



# RANDOM VETO PRESSO L'ESPERIMENTO NA62

RENATO FIORENZA

[renato.fiorenza@cern.ch](mailto:renato.fiorenza@cern.ch)

GRUPPO-I

21/12/2021

**SSM**  
Scuola Superiore Meridionale

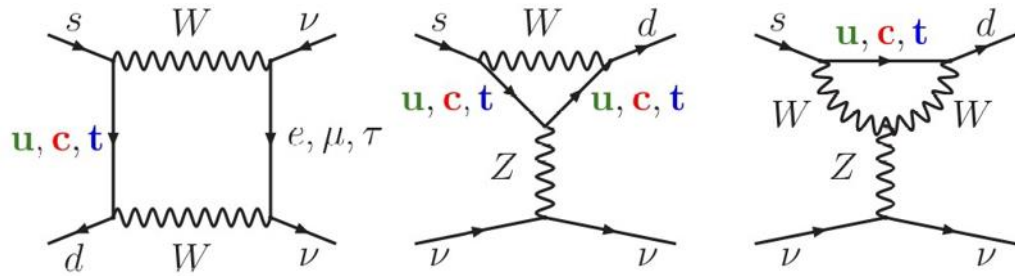


UNIVERSITÀ DEGLI STUDI DI NAPOLI  
**FEDERICO II**

**INFN**  
NAPOLI

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

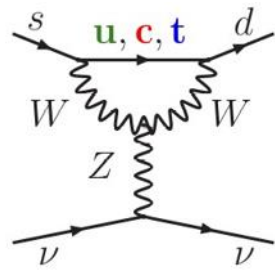
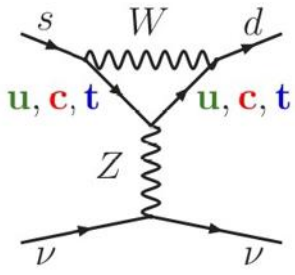
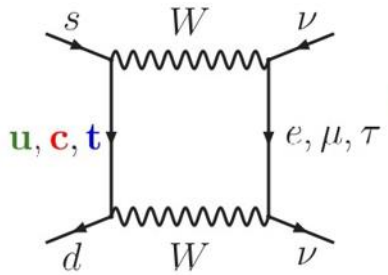
$$K^+ \rightarrow \pi^+ \nu \bar{\nu}$$



$$\text{BR}(K^+ \rightarrow \pi^+ \nu \bar{\nu})_{\text{SM}} = (8.4 \pm 1.0) \times 10^{-11}$$

Buras et al., JHEP 2015

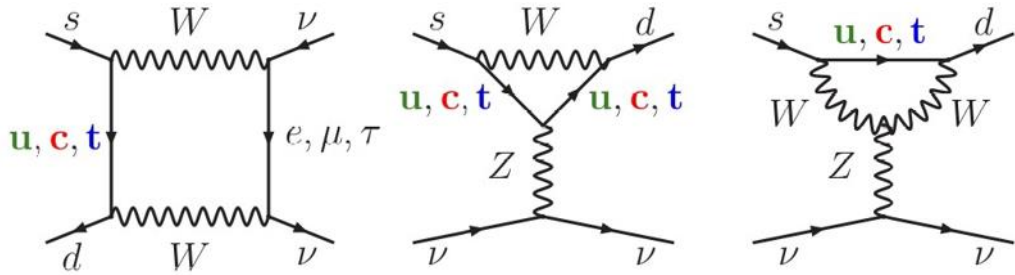
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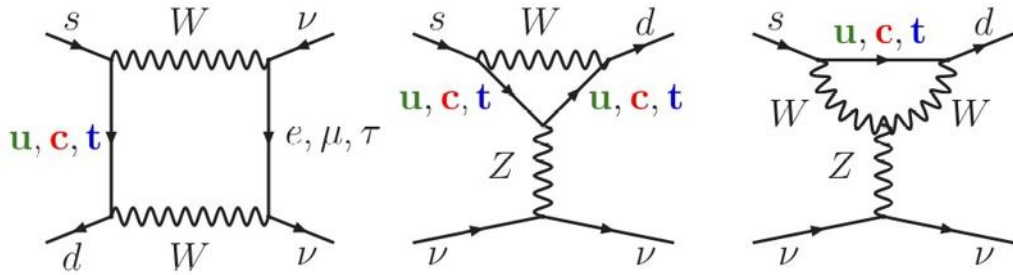
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Buras et al., JHEP 2015



Obiettivo

Misura di  $\text{BR}(K^+ \rightarrow \pi^+ \nu \bar{\nu})$   
con precisione  $\mathcal{O}(10\%)$



$$BR(K^+ \rightarrow \pi^+ \nu \bar{\nu})_{SM} = (8.4 \pm 1.0) \times 10^{-11}$$

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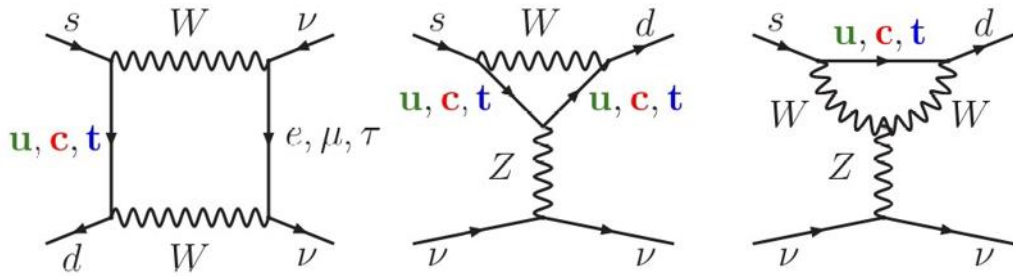
NA62

Obiettivo

Misura di  $BR(K^+ \rightarrow \pi^+ \nu \bar{\nu})$   
con precisione  $O(10\%)$

Tecnica

Bersaglio fisso,  
decadimento in volo



$$\text{BR}(K^+ \rightarrow \pi^+ \nu \bar{\nu})_{\text{SM}} = (8.4 \pm 1.0) \times 10^{-11}$$

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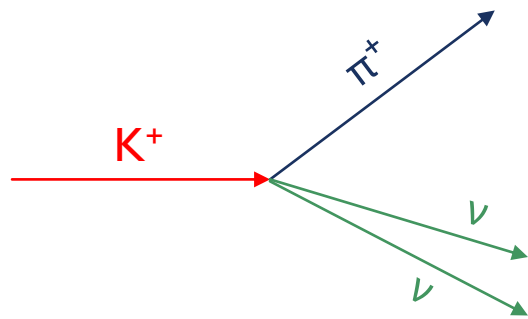
Tecnica

