Extreme Energy Events: first results from RUN2

Corrado Cicalo'

Centro Fermi and INFN Cagliari

on behalf of the EEE collaboration

Padova, 29 Settembre 2016

The Extreme Energy Events project

The EEE project is an experiment dedicated to the investigation of high energy cosmic rays

Large network of cosmic ray telescopes located on the Italian territory

- **Supported by Centro Studi e Ricerche Enrico Fermi (Roma) in collaboration with CERN, INFN and MIUR.**

Goals: scientific and educational

- **study an interesting physics case;**
- **involve high school students and teachers**

Main scientific goals of the EEE project

- Study of Extensive Atmospheric Shower (EAS)
- Variations of Muon Flux caused by solar flares
- Search of Anisotropy at the sub-TeV scale
- Identification of Muon decay in Up-going events

Telescope location

- 47 telescopes in Italian high schools
- 2 at CERN
- 3 in INFN sites

Each telescope is equipped with a GPS card
→synchronized with the network

The
network is able identify and study high energy cosmic rate (>10^{11} eV).

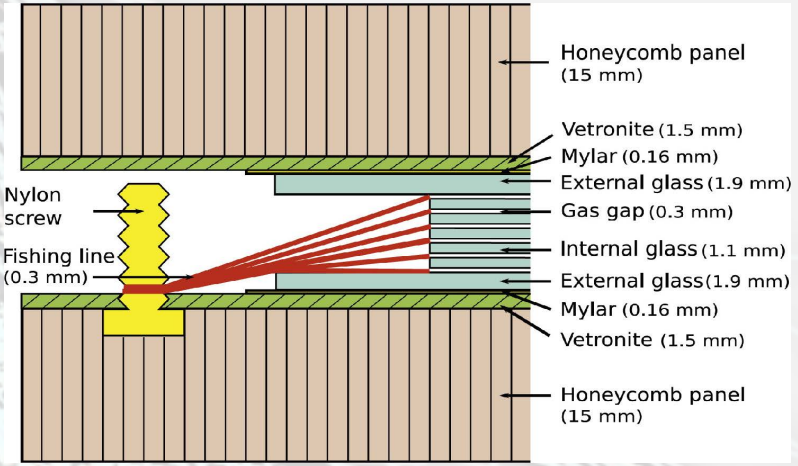
The Telescopes

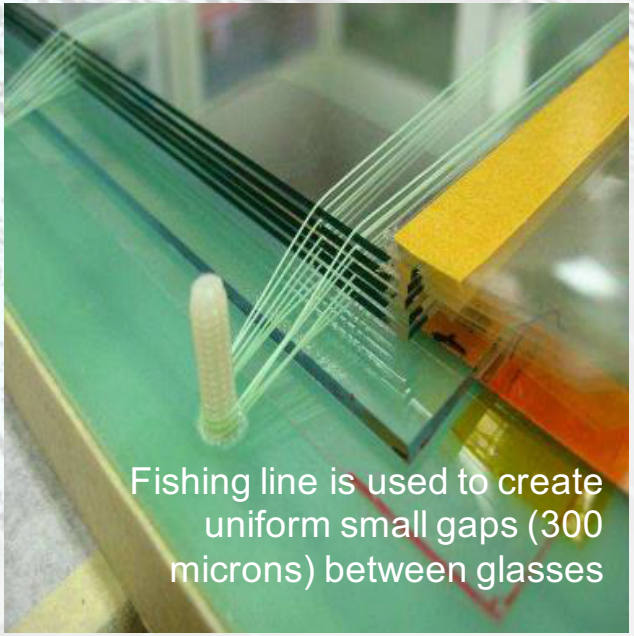
- 3 MRPC planes, 160 x 80 cm^2
- 6 Front End cards with 24 channels each → readout and trigger
- GPS card: time-stamp of each collected event (*see Corvaglia presentation*)
- VME-based DAQ
  - –1 Trigger card (six-fold coincidence of the 6 FE cards)
  - –2 Multi-hit TDCs (128 + 64 ch)
- Weather Station

The Detectors: Multigap Resistive Plate Chambers

Requirements:

- High efficiency
- Easy to assemble
- Easy to operate
- Long term operation
- Low cost





Same design as the MRPC developed for the ALICE TOF

Detector characteristics

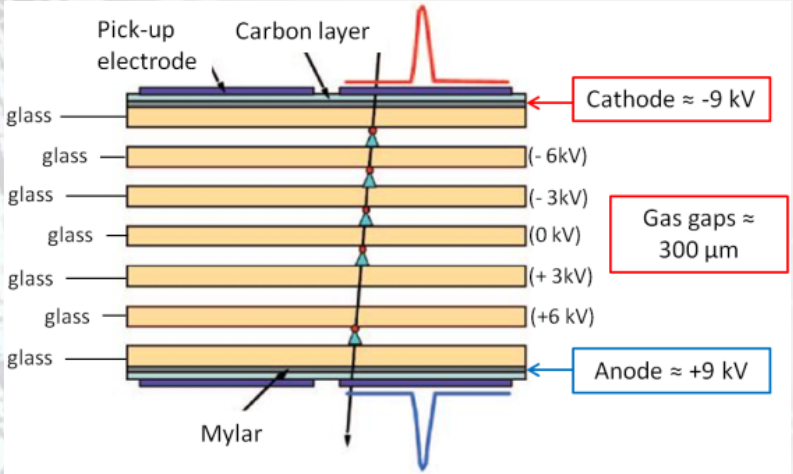
6 gas gap: 2 glass plates with their external surfaces painted with resistive paint; 5 floating glass plates (spaced by 300 μm)

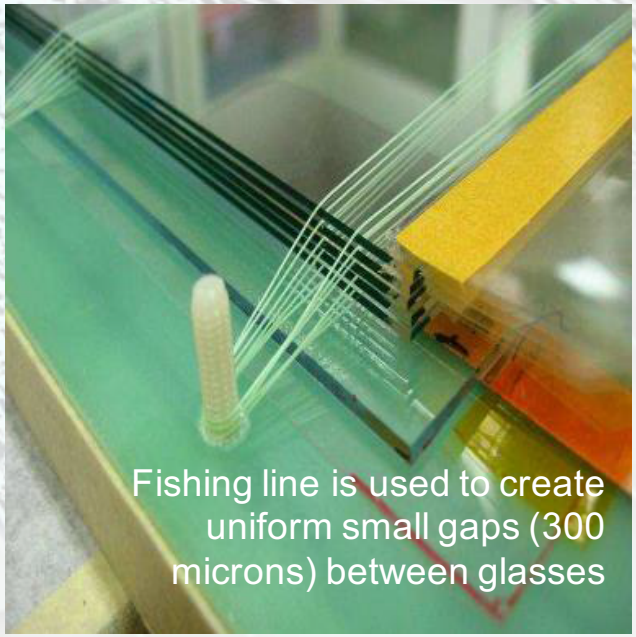
24 readout copper strips mounted on both sides of the stack of glass plates (i.e. cathode and anode read-out strips)

Strip pitch of 3.2 cm

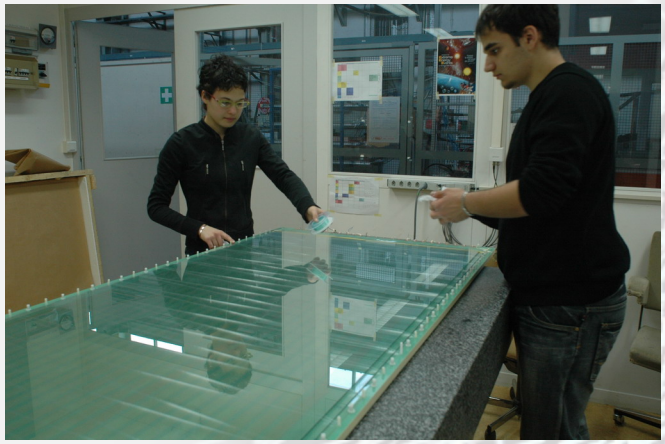
HV up to 20 kV (avalanche mode) supplied by 2 DC/DC converters

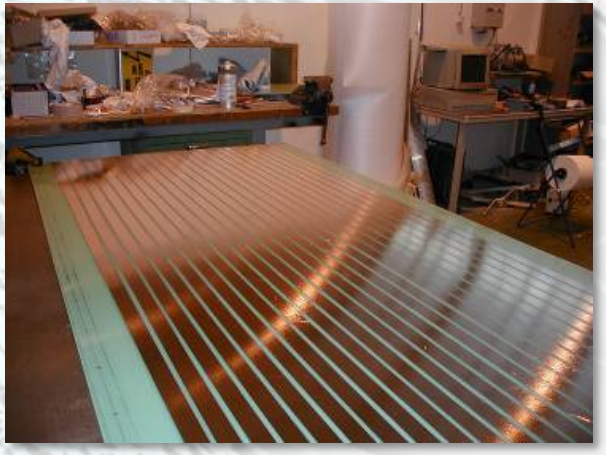
Gas: C2H2F4(98%) and SF6(2%) continuously fluxed (3l/h)





