Advance Gamma Tracking Array AGATA

Dino Bazzacco

INFN Padova

Part 1: Review of AGATA

Part 2: Data Processing

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Architecture of the system

- **Local Level : where the individual detectors <u>don't</u> know of each other.**
  - Electronics and computing follow a model with minimum coupling among the individual elements (detectors), which are operated independently as long as possible
  - Electronics is almost completely digital, operated on the same 100 MHz clock
  - Data processing (in the electronics and in the front-end computers) is the same for all detectors and proceeds in parallel
  - Every chunk of data produced is tagged with a time stamp that gives the absolute time (with a precision of 10 ns) since the last startup of the system. (with 48 bits the roll around takes place every 32.5 days)
- **Global Level : where the detectors <u>do</u> know of each other**
  - By means of the real time trigger, which reduce the data rate by selecting the class of interesting events
  - Via the event builder and merger that assemble the event fragments (including the ancillaries) into complete events that are further processed
  - In the tracking and in the Physical analysis stages

❖ The fact that 3 (and 2 at GSI) crystals are packed in clusters does not produce any correlation in the data processing (not so for the Detector Support System, but this is not relevant here)
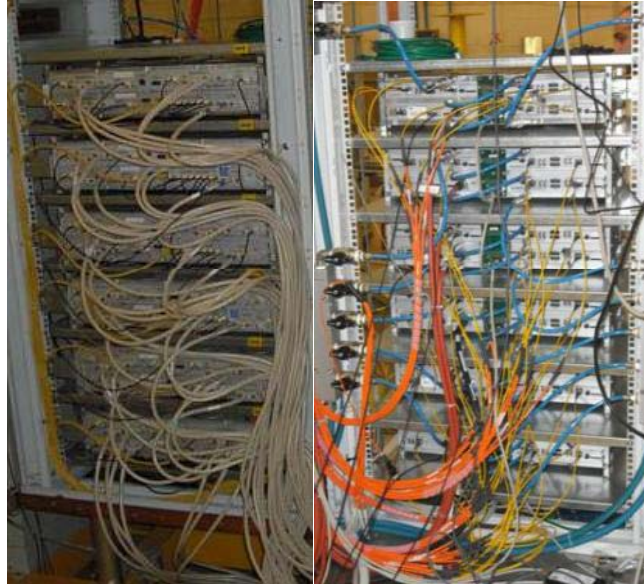
Structure of Electronics and DAQ
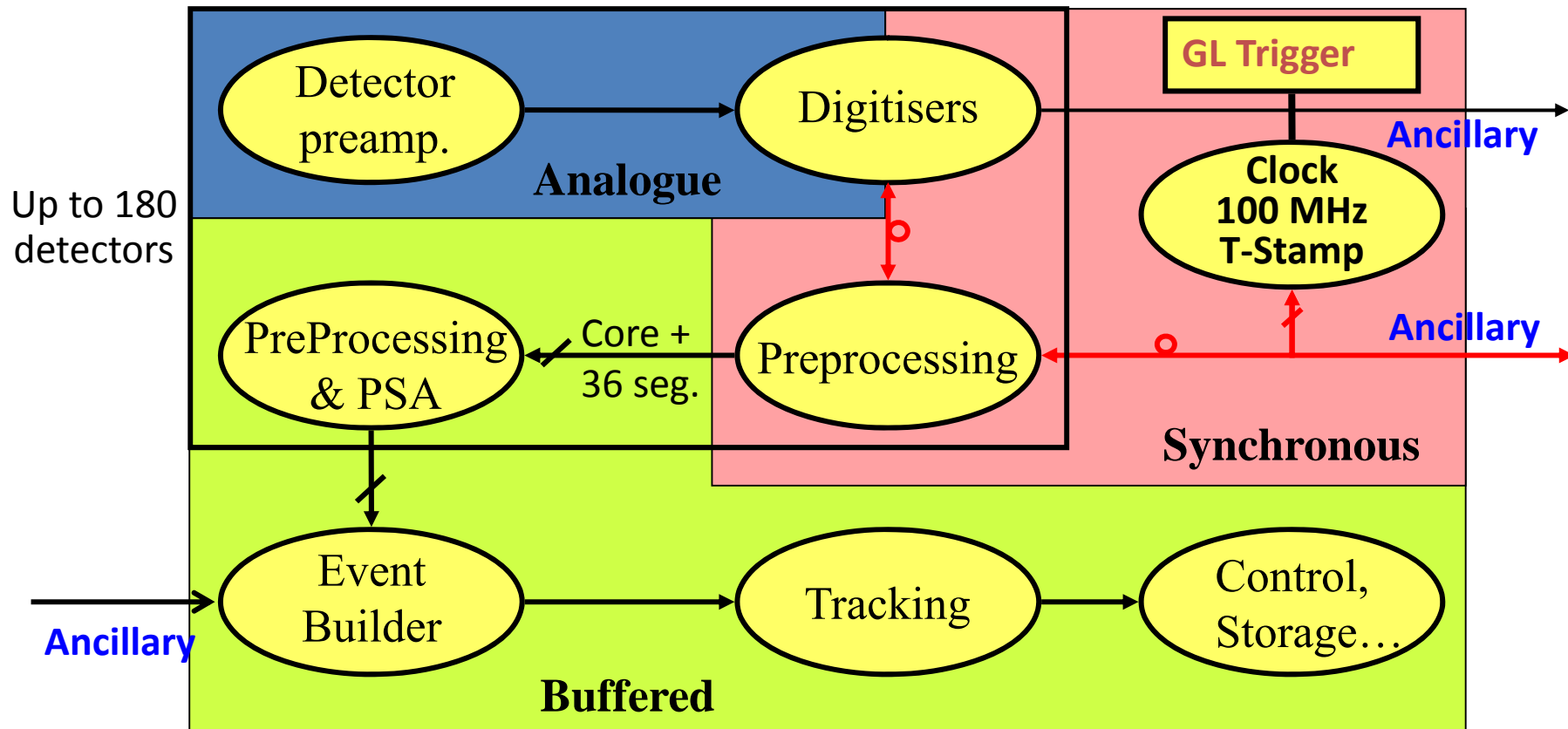
AGATA Data Processing

Digitisers
in the experimental hall

Digital proc. electronics
in the users area

Computer farm
in the computing room

10 m long MDR cables

80 m long optical fibers
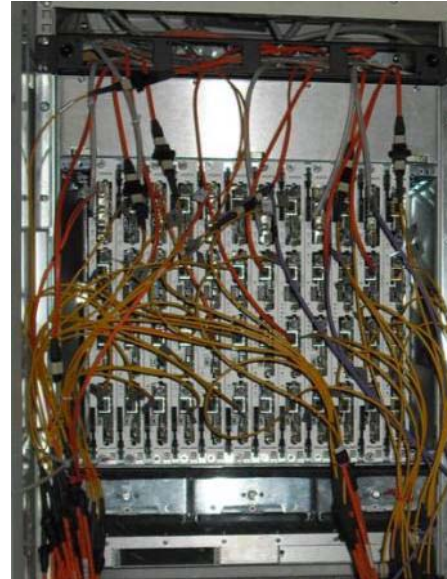
20 m long optical fibers

LAN to the disk servers

One digitizer per crystal:
- core module with
  1 core board (clock + 2 cores)
  2 segment boards (A B)
- segment module with
  4 segment boards (C D E F)

2 ATCA carriers per crystal:
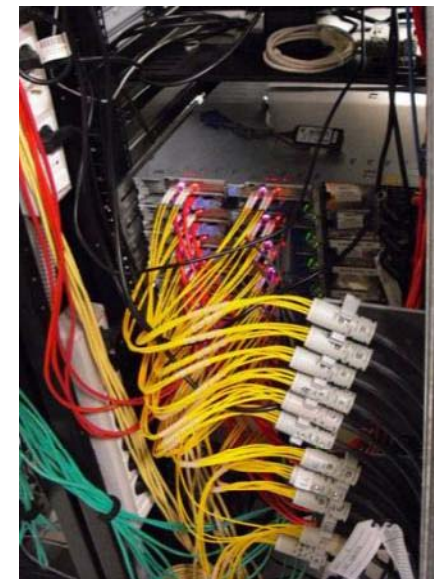- Master with
  1 GTS mezzanine
  3 proc. mezzanines (Core A B)
- Slave with
  4 proc. mezzanines (C D E F)

6 channels processing mezzanine

1 pizza-box per crystal:
- Readout and save orig. data
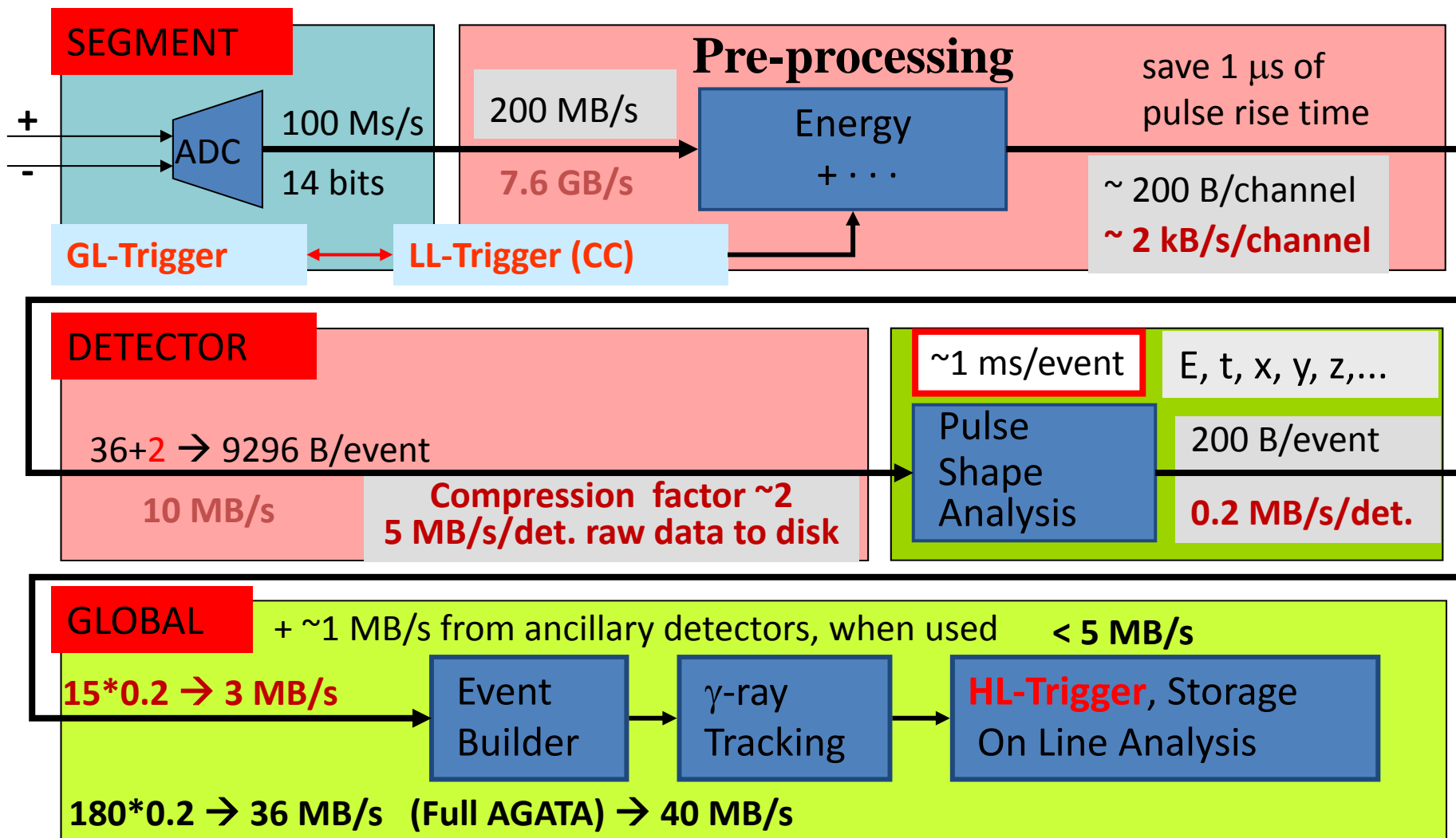- Pre-processing of events
- PSA

10 pizza-boxes for
  Event Builder and Merger
  Ancillary and Tracking

120 TB of storage +
Archiving on Grid T1

Data rates in AGATA Demonstrator

50 kHz singles → 1 kHz triggered

GTS : the system coordinator

All detectors operated on the same 100 MHz clock

Downwards   100 MHz clock + 48 bit Timestamp (updated every 16 clock cycles)

Upwards   trigger requests, consisting of address (8 bit) and timestamp (16 bit)

                 max request rate 10 MHz total, 1 MHz/detector

Downwards   validations/rejections, consisting or request + event number (24 bit)
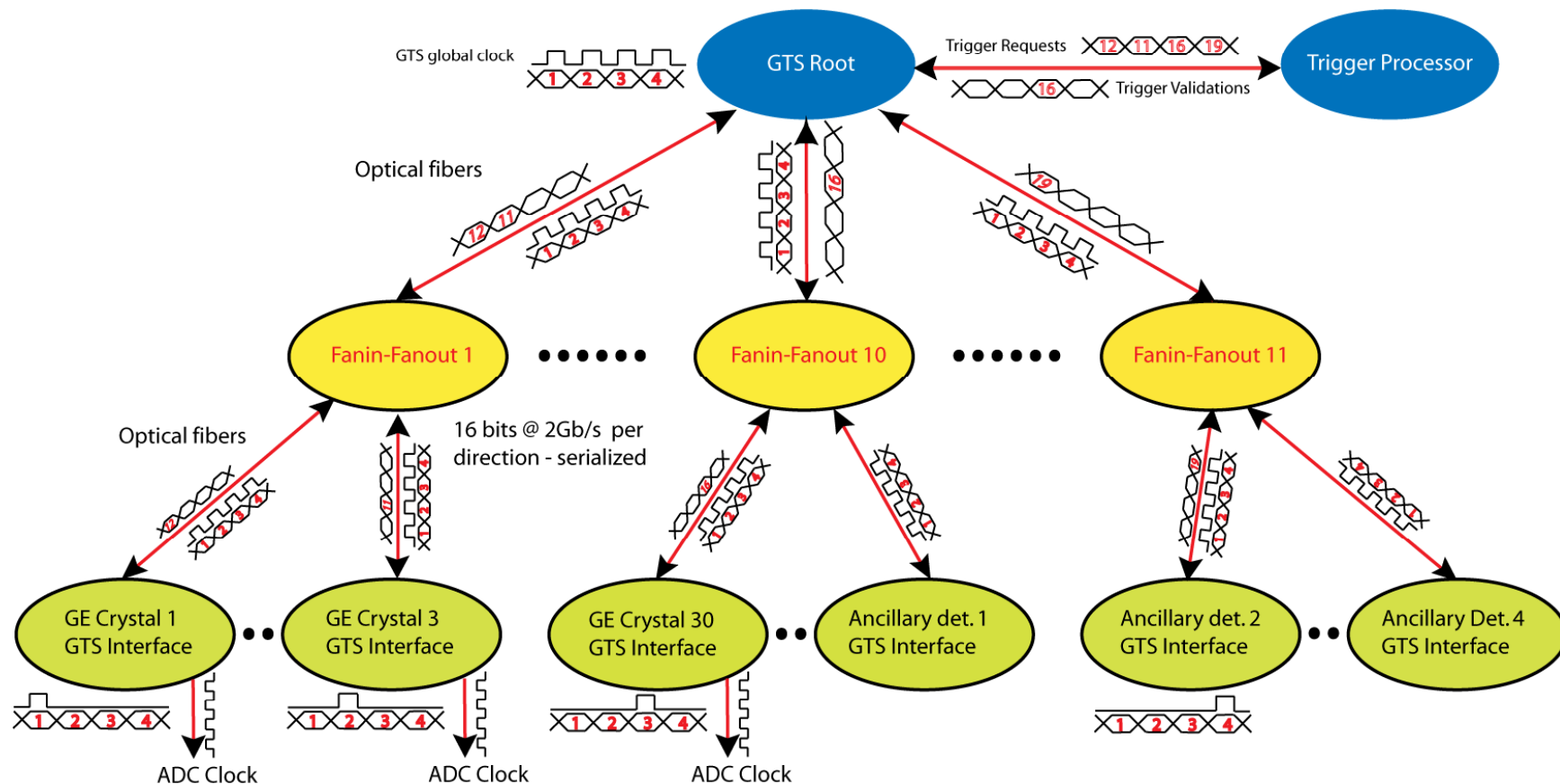
1:15 GTS Tree + 1 VME subsystem

