CDR on CEPC ECal

Tao Hu

IHEP

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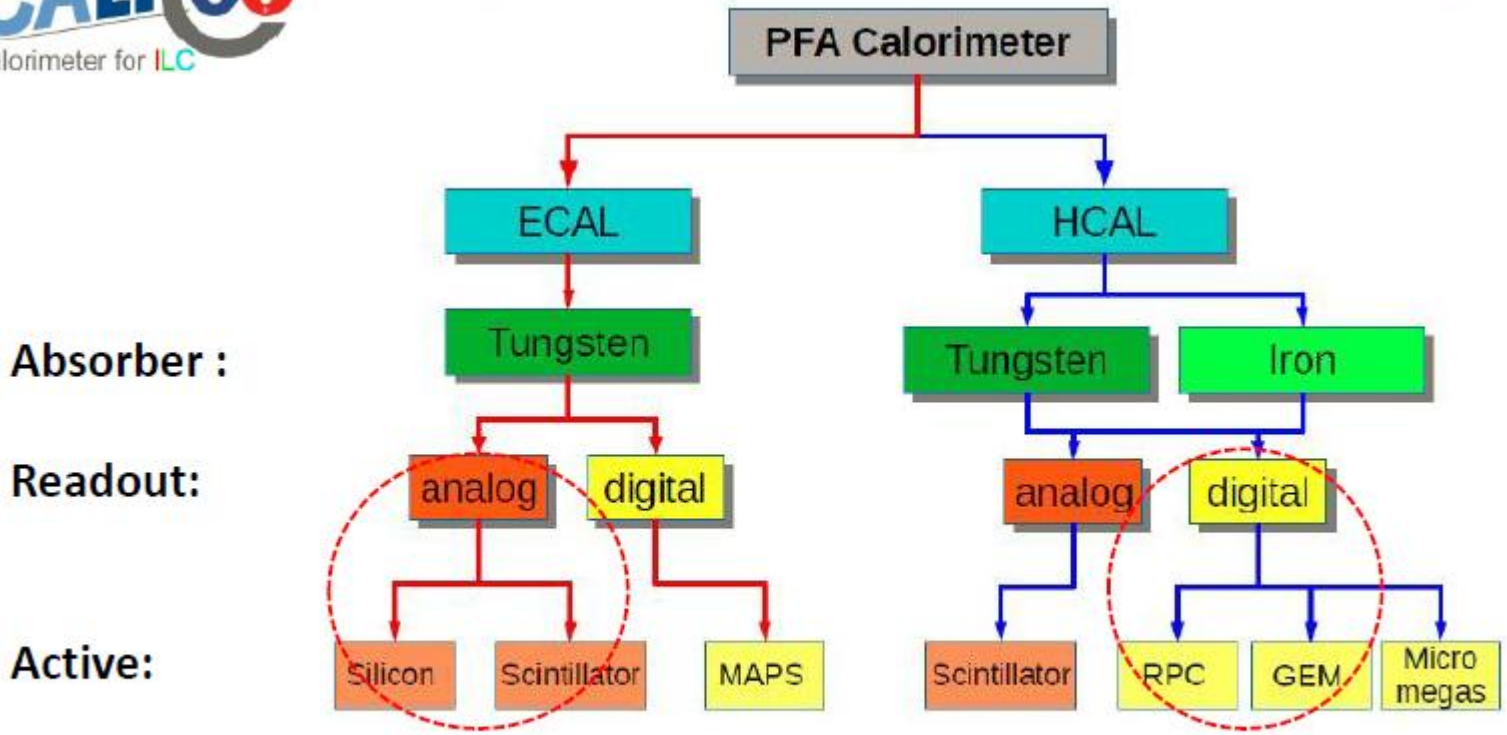
Contents

Global R&D of Imaging Calorimeters

CALICE Calorimeter for ILC

https://twiki.cern.ch/twiki/bin/view/CALICE/CalicePapers



Readout cell size: 144 - 9 cm^2 → 4.5 cm^2 → 1 cm^2 → 0.25 cm^2 → 0.13 cm^2 → 2.5×10^{-5} cm^2

Technology:	Scintillator + SiPM/MPPC	Scintillator + SiPM/MPPC	Gas detectors Silicon	Silicon	Silicon	Silicon (MAPS)

