New Physics searches at NA62

(Search for Lepton Number and Lepton Flavour violation and Heavy Neutral Lepton)

Elisa Minucci
on behalf of the NA62 Collaboration

Workshop on status and perspectives of physics at high intensity

INFN - Laboratori Nazionali di Frascati

9-11 November 2022

NA62: a general purpose experiment

NA62

Flavour physics

Search for NP at the EW scale with sizeable coupling to SM particles via indirect effects in loops. Golden mode: $\mathbf{K^+ \rightarrow \pi^+ \nu\nu}$;

$$Br(K^+ \rightarrow \pi^+ \nu\bar{\nu}) = (8.4 \pm 1.0) \times 10^{-11}$$

Searches for lepton flavour and number violation (LFV, LNV): $\mathbf{K^+ \rightarrow \pi^- l^+ l^+}$, $\mathbf{K^+ \rightarrow \pi^+ l^+ l'^-}$, $\mathbf{\pi^0 \rightarrow l^+ l'^-}$

Precision measurements: $\mathbf{K^+ \rightarrow \pi^+ l^+ l^-}$, $\mathbf{K^+ \rightarrow \pi^0 e^+ \gamma \nu}$, $\mathbf{K^+ \rightarrow e^+ \gamma \nu}$…

Hidden Sector

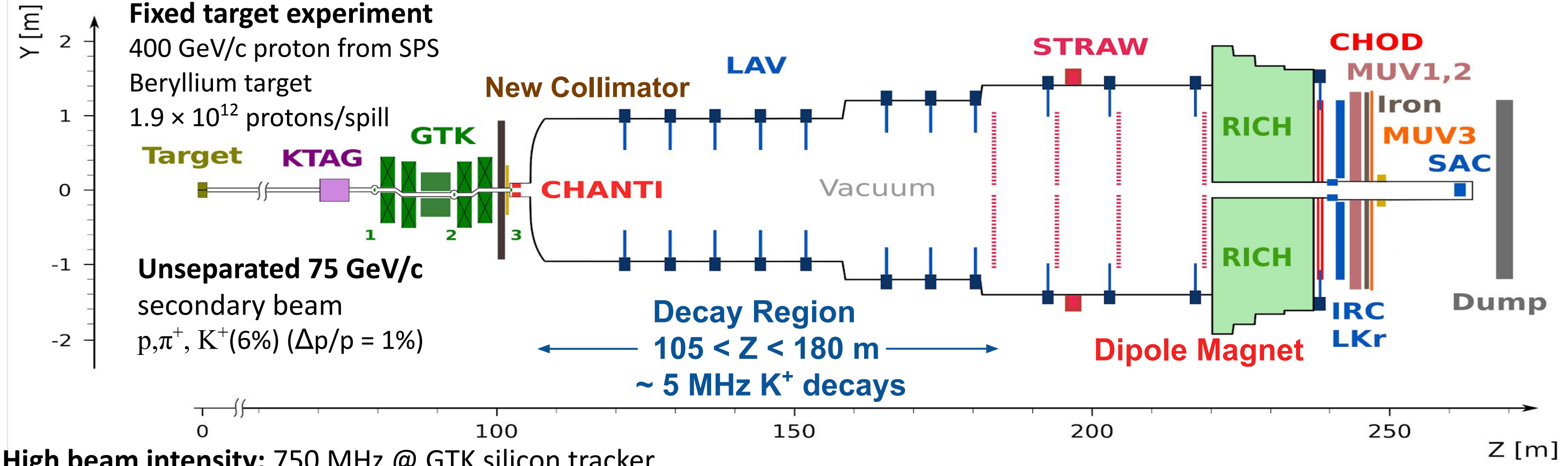
Search for NP below the EW scale (MeV-GeV range) feebly-coupled to SM particles via direct detection of long-lived particles: **HNL, Dark Photon, ALP …**

The NA62 experiment

2008 NA62 approval → **2009-2015 Detector R&D, installation, commissioning** → **2016-2018 Physics Run** → **2019-2021 LS2 Upgrades** → **2021-2025 Physics Run**

Fixed target experiment
400 GeV/c proton from SPS
Beryllium target
1.9×10^{12} protons/spill

Unseparated 75 GeV/c
secondary beam
p, π^+, K^+(6%) ($\Delta p/p$ = 1%)



High beam intensity: 750 MHz @ GTK silicon tracker
Precise timing: KTAG-GTK-RICH time resolution O(100 ps)
PID of incoming beam (KTAG) and daughter (RICH) particles
Tracking of daughter particles: σ_p/p ~ 1%, → O(10^4) rejection of 2-body decays
Hermetic photon veto system: O(10^8) π^0 rejection for E(π^0)>40 GeV
Muon id @ MUV3: O(10^7) muon rejection for 15 < P(π^+) < 35 GeV

Trigger system:

- L0 hardware trigger: simple information from fast detectors
- L1 software trigger

2016-2018 data taking ~ 10 trigger lines implemented

Lepton Number and Lepton Flavour violation (LNV&LFV)

$K^+ \rightarrow \pi^{\pm}\mu^{\mp}e^+$, $K^+ \rightarrow \pi^-\mu^+\mu^+$, $K^+ \rightarrow \pi^-(\pi^0)e^+e^+$, $K^+ \rightarrow \mu^-\nu e^+e^+$, $\pi^0 \rightarrow \mu^-e^+$

Heavy Neutral Lepton (HNL)

$K^+ \rightarrow \mu^+N$, $K^+ \rightarrow e^+N$

Search motivation

Lepton Number (**L**) and Lepton Flavour(**L_e**,**L_μ**,**L_τ**) are approximately conserved numbers within the Standard Model: their conservation is not imposed by any local gauge symmetry → interesting to search for New Physics effects, exploring high mass scale $\mathcal{O}$(100 TeV)*.

