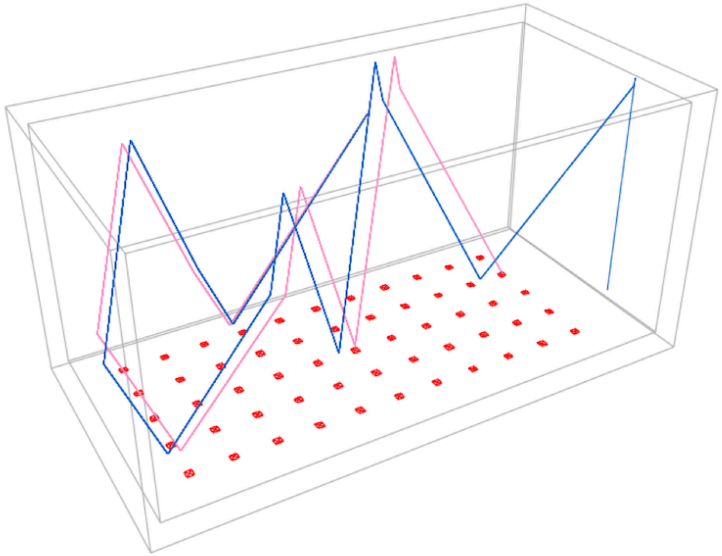


SiPM on WCD: time and spatial distribution studies

Michele Doro michele.doro@unipd.it,
Cedric Perennes cedric.perennes@unipd.it
+ Alessandro de Angelis, Luca Tosti, Ruben Conceicao, Bernardo Tome, …

Lisbon Meeting: 2019/05/21

Università degli Studi di Padova
INFN Istituto Nazionale di Fisica Nucleare

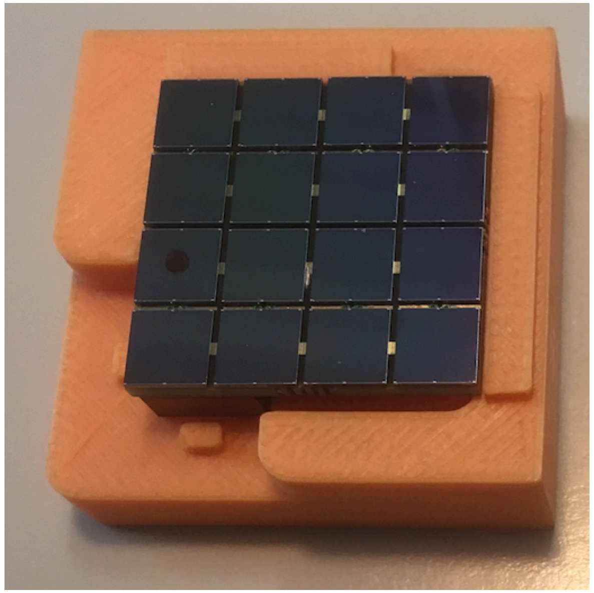
Remarks

Very recent results

Still very sketchy ideas

Not the unique SiPM design

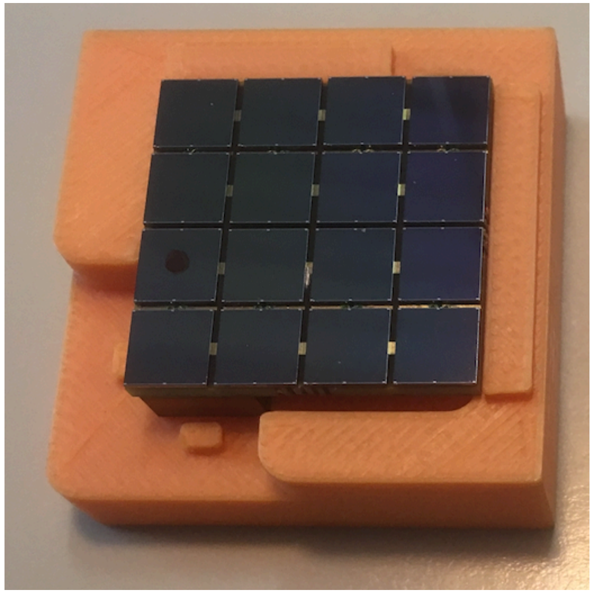
Why SiPM on WCD



- Generic pros
  - Fast time response
  - High-gain
  - Low after pulses
  - High quantum efficiency
  - Flexibility in geometrical arrangements (flat and small)
  - Insensitivity to magnetic fields
- Generic cons
  - Higher capacitance
  - Optical cross-talk
  - Fast evolving

- Likely Pros at 5k
  - Lower operating voltage
  - Reduced Ageing
  - Easier replacement
- Likely Cons
  - Small ares

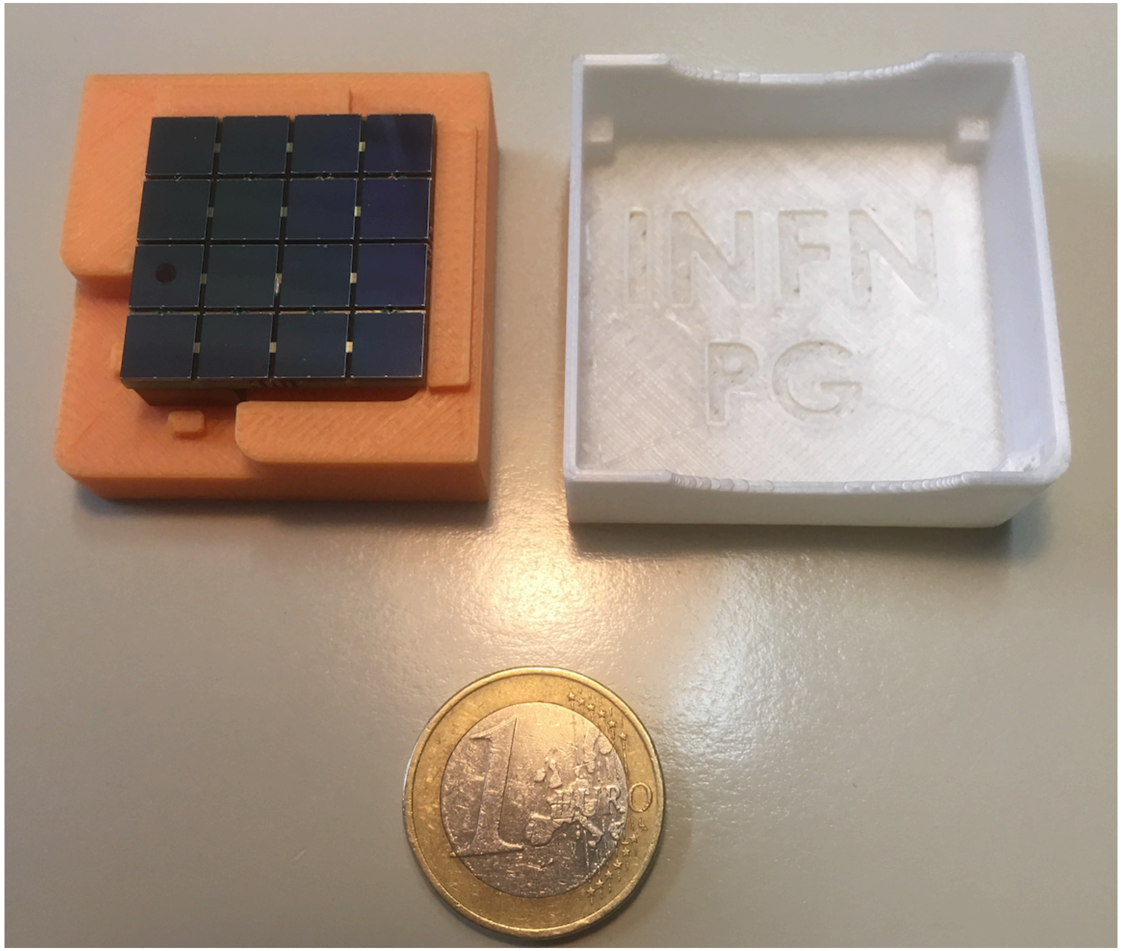
Why SiPM on WCD



Equip WCD with SiPMs in order to:

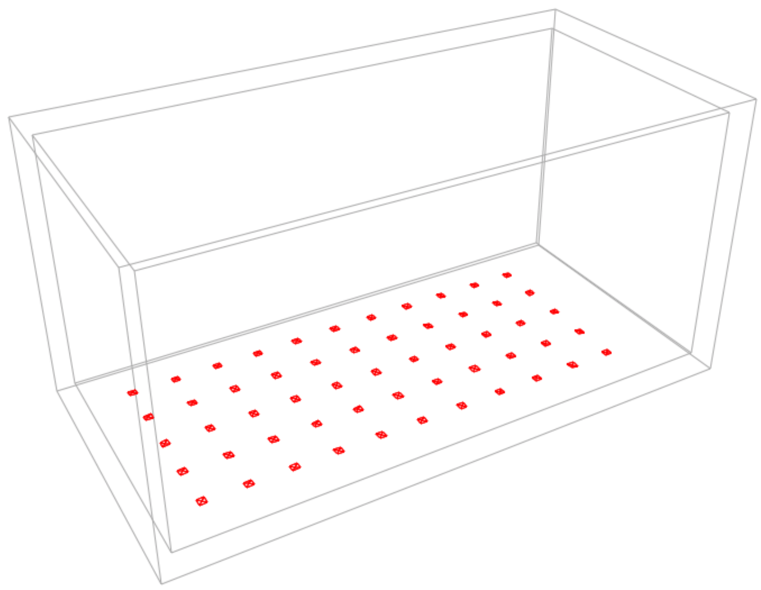
1. Improve generic shower reconstruction through ‘imaging’
2. Perform a basic γ/μ separation? (see also B. Tome’ tomorrow)

Let's start with the sensors



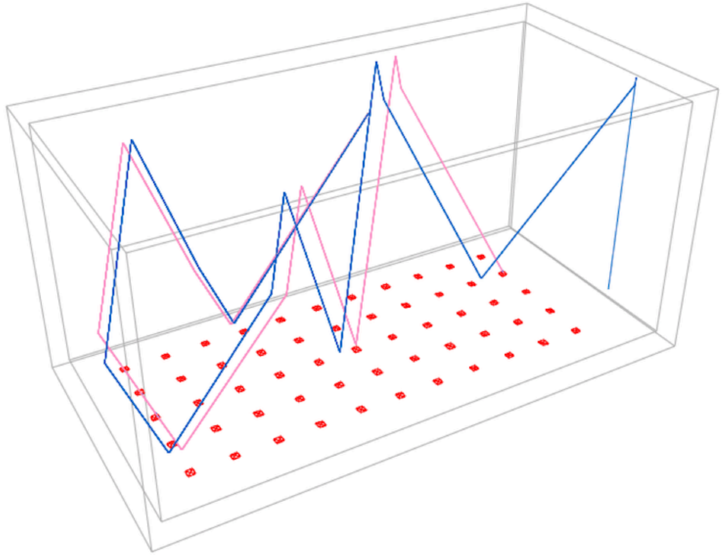
- 6x6 mm SiPM matrix
  - NUVHD3_2
  - Designed by FBK+INFN
  - Tested by several INFN sections
- Massively produced for pSCT (prototype Schwarchild-Couder Telescope) camera
- They work!

