Protection R&D at LAPP

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Outline

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SMD protection network

Protection network comparison

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Introduction

Why this R&D on sparks protections?

- We used COMPASS gassiplex board from SACLAY: no problem noticed with our Micromegas;
- We used the same protection on our next MM detector with different chip: problems began;
- And problems increase as the size of the mesh increases, with different chips (see my talk in WG5).

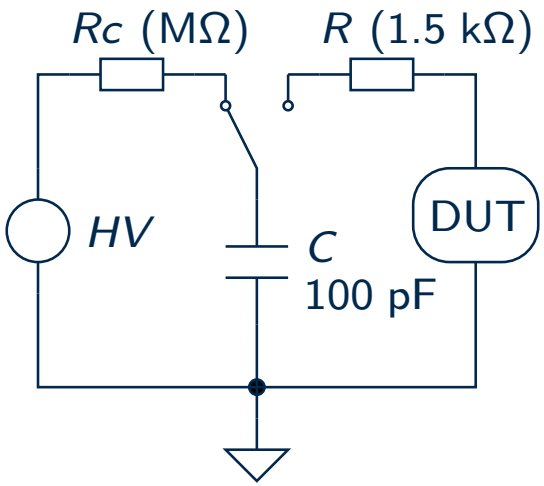
Moreover:

- We try to suppress all passive components on board (400 000 channels);
- We have to increase even more the size of mesh.

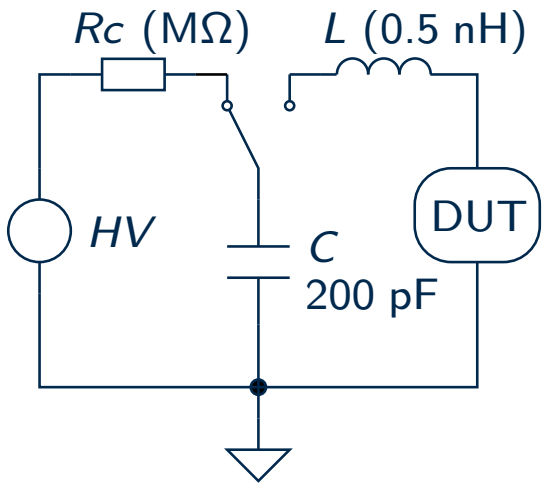
Better understanding well of the protection network is needed.

Naïve approach: ESD models

Two close models:



Human Body Model:
HT: at least 2 kV
E: 200 µJ

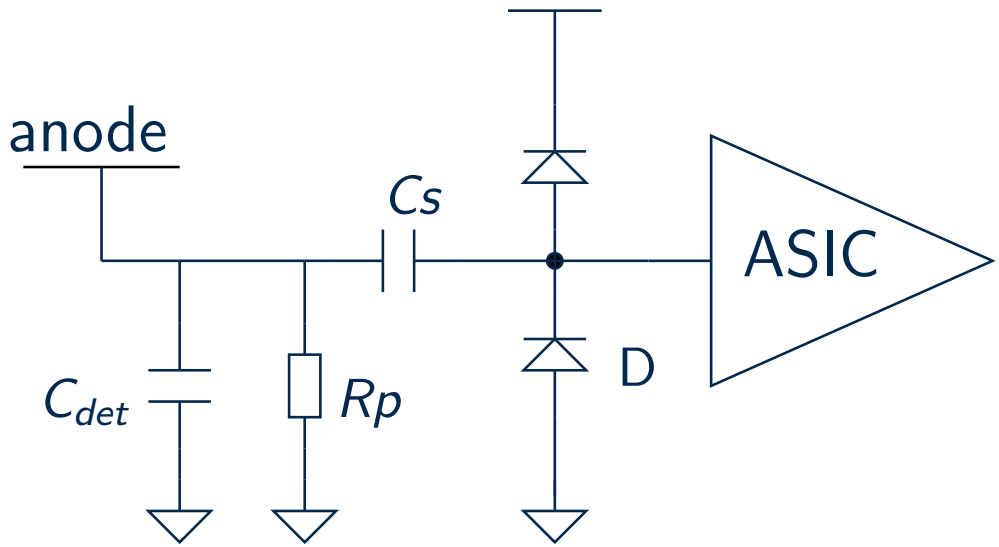


Machine Model:
HT: at least 200 V
E: 4 µJ

A 24 cm×32 cm bulk MICROMEGAS mesh has C=30 nF and stores E=2.5 mJ, with the timing of Machine Model!
The analog I/O of most ASICs recently designed at IN2P3 supports about 200 µJ HBM. A protection network is compulsory !

