Sci-Fi tracker for IT replacement

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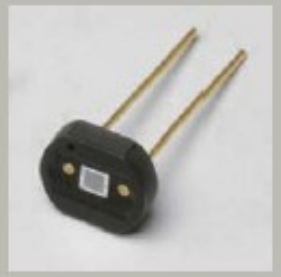
Commercial available SiPMs (MPPCs) from Hamamatsu

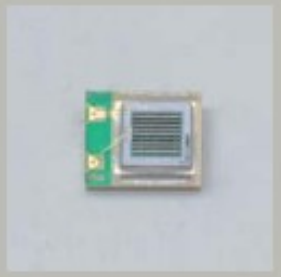
P.5

Active area: 1 × 1 mm type

Metal type



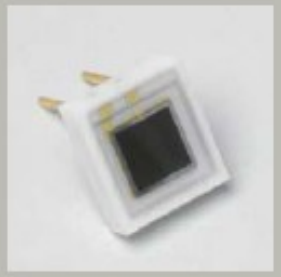
Ceramic type



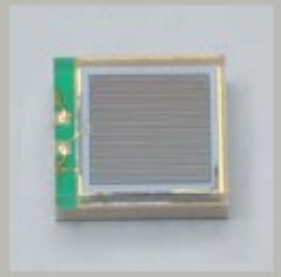
SMD type

P.7

Active area: 3 × 3 mm type



Ceramic type

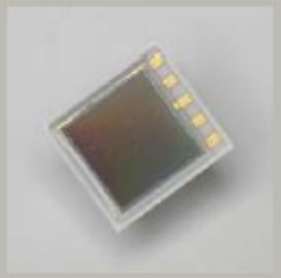


SMD type

P.9

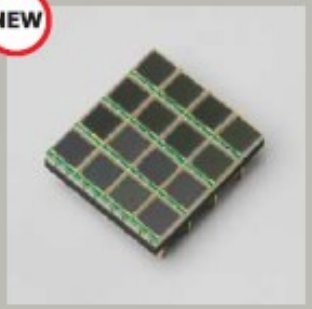
MPPC array

1 × 4 ch type



2 × 2 ch type

NEW



4 × 4 ch type

P.11

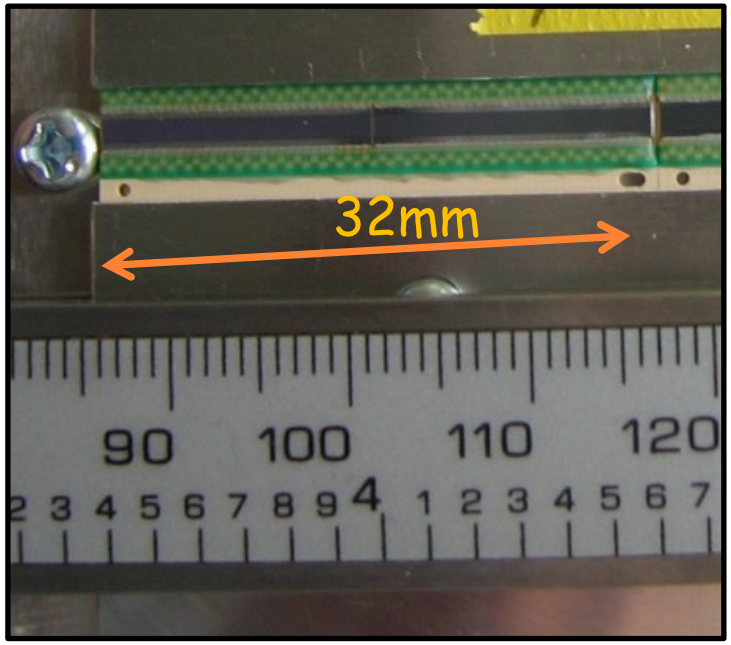
TE-cooled type

NEW

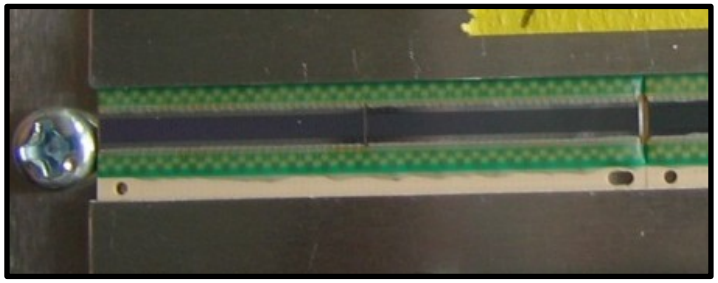
Metal type

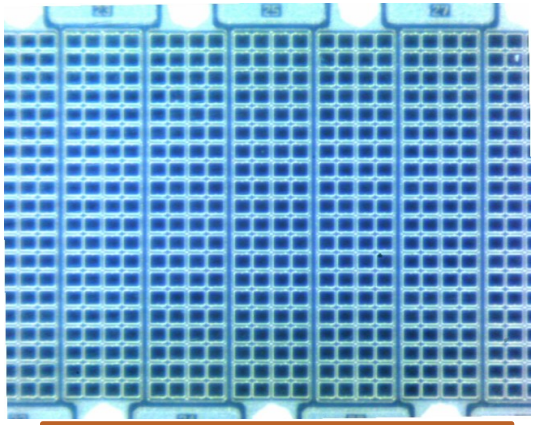
Customized 128 CH MPPC array for Sci-Fi tracker use

- Array optimized for small dead aera between modules
- Optimized for high channel number on one module
- For the use in LHCb and PEBS
  - A_{total}= 0.25mm x 1.2mm x 128
  - A_{pixel}=50um x 50um
  - N_{pixel}=88
  - G=0.75x10^6 e/PE
  - $N_{channel}$ = 128



