A. Poblaguev

Could we trust to the t_0/x_{DL} calibration?

Mathematics of Dead-Layer

$$\frac{dE}{dx} = f(E) \Rightarrow L(E) = \int_0^E \frac{d\varepsilon}{f(\varepsilon)} \Rightarrow \frac{dE}{dx} = 1/(dL/dE)$$

Dead-Layer condition: $L_0(E) - L_0(\alpha A) = d$

$$\boxed{L(p,E) - L(p,\alpha A) = 1} \qquad (L(p,E) = pL_0(E), \quad p = 1/d)$$

Stopping range parametrization:

1. $L(E) = pL_0(E)$ — "standard parametrization", p=1/d
2. $L(E) = pE$ — constant energy loss, $p=E_{loss}$
3. $L(E) = p_1E + p_2E^2 + p_3E^3 + \dots$ — polinomial
4. $L(E) = ?$

Carbon Energy from measured amplitude: $\boxed{E(\alpha A) = L^{-1}[1 + L(\alpha A)]}$

Inverse task:

If ***E(αA)*** is known then we can determine ***L(E)*** and ***dE/dx***

If t_0 is know then we can measure Carbon energy as a function of the amplitude ***αA***

$$E_{\text{Carbon}} = \frac{Ml^2}{2(t-t_0)^2} \quad \Longleftrightarrow \quad \alpha A$$

A model independent calibration of the amplitude

and thus we can measure ***dE/dx*** (*in deadlayer length units*)

WARNING: In such a way we measure ***effective dE/dx*** which may be different from ionization losses ***dE/dx***.

If t_0 is unknown we can make a fit, that is to try all possible t_0 and select one which provides best data consistency. It might provide us with value of t_0 and calibration of the measured amplitude $E_{Carbon} = E(\alpha A)$ **.**

WARNING: the fit may work incorrectly if parameterization of stopping range ***L(p, αA)*** can not approach well true *effective* ***dE/dx.***

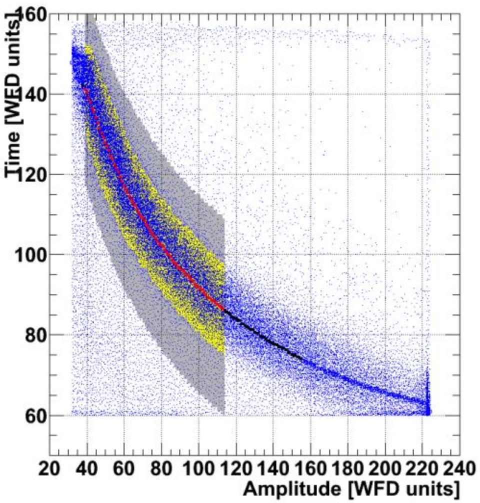
Banana is inconvenient to check the calibration

WFD

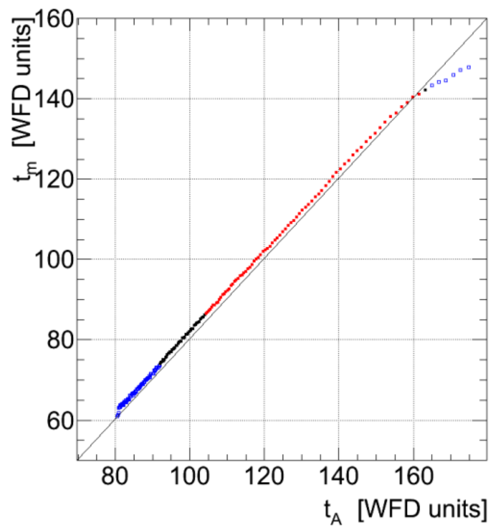
$$A \Rightarrow E_{\rm det} = \alpha A \Rightarrow E_A(E_{\rm det}, x_{\rm DL}) \Rightarrow t_A = \sqrt{\frac{M}{2}}\frac{L}{\sqrt{E_A}}$$

$$t \Rightarrow t_{\rm TOF} = t - t_0 \Rightarrow E_t = \frac{M}{2}\left(\frac{L}{t-t0}\right)^2$$

