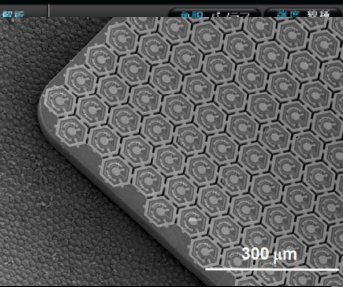
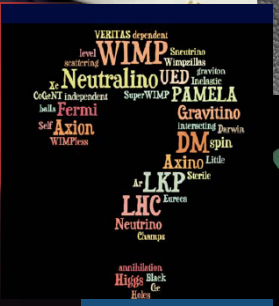
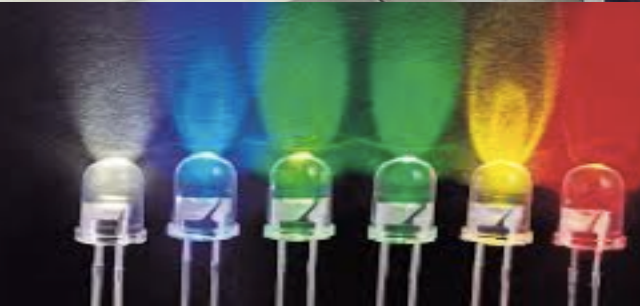
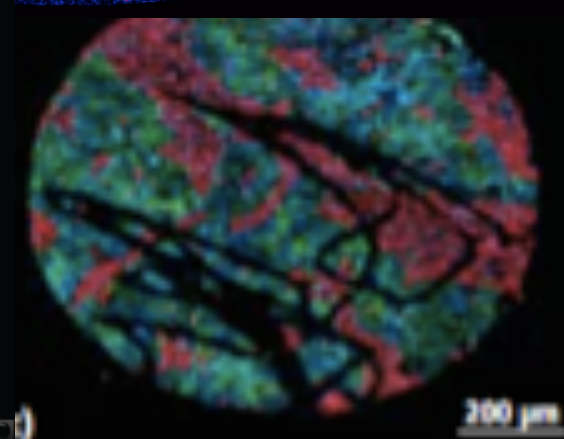
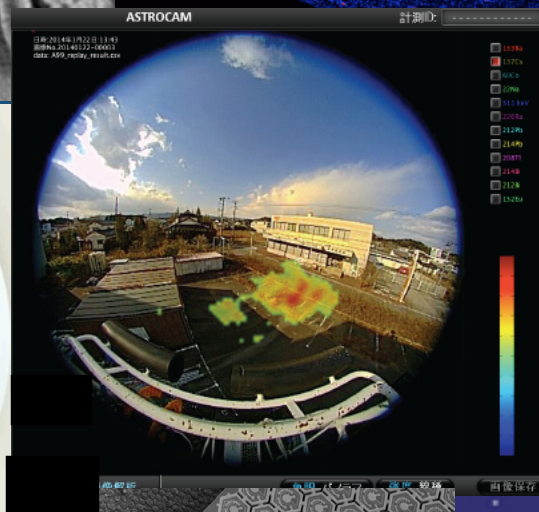
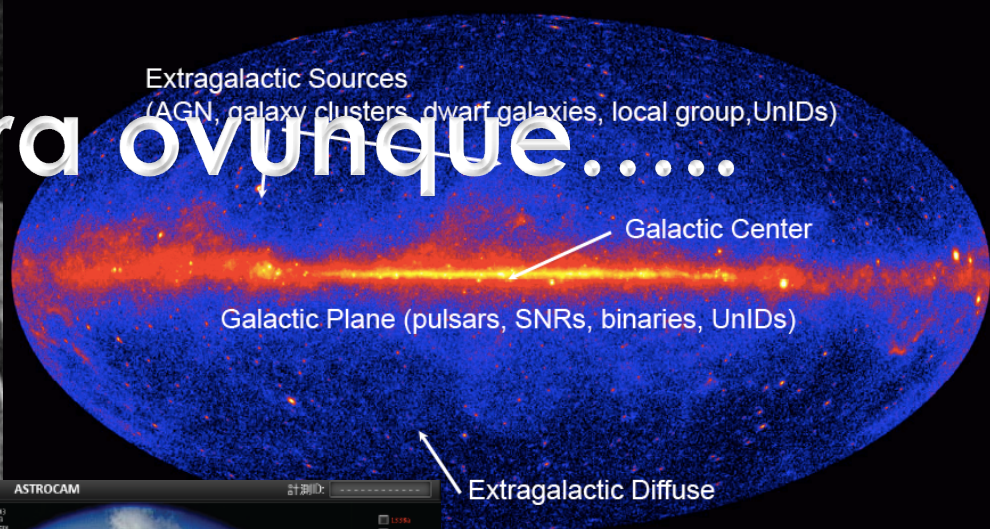


Svelare la luce visibile e invisibile

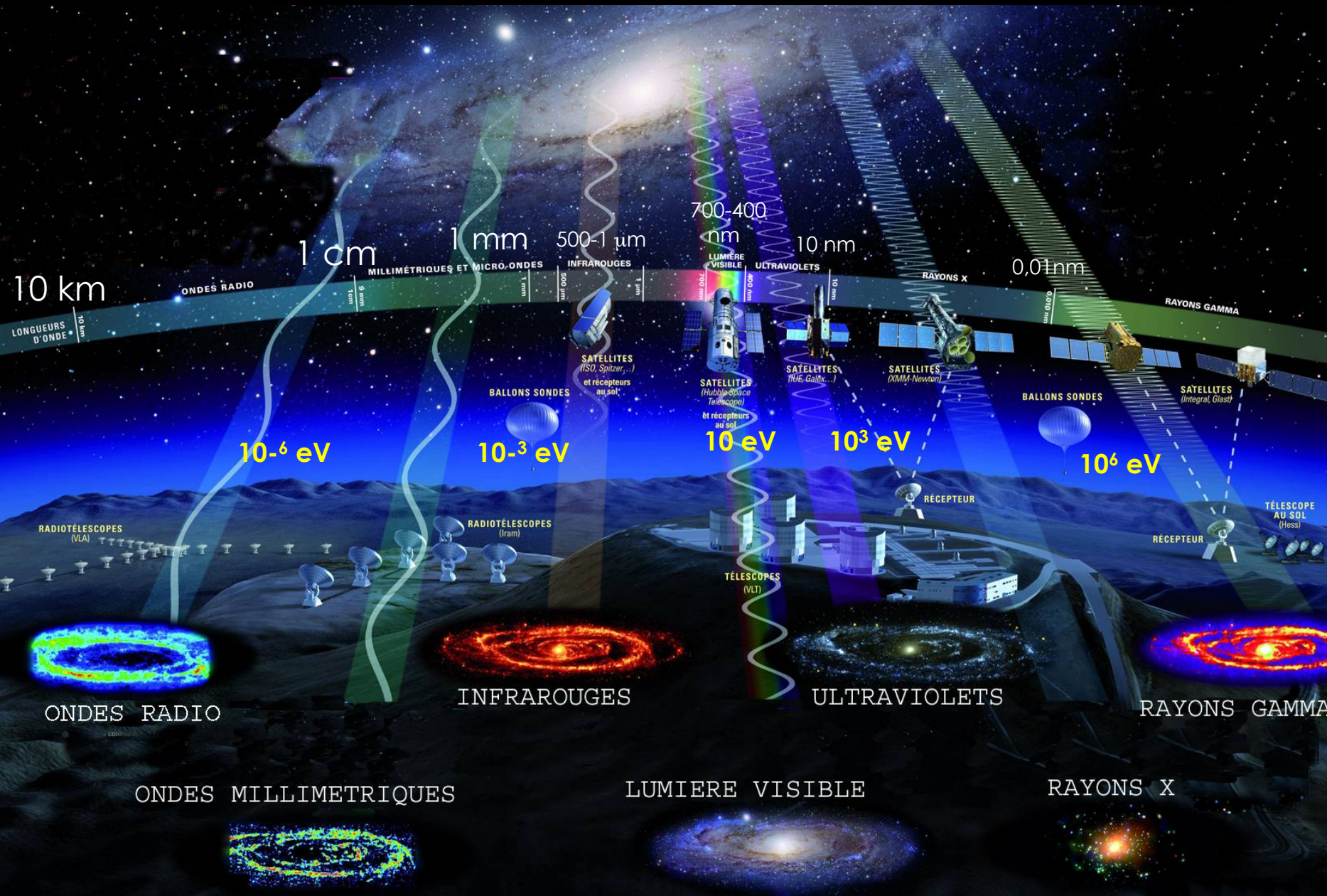
CERN

A. Cattai

Luce..... entra ovunque.....

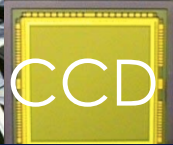
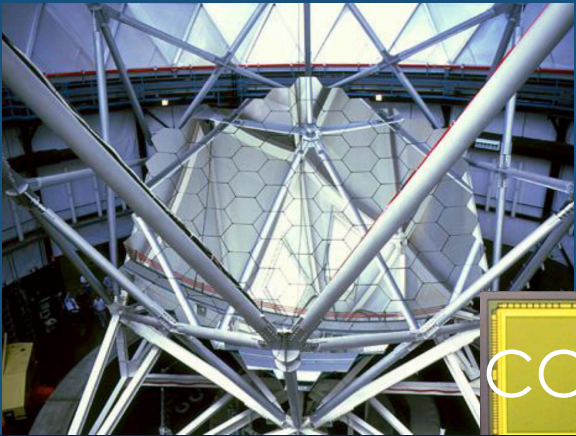


Spettro elettromagnetico

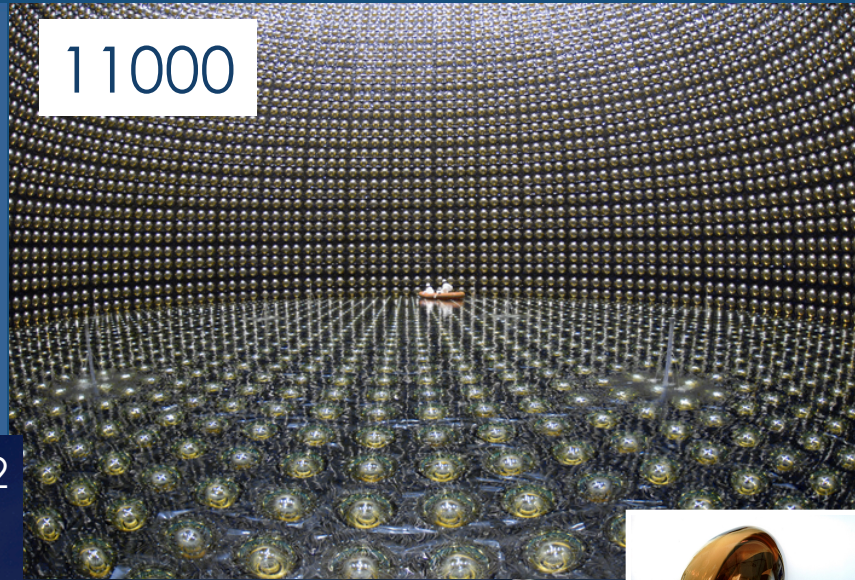
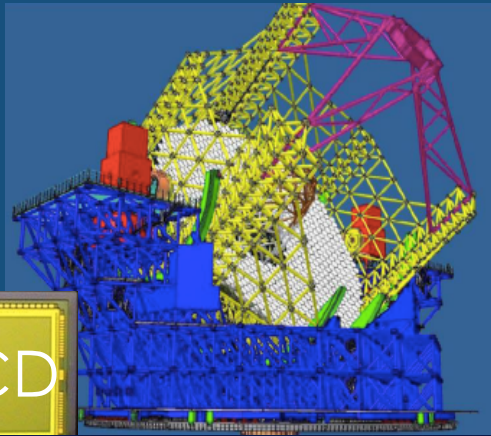


© Photographie: B. Cantel pour la page du CNRS, photos d'archives: 1 février et 30 2006, journal Astronomie & Astronomie&Ciel 2001, NASA/JPL/Caltech, Space University of Arizona, NASA/JPL/Caltech, B. Sobolew, V. Ivanov/REU, programy/DOU/MA/MSF/MSGA/MSZ/LI & G.D.Wang, Ansel/LI

una marea di esperimenti e di rivelatori...

