Gamma-gamma tagging system for KLOE2 experiment

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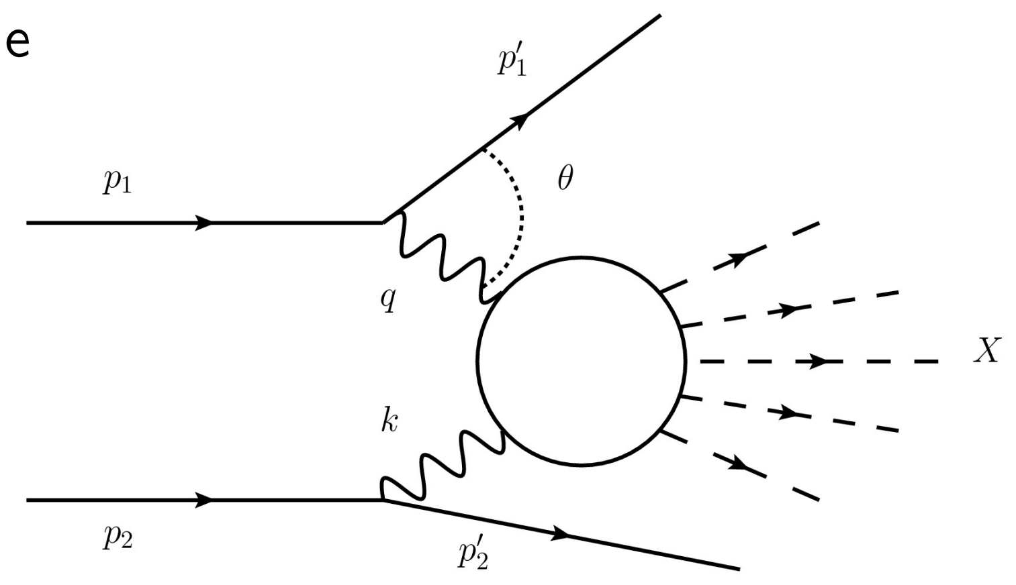
Physics Motivations

There is a strong interest in measuring the cross section for the process $\gamma\gamma\to\pi^0\pi^0$ in the low energy region for its relevance in the context of the assessing the existence and nature of the sigma meson.

A gamma-gamma reaction could be summarized as follows:

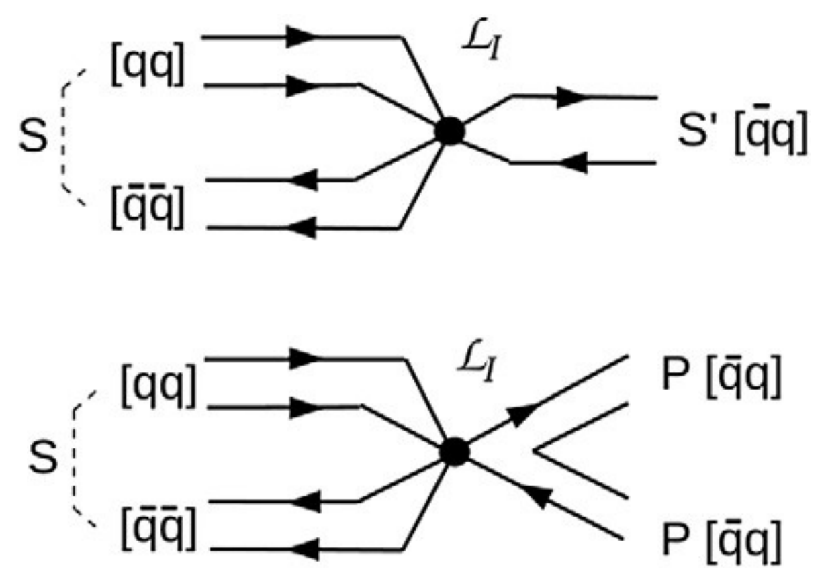
$$e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^- X$$