Present protection network

Schematic, from SACLAY Gassiplex board:



D: BAV99W or BAV99S (no differences in datasheets!)

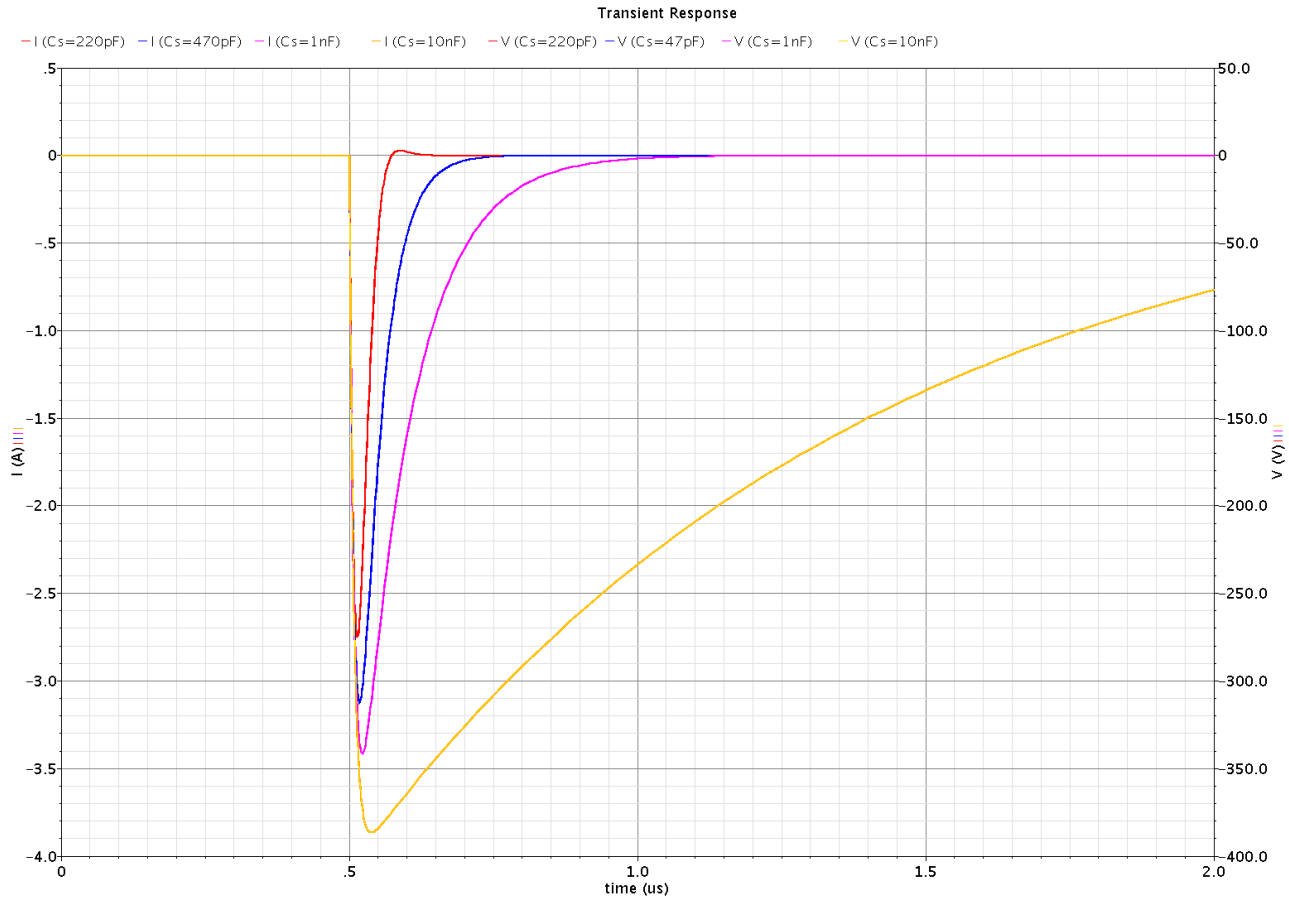
C: Yageo ref. CA0612JRNPO9BN471 (0612, ±5%, NPO, 50 V, 471 pF, 4 GΩ)

