Update on S3 echo and S2/S1 vs Field

ReD meeting Jan 21, 2019

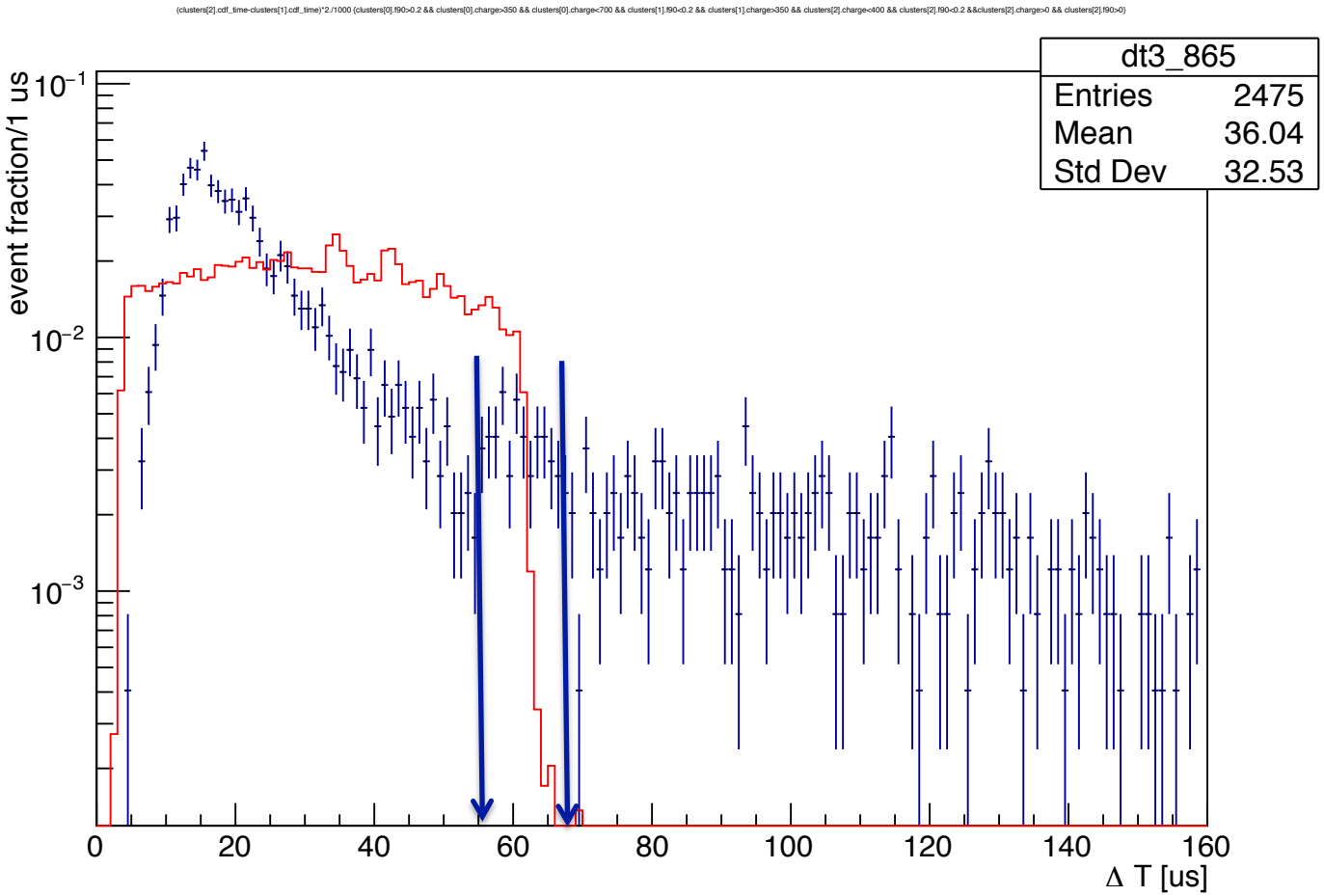
Single Electron selection

- Compared to previous work documented in docdb 3130 more straightforward selection implemented.
- Recent n-ple production fixed definition of mean_time and rms_time, however, on Naples data, further clean-up is not necessary, expecially in high E_el field runs.

- For reference here it is how the S3-S2 DT plot of slide at p. 4 is filled:
  - reco->Draw("(clusters[2].cdf_time-clusters[1].cdf_time)*2./1000>>dt3_888_l(160,0.0,160)","clusters[0].f90>0.2 && clusters[0].charge>350 && clusters[0].charge<700 && clusters[1].f90<0.2 && clusters[1].charge>4000 && clusters[2].charge<400 && clusters[2].f90<0.2 &&clusters[2].charge>0 && clusters[2].f90>0","norm")

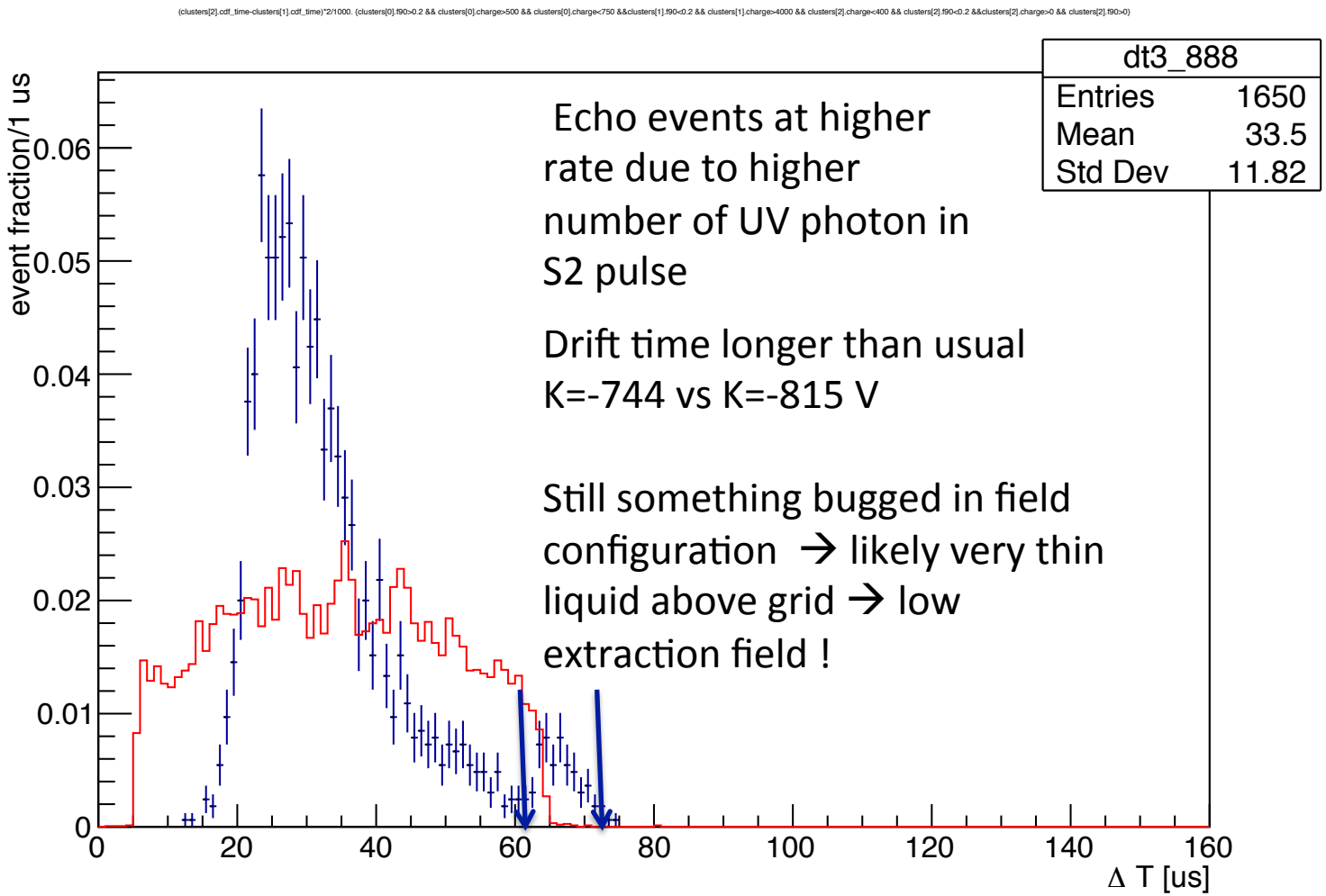
- Basically: trigger on S1, consistent with Am241 peak, single scatter S1+S2 event, followed by a small (i.e. <400 PE) S2-like pulse.

