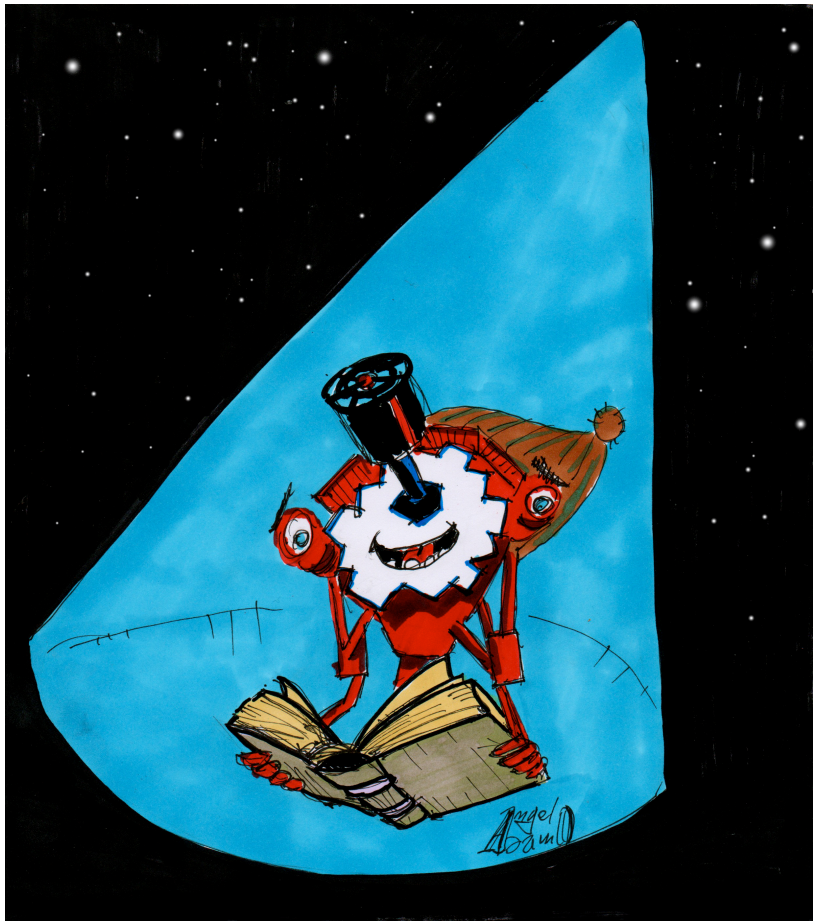
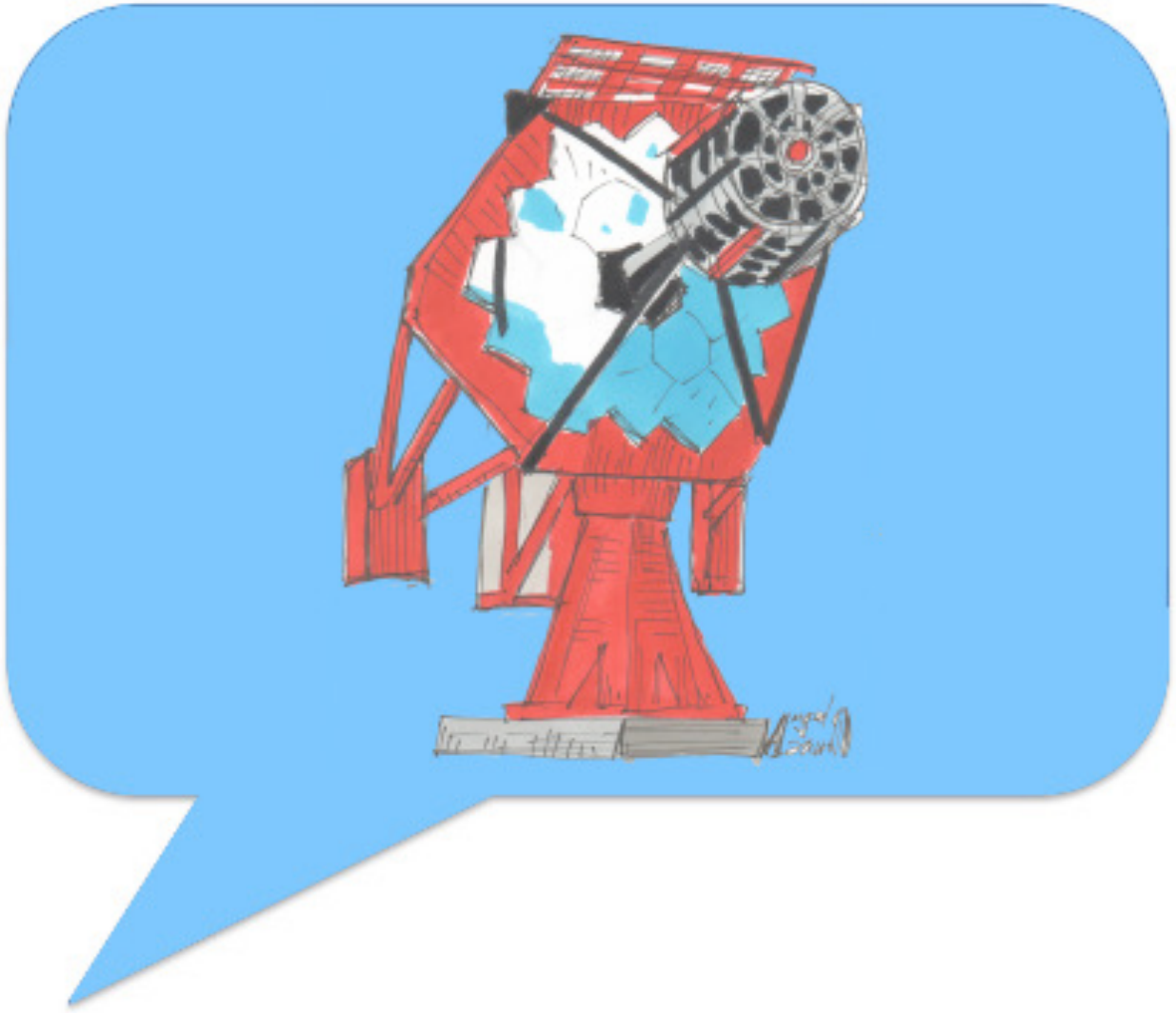
“CHERENZOO” – An Educational Project for Computers?

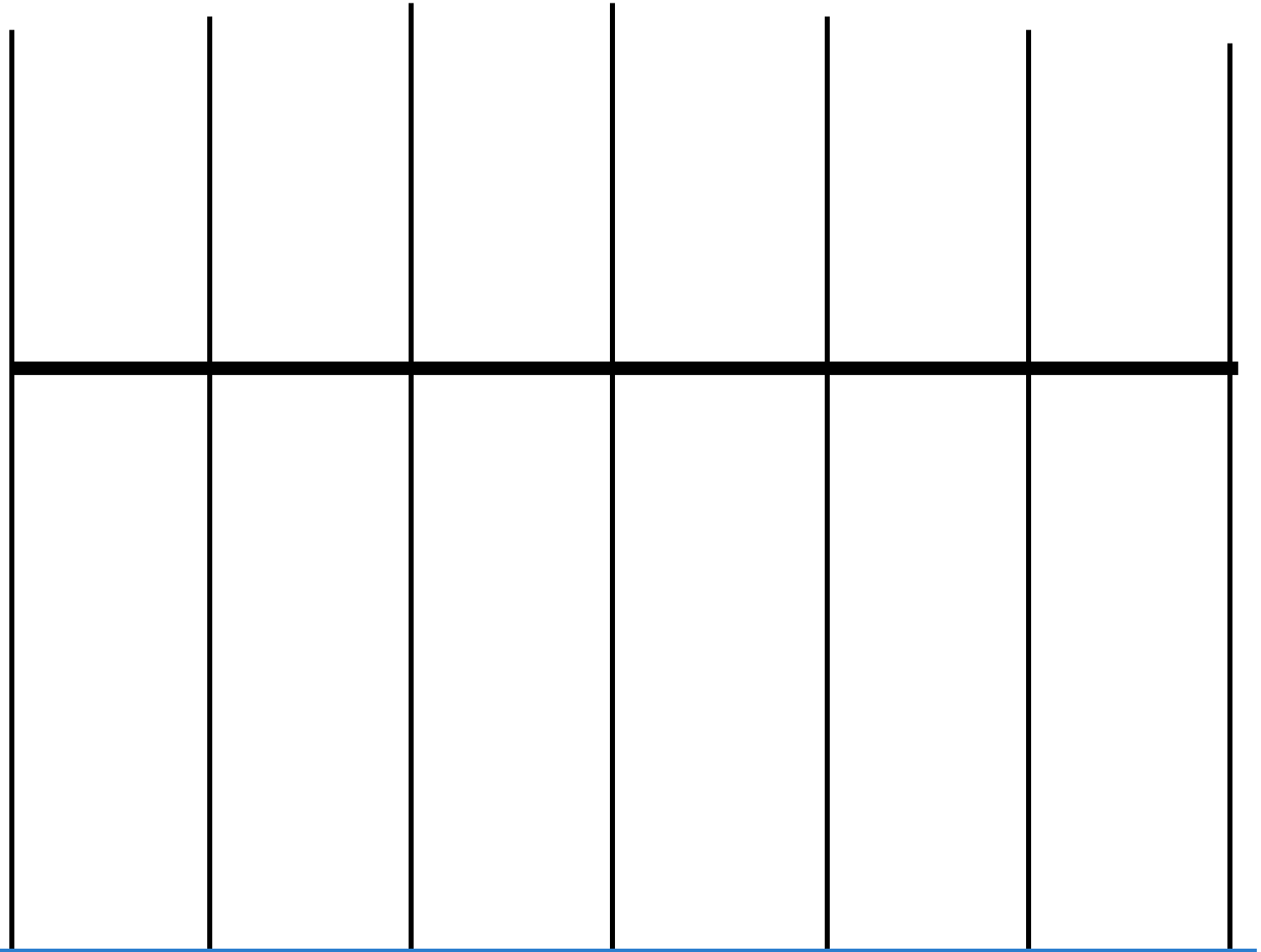


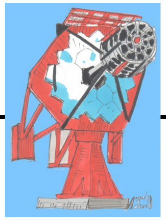
A. Adamo, M. Del Santo, V. La Parola, T. Mineo, S. Sandrelli, L. Lupo, M. Montoleone, A. Argento Zangara

I telescopi Cherenkov e il pubblico: Studi di comunicazione



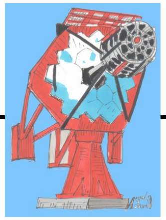
The outreach elettro-public spectrum





The outreach elettro-public  um

The outreach elettro-public ... um



μ

wavelenght

M-AMMA

0-7 years

The outreach elettro-public ım

μ wavelenght **M-AMMA** 0-7 years	**X** (who can understand them? 7-14				
					

The outreach elettro-public ım

μ	X	UV			
wavelenght **M-AMMA** 0-7 years	(who can understand them? 7-14	Ultrà-Violent 14-28			
					

The outreach elettro-public ım

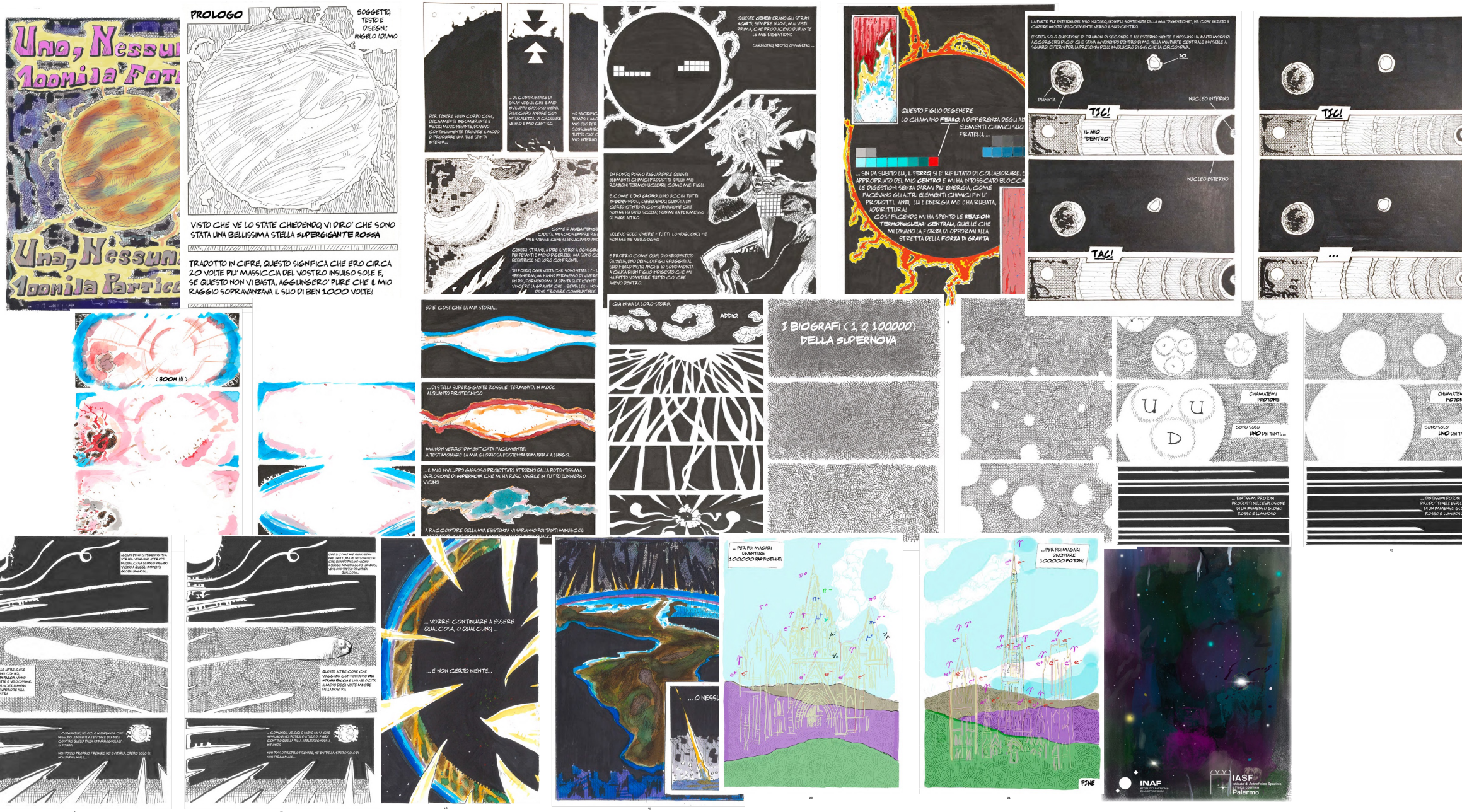
μ	X	UV	V		
wavelenght **M-AMMA** 0-7 years	(who can understand them? 7-14	Ultrà-Violent 14-28	liVable 28-56		
					

The outreach elettro-public ım

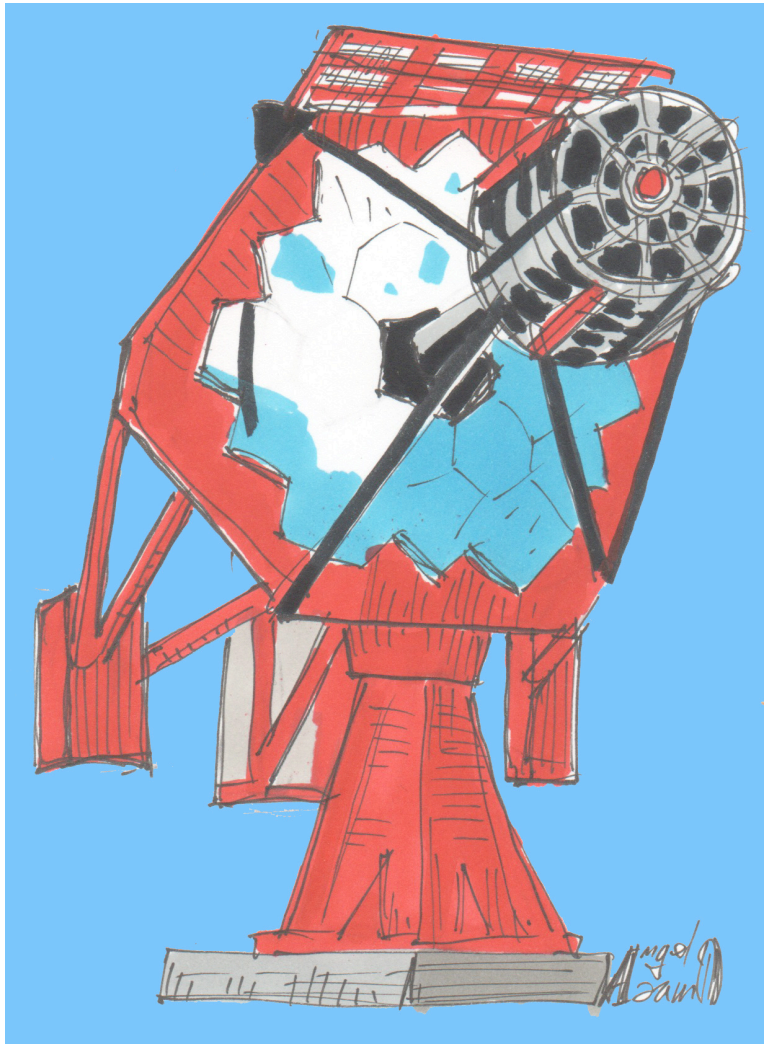
μ	X	UV	V	IR		
wavelenght **M-AMMA** 0-7 years	(who can understand them? 7-14	Ultrà-Violent 14-28	liVable 28-56	Broken (it.: InfRanti) 56-70		
						

The outreach elettro-public ım

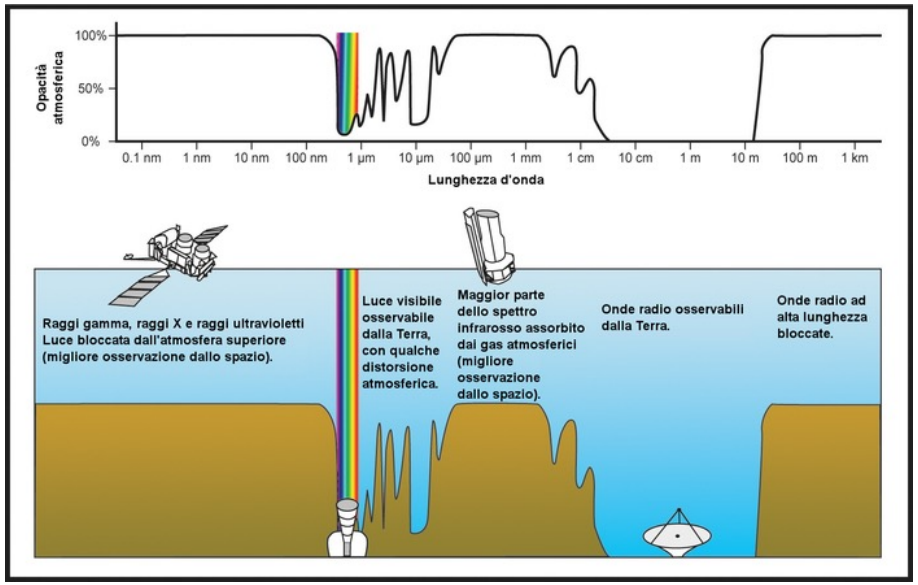
μ	X	UV	V	IR	RADIO
wavelenght **M-AMMA** 0-7 years	(who can understand them? 7-14	Ultrà-Violent 14-28	liVable 28-56	Broken (it.: InfRanti) 56-70	(& ULNA) over
					

