π^0 Dalitz Transition Form Factor and other news from NA62

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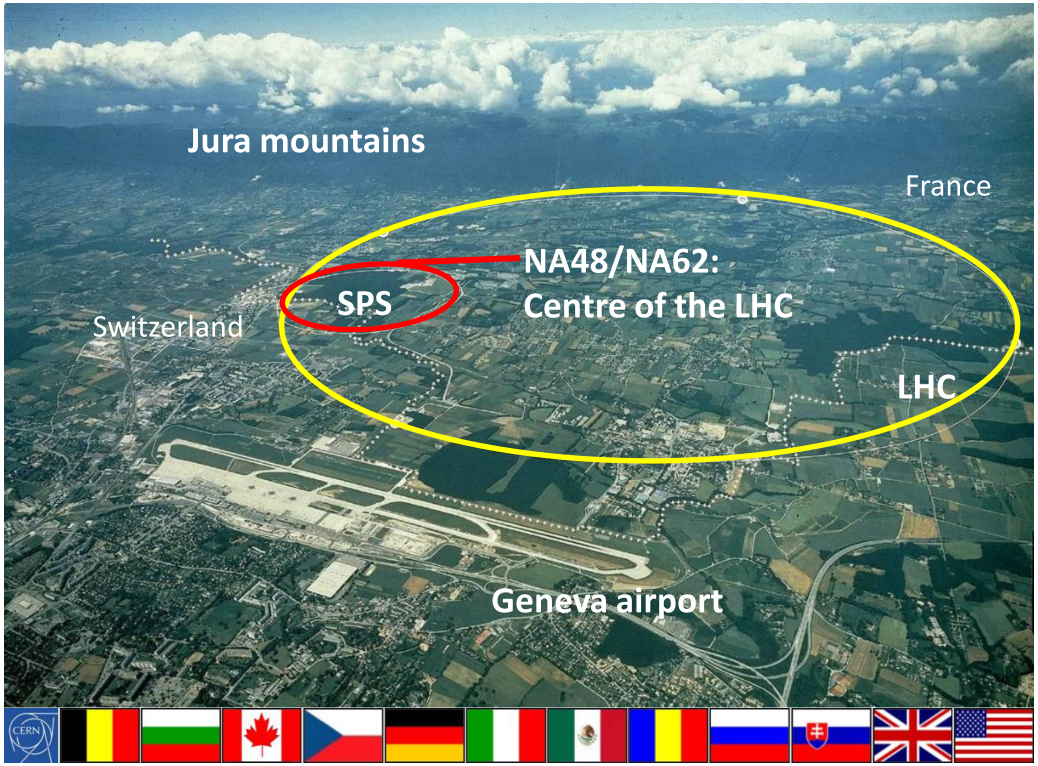
University of Birmingham, 26/04/2017

Outline

- π^0 transition form factor slope from the π^0 Dalitz decay at NA62 2007
- The $K^+ \to \pi^+ \nu\bar{\nu}$ decay
- Status of the NA62 detector
- Status of the $\mathrm{K}^+ \to \pi^+ \nu\bar{\nu}$ analysis
- Prospects for exotic searches at NA62

CERN NA48/NA62 experiments



Experiments history		
Earlier	NA31	
1997 ↓ 2001	NA48 (K_S/K_L)	$Re(\varepsilon'/\varepsilon)$ Discovery of direct CPV
2002	NA48/1 (K_S/hyperons)	Rare K_S and hyperon decays
2003 ↓ 2004	NA48/2 (K^+/K^-)	Direct CPV, Rare K^+/K^- decays
2007 ↓ 2008	$\mathrm{NA62_{R_K}}$ (K^+/K^-)	$R_K = K^\pm_{e2}/K^\pm_{\mu2}$ **1st part**
2014 ↓ …	NA62 (K^+)	$K^+ \to \pi^+\nu\bar{\nu}$, Rare K^+ and π^0 decays **2nd part**

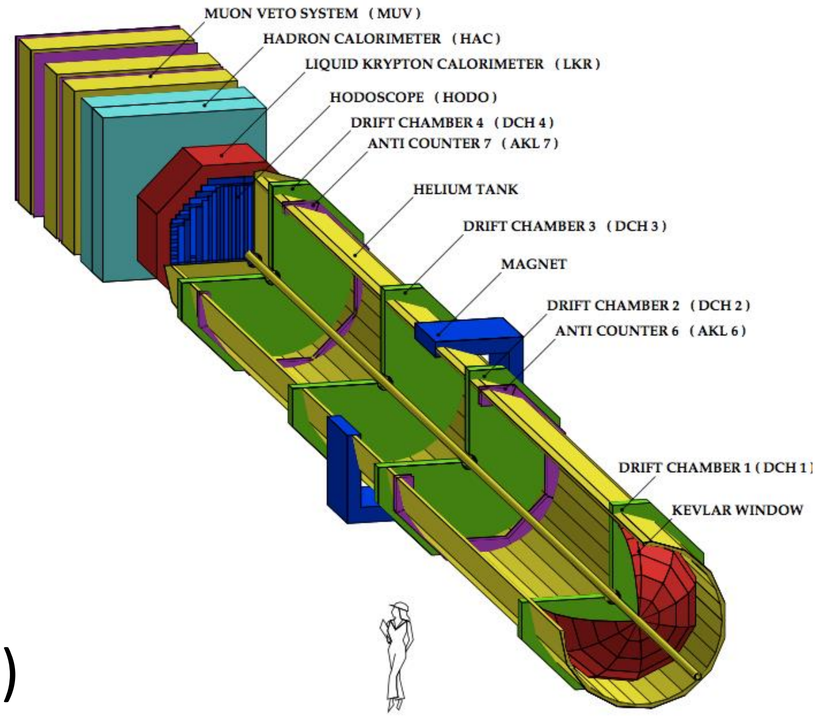
Kaon decay in flight experiment

NA62: currently ~200 participants, 29 institutions from 13 countries

A step back in the past

Experimental Setup (NA62 2007 data)

- Principal subdetectors
  - Scintillator hodoscope (HOD)
    - Low-level trigger,
      time measurement (150 ps)
  - Magnetic spectrometer (4DCHs)
    - 4 views/DCH high efficiency
    - $\frac{\sigma_p}{p} = 0.48\% \oplus 0.009\% \cdot p$ [GeV/c]
  - Liquid Krypton EM calorimeter (LKr)
    - High granularity, quasi-homogeneous
    - $\frac{\sigma_E}{E} = \left(\frac{3.2}{\sqrt{E}} \oplus \frac{9}{E} \oplus 0.42\right)\%$ [E in GeV]
    - $\sigma_x = \sigma_y = \left(\frac{4.2}{\sqrt{E}} \oplus 0.6\right)$ mm
      (1.5 mm @ 10 GeV)

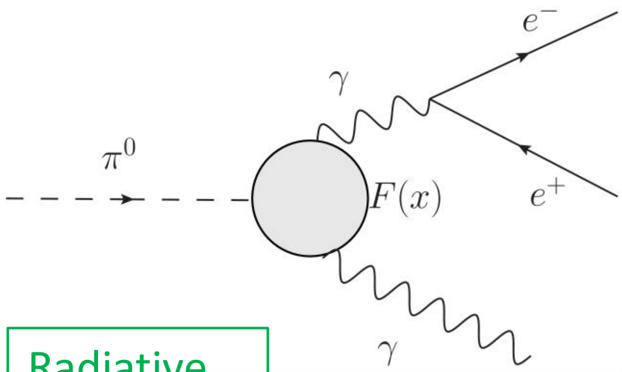


Data taking conditions

- $P_K = 74 \pm 2$ GeV/c
- Triggers: 1-track $e^{\pm}$, 1-track $\mu^{\pm}$
- Alternate K^+/K^- beam, possibility to block both beams

π^0 TFF: Dalitz Decay

$$\boldsymbol{\pi^0 \rightarrow e^+ e^- \gamma}$$



- Kinematic variables
  - $x = \frac{(p_{e^+} + p_{e^-})^2}{m_{\pi^0}^2}, \quad y = \frac{2p_{\pi^0} \cdot (p_{e^+} - p_{e^-})}{m_{\pi^0}^2 (1-x)}$
- Differential decay width
  - $\frac{1}{\Gamma(\pi^0_{2\gamma})} \frac{d^2\Gamma(\pi^0_D)}{dxdy} = \frac{\alpha}{4\pi} \frac{(1-x)^3}{x} \left(1 + y^2 + \frac{r^2}{x}\right) \left(1 + \delta(x,y)\right) |F(x)|^2$
- Form factor varies slowly:
  - Approximation $F(x) \approx 1 + ax$

Radiative corrections

Electromagnetic Transition Form factor

π^0 TFF: Motivations

- Computed in multiple theoretical framework:
  - Chiral perturbation theory [K. Kampf et al., EPJ C46 (2006), 191]:
    $$a = (2.90 \pm 0.50) \times 10^{-2}$$
  - Dispersion theory [M. Hoferichter et al., EPJ C74 (2014), 3180]:
    $$a = (3.07 \pm 0.06) \times 10^{-2}$$
  - Two-hadron saturation (THS) model [T. Husek et al., EPJ C75 (2015) 12, 586]:
    $$a = (2.92 \pm 0.04) \times 10^{-2}$$
  - All roughly agree on a value close to 3%
- Measured in experiment:
  - Space-like momentum transfer (CELLO) [H. J. Behrend et al., Z. Phys. C49 (1991), 401]:
    $$a = (3.26 \pm 0.26_{stat}) \times 10^{-2}$$
    - Most precise, but model dependent extrapolation
  - Time-like momentum transfer, many “old” results (latest result from 1992, but MAMI [P. Adlarson et al., Phys. Rev. C 95, 025202])
    - Limited by statistics and theoretical uncertainties on radiative corrections
    - No single clear evidence of non-zero value

π^0 TFF: Motivations

- Better model independent measurement is an important test of the theory models
- Important input for:
  - Hadronic light-by-light scattering contribution to $(g-2)_\mu$
    [A. Nyffeler, Phys. Rev. D 94, 053006 (2016)]
    - 3σ discrepancy between theory and experiment for $(g-2)_\mu$
    - The HLBL contribution is the second largest source of uncertainty
    - The π^0 contribution is about 25% of the HLBL uncertainty
  - $\pi^0 \to e^+e^-$ decay rate
    [A. E. Dorokhov and M. A. Ivanov, Phys. Rev. D 75, 114007]
    - 3.3σ discrepancy between theory and experiment in the *Br*
    - Hypothesis: transition form factor extrapolated from CELLO data is not valid (there are others)

π^0 TFF: Radiative Corrections

- Corrections from NLO differential width encoded in

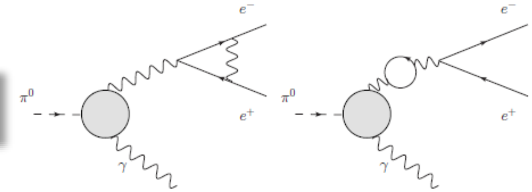
$$\delta(x,y) = \frac{d^2\Gamma^{\mathrm{NLO}}}{dxdy} \Big/ \frac{\mathrm{d}^2\Gamma^{\mathrm{LO}}}{\mathrm{dxdy}}$$

  - Mikaelian and Smith [Phys.Rev. D5 (1972) 1763]
  - Husek, Kampf and Novotny [Phys.Rev. D92 (2015) 5, 054027]

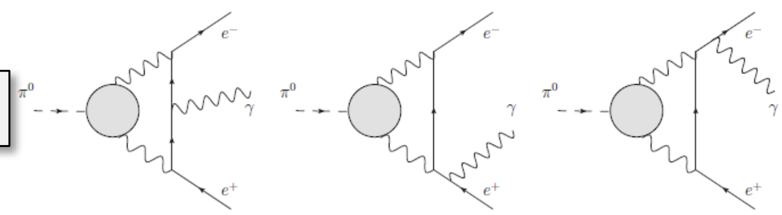
    New $\delta_{1\gamma IR}$ contribution

