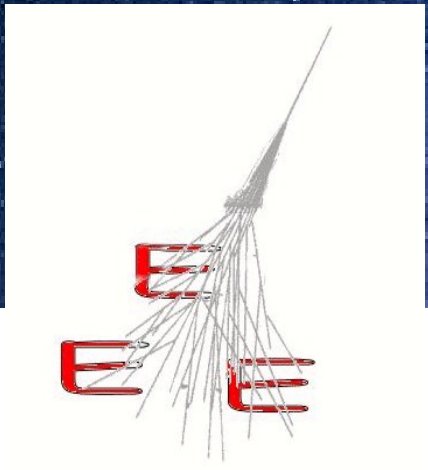
# 7th CONFERENCE ON CENTRO FERMI EEE PROJECT - "SCIENCE IN THE HEART OF THE YOUNG"



## Erice, 29-31 May 2017

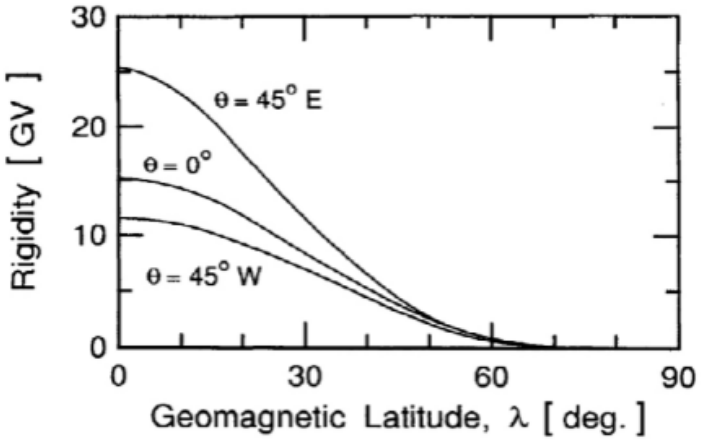
**Liceo Scientifico "G. Gandini" con**
**Annessa Sez.Classica "P.Verri"**

Via Giovanni XXIII, 1 - 26900 LODI

# WHERE WE STARTED FROM

We were interested in studying two effects we knew theoretically, which concretely influence the distribution of events we detect:

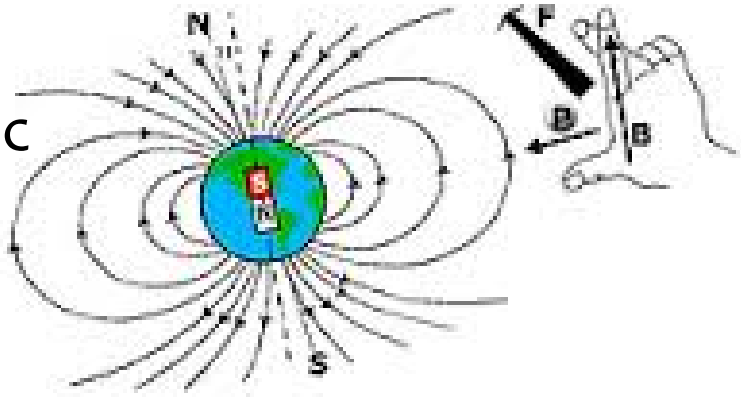
- the **latitude effect**: the more near to the equator you are, the fewer events you detect




This graph shows the variation of events energy as a function of the latitude

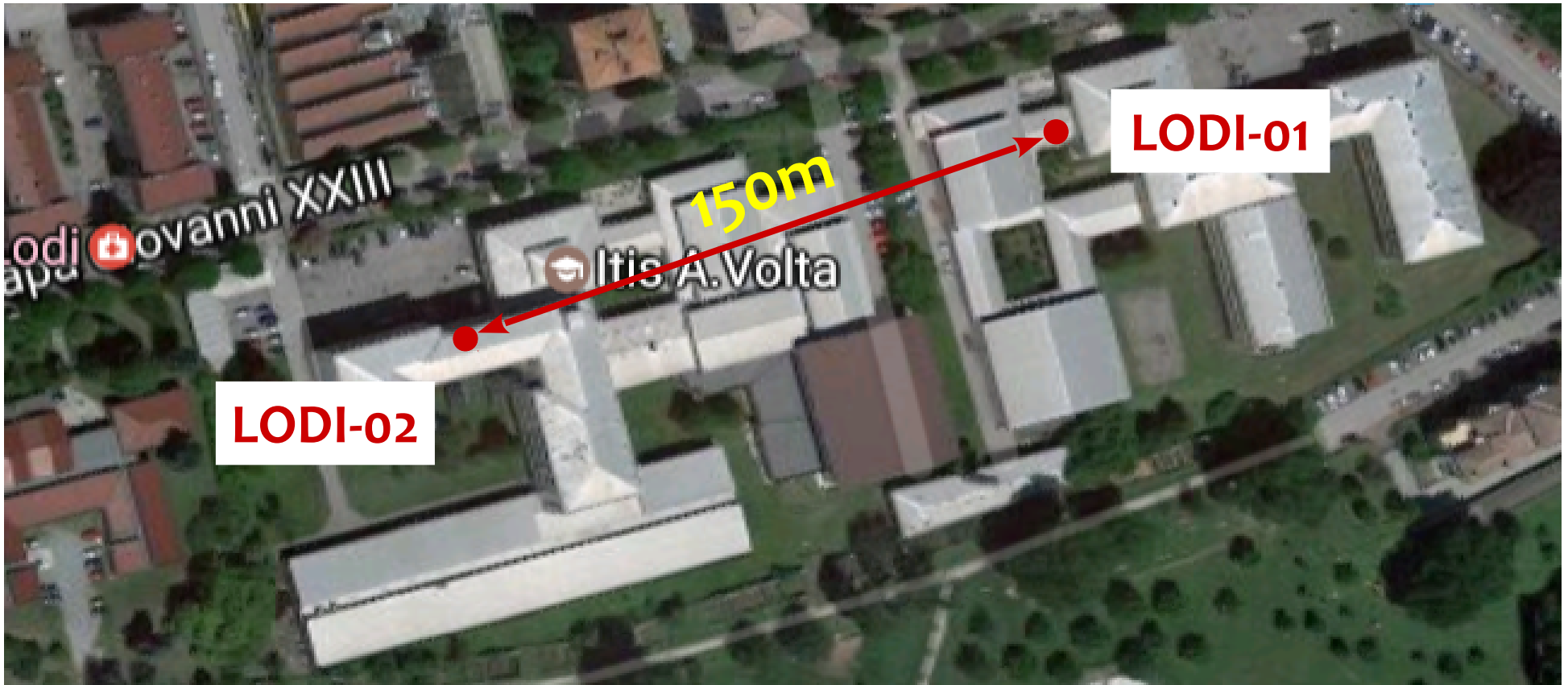
(fonte immagine: Rossi e Olbert 1970 in accordo con i dati di Stormer)

- the **east-west effect**: the most of the cosmic rays are positive and come from the West



We analyzed and compared **48 runs** aquired by **two telescopes**: LODI-01 at Gandini and LODI-02 at Istituto Tecnico Volta, which are placed at a distance of 150 metres.