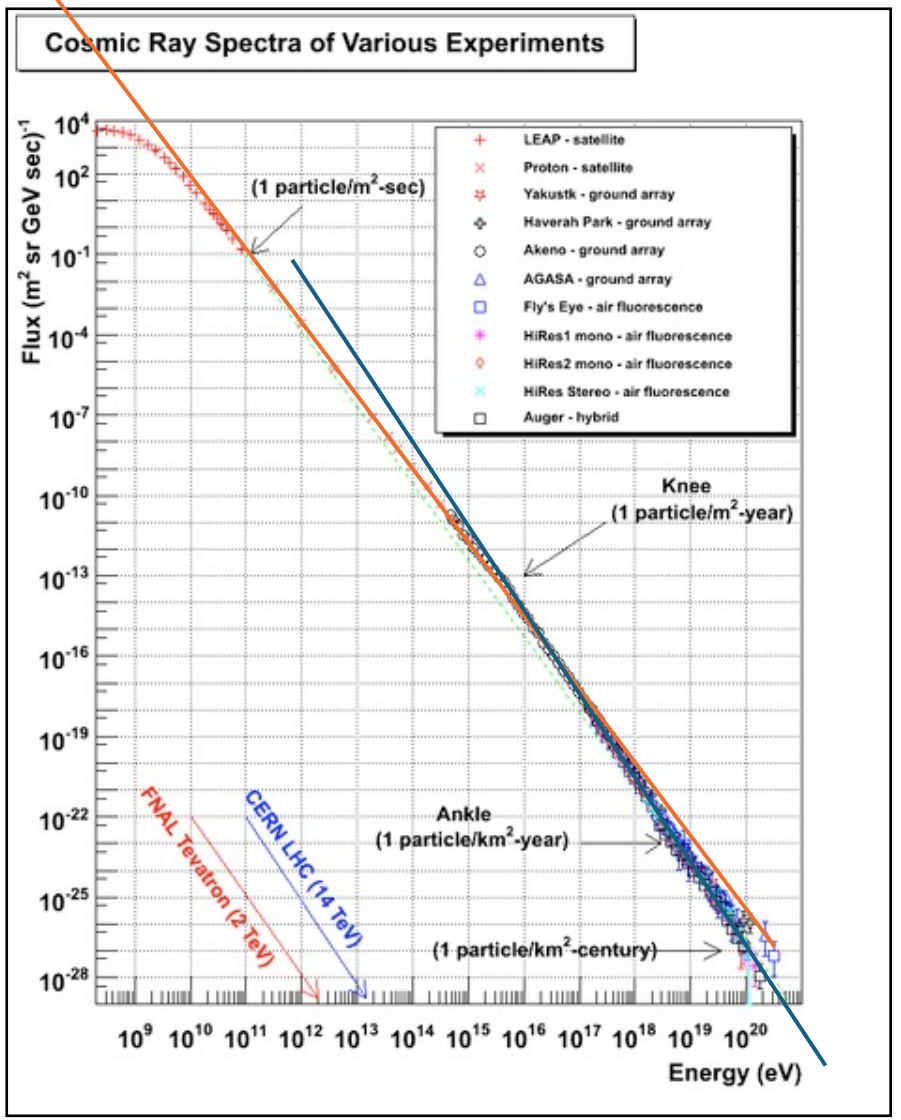

Uno, Nessuno e Centomila Fotoni
Una, Nessuna e Centomila Particelle
PROLOGO
SOGGETTO TESTO E DISEGNI: ANGELO ADAMO
VISTO CHE VE LO STATE CHIEDENDO, VI DIRO' CHE SONO STATA UNA BELLISSIMA STELLA SUPERGIGANTE ROSSA
TRADOTTO IN CIFRE, QUESTO SIGNIFICA CHE ERO CIRCA 20 VOLTE PIU' MASSICCIA DEL VOSTRO INSULSO SOLE E, SE QUESTO NON VI BASTA, AGGIUNGERO' PURE CHE IL MIO RAGGIO SOPRAVANZAVA IL SUO DI BEN 1000 VOLTE!
QUESTO FIGLIO DEGENERE LO CHIAMANO FERRO
PIANETA
NUCLEO INTERNO
NUCLEO ESTERNO
TIC!
TAC!
...
(BOOM !!!)
ED E' COSI' CHE LA MIA STORIA...
... DI STELLA SUPERGIGANTE ROSSA E' TERMINATA IN MODO ALQUANTO PROTECNICO
MA NON VERRO' DIMENTICATA FACILMENTE: A TESTIMONIARE LA MIA GLORIOSA ESISTENZA RIMARRA' A LUNGO...
... E MIO INVOLUPPO GASSOSO PROIETTATO ATTORNO DALLA POTENTISSIMA ESPLOSIONE DI SUPERNOVA CHE MI HA RESO VISIBILE IN TUTTO L'UNIVERSO VICINO
A RACCONTARE DELLA MIA ESISTENZA VI SARANNO POI TANTI MINUSCOLI
QUI FINISCE LA LORO STORIA...
ADDIO
1 BIOGRAFI (1, O 100000) DELLA SUPERNOVA
CHIAMATEMI PROTONE
SONO SOLO UNO DEI TANTI...
...TINTEGGIAN PROTONI PRODOTTI NELL'ESPLOSIONE DI UN IMMENSO GLOBO ROSSO E LUMINOSO
... VORREI CONTINUARE A ESSERE QUALCOSA, O QUALCUNO ...
... E NON CERTO NIENTE...
... O NESSU
... PER POI MAGARI DIVENTARE 100000 PARTICELLE
... PER POI MAGARI DIVENTARE 100000 FOTONI
FINE
INAF
IASF Palermo

Astrophysics Scenario:
γ (TeV) Astronomy with Cherenkov Telescopes

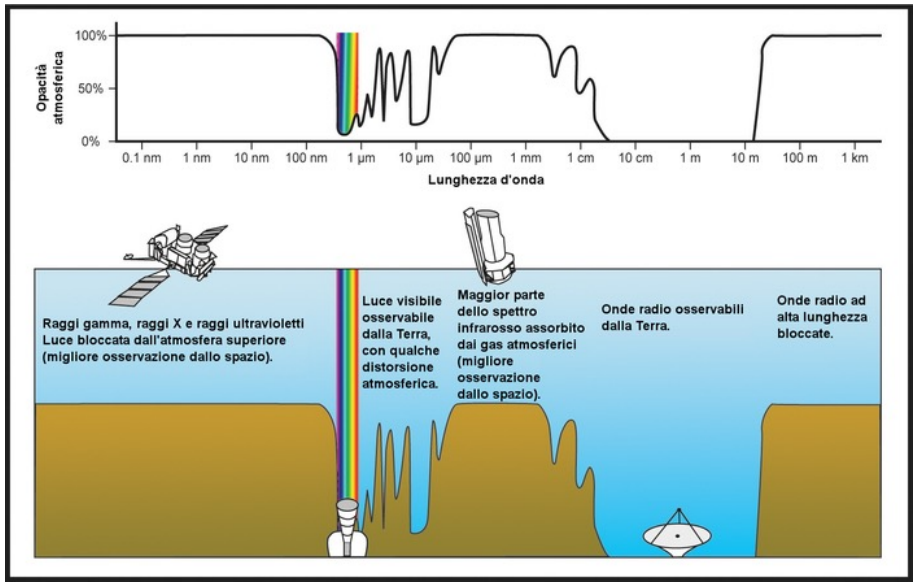


RC Energy Spectrum



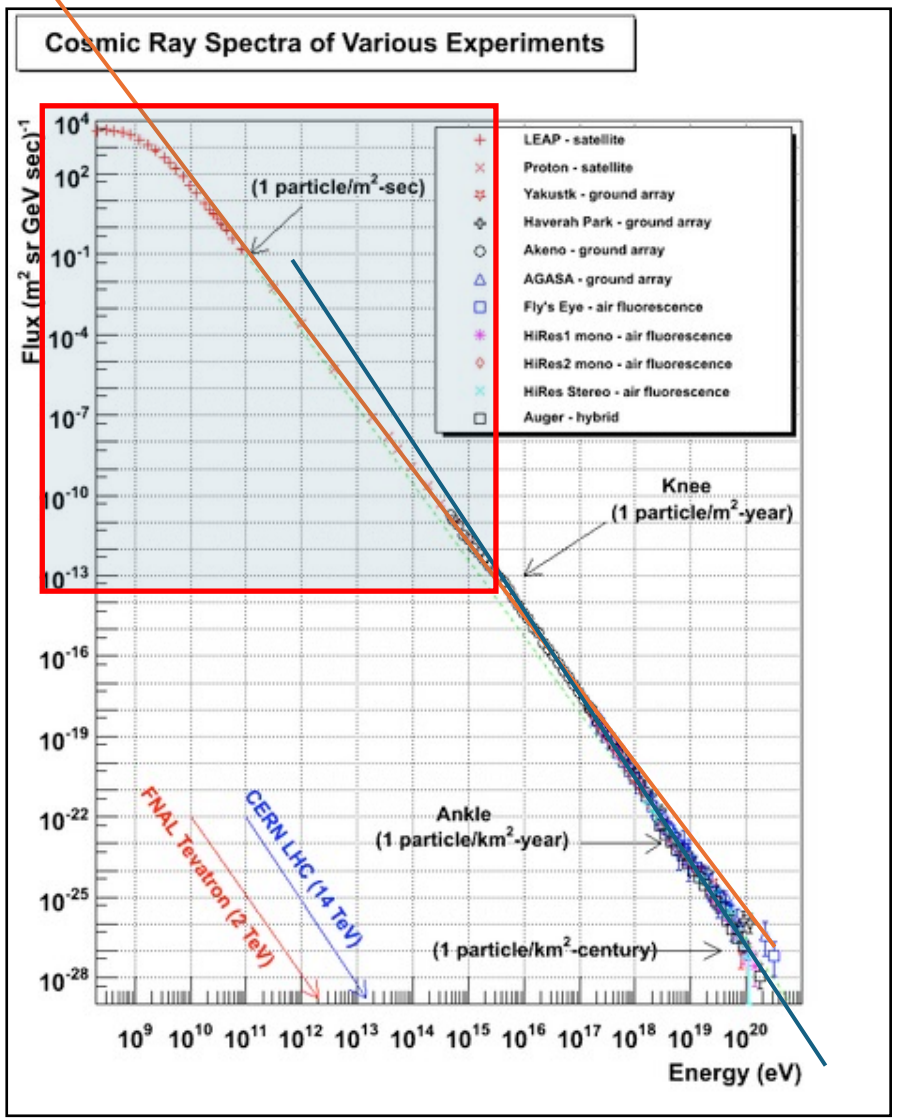


RC Energy Spectrum

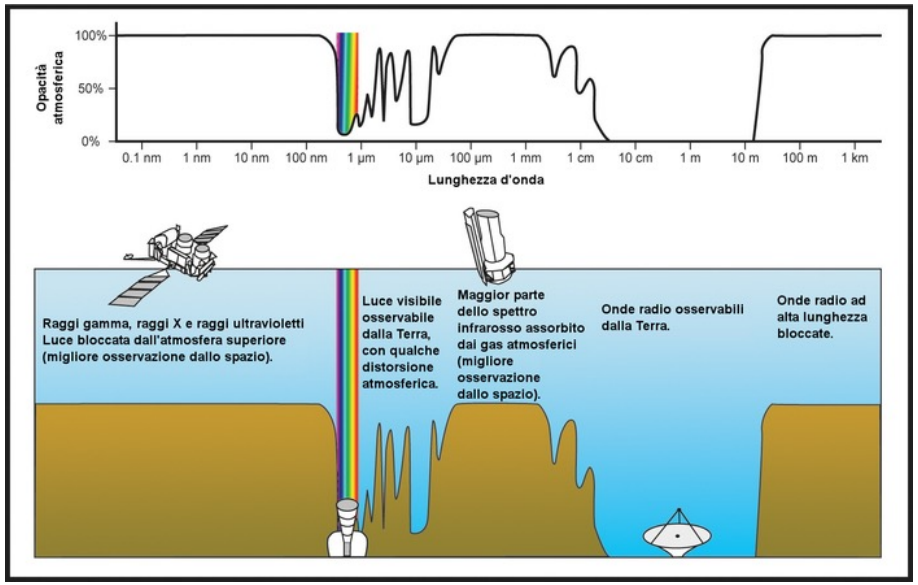


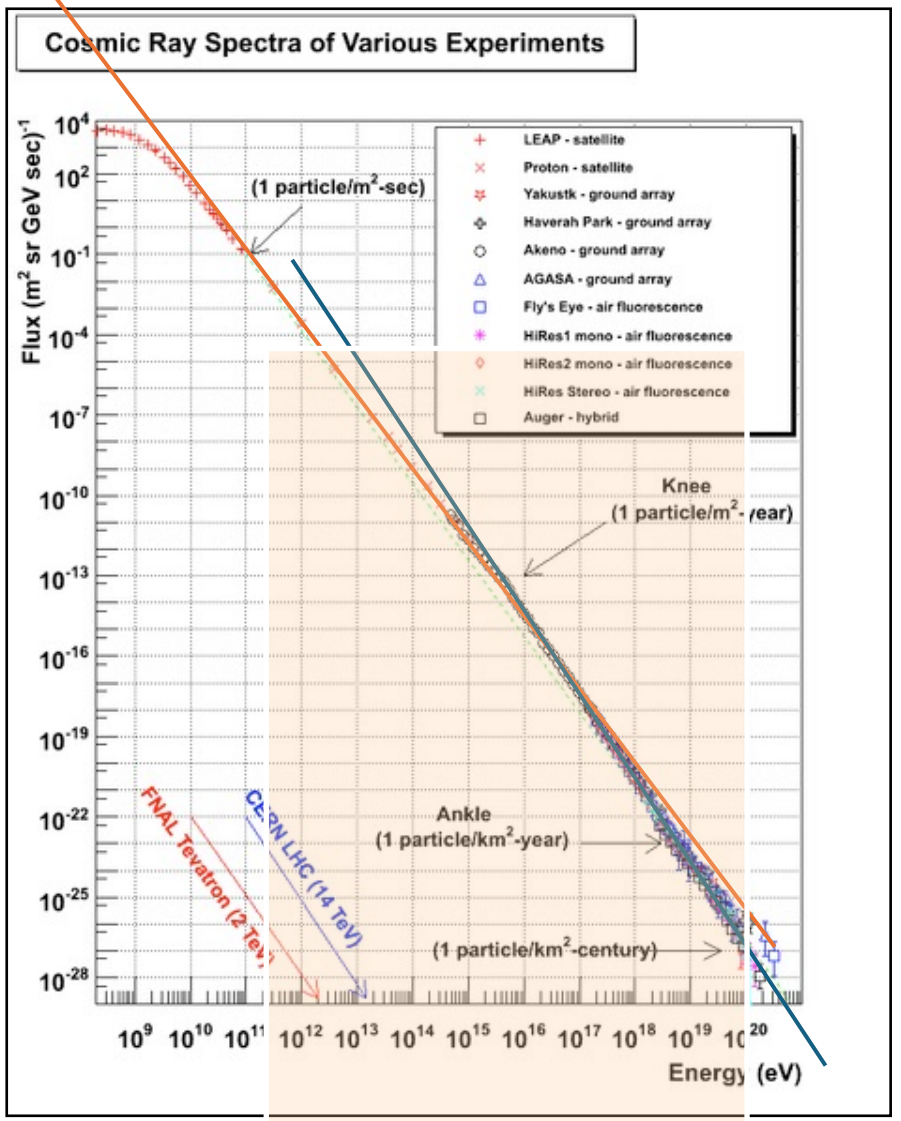
1) Direct measurements, E<10^{14} ev

Satellites, usable satellites up to ≈100 GeV

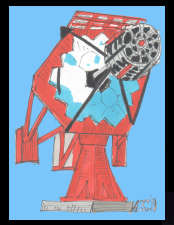


RC Energy Spectrum

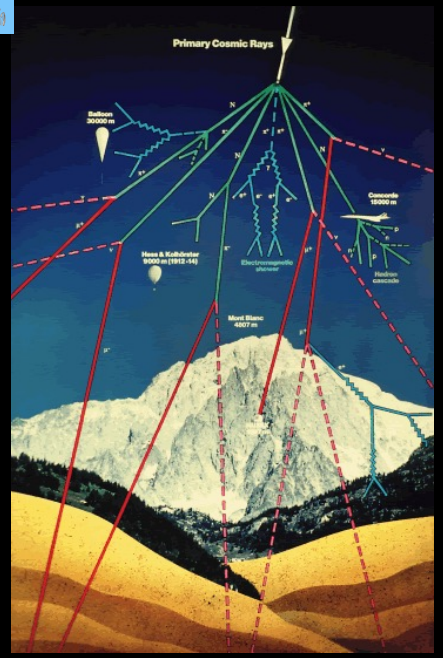


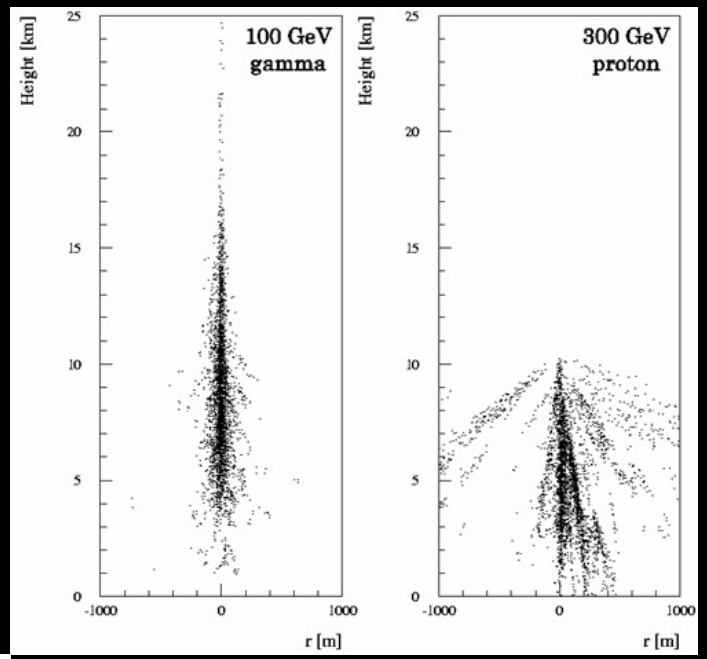


2) Indirect measurements, E>10^{14} ev,
Cherenkov telescopes using atmosphere as a detector

