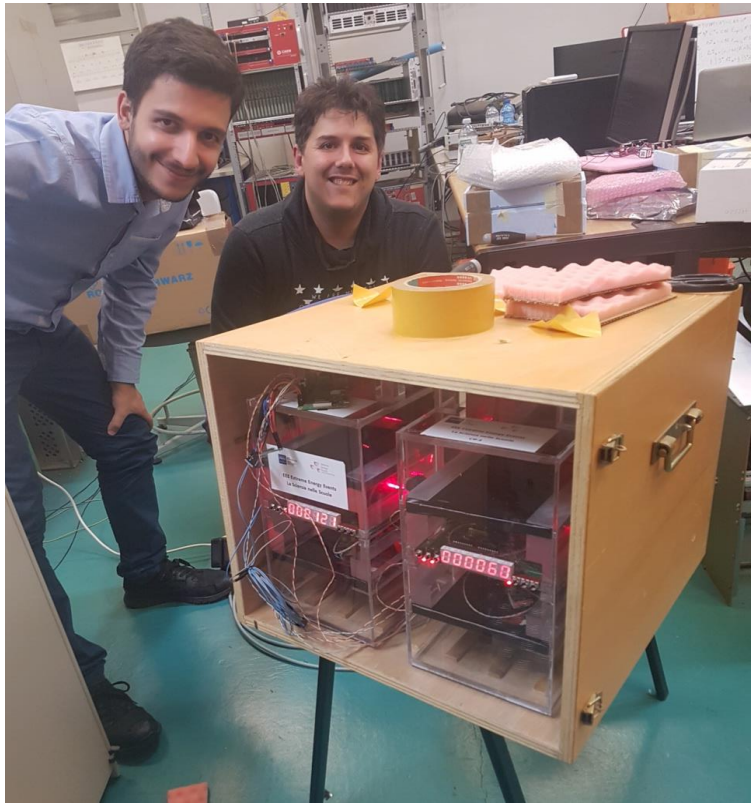
Update on measurements underground

Stefano Boi

Rome - January 14th, 2019

Experimental setup



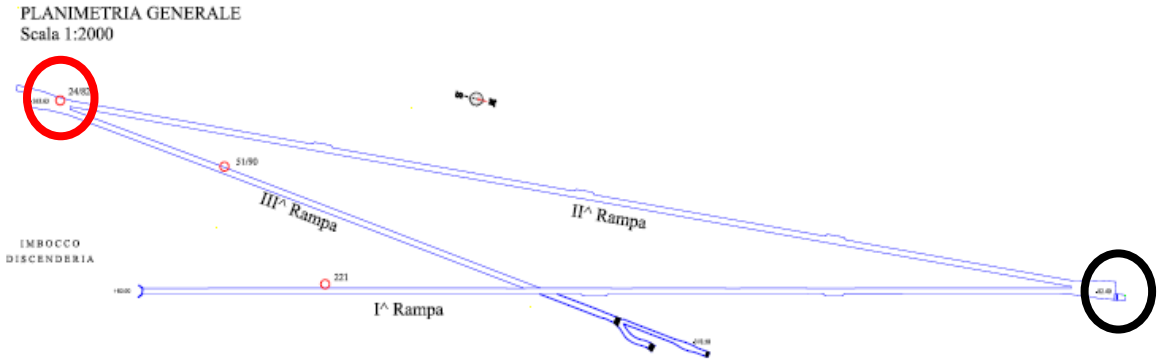
- 3 cosmic box enclosed in a wooden box
- 1 Raspberry Pi for DAQ
- 1 UPS for backup

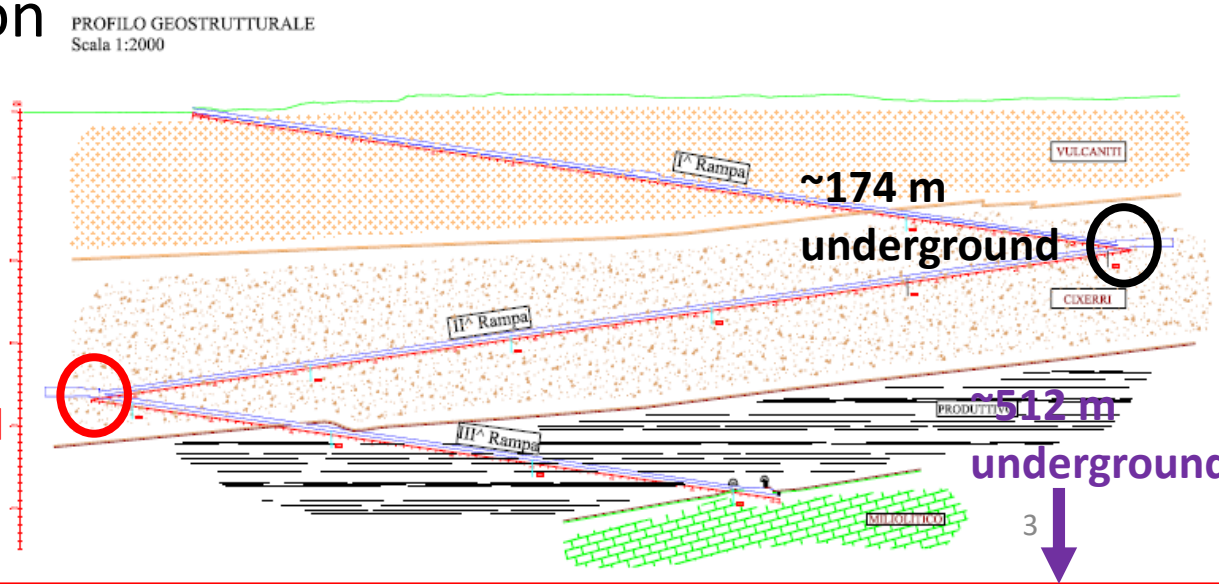
ASTRO

- Scintillator based detector (equipped with SiPM) enclosed in a waterproof suitcase
- Integrate backup battery
- Stand-alone DAQ

Status of measurements

- 1 measurement outside
  - ~48 minutes of acquisition
- 3 measurements underground (one ongoing)
  - 174 m ~71.5 hours ~ 3 days of acquisition
  - 339 m ~ 214.3 hours ~ 9 days of acqusition
  - 512 m ongoing at this time. A few problems during the acquisition

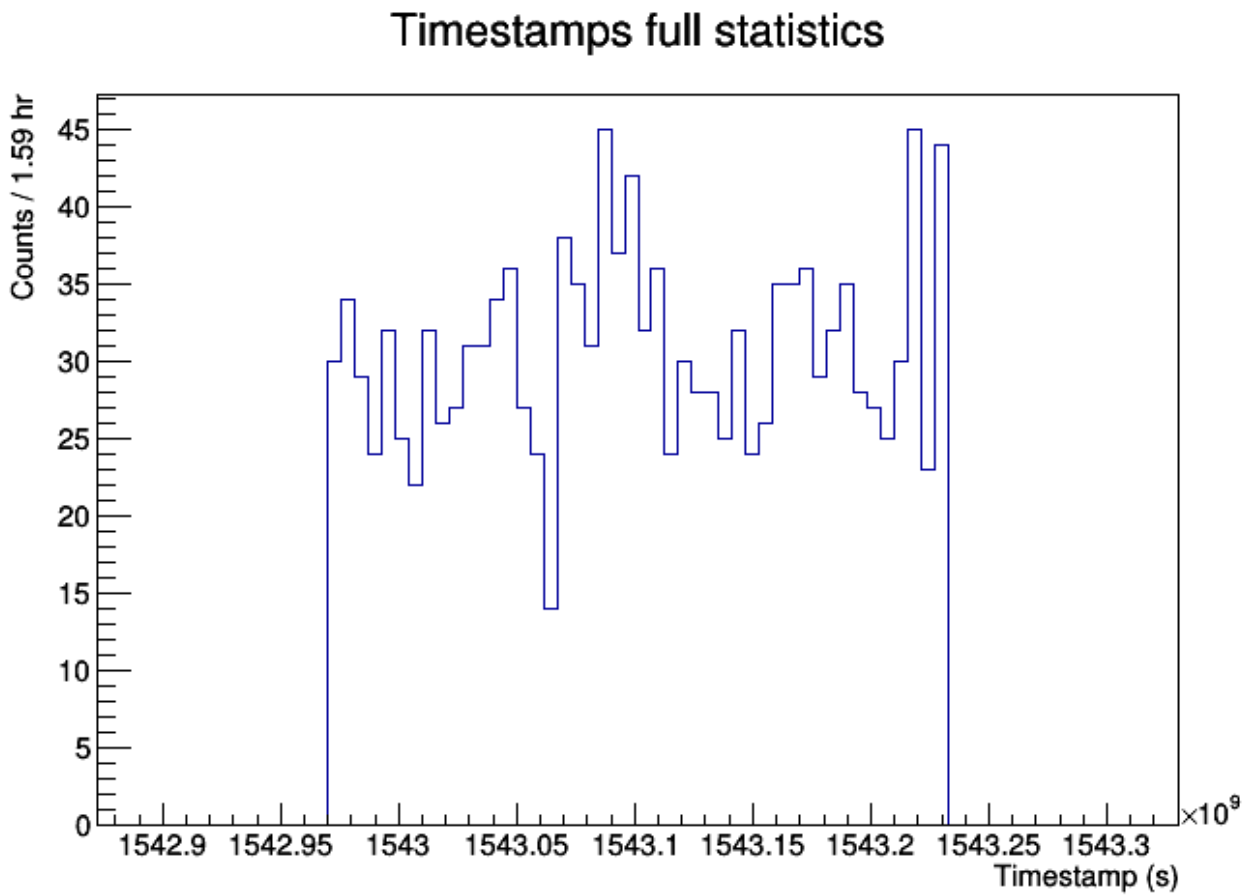




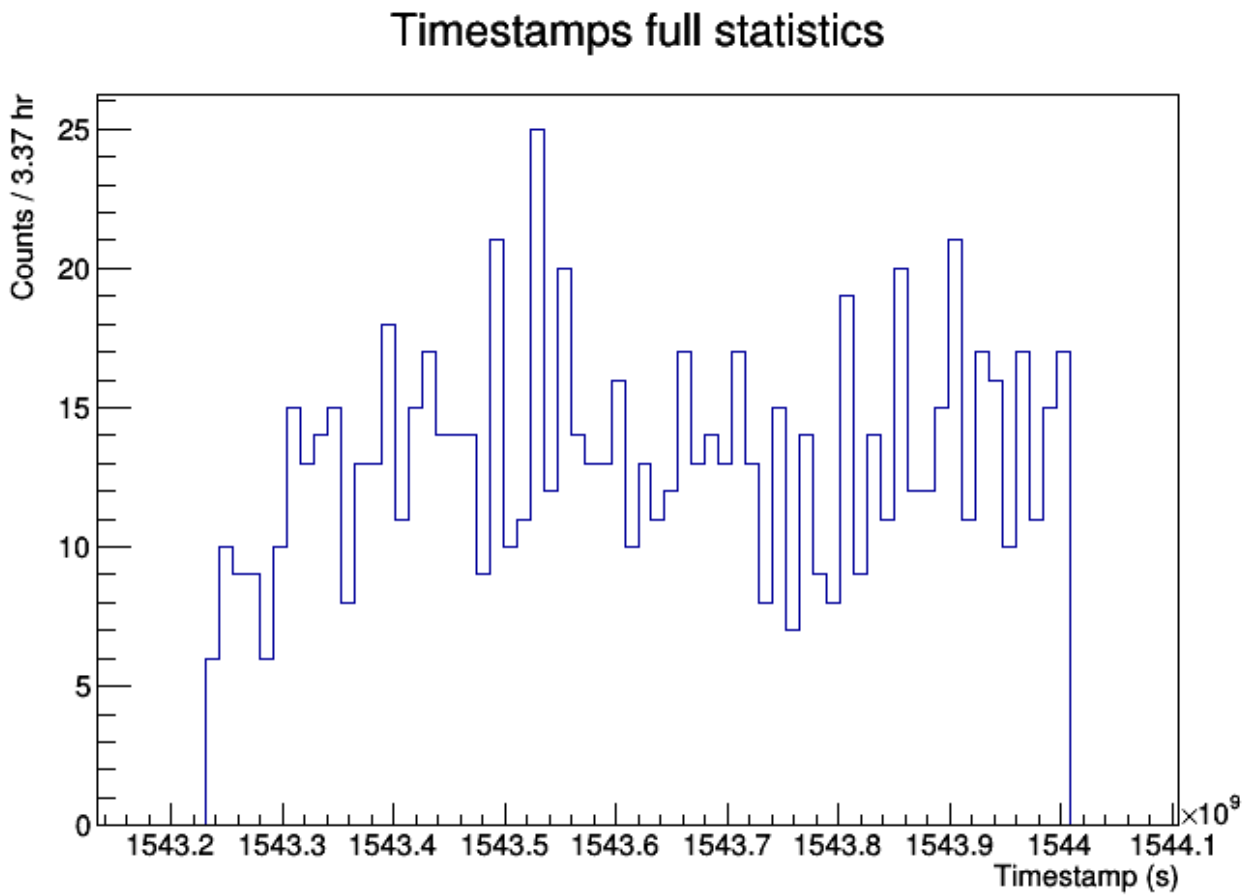
Workforce involved

- Preliminary measurements and studies:
  - 2 Centro Fermi researchers + 1 collaborator
- Underground measurements:
  - 5 Centro Fermi Researchers (one new entry)
  - 5 students + 3 professors from Liceo Scientifico “A. Pacinotti” (CAGL-01)
  - Carbosulcis S.p.A. employees for technical support during operations underground
- Technical support:
  - Daniele Monteleone for DAQ development and technical support
  - 4 undergraduate students for a few support in devices development
  - …

