

The MuX Project

Setup / DAQ / Analysis/ ...

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muX Detector setup



muX Detector setup

Detectors

- 2 μ scintillators
- 4 e- scintillators
- 9 coaxial HPGe detectors (60-75 %)
- 1 MiniBall cluster
- 2 low energy HPGe detectors
- 2+ BGO shields

tE1 area

- ### DAQ
- 2 digitizers @ 250 MHz
 - MIDAS DAQ
 - MIDAS Slow Control
 - Online analysis
 - Data backup

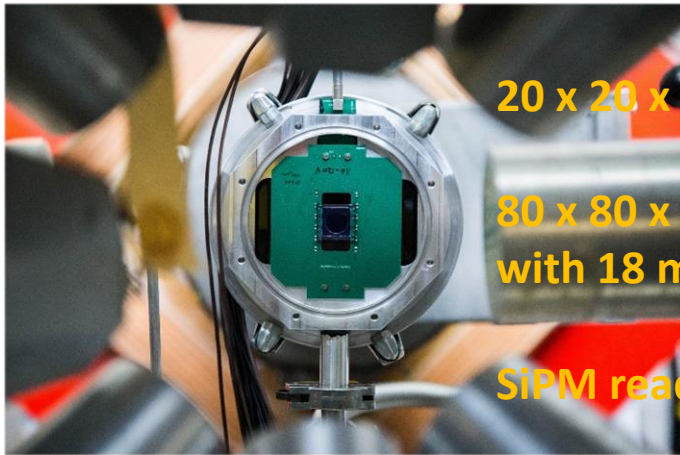
10-100 kHz μ
@ 20-40 MeV/c

Control Room

- Automatic offline analysis
- Data quality monitoring

muX Detector setup

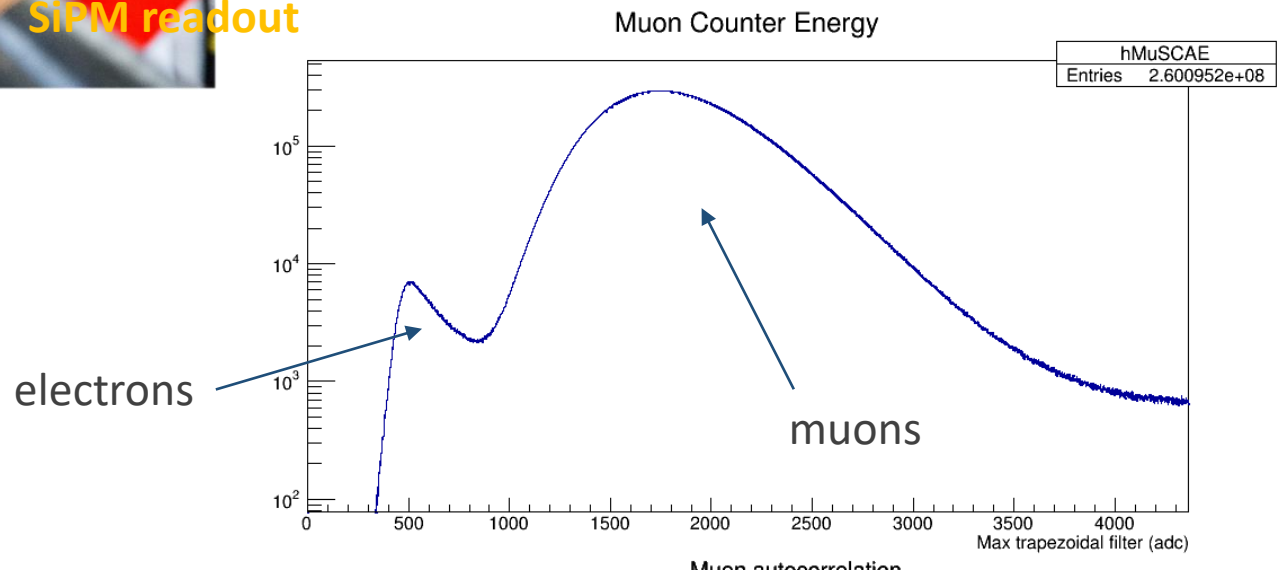
Muon entrance counter defines $t=0$



20 x 20 x 0.20 mm beam counter

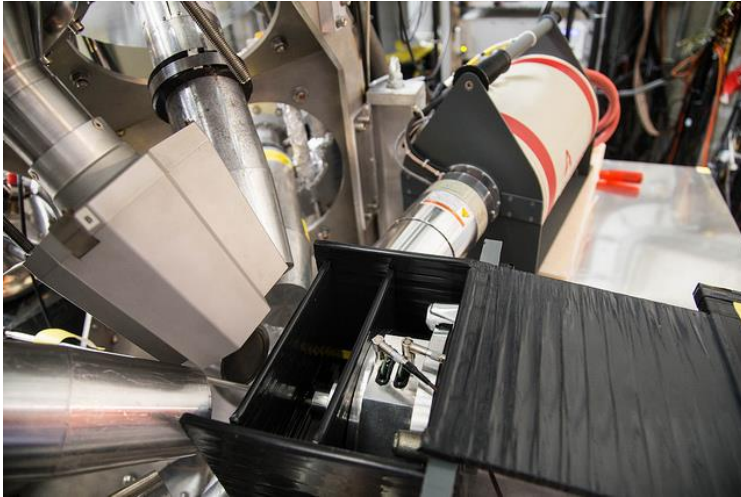
80 x 80 x 4 mm veto counter
with 18 mm hole

SiPM readout



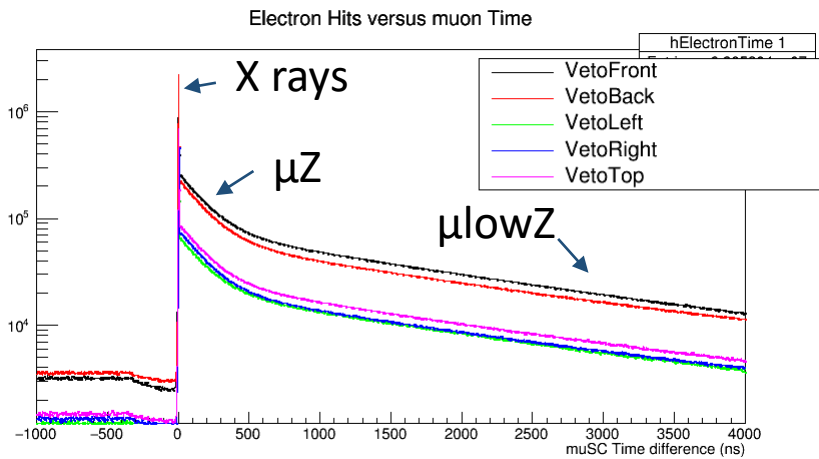
muX Detector setup

Electron Veto scintillators see the Michel electron with $\approx 100\%$ efficiency

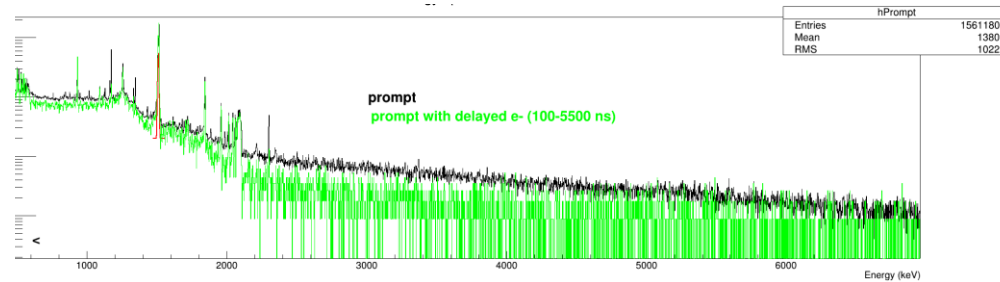


With these detectors you can

- Veto high energy Michel electrons
- Lifetime of the muonic atoms (e.g. μD decay)
- Veto capture events
- ...



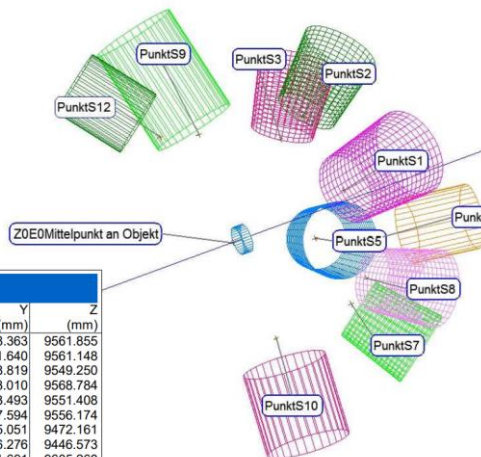
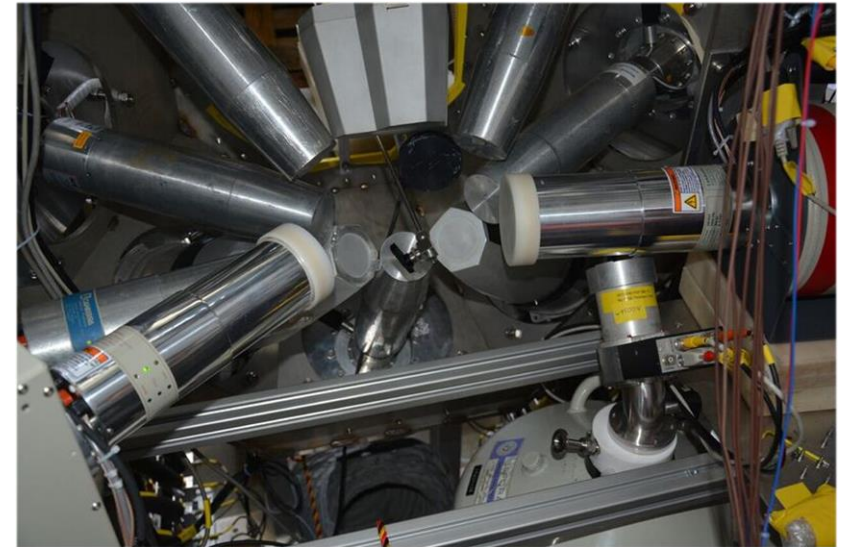
μZ decay in orbit \rightarrow no muon captures



