Search for $K^+ \to \pi^+ \nu\bar{\nu}$ at NA62

Riccardo Aliberti

Johannes-Gutenberg-Universität - Mainz

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Bundesministerium
für Bildung
und Forschung

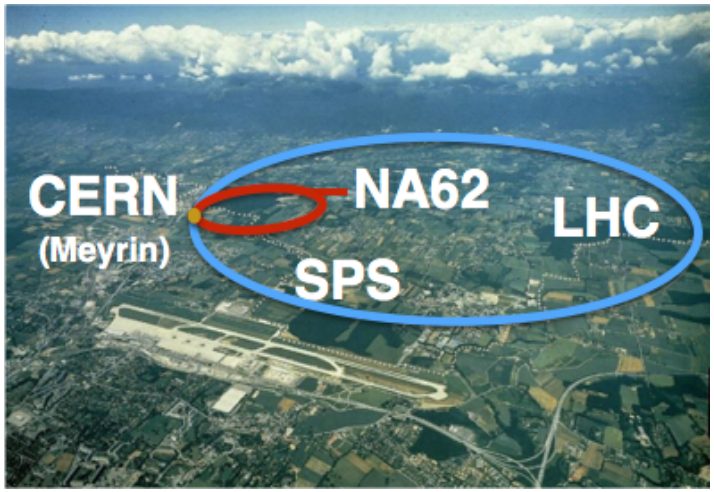
The NA62 Experiment

Fixed Target Experiment

Located at the North Area of CERN

75 GeV/c Secondary Hadron Beam

Carry on the tradition of Kaon experiments at CERN - SPS

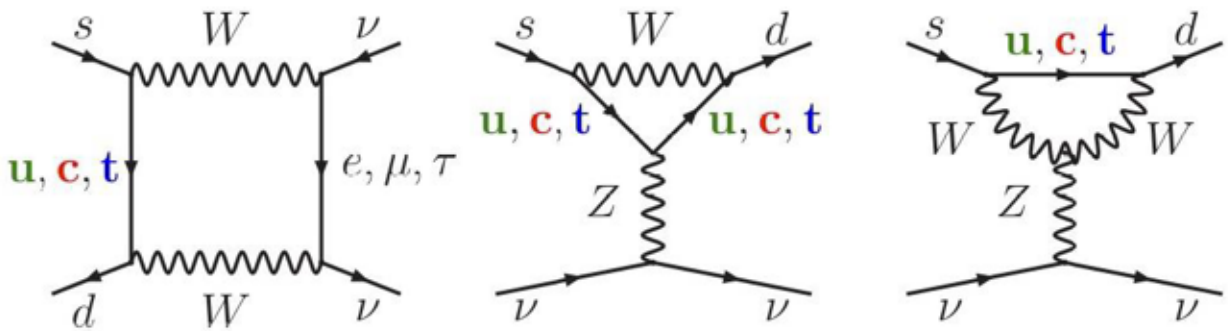


Kaon @ CERN - SPS

’86 - ‘89	NA31	Hint of direct CP violation in Neutral Kaon decays
’97 - ‘01	NA48	ε’/ε: Proof of direct CP violation
‘02	NA48/1	K_s rare decays
’03 - ‘04	NA48/2	CP violation in Charge Kaons decays
’07 - ‘08	NA62 (NA48/3)	Lepton Universality (R_k)
’14 - ’18	NA62	$K^+ \rightarrow \pi^+ \nu\bar{\nu}$ decay

Theoretical Motivation

FCNC loop process, highly suppressed, theoretically very clean



Well calculated inside the Standard Model [A.J. Buras et al., JHEP 1511 (2015) 033]

$$Br_{SM}(K^+ \to \pi^+ \upsilon\bar{\upsilon}) = (8.4 \pm 1.0)\times 10^{-11}$$

Previous Measurement (only 7 events) [BNL E787/E949: PRL101 (2008) 191802]

$$Br_{Exp}(K^+ \to \pi^+ \upsilon\bar{\upsilon}) = \left(17.3 \pm^{11.5}_{10.5}\right)\times 10^{-11}$$

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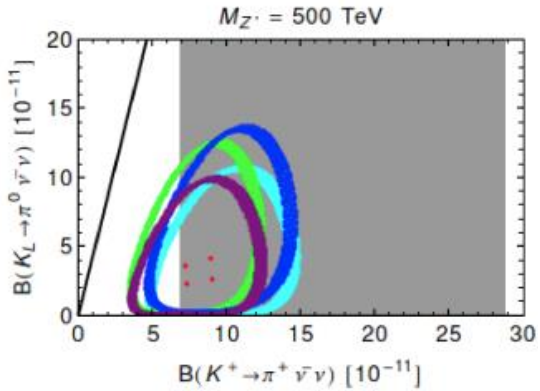
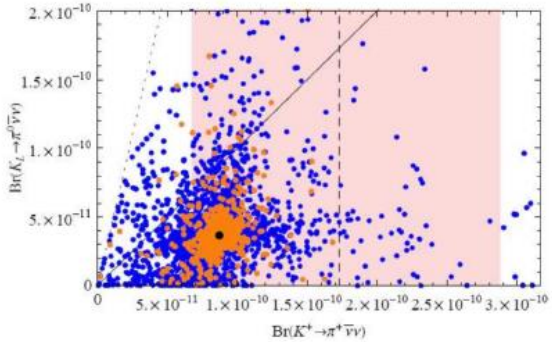
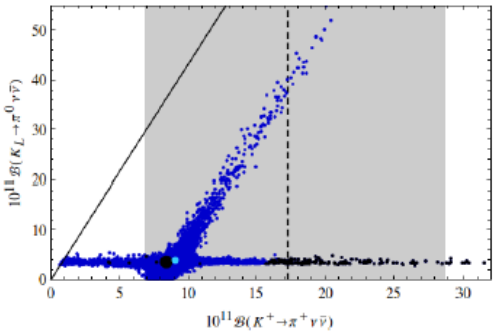
Z′ model



Randall - Sundrum



Littlest Higgs



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Any deviation from the SM prediction is a hint of new physics

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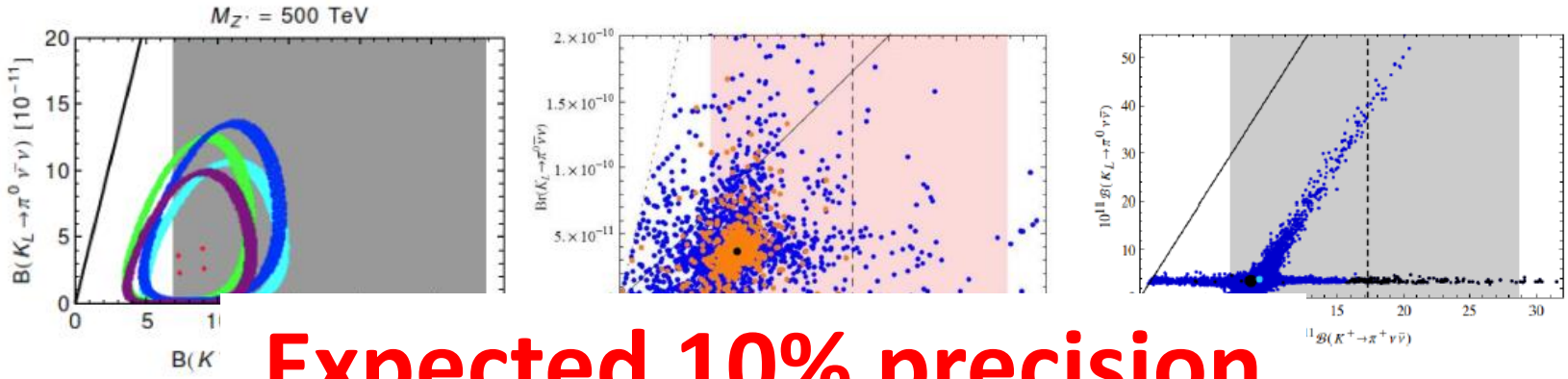