Rp: Yageo ref. YC164-FR-071ML (±1%, 100 V, 1 MΩ)

C_{det}: 80 pF (measured)

Simulations without diodes

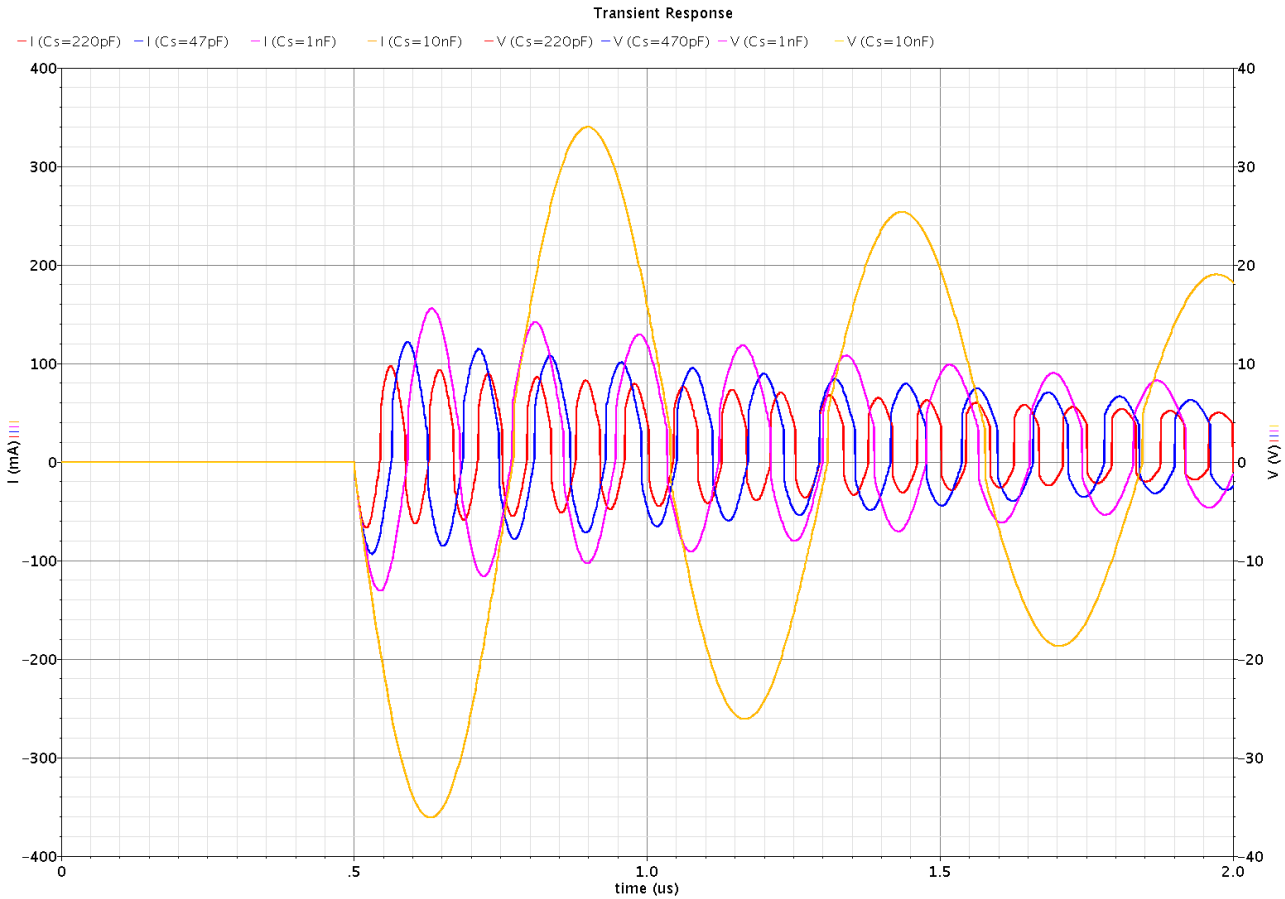
Stimulated with C=100 nF (equivalent to 0.5 m^2 mesh) charged at HV=-400 V, and loaded with Z=100 Ω, for different Cs values. The voltage and the current accross this Z are plotted:



Current and voltage are too large for ASIC !

