The Griffin Streaming Data Acquisition System

Abstract

Griffin is a gamma-ray spectrometer at the ISAC radioactive ion beam facility, part of the TRIUMF accelerator laboratory in Canada. Griffin comprises sixteen large clover-germanium detectors, along with a collection of various sets of ancillary detectors, which vary from experiment to experiment, with over one thousand DAQ channels.

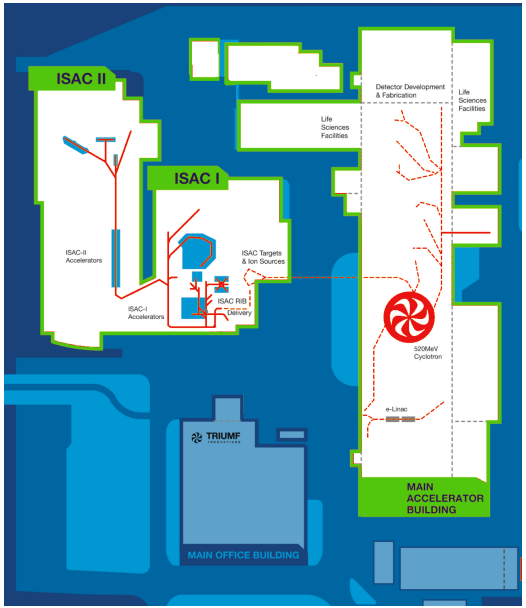
The DAQ is a triggerless system - every channel runs independently, and provides high resolution pulse-height and time, with the option to also collect signal waveforms.
This data is optionally filtered by specifying any required coincidence conditions between channels, before being streamed over, typically four to six (up to sixteen can be used), gigabit ethernet links, using udp, to a single computer for storage, the maximum data rate to disk is currently around 300Mbytes/s, scalable up to 2Gbytes/s.

Design started 2009, system completed 2016

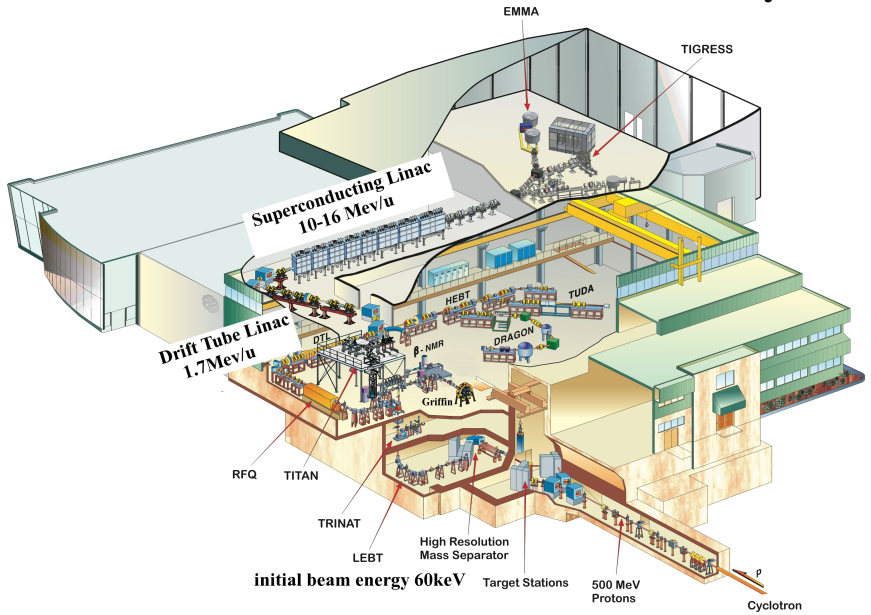
TRIUMF In Vancouver Canada



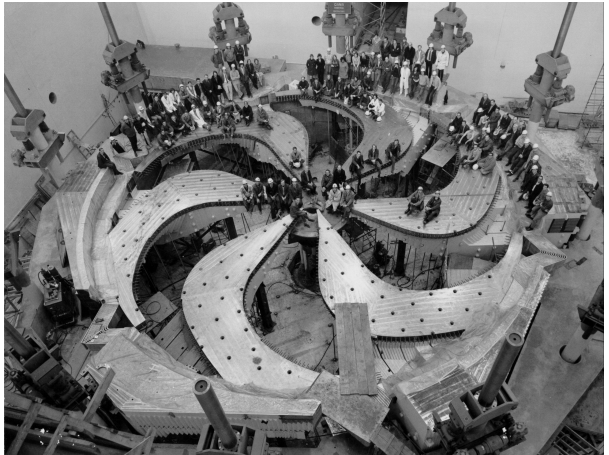
Lab Overview



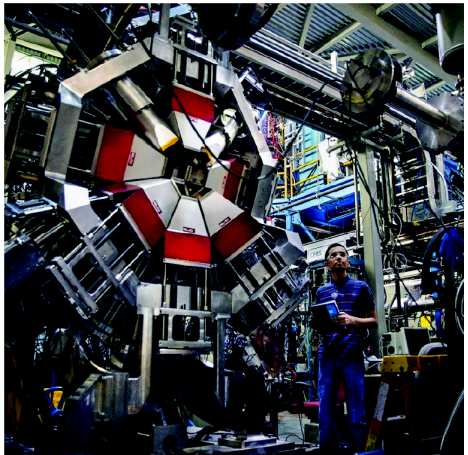
ISAC – ISOL Radioactive Ion Beam Facility