Decays as:

- Pure leptonic LFV processes: $\boldsymbol{\mu \to e\gamma}$ or $\boldsymbol{\mu \to 3e}$ **(MEG, MU2E, MU3E)**
- Quark-lepton LFV processes of the type **d → dμe** as the neutrino-less conversion $\mu + (A, Z) \to e + (A, Z)$
- Quark-lepton LFV processes of the type **s → dμe** as the kaon decays: $K^+ \to \pi^+ \mu e$ **(NA62)**
- Lepton number violating decays as the neutrino-less 2β-decay or $\boldsymbol{K^+ \to \pi^- l^+ l^+}$, $\boldsymbol{B^+ \to X^- l^+ l^+}$, where $X = \pi, K, \rho$ **(NA62, LHCb, Belle II)**

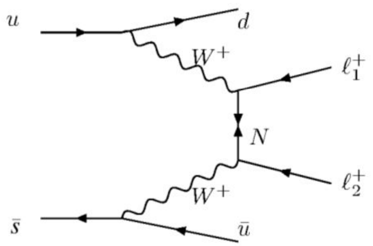
are forbidden within the Standard Model

Observation of neutrino oscillations provided the first proof of the non-conservation of LF, however no evidence of LNV has been observed so far. New physics models which explain experimental observations, such as neutrino oscillations or the possible flavour anomalies in B-physics, can introduce LN and LF violation involving charged leptons.

*assuming contribution at tree level without any specific flavour structure

Lepton Number & Lepton Flavour violation in K^+ decay

Lepton Number Violation

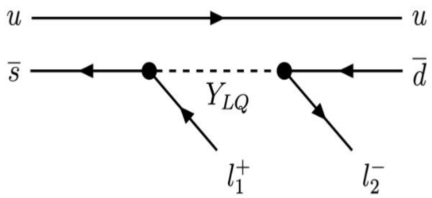


E.g: *Type I see-saw mechanism*
ΔL = 2 via exchange of Majorana neutrinos

Investigate the neutrino nature: Dirac or Majorana particles?

→ directly searching for HNL production and decays
→ searching for LNV processes

Lepton Flavour Violation



$\Delta L_i = 1$ & $\Delta L_j = 1$ i,j =[μ,e]
E.g mediated at tree level by:
leptoquark that can couples with fermions of more than one families
new heavy Z' boson with family non-universal coupling
flavour violating ALPs

Searches in K decays are complementary to searches in B-physics and in purely leptonic processes

Search for LNV and LFV

- ❑ **Blinded analysis strategy: signal region kept closed until final background validation in control regions**
- ❑ **Run1 = 2017+2018 data**
- ❑ analysis performed under the hypothesis that tracks and clusters, reconstructed in the detectors downstream the FV, are coming from the same decay point $\rightarrow$ Invariant Mass, M_{inv} , is the kinematic variable used to distinguish between signal and background

$$M_{inv} = \sqrt{(\sum_i P_i)^2}$$

where P_i is the four momentum of the selected track

- ❑ Normalization channel chosen according to the different final states, in order to optimise the cancellation of systematic effects such as trigger efficiency or intrinsic detector inefficiencies

Main step of the event selection

- Track selection: momentum, direction (STRAW) and time (CHOD or RICH)
- Reconstruct decay vertex within the FV
- Particle identification (PID): LKr, MUV3 (+RICH)

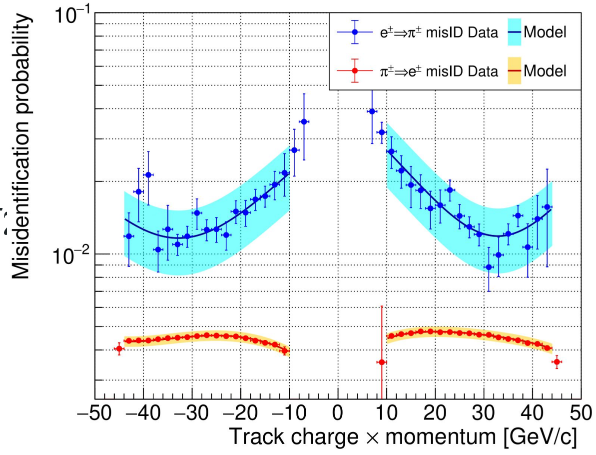
Background mechanism

1. Mis-identification (mis-ID)

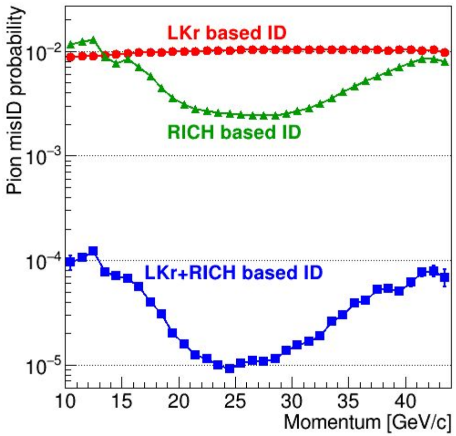
Probabilities measured from data

- $\pi^\pm \Rightarrow e^\pm$ from pure sample of $K^+ \to \pi^+\pi^+\pi^-$
- $e^\pm \Rightarrow \pi^\pm$ from pure sample of $K^+ \to \pi^+\pi^0$, $\pi^0 \to e^+e^-\gamma$

$\pi^\pm \Rightarrow \mu^\pm$ and $\mu^\pm \Rightarrow e^\pm$ have been considered (accidentals in muon detector (MUV3))



PID based on LKr and MUV3 (from $K^+ \to \pi\mu e$ analysis)



PID based on LKr and RICH (from $K^+ \to \pi(\pi)ee$ analysis)