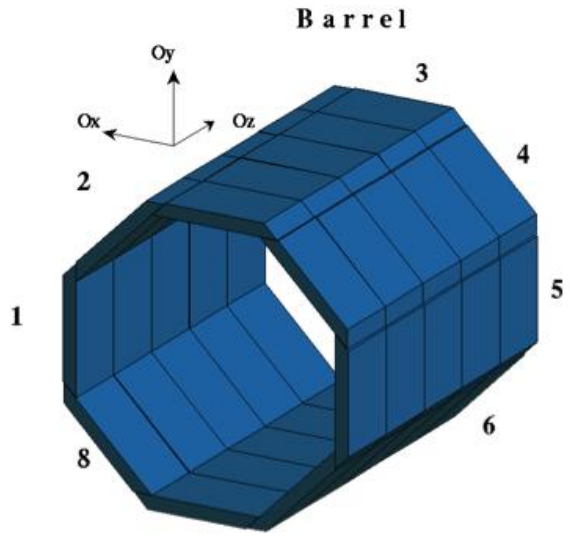
From Manqi

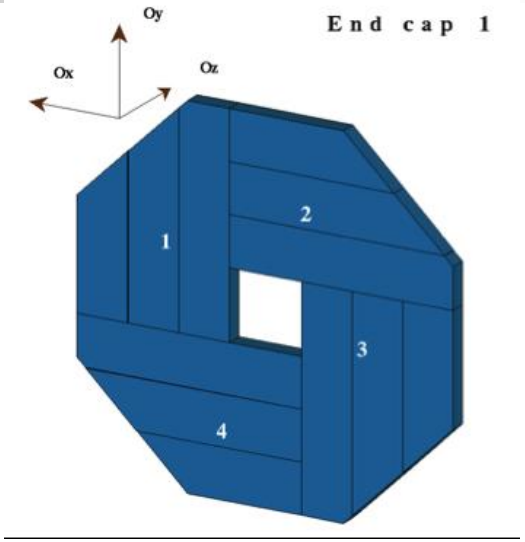
Feasibility & Optimized Parameters

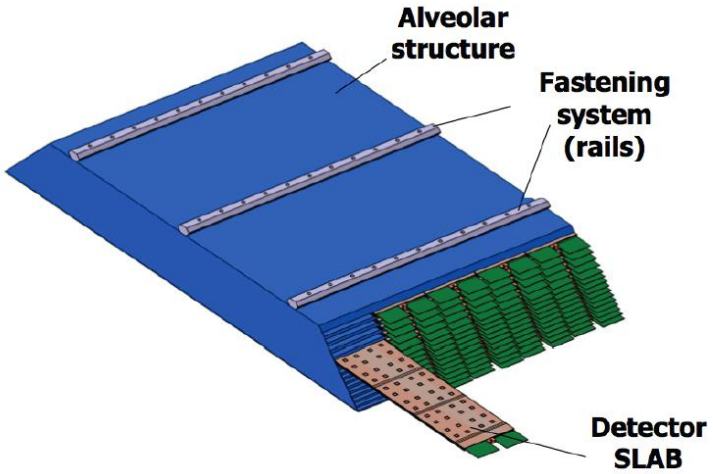
Feasibility analysis: TPC and Passive Cooling Calorimeter is valid for CEPC

	CEPC_v1 (~ ILD)	Optimized (Preliminary)	Comments
Track Radius	1.8 m	>= 1.8 m	Requested by Br(H->di muon) measurement
B Field	**3.5 T**	**3 T**	**Requested by MDI**
ToF	**-**	**50 ps**	**Requested by pi-Kaon separation at Z pole**
ECAL Thickness	84 mm	84(90) mm	84 mm is optimized on Br(H->di photon) at 250 GeV; 90mm for bhabha event at 350 GeV
ECAL Cell Size	5 mm	10 – 20 mm	Passive cooling request ~ 20 mm. 10 mm should be highly appreciated for EW measurements – need further evaluation
ECAL NLayer	30	20 – 30	Depends on the Silicon Sensor thickness
HCAL Thickness	**1.3 m**	**1 m**	-
HCAL NLayer	**48**	**40**	Optimized on Higgs event at 250 GeV; Margin might be reserved for 350 GeV.