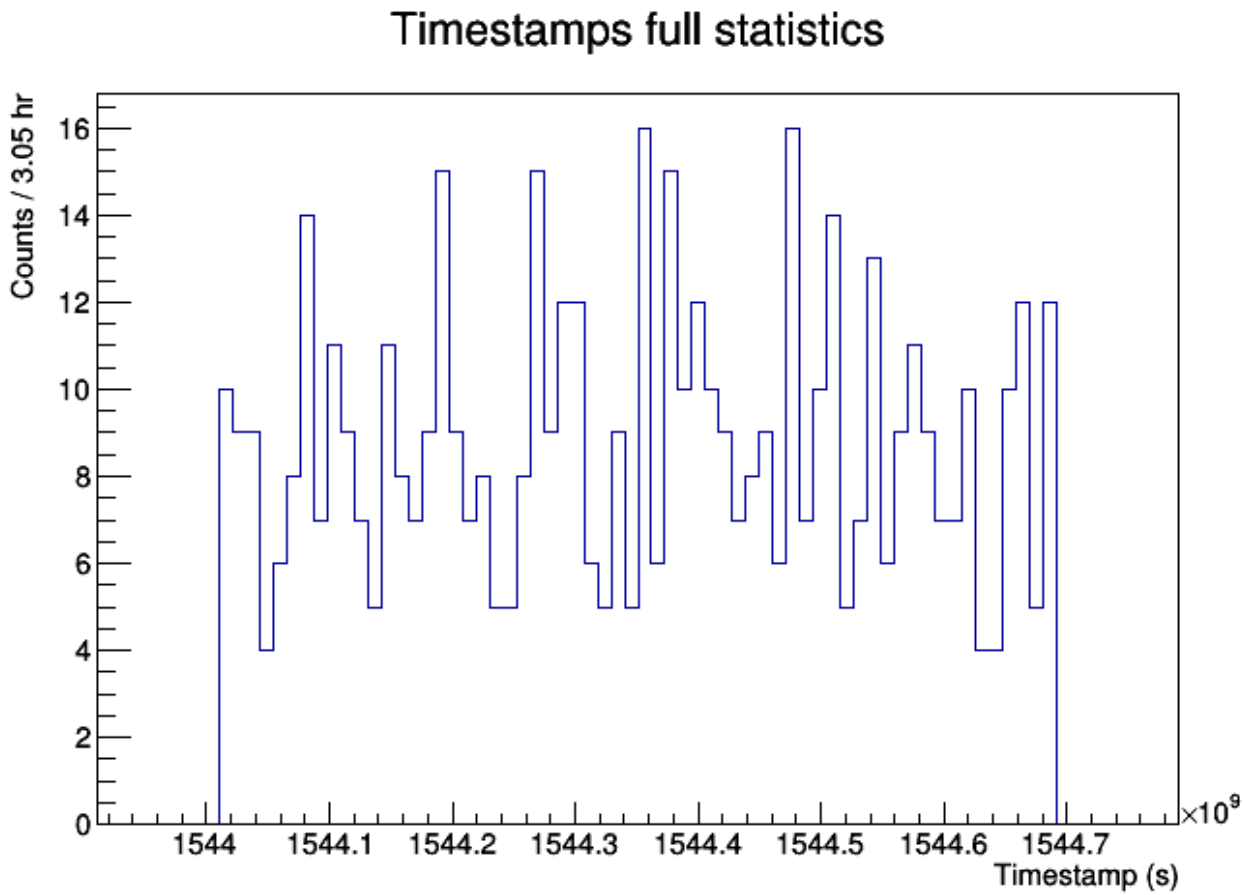
Acquisition stability
174 meters underground



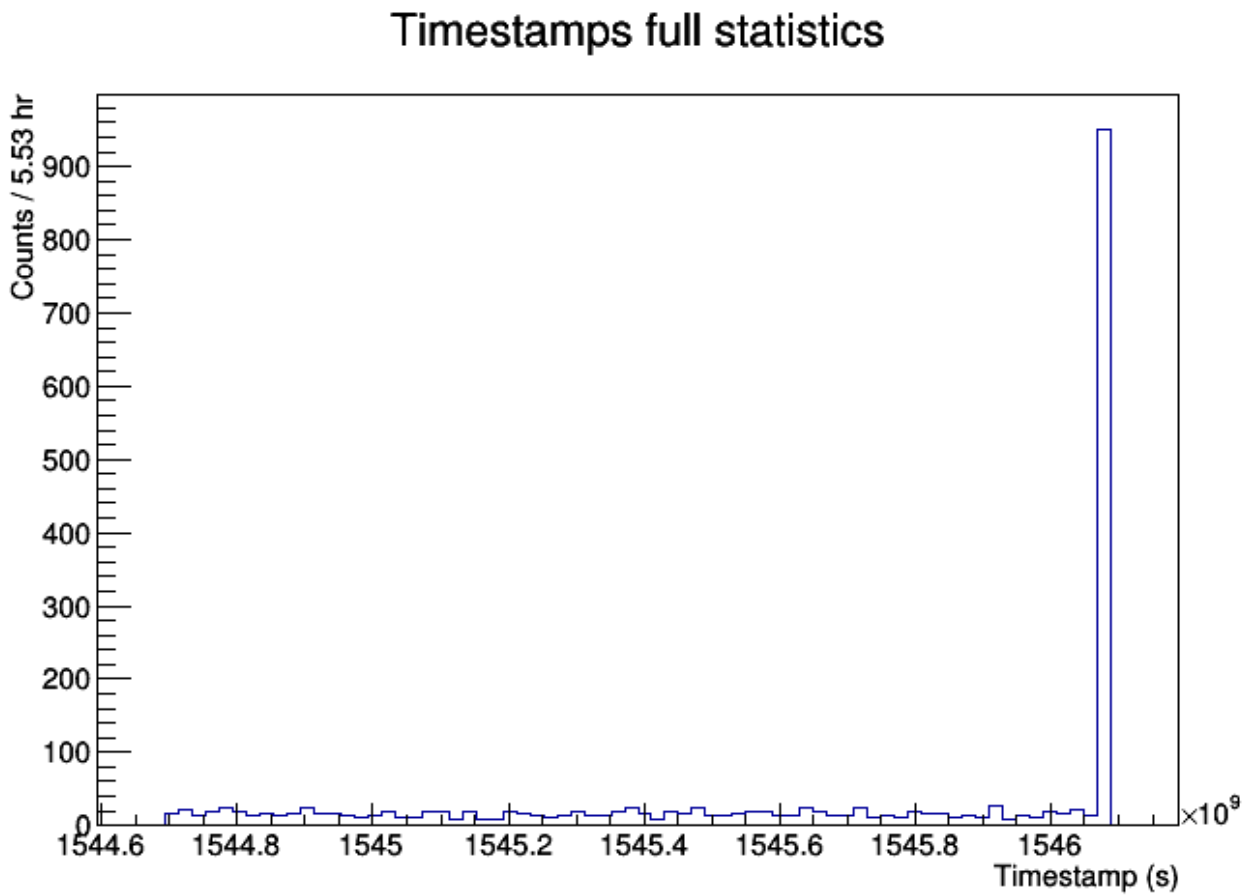
Acquisition stability
339 meters underground



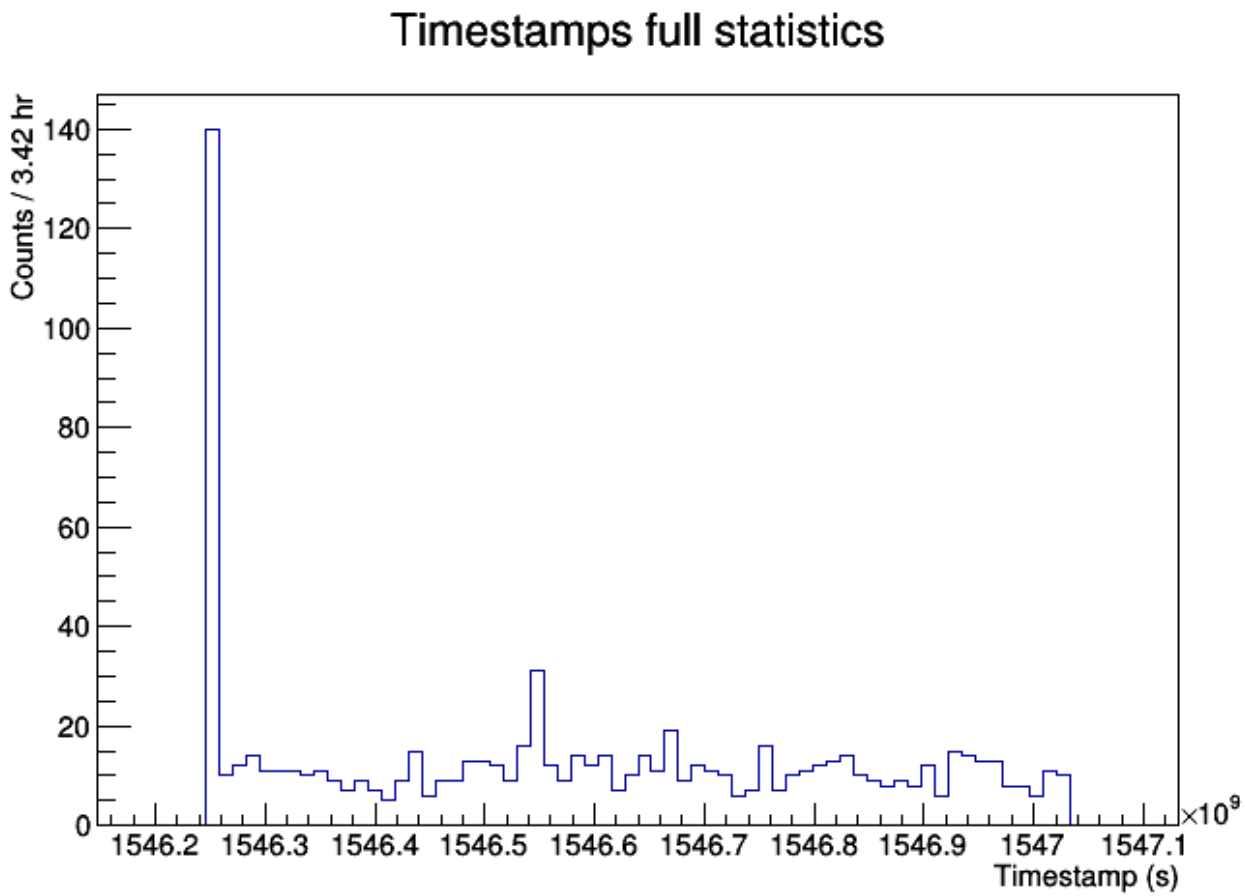
Acquisition stability
512 meters underground (1)



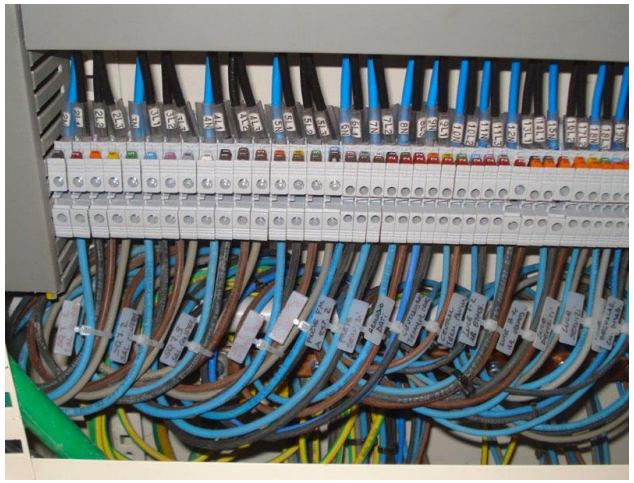
Acquisition stability
512 meters underground (2)



Acquisition stability
512 meters underground (3)



