Latest results from the NA62 experiment at CERN: precision measurements and searches in beam-dump mode

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on behalf of the NA62 Collaboration

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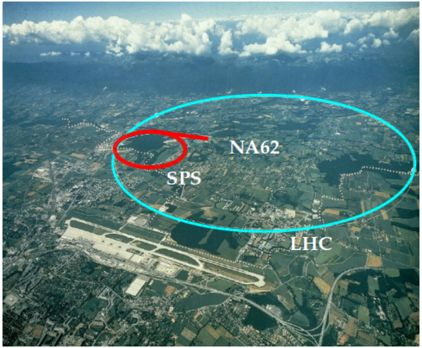
The NA62 experiment at CERN: the *charged kaon factory*

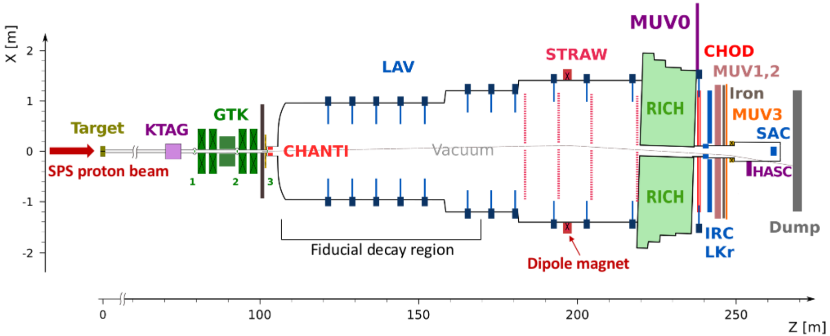
- NA62 is located in the CERN *North Area*, exploiting a 400 GeV/c proton beam extracted from the SPS accelerator
- Main goal: measurement of $\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu})$
- Full detector installation completed in 2016
- Physics runs in 2016, 2017 and 2018 (Run 1)
- Result from full Run 1 [JHEP 06 (2021) 093]:
  $\mathcal{B}^{\mathrm{NA62}}(K^+ \to \pi^+ \nu\bar{\nu}) = (1.06^{+0.40}_{-0.34\mathrm{stat}} \pm 0.09_{\mathrm{syst}}) \times 10^{-10}$
  3.4σ significance
- Data taking resumed in 2021, after CERN LS2, approved until CERN LS3



In this talk:

- Precision measurements: $K^+ \to \pi^0 e^+ \nu\gamma$, $K^+ \to \pi^+\mu^+\mu^-$, $K^+ \to \pi^+\gamma\gamma$
- Searches in beam-dump mode: $A' \to \mu^+\mu^-$, $A' \to e^+e^-$

NA62 beam and detector [2017 JINST 12 P05025]



- SPS beam: 400 GeV/c proton on beryllium target
- Secondary hadron 75 GeV/c beam
- 70% pions, 24% protons, 6% kaons
- Nominal beam particle rate (at GTK3): 750 MHz
- Average beam particle rate during 2018 data-taking: 450 — 500 MHz

- KTAG: Cherenkov threshold counter
- GTK: Si pixel beam tracker
- CHANTI: stations of plastic scintillator bars
- LAV: lead glass ring calorimeters
- STRAW: straw magnetic spectrometer
- RICH: Ring Imaging Cherenkov counter
- MUV0: off-acceptance plane of scintillator pads

- CHOD: planes of scintillator pads and slabs
- IRC: inner ring shashlik calorimeter
- LKr: electromagnetic calorimeter filled with liquid krypton
- MUV1,2: hadron calorimeter
- MUV3: plane of scintillator pads for muon veto
- HASC: near beam lead–scintillator calorimeter
- SAC: small angle shashlik calorimeter

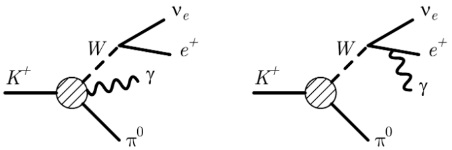
$K^+ \to \pi^0 e^+ \nu\gamma$ analysis [arXiv: 2304.12271 (2023), submitted to JHEP]

- Decay described in ChPT as direct emission, inner bremsstrahlung and their interference
- $\mathcal{B}(K^+ \to \pi^0 e^+ \nu\gamma)$ strongly **depends on** E_γ and $\theta_{e\gamma}$ cuts in K^+ rest frame
- **Three kinematic ranges** considered (defined by E_γ and $\theta_{e\gamma}$ → table below)
- **Measure** normalized $\mathcal{B}(K^+ \to \pi^0 e^+ \nu\gamma)$ **in ranges** $j = \{1, 2, 3\}$:

$$R_j = \frac{\mathcal{B}(K^+ \to \pi^0 e^+ \nu\gamma \mid E_\gamma^j, \theta_{e\gamma}^j)}{\mathcal{B}(K^+ \to \pi^0 e^+ \nu(\gamma))}$$

- **Test of T-conservation** thanks to T-odd observable ξ and its asymmetry:

$$\xi = \frac{\vec{p}_\gamma \cdot (\vec{p}_e \times \vec{p}_\pi)}{(M_K \cdot c)^3}, \quad A_\xi = \frac{N_{\xi>0} - N_{\xi<0}}{N_{\xi>0} + N_{\xi<0}}$$



Signal selection:

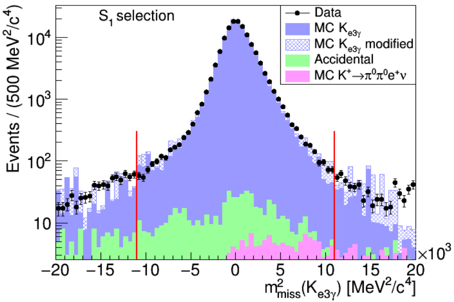
- Reconstruct and match K^+ and e^+ tracks
- Reconstruct $\pi^0 \to \gamma\gamma$ as two LKr clusters
- Radiative γ identified as isolated LKr cluster
- Kinematic constratint with the observable: $m^2_{miss} = (P_K - P_e - P_{\pi^0} - P_\gamma)^2$
- Minimal differences in signal and normalization selections, only related to the radiative photon ⇒ **reduced systematic effects**