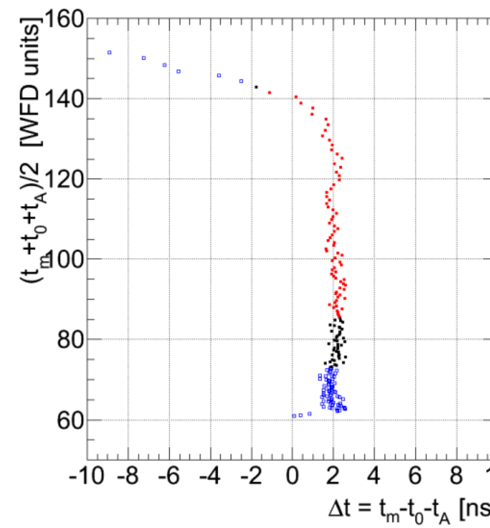
Banana: t vs E_A

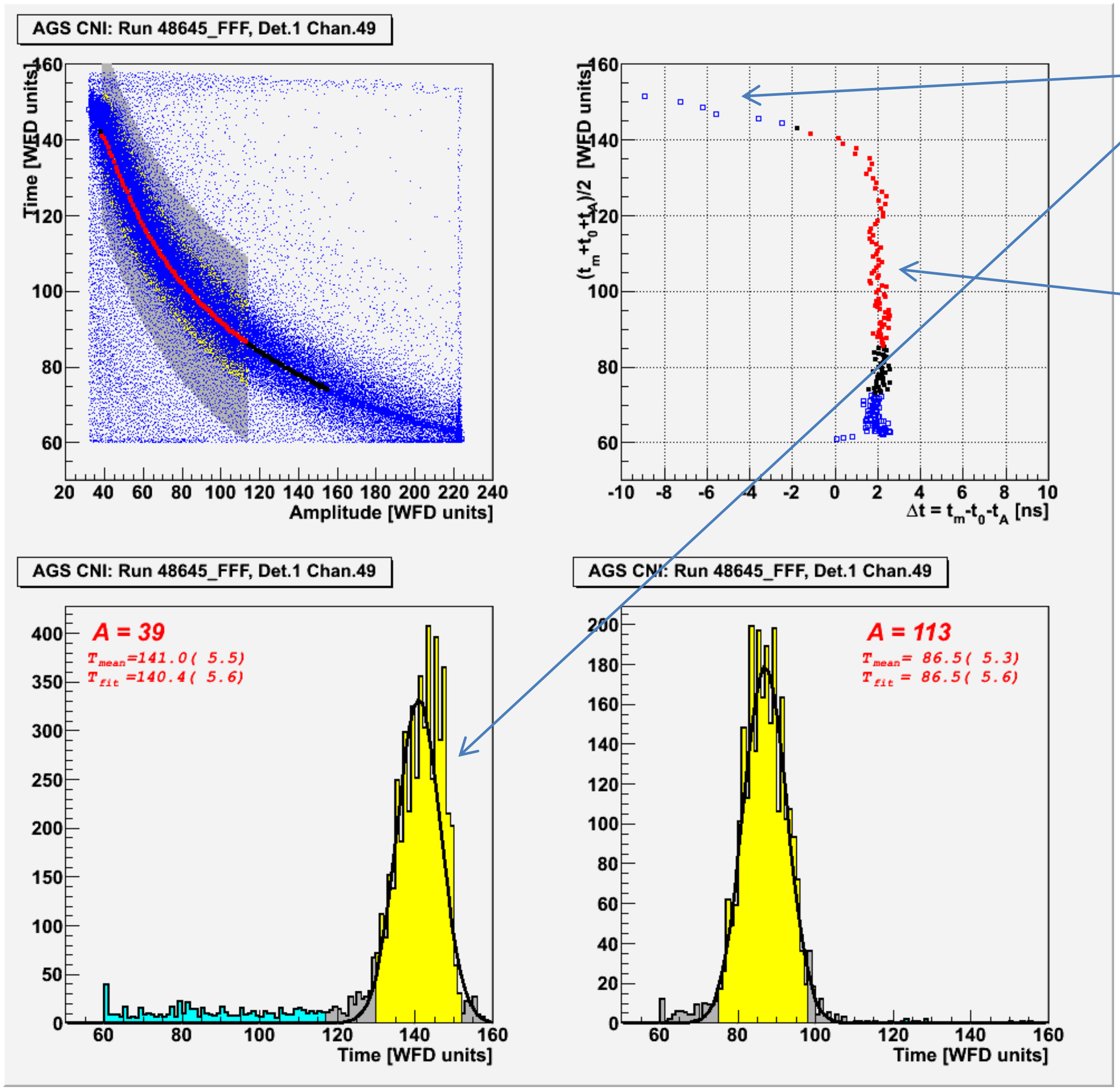


$t = t_0 + t_A$



$t - t_0 - t_A = 0$





Wrong determination of mean time

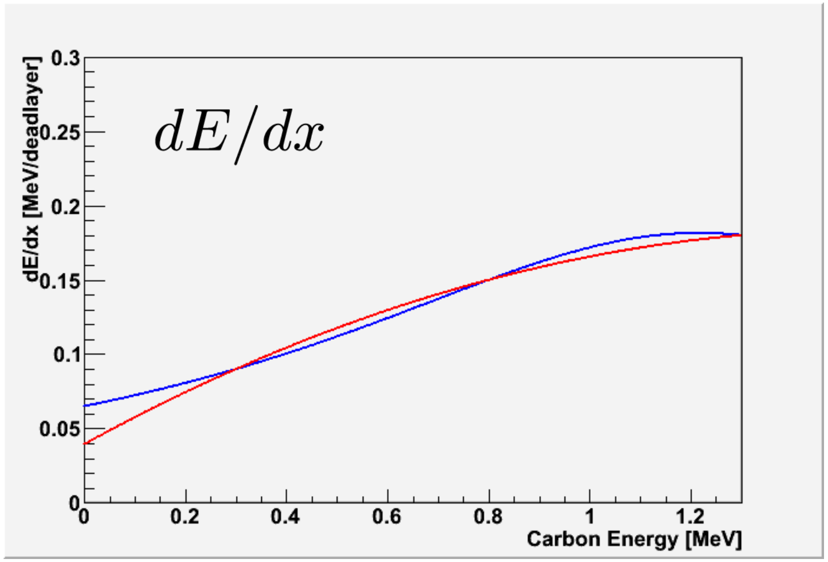
Picture can be rotated if
$A \rightarrow k\alpha$
$x_{DL} \rightarrow kx_{DL}$

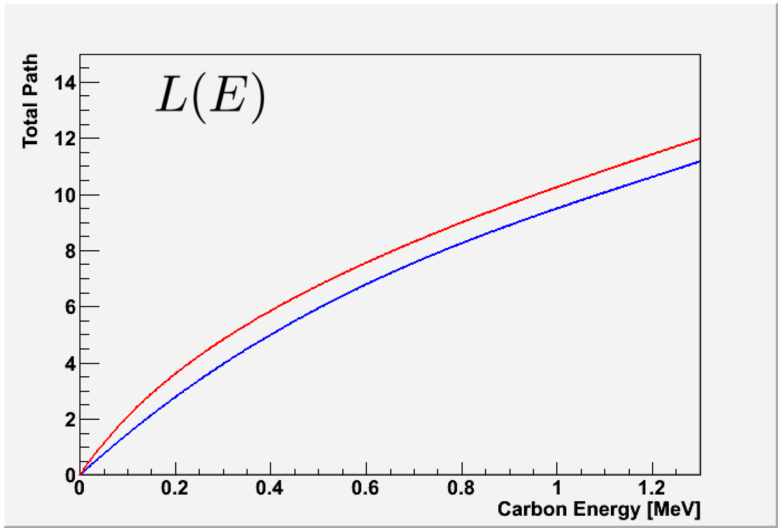
Simulation. *0.3<E<1.3 MeV*

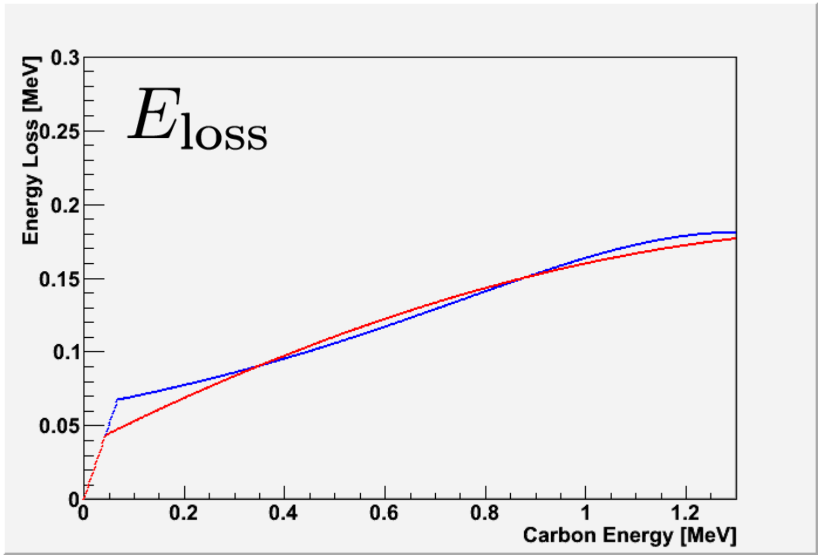
$$\frac{dE}{dx} = a + bE + cE^2 \quad L(E) = p_1 \ln \frac{1 + p_2 E}{1 + p_3 E}$$

$$\frac{dE}{dx} = \frac{1}{a + bE + cE^2} \quad L(E) = p_1 E + p_2 E^2 + p_3 E^3$$