Problems during acquisition at 512 meters underground



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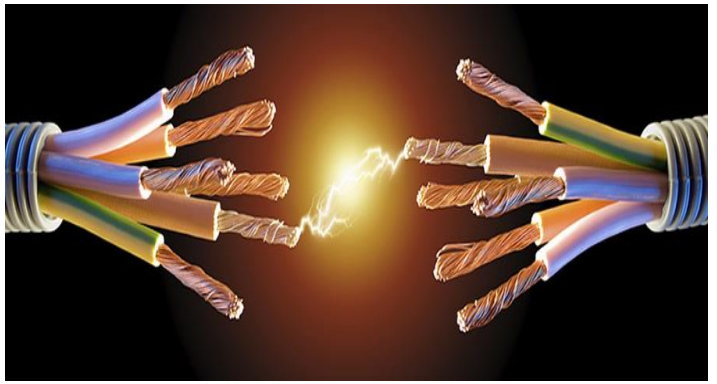
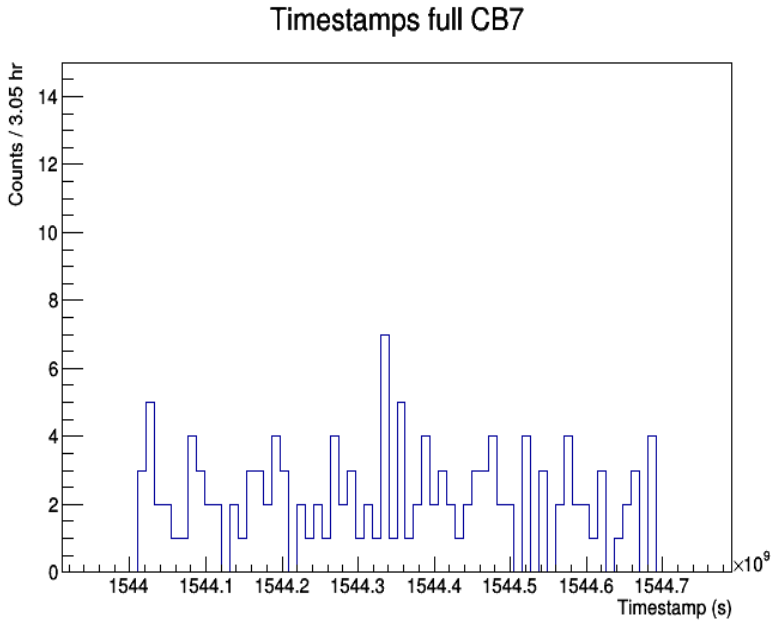
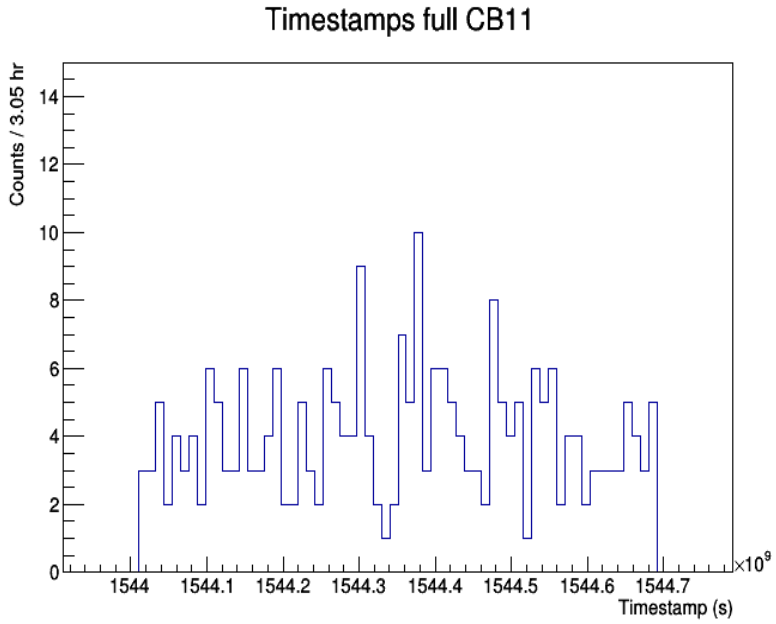
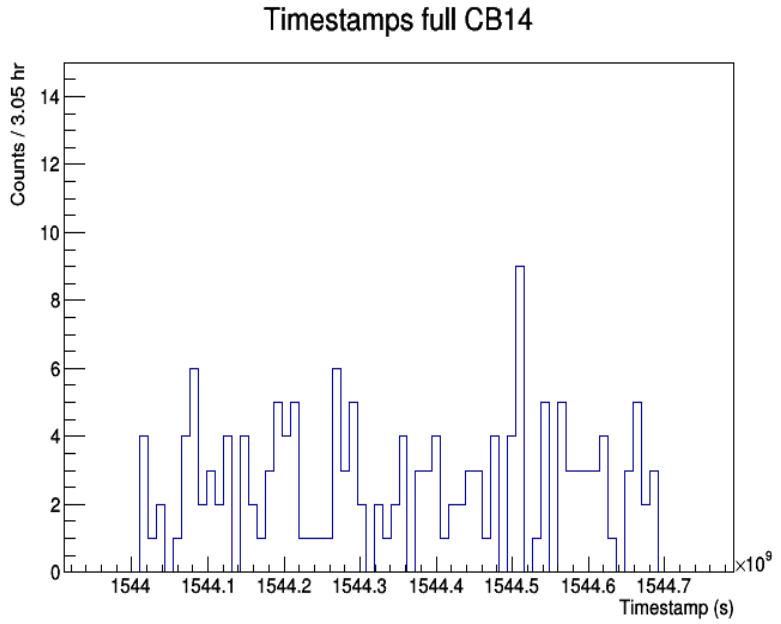


⇒DAQ STOP

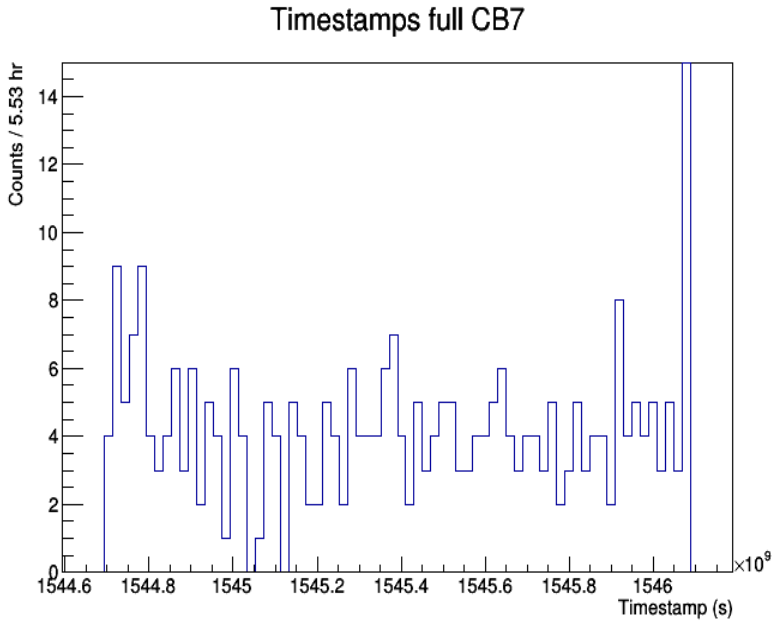
512 meters underground
From 2018-12-05 to 2018-12-13

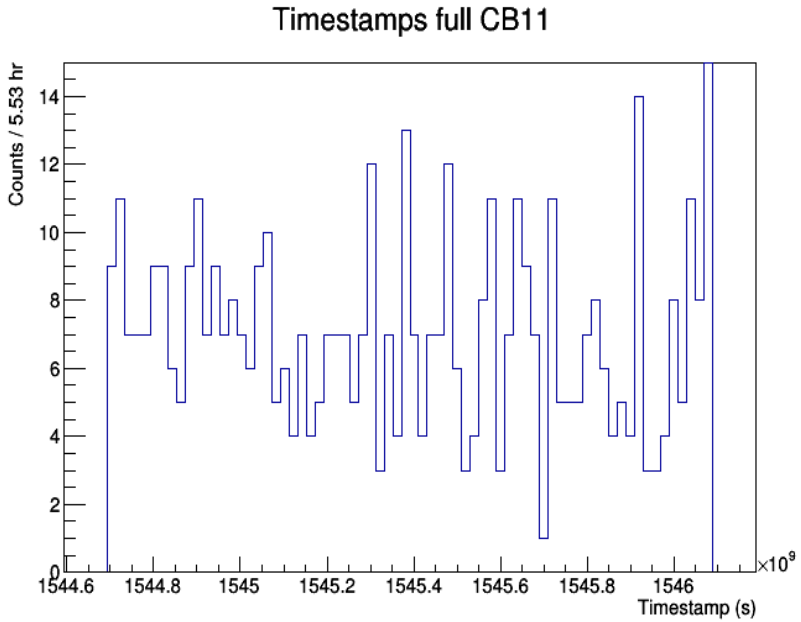


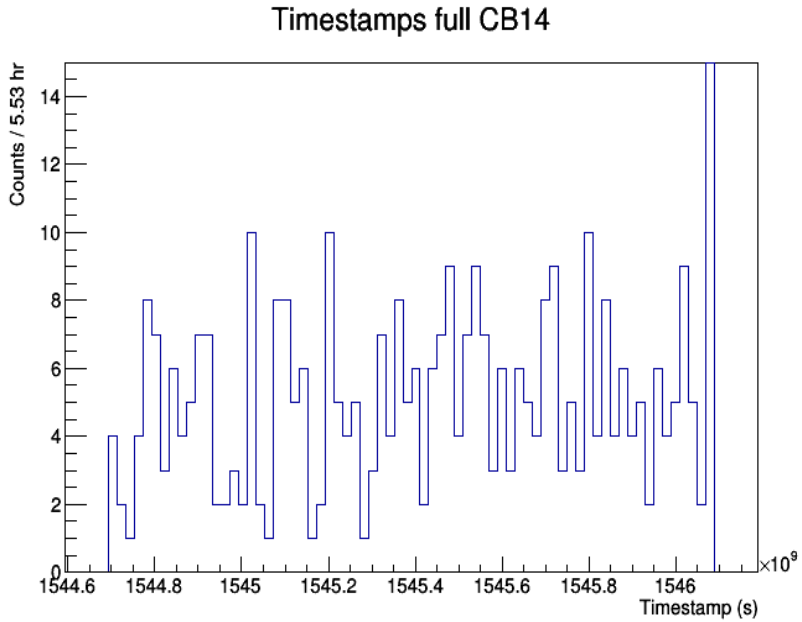




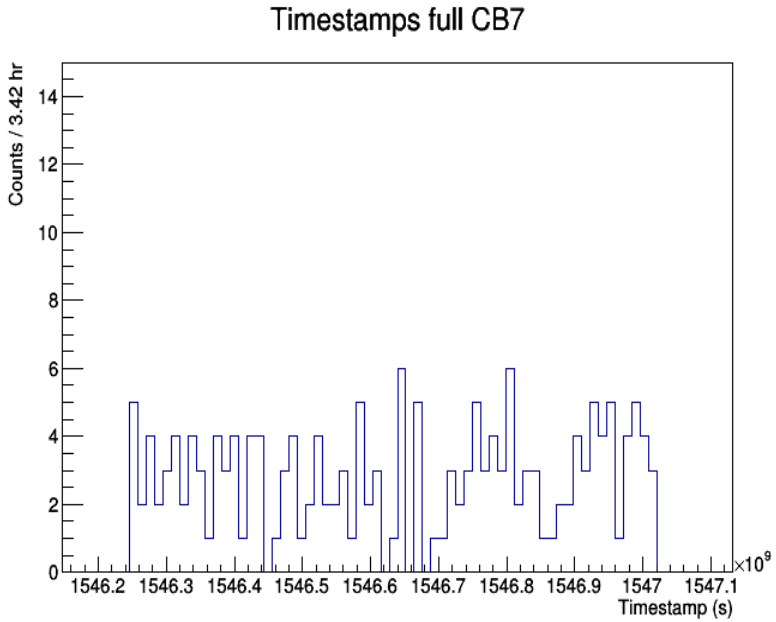
512 meters underground
From 2018-12-13 to 2018-12-31

