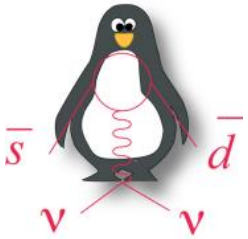


IFIN-HH

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

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

NA62 Goal

- We aim to measure with 10 % (or better) the

$$BR\,(K^+ \to \pi^+ \nu\ \bar{\nu}\,)$$

with in-flight decaying kaons

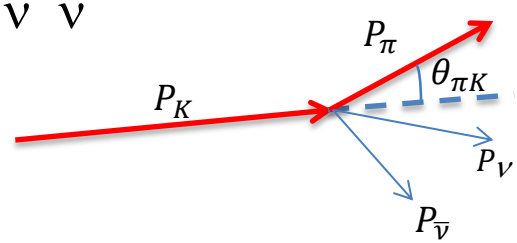
- State of the art:

Decay	Branching Ratio (x 10^{-10})	
	Theory (SM)	Experiment
$K^+ \to \pi^+ \nu\ \bar{\nu}$	0.911 ± 0.072 [1]	$1.73^{+1.15}_{-1.05}$ [2]

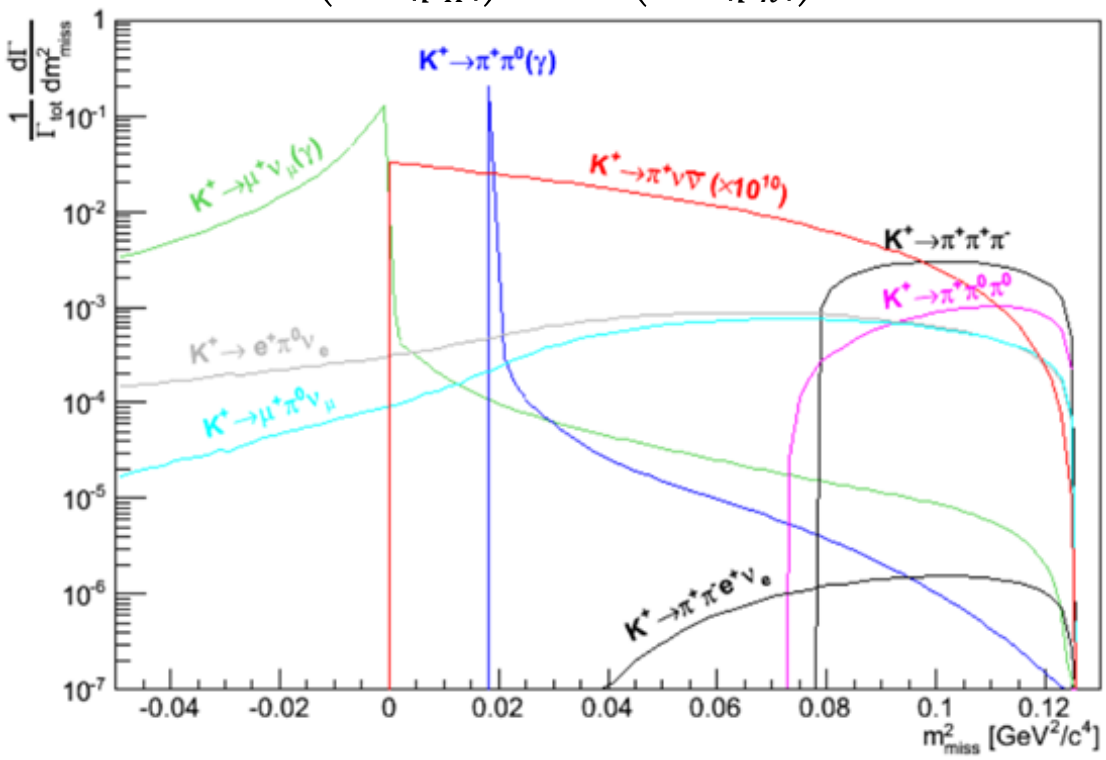
[1] A.J. Buras, D. Buttazzo, J. Girrbach-Noe and R. Knegjens arXiv:1503.02693
[2] AGS-E787/E949 PRL101 (2008) 191802, arXiv:0808.2459

Signal and Background

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



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



Background:

1) Other K^+ decay modes:

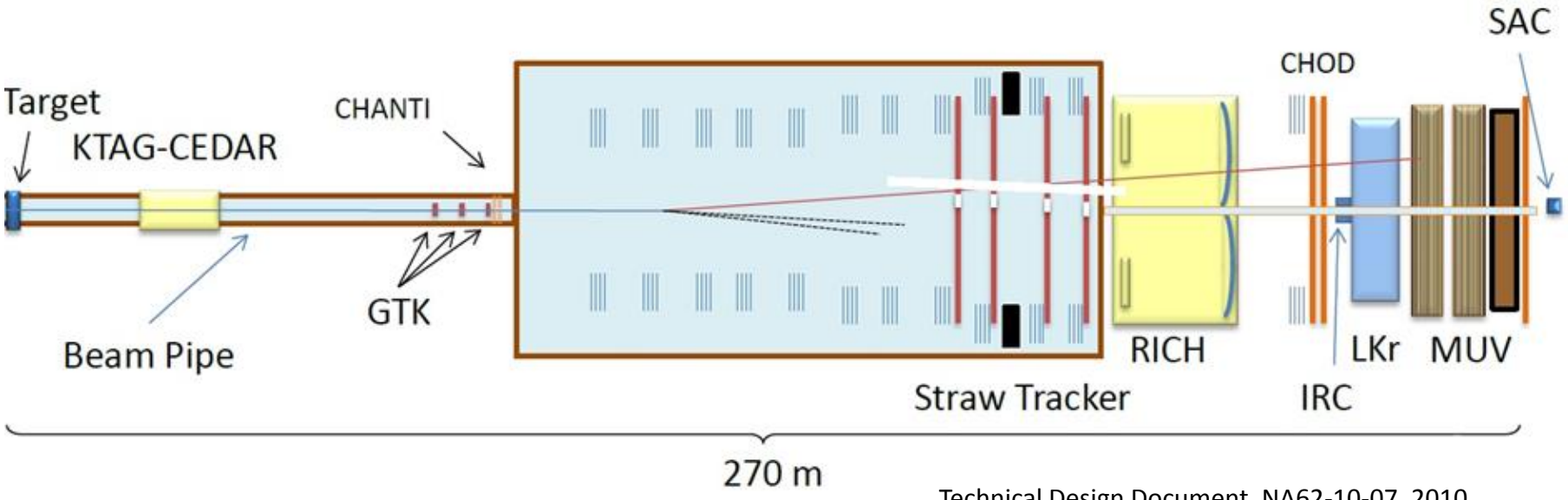
K^+ main decays	**BR**
$K^+ \to \mu^+\nu$	0.6355
$K^+ \to \pi^+\pi^0$	0.2066
$K^+ \to \pi^+\pi^+\pi^-$	0.0559
$K^+ \to \pi^0 e^+\nu$	0.0507
$K^+ \to \pi^0\mu^+\nu$	0.0335
$K^+ \to \pi^+\pi^0\pi^0$	0.0176
$K^+ \to \pi^+\pi^- e^+\nu$	4.257×10^{-5}