Bersaglio fisso,  
decadimento in volo

Raccolta dati

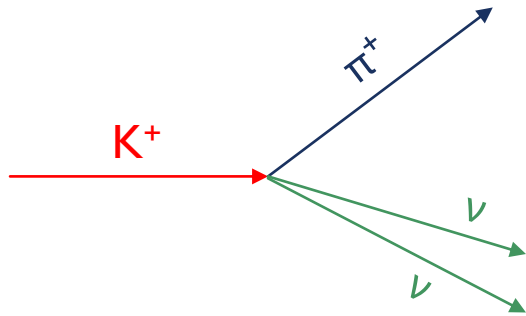
Run1: 2016 – 2018  
Run2: 2021 – 2024

# STRATEGIA



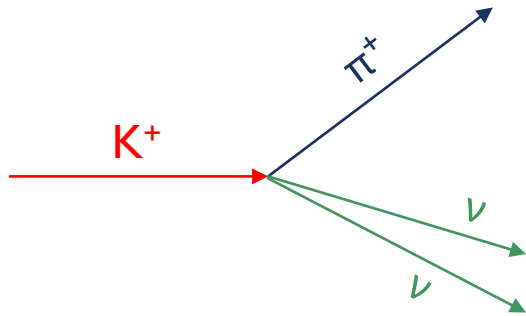


# STRATEGIA



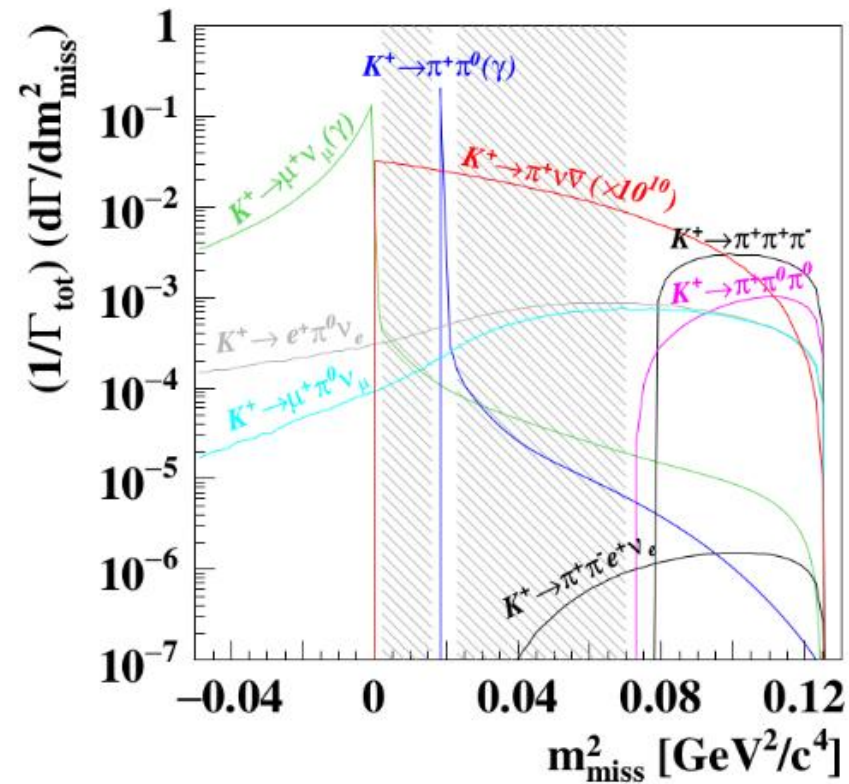
Decadimento	BR
$K^+ \rightarrow \mu^+ \nu_\mu (K_{\mu 2})$	63.6%
$K^+ \rightarrow \pi^+ \pi^0 (K_{2\pi})$	20.7%
$K^+ \rightarrow \pi^0 \ell^+ \nu_\ell (K_{\ell 3})$	8.4%
$K^+ \rightarrow \pi^+ \pi^+ \pi^- / \pi^+ \pi^0 \pi^0 (K_{3\pi})$	7.3%

# STRATEGIA

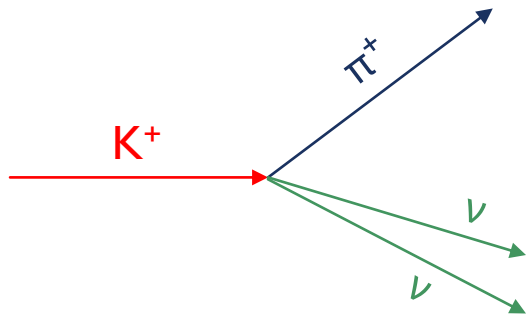


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$$m_{miss}^2 = (p_K - p_\pi)^2$$

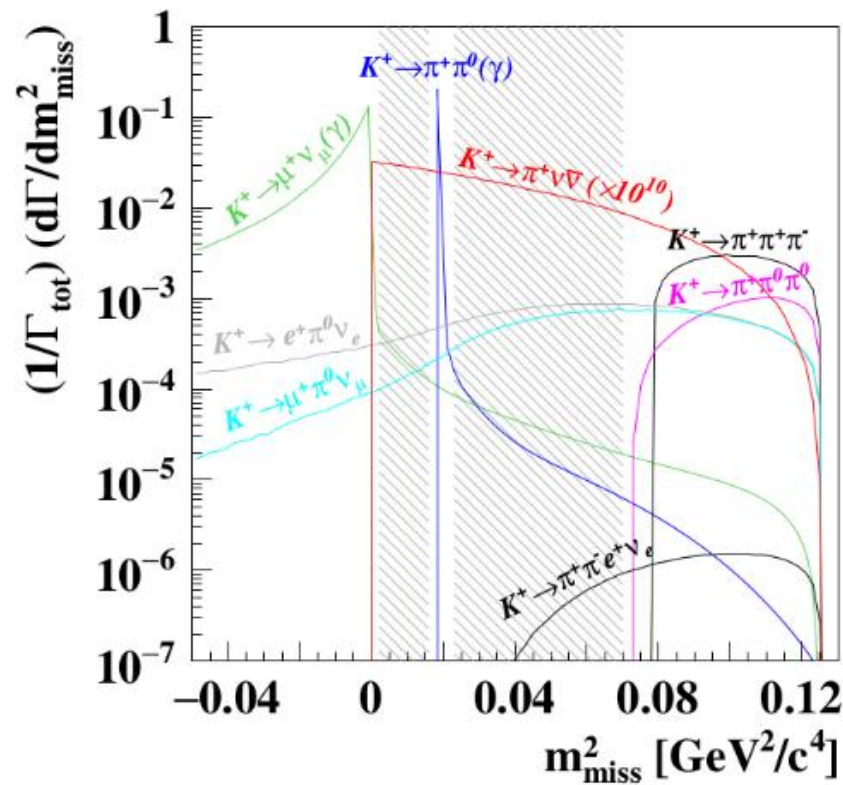


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## Punti chiave

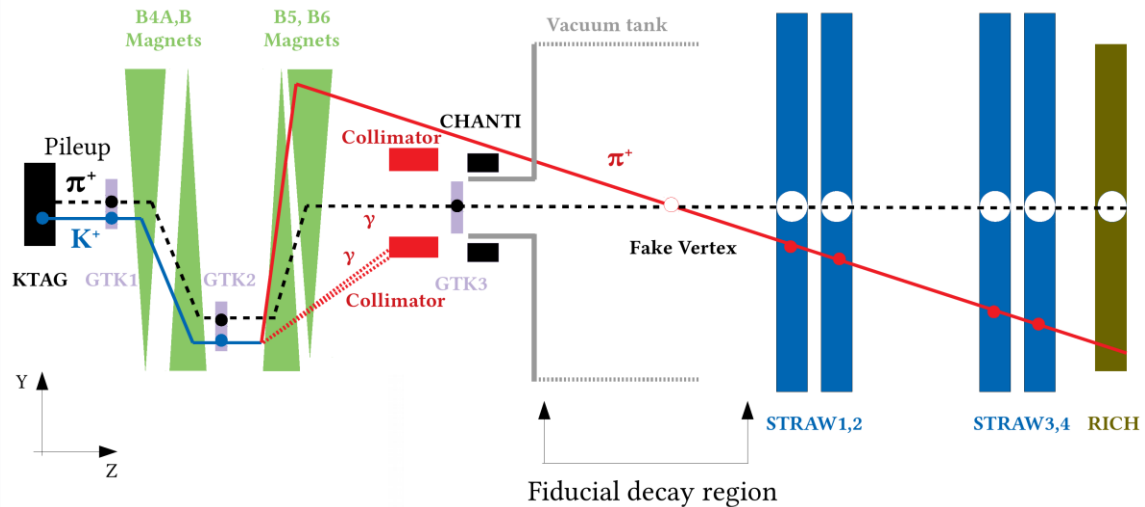
- Soppressione cinematica del fondo  $O(10^5)$
- $p_\pi$  in 15 – 45 GeV/c
- Coincidenza temporale  $O(100 \text{ ps})$
- Discriminazione  $\pi^+ / \mu^+$   
Reiezione  $\mu^+ O(10^6)$
- Veto fotoni  
Reiezione  $\pi^0 O(10^8)$

