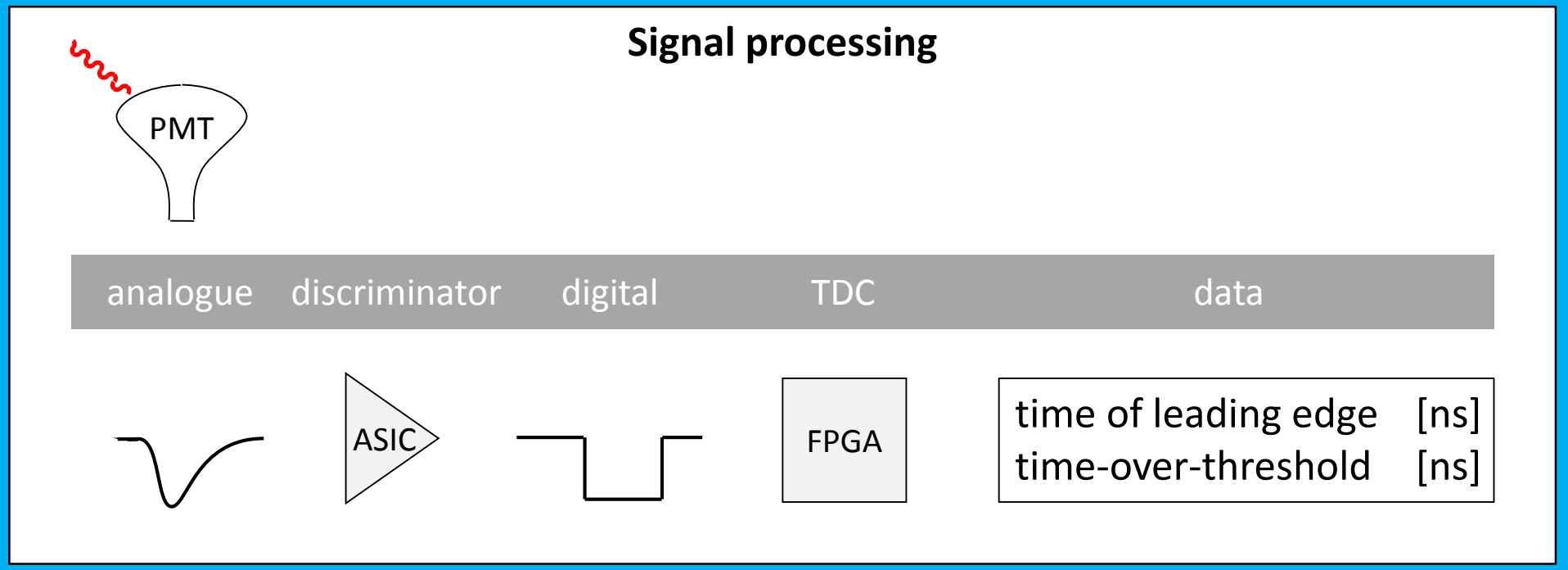
JPMTAnalogueSignalProcessor

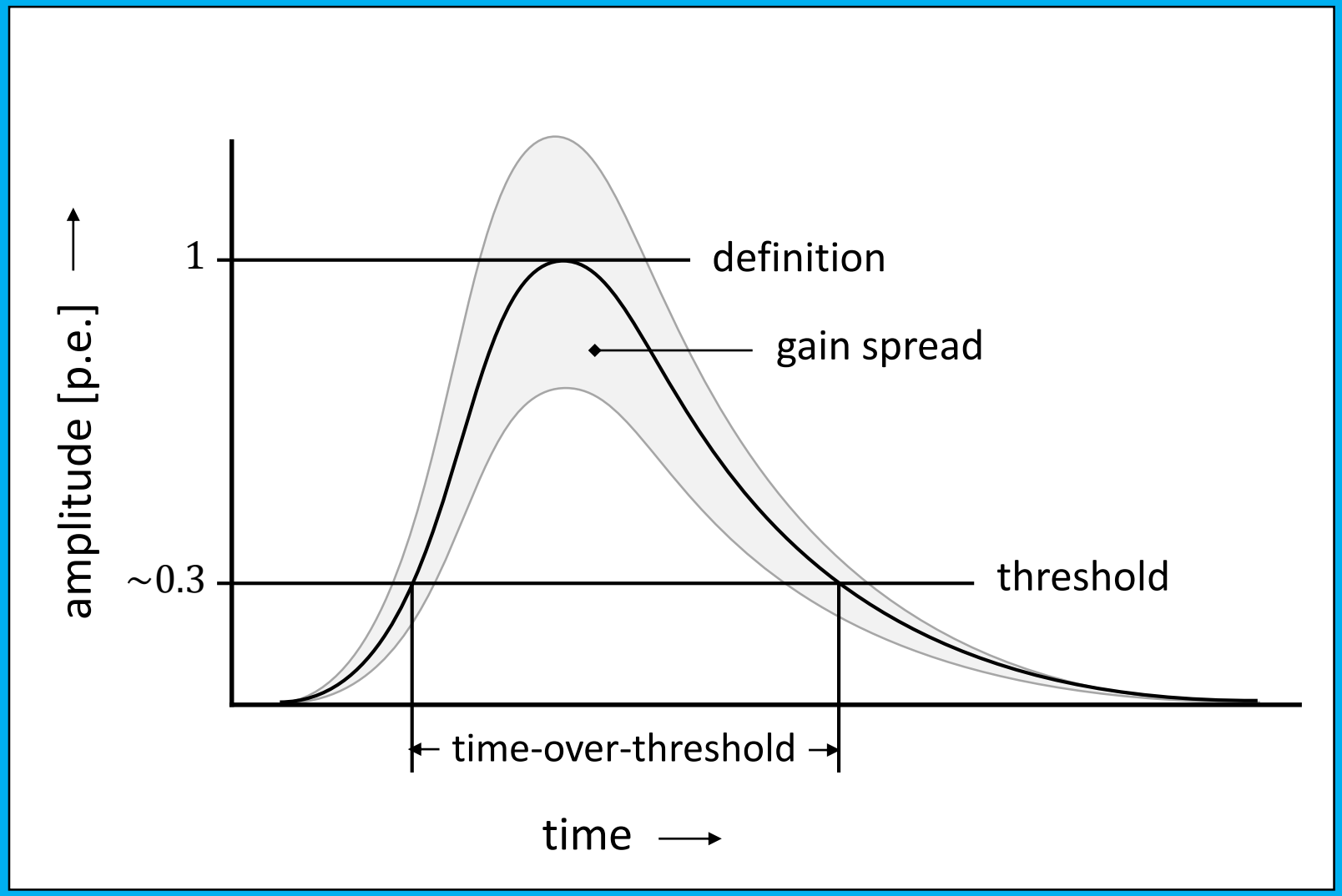
PMT analogue signal processor in Jpp

M. de Jong

Introduction (1/1)