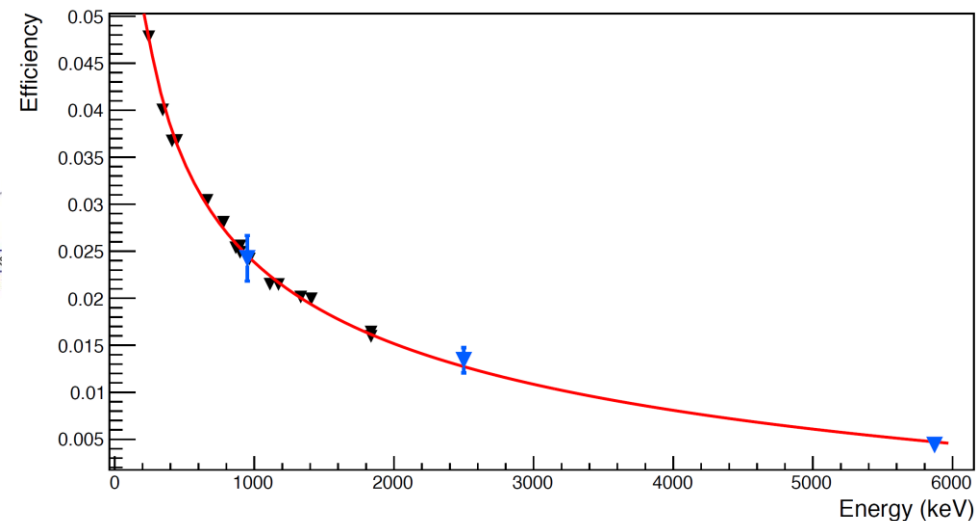
muX Detector setup

HPGe detector array

- 7 French/UK loan pool (60%)
 - 1 MiniBall Clusters (GeIA/GeIB/GeIB)
 - PSI 70 %
 - KuLeuven 70 %
 - ETH 15 %
 - PSI low energy (10%?)
- Moveable frame
 - Largely backward angles
 - 10-12 cm target-detector distance
 - \pm positioning, but well measured
 - ~ 3 keV FWHM energy resolution



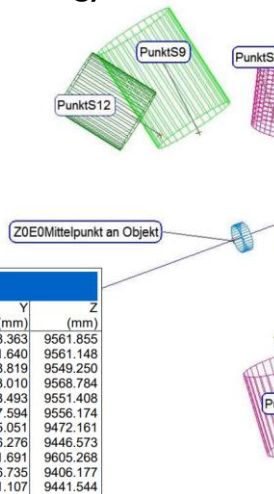
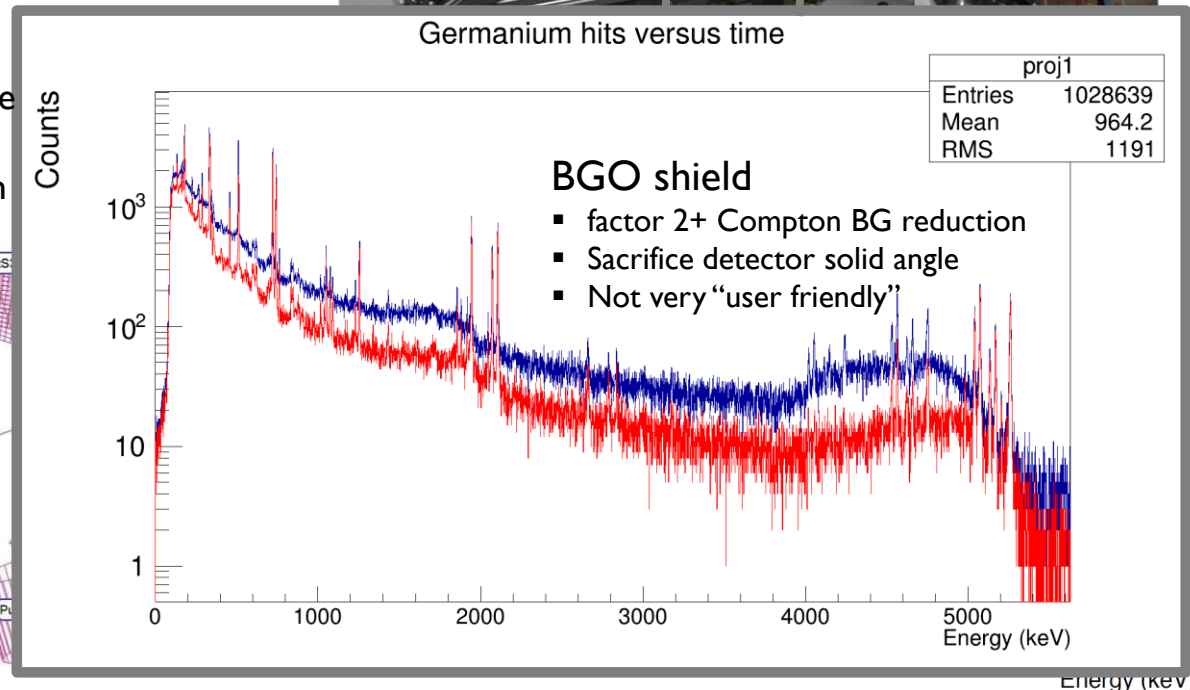
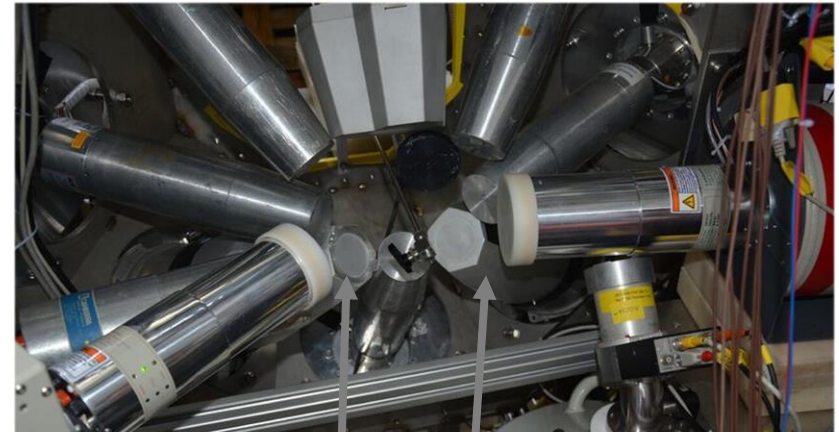
Punktgruppe 20180723:calc			
Punktname	X (mm)	Y (mm)	Z (mm)
PunktS1	0.798	69.363	9561.855
PunktS2	98.440	41.640	9561.148
PunktS3	94.961	-28.819	9549.250
PunktS5	-8.853	-113.010	9568.784
PunktS7	-105.366	-33.493	9551.408
PunktS8	-95.858	37.594	9556.174
PunktS9	135.930	-55.051	9472.161
PunktS10	-116.996	-6.276	9446.573
PunktS11	-51.745	-1.691	9605.268
PunktS12	136.211	16.735	9406.177
Z0E0Mittelpunkt an Objekt	-0.300	-1.107	9441.544



muX Detector setup

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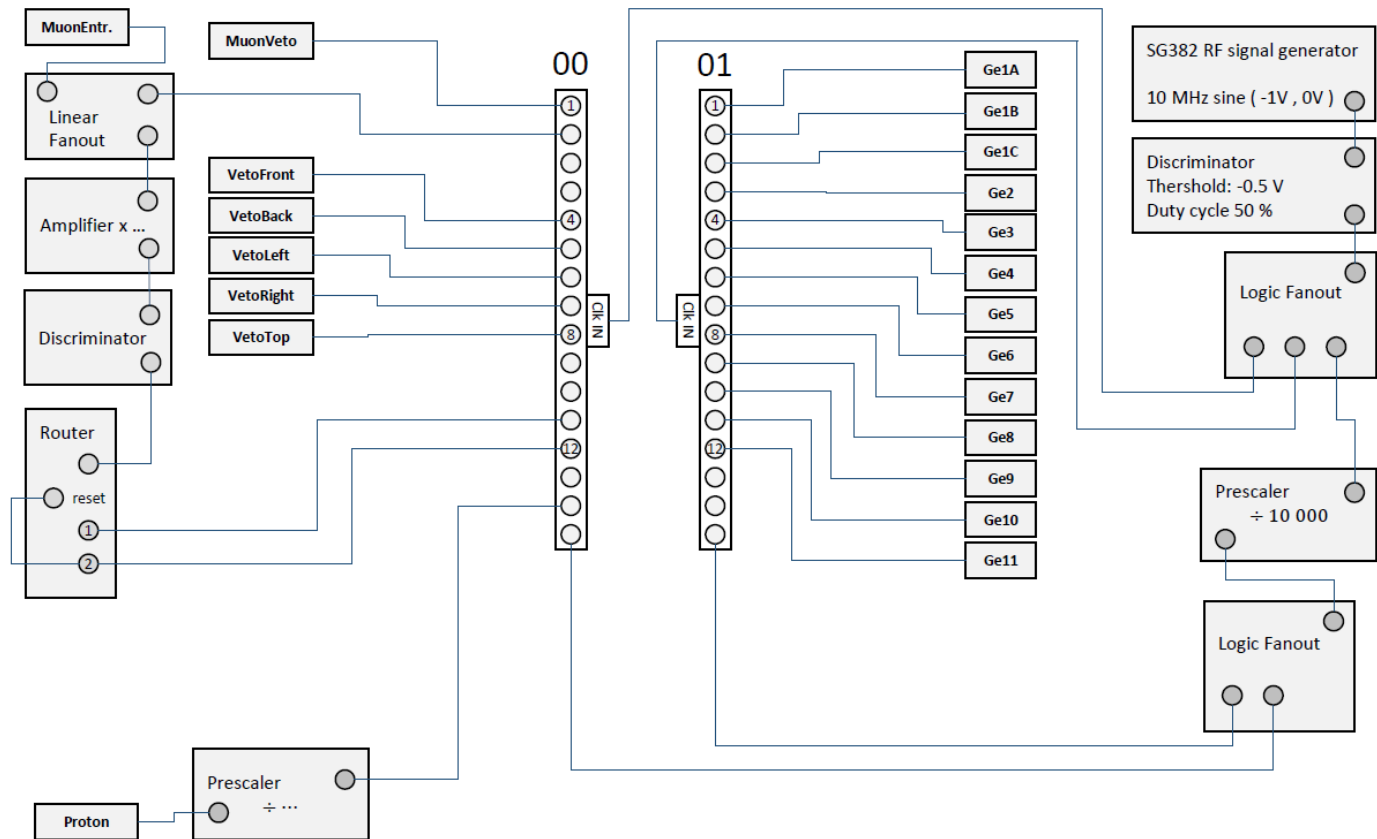
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readout

