The NA62 GigaTracKer and 4D track reconstruction

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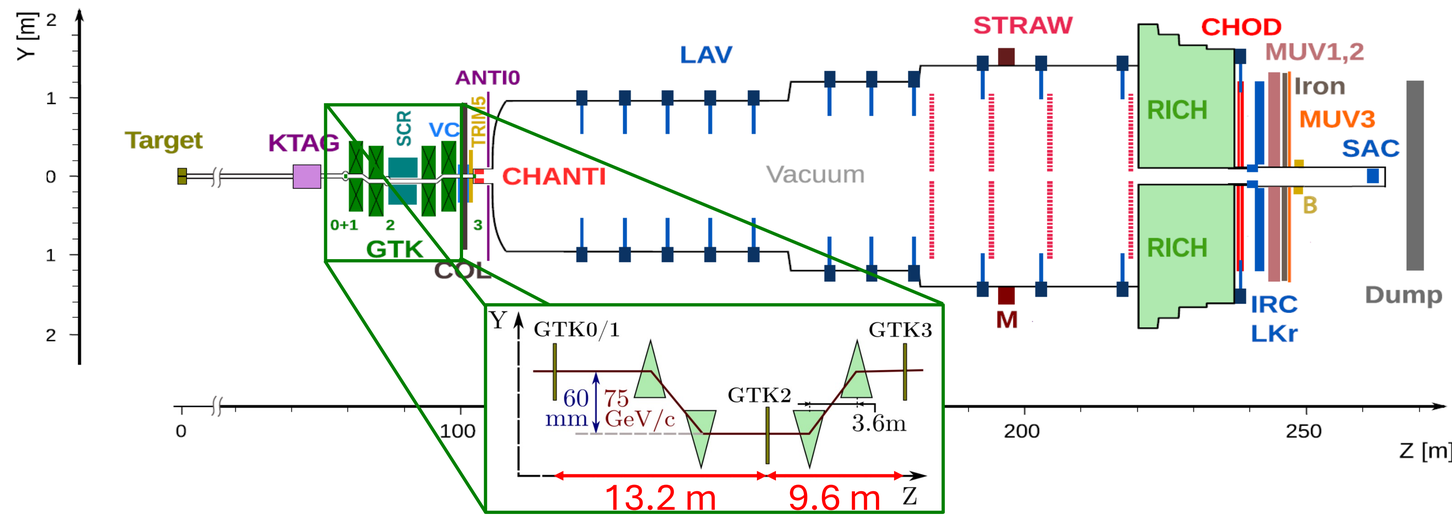
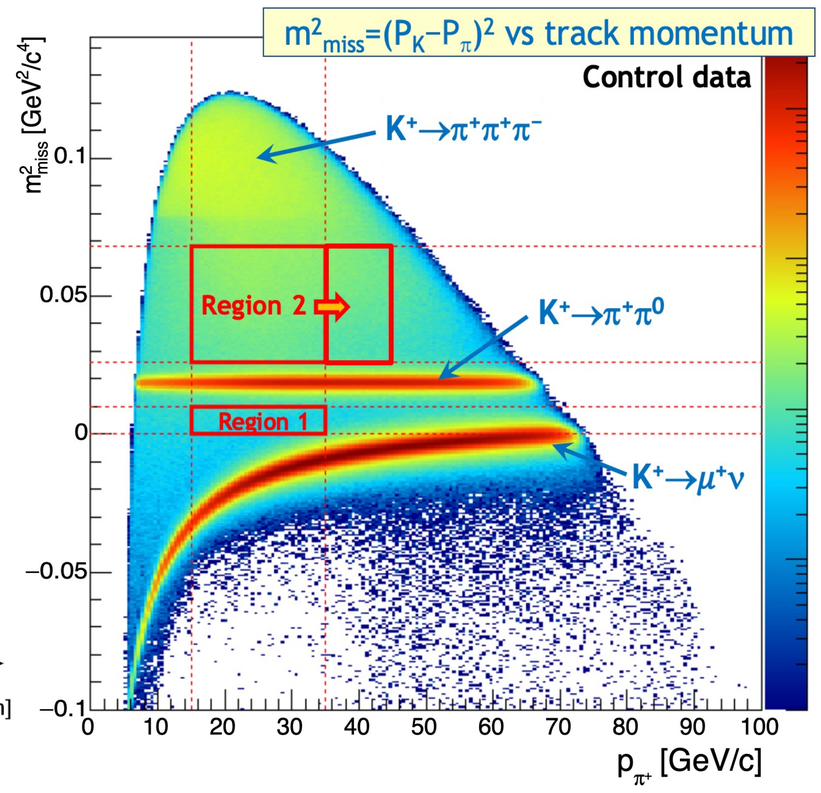
on behalf of NA62 collaboration