Structure of the ECAL







Slabs contains 2 symmetric layers of Silicon sensors glued on PCB, equipped with readout ASICs.

Silicon Sensors

high resistivity silicon pin diodes

- Stability:
  completely depleted pin-diode 's response to MIP mostly defined by the thickness of the sensor, with a very low dependence on temperature, radiation, humidity, ...
- Uniformity
  the control of the thickness over large batches can ensures a uniformity of response
- Flexibility
  the dimension and geometry of the cells are defined by the readout pad on the PCB
- High Signal-to-Noise ratio
  ~ 80 electron-hole pairs

Electronics

- Dynamic range
  1/3 – 10000 MPV
- Timing

  50-20ps

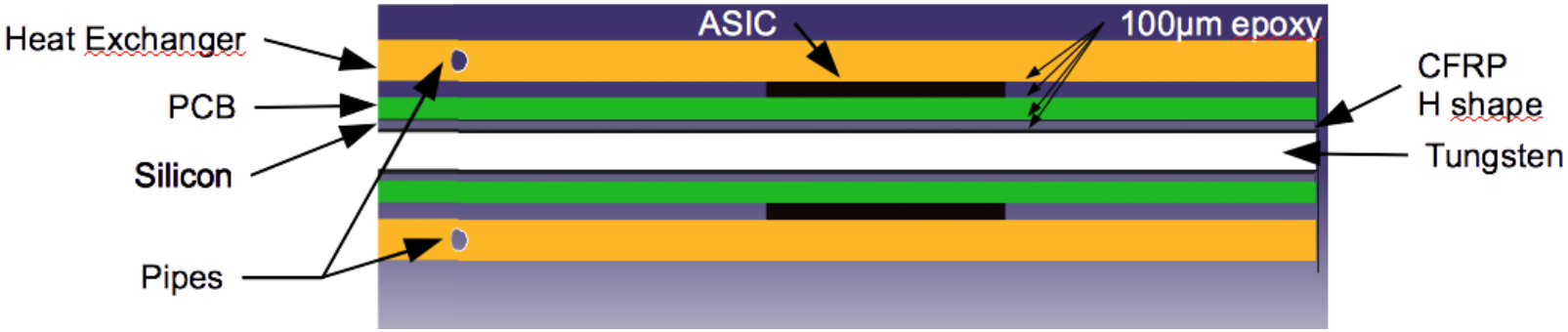
Power and Cooling

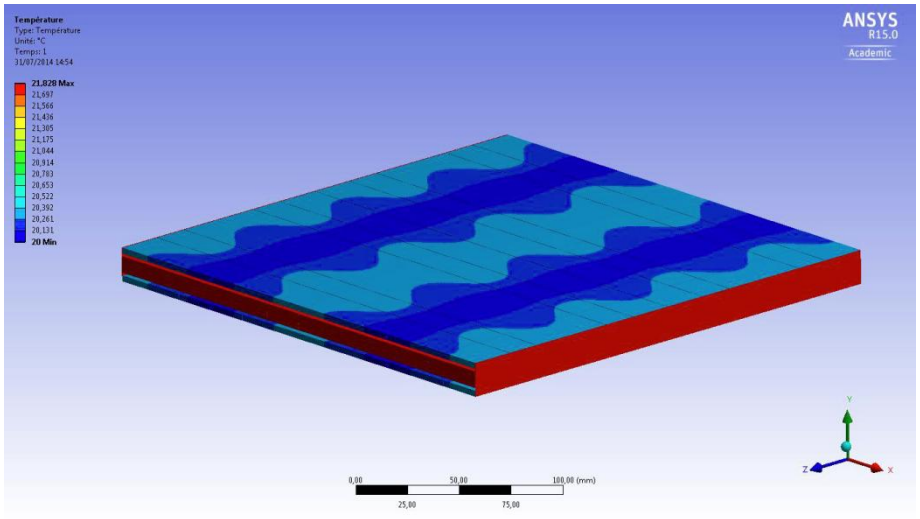
A ILD-like Calorimeter should work for CEPC but power pulsing

