NA62 and the upgrade HIKE

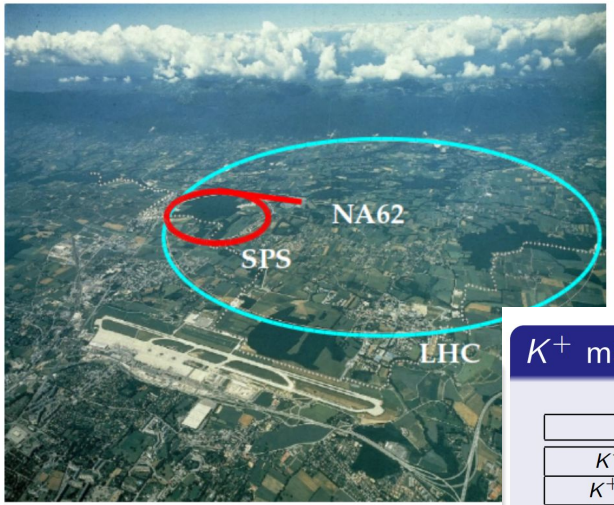
Roberto Ammendola

NA62 experiment at CERN

Standard Model prediction *[Buras et al., JHEP11(2015)033]*

$$Br^{SM}(K^+ \to \pi^+ \nu\bar{\nu}) = (0.84 \pm 0.10) \cdot 10^{-10}$$

- Full detector installation completed in 2016
- $K^+ \to \pi^+ \nu\bar{\nu}$ physics runs in 2016, 2017 and 2018 (Run 1)
- Result from full Run 1 published in [JHEP 06 (2021) 093]
- Data taking resumed in 2021, after CERN LS2, approved until CERN LS3