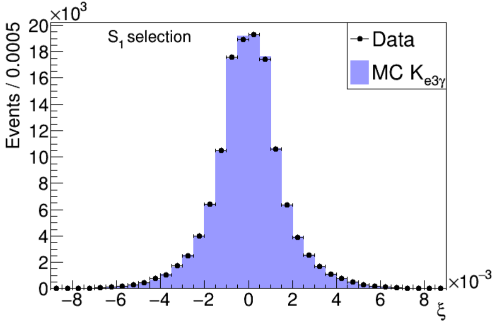
State of the art:

	E_γ^j, $\theta_{e\gamma}^j$	$\mathcal{O}(p^6)$ ChPT [EPJ C 50 (2007)]	ISTRA+ [PAN 70 (2007)]	OKA [EPJ C 81 (2021)]
$R_1 \times 10^2$	$E_\gamma > 10$ MeV, $\theta_{e\gamma} > 10°$	1.804 ± 0.021	$1.81 \pm 0.03 \pm 0.07$	$1.990 \pm 0.017 \pm 0.021$
$R_2 \times 10^2$	$E_\gamma > 30$ MeV, $\theta_{e\gamma} > 20°$	0.640 ± 0.008	$0.63 \pm 0.02 \pm 0.03$	$0.587 \pm 0.010 \pm 0.015$
$R_3 \times 10^2$	$E_\gamma > 10$ MeV, $0.6 < \cos\theta_{e\gamma} < 0.9$	0.559 ± 0.006	$0.47 \pm 0.02 \pm 0.03$	$0.532 \pm 0.010 \pm 0.012$

$K^+ \to \pi^0 e^+ \nu \gamma$ results [arXiv: 2304.12271 (2023), submitted to JHEP]

$N^{obs} = 1.3 \times 10^5$ with relative bkg contamination $< 1\%$





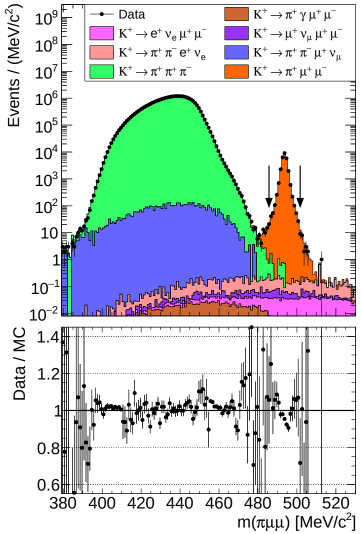
	range 1	range 2	range 3
$R \times 10^2$	$1.715 \pm 0.005_{\text{stat}} \pm 0.010_{\text{syst}}$	$0.609 \pm 0.003_{\text{stat}} \pm 0.006_{\text{syst}}$	$0.533 \pm 0.003_{\text{stat}} \pm 0.004_{\text{syst}}$
$A_\xi \times 10^2$	$-0.1 \pm 0.3_{\text{stat}} \pm 0.2_{\text{syst}}$	$-0.3 \pm 0.4_{\text{stat}} \pm 0.3_{\text{syst}}$	$-0.9 \pm 0.5_{\text{stat}} \pm 0.4_{\text{syst}}$

- NA62 measurements of R_j smaller than $\mathcal{O}(p^6)$ ChPT by 5% relative (disagreement: 3 std deviations)
- Improvement on experimental precision of R_j measurements by a factor > 2

$K^+ \to \pi^+\mu^+\mu^-$ analysis [JHEP 11 (2022) 011]

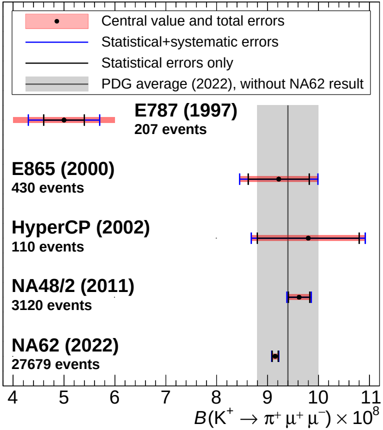
$K^\pm \to \pi^\pm l^+ l^-$ **decays** ($l = e, \mu$)

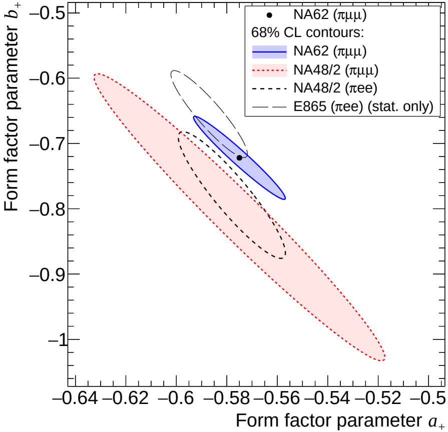
- **Flavour changing neutral current processes**
- Long distance dominated, mediated by virtual photon exchange: $K^\pm \to \pi^\pm \gamma^* \to \pi^\pm l^+ l^-$
- Main kinematic variable $z = m^2_{l^+l^-}/m^2_K$
- **Form factor** of $K^\pm \to \pi^\pm \gamma^*$ transition $\mathbf{W(z)}$ parametrized in ChPT at $\mathcal{O}(p^6)$ as
$$W(z) = (a_+ + z b_+) G_F m_K^2 + W^{\pi\pi}(z)$$
with **real parameters** a_+, b_+ and (known) complex function $W^{\pi\pi}(z)$
- Ideal for **test of lepton flavour universality**
- Measure **model independent** $\mathcal{B}(K^+ \to \pi^+\mu^+\mu^-)$
- Measure $|W(z)|^2$ from $d\Gamma(z)/dz$ distribution and determine form factor parameters a_+, b_+ (reweighting $K^+ \to \pi^+\mu^+\mu^-$ MC)
- Signal selection: three tracks identified as $\pi^+\mu^+\mu^-$, kinematic cuts suppressing $K_{3\pi}$ events
- Normalization channel to measure N_K decays: $K^+ \to \pi^+\pi^+\pi^-$. Minimal differences in event selections to **reduce systematic effects**



$K^+ \to \pi^+\mu^+\mu^-$ results [JHEP 11 (2022) 011]