# UPSTREAM BACKGROUND E RANDOM VETO

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## Upstream background

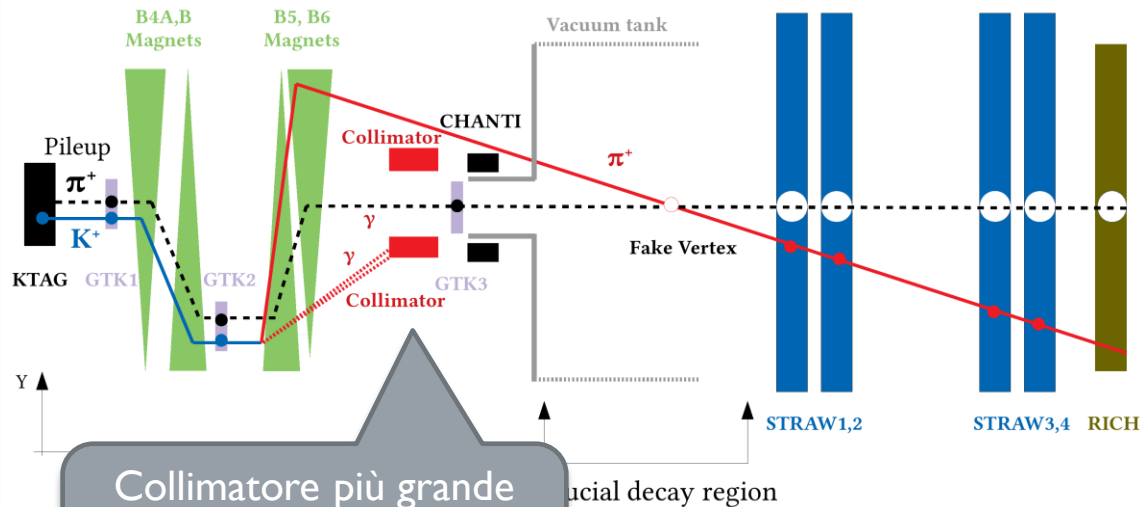
- Decadimento o interazione anelastica di  $K^+$  in GTK
- Particella del fascio in tempo



# UPSTREAM BACKGROUND E RANDOM VETO

## Upstream background

- Decadimento o interazione anelastica di  $K^+$  in GTK
- Particella del fascio in tempo

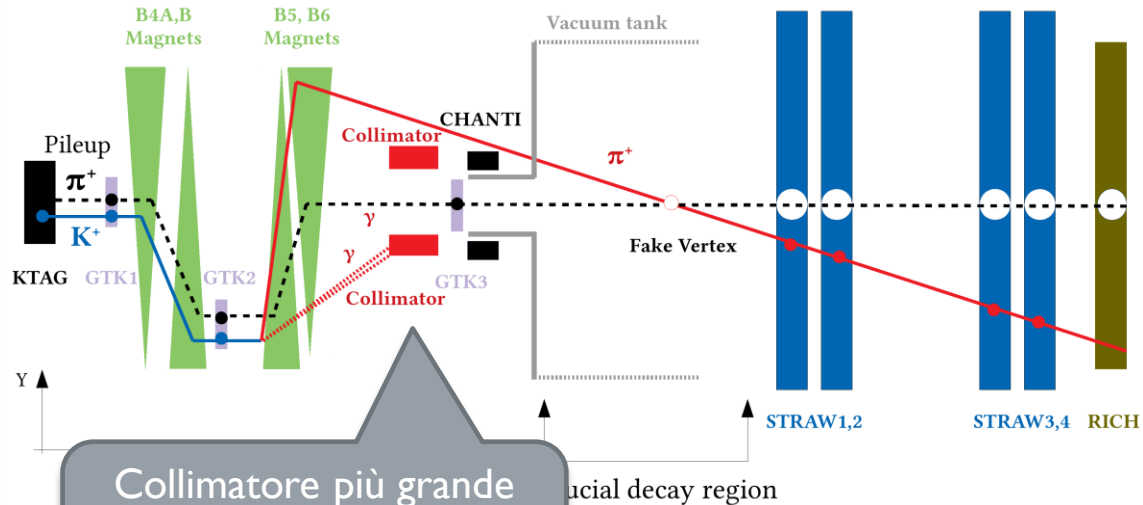


Collimatore piú grande  
installato nel 2018 +  
VetoCounter nel 2021

# UPSTREAM BACKGROUND E RANDOM VETO

## Upstream background

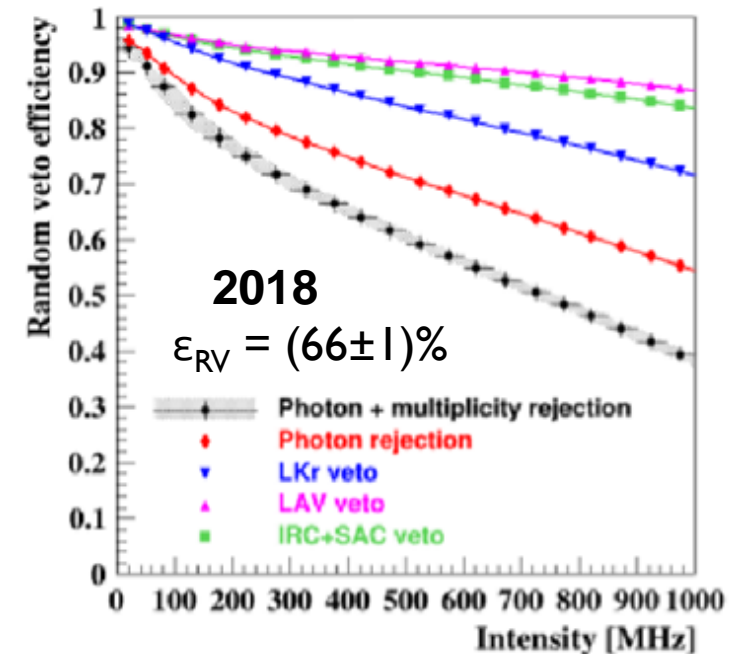
- Decadimento o interazione anelastica di  $K^+$  in GTK
- Particella del fascio in tempo



Collimatore più grande installato nel 2018 + VetoCounter nel 2021

## Random veto

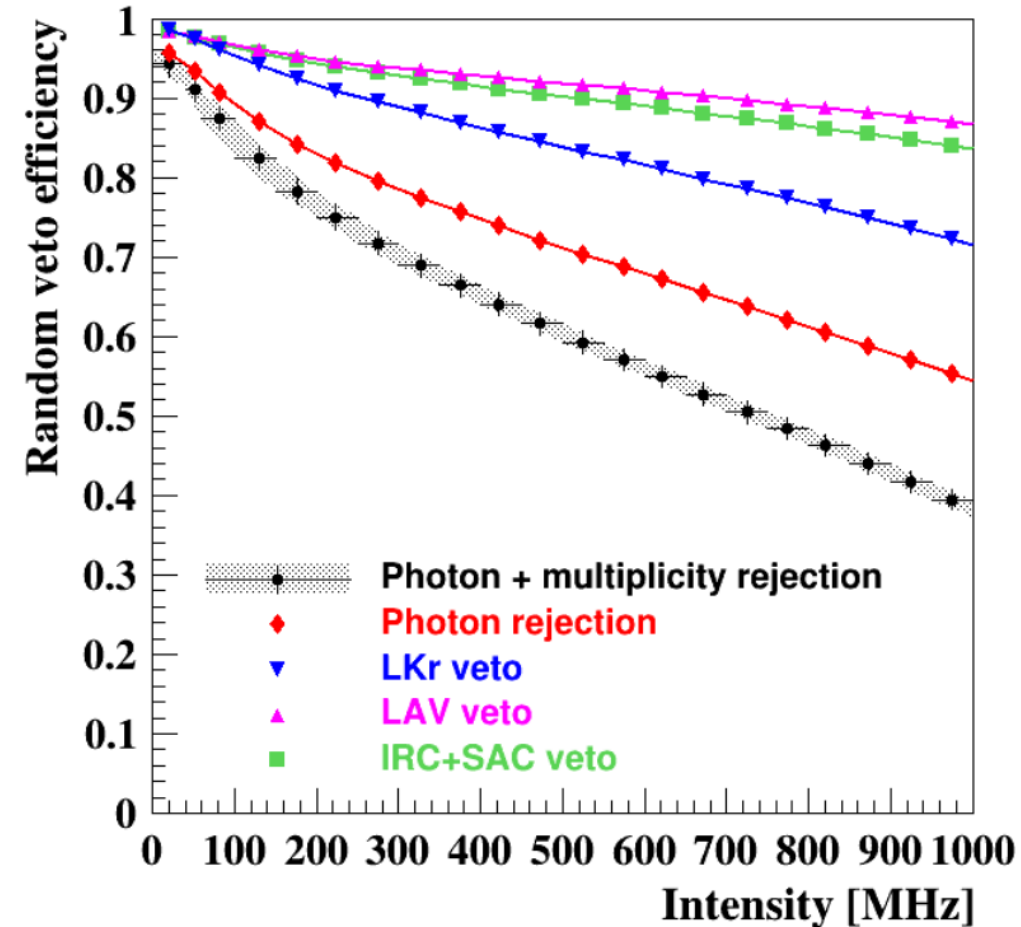
- Attività accidentale nell'apparato
- Aumenta con l'intensità del fascio