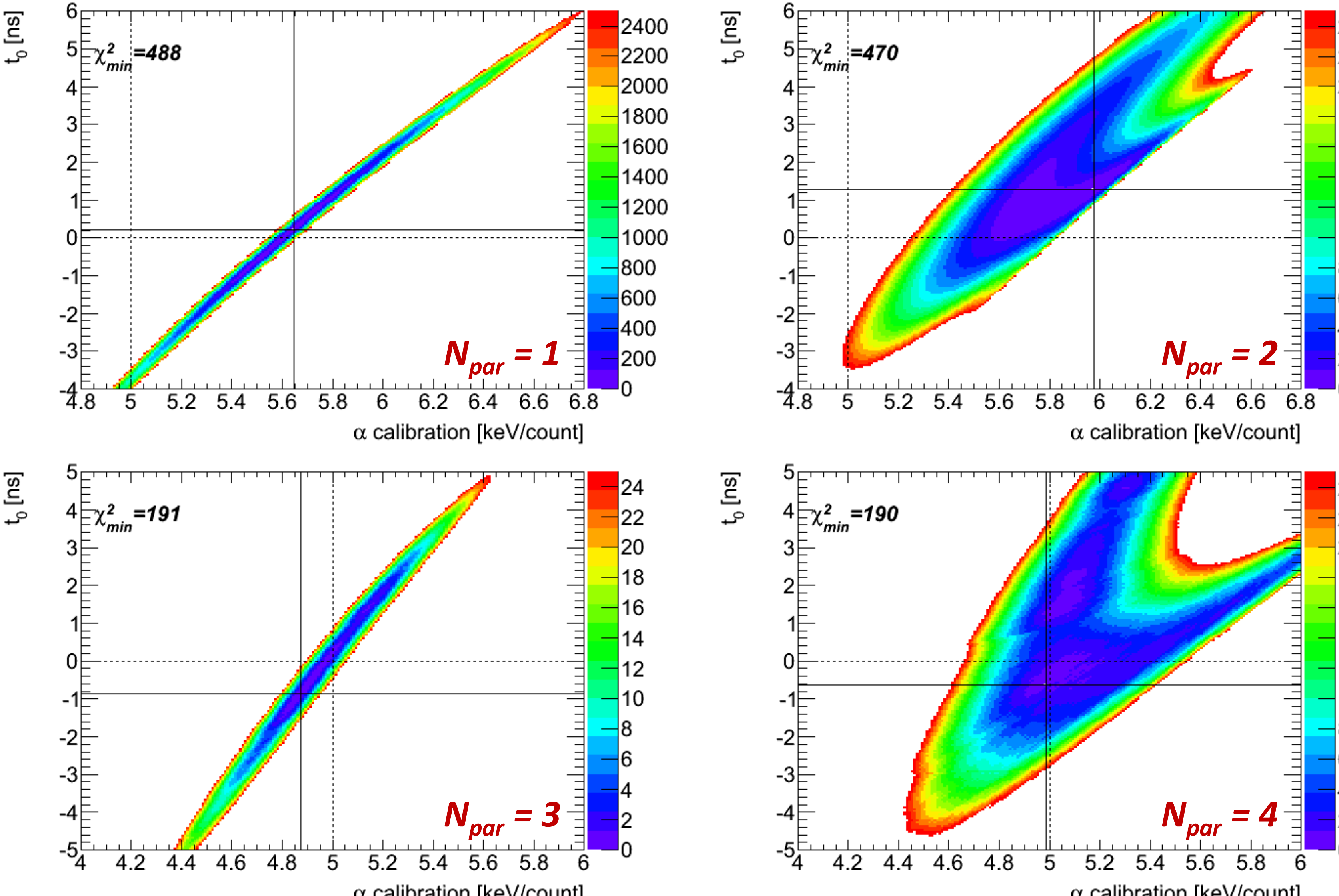
$$\text{Fit:} \quad L(E) = p_1 E + p_2 E^2 + p_3 E^3 + \ldots$$





