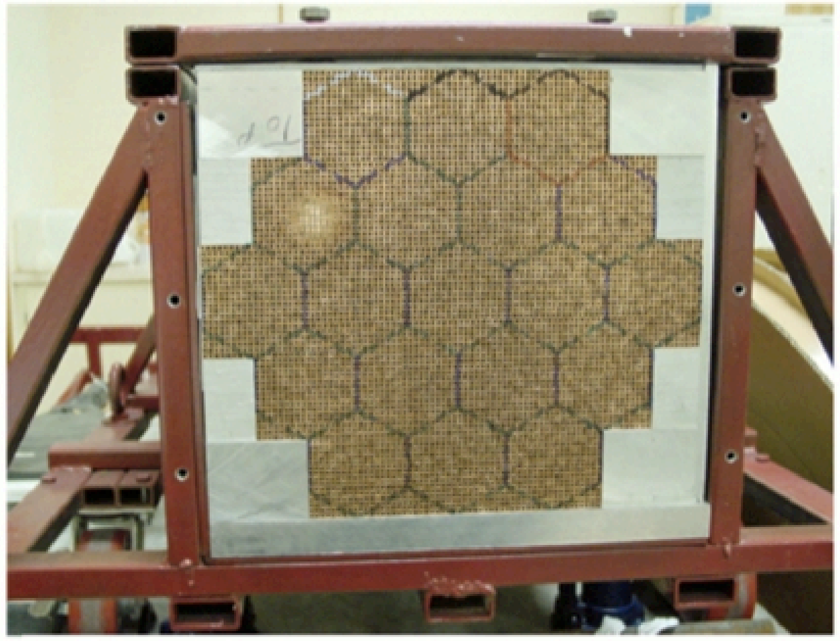
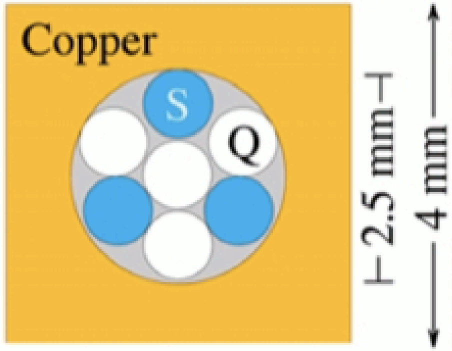
Estimate of neutrons event-by-event in DREAM

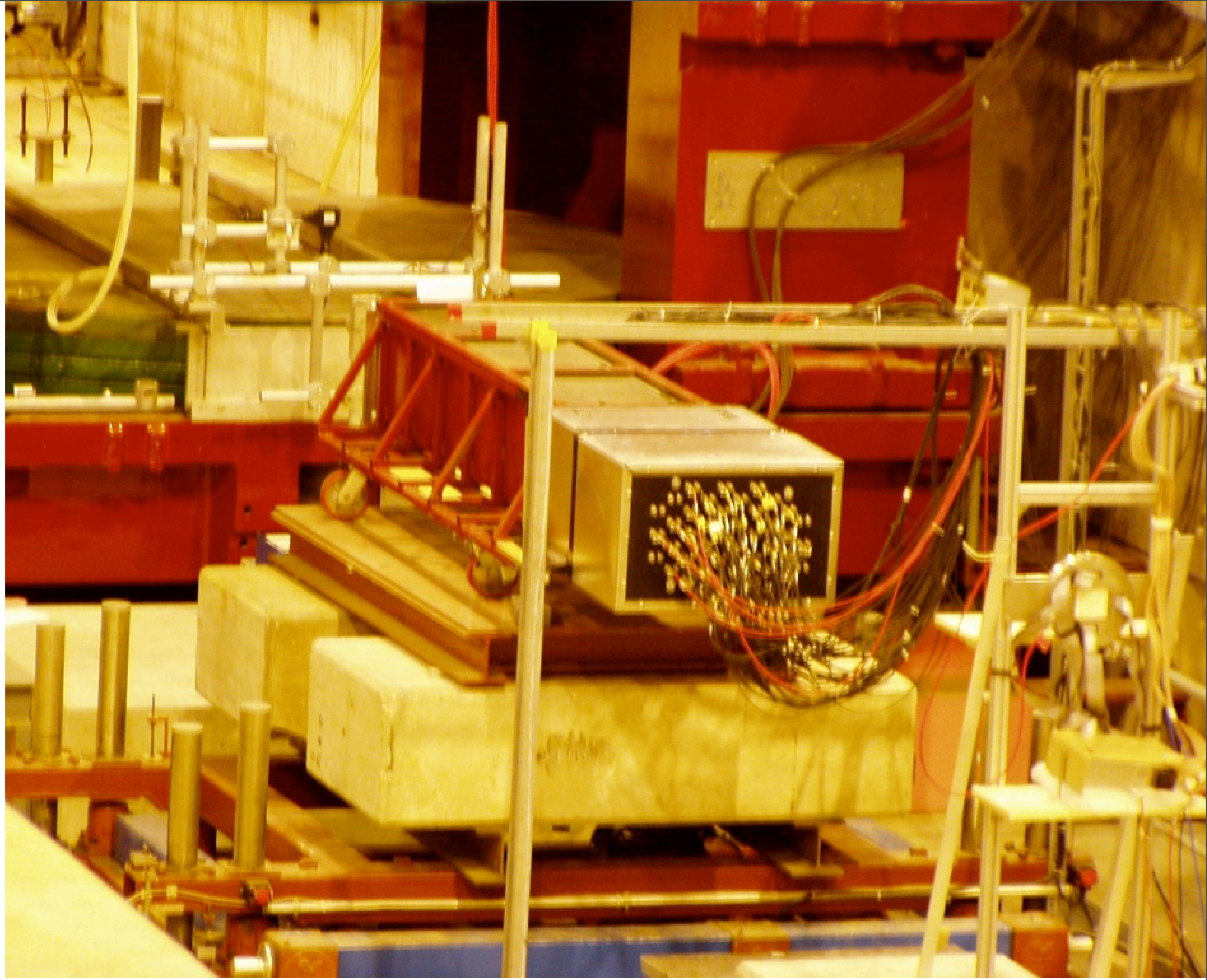
Pavia, CALOR08, 24-28 May 2008
John Hauptman, for the DREAM Collaboration

- The DREAM module was designed as a proof-of-principle module to test the idea of dual-readout as a means to suppress the large EM fluctuations in hadronic showers. It worked.
- The next largest are the binding energy loss fluctuations, and these can be estimated by measuring the MeV neutrons liberated in shower development.
- We have modified the DREAM module, measured these neutrons, and estimated the effect of these fluctuations on hadronic energy measurement.
- Improvements in these techniques are planned.