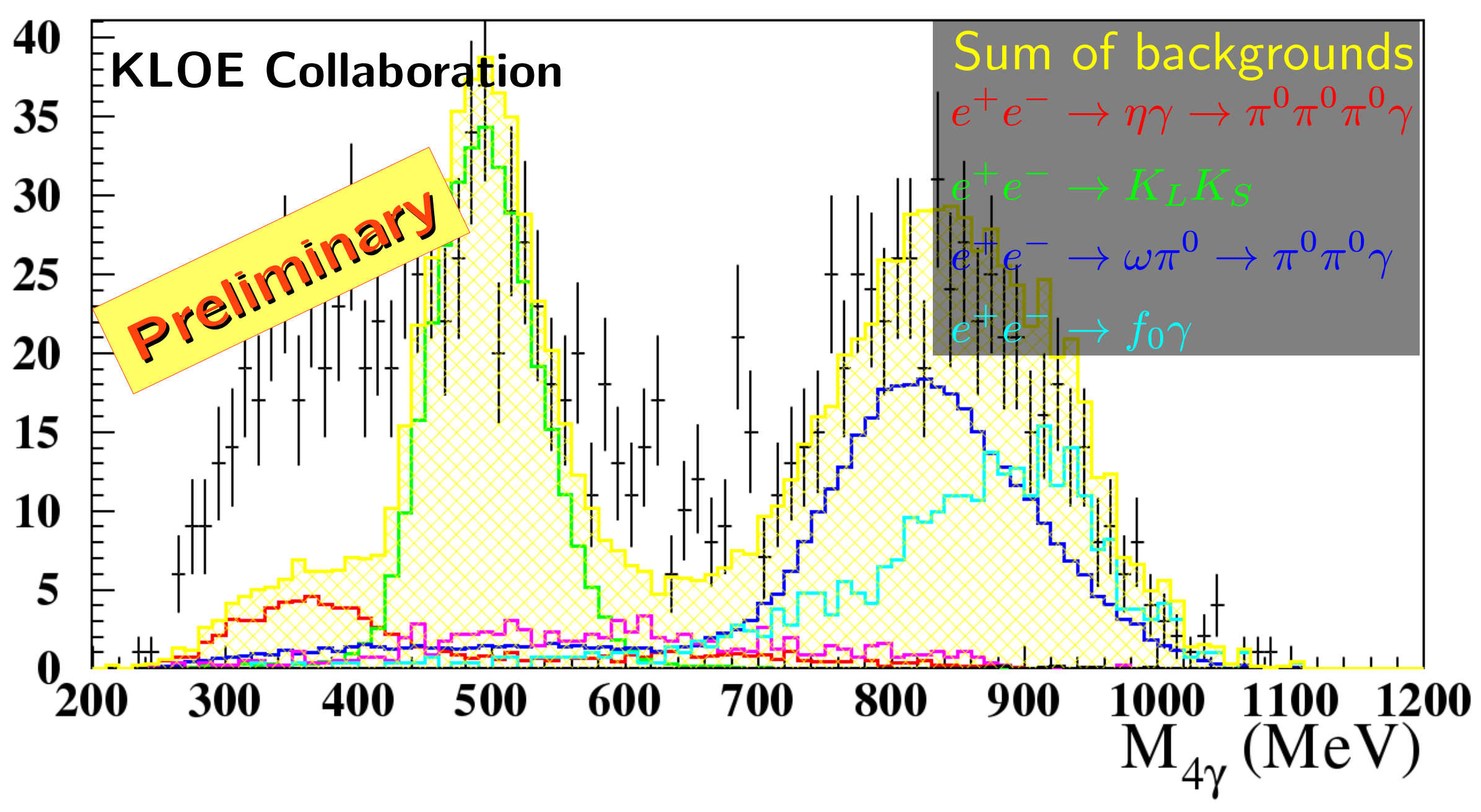
Since the 2 photons are in a C= +1 state and J=1 is excluded (Landau-Yang theorem), γ-γ scattering allows the study of final states X with JPC = $0^{(+-)+}$, $2^{(+-)+}$, not directly coupled to one photon.

The final states with pions are particularly interesting because they result from resonance decays. The study of the coupling between photons and mesons is important to understand the inner structure of produced resonances.

There is also a strong evidence that light scalars are diquark – antidiquak bound states, this can naturally reproduce the SU(3) nonet and its correct mass spectrum (PLB 662 (2008) 424–430).