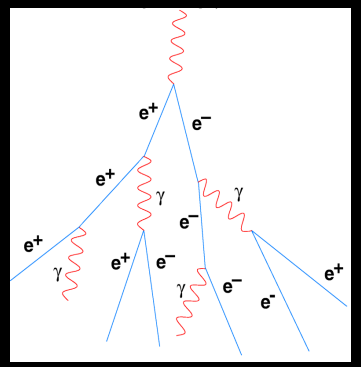


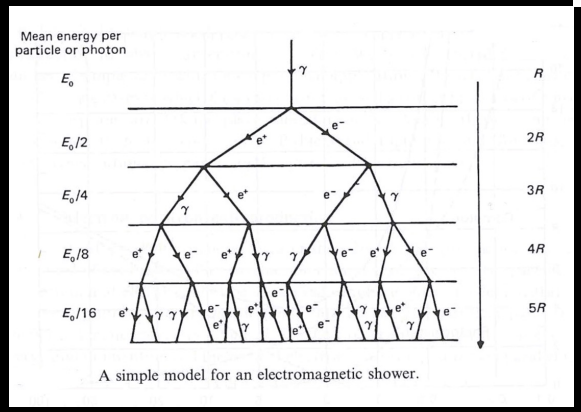
Secondary RC

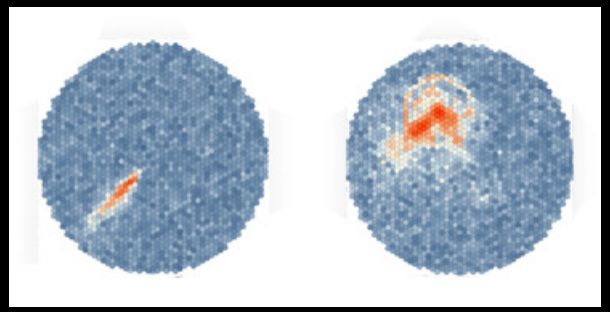


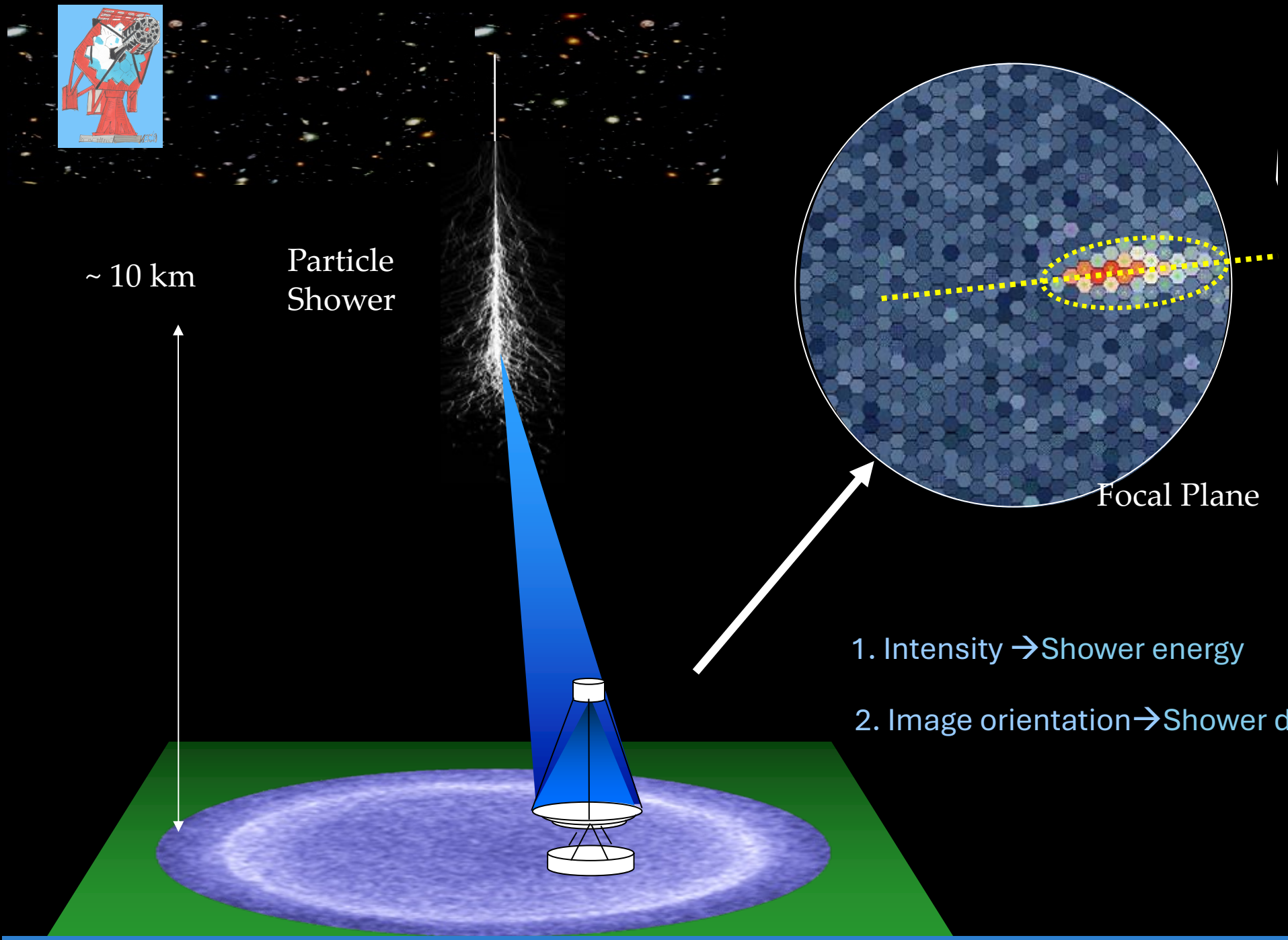


Heitler model

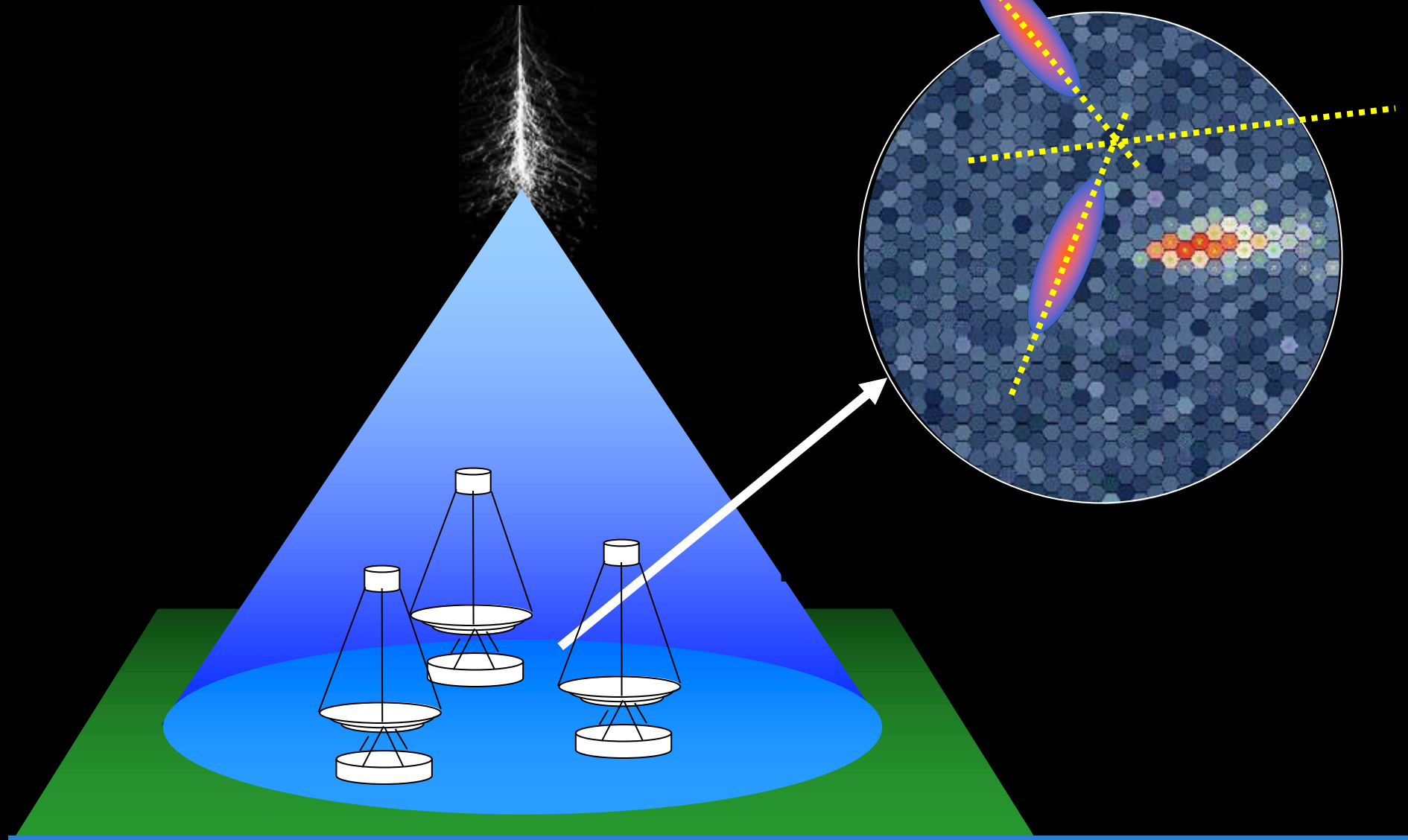




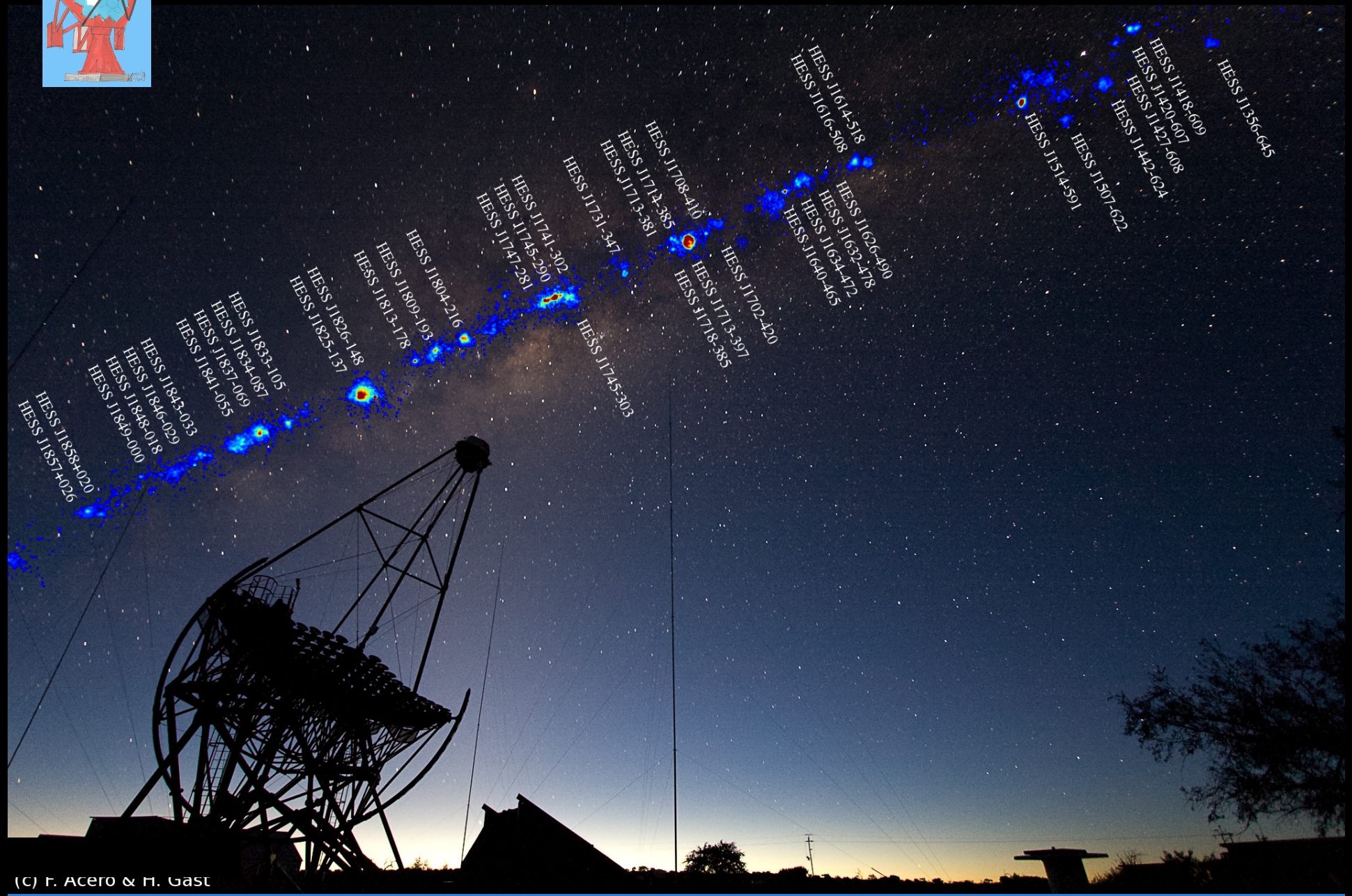


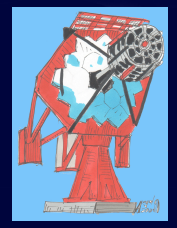

~ 10 km
Particle Shower
Focal Plane
1. Intensity →Shower energy
2. Image orientation→Shower direction

Stereoscopic Observations

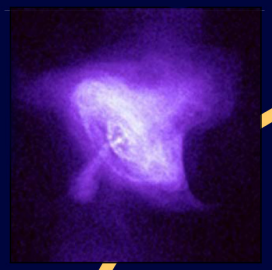


The sky in gamma rays, at TeV energies





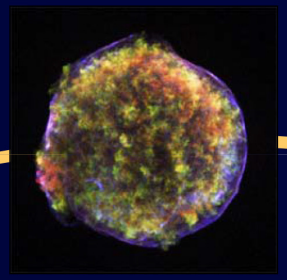
Pulsars



Binaries

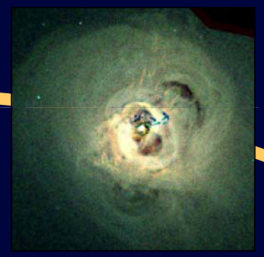
Jets, winds

SNRs



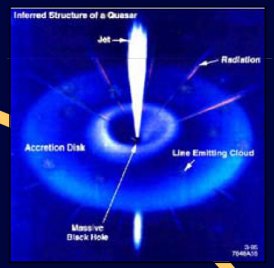
Shocks
Fermi Mech.

Starbursts

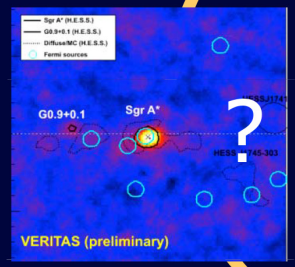


SN activity
Cosmic rays

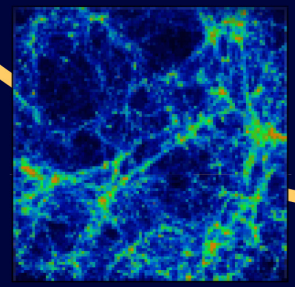
AGN



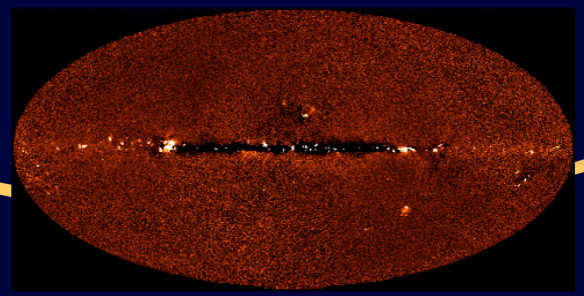
GRBs



Unknowns
(Gal Center)



Dark Matter



Cosmological Fields

Main goal:

implement a Citizen Science game designed specifically for babies and children, based on the images that the Cherenkov Telescope Array (CTA) instrument will capture.

The proposed goal was to start an active dissemination project ("learning by doing") both for humans and routines.

While children will simply play a game, humans interested in this project will take part in a citizen science project on 'gamma ray astronomy.

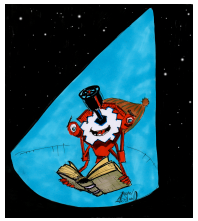
How to do

Thanks to their cataloguing using *pareidolia*, the participants in the game could teach the automatic algorithms (already quite efficient in discerning), the normal traces of particles and photons, to recognize even the most ambiguous ones.

It will therefore mainly be an "educational project for automatic routines" which will make use of the results of experiments conducted through structured interviews.

Due to their lack of preconceived ideas, this game will mainly involve children in nursery school and the first two classes of primary school with the aim of building a database of human solutions to some pattern recognition problems that still plague automatic routines who work on selecting light tracks captured by Cherenkov telescopes.

What is meant by “citizen science”?

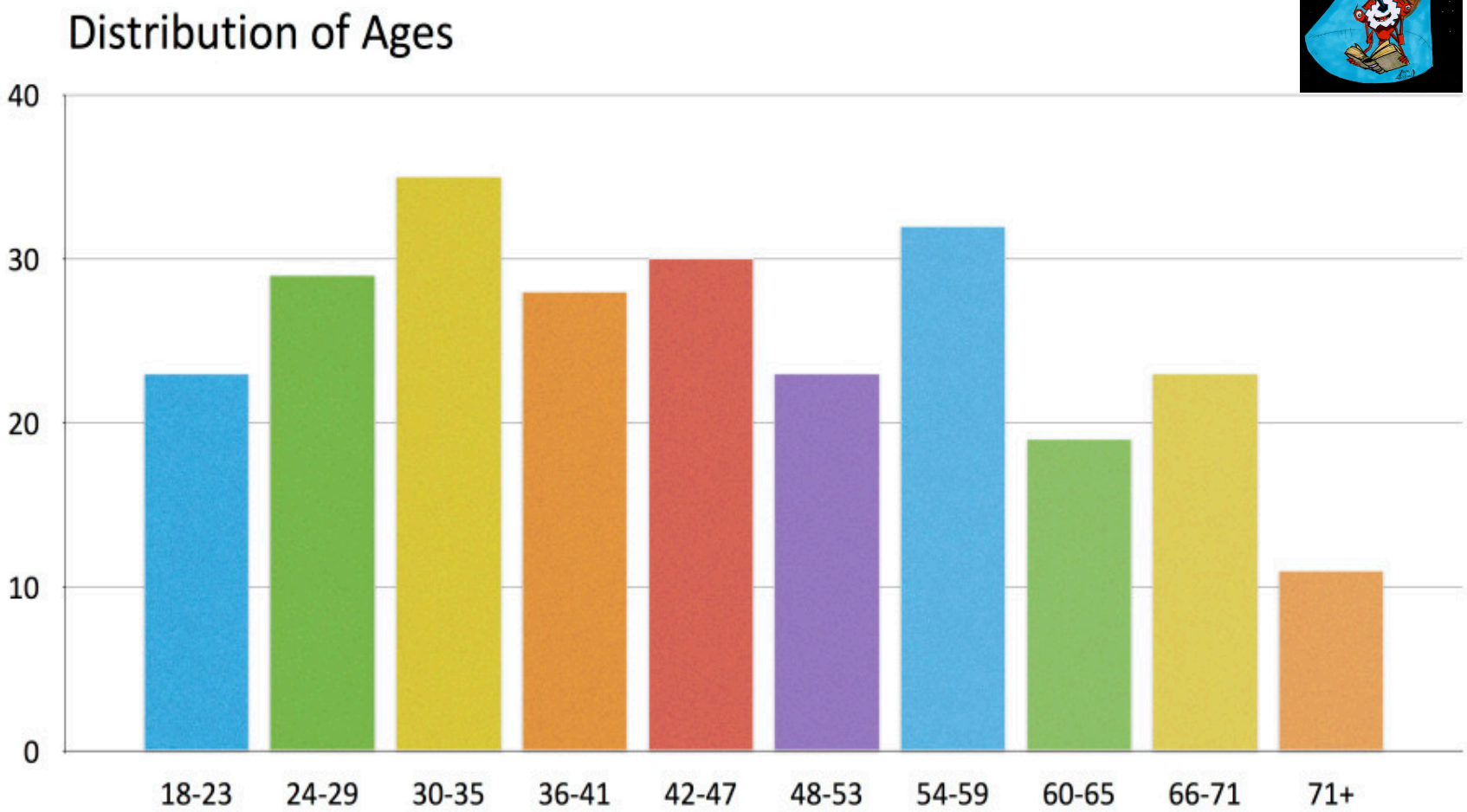


There is a growing number of scientific projects that actively include members of the general public in their research.

