Measurement of the Rare Decay $K^+ \to \pi^+ \nu \bar{\nu}$ at the CERN SPS

NA62 Project (Collaboration NA62)
Prologation for 2019-2021

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Bulgaria: University of Sofia St. Kliment Ohridski, Faculty of Physics **(Sofia);**
Canada: TRIUMF, University of British Columbia **(Vancouver);**
Czech Republic: Charles University (**Prague);**
Germany: Johannes-Gutenberg-Universitat Mainz (**Mainz);**
Italy: Università di Ferrara (**Ferrara),** Universita e INFN (**Florence),** Istituto Nazionale di Fisica Nucleare (INFN), Laboratori Nazionali di Frascati **(Frascati),** Universita e INFN (**Naples),** Universita e INFN (**Padua),** Universita e INFN (**Perugia),** Sezione di Pisa, INFN **(Pisa),** Universita degli Studi di Roma Tor Vergata, Sezione di Roma Tor Vergata, INFN (**Rome),** Universita e INFN, Roma I, Sezione di Roma I, INFN**(Rome),** Universita e INFN (**Turin);**
Mexico: Universidad Autónoma de San Luís Potosi, Instituto de Fisica (**San Luis Potosi);**
Romania: Horia Hulubei National Institute of Physics and Nuclear Engineering (**Bucharest-Magurele);**
Russia: Joint Institute for Nuclear Research – JINR (Dubna), Institute for Nuclear Research RAS (**Moscow),** Institute for High Energy Physics, Russian Federation State Research Centre (**Protvino);**
Slovakia: Comenius University (**Bratislava);**
Switzerland: Conseil Européen pour la Recherche Nucléaire – CERN (**Geneva)**
United Kingdom: University of Birmingham (**Birmingham),** University of Bristol, H. H. Wills Physics Laboratory (**Bristol),** University of Glasgow (**Glasgow),** University of Liverpool, Oliver Lodge Laboratory (**Liverpool);**
United States of America: Boston University (**Boston),** George Mason University (**Fairfax),** SLAC National Accelerator Laboratory (**Menlo Park),** University of California Merced (**Merced),** Brookhaven National Laboratory (BNL) (**Upton).**

Форма № 25

ЛИСТ СОГЛАСОВАНИЙ ПРОЕКТА

ИЗМЕРЕНИЕ РЕДКОГО РАСПАДА $K^+ \to \pi^+ \nu\bar{\nu}$ НА УСКОРИТЕЛЕ SPS ЦЕРН

Условное обозначение проекта - **NA-62**

Шифр темы: 02 - 1 -1096- 2010/2019

Руководители темы: В.Д.Кекелидзе, Ю.К.Потребеников

Руководители проекта: В.Д.Кекелидзе, Ю.К.Потребеников

УТВЕРЖДЕН ДИРЕКТОРОМ ОИЯИ	________________	**«____»__________20 г.**
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ОДОБРЕН		
ПКК ПО НАПРАВЛЕНИЮ	________________	**«____»__________20 г.**

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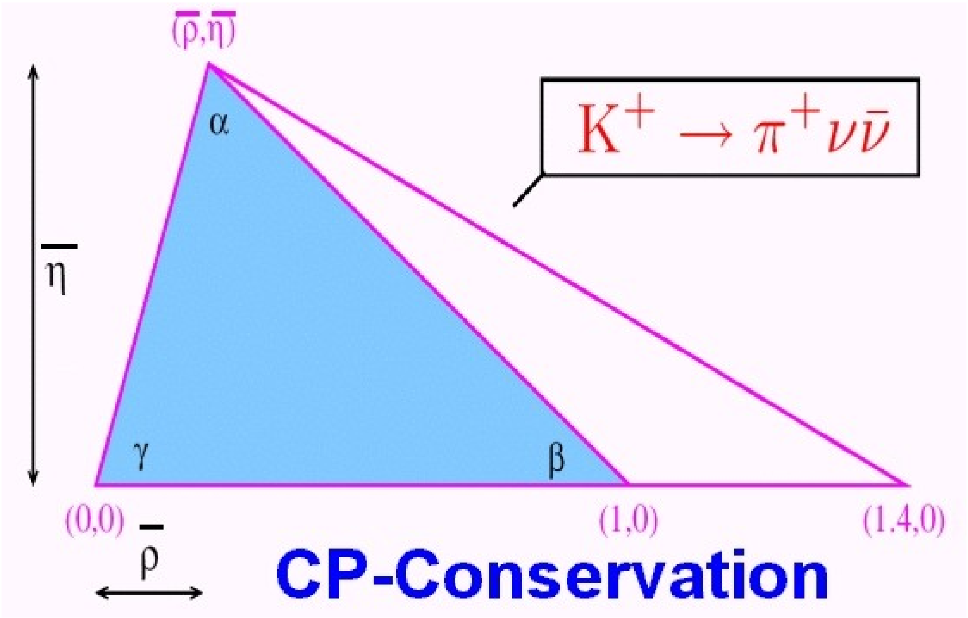
Kaon decays at CERN

- Prehistory: NA31 (1984-1990) – First evidence of direct CPV with K_L/K_S beams.

JINR participation

Experiment	Data taking	Main goal	Beams
NA48	1997-2001	direct CPV (ε'/ε)	K_L/K_S
NA48/1	2002	Rare K_S and hyperon decays	K_S
NA48/2	2003-2004	Direct CPV in charge asymmetry	K^+/K^-
NA62 (R_K)	2007	Test of μ/e universality $R_K = K_{e2}/K_{\mu 2}$	K^+/K^-
NA62	2014-2018 prolongation after 2020?	$K^+ \to \pi^+ \nu \bar{\nu}$ other rare kaon decays.	K^+

NA62 motivation



The "golden decays" $K^0 \to \pi^0 \nu\bar\nu$ and $K^+ \to \pi^+ \nu\bar\nu$ give an opportunity to make a very sensitive tests of SM, as their probabilities are directly related to η^2 (height of triangle) and $(\rho - 1.4)^2 + \eta^2$ in Wolfenstein notation of CKM.

- $K^+ \to \pi^+ \nu\bar\nu$ is theoretically clean, hadronic matrix element measured with K_{l3} decays
- SM predictions [Phys. Rev. D 83 034030 (2011), JHEP11 (2015) 033]:

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

- Experimental result is based on 7 events
[BNL, K decays at rest. Phys. Rev. D 79, 092004 (2009)] :

$$BR(K^+ \to \pi^+ \nu\bar\nu) = (17.3^{+11.5}_{-10.5}) \times 10^{-11}$$

Additional goals for the JINR group analysis

- Rare four-lepton decays $K^+ \to e^+ \nu \mu^+ \mu^-$, $K^+ \to e^+ \nu e^+ e^-$, $K^+ \to \mu^+ \nu e^+ e^-$ and $K^+ \to \mu^+ \nu \mu^+ \mu^-$ (not yet observed) with the branching ratios of the order of 10^{-8} (ChPT checks).

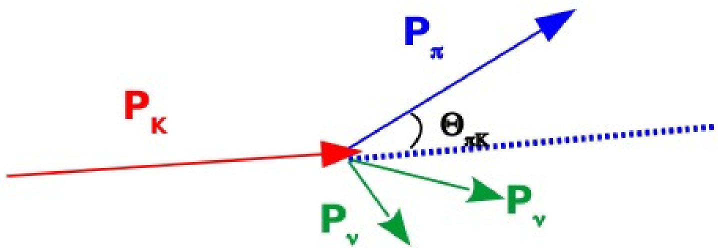
- Search for the forbidden modes $K^+ \to e^- \nu \mu^+ \mu^+$, $K^+ \to \mu^- \nu e^+ e^+$ (SM check).

- Search for the Goldstone fermion superpartners - “sgoldstino” P in decays $K^+ \to \pi^+ \pi^0 P$ ($P \to \gamma\gamma$). [Gorbunov, Rubakov. Phys.Rev.D73:035002,2006]

