NA62 status report

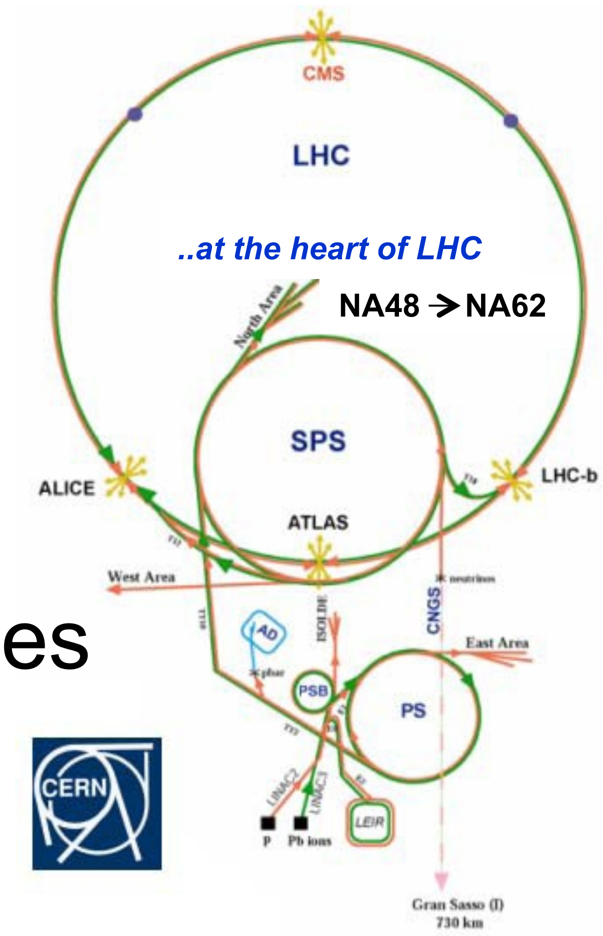
F. Ambrosino, T. Capussela, D. Di Filippo,

P. Massarotti, M. Napolitano, G. Saracino

Outline

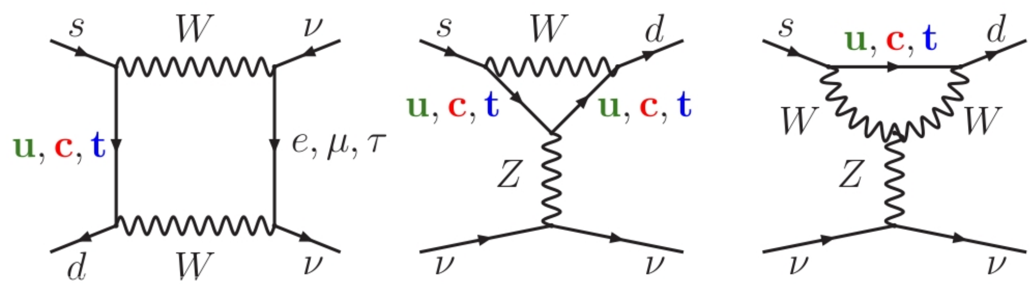
NA62: $K^+ \to \pi^+ \nu \bar{\nu}$ experiment

- experimental strategy
- main detectors description
- detectors developed in Naples



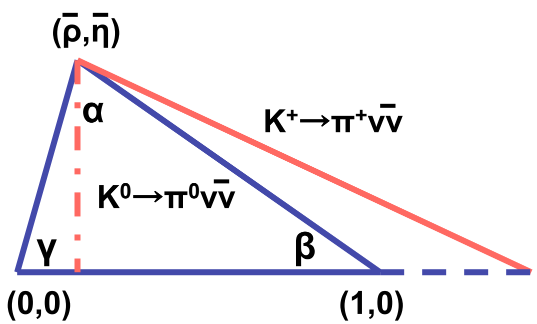
$K^+ \to \pi^+ \nu\bar{\nu}$: motivation

- FCNC process forbidden at tree level
- Only one loop contributions: Boxes and Penguins



Theoretical prediction:

$BR(K^+ \to \pi^+ \nu\nu) = (8.5 \pm 0.7) \times 10^{-11}$ **8% error**



- Cleanest way to extract $\mathbf{V_{td}}$ and to give independent determination of the unitarity triangle
- Complementarity with B physics
- Very sensitive to New Physics

$K^+ \to \pi^+ \nu\bar{\nu}$: motivation (II)

1) Short distance contributions (Wilson coefficients i.e. perturbative QCD) are dominant (hard GIM mechanism): $A_q \sim (m_q)^2/(m_W)^2$ $\mathbf{V_{qs}V_{qd}}$

top quark is dominant, smaller contribution from charm negligible from up

2) The hadronic matrix element (LD) uncertainty benefits from the Isospin symmetry and well measured semileptonic $K^+ \to \pi^0 e^+ \nu_e$ decays:

$$\left|\frac{\langle \pi^+ \nu\bar{\nu}|H_w|K^+\rangle}{\langle \pi^0 e^+ \nu_e|H_w|K^+\rangle}\right|^2 = \left|\frac{\langle \pi^+|H_w|K^+\rangle}{\langle \pi^0|H_w|K^+\rangle}\right|^2 = 2r_+$$

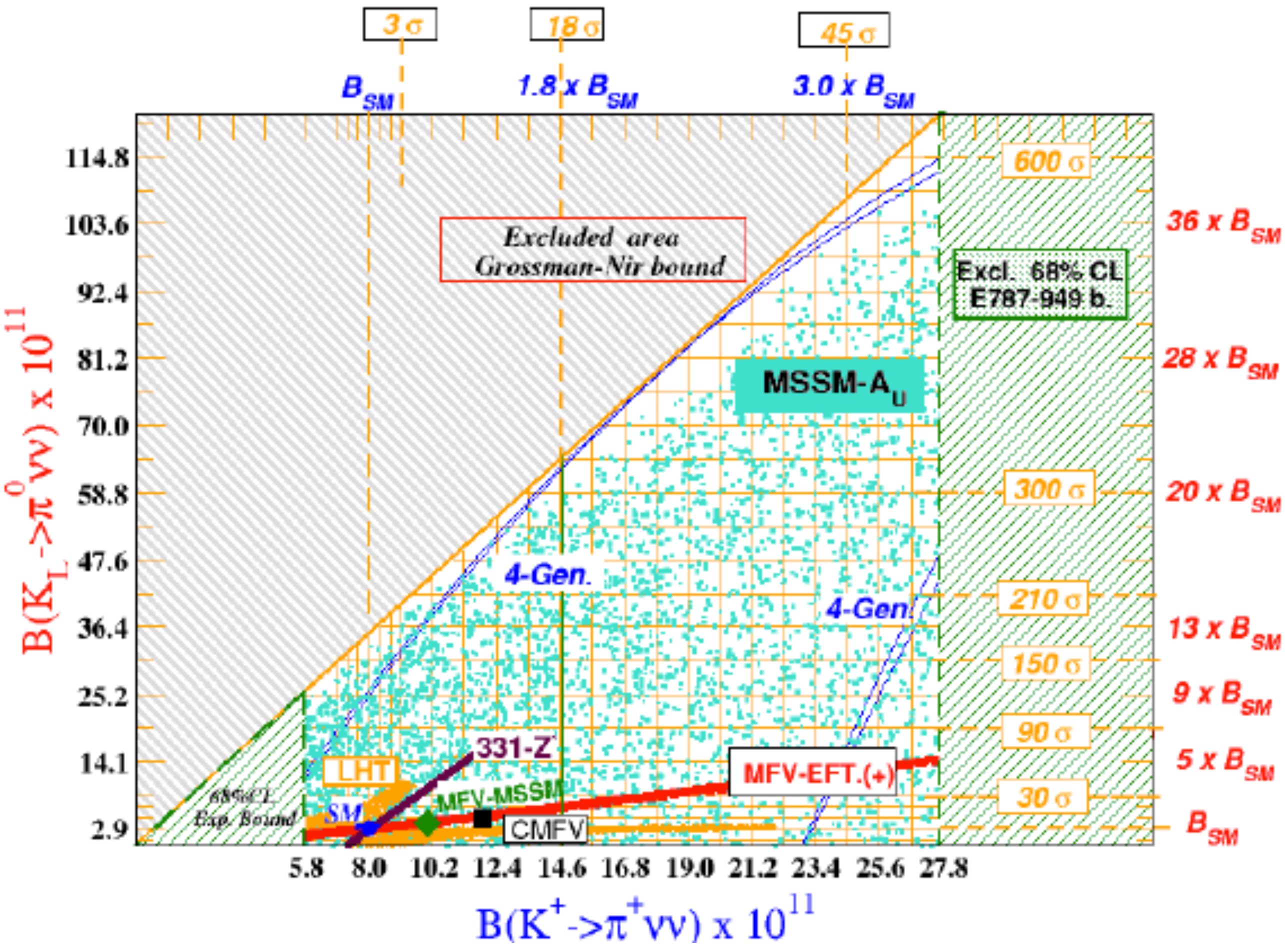
$$BR(K^+ \to \pi^+ \bar{\nu}\nu) = 6 r_{K^+} BR(K^+ \to \pi^0 e^+ \nu) \frac{|G_l|^2}{G_F^2 |V_{us}|^2}$$

$$G_l = \frac{\alpha\, G_F}{2\pi \sin^2 \Theta_W} \left[V_{ts}^* V_{td} X(x_t) + V_{cs}^* V_{cd} X_{NL}^l\right]$$

