Single Channel Eloss Recalibration for slats with hole

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What are we studying?

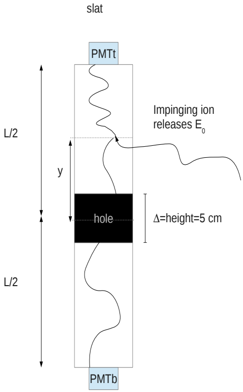
We need to calibrate the energy loss in a proper way in the slats with the hole: the central ones 52, 53, 54
plus some others that show a discontinuity 50, 51, 151

ADC readings, with pedestal subtraction in slats with hole: TOP HIT

The ADC readings, from which we subtract the pedestal values are $iADC'_t$ and $iADC'_b$.
If a particle is impinging on the slat, above the hole ($y > \Delta/2$)
i.e. HIT ON TOP we will have

$$\begin{cases} iADC'_t = \epsilon_t E_0 \exp[-\alpha_t(\frac{L}{2} - y)] \\ iADC'_b = \epsilon_b E_0 \; p \; \exp[-\alpha_b(\frac{L}{2} - \frac{\Delta}{2})] \exp[-\alpha_t(y - \frac{\Delta}{2})] \end{cases}$$

where ϵ_t, ϵ_b are the PMT gains,
α_t, α_b should be the attenuation constants for the two semi-slats,
E_0 is the energy released by the ion,
$\Delta = 5\ cm$ is the hole heigth and
p, unknown, is the light loss by reflection in the slat-air-slat interface.



$\log(\frac{iADC'_t}{iADC'_b})$

If we calculate $\log(\frac{iADC'_t}{iADC'_b})$ we obtain:

$$log(\frac{iADC'_t}{iADC'_b}) = log(\frac{\epsilon_t E_0 \exp[-\alpha_t(\frac{L}{2} - y)]}{\epsilon_b E_0\ p\ \exp[-\alpha_b(\frac{L}{2} - \frac{\Delta}{2})]\exp[-\alpha_t(y - \frac{\Delta}{2})]})$$

$$= log(\frac{\epsilon_t \exp[-\alpha_t(\frac{L}{2} - y)]}{\epsilon_b\ p\ \exp[-\alpha_b(\frac{L}{2} - \frac{\Delta}{2})]\exp[-\alpha_t(y - \frac{\Delta}{2})]})$$

$$= log(Gratio) - log(p) + log[\exp[-\frac{L}{2}(\alpha_t - \alpha_b)]\exp[-\frac{\Delta}{2}(\alpha_t + \alpha_b)]\exp(2\alpha_t\ y)]$$

$$= log(Gratio) - log(p) - \frac{L}{2}(\alpha_t - \alpha_b) - \frac{\Delta}{2}(\alpha_t + \alpha_b) + (2\alpha_t\ y)$$

$$= (2\alpha_t\ y) + log(Gratio) - log(p) - \frac{L}{2}(\alpha_t - \alpha_b) - \frac{\Delta}{2}(\alpha_t + \alpha_b)$$

$$= (p_{0,t}\ y) + p_{1,t}$$

being $Gratio = \frac{\epsilon_t}{\epsilon_b}$.

Therefore, in the plot $log(\frac{iADC'_t}{iADC'_b}) vs y$:

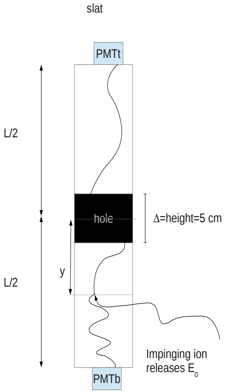
α_t can still be considered as an attenuation constant i.e. $\propto$ *the slope*;

Gratio instead is no more the only factor contained in the known term.

