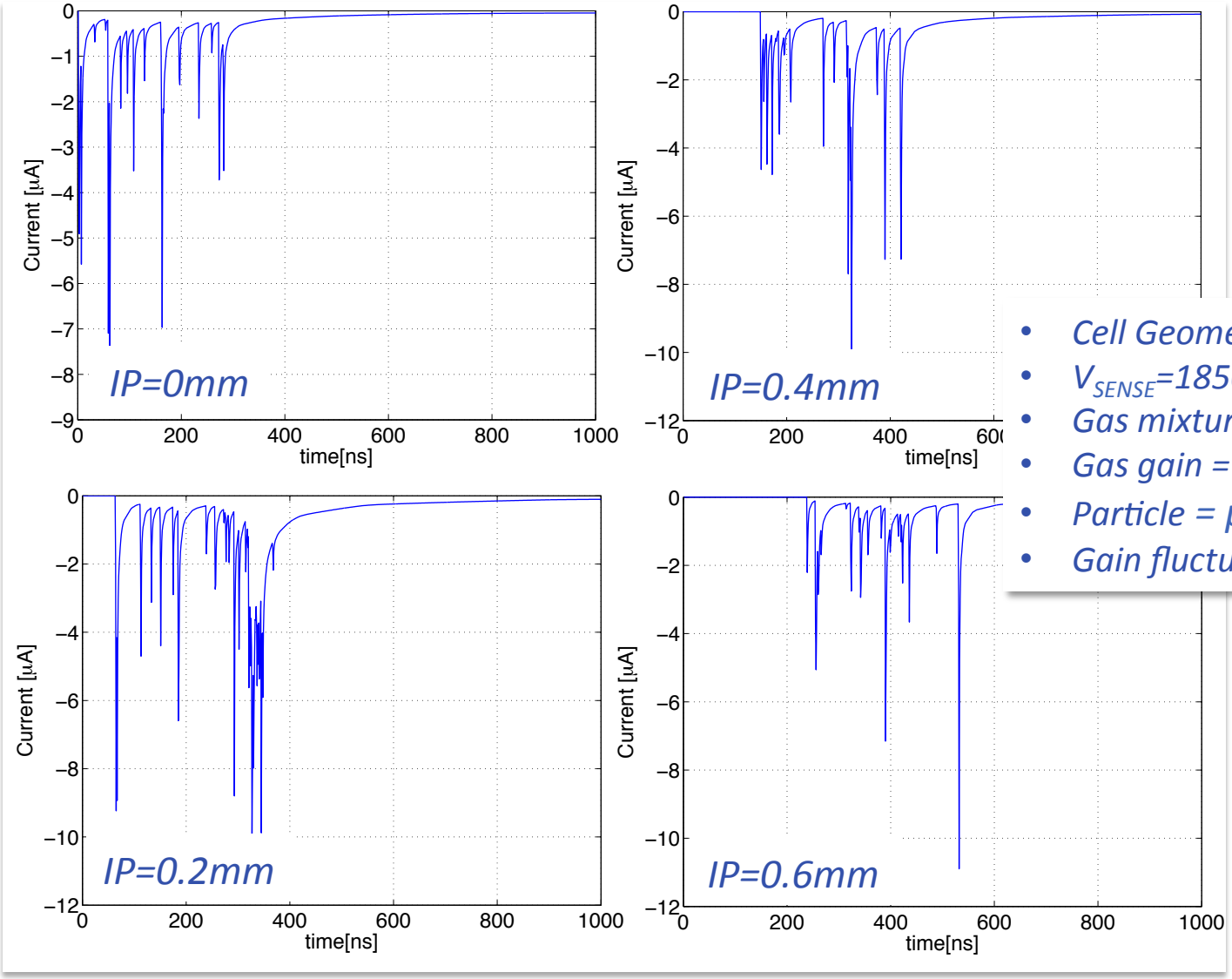
Electrons diffusion and SNR effects on cluster detection

ON-DETECTOR interconnections effect on signal BW

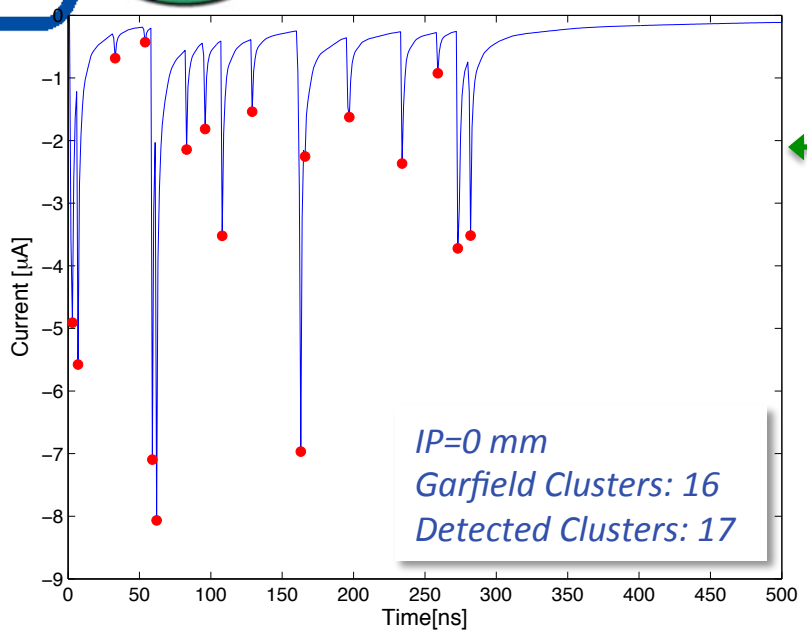
Electrons diffusion effects on cluster detection

Garfield Simulations (C. Gatti)



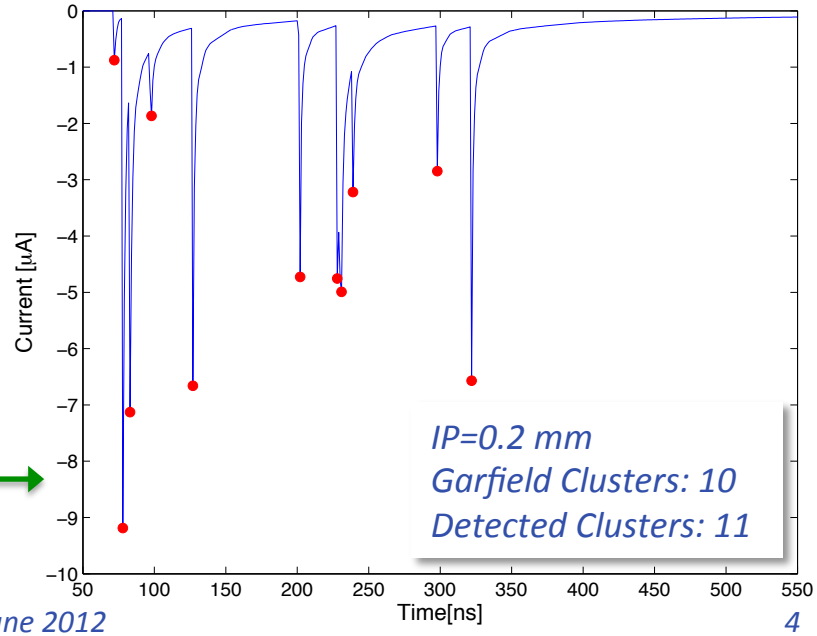
- Cell Geometry: ProtoII (L =1.4 cm)
- V_{SENSE}=1850
- Gas mixture= He/Iso-90/10
- Gas gain = 1.8×10^5
- Particle = μ (250 MeV)
- Gain fluctuation = Polya (theta=0.6)

SNR = ∞ ; Detected clusters fluctuation (I)