Effective coupling constant

$K^+ \to \pi^+ \nu \bar{\nu}$: motivation (III)

Several NP models and possibility to distinguish among different models

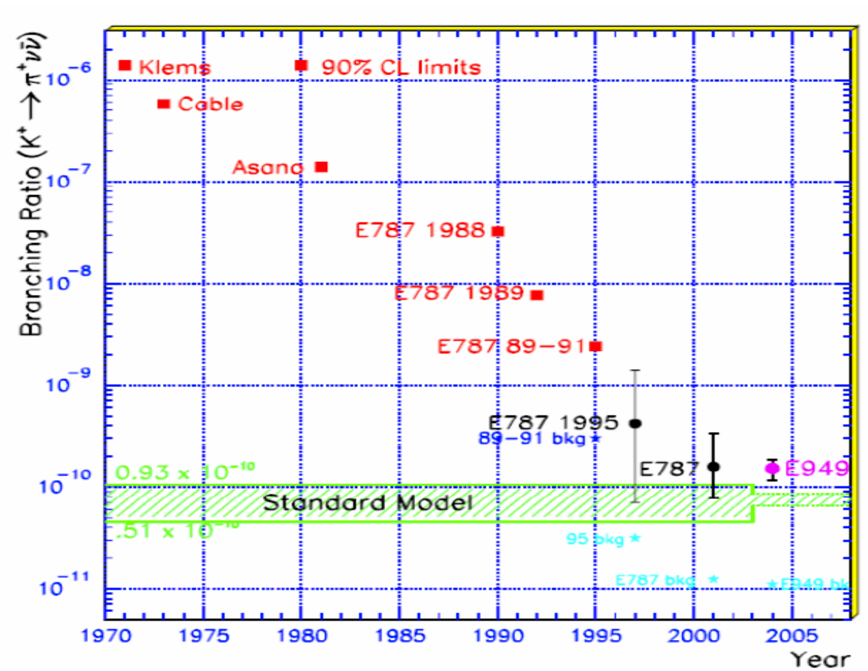


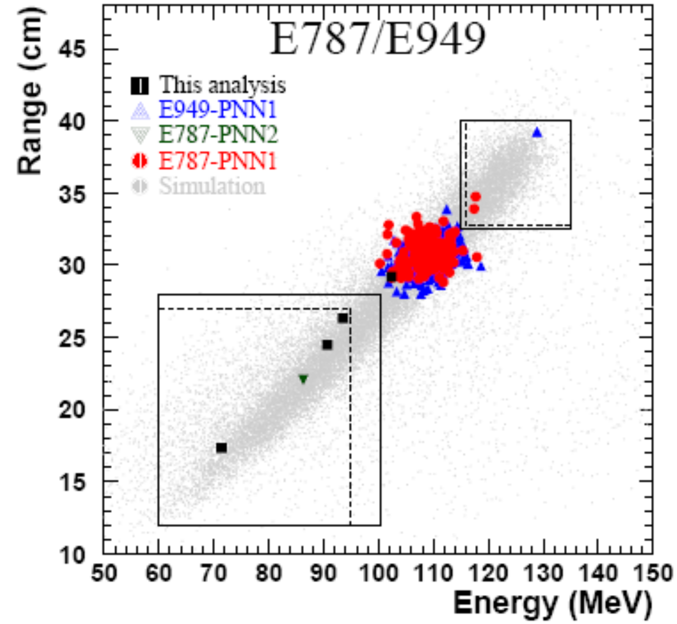
$BR(K^+ \to \pi^+ \nu\nu) \times 10^{10}$: selected models	
SM	0.82±0.08
MFV (hep-ph/0310208)	1.91
EEWP (NPB697 (2004) 133, hep-ph/0402112)	0.75±0.21
EDSQ (PRD70 (2004) 093003, hep-ph/0407021)	up to 1.5
MSSM (NPB713 (2005) 103, hep-ph/0408142)	up to 4.0

Experimental status

***BR*($K^+ \rightarrow \pi^+ \nu\nu$)$_{exp}$ = ($1.73^{+1.15}_{-1.05}$) $\times 10^{-10}$**

based on 7 candidates at BNL E787+E949



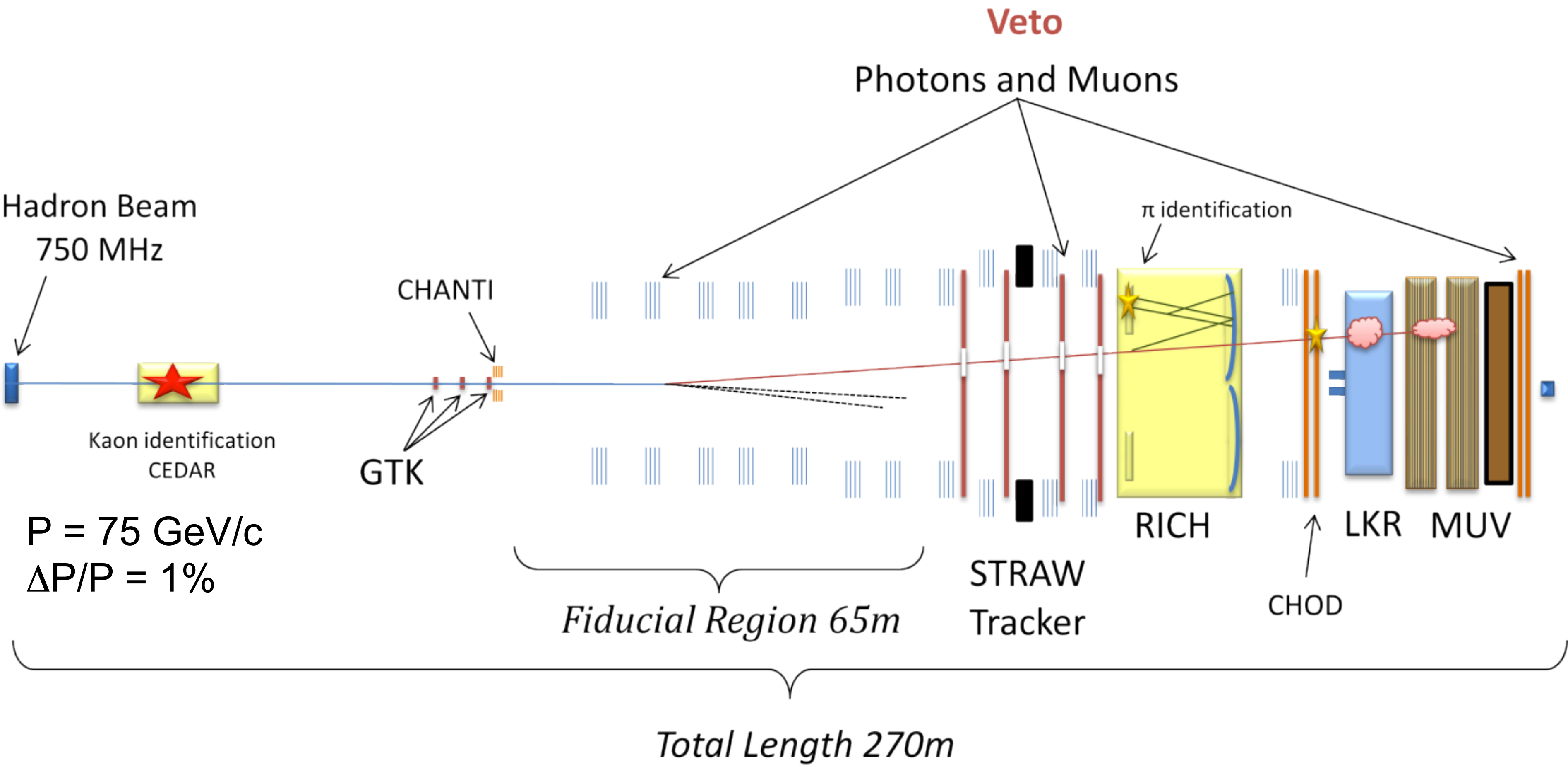


Probability that all 7 events are due to background: 10^{-3}

first experimental observation of $K^+ \rightarrow \pi^+ \nu\nu$

they have shown that all physics background can be under control at 10^{-11} level !

