Mu3e Integration Run 2021

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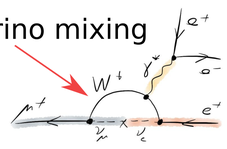
Summary

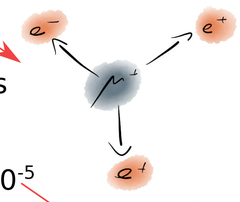
The Mu3e experiment at the Paul Scherrer Institute searches for the charged lepton flavour violating decay a of muon into two positrons and one electron. The experiment aims for an ultimate sensitivity of one in 10^{16} decays. The first phase of the experiment, currently under construction, will reach a branching ratio sensitivity of $\sim 10^{-15}$ by observing 10^8 muon decays per second over a year of data taking. The highly granular detector based on thin high-voltage monolithic active pixel sensors (HV-MAPS) and scintillating timing detectors will produce about 100 GB/s of data at these particle rates. The Field Programmable Gate Array based Mu3e Data Acquisition System will read out this data from the detector and reducing the event rate to 100MB/s by selecting possible events using a filter farm of graphics processing units. This poster presents the status of the DAQ and first results from the 2021 integration run, which for the first time operated a slice of the Mu3e detector with the πE5 muon beam line at PSI.

The Mu3e experiment

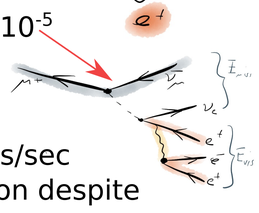
- Search for $\mu^+ \to e^+e^+e^-$
- Standard Model (SM) via neutrino mixing BR < 10^{-54}
- Observation of $\mu^+ \to e^+e^+e^-$ → Physics beyond SM



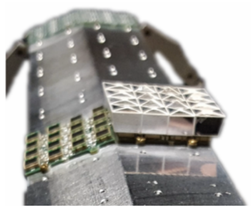
- Signal has one electron, two positrions from one vertex
- Random combinations as background from Michel decays with Bhabha scattering and photon conversion



- SM background with BR < 3.4 10^{-5} → suppress background with good vertex, timing and momentum resolution

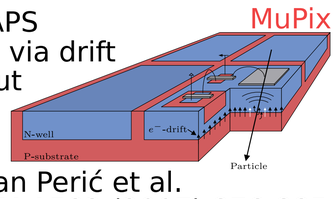


- High rates of 10^8 to 10^9 muons/sec
- Excellent momentum resolution despite low momentum of electrons → Low material budget & multiple scattering



Scintillating tile detector with time resolution of < 70 ps

- 50µm thin HV-MAPS
- Charge collection via drift
- Integrated readout electronics

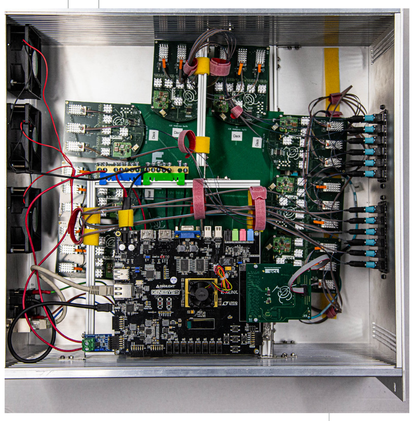


Ivan Perić et al. NIM A582 (2007) 876-885

Scintillating fibre detector with time resolution of < 500 ps

The Mu3e DAQ

15 copies of 125 MHz global clock & run transition commands

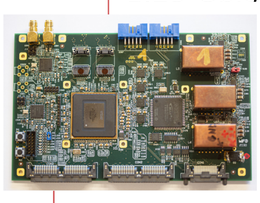


Clock & Reset System

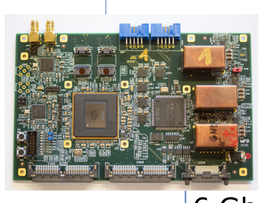
inside 1T magnet

1.25 Gbit/s LVDS Links

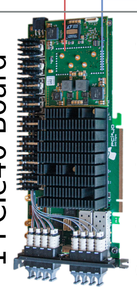
10 Front-end boards (FEBs)