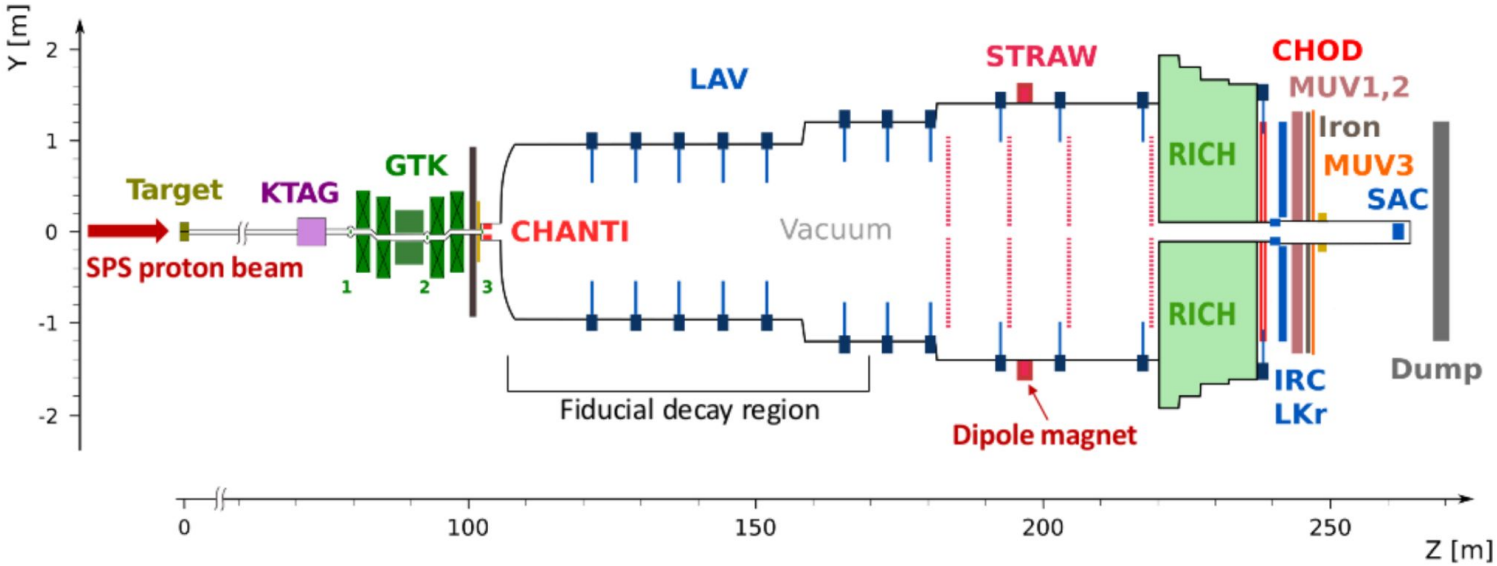


NA62 is located at CERN in the *North Area*, exploiting a 400 GeV/c proton beam extracted from the SPS accelerator

K^+ main (background) decays

Decay channel	Branching Ratio
$K^+ \to \mu^+ \nu$ ($K_{\mu 2}$)	$(63.56 \pm 0.11) \cdot 10^{-2}$
$K^+ \to \pi^+ \pi^0$ ($K_{2\pi}$)	$(20.67 \pm 0.08) \cdot 10^{-2}$
$K^+ \to \pi^+ \pi^+ \pi^-$ ($K_{3\pi}$)	$(5.583 \pm 0.024) \cdot 10^{-2}$
$K^+ \to \pi^+ \pi^- e^+ \nu$ (K_{e4})	$(4.247 \pm 0.024) \cdot 10^{-5}$

Beam and Detector



- SPS beam: 400 GeV/c proton on beryllium target
- Secondary hadron 75 GeV/c beam
- 70% pions, 24% protons, 6% kaons

- KTAG: Cherenkov threshold counter;
- GTK: Si pixel beam tracker;
- CHANTI: stations of plastic scintillator bars;
- LAV: lead glass ring calorimeters;
- STRAW: straw magnetic spectrometer;
- RICH: Ring Imaging Cherenkov counter;
- MUV0: off-acceptance plane of scintillator pads;

- CHOD: planes of scintillator pads and slabs;
- IRC: inner ring shashlik calorimeter;
- LKr: electromagnetic calorimeter filled with liquid kryptor
- MUV1,2: hadron calorimeter;
- MUV3: plane of scintillator pads for muon veto;
- HASC: near beam lead–scintillator calorimeter;
- SAC: small angle shashlik calorimeter.

Breaking news on 25/9/24

CERN Press release :

CERN Accelerating science

NA62 experiment at CERN observes ultra-rare particle decay

In the Standard Model of particle physics, the odds of this decay occurring are less than one in 10 billion

25 SEPTEMBER, 2024

INFN Press release :

INFN Istituto Nazionale di Fisica Nucleare

25 SETTEMBRE 2024

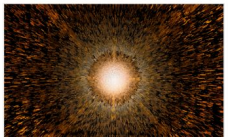
CERN: L'ESPERIMENTO NA62 OSSERVA UN PROCESSO RARISSIMO

UKRI Press release : UK Research and Innovation

CERN reports first observation particle decay

Scientific American :

SCI AM



OCTOBER 1, 2024 | 5 MIN READ

A One-in-10-Billion Particle Decay Hin Hidden Physics

Physicists have detected a long-sought particle process that ma forces and particles exist in the universe

ANSA

Evento rarissimo al Cern, potrebbe aprire alla nuova fisica

Grazie alla collaborazione NA62, coordinata da un italiano (ANSA)

1 mese fa

Università degli studi di Ferrara

Alla ricerca di una "nuova fisica" | Il contributo di Unife all'esperimento NA62 del CERN

Come si producono e si misurano i kaoni al CERN. L'esperimento NA62 è stato progettato specificamente per misurare un decadimento...

1 mese fa

Scienze Notizie

Rarissimo evento osservato al CERN: i dettagli dell'esperimento NA62

Protagonista dell'osservazione è la particella "kaone" ... L'esperimento che ha consentito di osservarlo è il NA62, frutto di una collaborazione...

