

DDAp - ITeDA+KIT

Física de Astropartículas - 2017

- **Unidad** 03 – Técnicas de detección
- **Clase** U03-b
- **Cont** Detectores
- **Cátedra** Asorey
- **Web** <https://github.com/asoreyh/astroparticulas>



El curso

- **Unidad 1:** Fenomenología de Astropartículas.
- **Unidad 2:** Lluvias Atmosféricas Extendidas (EAS).
Laboratorio: Simulaciones en CORSIKA
- **Unidad 3:** Técnicas de detección de Astropartículas.
- **Unidad 4:** Aplicaciones en LAGO y análisis de datos.
Laboratorio: Análisis de datos de meteorología del espacio v
del decaimiento del muón en

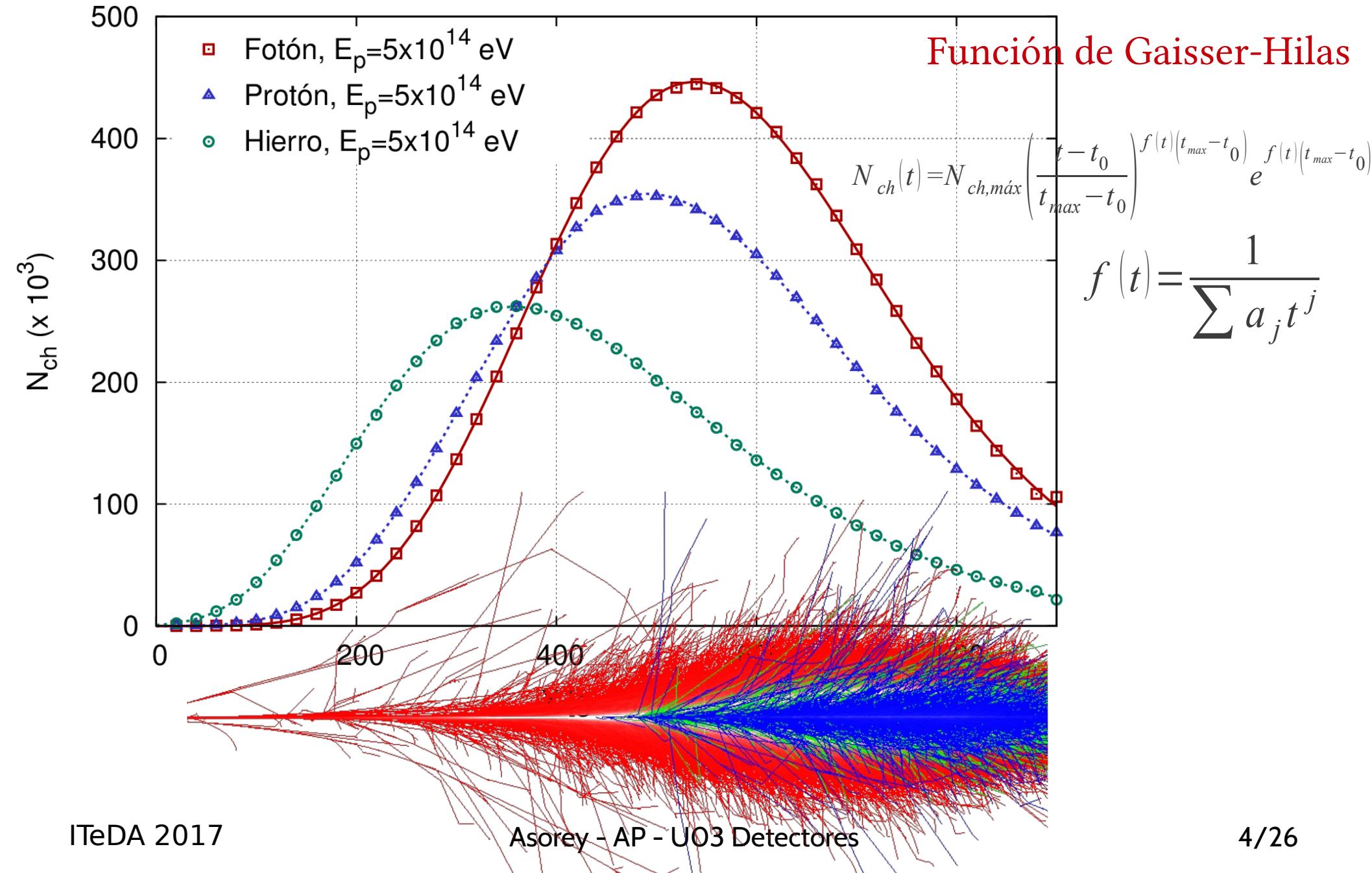


<https://github.com/la>

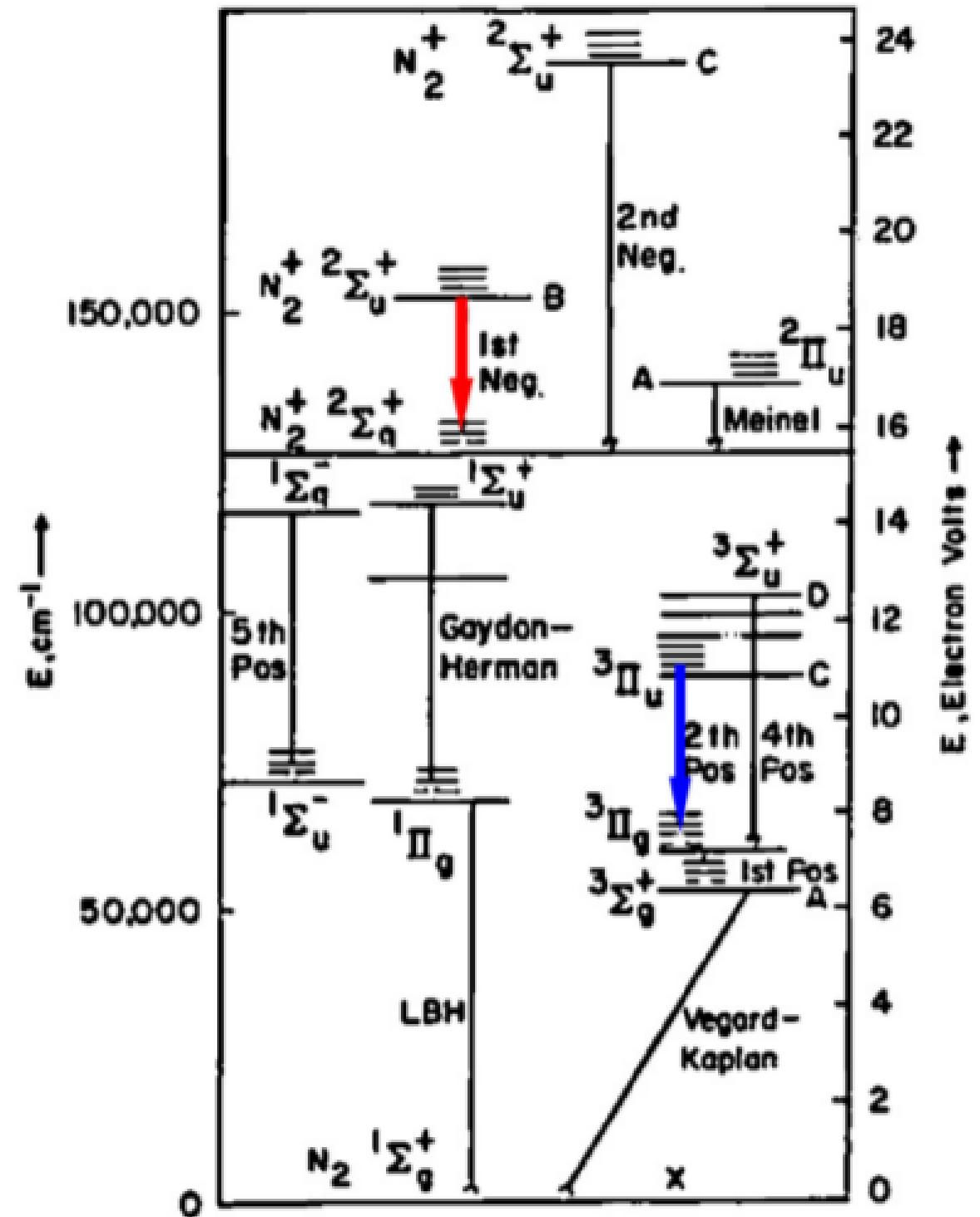


Mientras tanto, en la atmósfera

Desarrollo longitudinal ($t=X/X_{EM}$)