Run 865 (100 k sample run)

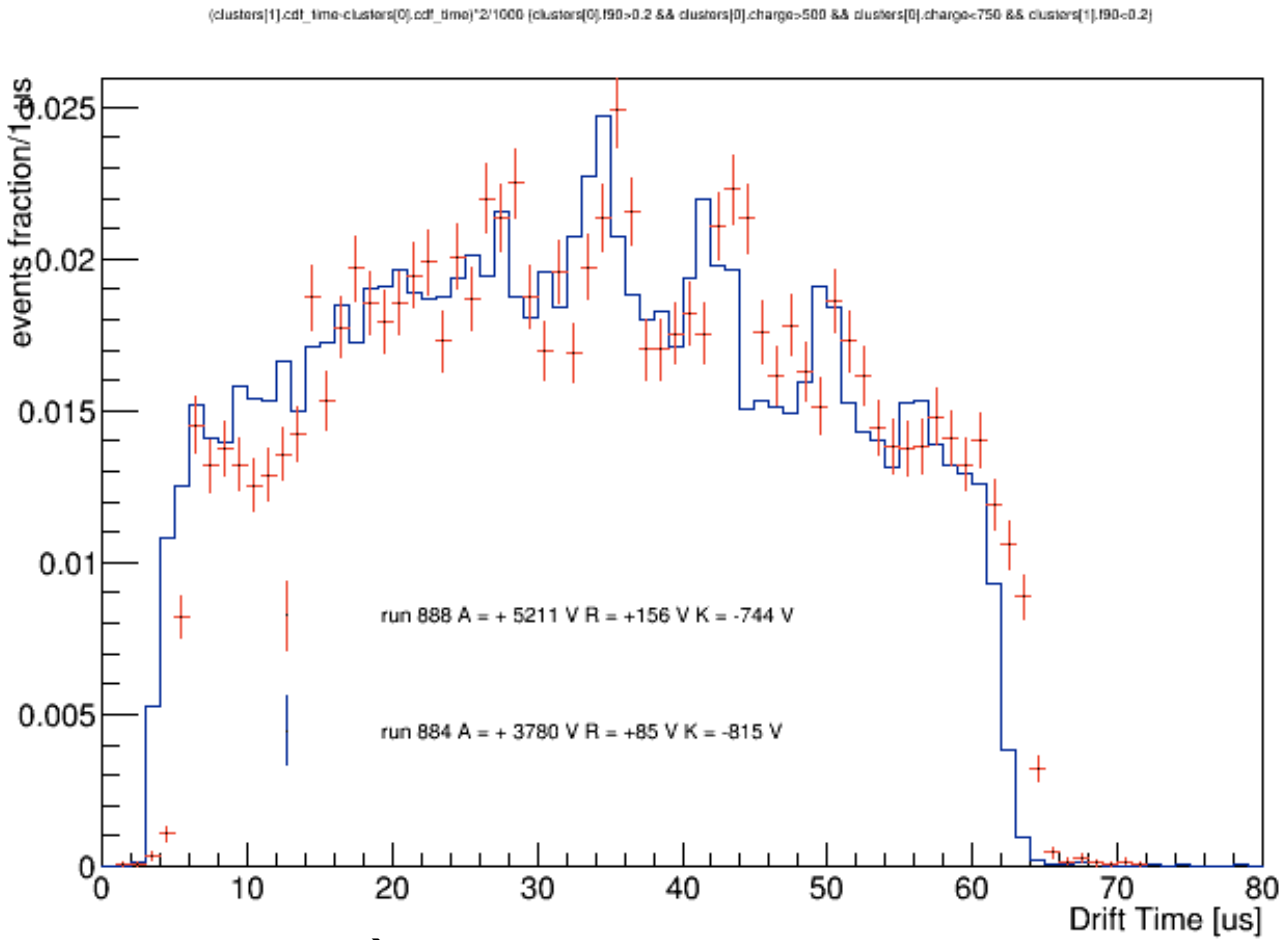


Population of low energy ionization pulses in the tail of S2 confirmed (charge<400 PE, here). Two different time constant apparent. Tantalizing evidence of a bump at the maximum drift time of 60 us. Totale Rate is few percent of good S1+S2 Americium events

Run 888 (A = + 5211 V R = +156 V K = -744 V)