Detector assembly at CERN

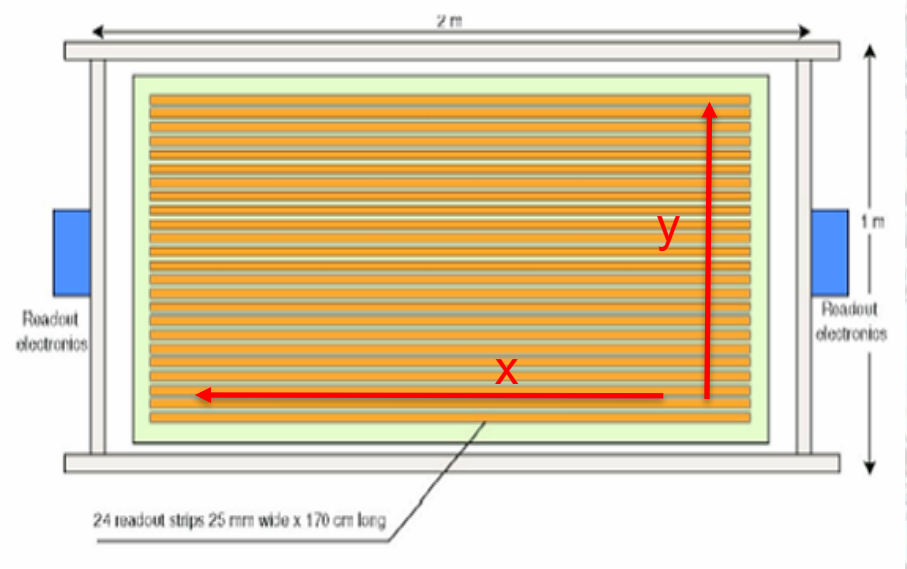


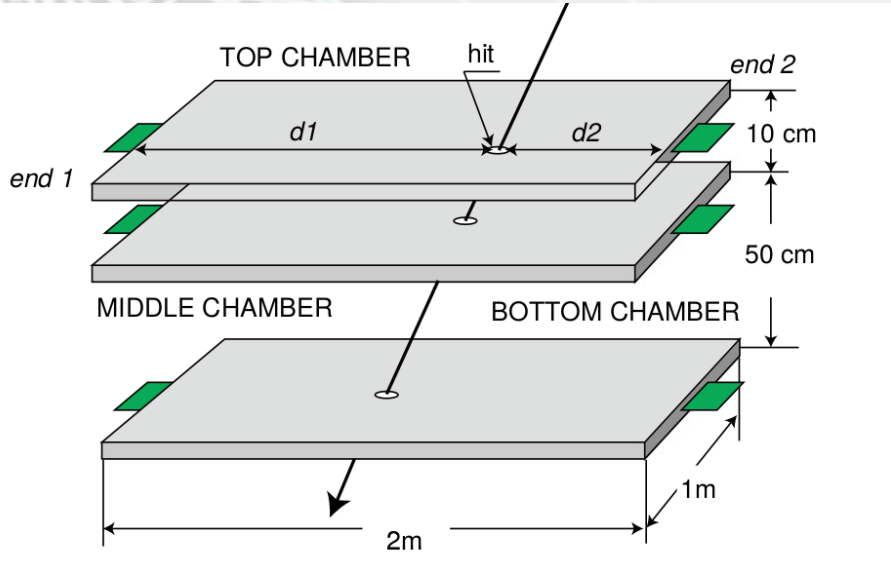


High school students and teachers actively participate to the construction, maintenance and data analysis of the telescopes.

Track reconstruction

Each module provides a two-dimensional position information with efficiency close to 100%

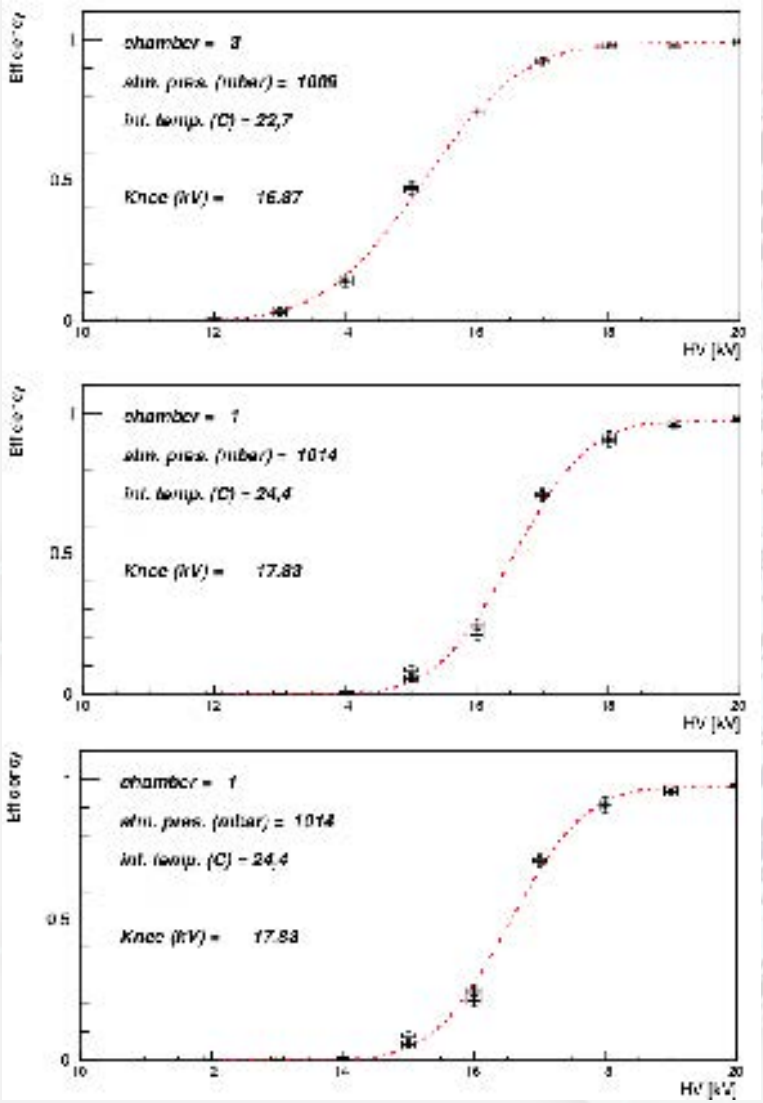


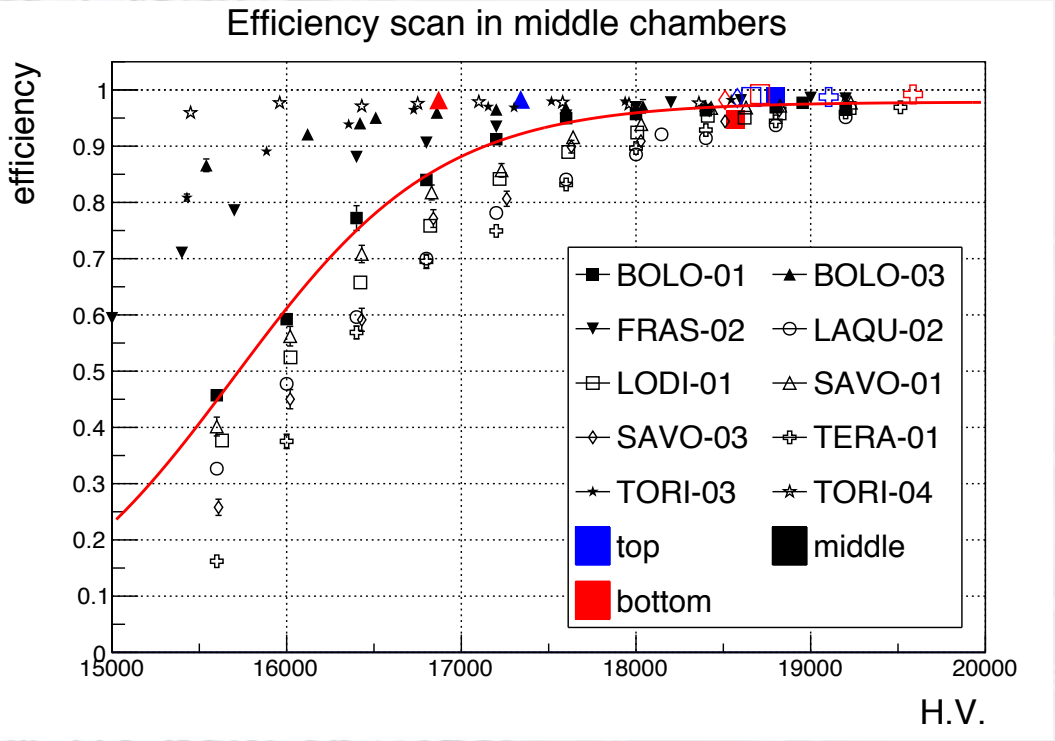


x coordinate: difference of signal arrival times at the strip ends measured by TDCs
y coordinate: fired strip

From the three plane coordinates the track direction is reconstructed

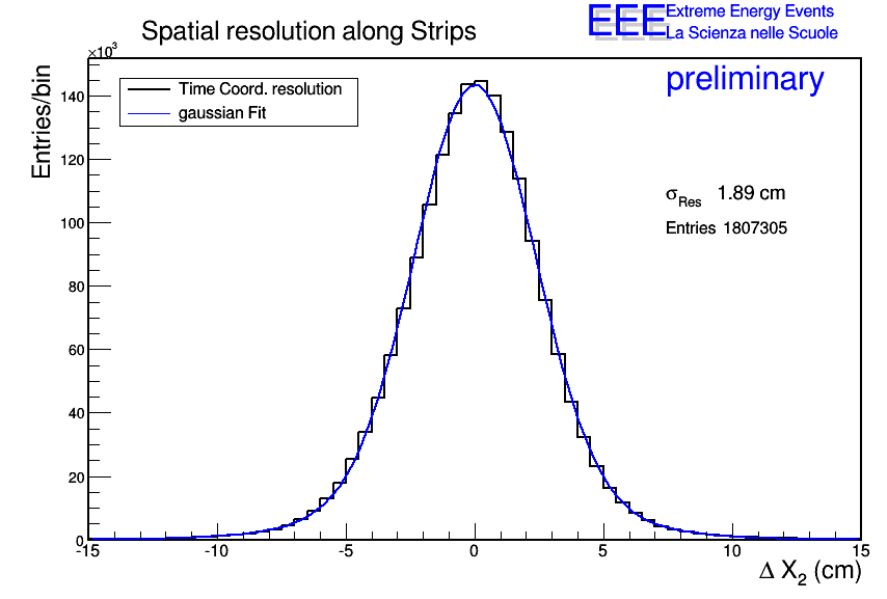
Detector Efficiency

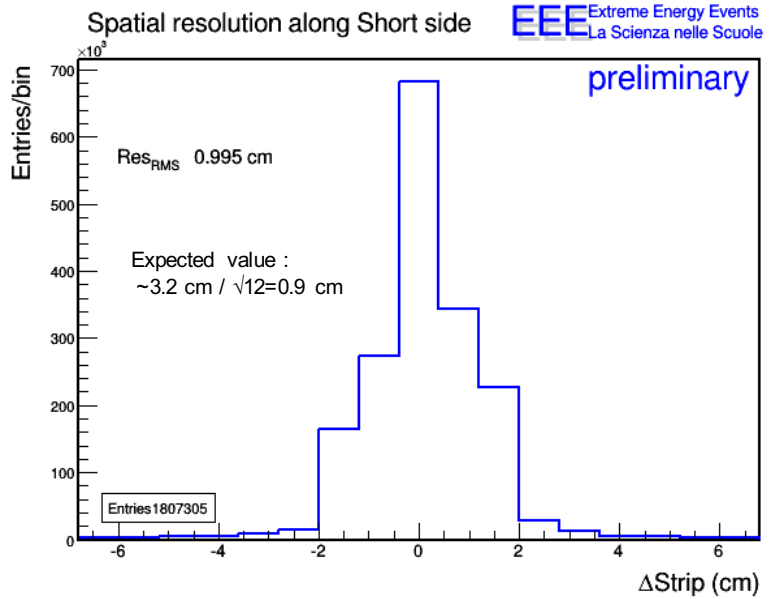




These measurements are performed at school by students and teachers supervised by EEE staff.