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

Background rejection:

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

The NA62 Experimental setup



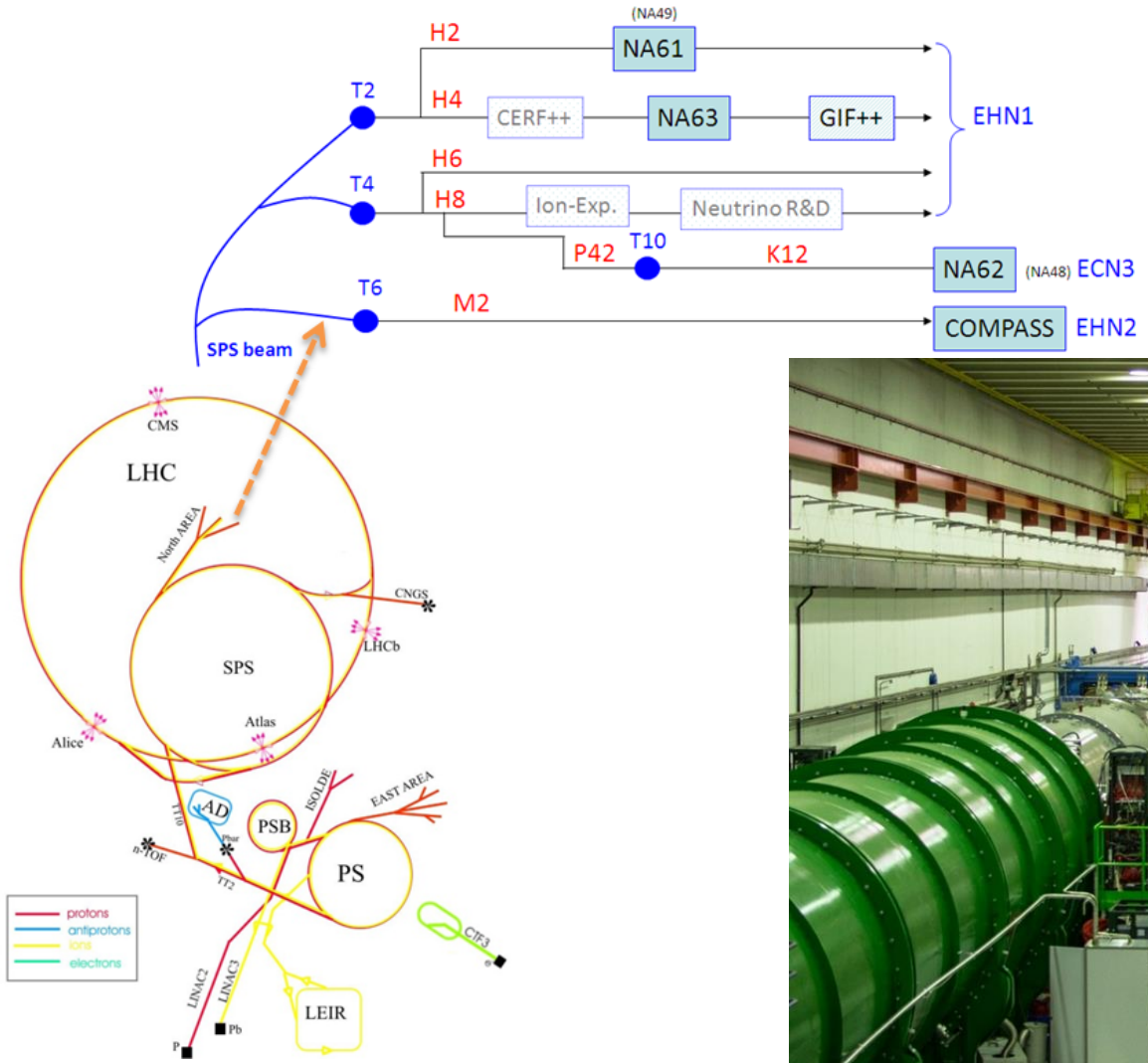
Technical Design Document, NA62-10-07, 2010

↓ **SPS extracted beam**: 1.1×10^{12} p (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

