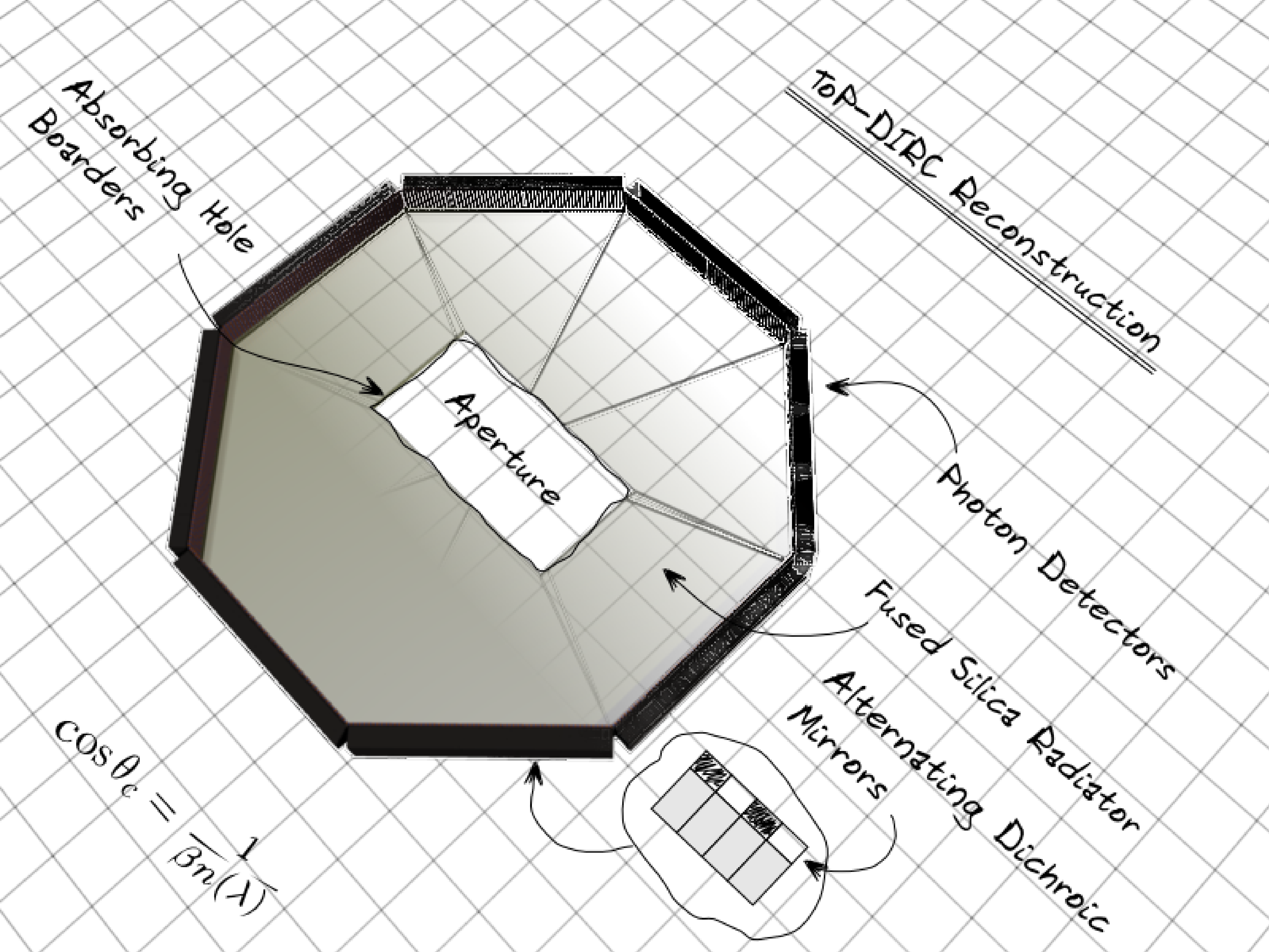
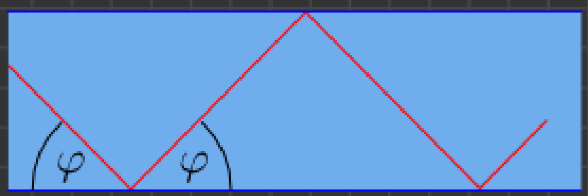

ToP-DIRC Reconstruction
Absorbing Hole Boarders
Aperture
Photon Detectors
Fused Silica Radiator
Alternating Dichroic Mirrors
$\cos\theta_c = \frac{1}{\beta n(\lambda)}$

Basic Principles

- Photon time of propagation depends on:
  - *group velocity*
  - *(3-dimensional) path*

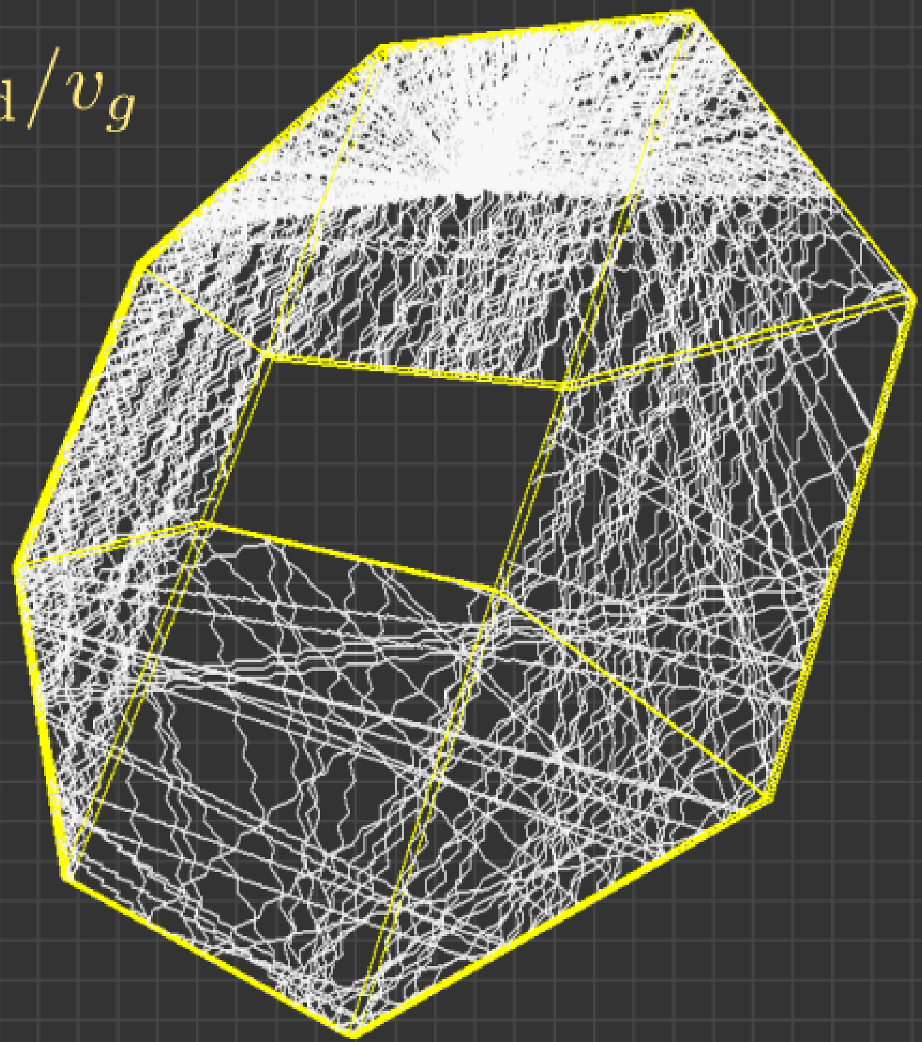
  $\Big\} \; t_{\mathrm{top}} = s_{\mathrm{3d}}/v_g$

