Preliminary results of last week's GSI experiment

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A little background

In addition to electromagnetic showers, the calorimeter will detect other particles used for calibration:

- MIPs (q=1)
- heavy ions.

The response of the calorimeter to relativistic ions must be determined experimentally, scintillation being a complex process. Not known before our study.

For CsI, at low energy (tens of MeV/nucleon) the response to heavy ions is different from that of protons in two different ways:

- For a given deposited energy, $(\text{pulse height})_{HI}$ is lower than $(\text{pulse height})_p$: "quenching"
- Two scintillation components are excited with different weights:

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

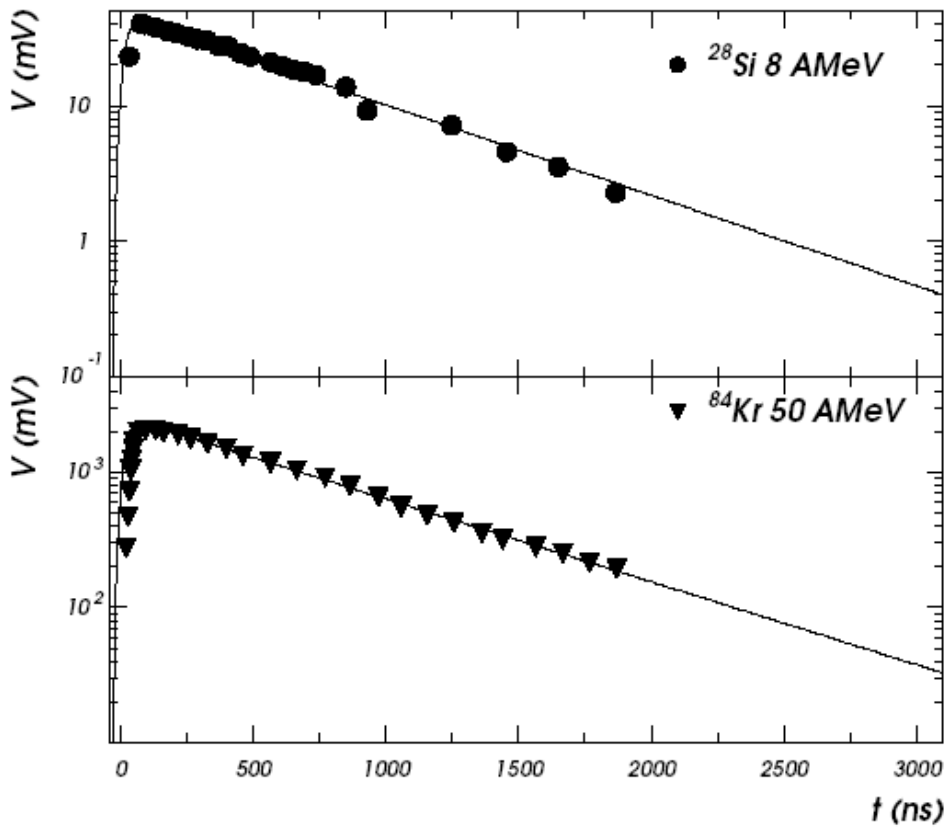
Slow component: τ_S=7 μs

< 10% for heavy ions

~ 35% for protons and increasing with E

Property widely exploited for pulse-shape identification

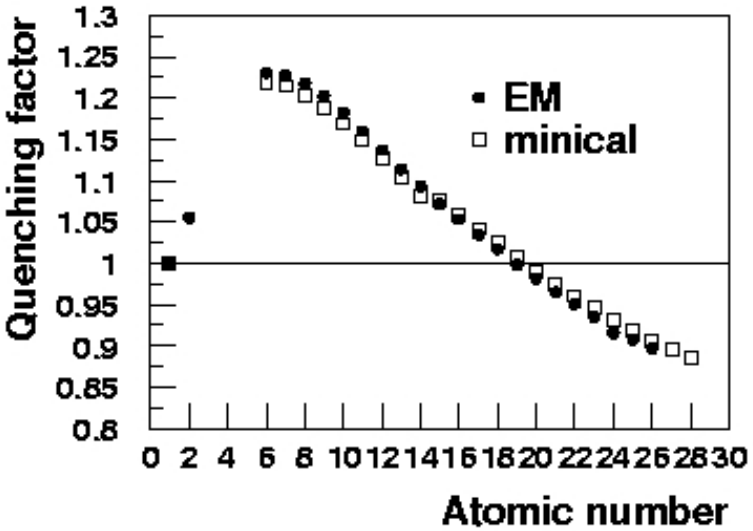
Pulse shape for low-energy heavy ions



Pulses measured with a phototube:

one component with $\tau = 0.65$ µs

Quenching factors



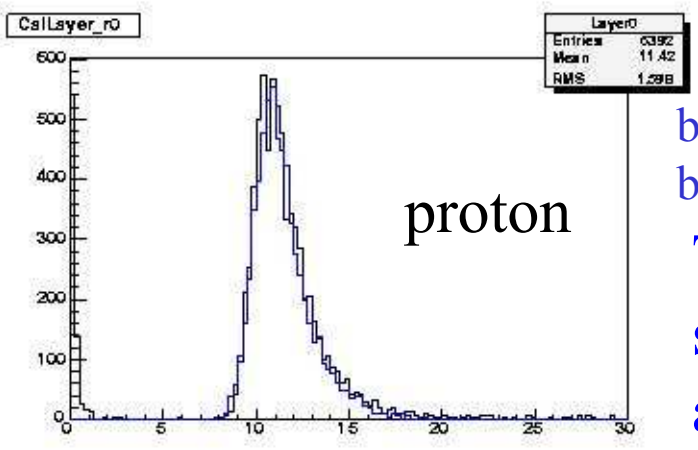
$E_{meas}/E_{exp} \equiv 1$
for protons, muons, electrons

Quenching factor ≡ measured/calculated deposited energy= E_{meas}/E_{exp}

Z=6 (C): E_{meas}/E_{exp} =1.23
Z=14 (Si): E_{meas}/E_{exp} =1.08
Z=26 (Fe): E_{meas}/E_{exp} =0.90

