

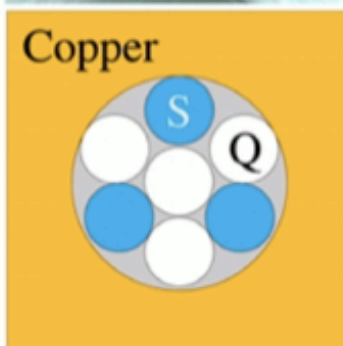
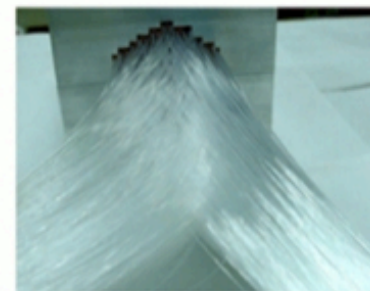
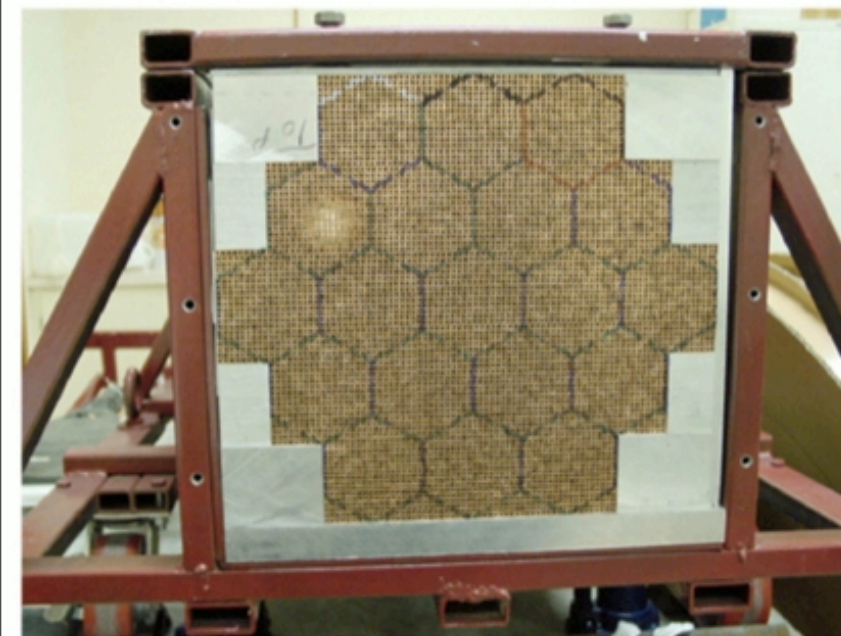
# Estimate of neutrons event-by-event in DREAM

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.