2 FEBs



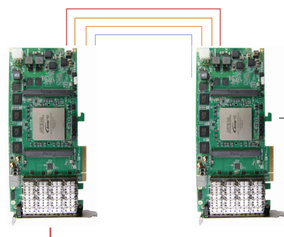
6 Gbit/s Fibre Links



1 PCIe40 Board

Cachemiche et al., JINST 11 (2016)

10 Gbit/s Fibre Links



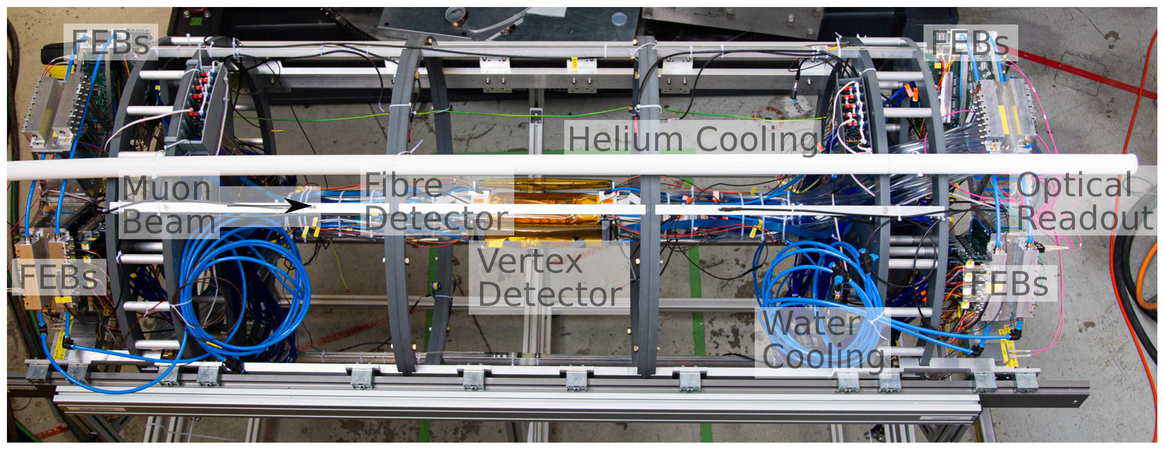
2 Terasic DE5

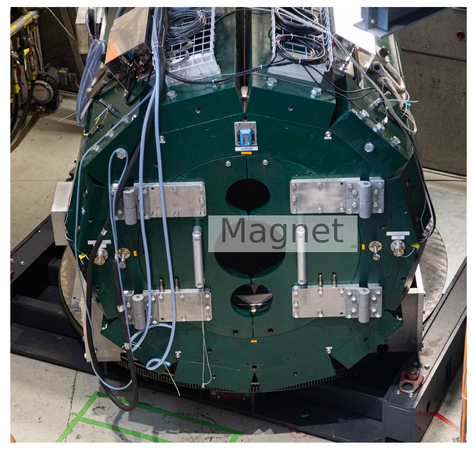
Ethernet

https://www.terasic.com
Filter Farm FPGA Boards

MIDAS Data Collection
https://midas.triumf.ca

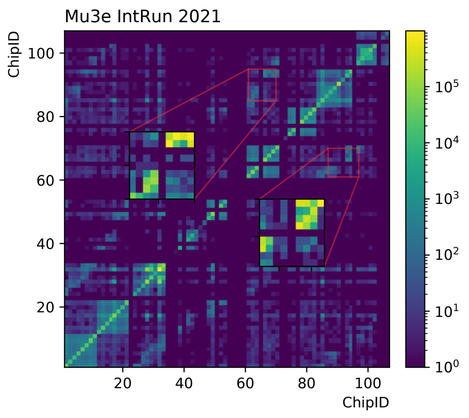
Integration Setup



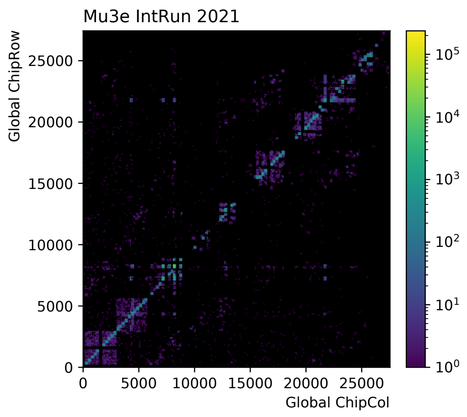


First Results

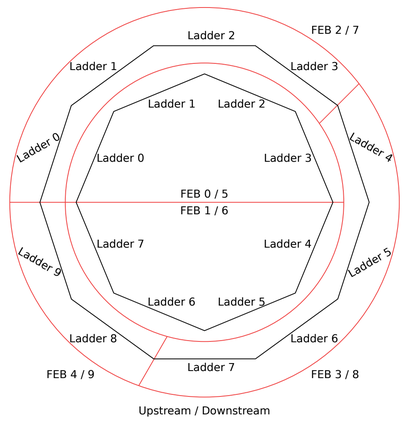
Vertex Detector
space correlation w/o magnet



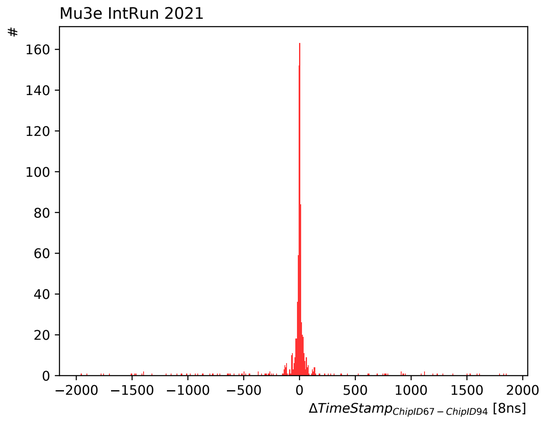