    - projected (2-dimensional) path
    - angle of total internal reflection



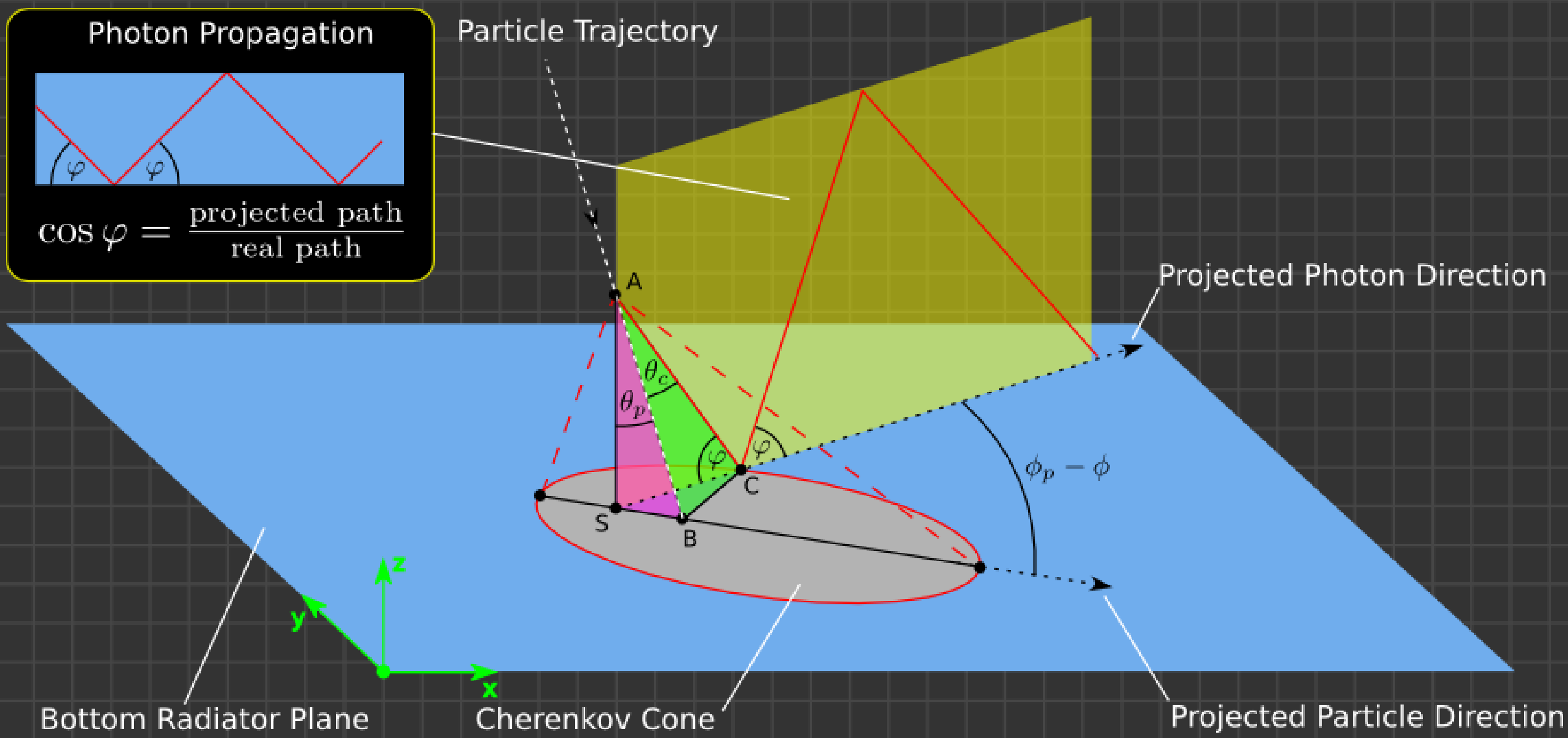
$$\cos\varphi = \frac{\text{projected path}}{\text{real 3d path}} = \frac{s_{\mathrm{2d}}}{s_{\mathrm{3d}}}$$

$$t_{\mathrm{top}} = s_{\mathrm{3d}}/v_g = \frac{s_{\mathrm{2d}}}{v_g \cdot \cos\varphi}$$



Basic Principles

- The angle of total internal reflection and the Cherenkov angle



$$\cos\theta_c = \sin\theta_p \cos(\phi_p - \phi)\cos\varphi + \cos\theta_p \sin\varphi$$