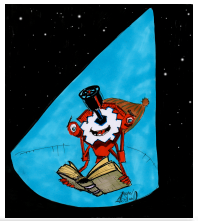
In such projects, a large number of non-specialists perform a wide range of mostly relatively simple task such as image analysis, pattern recognition, document transcription or data collection.

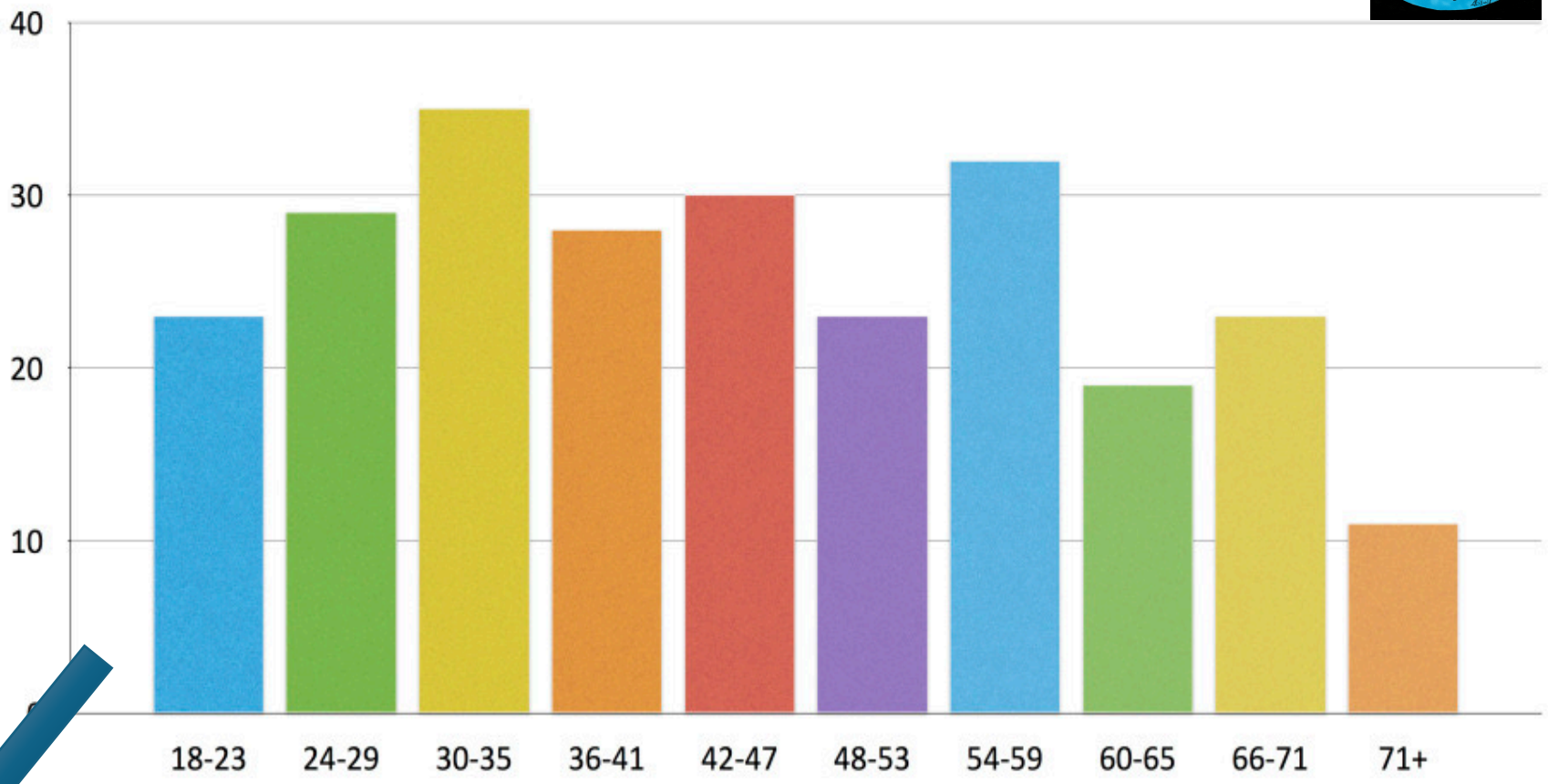
This type of active involvement of the general public is referred to as *citizen science* and currently it receives rising attention from the scientific community, policy maker and funding agencies.

Raddick et al., Galaxy Zoo: *Motivations of Citizen Scientists*, https://arxiv.org/abs/1303.6886



Age distribution of «Zooties»





Age distribution of «Zooties»

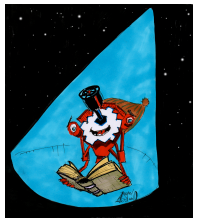
Lack of participants younger than 14 years

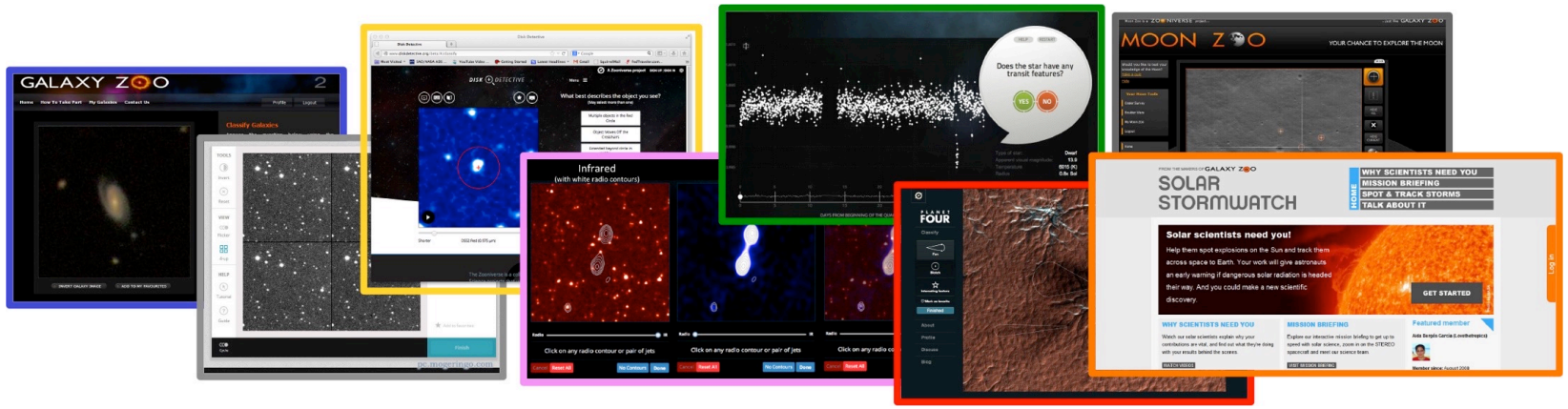
Wikipedia:

Pareidolia is the tendency for perception to impose a meaningful interpretation on a nebulous stimulus, usually visual, so that one detects an object, pattern, or meaning where there is none. (…)

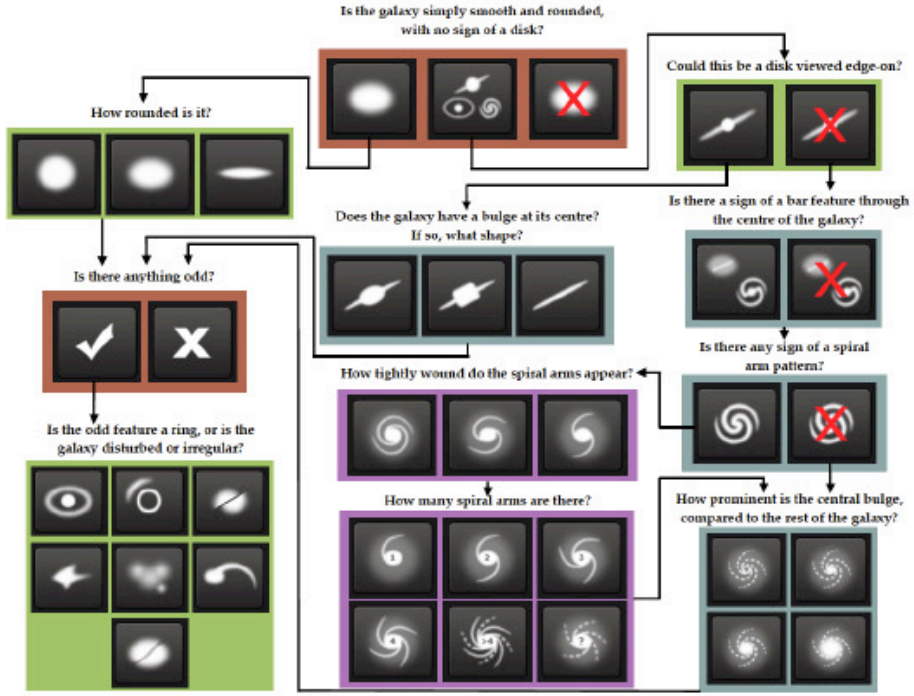
Common examples include perceived images of animals, faces, or objects in cloud formations; seeing faces in inanimate objects (…).

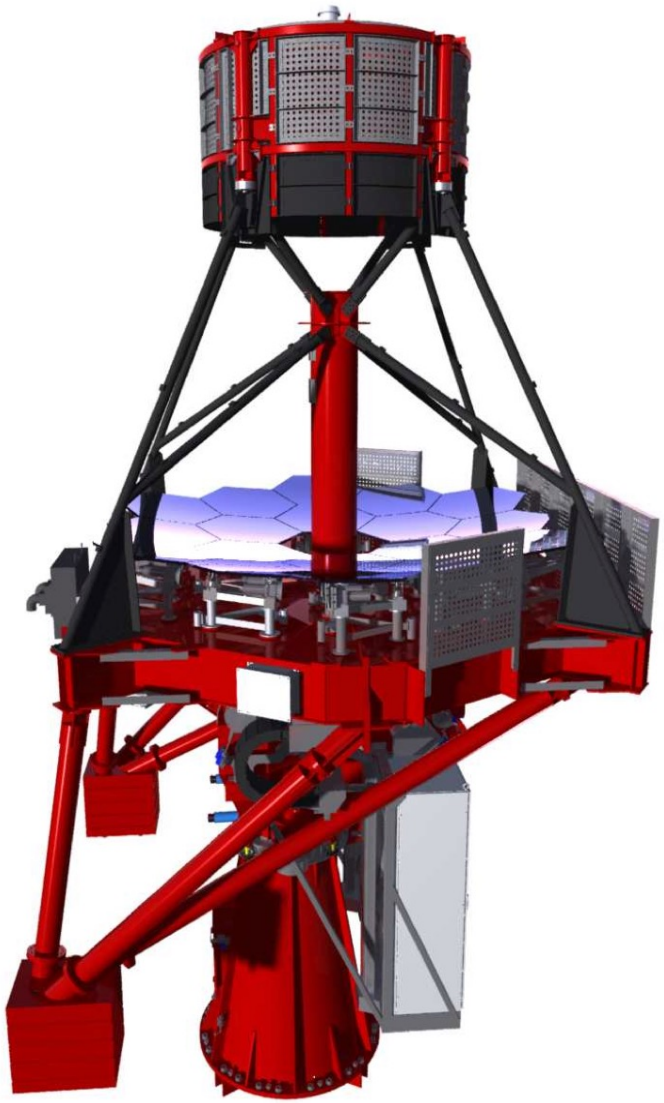
Example: *Galaxy Zoo*

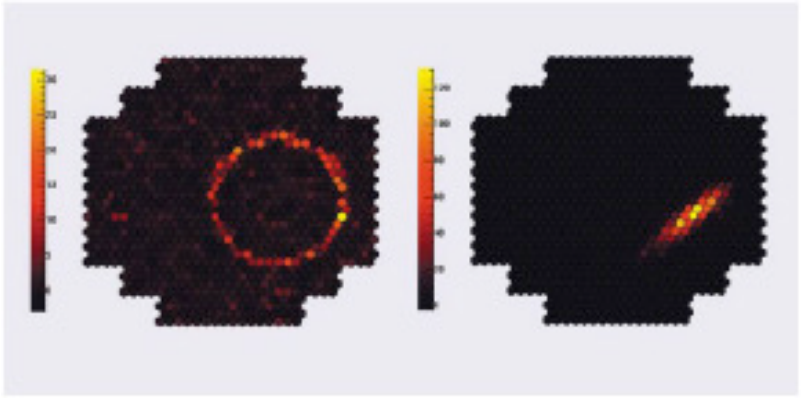


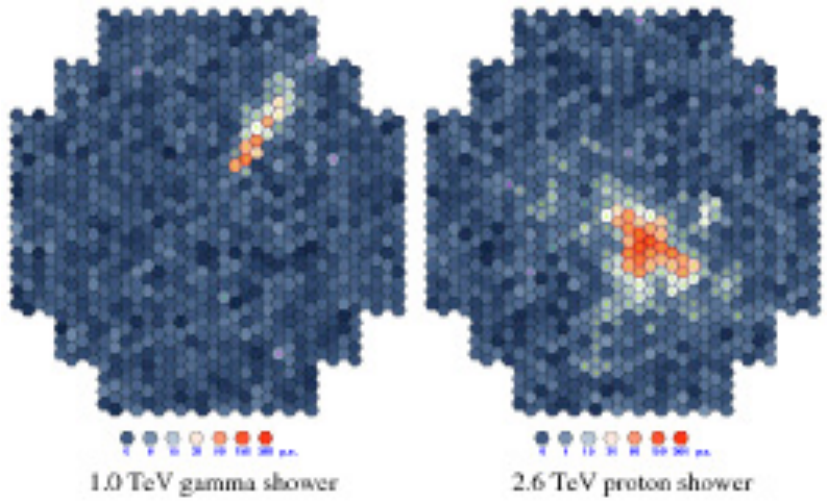


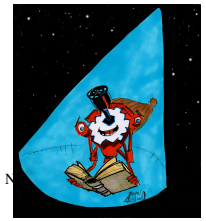
FEW, VERY SIMPLE PARAMETERS








1.0 TeV gamma shower
2.6 TeV proton shower



Laboratory for High Energy Astrophysics
Office of Guest Investigator Programs

SAS-2 Calibration Guide

SAS-2 CALIBRATION GUIDE

Paul Barrett, Brendan Perry,
& Ian M George
Code 668,
NASA/GSFC,
Greenbelt, MD 20771

Version: 1995 Feb 24

LOG OF SIGNIFICANT CHANGES

ground.

The post-flight selection of events was based on the following criteria. The detection of an inverted Y or V shape in one orthogonal view of the spark-chamber, and the elimination of single-track events or those intersecting the wall. After the event being accepted, its direction and energy were determined. The determination of event direction was based on a weighted bisector method: the direction was weighted toward the higher energy electron or positron. Details of this method can be found in Fichtel *et al*.(1972). The arrival direction is first determined in space-craft coordinates (altitude-azimuth), and then using the space-craft's attitude data, the celestial coordinates are determined.

The energy calculation is based on multiple Coulomb scattering of pair electrons in the tungsten plates. A description of this formalism is given by Pinkau (1966, 1968) and Kniffen (1969). The accuracy of measuring the scattering angle limits the maximum measurable energy, since higher energy γ-rays have smaller scattering angles. For SAS-2 this energy is about 200 MeV.

2.2.2 Human Selection

About 10% of events are considered marginal, based on the automated-selection criteria. Humans are then used to select those events which are γ-rays, by viewing the two orthogonal views of the spark-chamber on a graphics terminal. If the event is accepted then the direction and energy are determined using the automated selection software.

References

Derdeyn, S.M., Ehrmann, C.H., Fichtel, C.E., Kniffen, D.A. & Ross, R.W. 1972, *Nucl. Instr. & Methods*., **98**, 557.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A. & Sommer, M. 1972, *Astrophys. J*., **171**, 31.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A., Thompson, D.J., Bignami, G.F., Ögelman, H., Özel, M.E. & Tümer, T. 1975. *Astrophys. J*., **198**, 163.

Kniffen, D.A., 1969, *NASA Tech. Report TR R-308*.

Pinkau, K. 1966, *Zs. f. Phys*., **96**, 163.

Pinkau, K. 1968, Max-Plank-Institut preprint.

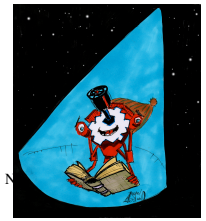
Chapter 3
POTENTIAL PROBLEMS

3.1 Earth Albedo

(*Source:* Marvin 1978)

One of the major problems with γ-ray astronomy is the interaction of cosmic-rays with the Earth's atmosphere producing high energy γ-rays. Most of these events were rejected and not included in the database, because the zenith angle (the angle between the estimated γ-ray direction and the zenith (the spacecraft pointing direction)) was > 90°, implying their direction is near the Earth's horizon.

During the creation of the *SAS-2* 2 database, the STDGTI (standard good-time-interval) and ALLGTI (all good-time-interval) were determined from the spacecraft orbital data using the following criteria:



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LOG OF SIGNIFICANT CHANGES

ground.

The post-flight selection of events was based on the following criteria. The detection of an inverted Y or V shape in one orthogonal view of the spark-chamber, and the elimination of single-track events or those intersecting the wall. After the event being accepted, its direction and energy were determined. The determination of event direction was based on a weighted bisector method: the direction was weighted toward the higher energy electron or positron. Details of this method can be found in Fichtel *et al*.(1972). The arrival direction is first determined in space-craft coordinates (altitude-azimuth), and then using the space-craft's attitude data, the celestial coordinates are determined.