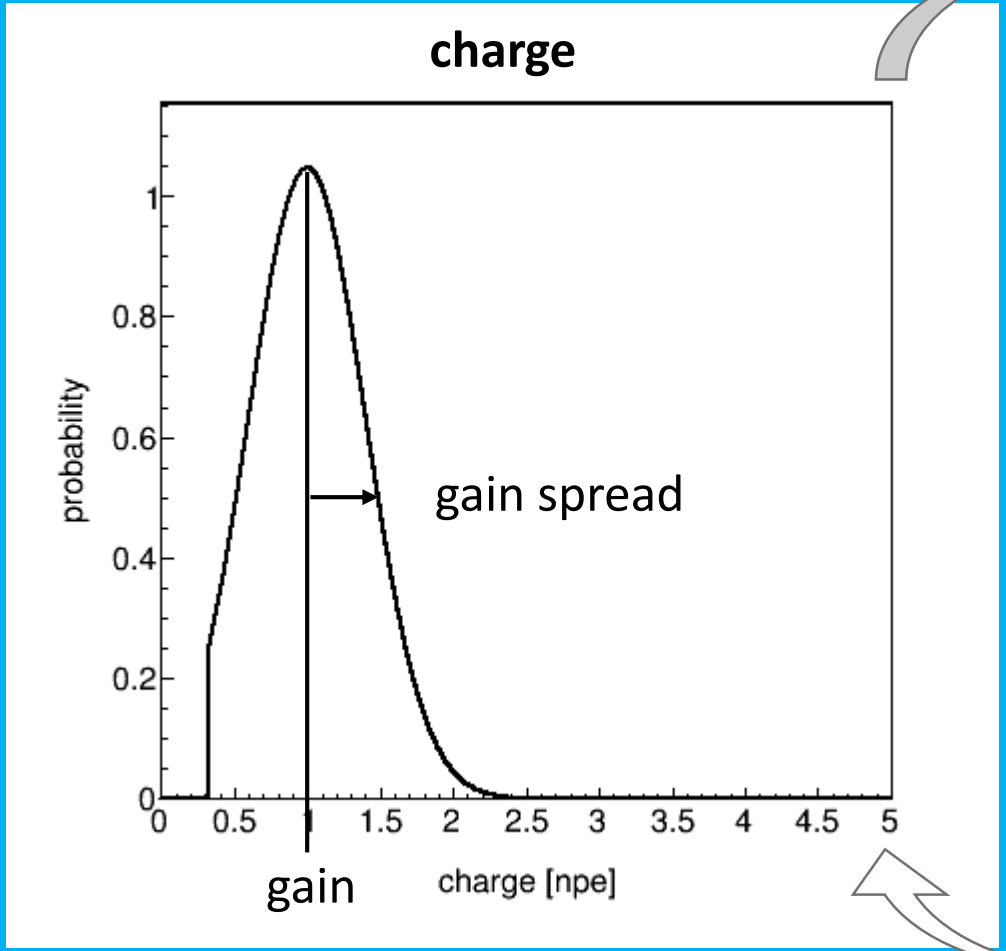


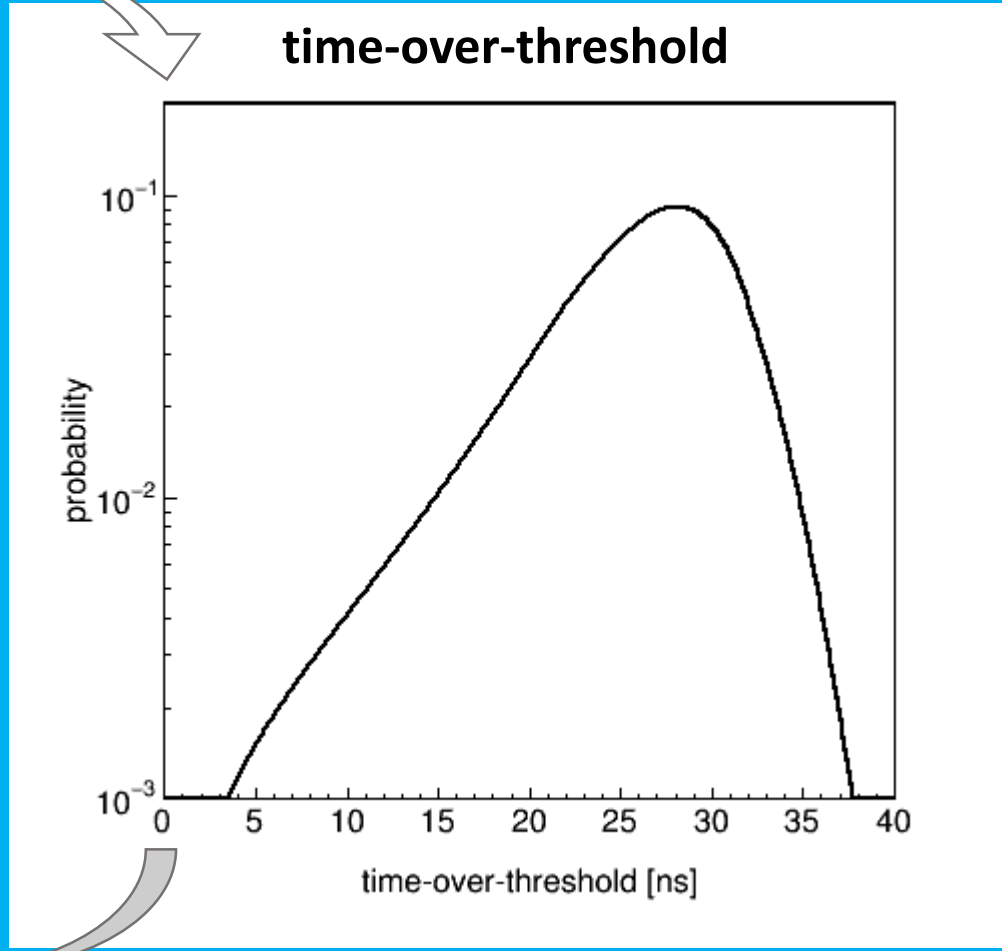
Introduction (2/3)



Introduction (3/3)

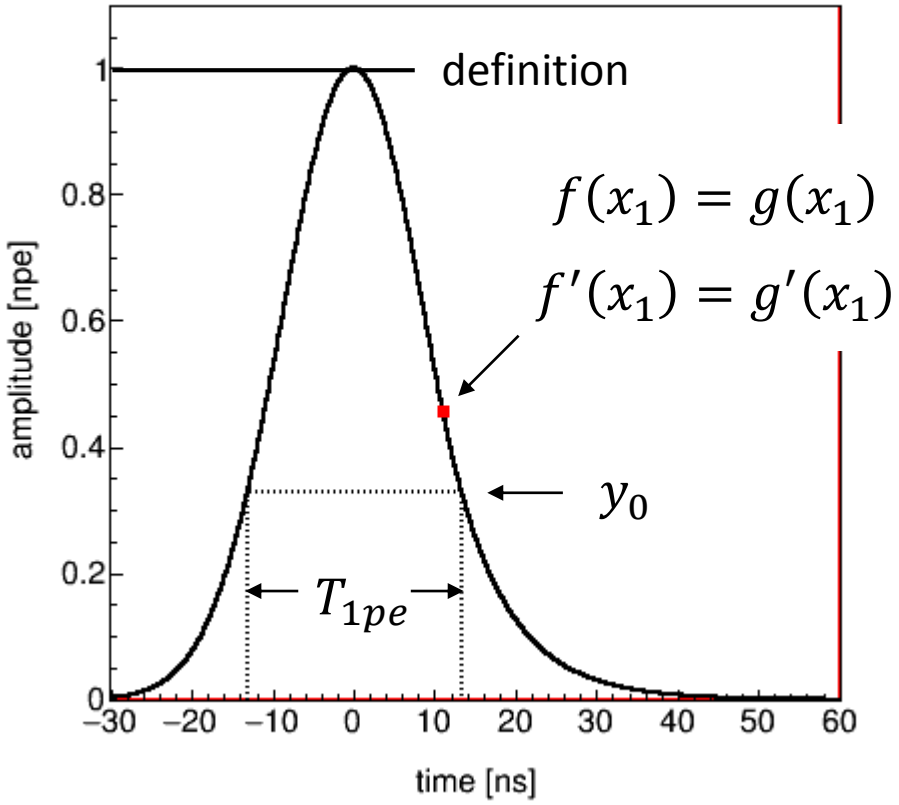
simulation





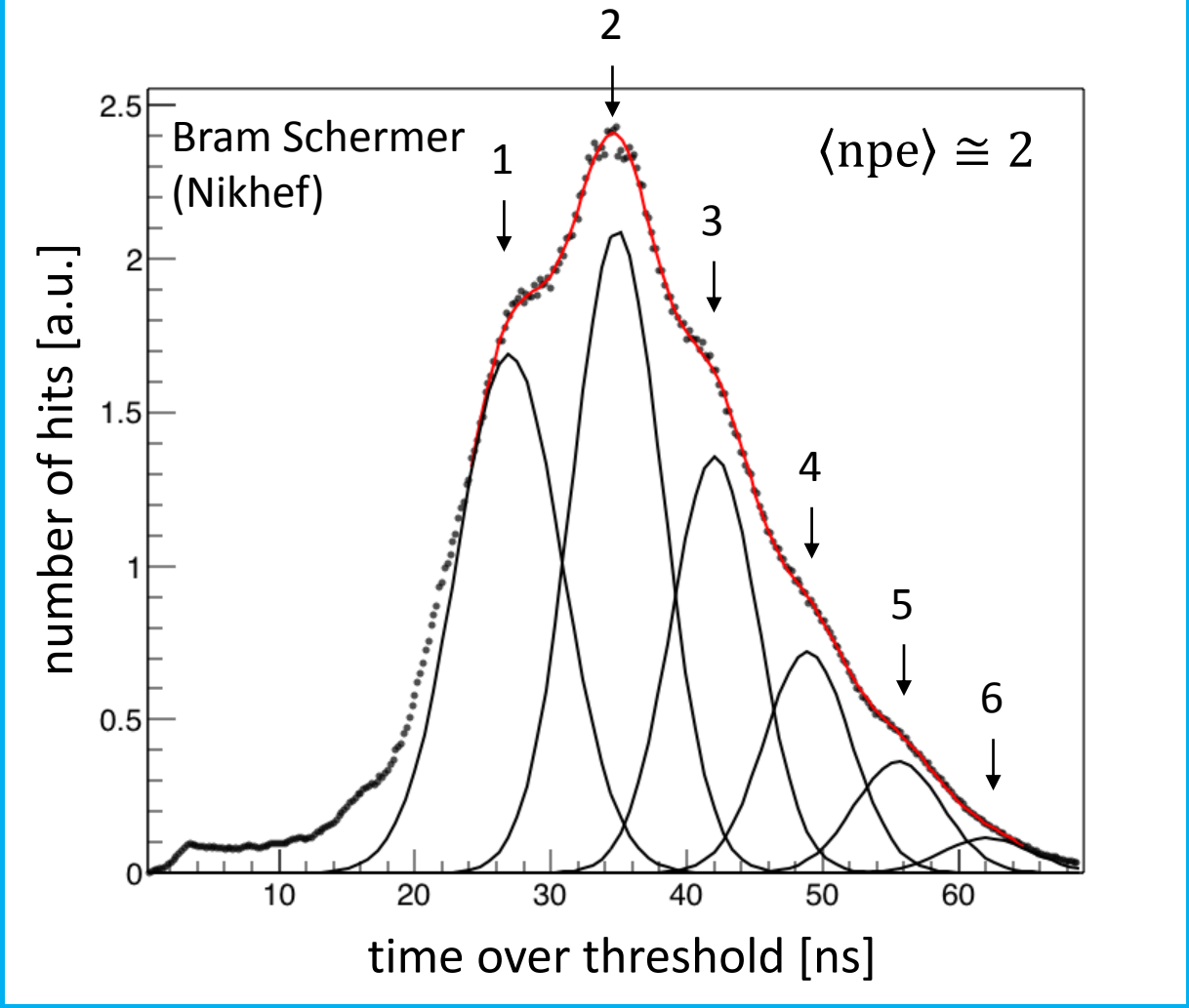
calibration

Model (1/4)