2. Decay in flight (DIF)

- $\pi^\pm \to \mu^\pm \nu_\mu$
- $\mu^\pm \to e^\pm \nu_e$
- $\pi^0 \to e^+e^-\gamma$ (Dalitz decay)

3. Accidental background

mostly due to pile-up muon coming from beam particles decays

$K^+ \to \mu^- \nu e^+ e^+$

$K^+ \to \pi^+\pi^+\pi^-$ (decay upstream FV)

mis-ID as e^+

DIF to $\mu^-\nu_\mu$

$K^+ \to \pi^- \mu^+ e^+$

$K^+ \to \pi^+ e^+ e^-$

DIF: $\pi^+ \to \mu^+\nu_\mu$

mis-ID: $e^- \to \pi^-$

Consideration to background evaluation

Background evaluated from MC simulation of kaon decays

For the main kaon decays as $K^+ \to \pi^+\pi^+\pi^-$ (Br=5.583%) it's impossible to produce the same statistics in data ($\mathcal{O}(10^{12})$) limited by CPU and storage space

To boosts statistical power

PID models applied to simulation

Biased $K^+ \to \pi^+\pi^+\pi^-$ MC simulation forcing pion decays in flight

MC simulation needs to be corrected:
Data samples collected using trigger conditions including a cut on the total energy deposited in the LKr detector $\to$ due to non perfect simulation of pion energy deposition in the LKr corrections are applied based on data distribution

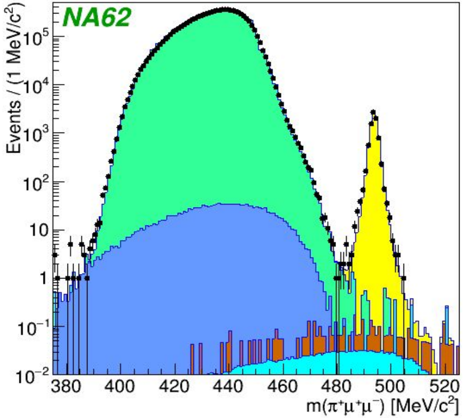
Search for $K^+ \to \pi^- \mu^+ \mu^+$ (PLB 797 134794 (2019))

Normalization Channel

$Br(K^+ \to \pi^+ \mu^+ \mu^-) = (9.4 \pm 0.6) \times 10^{-8}$

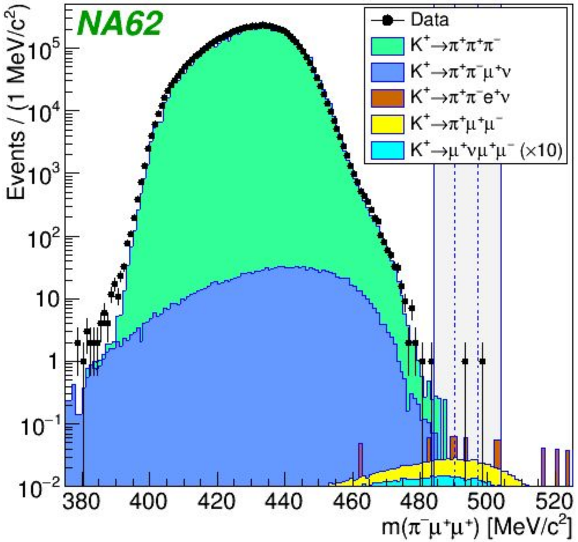
$N_K = (7.94 \pm 0.09_{stat} \pm 0.21_{ext}) \times 10^{11}$*

Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3



Process	Expected background
$K_{3\pi}$ (no $\pi^\pm$ decays)	0.007 ± 0.003
$K_{3\pi}$ (one $\pi^\pm$ decay)	0.25 ± 0.25
$K_{3\pi}$ downstream (at least two $\pi^\pm$ decays)	0.20 ± 0.20
$K_{3\pi}$ upstream (at least two $\pi^\pm$ decays)	0.24 ± 0.24
$K^+ \to \pi^+\mu^+\mu^-$	0.08 ± 0.02
$K^+ \to \pi^+\pi^-\mu^+\nu$	0.05 ± 0.05
$K^+ \to \pi^+\pi^-e^+\nu$	0.07 ± 0.05
$K^+ \to \mu^+\nu\mu^+\mu^-$	0.01 ± 0.01
Total	0.91 ± 0.41

Expected background in the signal region



$A_{\pi\mu\mu} = 9.81\ \%$
(signal acceptance)

$Br_{SES} = (1.28 \pm 0.04) \times 10^{-11}$

1 event observed in the signal region

$Br < 4.2 \times 10^{-11}$ @ 90% C.L

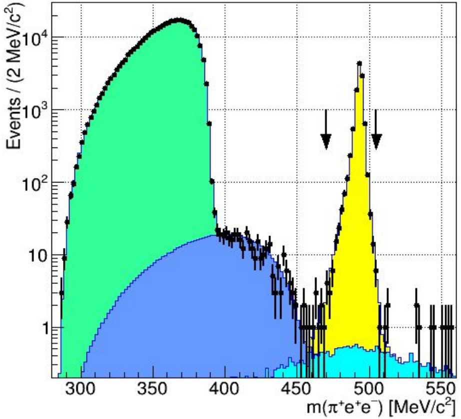
Search for $K^+ \to \pi^- e^+ e^+$ (PLB 830, 137172 (2022))

