ALPS
ASIC de Lecture Pour SiPM

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Réunion service électronique

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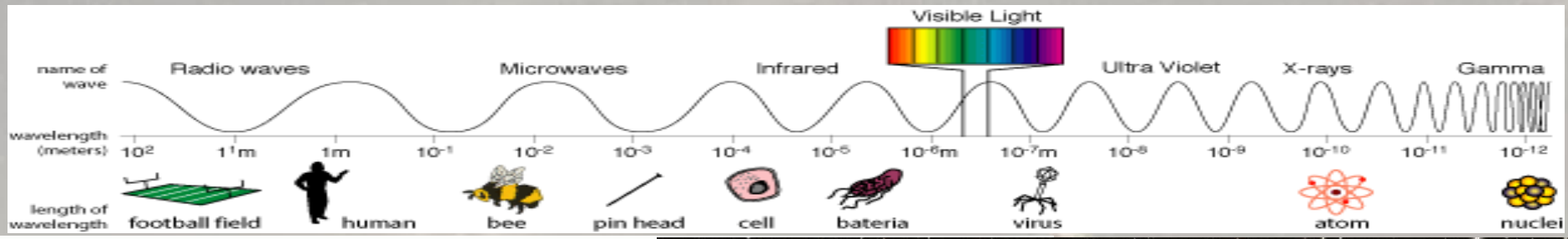
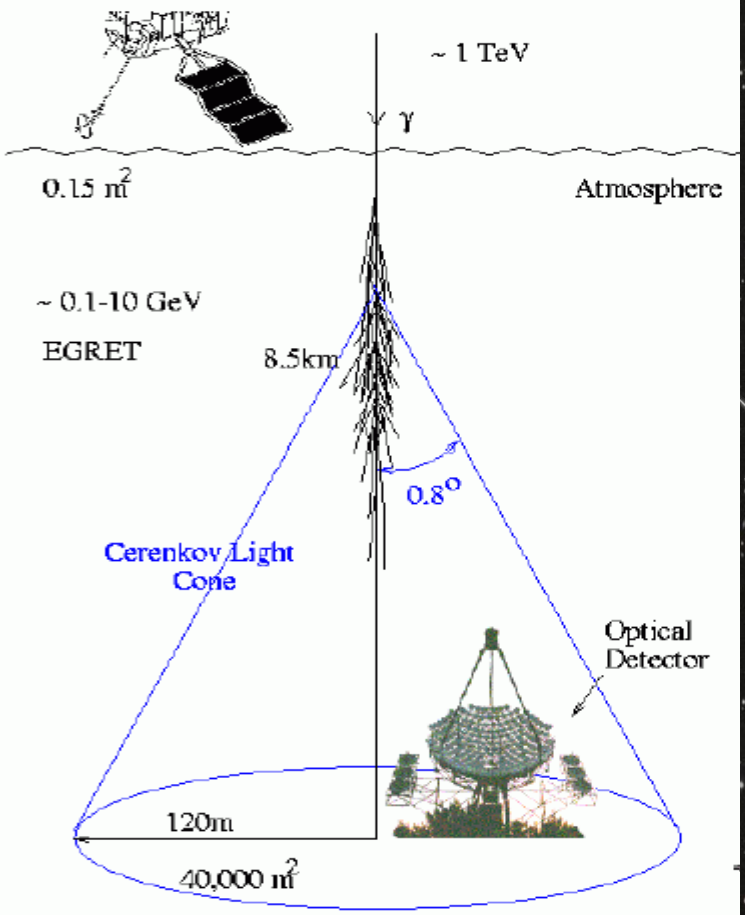
Sommaire

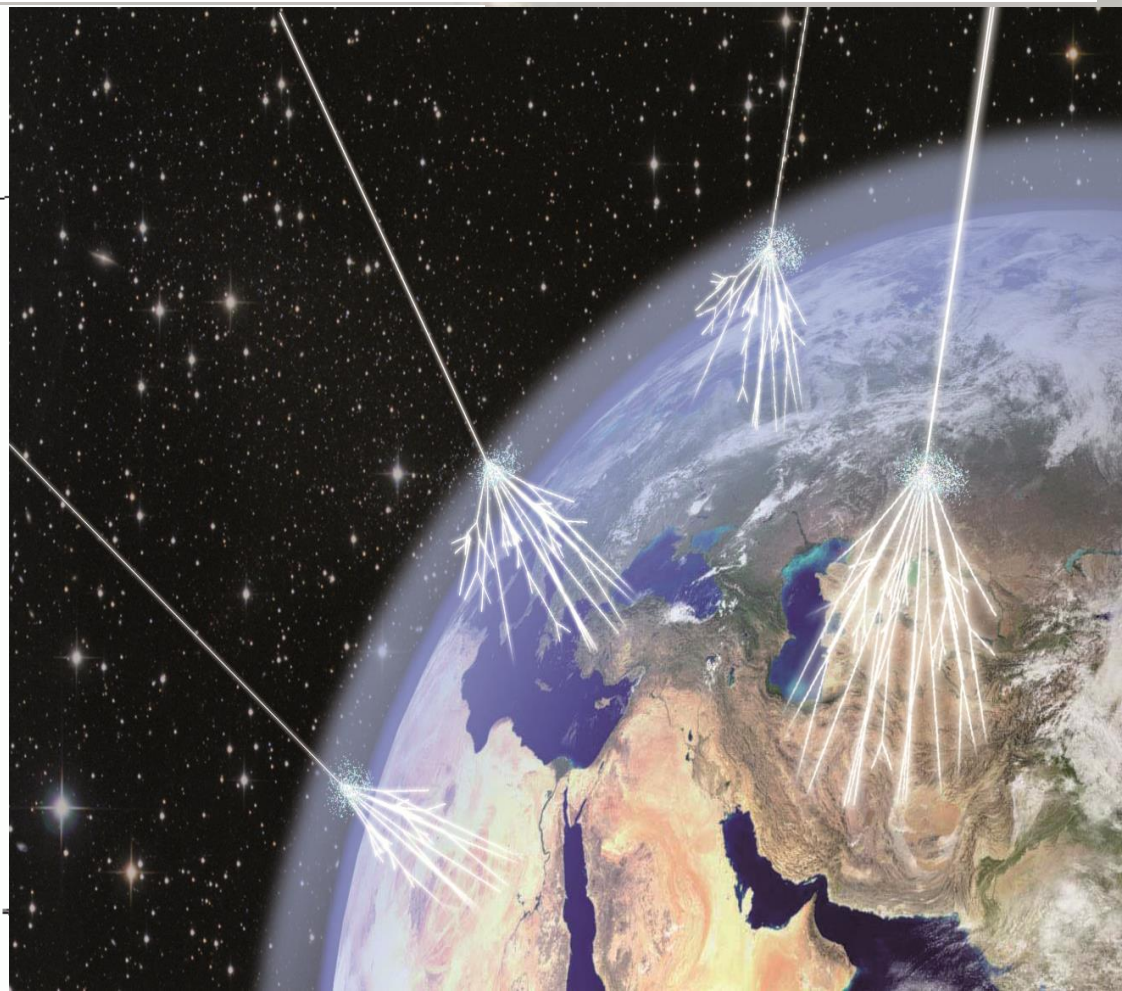
Motivation

- Cherenkov Telescope Array (CTA)
  - Rechercher l'origine des rayons cosmiques
  - Comprendre la nature et la varieté des processus d'accélération de particules autour des trous noirs
  - Etablir la nature de matière et la physique au delà du modèle standard
- Comment? Par la détection de rayons gamma sur terre!
- Pourquoi sur terre et encore Comment?