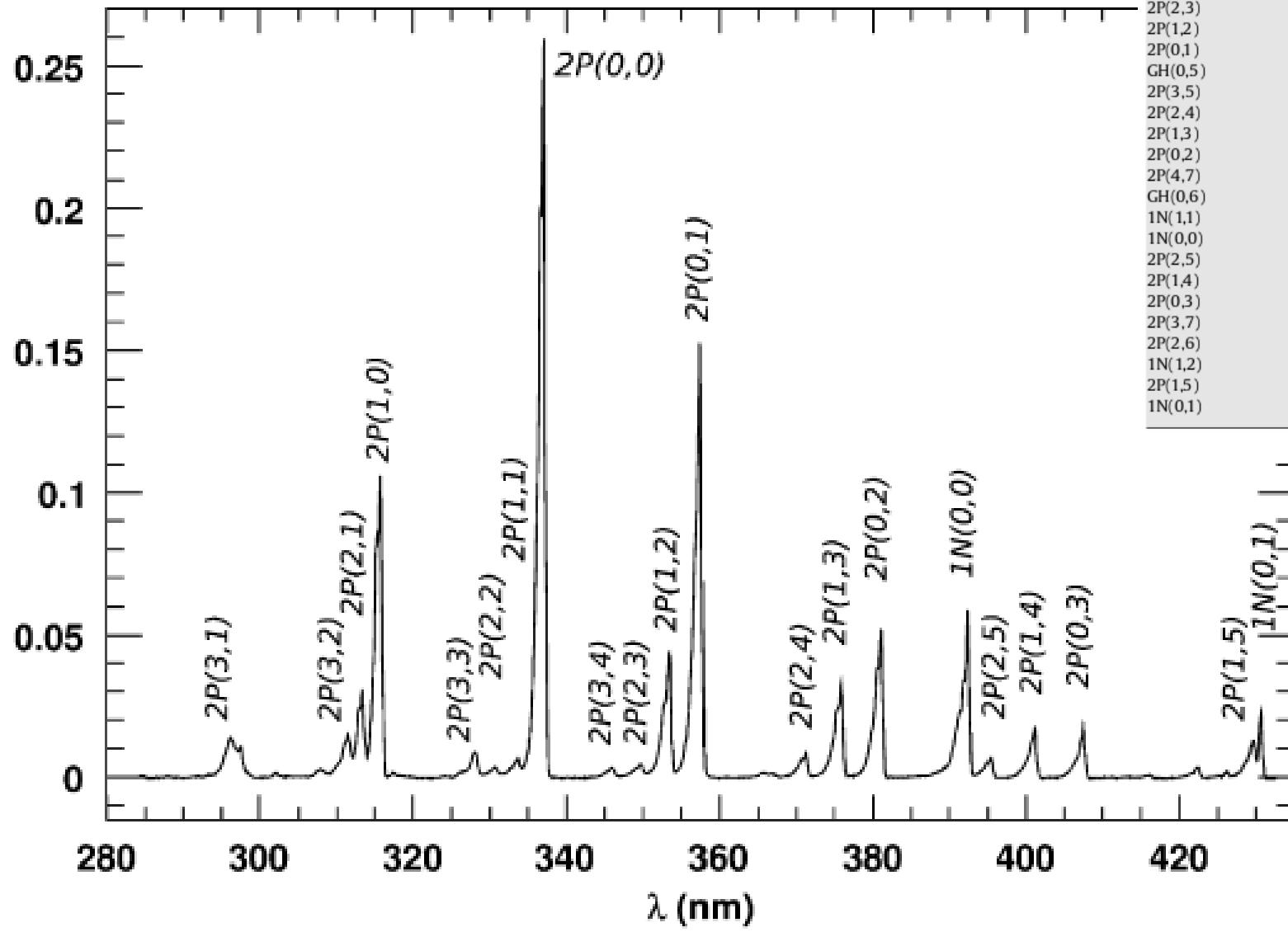


Excitación N₂



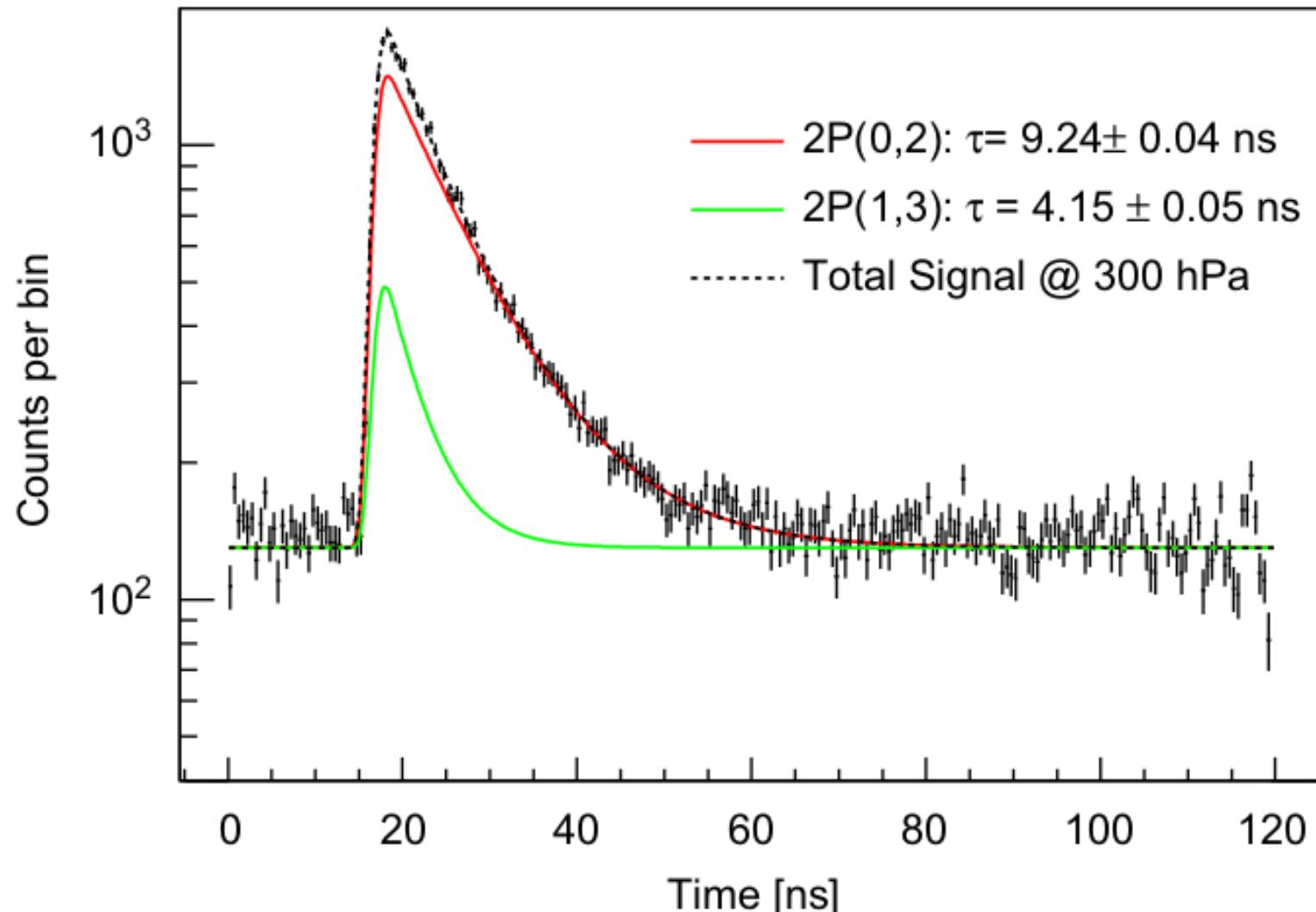
Desexcitación N₂

rel. Intensity (area scaled to unity)

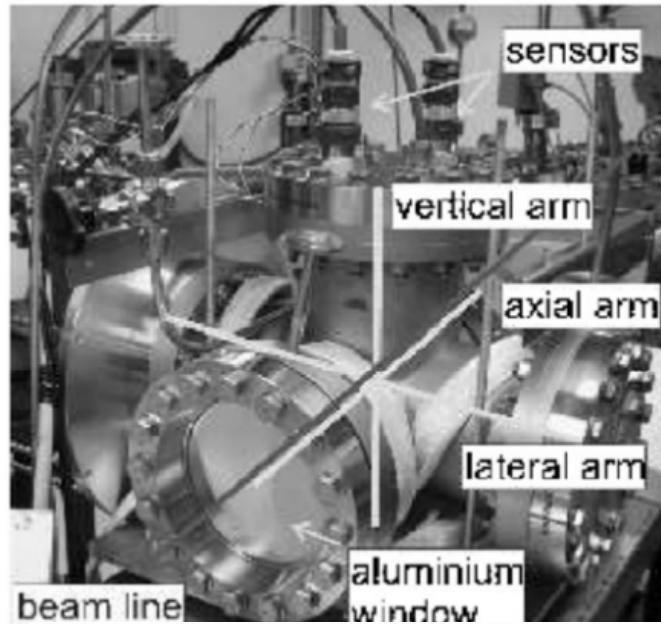


Transition	λ (nm)
2P(3,1)	296.2
2P(2,0)	297.7
GH(6,2)	302.0
GH(5,2)	308.0
2P(3,2)	311.7
2P(2,1)	313.6
2P(1,0)	315.9
GH(6,3)	317.6
2P(4,4)	326.8
2P(3,3)	328.5
2P(2,2)	330.9
2P(1,1)	333.9
2P(0,0)	337.1
GH(0,4)	346.3
2P(2,3)	350.0
2P(1,2)	353.7
2P(0,1)	357.7
GH(0,5)	366.1
2P(3,5)	367.2
2P(2,4)	371.1
2P(1,3)	375.6
2P(0,2)	380.5
2P(4,7)	385.8
GH(0,6)	387.7
1N(1,1)	388.5
1N(0,0)	391.4
2P(2,5)	394.3
2P(1,4)	399.8
2P(0,3)	405.0
2P(3,7)	414.1
2P(2,6)	420.0
1N(1,2)	423.6
2P(1,5)	427.0
1N(0,1)	427.8