# COME MISURARE IL RANDOM VETO?

## Approccio data-driven

- Selezione  $K_{\mu 2}$  (analoga a  $\pi\nu\nu$ )
  - Diversa selezione cinematica
  - PID invertita
- Intensità istantanea: attività fuori tempo del GTK
- Efficienza del veto dei fotoni
- Efficienza del veto di molteplicità

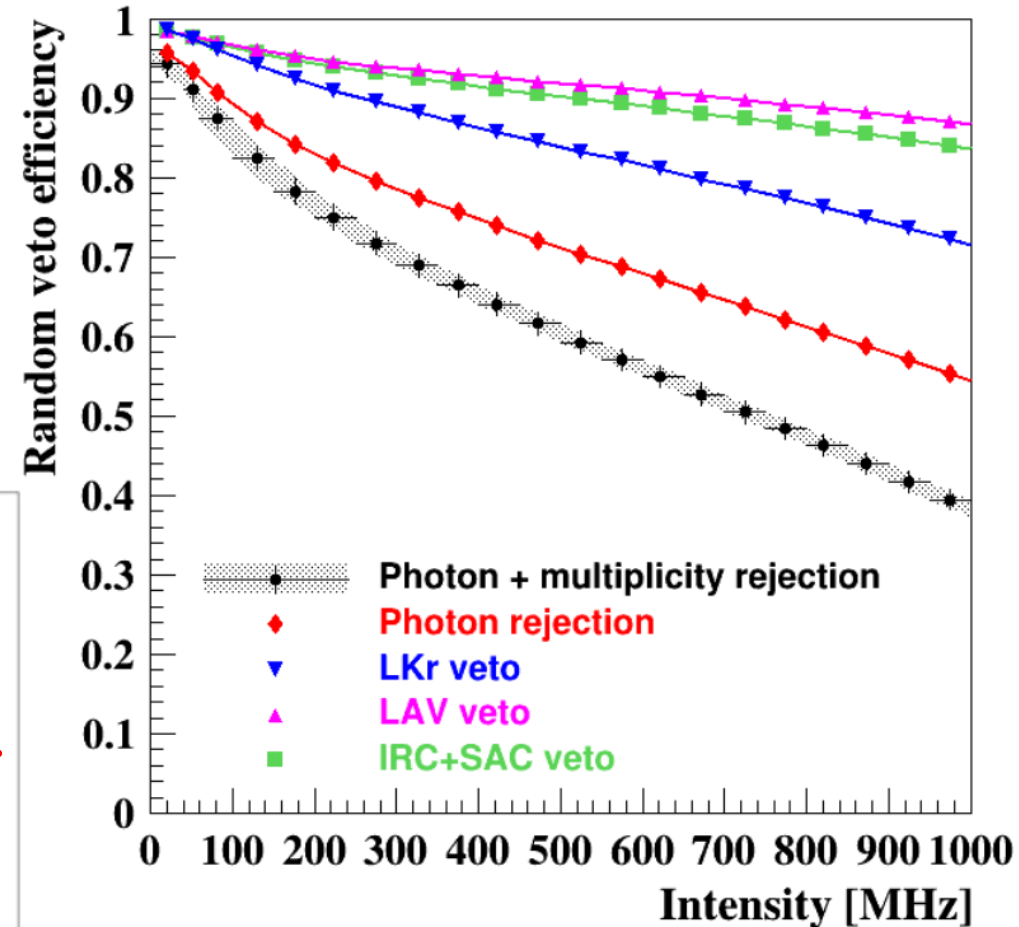
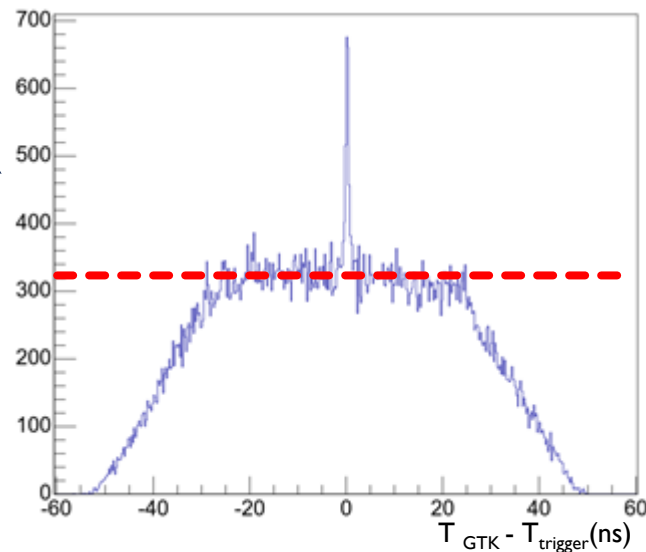




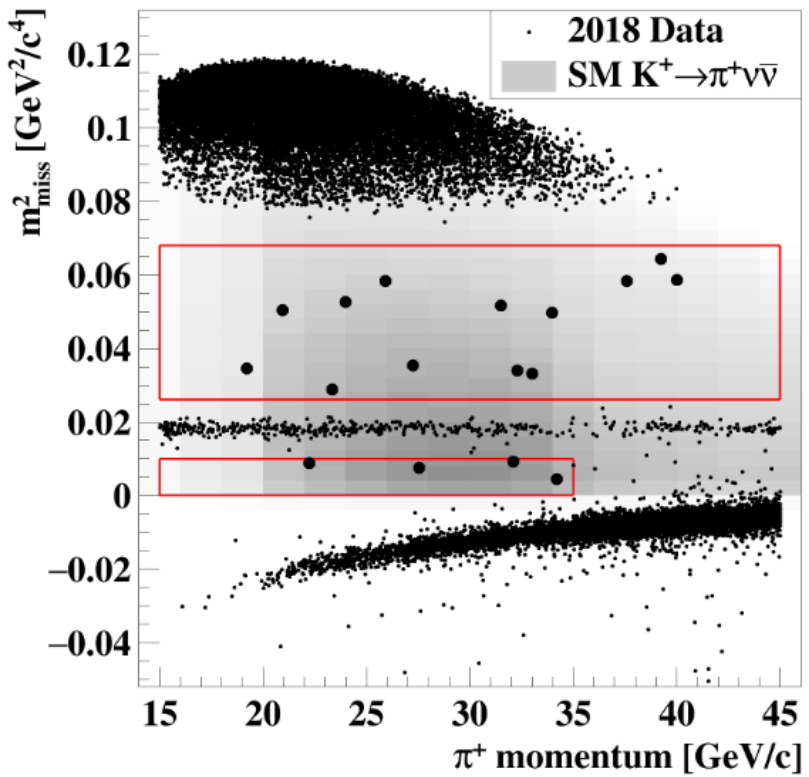
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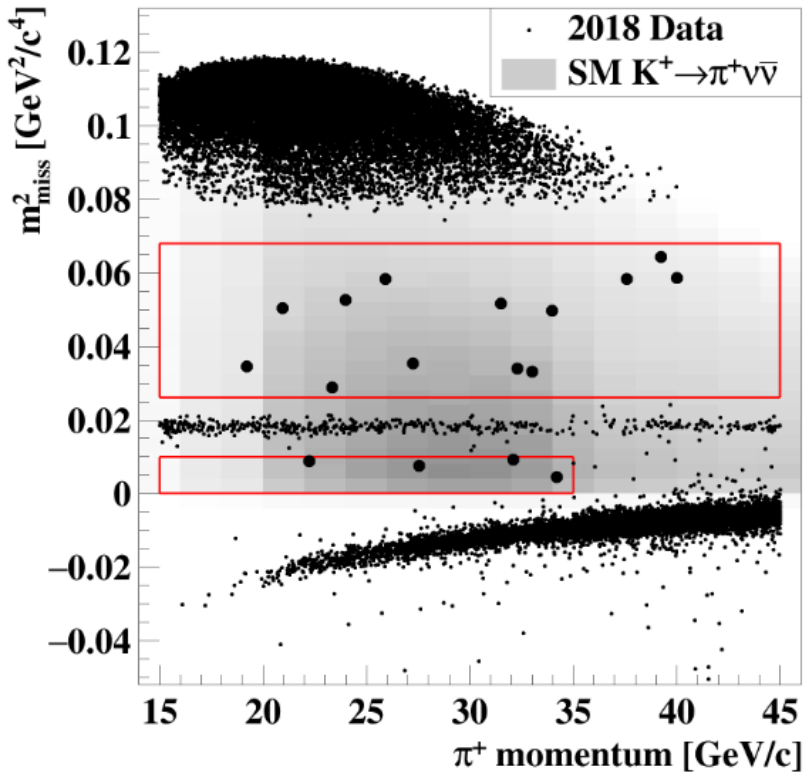
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# RISULTATI RUN1