2 x 250 MHz digitizers (Struck SIS3316)



Individual triggering channels



2018: +2 x HPGe + 2 x BGO

readout

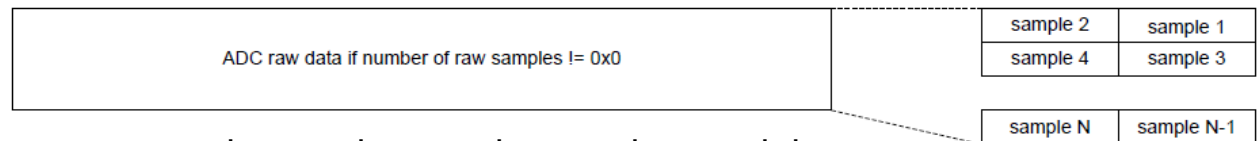
2 x 250 MHz digitizers (Struck SIS3316)



Timestamp [47:32]		Channel ID	Format bits
Timestamp [31:16]		Timestamp [15:0]	
Index of Peakhigh value [15:0]		Peakhigh value [15:0]	
Information [7:0]	Accumulator sum of Gate 1 [23:0]		
"0000"	Accumulator sum of Gate 2 [27:0]		
"0000"	Accumulator sum of Gate 3 [27:0]		
"0000"	Accumulator sum of Gate 4 [27:0]		
"0000"	Accumulator sum of Gate 5 [27:0]		
"0000"	Accumulator sum of Gate 6 [27:0]		
"0000"	Accumulator sum of Gate 7 [27:0]		
"0000"	Accumulator sum of Gate 8 [27:0]		
"0000"	MAW maximum value [27:0]		
"0000"	MAW value before Trigger [27:0]		
"0000"	MAW value after/with Trigger [27:0]		
Start Energy value (Energy value from first value of Trigger Gate)			
Max. Energy value (during Trigger Gate active)			

If Format bit 0 = 1
 If Format bit 1 = 1
 If Format bit 2 = 1
 If Format bit 3 = 1

31-28	27	26	25-0
0xE	MAW Test Flag	Status Flag	number of raw samples (x 2 samples, 32-bit words)



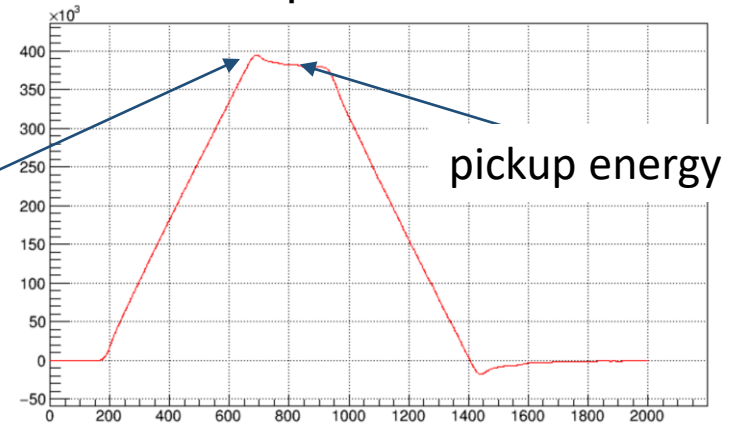
Frontend software extracts these packages and writes them to disk
 Minor data processing possible on the fly

readout

2 x 250 MHz digitizers (Struck SIS3316)



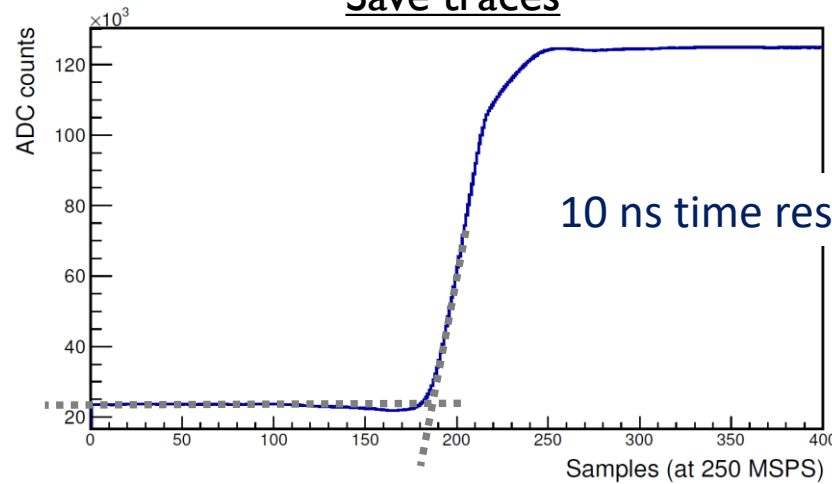
Trapezoid filter



preamp overshoot

pickup energy

Save traces



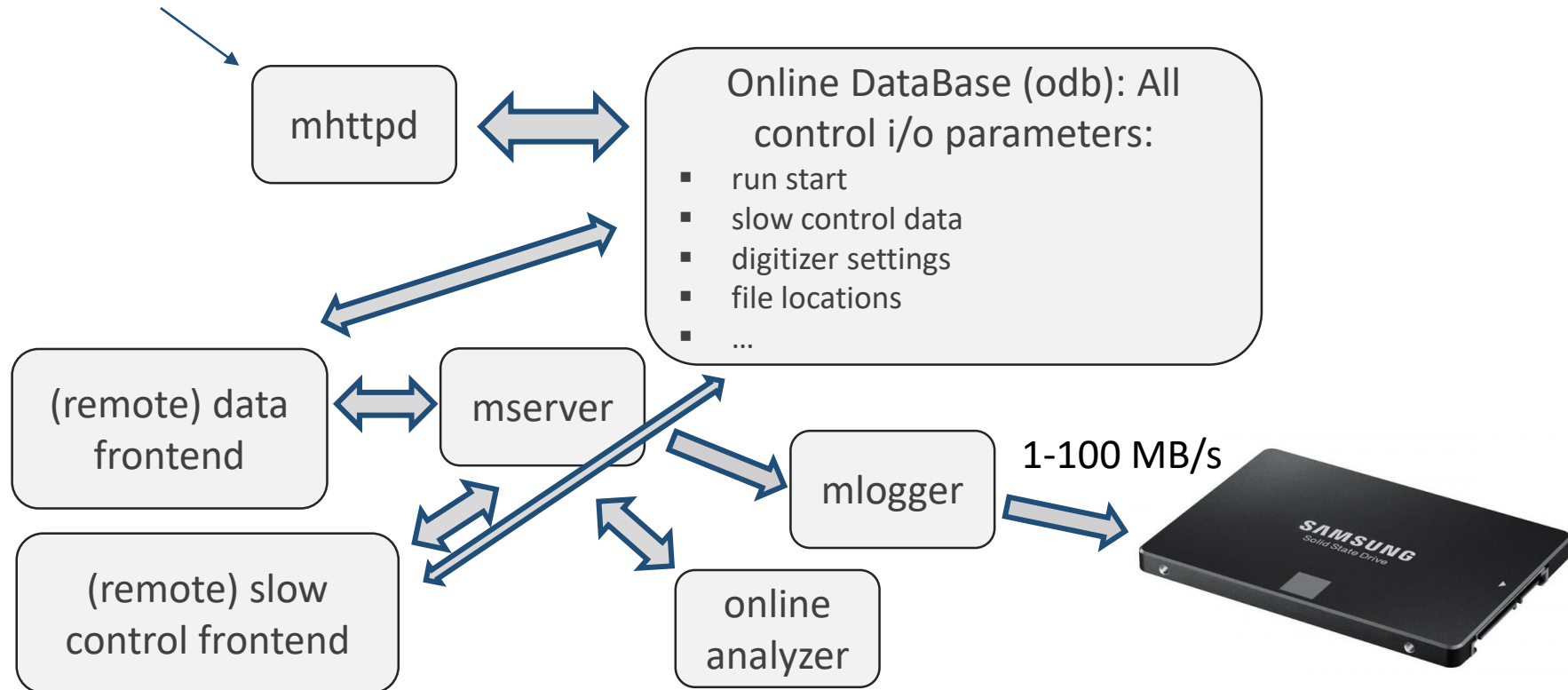
(first order time from trigger filter)

10 ns time resolution

Midas DAQ

Full Midas DAQ https://midas.triumf.ca/MidasWiki/index.php/Main_Page

- Core developed and supported @ PSI (Stefan Ritt)
- Widely in use (MEG, Mu3e, g-2, muX, T2K, ...)
- Maximal integration, modular
- https interface → can control the DAQ from anywhere