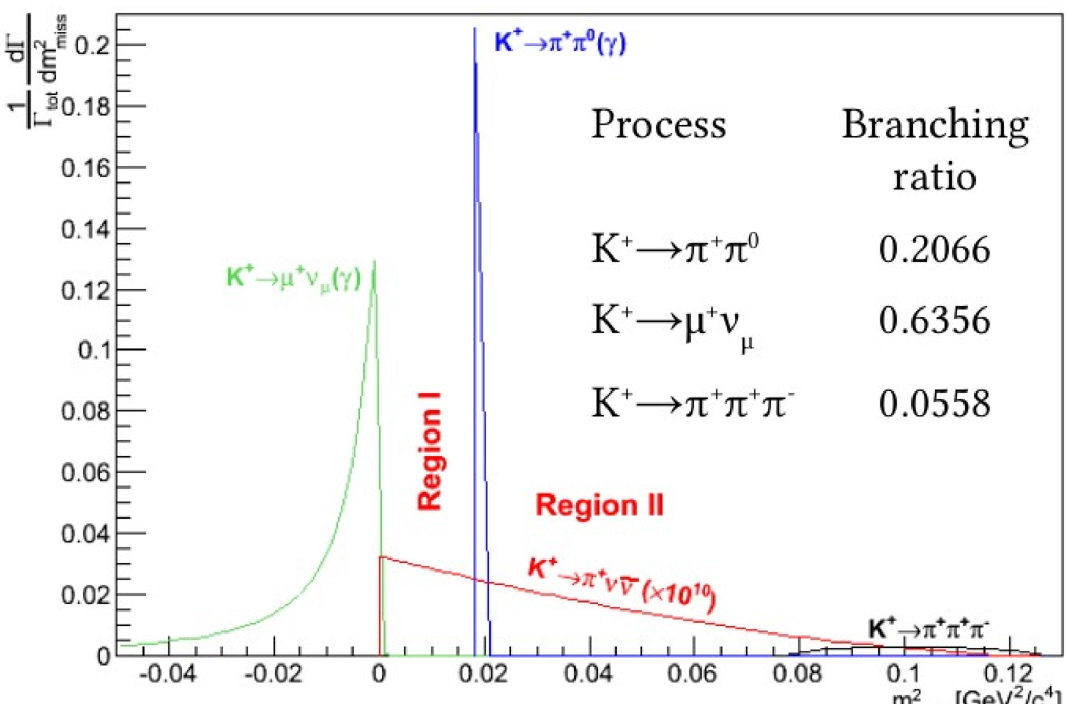
- Search for the Heavy Neutral Lepton in $K^+ \to e^+$ and $K^+ \to \mu^+$ topologies with the measured kaon and lepton momenta.

$\pi\nu\bar{\nu}$ strategy

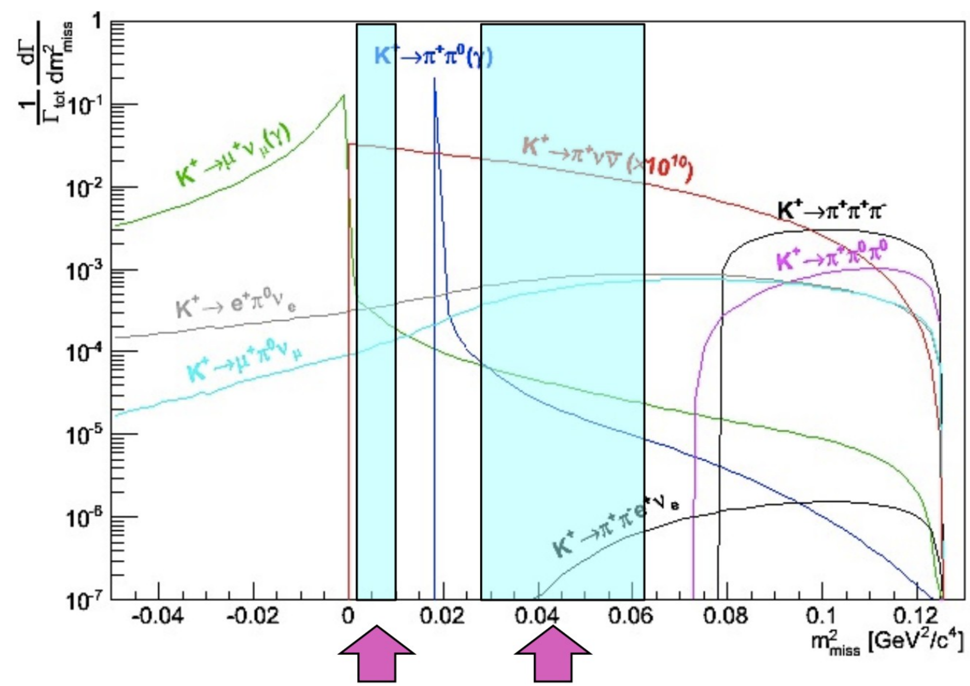
Decay in flight technique $m^2_{miss} = (P_K - P_{\pi^+})^2$



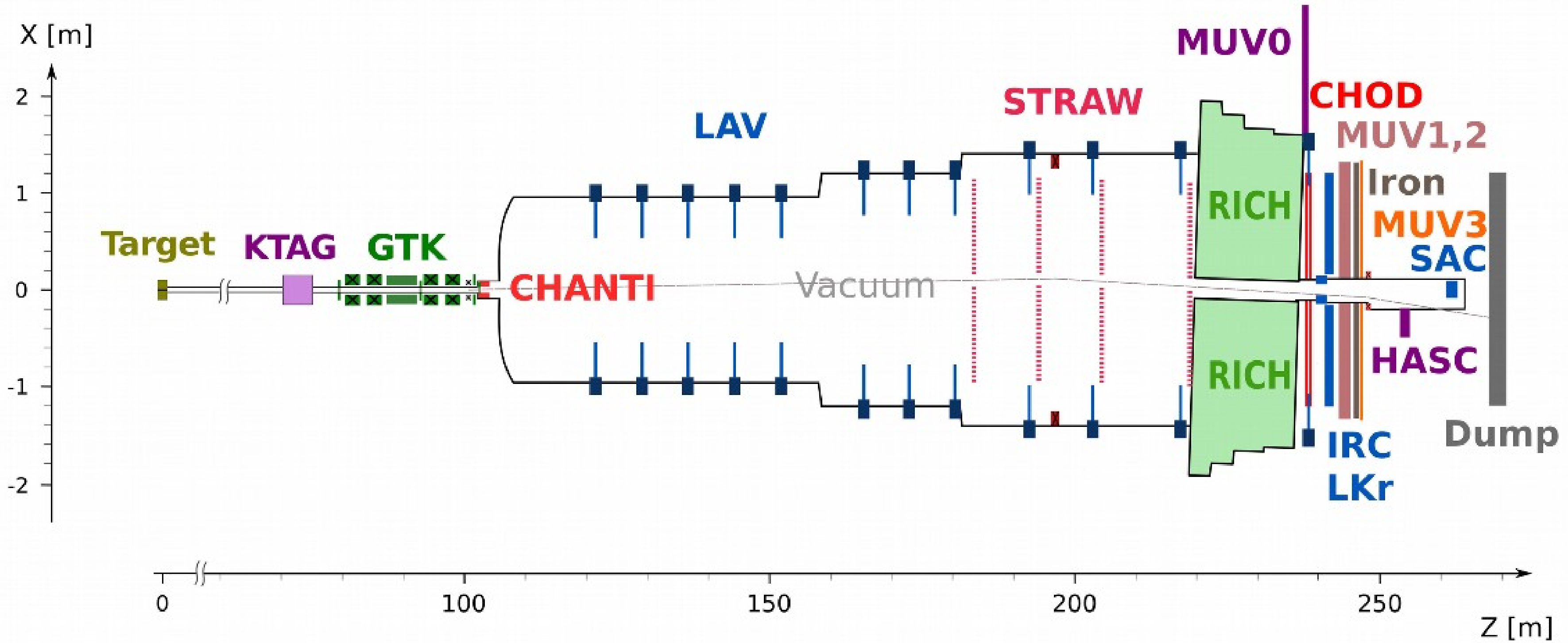
- Keystones of the analysis:
  - Timing between sub-detectors ~ O(100 ps)
  - Kinematic suppression ~ $O(10^4)$
  - Muon suppression > 10^7
  - π^0 suppression (from $K^+ \to \pi^+\pi^0$) > 10^7



Process	Branching ratio
$K^+ \to \pi^+\pi^0$	0.2066
$K^+ \to \mu^+\nu_\mu$	0.6356
$K^+ \to \pi^+\pi^+\pi^-$	0.0558

