Search for rare Kaon decays at NA62

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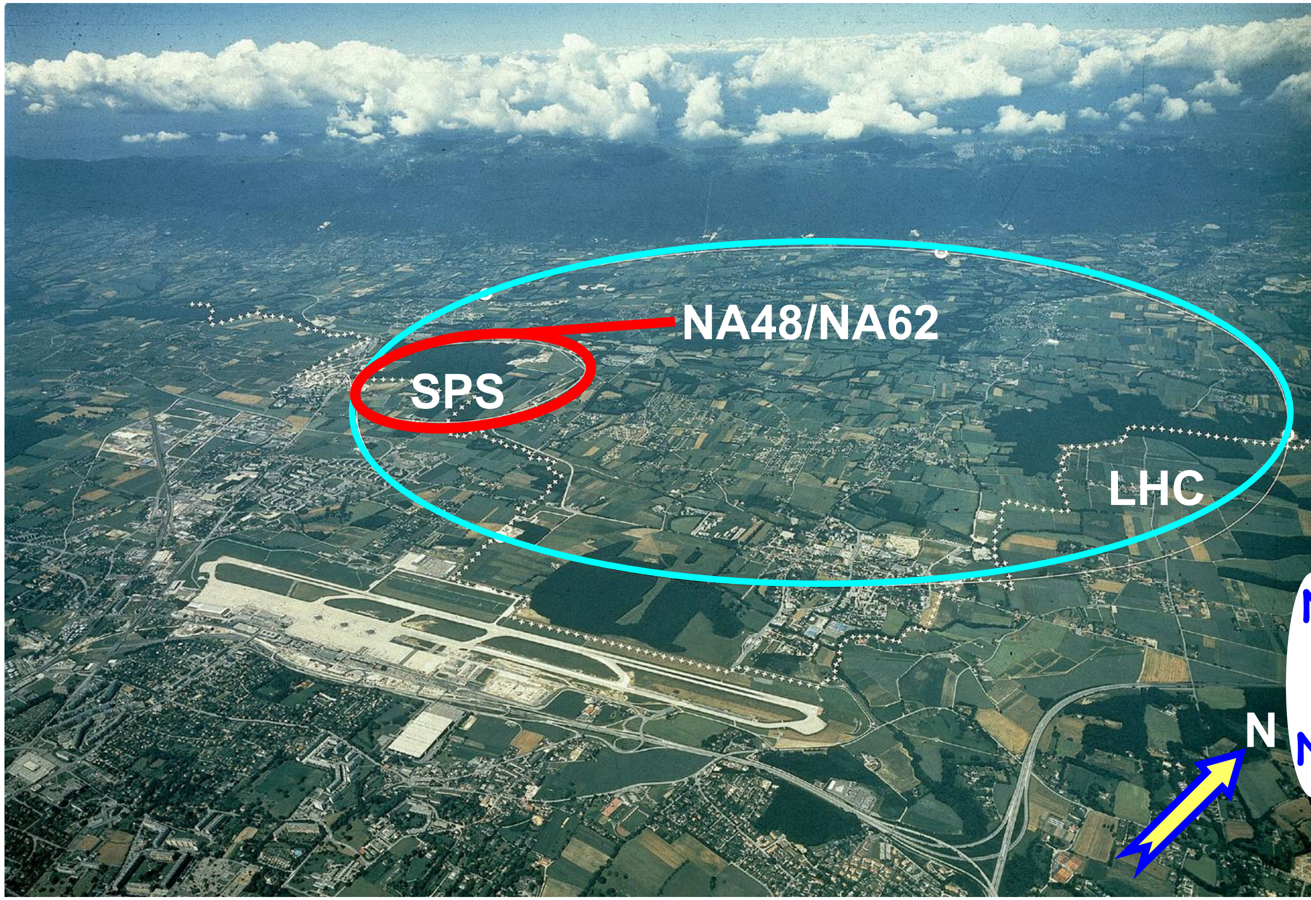
Outline:

1) Introduction to CERN kaon programme
2) The golden decay mode: $K^+ \rightarrow \pi^+ \nu \bar{\nu}$
3) Lepton flavour/number violation in K decays
4) Selected recent results, ongoing analyses
5) Rare π^0 decays
6) Summary

NA48+NA62: recent results



Primary SPS protons (400 GeV/c): 1.8×10^{12}/SPS spill
Un-separated secondary positive beam

NA48 (discovery of direct CPV)
- 1997: ε'/ε: K_L+K_S
- 1998: K_L+K_S
- 1999: K_L+K_S | K_S HI
- 2000: K_L only | K_S HI
- 2001: K_L+K_S | K_S HI

NA48/1
- 2002: K_S/hyperons

NA48/2
- 2003: K^+/K^-
- 2004: K^+/K^-

NA62 (R_K)
- 2007: $K^\pm_{e2}/K^\pm_{\mu2}$
- 2008: $K^\pm_{e2}/K^\pm_{\mu2}$

NA62
- 2007–2013: design & construction
- 2012: test run
- 2014: first data taking

Recent $K^{\pm}$ experiments at CERN

Experiment	NA48/2 ($K^{\pm}$)	NA62-R_K ($K^{\pm}$)	*NA62 (K^{+}; planned)*
Data taking period	2003–2004	2007–2008	*2014–2017*
Beam momentum, GeV/c	60	74	75
RMS momentum bite, GeV/c	2.2	1.4	0.8
Spectrometer thickness, X_0	2.8%	2.8%	1.8%
Spectrometer P_T kick, MeV/c	120	265	270
$M(K^{\pm}\to\pi^{\pm}\pi^{+}\pi^{-})$ resolution, MeV/c^2	1.7	1.2	0.8
K decays in fiducial volume	2×10^{11}	2×10^{10}	1.2×10^{13}
Main trigger	multi-track; $K^{\pm}\to\pi^{\pm}\pi^{0}\pi^{0}$	$e^{\pm}$	$K_{\pi\nu\nu}$ + …

Same detector (NA48)

The new NA62 detector:

beam spectrometer and kaon tagger;
improved mass reconstruction and particle identification;
hermetic photon veto.

Sensitivities to other rare decays

Composition: $K^+(\pi^+) = 5\%(63\%)$.
K^+ decaying in vacuum tank: 18%.

K^+ flux used	Modes	
~10^{13} (NA62)	In the fiducial region	
~10^{12}	LFV (μ^+e^-) $K^+\to\pi^+\nu\nu$	dedicated triggers
~10^{11} (NA48/2)	K_{e4}^{+-} K_{e4}^{00} (in progress) $K^+\to\pi^+e^+e^-$ $K^+\to\pi^+\mu^+\mu^-$ $K^+\to\pi^+\pi^0\gamma$ $K^+\to\pi^+\gamma e^+e^-$ $K^+\to\pi^+\pi^0e^+e^-$ (in progress) LFV (ee, μ^+e^+, μ^-e^+)	dedicated triggers
~10^{10} (NA62-R_K)	$K^+\to e^+\nu$ LFV ($\mu^+\mu^+$)	downscaled triggers
~10^9	$K^+\to\pi^+\gamma\gamma$	downscaled triggers
Below 10^9	$K_{\mu4}$	downscaled triggers

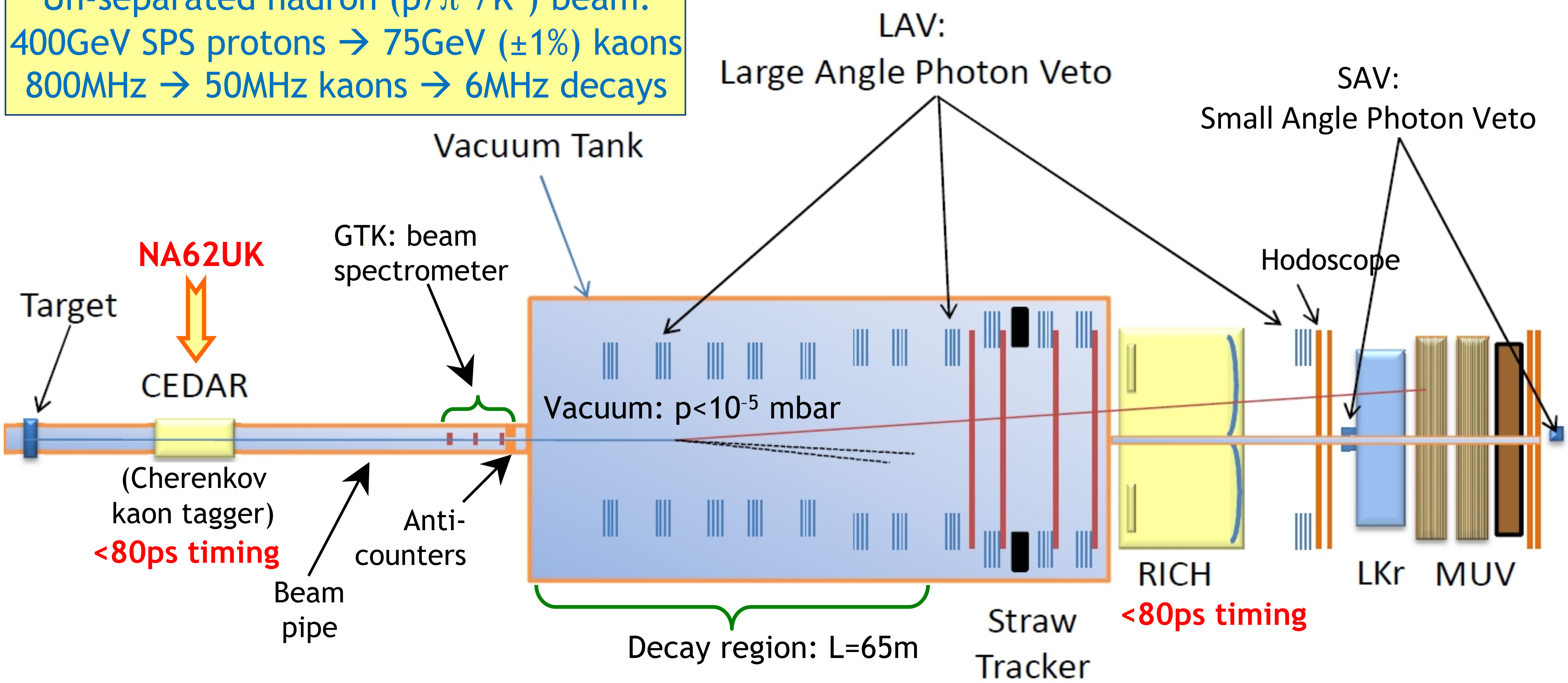
Typical acceptance ~ 10 - 15%

NA62 detector

Kaon decay in flight experiment
Currently ~200 participants, 27 institutions

Total length: ~270m

Un-separated hadron ($p/\pi^+/K^+$) beam:
400GeV SPS protons → 75GeV (±1%) kaons
800MHz → 50MHz kaons → 6MHz decays

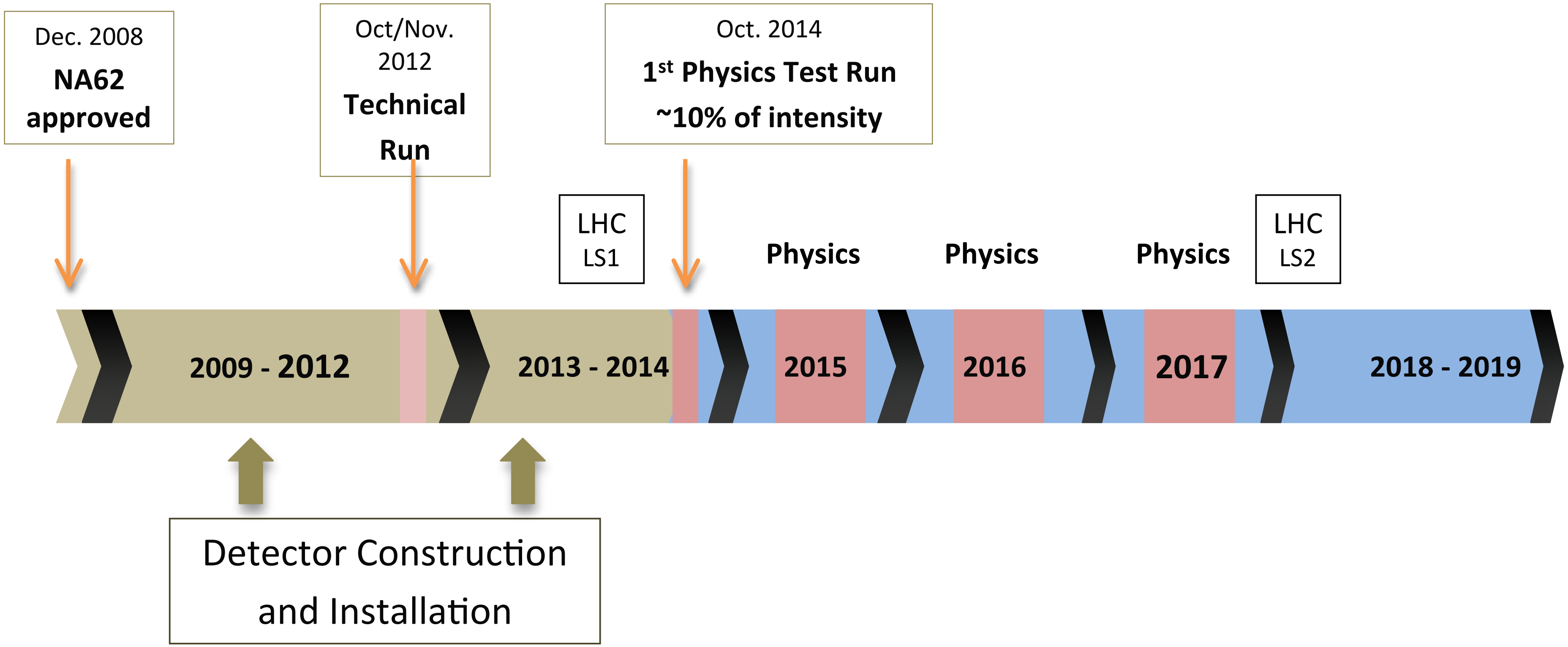


Kinematic rejection factors (limited by beam pileup and tails of MCS):
5×10^3 for $K^+\to\pi^+\pi^0$, 1.5×10^4 for $K\to\mu^+\nu$.

