New result on $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ from NA62

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CERN EP seminar
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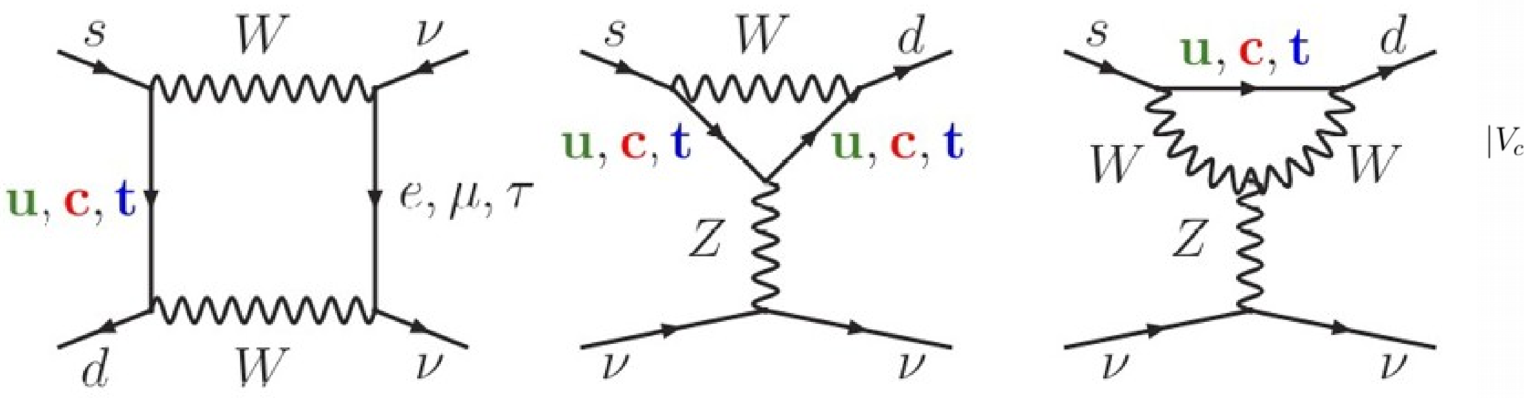
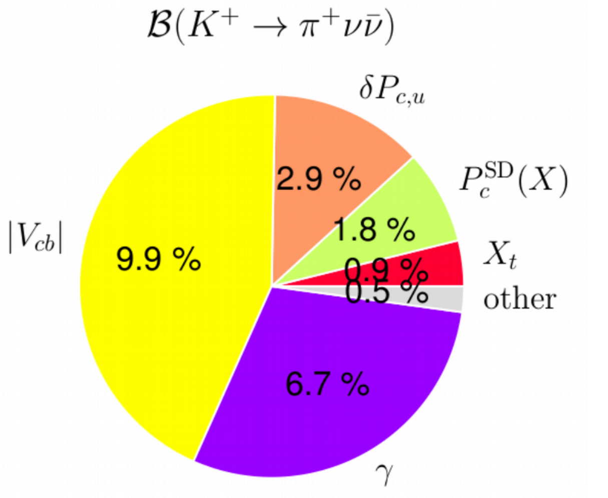
Outline

- $K^+ \longrightarrow \pi^+\nu\nu$ decays in the SM
- NA62 experiment
- $K^+ \longrightarrow \pi^+\nu\nu$ @ NA62 (2017 data)
- Summary and prospects

The FCNC process K→πνν





Parametric uncertainty dominates

[Buras. et. al., JHEP11(2015)033]

- FCNC loop processes: s ⟶ d coupling and highest CKM suppression
- Theoretically clean: Short distance contribution
- Hadronic matrix element measured with K_{l3} decays
- SM predictions: Buras. et. al., JHEP11(2015)033

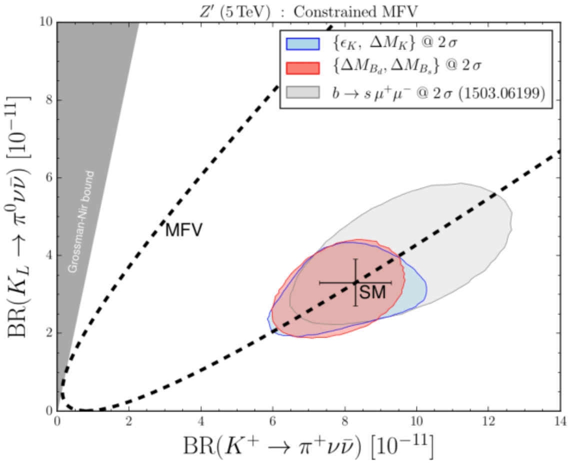
$$BR(K^+ \to \pi^+ \nu\bar{\nu}) = (0.84 \pm 0.03) \times 10^{-10} \left(\frac{|V_{cb}|}{0.0407}\right)^{2.8} \left(\frac{\gamma}{73.2^\circ}\right)^{0.74} = (0.84 \pm 0.10) \times 10^{-10}$$

$$BR(K_L \to \pi^0 \nu\bar{\nu}) = (0.34 \pm 0.05) \times 10^{-10} \left(\frac{|V_{ub}|}{0.00388}\right)^{2} \left(\frac{|V_{cb}|}{0.0407}\right)^{2} \left(\frac{\sin\gamma}{\sin 73.2^\circ}\right)^{2} = (0.34 \pm 0.06) \times 10^{-10}$$

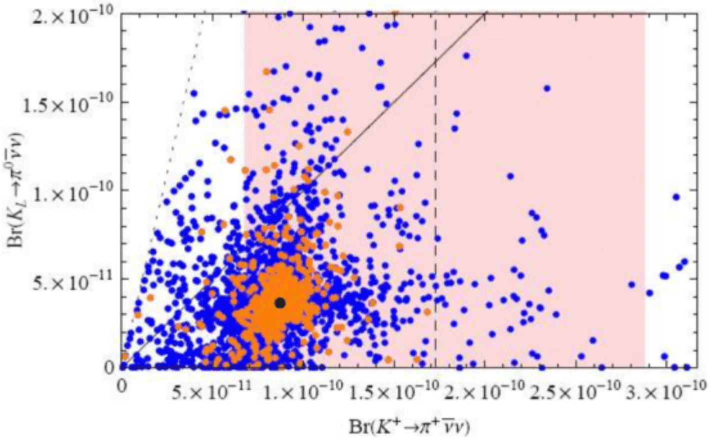
K→πνν beyond the Standard Model

- Custodial Randall-Sundrum [Blanke, Buras, Duling, Gemmler, Gori, JHEP 0903 (2009) 108]
- MSSM analyses [Tanimoto, Yamamoto, PTEP 2016 (2016) no.12, 123B02], [Blazek, Matak, Int.J.Mod.Phys. A29 (2014) no.27], [Isidori et al. JHEP 0608 (2006) 064]
- Simplified Z, Z' models [Buras, Buttazzo,Knegjens, JHEP11(2015)166]
- Littlest Higgs with T-parity [Blanke, Buras, Recksiegel, Eur.Phys.J. C76 (2016) 182]
- LFU violation models [Isidori et al., Eur. Phys. J. C (2017) 77: 618]
- Leptoquarks [S. Fajfer, N. Košnik, L. Vale Silva, arXiv:1802.00786v1 (2018)]
- Constraints from existing measurements (correlations model dependent)

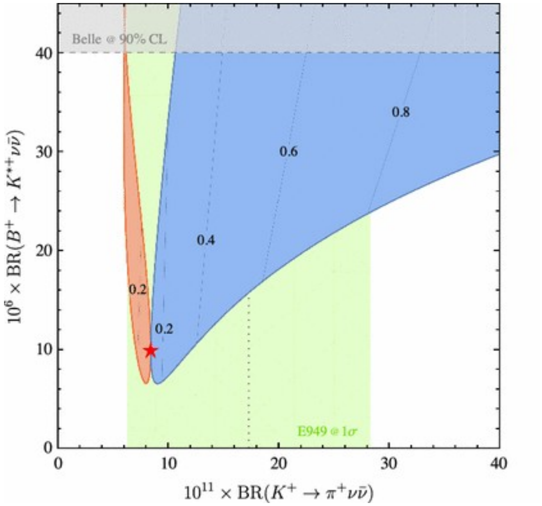
Z'(5 TeV) in Constrained MFV



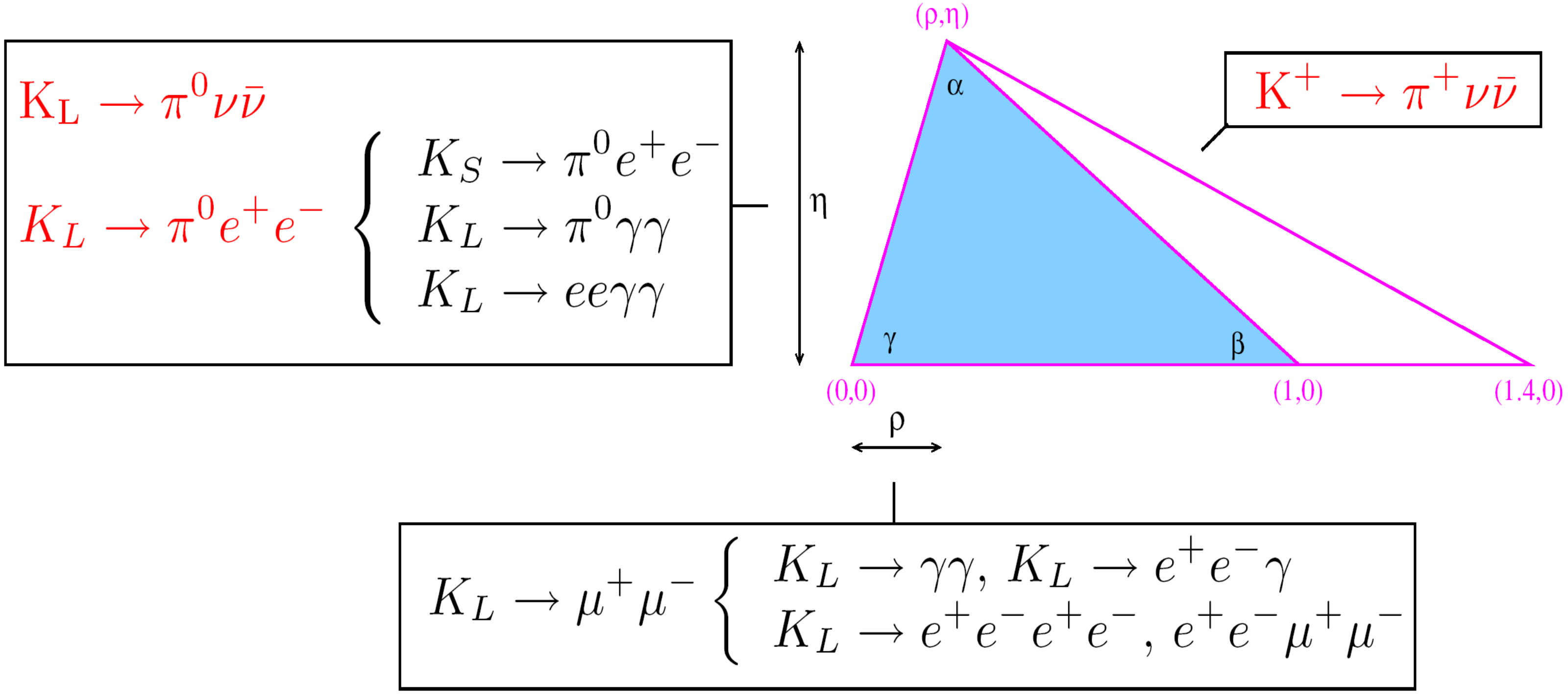
Randall Sundrum



LFU violation



Kaons and the CKM unitarity triangle



$\mathrm{K_L} \rightarrow \pi^0 \nu \bar{\nu}$

$$K_L \rightarrow \pi^0 e^+ e^- \left\{ \begin{array}{l} K_S \rightarrow \pi^0 e^+ e^- \\ K_L \rightarrow \pi^0 \gamma\gamma \\ K_L \rightarrow ee\gamma\gamma \end{array} \right.$$

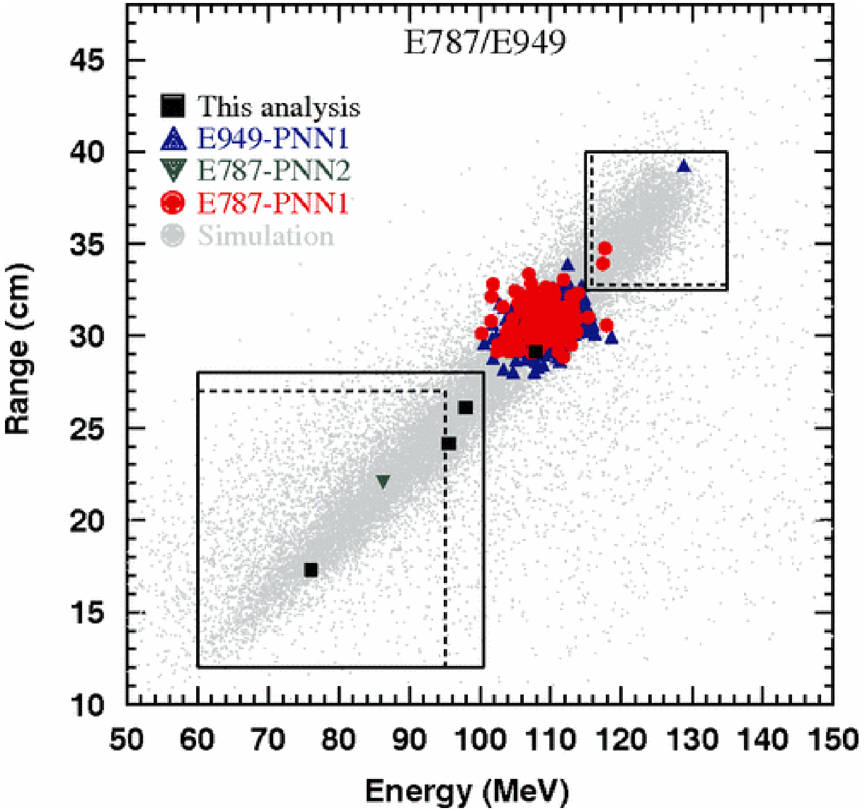
$\mathrm{K}^+ \rightarrow \pi^+ \nu \bar{\nu}$

$$K_L \rightarrow \mu^+ \mu^- \left\{ \begin{array}{l} K_L \rightarrow \gamma\gamma,\ K_L \rightarrow e^+ e^- \gamma \\ K_L \rightarrow e^+ e^- e^+ e^-,\ e^+ e^- \mu^+ \mu^- \end{array} \right.$$

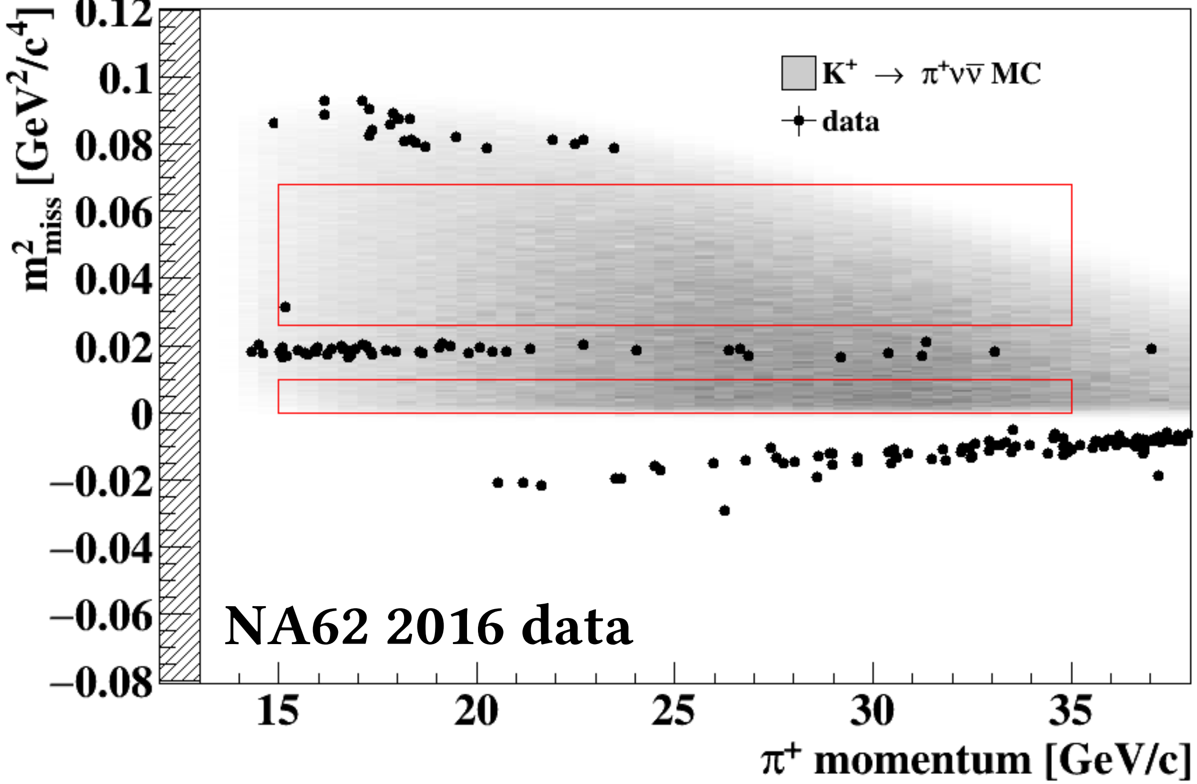
- The CKM unitarity triangle can be constrained by kaon physics alone
- Comparison with B physics can provide description of NP flavour dynamics

State of the art $K^+ \to \pi^+ \nu\nu$ experiments

K^+ decay-at-rest technique E787/E949



K^+ decay-in-flight technique NA62



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

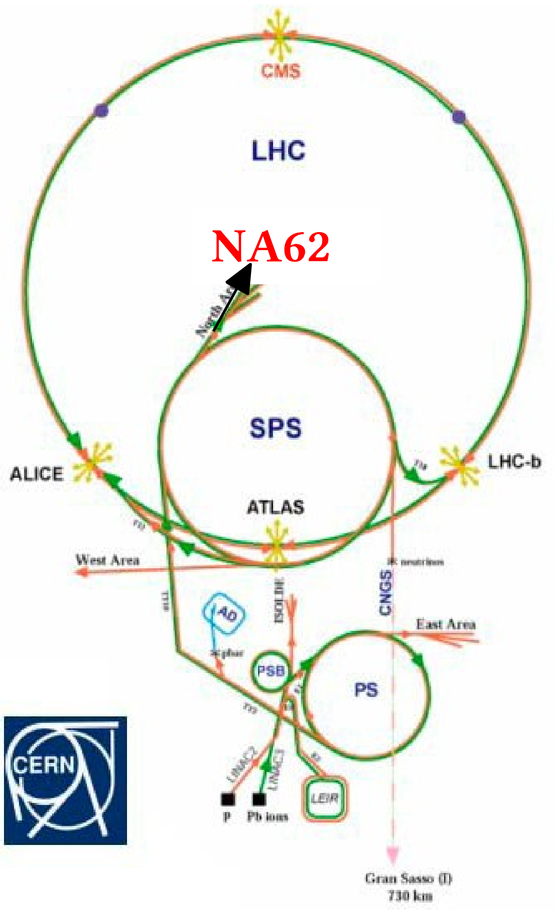
Phys. Rev. D 79, 092004 (2009)

Phys. Rev. D 77, 052003 (2008)

$$BR(K^+ \to \pi^+ \nu\overline{\nu}) < 14 \times 10^{-10} \text{ @ } 95\% \text{ CL}$$

Phys. Lett. B 791, 156 (2019)

The NA62 experiment



NA62 timeline

Dec 2008: NA62 Approval

2009 – 2014: Detector R&D and installation

2015: Commissioning

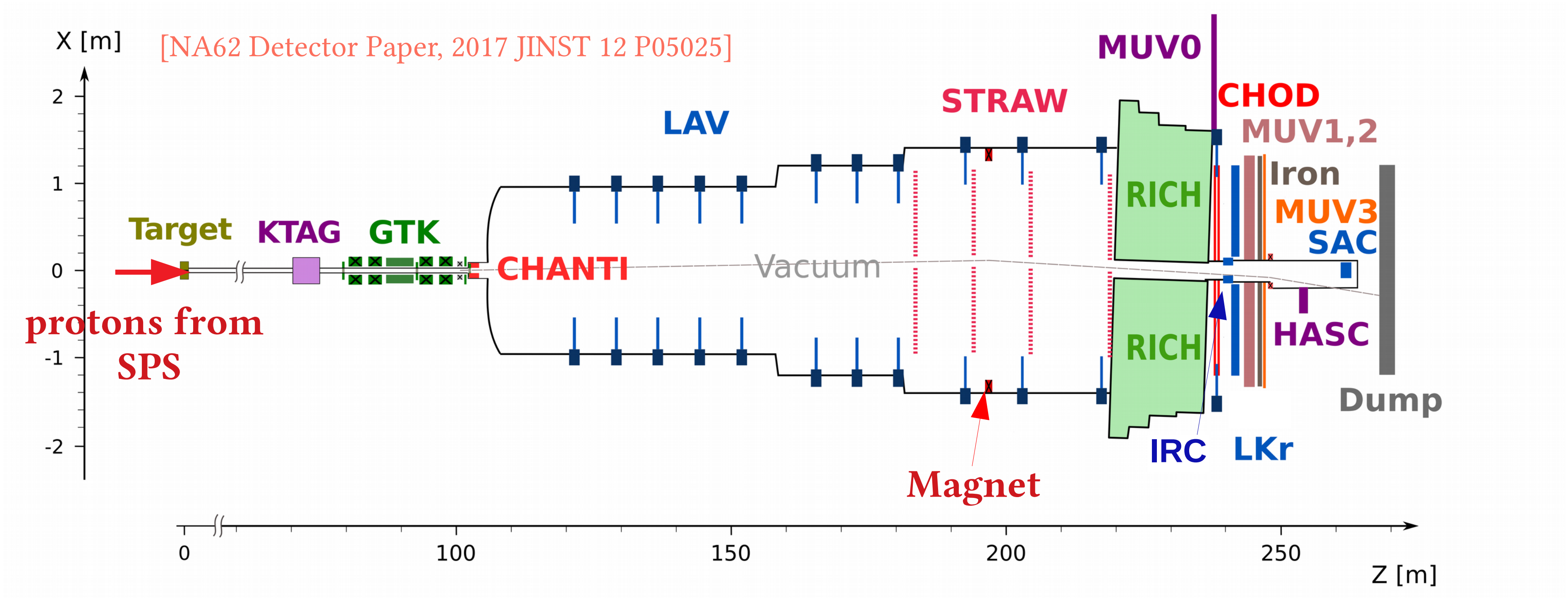
2016 – 2018: NA62 Run 1

2021 – 2023: NA62 Run2 (TBA)

NA62 primary goal: measurement of the ultra rare kaon decay $K^+ \longrightarrow \pi^+ \nu\nu$

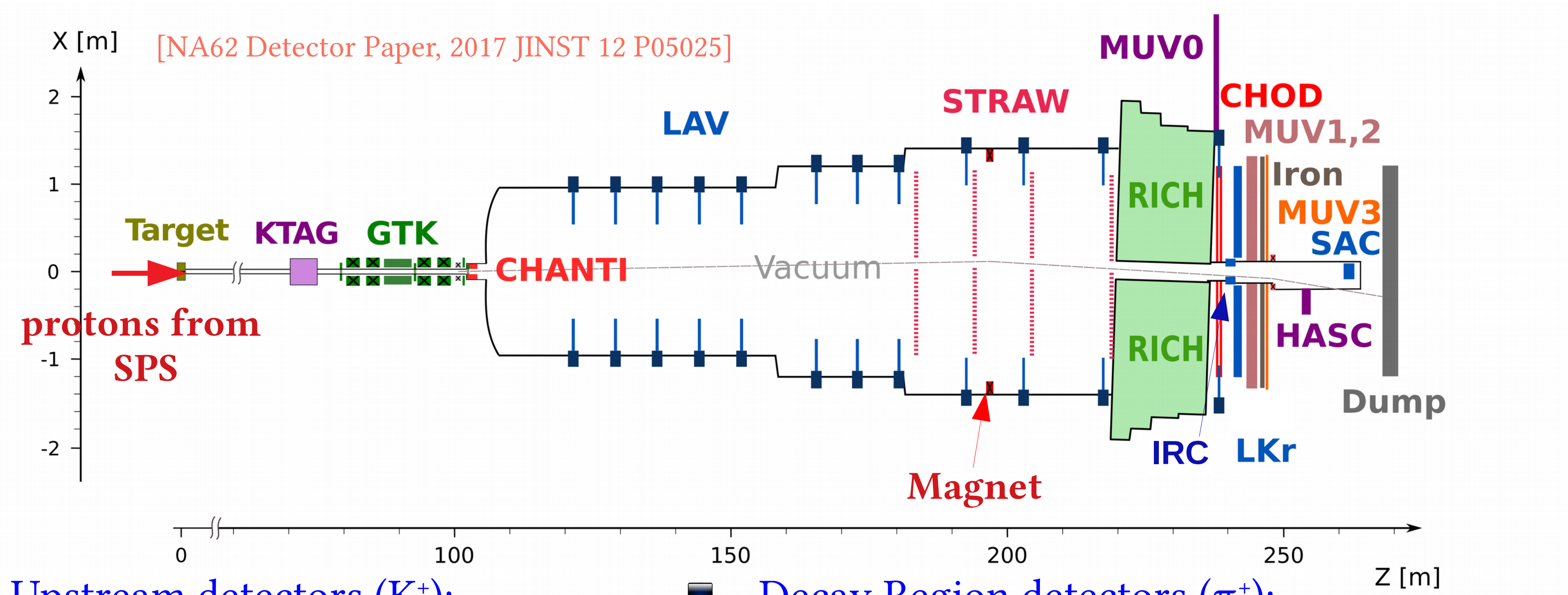
NA62 Collaboration consist of ~ 200 participants from: Birmingham, Bratislava, Bristol, Bucharest, CERN, Dubna, Fairfax, Ferrara, Firenze, Frascati, Glasgow, Lancaster, Liverpool, Louvain, Mainz, Moskow, Naples, Perugia, Pisa, Prague, Protvino, Rome I, Rome II, San Luis Potosi, Turin, TRIUMF, Vancouver UBC

NA62 detector


[NA62 Detector Paper, 2017 JINST 12 P05025]

