

A large radio telescope dish is silhouetted against a sunset sky. The dish is a large, curved structure with a grid-like pattern on its surface. The sky transitions from a bright yellow and orange glow at the horizon to a deep blue at the top. The telescope's support structure is visible in the foreground.

Camera Control System and GRB observation in MAGIC telescope

Particle Physics School Munich Colloquium
January 11th, 2013

Max-Planck-Institut für Physik
Föhringer Ring, Munich, Main Auditorium

Takeshi Toyama

Contents

1.MAGIC telescope

- Way to detect Very high energy gamma ray
- Target Science

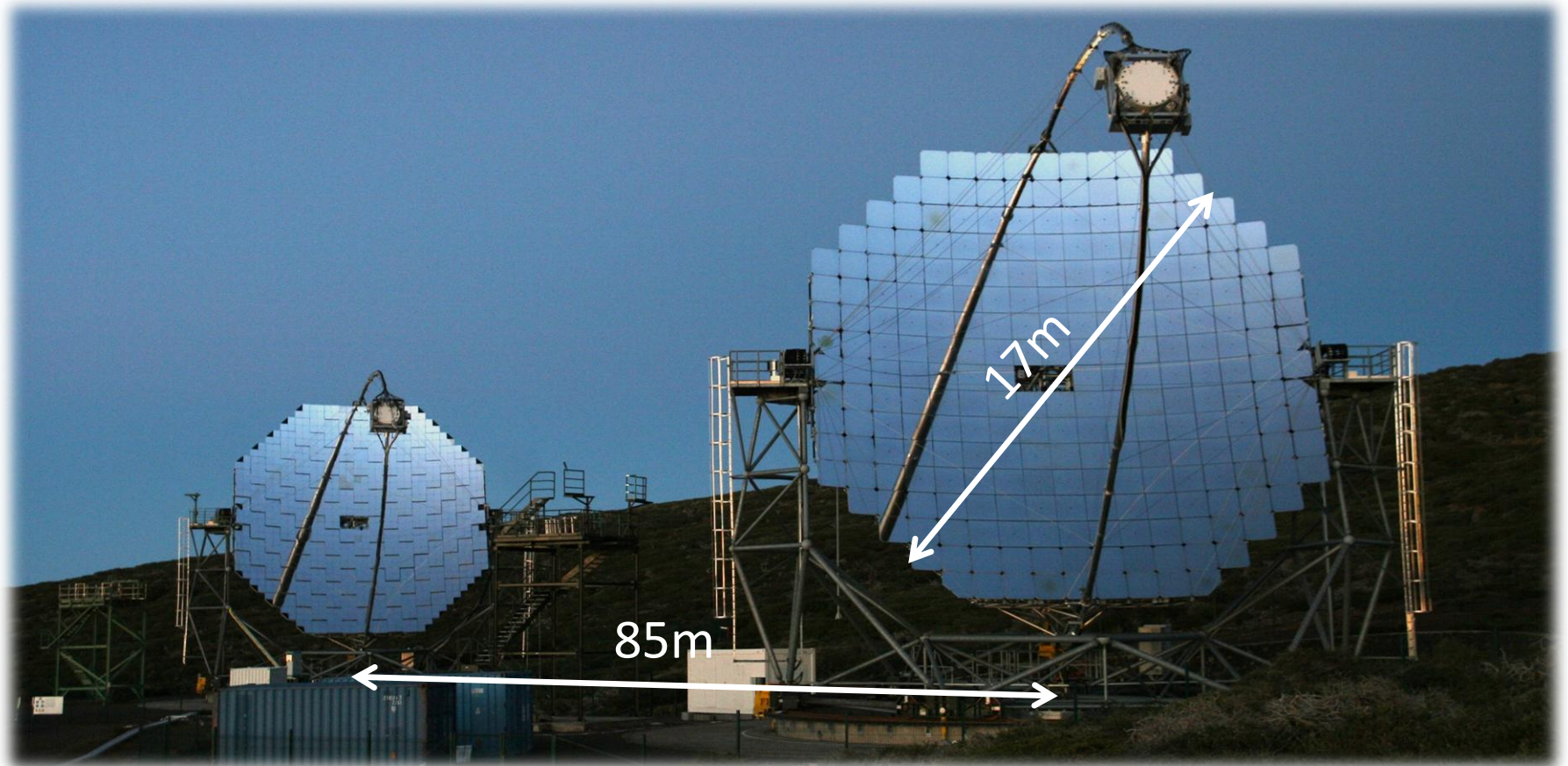
2.Camera Control System

- How do we manage camera of MAGIC telescope?
- We are also fighting against bad weather

3.Gamma Ray Burst (GRB) Observation

- Motivation for GRB Observation
- GRB Observation system by MAGIC telescope
- Future state

MAGIC telescope



Location	Canary Island La Palma
Energy range	50GeV - 50TeV
Angular resolution	$\sim 0.06^\circ$ (@1TeV)
Sensitivity	$\sim 0.06\%$ Crab (@500GeV with 50h observation)

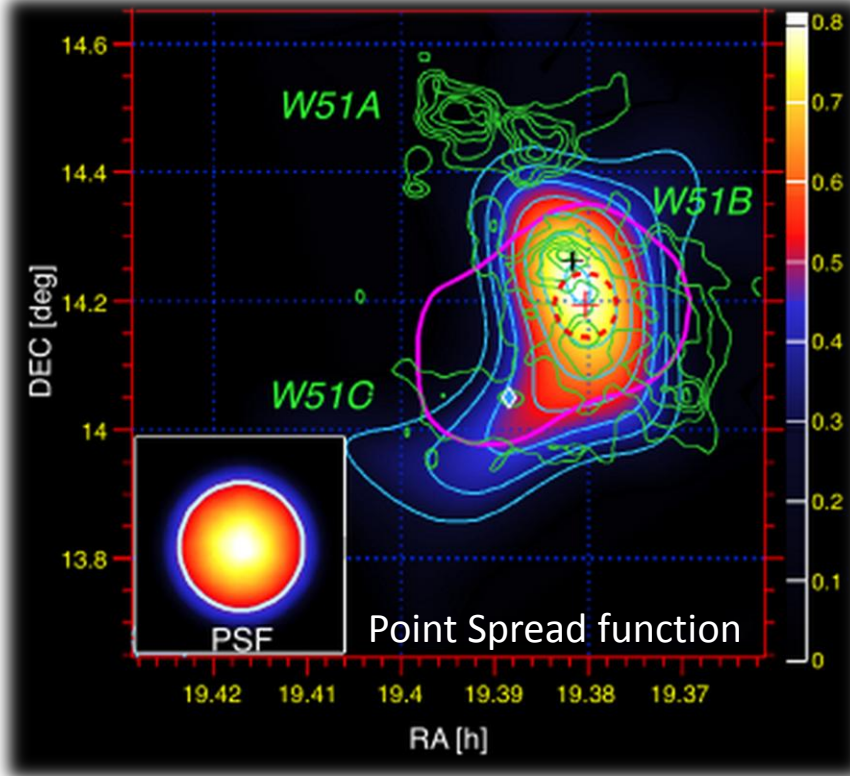
MAGIC telescope

Typical sources in GeV-TeV gamma

Flux
[$10^{-12} \text{ cm}^{-2} \text{ s}^{-1} \text{ TeV}^{-1}$ at 1 TeV]

Crab nebula	22–37
Galactic Center	2.5
R1713.7-3946	17
Mkn 421	12–97
Mkn 501	0.5–100

Data from F. Aharonian et al (2008)



J. Aleksic et al (2012)

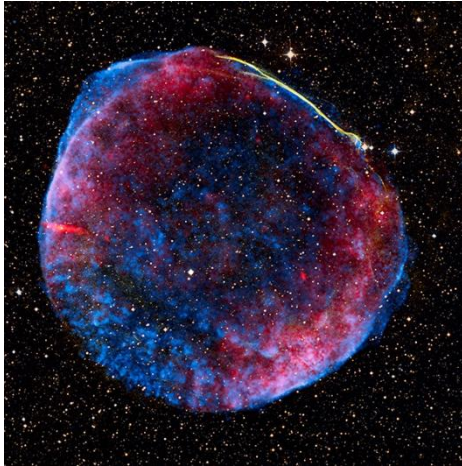
Location
Energy range
Angular resolution
Sensitivity