- Divergences cancel between δ_{virt} and δ_{brem}

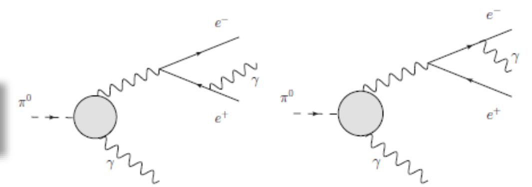
δ_{virt}



$\delta_{1\gamma IR}$



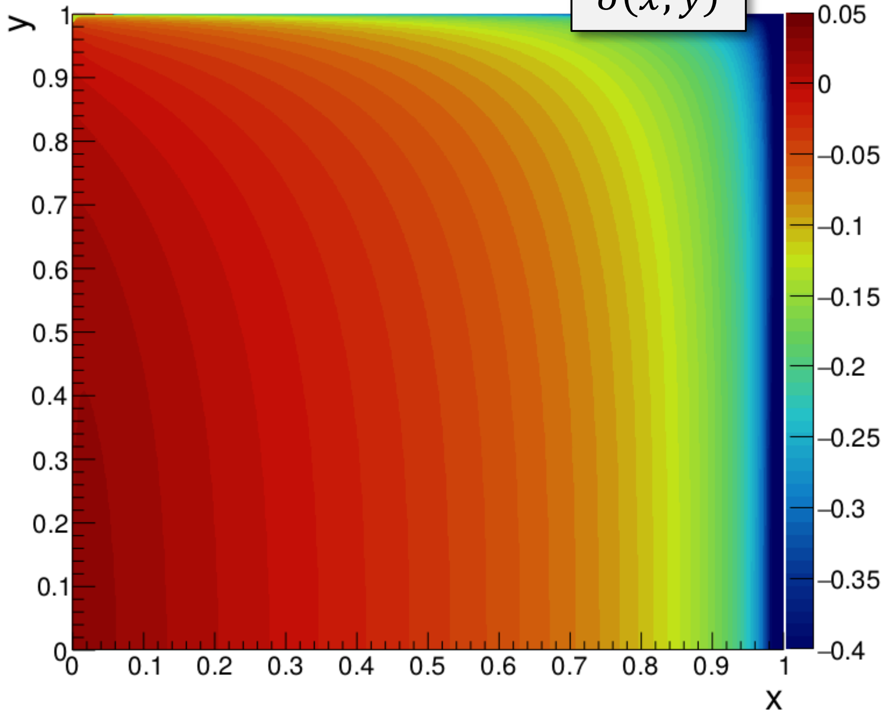
δ_{brem}



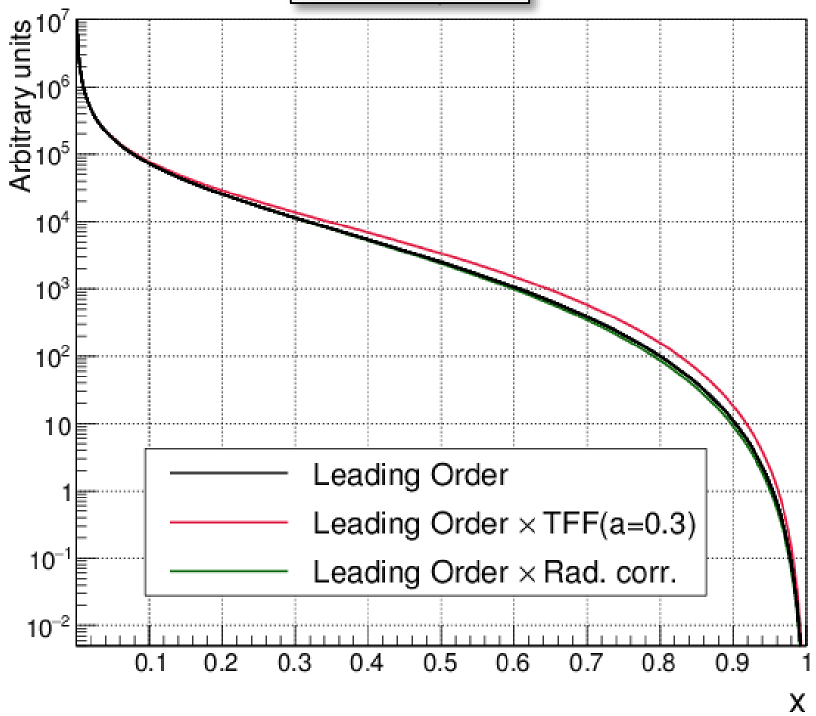
π^0 TFF: Radiative Corrections

- Corrections are of the same magnitude as TFF

$\delta(x, y)$

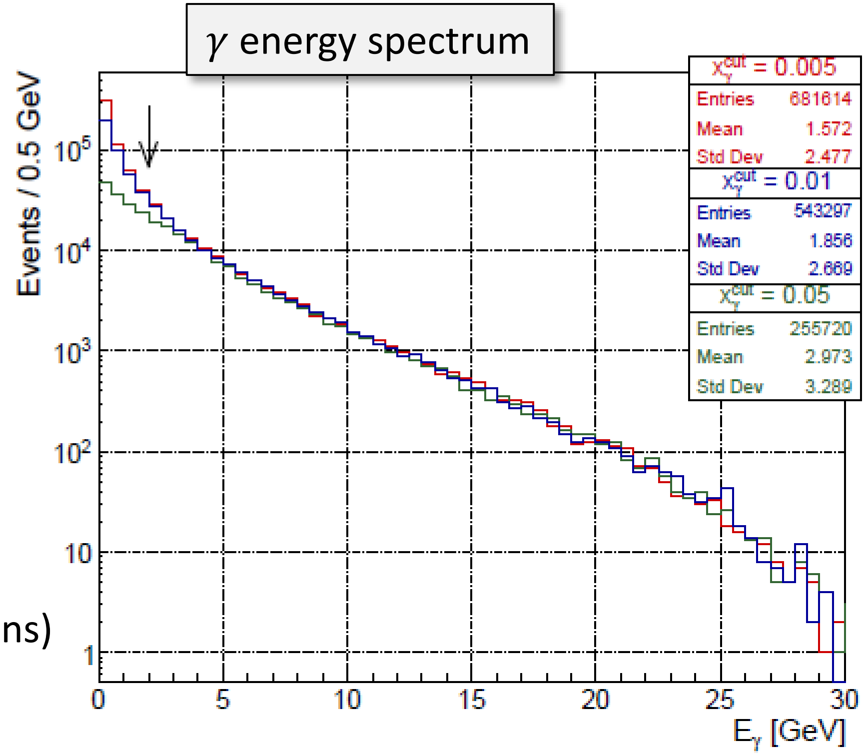


x spectrum



π^0 TFF: Radiative Corrections

- δ_{brem} is a 4-body decay $\pi^0 \rightarrow e^+e^-\gamma\gamma$
  $\Rightarrow$ discrepancies at low (Dalitz) photon energy
- New hybrid generator
  - 3-body generator with $\delta_{1\gamma IR}, \delta_{virt}$ radiative corrections and part of δ_{brem} necessary to cancel divergences
  - 4-body generator for remaining bremsstrahlung contribution
  - At the generator level, selection based on a cut-off parameter
- 3 MC samples produced
  - Main sample: blue
  - Convergence test:
    - red (agreement with main sample)
    - green (not enough bremsstrahlung photons)



π^0 TFF: Selection

- Measure the slope from a pure π^0_D sample from $\sim 2 \times 10^{10}\ K^+$ decays
- Use the $K^\pm \to \pi^\pm \pi^0\ (K_{2\pi D})$ decay chain
  $\hookrightarrow e^+ e^- \gamma$
  - 3-track vertex topology
  - Maximum three well reconstructed tracks
  - Photon: single isolated cluster in LKr
    (away from (un)deflected track impact points)

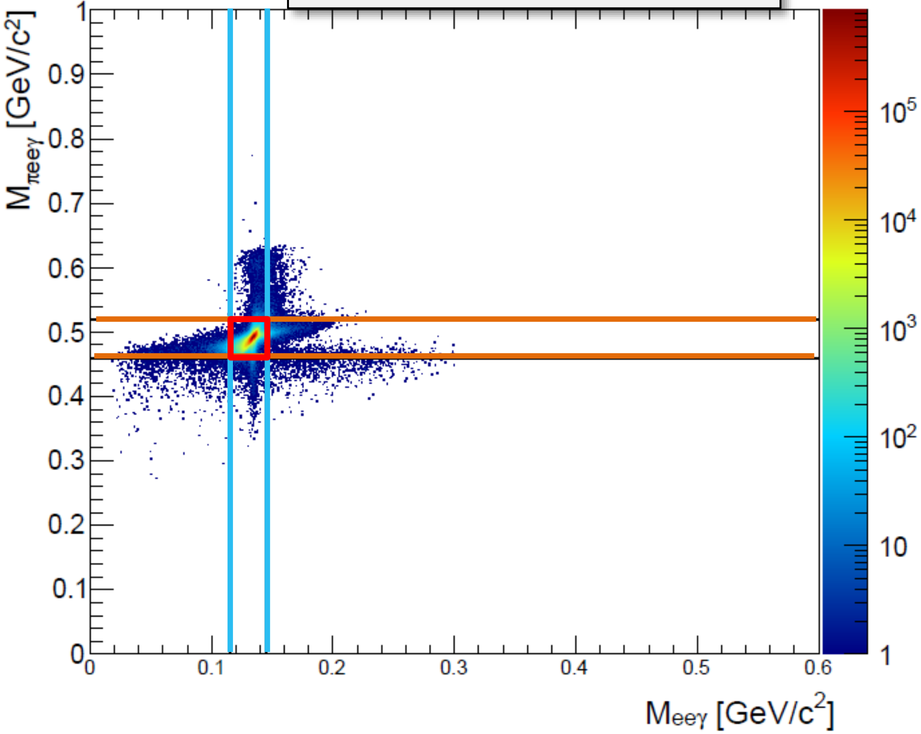
Remove track bremsstrahlung photons

π^0 TFF: Selection

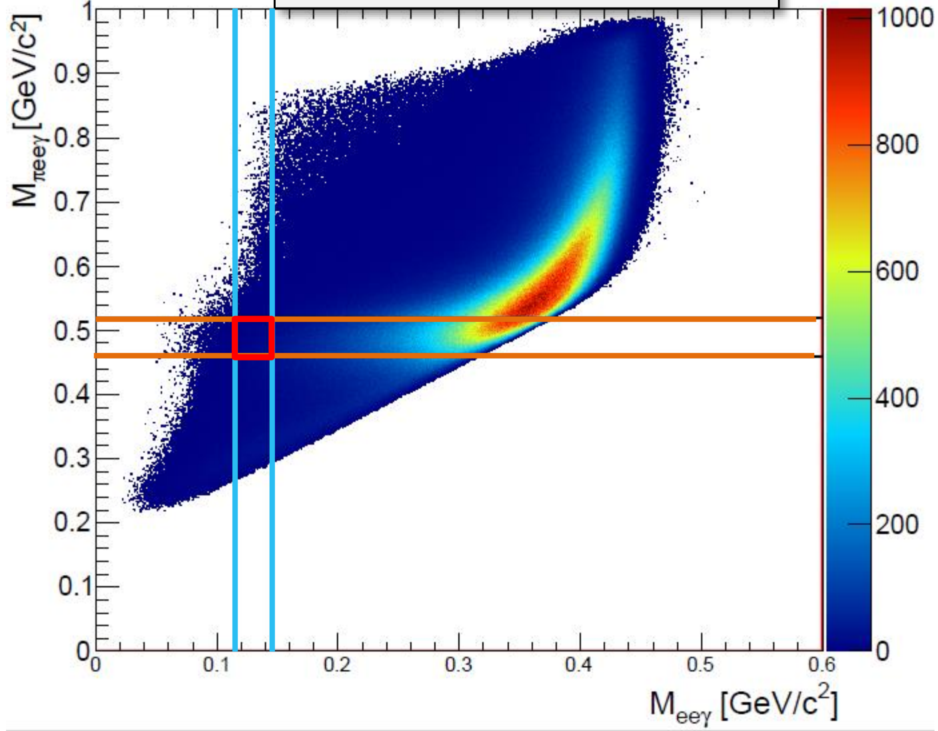
- Particle identification from reconstructed kinematics

$$115\ \mathrm{MeV}/c^2 < M_{ee\gamma} < 145\ \mathrm{MeV}/c^2$$
$$465\ \mathrm{MeV}/c^2 < M_{\pi^+\pi^0} < 510\ \mathrm{MeV}/c^2$$

Correct mass assignment



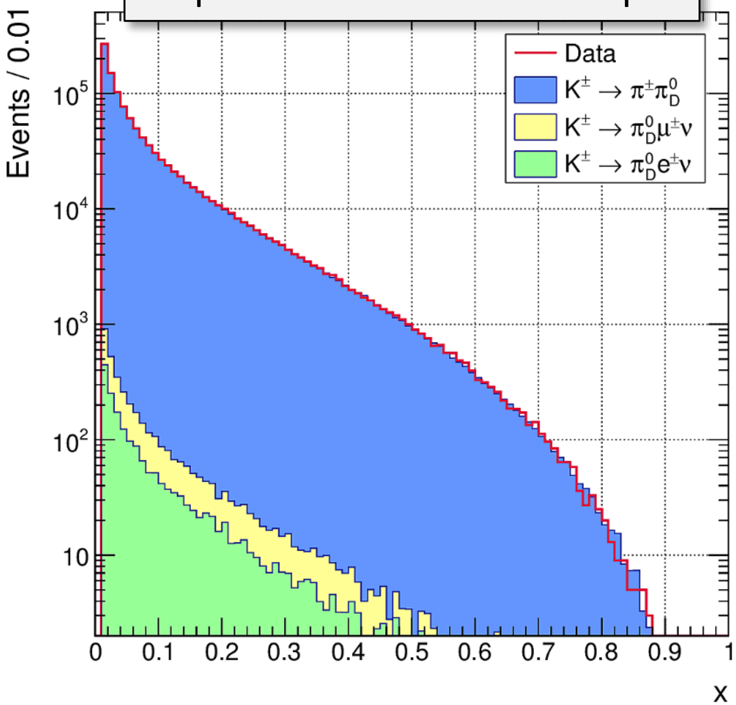
Incorrect mass assignment



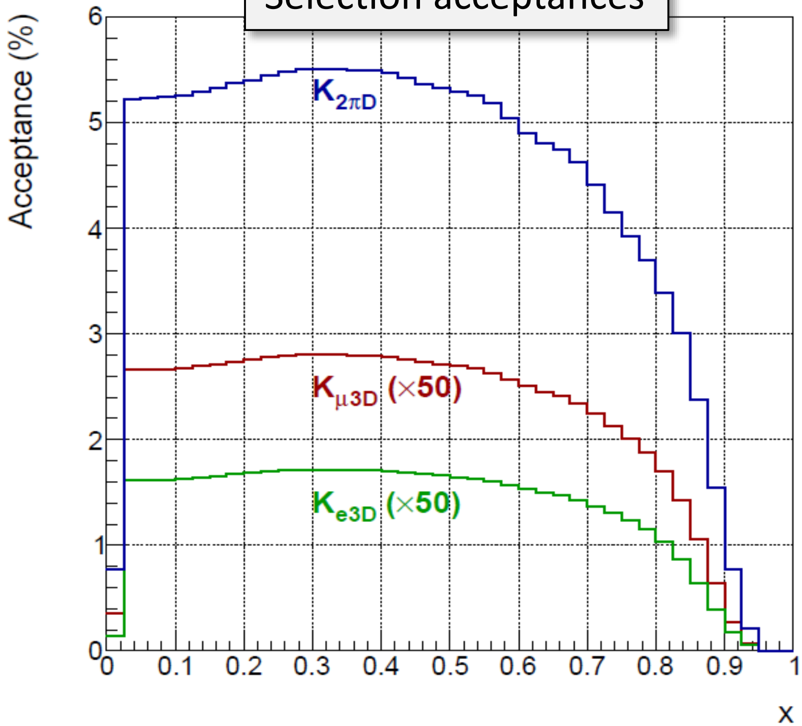
π^0 TFF: Selection

- Reconstructed Kaon compatible with beam properties and offline L2 and L3 trigger conditions
- Selected sample: 1.1×10^6 fully reconstructed π_D^0 events in the signal region $(x > 0.01)$

