

Introduction to CRT triggered light data

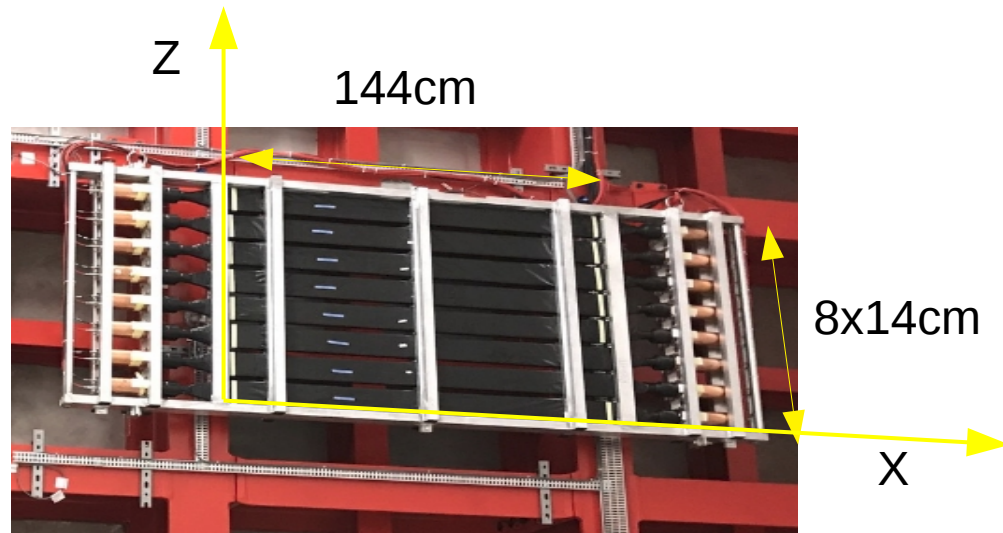
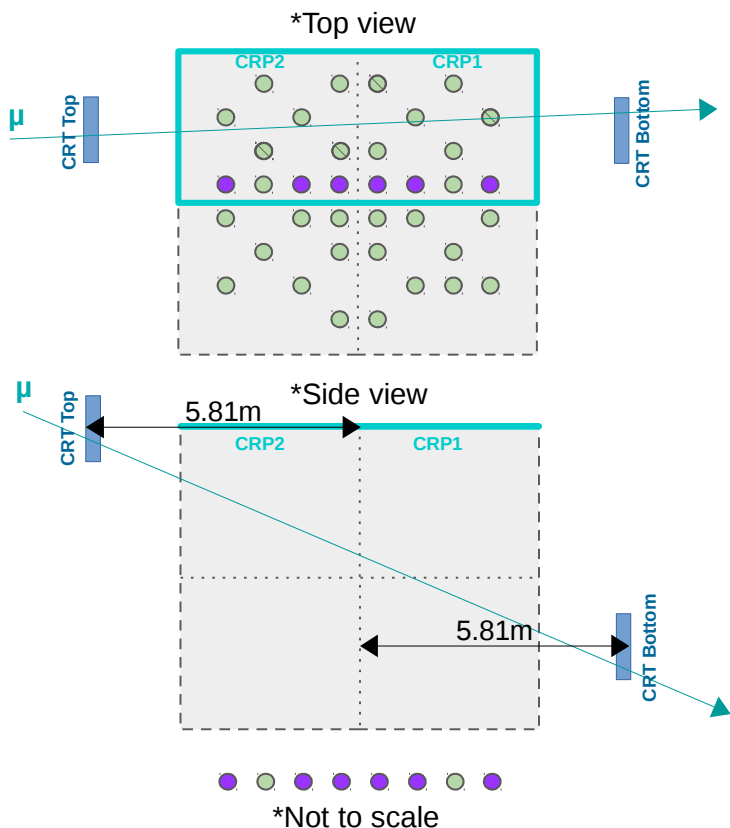
José Soto