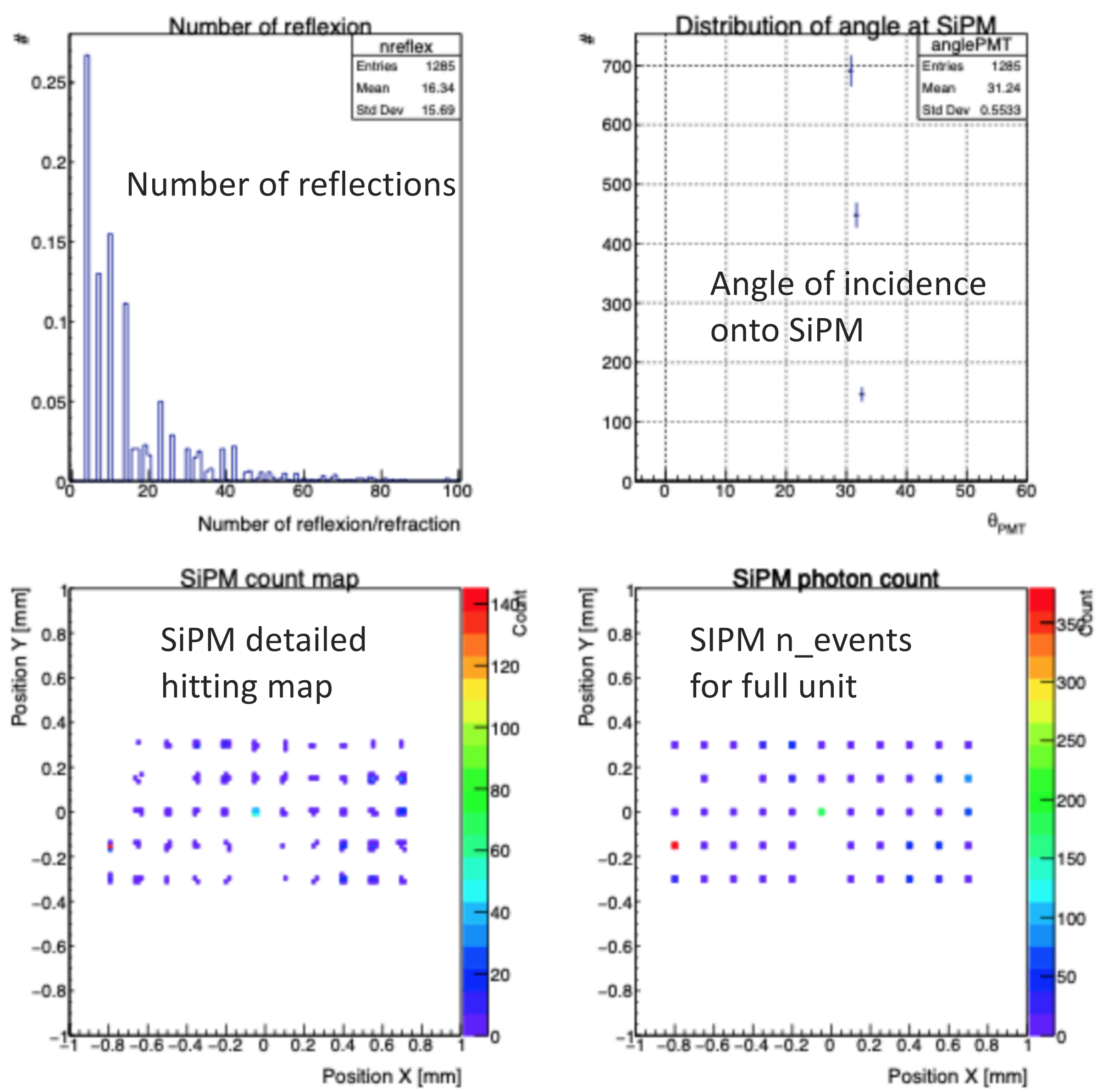
Simulation



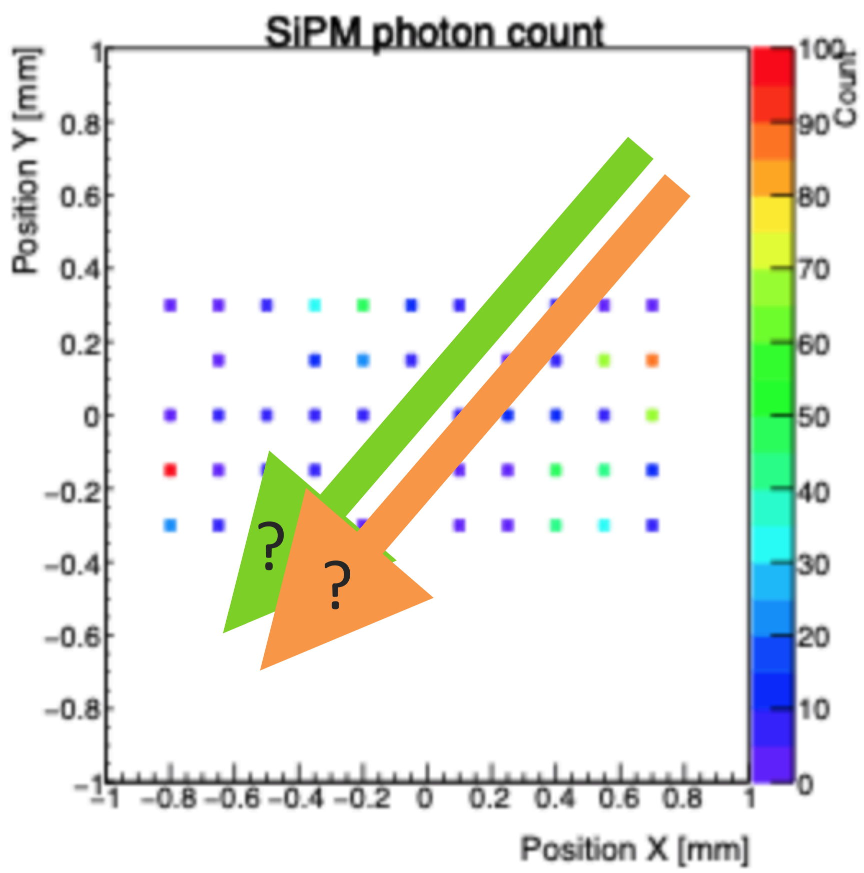
- Cedric Pernnes, I +LIP are developing simulation with
  - optical raytracing with open-source ROBAST code
  - Physical with GEANT4 (Lattesim→Common code)

Figure of merit (in prep)



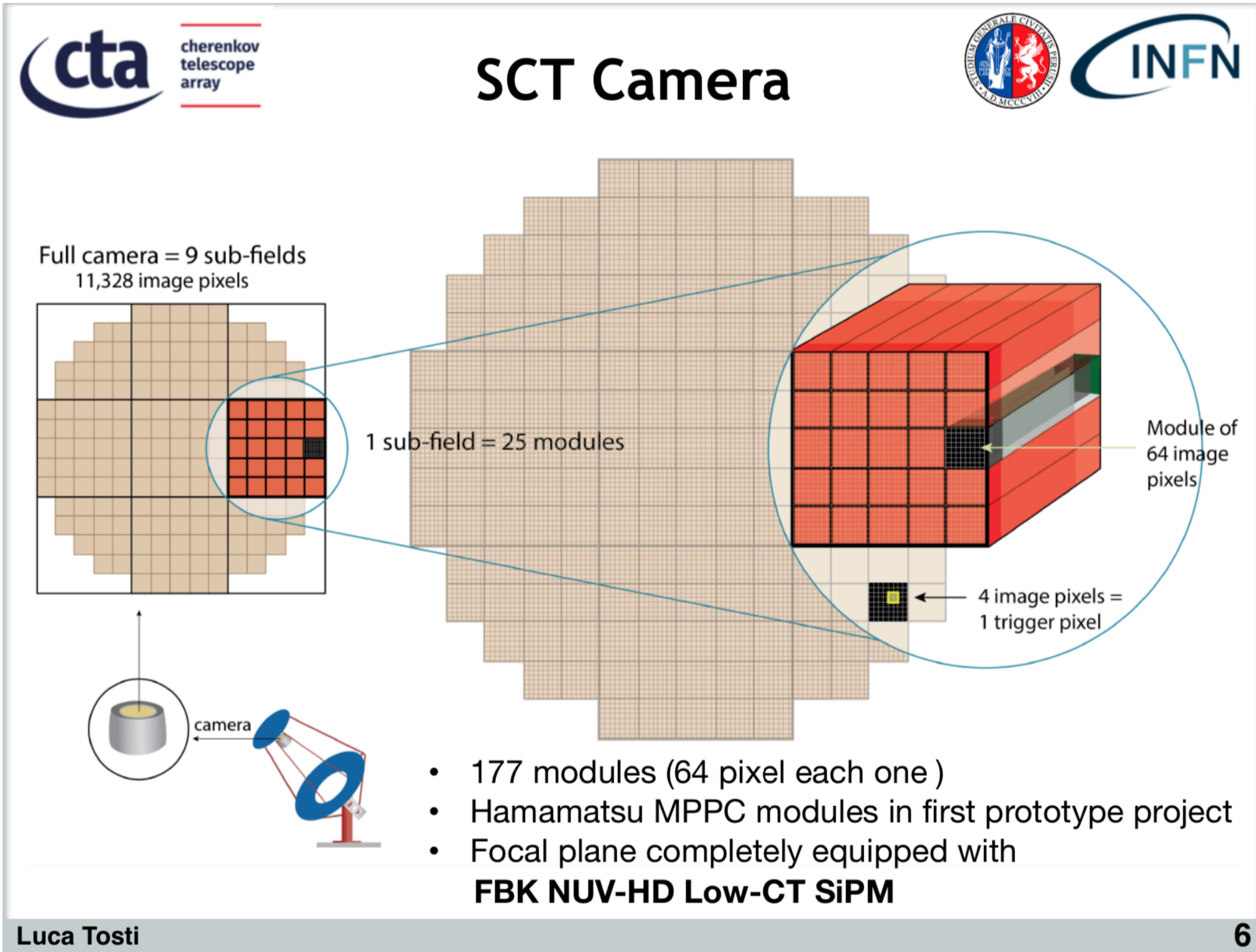


Expectations



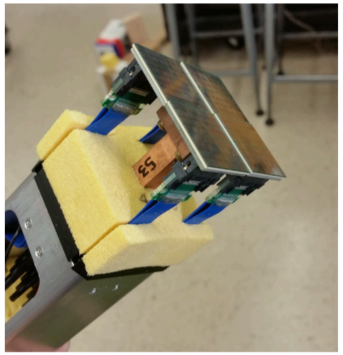
- Imaging from this seem feasible
  - Direction ☺
  - Energy deposited 😐
  - Particle type 😐

