

The Data Acquisition System of the NA62 experiment at CERN

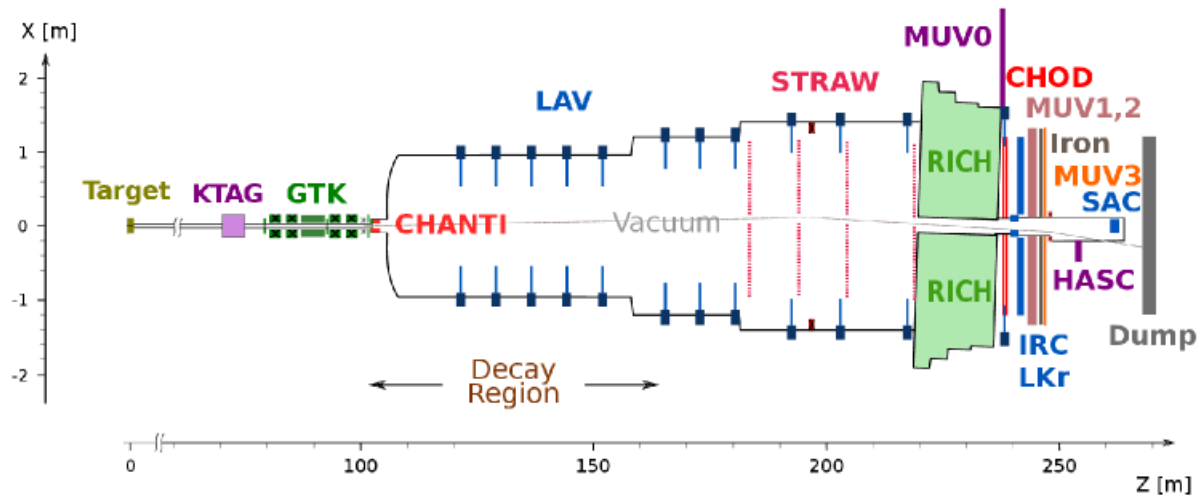
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The NA62 experimental apparatus



NA62 aims at measure the rare decay:

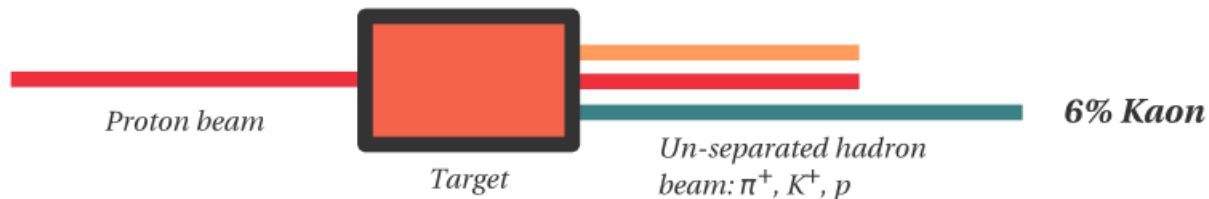
$$BR(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (0.84 \pm 0.10) \times 10^{-10}$$

- About 10^{13} Kaons decay have to be collected

Requirements:

- High intensity Kaon beam
- Efficient Data Acquisition System
- High background rejection

NA62 high intensity Kaon beam



- 400 GeV/c SPS primary **proton** beam
- 3×10^{12} protons/pulse
- 40cm berillium target

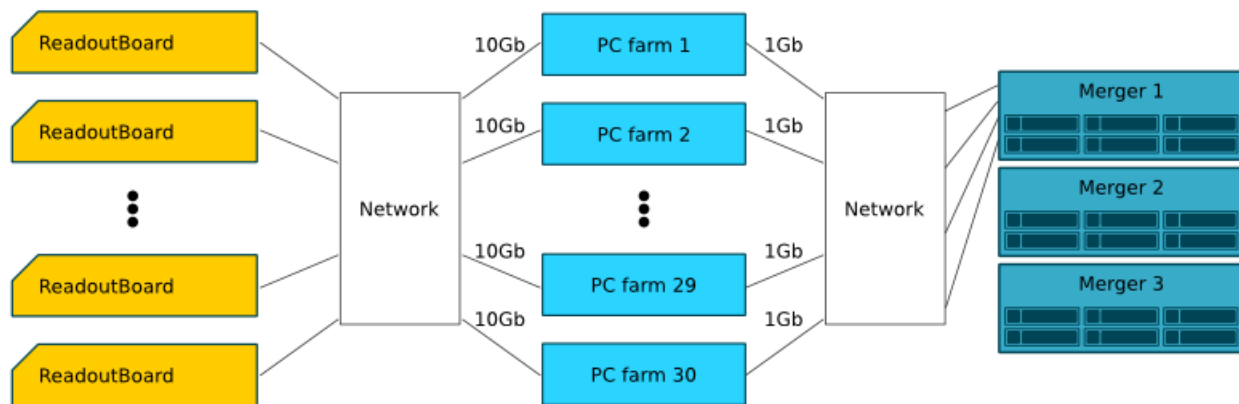
- 75 GeV/c un-separated hadron beam: **π^+ , K^+ and proton**
- 6% K^+ component



