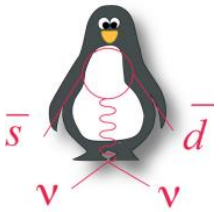


IFIN-HH

CERN Experiment	**NA62**
Project Title	**Study of rare kaon decays at the CERN SPS**

Main Objective:

$$\mathrm{BR}(K^+ \to \pi^+ \nu \bar{\nu})_{\mathrm{exp}}$$

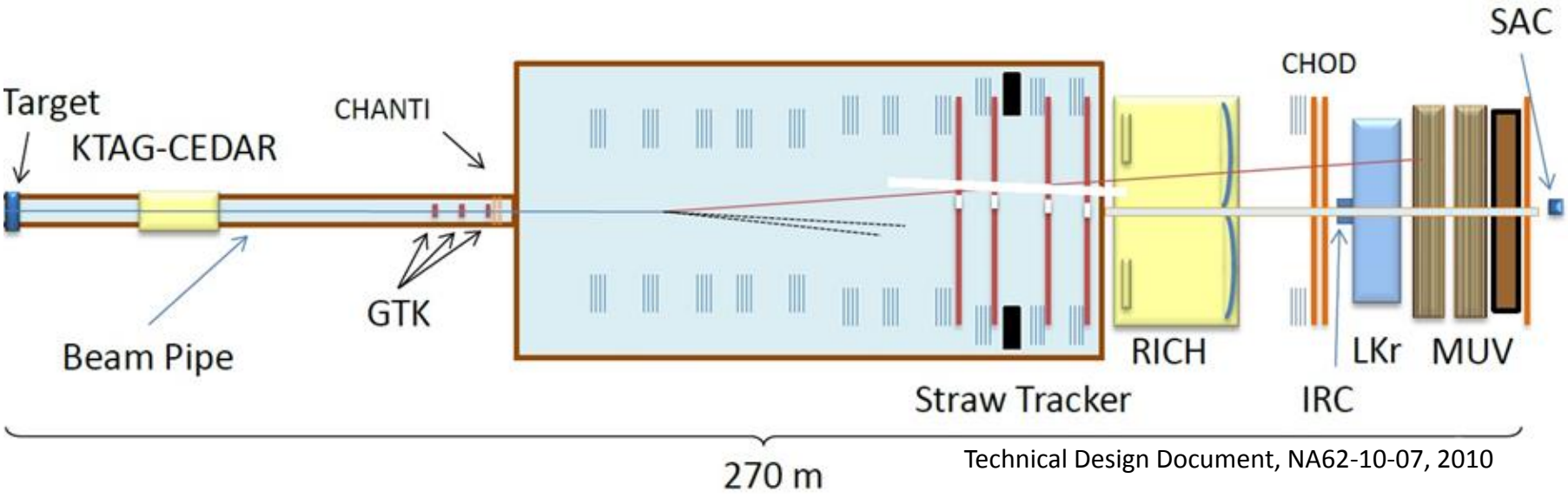
10 % precision measurement → **O(100)$_{SM}$ events in 2 years of data taking**

1st NA62 Physics Test RUN: Oct.-Dec. 2014

Alexandru Mario Bragadireanu, Particle Physics Department, IFIN-HH Măgurele

The NA62 Experimental setup

$$\mathrm{BR}(K^+ \to \pi^+ \nu\bar{\nu})_{\mathrm{SM}} = (7.8 \pm 0.8) \times 10^{-11}$$



Technical Design Document, NA62-10-07, 2010

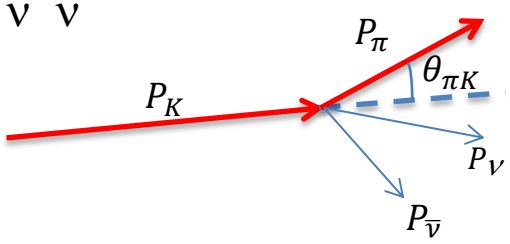
↓ SPS extracted beam: 1.1×10^{12} protons (400 GeV/c)
↓ Be target → 75 GeV/c secondary beam (1% res.)
↓ **750 MHz** hadron beam (p, π^+, ~ 6% K^+)
→ 45 x 10^6 K^+