GTS Tree with the
Fully Digital Trigger Processor

GTS tree to:
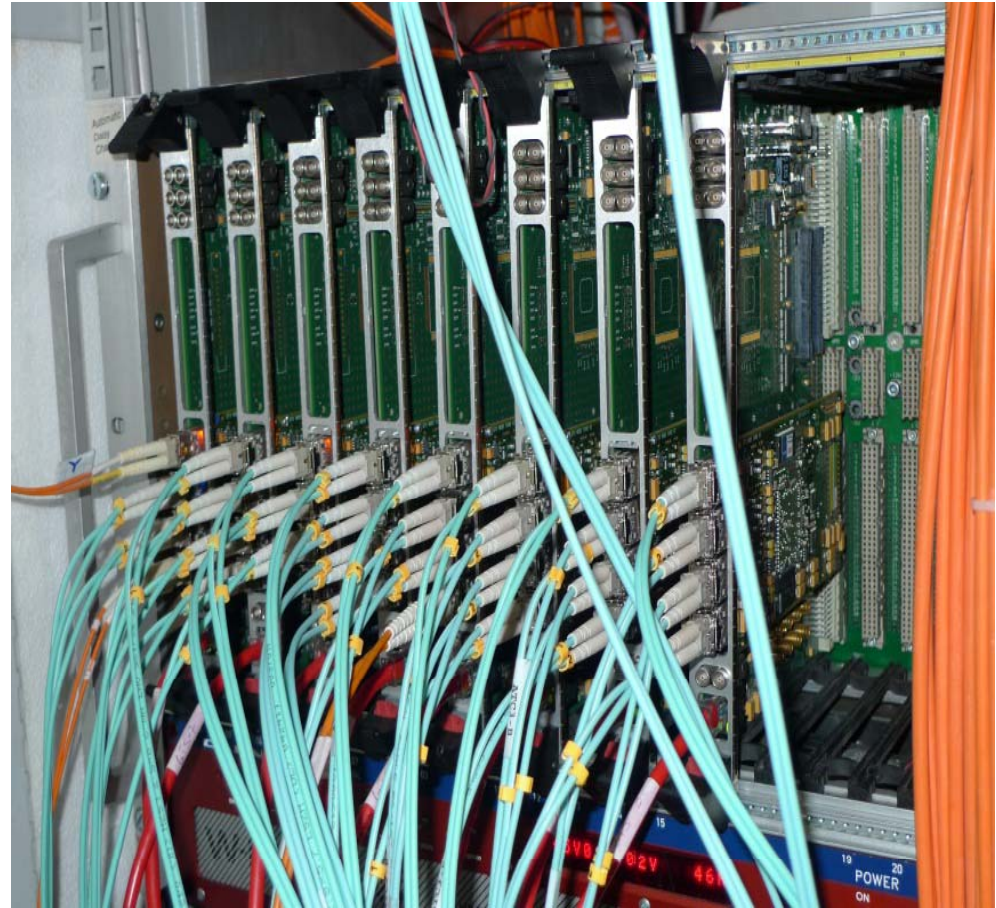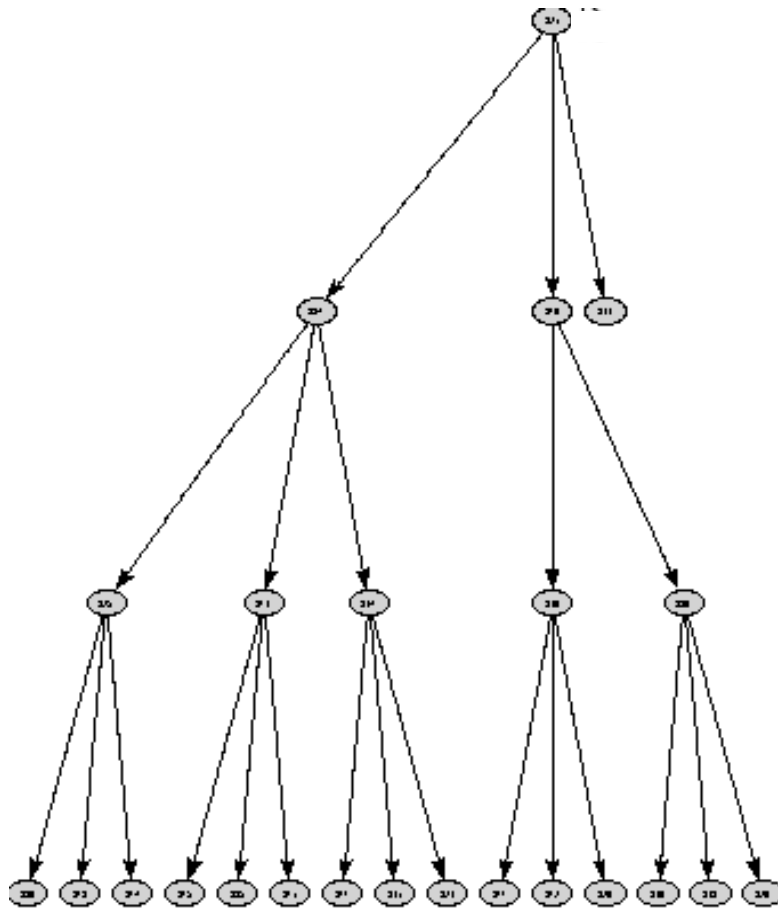- Distribute the 100 MHz clock
- Collect the trigger requests (i.e. 16-bit time stamp and address of the requesting node)
- Return validations or rejections messages to the requesting node

Max 1 MHz trigger requests/node

Built out of GTS mezzanines

The "3 to 1" structure can be extended up to 3 levels →
9 triple clusters or
8 triple clusters + 3 ancillaries

Marco Bellato, Luciano Berti, Joël Chavas
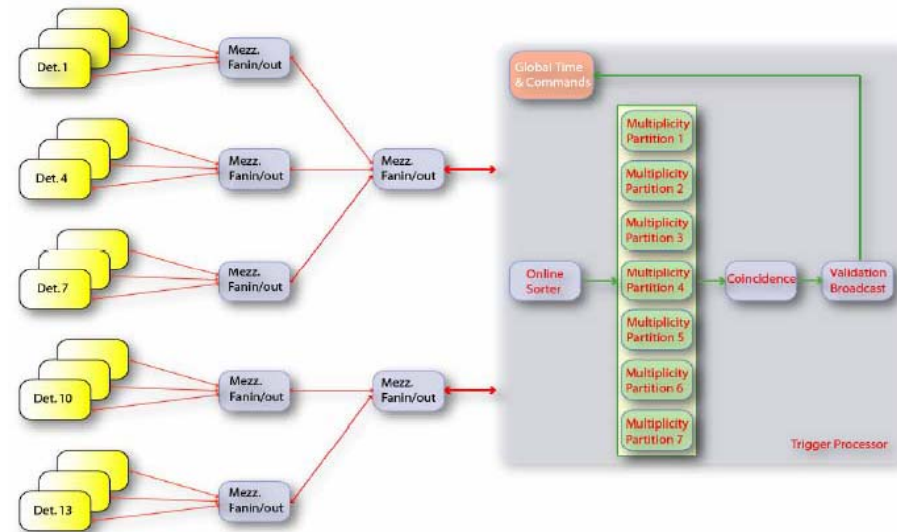
- Runs on an evaluation board with a VIRTEX5 FPGA
- Partitions and sum buses implemented in VHDL
- 2nd level logic is implemented in C and runs in the PPC
- **Uses idle-messages to timeout non-participating nodes**
- Present version has 48 inputs and 4 partitions
- Each partition has 4 multiplicity thresholds
- The two partitions can be operated in coincidence
  P1 with the Ge crystals   Trig1 → P1 >=1 & P2 = 1
  P2 with the ancillary   Trig2 → P1 >=2

Handles max 100 kHz of coincidences (limited by PPC)

Available Triggers

- multiplicity
  - up to 4 partitions(P), each one with 4 multiplicity thresholds
  - often used with 1 partition containing the 15 Ge detectors
  - digital version of the classical multiplicity sum bus
- ancillary
  - P1(Ge) AND P2(Ancillary) coincidence condition is a window on the timestamps
- ancillary2
  - (P1 AND P2) OR (P2 AND NOT P1) (e.g. validate PRISMA even if there is no gamma coincidence)
- Service triggers
  - validate_all
  - reject_all
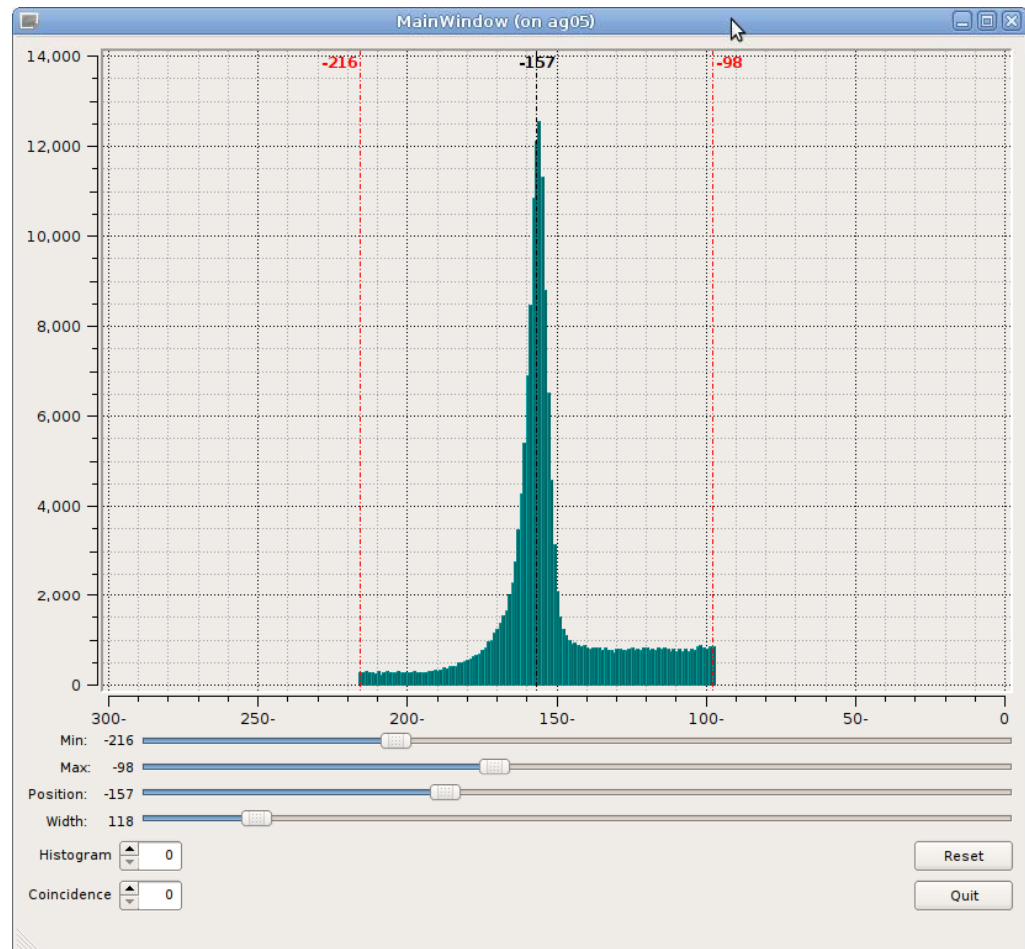
Preamplifiers

(→Bart)

Digitizers

- 100 MS/s
  - max frequency correctly handled is 50 MHz (Nyquist)
- 14 bits
  - Effective number of bits is ~12.5 (SNR ~75 db)
- 2 cores and 36 segments (in 6 boards)
- Core 2 ranges 5, 20 MeV nominal
- Segments either high or low gain
- The digitized samples are serialized and transmitted via optical fibre (1/channel) to the preprocessing electronics. Transmission rate is 2 Gbit/s on each of the 38 fibres.
- Power consumption 240 W
- Weight 35 kg

Beware of aliasing!

Sampling theorem: analogue input signals limited to a bandwidth f_{BW} can be reproduced from their samples <u>with no loss of information</u> if they sampled at a frequency $f_s \geq 2f_{BW}$ $\rightarrow$ **Nyquist frequency**
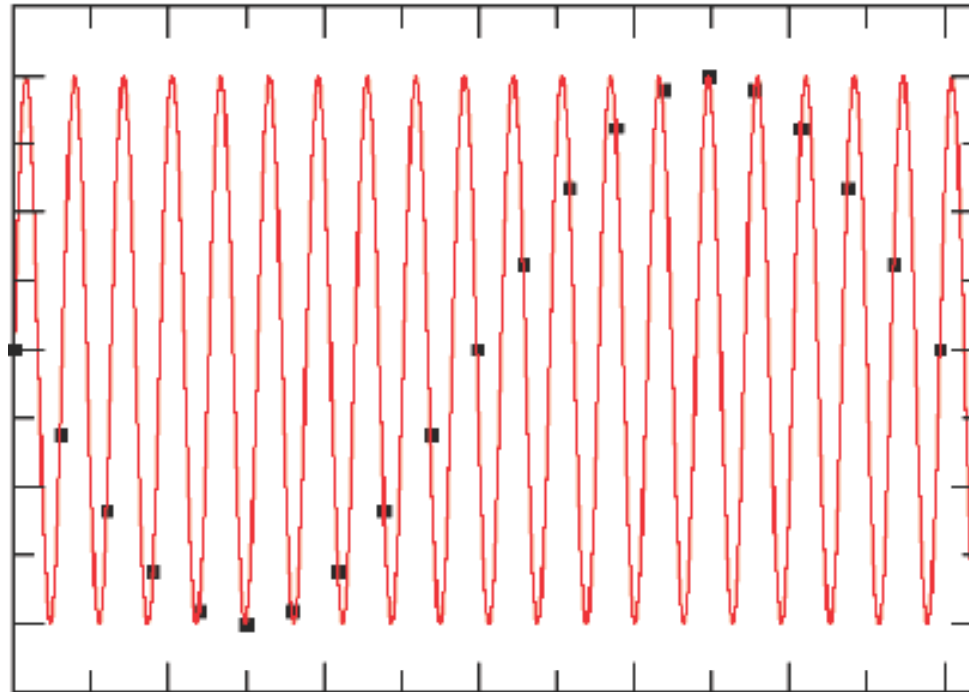
At 100 Ms/s, the preamplifier signals must be filtered, at the input of the, the digitizer to remove frequencies above 50 MHz (in practice above ~20 MHz)

AGATA Digitisers
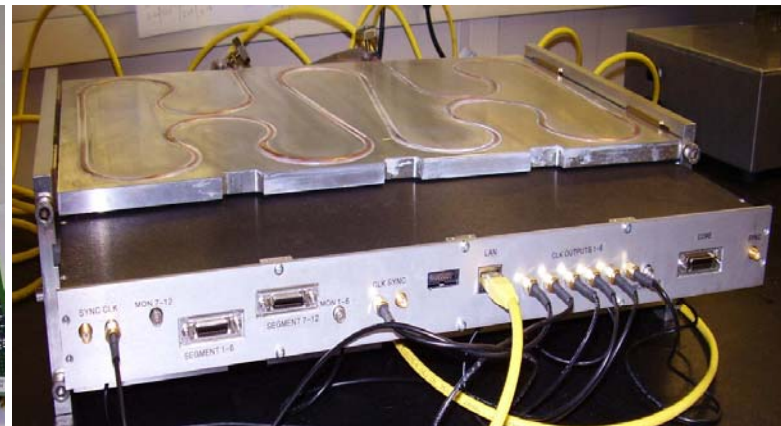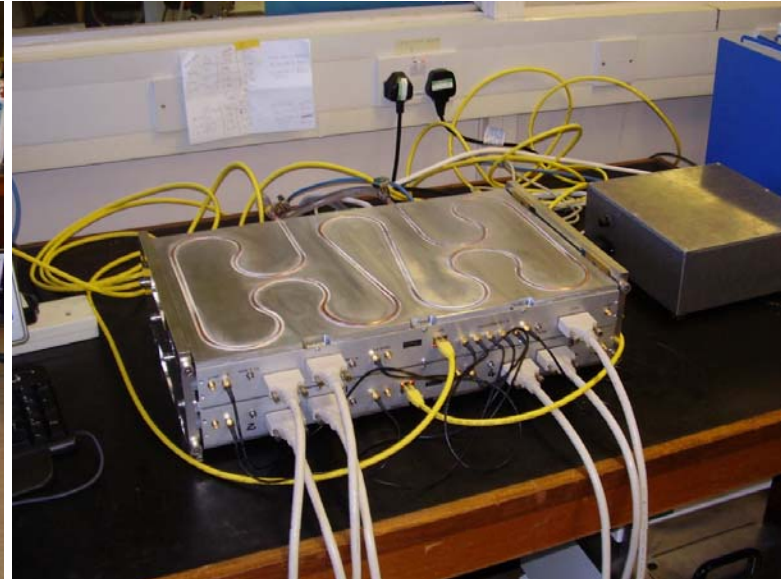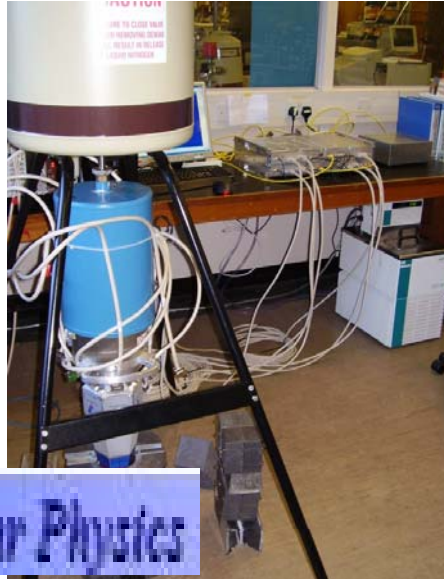
As the digitizers just digitize and transmit the sample, they operate very smoothly, need to be power-cycled very rarely, which is good for the gain stability of the signals.