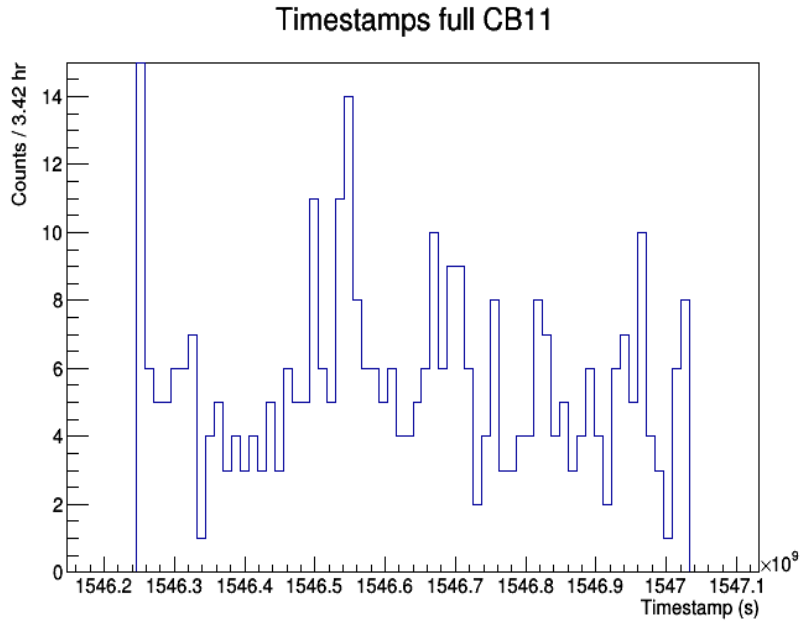


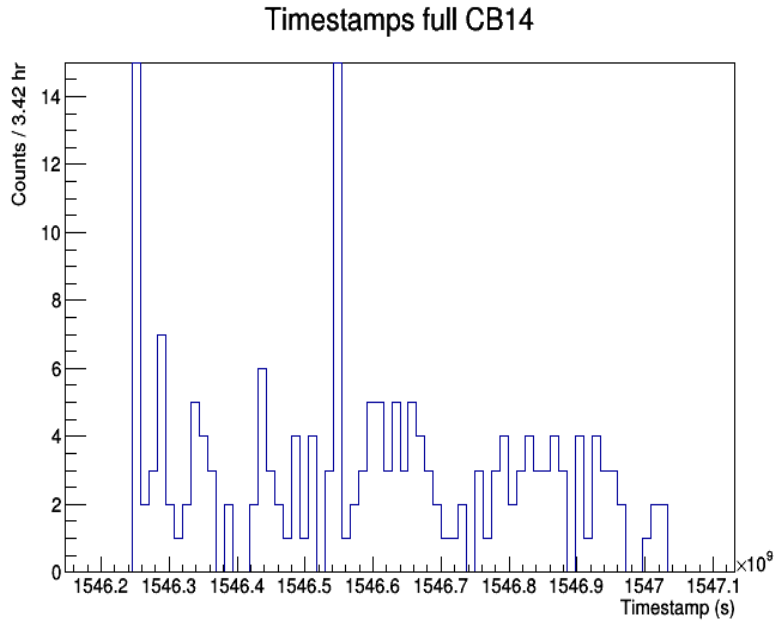




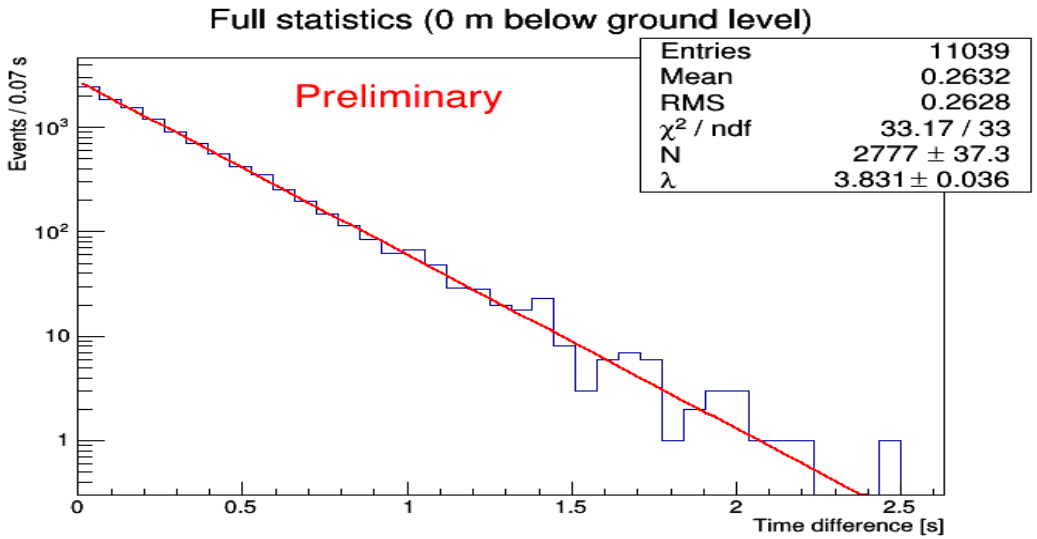
512 meters underground
From 2018-12-31 to 2018-12-09

