NA62 Charged Particle Hodoscope

Design and performance in 2016

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on behalf of NA62 collaboration

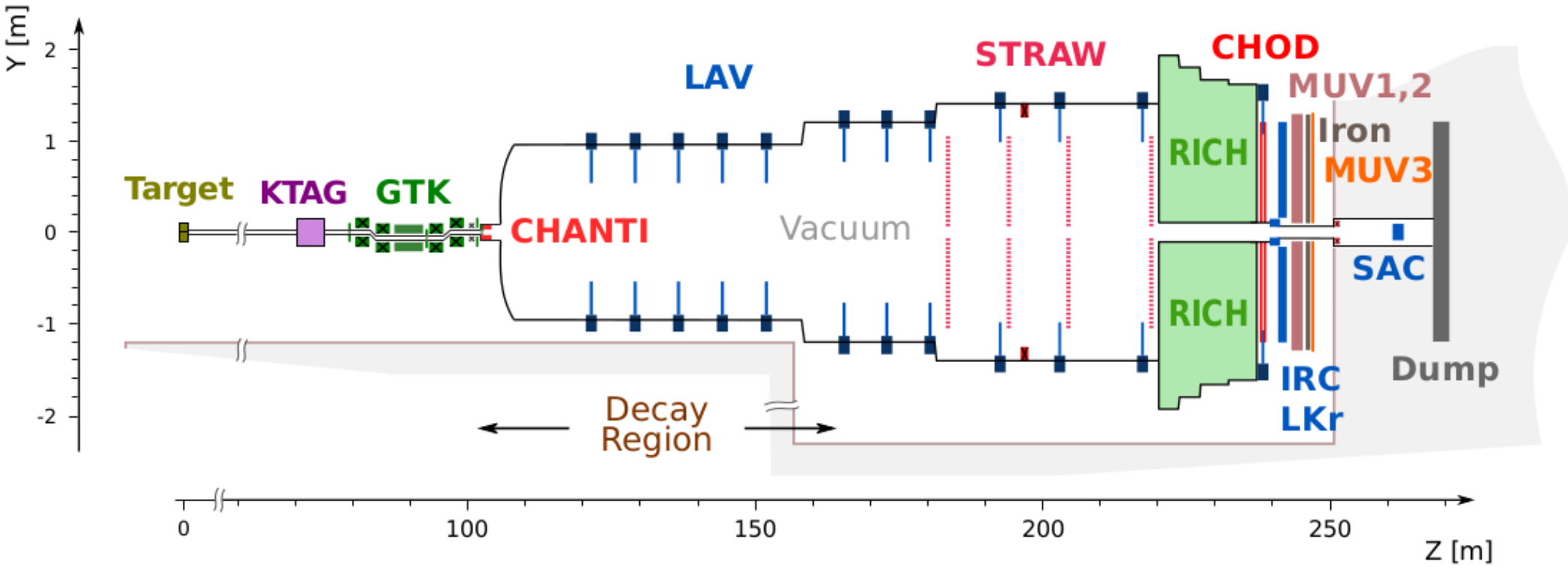
NA62 High intensity kaon beam

- SPS primary proton beam @ 400 GeV/c
- Protons on target: 3×10^{12} / pulse
- Secondary charged beam 75 GeV/c
- Rate @ beam tracker: 750 MHz
- 6% K^+ (others: 70% π^+, 24%proton)
- K decay rates: 4.5×10^{12} /year
  - In a 60 m decay volume
  - 10^{-6} mbar vacuum

The NA62 detector

Main goal: Measuring Br($K^+ \to \pi^+ \nu\bar{\nu}$) with 10% precision

PDG value: Br($K^+ \to \pi^+ \nu\bar{\nu}$) = (1.7 ± 1.1)x$10^{-10}$



- 75 (±1%) GeV/c unseparated secondary hadron (K/ p / π) beam
- Kaon decays in flight technique
- 750 MHz beam; 45 MHz Kaons (~6%); ~10 MHz L0 rate

Charged particle hodoscope: requirements

The main function of the hodoscope:

- To identify trigger topologies with charged particles in the fiducial volume
- To detect photon conversion and hadron interactions of particles in the material upstream.

An essential requirement for the NA62 Level 0 (L0) trigger:

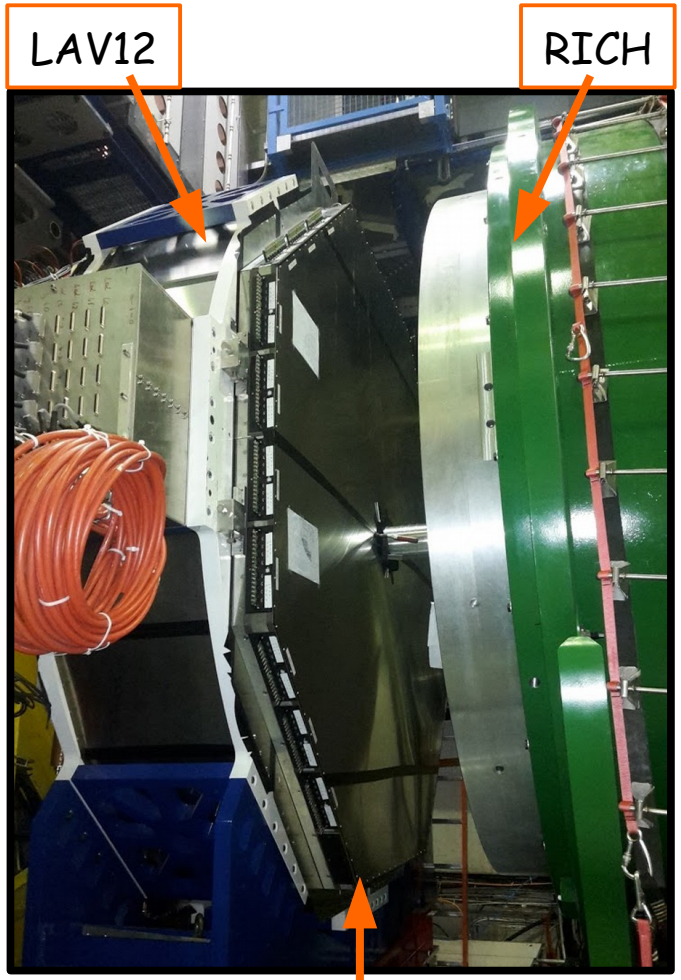
Detecting charged particles with:

- adequate efficiency
- Rate capability

  Expected rates @ full intensity: particle rate ~15 MHz; Hit rate ~ 45 MHz
- good time resolution (better then 1 ns)

  in measuring the signal arrival time comparable with other detectors used in the L0 trigger.