Fiber tracker for LHCb IT

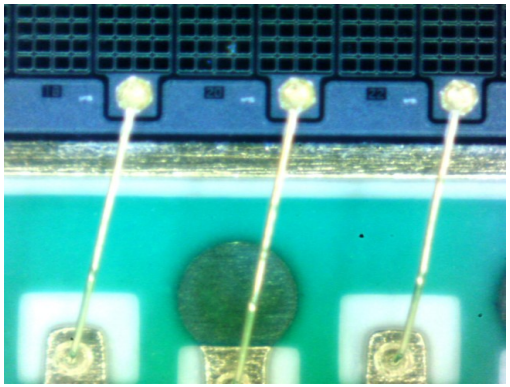




Rectangular channels

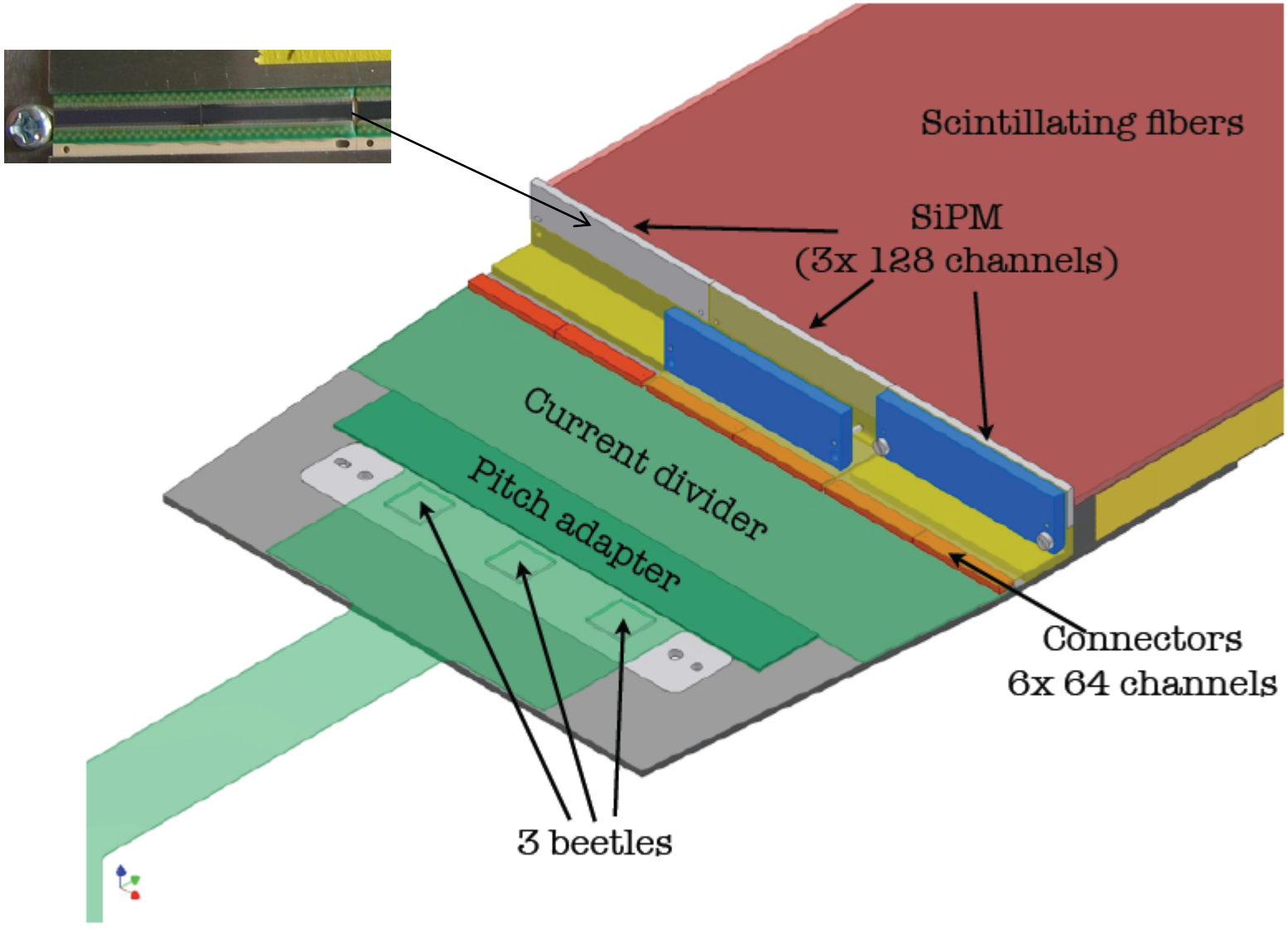
Reduce epoxy layer to decrease diffusion

Cross section view



Bonding wires

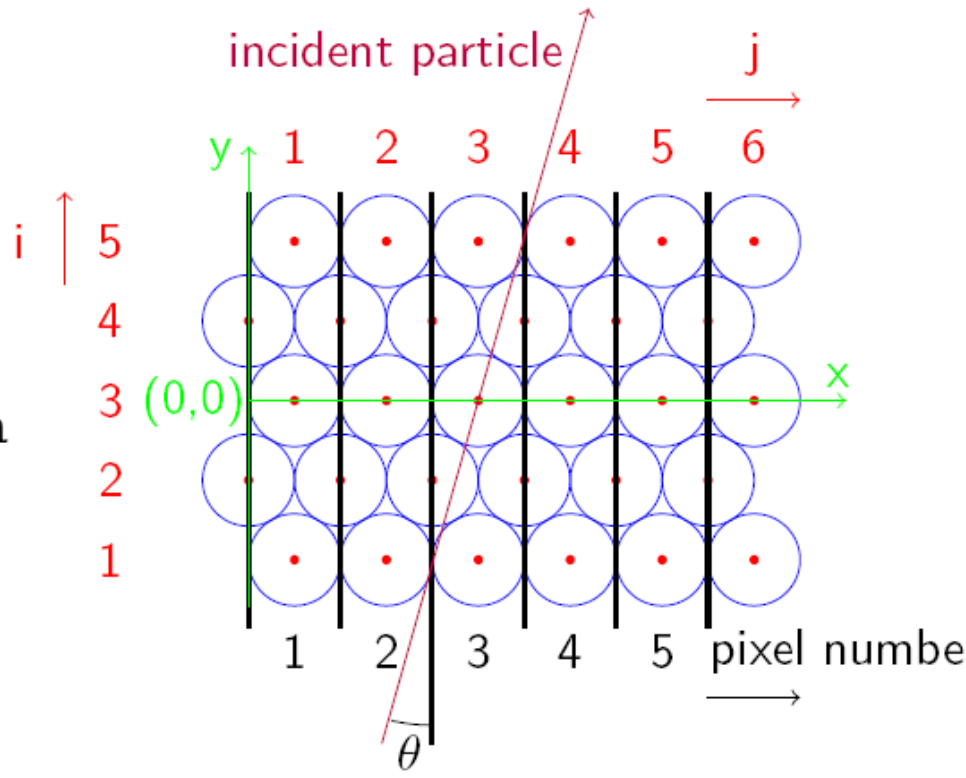
Fiber tracker for LHCb IT

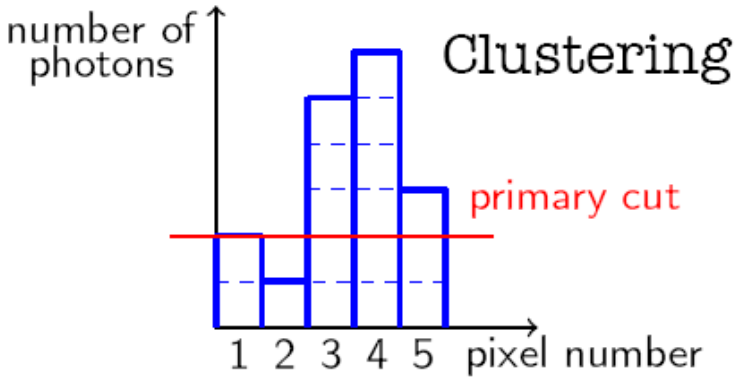


Signal reconstruction

Pierre Jaton

- 5 layers of 250µm fibers
- readout in 250µm 1100µm channels
- standalone simulation to study effects of:
  - integrated photon collection efficiency (assume 20pe/mm)
  - noise (assume 0.3pe/channel)
  - track angle (up to ±10°)
  - gaps / dead regions
  - saturation