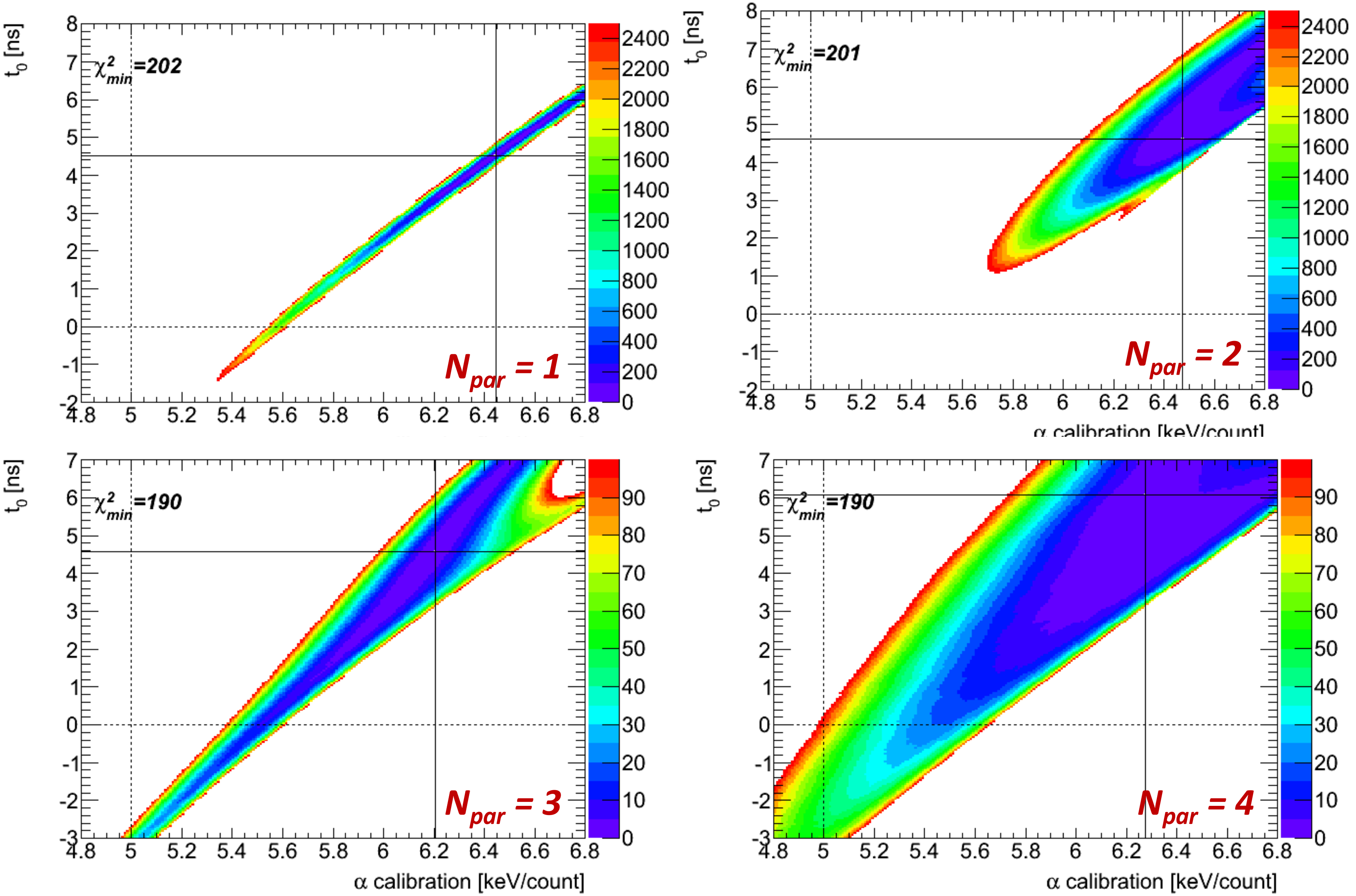


Fit α, t_0: $dE/dx = 1/(a+bE+cE^2)$



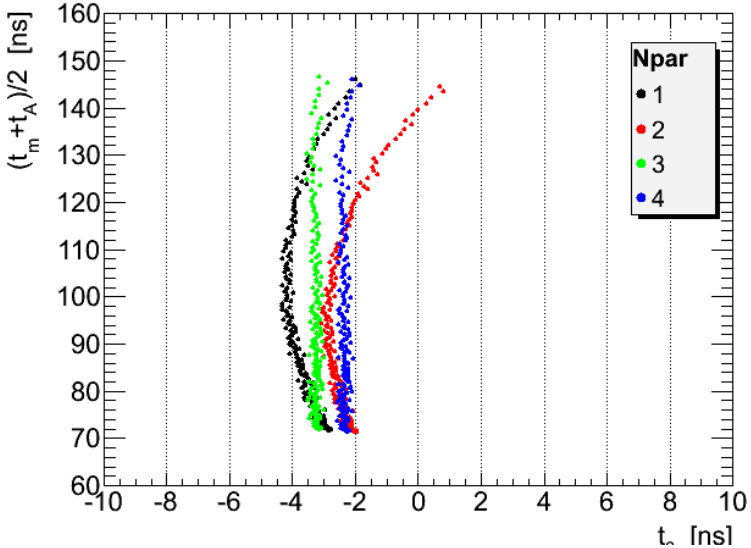
WARNING: there may be some disagreements between pictures due to actually implementd fit procedure

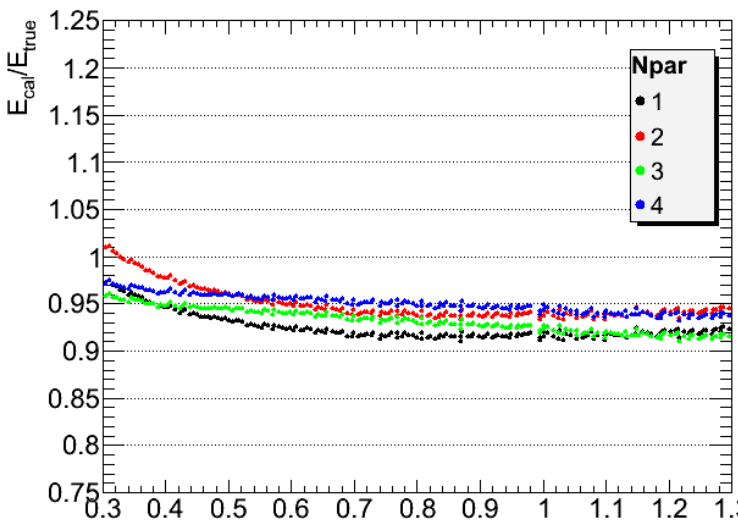
Fit α, t_0: $dE/dx = a + bE + cE^2$



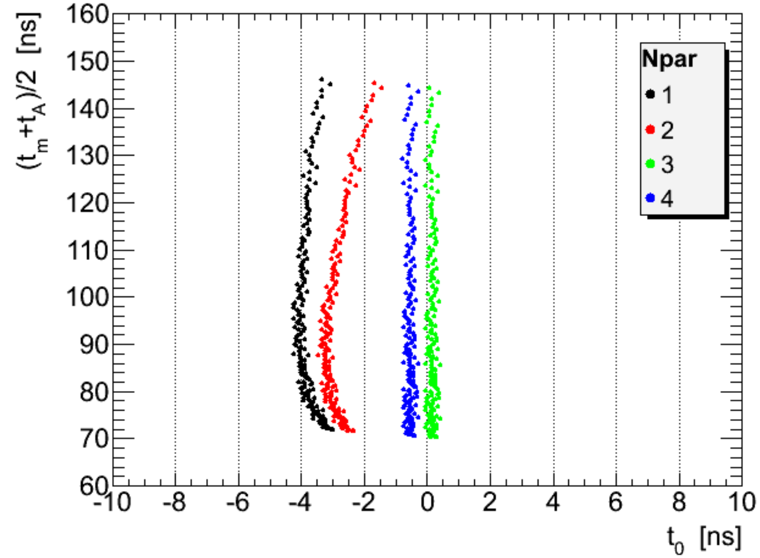
Some results for fixed α (5 keV/count)

