Waveform dependence on the signal source in the H-Jet
The RHIC H-Jet

Jet–Target atomic beam

Blue beam

Yellow beam
Geometry Based Calibration

For elastic pp scattering, the \( z \)-coordinate of the recoil proton in the H-Jet detector explicitly depends on its kinetic energy \( T \):

\[
\frac{z}{L} = \sqrt{\frac{T}{2M_p} \frac{E_{\text{beam}}}{E_{\text{beam}} - M_p}} \pm \frac{b}{L \sqrt{2M_p T}}
\]

“Mean” elastic amplitude \( A_s \) ↔ Kinetic energy \( T_s \) "known" from the geometry

We can calibrate every Si strip with well isolated elastic signal:

\[
E(A_s) = T_s
\]

\[
t_0 = t_s(A_s) - L \sqrt{\frac{M_p}{2T_s}}
\]

*Equivalent to a (single) \( \alpha \)-source calibration, but almost insensitive to the dead-layer*

*The measured \( t_0 \) strongly simplifies the dead-layer treatment.*
Comparison of the geometry based and prompt based calibrations.

\[ \Delta t = t_{\text{prompt}} - t_0^{(\text{geom})} \]

Comparison of the geometry based and \(\alpha\)-source calibrations.

\[ \delta E = \frac{E_{\text{geom}} - E_{\alpha}}{(E_{\text{geom}} + E_{\alpha})/2} \]

We have to conclude that \(t_0\) is amplitude dependent: 

\[ t_0(A) = \text{const} + 0.005 \times A \text{ ns} \]
**What time do we measure?**

Generally, measured time depends on the waveform.

*The $\Delta t$, which may be calculated by product, is a simple criteria to monitor the signal shape.*

\[ \Delta t = \frac{A_{\text{max}}/2}{dA/dt} = t_{1/2} - t_{\text{meas}} \]
Test of the waveform shape (Fill 17593, Ch#1)

The signal shape is different for the elastic pp and prompt signals. (Even for the same signal amplitude)
The formation of a electron/hole pair signal

The silicon strip is approximated by a detector with parallel plate geometry with uniform field.

For very large over-bias $V_b=170$ V:

- signal current is proportional to the velocity of the carrier
- signal duration equal to the drift time
- integral signal is independent of the electron/hole pair position

$S_{e,h} \sim v_{e,h} \sim q \frac{\mu_{e,h} V_d}{d^2}$

$t_h = \frac{x}{v_h}, \quad t_e = \frac{(d - x)}{v_e}$

$Q = S_h \frac{x}{v_h} + S_e \frac{d - x}{v_e} = q$

Parameters for the simulation:

$V_b = 170$ V

$d = 400$ $\mu$m

$\mu_e = 1350$ $cm^2V^{-1}s^{-1}$

$\mu_h = 450$ $cm^2V^{-1}s^{-1}$
The electron/hole distribution may be calculated using the Si stopping power for protons.

Simulation of the signals waveforms in the Si strip depending on the proton energy.

The charge collection time alters from 7 ns to 20 ns depending on the proton energy.
**Signal in the WFD**

\[
A(t) = \int S(\tilde{t})G(t - \tilde{t})d\tilde{t}
\]

**The electronics response function:**

\[
G(t) \propto t^n e^{-t/\tau}, \quad n = 2.74, \quad \tau = 6.8
\]

**The waveform fit:**

\[
W(t) = p + A_{\text{max}} a_{n,\tau}(t - t_s)
\]

\[
a_{n,\tau}(t) = \begin{cases} 
0 & \text{if } t \leq 0 \\
(t/n\tau)^n \exp(-t/\tau + n) & \text{if } t > 0 
\end{cases}
\]
Simulation of the measured/fit parameters dependence on the recoil proton energy?

**Measured parameters:**

![Graph showing measured parameters vs. proton energy]

- Error bars show the RMS of the distributions due to the digitization.

**The fit parameters:**

![Graph showing fit parameters vs. proton energy]

- The fit promises better suppression of the prompt event than the \( \Delta t \) method.
Summary

• The signal waveform simulation shows a visible dependence of the measured parameters on the signal amplitude and source.
• Some dependence of measured time on the signal amplitude was found but it cannot explain the experimentally observed t0 dependence on the amplitude.
• The simulated waveform difference between elastic pp and prompt events is in good agreement with the H-Jet data.
• This effect may be employed for the prompt background suppression.