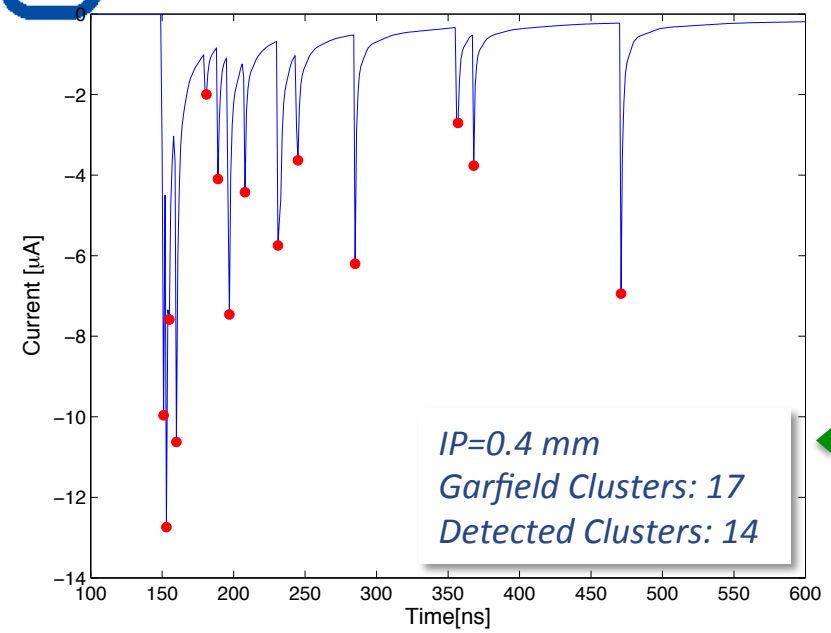


Ev#	Garfield	Detected
0	16	17
1	15	15
2	16	15
3	12	9
4	17	17
5	10	11
..	…	…

Ev#	Garfield	Detected
0	16	21
1	15	13
2	16	17
3	12	10
4	17	19
5	10	11
..	…	…

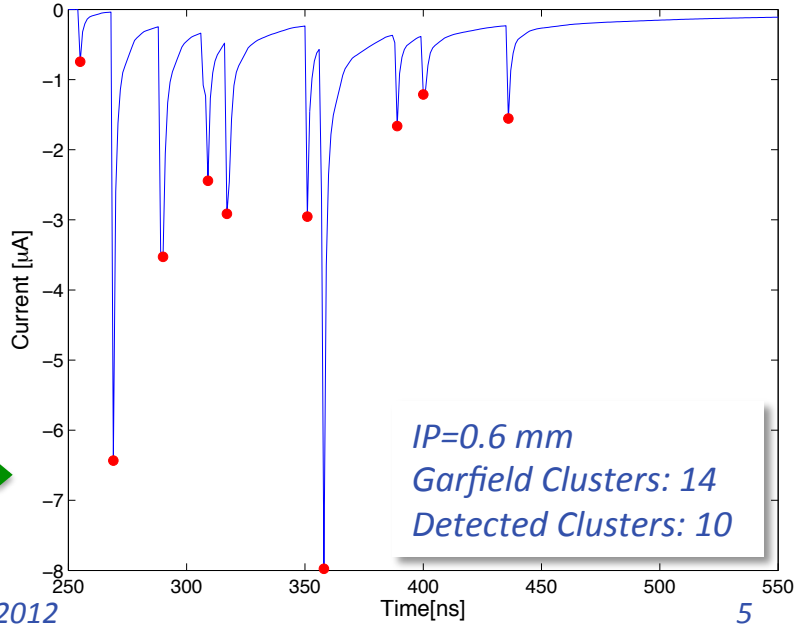


SNR = ∞ ; Detected clusters fluctuation (II)

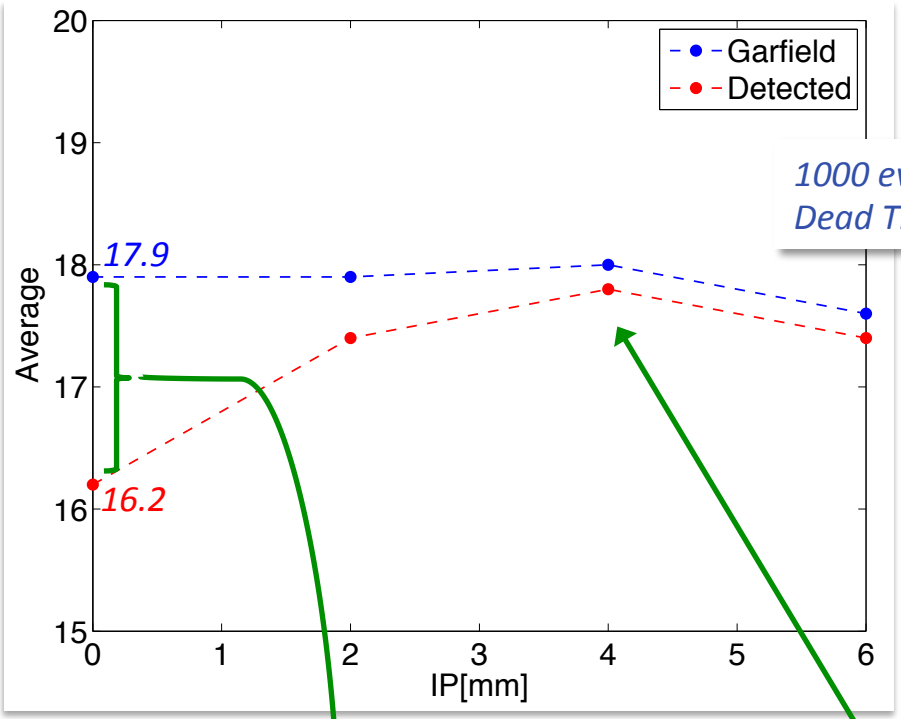


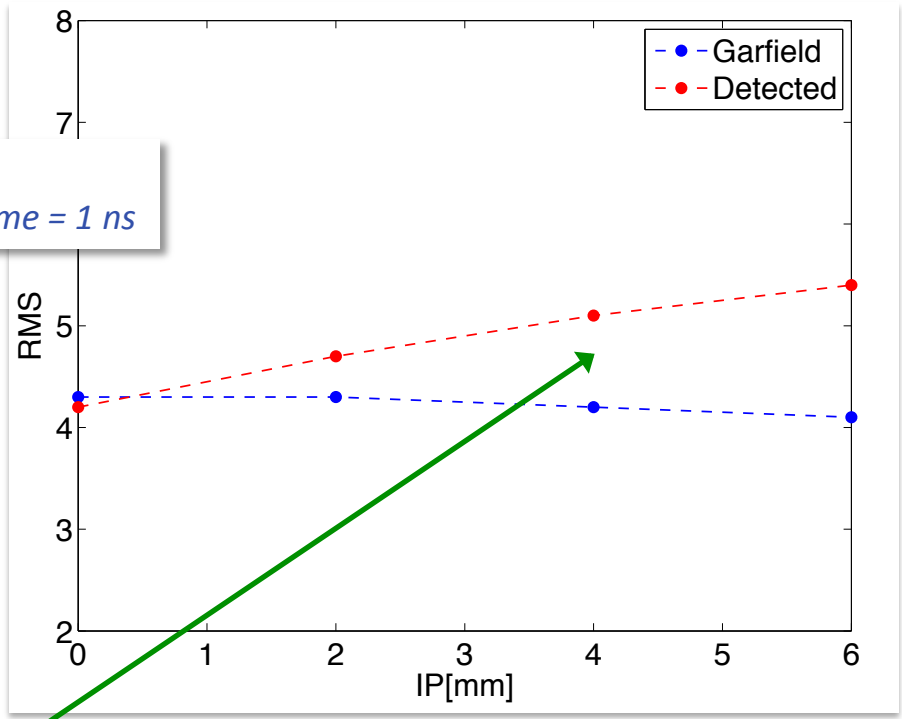
Ev#	Garfield	Detected
0	12	11
1	15	12
2	14	12
3	19	18
4	9	8
5	17	14
..	...	...