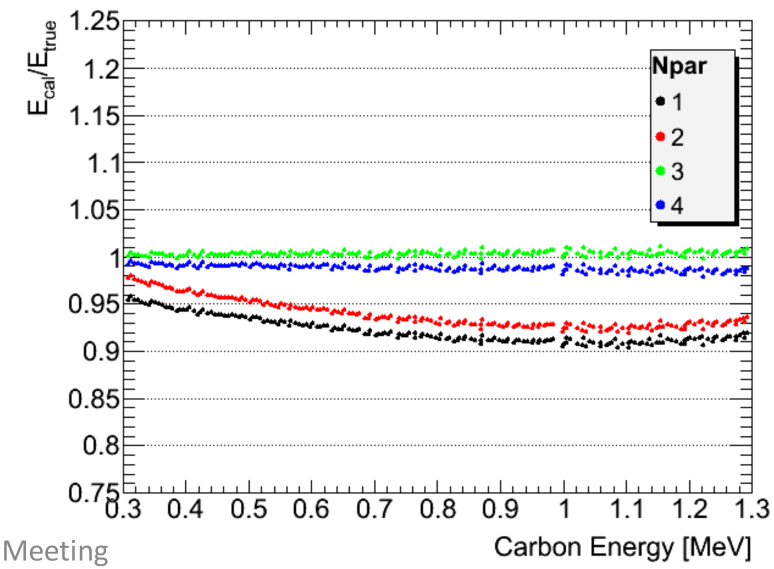
$$dE/dx = a + bE + cE^2$$



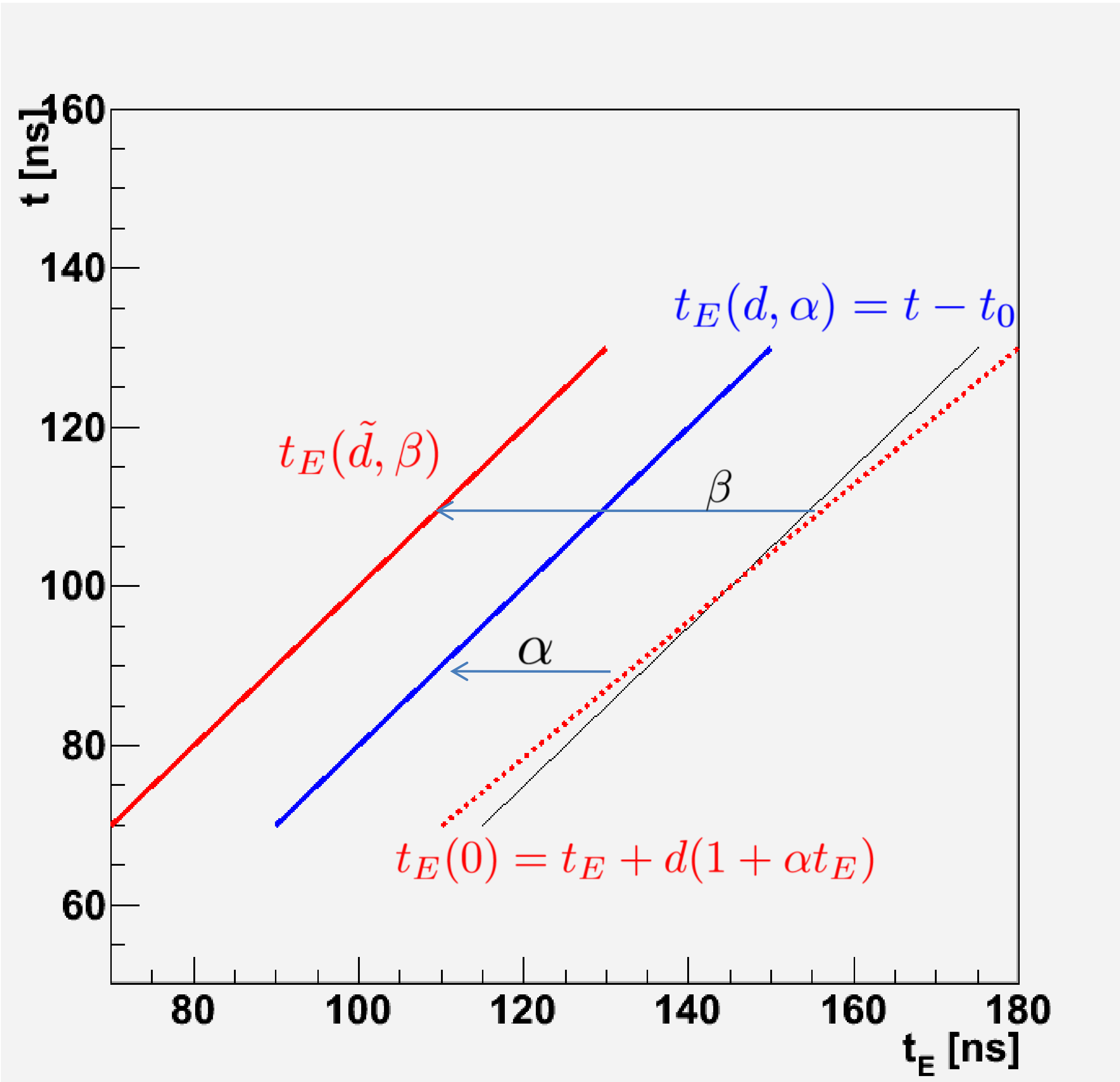


$$dE/dx = 1/(a + bE + cE^2)$$





Why fit is unstable? A toy example.



