NA62 Richieste e stato

Riunione con Referees 18/07/2025

Monica Pepe
INFN Perugia

La Collaborazione NA62-Italia

9 Sezioni INFN : FE (torna sigla nel 2026), FI, LNF, NA, PG, PI, RM1, RM2, TO (in Dot.1)

Da DB: 69 persone / 23.9 FTE *(sommando 0.5 FTE in sinergia a LNF)*

➔ indicazioni nel DB 0% per personale in congedo (ma che rientrerà nel 2026!)

Siamo circa il 23% della Collaborazione NA62

MA

incidiamo molto di più

Da Organigramma:

35 ruoli di responsabilità totali, di cui 15 ricoperti da NA62-Italia ➔ **43%**

Pubblicazioni

Dal 2024 a Luglio 2025: 9 articoli di cui 5 con NA62-Italia come corr. auth, convener o referee ➔ **~50%**

Editorial board: 4 persone (circa **30%** dell'EB) di NA62-Italia

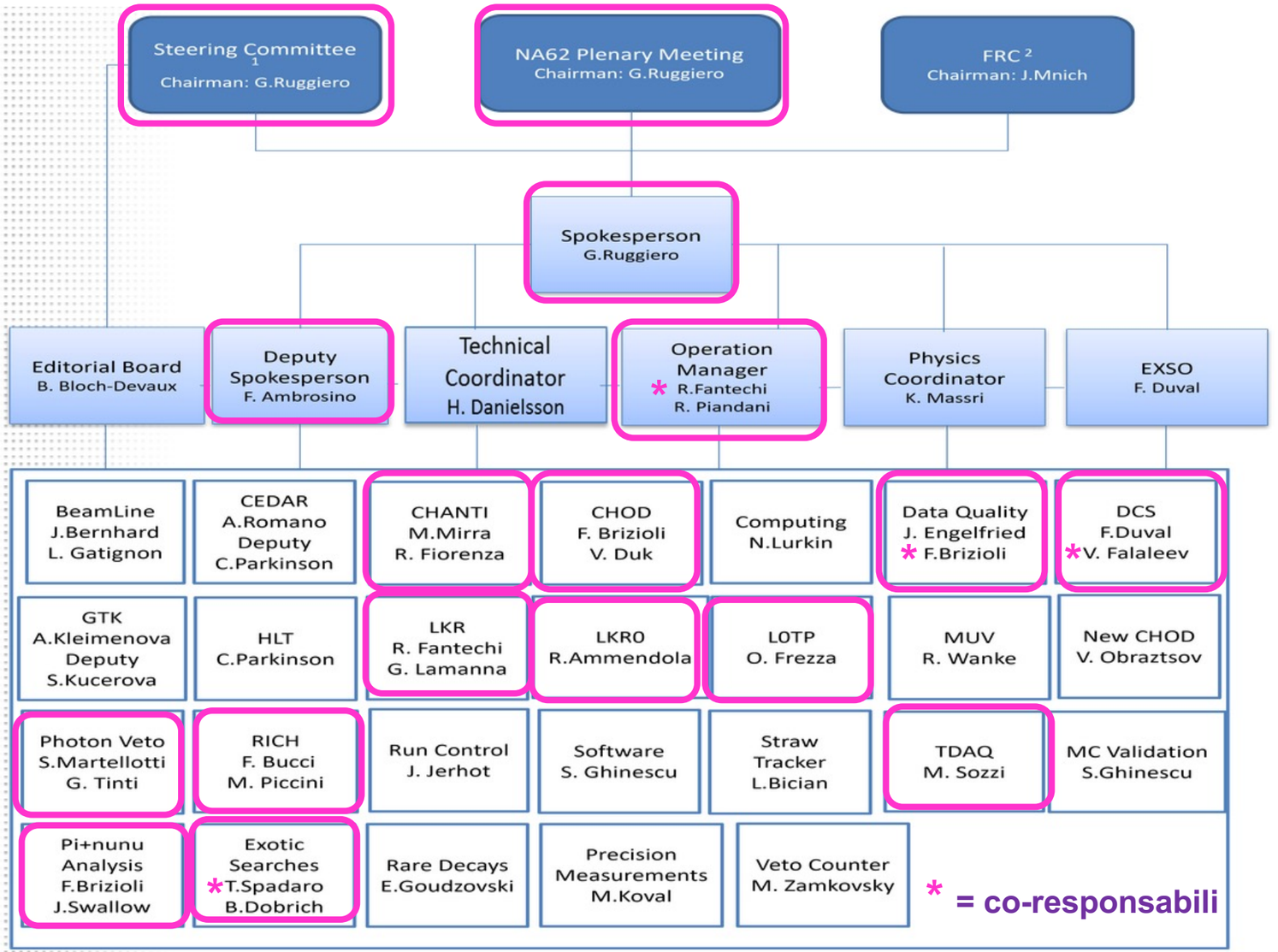
Run Coordinators:

Nel Run 2025: 15 persone R.C. di cui 7 di NA62-Italia ➔ 47%

Responsabilità INFN nella Collaborazione NA62

I gruppi italiani rappresentano il "core" di NA62 con numerose posizioni di leadership

- Spokesperson: G. Ruggiero (FI)
- Deputy Spokesperson: F. Ambrosino (NA)
- $K^+ \to \pi^+ \nu\bar{\nu}$ analysis WG convenors:
  F. Brizioli (PG) J. Swallow (LNF)
- Exotic searches WG co-convenor:
  T. Spadaro (LNF)
- TDAQ WG convenor:
  M. Sozzi (PI)
- Data Quality/Data Processing WG co-convenor:
  F. Brizioli (PG)



Responsabilità INFN della maggior parte dei rivelatori/sistemi:
LAV/SAV (LNF), CHOD (PG), CHANTI (NA), RICH (FI/PG)
LKR (PI), DCS (PG*), LKR0 (RM2), L0TP (RM1)

Membri Editorial Board:
F. Brizioli (PG) F.Bucci(FI) G.Ruggiero(FI) T.Spadaro(LNF)

Rinnovo cariche elettive Collaborazione NA62

- In corso le elezioni per il rinnovo delle 4 cariche più rilevanti della Collaborazione
- I nuovi eletti saranno in carica dal 1 Ottobre 2025 per 3 anni
- L'elezione delle cariche avviene attraverso steps successivi

- **Spokeperson**: riconfermato G. Ruggiero (FI) (eletto il 14/07)
- **Physics Coordinator:** 2 persone di NA62-Italia al ballottaggio (voto entro il 27/07)
- **Editorial Board Chair:** abbiamo un candidato INFN

➔ success rate ≥ 50%

Publications 2024 - 2025

Published

1) E.Cortina Gil et al., **Measurement of the $K^+ \to \pi^+\gamma\gamma$ decay**, *Phys. Lett. B 850 (2024) 138513* **(R2)**
2) A. Bethani et al., **Development of a new CEDAR for kaon identification at the NA62 experiment at CERN**, *2024 JINST 19 P05005* **(R2)**
3) E.Cortina Gil et al., **Search for leptonic decays of dark photons at NA62**, *Phys. Rev. Lett. 133, 111802 (2024)* **(BD-R2)**
   Exotics working group co-coordinator : T. Spadaro (LNF)
4) M. U. Ashraf et al., **First search for $K^+ \to \pi^0 \pi\mu e$ decays,** *Phys. Lett. B 859 (2024) 139122* **(R1)**
   INFN responsibility for internal review.
5) E.Cortina Gil et al., **First detection of a tagged neutrino in the NA62 experiment,** *Phys. Lett. B 863 (2025) 139345* **(R2)**
6) E.Cortina Gil et al., **Observation of the $K^+ \to \pi^+\nu\bar{\nu}$ decay and measurement of its branching ratio,** *JHEP Vol. 2025, Issue 02, 191* **(R2)**
   Corr. Auth.: F. Brizioli (PG), R. Fiorenza (NA), J. Swallow (LNF)
7) E.Cortina Gil et al., **Search for hadronic decays of feebly-interacting particles at NA62,** *Eur. Phys. J. C 85, 571 (2025)* **(BD-R2)**
   Exotics working group co-coordinator : T. Spadaro (LNF)
8) B.Bloch-Devaux et al., **Search for heavy neutral leptons in π^+ decays to positrons.** **(R2)** *arXiv:2507.07345* (CERN-EP-2025-152)

In preparation

9) E.Cortina Gil et al., **Hidden sector searches using $K^+ \to \pi^+X$ decays at NA62 (R1+R2)**

   Corr. Auth.: F. Brizioli (PG), M. Raggi (RM1), J. Swallow (LNF)

   Results from the study of the rare decays $K^+ \to \pi^+\nu\bar{\nu}$, $K^+ \to \pi^+\mu^+\mu^-$ and $K^+ \to \pi^+\gamma\gamma$ at the NA62 experiment at CERN are interpreted in terms of limits of $B(K^+ \to \pi^+X)$. The X particle is a hidden sector mediator which can decay into invisible dark matter candidates or a pair of Standard Model particles.

Considerazioni

NA62 is the last opportunity to study physics with charged kaons with high precision at CERN

must extract all we can from our data

- La collaborazione NA62 rimane solida.
- Target: prendere più dati possibili migliorando efficienza e qualità
- NA62-Italia continuerà ad assumere posizioni di responsabilità e di rilievo nell'analisi

Fondamentale il supporto della CSN1 dopo la fine della presa dati, quando tutti gli sforzi saranno concentrati sull'analisi

Envelope finanziario 2026

Il prossimo anno sarà anche l'ultimo di presa dati per NA62 (almeno a quanto sappiamo ora)

Il grosso del budget sarà quindi dominato dalle missioni per il run

RICHIESTE INSERITE IN DB PREVENTIVI

- Missioni 443 k€ (+ 7 k€ SJ ad eventuale attività decommissioning)
- Consumi (incluso metabolismo) 50 k€
- Servizi 30 k€
- Licenze Software 2 k€
- MOF (come da fattura 2025) 175 k€

TOTALE RICHIESTE 700 k€ + 7 k€ Missioni SJ

Richieste 2026 Missioni : 443 k€ + 7 k€ SJ

Metabolismo missioni:

- 1mp/FTE (estere) + 1 k€ /FTE (Italia)

Richieste specifiche:

- responsabilità dei conveners
- manutenzione apparato
- analisi giovani ricercatori
- Richieste RUN
- SJ per eventuale inizio smontaggio

N.B. il nuovo disciplinare Missioni aumenta del 10% la diaria al CERN

➔ abbiamo aumentato del 10% il valore del m.p. delle vecchie tabelle

Calcolo Missioni per il RUN 2026 (9-3 – 2/8)

- 21 settimane = 882 turni totali per circa 114 turnisti (nel 2025 ma con i Russi…)
- Quota turni/persona = 8
- 1 settimana/uomo = 4/5 turni
- Esperti «on call»: se condivisi, si tiene conto delle frazioni (es. RICH sharing FI-PG 50%)
- Esperti «on call» fanno turni per circa il 50% del loro tempo ➔ abbassano quota turni
- Run Coordinators: 3 settimane/persona/RC
- 2/4 settimane di preparazione al Run per ciascun sistema a seconda della complessità