ADC readings, with pedestal subtraction in slats with hole: BOTTOM HIT

If a particle is impinging on the slat, below the hole ($y < \Delta/2$)
i.e. HIT ON BOTTOM we will have

$$\begin{cases} iADC'_t = \epsilon_t E_0 \; p \; \exp[-\alpha_t(\frac{L}{2} - \frac{\Delta}{2})] exp[\alpha_b(y + \frac{\Delta}{2})] \\ iADC'_b = \epsilon_b E_0 \exp[-\alpha_b(\frac{L}{2} + y)] \end{cases}$$



$\log(\frac{iADC'_t}{iADC'_b})$

If we calculate $\log(\frac{iADC'_t}{iADC'_b})$ we obtain:

$$log(\frac{iADC'_t}{iADC'_b}) = log(\frac{\epsilon_t E_0 \ p \ \exp[-\alpha_t(\frac{L}{2} - \frac{\Delta}{2})] exp[\alpha_b(y + \frac{\Delta}{2})]}{\epsilon_b E_0 \exp[-\alpha_b(\frac{L}{2} + y)]})$$

$$log(\frac{\epsilon_t \ p \ \exp[-\alpha_t(\frac{L}{2} - \frac{\Delta}{2})] exp[\alpha_b(y + \frac{\Delta}{2})]}{\epsilon_b \exp[-\alpha_b(\frac{L}{2} + y)]})$$

$$= log(Gratio) + log(p) + log[\exp[-\frac{L}{2}(\alpha_t - \alpha_b)] \exp[\frac{\Delta}{2}(\alpha_t + \alpha_b)] \exp(2\alpha_b \ y)]$$

$$= log(Gratio) + log(p) - \frac{L}{2}(\alpha_t - \alpha_b) + \frac{\Delta}{2}(\alpha_t + \alpha_b) + (2\alpha_b \ y)$$

$$= (2\alpha_b \ y) + log(Gratio) + log(p) - \frac{L}{2}(\alpha_t - \alpha_b) + \frac{\Delta}{2}(\alpha_t + \alpha_b)$$

$$= (p_{0,b} \ y) + p_{1,b}$$

Therefore, in the plot $log(\frac{iADC'_t}{iADC'_b}) vs y$:
α_b can still be considered as an attenuation constant i.e. $\propto$ *the slope*;
Gratio instead is no more the only factor contained in the known term.

PMT top reads a top hit

Sweepruns:

$$lig'_t = \epsilon_t C_{peak} \exp[-\alpha_t(\frac{L}{2} - \frac{\overline{\Delta}}{2})]$$

Production runs:

$$iADC'_t = \frac{lig'_t}{C_{peak}} \exp(-\alpha_t \frac{\overline{\Delta}}{2}) E_0 \exp(\alpha_t y)$$

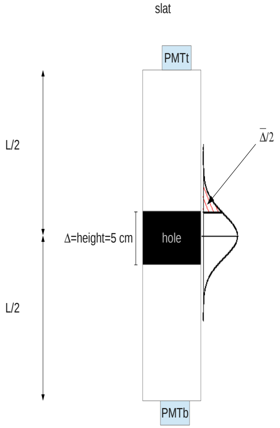
thus

$$E_0 = iADC'_t \exp(-\alpha_t y) \frac{C_{peak}}{lig'_t} \exp(\alpha_t \frac{\overline{\Delta}}{2})$$

$$= ADC_t \frac{C_{peak}}{lig'_t} \exp(\alpha_t \frac{\overline{\Delta}}{2})$$

$$= light_t \exp(\alpha_t \frac{\overline{\Delta}}{2})$$

where $\frac{\overline{\Delta}}{2}$ is the baricenter of the beam distribution tail seen by the top semi-slat during sweepruns ($\approx \frac{\Delta}{2}$).



PMT top reads a bottom hit

Sweepruns:

$$lig'_t = \epsilon_t C_{peak} \exp[-\alpha_t(\frac{L}{2} - \frac{\overline{\Delta}}{2})]$$

Production runs:

$$iADC'_t = \ p \ \frac{lig'_t}{C_{peak}} \exp(-\alpha_t \frac{\overline{\Delta}}{2}) \exp(\alpha_t \frac{\Delta}{2}) E_0 \exp(\alpha_b y) \exp(\alpha_b \frac{\Delta}{2})$$

then

$$E_0 = iADC'_t \exp(-\alpha_b y) \frac{C_{peak}}{lig'_t} \frac{1}{p} \exp(-\frac{\Delta}{2}(\alpha_t + \alpha_b)) \exp(\alpha_t \frac{\overline{\Delta}}{2})$$

but: p is unknown. Can we deduce it?

