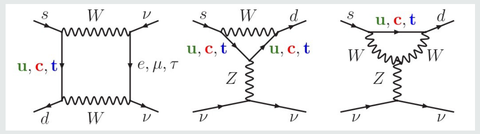
THE NA62 EXPERIMENT AT CERN

Birmingham, Bratislava, Bristol, Bucharest, CERN, Dubna, Fairfax, Ferrara, Florence, Frascati, Glasgow, Liverpool, Louvain, Mainz, Moscow, Naples, Perugia, Pisa, Prague, Protvino, Rome I, Rome II, San Luis Potosí, Sofia, Turin, TRIUMF, UBC Vancouver

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

SM theoretical framework

- FCNC loop process, short distance dominated
- hadronic matrix element from the (isospin rotated) semileptonic decay
- theoretically clean $|V_{td}|$ dependence



Perfect probe for New Physics, still complementary to LHC

Tree-level FCNC by Z': Buras et al, JHEP 1302 (2013) 116
Littlest Higgs with T parity: Blanke et al, Acta Phys. Polon. B41 (2010) 657
Custodial Randall-Sundrum: Blanke et al, JHEP 0903 (2009) 108
MSSM non-MFV: Isidori et al, JHEP 0608(2006) 064

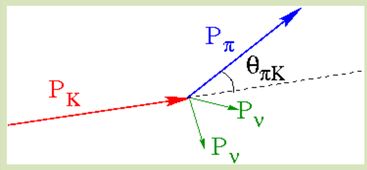
BR x 10^{10}	SM prediction	experiment
$K^+ \to \pi^+ \nu\bar{\nu}$	0.781±0.075±0.029	1.73±1.10
$K_L \to \pi^0 \nu\bar{\nu}$	0.243±0.039±0.006	<260

Brod, Gorbahn, Stamou: PRD83(2011) 034030, arXiv 1009.0947
BNL E787/E949: PRL101 (2008) 191802, arXiv 0808.2459
KEK E391a: PR D81 (2010) 072004, arXiv 0911.4789

Measurement principle

Goal : measure BR with 10% precision

- $O(100)$ SM events + systematics control at % level
- statistics = high intensity kaon beam + large signal acceptance
- systematics = large background rejection + redundancy



- technique: high momentum kaon decay in flight
- basic ingredients: precise timing & kinematic cuts
- signal signature : one K^+ track, one π^+ track
- kinematic variable : $m^2_{miss} = (P_K - P_\pi)^2$
- momentum measurement + particle-identification + veto

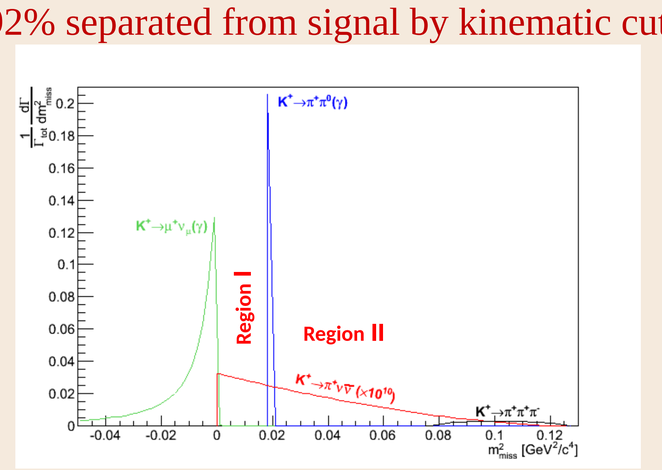
momentum
kaon tracker (GTK)
pion tracker (STRAW)

particle identification
kaon-ID (CEDAR)
π/μ/e-ID (RICH)

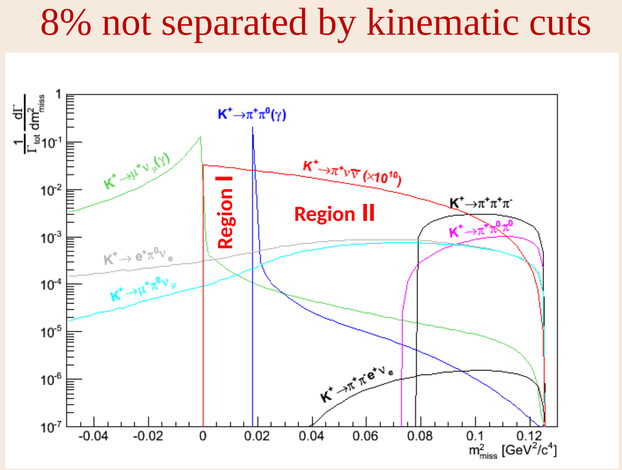
veto against
beam induced accidentals (CHANTI, CEDAR)
multiple charged particle decays (STRAW, CHOD)
photons and muons (LAV, LKr, IRC, SAV and MUV)