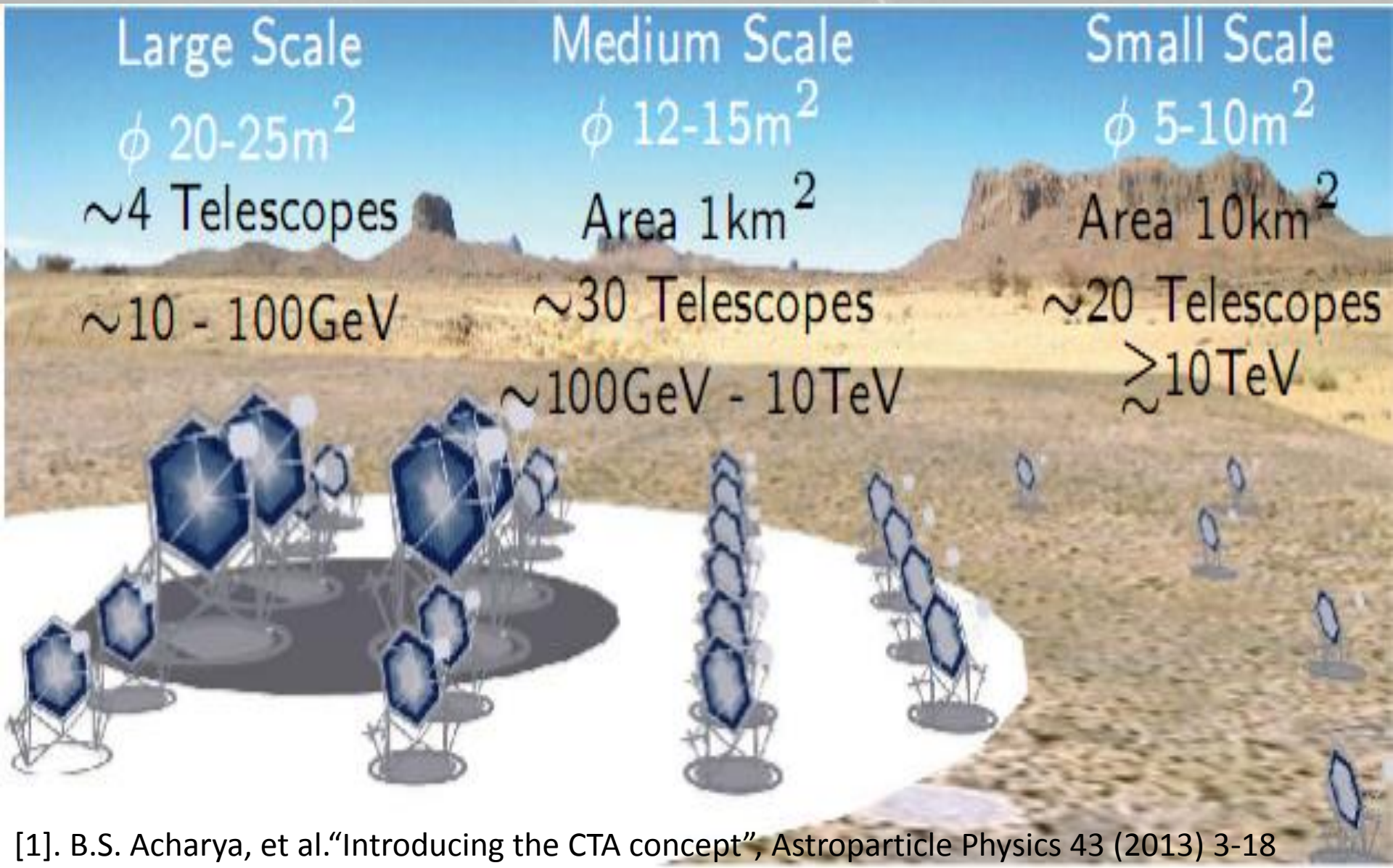
Technique de détection de rayon gamma





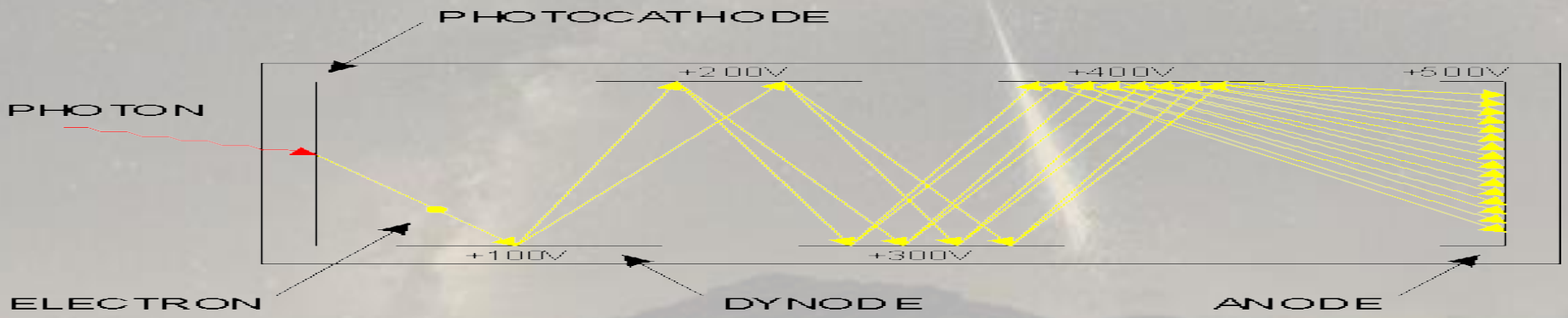


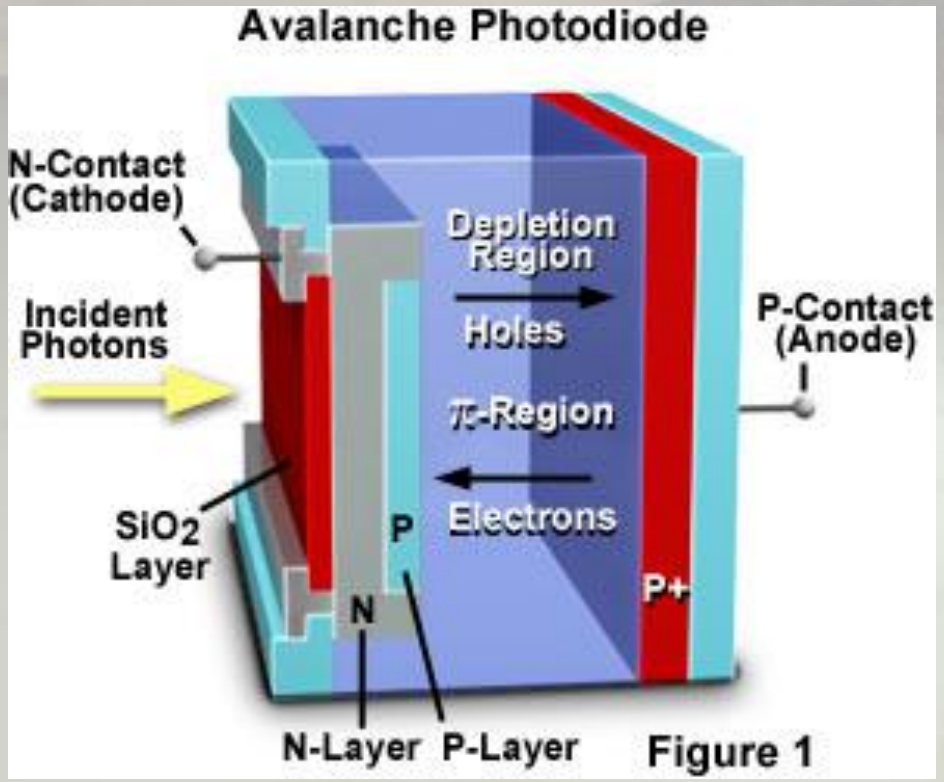
Structure de CTA [1]



[1]. B.S. Acharya, et al.“Introducing the CTA concept”, Astroparticle Physics 43 (2013) 3-18

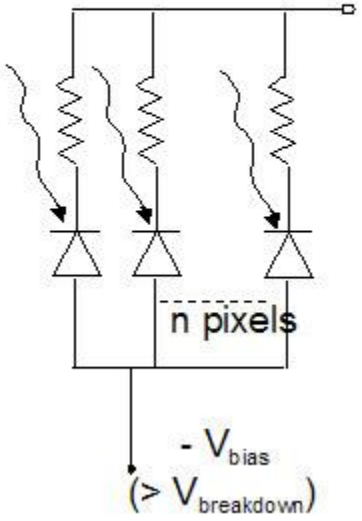