10% acceptance → 4.5 x 10^6 K^+ decaying in-flight

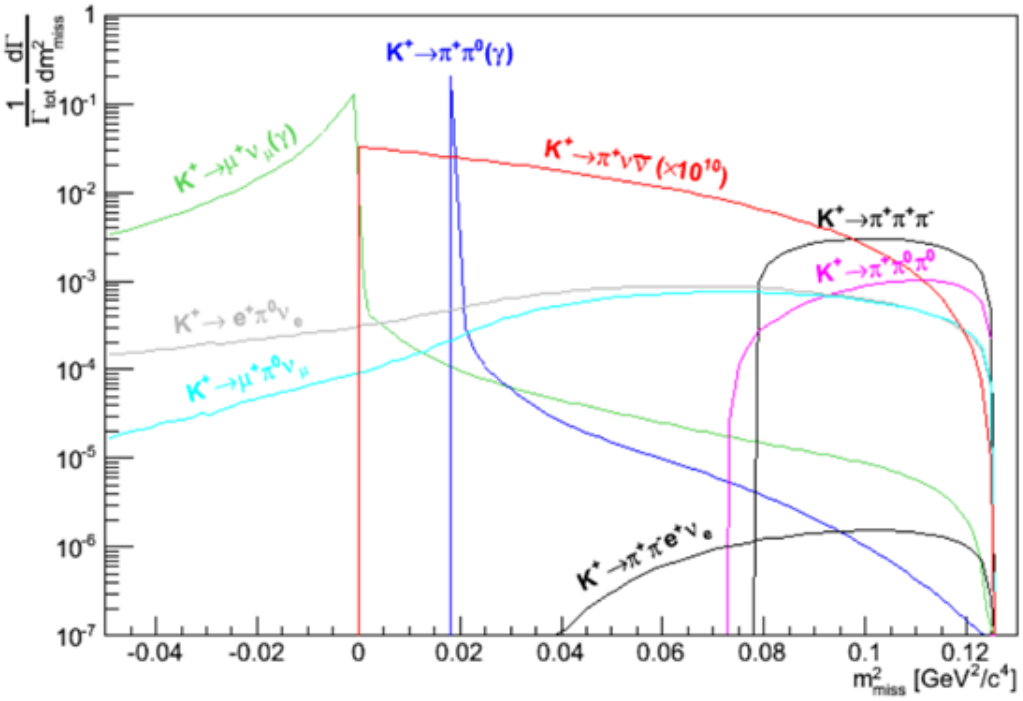
✓ accurate kinematic reconstruction
✓ precise timing
✓ efficiency of the vetoes
✓ excellent particle identification

Signal and Background

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



Kinematic variable $m^2_{miss} := (P_K - P_\pi)^2$



Background:

1) Other K^+ decay modes:

K^+main decays	BR
$K^+ \to \mu^+\nu$	0.6355
$K^+ \to \pi^+\pi^0$	0.2066
$K^+ \to \pi^+\pi^+\pi^-$	0.0559
$K^+ \to \pi^0 e^+\nu$	0.0507
$K^+ \to \pi^0\mu^+\nu$	0.0335
$K^+ \to \pi^+\pi^0\pi^0$	0.0176
$K^+ \to \pi^+\pi^- e^+\nu$	4.257×10^{-5}

2) Accidental single track matching with a K-like one

Background rejection:

Kinematic reconstruction (m^2_{miss}) combined with PID and VETO

IFIN-HH expected contribution

- $K^+ \rightarrow \pi^+\pi^+\pi^-$ rejection → **Read-Out for the "new" Hadronic Sampling Calorimeter (HASC)**
- TDAQ system - **high level trigger** (L1/L2) **software development**

