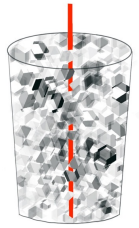

GRAiNITA status report

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GRAiNITA concept

Inspired by LiquidO technique for neutrino detector
(A. Cabrera et al. LiquidO Commun Phys 4, 273 (2021))

Typical sampling calorimeters:

$$\frac{\sigma_E}{E} \sim \frac{10\%-15\%}{\sqrt{E}}$$

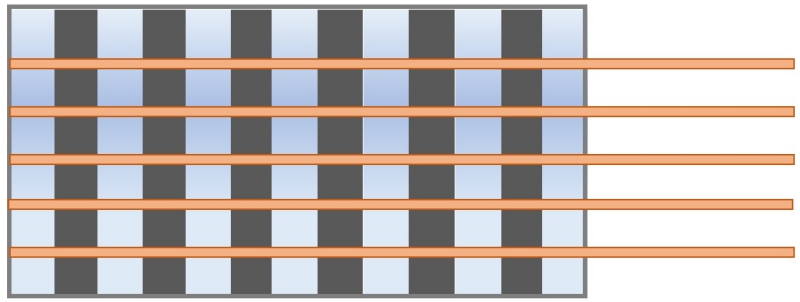
Crystal calorimeters :

$$\frac{\sigma_E}{E} \sim \frac{1\%-2\%}{\sqrt{E}}$$

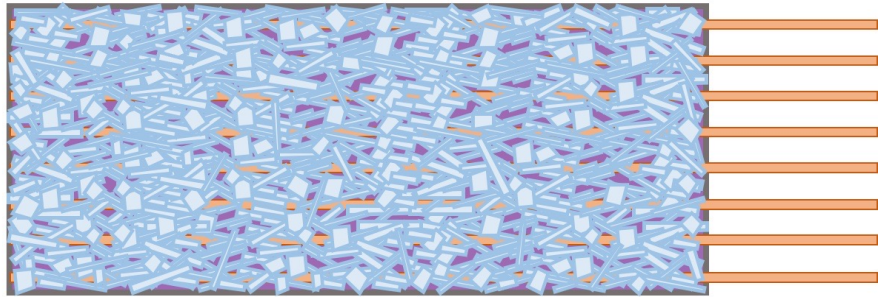
Requirements:

- fine sampling
- scintillation light locally contained

Shashlyk-type calorimeter



GRAiNITA

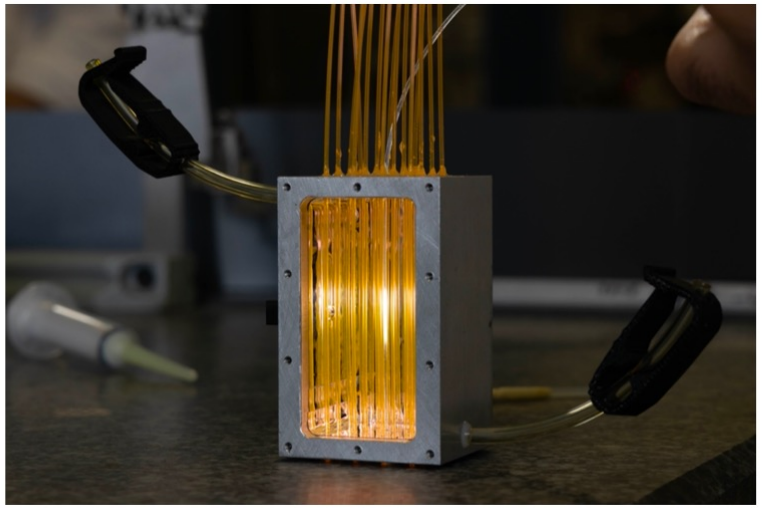


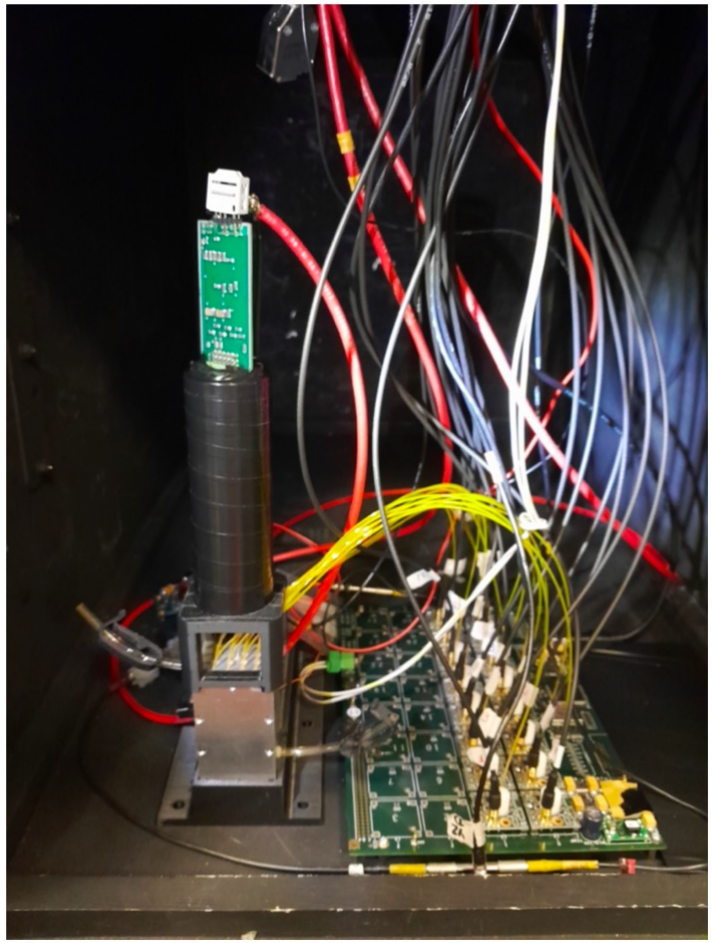
Where are we ?