$N^{obs} = 27679$ with relative bkg contamination $< 0.1\%$



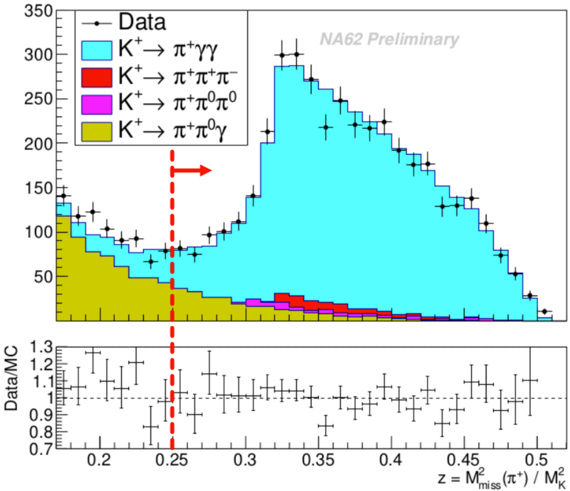


$$a_+ = -0.575 \pm 0.013,\ b_+ = -0.722 \pm 0.043,$$

$$\mathcal{B}(K^+ \to \pi^+\mu^+\mu^-) = (9.15 \pm 0.08) \times 10^{-8} \text{ at } 68\% \text{ CL}$$

$K^+ \to \pi^+\gamma\gamma$ analysis

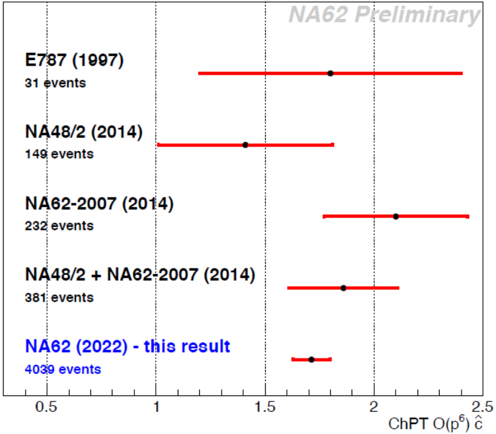
- Crucial **test of Chiral Perturbation Theory**
- Main kinematic variable: $z = \left(\frac{m_{\gamma\gamma}}{m_K}\right)^2$
- **Branching fraction** $\mathcal{B}(K^+ \to \pi^+\gamma\gamma)$ parametrized in ChPT by an unknown **real parameter** $\hat{c}$
- Branching fraction and $\hat{c}$ depend on several **external parameters** (fixed in this analysis, but recently updated $\to$ will be accounted for in the final result)
- Signal selection: single positive track identified as π^+ matched with a K^+ track, two γ clusters in LKr. **Signal region:** $z > 0.25$
- Normalization channel to measure N_K decays: $K^+ \to \pi^+\pi^0$. Minimal differences in event selections to **reduce systematic effects**
- Main background source: cluster merging in calorimeter ($K^+ \to \pi^+\pi^0\gamma$, $\pi^0 \to \gamma\gamma$ or $K^+ \to \pi^+\pi^0\pi^0$, $\pi^0 \to \gamma\gamma$)

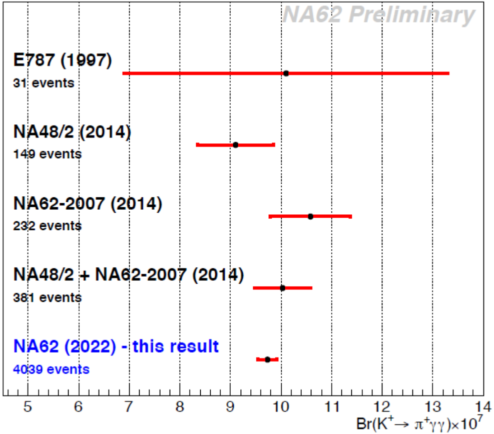


- $\hat{c}$ obtained by reweighting of $K^+ \to \pi^+\gamma\gamma$ MC and performing binned max-likelihood fit

$K^+ \to \pi^+\gamma\gamma$ preliminary results (paper in preparation)

$$N^{obs} = 4039,\ N^{exp}_{bkg} = 393 \pm 20$$





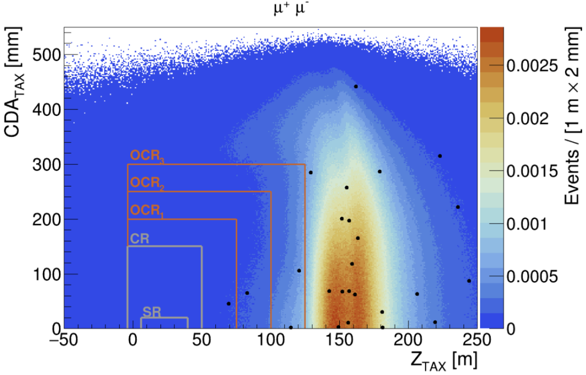
$$\hat{c} = 1.713 \pm 0.075_{\rm stat} \pm 0.037_{\rm syst}$$

$$\mathcal{B}(K^+ \to \pi^+\gamma\gamma) = (9.73 \pm 0.17_{\rm stat} \pm 0.08_{\rm syst}) \times 10^{-7} \text{ at } 68\% \text{ CL}$$

$A' \to \mu^+\mu^-$ in beam-dump [arXiv: 2303.08666 (2023), submitted to JHEP]

- Beam dump mode: 3.2 m Cu-Fe collimators (TAXes) used as a target
- In 2021, NA62 collected $(1.40 \pm 0.28) \times 10^{17}$ POT
- Search for feebly interacting dark photon (with free mass and coupling ϵ) produced in interaction with TAXes
- Signal selection: $\mu^+\mu^-$ vertex reconstructed within the NA62 decay region and pointing back to the proton beam interaction point at the TAXes.
- Main background: combinatorial from random superposition of two uncorrelated "halo" muons
- Bkg estimated selecting single tracks in a data sample orthogonal to the one used for the analysis: track pairs are artificially built to emulate a random superposition and reweighted