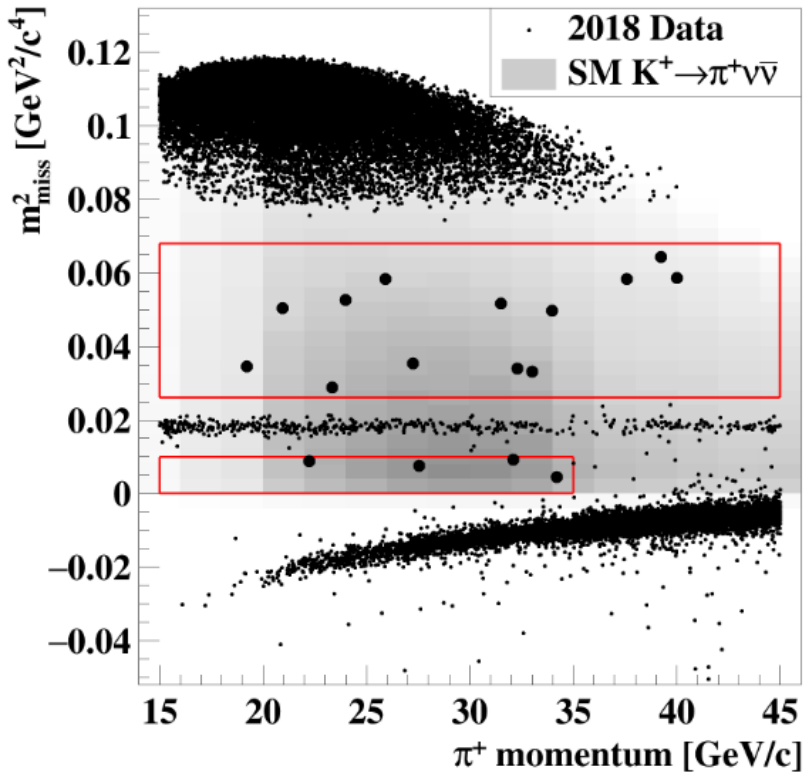


# RISULTATI RUN1



Background	Subset S1	Subset S2
$\pi^+ \pi^0$	$0.23 \pm 0.02$	$0.52 \pm 0.05$
$\mu^+ \nu$	$0.19 \pm 0.06$	$0.45 \pm 0.06$
$\pi^+ \pi^- e^+ \nu$	$0.10 \pm 0.03$	$0.41 \pm 0.10$
$\pi^+ \pi^+ \pi^-$	$0.05 \pm 0.02$	$0.17 \pm 0.08$
$\pi^+ \gamma \gamma$	$< 0.01$	$< 0.01$
$\pi^0 l^+ \nu$	$< 0.001$	$< 0.001$
Upstream	$0.54^{+0.39}_{-0.21}$	$2.76^{+0.90}_{-0.70}$
<b>Total</b>	$1.11^{+0.40}_{-0.22}$	$4.31^{+0.91}_{-0.72}$

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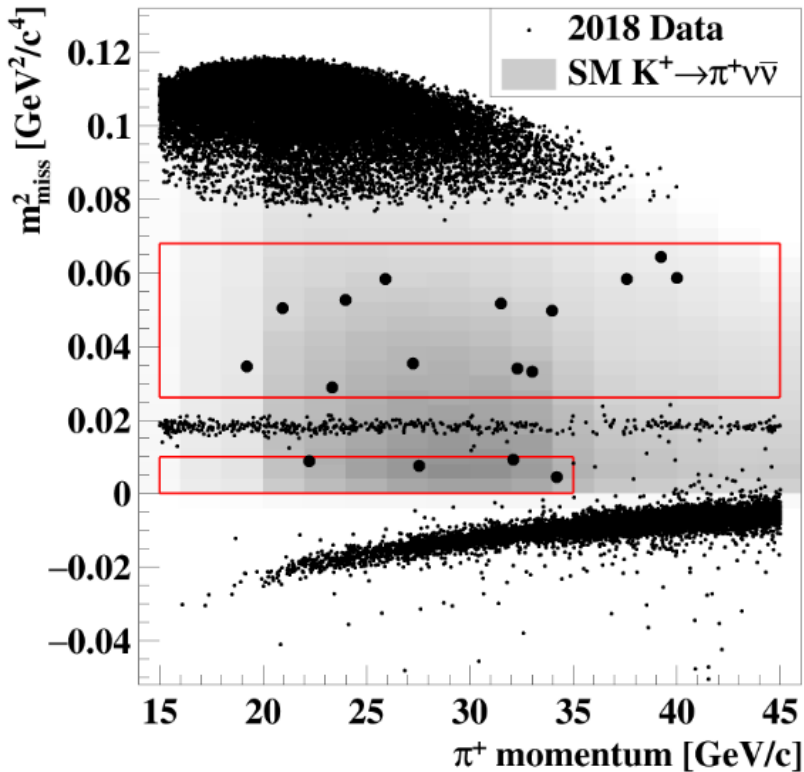
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$$N_{\pi \nu \bar{\nu}}^{\text{exp}} = 10.01 \pm 0.42_{\text{syst}} \pm 1.19_{\text{ext}}$$

$$N_{\text{background}}^{\text{exp}} = 7.03^{+1.05}_{-0.82}$$

$$N_{\text{obs}} = 20$$

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$$N_{\text{obs}} = 20$$

$$\text{BR}(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (10.6^{+4.0}_{-3.4}|_{\text{stat}} \pm 0.9_{\text{syst}}) \times 10^{-11} \text{ at } 68\% \text{ CL.}$$

# ANALISI $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ NEL RUN2

## Novità

- Intensità aumentata del ~50%
- Nuovi rivelatori installati

## Obiettivi per l'analisi

- Mantenere stabile il random veto (reiezione  $\gamma$  nel LKr)
- Riottimizzazione selezione (associazione K/ $\pi$ , definizione volume fiduciale, PID, timing)
- Riduzione del fondo (VetoCounter, HASC2)

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- Riduzione del fondo (VetoCounter, HASC2)

Giuseppe Ruggiero  
(Firenze)

Radoslav Marchevski  
(Firenze)

Joel Swallow  
(Birmingham)

Francesco Brizioli  
(Perugia)