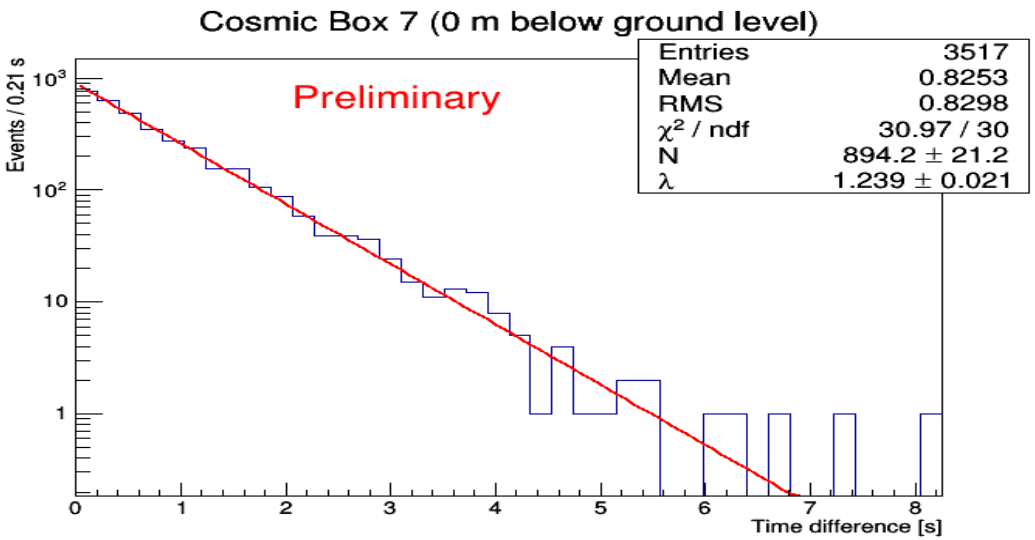


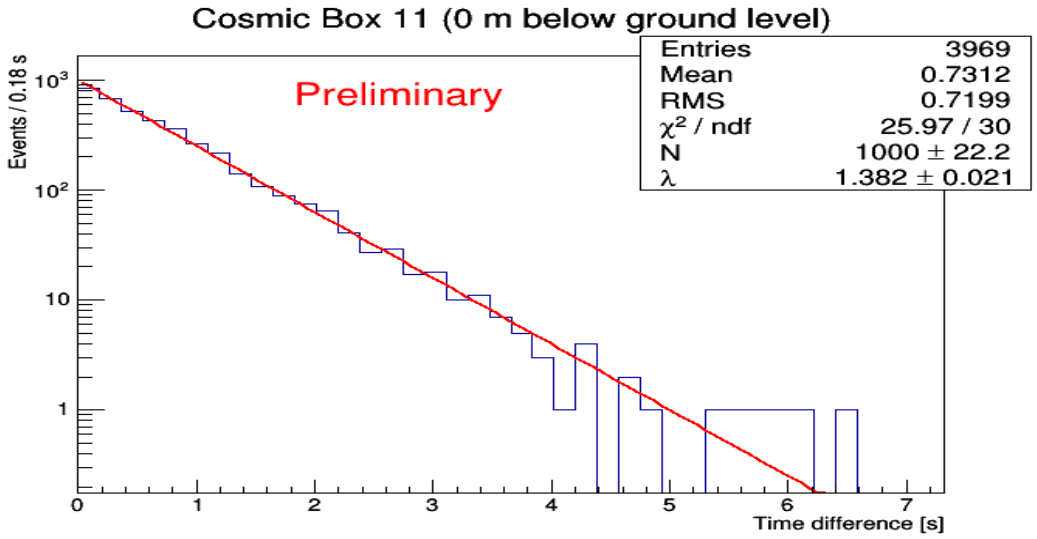


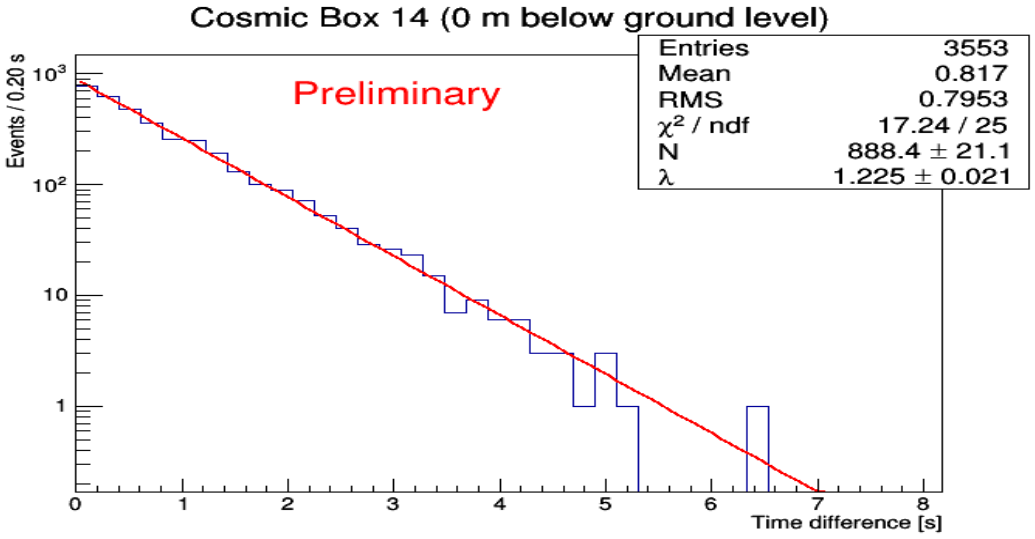


A few results – Ground level

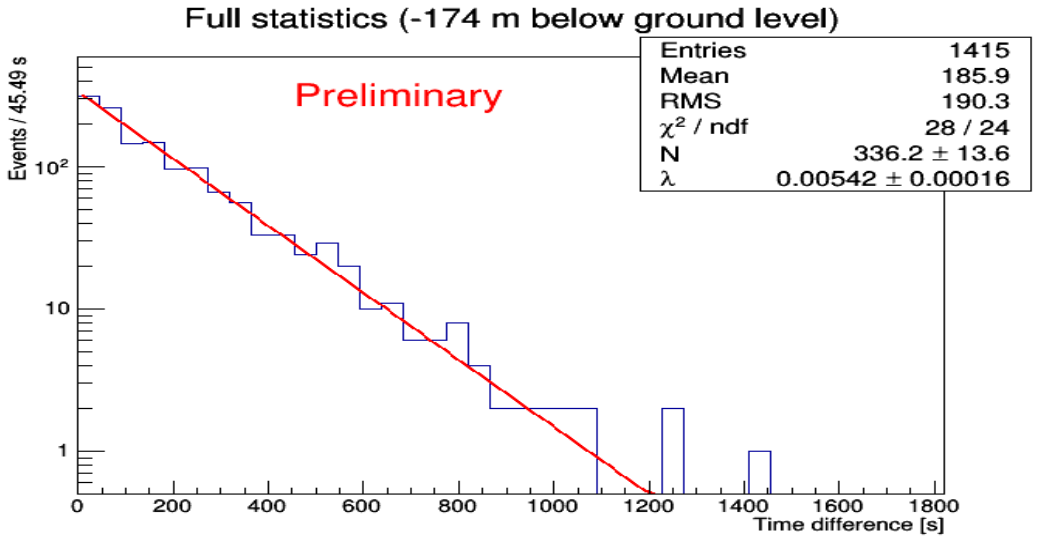


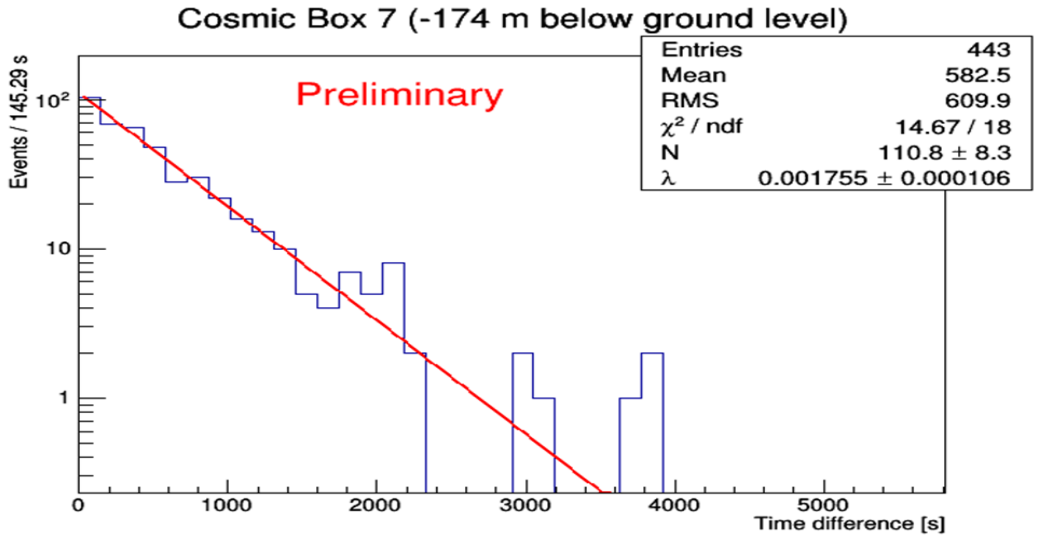


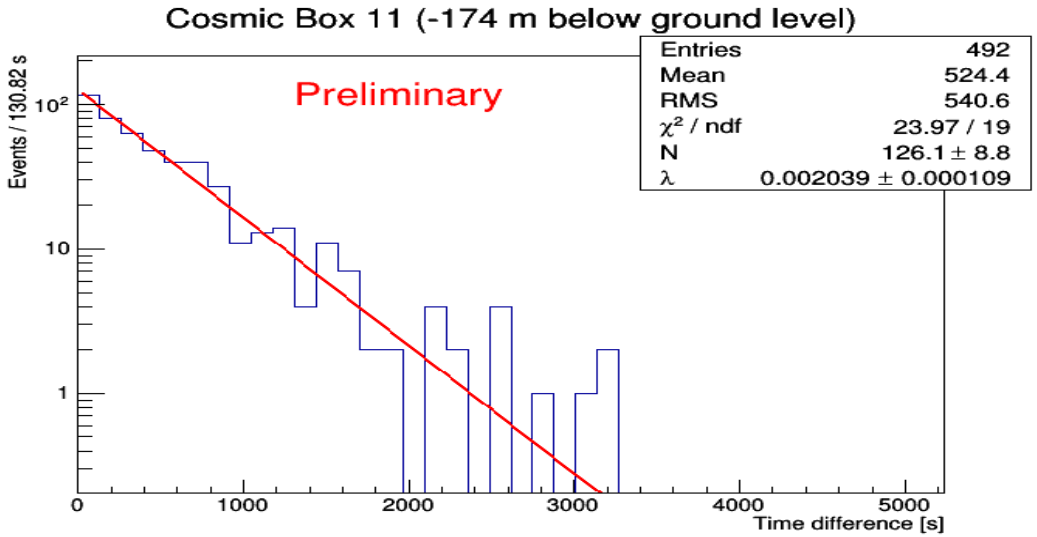


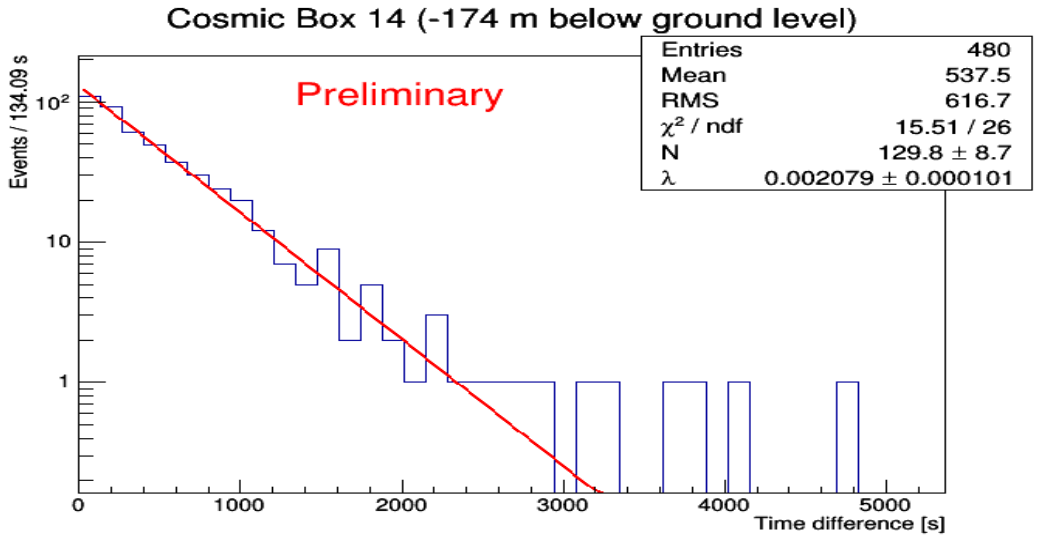


A few results – 174 meters underground

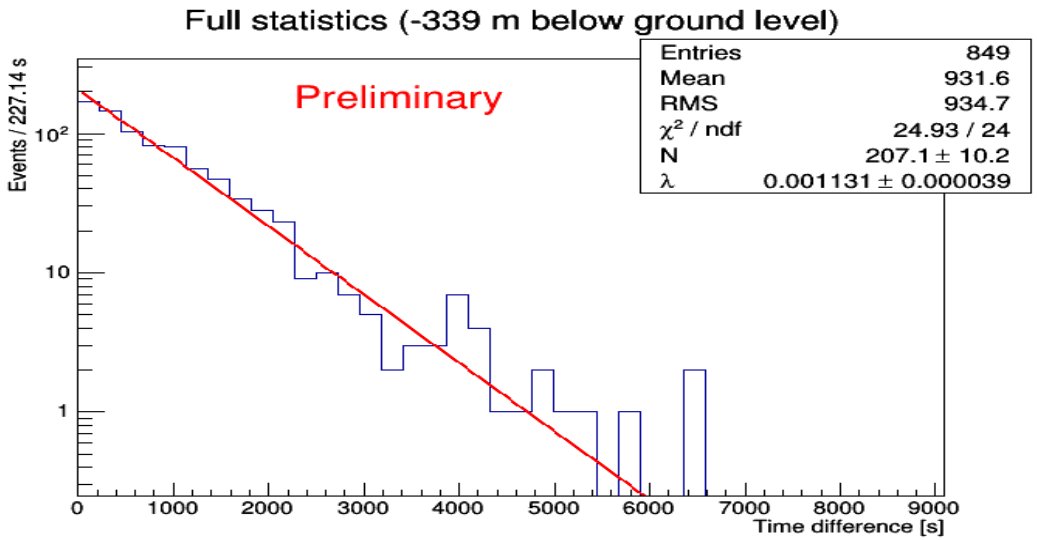


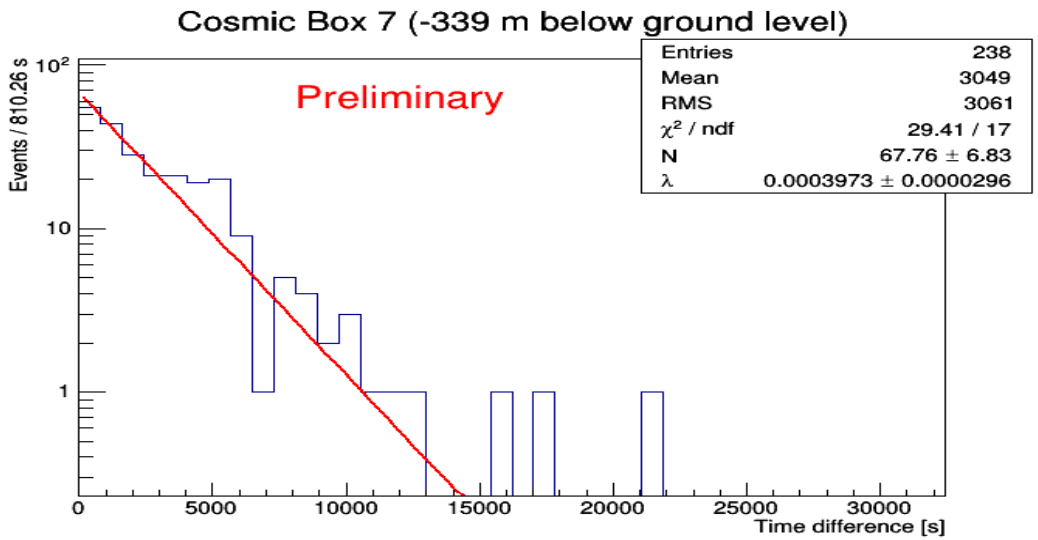


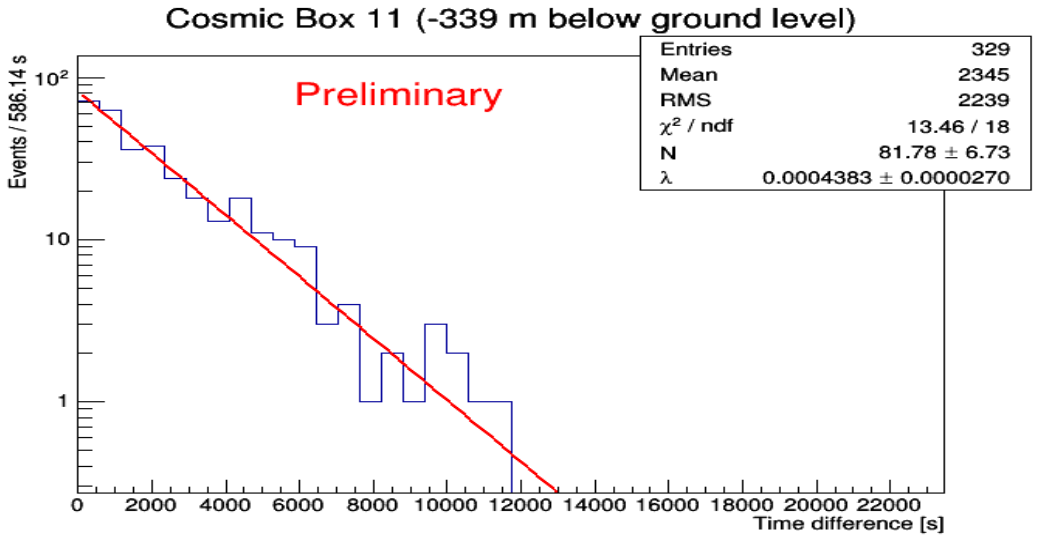


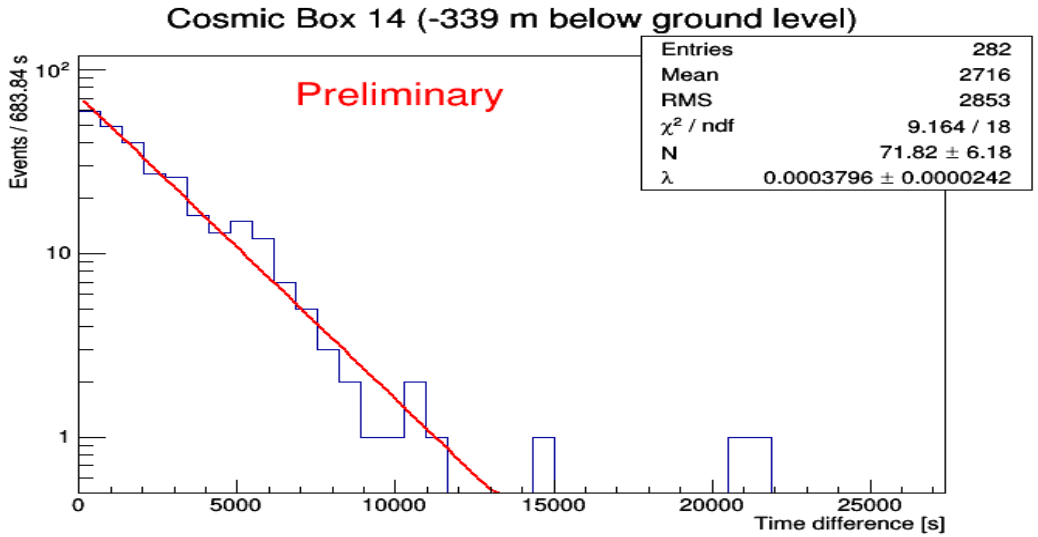


A few results – 339 meters underground