- Leading edge = Gaussian
  - $f(x) = e^{-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2}$
- Trailing edge = exponent
  - $g(x) = e^{\frac{1}{2}\left(\frac{\lambda}{\sigma}\right)^2} \times e^{-x/\lambda}$
- Specification: $T_{1pe} \equiv 26.4$ ns
  - $T = g^{-1}(y_0) - f^{-1}(y_0)$
    - relates σ and λ
    - constraints σ

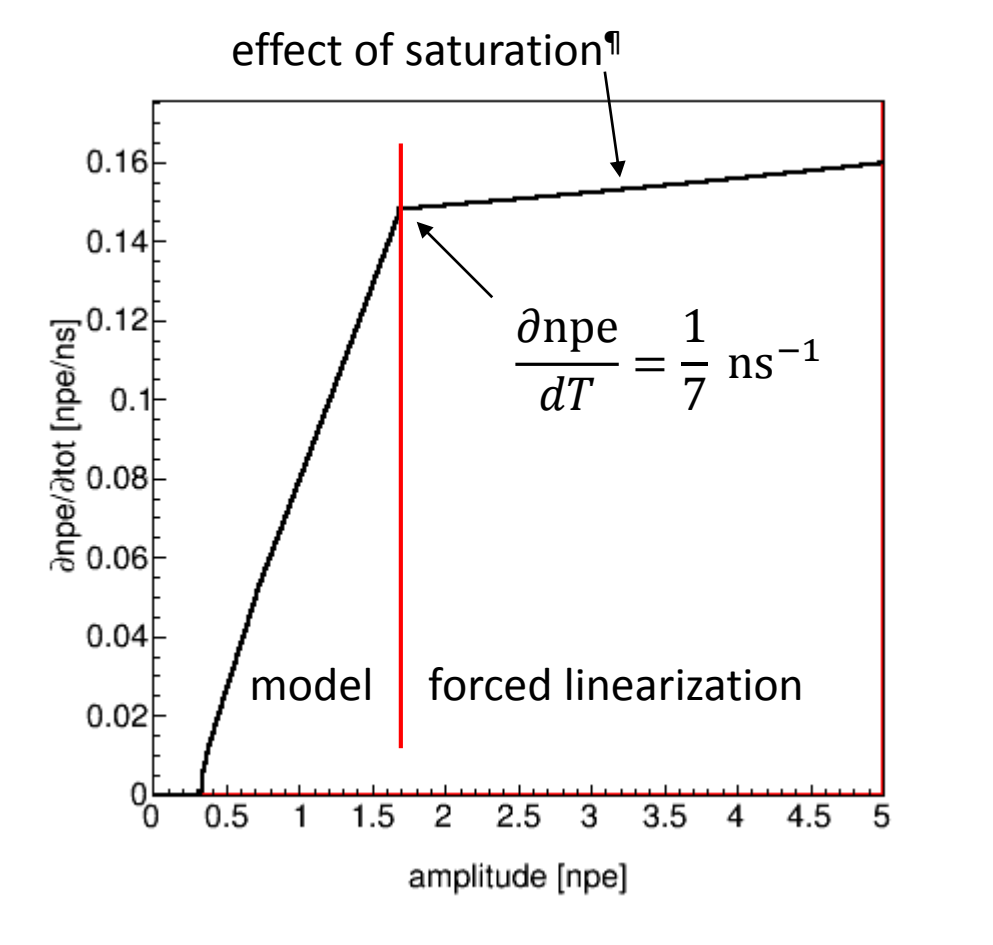
Model (2/4)



peak	ns
1	27
2	35
3	42
4	49
5	56
6	62

$$\frac{\partial T}{\partial \mathrm{npe}} \cong 7 \text{ ns}$$

Model (3/5)



- kink is equivalent of clipping of voltage at amplifier output

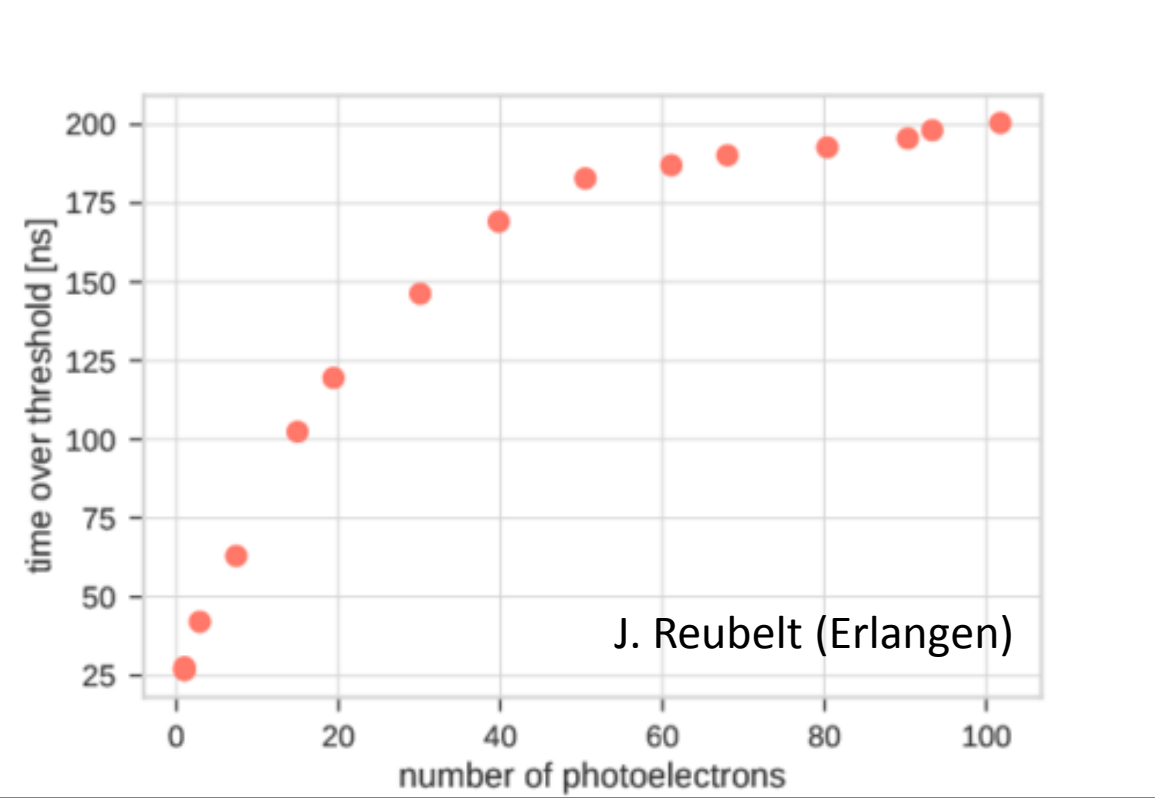
  $\Longrightarrow T \propto$ charge

- determination of transition point requires iterative procedure

  ✓few steps suffices

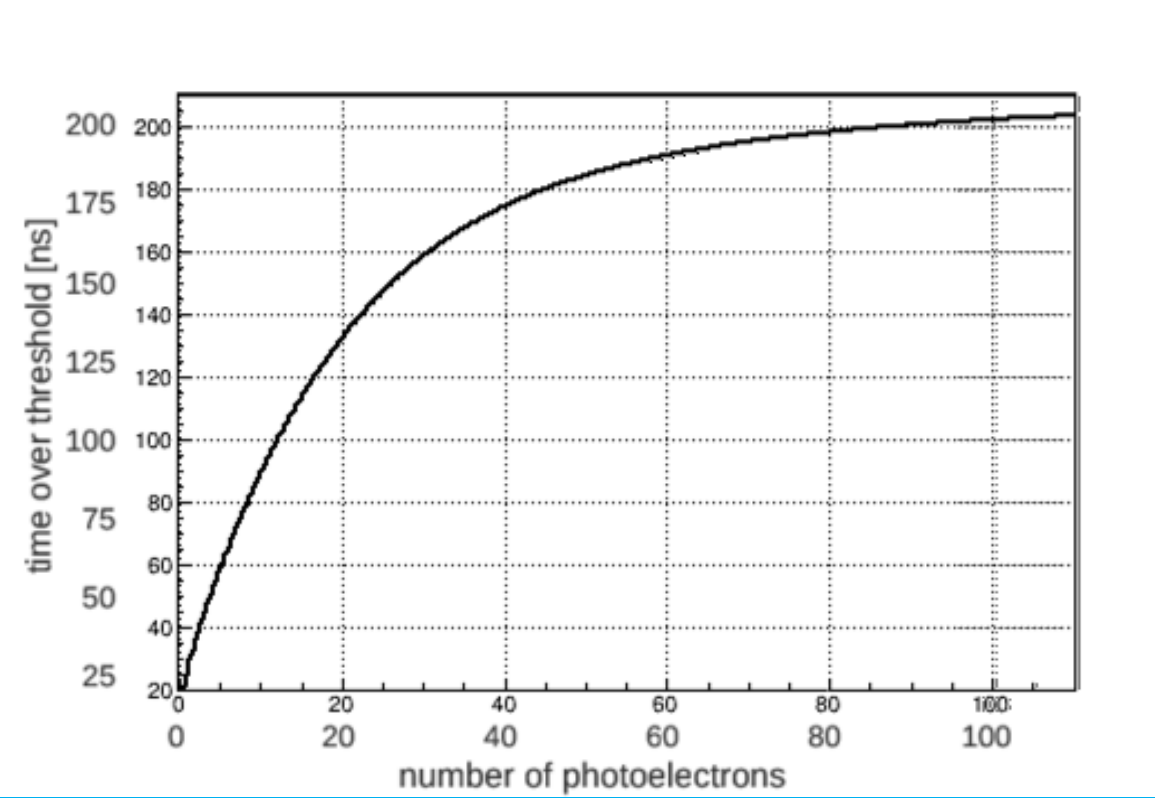
¶ See next slides.