Normalization Channel

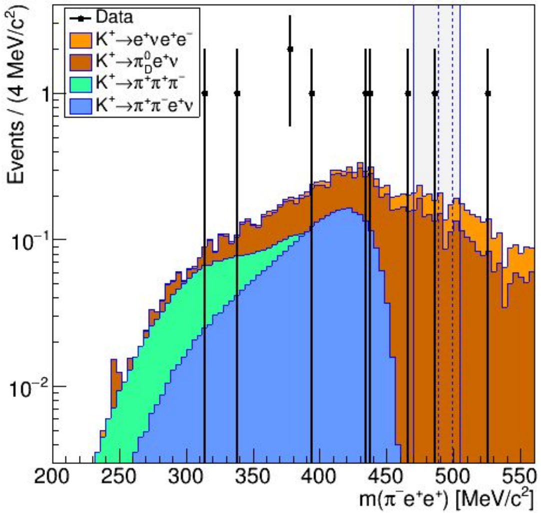
$Br(K^+ \to \pi^+ e^+ e^-) = (3.00 \pm 0.09) \times 10^{-7}$

$N_K = (1.015 \pm 0.010_{stat} \pm 0.030_{ext}) \times 10^{12}$

Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3



Mode	Lower region	Upper region	Masked region	Signal region
$K^+ \to \pi^+\pi^+\pi^-$	0.9	–	–	–
$K^+ \to \pi^+\pi^- e^+\nu$	3.3	–	–	–
$K^+ \to \pi^+\pi^0_D$	–	0.02	0.01	–
$K^+ \to \pi^0_D e^+\nu$	3.7 ± 0.7	1.20 ± 0.24	1.23 ± 0.25	0.29 ± 0.06
$K^+ \to e^+\nu e^+ e^-$	0.7 ± 0.1	0.76 ± 0.15	0.47 ± 0.09	0.14 ± 0.03
Total	8.6 ± 0.9	1.98 ± 0.39	1.71 ± 0.34	0.43 ± 0.09
Data	8	1	1	0



$A_{\pi ee} = 4.32\ \%$

(signal acceptance)

$Br_{SES} = (2.28 \pm 0.07) \times 10^{-11}$

0 event observed in the signal region

$Br < 5.3 \times 10^{-11}$ @ 90% C.L

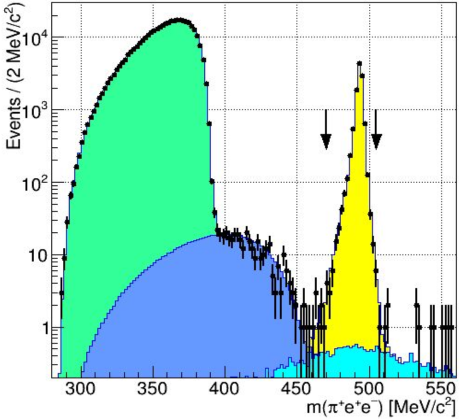
Search for $K^+ \to \pi^- \pi^0 e^+ e^+$ (PLB 830, 137172 (2022))

Normalization Channel

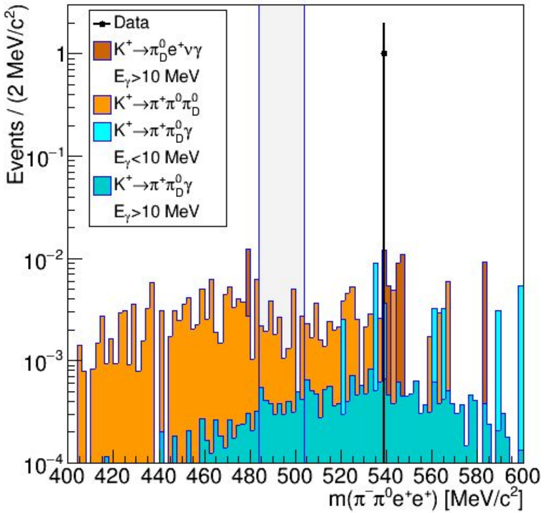
$Br(K^+ \to \pi^+ e^+ e^-) = (3.00 \pm 0.09) \times 10^{-7}$

$N_K = (1.015 \pm 0.010_{stat} \pm 0.030_{ext}) \times 10^{12}$

Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3



Mode	Control region	Signal region
$K^+ \to \pi^+\pi^0\pi^0_D$	0.16 ± 0.01	0.019
$K^+ \to \pi^+\pi^0_D\gamma$	0.06 ± 0.01	0.004
$K^+ \to \pi^0_D e^+\nu\gamma$	0.05 ± 0.02	–
$K^+ \to \pi^+\pi^0 e^+ e^-$	0.01	0.001
Pileup	0.20 ± 0.20	0.020 ± 0.020
Total	0.48 ± 0.20	0.044 ± 0.020
Data	1	0



$A_{\pi ee} = 0.271\ \%$

(signal acceptance)

$Br_{SES} = (3.68 \pm 0.12) \times 10^{-10}$

0 event observed in the signal region

$Br < 8.5 \times 10^{-10}$ @ 90% C.L

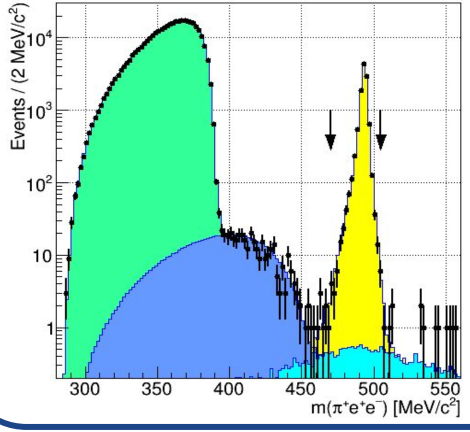
Search for $K^+ \to \mu^- \nu e^+ e^+$

Normalization Channel

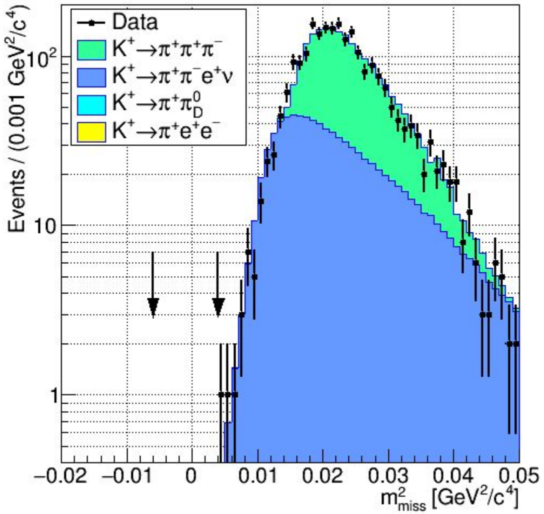
$Br(K^+ \to \pi^+ e^+ e^-) = (3.00 \pm 0.09) \times 10^{-7}$

