Study of the $K^+ \to \pi^0 e^+ \nu\gamma$ decay with NA62 experiment at CERN: possible T-violation measurement

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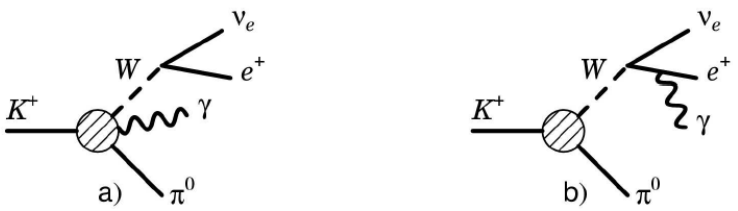
Overview

Ke3γ decay and T-asymmetry

$$K^+ \to \pi^0 e^+ \nu\gamma$$

Kinematic analysis: [1, 2].



$BR^{average}(Ke3\gamma) = (2.56 \pm 0.16) \cdot 10^{-4}$ [3]

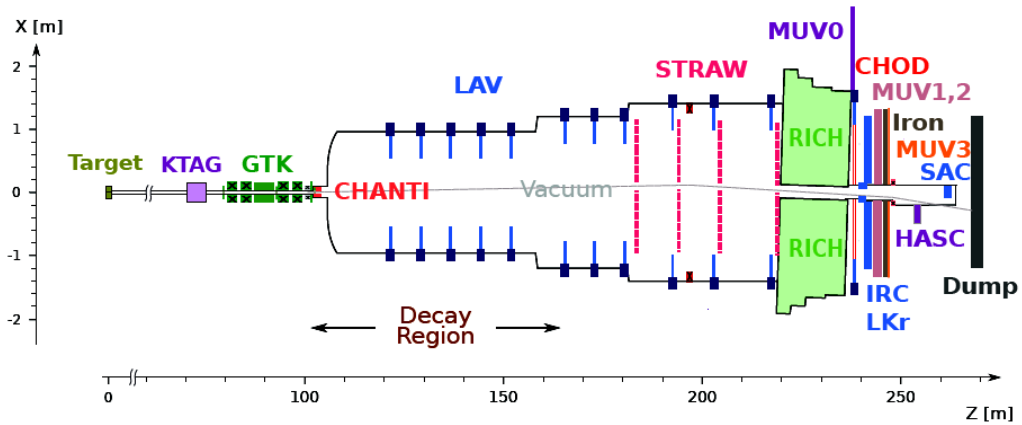
T-odd quantity and its asymmetry [4, 5]:

$$\xi = \frac{[\vec{p_\gamma} \cdot (\vec{p_e} \times \vec{p_\pi})]}{M_K^3} \; ; \; A_\xi = \frac{N_+ - N_-}{N_+ + N_-}$$

A_ξ Standard Model value [4, 5]:

$$A_\xi^{SM} = -0.59 \cdot 10^{-4}$$

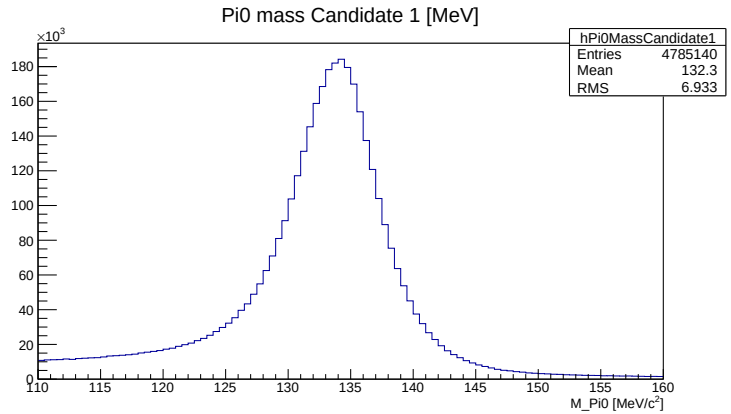
Event Reconstruction with NA62 setup [6, 7]

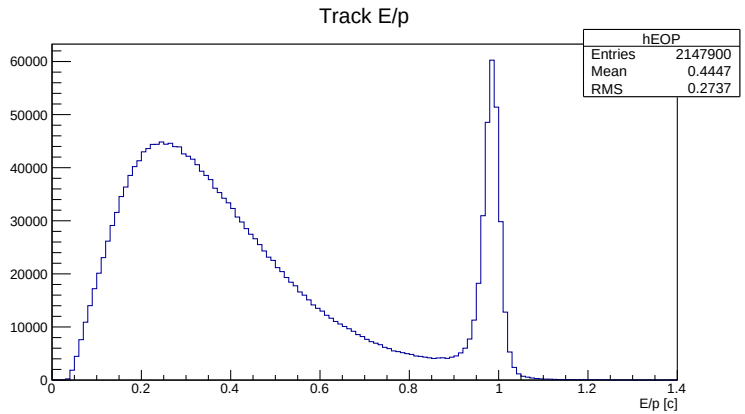


- KTAG to identify the kaon before its decay;
- GTK to measure the kaon momentum;
- STRAW to measure the positron momentum and to reconstruct the vertex decay position;
- LKr to measure energies and positions of positron and photons;
- RICH for charged particles identification (e^+, π^+, μ^+).