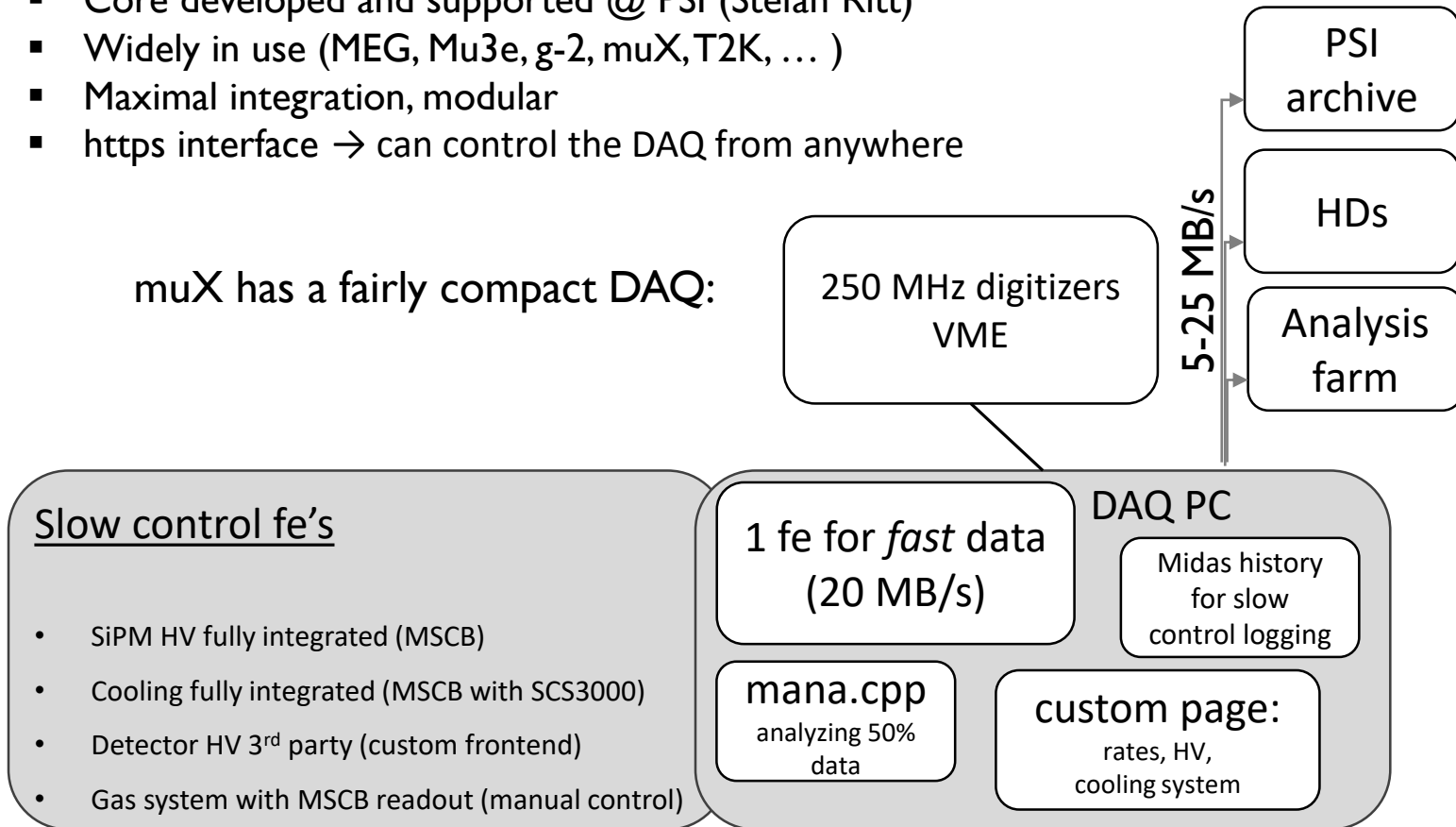


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muX has a fairly compact DAQ:



Midas DAQ

Web Interface: default pages

The screenshot shows a web browser window with the URL `https://frederik-aspire-v3-572:8443`. The interface has a sidebar menu on the left with items: Status, Start, Transition, ODB, Messages, Chat, Elog, Alarms, Programs, History, MSCB, Sequencer, Example, Help, Config, TriggerStats, Autofill, and Trend. The main content area displays four panels:

Run Status

Run 8065 Start: Tue Jun 5 15:42:53 2018 Stop: Mon Jun 4 17:28:10 2018
Stopped Alarms: On Restart: Off Logger not running

1541243362 12:09:22.497 2018/11/03 [ODBEEdit,INFO] Program ODBEdit on host localhost stopped

Equipment

Equipment +	Status	Events	Events[/s]	Data[MB/s]
Trigger	Frontend stopped	3	0.0	0.000
SCS-2000	Frontend stopped	0	0.0	0.000
SiPM_HV	Frontend stopped	1	0.0	0.000
Pos_HV	Frontend stopped	1	0.0	0.000
Autofill A	Frontend stopped	1	0.0	0.000
Autofill B	Frontend stopped	1	0.0	0.000

Logging Channels

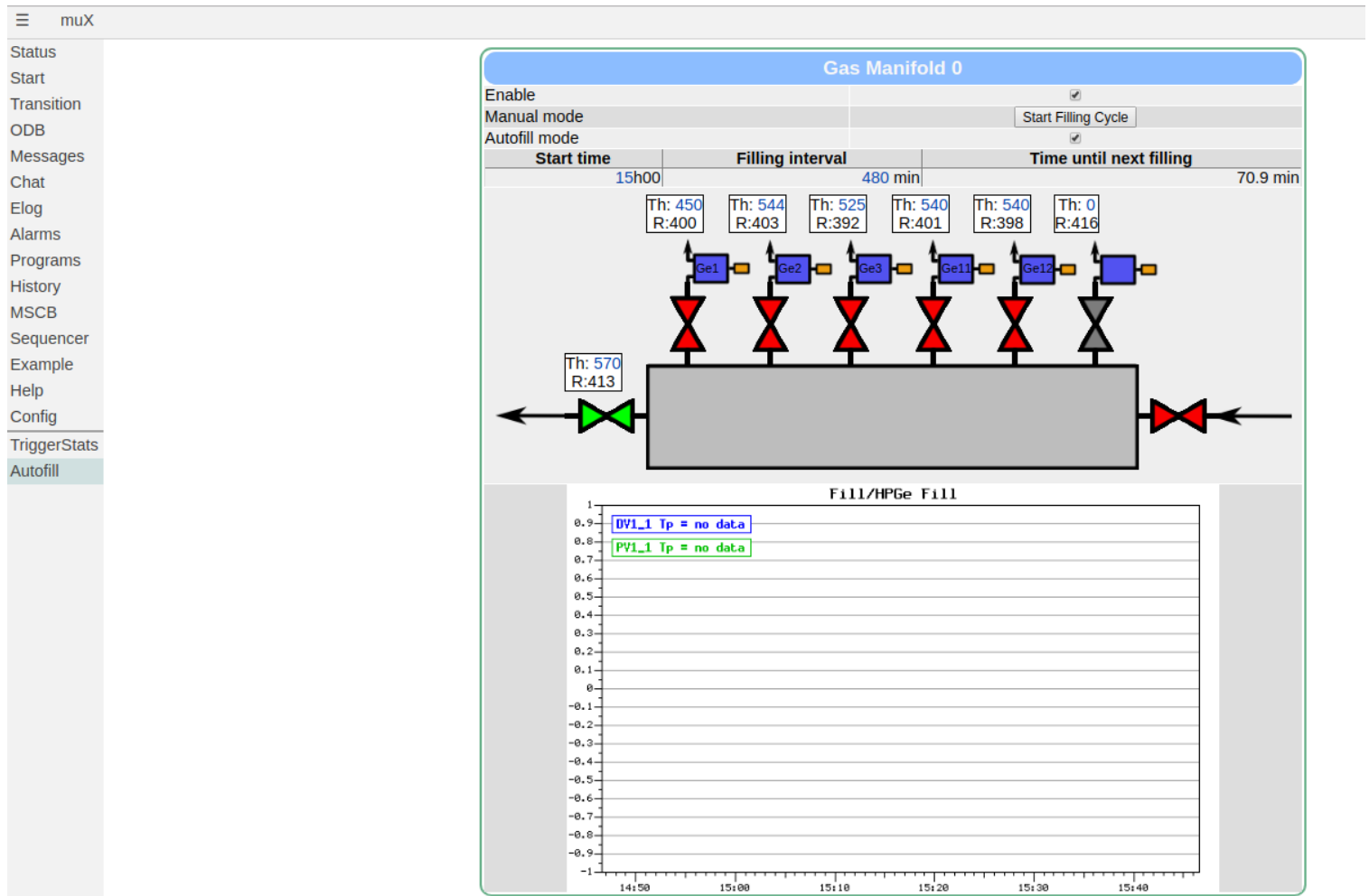
Channel	Events	MB written	Compr.	Disk Level
#0:	0	0.000	0.0%	0.0%
Lazy Label	Progress	File Name	# Files	Total

Clients

mhttpd [localhost]

Midas DAQ: slow control

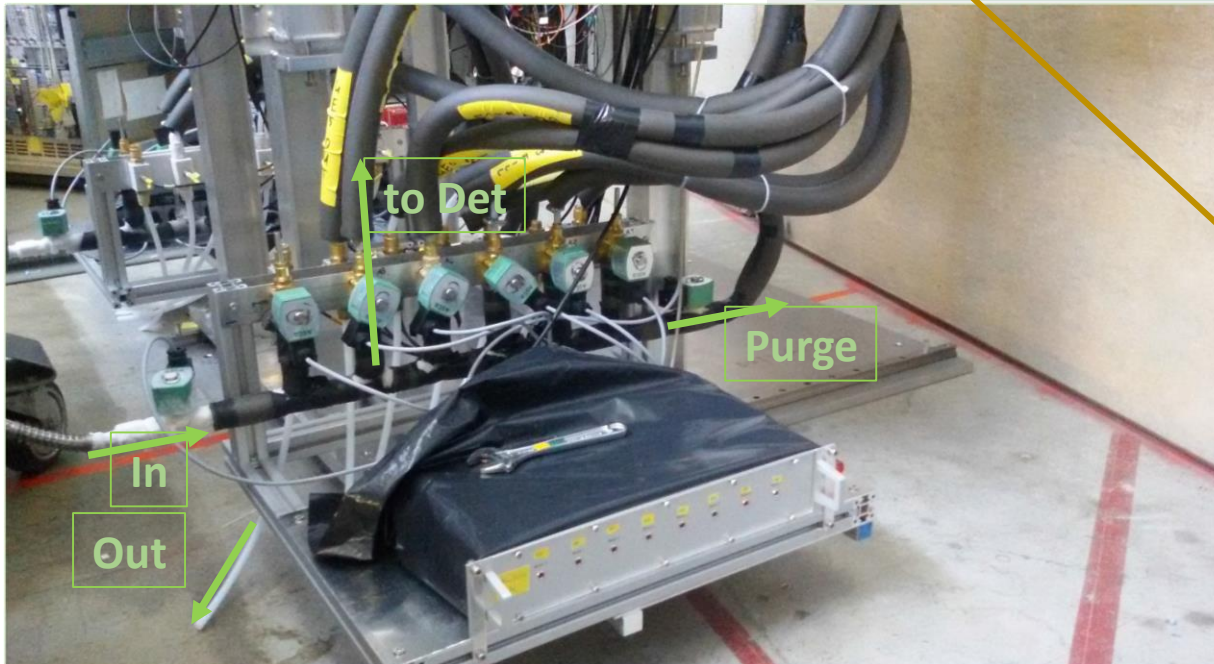
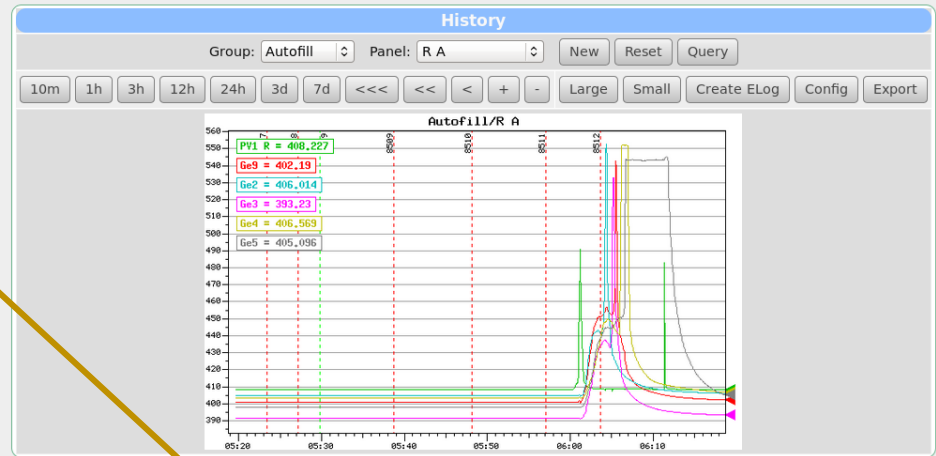
Web Interface: Custom user pages (display whatever you want)



