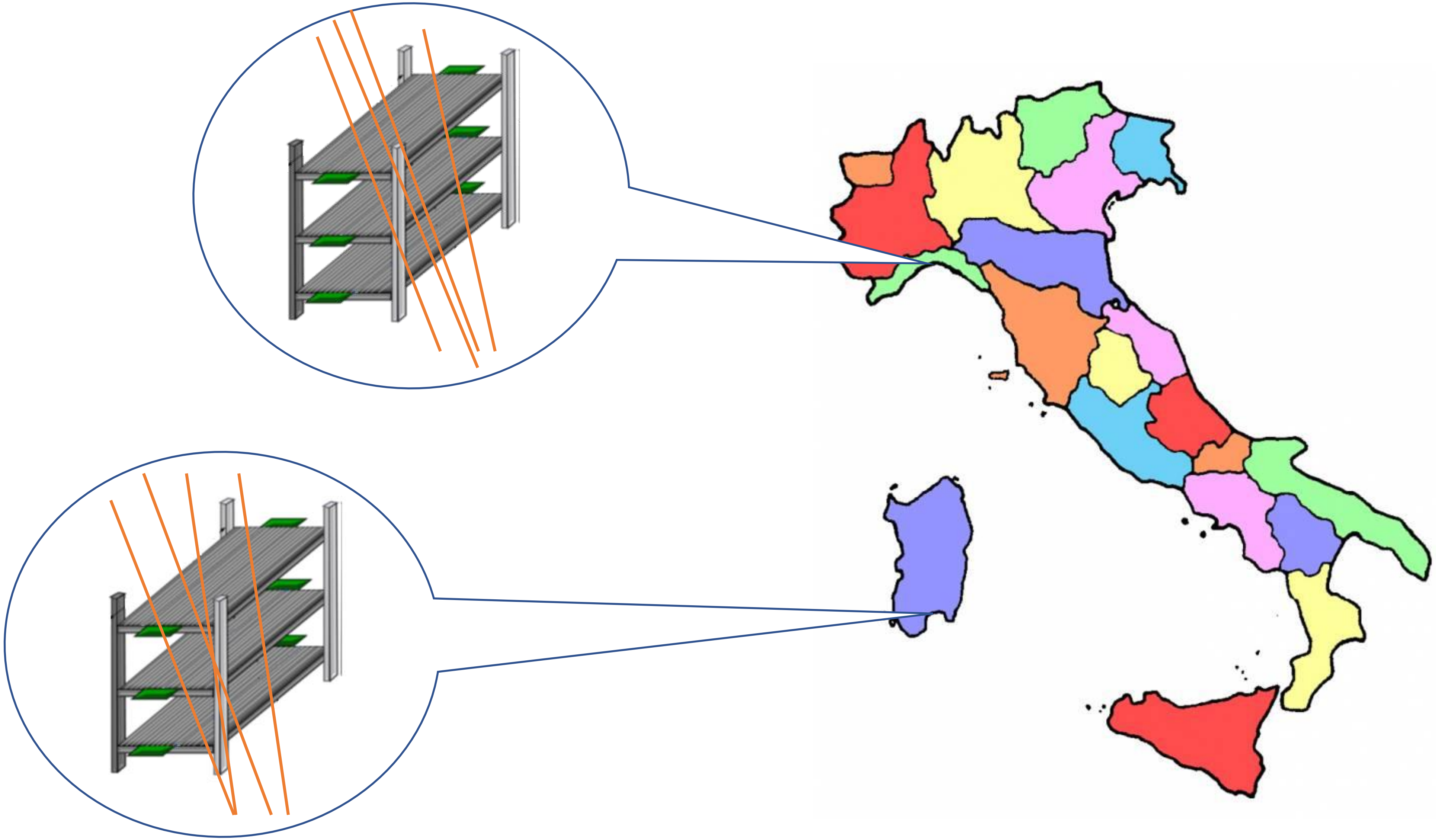
Search for long distance correlations from multi-track events