The energy calculation is based on multiple Coulomb scattering of pair electrons in the tungsten plates. A description of this formalism is given by Pinkau (1966, 1968) and Kniffen (1969). The accuracy of measuring the scattering angle limits the maximum measurable energy, since higher

2.2.2 Human Selection

About 10% of events are considered marginal, based on the automated-selection criteria. Humans are then used to select those events which are γ-rays, by viewing the two orthogonal views of the spark-chamber on a graphics terminal. If the event is accepted then the direction and energy are determined using the automated selection software.

References

Derdeyn, S.M., Ehrmann, C.H., Fichtel, C.E., Kniffen, D.A. & Ross, R.W. 1972, *Nucl. Instr. & Methods*., **98**, 557.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A. & Sommer, M. 1972, *Astrophys. J*., **171**, 31.

Fichtel, C.E., Hartman, R.C., Kniffen, D.A., Thompson, D.J., Bignami, G.F., Ögelman, H., Özel, M.E. & Tümer, T. 1975. *Astrophys. J*., **198**, 163.

Kniffen, D.A., 1969, *NASA Tech. Report TR R-308*.

Pinkau, K. 1966, *Zs. f. Phys*., **96**, 163.

Pinkau, K. 1968, Max-Plank-Institut preprint.

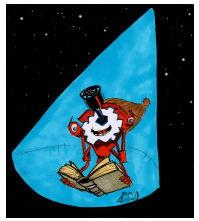
Chapter 3
POTENTIAL PROBLEMS

3.1 Earth Albedo

(*Source:* Marvin 1978)

One of the major problems with γ-ray astronomy is the interaction of cosmic-rays with the Earth's atmosphere producing high energy γ-rays. Most of these events were rejected and not included in the database, because the zenith angle (the angle between the estimated γ-ray direction and the zenith (the spacecraft pointing direction)) was > 90°, implying their direction is near the Earth's horizon.

During the creation of the *SAS-2* 2 database, the STDGTI (standard good-time-interval) and ALLGTI (all good-time-interval) were determined from the spacecraft orbital data using the following criteria:



HAWC

The High-Altitude Water Cherenkov Gamma-Ray Observatory

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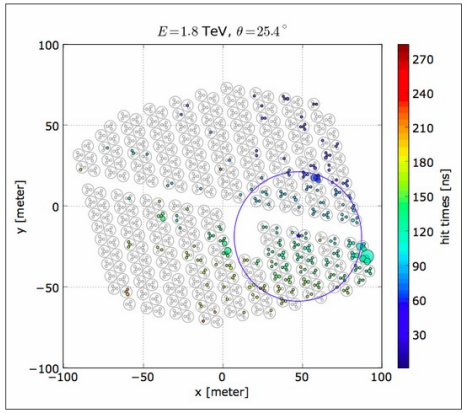
The Gamma/Hadron Separation Game!

Play this game to see how well you can distinguish events created by gamma rays and cosmic rays in the detector. (See Instructions.)

0/0 gamma-ray showers tagged so far
0/0 proton showers tagged so far



Is this a gamma-ray or a proton event?

It's a gamma-ray shower

It's a proton shower

Instructions

A simulated event is shown in the plot. Try to guess whether or not the event was caused by a gamma ray or a cosmic ray. The colors show the relative timing of the hits within the event (blue=early, red=late), and the marker sizes indicate the number of photoelectrons (PEs) in each channel. Large markers mean that a channel was hit by many photons due to a very large ground signal.

To identify cosmic rays, you should look for hard-hit channels far from the reconstructed shower core, which is shown as a blue star in the center of a 40-meter blue circle. Isolated hits indicate the presence of penetrating particles in the shower, a hallmark of cosmic-ray events.

Return to top.

HAWC

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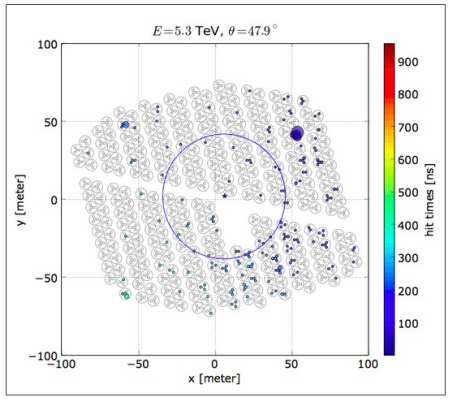
The Gamma/Hadron Separation Game!

Play this game to see how well you can distinguish events created by gamma rays and cosmic rays in the detector. (See Instructions.)

Correct! That last one was a proton.

0/0 gamma-ray showers tagged so far

1/2 proton showers tagged so far



Is this a gamma-ray or a proton event?

It's a gamma-ray shower

It's a proton shower

Instructions

A simulated event is shown in the plot. Try to guess whether or not the event was caused by a gamma ray or a cosmic ray. The colors show the relative timing of the hits within the event (blue=early, red=late), and the marker sizes indicate the number of photoelectrons (PEs) in each channel. Large markers mean that a channel was hit by many photons due to a very large ground signal.

To identify cosmic rays, you should look for hard-hit channels far from the reconstructed shower core, which is shown as a blue star in the center of a 40-meter blue circle. Isolated hits indicate the presence of penetrating particles in the shower, a hallmark of cosmic-ray events.

Return to top.

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- Latest news from HAWC
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- Follow @HAWC_Obs

TeV Astronomy
- Catalog of TeV Sources
- TeV Review Papers

Milagro Links
- Milagro γ-Ray Observatory
- Milagro Publications

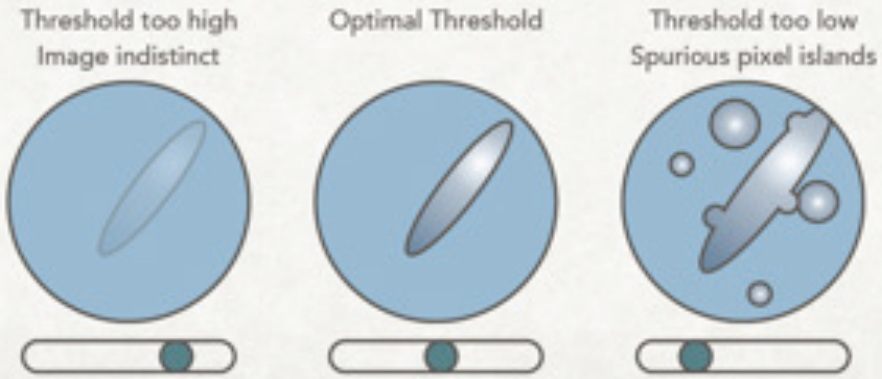
For HAWC Collaborators
- HAWC Star Chart
- HAWC Internal Pages

Local Weather:

LMT Site - Volcan Sierra Negra
Atzitzintla, MX
35.8°F / 2°C
ENE 28.1 mph / 45 km/h
LMT Weather station

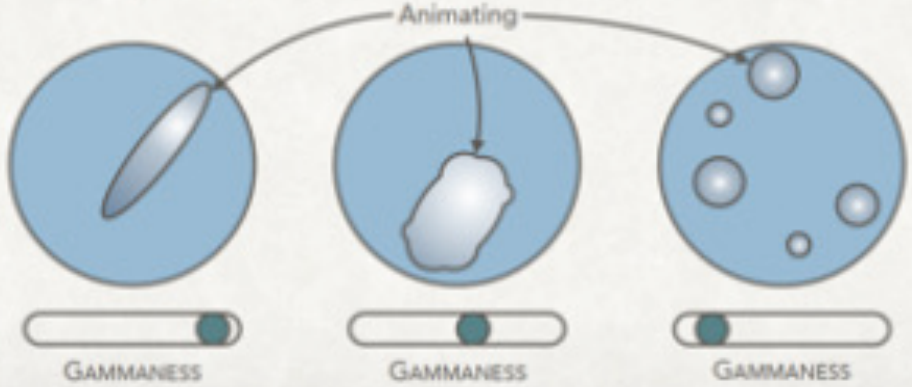
STEP 1: CLEANING

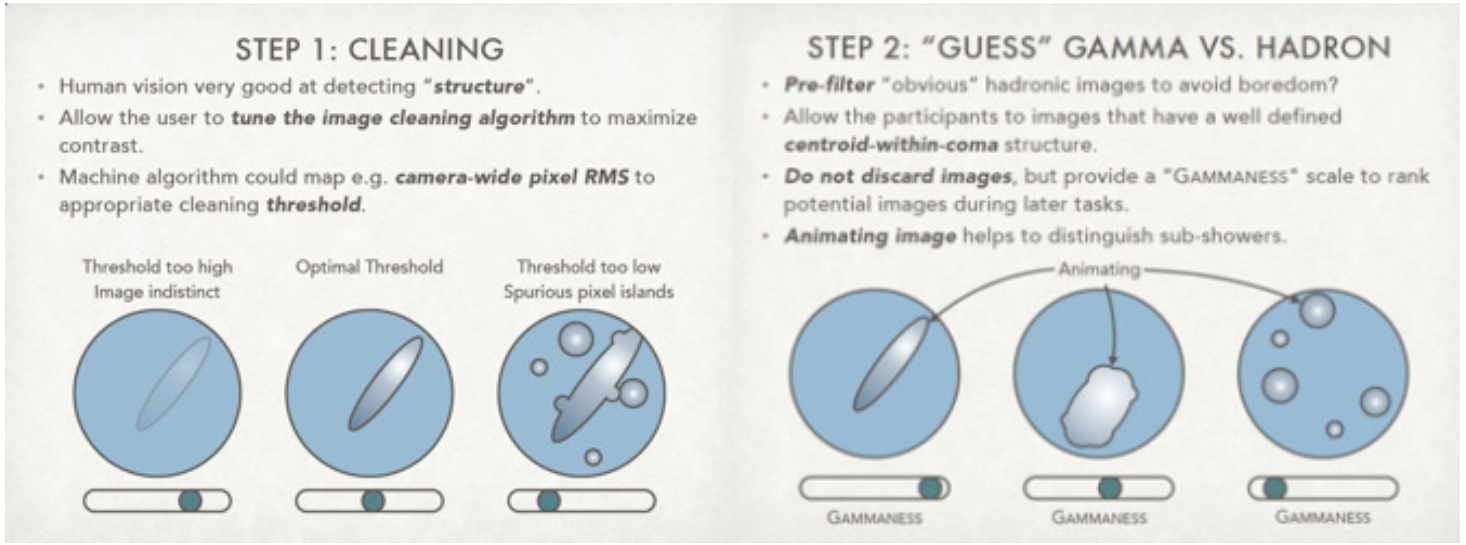
- Human vision very good at detecting "***structure***".
- Allow the user to ***tune the image cleaning algorithm*** to maximize contrast.
- Machine algorithm could map e.g. ***camera-wide pixel RMS*** to appropriate cleaning ***threshold***.

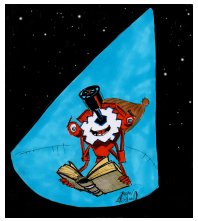


STEP 2: "GUESS" GAMMA VS. HADRON

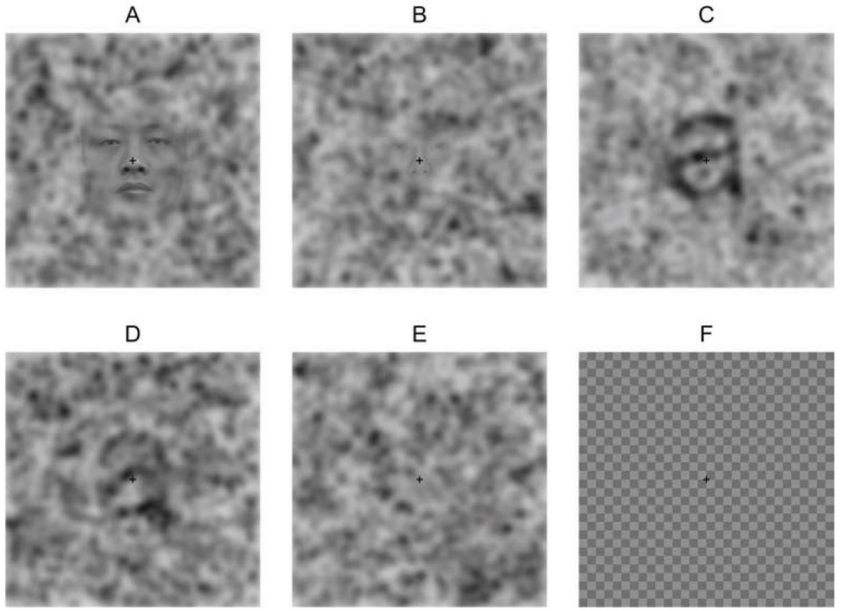
- ***Pre-filter*** "obvious" hadronic images to avoid boredom?
- Allow the participants to images that have a well defined ***centroid-within-coma*** structure.
- ***Do not discard images***, but provide a "GAMMANESS" scale to rank potential images during later tasks.
- ***Animating image*** helps to distinguish sub-showers.





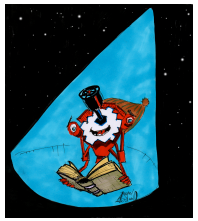


Pareidolia



Various levels of "immersion" of faces and letters in a Gaussian background

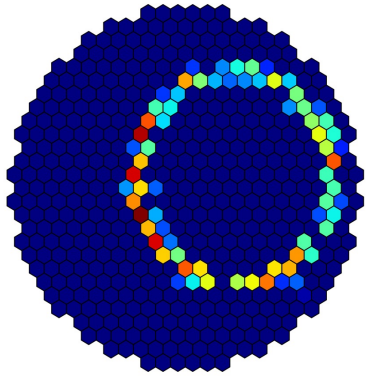
Muon Hunter (www.muonhunter.org)

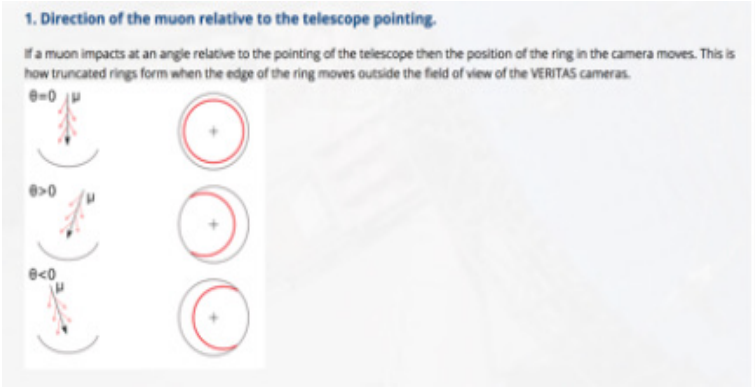


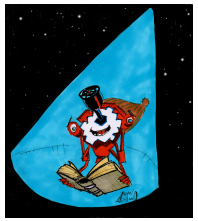
Muons (a particle like an electron, only heavier) are a prominent background contaminant when observing very-high-energy gamma rays on earth.

They leave a distinctive ring-like shape making them obvious to the human eye, but incomplete or truncated rings can appear very gamma-ray-like to automatic analysis algorithms.

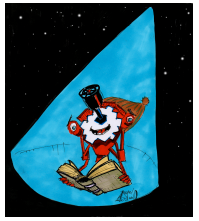
We need your help to identify camera images that contain muon rings so we can teach computers to better identify such images and efficiently filter out those pesky muons that are masquerading as gamma rays.







Citizen Technicians?

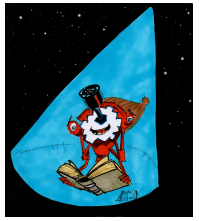


Children are better than adults at identifying and understanding less likely options.

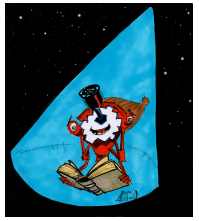
This may reflect a more general difference betweenvChildren's and adults' pareidolia.

Children may be particularly good at thinking about more unusual possibilities. After all, adults know a lot about how the world works, so it would be logical for them to rely on what they know.

This difference between children and adults reflects the "explore" versus "exploit" tension.



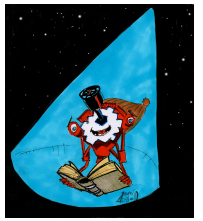
In “explore” learning we try to discover many possibilities, including the least possible ones, even though they may not have an immediate reward. To navigate a complicated world well, we need both of these types of learning.



In “explore” learning we try to discover many possibilities, including the least possible ones, even though they may not have an immediate reward. To navigate a complicated world well, we need both of these types of learning.

The adults keep to the verified-and-true; but four to six year-olds can afford the luxury of seeking out the strange and the fantastic.

Pareidolia = F (Age, culture, …)



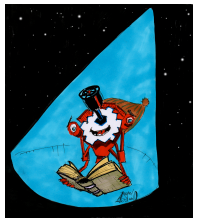
The first result is that as our knowledge grows, we become less open to new ideas.

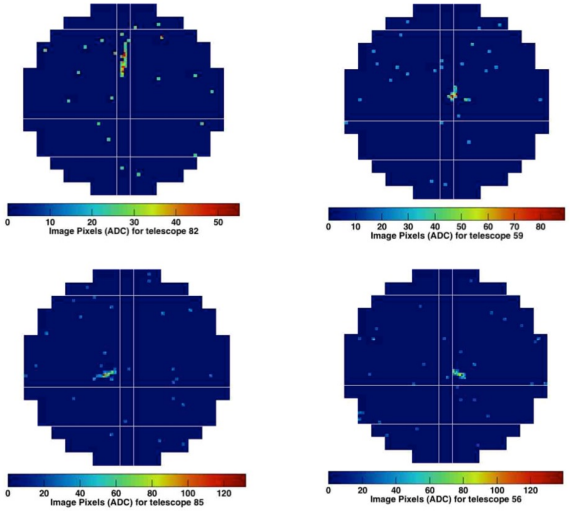
The second is that younger minds and brains are intrinsically more flexible and exploratory, although they are also less efficient as a result.

-20. Gopnik, Alison, *Essere genitori non è un mestiere*, Bollati Boringhieri, 2016, pp. 112-113;
-21. Gopnik, A. et al., *When Younger Learners Can Be Better (or, at least, more open-minded) Than Older Ones*, "Current Directions on Psychological Science", 24, n.2, (2015), pp. 87-92;

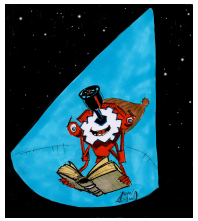
Citizen Teachers or citizen trainers (for routines)?