Simulations with diodes

Same parameters, but with BAV99 diodes:



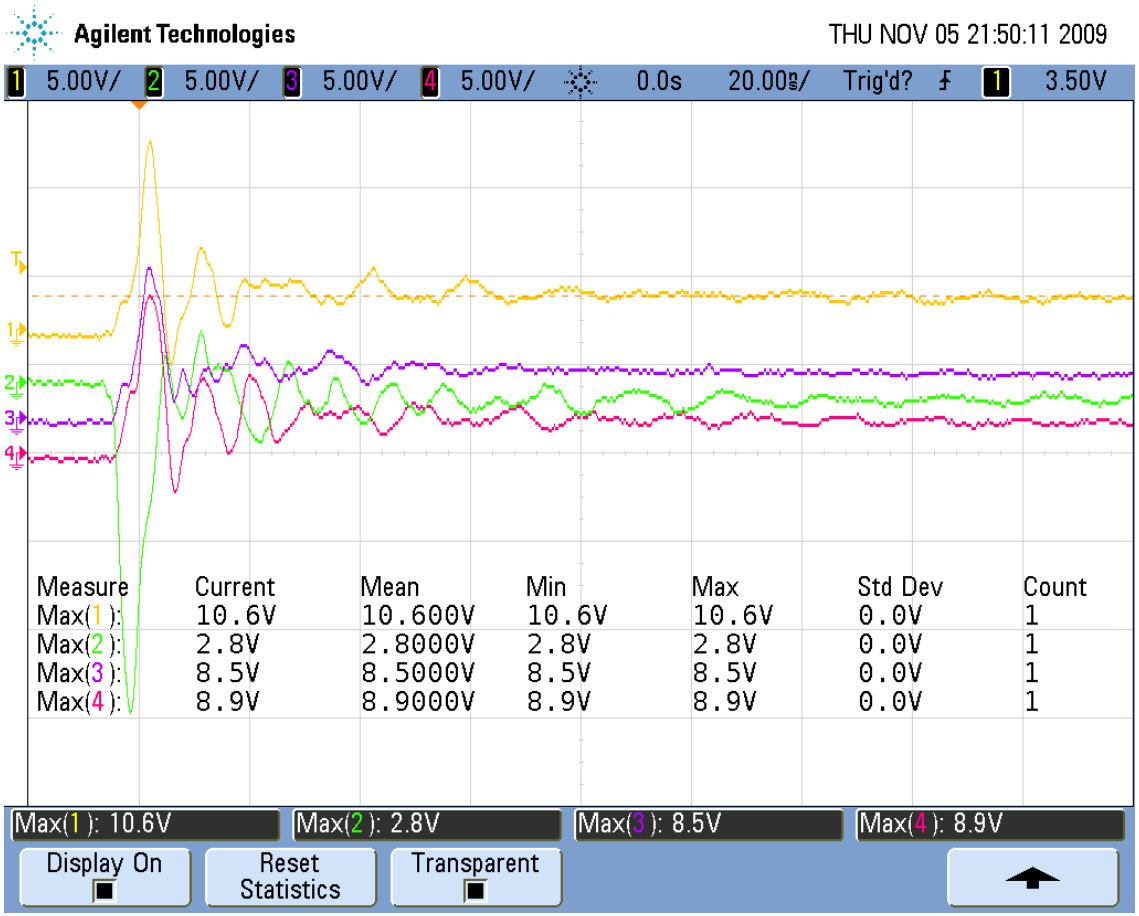
Current and voltage compatible with ASICs ones but ringing occurs.

Conclusions on simulation

- Need to protect from both polarity (ringing + mesh cross-talk $\rightarrow$ positive sparks, see next slide);
- When *Cs* value increase, signal increase, but spark induced signal increase too;
- The order of magnitude of the current accross diodes has been established;
- The main limitation of these simulations is the spark duration: the mesh is fully discharged.

