Why precision timing for Extreme Energy Events

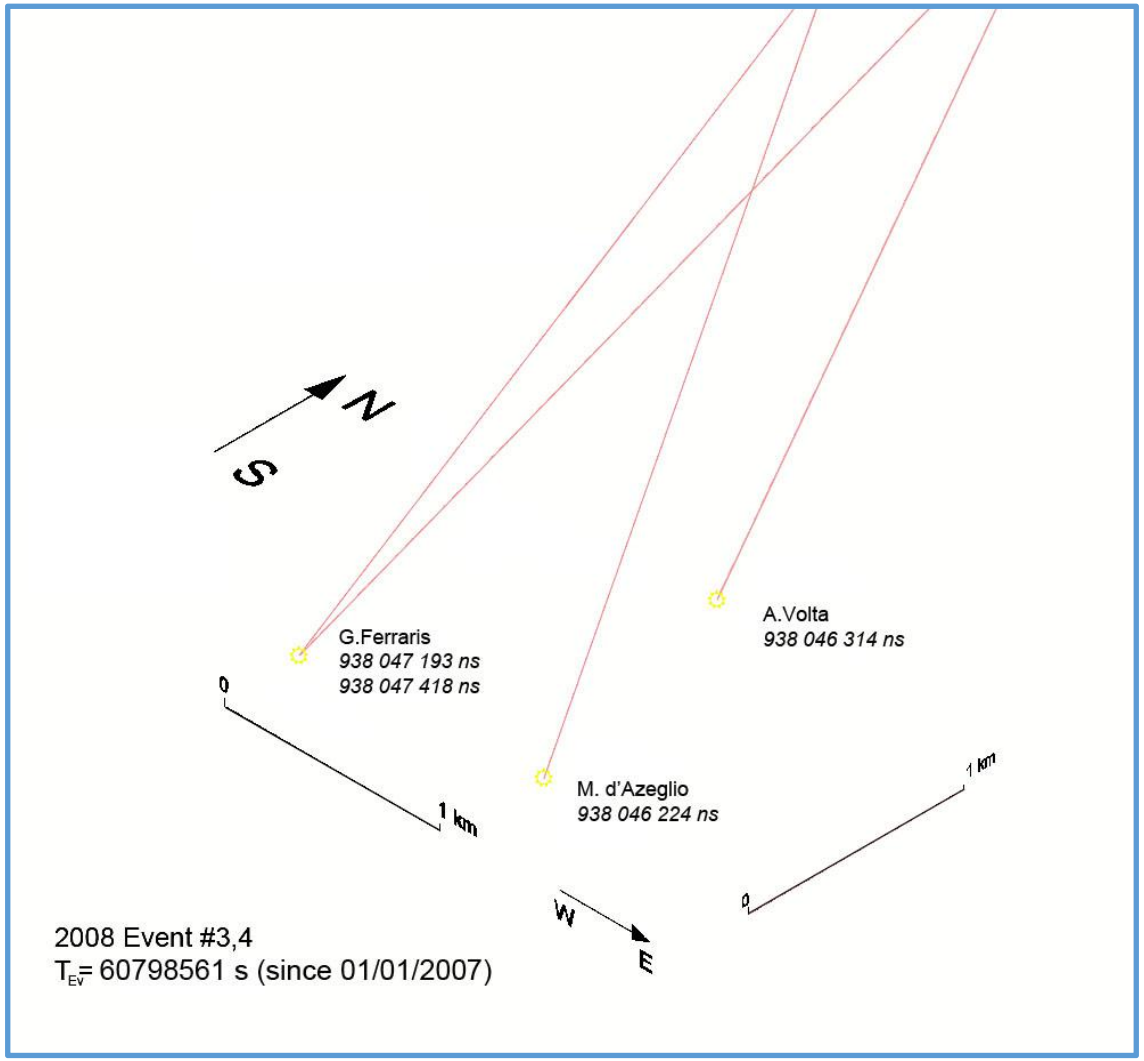
Giornate di Studio di Extreme Energy Events

6-7-8 marzo 2019

Aula Magna della Cavallerizza Reale

Torino

The first extensive shower event candidate at the EEE observatory



The time displacement among the 3 telescopes was

~ 1 microsecond

Cuts on the relative angles among tracks were applied

EEE has both

timing + tracking

capabilities!

An extensive air shower candidate: how to detect it?
Time plays a fundamental role

To “detect” a candidate EEE has to define a **coincidence time window** among telescopes.