Team: Paola La Rocca
Chiara Pinto
Silvia Pisano
Franco Riggi

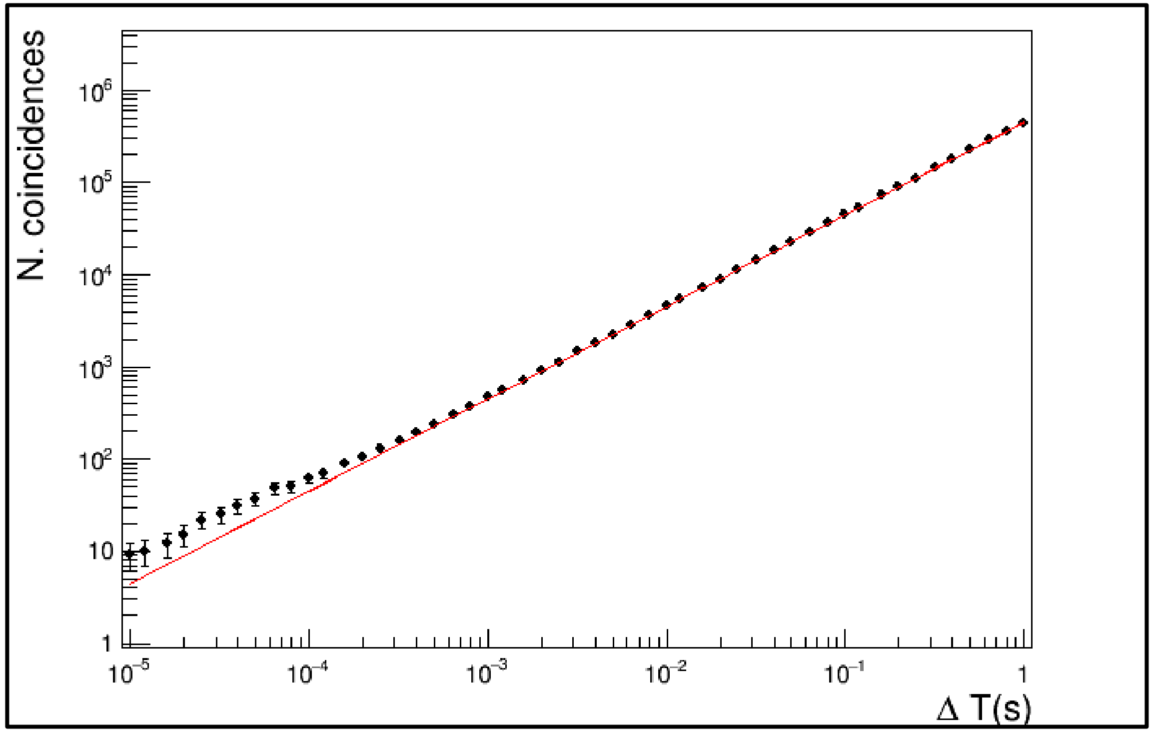
EEE Meeting – April 7th, 2021

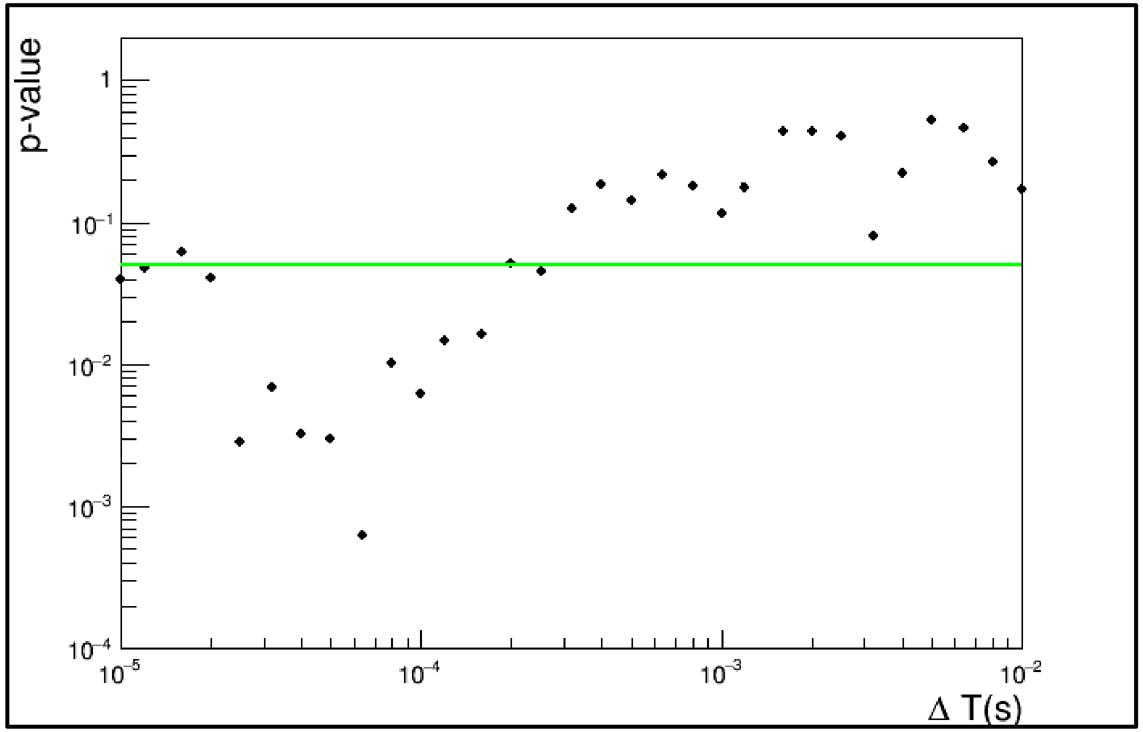
Long distance correlations between multi-tracks events



Latest results presented on March 5th, 2021

CUTS:
Distance between telescopes > 5 km
Number of tracks per event > 3

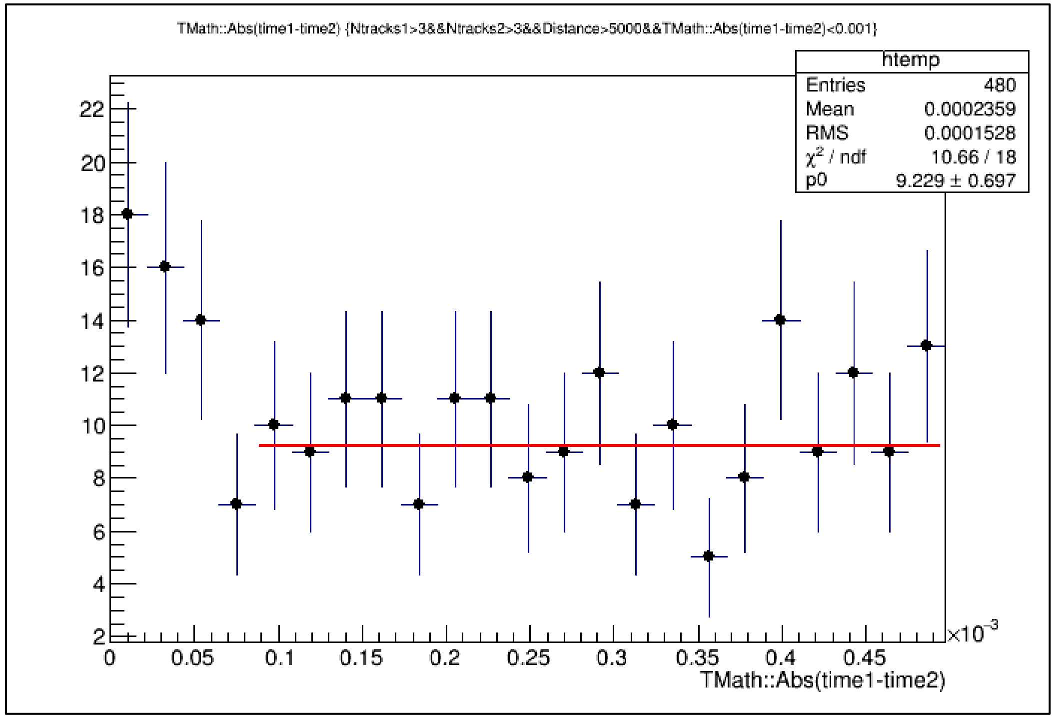




For $\Delta T = 6.4 \times 10^{-5}$ s → **48 (total) – 29 (background) = 19 (signal) ± 9**

Latest results presented on March 5th, 2021

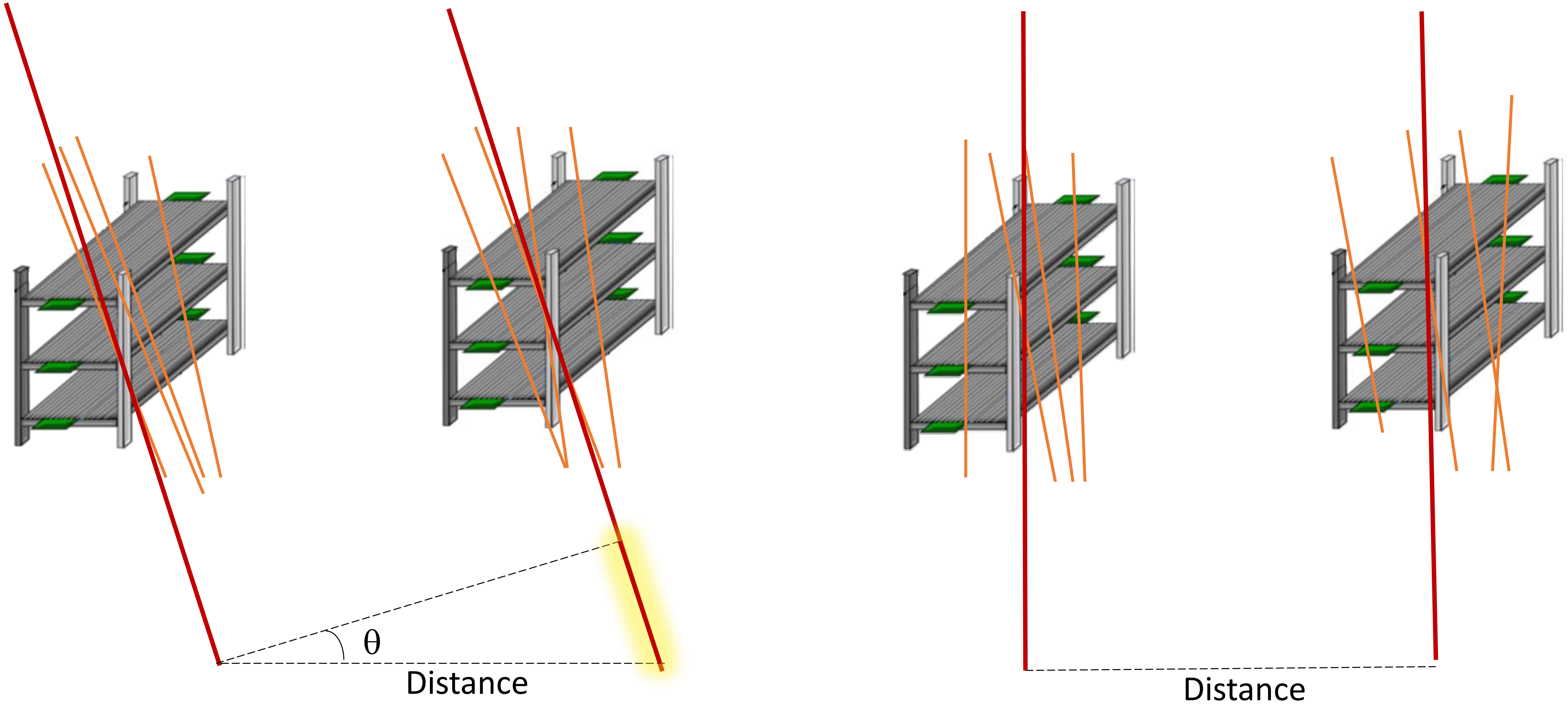
CUTS:
Distance between telescopes > 5 km
Number of tracks per event > 3