Canary Island La Palma
50GeV - 50TeV
 $\sim 0.06^\circ$ (@1TeV)
 $\sim 0.06\%$ Crab (at 500GeV with 50h observation)

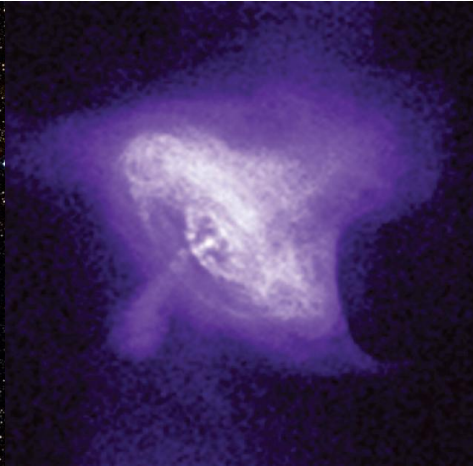


Science Target

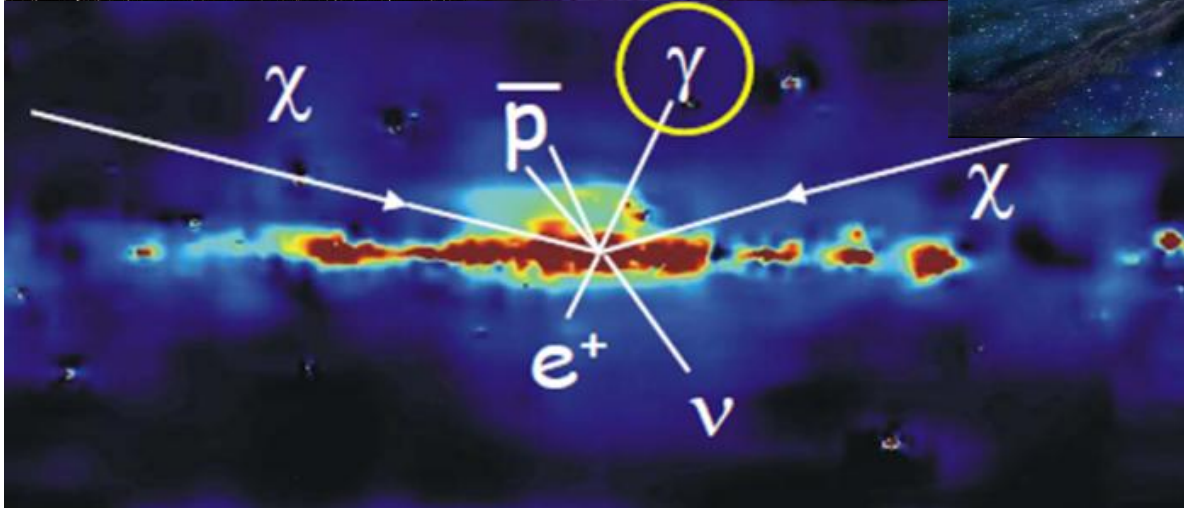
Super Nova Remnant



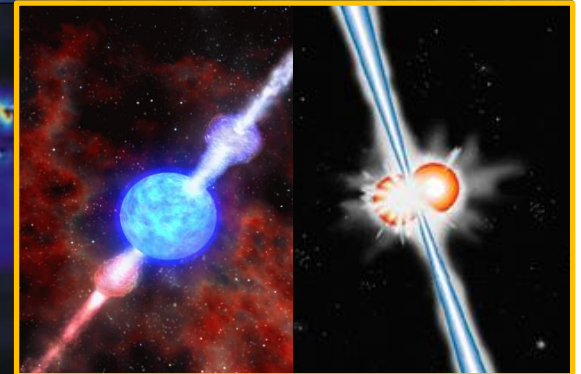
Pulsar / Pulse Wind Nebula



Active Galactic Nuclei



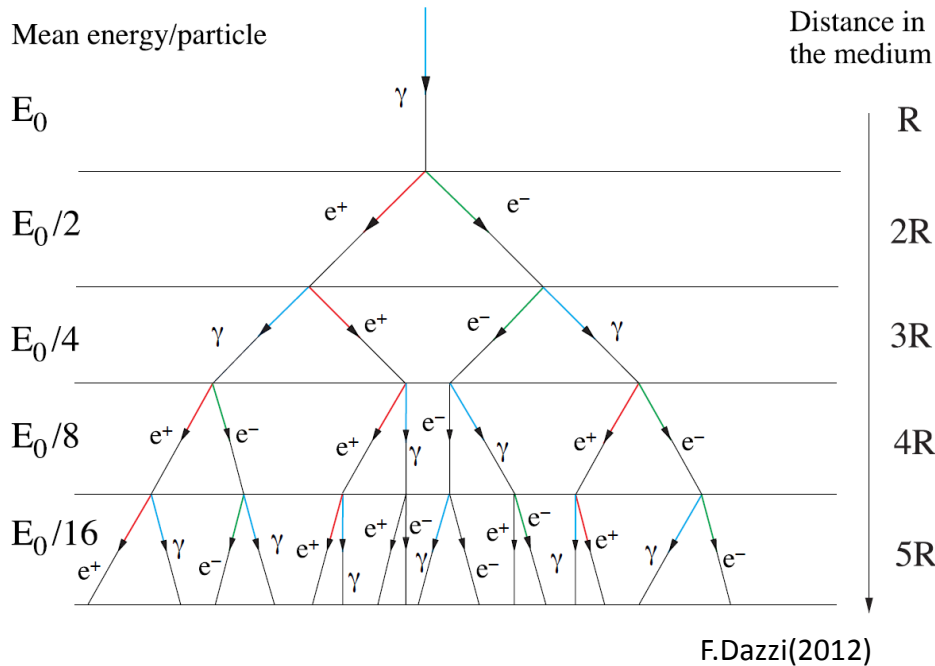
Indirect Dark Matter search



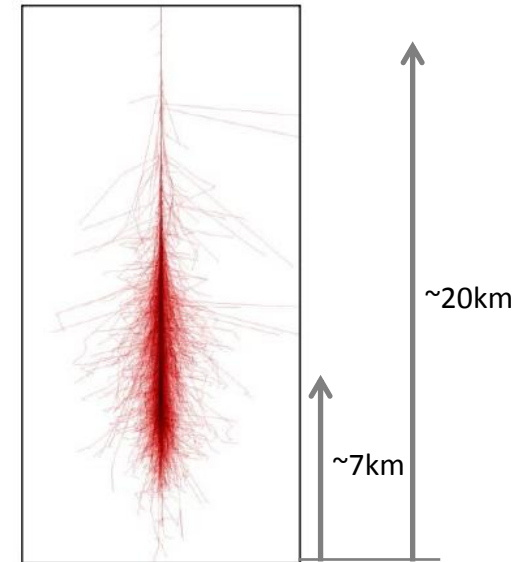
Gamma Ray Burst

Way to detect Gamma ray in MAGIC

When a gamma ray goes into atmosphere

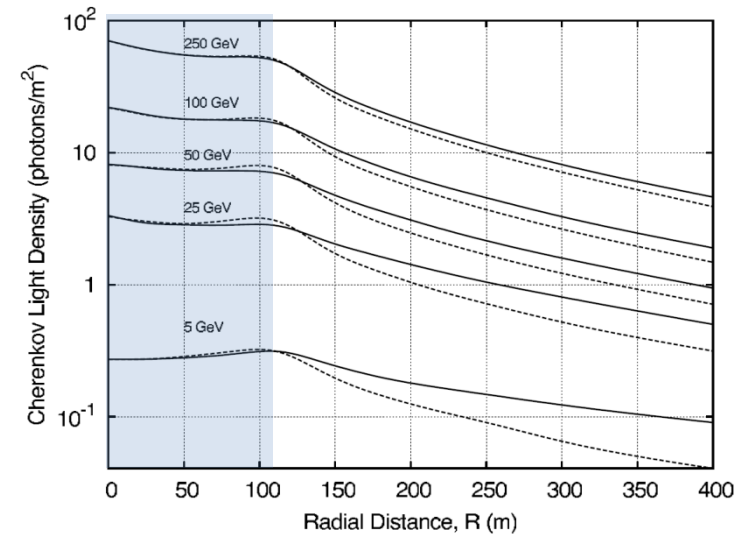
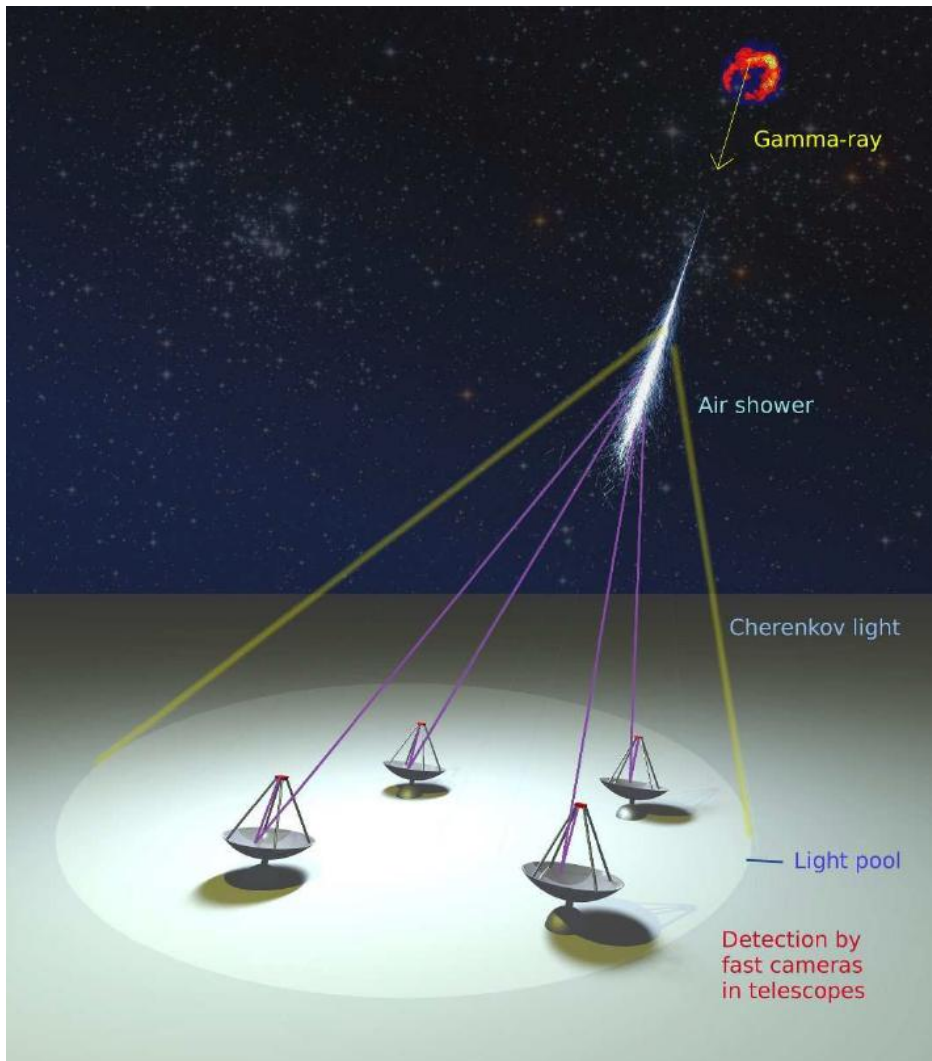