The window has to be as large as to include all possible shower direction

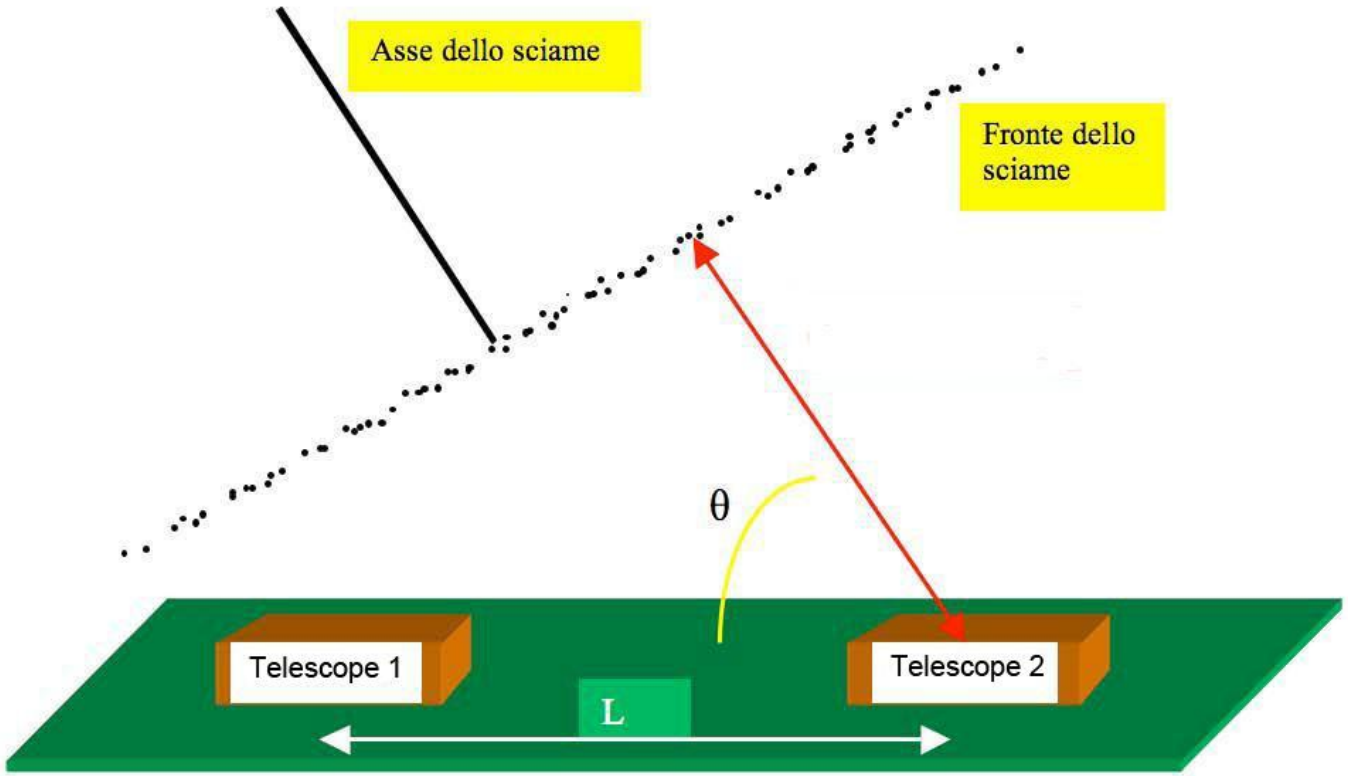
Thus, in principle the minimum coincidence window is

L/v

and if

L~1 km and **v~c**

ΔT ~ 3 microseconds!



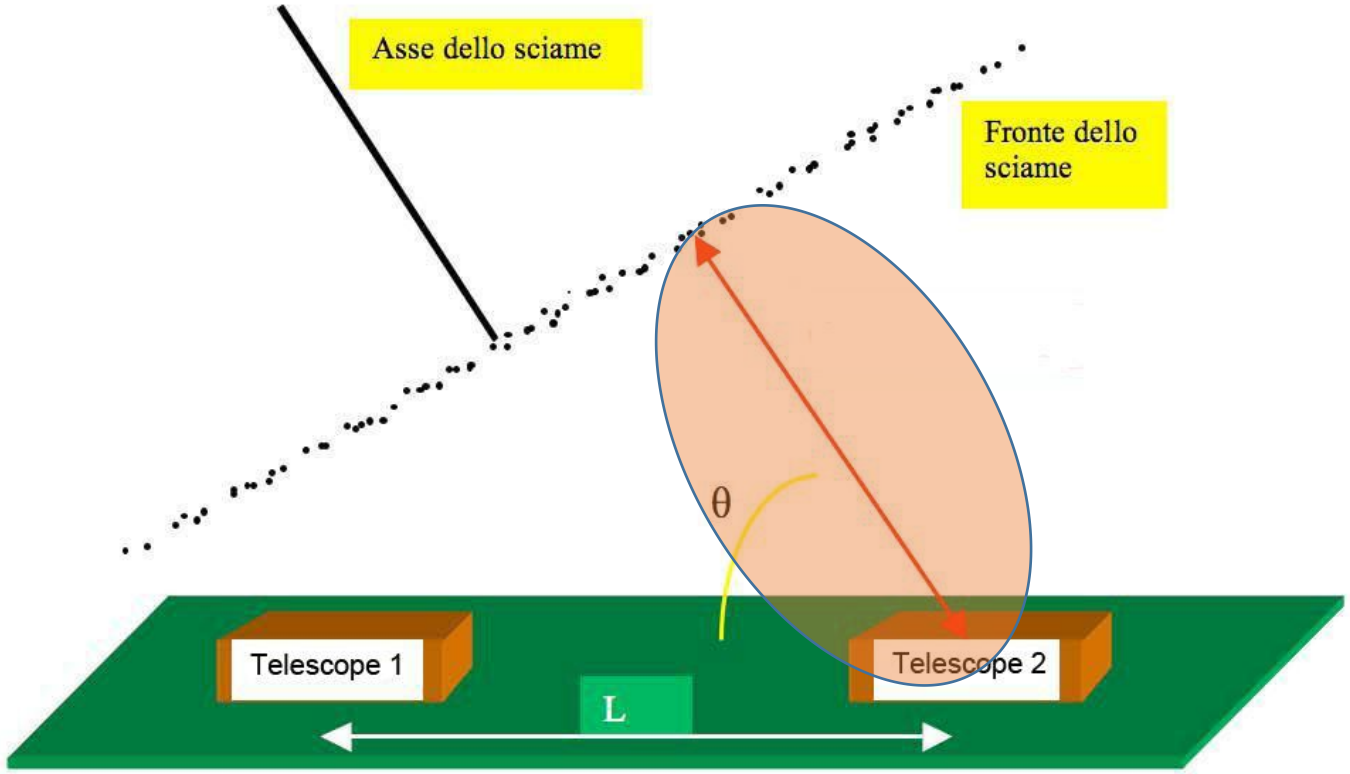
Can we correct some of the **sistematic** uncertainties?

using a “guess” on the shower direction
we can try to

correct the time difference between detectors

by subctracting to the
Telescope 2 particle time
the additional “light path”

ΔL cos(Θ) / v



Physics is always more complex than what one would think....

There are other uncertainties sources.