Ev#	Garfield	Detected
0	15	21
1	20	18
2	16	12
3	13	13
4	18	18
5	14	10
..	...	...



SNR = ∞ ; Detected clusters vs Impact Points





1000 ev
Dead Time = 1 ns

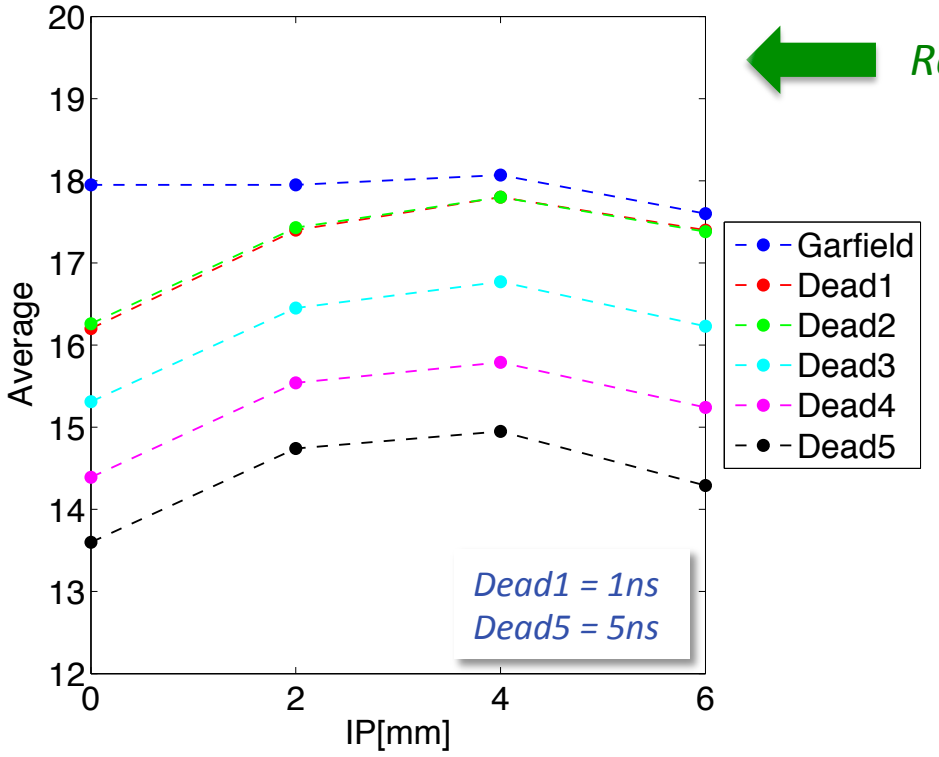
Electrons diffusion effect ?!

Efficiency @ IP=0 mm ≈ 91%

Efficiency estimate ≈ 94.5%

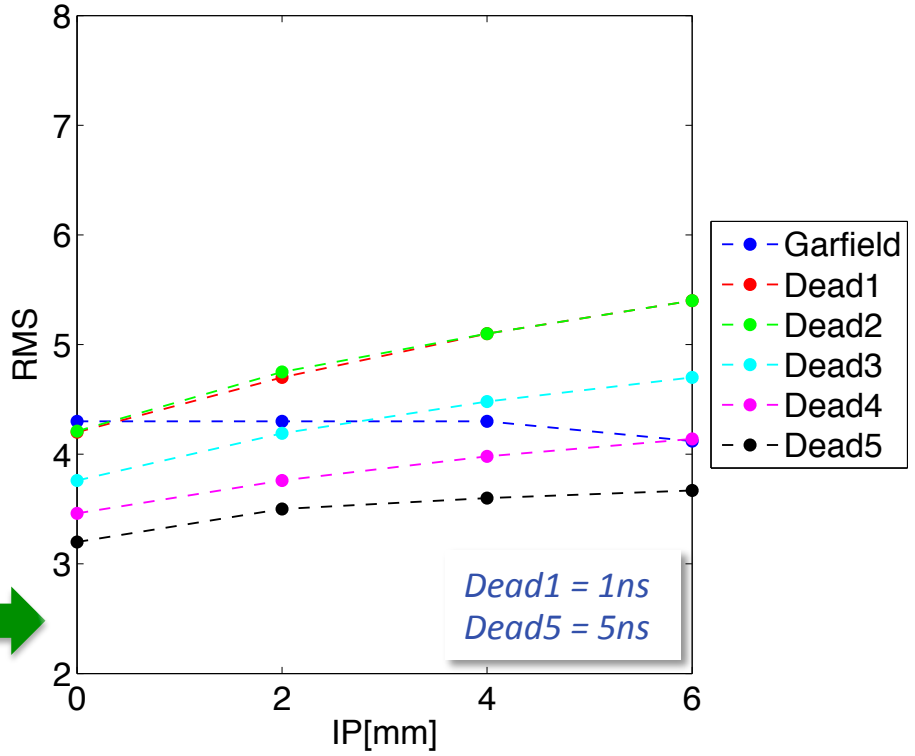
- $V_{DRIFT} \approx 12$ mm/μs
- $N_P \approx 13.3$/cm
- Dead Time = 1ns