Algoritmo ben collaudato in linea con i referee

Richieste 2026 Consumi- SPServizi – Licenze SW

CONSUMI 50 k€

- Metabolismo 1.5 k€ a FTE
- Manutenzione elettronica

SPSERVIZI 205 k€

- MOF-A: 160 kCHF ➔ 175 k€ come da fattura del 2025 incluse spese
- Magazzino e camionette CERN, telefoni CERN per esperti on-call

Licenze Software 2 k€

- PI: contributo licenze condivise software elettronica (Quartus, etc.) 1 k€
- RM2: Contributo licenze EUROPRACTICE 1 k€

Richieste 2026 per Sezione

Struttura	FTE	Missioni	Missioni_sj	Consumo	Licenze-SW	SpServizi	TOTALE	TOTALE_SJ
FE	2	23,5		3			26,5	
FI	2,1	69,5	1	5		2	76,5	1
LNF	4,9	81	2	8,5		2	91,5	2
NA	3,6	64	2	7,5		2	73,5	2
PG	3,5	79,5	2	8,5		197	285	2
PI	2	40		5	1	2	48	
RM1	2,8	45,5		4			49,5	
RM2	2	23		7	1		31	
TO (dtz)	1	17		1,5			18,5	
TOTALE	23,9	443	7	50	2	205	700	7

Milestones 2025

DATA	MILESTONE	STATO al 15/07/225
31/12/2025	Risultato preliminare HNL e ALP dati 2024 (mostrato a conferenza)	Kaon mode: OK *(arXiv:2507.07345)* Dump mode: 60%. Probabile raggiungimento 100% in autunno
31/12/2025	Sensitività PiNuNu dati 2023-2024 (mostrato a conferenza)	100% (vedi ad esempio FLASY 2025)
31/12/2025	Analisi dati Test Beam del SAC e pubblicazione	il TB sarà a settembre, è presumibile avere un arXiv entro l'anno

Milestones 2026

DATA	MILESTONE	COMMENTI
31/12/2026	Risultato preliminare PiNuNu dati 2023-2024 (mostrato a conferenza)	INFN Analysis leadership (Brizioli, Fiorenza, Swallow)
31/12/2026	Pubblicazione dell'articolo su HNL dati 2021-2024	INFN Analysis Co-convenor (Spadaro)
31/12/2026	Pubblicazione della prima osservazione del decadimento K+ -> mu+ nu mu+ mu- e misura del suo BR	Continuazione analisi INFN (vedi Boretto vincitore Premio Conversi 2020)

Decomissioning

A quanto ne sappiamo oggi, il 2026 sarà l'ultimo anno di presa dati di NA62

ma….

non abbiamo ancora una schedula ufficiale per lo smontaggio

Probabile schedula preliminare al Collaboration Meeting la settimana 1-4/09/2025
➔ potremmo inviarvela in via confidenziale prima della riunione CSN1
➔ per questo motivo richiesta missioni SJ

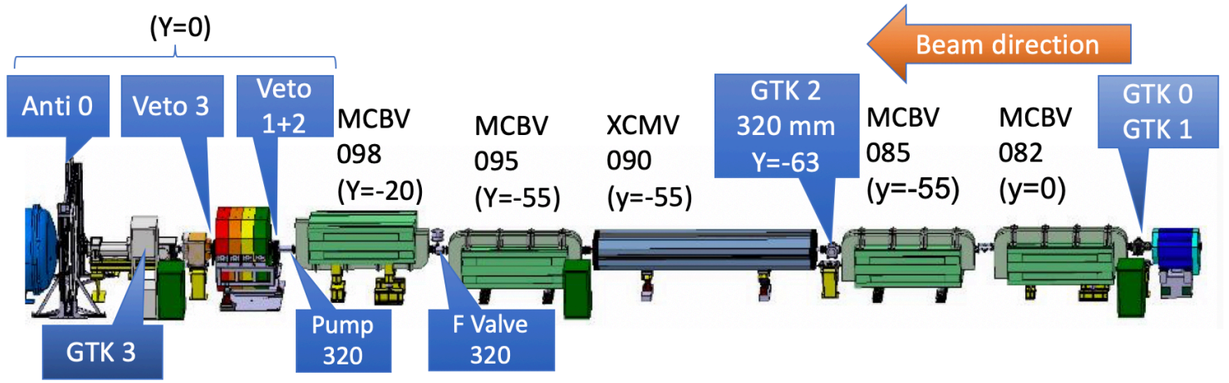
NA62 si propone di mantenere l'apparato installato fino a quando lo smontaggio non sarà più rimandabile

Recap: Slides per la CSN1 di Luglio 2025

≥ 2021 Run (Run2)

NA62 Scheduled to run until beginning LS3 (August 2026)

Layout modification: GTK2 moved by some meters and scraper of half a meter to mitigate the impact of beam interactions and allow space for the new Veto Counter



GTK0:	4^{th} station of Gigatracker to improve $K-\pi$ matching efficiency	**2021**
Veto Counter (VC):	veto of K decays occurring upstream	**2021**
Anti0:	veto "accidental" particles to improve background rejection	**2021**
HASC2:	improve photon rejection at small angles	**2021**
New TDC + FELIX to readout the VC:	test of new readout, suitable for high - rate detectors	**2022**
CEDAR - H:	reduce material along the beam line	**2023**
New L0 trigger processor (L0TP+):	increase trigger bandwidth	**2023**
New TDC + FELIX readout in CHANTI:	improve rate capability, provides TEL62 spares for trigger detectors	**2024**

INFN

2024 Run Summary

10/04 – 31/10

180 days in K mode, 10 days in dump, 7 days at low intensity: smooth and successful run.

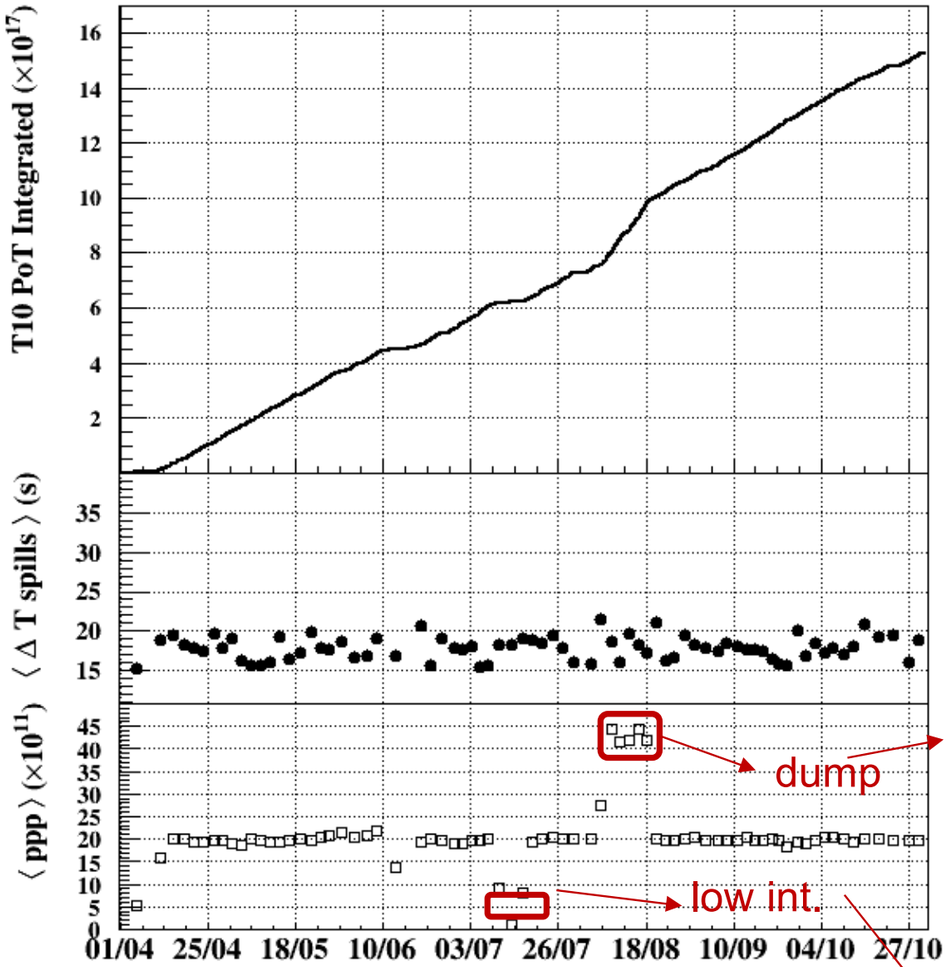
TEL62 readout replaced in CHANTI with FELIX readout (INFN Napoli)

Higher fraction of CHANTI bad bursts for some weeks due to firmware issues, then fixed

- Quick beam tuning
- 20×10^{11} ppp stable intensity, good spill quality
- *~ 600K bursts (or spills) collected* ➔ *the largest sample taken in one year*
- *The 2024 data have been processed online and their quality fully assessed. The reprocessing with the final calibration constants is completed.*

2024 Run PoT

No major issues with the beam delivery during data taking, the spill quality was good



⇨ **Integrated PoT $\sim 1.5\times10^{18}$ on T10**

1.29 x 10^{18} in kaon mode and 0.23 x 10^{18} in dump mode

⇨ **$\langle \Delta t$ spills$\rangle \approx 18\ s$**

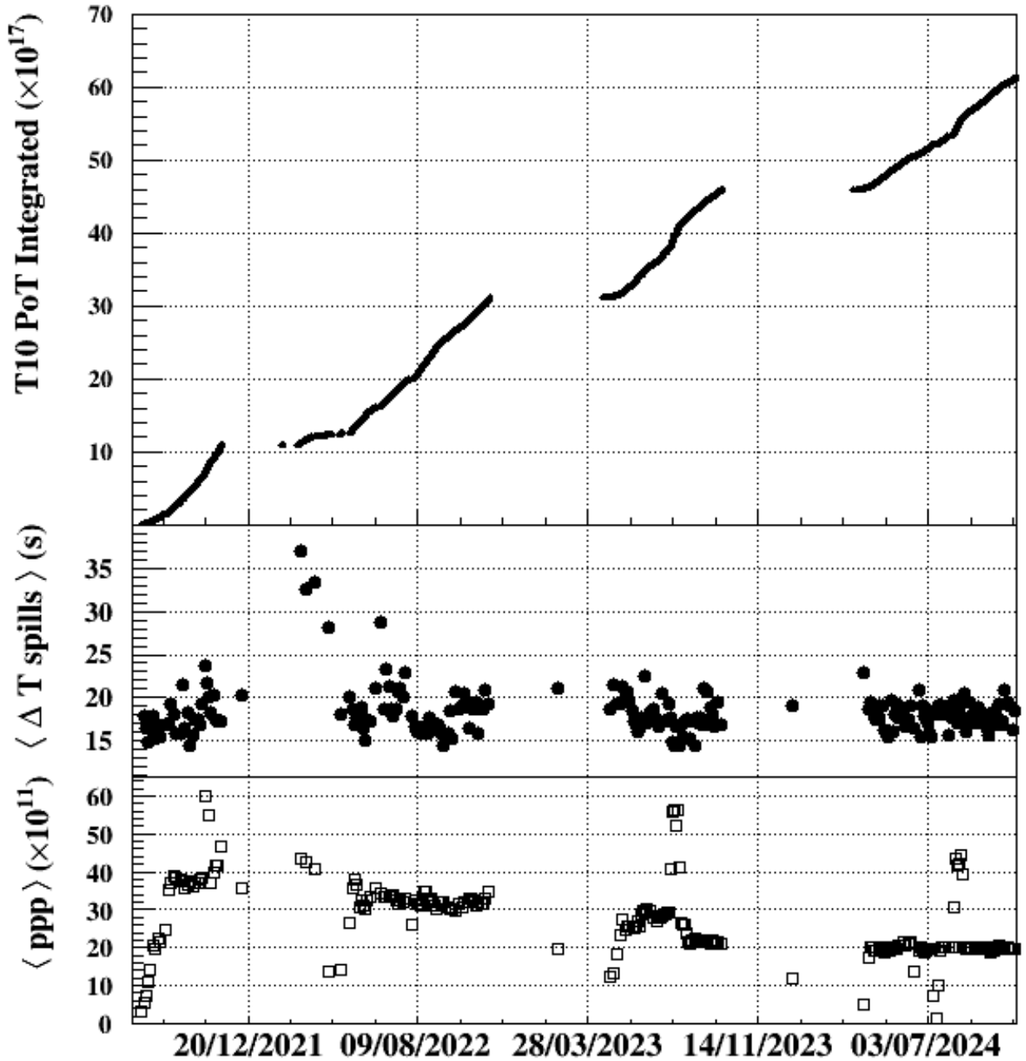
The actual time difference varied during the run from 14.4 s to 20–25 s depending on parallel activities