For $\Delta T = 8 \times 10^{-5}$ s $\rightarrow$ **55 (total) – 37 (background) = 18 (signal) ± 10**

Time correction for EASs orientation

If multi-tracks events are due to the simultaneous arrival of 2 parallel EASs, a time correction could be evaluated to take into account EASs orientation



Time correction for EASs orientation

We used a correction similar to that used for time coincidences between telescopes in the same town:

1. Average direction of EAS pair

phiAv = (phi1+phi2) / 2

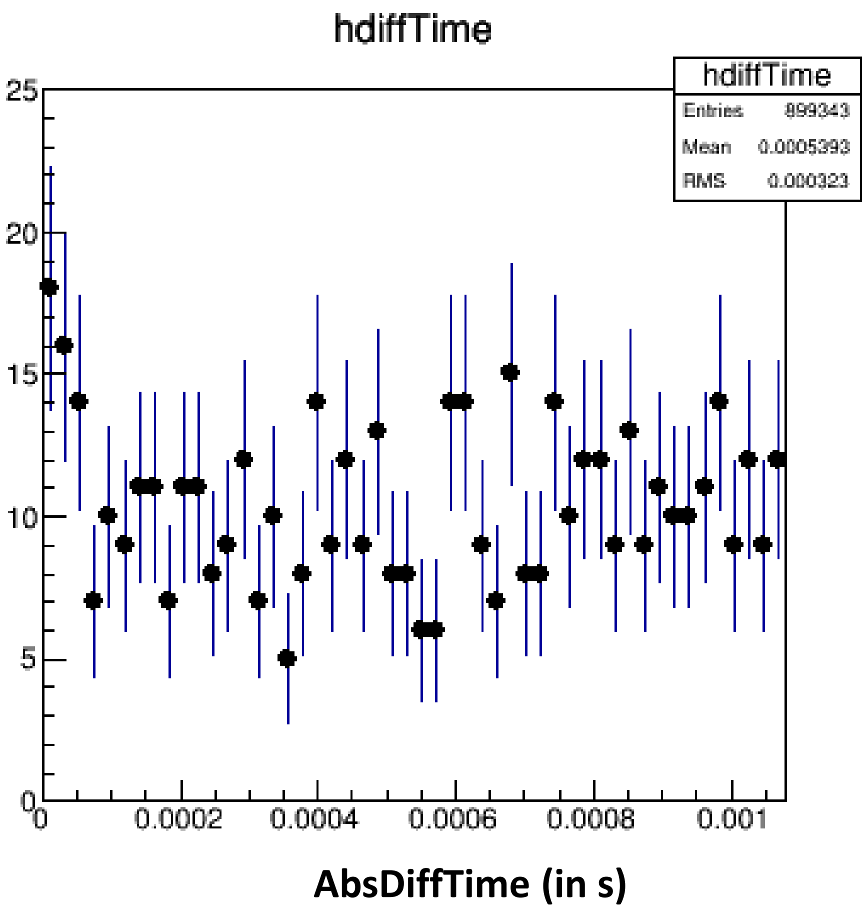
thetaAv = (theta1 + theta2) / 2

2. Time correction

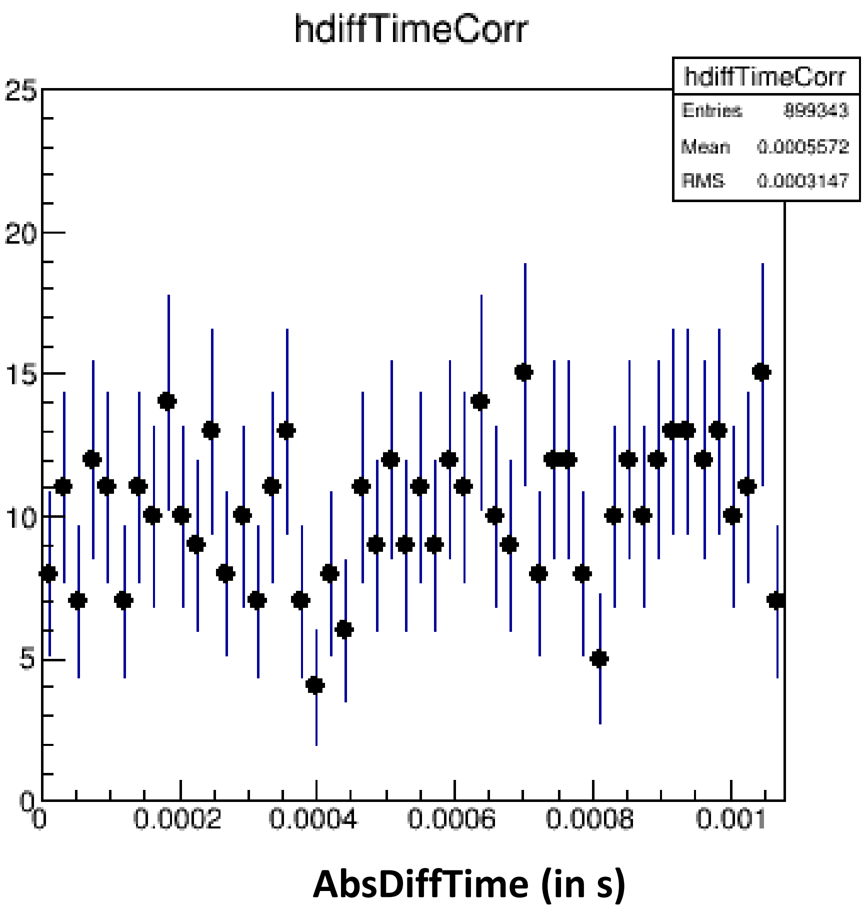
corr = Distance * Sin(thetaAv)*Cos(phiAv-Angle)/c

Time correction for EASs orientation

BEFORE THE CORRECTION



AFTER THE CORRECTION



Time correction for EASs orientation

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1. Average direction of EAS pair

phiAv = (phi1+phi2) / 2

thetaAv = (theta1 + theta2) / 2

→ phiAv and thetaAv evaluated from the direction cosines:

XDir = (XDir1 + XDir2) / Mod

YDir = (YDir1 + YDir2) / Mod

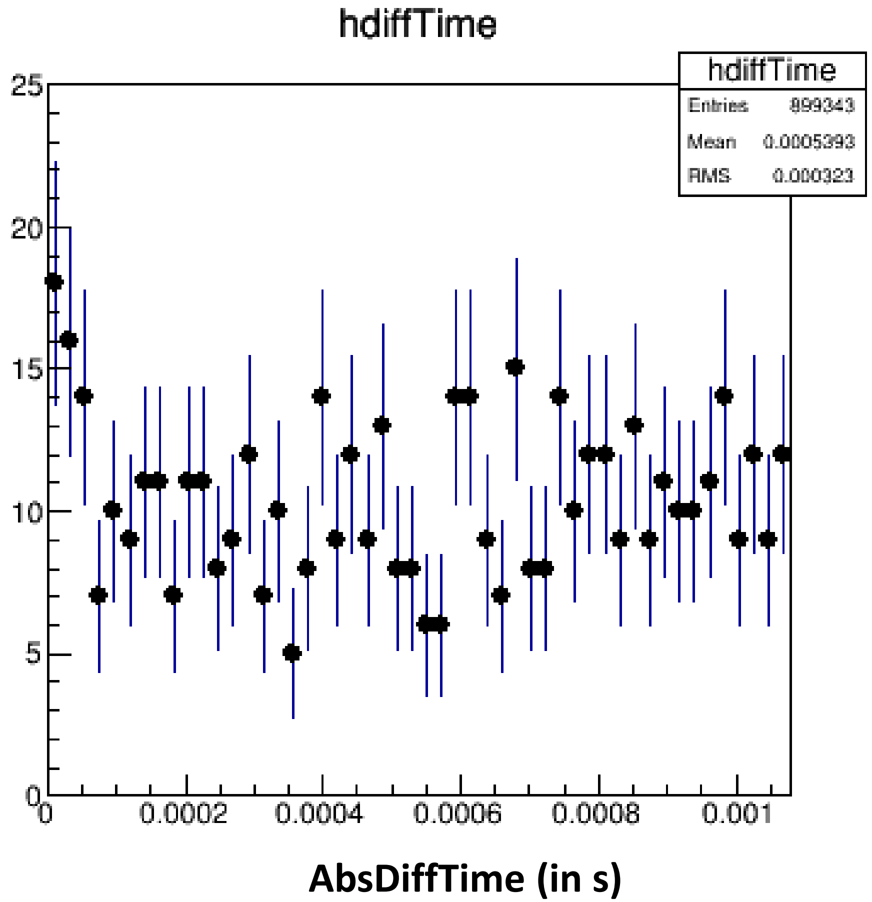
ZDir = (ZDir1 + ZDir2) / Mod

2. Time correction

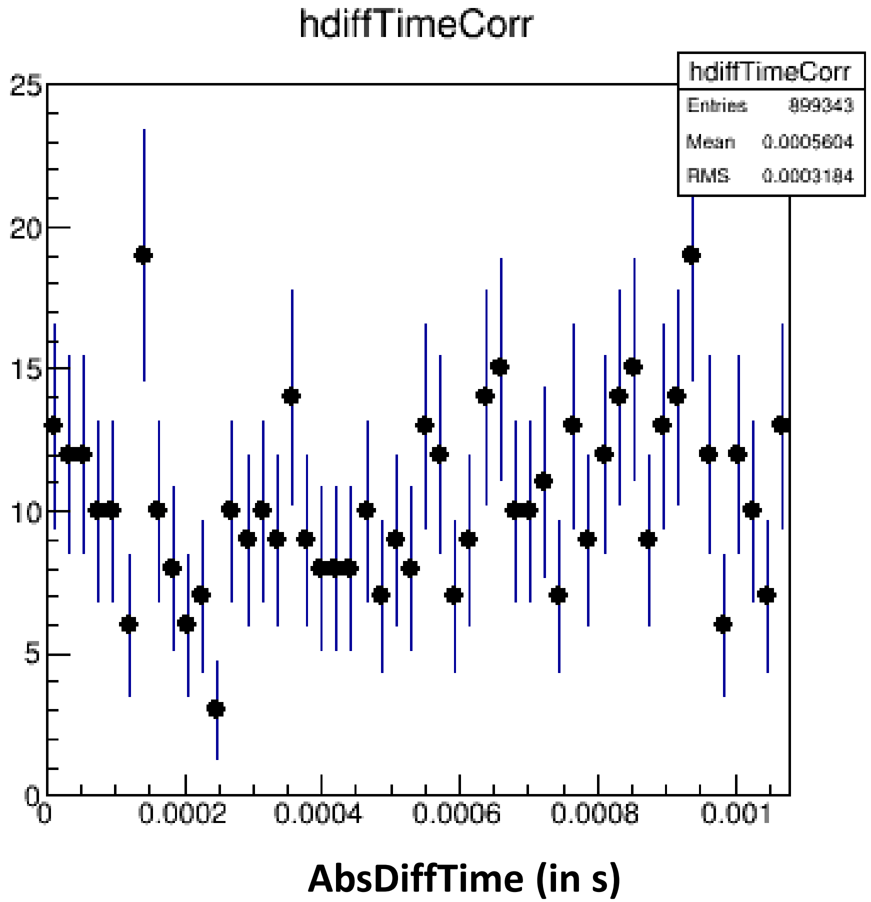
corr = Distance * Sin(thetaAv)*Cos(phiAv-Angle)/c