$N_K = (1.97 \pm 0.02_{stat} \pm 0.02_{sys} \pm 0.06_{ext}) \times 10^{12}$

Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3



Mode / Region	Lower	Signal	Upper
$K_{3\pi}$	< 0.07	< 0.07	1412 ± 11
$K_{3\pi}$ (upstream)	< 0.03	0.06 ± 0.03	1.5 ± 0.3
$K^+ \to \pi^+\pi^- e^+ \nu$	0.01 ± 0.01	0.16 ± 0.02	867 ± 1
$K^+ \to \pi^+\pi^- e^+ \nu$ (upstream)	0.01 ± 0.01	0.01 ± 0.01	0.14 ± 0.03
$K^+ \to \pi^0_D e^+ \nu$	0.02 ± 0.01	0.01 ± 0.01	0.02 ± 0.01
Total	0.04 ± 0.02	0.26 ± 0.04	2281 ± 11
Data	0	masked	2271



$A_{\pi ee} = 1.44$ %
(signal acceptance)

$Br_{SES} = (3.53 \pm 0.12) \times 10^{-11}$

0 event observed in the signal region

$Br < 8.1 \times 10^{-11}$ @ 90% C.L

Search for $K^+ \to \pi^\pm \mu^\mp e^+$ and $\pi^0 \to \mu^- e^+$ (PRL 127, 1131802 (2021))

additional constraint on the two leptons invariant mass: must be compatible with the π^0 mass

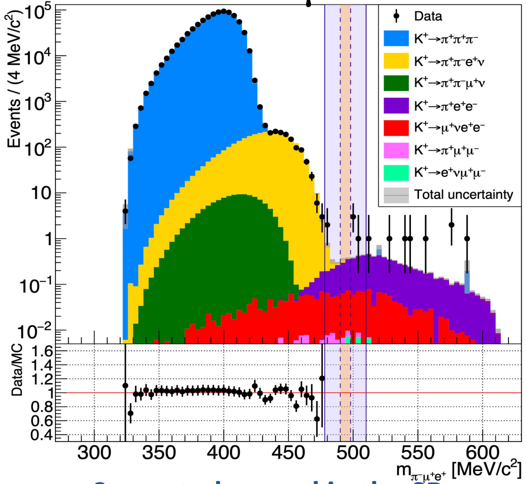
Normalization Channel

$Br(K^+ \to \pi^+\pi^+\pi^-) = (5.583 \pm 0.024)\ \%$

$N_K = (1.33 \pm 0.02_{sys}) \times 10^{12}$

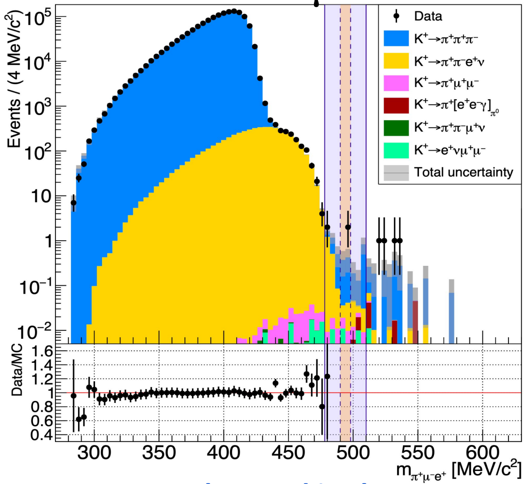
Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3
DV-2μ	3	160	5
Neutrino	15	10	3
Control	400	94	94

$K^+ \to \pi^-\mu^+e^+$



0 event observed in the SR

$K^+ \to \pi^+\mu^-e^+$



1 event observed in the SR

0 event observed in the SR for $\pi^0 \to \mu^- e^+$

	$K^+ \to \pi^-\mu^+e^+$	$K^+ \to \pi^+\mu^-e^+$	$\pi^0 \to \mu^-e^+$
$A_s \times 10^2$	4.90 ± 0.02	6.21 ± 0.02	3.11 ± 0.02
$\varepsilon_{LKr10} \times 10^2$	97.5 ± 1.3	97.5 ± 1.3	92.9 ± 1.2
$\varepsilon_{LKr20} \times 10^2$	74.1 ± 1.6	73.3 ± 1.6	45.3 ± 1.0
$\mathcal{B}_{SES} \times 10^{11}$	1.82 ± 0.08	1.44 ± 0.05	13.9 ± 0.9

$$\mathcal{B}^i_{SES} = \frac{1}{N^i_K A_s \varepsilon^i_s} \qquad \mathcal{B}_{SES} = \left[\sum_i (\mathcal{B}^i_{SES})^{-1}\right]^{-1}$$