Small (2 x 2 x 5.5 cm^3) prototype filled with ZnWO4 grains + water or Heavy Liquid (EGL or) and 16 WLS fibers

Depolished fiber in the center to allow for green light injection

	$ZnWO_4$
Effective Z	61
Density (g/cm^3)	7.87
Refractive index	2.0 - 2.3
Light yield (photons/MeV)	~ 9000
Peak emission wavelength (nm)	480
Decay time (μs)	20
Radiation length (cm)	1.20
Molière radius (cm)	1.98





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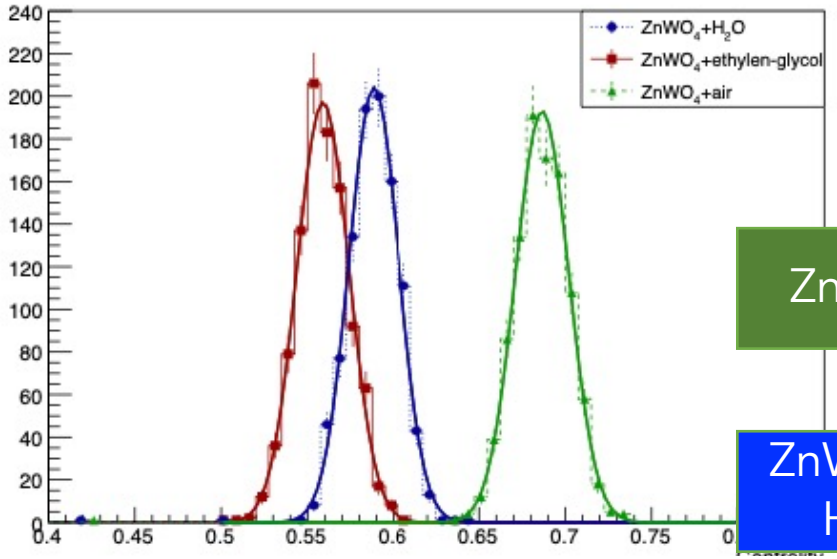
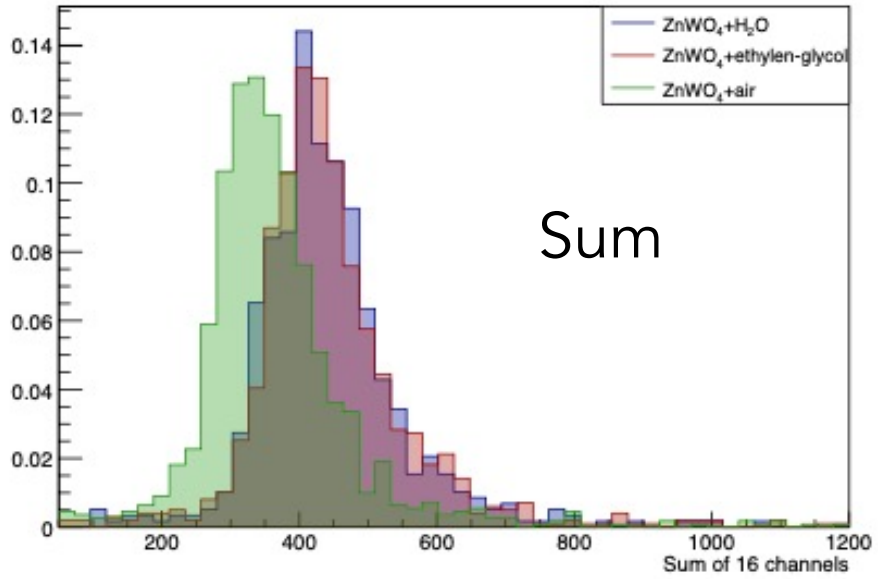


$ZnWO_4$

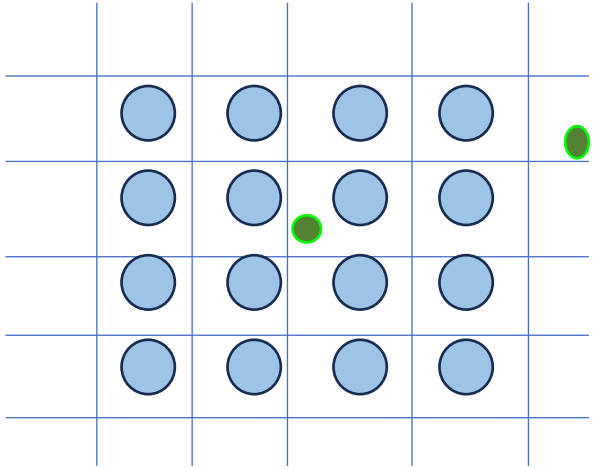
$ZnWO_4 + H_2O$

$$\text{Centrality} = \frac{4\ central\ channels}{Sum}$$

$ZnWO_4$ + EGL



Sum



Green light injection

1. Light is confined

2. Most Probable value (fit by Landau) : ~400

⇒ ~ 10 000 photo-electrons/GeV

⇒ opens the road to a a statistical fluctuation of 1% /sqrt(E) due to photon statistics

Many thanks to Yuri Guz
and Loris Martinazzoli

In March, we were informed of the possibility to be parasitic in a test beam for LHCb-U2 calorimeter tests in the H2 region in the CERN North Area