Range of digitizers 1
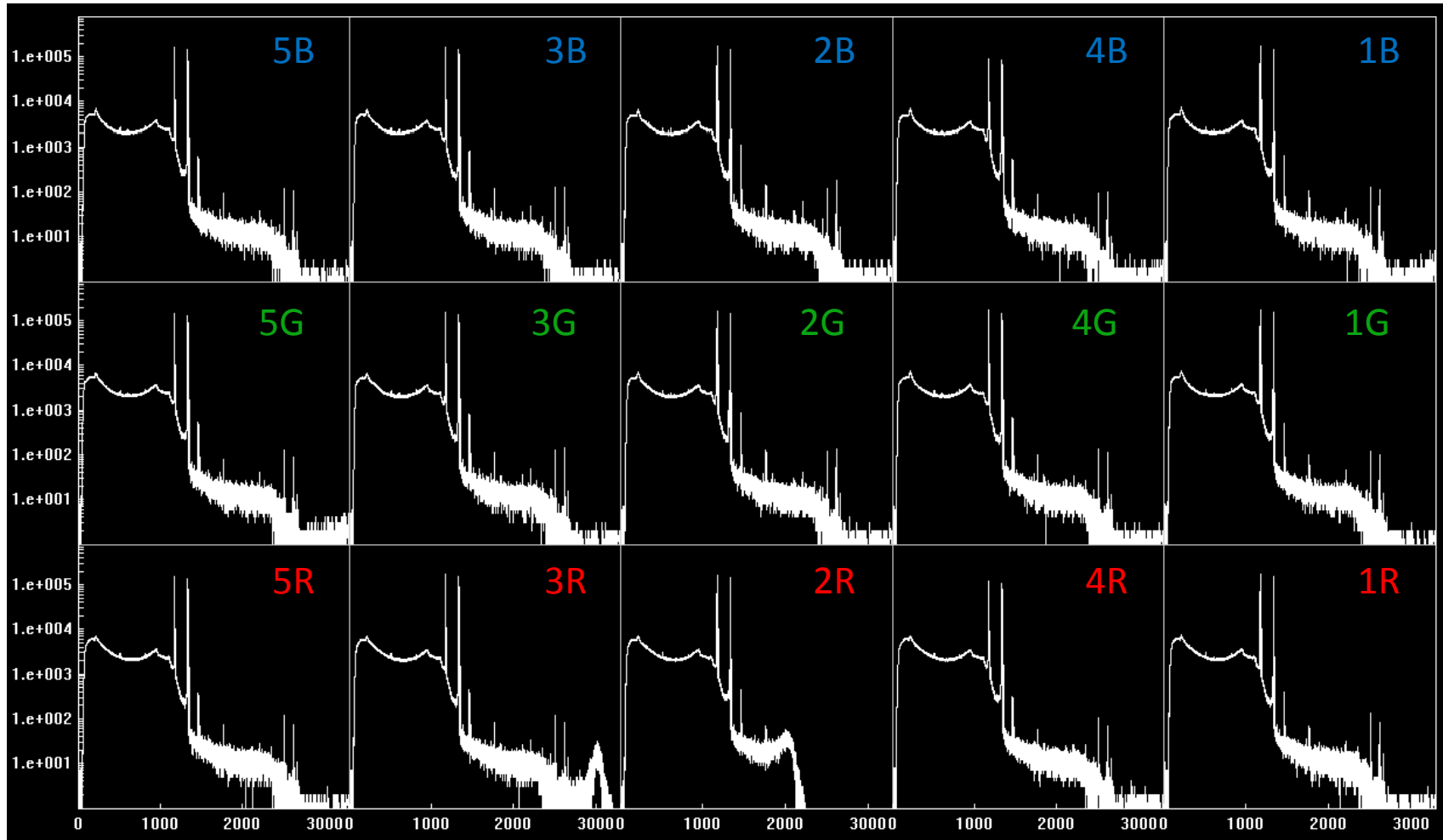
Some cores and segments saturate below 3 MeV on the high-gain range

Gain in the digitizers should be reduced by ~30%

test5atc_110603/run_000

Range of Digitizers
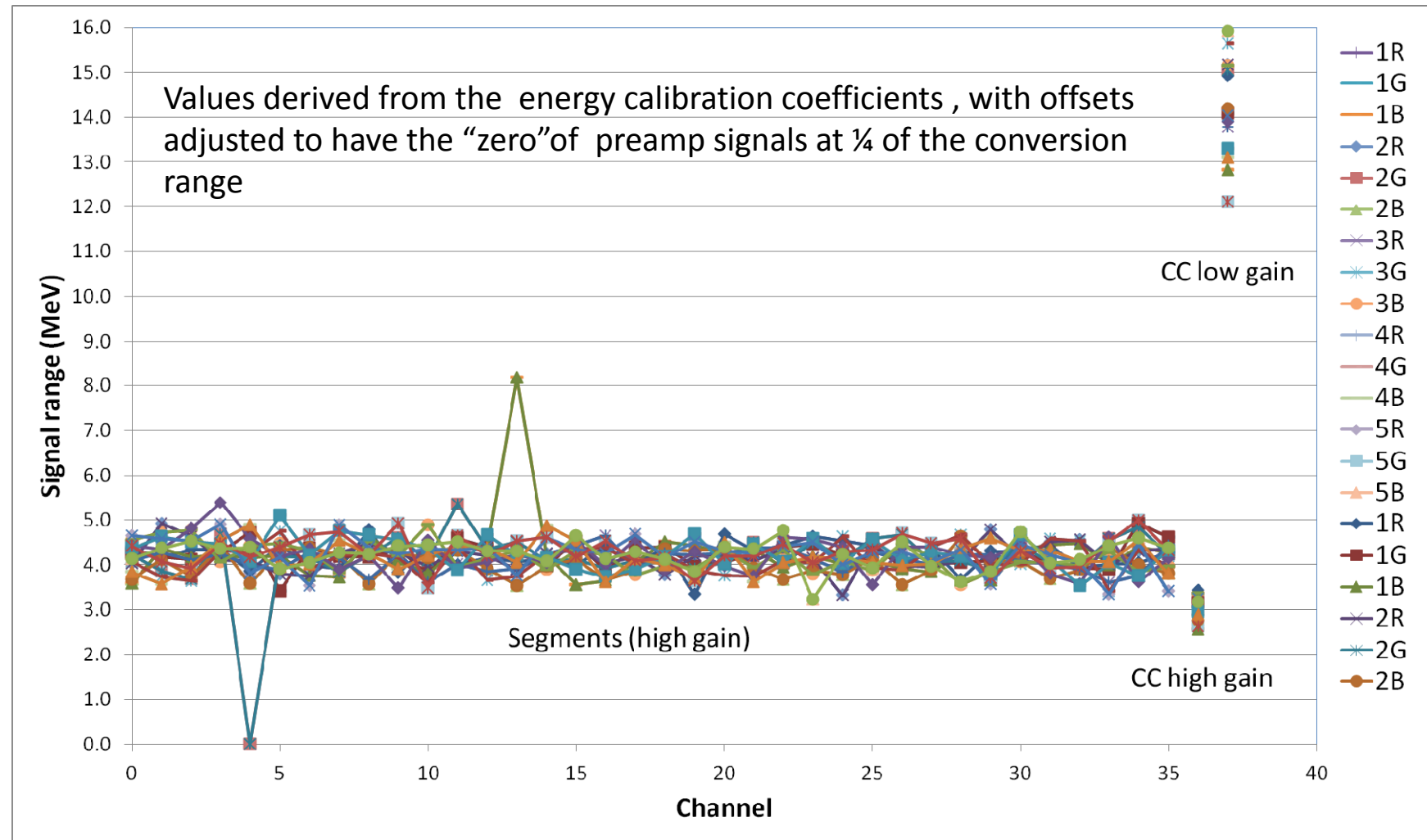
Range of digitizers 2

Operation at high counting rates

1 ms
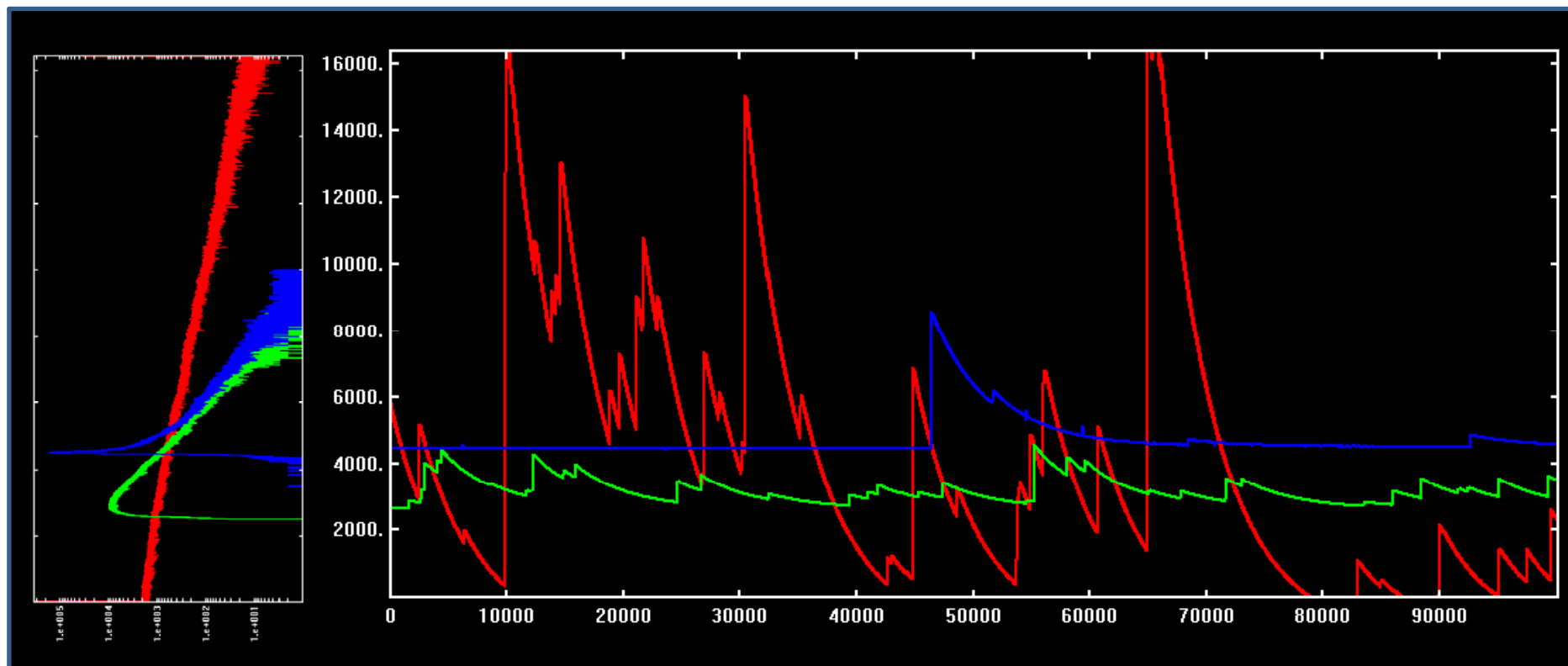
1R CC high gain   **1R CC low gain**   **1R B1 (low gain)**

CC ~30 kHz segment B1 ~7 kHz

Preprocessing Electronics

- Fully digital, processing 38 channels in parallel for each crystal.
- Receives the continuous stream of samples from the digitizers.
- Generates the energy by means of a trapezoidal shaper
- Generates the local trigger on the core (CC) signal by Leading Edge Discriminator (or CFD)
- Takes a snap shot of 1 μs (100 samples) on all 38 channels
- Sends validated events to the front-end computers
- For 1 crystals: 2 ATCA carrier boards, 7 processing mezzanines and 1 GTS node.

6 crystals in one ATCA crate
(228 high resolution channels)
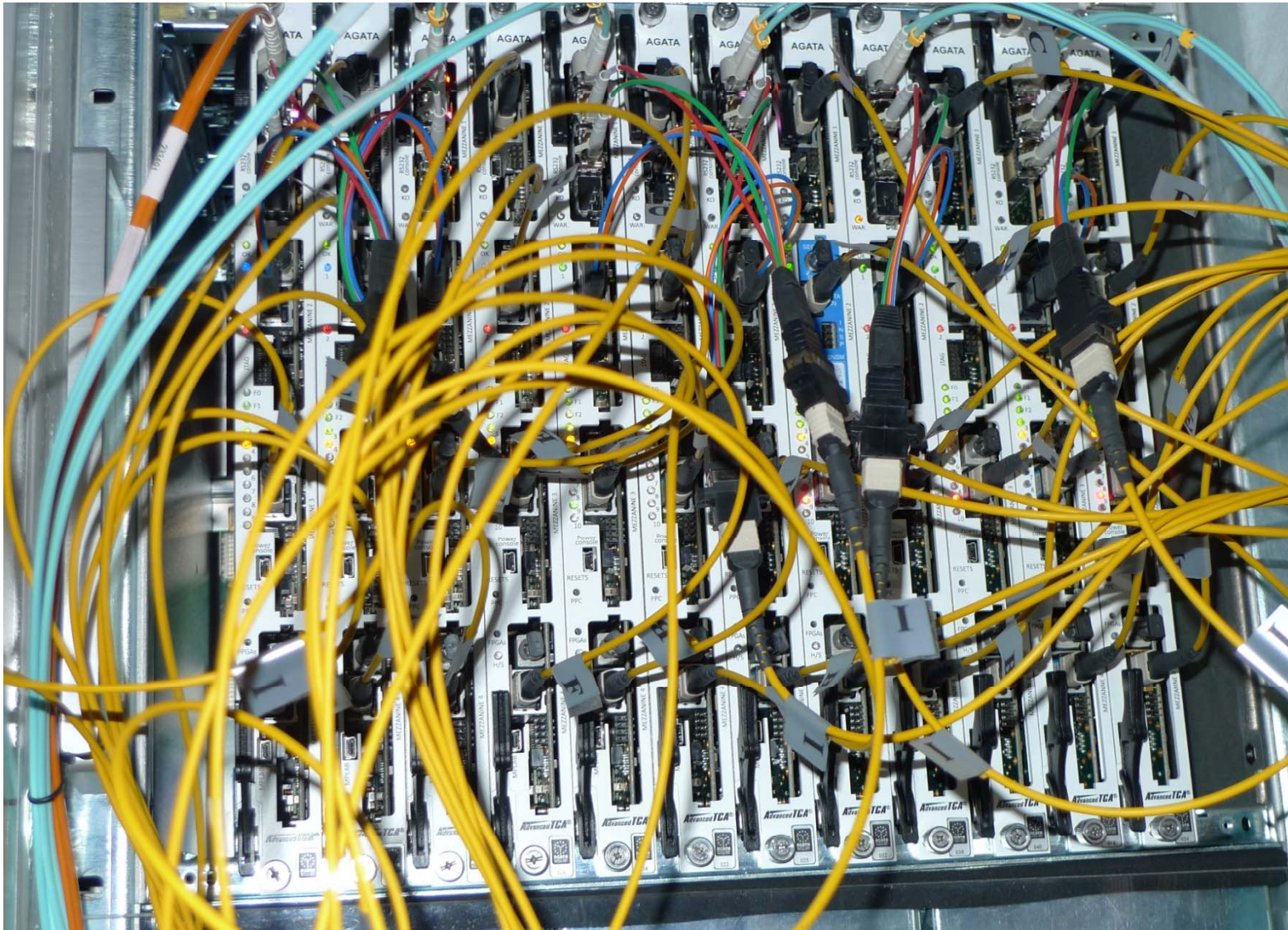
Signal Processing in the electronics

- – Noise and disturbances in the signals
- – Effective band width of the signals
- – Deconvolution of the main pole
- – Deconvolution of 2nd order effects in detector/preamp chain (multiple poles)
- – Triangular (trapezoidal) shaping
- – Adaptive shaping for high counting rates
- – More sophisticated BLR
- – Treatment of saturated signals by ToT
- – …

Convolution and Correlation

Signal processing blocks can be often described as linear (and time invariant) systems that act on an the input to produce an output.

$x[n] \longrightarrow$ Linear System $h[n]$ $\longrightarrow y[n]$ h[n] is the transfer function of the system
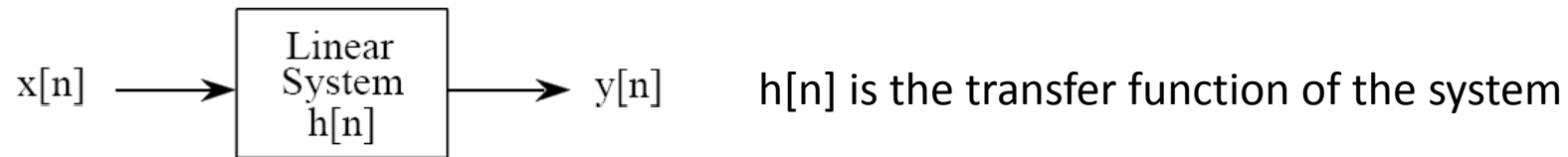
- Convolution: how a linear system acts on the input to produce the output

$$y[n] = x[n] \otimes h[n] = \sum_{i=0}^{N-1} x[i]h[n-i] = \sum_{i=0}^{N-1} x[n-i]h[i]$$

- Correlation: evidences similarity of two signals

$$R_{xy}[n] = x[n] * y[n] = \sum_{i=0}^{N-1} x[i]y[i-n] = \sum_{i=0}^{N-1} x[i-n]y[i]$$

- Autocorrelation: short and long term correlations in a signal

$$R_{xx}[n] = x[n] * x[n] = \sum_{i=0}^{N-1} x[i]x[i-n]$$

Transforms

- Mapping of one space to another (dual) in order to simplify and/or speed-up operations that are difficult and/or slow in the original one space.