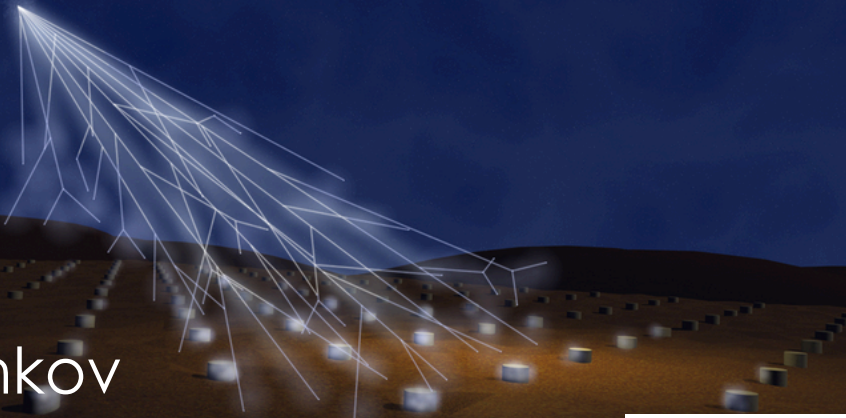


CCD

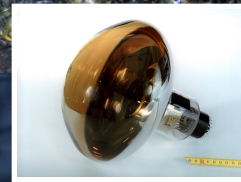


11000

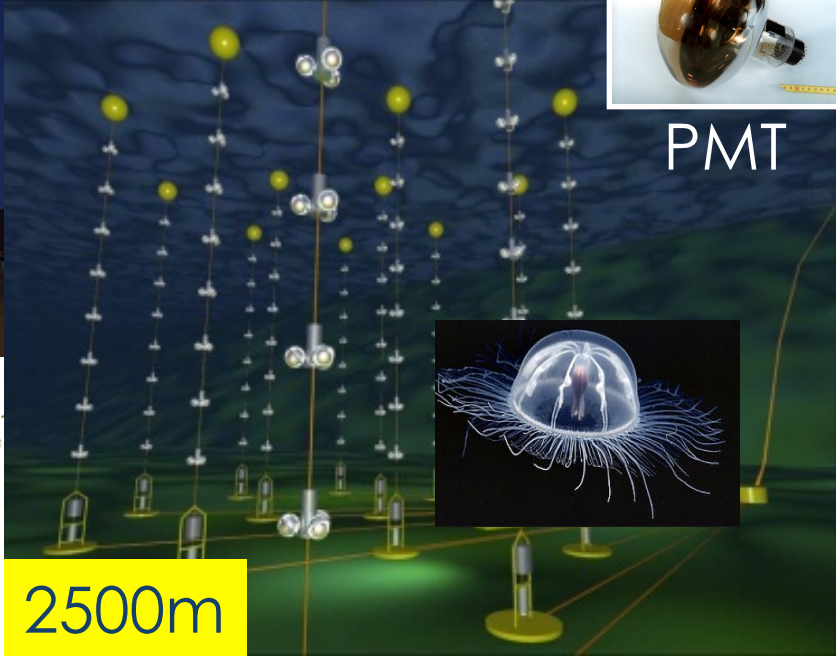
1660 stazioni su 3000 km²



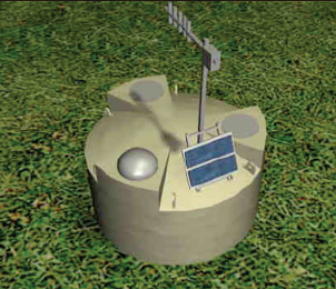
Cherenkov

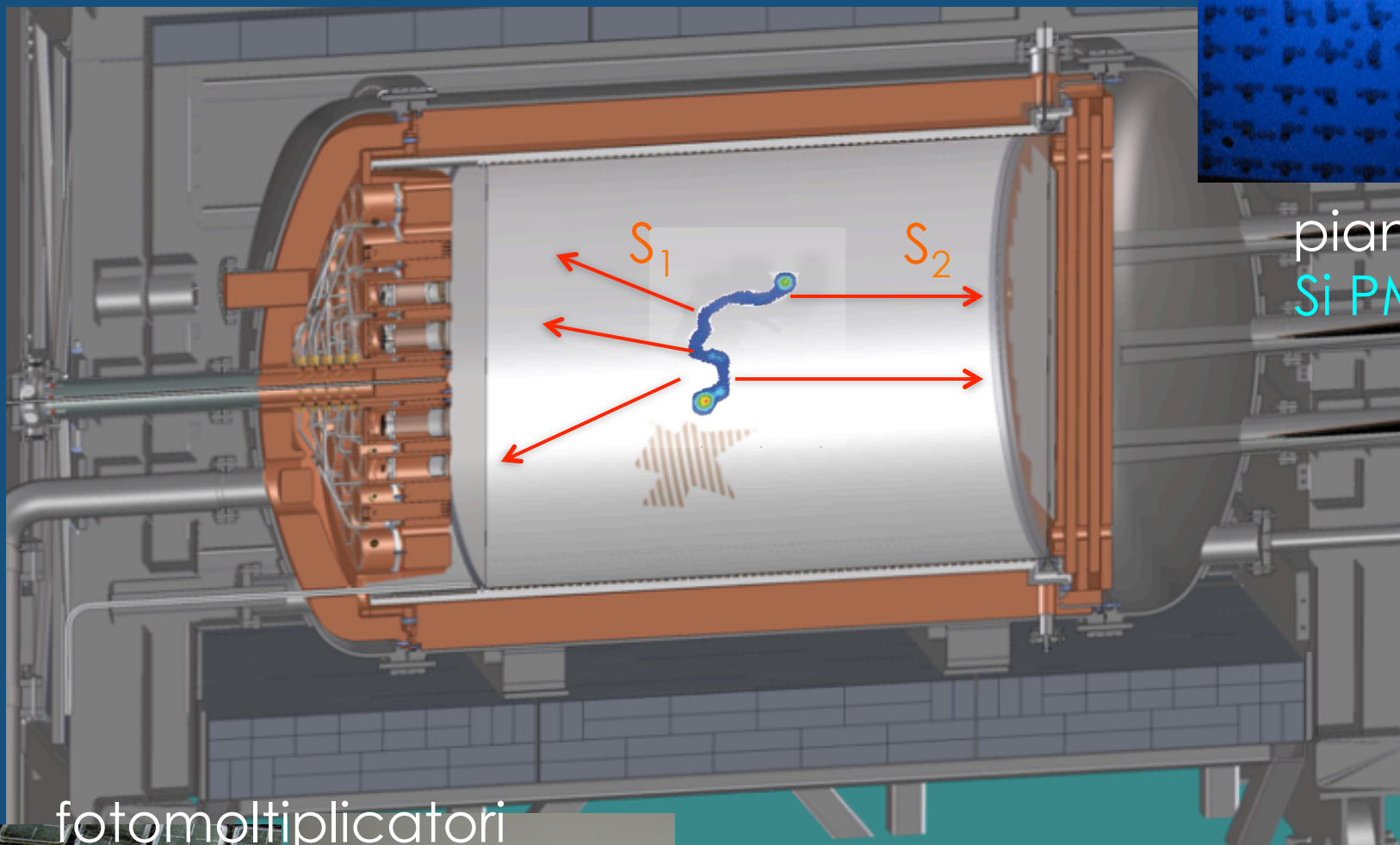


PMT



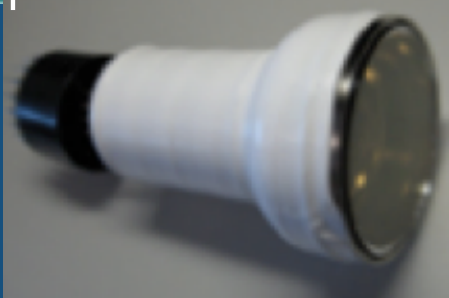
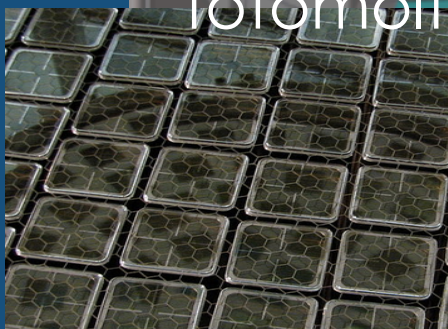
2500m



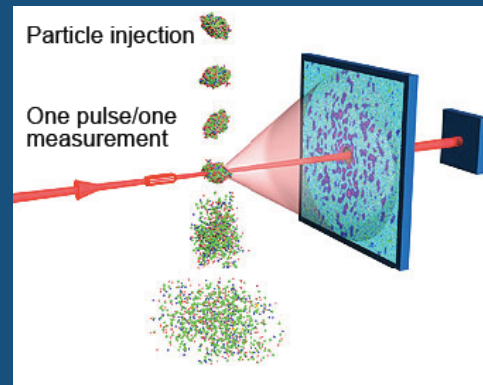
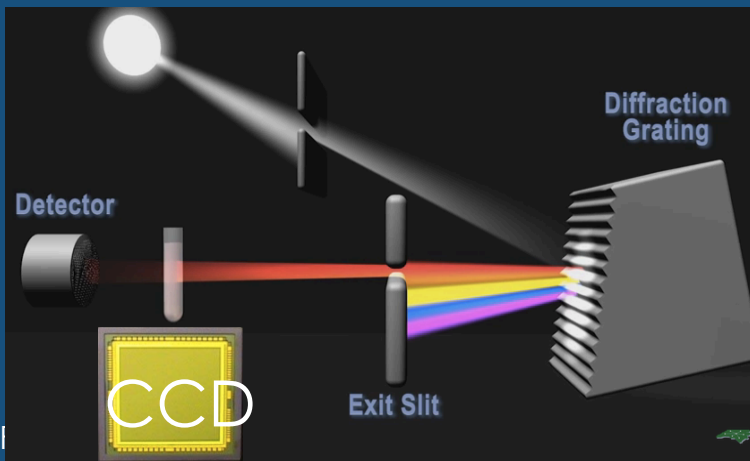
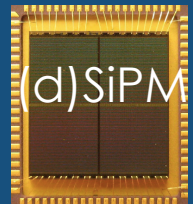
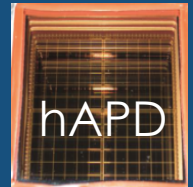
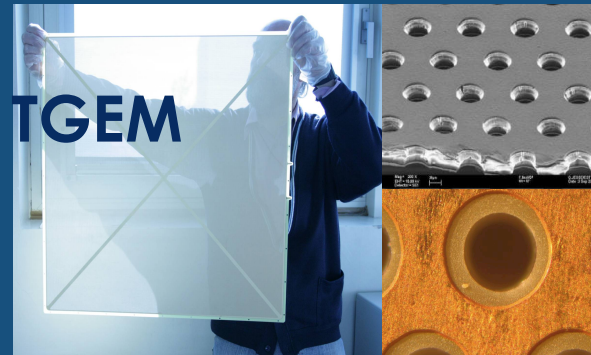
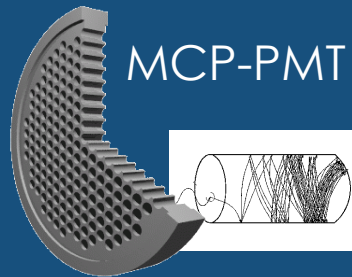
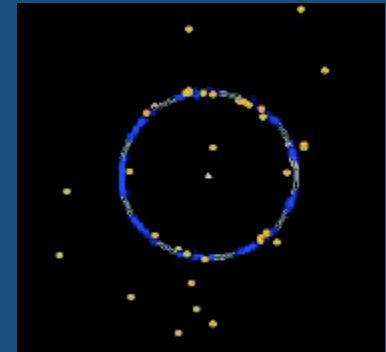
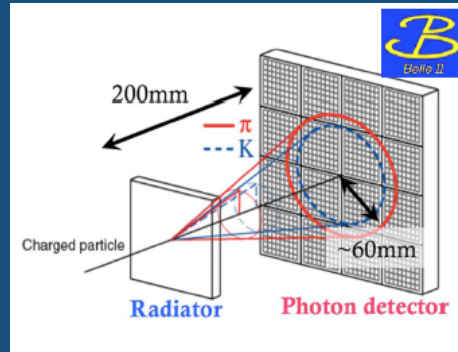
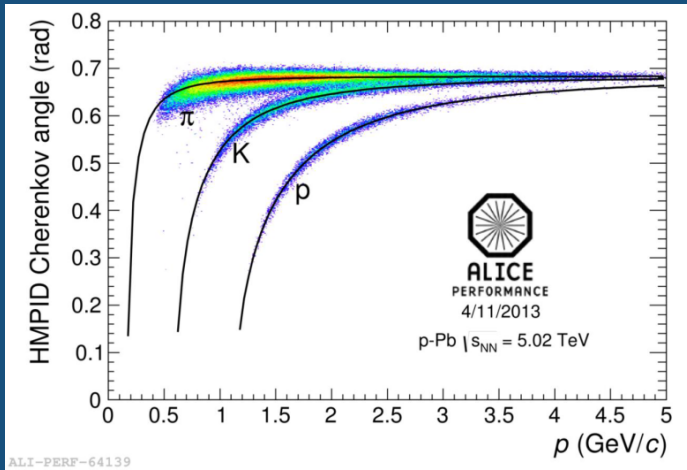