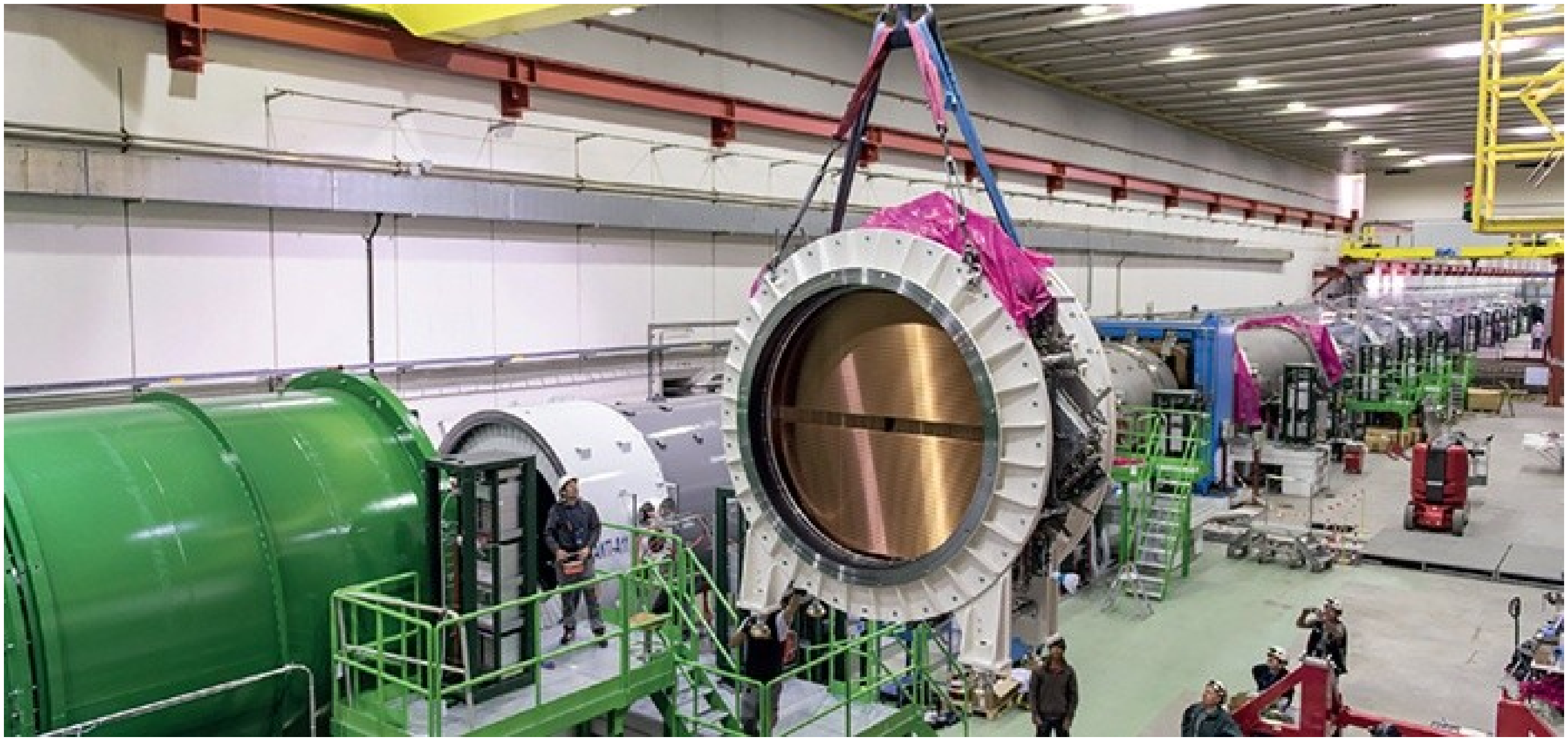


NA62 beam and detector



- SPS Beam:
  - 400 GeV/c protons
  - 10^{12} protons/spill
  - 3.5s spill
- Secondary positive Beam:
  - 75 GeV/c momentum, 1 % bite
  - 100 μrad divergence (RMS)
  - 60x30 mm^2 transverse size
  - $K^+(6\%)/\pi^+(70\%)/p(24\%)$
  - 33×10^{11} ppp on T10 (750 MHz at GTK3)
- Decay Region:
  - 60 m fiducial region
  - ~ 5 MHz K^+ decay rate
  - Vacuum ~ $O(10^{-6})$ mbar

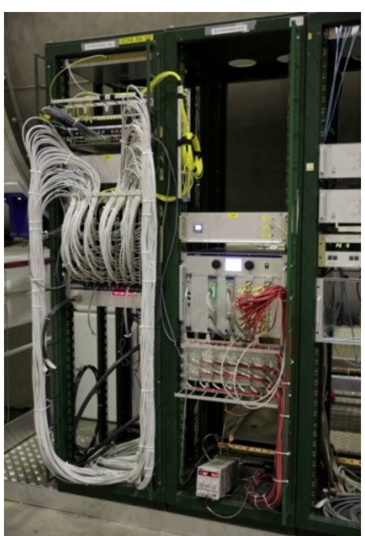
JINR+CERN responsibility :
Spectrometer made of straw tubes working in vacuum



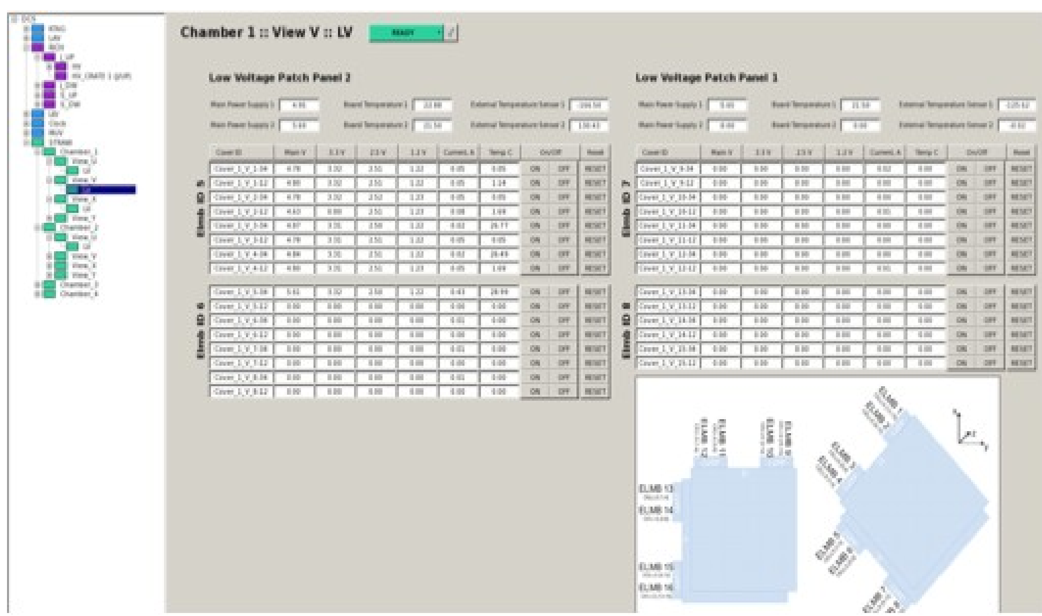
JINR contribution is very important and is defining in many aspects:

- R&D (2 prototypes),
- MC simulation,
- Straws geometry,
- Frames etc. design,
- straws production (~7000 in JINR),
- Modules assembling.

Installed in 2014.