Expected 10% precision by NA62

Well calcula

HEP 1511 (2015) 033]

11

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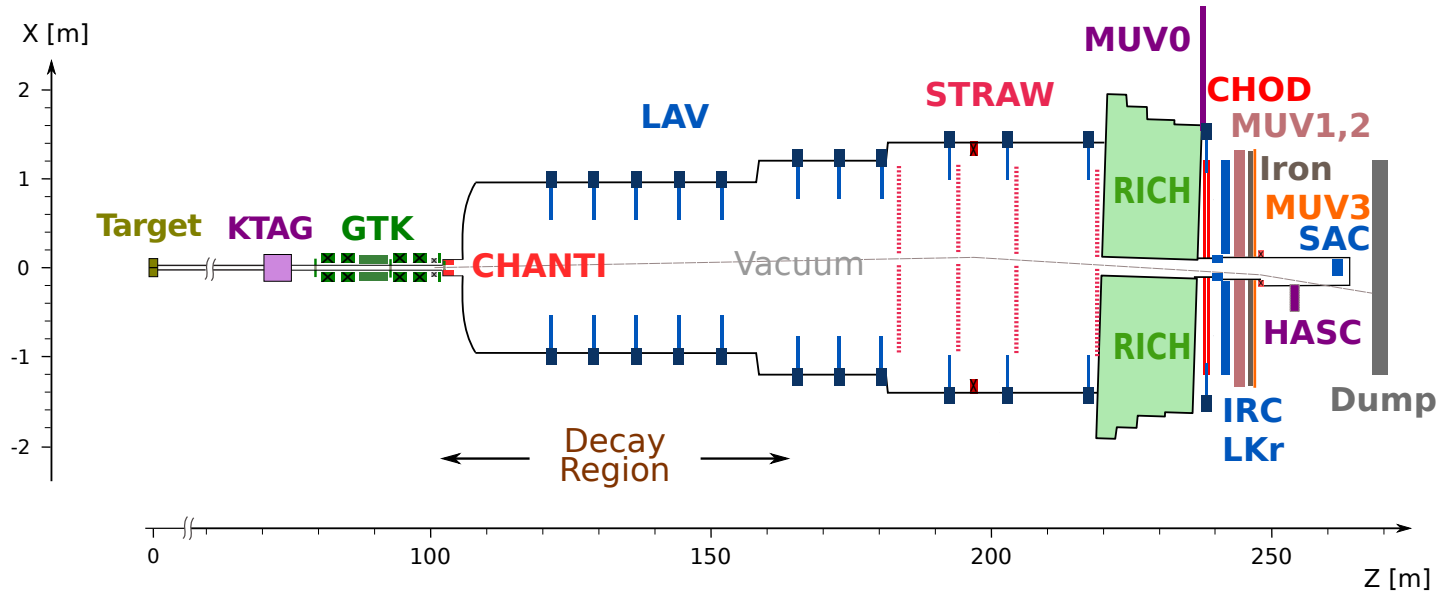
The NA62 Strategy and Apparatus



SPS Protons

400 GeV

10^{12} protons/s

3.5 s spill

→ Beryllium Target →

Secondary Beam

75 GeV,

$\Delta p/p \approx 1\%$

K (6%), p (23%), π (70%)

750 MHz

→

Kaon Decays

≈ 5 MHz

4.5 x 10^{12} per year

10^{-6} mbar vacuum

The NA62 Strategy and Apparatus

Signal:

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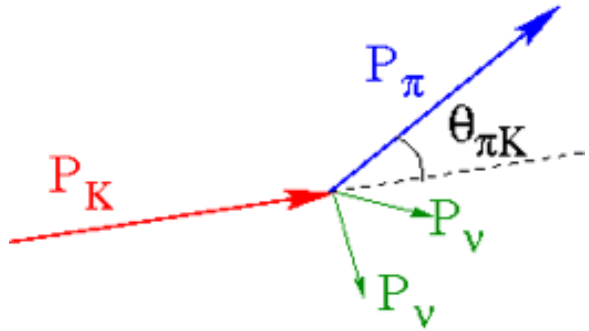
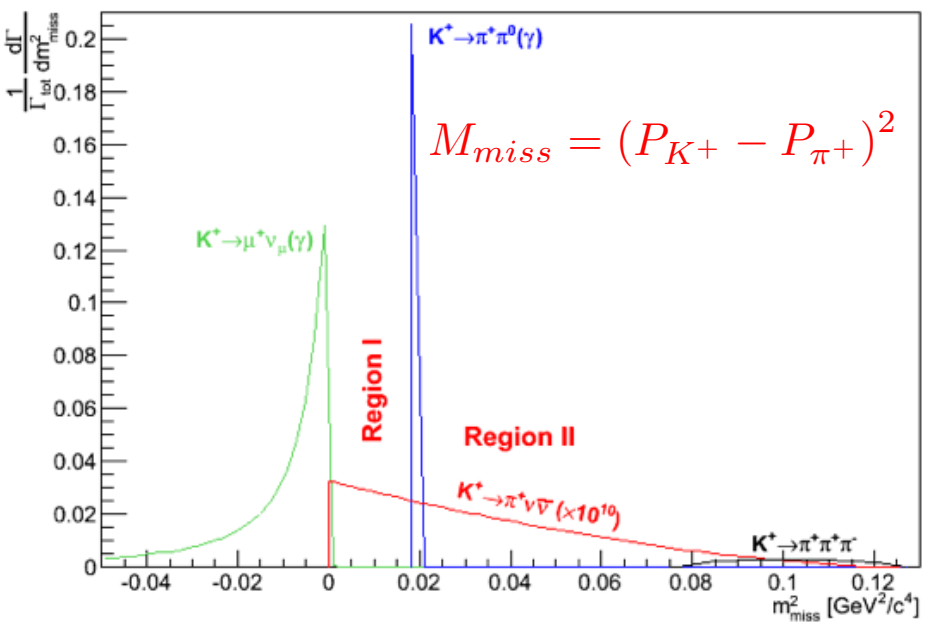
- ✓ One π^+
- ✓ Nothing else



Background:

- x Beam activity
- x Other K^+ decays



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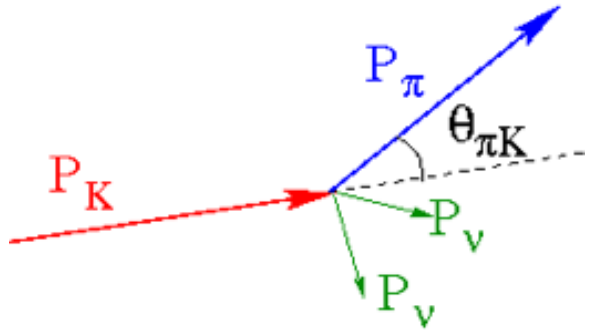