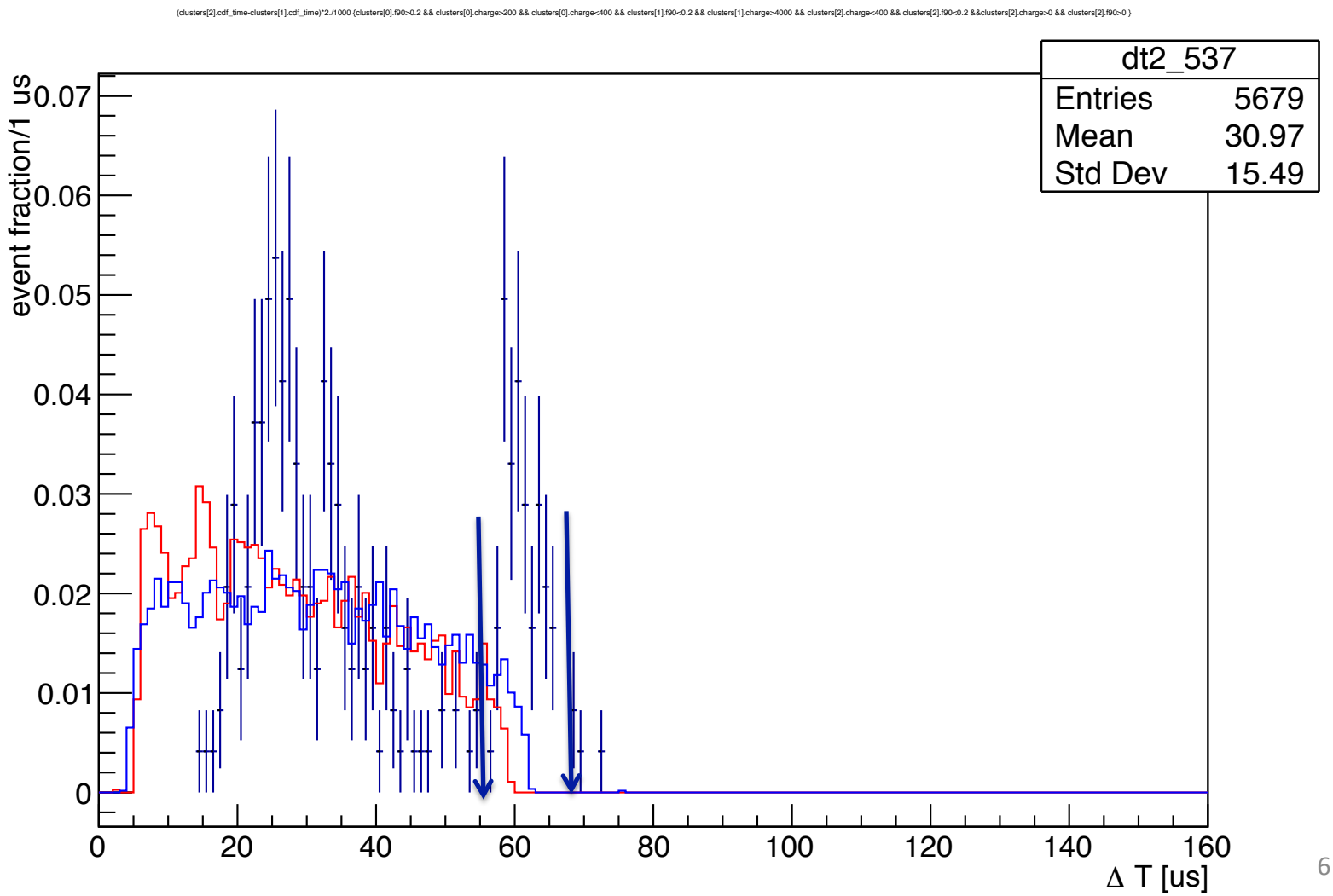


Further result on difference in drift velocity

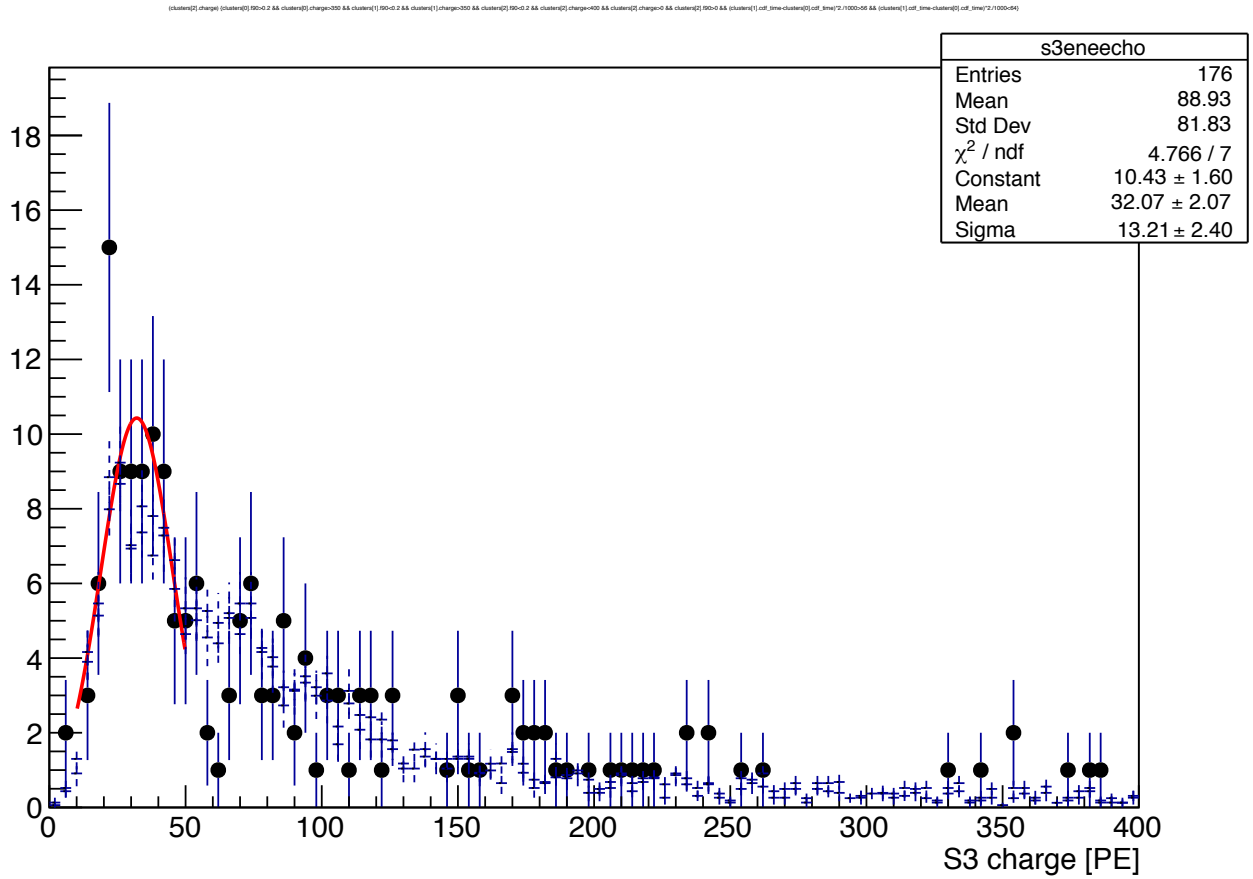


This is S2-S1 cdf_time → may be affected by difference in shape of S2 pulses in the two different runs, observation based on S2-S2 cdf_time difference more solid…

S3 echo from high amplification field run in Catania (run 554)

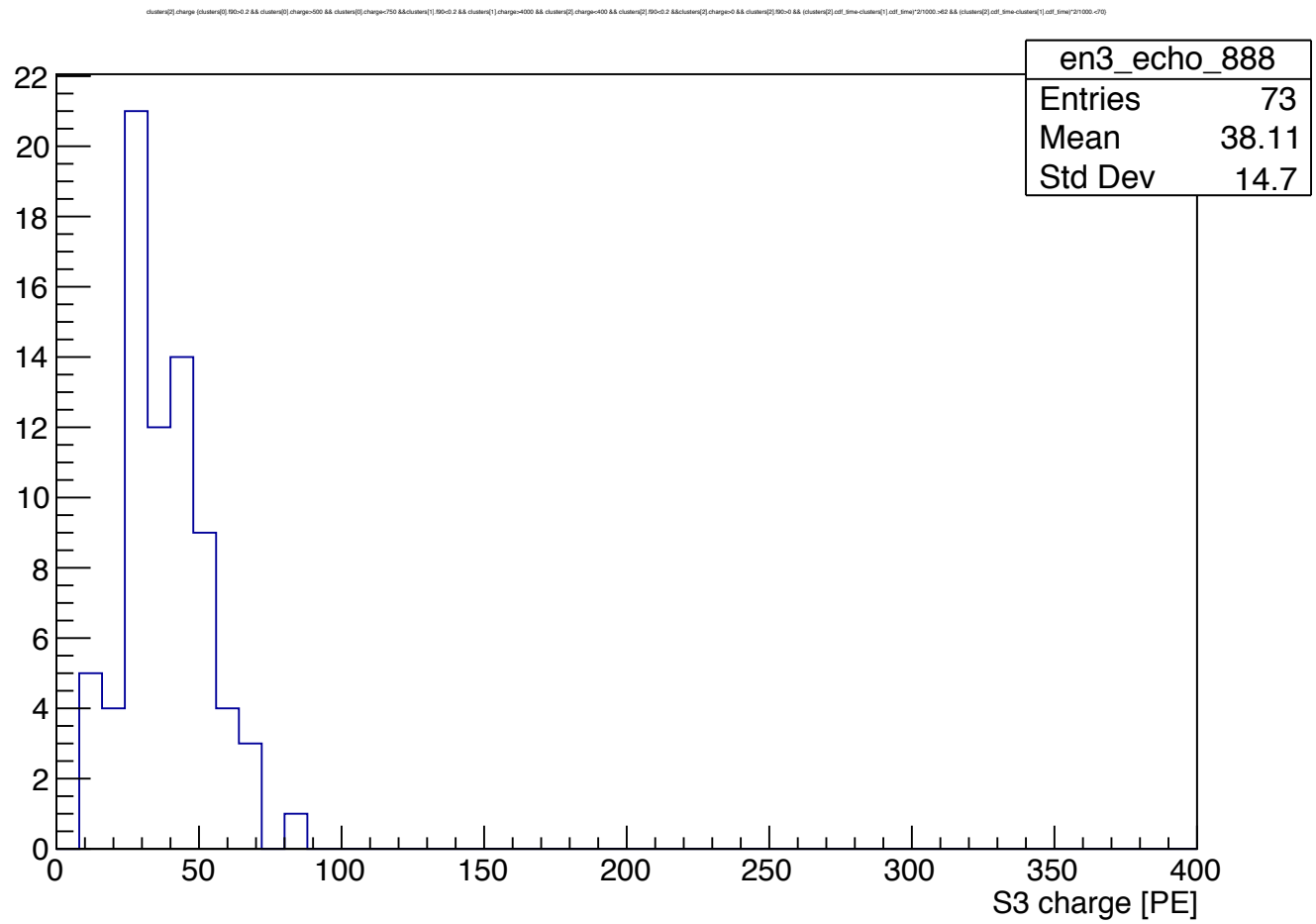


Echo event spectra/1 (run 865 100 k sample)

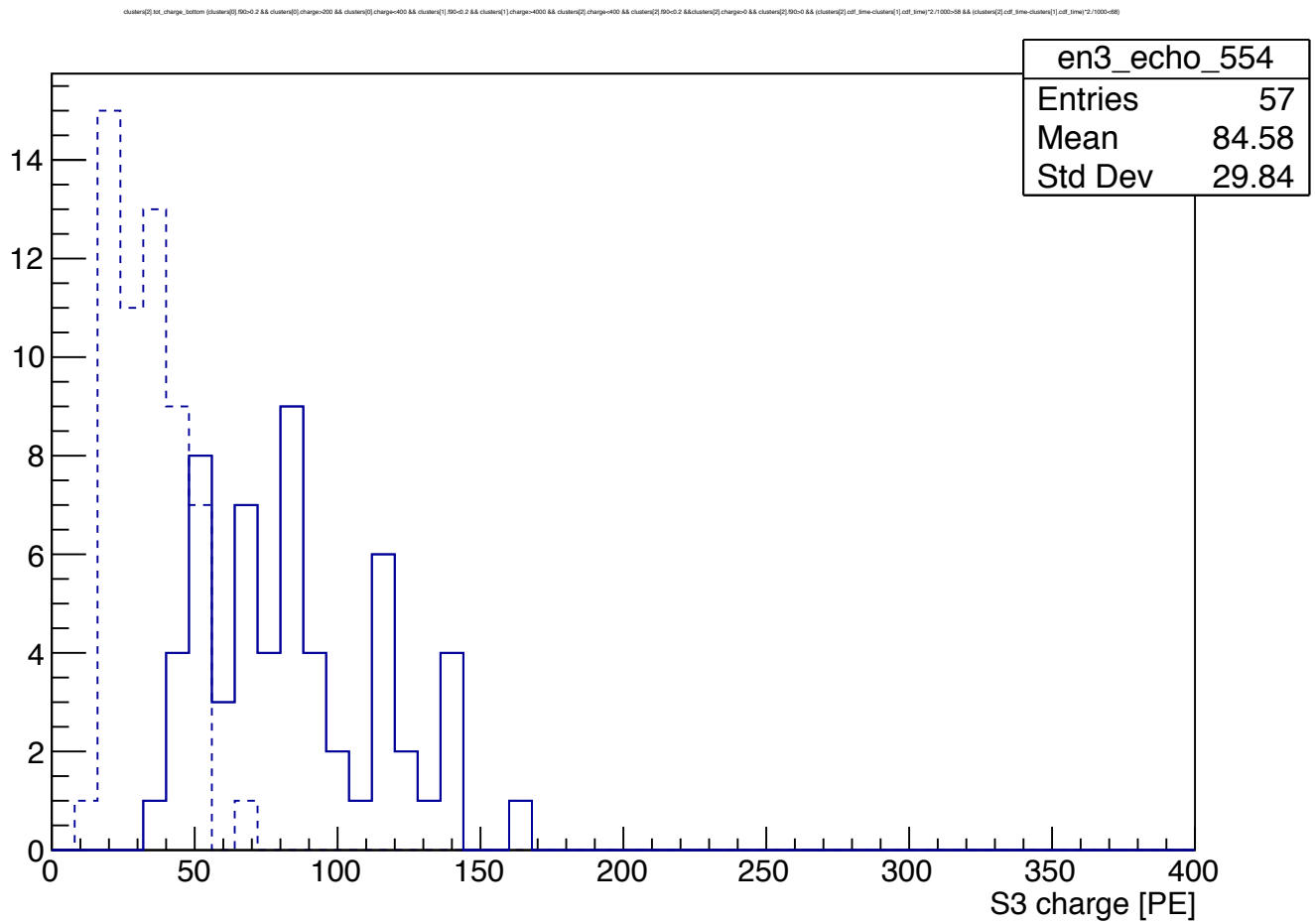


Spectrum peaked at 20-40 PE. Spectra of events in the 58-63 us ΔT wrt to S2 (point with error bar) compared to spectrum of all events and events with ΔT>30 us wrt S2 (dotted, dashed). Very similar spectra observed.
N.B. interpretation of this as a peak is still hampered