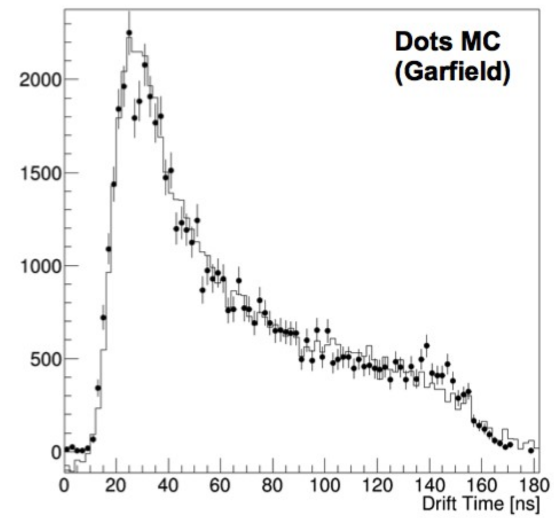


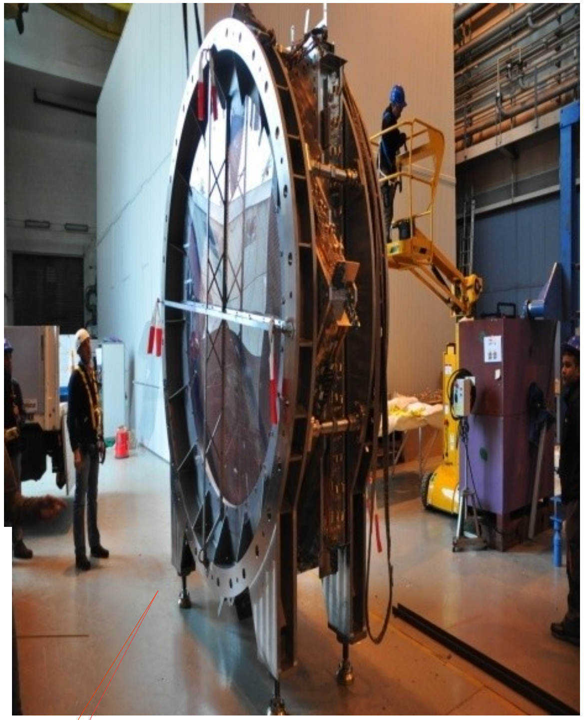
HV and LV power suppliers

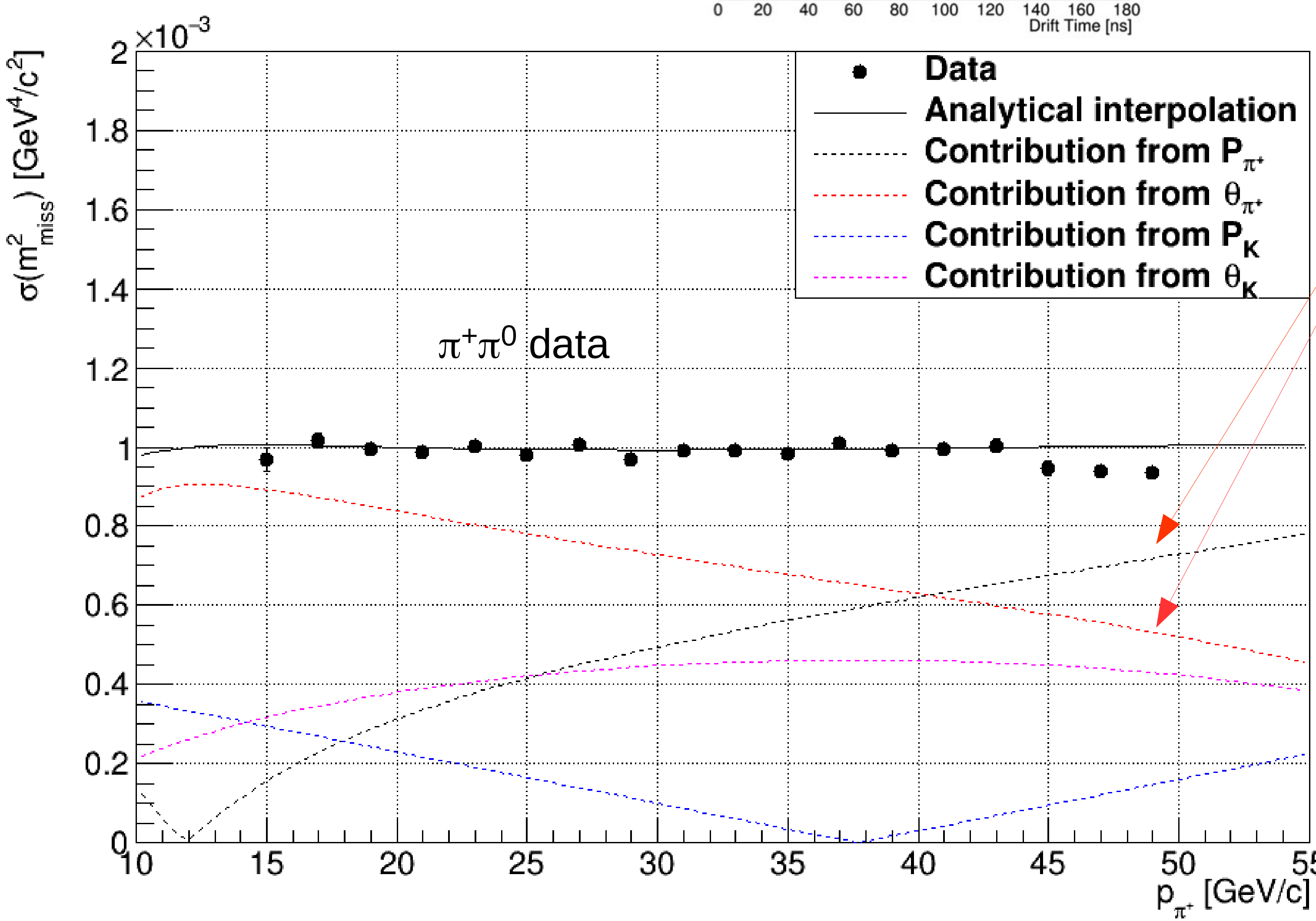


Detector Control Sysyem (DCS) for the NA62 Spectrometer

Spectrometer performance



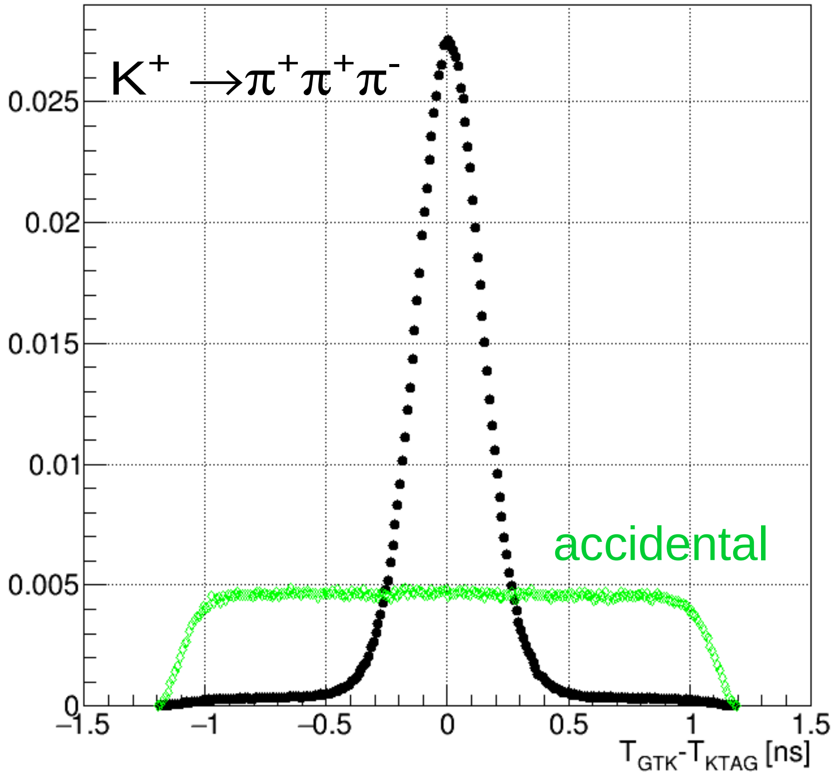




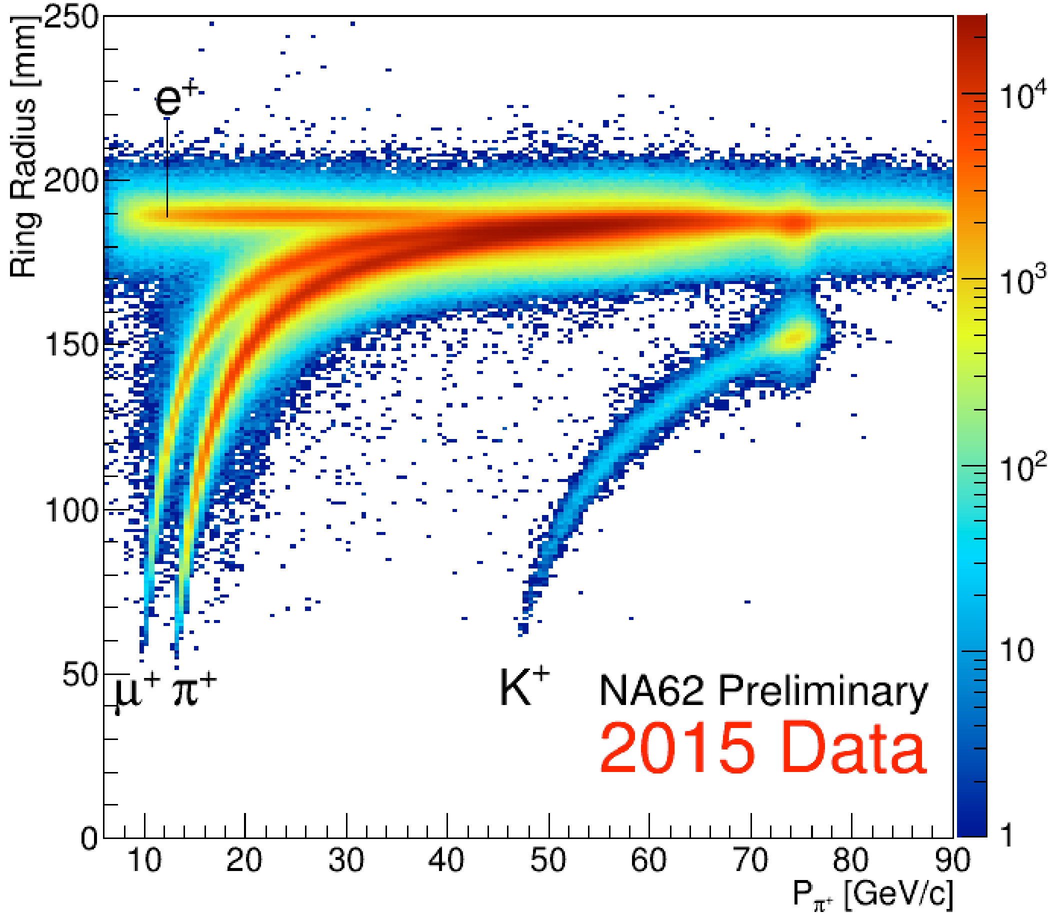
The largest expected contributions are from the spectrometer.

As expected even without very sofisticated alignment (just a wire centers positioning).