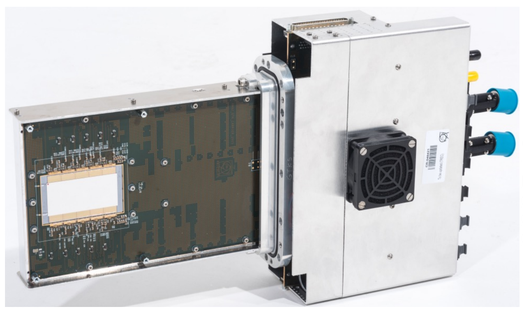
The NA62 experiment & detector

- NA62 located in CERN's North Area, designed to measure $\mathcal{B}(K^+ \longrightarrow \pi^+ \nu\bar{\nu})$
- Analysis strategy:
  1. Tag K^+ and **measure momentum**
  2. Identify π^+ and measure momentum
  3. **Match K^+ & π^+ in time**, reconstruct vertex
  4. **Compute $m^2_{miss} = (P_{K^+} - P_{\pi^+})^2$**
  5. Reject additional activity

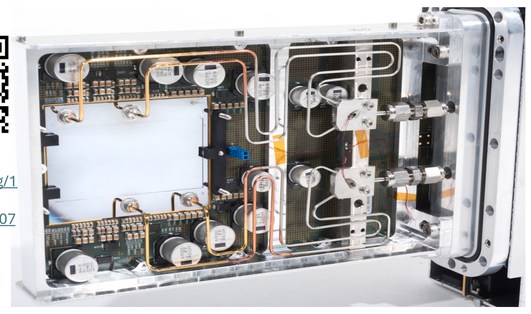




The GigaTracKer (GTK) detector



GTK & 4D tracking
https://doi.org/10.1088/1748-0221/14/07/P07010



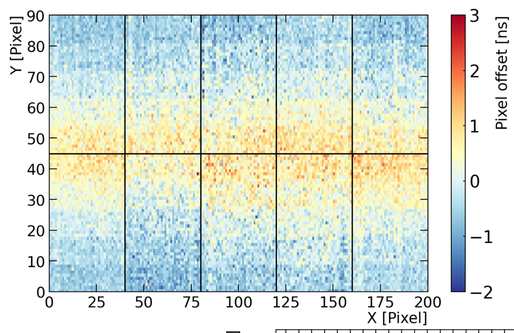
- Measure momentum, angle and time stamp of beam tracks
- High particle flux, minimal material budget
- Four planes of Si hybrid pixels
- Sensor: 200 μm thick (0.2% X_0)
- TDCPix: 100 μm thick (0.1% X_0)
- Installed in beam pipe vacuum (~10^{-6} mbar)
- Micro-channel cooling plate – first application in HEP

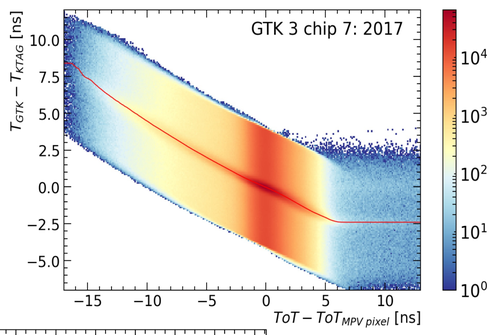
TDCPix
https://doi.org/10.1016/j.nima.2023.168331

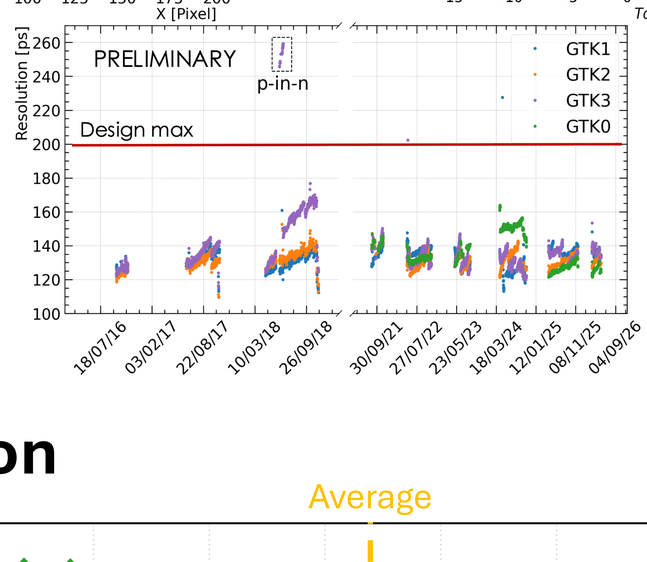
Beam rate	750 MHz-1 GHz
Peak particle flux	2.0 MHz/mm^2
Peak radiation	**4.5×10^{14} 1MeV n$_{eq}$/cm^2/200 days**
Efficiency	99%
Momentum resolution	0.2%
Angular resolution	16 μrad
Pixel time resolution	**<200 ps RMS**
Material budget	**0.5% X_0**
Detector size	**60.8×27 mm^2**
Pixel size	**300x300 μm**

Time calibration

- Cable T0s corrected wrt a Cherenkov detector (KTAG, ~70 ps) calculated every SPS spill
- Pixel time offsets extracted at MPV of ToT for each pixel (~3ns variation along a column)
- Time walk correction computed per chip (~300 ps/1ns ToT)
- Time delays arising from TDCPix architecture extracted every 1500 SPS spills