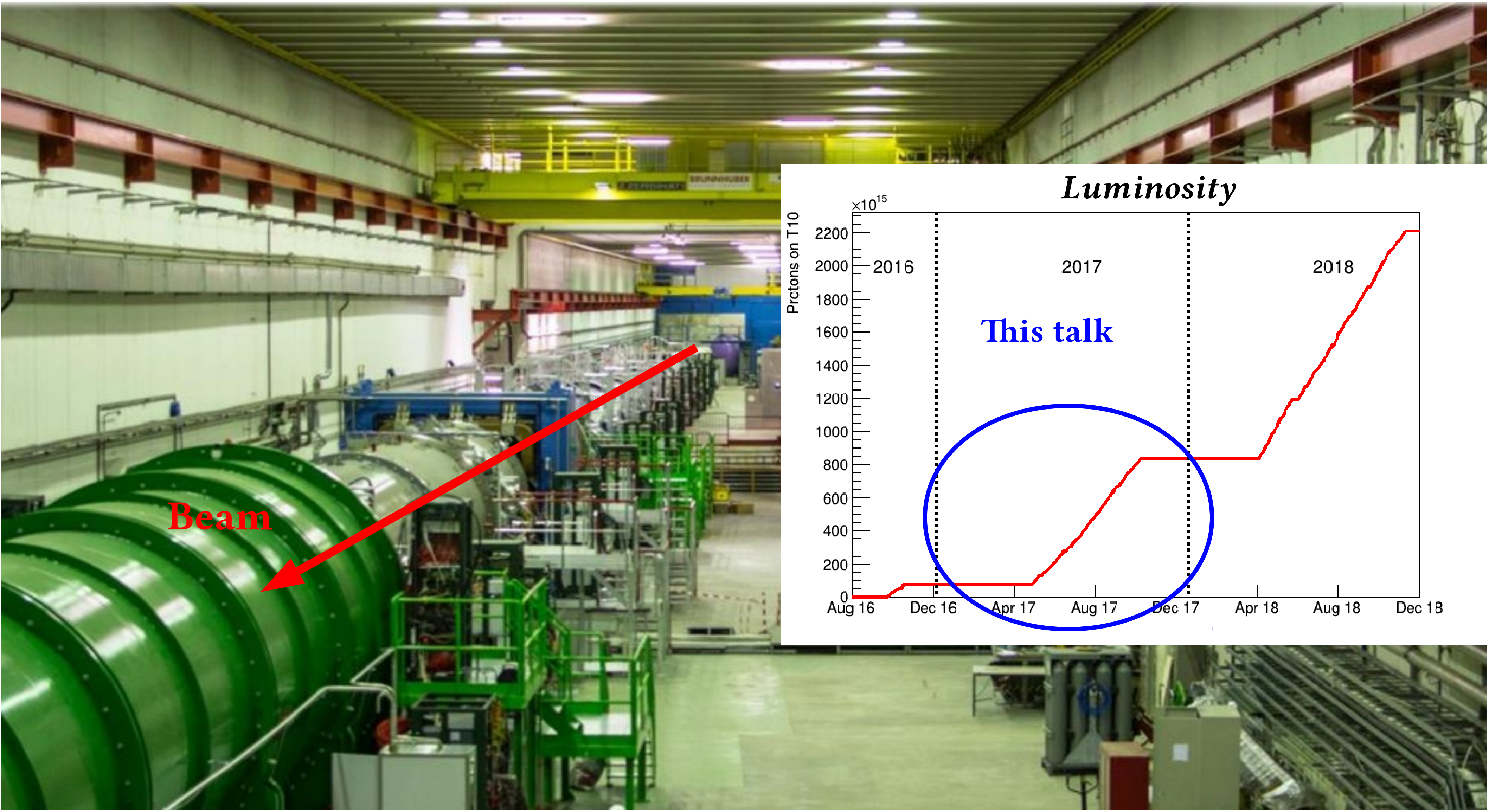
- SPS Beam:
  - 400 GeV/c protons
  - $1.9\text{x}10^{12}$ protons/spill
  - 3.5s spill
  - $\sim 10^{18}$ POT/year
- Secondary positive Beam:
  - 75 GeV/c momentum, 1% rms
  - 100 μrad divergence (RMS)
  - $60\text{x}30\ \text{mm}^2$ transverse size
  - **K^+(6%)**/π^+(70%)/p(24%)
  - 450 MHz of particles at GTK3
- Decay Region:
  - 60 m long fiducial region
  - ~ 3 MHz K^+ decay rate
  - Vacuum ~ $O(10^{-6})$ mbar

NA62 detector



- Upstream detectors (K^+):
  - **KTAG:** Differential Cherenkov counter for K^+ ID
  - **GTK:** Si pixel beam tracker
  - **CHANTI:** Anti-counter for inelastic beam-GTK3 interactions
- Decay Region detectors (π^+):
  - **STRAW:** track momentum spectrometer
  - **CHOD:** Scintillator hodoscopes
  - **LKr/MUV1/MUV2** : Calorimetric system
  - **RICH:** Cherenkov counter for $\pi/\mu/e$ ID
  - **LAV/SAC/IRC:** Photon veto detectors
  - **MUV3:** Muon veto

NA62 detector



Trigger and data collected

NA62 Run 1

2016: Physics run (45 days*)

2017: Physics run (160 days*)

2018: Physics run (217 days*)

This talk

Collected in 2017

1.9 x 10^{12} proton per spill on target

~2 x 10^{12} K^+ decays

* Includes periods with beam off

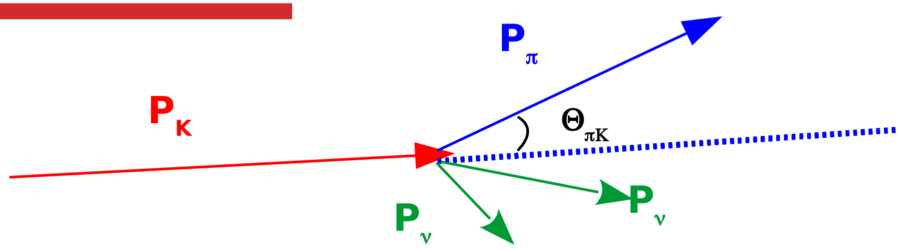
- Trigger streams (hardware L0 + software L1)
  - **"PNN":**
    - L0: presence of a charged particle, photon and muon veto
    - L1: kaon identification, photon veto, STRAW track reconstruction
  - **"Control":** minimum bias, presence of a charged particle downscaled by 400
- Offline analysis
  - Data samples: **PNN; Control:** $K^+ \to \pi^+\pi^0$, $K^+ \to \mu^+\nu$, $K^+ \to \pi^+\pi^+\pi^-$, $K^+ \to \pi^+\pi^-e^+\nu$
  - Blind analysis procedure: signal/validation regions masked during the analysis

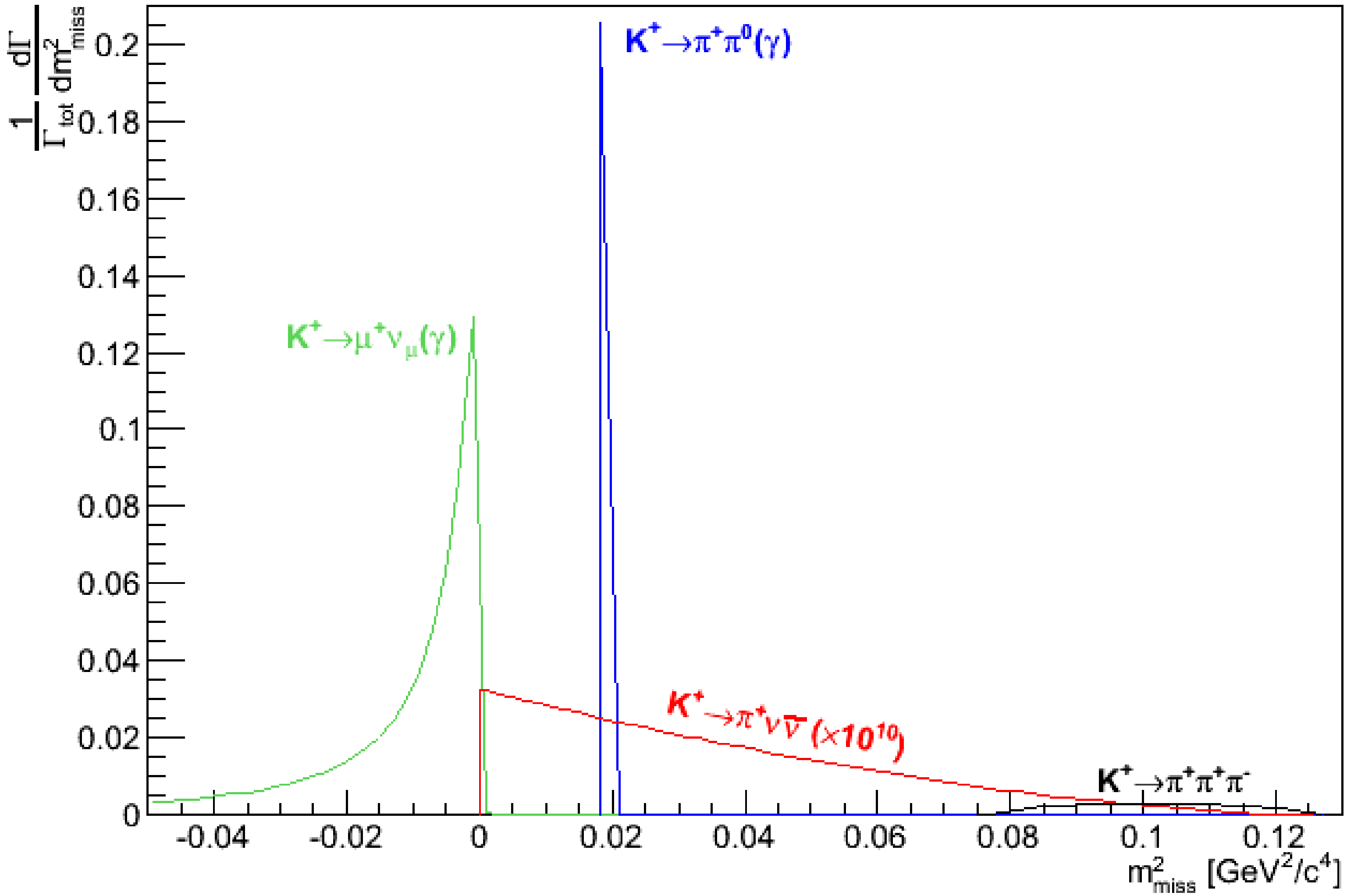
Analysis strategy

Decay-in-flight technique

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

π^+ mass hypothesis





Analysis strategy

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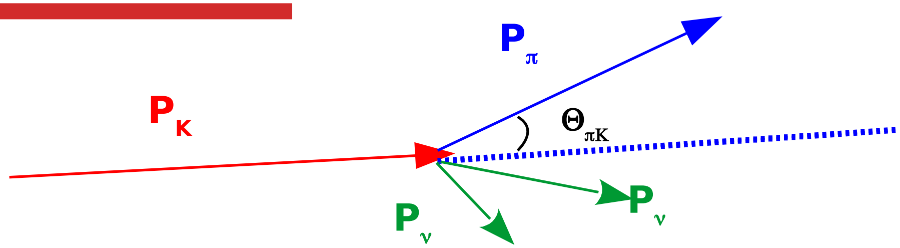

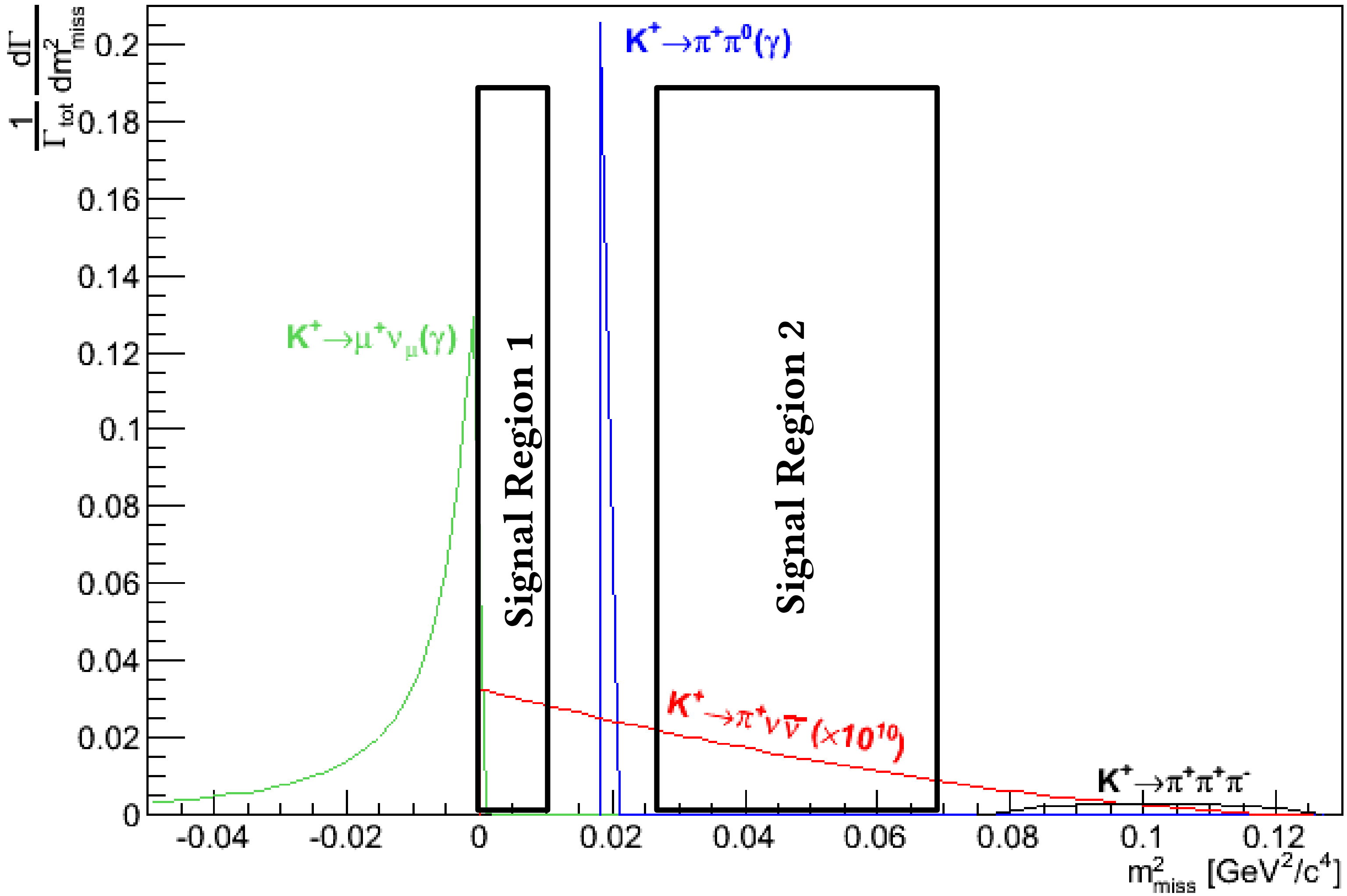

Analysis strategy

Decay-in-flight technique

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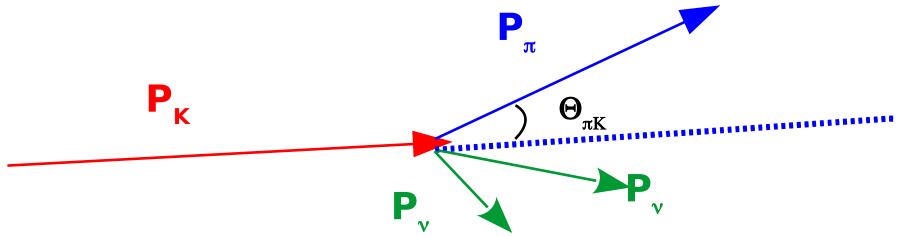
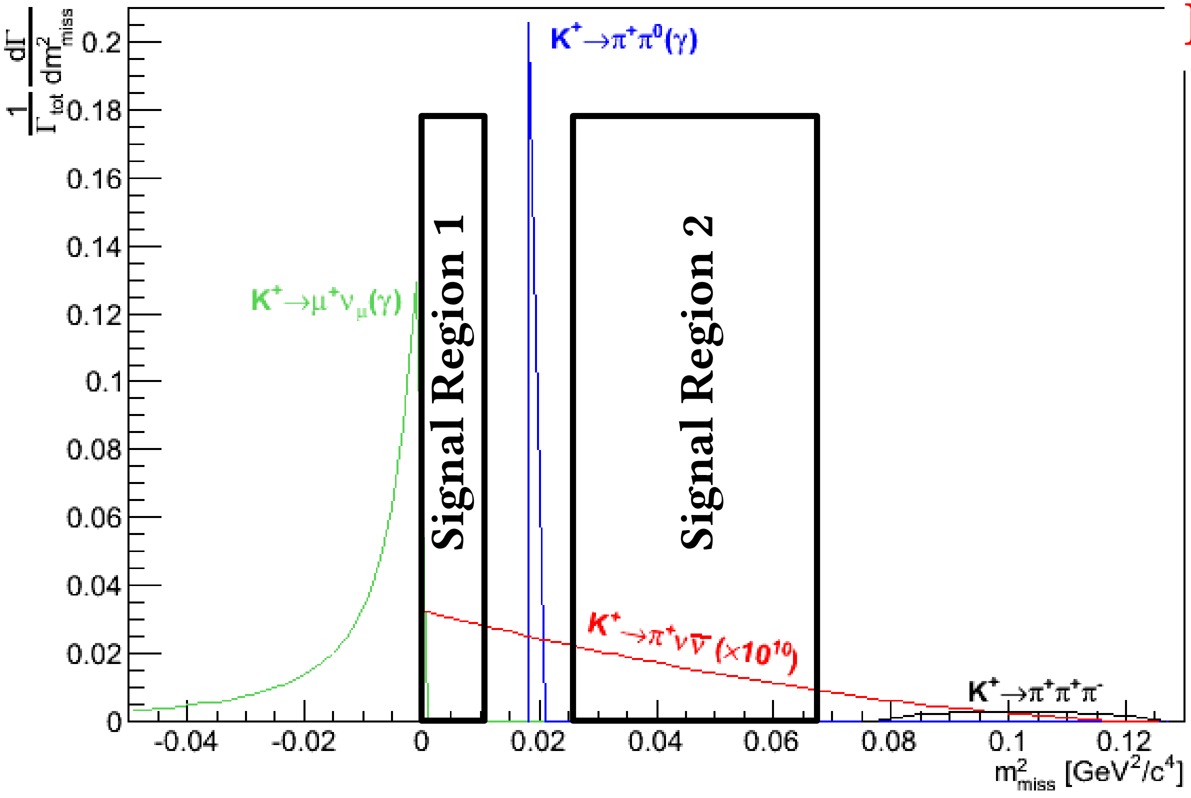


Process	Branching ratio
$K^+ \to \pi^+\pi^0$	0.2066
$K^+ \to \mu^+\nu_\mu$	0.6356
$K^+ \to \pi^+\pi^+\pi^-$	0.0558
$K^+ \to \pi^+\pi^-e^+\nu_e$	$4.3\text{x}10^{-5}$
$K^+ \to \pi^+\nu\nu$ (SM)	**$8.4\text{x}10^{-11}$**



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

\+ Particle ID(Cherenkov detectors)

Particle ID(Calorimeters)

Photon veto

Analysis steps

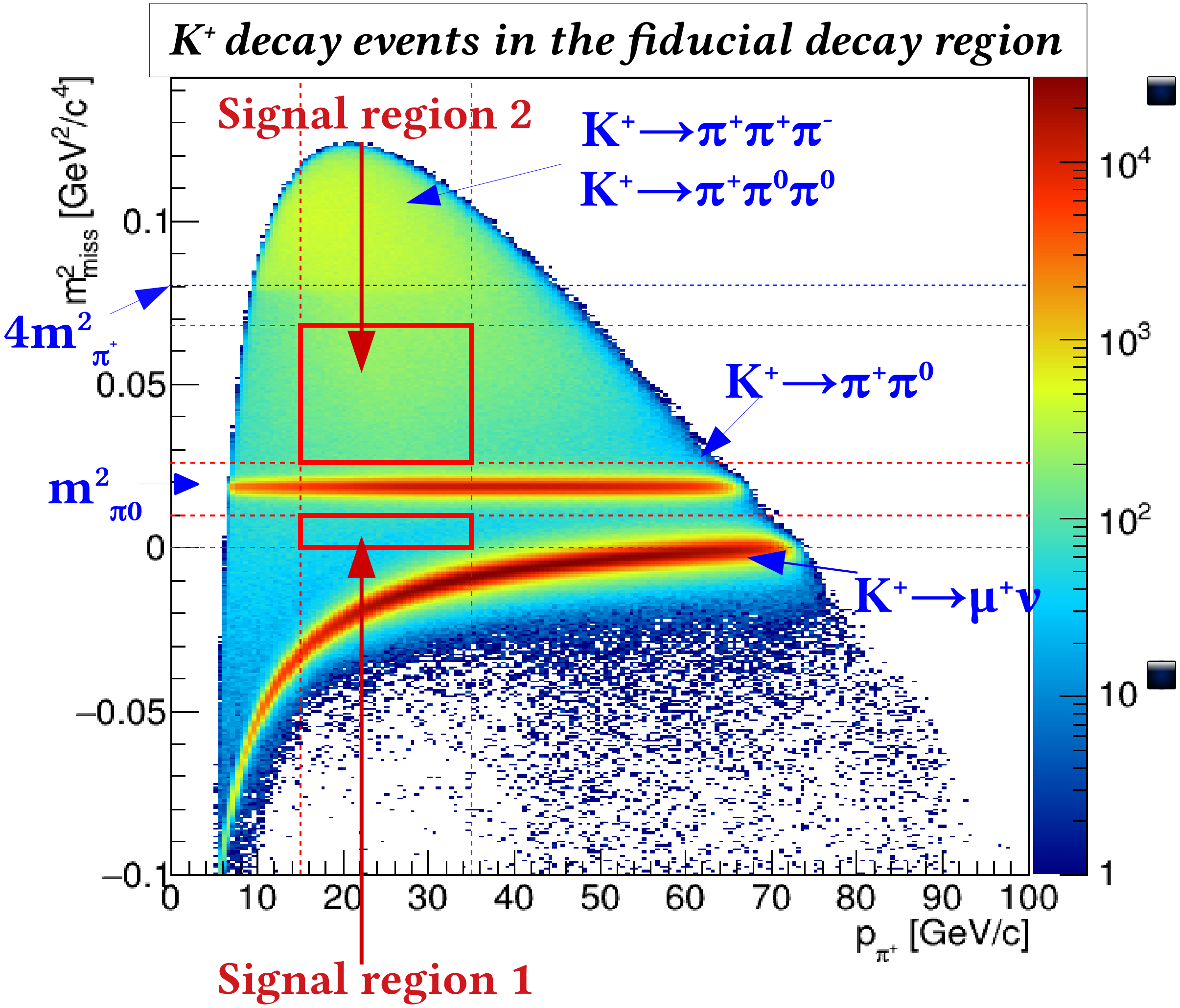
1) Signal selection
2) Single Event Sensitivity (S.E.S.) evaluation
3) Background evaluation and validation
4) Unblinding signal regions and results

1. Signal Selection

Keystones of the analysis

- **Muon suppression > 10^7**
- **π^0 suppression (from $K^+ \longrightarrow \pi^+\pi^0$) > 10^7**
- **Excellent time resolution O(100ps)**
- **Kinematic suppression ~ O(10^4)**

Signal selection



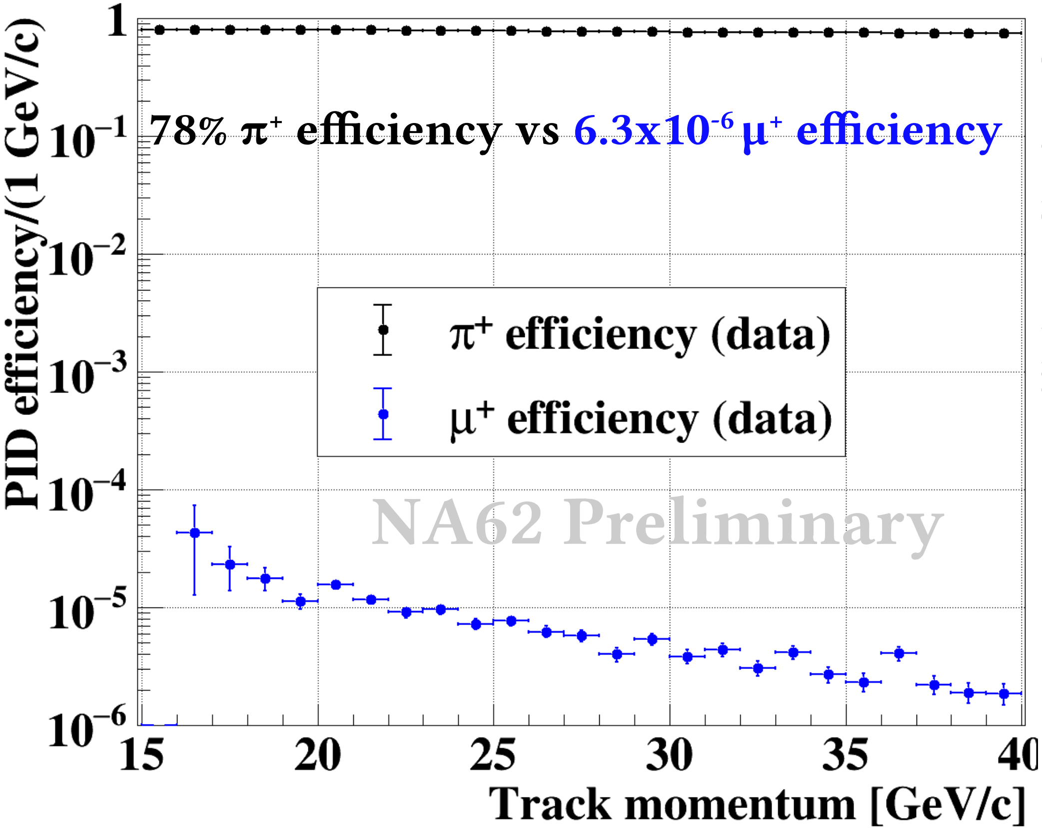
m^2_{miss} computed under π^+ mass hypothesis

- Selection criteria
  - ✫ single track decay topology
  - ✫ π^+ identification
  - ✫ photon rejection
  - ✫ multi-track rejection
- Performance
  - ✫ $\epsilon_{\mu^+} \sim 10^{-8}(64\%\ \pi^+\ \text{efficiency})$
  - ✫ $\epsilon_{\pi^0} = (1.4 \pm 0.1) \cdot 10^{-8}$
  - ✫ $\sigma(m^2_{miss}) = 1 \cdot 10^{-3}\ \text{GeV}^2/c^4$
  - ✫ $\sigma_T \sim O(100\ \text{ps})$

Keystones of the analysis: Particle identification

Calorimetric PID

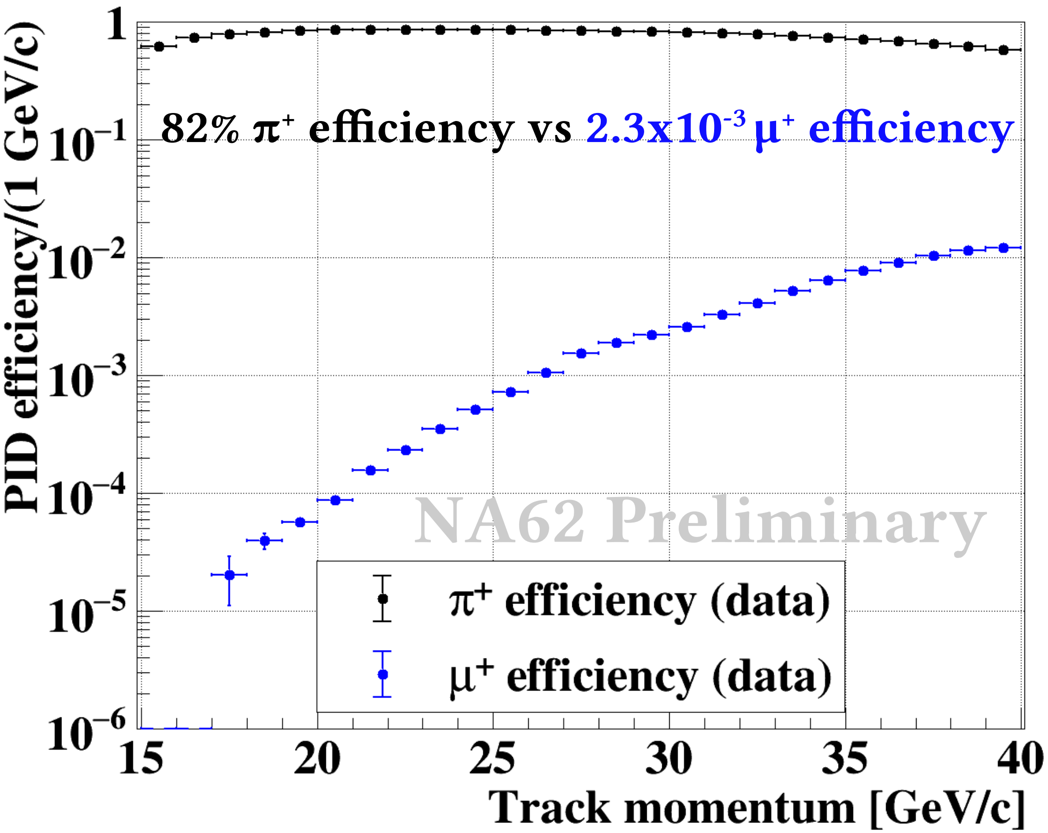
- Machine learning approach (BDT)
  - Energy deposition
  - Energy sharing
  - Shower shape profiles