SNR = ∞ ; Detected clusters vs Dead Time

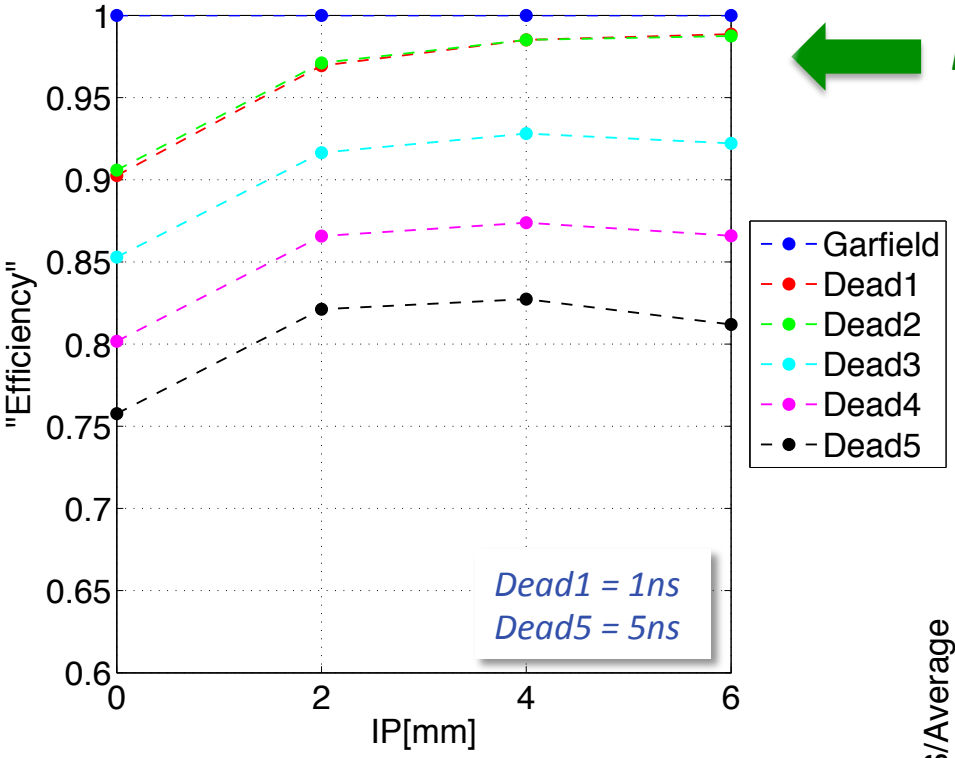


Reconstructed Clusters (average) vs Dead Time

Reconstructed Clusters (rms) vs Dead Time

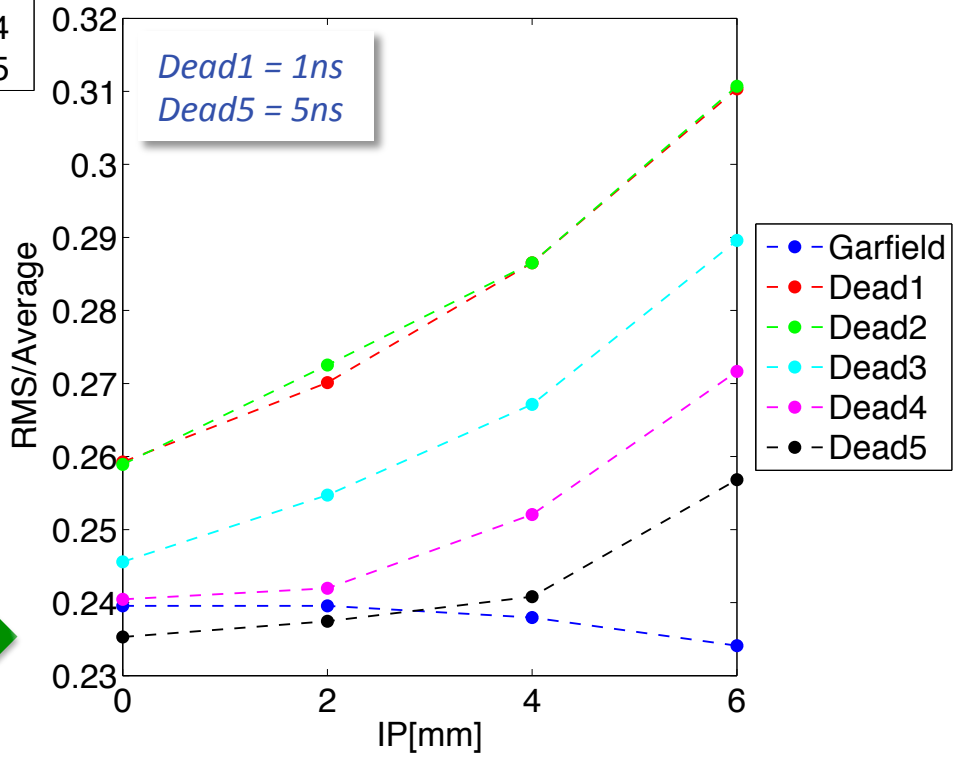


SNR = ∞ - "Efficiency" & "Quality Factor" vs Dead Time



Detection "Efficiency" vs Dead Time

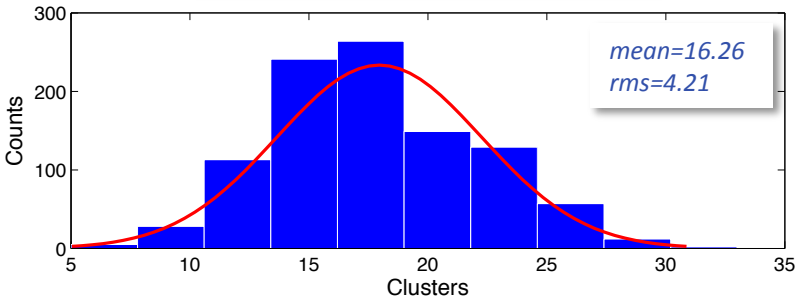
"Quality Factor" vs Dead Time



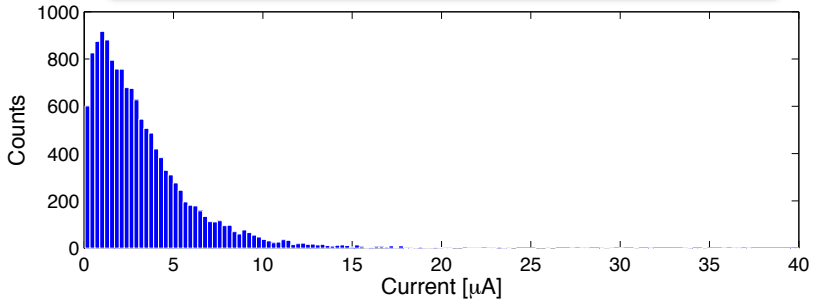
Signal SNR effects on cluster detection

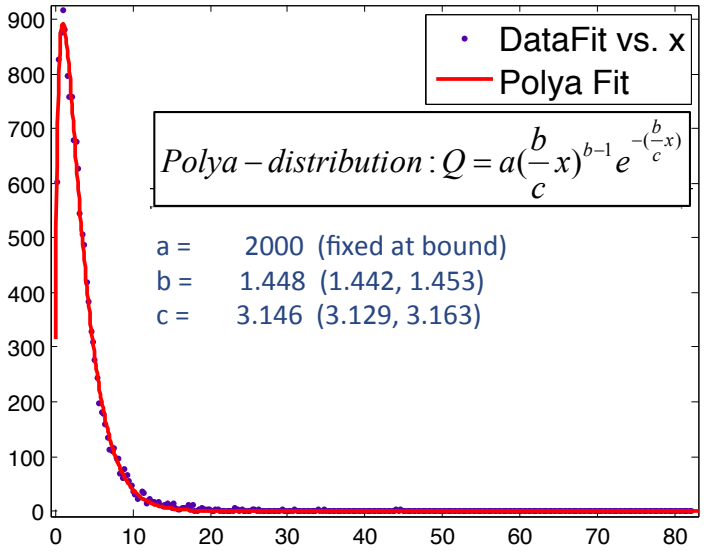
SNR = ∞ ; Average signal estimation