- Fourier Transform   time $\leftrightarrow$ frequency
  - Analysis of noise, detector response function, action of filters and shapers

- Laplace Transform   time $\leftrightarrow$ s
  - Solving differential equations

- Z Transform   sample number $\leftrightarrow$ z
  - Solving difference equations and expressing in an analytical way filters and shapers

- Common and useful properties
  - Linearity $T(a{\cdot}f(t) + b{\cdot}g(t)) = a{\cdot}T(f(t)) + b{\cdot}T(g(t))$
  - Derivation $D(f(t))$ $= s{\cdot}T(f(t)) + \text{initial condition}$
  - Integration $I(f(t))$ $= T(f(t))/s$
  - Convolution $T(f(t) \otimes g(t))$ $= T(f(t)) \cdot T(g(t))$

- In general the original and transformed variables are complex .
  In Signal Processing the original data is almost always real and the transformed variable is often also real (e.g. power spectra with all phases set to zero so that only the amplitude is of interest)

Fourier Transform(s)

Type of Transform	Example Signal
Fourier Transform *signals that are continious and aperiodic*	
Fourier Series *signals that are continious and periodic*	
Discrete Time Fourier Transform *signals that are discrete and aperiodic*	
Discrete Fourier Transform *signals that are discrete and periodic*	

Discrete Fourier Transform
of real signals

Time Domain

Frequency Domain

Forward DFT

x[ ]

0   N-1
N samples

Inverse DFT

Re X[ ]

0   N/2
N/2+1 samples
(cosine wave amplitudes)

Im X[ ]

0   N/2
N/2+1 samples
(sine wave amplitudes)

dspguide
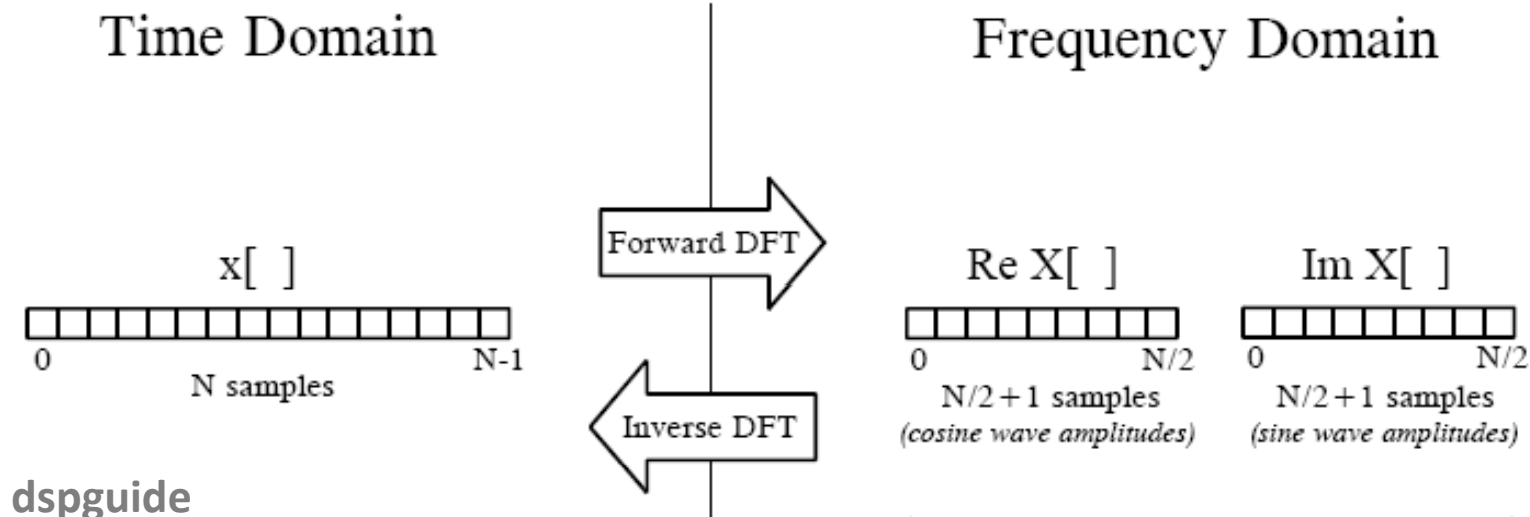
$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-i2\pi \frac{k}{N} n}$$

Forward → decomposition

$$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{i2\pi \frac{k}{N} n}$$

Inverse   → synthesis

N real signals mapped to N coefficients (N+2, but 2 are identically zero: sin[0], sin[N/2])
Vector representation (cos,sin) useful for calculations
Polar representation (magnitude, phase) used for human inspection
For large N, calculated using the Fast Fourier Transfor (FFT) algorithm

Useful theorems

- **Parseval**: correspondence between time and frequency power spectra

$$\sum_{0}^{N-1}\left|x_n\right|^2 = \frac{1}{N}\sum_{0}^{N-1}\left|X_n\right|^2 \qquad \sigma^2 = \frac{1}{N}\sum_{0}^{N-1}\left|x_n\right|^2 = \frac{1}{N^2}\sum_{0}^{N-1}\left|X_n\right|^2$$

$$\sigma = \frac{1}{N}\sqrt{\sum_{0}^{N-1}\left|X_n\right|^2} = \frac{\sqrt{2\cdot INP}}{N} \qquad FWHM = \sigma\sqrt{8\ln(2)} = \frac{3.33\sqrt{INP}}{N}$$

$\Sigma|x_n|^2 / N$ corresponds to the variance σ^2 if the "noise" spectra have $<x_n>=0$
The integrated noise power of the DFT spectra is multiplied by 2 because we use only positive frequencies up to Nyquist (unilateral representations).

- **Wiener-Kintchine**: the autocorrelation function of a signal is the Inverse Fourier Transform of its the power spectral density

$$R_{xx}[d] = \sum_{n=0}^{N-1} x[n]\cdot x[n-d] = F^{-1}(F(x)\overline{F}(x))$$

Noise spectrum from "empty" sampled signals

Sampled signals of "noise"

Averaged noise amplitude unsing only "empty" traces

100000 samples * 10 ns → 1 ms → frequency resolution 1 kHz
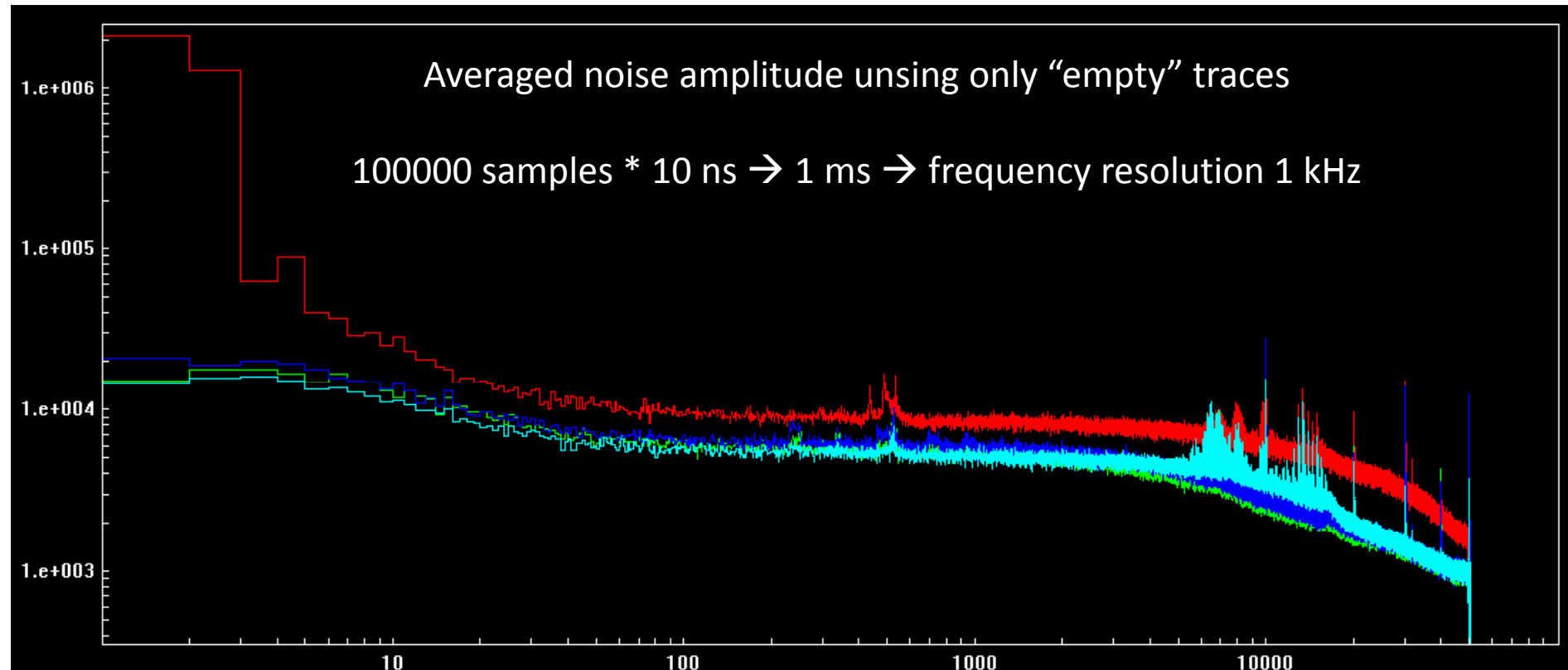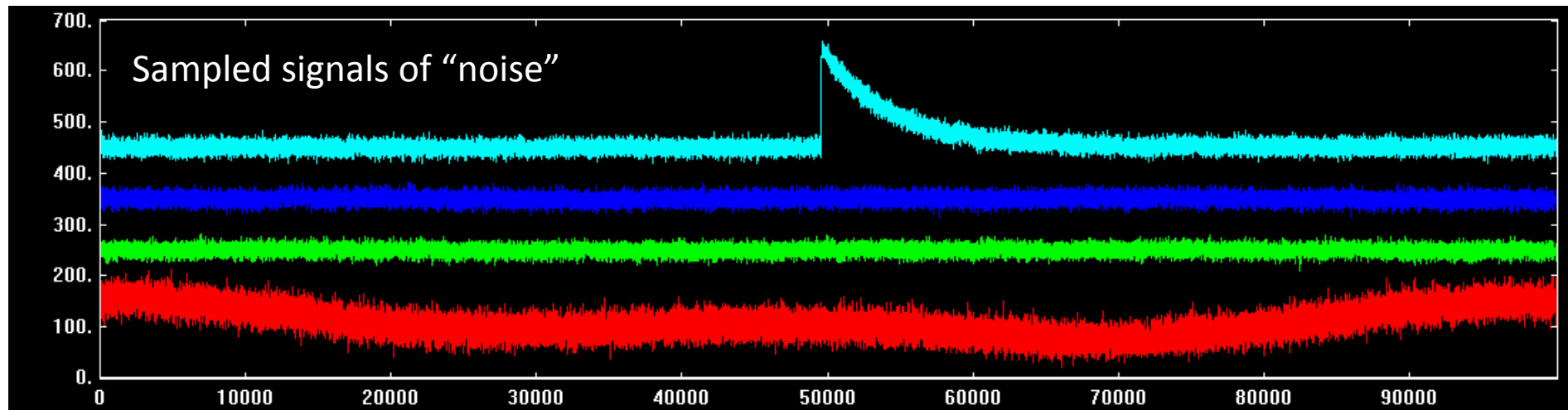
Noise spectra of ATC1

Amplitude (kev/√Hz)
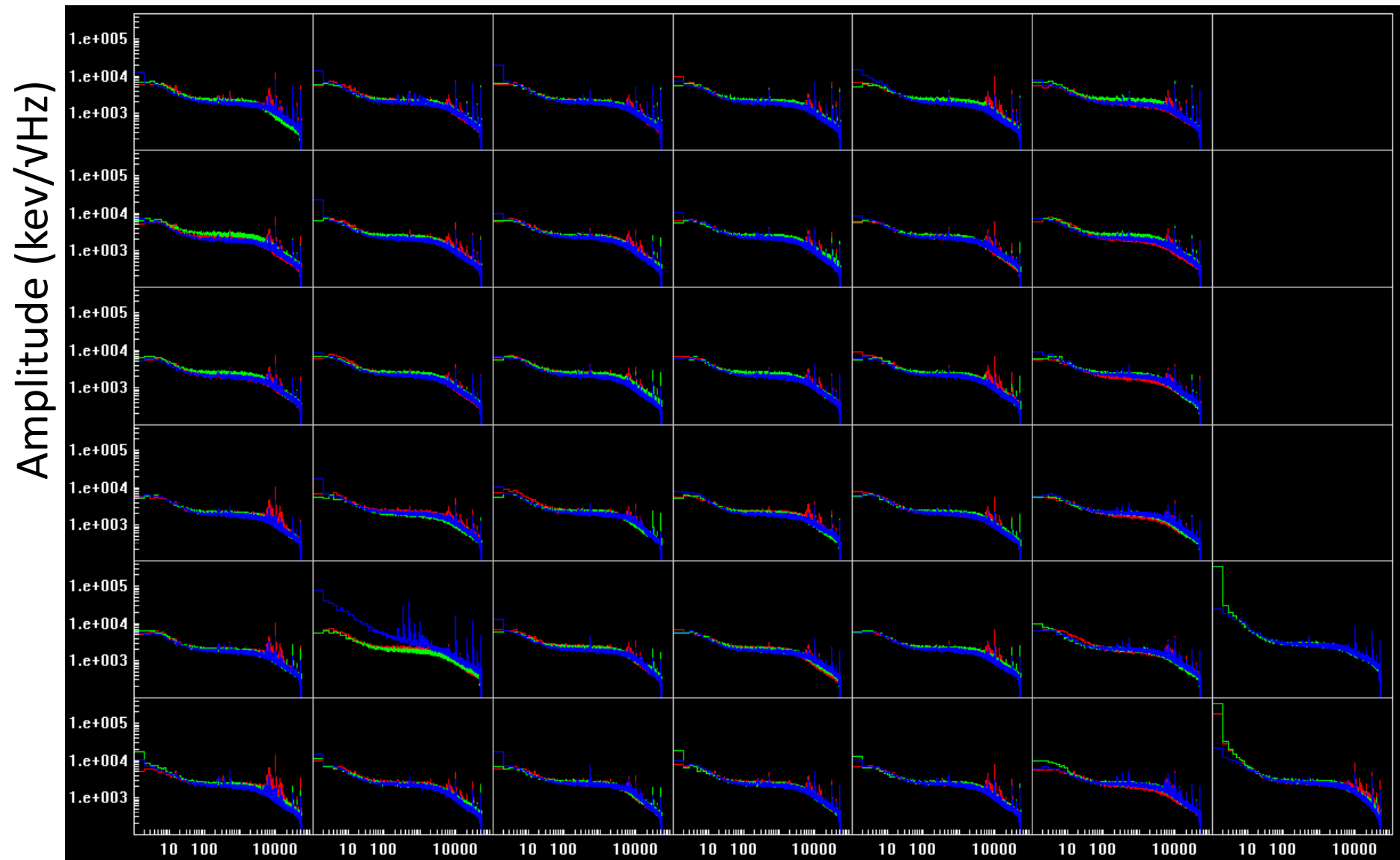
Frequency kHz

(2010-03-18 after improving grounding)

Autocorrelation of noise

- Autocorrelation determined from the inverse of the noise density power spectrum, obtained by averaging "empty" traces

- Autocorrelation enhances the evidence of periodic disturbances

- Allows to determine the high frequency cut of the total preamplifier+digitizer transfer function
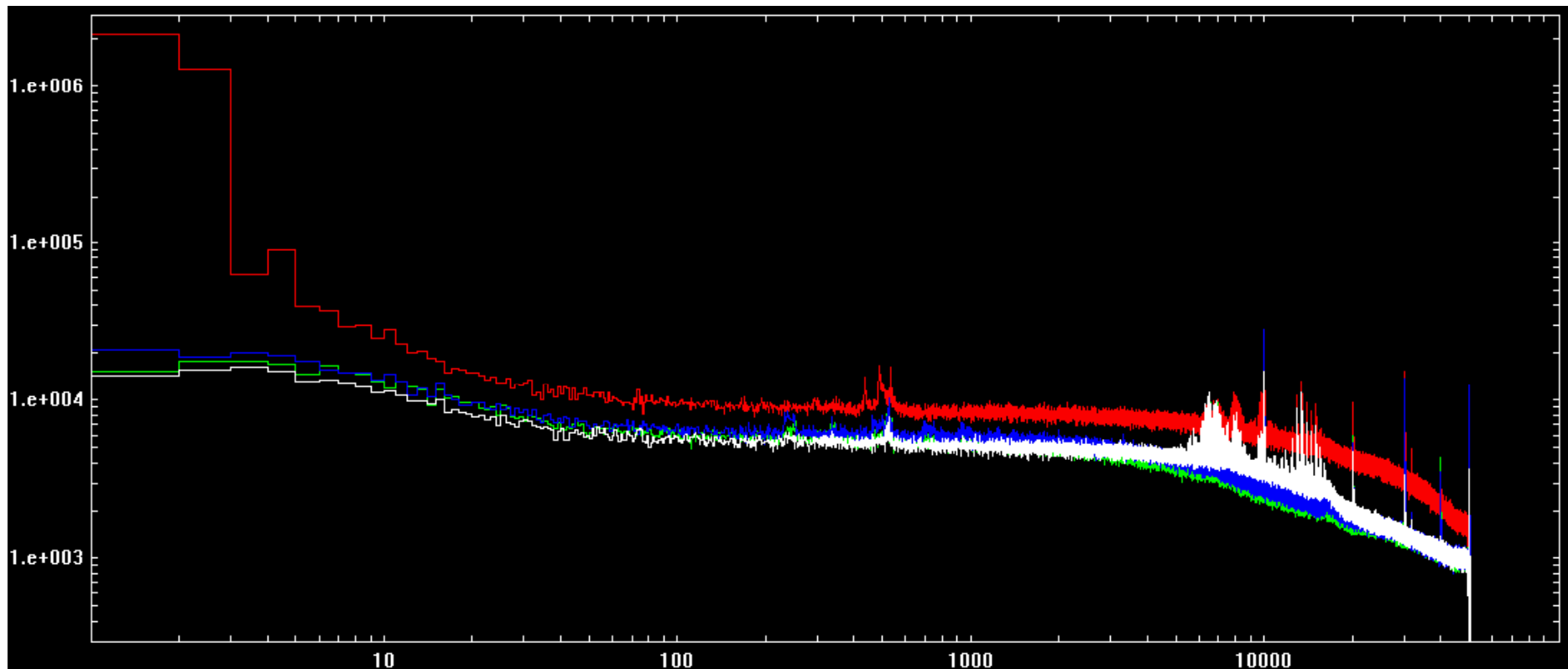
Repetitive disturbances