Midas DAQ: slow control

Cooling system:

- Based on MiniBall system (Elisa)
- 8h Filling cycles, control by hardware
- MSCB interface + muX GUI



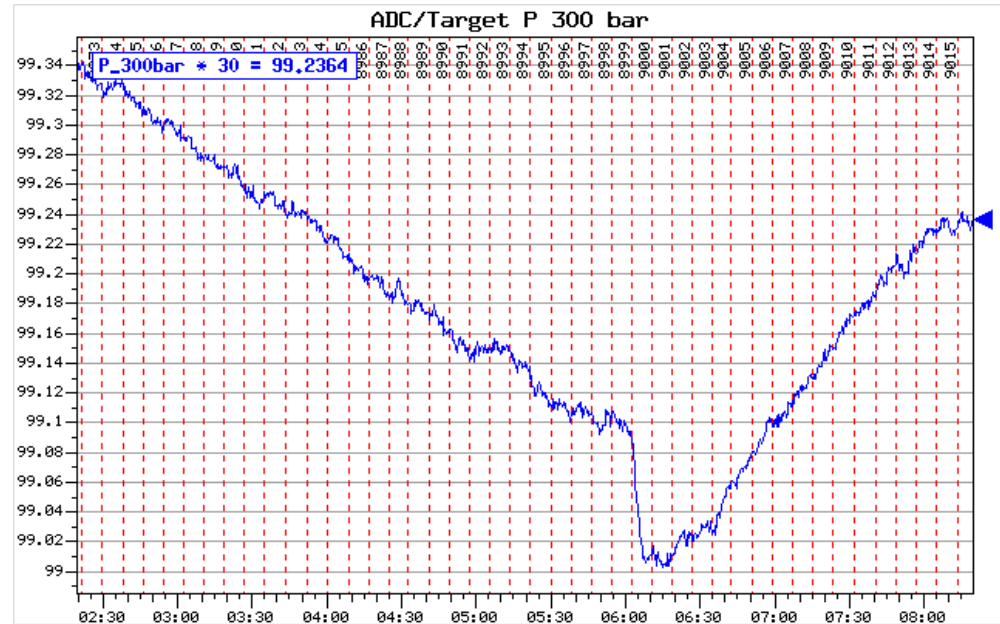
Midas DAQ: slow control

Gas system:

- Only monitoring
- Pressure and temperature

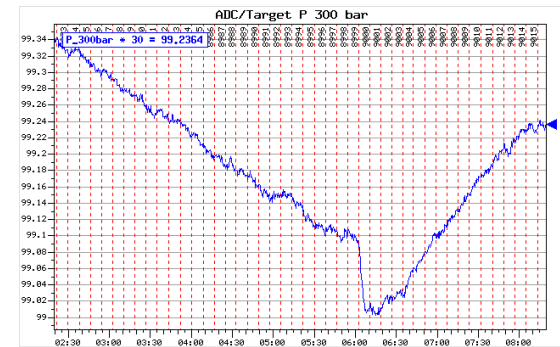
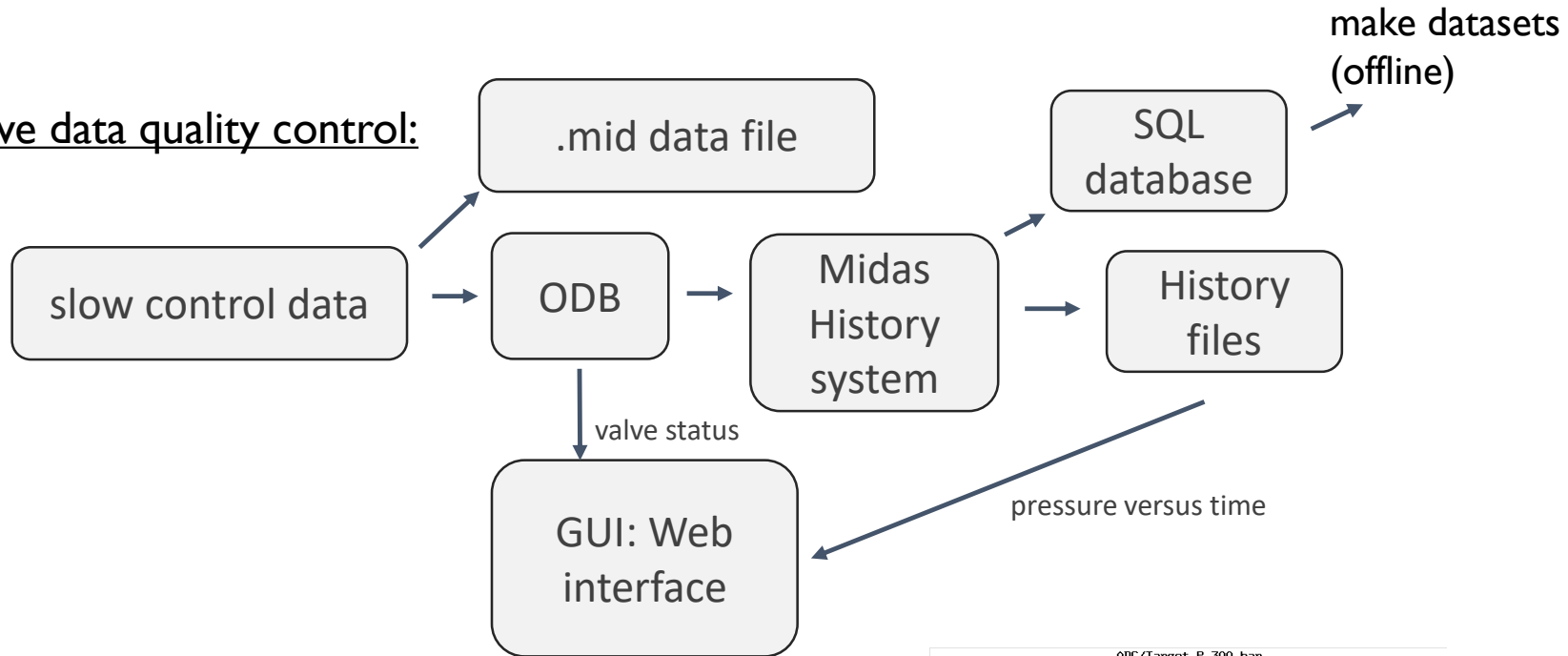
More:

- HPGe HV control
+ current/HV monitoring
- SiPM HV + current/HV monitoring
- Ambient temperature
- ...

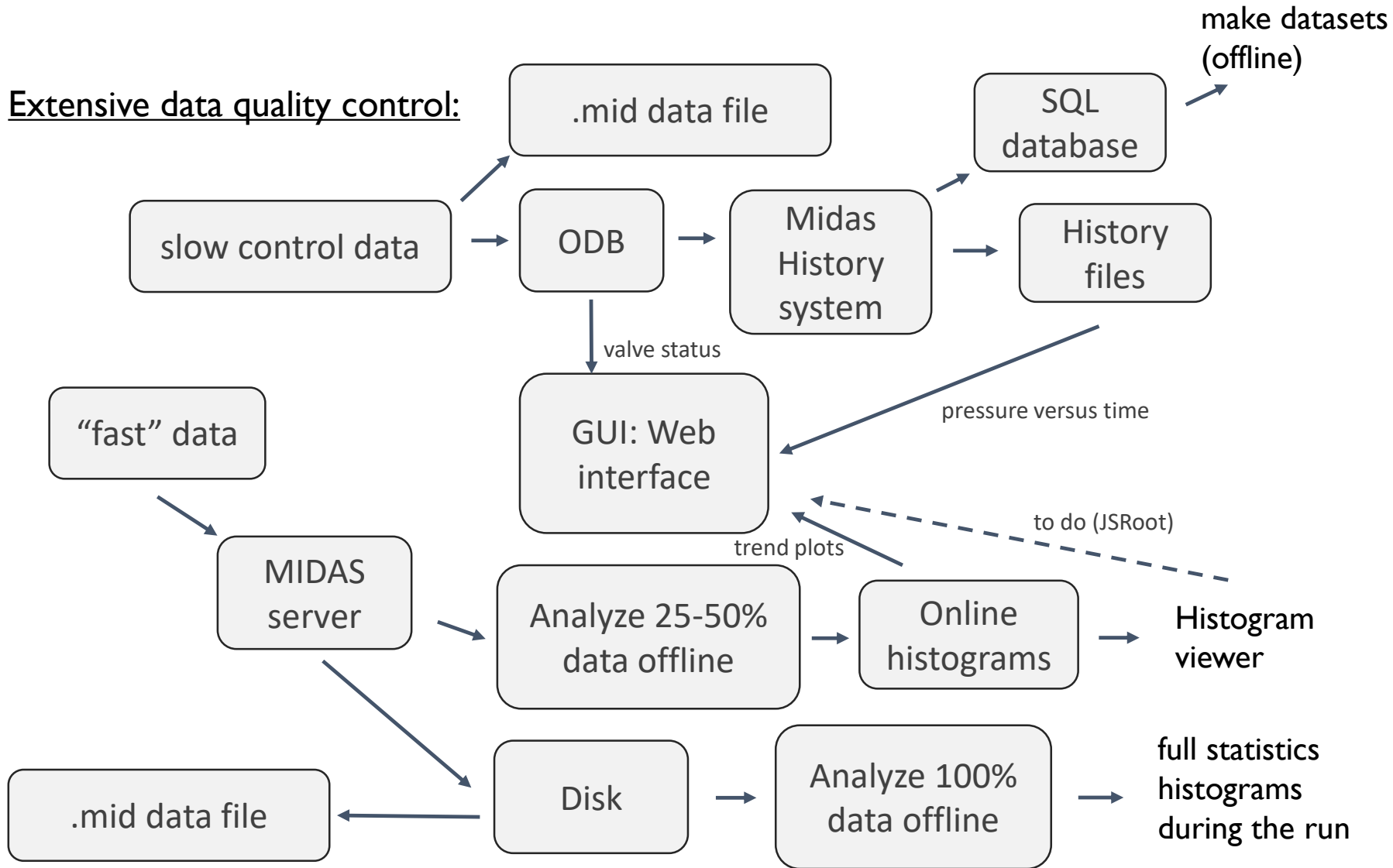


Midas DAQ: monitoring

Extensive data quality control:



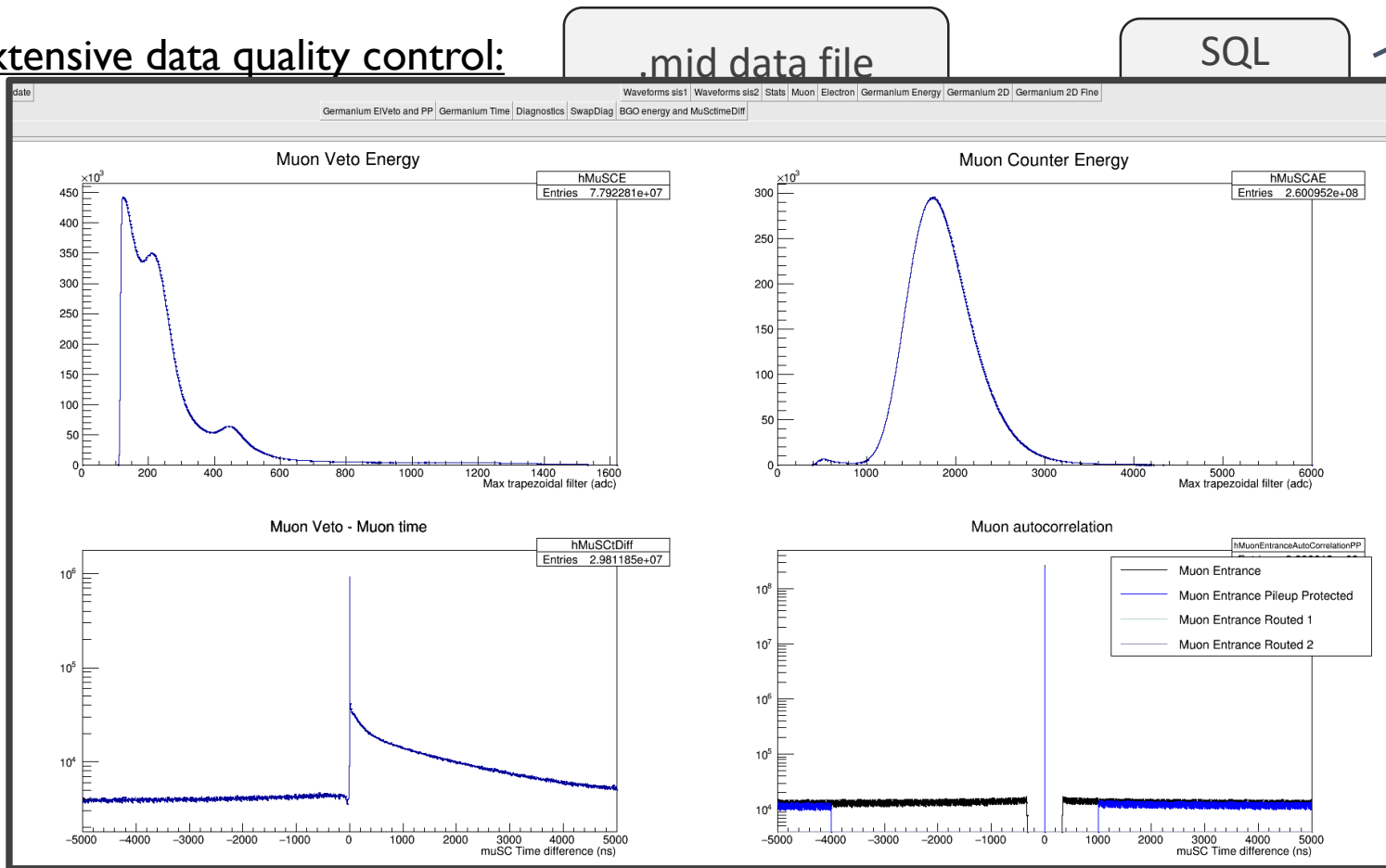
Midas DAQ: monitoring



Midas DAQ: monitoring

Extensive data quality control:

make datasets
(offline)



Disk

data offline

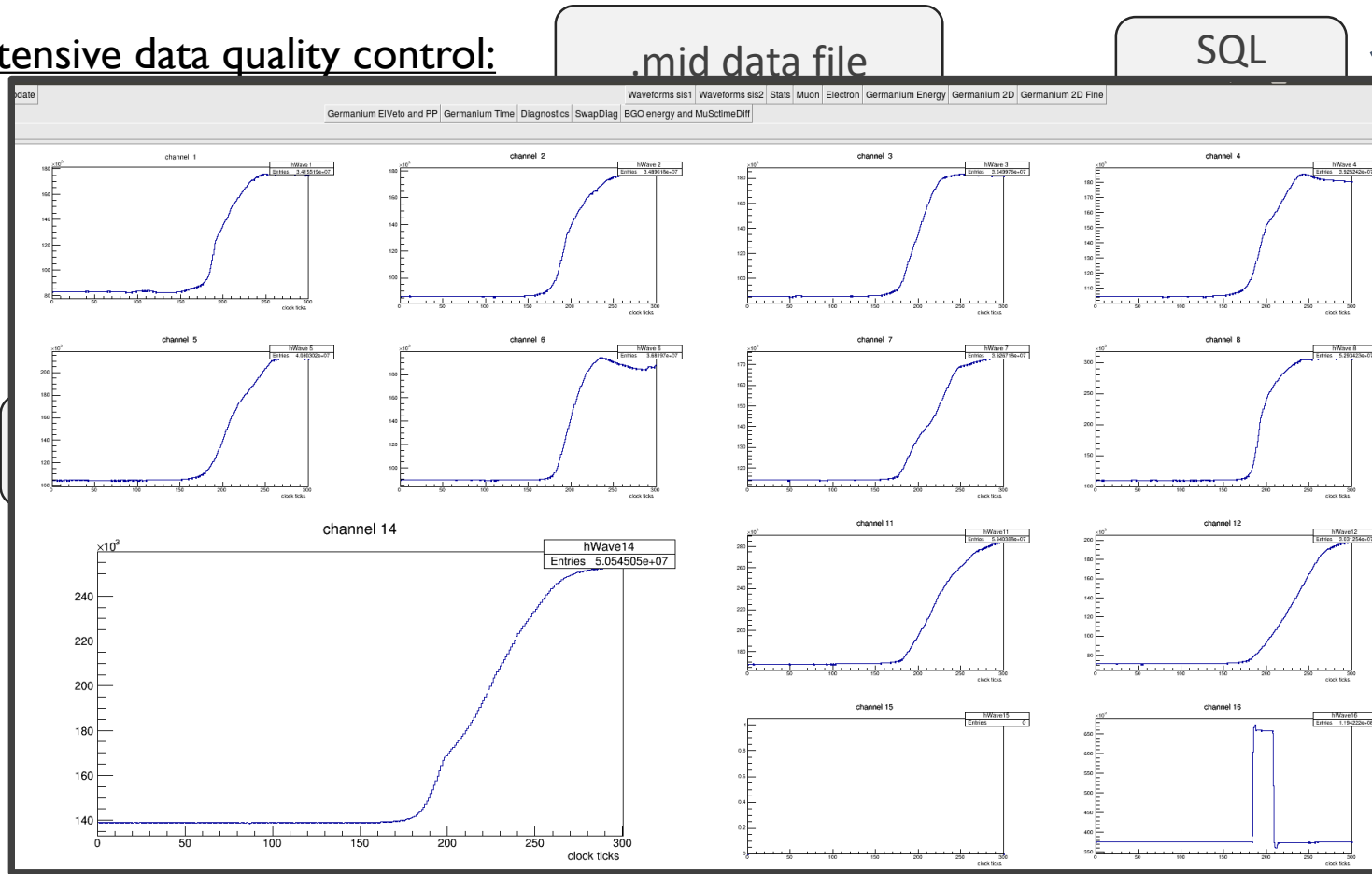
histogram
power

statistics
histograms
during the run

Midas DAQ: monitoring

Extensive data quality control:

make datasets
(offline)