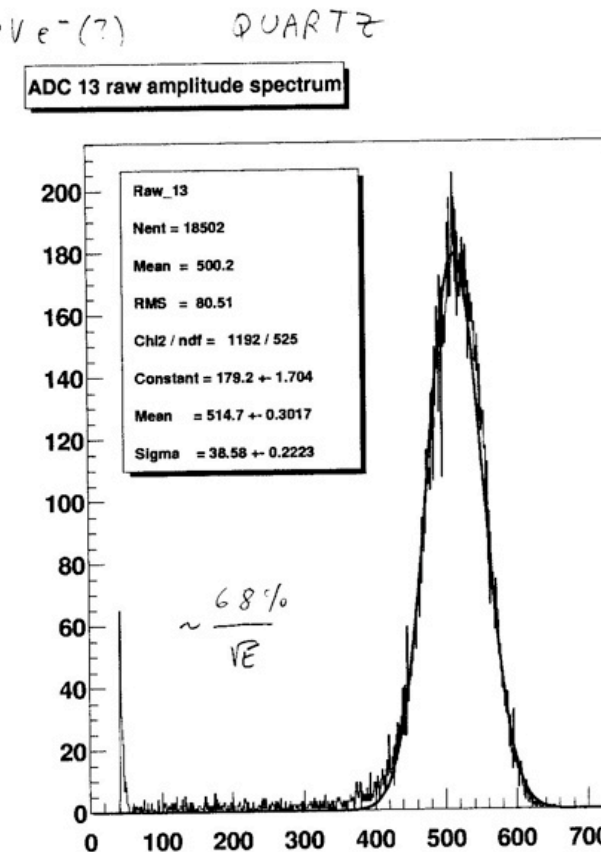
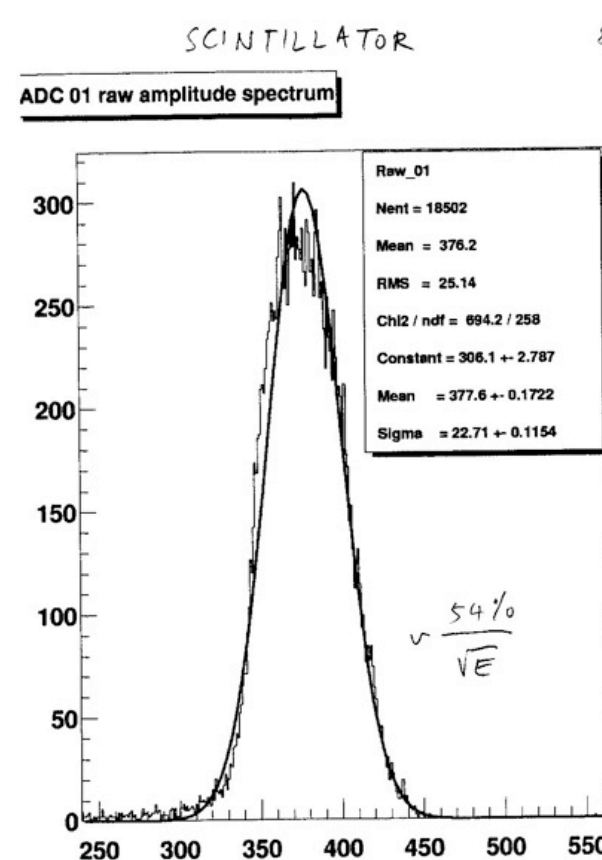
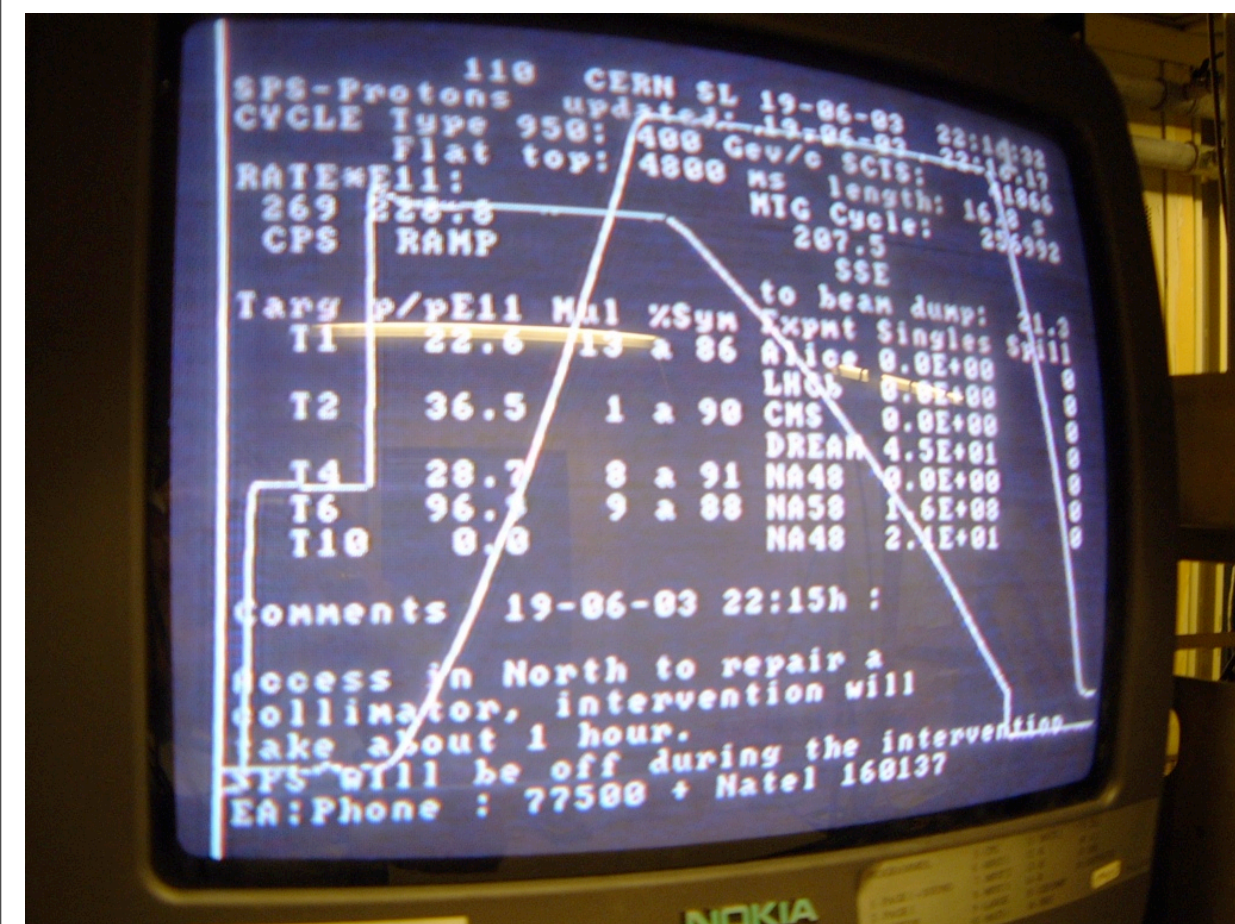
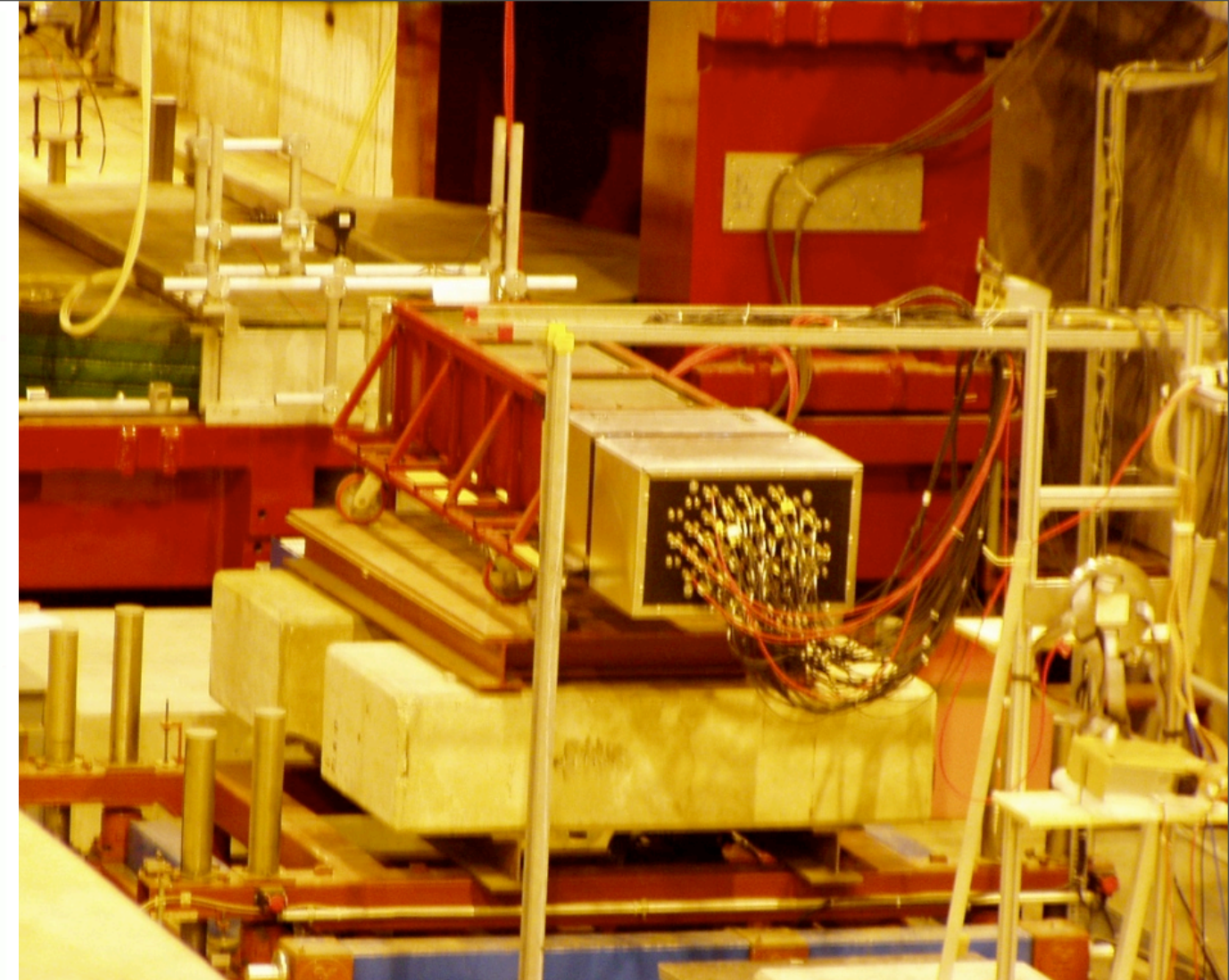
# Dual-readout DREAM: Structure



2.5 mm  
4 mm

## Some characteristics of the DREAM detector

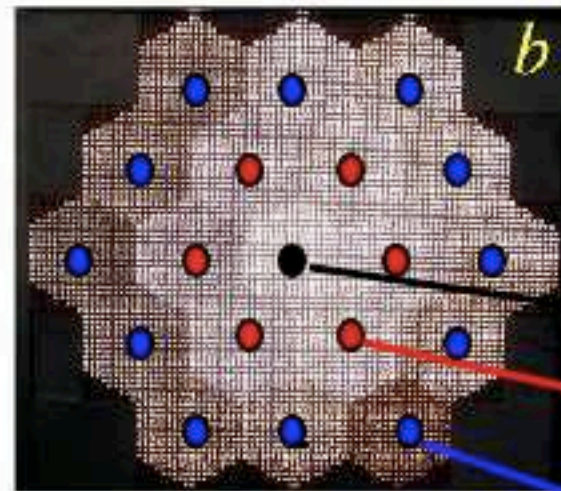
- **Depth** 200 cm ( $10.0 \lambda_{\text{int}}$ )
- Effective **radius** 16.2 cm ( $0.81 \lambda_{\text{int}}$ ,  $8.0 \rho_M$ )
- **Mass** instrumented volume 1030 kg
- Number of **fibers** 35910, diameter 0.8 mm, total length  $\approx 90$  km
- Hexagonal **towers** (19), each read out by 2 PMTs





