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RDSI LC TPC

3-D simulation of Si-Prot

Charge distribution, signal development

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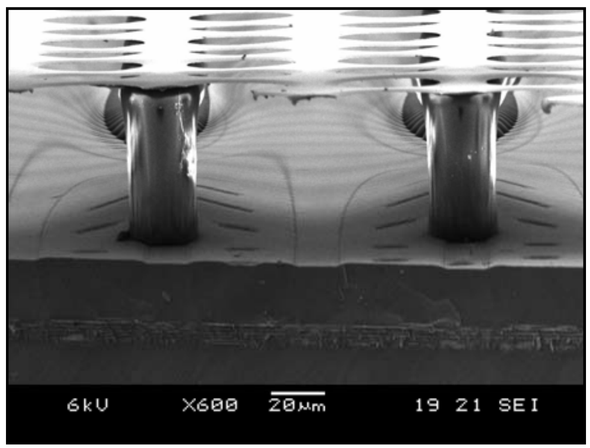
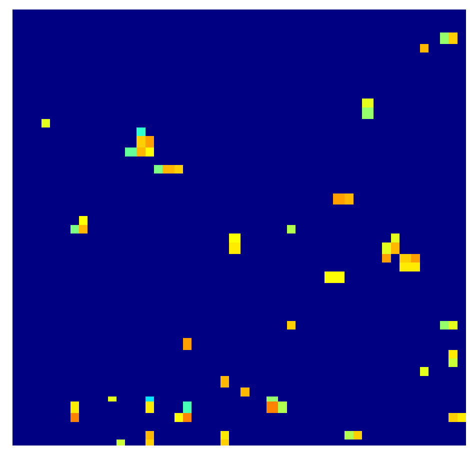




Introduction

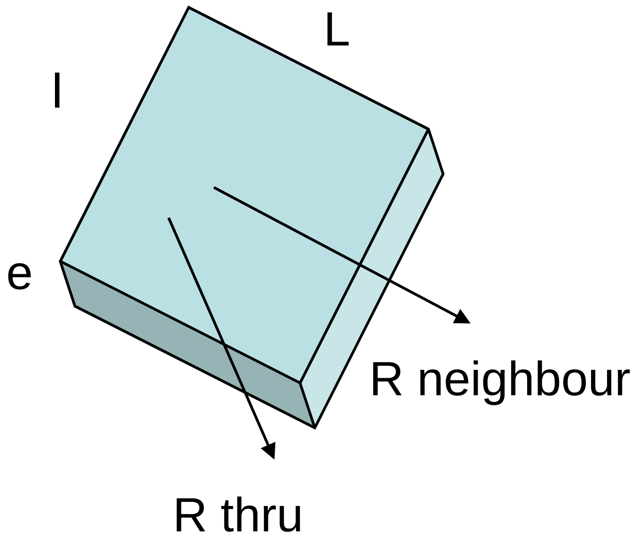
- **A single spark kills a TimePix chip**
  - High current, hot plasma -> destroys circuit
  - A sufficiently thick SiProt layer reduces and softens the sparks (See M.Fransen's talk)

- **How protection works?**
  - Allows charge to stay over the pad, lowering the local potential
  - Limits the current thru the amplifier
  - Protects mechanically
  - Avoids points, softens the surface?

- **Any damage to the signal?**
  - Amplitude loss?
  - Charge sharing with neighbouring pads?
  - Short-circuit of the amplifiers
  - Introduces dead time?