45 x 10^{11} ppp 20% less than 2023 because of radiation alarms in the TAX

⇨ **$\langle$ppp$\rangle \approx 20\times10^{11}$**

average instantaneous beam intensity of 410MHz @ GTK

2021-2024 Run PoT



⇨ **Integrated PoT $\sim 6\times10^{18}$ on T10**

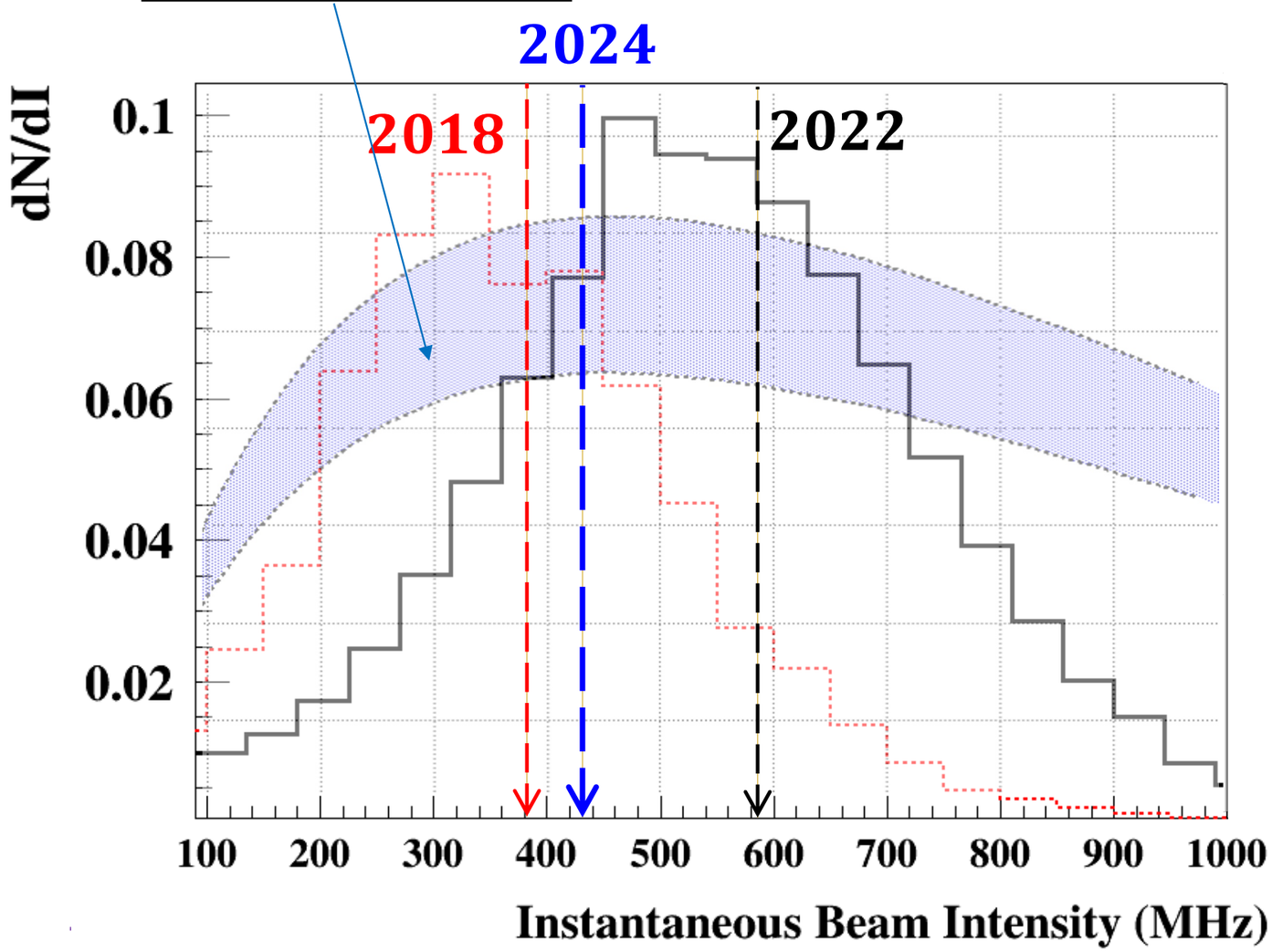
⇨ $\langle \Delta t \text{ spills} \rangle \approx 18\ s$

⇨ ***average intensity (protons per pulse) from the T10 intensity monitor (over 2x10⁴ spills)***

Optimal Intensity

Expected PNN yield from 2023 studies (arbitrary scale)

Rate that maximizes $K^+ \to \pi^+ \nu\bar{\nu}$ yield according to study performed in 2023



Instantaneous beam intensity measured from out-of-time activity in GTK

Selected signal yield saturates at high intensity mainly due to:

- TDAQ dead time and trigger veto windows
- Offline selection due to veto conditions.

Main sources of uncertainty:

- Online time-dependent miscalibrations.
- Fit uncertainty

2024 run at 75% of full intensity: optimal for NA62 hardware

Performance and Data Taking efficiency

Year	SoB ($\times 10^3$)	Bursts with beam on T10 ($\times 10^3$)	Bursts collected ($\times 10^3$)	PoT(Kaon) ($\times 10^{18}$)	PoT(Dump) ($\times 10^{18}$)
2024	942	734	636	1.29	0.23
2023	655	514	443	1.17	0.27
2022	817	553	402	1.78	–
2021	374	251	145	0.60	0.14

Year	T4	T10	NA62	DAQ	Total
2024	0.794	0.981	0.920	0.941	0.675
2023	0.812	0.967	0.922	0.935	0.677
2022	0.715	0.950	0.878	0.828	0.494
2021	0.738	0.915	0.850	0.796	0.454

2016-18: bursts collected $\sim 900K$, T4 ~ 0.74, Total ~ 0.55

T4: SoB with beam recorded on T4 vs SoB signals [primary beam issues]

T10: as above for T4&T10 target [includes failures in K12 and NA62 access]

NA62: spills recorded by NA62 in run vs spills with beam on T4 & T10 [includes NA62 with run stopped]

DAQ : spills recorded by NA62 vs spills saved with # triggers consistent with expectation [NA62 data flow issues]

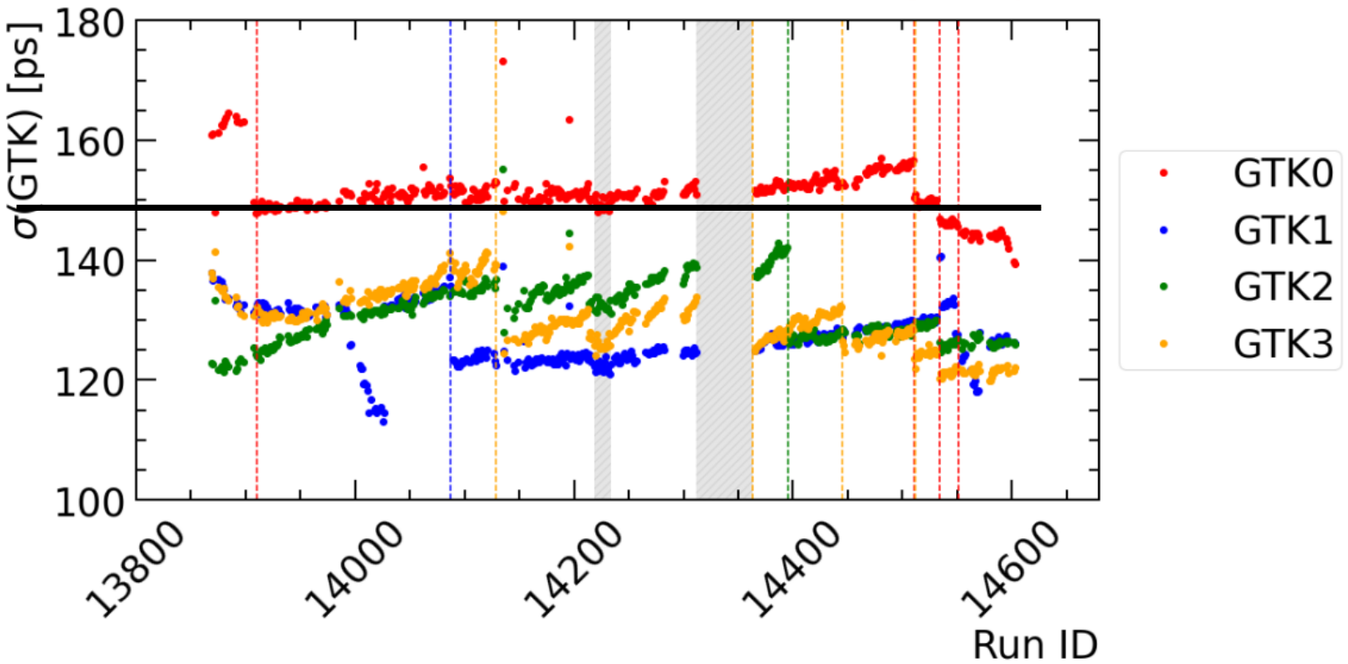
Detector Performance

RUN 2024

GTK

GTK1,2,3 worked smoothly

GTK0 quarter chip failure in June and missing until end-run



CHANTI

A problem with the timing distribution of the Felix TDCs at beginning of run, leading to inefficiencies in ~ 7% of the 2024 total collected spills.

Cured by an update of the firmware.

Part of the inefficiency (65% of affected spills) recovered at sofware level

All the other detectors

All worked smoothly with performance in line with previous years.

No significant deterioration/aging effect observed.