« Quenching »: $E_{meas}/E_{exp} < 1$
« Antiquenching »: $E_{meas}/E_{exp} > 1$

Width of measured deposited distributions

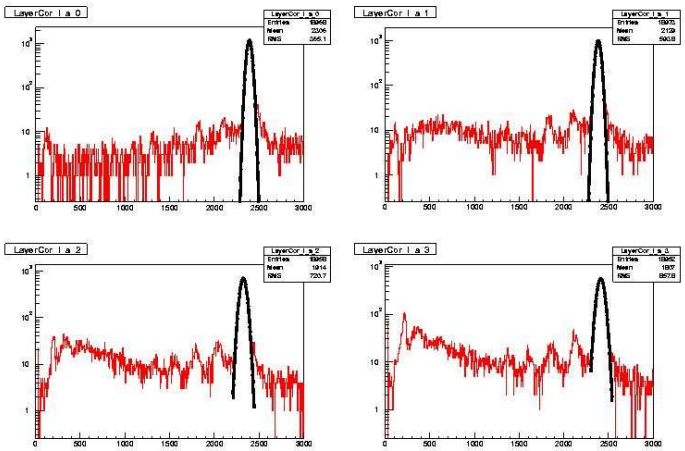


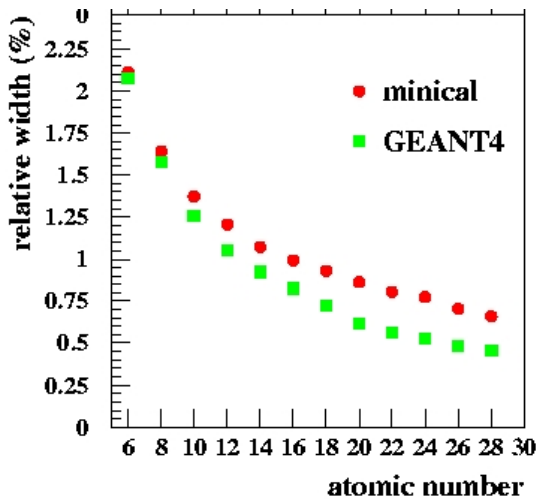
blue: G4+smearing (0.65 MeV)
black:data

There is correlation in the smearing between two ends: arises from scintillation!

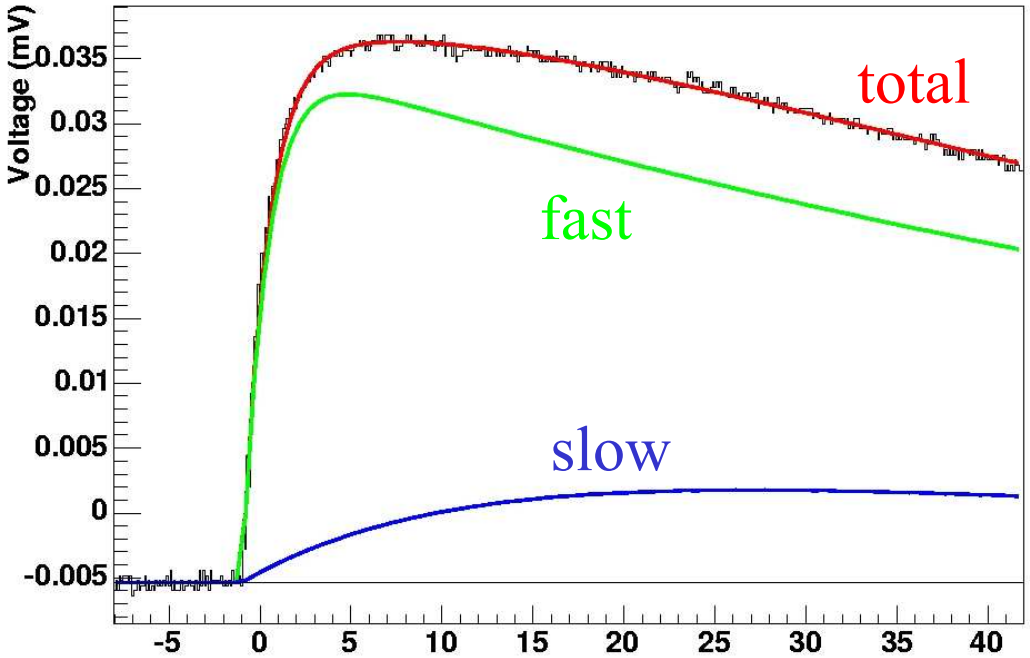
Not seen for heavy ions!

Z=14 (Silicon)





Pulse shape at the preamp output for cosmic muons



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

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

$RC=93\mu s$ $\alpha=0.75\pm0.01$ $\tau_1 = 1.27\pm0.04\mu s$ $\tau_2 = 10.0\pm0.7\mu s$

