

# Time resolution



# Introduction

The time resolution can be extracted from the width of the time differences computed from the LGADs and the SiPMs. Assuming that  $N$  devices with time resolutions  $\sigma_k$  are used, there are  $N \cdot (N-1)/2$  possible combinations. Assuming that the time resolutions of the devices are independent, for each combination, one has:

$$\sigma_{ij} = \sigma_i \oplus \sigma_j \quad (2)$$

where  $\sigma_{ij}$  is the width of the time difference distribution between device  $i$  and  $j$  and it is estimated as the width of a Gaussian function fitted iteratively on a range  $[-3\sigma_{ij}, 3\sigma_{ij}]$ . Therefore, one has  $N$  unknowns and  $N \cdot (N-1)/2$  constraints. For  $N=2$ , the system is under-constrained and no solution can be found without further assumptions. For  $N=3$ , the number of constraints equals the number of unknowns. In this case, the system of equations is linear considering the square of the time resolution as the unknown and it can be solved analytically. For  $N>3$ , the system is over-constrained and in order to fully use the available information, the time resolution can be extracted using a  $\chi^2$  minimization technique:

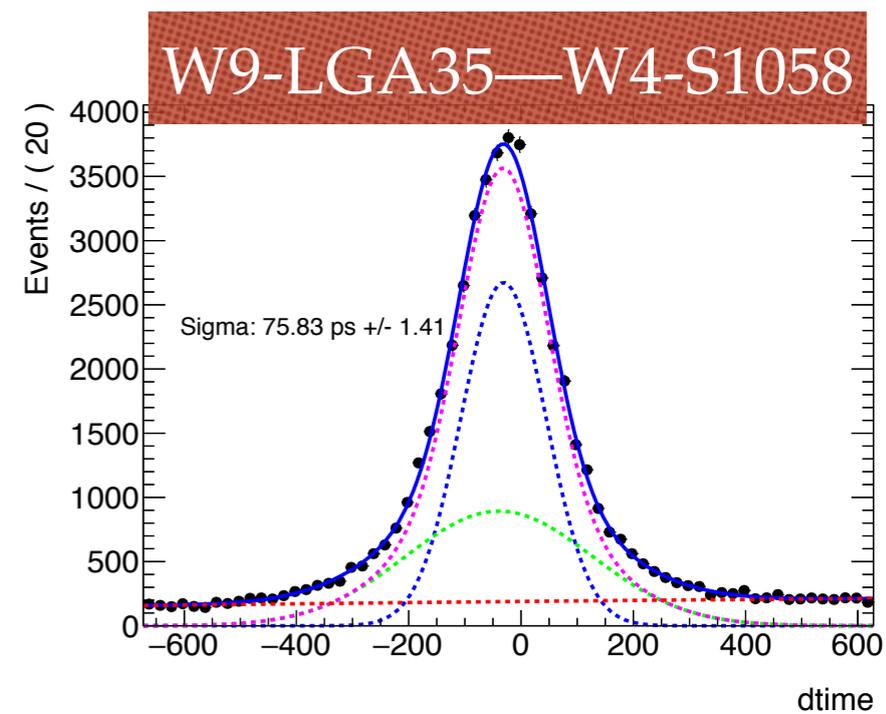
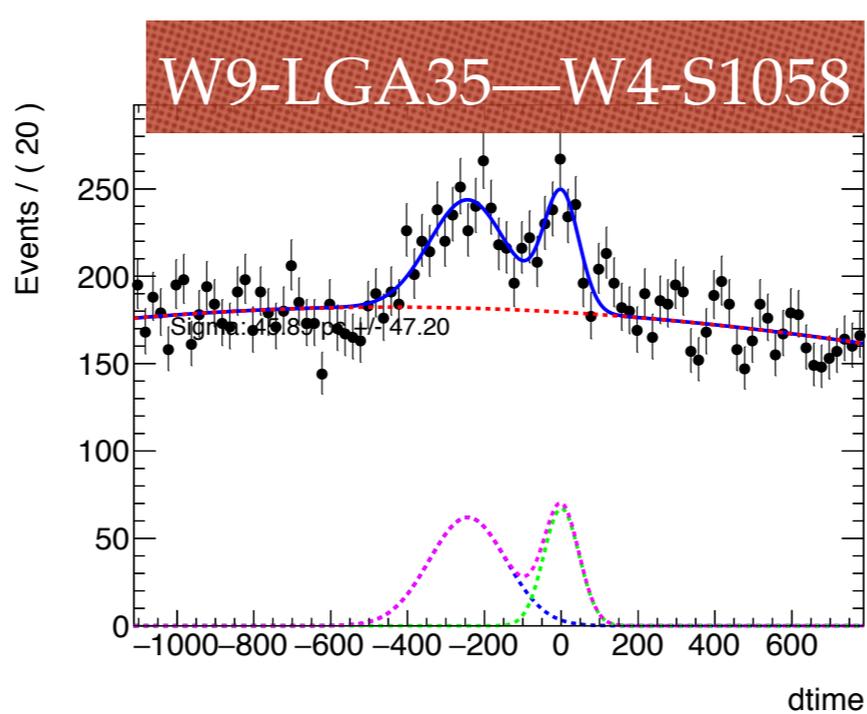
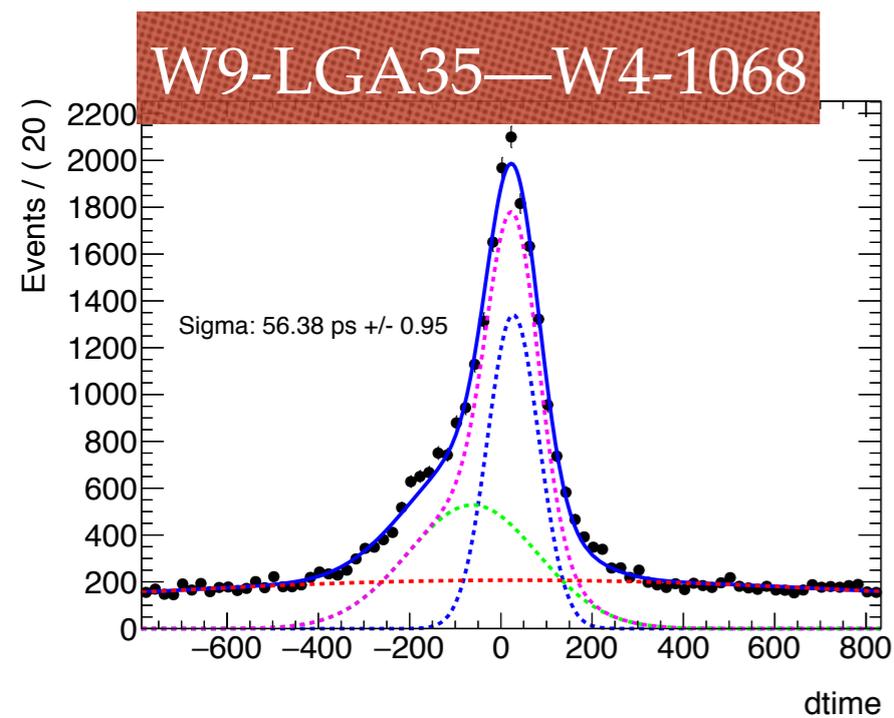
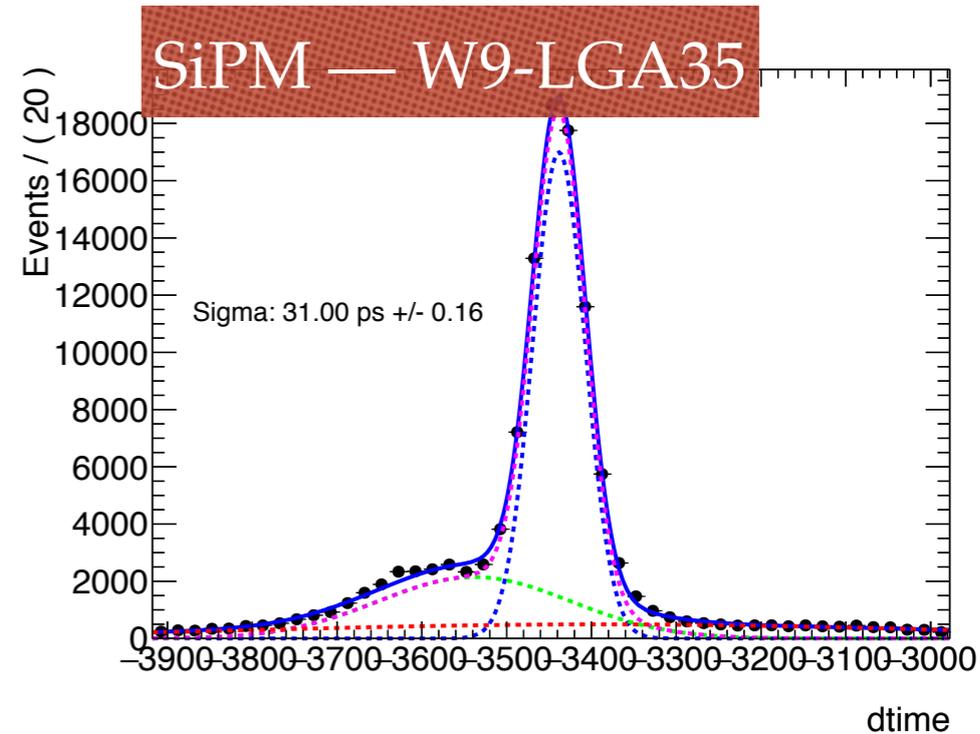