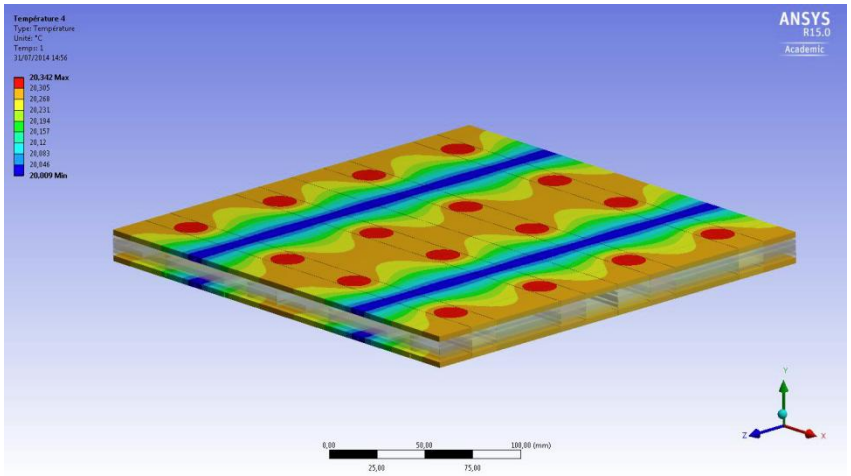
- a reduced number of channels (20x20 mm) may only need passive cooling
- A HGCAL like active cooling works for CEPC

$\Delta T \sim 2^{\circ}C$

Active cooling (CO_2)

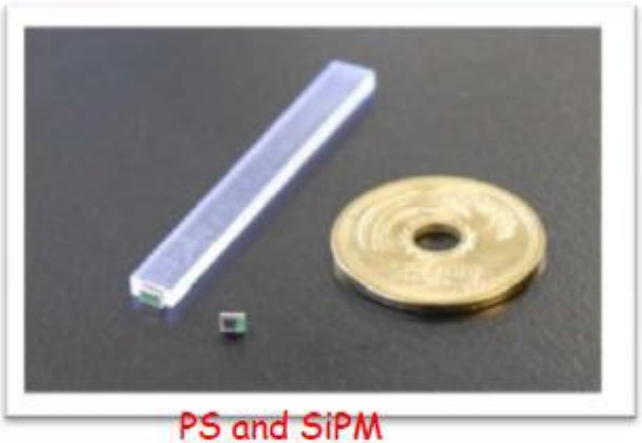






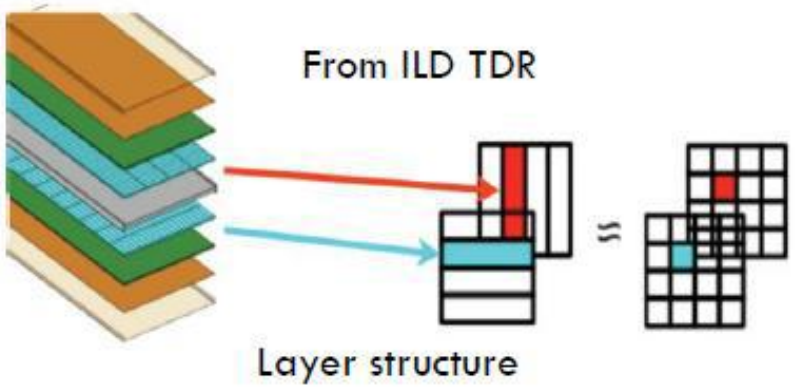
Scintillator-W option

- A super-layer (7mm) is made of
  - tungsten plate (3 mm thick)
  - 5x45 mm^2 scintillator strips (2 mm thick)
  - a readout/service layer (2 mm thick)