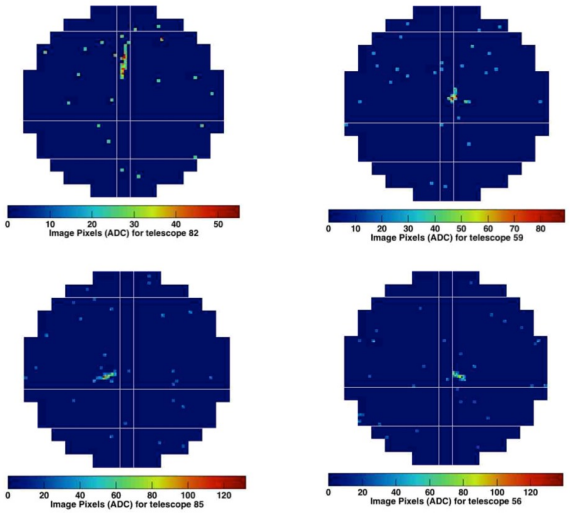
Narrative approach

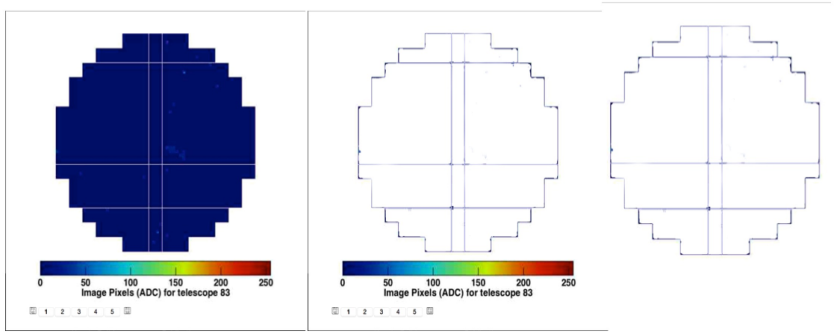




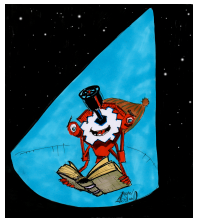
Narrative approach

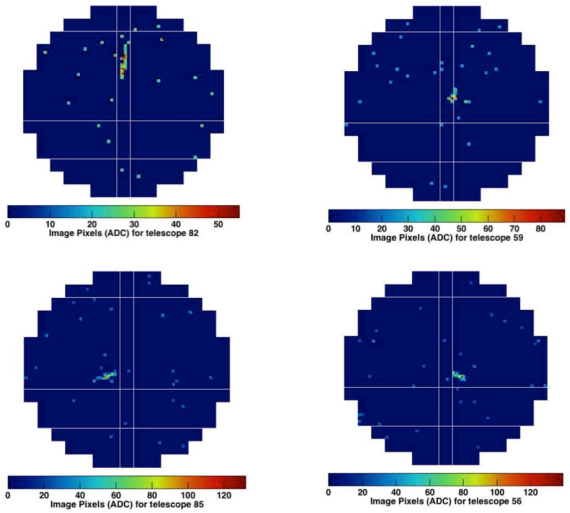


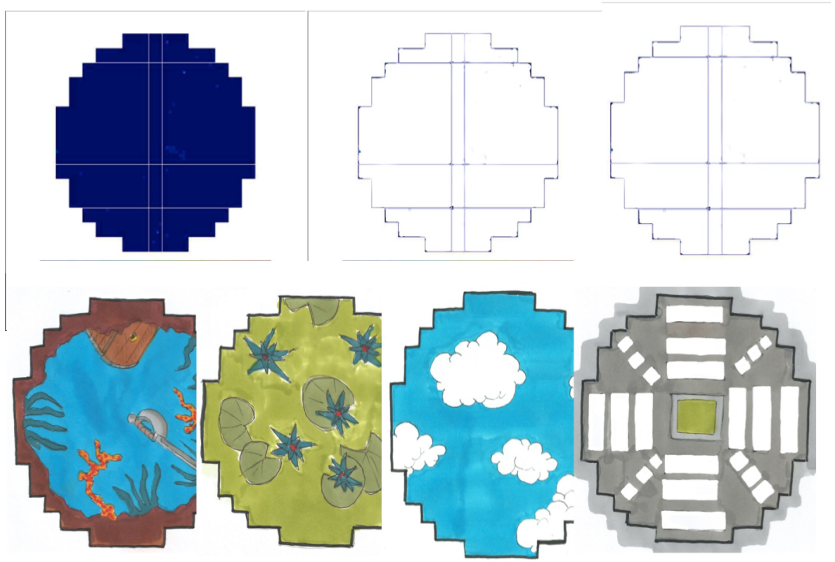




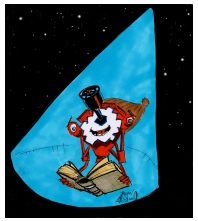
Narrative approach

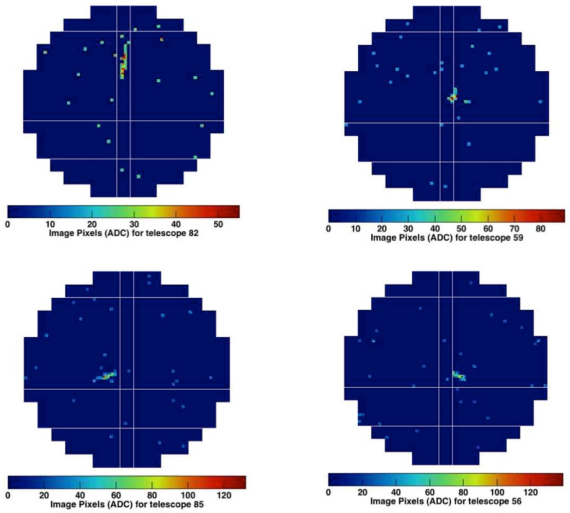


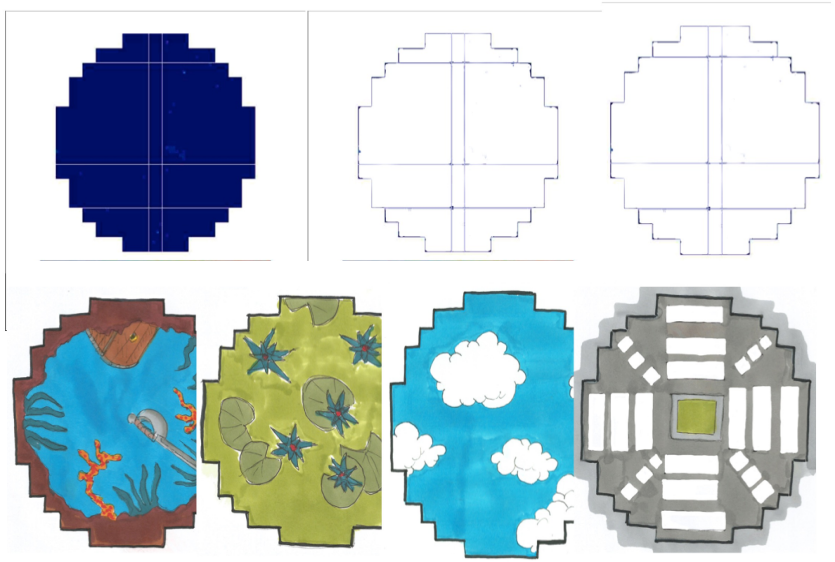


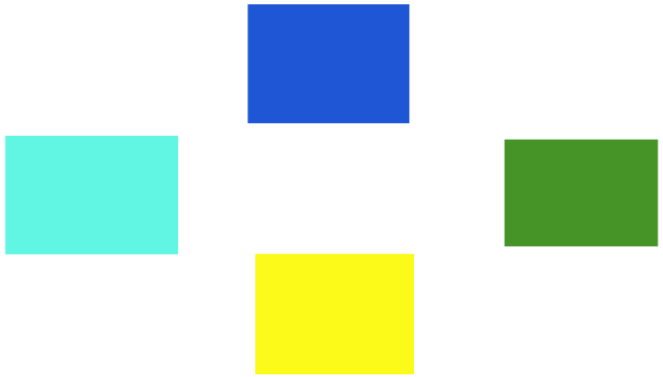


Narrative approach

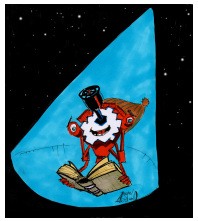


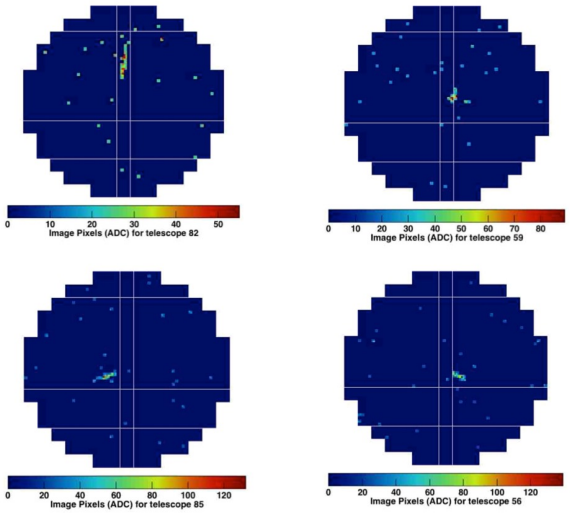


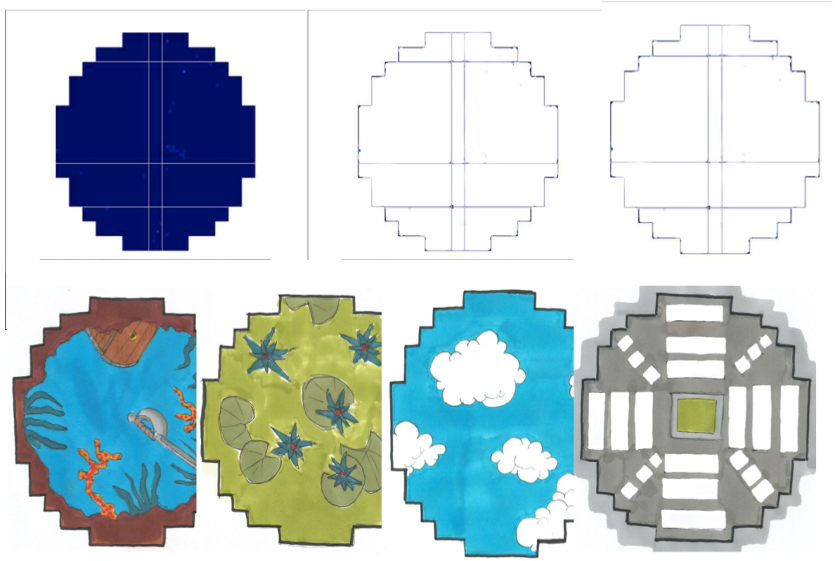


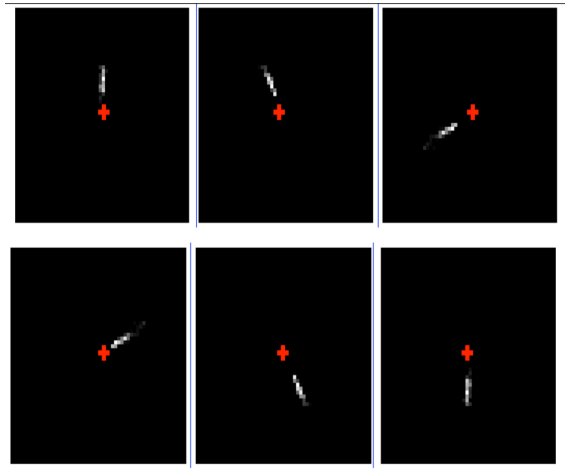


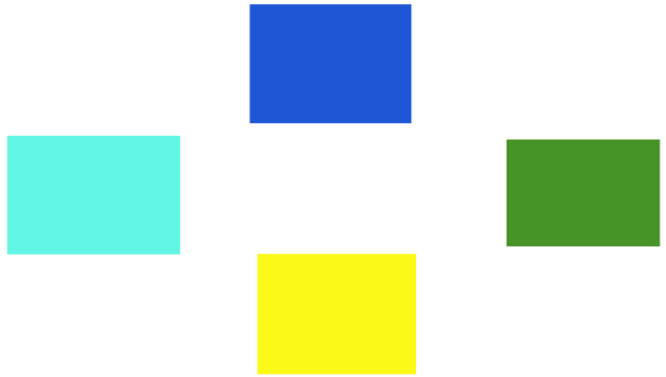
Narrative approach

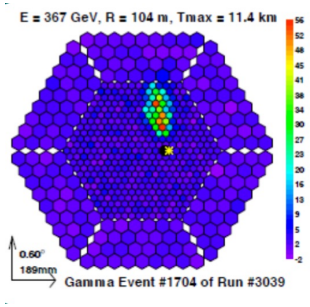








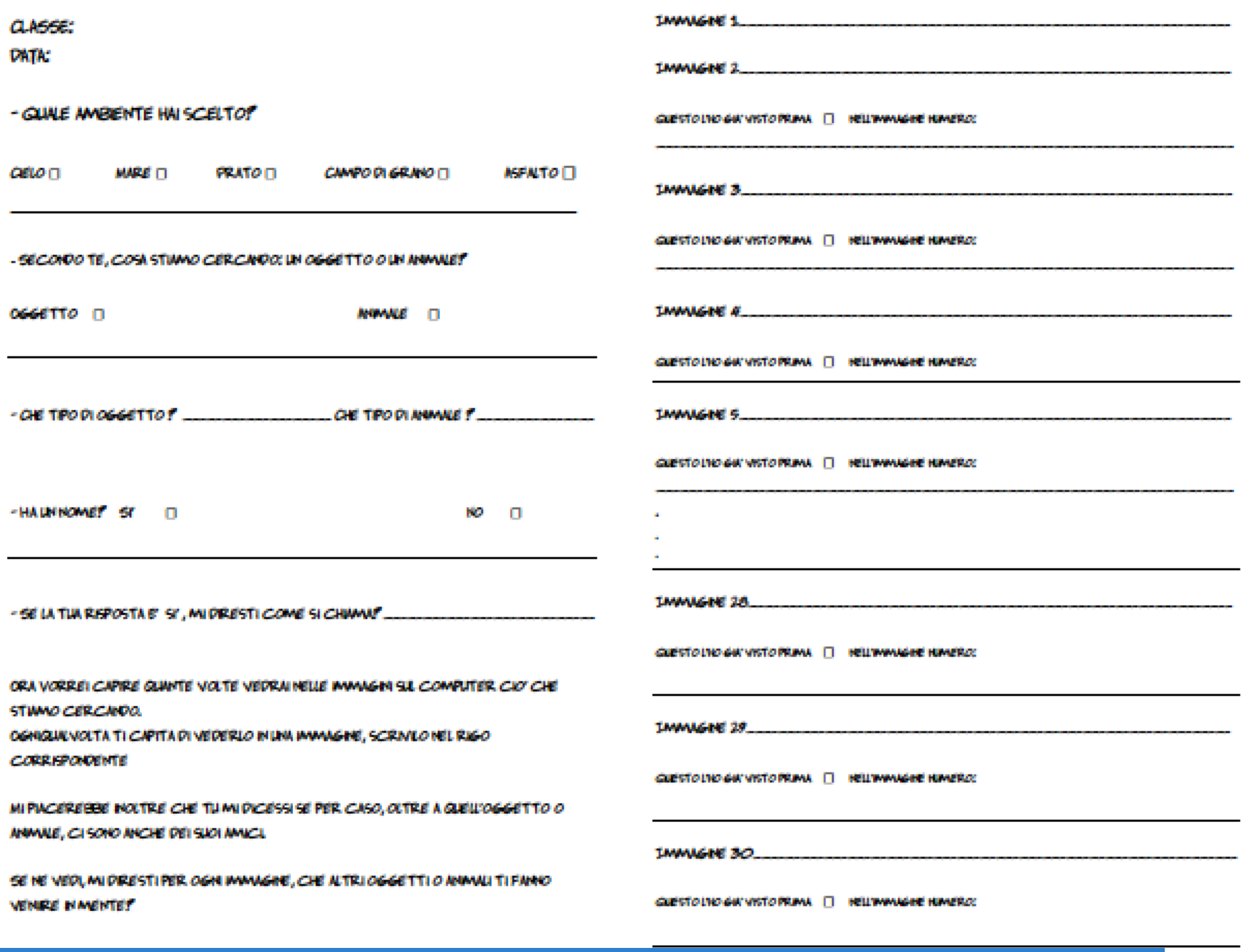




Appropriate questionnaire

The gamma Photon is the Main character.

Children have to give him a name and to look for him



CLASSE:

DATA:

- QUALE AMBIENTE HAI SCELTO?

CIELO ☐ MARE ☐ PRATO ☐ CAMPO DI GRANO ☐ ASFALTO ☐

- SECONDO TE, COSA STIAMO CERCANDO: UN OGGETTO O UN ANIMALE?

OGGETTO ☐ ANIMALE ☐

- CHE TIPO DI OGGETTO E' _____ CHE TIPO DI ANIMALE E' _____

- HA UN NOME? SI ☐ NO ☐

- SE LA TUA RISPOSTA E' SI', MI DIRESTI COME SI CHIAMA? _____

ORA VORREI CAPIRE QUANTE VOLTE VEDRAI NELLE IMMAGINI SUL COMPUTER CIO' CHE STIAMO CERCANDO.
OGNIQUALVOLTA TI CAPITA DI VEDERLO IN UNA IMMAGINE, SCRIVILO NEL RIGO CORRISPONDENTE

MI PIACEREBBE INOLTRE CHE TU MI DICESSI SE PER CASO, OLTRE A QUELL'OGGETTO O ANIMALE, CI SONO ANCHE DEI SUOI AMICI.

SE NE VEDI, MI DIRESTI PER OGNI IMMAGINE, CHE ALTRI OGGETTI O ANIMALI TI FANNO VENIRE IN MENTE?

IMMAGINE 1 _____

IMMAGINE 2 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

IMMAGINE 3 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

IMMAGINE 4 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

IMMAGINE 5 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

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.
.