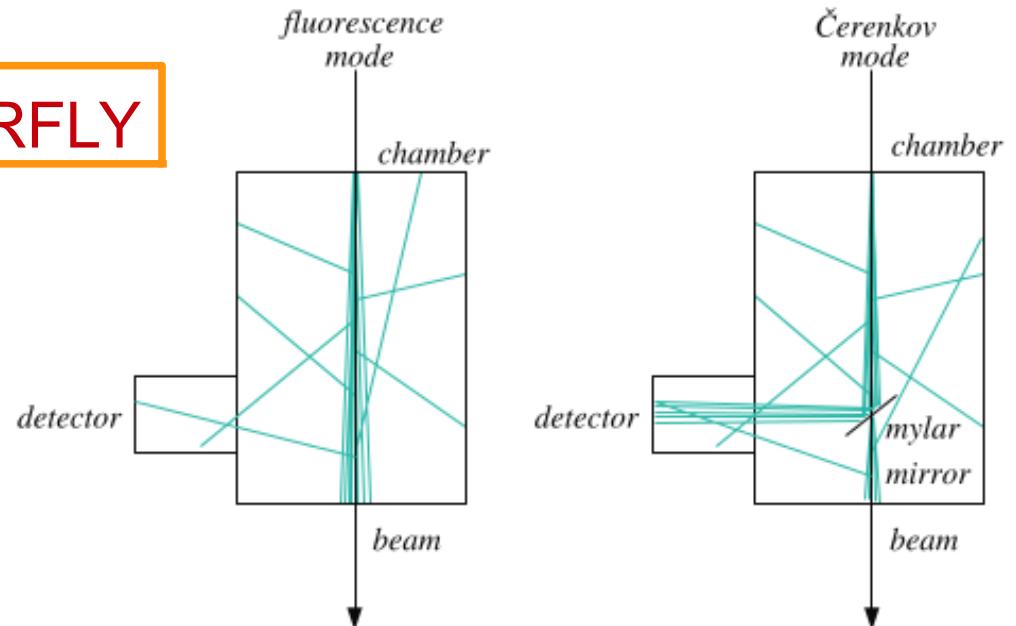
Tiempos característicos



Midiendo el Fluorescence Yield

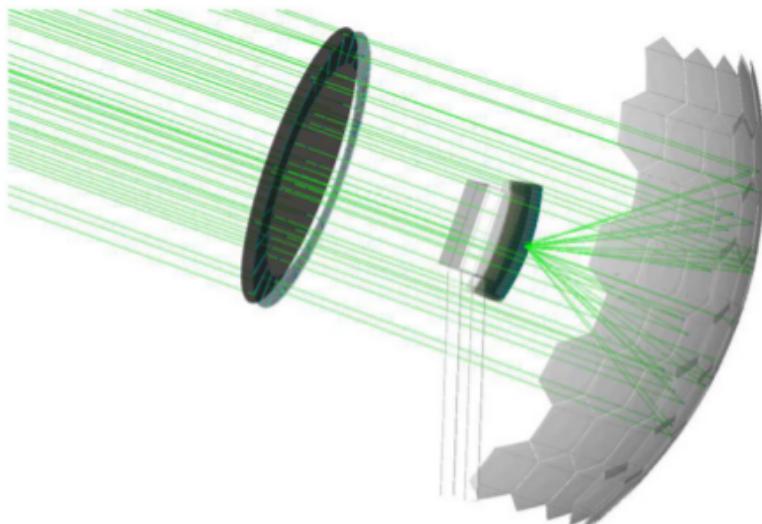
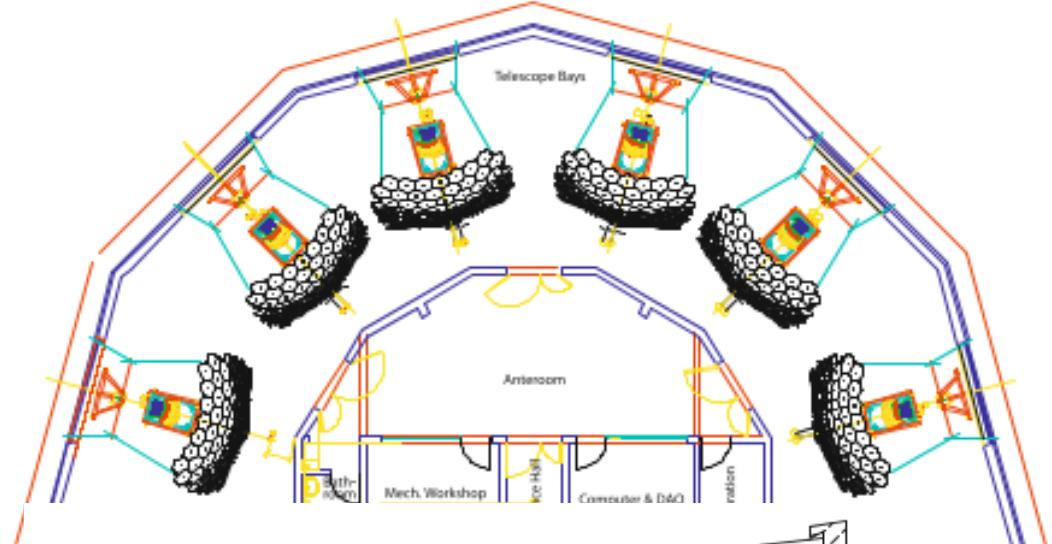
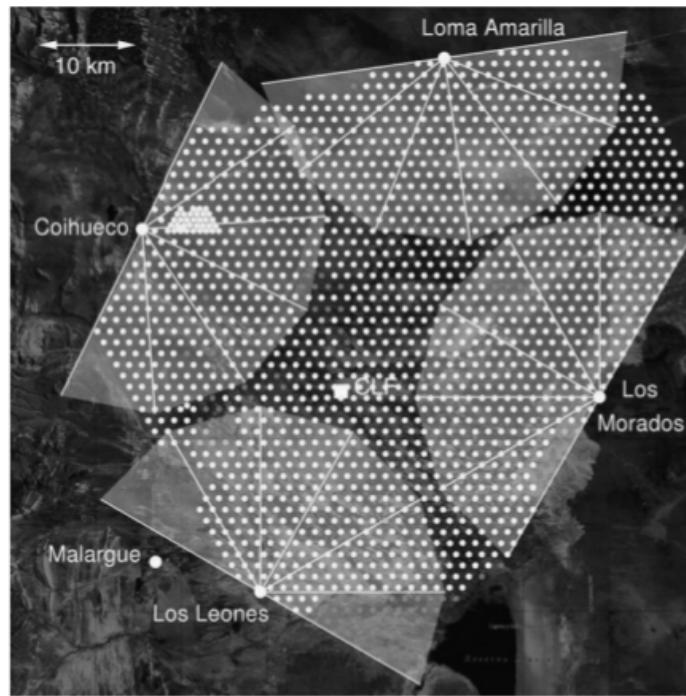


AIRFLY

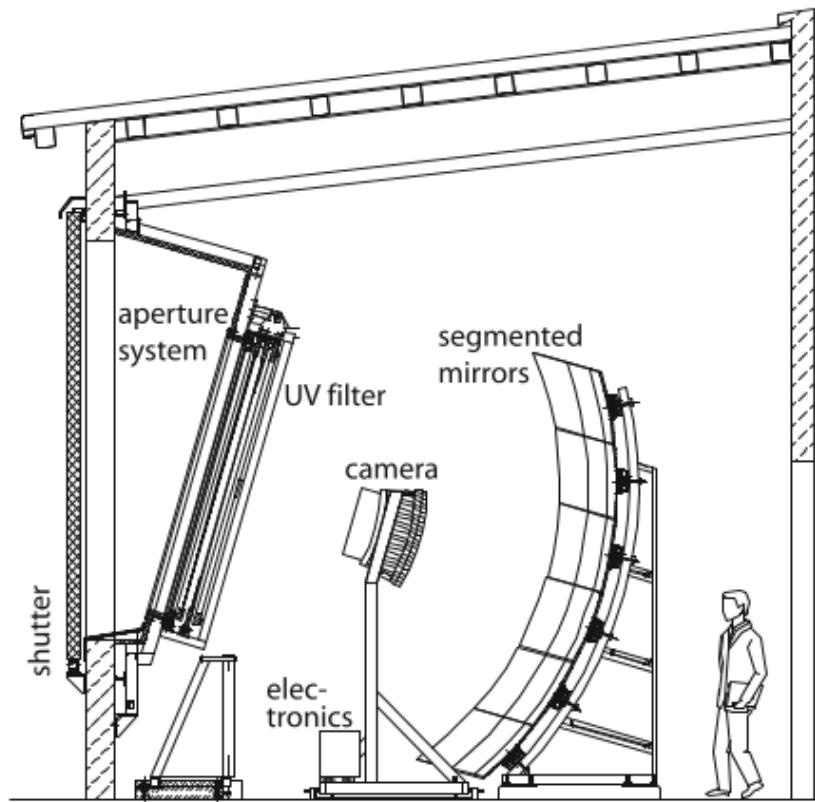


Experiment	E (MeV)	λ (nm)	P (hPa)	T (K)	Fluorescence yield			
					Wide spectrum		337 nm	
					(m $^{-1}$)	(MeV $^{-1}$)	(m $^{-1}$)	(MeV $^{-1}$)
AIRFLY [62]	350	337	993	291				4.12 ^a
FLASH [51]	2.85×10^4	300–420	1013	304		20.8		
Lefevre et al. [54]	0.85	300–430	1013	288	4.23			
Nagano et al. [47]	0.85	300–406	1013	293	3.81		1.02	5.03
		300–430			4.05			
MACFLY [52]	1.5	290–440	1013	296	3.14	17.6		
	2.0×10^4				4.22			
	5.0×10^4				4.44			
AIRLIGHT [50]	0.25–2.00	337	1013	293				5.68
Kakimoto et al. [45]	1.4–1000	300–400	800	288				5.7