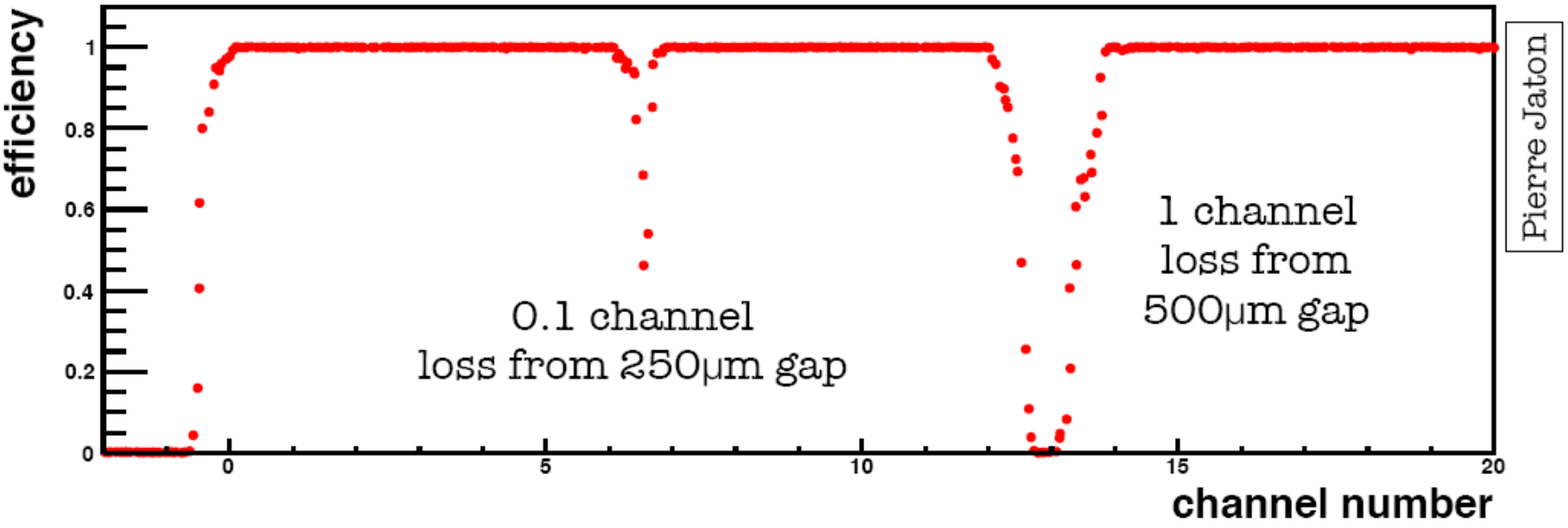




- **Efficiency >99.9%** with 1 noise / 1000 signal clusters

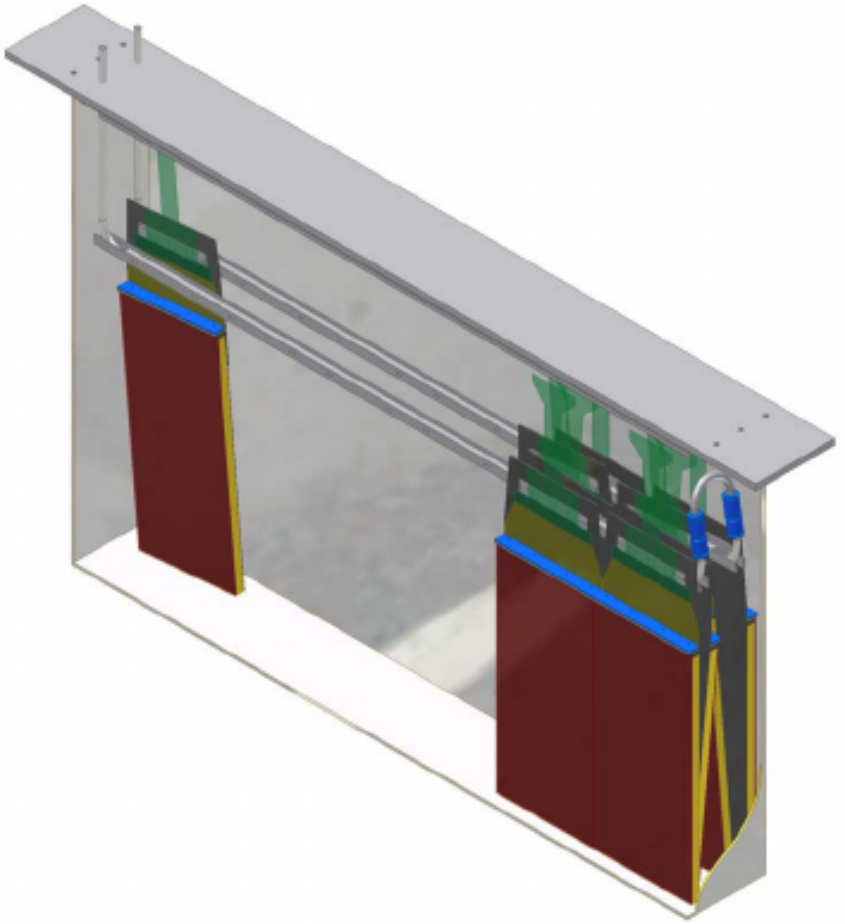
(In-)efficiency in readout gaps

- Simulated inactive SiPM channels:
  - 250μm gaps built in SiPM (≡1 channel)
  - 500μm gaps between adjacent sensors (≡2 channels)



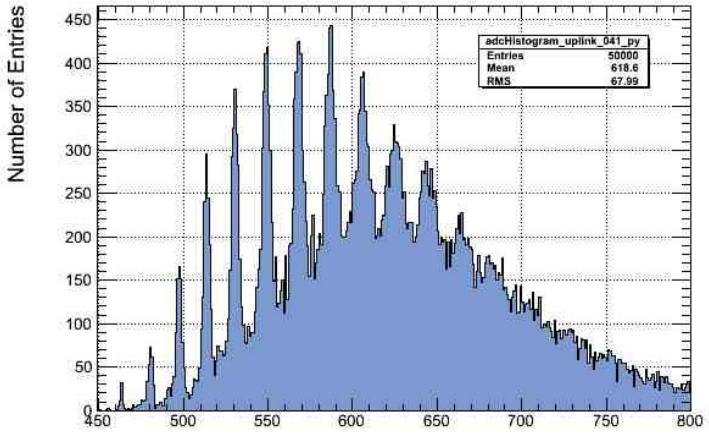
IT replacement detector box

- 6 modules per layer (7 for Silicon IT)
  - all modules at same z => no overlap, 500um readout gap, but no gap in fibers (impact discussed later)
- (X1/U) and (V/X2) layers glued together => better control of the alignment