TO ANSWER, NEED A SIMULATION

Orders of magnitude



$R_{neighb} = \rho\ L/el = \rho/e$ for square pads

For 10 µ aSi, $\rho=10^{11}\ \Omega.cm$, $R=10^{14}\ \Omega$/square

$R_{thru} = \rho\ e/Ll \sim 0.04\ 10^{14}\ \Omega$

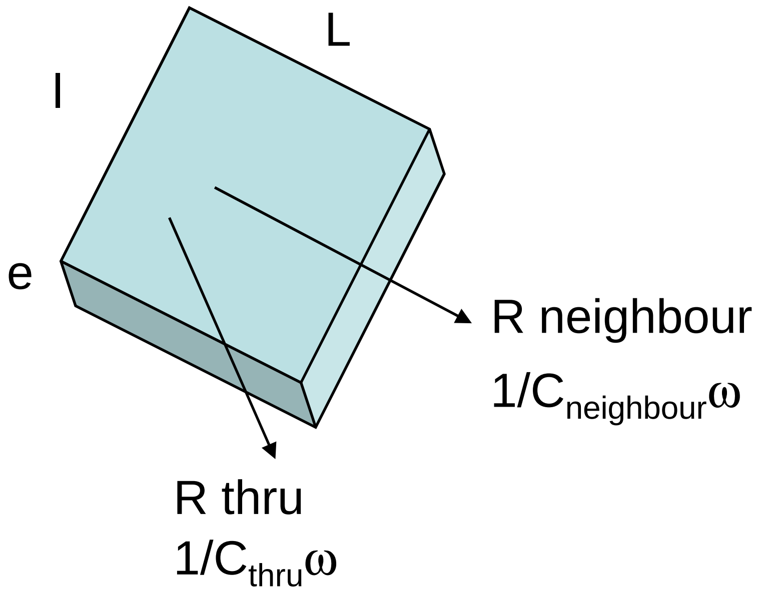
$R_{neighb}/R_{thru} = L^2/e^2$

e<<L to avoid spreading the charge by side conductivity. The charge preferentially escapes thru the pad, but with an extremely high resistance.

$C_{neighb} = \varepsilon_r\ \varepsilon_0\ Le/l = \varepsilon_r\ \varepsilon_0\ /e$ for square pads

$C_{thru} = \varepsilon_r\ \varepsilon_0\ Ll/e$ (note $\varepsilon_r \sim 11$ for Si)

The influence acts preferentially thru the pad if L>>e



Also $R_{thru} >> 1/C\omega$ to leave the induced signal

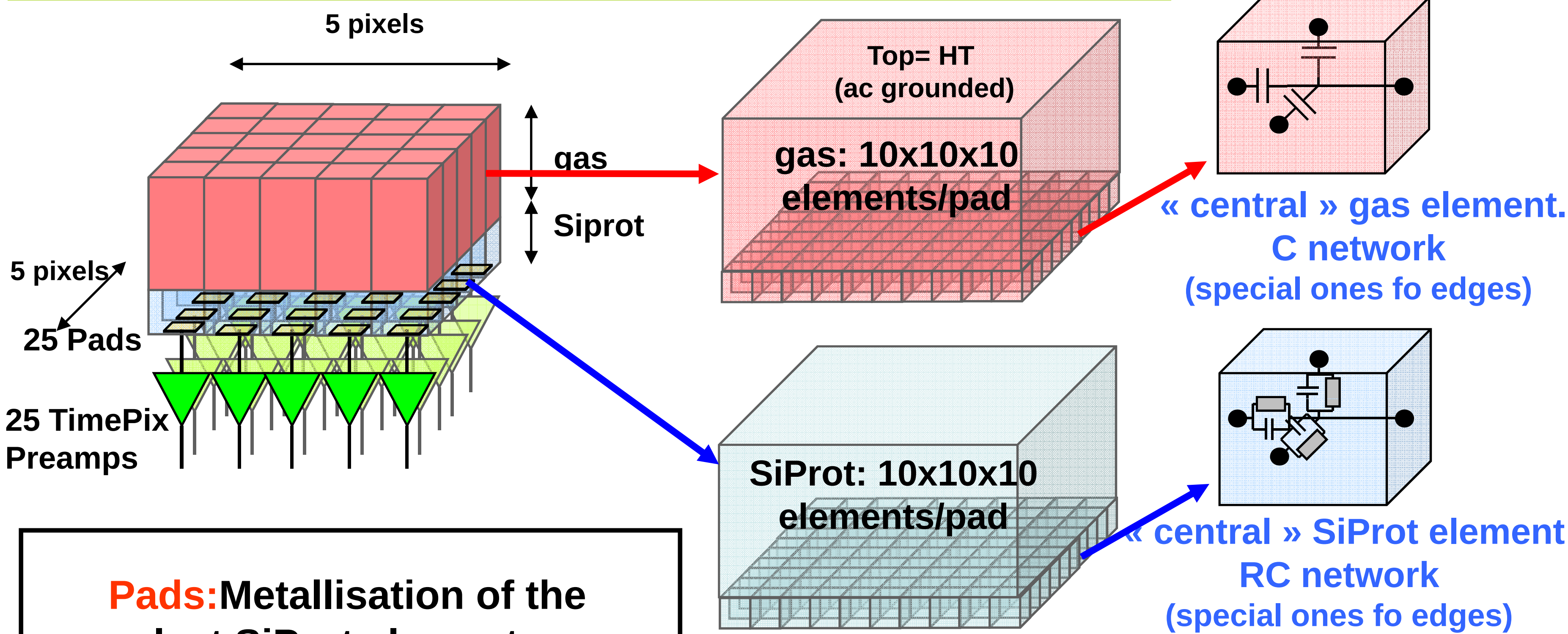
(OK with 10^{11} Ω.cm within 3 orders of magnitude for 10 ns signals)