Spatial resolution





Measured at school with cosmic rays

Statistics collected so far

Pilot RUN:

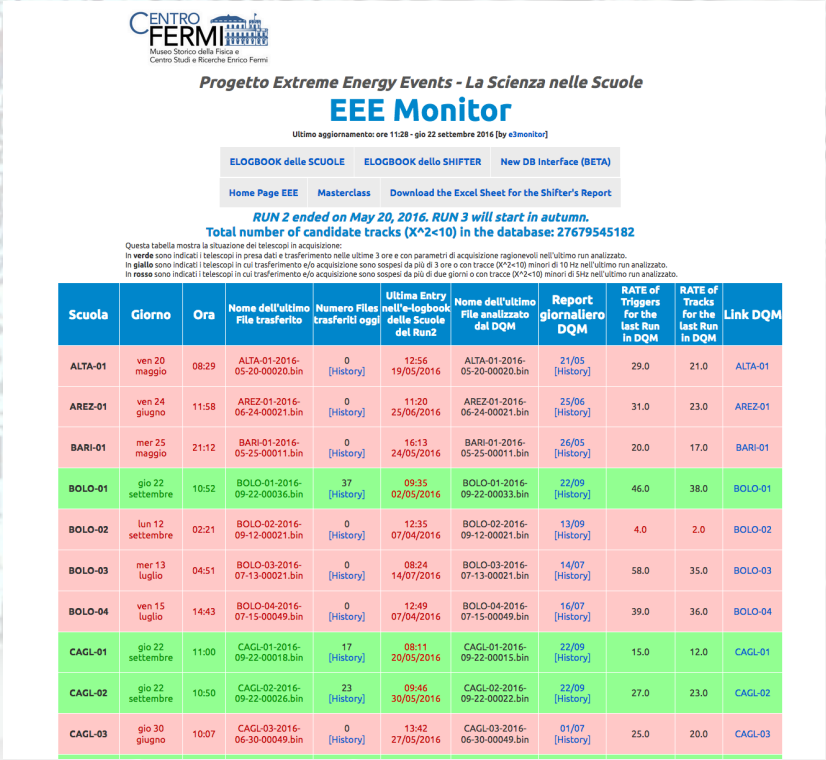
- first simultaneous acquisition of many telescopes (23)
- 27 October – 14 November 2014
- 1 billion muon tracks collected

RUN1:

- 35 active telescopes
- Three months duration (Feb - Apr 2015)
- more than 5 billion muon tracks collected

RUN 2

- October 2015 – May 2016
- More than 40 active stations
- Collected statistics: $15 \cdot 10^9$ reconstructed tracks
- Acquisition rate 20 –40 Hz in each station



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Progetto Extreme Energy Events - La Scienza nelle Scuole

EEE Monitor

Ultimo aggiornamento: ore 11:28 - gio 22 settembre 2016 [by e3monitor]

ELOGBOOK delle SCUOLE | ELOGBOOK dello SHIFTER | New DB Interface (BETA)

Home Page EEE | Masterclass | Download the Excel Sheet for the Shifter's Report

RUN 2 ended on May 20, 2016. RUN 3 will start in autumn.

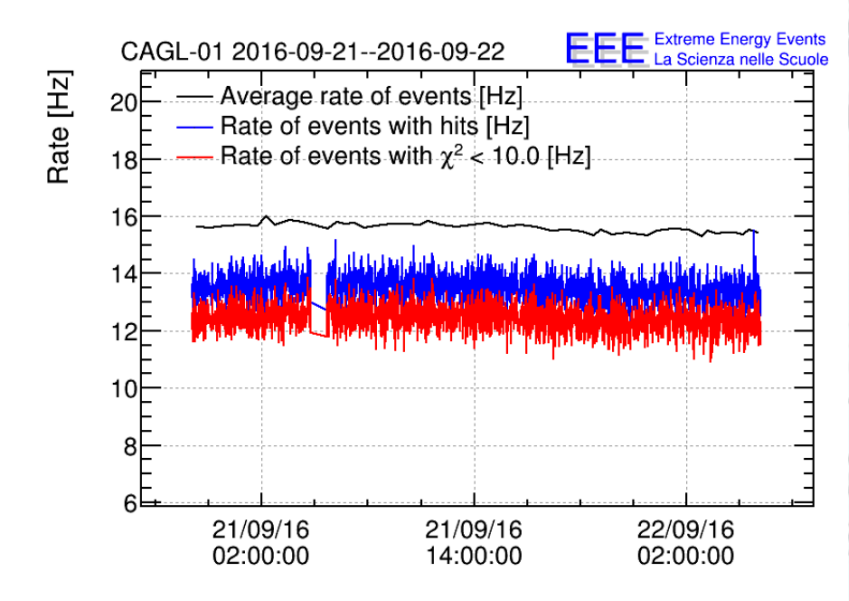
Total number of candidate tracks (X^2<10) in the database: 27679545182

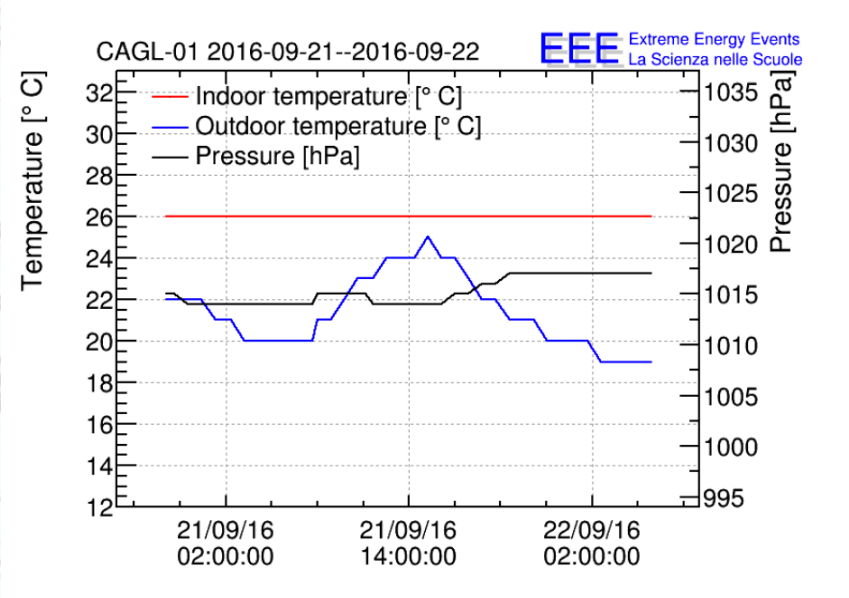
Questa tabella mostra la situazione dei telescopi in acquisizione:
In **verde** sono indicati i telescopi in presa dati e trasferimento nelle ultime 3 ore e con parametri di acquisizione ragionevoli nell'ultimo run analizzato.
In **giallo** sono indicati i telescopi in cui trasferimento e/o acquisizione sono sospesi da più di 3 ore o con tracce (X^2<10) minori di 10 Hz nell'ultimo run analizzato.
In **rosso** sono indicati i telescopi in cui trasferimento e/o acquisizione sono sospesi da più di due giorni o con tracce (X^2<10) minori di 5Hz nell'ultimo run analizzato.

Scuola	Giorno	Ora	Nome dell'ultimo File trasferito	Numero Files trasferiti oggi	Ultima Entry nell'e-logbook delle Scuole del Run2	Nome dell'ultimo File analizzato dal DQM	Report giornaliero DQM	RATE of Triggers for the last Run in DQM	RATE of Tracks for the last Run in DQM	Link DQM
ALTA-01	ven 20 maggio	08:29	ALTA-01-2016-05-20-00020.bin	0 [History]	12:56 19/05/2016	ALTA-01-2016-05-20-00020.bin	21/05 [History]	29.0	21.0	ALTA-01
AREZ-01	ven 24 giugno	11:58	AREZ-01-2016-06-24-00021.bin	0 [History]	11:20 25/06/2016	AREZ-01-2016-06-24-00021.bin	25/06 [History]	31.0	23.0	AREZ-01
BARI-01	mer 25 maggio	21:12	BARI-01-2016-05-25-00011.bin	0 [History]	16:13 24/05/2016	BARI-01-2016-05-25-00011.bin	26/05 [History]	20.0	17.0	BARI-01
BOLO-01	gio 22 settembre	10:52	BOLO-01-2016-09-22-00036.bin	37 [History]	09:35 02/05/2016	BOLO-01-2016-09-22-00033.bin	22/09 [History]	46.0	38.0	BOLO-01
BOLO-02	lun 12 settembre	02:21	BOLO-02-2016-09-12-00021.bin	0 [History]	12:35 07/04/2016	BOLO-02-2016-09-12-00021.bin	13/09 [History]	4.0	2.0	BOLO-02
BOLO-03	mer 13 luglio	04:51	BOLO-03-2016-07-13-00021.bin	0 [History]	08:24 14/07/2016	BOLO-03-2016-07-13-00021.bin	14/07 [History]	58.0	35.0	BOLO-03
BOLO-04	ven 15 luglio	14:43	BOLO-04-2016-07-15-00049.bin	0 [History]	12:49 07/04/2016	BOLO-04-2016-07-15-00049.bin	16/07 [History]	39.0	36.0	BOLO-04
CAGL-01	gio 22 settembre	11:00	CAGL-01-2016-09-22-00018.bin	17 [History]	08:11 20/05/2016	CAGL-01-2016-09-22-00015.bin	22/09 [History]	15.0	12.0	CAGL-01
CAGL-02	gio 22 settembre	10:50	CAGL-02-2016-09-22-00026.bin	23 [History]	09:46 30/05/2016	CAGL-02-2016-09-22-00022.bin	22/09 [History]	27.0	23.0	CAGL-02
CAGL-03	gio 30 giugno	10:07	CAGL-03-2016-06-30-00049.bin	0 [History]	13:42 27/05/2016	CAGL-03-2016-06-30-00049.bin	01/07 [History]	25.0	20.0	CAGL-03