DPPD Consortium

18th February 2020

Cosmic Ray Taggers

Size and positioning

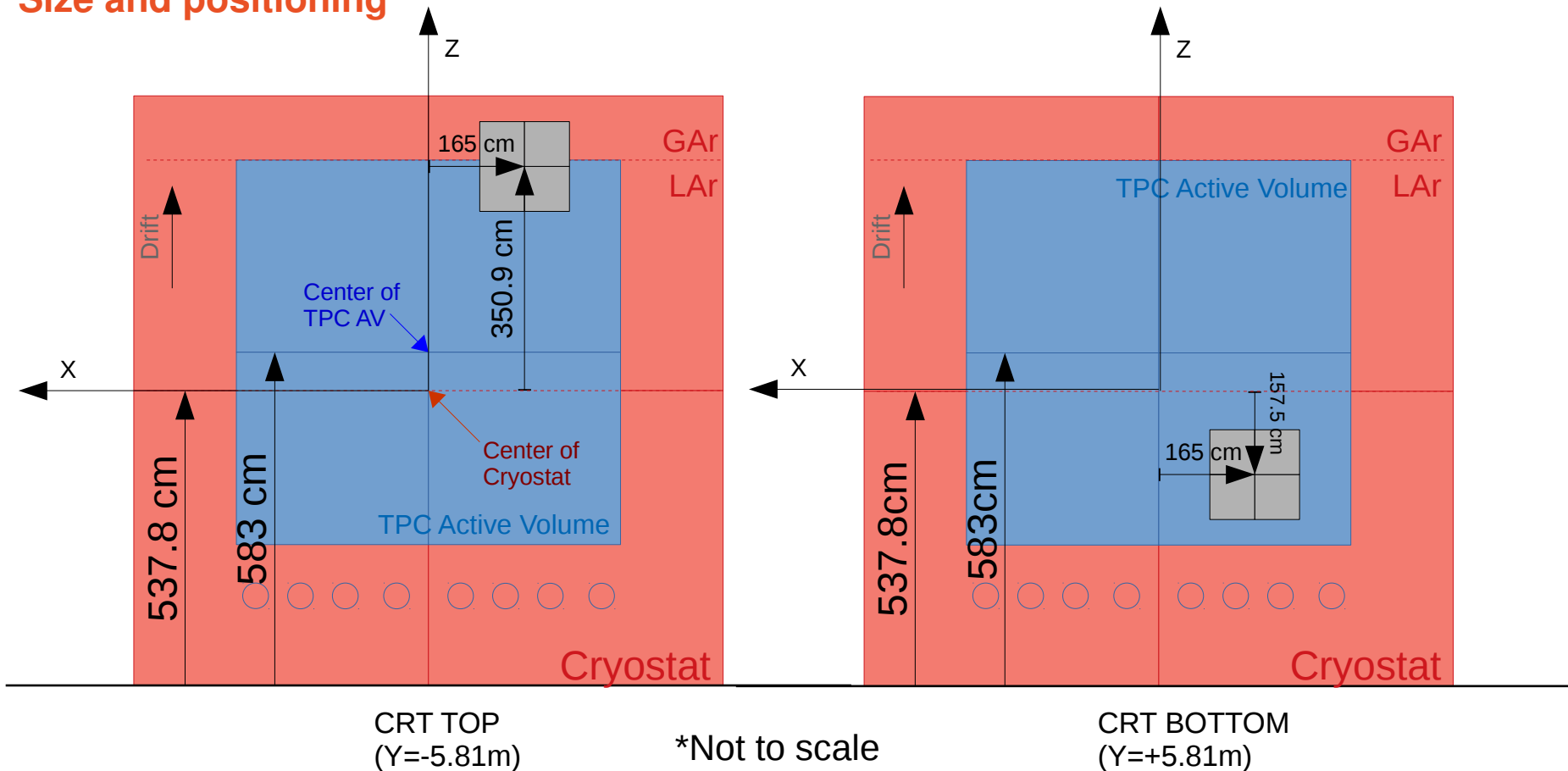


- 8 long bars (144cm length) spaced 14.3 cm
- CRTs are placed 5.81m away from the center of the cryostat.

CRT Track reconstruction given by the scintillator number (in Z), and the time of the hit in along the scintillator length (in X)
→ Precision in X to be checked with Grenoble team.

Cosmic Ray Taggers

Size and positioning



Cosmic Ray Taggers

Information provided by the CRTs

```

===== EVENT:0
tstamp      = 1576606654
deltatime   = 0
imult       = 1
jmult       = 1
Qtop        = 9744,
            -1, -1, -1, -1, -1,
            -1, -1
Xtop        = -1.37705,
            20, 20, 20, 20, 20,
            20, 20
Ytop        = -5.81
Ztop        = 3.009,
            3.151, 3.294, 3.437, 3.58, 3.723,
            3.866, 4.008
CFDtop      = -2.77421,
            -1000, -1000, -1000, -1000, -1000,
            -1000, -1000
Qbot        = -1,
            8851, -1, -1, -1, -1,
            -1, -1
Xbot        = 20,
            -1.97643, 20, 20, 20, 20,
            20, 20
Ybot        = 5.81
Zbot        = -2.075,
            -1.932, -1.789, -1.646, -1.503, -1.36,
            -1.217, -1.074
CFDbot      = -1000,
            40.0306, -1000, -1000, -1000, -1000,
            -1000, -1000
flag        = 1
ft          = 43.2936
    
```

- **Timestamp** (not White Rabbit) with seconds precision.
- Relative **delta time** w.r.t the first event, gives more precision (0.1s).
- **imult/jmult**: # hits in CRT_{TOP}/CRT_{BOT} (maximum 8 hits, one per scintillator).
- **XYZ_{top/bot}**: Entry/exit point of the track, given for each hit (20 by default, if there is no hit).

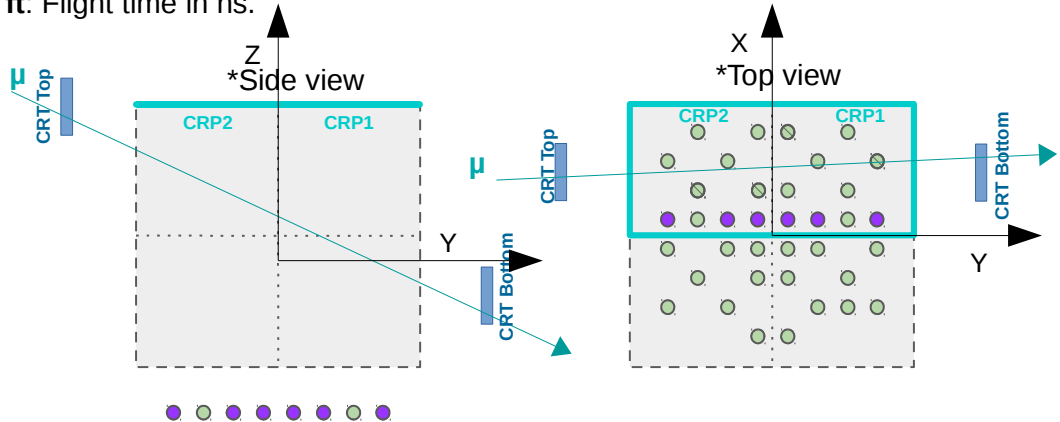
X is the position of the hit along the scintillator bar, origin in the center of the cryostat (reconstructed from time).