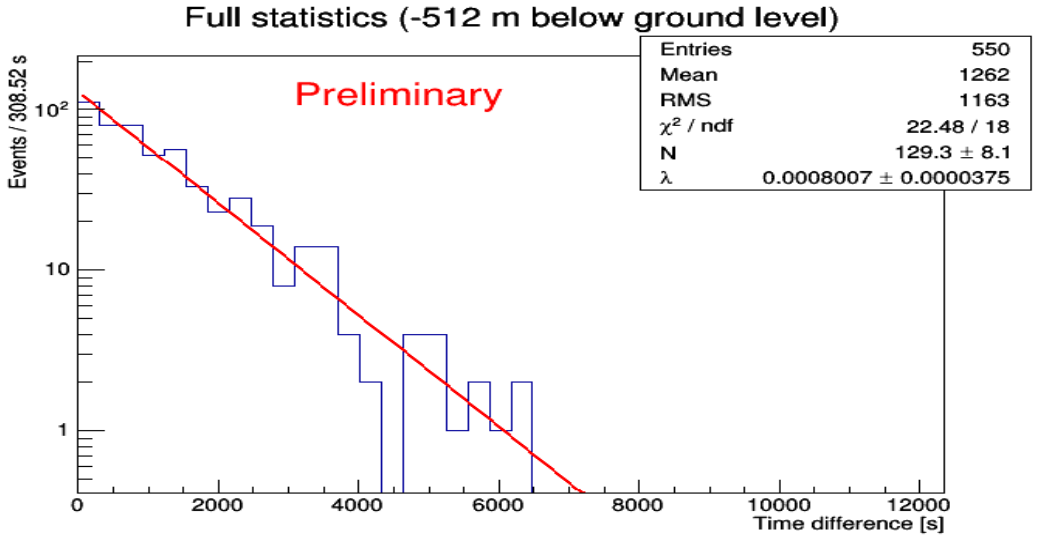


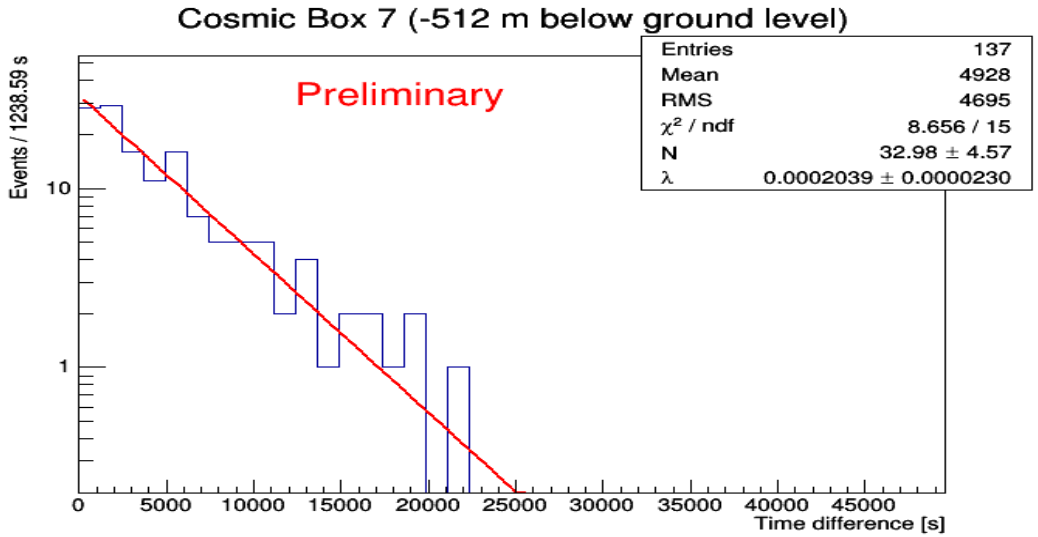


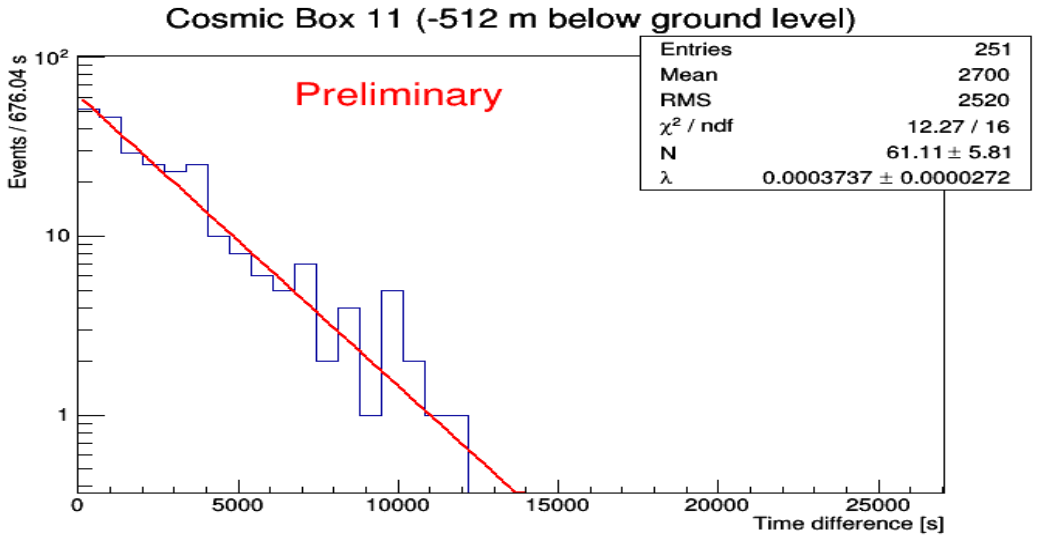


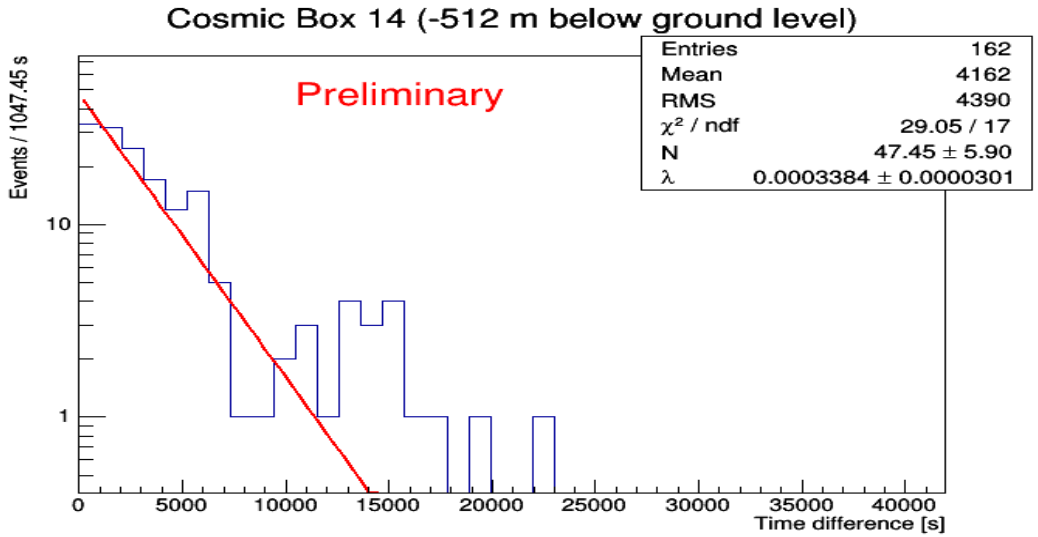


A few results – 512 meters underground (1)

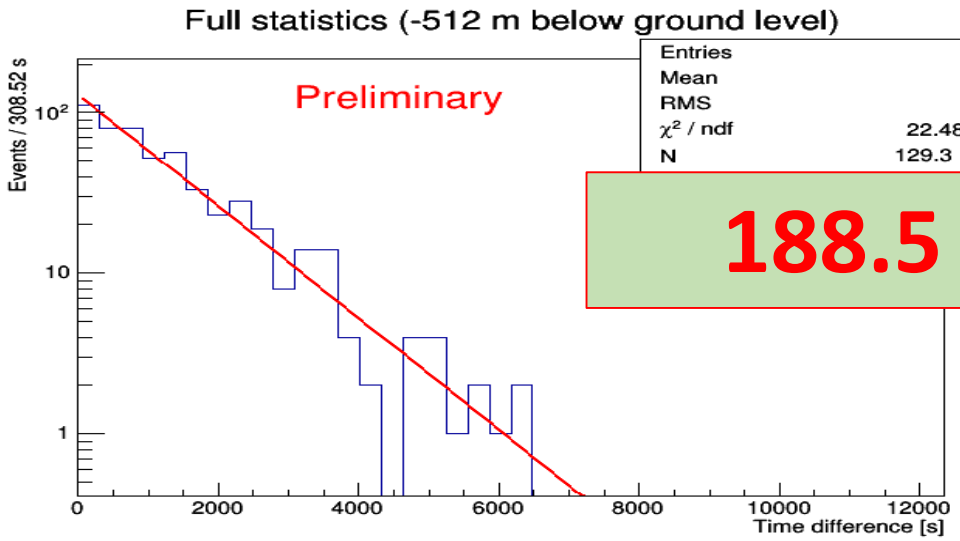


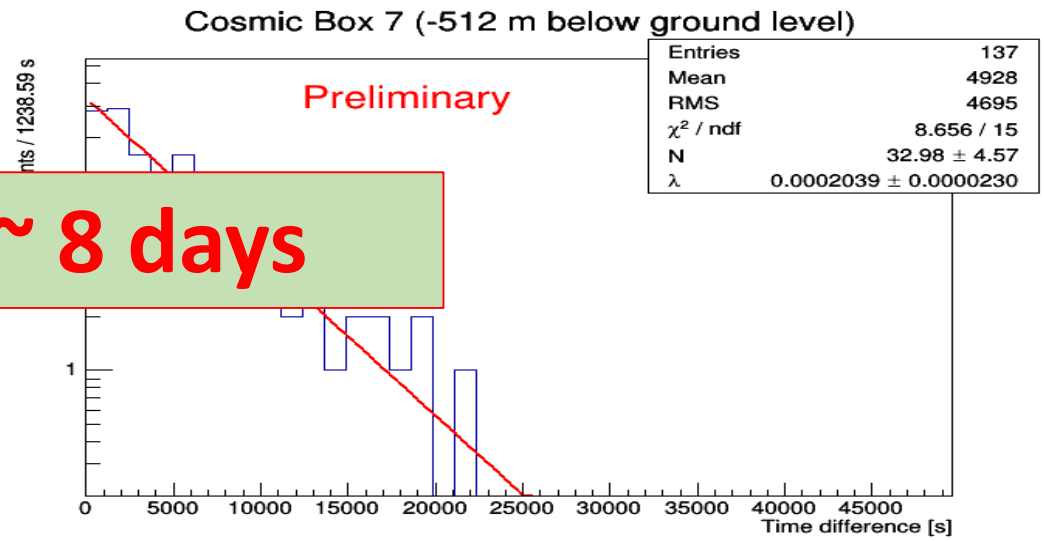




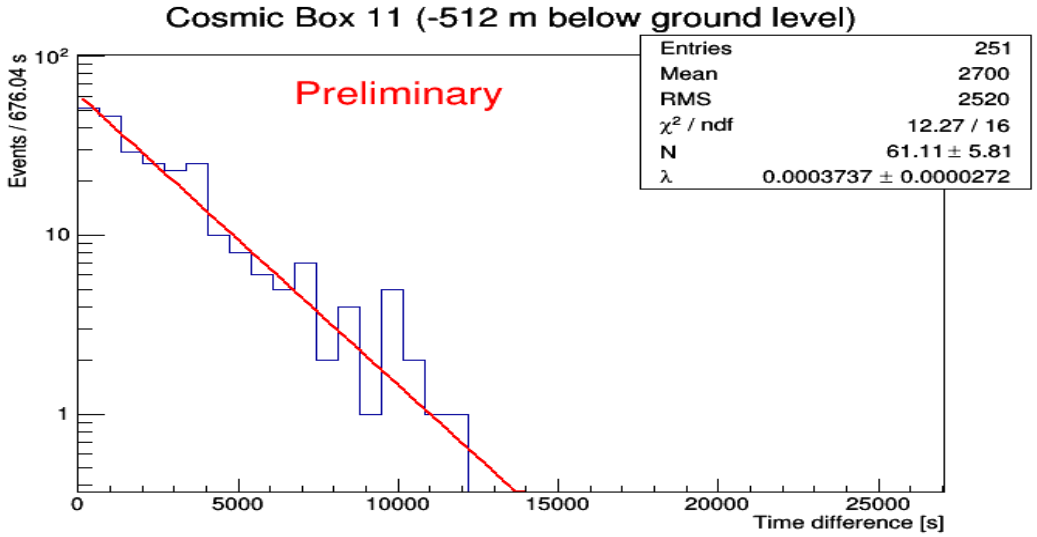


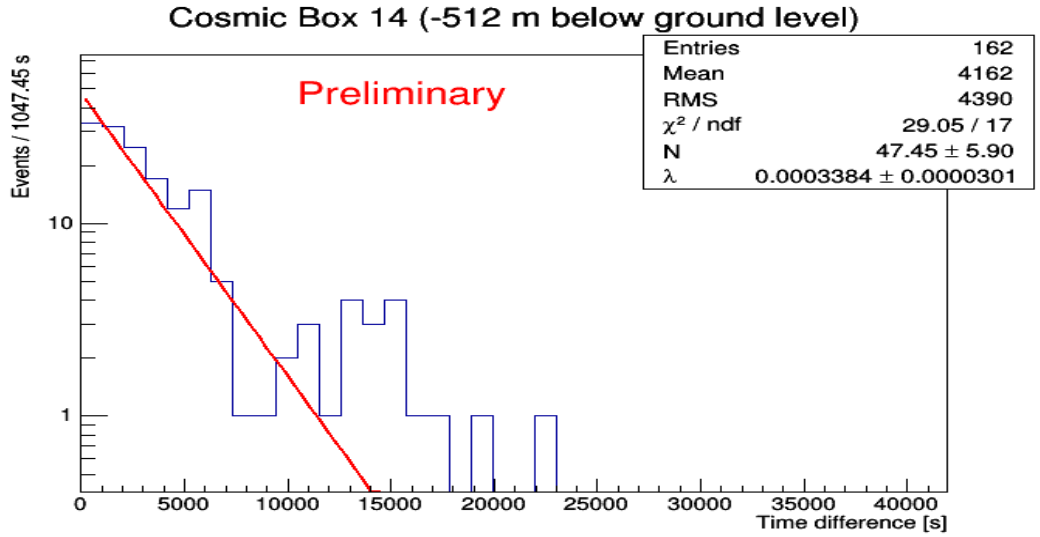
A few results – 512 meters underground (1)



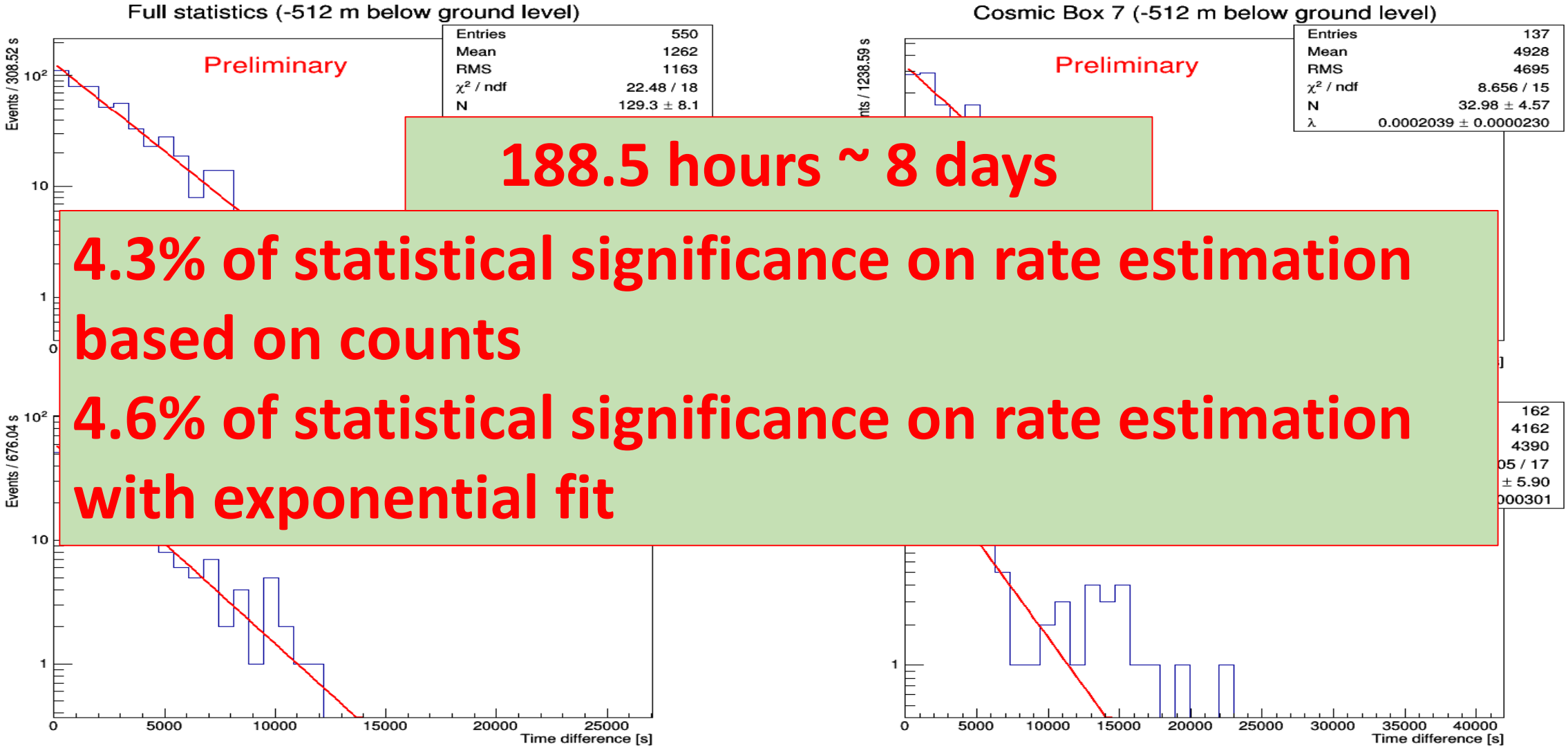


188.5 hours ~ 8 days





A few results – 512 meters underground (1)