Basic Principles

- All together

$$t_{\text{top}} = \frac{s_{2\text{d}}}{v_g \cdot \cos\varphi}$$

$$\cos\varphi = \frac{\Delta\cos\theta_c}{\Lambda} + - \sqrt{\frac{\cos^2\theta_p - \cos^2\theta_c}{\Lambda} + \left(\frac{\Delta\cos\theta_c}{\Lambda}\right)^2}$$

$$\Delta = \sin\theta_p \cos(\phi_p - \phi)$$

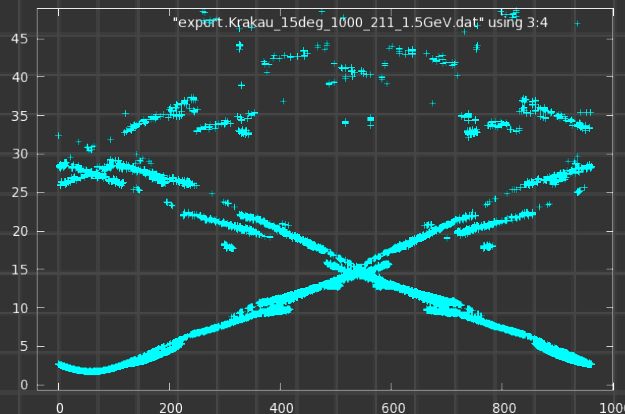
$$\Lambda = \Delta^2 + \cos^2\theta_p$$

- Path reconstruction
- Tracking information
- Unknown parameter

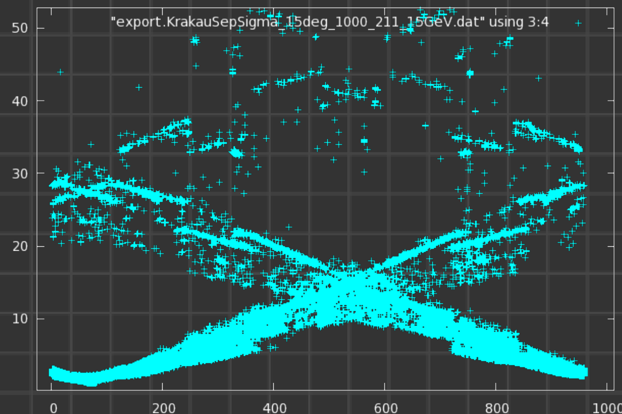
⇒ Need of path reconstruction to compute the Cherenkov angle

Problems to face

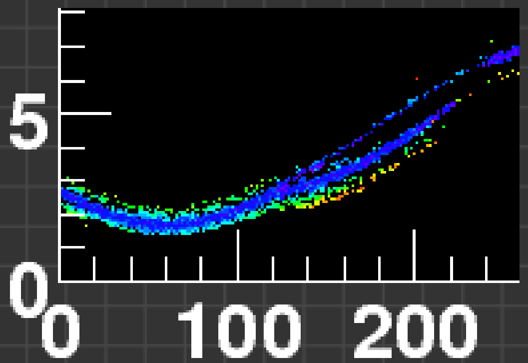
- Limited time-resolution of photon detectors and electronics
- Unknown point of photon emission, spatial pixel-size (PMT dimension)
- Dispersion; affects:
  - *Phase velocity of light (Cherenkov angle)*
  - *Group velocity of light ("propagation speed of the photon")*
- Cherenkov radiation from knock-on electrons (δ-rays)



without δ-rays



with δ-rays

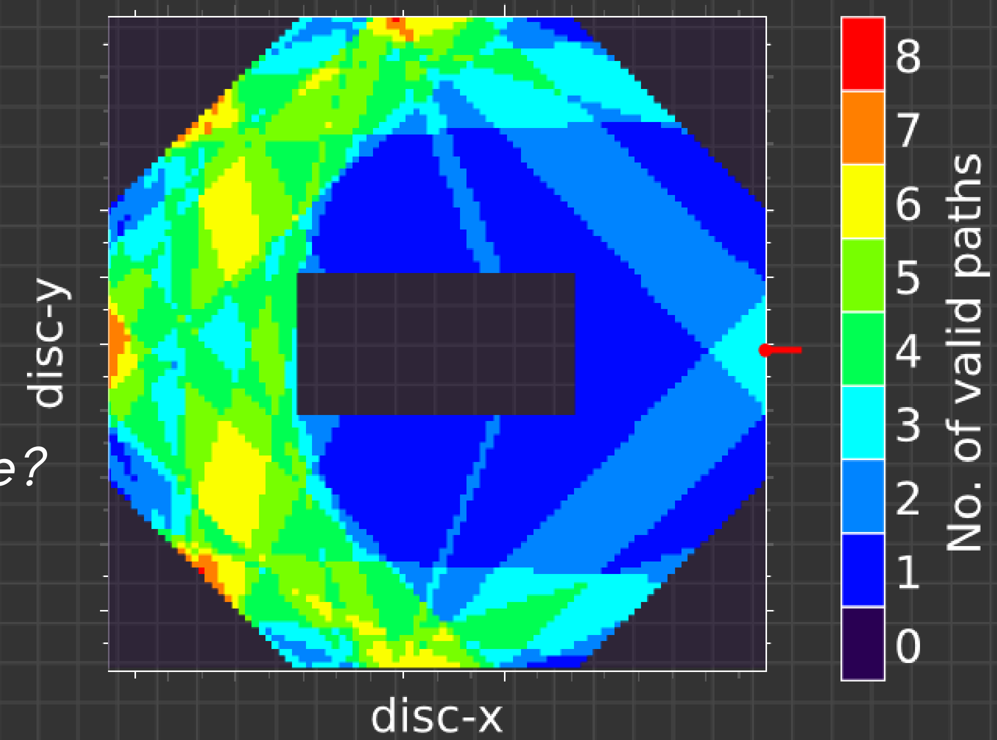


background suppression

- Coulomb scattering (minor effect)
- Missing start time -> only relative timing possible !

Solution

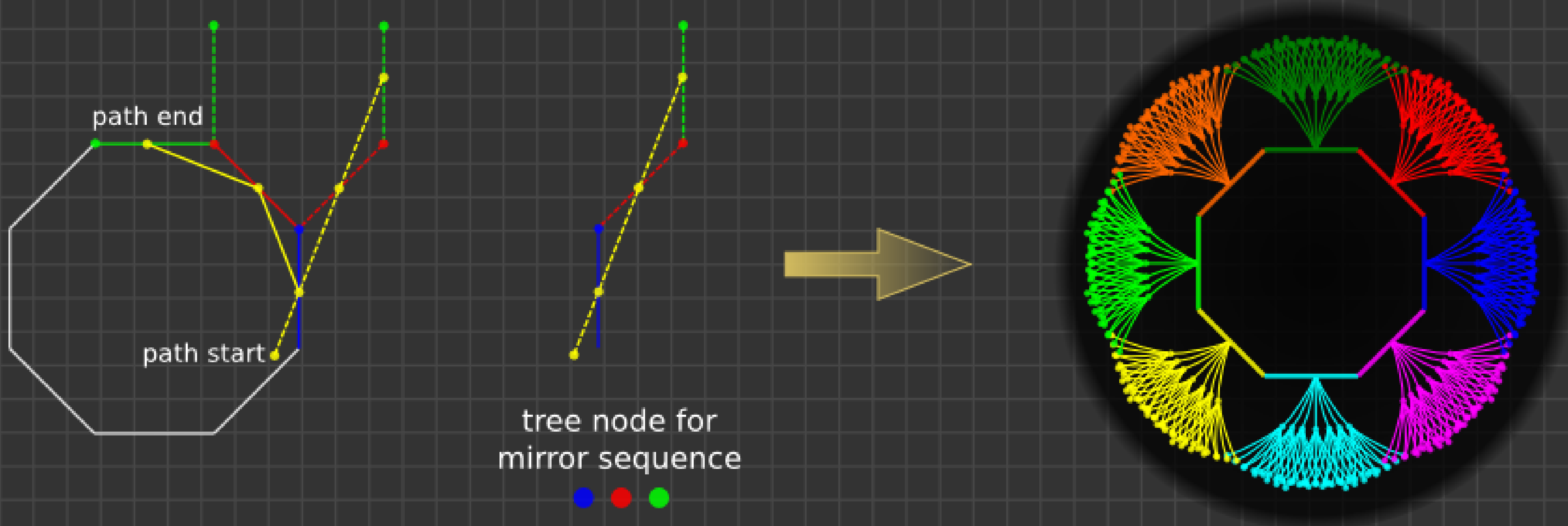
- Path reconstruction for single photons ??
  - *no start-time but*
    -> multiple solutions for the path !!!
  - *multiple incident particles*
    -> photon emitted from which particle?



