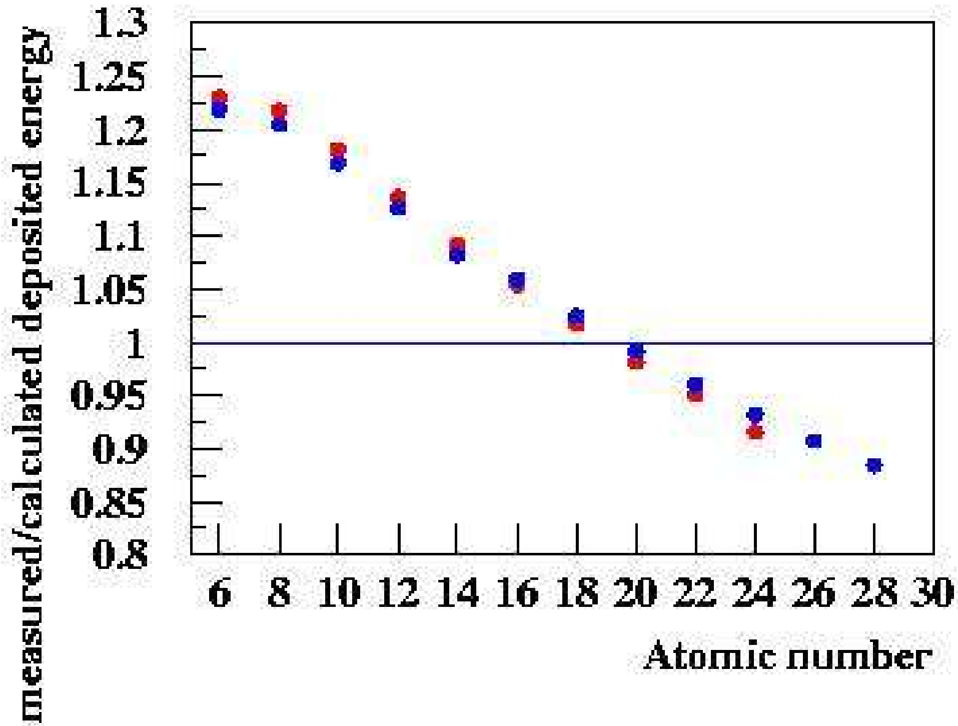
Status of the « antiquenching » issue



dL/dE = 1
for protons, muons,
electrons.

Quenching factor = measured/calculated deposited energy= dL/dE

Z=6 (C): dL/dE=1.23
Z=14 (Si): dL/dE=1.08
Z=26 (Fe): dL/dE=0.90

« quenching »: dL/dE <1
« antiquenching »: dL/dE>1

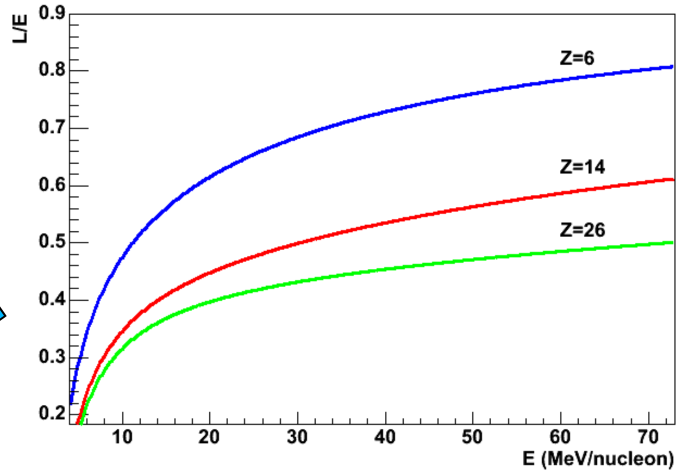
Benoît Lott

GANIL results (E < 73 MeV/nucleon, J. Bregeon’ s thesis)

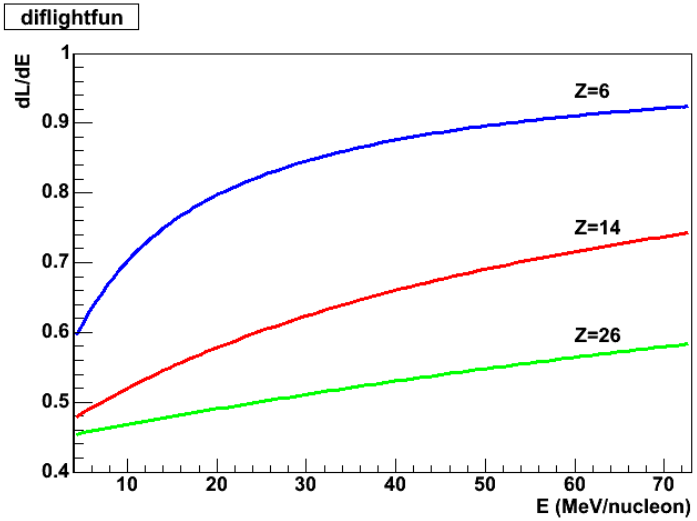
Minical: same electronics & same CsI logs (EM, Flight) as at GSI

Parlog et al.: $$L = a_1 \left\{ E_0 \left[1 - a_2 \frac{AZ^2}{E_0} ln \left(1 + \frac{1}{a_2 \frac{AZ^2}{E_0}} \right) \right] + a_4 a_2 AZ^2 ln \left(\frac{E_0 + a_2 AZ^2}{E_\delta + a_2 AZ^2} \right) \right\}$$

Fits of experimental data



differentiation



Quenching is observed (dL/dE <1) but the extrapolation to higher energy is compatible with the GSI results.