Y is the direction perpendicular to the CRT plane, fixed (+5.81m for CRT_{bot}, -5.81 for CRT_{top}).

Z is the vertical distance to the center of the cryostat, fixed for each scintillator bar.

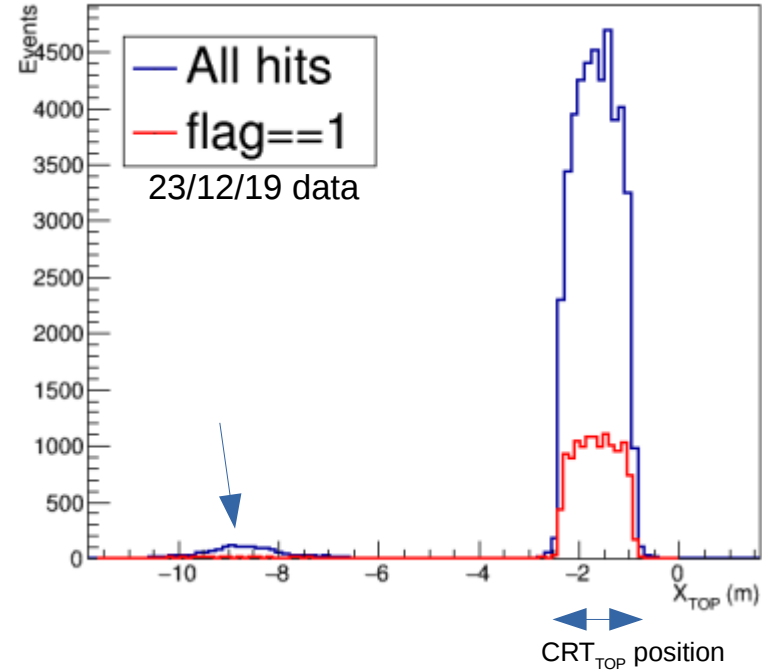
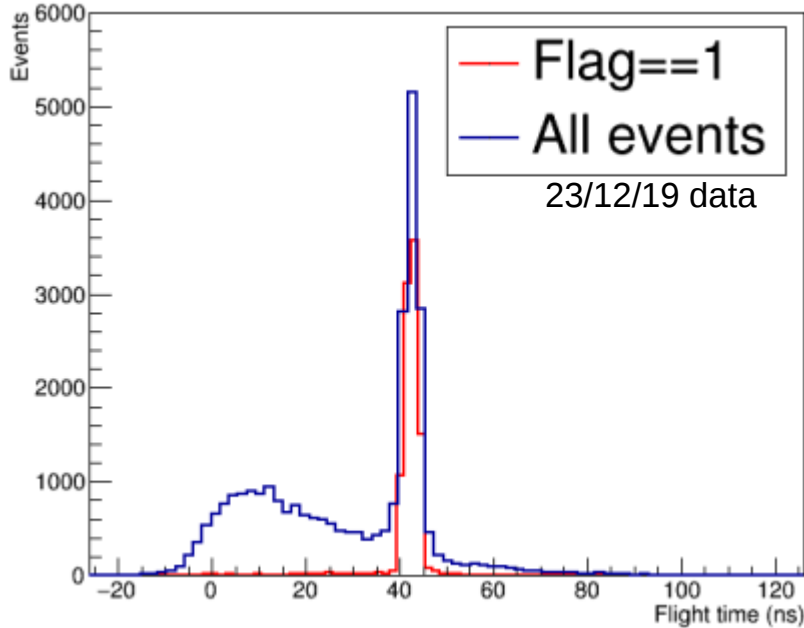
(see previous slide).

- **CFD_{top/bot}** time in CFD(?) for each scintillator, used to obtain **X_{top/bot}**
- **flag = 1** means there is at least one pair of bot-top scint that has a flight time = [40, 45] ns.
- **ft**: Flight time in ns.



Cosmic Ray Taggers

Information provided by the CRTs

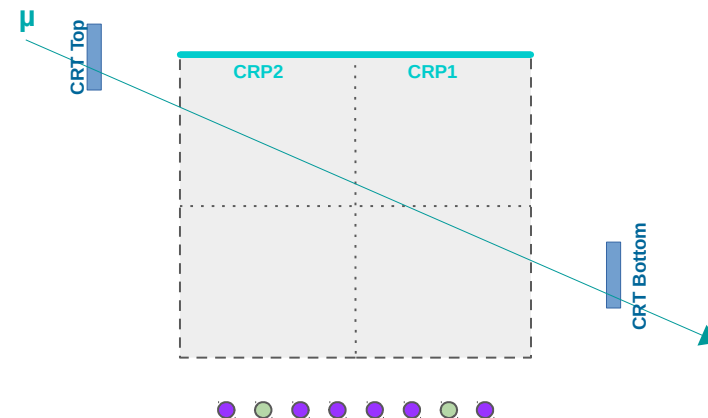


- Flight time of ~ 40 ns for the expected crossing muons. Showers strongly suppressed when applying the provided flag (still some events out of time).
- Bump in X coordinate 6 meters away of the CRT position (not physical) \rightarrow Strongly suppressed with the cut, but still some events after cuts.
- 35% events remaining after flag cut. From 0.32Hz \rightarrow 0.11Hz