- 2014 Pilot run
- 2015 Comissioning run
- Full detector installation completed in September 2016.
- First $\pi\nu\bar{\nu}$ dataset in 2016
- Continuous data taking until the end of 2018 (prolongation after 2020 is expected)

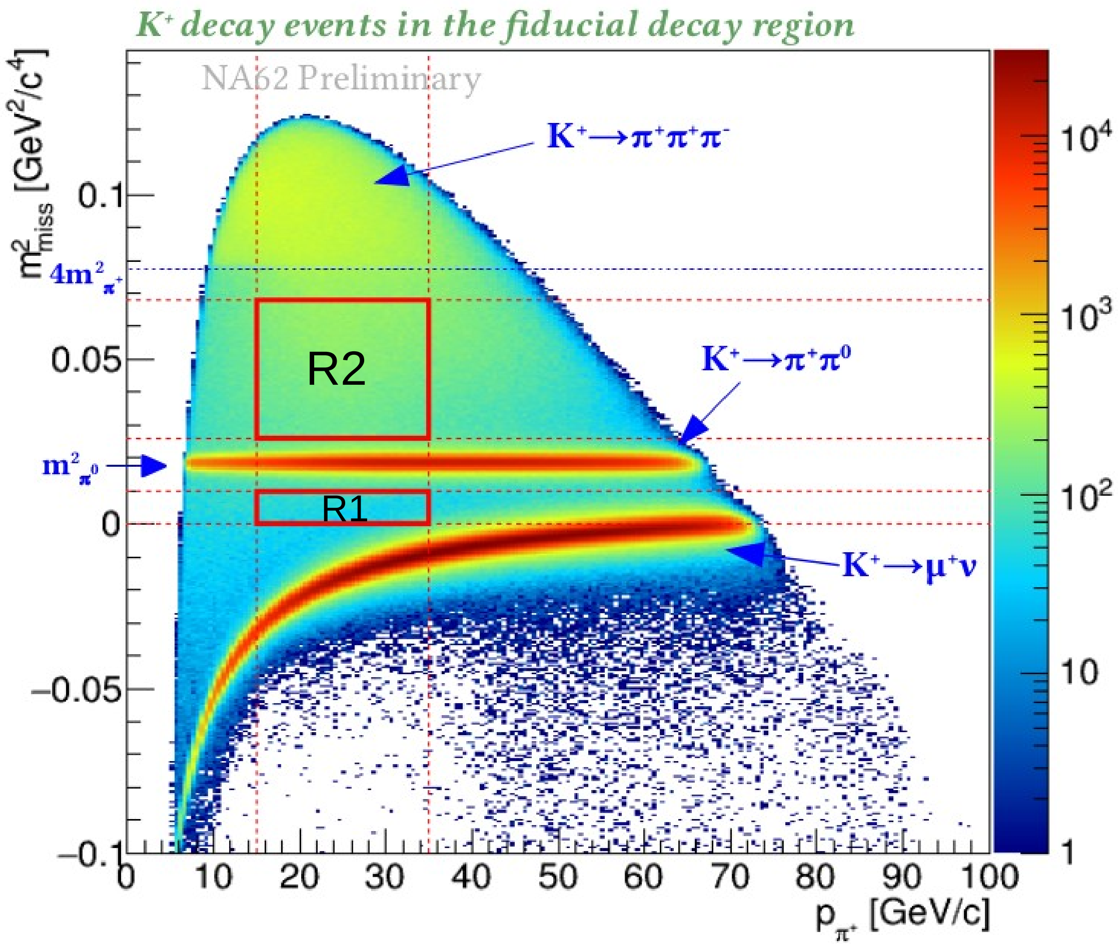


GTK and KTAG (CEDAR) time difference distributions



RICH ring radius vs the track momentum

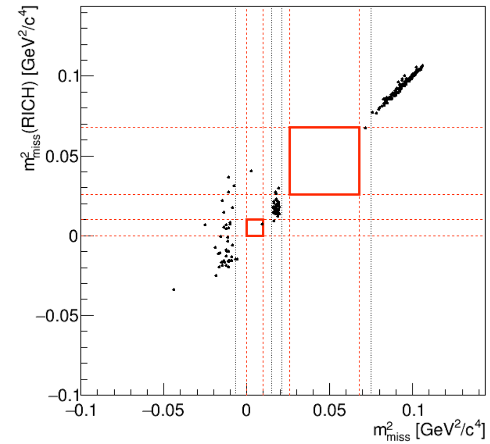
Signal regions R_1 and R_2

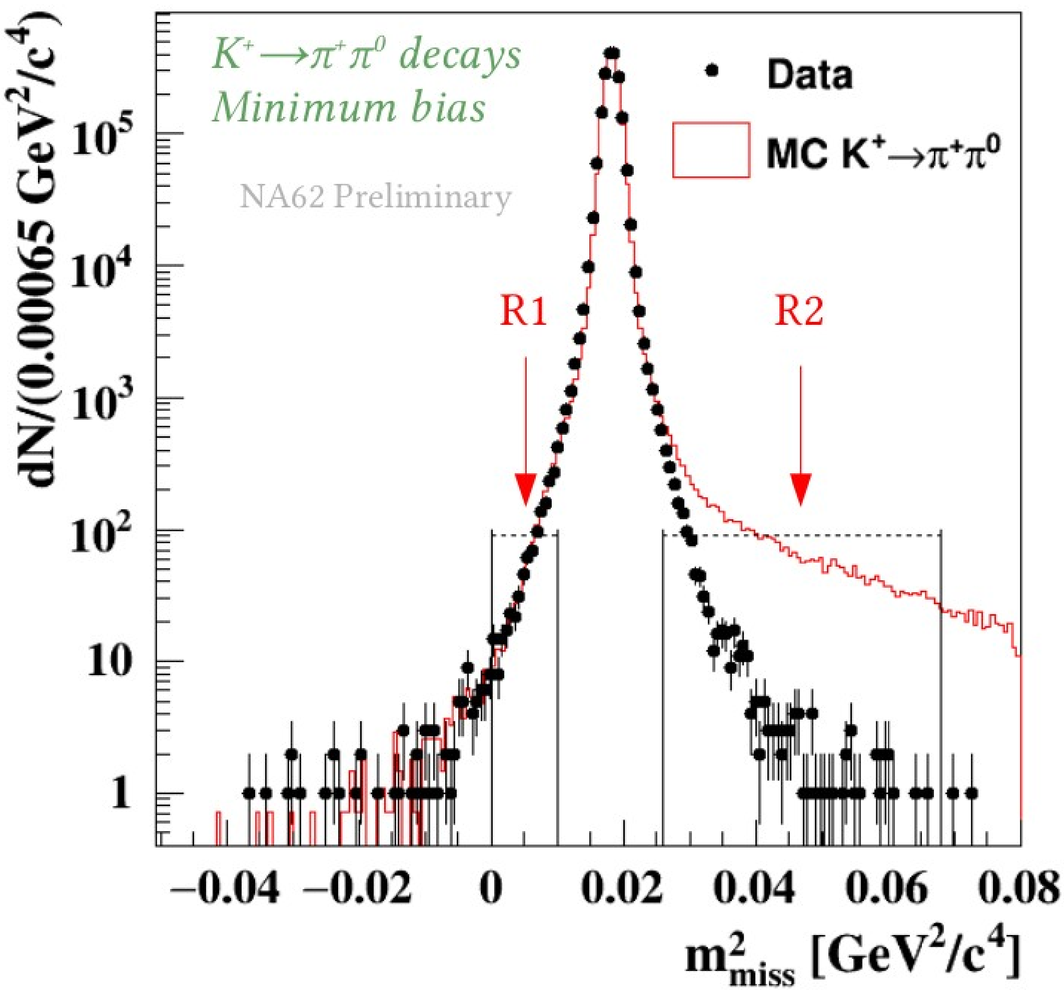


- Selection criteria
  - single track decay topology
  - π^+ identification
  - photon rejection
  - multi-track rejection

- Performance
  - $\epsilon_{\mu^+} = 1 \cdot 10^{-8}$ (64% π^+ efficiency)
  - $\epsilon_{\pi^0} = 3 \cdot 10^{-8}$
  - $\sigma(m^2_{miss}) = 1 \cdot 10^{-3}\ \mathrm{GeV}^2/c^4$
  - $\sigma_T \sim O(100\ \mathrm{ps})$

No signal events were observed in the first 5% of 2016 data. This 5% sample has been not used for the present result in order to conform the blind analysis strategy (signal regions are opened at the very end of the analysis in two independent groups).





- Three ways to compute the m^2_{miss}
  - m^2_{miss}(STRAW, GTK)
  - m^2_{miss} (RICH, GTK)
  - m^2_{miss} (STRAW, Beam)
- Protects against mis-reconstruction
- Kinematic suppression
  - Measured using data
  - Samples of $K_{\pi\pi}$ and $K_{\mu\nu}$
  - Selected using calorimeters
- Fraction of events in signal regions
  - $K^+ \to \pi^+\pi^0 \sim 1 \cdot 10^{-3}$
  - $K^+ \to \mu^+\nu_\mu \sim 3 \cdot 10^{-4}$

First NA62 result based on the 2016 data (reported in Moriond in March 2018)