78% π^+ efficiency vs 6.3x10^{-6} μ^+ efficiency

RICH PID

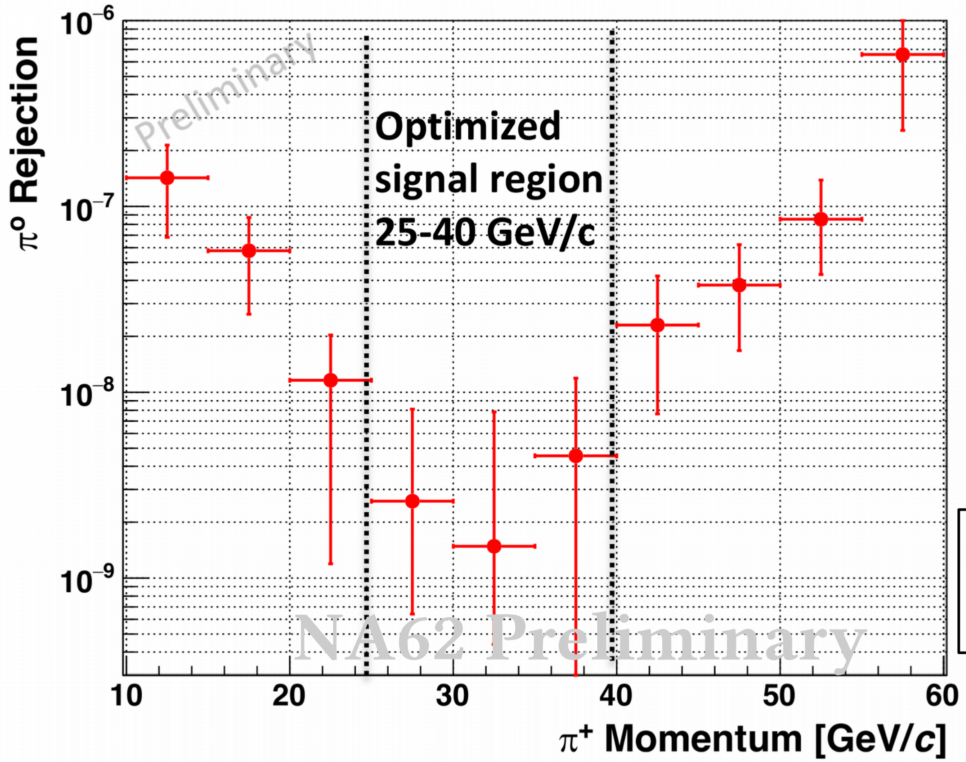
- Track driven likelihoods discriminant for π/μ/e separation
- Particle mass using track momentum
- Momentum measurement under mass hypothesis (velocity spectrometer)



82% π^+ efficiency vs 2.3x10^{-3} μ^+ efficiency

π^0 suppression and search for $\pi^0 \rightarrow$ invisible

- A priori evaluation of π^0 suppression of $K^+ \rightarrow \pi^+\pi^0$ decays ($0.015 < m^2_{miss} < 0.021$ GeV^2/c^4)
  - Selection and trigger stream identical to $K^+ \rightarrow \pi^+\nu\nu$ (1/3 of the data set used)
  - Single-γ detection efficiency from control $K^+ \rightarrow \pi^+\pi^0$ data (Tag & Probe)
  - π^0 suppression evaluated from convolution with MC $K^+ \rightarrow \pi^+\pi^0(\gamma)$
  - Validation: side bands with expected rejection O(10^{-7}) where **π^0 → invisible** excluded [E949, PRD72 (2005)]
- π^0 suppression expected = $(2.8^{+5.9}_{-2.1})\times10^{-9}$ (π^+ momentum region 25-40 GeV/c)



- Results
  - BR($\pi^0 \rightarrow$ invisible) normalized to $\pi^0 \rightarrow \gamma\gamma$
  - Expected background: 10^{+22}_{-8} events
  - Observed: 12 events

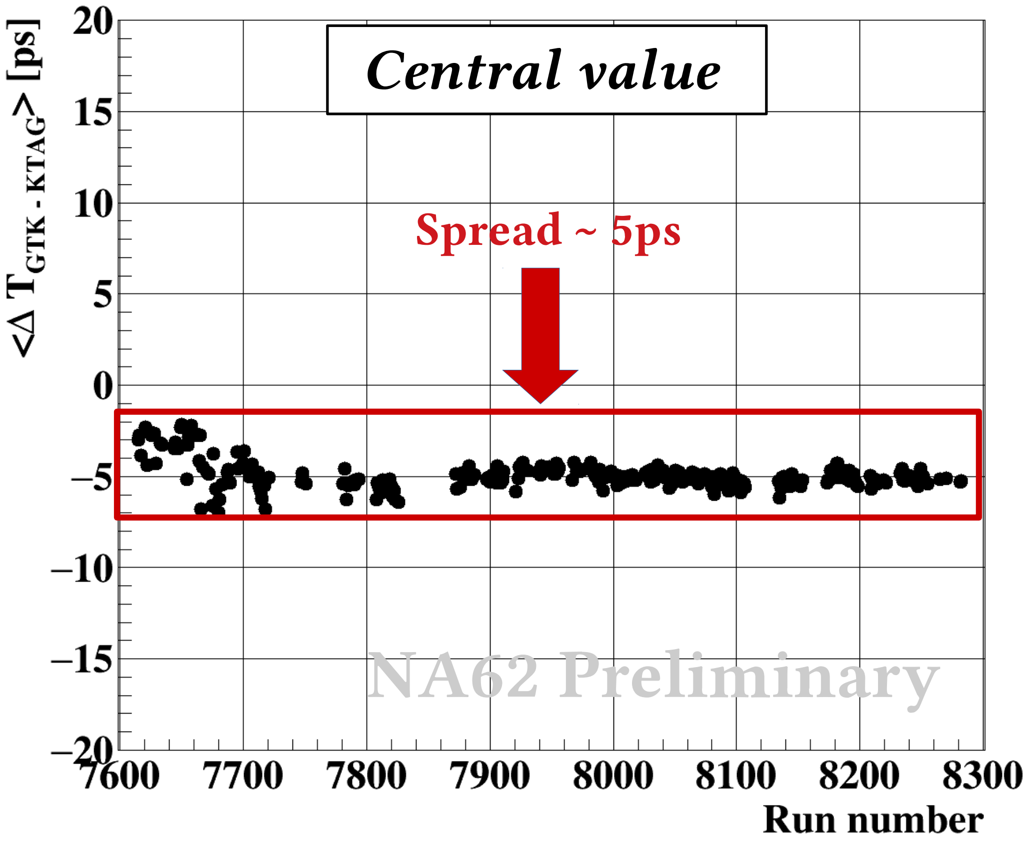
BR($\pi^0 \rightarrow$invisible) < 4.4×10^{-9} @ 90% CL

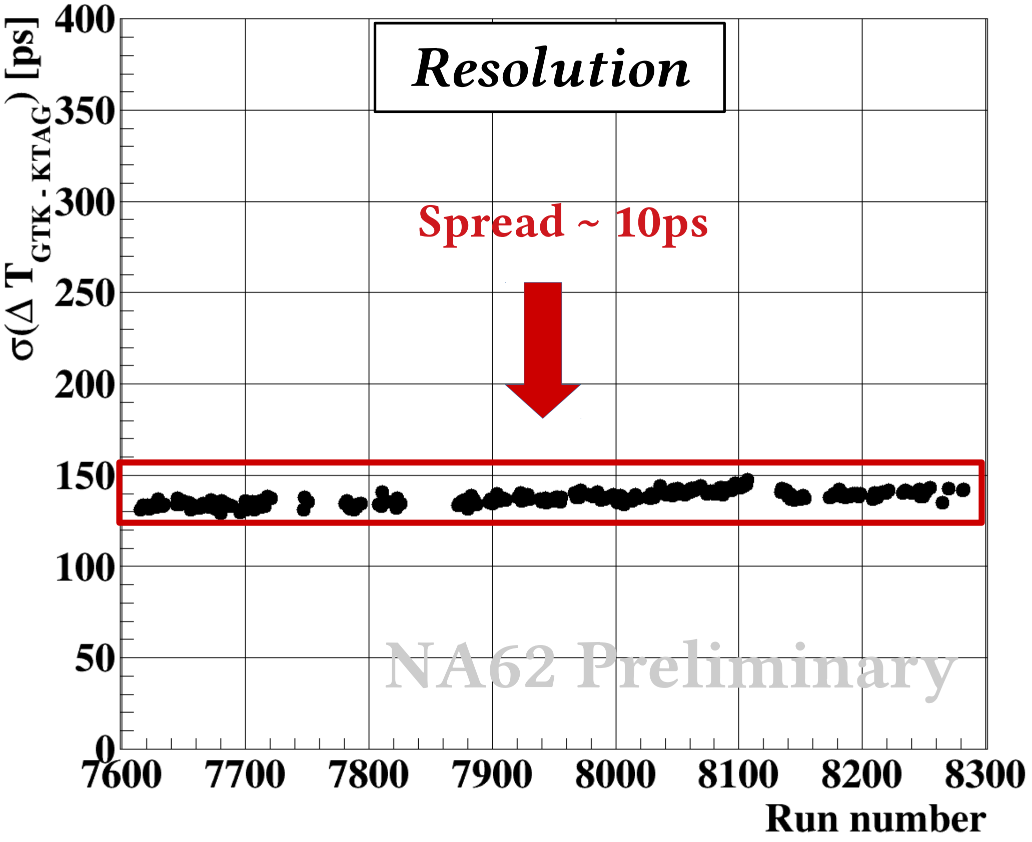
UL 60 times stronger than previous measurements

Keystones of the analysis: Time resolution

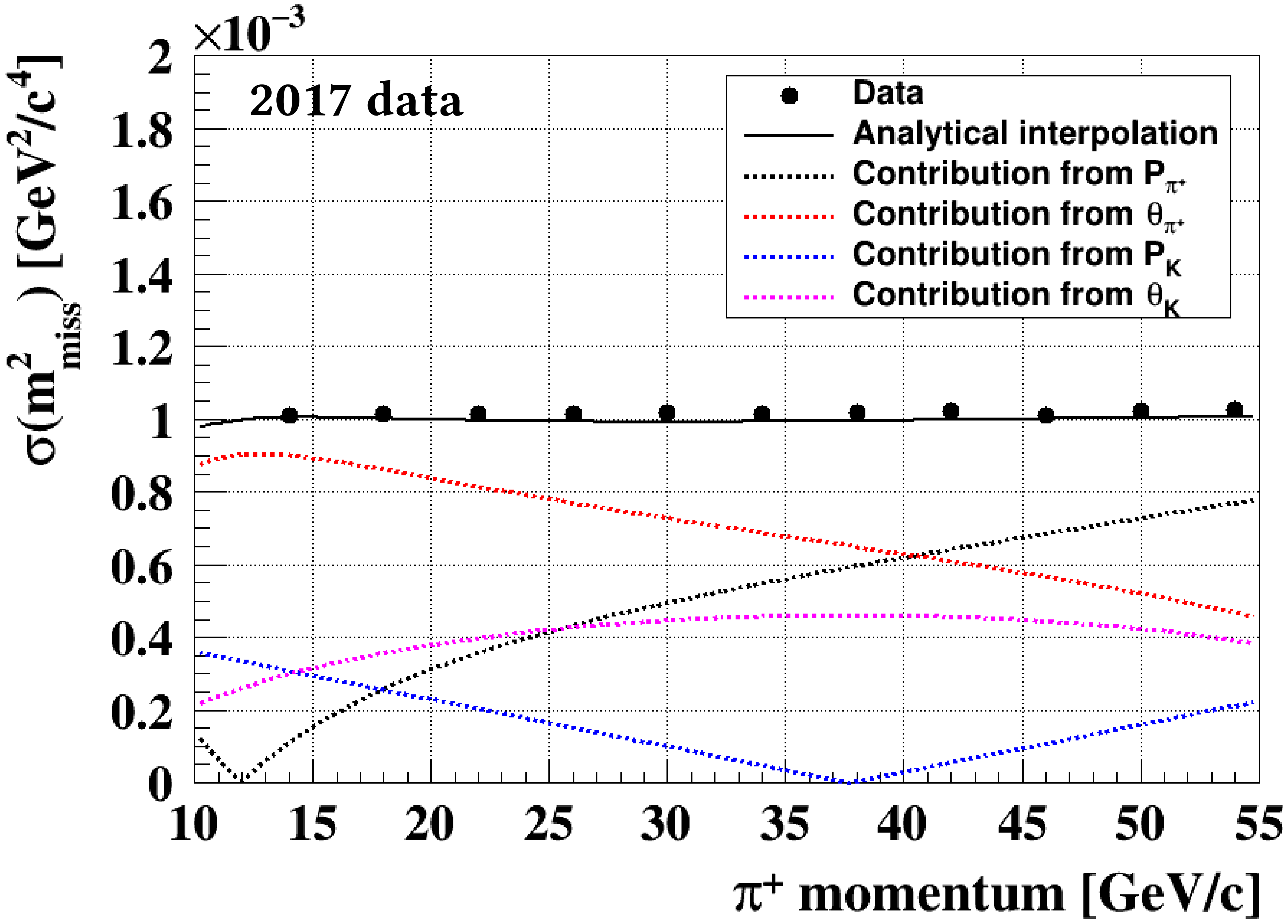
Time calibration stability

- Excellent calibration at the processing level in 2017
- Stable central value and time resolution
- Single-detector time resolution ~ 90ps





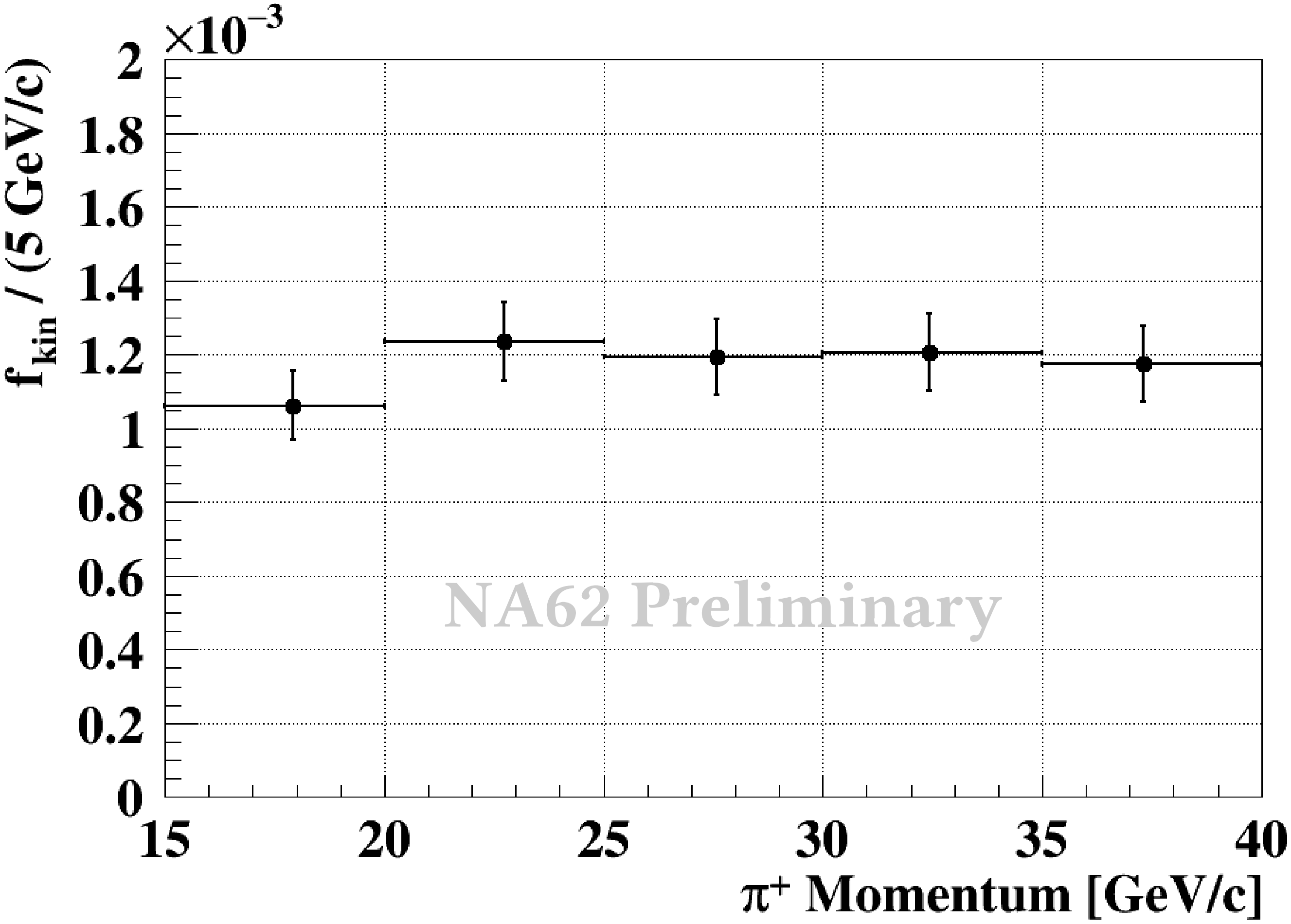
Keystones of the analysis: Kinematic resolution



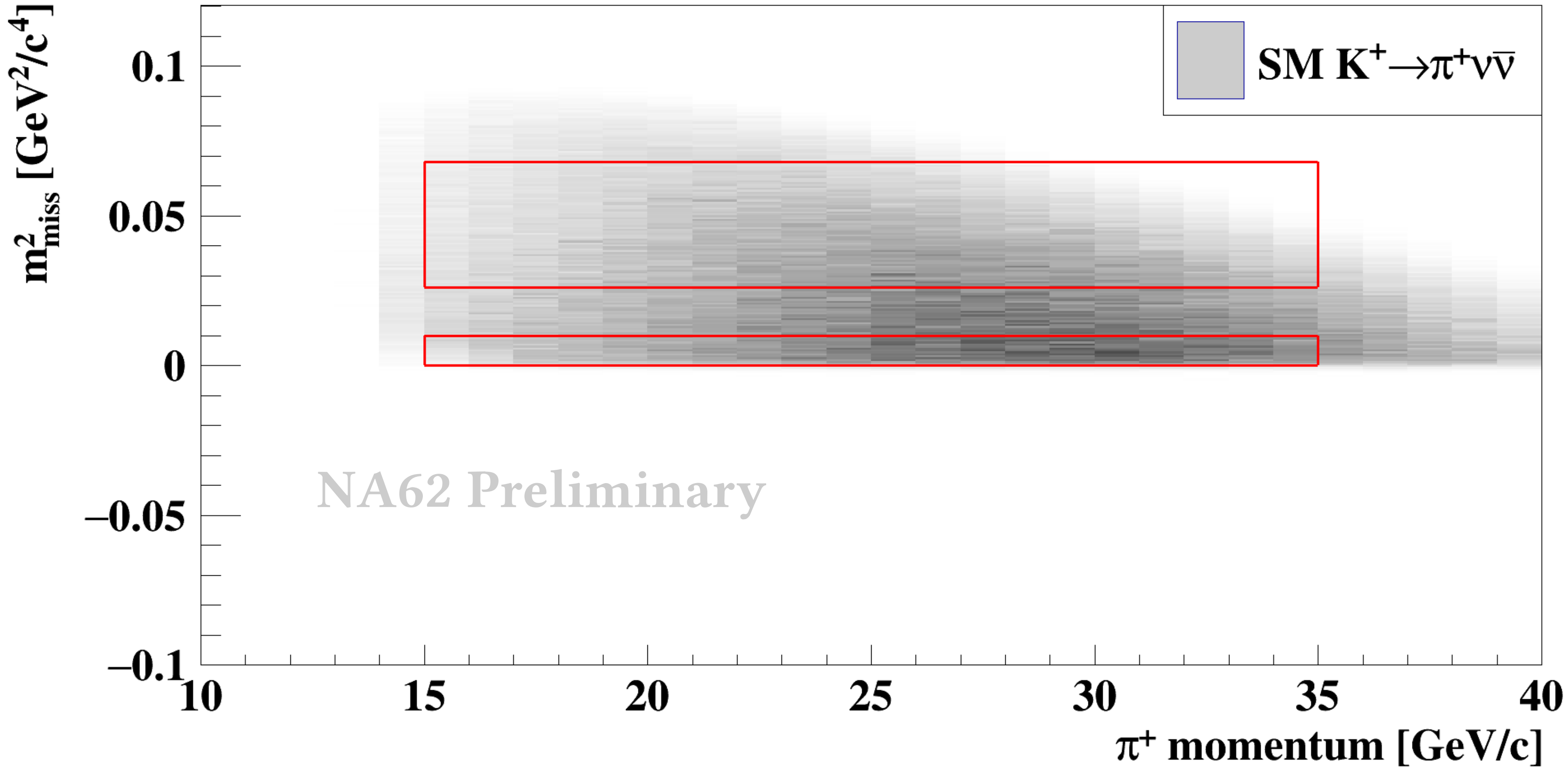
Keystones of the analysis: Kinematic suppression

$K^+ \longrightarrow \pi^+\pi^0$

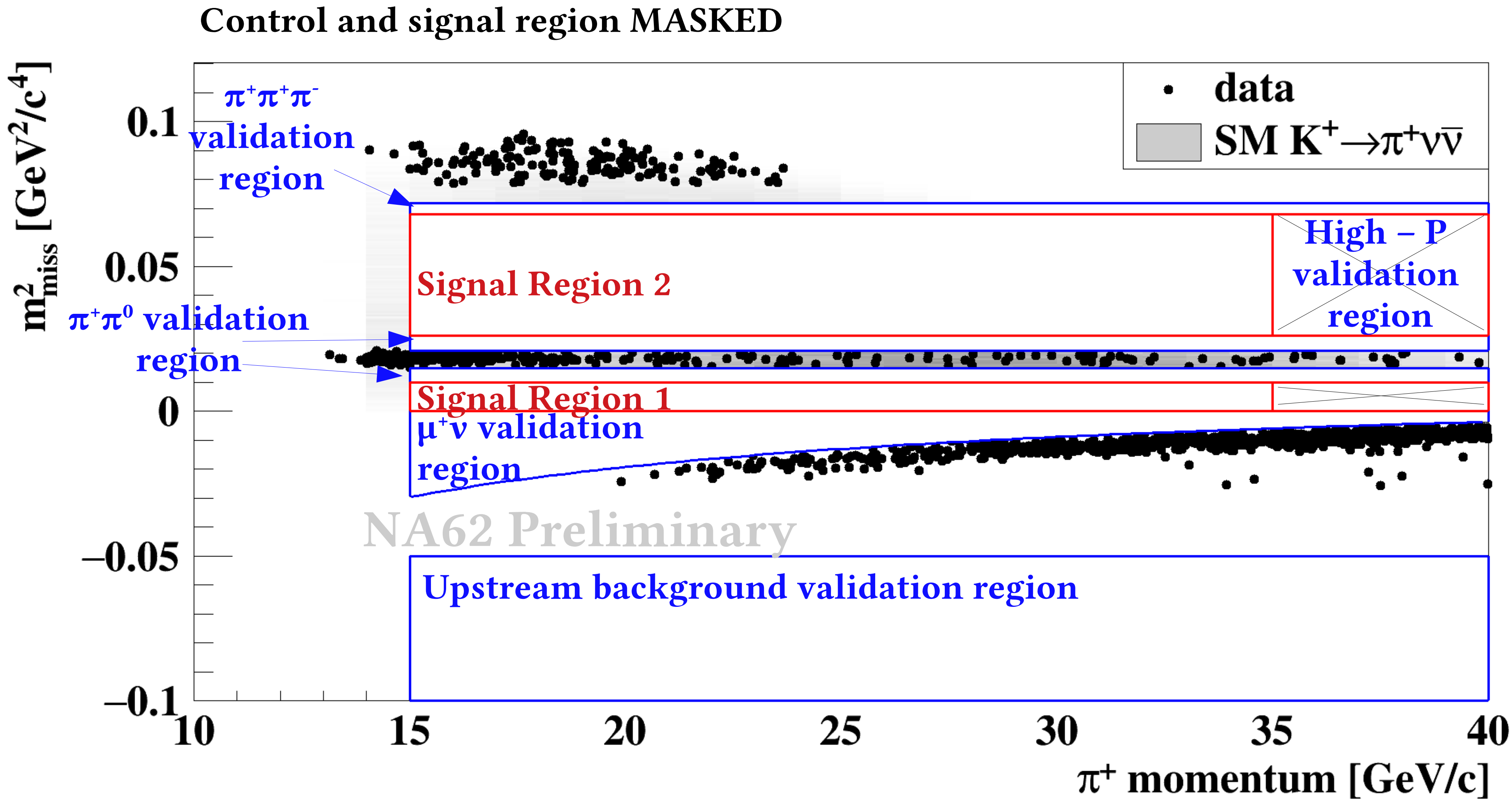
- Kinematic suppression measured on $K^+ \longrightarrow \pi^+\pi^0$ decays in data
- Fraction of events $\pi^+\pi^0$ entering m^2_{miss} signal region



Signal acceptance



Data after signal selection



2. Single event sensitivity

Single Event Sensitivity (S.E.S.): Definition

$$N^{exp}_{\pi\nu\nu} \approx N_{\pi\pi}\epsilon_{trigger}\epsilon_{RV}\frac{A_{\pi\nu\nu}}{A_{\pi\pi}}\frac{Br(\pi\nu\nu)}{Br(\pi\pi)} \Longrightarrow \text{S.E.S.} = \frac{Br(\pi\nu\nu)}{N^{exp}_{\pi\nu\nu}}$$

$N^{exp}_{\pi\nu\nu}$ $\Longrightarrow$ Expected number of πυυ events

$Br(\pi\nu\nu)$ $\Longrightarrow$ SM πυυ branching ratio

$N_{\pi\pi}$ $\Longrightarrow$ $K^+ \longrightarrow \pi^+\pi^0$ from control selected like πνν without γ/multi-track rejection

ϵ_{RV} $\Longrightarrow$ πνν loss due to γ/multi-track rejection because of random activity

$\epsilon_{trigger}$ $\Longrightarrow$ PNN trigger efficiency

$A_{\pi\nu\nu}(A_{\pi\pi})$ $\Longrightarrow$ Monte Carlo acceptances for πνν(~3%*) and $\pi^+\pi^0$ (~8.5%)

$Br(\pi\pi)$ $\Longrightarrow$ PDG $K^+ \longrightarrow \pi^+\pi^0$ branching ratio

* Vector form factor hypothesis

- Ratio of πνν and $\pi^+\pi^0$ acceptances allows cancellation of systematic effect
- Computation in bins of π^+ momentum and instantaneous beam intensity

Single Event Sensitivity (S.E.S.): Acceptance

$A_{\pi\nu\nu}$ $\Longrightarrow$ **Signal** Monte Carlo acceptance for πνν(~3%*)