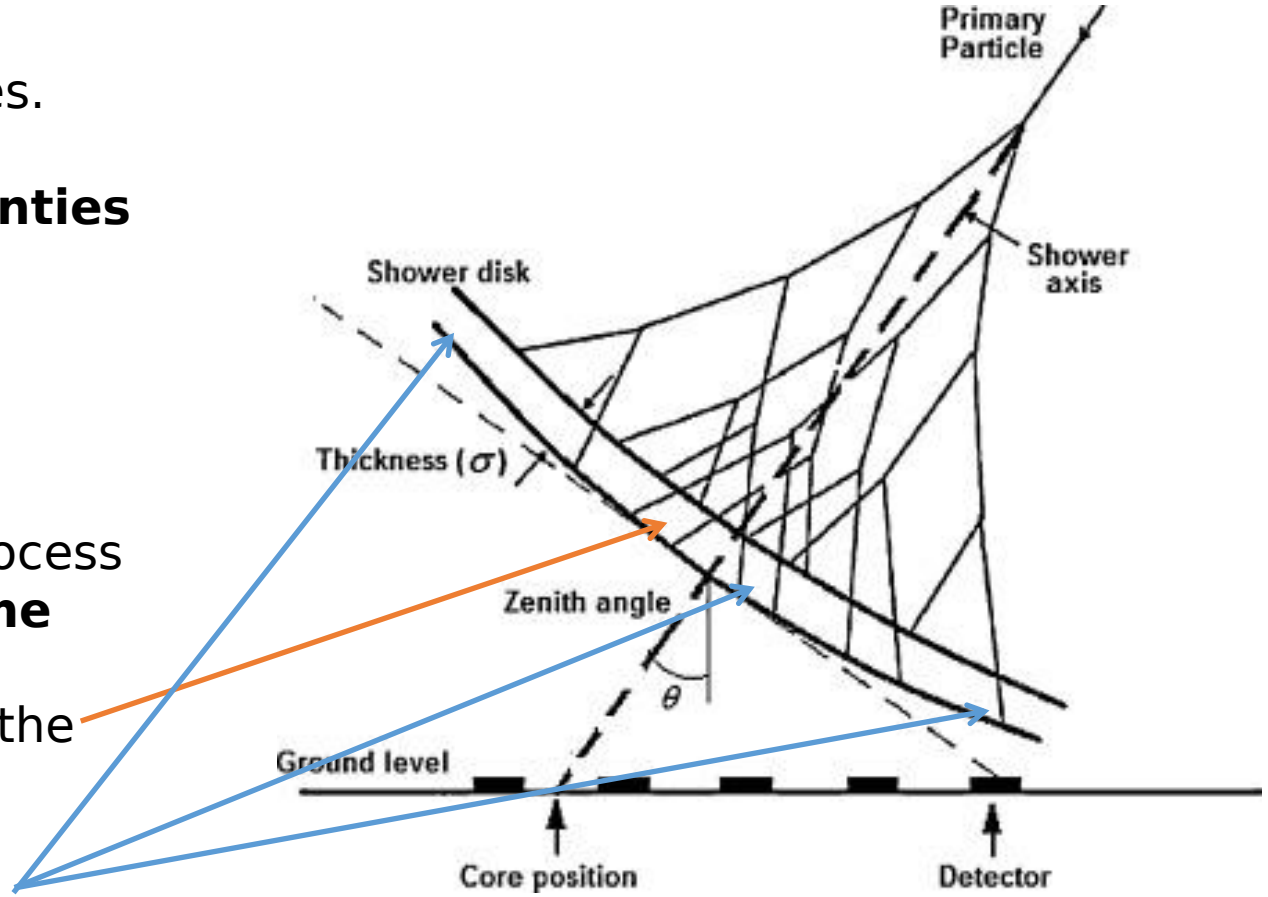
They are **not** just **sistematic uncertainties**

- **disc thickness**
- **disc shape**

due to the complex particle cascade process
particles are not travelling in time

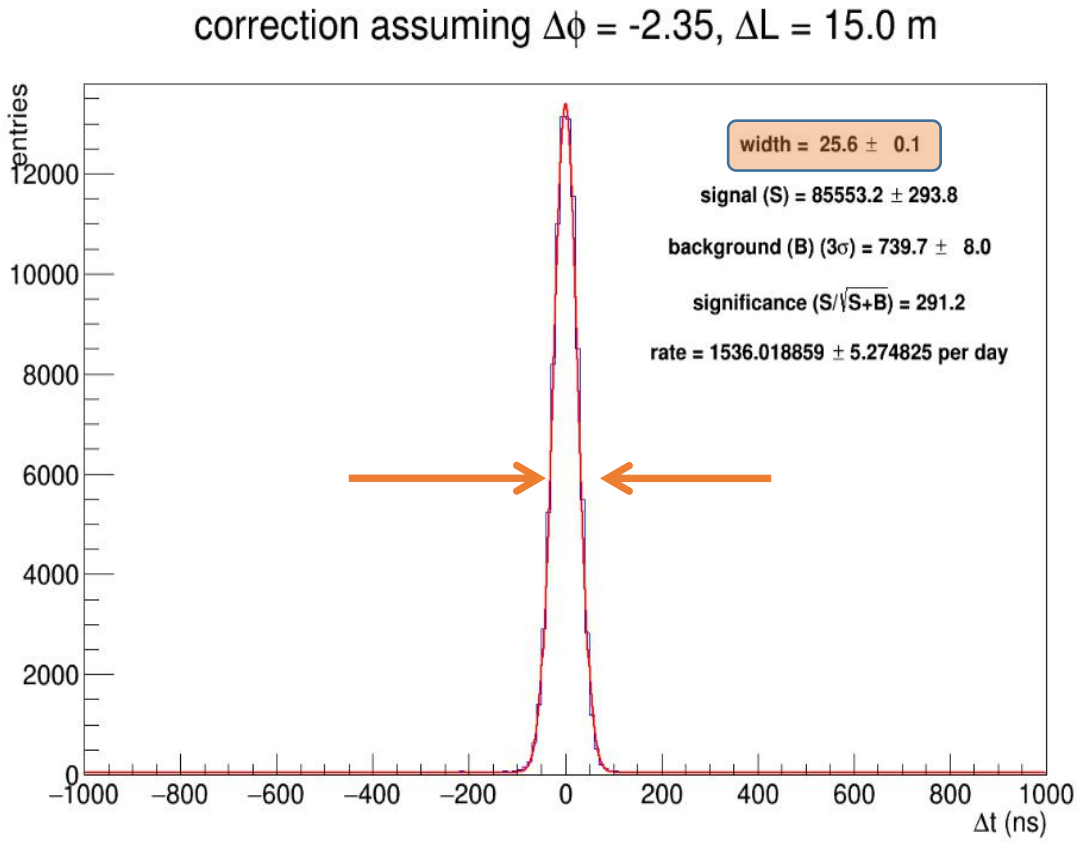
Disc thickness depends on energy of the primary particle