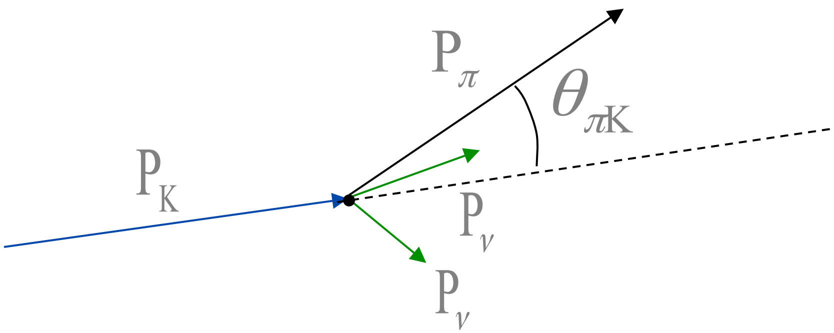
$K^+ \to \pi^+ \nu \bar{\nu}$ @ NA62



P = 75 GeV/c
ΔP/P = 1%

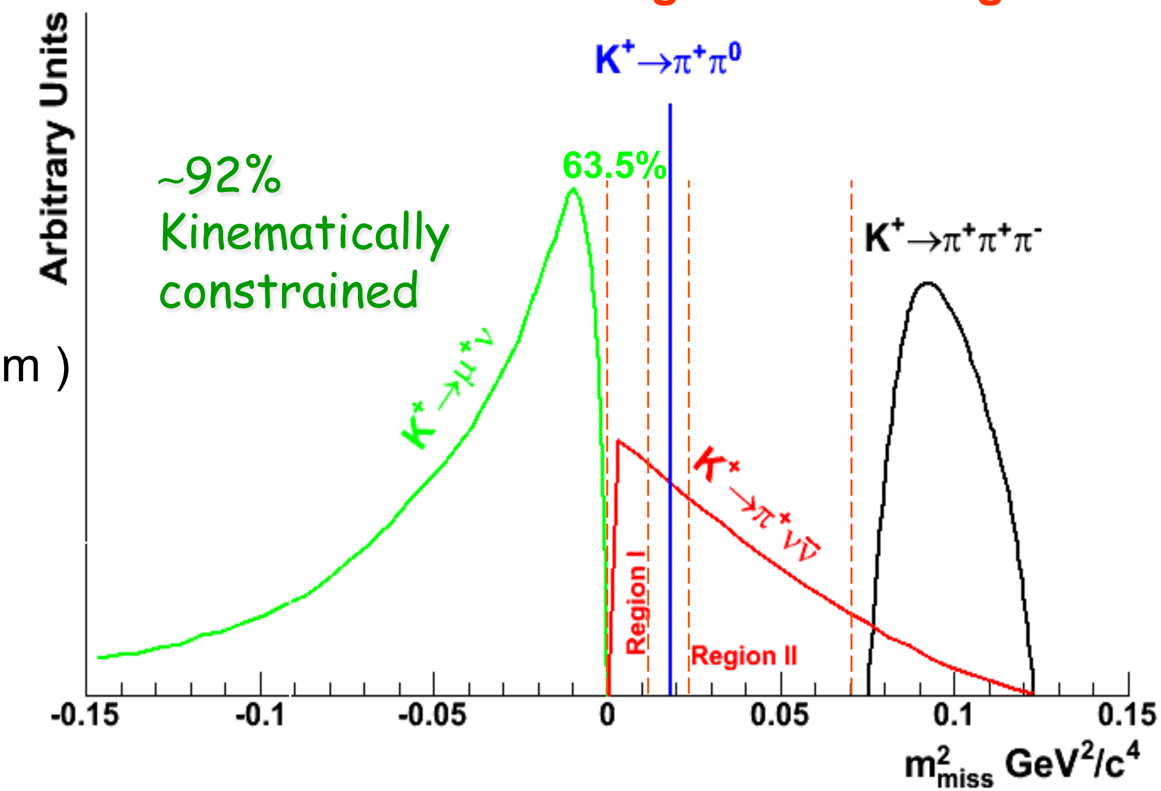
- High energy unseparated kaon beam
- Decay in flight technique
- Goal: **O(100) events with S/B ~10**

Kinematic reconstruction



$$m^2_{miss} \cong m^2_K\left(1-\frac{|P_\pi|}{|P_K|}\right)+m^2_\pi\left(1-\frac{|P_K|}{|P_\pi|}\right)-|P_K||P_\pi|\theta^2_{\pi K}$$

two background free regions



Requirements:

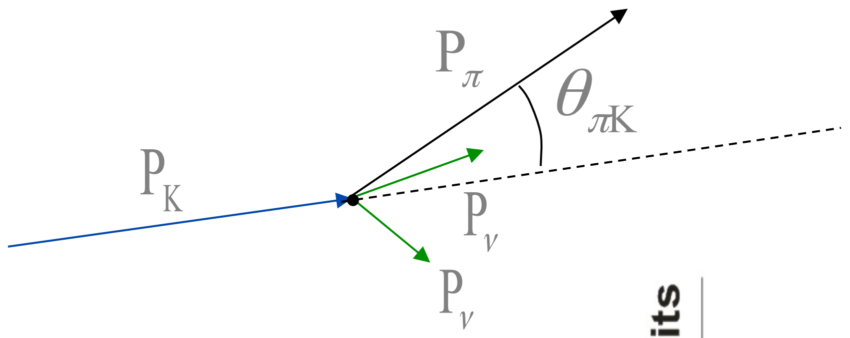
- low mult. scattering
→ low mass tracker operating in vacuum

- good space resolution (~100 μm)

Detectors:

- GigaTracker
- Straw Chamber Spectrometer

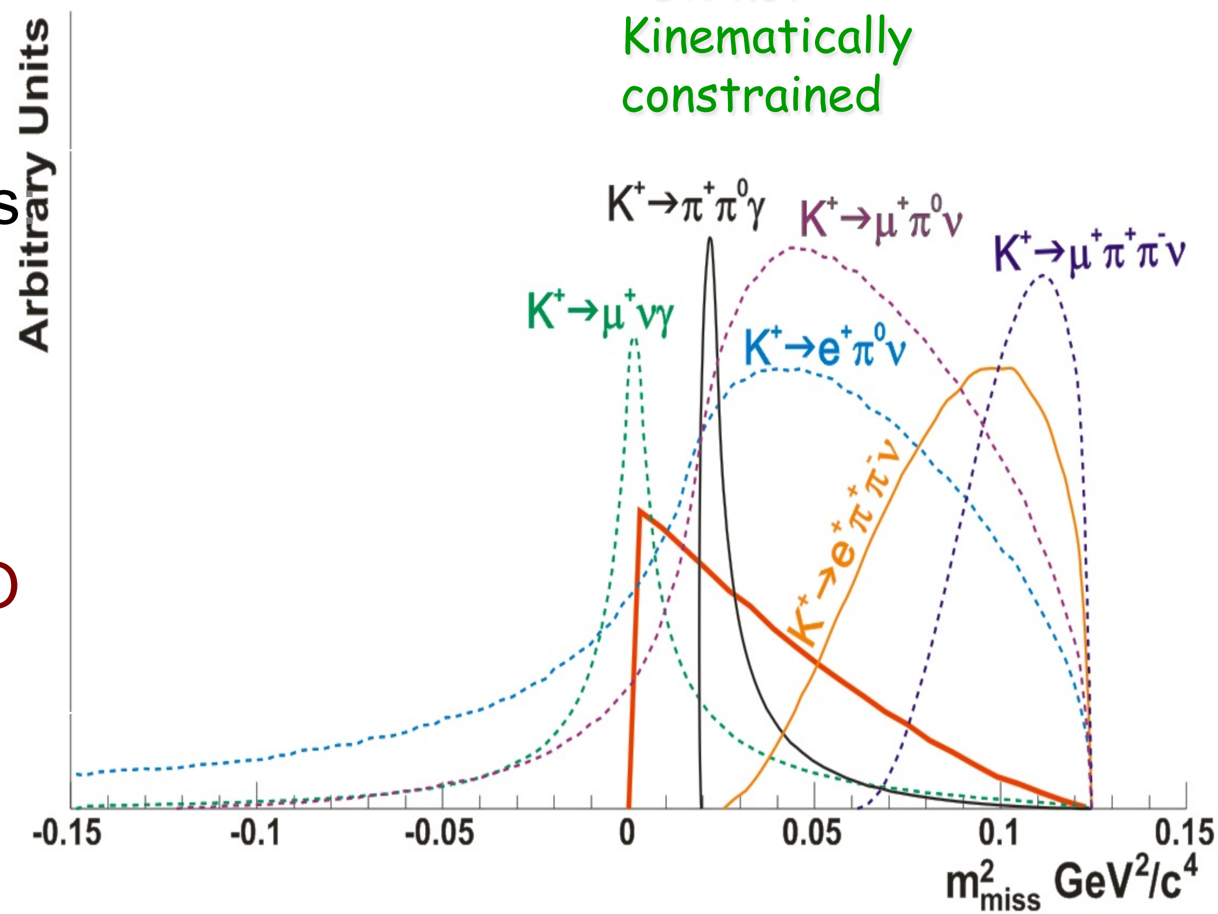
PID and Veto



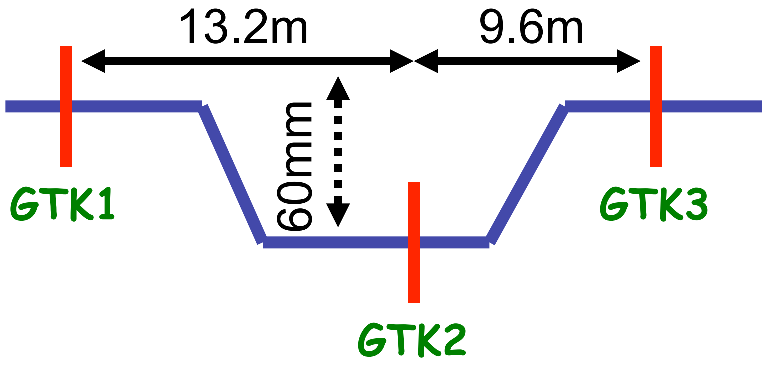
high efficiency detectors

Photon veto:
$K^+ \to \pi^+ \pi^0$ supp.