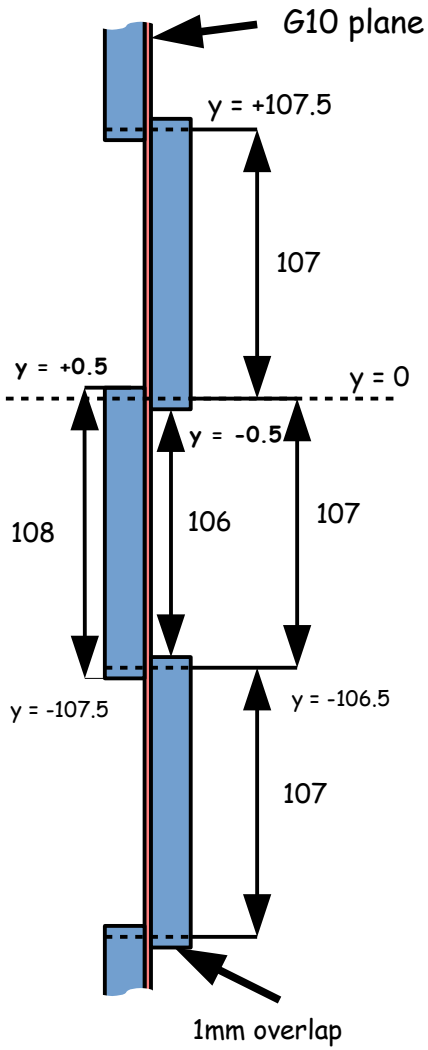
NA62 Experimental Hall



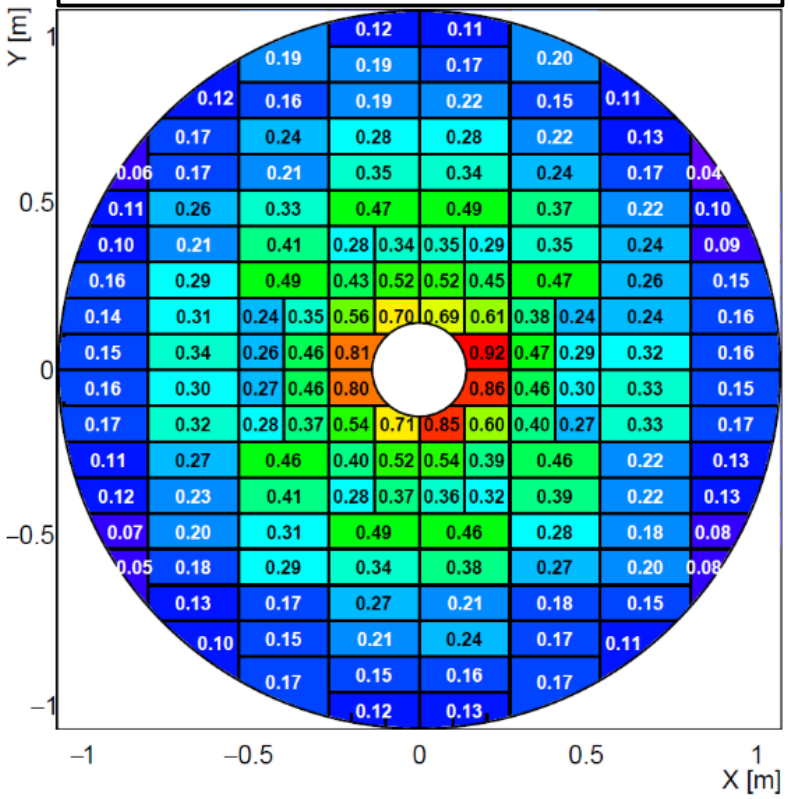
The hodoscope (CHOD) has been installed between RICH and last station of Large Angle VETO (LAV12)

Charged particle HODoscope

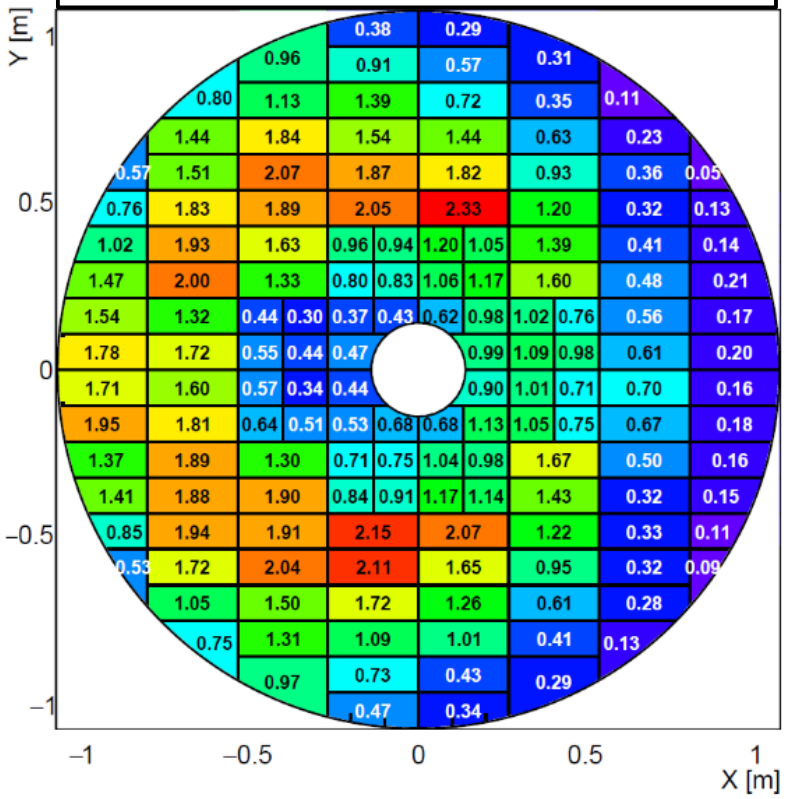
- The cell structure detector made of 30 mm thick scintillator tiles
- Consists of 38×4=152 scintillator tiles arranged in 4 quadrants.
- Covers the area 140 mm < R < 1070 mm
- tiles: 267.5 × 108 mm² and 133.75 × 108 mm²
- Dual channel readout (2 readout channels for each tile)
- Coincidence of the two signals identified as a particle
- Using a mean signal arrival time



Expected rates in CHOD tiles at nominal beam intensity (in MHz)