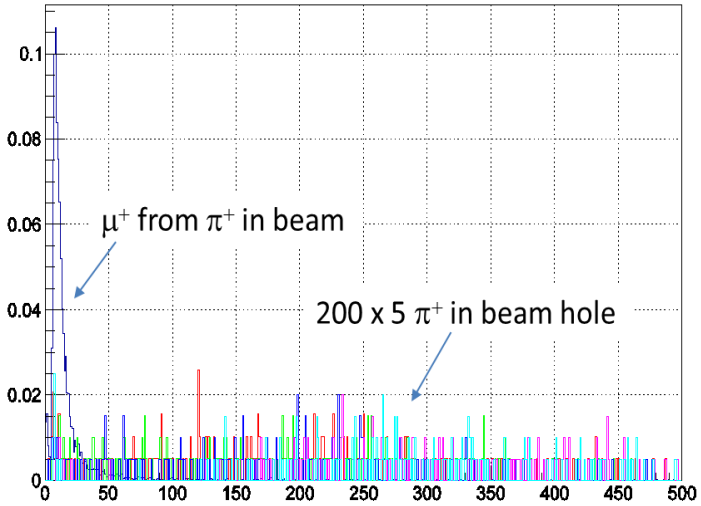
IFIN-HH Team (2014): Dr. A.M. Bragadireanu, Dr. D. Pietreanu, Dr. M.E. Vasile

Hadronic Sampling Calorimeter

9 Modules salvaged from an NA61 prototype
(NIM A598(2009)268–269)

Module specs.
- 10x10x160 cm3 (WxHxL);
- 120 tiles (lead/scintillator), sampling 4:1;
WLS fibers embedded in the scintillator
- 10 sections with 6 fibers/section;
- 10 optical read-out connectors
(designed for 3x3 mm² MAPD).

$K^+ \rightarrow \pi^+\pi^+\pi^-$
- π^- undergoes hadronic interaction in the 1st STRAW;
- π^+ (~40 GeV/c) through the beam hole, emerging at z > 253 m;

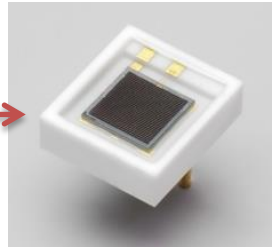


M.C. E_{dep} range:
(/ channel)

5 (mips) - 500 MeV

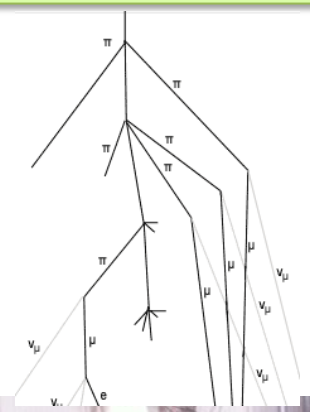
After multiplicity & kinematical cuts there are still **10 ± 4 events/year** surviving (S. Balev – NA62 Monte Carlo)

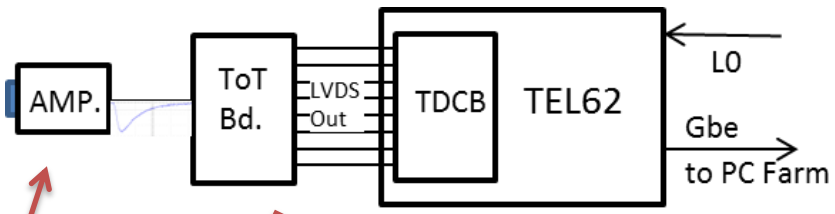
HASC Read-Out evaluation

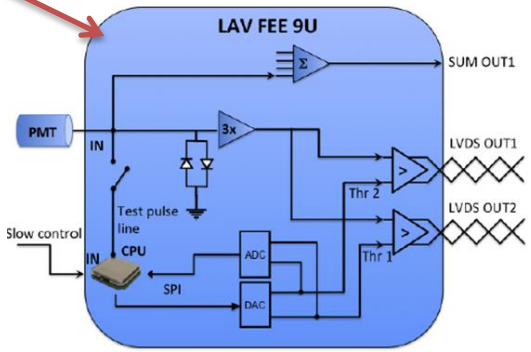


Hamamatsu 3x3 mm^2 MPPC
(model:S12572-015C)

- 40.000 pixels;
- 3x10^5 @ 69V (typ.)