Follows the SPS cycle

- 6s beam (**burst**), 12s no-beam

The Data Acquisition System



- Each detector is composed by a variable number of boards

- 30 computers (PC farm nodes)
- 3 mergers (~15Tb storage each)

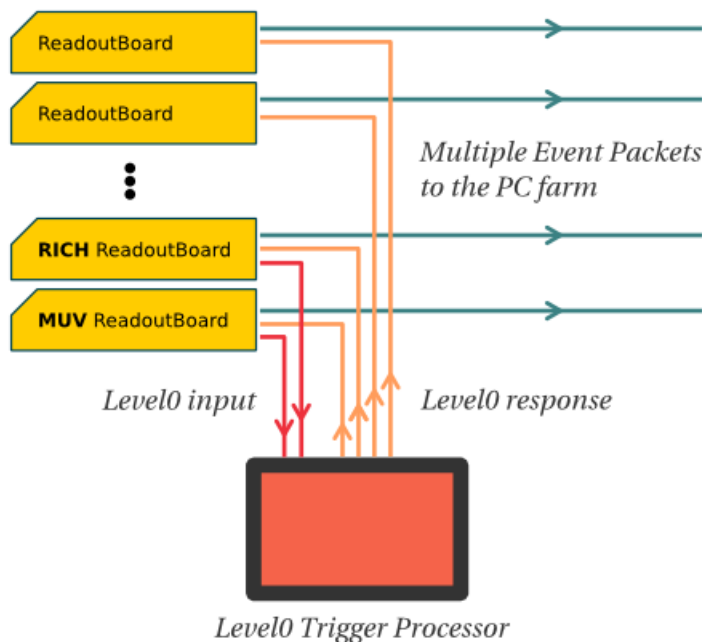
The L0 trigger

NA62 relies on a multi-level trigger system composed by:

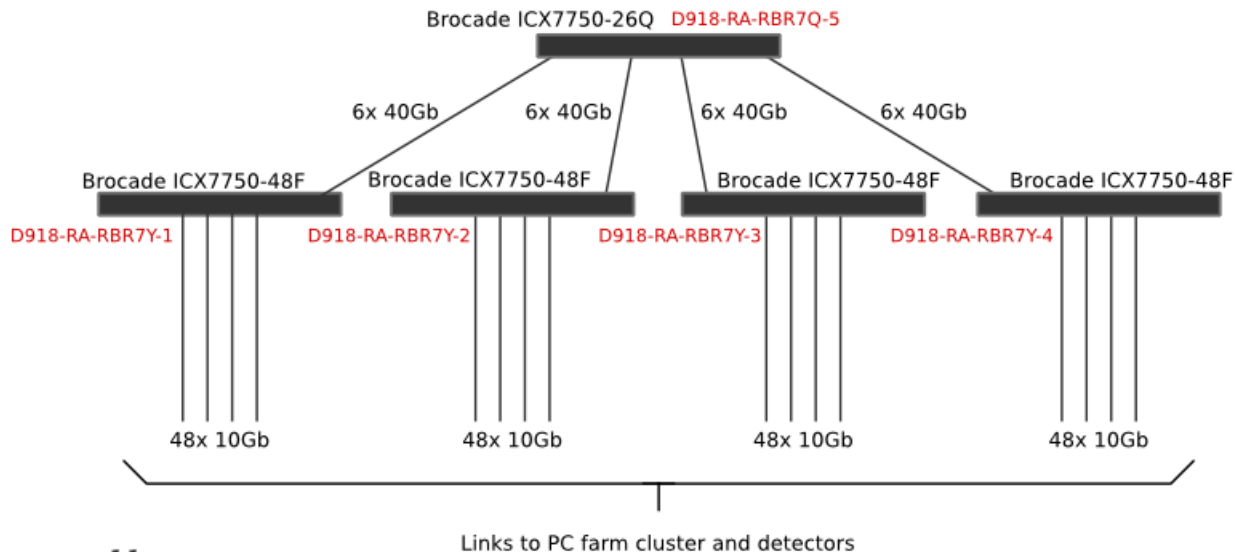
- Level0 trigger (FPGA)
- High Level Triggers (Software):
Level1 and Level2