α, d – true parameters

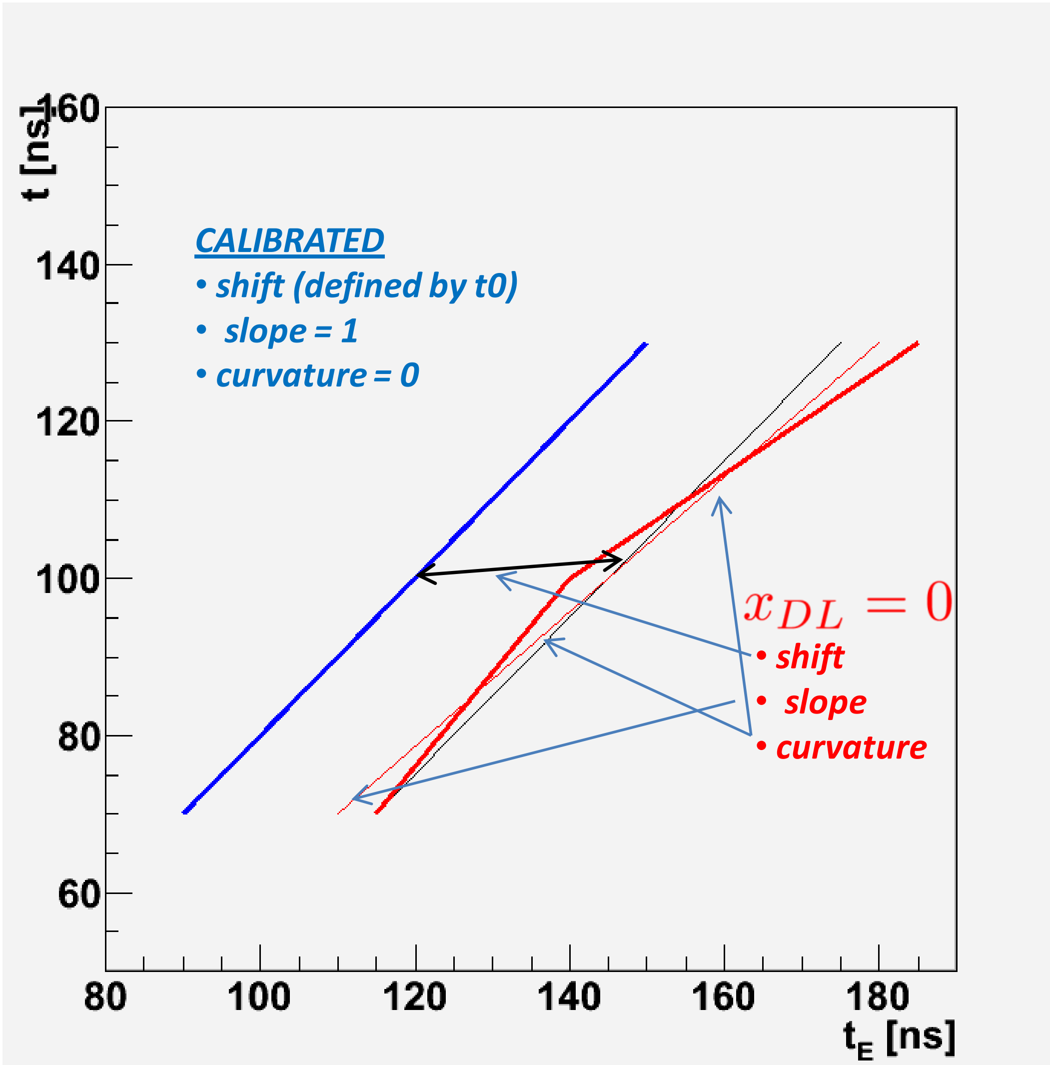
β – supposed parameter

$$\alpha, \beta \ll 1$$

$$\delta t_0 = \frac{d}{1+\alpha d}\,\frac{\alpha-\beta}{\beta}$$

Very big error in estimate of t0 was caused by small second order corrections

More realistic example



The problem

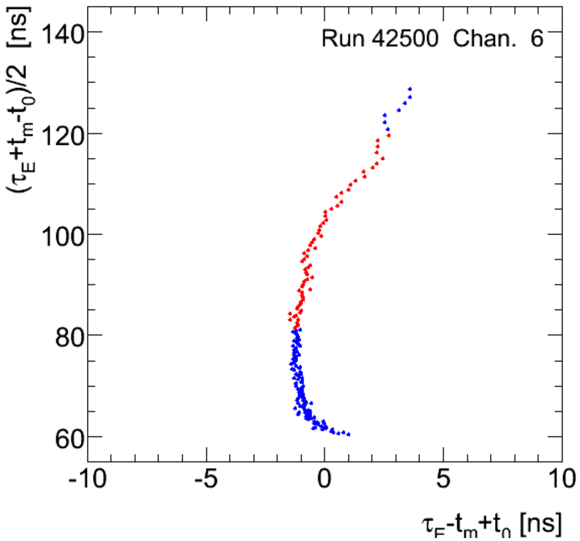
As it was reported by Dmitri and Bill we observe significant (~ 5 ns) change in "calibrated" value of t0, but do not see variation of t0 in direct measurements (PMT).

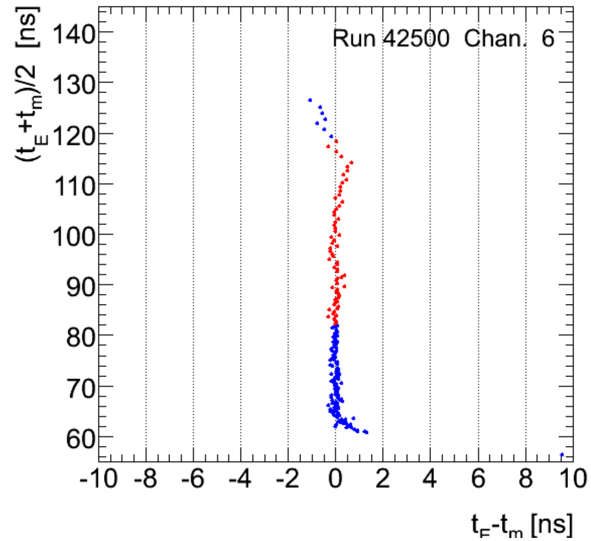
This is **clear** indication that calibration does not work properly

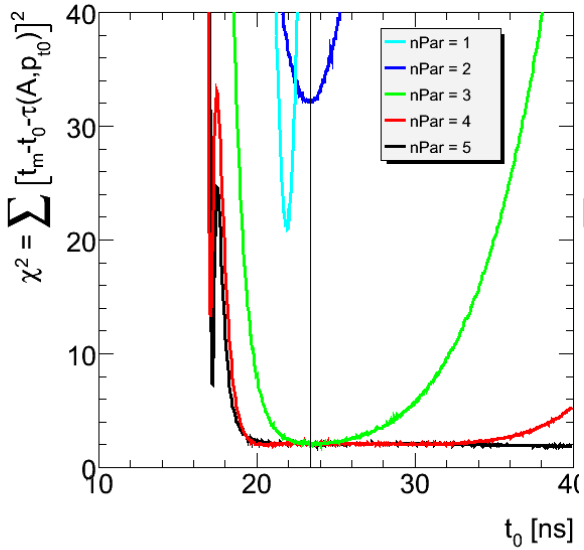
5 ns error in t0 corresponds to 10-20% error in the energy scale !