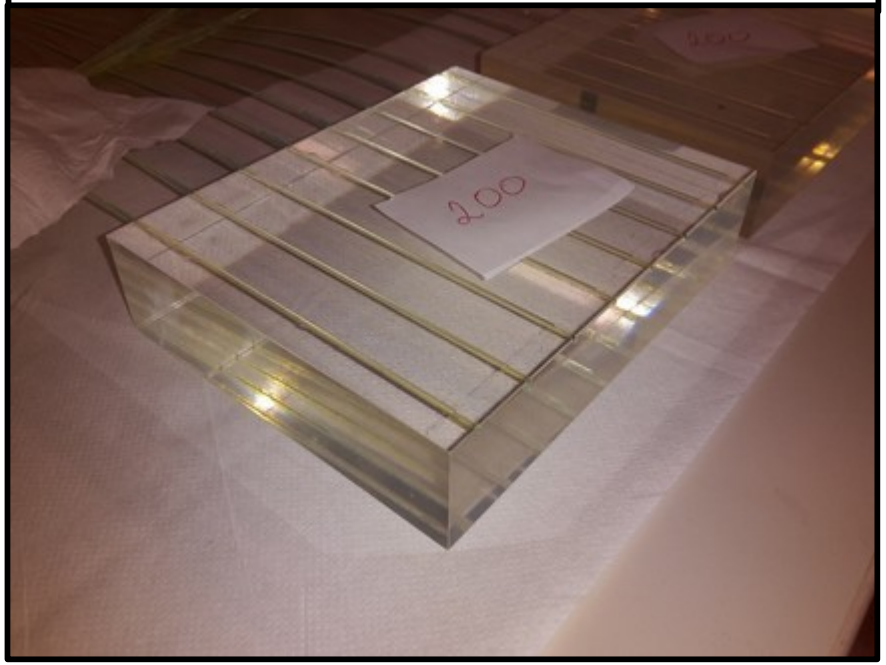


Probability of detecting a signal in each tile for $K^+ \to \pi^+ \bar{\nu}\nu$ decay

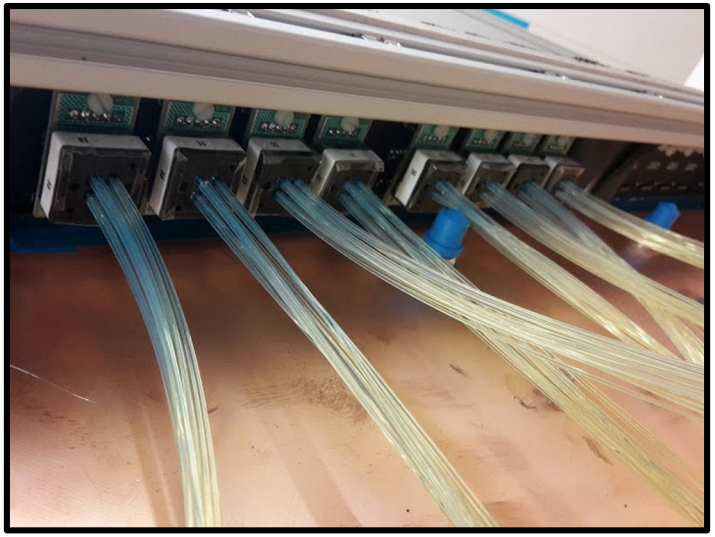


Charged particle HODoscope

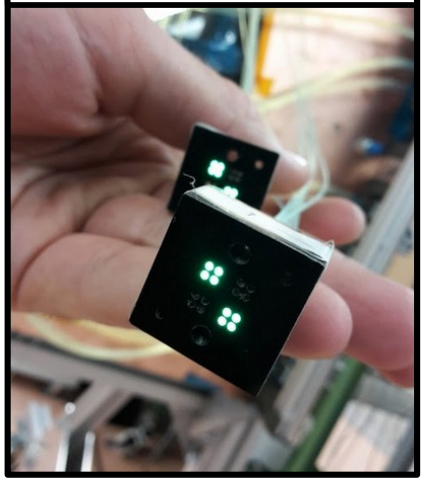
WLS-Fibers d=1mm Y11(200) type S
Length: 1.35 m, 1.6 m, 1.8 m & 2.0m

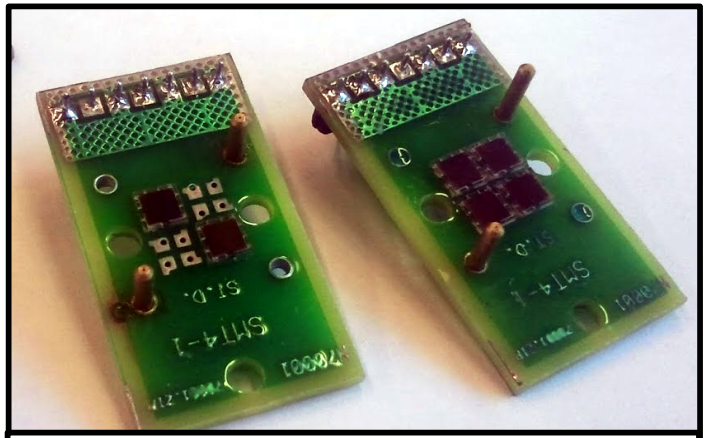


Tiles made of SC-201 scintillator 30 mm thick.
Wrapped: combination of Tyvek and 70μm Al-Mylar



Cookies (Frames)