E_0 : Original energy of gamma
 R : Radiation length



Air shower by gamma at 300 GeV

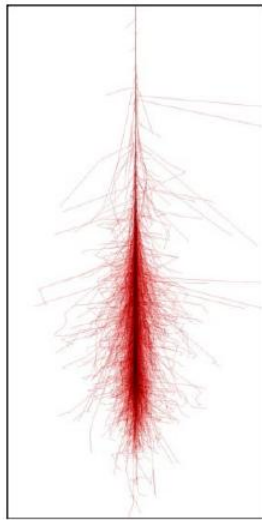
Way to detect Gamma ray in MAGIC



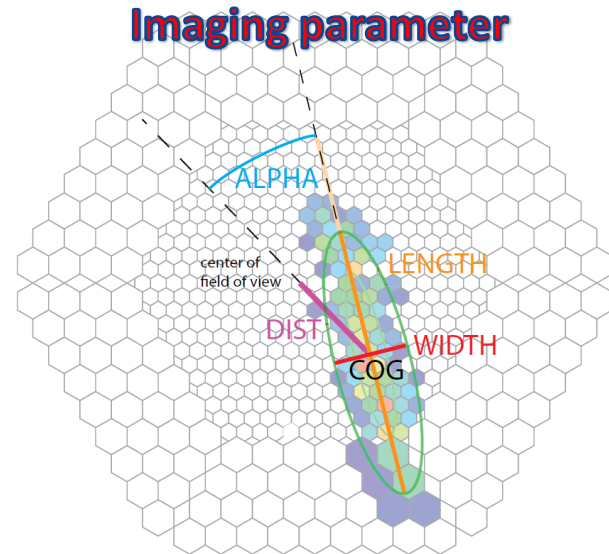
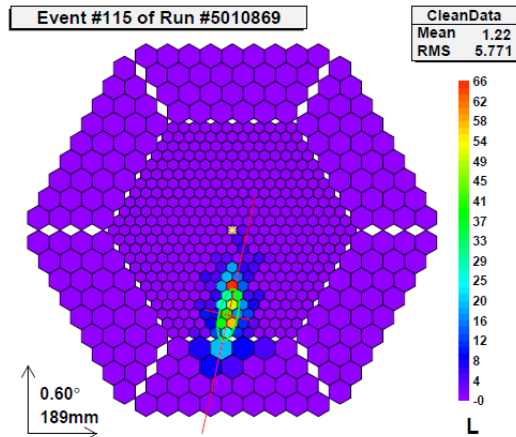
Signal is **faint**(10ph/m²) at 50GeV
and **short**(a few nsec)



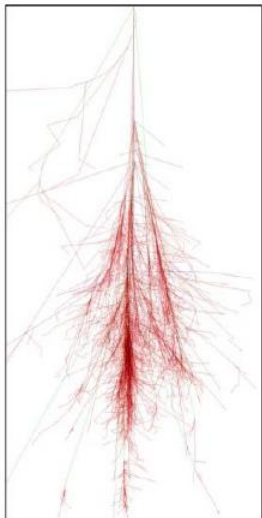
Way to detect Gamma ray in MAGIC



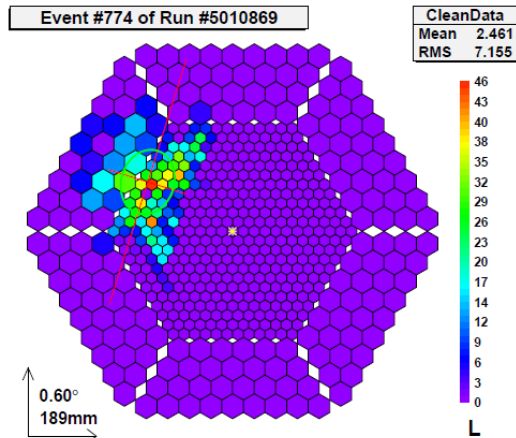
Air shower by gamma ray



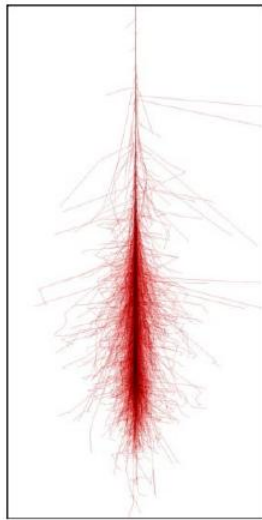
This parameter is used to discriminate gamma from hadron to measure direction and energy of signal