1 mese fa

Unina

Al CERN presentato un nuovo risultato con il contributo di fisici federiciani

L'esperimento NA62 del CERN, cui partecipa un gruppo di fisici dell'Ateneo federiciano e della Sezione di Napoli dell'Istituto Nazionale di...

1 mese fa

le Scienze

edizione italiana di Scientific American

CLIMA GENETICA FISICA NOBEL ASTRONOMIA INTELLIGENZA ARTIFICIALE

02 ottobre 2024

Il decadimento di una particella su 10 miliardi suggerisce una fisica nascosta

di Clara Moskowitz/Scientific American

Una fase di allestimento dell'esperimento NA62 al CERN di Ginevra (©CERN) ()

Al CERN di Ginevra i fisici hanno rilevato un processo cercato da molti anni che potrebbe suggerire l'esistenza di nuove forze e particelle nell'universo

l'esperimento

a rivoluzionaria che

poletano. I
biare la Fisica
esperimento tenutosi

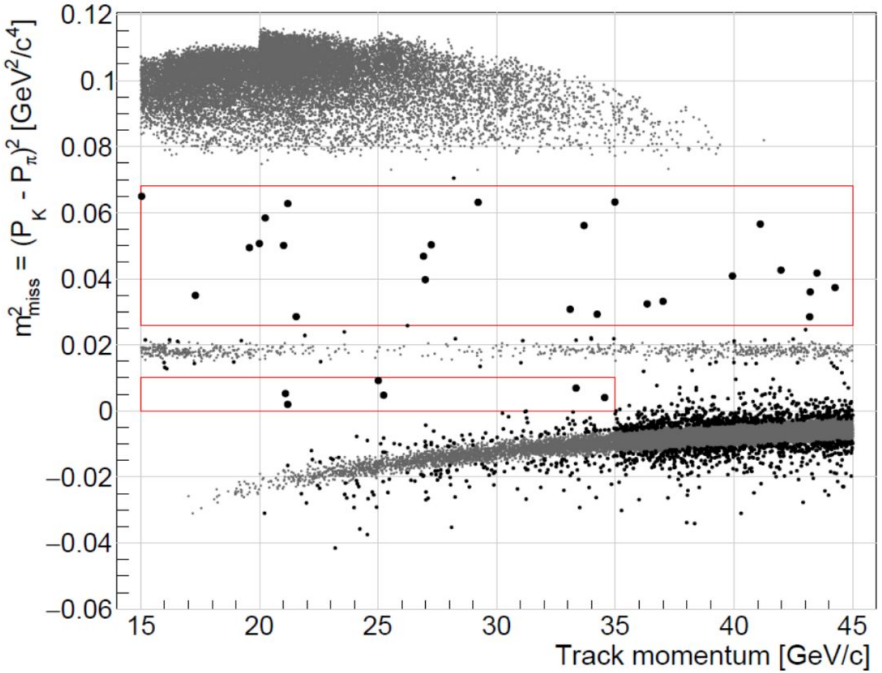
a la scoperta
liard

o osservato da

i2 al Cern. Il contributo

Analysis of 2021 and 2022 data

PNN: Opening Signal Regions (2021+22)



	Number of events
Expected signal	10.00 ± 0.34
Expected background	$11.0^{+2.1}_{-1.9}$
Total expected	$21.0^{+2.2}_{-1.9}$
Observed	**31***