Echo event spectra/2 (run 888 high amplification run)



Echo event spectra/3 (run 554, high amplification run, only bottom tile on, should be multiplied by 2.5)

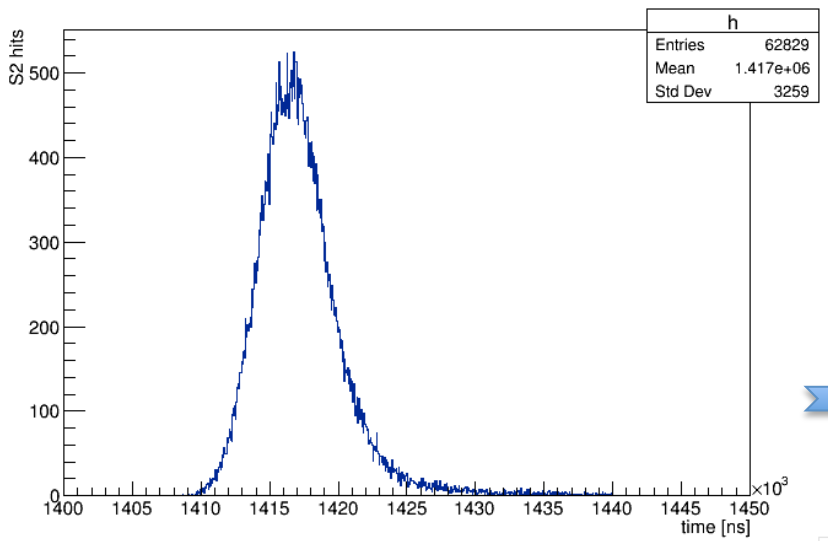


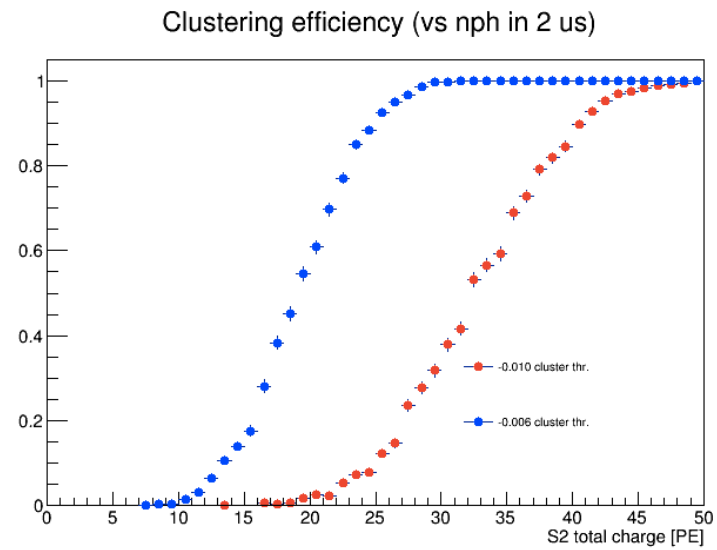
Summary on S3 echo events

- Evidence by time difference wrt to S2 pulses
- Rate scale with S2 size (i.e. with amplification field)
- Size of S3 echo seems to not scale with amplification

  →Maybe pulse finding efficiency should be considered !