x spectrum of selected sample



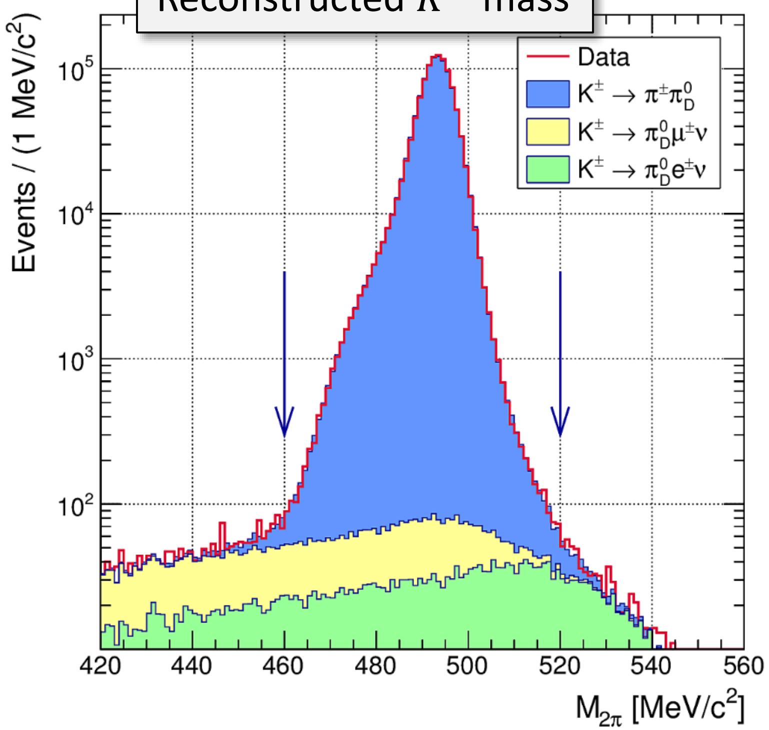
Selection acceptances



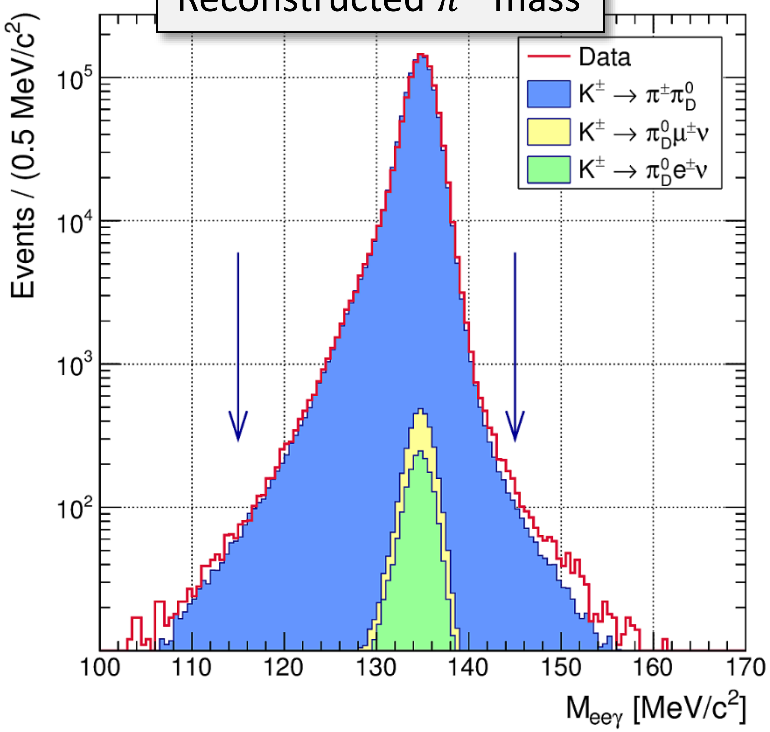
π^0 TFF: Selection

- ❑ Reconstructed Kaon compatible with beam properties and offline L2 and L3 trigger conditions
- ❑ Selected sample: 1.1×10^6 fully reconstructed π^0_D events in the signal region $(x > 0.01)$

Reconstructed K^+ mass



Reconstructed π^0 mass



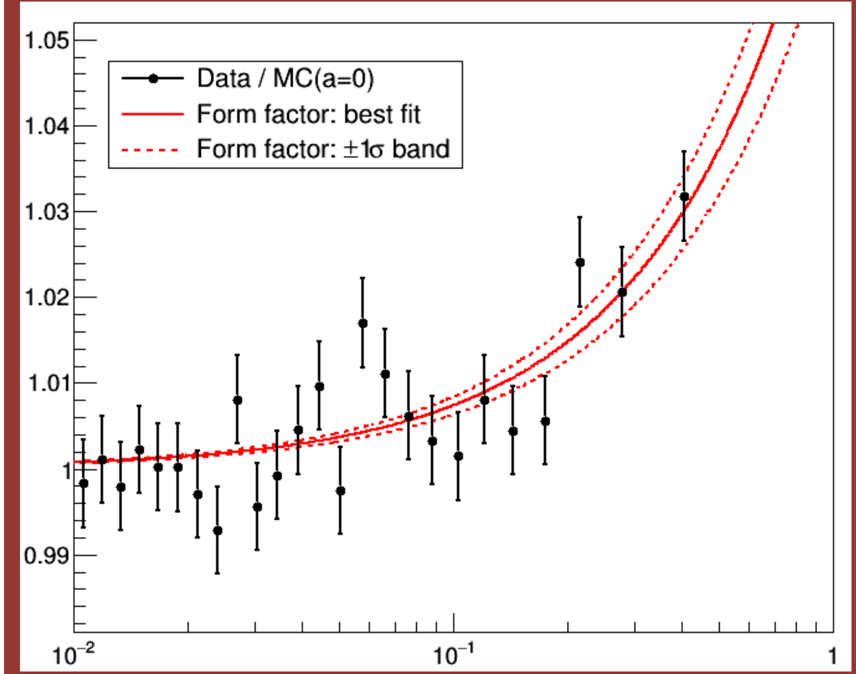
π^0 TFF: Result

- Build x Dalitz distribution for data and MC (equal population bins)
- For each TFF slope value hypothesis, reweight simulated events ($a_{sim} = 0.032$)

$$w(a) = \frac{(1+ax_{true})^2}{(1+a_{sim}x_{true})^2}$$

- Minimise $\chi^2(a)$ of Data/Simulation wrt. a

Fit result illustration
- Data/MC(a=0) ratio
- 25 equal population bins
- Points in bin barycentre



- $a = \left(3.68 \pm 0.51_{stat} \pm 0.25_{syst}\right) \times 10^{-2}$

  $= (3.68 \pm 0.57) \times 10^{-2}$

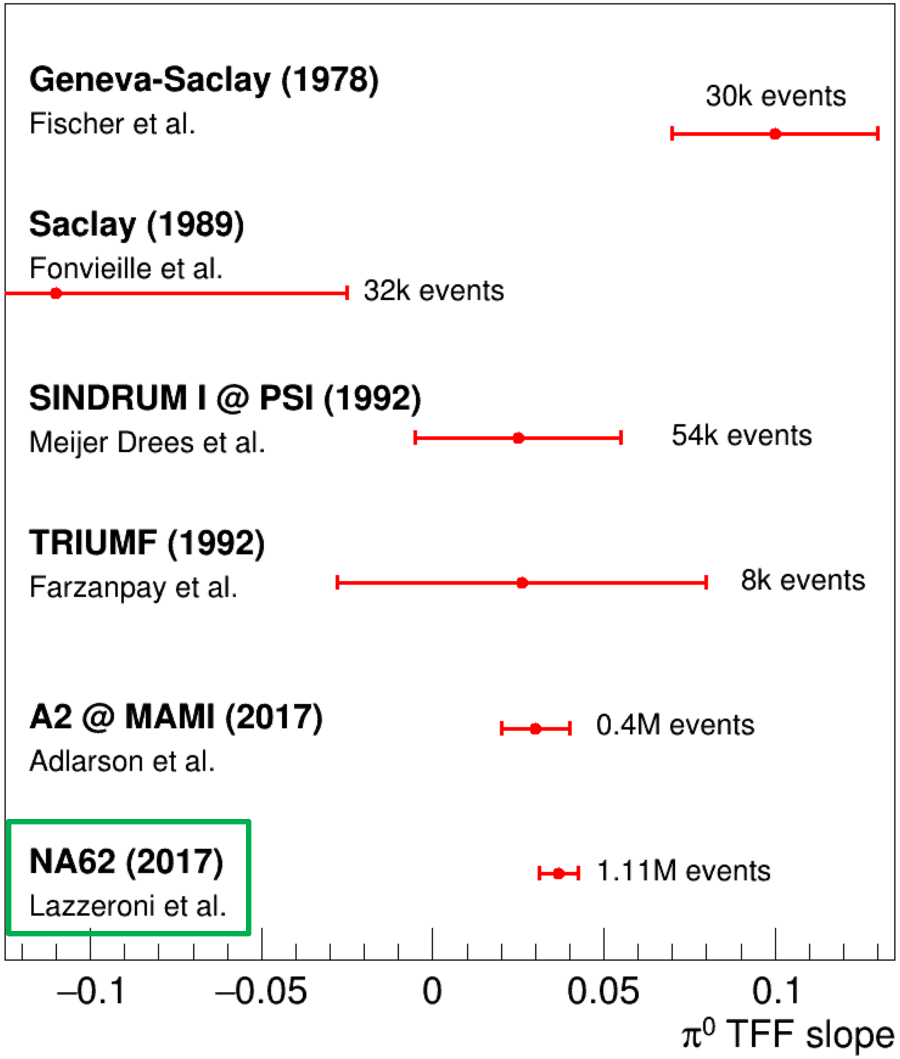
(χ^2/n.d.f: 54.8/49, p-value: 26.4%)

π^0 TFF: Result

- Systematic effects
  - Trigger efficiency
  - π^0 Dalitz decay generator
  - Detector calibration and resolution
  - Accidentals
  - Particle identification
  - Neglected π_D^0 sources
  - Beam momentum simulation

Uncertainties	
Source	$\delta a(\times 10^{-2})$
Statistical – Data	0.48
Statistical – MC	0.18
Spectrometer momentum scale	0.16
Accidental background	0.15
Particle mis-ID	0.06
Calorimeter trigger efficiency	0.06
Spectrometer resolution	0.05
LKr non-linearity and energy scale	0.04
Beam momentum spectrum simulation	0.03
Neglected π_D^0 sources in MC	0.01

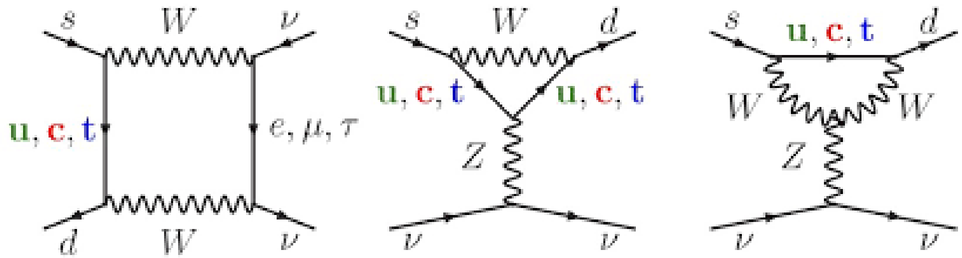
π^0 TFF: World Data



- ❑ Theory expectations (reminder)
  - ➢ Chiral perturbation theory: $a = (2.90 \pm 0.50) \times 10^{-2}$
  - ➢ Dispersion theory: $a = (3.07 \pm 0.06) \times 10^{-2}$
  - ➢ Two-hadron saturation model: $a = (2.92 \pm 0.04) \times 10^{-2}$
- ❑ CELLO measurement:
  - ➢ Extrapolation using VMD model: $a = (3.26 \pm 0.26_{stat}) \times 10^{-2}$
- ❑ NA62 measurement
  - ➢ Compatible with previous measurements
  - ➢ Compatible with theory ($\sim 1\sigma$ above VMD expectations)
  - ➢ 15% relative uncertainty (2x better than previous measurement)

Back to present days!