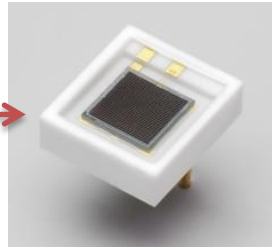
NA62 Experiment in ECN3



Beam time 2015: Jun. 22 – Nov. 15

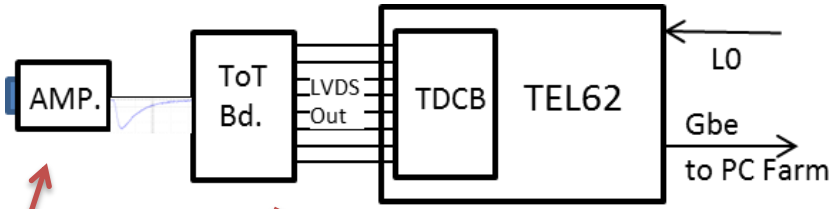
- $>10^{10}$ Kaon triggers on tape
- 10 – 40% of nominal beam intensity

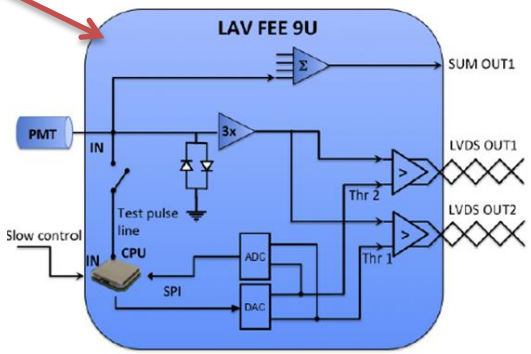
NA62 Hadronic Sampling Calorimeter (HASC)



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

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





NA62 LAV FEE, JINST 8 C01020

Detect 1 π^+ from $K^+ \rightarrow \pi^+\pi^+\pi^-$ when:

- the K+ and one π^+ are identified;
- π^- undergoes hadronic interaction in the 1st STRAW;
- the other π^+ (~40 GeV/c) through beam pipe, emerging at z > 253 m;

✓ 9 Calorimeter Modules salvaged from an NA61 prototype

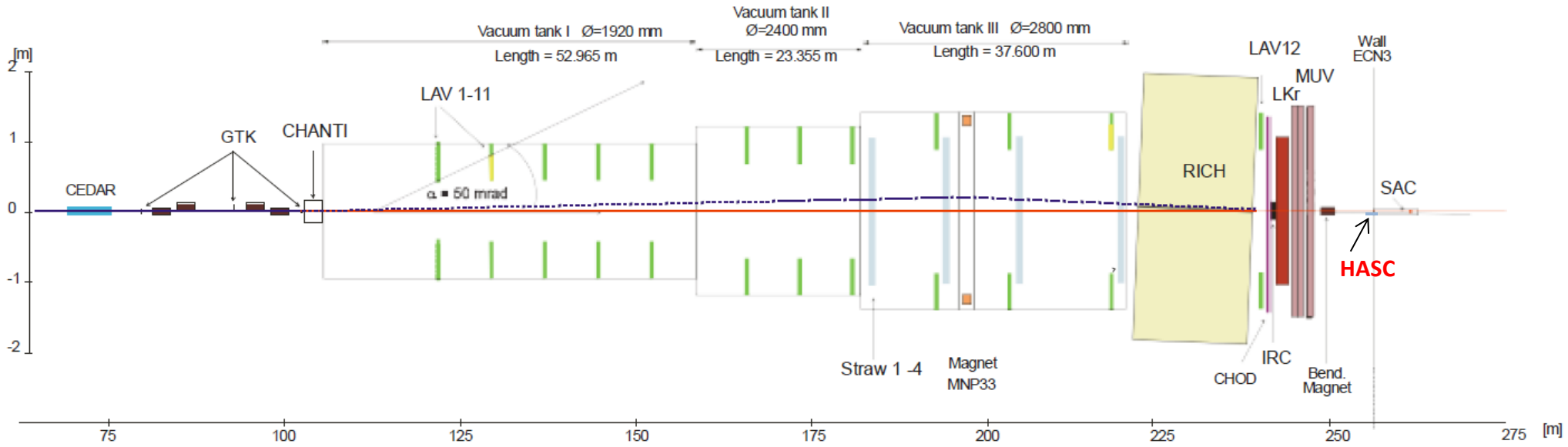
IFIN-HH team responsible with:

- building of HASC Read-Out system;
- installation, maintenance & operation of HASC;

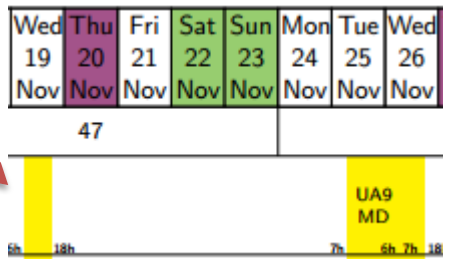
✓ 3x3 mm2 MPPC, front-end electronics together with Time over Threshold(s) method were validated with cosmic rays;

➢ Beam test anticipated in the last ISAB CERN-RO meeting.

HASC Beam test during NA62 Pilot Run

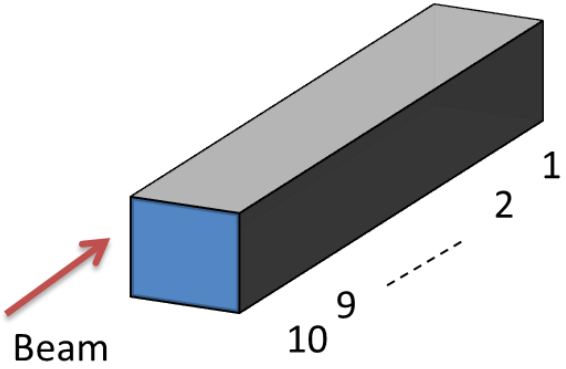


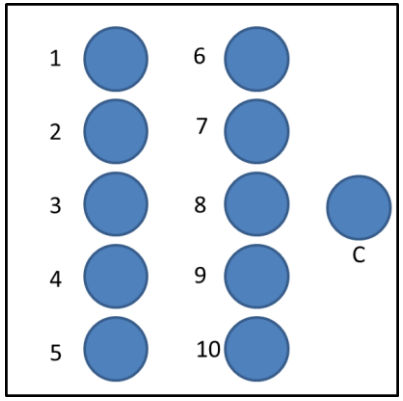
Capture from Ferdinand Hahn presentation @ DISCRETE 2014 + HASC