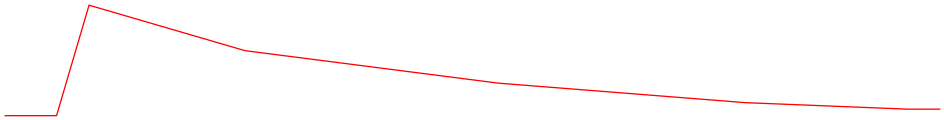
520 Mev 400uA H– Cyclotron



GRIFFIN Spectrometer



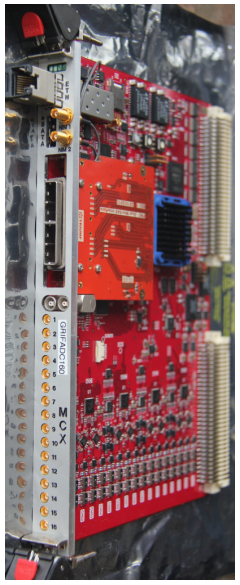
Detector Signals ~100mV ~200ns Rise ~200us Fall



Signal Processing Time 5–10us

Require High Resolution [~0.1%] pulse–height
Around 1000 DAQ Channels
Rates ~50kHz/channel [System rate: 10Mhz 300Mbytes/s]
Rapid Reconfiguration

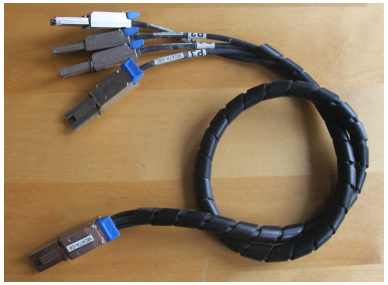
DAQ – 2 types of custom electronics module



16 ADC channels 100MS/s 14bits

Altera ArriaV FPGA
360k LE, 18Mbits SRAM
24 6.5G transceivers

Single FMC – MiniSAS
Or optionally, an
Additional 32 ADC channels
50Ms/s 14bits



MiniSAS
10Gbits/s, <10m, robust



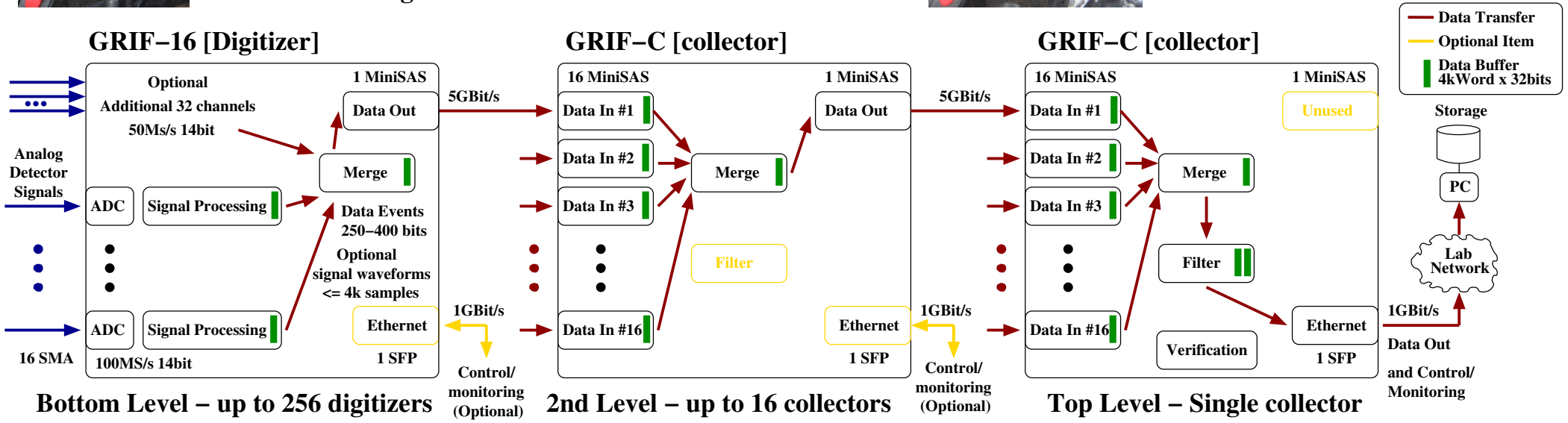
Altera Stratix4 FPGA
230k LE, 16Mbits SRAM
24 10G transceivers