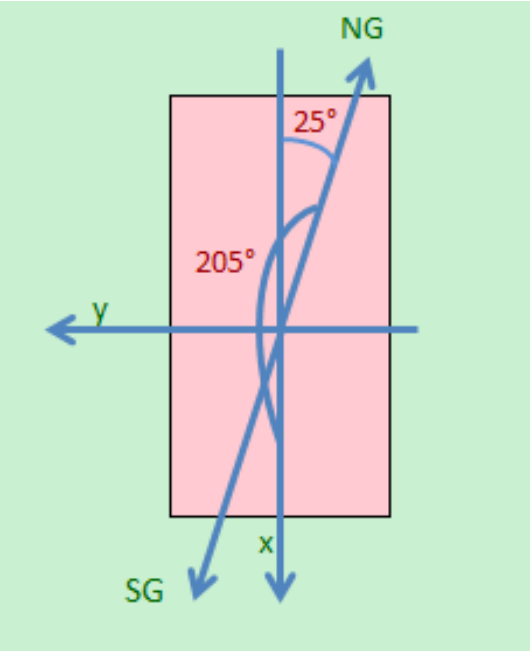
24 runs were collected **on 6 different days**: 21, 28 February; 7, 14 and 21 March and 7 April. On those days we collected 4 runs, **once every 6 hours** (more or less) at the same time.



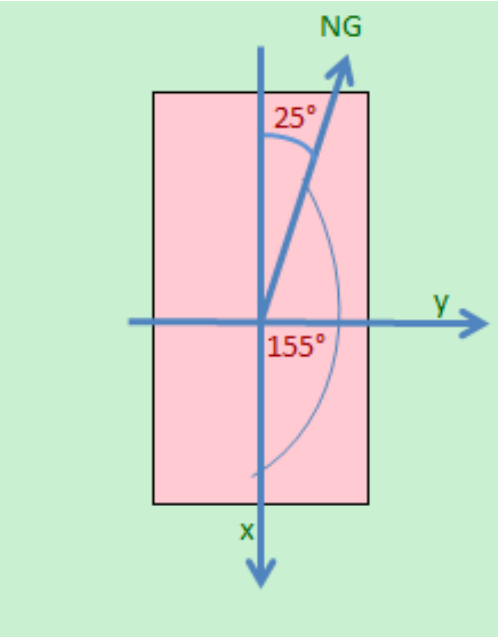
# COORDINATE REFERENCE SYSTEM

In order to compare the data, we needed to use the same coordinate reference system, so we found the direction of the North but **we still have a problem with the orientation** of the telescope:

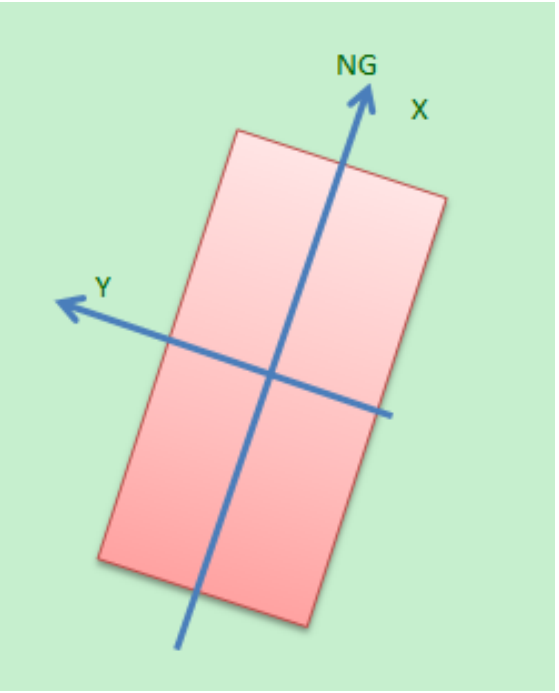
**Clockwise sense**




**Counterclockwise sense**



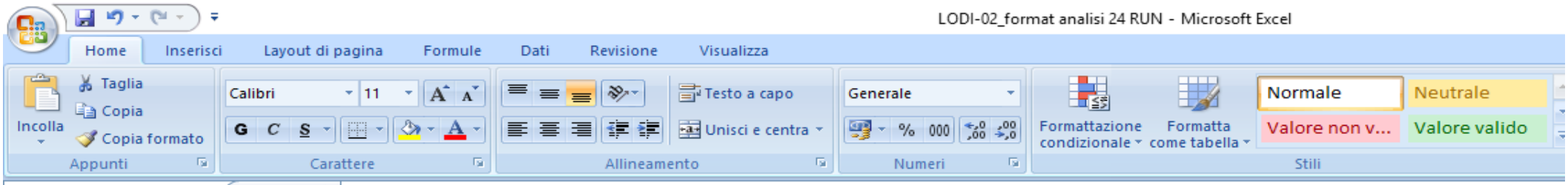
# Orientation of LODI-02 and the geometric correction




We thought that the **greater detection surface corresponding to the North-South direction, as the MRPC are rectangular**, could invalidate our graphs. So we introduced a geometric correction (elaborated by LODI-02 group).

But comparing graphs with and without this correction, we found that it has not a significant influence