piano
Si PM

fotomoltiplicatori

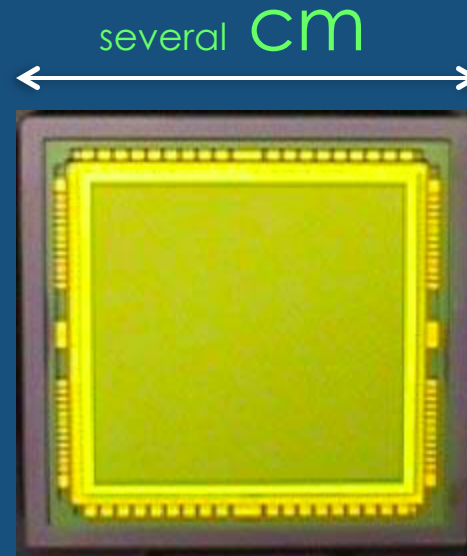
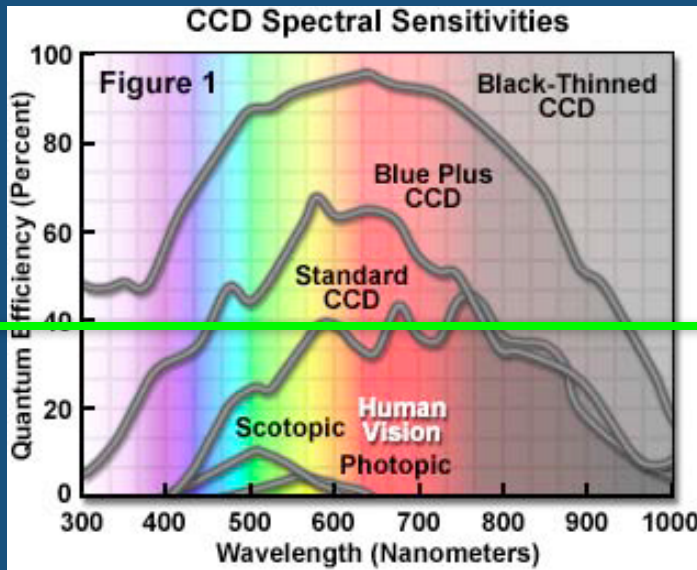


radiopuri !!!
<0.25 mBq/kg

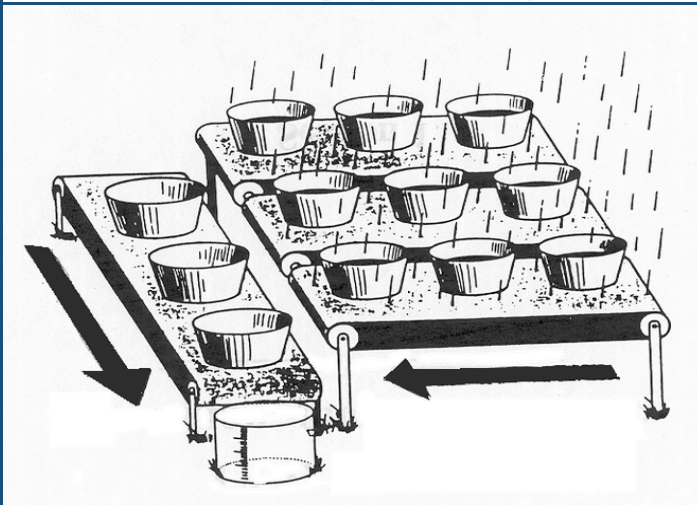


Charge-Coupled Devices CCD

Quantum efficiency & wavelength coverage (300-1000 nm)
imbattibili !!!!!!!



pixels
20 μ m
x
20 μ m



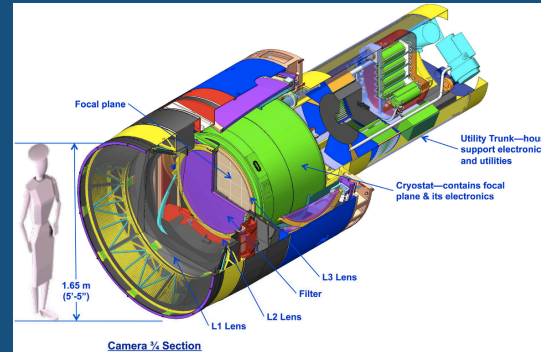
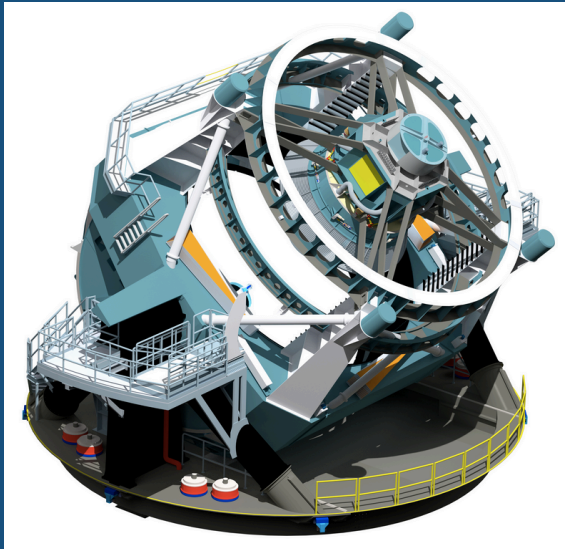
μ sec !!! \rightarrow parallel 50 MHz

rad hard $< 10^{10} n_{eq} cm^{-2}$

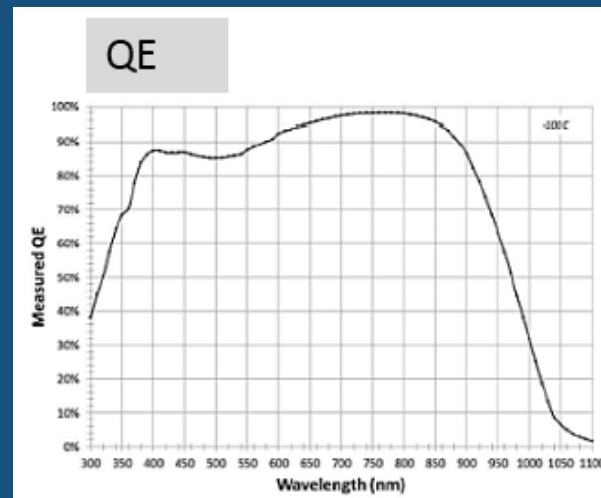
The Large Synoptic Survey Telescope

320 – 1100 nm wavelength range

@ Cerro Pachón, Chile



$3.2 \cdot 10^9$ $10\mu\text{m}$ CCD pixels @ -100°C
→ copre un'area 40 volte a luna
→ 30 terabytes dati/notte

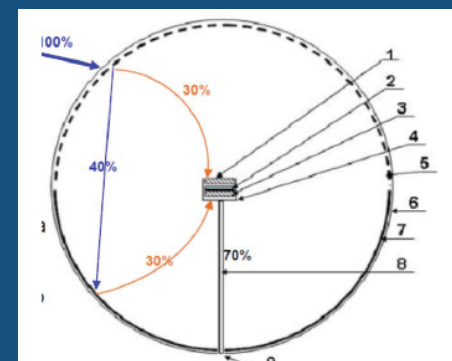
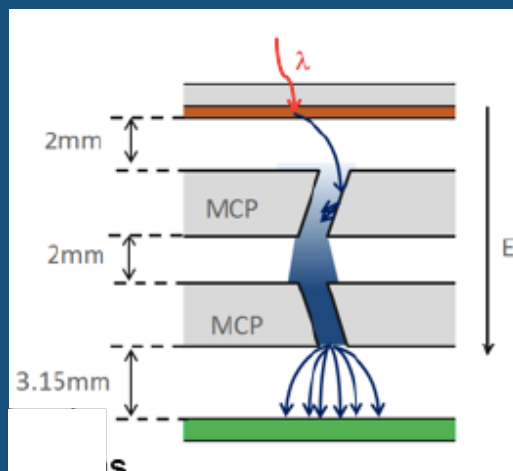
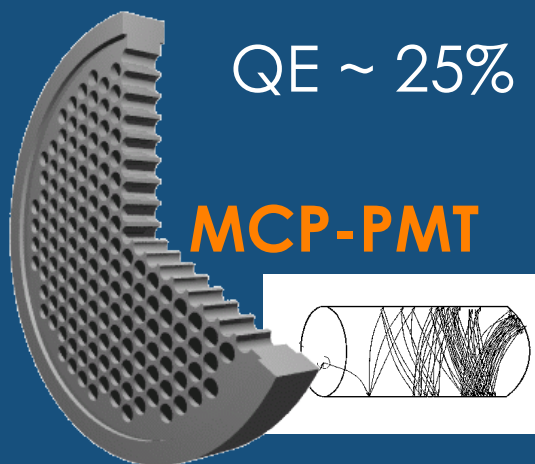
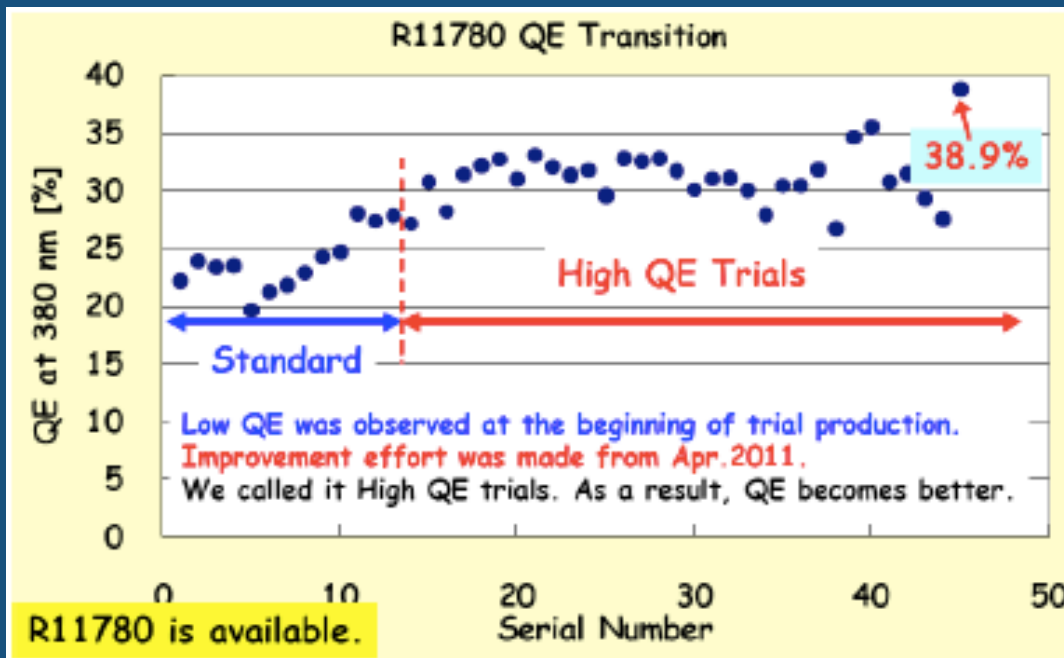


<http://www.lsst.org/>

fotomoltiplicatori

... e affini **MCP**

large area PM 12-inch



~4π fotocatodo sferico
QE ~ 25% CE > 60%

SiPM

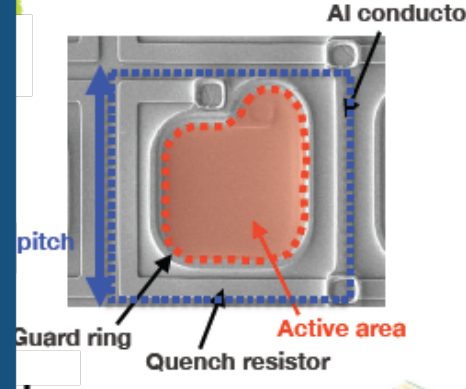
PPD SSPM MAPD MRS SPM MPPC
SiMPI dSiPM DAPD

photodiode Geiger mode: 10 → 100 μm
 celle: 1 → 6 mm² matrici: 8X8 celle

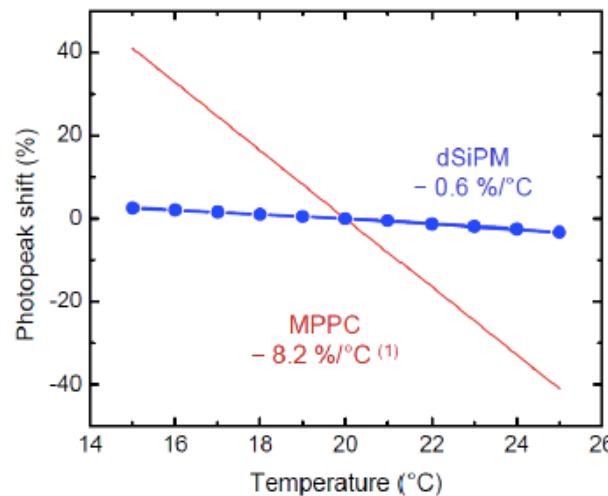
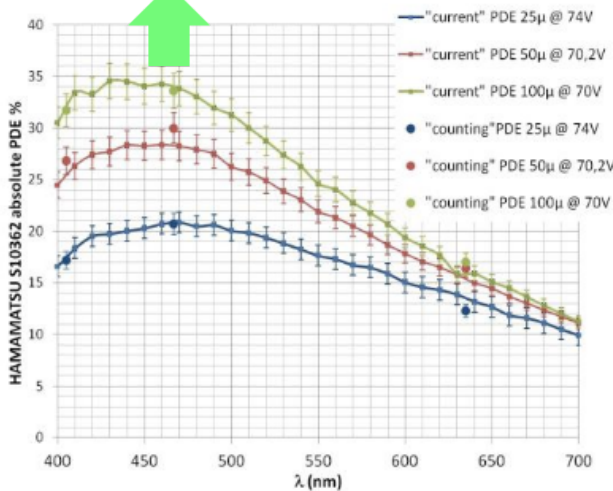
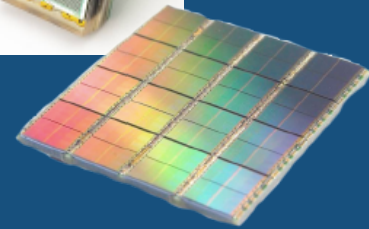
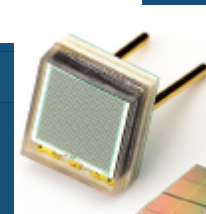
$$P_{\text{article}} D_{\text{etection}} E_{\text{fficiency}} = \varepsilon \times QE \times P_{\text{trigger}} \sim 10\text{-}35\%$$

