

# Data Acquisition improvements at ISOLDE: first ideas

ISCC meeting 31.01.2012

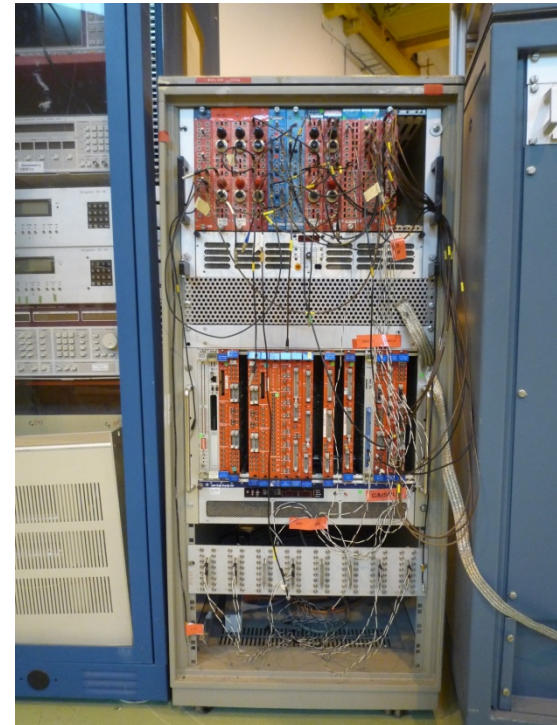
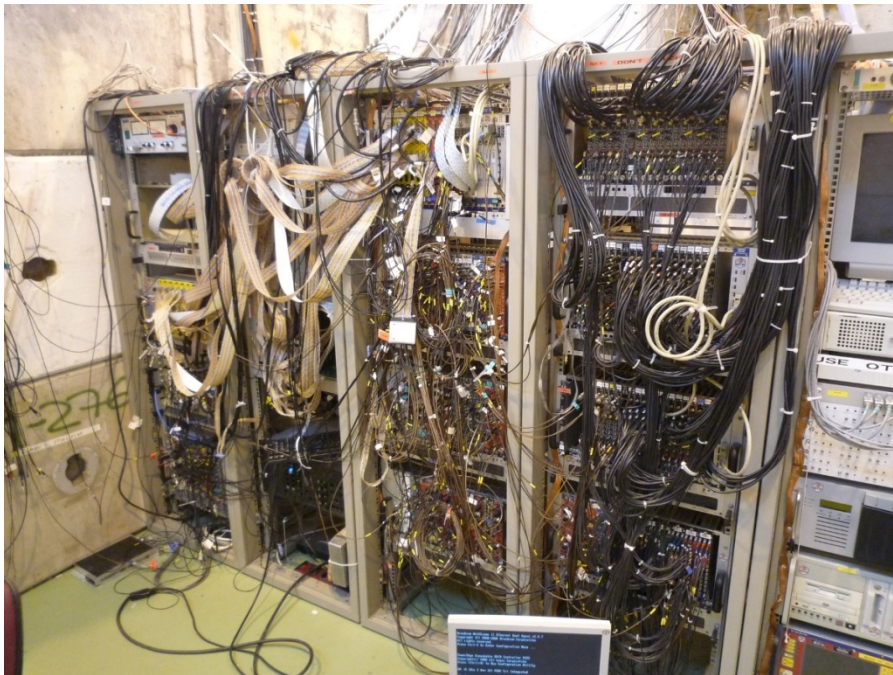
Jan Kurcewicz



# ISOLDE DAQ systems - overview

Different DAQ solutions available for ISOLDE experiments

- Standard VME-based systems
- XIA-DGF4C + mb\_collector software (Miniball, Nicole, ISOLTRAP, CRIS...)
- other (Digital oscilloscope, MCA...)



