



The NA62 $K^+ \rightarrow \pi^+ \nu\bar{\nu}$ experiment at CERN

Marco Boretto - INFN Torino
on behalf of the NA62 collaboration
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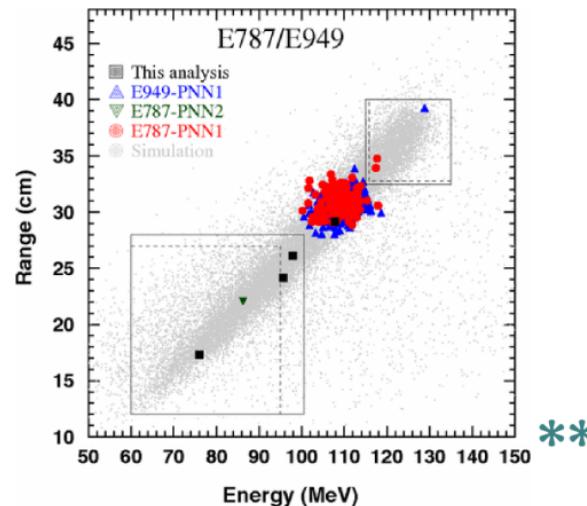


Why measuring $K^+ \rightarrow \pi^+ \nu \bar{\nu}$

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

- is one of the theoretically cleanest meson decay where to look for of new physics;
- this process extremely rare: is Flavor Changing Neutral Current decay

$$BR(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (0.84 \pm 0.10) \times 10^{-10} *$$



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

The NA62 Collaboration aims to collect **few tens** $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ decays in 3 years of data-taking, with:

- 10% precision and
- ~10% of acceptance.

*Buras et al., JHEP 1511 (2015) 033

**E787/E949 Collab., PRL 101 (2008) 191802

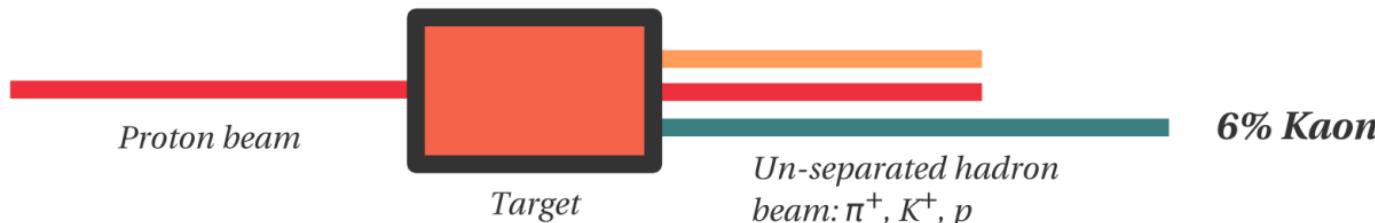
The NA62 experiment at CERN



Birmingham, Bratislava, Bristol, Bucharest, CERN, Dubna (JINR), Fairfax, Ferrara, Florence, Frascati, Glasgow, Liverpool, Lancaster, Louvain-la-Neuve, Mainz, Merced, Moscow(INR), Naples, Perugia, Pisa, Prague, Protvino (IHEP), Rome I, Rome II, San Luis Potosi, Sofia, TRIUMF, Turin, Vancouver (UBC) ~ 200 participants, ~ 30 institutions