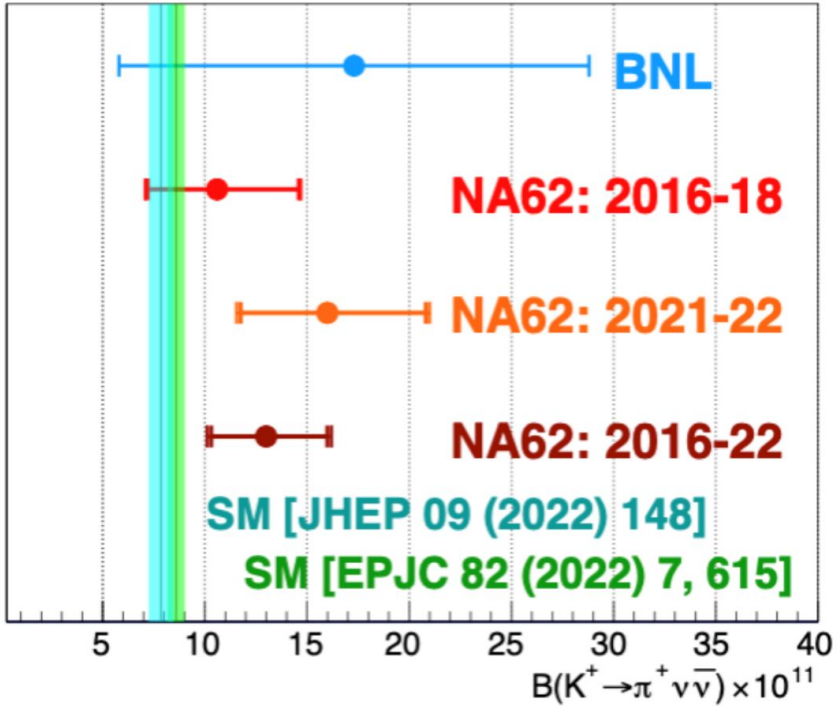
Analysis of 2021 and 2022 data

PNN: Result RUN1+RUN2 (21+22)

$$\mathcal{B}_{\pi\nu\bar{\nu}}^{RUN1} = \left(10.6^{+4.1}_{-3.5}\right) \times 10^{-11}$$

$$\mathcal{B}_{\pi\nu\bar{\nu}}^{RUN2} = \left(16.0^{+5.0}_{-4.5}\right) \times 10^{-11}$$

$$\mathcal{B}_{\pi\nu\bar{\nu}}^{NA62} = \left(13.0^{+3.2}_{-2.9}\right) \times 10^{-11}$$



Analysis of 2021 and 2022 data

PNN Result: Some Considerations

- Result combined $(13.0 \pm 3.2) \times 10^{-11}$
- Statistical error 3×10^{-11}, Systematics 1×10^{-11}
- Sigma from SM (8×10^{-11}): 1.6

- Assumption: same average value, PNN statistics in 2023,2024,2025,2026 as in 2021+2022 (10 SM PNN / year average)
- 2023+2024: $(13.0 \pm 2.4) \times 10^{-11}$ (2.1 sigma from SM)
- 2023+2024+2025: $(13.0 \pm 2.0) \times 10^{-11}$ (2.5 sigma from SM)
- 2023+2024+2025+2026: $(13.0 \pm 1.8) \times 10^{-11}$ (2.8 sigma from SM)

We may reach 3σ discrepancy from SM only with an additional year of run (unless surprises)

HIKE proposal in 2023

HIKE
High Intensity Kaon Experiments

HIKE Phase 1 & 2 proposal: 194 collaborators from 41 institutions

[CERN-SPSC-2023-031; SPSC-P-368]

Principal HIKE Physics goals:

Phase 1:

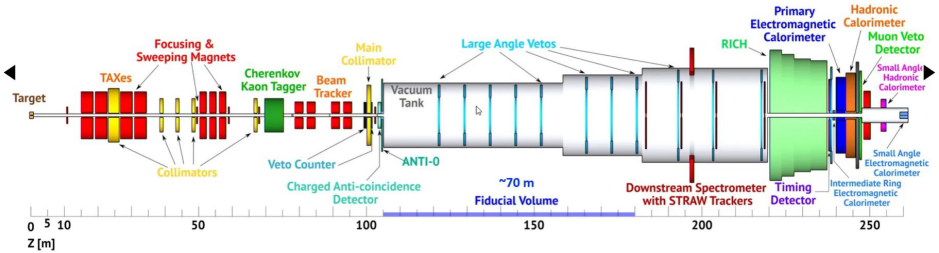
- Measure BR($K^+ \to \pi^+ \nu\bar{\nu}$) at 5% precision

Phase 2:

- Measure ($K_L \to \pi^0 l^+ l^-$) at 20% precision

HIKE-Phase1 detector optimized for the measurement of BR($K^+ \to \pi^+ \nu\bar{\nu}$) at 5% precision

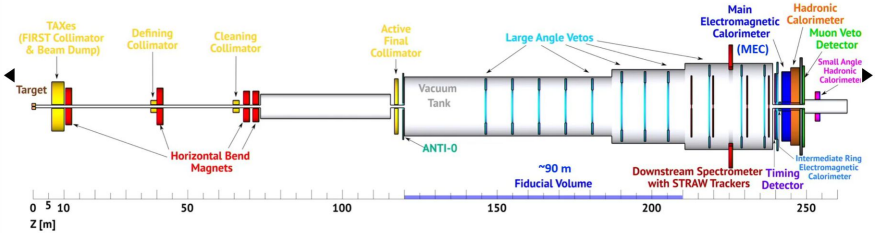
Max possible beam intensity in HIKE-Phase1 (after major beamline upgrades):
1.2 ×10^{13} POT / spill = 4x NA62 max beam intensity
Statistical power: 2×10^{13} Kaon decays in decay volume per year (7×10^{18} POT / year)



NA62-like design of experiment will work at high intensity

HIKE-Phase2 detector optimized for the measurement of BR($K_L \to \pi^0 l^+ l^-$) at 20% precision

Max possible intensity in HIKE-Phase2 (upgraded NA48 neutral beamline): 2 ×10^{13} POT / spill
Statistical power: 3.8×10^{13} Kaon decays in decay volume per year (1.2×10^{19} POT / year)



NA48 neutral beam-like design of experiment will work at high intensity

HIKE end in 2024

Funding agencies	MCHF	Subsystems
Italy (INFN)	9	MEC, SAC, RICH, beam tracker, Trigger/DAQ
UK (STFC)	6	Kaon tagger, beam tracker, LAV
CERN	4.1	Beam tracker, Straw Chambers, Trigger/DAQ
Germany (BMBF, MPG)	2.1	Hadronic calorimeter, ANTI-0, muon veto
Switzerland (SNSF)	1.0	Upstream vetoes, LAV
All others	2.5	
Total contributions	**24.7**	
Total HIKE cost estimate	27.5	
Fraction of costs covered	90%	

Table 2: Expected contributions to detector construction, by funding agency.

News from the March CERN Council Session

The successful restart of the accelerator complex, Brazil's Associate Membership and the next update of the European Strategy for Particle Physics were among many topics discussed in the 216th session of the CERN Council

By Fabiola Gianotti
Fabiola Gianotti is the Director-General of CERN.

27 MARCH, 2024

On 22 March, the CERN Council concluded a very fruitful March Session. The delegates congratulated CERN and its personnel on the successful year-end technical stop and restart of the accelerator complex and the experiments, and on the excellent progress made across the full spectrum of Laboratory activities, as was also demonstrated by the depth and breadth of the 2023 Annual Progress Report.

During presentations of the scientific programme, the Council delegates were informed that the SHiP experiment, which will search for feebly interacting particles, has been chosen to run in the North Area's ECN3 hall using high-intensity proton beams from the SPS. This decision concluded a process that took more than a year, involving the Physics Beyond Colliders study group and the SPS and PS Experiments Committee (SPSC).

HIKE Proposal submitted in CDS on 31 October, and on arXiv in early November.
Tensioned against BDF/SHIP proposal, also in ECN3.

SPSC meeting in November didn't reach a decision based on physics.
Both HIKE and SHIP graded excellent, see feedback from Research Board in next page.
SPSC minutes not available yet.

Research Board in early December also didn't take a decision (see feedback received in next page).
SPC and Council discussed the matter in December, but there was no specific outcome.

We received questions from the CERN Directorate, mostly on financial and organization matters, in January 2024. We sent answers on Feb 6 (see attachment).

Decision is now in the hands of the CERN Directorate.
We expect a decision at the next Research Board in March.