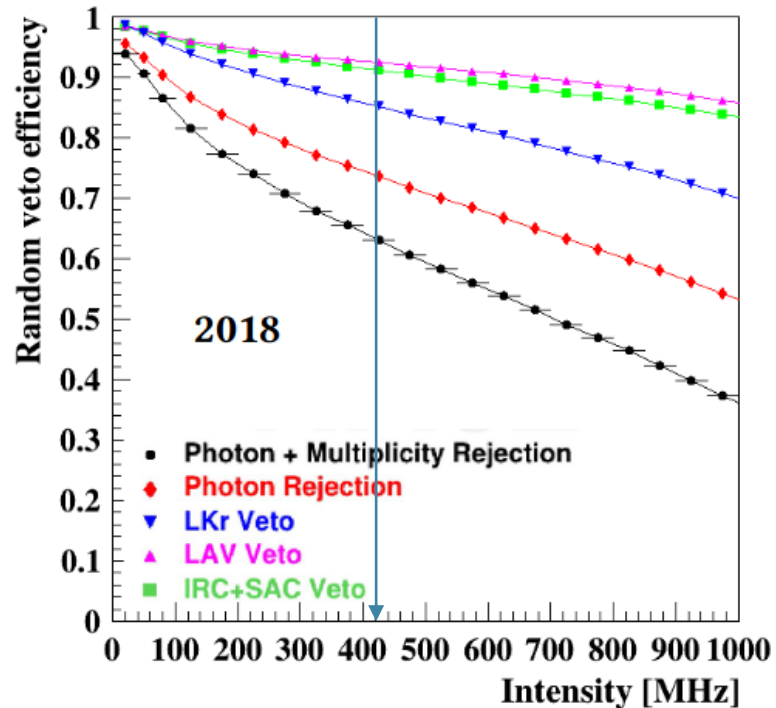
Renato Fiorenza  
(Napoli)

Associazione  $K/\pi$

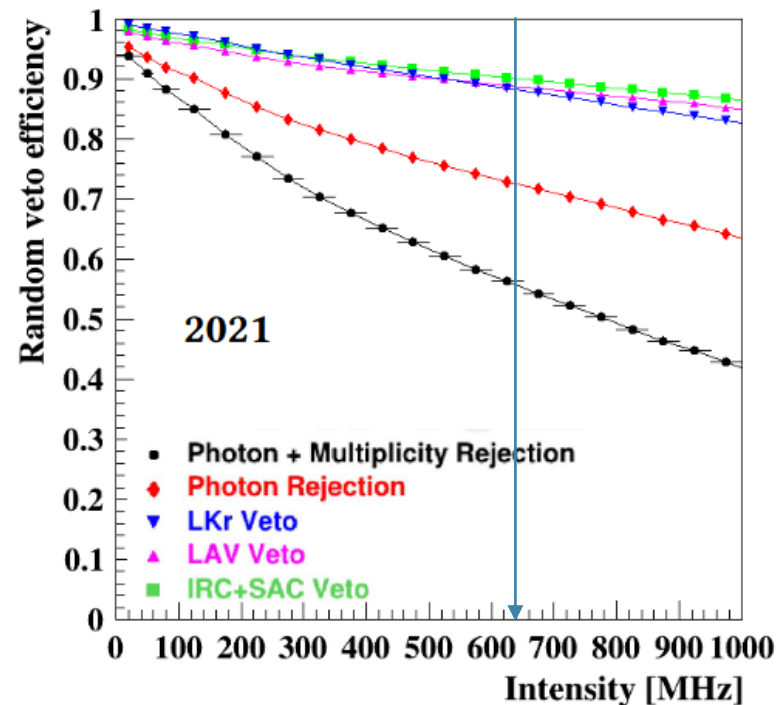
Reiezione fondi

Random veto

# RANDOM VETO NEL 2021



$$\epsilon_{RV} = (66 \pm 1)\%$$
$$\epsilon_{\pi^0} = (1.8 \pm 0.5) \times 10^{-8}$$

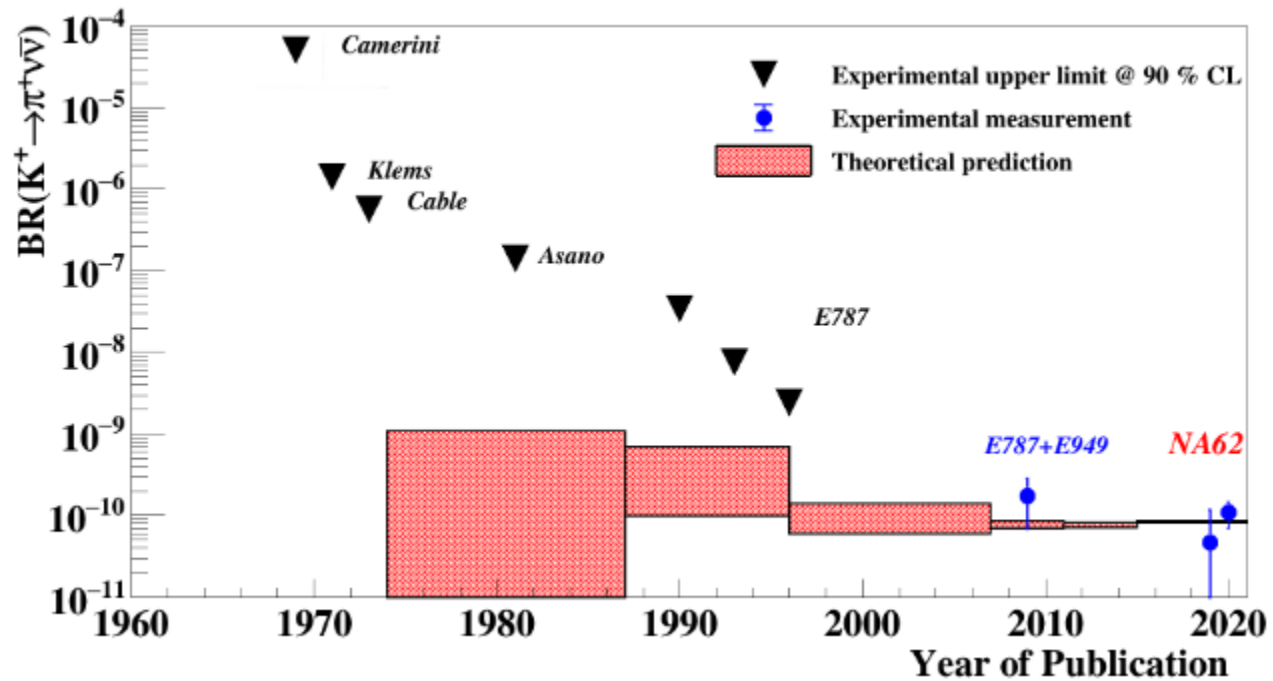


$$\epsilon_{RV} = (62 \pm 1)\%$$
$$\epsilon_{\pi^0} = (0.9 \pm 0.3) \times 10^{-8}$$

- Nuova ricostruzione LKr e conseguente possibilità di ridurre la finestra temporale per veto
- Migliore andamento in funzione dell'intensità
- Random veto tenuto stabile
- Miglioramento reiezione  $\pi^0$  (HASC2)