Hermetic photon veto: $\sim10^8$ suppression of $\pi^0\to\gamma\gamma$.

Particle ID (RICH+LKr+MUV): $\sim10^7$ muon suppression.

NA62 Timeline

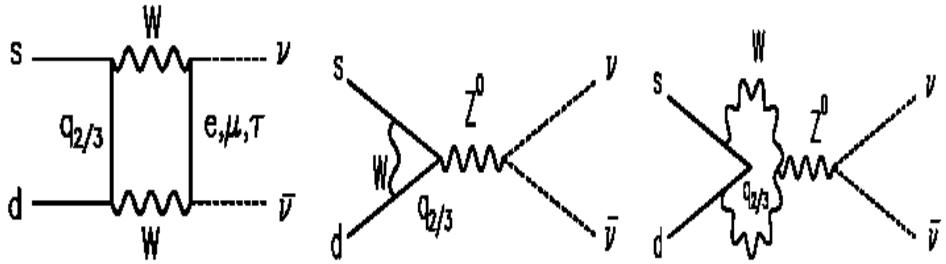


- 5 years of construction interleaved with a Technical Run in fall 2012
- In 2014 a first Run with full detector
- 3 years of Physics data taking before LHC Long Shutdown 2 (LS2)

The golden decay: $K^+ \rightarrow \pi^+ \nu \bar{\nu}$

$K\to\pi\nu\nu$: Theory in the Standard Model

- **FCNC loop processes**
- **SM precision surpasses any other FCNC process involving quarks**
- **Short distance dynamics dominated**



$\lambda = V_{us}$
$\lambda_c = V^*_{cs} V_{cd}$
$\lambda_t = V^*_{ts} V_{td}$

$$x(q) \equiv \frac{m_q^2}{m_W^2}$$

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

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

Charm contribution

Top contribution

$$\kappa_+ = r_{K^+} \cdot \frac{3\alpha^2 Br(K^+ \to \pi^0 e^+ \nu)}{2\pi^2 \sin^4\theta_W} \cdot \lambda^8$$

The Hadronic Matrix Element is measured and isospin rotated

Brod et al., PRD 83 (2011) 034030

Mode	$BR_{SM} \times 10^{11}$
$K^+\to\pi^+\nu\nu(\gamma)$	7.81±0.75±0.29
$K_L\to\pi^0\nu\nu$	2.43±0.39±0.06

Theoretically clean, sensitive to new physics, almost unexplored

BNL E787/949: $K^+ \to \pi^+ \nu \nu$

Technique: K^+ decay at rest

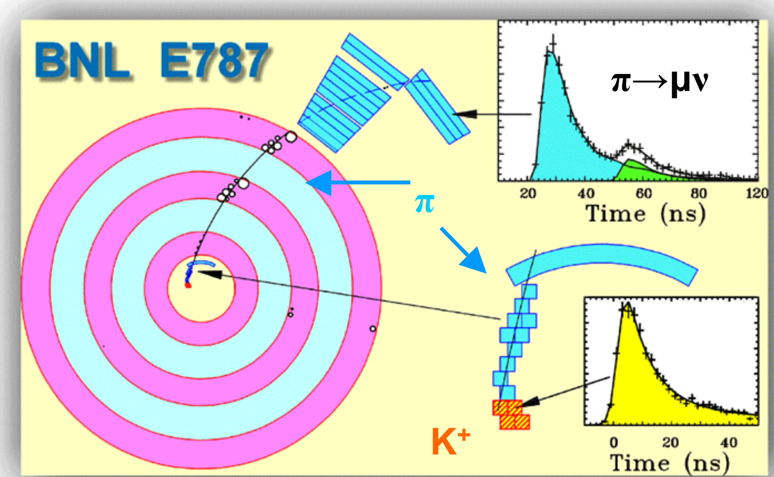
Data taking: E787 (1995–98), E949 (2002)

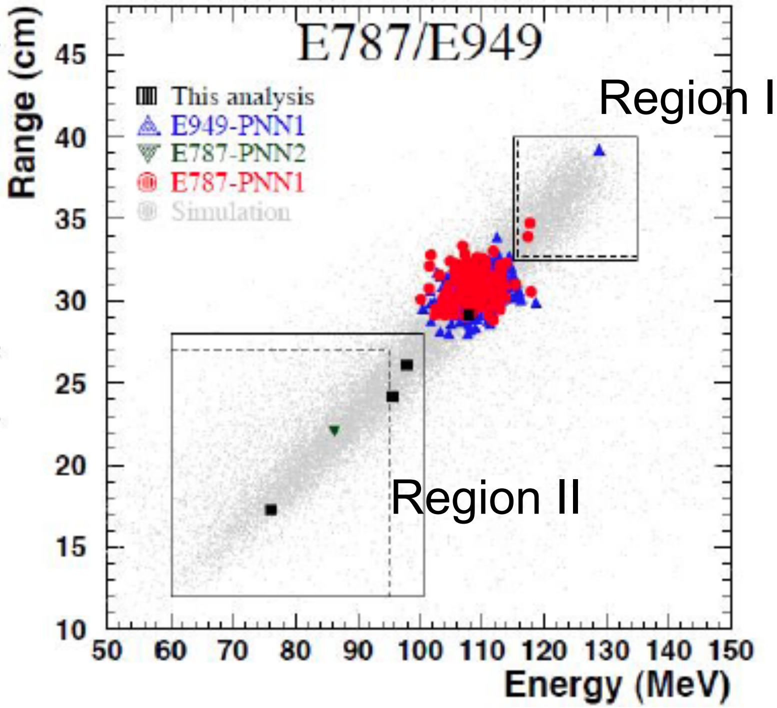
Separated K^+ beam (710 MeV/c, 1.6MHz)

PID: range (entire $\pi^+ \to \mu^+ \to e^+$ decay chain)

Hermetic photon veto system

1.8 x 10^{12} stopped K^+, ~0.1% signal acceptance





Background in Region 2 from the $K_{2\pi}$ decay with π^+ scattering in the target.

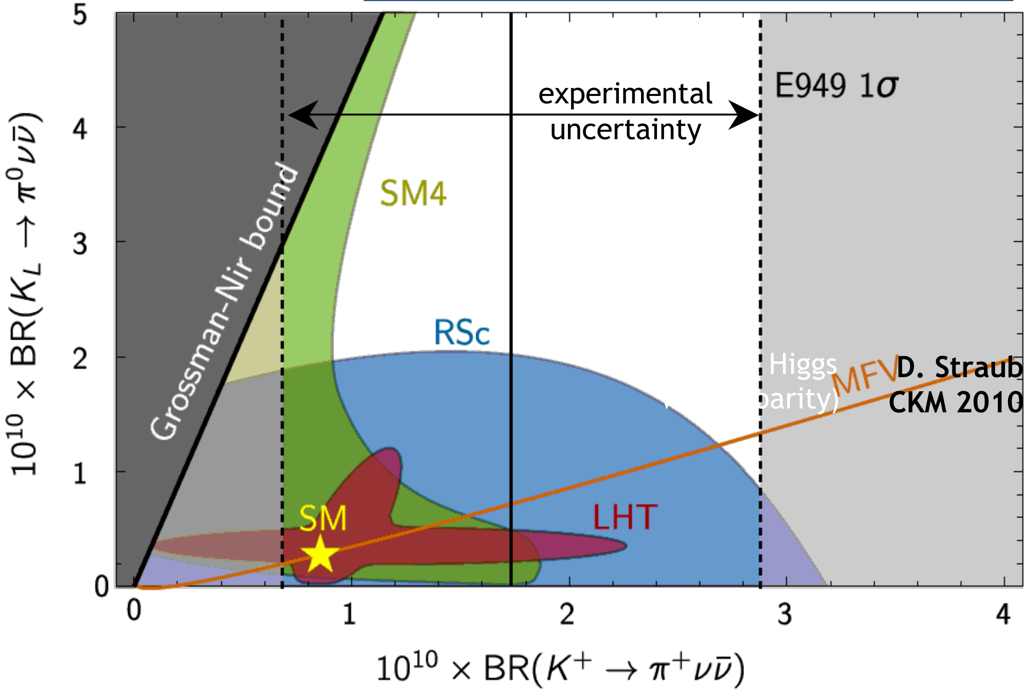
E787/E949: $BR(K^+ \to \pi^+ \nu\nu) = 1.73^{+1.15}_{-1.05} \times 10^{-10}$

PRL 101 (2008) 191802; PRD 79 (2009) 092004

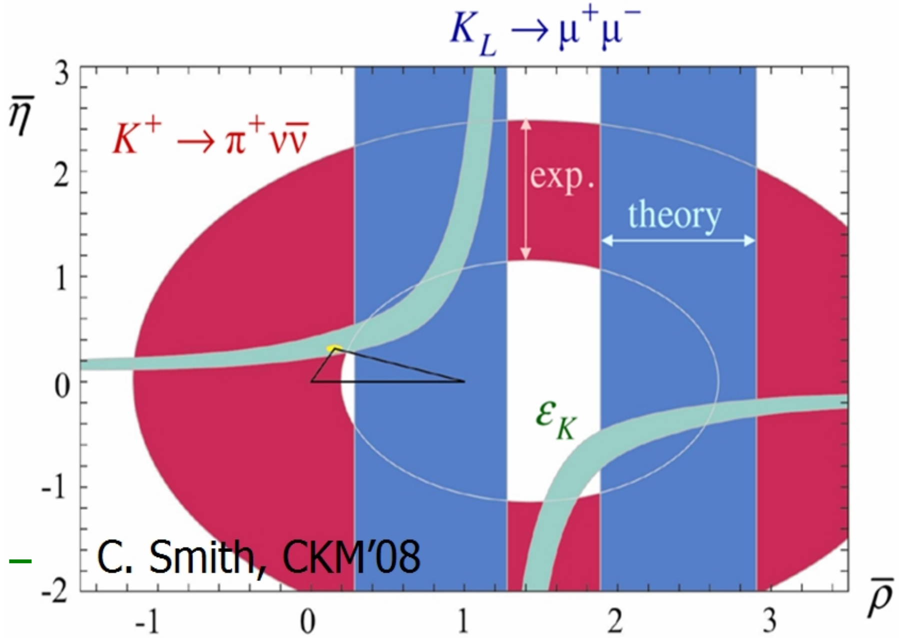
- 7 observed candidates, 2.6 expected background
- Probability that 7 observed events are all background is 10^{-3}
- Still compatible with SM within errors

Experiment vs theory

BR($K_L \to \pi^0 \nu\bar{\nu}$) vs BR($K^+ \to \pi^+ \nu\bar{\nu}$)



CKM unitarity triangle with kaons



NA62 @CERN: $K^+ \rightarrow \pi^+ \nu\nu$

NA62 aim: collect O(100) SM $K^+ \rightarrow \pi^+ \nu\nu$ decays with <20% background in 2 years of data taking using a novel decay-in-flight technique

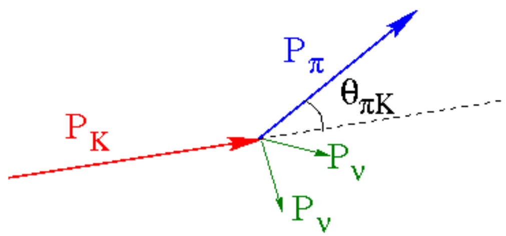
Decay signature: high momentum K^+ (75GeV/c) → low momentum π^+ (15–35 GeV/c)

Advantages: max detected K^+ decays/proton ($p_K/p_0 \approx 0.2$); efficient photon veto (>40 GeV missing energy); good π^+ vs μ^+ identification with RICH

Un-separated beam (6% kaons) → higher rates, additional backgrounds

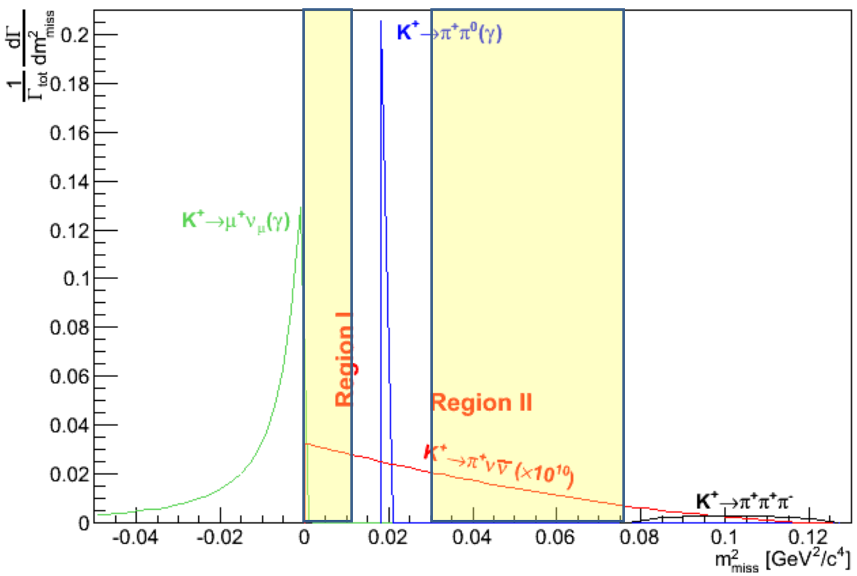
Kinematic variable:

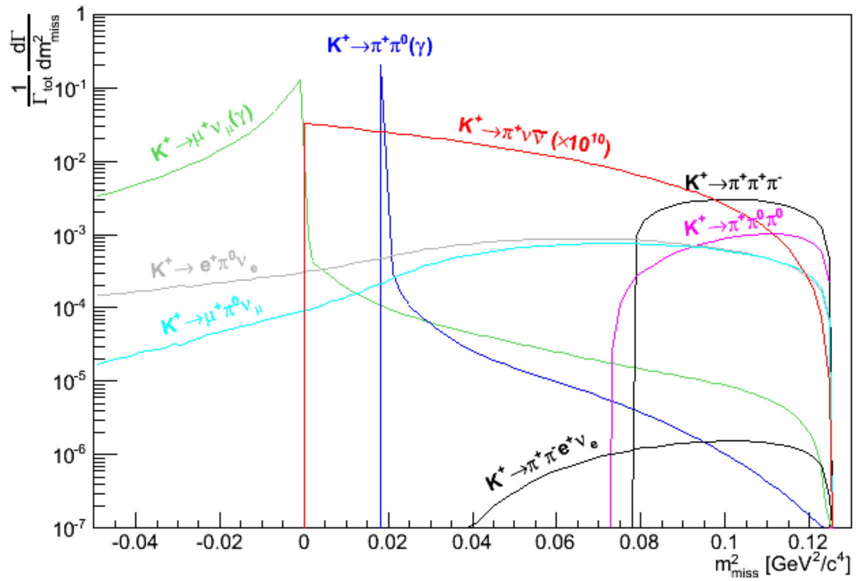
$$m^2_{miss} = (P_K - P_{\pi^+})^2$$



Backgrounds

K decays





Background

1) K^+ decay modes

2) Accidental single track matched with a K-like track

Accidental single tracks:

Beam interactions in the beam tracker

Beam interactions with the residual gas in the vacuum region.