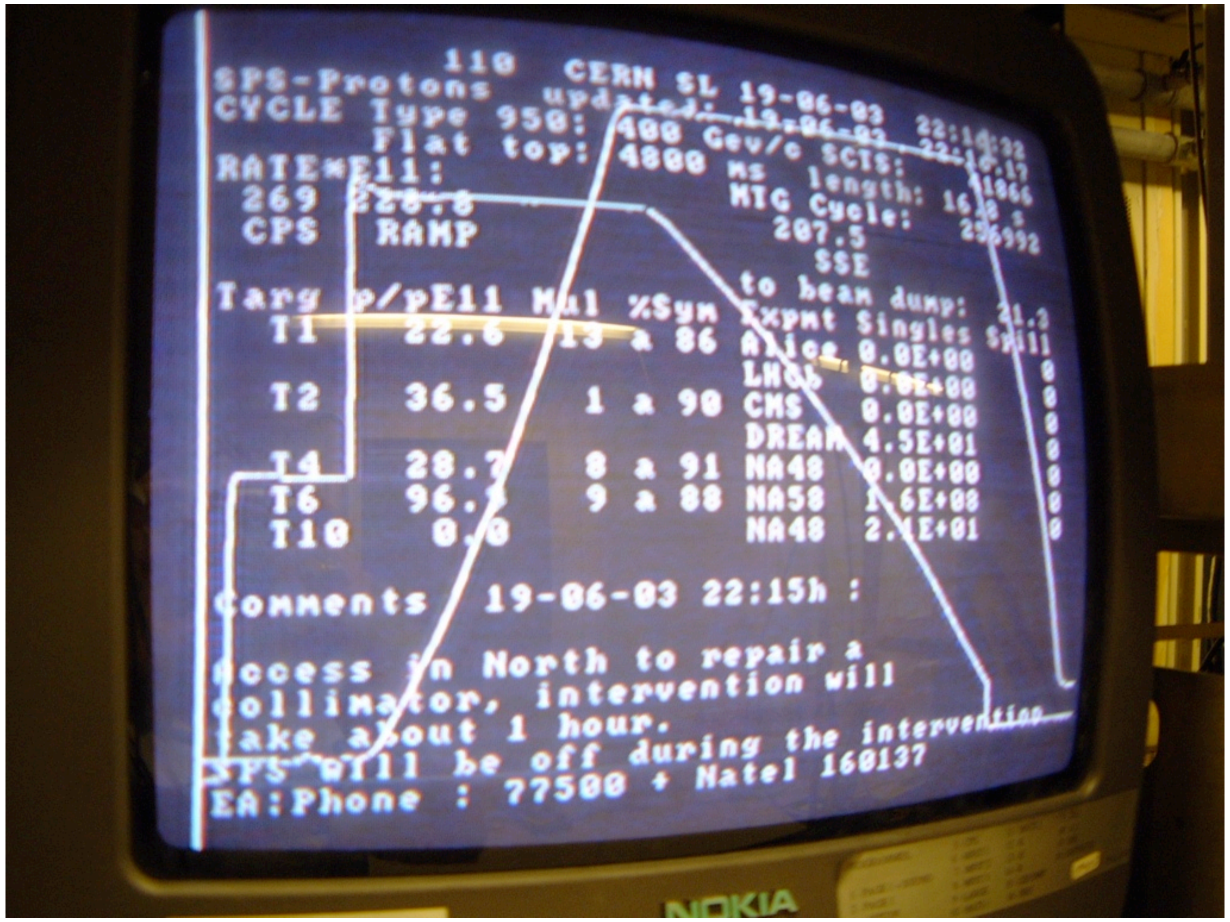
Dual-readout DREAM: Structure







- *Some characteristics of the DREAM detector*
  - Depth 200 cm (10.0 λ_{int})
  - Effective radius 16.2 cm (0.81 λ_{int}, 8.0 ρ_M)
  - Mass instrumented volume 1030 kg
  - Number of fibers 35910, diameter 0.8 mm, total length ≈ 90 km
  - Hexagonal towers (19), each read out by 2 PMTs



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            110   CERN SL 19-06-03
SPS-Protons   updated: 19-06-03   22:14:32
CYCLE Type 950: 400 Gev/c SCTS:   22:16:17
         Flat top: 4800 ms  length:   11866
RATE*E11:                MTG Cycle: 16.8 s
 269 228.8                207.5     236992
 CPS  RAMP                  SSE
                      to beam dump:   21.2
Targ p/pE11 Mul %Sym Expmt Singles Spill
 T1   22.6  13 a 86 Alice 0.0E+00     0
                    LHCb  0.0E+00     0
 T2   36.5   1 a 90 CMS   0.0E+00     0
                    DREAM 4.5E+01     0
 T4   28.7   8 a 91 NA48  0.0E+00     0
 T6   96.3   9 a 88 NA58  1.6E+08     0
 T10   0.0          NA48  2.1E+01     0

Comments   19-06-03 22:15h :