.mid data file

SQL

Disk

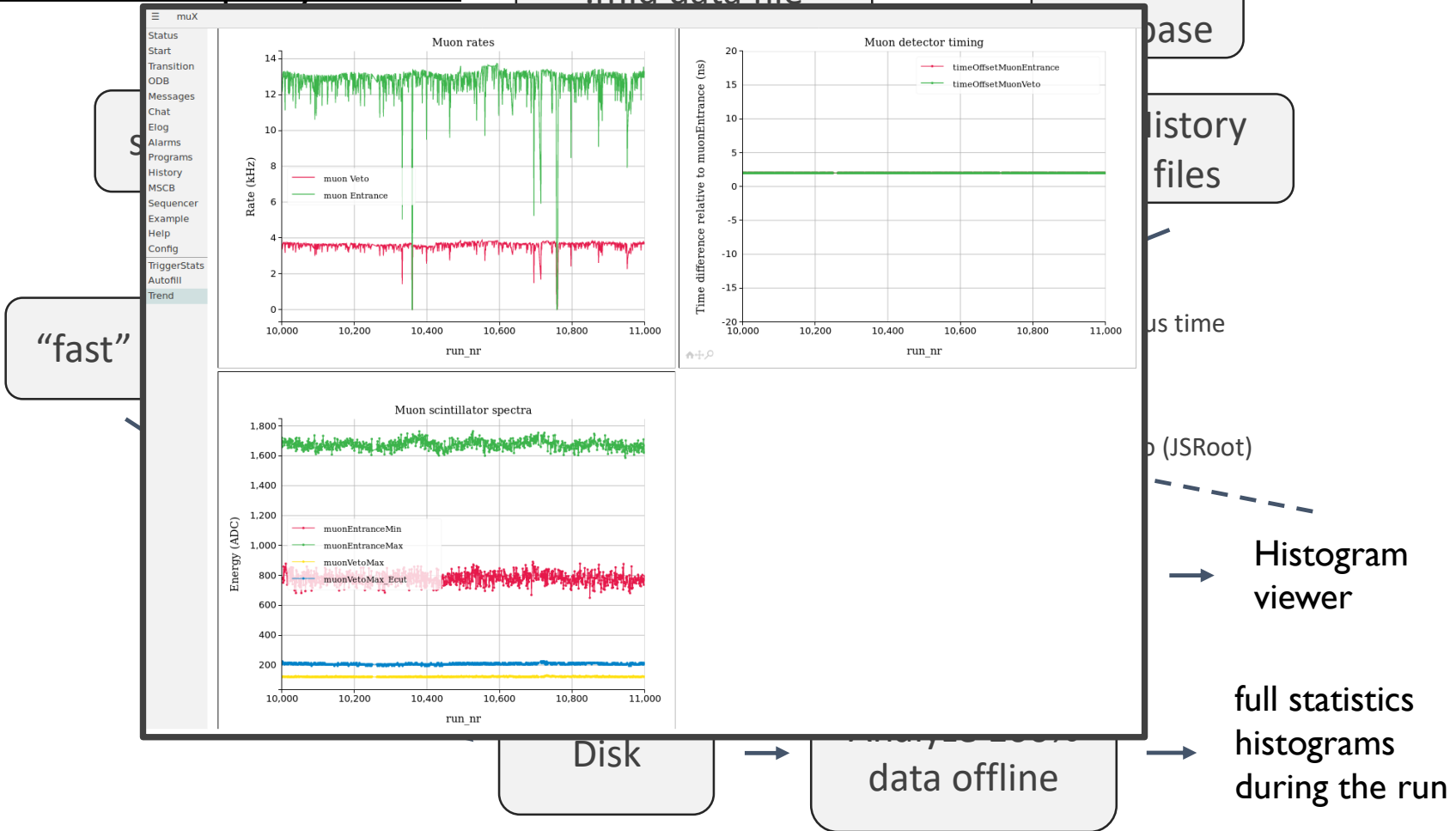
data offline

histogram
lower

statistics
histograms
during the run

Midas DAQ: monitoring

Extensive data quality control:



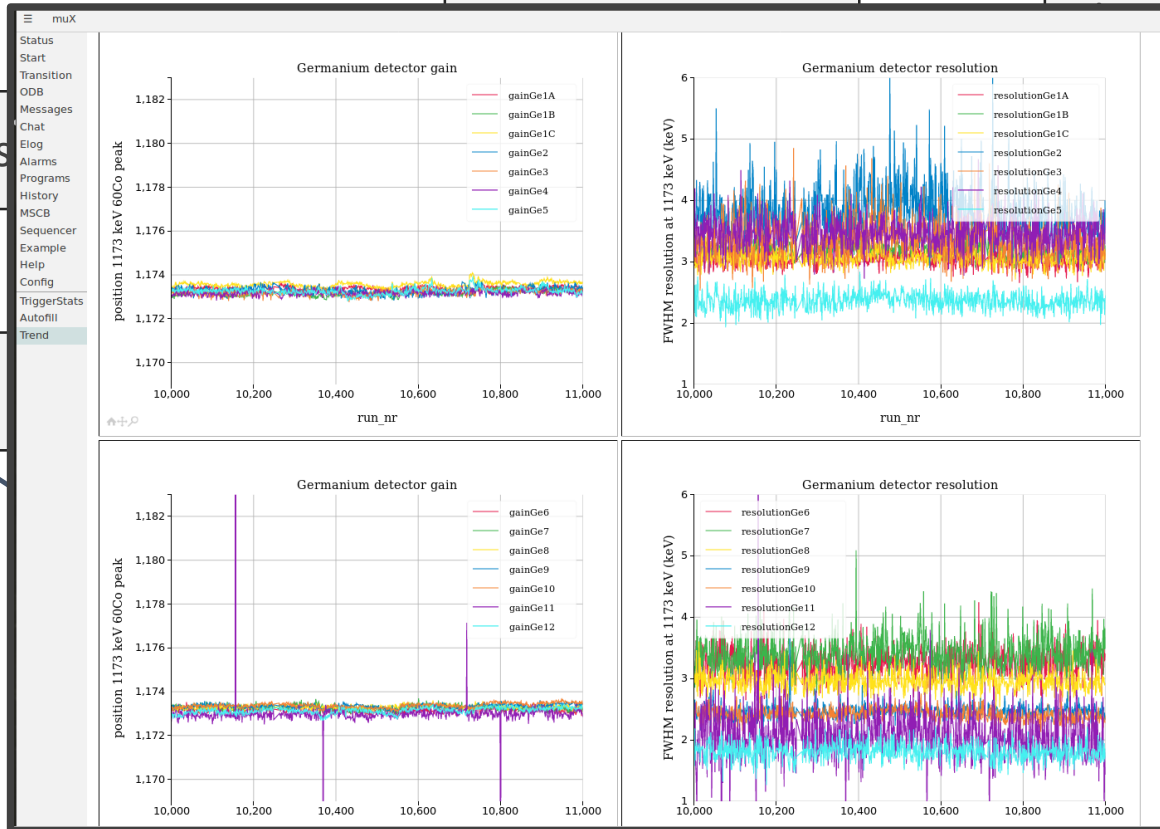
Midas DAQ: monitoring

Extensive data quality control:

make datasets
(offline)

.mid data file

SQL
base



"fast"

History
files

us time

(JSRoot)

Histogram
viewer

full statistics
histograms
during the run

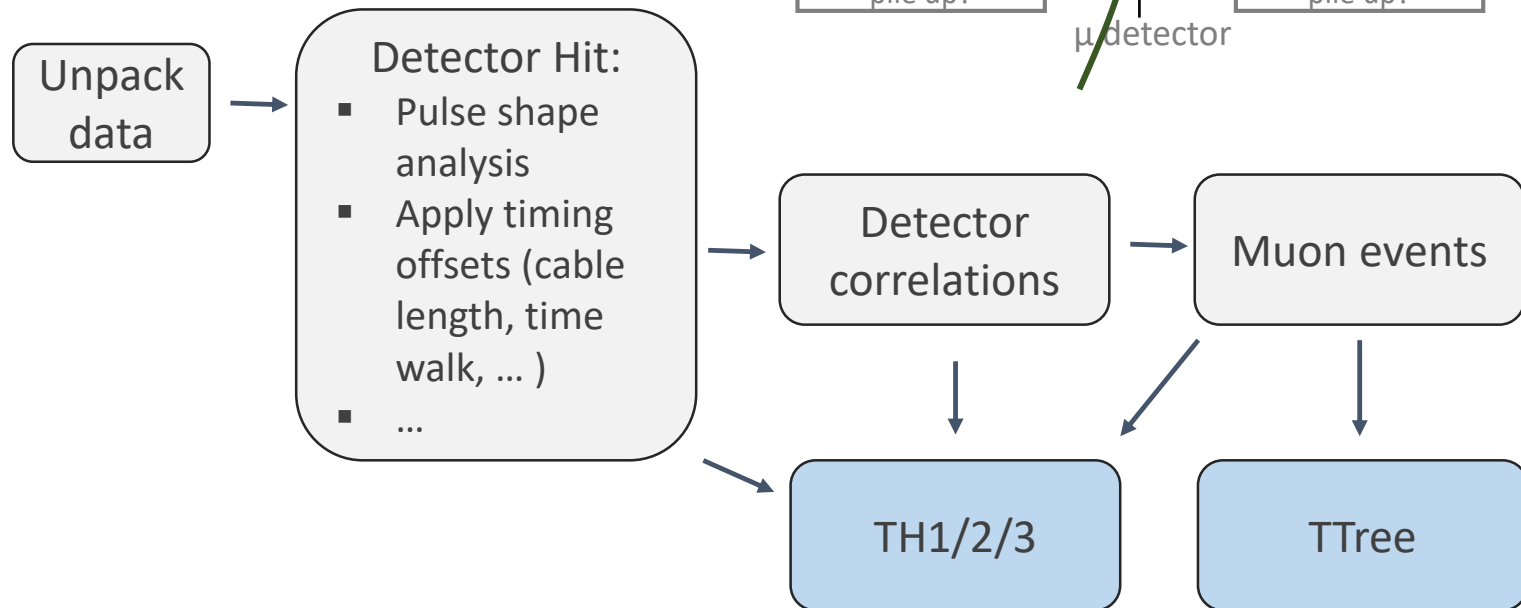
Disk

Analyze 100%
data offline

Midas DAQ: analyzer

C++ analyzer with MIDAS interface:

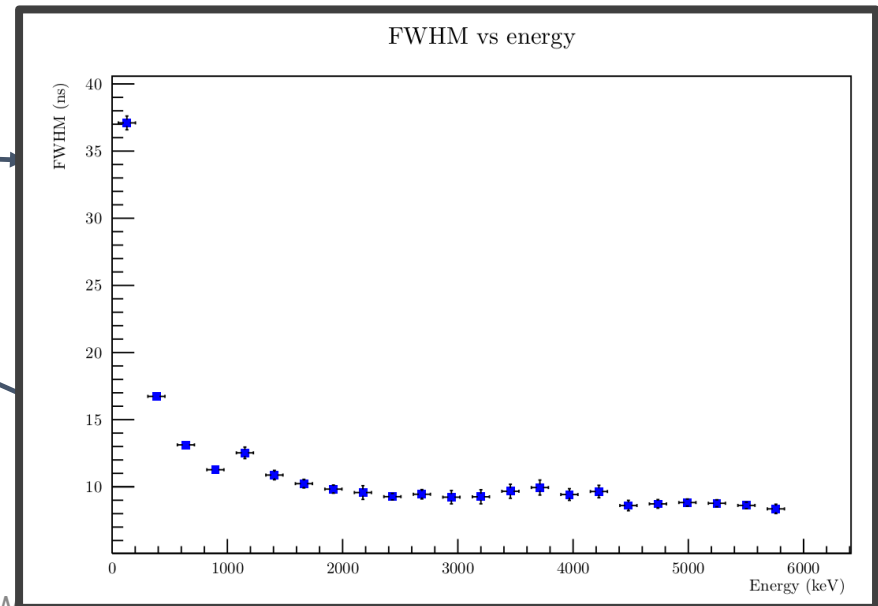
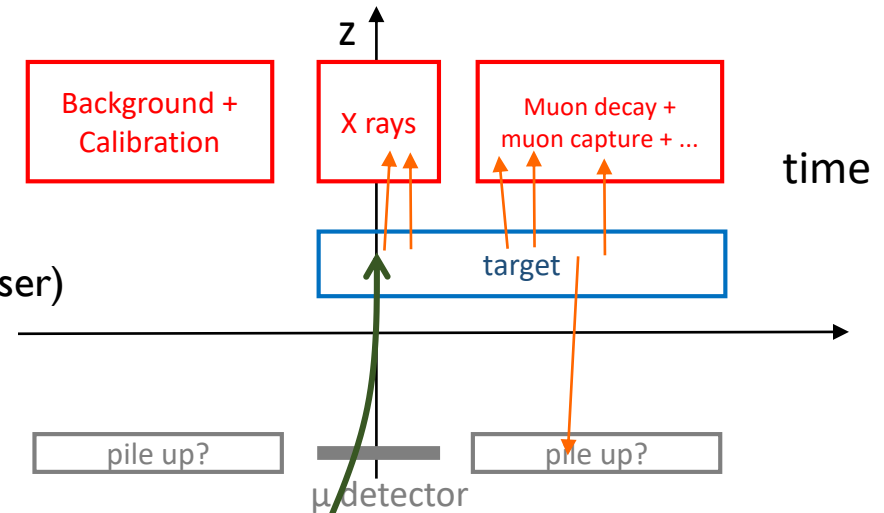
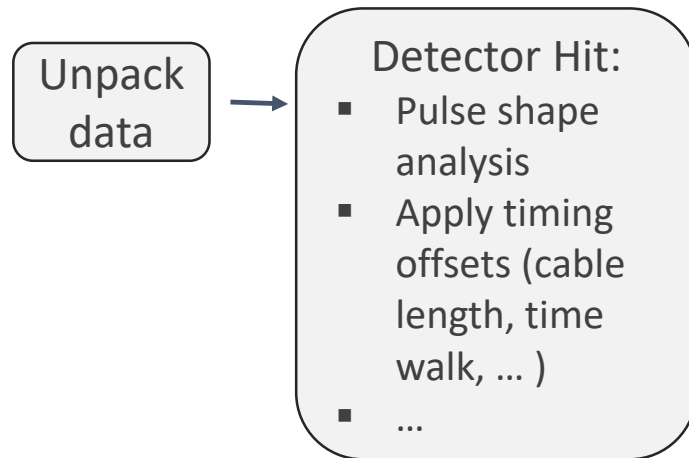
- *.mid file unpacker
- ODB interface for settings
- Sequential analysis modules (mandatory + user)
- First stage analyzer = online analyzer
- ROOT hist and TTree output



Midas DAQ: analyzer

C++ analyzer with MIDAS interface:

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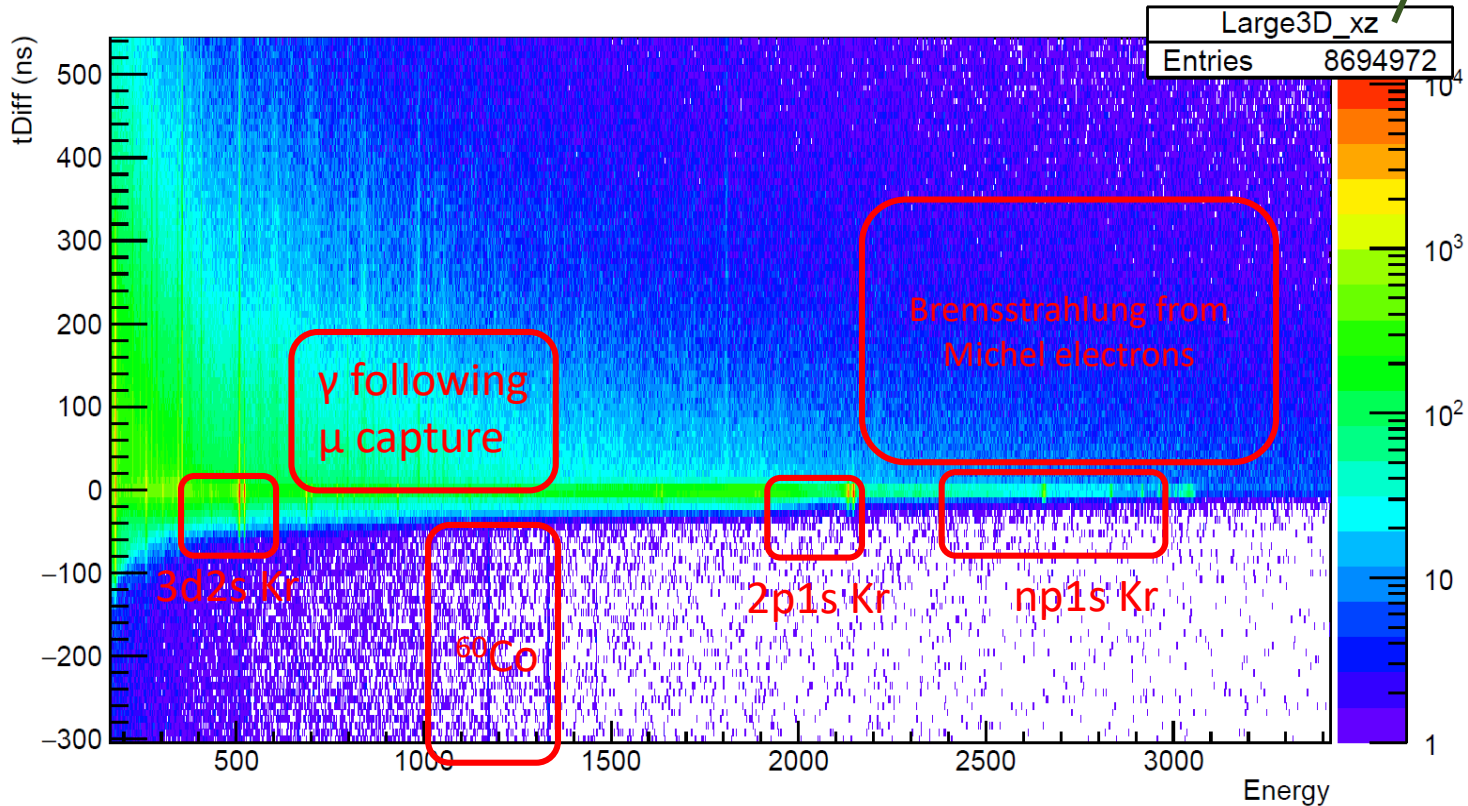
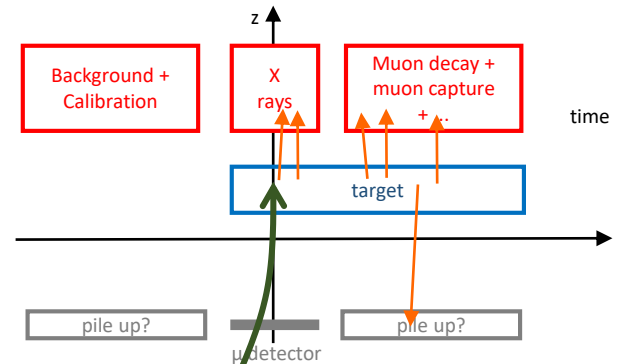


Midas DAQ: analyzer

- All detectors energy calibrated
- All timing offsets tuned
- pulse shape analysis in place

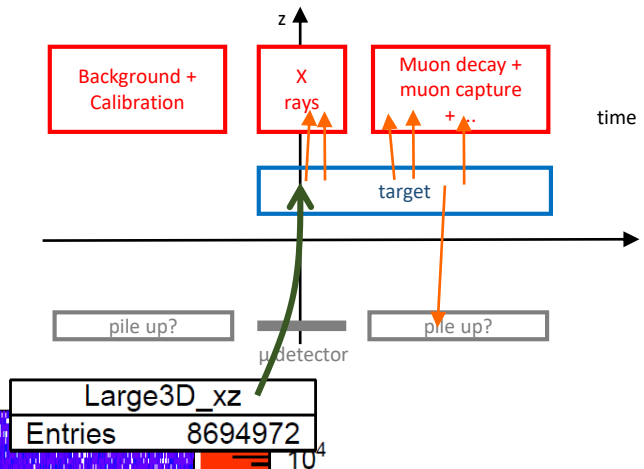
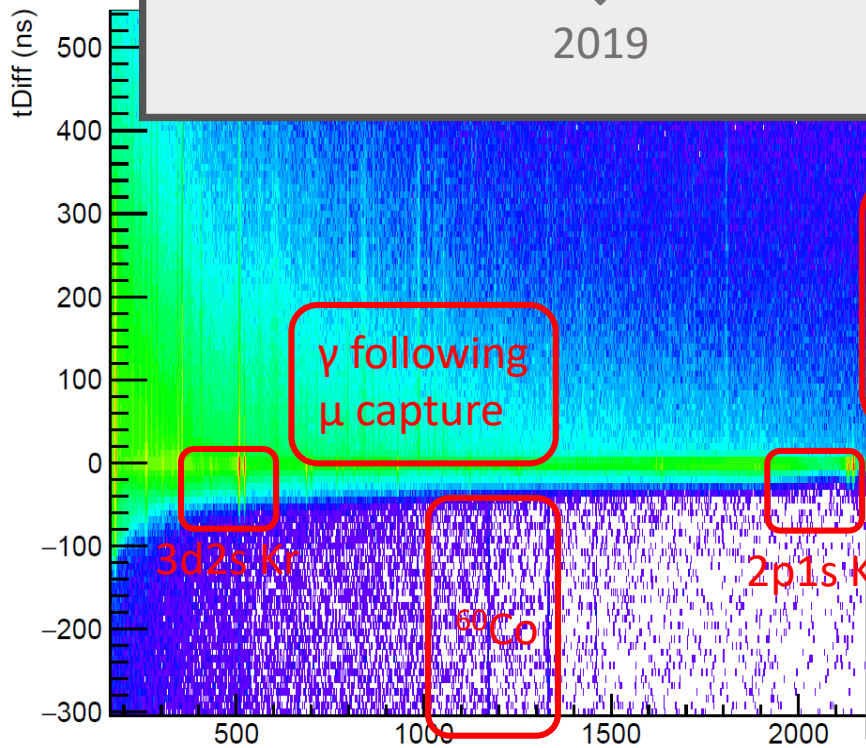
first version in place during the run

Bread and butter spectrum



Midas DAQ: analyzer

Conclusion:
Well running system in 2017-2018
All the software on Bitbucket
↓
2019



- 2019 wish list:
- lighter snout (size and material)
 - ROOT histograms in web interface
 - neutron detector for monitoring
 - further optimize high-rate performance
 - Can timing still be better?
 - more MiniBall clusters?