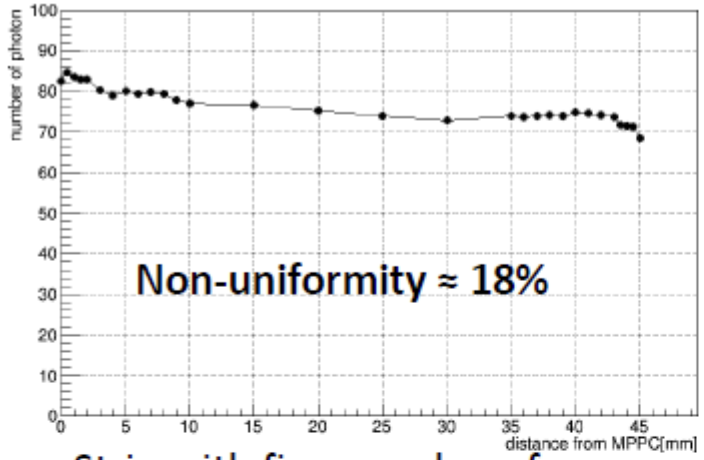


PS and SiPM

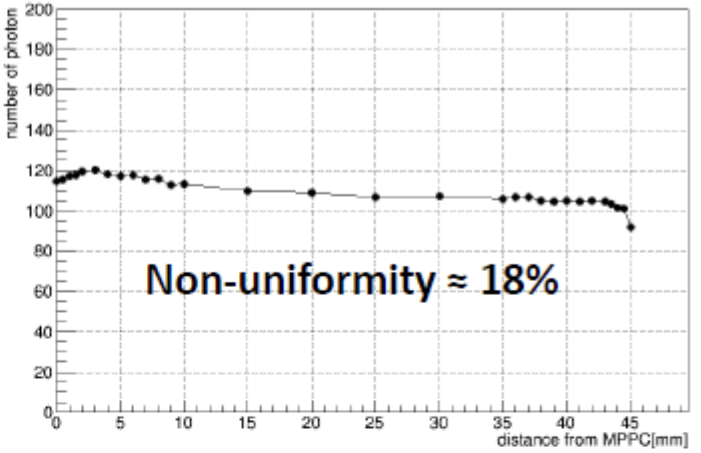
cell size: 5x5 mm^2



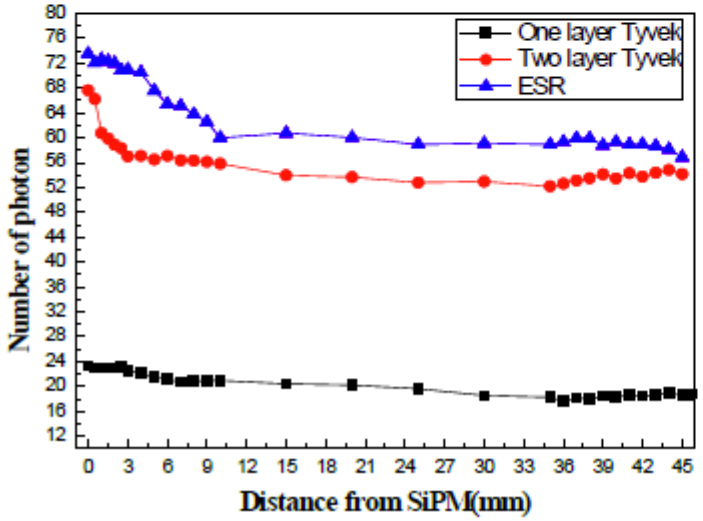
Light output and uniformity



Strip with five rough surfaces

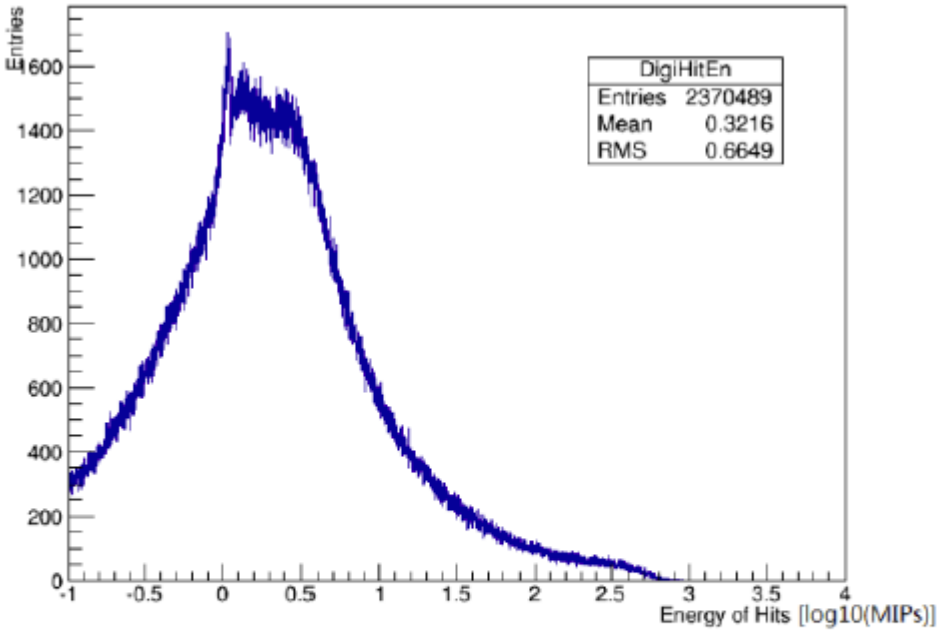


Embed SiPM into scintillator strip



- Rough Reflective surfaces and suitable coupling mode can improve uniformity of light output along scintillator strip.
- Further optimization is under study

SiPM dynamic range



ννHiggs→ γγ

Cell size of scintillator is
5mm×45mm×2mm

- The range of energy deposition in scintillator module is quite large.
- 10k pixel number SiPM is required for big dynamic range (1 MIP>10 p.e.)