Photo détection – principe [2]





SiPM:

- matrix of n pixels (~1000) in parallel
- each pixel: GM-APD + $R_{quenching}$

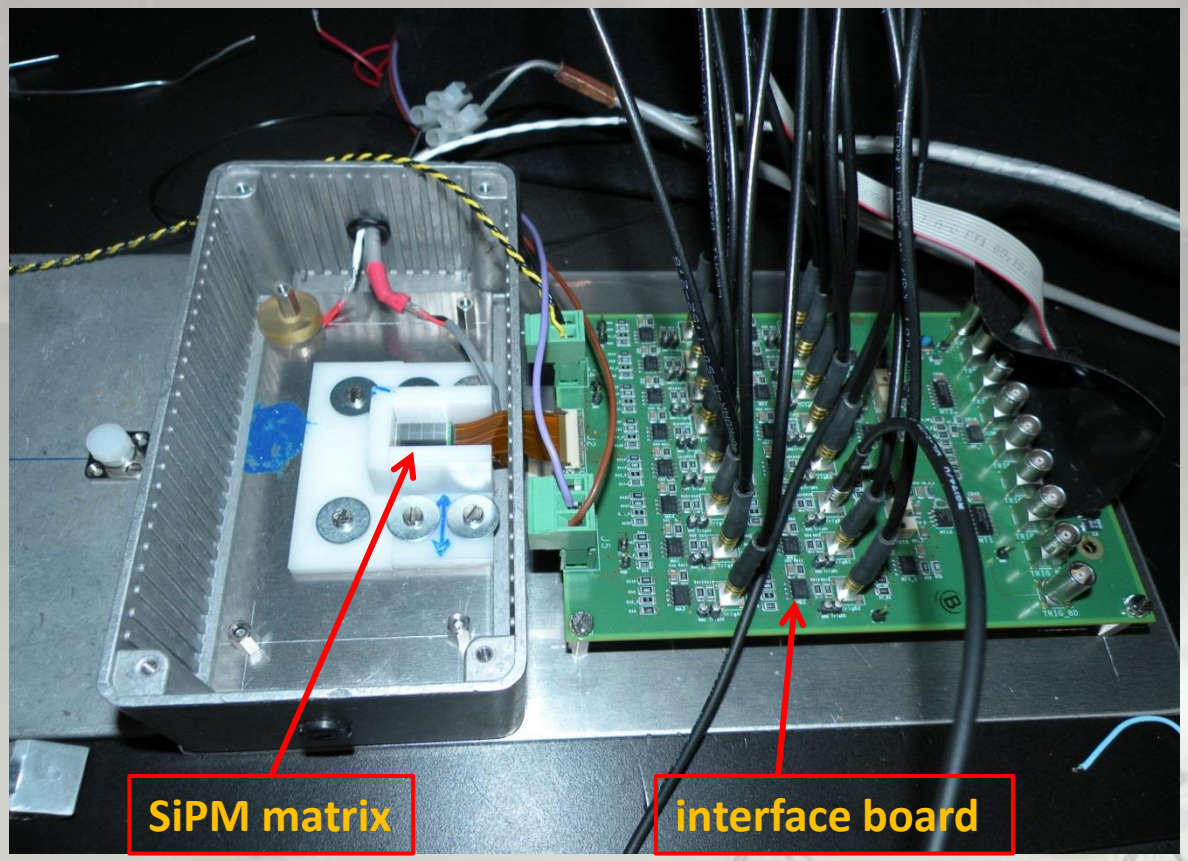


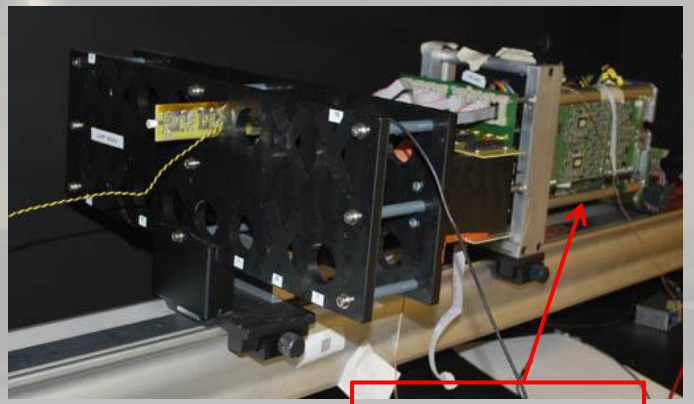
[2]. H. Mathieu, «Physique des semiconducteurs et des composants électroniques»