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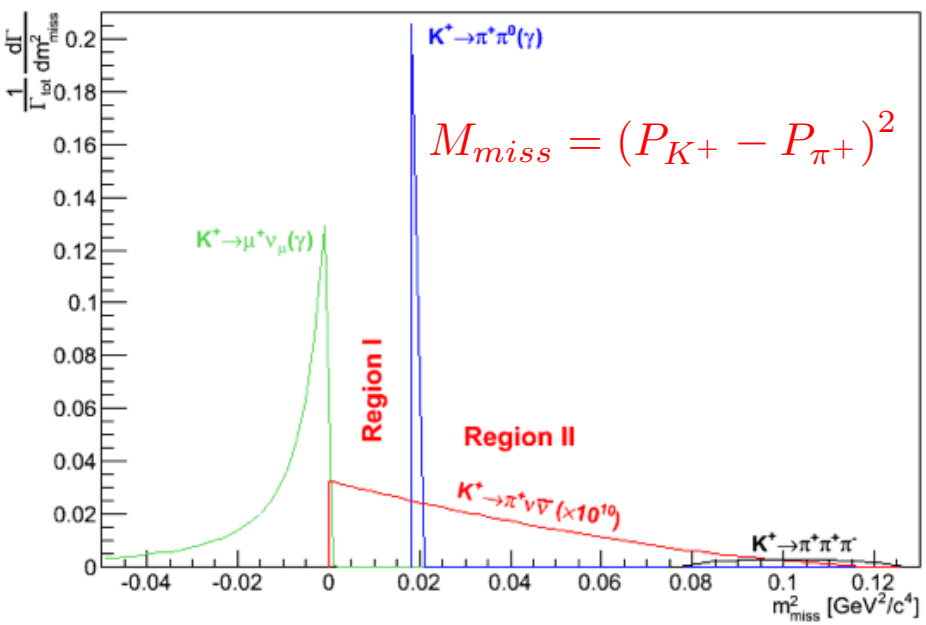

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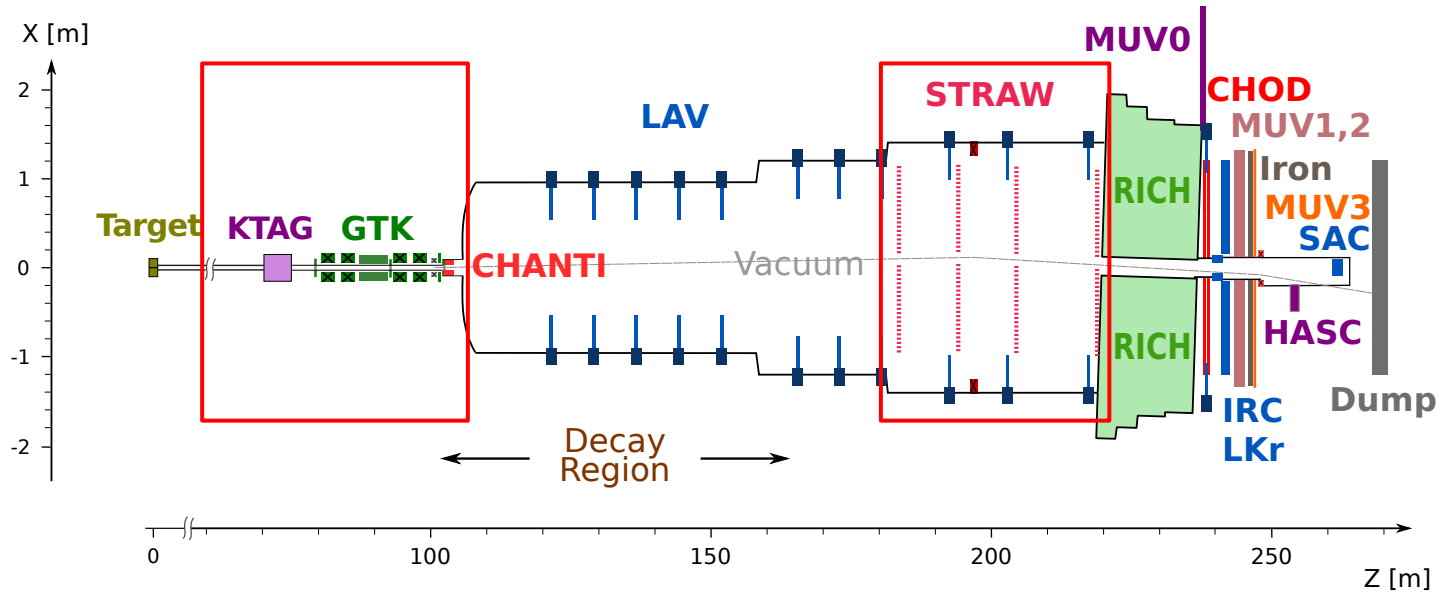

Kaon Tagging – CEDAR

45 MHz rate

time: 100 ps

Kaon Tracking – GTK

time: ≈ 200 ps

momentum: dp/p < 0.4%

direction : ≈ 0.016 mrad

Spectrometer – STRAW

momentum: dp/p < 0.33%

direction : ≈ 10 mrad

extracted vertex: ≈ 1 mm

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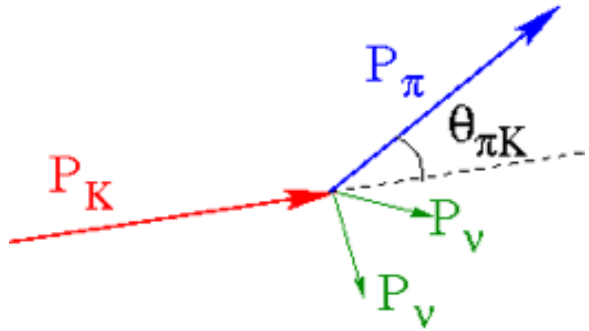

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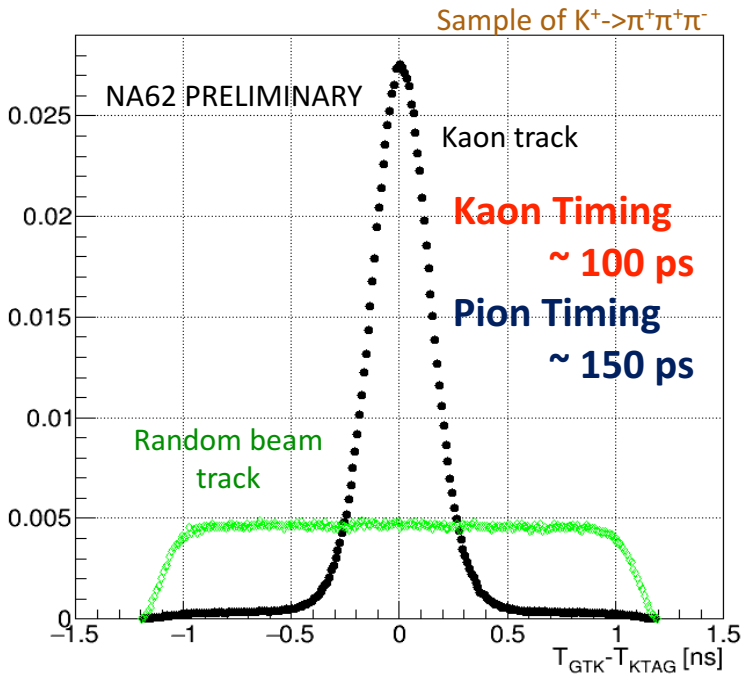