Can we evaluate p?

HIT on TOP

$$log(\frac{iADC'_t}{iADC'_b}) = (p_{0,t}\ y) + p_{1,t}$$

HIT on BOTTOM

$$log(\frac{iADC'_t}{iADC'_b}) = (p_{0,b}\ y) + p_{1,b}$$

with

$$p_{1,t} = log(Gratio) - log(p) - \frac{L}{2}(\alpha_t - \alpha_b) - \frac{\Delta}{2}(\alpha_t + \alpha_b)$$

and

$$p_{1,b} = log(Gratio) + log(p) - \frac{L}{2}(\alpha_t - \alpha_b) + \frac{\Delta}{2}(\alpha_t + \alpha_b)$$

then

$$p_{1,t} - p_{1,b} = -2[log(p) + \frac{\Delta}{2}(\alpha_t + \alpha_b)]$$

and since

$$\frac{p_{0,t}}{2} = \alpha_t \ and \ \frac{p_{0,b}}{2} = \alpha_b$$

$$\frac{-(p_{1,t} - p_{1,b})}{2} = log(p) + \frac{\Delta}{4}(p_{0,t} + p_{0,b})$$

Can we evaluate p?

$$\frac{-(p_{1,t} - p_{1,b})}{2} = log(p) + \frac{\Delta}{4}(p_{0,t} + p_{0,b})$$

from which we can evaluate log(p):

$$log(p) = \frac{-(p_{1,t} - p_{1,b})}{2} - \frac{\Delta}{4}(p_{0,t} + p_{0,b})$$

and p:

$$p = e^{[\frac{-(p_{1,t} - p_{1,b})}{2} - \frac{\Delta}{4}(p_{0,t} + p_{0,b})]}$$

Error on p?

If we call log(p)=z:

$$z = log(p) = -\frac{p_{1,t}}{2} + \frac{p_{1,b}}{2} - \frac{\Delta}{4} p_{0,t} - \frac{\Delta}{4} p_{0,b}$$

we will have the error on z (squared) given by:

$$(\delta z)^2 = (\frac{\partial z}{\partial p_{1,t}})^2 * (\delta p_{1,t})^2 + (\frac{\partial z}{\partial p_{1,b}})^2 * (\delta p_{1,b})^2 + (\frac{\partial z}{\partial p_{0,t}})^2 * (\delta p_{0,t})^2 + (\frac{\partial z}{\partial p_{0,b}})^2 * (\delta p_{0,b})^2$$

$$= (\frac{1}{4}) * (\delta p_{1,t})^2 + (\frac{1}{4}) * (\delta p_{1,b})^2 + (\frac{\Delta^2}{16}) * (\delta p_{0,t})^2 + (\frac{\Delta^2}{16}) * (\delta p_{0,b})^2$$

assuming we know the hole height Δ without any error and knowing the errors on $p_{0,t},\ p_{0,b},\ p_{1,t}\ and\ p_{1,b}$ from fits.

Since $p = e^z$

$$(\delta p)^2 = (\frac{\partial p}{\partial z})^2 * (\delta z)^2 = e^{2z} * (\delta z)^2$$

$$= e^{2z} * [(\frac{1}{4}) * (\delta p_{1,t})^2 + (\frac{1}{4}) * (\delta p_{1,b})^2 + (\frac{\Delta^2}{16}) * (\delta p_{0,t})^2 + (\frac{\Delta^2}{16}) * (\delta p_{0,b})^2]$$

and

$$(\delta p) = e^z * \frac{1}{2}\sqrt{(\delta p_{1,t})^2 + (\delta p_{1,b})^2 + \frac{\Delta^2}{4}((\delta p_{0,t})^2 + (\delta p_{0,b})^2)}$$