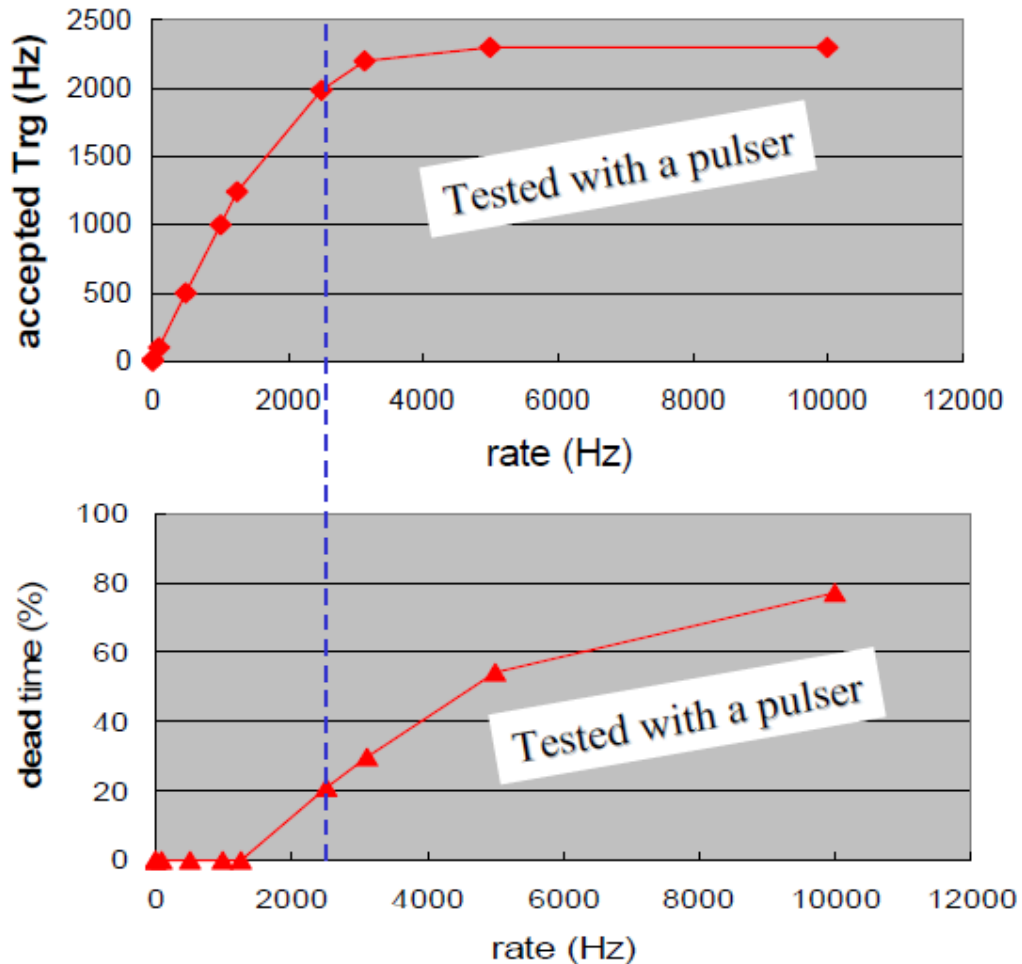
# ISOLDE DAQ systems - MBS

Standard VME-based system

- The software is based on the MBS acquisition system from GSI (N. Kurz et al.).
- CES RIO2 processor
- The system comprises a set of CAEN V775/V785 TDCs and peak sensing ADCs
- TRIVA trigger synchronization module
- Well established within collaboration



# MBS – single event mode (example)



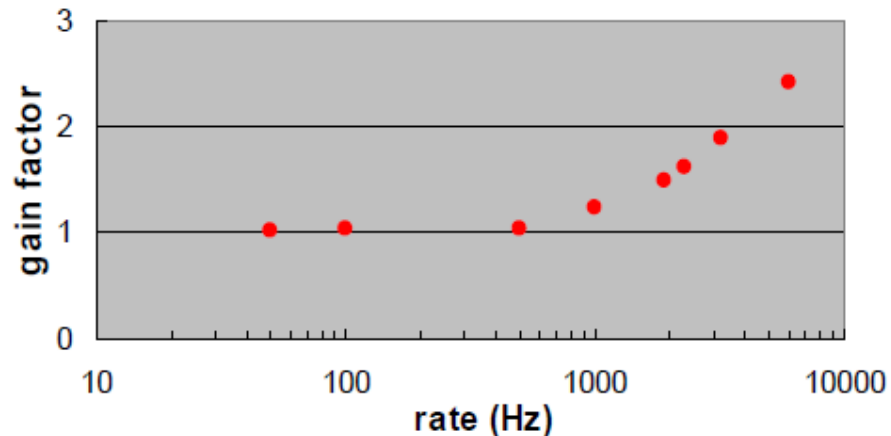
C. Nociforo et al.

The data sender is a RIO-3 CES (800MHz) processor which is located in the FRS VME crate. In this particular case, each event (i.e. VME ADC, TDC, QDC signals) is read out at each accepted trigger as 34 words. During this period, typically 120  $\mu$ s, the DAQ is busy and any other trigger is rejected.

# MBS – multi event mode

FRS multi-event DAQ tested with **real particle rate** and compared to single-event one:

- runs in stable condition
- more effective starting from 400 Hz
- **gain factor = 2 at 4 kHz**
- dead time at 10 kHz : 48%



C. Nociforo, N. Kurz, GSI report (2009)

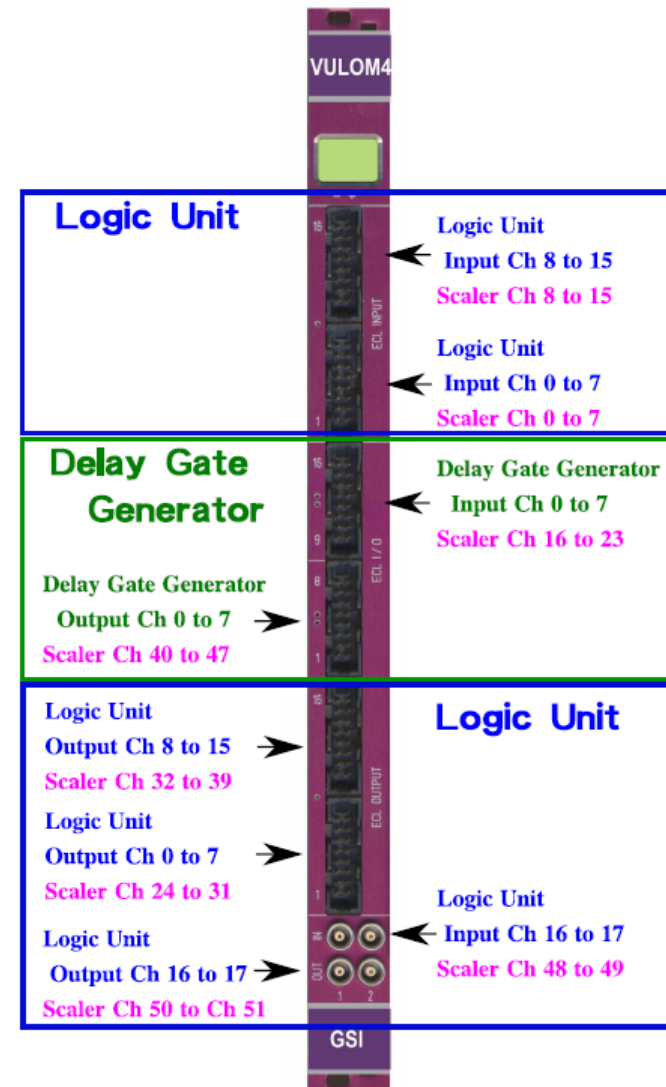
more efficient read out in BLock Transfer mode (BLT), which is supported by the VME Caen modules. A BLT read out of 32x34 words takes place and allows to read all events stored in the buffer (multi event mode).