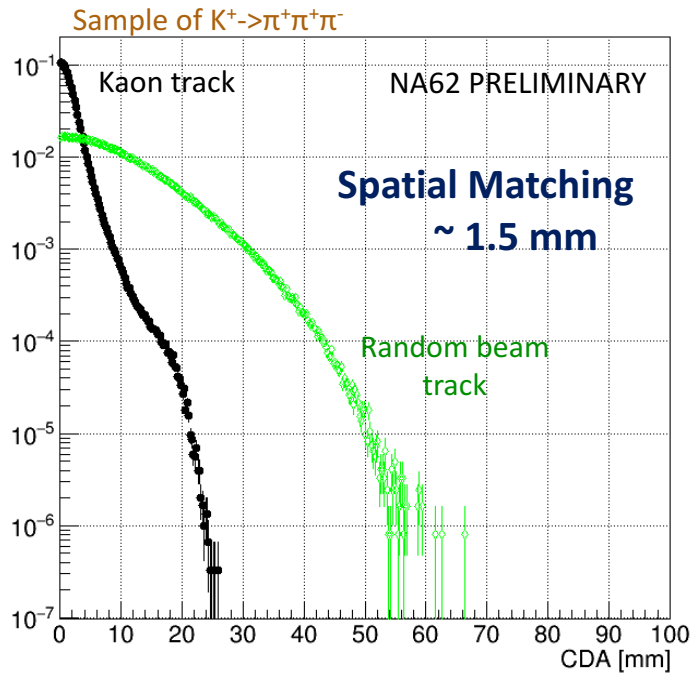

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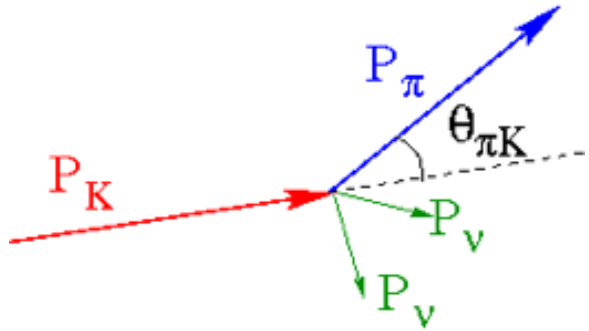

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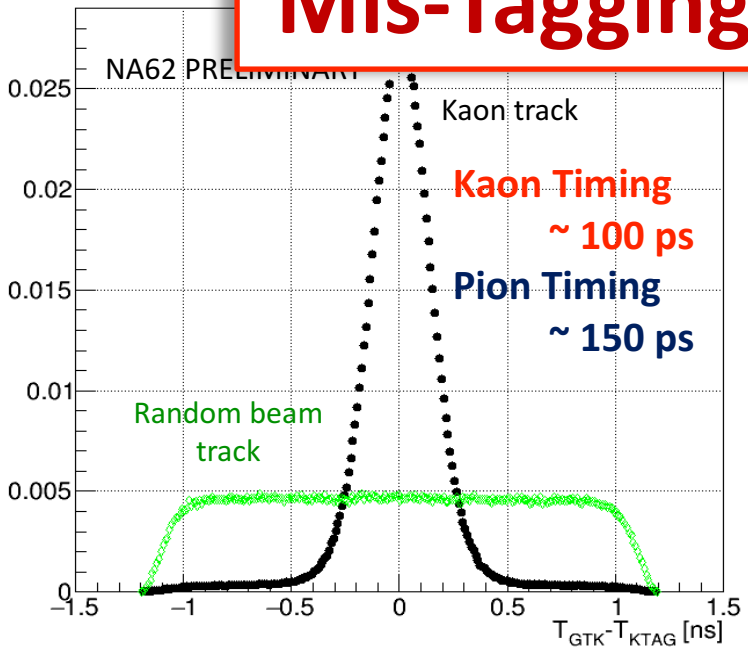
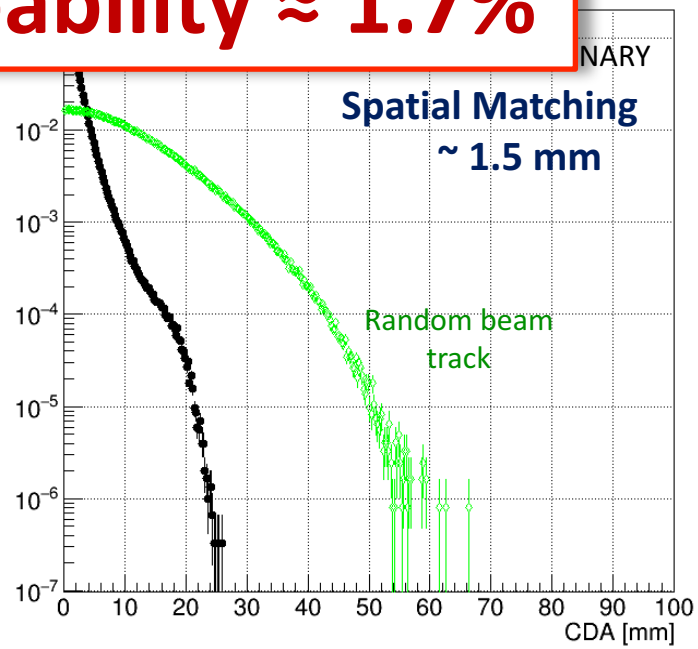
Mis-Tagging probability ≈ 1.7%





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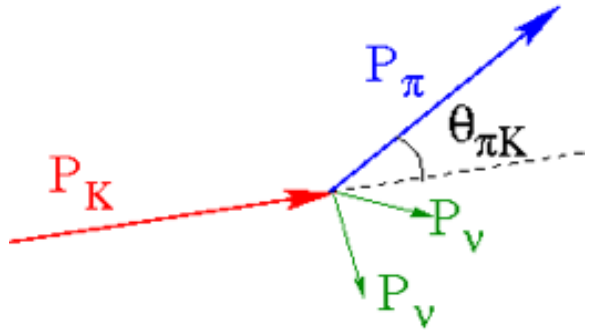

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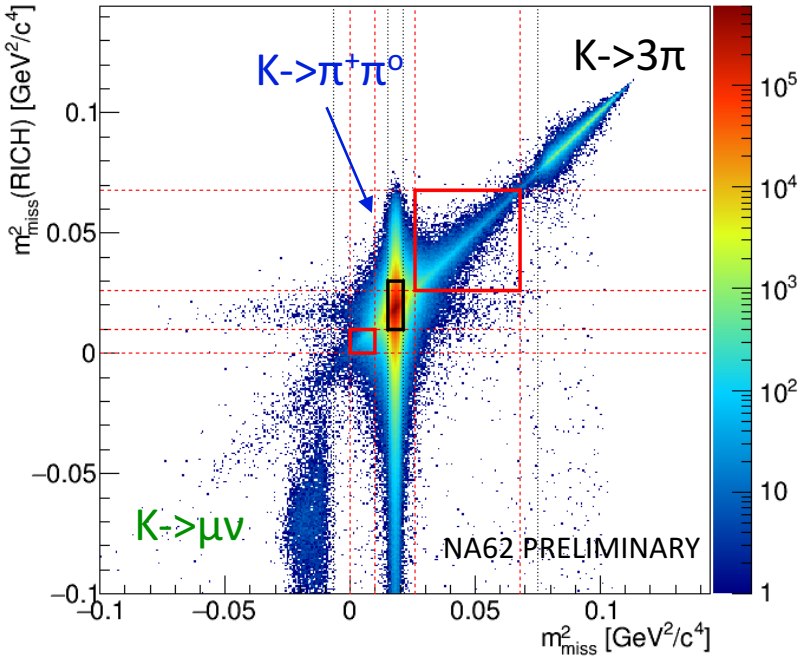

Kinematics cut on a 3D space:

- Squared Missing Mass STRAW – GTK
- Squared Missing Mass RICH – GTK
- Squared Missing Mass STRAW – Nominal

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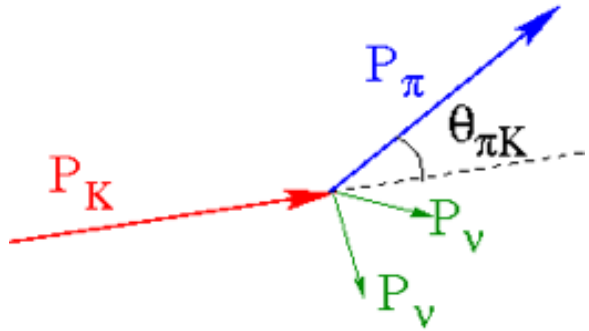