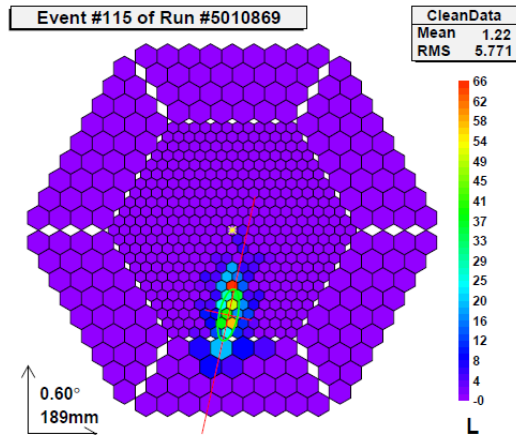
Air shower by hadron



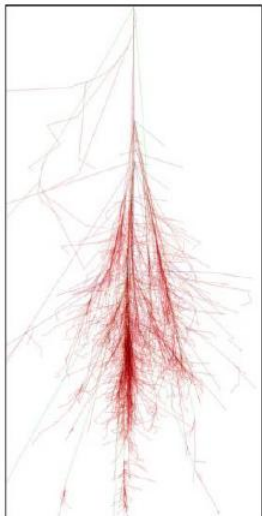
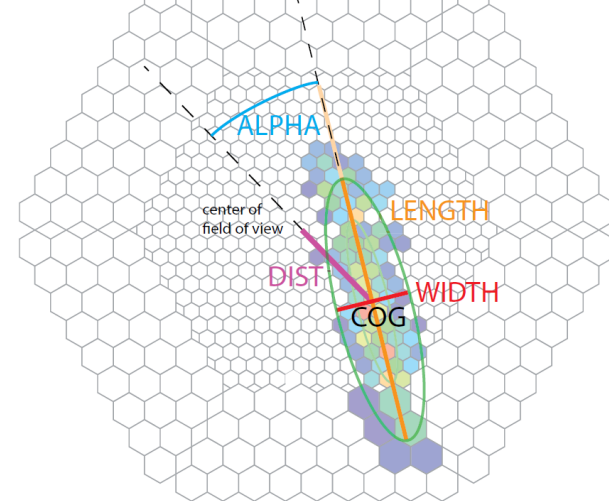
Way to detect Gamma ray in MAGIC



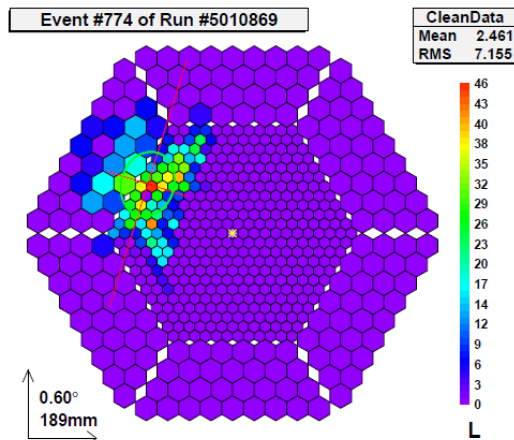
Air shower by gamma ray



Imaging parameter



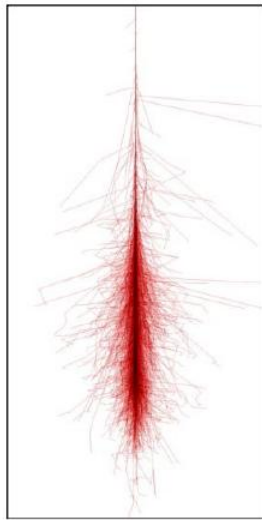
Air shower by hadron



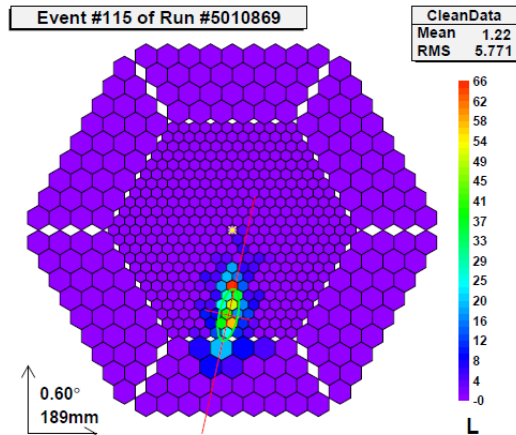
Gamma ray signal in many background!

Gamma ray: Hadron \doteq 1 : 1000
(even observing strong source)

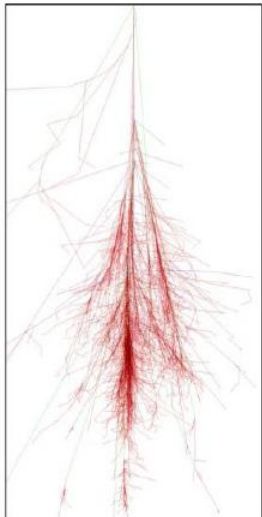
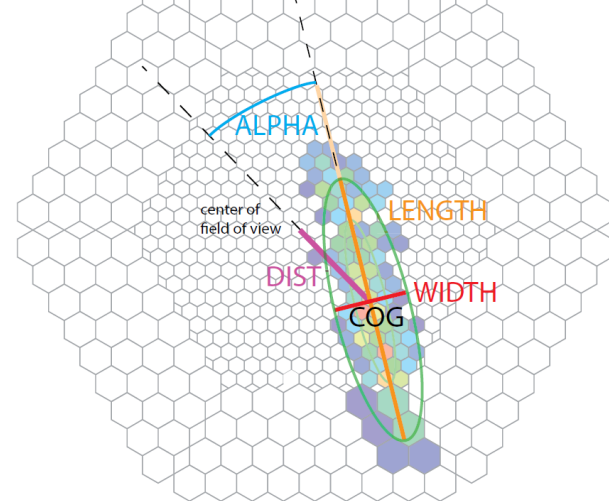
Way to detect Gamma ray in MAGIC



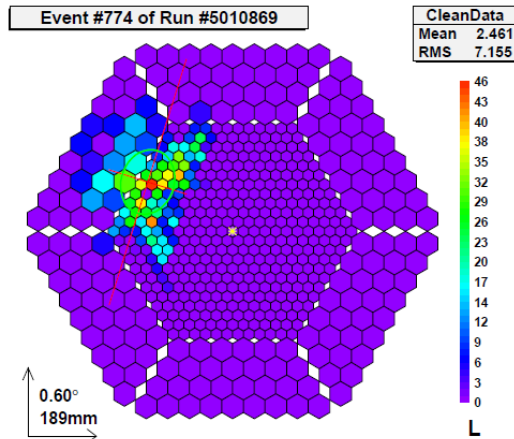
Air shower by gamma ray



Imaging parameter



Air shower by hadron



Gamma ray signal in many background!



Camera of MAGIC telescope



Camera consist of 1039 PMTs
Why don't we use CCD??