Source	$K^+ \to \pi^-\mu^+e^+$	$K^+ \to \pi^+\mu^-e^+$	$\pi^0 \to \mu^-e^+$
$K^+ \to \pi^+\pi^+\pi^-$	0.22 ± 0.15	0.84 ± 0.34	0.22 ± 0.15
$K^+ \to \pi^+e^+e^-$	0.63 ± 0.13	negligible	negligible
$K^+ \to \mu^+\nu_\mu e^+e^-$	0.13 ± 0.02	negligible	negligible
$K^+ \to \pi^+\pi^-e^+\nu_e$	0.07 ± 0.02	0.05 ± 0.03	0.01 ± 0.01
$K^+ \to \pi^+\mu^+\mu^-$	0.01 ± 0.01	0.02 ± 0.01	negligible
$K^+ \to e^+\nu_e\mu^+\mu^-$	0.01 ± 0.01	0.01 ± 0.01	negligible
Total	1.07 ± 0.20	0.92 ± 0.34	0.23 ± 0.15

Search for $K^+ \to \pi^\pm \mu^\mp e^+$ and $\pi^0 \to \mu^- e^+$ (PRL 127, 1131802 (2021))

Normalization Channel

$Br(K^+ \to \pi^+\pi^+\pi^-) = (5.583 \pm 0.024)$ %

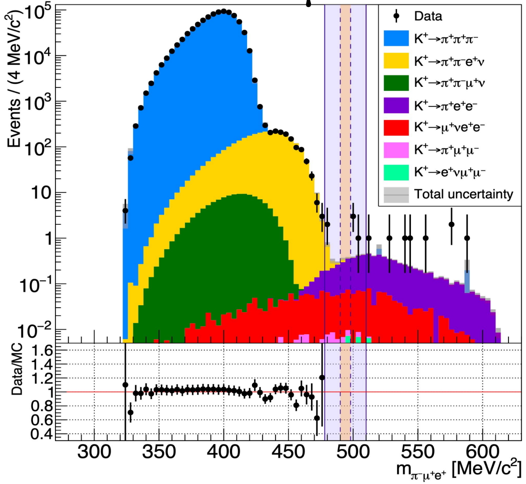
$N_K = (1.33 \pm 0.02_{sys}) \times 10^{12}$

Trigger line	Downscaling	L0 triggers [10^3]	L1 triggers [10^3]
PNN	1	1540	74
Non-μ	200	30	12
MT	100	39	4
2μMT	2	150	30
eMT	8	193	22
μMT	5	99	10
DV-μ	5	140	0.3
DV-2μ	3	160	5
Neutrino	15	10	3
Control	400	94	94

	$K^+ \to \pi^-\mu^+e^+$	$K^+ \to \pi^+\mu^-e^+$	$\pi^0 \to \mu^-e^+$
$A_s \times 10^2$	4.90 ± 0.02	6.21 ± 0.02	3.11 ± 0.02
$\varepsilon_{LKr10} \times 10^2$	97.5 ± 1.3	97.5 ± 1.3	92.9 ± 1.2
$\varepsilon_{LKr20} \times 10^2$	74.1 ± 1.6	73.3 ± 1.6	45.3 ± 1.0
$\mathcal{B}_{SES} \times 10^{11}$	1.82 ± 0.08	1.44 ± 0.05	13.9 ± 0.9

$$\mathcal{B}^i_{SES} = \frac{1}{N^i_K A_s \varepsilon^i_s} \qquad \mathcal{B}_{SES} = \left[\sum_i (\mathcal{B}^i_{SES})^{-1}\right]^{-1}$$

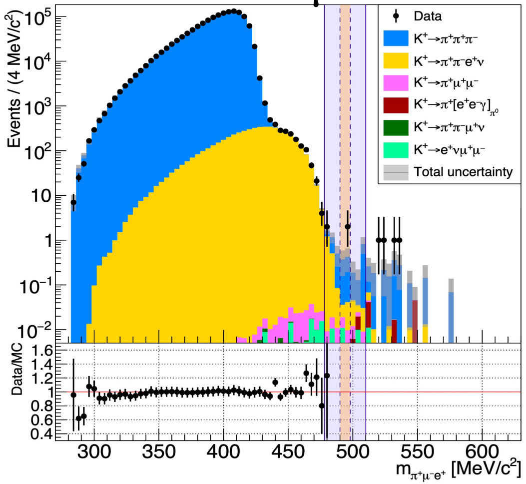
$K^+ \to \pi^-\mu^+e^+$



0 event observed in the SR

Br < 4.2× 10⁻¹¹ @ 90% C.L

$K^+ \to \pi^+\mu^-e^+$



1 event observed in the SR

0 event observed in the SR for $\pi^0 \to \mu^- e^+$

$Br < 6.6 \times 10^{-11}$ @ 90% C.L

$Br < 3.2 \times 10^{-10}$ @ 90% C.L
$\pi^0 \to \mu^- e^+$

Heavy Neutral Lepton searches

How to detect HNL:

Production: $K^+ \to l^+ N$

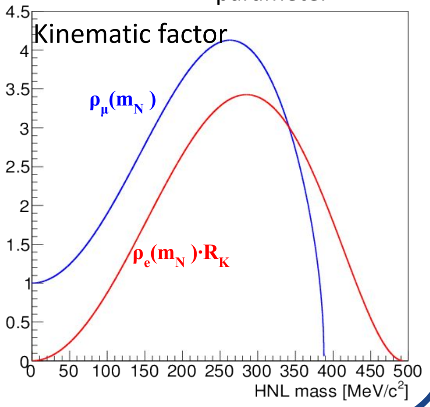
Search for a peak in $m_N^2 = m_{miss}^2 = (P_K - P_l)^2$

$$\Gamma(K^+ \to l^+ \nu_h) = \Gamma(K^+ \to l^+ \nu) \cdot \rho_l(m_N) \cdot |U_{l4}|^2$$

Width of the K + leptonic decay involving SM neutrino

squared neutrino mixing parameter

HNL production is enhanced kinematically wrt SM decays (except near kinematic endpoints). Factor ~10^5 enhancement in the $K^+ \to e^+ N$ case: helicity suppression is relaxed.