Amount of kaon decays in the fiducial volume: $N_K = 1.21(2)\times10^{11}$

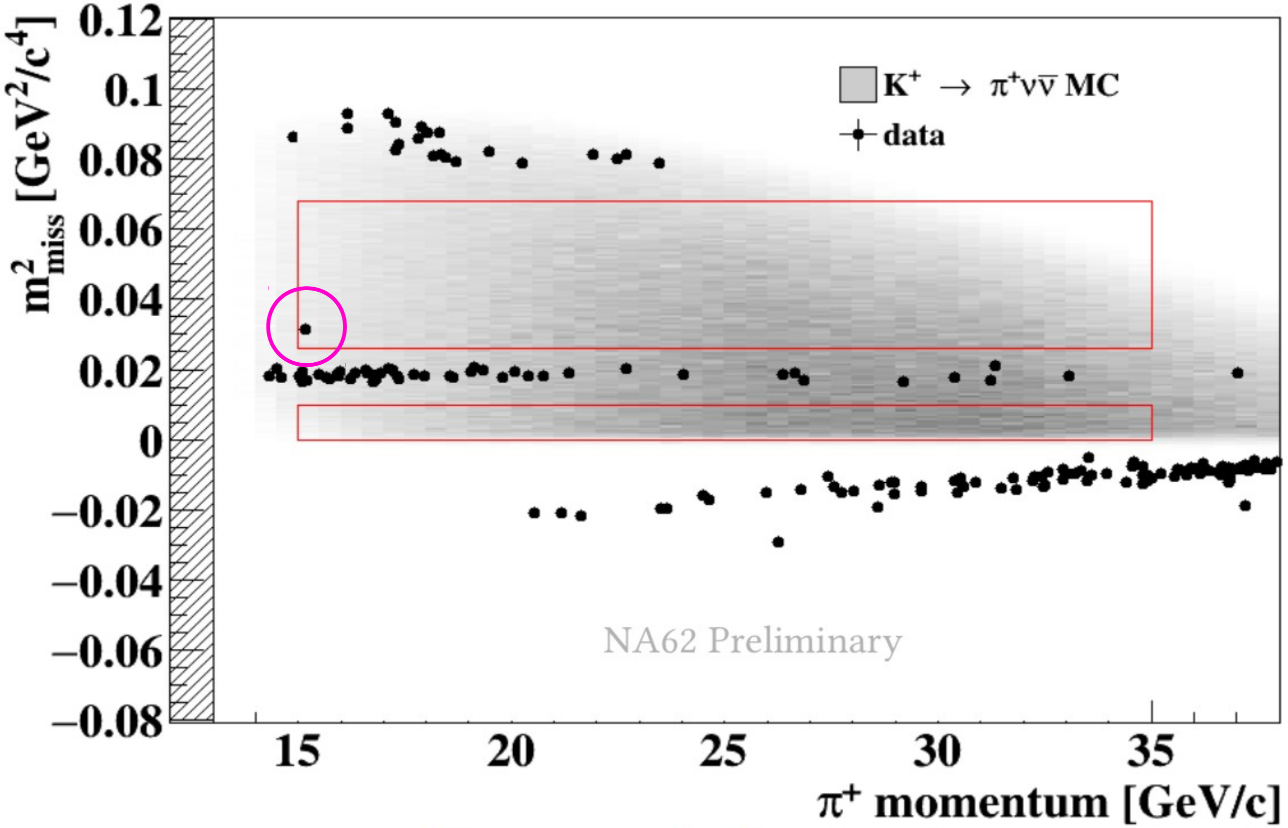
Full set of 2016 data

Process	Expected events in R1 + R2
$K^+ \to \pi^+ \nu\bar{\nu}$ (SM)	$0.267 \pm 0.001_{stat} \pm 0.029_{syst} \pm 0.032_{ext}$
$K^+ \to \pi^+\pi^0(\gamma)$ IB	$0.064 \pm 0.007_{stat} \pm 0.006_{syst}$
$K^+ \to \mu^+\nu_\mu(\gamma)$ IB	$0.020 \pm 0.003_{stat} \pm 0.003_{syst}$
$K^+ \to \pi^+\pi^- e^+\nu_e$	$0.018^{+0.024}_{-0.017}\vert_{stat} \pm 0.009_{syst}$
$K^+ \to \pi^+\pi^-\pi^+$	$0.002 \pm 0.001_{stat} \pm 0.002_{syst}$
Upstream background	$0.050^{+0.090}_{-0.030}$
Total background	$0.15 \pm 0.09_{stat} \pm 0.01_{syst}$

- Signal acceptance 4%

- Control triggered $K\to\pi^+\pi^0$ used for normalization
- Normalization acceptance 10%

Results



One event observed

$BR(K^+ \to \pi^+\nu\bar{\nu}) < 14 \times 10^{-10}$ @ 95% CL

For comparison: $BR(K^+ \to \pi^+\nu\bar{\nu}) = 28^{+44}_{-23} \times 10^{-11}$ @ 68% CL

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

$$BR(K^+ \to \pi^+\nu\bar{\nu})_{exp} = (17.3^{+11.5}_{-10.5}) \times 10^{-11}$$ (BNL, "kaon decays at rest")

- 2017 data processing is in progress (~ 20 times more data, reduction of background expected)
- 2018 data taking: 218 days
- ~ 20 SM events expected before LS2 (LHC Long Shutdown 2019-2020)
- Running after 2018 to be approved

NA48/2 and NA62 data (collected in 2003–2010) analysis done in parallel with the NA62 data taking (during 2016-2018):

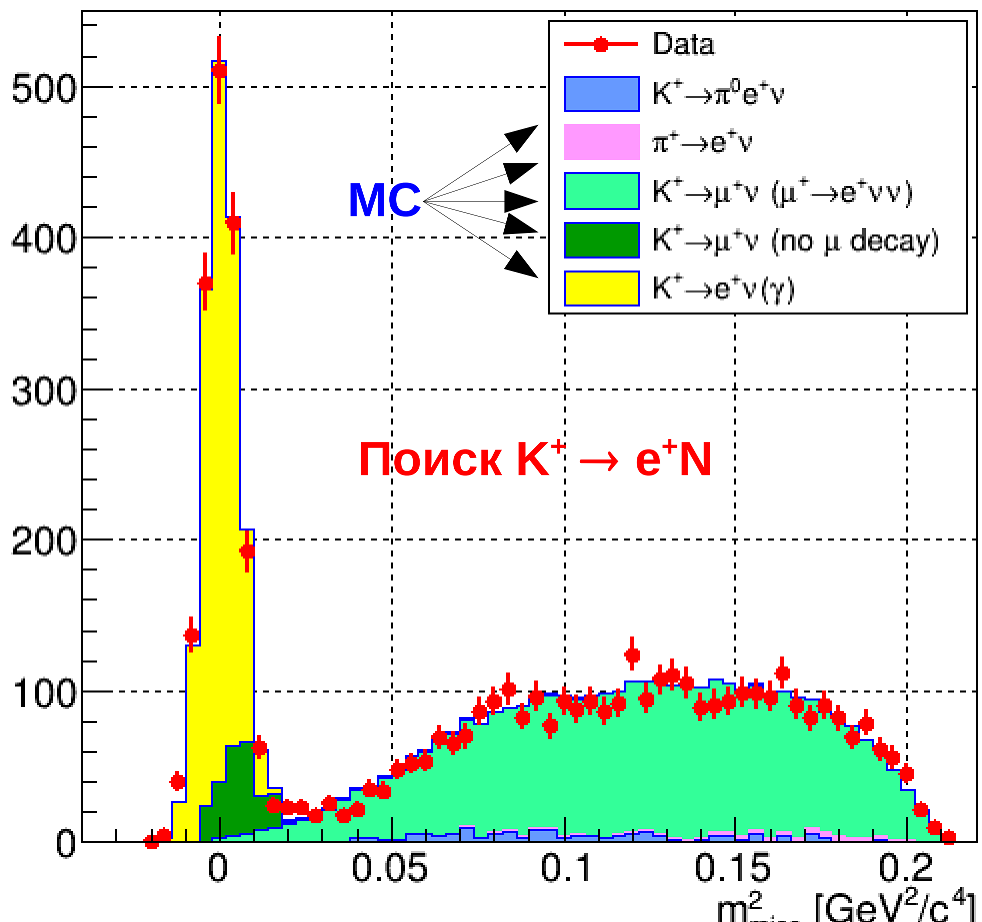
- NA48/2 (2003-2004): an upper limit on the lepton number violating decay: B($K \rightarrow \pi\ \mu^{\pm}\mu^{\pm}$) < 8.6×10^{-11} at 90% CL. The upper limits for the products of branching ratios B($K^{\pm} \rightarrow \mu^{\pm} N_4$)B($N_4 \rightarrow \pi\mu$) and B($K^{\pm} \rightarrow \pi^{\pm} X$)B($X \rightarrow \mu^+\mu^-$): 10^{-9} and 10^{-11} for the resonance lifetime below 100 ps.
- NA62 (2007): a measurement of π^0 electromagnetic transition **form factor slope** $a=(3.68\pm0.57)\times10^{-2}$.
- NA62 (2007): A **peak** search in the reconstructed missing mass spectrum of $K^+ \rightarrow \mu^+\nu$. Limits in the range 2×10^{-6} to 10^{-5} on the squared matrix element $|U_{\mu4}|^2$ describing the mixing between the muon and heavy neutrino states, for the heavy neutrino masses in the range 300-375 MeV/c^2.
- The paper on the **form factors of K_{e3} and $K_{\mu3}$** decays based on NA48/2 data (Dubna group responsibility) is in preparation after the internal reviewing.
- The analysis of the new rare decay $K^{\pm} \rightarrow \pi^{\pm}\pi^0 e^+ e^-$ based on NA48/2 data (first observation) is in its final stage. Preliminary Br($\pi^{\pm}\pi^0 e^+ e^-$)= $(4.22 \pm 0.06_{stat} \pm 0.04_{syst} \pm 0.13_{ext})\times10^{-6}$.
- The study of $K_{\mu4}^{00}$ rare decay on the basis of NA48/2 data is in progress (first observation), a preliminary branching ratio is almost ready.
- The analysis of the **four-lepton kaon decays** is started on the basis of the NA62 data collected in 2016 and 2017 years.