# Data analysis – format arrangement




| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | run_num | actual_number | event_number | secs_since_1,1,2007 | nanosec | microseconds_since_start_of_run track | unit_vector_x | unit_vector_y | unit_vector_z | chi_squared | time of flight[ns] | track length[cm] | teta (rad) | teta (Grad) | calcolo di phi con programma Acquis. Dati | |
| 2 | 65 | 0 | 0 | 321.297.568 | 76.468.408 | 76.468 | -0,49852 | 0,43751 | 0,74837 | 1,50514 | 4,90002 | 138,968 | 0,7252 | 41,5504 | 138,7084 | 138,7084 |
| 3 | 65 | 1 | 1 | 321.297.568 | 109.932.959 | 109.932 | -0,34669 | 0,39666 | 0,84998 | 2,26282 | 3,40002 | 122,355 | 0,5548 | 31,7902 | 131,1292 | 131,1292 |
| 4 | 65 | 2 | 2 | 321.297.568 | 145.591.855 | 145.591 | -0,08034 | -0,12457 | 0,98895 | 0,09303 | 4,75000 | 105,162 | 0,1488 | 8,5243 | 237,2085 | 237,2085 |
| 5 | 65 | 3 | 3 | 321.297.568 | 151.775.360 | 151.775 | 0,10522 | 0,22648 | 0,96832 | 1,75995 | 4,60001 | 107,403 | 0,2524 | 14,4617 | 65,1143 | 65,1143 |
| 6 | 65 | 4 | 4 | 321.297.568 | 164.862.632 | 164.862 | 0,18123 | 0,06041 | 0,98159 | 0,23487 | 3,10004 | 105,951 | 0,1922 | 11,0127 | 18,4434 | 18,4434 |
| 7 | 65 | 5 | 5 | 321.297.568 | 172.336.041 | 172.336 | 0,16552 | 0,53523 | 0,82833 | 82,74250 | -45,90000 | 125,554 | 0,5947 | 34,0722 | 72,8531 | 72,8531 |
| 8 | 65 | 6 | 6 | 321.297.568 | 184.375.166 | 184.375 | -0,27521 | -0,02149 | 0,96114 | 2,13028 | 3,30002 | 108,204 | 0,2797 | 16,0244 | 184,4666 | 184,4666 |
| 9 | 65 | 7 | 7 | 321.297.568 | 238.594.174 | 238.594 | 0,53859 | -0,05095 | 0,84103 | 0,75873 | 4,30002 | 123,658 | 0,5716 | 32,7514 | -5,4064 | 354,5936 |
| 10 | 65 | 8 | 8 | 321.297.568 | 263.208.687 | 263.208 | 0,14263 | 0,18331 | 0,97265 | 4,72659 | 6,14999 | 106,924 | 0,2344 | 13,4303 | 52,1395 | 52,1395 |
| 11 | 65 | 9 | 9 | 321.297.568 | 282.064.080 | 282.064 | -0,31678 | 0,17046 | 0,93306 | 8,28537 | 6,35001 | 111,462 | 0,3680 | 21,0837 | 151,7005 | 151,7005 |
| 12 | 65 | 10 | 10 | 321.297.568 | 284.268.677 | 284.268 | 0,17361 | -0,09049 | 0,98065 | 1,40665 | 3,54999 | 106,052 | 0,1970 | 11,2900 | -27,5449 | 332,4551 |
| 13 | 65 | 11 | 11 | 321.297.568 | 287.065.684 | 287.065 | 0,43862 | 0,16069 | 0,88419 | 2,73311 | 4,95001 | 117,622 | 0,4860 | 27,8480 | 20,1301 | 20,1301 |
| 14 | 65 | 12 | 12 | 321.297.568 | 313.591.420 | 313.591 | 0,54072 | -0,24047 | 0,80610 | 1,81958 | 5,50000 | 129,016 | 0,6333 | 36,2834 | -23,9884 | 336,0116 |
| 15 | 65 | 13 | 13 | 321.297.568 | 349.655.568 | 349.655 | -0,02045 | 0,04106 | 0,99895 | 0,85046 | 3,35001 | 104,110 | 0,0459 | 2,6296 | 116,4378 | 116,4378 |
| 16 | 65 | 14 | 14 | 321.297.568 | 351.685.464 | 351.685 | -0,28188 | -0,02997 | 0,95898 | 0,08295 | 3,14999 | 108,448 | 0,2874 | 16,4670 | 186,0718 | 186,0718 |
| 17 | 65 | 15 | 15 | 321.297.568 | 376.840.054 | 376.840 | 0,48502 | 0,07789 | 0,87103 | 1,38864 | 5,85004 | 119,399 | 0,5135 | 29,4218 | 9,1279 | 9,1279 |
| 18 | 65 | 16 | 16 | 321.297.568 | 429.201.424 | 429.201 | 0,52915 | 0,43100 | 0,73092 | 1,44715 | 4,25000 | 142,287 | 0,7511 | 43,0366 | 39,1828 | 39,1828 |
| 19 | 65 | 17 | 17 | 321.297.568 | 461.407.721 | 461.407 | 0,14375 | 0,13573 | 0,98026 | 5,39802 | 4,55002 | 106,094 | 0,1990 | 11,4027 | 43,3775 | 43,3775 |
| 20 | 65 | 18 | 18 | 321.297.568 | 467.869.520 | 467.869 | 0,41011 | -0,05515 | 0,91037 | 0,08744 | 3,35001 | 114,240 | 0,4266 | 24,4440 | -7,6624 | 352,3376 |
| 21 | 65 | 19 | 19 | 321.297.568 | 468.593.716 | 468.593 | -0,09580 | 0,50422 | 0,85825 | 0,56177 | 3,14996 | 121,177 | 0,5390 | 30,8798 | 100,7175 | 100,7175 |
| 22 | 65 | 20 | 20 | 321.297.568 | 471.360.921 | 471.360 | -0,03435 | -0,26672 | 0,96316 | 2,01822 | 3,85001 | 107,978 | 0,2723 | 15,6003 | 262,7040 | 262,7040 |
| 23 | 65 | 21 | 21 | 321.297.568 | 483.792.662 | 483.792 | -0,62658 | -0,22832 | 0,74517 | 3,96712 | 5,34998 | 139,566 | 0,7300 | 41,8266 | 200,0315 | 200,0315 |
| 24 | 65 | 22 | 22 | 321.297.568 | 491.995.573 | 491.995 | 0,07048 | -0,02972 | 0,99707 | 0,56156 | 2,55002 | 104,306 | 0,0766 | 4,3871 | -22,8765 | 337,1235 |
| 25 | 65 | 23 | 23 | 321.297.568 | 542.090.237 | 542.090 | 0,00990 | 0,04514 | 0,99893 | 0,89232 | 3,75000 | 104,111 | 0,0462 | 2,6495 | 77,6659 | 77,6659 |
| 26 | 65 | 24 | 24 | 321.297.568 | 683.836.400 | 683.836 | -0,54635 | 0,11487 | 0,82964 | 1,63524 | 4,44998 | 125,356 | 0,5923 | 33,9383 | 168,1203 | 168,1203 |
| 27 | 65 | 25 | 25 | 321.297.568 | 741.504.788 | 741.504 | 0,13027 | 0,03049 | 0,99101 | 0,08299 | -9,15002 | 104,944 | 0,1342 | 7,6890 | 13,1807 | 13,1807 |
| 28 | 65 | 26 | 26 | 321.297.568 | 745.855.033 | 745.855 | -0,01277 | 0,12309 | 0,99231 | 0,40809 | 2,39999 | 104,806 | 0,1241 | 7,1083 | 95,8827 | 95,8827 |
| 29 | 65 | 27 | 27 | 321.297.568 | 786.405.444 | 786.405 | -0,00528 | -0,02043 | 0,99978 | 1,48569 | 2,95001 | 104,023 | 0,0211 | 1,2100 | 255,5525 | 255,5525 |

# Sideral time calculus

S6

## CALCOLO DEL TEMPO SIDERALE

N.B.: l'unico dato in input è la longitudine del luogo ove si trova il Telescopio (riga 29)