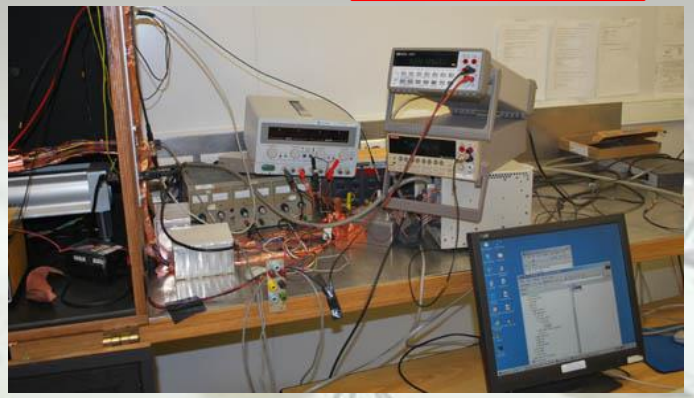
Photo détection - PMT vs SiPM

	PMT	SiPM
Sensibilité au champ magnétique et à la forte intensité lumineuse	Oui détruit	Non
Taille	volumineux	compact
Tension de polarisation	~ KV	≈ 70 V
Efficacité quantique	20 – 30 % (λ: 300-450 nm)	30 - 40 % (lumière visible)
Gain	$10^6 – 10^8$	~ 10^6
Bruit (Courant d'obscurité)	bas	3 µA / canal
Crosstalk	Non	Oui

Banc de test @ LAPP – tiroir HESS II

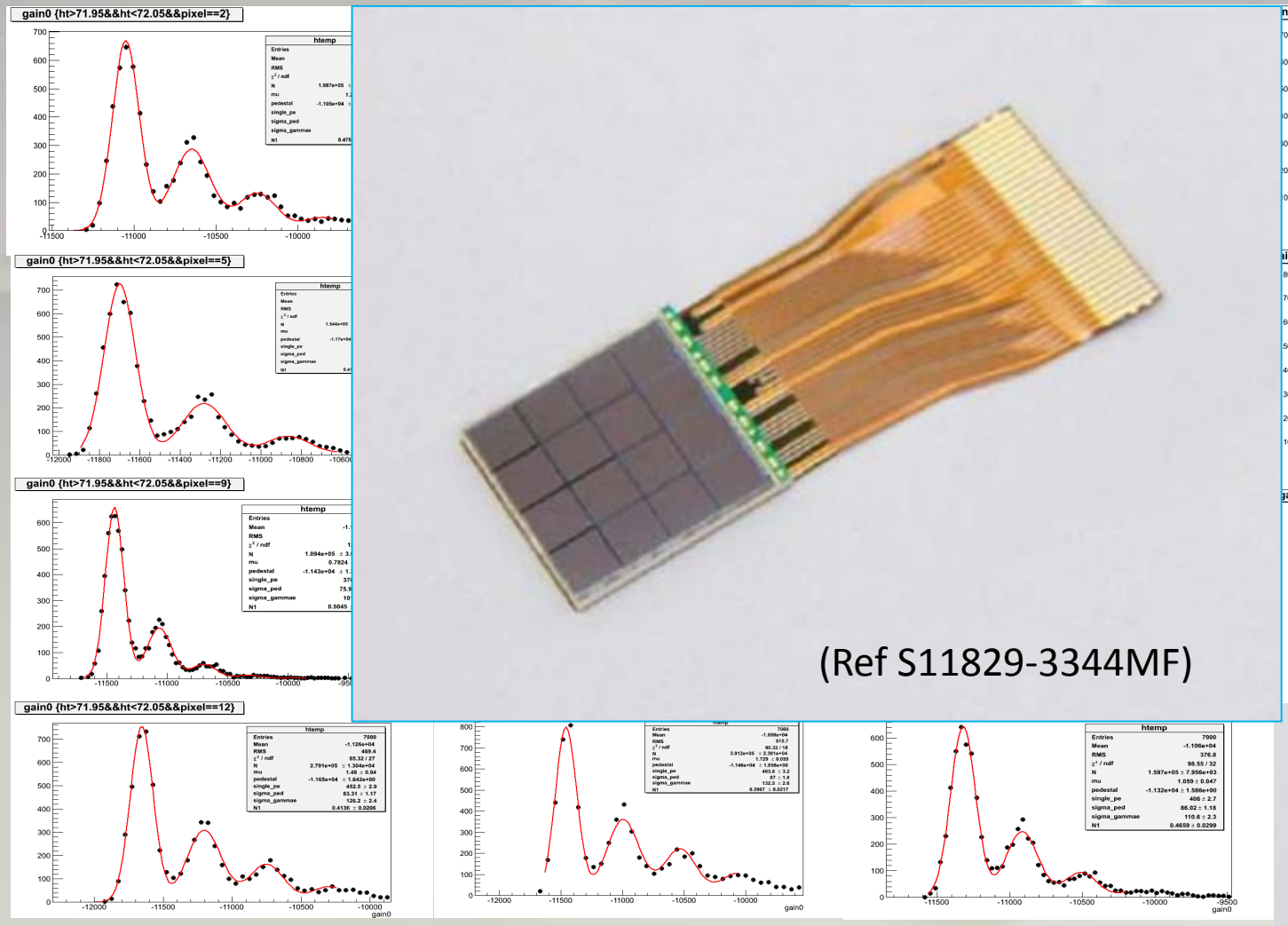




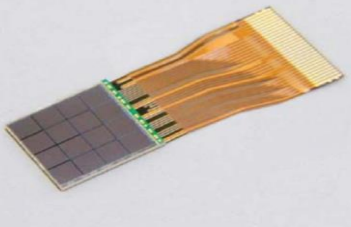


- Test with light source.
- An interface of gain stage and inversion => compatible with the HESS2 module.