Equivalently, RC time constant >> 10ns

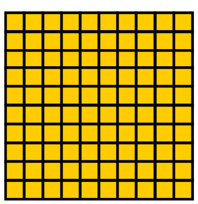
The signal is fully capacitive

SiProt Simulation with Analog Artist

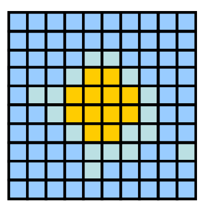
E. Delagnes, S.Turnbull



Pads: **Metallisation of the last SiProt elements**



« Full » shape
100% of pixel aluminized

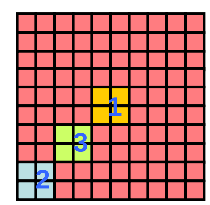


« Cross » shape
12% of pixel Al, rest SiN_2

Charge Injection at the gas / SiProt interface in the central pixel

Size = 4 elts

3 positions.

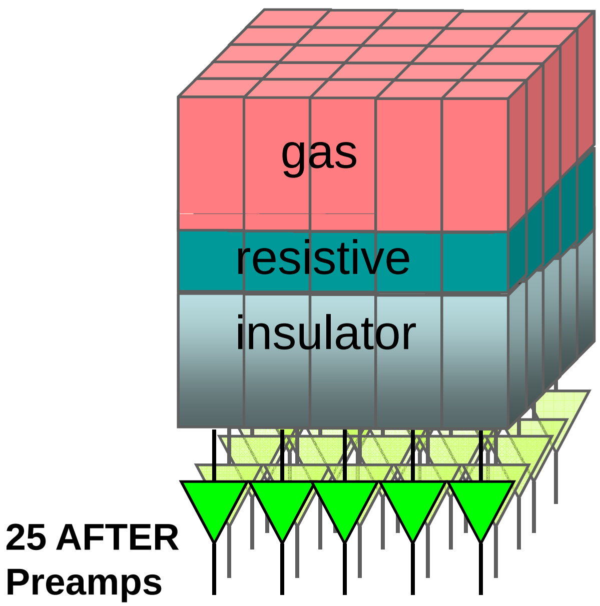


Note that SiProt is very different from the charge spreading for improving the resolution (M. Dixit et al.).

In that case, there is an insulating layer (50-100 μ) below a low-resistivity coating: 1 MΩ/sq, 100 nm (i.e. 10 Ω.cm). In that case, the charge obeys the telegraph equation (see Stephen Turnbull's talk). In SiProt, the signal is capacitive and the charge slowly evacuates in thru the coating and the amplifier.