**ATTENZIONE**
**I dati in input vanno inseriti soltanto nelle celle di colore giallo. Nelle celle di colore scuro ci sono valori in fase di elaborazione; pertanto non vanno considerate. I risultati sono, invece, evidenziati in verde.**

### 1) STEP: CALCOLO DEL GIORNO GIULIANO (JD)

| inserisci data | | | calcoli | | |
|---|---|---|---|---|---|
| anno | mese | giorno | A | B | JD |
| 2.017 | 3 | 7 | 2017 | 3 | 2.457.819,50 |
| | | | 20 | -13 | |

### 2) STEP: CALCOLO DEL TEMPO (T) IN SECOLI GIULIANI DI 36525 gg DELLE EFFEMERIDI

| T |
|---|
| 1,171786 |

### 3) STEP: CALCOLO DEL TEMPO SIDERALE MEDIO DI GREENWICH (TSMG)

| Gamma | TSMG | T(h) | T(m) | T(s) | trasforma n-->testo | T(h-m-s) |
|---|---|---|---|---|---|---|
| 117,4581 | 10,9936 | 10 | 0,99364 59,6186 | 59 0,61858 37,11 | 10 59 37,11 | 10h 59m 37,11s |
| | 0,45807 | | | | | |
| | 10,9936 | | | | | |

### 4) STEP: CALCOLO DEL TEMPO SIDERALE MEDIO LOCALE (TSML)

giorno siderale = giorno solare (365,25 g.) + 3 minuti e 56,55 secondi
un anno siderale = 366,25 giorni

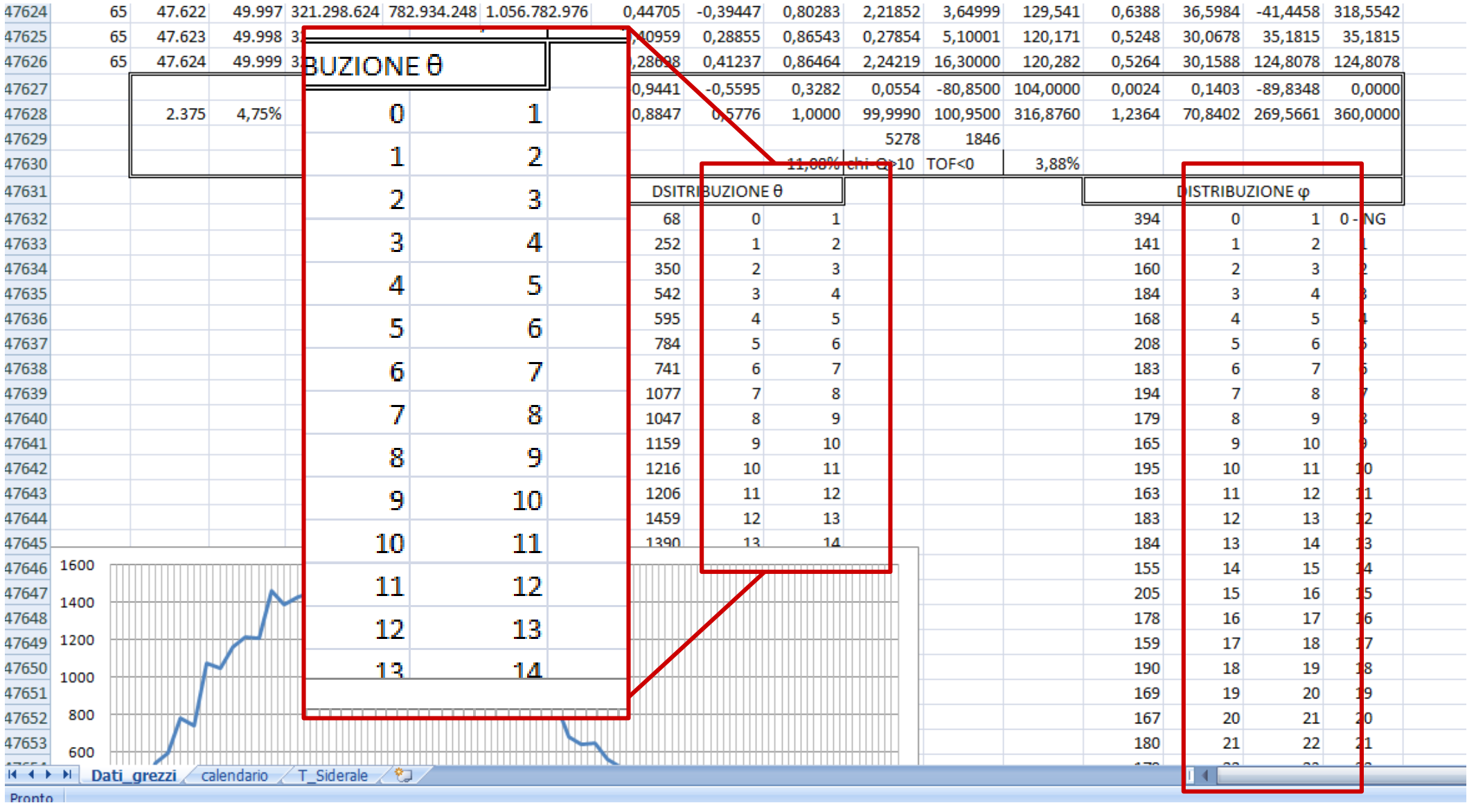
| Ora locale TMEC (tempo medio europa centrale) | | | | Tempo Universale (TU) Greenwich | | | | Longitudine in decimale | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inserisci ore, minuti e secondi | ora | minuti | secondi | ora | minuti | secondi | | 9,50056 | gradi | primi | secondi | parte decimale long. | |
| soltanto in F27, G27, H27 | 17 | 19 | 28 | 16 | 19 | 28 | Dlong (min. sec.) | 38,002222 | 9 | 30 | 2 | 0,03333 | 30,03333 |
| | gradi | primi | secondi | | | | Diff. Long. | 0,002222 | Long. in dec. | primi dec | sec dec | | |
| Inserisci la longitudine | 9 | 30 | 2 | | | | 38 0,13332 | 9,5005555 | | 50,0556 | 5005556 | | |
| | | | | | | | | | | 0,05555 | 05555 | | |

Conversione del TU in TS

| ora | | minuti | secondi | calcoli | | | |
|---|---|---|---|---|---|---|---|
| 2 | 3 | 19 | 5,11465 | 3 | 19 | 5,247 | |
| | | 19 | 65,1147 | 3 | 57 | 5,247970121 | 3 57 5,248 |
| 26 | | 79 | | | | | |

alle ore 16h 19m 28s del tempo universale, l'ora siderale media locale (TSML) è:
3h 57m 5,247s

# We built the angular distribution graphs with a gap of 1° between every value on the x axis (azimut angles) and the value next to it