Hamamatsu 4x4 matrice SiPM

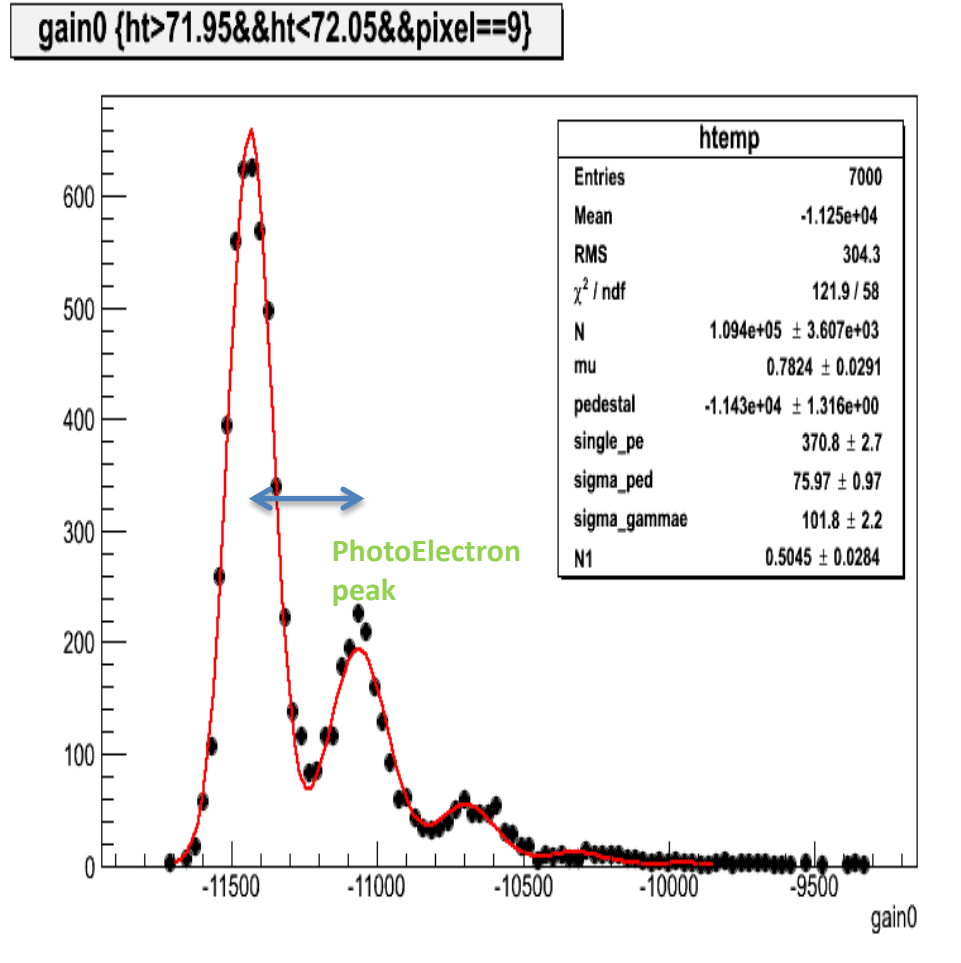


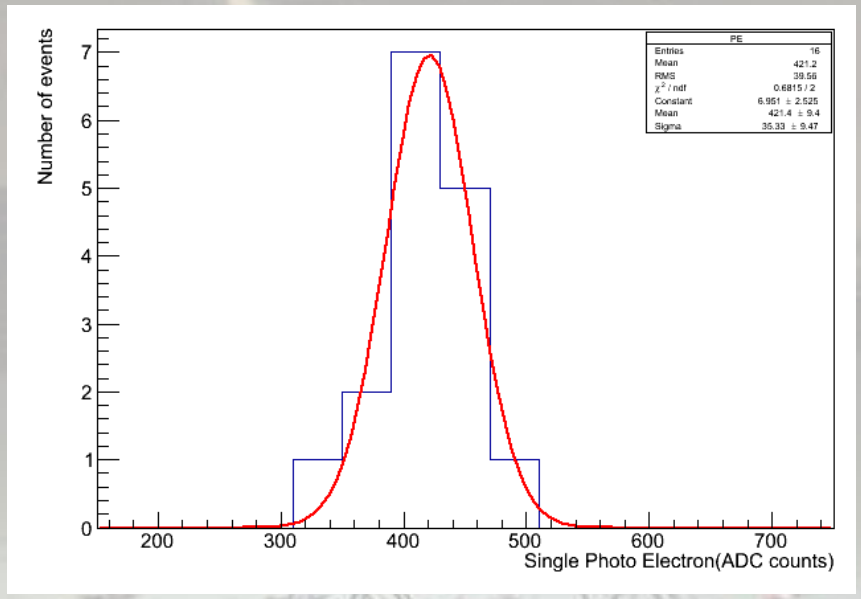
(Ref S11829-3344MF)



(Ref S11829-3344MF)