Time correction for EASs orientation

BEFORE THE CORRECTION

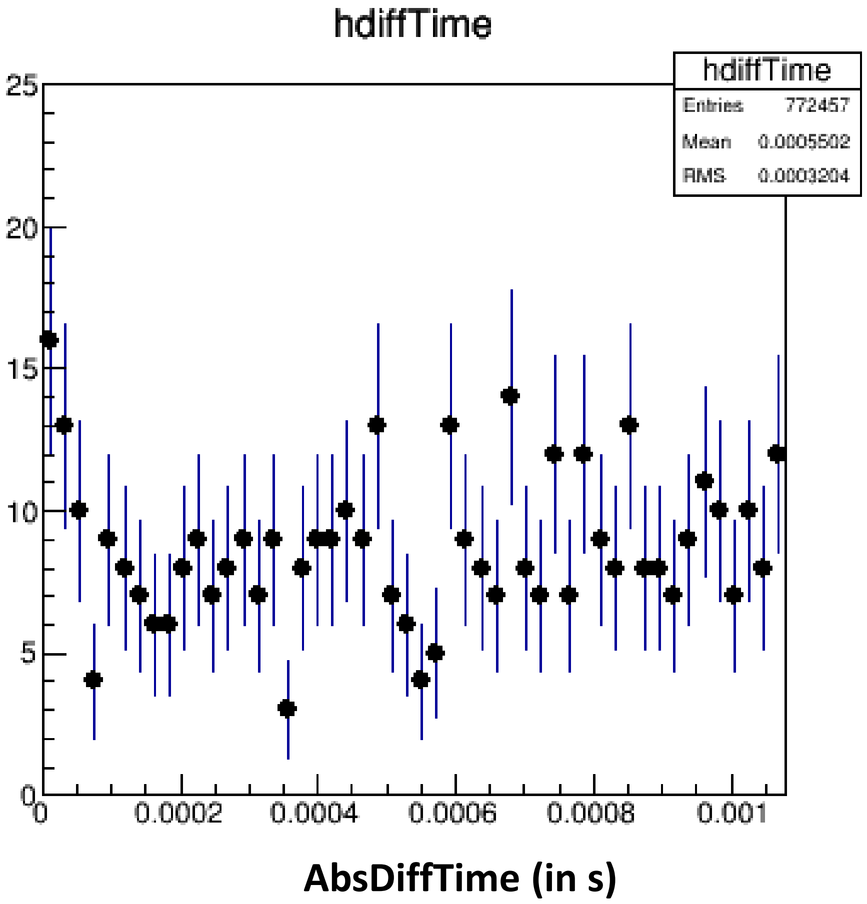


AFTER THE CORRECTION

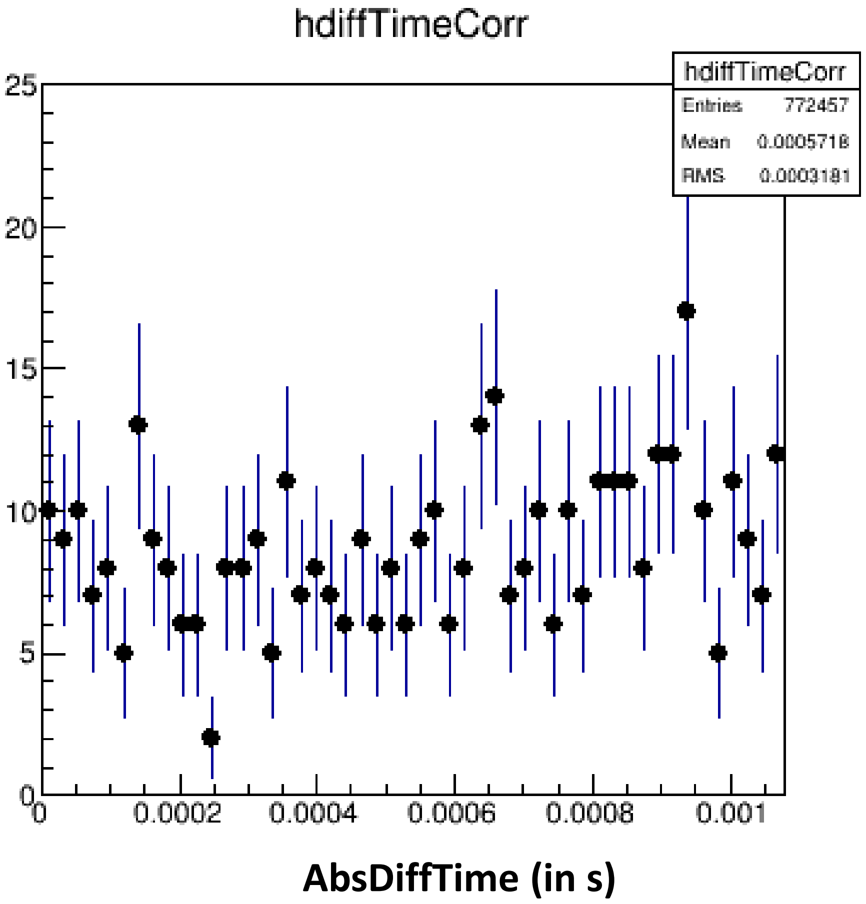


Time correction for EASs orientation

BEFORE THE CORRECTION

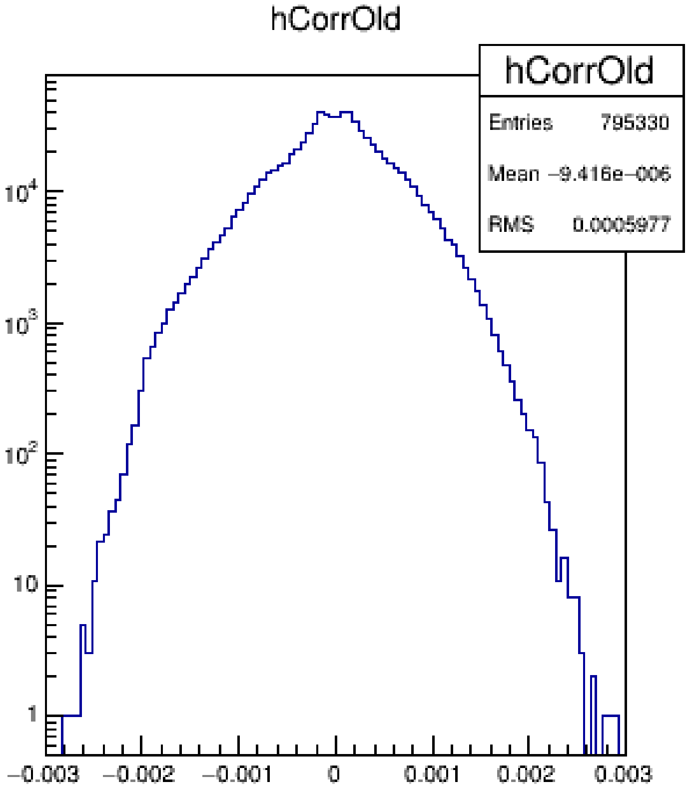


AFTER THE CORRECTION (thetaRel < 60°)

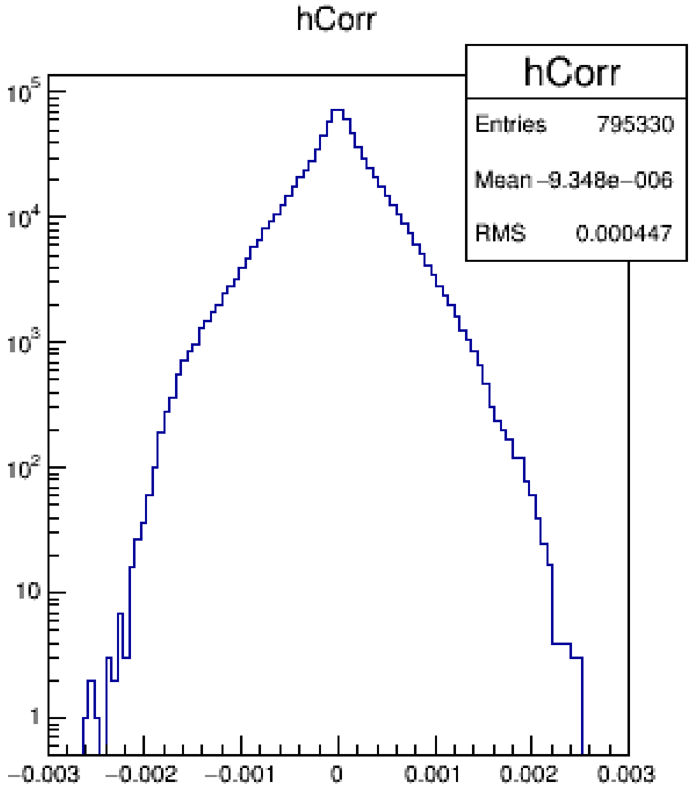


Time correction for EASs orientation

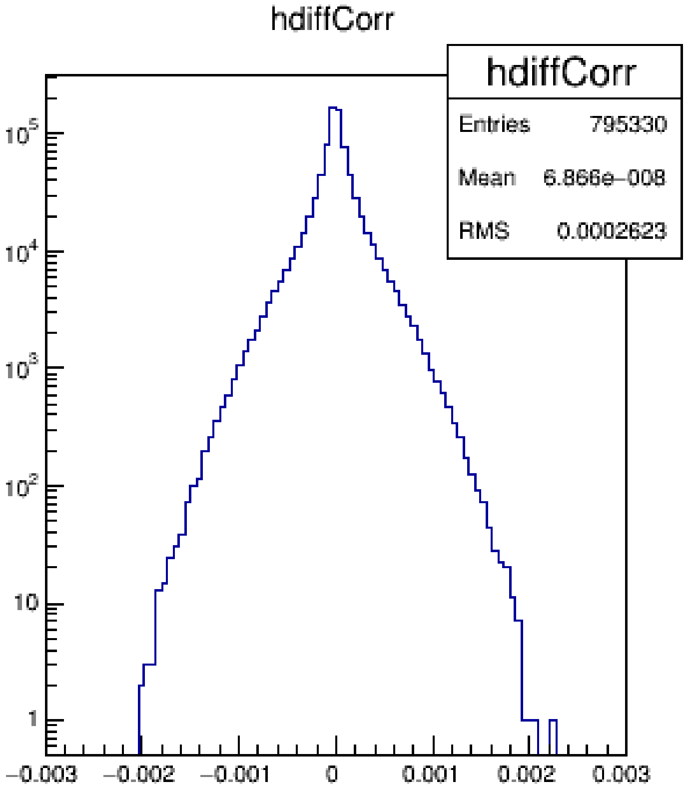
COMPARISON BETWEEN THE 2 CORRECTIONS



Time correction 1 (in s)



Time correction 2 (in s)



Time corrections difference (in s)

Time correction for EASs orientation

The applied time correction seems to worsen the observed excess of events…

Possible interpretations:

1. The recontruction of EAS orientation is not accurate enough
2. EASs are correlated in time but not in orientation (expected deflections due to solar and earth magnetic field)
3. The observed excess of events is due to something else (?)