Off-energy data @ KLOE



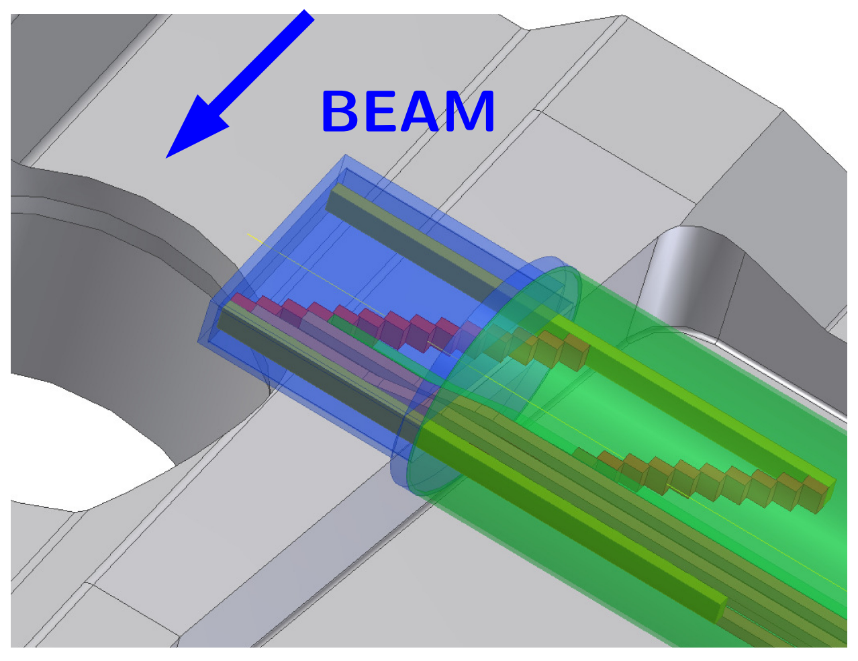
At the ϕ mass peak ($M_\phi = 1019.45$ MeV) background overwhelm the signal. Then a tagging system is absolutely needed in order to run at the ϕ energy during the standard KLOE runs.

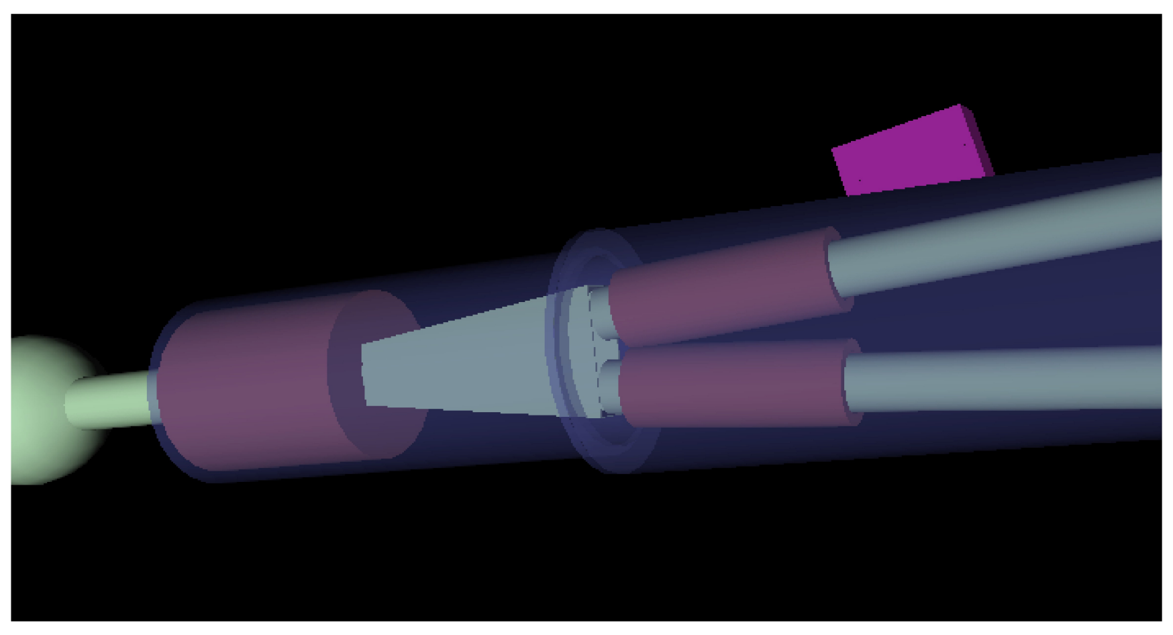
HET & LET Detectors

The LET detector should consist in a calorimeter capable of detecting electrons and positrons within a wide energy range peaked around 200 MeV. The environmental conditions require radiation-tolerant devices, insensitive to magnetic fields. The physical requirements are the following:

- Good energy resolution to improve the reconstruction of the $\gamma\gamma$ invariant mass from the decay products;
- Good time resolution to associate detected events with the proper bunch crossing;
- Small size.