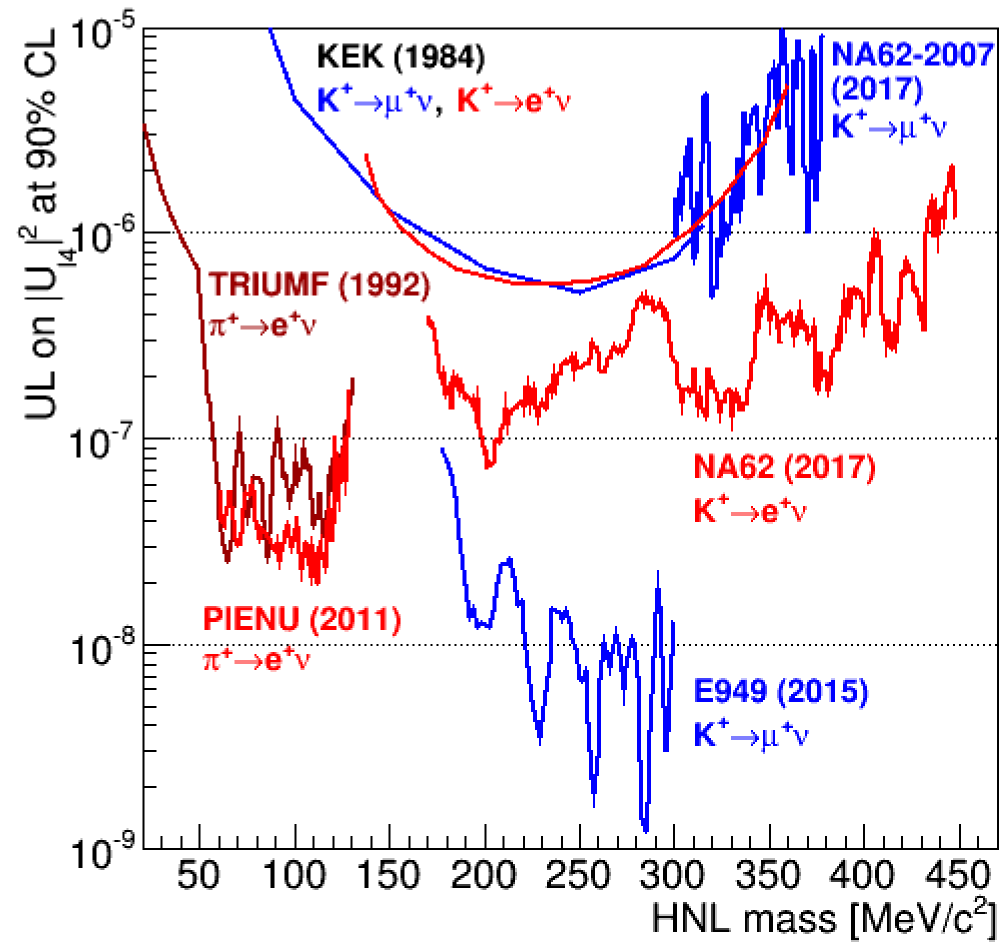
Одна из дополнительных задач:

Поиск тяжёлых нейтральных лептонов в NA62

Среди дополнительных задач по редким распадам – поиск гипотетических тяжёлых нейтральных лептонов (HNL) неизвестной массы, предсказанных в ряде расширений SM.

Уже данные тестового сеанса 2015 года (1% от номинальной интенсивности) позволили получить конкурентоспособные ограничения снизу на параметр смешивания $|U_{l4}|^2$, определяющий вероятность распадов **$K^+ \to e^+N$** и **$K^+ \to \mu^+N$**.
Принцип: поиск пиков в спектре недостающей массы (N долгоживущая и неуловимая).





Methodical and theoretical results in 2016-2018

- **Software tools** for NA62 collaboration: interactive straw map, straw timing stability monitor, straw wires and tubes positioning control.
- **A review** of the kaon decay studies in NA48, NA48/1, NA48/2 is published.
- NA62 drift **chamber design and acquisition system are described** in journal papers.
- **Straw stability under internal pressure** is studied and a technique of its prediction is developed
- **Wire position measurement** technique with an optical microscope is developed.
- A **device for the straw tubes production is described** in a journal paper.
- Interactions of **polarized mesons with nucleons** are studied theoretically.

- Obtained results in 2016-2018 were presented at the international conferences, including 12 presentations given by the representatives of JINR group.
- During the NA62 experimental runs in 2016-2018 the JINR group members will perform in total about 250 shifts.
- The series of scientific works of Dubna group “Development and construction of gas-filled detectors based on a new type of straw tubes for operation in vacuum in the track spectrometer of the NA62 experimental set-up” was awarded a first JINR prize (2017) in the nomination of scientifically-methodical works.
- Two patents for inventions are obtained by the JINR group members.

NA62 JINR group plans for 2019-2021

- Fine calibration and alignment of straw detector on the basis of collected data
- Improvement of the straw detector Monte Carlo simulation used for the main NA62 analysis
- Participation in the analysis of some background sources for $K^+ \rightarrow \pi^+ \nu \bar{\nu}$
- Data processing and analysis of the collected experimental data to measure the four-lepton decay modes of charged kaon
- Search for the light sgoldstio signatures
- Diagnostics and necessary repair of the Spectrometer straw chambers and their low and high voltage power supply during the shutdown in 2019-2020
- Participation in the next NA62 data taking run in 2021
- Support the Spectrometer during the data taking run in 2021

Journal papers (2016-2018)

1) Eduardo Cortina Gil *et al.* The beam and detector of the NA62 experiment at CERN. JINST 12 (2017) no.05, P05025.
2) J.R.Batley *et al.* Searches for lepton number violation and resonances in $K^{\pm}\rightarrow\pi\mu\mu$ decays. Phys.Lett. B769 (2017) 67-76.
3) C.Lazzeroni *et al.* Measurement of the π^0 electromagnetic transition form factor slope. Phys.Lett. B768 (2017) .
4) C.Lazzeroni *et al.* Search for heavy neutrinos in $K^{+}\rightarrow\mu^{+}\nu$ decays. Phys.Lett. B772 (2017) 712-718.
5) A.Cecucci, E.Goudzovski, V.Kekelidze, D.Madigozhin, I.Potrebenikov. Kaon decay studies at CERN SPS in the last decades. Phys.Part.Nucl. 47 (2016) no.4, 567-590.
6) N.Azorskiy *et al.* A drift chamber with a new type of straws for operation in vacuum. Nucl.Instrum.Meth. A824 (2016) 569-570.
7) N.Azorskiy *et al.* The NA62 spectrometer acquisition system. JINST 11 (2016) no.02, C02064.
8) L.Glonti *et al.* Determination of the anode wire position by visible light in a new type straw for NA62 experiment tracker. Nucl.Instrum.Meth. A824 (2016) 532-534.
9) N.I.Azorskii *et al.* New type of drift tubes for gas-discharge detectors operating in vacuum: production technology and quality control. Phys.Part.Nucl.Lett. 14 (2017) no.1, 144-149.
10) E.Chudakov, S.Gevorkyan, A.Somov. Photoproduction of ω mesons off nuclei and impact of polarization on the meson-nucleon interaction. Phys.Rev. C93 (2016) no.1, 015203.
11) L.Afanasyev, S.Gevorkyan, O.Voskresenskaya. Production of dimeson atoms in high-energy collisions. Eur.Phys.J. A53 (2017) no.4, 78.

Preprints (2016-2018)

- E.Cortina Gil *et al.* Search for heavy neutral lepton production in K^{+} decays. CERN-EP-2017-311. 2017. 15 pp.
- L.Glonti *et al.* Longitudinal tension and mechanical stability of a pressurized straw tube. JINR preprint E1-2017-20. 20 pp.