NA62 LAV FEE, JINST 8 C01020

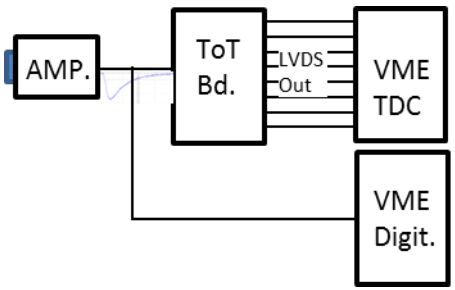
Cosmic rays test

July

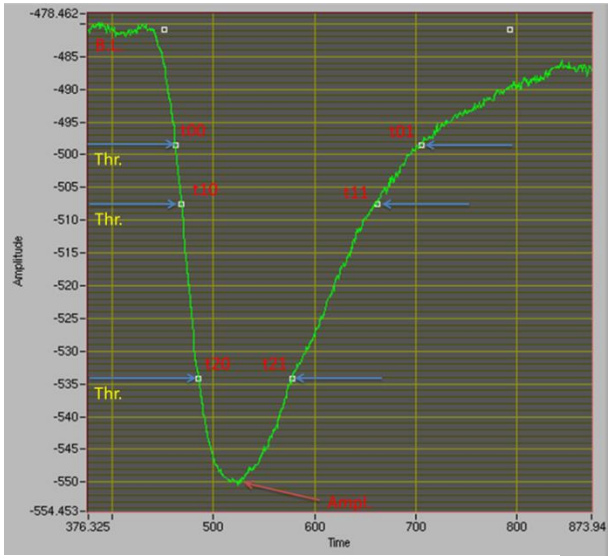
- Tune the amplifier gain in the range (10 mV – 1000 mV) corresponding to the energy deposition range of 5 MeV – 500 MeV, expected in one HASC section (channel);
- Evaluate the possibility to use the same ToT technique used by the NA62 LAV sub-detector;
- Test the possibility to use an amplifier board built in IFIN-HH with a price/ch. significantly lower than the alternative solution developed in INFN-LNF.

Oct.

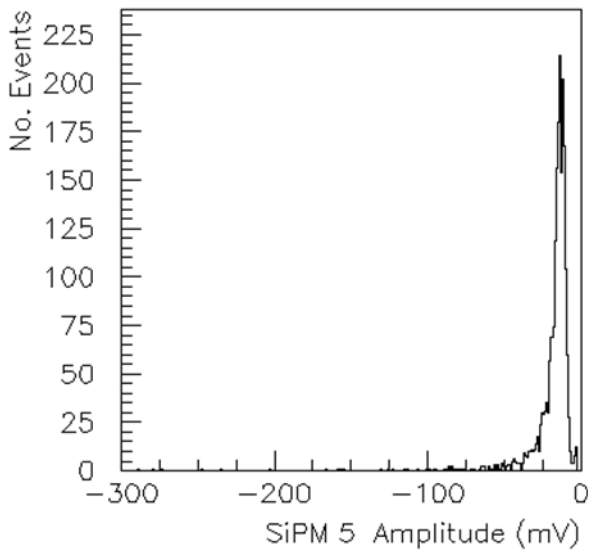
HASC Read-Out evaluation (cont.)

