

# VeLoC - Vertex Locator Clock



Project 14

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on behalf of **DeNVer** collaboration



Detector  
with  
Nice  
Vertex  
Resolution

# VeLoC requirements



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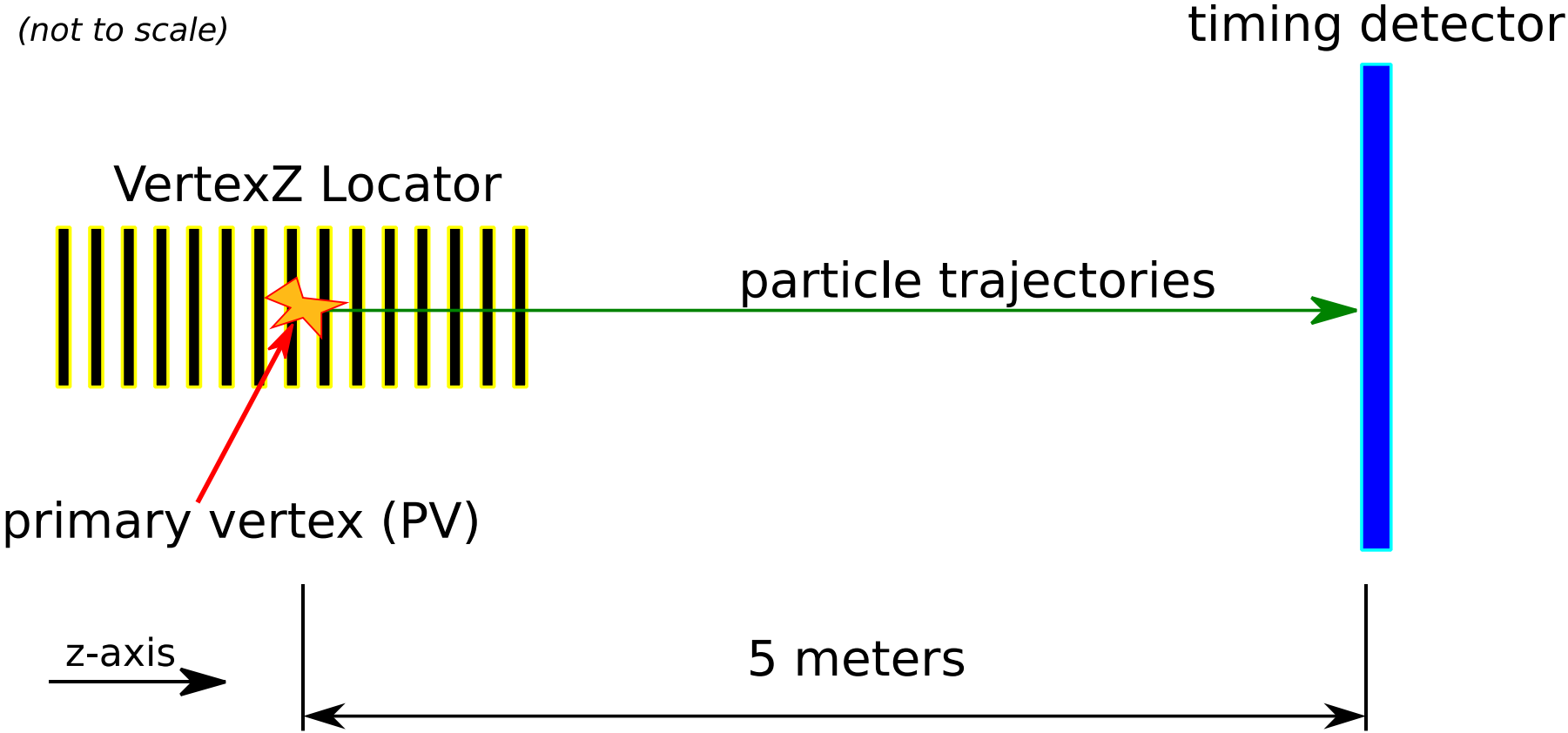
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- Identify and reject primary vertexes (PVs) from pileup at the HLLHC
  - ▣ Collision vertices distributed in  $z$  and  $ct$  with  $\sigma \sim 5$  cm
  - ▣ High precision timing detectors + tracking devices
    - Timing detector accuracy of 10 to 30 ps
    - Silicon tracker resolution of 1 mm
  