FD: Detector de Fluorescencia



...ey - AP

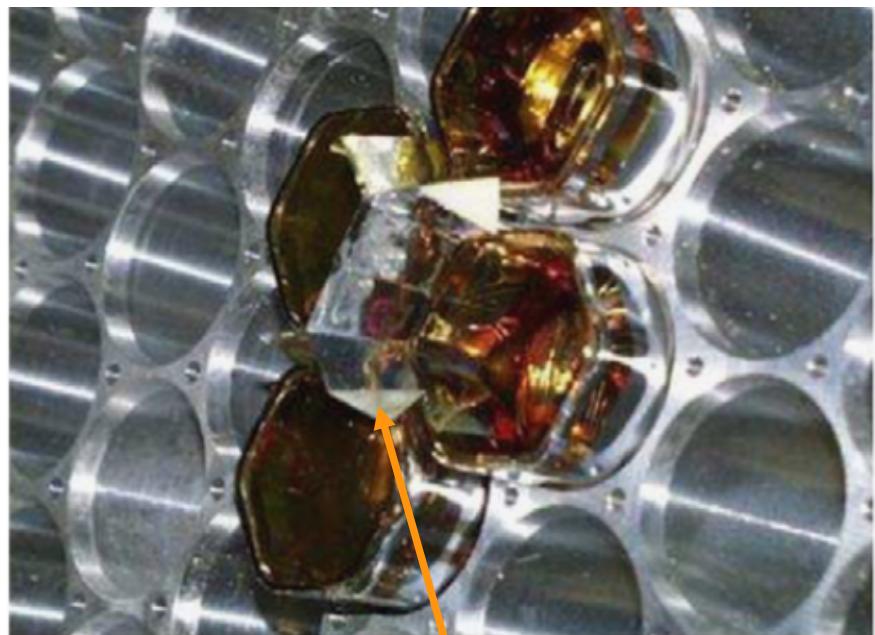
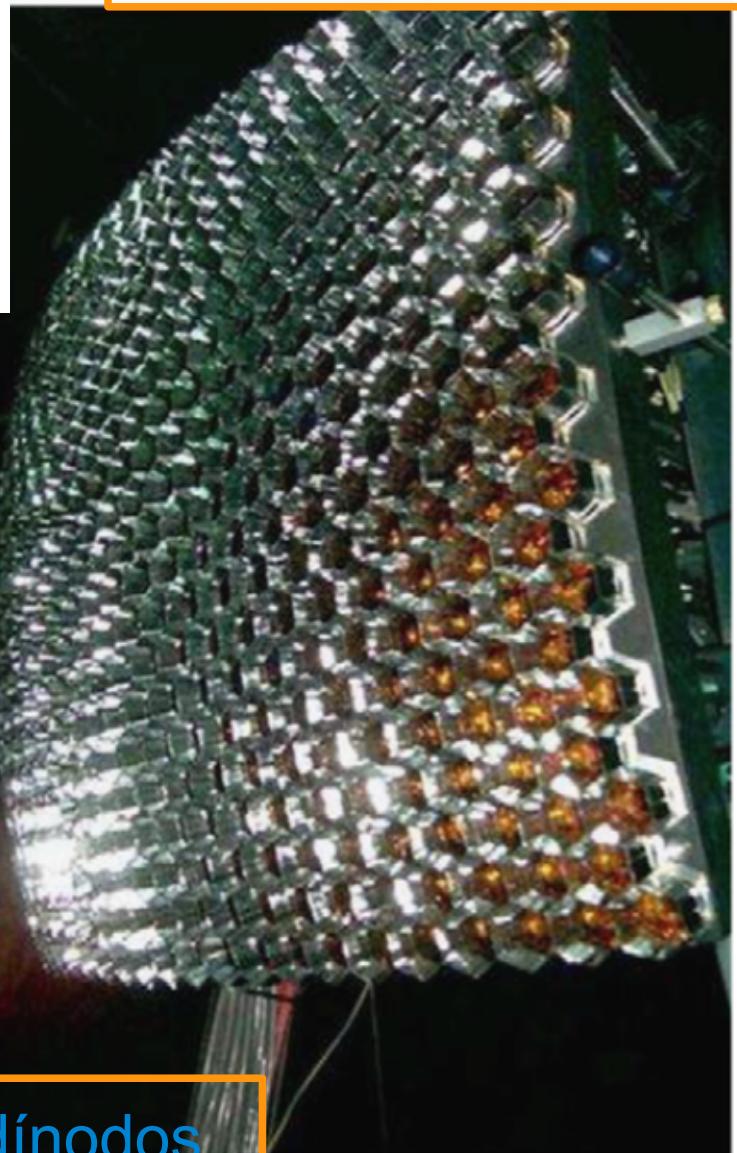


15bits ($2^{15}=32768$) @ 10 MHz (100 ns)

Cámara



22x20 – FOV: 30°x30°



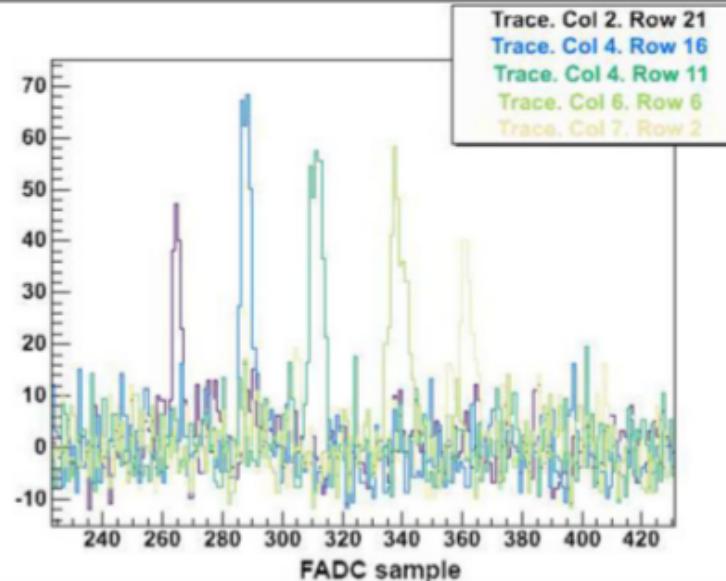
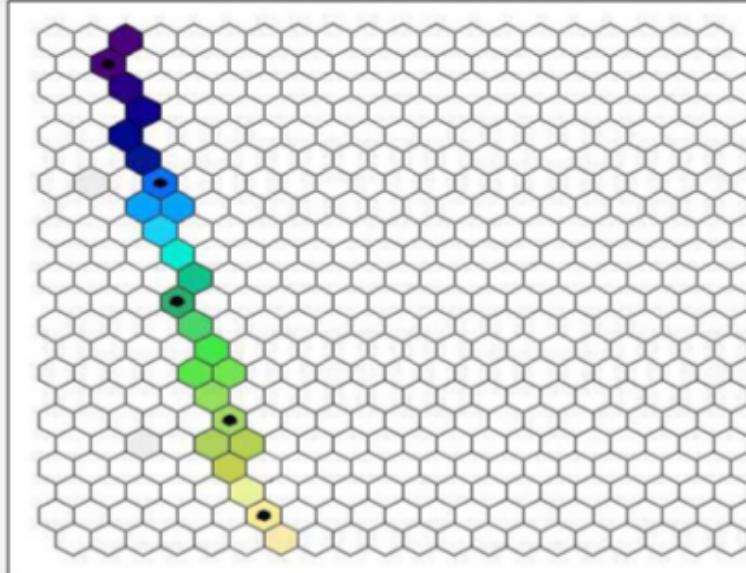
“Mercedes” Star

440 PMT Photonis XP3062 40mm, 8 díodos,

Cada píxel observa un pedacito del cielo

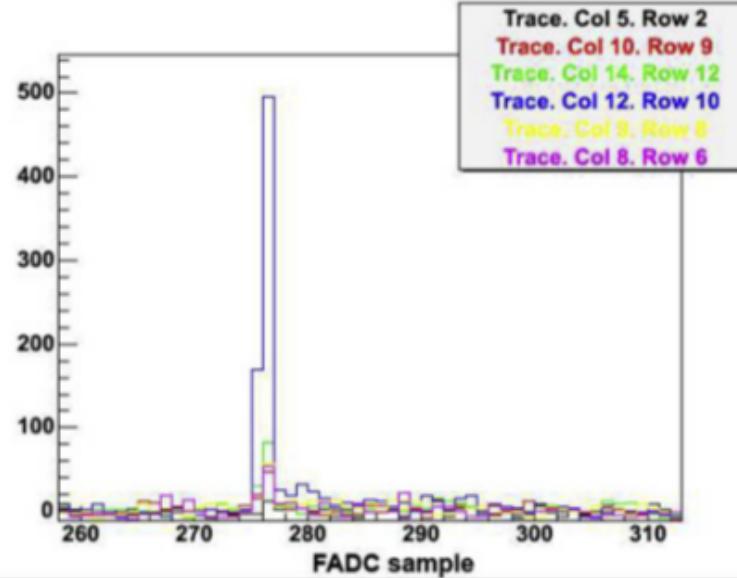
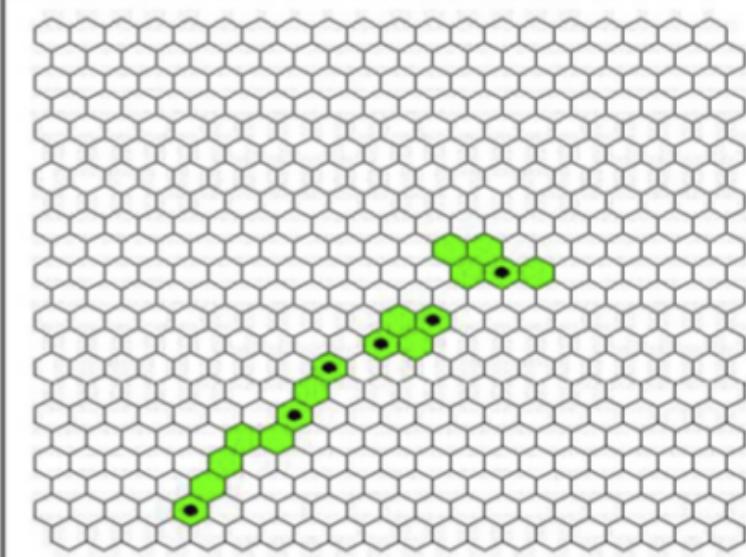
Una lluvia en FD