The $K^+ \to \pi^+ \nu\bar{\nu}$ decay



- Ultra rare FCNC decay
  - Highly CKM suppressed: $Br \sim |V_{ts}^{*} V_{td}|^2$
  - Theoretically very clean
    - Largely dominated by top quark contribution
    - Small contribution from the charm quark
    - Small long-distance corrections
    - Hadronic matric element from $Br(K^+ \to \pi^0 e^+ \nu)$

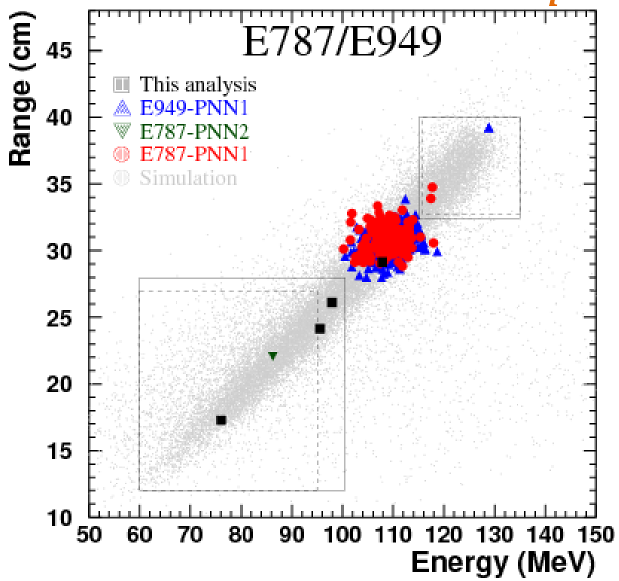
    Theoretically very clean
  - Largest uncertainties from CKM parameters
- Small SM contribution → New physics contribution can be of the same order

Status of $K^+ \to \pi^+ \nu \bar{\nu}$

- Theoretical status:
- $Br(K^+ \to \pi^+ \nu \bar{\nu})_{SM} = (9.11 \pm 0.72) \times 10^{-11}$

[A.J. Buras et al., JHEP 1511 (2015) 033]

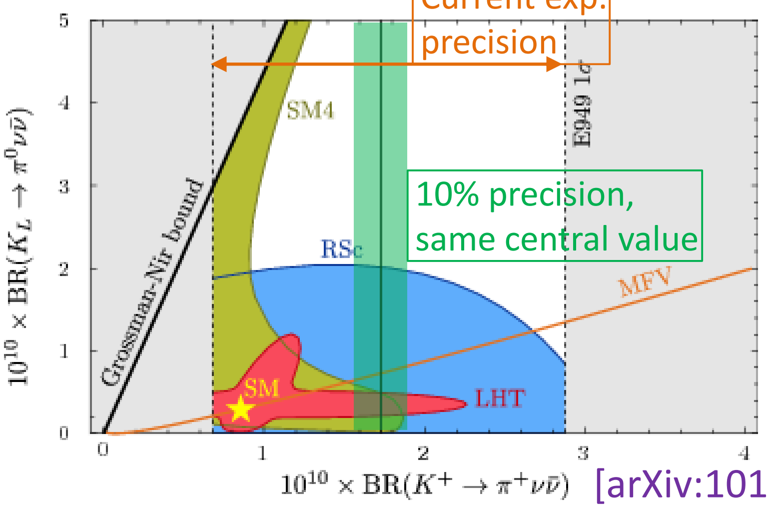
- Experimental status:
  - Seven signal candidates from E787/E949 experiment at BNL
  - Stopped kaon technique
- $Br(K^+ \to \pi^+ \nu \bar{\nu})_{exp} = \left(17.3^{+11.5}_{-10.5}\right) \times 10^{-11}$



[E787/E949, Phys.Rev.Lett.101, 191802, 2008]

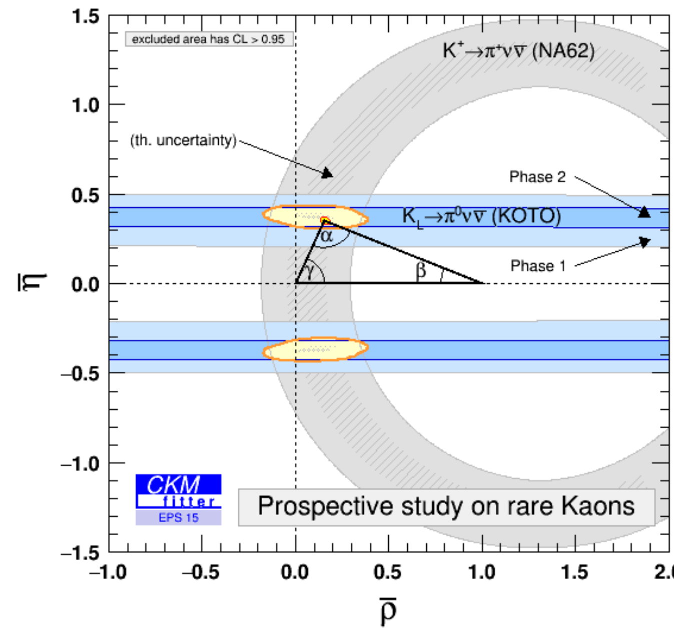
Impact of $K^+ \to \pi^+ \nu\bar{\nu}$

- Impose bounds on new physics models
  - Littlest Higgs with T-parity (LHT) [Acta Phys. Polonica B41(2010)657]
  - Best probe of MSSM non-MFV [JHEP 0608 (2006) 064]
  - Custodial Randall-Sundrum [JHEP 0903 (2009) 108]
  - Z' bosons [JHEP 1302 (2013) 116]



[arXiv:1012.3893 [hep-ph]]

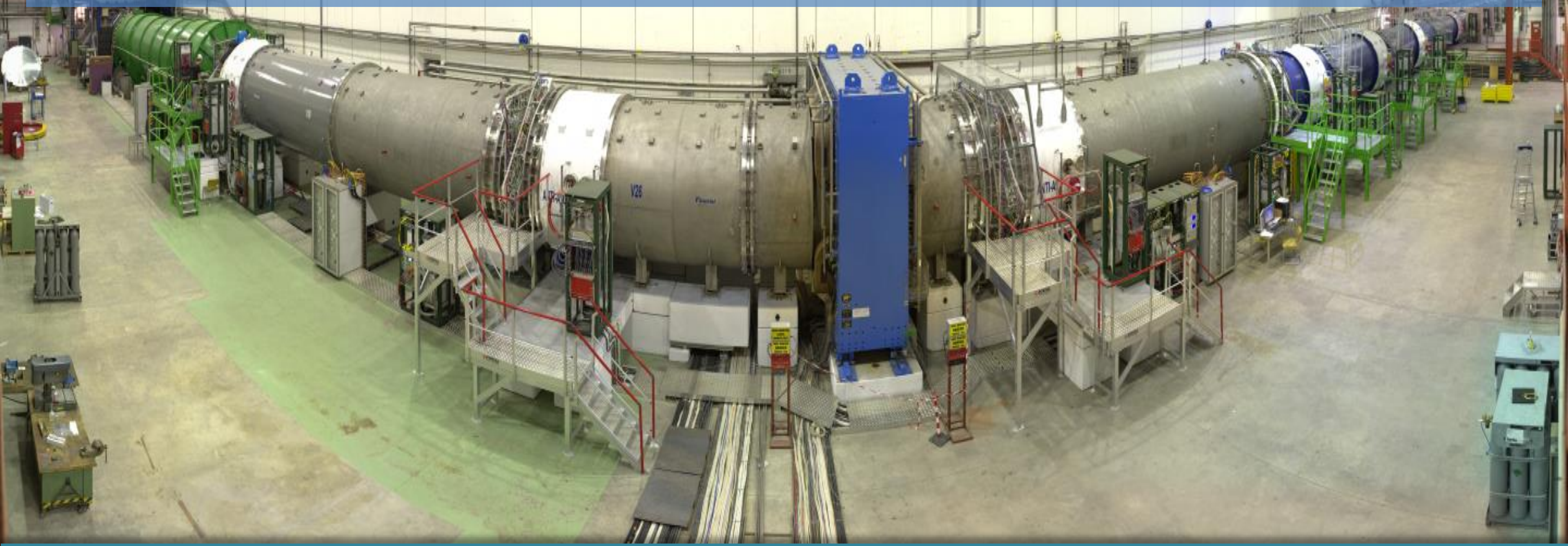
- Measurement of $|V_{td}|$ complementary to LHCb



- Searches complementary/alternative to LHC
- Accessible mass scales beyond those of LHC

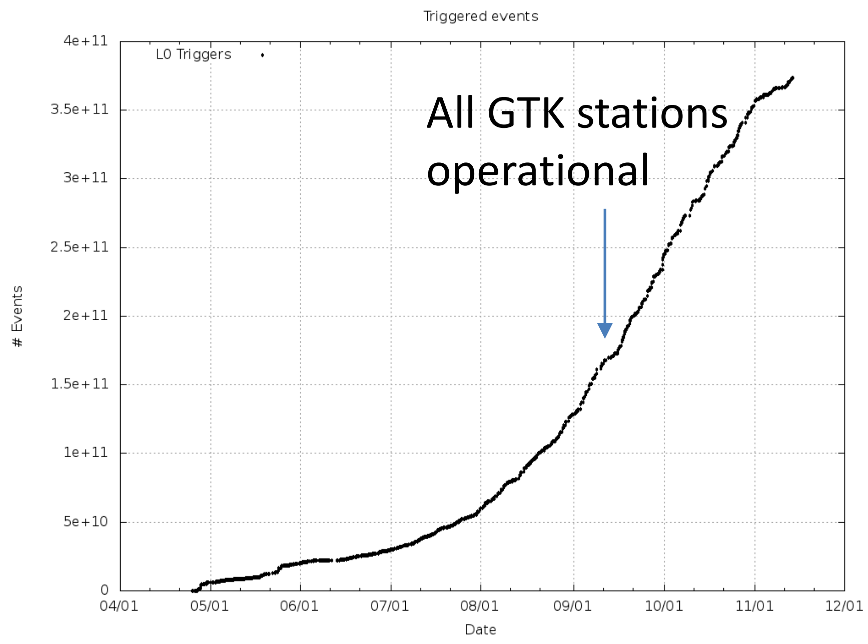
NA62: The current experiment

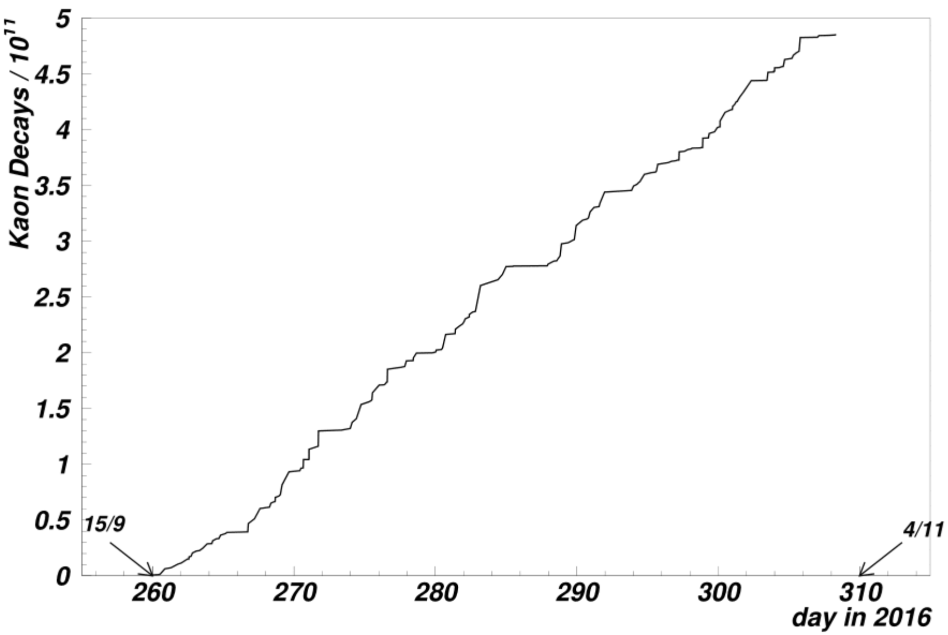
- Operation started in 2014
  - 2014 Pilot run
  - 2015 Commissioning run
    - Including a minimum bias run at $\sim 1\%$ intensity
  - 2016 Commissioning + Physics run
    - Data taken at $\sim 40\%$ of the nominal intensity



2016 run statistics

- Low level triggers acquired in 2016
  - 07/05 → 22/07: commissioning
  - 3/07 → 13/09: Final commissioning (L1 Trigger, GTK) + Physics (exotic, rare/forbidden decays)
  - 16/09 → 03/11: Physics ($\pi\nu\nu$, exotic, rare/forbidden decays)
- Data analysed and presented
  - On disk [$\pi\nu\nu$ period, 60m fiducial volume]
  - 13×10^{11} ppp on T10 [average, 40% nominal]
  - 10^3 Tbyte Data
  - $\sim$5% of 2016 data (2.3×10^{10} K^+ decays)





Main physics goal

- Measurement of $Br(K^+ \to \pi^+ \nu \bar{\nu})$
  - $\mathcal{O}(10\%)$ precision
  - $\mathcal{O}(10\%)$ signal acceptance

    $\Rightarrow$ Need 10^{13} K^+ decays in the fiducial volume
    $\Rightarrow$ Need intense beam

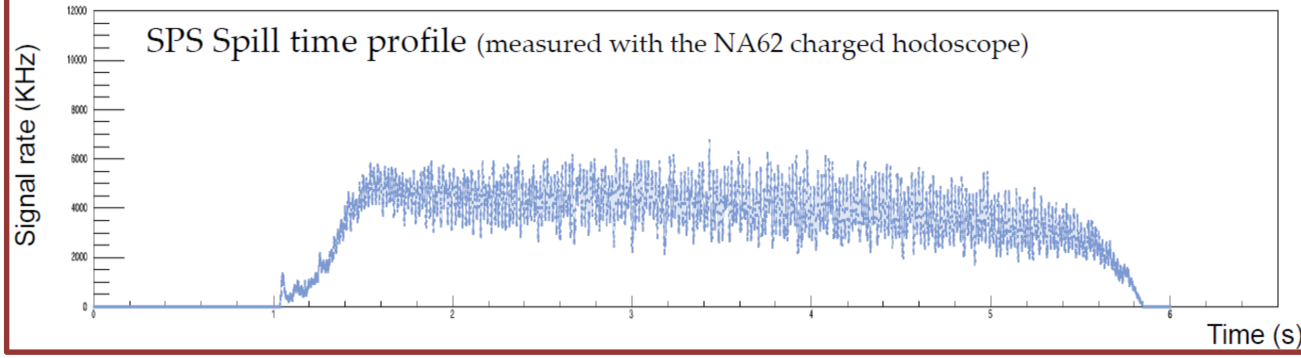
Momentum	$75\ \mathrm{GeV}/c^2$, 1% bite
Divergence (RMS)	$100\ \mu\mathrm{rad}$
Transverse size	$60 \times 30\ mm^2$
Composition	$K^+(6\%), \pi^+(70\%), p(24\%)$
Nominal rate	33×10^{11} ppp on T10 (750 MHz at GTK3). 10% decay in fiducial volume