Signal & backgrounds (events/year)	
Signal	45
$K^+\to\pi^+\pi^0$	5
$K^+\to\mu^+\nu$	1
$K^+\to\pi^+\pi^+\pi^-$	<1
Other 3-track decays	<1
$K^+\to\pi^+\pi^0\gamma$ (IB)	1.5
$K^+\to\mu^+\nu\gamma$ (IB)	0.5
Total background	<10

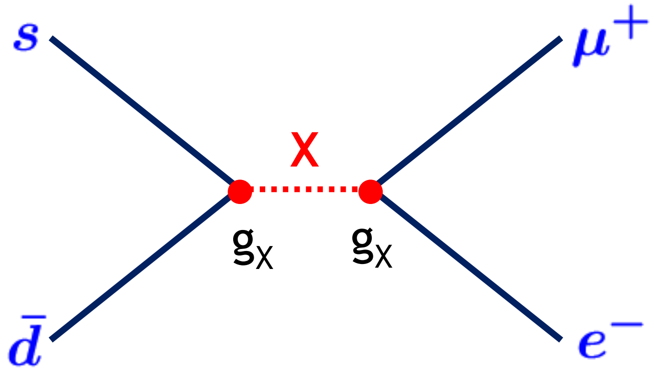
Lepton Flavour and Lepton Number Violation

LFV in kaon decays

Copious production: high statistics
Simple decay topologies: clean experimental signatures

High NP mass scales accessible for tree-level contributions

Example: $K_L \to \mu^+ e^-$



Dimensional argument:

$$\frac{\Gamma_X}{\Gamma_{SM}} \sim \left(\frac{g_X}{g_W} \cdot \frac{M_W}{M_X}\right)^4$$

For $g_X \approx g_W$ and $\mathcal{B} \sim 10^{-12}$:

$$M_X \sim 100 \text{ TeV}$$

LFV in $K^\pm$ decays

Mode	UL at 90% CL	Experiment	Reference
$K^+ \to \pi^+\mu^+e^-$	1.3×10^{-11}	BNL E777/E865	PRD 72 (2005) 012005
$K^+ \to \pi^+\mu^-e^+$	5.2×10^{-10}	BNL E865	PRL 85 (2000) 2877
$K^+ \to \pi^-\mu^+e^+$	5.0×10^{-10}	BNL E865	PRL 85 (2000) 2877
$K^+ \to \pi^-e^+e^+$	6.4×10^{-10}	BNL E865	PRL 85 (2000) 2877
$K^\pm \to \pi^\mp\mu^\pm\mu^\pm$	1.1×10^{-9}	CERN NA48/2	PLB 697 (2011) 107
$K^+ \to \mu^-\nu e^+e^+$	2.0×10^{-8}	Geneva-Saclay	PL 62B (1976) 485
$K^+ \to e^-\nu\mu^+\mu^+$	no data		

CERN NA48/2 sensitivities for these 3 modes are similar to those of BNL E865

Expected NA62 single event sensitivities: ~10^{-12} for $K^\pm$ decays

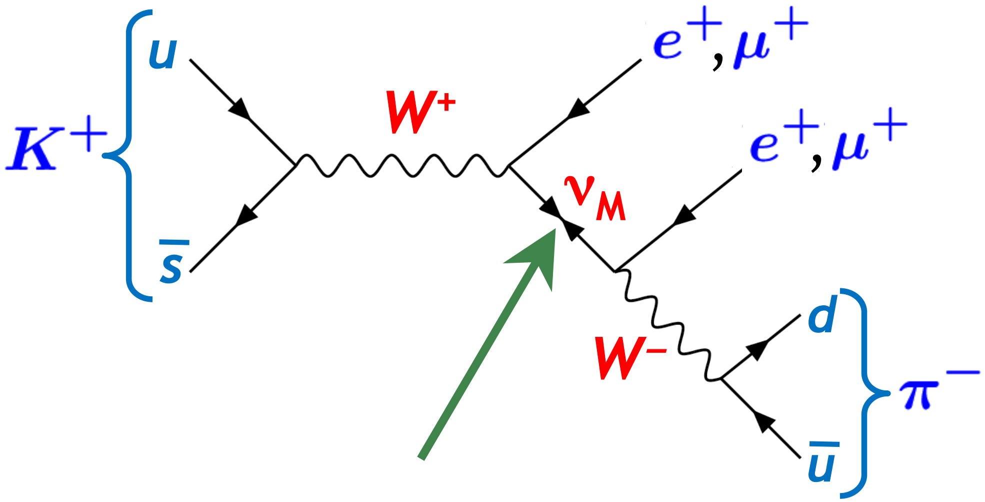
NA62 is capable of improving on all these decay modes
e.g. 2003-4 data $K^+\to\pi^-\mu^+\mu^+$: $\mathcal{B}(K^\pm \to \pi^\mp\mu^\pm\mu^\pm) < 1.1\times10^{-9}$ @90% CL

Precision limited by background from $\pi^\pm\to\mu^\pm\nu$ decays in spectrometer, despite SES ≈ 3×10^{-11}

In future, no $K_{3\pi}$ background expected due to high spectrometer P_T (270 vs 120 MeV/c) and improved $\pi\mu\mu$ mass resolution (1.1 vs 2.6 MeV/c^2)

Sensitivity to Majorana neutrino

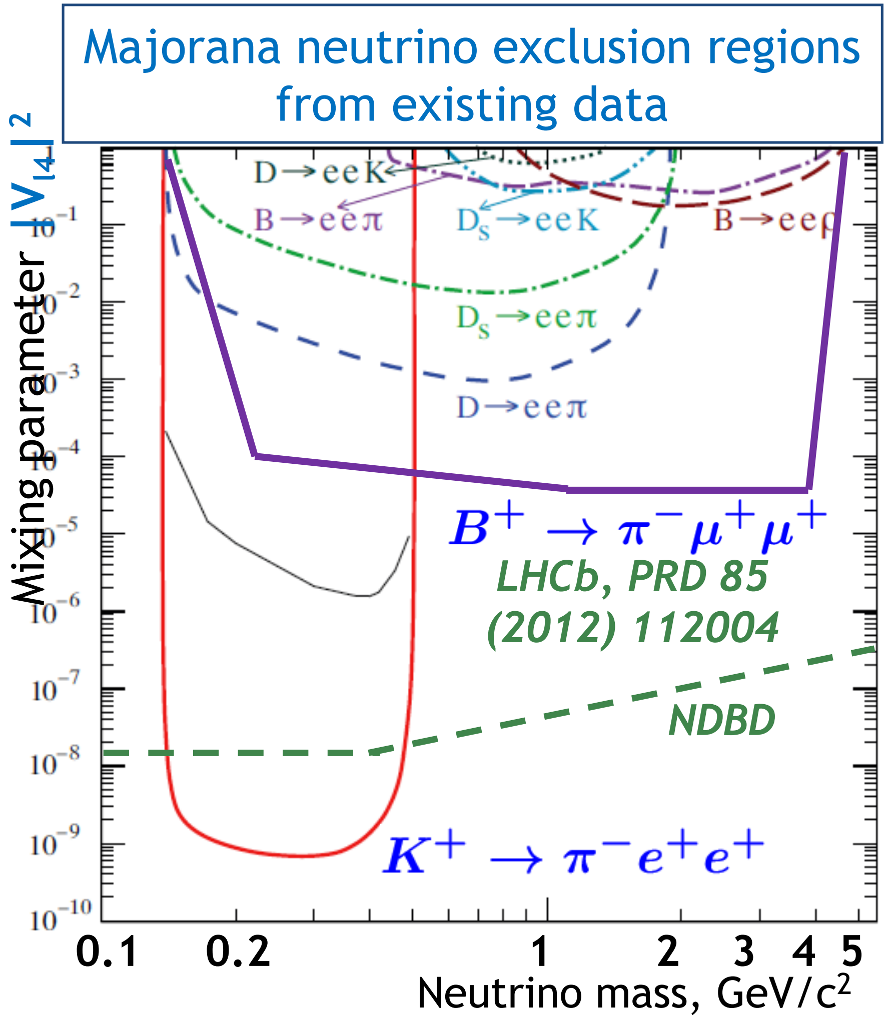
$$K^+ \to \pi^- \ell_1^+ \ell_2^+, \quad \ell = e, \mu$$



resonant enhancement for

$$m_\pi \lesssim m_\nu \lesssim m_K$$

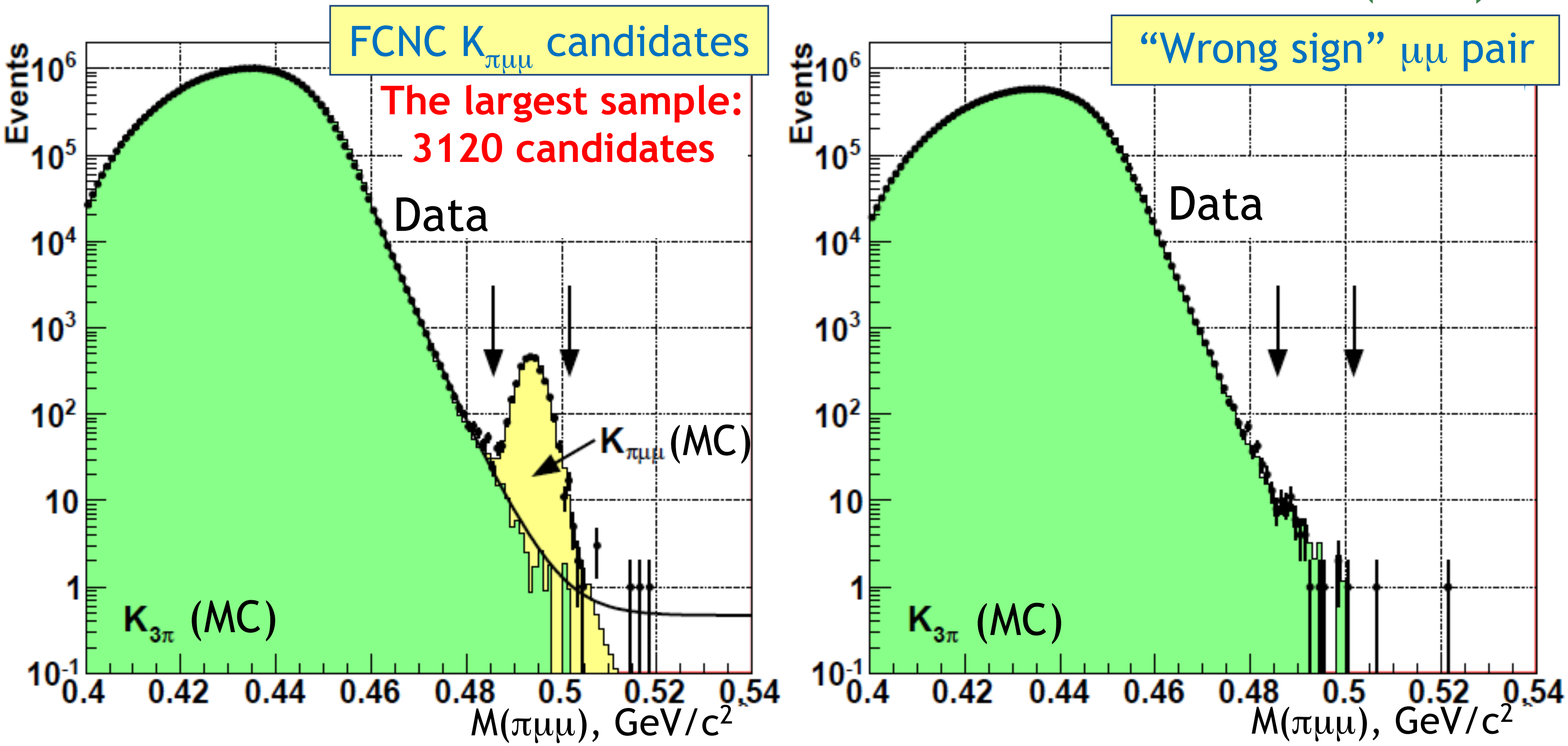
Littenberg and Shrock, PLB491 (2000) 285