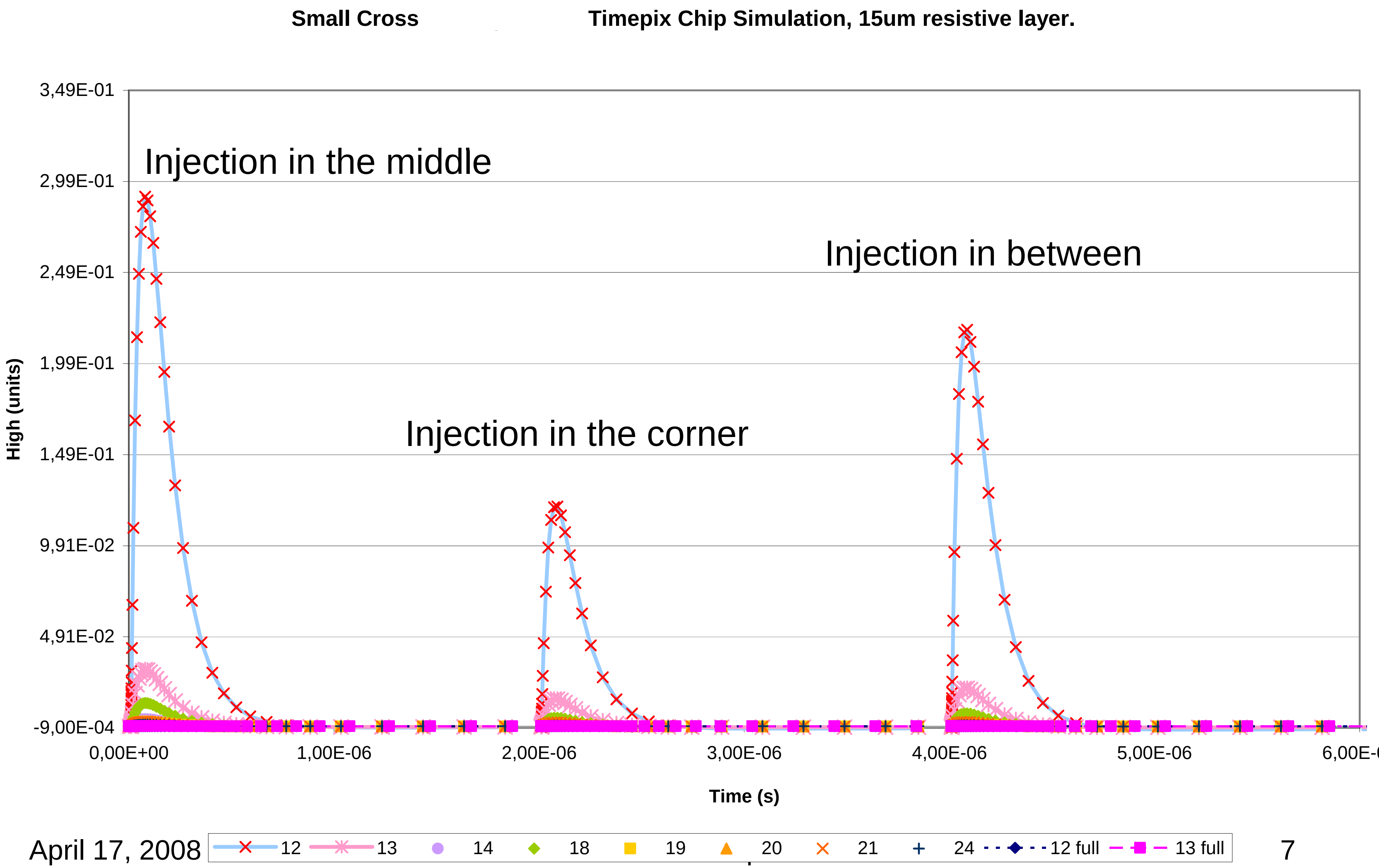
This Analog Artist simulation can also be used for double layers with 2 different resistivities.

Run time for SiProt: 10 h per set of parameters.