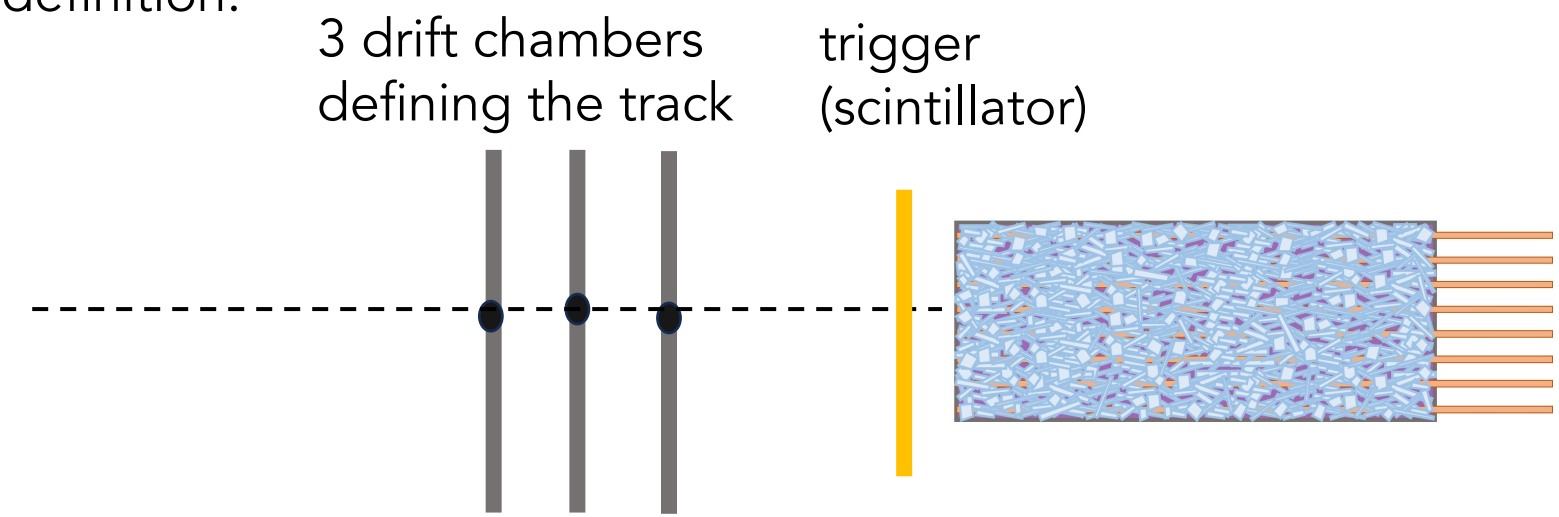
We decided to put our small prototype in a beam of muons and pions (about only ~5% of the pions are supposed to interact in our prototype).
It was a nice week-end

We have recorded in ~ 48h millions of muon and pion triggers in two configurations : $ZnWO_4$ grains immersed in water or in HL

Hervé input (a drawing) ?? I think I remember one

Heavy liquid name ???

Track definition:

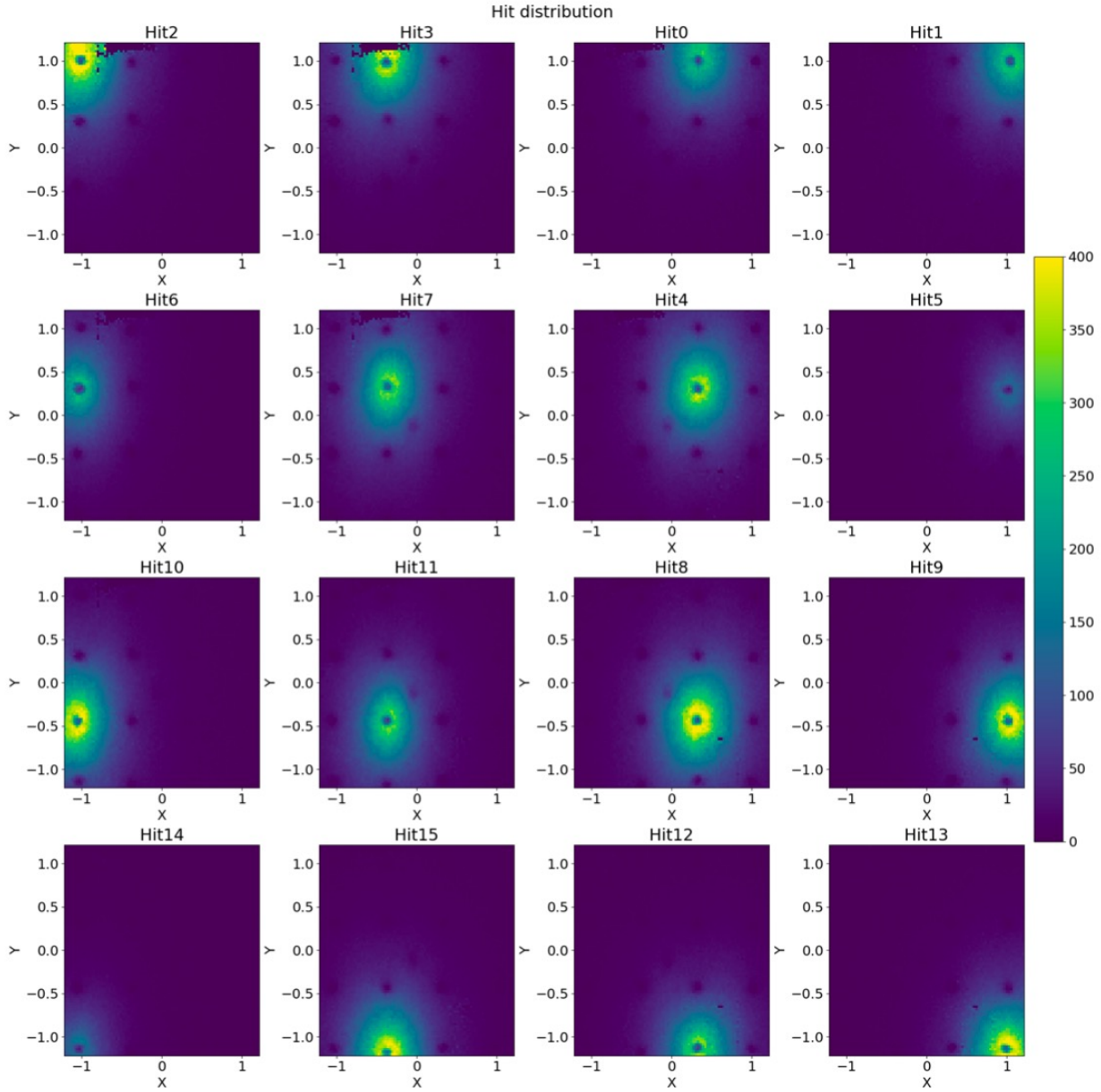


read-out by a 16-channels wave catcher adapted to count the number of photo-electrons in a 25 μs window

Do we want to mention that
GRAiNITA & DCH are read-out separately ?