Access in North to repair a
collimator, intervention will
take about 1 hour.
SPS will be off during the intervention
EA:Phone : 77500 + Natel 160137
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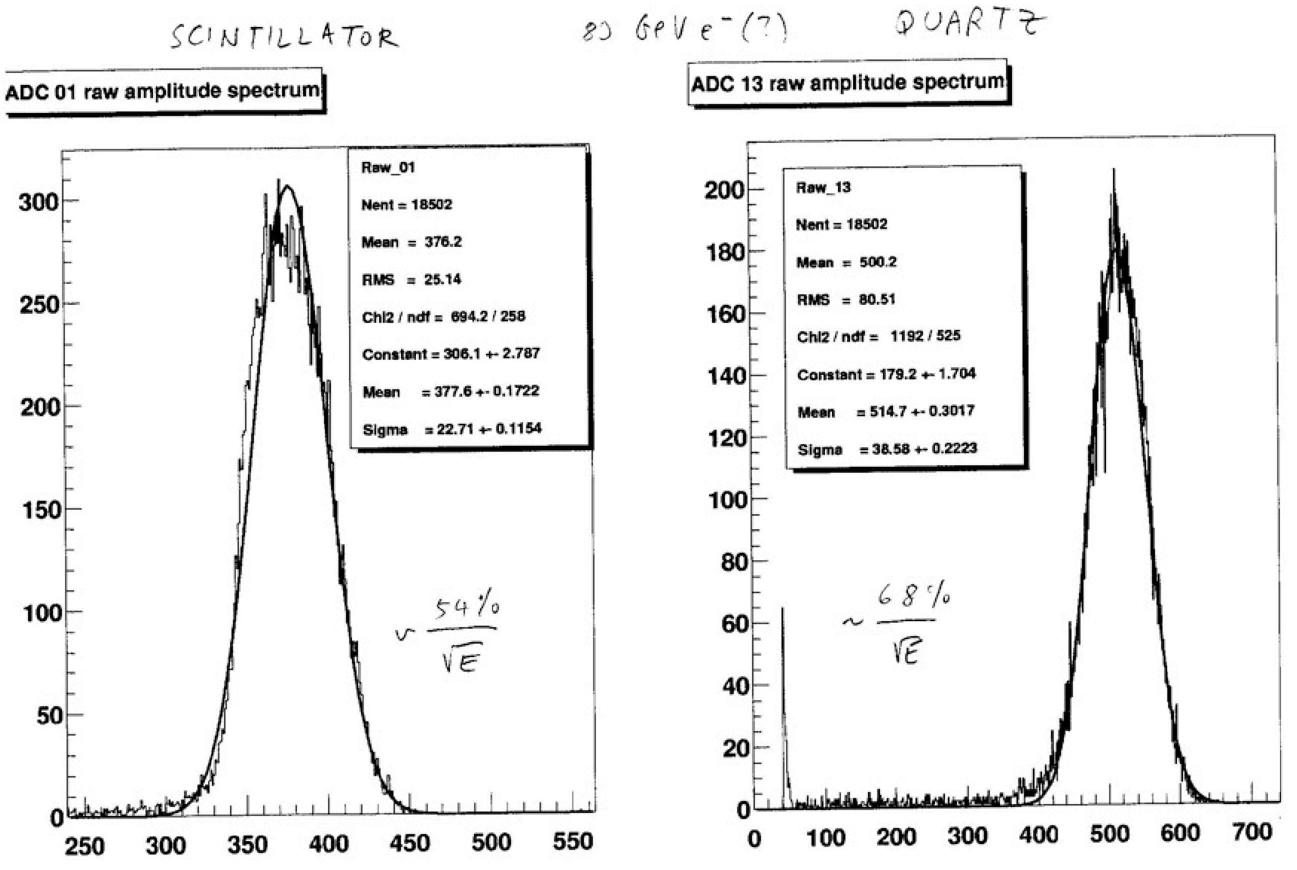
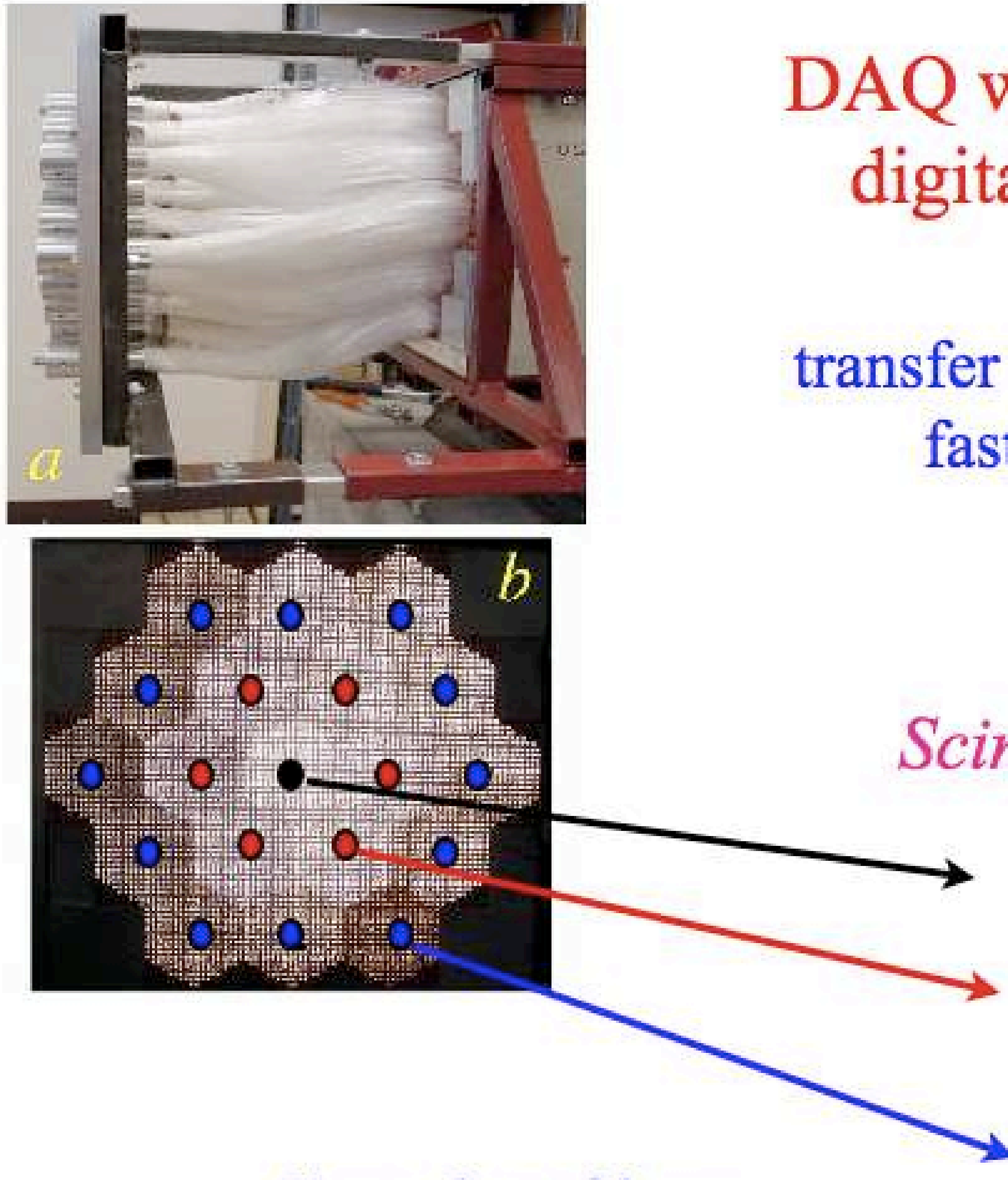


DREAM beam test summer '07

Reconfigure DREAM module to sum nearly the entire volume into three scintillation and one Cerenkov channel. Deliver these to a fast oscilloscope.