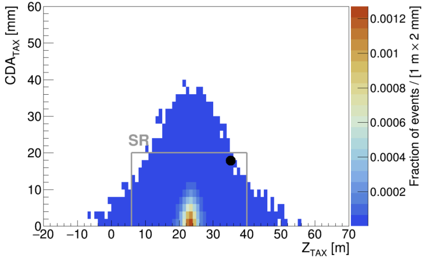
Bkg distributions - SR and CR masked

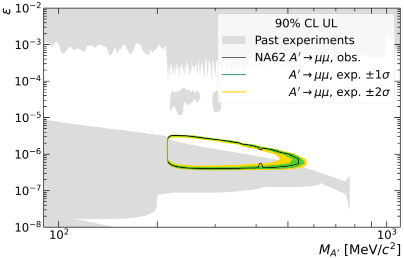


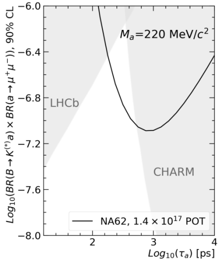
$N^{exp}_{bkg}(CR) = 0.17 \pm 0.02$, $N^{exp}_{bkg}(SR) = 0.016 \pm 0.002$

$A' \to \mu^+\mu^-$: results [arXiv: 2303.08666 (2023), submitted to JHEP]

1 event observed in SR, counting experiment with 2.4σ global significance

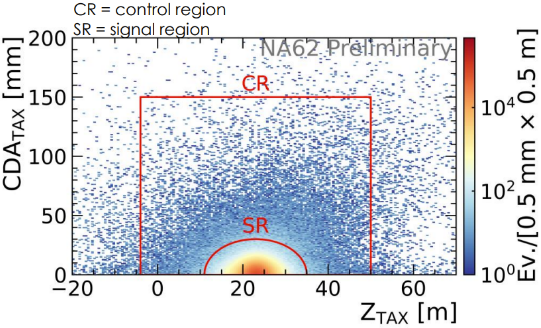


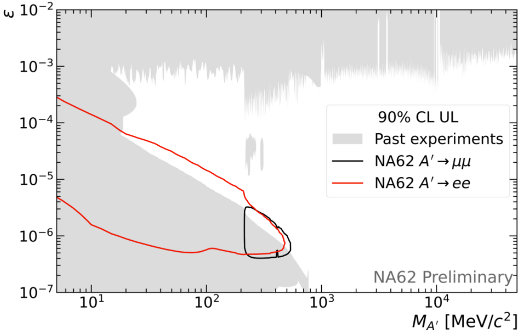




- Limits of previous experiments extended in the dark photon mass range 215–550 MeV/c^2 for coupling constants of the order of 10^{-6}
- Result also interpreted in terms of the emission of axion-like particles in a model-independent approach, improving on previous limits for masses below 280 MeV/c^2

$A' \to e^+e^-$: preliminary results (paper in preparation)





- $N^{exp}_{bkg}(CR) = 0.0097^{+0.049}_{-0.009}$ at 90% CL, $N^{exp}_{bkg}(SR) = 0.0094^{+0.049}_{-0.009}$ at 90% CL
- No events observed
- Exlcusion limits combined with $A' \to \mu^+\mu^-$
- Limits of previous experiments extended for dark photon mass above 20 MeV$/c^2$

Conclusions

- Precision measurements from NA62 Run 1 data, with sizable improvements with respect to the state the art:
    - $K^+ \to \pi^0 e^+ \nu \gamma$
    - $K^+ \to \pi^+ \mu^+ \mu^-$
    - $K^+ \to \pi^+ \gamma\gamma$
- Searches in beam-dump mode from NA62 2021 data, with exclusion limits extended with respect to previous experiments:
    - $A' \to \mu^+ \mu^-$
    - $A' \to e^+ e^-$
- NA62 physics Run 2 ongoing, until CERN LS3

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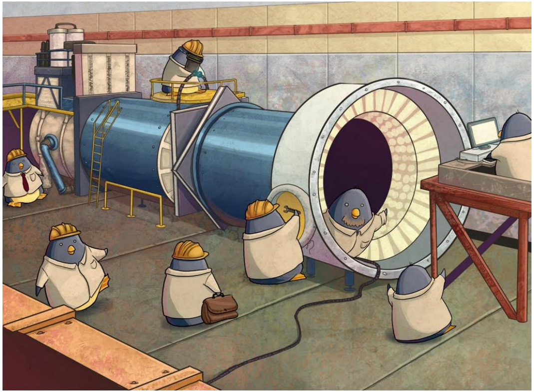
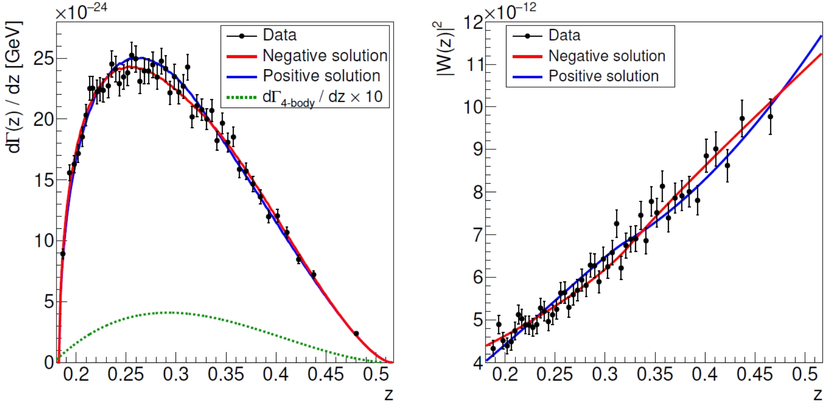


$K^+ \to \pi^0 e^+ \nu \gamma$ analysis: error budget [arXiv: 2304.12271 (2023), submitted to JHEP]

	$\delta R_1/R_1$	$\delta R_2/R_2$	$\delta R_3/R_3$
Statistical	0.3%	0.4%	0.5%
Limited MC sample size	0.2%	0.4%	0.4%
Background estimation	0.1%	0.2%	0.1%
LKr response modelling	0.4%	0.5%	0.4%
Photon veto correction	0.3%	0.4%	0.3%
Theoretical model	0.1%	0.5%	0.1%
Total systematic	0.6%	0.9%	0.7%
Total	0.7%	1.0%	0.8%

$K^+ \to \pi^+\mu^+\mu^-$: decay width and form factors [JHEP 11 (2022) 011]