# 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

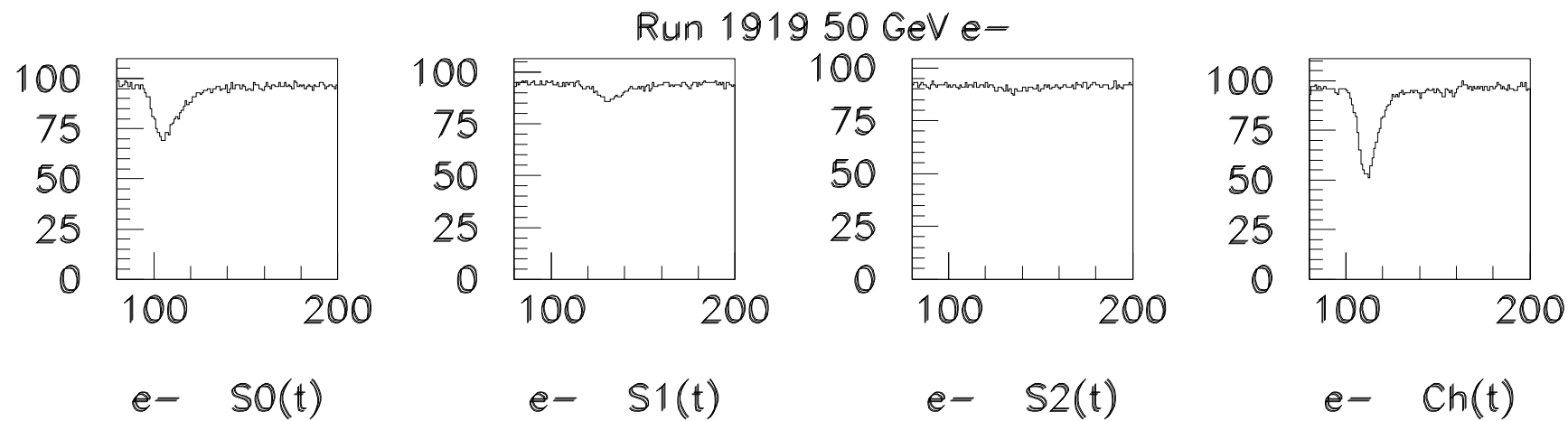
Fast-2

Fast-3

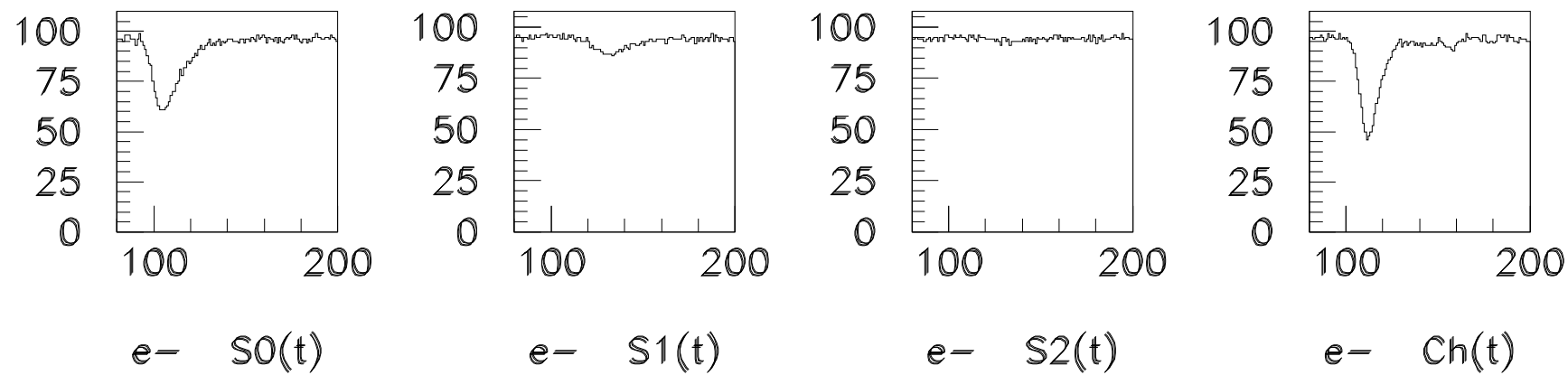
Fast-4

50 GeV e-  
data events

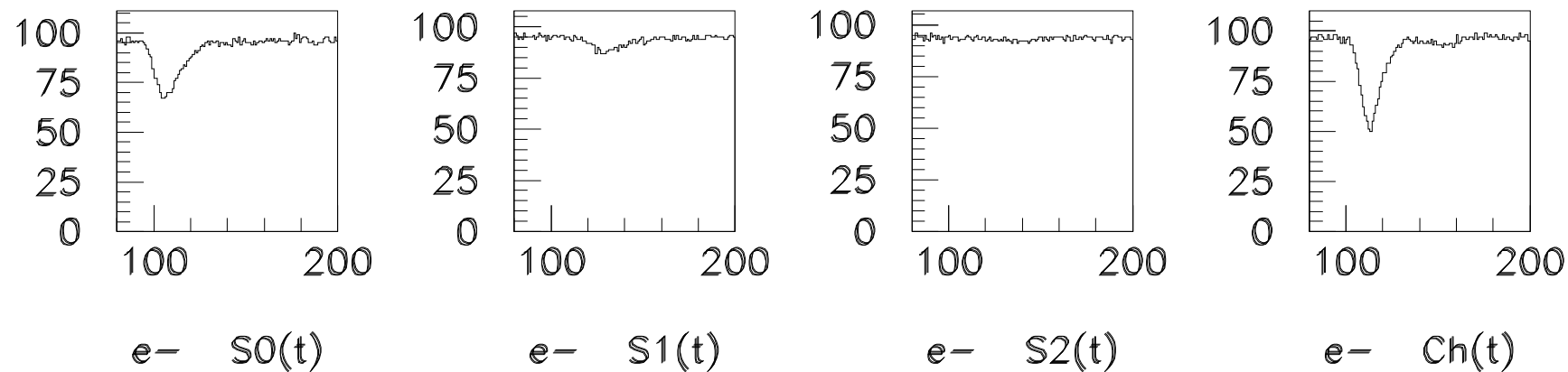
event #1



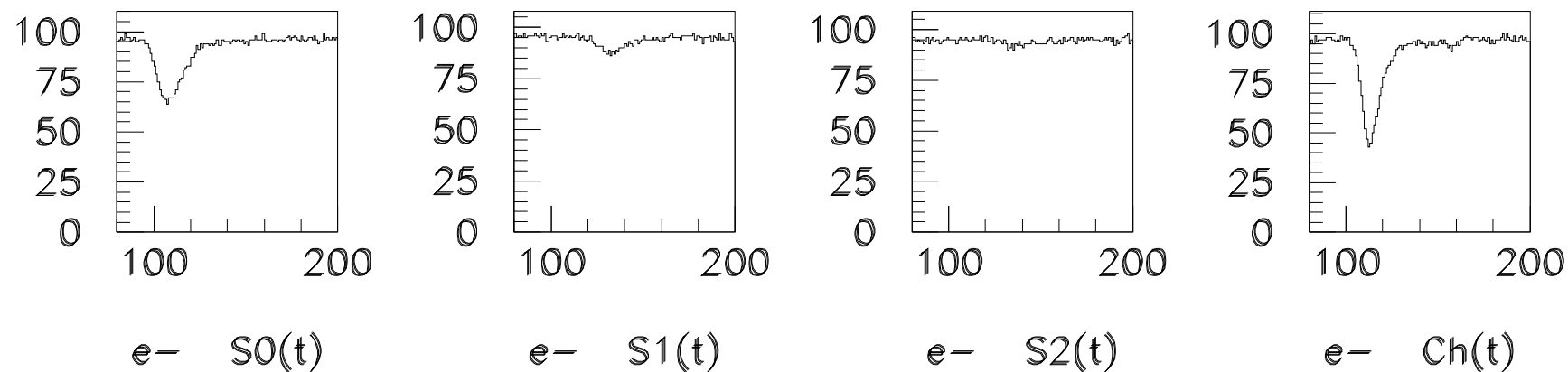
event #2



event #3



event #4



(clearly  
electrons)