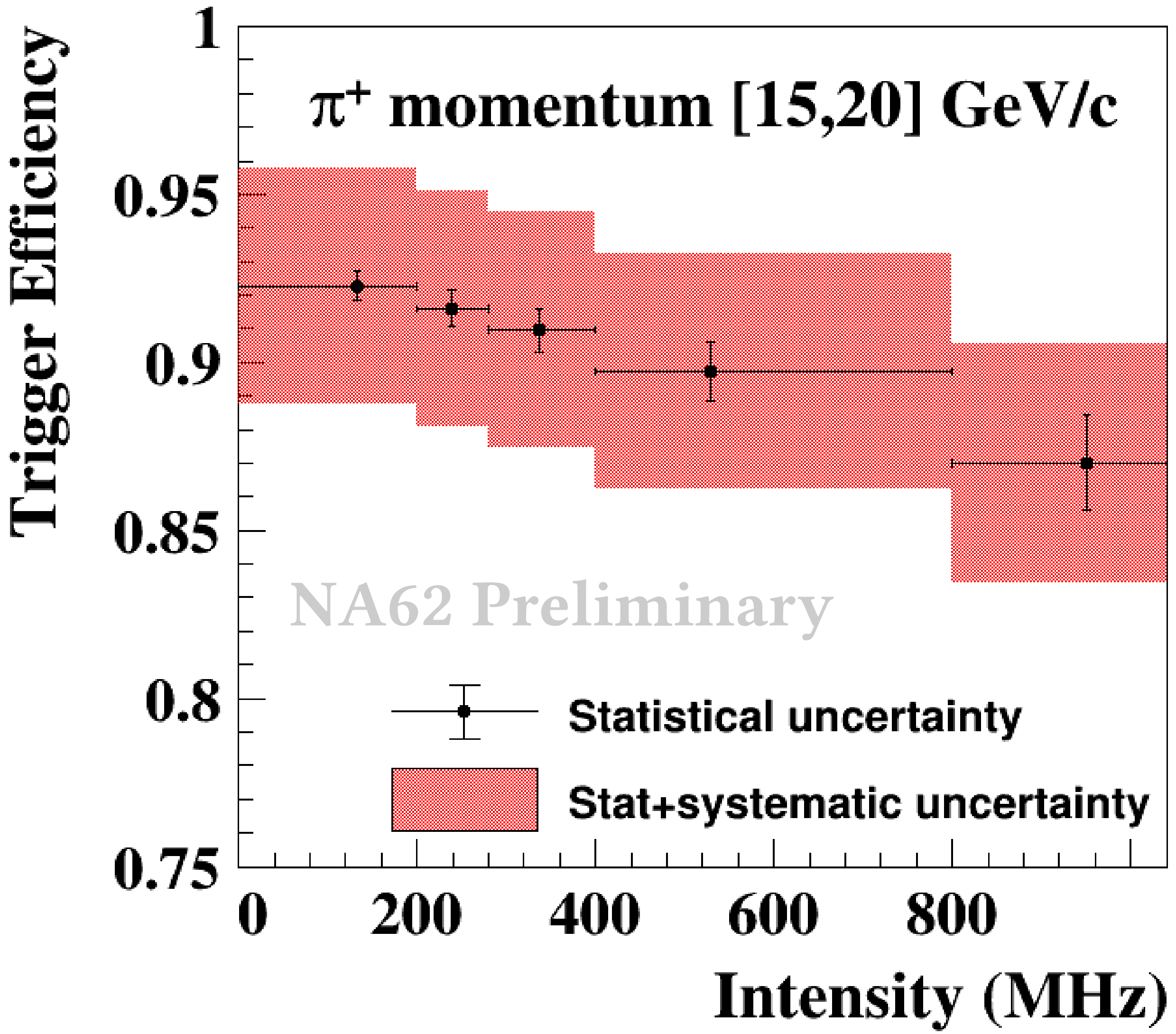
$A_{\pi\pi}$ $\Longrightarrow$ **Normalization** Monte Carlo acceptance $\pi^+\pi^0$ (~8.5%)

* Vector form factor hypothesis

- Ratio of πνν and $\pi^+\pi^0$ acceptances allows cancellation of systematic effect
  - Particle identification efficiency
  - Detector efficiencies
  - Kaon ID efficiency and beam-related acceptance loss
- Main differences between signal and normalization selection
  - m^2_{miss} region definition (3-body vs 2-body final state)
  - π^+ – induced acceptance loss from π^0 rejection (applied only to signal)
  - Geometrical cut against upstream background (applied only to signal)

Single Event Sensitivity: Trigger efficiency

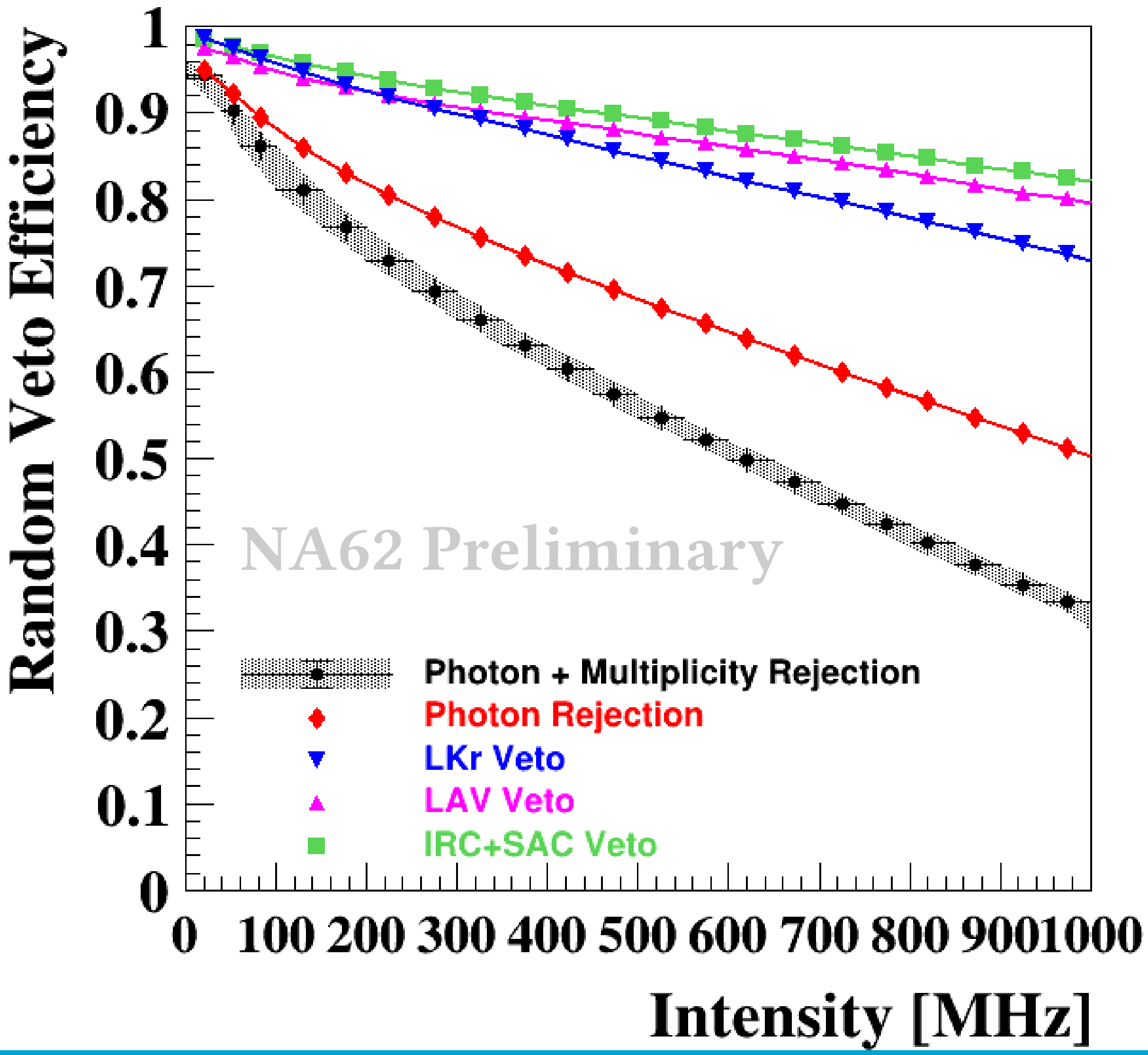
ε_{trigg}: *trigger efficiency measured on data*



- Intensity measured event-by-event using Gigatracker time sidebands

Single Event Sensitivity: Random veto

ε_{RV}: measured on $K^+ \to \mu^+ \nu$ decays in data



- **Intensity measured event-by-event using Gigatracker time sidebands**

Single Event Sensitivity: Results

◆ **Integrated over beam intensity and π^+ momentum**

$$\text{S.E.S.} = (0.389 \pm 0.021) \times 10^{-10}$$

$$N^{exp}_{\pi\nu\nu} = 2.16 \pm 0.12 \pm 0.26_{ext}$$

S.E.S error budged ⇒

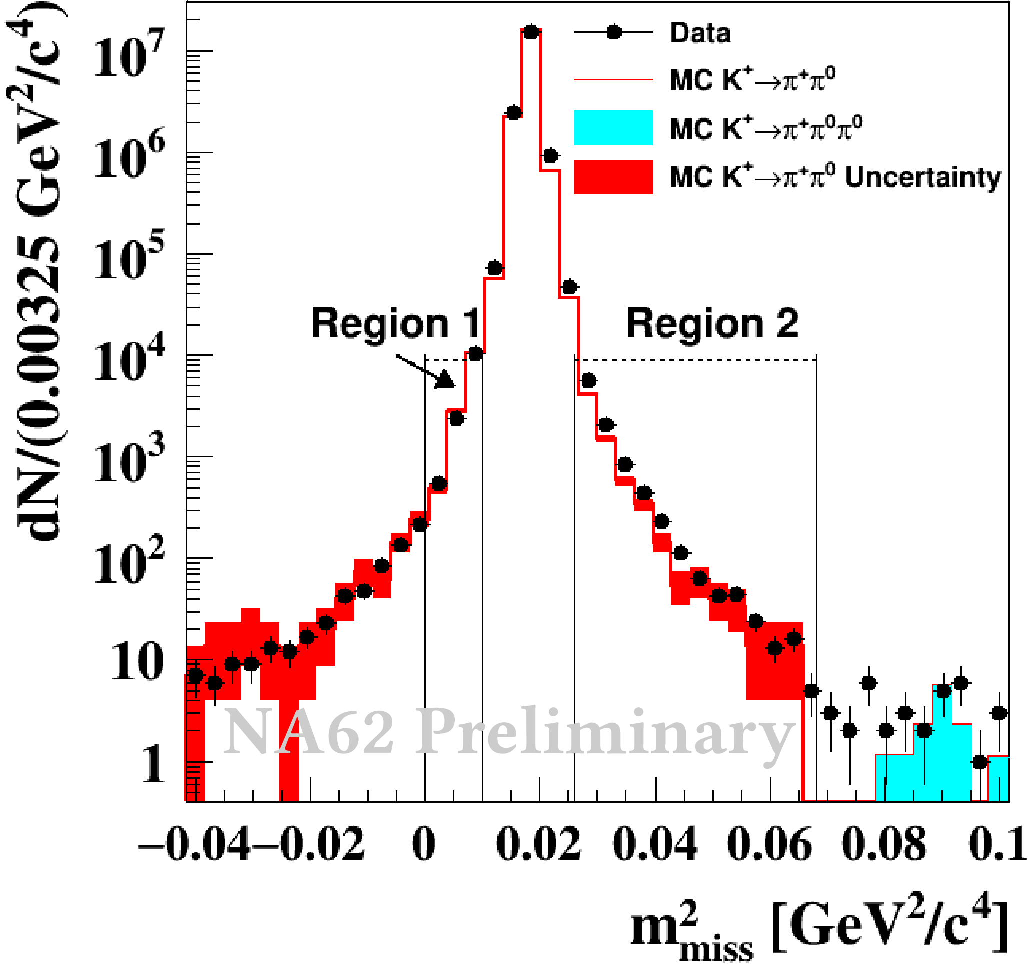
Source	Uncertainty$\times 10^{-10}$
L0 trigger	± 0.015
Acceptance	± 0.012
Random veto	± 0.008
L1 trigger	± 0.003
Normalization background	negligible

◆ **External error on $N^{exp}_{\pi\nu\nu}$ from $Br(\pi\nu\nu) = (0.84 \pm 0.10)\text{x}10^{-10}$**

3. Background evaluation and validation

Background: $K^+ \rightarrow \pi^+\pi^0$

Control $K^+\rightarrow\pi^+\pi^0$ data used to study the tails of the m^2_{miss} distribution



Data in $\pi^+\pi^0$ region after $\pi\nu\nu$ selection (including π^0 rejection)

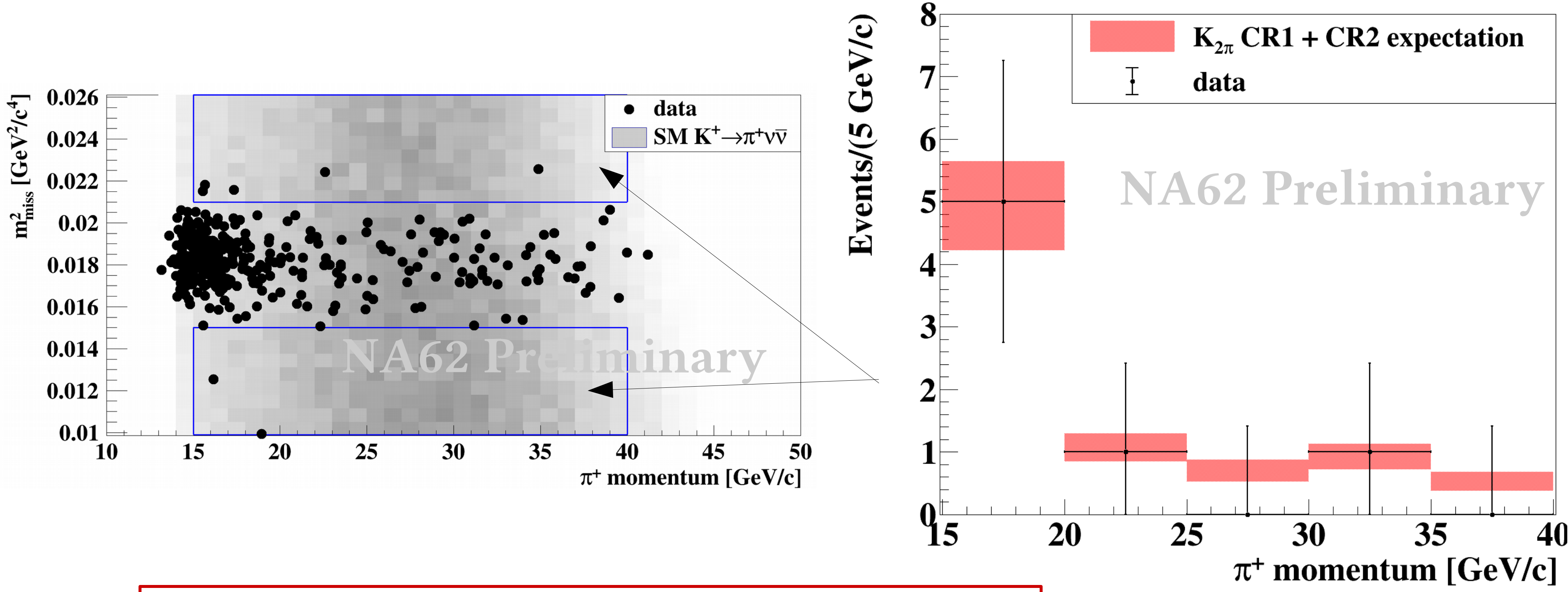
$$\boxed{N^{exp}_{\pi\pi}(region)} = \boxed{N(\pi^+\pi^0)} \cdot \boxed{f_{kin}(region)}$$

Expected $K^+\rightarrow\pi^+\pi^0$ in signal regions after the $\pi\nu\nu$ selection

Fraction of $\pi^+\pi^0$ in signal region measured on control data

Background: $K^+ \rightarrow \pi^+\pi^0(\gamma)$ IB validation

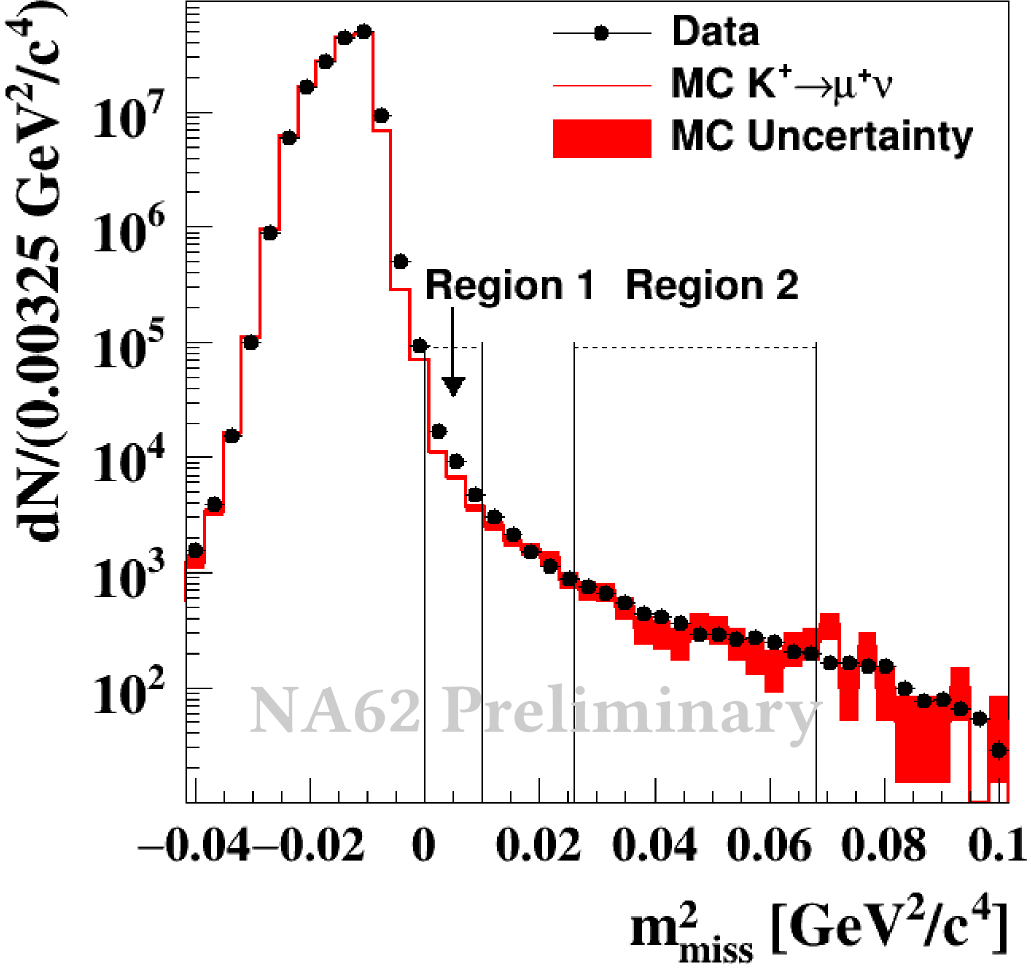
- Agreement between expected and observed kinematic suppression in validation regions

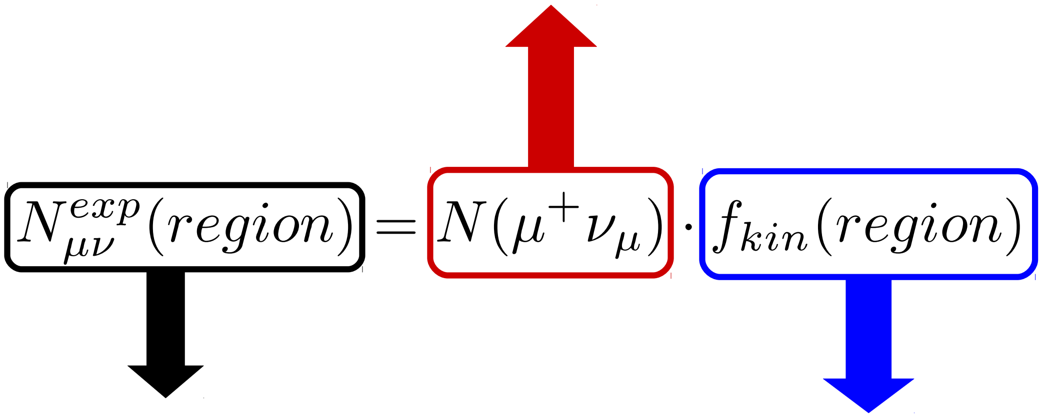


$$\boxed{N^{bg}_{\pi\pi(\gamma)\mathrm{IB}} = 0.29 \pm 0.03_{stat} \pm 0.03_{syst}}$$

Background: $K^+ \rightarrow \mu^+\nu_\mu(\gamma)$ IB

Control $K^+\rightarrow\mu^+\nu_\mu(\gamma)$ data used to study the tails of the m^2_{miss} distribution





Data in $\mu^+\nu_\mu$ region after $\pi\nu\nu$ selection

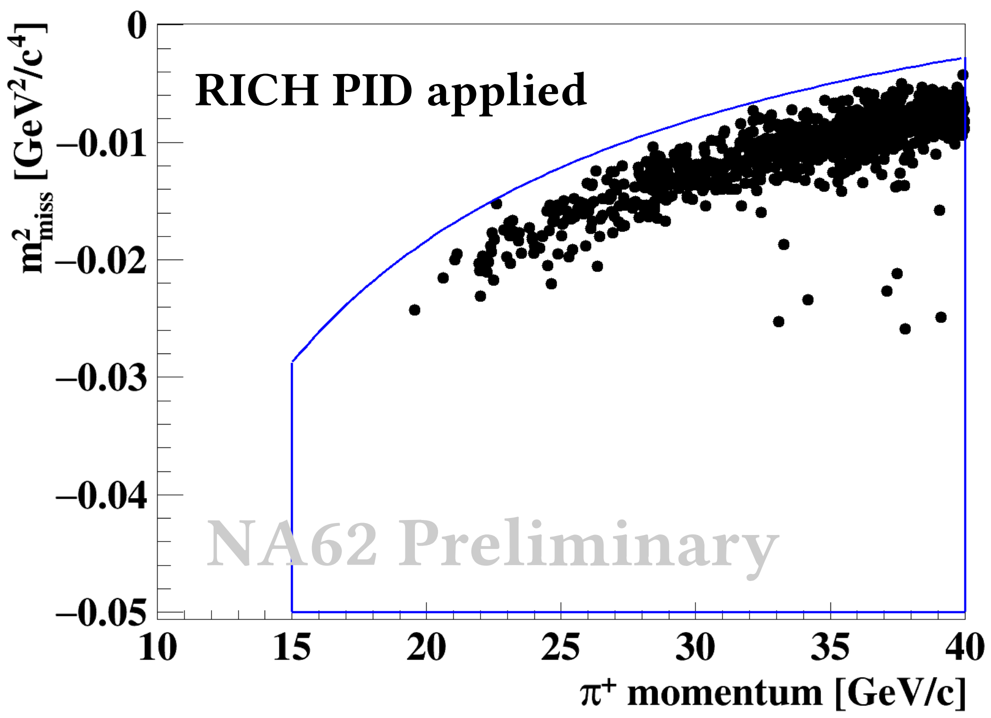
$$\boxed{N^{exp}_{\mu\nu}(region)} = \boxed{N(\mu^+\nu_\mu)} \cdot \boxed{f_{kin}(region)}$$

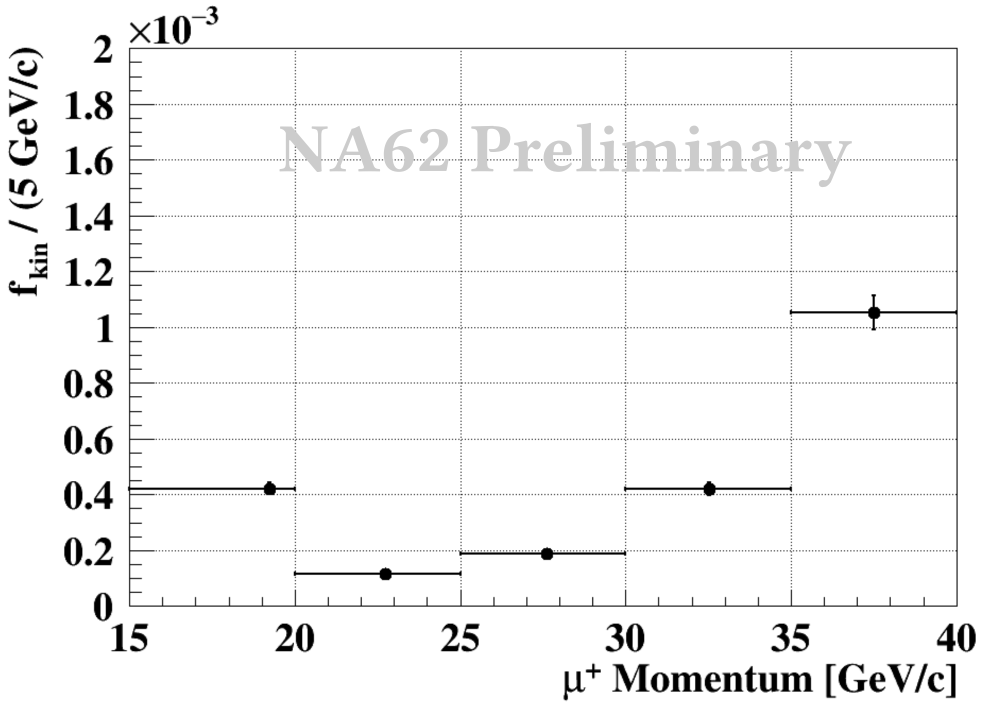
Expected $K^+\rightarrow\mu^+\nu_\mu$ in signal regions after the $\pi\nu\nu$ selection

Fraction of $\mu^+\nu_\mu$ in signal region measured on control data

Background: $K^+ \rightarrow \mu^+\nu_\mu(\gamma)$ IB

- Correlations between kinematic suppression and RICH PID
  - RICH variables use momentum measured by the spectrometer