B. Shwartz (BELLE) also found a very slow component ($\alpha=0.75$, $\tau_2 = 17\mu s$).

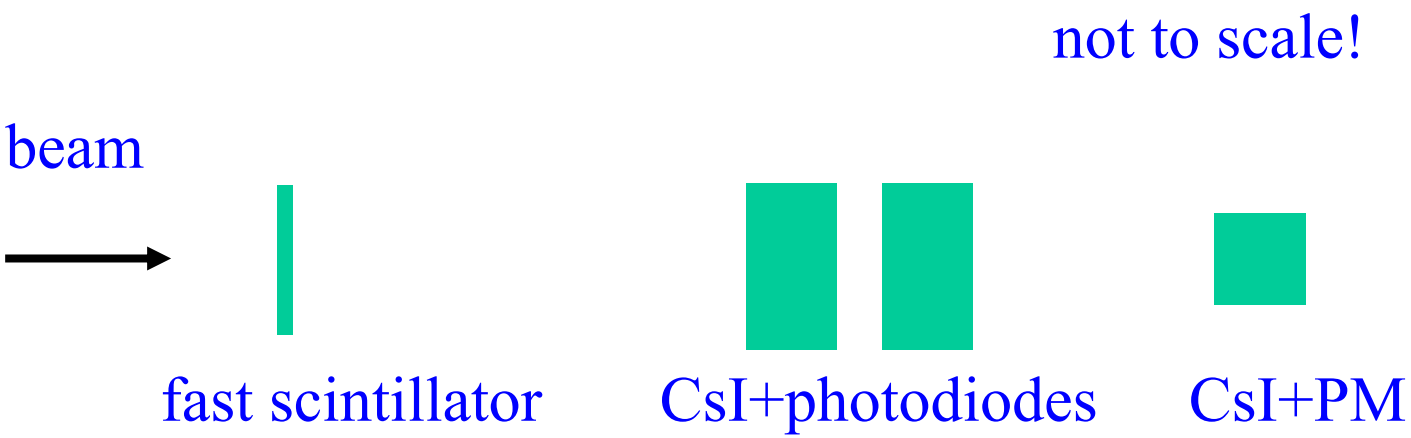
Rationale for the July 2005 experiment

Possible interpretation of the antiquenching effect, based on an extrapolation on what is known at low-energy:
For MIPs, part of the energy goes into a slow scintillation component, that could be absent for heavy ions. This slow component is essentially filtered out by our electronics, resulting in the measured energy being lower for MIPs than for heavy ions.

Check whether there are different scintillation components for MIPs and heavy ions:
Pulse shape from a CsI+Phototube detector