DAQ was 1 GHz 4-chan digital storage scope

transfer to counting house in fast air-core cables



Scintillating fibers

"Fast 1"

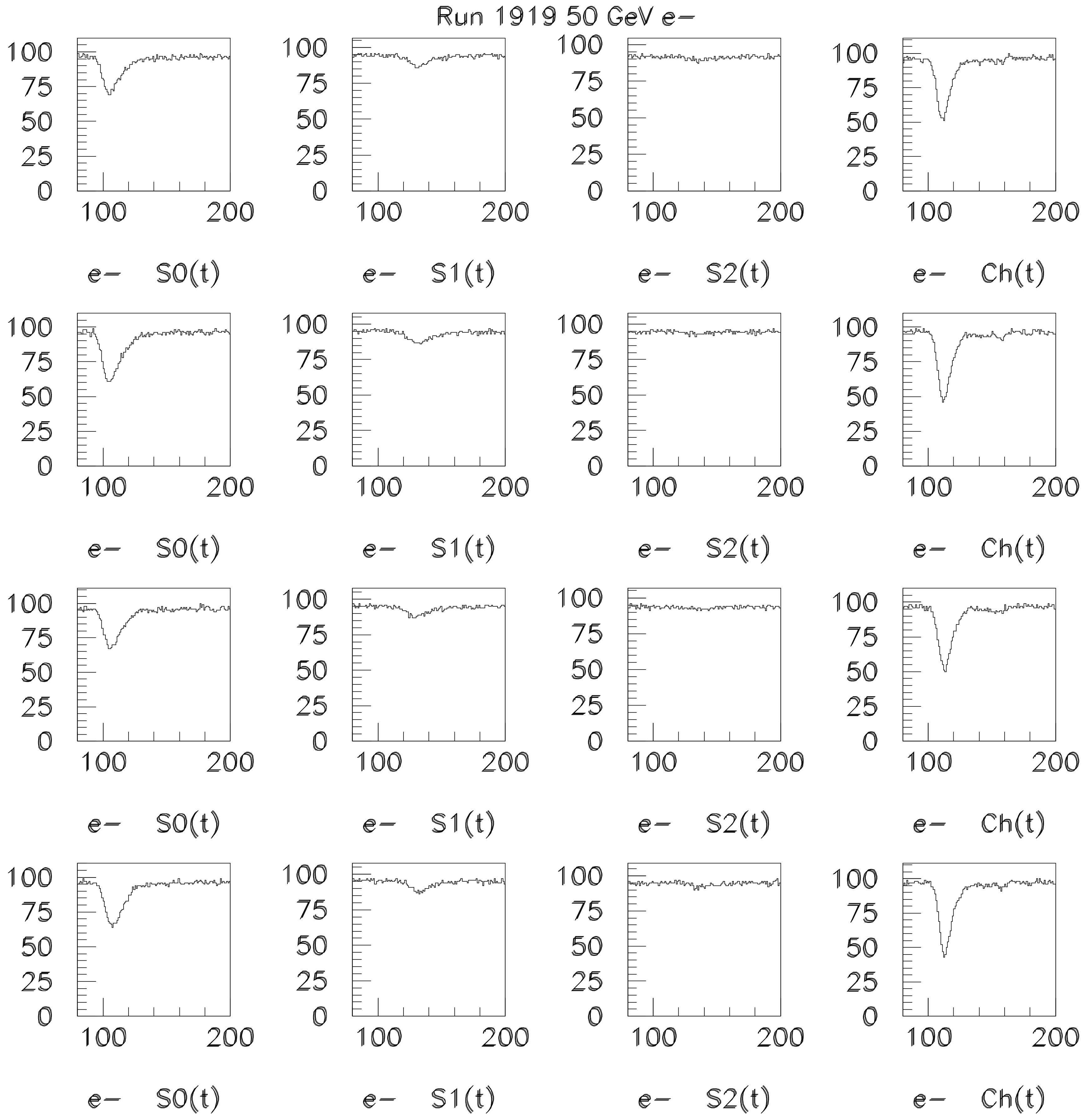
"Fast 2"

"Fast 3"

Cerenkov fibers

1● + 6● + 9● → "Fast 4"