Gain=F(T) → ~ up to 8% / deg
 rad hard ~ 10¹² 1Mev n_{eq}/cm²

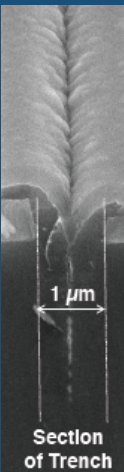
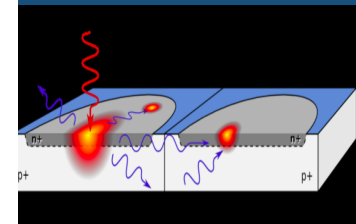
few SiPM @ 50 - 60%



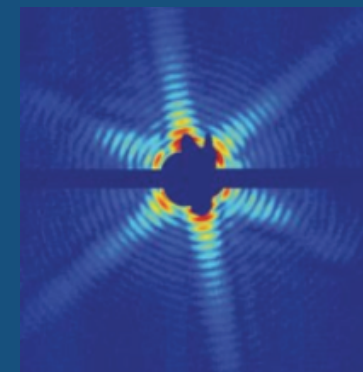
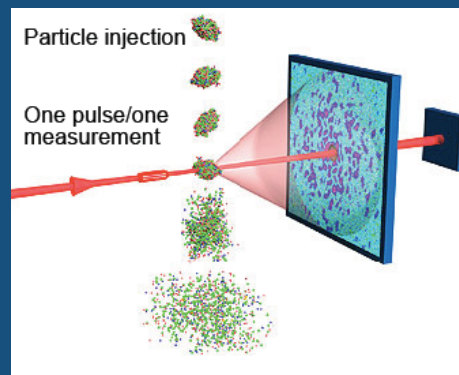
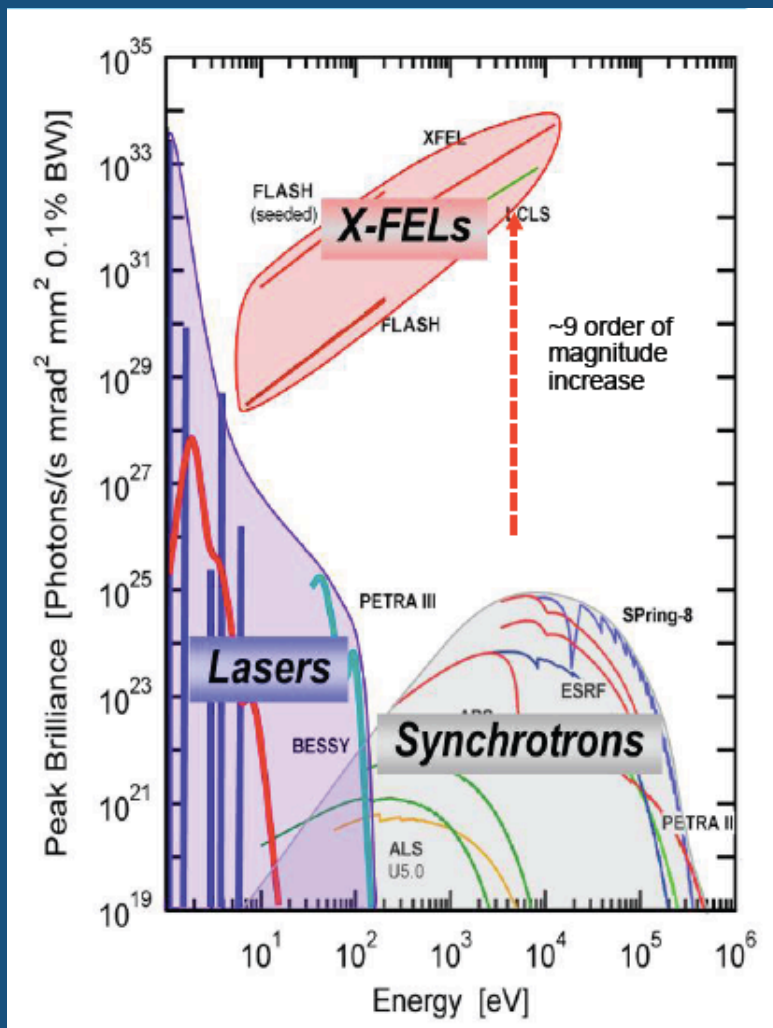
dead area



optical Xtalk



extreme pixel detectors a stato solido



Spatial resolution: as low as $75 \times 75 \mu\text{m}^2$

High dynamic range:

da 1γ up to $10^4 \gamma/\text{pixel}/\text{pulse}$

→ low noise \ll signal $\sim O(100 e^-)$

large area: $40 \times 40 \text{ cm}^2$

→ patch di molti rivelatori

→ no dead area

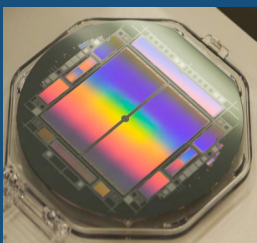
radiation hard: $10 \text{ MGy} \rightarrow 1 \text{ G Gy}$ over 3y

fast readout: up to $1 \text{ MHz}/\text{pixel}$

vacuum compatible: son dolori !!!!

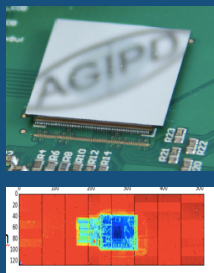
saturazione del segnale o inefficienze ceano ambiguita' nella ricostruzione

pn-CCD



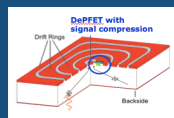
QE > 80%
 area 60 cm²
 75x75 μm²
 single γ
 dyn. r. > 10⁴
 lenta ~ 200 Hz
 rad hard ???

AGIPD



QE ~ 90%
 area 30 cm²
 200x200 μm²
 single γ
 dyn. r. > 10⁴
 frames 4 MHz
 300 cells

DePFET+signal compression

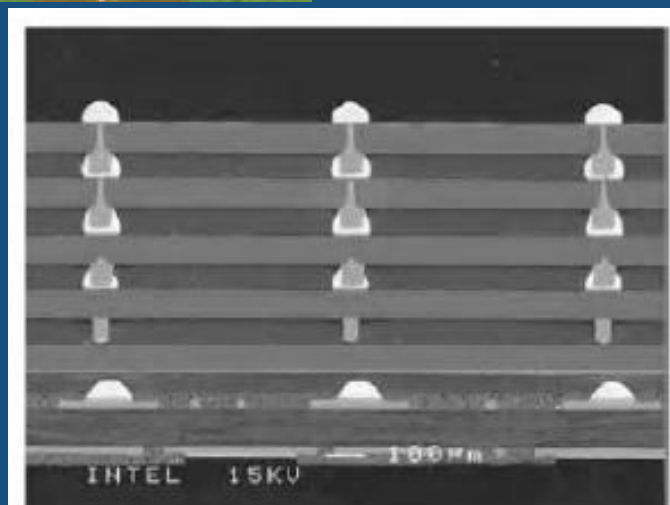
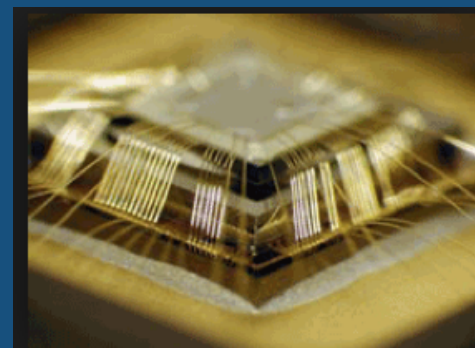
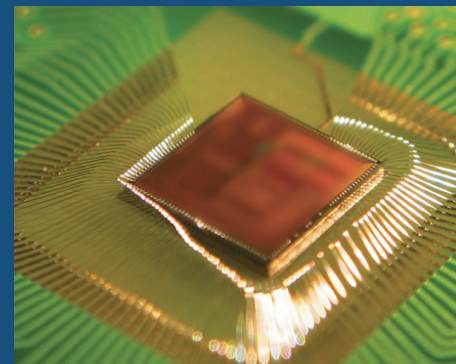


area 400 cm²
 236x236 μm²
 single photon
 dyn. r. > 10⁴
 frames 4.5 MHz
 640 cells
 rad hard ????

Large Pixel Det., Percival (MAPS)

PixFEL

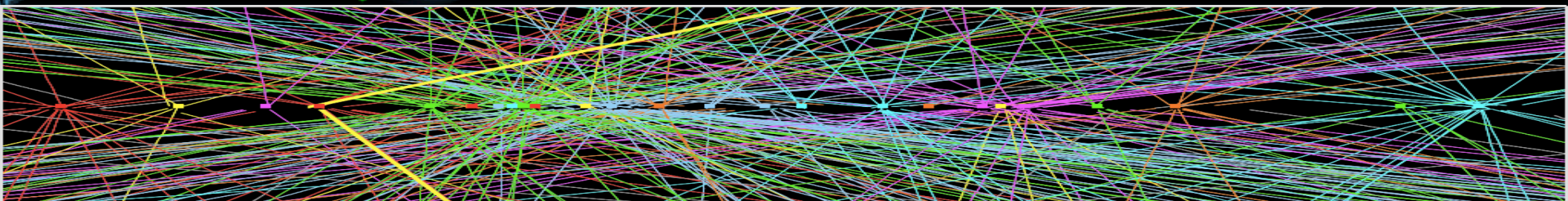
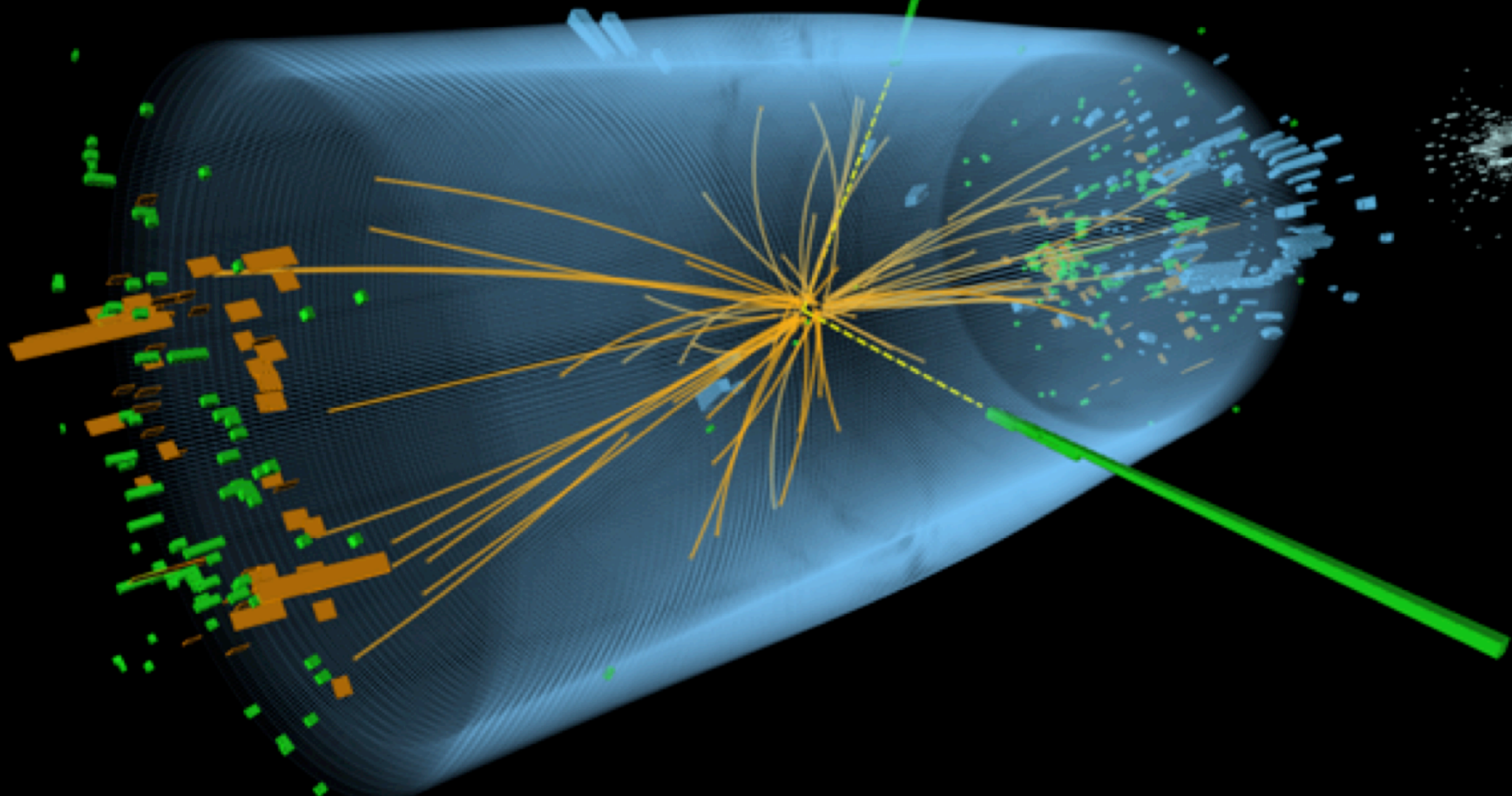
65nm CMOS
 area 20x20 cm²
 2% dead area
 100x100 μm²
 single photon
 dynamic r. > 10⁴
 frame rate 5 MHz
 1k storage cells
3D vert int TSV