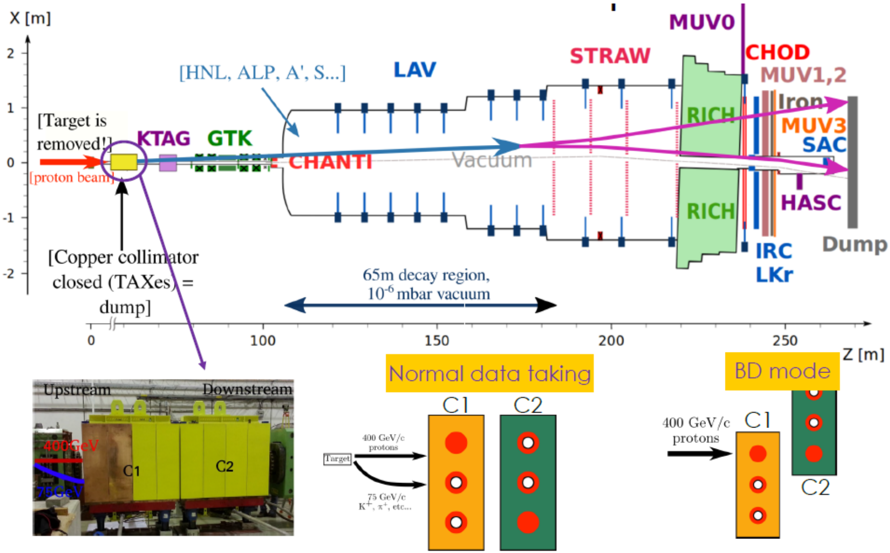
$$\frac{\mathrm{d}\Gamma(z)}{\mathrm{d}z} = \frac{\mathrm{d}\Gamma_{3\text{-body}}(z)}{\mathrm{d}z} + \frac{\mathrm{d}\Gamma_{4\text{-body}}(z)}{\mathrm{d}z} = g(z)\cdot|W(z)|^2 + \frac{\mathrm{d}\Gamma_{4\text{-body}}(z)}{\mathrm{d}z}$$

$K^+ \to \pi^+\mu^+\mu^-$ analysis: error budget [JHEP 11 (2022) 011]

	δa_+	δb_+	$\delta \mathcal{B}_{\pi\mu\mu} \times 10^8$
Statistical uncertainty	0.012	0.040	0.06
Trigger efficiency	0.002	0.008	0.02
Reconstruction and particle identification	0.002	0.007	0.02
Size of the simulated $K_{\pi\mu\mu}$ sample	0.002	0.007	0.01
Beam and accidental activity simulation	0.001	0.002	0.01
Background	0.001	0.001	—
Total systematic uncertainty	0.003	0.013	0.03
$K_{3\pi}$ branching fraction	0.001	0.003	0.04
$K_{\pi\mu\mu}$ radiative corrections	0.003	0.009	0.01
Parameters α_+ and β_+	0.001	0.006	—
Total external uncertainty	0.003	0.011	0.04
Total uncertainty	**0.013**	**0.043**	**0.08**

$K^+ \to \pi^+\gamma\gamma$ analysis: error budget

	$\delta\hat{c}_6$	$\delta\mathcal{B}\times10^7$
Cluster merging	0.029	0.06
$K^+\to\pi^+\pi^+\pi^-$ background	0.003	<0.01
MC background stat.	0.013	0.03
z resolution	<0.001	<0.01
LKr energy calibration	0.018	0.04
Trigger emulation	0.001	<0.01
Total error	0.037	0.08
$\hat{c}_6$	$1.713\pm0.075_{stat.}\pm0.037_{syst.}$	
$\mathcal{B}(K^+\to\pi^+\gamma\gamma)\times10^7$	$9.73\pm0.17_{stat.}\pm0.08_{syst.}$	


X [m]
2
1
0
-1
-2
[Target is removed!]
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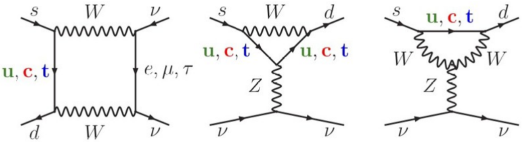
KTAG
GTK
CHANTI
[HNL, ALP, A', S...]
LAV
Vacuum
STRAW
MUV0
CHOD
MUV1,2
Iron
MUV3
SAC
RICH
RICH
HASC
IRC
LKr
Dump
[Copper collimator closed (TAXes) = dump]
65m decay region,
10^{-6} mbar vacuum
0
100
150
200
250
Z [m]
Upstream
Downstream
400GeV
75GeV
C1
C2
Normal data taking
C1
C2
Target
400 GeV/c protons
75 GeV/c
K^+, π^+, etc...
BD mode
400 GeV/c protons
C1
C2

The physics case: $\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$



- $\bar{s} \to \bar{d}\nu\bar{\nu}$ transition: **flavour changing neutral current** process (GIM mechanism) with high CKM suppression
- **Clean theoretical prediction**: short distance contributions
- Hadronic matrix elements: obtained from $K^+ \to \pi^0 l^+ \nu$ (K_{l3}) measurements and SU(2) isospin symmetry

Standard Model prediction *[Buras et al., JHEP11(2015)033]*

$$\mathcal{B}^{SM}(K^+ \to \pi^+\nu\bar{\nu}) = (0.84 \pm 0.10) \cdot 10^{-10}$$

main uncertainty due to CKM elements knowledge:

$$\mathcal{B}^{SM}(K^+ \to \pi^+\nu\bar{\nu}) = (0.839 \pm 0.030) \cdot 10^{-10} \cdot \left(\frac{|V_{cb}|}{40.7 \cdot 10^{-3}}\right)^{2.8} \cdot \left(\frac{\gamma}{73.2^\circ}\right)^{0.74}$$