Cluster Distribution @ IP = 0



Cluster Amplitude Distribution @ IP = 0

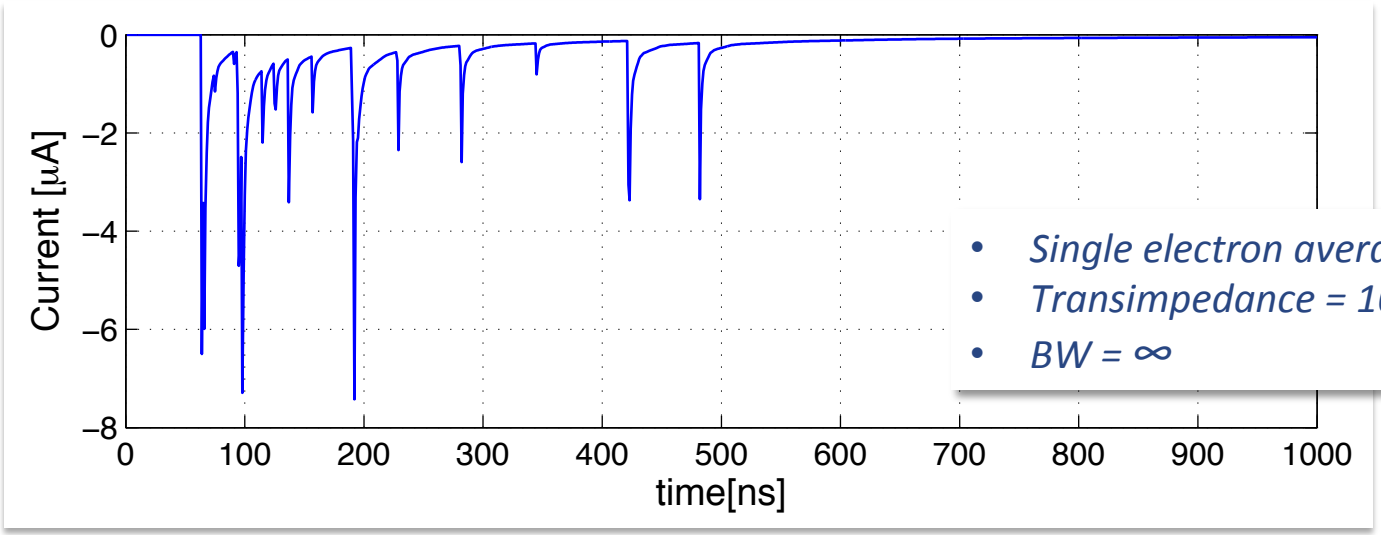




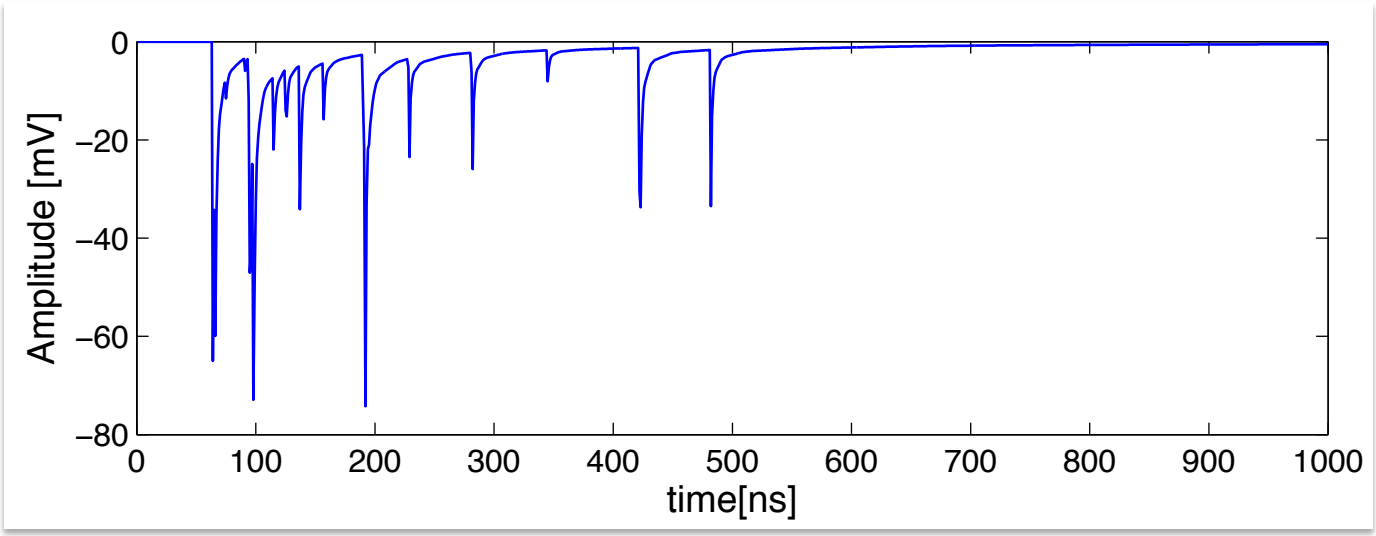
IP	<Current>
0	-3.146
2mm	-3.609
4mm	-3.699
6mm	-3.325
average	3.445

- *Average current ≈ 3.445 μA*
- *He/Iso-90/10 average cluster multiplicity ≈ 1.6*
- *Single electron average current ≈ 2.1 μA*

SNR = ∞ ; BW= ∞ ; 10kΩ transimpedance

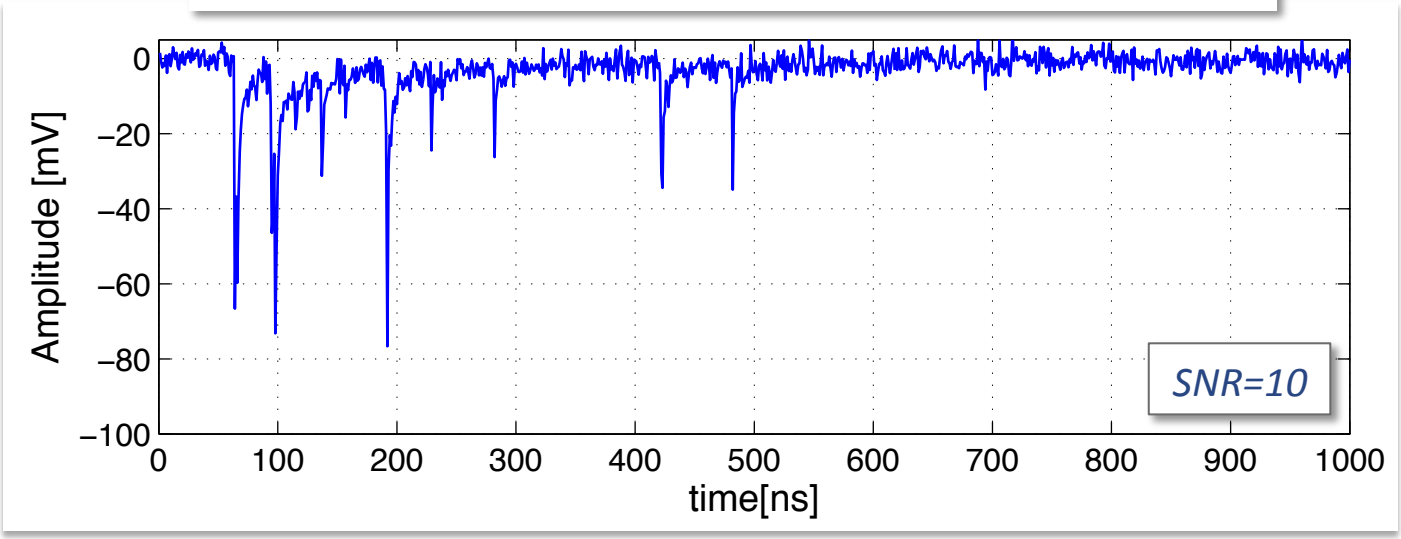


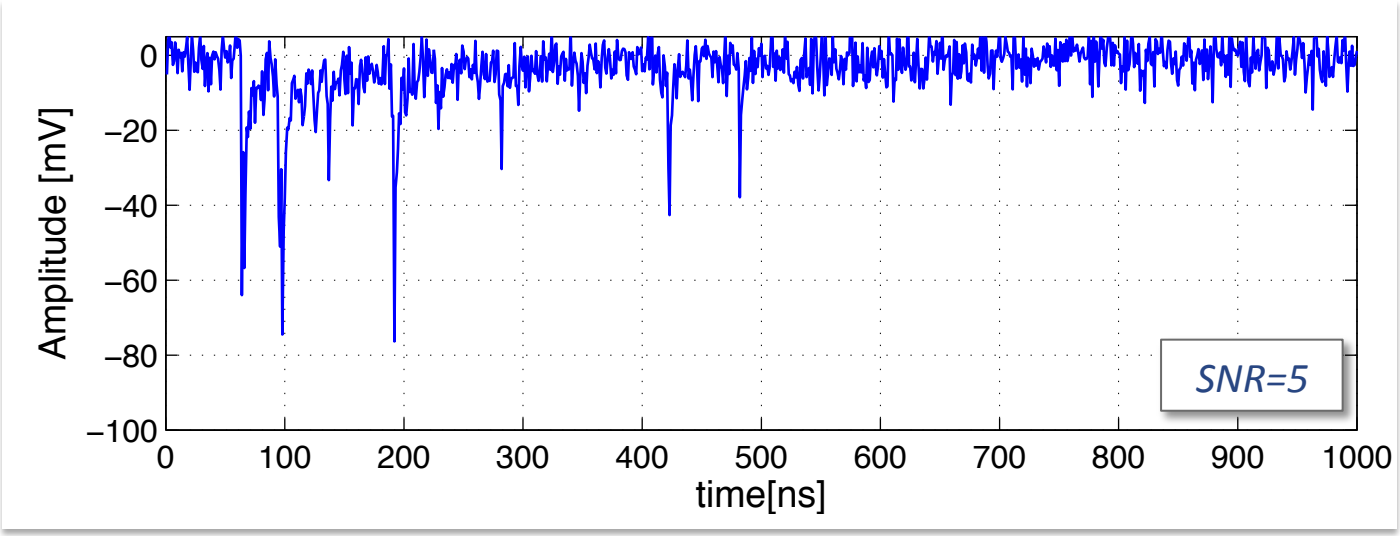
- *Single electron average current ≈ 2.1 μA*
- *Transimpedance = 10 kΩ*
- *BW = ∞*