Analyse



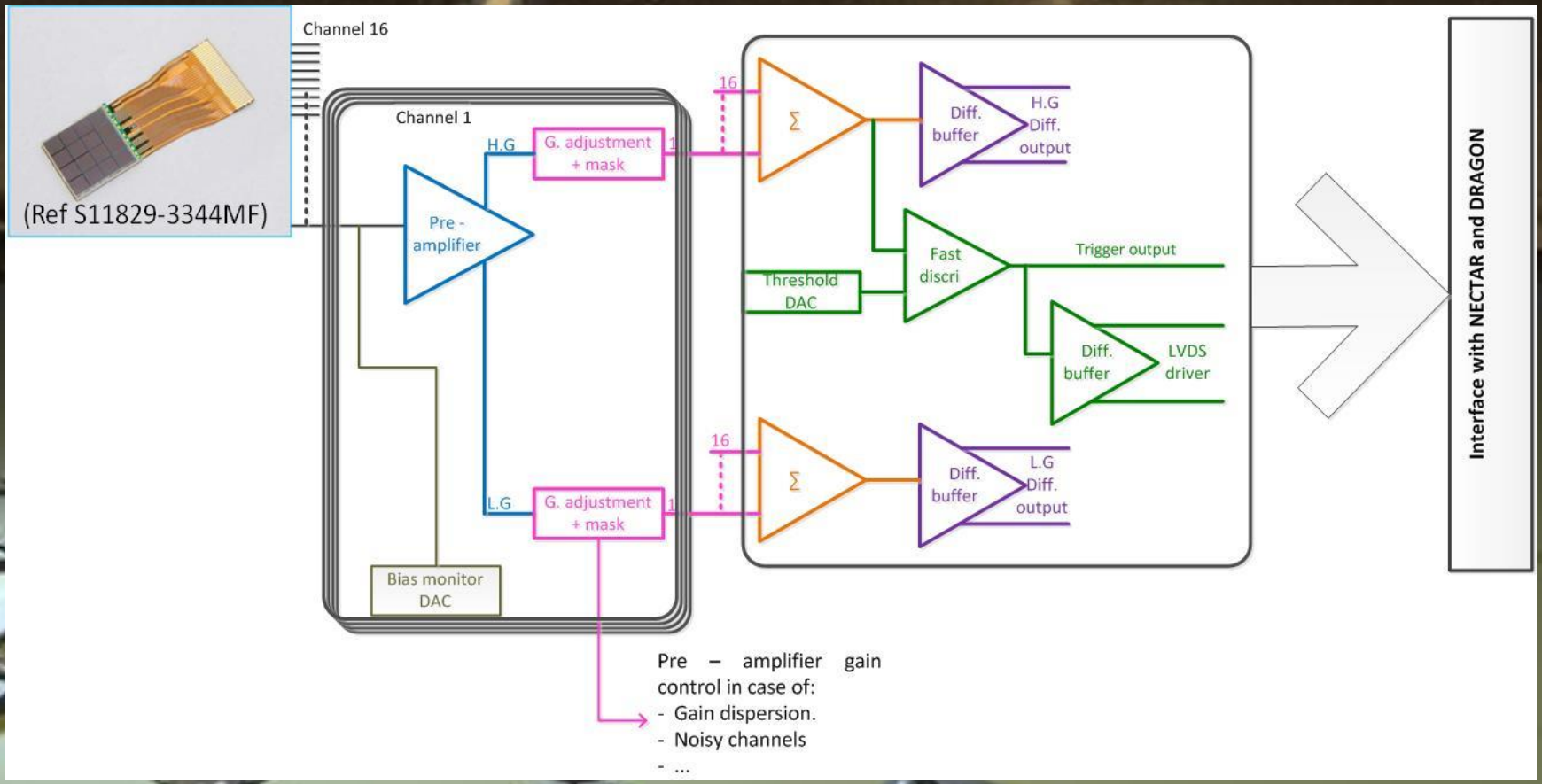


- Photoelectron ranging from : 371 to 490 (ADC counts) for **HV=72 Volts**, equivalent to a gain of **5 10^5**
- **Spread ~ 10 %**
  => On-chip DAC for pixel overvoltage adjustment (performance optimization: gain and cross talk)

Electronique de lecture – cahier des charges

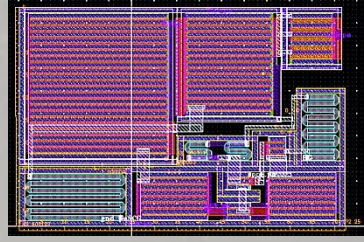
- 16 canaux de lecture par chip
  - Mesure de 1 p.e avec S/N $\geq$ 5
  - Gamme dynamique de 2000 p.e. => 2 gains
  - Ajustement des gains
  - On-chip DAC - calibration de «overvoltage » par pixel
  - Somme analogique
  - Trigger :
    - Fast discriminator avec un seuil programmable
  - **Interfacer avec DRAGON / NECTAR**