Plot from Atre et al., JHEP 0905 (2009) 030

NA48/2 $K^{\pm}\to\pi^{\mp}\mu^{\pm}\mu^{\pm}$ upper limit

PLB 697 (2011) 107

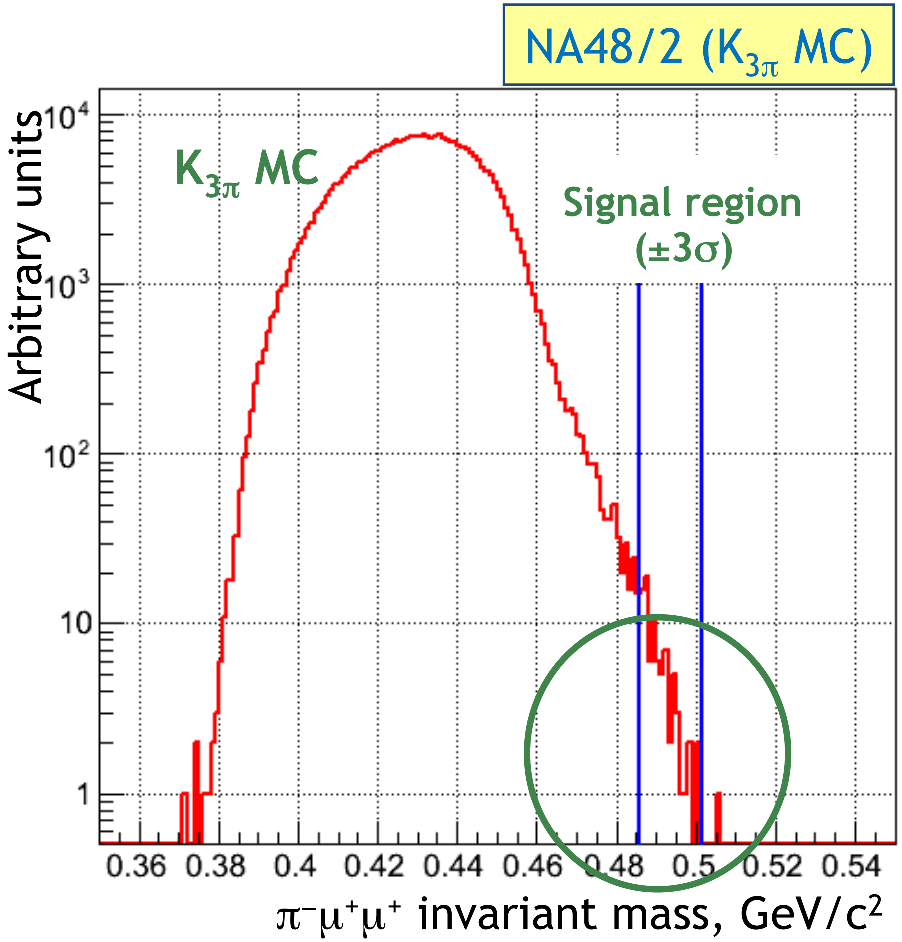


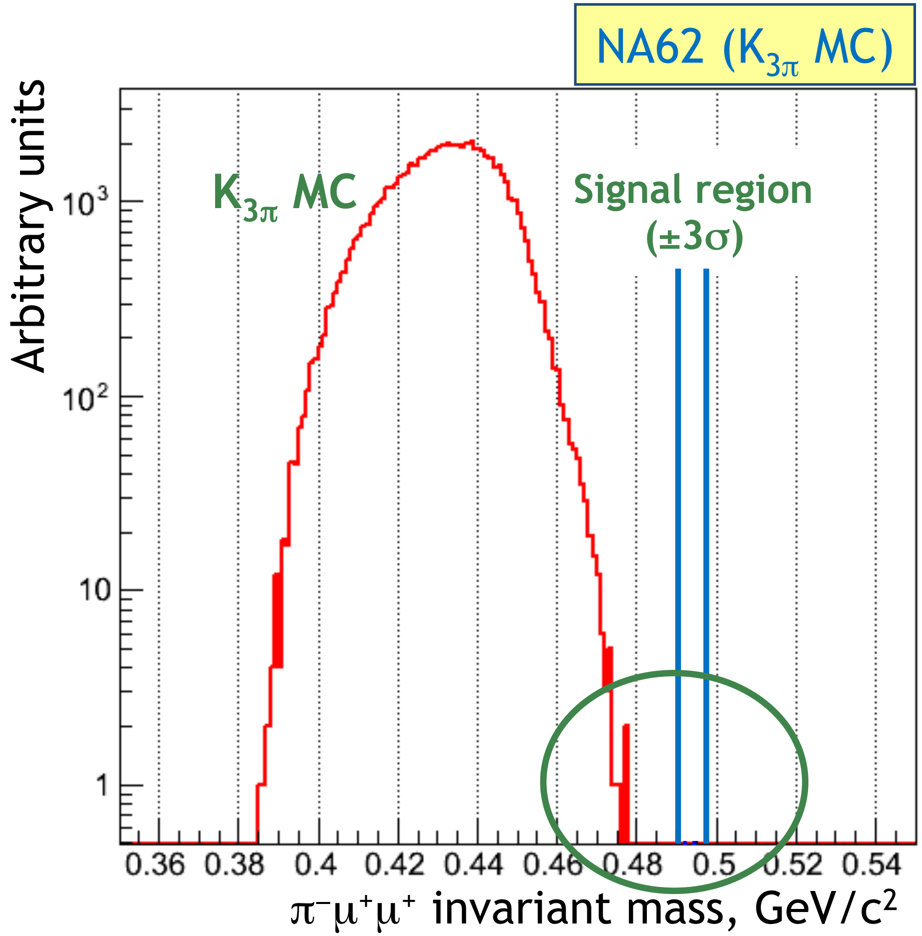
$N_{data} = 52$
$N_{bkg} = 52.6 \pm 19.8_{syst.}$

$\Rightarrow$ $\mathcal{B}(K^{\pm}\to\pi^{\mp}\mu^{\pm}\mu^{\pm}) < 1.1\times10^{-9}$ @90% CL

Precision limited by background from $\pi^{\pm}\to\mu^{\pm}\nu$, despite SES $\approx 3\times10^{-11}$.
Flat phase space assumed (rather than Majorana neutrino exchange).
A dedicated re-analysis has a potential sensitivity of $\sim10^{-10}$.

$K^{\pm} \rightarrow \pi^{\mp}\mu^{\pm}\mu^{\pm}$ at NA62





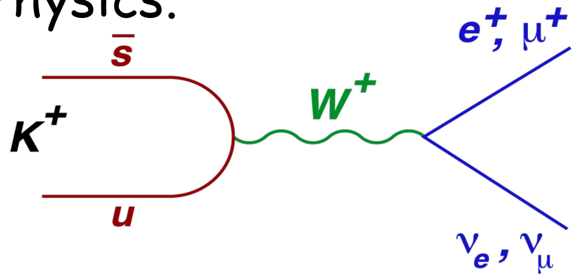
NA48/2: $K_{3\pi}$ background to $K_{\pi\mu\mu}$ due to $\pi^{\pm} \rightarrow \mu^{\pm}\nu$ decays in the spectrometer

NA62: no $K_{3\pi}$ background expected due to high spectrometer P_T (270 vs 120 MeV/c) and improved $\pi\mu\mu$ mass resolution (1.1 vs 2.6 MeV/c^2)

Selected recent results, ongoing analyses

R_K in the SM

A precise measurement of the ratio of $K \to l\nu_l$ leptonic decays provides an ideal test of SM and indirect search for New Physics.



Hadronic uncertainties cancel in the ratio $K_{e2/K\mu2}$
SM prediction: excellent sub-permille accuracy

R_K is sensitive to lepton flavour violation and its SM expectation:

$$R_K = \frac{\Gamma(K^\pm \to e^\pm \nu)}{\Gamma(K^\pm \to \mu^\pm \nu)} = \frac{m_e^2}{m_\mu^2} \cdot \left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 \cdot (1 + \delta R_K^{rad.corr.})$$

Helicity suppression: $f \sim 10^{-5}$

Radiative correction (few %)
due to $K^+ \to e^+\nu\gamma$ (IB) process,
by definition included into R_K
[V.Cirigliano, I.Rosell JHEP 0710:005 (2007)]

helicity suppression of R_K might enhance sensitivity to non-SM effects to an experimentally accessible level.

$R_K^{SM} = (2.477 \pm 0.001) \times 10^{-5}$

Phys. Rev. Lett. 99 (2007) 231801

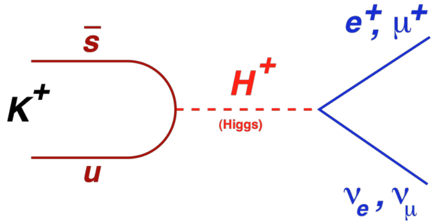
R_K beyond the SM

In the MSSM large tanβ scenario, the presence of LFV terms (charged Higgs coupling) introduces extra contributions to the SM amplitude ~1% effect
Girrbach and Nierste, arXiv:1202.4906

2HDM - tree level

$K^{\pm} \to l^{\pm}\nu$ can proceed via charged Higgs $H^{\pm}$ (in addition to $W^{\pm}$) exchange

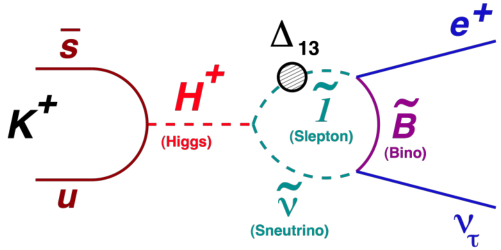
→ Does not affect the ratio R_K



2HDM - one-loop level

Dominant contribution to R_K: $H^{\pm}$ mediated LFV (rather than LFC) with emission of ν_τ

→ R_K enhancement can be experimentally accessible



PRD 74 (2006) 011701, JHEP 0811 (2008) 042

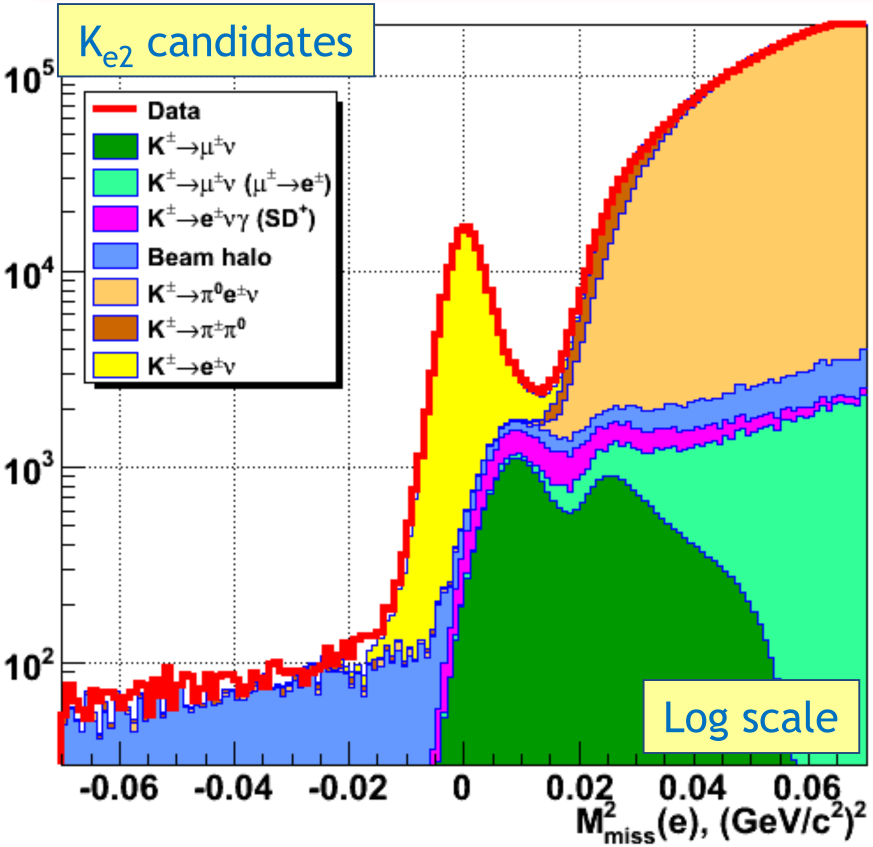
$$R_K^{LFV} = \frac{\Gamma_{SM}(K \to e\nu_e) + \Gamma_{LFV}(K \to e\nu_\tau)}{\Gamma_{SM}(K \to \mu\nu_\mu)}$$

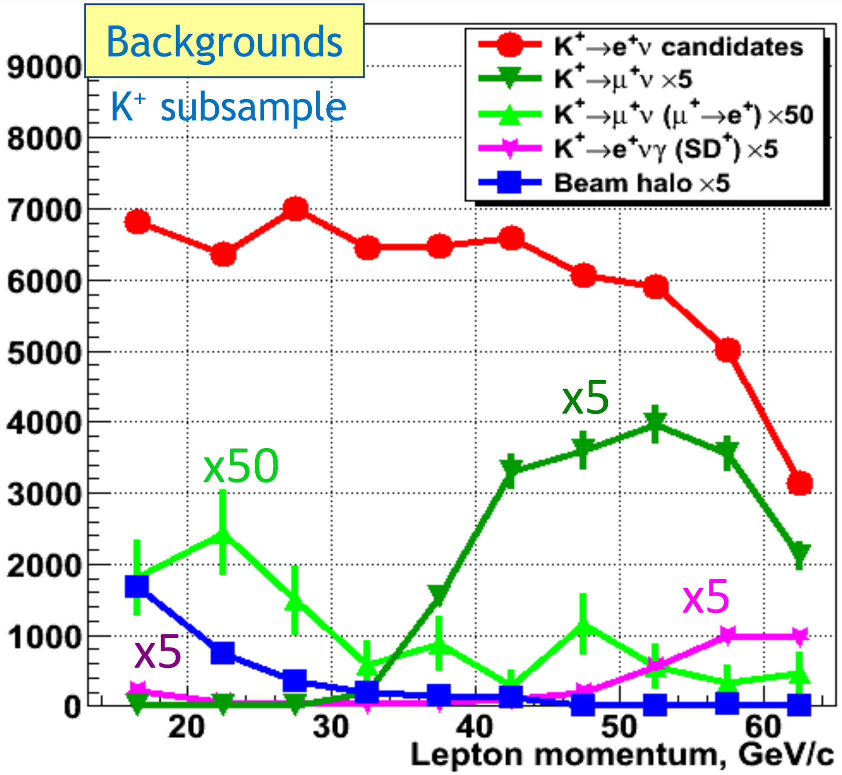
$$R_K^{LFV} \approx R_K^{SM}\left[1 + \left(\frac{m_K^4}{m_{H^\pm}^4}\right)\left(\frac{m_\tau^2}{m_e^2}\right)|\Delta_{13}|^2 \tan^6\beta\right]$$

Much limited by the recent B and τ measurements
Fonseca, Romão and Teixeira, EPJC 72 (2012) 2228

Sensitive to SM extensions with 4th generation, sterile neutrinos
Lacker and Menzel, JHEP 1007 (2010) 006;
Abada et al., JHEP 1302 (2013) 048