$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ in the SM

Standard Model prediction *[Buras et al., JHEP11(2015)033]*

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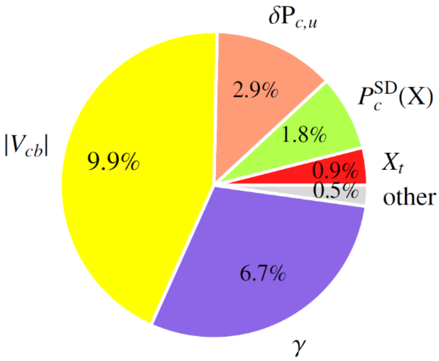
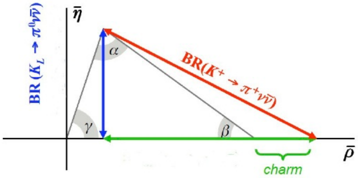
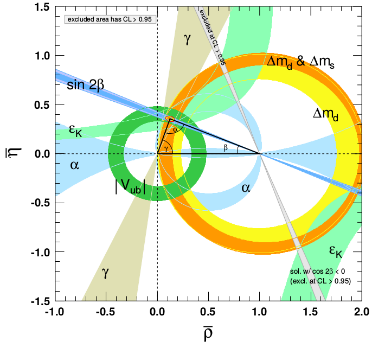


$K \to \pi\nu\bar{\nu}$ and the unitarity triangle





Standard Model calculation *[Buras et al., JHEP11(2015)033]*

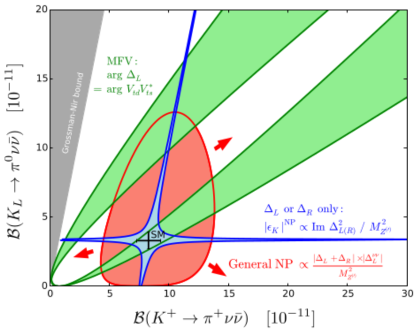
$$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu}) = \kappa_+(1+\Delta_{EM}) \cdot \left[\left(\frac{\Im(\lambda_t)}{\lambda^5}X(x_t)\right)^2 + \left(\frac{\Re(\lambda_c)}{\lambda}P_c(X) + \frac{\Re(\lambda_t)}{\lambda^5}X(x_t)\right)^2\right]$$

$$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu}) = \kappa_L \cdot \left(\frac{\Im(\lambda_t)}{\lambda^5}X(x_t)\right)^2$$

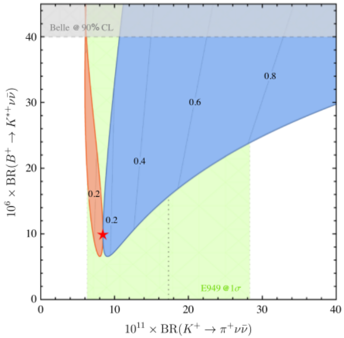
The $K^+ \to \pi^+ \nu \bar{\nu}$ decay beyond the Standard Model

New Physics search, $\mathcal{B}$ sensitive to the highest mass scales

[Buras et al., JHEP11 (2015) 166]



[Isidori et al., Eur.Phys.J. C (2017) 77: 618]



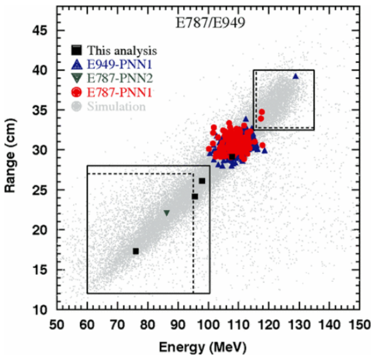
New Physics models for $K \to \pi \nu \bar{\nu}$

MFV; Simplified Z, Z'; LFU violation; Custodial Randall-Sundrum; MSSM; Littlest Higgs with T-parity; Leptoquarks.

Experimental status before NA62

BNL E787/E949 experiments

[Phys. Rev. D 77, 052003 (2008)] - [Phys. Rev. D 79, 092004 (2009)]



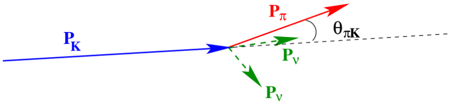
- Kaon *decay-at-rest* technique
- sensitivity for ~ 1 SM signal event
- 7 events observed in signal regions
- statistical reweighing procedure to take into account the background

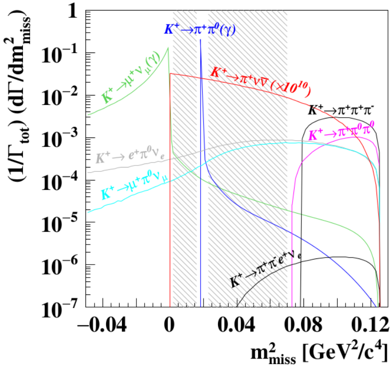
$$\mathcal{B}^{BNL}(K^+ \to \pi^+ \nu \bar{\nu}) = (1.73^{+1.15}_{-1.05}) \cdot 10^{-10}$$

NA62: the experimental strategy

Keystones

- *decay-in-flight* technique ($P_K = 75\ GeV/c$)
- main kinematic variable: $m^2_{miss} = (P_K - P_\pi)^2$
- pion momentum range: $[15; 45]\ GeV/c$
- charged particle identification
- muon and photon rejection
- signal and control kinematic regions *blinded* during the analysis





Required performance

- time coincidence: $O(100\ ps)$
- kinematic rejection: $O(10^4)$
- muon rejection: $> 10^7$
- π^0 rejection: $> 10^7$

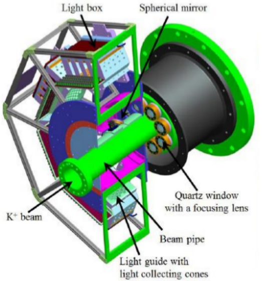
K^+ main (background) decays

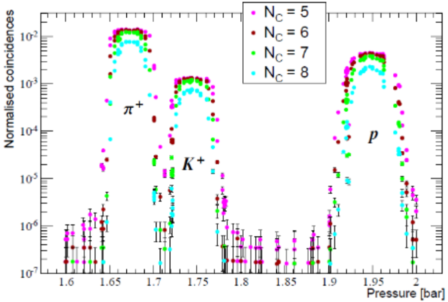
Decay channel	Branching Ratio
$K^+ \to \mu^+\nu\ (K_{\mu 2})$	$(63.56 \pm 0.11) \cdot 10^{-2}$
$K^+ \to \pi^+\pi^0\ (K_{2\pi})$	$(20.67 \pm 0.08) \cdot 10^{-2}$
$K^+ \to \pi^+\pi^+\pi^-\ (K_{3\pi})$	$(5.583 \pm 0.024) \cdot 10^{-2}$
$K^+ \to \pi^+\pi^- e^+\nu\ (K_{e4})$	$(4.247 \pm 0.024) \cdot 10^{-5}$

Beam particle tagging: KTAG

KTAG: a Cherenkov threshold counter.