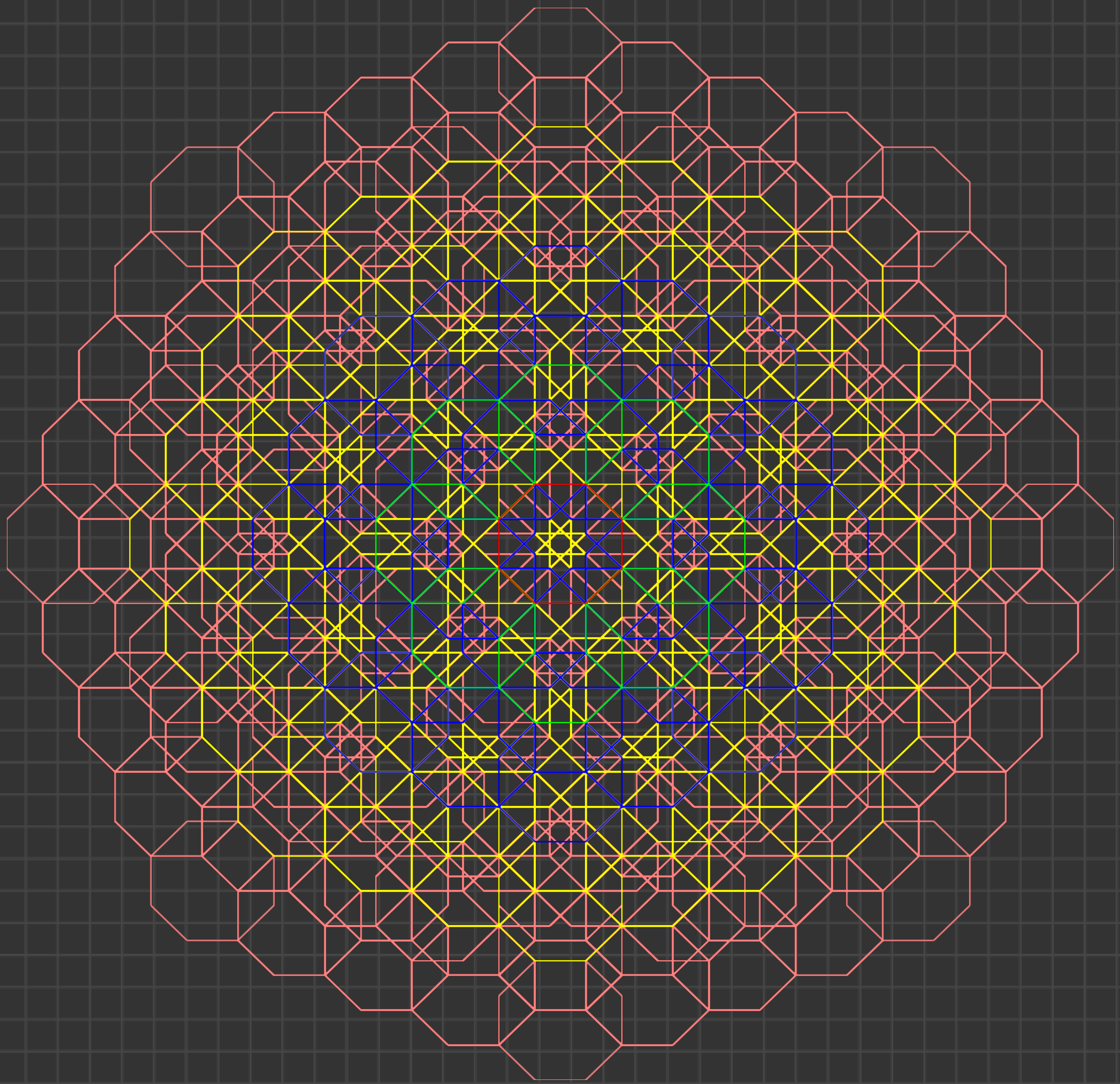
- Better: use relative timing instead
  - *compute theoretical hitpattern from hypothesis (pion/kaon/...)*
  - *compare the result with measured times*
  - *use unknown start time as fit parameter*