Cables for signal

Lid can be controlled by remote

Cable for cooling

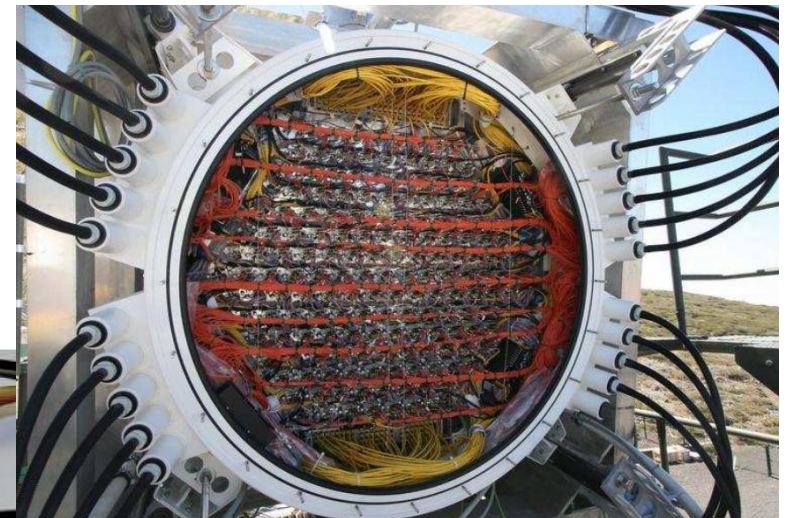
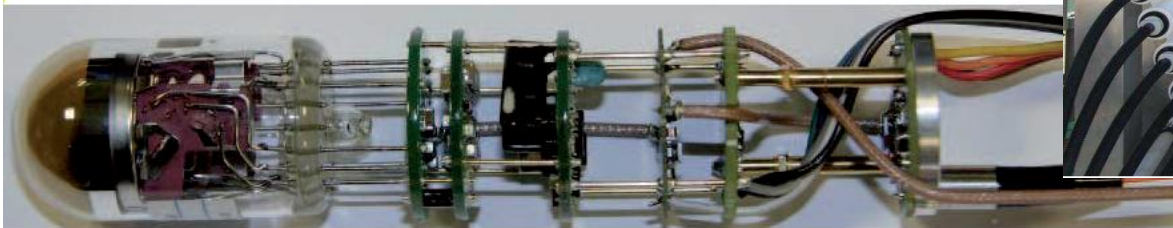


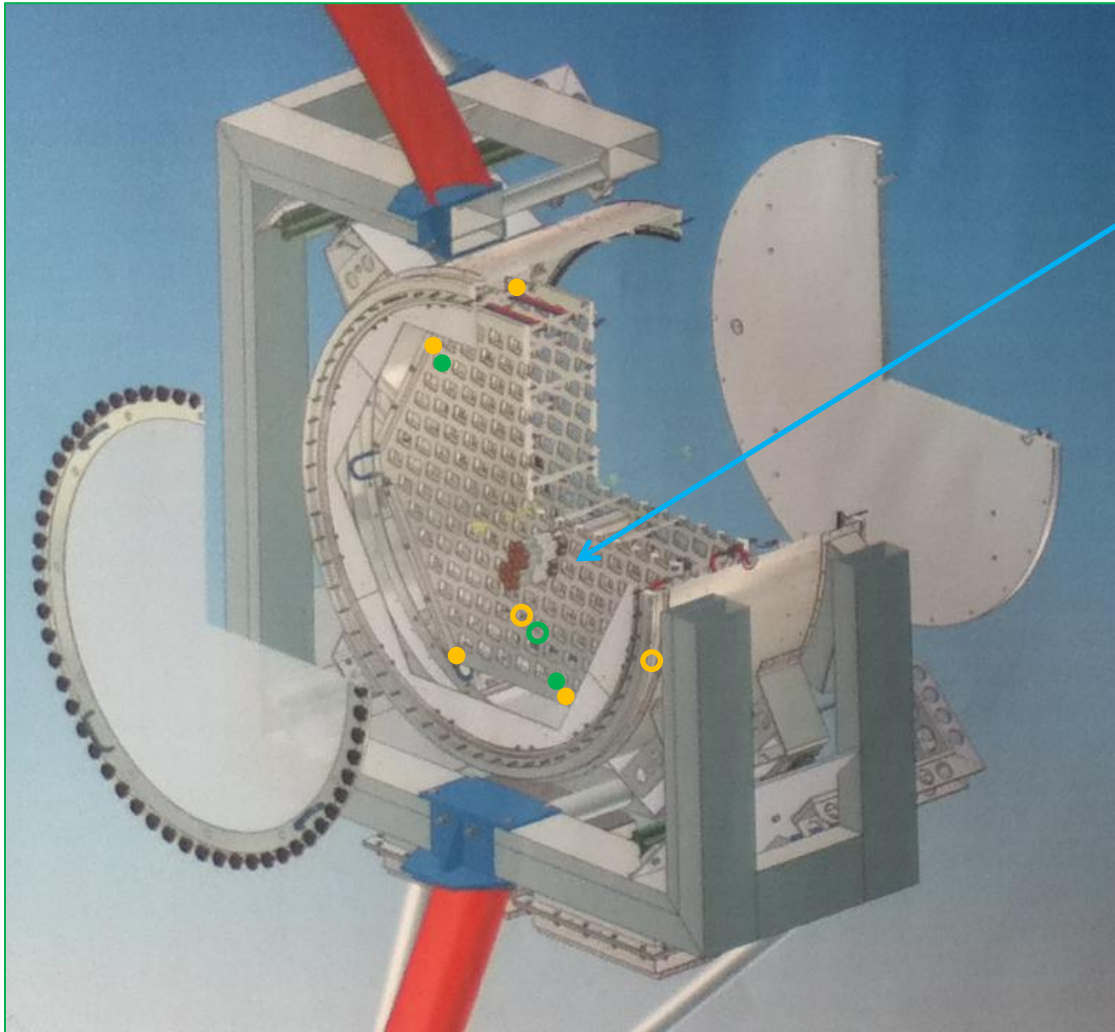
Photo Multiplier Tube (PMT)

Temperature sensor



Cockcroft Walton Circuit to supply High voltage (HV)

Devices for safe operation



- Temperature sensors
- Humidity sensors
- Cooling Plate
- Device to measure wind speed



Camera Control Software System

CaCol

Lid
close [v] [green bar]
Lid Global Error? [black dot] [Lid Reset]

Low Voltage
Power LV [green bar]

EXIT Exit routine ongoing [green bar]
Power pulser [green bar] Reset SuperArehucas Communication [green bar]
Write report [green bar] Read command [green bar]

Weather station
Temp: 24.14
Humidity: 16.79
Windspeed: 10.32
Dust (ug/cm²): 36.379
Seeing: N/A
Weather Alert? [black dot]

Starguider
[black bar] No Comment
[black bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment
[green bar] No Comment

Camera temperatures
Temp camera mean: 20.05 +/- 2.43
Temperature Alert? [black dot]
Plate-Front-Left-Top: 17.96
Plate-Front-Right-Bottom: 17.9
Plate-Rear-Left-Top: 17.9
Plate-Rear-Right-Bottom: 17.4
Air-Front-Left-Top: 21.96
Air-Front-Right-Bottom: 22.09
Air-Rear-Left-Top: 22.84
Air-Rear-Right-Bottom: 22.34

LV boxes
Temp LV 1: 28.96 +/- 0.24
Temp LV 2: 27.82 +/- 0.49
Humi LV1: 36.9
Humi LV2: 38.2

Camera humidity
Camera humi mean: 24.01 +/- 1.37
Humidity Alert? [black dot]
25.4 rear bottom left
22.3 rear top left
24.7 front bottom right
23.7 front top right

Single Hot Pixel (HP) reaction
(automatic reduction of HV and set back, part of the Sentinel)
HP reaction ongoing? [green bar]
Forced set back of reduced pixel [green bar]
HP routine on / off [green bar]
Stepwise HP treatment [green bar]
HP list

HV read
Choose value to be displayed: HV read
Read out value is displayed

Pixel Hard Number (1-1039)
Cluster Number (1-169)
DC [muA]: 0
mean DC [uA]: 0.14 +/- 0.02
HV set [V]: 0
HV read [V]: 0
mean HV [V]: 198 +/- 8
Temp [deg C]: 0
PD [uA]: 0
Attenuator (desired value): 0
Bias [ADC counts] (desired value): 0
Low Voltage [V]: 0

DC
Choose value to be displayed: DC
Read out value is displayed

Pixel Hard Number (1-1039)
Cluster Number (1-169)
DC [muA]: 0
mean DC [uA]: 0.14 +/- 0.02
HV set [V]: 0
HV read [V]: 0
mean HV [V]: 198 +/- 8
Temp [deg C]: 0
PD [uA]: 0
Attenuator (desired value): 0
Bias [ADC counts] (desired value): 0
Low Voltage [V]: 0