Model (4/5)



- Saturation
  - $x' = x \times \frac{c}{\sqrt{x^2+c^2}}$
    - $x \equiv$ time-over-threshold

Model (5/5)

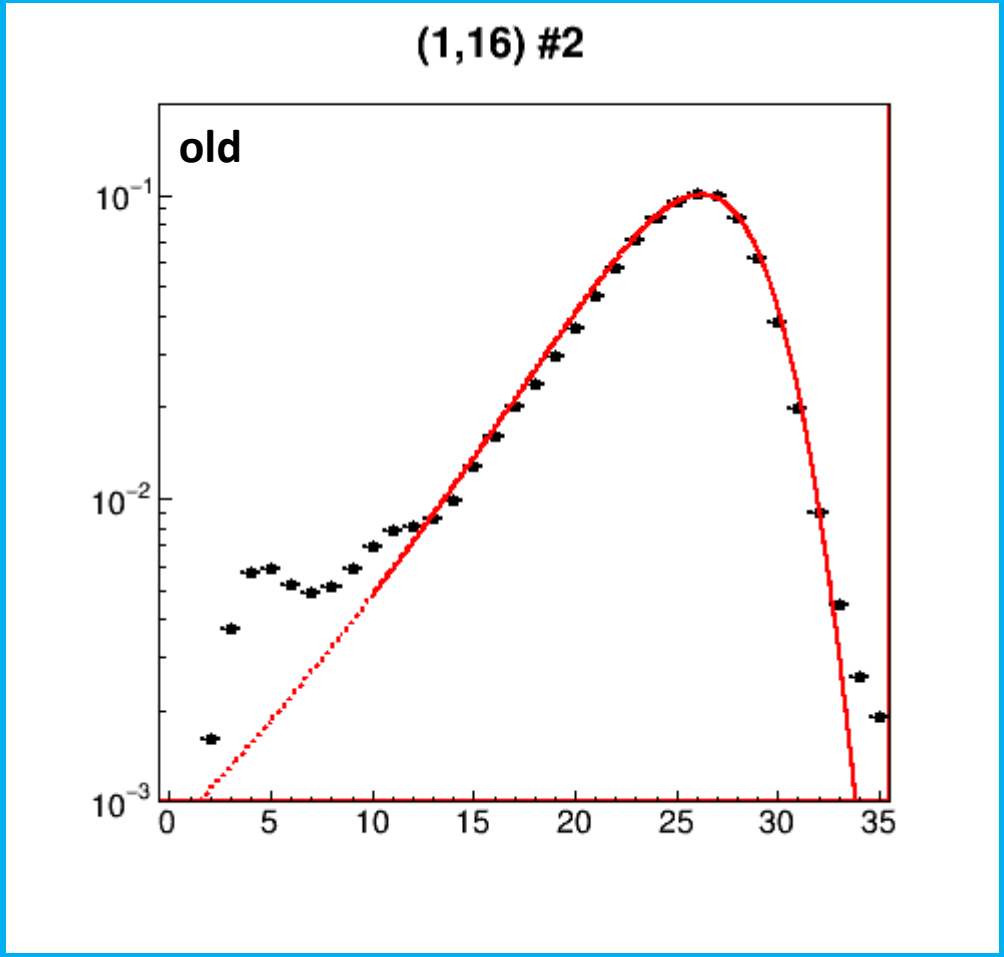


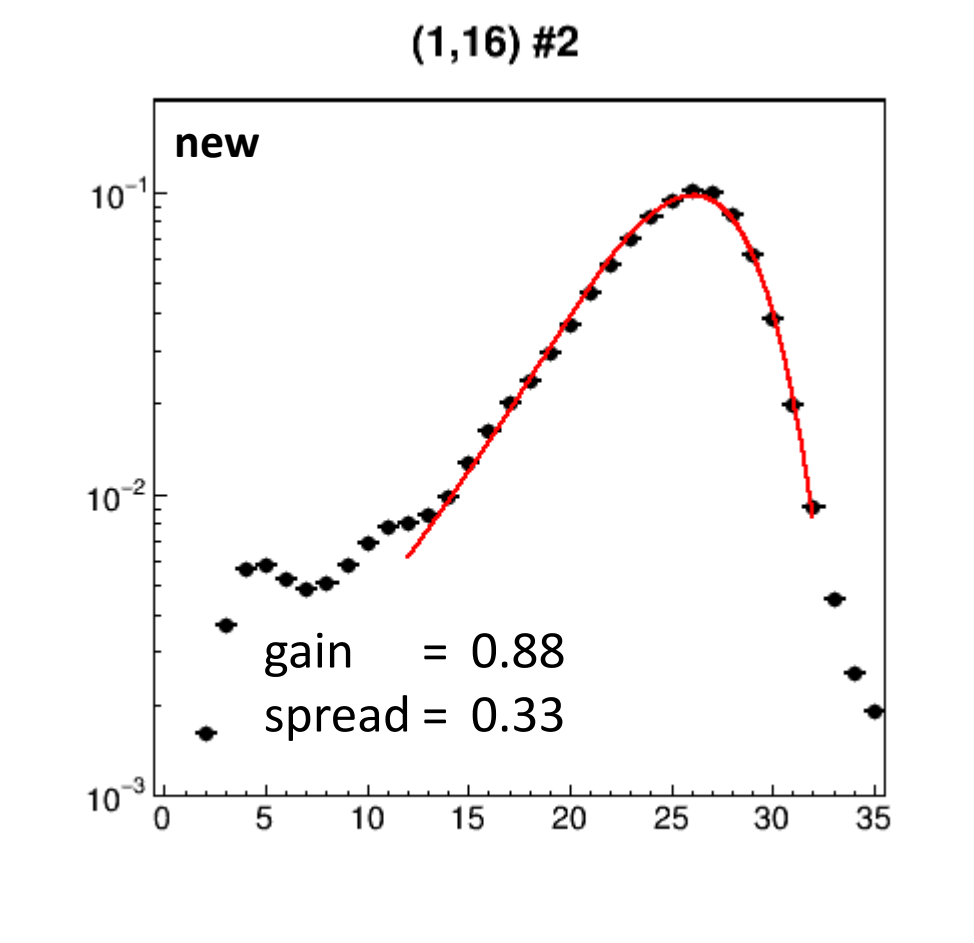
- Saturation
  - $c \cong 210\ \mathrm{ns}$
    - good agreement

Results (1/4)

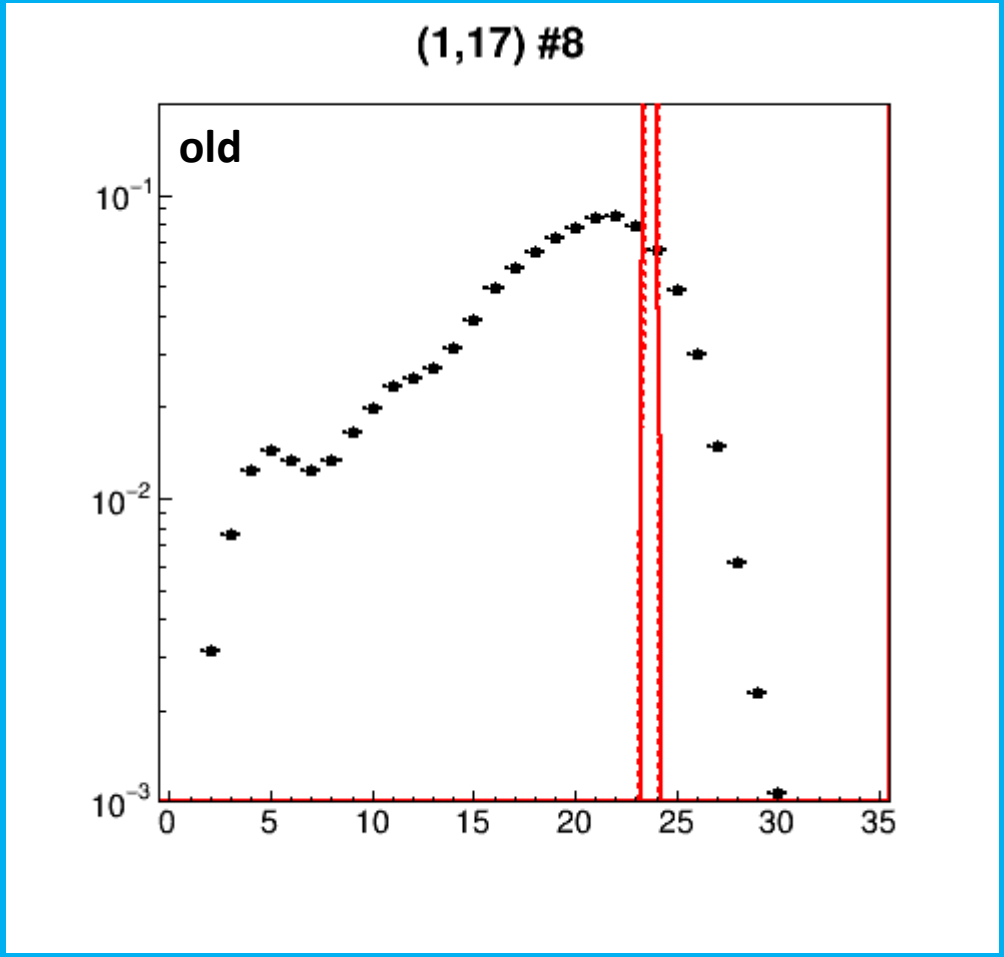
- input KM3NeT_00000014_00005282.root (L0 data)
- old = Jpp trunk (11531)
- new = this analysis