Summary of CRT triggered runs

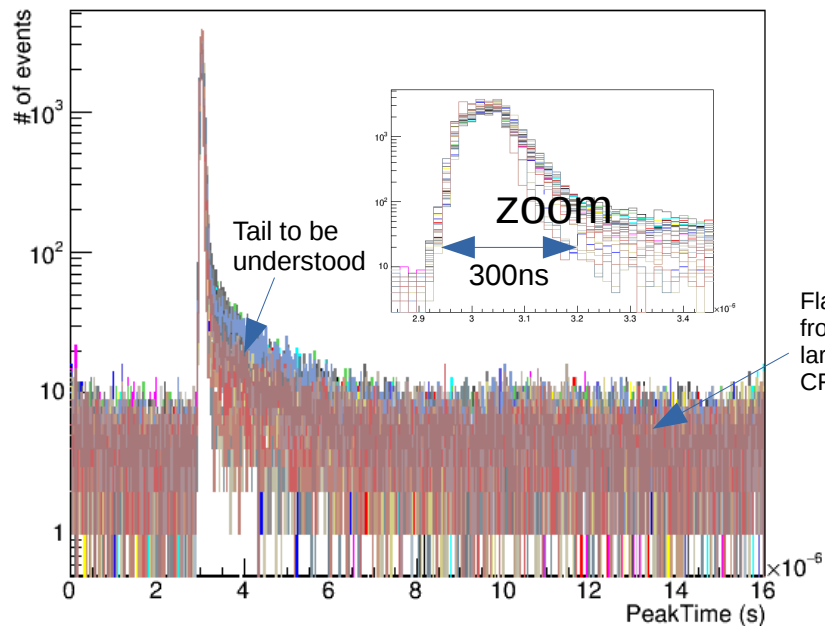
Date	Run	Cathode	LEMs (CRP1,CRP2)	Extraction (CRP1,CRP2)	CRT info	Comment
18/12/19	2381	off	(3.0kV,off)	(4kV,off)	Only flag*	1 hour run.
23/12/19	2413	off	off	off	yes	Full night.
21/01/20	2471	50kV	(off, 3.2kV)	(off, 2.3kV)	Not yet	Full night.
30/01/20	2486,2487	50kV	(3.2kV, 3.2kV)	(0kV,2.3kV)	Not yet	Full night.
05/02/20	2547-2555	Scan (0,5,10,20,30,40,50) kV	off	off	Not yet	1 hour per step. (not in eos yet).

- CRT information is not available for all runs yet (and validation is still ongoing!). It will be in EOS at some point.
- Some new runs from yesterday are missing (Scan in extraction field on CRP 2).



Quick look at run 2413

Minimum of the waveform

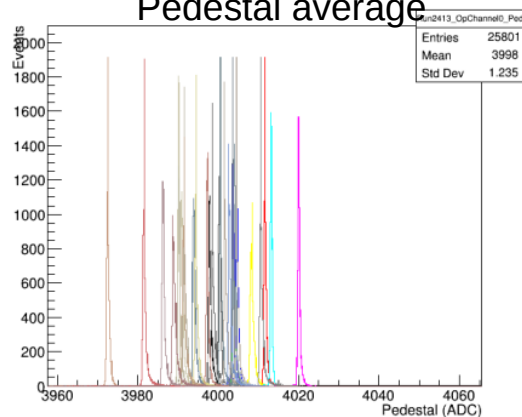


- PMTs always detect light at the trigger time → Low noise at the CRTs
- Width of 300ns in the trigger time → To be understood.

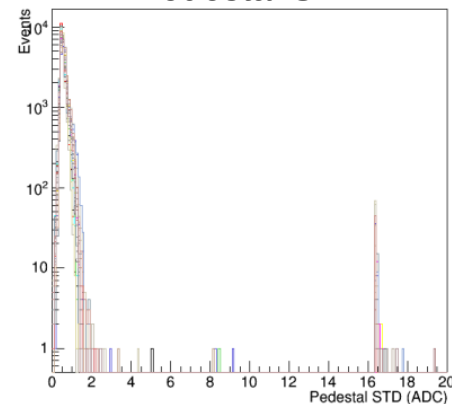
Run 2413:

- Long run during Xmas
- 24h of data
- 26k events.
- No Fields: all HV off
- Gains = PEN at $5e7$, TPB at $6e6$
- Cuts:
 - CRT Flag = 1 → 9836 events after cut.
 - Event kept if max-min < 5ADC within the pedestal range → 98%
 - Event kept if PedSTD < 2ADC → 100%