BW= ∞ ; 10kΩ transimpedance ; Noise

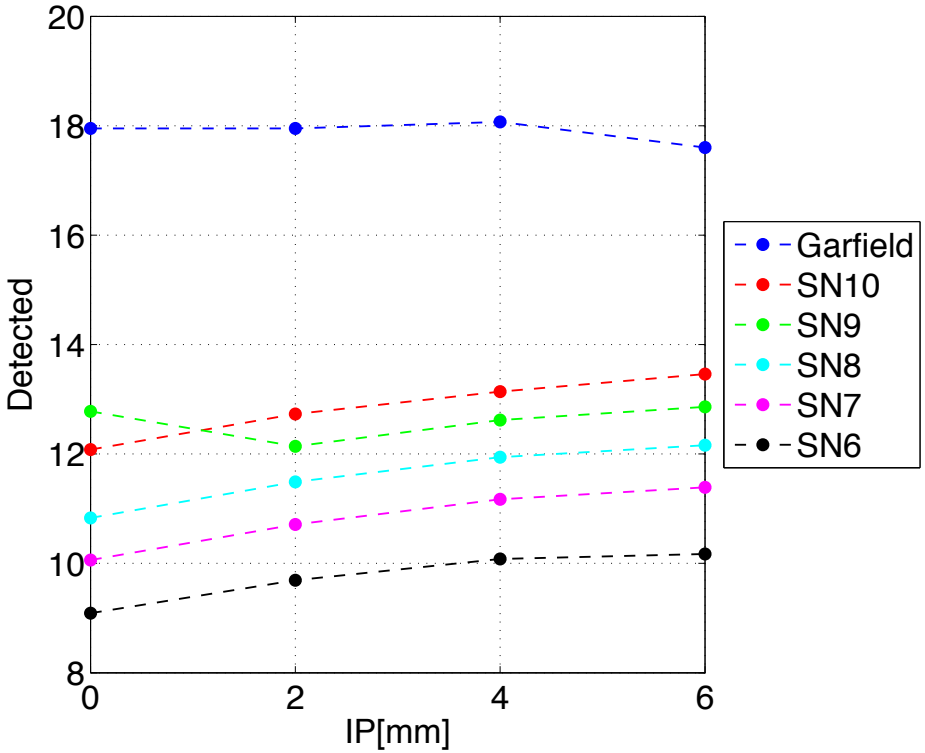
Linear combination of Gaussian noise and white noise normalized to the average single electron cluster amplitude

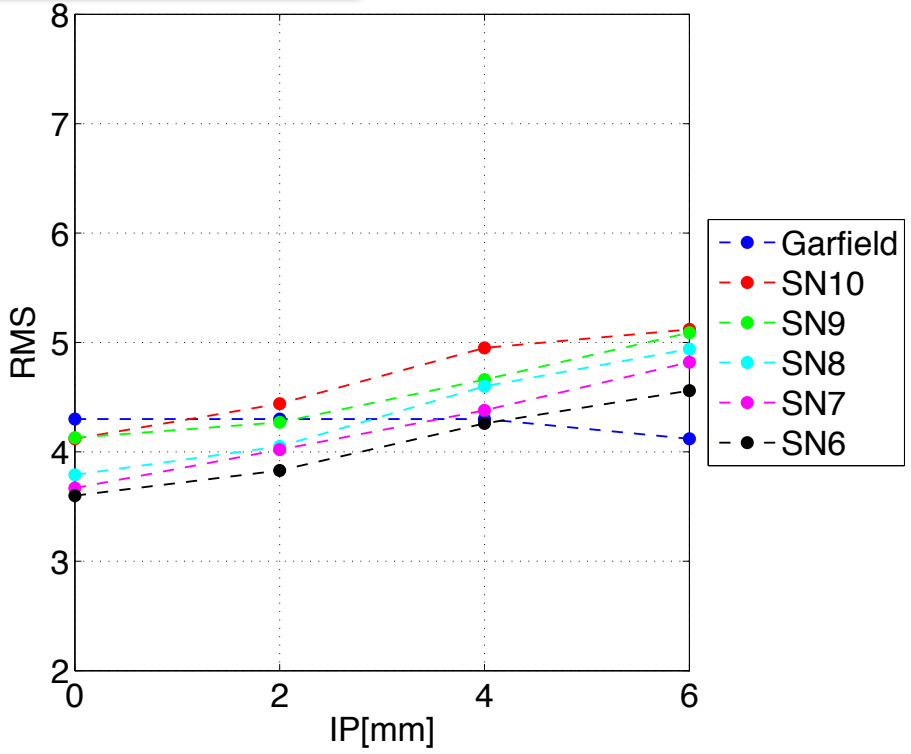




Detected clusters (average & rms) vs SNR

BW= ∞ ; 10kΩ transimpedance ; Noise; Dt=2 ns





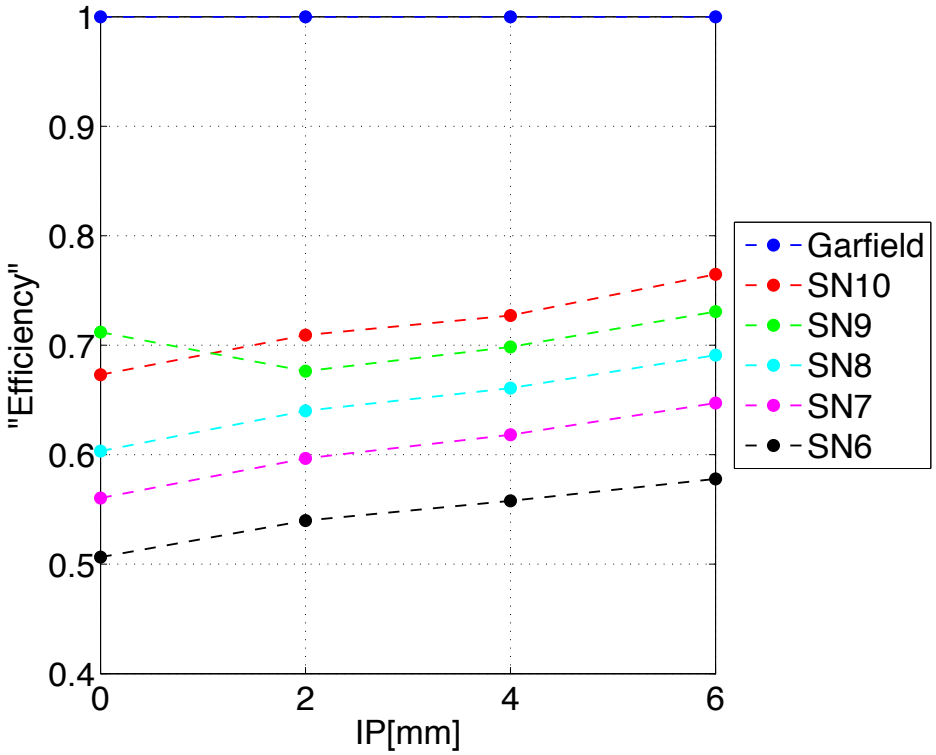
$$D = A_n - \left(\frac{A_{n-1} + A_{n+1}}{2}\right) \geq 4\sigma_d$$