Beams: Carbon, deuterons (MIPs) at 1.7 GeV/nucleon
1 night of beam time

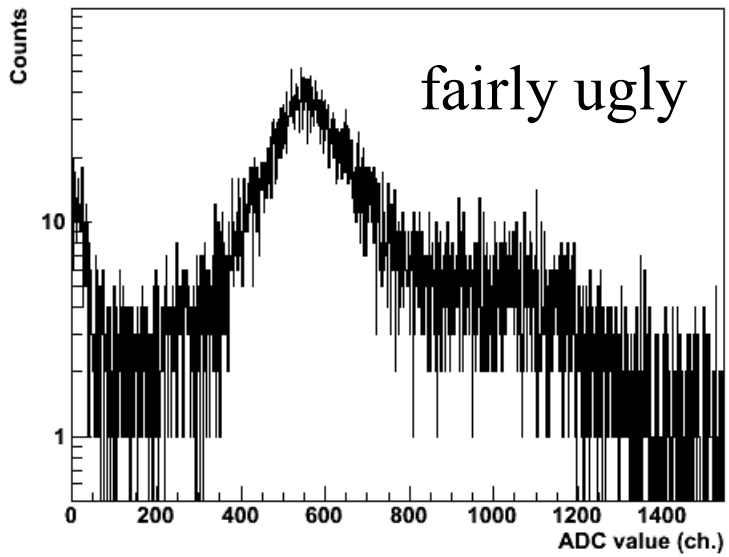
Sketch of the July 2005 setup



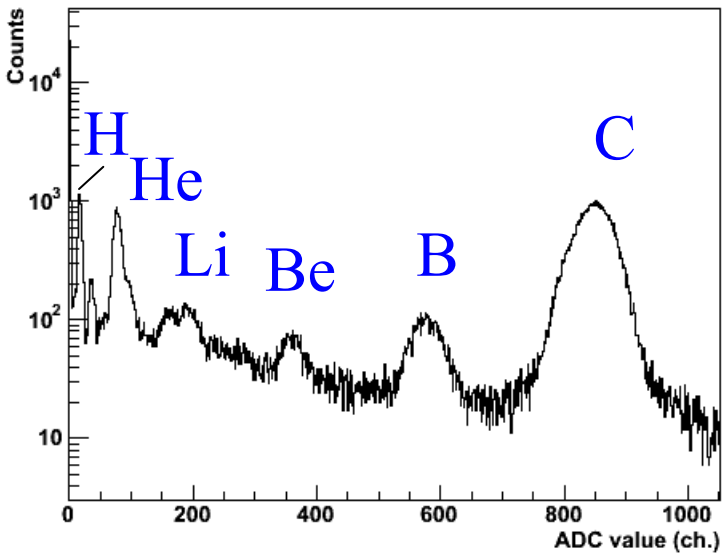
Acquisition system: digital oscilloscope
(+gpib interface driven by LabView)

Results from the CsI+ photodiode detector

d 1.7 GeV/nucleon



C 1.7 GeV/nucleon

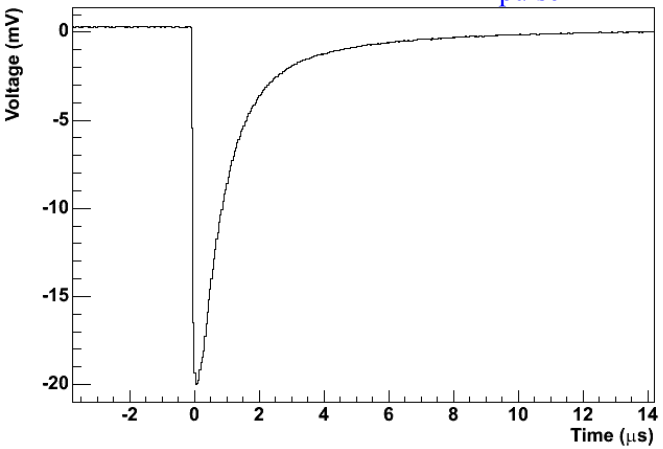


$E_{meas,d}$ =11 MeV → $E_{meas,C}$ ~500 MeV

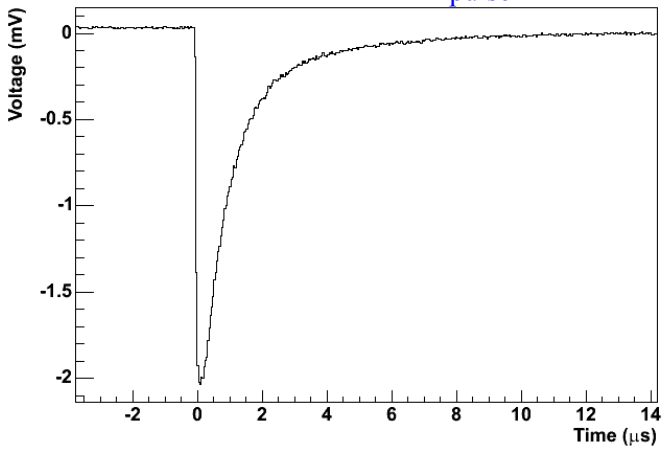
$E_{exp,C}$ ~400 MeV, quenching factor ~1.25