The Level0 Trigger Processor

- Receives as input a subset of detectors (CHOD, RICH, MUV and LKR)
- Up to **10MHz** of primitives per detector in UDP packets
- Compute the response with fixed latency according to physics requirements
- Send the response to 64 sources which transfer the data to the PC farm
- Generates **~2.3M** triggers per burst



The NA62 network



Composed by:

- 4 routers with 48x10GbE and 6x40GbE ports
- 1 router with 26x40GbE ports

The PC farm software

The NA62 data acquisition software is deployed on 30 computers

- Written in C++
- Multi-threaded
- Each node handles **1/30** of the events (Round-Robin)

Level0 Triggers/burst ~2,3M

UDP Packets/burst/computer ~600K

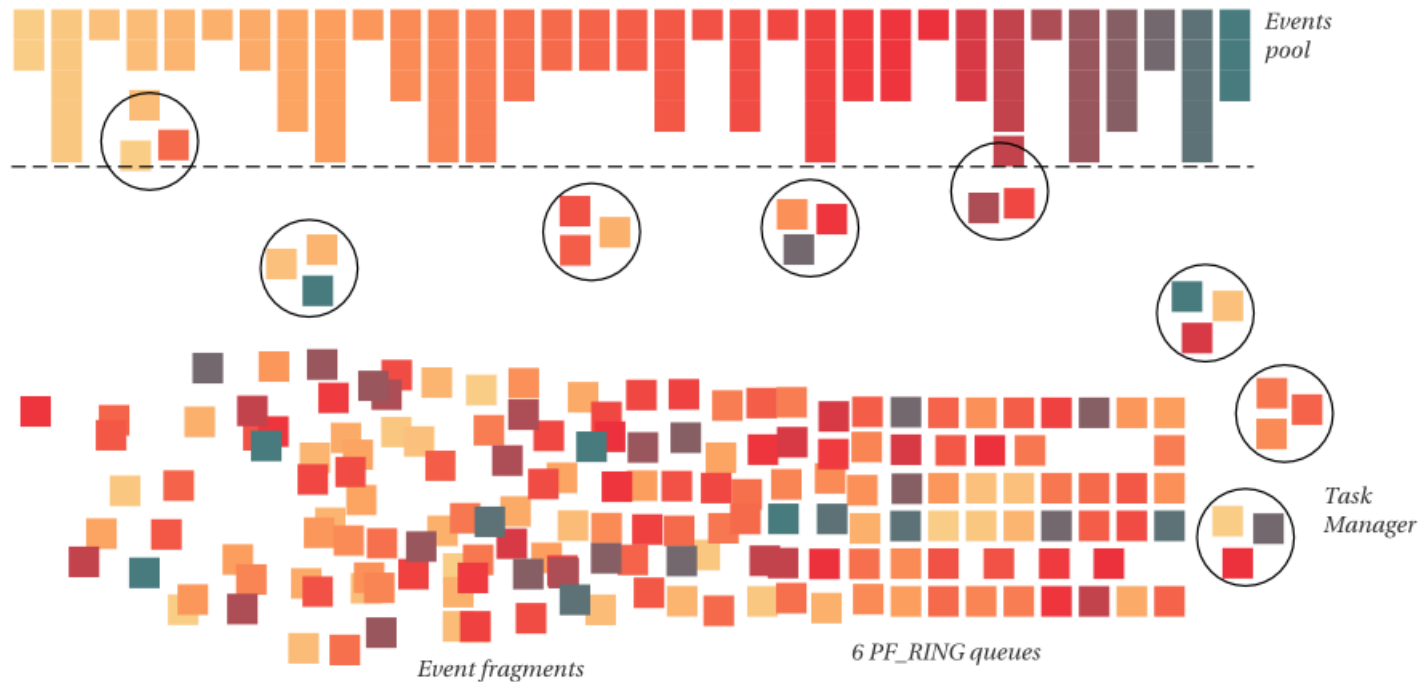
Main functions:

- Build the L1 event
- Execute the High Level Trigger Algorithms
- Send the request to complete the L2 event
- Build the L2 event
- Serialize the complete event
- Send the event to the merger

PF_RING

- Highest collection efficiency
- Direct access to the NIC (Kernel driver)
- Need to care of ARP and IP fragmentation

The PC farm software



The L1 trigger algorithms

Aim at skim events before complete them with the missing sources.