In-depth analysis of the candidate events

48 candidate events selected ($\Delta T = 6.4 \times 10^{-5}$ s)

sch1	sch2	time1	date1	hh:mm:ss	time2	date2	hh:mm:ss2	distance	relative_angle(rad)
FRAS-03	TRIN-01	261683526,943458	17/04/2015	17:52:06	261683526,943417	17/04/2015	17:52:06	289258	0,1708
CAGL-03	CATZ-01	288836904,279929	26/02/2016	00:28:24	288836904,279960	26/02/2016	00:28:24	650125	0,0940
CATZ-01	SAVO-01	289764878,414078	07/03/2016	18:14:38	289764878,414026	07/03/2016	18:14:38	910627	0,5833
CAGL-03	SAVO-01	290287985,208677	13/03/2016	19:33:05	290287985,208674	13/03/2016	19:33:05	568909	0,8577
FRAS-02	LODI-01	290727088,805182	18/03/2016	21:31:28	290727088,805130	18/03/2016	21:31:28	464711	1,0761
SAVO-02	TORI-04	292339881,261160	06/04/2016	13:31:21	292339881,261122	06/04/2016	13:31:21	104566	0,1993
BOLO-01	SAVO-01	293118509,081264	15/04/2016	13:48:29	293118509,081205	15/04/2016	13:48:29	229219	1,0631
LODI-01	VIAR-02	294237880,247904	28/04/2016	12:44:40	294237880,247883	28/04/2016	12:44:40	171060	0,7658
GROS-01	TORI-03	295033469,292295	07/05/2016	17:44:29	295033469,292305	07/05/2016	17:44:29	377407	0,4807
ALTA-01	CAGL-03	295272116,589156	10/05/2016	12:01:56	295272116,589093	10/05/2016	12:01:56	657381	0,9469
LAQU-01	LODI-01	296193982,644303	21/05/2016	04:06:22	296193982,644324	21/05/2016	04:06:22	453547	0,3313
BOLO-01	CATZ-01	296476165,716021	24/05/2016	10:29:25	296476165,715983	24/05/2016	10:29:25	767467	0,1906

Created a macro to:

- Retrieve dst files containing the selected events @CNAF
- Select and store a subset of events (+/- 300 sec) around each candidate event

In-depth analysis of the candidate events

Reliability of the GPS tagging

1. Gamma functions

For each candidate event, the distribution of the time difference between event *i* and event *i*-1 (or *i*-2 or *i*-3) was evaluated.

This time difference distributions are theoretically described by gamma functions:

$$\frac{dP}{dt} = \frac{\lambda^n t^{n-1}}{(n-1)!} e^{-\lambda t}$$

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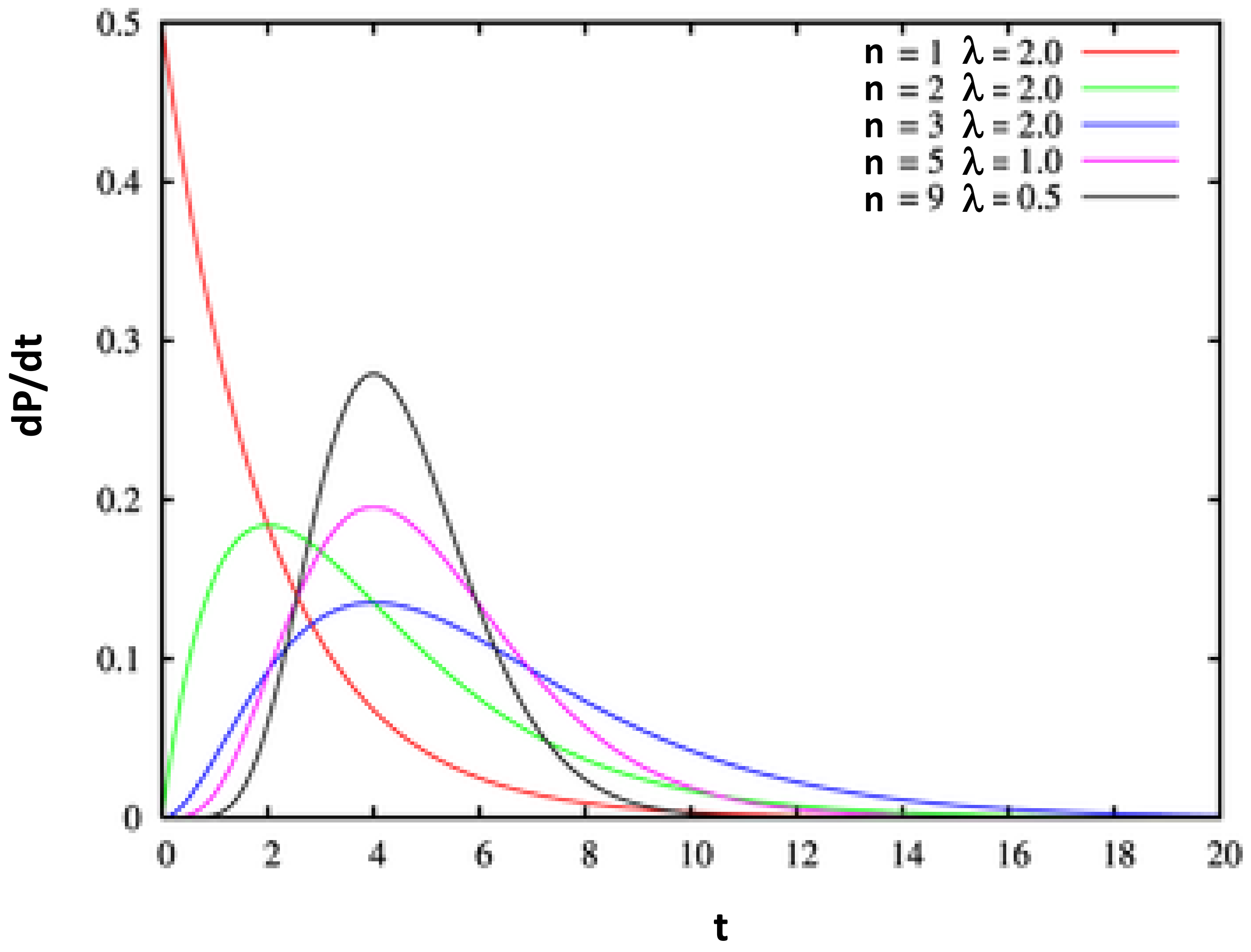