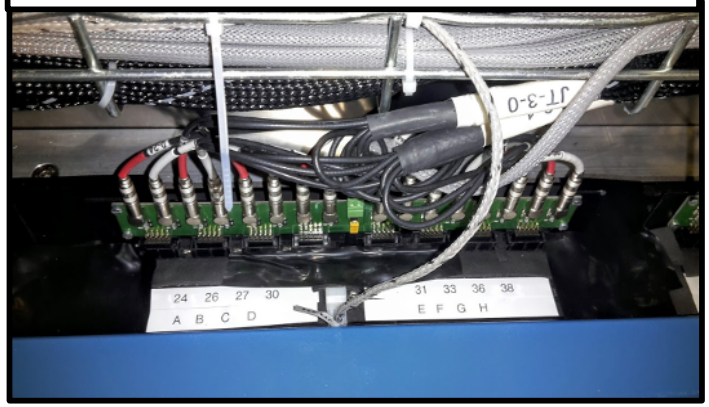


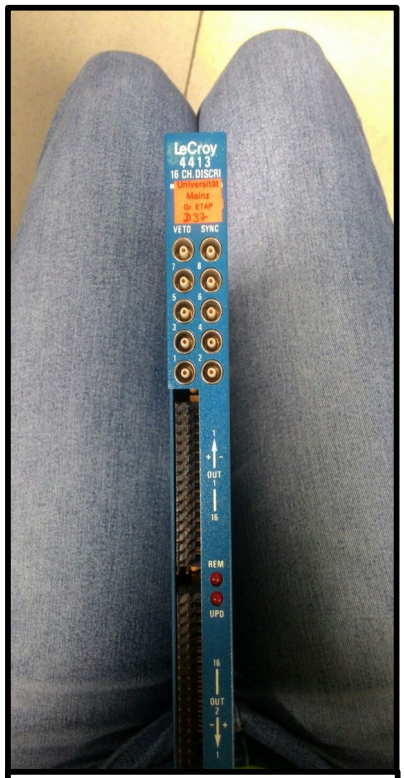


Silicon photomultipliers:
SensL MicroFC-30035

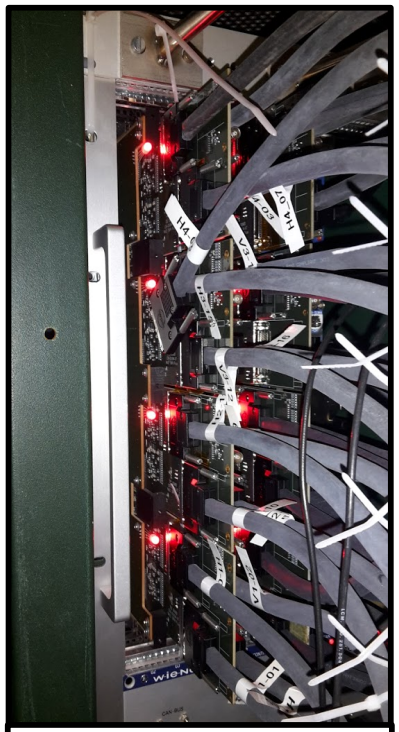
Readout electronics

Amplifiers



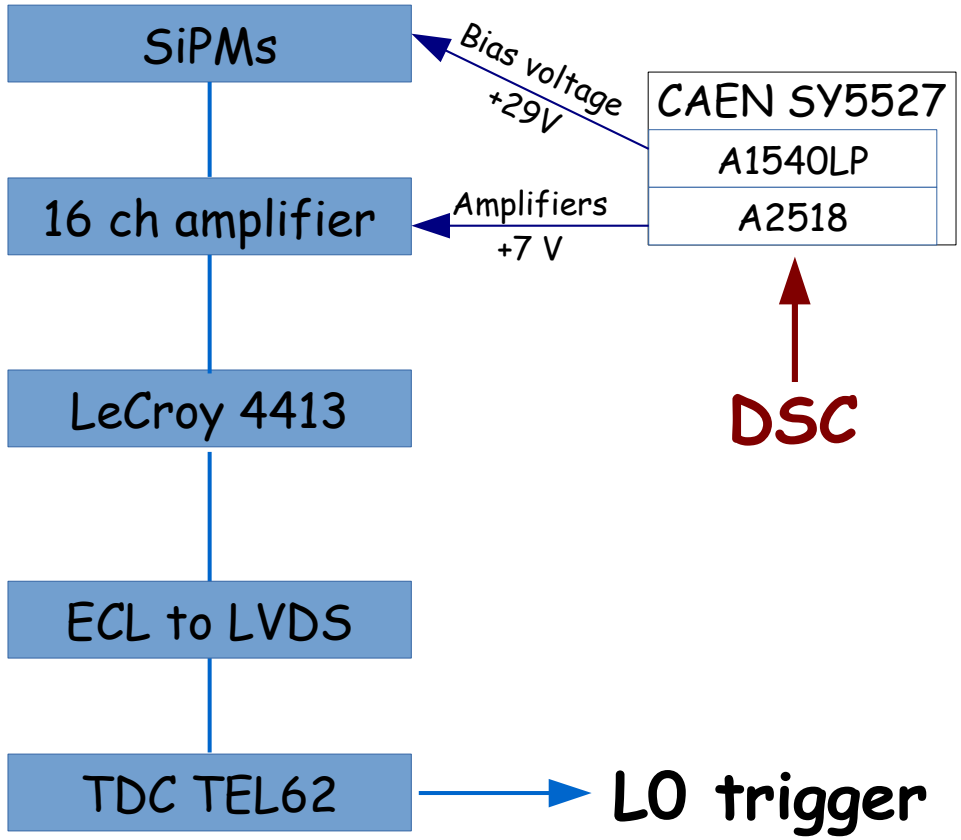


Discriminator



TDC module (TEL62)

From each optical-electronic node:



In total there are:

x20 optical-electronic nodes

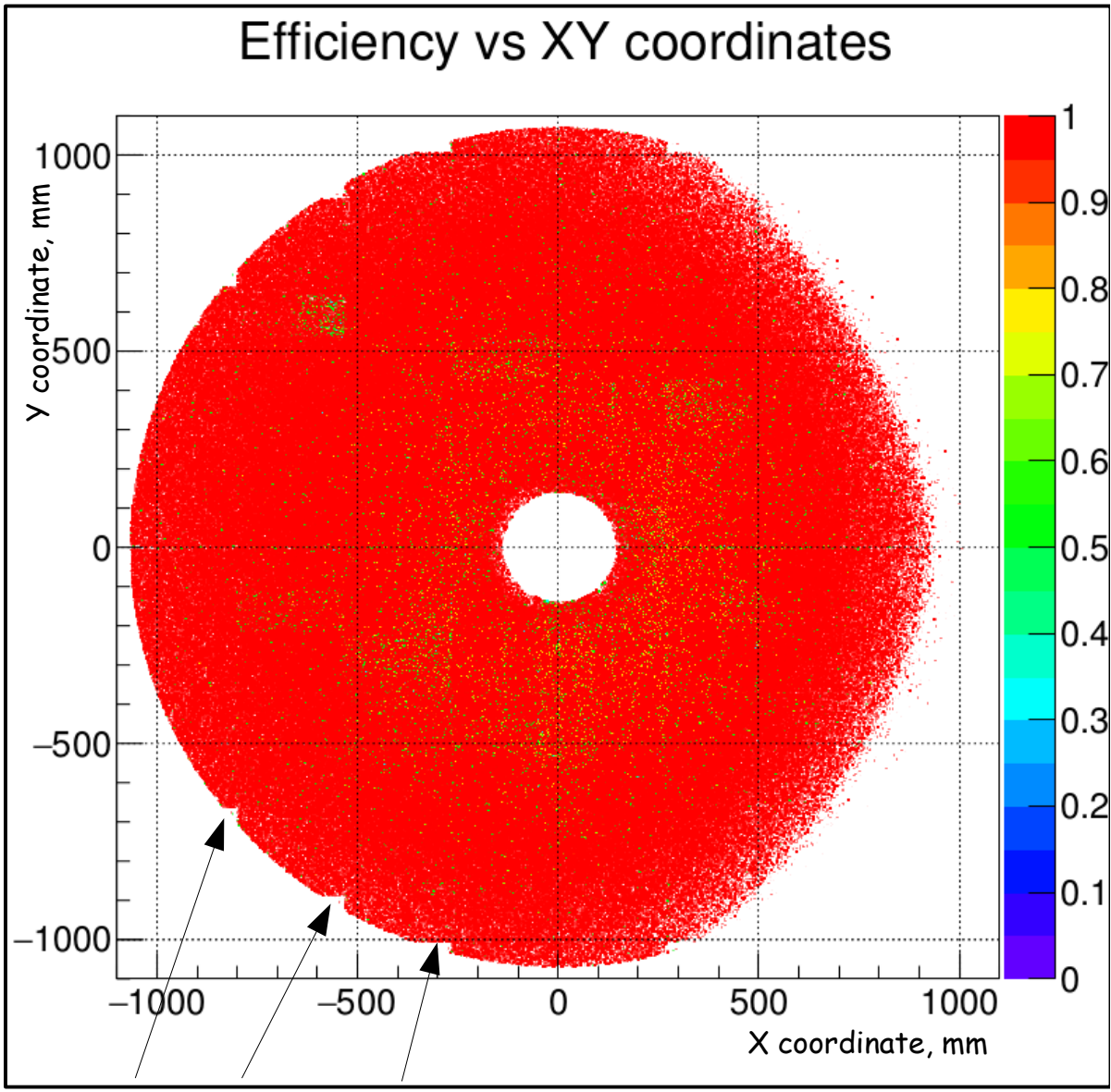
Performance: Efficiency (1)