Background rejection

92% separated from signal by kinematic cuts



8% not separated by kinematic cuts



including particle ID and vetos

Decay mode	Events (flux 4.5 10^{12} decays)
$K^+ \to \pi^+ \nu\bar{\nu}$ Signal [SM]	~30 events /year
$K^+ \to \pi^+\pi^0$	5
$K^+ \to \mu^+\nu$	1
$K^+ \to \pi^+\pi^-\pi^+$	< 1
$K^+ \to \pi^+\pi^-e^+\nu$ + other 3–track decays	< 1
$K^+ \to \pi^+\pi^0\gamma$ (IB)	1.5
$K^+ \to \mu^+\nu\gamma$ (IB)	0.5
$K^+ \to \mu^+(e^+)\,\pi^0\nu$, others	neg.
Expected background	< 10

Schedule

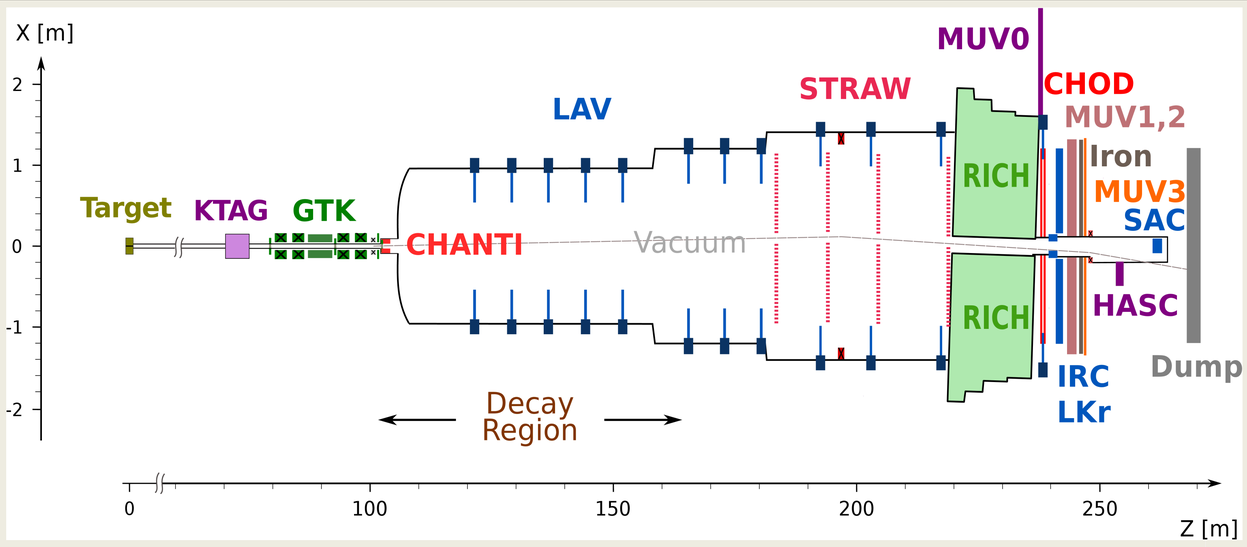
- 2010-2014: construction
- 2015: Detector commissioning
- October 2015-2018: $K^+ \to \pi^+ \nu\bar{\nu}$ physics data taking
- 2021: Plans to continue with data taking after LS2