"Pulse-shape" hypothesis

I have investigated the possibility of different decay times bringing about the observed antiquenching effect.

In the litterature (F. Benrachi et al., NIM A281 (1989) 137):

$$L(t) = \frac{h_f}{\tau_f}\exp(-\frac{t}{\tau_f}) + \frac{h_S}{\tau_S}\exp(-\frac{t}{\tau_S})$$

Fast component: τ_f=0.5-1 μs dependent on the particle

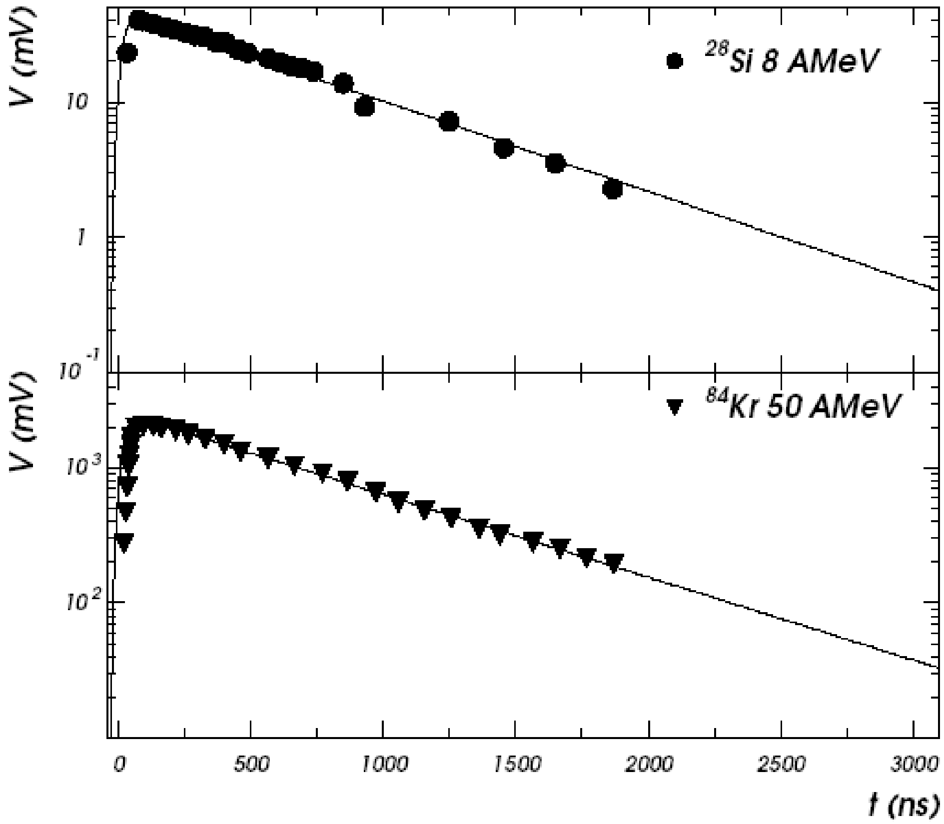
Slow component: τ_S=7 μs for all particles