(2014)

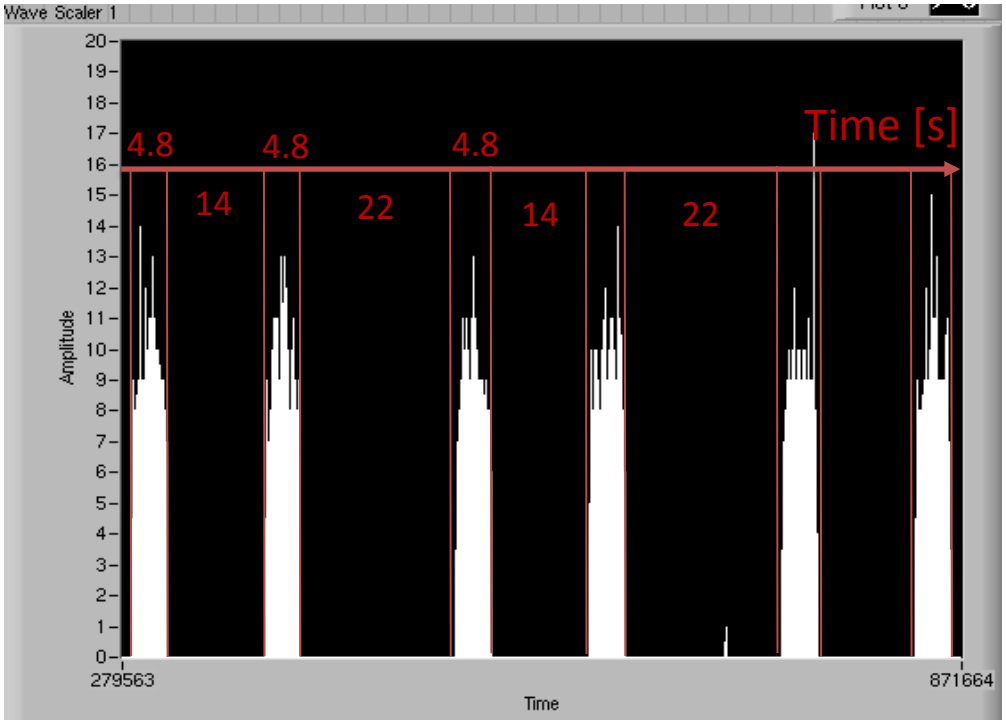
HASC Beam test during NA62 Pilot Run

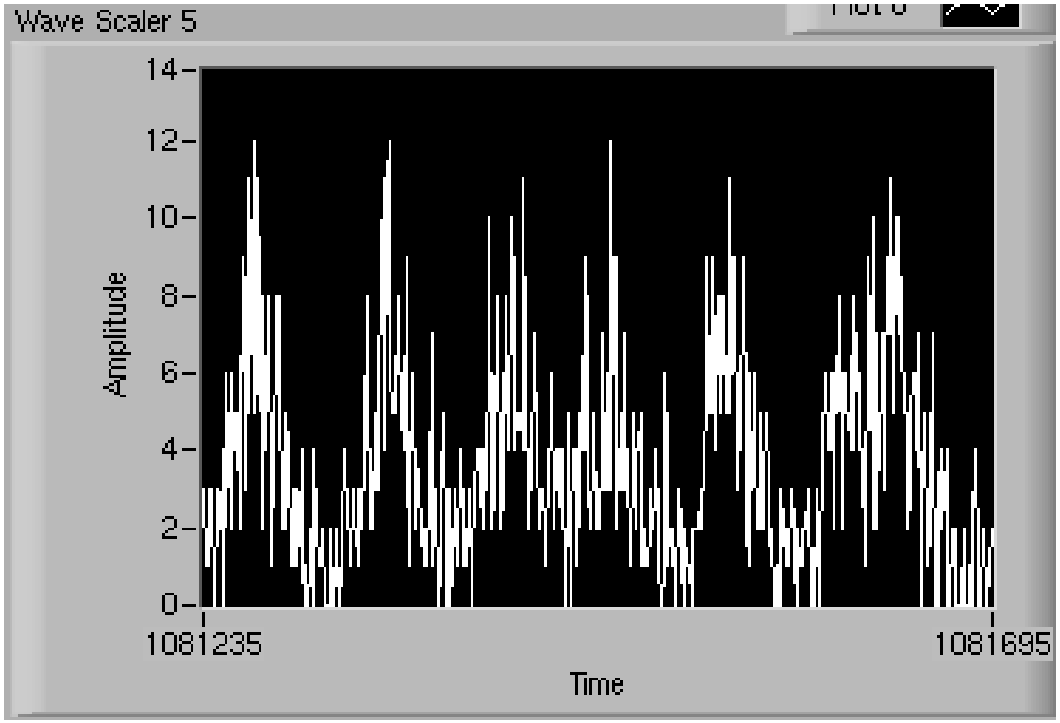




Rd.Out	SipM Vn [V]	SiPM Gain	Amp. Gain
10	67.94	2.29E+05	2.6
9	67.9	2.30E+05	4.2
8	68.03	2.31E+05	7.7
7	67.49	2.32E+05	2.6
6	67.48	2.29E+05	4.2
5	67.83	2.30E+05	7.7

HASC Beam test during NA62 Pilot Run





SiPM10 – scaler data

Beam structure:

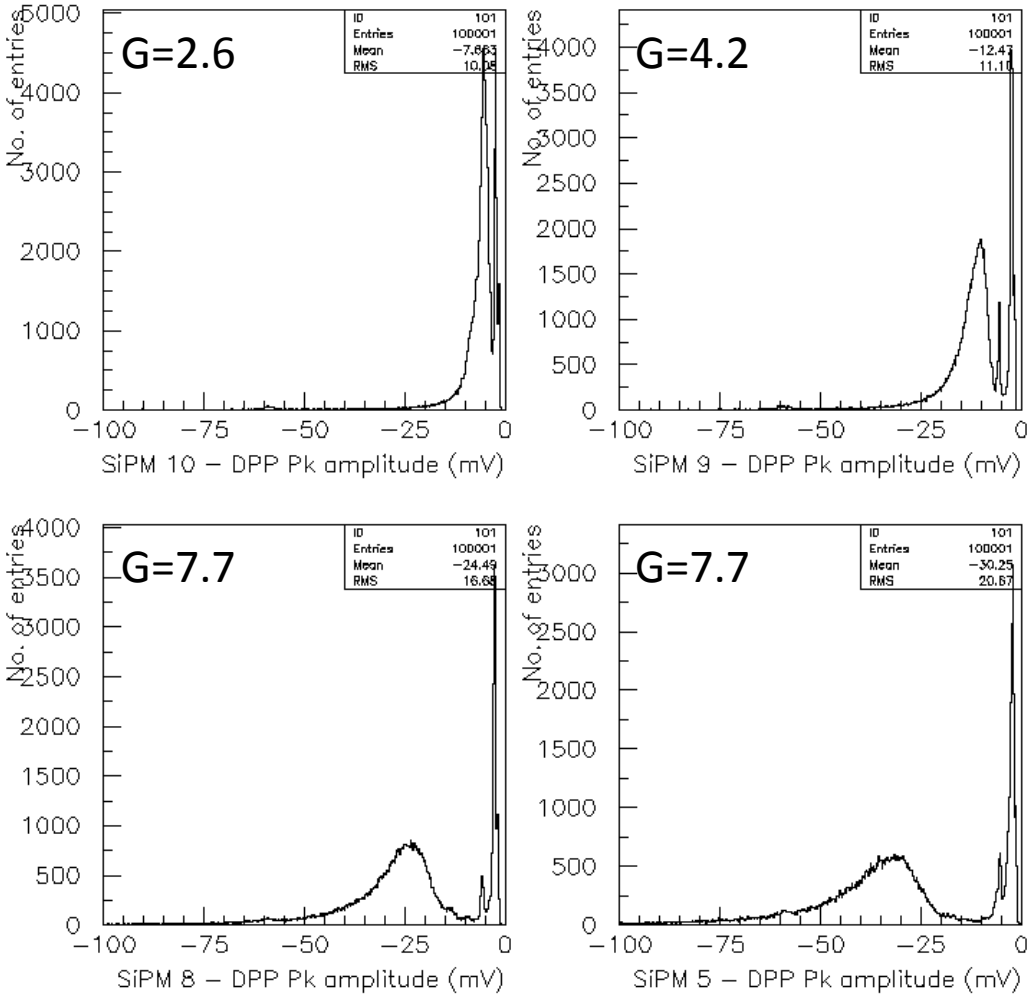
- Spill length ~ 4.8 s
- Extraction: 14, 22 s cycle

SIPM (8 & 9) – scaler data

Spill structure:

- 50 Hz modulation;
- From FFT there is also a 75 Hz component

HASC Beam test during NA62 Pilot Run



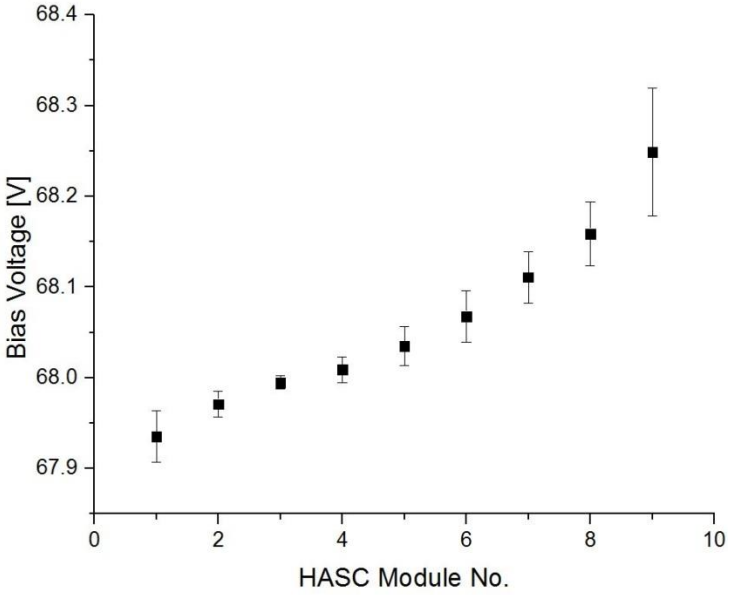
m.i.p. (μ - beam halo) signal

Rate Evaluation (typ. sample):
Beam intensity @5% from nominal
Scaler readings: $3x10^6$
Duration: 611392643 us (PC clock)

Single
SiPM 10: 9.7 KHz
SiPM 9: 18.6 KHz
SiPM 8: 97.5 KHz
Coincidence
8.and.9.and.10 : 3.4 KHz
8.and.9: 17.4 KHz

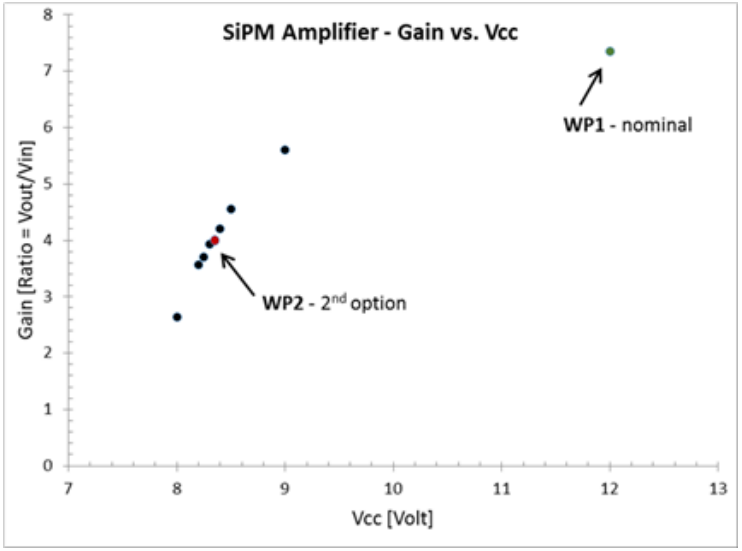
Test conclusions:
- G=7.7
- @ Nominal beam intensity we expect rates of up to 2 MHz /ch. for low thresholds