2025 Restart

Plans:

209 days expected

10 days in dump mode, 1 week at low intensity

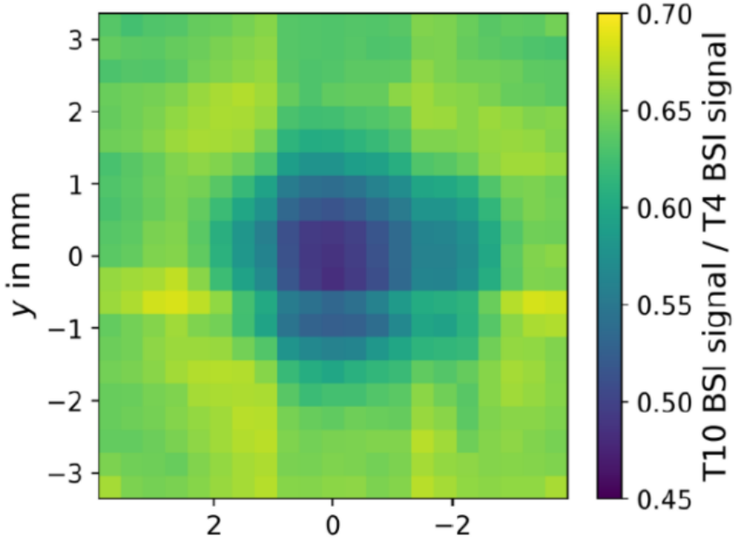
Restart of data taking

Beam commissioning smooth: beam ready well before official physics start

- T10 intensity monitor more and more degraded
  (up to 40% response variation across the surface due to radiation damage)

➔ Some days needed to adjust the optimal intensity from reconstructed data

Intensity measured by GTK with out-of-time events



Detectors calibrated and aligned before the start physics run

- Slow restart of GTK due to power converter fault and cooling issues

- Data Quality is good
- Very good DAQ peformance,

2025 Data Taking

Stato al 2/06/2025

Period start	Thu Apr 17 09:00:13 2025
Period end	Mon Jun 2 07:59:25 2025
Total seconds	3970752
Total POT on T4	7.0538e+17
Total POT on T10	3.1738e+17

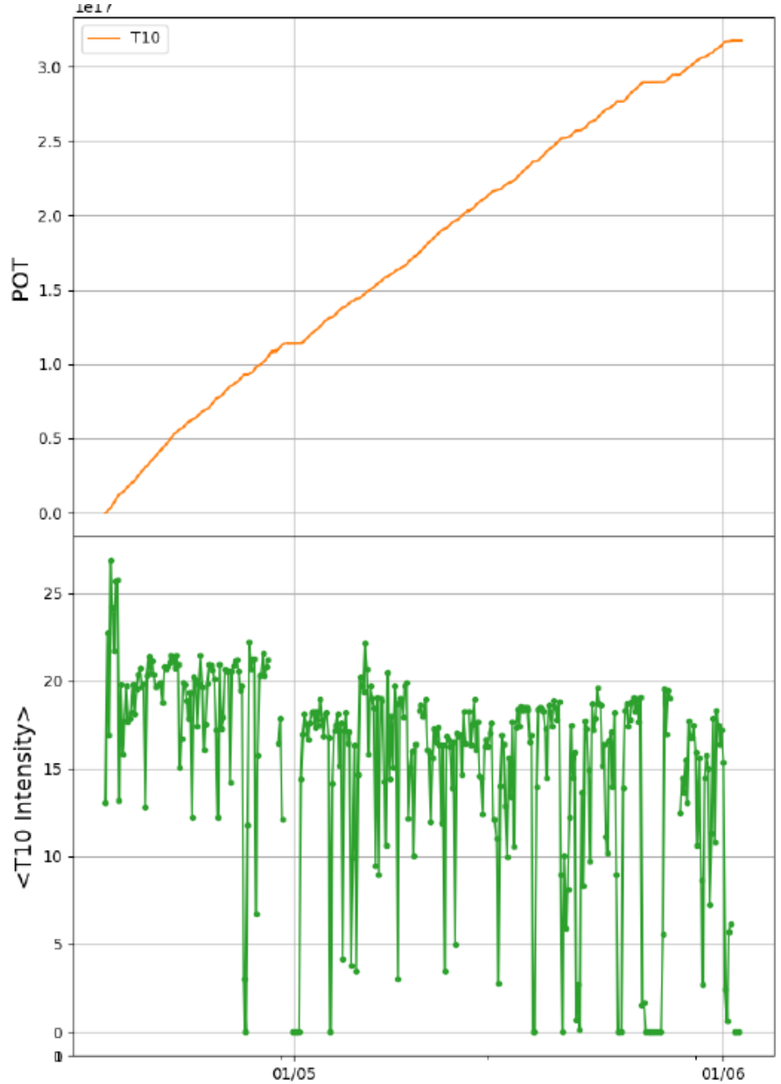
	Total	Δt
SOB	210773	18.8 s
T4 non-empty bursts (>10e11)	166870	19.0 s
T10 non-empty bursts (>3e10)	164829	18.9 s
ARGONION non-empty bursts (>5.e8)	163042	19.0 s

Total runs	137
Total runs saved	132
Saved bursts	162040
Total good runs	130
Total good bursts	149869

	Eff 2025	Eff 2024
T4	79.2%	79.4%
T10	98.8%	98.1%
NA62 inrun	98.3%	92.0%
NA62 daq	92.5%	94.1%

2025 Data

(WORK IN PROGRESS)



2025 Data Taking statistics

Year	SoB ($\times 10^3$)	Bursts with beam on T10 ($\times 10^3$)	Bursts collected ($\times 10^3$)	PoT(Kaon) ($\times 10^{18}$)	PoT(Dump) ($\times 10^{18}$)
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2023	655	514	443	1.17	0.27
2022	817	553	402	1.78	–
2021	374	251	145	0.60	0.14
2025	**317**	**228**	**210**	**0.43**	**–**

- In 71 days of data taking until 25/06 (stop for Ion Run) ➔ 1/3 of 2024 bursts collected
- Run 2025 = 210 days ➔ we are at 1/3 of 2025 data taking period

➔ 2025 should be equivalent to 2024 Run (if beam behaves well….)

(Expected number of SM $K^+ \to \pi^+ \nu\bar{\nu}$ proportional to number of Bursts)

$K^+ \to \pi^+ \nu\bar{\nu}$ analysis

- Headline NA62 analysis
- Primary objective: measure $\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu})$ with $\mathcal{O}$(15%) precision
- INFN Analysis leadership: convenors F. Brizioli (Perugia) and J. Swallow (LNF)

2021-2022 Analysis

[JHEP 02 (2025) 191]

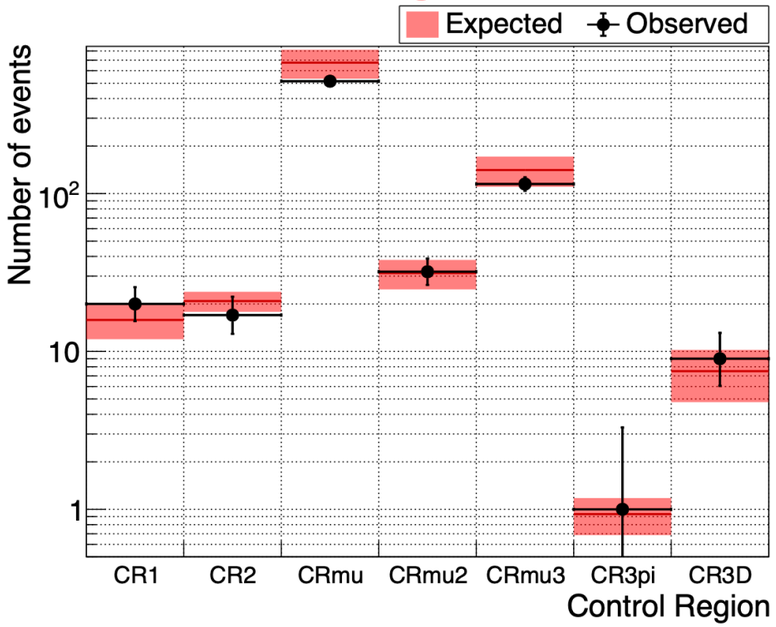
Analysis re-optimised for high intensity data

- *Improve signal yield by 50% and improving overall sensitivity*
  Selection optimized in six 5 GeV momentum bins in the range 15-45 GeV.
- *Number of **expected signal events per good SPS spill** increased:*
  $1.7 \times 10^{-5} \rightarrow 2.5 \times 10^{-5}$

Expected events

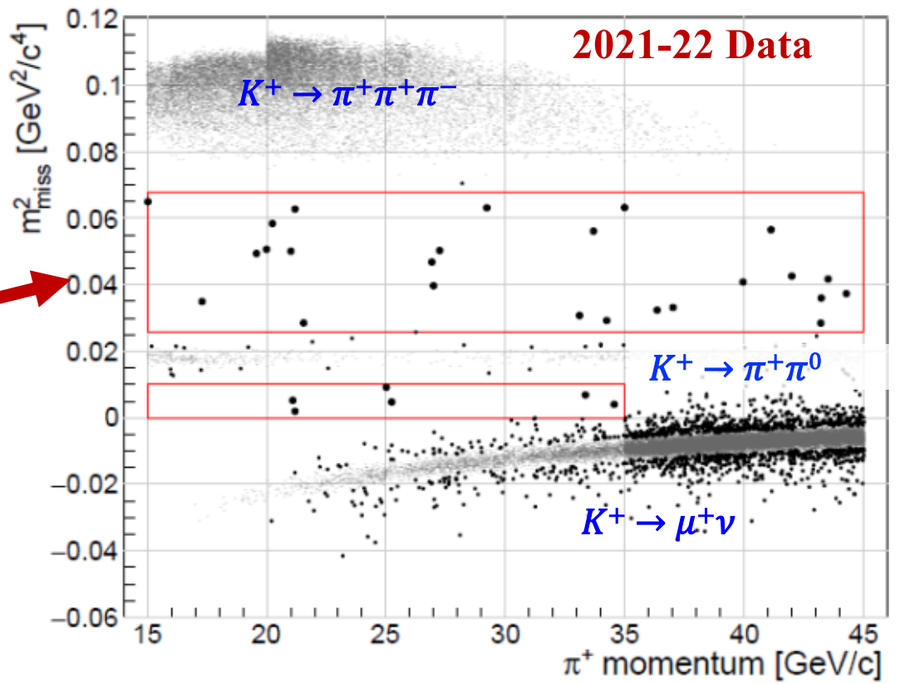
Background	Events
$K^+ \to \pi^+\pi^0(\gamma)$	0.83 ± 0.05
$K^+ \to \mu^+\nu(\gamma)$	1.70 ± 0.47
$K^+ \to \pi^+\pi^+\pi^-$	0.11 ± 0.03
$K^+ \to \pi^+\pi^-e^+\nu$	$0.89^{+0.33}_{-0.27}$
$K^+ \to \pi^+\gamma\gamma$	0.01 ± 0.01
$K^+ \to \pi^0\ell^+\nu$	< 0.001
Upstream	$7.4^{+2.1}_{-1.8}$
Total	$11.0^{+2.1}_{-1.9}$
Signal	**Events**
$K^+ \to \pi^+\nu\bar{\nu}$	9.91 ± 0.34