Profit of pSCT/CTA INFN experience

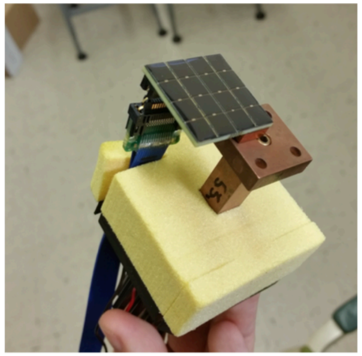


The INFN modules

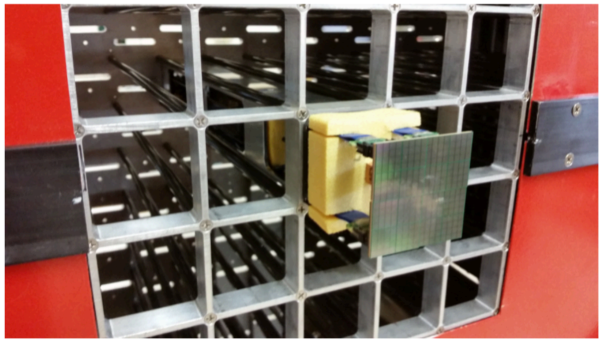
pSCT Camera (optical modules)



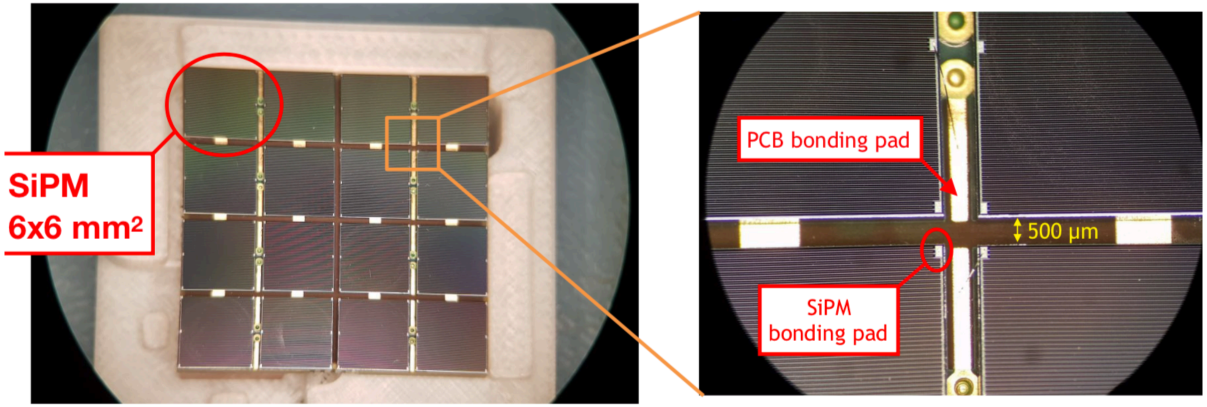
Hamamatsu US module



INFN FBK prototype (2016)