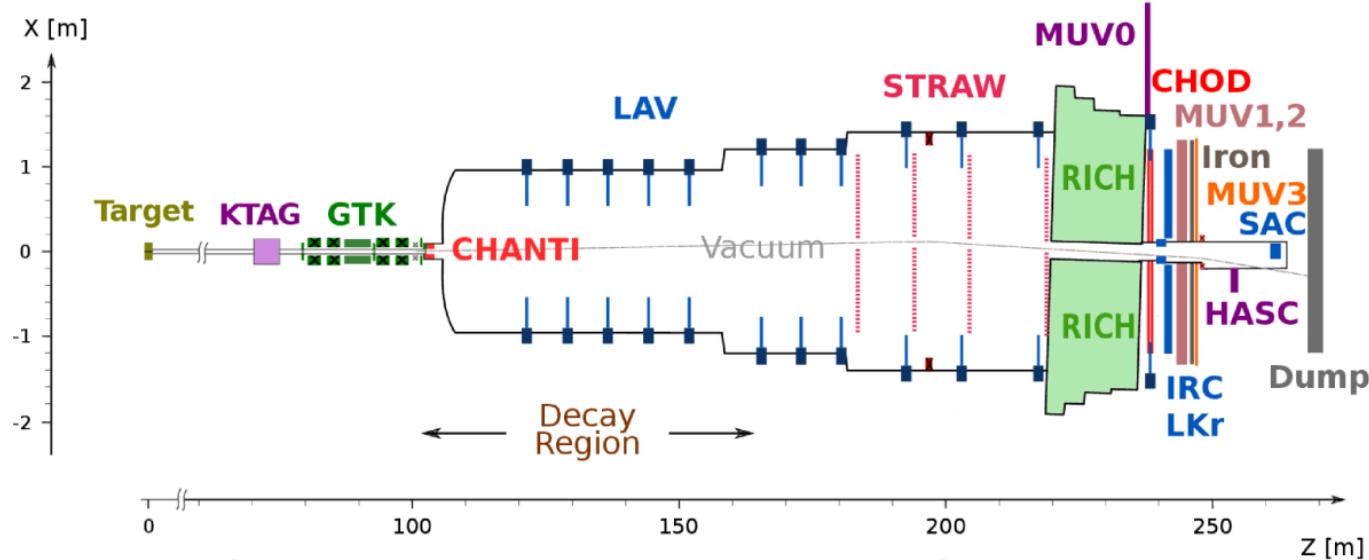


NA62 high intensity Kaon beam



- 400 GeV/c SPS primary **proton** beam
- 3×10^{12} protons/pulse
- 40cm berillium target
- 75 GeV/c un-separated hadron beam: π^+ , K^+ , **proton** ($\Delta p/p \pm 1\%$)
- 6% K^+ component
- $4.8 \times 10^{12} K^+$ decays/y → Single Event Sensitivity $\sim 10^{-12}$

The NA62 detector



Incoming particle:

- GTK beam tracking
- KTAG: K^+ identification

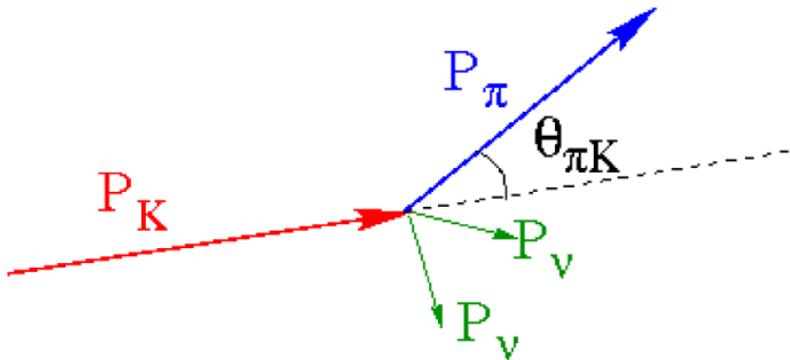
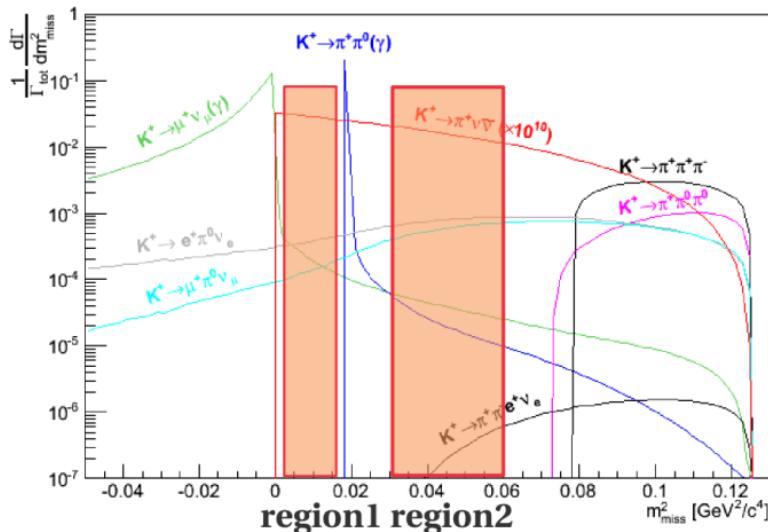
Decay products:

- STRAW secondary particles tracking
- RICH: π/μ identification
- LAV, LKR, SAV: photon vetoes

Background and kinematics

$K^+ \rightarrow \pi^+ \nu \bar{\nu}$ **fingerprint** is:

- one Kaon candidate in the initial state,
- one π^+ candidate in the final state and
- nothing else



$$m_{miss}^2 = (P_{K^+} - P_{\pi^+})^2$$

Defines two low background signal regions separated by $K2\pi$ peak.

The $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ analysis

Data-taking 2016

- ~ 4×10^{11} K^+ decays collected suitable to $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ analysis.
- the complete analysis is done blindly
- 5% of the 2016 dataset is presented

The main requirements for the analysis are:

- very good kinematic reconstruction and precise timing;
- particle identification between $\pi/\mu/e$ tracks to suppress decays with μ^+ or e^+ in the final state;
- photon rejection to suppress decays with $\pi^0 \rightarrow \gamma\gamma$ and radiative decays.

K^+/π^+ matching

Selection:

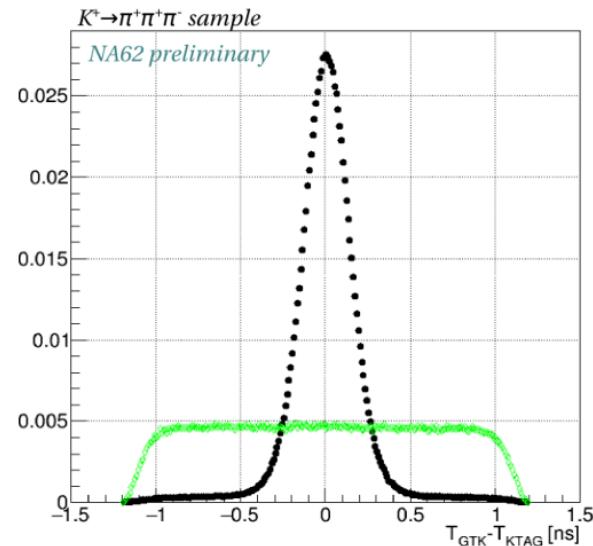
- Single π^+ topology in downstream detectors (STRAW, CHOD, LKr)
- K ID in KTAG
- K/π matching based on time and spatial measurements up and downstream(Closest Distance of Approach-CDA)

Timing π^+ : σ_T (CHOD)~250ps, σ_T (RICH)~150ps

Timing K^+ : σ_T (KTAG)~80ps, σ_T (GTK)~100ps

Spatial matching: σ_{CDA} ~1.5mm

K^+/π^+ matching studied with a sample of $K^+\rightarrow\pi^+\pi^+\pi^-$
 Kaon Mis-tagging probability: ~1.7%
 [40% nominal intensity]



Distribution of the time difference between GTK and KTAG time candidates for K^+ and π^+ selected $K^+\rightarrow\pi^+\pi^+\pi^-$ (black dots); green dots are computed with a random beam track.