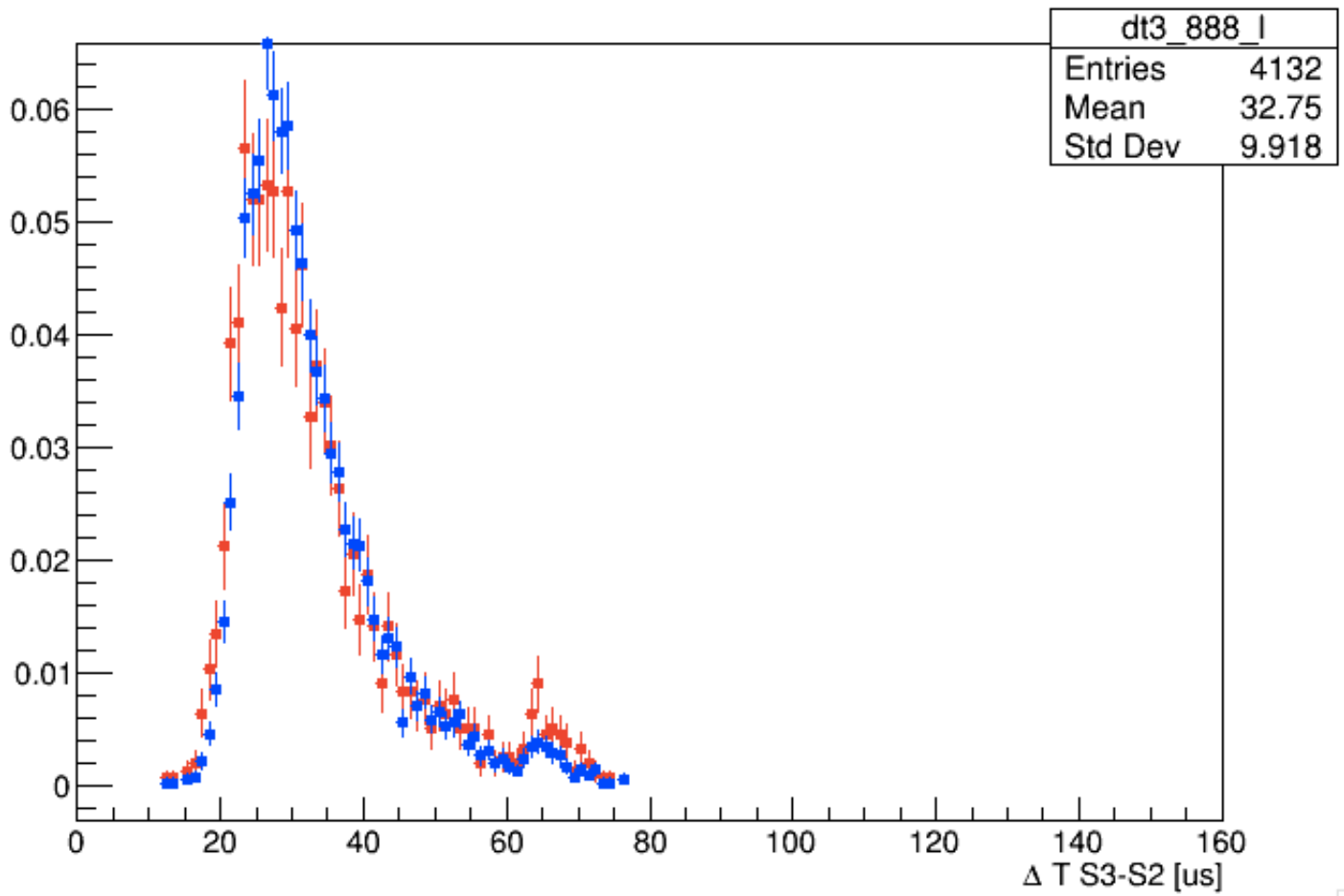
S2 clustering emulation



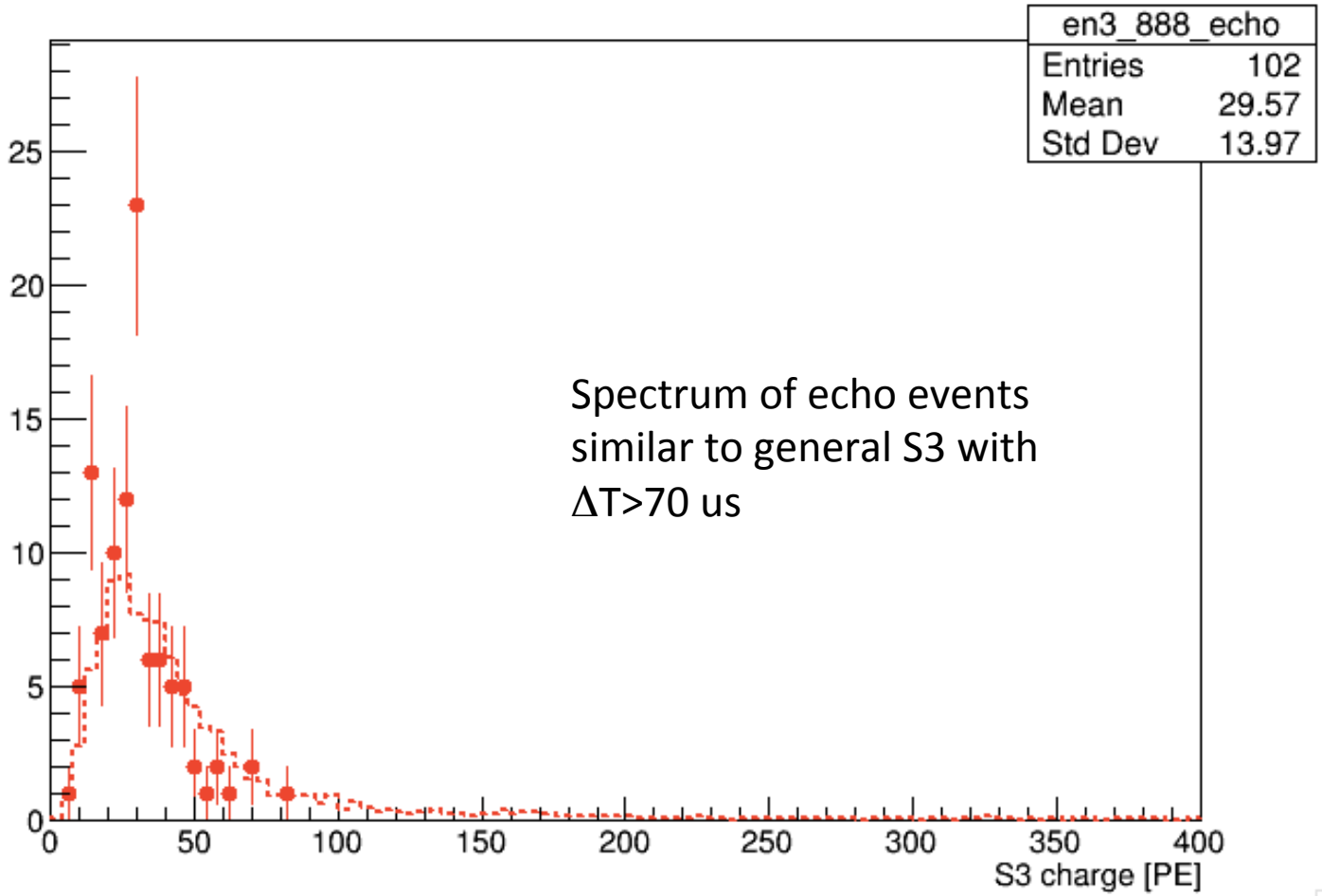


- Resurrected old simple code to simulate S2 trigger efficiency in DS50
- Start from a simulated waveform to generate independent samples and apply condition
- Apply nph > 10 in 2 us or nph > 6 in 2 us vs total number of ph in S2
- Reprocess run 865 (100 k sample) and run 888 (high amplification field run) with threshold set to -0.006 (instead of -0.01).
- Further reducing threshold (-0.003) preoduce too much clusters…

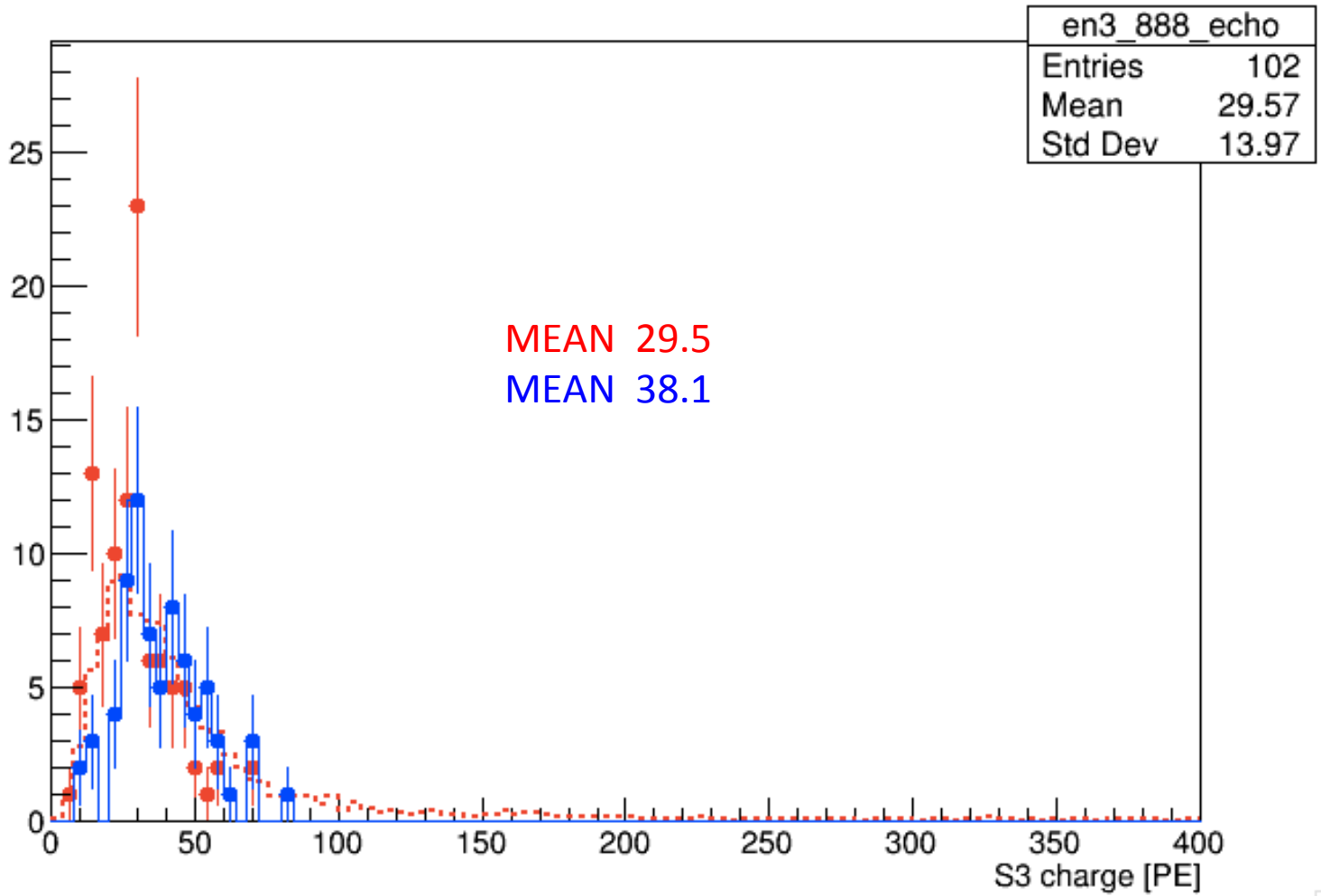
Run 888 low threshold vs default



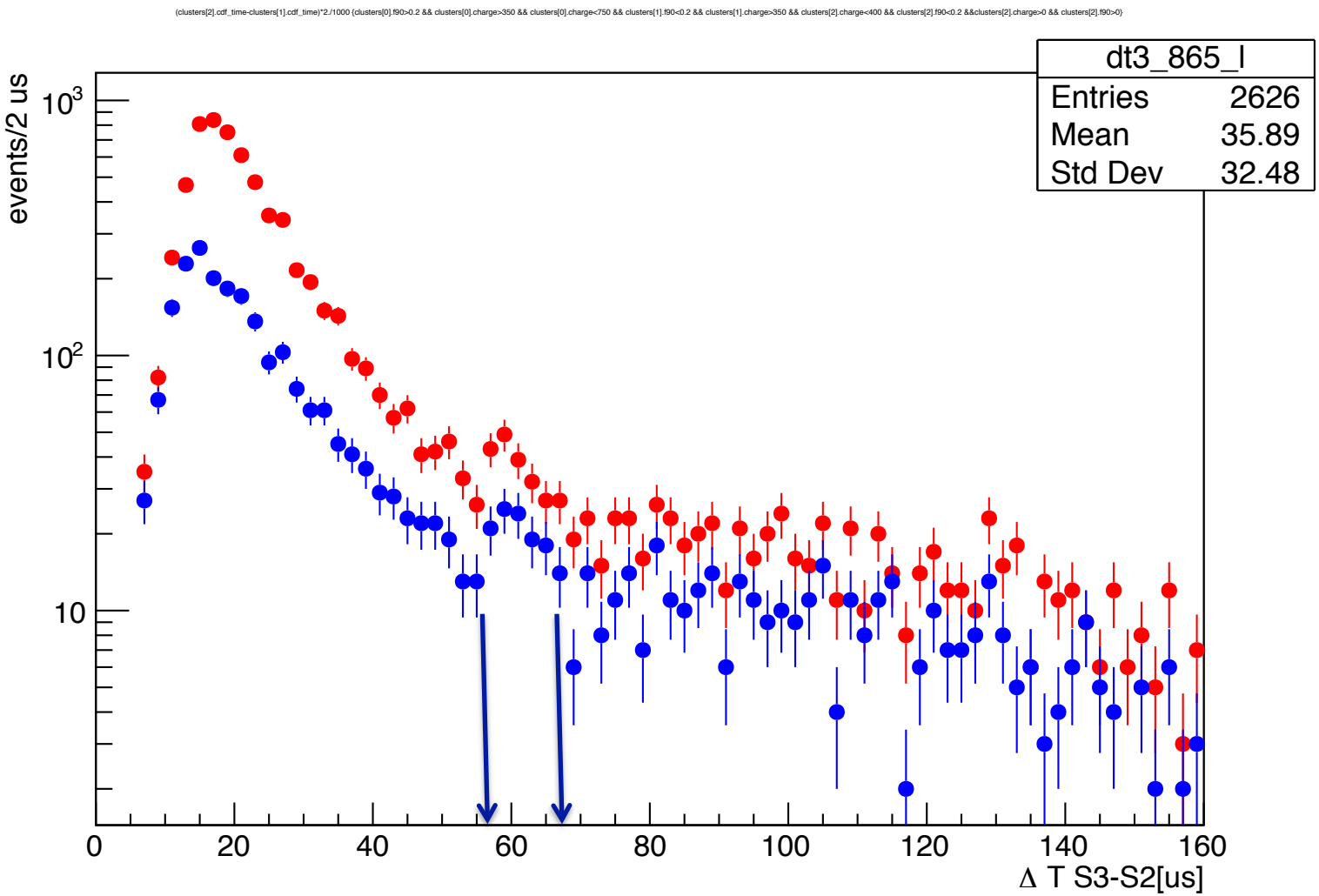
Spectrum of S3 echo events (run 888)