Validation of background estimates



$N_{\pi\pi}^{\text{eff}}$	Effective number of normalisation events	$(1.953 \pm 0.005) \times 10^8$
$A_{\pi\pi}$	Normalisation acceptance	$(13.410 \pm 0.005)\%$
N_K	Effective number of K^+ decays	$(2.85 \pm 0.01) \times 10^{12}$
$A_{\pi\nu\bar{\nu}}$	Signal acceptance	$(7.62 \pm 0.22)\%$
$\varepsilon_{\text{trig}}$	Trigger efficiency ratio	$(85.9 \pm 1.4)\%$
ε_{RV}	Random veto efficiency	$(63.2 \pm 0.6)\%$
$\mathcal{B}_{\text{SES}}$	Single event sensitivity	$(8.48 \pm 0.29) \times 10^{-12}$
$N_{\pi\nu\bar{\nu}}^{\text{SM}}$	Number of expected SM $K^+ \to \pi^+\nu\bar{\nu}$ events	9.91 ± 0.34

Observed events : 31



$$\mathcal{B}_{2021-2022}(K^+ \longrightarrow \pi^+\nu\bar{\nu}) = (16.2(^{+4.9}_{-4.3})_{stat}(^{+1.4}_{-1.4})_{syst}) \times 10^{-11}$$

$$= (16.2^{+5.1}_{-4.5}) \times 10^{-11}$$

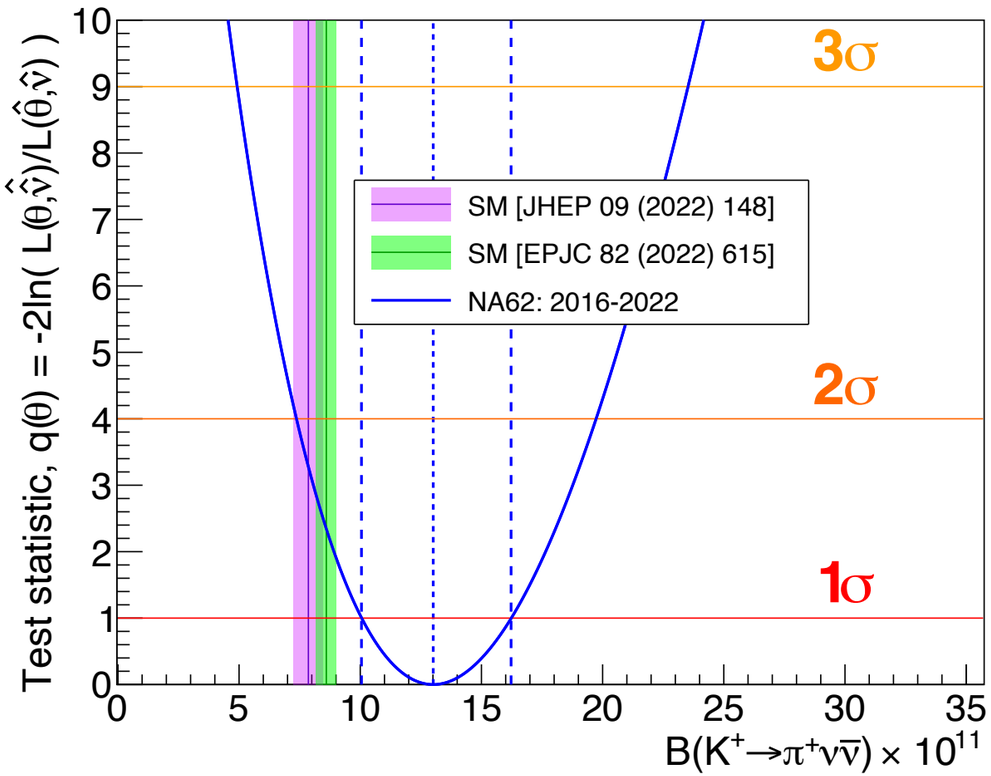
Combination: 2016-2022 Result [JHEP 02 (2025) 191]

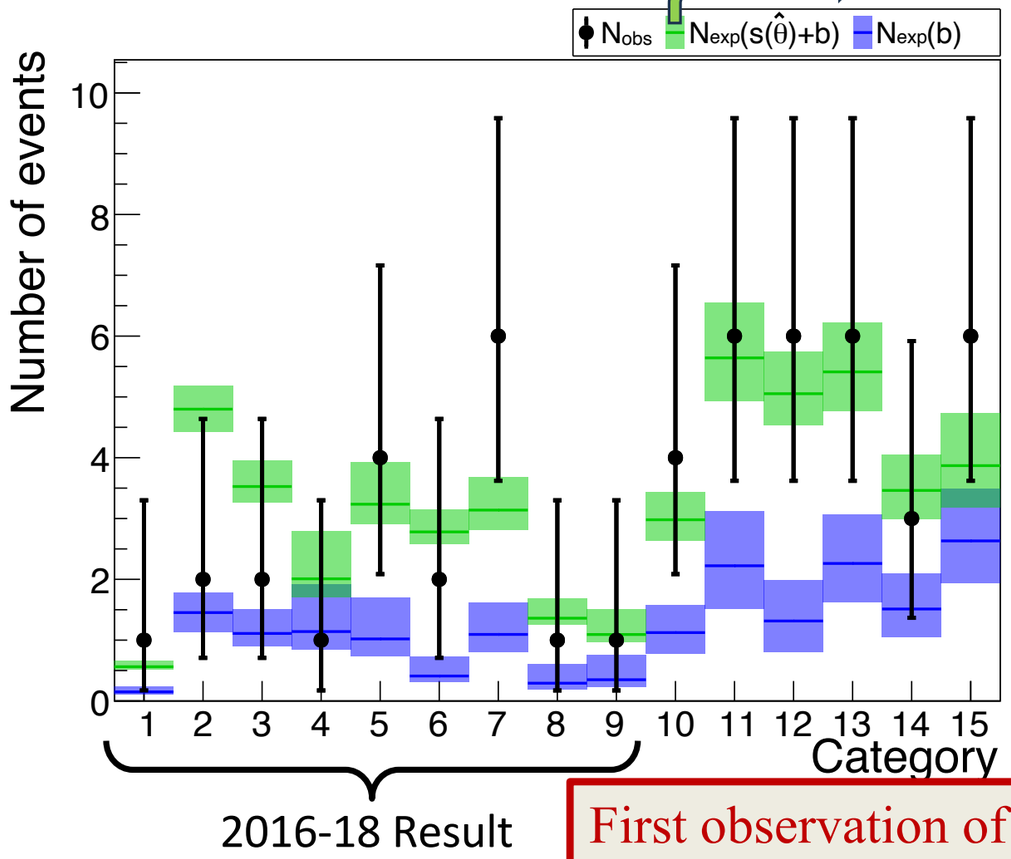
Single Event Sensitivity	$(0.42 \pm 0.02)\times10^{-11}$
Expected background	18^{+3}_{-2}
Observed	**51**

background-only hypotesys p-value = 2×10^{-7} ⇒ significance: $Z > 5\sigma$

$$\mathcal{B}_{\pi\nu\bar{\nu}} = \left[13.0\binom{+3.0}{-2.7}_{stat}\binom{+1.3}{-1.3}_{syst}\right]\times10^{-11}$$