HASC Read-Out Construction



100 3x3 mm² MPPC sensors received from Hamamatsu (March)

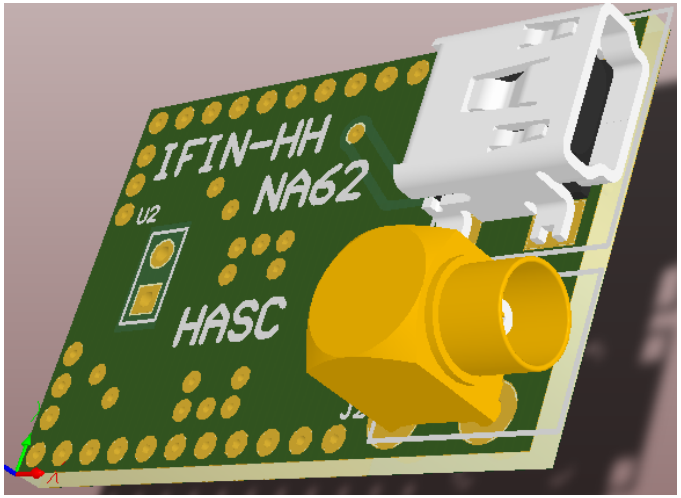
- ✓ MPPC sensors tested individually;
- ✓ grouped according to the nominal bias voltage; 10 MPPC's/ HASC module;
- ✓ advantage: 10 HV channels instead of 90
- ▪ HV +LV distribution box solution



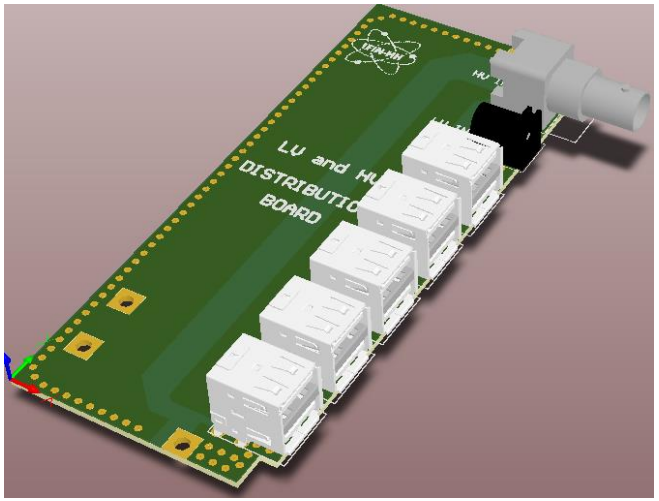
<u>Gain "dilemma"</u>

- ▪ Gain 4 is maintaining a high dynamic range for the TOT input;
- ▪ Gain 7 is providing a better approximation of signal tails, at low amplitude, with two ToT hardware thresholds;
- ▪ Solution: final design with Gain 7 and use (if needed) the Vcc for gain tuning.

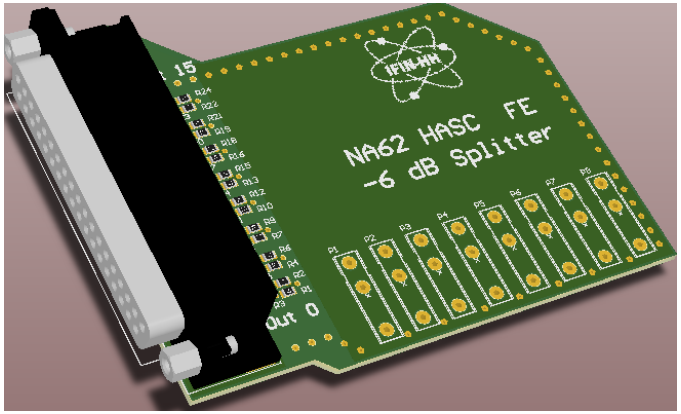
HASC Read-Out Construction (April-August)



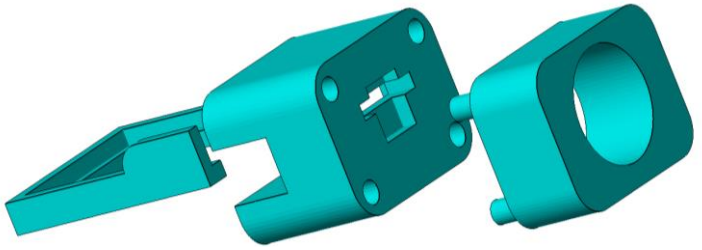
Amplifier board (100 pc's)



HV and LV distribution board (10 pc's)