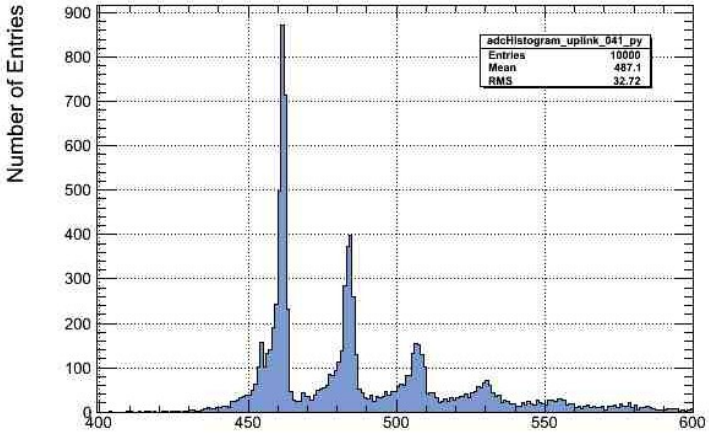


Measurements with 25,50 and 100um pixel detectors

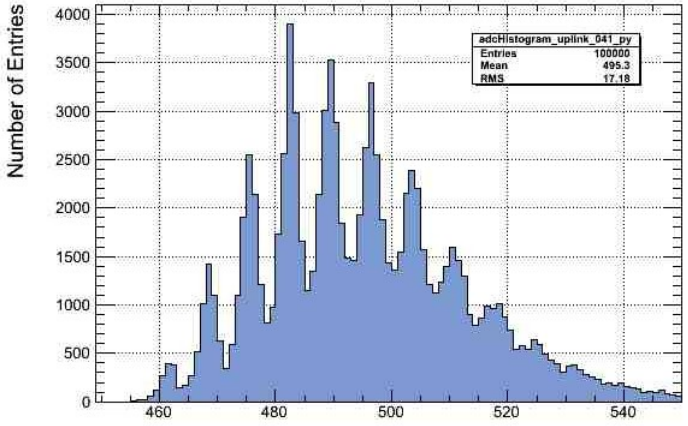
1mm2, 50umx50um
F_{dark}=0.4MHz



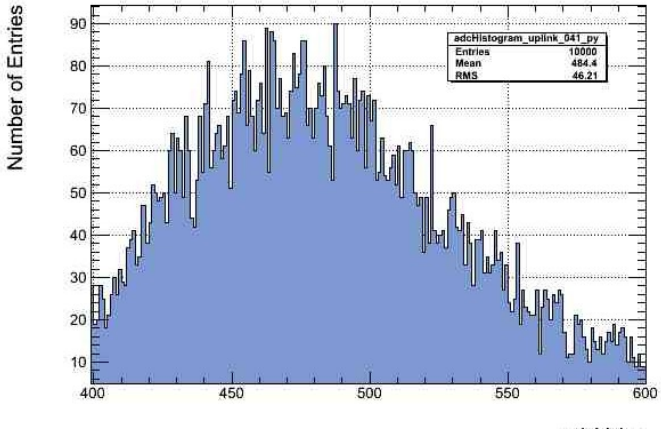
1mm2, 50umx50um



2mm2, 25umx25um
F_{dark}=0.6MHz



9mm2, 100umx100um
F_{dark}=10MHz



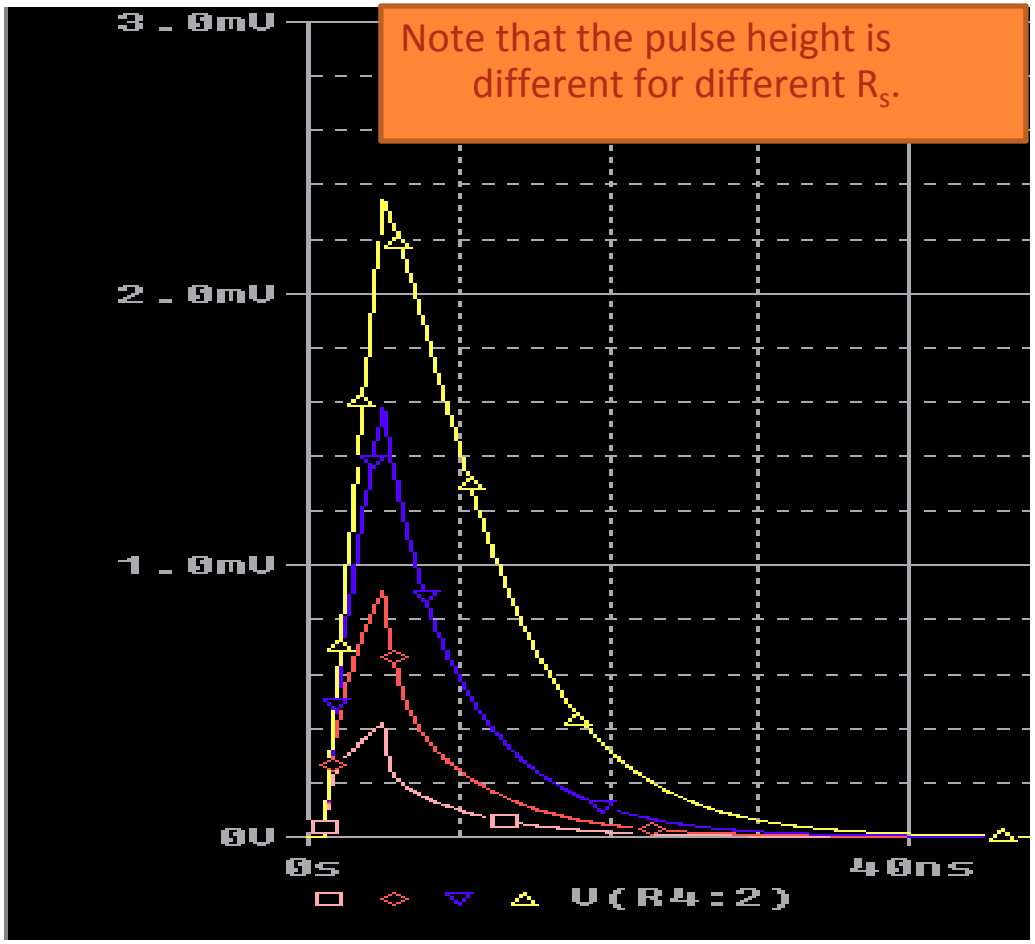
Adaptation of the Beetle input circuit for the use with an SiPM

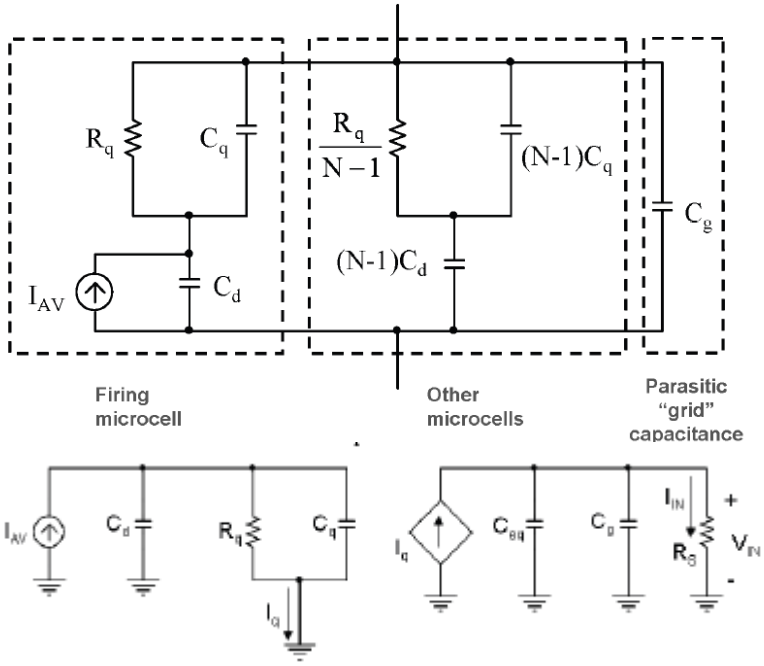
Why do we need an adaption? Difference between the SiPM and the silicon strip readout.