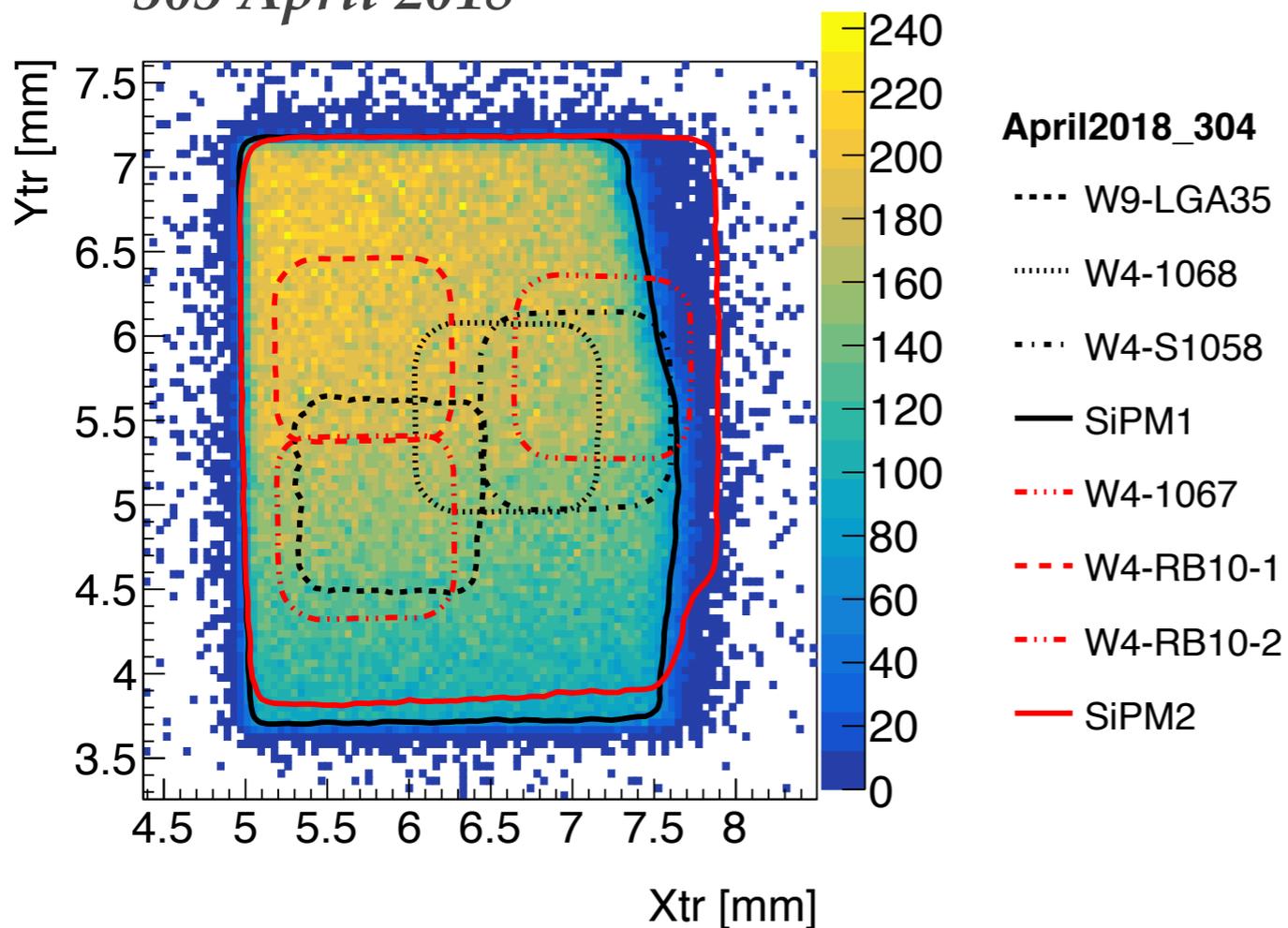
$$\chi^2 = \sum_{i=1}^N \sum_{j=1}^{j<i} \frac{(\sigma_{ij}^2 - \sigma_i^2 - \sigma_j^2)^2}{\sigma_{\sigma_{ij}}^2}$$

[https://gitlab.cern.ch/atlas-hgtd/TestBeam/PyAna/blob/master/Macros/Q\\_getResoExample.py](https://gitlab.cern.ch/atlas-hgtd/TestBeam/PyAna/blob/master/Macros/Q_getResoExample.py)



# Requirement: aligned

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# Quick results

W9-LGA35	0	26.069632717	+/-	1.09402131091
W4-1068	1	49.990785651	+/-	0.570519814575
SiPM	3	16.7742138415	+/-	1.70027245566

W4-1068	1	46.5868484661	+/-	1.26556302018
W4-S1058	2	59.8318848943	+/-	0.985404233034
SiPM	3	24.7005759042	+/-	2.38693190288

Studying more runs