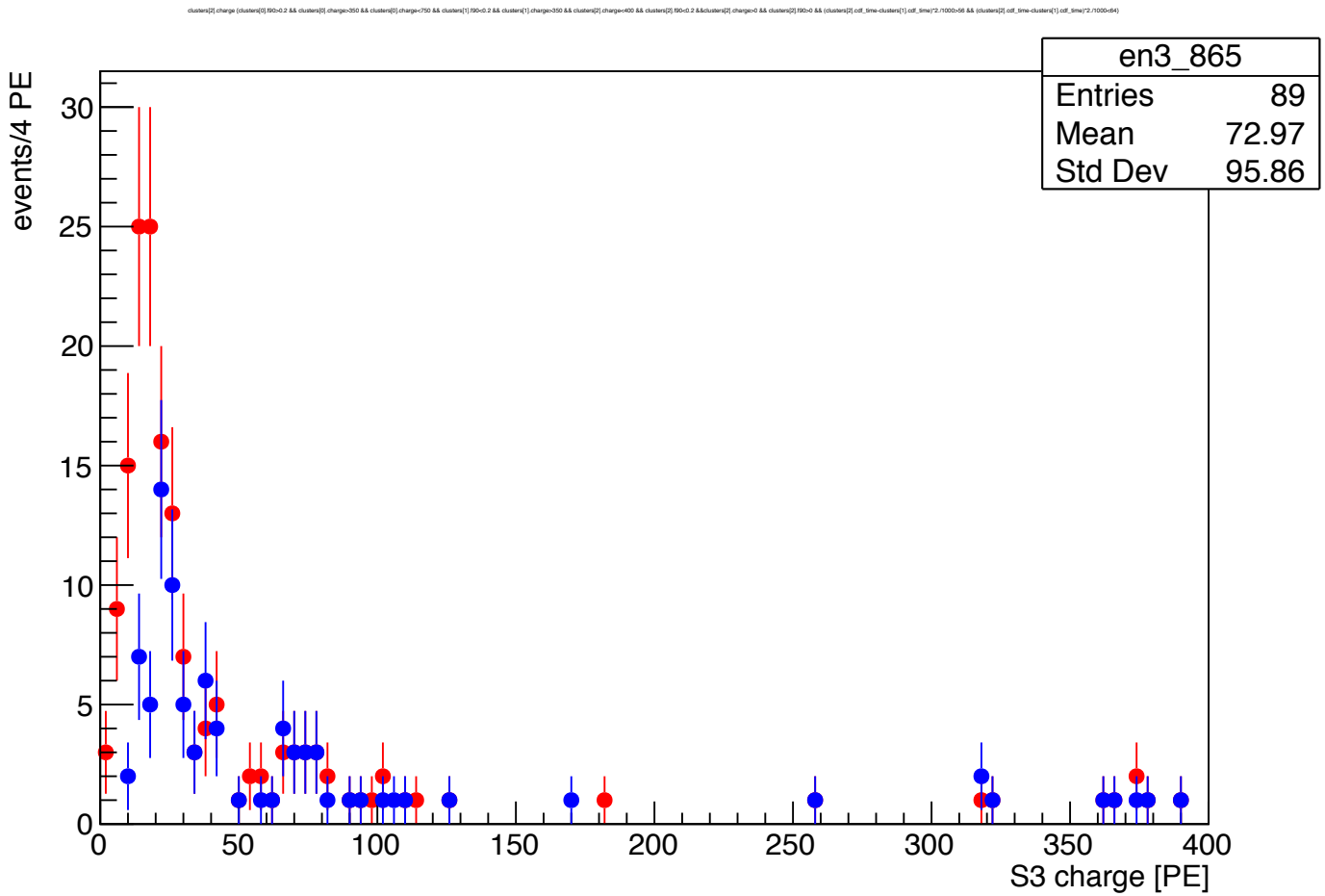
Compare echo spectrum low threshold vs default