Computation of the Hitpattern

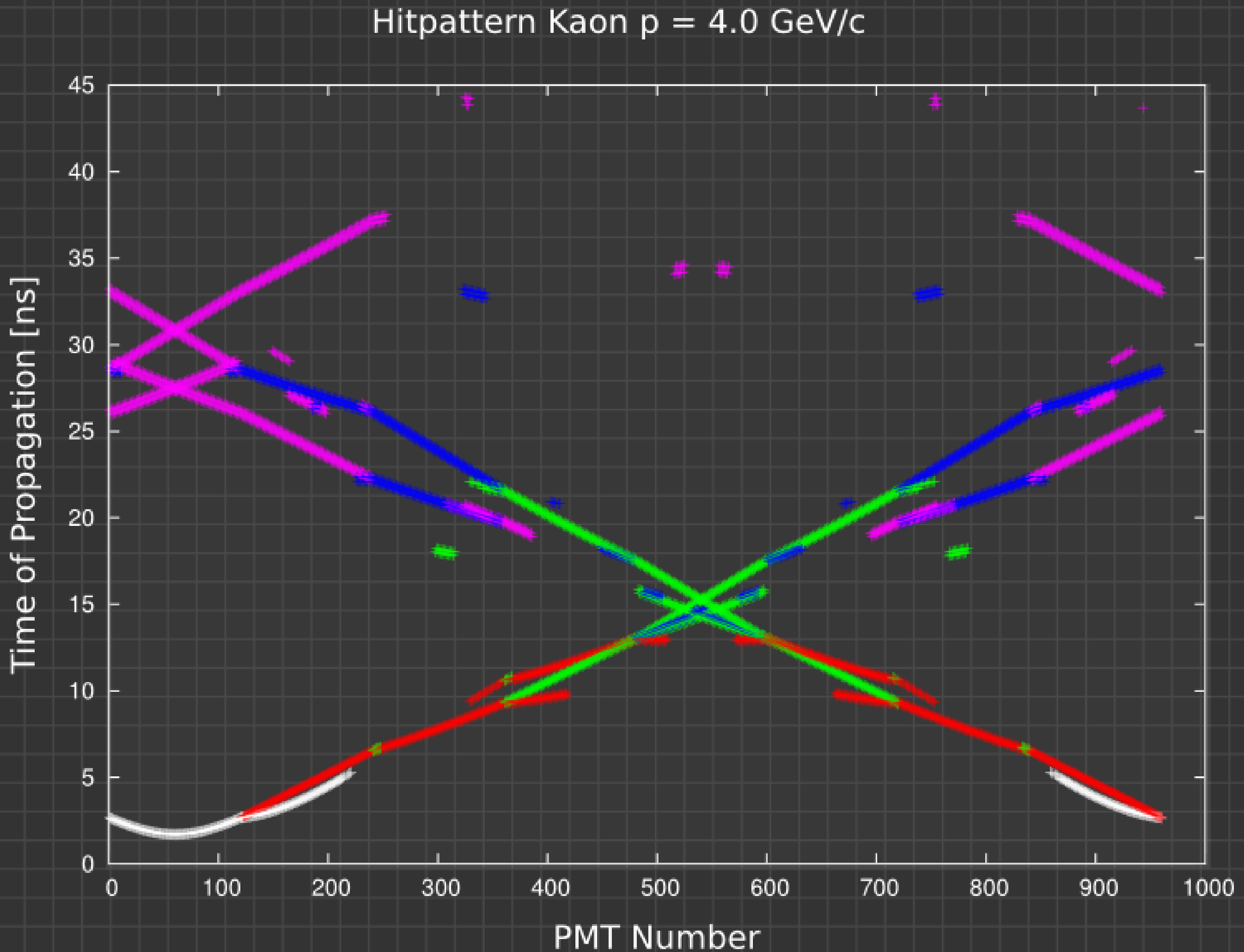
- Simple approach :
  - *Compute all possible projected paths in 2 dimensions*
  - *Use the shown formula to transform the results to ToP values*
- How to compute all possible projected paths?
  - *currently used algorithm uses a graphical approach implemented as iteratable tree*