Signal development

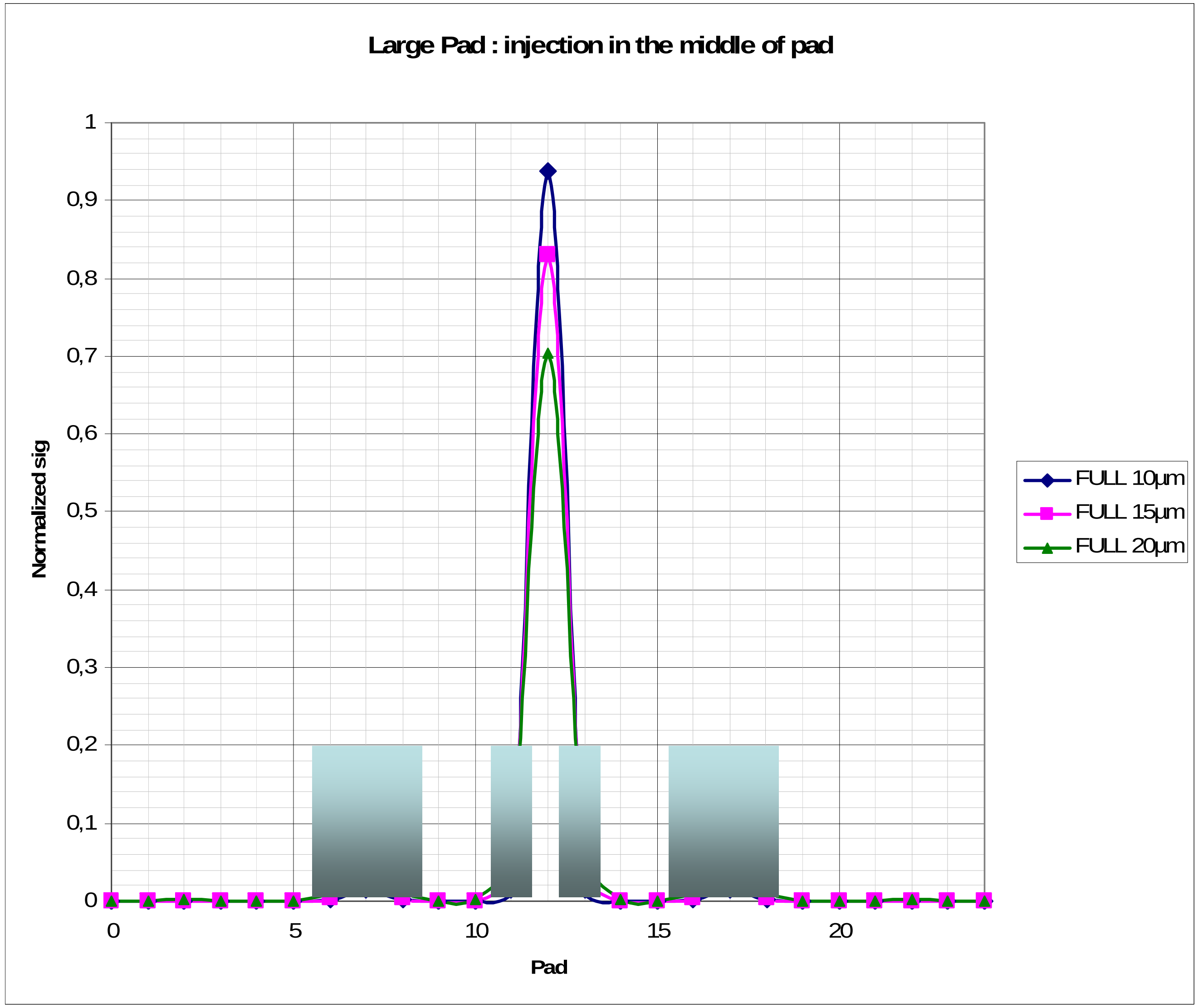
Charge pulse: 1ns trapezoidal current pulse