Disc shape is not linear (parabolic)

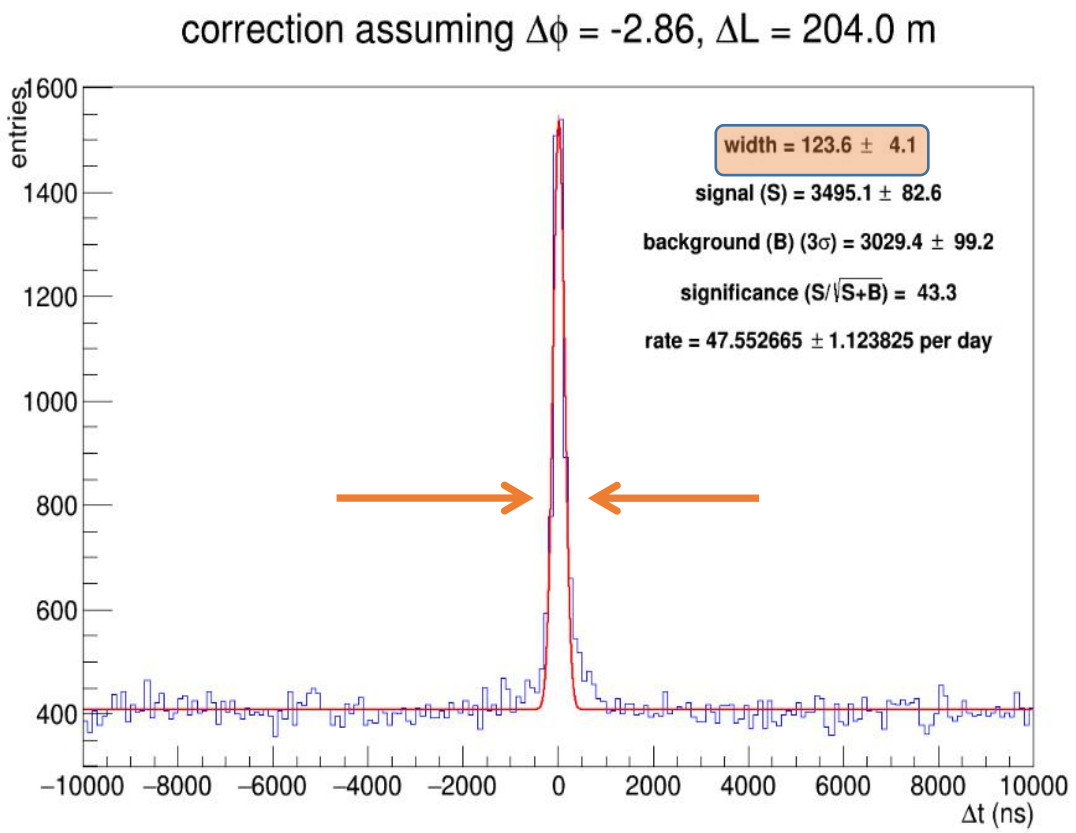


Examples of what we get after corrections

CERN (15 m)

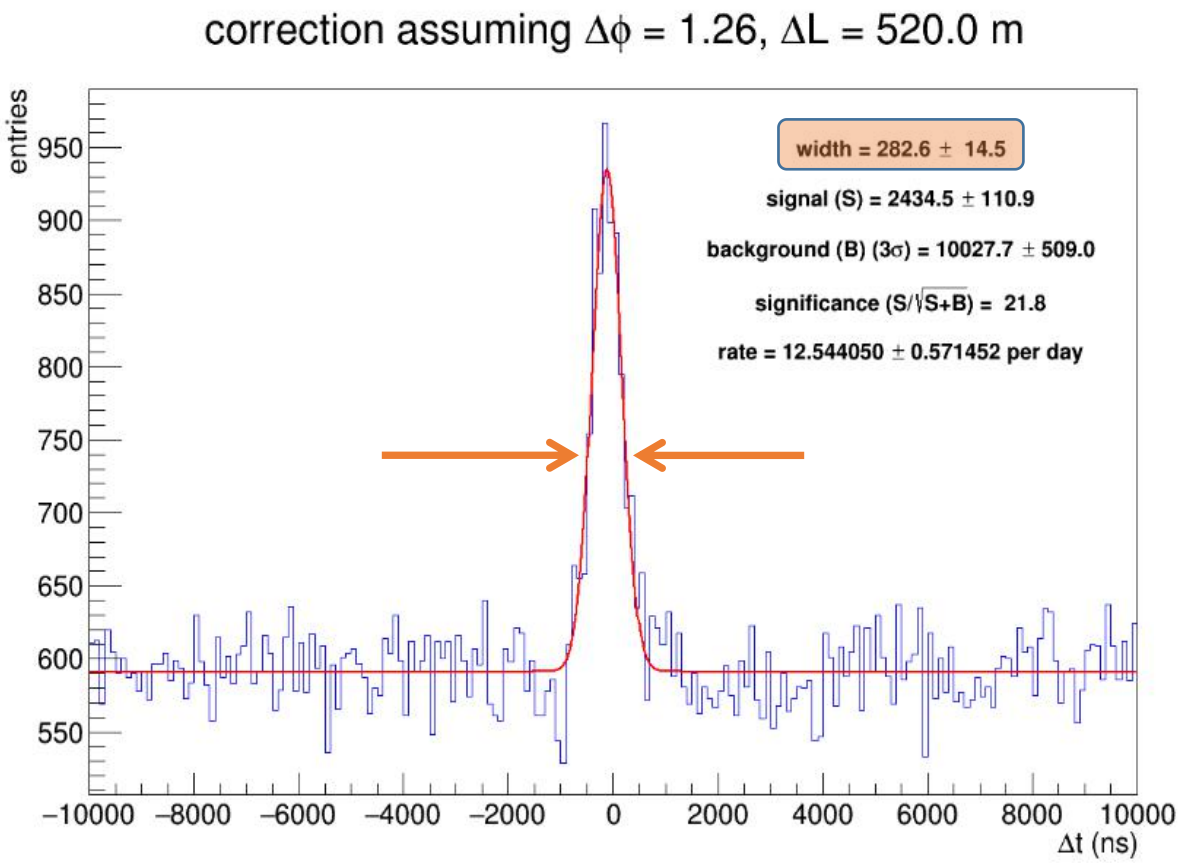


LAQU (204 m)