Fast-1 Fast-2 Fast-3 Fast-4



50 GeV e-
data events

event #1

event #2

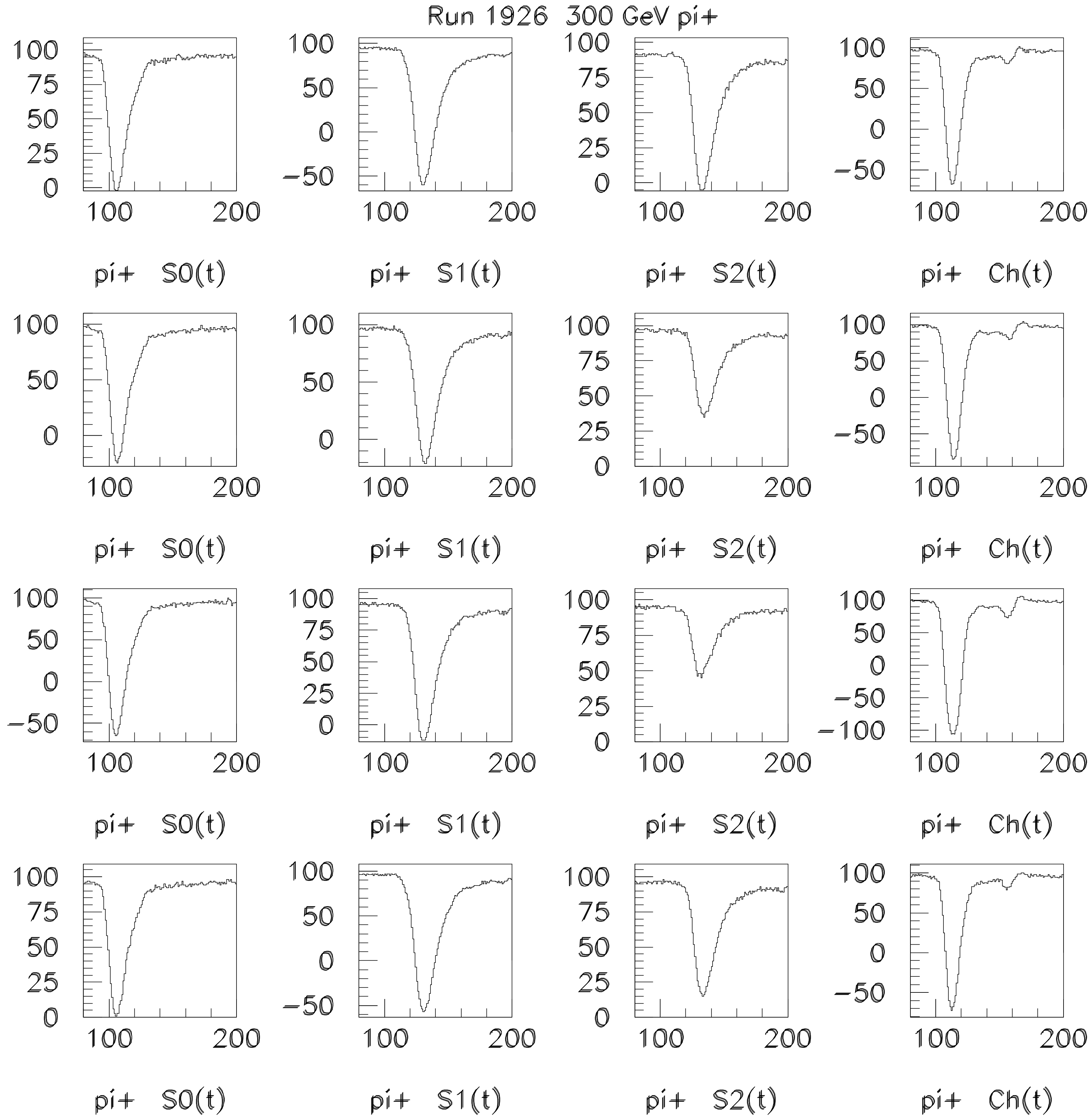
event #3

event #4

(clearly electrons)