IMMAGINE 28 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

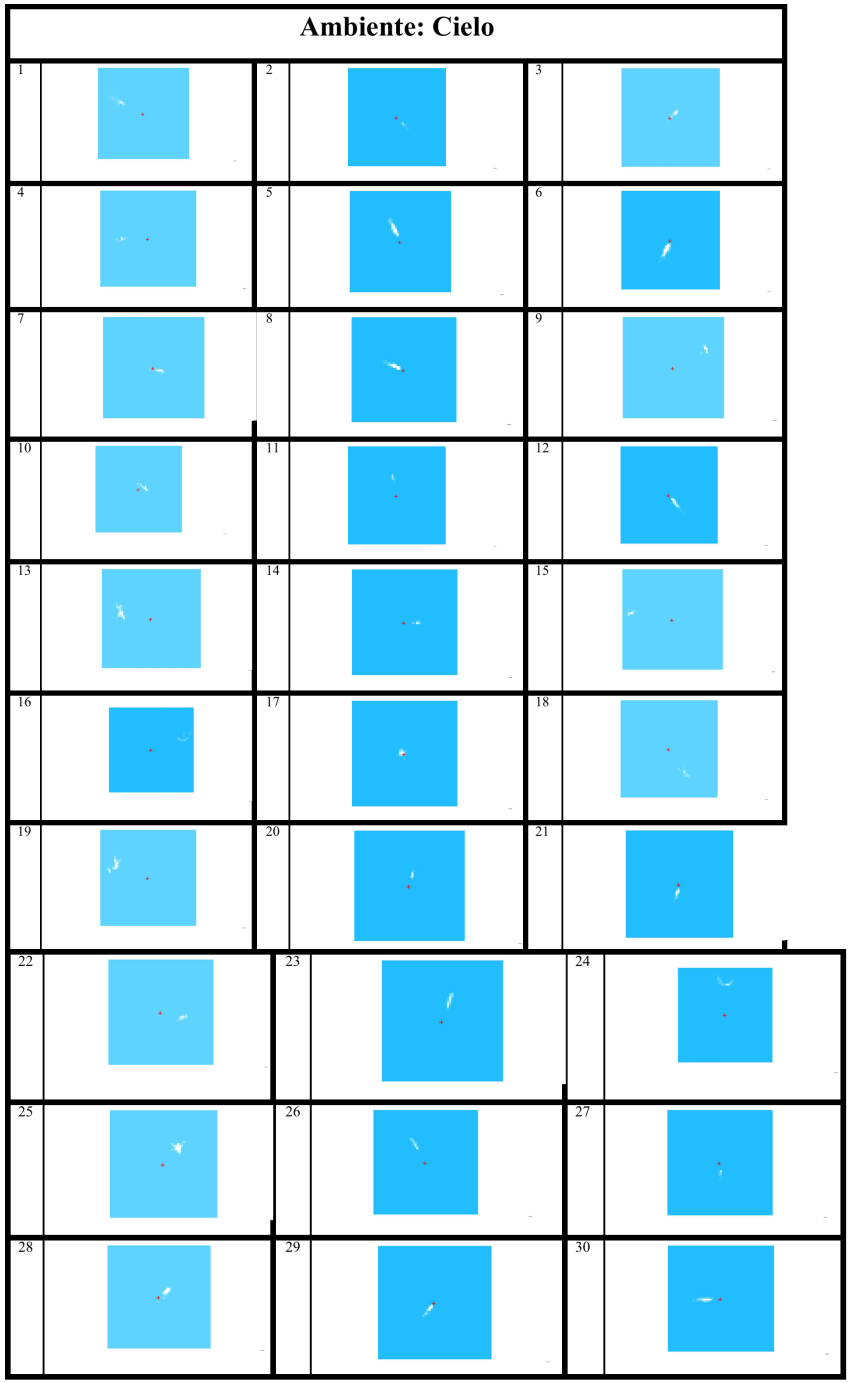
IMMAGINE 29 _____

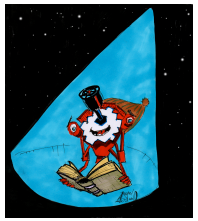
QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

IMMAGINE 30 _____

QUESTO L'HO GIA' VISTO PRIMA ☐ NELL'IMMAGINE NUMERO: _____

Ambiente: Cielo





GUARDANDO TUTTE QUESTE IMMAGINI, TI E' CAPITATO DI PENSARE A UNA STORIA NELLA QUALE VI SONO TUTTI I PERSONAGGI CHE HAI TROVATO?

SI' ☐ NO ☐

SE LA TUA RISPOSTA E' SI', ME LA RACCONTERESTI?
(SE TI VA, SCRIVILA QUI IN BASSO)

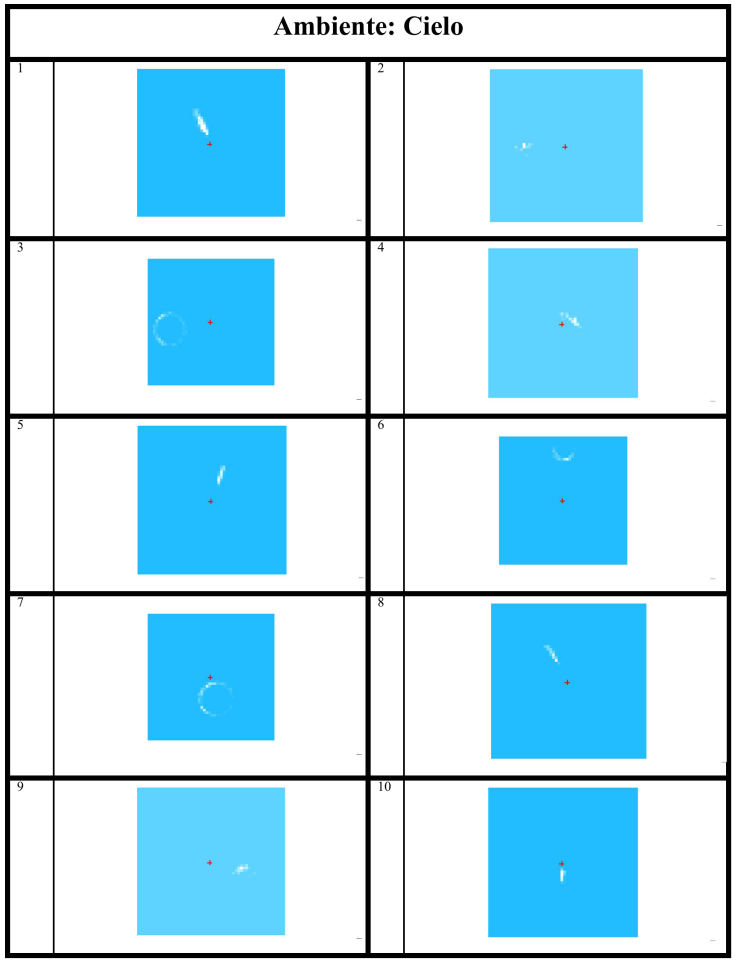
In asking to babies (who still were not able to write) the questions of the survey, any too marked variations in the tone of voice or too broad gestures could have betray or make the children interviewed perceive our preference or some implied suggestion.

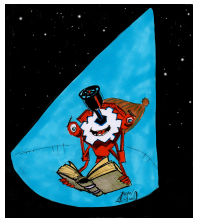
Our attempt to prevent these problems was done trying to be very careful in using tones of voice and gestures.

We still had to maintain an adequate colloquialism and essential lightness to put children at ease hoping to build this way a communication bridge with them.

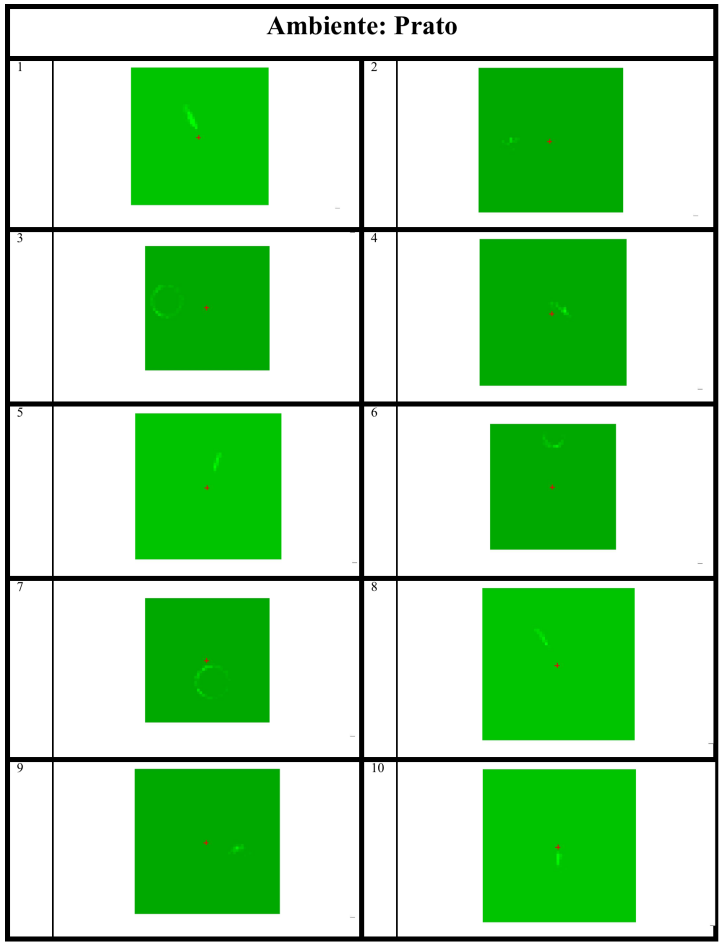
We therefore hope that we have managed to **clean up** our way of speaking from this genre of **bias** (for partial verification, we have the audio recordings of the interviews),

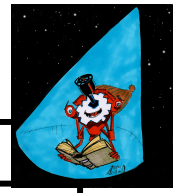
Ambiente: Cielo

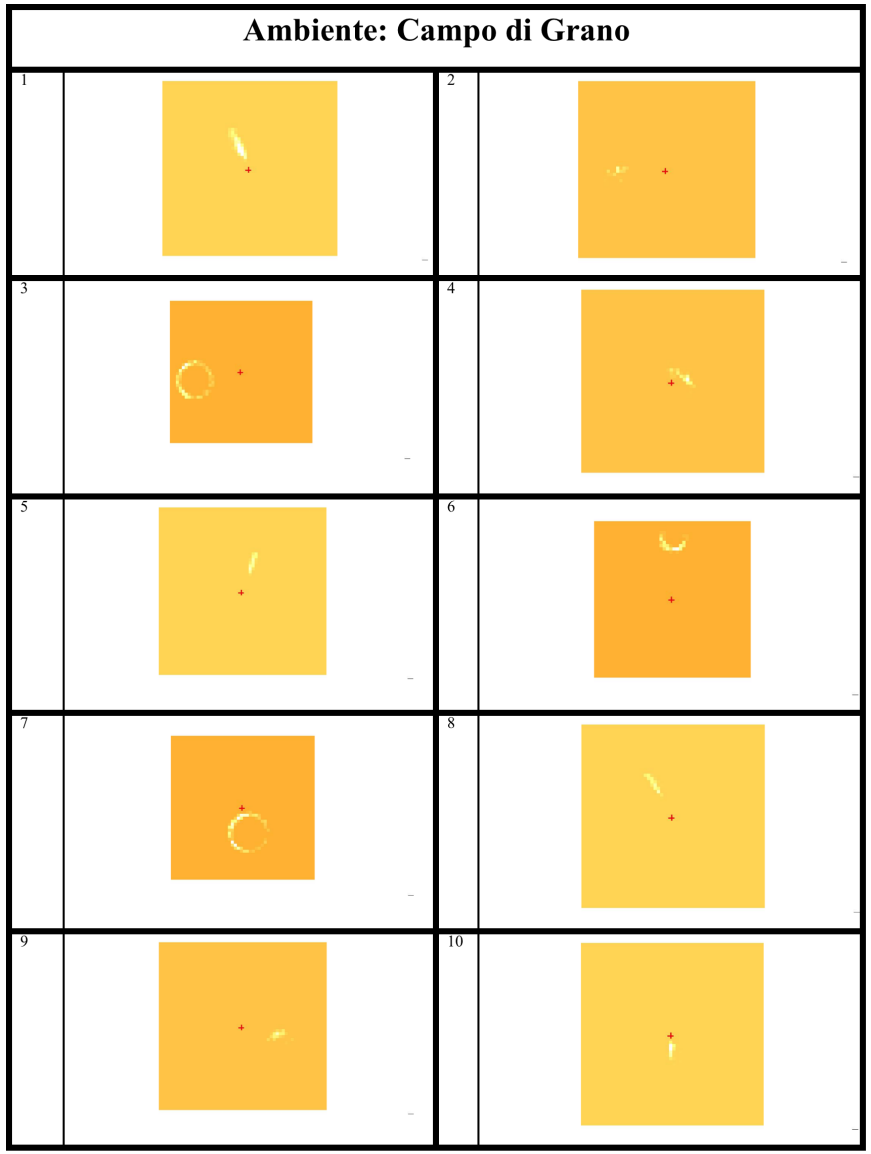


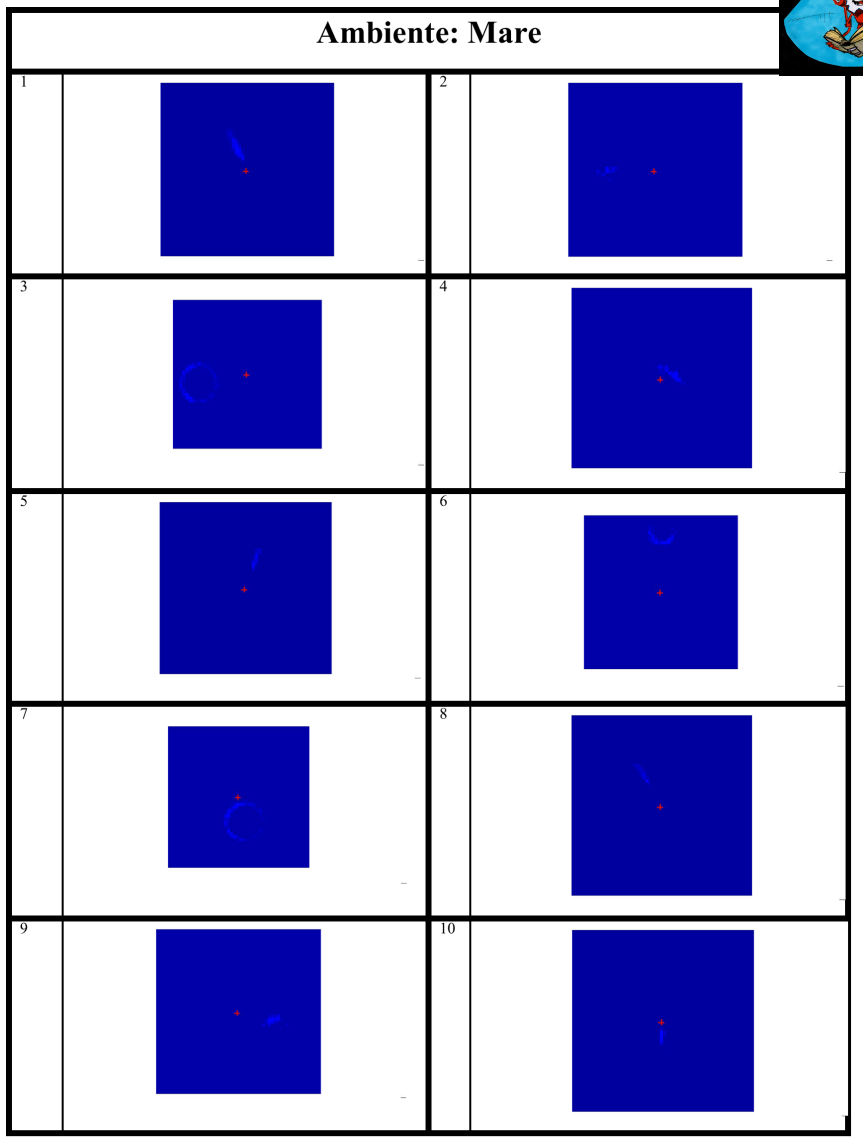


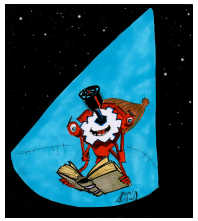
Ambiente: Prato



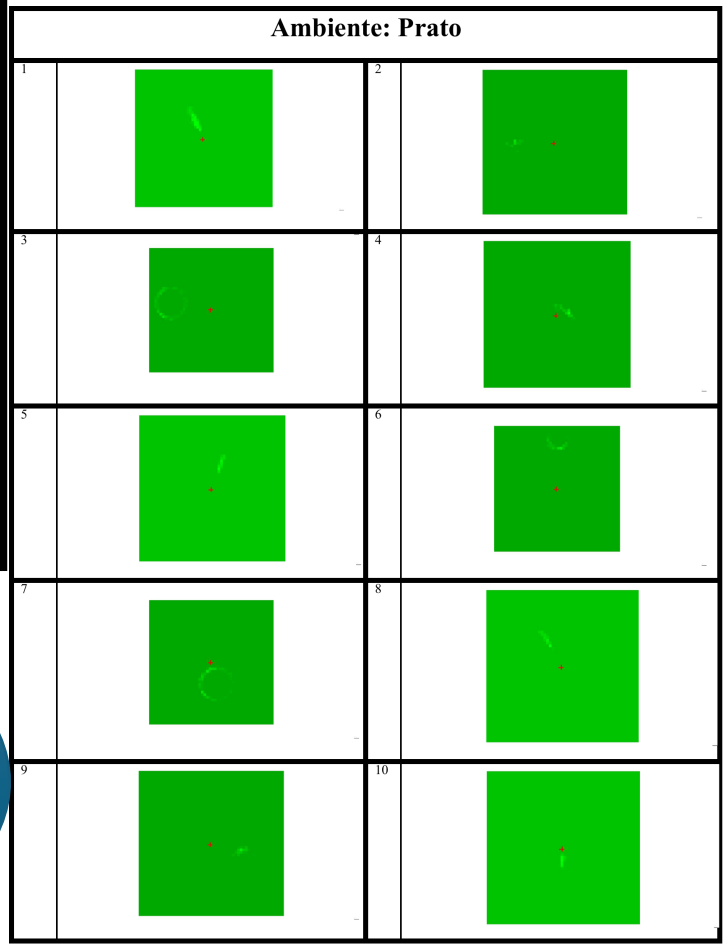



Ambiente: Campo di Grano
1
2
3
4
5
6
7
8
9
10

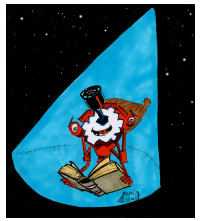

Ambiente: Mare
1
2
3
4
5
6
7
8
9
10



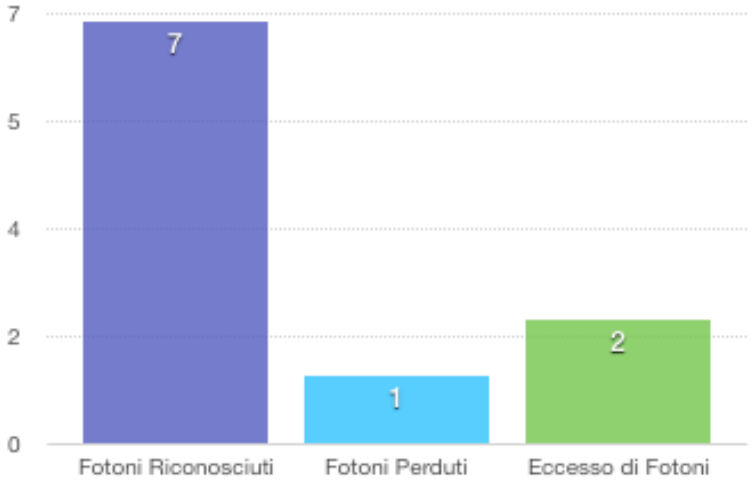
Scuola Primaria – I C, Istituto Ferrara, 6 Giugno 2017		
Scheda 18, età: 6 anni, 2:22:00		
Ambiente: prato	Animale: bruco	Nome: //
Numero Immagine	**Commento**	**Fotone/Adrone/Muone**
1	Bruco	Gamma
2	No, non mi vengono in mente animali perché ha la testa lontano dal corpo	Adrone
3	No	Muone
4	Somiglia a bruco. È simile. L'ho visto già nella 2	Adrone
5	Bruco	Gamma
6	No	Muone
7	No, l'abbiamo incontrato nella 3 e nella 6. La 6 è come la 7 ma è in alto quindi non si vede l'altra parte	Muone
8	Bruco	Gamma
9	No, già visto nella 2	Adrone
10	Bruco	Gamma

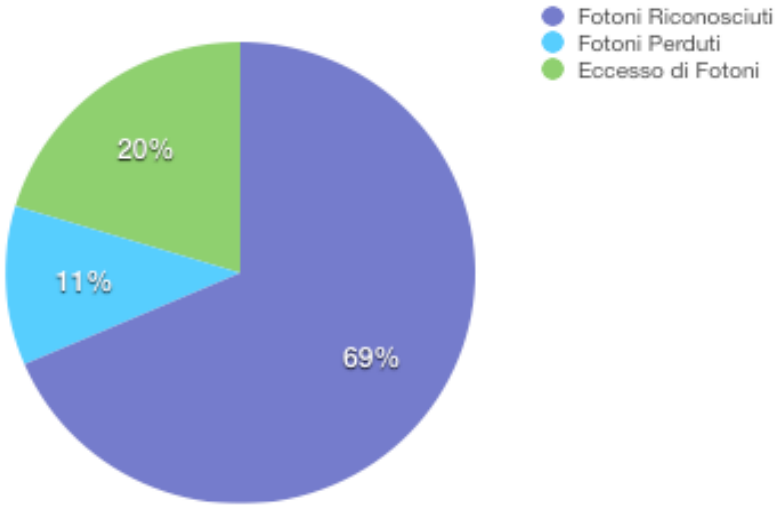


4 out of 4 photons recognized
3 out of 3 protons recognized
3 out of 3 muons recognized
This is the ideal case!