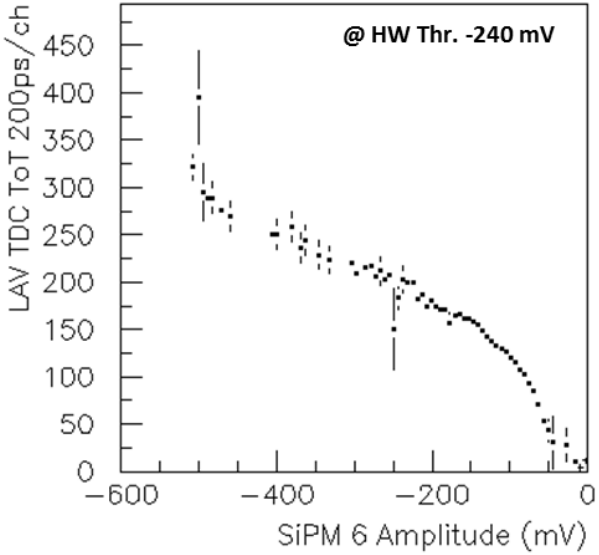


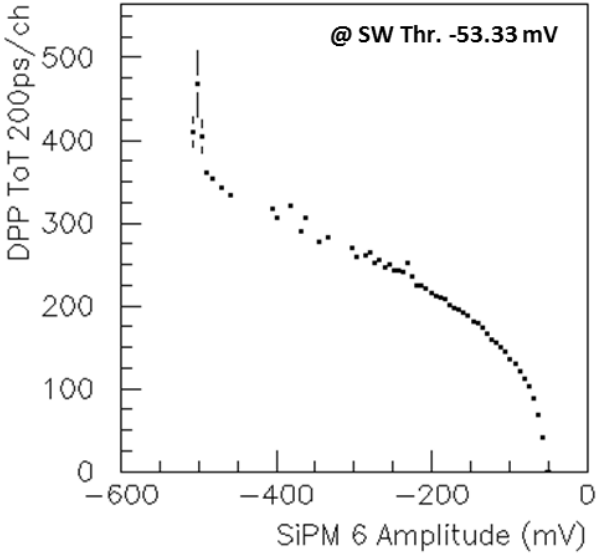
2 data files/run :
-TDC data;
-Digitizer waveforms – for off-line Digital Pulse Processing (DPP);



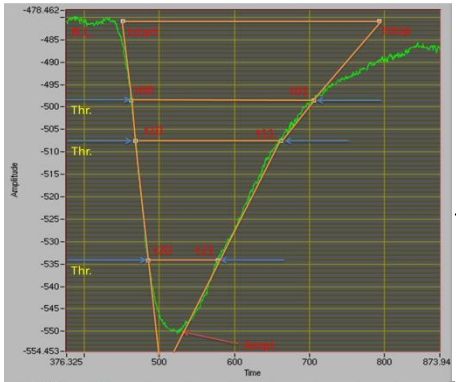
Software development of custom DPP code: Pk. detect, ToT, Timing, Charge Integration ….