  - $\mathcal{O}(5/1)$ Signal/Background

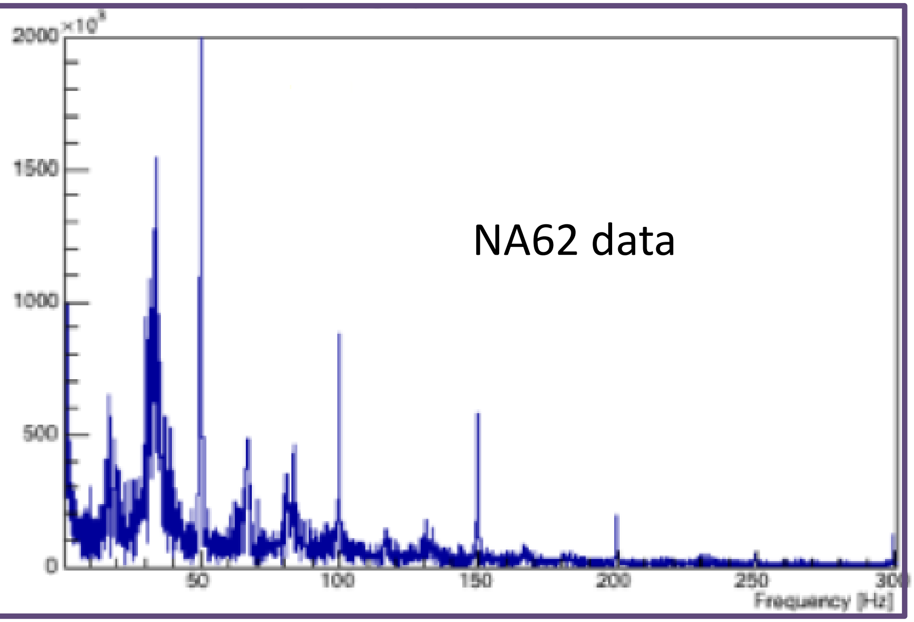
    $\Rightarrow$ Need $\mathcal{O}(10^{12})$ background rejection factor
    $\Rightarrow$ Need powerful discriminant and vetoes

Beam

- ❑ Maximum achievable intensity and DAQ capability depends on the spill quality



- ❑ Spill frequency spectrum is computed online
  - ➢ Bad spill
    - Strong 50 Hz component (and harmonics)



The NA62 Challenge

Decay backgrounds	
Decay mode	**BR**
$\mu^+\nu(\gamma)$	63.5%
$\pi^+\pi^0(\gamma)$	20.7%
$\pi^+\pi^+\pi^-$	5.6%
$\pi^0 e^+\nu$	5.1%
$\pi^0\mu^+\nu$	3.3%
$\pi^+\pi^0\pi^0$	1.8%
$\pi^+\pi^- e^+\nu$	4.1×10^{-5}

Other backgrounds

Beam-gas interactions

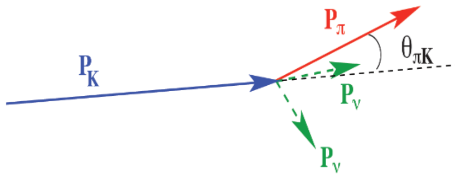
Upstream interactions

Time resolution

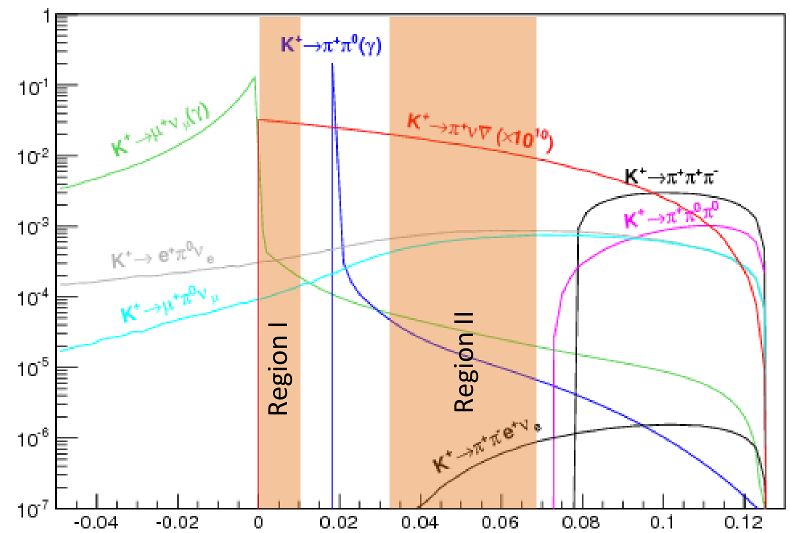
Matching of upstream-downstream activity (< 100 ps time resolution)

Kinematic rejection

- Kaon momentum (GigaTracker)
- π momentum (Straw)



$$m^2_{miss} \cong m^2_K\left(1-\frac{|P_\pi|}{|P_K|}\right)+m^2_\pi\left(1-\frac{|P_K|}{|P_\pi|}\right)-|P_K||P_\pi|\theta^2_{\pi K}$$



PID and high efficiency Veto systems ($< 10^{-5}$ inefficiency)

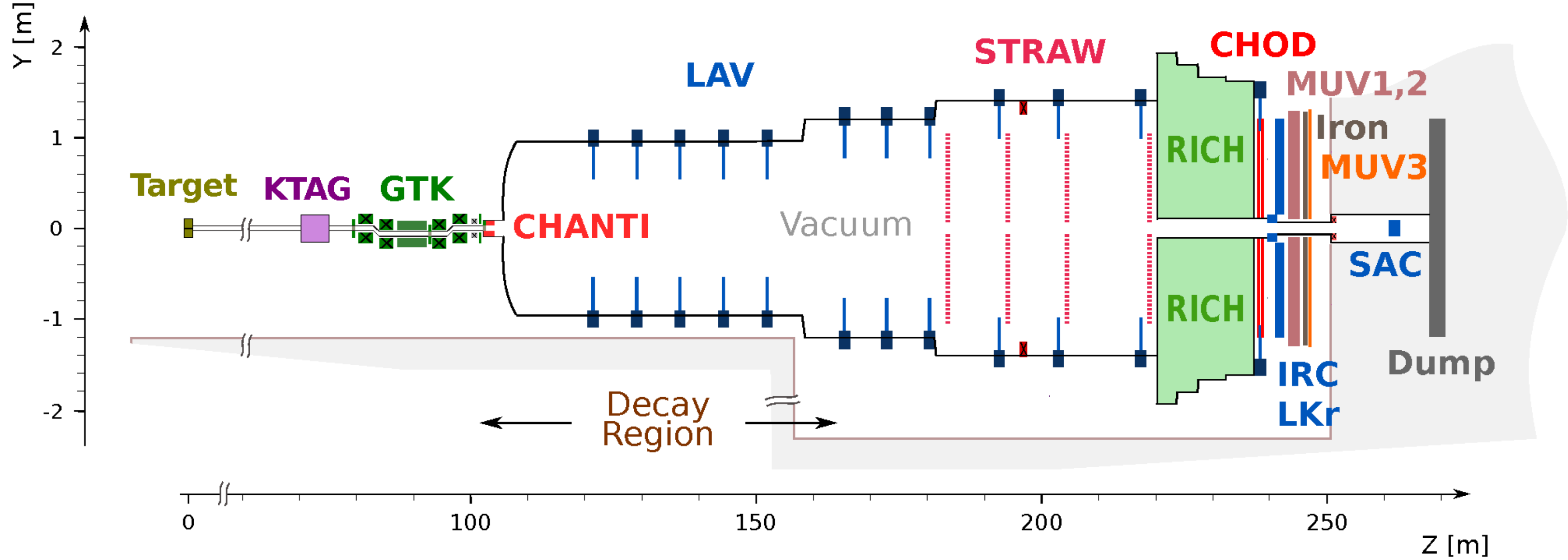
- Photons vetoes (LAV, LKr, IRC, SAC)
- Leptons vetoes (LKr, MUV)
- Accidentals vetoes (CHANTI)
- PID (KTAG, RICH)

The NA62 detector

- Momentum measurement (GTK, STRAW)
- Particle ID (KTAG, RICH)
- Photon vetoes (LAV, IRC, SAC, LKr)
- Muon vetoes (MUV1,2, MUV3)
- Accidentals vetoes (CHANTI)
- Trigger (CHOD)

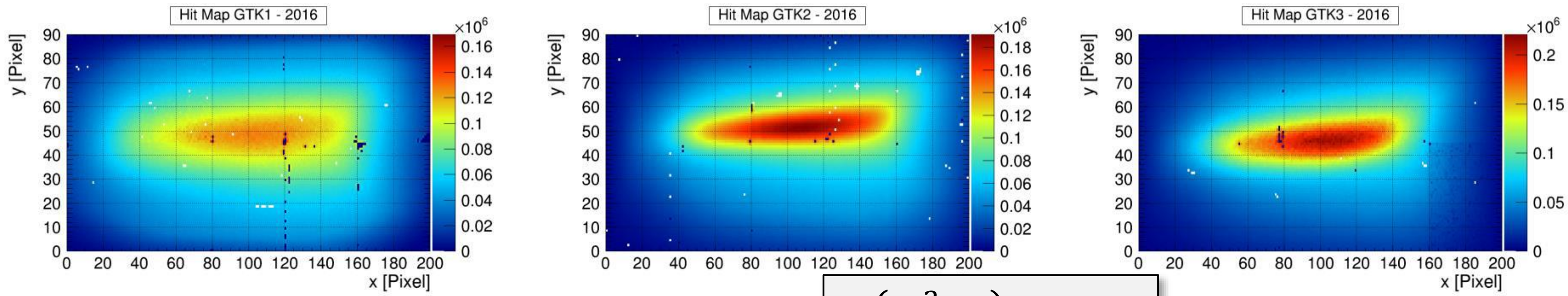
- Decay region
  - Fiducial region 60 m

[NA62 Detector Paper, arXiv:1703.08501]



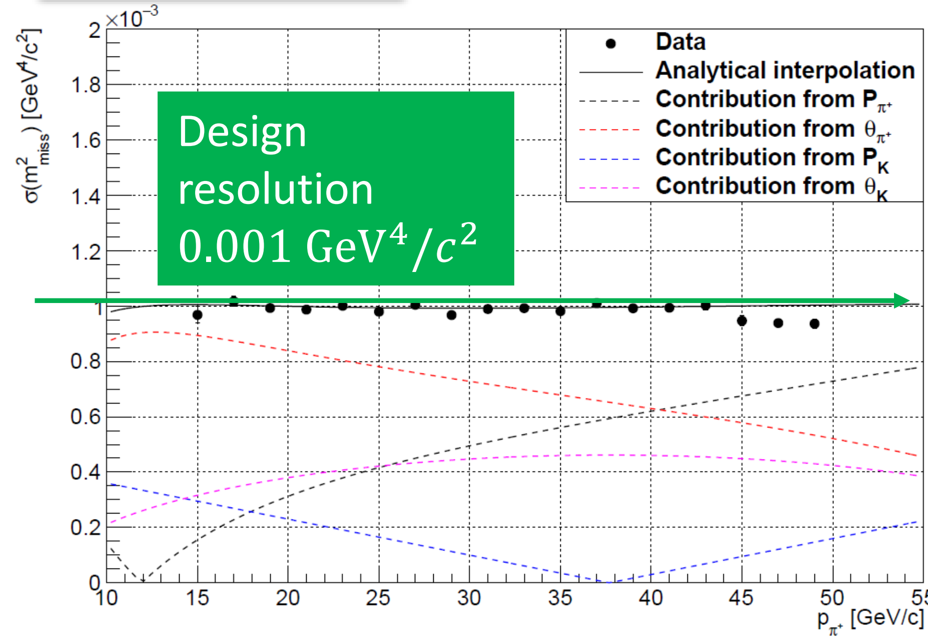
Gigatracker

- All stations fully operational since September



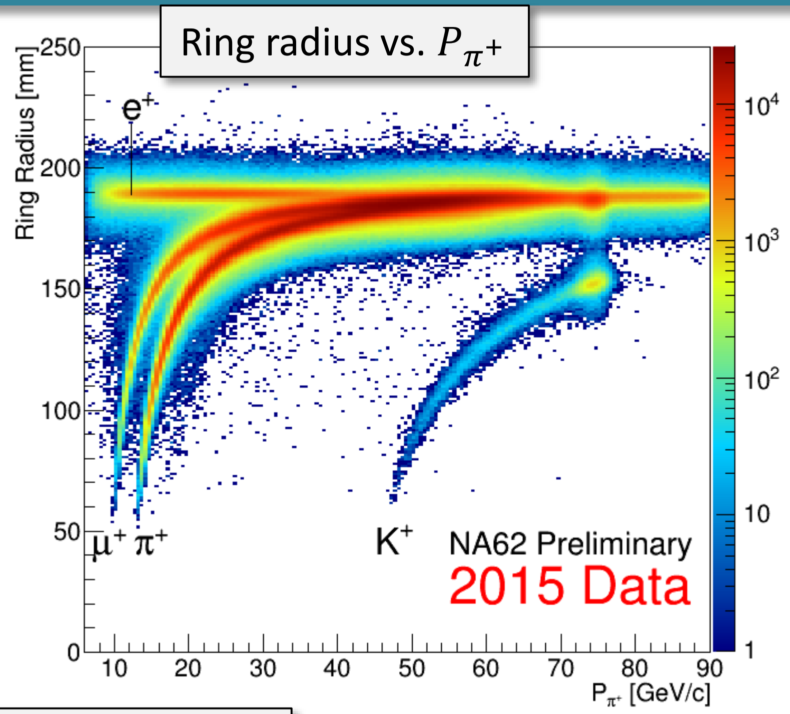
- Final m^2_{miss} resolution using GTK
  - $\frac{\sigma(p_{\pi^+})}{p_{\pi^+}} = 0.3\% \oplus 0.005\% \cdot p_{\pi^+}$
  - $\frac{\sigma(p_K)}{p_K} = 0.2\%$
  - $\sigma(\theta_{\pi^+}) = 20 \div 100\ \mu\text{rad}$
  - $\sigma(\theta_K) = 15\ \mu\text{rad}$