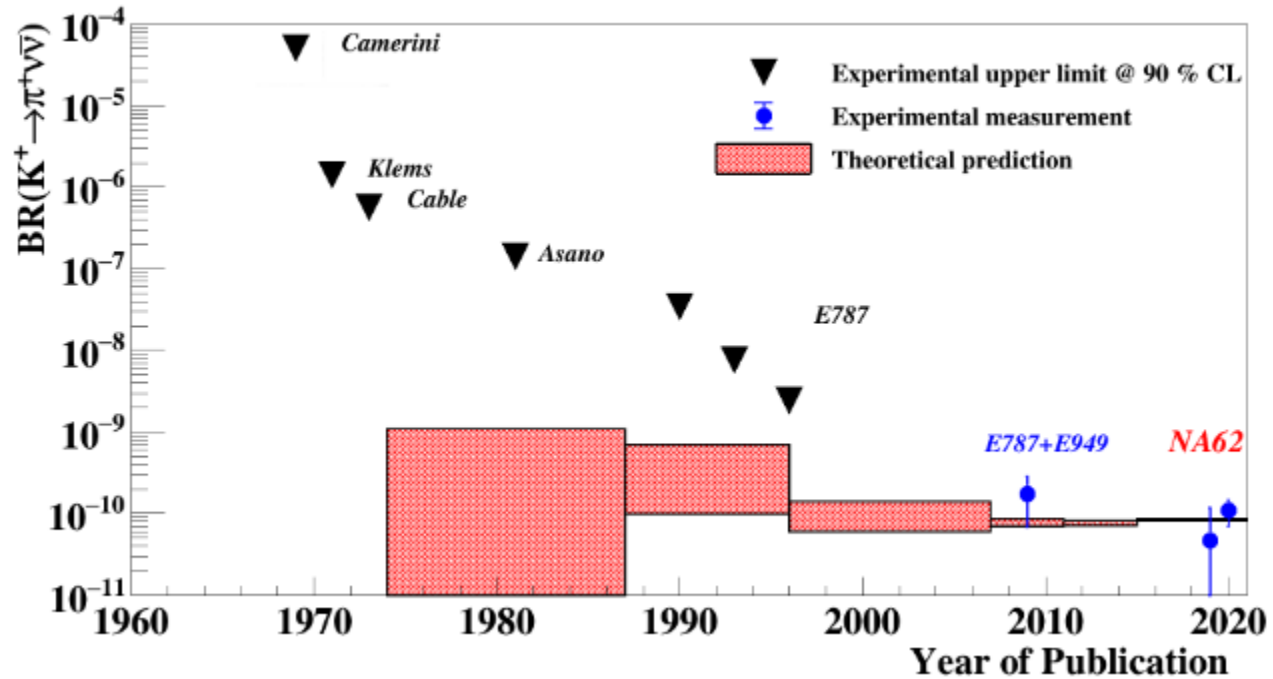


# PROSPETTIVE PER RUN2



- 3 anni presa dati condizioni 2018: precisione  $O(20\%)$
- 3 anni presa dati maggiore intensità + ottimizzazione analisi: precisione  $O(10\%)$

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Grazie per l'attenzione!