Fast-1

Fast-2

Fast-3

Fast-4

300 GeV pi-  
data events

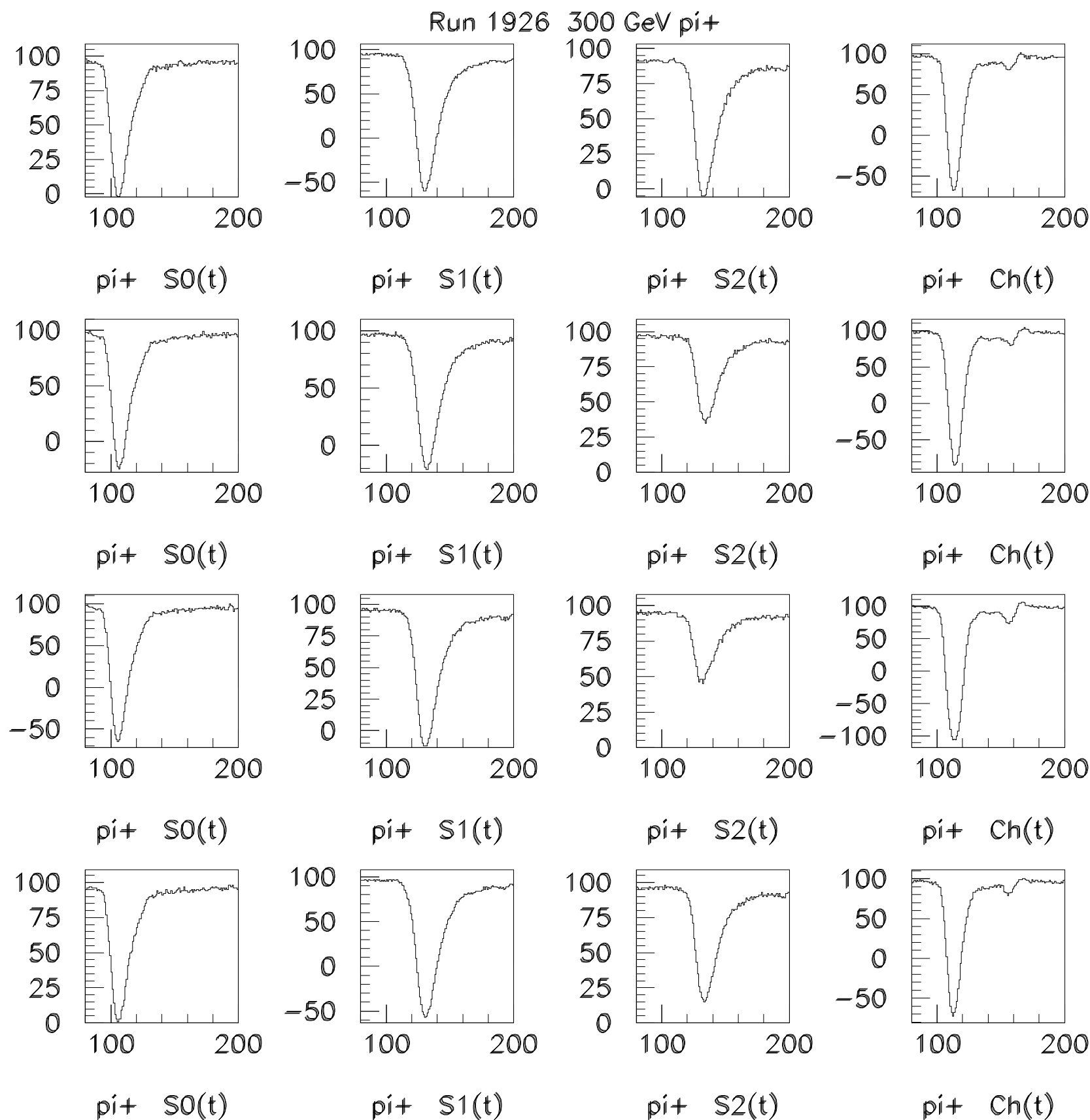
event #1

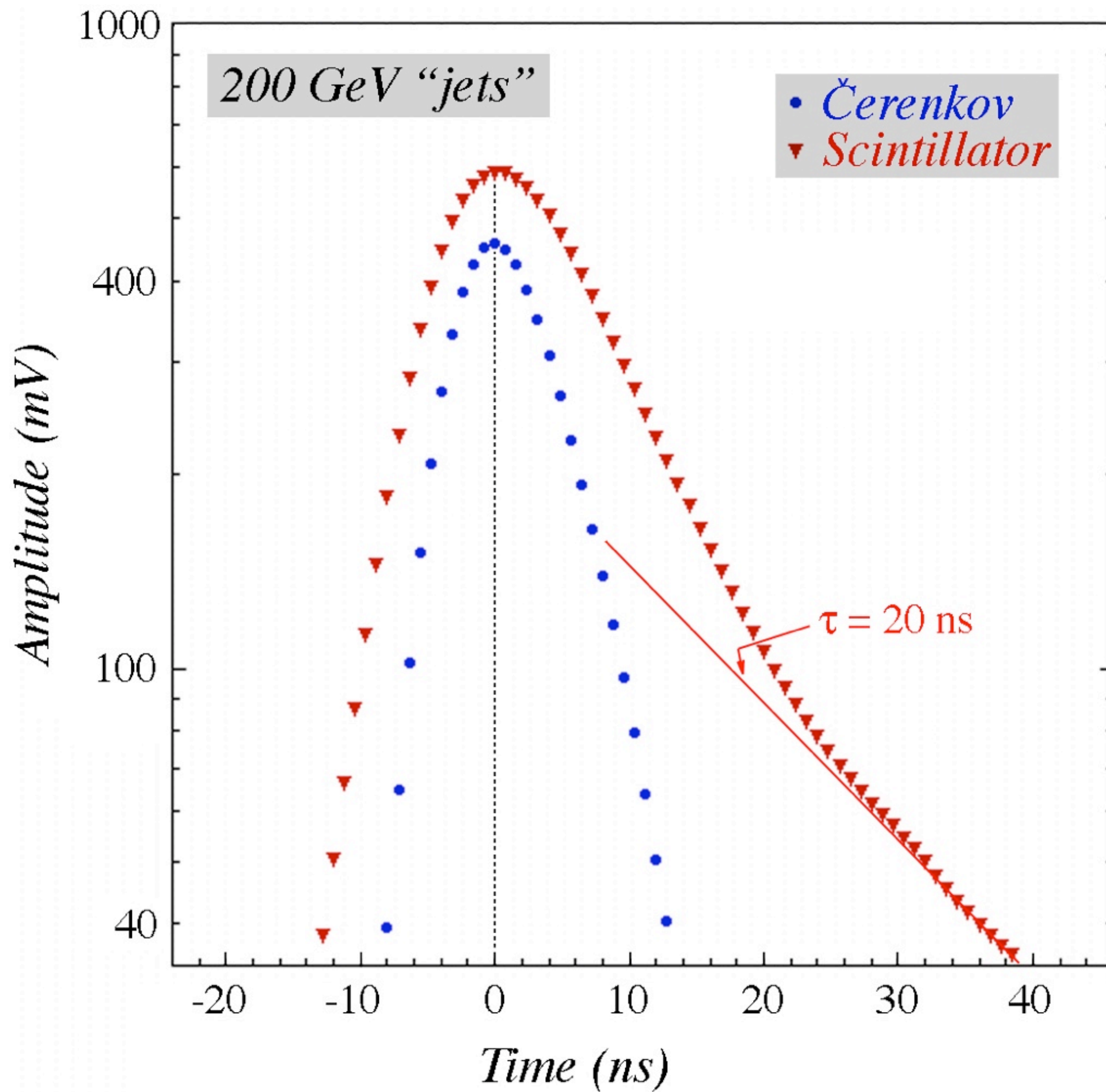
event #2

event #3

event #4

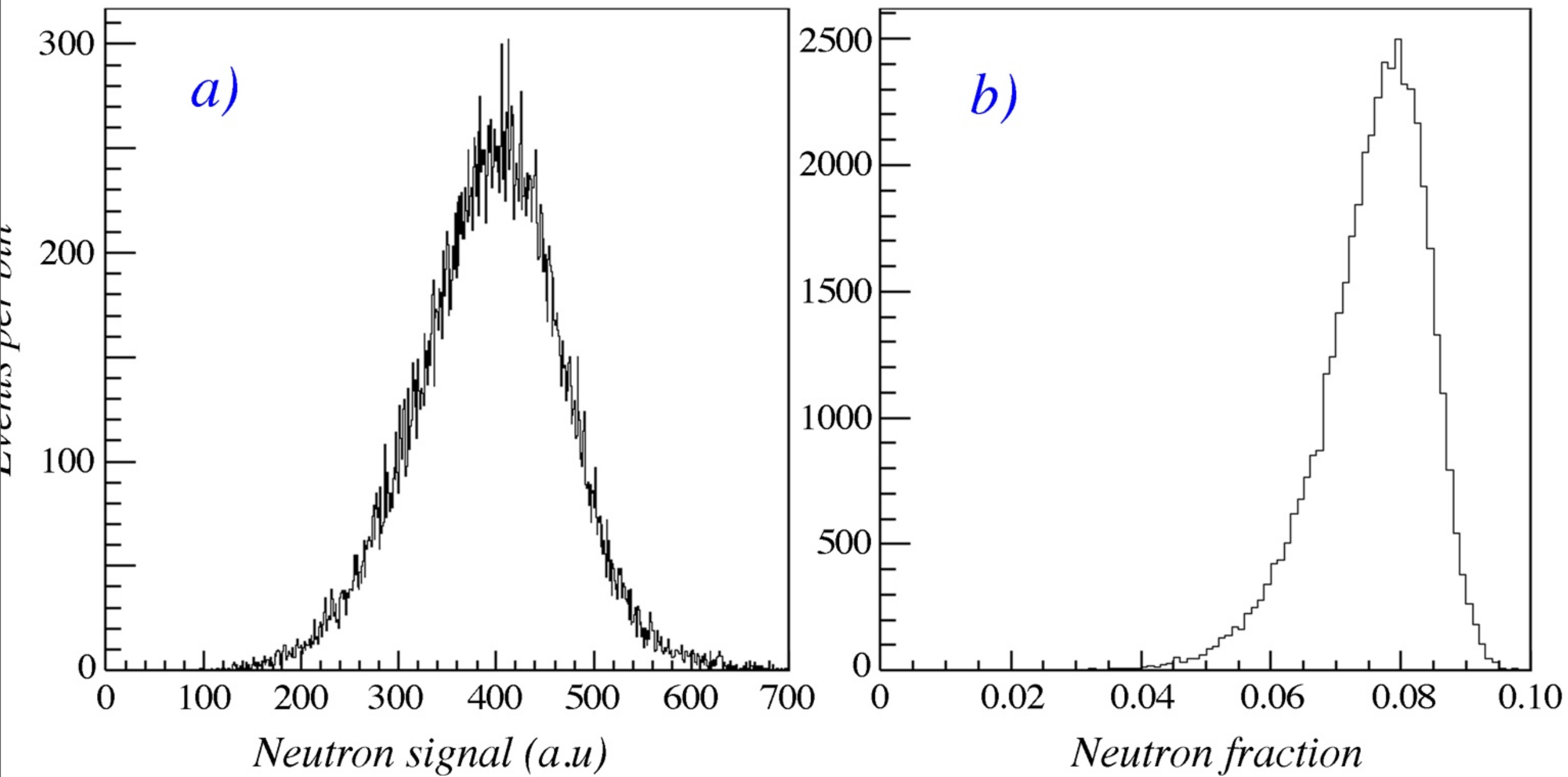
(clearly  
pions)