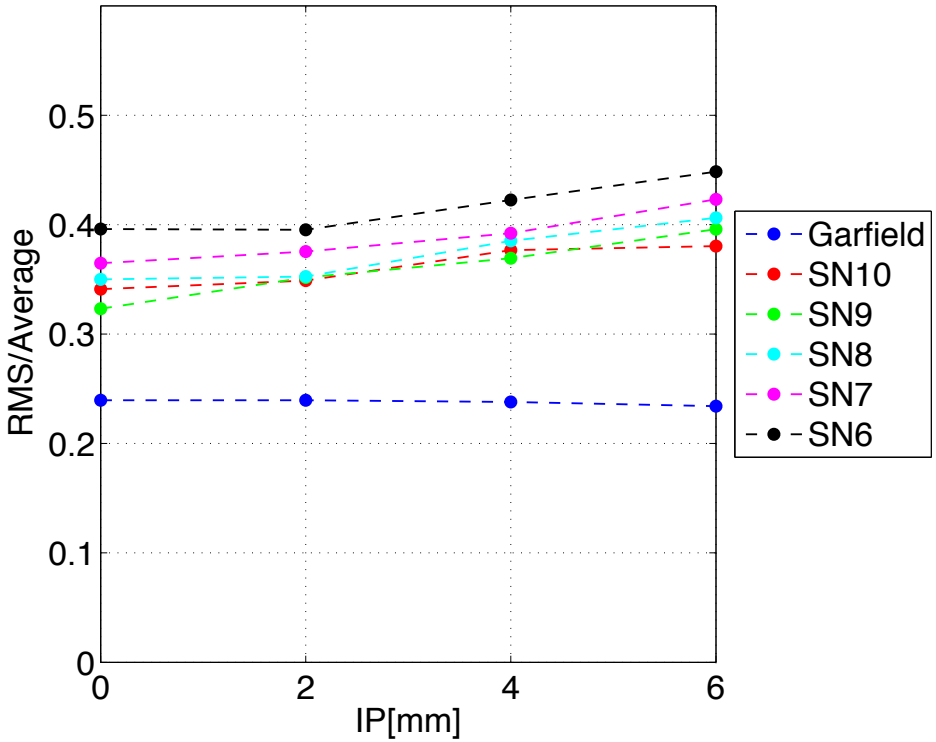
Peak Found Condition

Luigi Cappelli
on behalf of CLUTIM Group

Detected clusters (efficiency & "quality factor") vs SNR

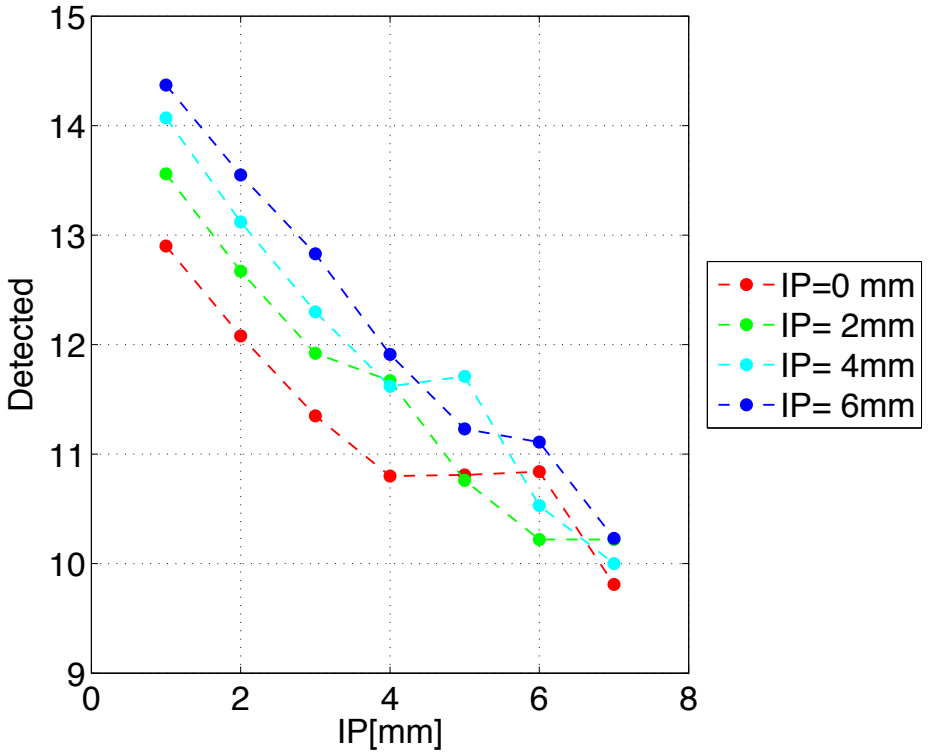
BW= ∞ ; 10kΩ transimpedance ; Noise; Dt=2 ns