Most relevant selection cuts

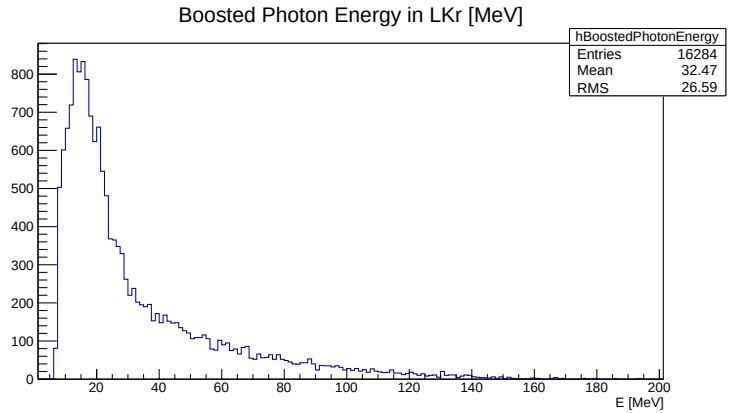
- four clusters in LKr at least, with $E > 2GeV$ and one pair of clusters with an invariant mass consistent with the π^0 mass (due to the $\pi^0 \to \gamma\gamma$ decay), in the range $m_{\pi^0} \pm 10MeV$;
- positron E/p ratio in the range $0.9 < E/p < 1.1$ and one ring in the RICH with radius grater than 180 mm, in order to identify positrons and reject muons and pions;

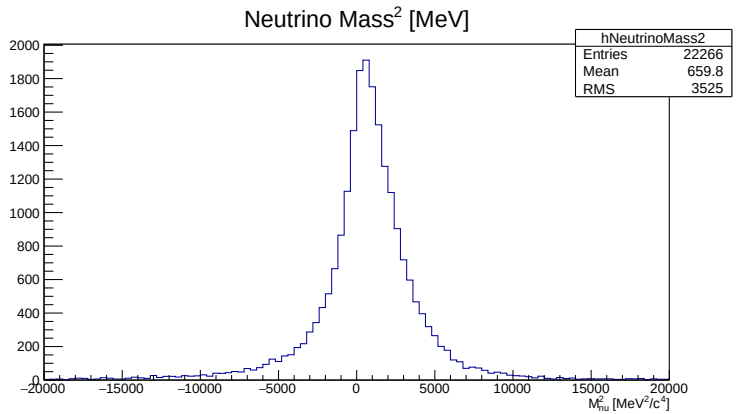




Most relevant selection cuts

- vertex decay Z coordinate in the range $110\ m < Z_{vertex} < 180\ m$;
- $E_\gamma > 10 MeV$ and $\theta_{e,\gamma} > 10^\circ$ in the kaon rest frame, in order to cure the Ke3γ amplitude divergence;
- $|m^2_{miss}| < 10000 MeV^2/c^4$;
- all signals in time coincidence.





Branching ratio measurement

$$\frac{BR(Ke3\gamma)}{BR(Ke3)} = \frac{\#SelectedEvents(Ke3\gamma)}{\#SelectedEvents(Ke3)} \cdot \frac{\epsilon_{acc}(Ke3)}{\epsilon_{acc}(Ke3\gamma)} \cdot \frac{\epsilon_{trig}(Ke3)}{\epsilon_{trig}(Ke3\gamma)}$$

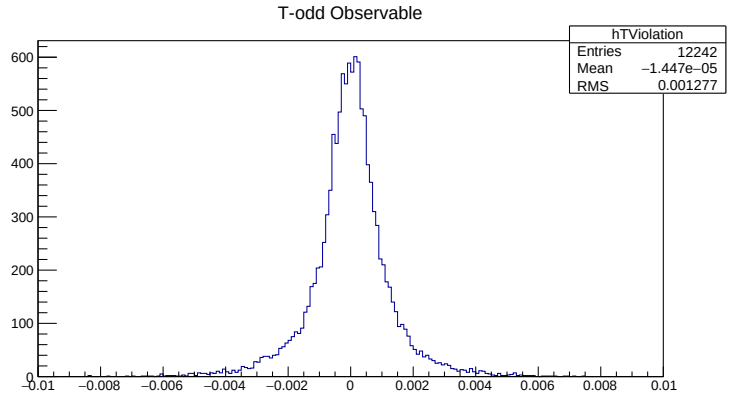
Selections acceptances (signal and background): *Monte Carlo* simulations;
Trigger efficiencies do not change between the two selections: cancelled;