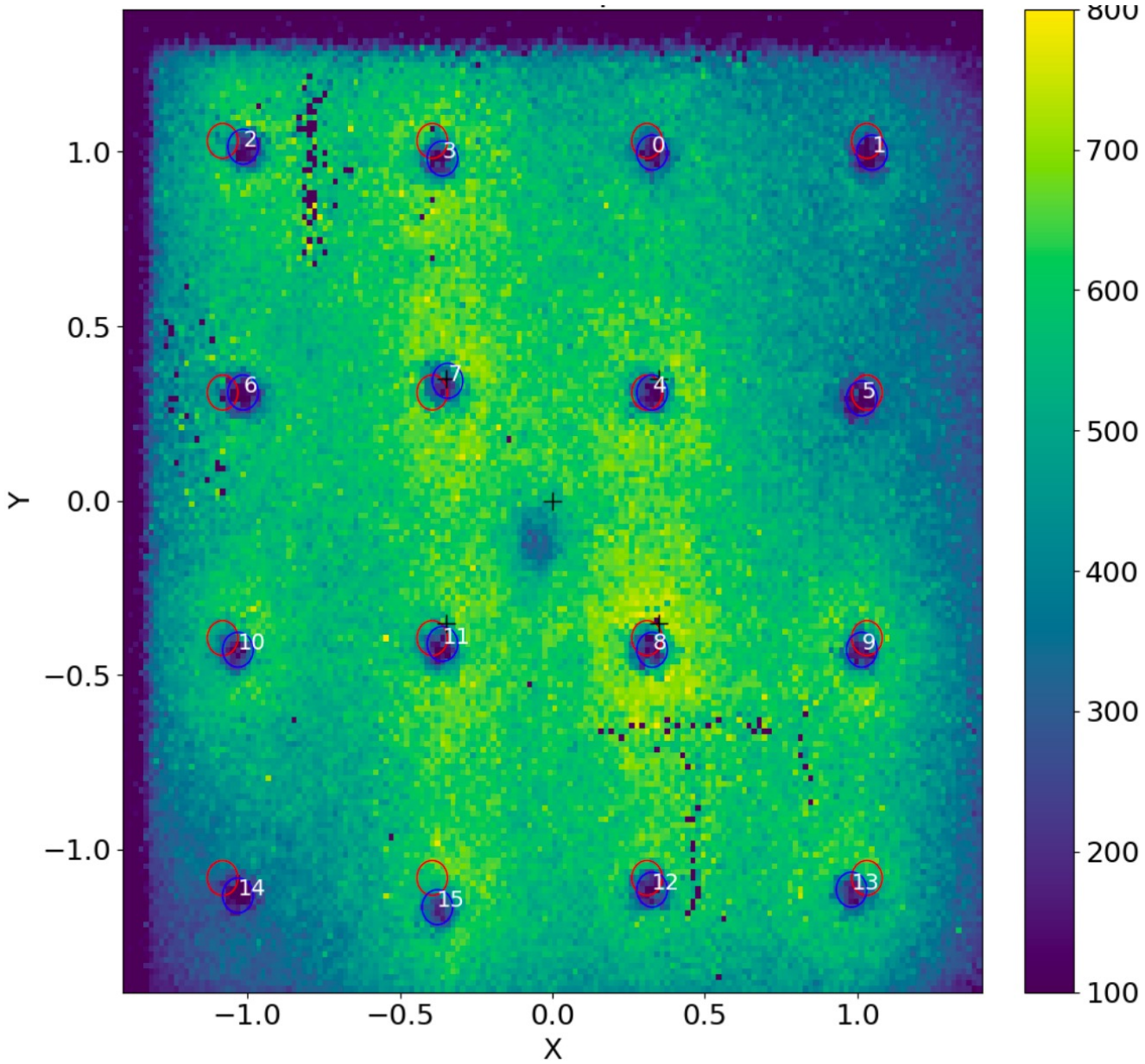
Millions of triggers

Plot for all tracks the position of the track weighted by the response from each fiber

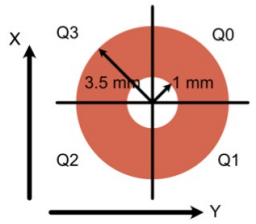


Confirmation of the light confinement

Plot for all tracks the position of the track weighted by the global answer from the prototype