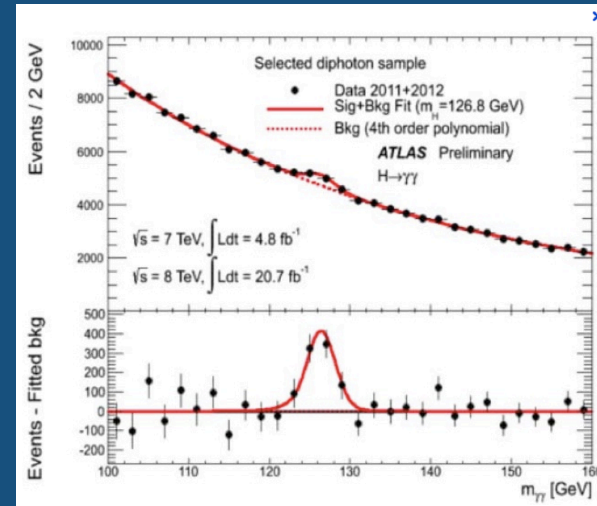
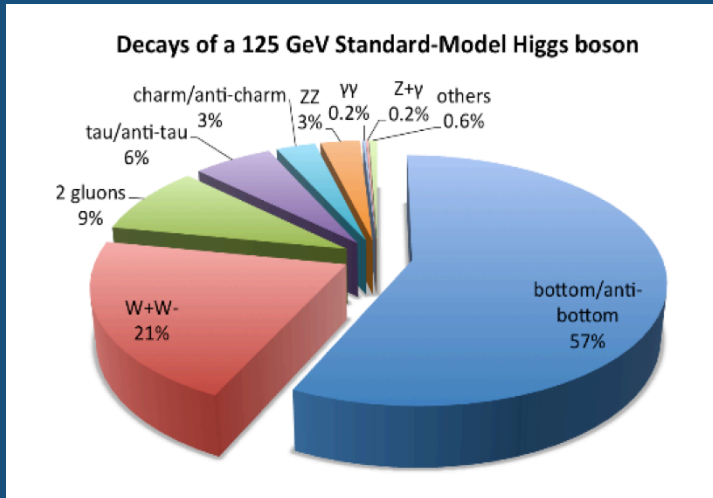


CMS Experiment at the LHC, CERN
Data recorded: 2012-11-13 13:59:58.14.621333.00 NT
Run/Event: 194.01 / 6424100

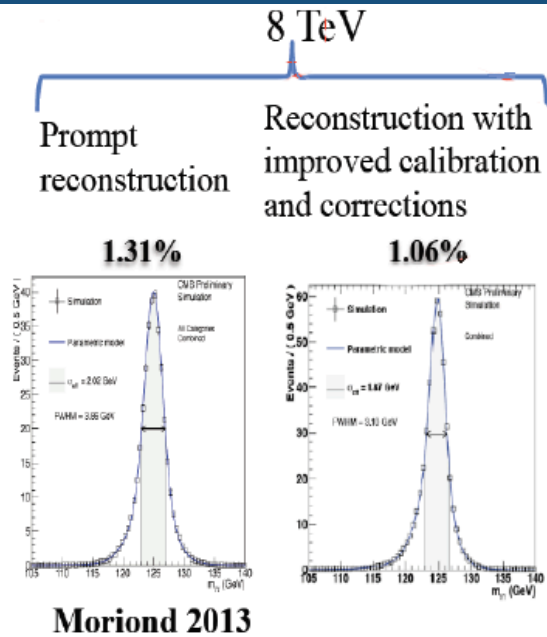
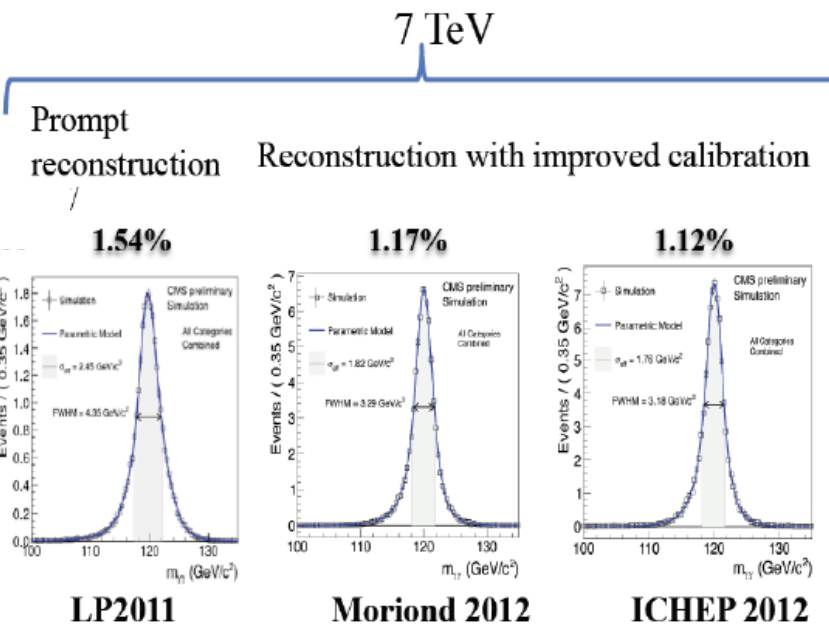
I fotoni piu' famosi al mondo

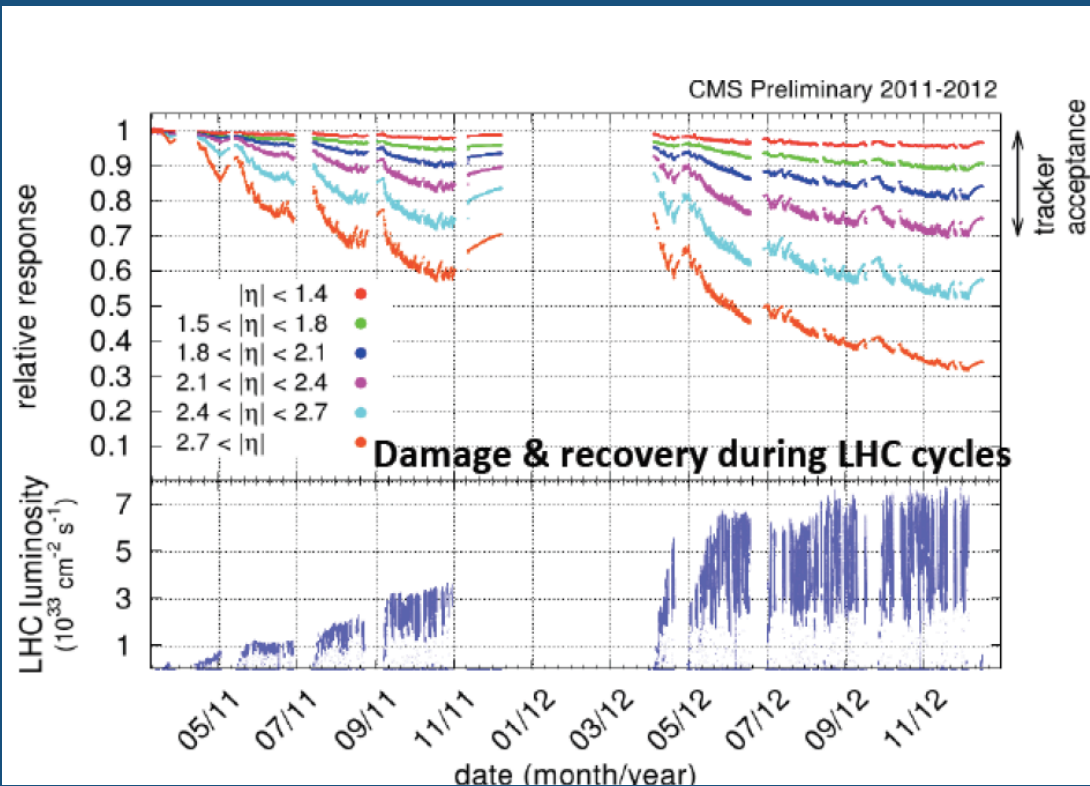


H \rightarrow $\gamma\gamma$ history



CMS

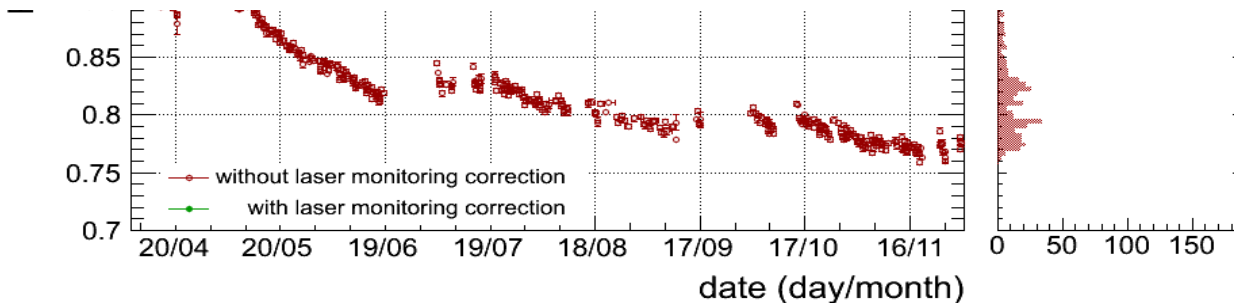




stabilita' del calorimetro negli anni i dati degradano nel tempo

$\leq 6\%$ nel barrel
 $\leq 30\%$ nell'endcap
 $\sim 70\%$ alto η

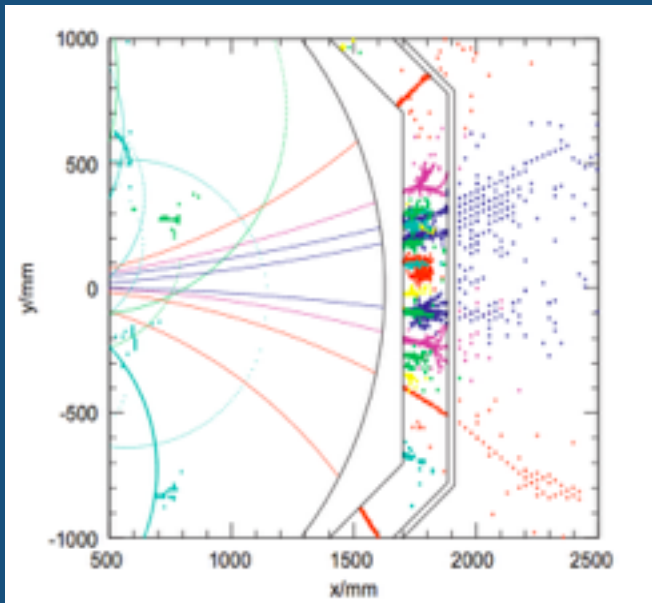
piu' che la particella "di Dio"
 e' un miracolo di calibrazione



solo un assaggio di cosa vuol dire recuperare tutta la LUCE....

PbWO₄

- si inietta via fibre ottiche in ciascun dei **75000** cristalli luce laser calibrata
- normalizza rispetto la risposta del read-out
- circa ogni **40 min**



Calorimetri di ILC

~10⁷ celle di scintillatore 30×30×3mm²
ciascuna letta da **un SiPM**

A Napoli debutta la pizza del Bosone di Higgs, inventata da un fisico partenopeo

CRONACA
Mi place Condividi 1,6mila Tweet 38 Condividi

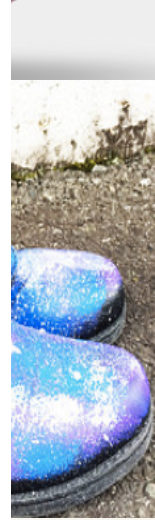
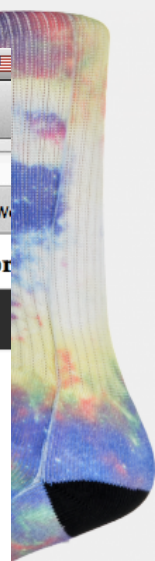


La pizza del 'bosone di Higgs' (Foto INFN Alessandro Catocci- Francesca Cuicchio)