Using Control data only!

muons from Kmu2 decay:

Looking for hits in CHOD

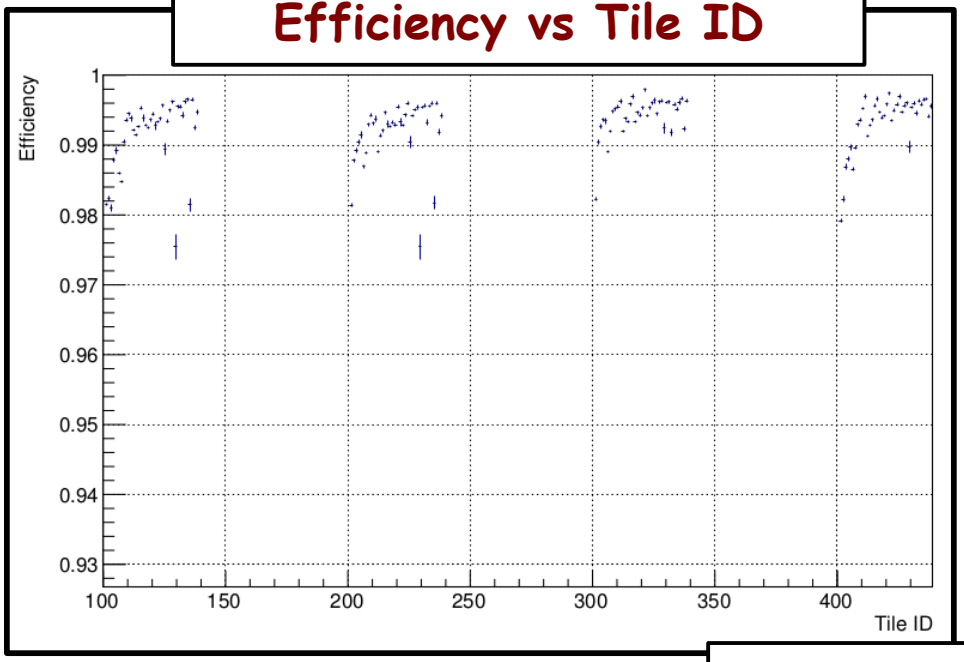
Time(CHOD – Cedar) < 10ns



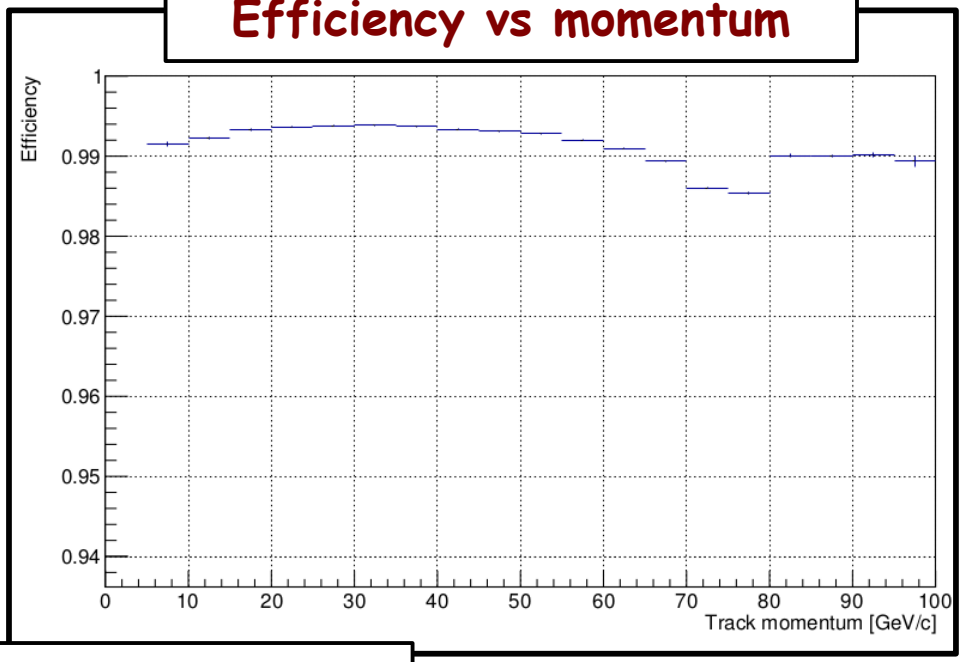
One may point out an empty corners which are physically empty (special cut for the ties to fix periphery tiles).

Performance: Efficiency (2)