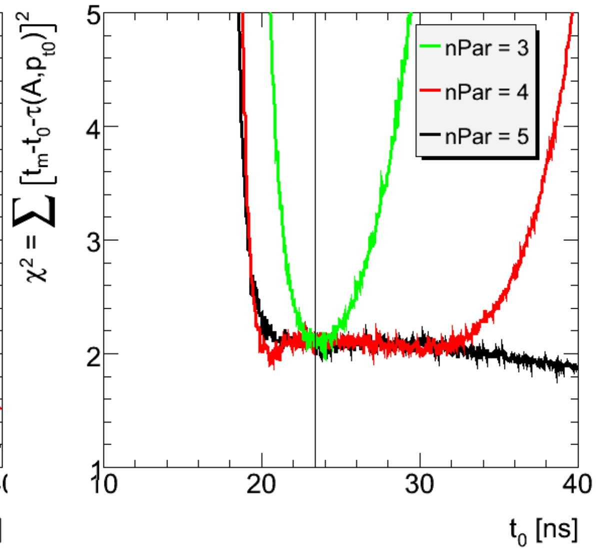
We should fix the value of t0 ! Even if it will be wrong value, the energy scale will be permanent. Such errors in energy scale will be absorbed in modified analyzing power function.

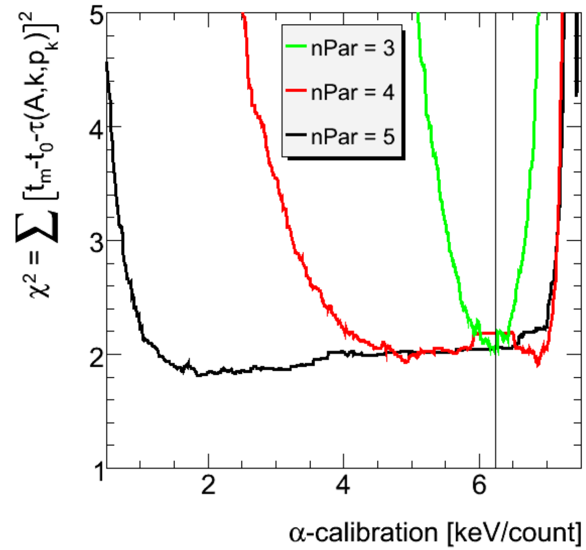
Exercise with real data (Run 09)











No good results for Run 11 yet

Conclusion

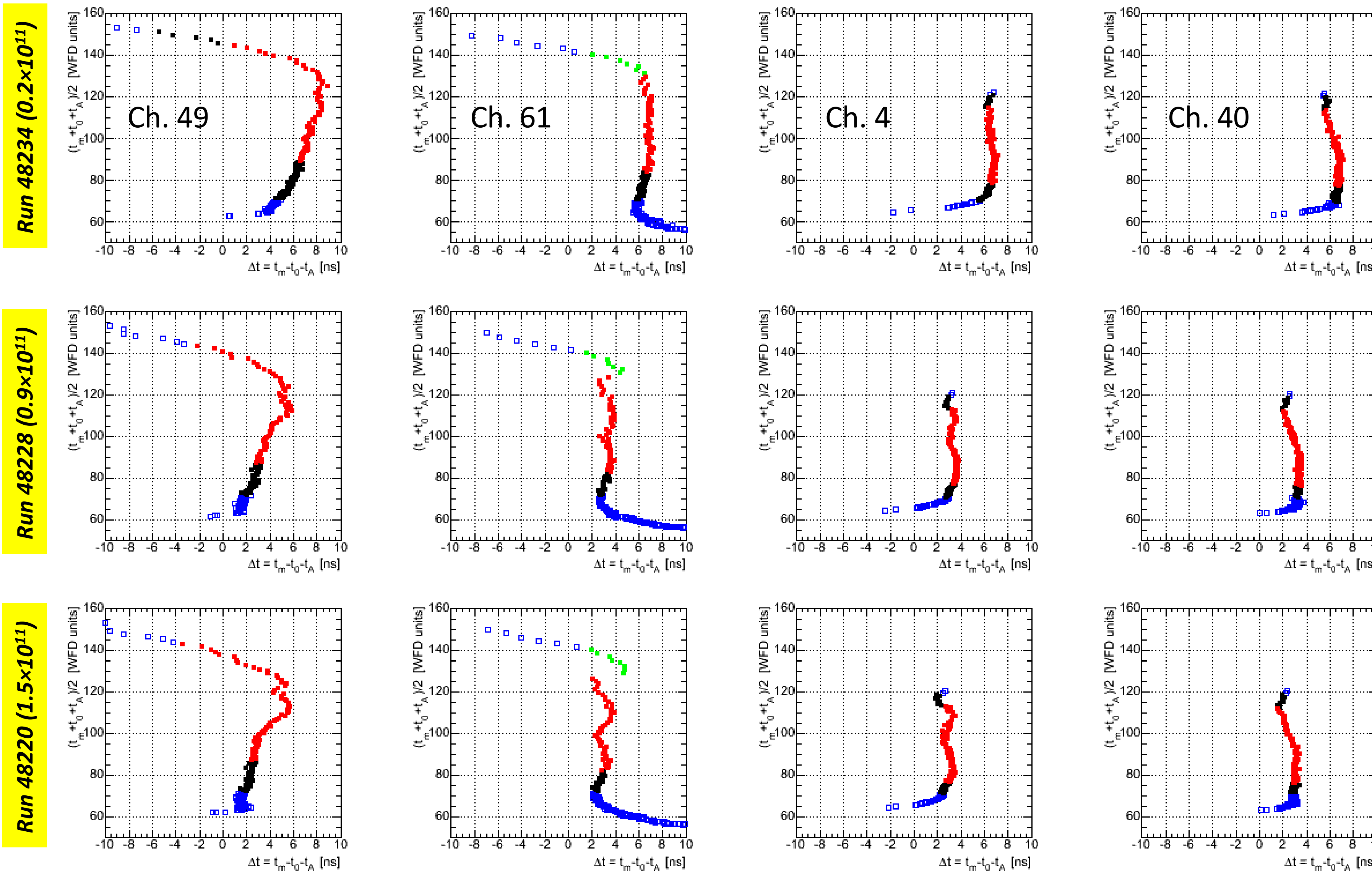
- We can not trust to the existing t_0/x_{DL} calibration.
- 10% error sin energy scale are likely
- Even small disagreement between effective ***dE/dx*** and its parameterization may result in significant corruption of the calibration.
- Independent determination of t_0 is needed

Could we improve the calibration ?

- Find a better parameterization
- Simultaneous fit of t_0 and α may give verification of a good parameterization.
- Make calibration in other energy range (*for example* 800 < E < 1500 keV).
- Fix the value of t0 (even it will not be correct , we always will have the same energy scale).