INFN optical modules

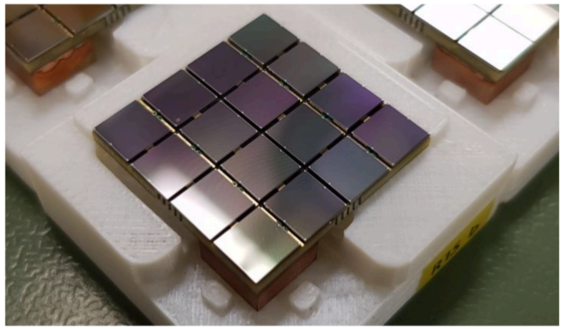


Custom PCB designed by INFN

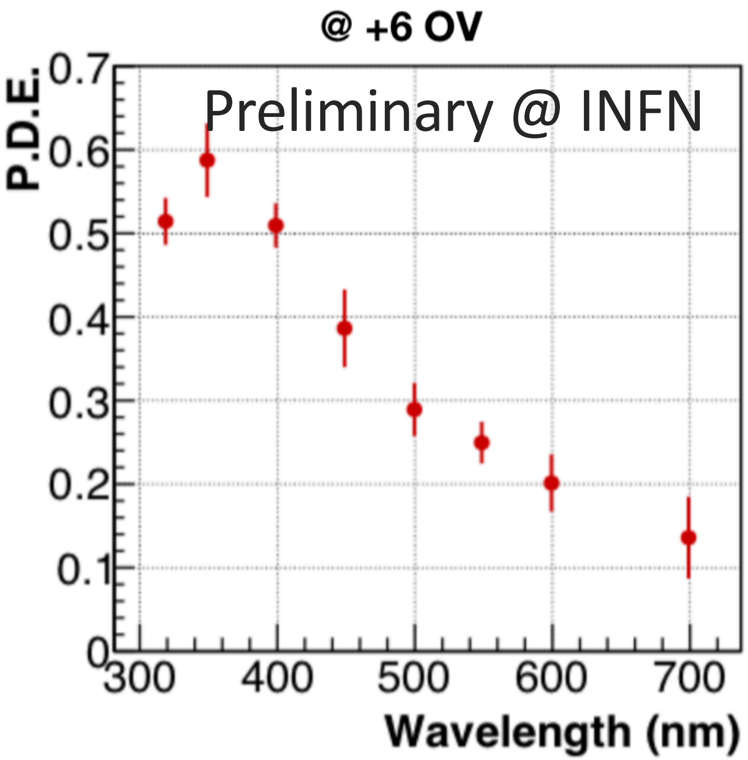
27x27mm² PCB equipped with 16 SiPMs

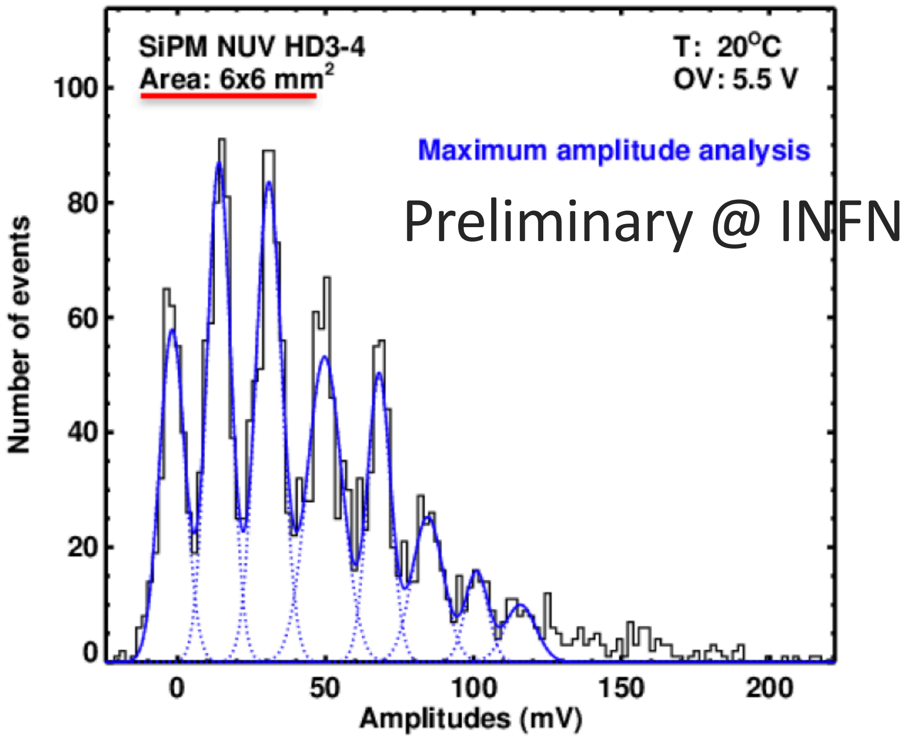
↓

maximum uniformity of the camera covering



Excellent performance

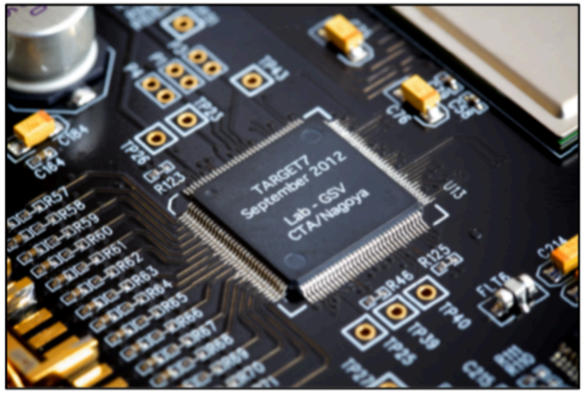




Readout – Target board

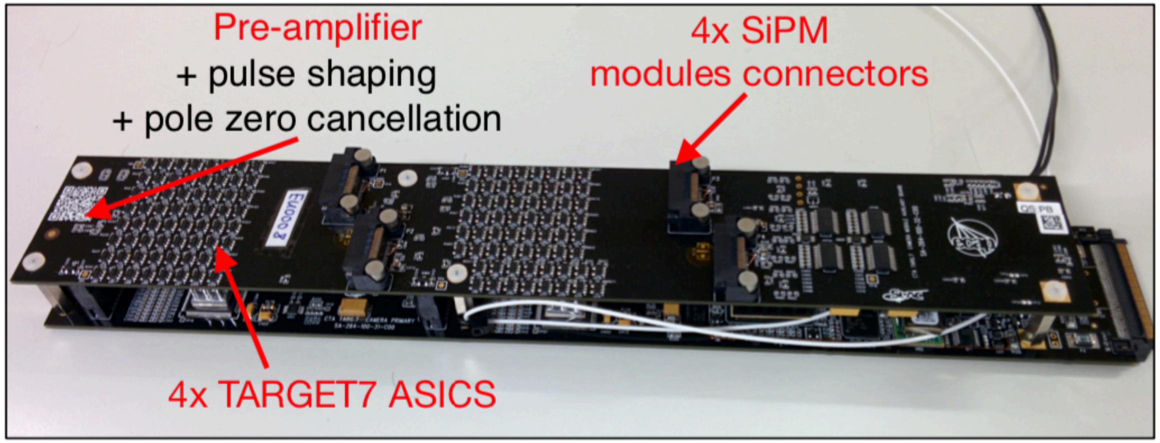
Signal read with "**T**eV **A**rray **R**eadout with **G**S/s sampling and **E**vent **T**rigger" board (TARGET7)

- **Compact chip for high density channel camera**
- 16 input channels
- Analogical Buffer (16384 capacitors)
- Switched Capacitors Array
- **Sampling and waveform digitation (** $16\mu s$ **) at 1GS/s**

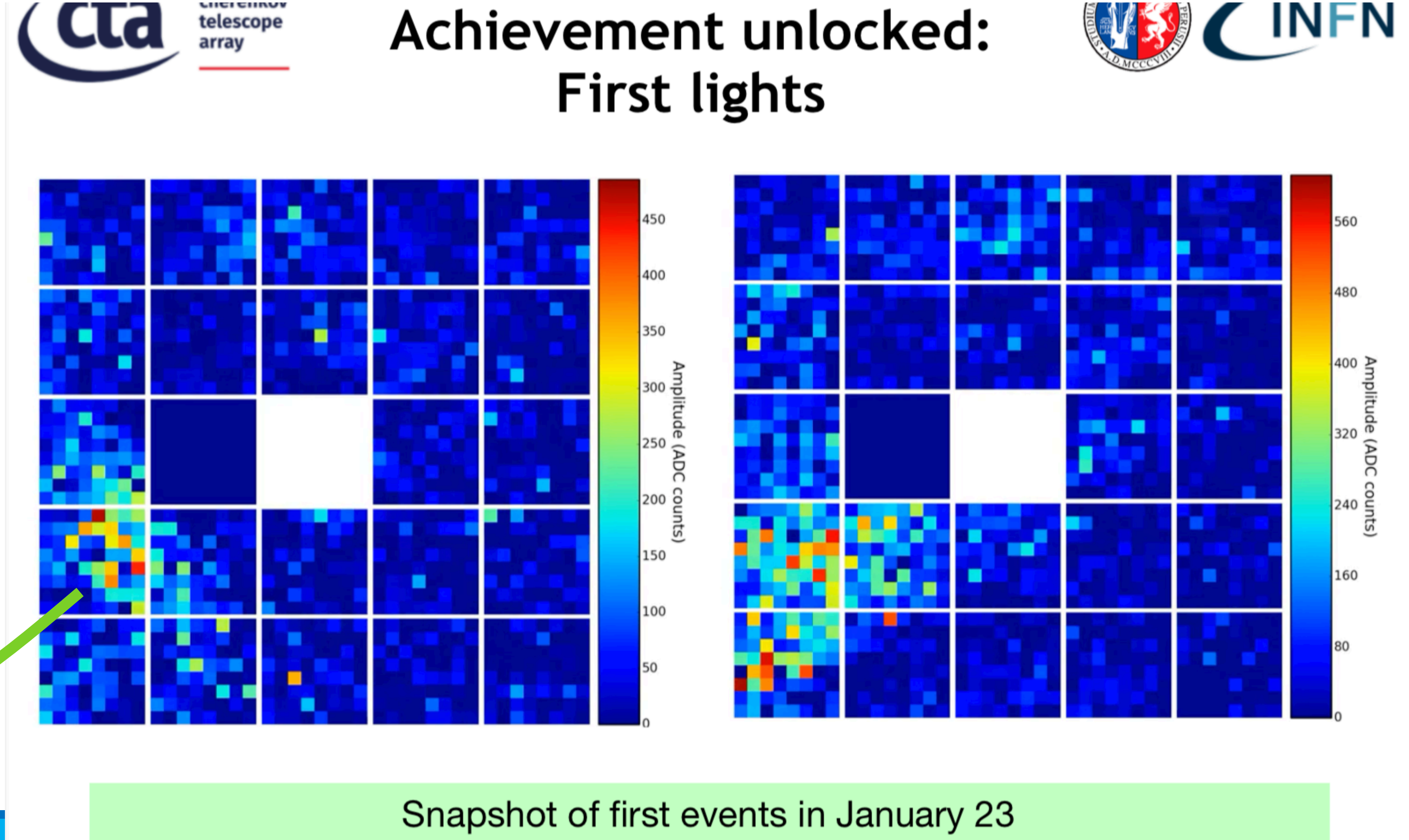


Quality tests made in INFN section of Pisa and Bari:

- Pedestal calibration
- Waveform acquisition (with laser)
- Trigger efficiency tests



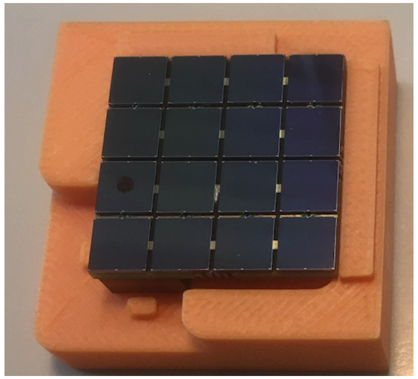
It all works!

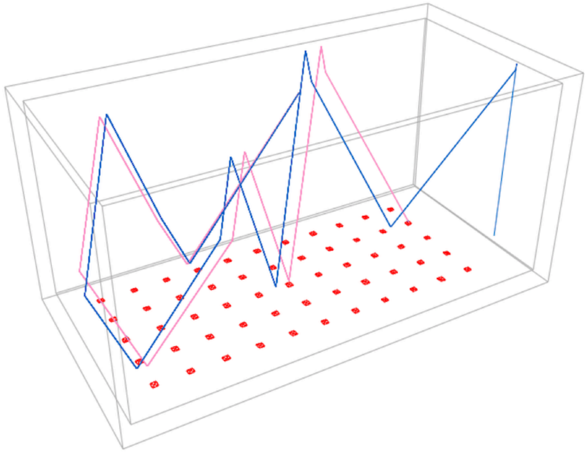


INFN
module

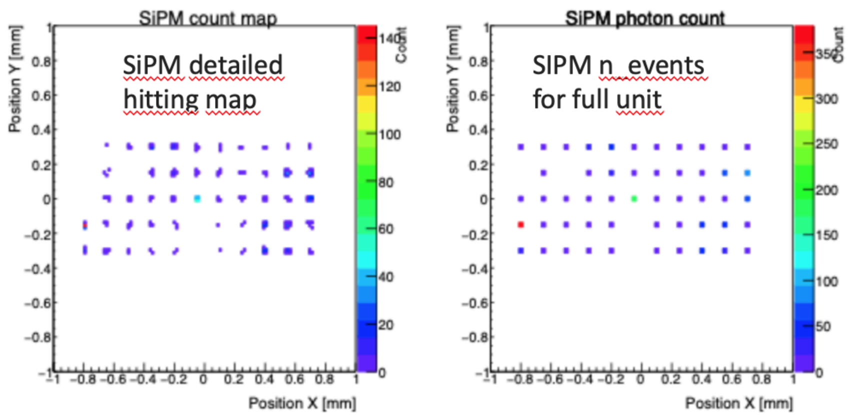
Photon unit

sub-unit

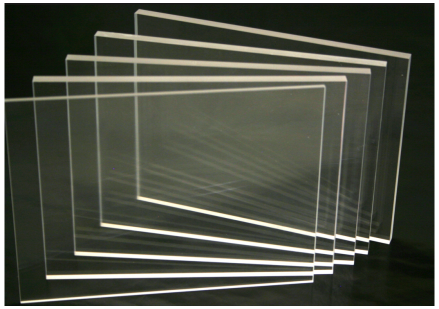


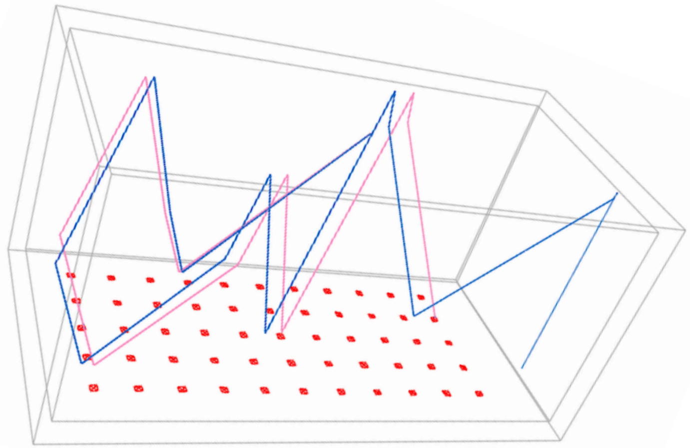


- P-SCT module is a 5x5cm square block composed of 4 sub-units of 16 SiPM units each
- Sub-unit is physical and has 16 6x6 mm SiPM (~25x~25mm)
  - Unit photo-sensor is then pSCT subunit
  - Or individual SiPM to be read?