To obtain these characteristics we have to use an high-Z material with high light yield and fast emission, coupled with radiation hard photodetectors insensitive to magnetic field. Detailed description of performances and characteristics are described in Salvatore Fiore's talk.





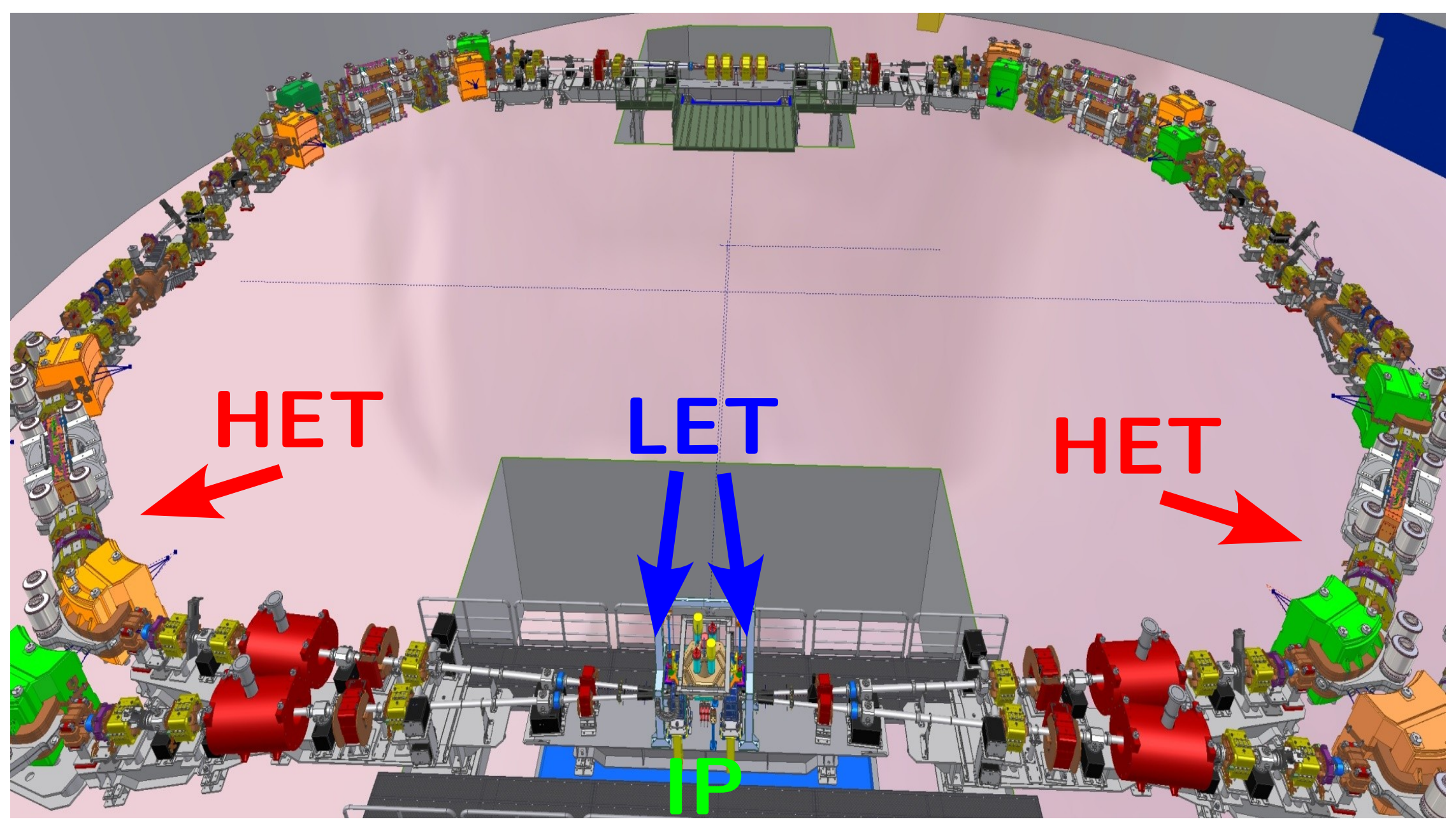
The HET detector consists in a position detector with a pitch of few millimeter ($\sigma_E \sim 0.6$ MeV/mm). The characteristics of this detector are the following:

- Good time resolution to disentangle each bunch (~2.7 ns bunch spacing);
- Capability to acquire data at a frequency of 368 MHz in order to permit event reconstruction with KLOE apparatus (Lorenzo Iafolla's poster);
- Radiation hardness for long time acquisition. This detector should be located at 30 mm from the beam axis;
- Tiny size to allow the installation with the mechanical support inside the DAΦNE vacuum chamber.

These requirements imply the choice of fast plastic scintillator (Bicron BC418), coupled with a proper light guide (Bicron BC800) and MPPC (aka SiPM) sensors. In order to reduce the space occupancy of the front-end electronics we evaluate the possibility to use a custom VLSI chip (Davide Badoni's poster).

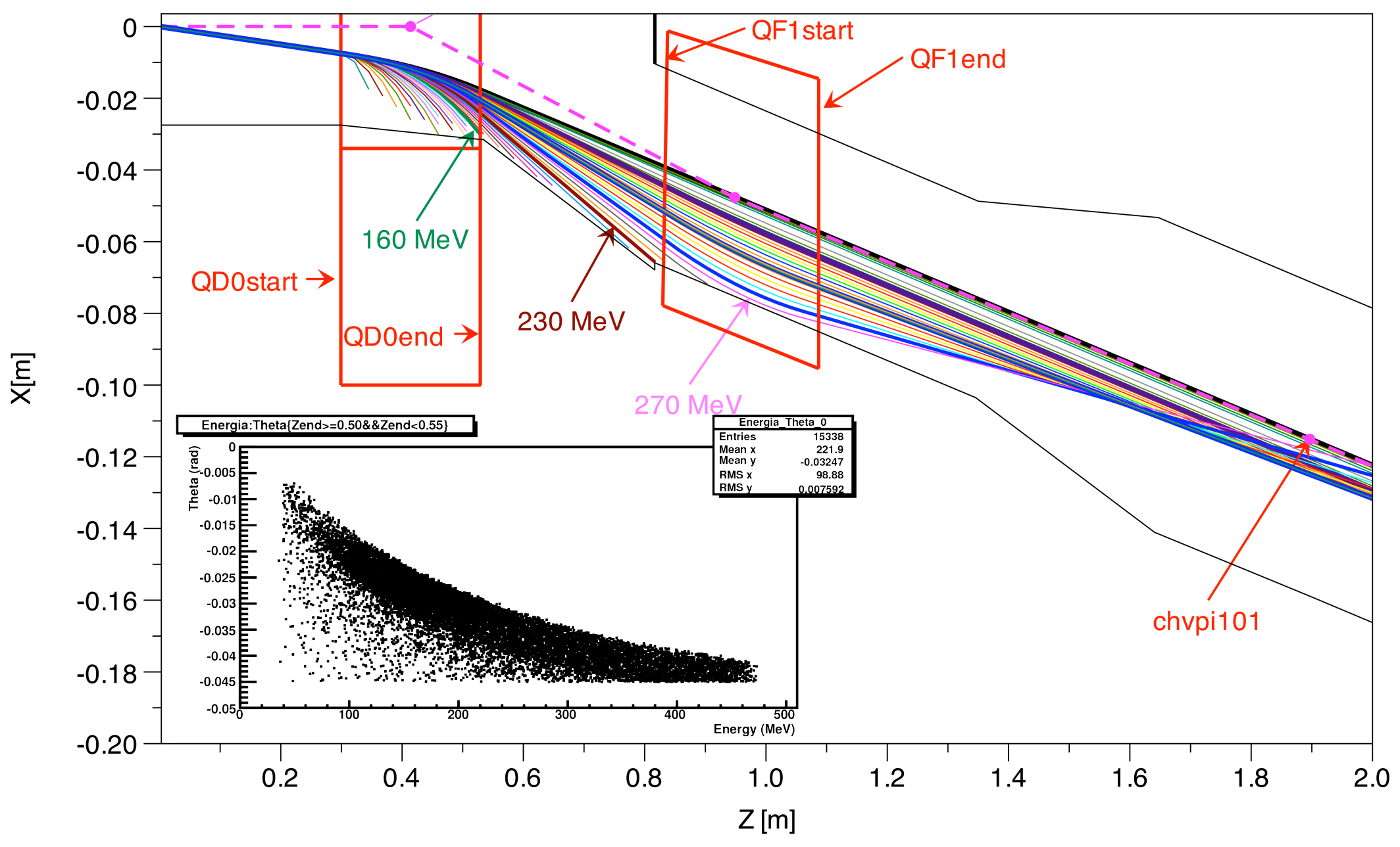
Tracking

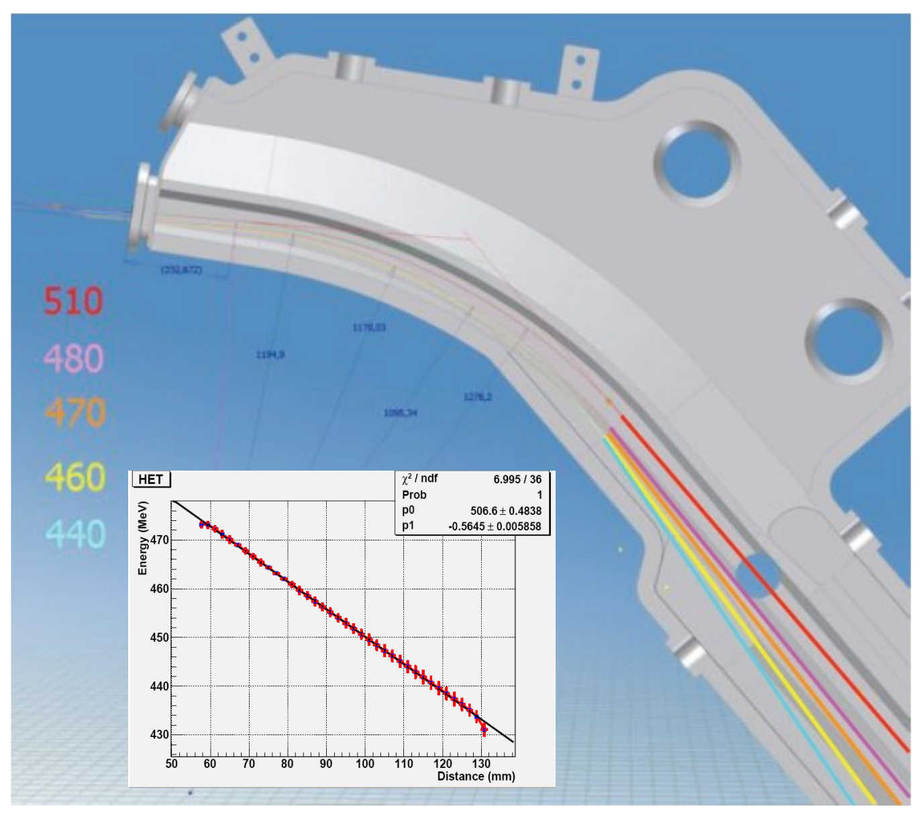
In order to properly locate the e⁺e⁻ taggers for $\gamma\gamma$ physics in DAΦNE, we need to accurately track the off-energy particles along the machine optics, starting from interaction point (IP). We are interested in evaluating the impact point of this particles onto the DAΦNE beam pipe. This study is based on BDSIM code. In the first step only two regions are accessible: in the LET (Low Energy Tagger) region we can observe electrons that have lost a big fraction of their energy (> 240 MeV); the HET (High Energy Tagger) region corresponds to place reached by the electrons having energy greater than 420 MeV.



The leptons that reach the LET have been deflected only by the magnetic field of the first quadrupole after the IP. Therefore, the energy of the lepton is clearly uncorrelated to the position of the hitting point. For this reason the LET detector has to be a colorimeter.

The particles impinging on the HET detector, on the other hand, show a clear correlation between energy and position. We can use a position detector to measure the energy of the particles that reach the HET detector.





Information coming from the both tagger is sufficient to close the kinematics and reconstruct the invariant mass of $\gamma\gamma$ ($W_{\gamma\gamma}$). Using both the data coming from the tagger and from KLOE we could reduce background events with an high efficiency.