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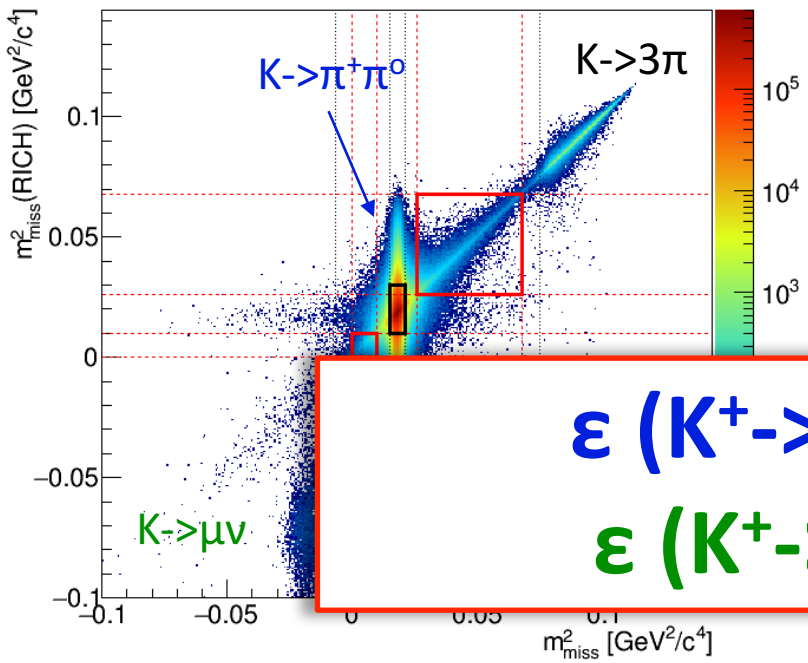

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- Squared Missing Mass STRAW – GTK
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$$\varepsilon\,(K^+ \to \pi^+\pi^o) \approx 6 \cdot 10^{-4}$$

$$\varepsilon\,(K^+ \to \mu^+\nu) \approx 3 \cdot 10^{-4}$$

The NA62 Strategy and Apparatus

Signal:

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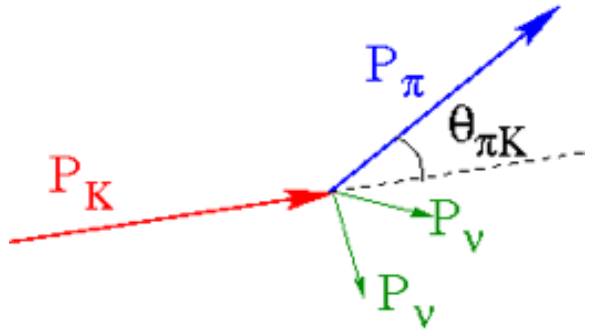

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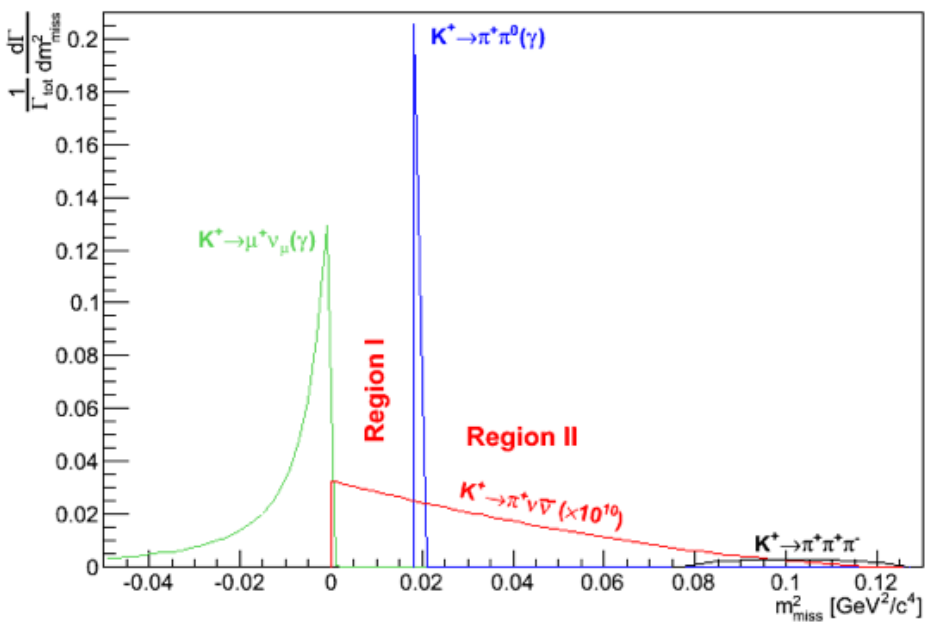

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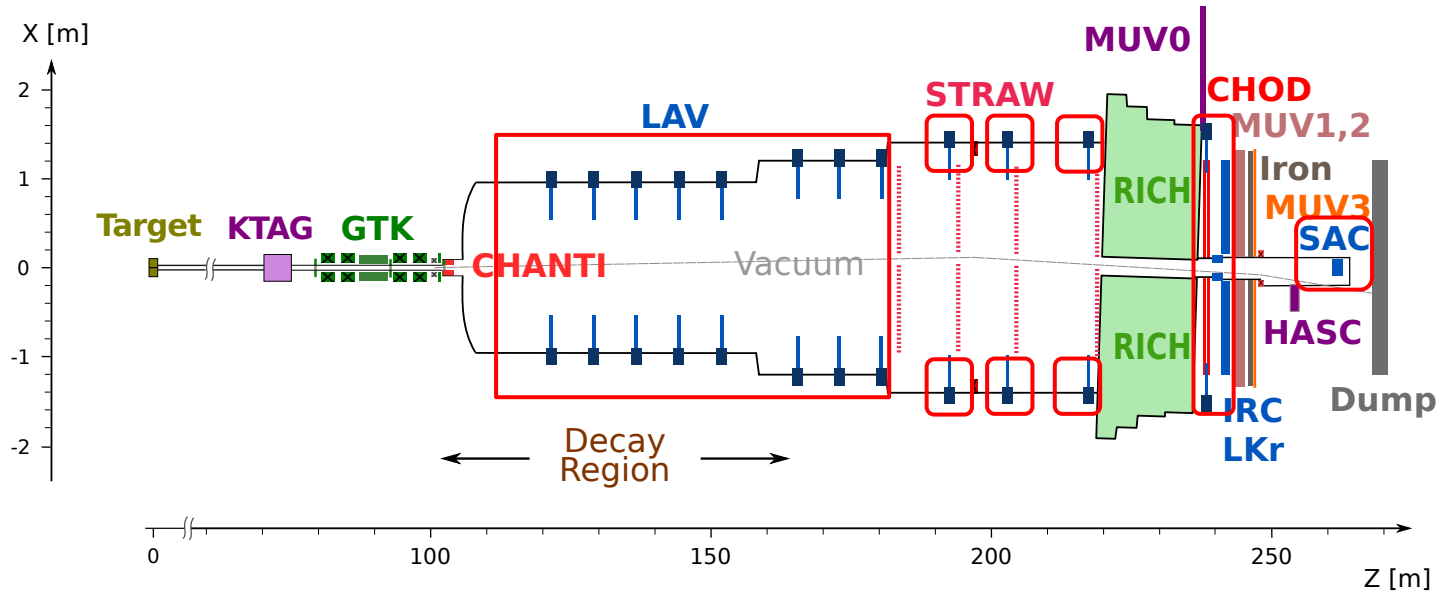