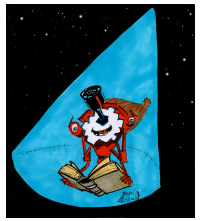


ADULTI	CONTEGGI
Fotoni Riconosciuti	7
Fotoni Perduti	1
Eccesso di Fotoni	2

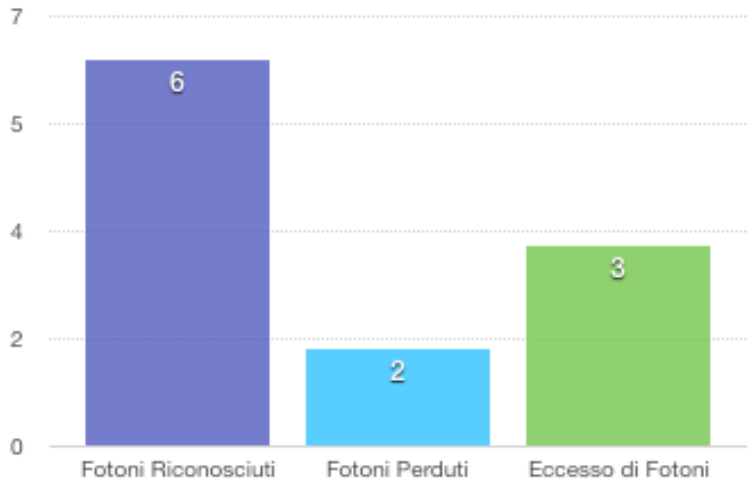


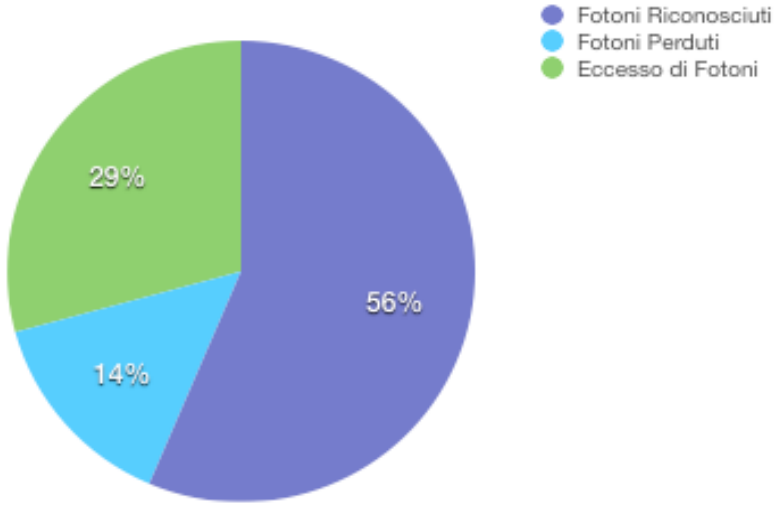


1

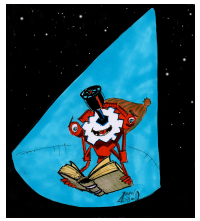


STUDENTI SCUOLE SUPERIORI	CONTEGGI
Fotoni Riconosciuti	6
Fotoni Perduti	2
Eccesso di Fotoni	3

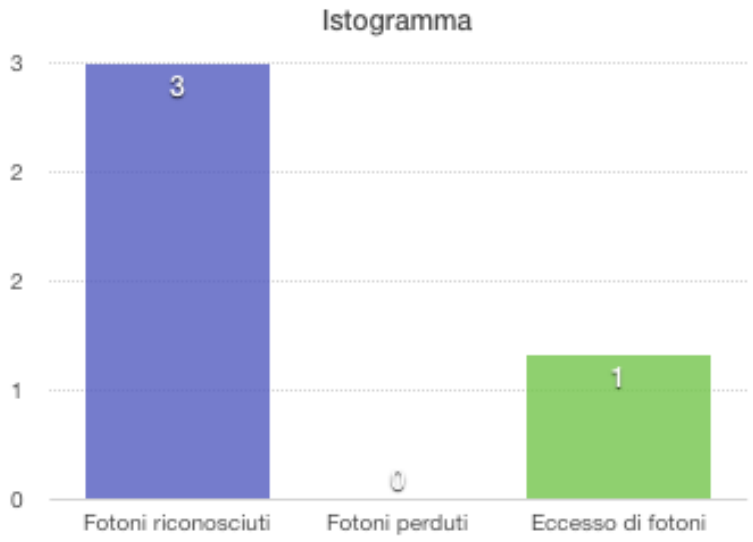


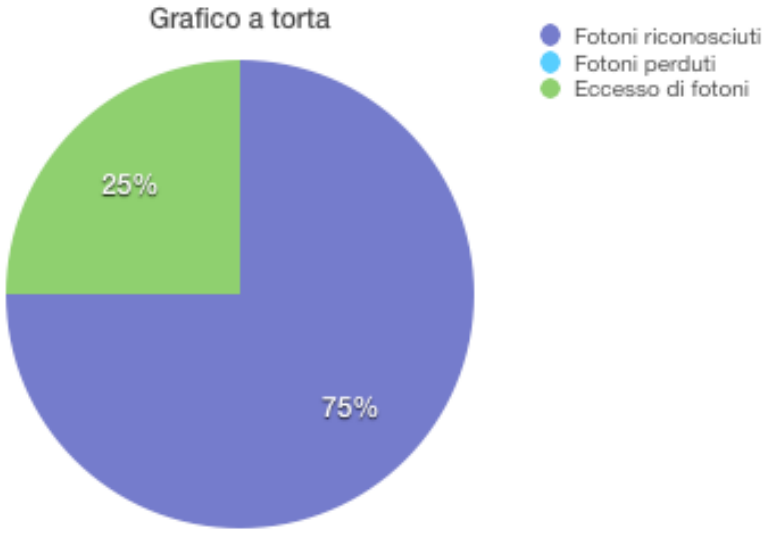


1

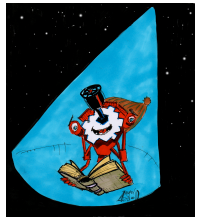


BAMBINI SCUOLA PRIMARIA	CONTEGGI
Fotoni riconosciuti	3
Fotoni perduti	0
Eccesso di fotoni	1

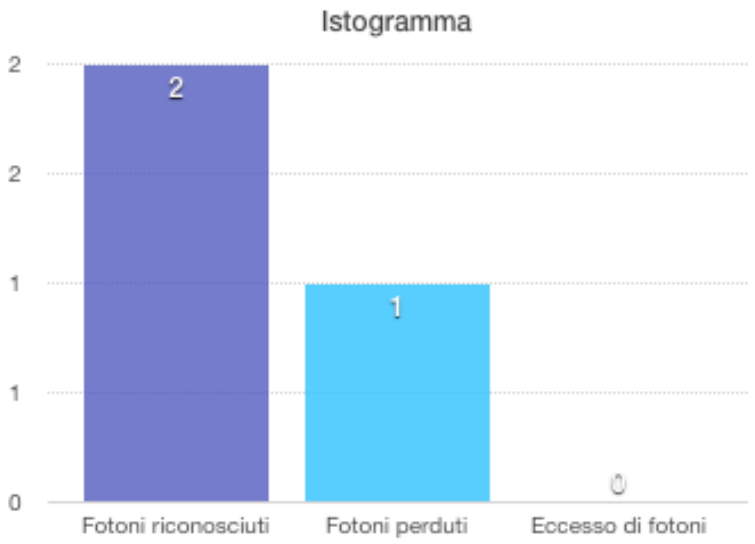


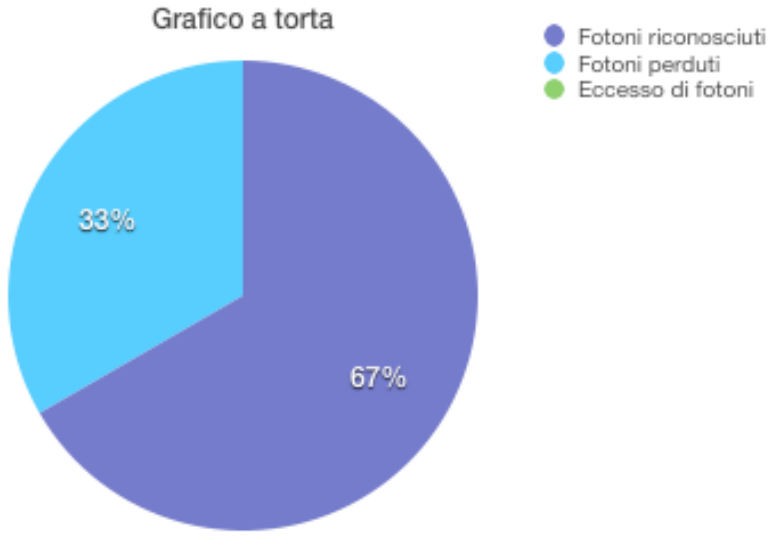


1

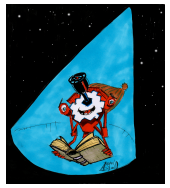


BAMBINI SCUOLA MATERNA	CONTEGGI
Fotoni riconosciuti	2
Fotoni perduti	1
Eccesso di fotoni	0

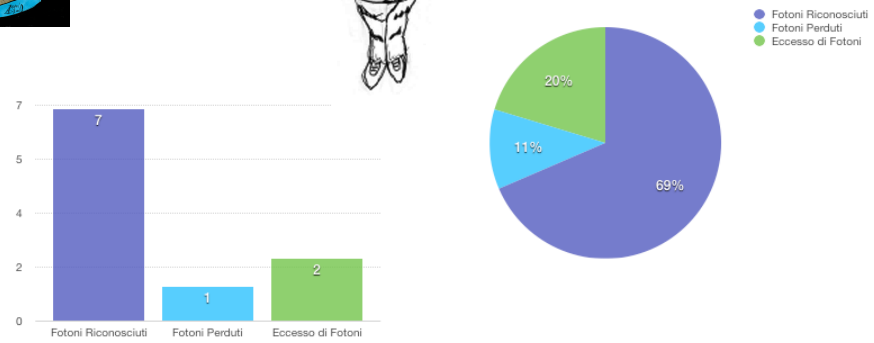




1

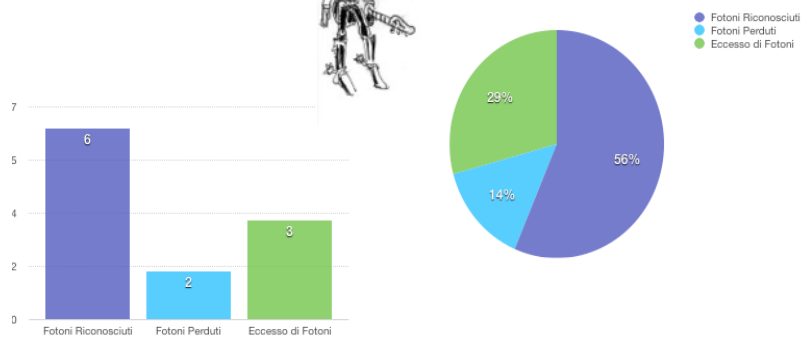


ADULTI	CONTEGGI
Fotoni Riconosciuti	7
Fotoni Perduti	1
Eccesso di Fotoni	2



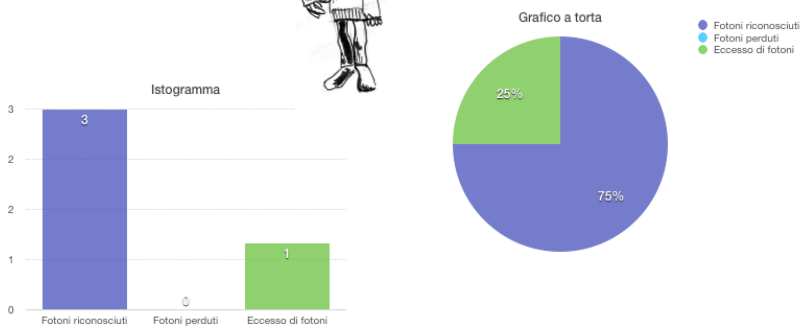
1

STUDENTI SCUOLE SUPERIORI	CONTEGGI
Fotoni Riconosciuti	6
Fotoni Perduti	2
Eccesso di Fotoni	3



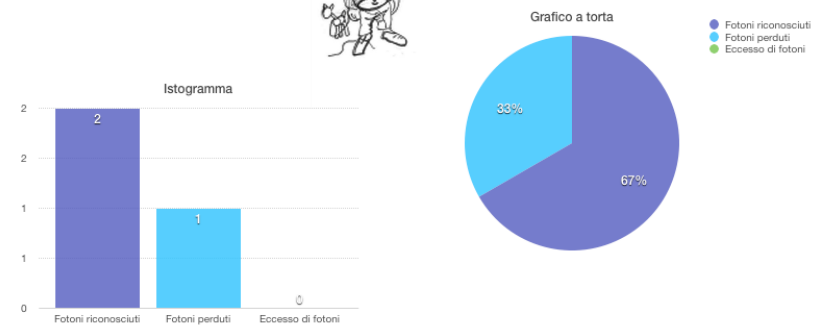
1

BAMBINI SCUOLA PRIMARIA	CONTEGGI
Fotoni riconosciuti	3
Fotoni perduti	0
Eccesso di fotoni	1

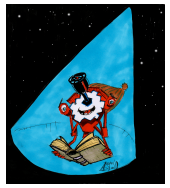


1

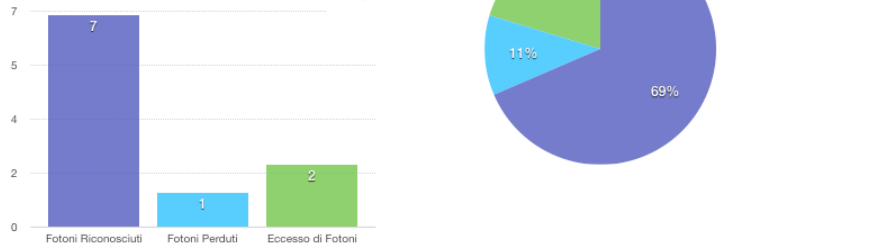
BAMBINI SCUOLA MATERNA	CONTEGGI
Fotoni riconosciuti	2
Fotoni perduti	1
Eccesso di fotoni	0



1

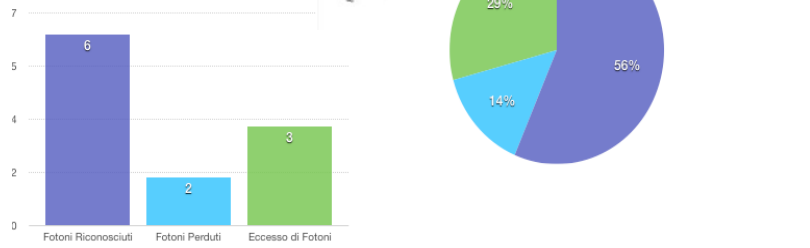


ADULTI	CONTEGGI
Fotoni Riconosciuti	7
Fotoni Perduti	1
Eccesso di Fotoni	2



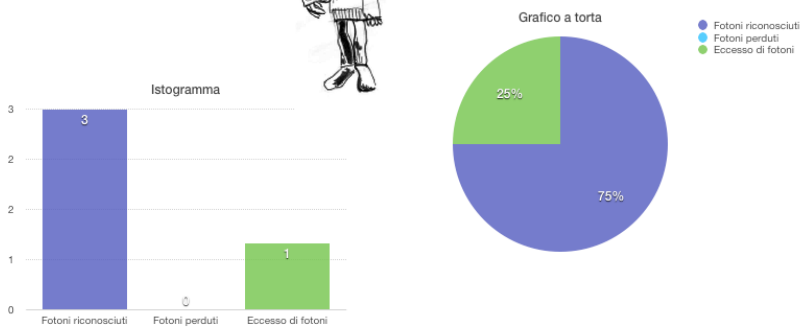
1

TUDENTI SCUOLE SUPERIORI	CONTEGGI
toni Riconosciuti	6
toni Perduti	2
cesso di Fotoni	3



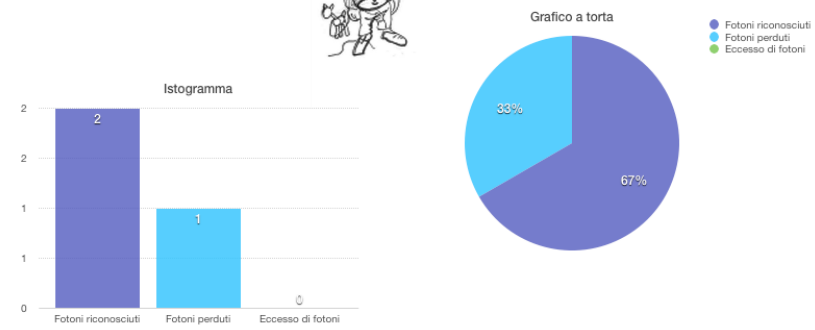
1

BAMBINI SCUOLA PRIMARIA	CONTEGGI
Fotoni riconosciuti	3
Fotoni perduti	0
Eccesso di fotoni	1



1

BAMBINI SCUOLA MATERNA	CONTEGGI
Fotoni riconosciuti	2
Fotoni perduti	1
Eccesso di fotoni	0



1

Sarah-Jane Blakemore: *Inventare se stessi - Cosa succede nel cervello degli adolescenti*, Bollati Boringhieri

THANK YOU!!!