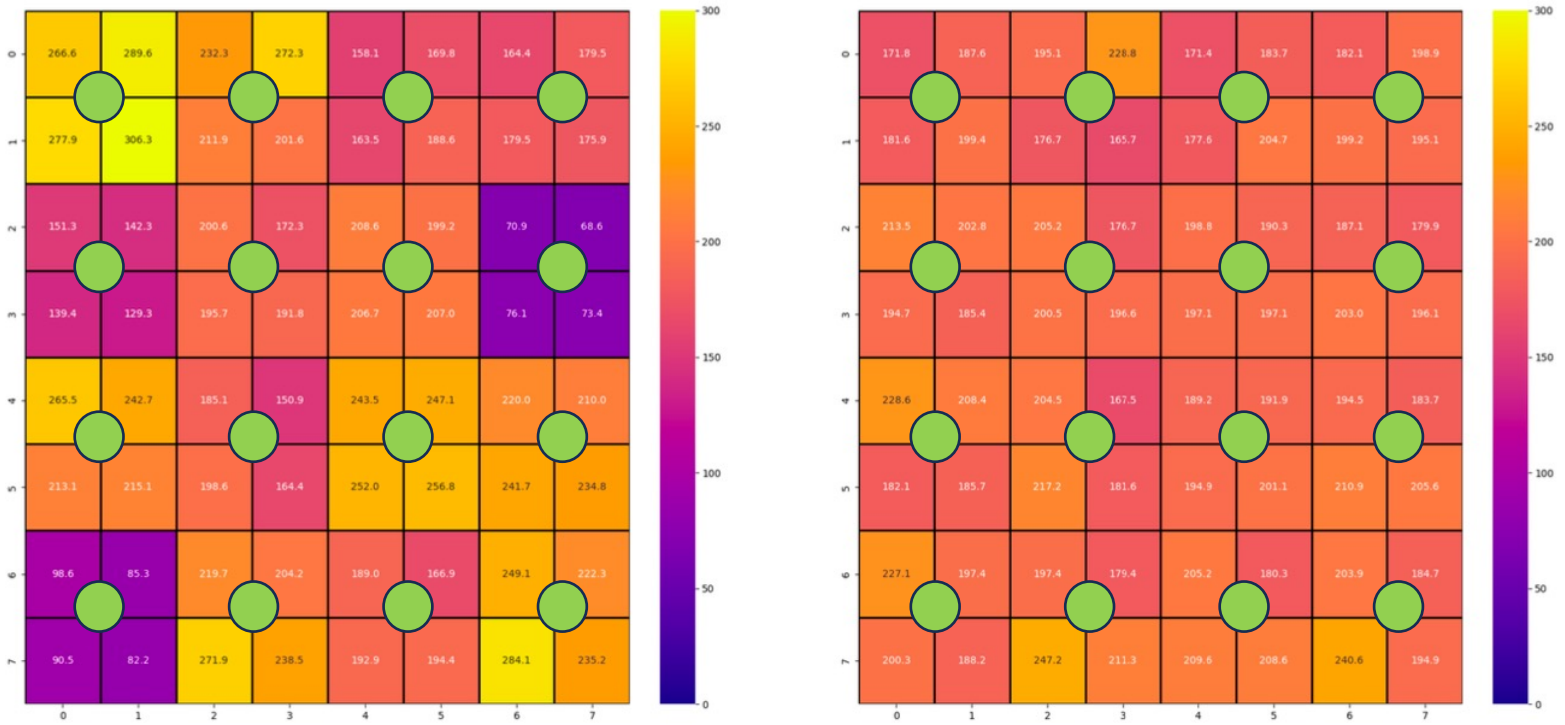
Uniformisation of the fiber response



For each fiber:

- plot the fiber response (avoiding edge effect) and fit with Landau⊗Gaussian → MPV
- compute the average of the MPV (<MPV>).
- → 16 coefficients (one per fiber)