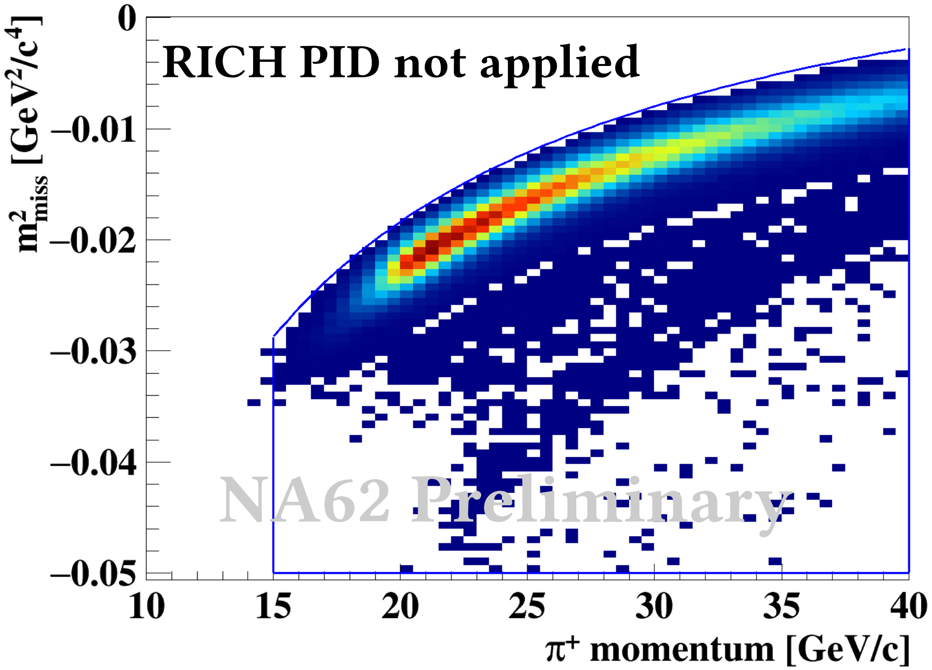


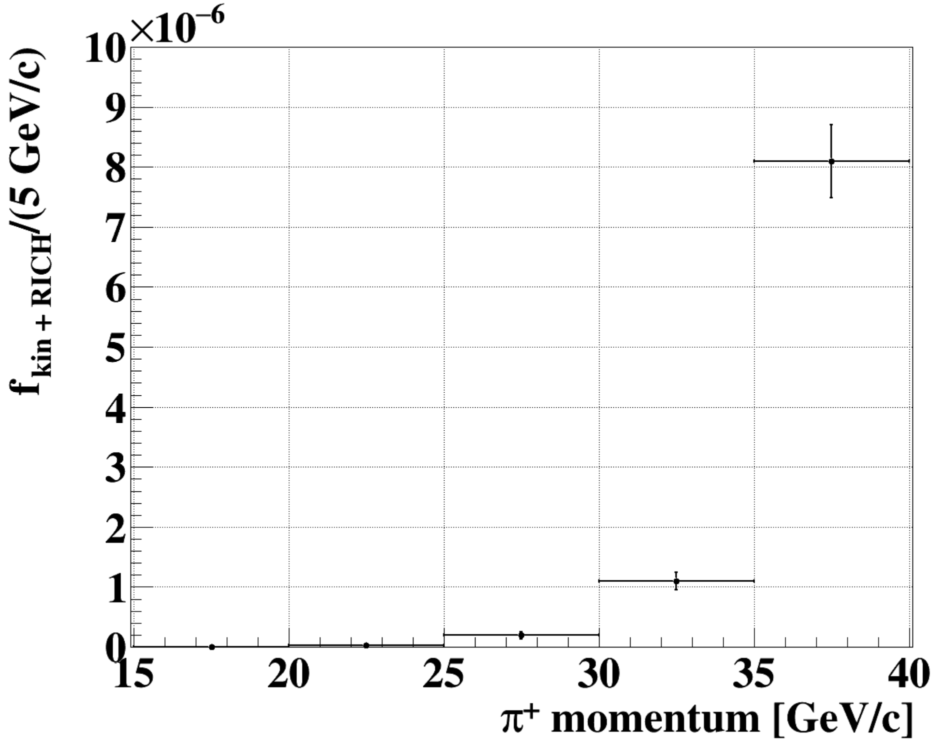


Assumed that RICH PID and f_{kin} are uncorrelated

Background: $K^+ \rightarrow \mu^+\nu_\mu(\gamma)$ IB

- Alternative method for $K^+ \rightarrow \mu^+\nu_\mu(\gamma)$ background estimation
  - Correlations between kinematic suppression and RICH PID included
- Differences between the background estimates using the two methods assigned as a systematic uncertainty

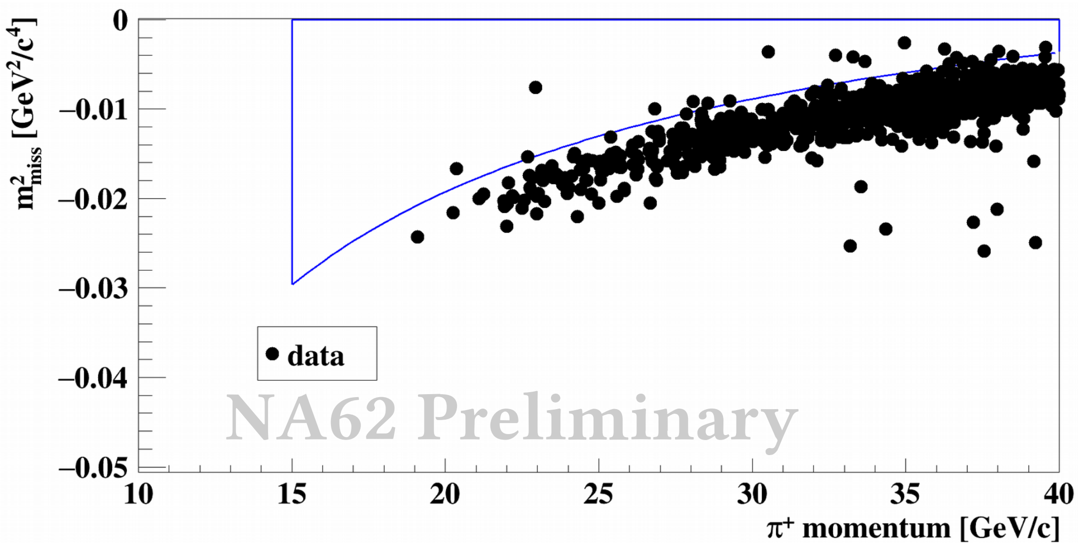


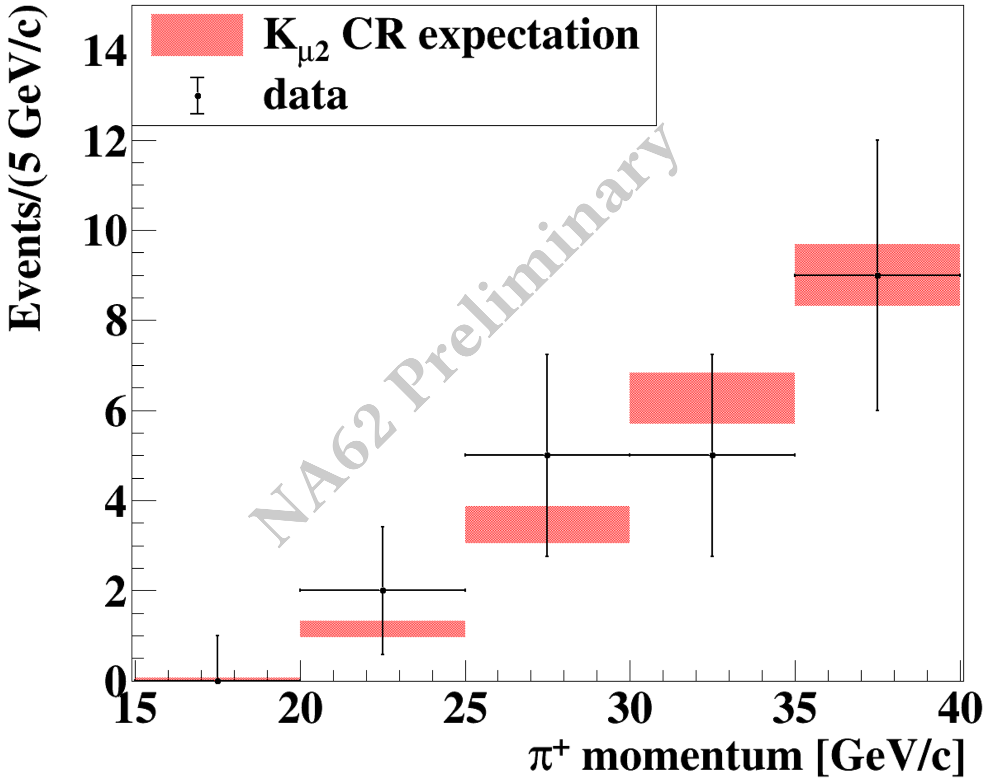


The combined effect of RICH PID and f_{kin} measured

Background: $K^+ \to \mu^+\nu_\mu(\gamma)$ IB validation

- Agreement between expected and observed kinematic suppression in validation regions

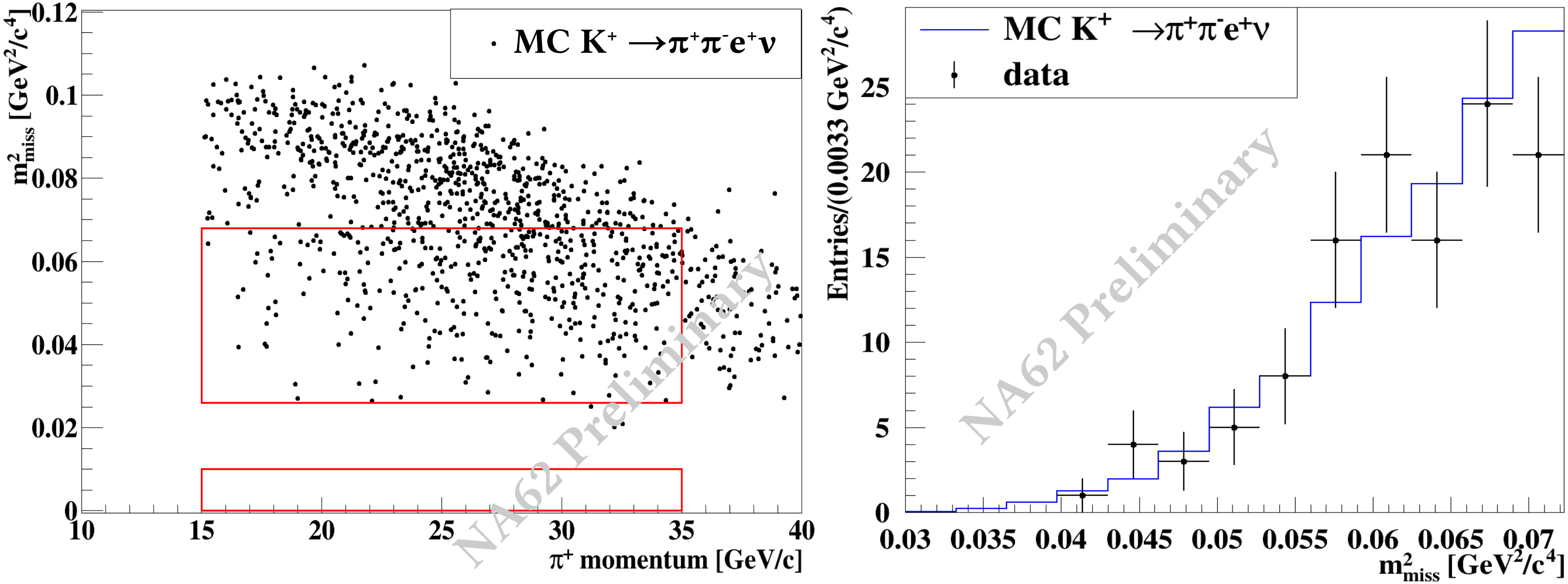




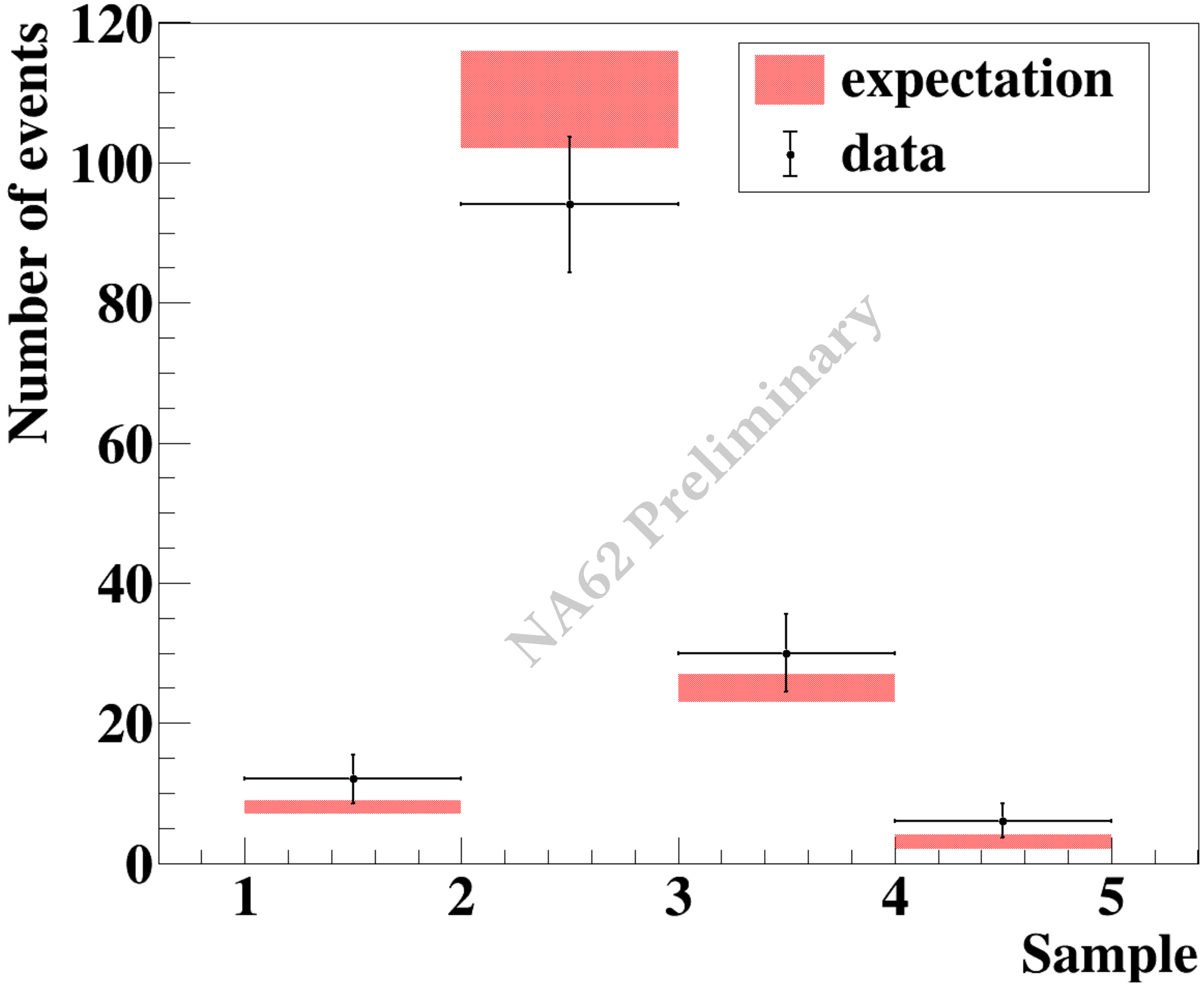
$$\boxed{N^{bg}_{\mu\nu_\mu(\gamma)\mathrm{IB}} = 0.15 \pm 0.02_{syst} \pm 0.04_{syst}}$$

Background: $K^+ \rightarrow \pi^+\pi^-e^+\nu$

- Sample of $2\text{x}10^9$ MC generated $K^+ \rightarrow \pi^+\pi^-e^+\nu$ decays used for background estimation
  - Correlation between m^2_{miss}, kinematics and multi-track rejection
- MC simulation validated using data
- $K^+ \rightarrow \pi^+\pi^-e^+\nu$ expectation normalized to S.E.S. (m^2_{miss} shape well reproduced)



Background: $K^+ \rightarrow \pi^+\pi^-e^+\nu$ validation



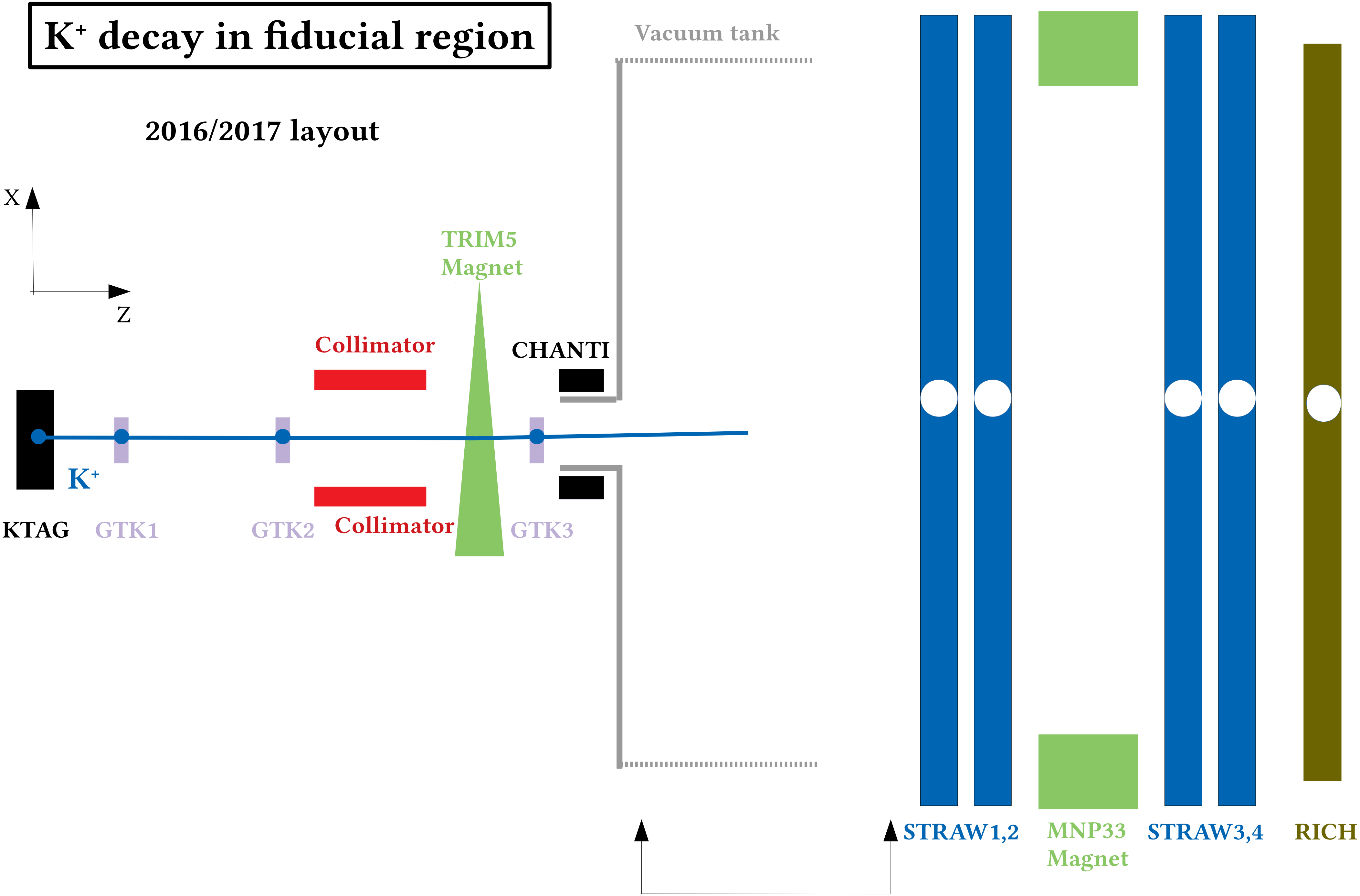
$$\boxed{N^{bg}_{Ke4} = 0.12 \pm 0.05_{stat} \pm 0.03_{syst}}$$

K^+ decay background summary

Process	Expected events
$K^+ \to \pi^+ \nu \bar{\nu}$ (SM)	$2.16 \pm 0.12_{stat} \pm 0.26_{ext}$
$K^+ \to \pi^+ \pi^0 (\gamma)$ IB	$0.29 \pm 0.03_{stat} \pm 0.03_{syst}$
$K^+ \to \mu^+ \nu_\mu (\gamma)$ IB	$0.15 \pm 0.02_{stat} \pm 0.04_{syst}$
$K^+ \to \pi^+ \pi^- e^+ \nu_e$	$0.12 \pm 0.05_{stat} \pm 0.03_{syst}$
$K^+ \to \pi^+ \pi^- \pi^+$	$0.02 \pm 0.02_{syst}$
$K^+ \to \pi^+ \gamma\gamma$	$0.005 \pm 0.005_{syst}$
$K^+ \to l^+ \pi^0 \nu_l$	negligible
Total background	$0.59 \pm 0.06_{stat} \pm 0.06_{syst}$