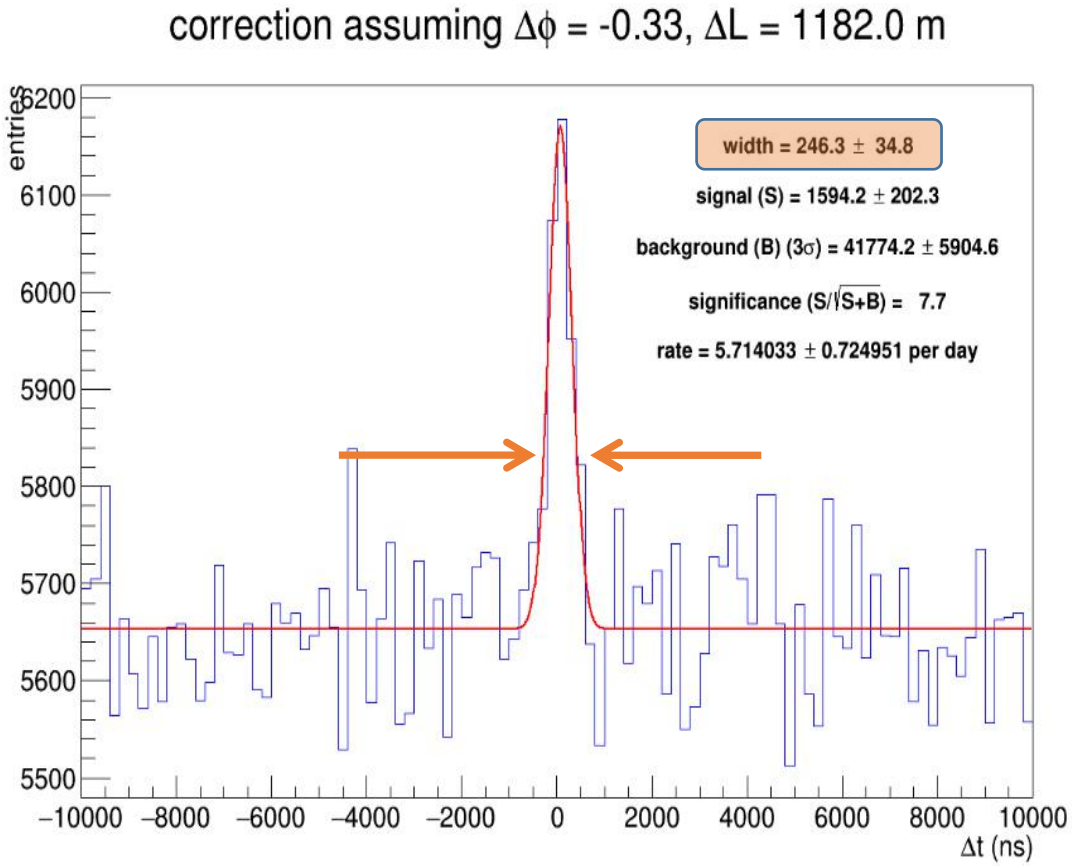


Examples of what we get after corrections

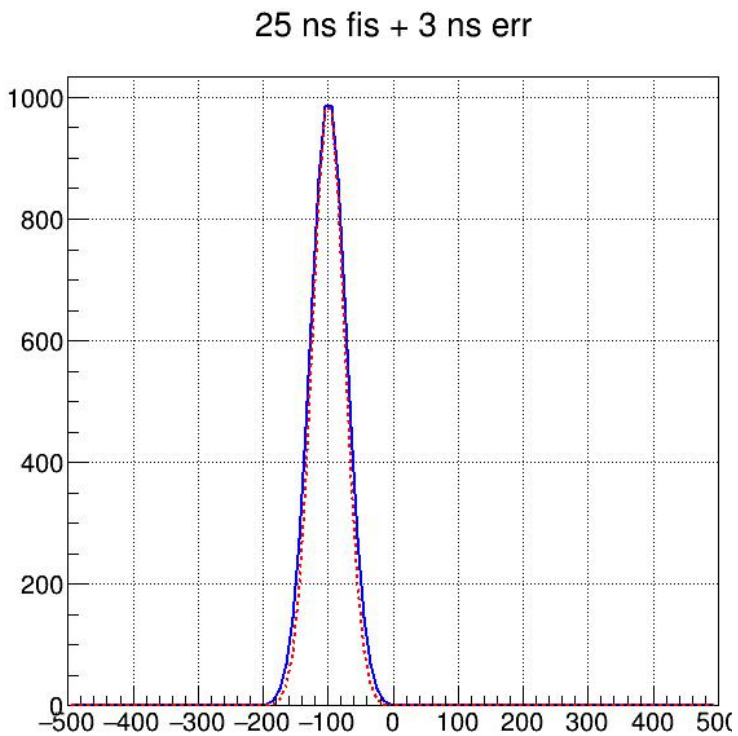
CAGL (520 m)