Event Display | All mirrors |



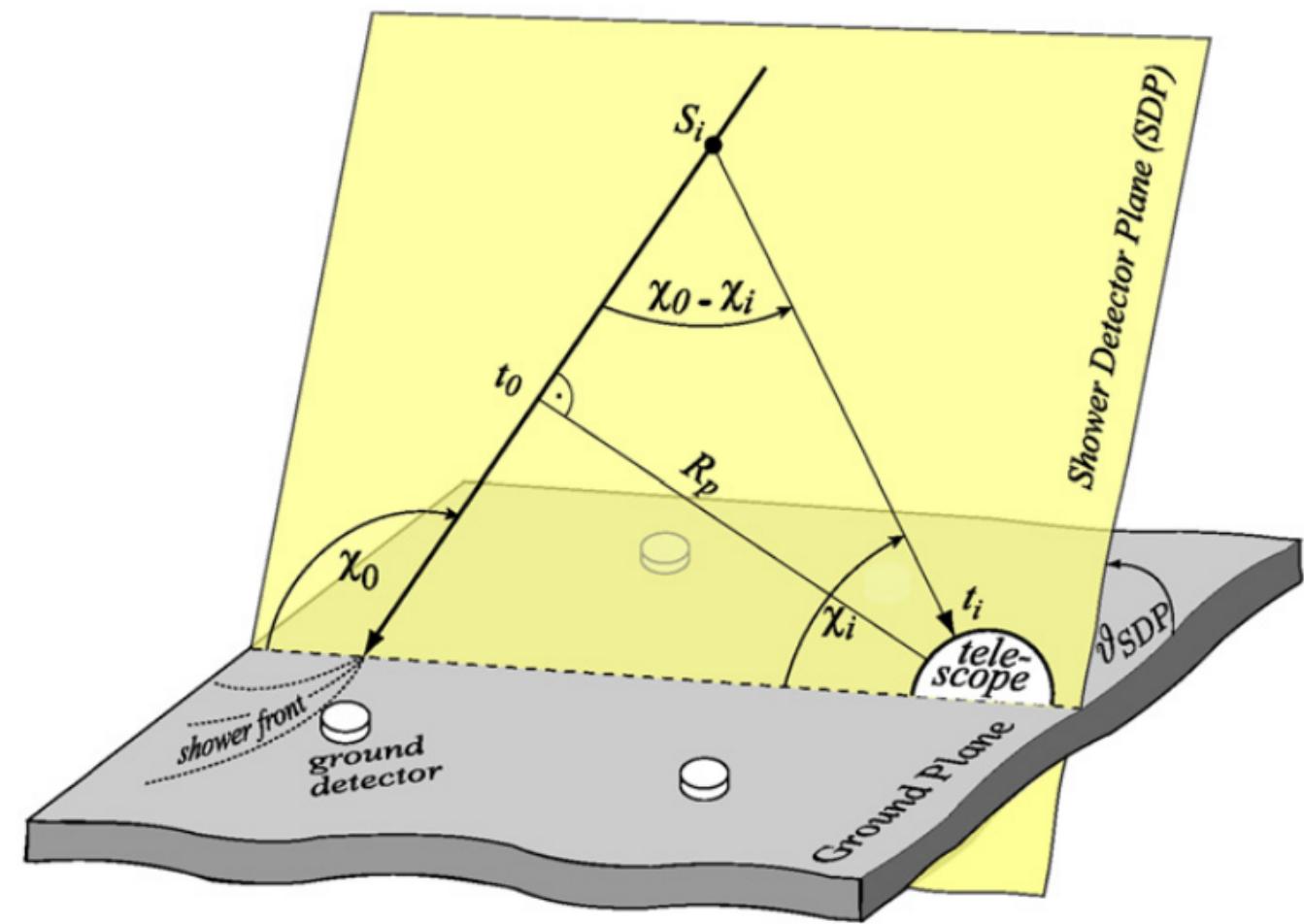
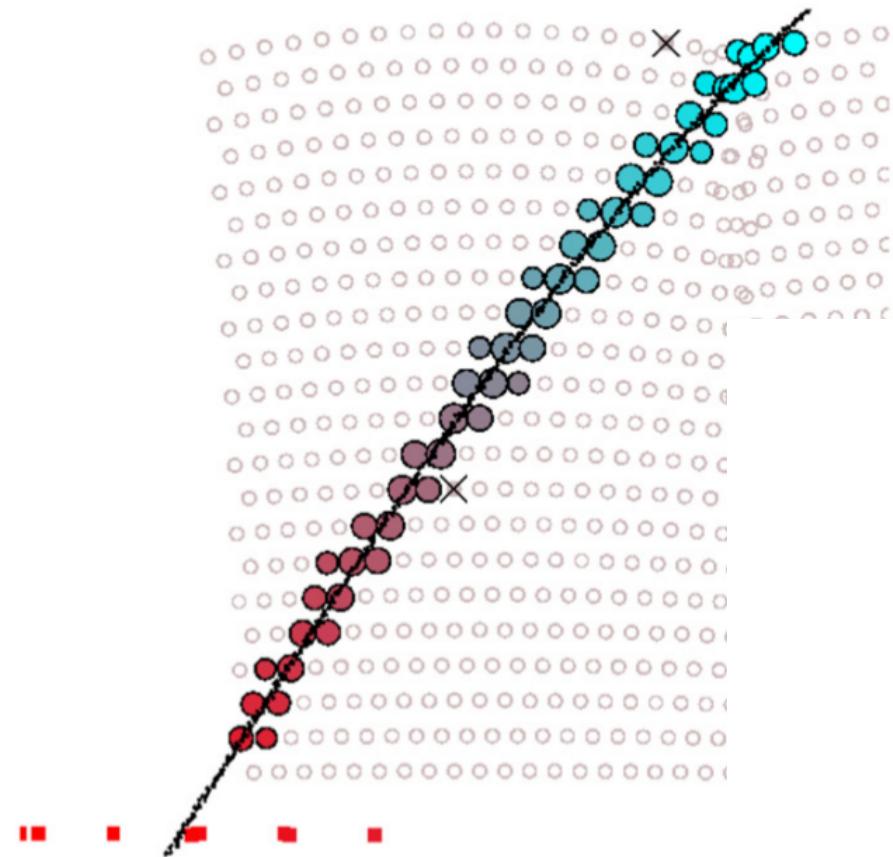
EAS