- Estimate how many vertexes are left by using a tracker detector with a 1 mm  $z$  resolution and a timing detector with a 10 ps resolution

# Detector



(not to scale)



# Approach



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- 15 particles per PV, after  $|p|$  cut (realistic compared to ATLAS)
- 200 PVs
- All particles go straight with light speed
- Simulation in 4 steps:
  - ▣ Generate particles
  - ▣ Generate detector response (and resolution)
  - ▣ Look at the distribution of the response around the PV
  - ▣ Try to generate clusters out of detector response

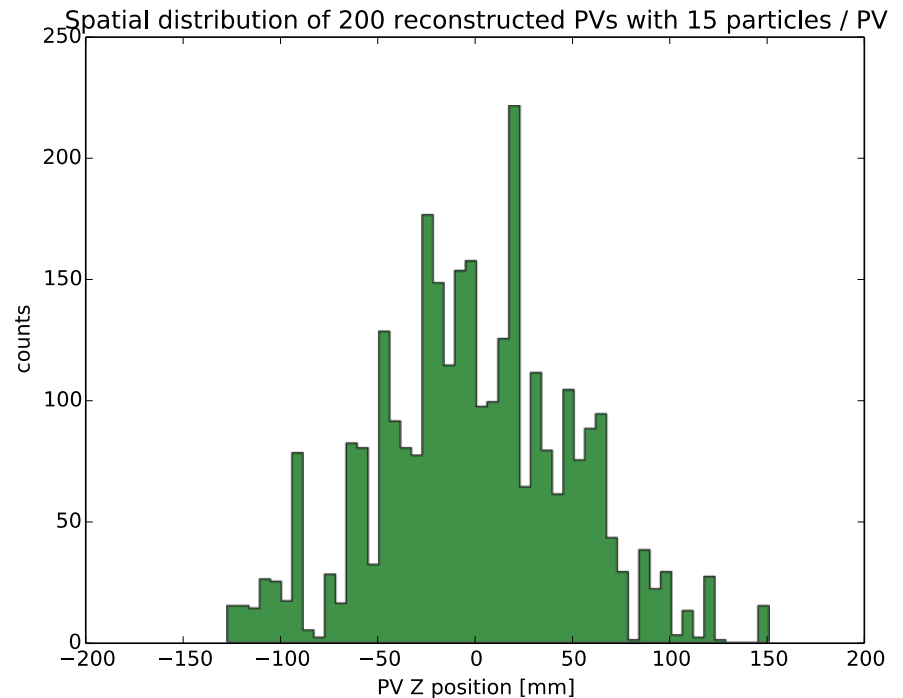
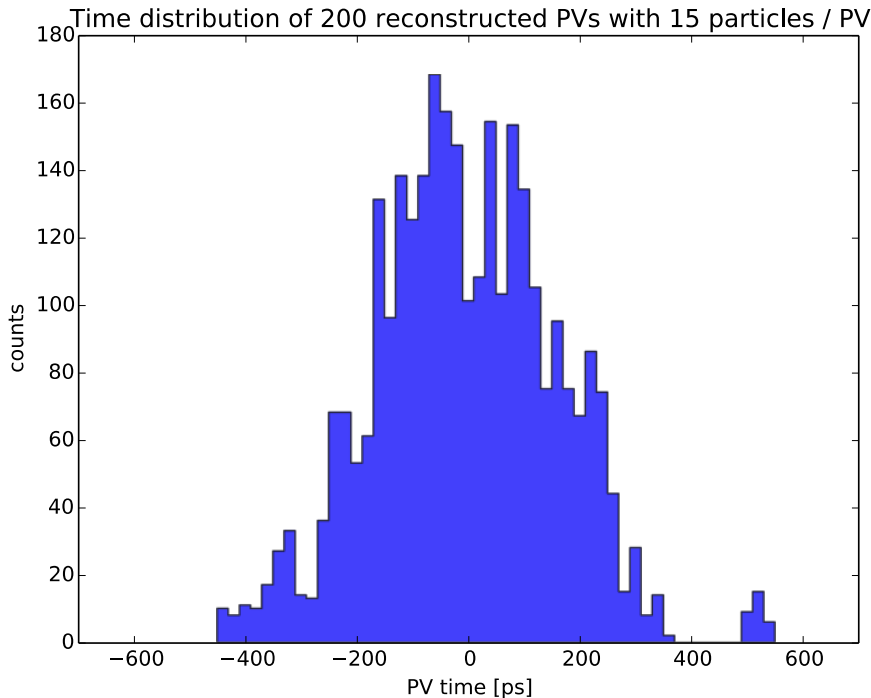
# Detector response 1D view