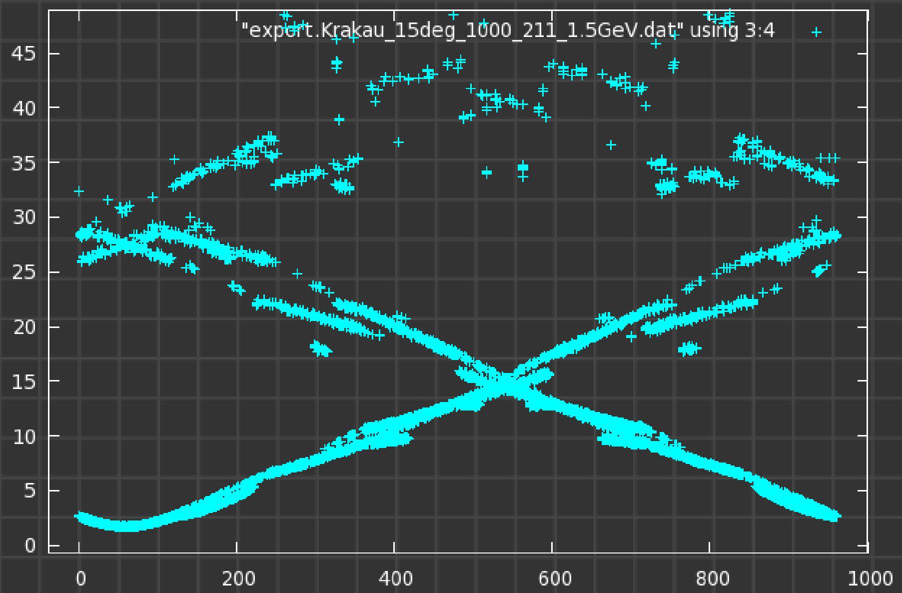
Visualization of the Lookup Trees



A computed Hitpattern

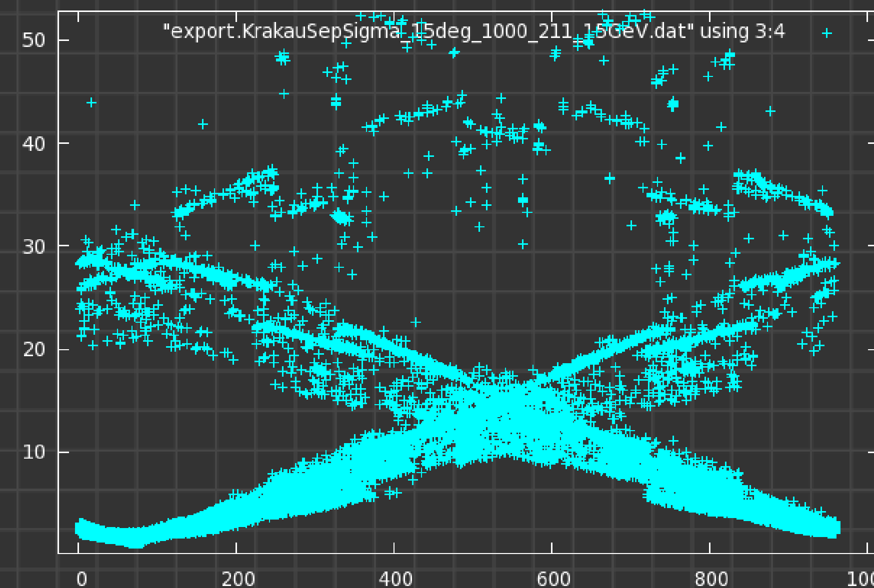


Datasets with and without knock-on electrons

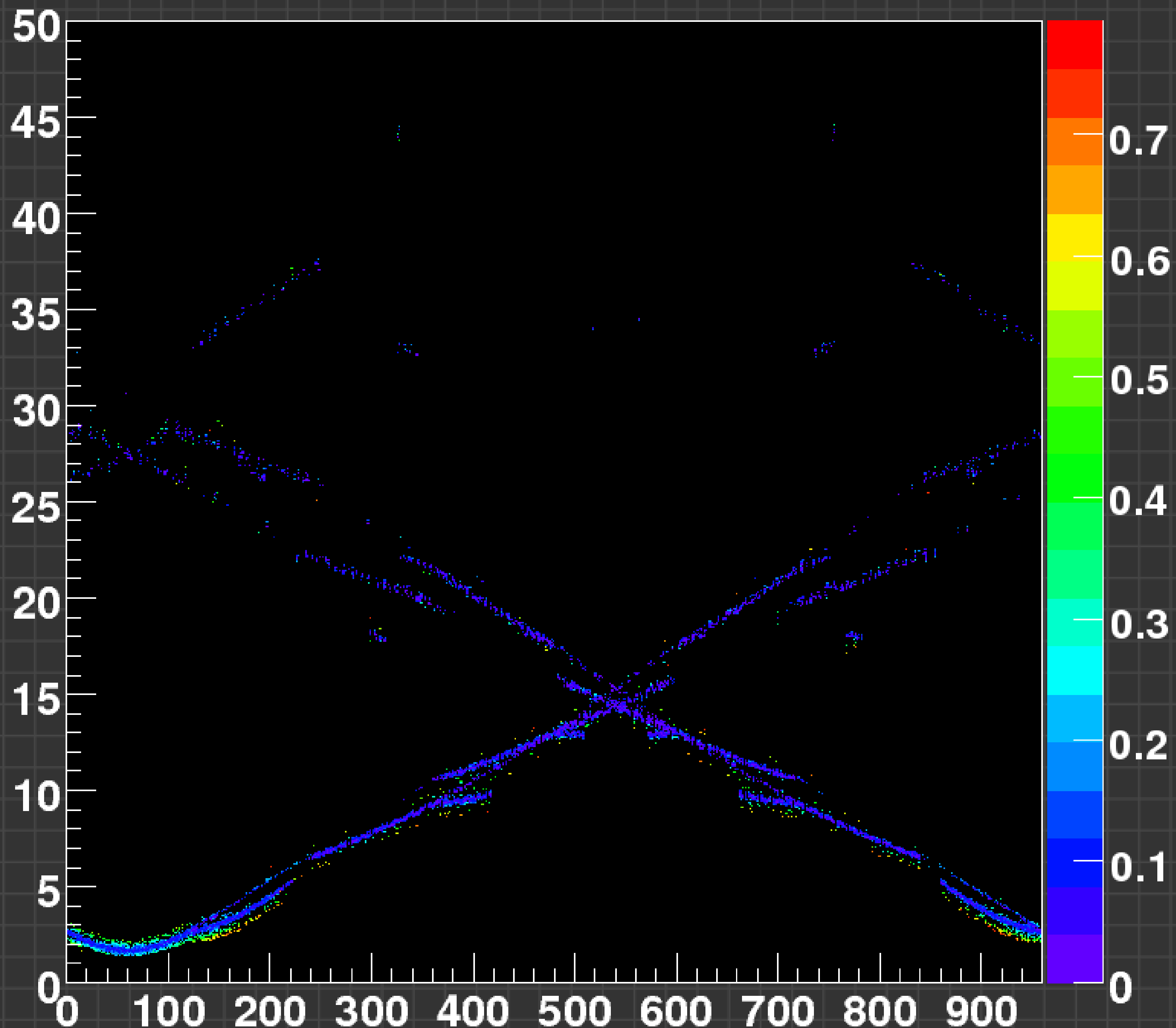


<- clean pattern, 1000 pions at p=1.5 GeV/c

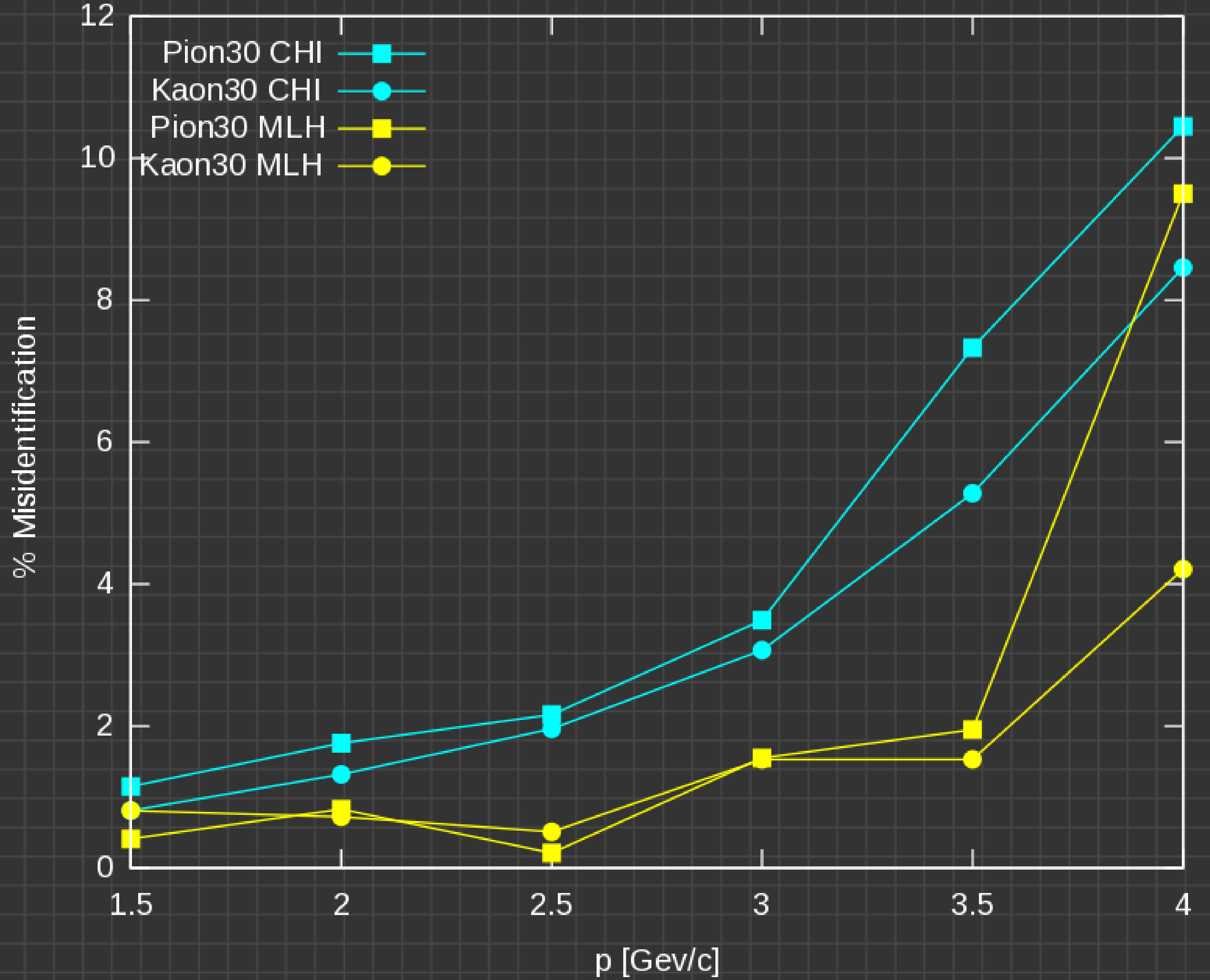
noisy pattern, 1000 pions with -> knock-on electrons. (p=1.5 GeV/c)