NA62-R_K data: K_{e2} sample





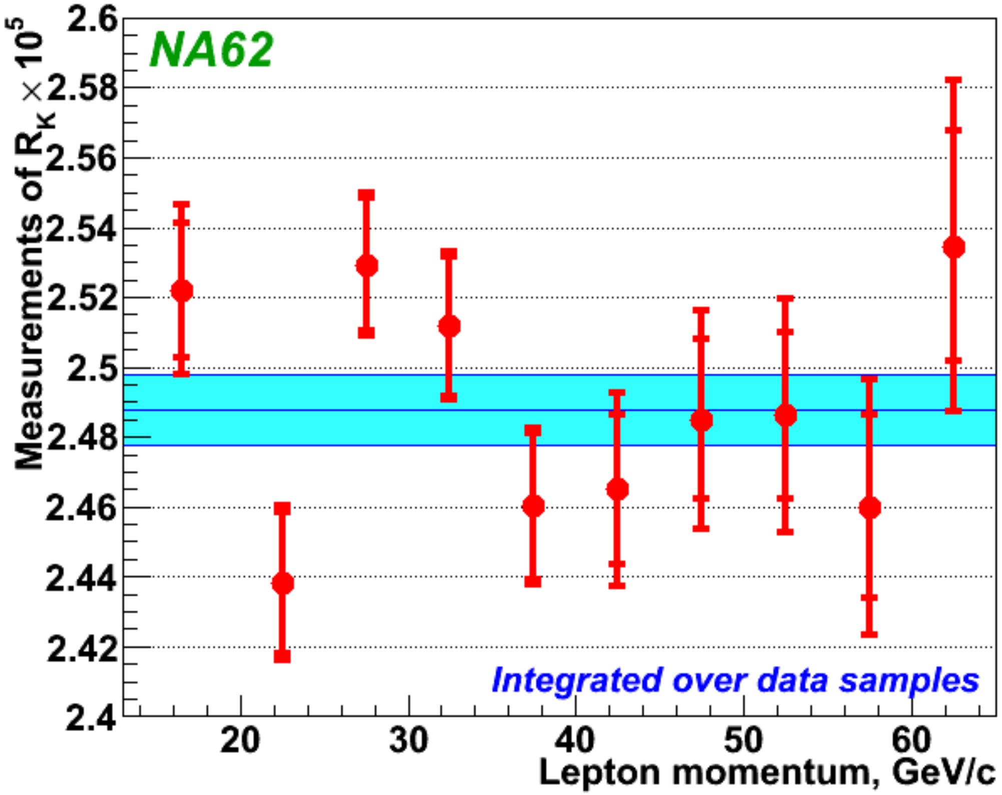
145,958 $K^\pm \to e^\pm \nu$ candidates.
Background: $B/(S+B)=(10.95\pm0.27)\%$.
Electron ID efficiency: $(99.28\pm0.05)\%$.

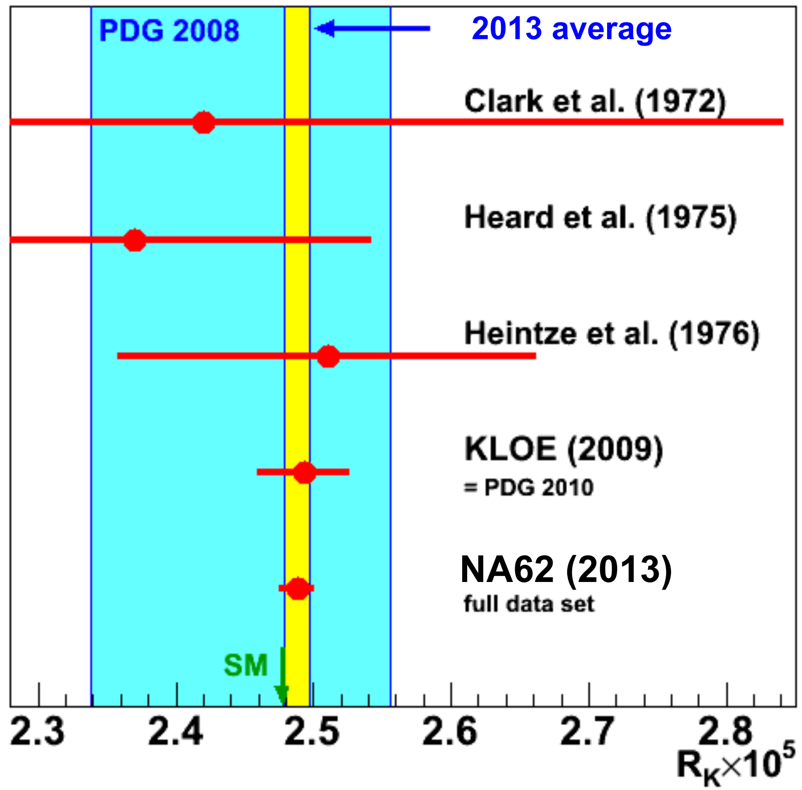
Source	B/(S+B)
$K_{\mu2}$	$(5.64\pm0.20)\%$
$K_{\mu2}$ ($\mu \to e$)	$(0.26\pm0.03)\%$
$K_{e2\gamma}$ (SD)	$(2.60\pm0.11)\%$
$K_{e3(D)}$	$(0.18\pm0.09)\%$
$K_{2\pi(D)}$	$(0.12\pm0.06)\%$
Opposite sign K	$(0.04\pm0.02)\%$
Beam halo	$(2.11\pm0.09)\%$
Total	$(10.95\pm0.27)\%$

NA62 final result

$$R_K = (2.488 \pm 0.007_{stat} \pm 0.007_{syst}) \times 10^{-5}$$
$$R_K = (2.488 \pm 0.010) \times 10^{-5}$$

[Phys. Lett. B 719 (2013) 326]





Independent measurements in lepton momentum bins

(systematic errors included, partially correlated)

World average	$R_K \times 10^5$	Precision
PDG 2008	2.447±0.109	4.5%
2013	2.488±0.009	0.4%

R_K: Future prospects

Future NA62 (data taking in 2014–2015):

Hermetic veto (large-angle and small-angle veto counters) will strongly decrease the background.
Beam spectrometer (beam tracker plus beam Cherenkov) will allow time correlation between incoming kaons and decay products (improved PID).

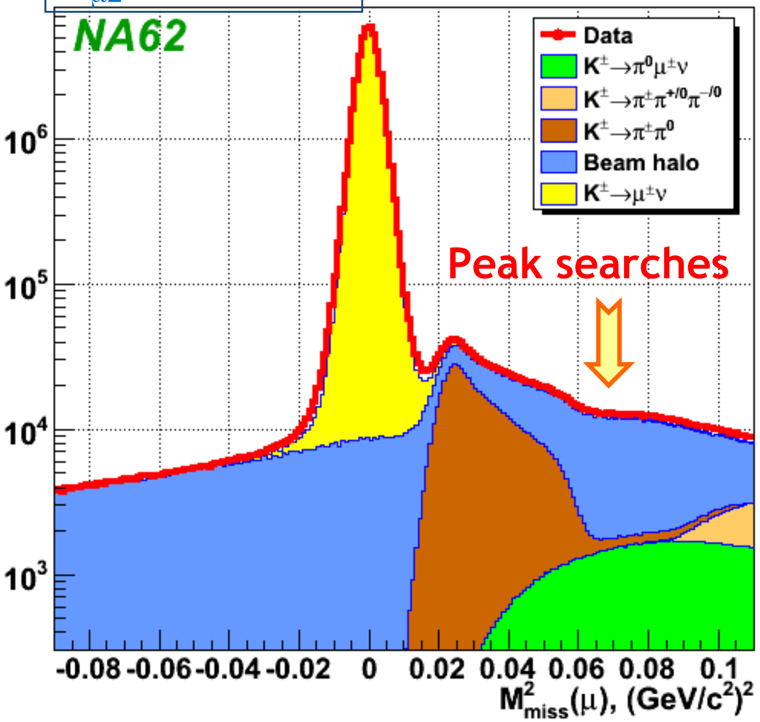
Only the $K_{\mu 2}$ ($\mu \to e$) background will remain: well known ~0.1% contamination.

Assuming an analysis at low lepton momentum and not using electron ID, measurement of R_K with much improved relative precision is feasible.

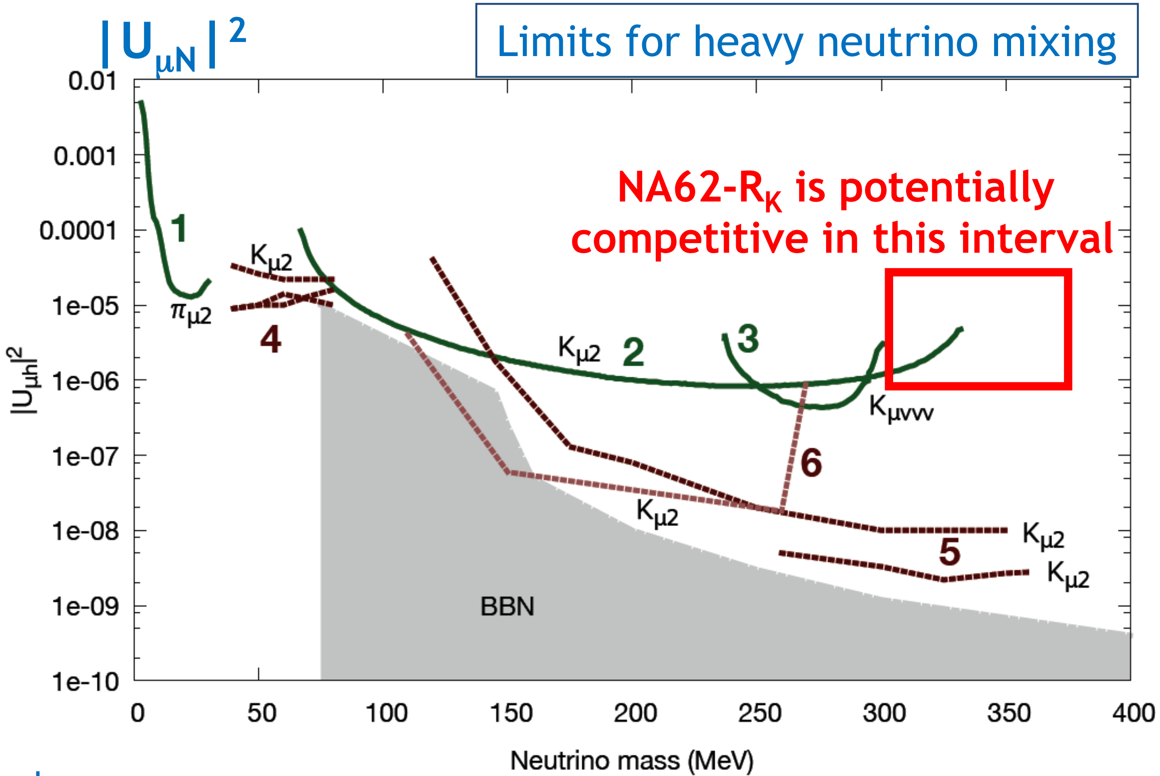
Required statistical uncertainty is ~0.05% → few million K_{e2} candidates.
Required kaon decay flux: $N_K \sim 10^{12}$
Expected NA62 flux: $N_K \sim 10^{13}$

$K_{\mu 2}$: heavy sterile neutrinos

$K_{\mu 2}$ candidates



Limits for heavy neutrino mixing



NA62-R_K subsample: 18.0M $K^+\to\mu^+\nu_\mu$

→ Search for heavy sterile neutrino: $K^+\to\mu^+N$

NA62-R_K Upper Limit if no backgrounds:

$|U_{\mu N}|^2<10^{-7}$, $100\ MeV/c^2<M_N<380\ MeV/c^2$

Sensitivity is limited by background fluctuation (mainly beam halo)

NA62-R_K is competitive at high M_N

Peak searches (long-lived ν_h)

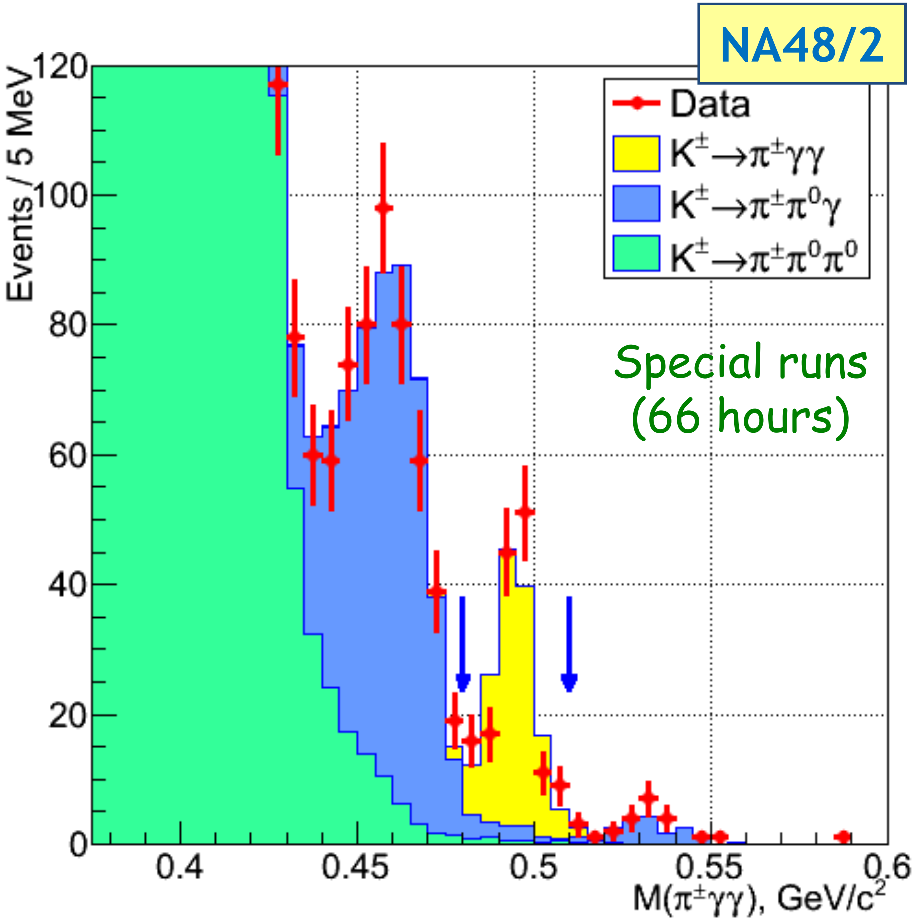
1. PSI, PLB 105 (1981) 263.
2. KEK, PRL 49 (1982) 1305.
3. LBL, PRD 8 (1973) 1989.