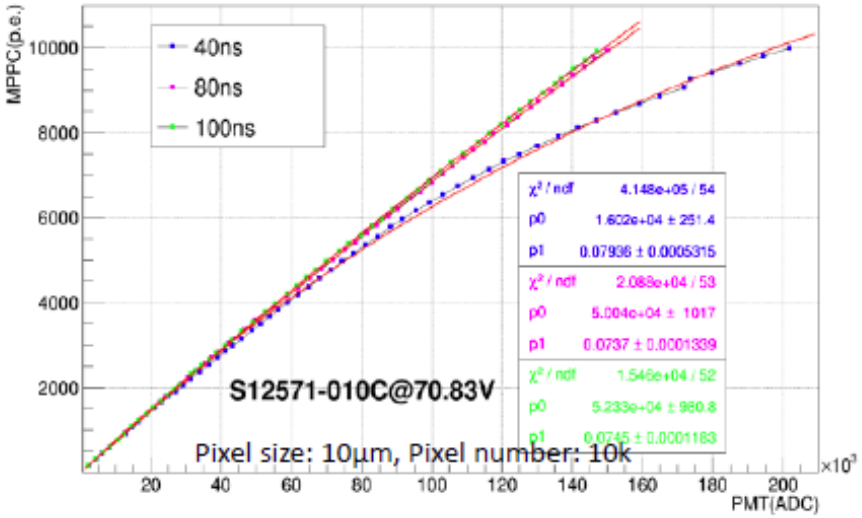
SiPM response test

- When the recovery time of each pixel of SiPM is faster than the duration of one event, some pixels will contribute to an signal more than once. It makes the effective response pixels larger than the real number of pixels, and extend the dynamic range of SiPM
- The effective response pixels can be described by following formula

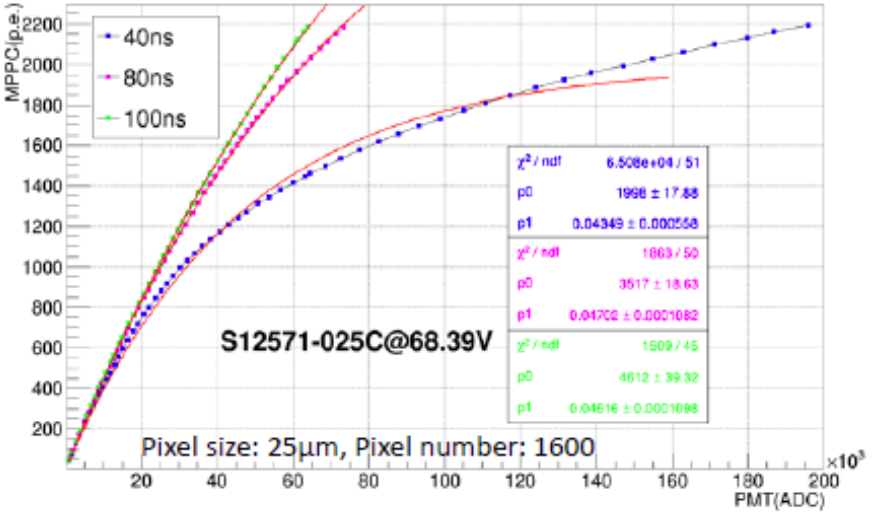
$$N_{fire} = N_{eff}(1 - e^{-\epsilon N_{in}/N_{eff}})$$

N_{fire}: the number of fired pixels, N_{eff}: the effective pixel number of pixels

ε : photon detection efficiency, N_{in} : the number of incident photons.