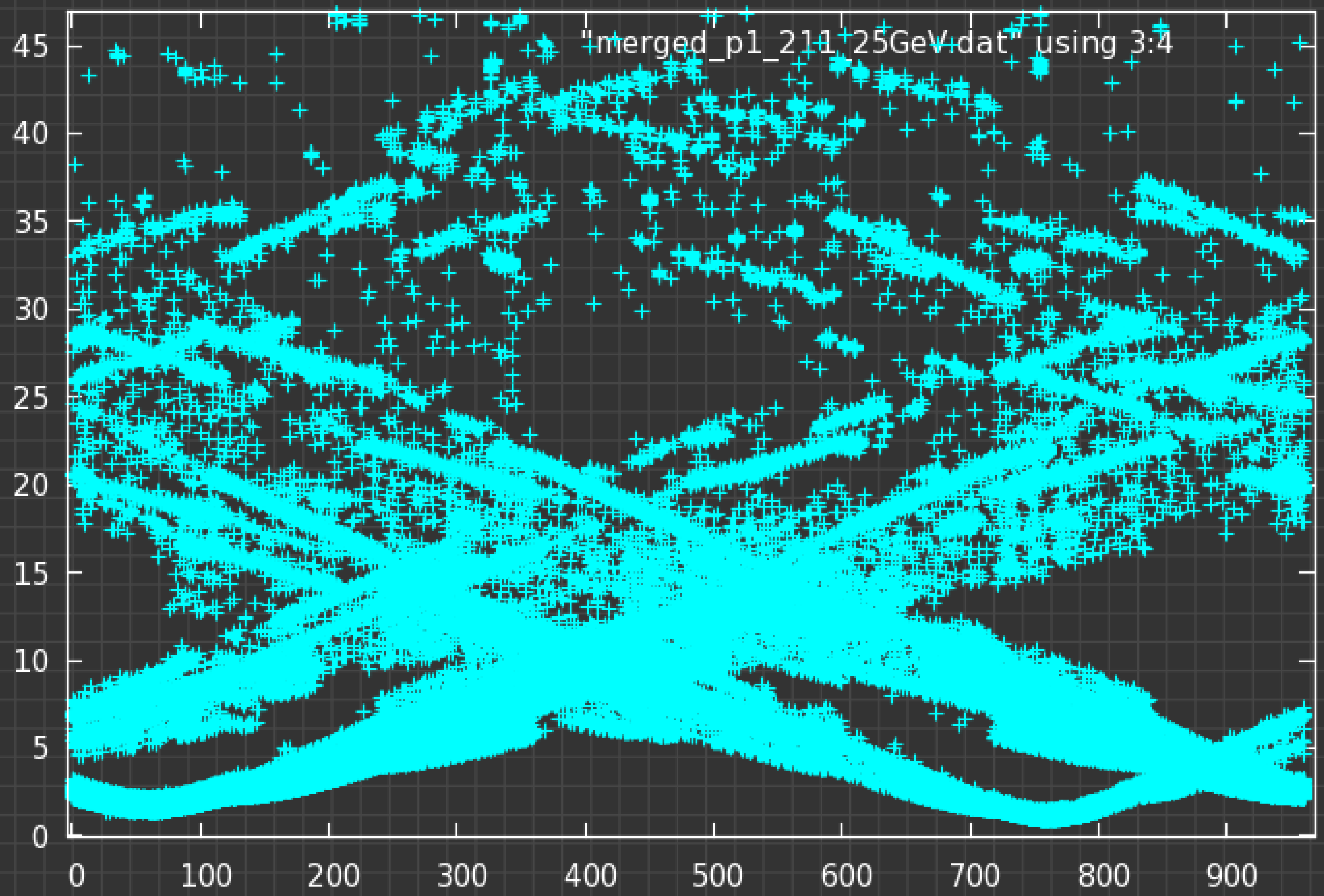
Color-coded time difference



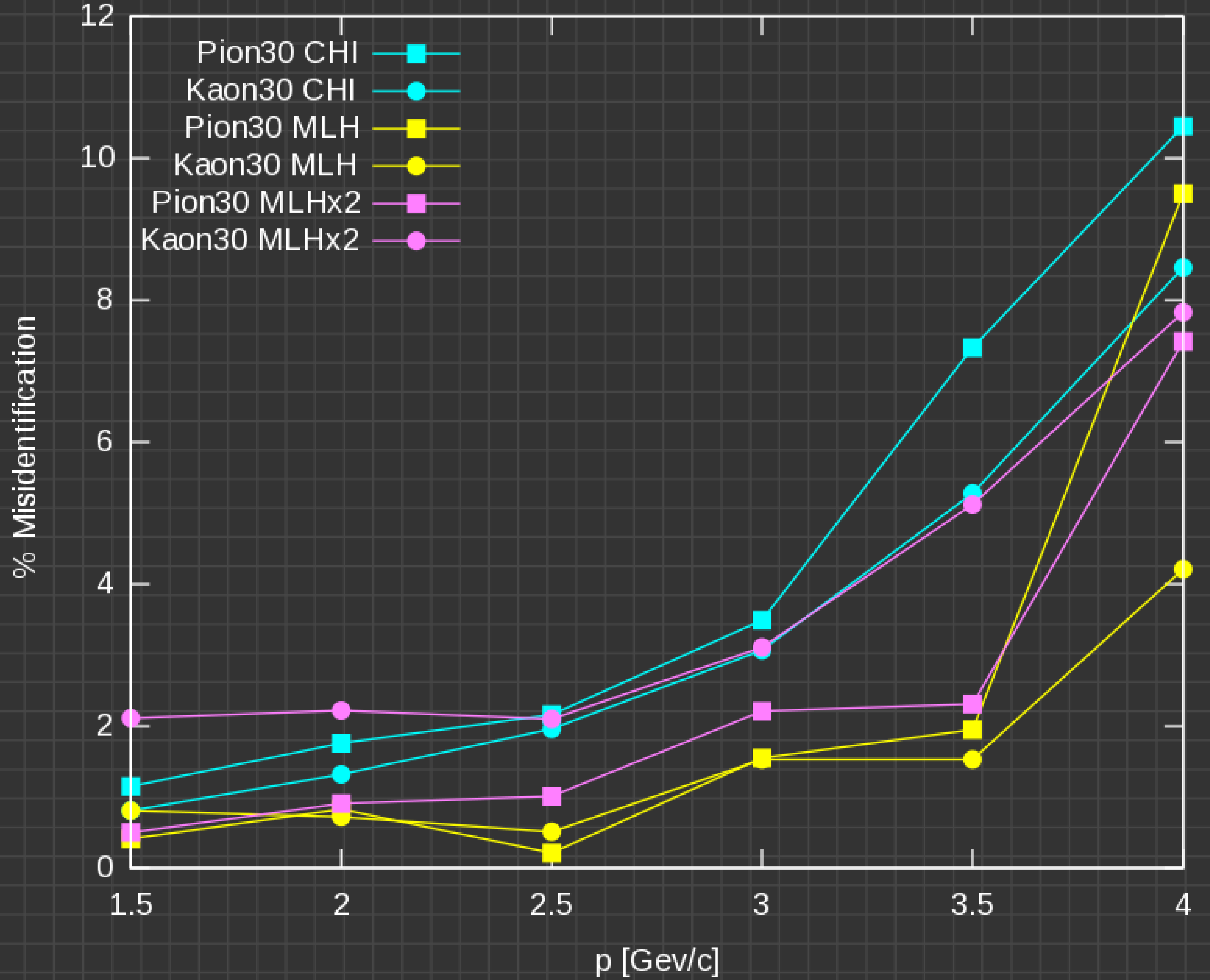
Results (1000 particles, δ-rays, 40ps res./25ps bins)



2 incident particles at the same time



Results (1000 particles, δ-rays, 40ps res./25ps bins)



Outlook

- Find a more realistic likelihood function / improve separation power