Small Angle – IRC, SAC

coverage: < 1 mrad

Large Angle – LAV

coverage: 8.5 – 50 mrad

time: ≈ 1 ns

EM Calorimeter – LKr

coverage: 1 – 8.5 mrad

time: ≈ 300 ps

resolution: $\frac{\sigma_E}{E}(20\ GeV) < 1\%$

The NA62 Strategy and Apparatus

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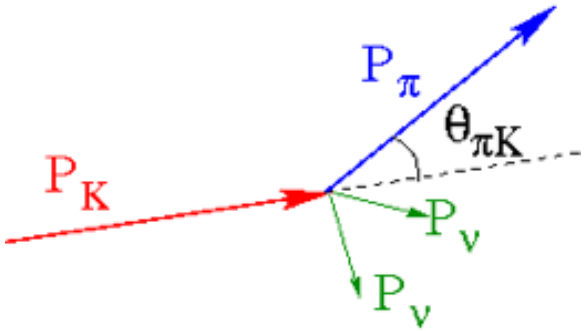

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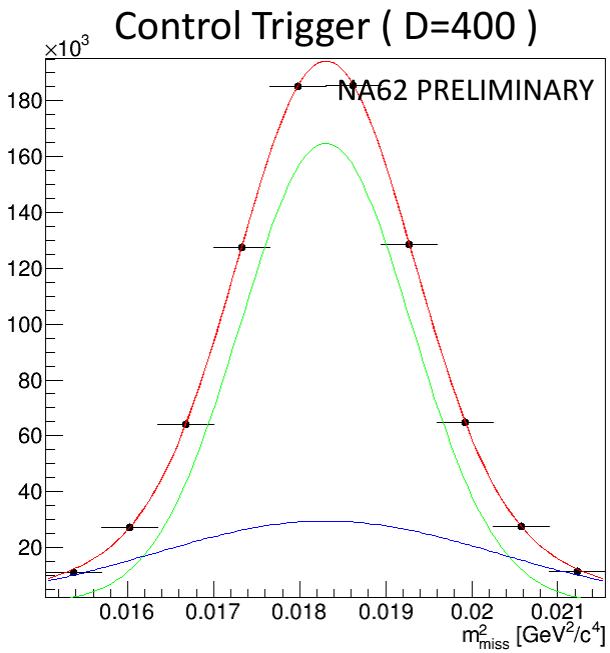

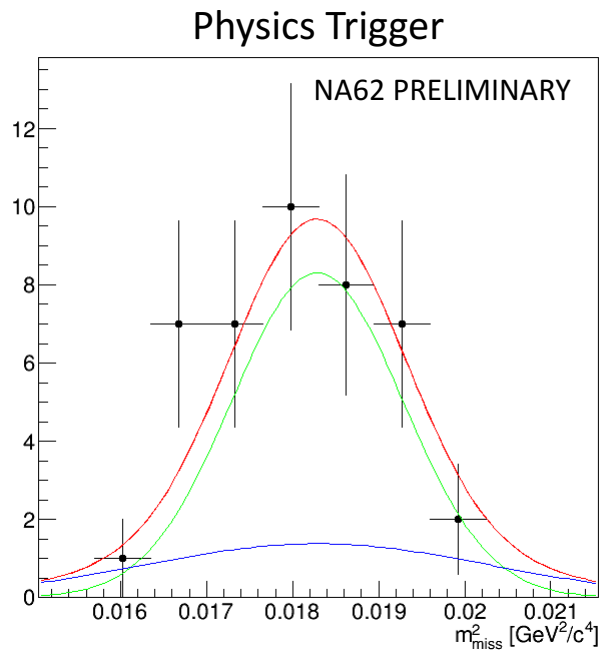

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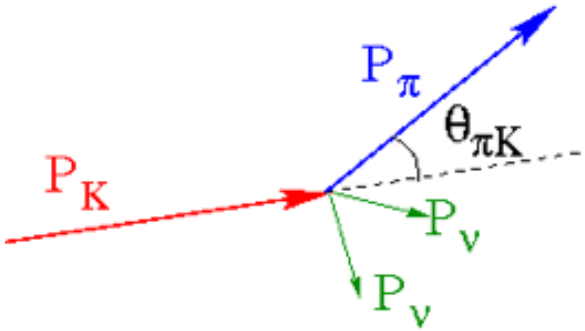

Background:

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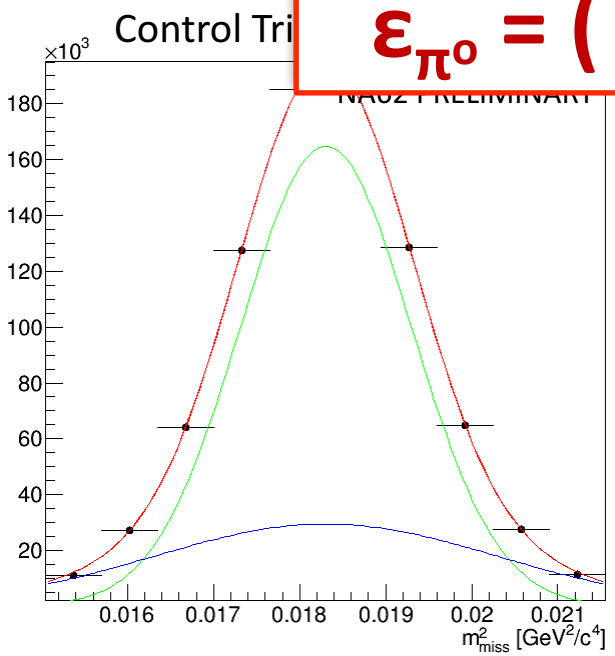
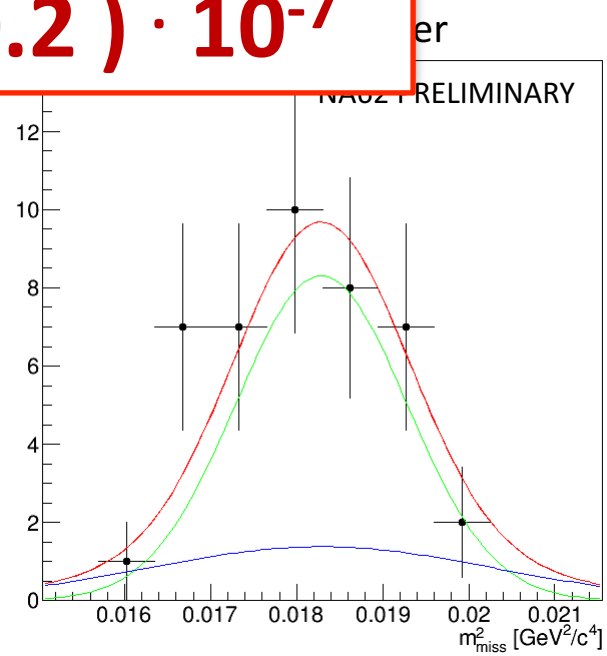
$$\varepsilon_{\pi^0} = (1.2 \pm 0.2) \cdot 10^{-7}$$





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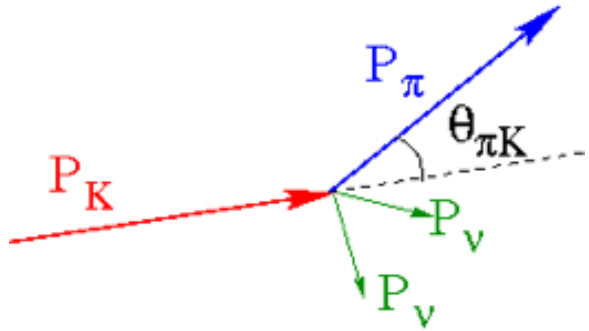