Backup

Beam Intensity Dependence

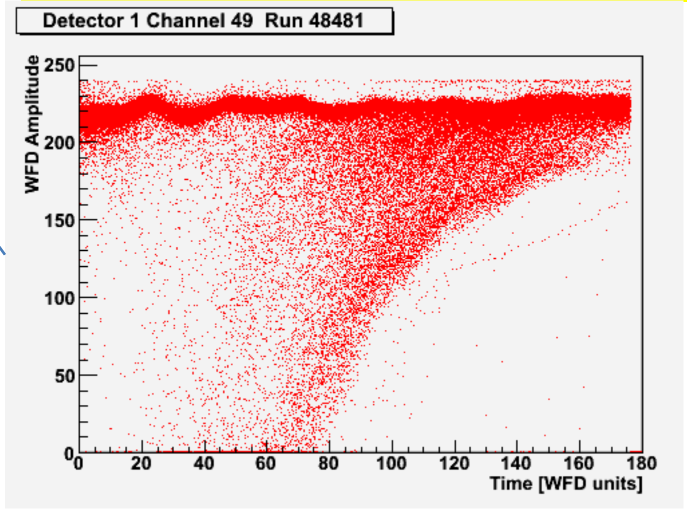


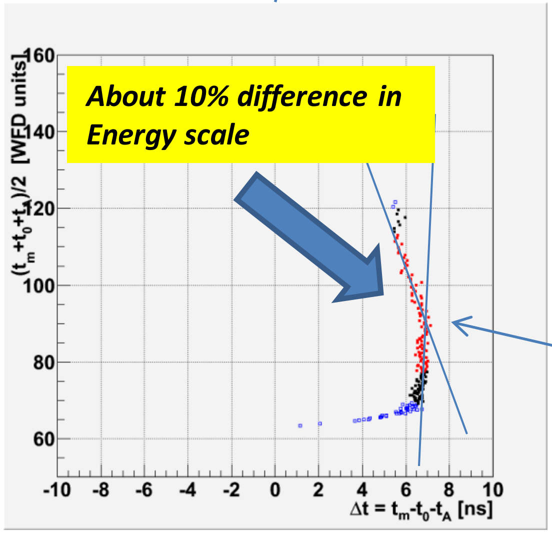
Conclusions from previous slide

- t_0 is intensity dependent
- data is affected by "beam correlated noise"
- standard t_0/x_{DL} calibration may give biased estimate of t_0 (wrong Energy scale)
- *do we really see that energy scale depends on energy?*

Must not affect Polarization measurement

May corrupt the t0/xDL calibration

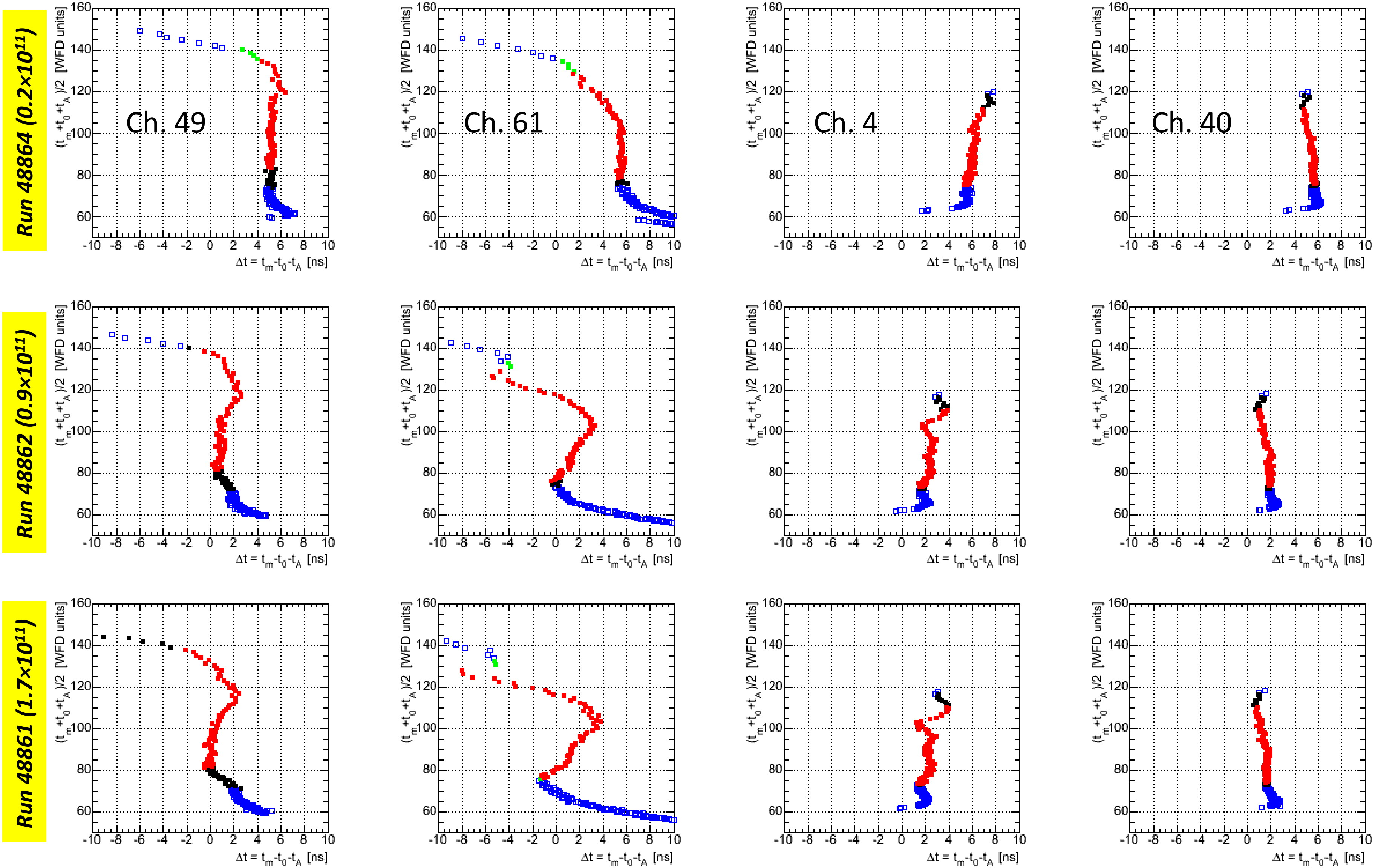




If YES than it gives direct explanation why results of measurements depend on intensity.

The <u>effective</u> dE/dx is not the same as ionization losses dE/dx

Recent data



Run 48864 (0.2×10^11)
Run 48862 (0.9×10^11)
Run 48861 (1.7×10^11)
Ch. 49
Ch. 61
Ch. 4
Ch. 40
$(t_m+t_0+t_A)/2$ [WFD units]
$\Delta t = t_m-t_0-t_A$ [ns]