# VULOM – VME Universal Logic Module

- VULOM ( VME Universal Logic Module) - 1-unit-wide VME 6U module with 16 ECL-inputs, 16 ECL-outputs, 16 ECLI/Os, 2 NIM-inputs and 2 NIM-outputs on its front-panel and a FPGA ( Virtex 4 by Xilinx corp. )
- The logic to be loaded to the FPGA can be easily replaced via VME access - possible to use VULOM for various different purposes replacing many analogue modules
- An 18-input 18-output logic unit combined with clock generators.
- An 8-channel delay and gate generator.
- A scaler for 26 inputs and 26 outputs.

The logic unit with clock generators can produce OR or AND signals of inputs with enable, disable and inverse for both inputs and outputs, and clock signals by internal clock of the FPGA with frequency of 1 Hz-10 MHz.

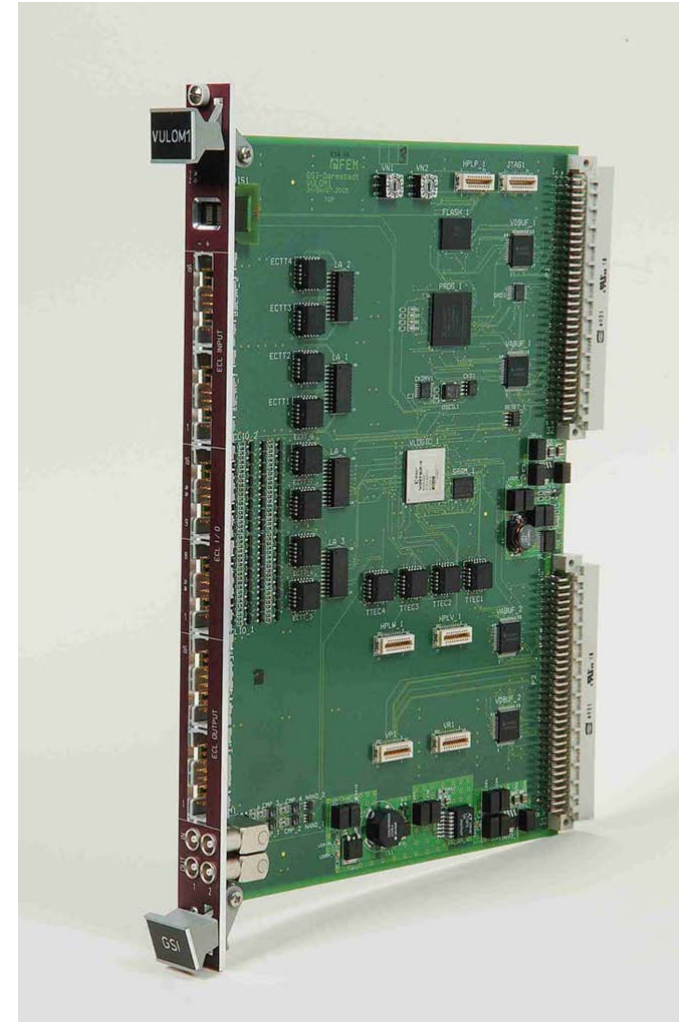


# VULOM trigger electronics

## Logic Matrix Unit

LMU setup Bit patterns Output

LMU Setup (1 to 16)	valid Input example	Output (1 to 16)
XXXXXXXXXX+X+XX	01011011110 <b>11110</b>	<b>1</b> 00000000000000
-XXXXX+XXXXXX+XX	<b>0</b> 0001110000 <b>11111</b>	<b>01</b> 00000000000000
-XXXXXXXXXXXXX+XX	<b>0</b> 1001011010 <b>11111</b>	<b>001</b> 00000000000000
-XXXXX+XXXXXX+XX	<b>0</b> 10011110101 <b>1111</b>	<b>0001</b> 00000000000000
X-XXXXXXXXXX+XX+	<b>1</b> 0001110101 <b>1111</b>	<b>00001</b> 00000000000000
XXXXX+XXXXXX+XX+	100111101011 <b>1001</b>	0000 <b>01</b> 00000000000000
+..XXX+XXXXXX+XX	<b>101</b> 011110101 <b>1111</b>	000000 <b>1</b> 0000000000
+..XXX+XXXXXX+X-	<b>100</b> 011110101 <b>1110</b>	0000000 <b>1</b> 0000000000
XXXXXXXXX++XXX+XX	010011111 <b>110</b> 11111	00000000 <b>1</b> 00000000
-XXXXX++XXXXXXX+	<b>0</b> 10011111010 <b>1111</b>	000000000 <b>1</b> 0000000
-XX-XX+X+XXXXXX+	<b>011</b> 0111110101 <b>1111</b>	0000000000 <b>1</b> 00000
-XX-XX+XX+XXXXX+	<b>0</b> 100111101 <b>110</b> 11111	00000000000 <b>1</b> 0000
-XX-XX+XXX+XXXX+	<b>011</b> 011110101 <b>111</b>	000000000000 <b>1</b> 000
-XX-XX+XXXX+XXX+	<b>00</b> 10111101 <b>1100</b> 11	0000000000000 <b>1</b> 00
-XX-XX+XXXXX+XX+	<b>000</b> 011110101 <b>1111</b>	00000000000000 <b>1</b> 0
-XX-XX+XXXXX+X+	<b>011</b> 01111000 <b>1110</b> 1	00000000000000 <b>1</b>