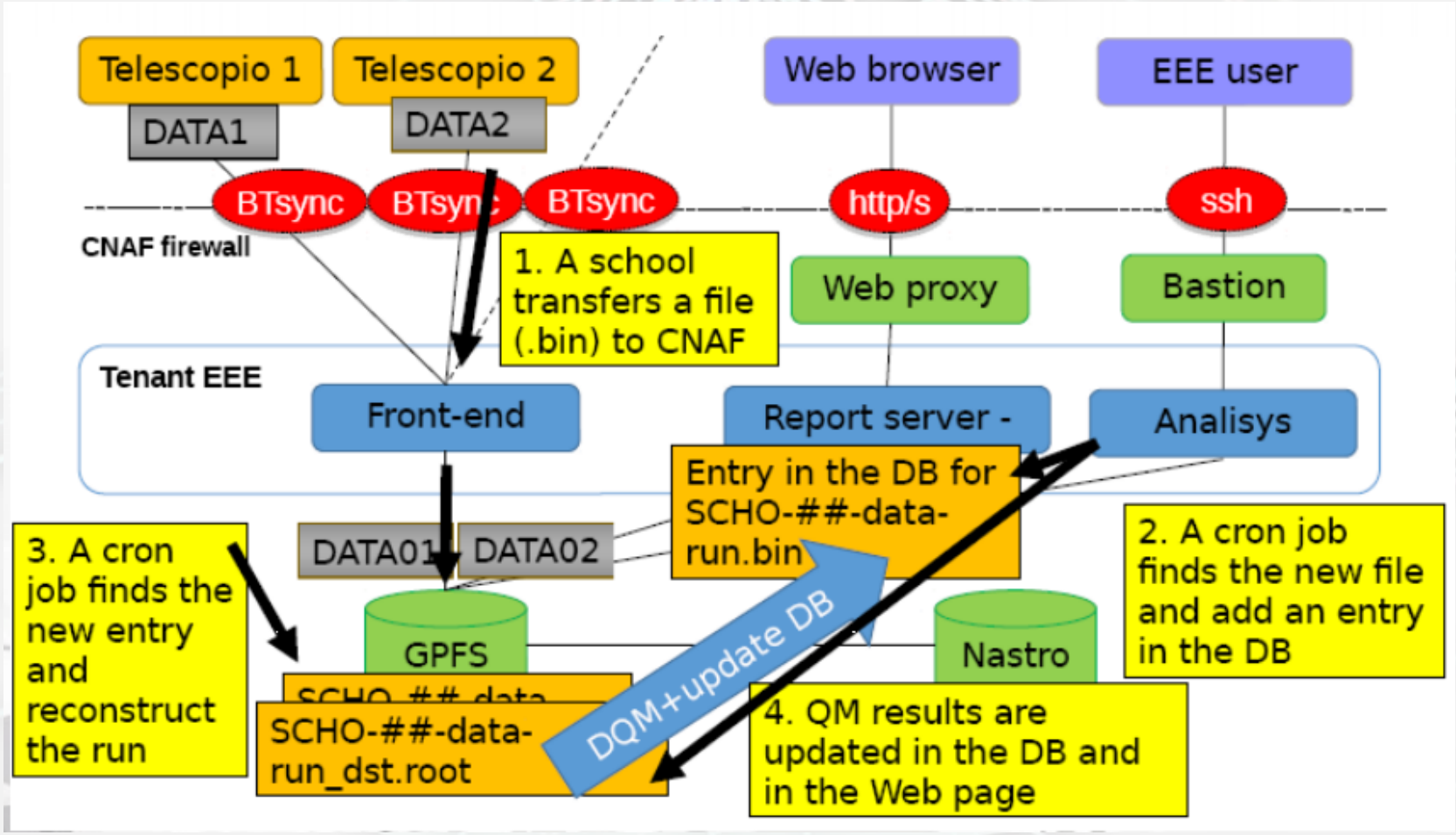
Telescope Monitor

Data Quality Monitor

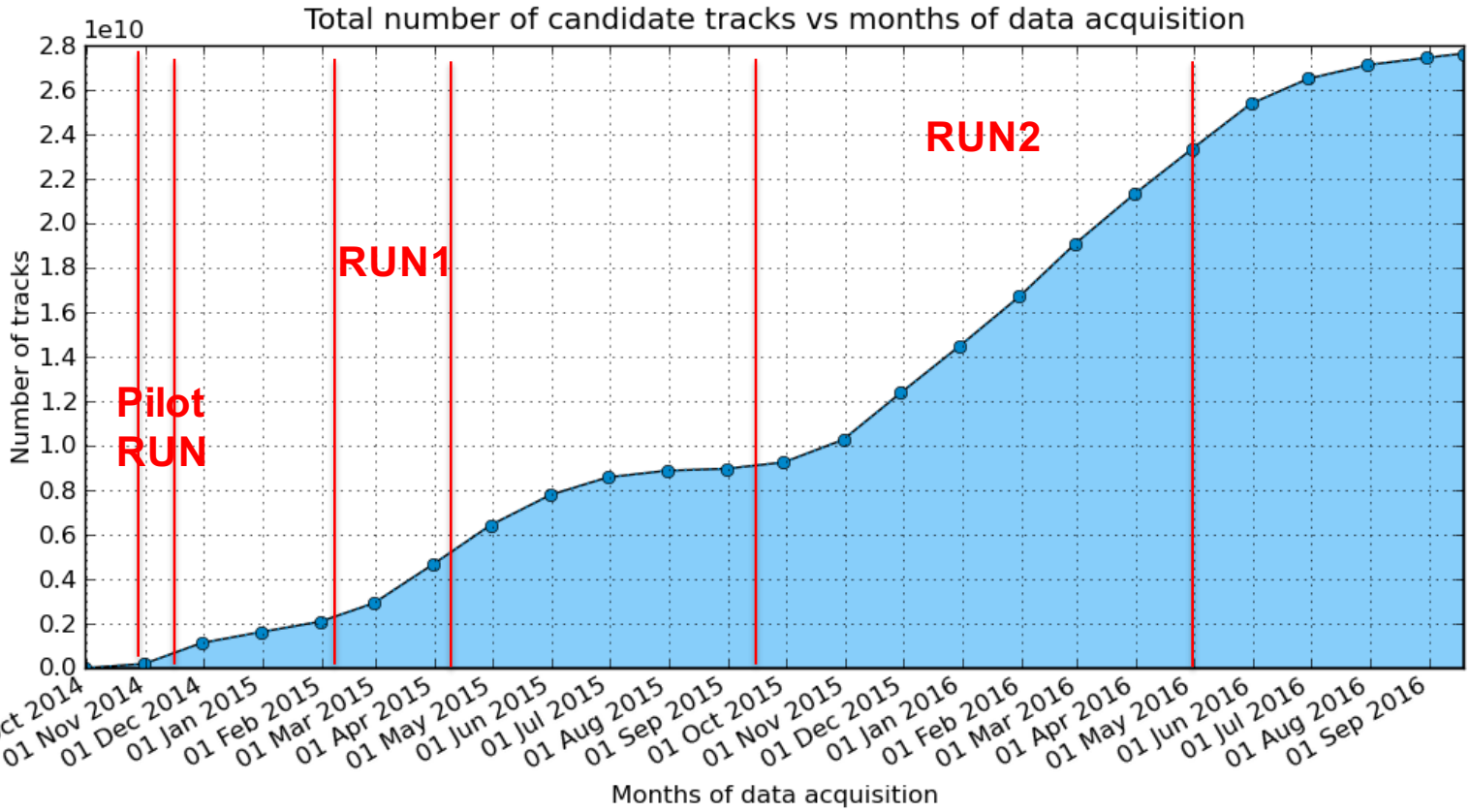




Data transfer schools → CNAF



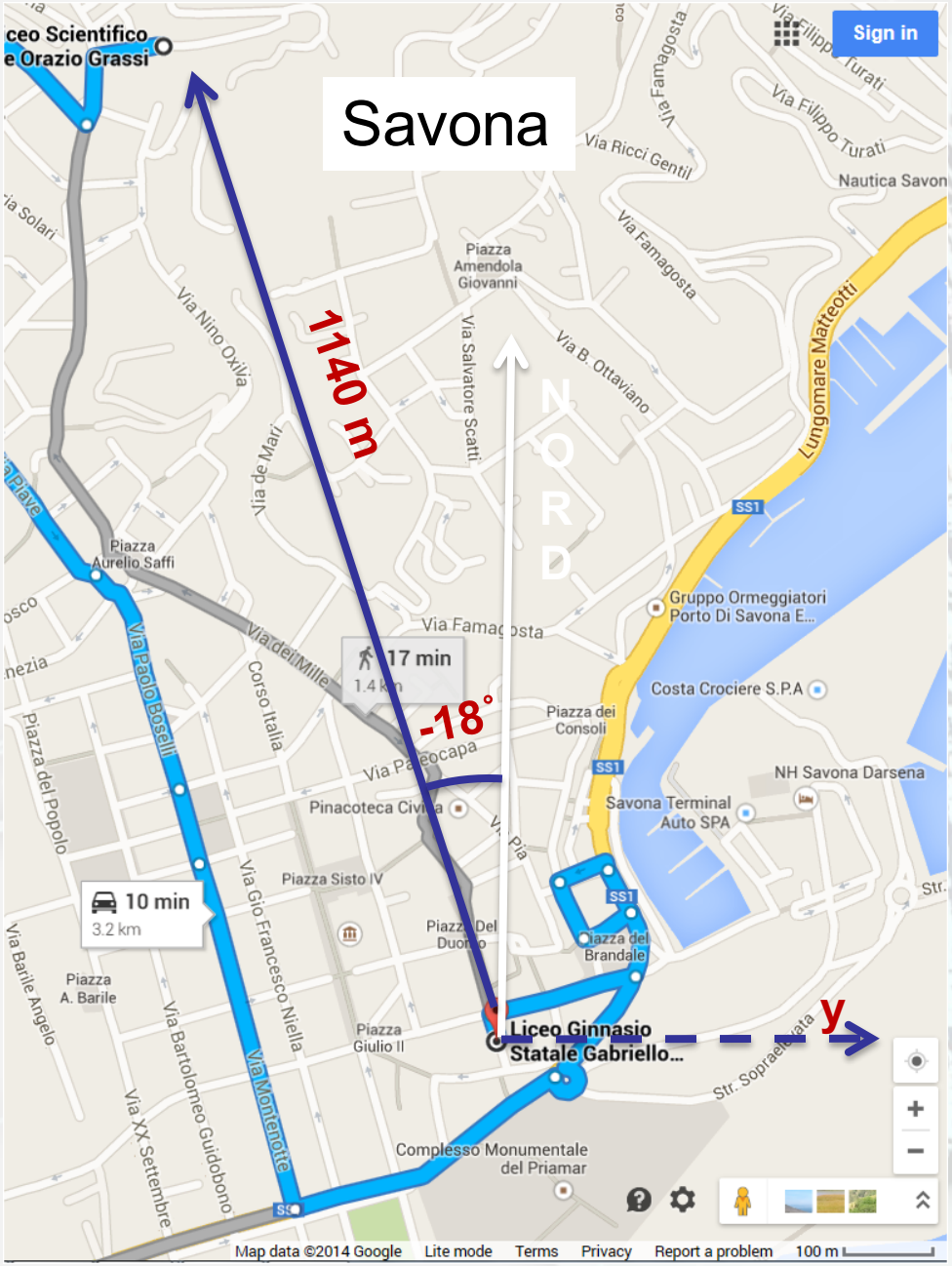
Total collected statistics

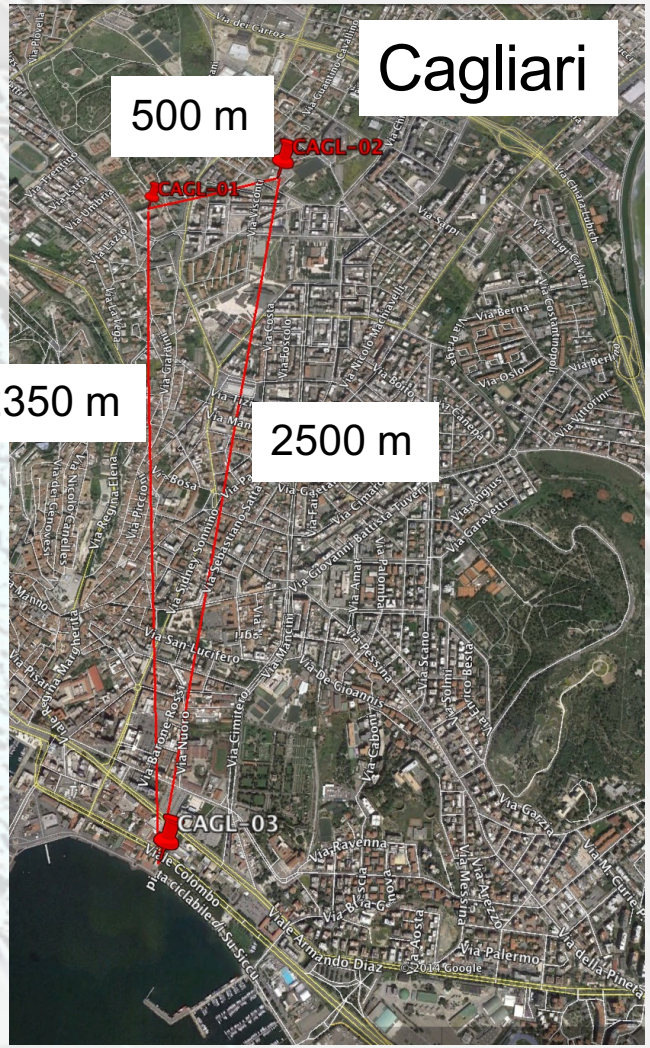


Observation of Extensive Atmospheric Showers

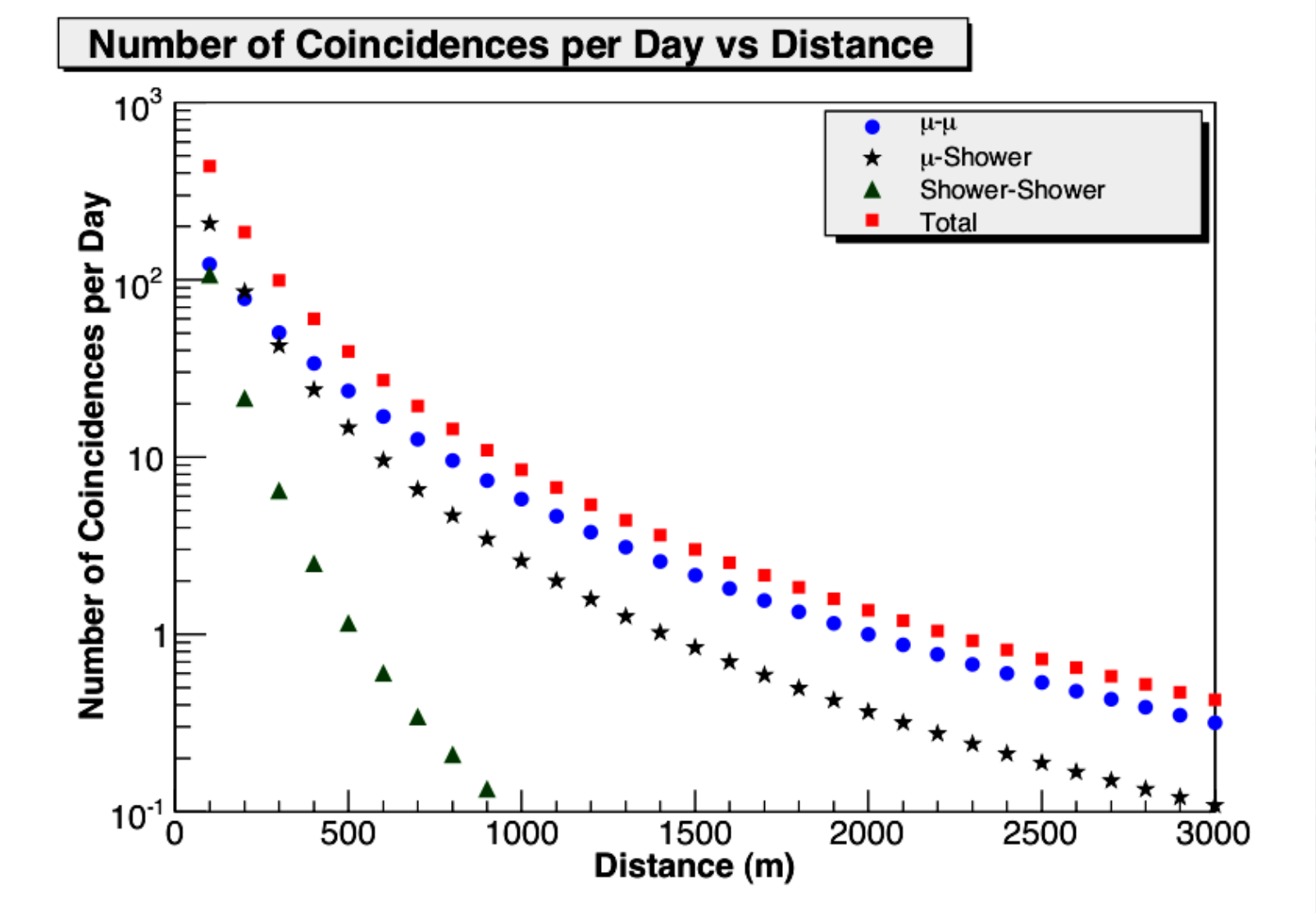