300 GeV pi- data events

Fast-1 Fast-2 Fast-3 Fast-4



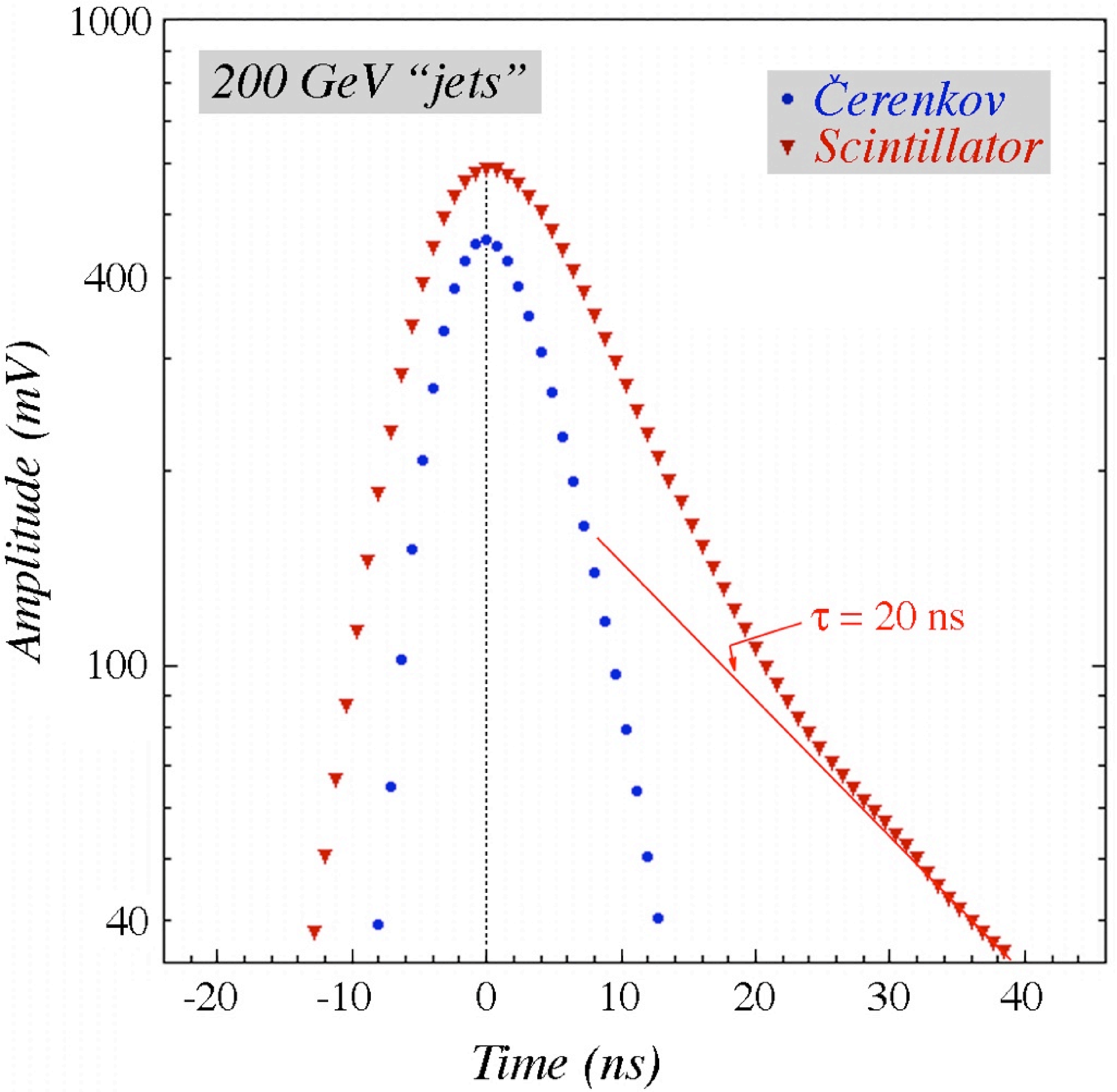
event #1

event #2

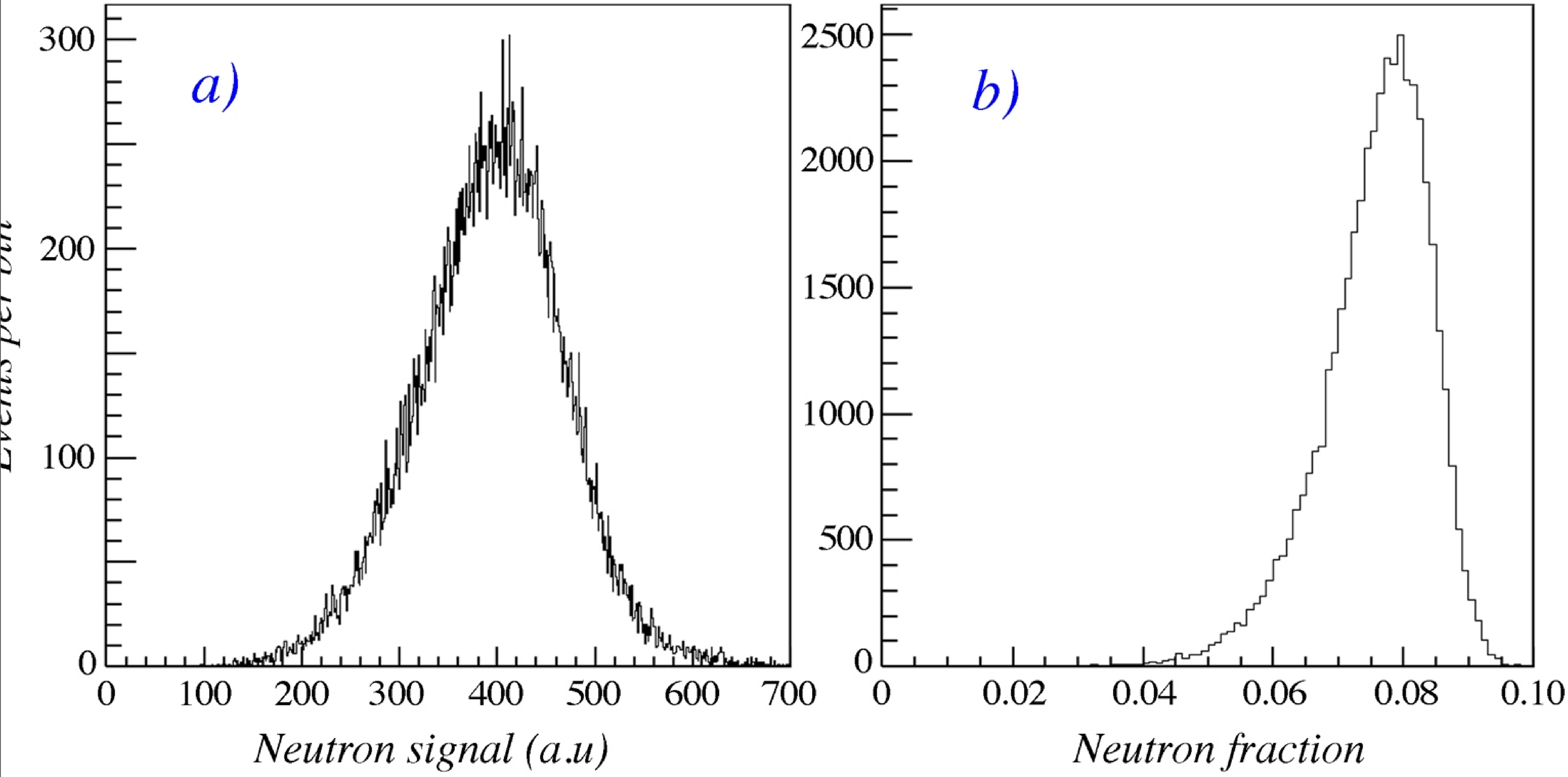
event #3

event #4

(clearly pions)

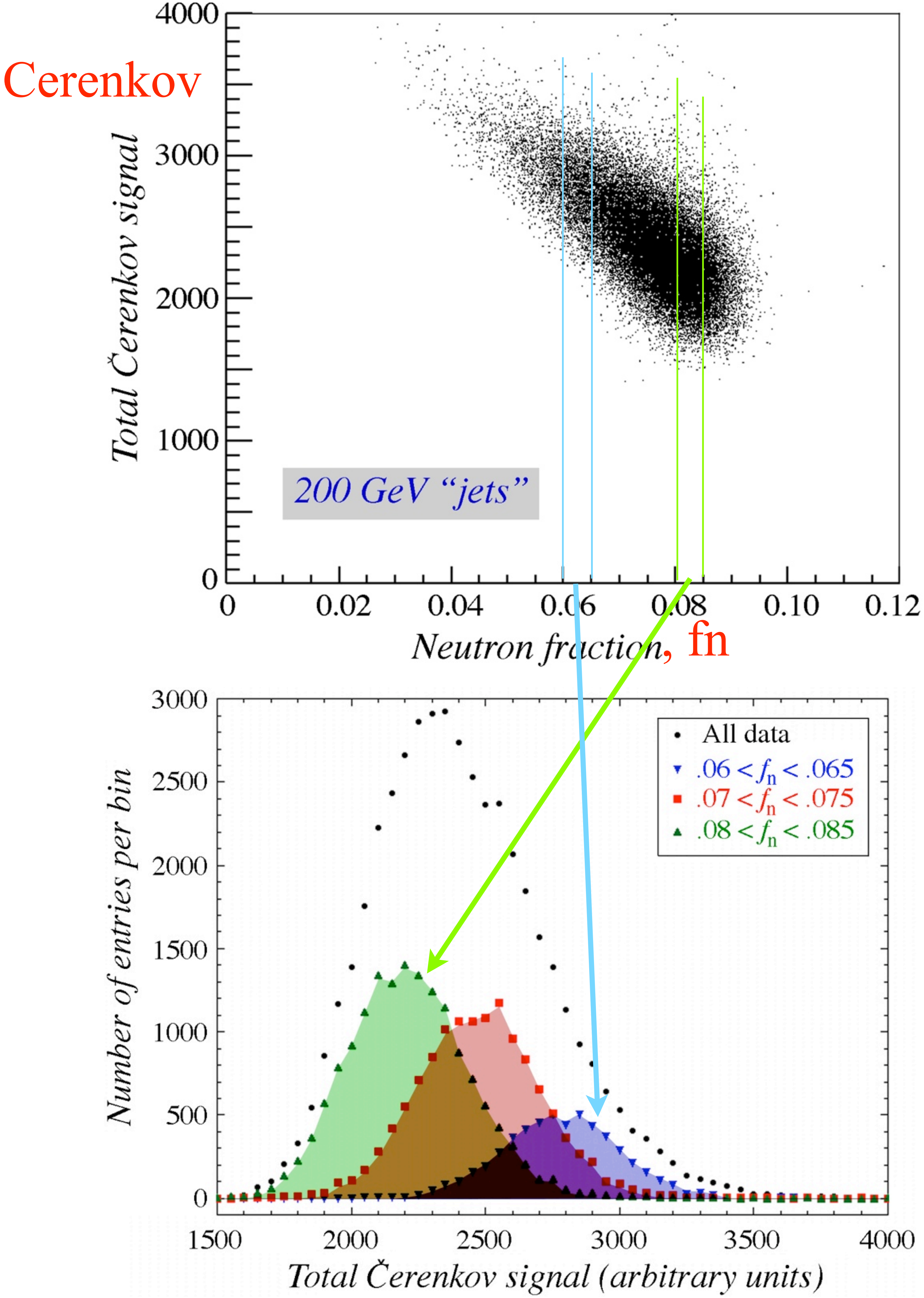


"neutron signal"
defined simply
as the integral of
the Scintillation
pulse over
20-40 ns