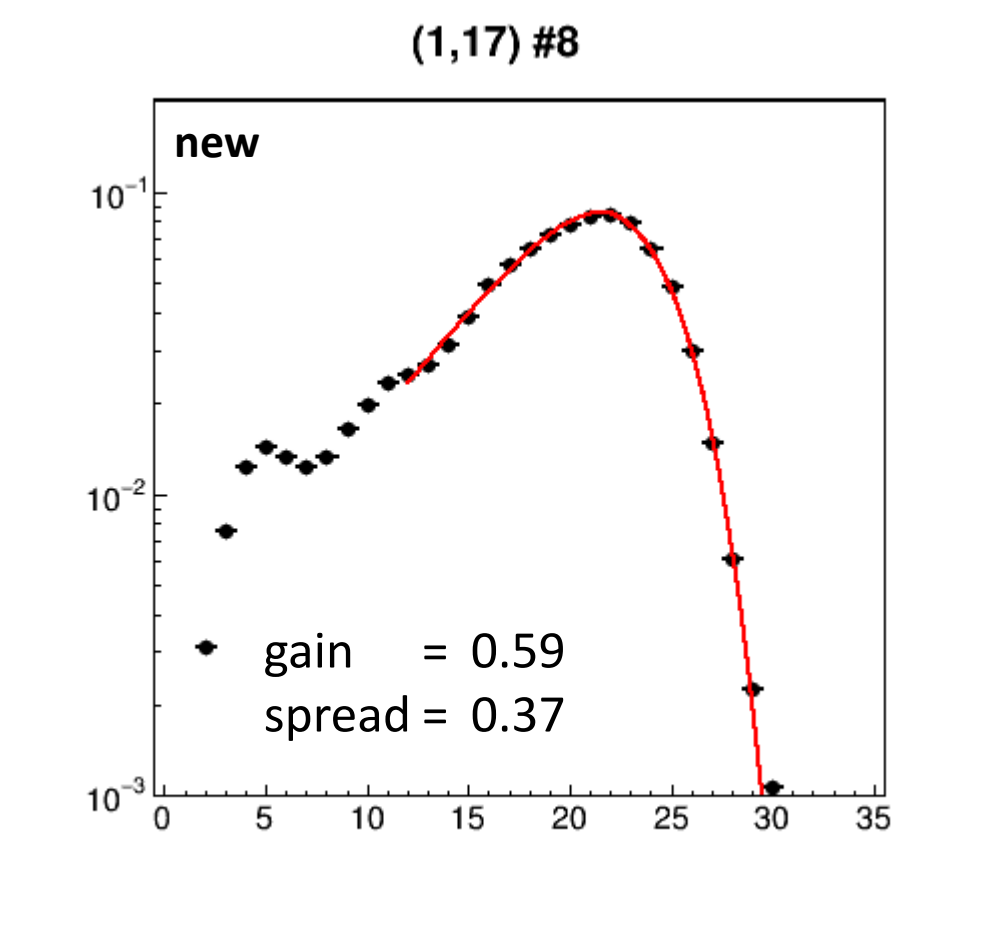
Results (2/4)


(1,16) #2
old
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35

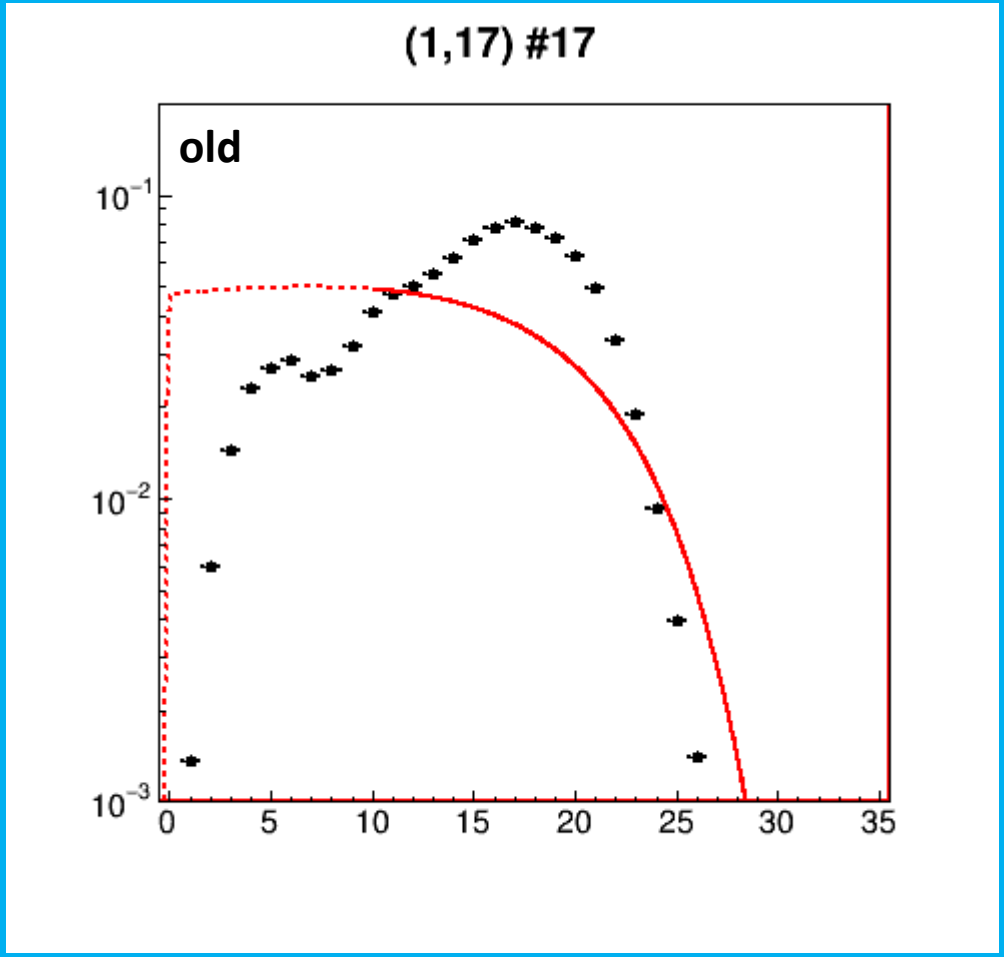

(1,16) #2
new
10^{-1}
10^{-2}
10^{-3}
gain = 0.88
spread = 0.33
0
5
10
15
20
25
30
35

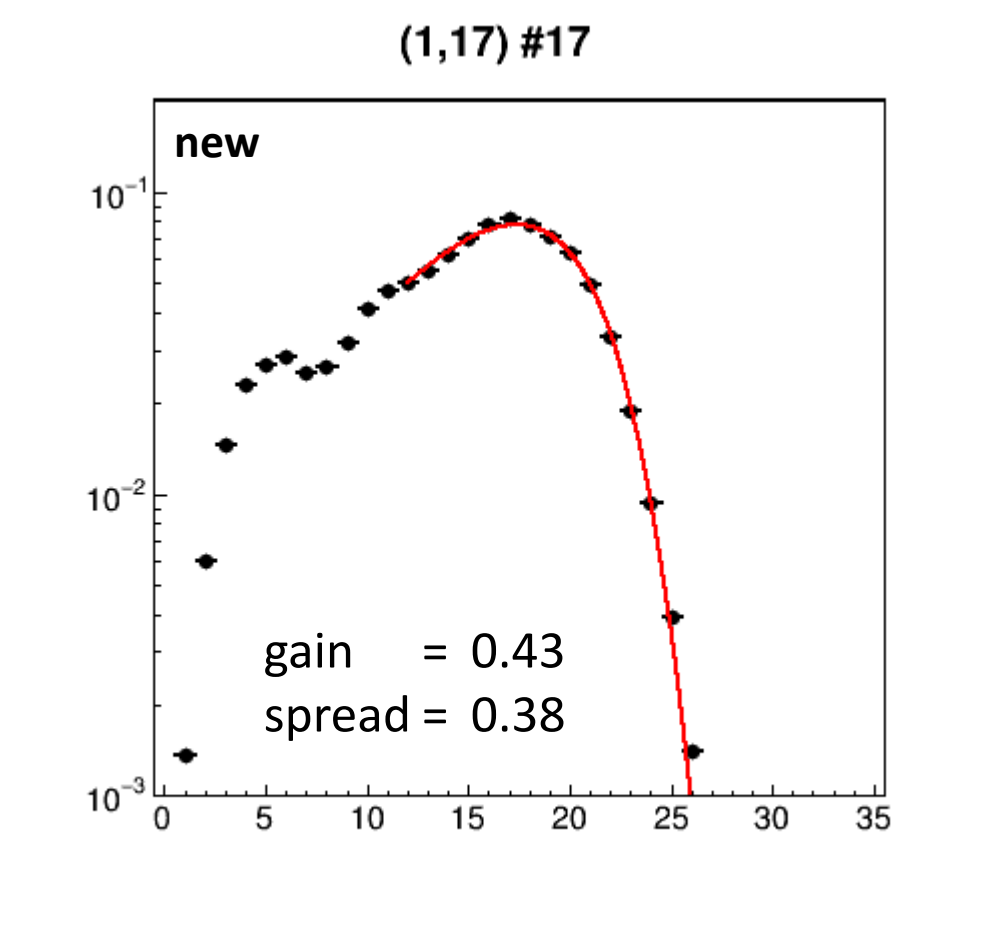
Results (3/4)