Results

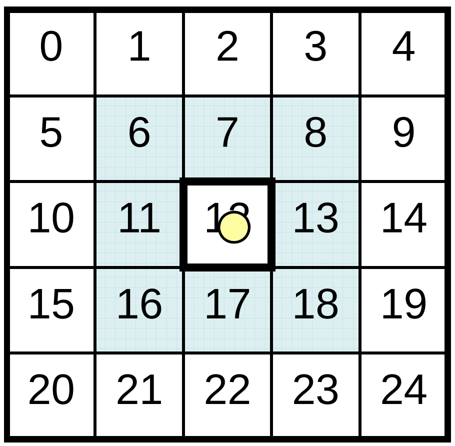
Pads fully covered with Al

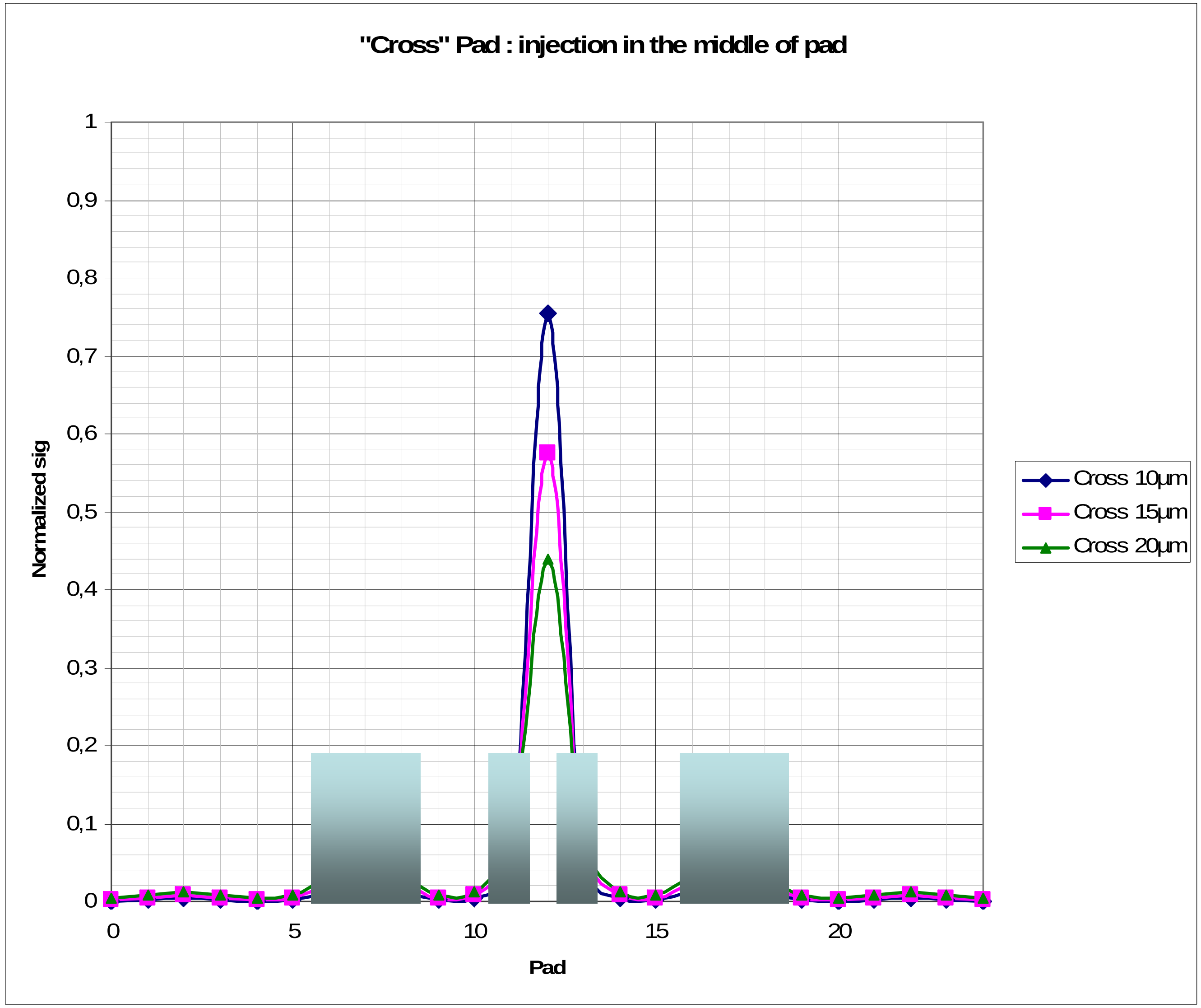
0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24



Results

Pads 12% covered.