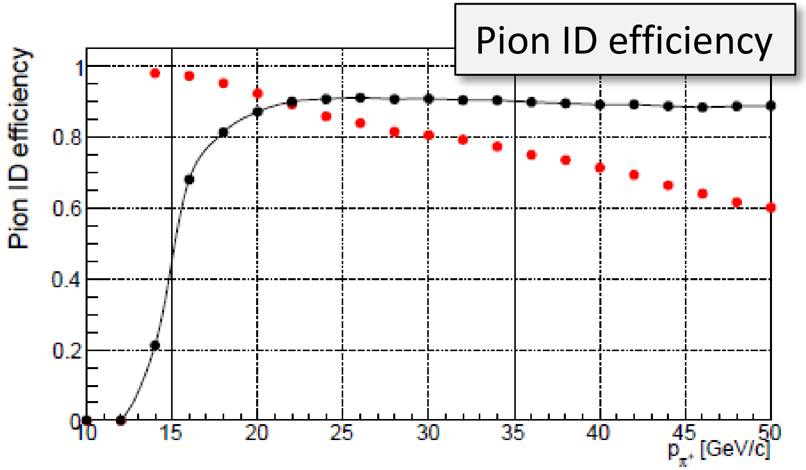
$\sigma(m^2_{miss})\ vs.\ P_{\pi^+}$

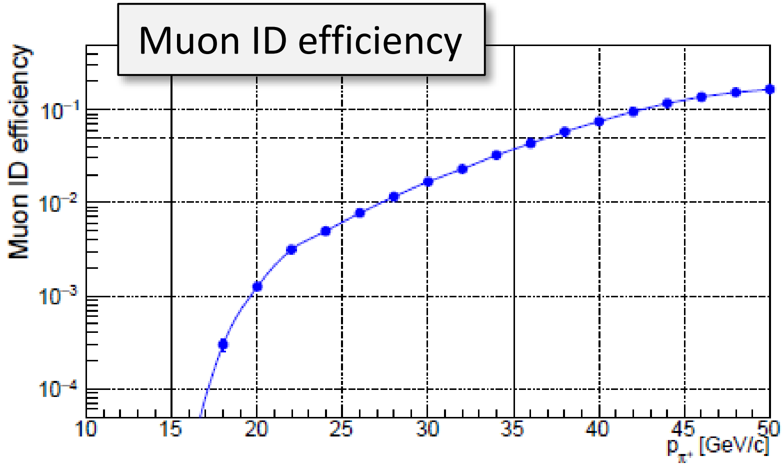


Downstream Particle Identification

- Particle identification using the RICH detector
  - Best separation for $15\ GeV/c^2 < p_{\pi^+} < 35\ \mathrm{GeV}/c^2$
- RICH ring-finding algorithm
  - Ring efficiency: $\varepsilon_{ring} \sim 90\%$
  - Maximum likelihood with π^+ hypothesis, using ring radius, p_π from Straw
  - $\varepsilon_\mu \sim 10^{-2}$ $\varepsilon_\pi \sim 80\%$



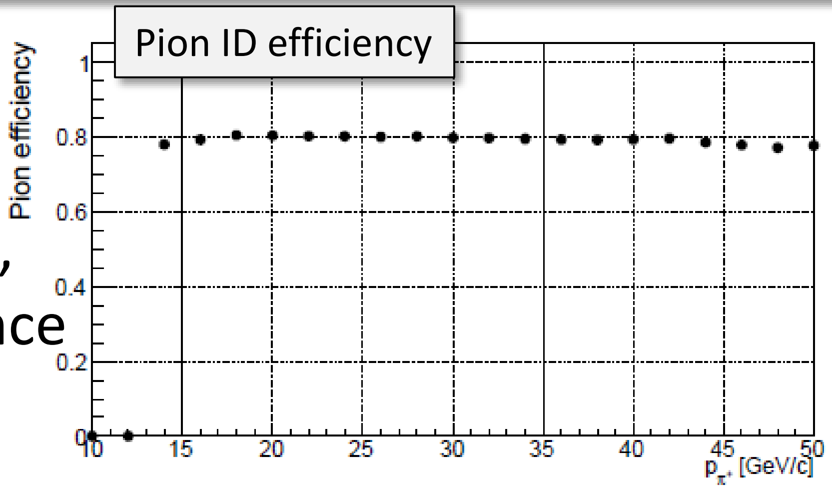


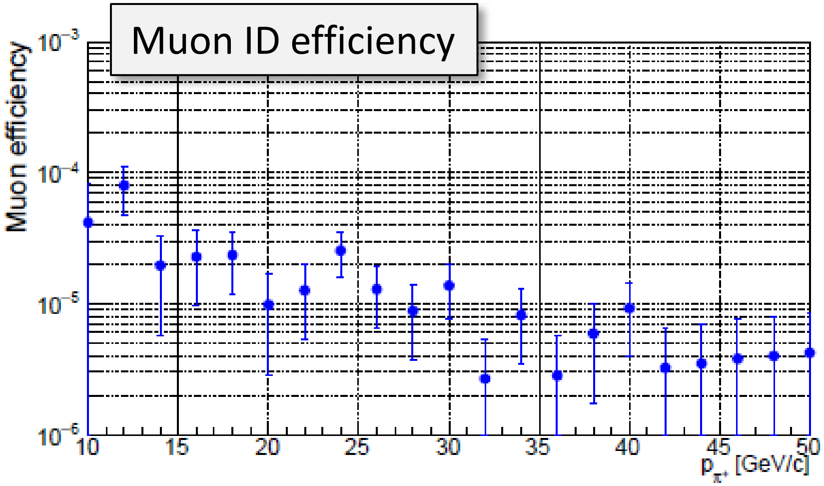


Downstream Particle Identification

- Particle identification using calorimeters (LKr, MUV1,2, MUV3)
  - BDT technique, using E, E sharing, cluster shape, track-cluster distance

$\varepsilon_\mu \sim 10^{-5}$ $\varepsilon_\pi \sim 80\%$





- Combined efficiency
  - Pion efficiency: 60%
  - Muon rejection: 10^{-7}

$K^+ \to \pi^+\nu\bar{\nu}$ analysis

- Expectations

Signal & background (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**

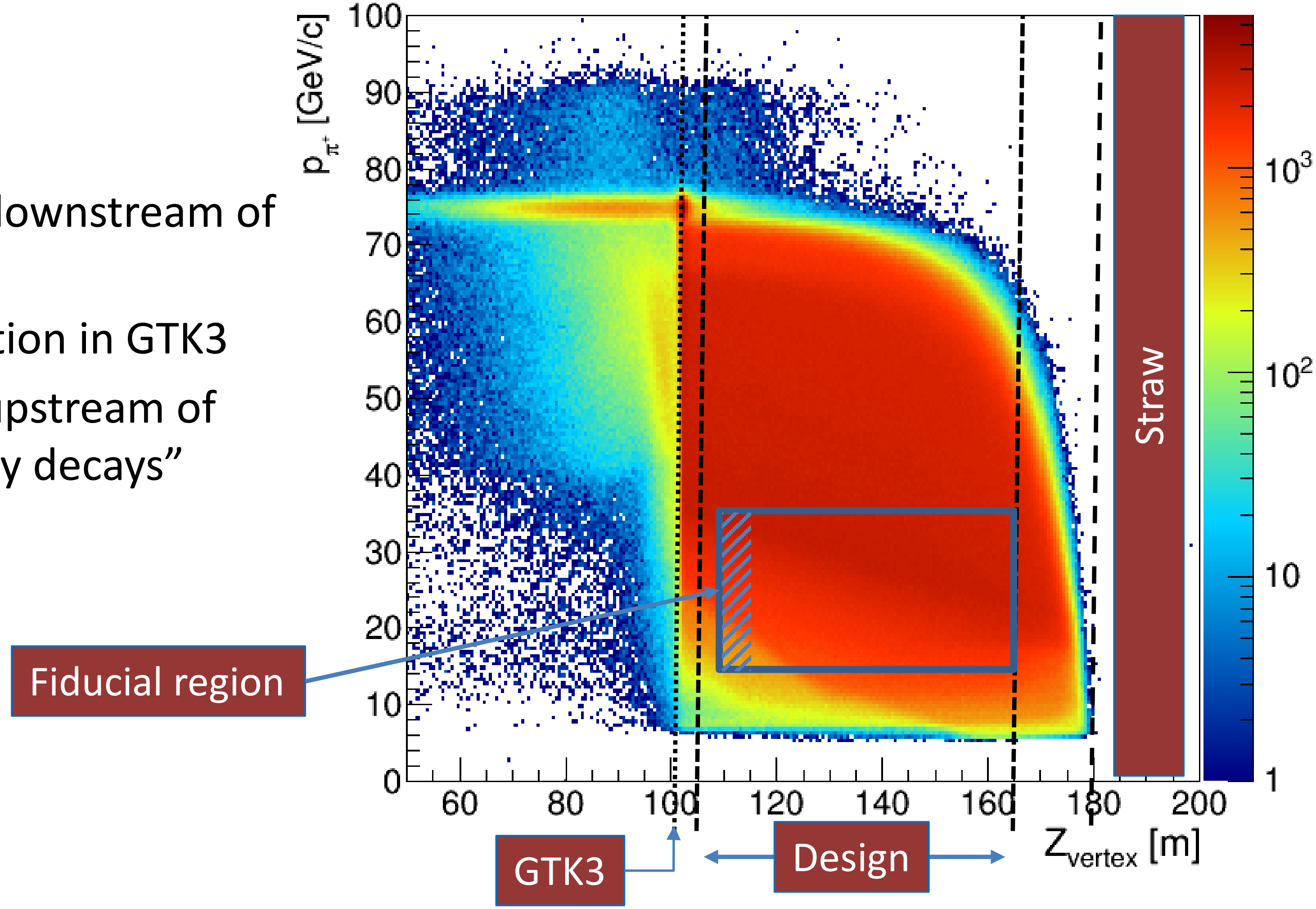
- In 2016, study single event sensitivity
- Start selection with "single track kaon decay"
  - Single track topology
  - Apply timing cuts to reject accidentals
  - KTAG signal
  - GTK track – Straw track matching
- Trigger
  - PNN: Kaon signal, Single track, no muon signal, no electromagnetic energy
  - Control: CHOD (at least one track, D=400)

Fiducial decay region

✓ "single track kaon decay"

p_{π^+} vs. z_{vtx} for single track kaon decays

- Decay origin
  - K^+ decay downstream of GTK3
  - K^+ interaction in GTK3
  - K^+ decay upstream of GTK3: "early decays"

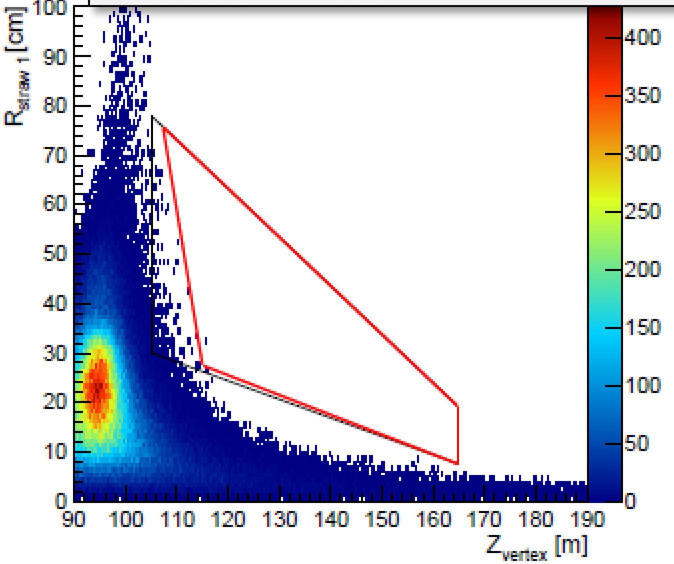


Fiducial decay region

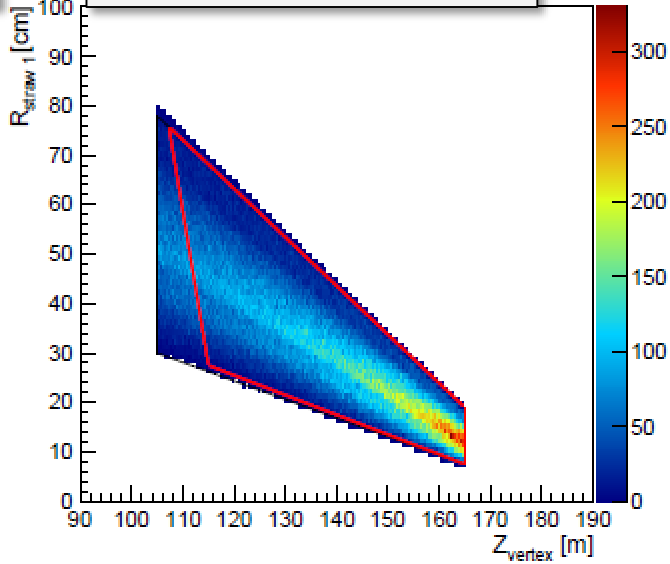
- Early decays are source of π^+ tracks in GTK
- Possible mismatching of the straw track (from genuine K^+ decay) with the π GTK track
  - Fake vertex: distributions are different for background and signal

$$110/115 < z_{vtx} < 165\ \mathrm{m}$$

R_{straw1} vs. z_{vtx} (π GTK track)



R_{straw1} vs. z_{vtx} (signal)