(Fixation)

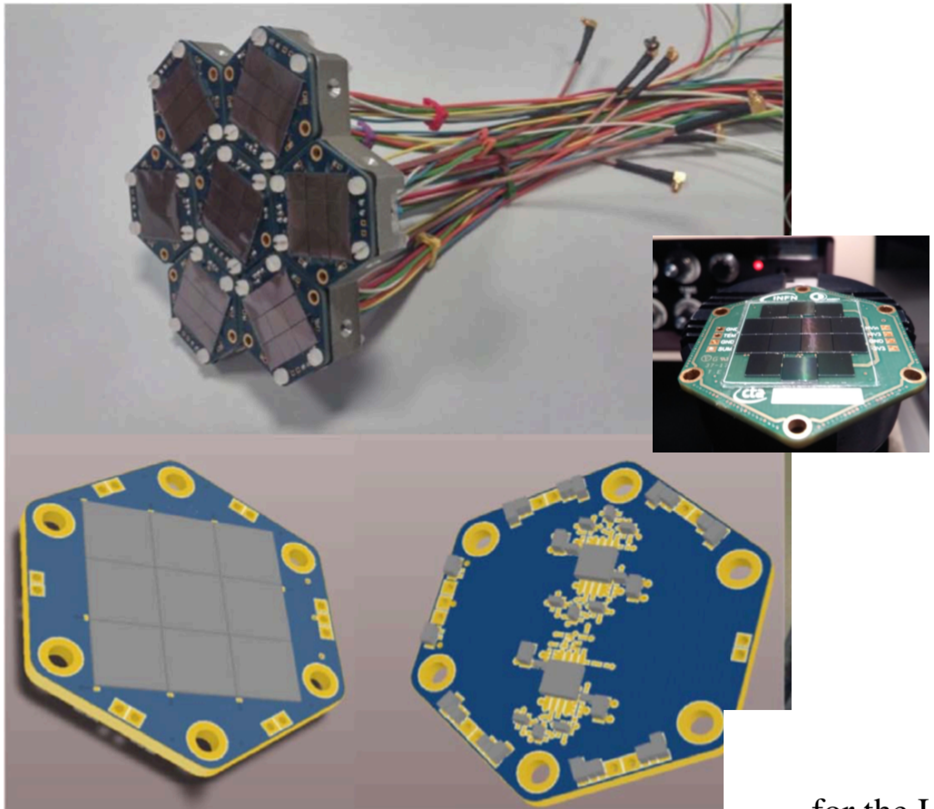




SiPM may be accessible from below for maintenance

- If WCD is made of PMMA (UV transparent)
  - WCD can be built on site
  - SiPM can be directly attached to it via an optical glue
  - PMMA must come coated on the outside (dark) and inside (reflective)
- Gluing/ungluing is possible in case of exchanges
- PMT in thermal coupling with water/tank → sufficient?

INFN Padova custom summation



PROCEEDINGS OF SCIENCE

Silicon Photomultiplier Research and Development Studies for the Large Size Telescope of the Cherenkov Telescope Array

Riccardo Rando[*ab], **Daniele Corti**[a], **Francesco Dazzi**[c], **Alessandro De Angelis**[d],

Nuclear Instruments and Methods in Physics Research A 876 (2017) 26–30

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/nima

Studies on a silicon-photomultiplier-based camera for Imaging Atmospheric Cherenkov Telescopes

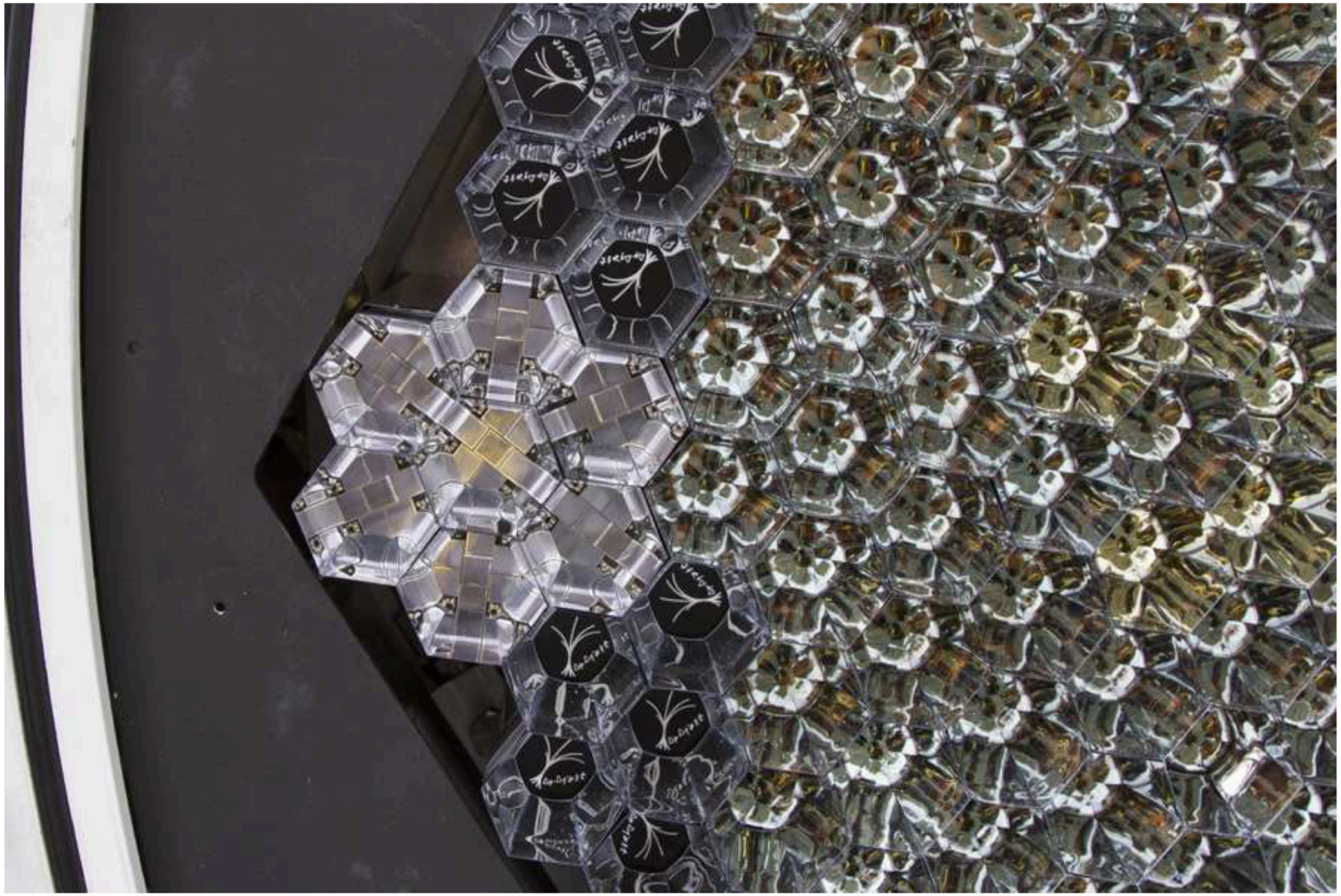
C. Arcaro[a,b,*], D. Corti[b], A. De Angelis[b,c,d], M. Doro[a,b], C. Manea[e], M. Mariotti[a,b], R. Rando[a,b],

Design of a SiPM-based cluster for the Large Size Telescope camera of the Cherenkov Telescope Array

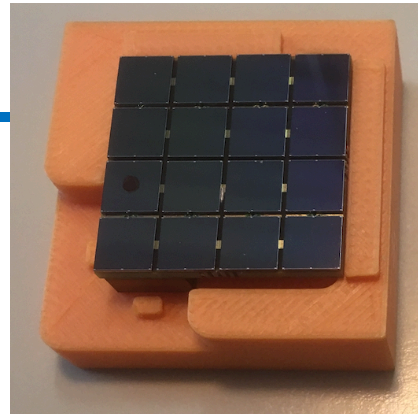
arXiv:1807.06281

M. Mallamaci[a,*], B. Baibussinov[a], G. Busetto[a,b], D. Corti[a], A. De Angelis[a,c,d,e], F. Di Pierro[f], M. Doro[a,b], L. Lessio[c], M. Mariotti[a,b], R. Rando[a,b], E. Prandini[a,b], P. Vallania[f,g], C. F. Vigorito[f,h], for the CTA LST project

Tests on MAGIC cameras



ASIC Summation



MUSIC: An 8 channel readout ASIC for SiPM arrays

Sergio Gómez, David Gascón, Gerard Fernández, Andreu Sanuy, Joan Mauricio, Ricardo Graciani, David Sanchez [a]

[a]Institute of Cosmos Sciencies - University of Barcelona (ICC-UB), Martí i Franquès, 1, 08028, Barcelona, Spain

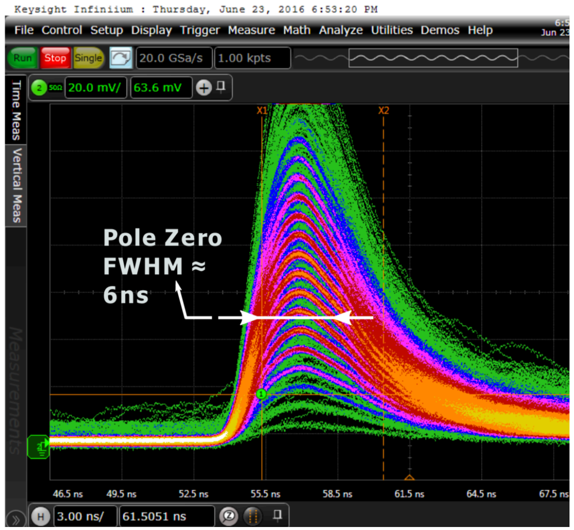
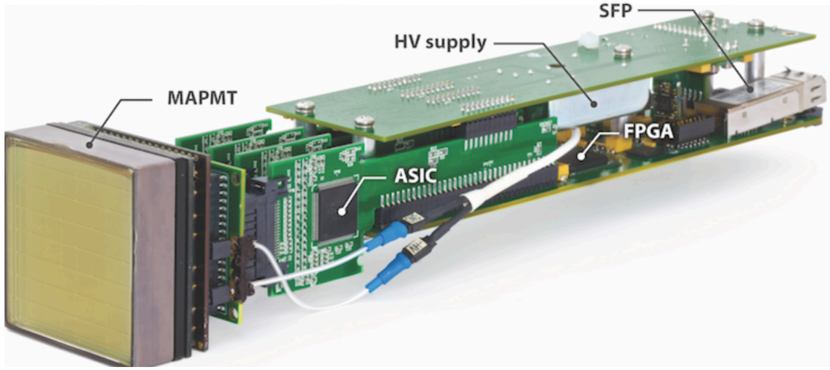