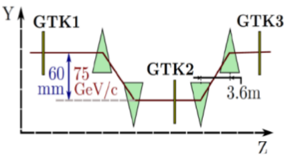
- Filled with nitrogen (N_2) at 1.75 bar at room temperature.
- Geometrically aligned with the beam.
- Time resolution: $\simeq 70\ ps$
- Kaon tagging efficiency: $> 95\%$

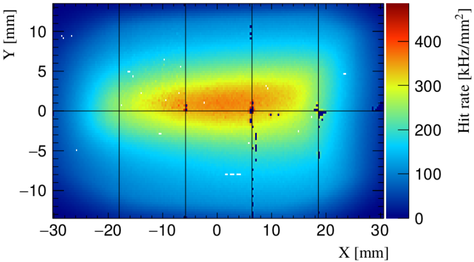




GTK: a silicon pixels tracker.

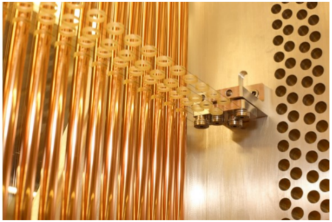
- 3 stations in Run 1, 4 stations in Run 2
- In each station: 18.000 pixels of 300x300 μm^2 ($< 0.5\ X_0$)
- Read out by application-specific integrated circuits (ASIC) arranged in two rows of five chips
- Time resolution: $< 150\ ps$ per station
- RICH and KTAG used as time reference

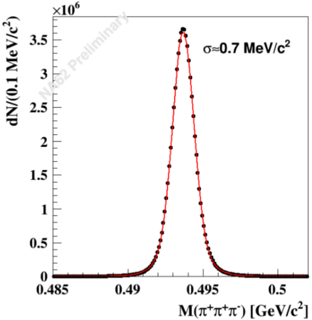




Pion tracking: STRAW Spectrometer

- 4 straw chambers and a large aperture dipole magnet ($\simeq 1.8\ X_0$)
- Each straw chamber is composed of two modules providing 4 different views.
- Gas inside the straws: 70% Ar and 30% CO_2
- Each chamber contains 1792 straws of 9.82 mm diameter and 2160 mm length, made by 36 μm thick polyethylene terephthalate (PET)
- $>$ 95% reconstruction efficiency



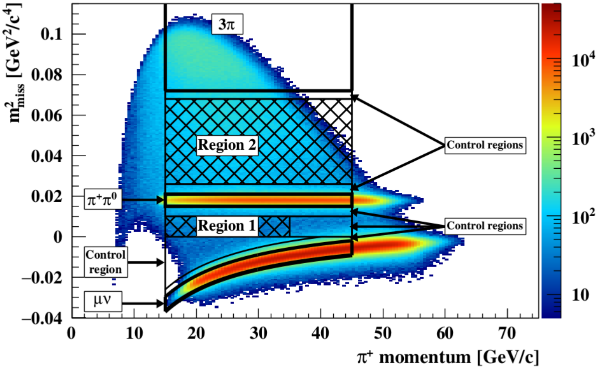


$K^+ \to \pi^+\nu\bar{\nu}$ kinematic selection

The squared missing mass

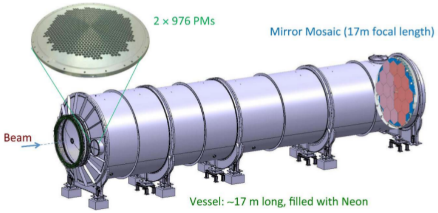
$$m^2_{miss} = (P_K - P_\pi)^2$$

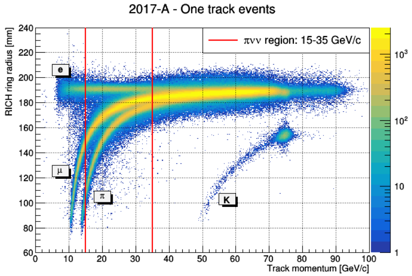
- P_K: K^+ 4-momentum (GTK 3-momentum + K^+ mass hypothesis)
- P_π: π^+ 4-momentum (STRAW 3-momentum + π^+ mass hypothesis)



Charged Particle Identification: RICH

- Ring Imaging CHerenkov counter, filled with neon gas
- Muon suppression factor > 100
- Time resolution $\simeq 80ps$

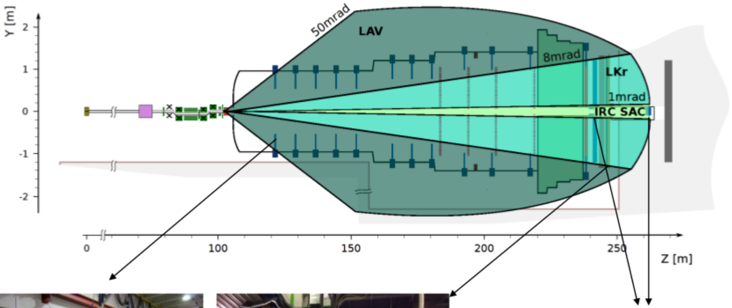


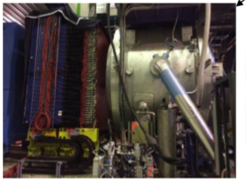


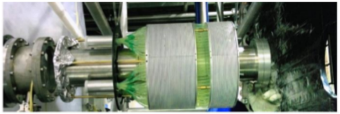
$$\cos\theta_C = \frac{1}{n\cdot\beta} \rightarrow m^2 = m^2(p,R) = p^2 \cdot \left(\frac{F^2\cdot n^2}{F^2+R^2} - 1\right)$$

Photon rejection: LKr, LAV, IRC, SAC

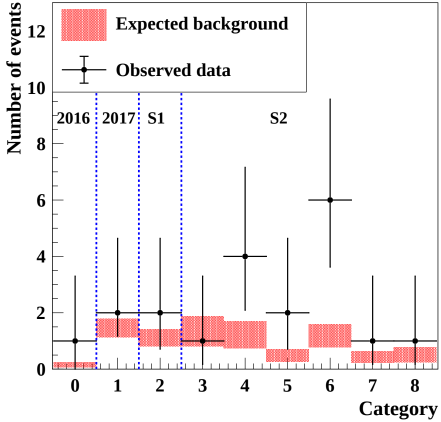
Hermeticity against photons emitted in standard kaon decays up to 50 mrad