Telescopes distances range from few hundred meters for clusters of 2, 3 and 4 telescopes in the same city, to more than 1000 km for the farthest stations. Muons from the same EAS are detected by different stations.

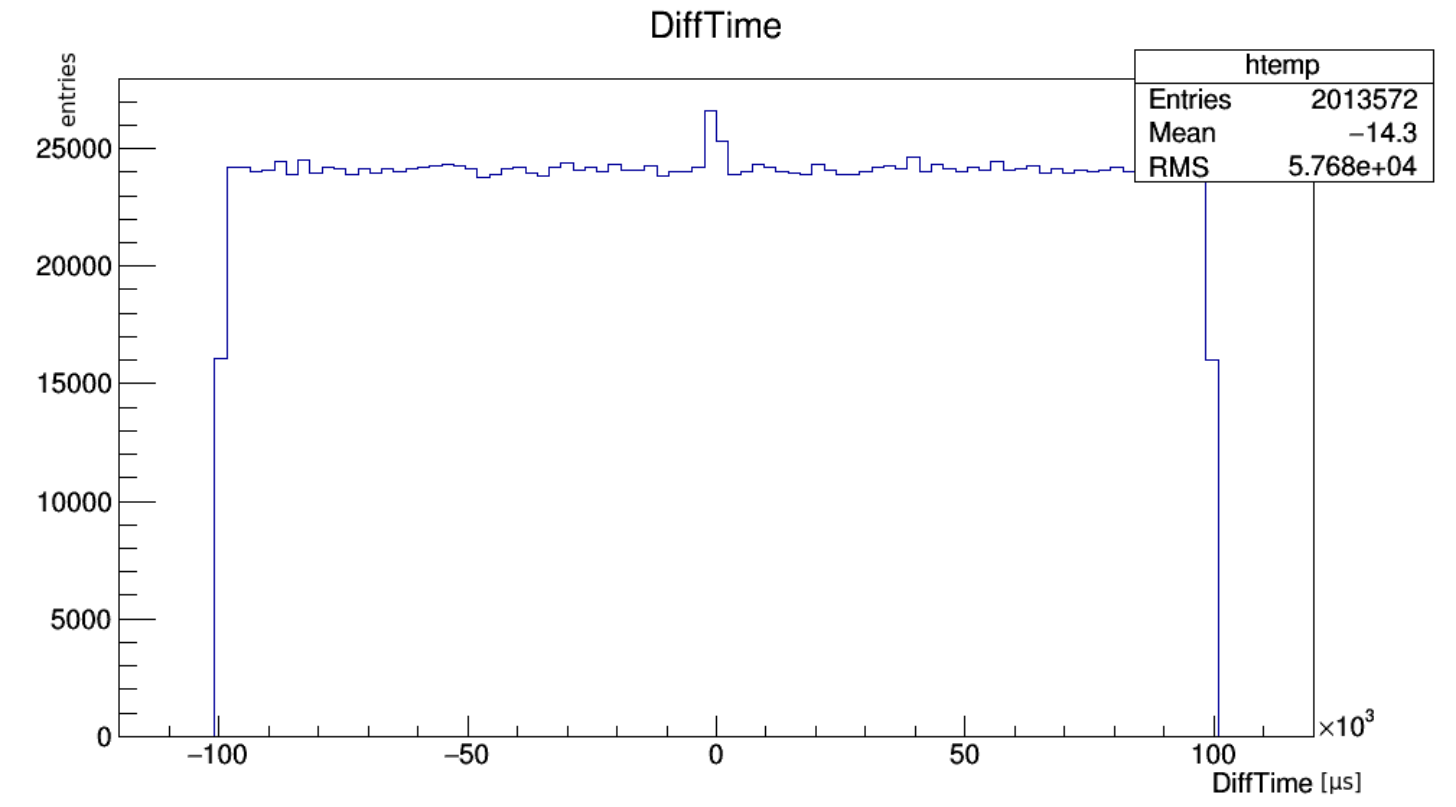
Telescopes location





Expected Coincidences (Montecarlo)