Event Display | All mirrors |

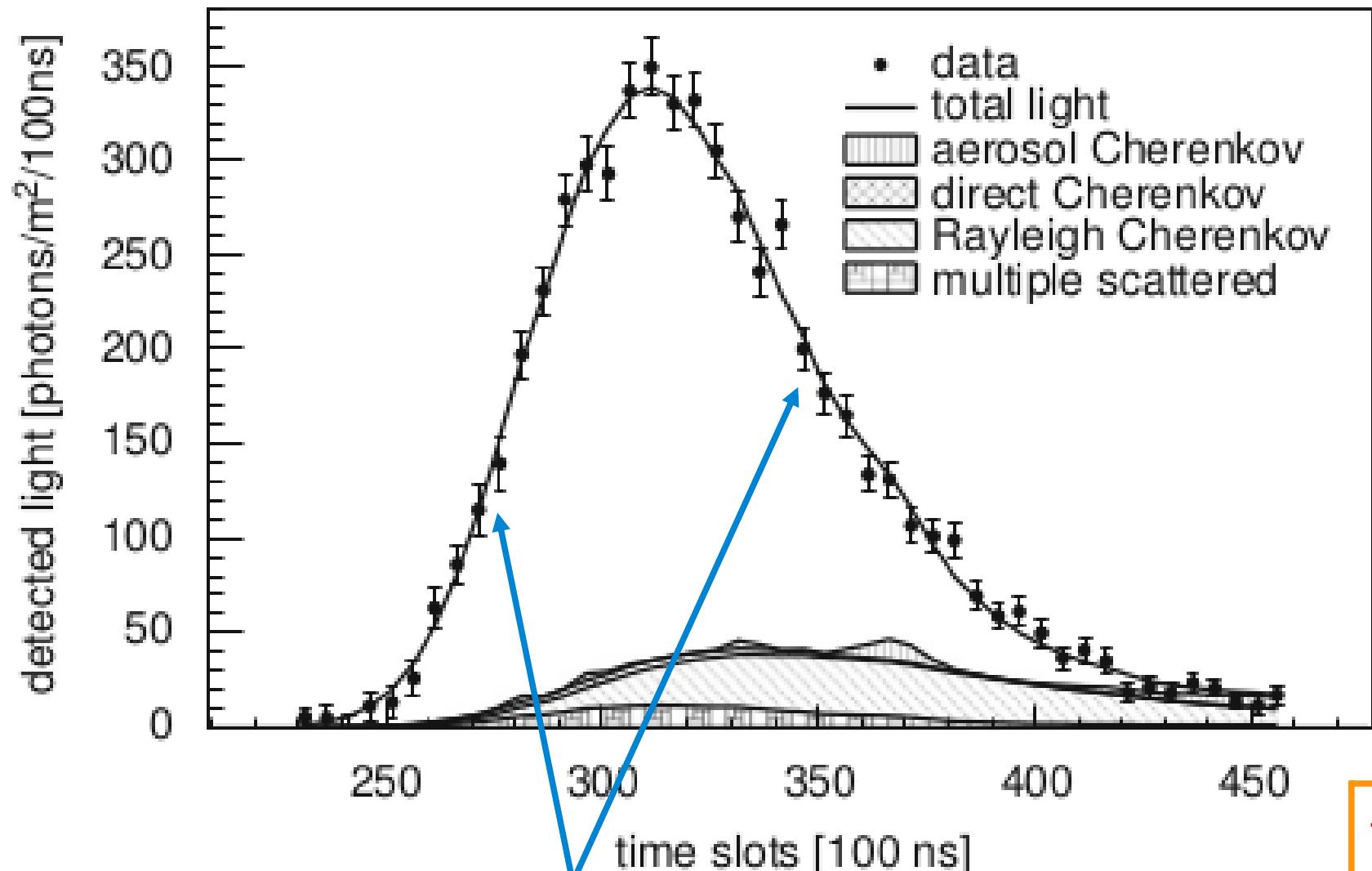


Ruido

Evento híbrido

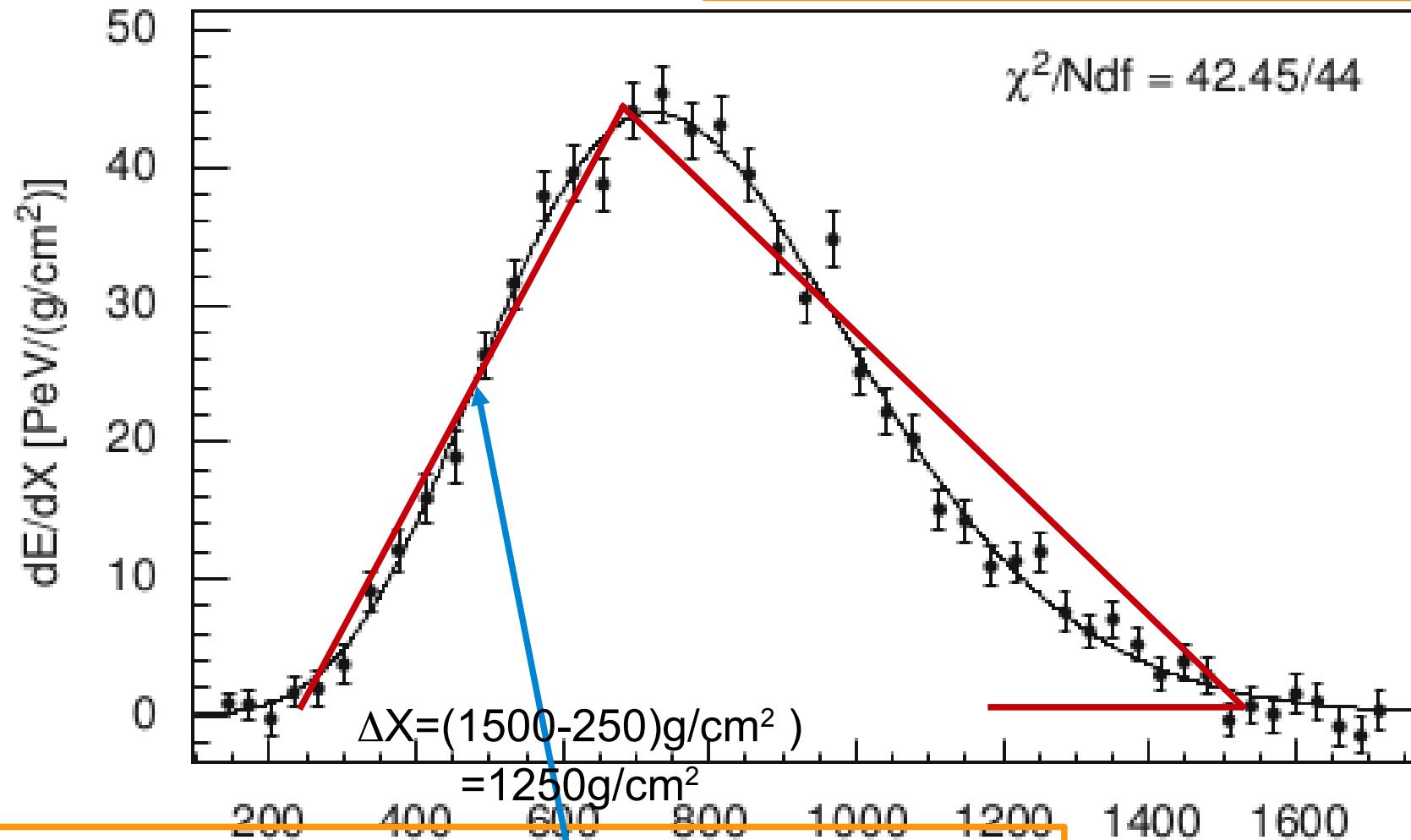


Luz como función del tiempo



Energía depositada en la atmósfera

$$E_p = 1/2 \Delta X \frac{dE}{dX} = \sim 2.8 \times 10^{19} \text{ eV}$$



Otros FD: Fly's Eye (1981-1993)



HI RESolution fly's eyes (1994-2000)



- Mono y stereo
- Observación GZK



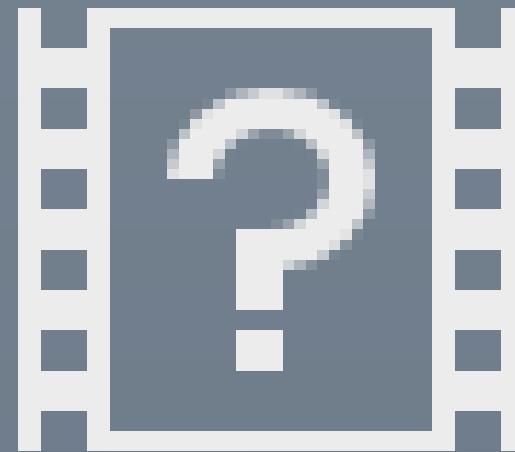
Telescope Array (2007-)

- Utah
- Centelladores + FD
- 3 FD en un triángulo de 35 km de lado
- 12-14 telescopios por sitio
- 256 PMT x cámara
- FOV: 3° - 33° x 108°

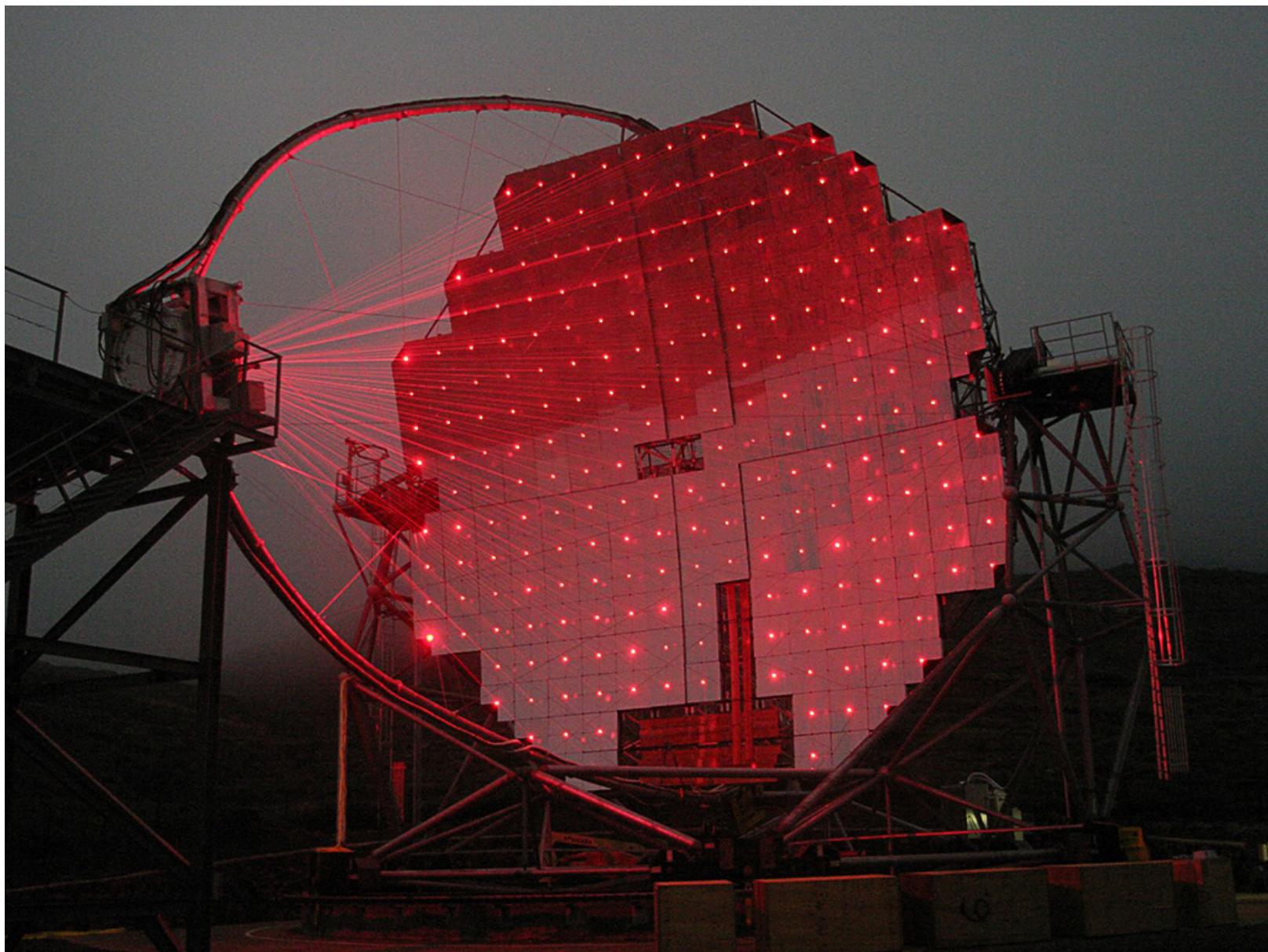


¿Y el Cherenkov en el aire?