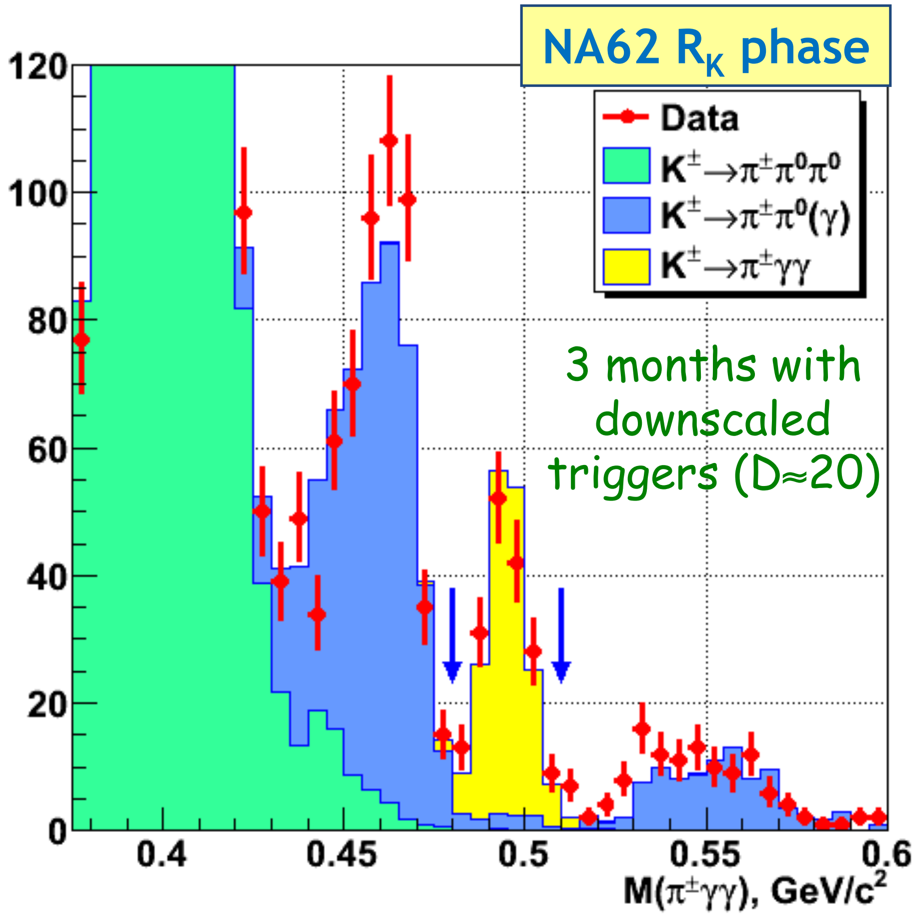
Decay searches (short-lived ν_h)

4. ISTRA+, PLB 710 (2012) 307.
5. CERN-PS191, PLB 203 (1988) 332
6. BNL-E949, preliminary

Analysis in progress

Minimum bias data: $K^{\pm}\rightarrow\pi^{\pm}\gamma\gamma$

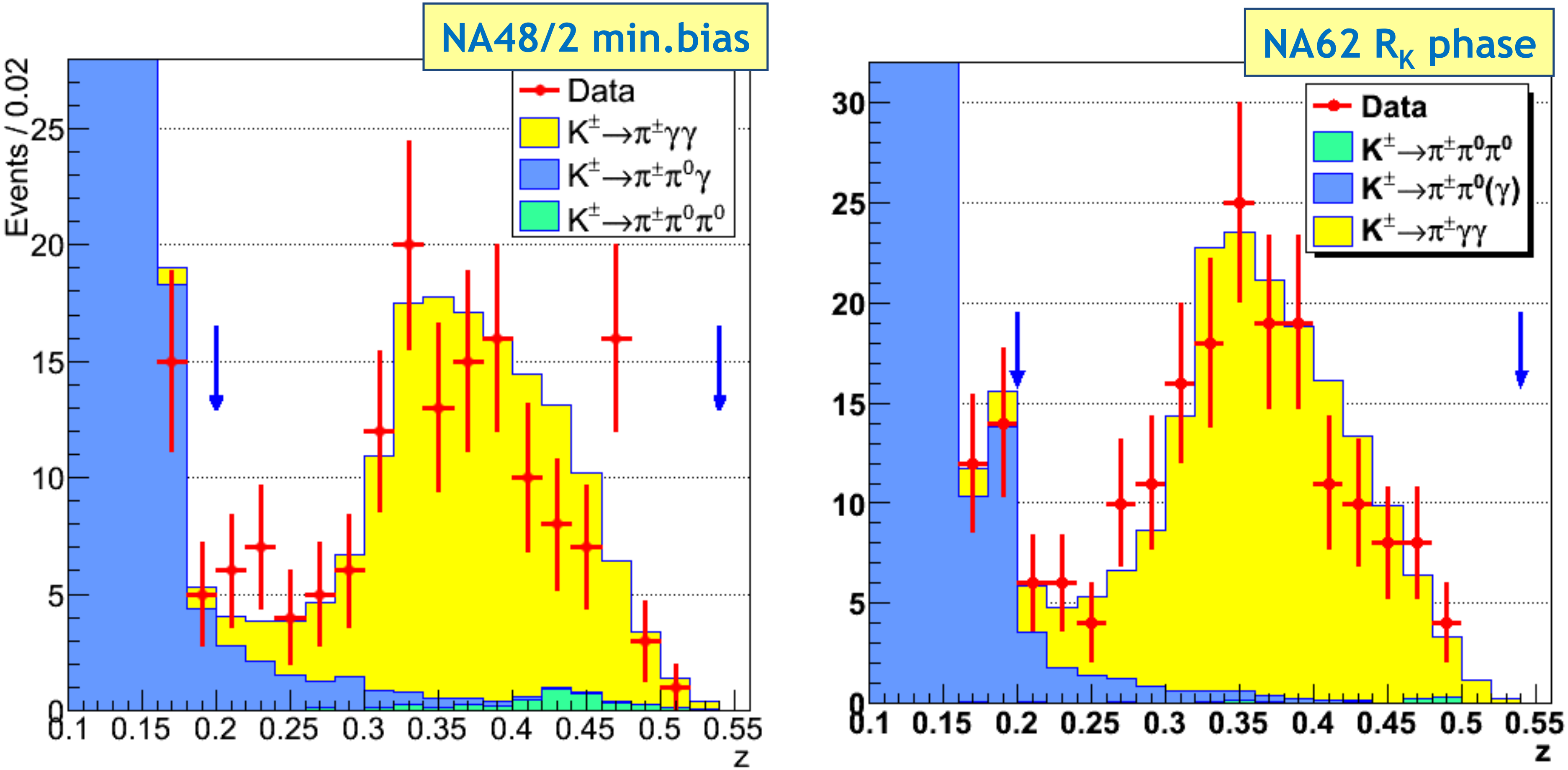




$K_{\pi\gamma\gamma}$ candidates	149
$K_{2\pi(\gamma)}$ background	11.4±0.6
$K_{3\pi}$ background	4.1±0.4
$K_{\pi\gamma\gamma}$ signal	134±12

$K_{\pi\gamma\gamma}$ candidates	175
$K_{2\pi(\gamma)}$ background	11.1±1.0
$K_{3\pi}$ background	1.3±0.3
$K_{\pi\gamma\gamma}$ signal	163±13

Fits to ChPT description



→ Data support the ChPT prediction: cusp at di-pion threshold

NA48/2 final result: **$BR_{MI}(z>0.2) = (0.877 \pm 0.087_{stat} \pm 0.017_{syst}) \times 10^{-6}$**

Measurement of the ChPT parameters: publications in preparation

Dark photon: experimental status

M.Pospelov, PRD80 (2009) 095002

Secluded U(1) sector with weak admixture to photons: a natural SM extension.

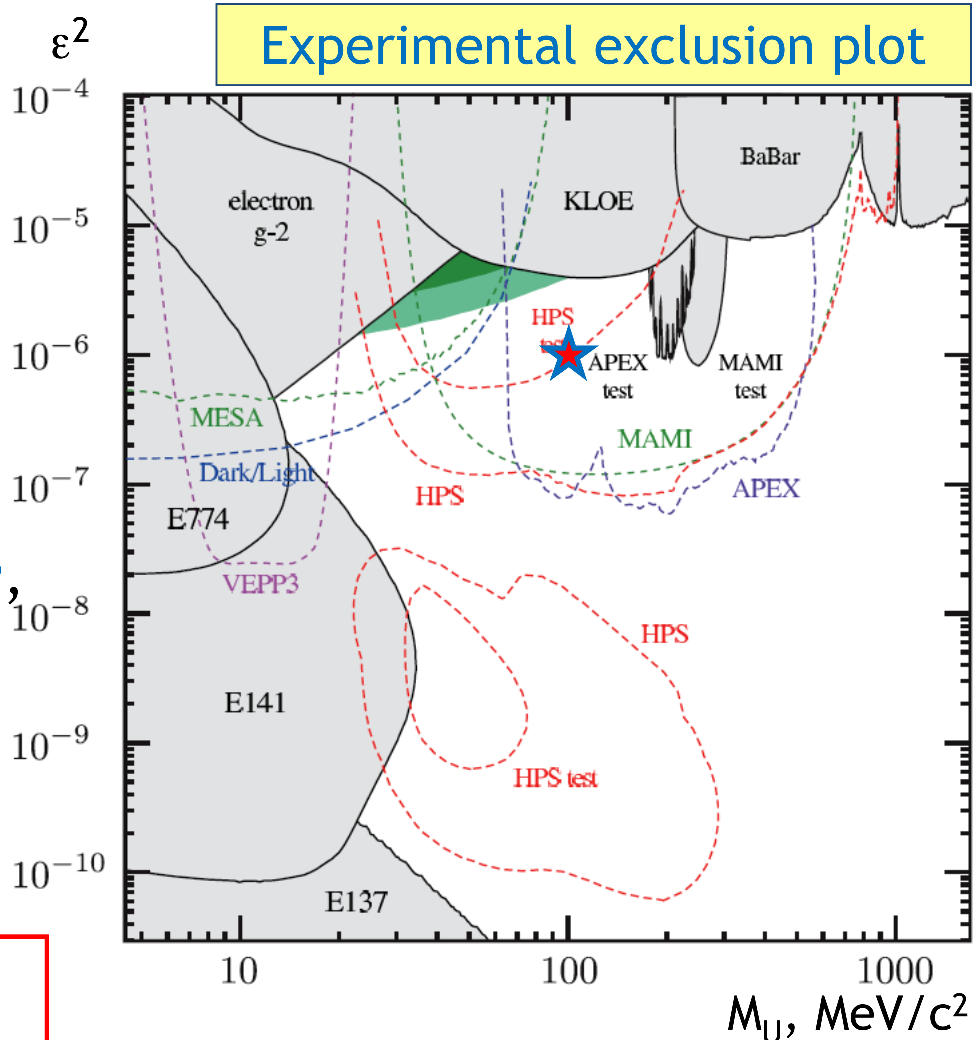
A new light vector boson: the **dark photon**.

Possible parameters:
mixing parameter: $\varepsilon^2 \sim (\alpha/\pi)^2 \sim 10^{-6}$,
DP mass: $M_U \sim \varepsilon M_Z \sim 100$ MeV/c^2.

Can explain some astrophysical observations as well as the muon **g–2** anomaly.

NA48/NA62 are well suited to explore the favoured region ($\varepsilon^2 \approx 10^{-6}$, $M_U \approx 100$ MeV/c^2)