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



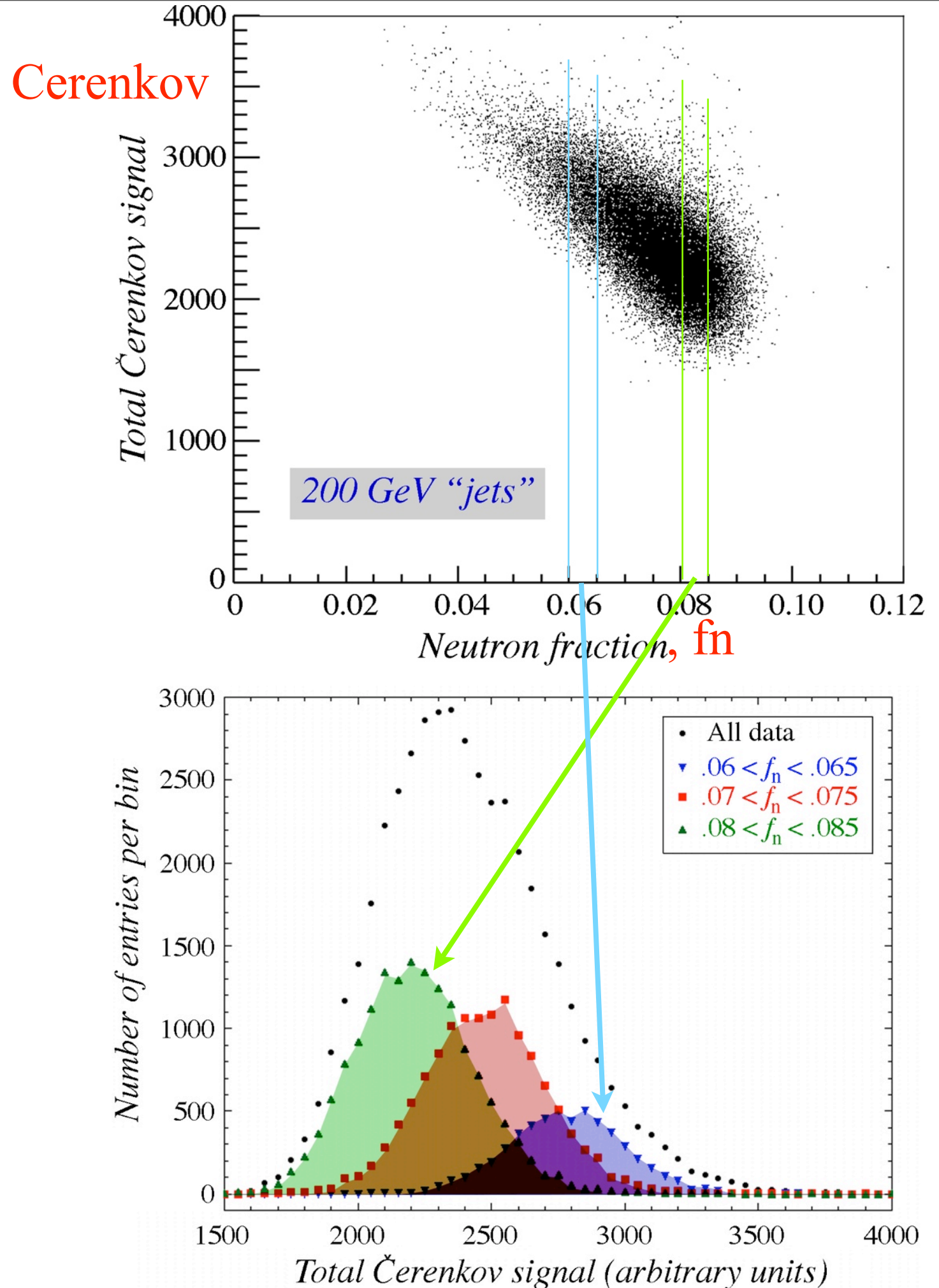


$$\text{fn} = E_n (\text{EM energy units}) / 200 \text{ GeV}$$

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

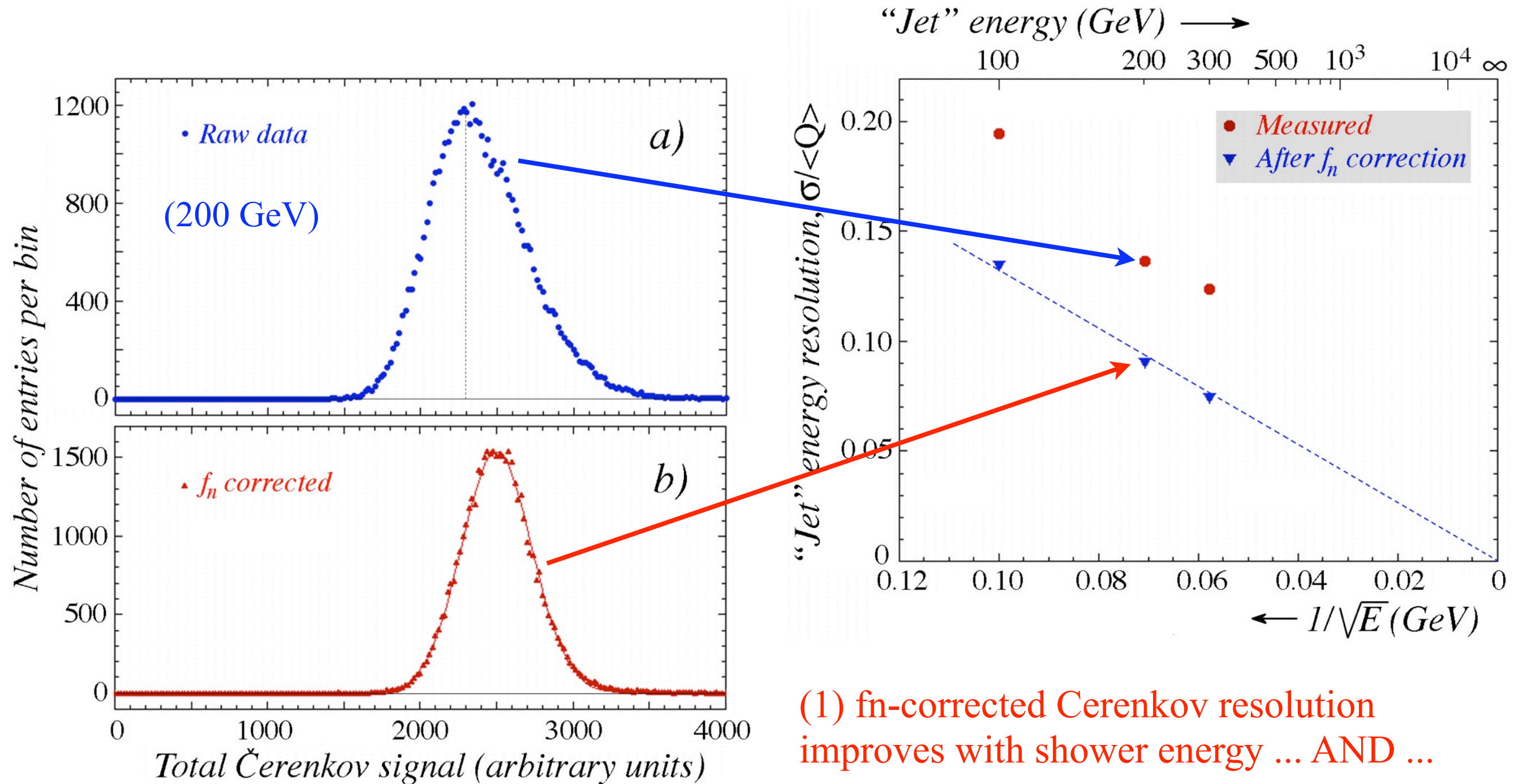
More interestingly, the total Cerenkov distribution can be decomposed into its constituent parts as a function of  $f_n$ .