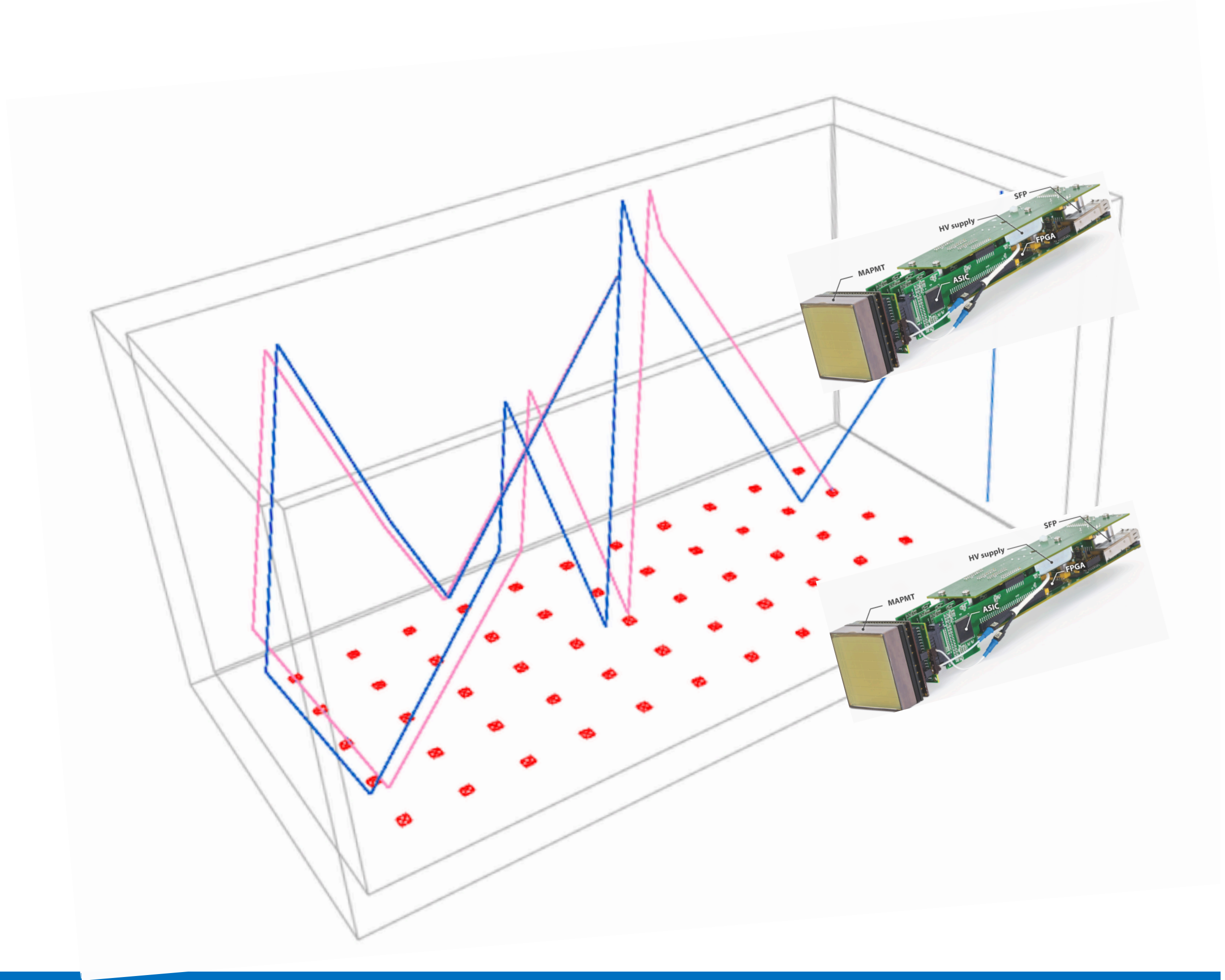
Table 1: Main characteristics of the MUSIC circuit.

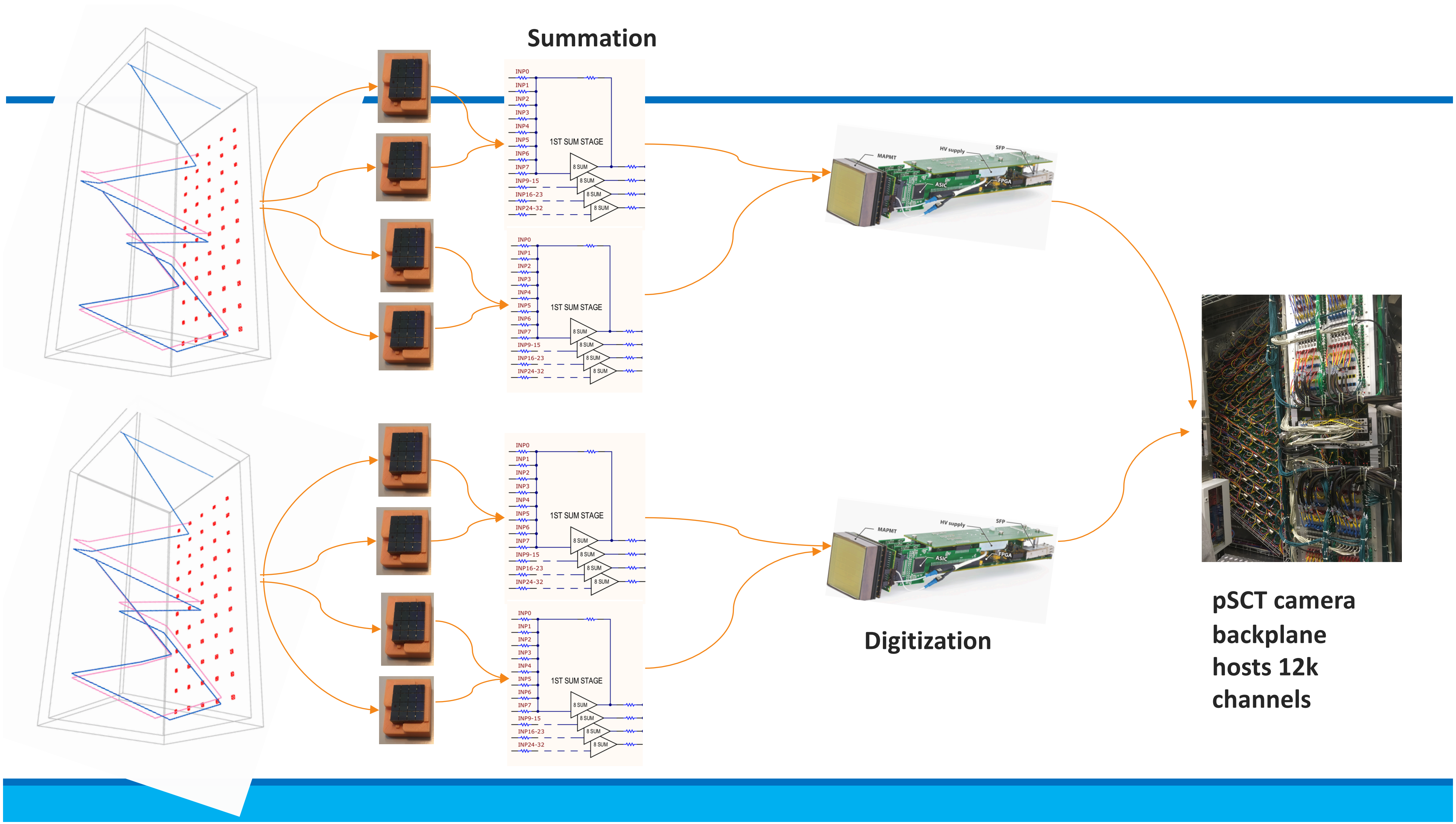
List of specifications
500MHz bandwidth for channel sum.
150MHz bandwidth for A/D channels.
Low input impedance (≈32Ω).
Single photon output pulse width at half maximum (FWHM) between 5 and 10ns.
Power consumption of ≈30mW per individual channel.
Power consumption of ≈200mW for the 8 channel sum.
Adjustable input node DC voltage per channel.
High dynamic range (15bit) to operate SiPM at high over-voltage.
Zero components interface between sensor and device.
Total die size of 9mm^2 (3274μm x 2748μm).
64-QFN 9x9mm package.

Readout

- Target board can read 16 channels:



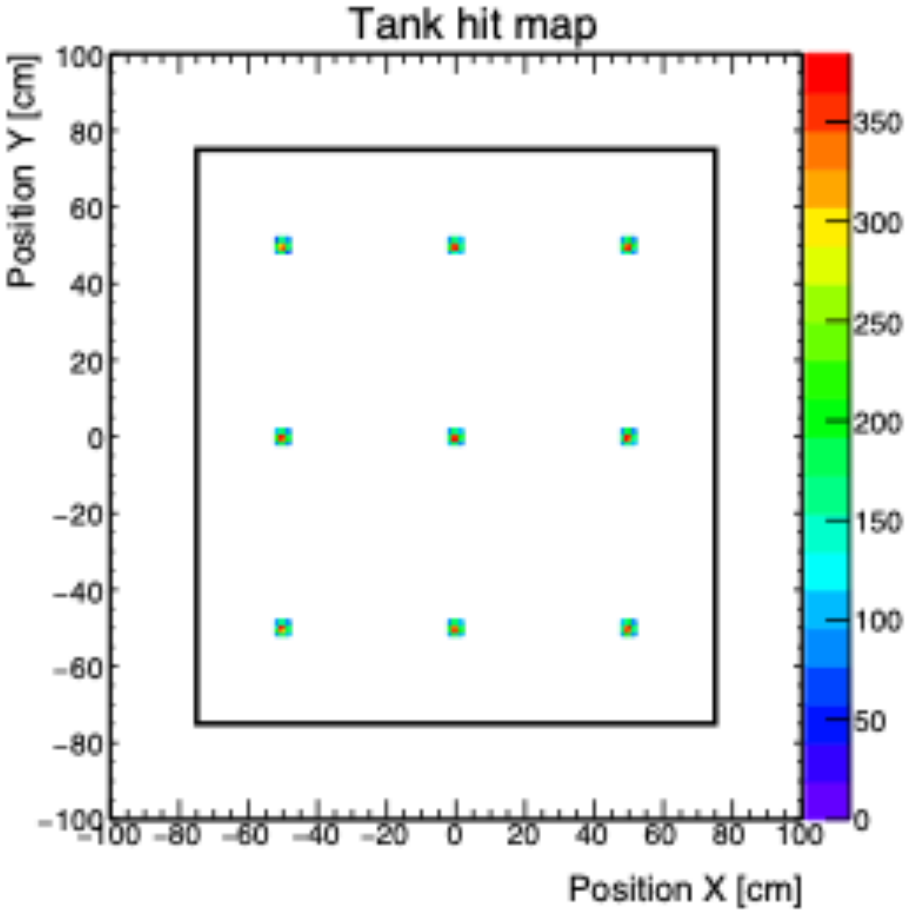




Summation
1ST SUM STAGE
8 SUM
MAPMT
HV supply
SFP
ASIC
FPGA
Digitization
pSCT camera backplane hosts 12k channels