SELECTION CHANNEL	SELECTED EVENTS	BACKGROUND VS SIGNAL
Ke3γ	12242	$(3.5 \pm 1.4)\%$
Ke3	2280352	$(0.64 \pm 0.04)\%$

E_γ CUT	$\theta_{e,\gamma}$ CUT	ISTRA+ $\frac{BR(Ke3\gamma)}{BR(Ke3)}$ [3, 8]	NA62 $\frac{BR(Ke3\gamma)}{BR(Ke3)}$
$E_\gamma > 10MeV$	$0.6 < \cos\theta_{e,\gamma} < 0.9$	$(0.47 \pm 0.02 \pm 0.03) \cdot 10^{-2}$	$(0.57 \pm 0.02) \cdot 10^{-2}$
$E_\gamma > 30MeV$	$\theta_{e,\gamma} > 20^\circ$	$(0.63 \pm 0.02 \pm 0.03) \cdot 10^{-2}$	$(0.68 \pm 0.03) \cdot 10^{-2}$
$E_\gamma > 10MeV$	$\theta_{e,\gamma} > 10^\circ$	$(1.81 \pm 0.03 \pm 0.07) \cdot 10^{-2}$	$(1.95 \pm 0.04) \cdot 10^{-2}$

T-asymmetry measurement

$$\xi = \frac{[\vec{p_\gamma} \cdot (\vec{p_e} \times \vec{p_\pi})]}{M_K^3} \; ; \; A_\xi = \frac{N_+ - N_-}{N_+ + N_-}$$



NA62 measurement

$$A_\xi = (0.016 \pm 0.017)$$

off-set measured with *Monte Carlo* has been taken into account.

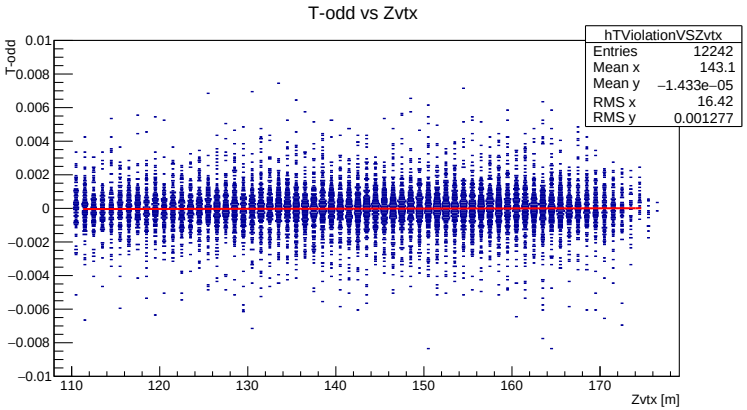
ISTRA+ measurement [8]

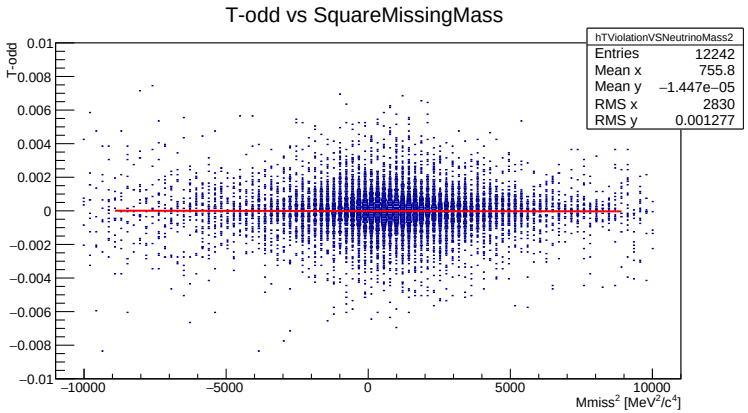
$$A_\xi^{ISTRA+} = (-0.015 \pm 0.021)$$

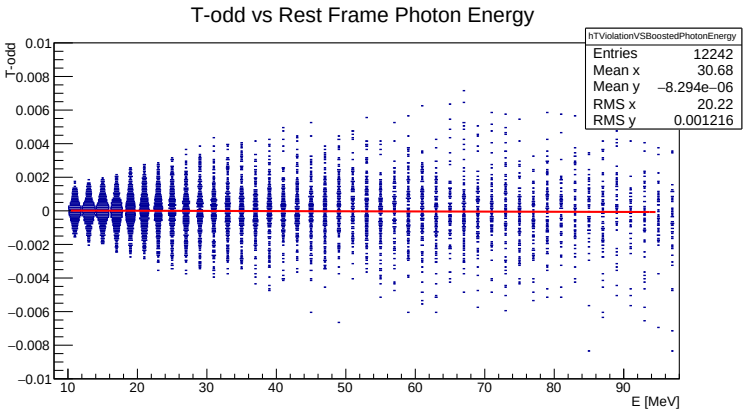
with ξ defined with the opposite sign.

Systematic error

T-odd observable ξ plotted with respect to several physics quantities characterizing the decay: **flat**.
At this level of the analysis the systematic error is negligible with respect to the statistical one.







Conclusions and outlook

- Studying the Ke3γ decay with the NA62 experiment, branching ratio measurements of this decay channel have been performed.
- A first attempt to measure T-violation has also been performed: the result is consistent with zero within the statistical error.
- Both the measurements are competitive with the existing ones.
- I estimated that with all the NA62 data taken in 2016 and 2017 the statistical error could be reduced by a factor 3. Taking data with an appropriate trigger mask definition could give the possibility to reduce the statistical error up to 10^{-3} and to perform a very interesting and competitive measurement of T-asymmetry in the weak interactions field.

References

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