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- 1 Dimensional analysis doesn't show any cluster formation
- 1D info are not enough to discriminate the PVs
- 2D analysis required



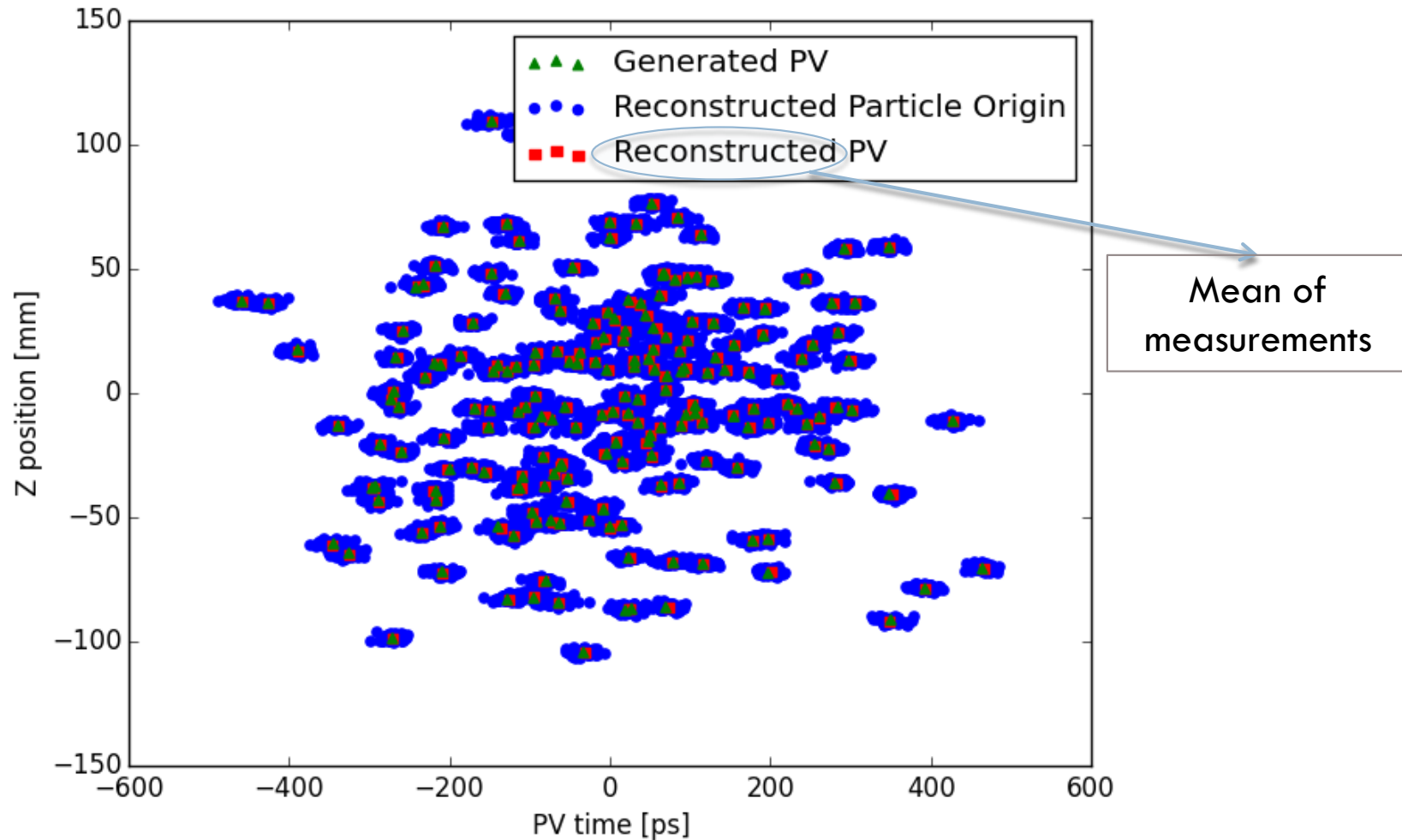
# Detector response 2D view



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Matching PV “reconstructed” and generated



# Detector measurements



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- How often is a particle closer to a different PV than its own PV?