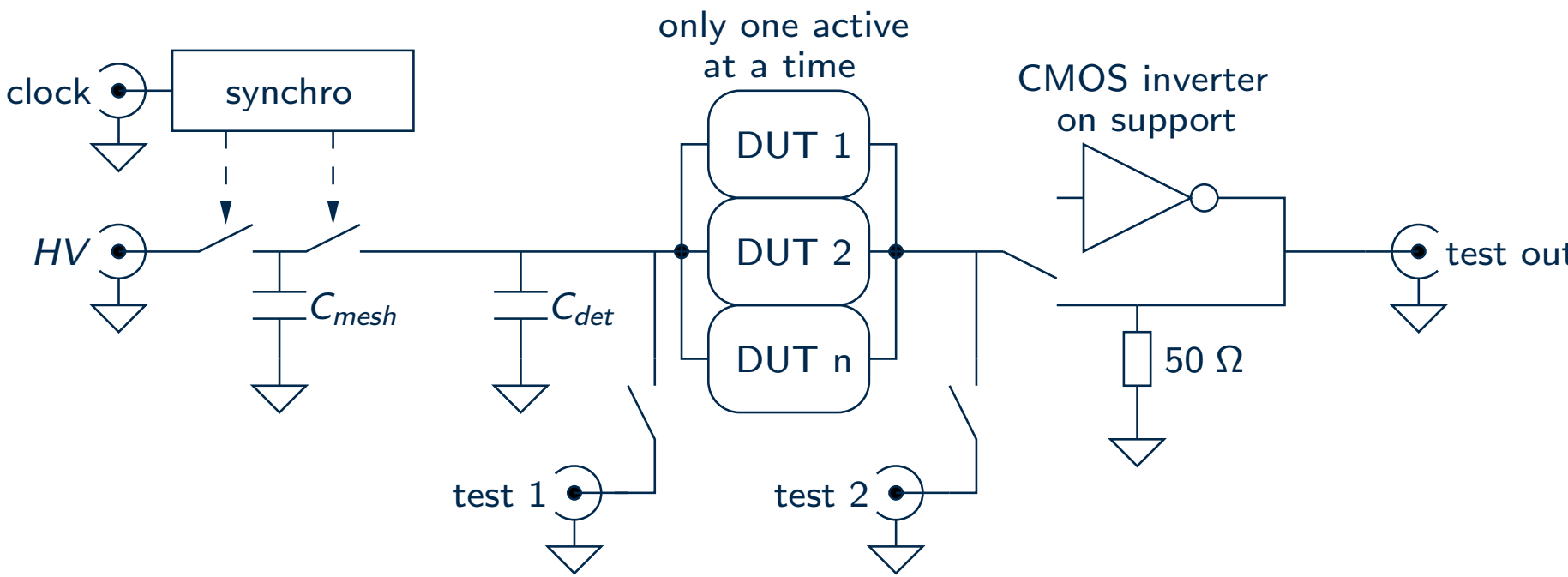
Interlude on cross-talk

Scope capture of spark X-talk at input pins of the ASIC, 8 cm×8 cm bulk MM in beam:



Protection test board

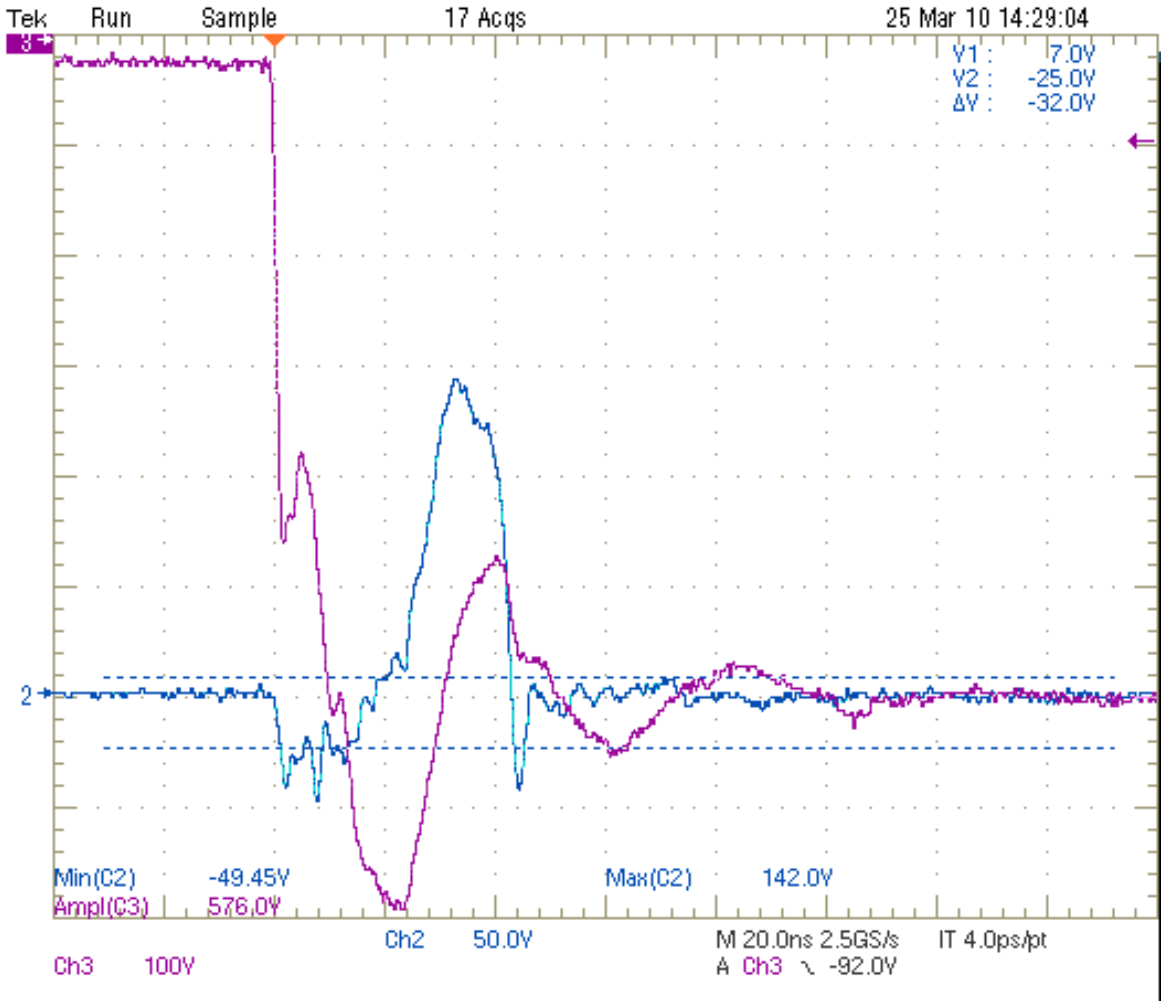
Idea adapted from E. Noschis *et al.* in *Protection circuit for the T2 readout electronics of the TOTEM experiment*. The aim is to compare structure under the same sparks conditions.



Work has just been started, so only the first structure previously presented has been tested.

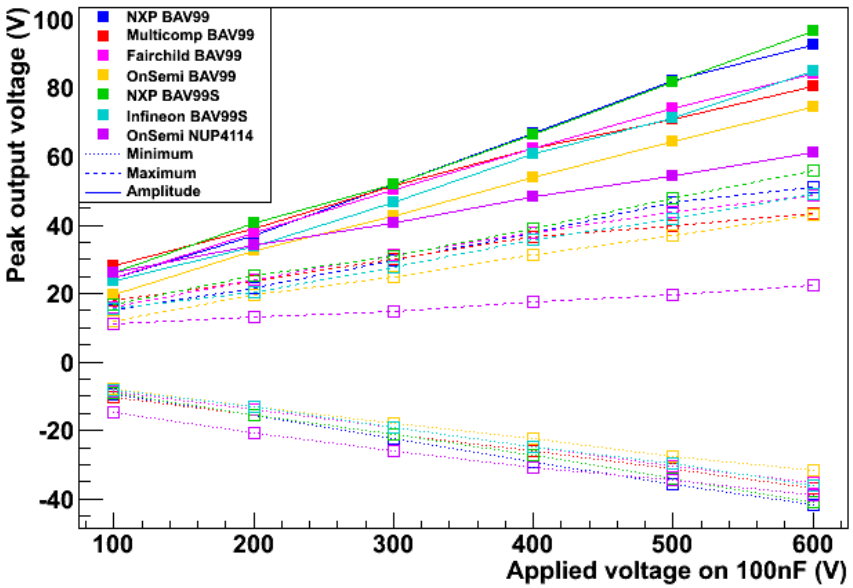
Protection test board operation

High voltage relays operated with non-overlapping clock allows to produce high voltage peaks with extremely low rising time.