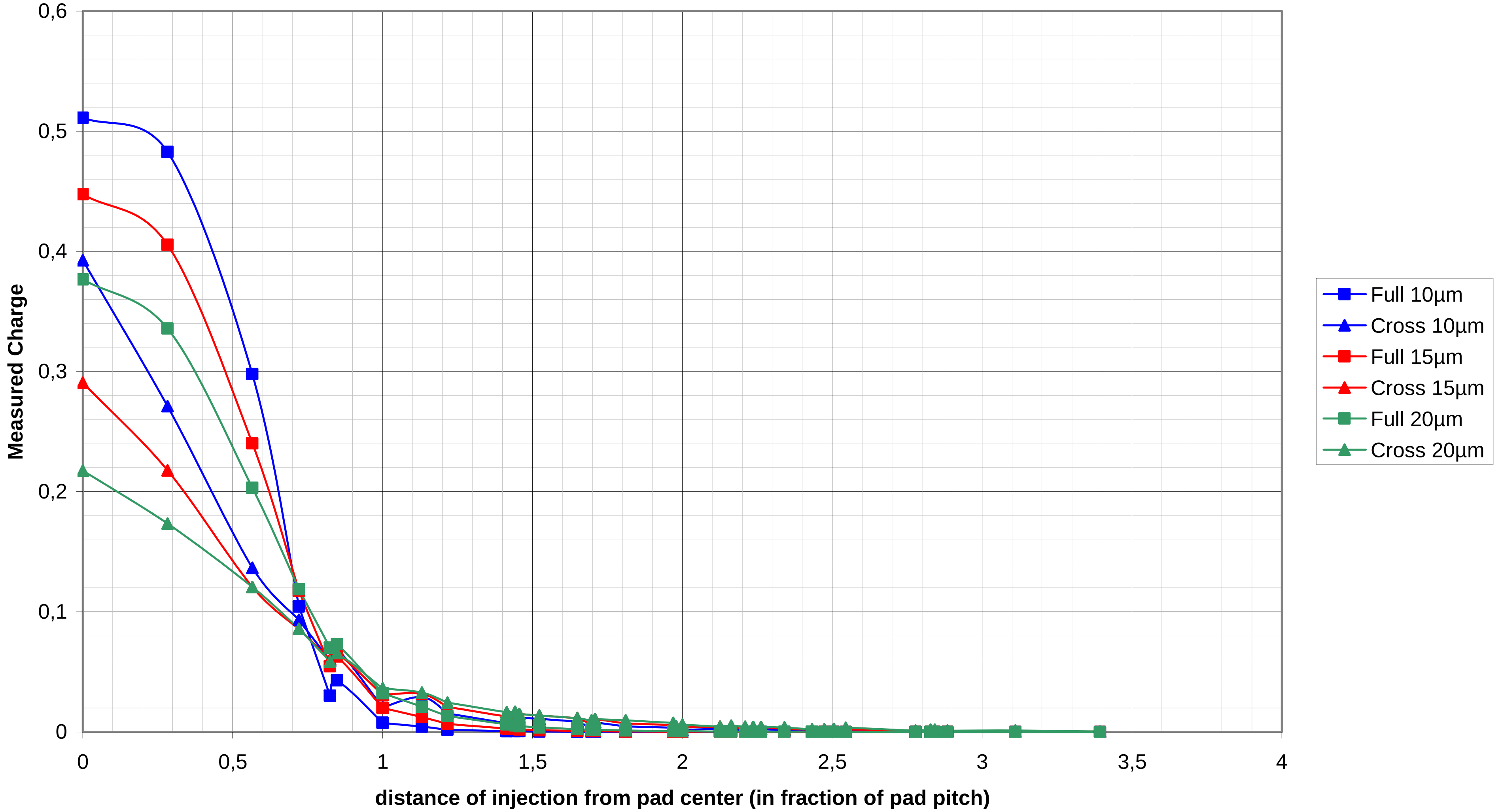




Charge injected in the middle of the pad

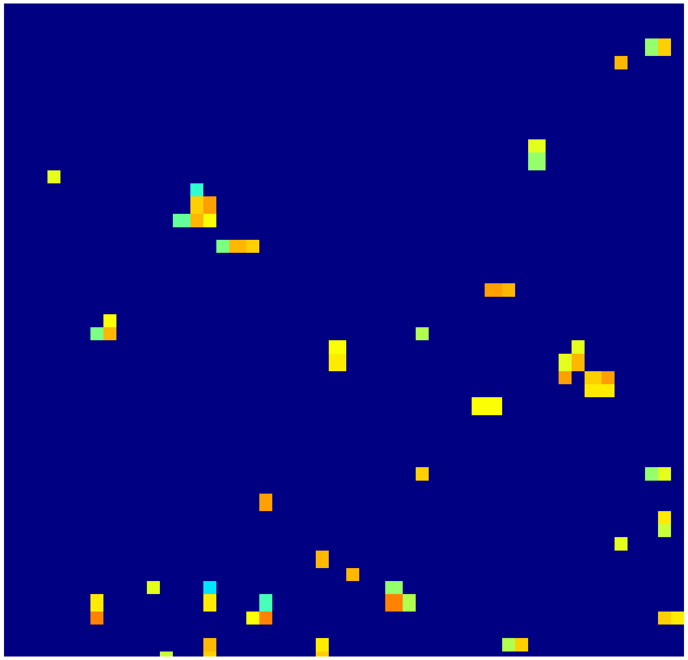
thickness	Signal frac. on central pad (Full pads)	Signal frac. on central pad (cross)
10 µ	94 %	76 %
15 µ	83 %	57 %
20 µ	70 %	44 %

Pad Response Function



Data

- With 20 µ SiProt, the spreading over several pads is clearly seen, but the grid misalignment also contributes.