Decay: N decay only in SM particles

$$\Gamma(N \to \text{SM particles}) \sim |U_{l4}|^2 \cdot m_N^3$$

For HN mass below 500 MeV/c^2 the dominant decays are :

$$N \to \pi^0 \nu,\ N \to \pi^\pm \mu^\pm,\ N \to \pi^\pm e^\pm,\ N \to \nu\nu\nu$$

In NA62 the mean free path for $K^+ \to l^+ N$ assuming $|U_{l4}|^2 < 10^{-4}$ is greater than 10 Km → not possible to perform such search

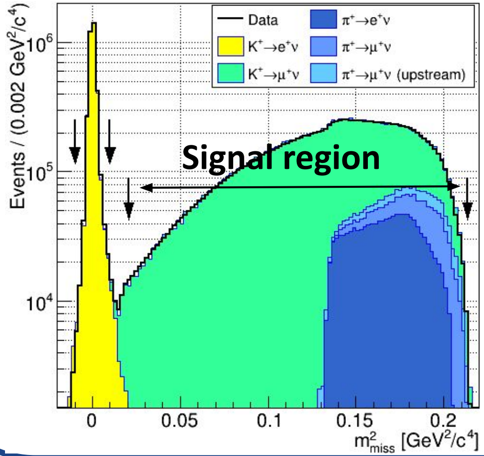
Search for HNL production in K^+ decays to lepton

- precise tracking and powerful PID to reconstruct both the K^+ and e^+/μ^+
- matching the two tracks together
- veto any other in-time activity, time resolution $\mathcal{O}$(100ps)
- $K^+ \to l^+N$ decays should appear as a sharp bump in the positive m^2_{miss} side-band of candidate $K^+ \to l^+\nu$ decays

$K^+ \to e^+N$

N_{SM} = 3.49 x 10^6 $K^+ \to e^+\nu$ candidates

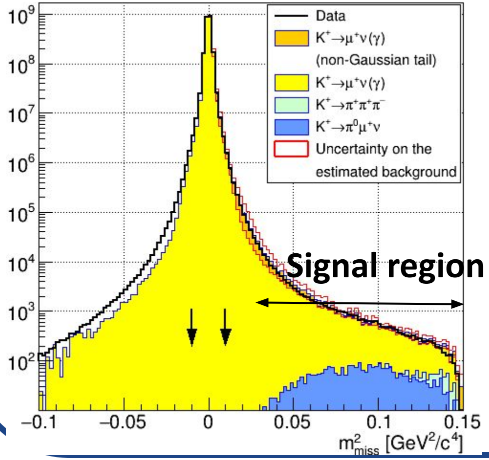
N_K = 3.52 x 10^{12} (analysis-dependent sample size)



$K^+ \to \mu^+N$

N_{SM} = 2.19 × 10^9 $K^+ \to \mu^+\nu$ candidates

N_K = (1.14 ± 0.02) × 10^{10} (~400 trigger downscale)



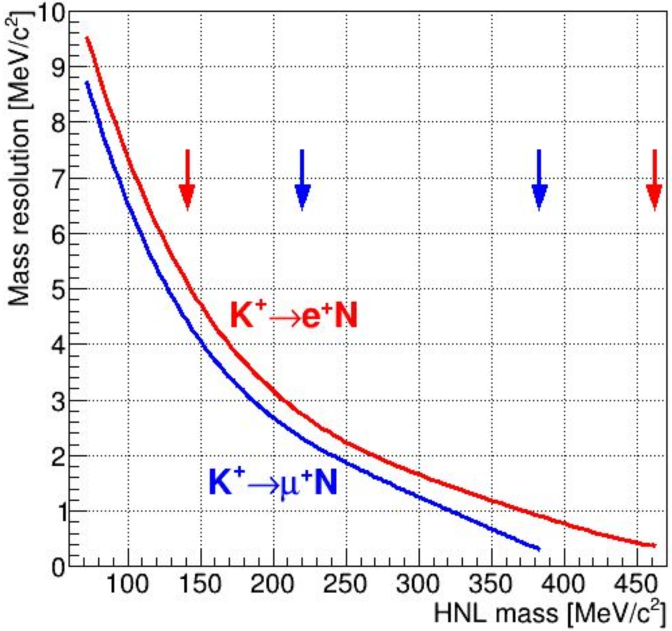
π^+ decays negligible

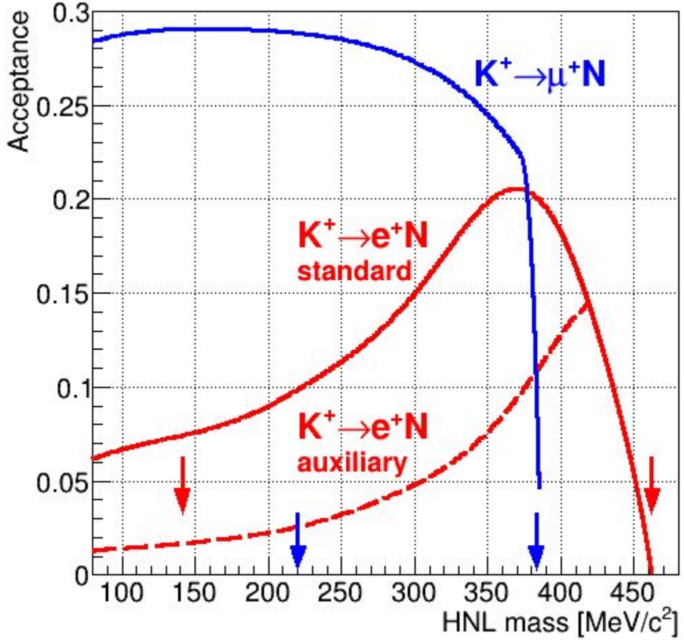
Simulation of beam-particle pileup and GTK inefficiency causes deficit of simulated events in non-gaussian tails of m^2_{miss} (assign a 100% systematic uncertainty)