10% for heavy ions, regarless of E

35% for protons and increasing with E

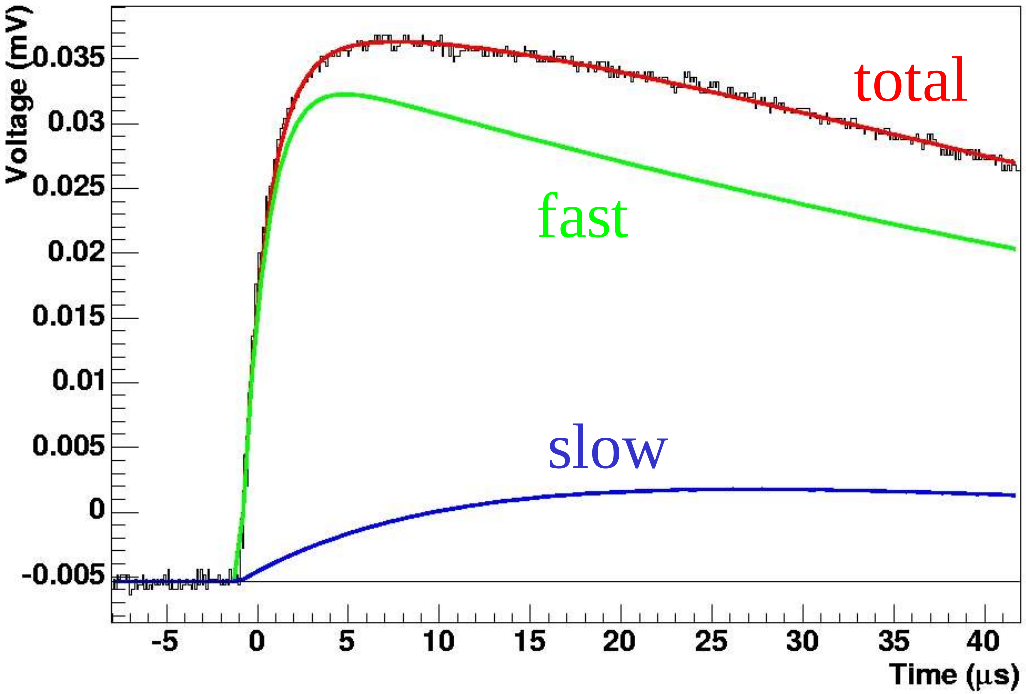
Data limited to E_{max}= 23 MeV/nucleon

Pulse-shape for low-energy heavy ions (Indra)



Pulses measured with a phototube:
one component with $\tau = 0.65\ \mu s$

Pulse shape at the preamp output for cosmic muons



minical electronics
same CsI crystals
& PIN diodes
as EM & Flight

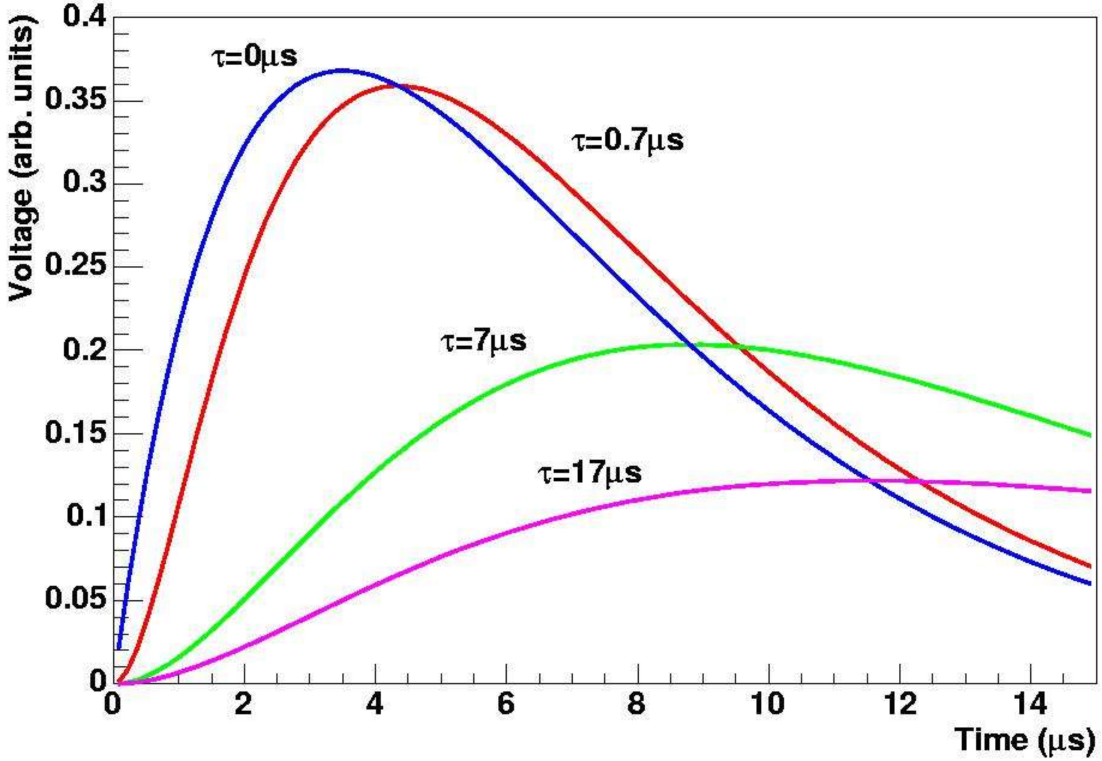
$$V(t) = V_0\{e^{-t/RC} - [\alpha e^{-t/\tau_1} + (1-\alpha)e^{-t/\tau_2}]\}$$

RC=93μs α=0.75±0.01 τ_1 = 1.27±0.04μs τ_2 = 10.0±0.7μs

B. Shwartz (BELLE) also found a very slow component (α=0.75, τ_2 = 17μs).

Pulse shape at the amplifier output

I have calculated the shape of the voltage pulses ouput by the amplification chain, for charge pulses with different time distributions: a δ-function and exponentials with differerent decay times τ . The shaping constant is taken as 3.5 μs.



Current view on the antiquenching effect

- With our electronics, antiquenching « naturally » prevails for heavy ions if the slow component observed for e,p, muons is missing, which seems to be the case.

- This behavior is hidden at low energy since real quenching (due to energy going into non-radiative channels) is very strong for heavy ions and overbalances this effect.

- As quenching is reduced at higher energy, the «natural » behavior emerges.