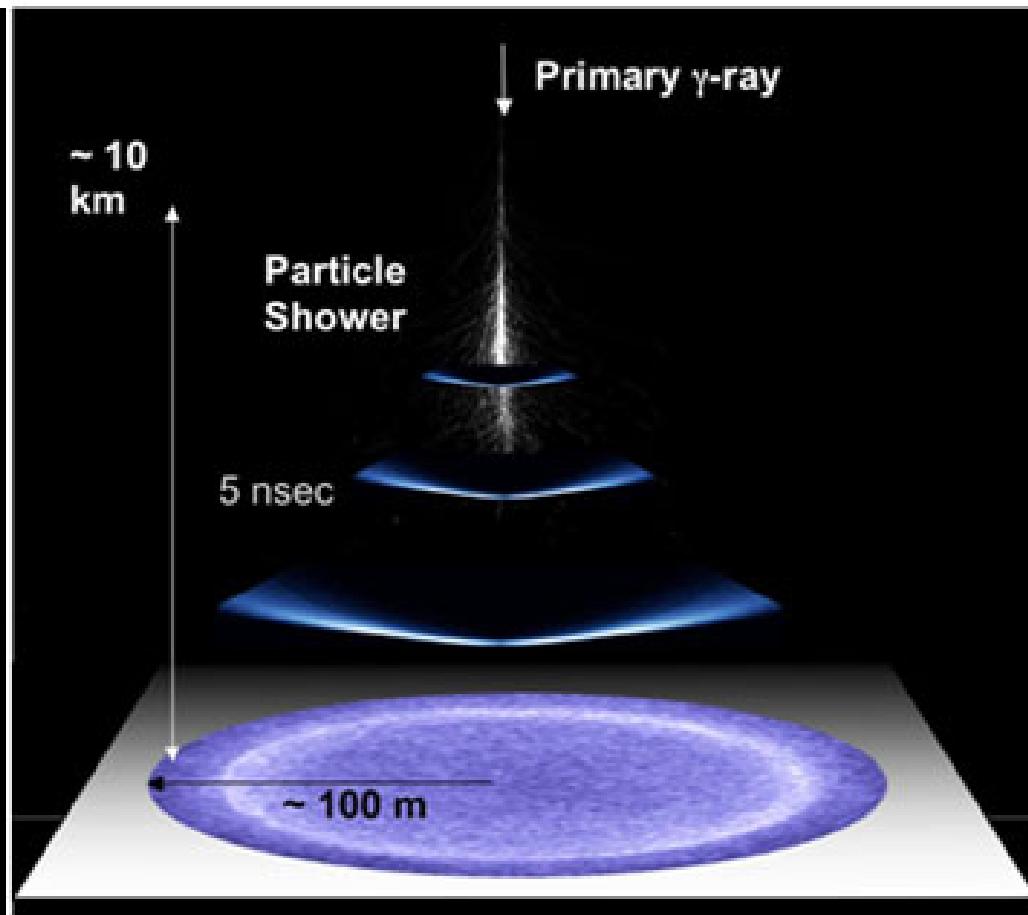
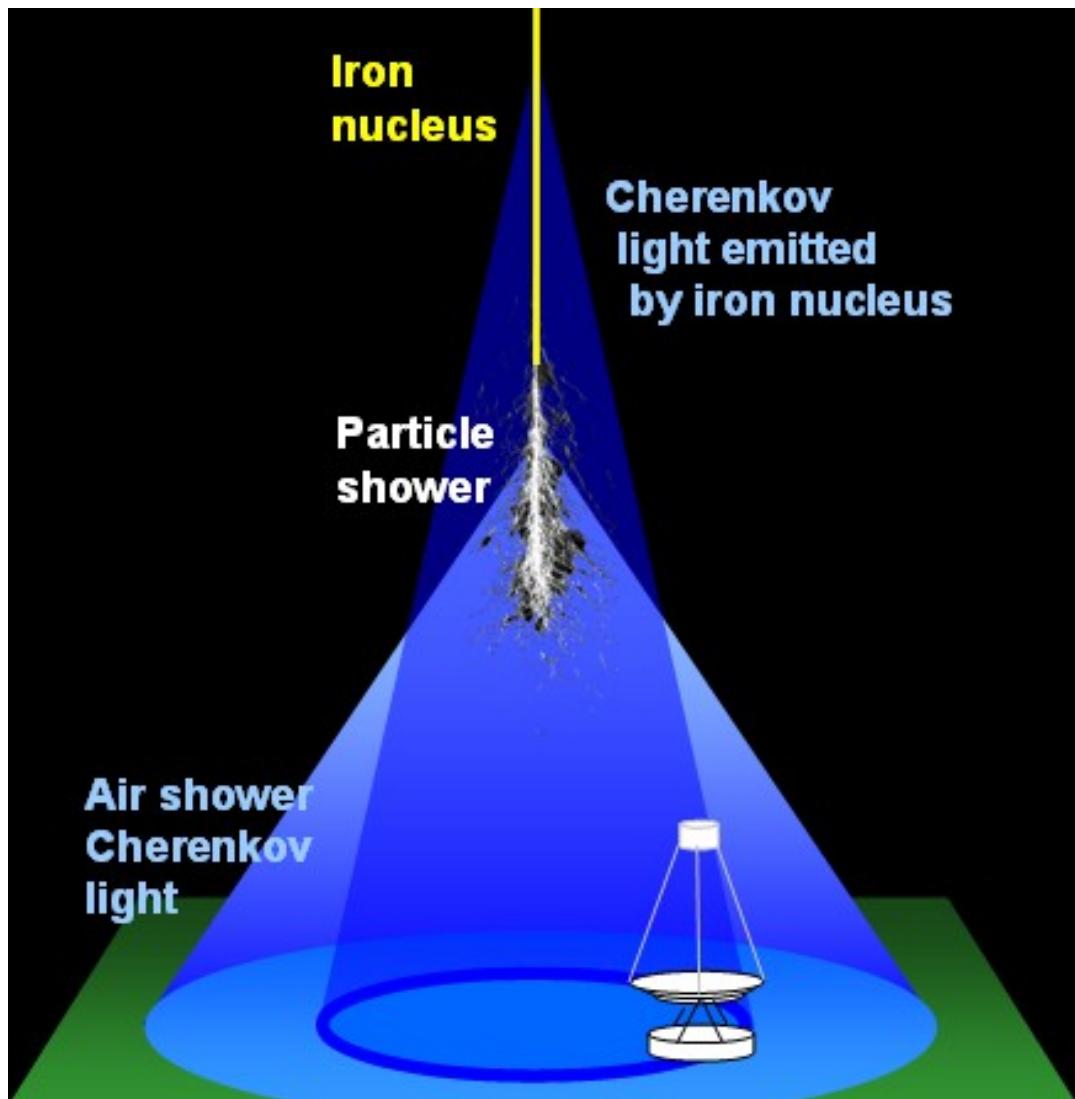
Recordemos...



IACT (Imaging Air Cherenkov Technique)



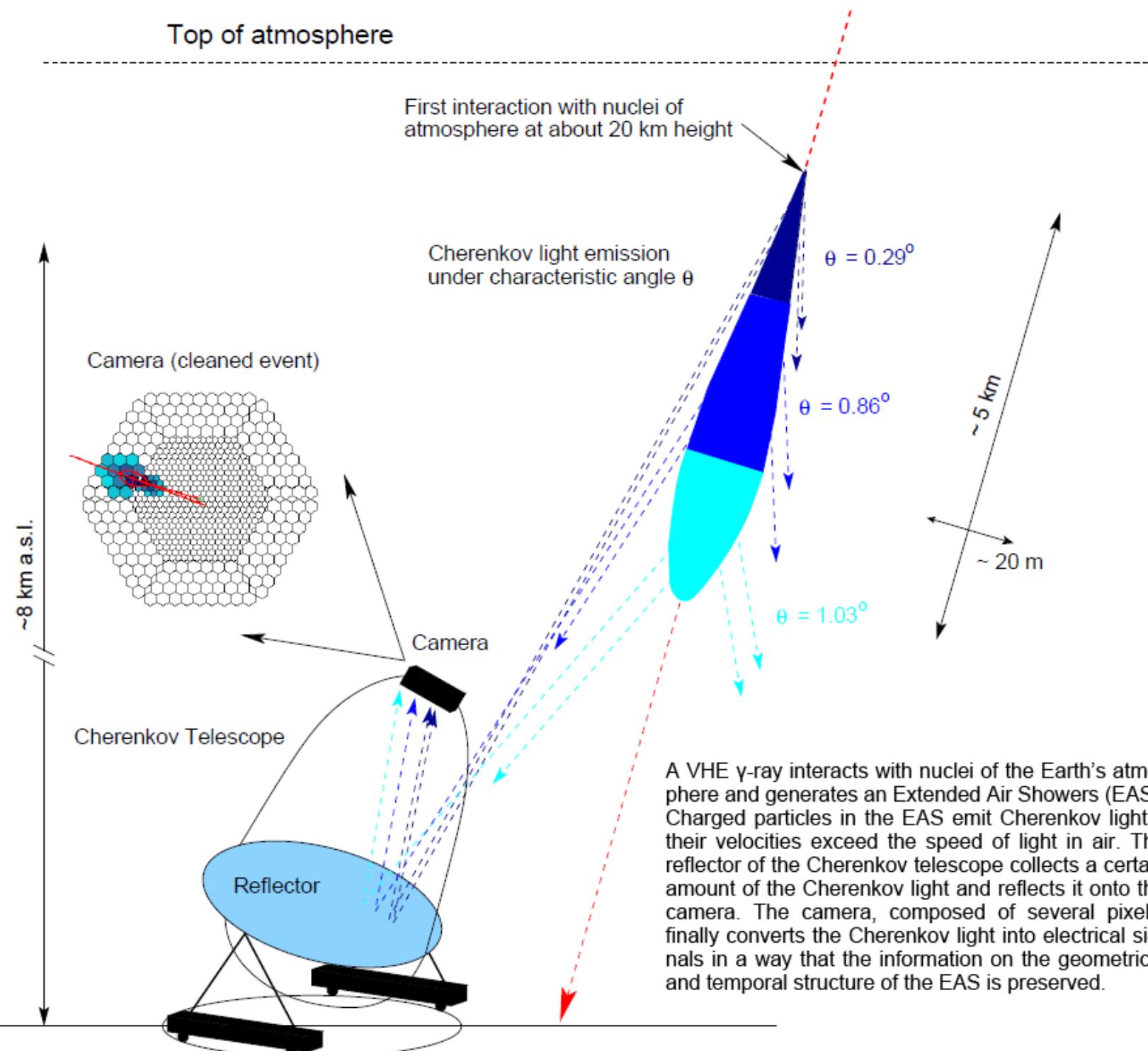
Cada partícula cargada produce un cono de 1.4°



$$\theta_{\text{Ch,aire}} = \arccos \frac{1}{\beta n_{\text{aire}}} \approx 1.4^\circ$$