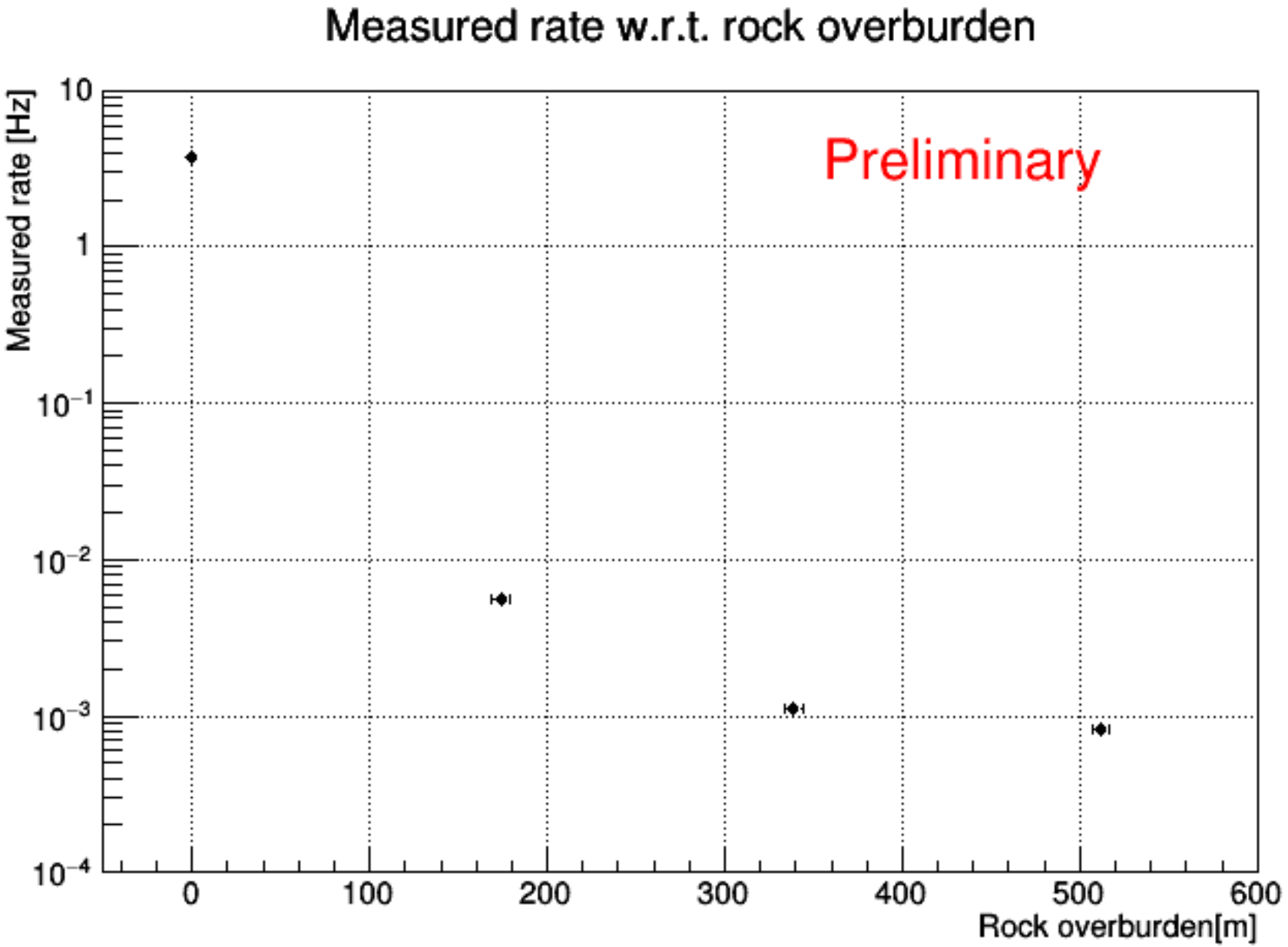
188.5 hours ~ 8 days

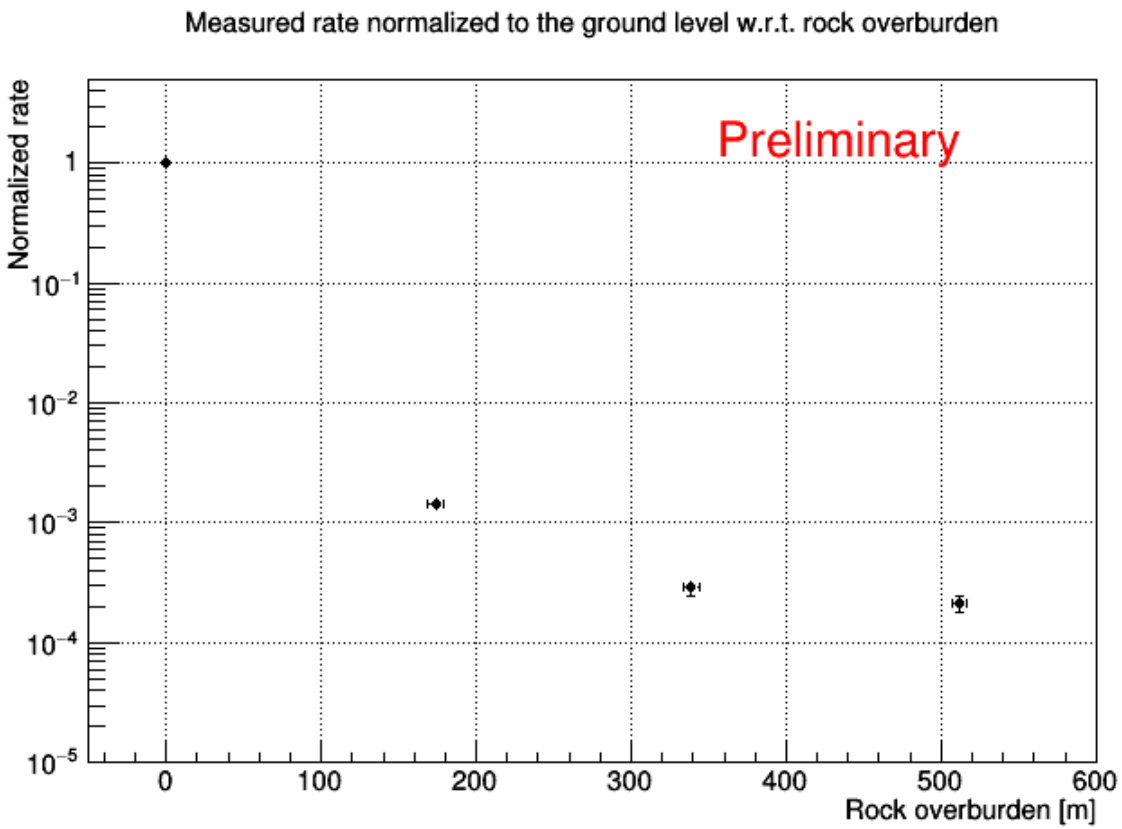
4.3% of statistical significance on rate estimation based on counts

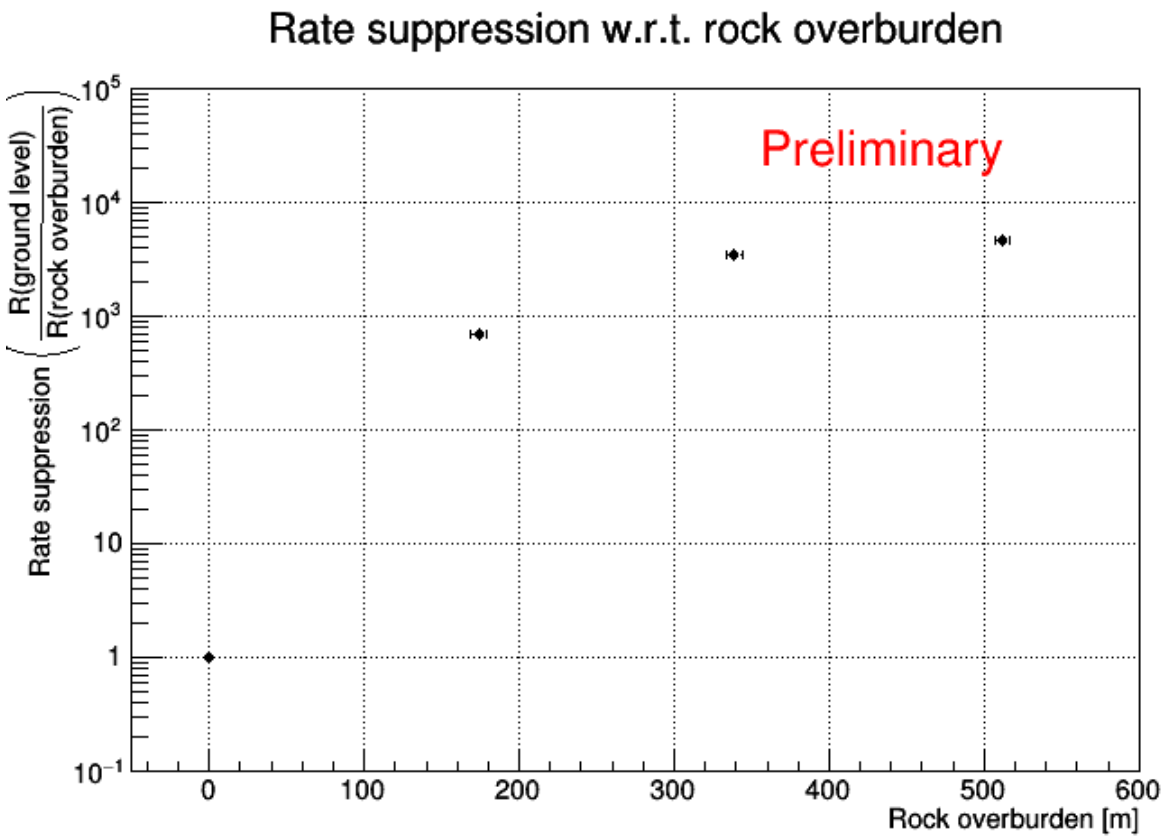
4.6% of statistical significance on rate estimation with exponential fit