- Improve minimization -> faster fits
- Use final version for design optimization

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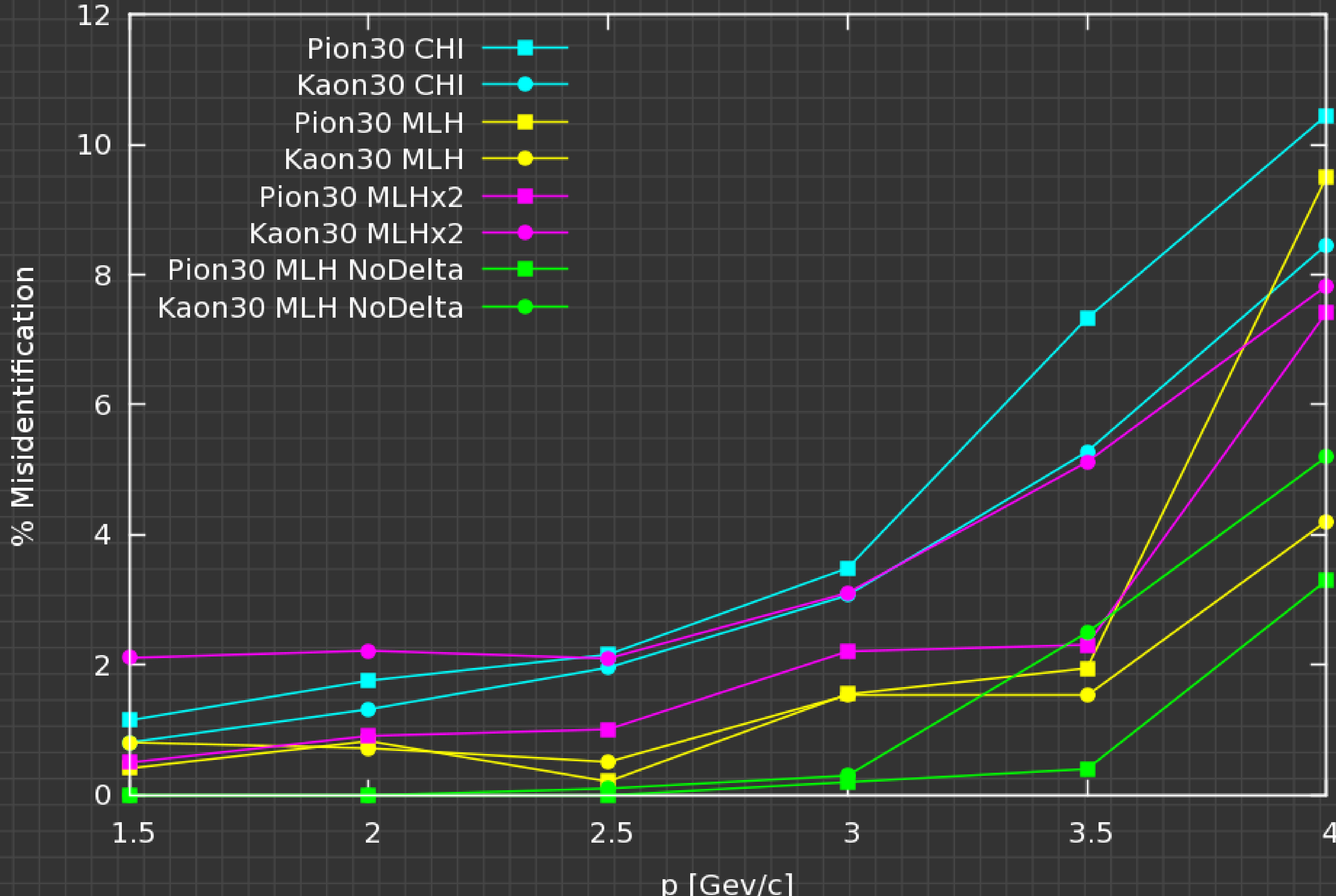
Arbeitsgruppe Düren

Appendix A - Results without δ-Rays



Appendix B - Dispersion and Dichroic Mirrors