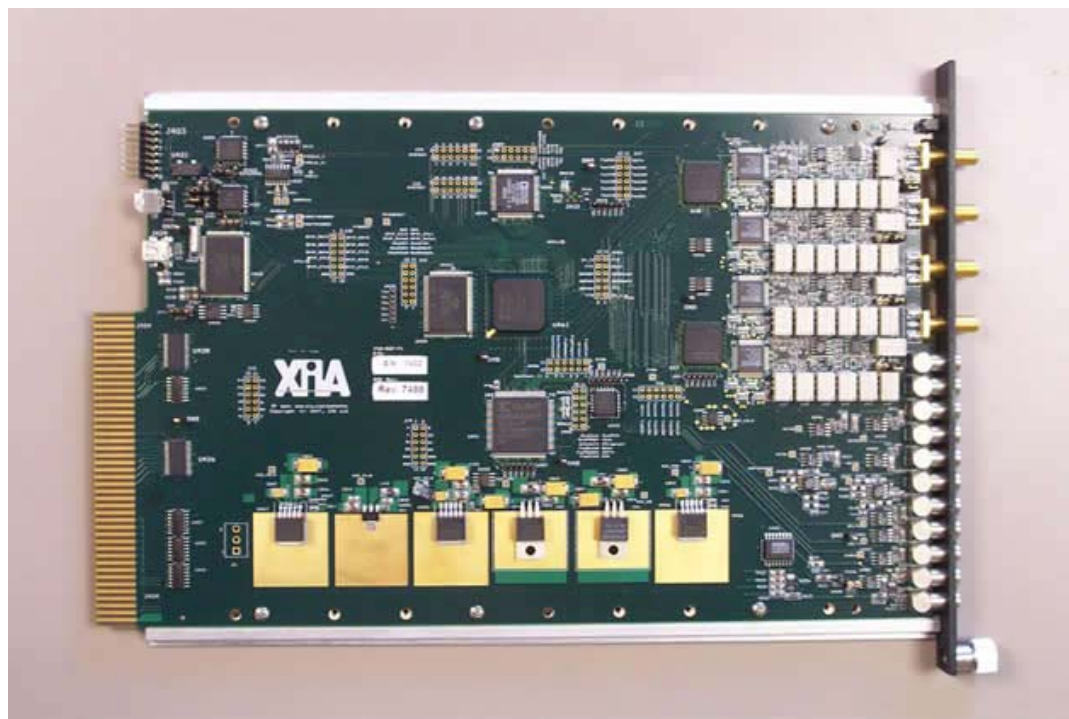
# Digital Pulse Processing - alternatives

## Digital Pulse Processing electronics (CAEN)

- V1724 14 bit 100 MS/s ADC, 8 channels
- FPGA for real time Digital Pulse Processing:
  - [Pulse Height Analysis \(DPP-PHA\)](#)
  - Zero Suppression (Standard Firmware)
- 2.25 Vpp input range (single ended or differential); single ended 500 mVpp & 10 Vpp also available – but **no** adjustable gain
- 16-bit programmable DC offset adjustment:  $\pm 1.125$  V ( $\pm 0.25$  V / 5 V)
- Trigger Time stamps
- Memory buffer: 512 kS/ch or 4 MS/ch, up to 1024 events
- Programmable event size and pre-post trigger adjustment
- Analog Sum/Majority and digital over/under threshold flags for Global Trigger logic
- Front panel clock In/Out available for multiboard synchronisation (direct feed through or PLL based synthesis)
- Can be handled by MBS
- High hardwired threshold value – can be a problem for low energy X and gammas