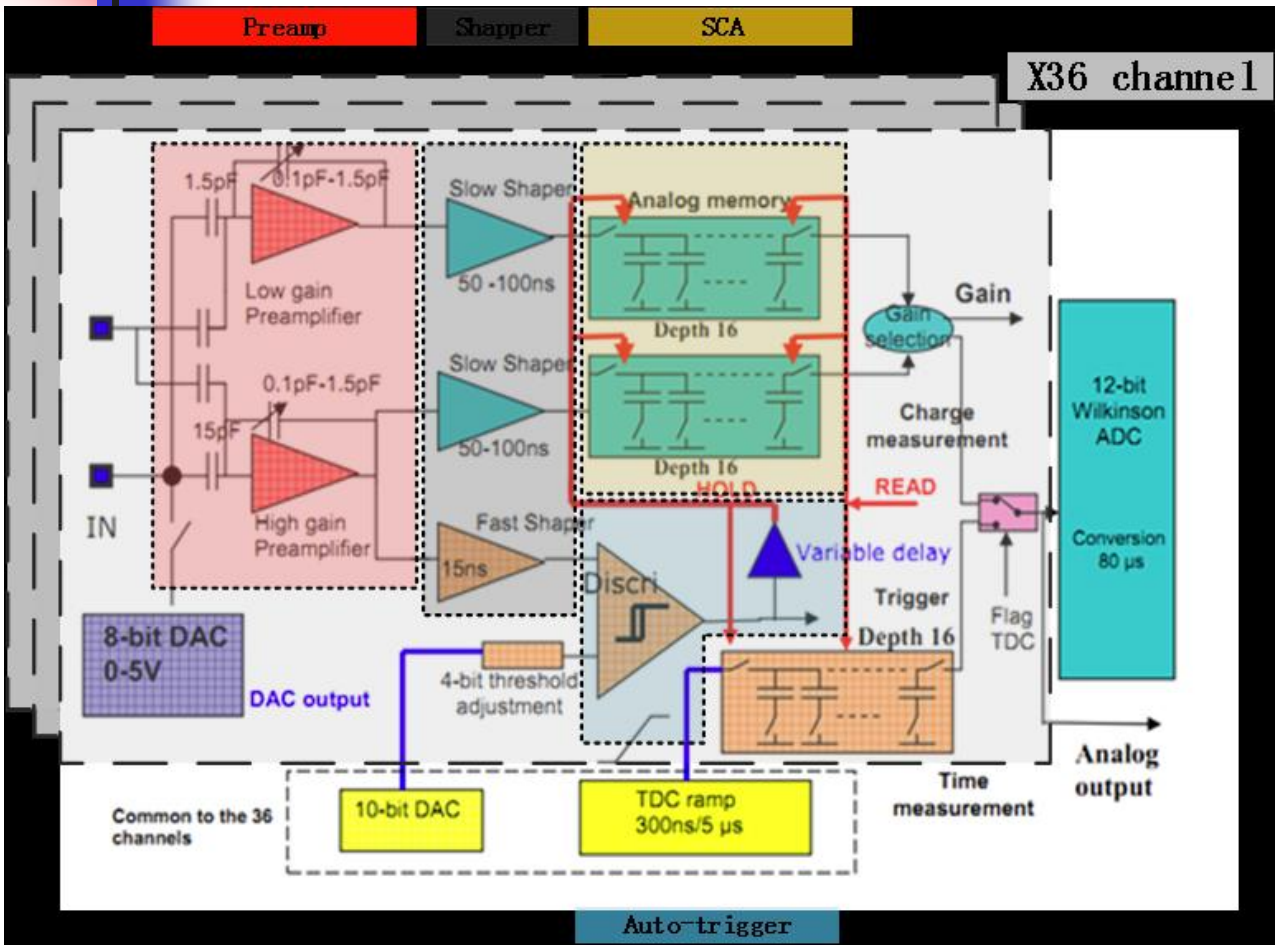


Response curve at different pulse width



Response curve at different pulse width

Electronics



- Based on SPIROC2b
- dynamic range 100fC-300pC gotten