Statistical significance

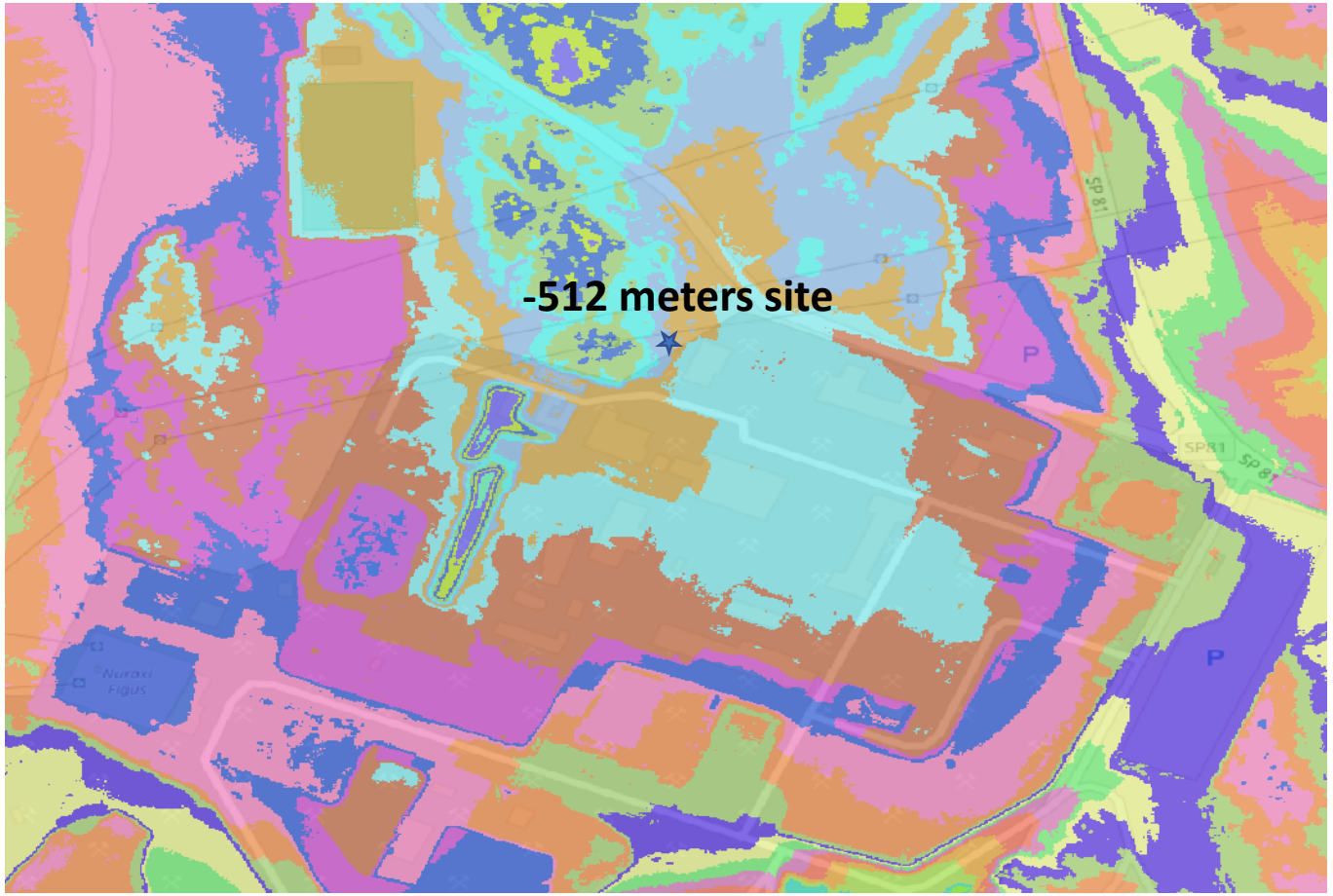
Depth (m)	Rate ($^{N}/_{T}$) [Hz]	Significance ($^{\sqrt{N}}/_{N}$)	Rate (λ) [Hz]	Significance ($^{\delta\lambda}/_{\lambda}$)
0	3.80 (4)	0.010	3.83 (4)	0,009
174	$5.5(1) \cdot 10^{-3}$	0.027	$5.4(2) \cdot 10^{-3}$	0,030
339	$1.1(4) \cdot 10^{-3}$	0.034	$1.13(4) \cdot 10^{-3}$	0,034
512	$8.1(3) \cdot 10^{-4}$	< 0.043	$8.0(4) \cdot 10^{-4}$	< 0,046


Measured rate w.r.t. rock overburden
Preliminary
Measured rate [Hz]
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
100
200
300
400
500
600
Rock overburden[m]


Measured rate normalized to the ground level w.r.t. rock overburden
Preliminary
Normalized rate
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
100
200
300
400
500
600
Rock overburden [m]

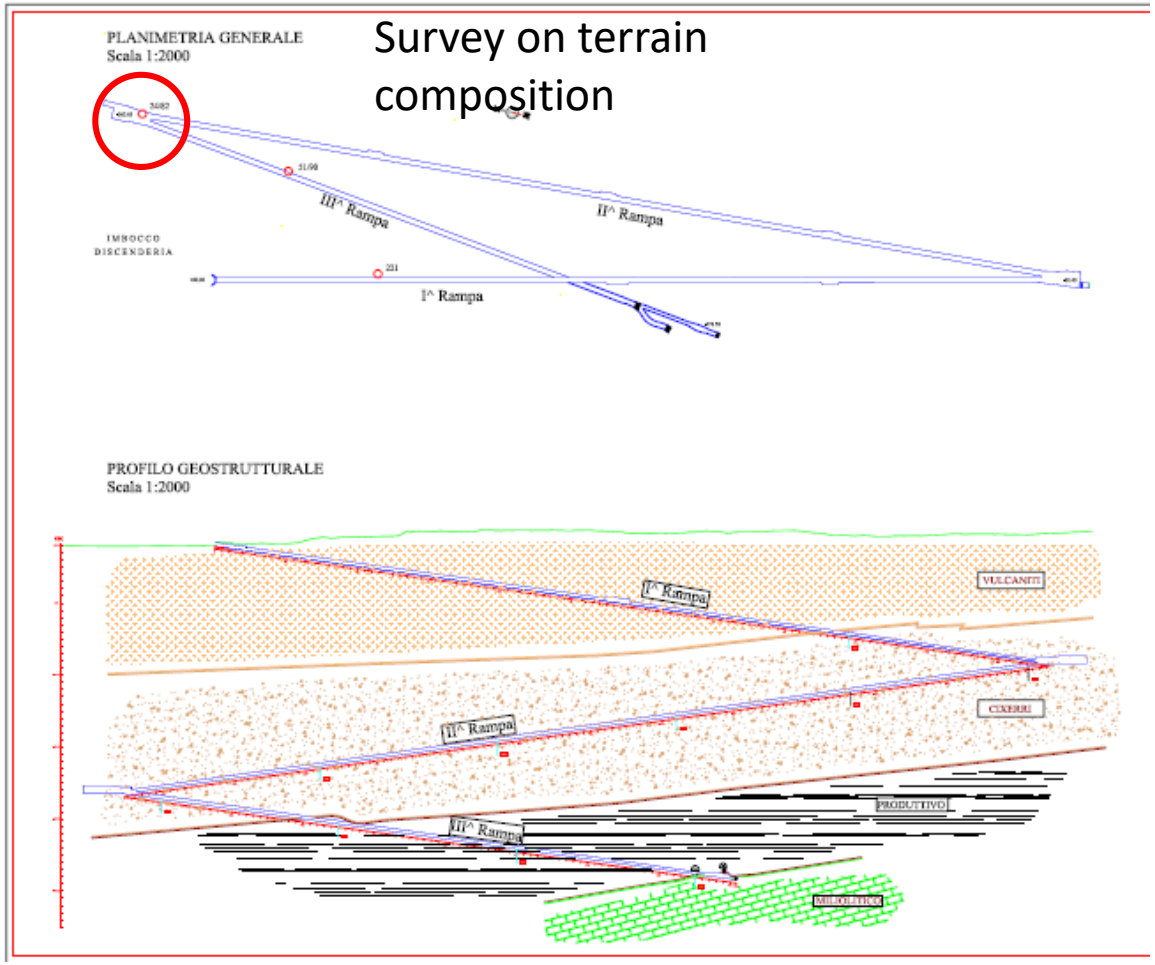

Rate suppression w.r.t. rock overburden
Preliminary
Rate suppression $\left(\frac{\text{R(ground level)}}{\text{R(rock overburden)}}\right)$
10^5
10^4
10^3
10^2
10
1
10^{-1}
0
100
200
300
400
500
600
Rock overburden [m]

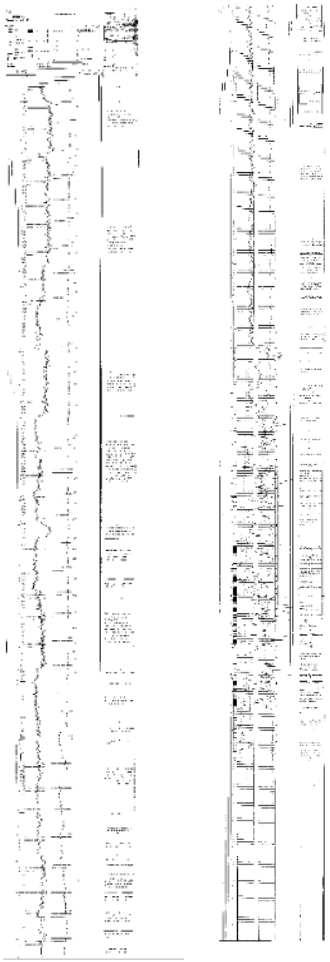
Study of the terrain above measurements sites (1)

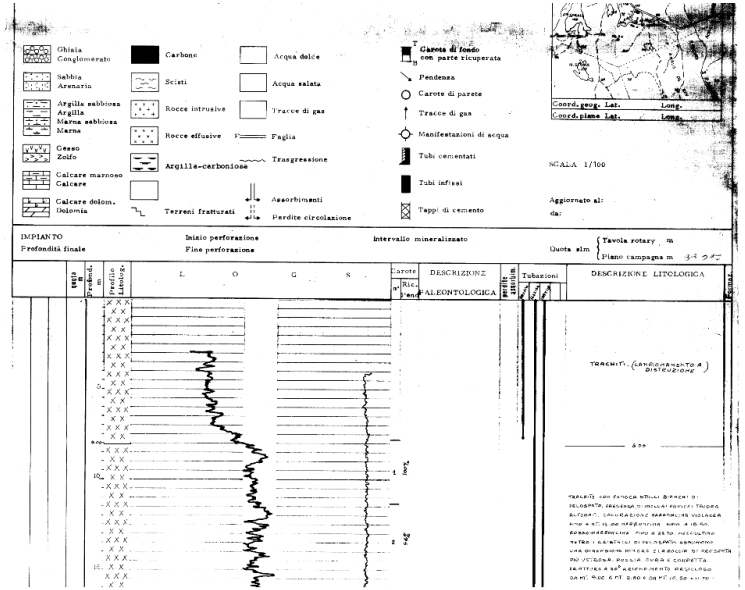


- Possibility to find the exact position of the measurements sites thanks to QGIS layers (not yet) available from Carbosulcis S.p.A.
- Possibility to find the exact ground altitude a.s.l. thanks to data available from Regione Autonoma della Sardegna (http://www.sardegnageoportale.it)

Study of the terrain above measurements sites (2)







Study of the terrain above measurements sites (3)

Carota	Quota dal p.c. (m)	Spessore rivestimento (m)	Lunghezza carotaggio (m)	Campione per prove geomeccaniche	RQD (%)	Peso di volume (g/cm3)	Resistenza a rottura (N/mm^2)	Modulo Young assiale Et (50) (N/mm2)	Modulo Young diametrale (N/mm2)	Rapporto di Poisson (50)	Modulo di Bulk k	Valori caratteristici RMR	Valori caratteristici coesione (kPa)	Calori caratteristici angolo di attrito (°)	Litologia
S1	10.00	0.30	1.50	C1S1	58	1,249	1,50	244,34	- 1078,43	0,23	148,93	51	255	31	Ignimbrite cineritica (Unità di acqua sa Canna)
S2	22.00	0.30	1.50	C2S2	50	1,470	4,80	2100,21	-7880,00	0.27	1499,24	51	255	31	Ignimbrite cineritica (Unità di acqua sa Canna)
S3	30.00	0.30	1.50	C3S3	88	1,451	4,50	1798,56	-7009,35	0.26	1231,53	51	255	31	Ignimbrite cineritica (Unità di acqua sa Canna)
S4	40.00	0.50	1.50	C4S4	83	2,203	63.10	20000,00	-94285,71	0.21	11578,95	70	350	40	Ignimbrite competente (Unità di Lenzu)
S5	51.00	0.33	1.50	C5S5	74	2,03	6,50	2016,92	-5871,21	0.34	2148,30	45/70	225/350	27/40	Microcongl. continentali (Livello detritico)
S6	63.00	0.35	1.50	C6S6	69	2,37	54,80	18600,25	-161202,19	0.12	8060,11	70	350	40	Ignimbrite competente (Unità di Corona Maria)
S7	75.50	0.46	1.50	///	67	///	///	///	///	///	///	70	350	40	Ignimbrite competente (Unità di Corona Maria)
S8	87.50	0.42	1.50	C7S8	88	2,16	4,8	2315,79	-6145,25	0.38	3133,90	45/70	225/350	27/40	Arenarie medio-grossolane (Formazione del Cixerri)
S9	99.40	0.23	1.50	///	100	///	///	///	///	///	///	30/67	150/335	20/38	Siltiti ocracee (Formazione del Cixerri)
S10	111.40	0.33	1.50	C8S10	75	2,298	6,30	2012,07	-4854,37	0.,41	3921,57	45/70	225/350	27/40	Arenerie ciottolose grigie (Formazione del Cixerri)
S11	131.00	Frantumata dal carotiere				///	///	///	///	///	///	45/70	225/350	27/40	Conglomerati e arenarie (Formazione del Cixerri)
S12	159.00	0.43	1.50	C9S12	82	2,427	11,50	9667,17	-28415,30	0,30	10766,05	30/67	150/335	20/38	Siltite dura e compatta (Formazione del Cixerri)
S13	207.40	0.52	1.50	///	78	///	///	///	///	///	///	30/67	150/335	20/38	Siltite grigio-verde compatta (Formazione del Cixerri)
S14	255.40	0.33	1.50	C10S14	65	2,625	26,18	13974,96	-123050,85	0,11	6027,40	30/67	150/335	20/38	Siltite compatta (Formazione del Cixerri)
S15	303.40		1.50	///	///	///	///	///	///	///	///	17/36	85/180	13/95	Argilliti bituminose (Tetto Produttivo)
S16	335.60		1.50	///	///	///	///	///	///	///	///	17/36	85/180	13/95	Carbone (Produttivo)

Geological data from Seruci site (a few km away)

Meters underground to meter water equivalent conversion

- Not so difficult to estimate the terrain composition, even with some big uncertainties
- But it requests very much time to recover and implement all terrain data
- A few important information are not yet available

Conclusions and perspectives

- 1 measurement done outside (we could repeat it at the end)
- 2 measurements done underground (174 m and 339 m)
- 1 ongoing at deepest level (512 m) with some (solvable) problems

Perspectives

- At least two other measurements at different depth
- Check on environmental stability with data from weather sensors
- Implement geological data and rescale depth in mwe
- Simulation of detector acceptance and, maybe, of physics (GEANT4?)
- Comparison with ASTRO data
- Any other idea?