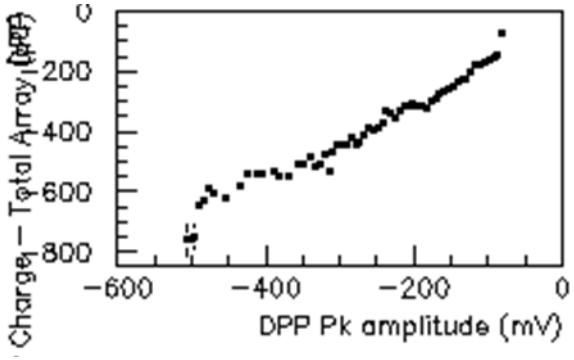


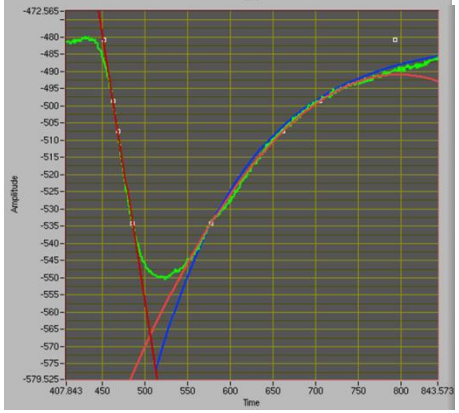


DPP of SiPM signal

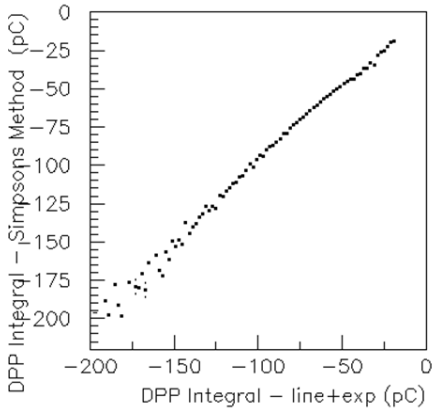


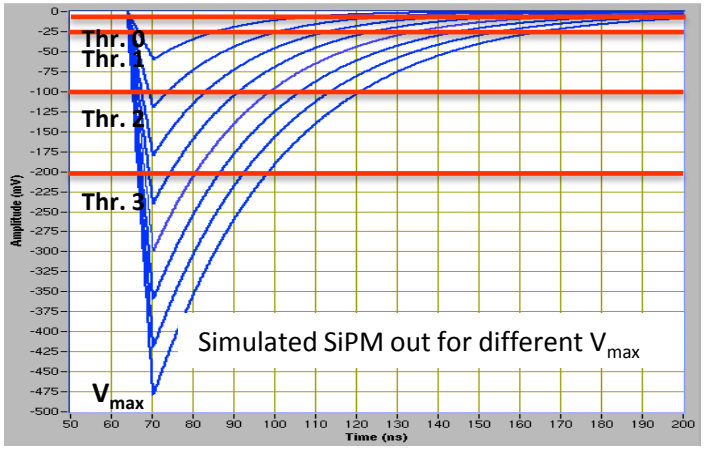
regular arrays →





analytical signal "envelope" →





SiPM signal model

↓

Generate "signal" database

↓

ToT -> Charge lookup table

Signal integral software development

Three methods based on 3 (4) ToT thresholds:

1) Signal divided into regular geometrical arrays;

2) Analytical signal "envelope";

HASC readout evaluation with cosmic rays, NA62 Collaboration Meeting, Ferrara, September 1 -5, 2014

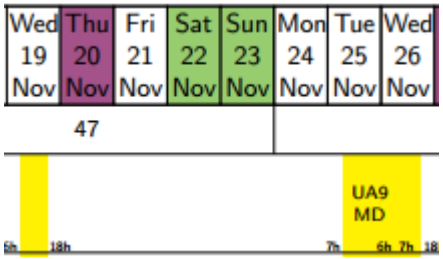
http://indico.cern.ch/event/322643/contribution/5/material/slides/0.pdf

3) ToT -> Charge lookup table (under study)

Each method can be implemented into vhdl code (TEL62 FPGA) => **HASC integration into the NA62 TDAQ system**

Planning 2014 / 2015

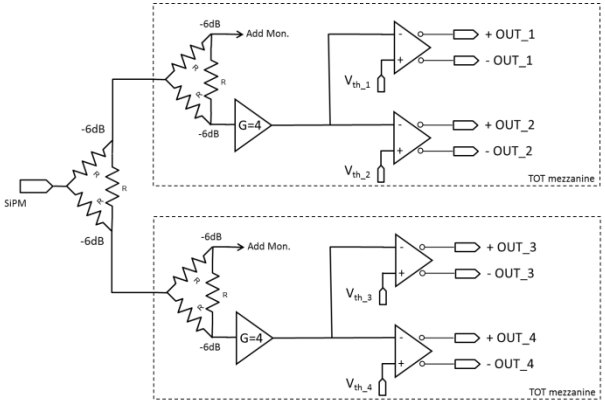
2014 SPS schedule



Beam test during NA62 Pilot Run (18 November – 5 December 2014)

Install one HASC module near the beam pipe at z ≈ 253-254 m

- Test all the IFIN amplifiers (Gain = 2.7, 4.2 and 7.7) and record analog outputs with a 12bit@5GS/s digitizer;
- Rate measurement;



2015

Full HASC assembly & commissioning

- min. 90 RO channels: amplifier boards, 360 ToT channels, TEL62, crates;
- implementation of one of the integral methods in the TEL62 FPGA;
- L1/L2 algorithms for the HASC charge integral and timing;
- staged installation and commissioning at CERN.

High level trigger software development for other NA62 sub-detectors;
Shifts during the NA62 physics runs.