K^+ decay in fiducial region

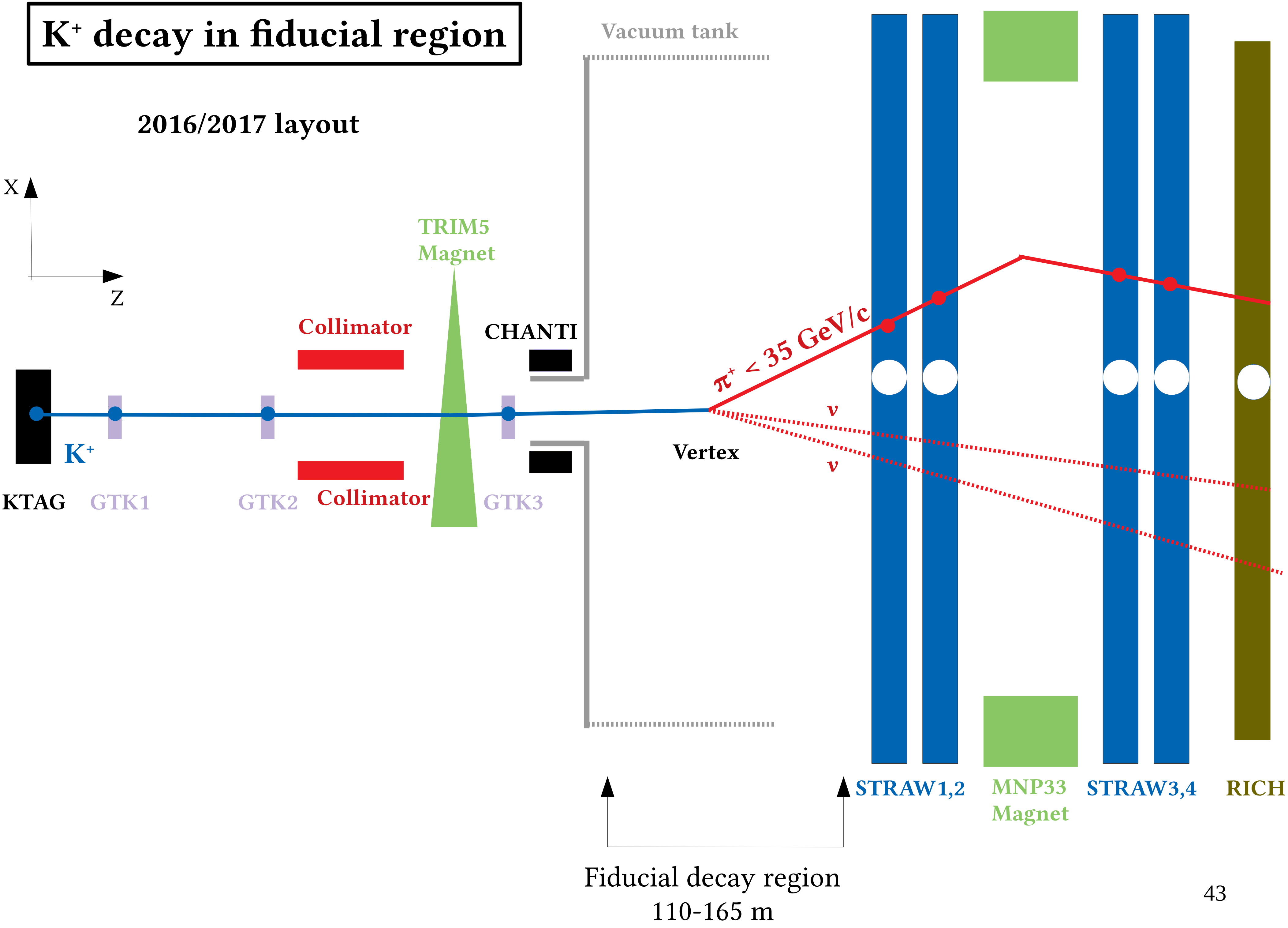
2016/2017 layout



Fiducial decay region
110-165 m

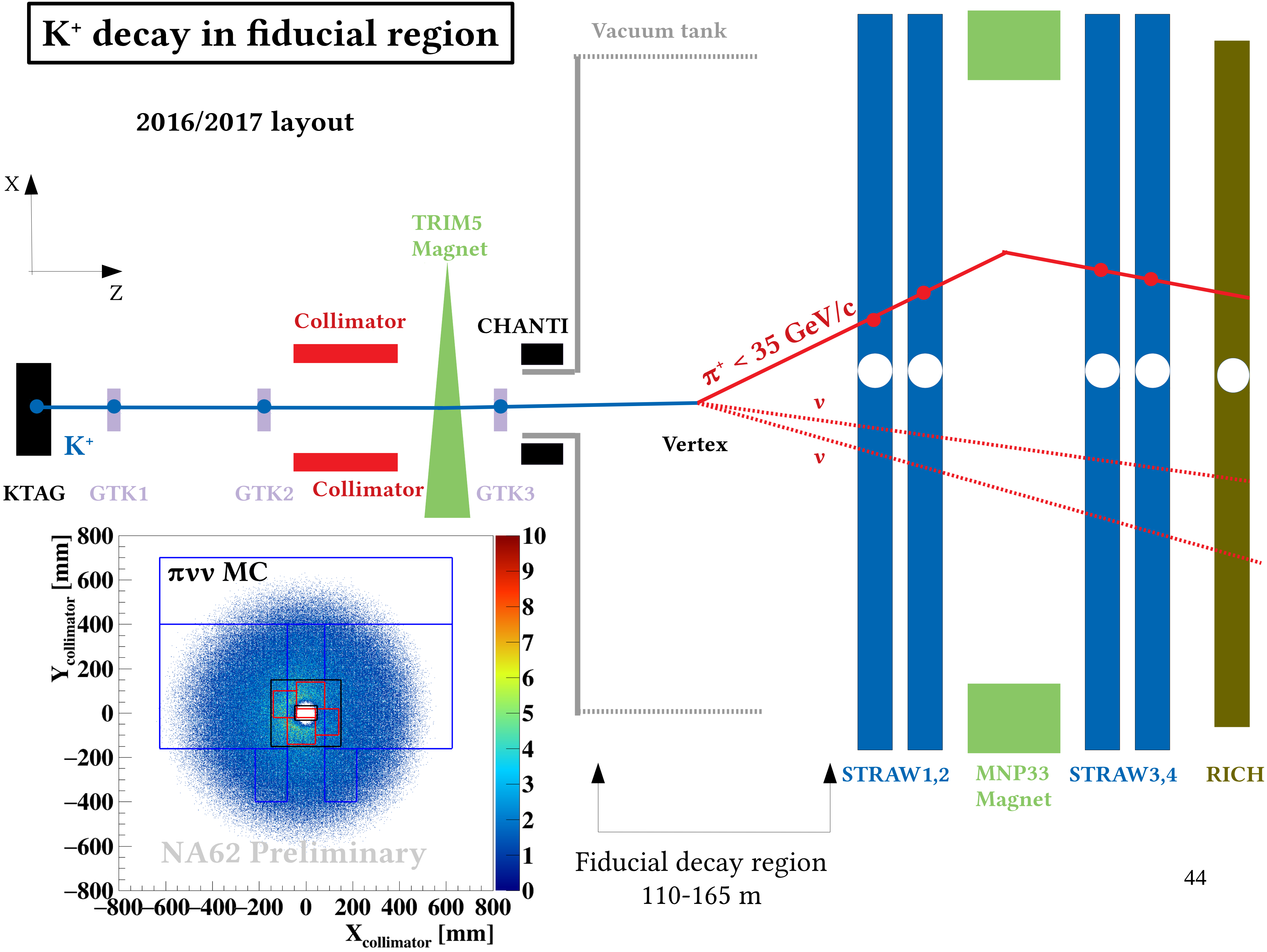
K^+ decay in fiducial region

2016/2017 layout



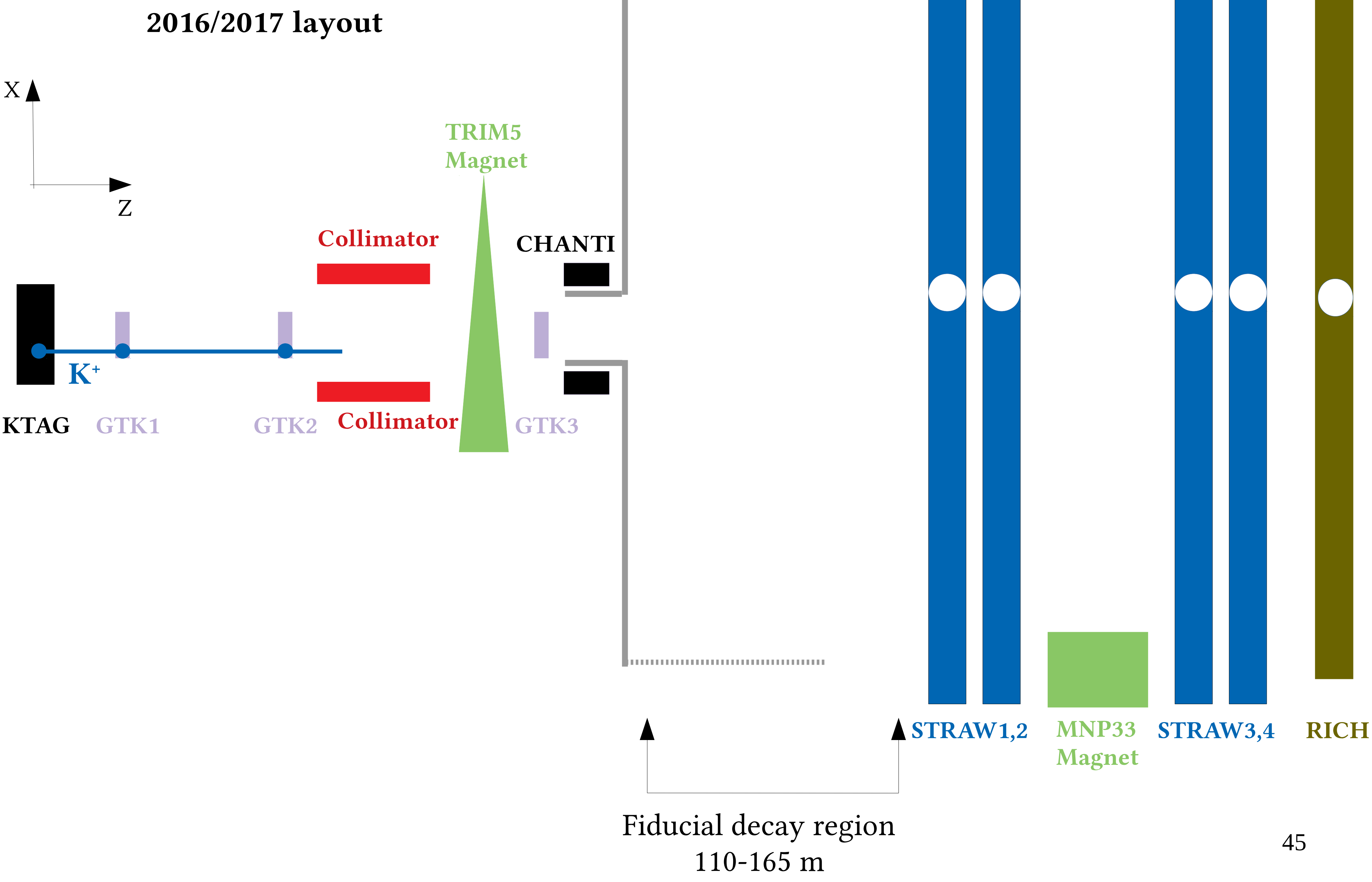
K⁺ decay in fiducial region

2016/2017 layout



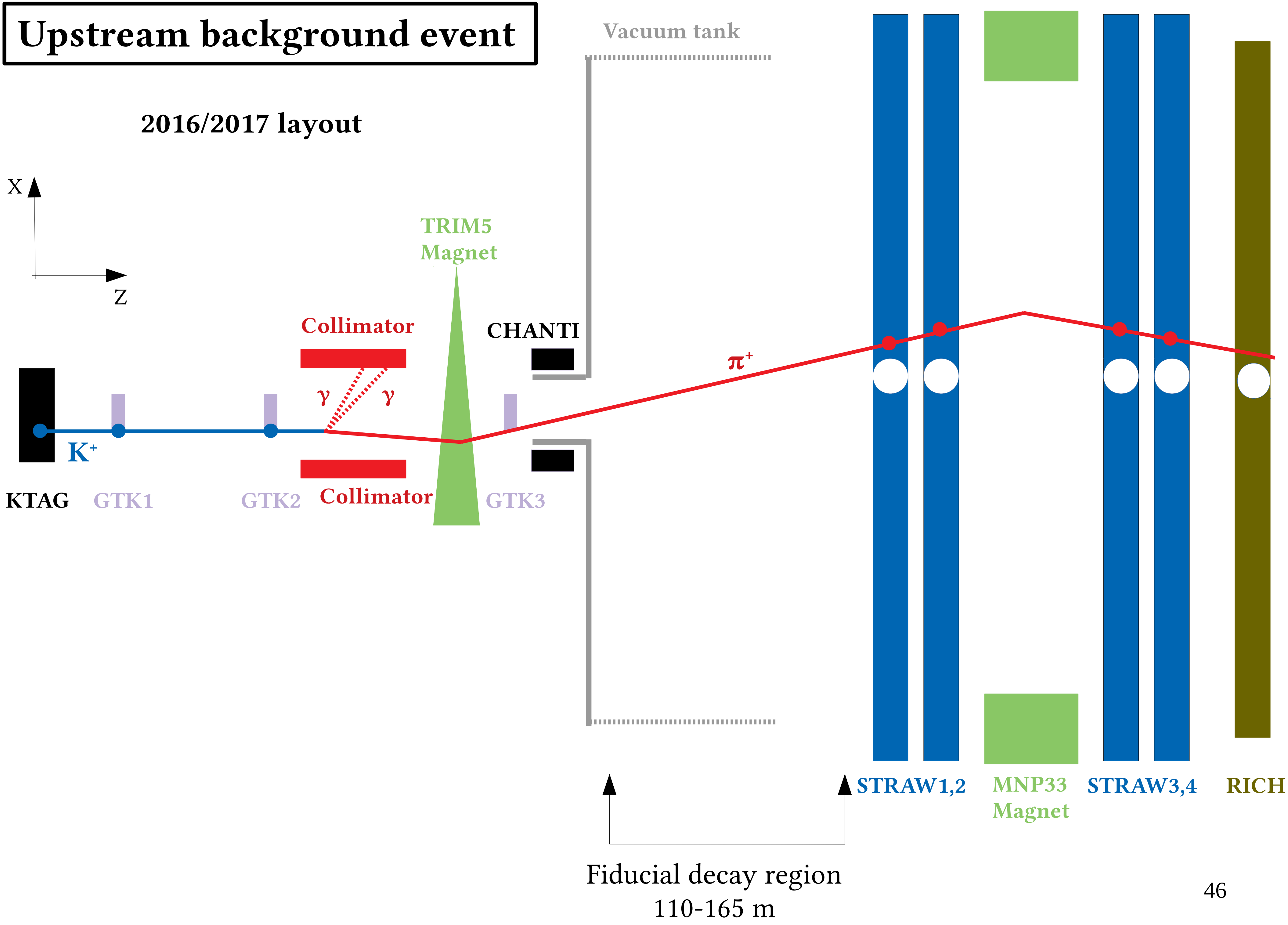
Fiducial decay region
110-165 m

Upstream background event



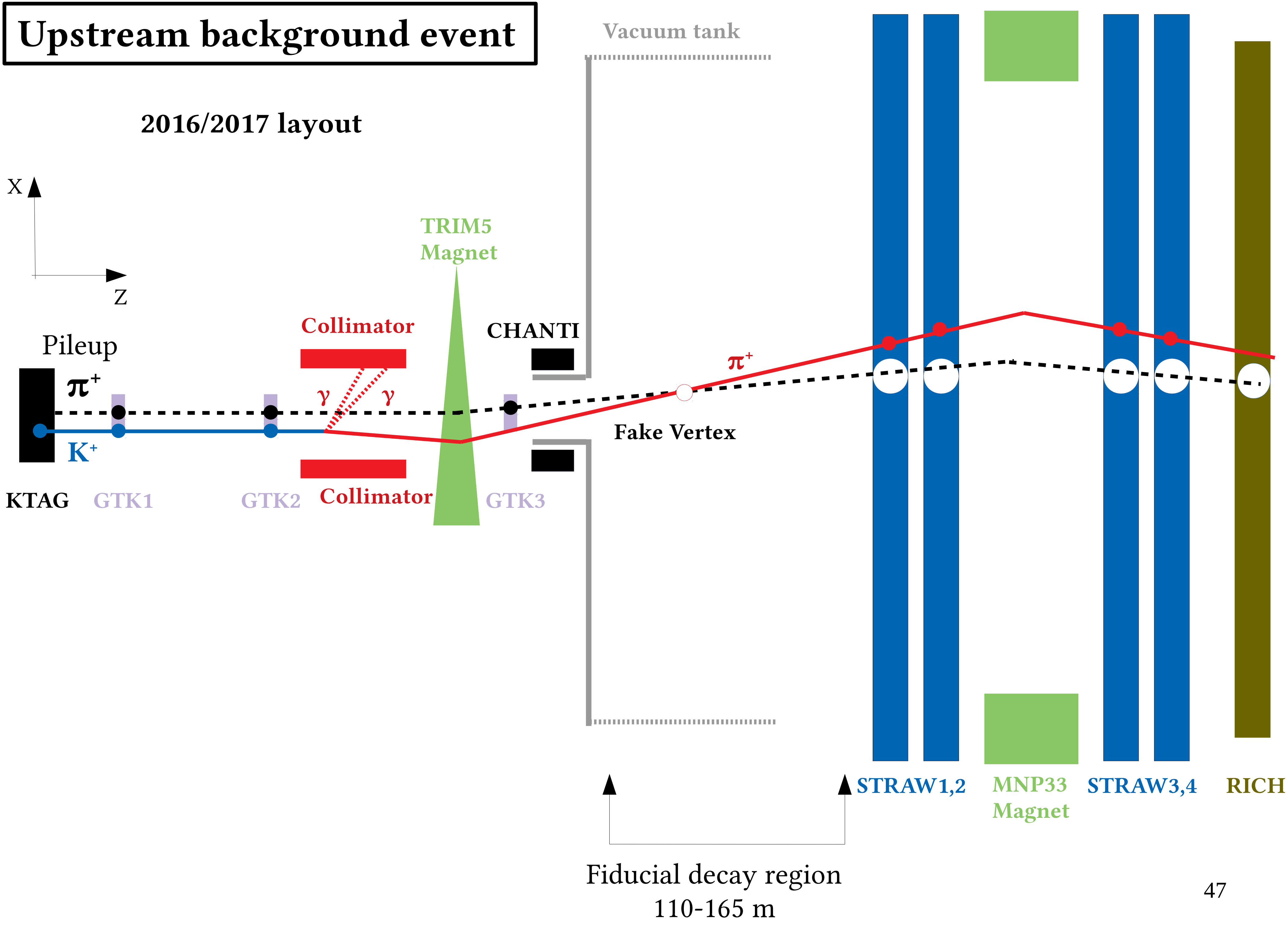
Upstream background event

2016/2017 layout



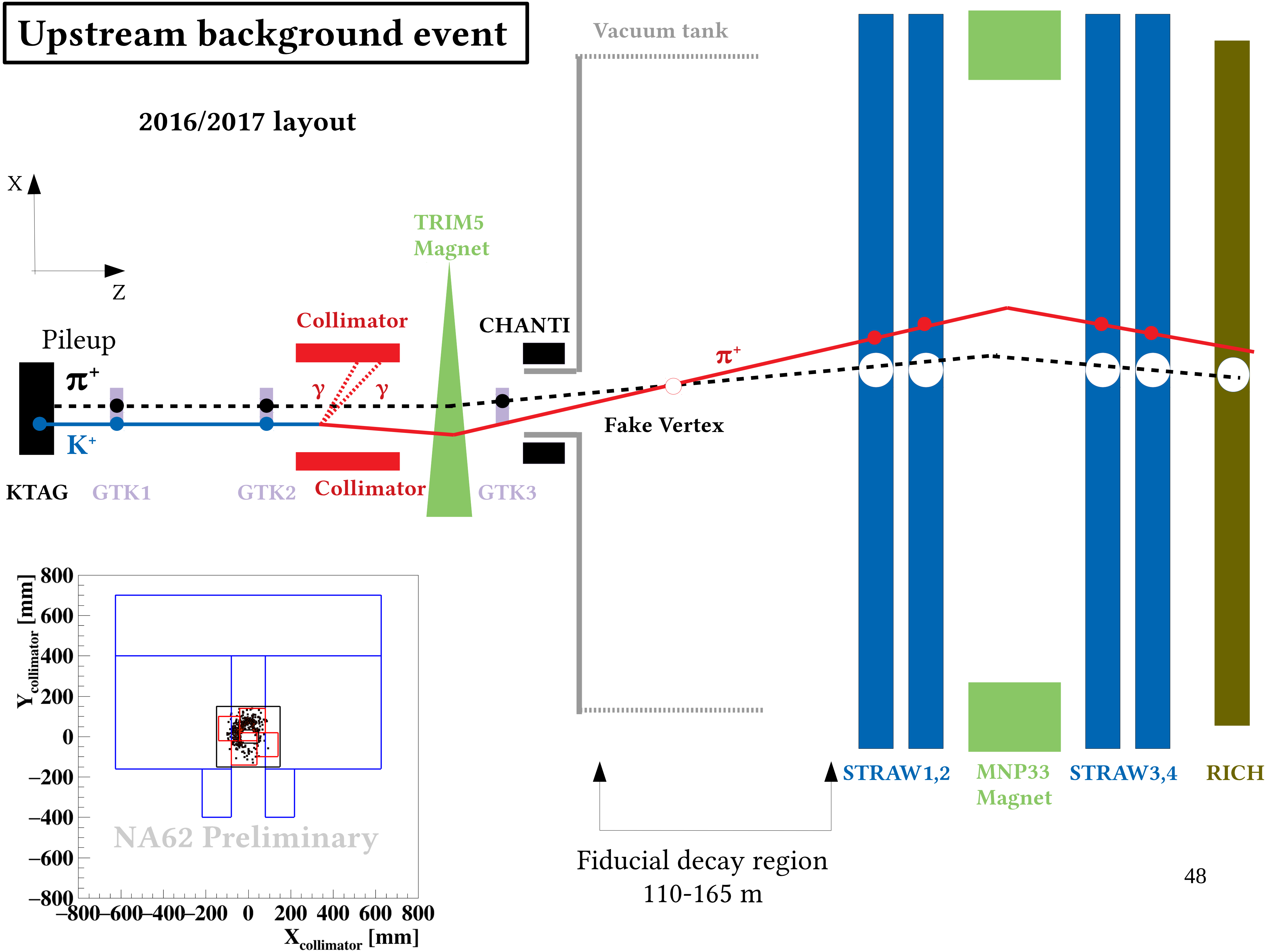
Upstream background event

2016/2017 layout



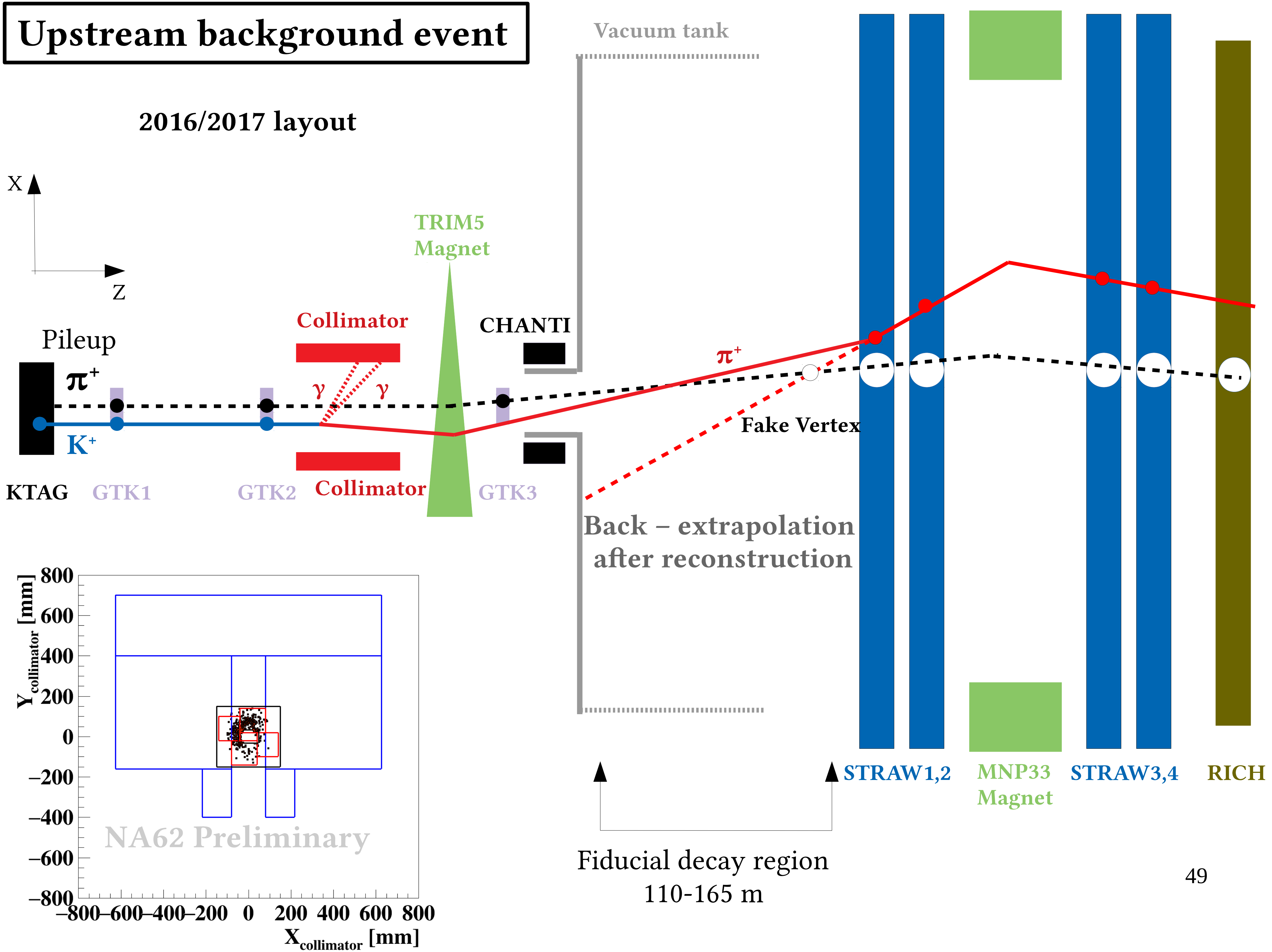
Upstream background event

2016/2017 layout



Upstream background event

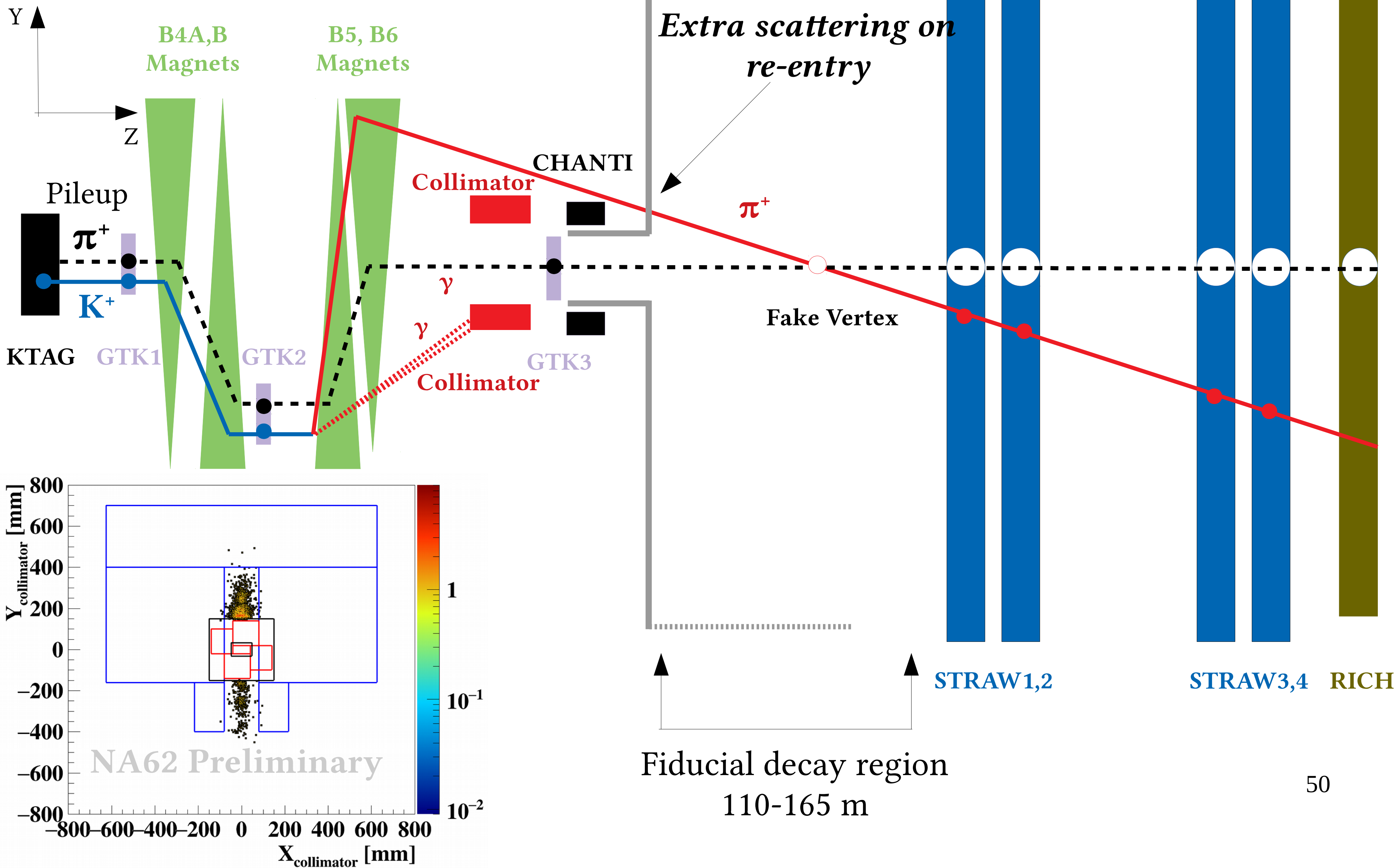
2016/2017 layout



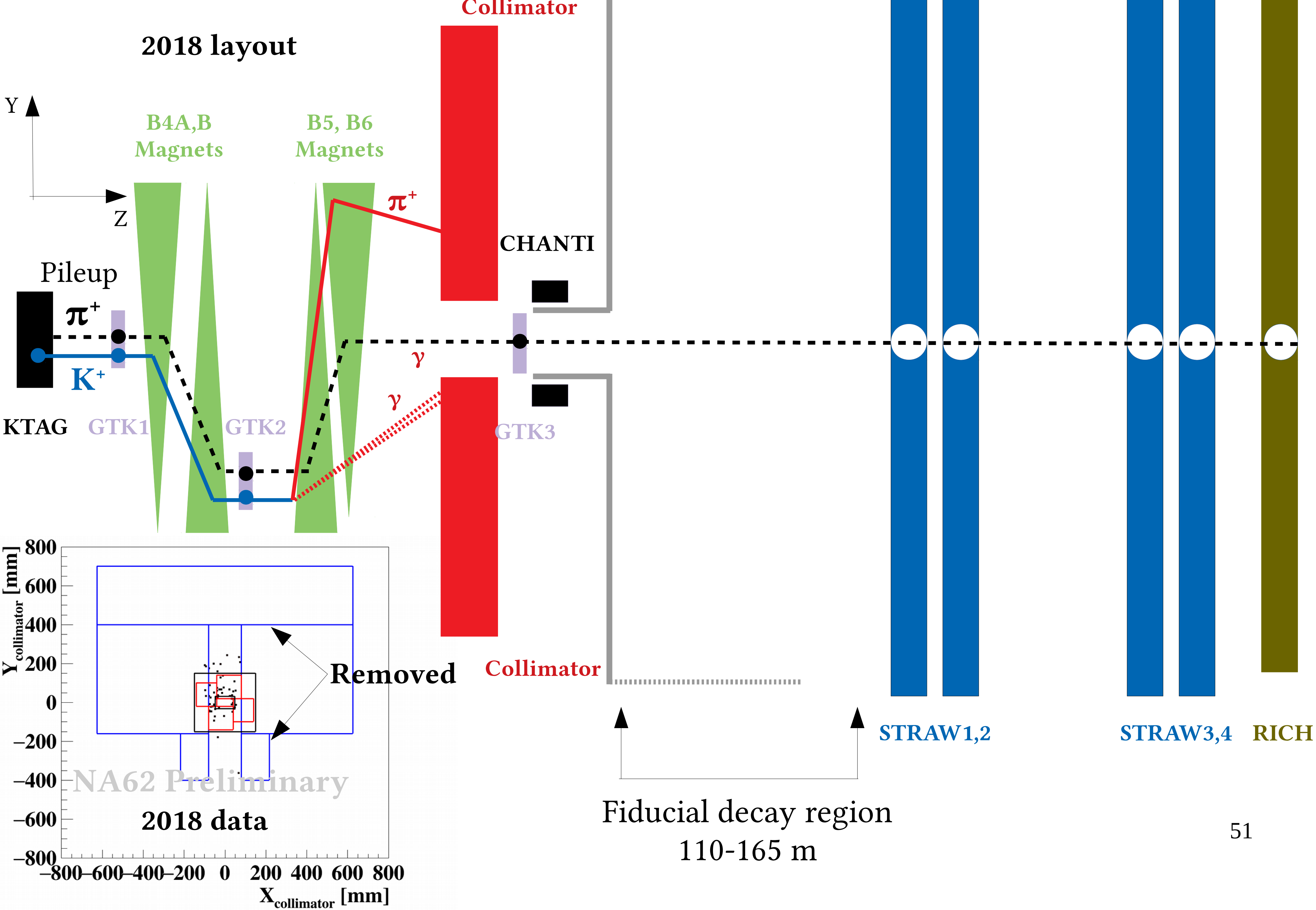
Fiducial decay region
110-165 m

Upstream background event

2016/2017 layout



Upstream background event



Background: Upstream decays

$$N^{bg}_{upstream} = N^{upstream}_{\pi+} \cdot P^{reco}_{pileup} \cdot P^{matching}_{K-\pi}$$

$N^{upstream}_{\pi+}$ $\Longrightarrow$ Events with a downstream 15-35 GeV/c π^+ originating upstream of GTK3

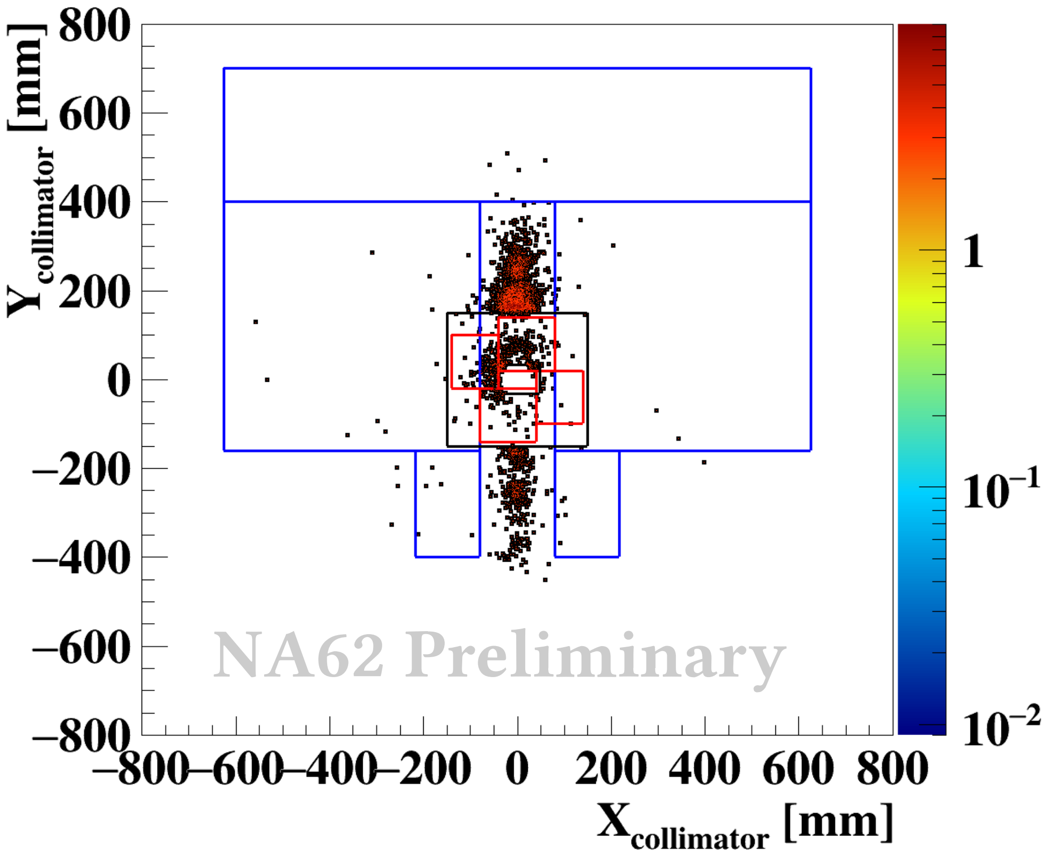
P^{reco}_{pileup} $\Longrightarrow$ Probability that the source of upstream π^+ is reconstructed in the GTK