based on measured $\mathcal{BR}$

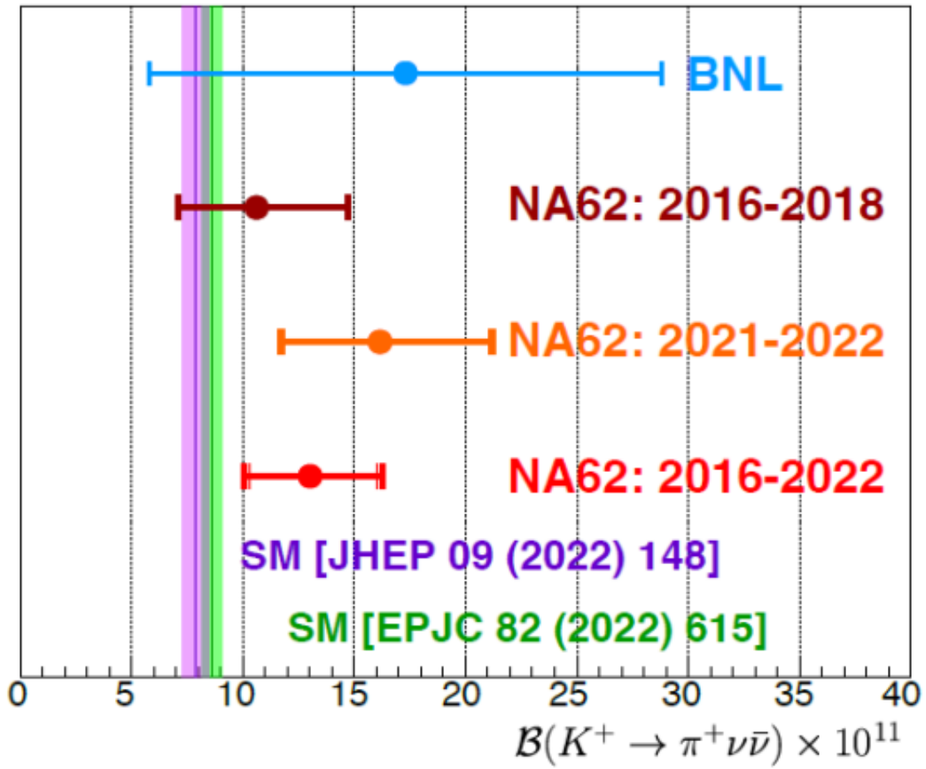


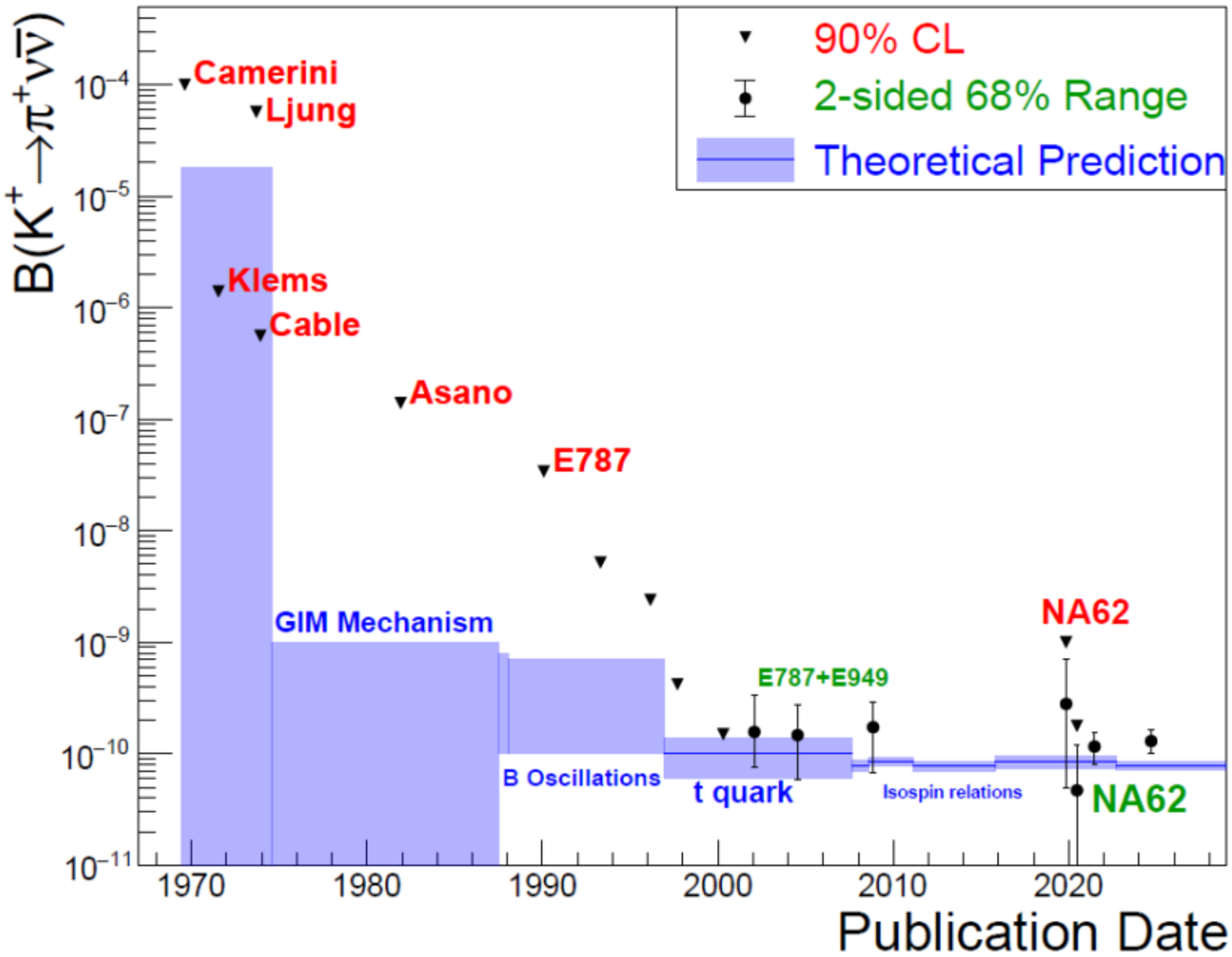


First observation of $K^+ \longrightarrow \pi^+\nu\bar{\nu}$

2016-2022 Result

$$\mathcal{B}_{2016-2022}(K^+ \longrightarrow \pi^+\nu\bar{\nu}) = (13.0^{+3.3}_{-3.0})\times 10^{-11}$$



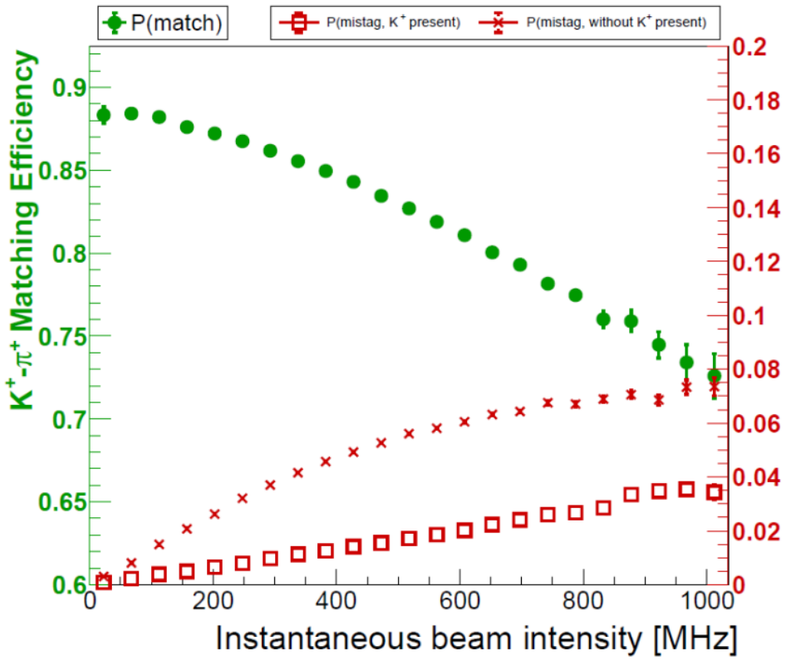


- NA62 results are consistent
- Central value moved up (now 1.5-1.7σ above SM)
- Relative precision improved from 40% to 25%
- Smallest BR measured with a signal significance above 5σ

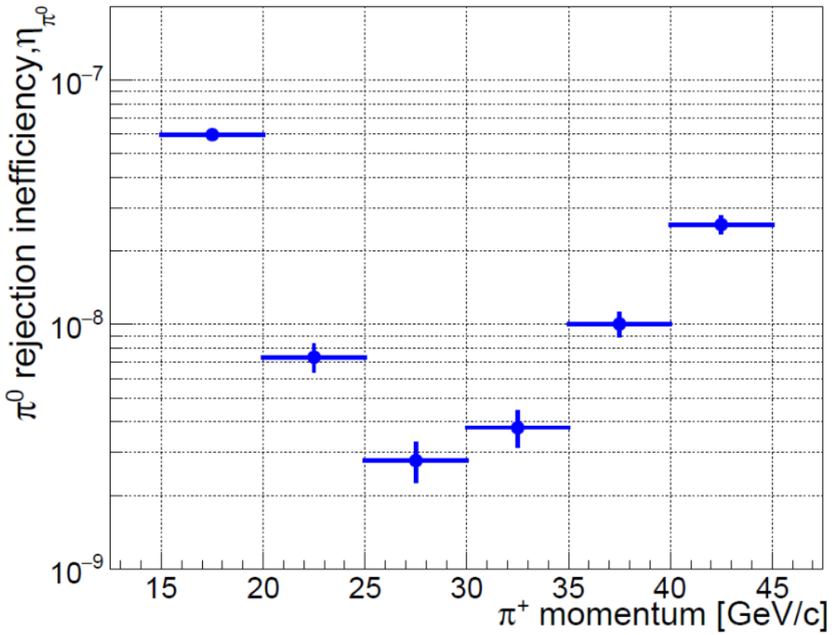
2024 Data Quality

- **92**% of data processed online in 2024 for monitoring and «express» analysis
- Data reprocessing completed beginning of 2025
- Burst collected: $\sim\mathbf{567}\times\mathbf{10^3}$ in K mode, $\sim\mathbf{50}\times\mathbf{10^3}$ in beam dump mode, $\sim\mathbf{20}\times\mathbf{10^3}$ low intensity
- «Bad» bursts for $K^+ \to \pi^+\nu\bar{\nu}$ analysis about 9% (like 2023)
- Very good quality of data (like in 2023). All performance within specification for $\pi^+\nu\bar{\nu}$ analysis

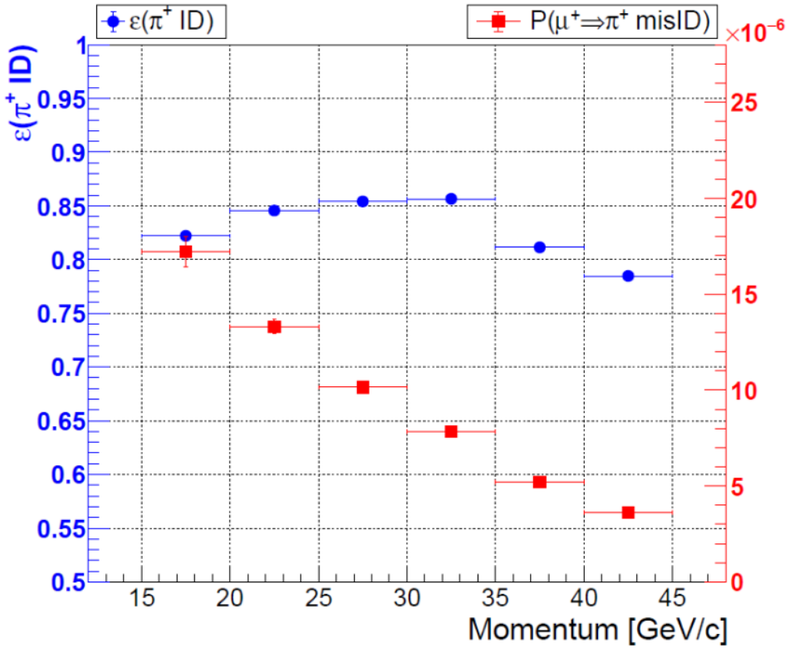
K^+ - π^+ matching



π^0 rejection inefficiency



PID performance



2023-2024 Analysis

[CERN-SPSC-2025-022 / SPSC-SR-363 13/05/2025]

Published

Work-in-progress

Dataset	2022	2023	2024
Number of spills $[10^3]$	326	363	519
$<$ Beam intensity $>$ [GHz]	0.57	0.48	0.41
$< N_{\pi\pi}/\text{spill} >$ $[10^2]$	4.9	4.7	4.4
N_K $[10^{12}]$	2.3	2.5	3.3
ε_{RV}	0.63	0.68	0.73
$N_{\pi\nu\nu}$	8	9	13
$N_{\pi\nu\nu}/\text{spill}$ $[10^{-5}]$	2.5	2.5	2.6
$B_{\text{total}}/N_{\pi\nu\nu}$	1.1	1.1	1.0

Data-taking efficiency in 2024:
the best achieved to date
➔ **excellent new dataset for analysis**

Using a 2022-like analysis the $\pi\nu\bar{\nu}$ yield per spill have slightly increased

$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ with 2023+2024 data expected for conferences in the first half of 2026

Sensitivity 2023 – 2024 shown at conferences, e.g. FLASY 2025 (Milestone 2025 @ 100%)

$K^+ \to \pi^0\pi\mu e$ Search

PLB 859 (2024) 139122

Theory: LNV ($K^+ \to \pi^0\pi^-\mu^+e^+$) and LFV ($K^+ \to \pi^0\pi^+\mu^+e^-$, $K^+ \to \pi^0\pi^+\mu^-e^+$) decays

Goal: Discovery or upper limit on branching ratio

Analysis: 2016-18 Data

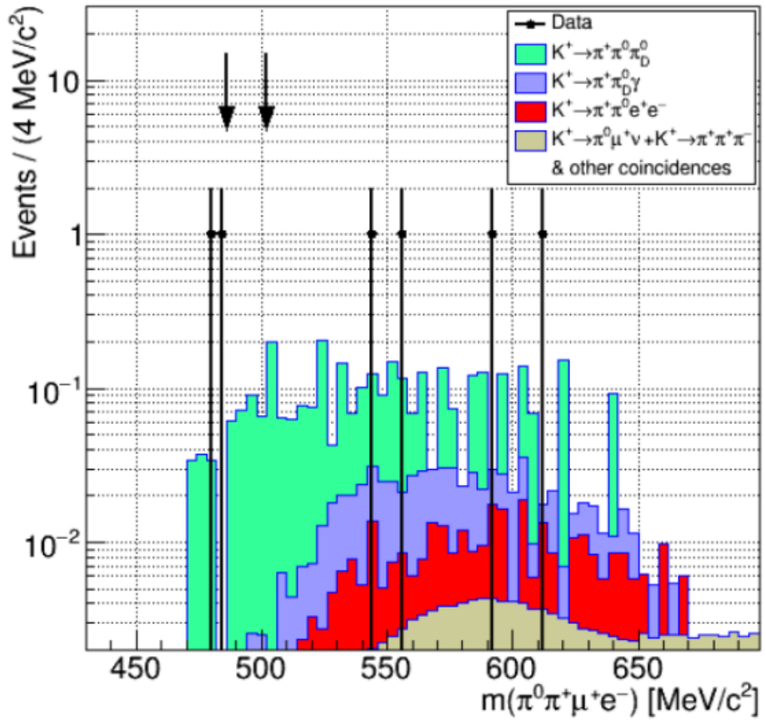
Pre-scaled trigger lines of type "multi-track" + e or μ