	Silicon strip	SiPM 0.25mmx1.2mm 50um pixel
Detector capacitance	10-15pF	10pF
Gain	22ke/MIP (300um Si)	$0.75*10^6$/Pe (15Pe /MIP)
Rel Gain / MIP	1	511
Load resister required for fast readout (25ns)	~1kOhm	100-200 Ohm
Dynamic range	0..5MIP	0..3MIP (reduce signal by 300)

Model of SiPM (1mmx1mm, 50um pixel) voltage on R_s

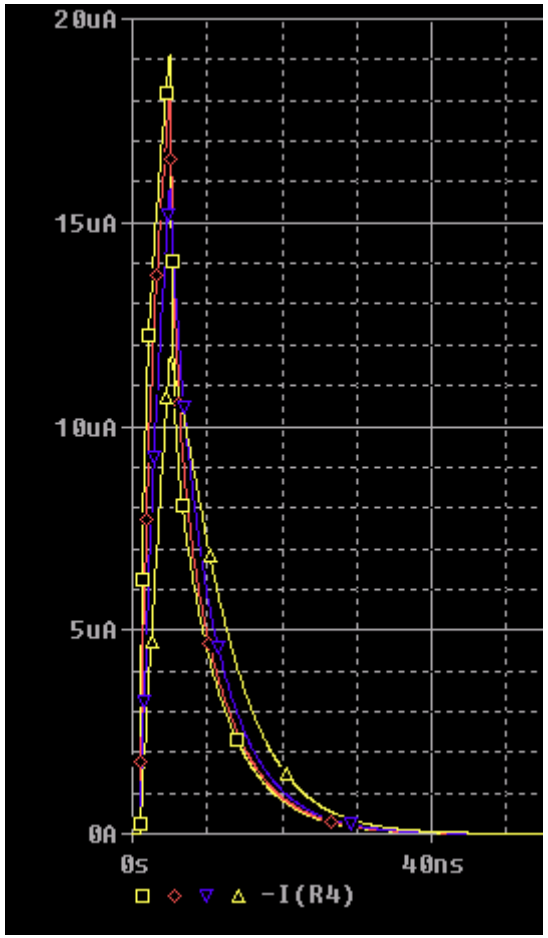
Adjusted the model of the SiPM to the measured pulses, the graphs show voltage on Rs

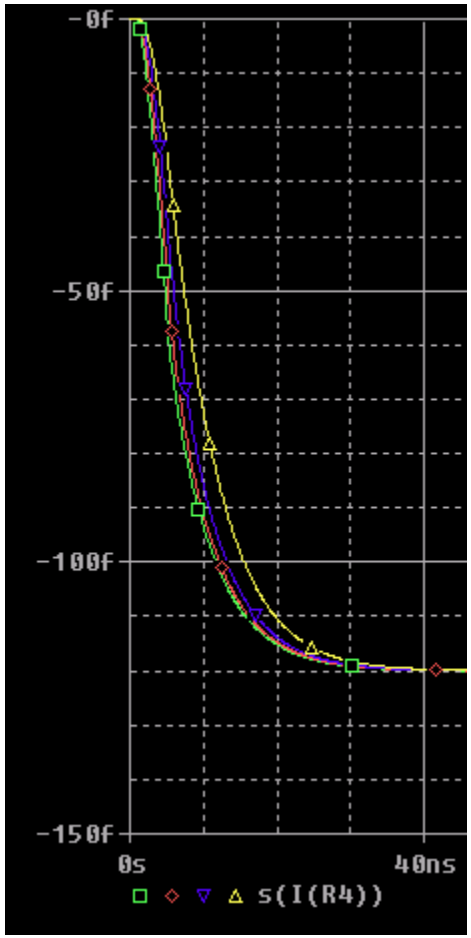




Model of SiPM (1mmx1mm, 50um pixel) Charge Q

Adjusted the model of the SiPM to the measured pulses, the graphs show the current and the charge injected to the Beetle from the





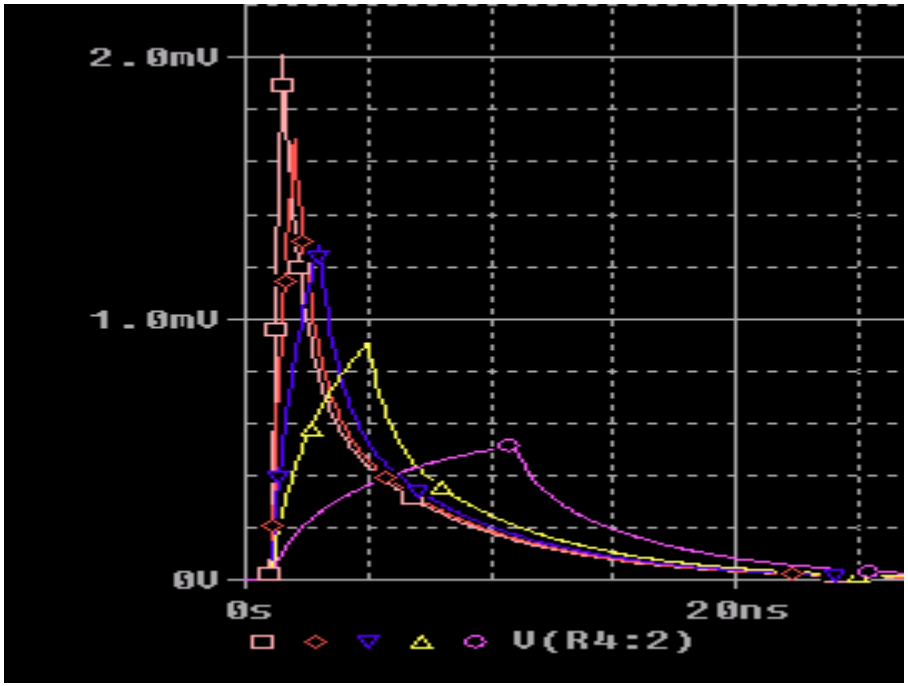
120fC = $0.75*10^6$e

The simulation shows the values for different R_s.

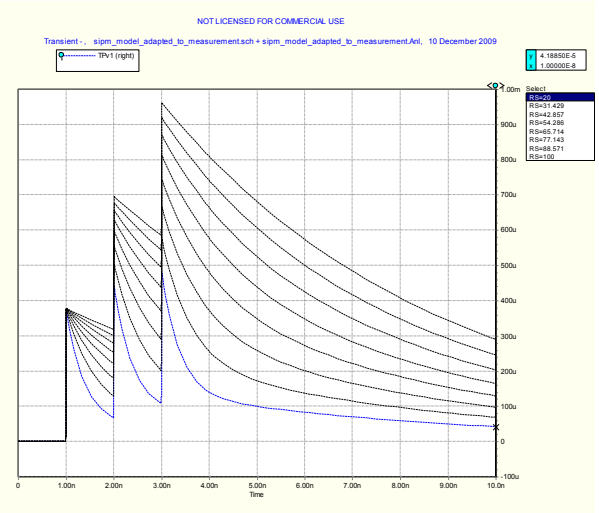
The charge is equal for all R_s

Beetle response for different injection time

The arrival of several photons on the detector slows down the rise time of the pulse of the detector measured at Rs, this doesn't result in a different charge injected. The falling edge fast time constant is responsible for a partial discharge during the arrival of the different photons.