$P^{matching}_{K-\pi}$ $\Longrightarrow$ Probability the downstream π^+ to be matched to a GTK track

Background: Upstream decays

$$N^{bg}_{upstream} = \boxed{N^{upstream}_{\pi^+} \cdot P^{reco}_{pileup}} \cdot P^{matching}_{K-\pi}$$

Count events in an upstream enriched sample

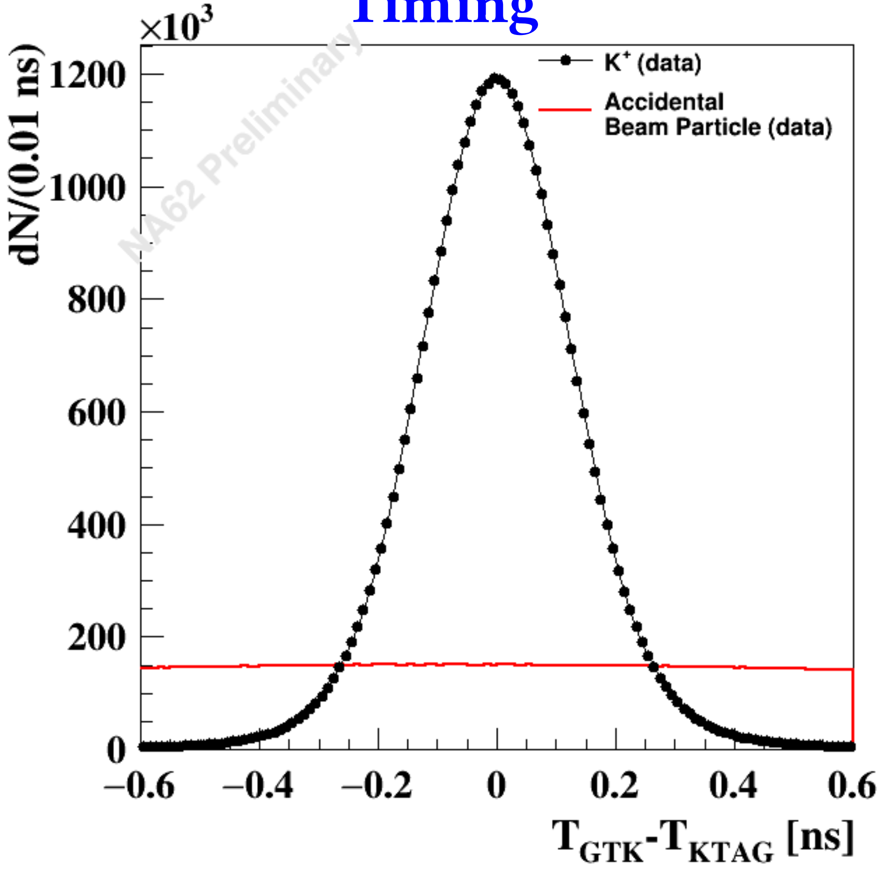


Background: Upstream decays

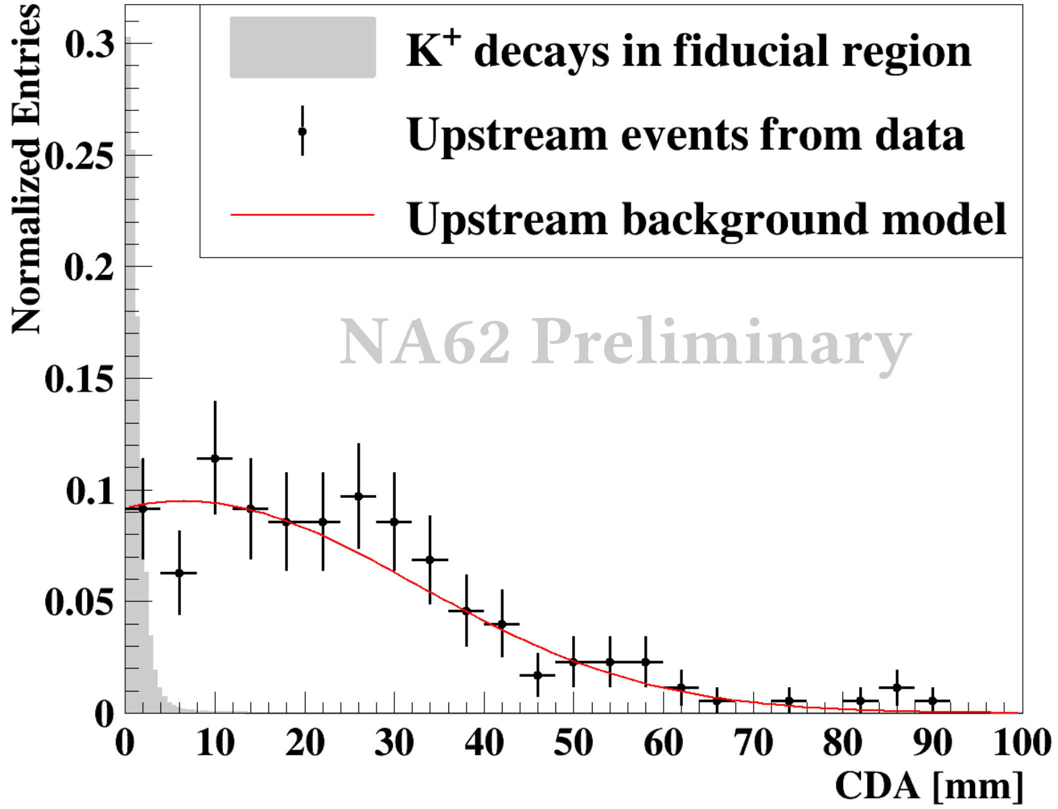
$$N^{bg}_{upstream} = N^{upstream}_{\pi^+} \cdot P^{reco}_{pileup} \cdot \boxed{P^{matching}_{K-\pi}}$$

Measured

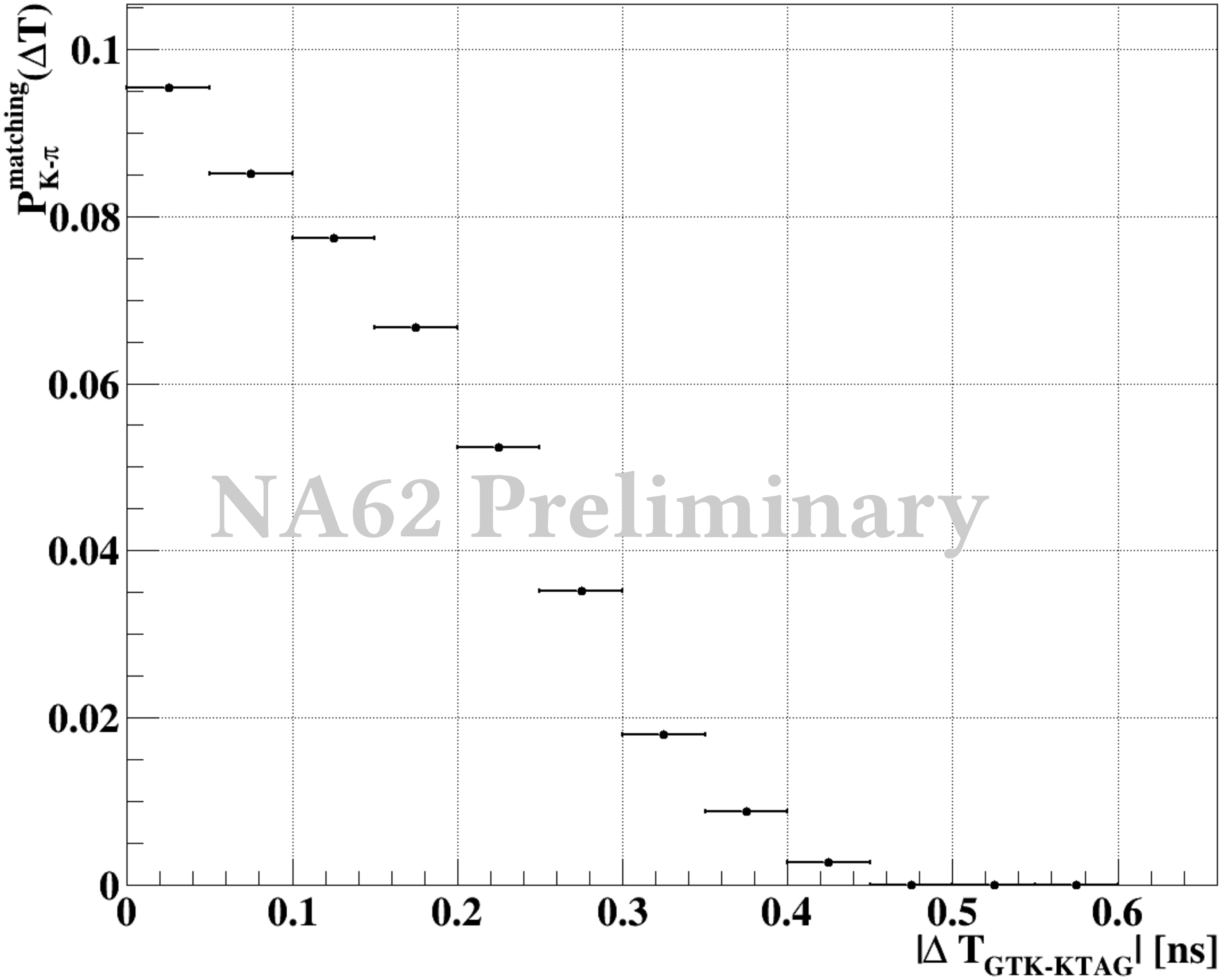
Timing



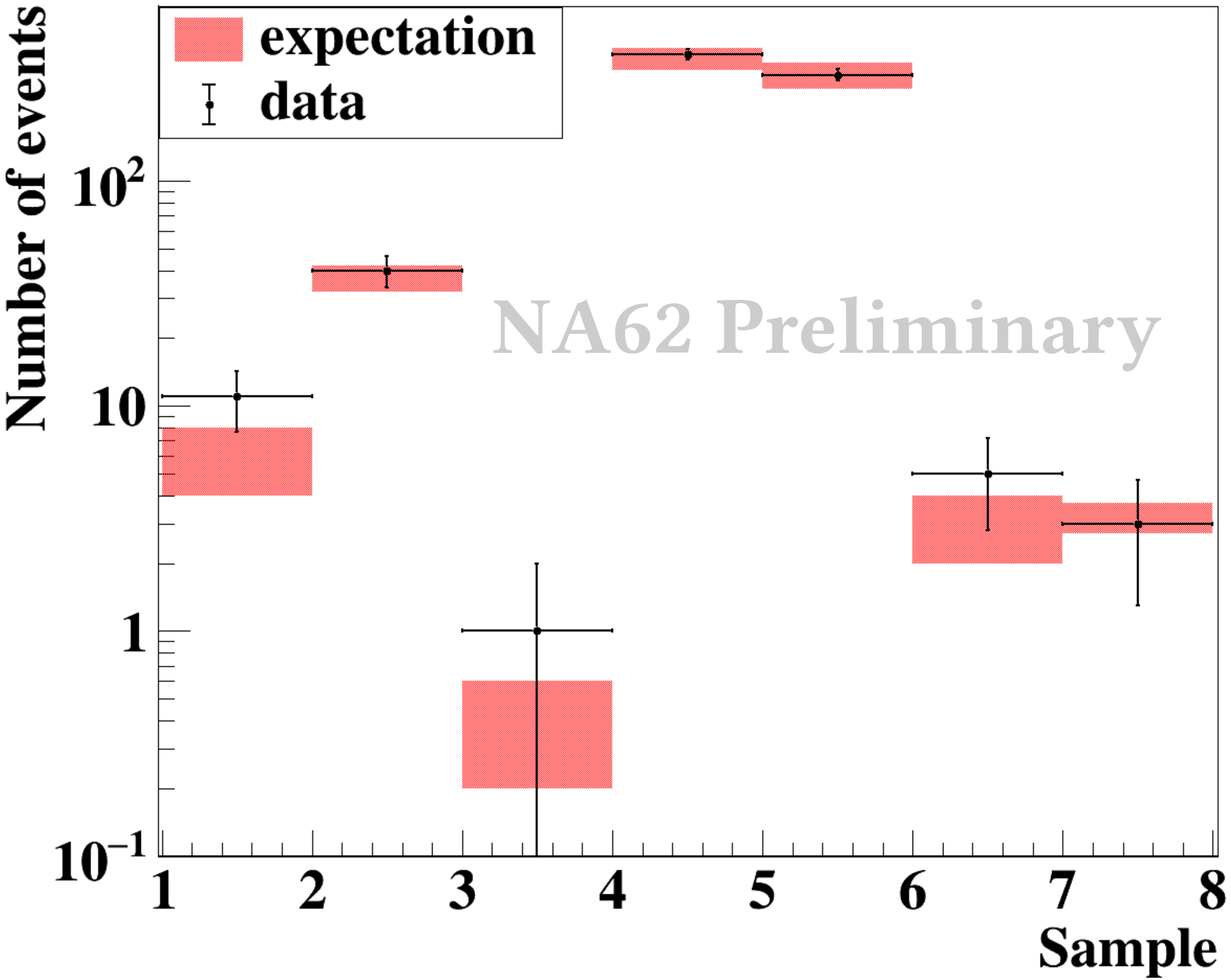
Closest distance of approach (CDA)



Background: $P^{matching}_{K-\pi}$ measurement



Background: Upstream decays validation



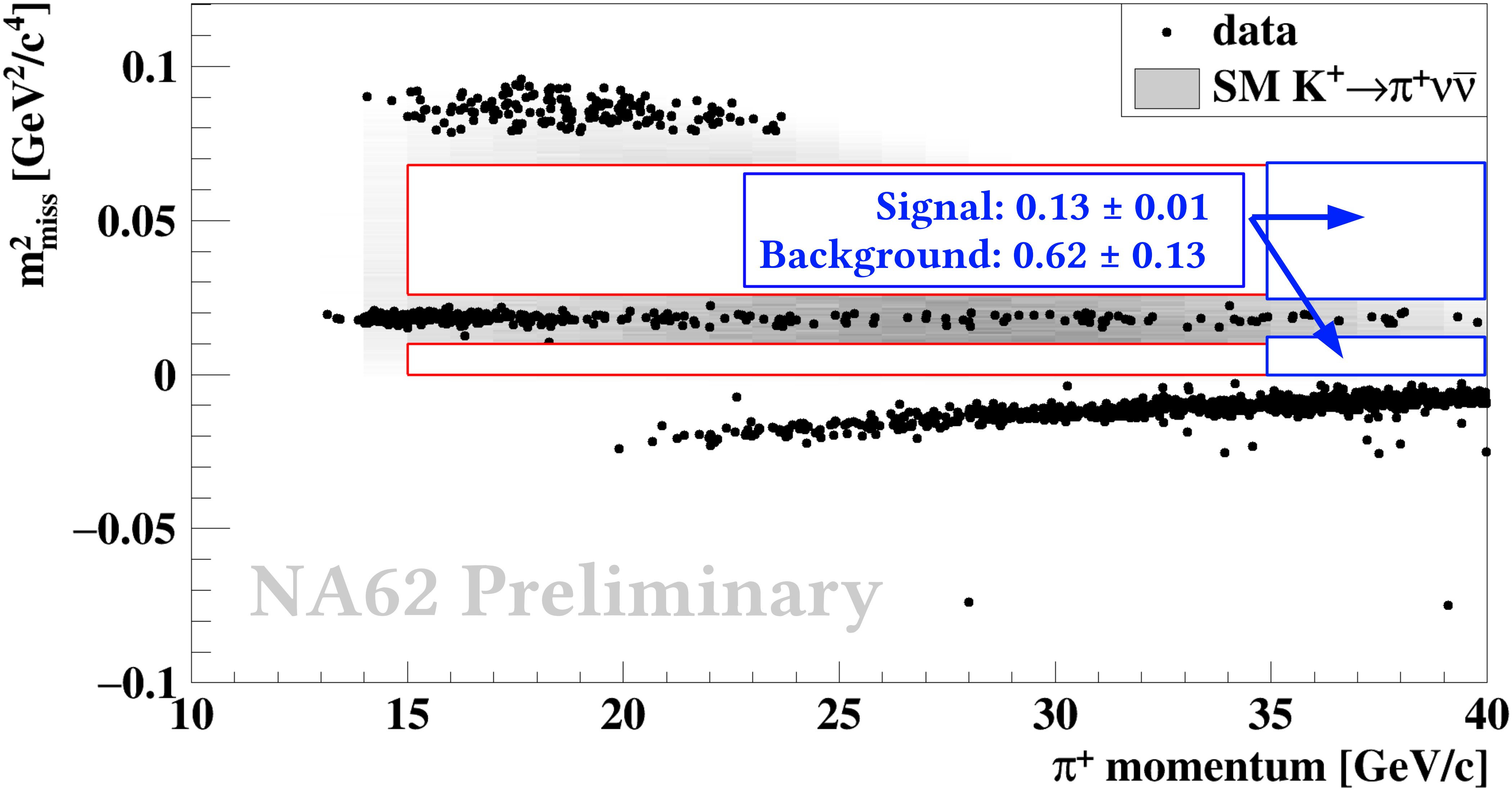
Total expected background

Process	Expected events
$K^+ \to \pi^+ \nu \bar{\nu}$ (SM)	$2.16 \pm 0.12_{stat} \pm 0.26_{ext}$
$K^+ \to \pi^+ \pi^0 (\gamma)$ IB	$0.29 \pm 0.03_{stat} \pm 0.03_{syst}$
$K^+ \to \mu^+ \nu_\mu (\gamma)$ IB	$0.15 \pm 0.02_{stat} \pm 0.04_{syst}$
$K^+ \to \pi^+ \pi^- e^+ \nu_e$	$0.12 \pm 0.05_{stat} \pm 0.03_{syst}$
$K^+ \to \pi^+ \pi^- \pi^+$	$0.02 \pm 0.02_{syst}$
$K^+ \to \pi^+ \gamma\gamma$	$0.005 \pm 0.005_{syst}$
$K^+ \to l^+ \pi^0 \nu_l$	negligible
Upstream background	$0.9 \pm 0.2_{stat} \pm 0.2_{syst}$
Total background	$1.5 \pm 0.2_{stat} \pm 0.2_{syst}$

4. Unblinding signal regions

Final background validation

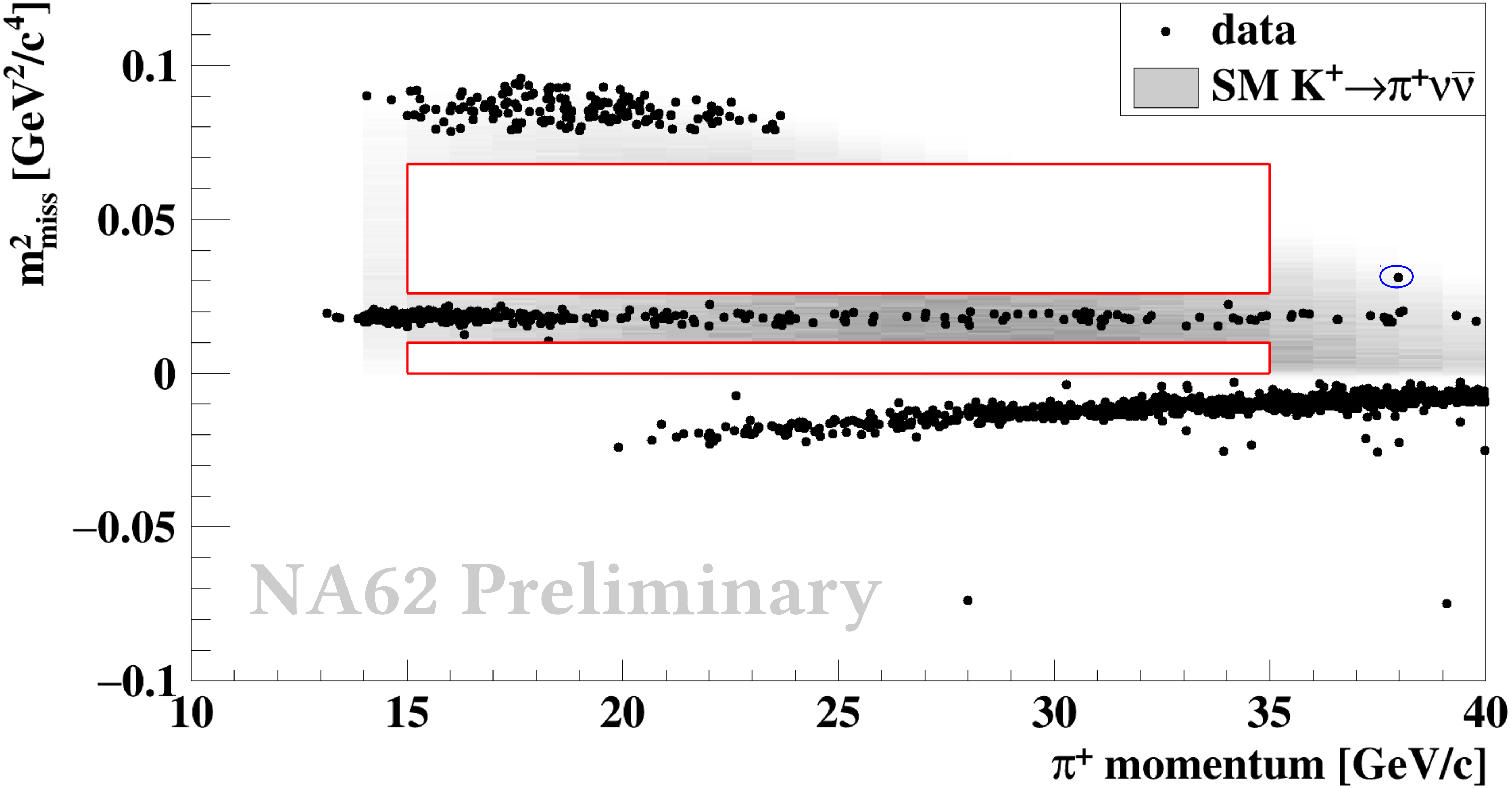
Signal and background evaluated in the 35-40 GeV/c signal-like region