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

Key points: multi-track and photon reconstruction, calorimetric PID

Data-driven simulation of PID, background from simulation, validated on data

Signal acceptances $\mathcal{O}(3\times10^{-3})$



Result:

Background from mis-ID:

K^+ decay ($\pi^+\pi^0\pi^0_D$ with $e \to \pi$)

pairs of K^+ decays

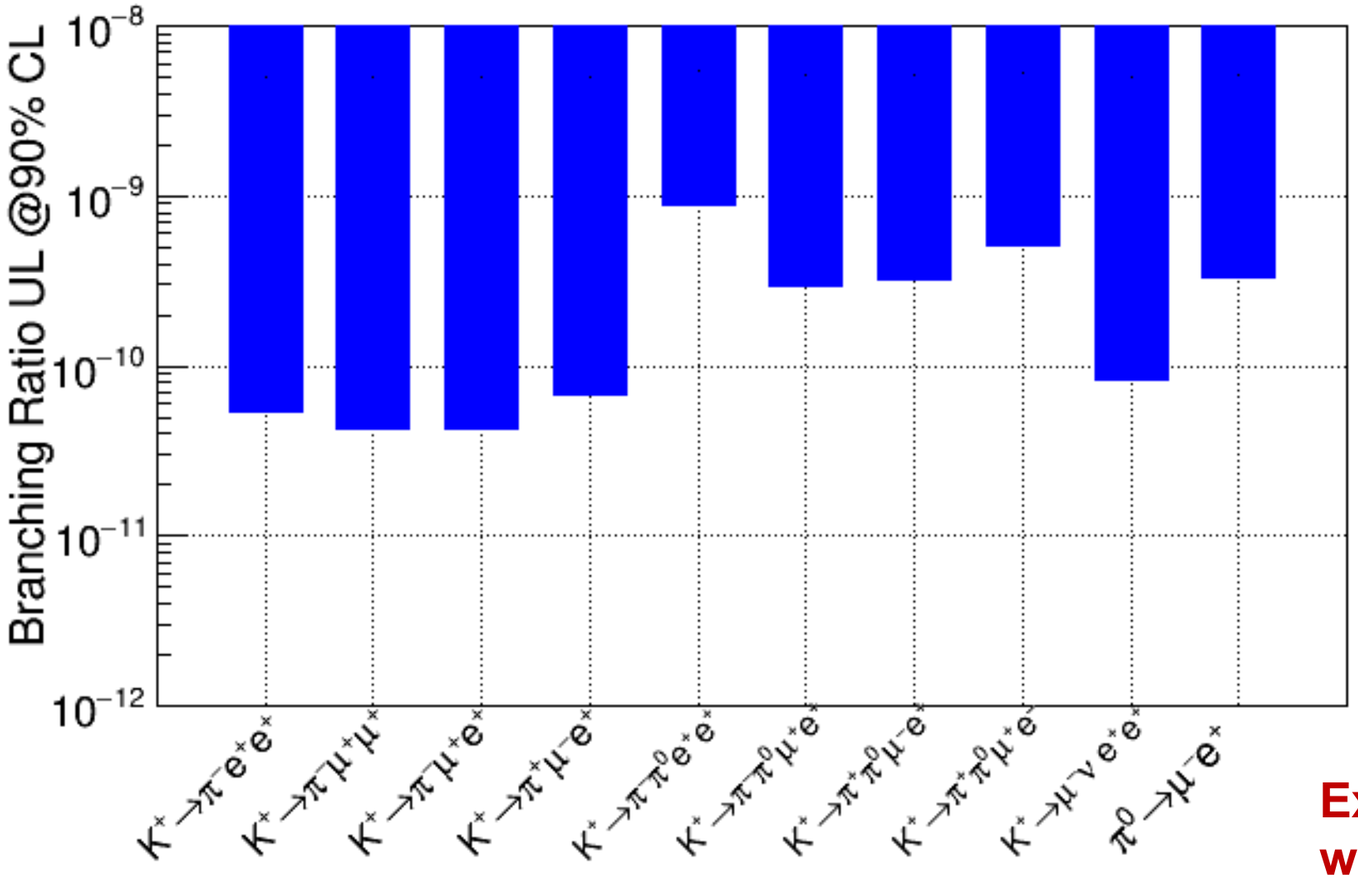
$$K^+ \to \pi^0\pi^-\mu^+e^+ : \quad N_{\rm bkg} = 0.33 \pm 0.07,$$
$$K^+ \to \pi^0\pi^+\mu^-e^+ : \quad N_{\rm bkg} = 0.004 \pm 0.003,$$
$$K^+ \to \pi^0\pi^+\mu^+e^- : \quad N_{\rm bkg} = 0.29 \pm 0.07.$$

No candidates found in SR → 90% CL upper limit ⇒

$$\mathcal{B}(K^+ \to \pi^0\pi^-\mu^+e^+) < 2.9 \times 10^{-10},$$
$$\mathcal{B}(K^+ \to \pi^0\pi^+\mu^-e^+) < 3.1 \times 10^{-10},$$
$$\mathcal{B}(K^+ \to \pi^0\pi^+\mu^+e^-) < 5.0 \times 10^{-10}.$$

LFV/LNV Decay Search Summary

NA62: 2016-18 Data, published results, best limits to date



- RUN1 data only
- Factor 3 – 10 improvement over existing limits, plus first ever limits
- With RUN2 data significant improvements: increase of statistics also thanks to trigger improvements

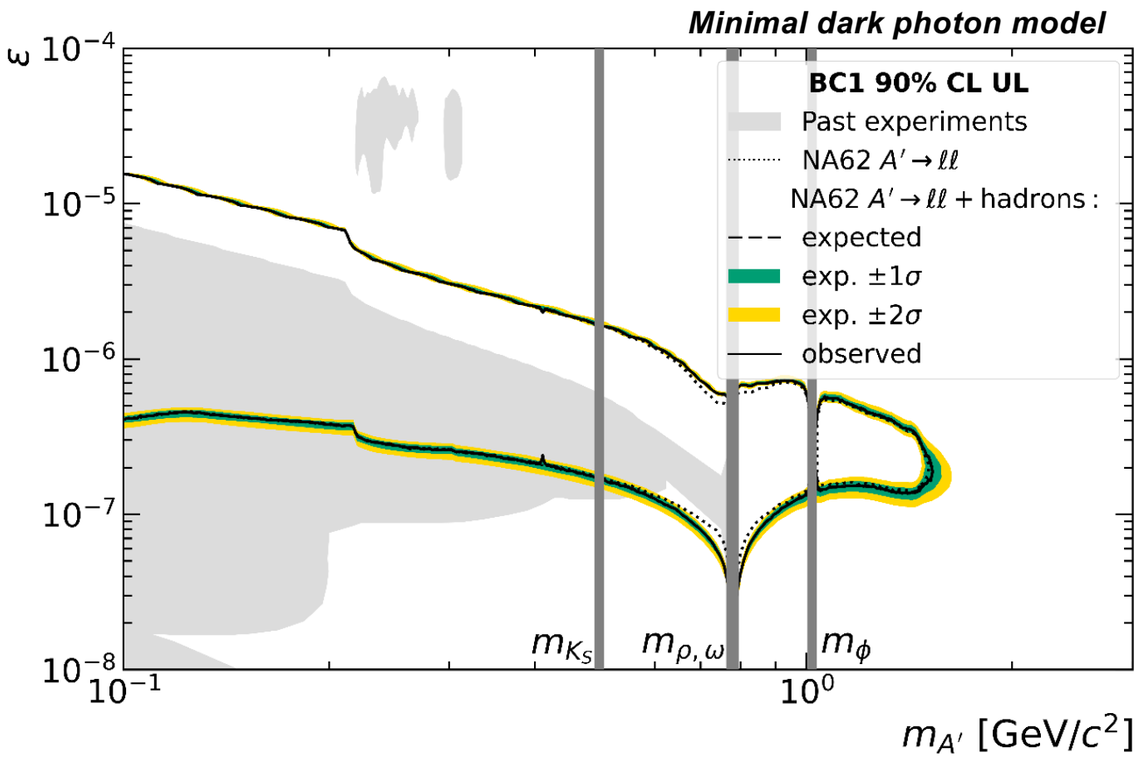
Expected UL decrease of 1 order of magnitude with full data set

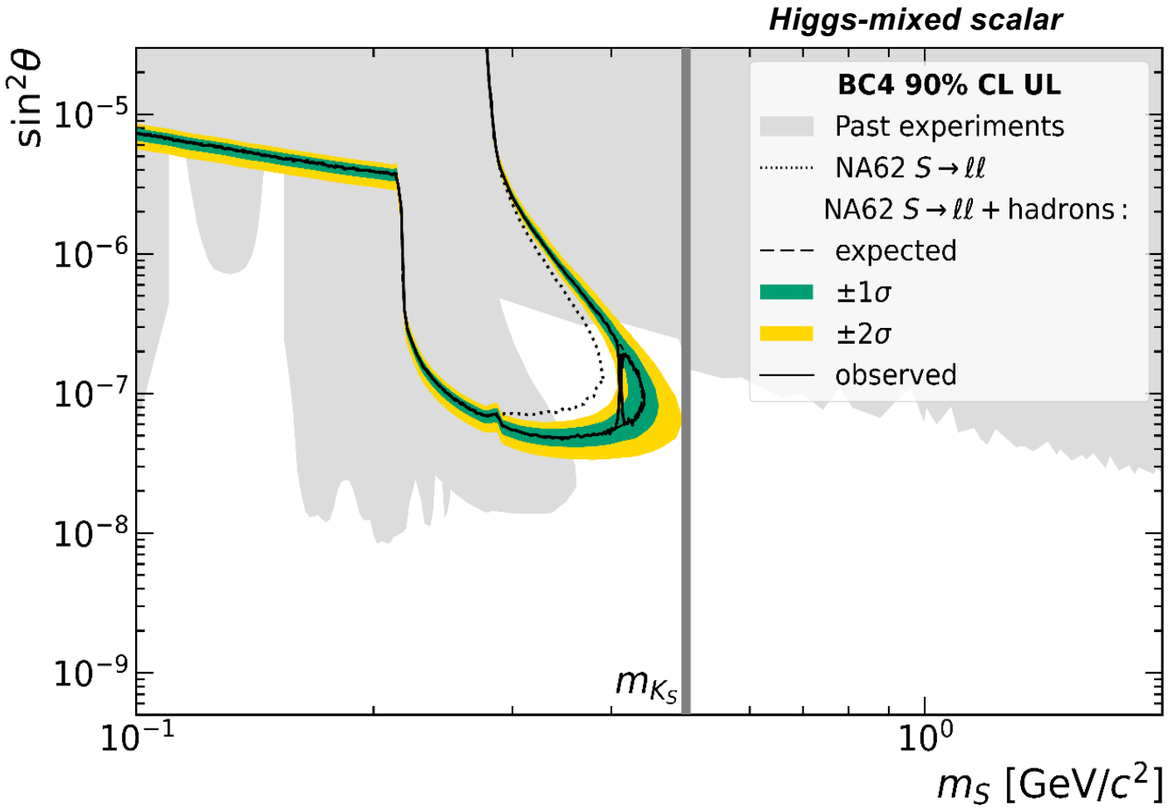
FIPs in Beam Dump Mode [Eur. Phys. J. C 85, 571 (2025)]

NA62 has achieved sensitivity to long-lived light mediators in several New Physics scenarios

2021 Data, 1.4×10^{17} PoT, combined limits from dilepton and hadron analyses

The background is <0.01 events in all the channels.