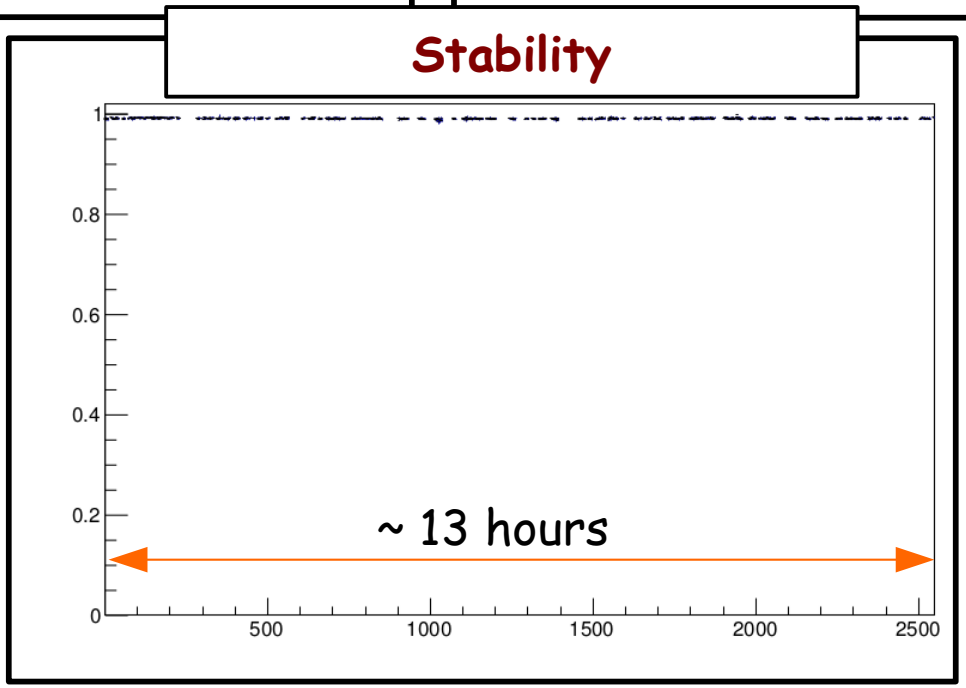
Efficiency vs Tile ID



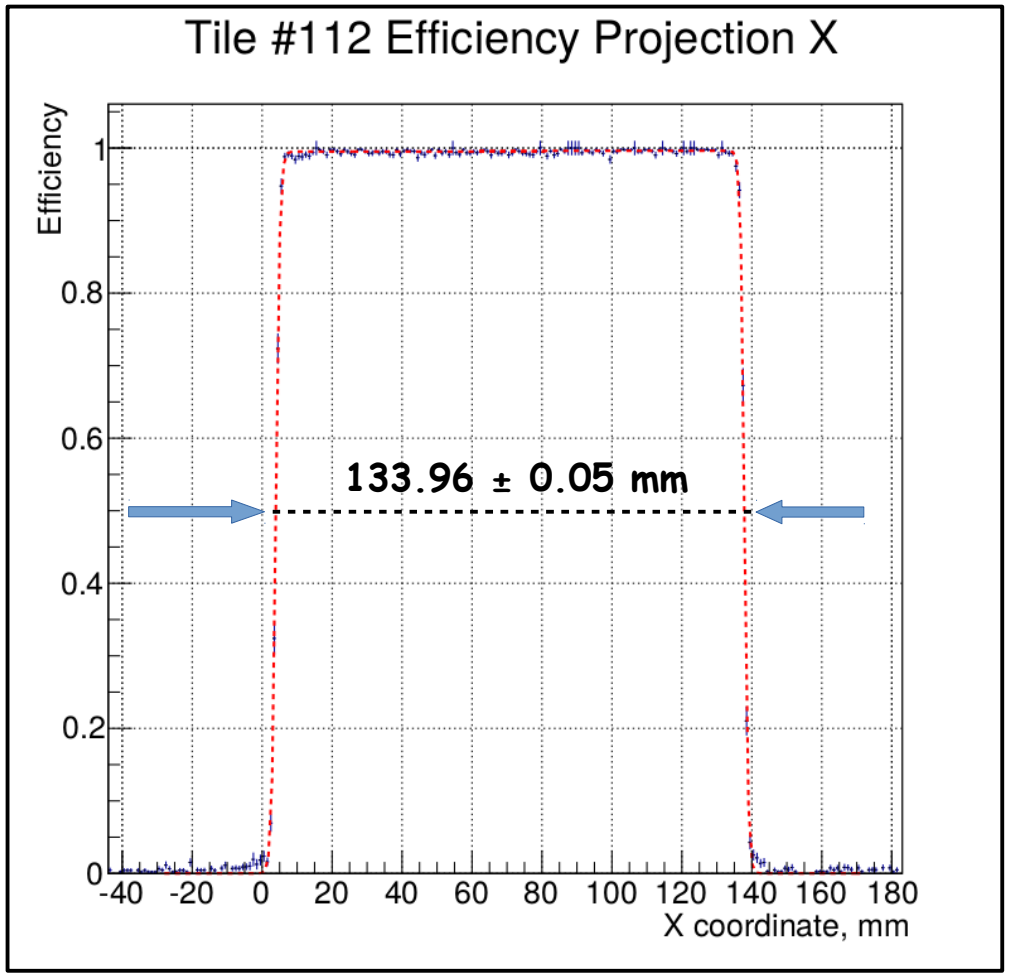
Efficiency vs momentum

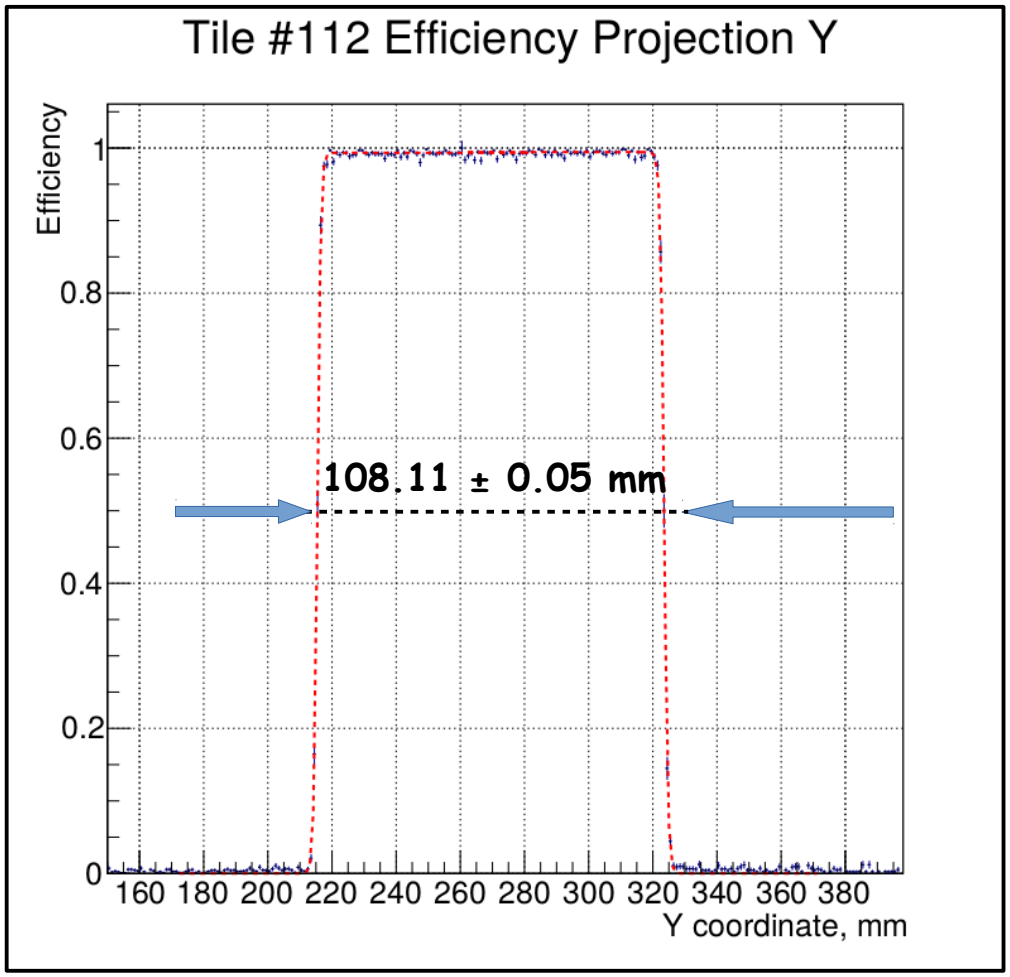


Stability



Performance: Efficiency (3)