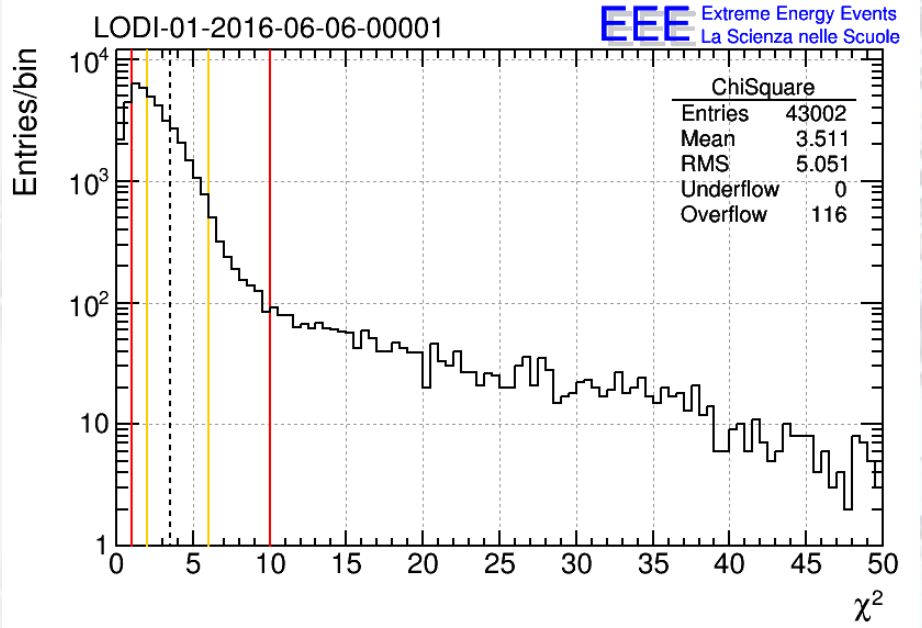


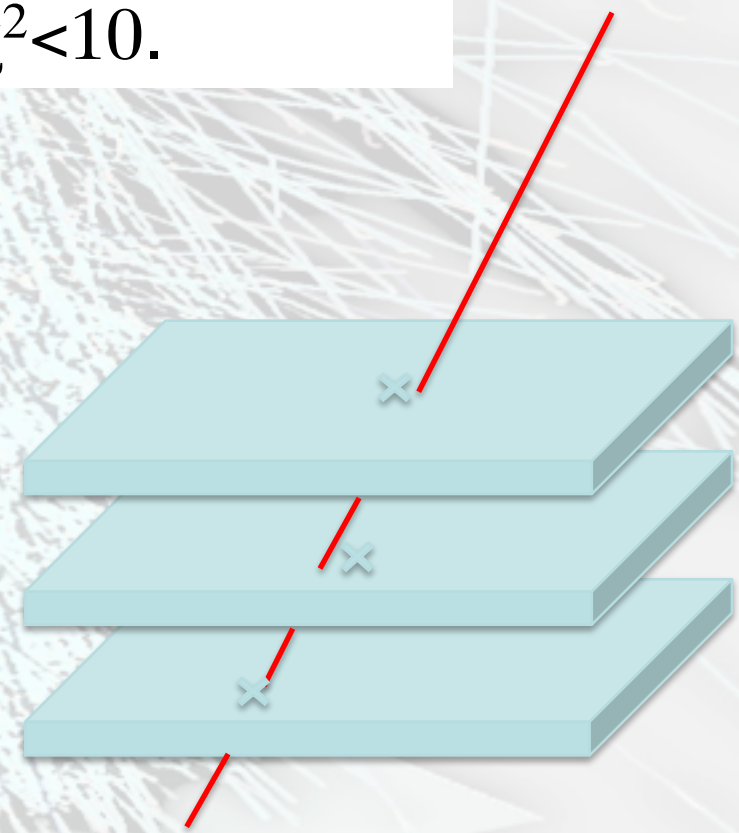


Raw time difference between CAGL-01 and CAGL-02. No cuts applied

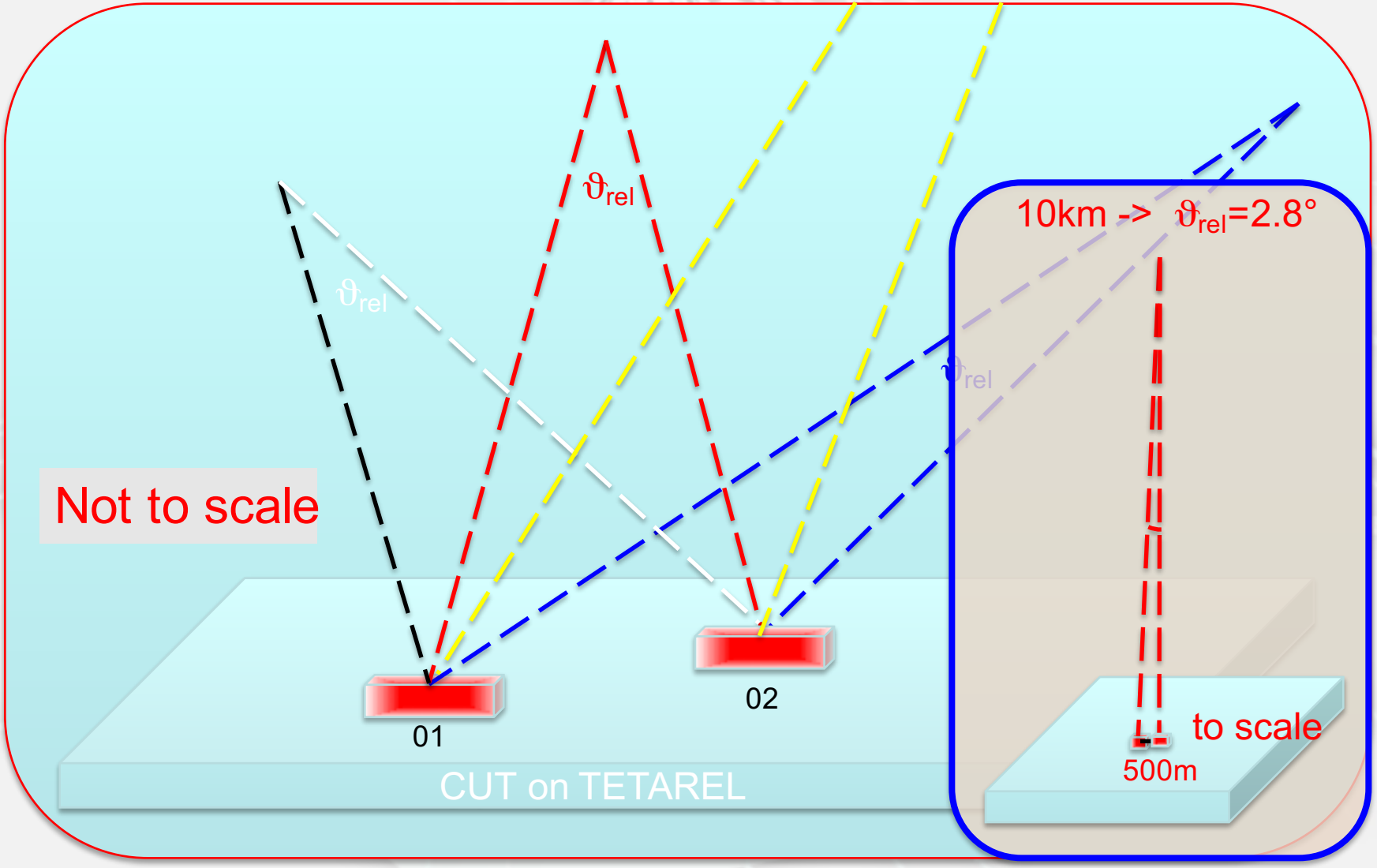
Data quality selection

First: are the tracks well reconstructed?
Choose only "good tracks" $\chi^2<10$.





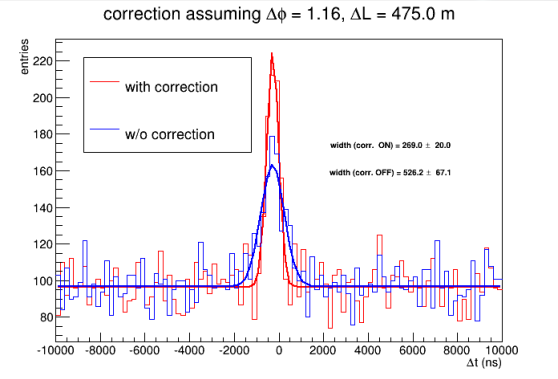
Second: cut on muon relative angle ϑ_{rel}



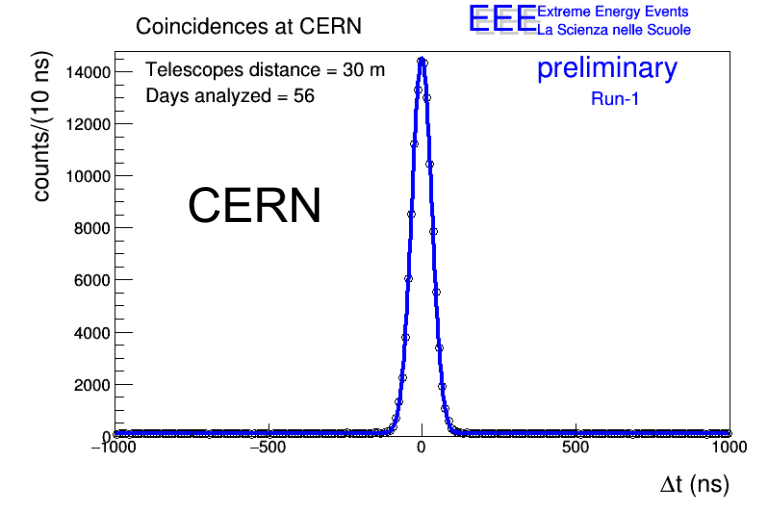
Correction on shower direction

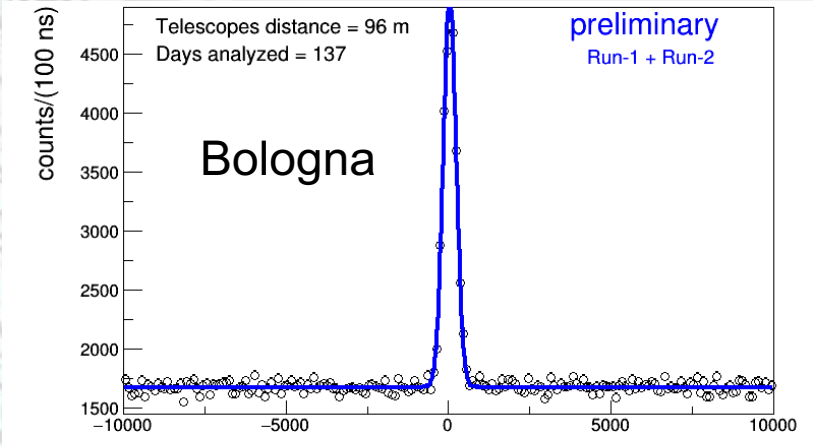
The correction is:

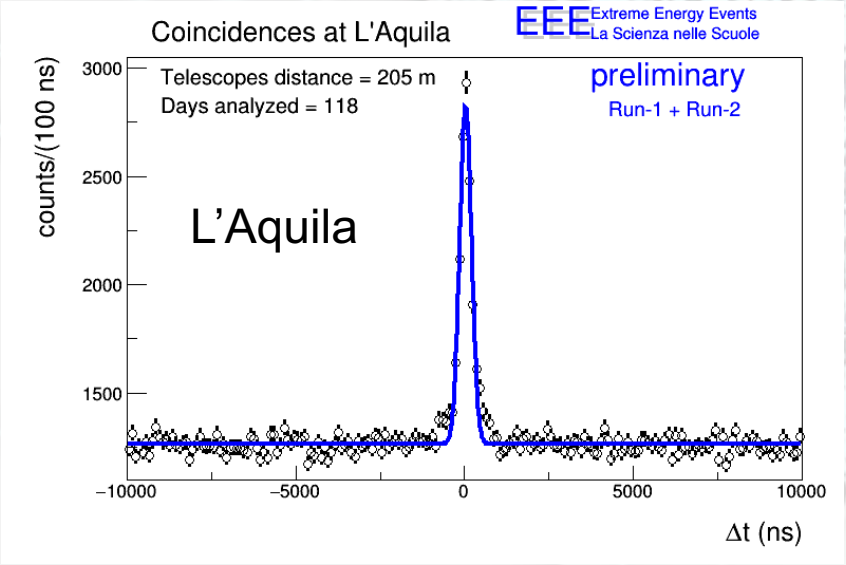
$\Delta t = \cos(\Delta\phi_{school} - \phi)\ \Delta L_{school}\ \sin\vartheta / c$