Gaussian bursts
Repetition 50 kHz
High frequency 8 MHz
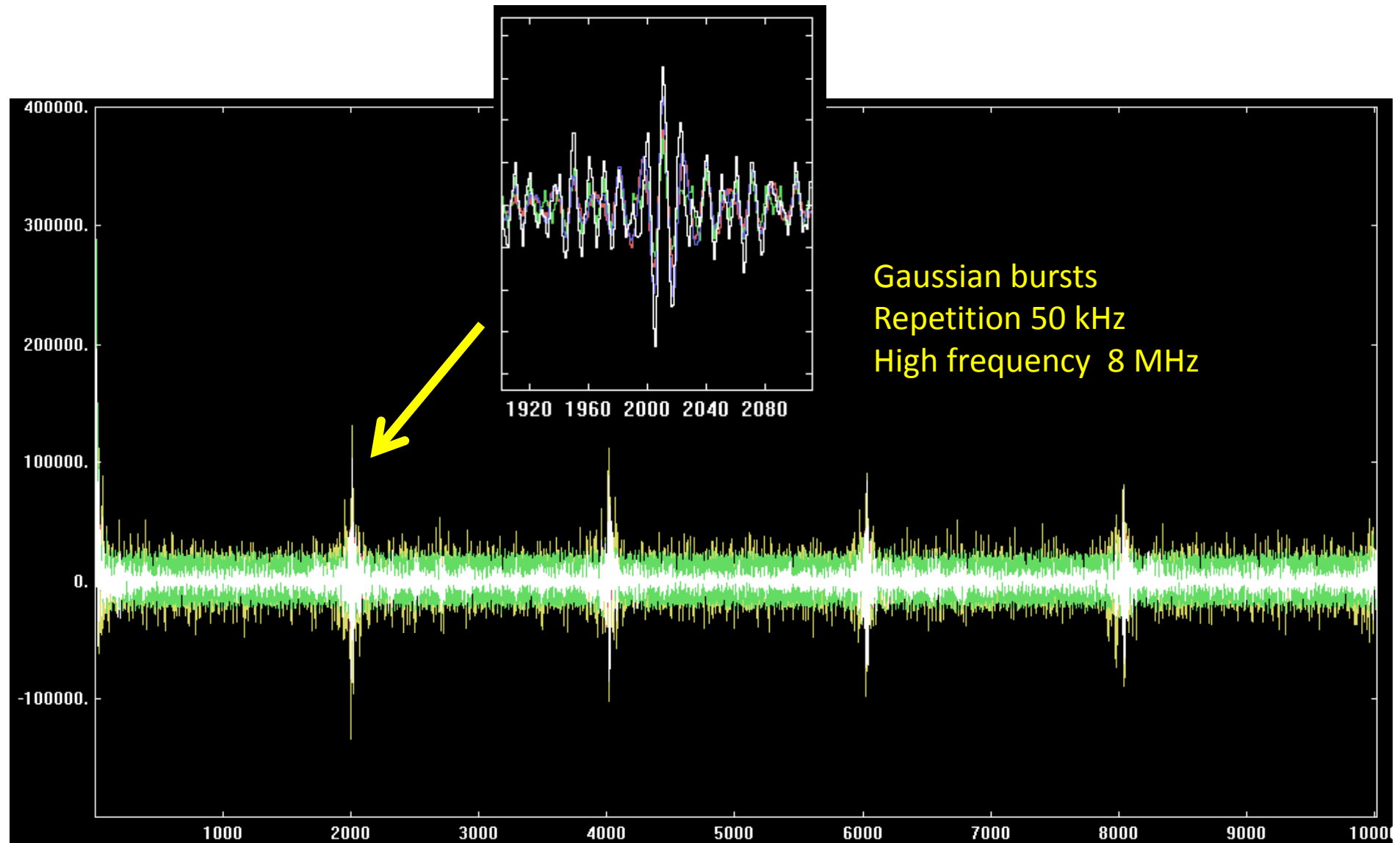
High frequency cut of spectrum

Autocorrelation rotated to the centre; normalized to the maximum for the 4 channels

CC $\rightarrow$ τ = 16 ns
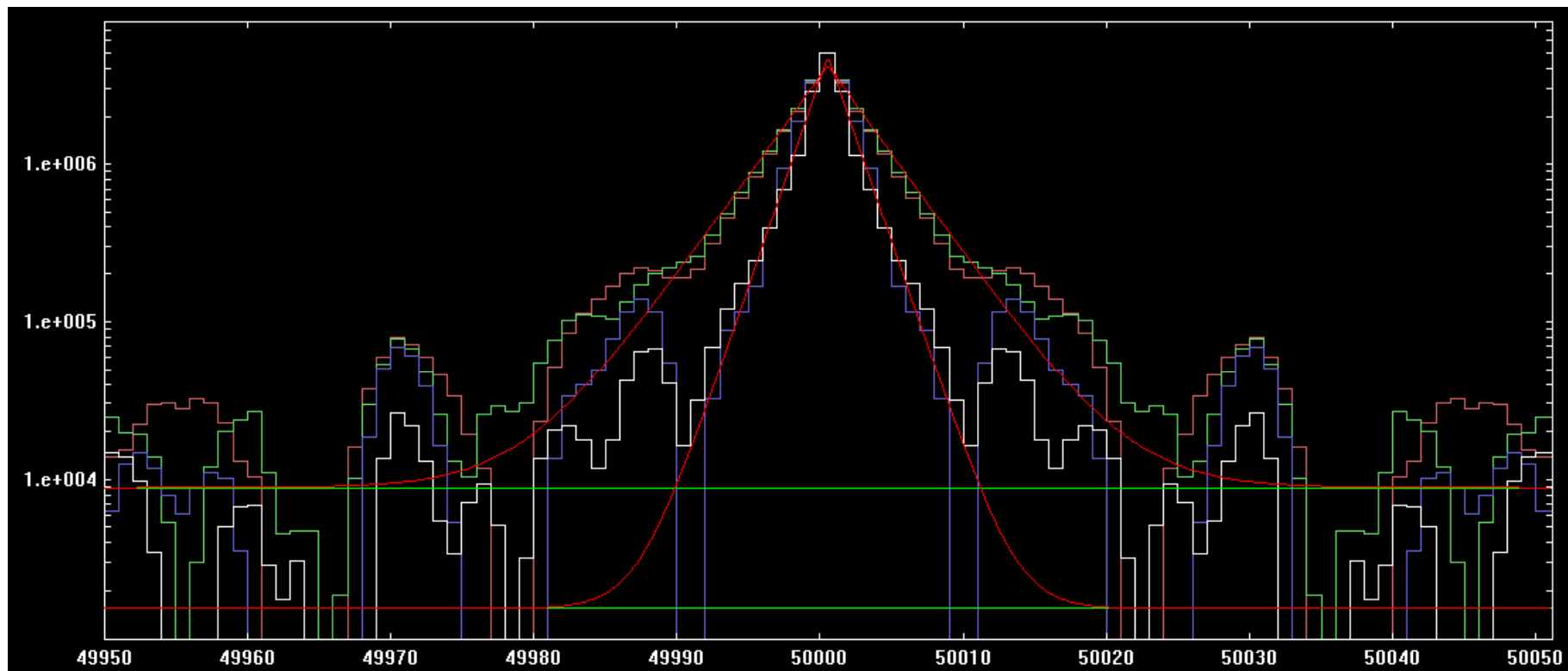
A4,A5 $\rightarrow$ τ = 30-35 ns as most of the other segments

A1 $\rightarrow$ τ = 14 ns as A2 and A3   (preamplifier board not slowed down)

"Deconvolution" of Ge signals

- Signals from Ge preamplifiers are, ideally, exponentials with only one decay constant
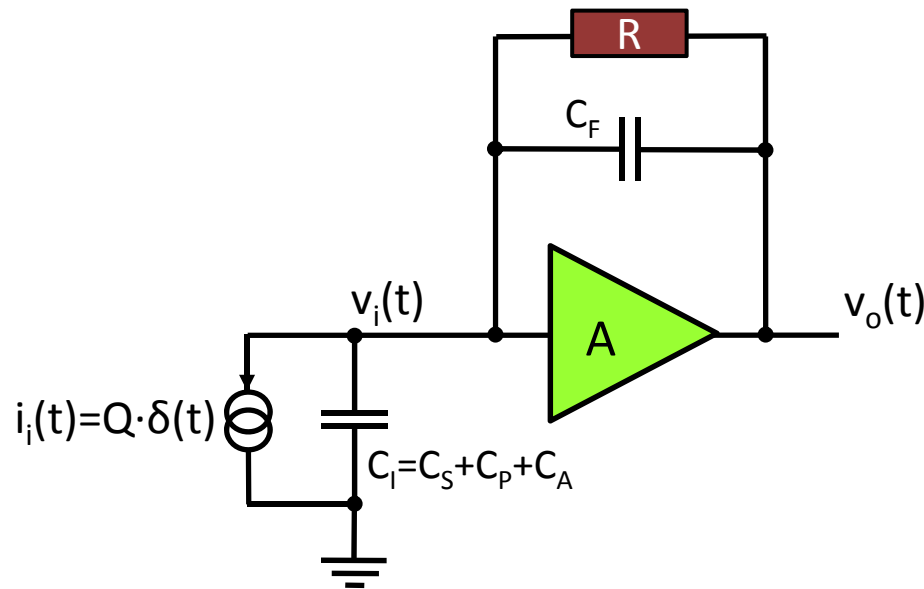
In practice the output exponential is produced in stages :
- RC_F charge loop with decay constant τ_0~1 ms
- CR differentiation to reduce the decay constant to τ_1 ~50 μs
- P/Z cancellation to remove the undershoot and the long recovery (with $\tau=\tau_0$) due to the differentiation of the first exponential.

- Task of the **deconvolution** is to remove the exponential to recover the original $\delta(t)$ at the input of the preamplifier
- **Trapezoidal shaping** is then just an integration followed by delayed subtraction followed by a moving average
- In practice **Trapezoidal shaping** is the optimum shaping if the noise is white and the collection time (width of the "delta") varies a lot as in the large volume semi-coax Ge AGATA detectors

Essentials of the z-transform

- Development of shapers done using the z-transform formalism.
- The most useful result is: if in the z domain the system function can be expressed as ratio of polynomials, in the time domain it is possible to realize it as a FIR or an IIR recursive filter with coefficients given by the coefficients of the polynomials.
- We proceed in an informal way, assuming that the ROC exists and corresponds to one-sided casual signals
- The relevant z-transform features are:

delta function $\qquad \delta[n] \longleftrightarrow 1$

step function $\qquad u[n] \longleftrightarrow \dfrac{1}{1-z^{-1}}$

k - units delay operator $\quad z^{-k} \qquad\qquad\qquad\qquad y_n = x_{n-k}$

decaying exponential $\quad e^{-\frac{n}{\tau}} \longleftrightarrow \dfrac{1}{1-az^{-1}} \;\; (a = e^{-\frac{1}{\tau}}) \qquad y_n = x_n + a\,y_{n-1}$

deconvolution of exp. $\quad D(\tau(\longleftrightarrow 1-az^{-1} \;\; (D \otimes e = \delta) \quad y_n = x_n - a\,x_{n-1}$

integration $\qquad I(\tau(\longleftrightarrow \dfrac{1}{1-z^{-1}} \;\; (I \otimes \delta = u) \quad y_n = x_n + y_{n-1}$

$\underbrace{\phantom{\dfrac{1}{1-z^{-1}}}}_{\text{z-domain}} \qquad\qquad \underbrace{}_{\text{time domain}}$

Synthesis of Trapezoid by a cascade of filters

Exponential input signal

$$X_1 = \frac{1}{1 - az^{-1}}$$

Deconvolution of exponential

$$X_2 = X_1(1 - az^{-1})$$

Integrate to get a step

$$X_3 = X_2 \frac{1}{1 - z^{-1}} = X_1 \frac{1 - az^{-1}}{1 - z^{-1}}$$

Delayed step $(K + M)$

$$X_4 = X_3 \, z^{-(K+M)}$$

Subtract delayed step

$$X_5 = X_3 - X_4 = X_1 \frac{1 - az^{-1}}{1 - z^{-1}} (1 - z^{-(K+M)})$$

Moving sum

Integrate

$$X_6 = X_5 \frac{1}{1 - z^{-1}}$$

Delay by K

$$X_7 = X_6 z^{-K}$$

Subtract and normalize

$$X_8 = \frac{X_6 - X_7}{K} = X_5 \frac{1 - z^{-K}}{1 - z^{-1}} = X_1 \frac{1 - az^{-1}}{1 - z^{-1}} \frac{1 - z^{-(K+M)}}{1 - z^{-1}} \frac{1 - z^{-M}}{K}$$

Moving average

Transfer function

$$H(z) = \frac{1 - az^{-1}}{K} \frac{1 - z^{-(K+M)}}{1 - z^{-1}} \frac{1 - z^{-K}}{1 - z^{-1}}$$

Other formulations and implementations
A.Georgiev and W. Gast, IEEE Trans. Nucl. Sci., 40(1993)770 → "Moving Window Deconvolution"
V.T.Jordanov and G.F.Knoll, Nucl.Instr.Meth., A353(1994)261

Deconvolution and shaping: ideal exponential

2011_week23   (R.Chapman, F.Haas)