RICH and MUON VETO
for muon suppression



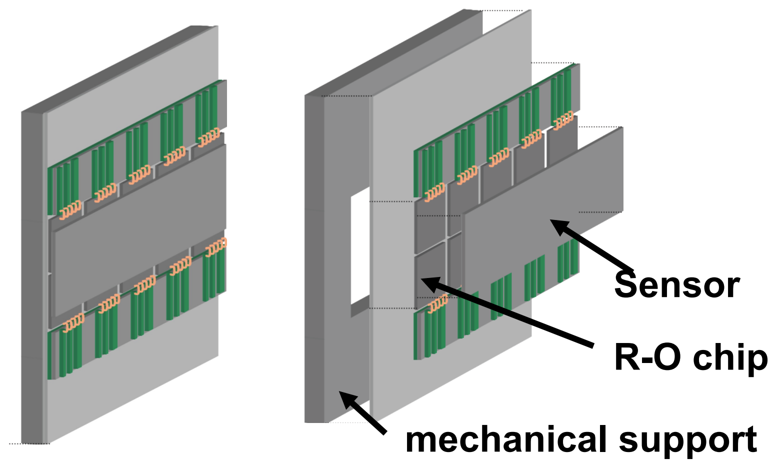
NA62: Gigatracker



- Very thin silicon sensor and readout chip (200+100 μm ~ $0.5X_0$)
- On site bump bonded readout chip 0.13 μm CMOS tech
- 60x27 mm^2 per station
- 300μmx300μm pixels

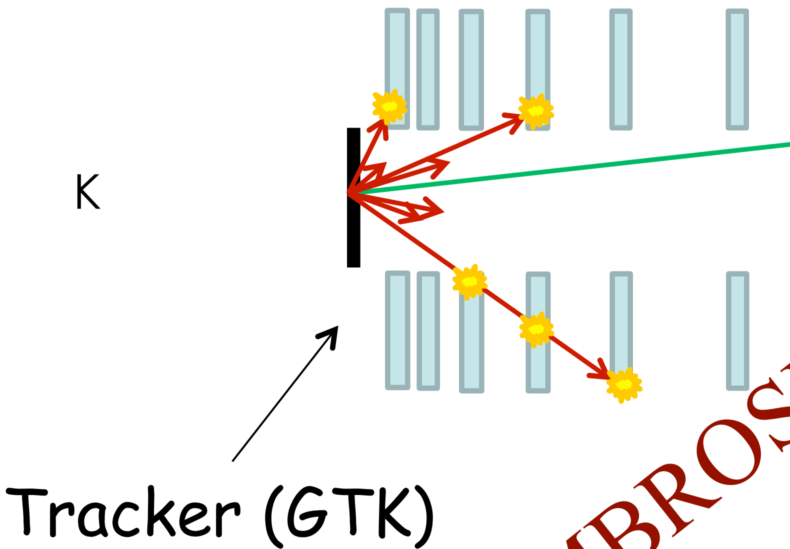
Requests:

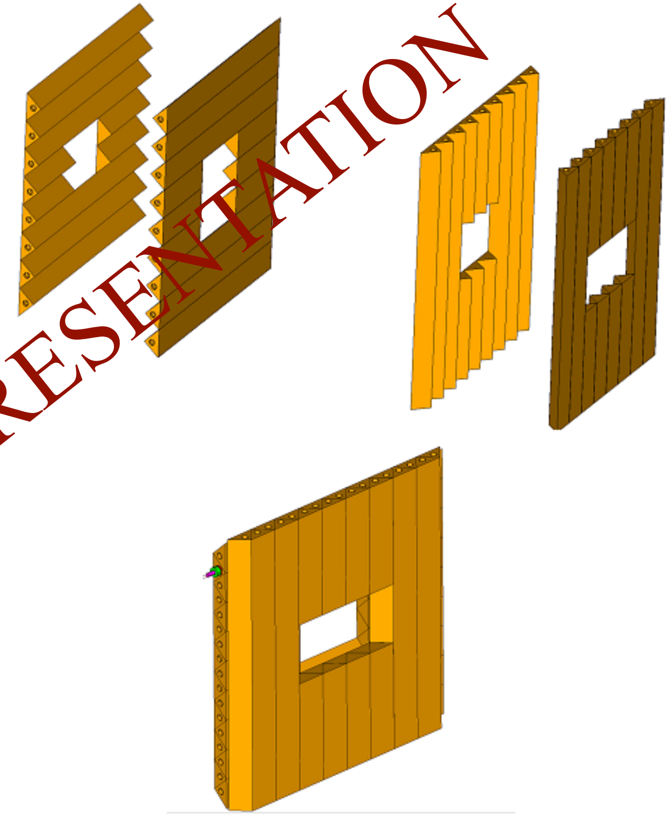
- Beam spectrometer: 3 stations
- Good space resolution
- Low material budget
- Very high intensity hadron beam: 800MHz
- Excellent time resolution: 200 ps



- Readout chip and sensor prototypes under construction
- Tested in 2009

CHANTI: purpose and methods





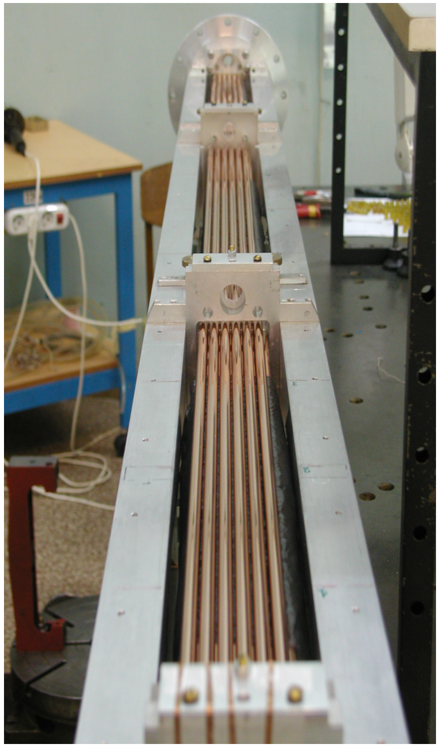
SEE FABIO AMBROSINO'S PRESENTATION

NA62: Straws

Requests:

- 4 chambers
- good space and momentum resolution
- Low material budget: $X/X_0 < 0.5\%$ per chamber
- operation in vacuum
- small inactive area around kaon beam

- 4 views with staggered planes
- Straw tubes in alluminium ultrasonic welded (no glue)
- measured resolution: 130μm per hit



- Prototypes tested on vacuum with hadronic beam, muons and electrons
- Readout under definition
- Detector in construction

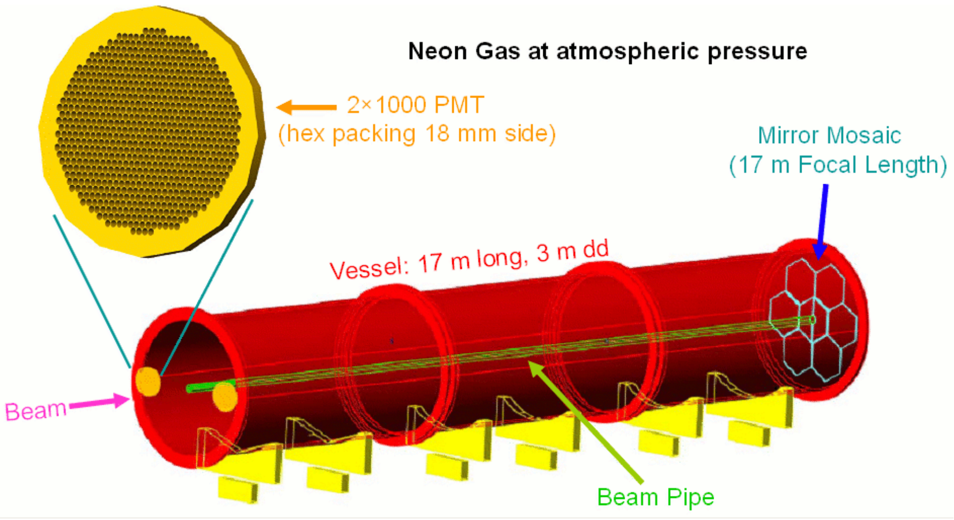
NA62: Rich

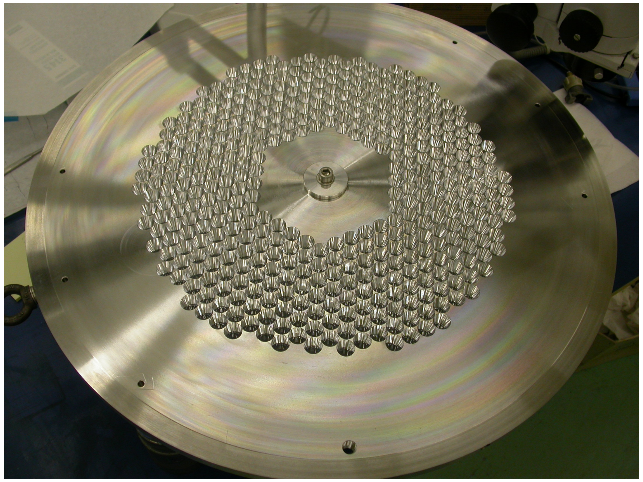
Requests:

- Provide π/μ separation at 5×10^{-3} in the range $15<p<35$ GeV/c
- Measure track time with 100 ps res
- Provide the main trigger for charged particle

- 18 m long tube filled with Neon
- Mirrors with f=17 m
- 2000 single anode PMTs, 1 cm in diameter
- 18mm "pixel" with Winston cones

- 400PMTs prototype with new readout electronics tested in May 2009





The Photon Veto System

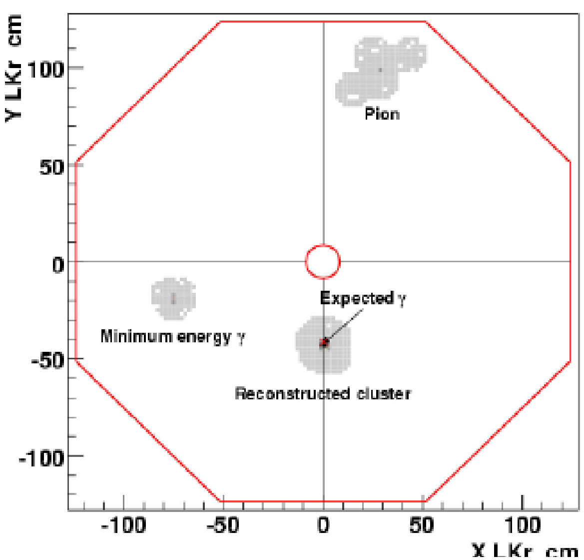
To obtain the required rejection factor on **$K^+ \to \pi^+\pi^0$** a photon detectors system with **10^8 rejection factor on $\pi^0 \to \gamma\gamma$ is required**

Three different angular regions to be covered

- LAV: Large Angle Veto: (10:50 mrad)
- LKr: Liquid Kripton calorimeter (1:10 mrad)
- IRC and SAC <1mrad

requiring $P(\pi^+) < 35$ GeV/c we get $P(\pi^0) > 40$GeV/c and high energy photons: photons > 1 GeV hit the LKr → high detection efficiency

NA62: LKr



Requests:

- Very high efficiency on forward photons (1<acceptance<10mrad)
- Good time resolution

- NA48 LKr calorimeter
- The efficiency has been measured with a special run in 2006
- 1-ε $<10^{-6}$ for E>10 Gev, 1-ε$<10^{-3}$ for 2.5<E<5.5 GeV

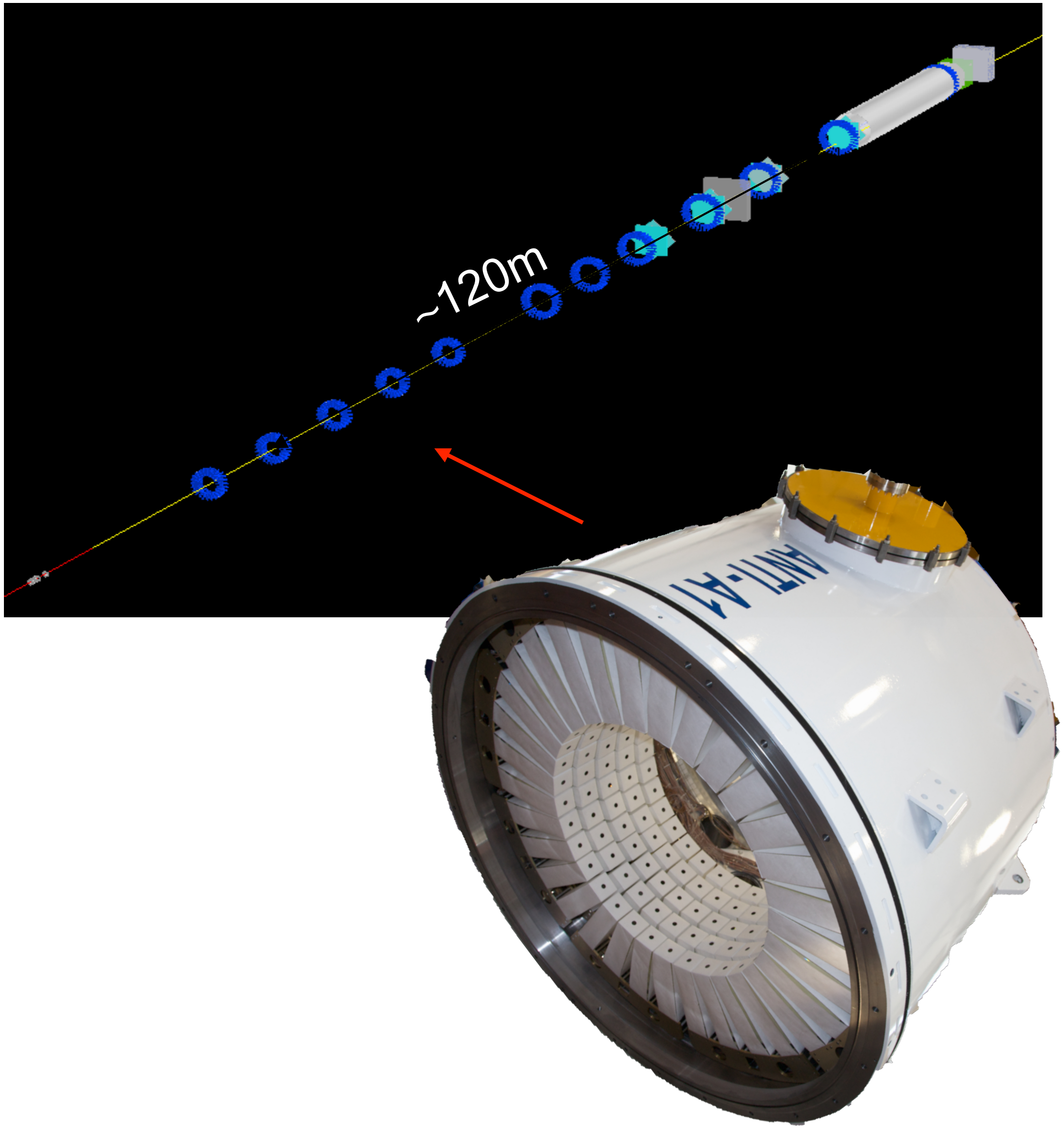
- New cryogenics system and new FE readout already done
- New electronics to allows faster triggering in construction

Large Angle Veto

Large Angle Veto (I)

12 rings to cover the large angle photons requirements:

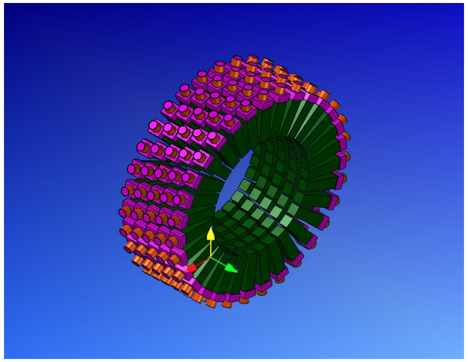
- Inner-outer radii: 60-96 to 90-140 cm
- Almost hermetic
- Large area: ~30 m^2
- Good efficiency down to "low" energy (200 MeV) photons
- Operating in vacuum

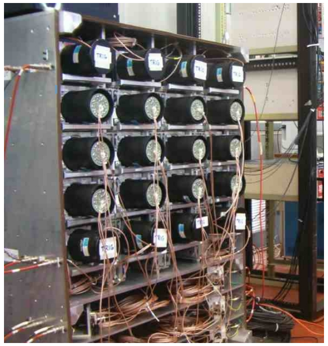


Large Angle Veto (II)

3606 blocks available (thanks to Tokyo-OPAL coll.)
2946 needed for the 12 stations
each station has 5 layer with a relative phase

All the blocks have to be polished, tested, re-cabled, reinforced and wrapped again
Gain and PeY are measured by LED and Cosmic





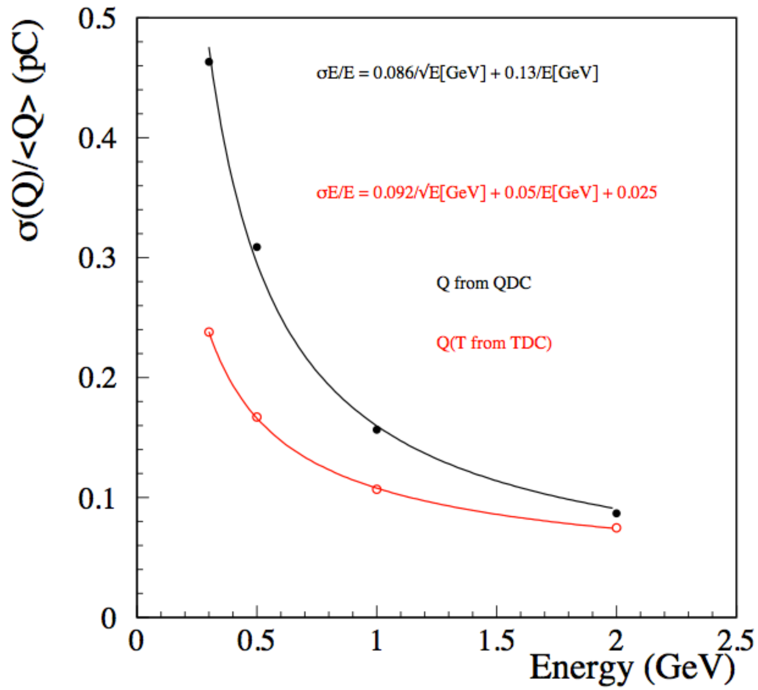
Six station assembled at LNF and arrived to CERN for the installation in the vacuum tube)