Maximum: 1500 V
Minimum: 0 V

Maximum: 6 uA
Minimum: 0 uA

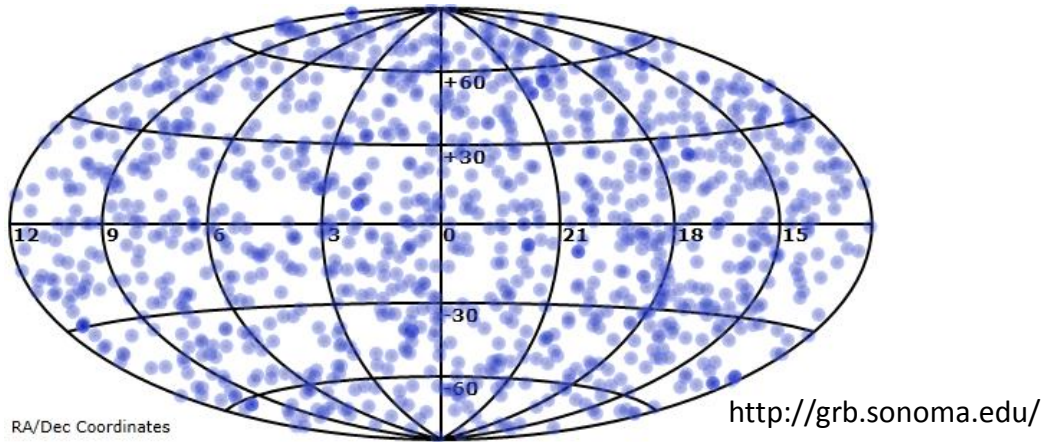
Security Routine for Camera

1. Direct current (from PMT) over 20 μ A?
HV is reduced to protect PMT
2. Pixel Temperature over 40 degree?
Power supply is OFF, Alert warning to check Cooling system
3. Humidity in Camera over 98%?
HV is OFF, Wait for fine weather
4. Wind speed over 40km/h?
Camera Lid is close to protect MAGIC CAMERA, Alert warning to stop tracking

We are monitoring and controlling HV DC.

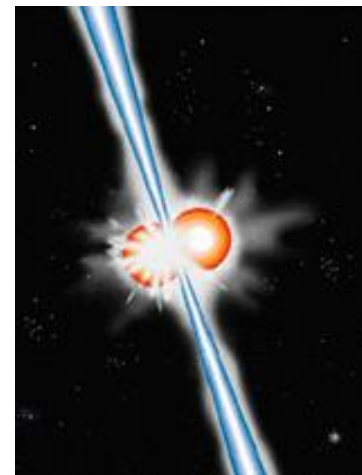
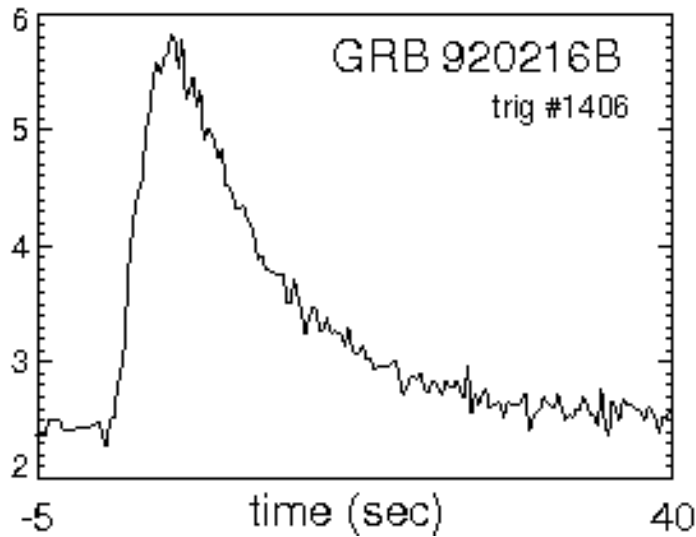
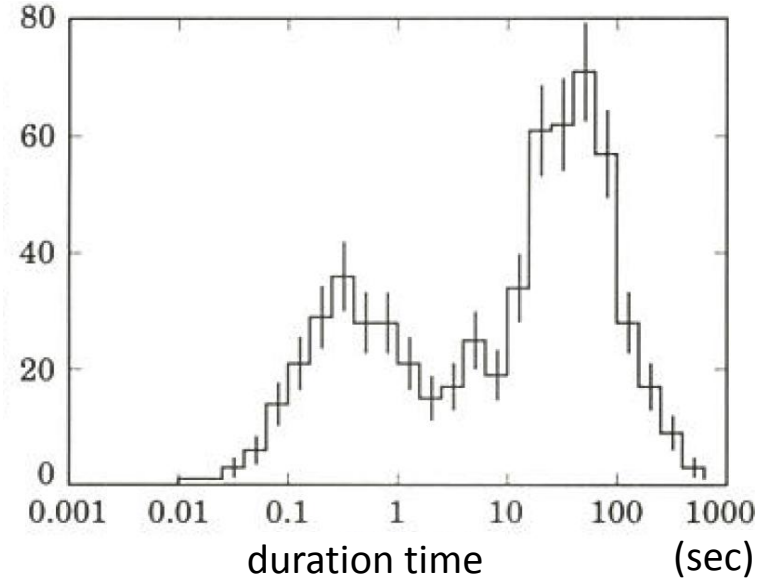
We are also fighting against wind, humidity, temperature, strong light