Segment A6 ~3 kHz
Shaping   2.5-1-2.5 µs

Core (low gain) ~40 kHz
Shaping   2.5-1-2.5 µs

Base line not at zero and fluctuating.   Need to use the
Base Line Restorer (BLR), a time variant filter that averages
the baseline when the trapezoid is below a given amplitude.
Signal Amplitude = Value at flat-top – value of baseline
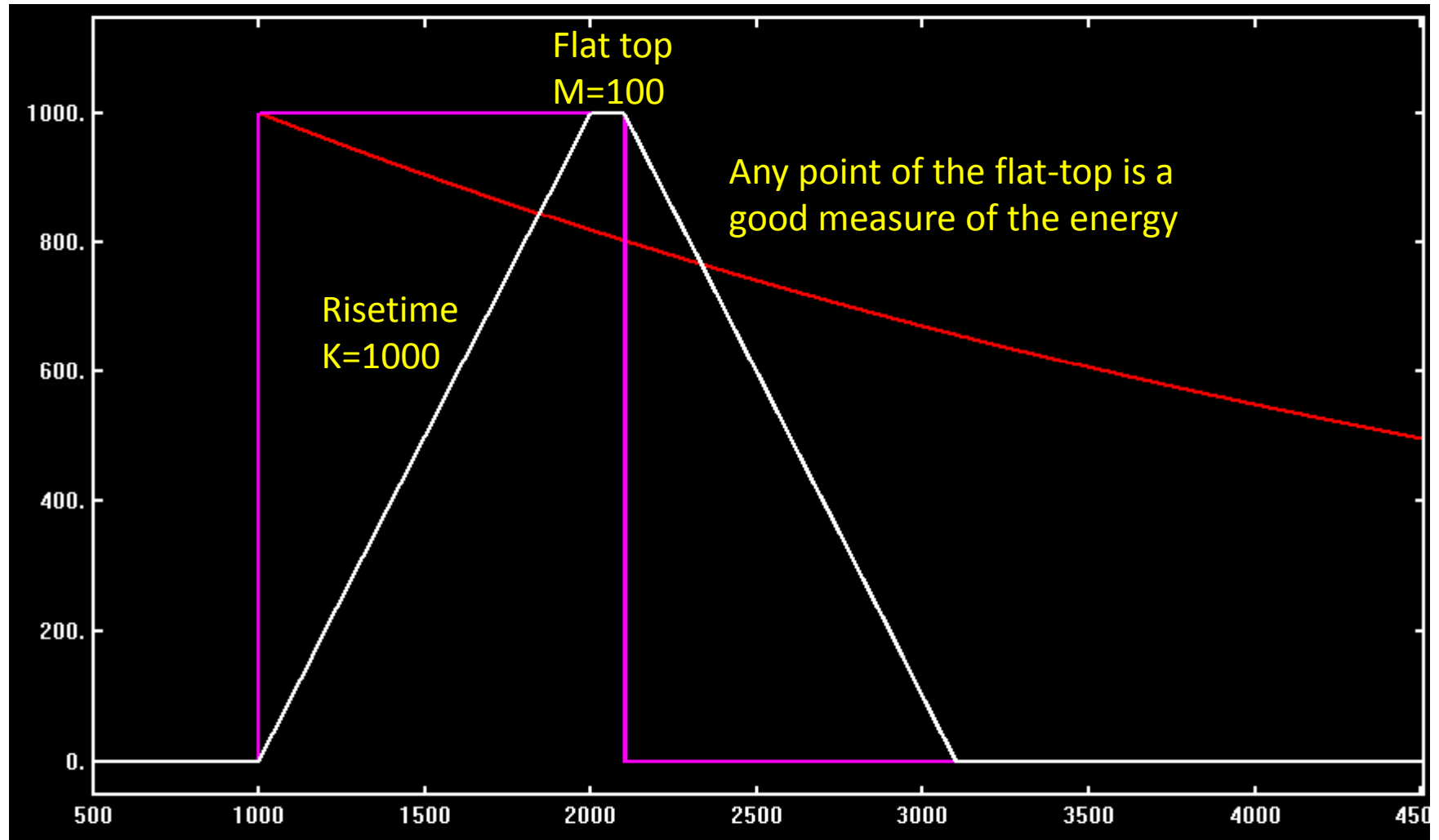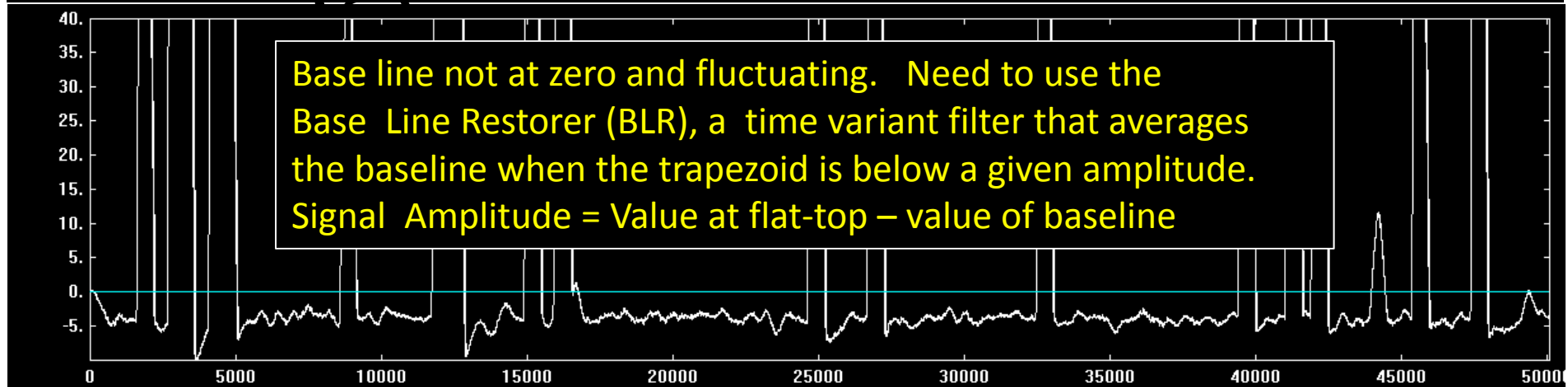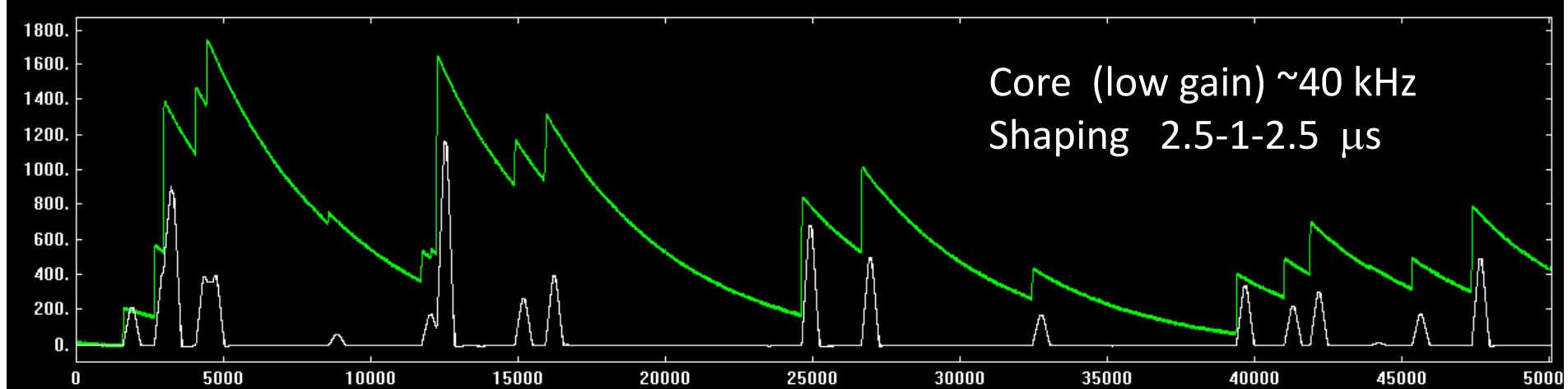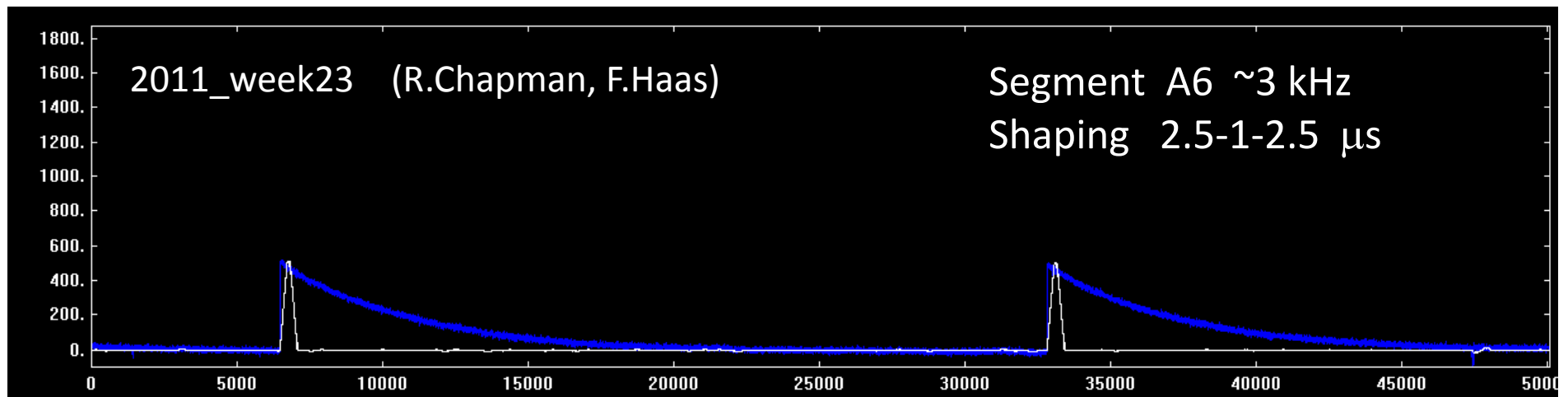
Base-line stabilisation

- continuous (exponential) average of baseline
- automatic detection of pulses based on variance
- feed-back to deconvolution stage to bring baseline down to zero
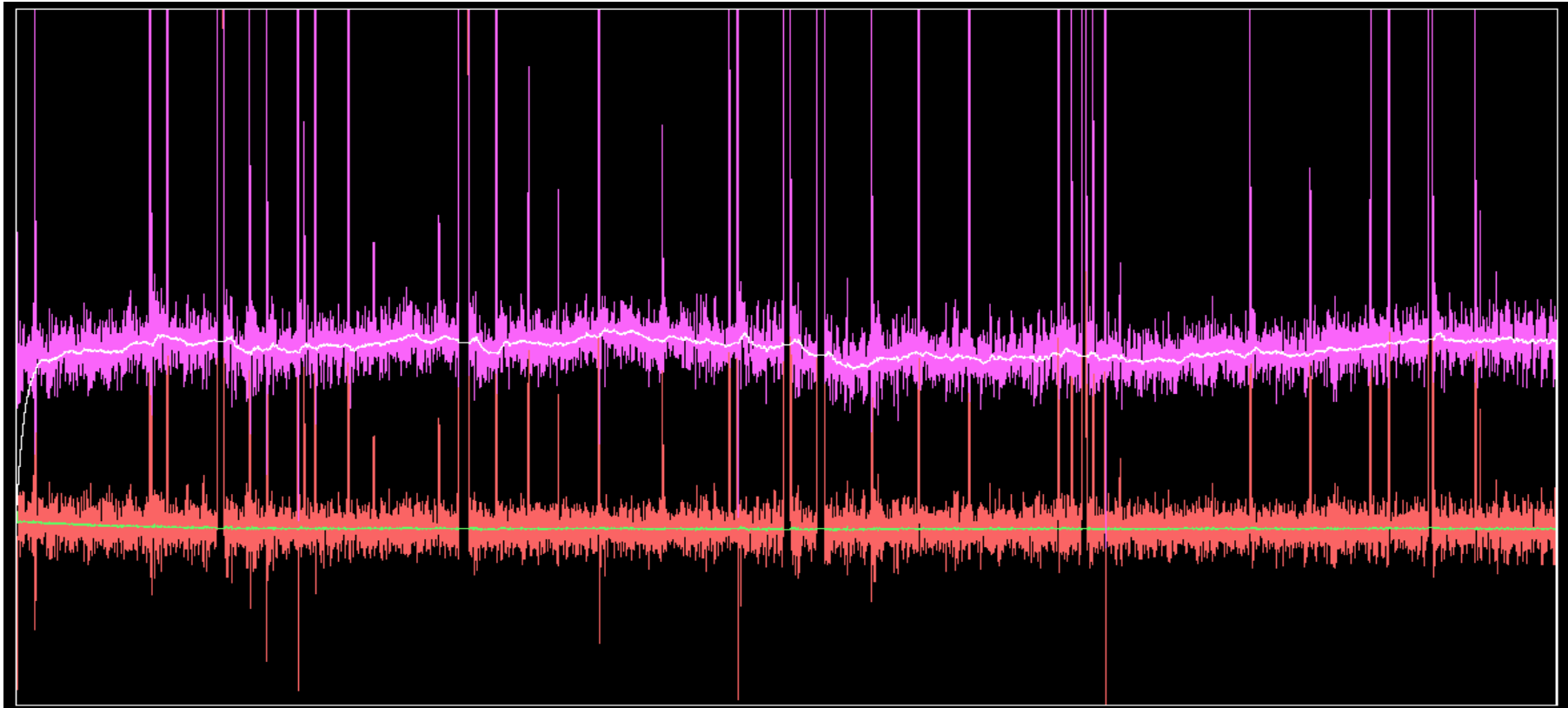
Upper part → without feedback (as used at present)
Lower part → with feedback   (used in the next electronics)

Adjustment of decay constant is critical for a good flat top

Energy readout towards the end of flat top
Readout time fixed by the trigger on CC

$\tau = 43.6 \ \mu s$
$\tau = 46.4 \ \mu s$
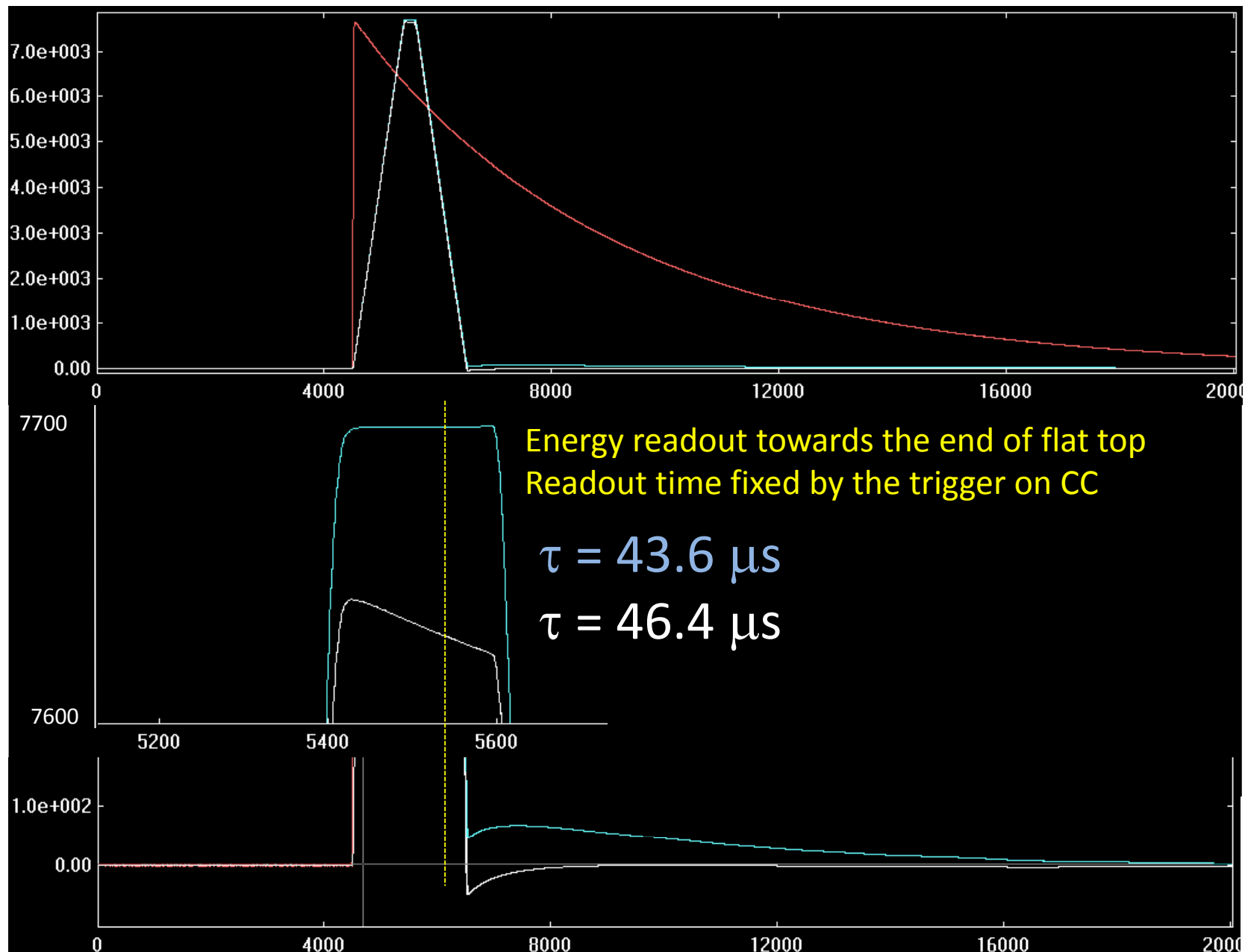
Effect of shaping on noise

Exponential with τ=4600 samples

Trapezoidal shaping 1900-100-1900
Total width 3900

Trapezoid 1000-1000-1000 + averaging 900
Flat top 100
Total width 3900

Fourier spectrum of noise for S001 CC

Amplitude keV/√(kHz)

frequency (kHz)

Noise spectrum from DFT^{-1}

Amplitude

FWHM = 4.87*2.355 = 11.48 keV

Sample number

Time domain convolution with the 2 transfer functions

Quasi triangular
Trapezoidal + average

FWHM (quasi-triangular) = 0.559*2.355 = 1.32 keV
FWHM (trap. + average)   = 0.612*2.355 = 1.44 keV

Frequency domain multiplication with the 2 transfer functions

Original
Shaped by quasi-triangular
Shaped by trap. + average

Noise component of energy resolution from Integrated Power Spectra
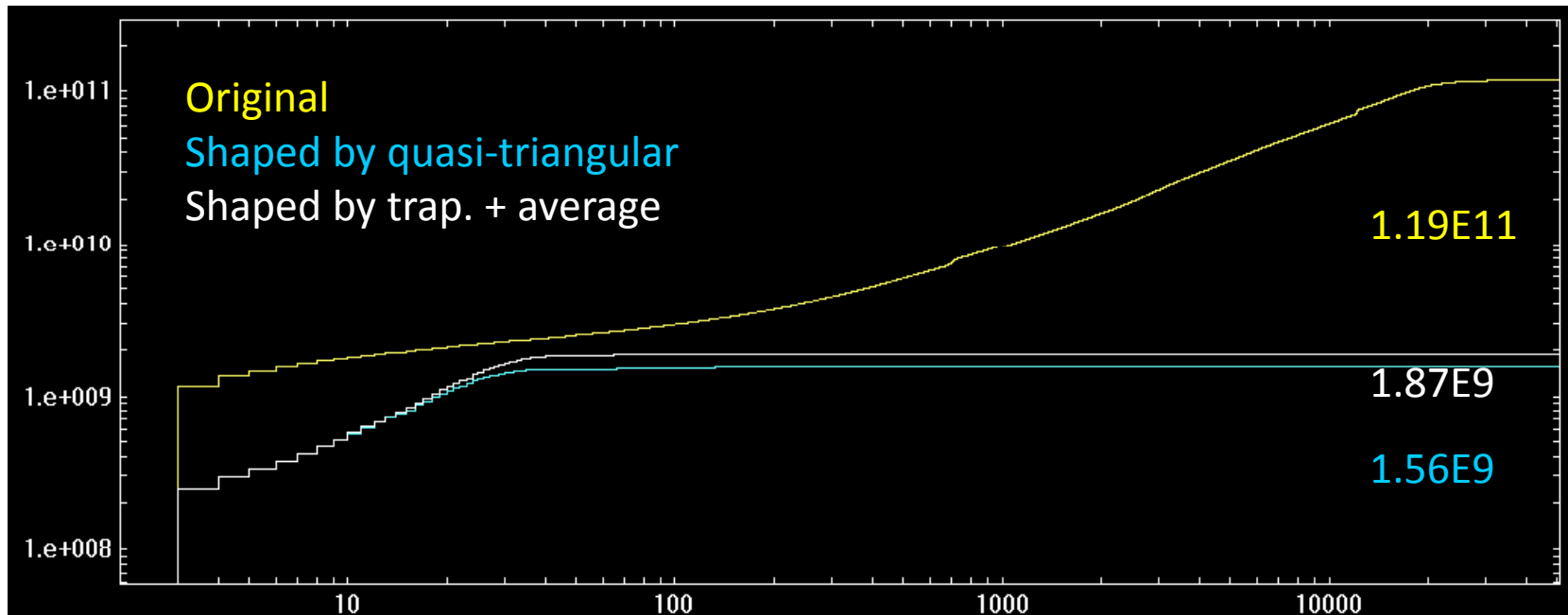
Original   FWHM = 3.33 $\sqrt{(1.19 \ 10^{11})}$ /10^5 = 11.49 keV