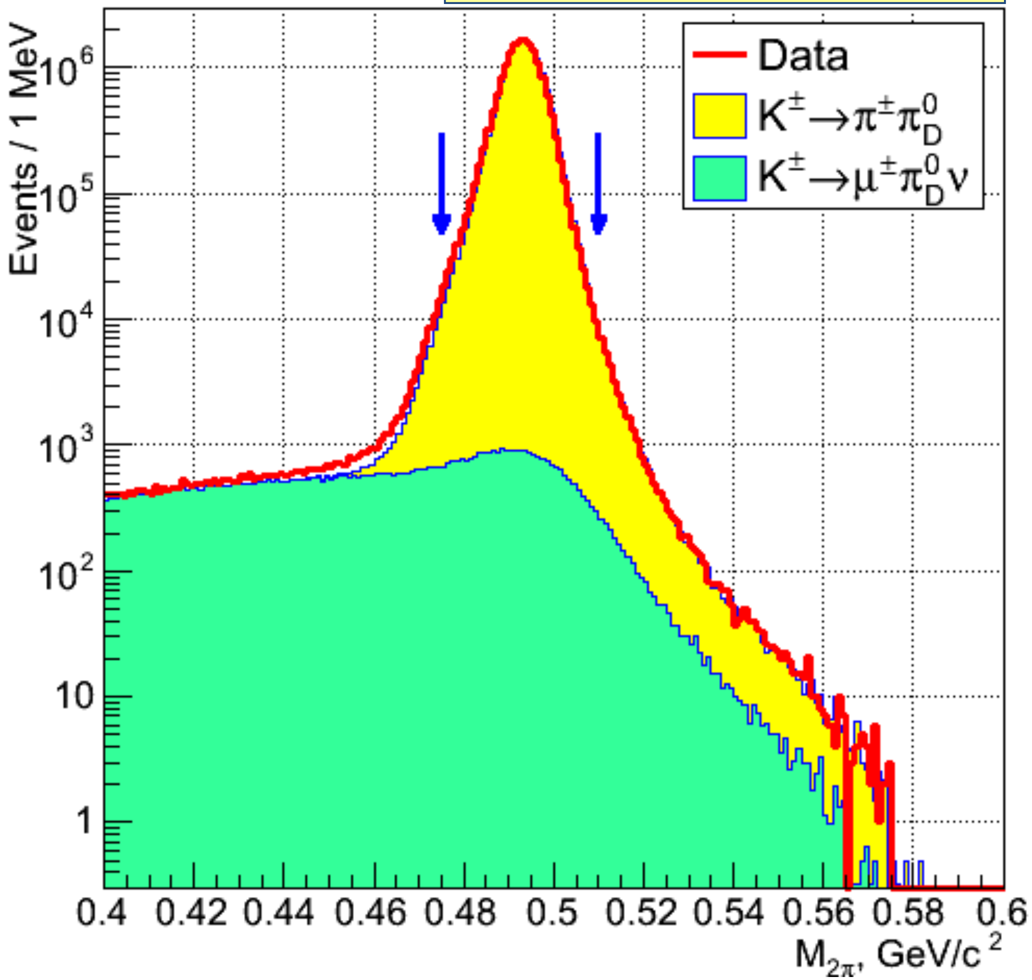
Experimental exclusion plot



Plot from M.Endo et al., PRD86 (2012) 095029

NA48/2: $\pi^0_D \to e^+e^-\gamma$ sample

$\pi^{\pm}\pi^0_D$ mass spectrum



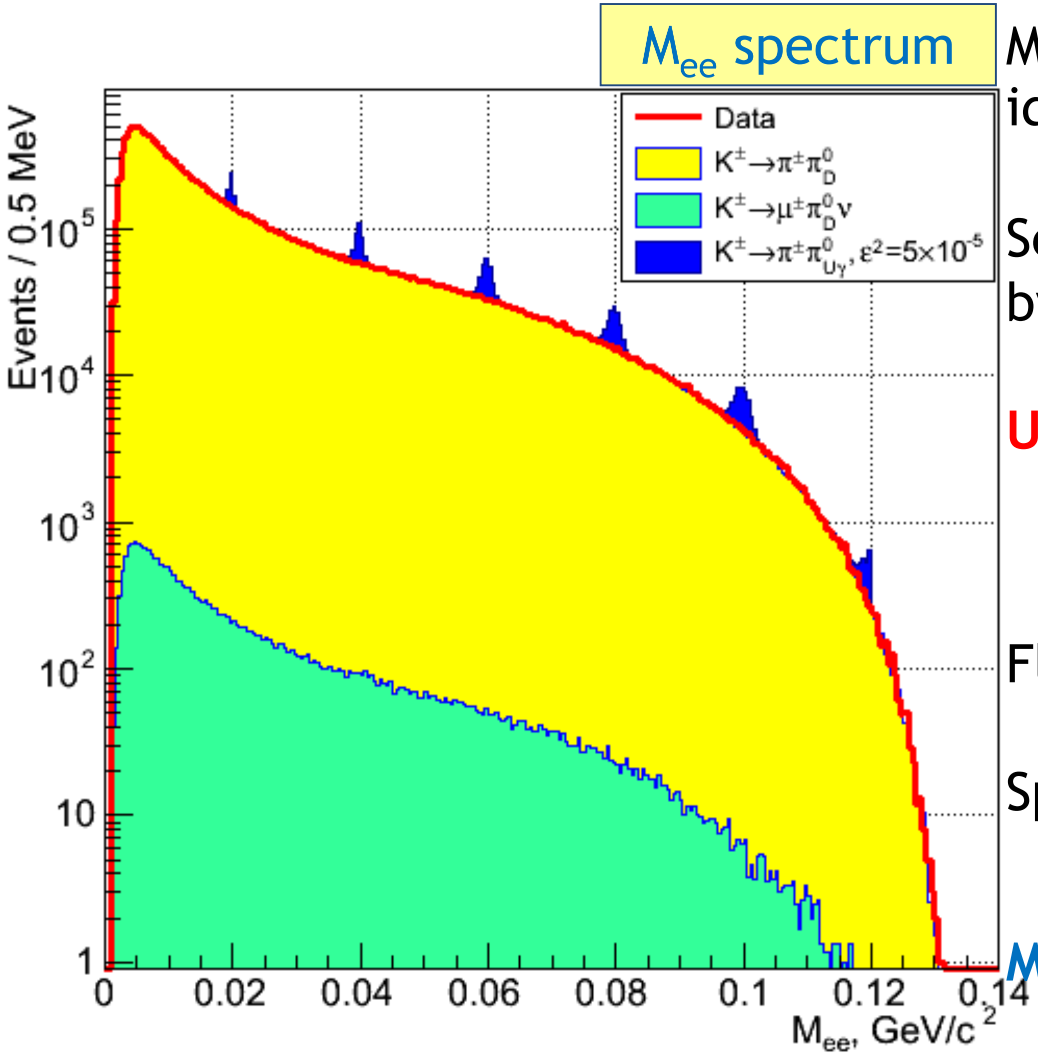
An **existing data sample** collected in 2003–2004 with a 3-track trigger. Trigger efficiency: **~98%**.

Large sample of tagged π^0_D decays: **~2×10^7 $K^{\pm}\to\pi^{\pm}\pi^0_D$**.

Further π^0_D samples available from **$K^{\pm}\to\pi^0_D l^{\pm}\nu$** decays.

Search for **$\pi^0\to U\gamma$, $U \to e^+e^-$**.
$BR(U\to e^+e^-)=1$ for **$M_U<2M_\mu$**.

NA48/2: M_{ee} spectrum of π^0_D



π^0 form-factor measurement on-going

Mean dark photon free path **~1mm**: identical signatures $\pi^0 \to U\gamma$ and π^0_D.

Sensitivity to dark photon limited by $K_{2\pi D}$ background fluctuation.

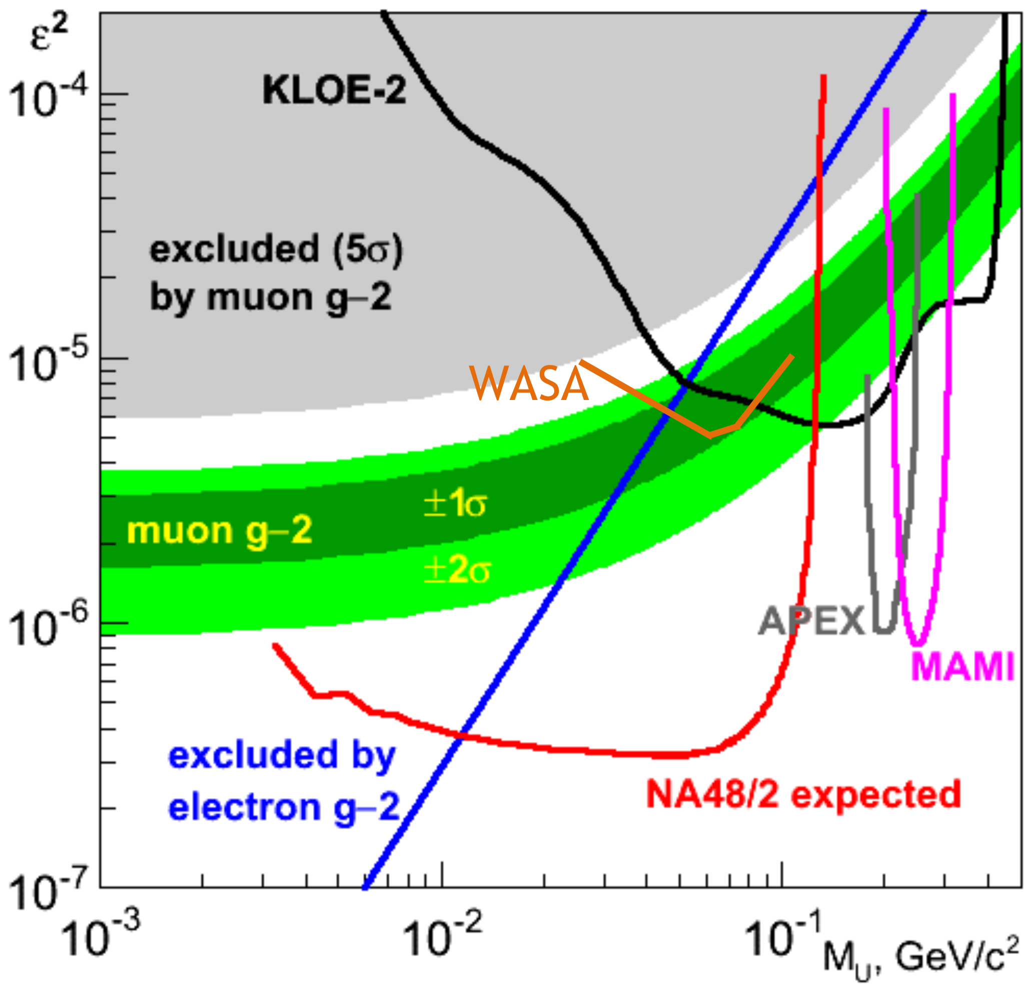
Upper limit ~ **$(\text{Kaon Flux})^{-1/2}$** × **$(\text{Acceptance})^{-1/2}$** × **$(M_{ee}\ \text{resolution})^{-1/2}$**

Flux **~2×10^{11}** , acceptance **~5%**.

Spectrometer resolution:
$\delta M_{ee} \approx 0.012 M_{ee}$ (**<1.4 MeV/c**).

M_{ee} resolution can be improved using the $(P_K - P_\pi)^2$ constraint.

NA48/2 vs other limits at low M_U



Experimental constraints

Electron and muon g–2:
Endo et al., PRD86 (2012) 095029

KLOE-2 [$\phi \to \eta e^+ e^-$]:
Babusci et al., PLB720 (2013) 111

A1 @ MAMI (Mainz Microtron)
Merkel et al., PRL106 (2011) 251802

APEX @ J-LAB
Abrahamyan et al., PRL107 (2011) 191804

WASA preliminary [$\pi^0 \to \gamma e^+ e^-$]:
Adlarson et al., arXiv:1304.0671

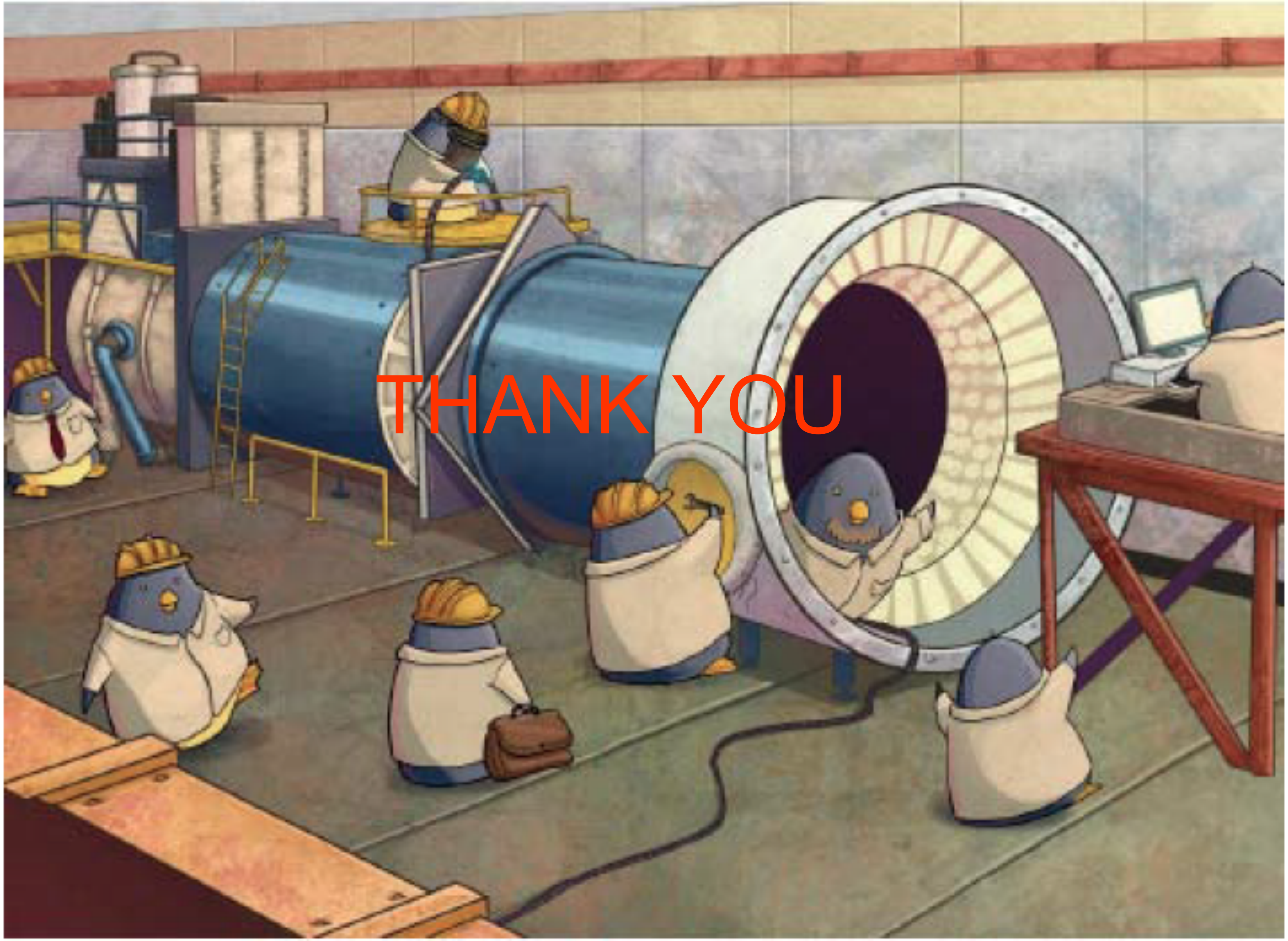
NB: the NA48/2 curve is the expected sensitivity, not a result!

Summary

- **NA62-R_K** (2007–2008): minimum bias electron trigger.
  - ✓ Lepton Universality test at record **0.4%** precision: **$BR(K^\pm \to e^\pm \nu)/BR(K^\pm \to \mu^\pm \nu) = (2.488 \pm 0.010) \times 10^{-5}$**;
  - ✓ rare decays, heavy neutrinos: analyses on-going.