Conference talks (2016-2018)

1) D.Madigozhin. New and recent results from NA48/2. Proceedings of the 52nd Recontres de Moriond. QCD and High Energy Interactions. ARISF. 2017.
2) S.Gevorkyan. The impact of vector mesons polarization on meson-nucleon interaction. 16th Workshop on High Energy Spin Physics (DSPIN-15). J.Phys.Conf.Ser. 678 (2016) no.1, 012033.
3) S.Gevorkyan. Vector mesons polarization versus color transparency. 23rd International Baldin Seminar on High Energy Physics Problems : Relativistic Nuclear Physics & Quantum Chromodynamics. (Baldin ISHEPP 23). EPJ Web Conf. 138 (2017) 08004.
4) Yu.Potrebenikov. A new system of STRAW chambers operating in vacuum for the NA62 experiment. J.Phys.Conf.Ser. 800 (2017) no.1, 012047.
5) S.Shkarovskiy. NA62 spectrometer to search for $K^+ \to \pi^+ \nu \bar{\nu}$. 14th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD16). Siena. Italy. 2016. JINST 12 (2017) no.02, C02027.
6) S.Shkarovskiy. Recent measurement of Kl3 form factors at NA48. 23th International Workshop on High Energy Physics and Quantum Field Theory (QFTHEP 2017). EPJ Web Conf. 158 (2017) 03007.
7) S.Shkarovskiy. Recent QCD-related Results from Kaon Physics at CERN (NA48/2 and NA62). 9th Workshop "Excited QCD" 2017. Acta Phys.Polon.Supp. 10 (2017) 1153-1158.
8) S.Shkarovskiy. Recent results from the NA48 experiment at CERN. 3rd International Conference on Particle Physics and Astrophysics (ICPPA 2017). J.Phys.Conf.Ser. 934 (2017) no.1, 012031.
9) E.Goudzovski. Kaon experiments at CERN: recent results and prospects. 14th International Workshop on Meson Production, Properties and Interaction (MESON 2016). EPJ Web Conf. 130 (2016) 01019.
10) E.Goudzovski. Neutral pion form factor measurement at NA62. 38th International Conference on High Energy Physics (ICHEP 2016). PoS ICHEP2016 (2017) 642.
11) D.Madigozhin *et al*. Searches for lepton number violation and resonances in the $K^{\pm} \to \pi\mu\mu$ decays at the NA48/2 experiment. New Trends in High-Energy Physics. Budva, Becici, Montenegro. 2016.
12) A.Zinchenko *et al*. Searches for lepton number violation and resonances in the $K^{\pm} \to \pi\mu\mu$ decays by NA48/2 at CERN. 14-th International Conference on Meson-Nucleon Physics and the Structure of the Nucleon. July 25-30, 2016, Kyoto, Japan.

Patents

- S.A.Movchan *et al*. A device for the production of cylinder tubes for the gas-filled drift detectors of ionizing radiation. Patent #2555693. 8.06.2016.
- L.Glonti *et al*. A device for the measurement of wire positions in gas wire chambers. Patent #2602492. 15.09.2016.

Costs in the past

Total NA62 setup creation - **40 million CHF**; JINR contribution - **1.5 million CHF**.

On previous stages of the NA62 project at JINR 12 experts of different fields have been involved. We propose to involve 2 more PhD students for the third part of the Project.

The total JINR expenses during 2016-2018 years to the third stage of the project (the theme of 1096) are **$504.7k**.

About **$10k** have been paid by CERN and collaboration NA62 for the support of the straw detector;

about **$10k** were allocated by CERN for travel support of the JINR experts to CERN.

30K CHF in 2016 for JINR engeneers to support of common works during the preparation of the experiment.

Request for the years 2019-2021 from the JINR budget - **$370k**.

From other sources expected - **$10k**.

Форма №29

Смета расходов по проекту из бюджета ОИЯИ

N	Наименование статей затрат	Единица измерения	1-год	2-год	3-год	2019 – 2021 гг
	Прямые расходы на проект					
0.	Эксплуатационные расходы	тыс. US$	35	35	35	105
1.	Ускоритель					
2.	КБ					
3.	ООЭП					
4.	Материалы	тыс. US$	5	5	10	20
5.	Оборудование	тыс. US$	10	10	15	35
6.	Оплата НИР, выполняемых по договорам					
7.	Командировочные расходы, в т.ч	тыс. US$	53	53	114	220
	а) в страны нерублевой зоны	тыс. US$	*50*	*50*	*110*	*210*
	б) в города стран рублевой зоны	тыс. US$	*3*	*3*	*4*	*10*
	в) по протоколам					
	Итого по прямым расходам:	**тыс. US$**	**103**	**103**	**174**	**380**

Руководители проекта

В.Д.Кекелидзе

Ю.К.Потребеников

Main expences:

- participation in the run 2021 and NA62 maintenance.
- development of straw detectors and on-line software systems.
- contributions to the NA62 common fund.
- computer and technical support of simulation, processing and analysis of experimental data.

Current full-time equivalent values for JINR participants

Name	FTE	PhD student	Work (apart from common duties like shifts)
D. Baygarashev	1.0	+	Data quality control, calibration, physical analysis
A. Baeva	0.5	+	Physical analysis
S. Gevorkian	1.0		Theory of rare decays, MC models development
L. Glonti	0.5		Spectrometer calibration and performance checks.
E. Goudzovski	0.1		MC development, analysis
D. Emelyanov	1.0	+	Software tools development, analysis
T. Enik	0.3		Hardware development and support
V. Kekelidze	0.1		Project leader
A.Korotkova	0.7	+	Physical analysis
D.Madigozhin	1.0		MC development, data quality control, analysis
M. Misheva	0.3	+	Physical analysis
N. Molokanova	0.9		Physical analysis
S. Movchan	0.2		Hardware development and support
I. Polenkevich	0.0		Currently in a long vacation (child)
Yu. Potrebenikov	0.5		Project leader
S. Shkarovskiy	1.0	+	DCS development, hardware support, analysis
TOTAL	**9.1**		

SPARES

Michal Hnatic (MH) :
Weaknesses and potential risks? Strategies for risk scenarios?
Why the aim is not achieved yet?

Answer: The largest risks should be foreseen at the beginning of the project: there are few completely new detector elements, and if the key ones would not be built (for example, Straw spectrometer or Gigatracker), the experiment would be completely lost. Nevertheless, this is our job – new science may be done only with the challenging and risky projects.

In fact, all the problems that were expected from the very beginning and were considered in the Technical Design Progect, have been solved by means of **delays in data taking** (one reason), and JINR group never was responsible for delays. 2014,2015 and the most of 2016 were the setup building stage with a completely operational Spectrometer.

From the other hand, two more problems have appeared without any scenarios (second reason why the aim is not achieved yet):

1) Unexpectedly high variations of the beam intensity (it is also provided for LHC, and we are just a second priority user). Leads to higher maximum intensity on detectors = problems with back-end electronics = we must limit the intensity per burst (40% in 2016 → 60% in 2017).

2)The new sofisticated source of background has been discovered (related to upstream interactions and decays) that enforce us to decrease the fiducial volume => acceptance is smaller than in the design.

The performed analysis of 2016 data show that no other risks of this kind may appear, and only improvements are expected.

As a result, the goal of ~ 100 events may be achieved only with the run prolongation in 2021, at least for 2 years (the improvements in electronics firmware and upstream particles shielding are in progress).

Realistic risks for now (apart from the WW3 etc...):

- There will be no run prolongation after LS2 (not so high probability);

  spare strategy:

  - analysis of the collected data that will give 20 SM events of $\pi\nu\nu$

  - other additional analyses with the available statistics.

- There will be not enough manpower for the fast finishing of all the additional analyses.

  spare strategy:

  - we try to attract even more brilliant young people

  - we will finish all analyses later in parallel with another projects (currently we still work on the NA48/2 data collected in 2003/2004).

MH: what is a fraction of the accumulated data analyzed up to now?
Why 5% of 2016?

Before the 8 of March it was officially only 5% of 2016. It was used for the procedure testing and is excluded from the blind analysis (that is why it was so small).

Now it is the complete 2016 data set (very beginning of full operation), that is ~ 1% of expected (2016-2018) or ~2-3% of the collected data (2017 mainly).

MH: Why is there a schedule break in data collection for 2 years?

LS2 in CERN

MH: What is the target precision, what are the conditions should be met?
Time of running at what luminosity?

Target precision is still 10% for BR($K \rightarrow \pi\nu\nu$).

Accelerator beam intensity itself is not a limiting resource (it is larger that needed) – the burst quality is an issue (variations) that enforces us to diminish the collimator slits, otherwise electronics can't process the data flux.

The realistic request taking into account the expected improvements is 2 years more starting from 2021, and the prolongation process in CERN is in progress.

MH: When enough data will be collected for sgoldstio?

Roughly proportional to $\pi\nu\nu$ (100 SM $\pi\nu\nu$ – 50 sgoldstino for the upper limit of 10^{-8} if no unexpected problems will appear).

MH: How the group will participate in the experiment?

Straw spectrometer is built in the past. Now for the prolongation period (some tasks are overlaid in one person):
- Technical hardware support of the Spectrometer (3 persons).
- Spectrometer on-call expert during the data taking, Detector Control System development and maintenance. (1)
- Software for the data quality control and monitoring development and maintenance. (2)
- Participation in the MC development in the Spectrometer part (1)
- Physical analysis: specific background sources for $\pi\nu\bar{\nu}$, additional physical goals for our group listed above (10 persons with a different intensity).

MH: Are there JINR participants who could be the responsible for the paper writing?

Goudzovskiy and Madigozhin yet were the responsible writers in the past for NA48/NA62 and both are responsible now for the currently prepared papers. Shkarovskiy is currently responsible for a NA48/2 paper. But we expect also that at least each of our PhD students will become a responsible author for his analysis.

MH: New PhD students?
Yes, we need more analysers now and promise a good prospects for PhD thesis, so we currently increase our group by at least two new PhD students.