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





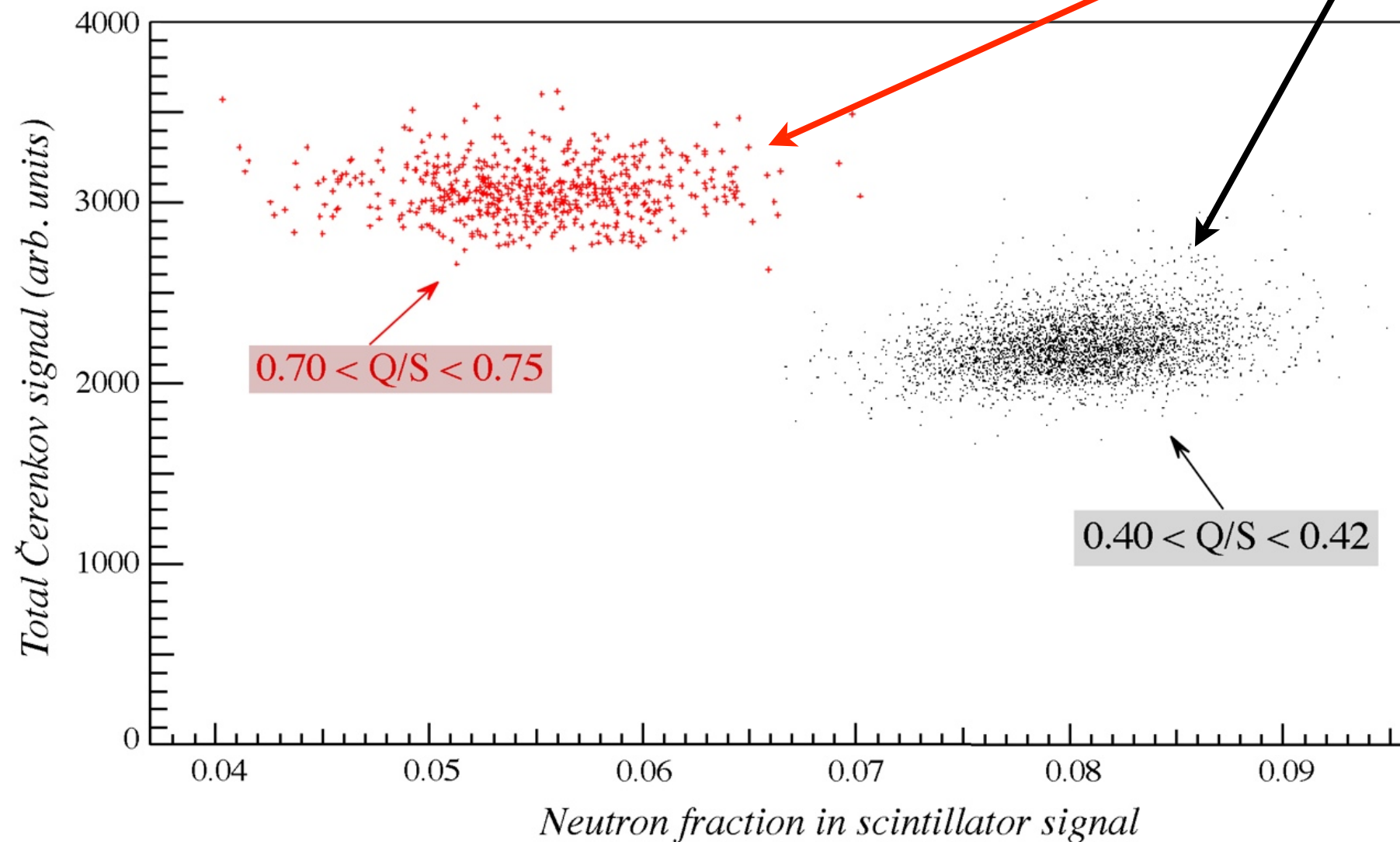
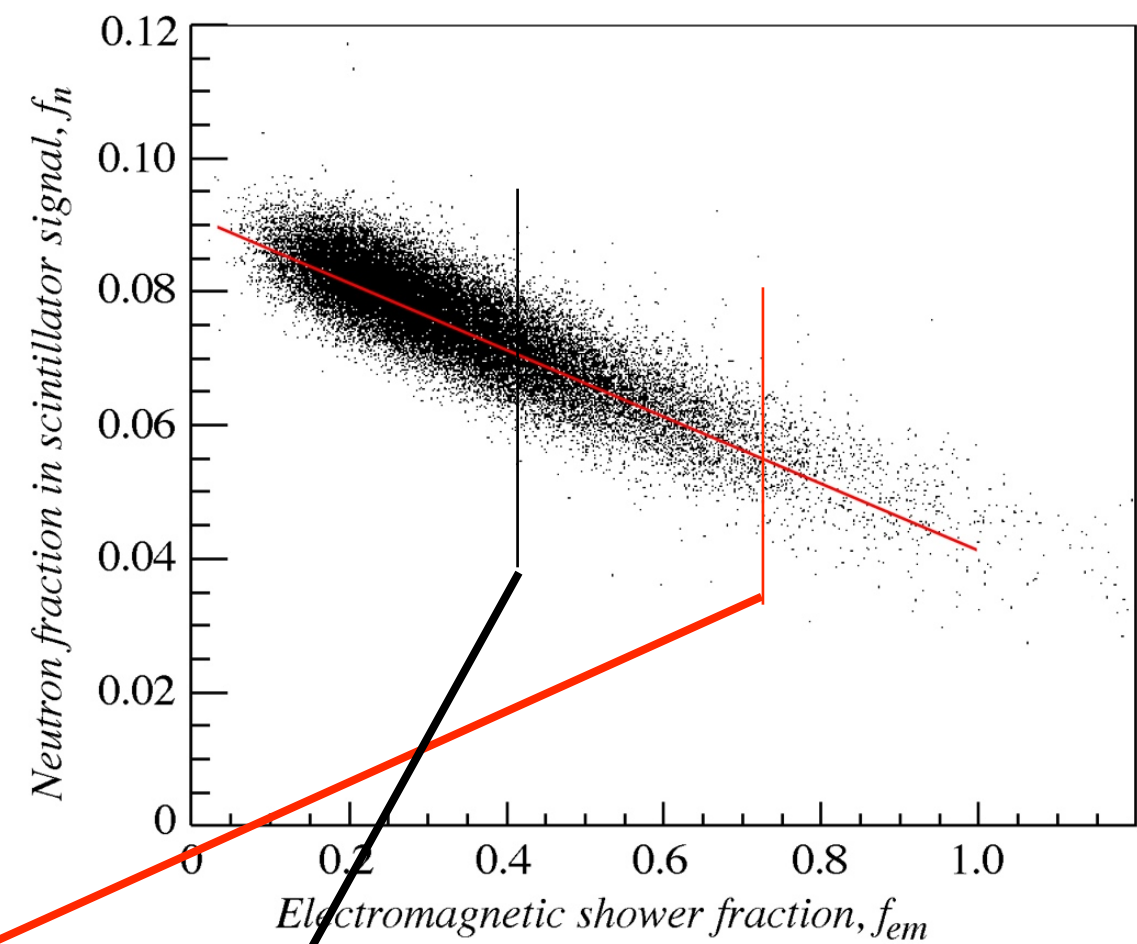
Linearly correcting each Cerenkov distribution  
in an  $f_n$  bin to  $f_n=0.07$  (arbitrary, middle value)  
results in the “ $f_n$  corrected” distribution