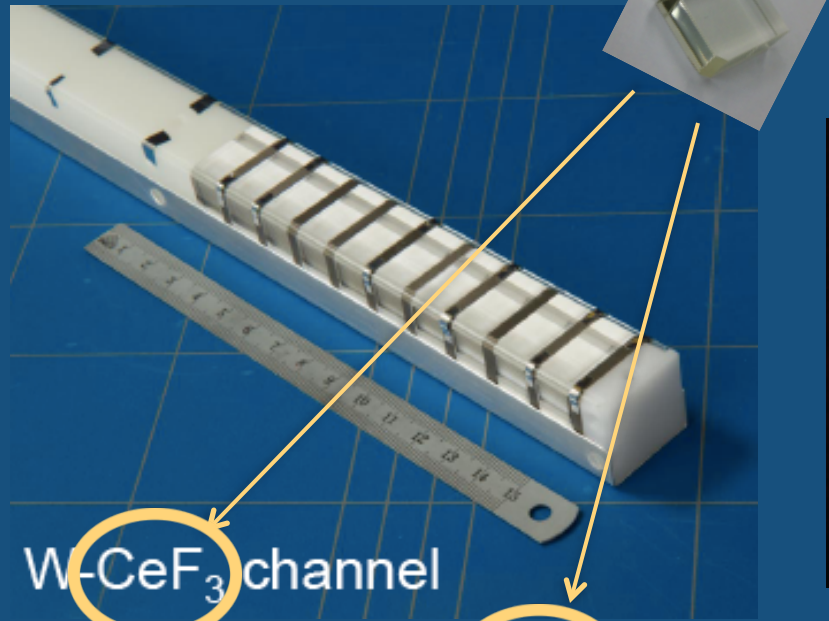
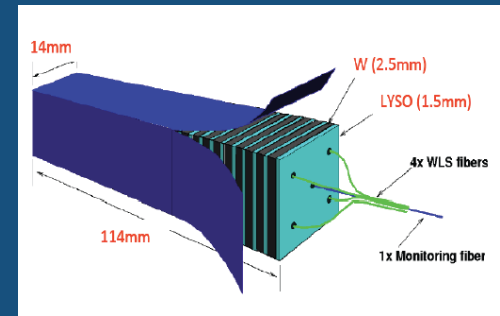


Pu
E' p
ha
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Hig
gen
"me
e in
La p
sett
"Ar
la s
del
di Higgs e nata durante una chiacchierata fra me ed il presidente dell'Infn, Fernando Ferroni, un appassionato di enogastronomia come me. Guardavamo le foto del bosone di Higgs e ci siamo detti: sembra proprio una pizza" racconta all'Adnkronos Pierluigi Paolucci, ricercatore Infn che ha

enziati non
stanza a LHC
i, si è
pizzaiolo
el bosone di
e dei colori
è un
ine, sedano
o, 15
e della mostra
li illustrano
e
za del Bosone

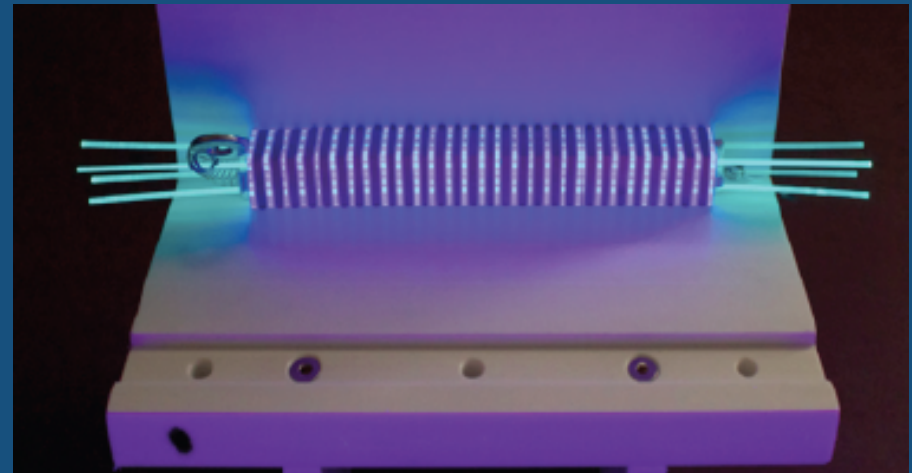


Sampling di W + cristallo

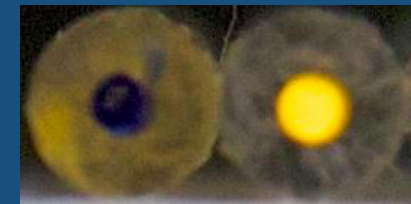
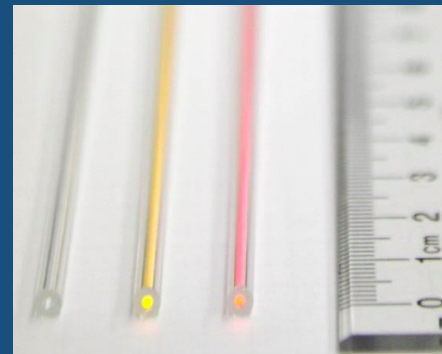


W-CeF₃ channel

W+LYSO+Capillaries di quarzo riempiti di WLS liquido



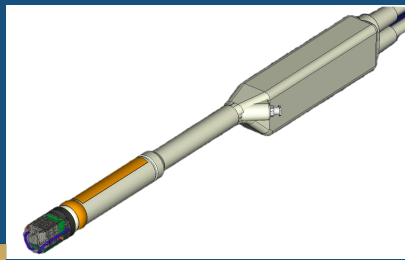
$$\frac{\sigma(E)}{E} = \frac{1.1}{\sqrt{E[GeV]}} \oplus \frac{0.4}{E[GeV]} \oplus 1.2\%$$



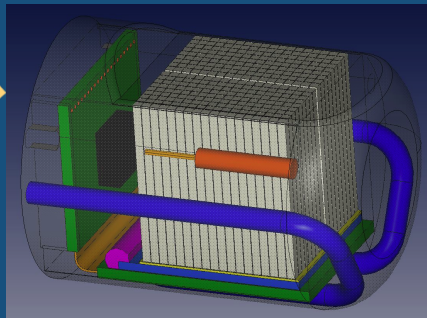
Cristalli per il TOF-PET Endoscopico + Ultrasuoni

tecnica per esaminare endoscopicamente pancreas e prostata

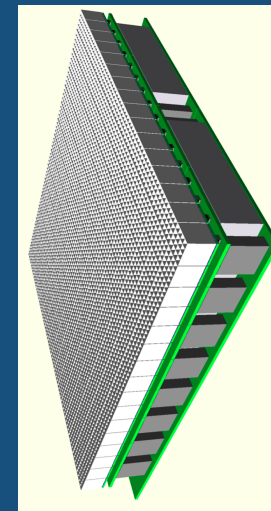
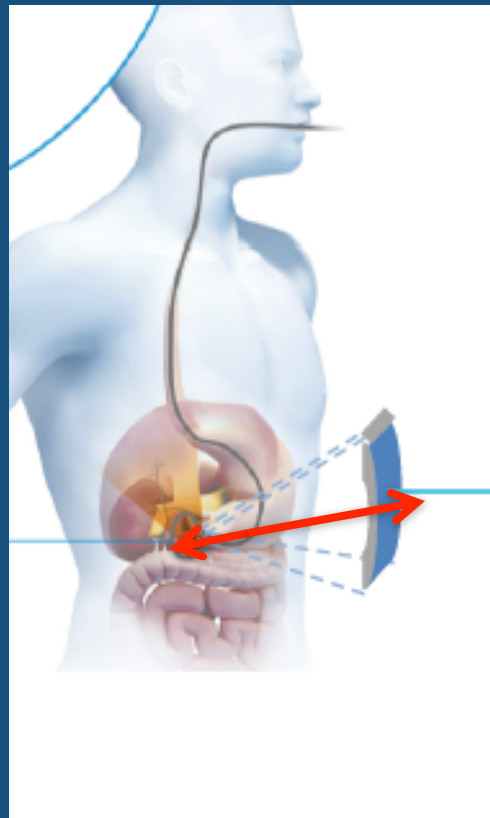
inietta un radiotracciante β^+ (3-7 MBq per kg) \rightarrow dopo 1 ora si rivela
 $e^+e^- \rightarrow 2 \gamma$ back-to-back per circa $\frac{1}{2}$ ora



endoscopio



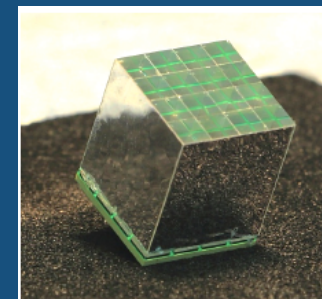
324 LYSO cristalli
 $0.7 \times 0.7 \times 15 \text{ mm}^3$
 \rightarrow digital SiPM



rivelatore PET
esterno

4096 LYSO
 $3.5 \times 3.5 \times 15 \text{ mm}^3$

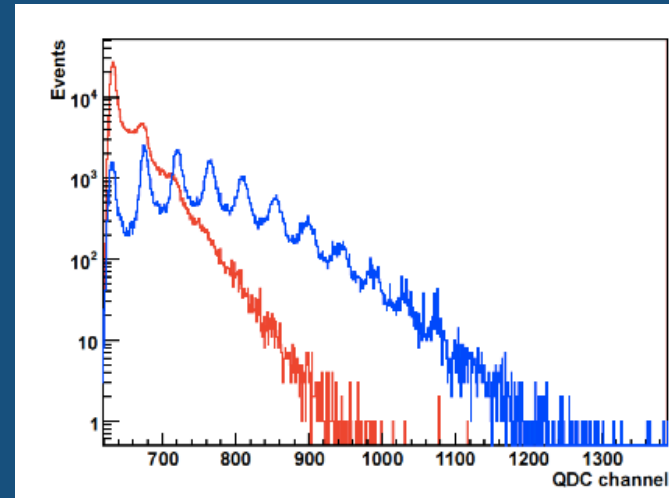
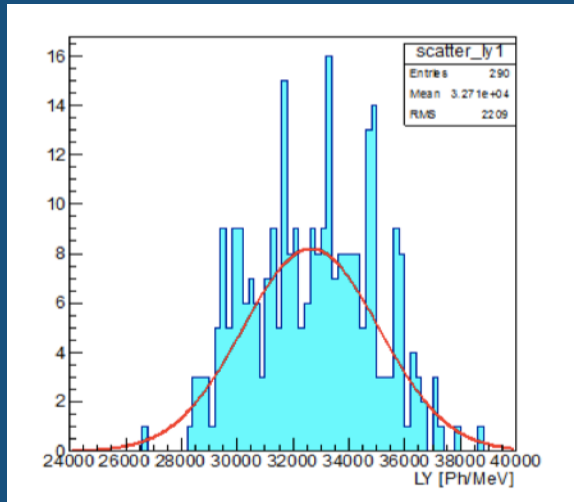
Through-Si Via
 \rightarrow SiPM
MPPC Hamamatsu



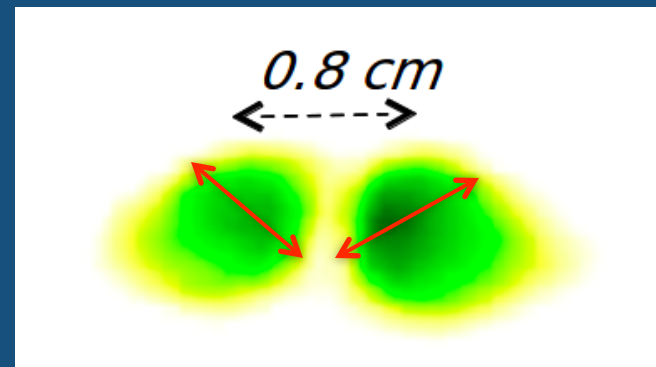
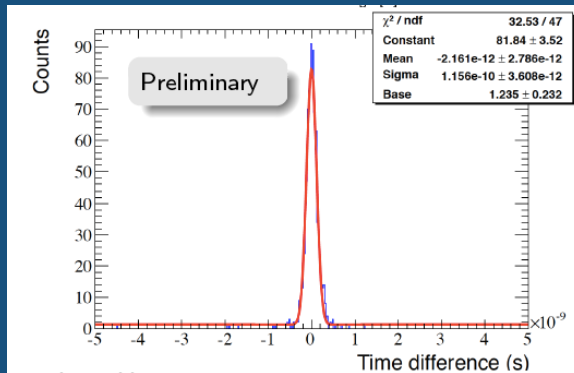
$^{22}\text{Na} \rightarrow \text{LYSO} + \text{MPPC} + \text{TOFPET read-out chip}$

light yield: 32K ph/MeV

spettro single γ -electron

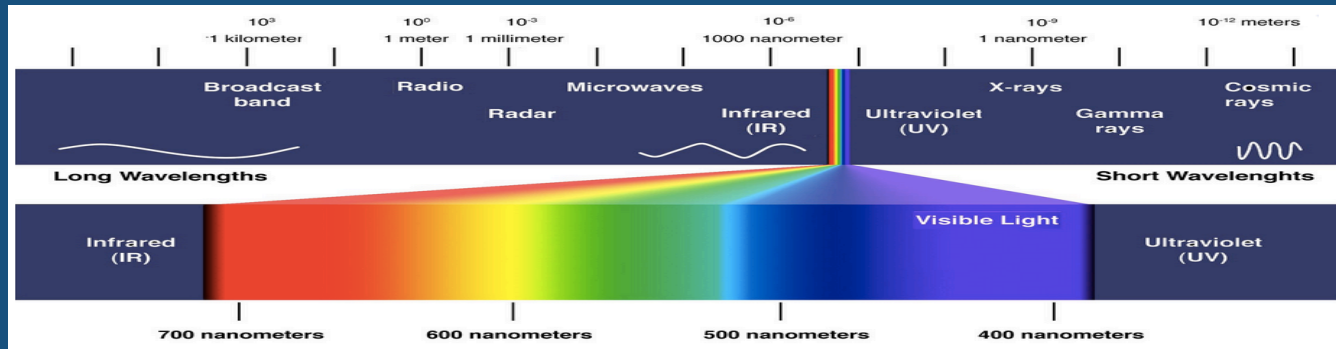


dark noise

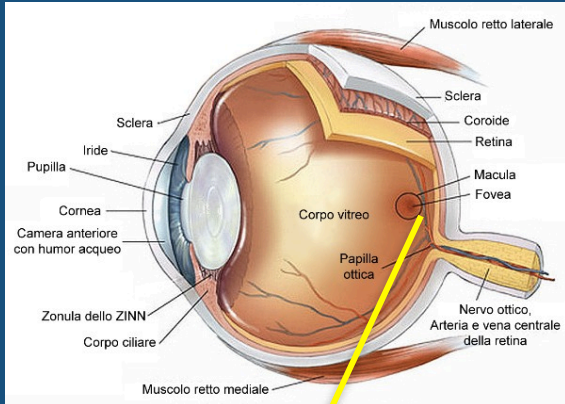


differenza temporale tra i due γ \sim 270 ps \rightarrow 1 mm spatial resolution

difficile dire luce e non pensare in primis al visibile.....



