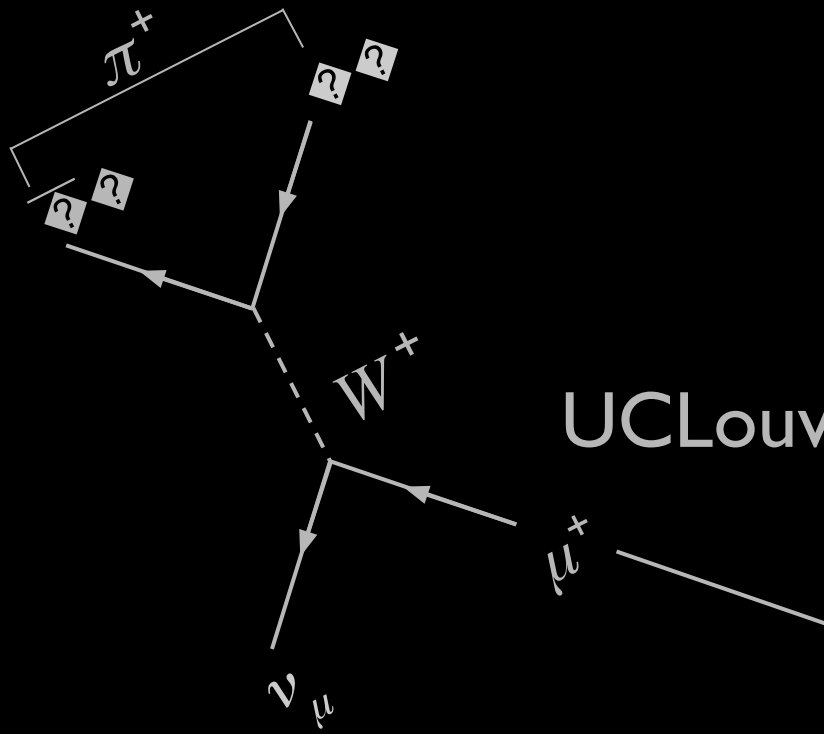


Binned clustered algorithm

UCLouvain - Louvain-la-Neuve, Belgium

Maxime Lagrange

Binned clustered algorithm: event reconstruction

A binned clustering algorithm to detect high-Z material using cosmic muons, 2013 JINST 8 P10013

- Finding **POCA points**, but account for **measurement errors on hit position** σ_{hi}.

$$E_x = \sum_{i=1}^{3} \frac{(h_i - (\nu_x + k_{x,upper} \cdot t))^2}{\sigma_{h_i}^2} + \sum_{i=4}^{6} \frac{(h_i - (\nu_x + k_{x,lower} \cdot t))^2}{\sigma_{h_i}^2}$$

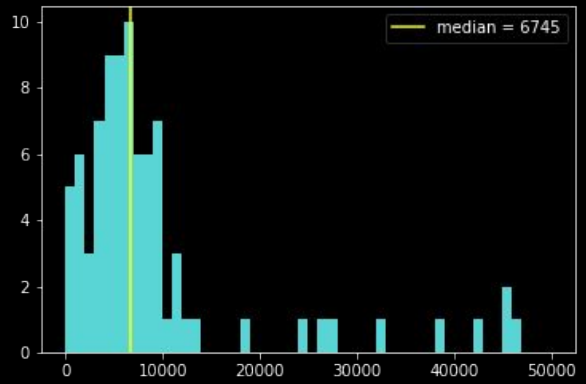
- E_x is minimized using MINUIT.
- If all **hits** have the **same** σ_{hi}, equivalent to POCA algo.