Difference to <MPV>

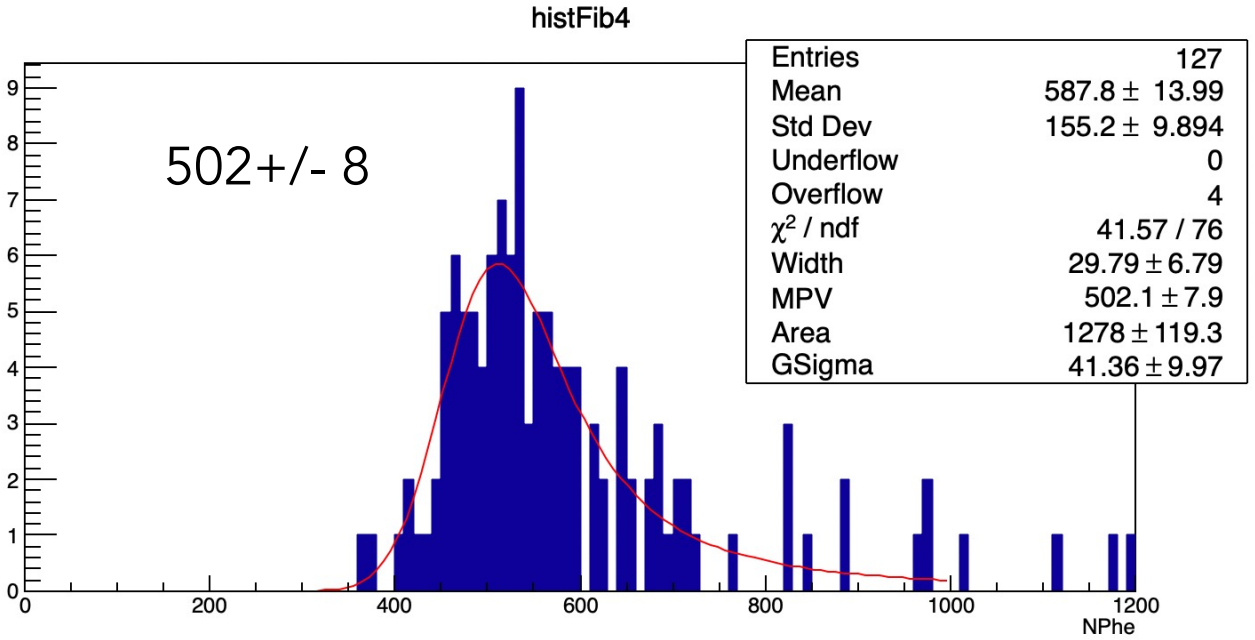


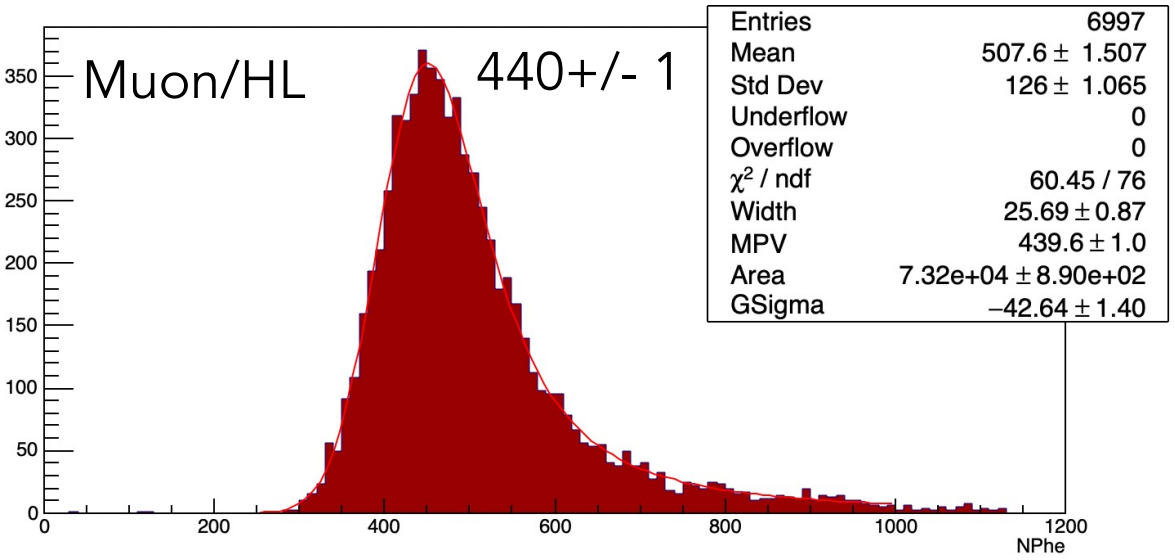
Before

After

Near Uniformisation parameters to do more than 1 fiber

Muon/Water





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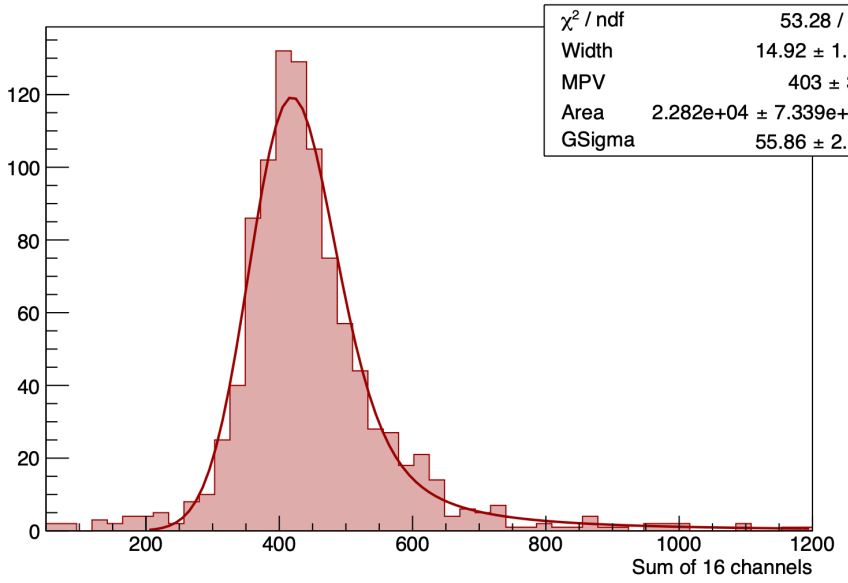
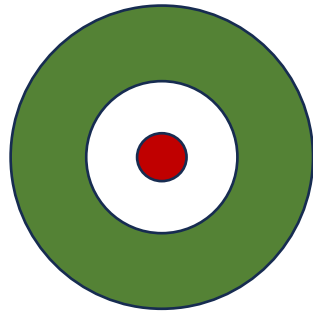


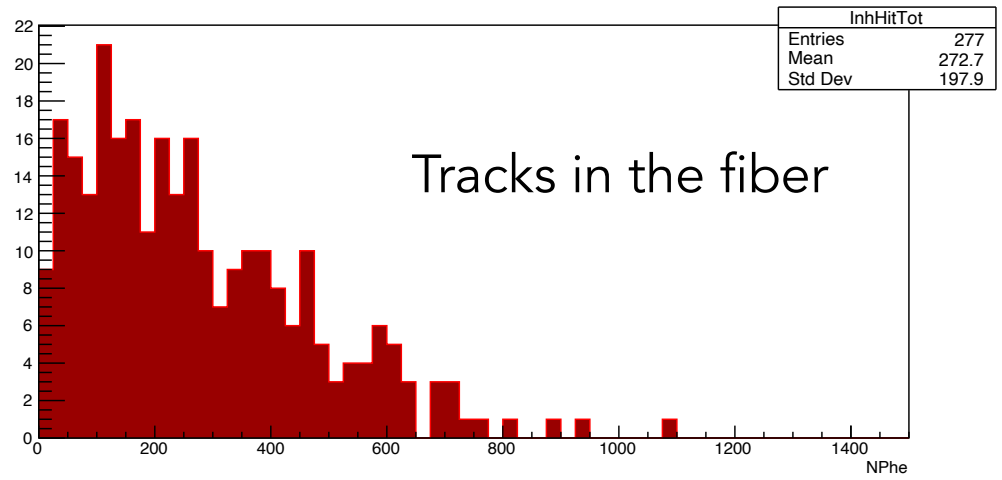
confirmation of the sampling term !

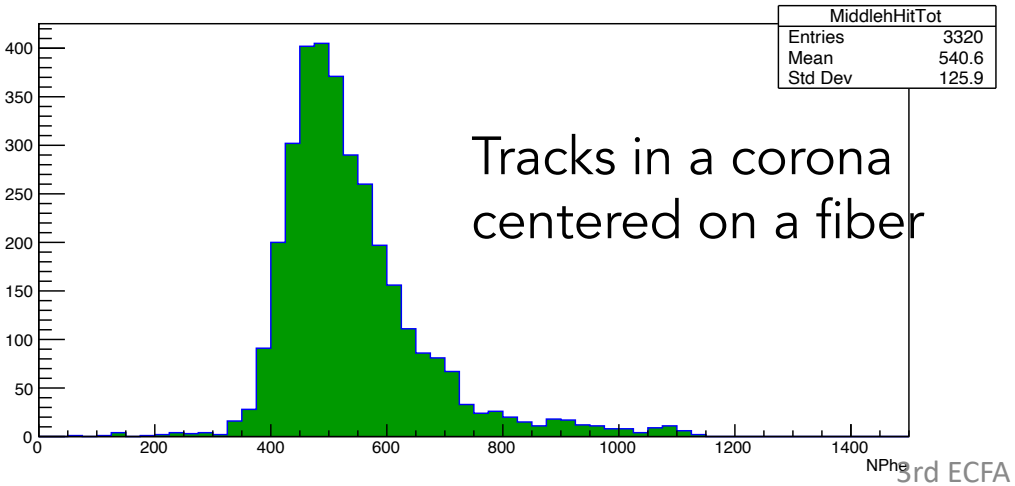
Towards the uniformity study

How does the signal evolves around a fiber ?