3 FMC
Upper/Lower FMC [Data in]
Each – Dual 4channel MiniSAS

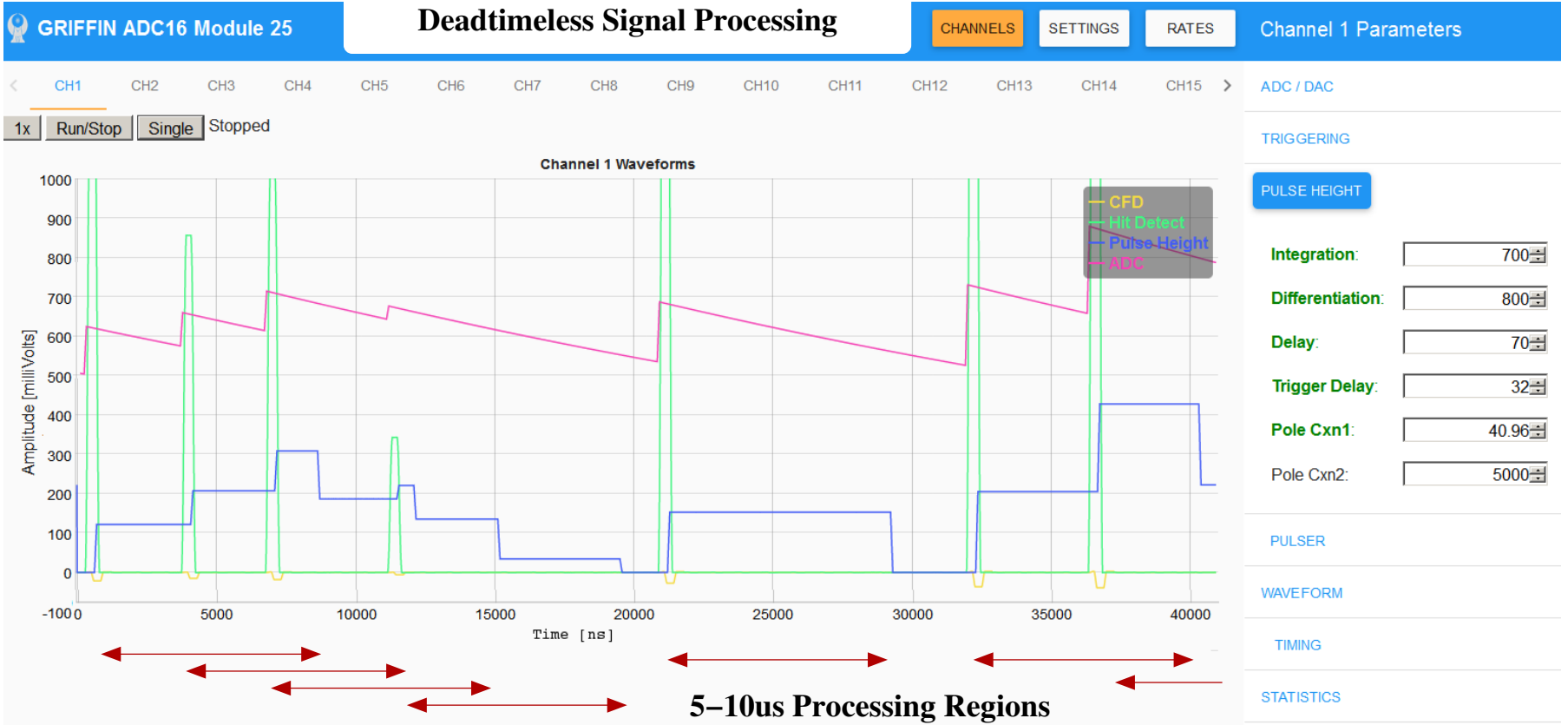
Center FMC [Data out]

Hardware arranged in 3–level tree

Diagnostic data events + verification



Deadtimeless Signal Processing



5–10us Processing Regions

Parallel Processing of up to 8 overlapping signals

All channels can retrigger every clock

Realtime Event Filter

TIGRESS typically filters its data
GRIFFIN typically does not

Filtering Method

A required multiplicity [8bits] specified for each type of detector [14 types], within user−defined time window [unlimited]

Every channel in the system is assigned a detector type

("detector type", can also distinguish different positions of the same sort of detector, e.g. upstream etc.)

Multiple independant filter conditions can be specified at once [~2kbits of parameters to specify and check]

Data satisfying any condition is kept, other data is discarded

Use of time window requires time−ordered events

Bucket sort over 160us reordering region, one bucket for each of 16000 clocks in region

[channel to channel time skew typically <20us on arrival at filter]

Distributed filter

Filter condition checks do not require full ~400 bits data event

64bit "data pointers" contain lower bits of timestamp, detector type, filter condition pass/fail bits (and storage location of full data)

Filter tasks:

Event storage and pointer generation

Time ordering, coincidence−window + condition checks

Event retrieval and readout

Only task #2 needs to be done in the top level collector, and uses only the smaller pointer data

pass/fail bits are calculated, then pointers are sent back down data links

full event data is retreived and read out at middle level

up to 16 collectors each output up to 1Gbit/s of data in parallel via ethernet

Summary

deadtimeless including when collecting signal waveforms

realtime distributed data filter

scalable datarate

diagnostics and verification

high performance, flexibility, reliability and ease of use.