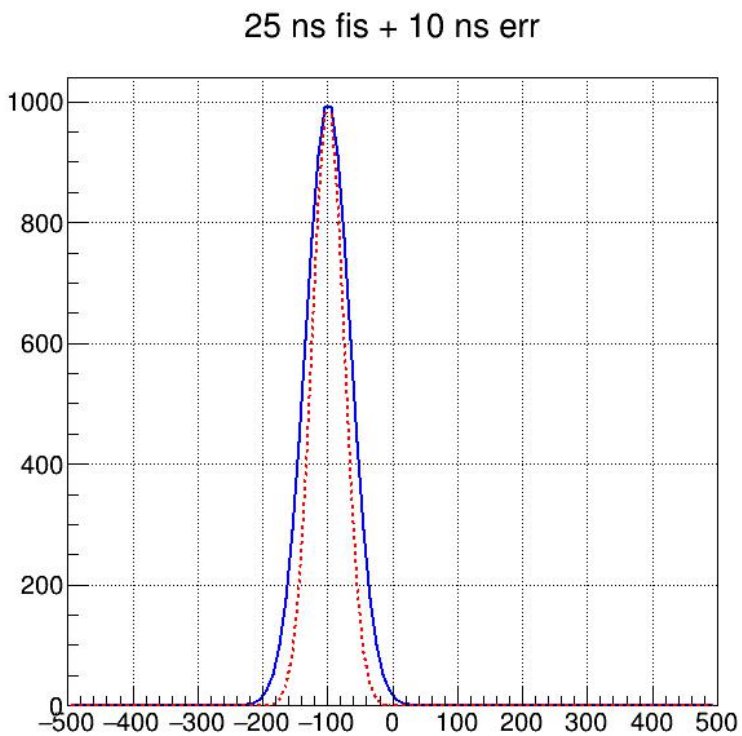


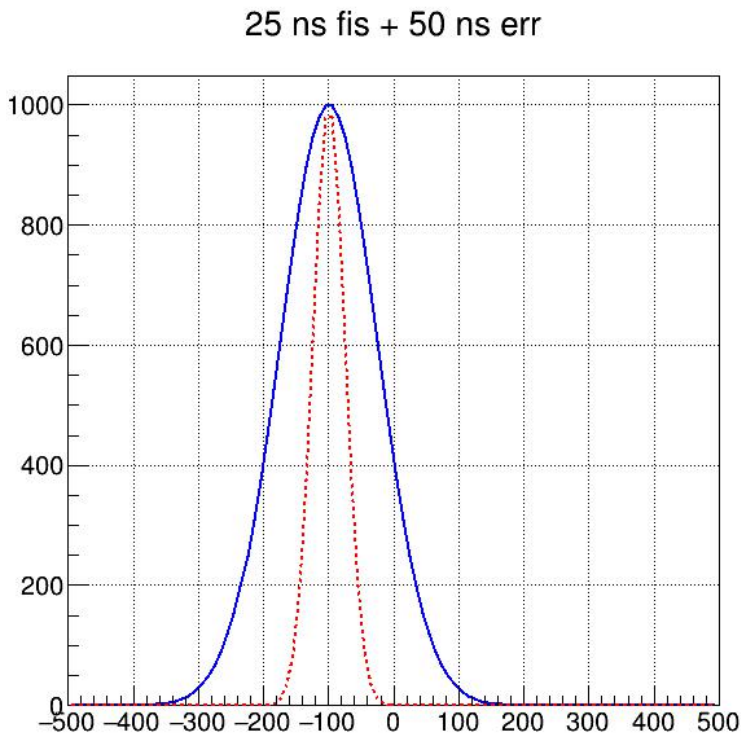
SAVO (1182 m)



How much the time measurement uncertainty matters







How much the time measurement uncertainty matters

Spurious coincidences (blue area) = 2 f1 f2 ΔT

N1 = f1 ΔT

number of events within a time window ΔT for a given telescope with a typical event frequency f1

Number of possible pairs of coincidence within the same time window

N1 N2 = f1 ΔT f2 ΔT

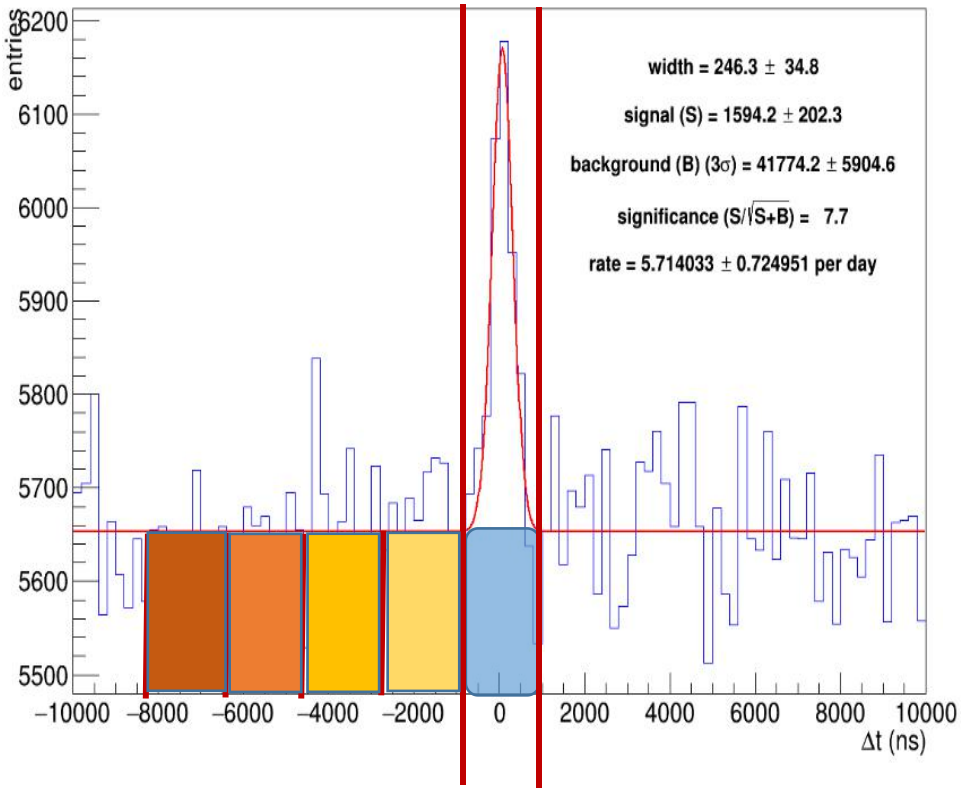
Therefore the frequency of spurious pairs is