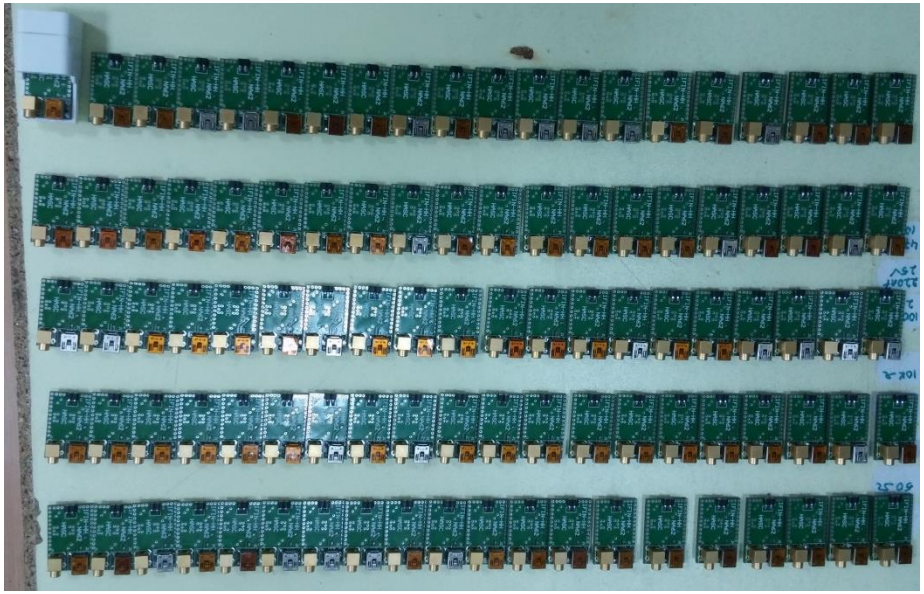


Analog splitter for ToT boards (14 pc's)

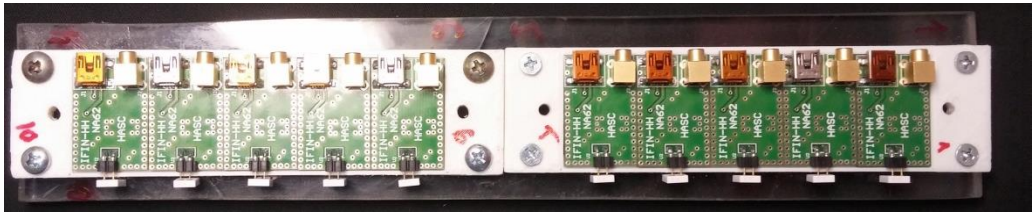


Support for sensor and amplifier board(100 pc's)

HASC Read-Out Construction (April-August)