**For  $nPVs = 200$ ,  $\#Particles/PV = 15$ ,  
Bunch crossing = 20**

Info on:	Mis-associated particles to PV [%]
T only	$83.75 \pm 1.10$
Z only	$64.16 \pm 1.85$
T and Z	$28.43 \pm 2.38$

# 1° clustering algo - DBSCAN



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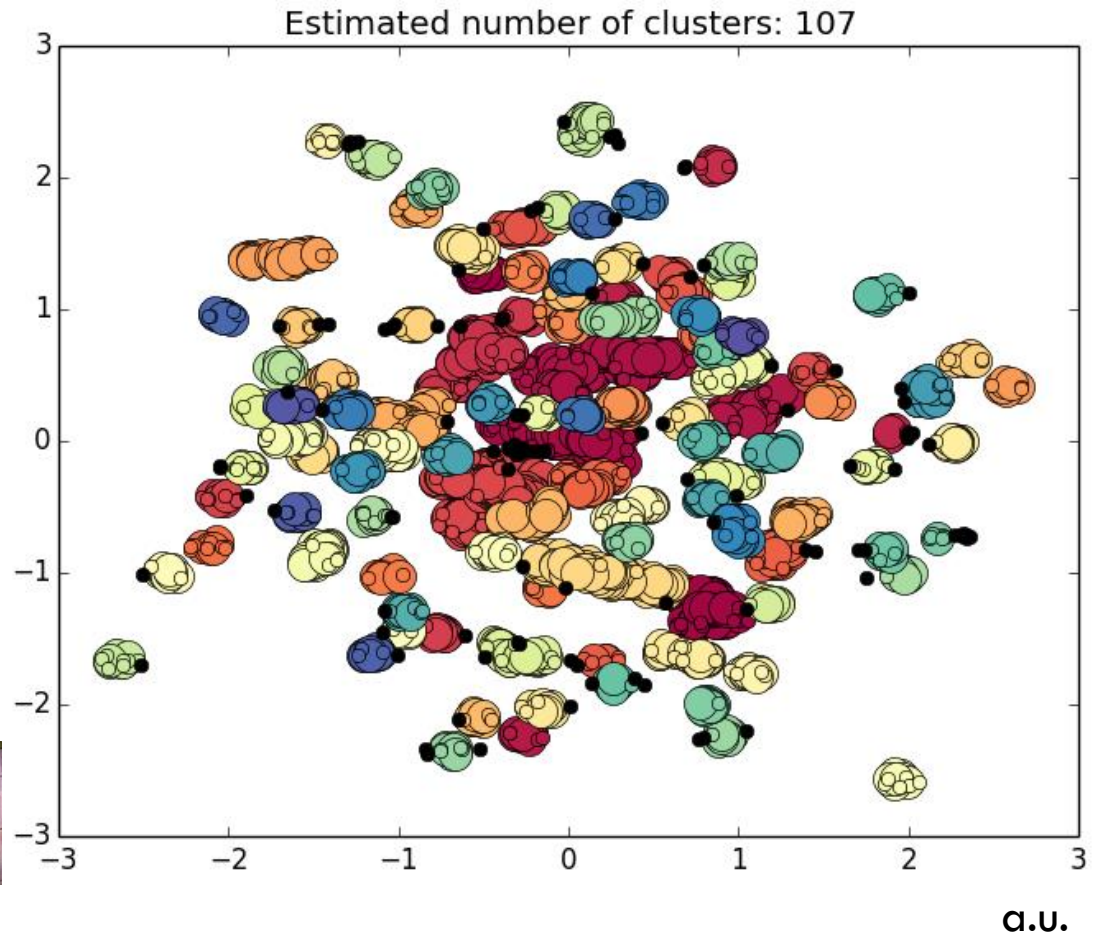
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▣ Method to estimate the number of clusters in a plane of measurements