Binned clustered algorithm: metric

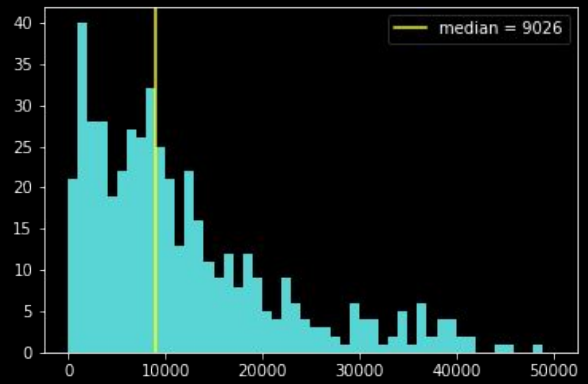
- For each **pair of POCA within** a given **voxel**, one computes:

$$m_{ij} = ||POCA_i - POCA_j|| \quad (1) \qquad \tilde{m_{ij}} = \frac{m_{ij}}{(\theta_i p_i) \cdot (\theta_j p_j)} \quad (2)$$

- The **distribution** of m_{ij} depends on the **voxel density**:



low density (wood)



high density (copper)

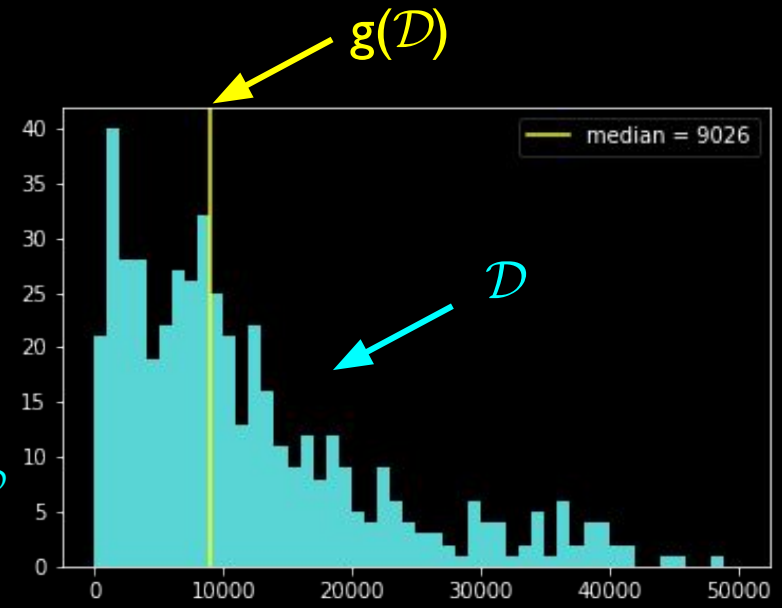
Binned clustered algorithm: logic

Initialisation:

- Only **keep** events with $\Delta\theta_- < \Delta\theta < \Delta\theta_+$.
- Only **keep** the *n* highest $\Delta\theta$ events in each voxel

Scan:

- For each **voxel:**
  - if # POCA points > `n_min_per_vox`
    - For each pair of **POCA point:**
      - Compute m_{ij} from (2)
      - Append $f(m_{ij})$ to the voxel distribution $\mathcal{D}$
  - else:
    - **voxel final score** is set to **0**



End of the scan:

- For each **voxel:**
  - Compute the final voxel score as $g(\mathcal{D})$
  - Replace all 0 scores by max(final scores)*

Binned clustered algorithm: parameters

Parameter	Use momentum	Scattering angle cuts	Metric	Score extraction	Event filtering
Description	Use momentum or not?	keep events with $\Delta\theta_- < \Delta\theta < \Delta\theta_+$	which value to append to $\mathcal{D}$	final score computed as $g(\mathcal{D})$	keep events with n largest $\Delta\theta$
Symbol		$\Delta\theta_-, \Delta\theta_+$	$f(m_{ij})$	$g(\mathcal{D})$	n
Options	True / False	[0.1, 10] deg	$\ln(m_{ij})$, $\mathrm{sqrt}(m_{ij})$, $\log(m_{ij})$, m_{ij}	median, mean, quartile, std	depends on acquisition time
In the paper	True	NO	$\ln(m_{ij})$	median	n = 50 (for 150k tracks)
Muograph variable	`use_p`	`dtheta_range`	`metric_method`	`score_method`	`n_max_per_voxel`