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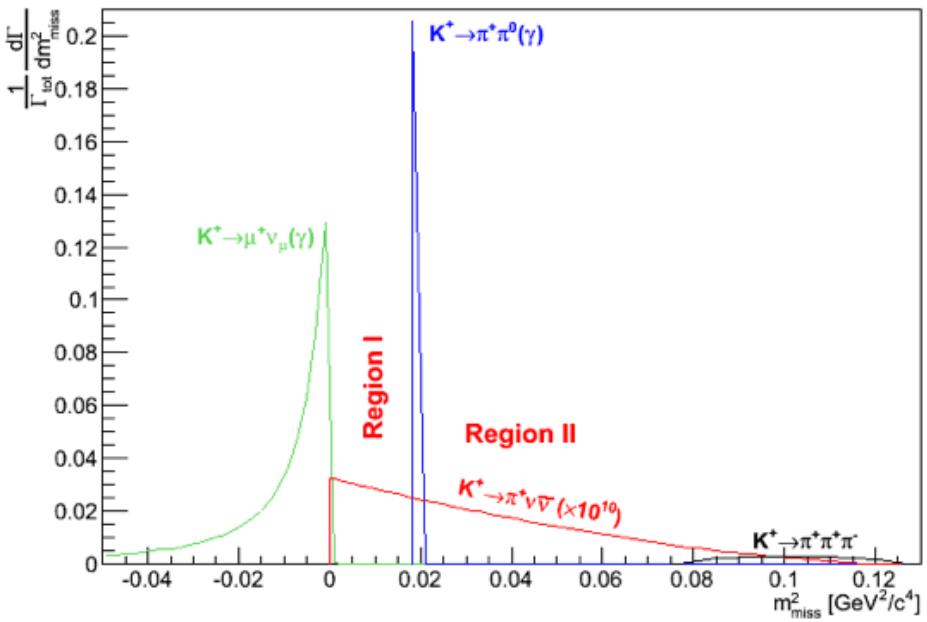

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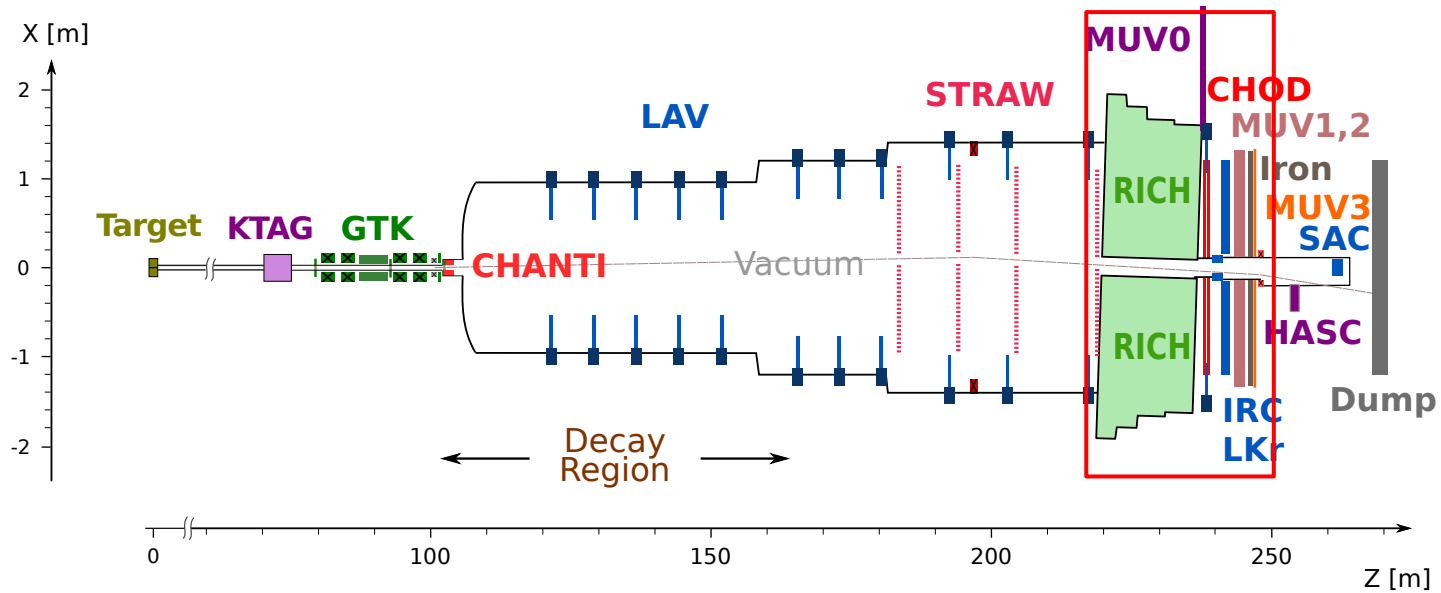

RICH

time: < 100 ps

muon rejection: 100

Fast Muon Veto

time: ≈ 300 ps

Calorimeters – LKr, HAC

Hadronic Shower Reconstruction

muon rejection: 10^5

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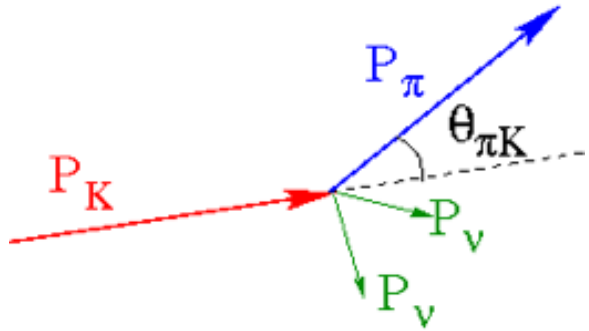

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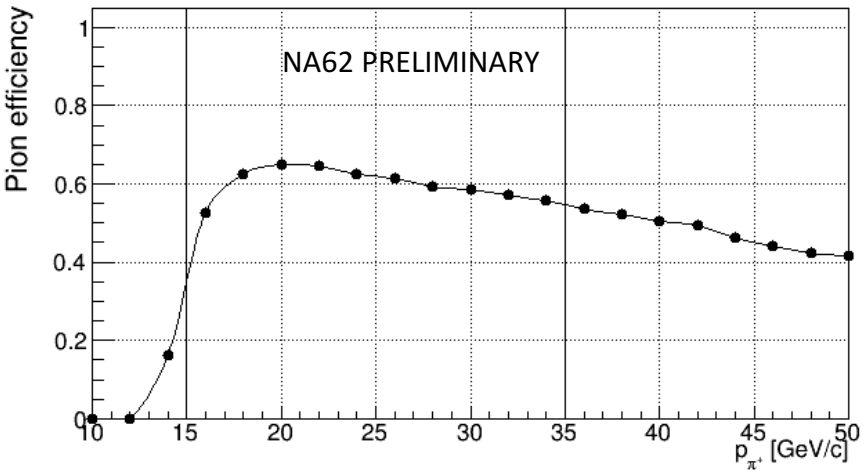
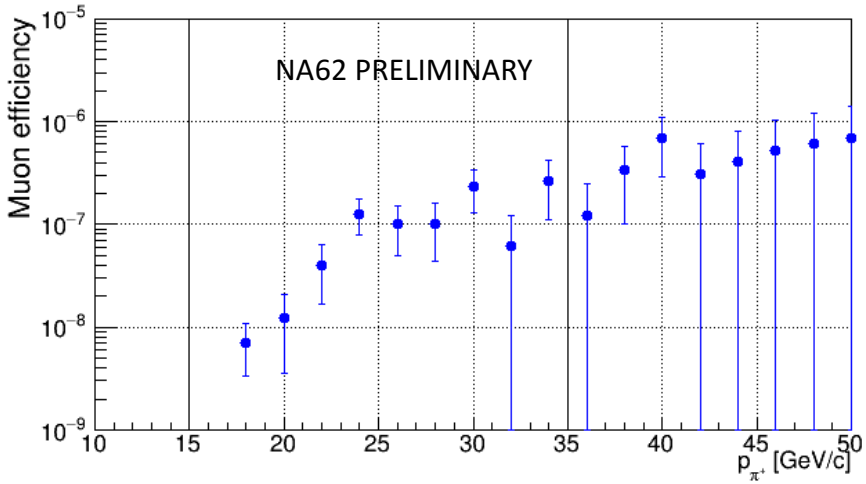