- **KTAG** trigger exploits sector multiplicity to identify Kaons
- **LAV** trigger uses hit-multiplicity, aims at reduce background identifying photons
- **STRAW** reconstruct particle tracks to reject multi-track events

**Passing the L1 Trigger ~250K events/burst
Reduction factor ~9 (combining all the physics masks)**

L1-selected events are completed with the larger missing fragments from LKR and GTK detectors.

- PC farm request the events to the 448 missing sources

UDP packets/burst/computer ~3,5M

Complete events are serialized and sent via TCP to one of the 3 Mergers in a Round-Robin way

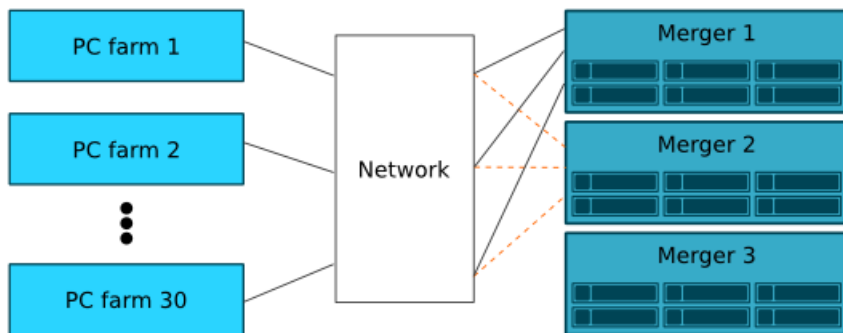
The Merger software

The NA62 merger software is deployed on 3 computers

- Written in C++
- Multi-threaded

Main functions:

- Collects the events from the 30 PC farm nodes generated during a burst
- Collects additional metrics from NA62 detectors (beam information, End Of Burst summaries..)
- Write events and metrics on file

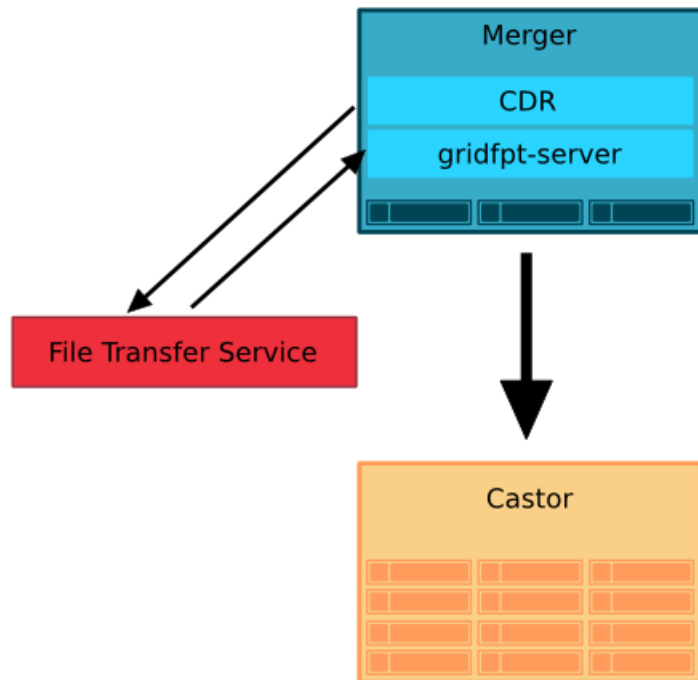


The CDR system

Designed to transfer the raw data to CASTOR. It is composed of:

- The book-keeping database and its replica
- The gridftp-server
- The CDR software

Exploit File Transfer Service the same technology used for the GRID.



Conclusions

- The PC farm software equipped with PF_RING is capable to sustain the packets rate, despite a solution based on standard tools would be easier to maintain and debug.
- The network node composed of 5 routers has been successfully commissioned in the 2016 EYETS.
- The CDR software transferred 730K raw data files on CASTOR over the 2017 run, 90% in less than a minute.
- The presented DAQ infrastructure is currently used, with minimal changes, for the 2018 run.

Outlooks

- Develop L2 algorithms to further reduce the stored events.
- Explore possible solutions to replace PF_RING.