Quasi-Tr.   FWHM = 3.33 $\sqrt{(1.56 \ 10^{11})}$ /10^5 = 1.32 keV

Trapz.+Av   FWHM = 3.33 $\sqrt{(1.87 \ 10^{11})}$ /10^5 = 1.45 keV

Noise performance of shapers
Core and Segment C3
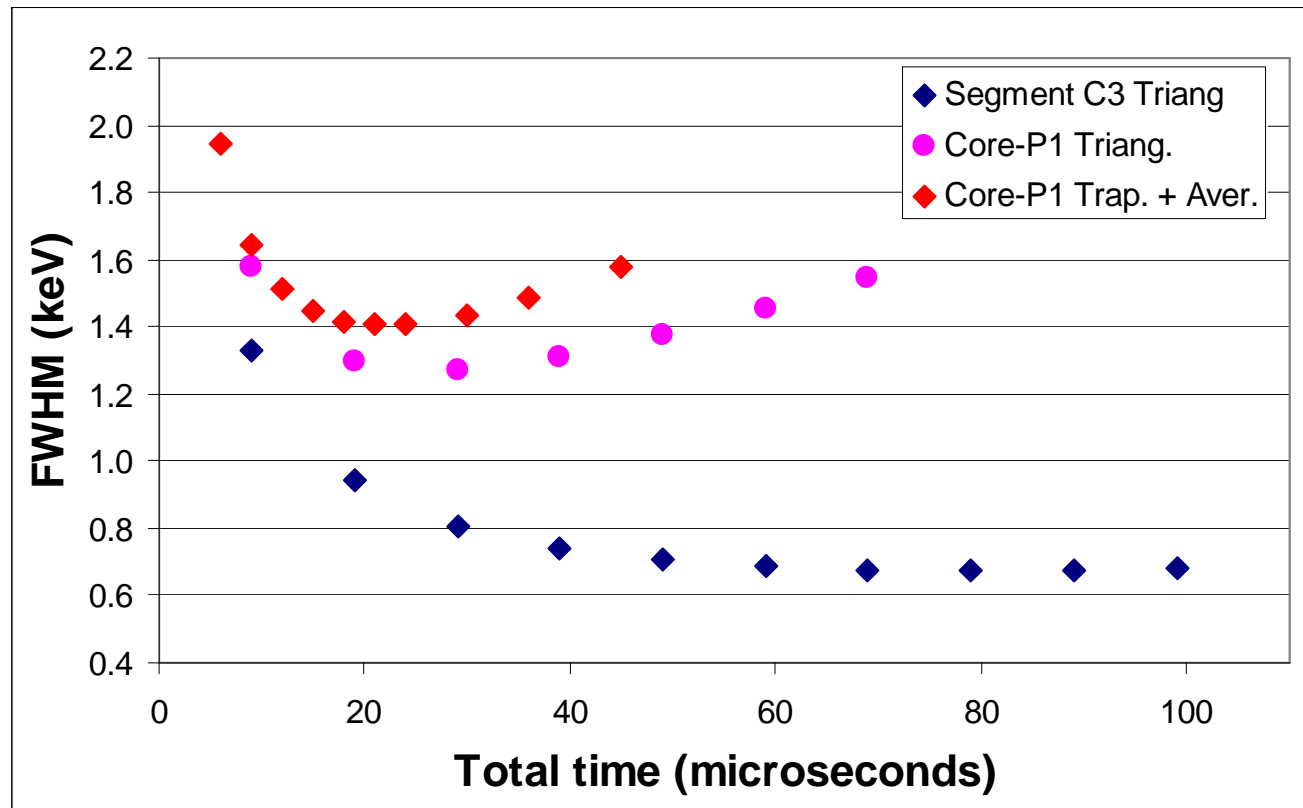
In the limit of very low counting rate and perfect BLR, the best resolution would be :

C3: 0.675 keV at [39-1-39] (Pt=40 Tt=78) Triangular with 1 μs flat top

CC: 1.269 keV at [14-1-14] (Pt=15 Tt=29) Triangular with 1 μs flat top

CC: 1.406 keV at [7-7-6]   (Pt=14 Tt=27) Trapezoidal + Average with 1 μs flat top

Singles rates and shaping time

6 different rates x 4 trapezoid risetimes x 6 BLR lengths

^{60}Co - fixed

^{137}Cs – 6 positions
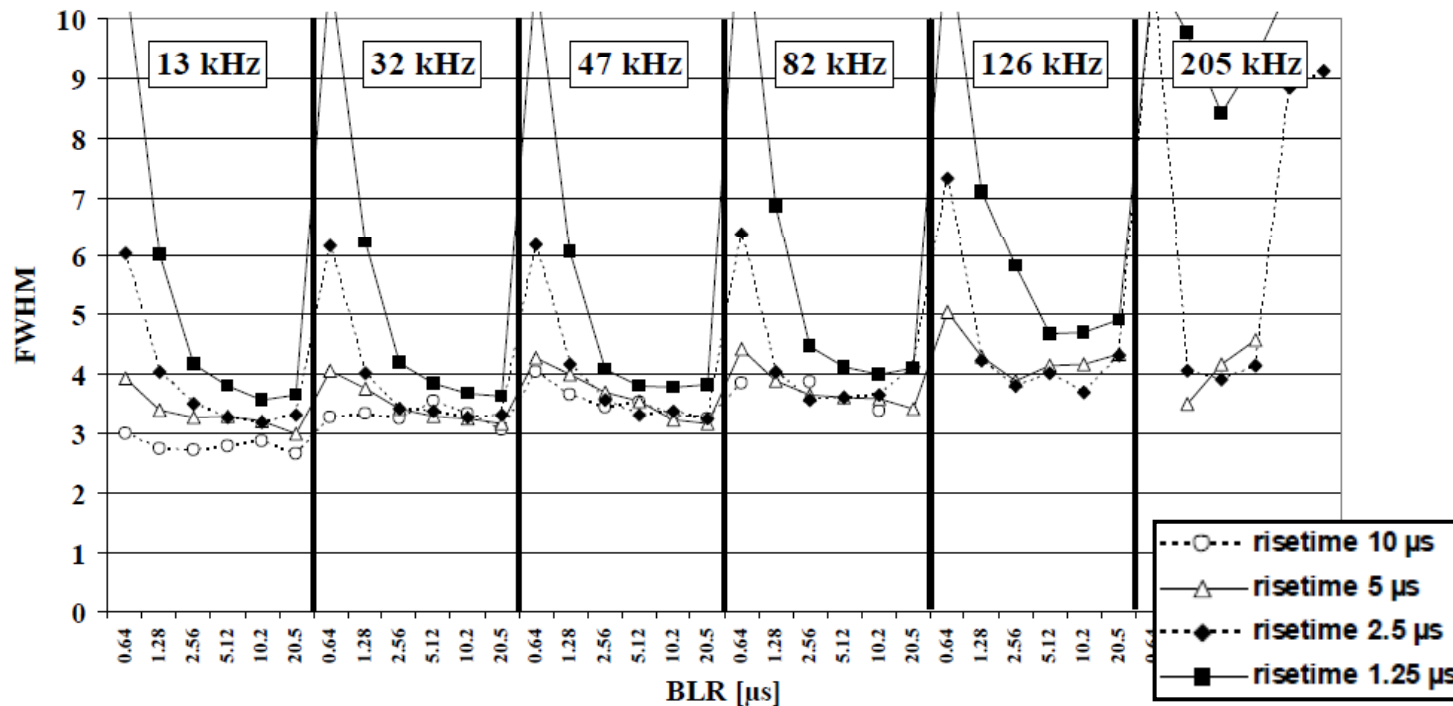
Two independent sources of dead-time: pile-up rejector and GTS

F.Recchia

Structure of Data Processing

- **Local level processing**
  - AGATA
    - Readout
    - Pre-processing
    - PSA
  - Ancillaries
    - Readout
    - Pre-processing

- **Global Level processing**
  - Event builder
  - Event merger
  - Pre-processing
  - Tracking
  - Post-Processing
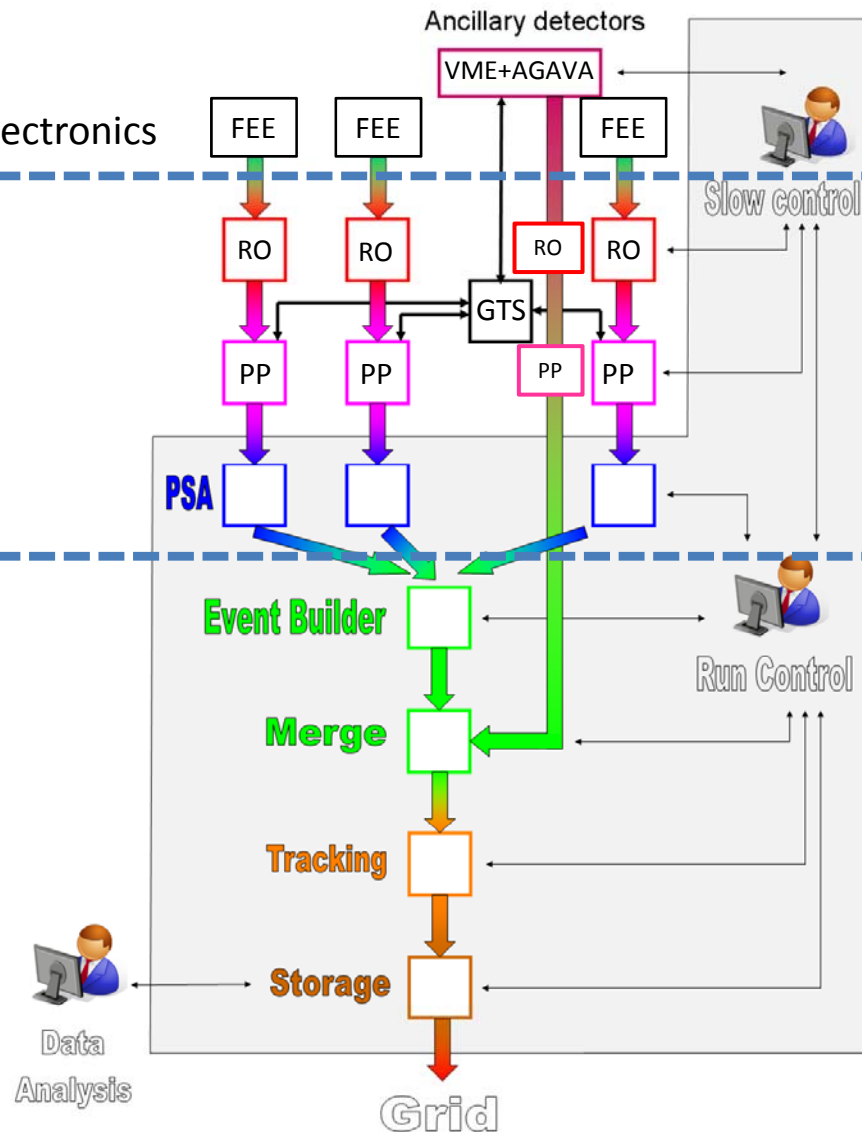
DAQ Farm

11 IBM pizza-box servers
  (+ 1 pizza/crystal)
1 Host gateway
1 KVM, 2 Switches, …

60 (+60) TB storage
15 TB for local backups
Permanent storage and data distribution
→ exploring GRID-approach via CNAF

1 U pizza-box server
2 4-core CPUs
16 GByte memory

1R 1G 1B ....

Ancillary

```
┌─────────────────────┐                              ┌─────────────────────┐
│     Digitizer        │                              │        VME          │
│  or raw data file    │                              │   or raw data file   │
└─────────────────────┘                              └─────────────────────┘
           ┊                                                      ┊
           ▼                                                      ▼
┌─────────────────────┐      ┌──────────────┐       ┌─────────────────────┐
│   CrystalProducer    │      │  EventBuilder │       │  AncillaryProducer   │
└─────────────────────┘      └──────────────┘       └─────────────────────┘
           │                         │                            │
           ▼                         ▼                            ▼
┌─────────────────────┐      ┌──────────────┐       ┌─────────────────────┐
│ PreprocessingFilter  │      │ EventMerger  │◀──────│   AncillaryFilter    │
└─────────────────────┘      └──────────────┘       └─────────────────────┘
           │                         │
           ▼                         ▼
┌─────────────────────┐      ┌──────────────┐
│      PSAFilter       │      │ TrackingFilter│
└─────────────────────┘      └──────────────┘
           │                         │
           ▼                         ▼
┌─────────────────────┐      ┌──────────────┐
│      Consumer        │      │   Consumer    │
│   Save PSA output    │      │ Save tracked  │
│                      │      │    output     │
└─────────────────────┘      └──────────────┘
```
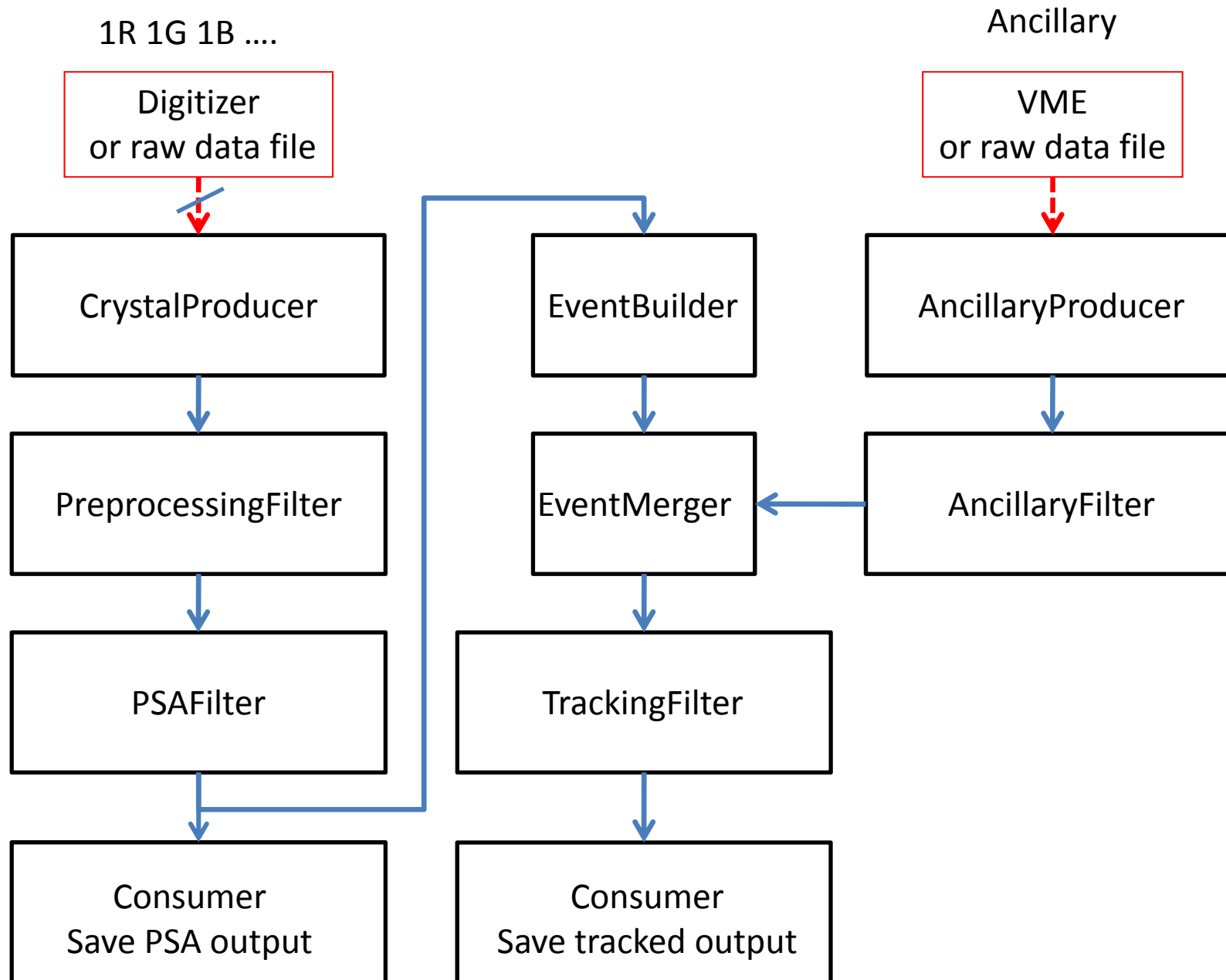
Narval Topology for
5 ATC + Ancillary
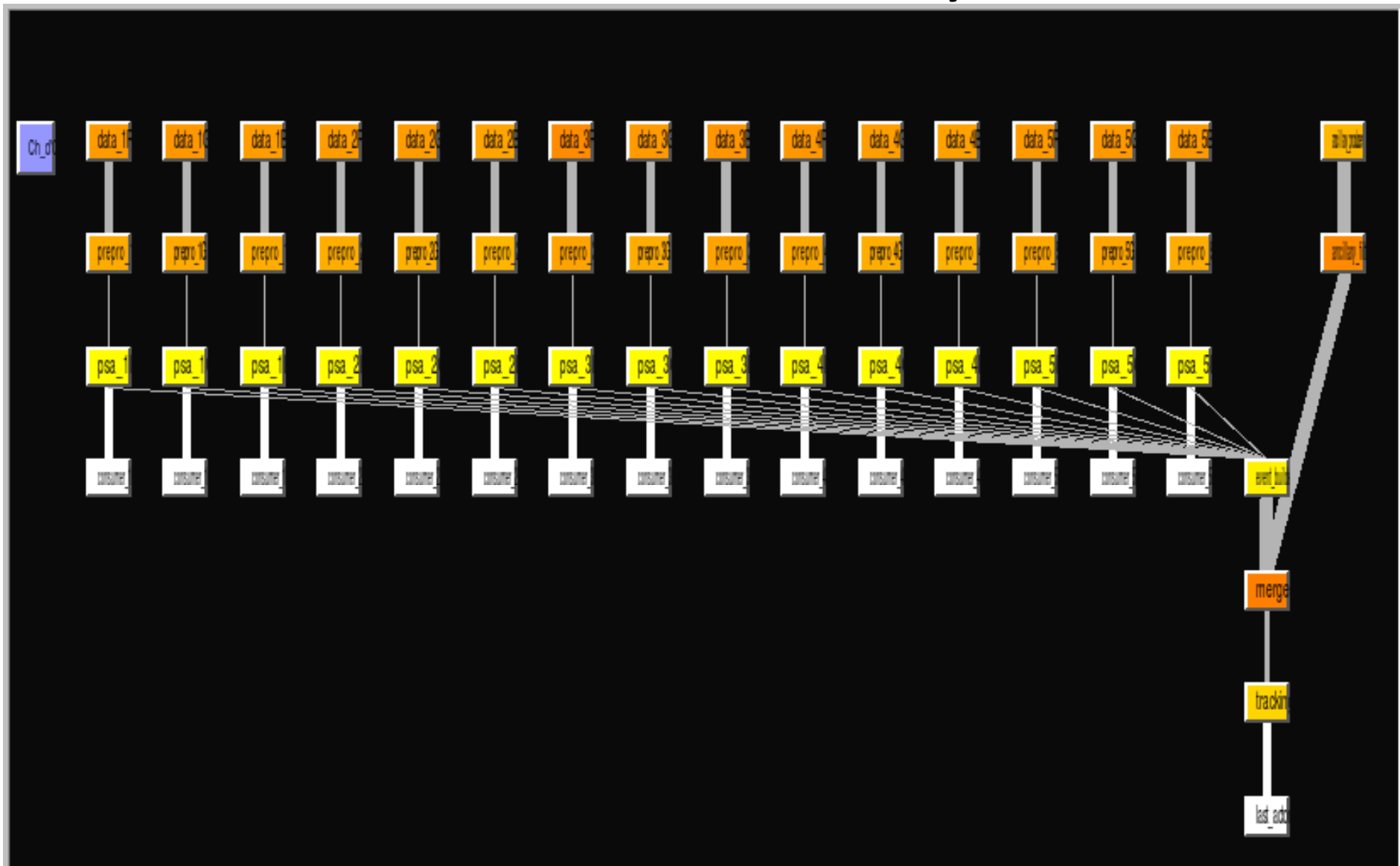
Data processing and replay