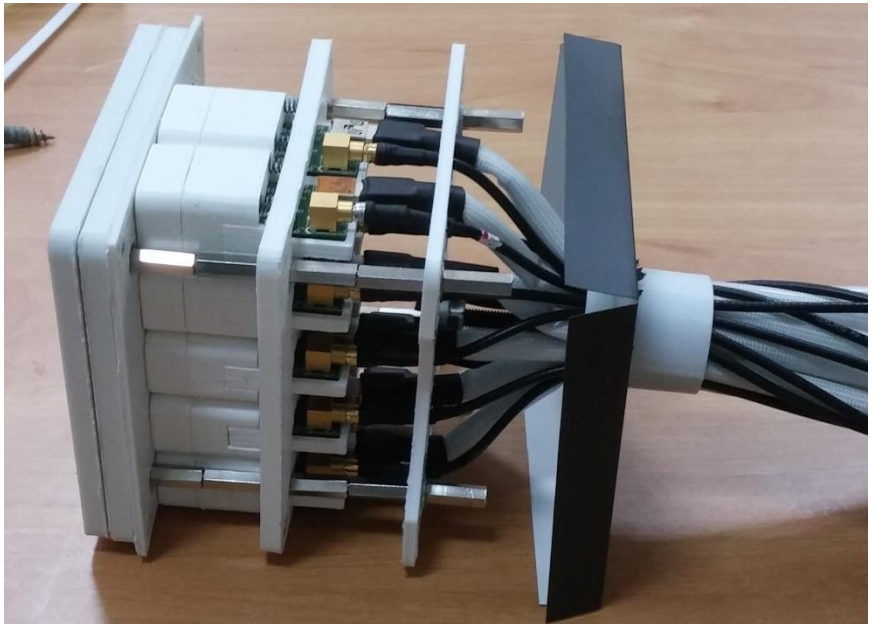


Assembled amplifier boards



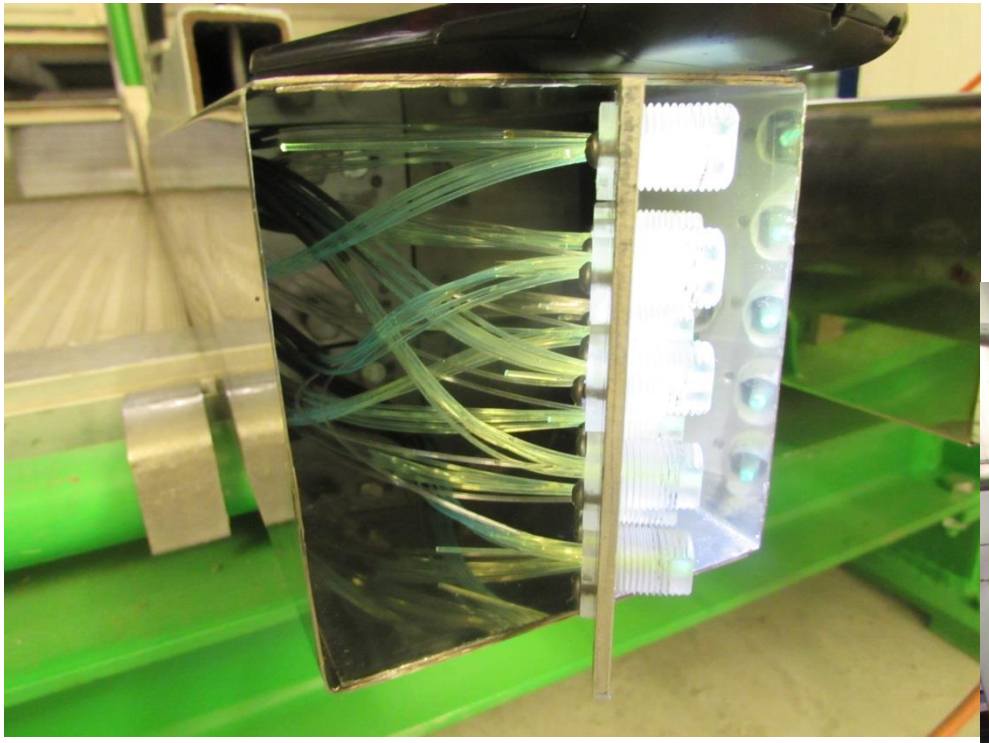
Amplifier test setup

HV and LV distribution box

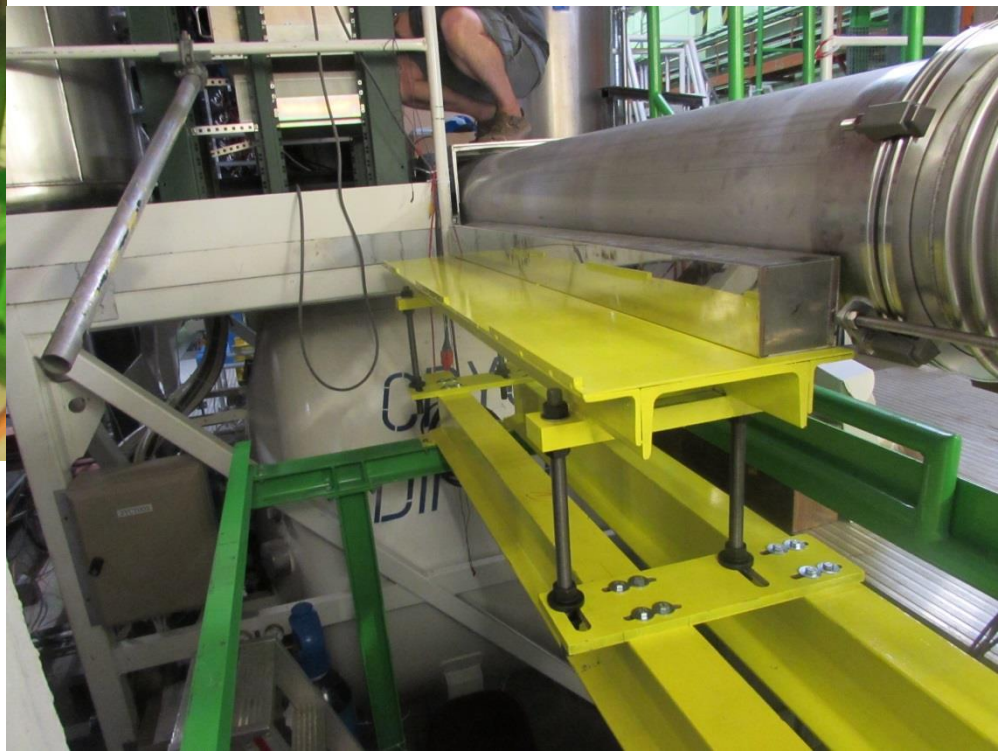


HASC Module Read-out – full assembly test

HASC Read-Out Assembly at CERN (September)



Module front plate dismounting for bolts exchange



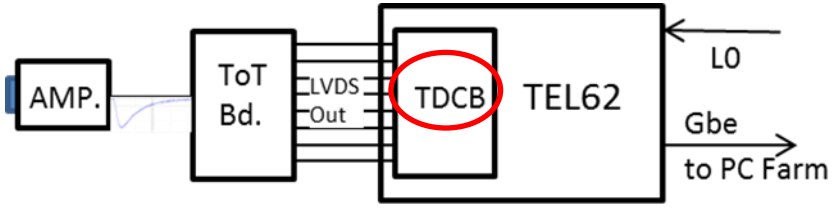
HASC platform together with 1st calorimeter module

HASC Read-Out Assembly at CERN (September)

HASC modules with front-end electronics

HASC Status (November)

- 8 HASC modules are ready (in ECN3) for read-out
- The Time-over–Threshold boards produced by Artel srl. (Italy) arrived (5 Nov.) with 3 weeks of delay
- The Read-out system is incomplete due to the unavailability of TDC mezzanines (INFN Pisa will produce 10 new TDCB mezzanines until the end of 2015)



- HASC control system software under development (prototype ready)
- Integration in the NA62 DCS planned for the beginning of 2016

NA62 Analysis

- Background suppression for events with more than 1 charged particle in the final state
  - $K^+ \rightarrow \pi^+\pi^+\pi^-$
  - secondary beam interaction with the material along the beam pipe

- Shorter time scale (suitable for master thesis):
  - geometrical alignment of the STRAW spectrometer
  - inclusion of the full magnetic field in the track fitting procedure
  - single-photon detection efficiency of the LKr calorimeter

Planning 2015, 2016

- Nov.-Dec. 2015 – Testing of ToT boards; HASC DCS; HASC model building (outreach)
- Dec. 2015 - NA62MC, Reconstruction and Analysis training at CERN
- Dec. 2015 – NA62 Collaboration Meeting (CERN)

Year	2016			
Quarter	1	2	3	4
HASC assembly & commissioning				
Development of HASC firmware for TEL62 FPGA				
L1/L2 algorithms				
Integration of HASC in NA62 TDAQ and DCS				
Shifts				

The Team + friends support

Name	Position
Alexandru-Mario BRAGADIREANU	Physicist (CS III) – IFIN-HH
Valeriu-Florin COTOROBAI	Physicist (CS III) – IFIN-HH
Stefan-Alexandru GHINESCU	Technician – IFIN-HH, Student (Physics)
Ovidiu-Emanuel HUTANU	Engineer - IFIN-HH, Master Student (Electronics)
Dorel PIETREANU	Physicist (CS III) – IFIN-HH (**left the group in February 2015**)
Victor-Radu VOICU	Engineer - IFIN-HH, Student (Physics)

Special thanks to our colleagues and friends: Michele Renda and Calin Alexa