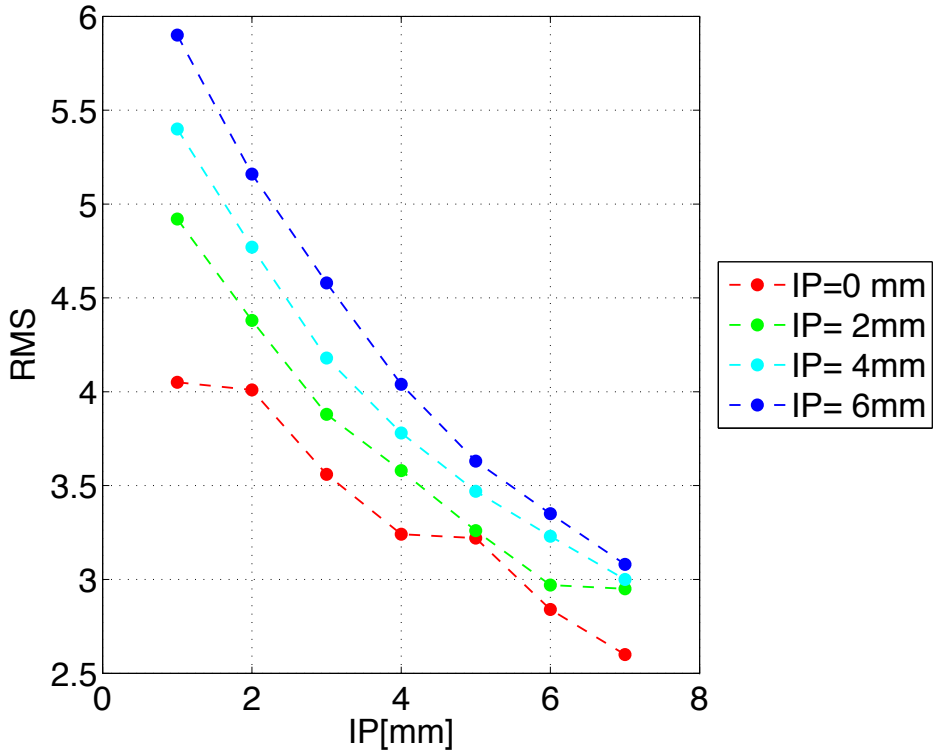




Detected clusters (average & rms) vs SNR

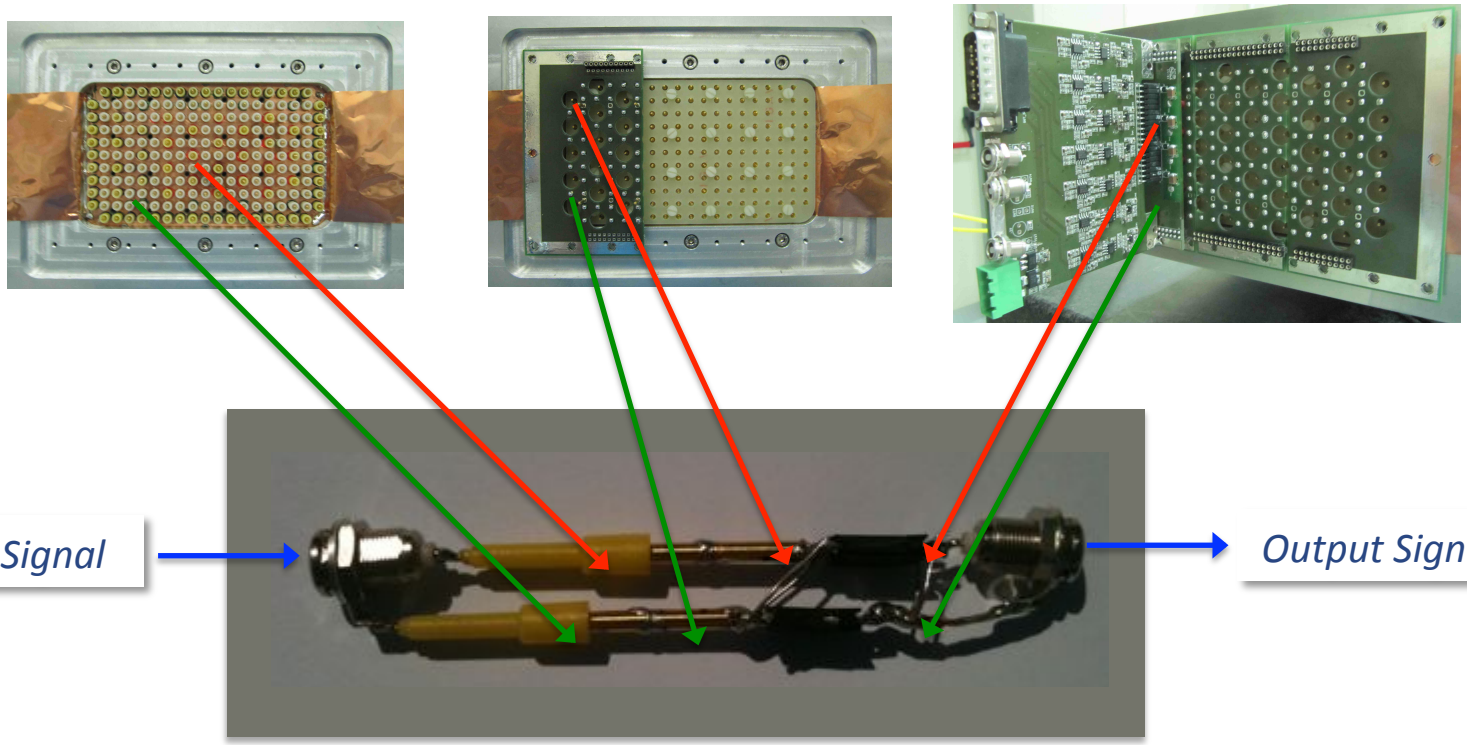
BW= ∞ ; 10kΩ transimpedance ; Noise; Dt= 1-7 ns





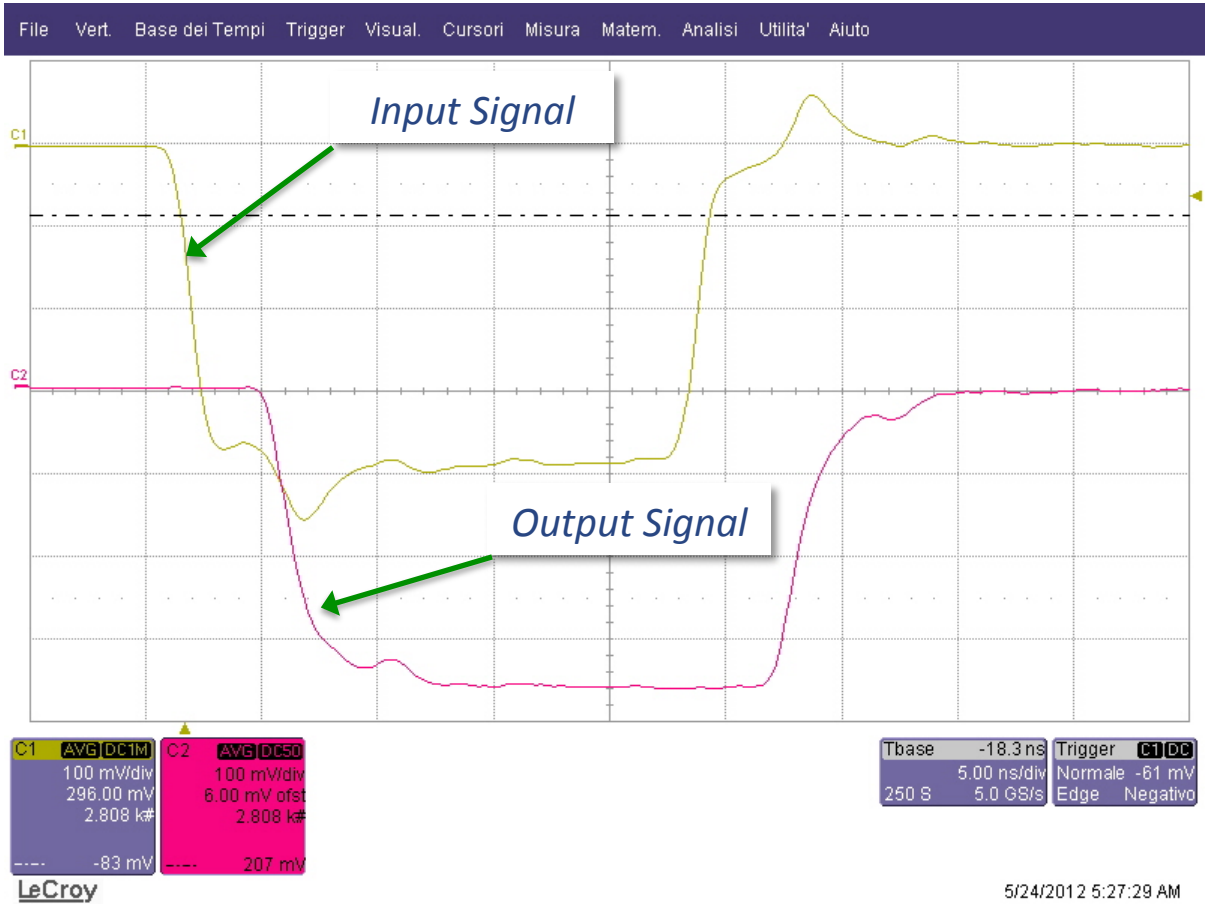
ON-DETECTOR interconnections effect on signal BW

Sense wire - Preamplifier interconnections BW (I)



Sense Wire – Preamplifier – GND Interconnections

Feedthrough-Preamplifier interconnections BW (II)



DCH FEE TDR contents

Standard Readout
(dE/dx based on charge measurements)

Sampled Waveform
(dE/dx based on Cluster Counting)

Common features

Conclusions & To Do

- *According to Garfield simulations diffusion has a not negligible effect on detected "clusters" for impact points far from sense wires ("extra counting")*
- *Dead Time insertion on detected cluster algorithm can, partially, compensate the effect of "extra counting"*
- *Signal SNR is critical for correct counting. Simple peak finding algorithm applied to Garfield simulated signal shows that SNR should be grater than 8*
- *Interconnections between Sense Wires and ON-DETECTOR electronics must be carefully designed to avoid signal or BW distortion*
- *Finalize TDR DCH FEE section & LVPS requirements*
- *Analysis on Garfield data sets using more advanced (and time consuming) algorithms*
- *Evaluate contribution of sense wire resistance on signal propagation*