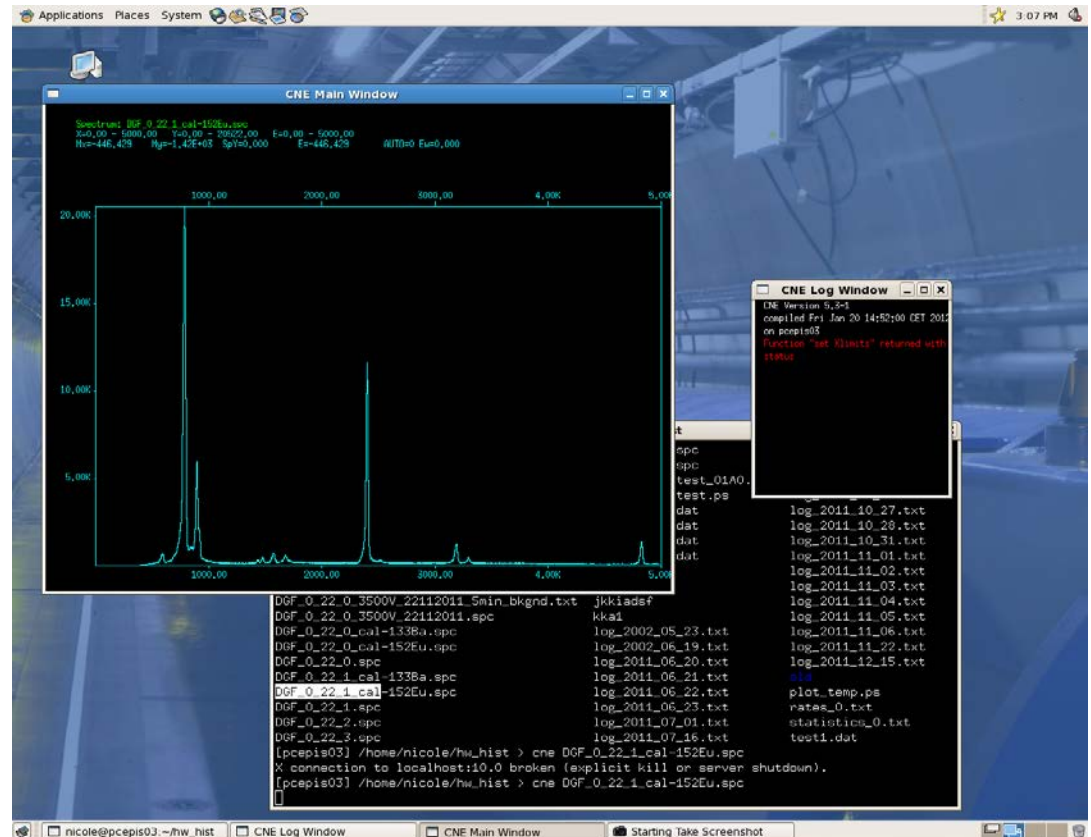


- Digital Gamma Finder (DGF) is a pulse processor with capabilities for measuring both energy and pulse shape
- Common clock distribution
- Above input rate of 5 kHz dead-time significant dead-time
- 40 MHz sampling rate (rev. D, E) → 80 MHz (rev. F). Upgrade presently being done.