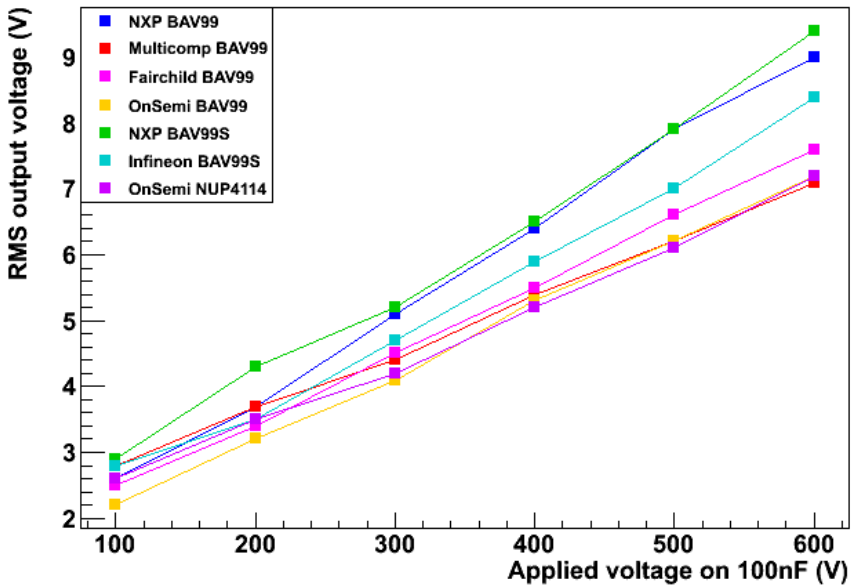


Result of diode comparison (1/2)

A lot of parameter of residual pulses have been recorded. For example:



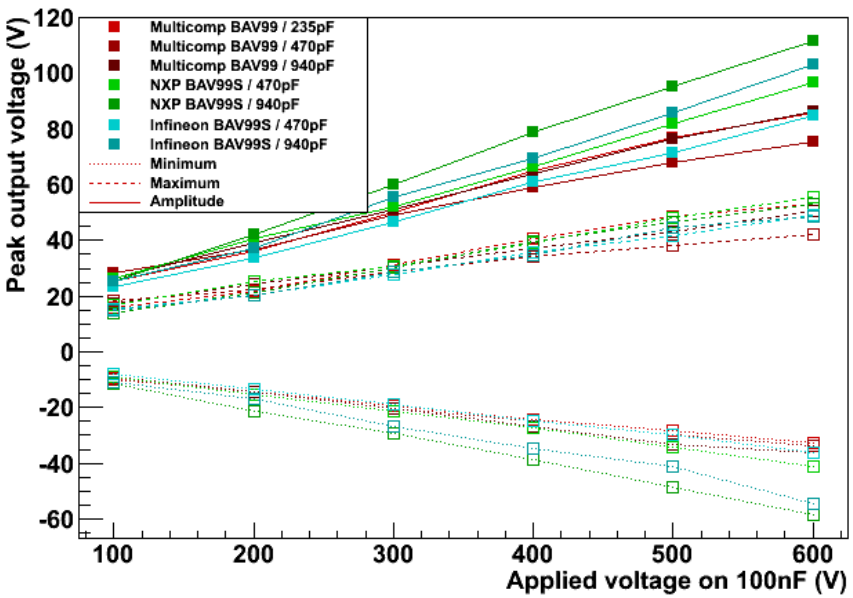
Voltage peak



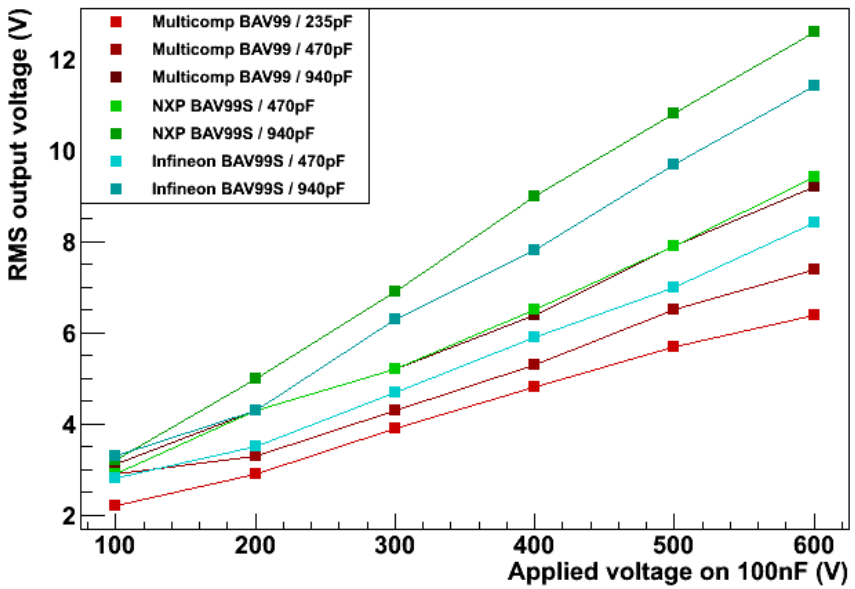
RMS voltage

Result of diode comparison (2/2)

As a function of C_s:



Voltage peak



RMS voltage

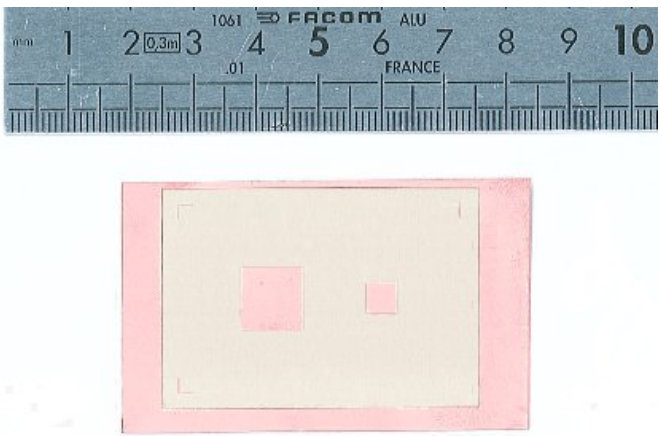
Conclusions on firsts comparisons

- There are obvious differences between diode manufacturers;
- NUP4114 (choosen for SRS) are better than BAV99: we will update our design!
- SMD capacitors dielectric other than NPO are not reliable (even high-voltage rated ones);
- Decoupling of diodes is very important for positive ringing suppression.

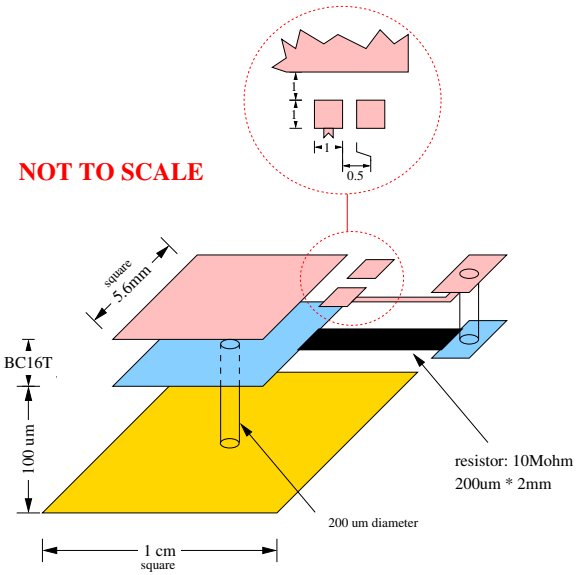
Still a lot of structures to compare and characterise, including a TOTEM protection chip.

PCB embedded network

Objective is to check feasibility of embedding capacitors and resistors inside the detector PCB, and diode inside ASIC.
To reach a capacitance value of 470 pF, we need special dielectric film, as BC16T from Oak-Mitsu (Provided through Rui).



Few samples of BC16T have been produced by Rui's workshop, charaterised at LAPP and validated.



After wondering which is the best structure and some vertical resistive tests, this design is currently under manufacturing at Rui's.

Conclusions

Early results help us to:

- Upgrade our current protection network to avoid ASIC destruction, without loosing any detector signal;
- Upgrade ASIC hardness against spark (see WG5 talk).

In parallel, we'll test soon detector with resistive coating on pads (see Rui's talk).