Results from the CsI+phototube detector

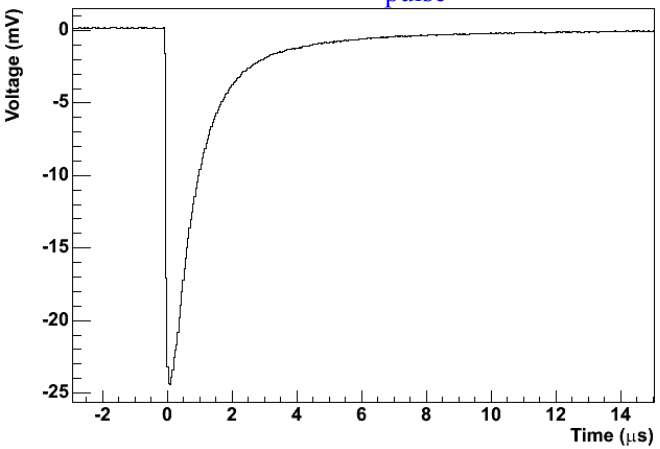
Cosmic muons (N_{pulse}=325)



Deuterons (N_{pulse}=31)

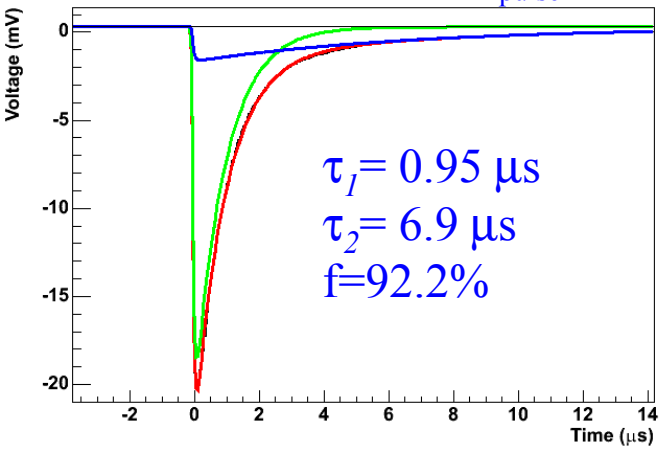


Carbon (N_{pulse}=58)



Results from CsI+phototube

Cosmic muons (N_{pulse}=325)



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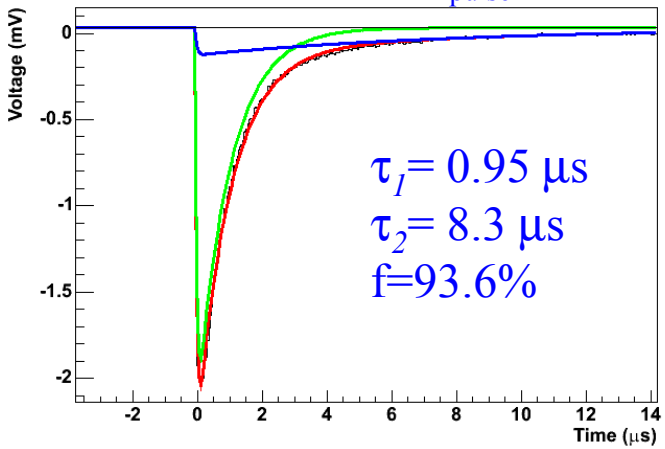

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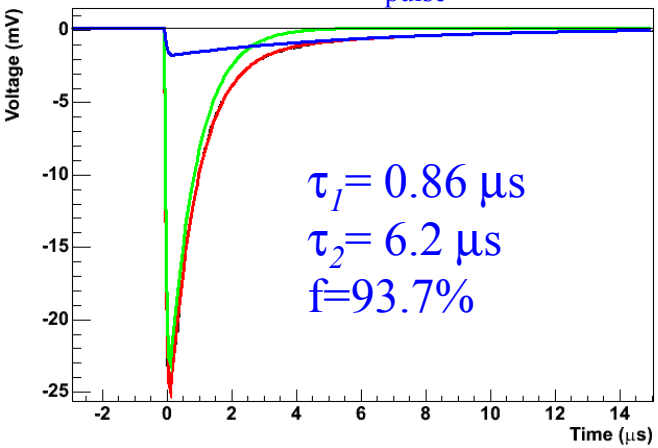

Another unexpected result…