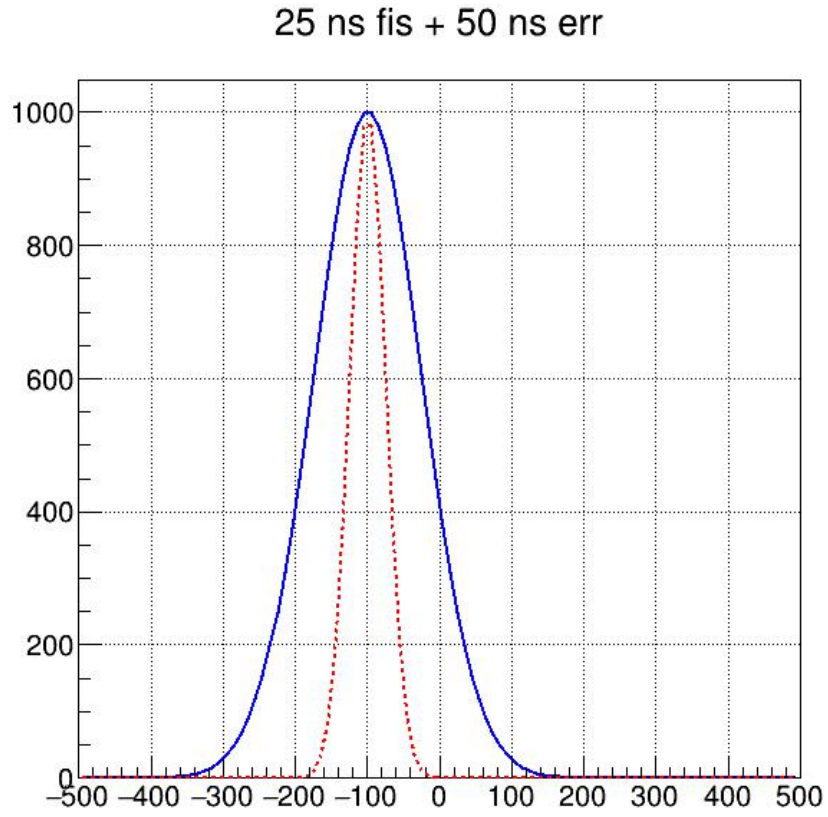
N1 N2 / ΔT = f1 f2 ΔT

N2 = f2 ΔT
number of events within a time window ΔT for a given telescope with a typical event frequency f1