Signal region

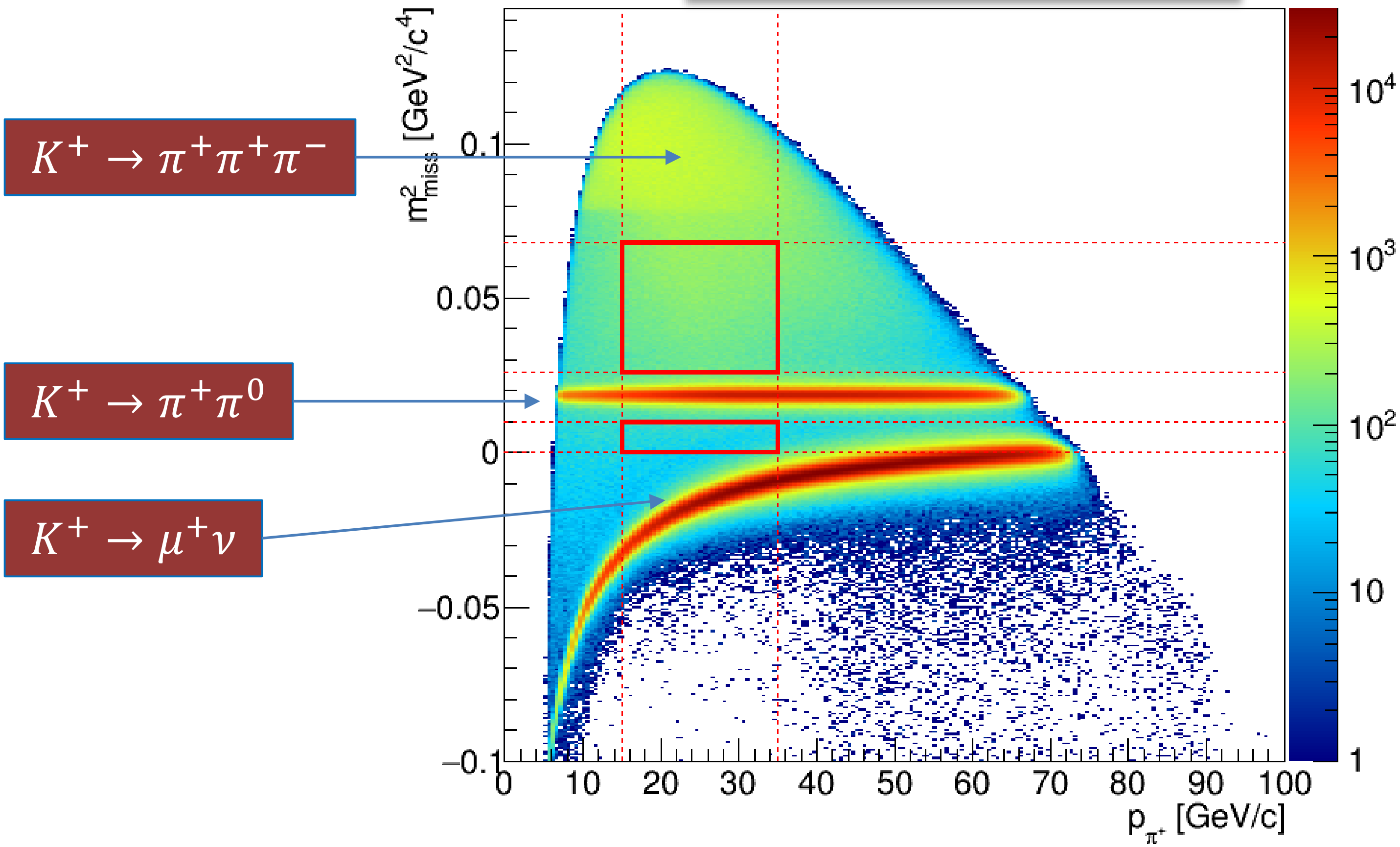
$15 < p_{\pi^+} < 35$ GeV/c

Region I: $0 < m^2_{miss} < 0.01 \text{ GeV}^4/c^2$

Region II: $0.026 < m^2_{miss} < 0.068 \text{ GeV}^4/c^2$

✓ "single track kaon decay"
✓ Fiducial region

m^2_{miss} vs. p_{π^+} (fiducial region)



Signal region

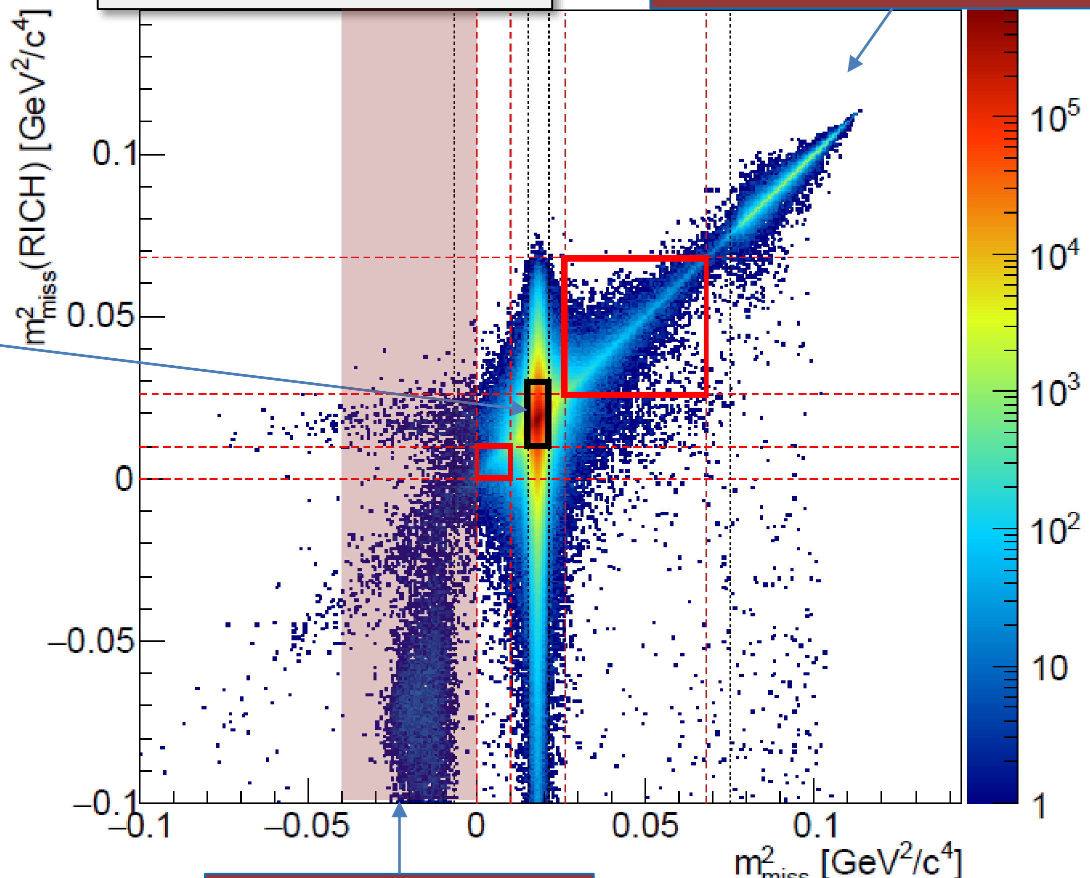
- $m^2_{miss}(\mathrm{RICH})$: pion track 3-momentum measured by RICH
- $m^2_{miss}(\mathrm{No-GTK})$: Assume nominal kaon track 3-momentum
- Apply particle ID
  - RICH
  - Calorimeters

$K^+ \to \pi^+\pi^0$ region

✓ "single track kaon decay"
✓ Fiducial region
✓ Particle ID

$m^2_{miss}(\mathrm{RICH})$ vs. m^2_{miss}

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

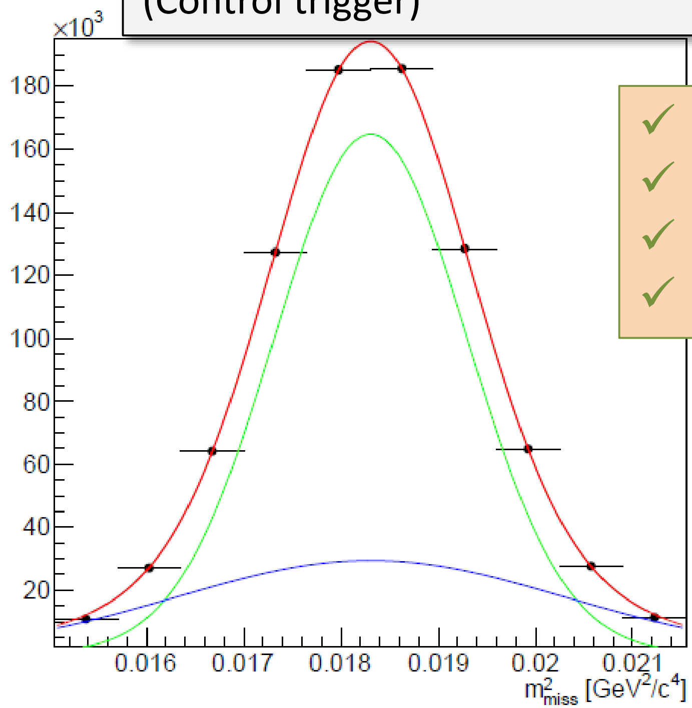


$K^+ \to \mu^+\nu$ region

- Apply photon veto condition (LKr, LAV, IRC, SAC)
- $\pi^+\pi^0$ suppression:

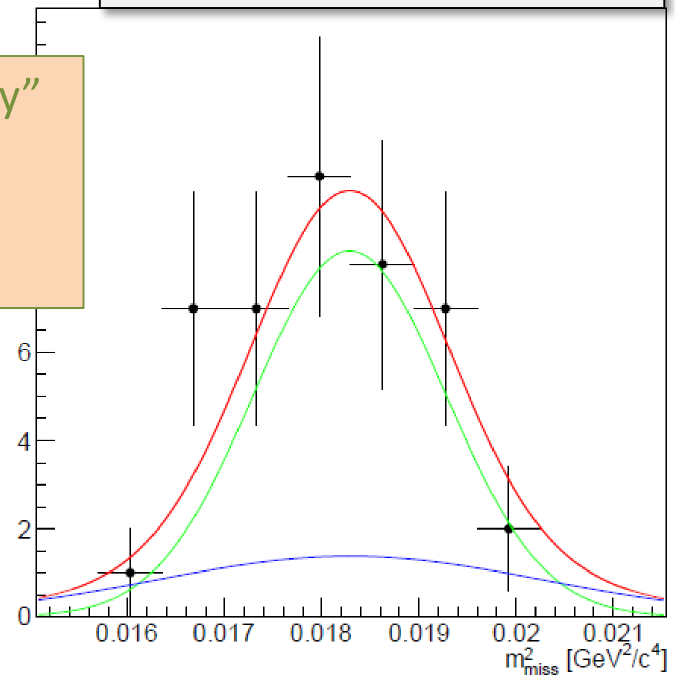
$$\varepsilon_{\pi^0} = \frac{N(\text{after } \gamma \text{ rej,PNN trigger})}{D \cdot N(\text{before } \gamma \text{ rej,min.bias})} = (1.2 \pm 0.2) \times 10^{-7}$$

$\pi^+\pi^0$ region, before γ rejection (Control trigger)



- ✓ "single track kaon decay"
- ✓ Fiducial region
- ✓ Particle ID
- ✓ Signal region

$\pi^+\pi^0$ region, after γ rejection (PNN trigger)



$K^+ \to \pi^+ \nu\bar{\nu}$ result

- $N^{exp}_{\pi\nu\nu} = D^{control} \cdot N^{control}_{\pi\pi} \cdot \frac{Br_{\pi\nu\nu}}{Br_{\pi\pi}} \cdot \frac{A_{\pi\nu\nu}}{A_{\pi\pi}} \cdot \varepsilon^{trigg} = 0.064$

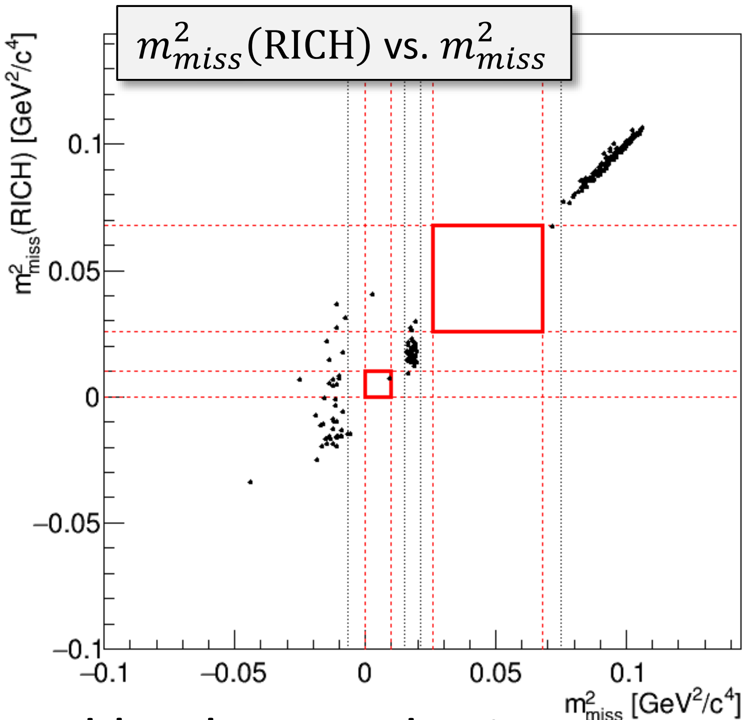
Normalisation: $K^+ \to \pi^+\pi^0$ control trigger data passing signal selection but the photon rejection

$\sim 0.6/0.86$ from MC

$\sim 85\%$ (preliminary) measured with data

- Event in the box has $m^2_{miss}(No - GTK)$ outside the signal region

Background level	
$K^+ \to \pi^+\pi^0$	0.024
$K^+ \to \mu^+\nu$	0.011
$K^+ \to \pi^+\pi^+\pi^-$	0.017
Total background	**0.052**
Estimated S/B	**80%**



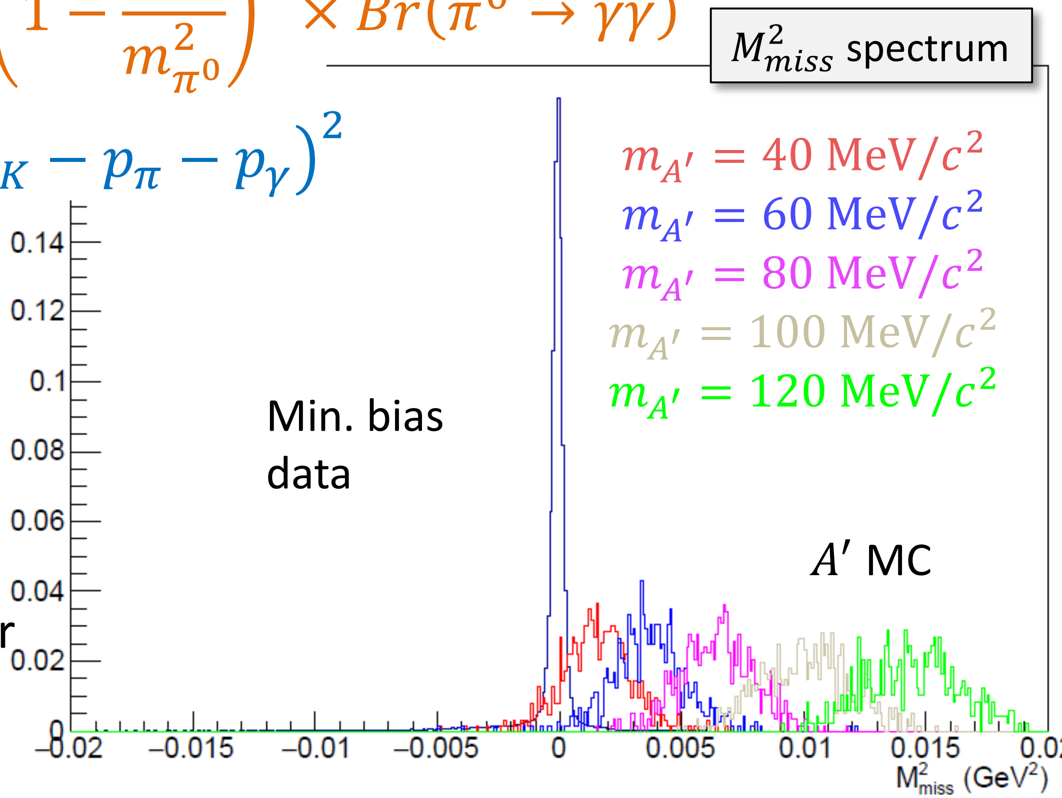
- More improvements in signal efficiency and background rejection expected in the future