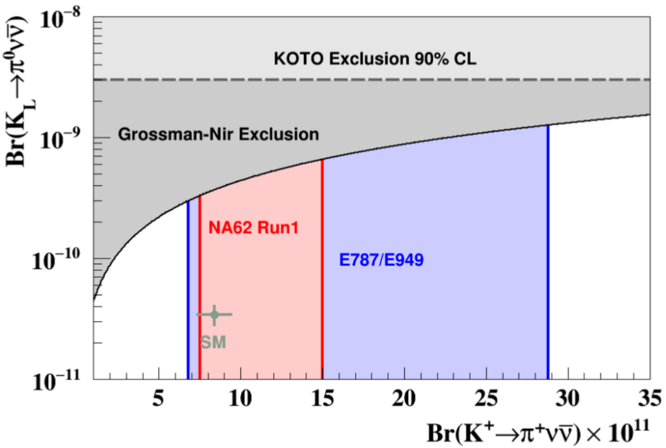
Result from NA62 Run 1 (2016+2017+2018 data)



[JHEP 06 (2021) 093]

$$\mathcal{B}^{NA62}_{16+17+18}(K^+ \to \pi^+ \nu\bar{\nu}) = (1.06^{+0.40}_{-0.34 stat} \pm 0.09_{syst}) \cdot 10^{-10}$$
$$3.4\sigma \text{ significance, } P(only\ bkg) = 3.4 \cdot 10^{-4}$$

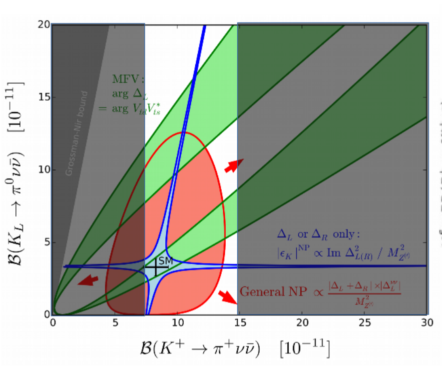
Status of $\mathcal{B}(K \to \pi\nu\bar{\nu})$ measurement

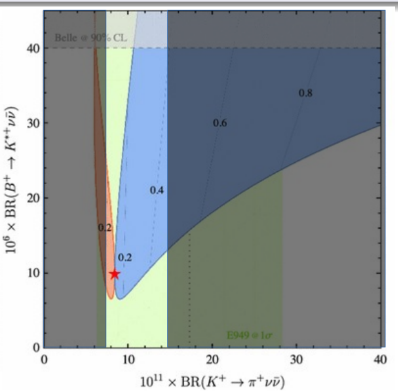


- $\mathcal{B}^{SM}(K^+ \to \pi^+\nu\bar{\nu}) = (0.84 \pm 0.10) \cdot 10^{-10}$, $\mathcal{B}^{SM}(K_L \to \pi^0\nu\bar{\nu}) = (0.34 \pm 0.06) \cdot 10^{-10}$ *[Buras et al., JHEP11(2015)033]*
- Grossman-Nir limit: $\mathcal{B}(K_L \to \pi^0\nu\bar{\nu}) < 4.4 \cdot \mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ *[Phys. Lett. B 398, 163 (1997)]*

New $\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu})$ measurement from NA62 and BSM scenarios

$$\mathcal{B}^{NA62}_{16+17+18}(K^+ \to \pi^+ \nu\bar{\nu}) = (1.06^{+0.40}_{-0.34\,stat} \pm 0.09_{syst}) \cdot 10^{-10}$$





Large $\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu})$ values with respect to SM expectation start to be improbable: high precision measurement needed!

The NA62 published measurements

- *Search for K^+ decays into the $\pi^+ e^+ e^- e^+ e^-$ final state*, arXiv: 2307.04579 [hep-ex] (2023), submitted to Phys. Lett. B.
- *A study of the $K^+ \to \pi^0 e^+ \nu \gamma$ decay*, arXiv: 2304.12271 [hep-ex] (2023), submitted to JHEP.
- *Search for dark photon decays to $\mu^+ \mu^-$ at NA62*, arXiv: 2303.08666 [hep-ex] (2023), submitted to JHEP.
- *A search for the $K^+ \to \mu^- \nu e^+ e^+$ decay*, Phys. Lett. B 838 (2023) 137679.
- *A measurement of the $K^+ \to \pi^+ \mu^+ \mu^-$ decay*, JHEP 11 (2022) 011.
- *Searches for lepton number violating $K^+ \to \pi^- (\pi^0)\, e^+ e^+$ decays*, Phys. Lett. B 830 (2022) 137172.
- *Search for Lepton Number and Flavor Violation in K^+ and π^0 Decays*, Phys. Rev. Lett. 127 (2021) 131802.
- *Measurement of the very rare $K^+ \to \pi^+ \nu \bar{\nu}$ decay*, JHEP 06 (2021) 093.
- *Search for K^+ decays to a muon and invisible particles*, Phys. Lett. B 816 (2021) 136259.
- *Search for a feebly interacting particle X in the decay $K^+ \to \pi^+ X$*, JHEP 03, (2021) 058.
- *Search for π^0 decays to invisible particles*, JHEP 02, (2021) 201.
- *An investigation of the very rare $K^+ \to \pi^+ \nu \bar{\nu}$ decay*, JHEP 11 (2020) 042.
- *Search for heavy neutral lepton production in K^+ decays to positrons*, Phys. Lett. B 807 (2020) 135599.
- *Searches for lepton number violating K^+ decays*, Phys. Lett. B 797 (2019) 134794.
- *Search for production of an invisible dark photon in π^0 decays*, JHEP 1905 (2019) 182.
- *First search of $K^+ \to \pi^+ \nu \bar{\nu}$ using the decay-in-flight technique*, Phys. Lett. B 791 (2019) 156.
- *Search for heavy neutral lepton production in K^+ decays*, Phys. Lett. B 778 (2018) 137.