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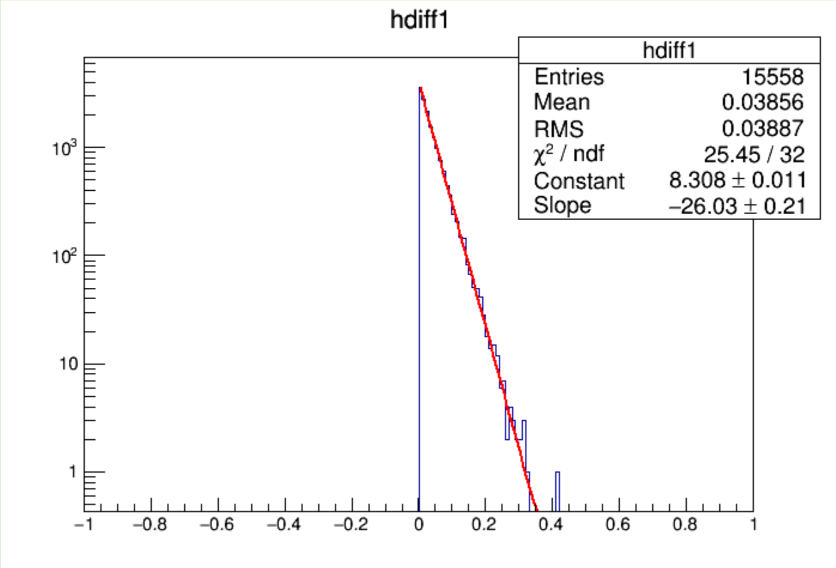
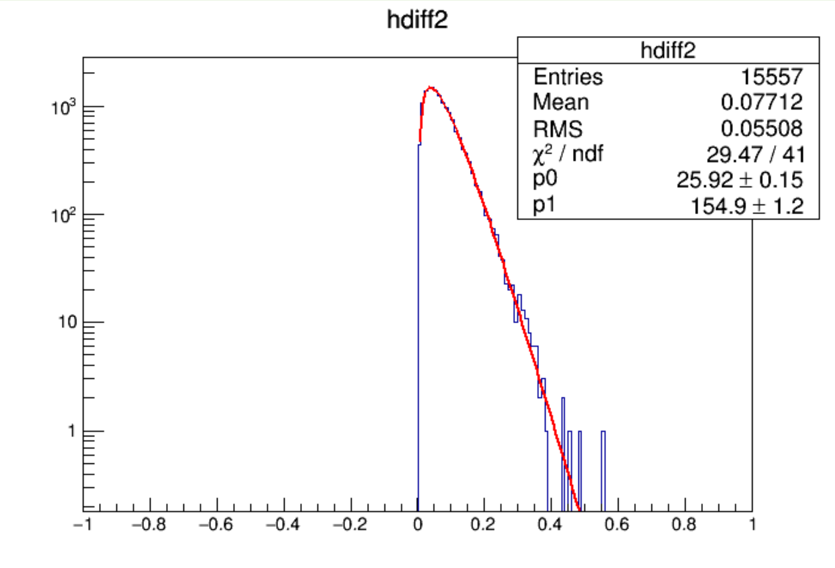
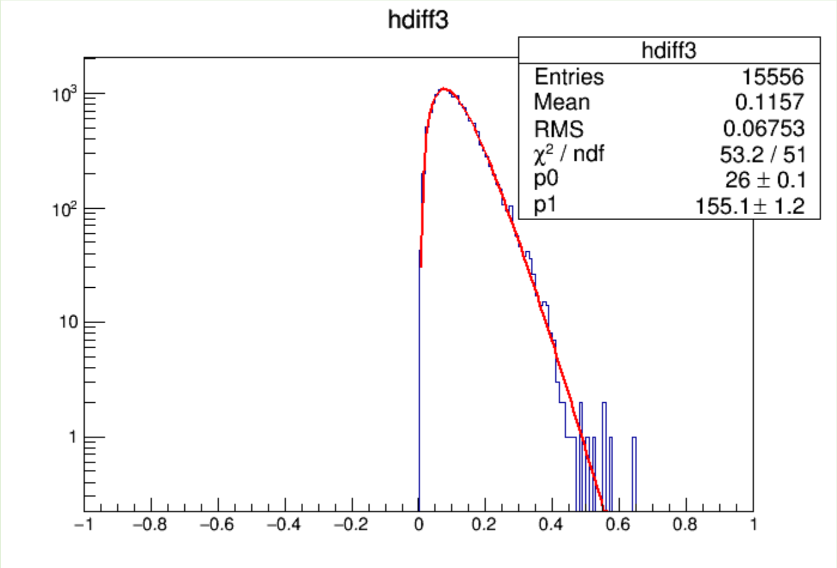


$T_i - T_{i-1}$



$T_i - T_{i-2}$



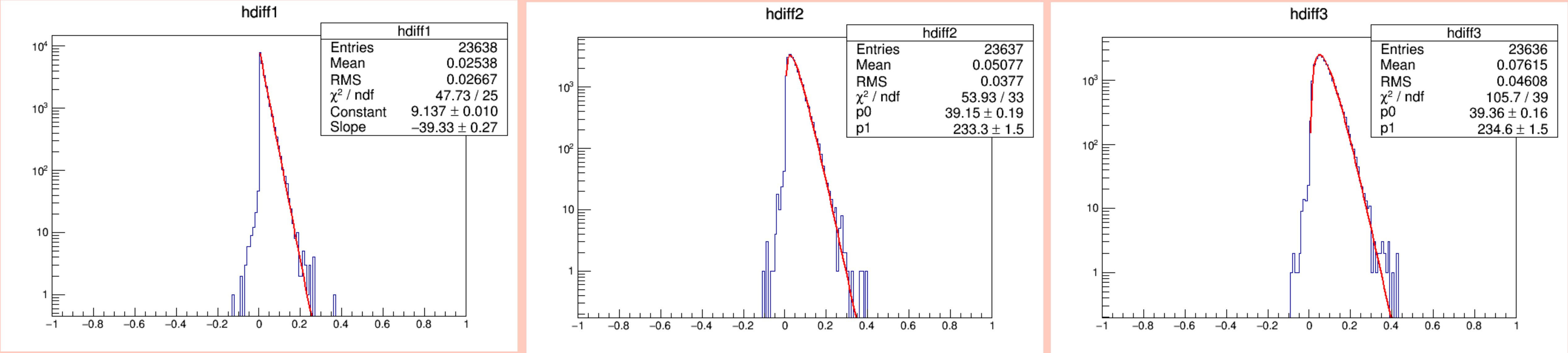
$T_i - T_{i-3}$

ALTA-01-2016-05-10-00031

In-depth analysis of the candidate events

Reliability of the GPS tagging

1. Gamma functions



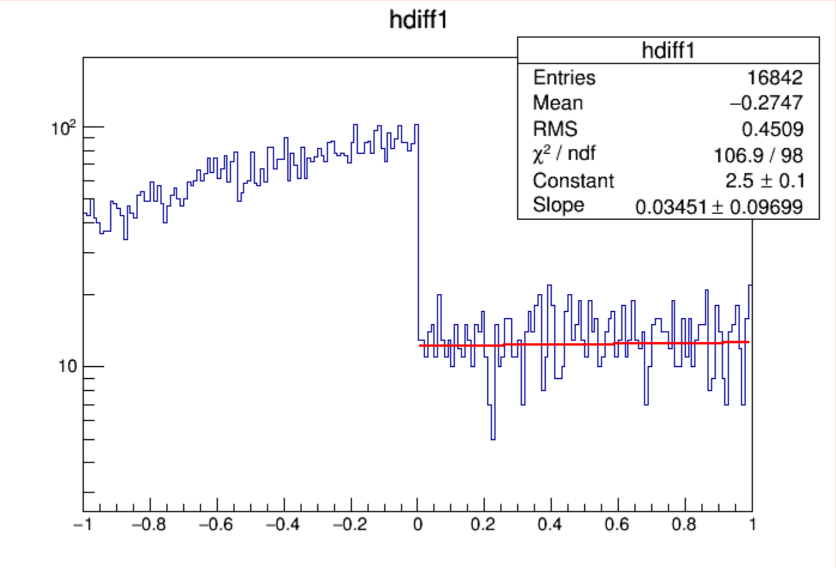
$T_i - T_{i-1}$ $T_i - T_{i-2}$ $T_i - T_{i-3}$