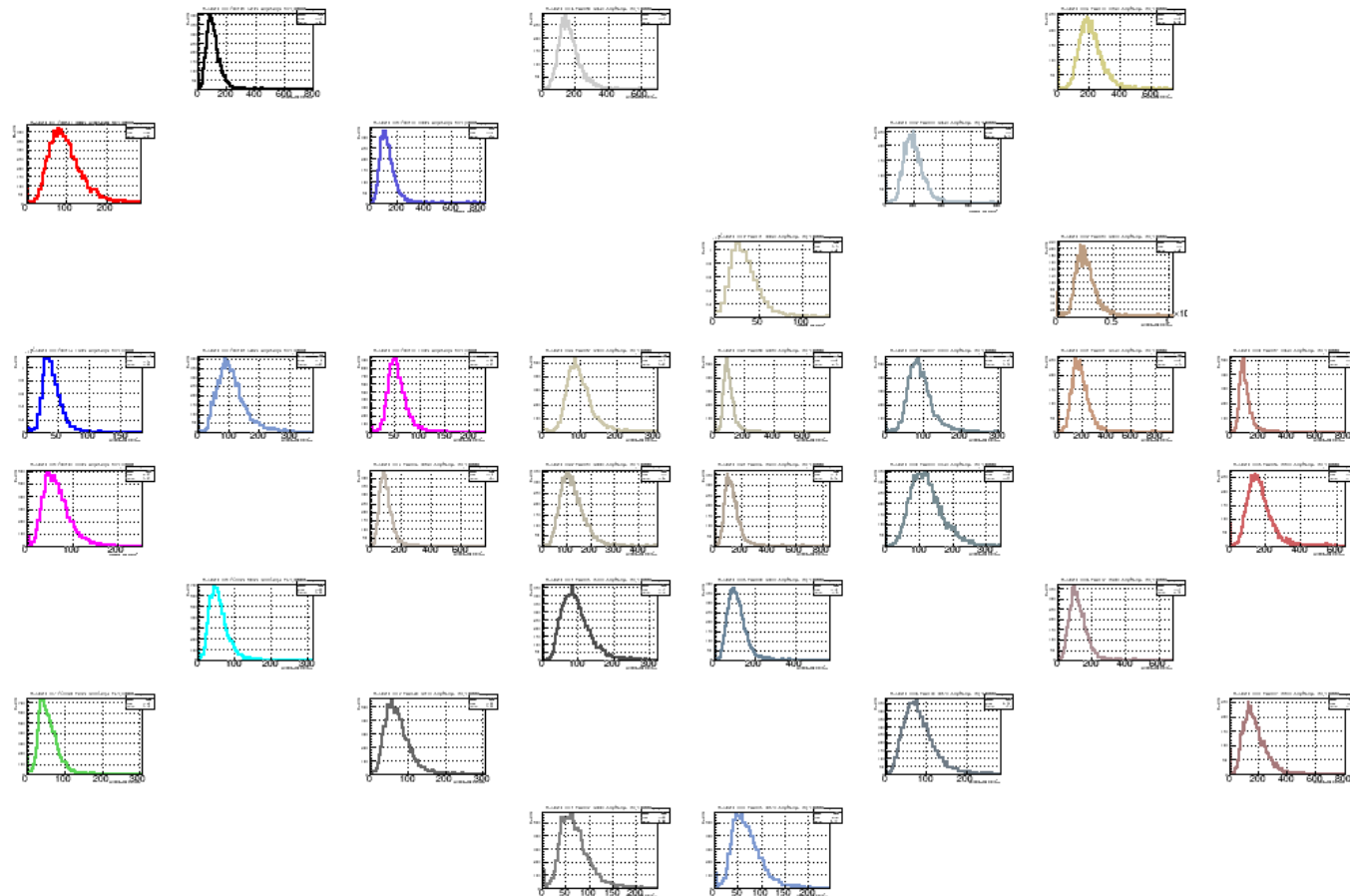
Pedestal average



Pedestal STD



Quick look at run 2413



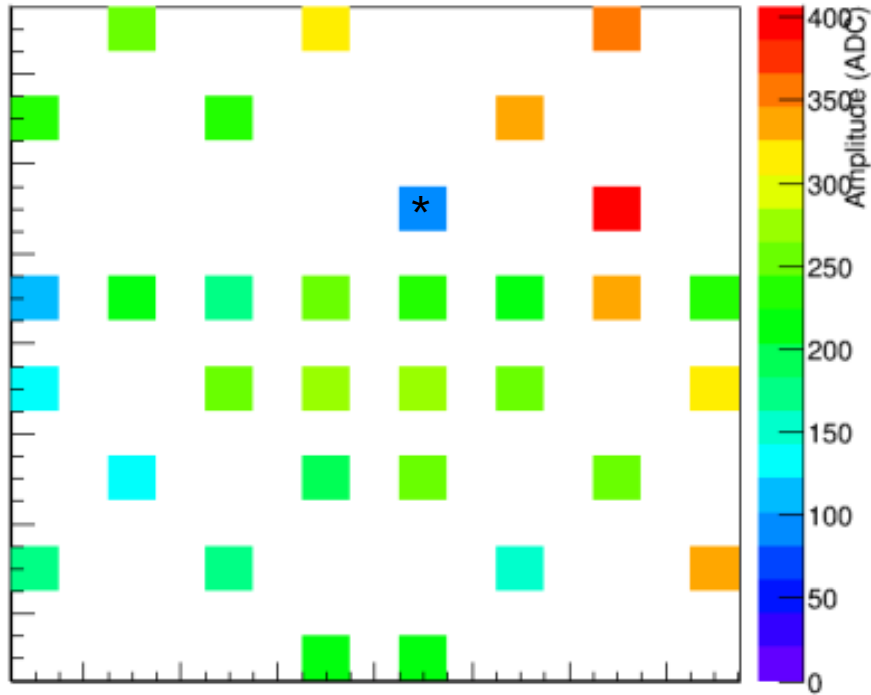
Left: Maximum amplitude in the trigger time (2.9,3.2 μ s) in ADC counts \rightarrow S1 amplitude from the Muon.