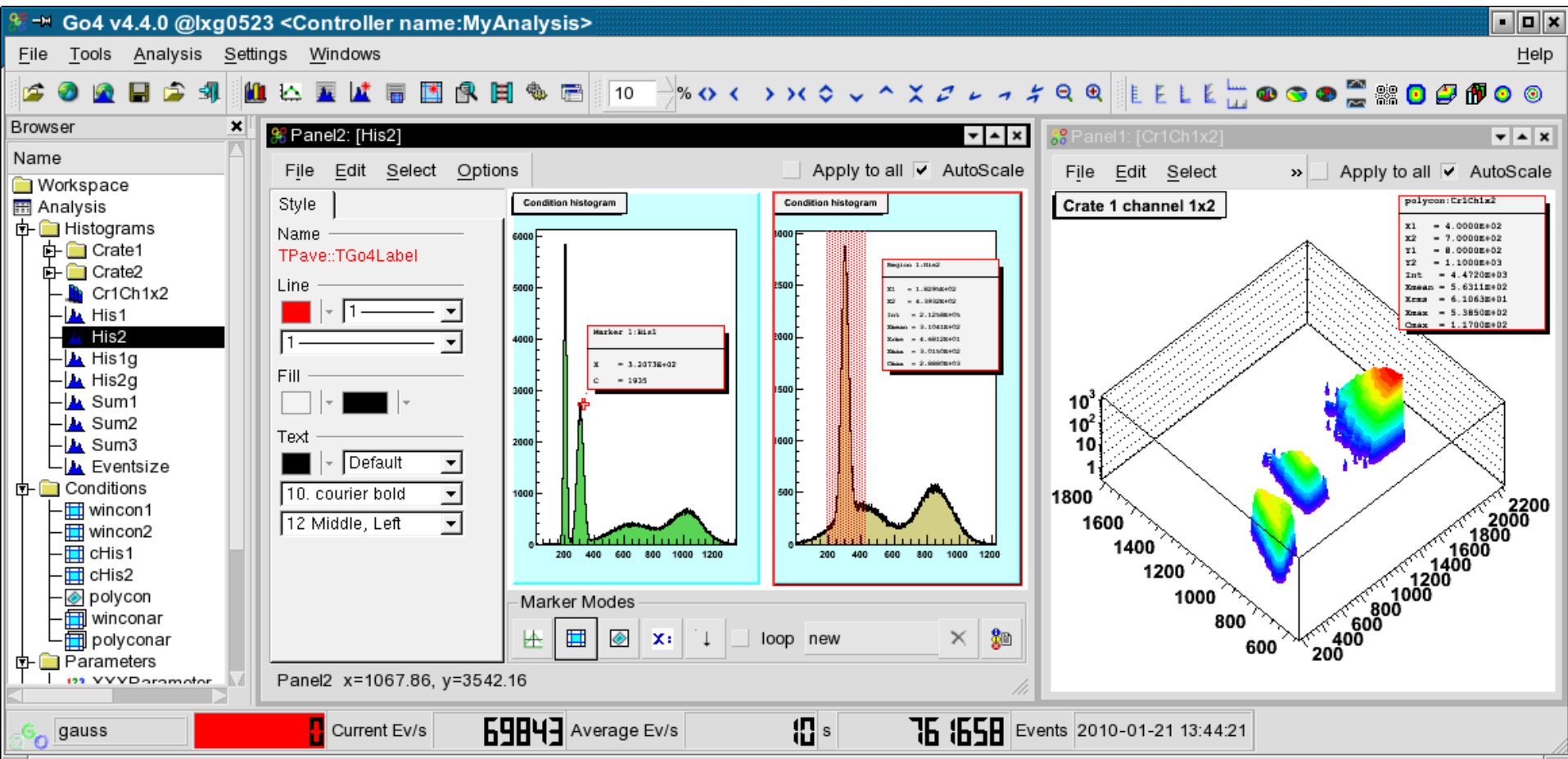
# DGF4C - DAQ system

XIA DGF4c-based system (CRIS, ISOLTRAP, MB, NICOLE, others)

- Based on MB collector code (N. Warr, G. Simpson)
- Online monitoring using cne software
- Offline analysis by ROOT is also available.



# GO4 - View panel



- Graphical **ROOT** editor
- Show **same histogram in different views** (ranges, line and fill colors)
- Improved **marker editor**, may also edit conditions
- Info on **time/date** and **full object path**

# GO4 – Dynamic list editor

## Histogramming “ad hoc” from event data

The screenshot displays the Go4 v4.4.0 software interface. The main window title is "Go4 v4.4.0 @lxx0523 <Controller name:MyAnalysis>". The interface is divided into several panels:

- Browser:** A tree view on the left showing the project structure. The "adHocHisto" folder is selected. A blue arrow labeled "Drag" points from the "UnpackEvent" folder in the "EventObjects" section to the "Dynamic List Editor".
- Dynamic List Editor:** A central panel with the following settings:
  - Entry: TGo4HistogramEntry
  - enable Analysis/DynamicLists/AdHoc
  - Histogram: Analysis/Histograms/adHocHisto
  - Event data | Condition | TreeDraw (selected)
  - X: UnpackEvent/fiCrate1[0]
  - Y: (empty)
  - Z: (empty)
- Panel1: [adHocHisto]:** A histogram plot on the right with the following characteristics:
  - Title: histogram title
  - Y-axis: 0 to 12000
  - X-axis: 0 to 1000
  - Plot: A yellow histogram showing a sharp peak at approximately x=200 and a broader distribution starting around x=300.
  - Buttons: File, Edit, Select, Apply to all, AutoScale
- Status Bar:** Displays real-time data:
  - gauss
  - 3442 Current Ev/s
  - 34853 Average Ev/s
  - 199 s
  - 6968000 Events
  - 2010-01-21 13:58



# GO4 – User GUI (Qt)

- Created with Qt Designer by user
- Plugged in by dynamic library
- All Go4 services available
- Started inside Go4 GUI workspace

The screenshot displays the MDC Go4 online GUI with several panels:

- Mdc Raw Error Stat:** A bar chart showing error bit counts.
- Mdc Raw Roc Subevent Size:** A scatter plot of subevent size vs ratio.
- Mdc hcuthits:** A 3D bar chart showing hit counts across sectors and subevents.
- Mdc tim:** A plot of counts vs time.
- trigger online monitor:** A central panel with a table of statistics and four subplots:
 

#Leptons / #Hits	sec0	sec1	sec2	min 1 ring	min 2 rings
glob: 0.764	0.044	0.797	0.752	100	100
g: 0.27	0.49	0.48	0.56	0.04	0.05
	s1	s2	s3	s4	s5
	0.48	0.56	0.55	0.62	0.57
- Hades Configuration:** A panel with various settings:
  - General Specs: Tree Size (kBytes), Refresh rate (next)
  - Eventloop: nLoop (100), sleep (100), maxrate (1000)
  - Refresh: Triggerrefresh (500), StartRefresh (500), RichRefresh (500), RichODRefresh (500), MdcRefresh (500), ToRefresh (500), TofinoRefresh (500), ShowerRefresh (500)
  - Tasks: Trigger, Start (hit), Rich (cal), Mdc (fit), ToF (cal), Tofino (cal), Shower (hit)
  - MDC SETUP: Calibrator (TimeCuts, NoStarAndCal)
  - TrackFinder: magnet on, single Chamber, nLayers (6, 6, 6), Level (10, 50, 10, 50), Segments (1, 3)
  - Fitter: single Chamber

HADES  
on-line monitoring

Courtesy HADES coll.