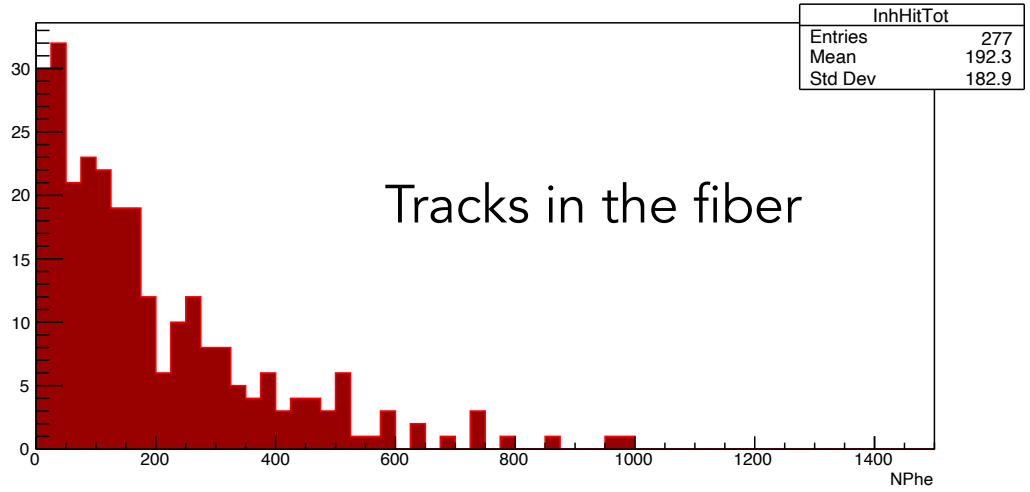


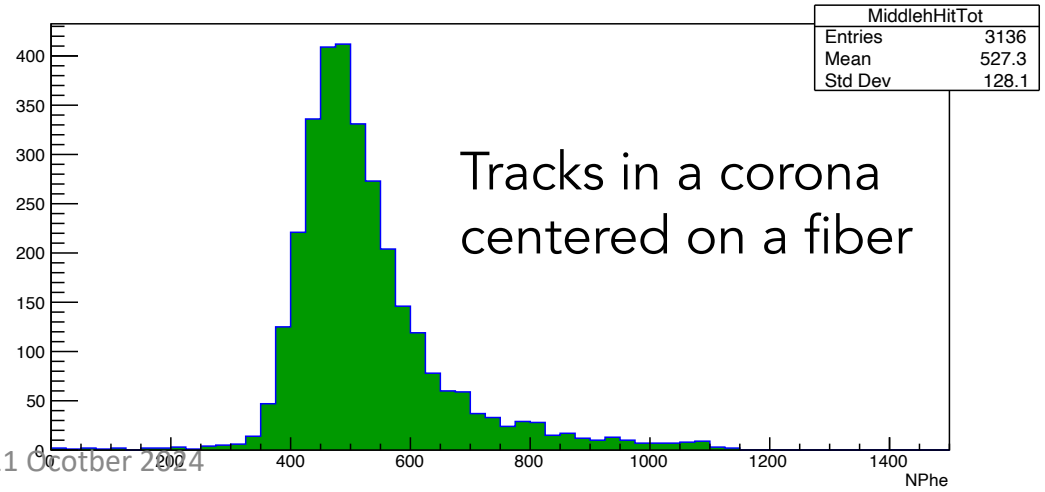
Fiber7





Fiber4





Towards non-uniformity determination

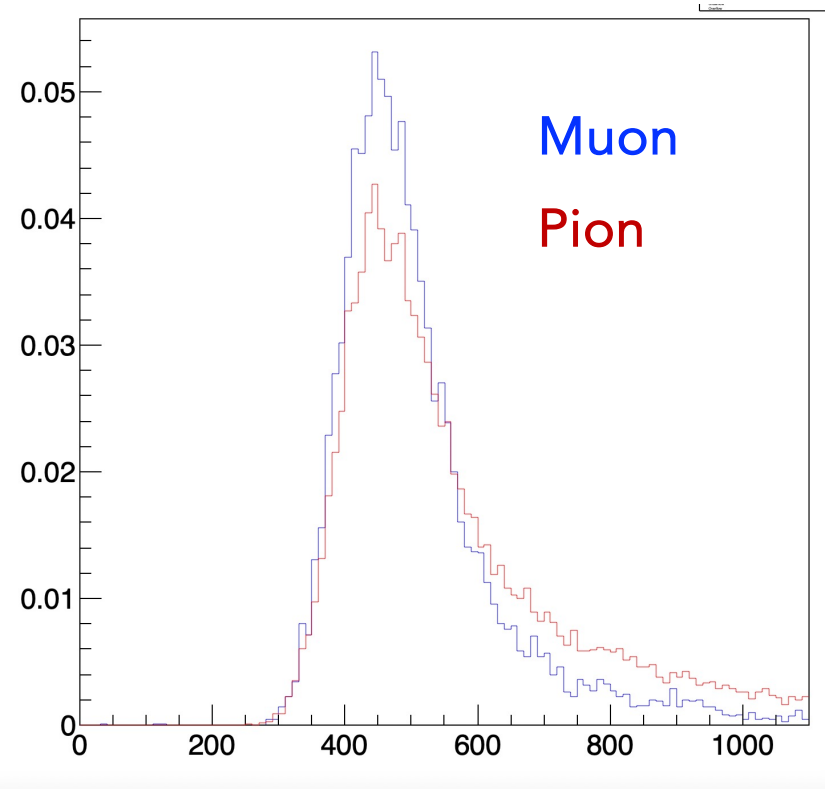
Explain we restrict to the central region (VM2000, border effects)

Show some 1D plots something with Muon-only ??? (do we dare adding 33 -34 + 59 & 60 to increase the stat, here I assume SiBB correction is fine ??(meaning add water and HL)

Give a rough number of the corresponding constant term …. ?????