Gamma Ray Burst

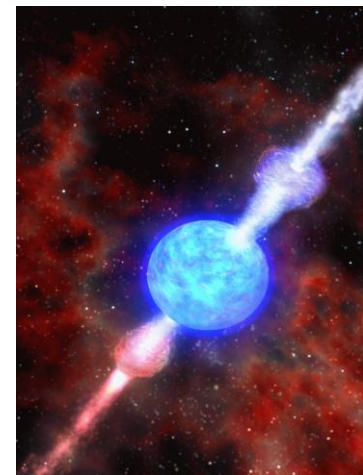


No anisotropy

Number of burst



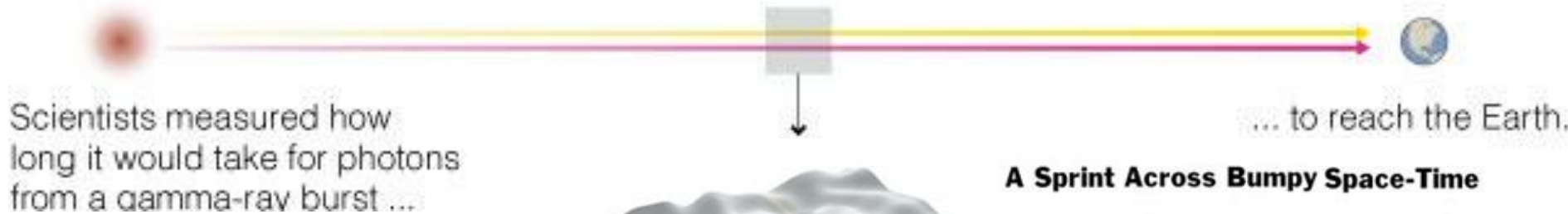
Short GRB



Long GRB

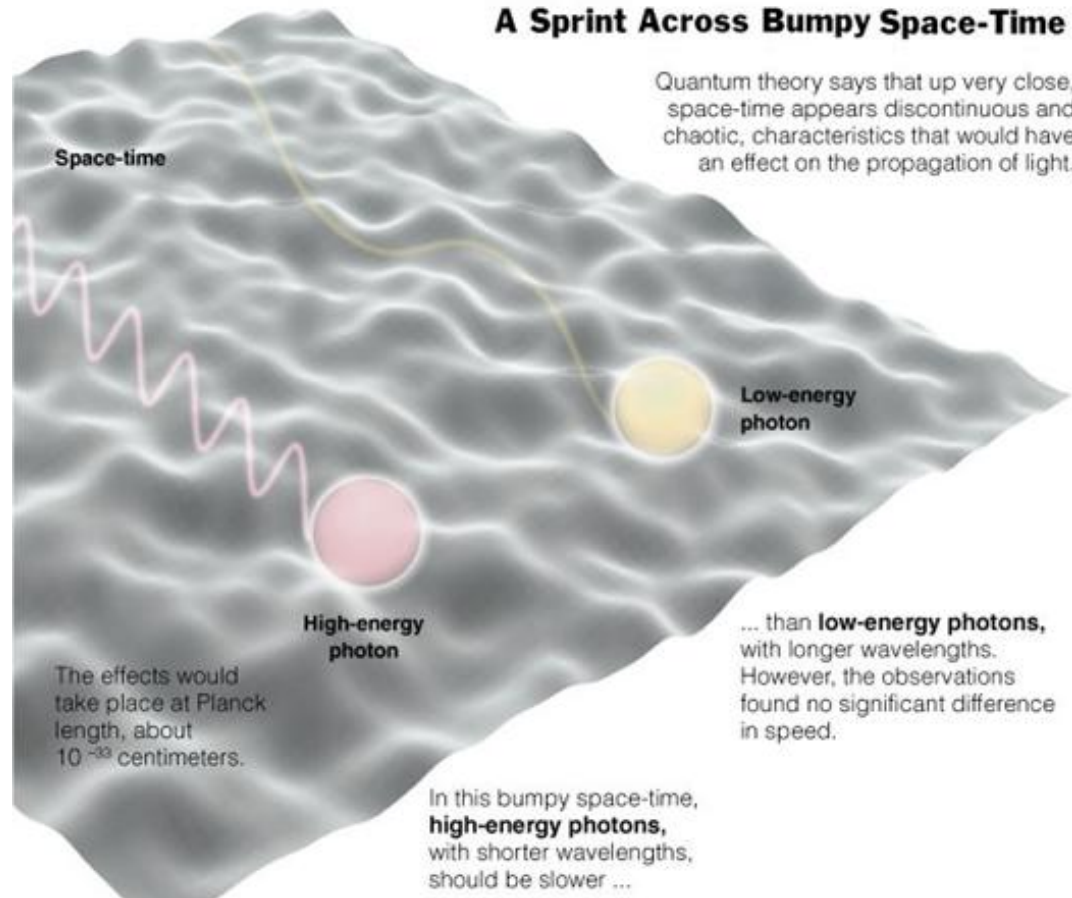
One of Motivations

THE EXPERIMENT

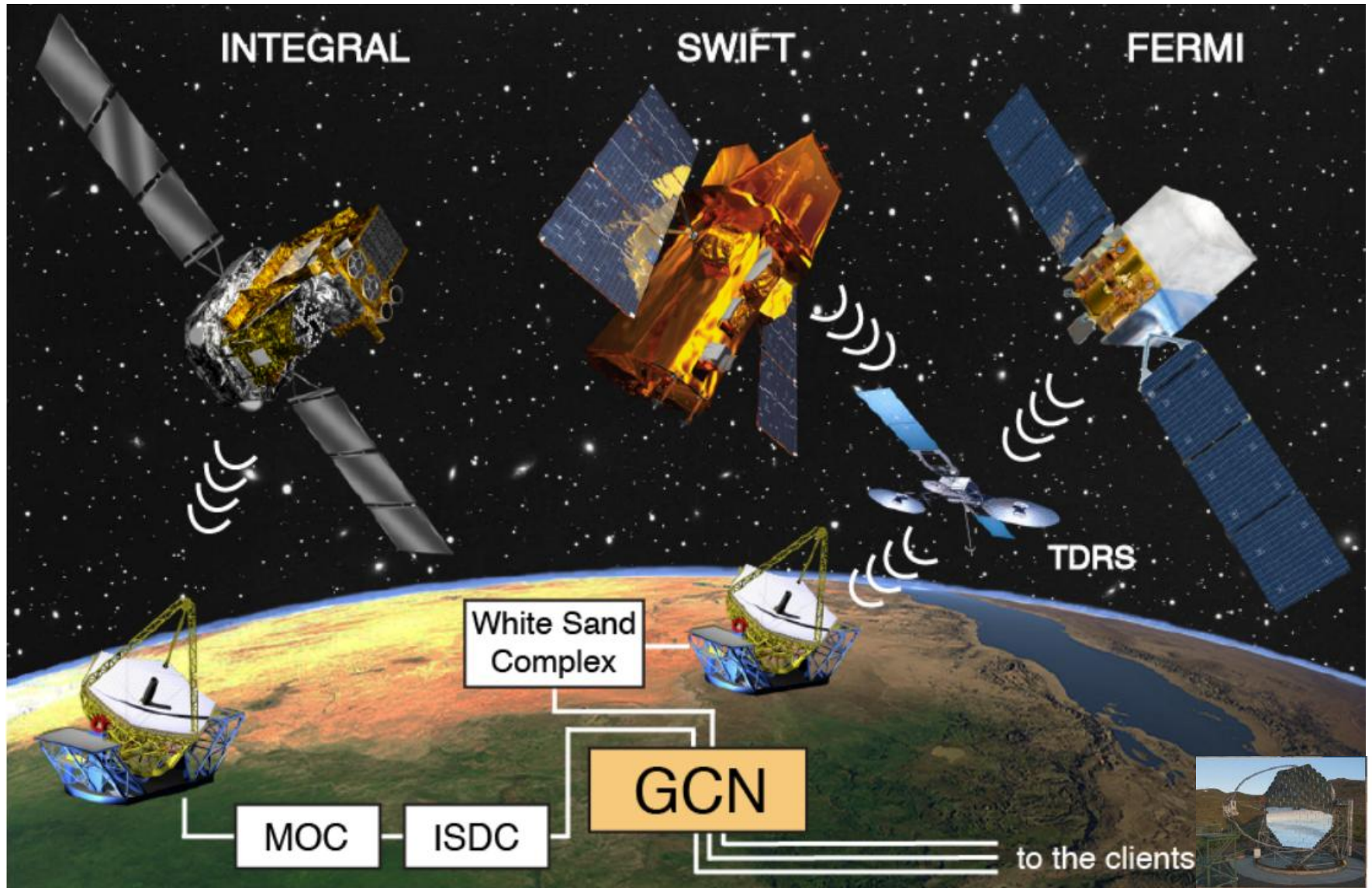


A Sprint Across Bumpy Space-Time

Quantum theory says that up very close, space-time appears discontinuous and chaotic, characteristics that would have an effect on the propagation of light.



GRB observation in MAGIC



GRB observation in MAGIC

Satellite/instrument	Energy range	Observed GRB rate (yr ⁻¹)	Typical localisation error (radius)	Typical delay time
Swift BAT	15–150 keV	95	few arcmin	20 s
Swift XRT	0.3–10 keV	90	<3''	~70 s
Fermi GBM	8 keV–40 MeV	250	10° / 1-3°	20-300 s / 20 min-2 hr
Fermi LAT	20 MeV–300 GeV	10	few deg / 10-60'	<1 min / 4-8 hr