➤ No PVs info

➤ No limits on cluster size

◆ Only 107 PV





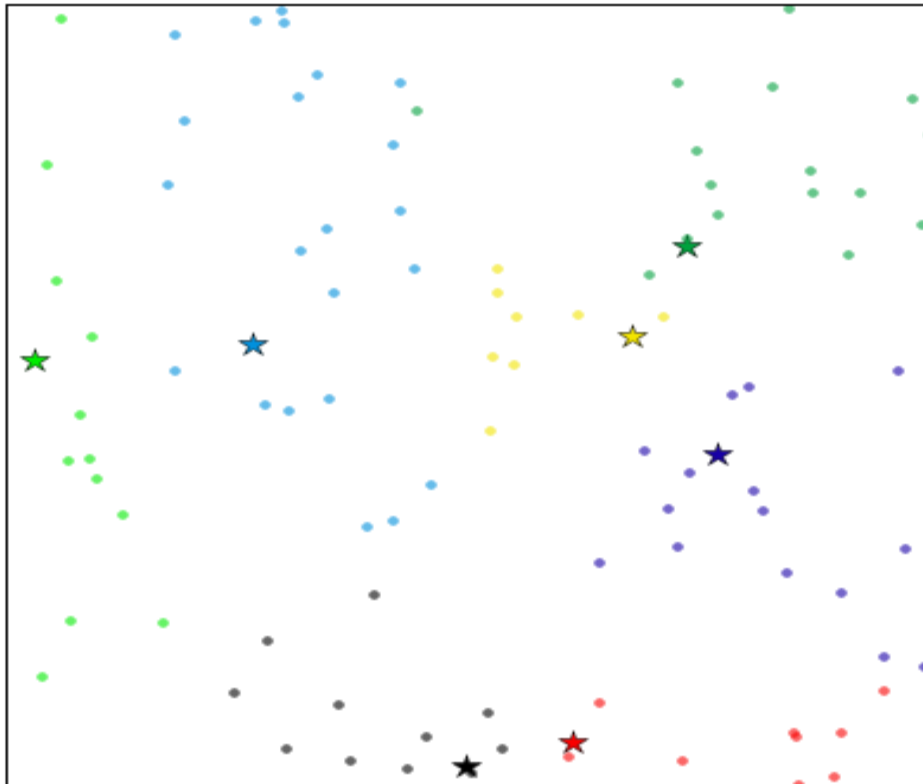
# 2° clustering algo - Kmeans



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- Starting with a good guess on the number of primary vertices, try to distribute these vertices around the measurements  $\sum_{i=1}^k \sum_{\mathbf{x} \in S_i} \|\mathbf{x} - \mu_i\|^2$  is minimized
- It takes into account the number of generated PVs