ALPS – Diagram

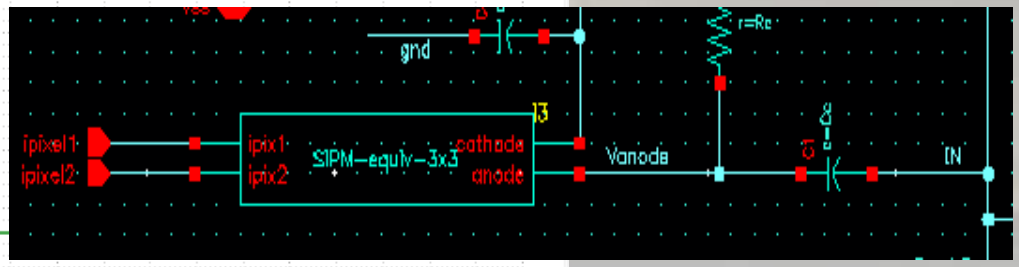


Pre - amplifier

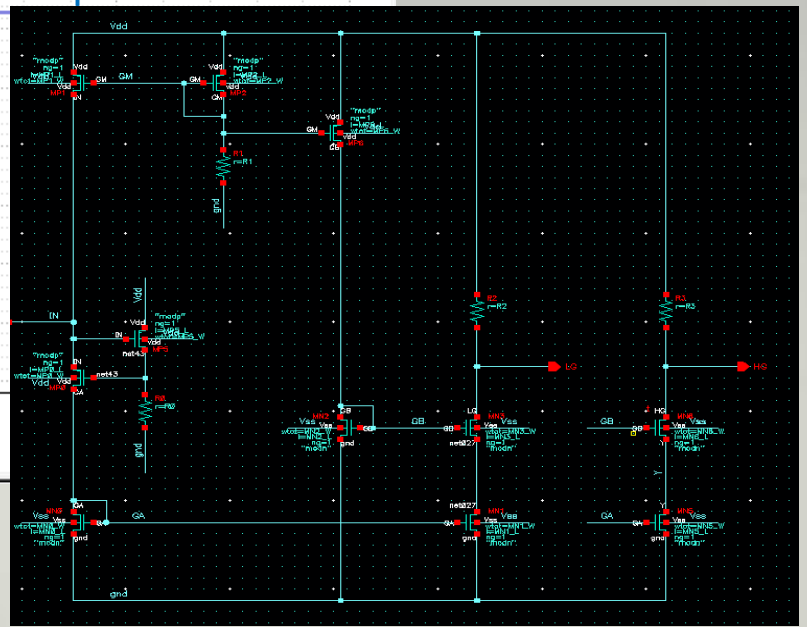
Pré-amplificateur simulation



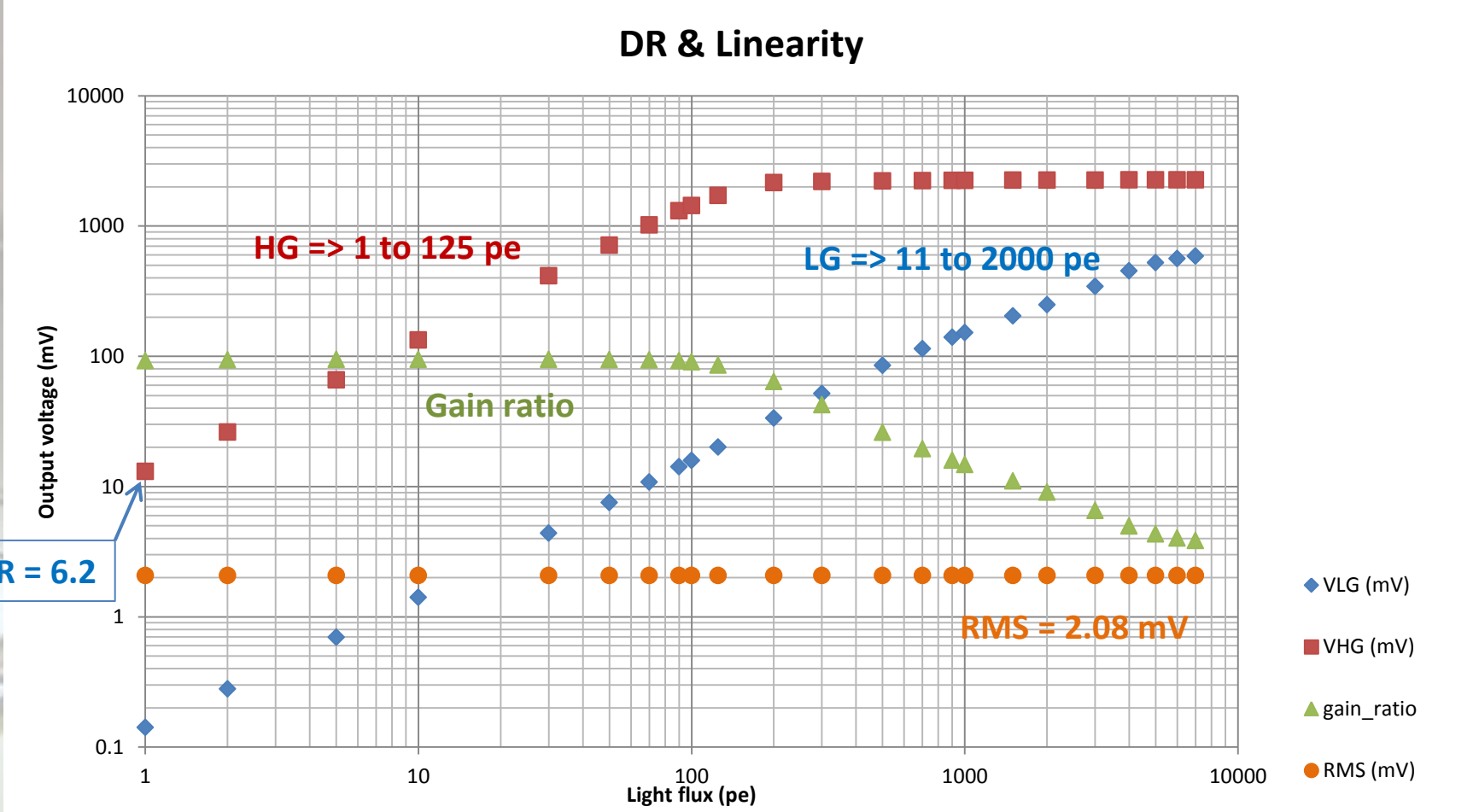
Simulated SiPM signal 1pe



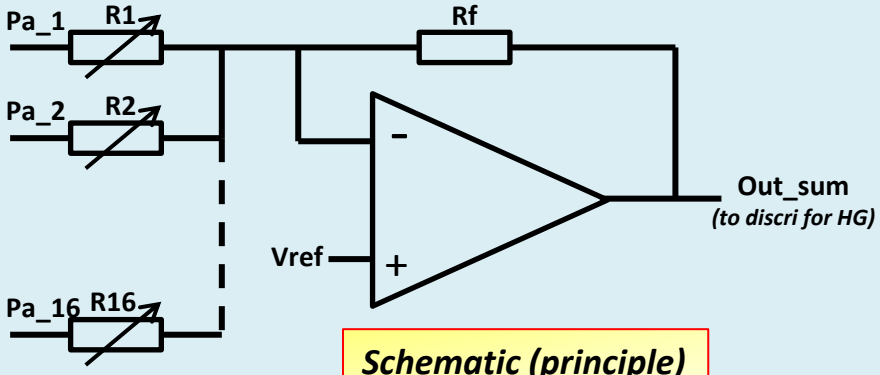
High gain response



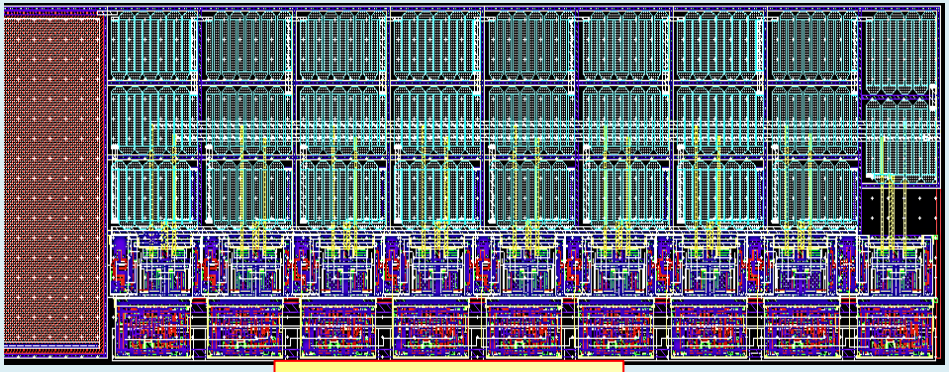
Pré-amplificateur simulation



Somme analogique et ajustement des gains



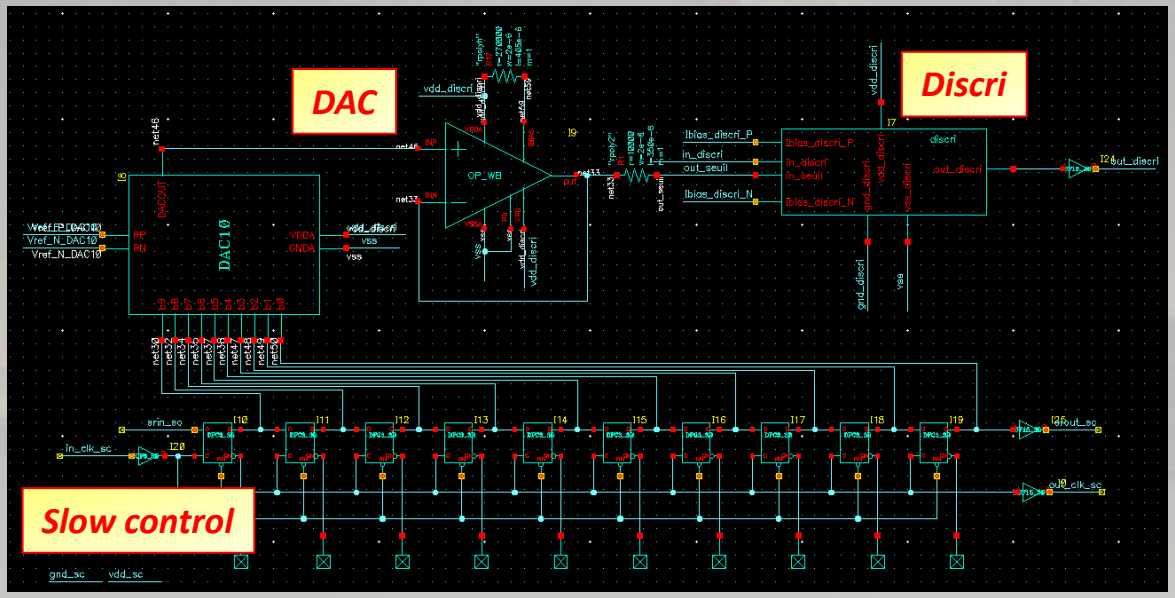
Schematic (principle)