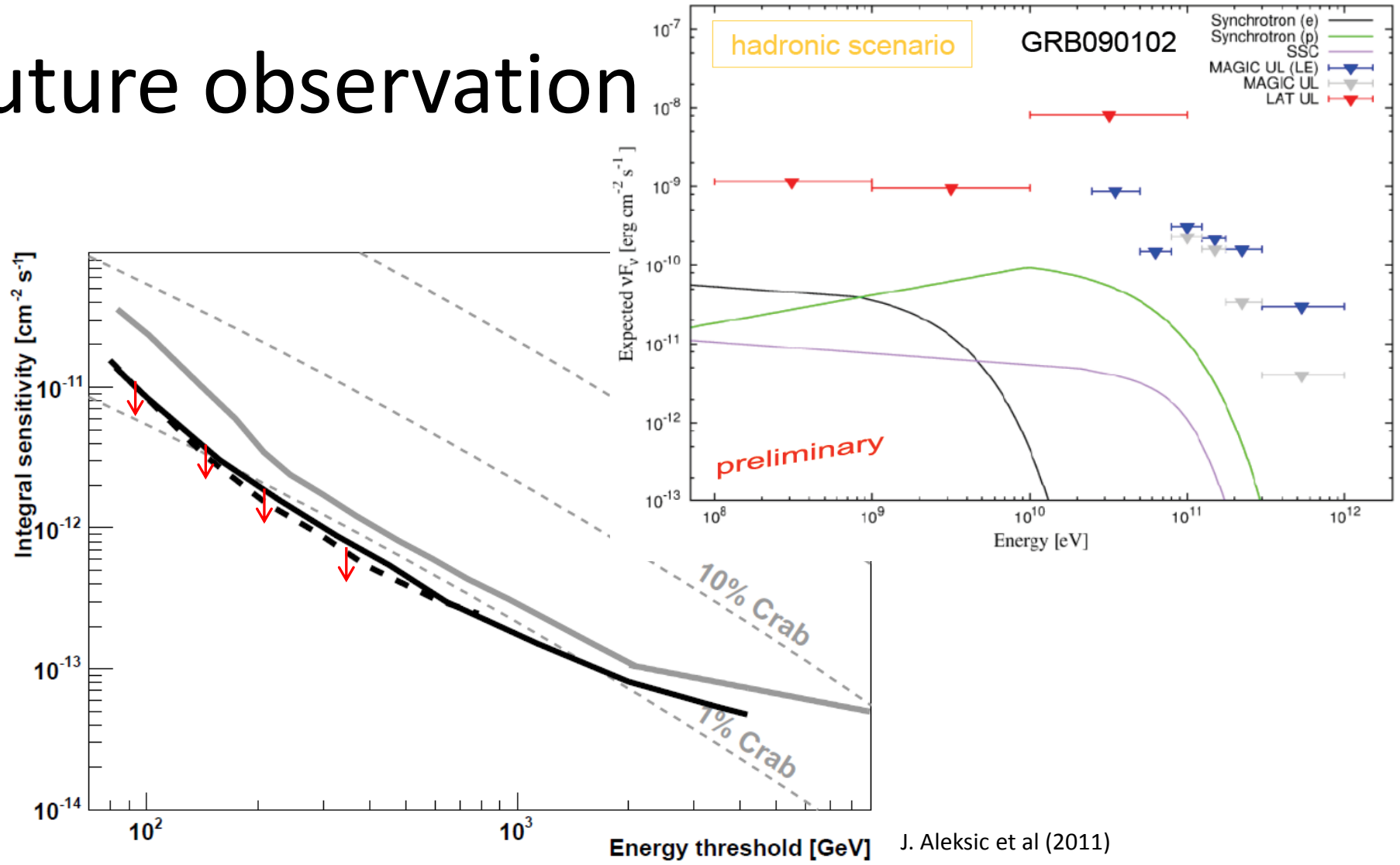
S. Inoue et al 2012

	GRB	z	T_{90} [s]	ΔAz [deg]	rep. time [s]	Zd [deg]	start obs. [s]	obs. time [min]
1.	050421	–	10.3	30	26	52	108	76
2.	050505	4.27	60.0	114	90	49	717	101
3.	050509a	–	11.6	128	108	58	131	119
4.	050509b	0.23	0.04	86	83	70	108	8
5.	050528	–	10.8	7	12	49	77	28
6.	050713a	–	70	50	17	49	40	37
7.	050904	6.29	225	55	54	24	145	147
8.	060203	–	60	268	84	44	268	43
9.	060206	4.05	7	44	35	13	59	49
10.	060522	5.11	69	64	58	60	2786	13
11.	060602b	–	9	102	191	60	4109	26
12.	060825	–	8.1	7	30	23	57	33
13.	060924a	–	8.9	1	20	60	42	1
14.	060912	0.94	5.0	127	40	60	24291	18
15.	060923	3.21	8.9	246	83	31	12923	23
16.	061102	–	1.6	51	72	30	169	100
17.	061110b	3.44	128	196	69	43	698	59
18.	061217	0.83	0.30	126	45	60	786	66
19.	070411	2.95	101	–	–	38	2652	128
20.	070412	–	34	26	9	23	701	124

We should follow GRB as soon as possible in duration time

D. Bastieri et al 2012

Future observation



J. Aleksic et al (2011)

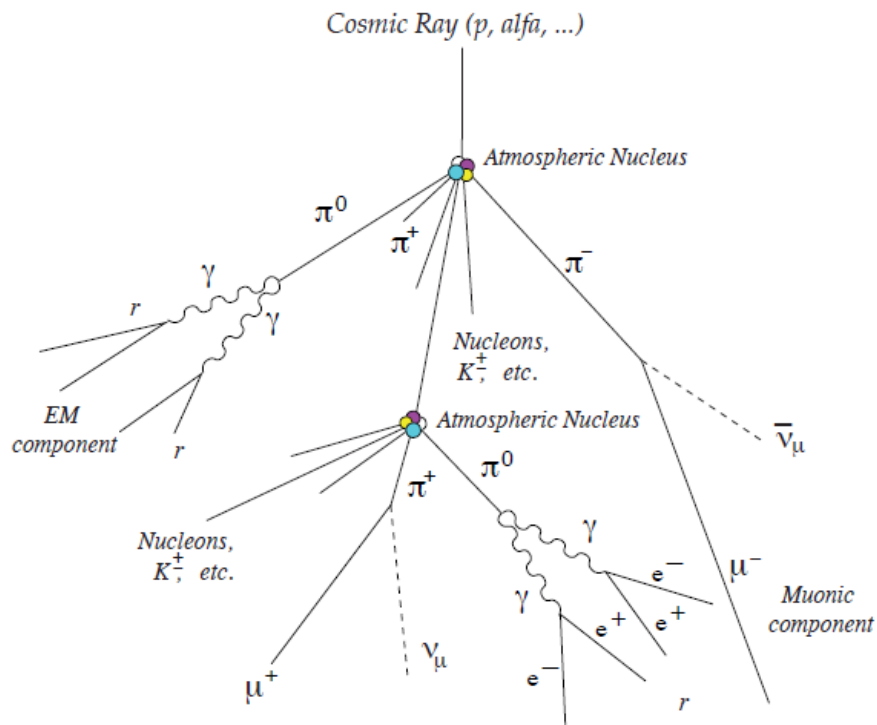
After upgrade we can get better sensitivity in low energy (<500GeV)

Moreover,

In this year, New trigger system will be installed to achieve lower threshold energy (~25GeV)

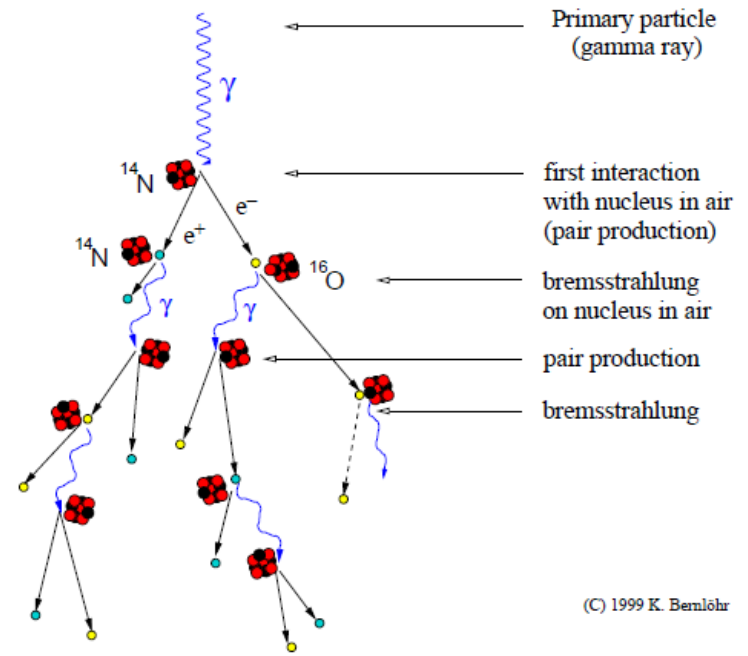
Summary

- Camera Control System is not only controlling HV and monitoring DC&HV, but also saving camera from bad weather, accident.
- To detect GRB by MAGIC, it is important to point quickly and certainly in duration time of burst.
- After upgrade of new trigger, we will achieve lower threshold energy ($\sim 25\text{GeV}$). This helps GRB observation.



(a) Hadronic shower

Development of gamma-ray air showers



(C) 1999 K. Bernlöhr

(b) Electromagnetic shower