PID with Calorimeters (MVA):

$\varepsilon_{\pi+}$ = 80% with $\varepsilon_{\mu+}$ ~ 10^{-5}



PID with RICH:

$\varepsilon_{\pi+}$ ≈ 80% with $\varepsilon_{\mu+}$ ~ 10^{-2}

(Momentum dependent)

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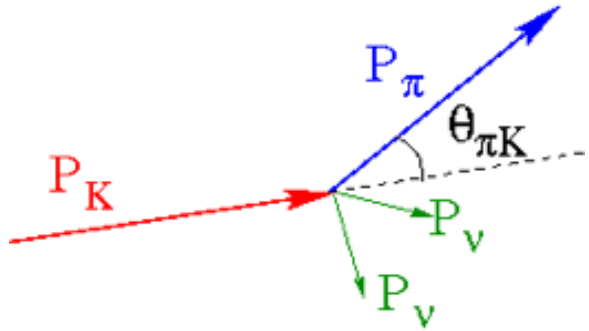

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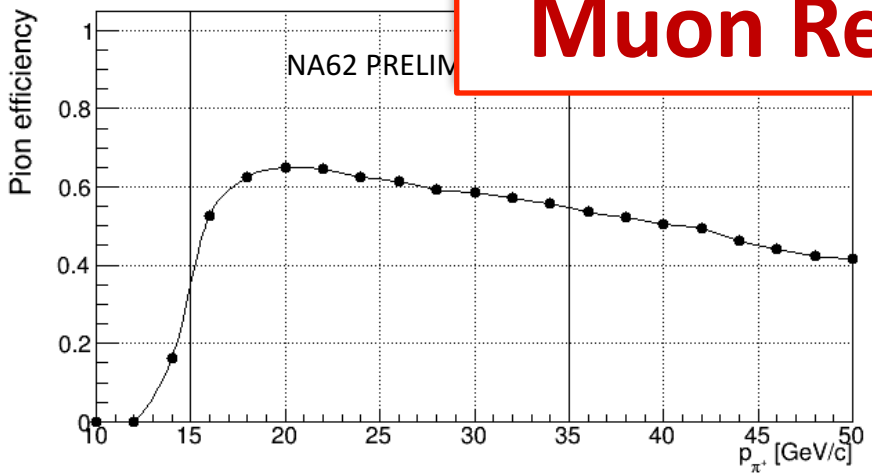
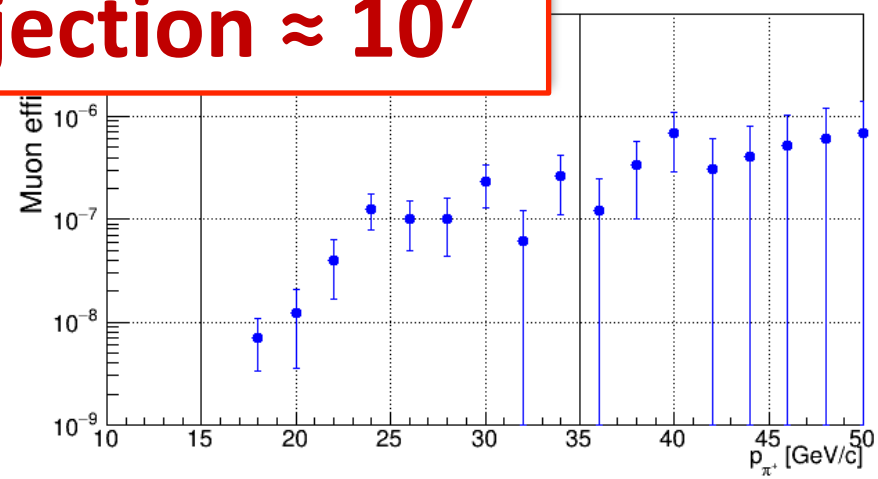
Muon Rejection ≈ 10^7





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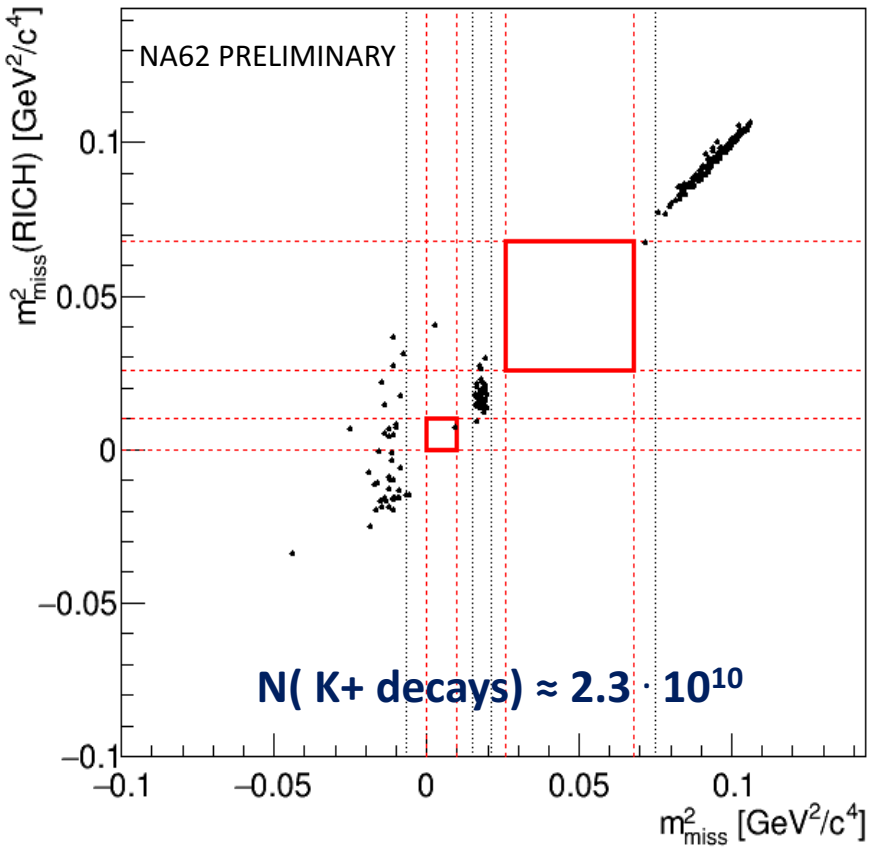
Preliminary Results

5% of 2016 Statistics



5% of 2016 data sample analyzed

Expected $K^+ \to \pi^+ \nu\bar{\nu}$ ≈ 0.064

- Normalization: $K^+ \to \pi^+\pi^o$

Expected Background < 0.057

- $K^+ \to \pi^+\pi^o$ ≈ 0.024
- $K^+ \to \mu^+\nu$ ≈ 0.011
- $K^+ \to 3\pi$ ≈ 0.017
- Beam < 0.005

Standard Model Sensitivity reachable with 2016 data

Analysis optimization on going!

Conclusion

NA62 is one of the main player in the search of new physics beyond the standard model trought the measurement of the golden channel $K^+ \rightarrow \pi^+ \nu\bar{\nu}$

The commissioning phase of the experiment finished on September 2016 and is now collecting physics data until 2018.

SM sensitivity is already achievable with 2016 data

Analysis optimization still on going

Conclusion

NA62 is one of the main player in the search of new physics beyond the standard model thought the measurement of the golden channel $K^+ \rightarrow \pi^+ \nu\bar{\nu}$

The ... ned on Sep ... a until 2018.

Stay tuned for updates and final results!

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Analysis optimization still on going