Assuming the edge coordinate as a point with 50% efficiency…

The plateau efficiency value is 99.48 +- 0.08%

X size = 133.96 ± 0.05 mm physical size = 133.75 mm

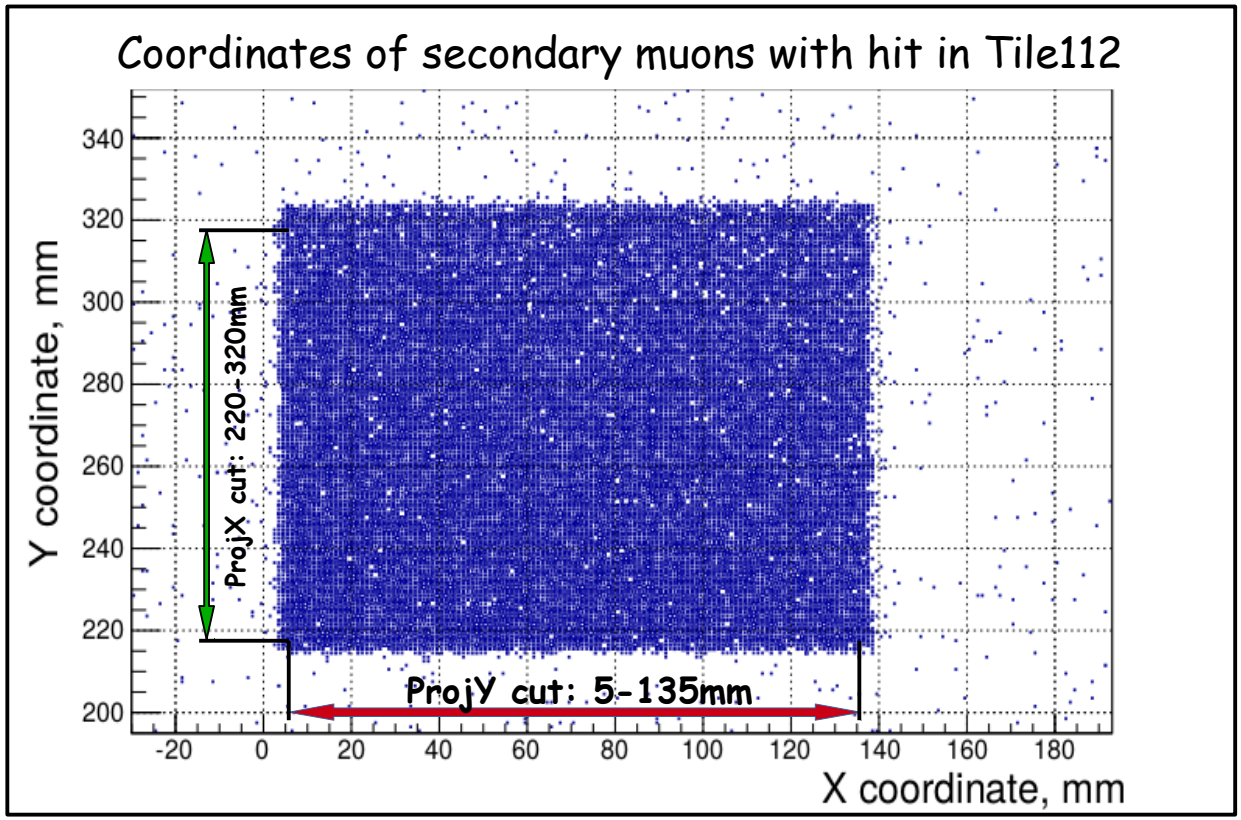
Y size = 108.11 ± 0.05 mm physical size = 108 mm

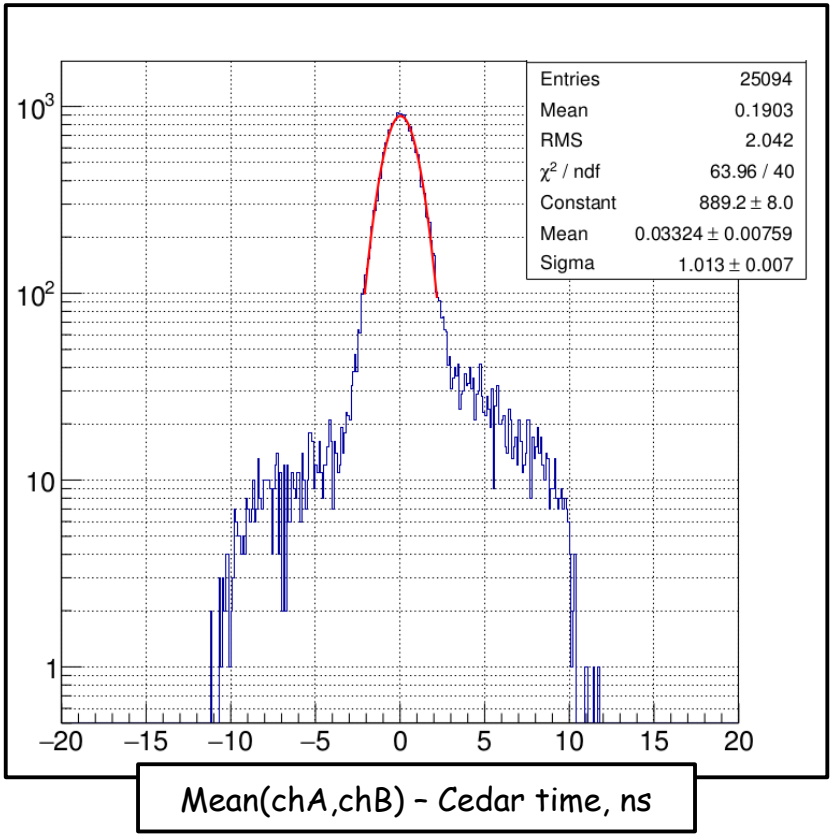
Perfomance: Time resolution (1)

Using Control trigger data:

Selecting muons from Kμ2 decay.