# GO4 – Fit panel

Interactive peak finding and fitting. Save fitter for use in macros

The screenshot displays the Go4 v4.4.0 software interface. The main window is titled "Go4 v4.4.0 @lxg0523 <2>". The menu bar includes "File", "Tools", "Analysis", "Settings", "Windows", and "Help". The toolbar contains various icons for file operations and analysis. The "Fit panel" is active, showing the "Fitter" tab. The "Name" field is set to "Fitter". The "Minimizer" and "Peak finder" buttons are visible. The "Data" field is set to "Data0". The "Models" list includes Gauss4 through Gauss11, with Gauss9 selected. The "Model: Gauss9 of class: TGo4FitModelGaus" is displayed. The "background" and "use buffers" checkboxes are unchecked. A table shows the fit parameters:

	Fixed	Value	Error	Epsilon
Ampl	<input type="checkbox"/> fix	92.8146	3.29964	
Pos	<input type="checkbox"/> fix	2717.64	0.787184	
Width	<input type="checkbox"/> fix	11.6812	0.668406	

The "Rebuild" button and "+", "-", "\*" operators are also visible. The "Panel2: [hDeg120\_CND]. :DataModel" window is open, showing a histogram plot of "hDeg120\_CND" data. The plot displays a black histogram and a red fit line. The x-axis ranges from 2000 to 3400, and the y-axis ranges from 100 to 600. A legend in the top right corner identifies the black line as "histograms.root/hDeg120\_CND" and the red line as "Model".

# DABC – Data Acquisition Backbone Core

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- High speed network event building system for FAIR
- Test bed for the full readout chain from detectors, digitizers, readout controllers, data combiners to event building, filtering, and archiving.
- Self-triggered front-end systems with a very precise time distribution system.
- Sorting of the data over the network will probably be not based on events, but rather on data packets of time slices. Only after the composition of these time slice fragments at the receiver nodes of the network an event definition will be possible.
- After that event data can be processed for filtering, compression, on-line analysis and storage. This processing might need large processing farms able to handle high data flows.
- Compatibility with existing DAQ (MBS)

<http://dabc.gsi.de>

# DABC – controlling MBS

The screenshot displays the DABC Controls and Monitoring software interface, which is used for controlling and monitoring the MBS (Micro Beam System). The interface is divided into several main sections:

- MBS servers ready:** A configuration panel showing server details such as Name server (lsg0243.gsi.de), User name (fopi), Password (RET), Master node (x86g-15), Servers (15), System path (/mbs/v51), User path (nxm/), Startup (startup.scom), Shutdown (shutdown.scom), Command (@startarch), and Launch file (MbsControl.xml).
- Commands:** A list of commands including set\_x86g-b, showwacq.scom, showtapes.scom, showtrig.scom, shutdown.scom, starcharch-to-disk.scom, start\_dr.scom, and startacq.scom.
- Command showtrig.scom, scope Common:** A panel for executing commands, currently showing (C):.
- RateMeters:** A grid of 24 sub-panels, each displaying a different metric for various MSG (Message) nodes (e.g., R2-33, R2-9, R2F-1, R3-42, R3G-5, R3G-6, X86G-15, X86G-16, X86G-17, X86G-5, X86G-6). Each panel includes a graph of the rate over time and a numerical value.
- SpillCounter:** Three panels showing spill counts for different triggers: SpillCounts-Trigger1 (Int=264320), SpillCounts-Particles (Int=485424156), and SpillCounts-TtoP (Int=5404). Each panel has a graph of spills over time.
- Infos:** A log window displaying detailed information for various MSG nodes, including Events, MBytes, E/s, and MB/s. For example, R2-22: Events: 14761601, MBytes: 7921, E/s: 166, MB/s: 0.10.
- States:** A panel showing the status of various components, such as R2-22:Acquisition (Running), R2-9:BuildingMode (Delayed), R2F-1:Acquisition (Running), R2F-1:SpillOn (Spill OFF), R3G-11:Acquisition (Running), X86G-15:Acquisition (Running), X86G-16:FileOpen (S.File open), X86G-5:Acquisition (Running), and X86G-6:FileOpen (S.File open).
- Layout:** A panel showing the layout of various components, including R2-22:Acquisition (Running), R2-33:Acquisition (Running), R2-9:Acquisition (Running), R2-9:BuildingMode (Delayed), R2-9:EventBuilding (Suspended), R2-9:SpillOn (Spill OFF), R2F-1:Acquisition (Running), R2F-1:BuildingMode (Delayed), R2F-1:EventBuilding (Working), R2F-1:SpillOn (Spill OFF), R3-42:Acquisition (Running), R3G-10:Acquisition (Running), R3G-5:Acquisition (Running), R3G-6:Acquisition (Running), X86G-15:Acquisition (Running), X86G-15:FileOpen (S.File open), X86G-16:Acquisition (Running), X86G-16:FileOpen (S.File open), X86G-17:Acquisition (Running), X86G-17:FileOpen (S.File open), X86G-5:Acquisition (Running), X86G-5:FileOpen (S.File open), and X86G-6:Acquisition (Running).

At the bottom of the interface, there is a status bar showing DIM servers: X86G-15:PRM R3G-6:MSG R3G-5:MSG R3-42:MSG R2F-1:MSG R2-22:MSG X86G-17:MSG DNS=lxg0243 X86G-6:MSG R2-33:MSG X86G-5:MSG R2-9:MSG R3G-11:MSG R3G-10:MSG X86G-16:MSG X86G-15:MSG

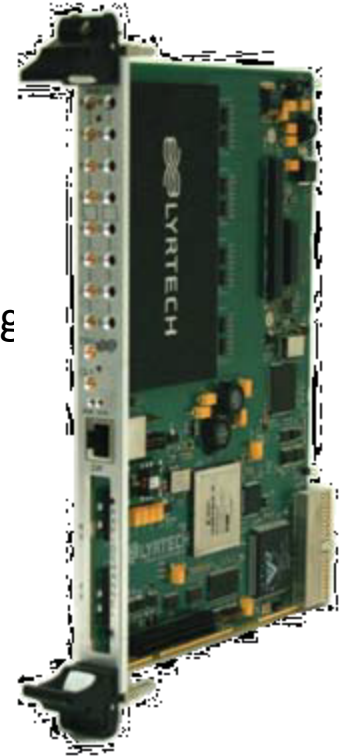
# GRAIN

Grain is a data analysis framework developed at JYU to be used with the novel Total Data Readout (TDR) data acquisition system.