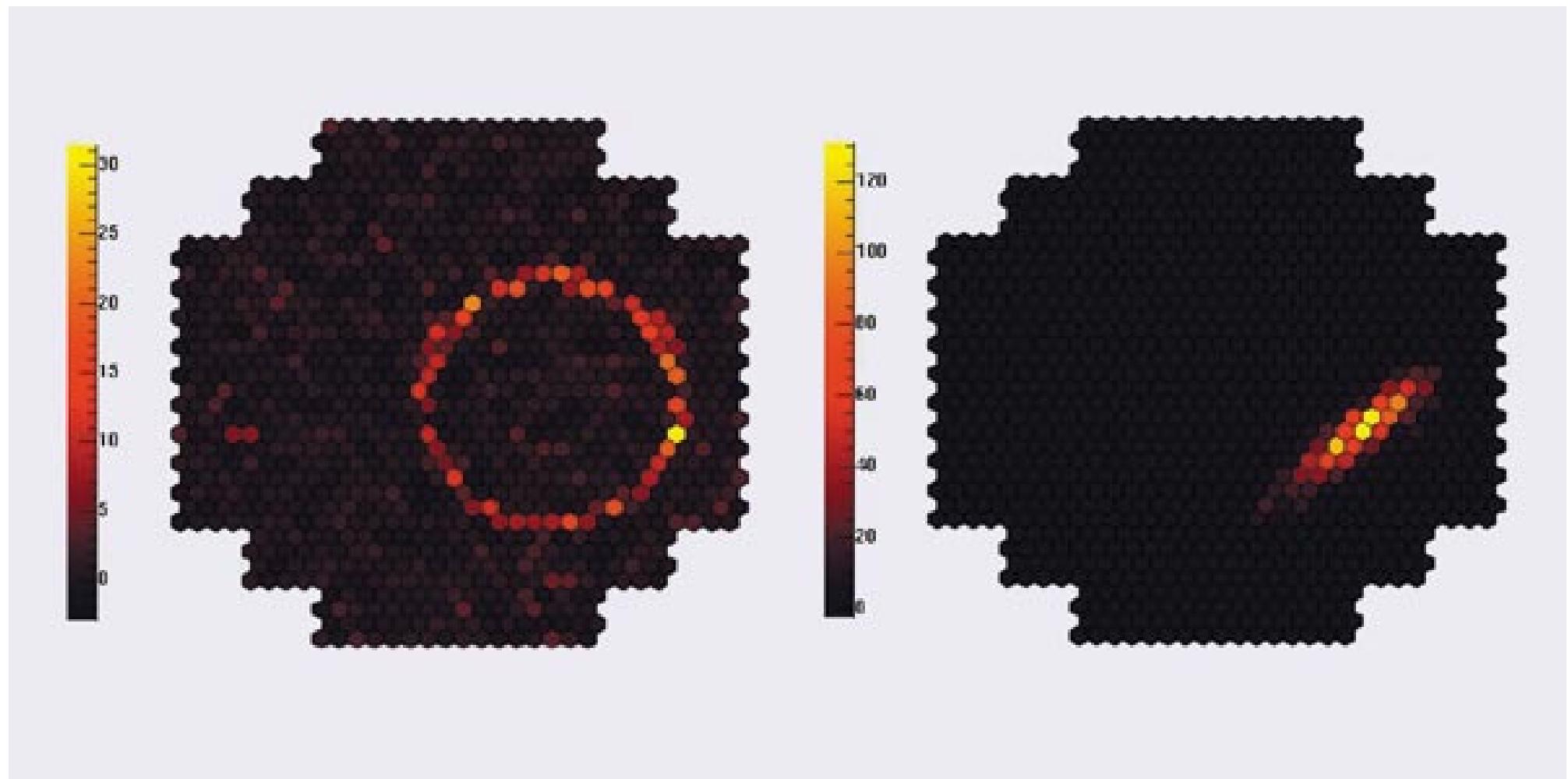
Illustration of an Imaging Air Cherenkov Telescope (IACT).

Primary particle (1 TeV)



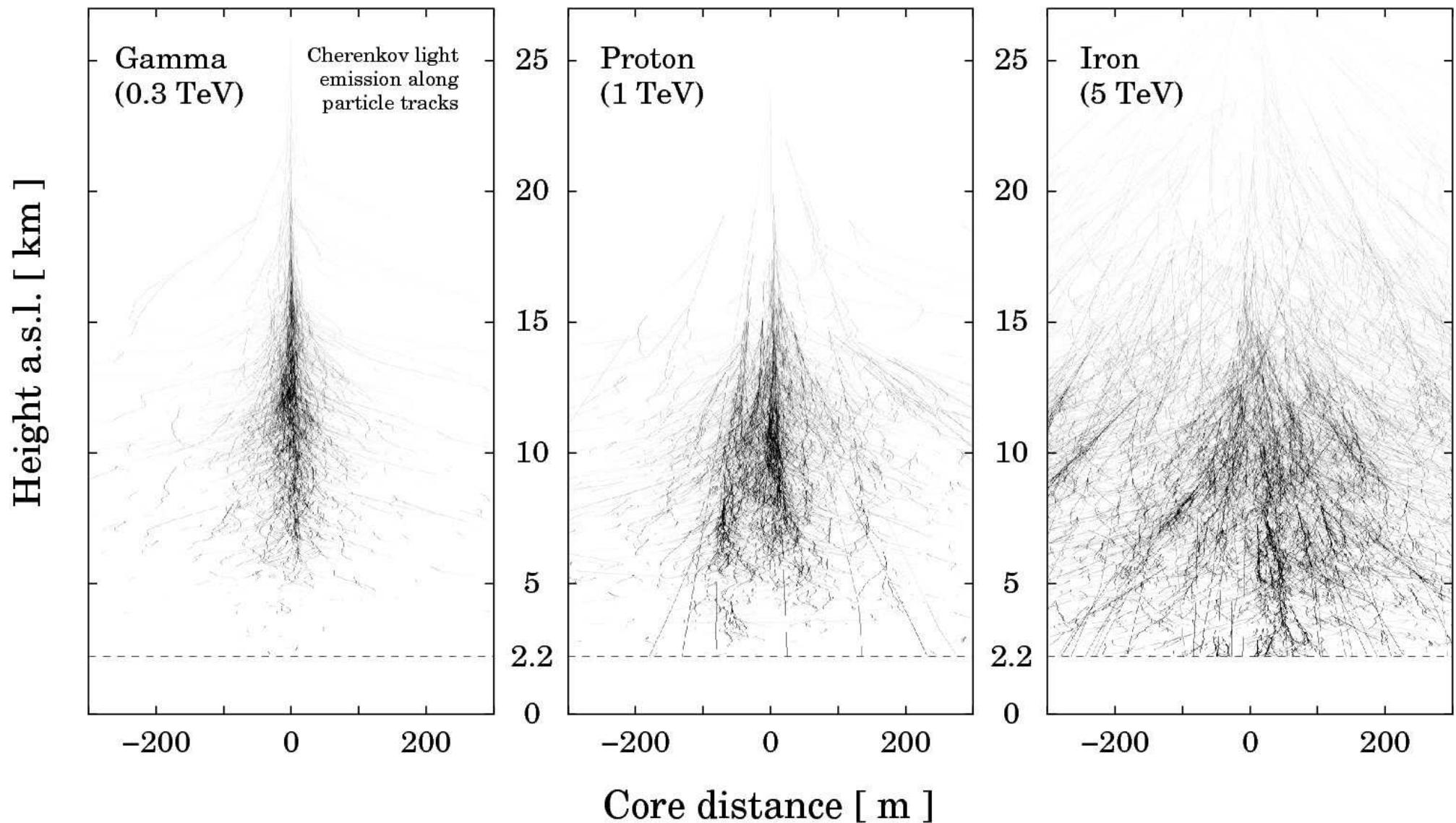
Producción Cherenkov en CORSIKA

- LAGO CORSIKA puede ser re-compilado para calcular el Cherenkov en el aire
- Activar ademas opciones 1a o 1b, 1c y 7c
- Se usa **rain.pl** con opción -z. Adicionalmente -m, -q, -p
- Analizar salidas .CER con **cherenkov.cc**



El problema: ruido hadrónico

Bernlöhr, 2008



Soluciones → Arreglos

