<table>
<thead>
<tr>
<th>CERN Experiment</th>
<th>NA62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Title</td>
<td>Study of rare kaon decays at the CERN SPS</td>
</tr>
</tbody>
</table>
NA62 Goal

- We aim to measure with 10 % (or better) the
  
  $\text{BR} \left( K^+ \rightarrow \pi^+ \nu \bar{\nu} \right)$

  with in-flight decaying kaons

- State of the art:

  \[
  \begin{array}{c|cc}
  \text{Decay} & \text{Branching Ratio} \times 10^{-10} \\
  \hline
  K^+ \rightarrow \pi^+ \nu \bar{\nu} & 0.911 \pm 0.072^{[1]} & 1.73^{+1.15}_{-1.05}^{[2]} \\
  \end{array}
  \]

  arXiv:1503.02693

Signal and Background

**Signal:** \( K^+ \rightarrow \pi^+ \nu \bar{\nu} \)

\[
m^2_{miss} \approx m_K^2 \left( 1 - \frac{|p_\pi|}{|p_K|} \right) + m_\pi^2 \left( 1 - \frac{|p_K|}{|p_\pi|} \right) - |p_K||p_\pi|\theta^2_{\pi K}
\]

**Background:**

1) Other \( K^+ \) decay modes:

<table>
<thead>
<tr>
<th>( K^+ ) main decays</th>
<th>BR</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K^+ \rightarrow \mu^+\nu )</td>
<td>0.6355</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^+\pi^0 )</td>
<td>0.2066</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^+\pi^+\pi^- )</td>
<td>0.0559</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^0 e^+\nu )</td>
<td>0.0507</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^0 \mu^+\nu )</td>
<td>0.0335</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^+\pi^0\pi^0 )</td>
<td>0.0176</td>
</tr>
<tr>
<td>( K^+ \rightarrow \pi^+\pi^- e^+\nu )</td>
<td>4.257 \times 10^{-5}</td>
</tr>
</tbody>
</table>

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

SPS extracted beam: $1.1 \times 10^{12}$ p (400 GeV/c)
Be target $\rightarrow$ 75 GeV/c secondary beam (1% res.)
750 MHz hadron beam (p, $\pi^+$, $\sim 6\% K^+$)
$\rightarrow$ $45 \times 10^6$ $K^+$

10% acceptance $\rightarrow$ $4.5 \times 10^6$ $K^+$ 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
Detect 1 $\pi^+$ from $K^+ \to \pi^+ \pi^+ \pi^-$ when:
- the K+ and one $\pi^+$ are identified;
- $\pi^-$ undergoes hadronic interaction in the 1$^{\text{st}}$ STRAW;
- the other $\pi^+$ (~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 mm$^2$ 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
HASC Beam test during NA62 Pilot Run

<table>
<thead>
<tr>
<th>Rd.Out</th>
<th>SipM Vn [V]</th>
<th>SiPM Gain</th>
<th>Amp. Gain</th>
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<tbody>
<tr>
<td>10</td>
<td>67.94</td>
<td>2.29E+05</td>
<td>2.6</td>
</tr>
<tr>
<td>9</td>
<td>67.9</td>
<td>2.30E+05</td>
<td>4.2</td>
</tr>
<tr>
<td>8</td>
<td>68.03</td>
<td>2.31E+05</td>
<td>7.7</td>
</tr>
<tr>
<td>7</td>
<td>67.49</td>
<td>2.32E+05</td>
<td>2.6</td>
</tr>
<tr>
<td>6</td>
<td>67.48</td>
<td>2.29E+05</td>
<td>4.2</td>
</tr>
<tr>
<td>5</td>
<td>67.83</td>
<td>2.30E+05</td>
<td>7.7</td>
</tr>
</tbody>
</table>
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

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
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

Gain “dilemma”
- 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

HV and LV distribution box

Amplifier test setup

HASC Module Read-out – full assembly test
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
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)

<table>
<thead>
<tr>
<th>Year</th>
<th>2016</th>
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<tbody>
<tr>
<td>Quarter</td>
<td>1</td>
</tr>
<tr>
<td>HASC assembly &amp; commissioning</td>
<td></td>
</tr>
<tr>
<td>Development of HASC firmware for TEL62 FPGA</td>
<td></td>
</tr>
<tr>
<td>L1/L2 algorithms</td>
<td>X</td>
</tr>
<tr>
<td>Integration of HASC in NA62 TDAQ and DCS</td>
<td>X</td>
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<tr>
<td>Shifts</td>
<td></td>
</tr>
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# The Team + friends support

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
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<tbody>
<tr>
<td>Alexandru-Mario BRAGADIREANU</td>
<td>Physicist (CS III) – IFIN-HH</td>
</tr>
<tr>
<td>Valeriu-Florin COTOROBAI</td>
<td>Physicist (CS III) – IFIN-HH</td>
</tr>
<tr>
<td>Stefan-Alexandru GHINESCU</td>
<td>Technician – IFIN-HH, Student (Physics)</td>
</tr>
<tr>
<td>Ovidiu-Emanuel HUTANU</td>
<td>Engineer - IFIN-HH, Master Student (Electronics)</td>
</tr>
<tr>
<td>Dorel PIETREANU</td>
<td>Physicist (CS III) – IFIN-HH (left the group in February 2015)</td>
</tr>
<tr>
<td>Victor-Radu VOICU</td>
<td>Engineer - IFIN-HH, Student (Physics)</td>
</tr>
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Special thanks to our colleagues and friends: Michele Renda and Calin Alexa