fn = En (EM energy units) / 200 GeV

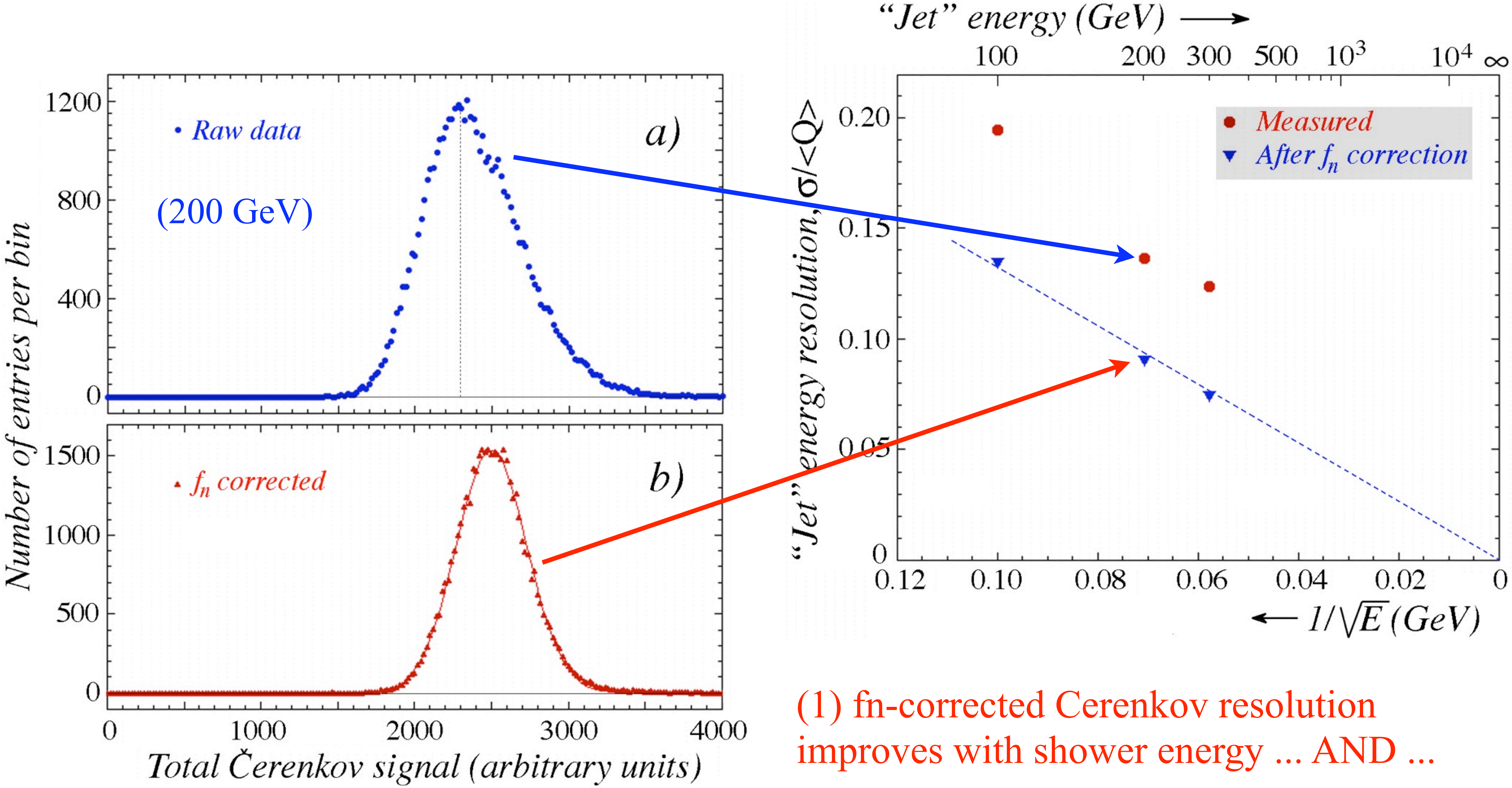
The neutron fraction is anti-correlated with the Cerenkov signal - as expected



More interestingly, the total Cerenkov distribution can be decomposed into its constituent parts as a function of fn.

This is the analog to the same plot decomposed into fEM parts.

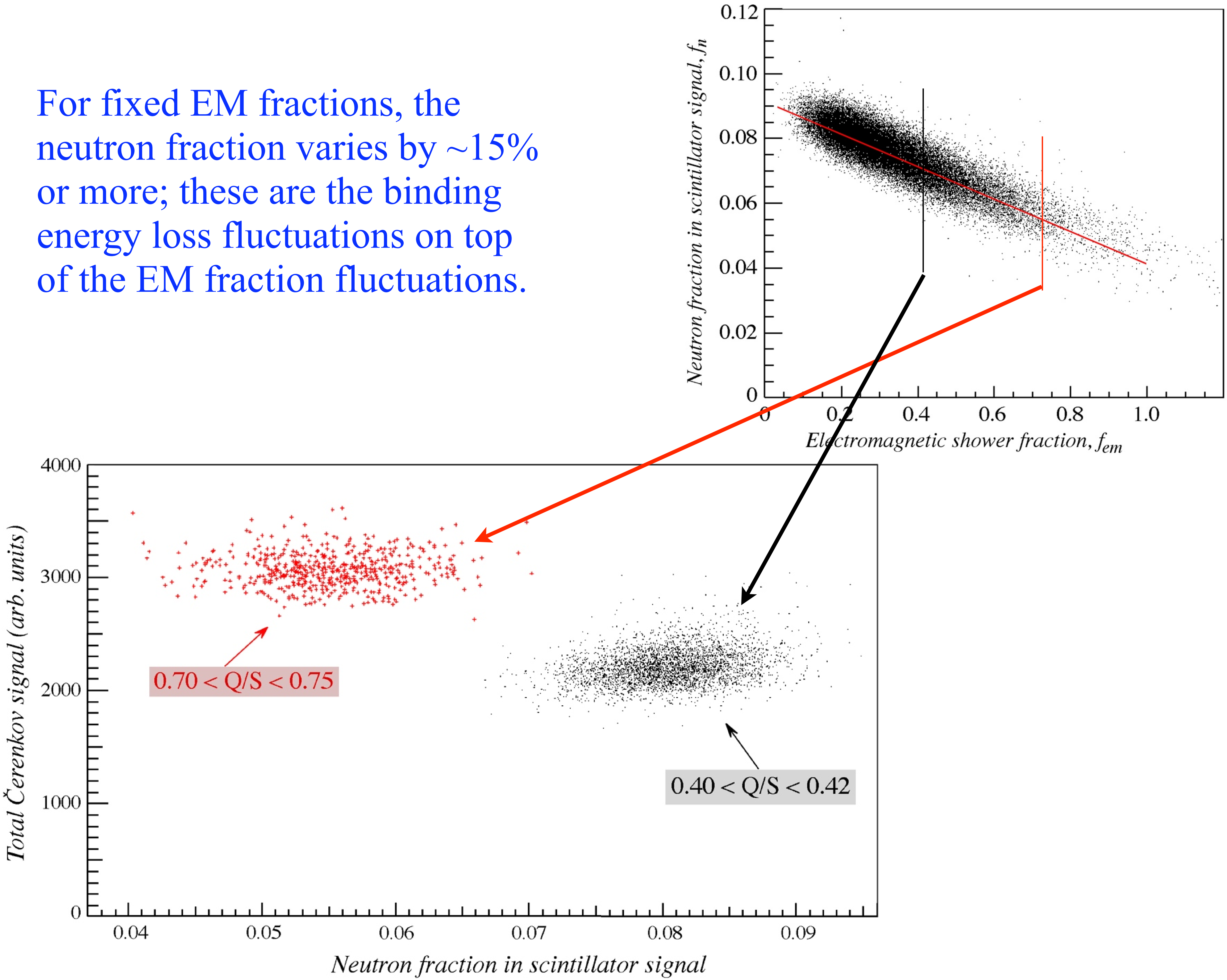
Linearly correcting each Cerenkov distribution in an fn bin to fn=0.07 (arbitrary, middle value) results in the "fn corrected" distribution



