A tutorial for NA62Analysis: creating the VertexCDA and Pi0Reconstruction analyzers.

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This document will describe the process of creating the VertexCDA and Pi0Reconstruction analyzers within the NA62Analysis framework. It is intended to guide future analyzer authors by describing the complete procedure.

1 VertexCDA

The aim of this analyzer is to implement an algorithm that will compute the Kaon decay vertex and make it available to further analyzers. Though different methods are available for this purpose, the focus is given on a closest distance of approach (CDA) algorithm. The algoritm implemented by this analyzer can be used for the class of processes $K^{\pm} \to C^{\pm} + \ldots$ where $K^{\pm}$ is the incoming charged kaon measured in GigaTracker and $C^{\pm}$ is a charged particle measured in the Spectrometer. Even if the tracks are supposed to originate from the same point they are in practice never intersecting because of the finite measurement precision. The CDA will find the unique point $\vec{v} = (v_x, v_y, v_z)$ where the distance between v and the first track and the distance between v and the second track are minimums. For this point only, the line l passing through v and joining both tracks is perpendicular to them.

We define $\vec{x}_{1,2}$ being the track origin and $\vec{p}_{1,2}$ the momentum of the track. Any point $\vec{C}_{1,2}$ on track can be described by a single parameter $s_{1,2}$.

$$\vec{C}_{1,2} = \vec{x}_{1,2} + s_{1,2}\vec{p}_{1,2} \tag{1}$$

The vector joining $\vec{C}_1$ and $\vec{C}_2$ is then

$$\begin{aligned} \vec{l}(s_1, s_2) = \vec{C}_1 - \vec{C}_2 &= \vec{x}_1 + s_1\vec{p}_1 - \vec{x}_2 - s_2\vec{p}_2 && (2)\\ &= \vec{x}_1 - \vec{x}_2 + s_1\vec{p}_1 - s_2\vec{p}_2 && (3)\\ &= \vec{l}_0 + s_1\vec{p}_1 - s_2\vec{p}_2 && (4) \end{aligned}$$

with $\vec{l}_0 = \vec{x}_1 - \vec{x}_2$. Using the property that $\vec{l}$ is perpendicular to $\vec{p}_1$ and $\vec{p}_2$ when it's length is minimum gives the following equations:

$$\vec{l}(s_{1c}, s_{2c}) \cdot \vec{p}_1 = \vec{l}_0 \cdot \vec{p}_1 + s_{1c}|\vec{p}_1|^2 - s_{2c}(\vec{p}_1 \cdot \vec{p}_2) \qquad = 0 \tag{5}$$

$$\vec{l}(s_{1c}, s_{2c}) \cdot \vec{p}_2 = \vec{l}_0 \cdot \vec{p}_2 + s_{1c}(\vec{p}_2 \cdot \vec{p}_1) - s_{2c}|\vec{p}_2|^2 \qquad = 0 \tag{6}$$

That we solve for s_{1c} and s_{2c}:

$$s_{1c} = \frac{(\vec{p}_1 \cdot \vec{p}_2)(\vec{l}_0 \cdot \vec{p}_2) - (\vec{l}_0 \cdot \vec{p}_1)|\vec{p}_2|^2}{|\vec{p}_1|^2|\vec{p}_2|^2 - (\vec{p}_1 \cdot \vec{p}_2)^2} \tag{7}$$

$$s_{2c} = \frac{|\vec{p}_1|^2(\vec{l}_0 \cdot \vec{p}_2) - (\vec{p}_1 \cdot \vec{p}_2)(\vec{l}_0 \cdot \vec{p}_1)}{|\vec{p}_1|^2|\vec{p}_2|^2 - (\vec{p}_1 \cdot \vec{p}_2)^2} \tag{8}$$

The vertex being in the middle of the $\vec{l}(s_{1c}, s2c)$ vector:

$$v = \vec{C}_1 + 0.5\vec{l}(s_{1c}, s_{2c}) \tag{9}$$