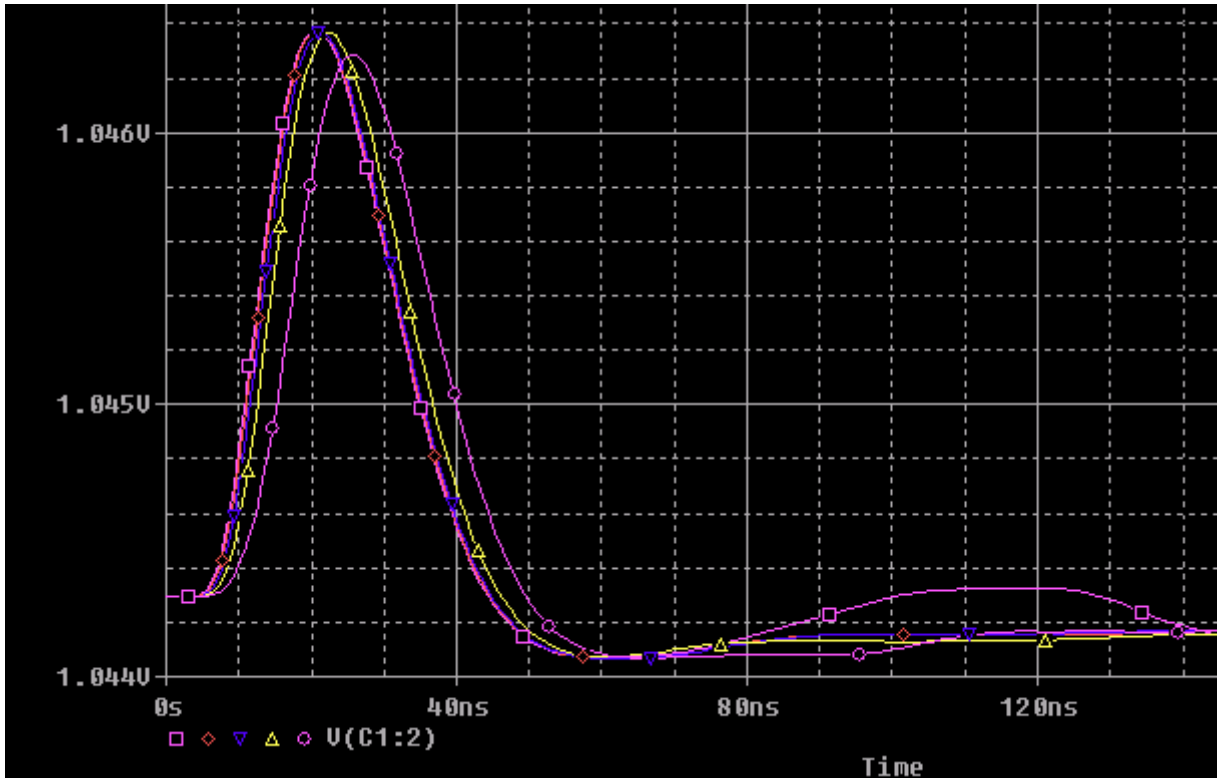
Note that the pulse height is different for different length o interval of injection time.



Beetle response with SiPM signal

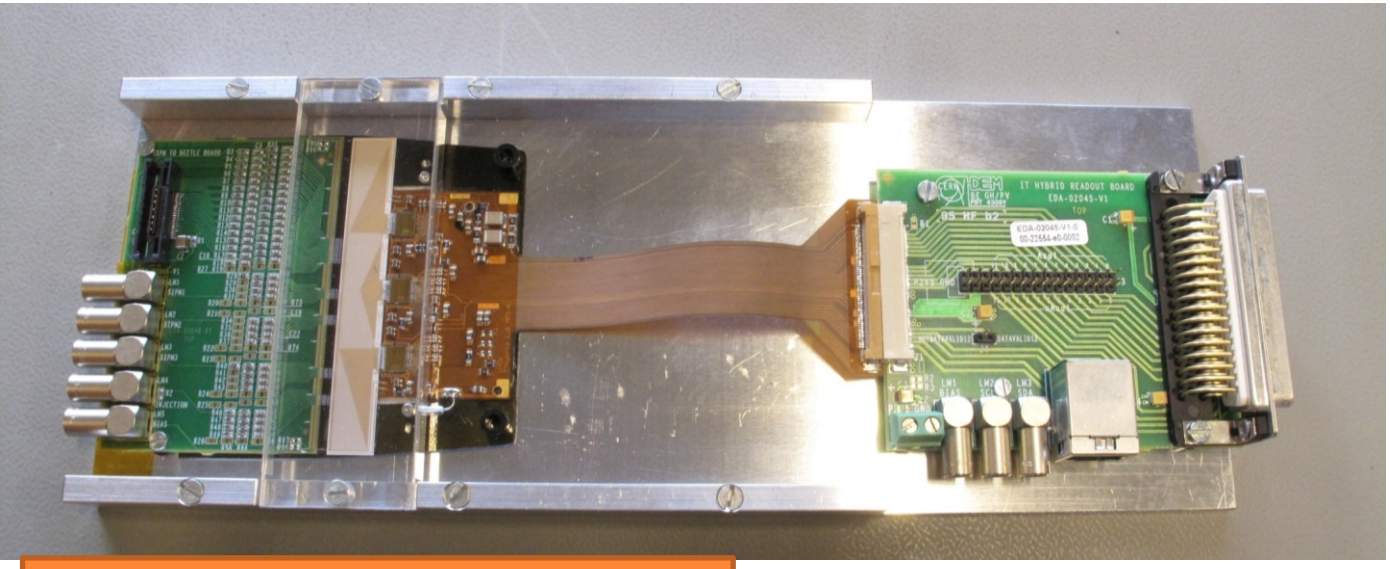
Different injection interval (0.5ns, 1ns, 2ns, 4ns, and 10ns) to observe the effect of the arrival of a pulse with different arrivals of the photons.

R-R current divider is used.



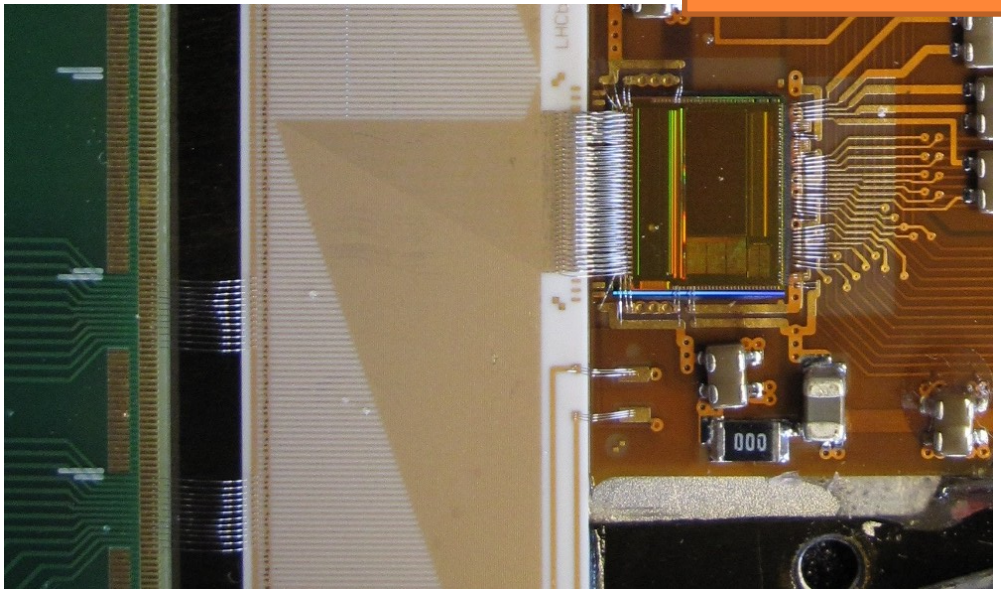
Only with 10ns some degradation is observed. Response height is almost the same.