- **NA62** (construction/commissioning).
  - ✓ expected single event sensitivity for K^+ decays: **$\sim 10^{-12}$**;
  - ✓ preparing for the physics run in 2014 (low intensity);
  - ✓ a diverse physics programme is taking shape;

Opportunity of close collaboration with LHCb on kaon physics


THANK YOU

Rare π^0 decays

Other $K_{\pi\nu\nu}$ experiments

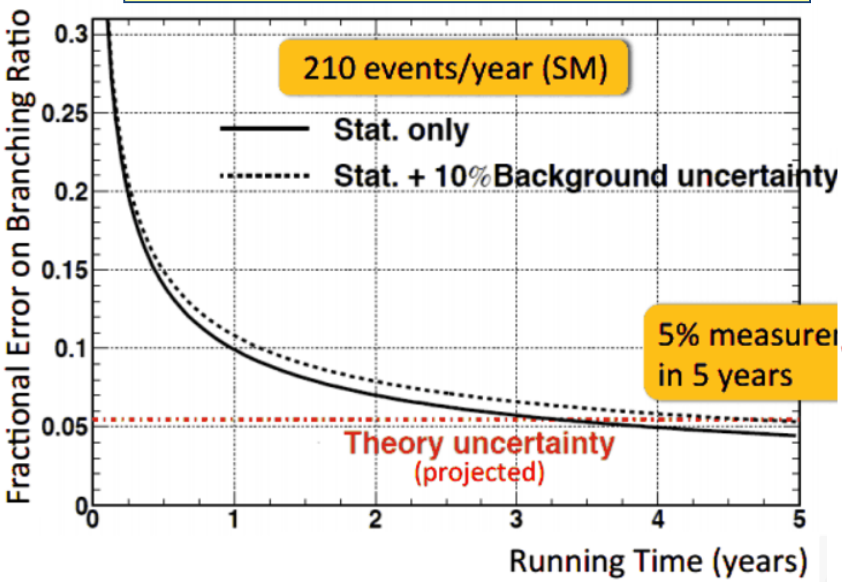
ORKA @ FNAL Main Injector (K^+):

- Builds on BNL stopped-kaon technique.
- Expect ~100 times higher sensitivity.
- Goal: $O(10^3)$ SM $K^+ \rightarrow \pi^+ \nu\nu$ events.
- Fits inside the CDF solenoid.
- Re-use CDF infrastructure.

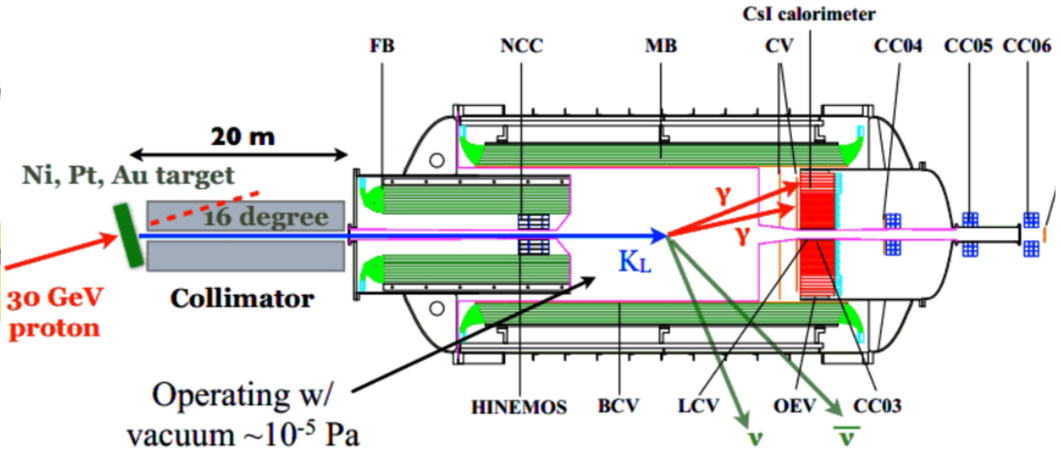
KOTO @ J-PARC (K_L):

- Builds on KEK E391a technique.
- E391a: $BR < 6.8 \times 10^{-8}$ @ 90%CL.
- Expect ~10^3 times higher sensitivity.
- Goal: ~3 SM $K_L \rightarrow \pi^0 \nu\nu$ events.
- Data taking: 2013–2017.
- Possible step 2: ~100 SM events.

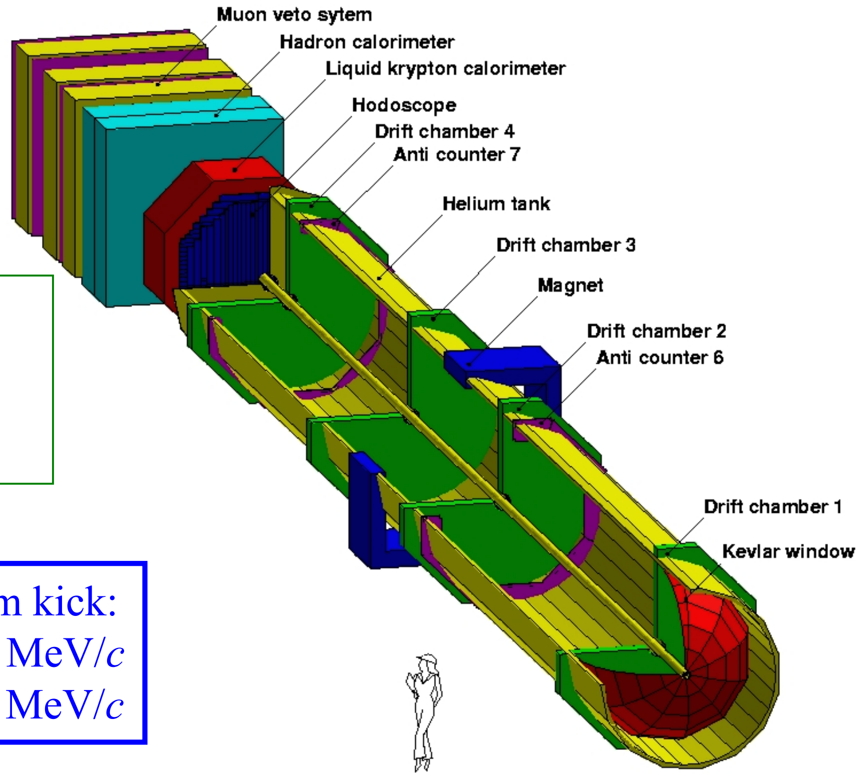
ORKA expected sensitivity



"Two photons + nothing"



Detector



Magnetic spectrometer:

$\sigma_p/p = (1.0 \oplus 0.044\ p)\%$ [GeV/c] 2004

$\sigma_p/p = (0.48 \oplus 0.009\ p)\%$ [GeV/c] 2007

Trigger Hodoscope:

σ_t=150ps

Momentum kick:
2004: 120 MeV/*c*
2007: 265 MeV/*c*

LKr electromagnetic calorimeter:

$\sigma_E/E = (3.2/\sqrt{E} \oplus 9.0/E \oplus 0.42)\%$

(E in GeV)

$\sigma_x = \sigma_y \sim 1.5$mm for E=10 GeV

$\sigma(M_{\pi\pi^0\pi^0}) = 1.4$ MeV/c^2

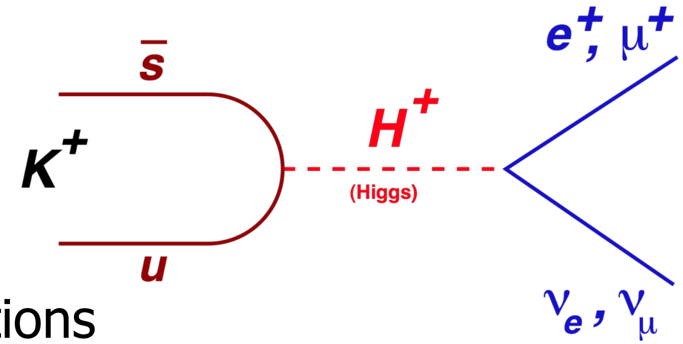
E/p ratio used for e/π discrimination

- ~100 m long decay region in vacuum
- Similar acceptance between K^+ and K^- beams checked reversing magnetics fields
- Pion decay products, from the hadronic beam, remain into the beam pipe

Leptonic meson decays: $P^+ \to l^+ \nu$

SM contribution is helicity suppressed:

$$\Gamma(P^+ \to l^+\nu) = \frac{G_F^2 M_P M_l^2}{8\pi}\left(1 - \frac{M_l^2}{M_P^2}\right)^2 f_P^2 |V_{qq'}|^2$$



Sizeable tree level charged Higgs ($H^\pm$) contributions in models with two Higgs doublets (2HDM including SUSY)

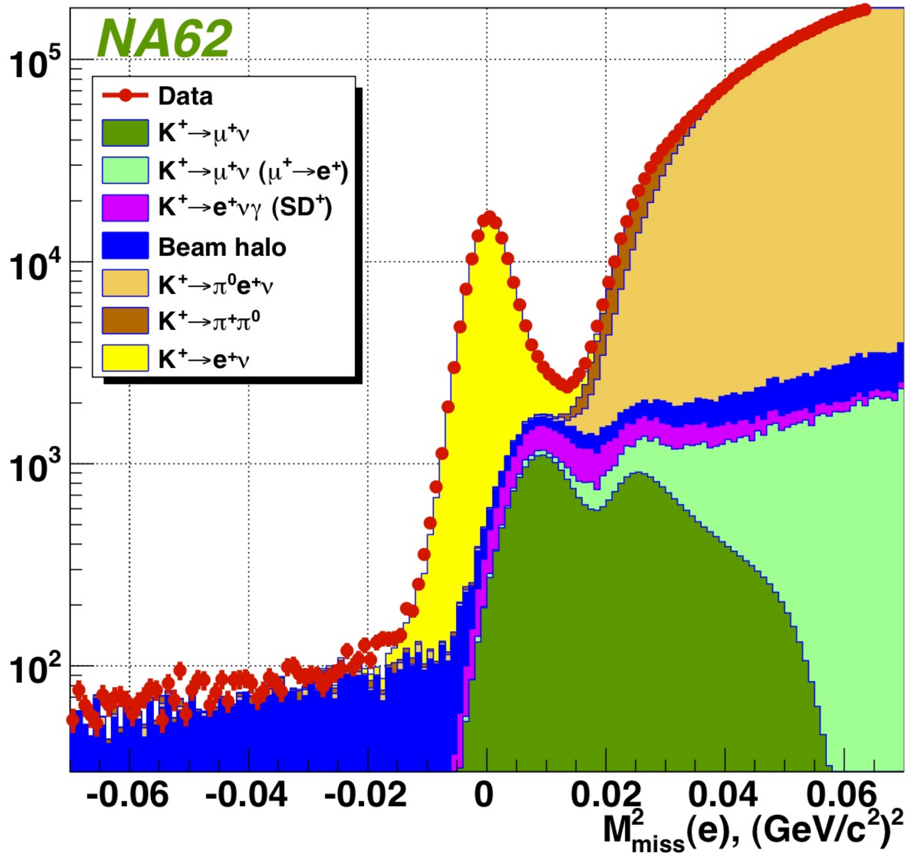
PRD48 (1993) 2342; Prog.Theor.Phys. 111 (2004) 295

(numerical examples for M_H=500GeV/c², tanβ = 40)

$\pi^+ \to l\nu$:	$\Delta\Gamma/\Gamma_{SM} \approx -2(m_\pi/m_H)^2\, m_d/(m_u+m_d)\, \tan^2\beta$	$\approx 2\times10^{-4}$
$K^+ \to l\nu$:	$\Delta\Gamma/\Gamma_{SM} \approx -2(m_K/m_H)^2 \tan^2\beta$	$\approx$ 0.3%
$D^+_s \to l\nu$:	$\Delta\Gamma/\Gamma_{SM} \approx -2(m_D/m_H)^2\, (m_s/m_c)\, \tan^2\beta$	$\approx$ 0.4%
$B^+ \to l\nu$:	$\Delta\Gamma/\Gamma_{SM} \approx -2(m_B/m_H)^2 \tan^2\beta$	$\approx$ 30%

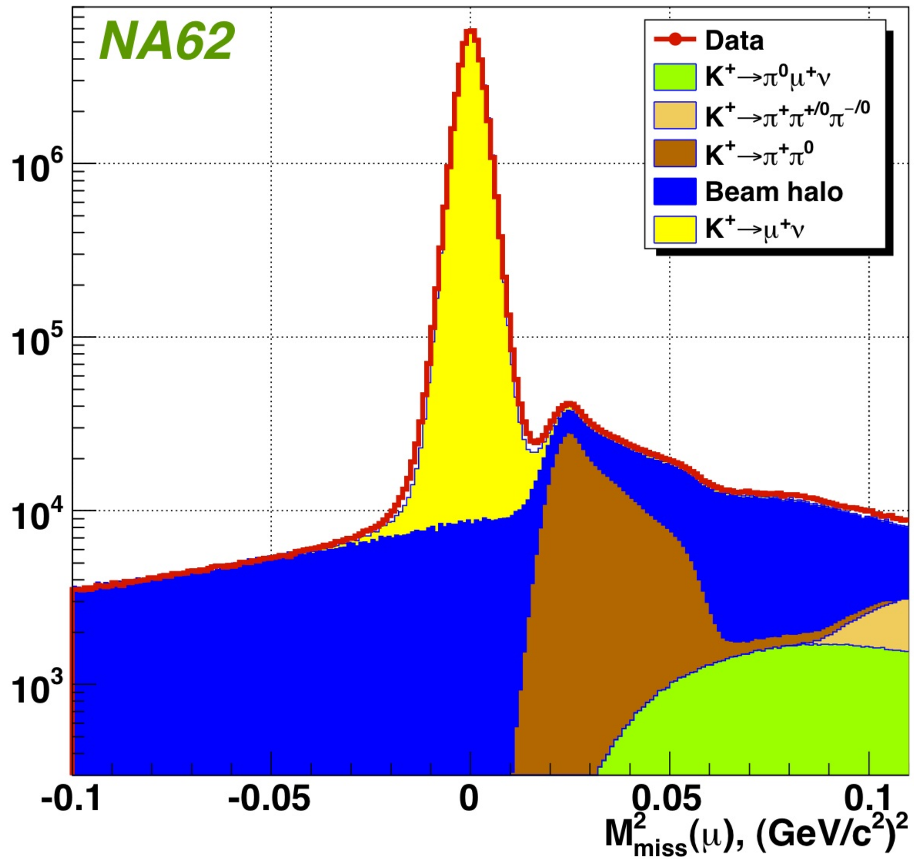
NA62 data set for R_K

K_{e2} candidates



145,958 $K^+ \to e^+ \nu$ candidates.
Positron ID efficiency: (99.28±0.05)%.
B/(S+B) = (10.95±0.27)%.

$K_{\mu 2}$ candidates



42.817M candidates
with low background
B/(S+B) = (0.50±0.01)%

NA62 Detector 2012 and 2014