How much the time measurement uncertainty matters

Spurious coincidences (blue area) = 2 f1 f2 ΔT

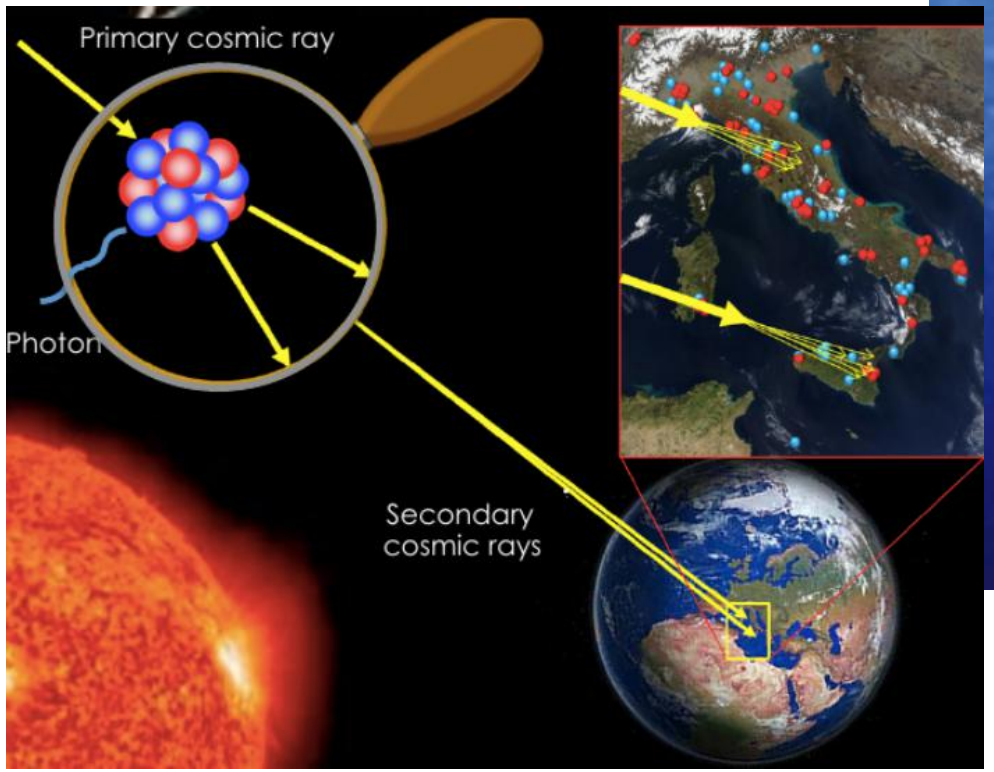


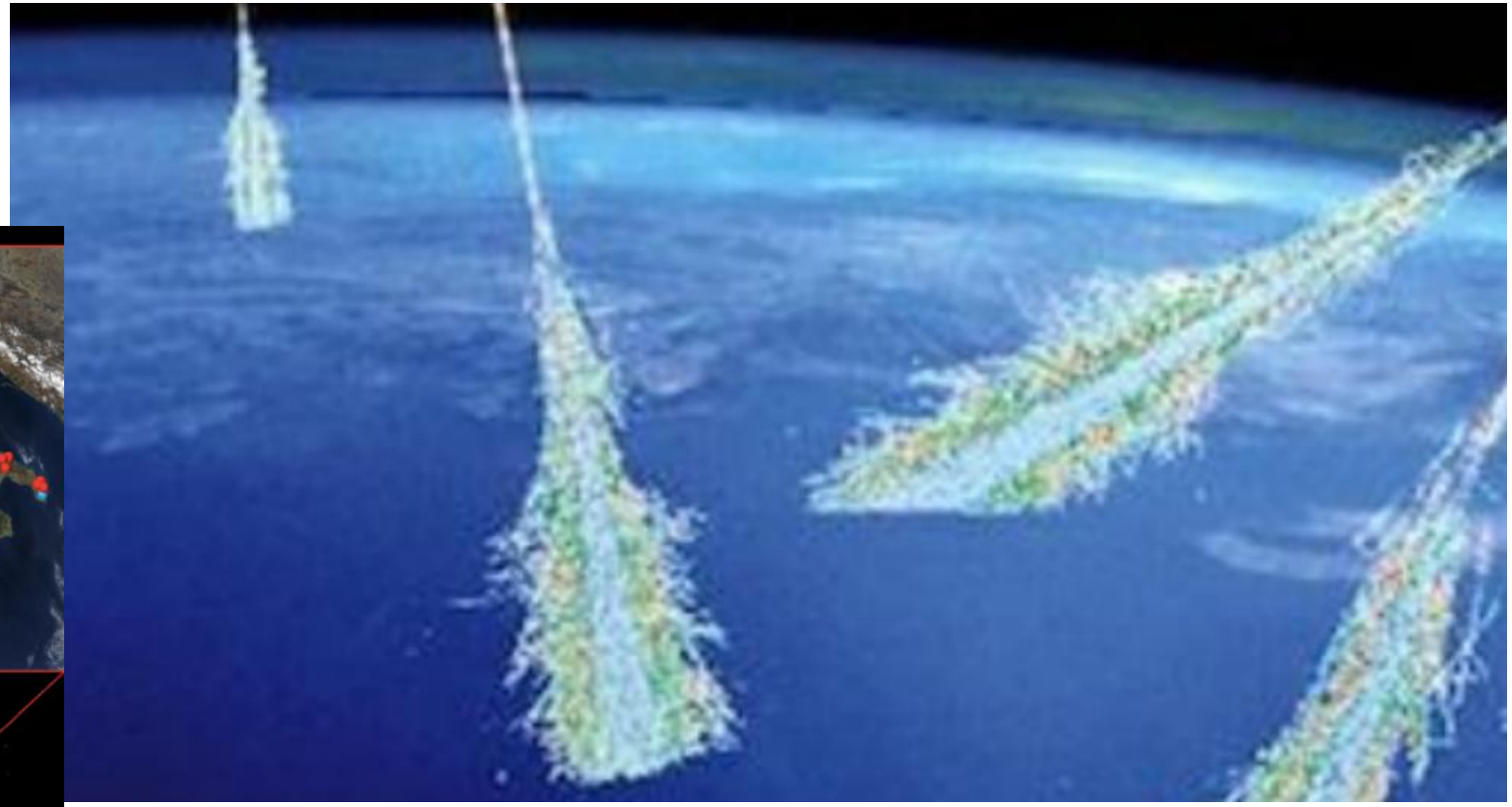


A very rare event search... where time really matters!

L~1000 km and **v~c**

ΔT ~ 3 milliseconds



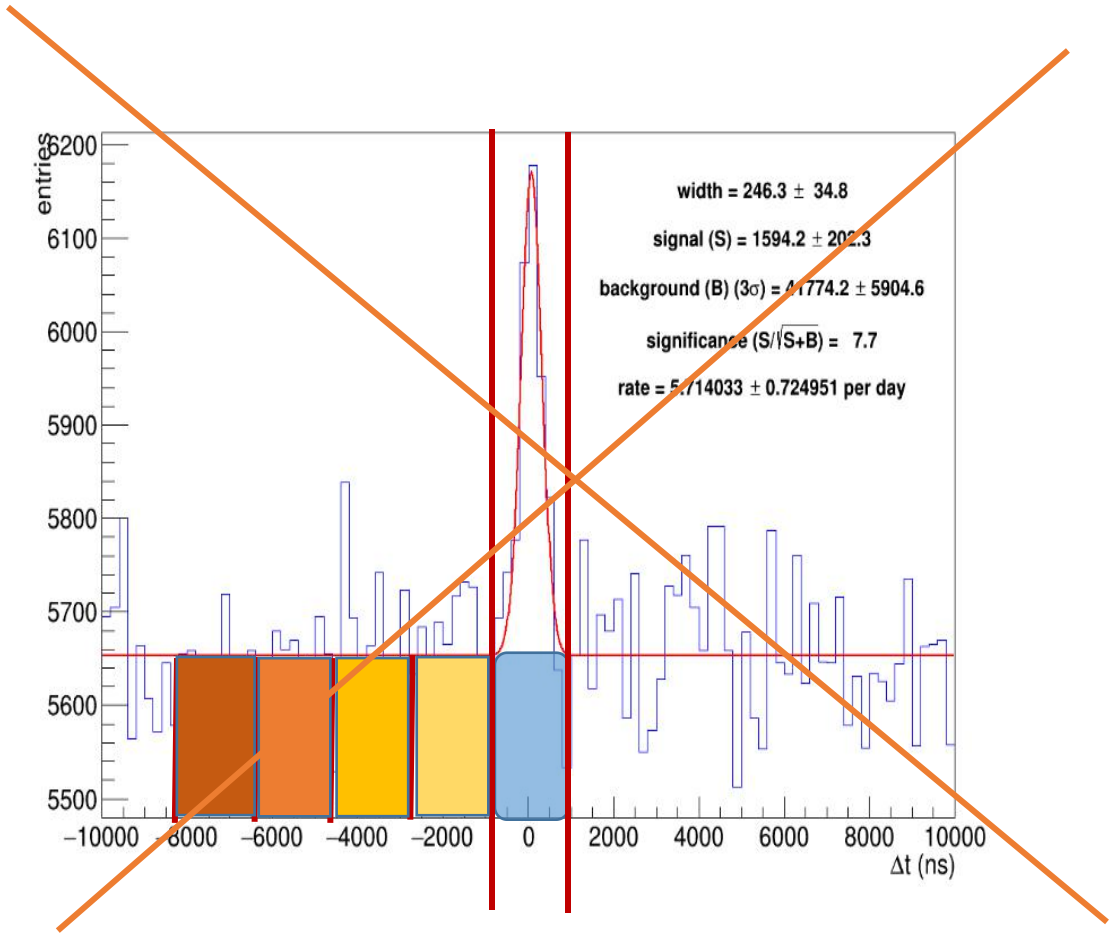


A very rare event search... where time really matters!

- Physics is not known
  - a **wide time displacement** between events could be driven by **physics**
- Very **low statistics**
  - Signal/Noise not possible

In case of clock misalignement

NO EVENTS!!!



thus ....
let's try to deepen
our knowledge about
Time....