BOLO-04-2018-01-10-00064

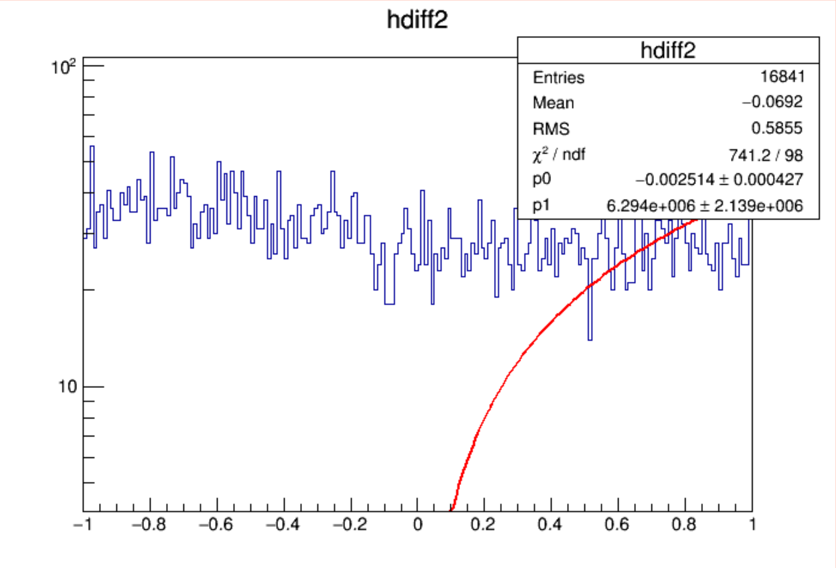
In-depth analysis of the candidate events

Reliability of the GPS tagging

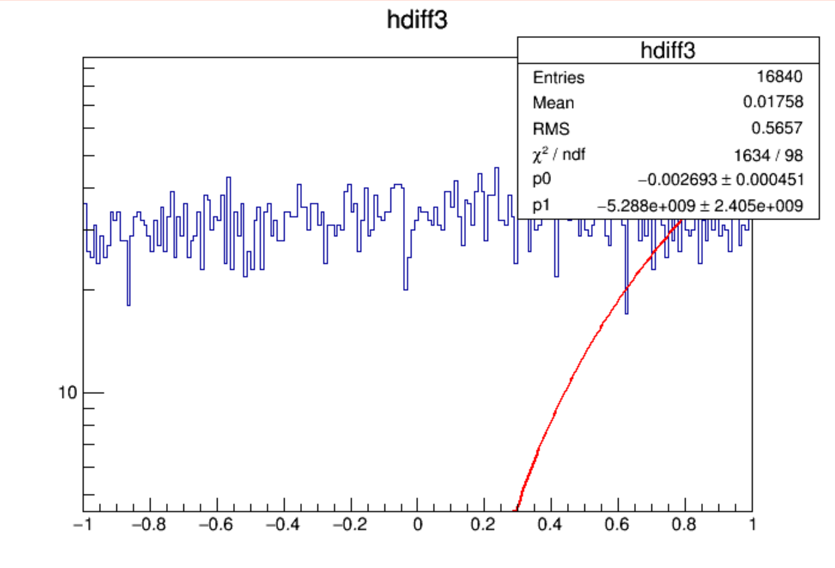
1. Gamma functions



$T_i - T_{i-1}$



$T_i - T_{i-2}$



$T_i - T_{i-3}$

LECC-01-2017-06-02-00045

In-depth analysis of the candidate events

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1. Gamma functions $\rightarrow$ 14 events should be checked (but we can investigate the GPS tagging in smaller time windows around the candidate events)

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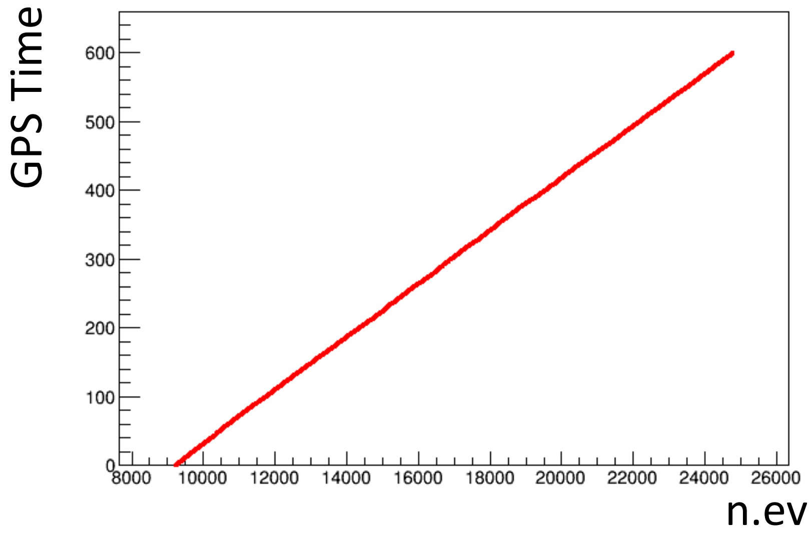
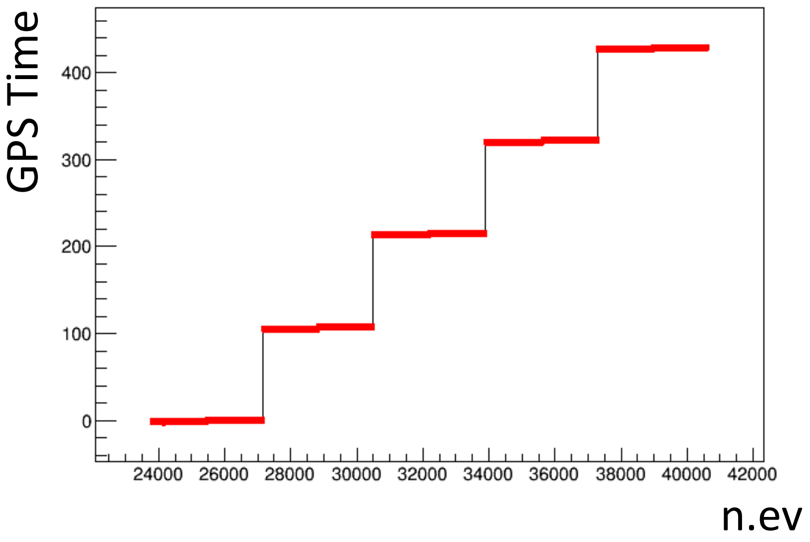
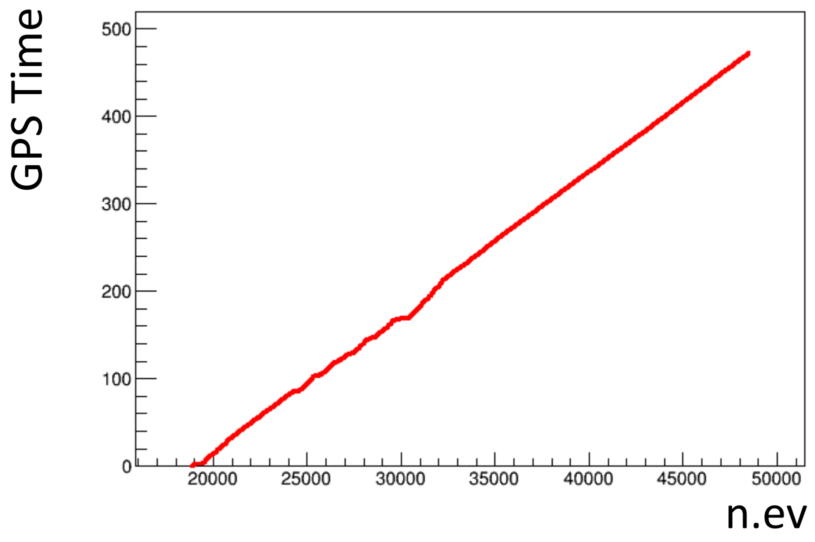


ALTA-01-2016-05-10-00031



LECC-01-2017-06-02-00045



SAVO-01-2016-03-07-00088

Conclusions and Outlook

- **Time correction for EASs orientations does not improve S/N**
- **Investigation of the characteristics of the candidate events ongoing, additional checks are needed**