(1,17) #8
old
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35

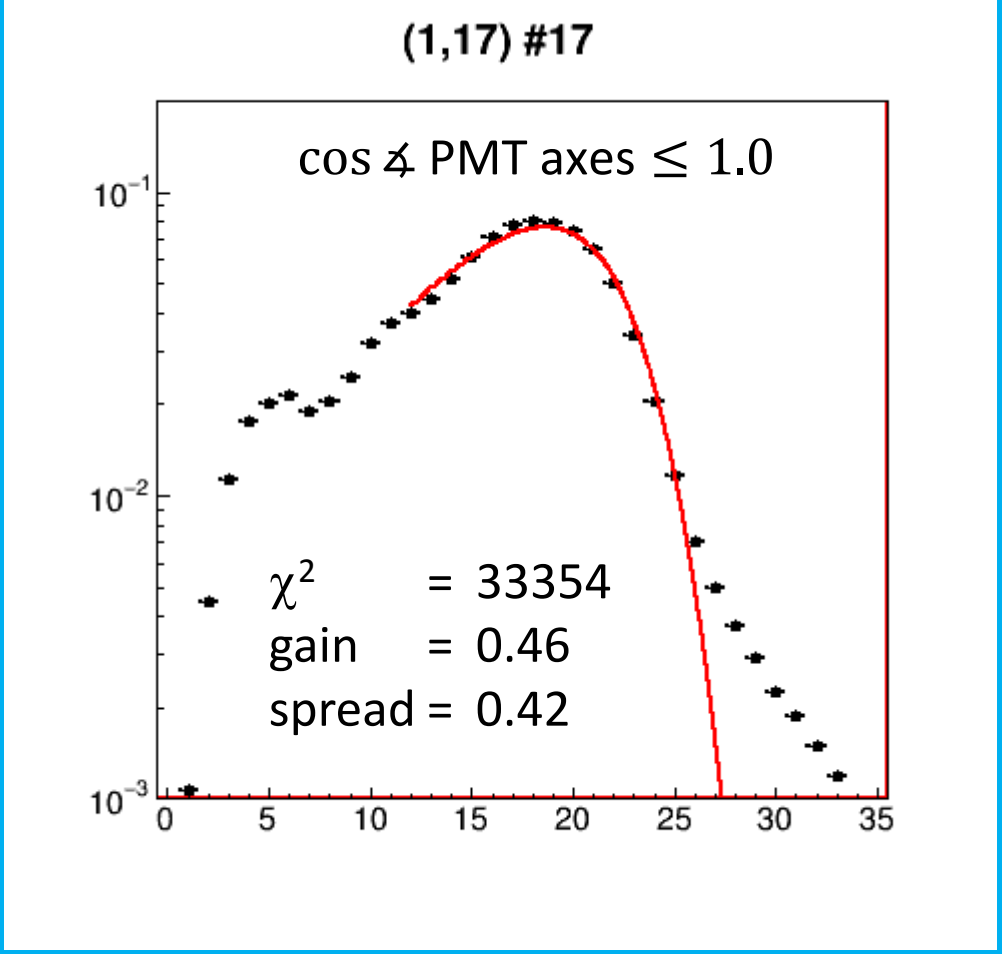

(1,17) #8
new
10^{-1}
10^{-2}
10^{-3}
gain = 0.59
spread = 0.37
0
5
10
15
20
25
30
35

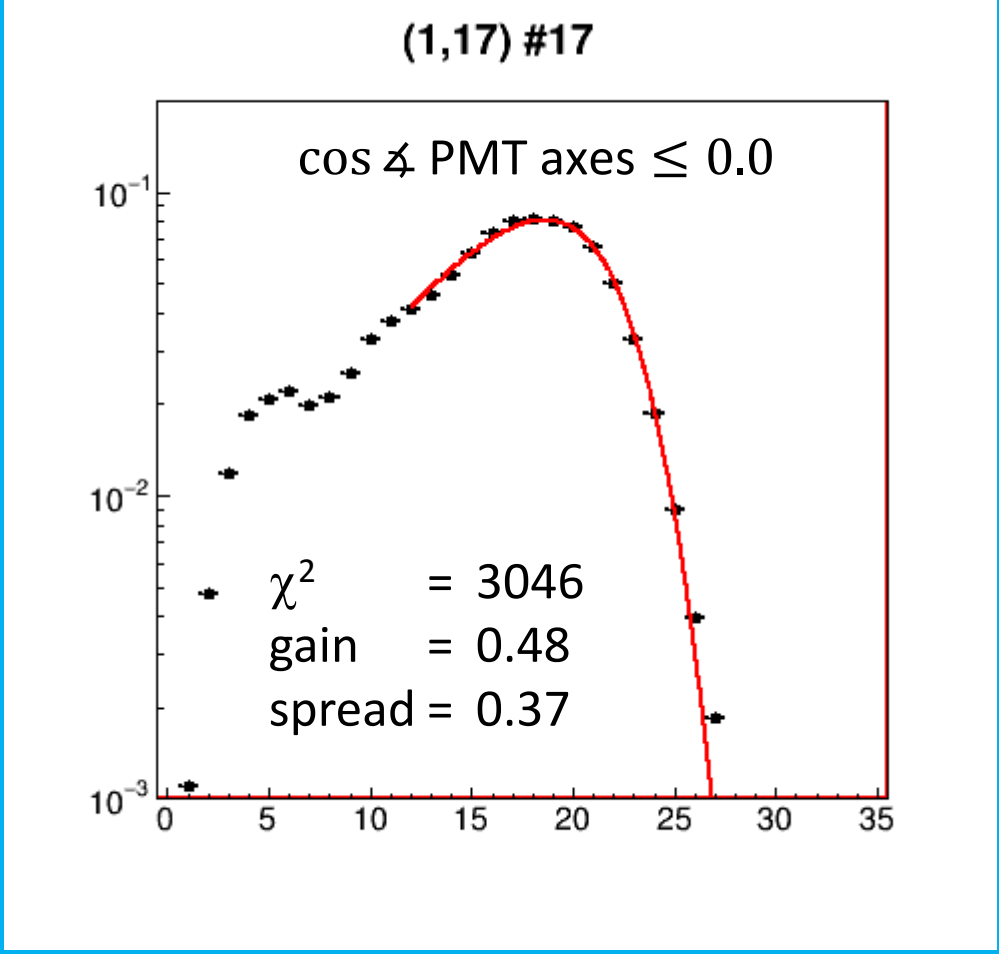
Results (4/4)


(1,17) #17
old
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35


(1,17) #17
new
10^{-1}
10^{-2}
10^{-3}
gain = 0.43
spread = 0.38
0
5
10
15
20
25
30
35