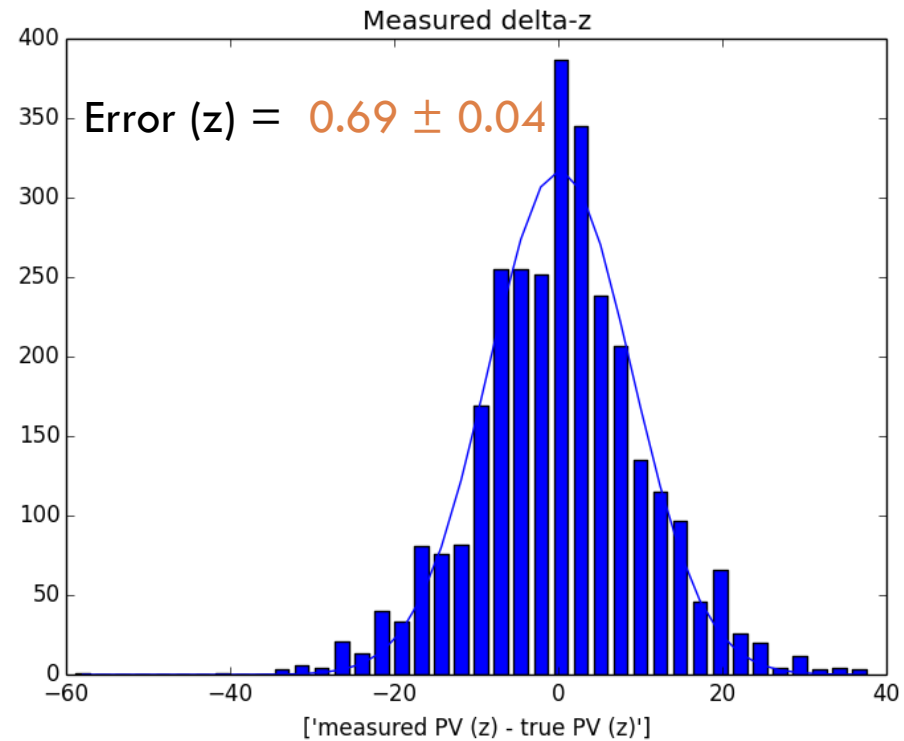
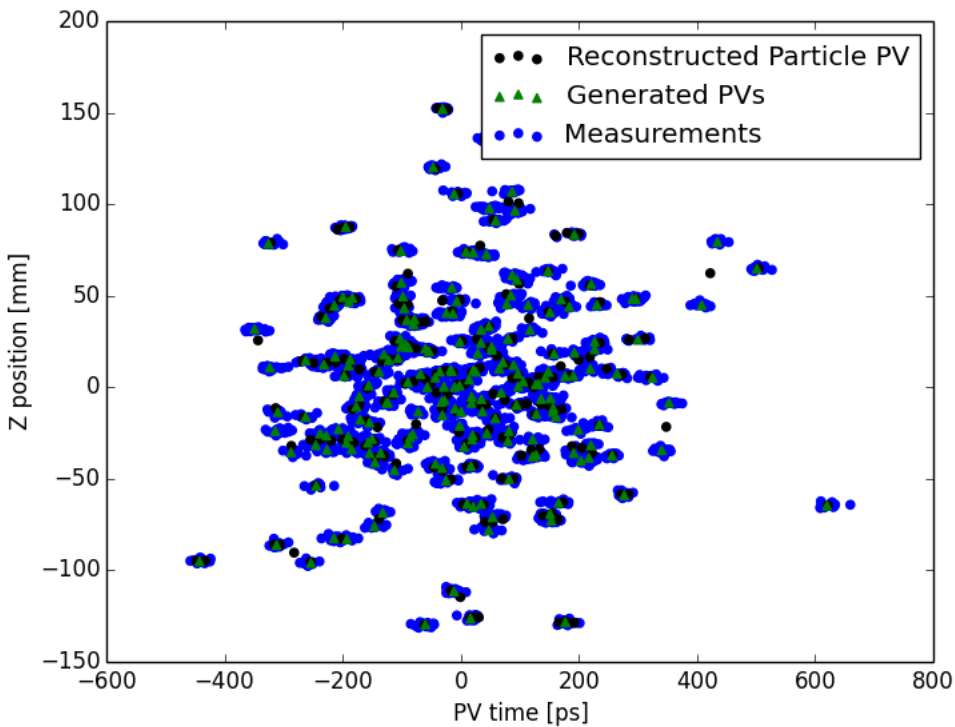


- Total number of particles (PV\*tracks) = 100
- Number of vertices = 7
- Total iteration = 7