Large Angle Veto (pictures)

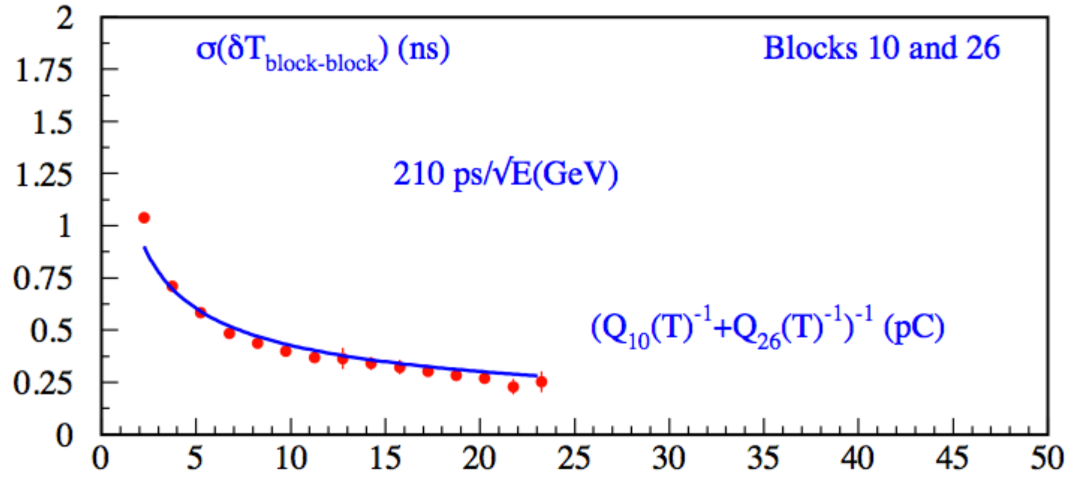
Detector performances

Good linearity of energy response using single average parametrization <Q(T)>

Good energy resolution measured



Excellent time resolution measured after slewing corrections.



Large Angle Veto MonteCarlo

LAV MC simulation developed and committed by Domenico Di Filippo

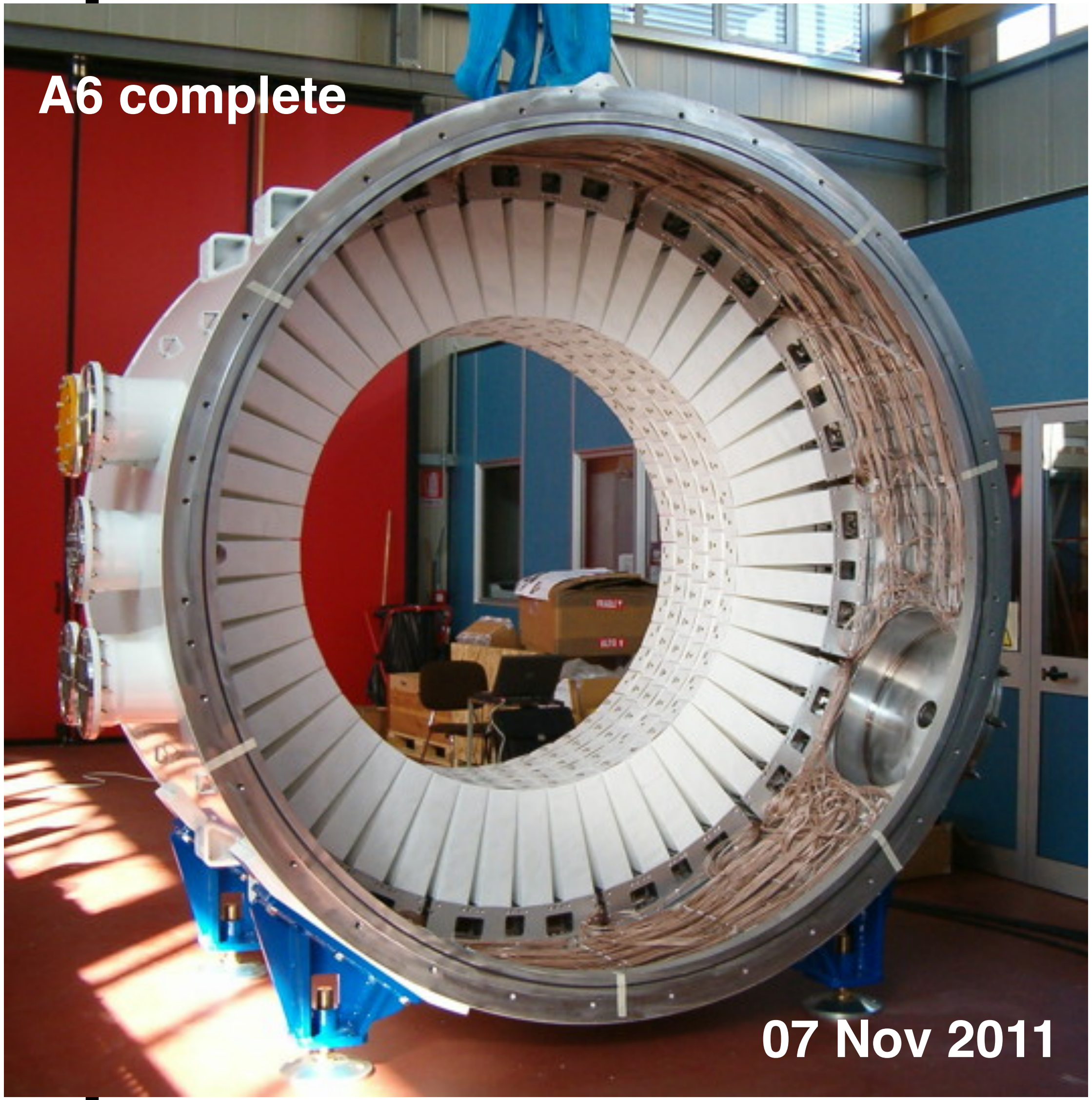
All geometry: vessels, supports, layers, bananas and blocks

Two MC simulations developed:

complete optical photons tracking simulation

optical photons tracking parameterization

LAV construction: Status and overview



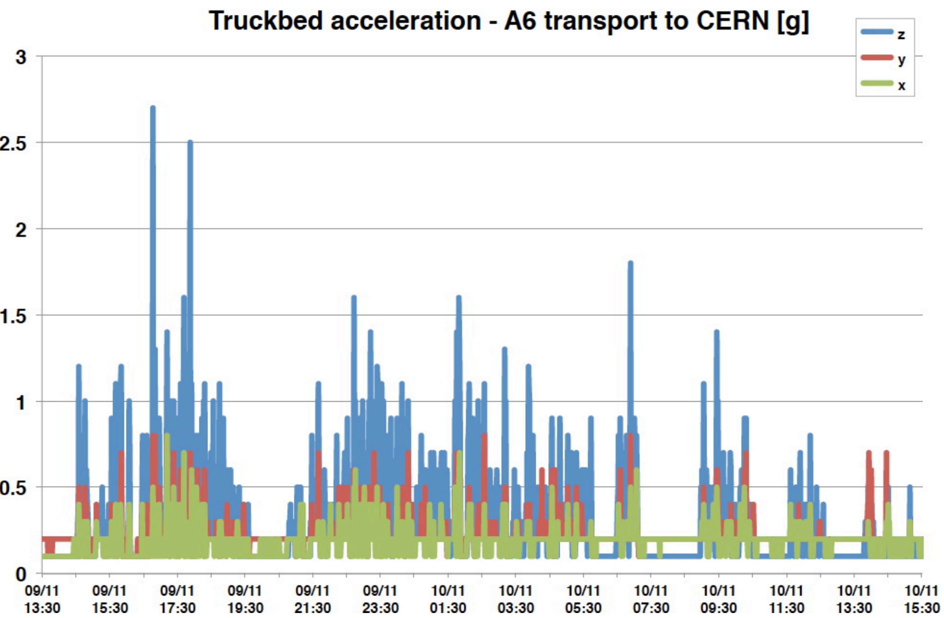
NA62 Photon-Veto Working Group Meeting

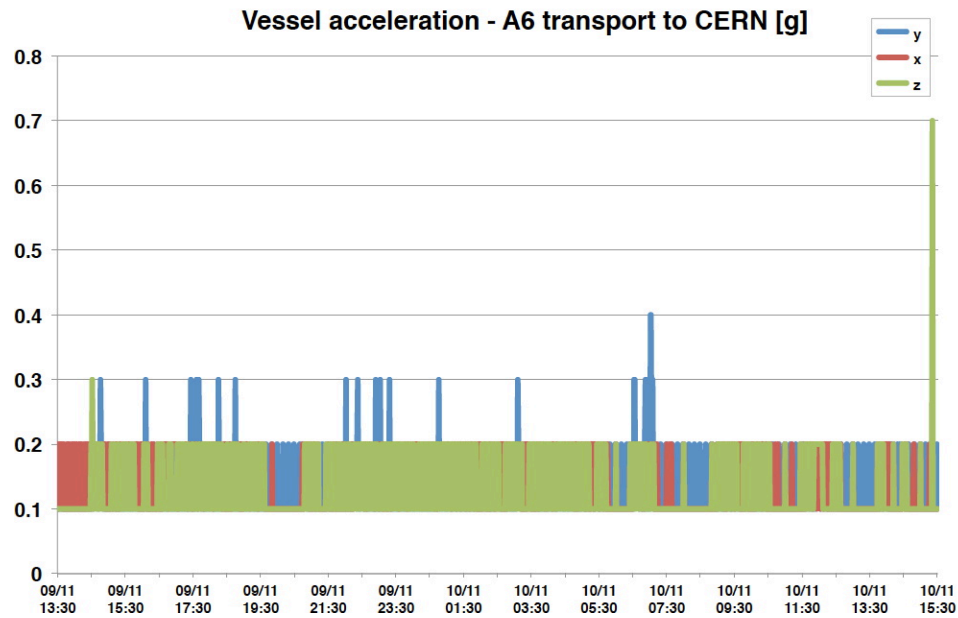
CERN, 13 December 2011

Current status of A7

Ready for delivery week of 16 Jan

A6 transport accelerometer data





Truckbed:

6 events >1.5g

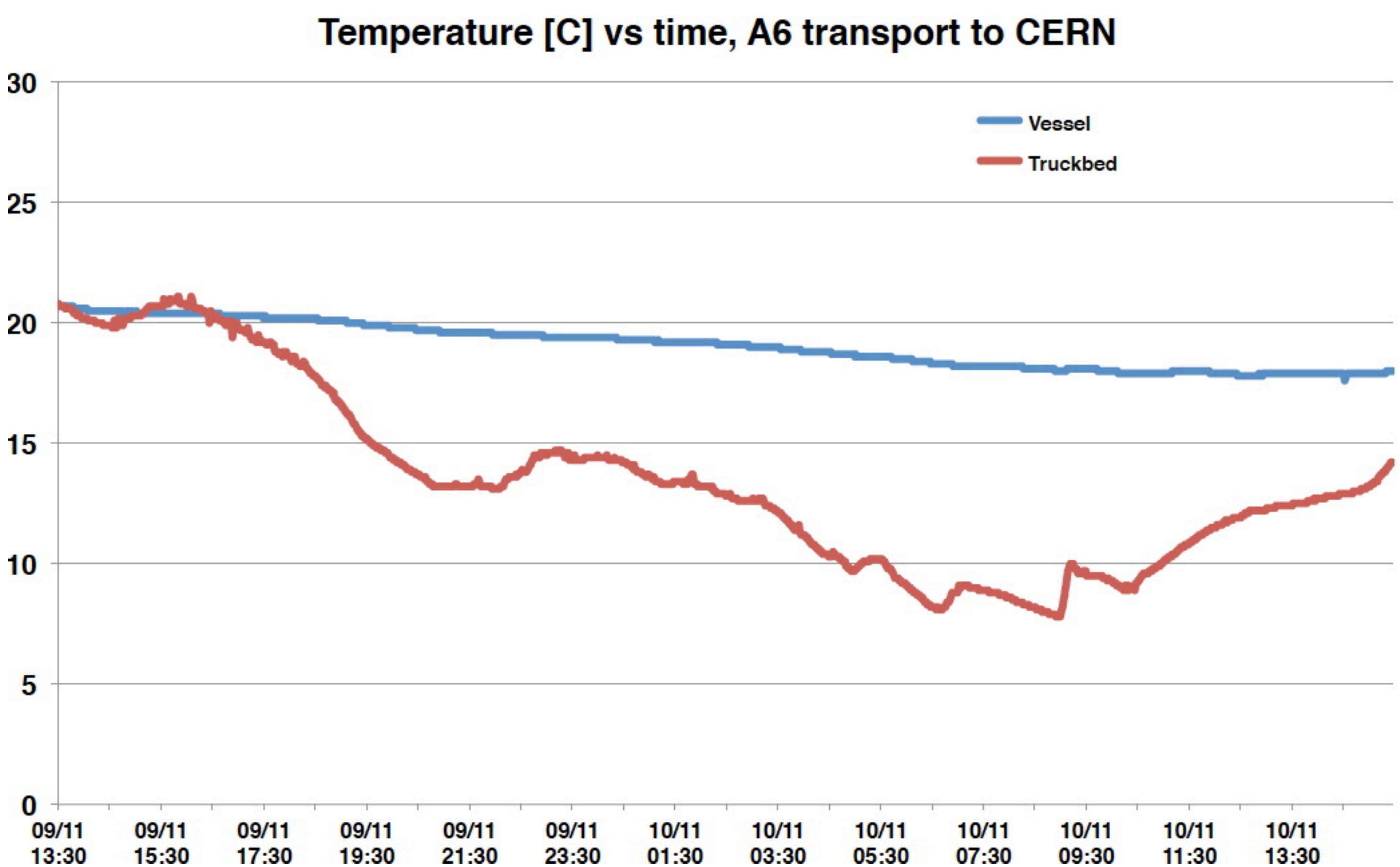
1 event >2.5 g

Vessel:

Essentially no events

No surprises – One of our “quieter” transports

A6 transport temperature data



Qualitatively same thermal stability obtained for earlier transports
Future transports will additionally use thermostatic heating blanket

Summary

A6 delivered to CERN on 9 November

First transport of medium-sized vessel

No problems – temperature issues under control

A7 ready for delivery to CERN by week of 16 January

On track for A8 delivery in mid-March, A11 in mid-June

A9-A10 invitation to tender completed for the beginning 2012

Conclusions

- The 0(100) events measurement of the $K^+ \rightarrow \pi^+ \nu\nu$ decay could be a good opportunity to found NP and to distinguish among NP models

- The NA62-2 is a challenging experiments aiming at O(100) events with S/ B=10

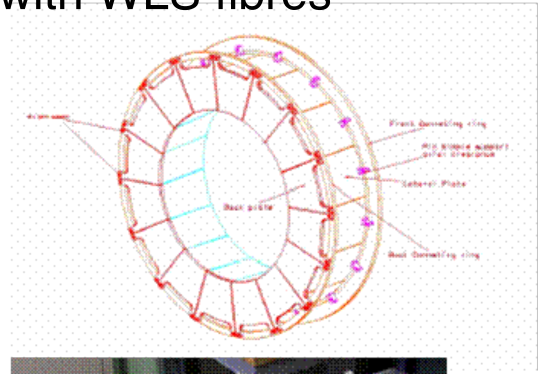
- In August/September 2012 test run

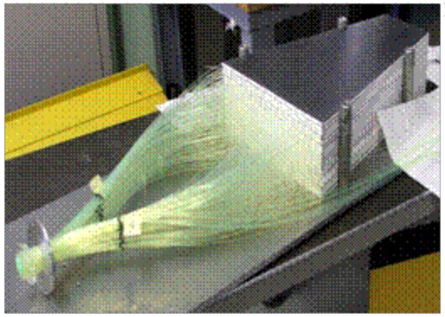
- The data taking should start in the 2014

Large Angle Veto (II)

R&D three different technologies studied:

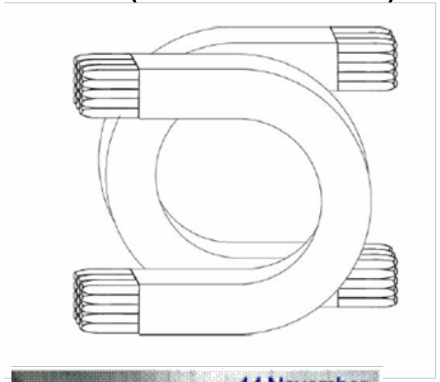
Tile calorimeter: lead-plastic scintillator foils with WLS fibres