Injection prototype with Beetle FE chip

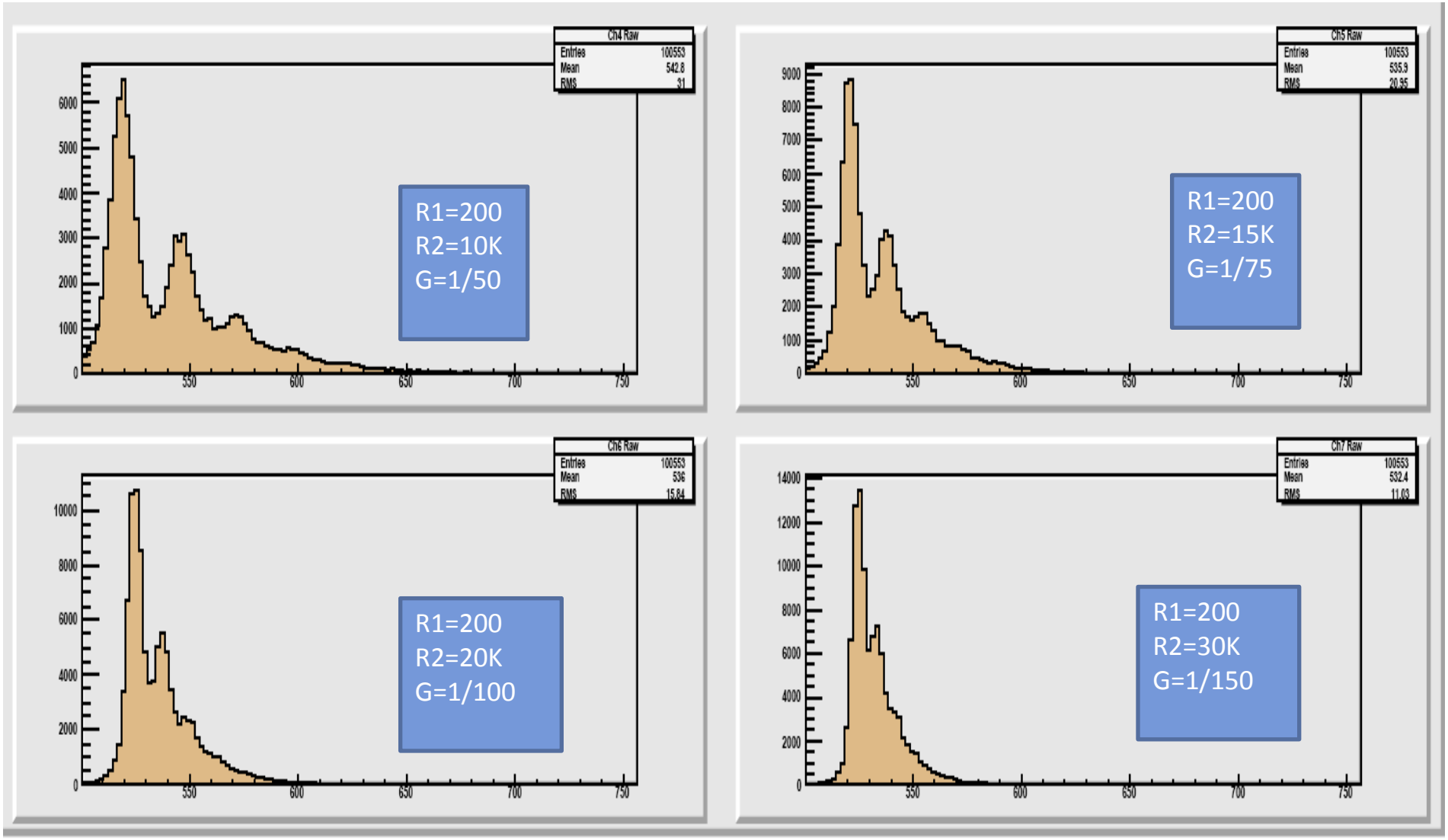


- Use the IT hybrid with Beetle 1.3
- Using the Velo analog data signal chain for DAQ (repeater, analog cable, ADC on Tell1
- Attenuator test circuit bonded to pitch adapter