# Kmeans results



## Reconstructed PVs vs generated PVs



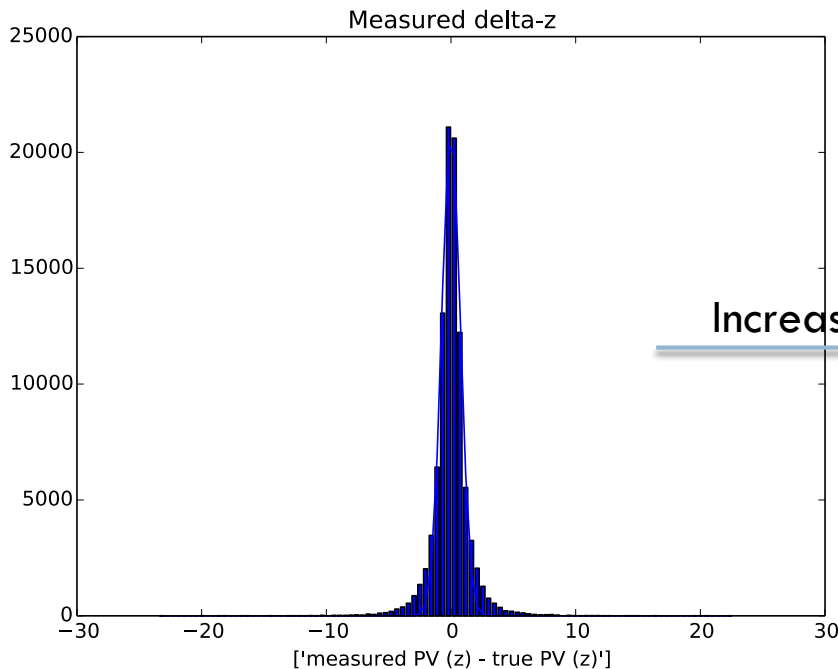
# Weighted Kmeans



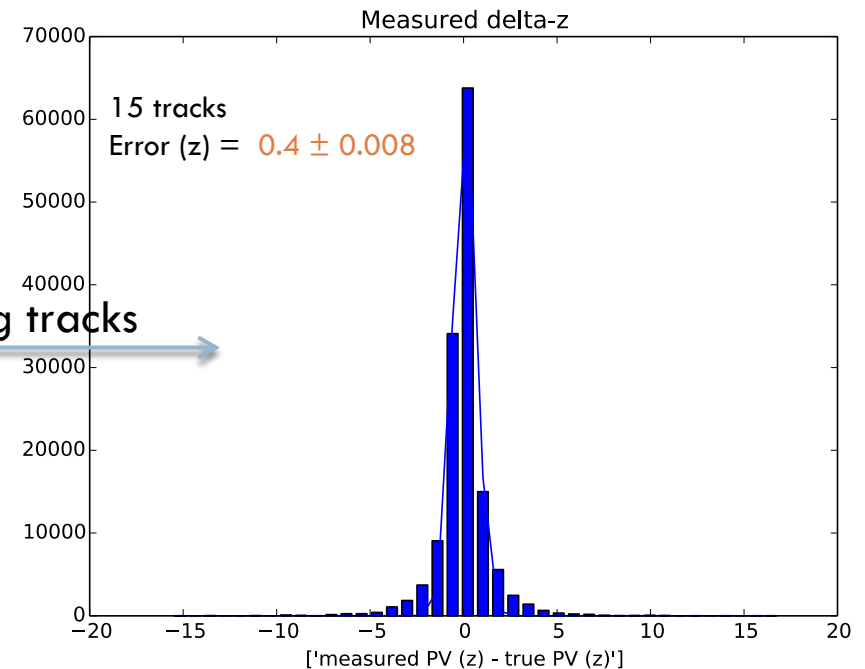
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- Weighted algorithm along the two different dimensions:  $z$  and  $T$
- Algorithm performances get better with the number of tracks



Increasing tracks



# Conclusions



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- VeLoC aims to distinguish PVs in a high pile up environment
- VeLoC shows a 28% mis-associated particles to PV
- Algorithm were performed with the following results:
  - ▣ Unbiased DBscan: 107 PV over 200 identified
  - ▣ Kmean (number of PV and tracks given): 0.7 mm resolution
  - ▣ Kmean weighted: 0.4 mm resolution
- Improvements:
  - Calorimetric information can provide number of PVs
- VeLoC + Calo can provide a vertex resolution of 0.4 mm

# Thanks for your attention!