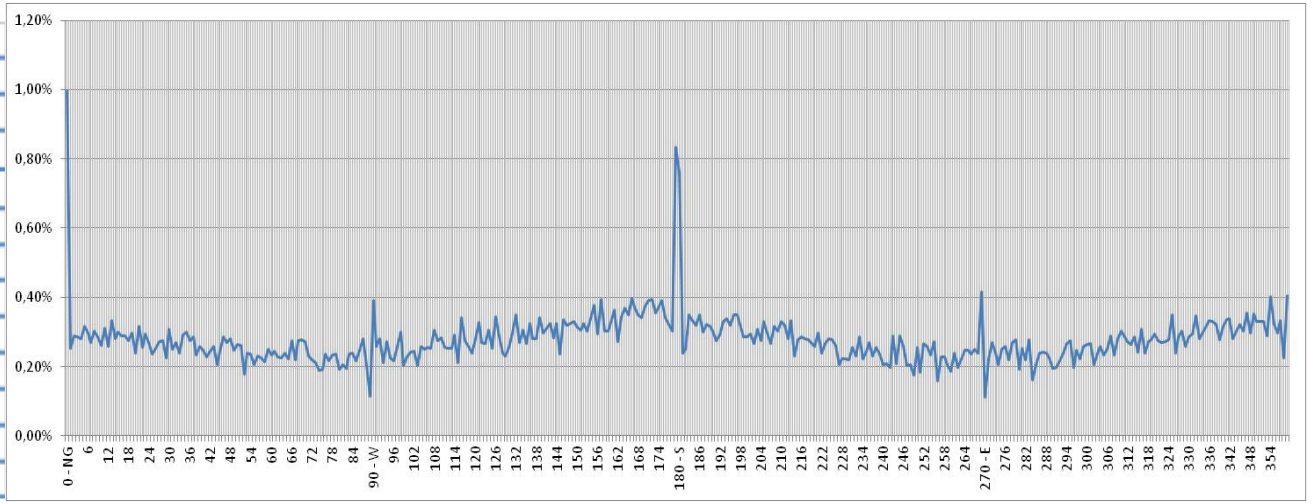
| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | Questo foglio NON VA MODIFICATO IN NESSUNA SUA PARTE; serve per calcolare data, ora di inizio e di fine RU | | | | | | | | |
| 2 | | 321.297.568 | 86400 | | | | | | | |
| 3 | | 3.718,721852 | 3.718 | | | | | | | |
| 4 | | 01/01/2007 | 321.235.200 | | | | 321.298.624 | | | |
| 5 | | 07/03/2017 | 62.368 | | | | 1.056 | | | |
| 6 | | 7 | 17,3244444 | 17 | | | 17,6000000 | 17 | | |
| 7 | | 3 | 61.200 | | | | 36 | 1.020 | | |
| 8 | | 2.017 | 1.168 | | | | 36 | 17 | 36 | |
| 9 | | | 19,466667 | 19 | | | 64 | 64 | 37 | |
| 10 | | | 1.140 | | ora locale | ora siderale TSML | | 4 | ora locale | |
| 11 | | | 28 | | 17h 19m 28s | 3h 57m 5,247s | | | 17h 37m 4s | |
| 12 | | | | | | | | | | |
| 13 | LODI-02 | Il RUN n° | 65 | del | 07/03/2017 | | | | | |
| 14 | | | | Run Start: | 17h 19m 28s | | | | | |
| 15 | | | | Local Mean Sidereal Time: | 3h 57m 5,247s | | | | | |
| 16 | | | | Run End: | 17h 37m 4s | | | | | |
| 17 | | | | Δt = | 1056s | | | | | |
| 18 | | | | Number of events with Hits: | 47.624 | | | | | |
| 19 | | | | Rate: Ev/s | 45 | | | | | |
| 20 | | | | % Number of events No Hits: | 4,75% | | | | | |
| 21 | | | | % Number of events with $\chi 2$ >10: | 11,08% | | | | | |
| 22 | | | | % Number of events with time of flight<0: | 3,88% | | | | | |
| 23 | | | | % Number of events with time of flight<0 & $\chi 2$ >10: | 14,96% | | | | | |
| 24 | | | | Lunghezza minima della traccia: | 104,000 | | | | | |
| 25 | | | | Lunghezza massima della traccia: | 316,876 | | | | | |
| 26 | | | | | | | | | | |

Dati_grezzi | calendario | T_Siderale

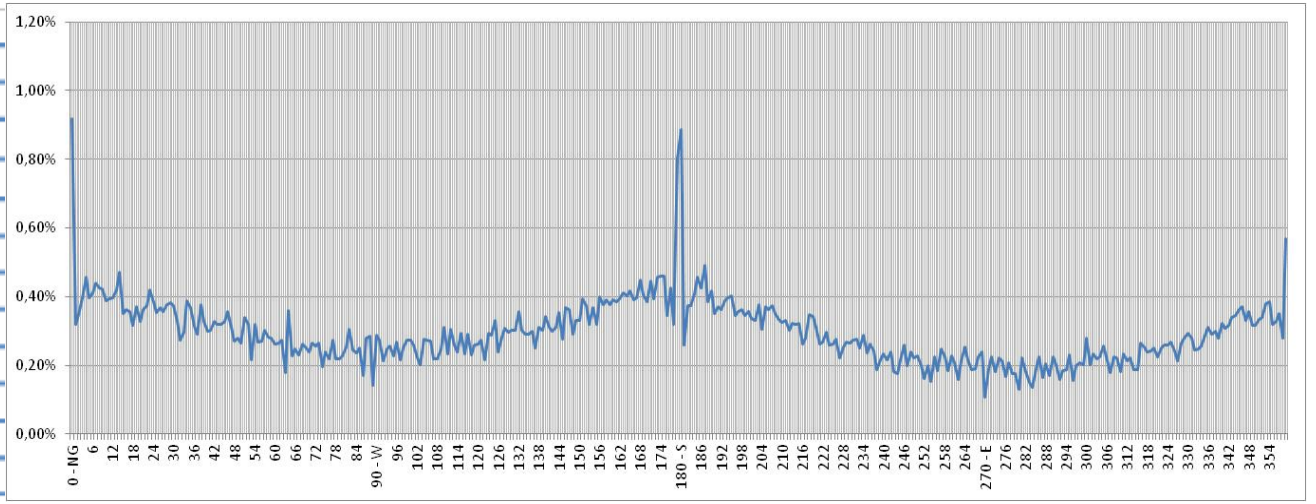
We built for each run a table with all the important data