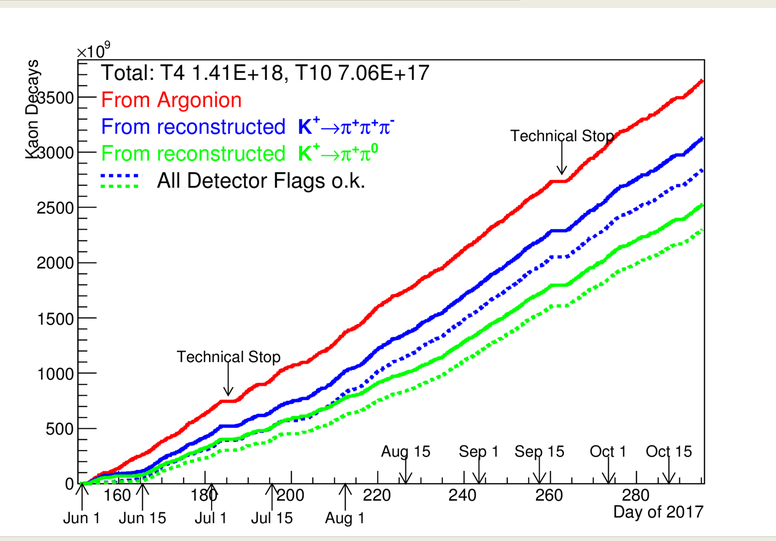
TRIGGER L0 (Hardware level) → L1(single detector Software level) → L2(multi detector Software level)
~10 MHz (RICH, LKr, LAV, MUV) ~1 MHz ~100 KHz → Few KHz

Beam

***Primary SPS Beam*:**
- 400 GeV/c protons
- $3x10^{12}$ protons/pulse
- 4.8/16.8 s duty cycle

***Secondary Beam*: ~ 6% K^+**
- p=75 GeV/c (Δp/p~1%)
- beam acc.: 12.7 mstr
- total rate: 750 MHz
- $4.5x10^{12}$ K^+decays/year

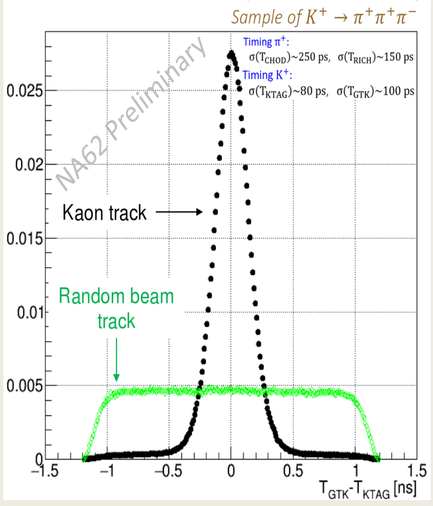


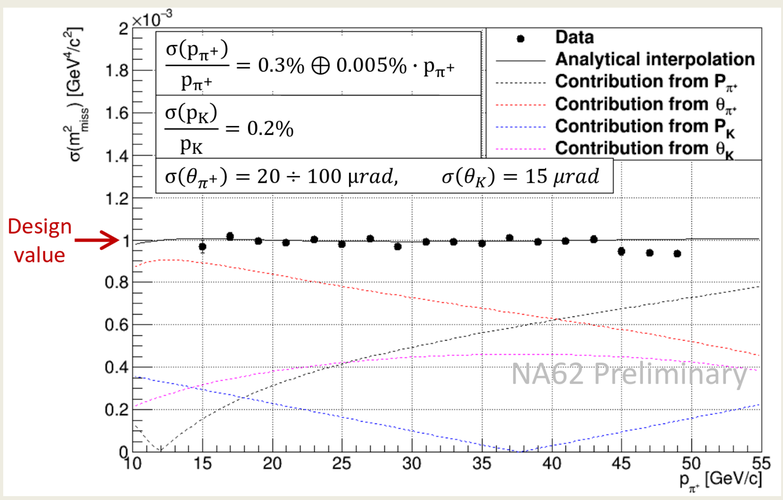


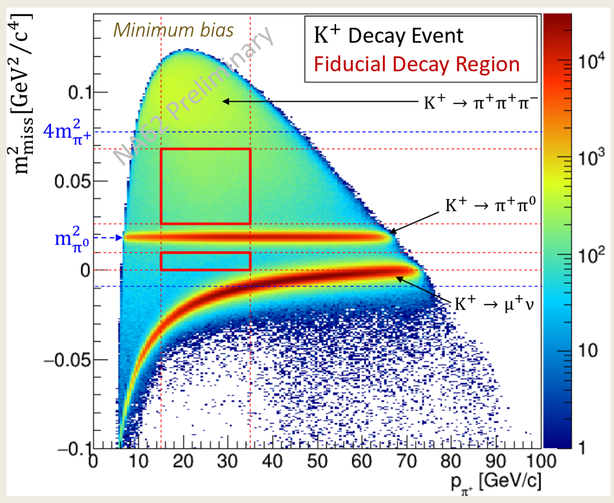
Selection:
Single "π^+" topology (STRAW, CHOD, LKr)
K ID in KTAG
K-"π" matching