- All PMTs see light from the muon.

- Next slide to see the average of every distribution.

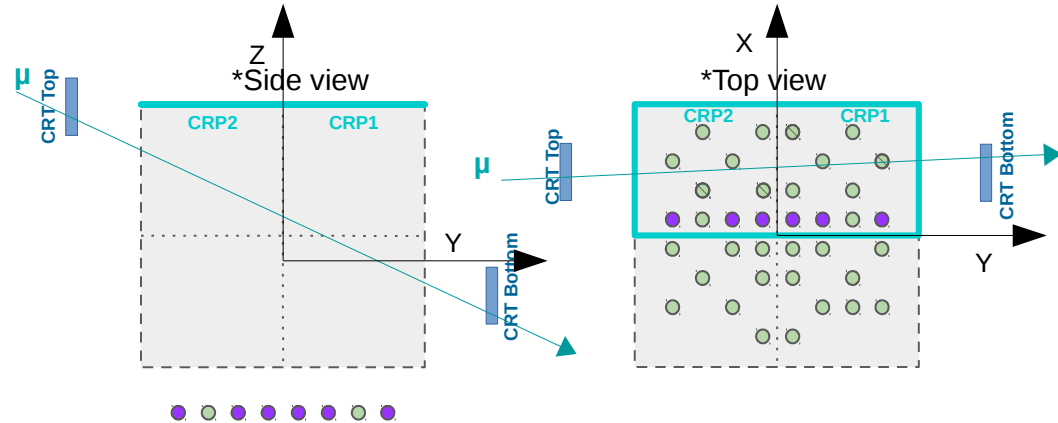
Quick look at run 2413

Average S1 amplitude (ADC)



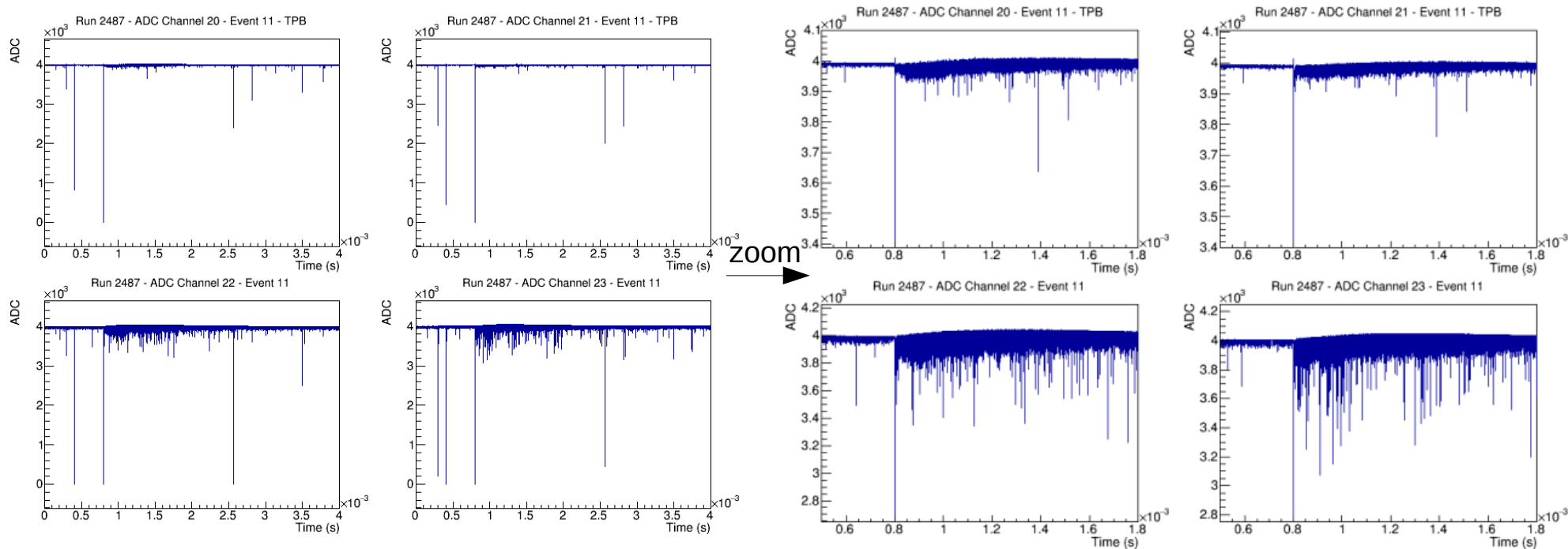
Top view: Every square is a PMT.

- Gains are tuned to equalize the PMT response.
- The pattern $\text{CRT}_{\text{TOP}} - \text{CRT}_{\text{BOTTOM}}$ is clearly visible, increasing the amount of light as the muons get closer to the PMTs.
- * This PMT was not well calibrated.