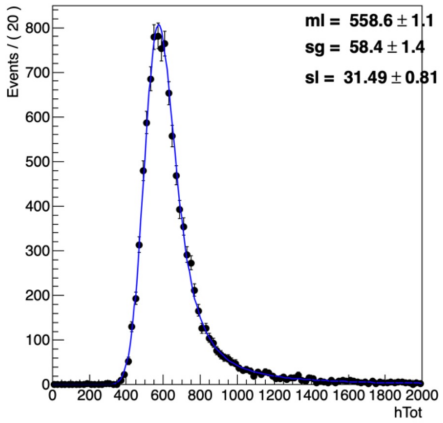
Towards the use of the π beam data

About 5% of the π interact in the prototype
π beam has higher-stat but is more less pure

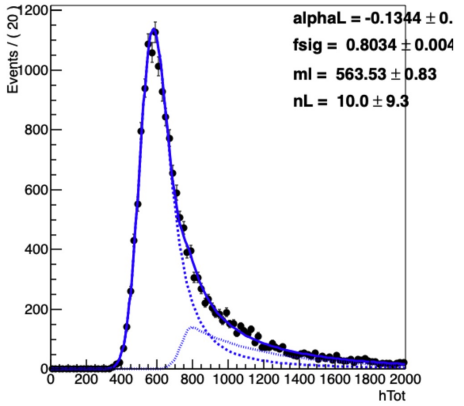


Use the tracks close to a fiber (here Fiber8) for the modelling of the response

Muon Fit:
Landau⊗Gaussian

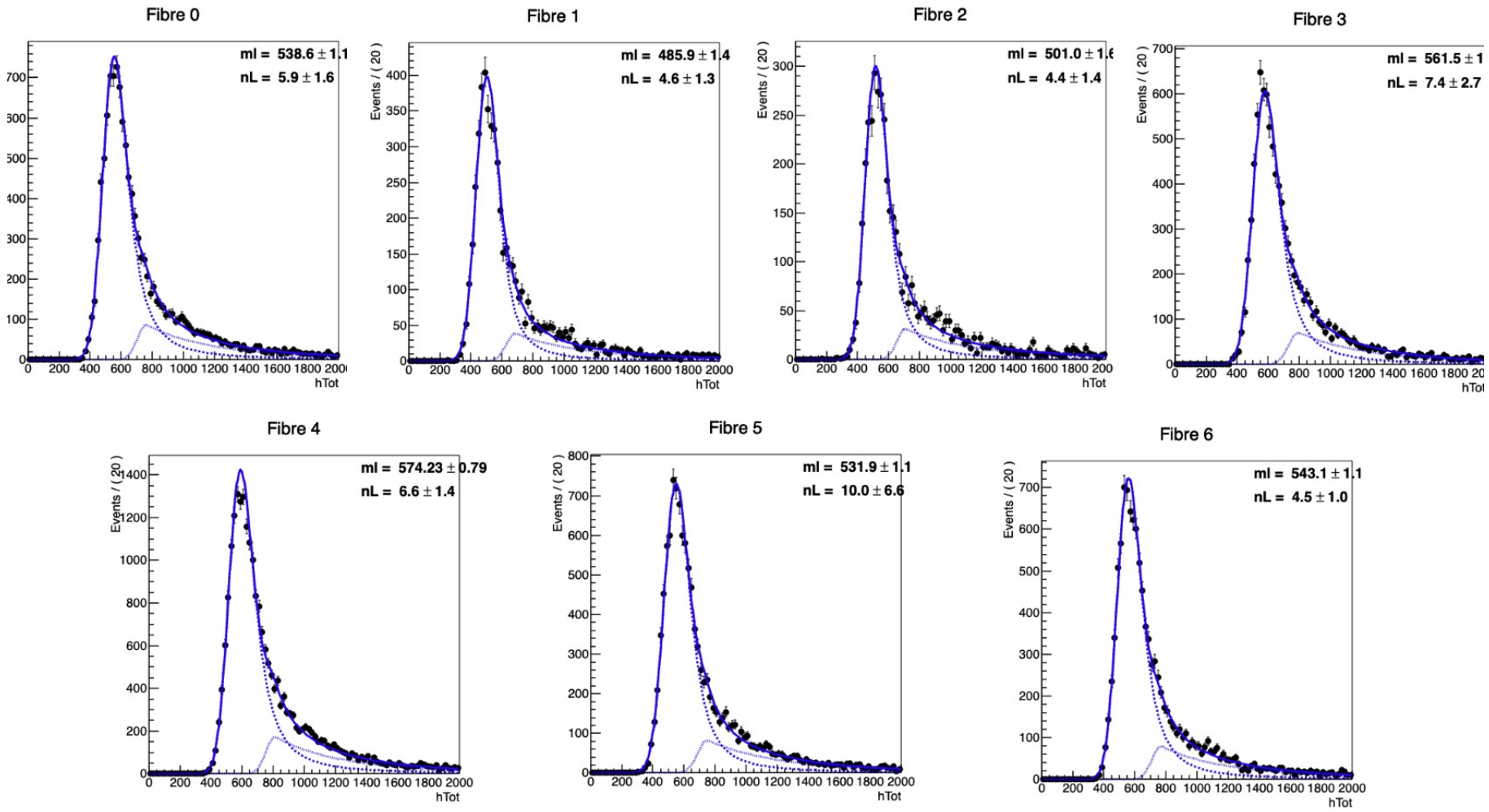


Pion fit :
Landau⊗Gaussian (parameters from Muon, but MPV) + Asym-CB (mean and sigma related to Landau ⊗Gaussian)



Near Uniformisation parameters otherwise misleading

Is this shape universal enough ?



seems promising

Conclusion

- Confirmation of the number of photo-electron : statistical fluctuation of $\frac{1\%}{\sqrt{E}}$
- If the track is more than 5 mm away from the limit of the fiber the variation are small
- A priori enough data for a first study of the uniformity
- Limitations due to the prototype size