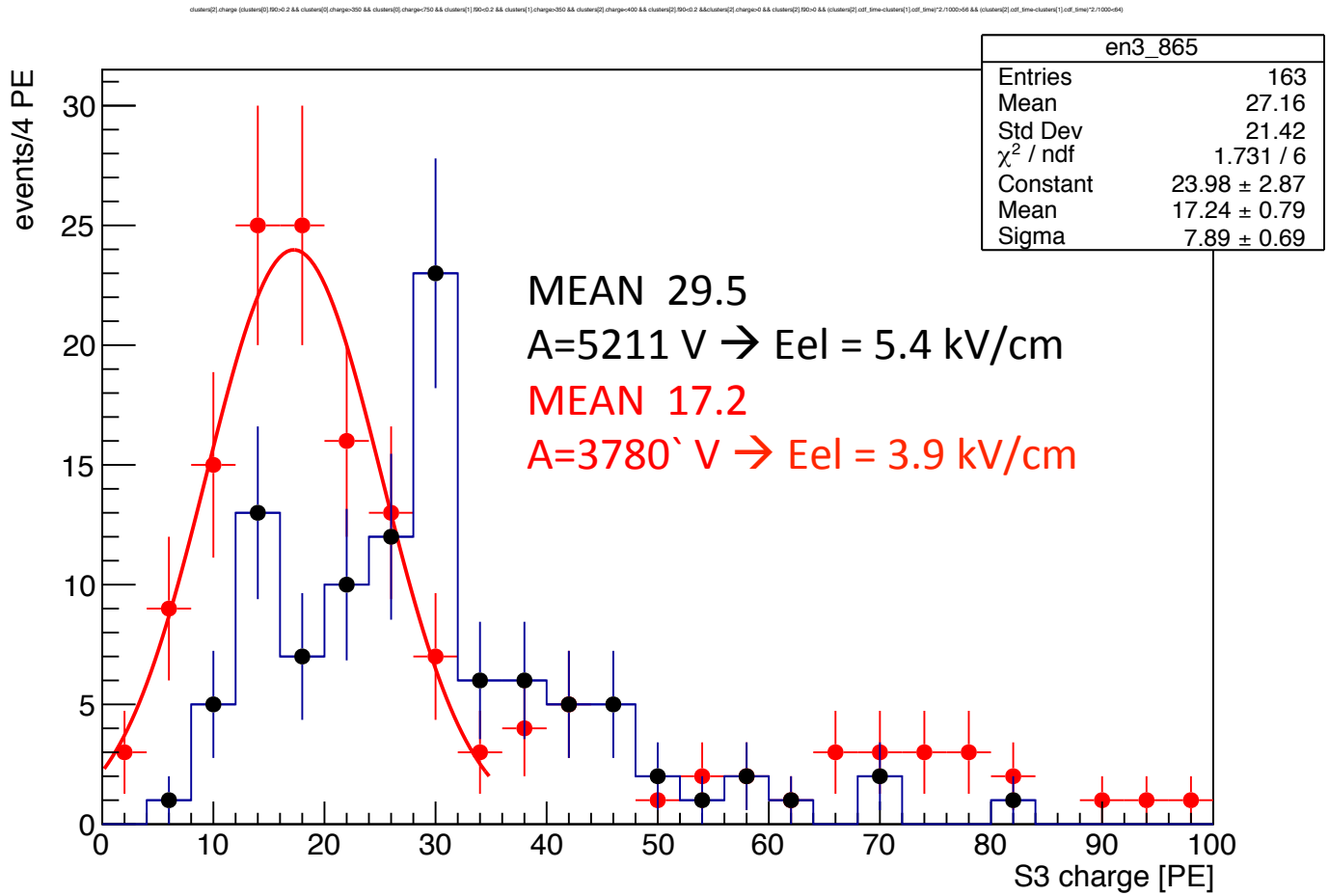
Run 865 low threshold vs default



Run 865 low threshold vs default



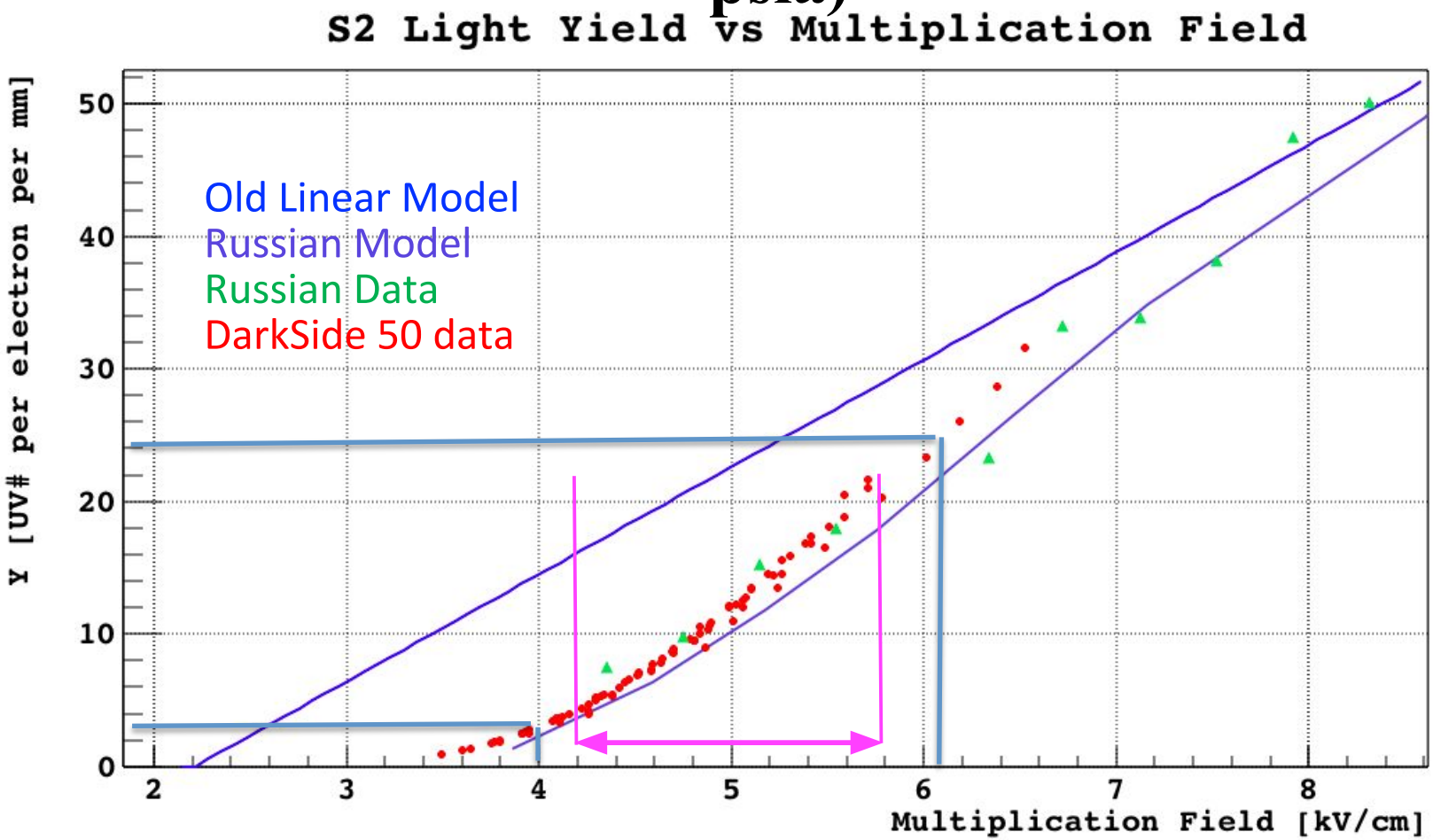
Run 888 vs Run 865



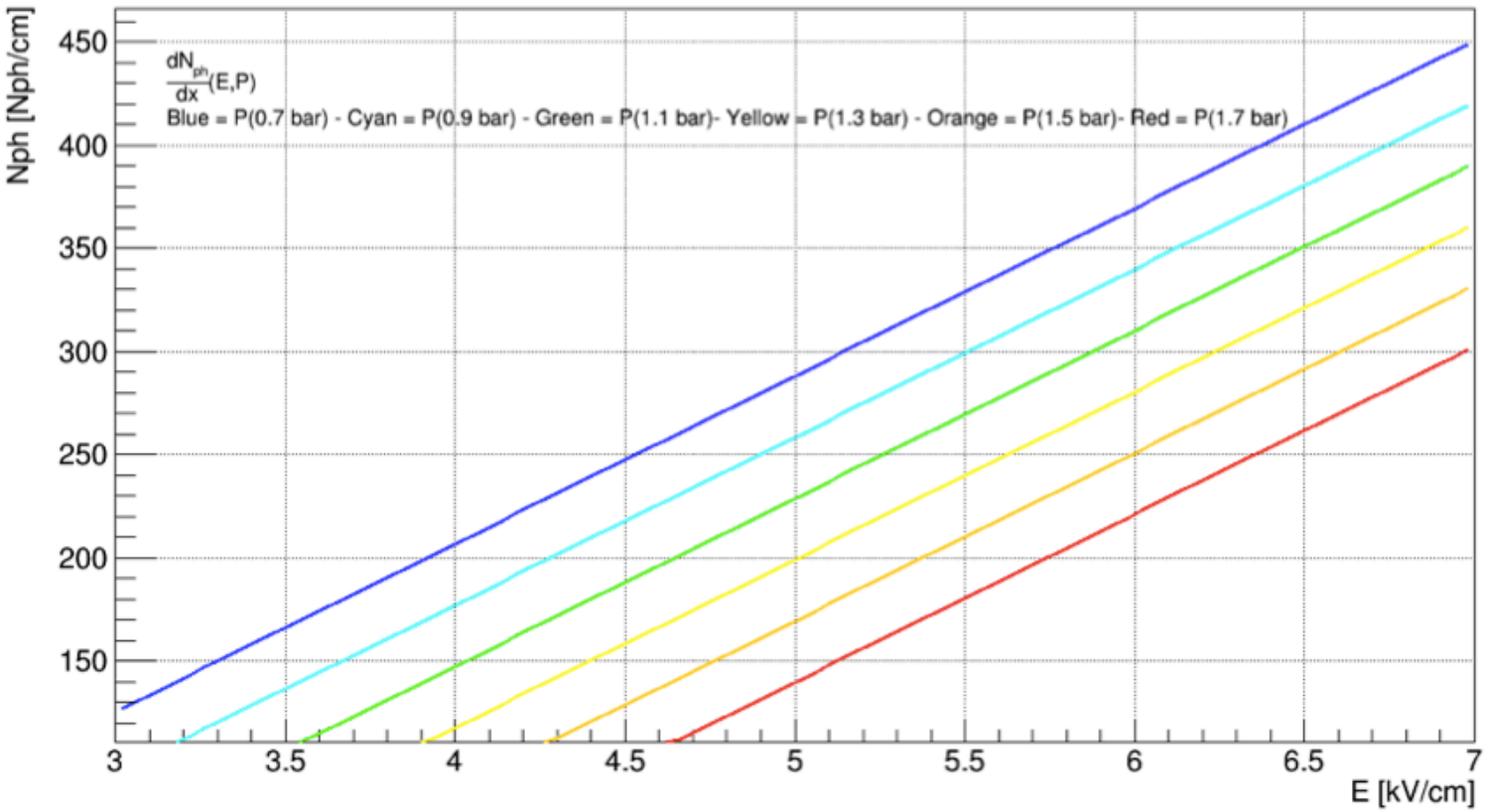
WHAT TO EXPECT?