(1) fn-corrected Cerenkov resolution improves with shower energy ... AND ...

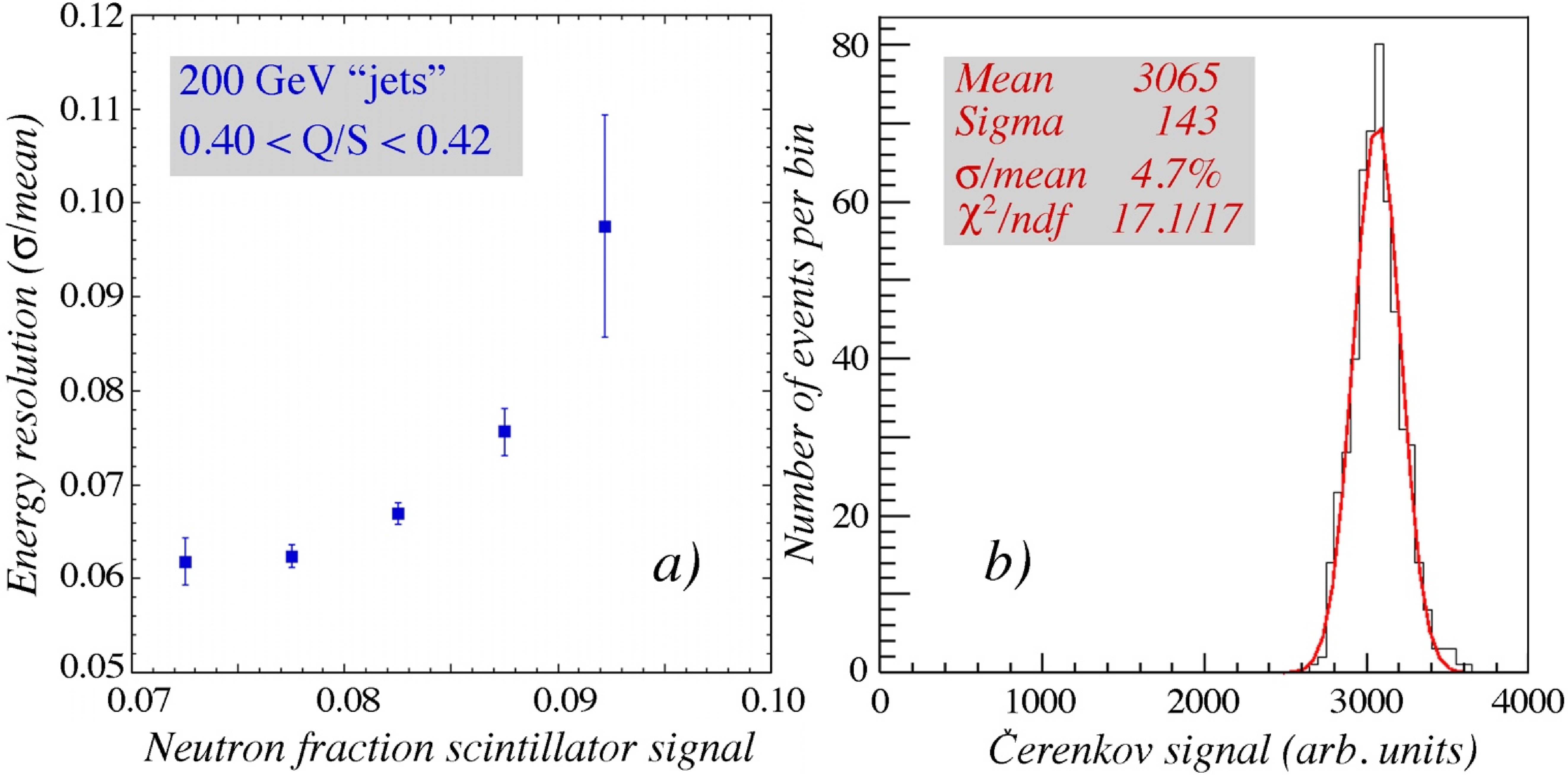
(2) Its dependence leaves no "constant term"

For fixed EM fractions, the neutron fraction varies by ~15% or more; these are the binding energy loss fluctuations on top of the EM fraction fluctuations.



For fixed EM fraction, the resolution in the Cerenkov signal worsens as the neutron fraction grows larger, and its fluctuations grow larger.

For fixed EM fraction ~0.55 and 0.045<fn<0.065, the resolution in Cerenkov signal is 4.7%. For a tighter fn, 0.050<fn<0.055, the resolution is 4.4%.



Note bene: leakage fluctuations in DREAM are ~4%.

Summary and plans for neutrons in DREAM

- This is a "first cut" analysis.
- The time history of every channel with the Domino Ring Sampler (DRS) will yield the best data we can expect from the DREAM module; this analysis will be repeated and further analyses done with new data next July-August.
- It is not yet clear what hadronic energy resolution we can achieve, but the "ultimate" resolution is about $15\%/\sqrt{E}$. Will it be 15% ... 20% ... 25% ... ?
- It will be *a pleasure* to be limited in a collider experiment by jet-finding, reconstruction, jet energy scale, and other confusions and systematics ... but not the hadronic calorimeter energy resolution!