Looking for selected tile with both channels hit (±5ns).





On average on-line* time resolution (sigma) of the tiles ~ 1 ns

* value that goes to the L0 trigger

Perfomance: Time resolution (2)

Using Control data only!

- Selected Kμ2 decay
- Asking for track to be a few millimeters away from the edges
- For each tile working

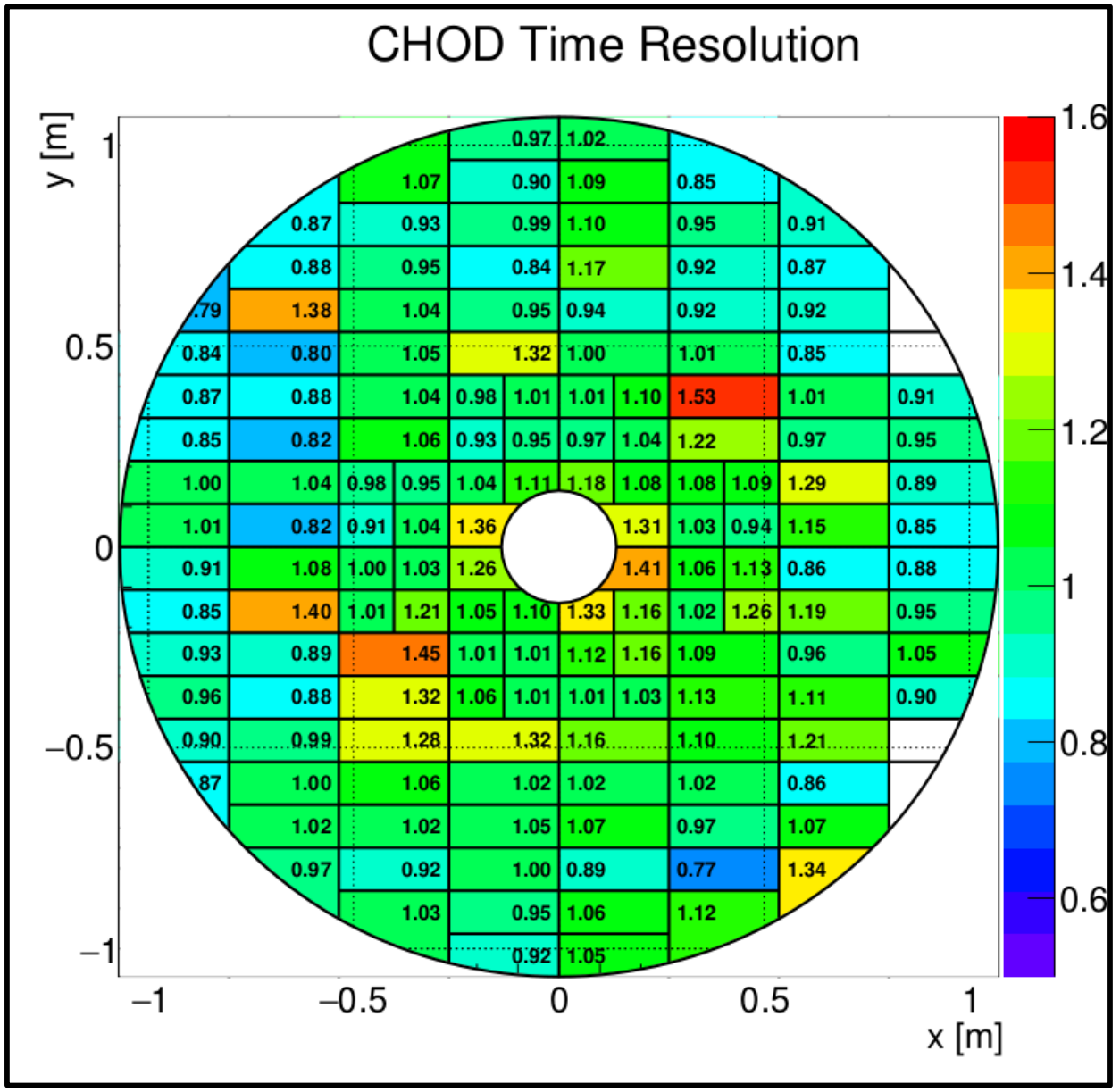
MeanTime(chA,chB) – Cedar time

- NEntries > 100

(that's why 4 tiles are blank on the right side)

- Gaussian fit

Plotting sigma values



NA62 CHOD in L0-trigger

List of produced L0-trigger primitives:

- Hit in specified quadrant only (1-4)
- Hit/tight hit in specified tiles
- Hit in any tile
- Hits in at least two tiles
- At least two quadrants are hit [multi-track trigger]
- At least two diagonally-opposite quadrants are hit [multi-track trigger]
- Event satisfies the upper tight-hit-multiplicity cut (event has less than 5 hits)

Summary

Before the start of 2016 run:

- A new detector has been assembled and installed in the experimental hall.
- Fully integrated in NA62 Data Acquisition and Detector Control (DCS) systems
- Included in L0-trigger

During the run 2016: reasonable performance:

For the single track events (muons from Kmu2 decay):

Time resolution ~ 1ns (with "classic" threshold discriminators LeCroy 4413)

Efficiency ~ 99%.

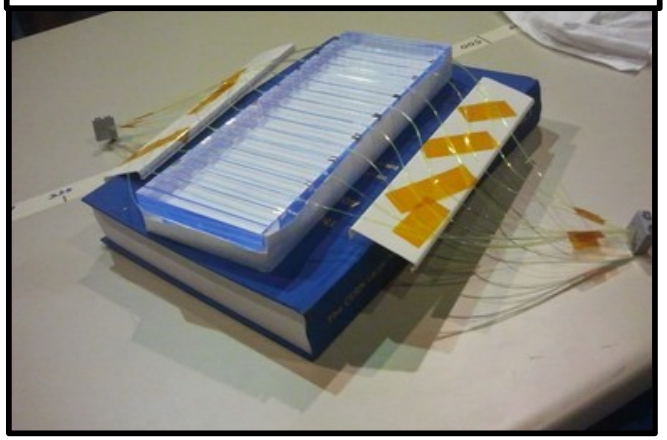
For 2017 Run expecting to improve time resolution from 1 ns to 0.6 ns:

- By changing "classical" threshold discriminators to CFD.
- Possibility of adjusting thresholds individually channel by channel.

spares

CHOD history

2013
Single tile R&D



October 2014
A prototype with 17/152 tiles

November 2015 Charged particle hodoscope assembling complete

Vladimir Rykalin (Protvino)

with 1 of 4 polymerized

scintillator object produced

for the NA62 CHOD

26th of November 2015. Assembling complete

3rd of March 2016. CHOD installed