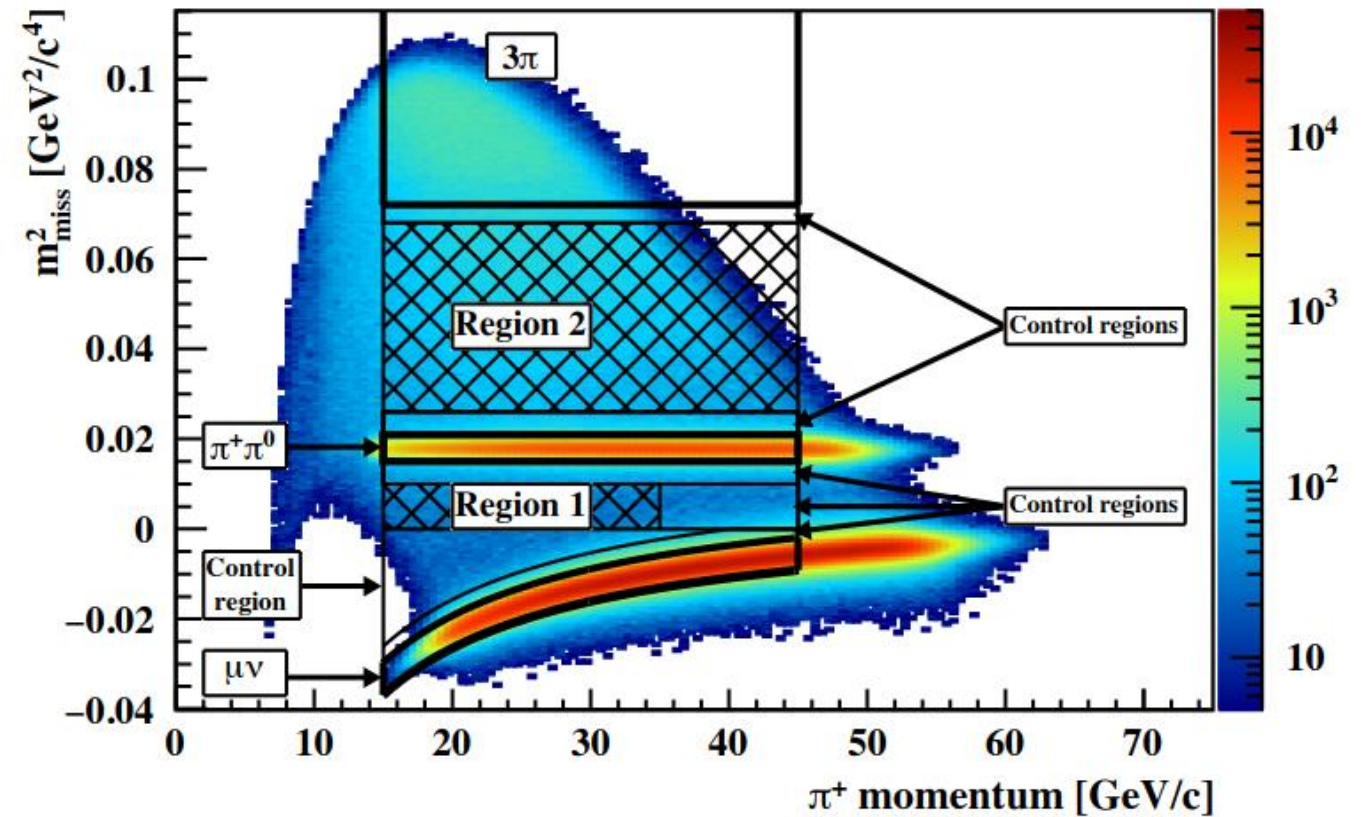


BACKUP

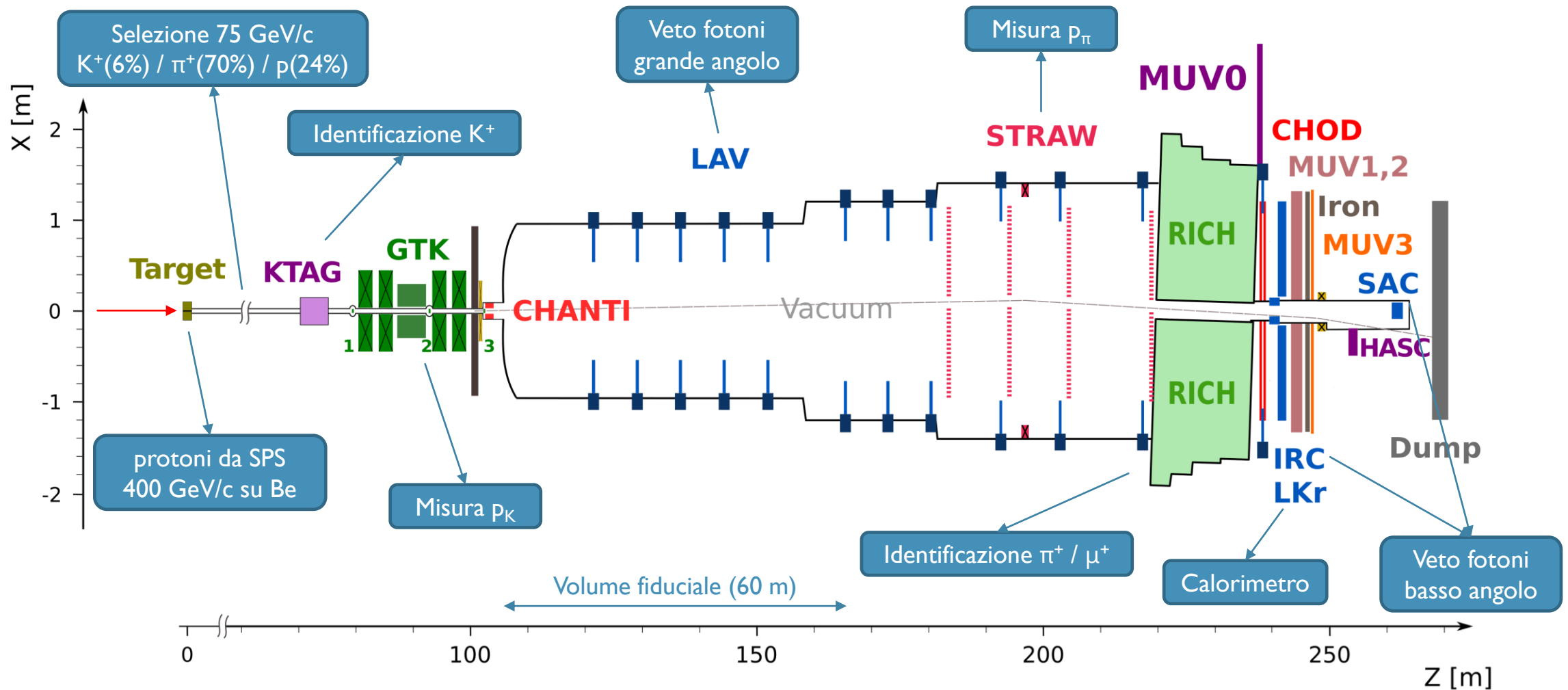


# SELEZIONE $K^+ \rightarrow \pi^+ \nu \bar{\nu}$

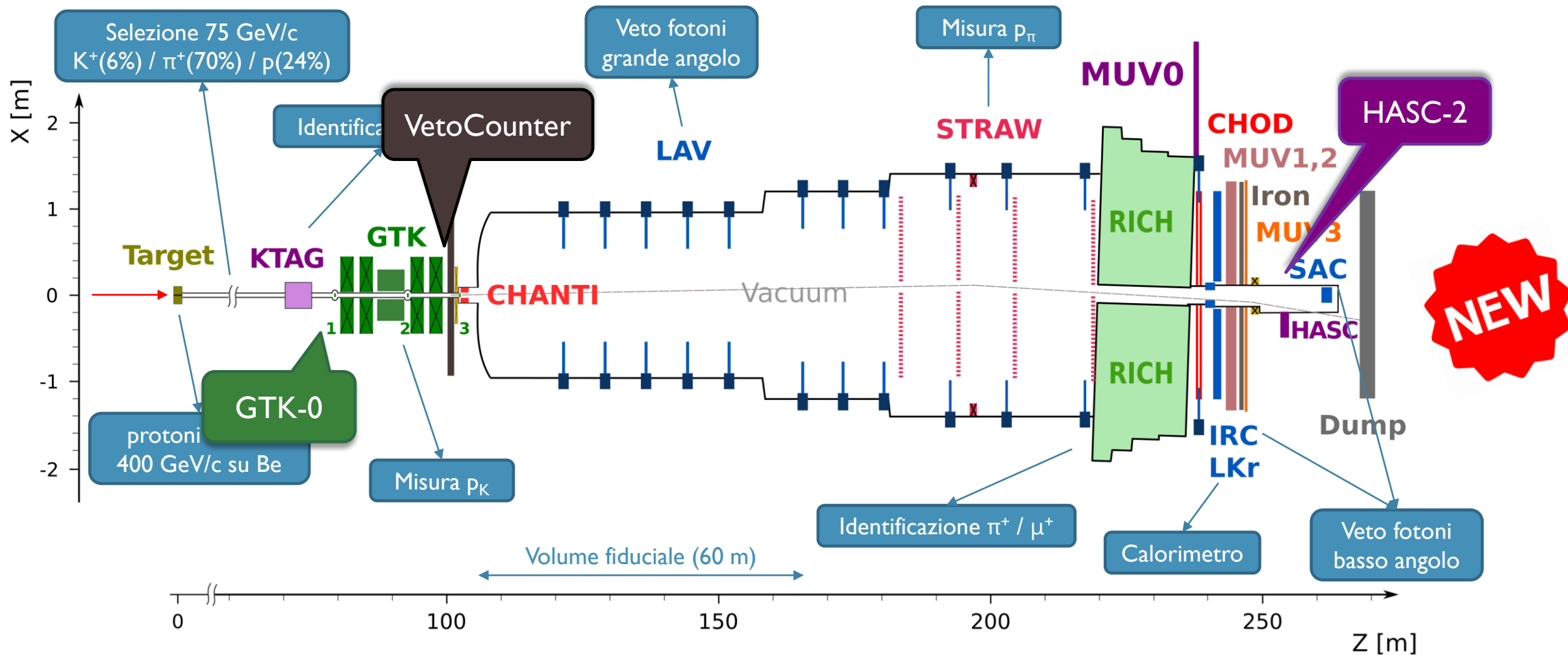
- Ricostruzione tracce  $K^+$  e  $\pi^+$
- Associazione  $K^+ / \pi^+$
- Ricostruzione del vertice
- Identificazione del  $\pi^+$  (reiezione  $\mu^+$ )
- Veto fotoni
- Veto molteplicità (tracce cariche)
- Selezione cinematica



# NA62: APPARATO SPERIMENTALE

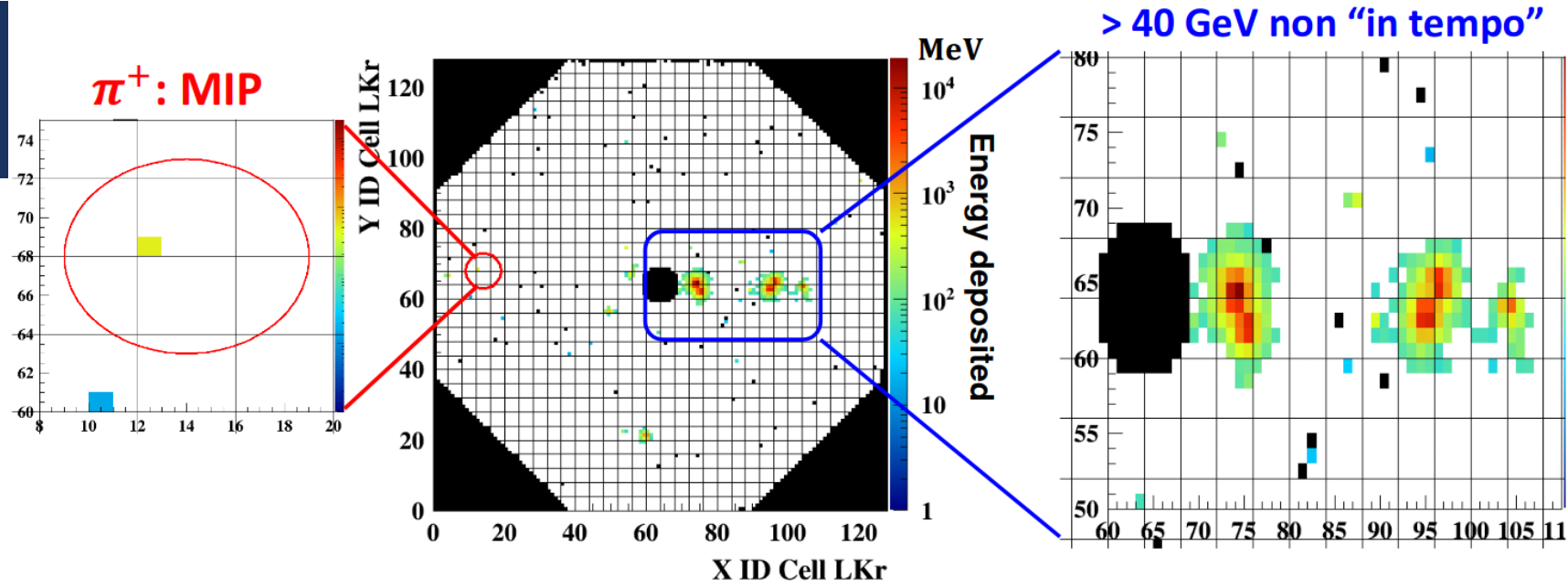


# NA62: APPARATO SPERIMENTALE



# RICOSTRUZIONE LKR

Visualizzazione in energia



Visualizzazione in tempo