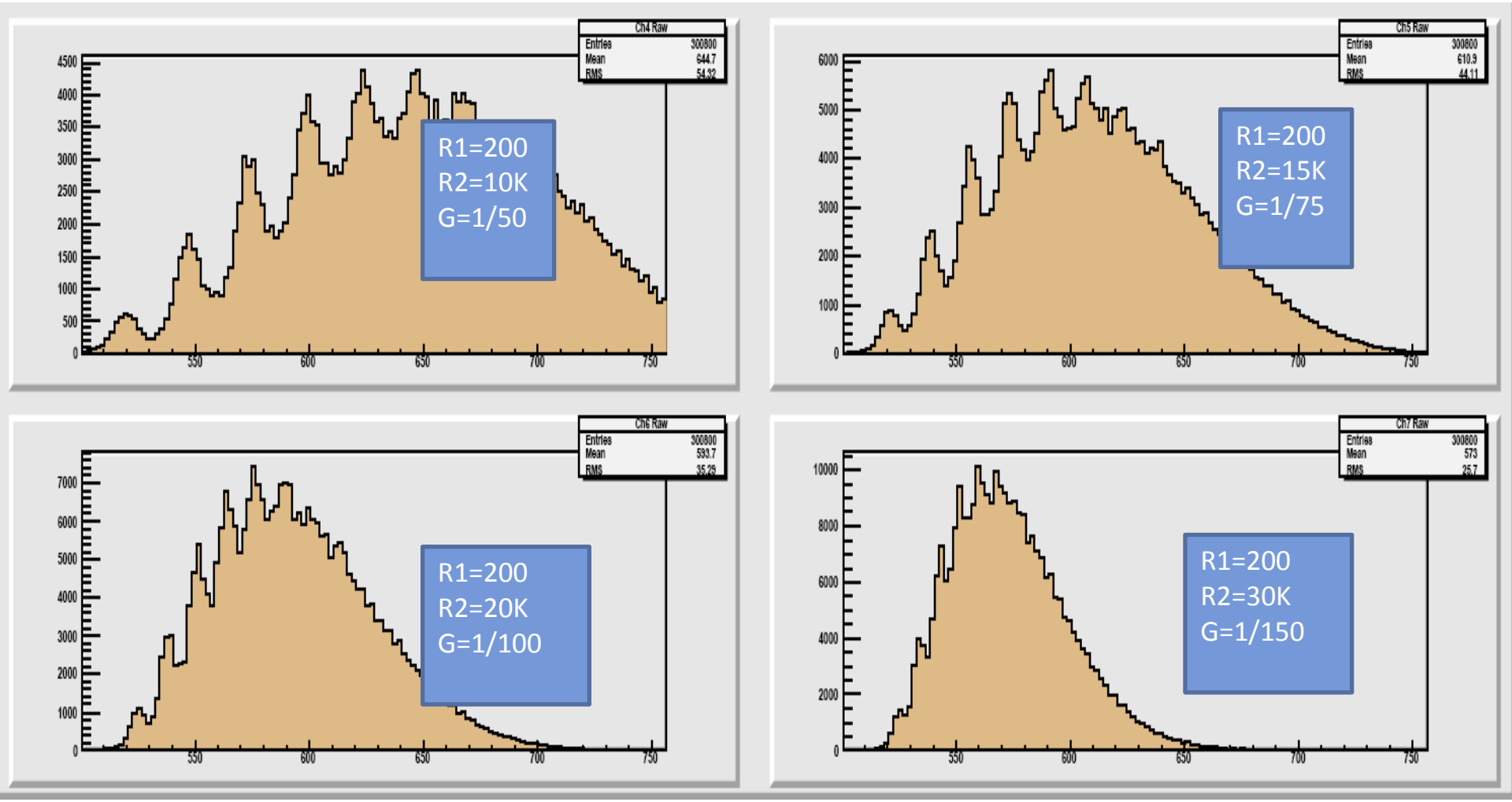
Beetle 1.3 IT hybrid



Use very low number of photons

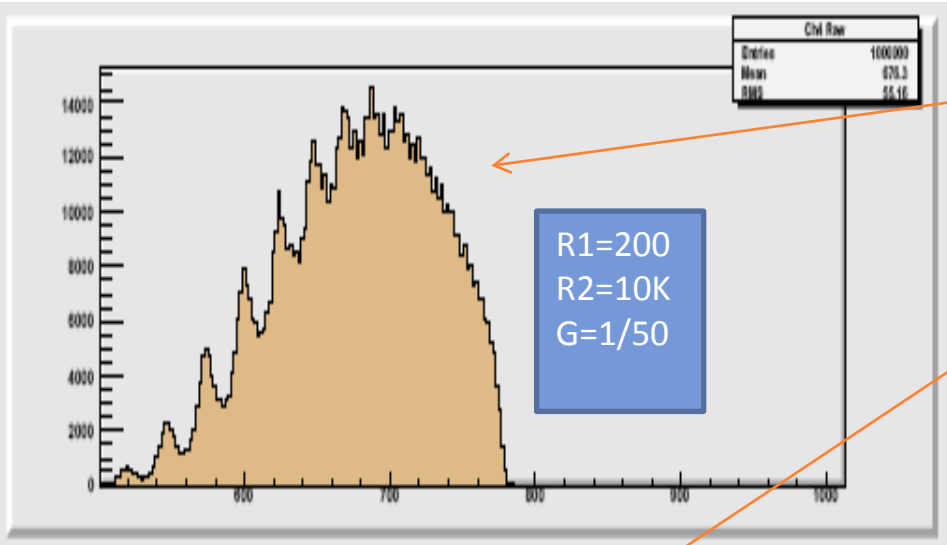


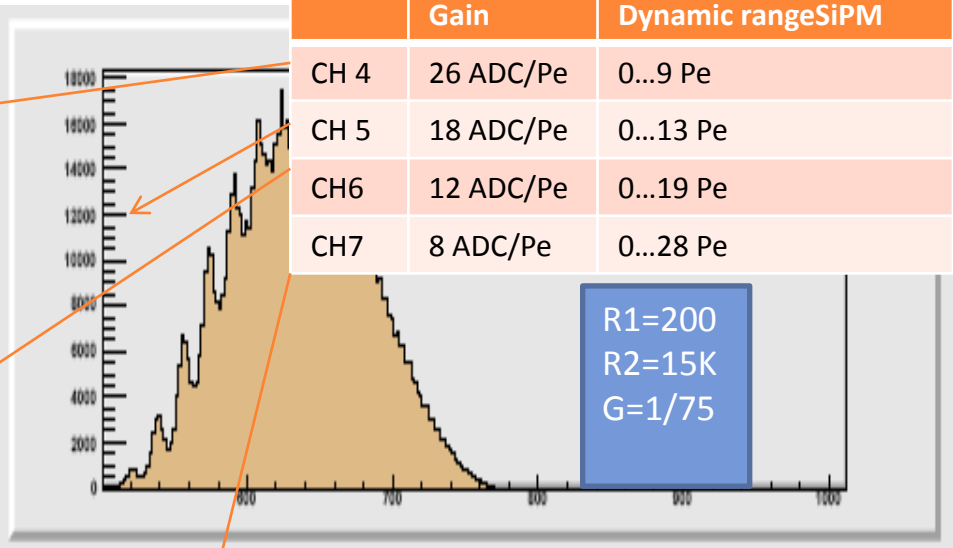
Inject more photons

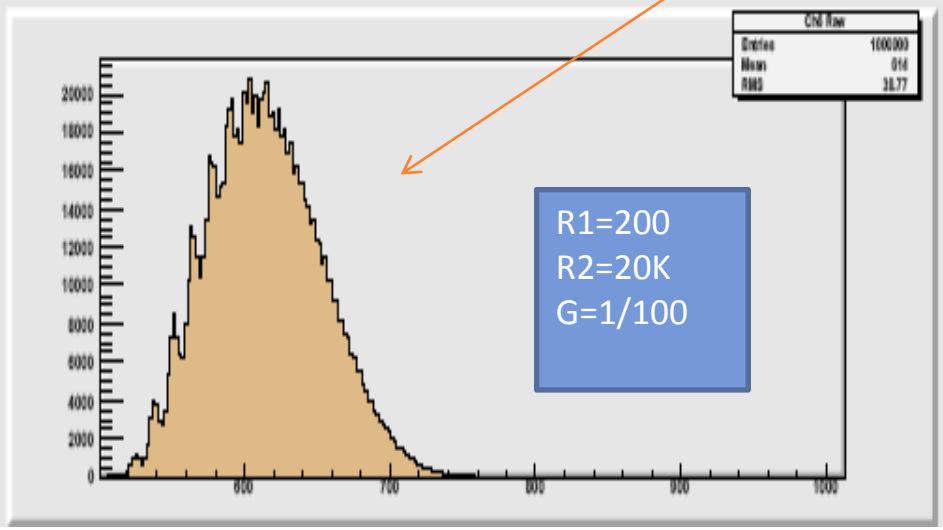


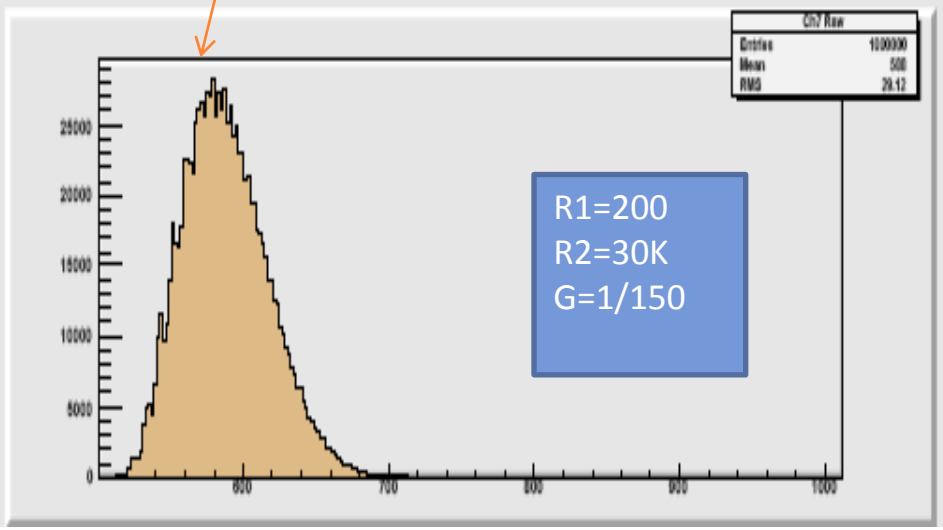
Inject more photons, saturation for the highest gain channels sets in

	Gain	Dynamic rangeSiPM
CH 4	26 ADC/Pe	0…9 Pe
CH 5	18 ADC/Pe	0…13 Pe
CH6	12 ADC/Pe	0…19 Pe
CH7	8 ADC/Pe	0…28 Pe









Outlook (electronics view)

- Designing new IT hybrids with current divider integrated
- Designing flex PCB modules for 128CH MPPC modules
- Characterize electronics performance (noise and dynamic range)
- Integrating Sci-Fi modules with IT replacement dimensions produced by Aachen PEBS group
- Further radiation tests
  - Testing shielded box
  - Testing SiPM irradiated by LHCb