Kinematic reconstruction performances

3 Missing mass definitions:

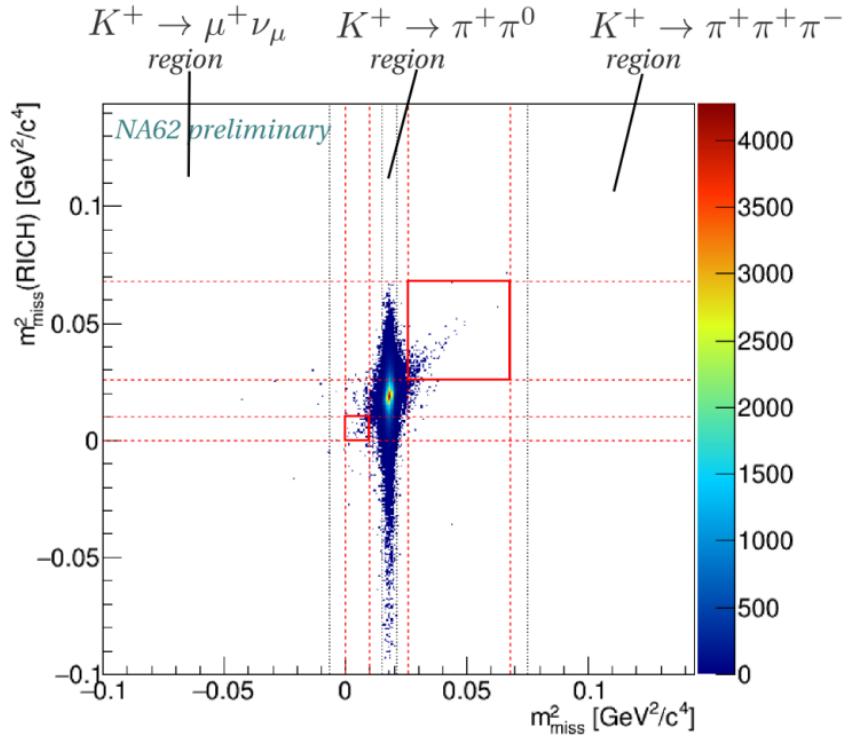
$$m_{miss}^2 = (P_{K^+}^{GTK} - P_{\pi^+}^{STRAW})^2$$

$$m_{miss}^2(RICH) = (P_{K^+}^{GTK} - P_{\pi^+}^{RICH})^2$$

$$m_{miss}^2(NoGTK) = (P_{K^+}^{beam} - P_{\pi^+}^{STRAW})^2$$

Kinematic suppression measured on the data:

- $K^+ \rightarrow \pi^+ \pi^0 \sim 6 \times 10^{-4}$
- $K^+ \rightarrow \mu^+ \nu \sim 3 \times 10^{-4}$



Particle identification π/μ separation

Particle ID with calorimeters (LKr, MUV1, 2 and 3):

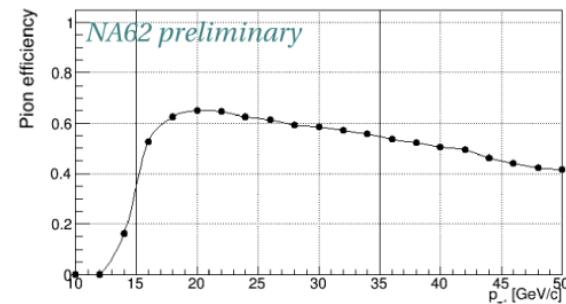
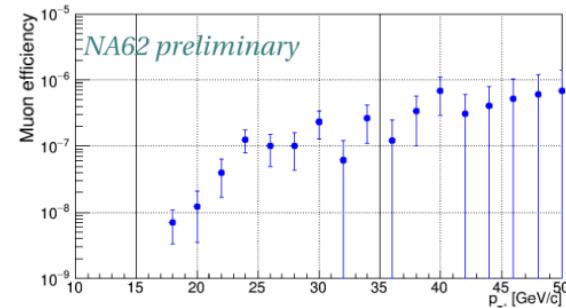
- $\epsilon(\mu) \sim 10^{-5}$
- $\epsilon(\pi) \sim 80\%$

Particle ID with RICH:

- $\epsilon(\mu) \sim 10^{-2}$
- $\epsilon(\pi) \sim 80\%$

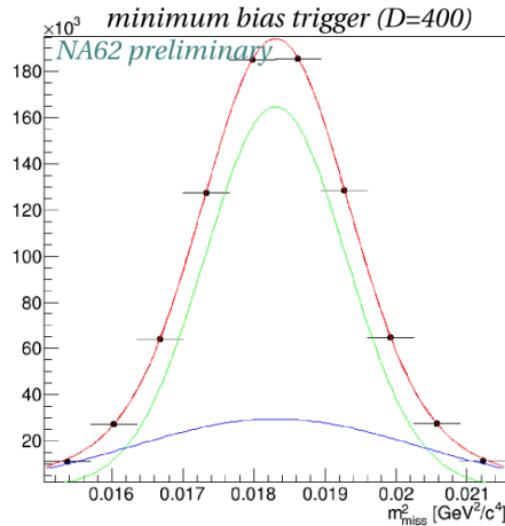
Combined PID performance using calorimeters and RICH:

- $\epsilon(\mu) \sim 10^{-7}$
- $\epsilon(\pi) \sim 60\%$

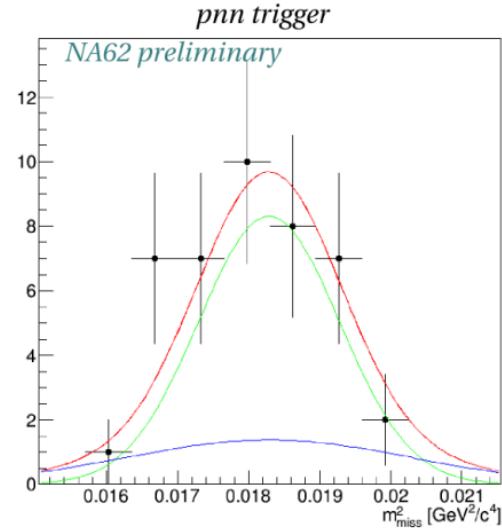


Combined pion and muon efficiency (calorimeter and RICH) assuming that the two detectors are independent.

Photon rejection



Before photon rejection



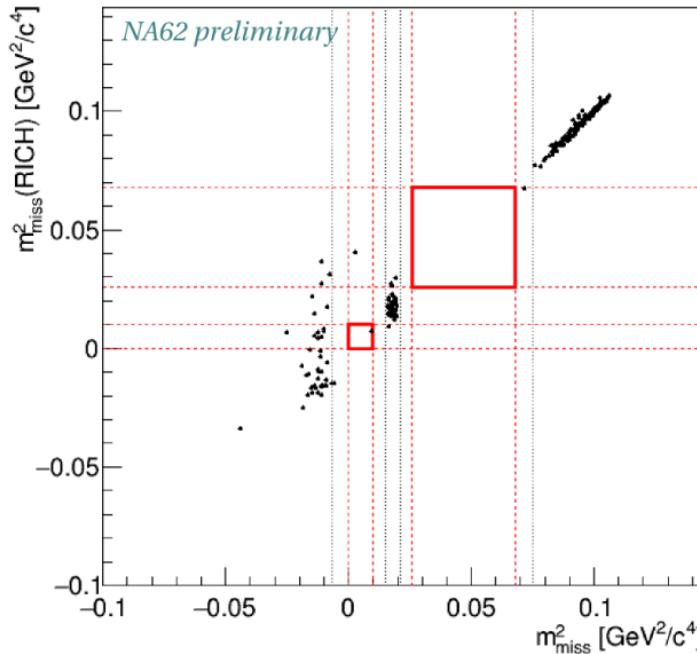
After photon rejection

Photon Veto: LKr, LAV, IRC, SAC

π^0 suppression efficiency in the $K^+ \rightarrow \pi^+ \pi^0$ region:

$$\epsilon_{\pi^0} = \frac{n_{\pi\pi}^{PNN}}{D^{\text{control}} \cdot N_{\pi\pi}^{\text{control}}} = (1.2 \pm 0.2) \times 10^{-7}$$

NA62 preliminary result



Expected $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ events:

- 0.064 out of the 2.3×10^{10} kaon decays
(5% of the 2016 dataset)

No events in signal regions

Event in box has m_{miss}^2 (No GTK) outside the signal region

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

- Analysis on the full 2016 data set is progressing
- Processing for the 2017 data set on-going ($\sim 3 \times 10^{12}$ K^+ decays collected, expected [10-15] $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ signal events)
- Data taking will resume in April 2018, until November 2018
- To reach the ultimate sensitivity NA62 may need to continue the data-taking after Long Shut-down 2
- Along with the $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ measurement, a rich programme of physics will be addressed.