Multiplication vs Electroluminescence Field

DarkSide-50 (15.6 psia)

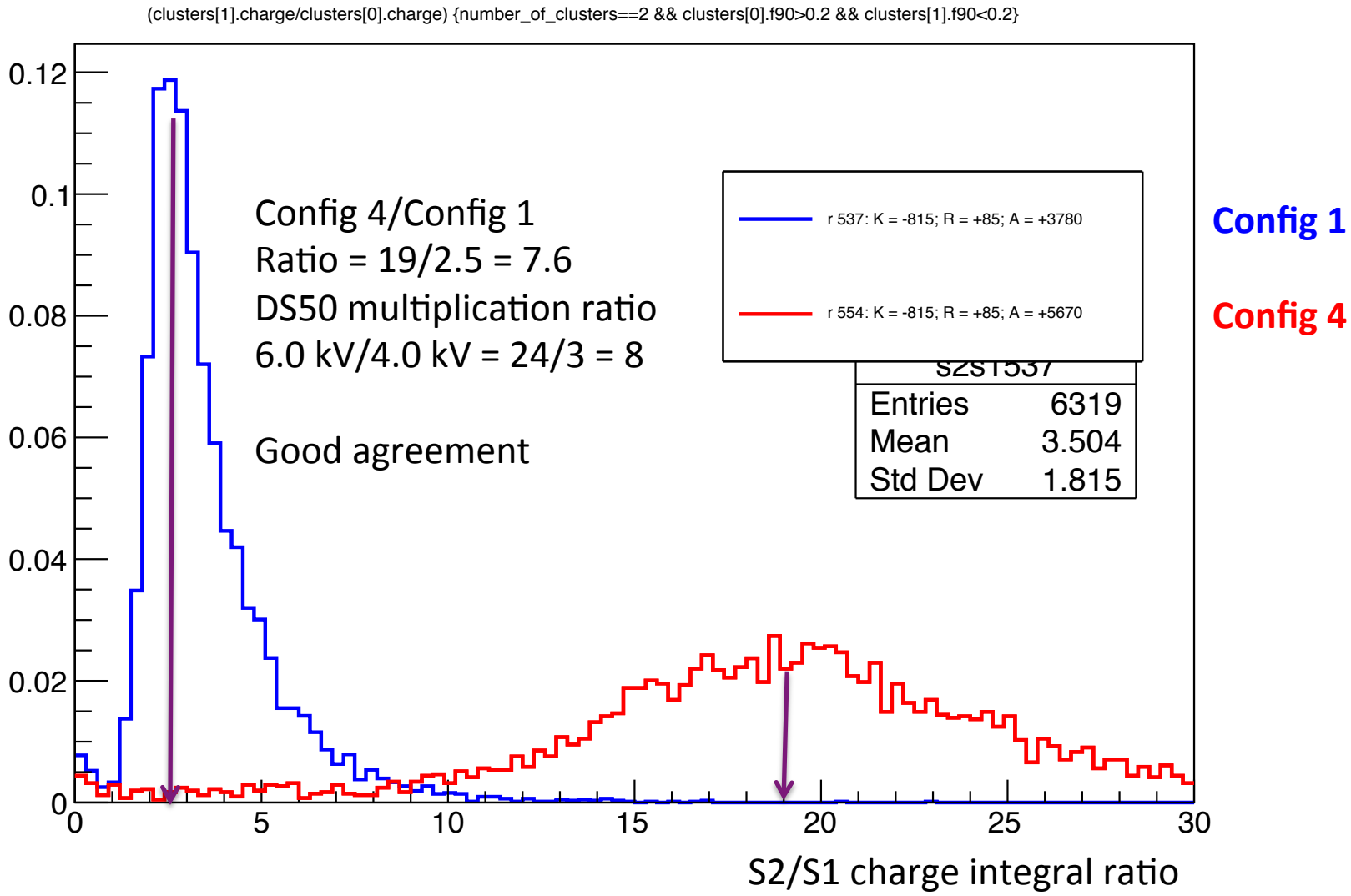


Photon in gas vs pressure;field



From Mauro PHD thesis.
Electroluminescence coefficient from: V. Chepel and H. Araujo. “Liquid noble gas detectors for low energy par- ticle physics”. In: JINST 8 (2013), R04001;arXiv: 1207.2292 [physics.ins-det].

TPC Am241 runs with different Fields



Expected and observed S2 amplification

- Same simple ratio of S2/S1 ratio used to extract S2 ratio also for Napoli runs

Condition	Eel kV 3 mm	Eel kV 1 mm	Eel Comsol (3 mm)		Mult Ratio (Ds50)	Mult Ratio (Mauro)	S2/S1 Ratio (Data)
Standard	4.2	3.9	4		1	1	1
Config 4	6.3	5.9	6		8÷11	2÷2.5	7.6
Napoli A +4.4 kV	5	4.6			3÷3.3	1.4÷1.5	4.3
Napoli A +5.2 kV	5.8	5.4			7÷8	1.7÷1.9	11

- Not consistent with linear model
- Not fully consistent with DS model, at least, in Naples
- Interplay of extraction and multiplication? still problems with Anode HHV settings? missing z/xy correction?

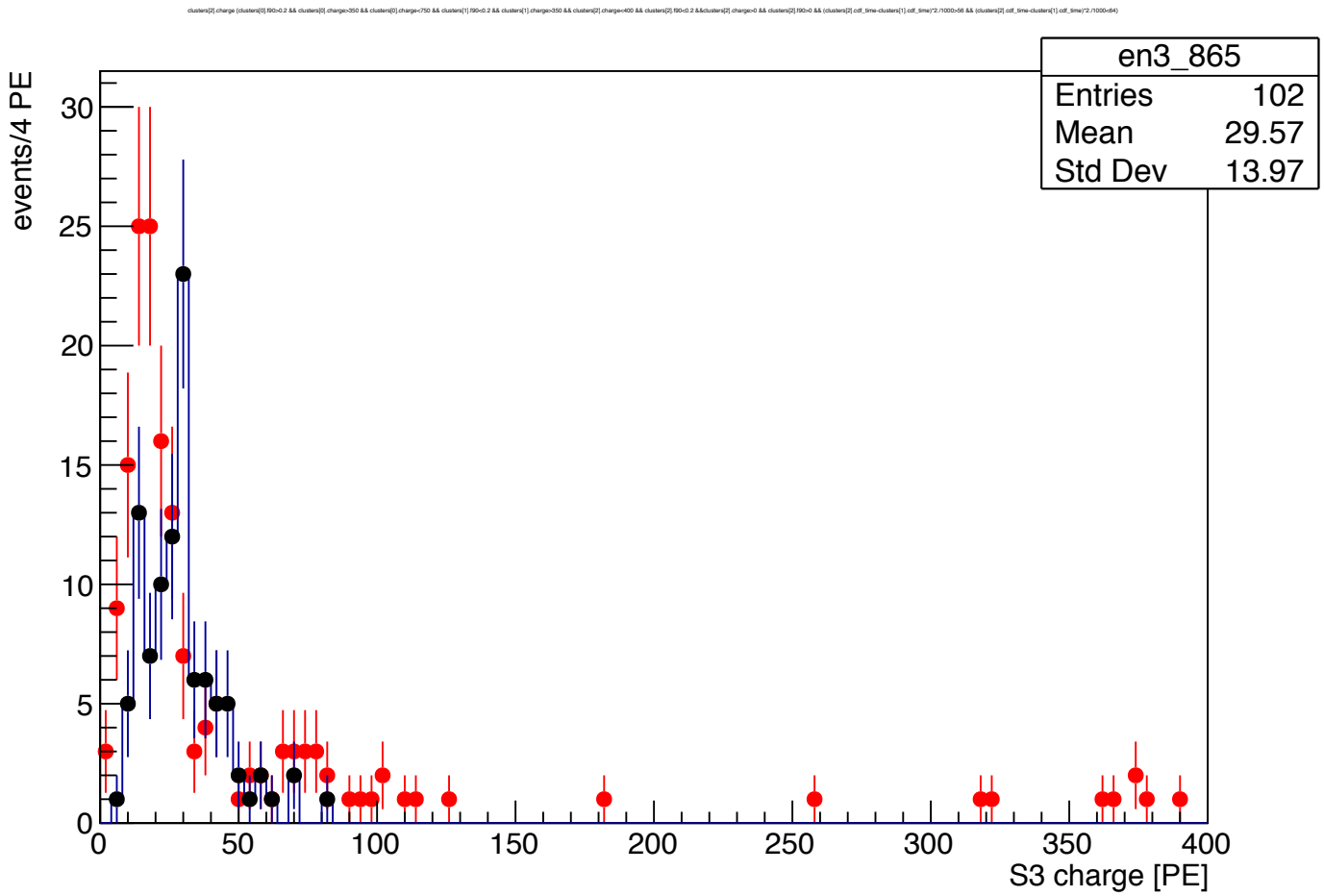
Conclusion and to do

- The vast majority of remaining S3 events looks like real pulses
- An excess of low-energy S2-like pulses trailing main S2 events is there
- Confirmed in a 200 us acquisition window (run 865)
- S2 pulses are integrated for too little time in any case (marginal impact, see backup)!
- If interpreted as single-electrons induced by S2 the multiplication should not be the reason for low S2/S1 (we see ~40 PE/e- with standard clustering cuts)
- However, low threshold clustering reveals more events at lower PE. At least provide some evidence for a scaling in single-electron S2 signa.
- Scaling with amplification field, likely inconsistent with expectation based on ds50 data ! Consistent with linear model but the latter is inconsistent with S2/S1 scaling

- Look also at S2 only events → need to correct for trigger on bottom only channels(?)
- Try and look at low energy pulses in-beam to see if the estimate of "accidentals" affected

- Suggest to take some further runs with 100 k and higher energy source if possible.

Run 888 vs Run 865



Effect of changing integration window on S2/S1