# Then we compared the graphs and the tables of every couple of simultaneous runs

| LODI-01 | II RUN n° | 1 | del | 20/02/2017 |
|---|---|---|---|---|
| | | | Run Start: | 23h 7m 44s |
| | | | Local Mean Sidereal Time: | 8h 34m 23,25s |
| | | | Run End: | 23h 22m 8s |
| | | | Δt = | 864s |
| | | | Number of events with Hits: | 44.745 |
| | | | Rate: Ev/sec | 52 |
| | | | % Number of events No Hits: | 10,51% |
| | | | % Number of events with χ2 >10: | 4,33% |
| | | | % Number of events with time of flight<0: | 0,68% |
| | | | % Number of events with time of flight<0 & χ2 >10: | 5,00% |
| | | | Lunghezza minima della traccia: | 93,000 |
| | | | Lunghezza massima della traccia: | 242,127 |




| LODI-02 | II RUN n° | 1 | del | 20/02/2017 |
|---|---|---|---|---|
| | | | Run Start: | 23h 14m 8s |
| | | | Local Mean Sidereal Time: | 8h 40m 0,133s |
| | | | Run End: | 23h 32m 48s |
| | | | Δt = | 1120s |
| | | | Number of events with Hits: | 47.465 |
| | | | Rate: Ev/s | 42 |
| | | | % Number of events No Hits: | 5,07% |
| | | | % Number of events with χ2 >10: | 10,66% |
| | | | % Number of events with time of flight<0: | 3,62% |
| | | | % Number of events with time of flight<0 & χ2 >10: | 14,28% |
| | | | Lunghezza minima della traccia: | 104,000 |
| | | | Lunghezza massima della traccia: | 359,563 |



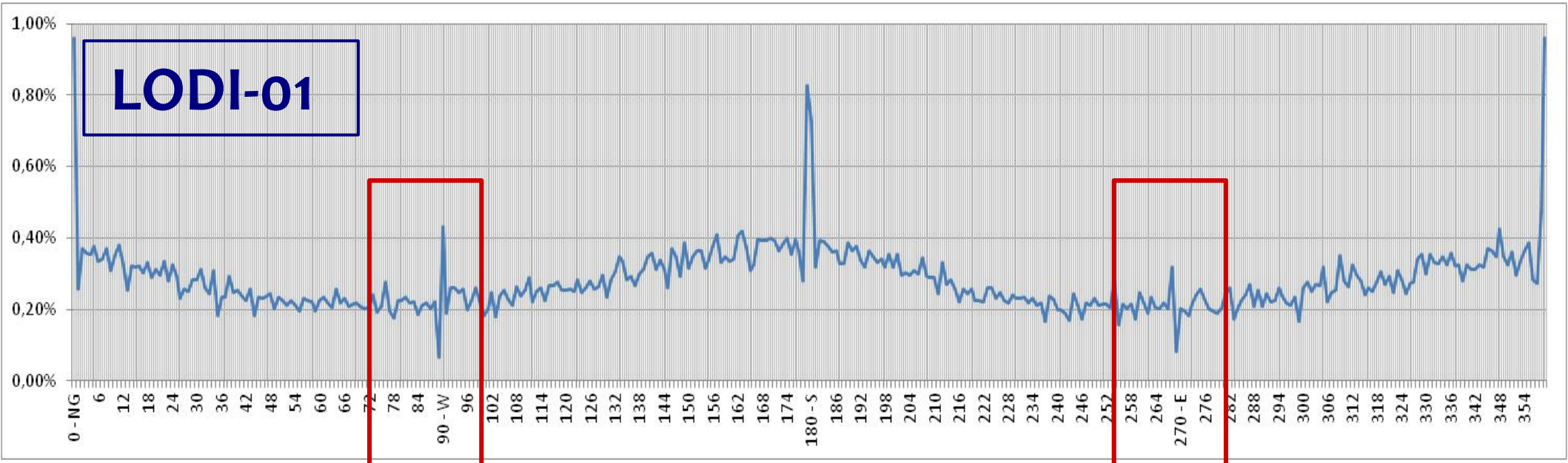
# From the comparison we found that:

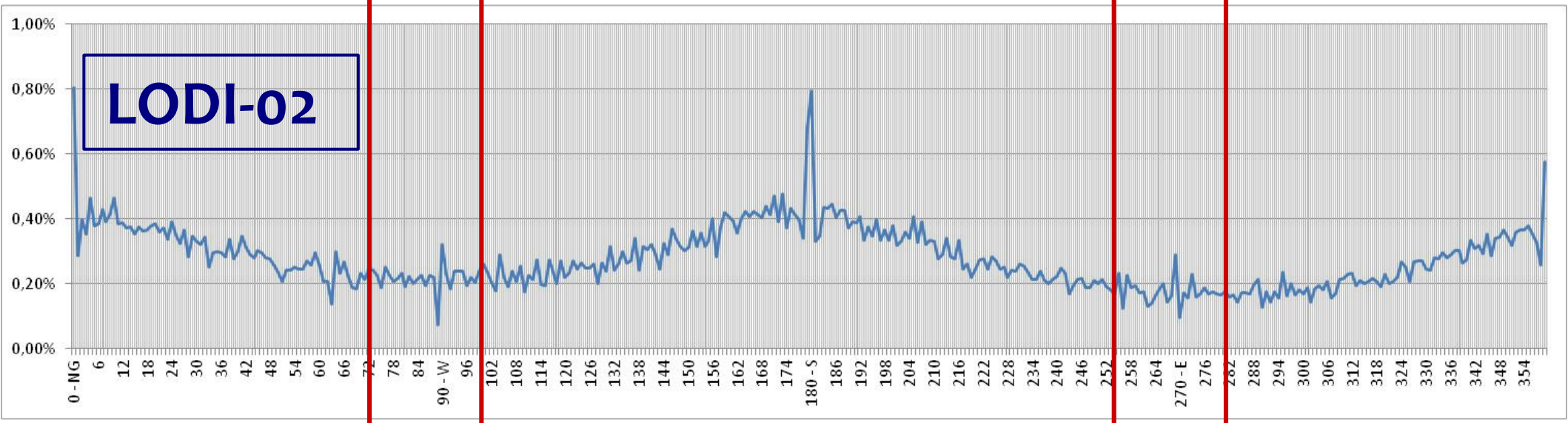
- LODI-01 has a higher rate than LODI-02 (~55 the first and ~45 the second) but the percentage of events with No Hits is about 2 times bigger

- in the angular distribution graphs we can see **summits corresponding to the East and the West**, but only at certain hours (usually at night).