TDR based on Lyrtech VHS-ADC (Virtex IV FPGA) modules - sampling rate 105 MHz, 8ch 14bit, capable to handle rates  $\sim 30\text{kHz/ch}$  (DC beam).

In Total Data Readout all the electronics channels are read out asynchronously in singles mode and each data item is timestamped. Event building analysis has to be done entirely in the software post-processing the data stream.

A flexible and efficient event parser and the accompanying software framework written entirely in Java.



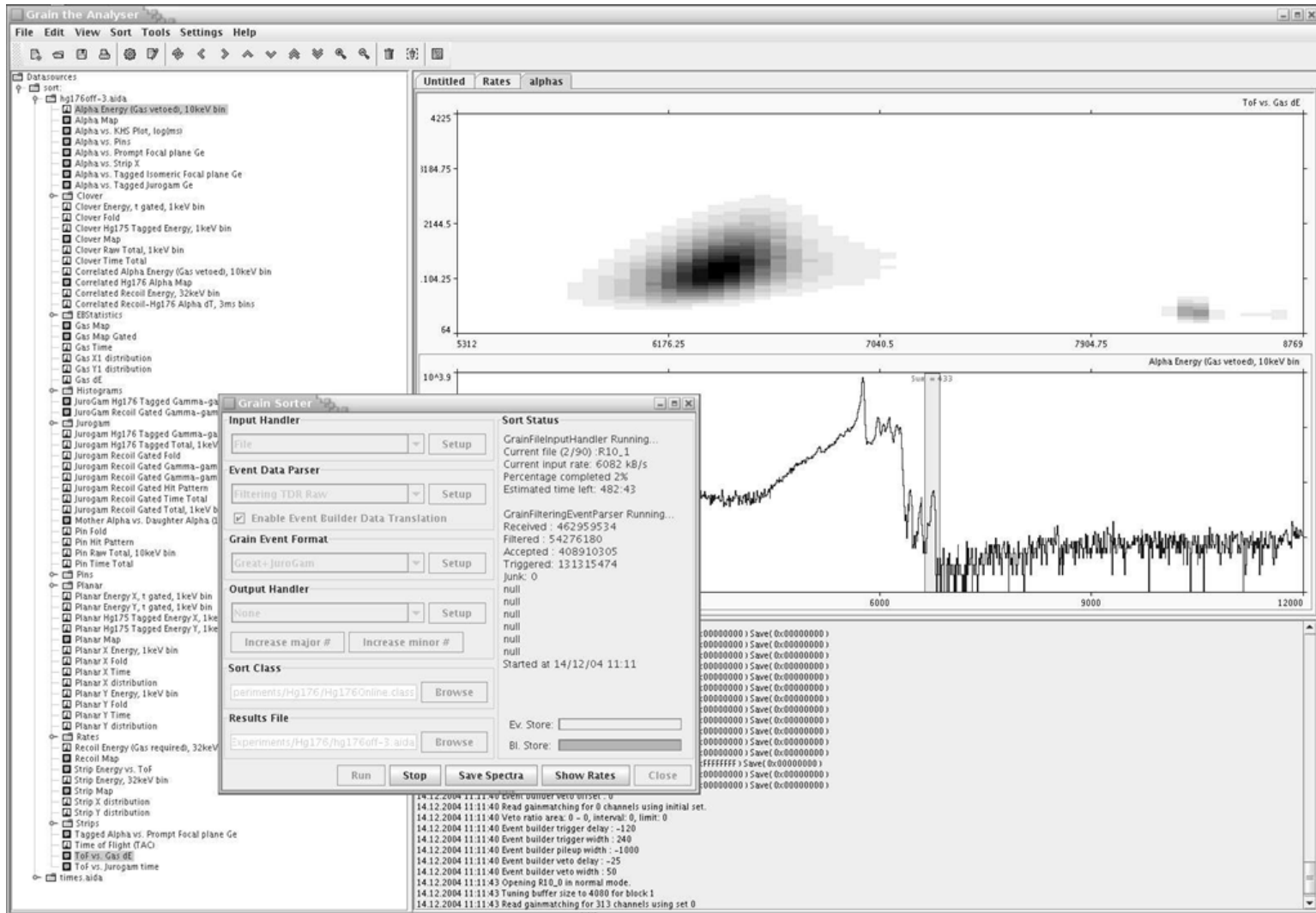
P. Rahkila, Grain - A Java Data Analysis System for Total Data Readout Nucl. Instr. and Meth. A 595, 637 (2008)

Grain



<https://trac.cc.jyu.fi/projects/grain>

# GRAIN



<https://trac.cc.jyu.fi/projects/grain>



# Summary

- Different solutions possible (hardware/software)
- Main problems reported by the community:
  - rate handling capability
  - DAQ/analysis GUI
- DAQ for low rate experiments requires smaller changes

This work is supported by ENSAR