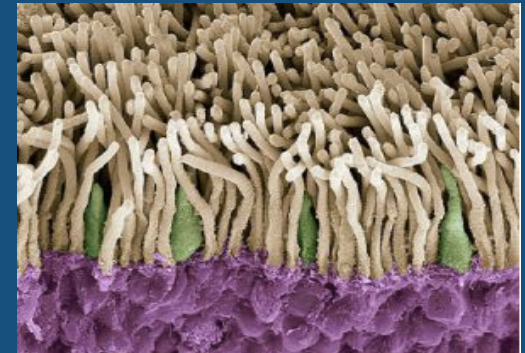
ma: e' l'occhio un buon rivelatore ????



retina ~ 3 cm²

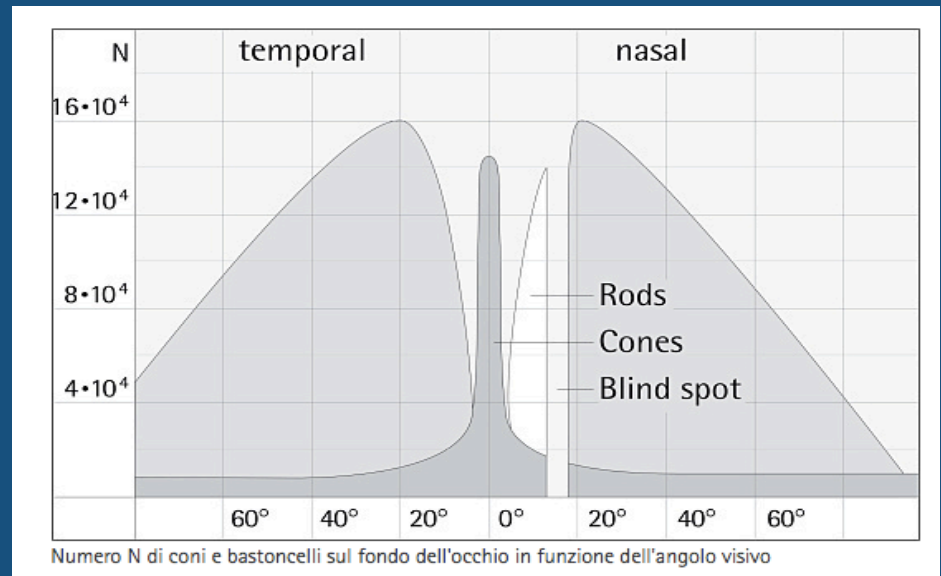
fotorivelatori

coni
bastoncelli



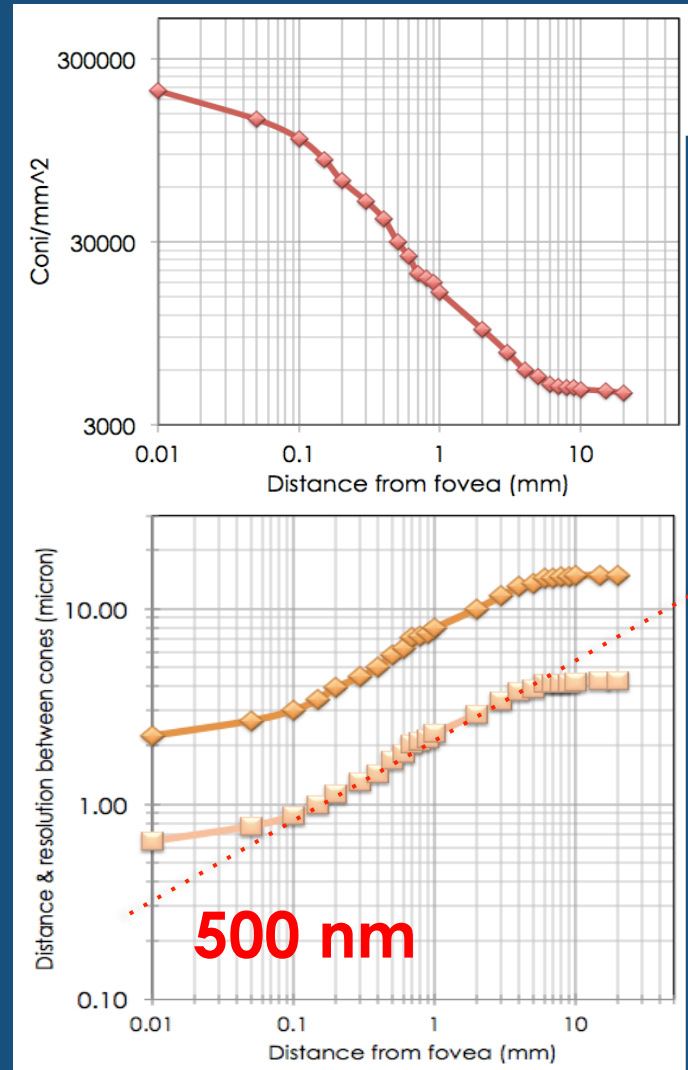
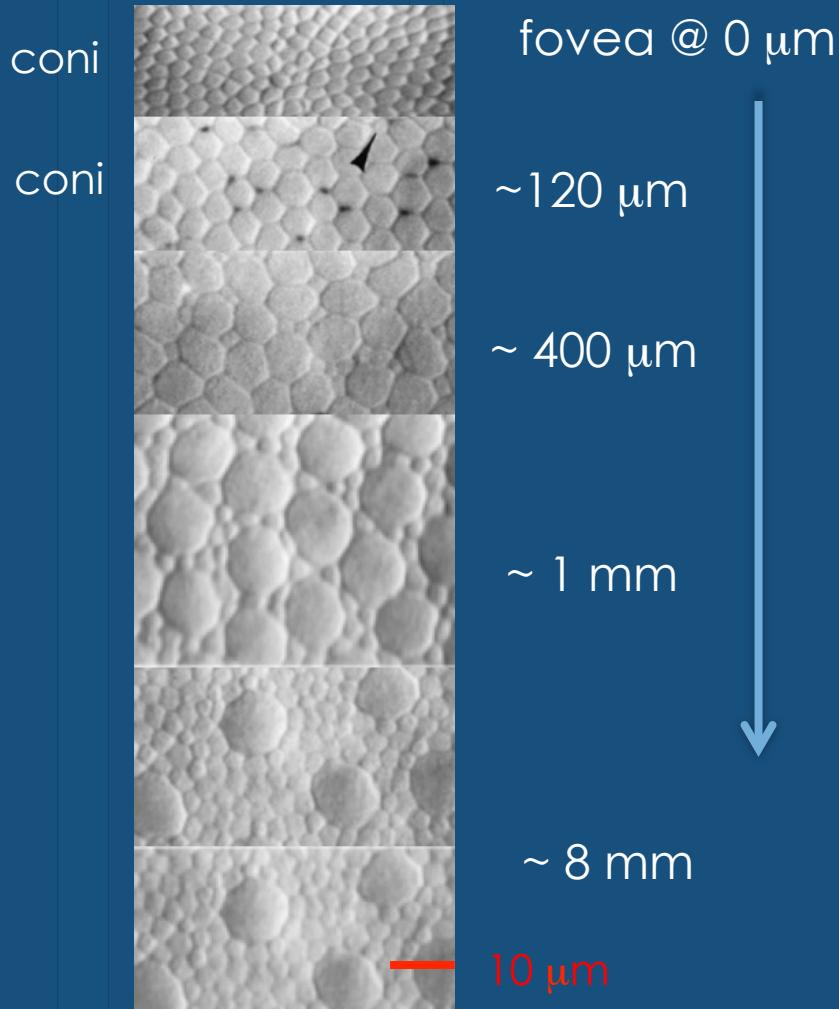
macula lutea ~ 5.5 mm
fovea ~ 1.5 mm
fovea centralis ~ 0.25 mm

numero di coni/bastoncelli
in funzione dell'angolo
visivo ???



distanza tra coni ? → densita' ?
 risoluzione spaziale in funzione della distanza dalla fovea ?????

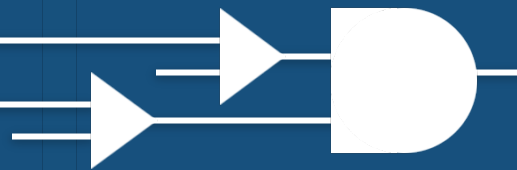
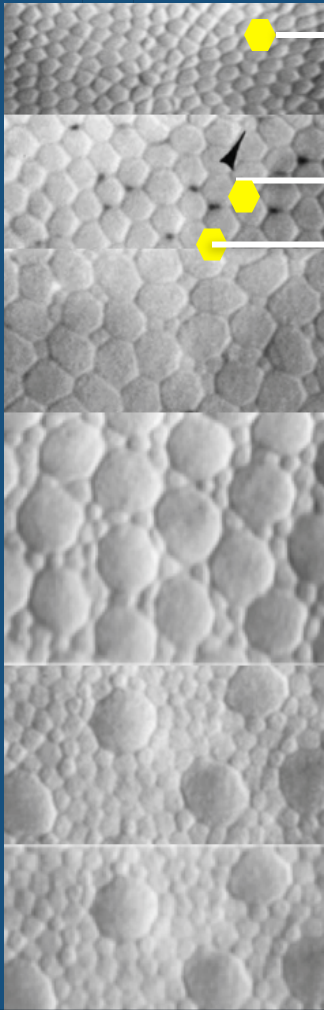
A. Cattai



coni: fotosensori visti da un fisico

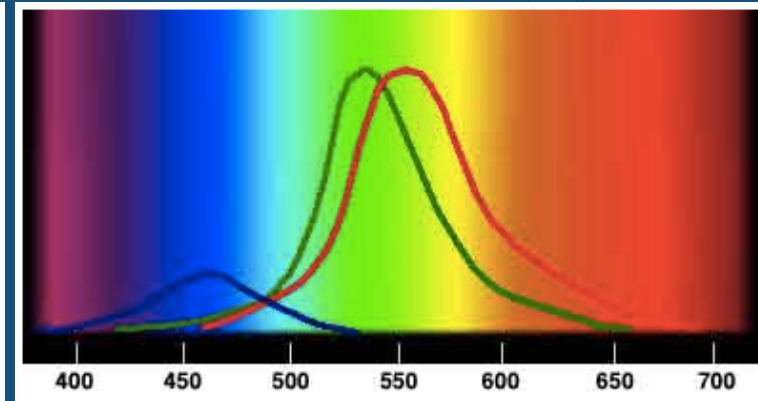
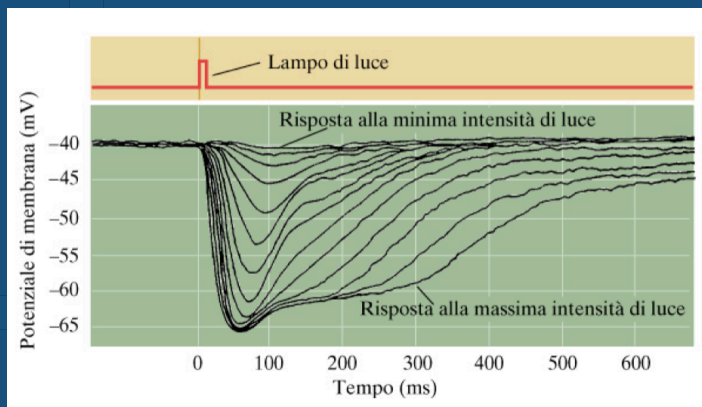
→ impulso luminoso in nervoso/elettrico

- ciascuno e' connesso ad **UNA** cellula ganglionare cioe' a **UN** circuito elettrico ed ad **UN** comparatore



nitidezza delle immagini
contrasto

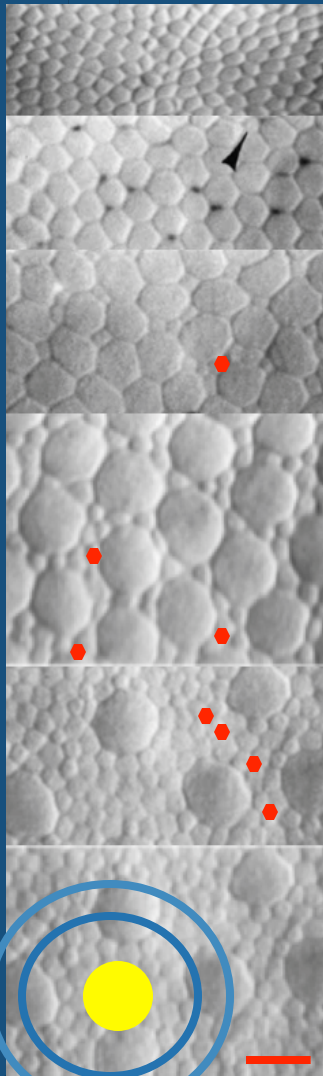
- $N_{\text{threshold}} = 100$ fotoni
→ responsabile della visione diurna
- assorbono a 3 lunghezze d'onda → colori
- risposta veloce msec