Quick look at 2487 (LEMs+Grid ON)

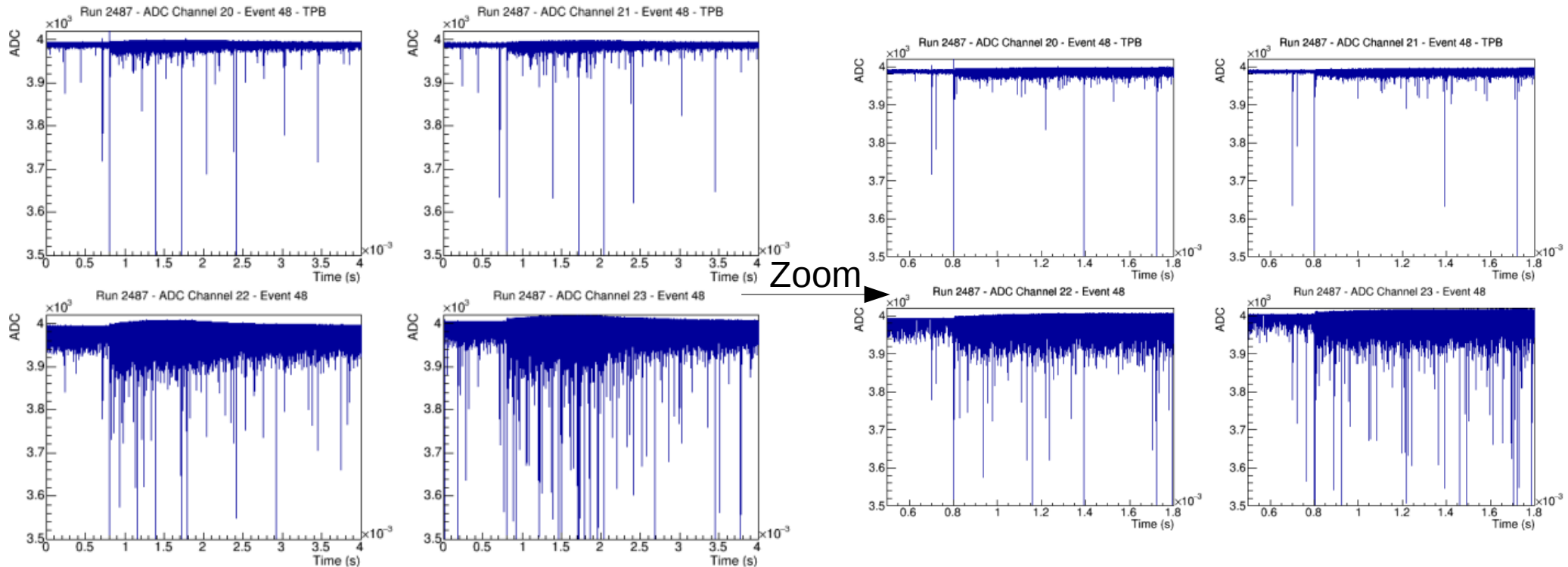
- CRT information is not available, but we can have a look at some events.
- We see many events with S1+S2 as expected:



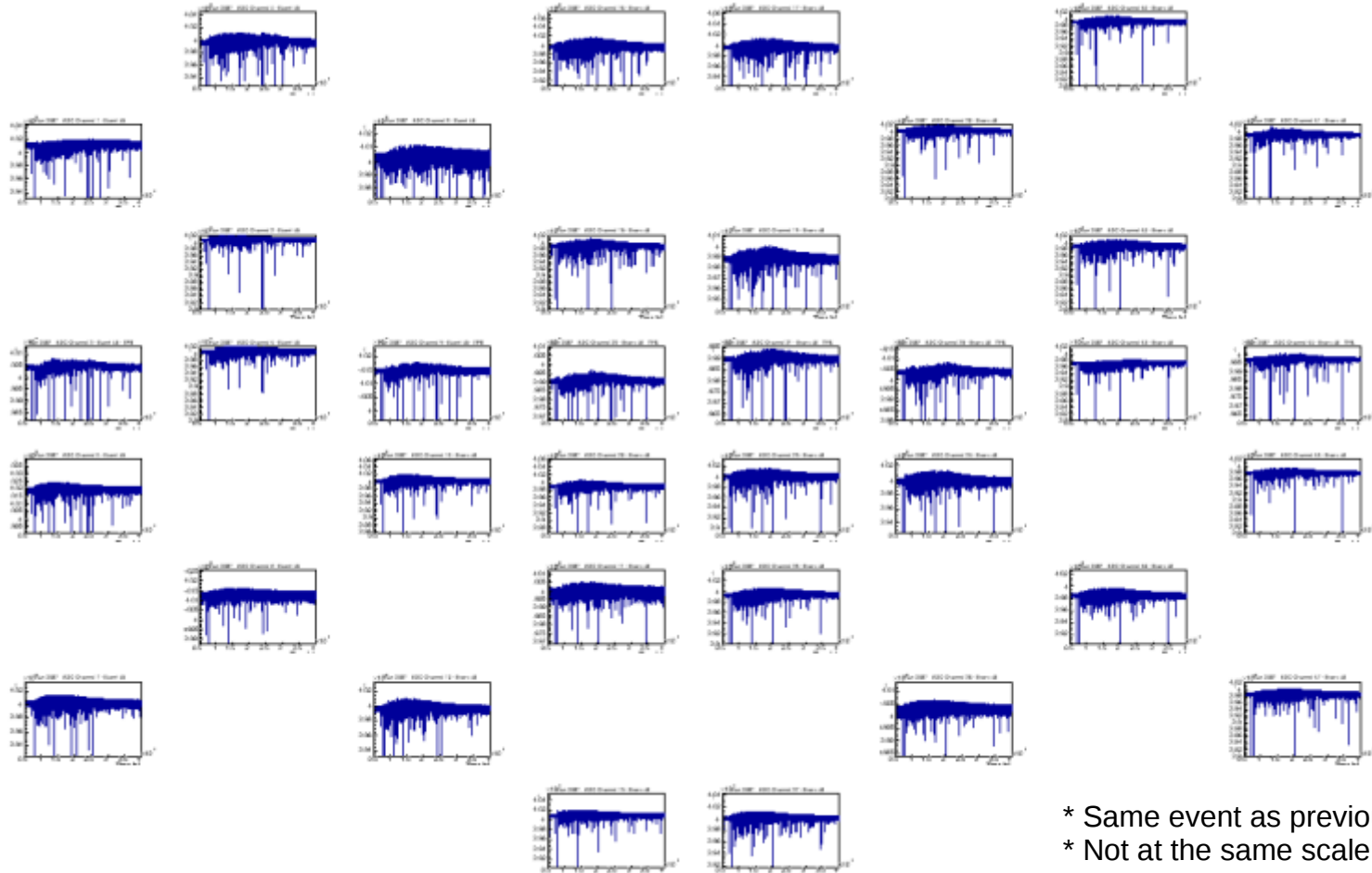
Trigger time at 800 μ s

Quick look at 2487 (LEMs+Grid ON)

- Very long S2 without a clear end... Since the field is not uniform, it takes more time to drift and extract the electrons. This is the equivalent of the curves tracks they see in the charge.



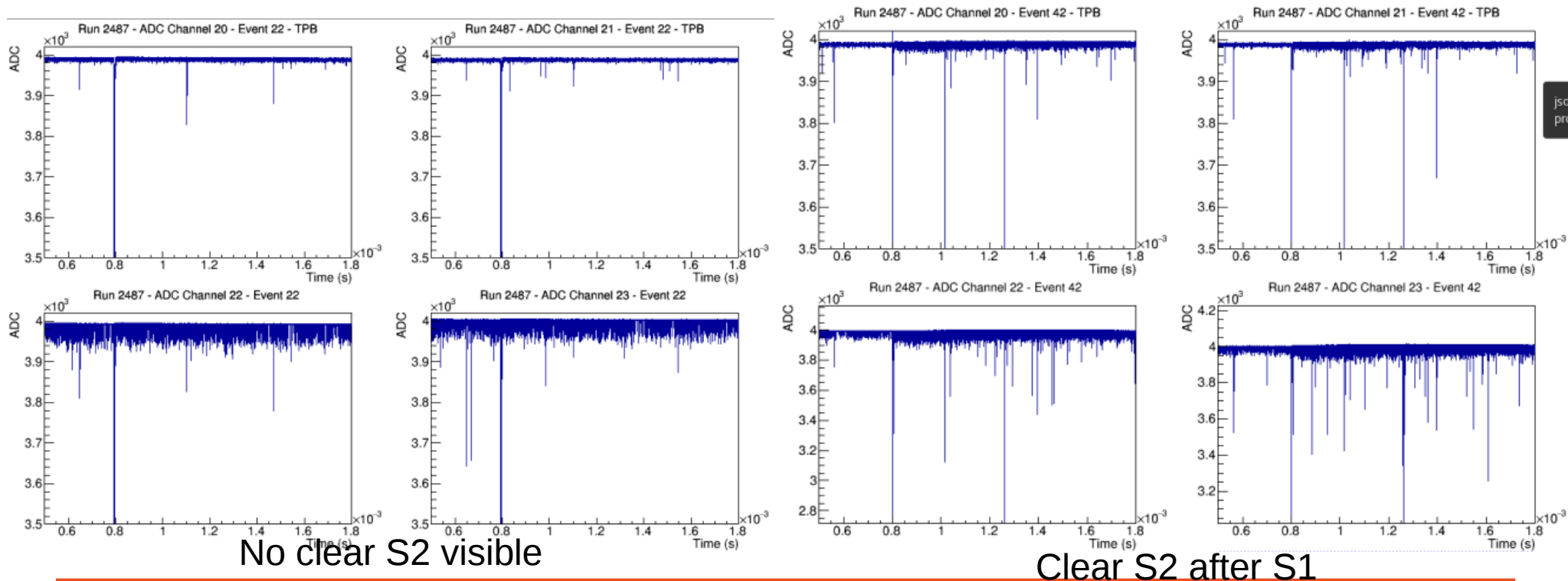
Quick look at 2487 (LEMs+Grid ON)



- * Same event as previous slide.
- * Not at the same scale.

Quick look at 2487 (LEMs+Grid ON)

- We see many events with S1+S2 as expected, but also events without S2. But remember:
 - No extraction on CRP1.
 - We still don't have the CRT info: I might not be a muon.



Conclusions

- CRT trigger is operative and light runs have already be taken.
- CRT information is still being validated, it is not available by default yet, but they seem to be progressing fast.
- CRT information is very useful to do many interesting studies with the data already available:
 - Birks law, drift velocity, light yield ...

Also many interesting new data to take:

- Scan in extraction, scan in LEM amplification, with both CRP operative, only with CRP1...
- All of them, but in coincidence with the charge!

On going: Comparison with the Monte Carlo simulation.