Exotic searches: Dark photon

- Multiple opportunities for exotic searches in the current conditions
- Search for dark photon
  - Search the decay chain $K^+ \to \pi^+\pi^0, \pi^0 \to A'\gamma, A' \to \text{invisible}$

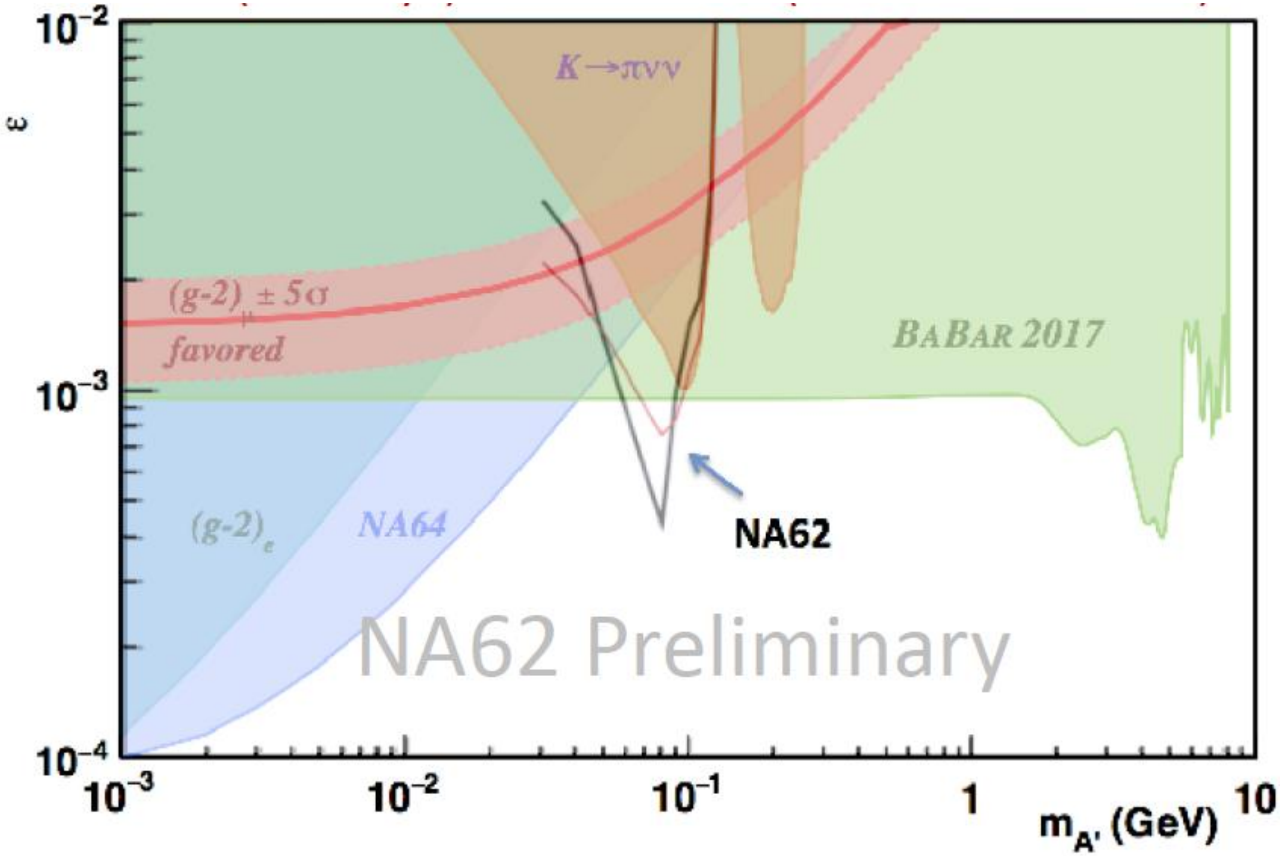
$$Br(\pi^0 \to A'\gamma) = 2\epsilon^2 \left(1 - \frac{m_A^2}{m_{\pi^0}^2}\right)^3 \times Br(\pi^0 \to \gamma\gamma)$$

  - Peak search in $M_{miss}^2 = (p_K - p_\pi - p_\gamma)^2$
- Analysis:
  - PNN trigger
  - Selection:
    - Same π^+ as in $\pi^+\nu\bar{\nu}$
    - 1γ in LKr
    - Missing momentum in LKr
    - Veto for extra γ



Dark photon

- Black line: na62 search result (3% of 2016 data)
- Red line: assume equal counts for data and background
- $K \rightarrow \pi\nu\nu$: model dependent limit from E787/E949

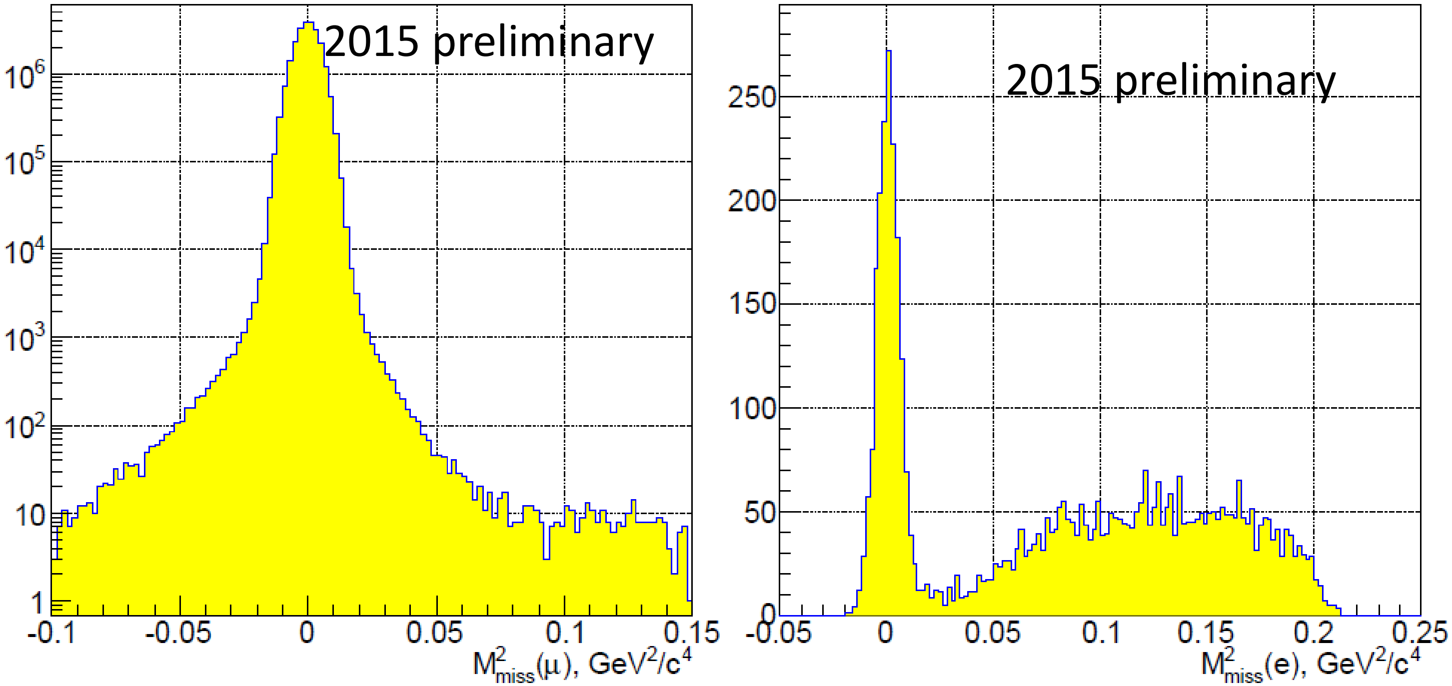


Heavy Neutral Lepton

- Peak search in M^2_{miss} spectrum of $K^+ \to \ell^+\nu_\ell$ $(\ell = \mu, e)$ decays
- Using 2015 minimum bias sample:

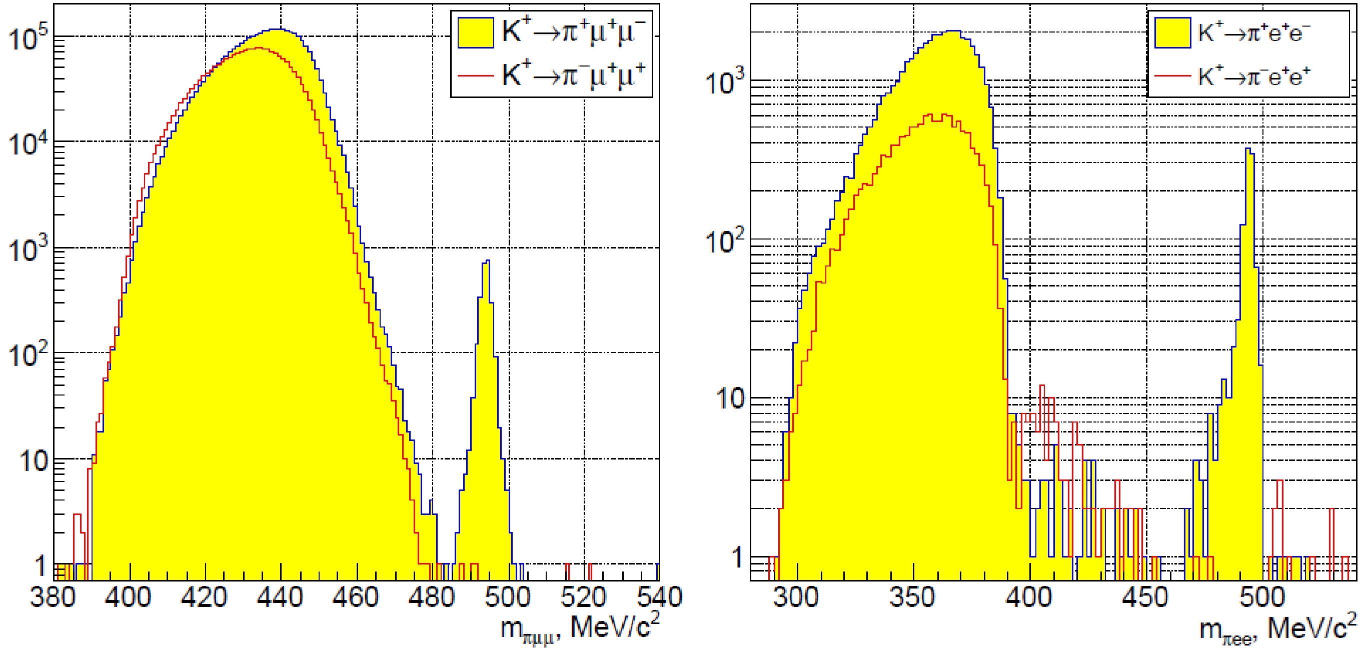
$$23\text{M } K^+ \to \mu^+\nu_\mu; 1500\ K^+ \to e^+\nu_e$$

- Background 100x lower than NA62 2007
- Can set worlds most stringent limits on heavy neutrino production



Rare/Forbidden decays

- Measurement of rare decays $K^+ \to \pi^+\ell^+\ell^-$ $(\ell = \mu, e)$
- Search for LFV/LNV modes $K^+ \to \pi^-\ell^+\ell^+, K^+ \to \pi^+\mu^\pm e^\mp$
- Use Multi-track trigger
- 2016A dataset event yield comparable to NA48/2, but much lower background level $(\sim 2k\ K^+ \to \pi^+\mu^+\mu^-, \sim 1k\ K^+ \to \pi^+e^+e^-)$



Other exotic searches

- 2 runs (17h total) dedicated to ALP searches
  - Beam dump mode (remove target, close collimators)
  - ALP couples to 2γ and produced in the upstream collimator
- Long-lived exotic particles
  - 10^{18} protons on target/year: $\pi/\eta/\eta'/\Phi/\ \rho/\omega$ and charmed mesons produced
  - Can decay into long-lived exotic particles, decaying inside the NA62 decay volume


RETURN
TO THE FUTURE
VERY NEAR

Plan for 2017

- Stable data taking for
  - $K^+ \rightarrow \pi^+ \nu\bar{\nu}$
  - More exotics, rare and forbidden decays
- Run at 40% to 60% of nominal intensity (depending on beam quality)
- Expect 14-15 SM $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ events in 2017

Summary

- New result from NA62 2007: π^0 transition form factor slope from π^0 Dalitz decay:

$$a = \left(3.68 \pm 0.51_{stat} \pm 0.25_{syst}\right) \times 10^{-2}$$

- NA62 detector, beam line and trigger fully commissioned
  - GTK is fully operational, performances are nominal
  - Veto capabilities at the level of 10^{-7}
- $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ analysis on-going
  - 5% of 2016 data analysed
  - Signal efficiency lower and background larger than expected
  - Improvements are expected
- Exotic searches being performed with 2015 and 2016 data
  - Already some worlds best limits in some channels

First results expected this year, many more in the coming years