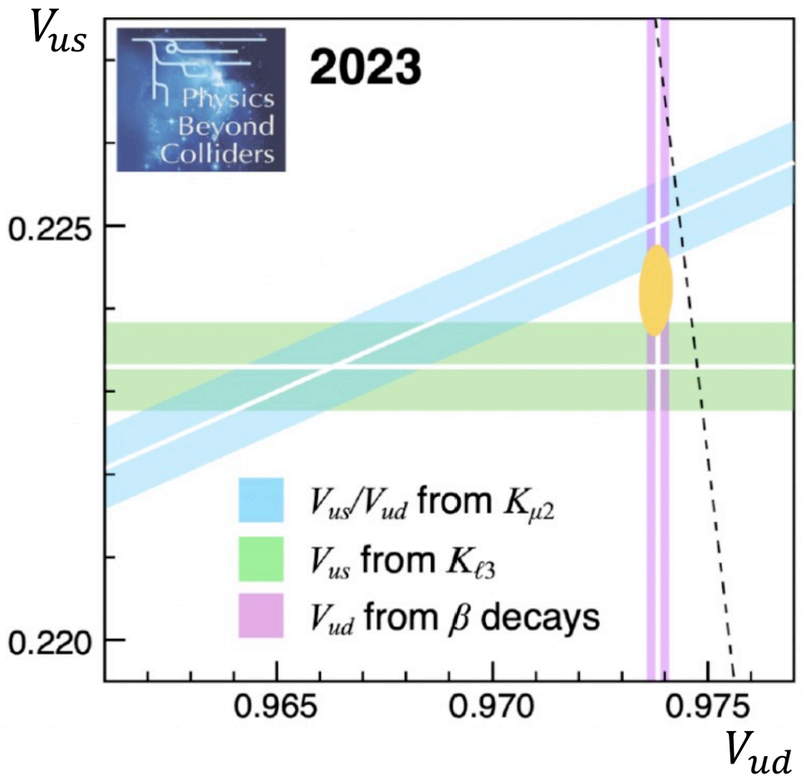


NA62 will collect 10^{18} PoT : no background limitations expected

Exotics working group co-coordinator : T. Spadaro [LNF]

Low Intensity Data

Goal: Study the Cabibbo angle anomaly



$$\Delta^u_{CKM} \approxeq |V_{ud}|^2 + |V_{us}|^2 - 1 = 0$$

$$\Delta^u_{CKM} = -0.0018 \pm 0.0006 \Rightarrow -2.8\sigma$$

Intensity: 10^{11} ppp (about 1% of maximum)

Min Bias trigger: high statistics "common" Kaon decays

3 x10^9 kaon decays in the fiducial volume

Analysis:

- Measurement of ratios:

$\Gamma(K^+ \to \mu^+\nu)/\Gamma(\pi^+ \to \mu^+\nu)$, with π^+ from $K^+ \to \pi^+\pi^0$

$\Gamma(K^+ \to \pi^0\mu^+\nu)/\Gamma(\pi^+ \to \mu^+\nu)$,

$\Gamma(K^+ \to \pi^0\mu^+\nu)/\Gamma(K^+ \to \mu^+\nu)$

- Other ratios: $K^+ \to \pi^0 e^+\nu$, $K^+ \to \pi^+\pi^0$, $K^+ \to \pi^+\pi^+\pi^-$, $K^+ \to \pi^+\pi^0\pi^0$
- K_{l3} form factors
- Determination of V_{us}/V_{ud}

Precisions required $< 1\%$ *(including 2025 data)*

2024 statistics: $N_{\mu 2} \sim 7\times10^8$, $N_{\mu 3} \sim 2\times10^7$

Analysis lead: M. Moulson, J. Swallow [LNF]

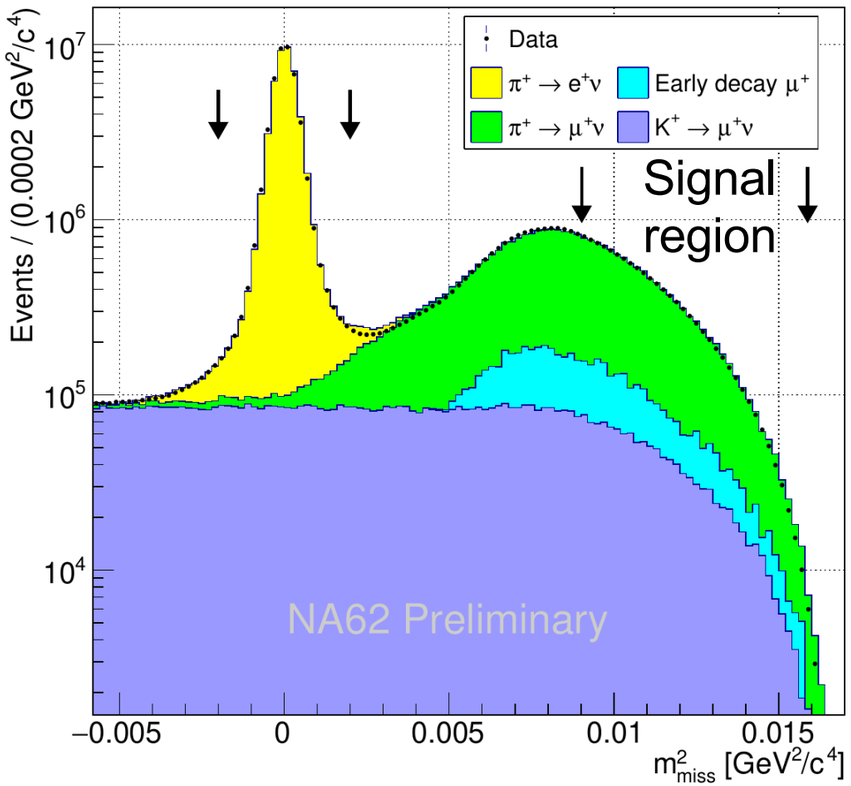
HNL: $\pi^+ \to e^+ N$ Search

Theory: Heavy Neutral Leptons produced in π^+ decay

Analysis: 2017-24 data. Beam π^+ accidentally in time with a K^+ decay

Key points: PNN trigger, kinematic resolution, PID, photon rejection

Normalization $\pi^+ \to e^+ \nu$; signal acceptance dependent on m_N



HNL

mass 95–126 MeV/c^2

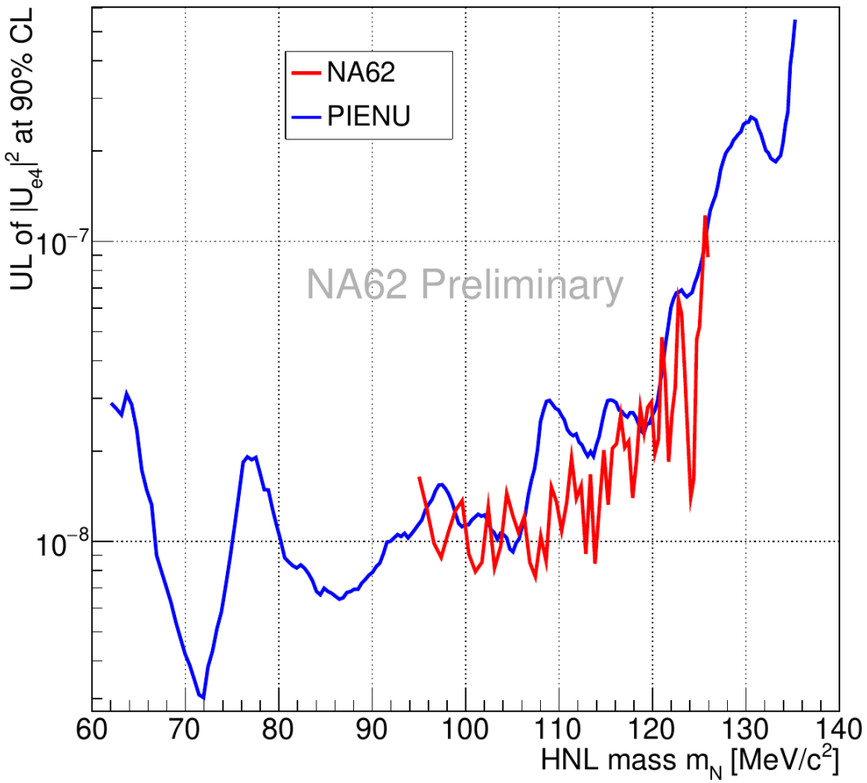
lifetime > 50 ns

Result: $N_{\pi^+} = (6.54 \pm 0.03) \times 10^{12}$

Mass peak search in the m^2_{miss}

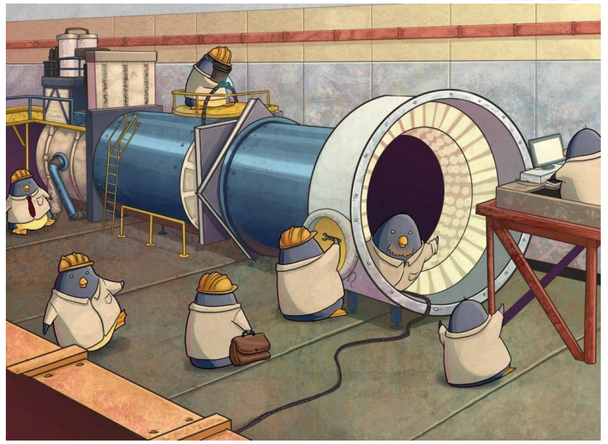
Search window: $\left|m^2_{miss} - m^2_N\right| < 1.5\sigma$

$\sigma \sim 200 - 100$ MeV^2 , $m_N \in (95,126.5)$ MeV



arXiv:2507.07345 (CERN-EP-2025-152)

Conclusions



- Successfull run in 2024 and smooth restart in 2025
  - NA62 is running at optimal conditions for $K^+ \to \pi^+ \nu\bar{\nu}$

- $K^+ \to \pi^+ \nu\bar{\nu}$ analysis:
  - Major achievement in 2024 with observation and 25% uncertainty BR measurement
  - 2023-24 data has the same statistics as the 2016-22 datasets
  - Possibility to reach 15% uncertainty BR measurement when including also 25-26 data

- Other physics analysis (kaon, pion, exotics, neutrinos):
  - World-leading results published/released
  - Several new results under preparation

NA62 is the last opportunity to study physics with charged kaons with high precision at CERN

must extract all we can from our data