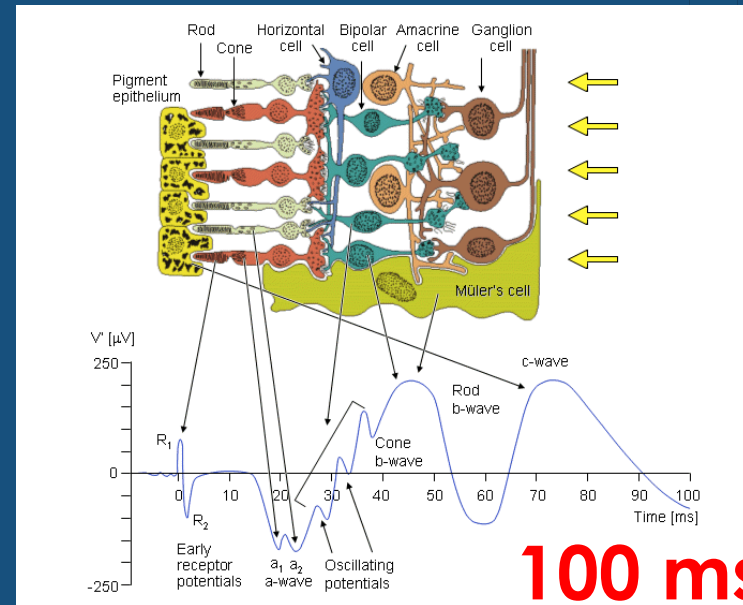
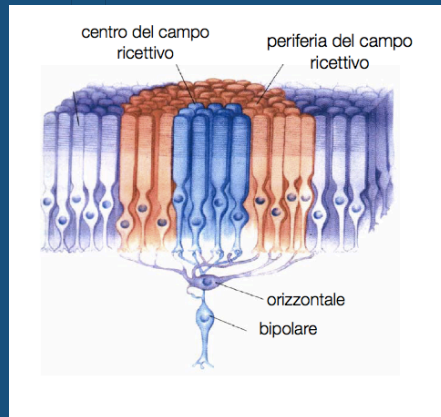
— 10 μm

bastoncelli: visti da un fisico

- multiplexati verso molte cellule
- $N_{\text{threshold}} = \text{singolo fotone} \rightarrow \text{AMPLIFICANO} \rightarrow \text{responsabile visione a scarsa luminosità}$
- SATURANO evitando così l'accecamento
- risposta lenta
- assorbono monocromatico a 500 nm



10 μm



20 livelli di trigger in parallelo
data compression (30 msec)

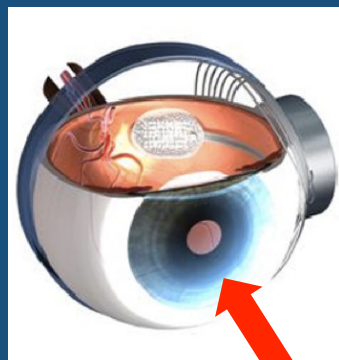
gara tra tecnologia e natura

	OCCHIO		vari μ VX e amici
	bast.	coni	
surface	3 cm ²		2 m ²
n canali	120 M + 7 M		~ 10 M
singola cella minima	2 x 2 μ m		50 x 425 μ m → 28 x 28 μ m (upgrade)
point resolution	<< 300 nm		12 μ m r Φ – 100 μ m Z → 4 μ m
soglie	1 γ → 2.5 eV	100 γ	1 γ → 10 ⁵ @ xFEL
livelli di trigger	20 in parallelo + switchboard		3
elaborazione segnale	msec		nsec
trasmissione	10 Mbps velocita Eth.		Gb/s
inefficienza	0.6 %		~ 4 % (in 4y)

occhio bionico

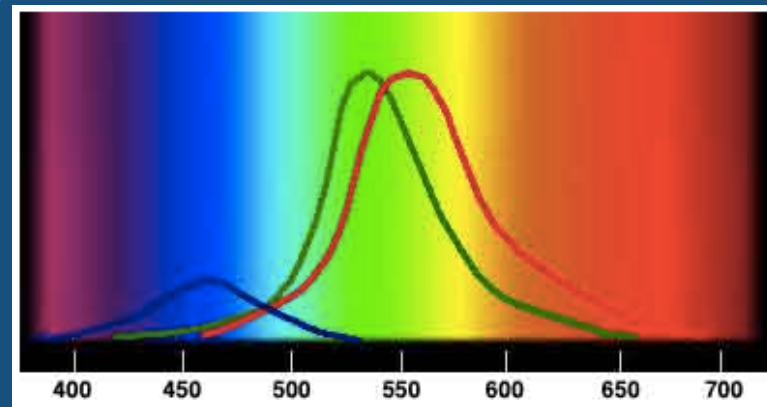


microchip
implanted
in the eye



trasmissione:

- fili
- high frequency radio
- infra-red



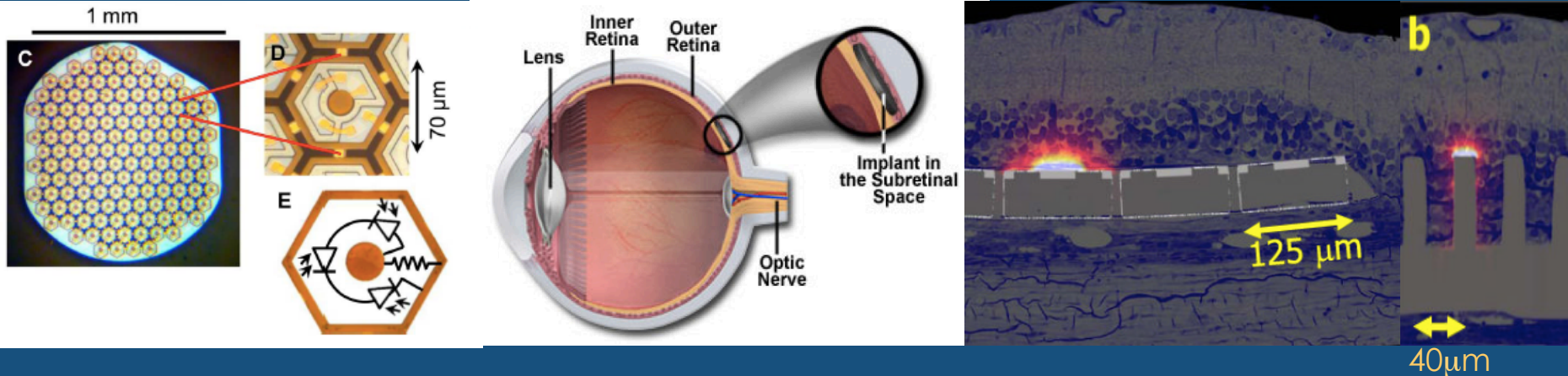
video camera installata
sugli occhiali

info da video camera

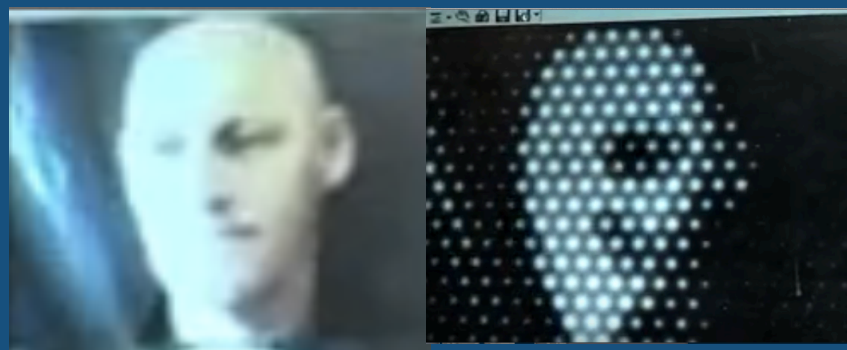


occhio bionico (.....collection)

impianto subretinale



70 x 70 μm pixel con 3 photodiodi (funzionanti con corrente fotovoltaica) converte la luce in corrente stimolando un elettrodo (20 μm) che stimola la retina



aumentare la risoluzione

→ surriscaldamento

→ cross-talk

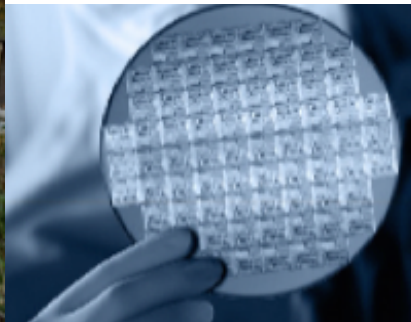
→ optical physical trench ??

H. Zrenner, H. Lorach, D. Palanker, BioVision Australia

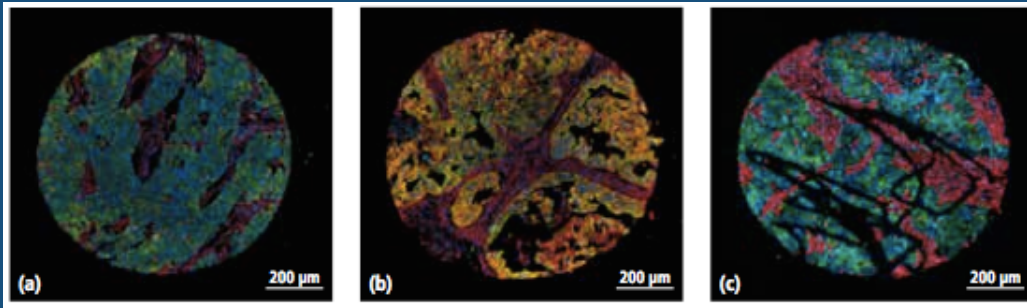
Tecniche di misura: spettrofotometria



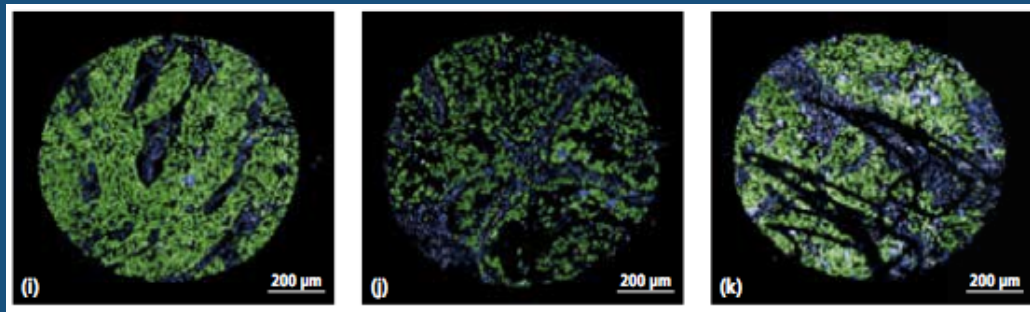
controlli di qualità



separazione di cellule tumorali dal tessuto connettivo di supporto dell'organo

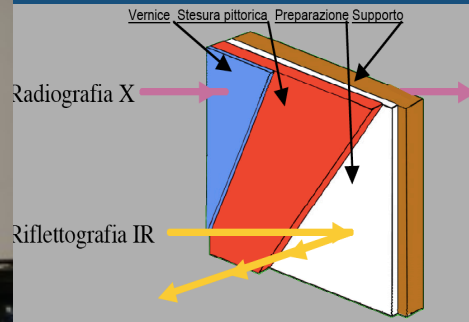


- 3 vetrini convenzionali
- tessuti tumorali (verde e blu)
- tessuti stroma (rosso)



ricostruzione ottenuta con traccianti fluorescenti DAQ di CCD e algoritmi di ricostruzione on-line
~ 0.23 µm/pixel
dimensione cellule
→ 10-100 µm

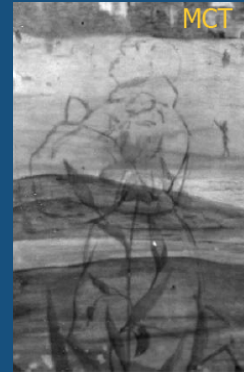
Riflettografia Infrarossa



IR penetrano i pigmenti
grande $\lambda \rightarrow$ maggior
penetrazione

investigazione

- disegno preparatorio
- restauri
- pentimenti
- falsi



quindi

con convinzione:

- rivelare la luce, o poter contribuire a “rivelarla” e'..... un'avventura bellissima
- per fare questo, tutte le nostre comunita' di fisici hanno messo a punto strumenti sofisticatissimi
- molto di quello che abbiamo elaborato all'interno delle nostre comunita' e per le nostre ricerche e' di utilita' INDISCUTIBILE per altre discipline e per la societa'
- e' fondamentale mantenere una sinergia tra le nostre comunita' e favorire al massimo lo scambio di informazione scientifica

Grazie a...

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BioVision Australia

A. Ghez and her research team at UCLA with data sets obtained with the W. M. Keck Telescopes