Spatial matching:
intersection of GTK and Straw track
σ(CDA)~1.5 mm

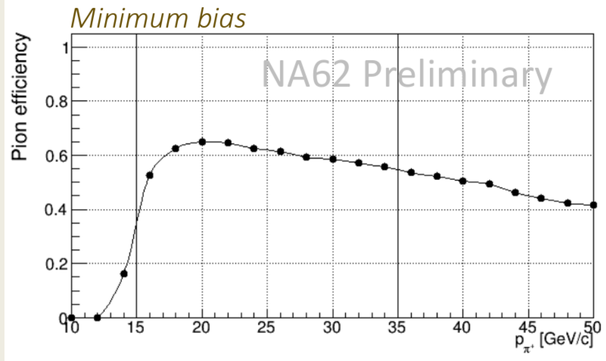
Mis-tagging probability: ~1.7%
[40% nominal intensity, 75% efficiency]

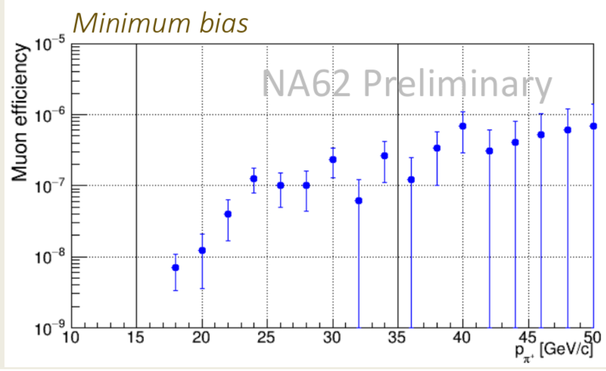






Particle ID with calorimeters
$\varepsilon(\mu) \div \varepsilon(\pi) \sim 10^{-5} \div 80\%$
- LKr, MUV1,2, MUV3
Particle ID with RICH
$\varepsilon(\mu) \div \varepsilon_{ID}(\pi) \sim 10^{-2} \div 80\%$
- ring radius & p_{π^+} from STRAW

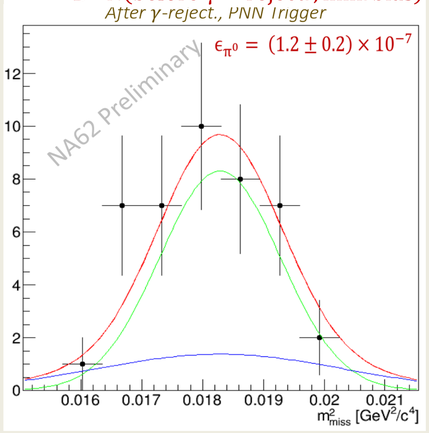




$\pi^+\pi^0$ suppression measurement:
- events in $K^+ \to \pi^+\pi^0$ region (N)

$$\epsilon_{\pi^0} = \frac{N(\text{after } \gamma - \text{reject., PNN stream})}{D \cdot N(\text{before } \gamma - \text{reject., min. bias})}$$

After γ-reject., PNN Trigger



$$N^{exp}_{\pi\nu\nu} = D^{control} \cdot N^{control}_{\pi\pi} \cdot \frac{BR_{\pi\nu\nu}}{BR_{\pi\pi}} \cdot \frac{A_{\pi\nu\nu}}{A_{\pi\pi}} \cdot \epsilon^{trig} = 0.064$$

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

~ 0.6/0.86 from MC and cancellations

~ 85% (preliminary) measured with data

main bkg processes	fraction of bkg events in signal region	estimation method	expected events
$K^+ \to \pi^+\pi^0$	(5.9 +/- 0.2) 10^{-4}	from data	0.024
$K^+ \to \mu^+\nu$	(2.9 +/- 0.2) 10^{-4}	from data	0.011
$K^+ \to \pi^+\pi^+\pi^-$	~10^{-4}	from MC	0.017
early decays			< 0.05

NA62 Preliminary

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