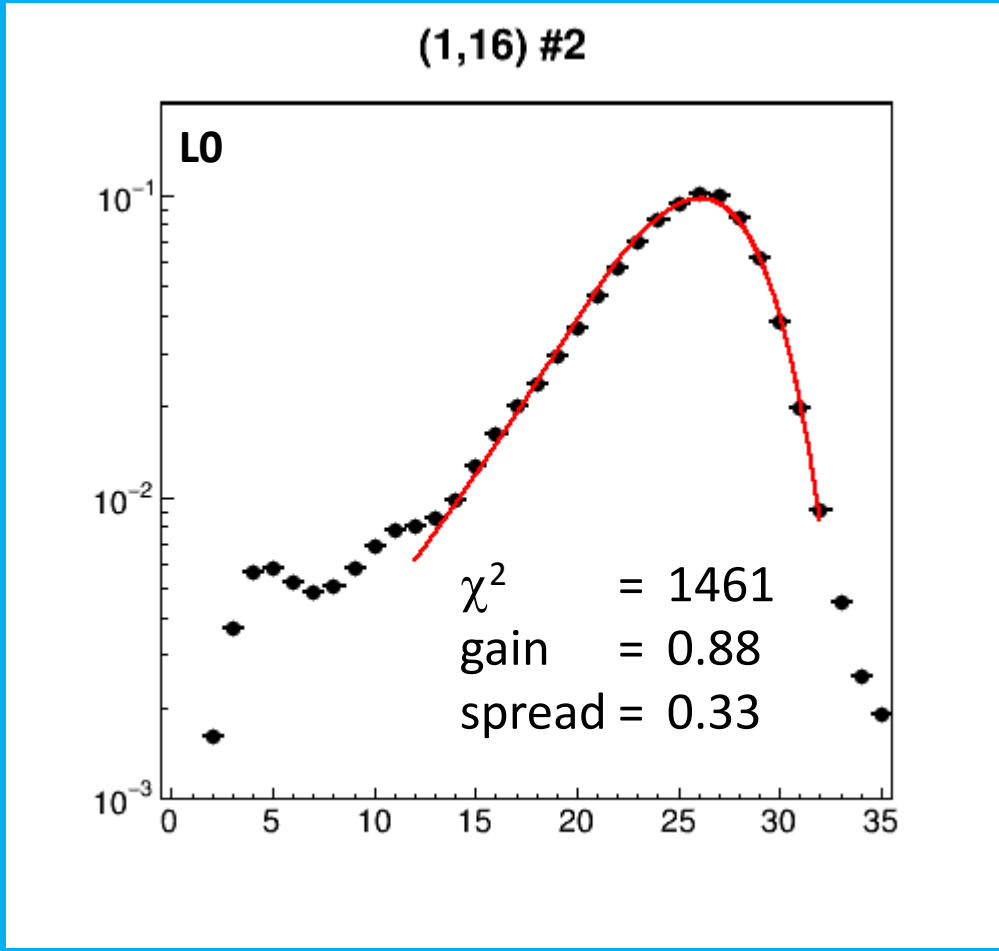
L1 data selection¶ (1/1)

