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, \((\text{pulse height})_{\text{HI}}\) is lower than \((\text{pulse height})_{\text{p}}\): “quenching”
- Two scintillation components are excited with different weights:
  Fast component: \(\tau_f=0.5-1\ \mu\text{s}\) dependent on the particle
  Slow component: \(\tau_s=7\ \mu\text{s}\)
    < 10% for heavy ions
    ~ 35% for protons and increasing with E

Property widely exploited for pulse-shape identification

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Pulse shape for low-energy heavy ions

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

Quenching factor $\equiv$ measured/calculated deposited energy $= E_{\text{meas}}/E_{\text{exp}}$

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

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

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

\( RC = 93 \mu s \quad \alpha = 0.75 \pm 0.01 \quad \tau_1 = 1.27 \pm 0.04 \mu s \quad \tau_2 = 10.0 \pm 0.7 \mu s \)

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

$E_{\text{meas},d} = 11$ MeV

$E_{\text{exp},C} \sim 400$ MeV, quenching factor $\sim 1.25$

$C$ 1.7 GeV/nucleon

$E_{\text{meas},C} \sim 500$ MeV
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)

$\tau_1 = 0.95 \mu s$

$\tau_2 = 6.9 \mu s$

$f = 92.2\%$

Deuterons (N_{pulse} = 31)

$\tau_1 = 0.95 \mu s$

$\tau_2 = 8.3 \mu s$

$f = 93.6\%$

Carbon (N_{pulse} = 58)

$\tau_1 = 0.86 \mu s$

$\tau_2 = 6.2 \mu s$

$f = 93.7\%$

Another unexpected result…