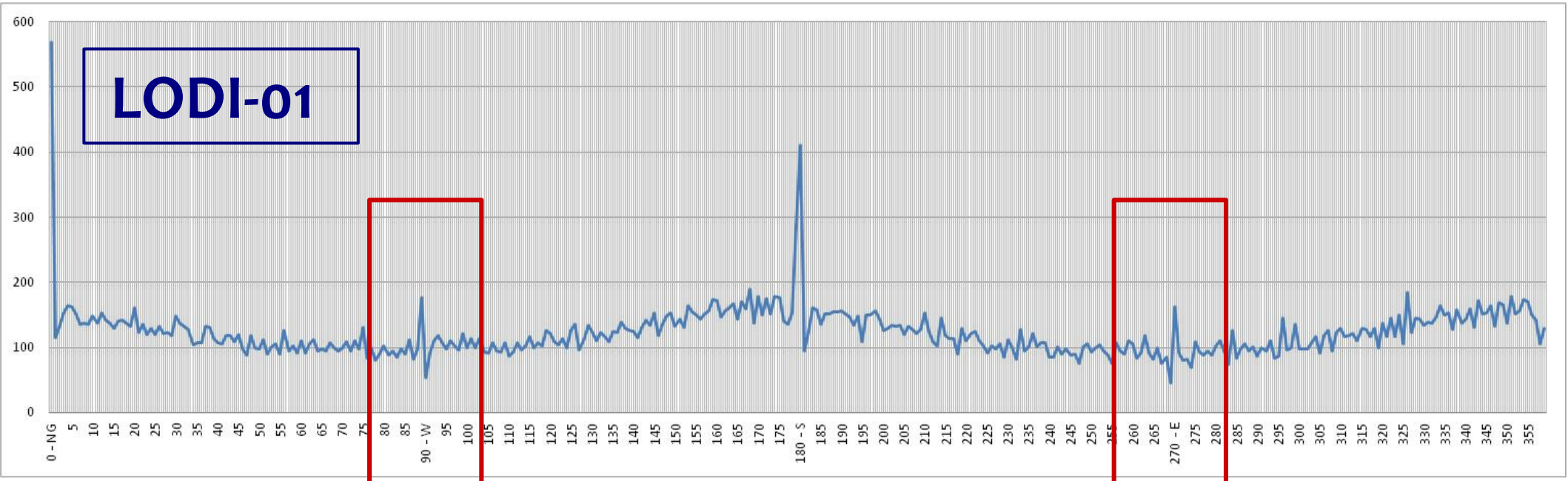
We looked for an explanation in the variation of the pressure but we did not found anything significant

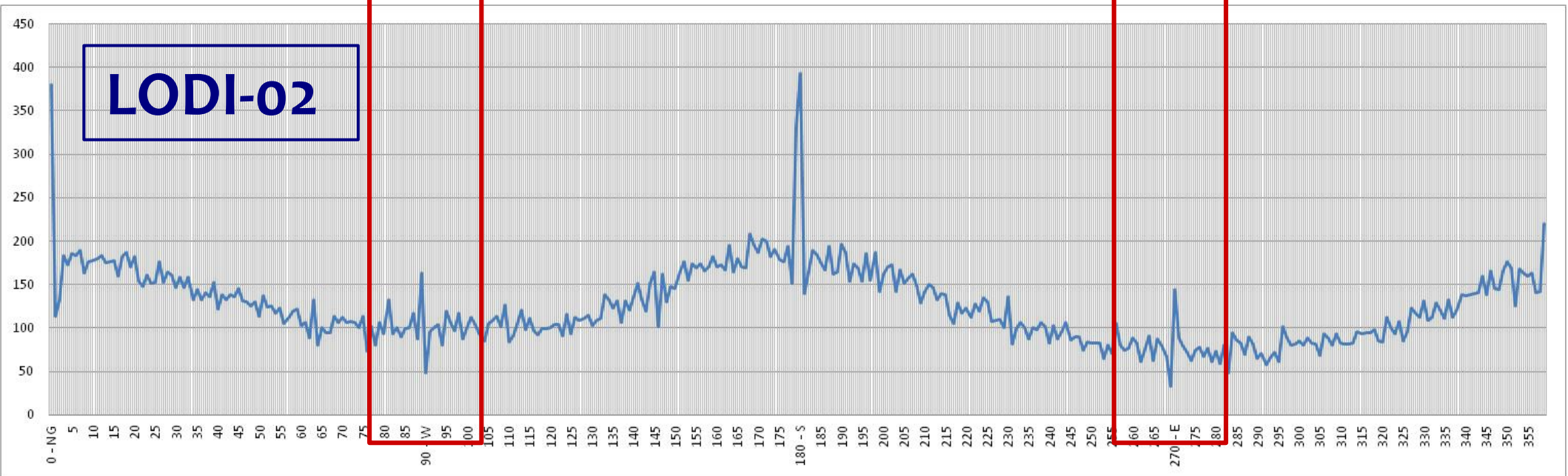
# 21-02-2017


LODI-01
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
0 - NG
90 - W
180 - S
270 - E


LODI-02
1,00%
0,80%
0,60%
0,40%
0,20%
0,00%
0 - NG
90 - W
180 - S
270 - E

# 28-02-2017


LODI-01
600
500
400
300
200
100
0
0 - NG
90 - W
180 - S
270 - E


LODI-02
450
400
350
300
250
200
150
100
50
0
0 - NG
90 - W
180 - S
270 - E

# WORK IN PROGRESS

- **Coincidences:** we tried to find them but we had not adequate instruments, now we are looking for new methods

- Comparing our data with some detected by telescopes at different latitudes to verify the latitude effect

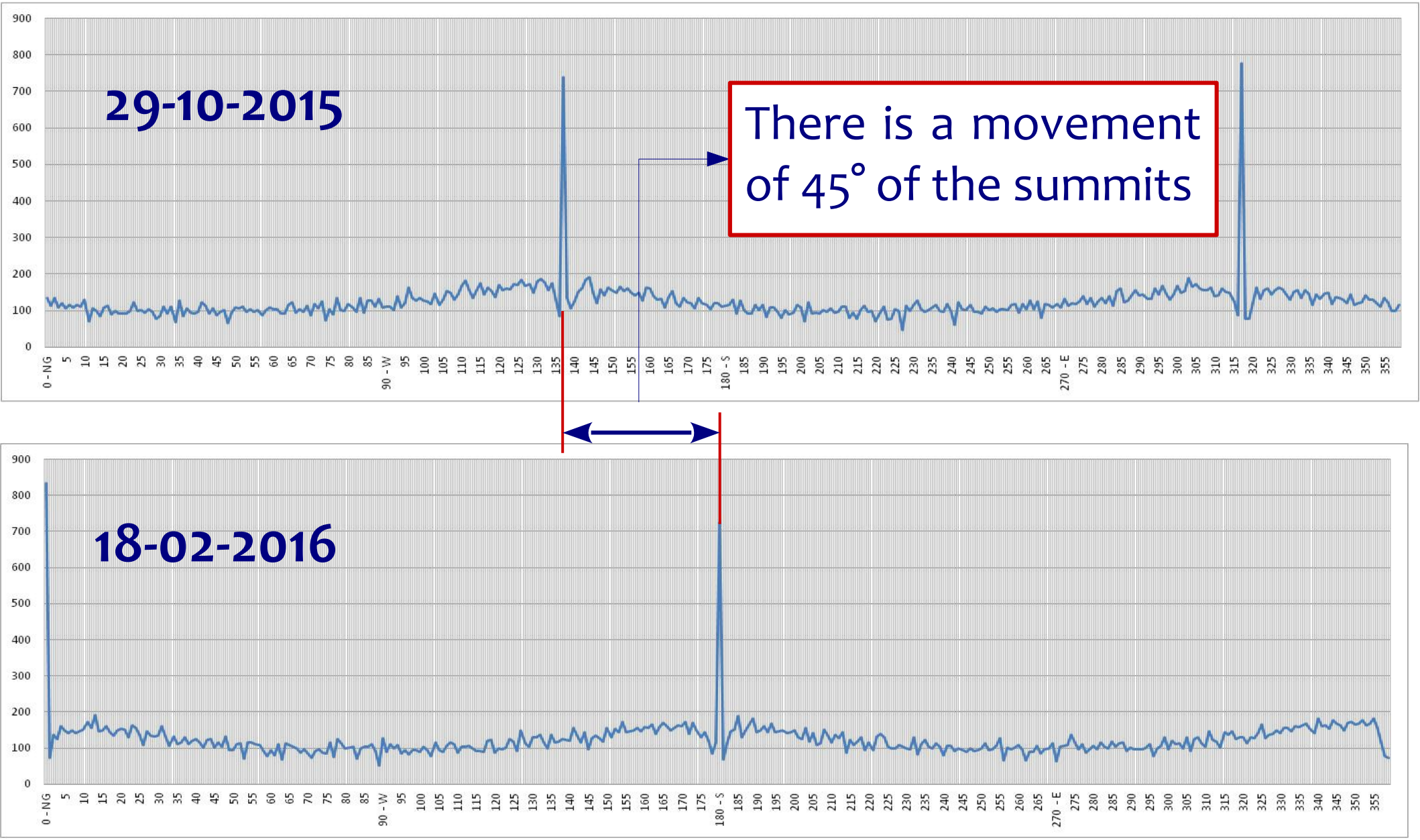
- Going on with our research comparing data detected during a longer period of time