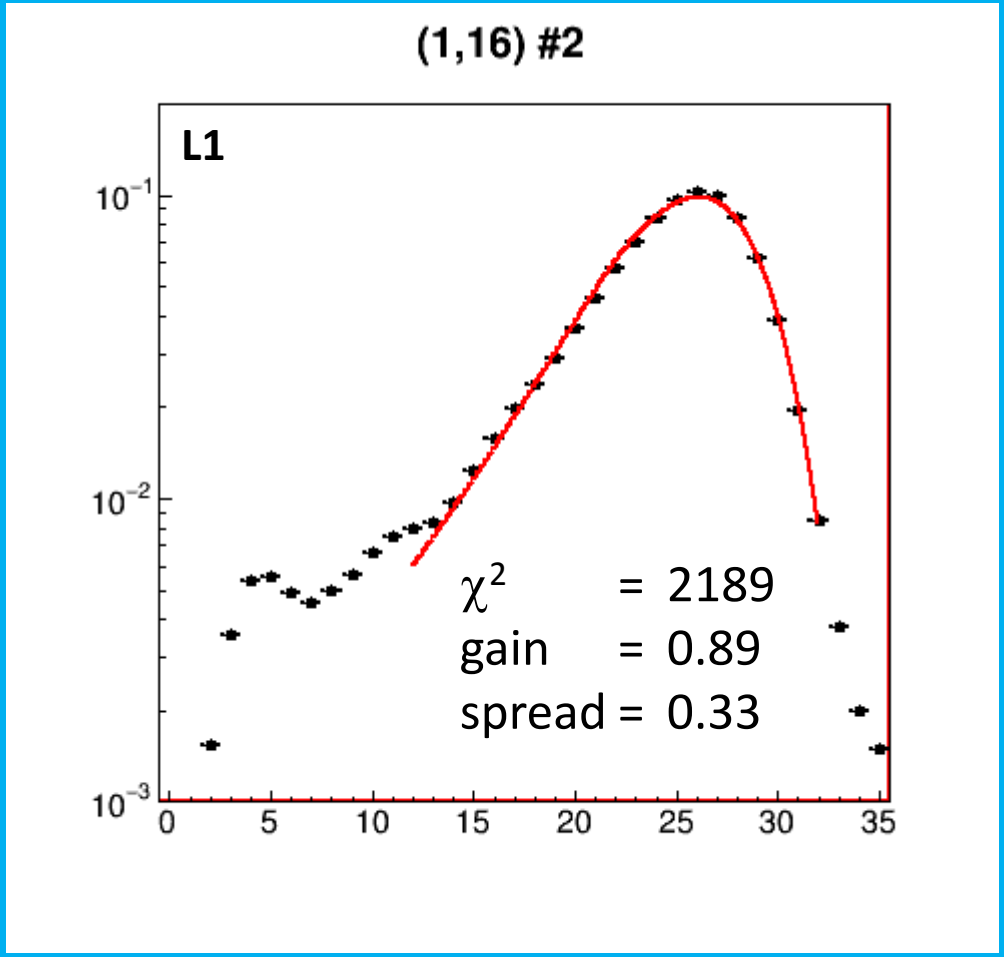




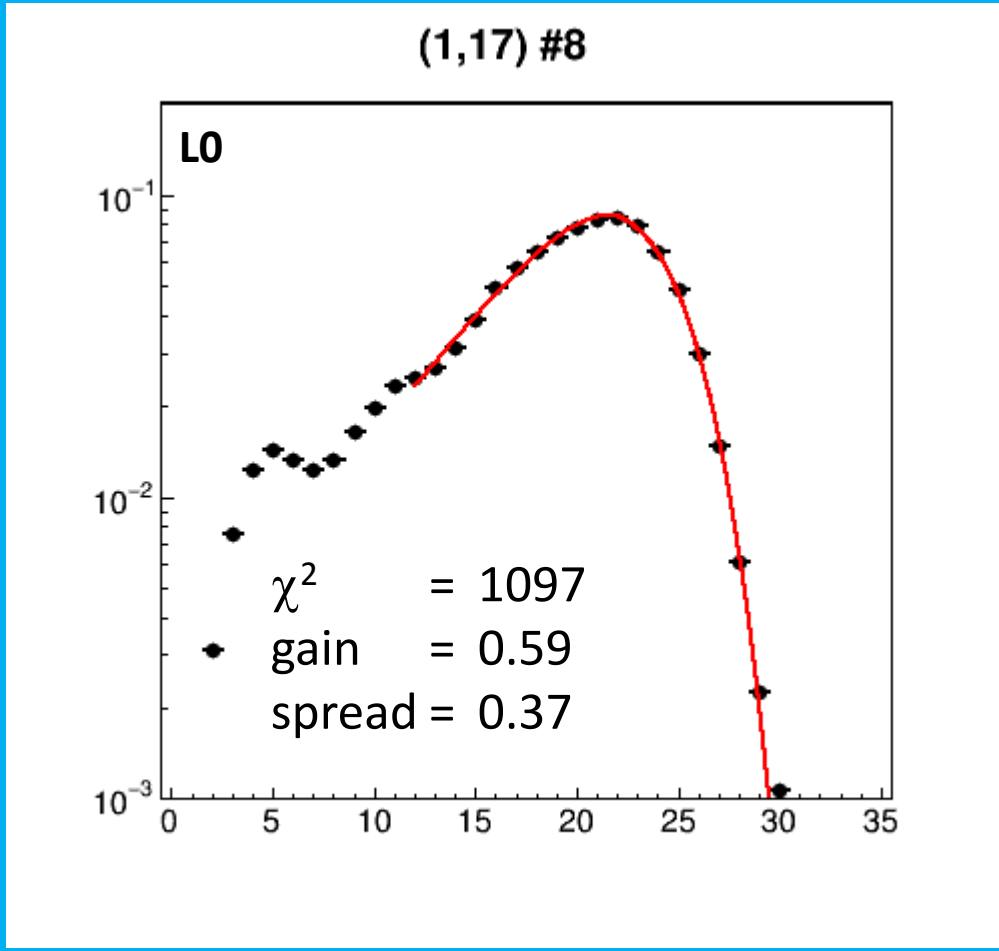
¶ KM3NeT_00000014_00005009.root

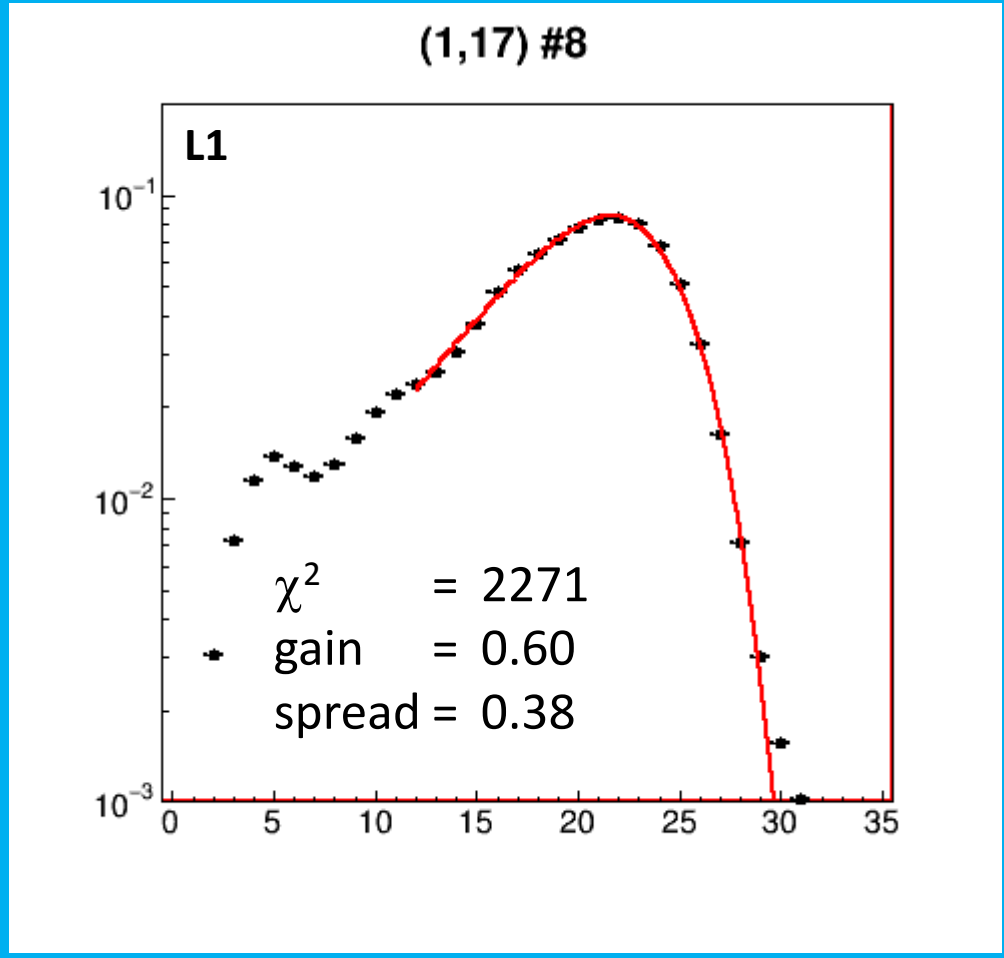
Comparison L0 – L1 data (1/3)



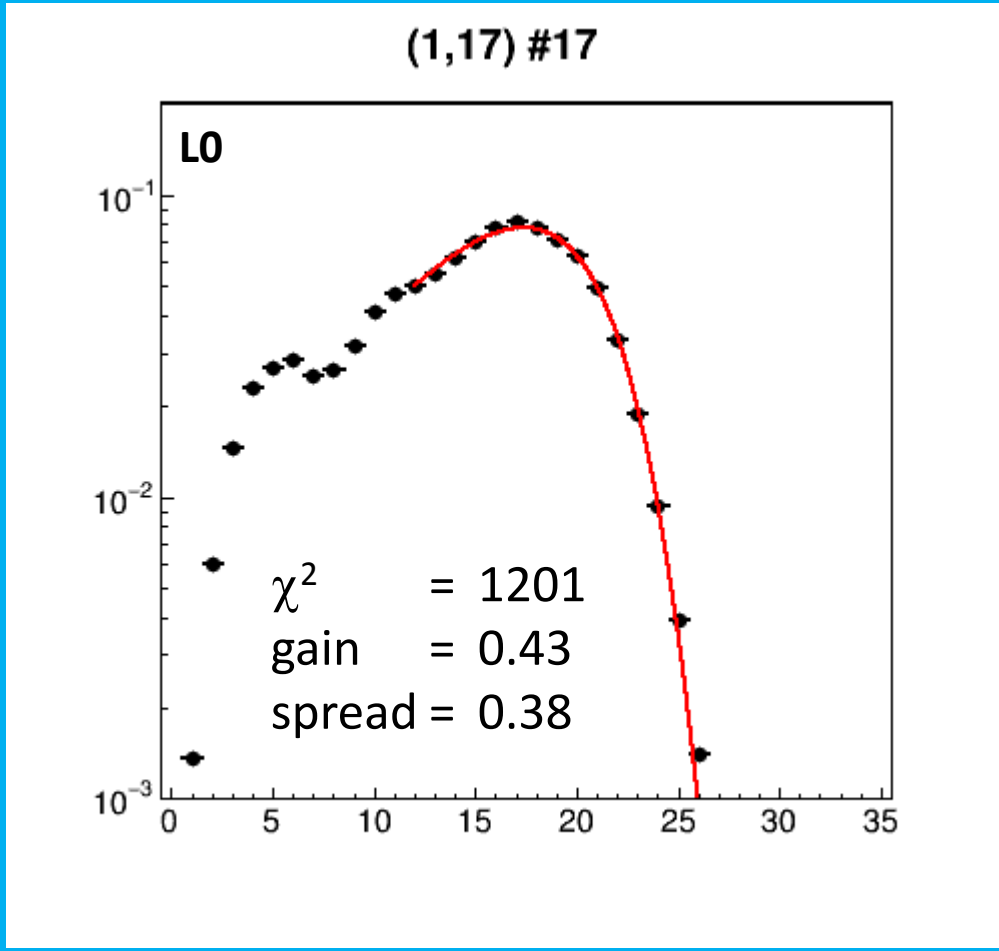


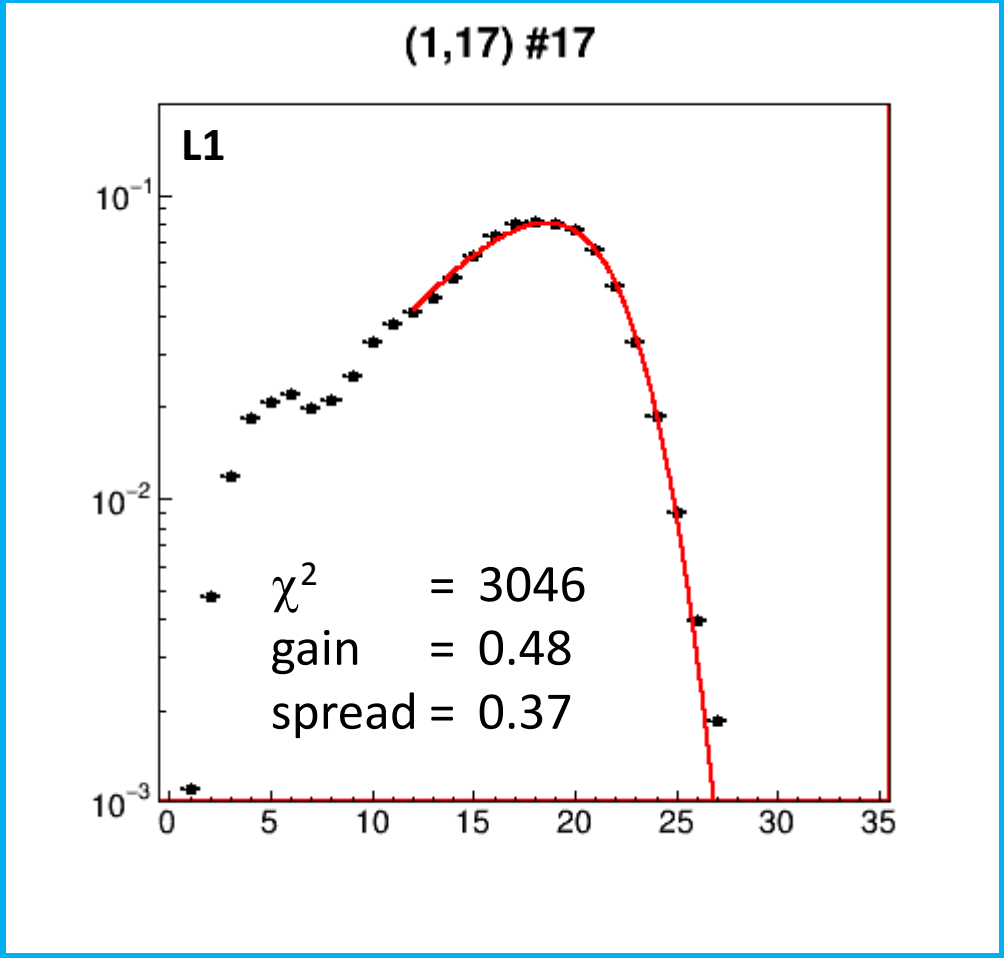
Comparison L0 – L1 data (2/3)





Comparison L0 – L1 data (3/3)





Backward compatibility (1/2)

- ✓ New model has less parameters than old model
  - QE; gain; gain spread; rise time; TTS; threshold; ~~offset;~~ slope; ~~curvature;~~ and saturation

- ✓ I/O of model parameters backward compatible (PMT efficiency file)
  - QE; gain; gain spread; rise time; TTS and threshold

Backward compatibility (2/2)

- Some parameters of new model should have different values[¶]
  - threshold ~ 0.3 pe
  - rise time ~ 8.5 ns

- Future proofness
  A. convert existing files by hand[§]
  B. overwrite threshold and rise time upon reading file

[¶] Rise times in current PMT files exceeds maximal value.
[§] Tool could be provided.

Summary & Outlook (1/2)

- ARCA2 data were taken with too low HVs on various PMTs
  - causes a deficiency, most notably culprit(s) in analysis of depth dependence of atmospheric muons
- To measure gain [and gain spread] of PMT,
  one needs to model time-over-threshold distribution
  - new model seems to reliably work for any gain
  - can be applied to L0 as well as L1 data

Summary & Outlook (2/2)

- Next steps (in this order)
  1. implement the new model as default in Jpp
  2. tune common parameters (threshold, rise time and fit range)
  3. test fits on large number of PMTs and runs (à la QE fits)
  4. measure gain per PMT (new)
  5. re-measure QE per PMT (as before, but will yield different values)
  6. simulate detector response (JTriggerEfficiency)
  7. redo data – Monte Carlo comparisons