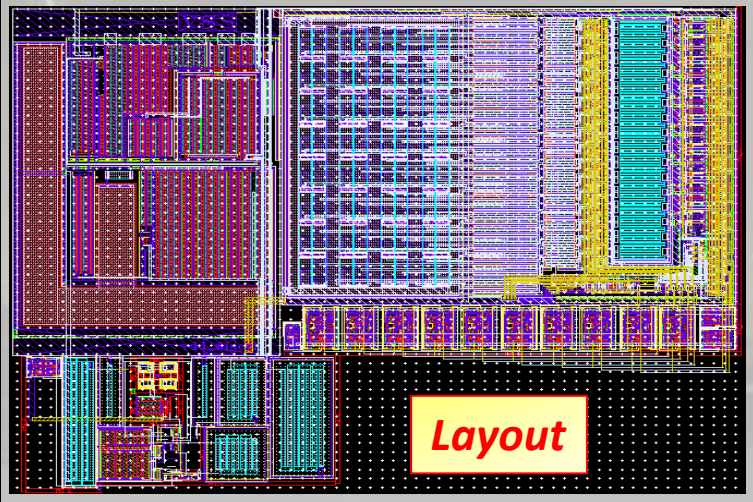


Layout of 1 resistor

- Somme des 16 sorties de préamp (résistances contrôlées)
- R-2R architecture :
  - Préamp voit toujours la même charge (mieux pour la linéarite)
  - Ajustement des gains – résolution 8 bits
  - Suppression des canaux bruyants
- CR shaping inclus dans chaque canal
- Vref ajustée selon le seuil du discriminateur

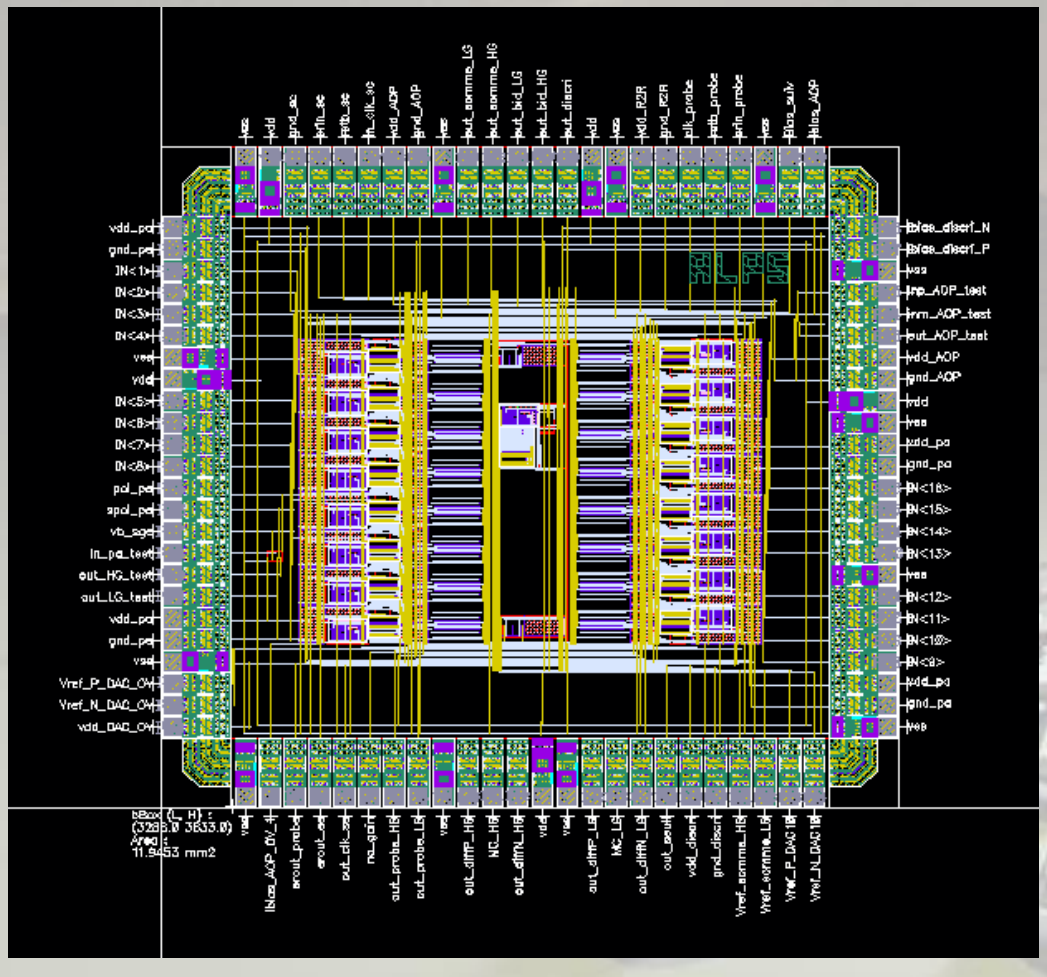
Trigger (DAC + discri)





- Discriminator (full custom) :
  - étage entrée (Dual bipolar) => minimiser l'offset
  - Self-biased
  - Buffered digital output for trigger
- DAC (10 bits seuil)
  - AMS standard cell
  - Seuil controlable

ALPS - layout



- **AMS BiCMOS 0.35µm**
- **96 pin out**
- **Die size:**

about 3.673 X 3.298 mm²

- En fabrication depuis Mars

- Test en juin

Bibliography

[1]. B.S. Acharya, et al.“Introducing the CTA concept”, Astroparticle Physics 43 (2013) 3-18

[2]. H. Mathieu, «Physique des semiconducteurs et des composants électroniques »,