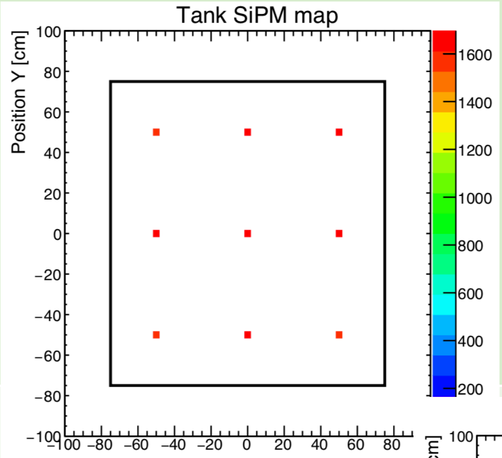
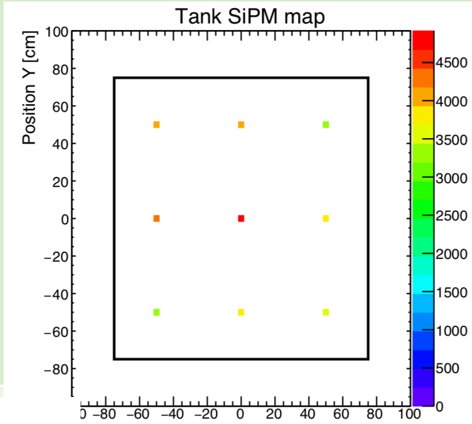
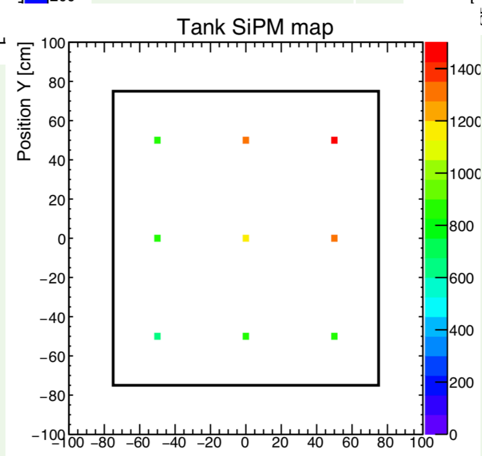
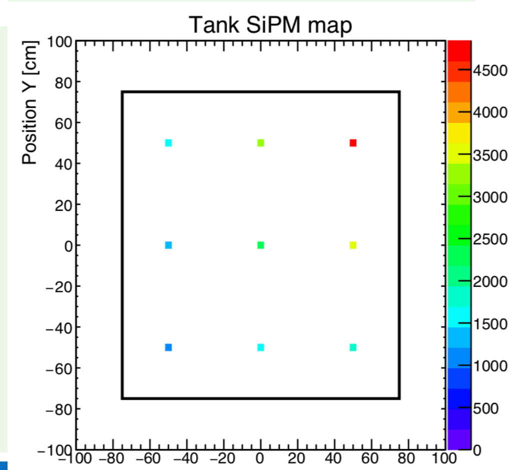
Next steps

- We should go on in two ways
  - Technical implementation
  - Simulation LATTESSIM/ ROBAST



Geant4 simulations with 9 SiPM at the bottom of the tank

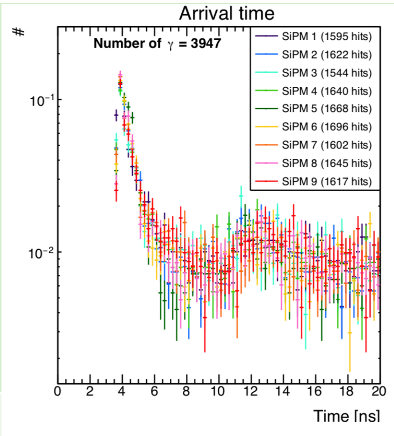
Hit maps

	Gammas	muons
Vertical		
45deg		

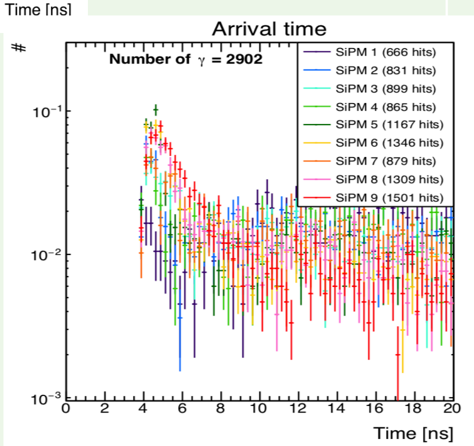
Time maps

	Gammas	muons
Vertical	see first gamma plot below	see first muon plot below
45deg	see second gamma plot below	see second muon plot below

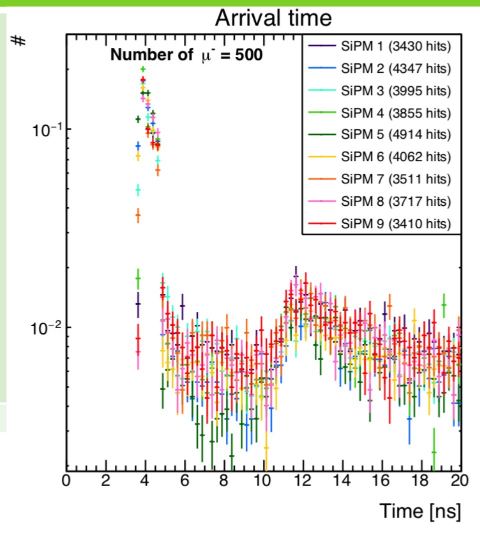
Gammas – Vertical



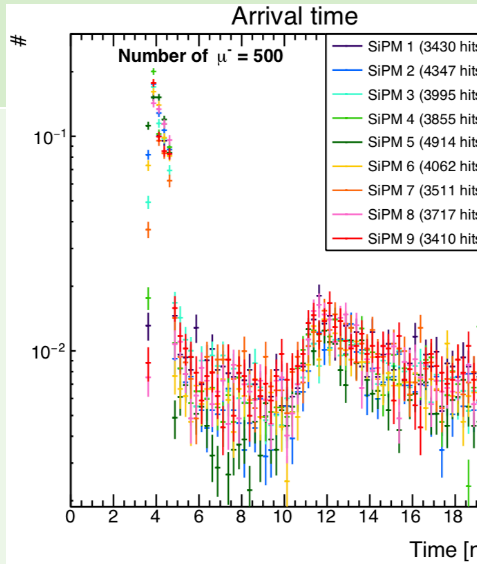
Gammas – 45deg



muons – Vertical



muons – 45deg

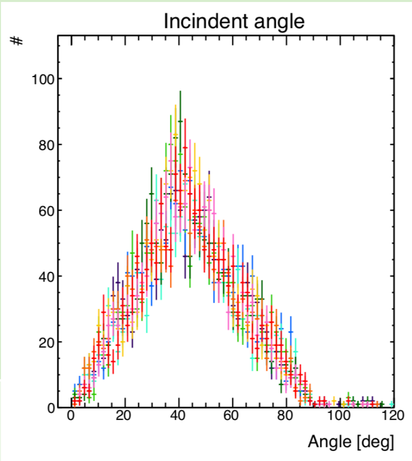


Incident angles

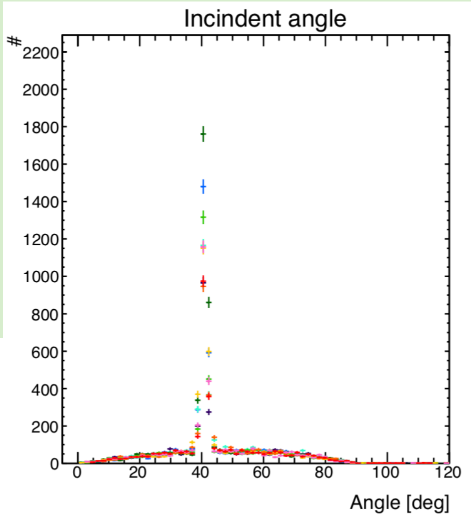
	Gammas	muons

Vertical

Gammas:

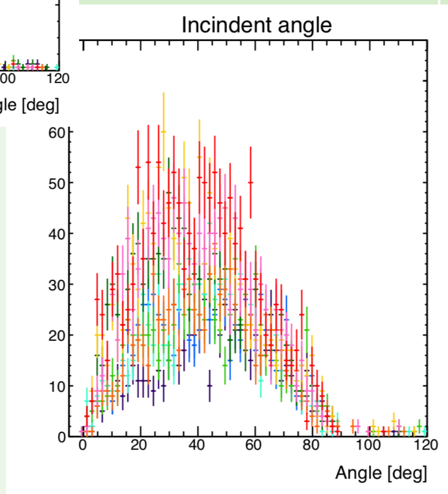


muons:

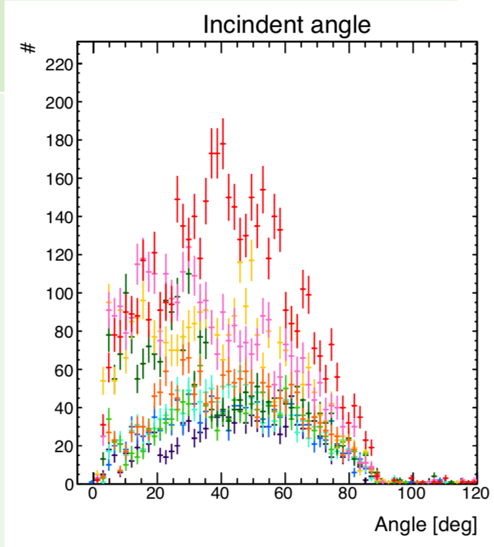


45deg

Gammas:

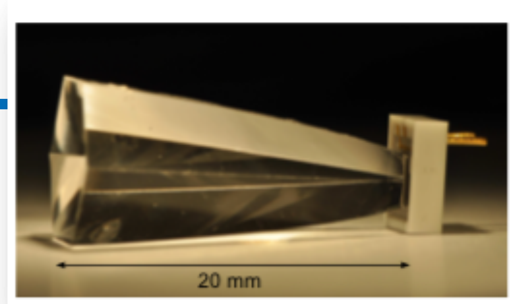


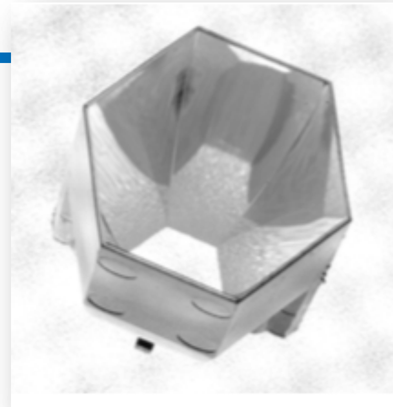
muons:

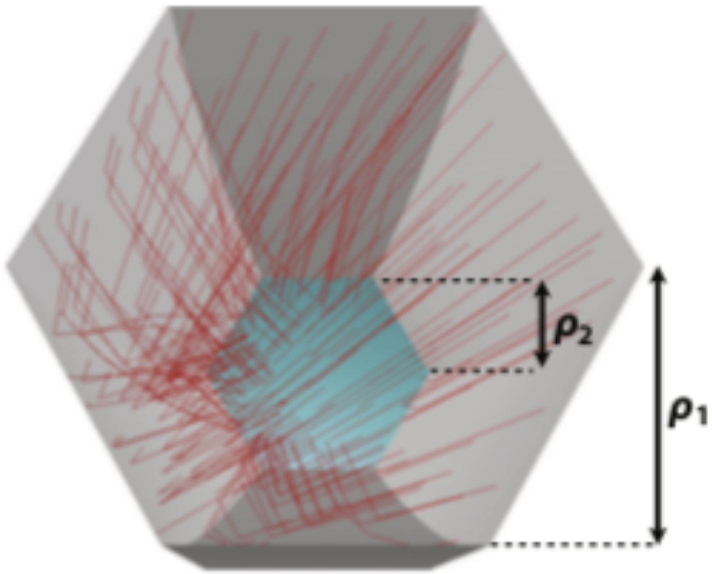


Light guide

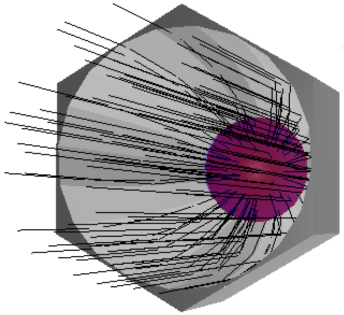
- Different purposes
  - Increase effective area
  - Reduce stray light contribution and control aperture acceptance
- Used in the past/present by:
  - FACT telescope
  - SST-1M; Astri



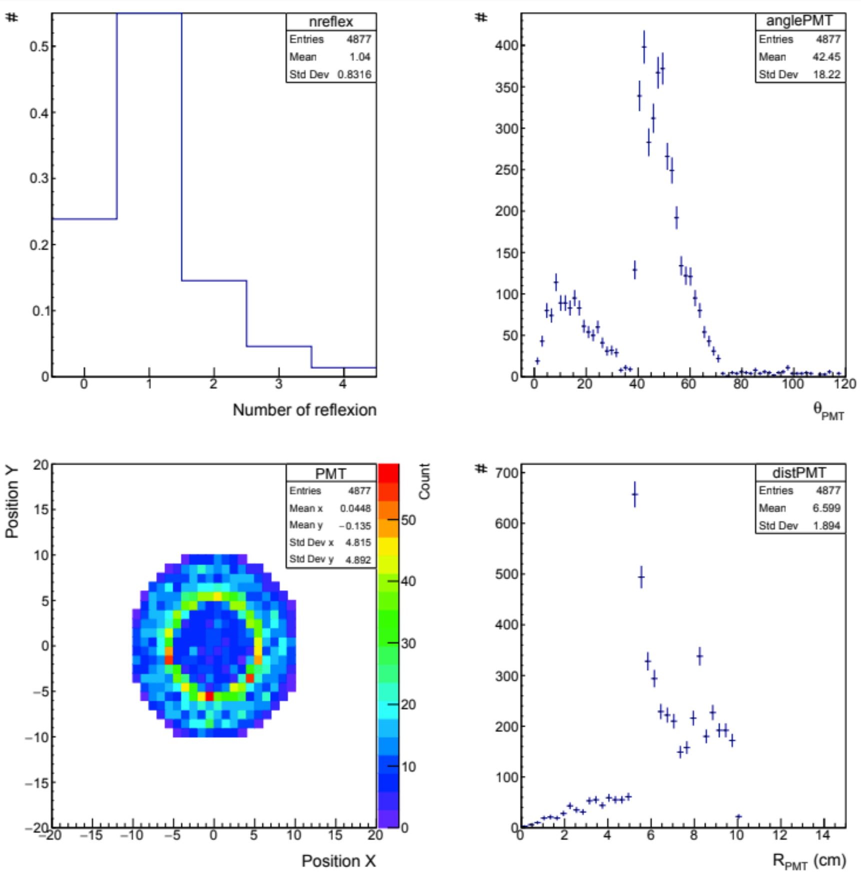




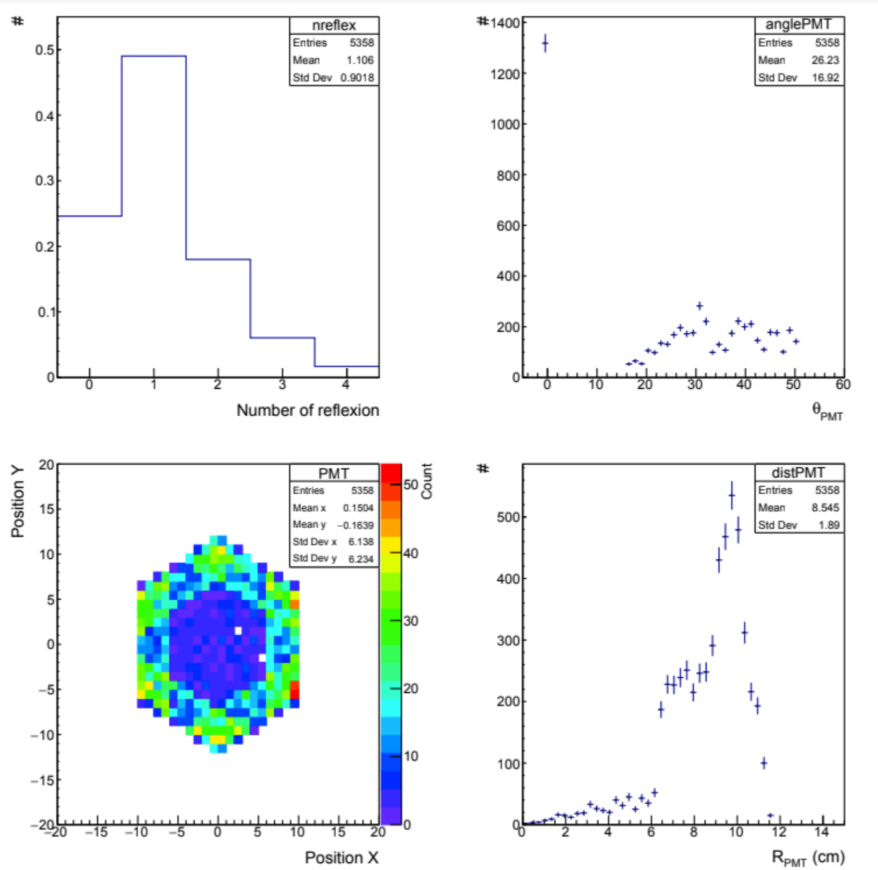
Light Guide



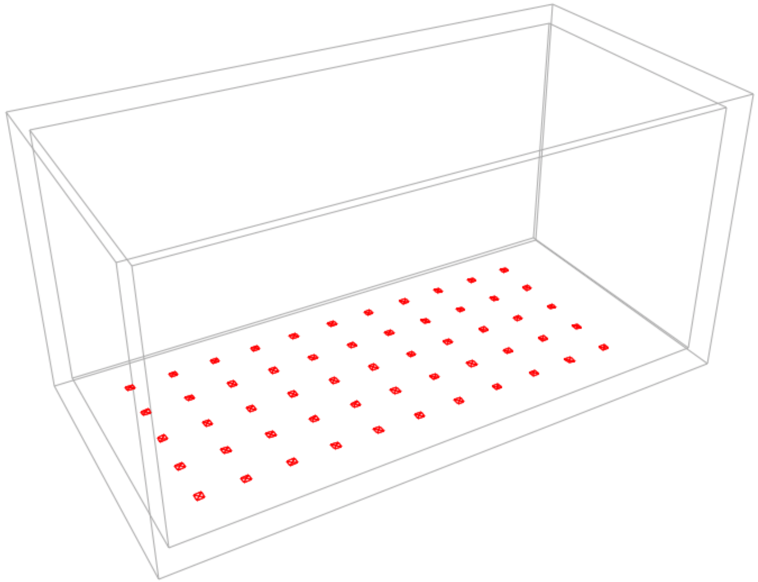
Hollow Light Guide



Solid Light Guide



Summary



1. Complete GEANT4 design simulation
   - Input right SiPM performance
2. Optimize
   - Nr. Channels
   - Spatial distribution
3. Technical implementation
   - Special tank?
   - Optical coupling? Light guides?
   - Maintenance

THANKS !