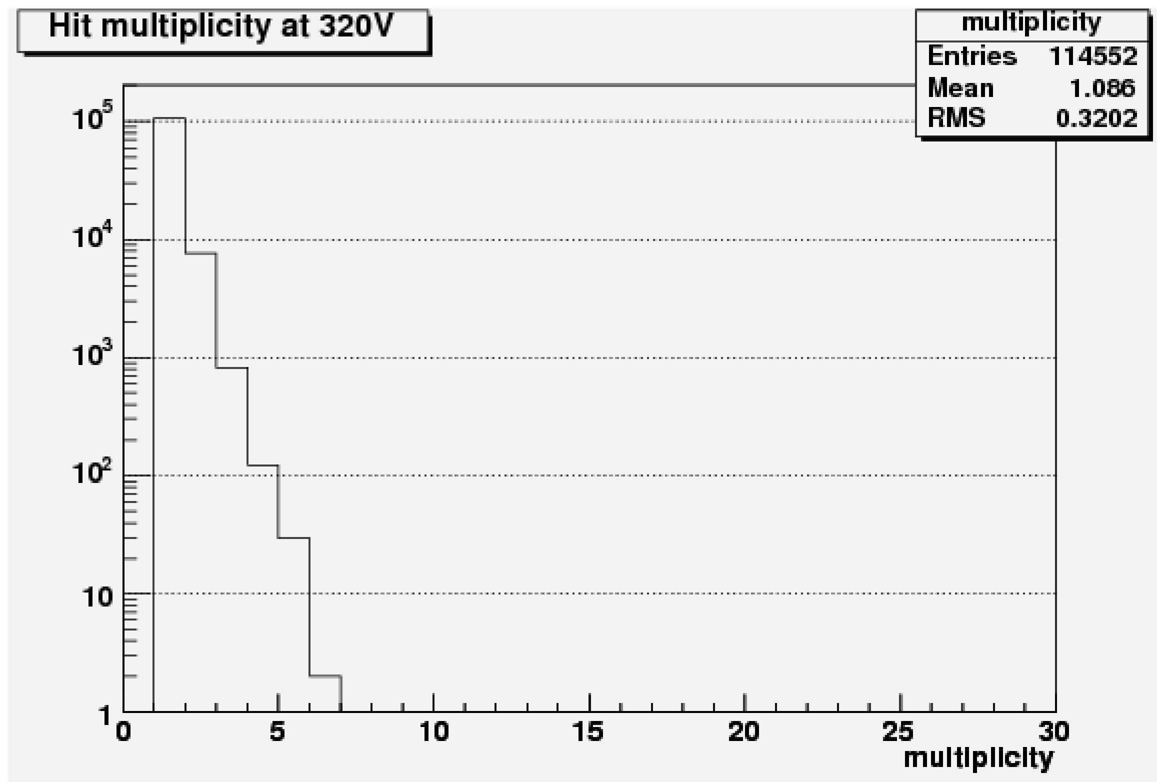


Data

InGrid-equipped TimePix, Nikhef

With 15 micron SiProt, pixel multiplicity of isolated clusters shows 91% of single pixels at a gain of 4000.

Difficult to relate precisely to the measurement, but no evidence for strong spreading.



Conclusions

- Charge spreading is limited both in space and time for SiProt thickness less than 10-15 μm.
- Fully covered anodes spread less than partially covered anodes

TimePix-Micromegas collaboration

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  Max Chefdeville
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  Arnaud Giganon
  Ioannis Giomataris
  Marc Riallot
  Stephen Turnbull

- **CERN**
  Michael Campbell
  Xavier Llopart

- **Nikhef**
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  Max Chefdeville
  Martin Fransen
  Fred Hartjes
  Jan Timmermans
  Harry van der Graaf
  Jan Visschers