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

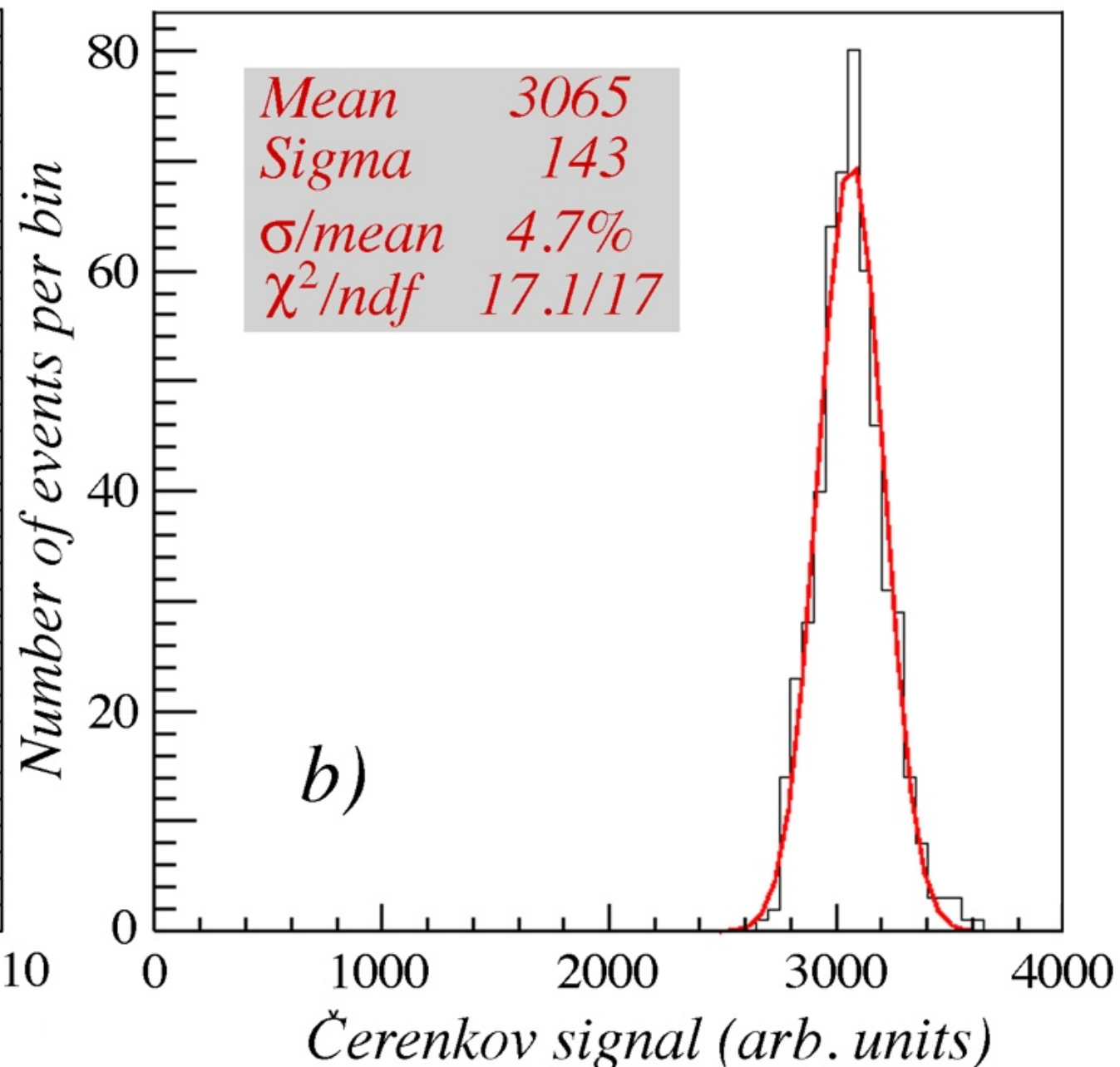
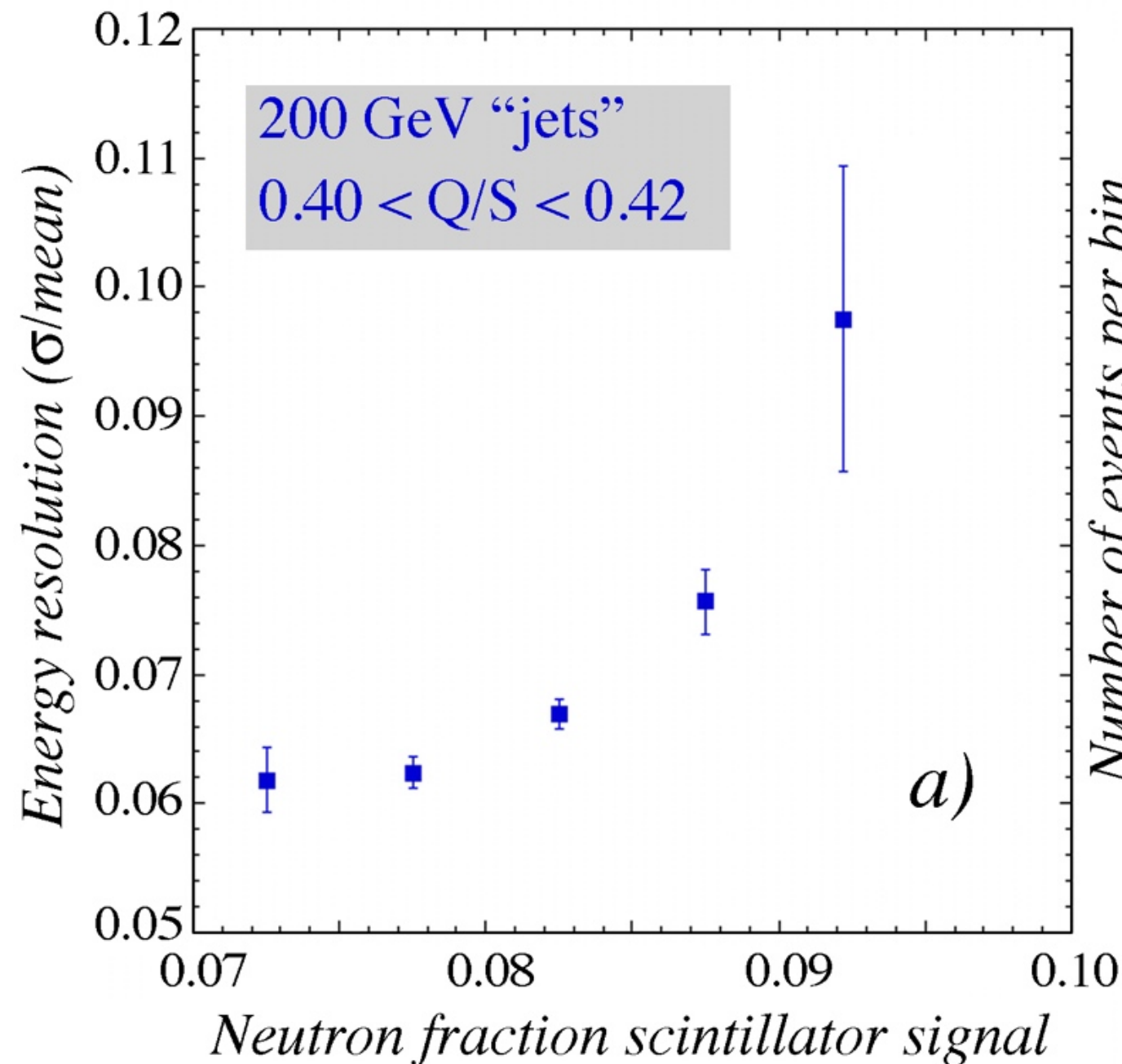
(2) Its dependence leaves no “constant term”

For fixed EM fractions, the neutron fraction varies by  $\sim 15\%$  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  $\sim 0.55$  and  $0.045 < f_n < 0.065$ , the resolution in Cerenkov signal is 4.7%. For a tighter  $f_n$ ,  $0.050 < f_n < 0.055$ , the resolution is 4.4%.



*Note bene: leakage fluctuations in DREAM are  $\sim 4\%$ .*



# 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!