HNL mass resolution and acceptance

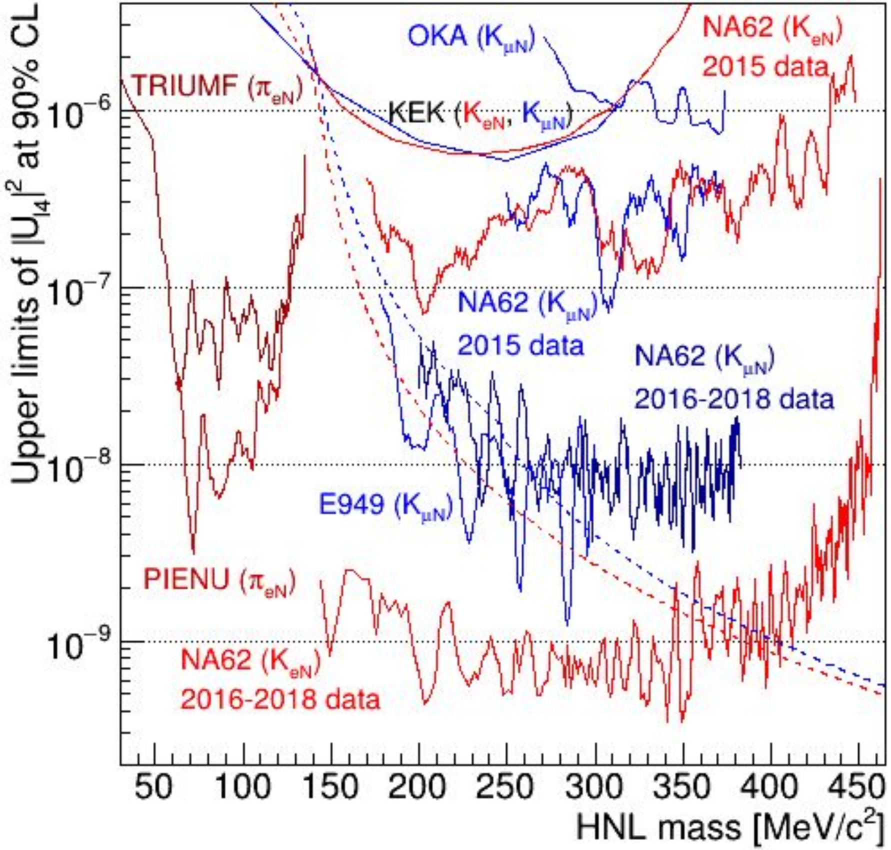
Selection for each HNL mass hypothesis (m_N) includes a "mass window" condition: $|m-m_N| < 1.5\ \sigma_m$: background is proportional to mass resolution.

Resolution is crucial to resolve possible HNL mass splitting.





Results from full Run 1 data set



$\mathcal{O}(10^{-9})$ limits on $|U_{e4}|^2$ and $\mathcal{O}(10^{-8})$ limits on $|U_{\mu 4}|^2$

More than 2(1) orders of magnitude improvements from run 1 data for e^+ (μ^+) with respect to previous results.

For μ^+ : NA62 consistent with the E949 result and extends UL to higher masses

For e^+: values favored by the Big Bang Nucleosynthesis (BBN) constraint (dashed red line) are excluded for HNL masses up to 340 MeV/c^2

PLB 816 136259 (2021)
PLB 807 135599 (2020)

Summary: new upper limits on LNV and LFV decays from NA62

	Previous UL @ 90% C.L	NA62 UL @ 90% C.L	
$K^+ \rightarrow \pi^- \mu^+ \mu^+$	8.6×10^{-11}	4.2×10^{-11}	2017 data → improved by factor 2
$K^+ \rightarrow \pi^- e^+ e^+$	6.4×10^{-10}	5.3×10^{-11}	2017+2018 data → improved by factor 12
$K^+ \rightarrow \pi^- \pi^0 e^+ e^+$	no limit	8.5×10^{-10}	2017+2018 data → first limit
$K^+ \rightarrow \pi^- \mu^+ e^+$	5.0×10^{-10}	4.2×10^{-11}	2017+2018 data → improved by factor 12
$K^+ \rightarrow \pi^+ \mu^- e^+$	5.2×10^{-10}	6.6×10^{-11}	2017+2018 data → improved by factor 8
$\pi^0 \rightarrow \mu^- e^+$	3.4×10^{-9}	3.2×10^{-10}	2017+2018 data → improved by factor 13
$K^+ \rightarrow \pi^+ \mu^+ e^-$	1.3×10^{-11}	-	sensitivity similar to the previous search
$\pi^0 \rightarrow \mu^+ e^-$	3.8×10^{-10}	-	sensitivity similar to the previous search
$K^+ \rightarrow \mu^- \nu e^+ e^+$	2.1×10^{-8}	8.1×10^{-11}	2017+2018 data → improved by more than 2 order of magnitude
$K^+ \rightarrow e^- \nu \mu^+ \mu^+$	no limit	-	Ongoing analysis: 2017+2018 data *S.E.S* ~ 10^{-11}

Conclusions and Prospects

The NA62 2016-2018 data taking led to a lot of new results:

- ❑ Large improvements on most of the LN and LF violating K^+ and π^0 decays → sensitivity up to 10^{-11}
- ❑ New limits on the $|U_{4l}|^2$ up to 10^{-9}, searching for HNL production in K^+ decays to leptons have been set, improving on previous results and covering larger mass range

NA62 resumed the data taking in 2021, with detector upgrades and optimizations of the trigger lines.

New data have been already collected and new results on LNV, LFV and HNL searches are expected.

Stay tuned