Vertex Detector
chip to chip shadow map w/o magnet



Vertex Detector
geometry

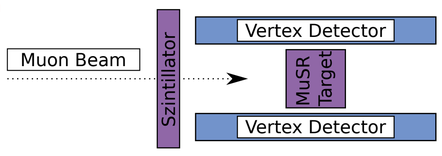


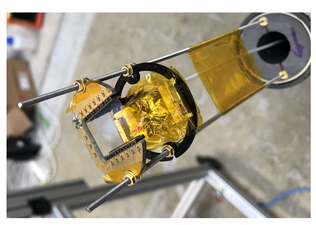
Vertex Detector
time correlation w/o magnet



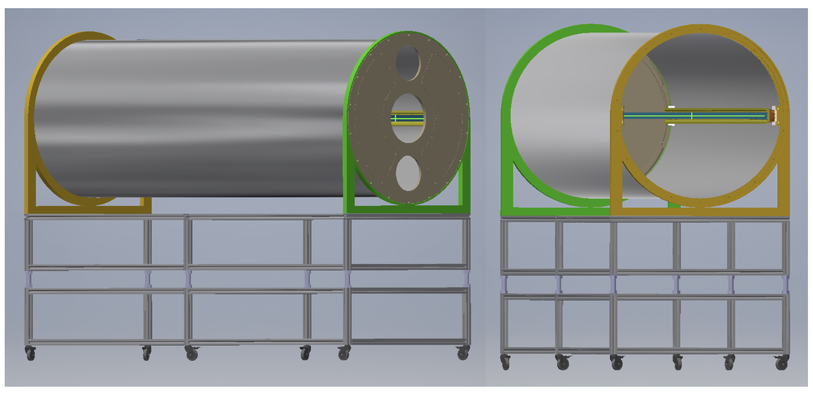
- Space and time correlations inside the vertex detecor
- Detector readout works for multiple Front-end boards
- First time working readout via the PCIe40 board

MuSR Setup





Outlook



- Cage at PSI for detector tests
- Integration run planned for 2022
- Integration of scintillating detectors

www.psi.ch/mu3e

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