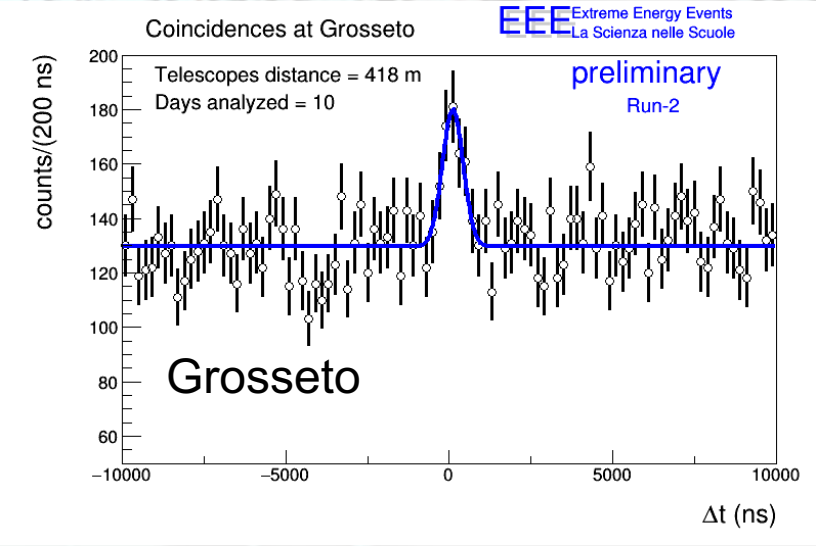


Two telescope coincidences

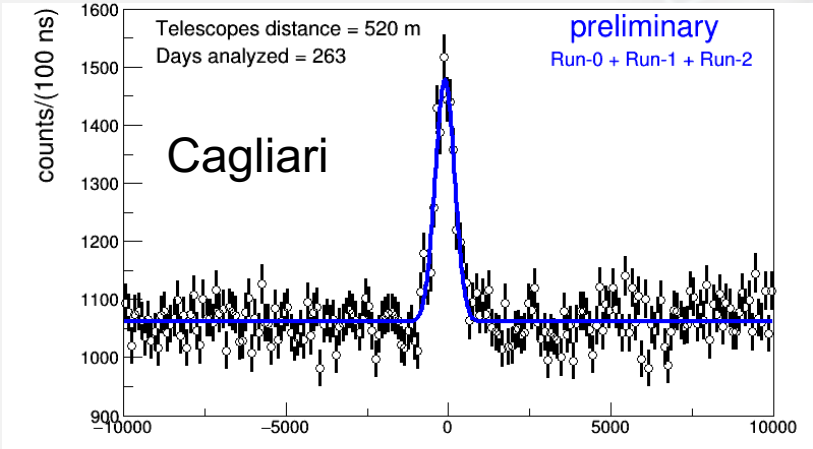


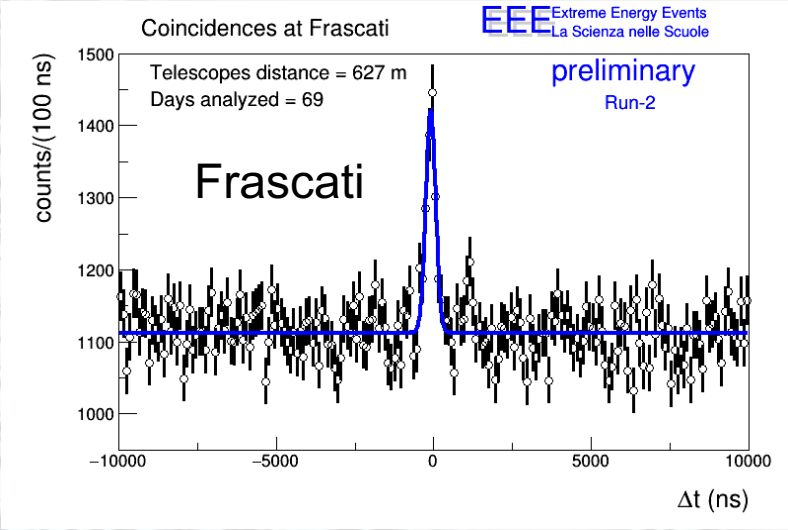


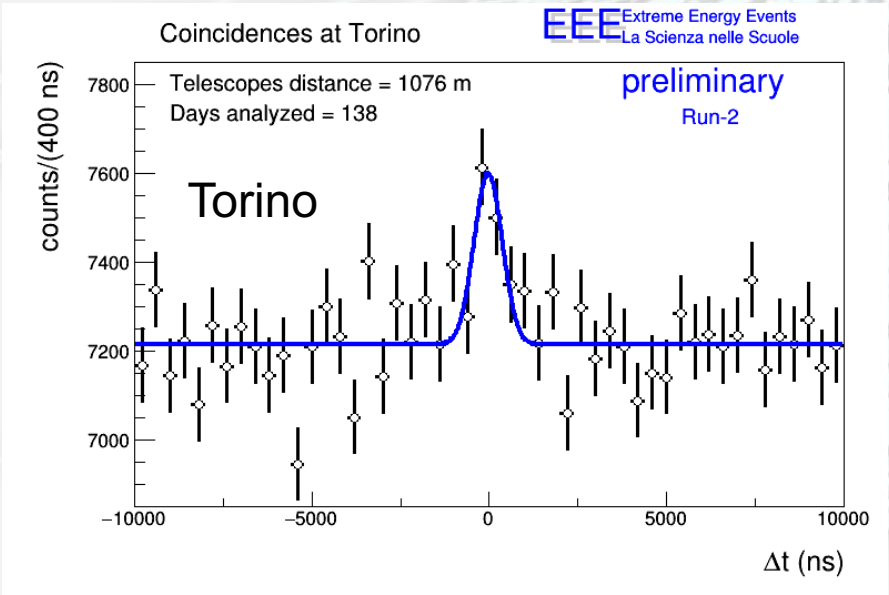


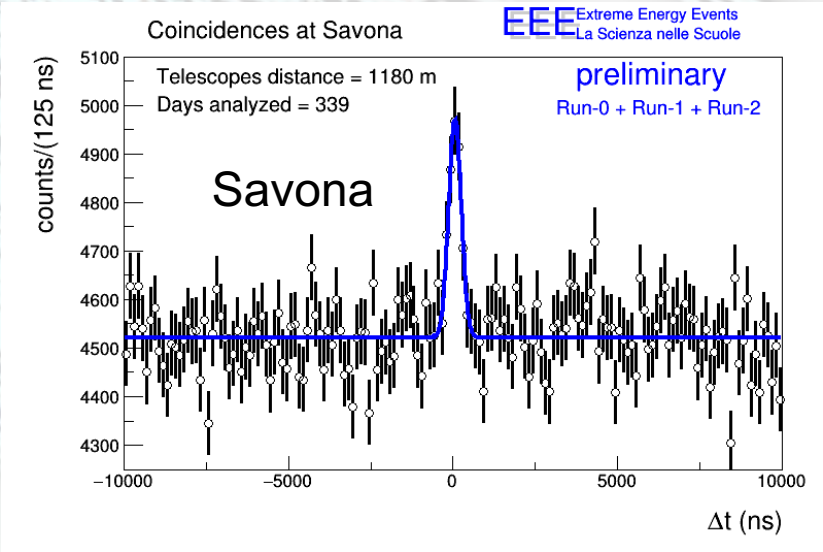


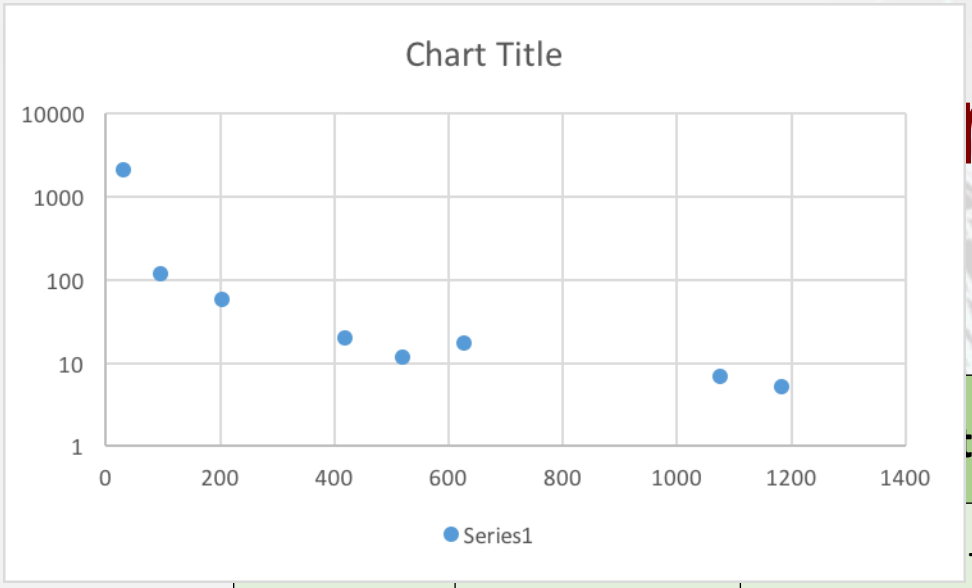
Two telescope coincidences











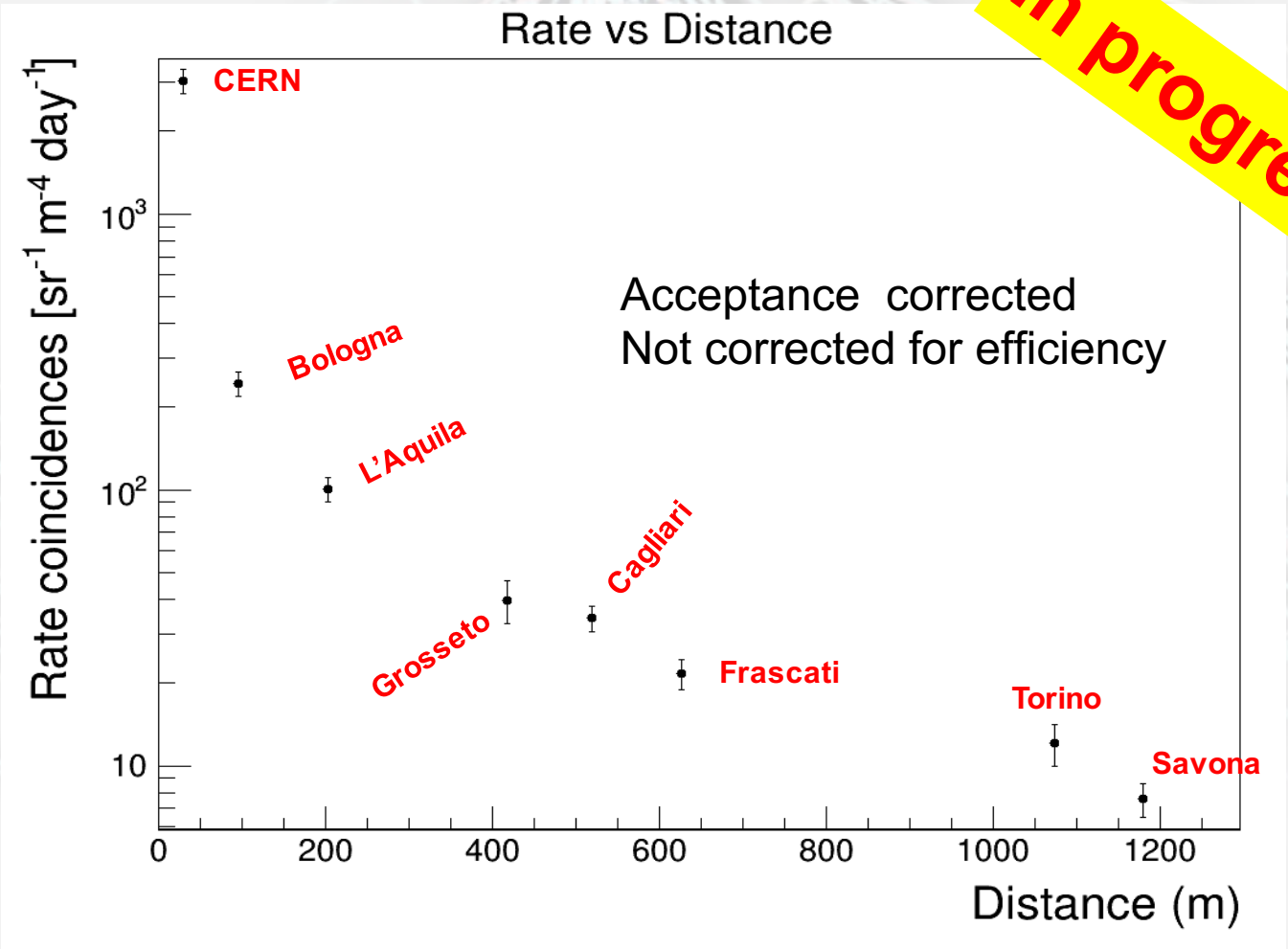
r day statistics

			Days	Events/Day
		735	56	2120
BOLO	96	16527,3	137	121
LAQU	204	6938,85	118	59
GROS	418	201,778	10	20
CAGL	520	3121,86	263	12
FRAS	627	1214,18	69	18
TORI	1076	966,912	138	7
SAVO	1182	1746,63	339	5

Preliminar acceptance evaluation for pair of telescopes

Telescope #1		Telescope#2		acceptance (m^4 sr)
	Plane distance (cm)		Plane distance (cm)	
CERN-01	88	CERN-02	88	0.88
BOLO-01	100	BOLO-02	120	0.62
LAQU-01	100	LAQU-02	100	0.73
GROS-01	110	GROS-02	110	0.62
CAGL-01	140	CAGL-02	140	0.43
FRAS-01	70	FRAS-02	88	1.02
TORI-01	100	TORI-02	100	0.73
SAVO-01	92	SAVO-02	87	0.86

Observed coincidences per day



To be analized

TORI-02 TORI-04 → 1165 m (57 days)

VIAR-01 VIAR-02 → 1344 m (159 days)

SAVO-01 SAVO-03 → 1367m (165 days)

TORI-02 TORI-03 → 1416 m (66 days)

SAVO-02 SAVO-03 → 1710 m (166 days)

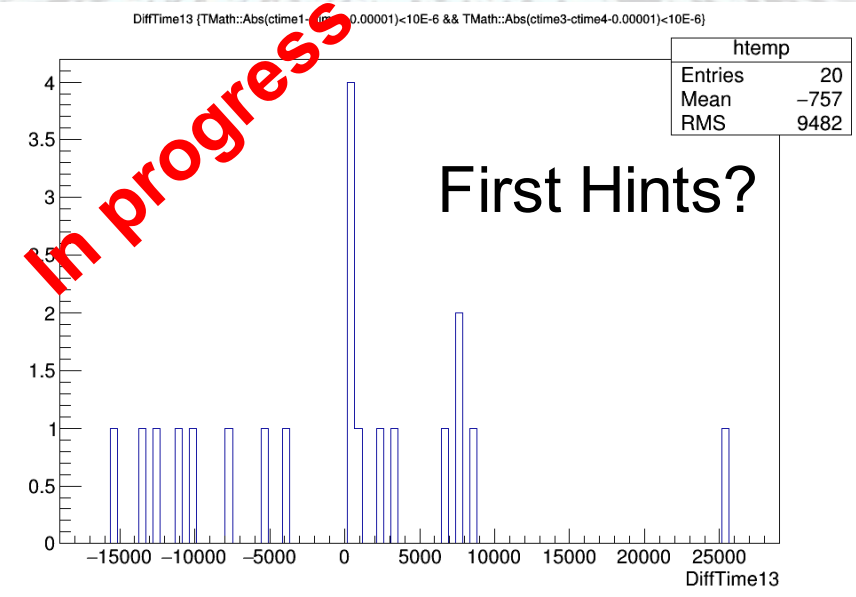
CAGL-01 CAGL-03 → 2350 m (150 days)

CAGL-02 CAGL-03 → 2517 m (133 days)

CATA-01 CATA-02 → 3034 m (67 days)

Ongoing work: three telescope coincidences

- Small signal, but strong background reduction
- Need for high statistics, very good working stability, accurate selection



Outlook

- Next data taking: RUN3, starting on Oct 14th. Duration foreseen; 9 months
- All the 52 telescopes active
- Same distance between telescope planes →50 cm

Stay tuned

eee.centrofermi.it

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Progetto Extreme Energy Events (EEE)
La Scienza nelle Scuole

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Gli studenti dell'IISS Staffa di Trinitapoli mentre lavorano sul telescopio

Extreme Energy Events (EEE) - La Scienza nelle Scuole

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Il Progetto EEE – La Scienza nelle Scuole consiste in una speciale attività di ricerca, in collaborazione con il CERN, l'INFN e il MIUR, sull'origine dei raggi cosmici, condotta con il contributo determinante di studenti e docenti degli Istituti Scolastici Superiori.

In ciascuna delle scuole aderenti al Progetto viene costruito un "telescopio" fatto con i più moderni e avanzati rivelatori di particelle (Multigap Resistive Plate Chambers, MRPC), da mettere in coincidenza tramite strumentazione GPS con i telescopi di altre scuole allo scopo di rivelare i muoni cosmici e gli sciami estesi, grandi anche quanto intere cittadine o più, prodotti dai raggi cosmici primari di più alta energia.

Ai ragazzi viene dato, inoltre, l'importantissimo compito della costruzione degli stessi rivelatori a partire da elementi di base, affinché si rendano conto di come si possa passare da materiali poveri a strumenti di altissima precisione. La costruzione dei rivelatori avviene nei laboratori del CERN, nei luoghi più esclusivi della ricerca più avanzata, che vengono resi a tale scopo accessibili ai ragazzi.

Attualmente risultano operative o prossime all'operatività tutte le stazioni realizzate (40) presso le scuole ed è in

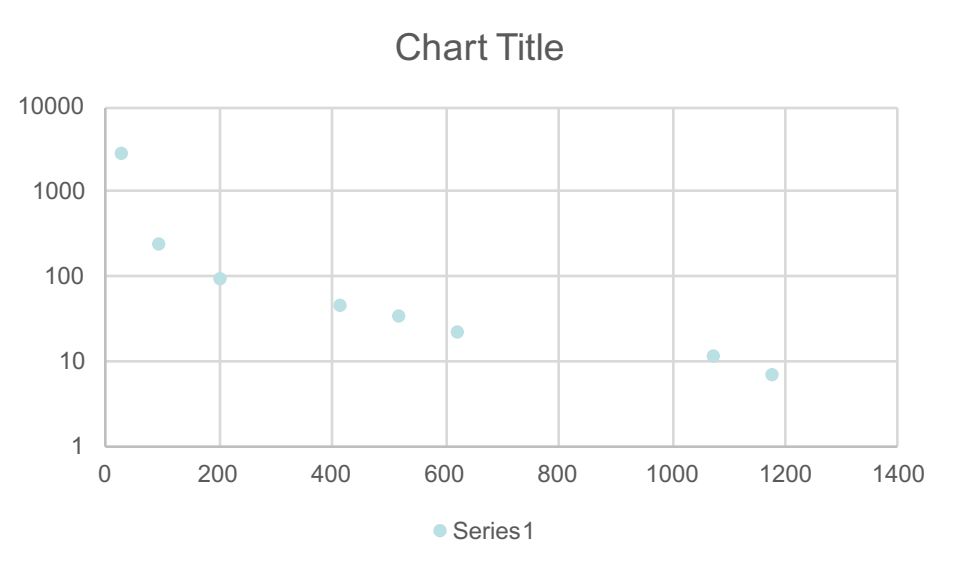
EEE News

E' entrato in funzione il telescopio EEE del Liceo Scientifico Enrico Fermi di Paternò

IISS Staffa di Trinitapoli: gli studenti al lavoro per sistemare il telescopio di EEE

E' entrato in funzione il Telescopio EEE del Liceo Statale Duca degli Abruzzi di Treviso

THANKS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Series1