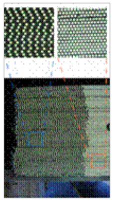




one sector prototype borrowed by CKM prop. exp. at FNAL

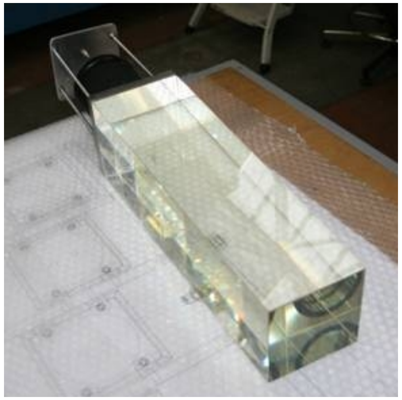
Scintillating fibres embedded in lead foils (EMC KLOE)





one U prototype build at LNF

Lead-glass blocks from the LEP OPAL EMC



some blocks from OPAL store at CERN

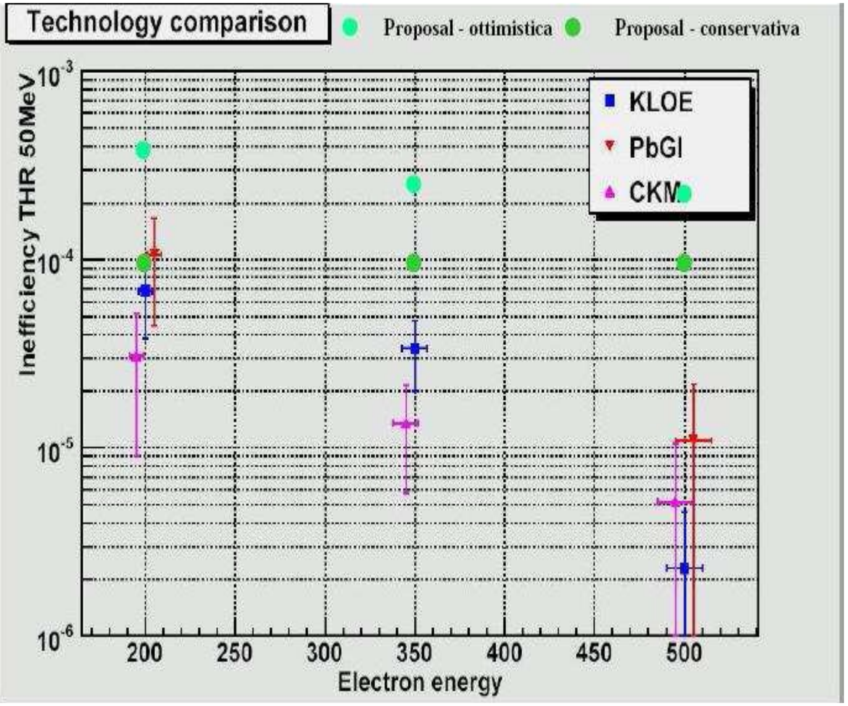
Large Angle Veto (III)

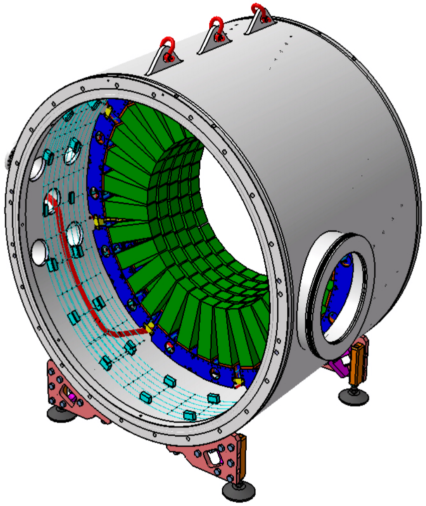
The three prototype tested at the BTF a LNF in Frascati:
50 Hz single e^+/e^- 200-500 MeV

all detectors fulfilled the requested efficiencies

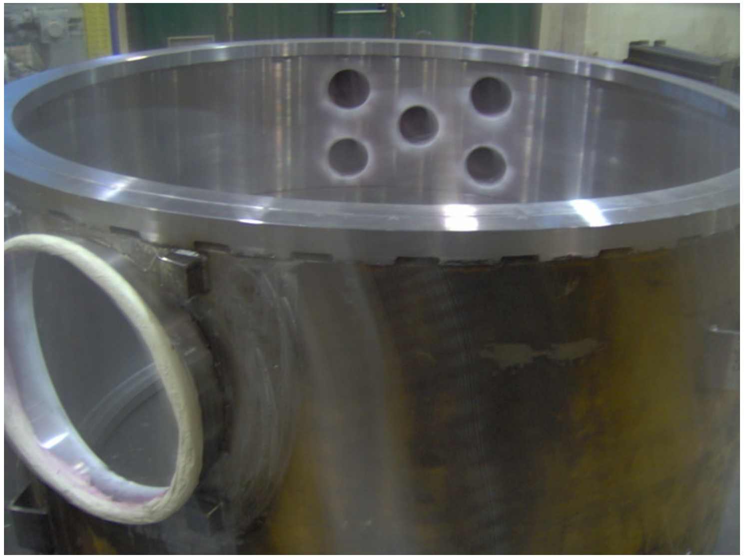
OPAL LG choice for economic reasons

mechanic to hold the blocks was designed





Status of A8 and A11 vessels



A8: carpentry complete - holes being drilled on CNC.

Needs final cleaning, vacuum test, painting

Delivery expected week of **23 Jan**

A11: rolled, being lathed in preparation for seam welding

Flanges ready for welding

Delivery estimated 60 working days from now: week of **12 Mar**

NA62-I

R_K with Kl2 decays published in **Phys.Lett.B698:105-114,2011**

The first NA62 Physics paper !

arXiv:1101.4805v1 [hep-ex] 25 Jan 2011

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PH-EP-2011-004
21 January 2011

Test of Lepton Flavour Universality in $K^+ \to \ell^+\nu$ Decays

The NA62 collaboration *

Abstract

A precision test of lepton flavour universality has been performed by measuring the ratio R_K of kaon leptonic decay rates $K^+ \to e^+\nu$ and $K^+ \to \mu^+\nu$ in a sample of 59813 reconstructed $K^+ \to e^+\nu$ candidates with $(8.71 \pm 0.24)\%$ background contamination. The result $R_K = (2.487 \pm 0.013) \times 10^{-5}$ is in agreement with the Standard Model expectation.

Submitted for publication in Physics Letters B

Ke2: R_K and LFV

- The hadronic uncertainties cancel in the ratio $K_{e2}/K_{\mu 2}$ (no f_K)
- For this reason the SM prediction is very accurate dR_K/R_K~0.04%

$$R_K^{SM} = \frac{\Gamma(K \to e\nu_e)}{\Gamma(K \to \mu\nu_\mu)} = \frac{m_e^2}{m_\mu^2}\left(\frac{m_K^2 - m_e^2}{m_K^2 - m_\mu^2}\right)^2 (1 + \delta R_{QED}) =$$

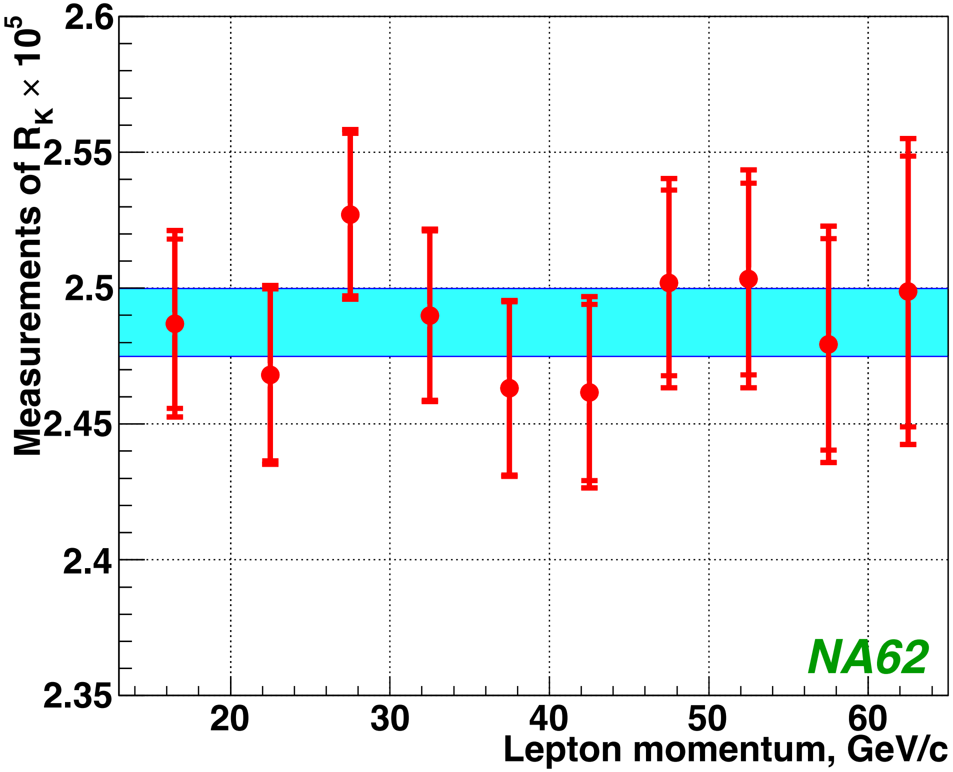
$$= (2.477 \pm 0.001) \cdot 10^{-5}$$

[V.Cirigliano, I.Rosell JHEP 0710:005(2007)]

- The only difference between electron and muon channel is due to the V-A coupling
- A small correction has to be included due to the IB part of the radiative decay

R_K Result (40% data set)

$$R_K = (2.487 \pm 0.011_{stat} \pm 0.008_{syst}) \times 10^{-5}$$
$$= (2.487 \pm 0.013) \times 10^{-5})$$



Source	$\delta R_K \times 10^5$
Statistical	0.011
$K_{\mu 2}$ background	0.005
$K^+ \to e^+ \nu \gamma$ (SD^+) background	0.001
$K^+ \to \pi^0 e^+ \nu$, $K^+ \to \pi^+ \pi^0$ backgrounds	0.001
Beam halo background	0.001
Helium purity	0.003
Acceptance correction	0.002
Spectrometer alignment	0.001
Positron identification efficiency	0.001
1-track trigger efficiency	0.002
LKr readout inefficiency	0.001
Total systematic	0.007
Total	0.013

Precision 0.52%

The whole sample will decrease the statistical uncertainty down to ~0.3% and a total uncertainty of 0.4%