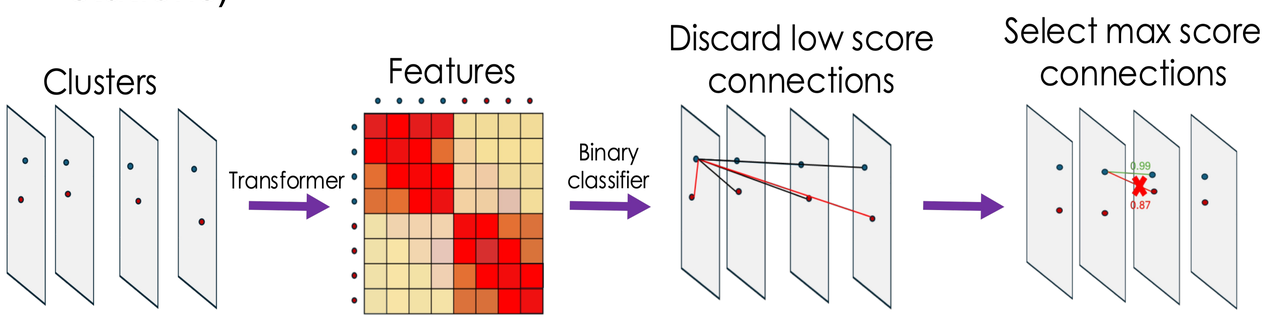


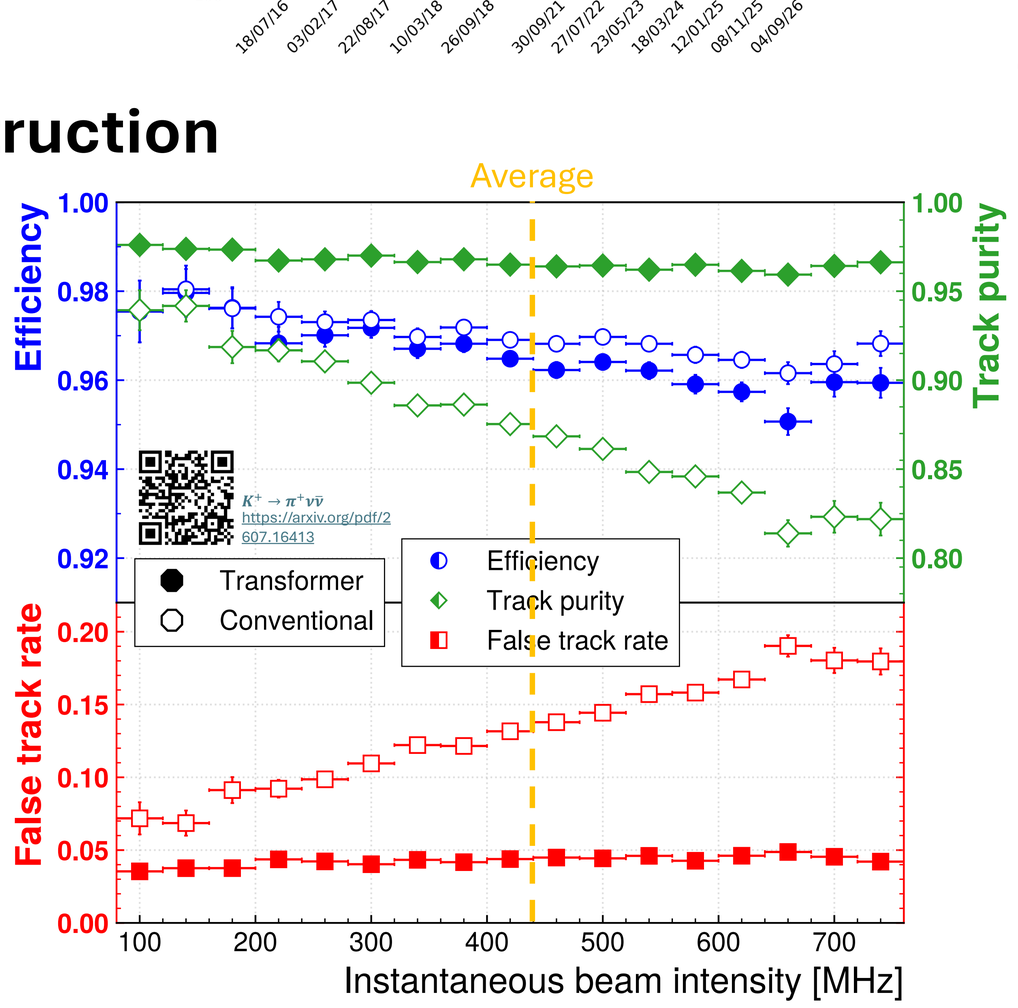
4D Track reconstruction

Step 1: clustering:
- Hits in each layer are clustered based on space and time: >90% of clusters contain 1 pixel

Step 2: track reconstruction
- Deep learning-based method developed

Step 3: track fitting
- LSF fit used to get θ_X (and θ_Y if information available from all 4 stations)





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