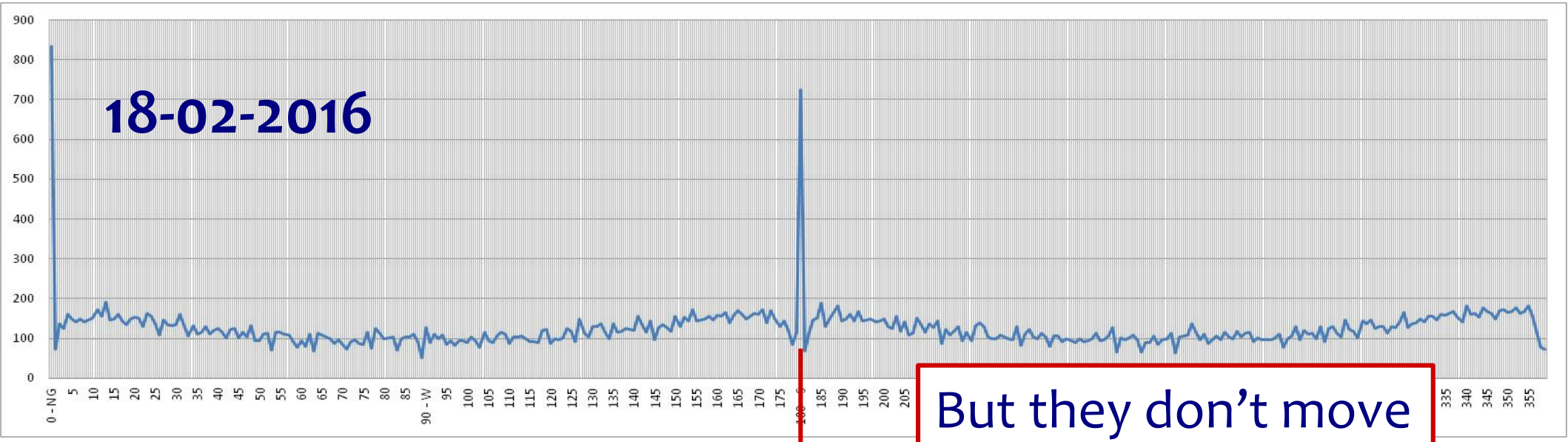
- time of flight < 0

- Clarifying the summits at the North and the South

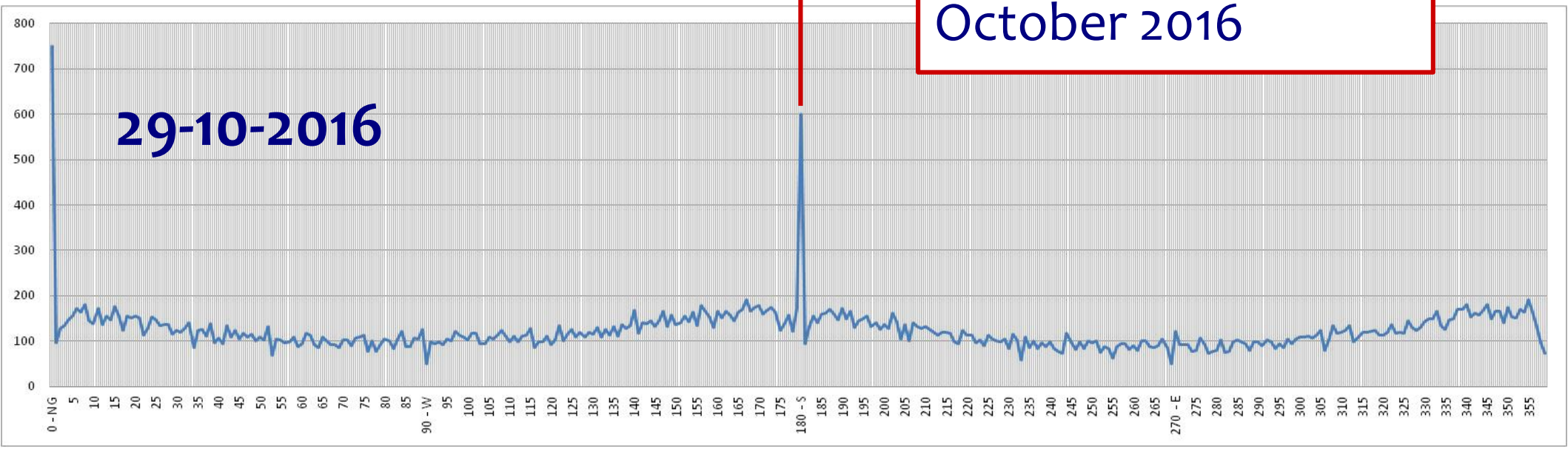
- **THIRD TELESCOPE**

# We looked for changing in the angular distribution during the last year and a half but we found something we don't understand






But they don't move from February to October 2016



# TELESCOPES POSITIONS

A: LODI-01 (Gandini) – B: LODI-02 (Volta)

C: LODI-03 (next installation)