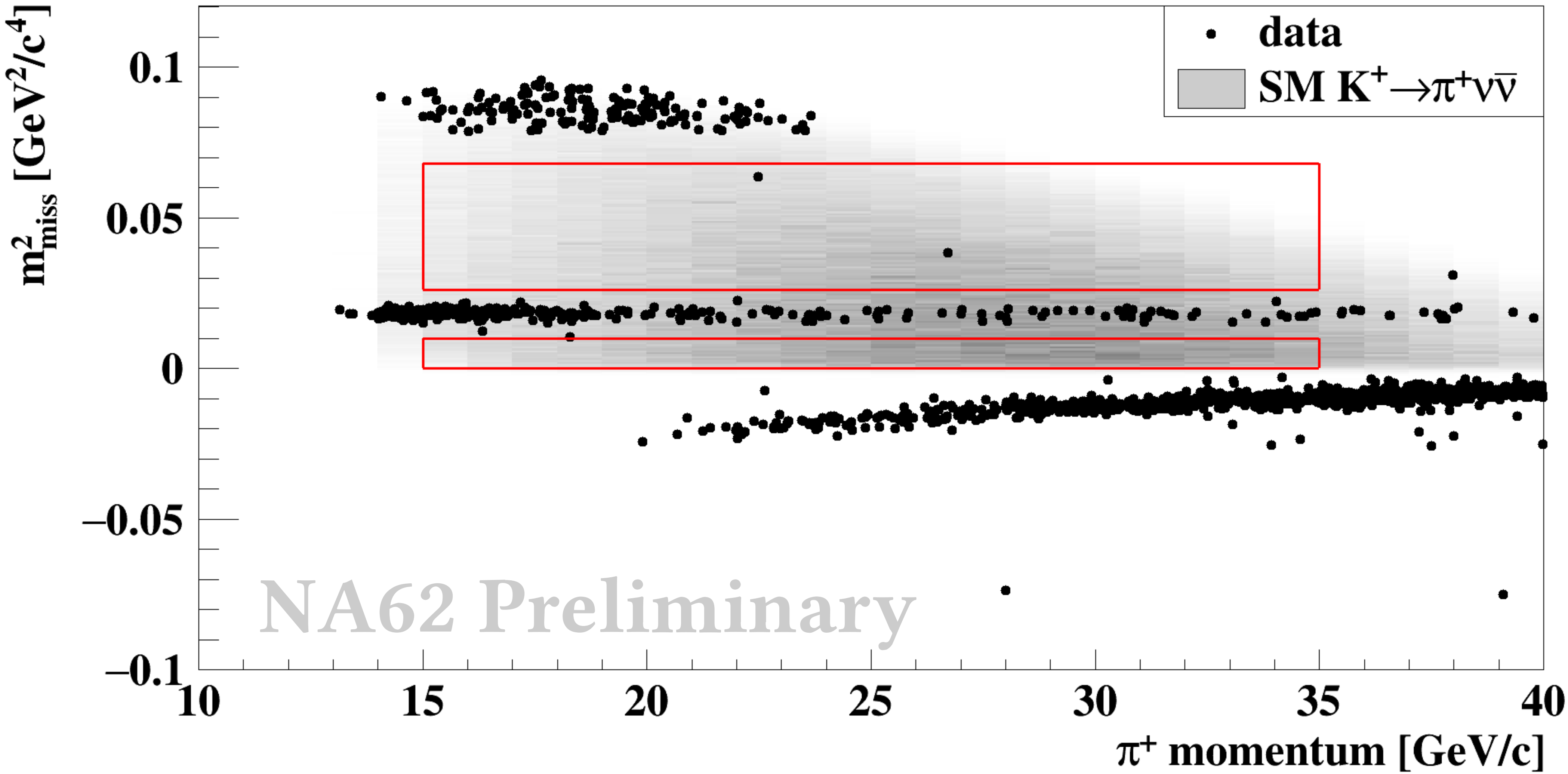
Signal: 0.13 ± 0.01

Background: 0.62 ± 0.13

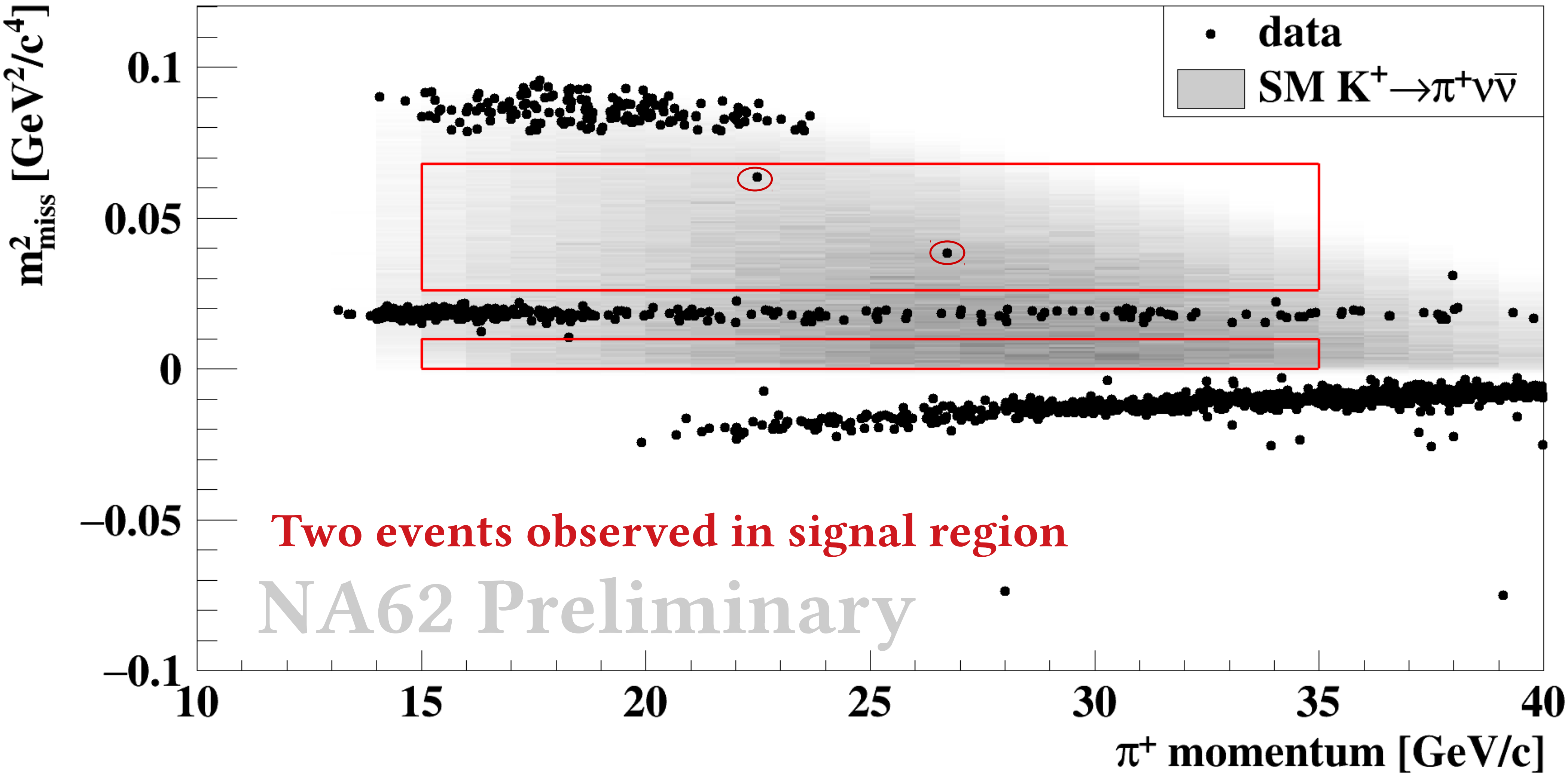
Final background validation



Opening the box

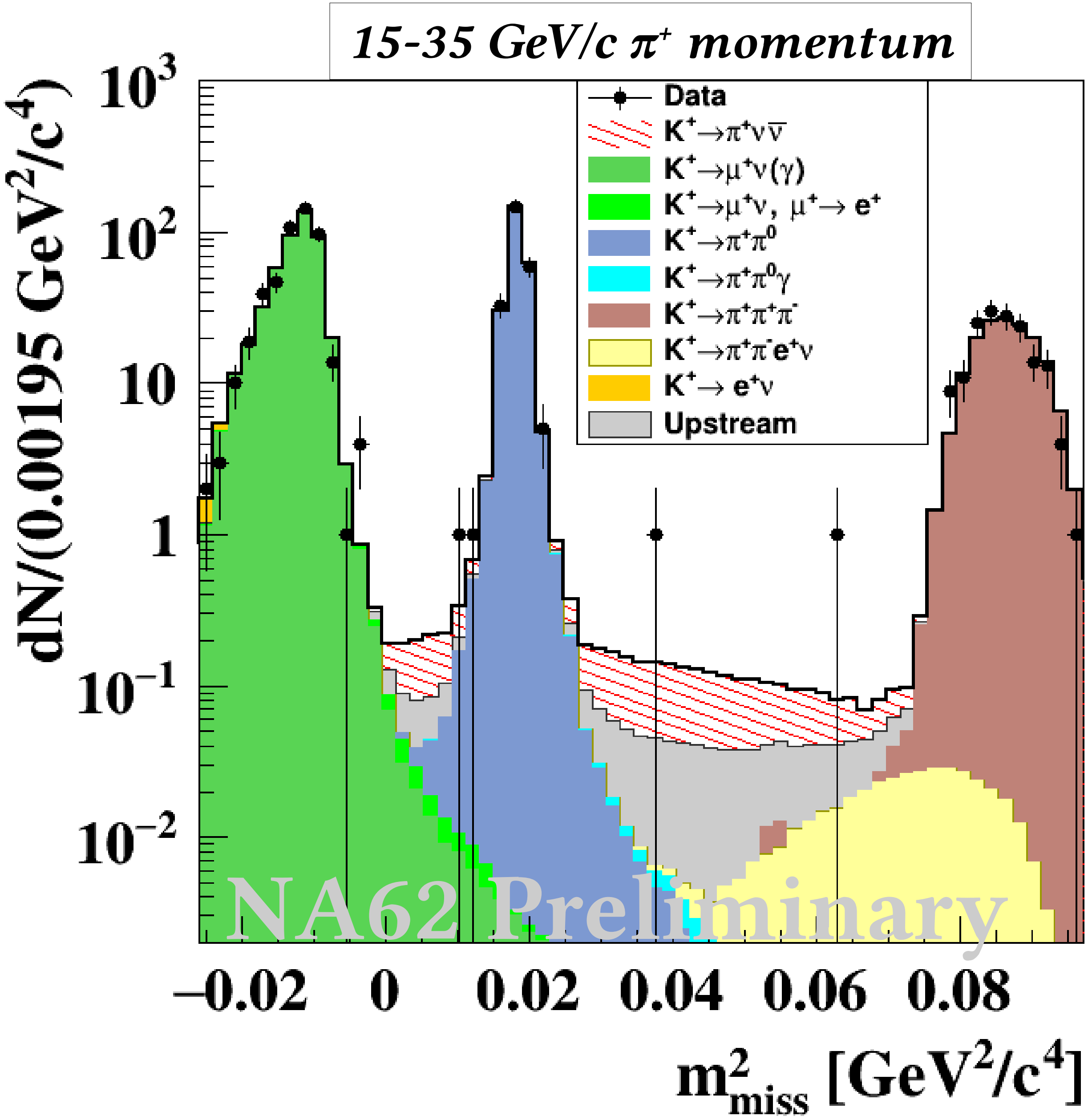


Opening the box

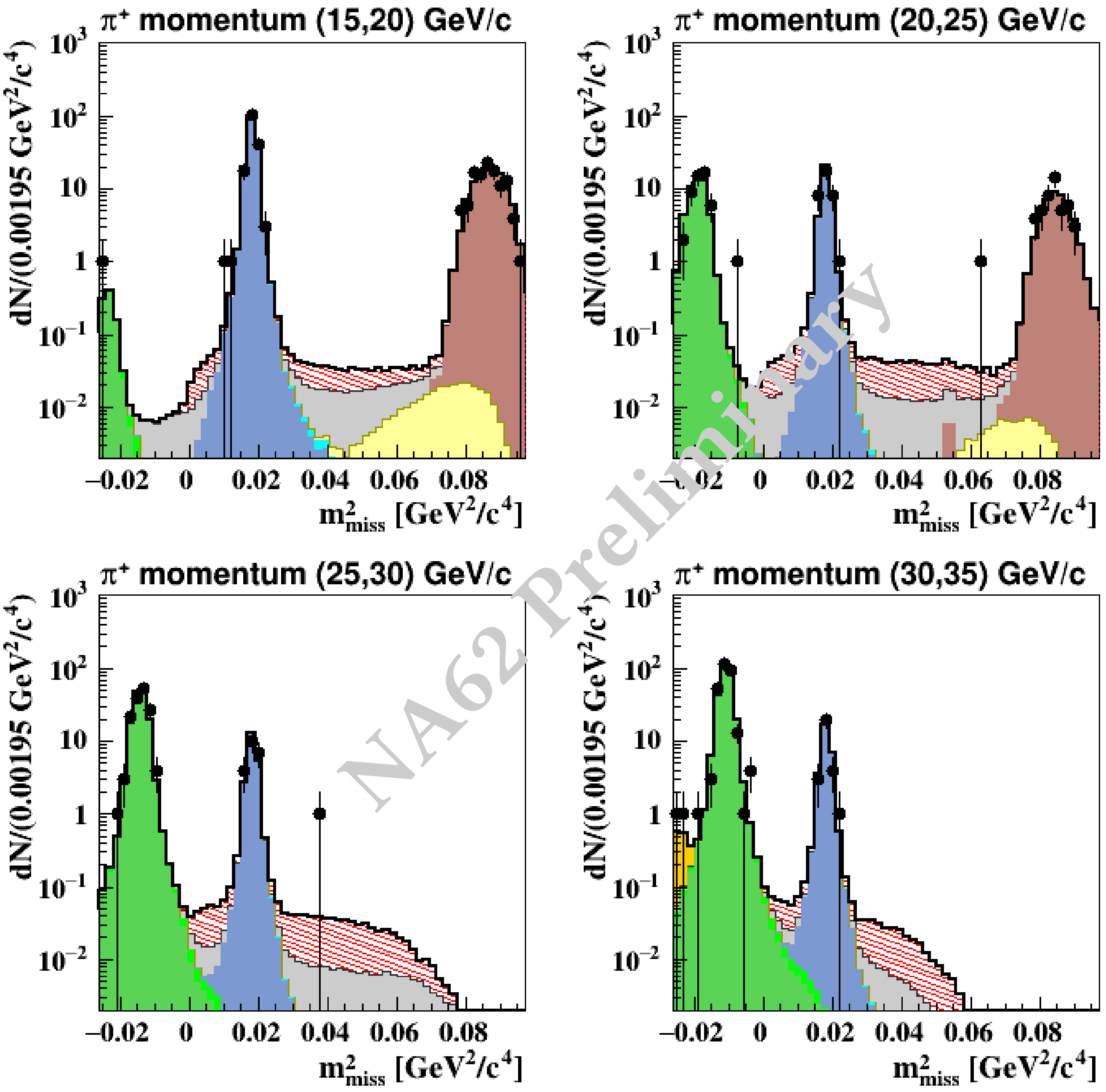


Two events observed in signal region

m^2_{miss} signal and background 2017



m^2_{miss} signal and background 2017



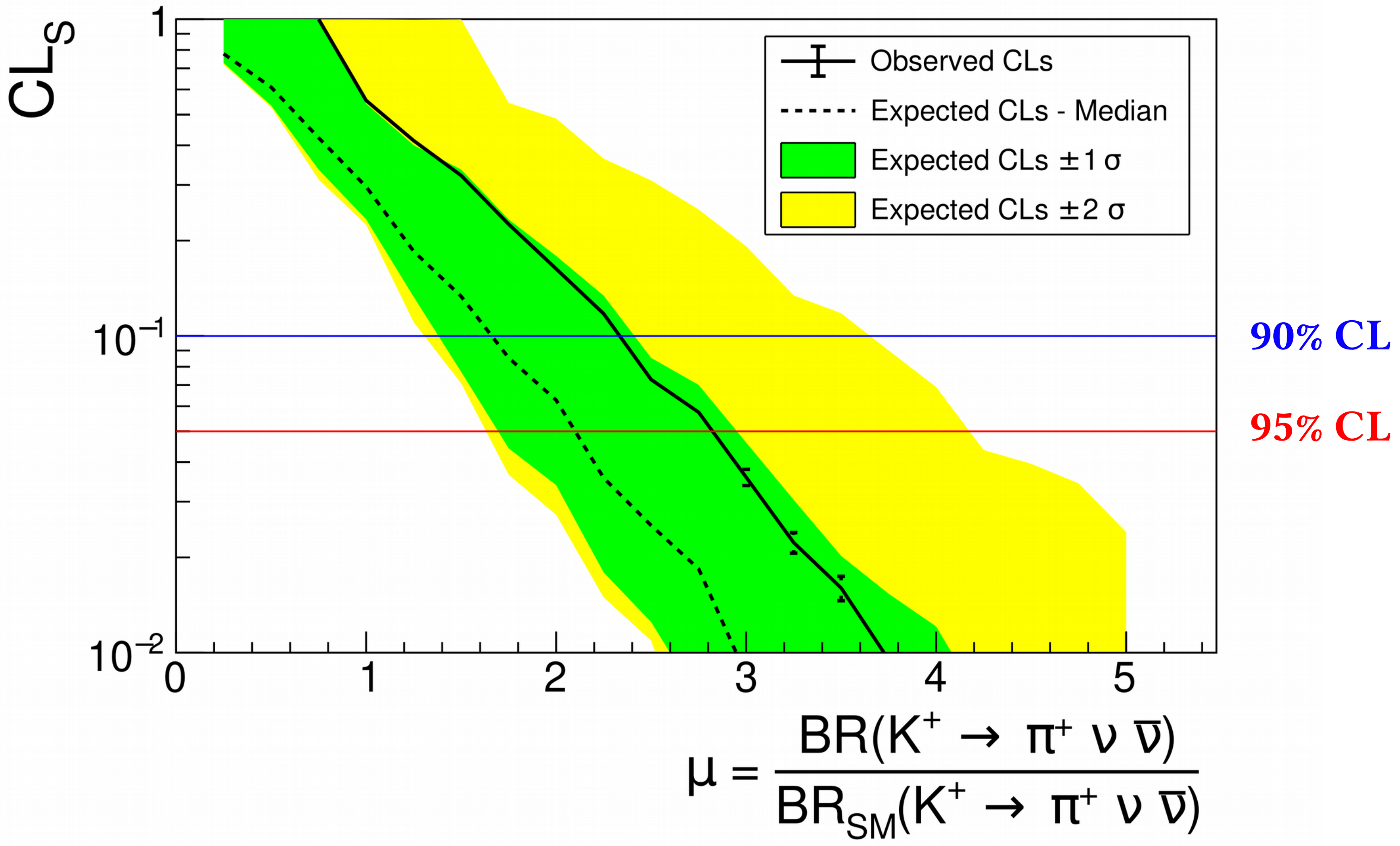
2016+2017 result

- Counting experiment:

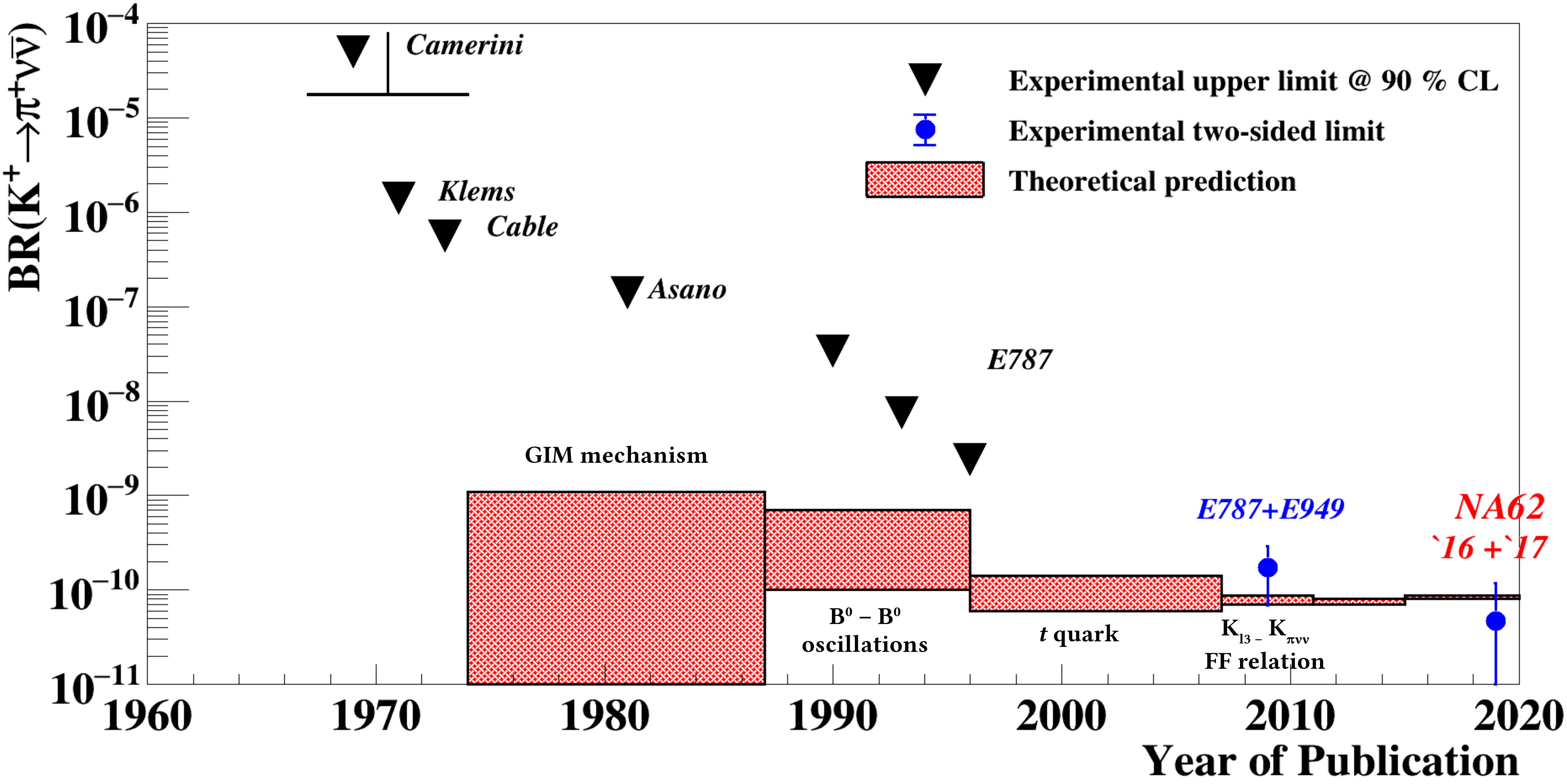
Events observed	**3**
Single event sensitivity	**$(0.346 \pm 0.017) \times 10^{-10}$**
Expected background	**1.65 ± 0.31**

- Two-sided 68% band:

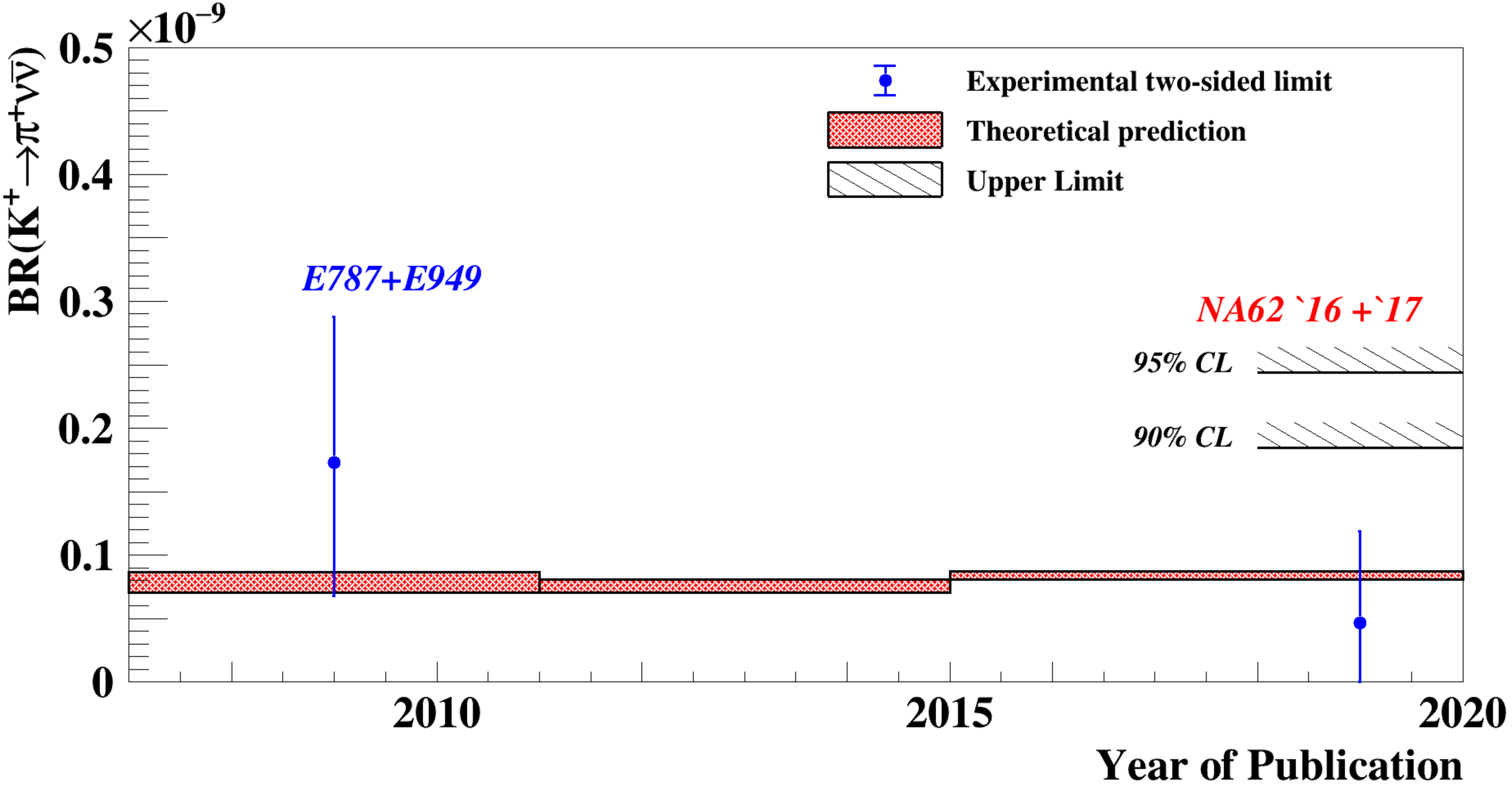
$Br(K^+ \rightarrow \pi^+ \nu\nu) = (0.47^{+0.72}_{-0.47}) \times 10^{-10}$



$K^+ \rightarrow \pi^+\nu\nu$: historical perspective

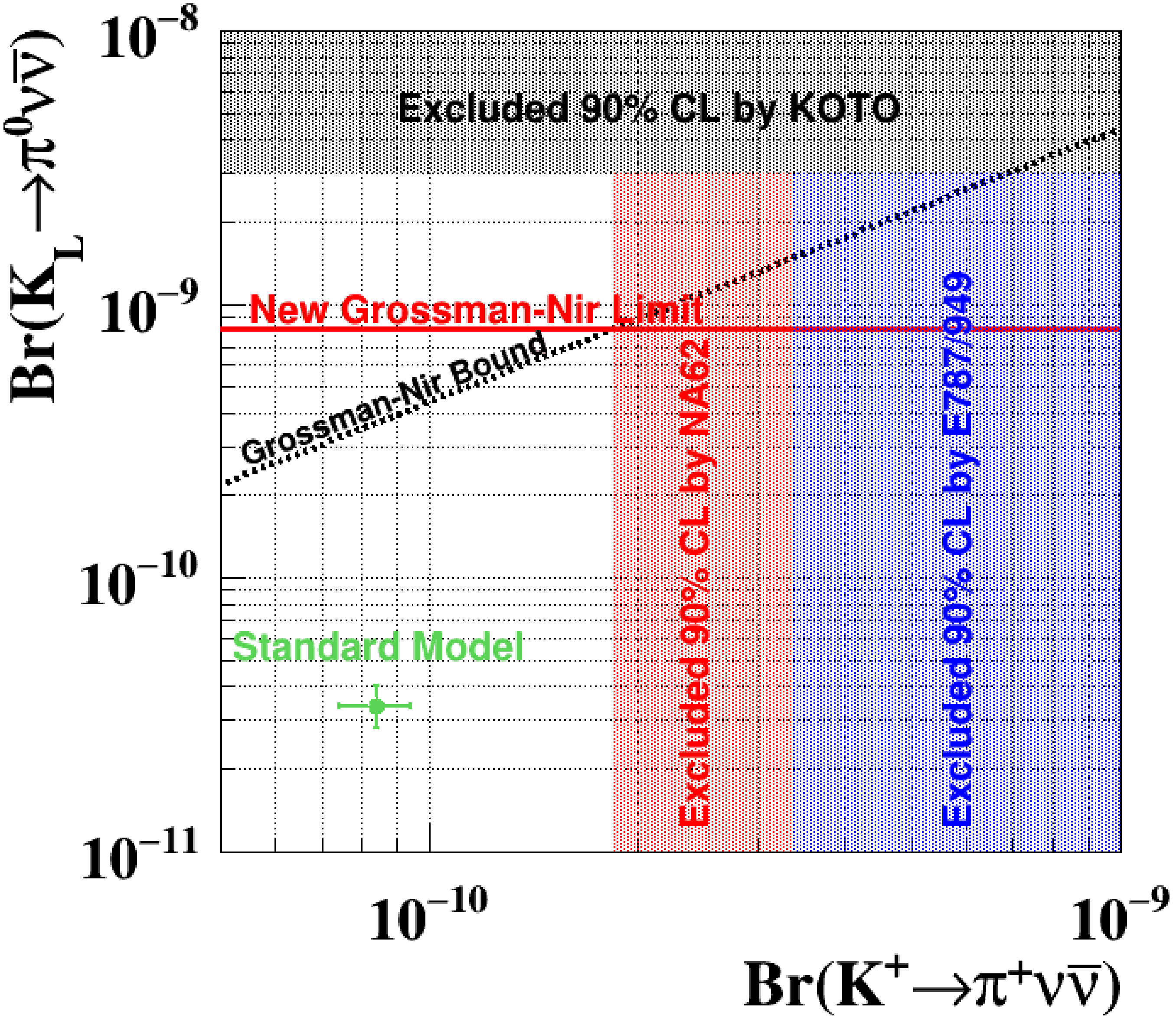


K⁺ → π⁺υυ: historical perspective



$K^+ \rightarrow \pi^+\upsilon\upsilon$: Grossman – Nir limits

- Grossman – Nir limit: **$Br(K_L \rightarrow \pi^0 \nu\nu) < 8.14\text{x}10^{-10}$ @ 90% CL**



Conclusions

- Two events in signal region observed in 2017 data
- 2016+2017 NA62 result

$$BR(K^+ \to \pi^+ \nu\nu) < 1.85 \times 10^{-10} \text{ @ 90 \% CL}$$

$$BR(K^+ \to \pi^+ \nu\nu) = 0.47^{+0.72}_{-0.47} \times 10^{-10}$$

- Constraints on the largest enhancements allowed by NP models

Prospects for the 2018 data

- 2018 data analysis in progress
  - Factor 2 more data than in 2017
- On-going studies to increase signal efficiency (selection optimization)
- Presence of the new collimator
  - Increase of signal acceptance
- Improvement in modelling the m^2_{miss} and momentum distribution of upstream decays thanks to the higher statistics

NA62 in 2021

- Plans to modify beam line set-up in order to suppress the upstream background
  - Bending magnets used in the current achromat too weak to swipe away all π^+ from K^+ decays
  - Studies are on-going and subject to improvement
- Add fourth Gigatracker station (GTK4) to reduce mistagging probability
- Improve multi-charged rejection at small angles (impact of π^0 rejection)
  - Reduction of background from $\pi^+\pi^0$ and multi-charged decay modes ($\pi^+\pi^+\pi^-$, $\pi^+\pi^-e^+\nu$)