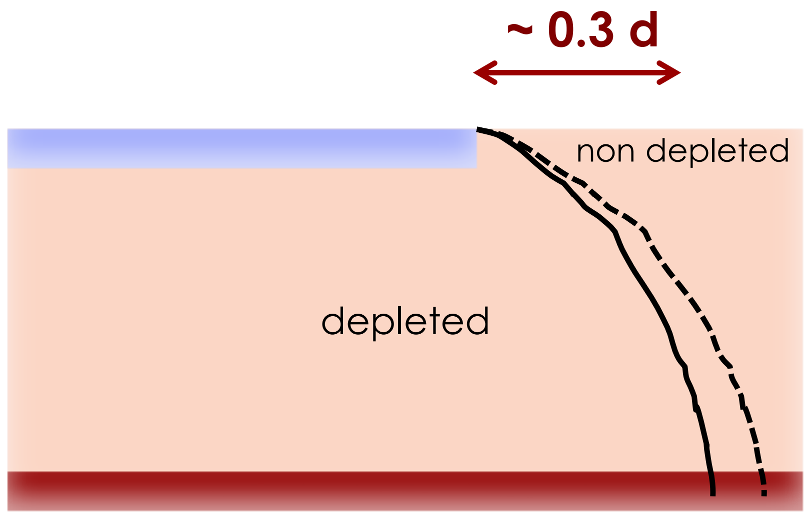
Very important: **need n-deep well** at the end of each pad to prevent particles hitting in between pads from reaching the gain region.

Dead region: ~ 50 micron along each internal pad border = 5 mm^2
Active area: 67/72 = 93% per sensor.

Sensor thickness and slim edge

Rule: when the depletion volume reaches the edge, you have electrical breakdown.

It's customary to assume that the field extends on the side by ~ 1/3 of the thickness.



edge = k* thickness

- k = 1 very safe
- k = 0.5 quite safe
- K = 0.3 limit

By construction, thin detectors (~ 50 micron) have therefore slim edge

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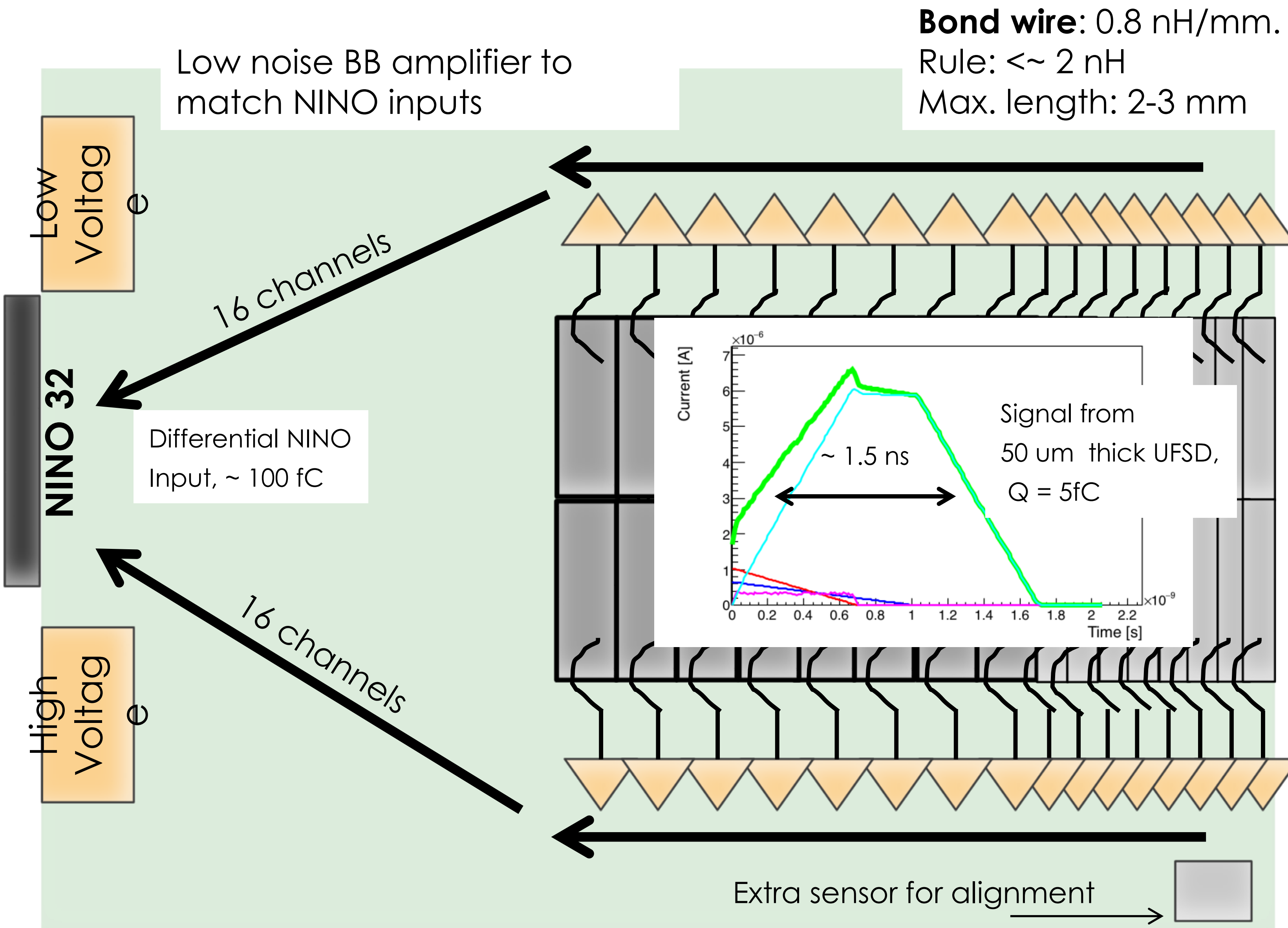
PPS proposed read-out card



Next steps

Done:

Testbeam in July with 300 micron thick UFSD sensors. Preliminary analysis indicates a time resolution of ~85 ps for a gain~20, and ~145 ps for a gain~10.

We finalized the 50 and 100 micron thick sensor design, and submit the production at CNM. Turn around time ~ 3-4 months.

➔ Foreseen time resolution ~ 40 ps

To be done:

- Develop the pre-amplifier chain, to be compatible with the NINO inputs. Need to be rad-hard. ➔Torino, Pilsen, Santa Cruz…?? ~ 6 month
- Evaluate the heating requirements
- Study the NINO behavior for very short pulses (Jose might help in this topic). Hopefully it works….
- Define the services needed in the tunnel: Low voltage, High voltage, cooling

Conclusions

Simulation shows a time resolution of ~ 40 ps for 4-6 pF sensors with gain ~ 15.

We have developed a sensor design with minima dead area, short bond-wires and the possibility of 100% coverage. Ready by ~ winter 2015.

We are working towards a pre-amplifier design compatible with the NINO+HPTDC read-out chain.

➔ Need to evaluate the NINO chip with UFSD sensors. Does it work?