- Online = Offline
- A series of programs organized in the style of Narval actors
- Director of the actors
  - **Online** : **Narval**
  - **Offline** : **Narval** or narval emulator(s)
    - Depending on the available computing resources
    - Single computer
    - Farm with distributed processing
- The system is complex and "difficult" to manage
  - Very large number of detectors NumberOfCrystals*38 → 5 ATC = 555
  - No chance to take care of them individually
  - Rely on automatic procedures
  - Hope that the system is stable
  - Result depends on average performance

Several "problematic" segments

Problems fixed

Data processing and replay

- Online = Offline
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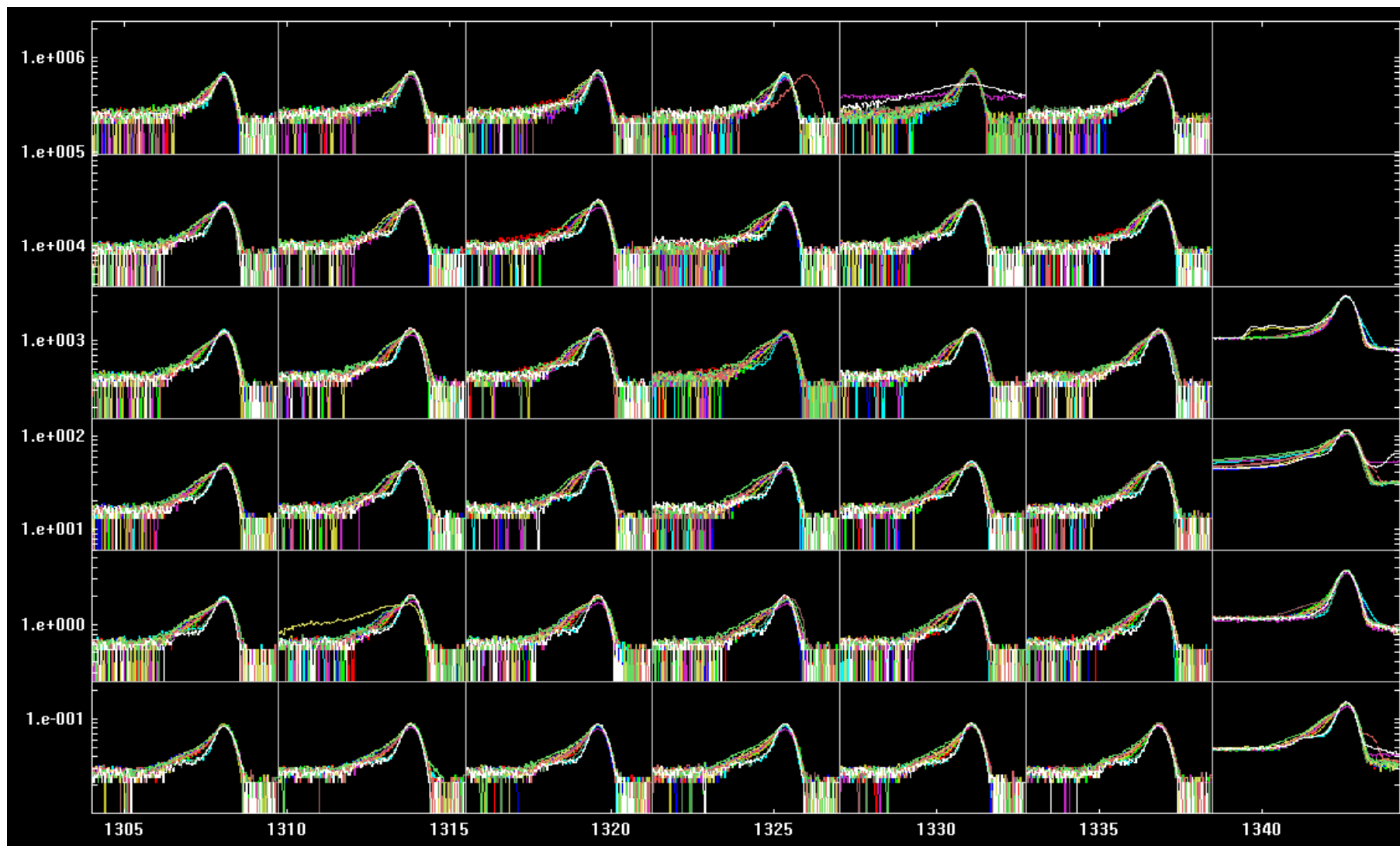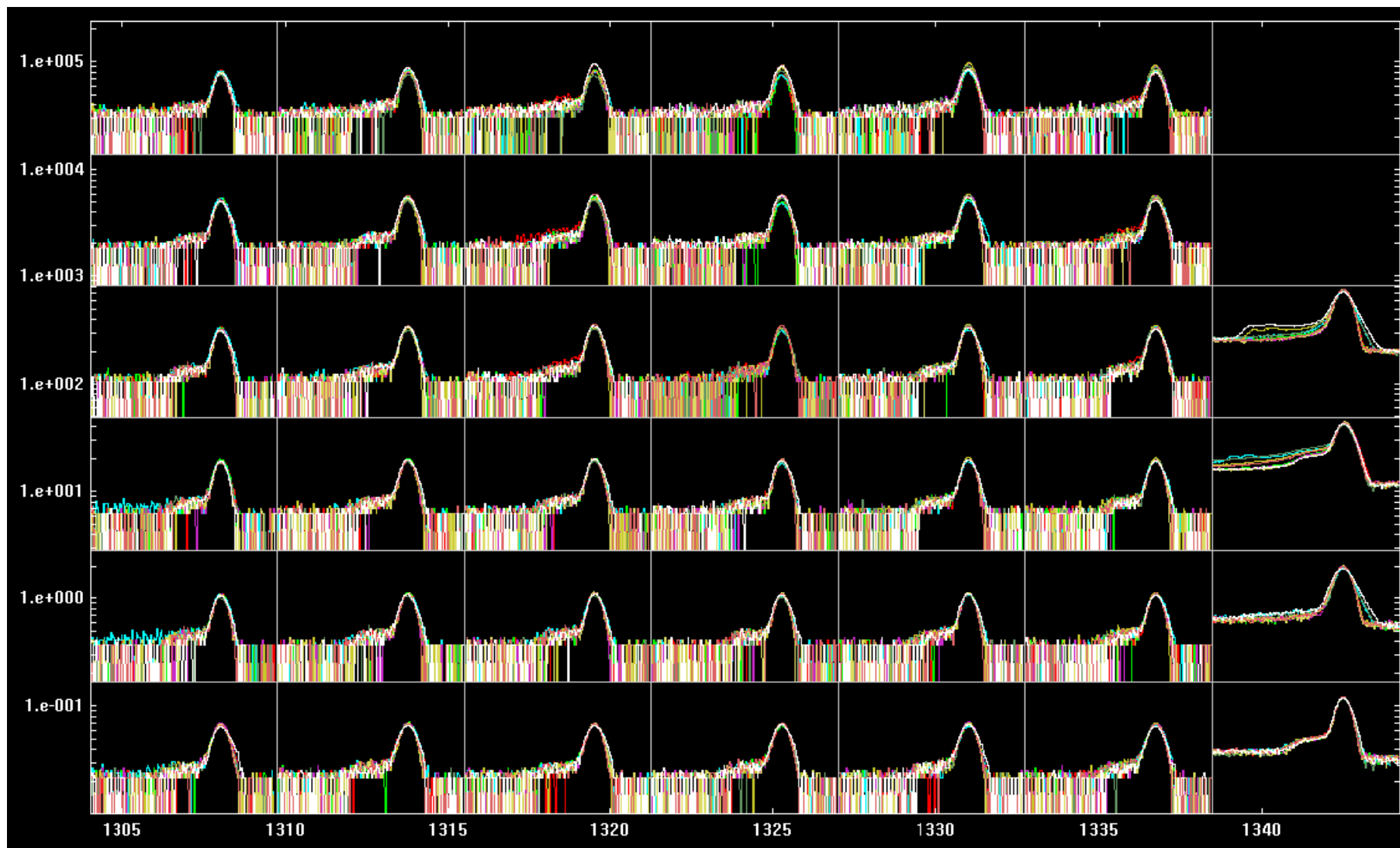- The system is complex and "difficult" to manage
  - Very large number of detectors NumberOfCrystals*38 → 5 ATC = 555
  - No chance to take care of them individually
  - Rely on automatic procedures
  - Hope that the system is stable
  - Result depends on average performance

- **Need GUIs, Histogram Viewers and and scripts to manage the work**

- Processing/Analysis model developed with contributions of several people
  - Xavier Grave Olivier Stezowski and their groups for the architecture and the basic tools
  - Joa Ljungvall, Daniele Mengoni, Enrico Calore, Francesco Recchia
  - The users and their feedback

Structure of analysis directories

- The directory where you produce your data
  (e.g. /agatadisks/data/2011_week41/zCurrentNarvalDataDir)
  contain some standard sub-directories
  - Conf → contains configuration of actors, calibrations, …
    for each detector

    1R 1G 1B 2R … 5B Ancillary Global

    <u>with minimal differences between online and offline</u>
  - Data → contains the data produced during the experiment

    1R 1G 1B 2R … 5B Ancillary Global
    Online writes data here
    Offline takes data from here
  - Out → where we write the offline data

    1R 1G 1B 2R … 5B Ancillary Global
    Offline writes data here

  Conf, Data and Out are often symbolic links to actual directories

The actors

- Producers
  - CrystalProducer / CrystalProducerATCA
  - AncillaryProducerTCP
  - BasicAFP
- Filters
  - PreprocessingFilter / PreprocessingFilterPSA
  - PSAFilter / PSAFilterGridSearch
  - TrackingFilter / TrackingFilterOFT
- Consumers
  - BasicAFC
- Builders
  - EventBuilder/EventMerger
    - ADA version for the online
    - C++ version in the femul emulator

CrystalProducer

- Reads the data from:
  - The PCI express driver connected to the ATCA electronics
  - Raw data files (event_mezzdata.bdat) for the offline
- Acts as a local event builder to check and merge the sub-events coming from the ATCA readout (or from the raw data file)
  - For the online has to work in nonblocking-mode to avoid blocking the ACQ
  - This feature was implemented with boost::threads
  - Damiano has now implemented the "select" and threads have been removed
  - The local event builder and the management of the mezzanine data should be completely rewritten …
- Can write the original data with the format of the ATCA electronics, and various other formats (e.g. only the energies for calibrations)
- Prepares data:crystal frames, without using adf (version using adf exists, maybe slower)

PreprocesssingFilter

- Performs
  - Energy calibrations and xTalk corrections
  - Analysis of traces
    - Calculation of T0 from core (Digital CFD or linear fit of the first samples)
    - Time calibrations and shifts
    - Vertical normalization of traces
    - Define the net-charge segments
  - Reformats the data as data:ccrystal frames

- The calibration files are produced by external programs as part of the calibration procedures; these programs work on more compact data files written by the CrystalProducer.

PSAFilter

- Signal decomposition
- Implemented algorithm is the Grid Search
  - As a full grid search
  - As a coarse/fine search (AGS)
- Reduces size of data by factor 20
- Provides the parameters for the correction of neutron damage (can also perform it)
- Must be expanded to improve timing
- **Takes ~95 % of total CPU time**
- Is the critical point for the processing speed of online and offline analyses

AncillaryProducerTCP

- Written as a tcp server
- Is not an ADF::NarvalProducer (but, for the sake of the emulators can inherit from it)
- Reads data via tcp
- Decodes the AGAVA structure and VME data
- Formats the data as data:ranc0, not using adf
- Can write the input data as raw binary files event_vmedata.bdat

AncillaryFilter

- Analysis of Ancillary data
- Changes a lot from experiment to experiment
  - PRISMA
  - Dante
  - Silicon strip detectors
  - Scintillators
- Almost impossible to set int up properly during the experiment
- In the last experiments, people gave up trying to analyse them on-line and usually opt for root-like methods
- What remains is simply raw or calibrated projections of VME data

EventBuilder/EventMerger

- Work on data filtered by the real-time digital trigger
- The software builders use the timestamp of the data coming from the detectors
    - Could also reconstruct using the eventnumber but this is given with only 24 bits and rolls over every 16M events → modulo electronics
- The online Narval builders had a hard life in keeping up with the variability of data flow and sometimes lost synchronization.
    - A solution was to have very large timeouts in the reconstruction algorithms but this slowed too much down the stop procedures
    - The latest improvements by Xavier Grave have not yet been tested
- The offline builders have a simpler life because data flow from files is (?) more smooth (and the timeouts in the reconstruction algorithms can be very large)

TrackingFilter

- This is the first point where we can check integrity of global events and analyse them
  - As AGATA only
    - Build global spectra: energy, time and $T_{\gamma\gamma}$
    - Adjust gain of CC (and SG, not implemented) → should be moved to postPSA
    - Force sum energy of segments to energy of CC → small loss of resolution but removes extra left tail
  - As AGATA + Ancillary
    - Spectra of Ge in coincidence with ancillary
    - Gate on T_{Ge}-T_{anc} (still timestamp only) to select the data for tracking
- Input of tracking can be written in mgt-style for offline tracking with OFT or MGT
- **Tacking algorihm**
  - TrackingFilterOFT
  - Waely's, parameter-free cluster tracking algo
  - Has been a bottleneck, but now can achieve 20 kHz
  - Problem: Timing not reported well
- Output of Tracking written as adf or root tree
  - Both outputs keep the input hits (and the Ancillary data if present), adding the tracked gammas and the Ancillary filter
  - Timing is not yet reported properly

For the workshop?

- Energy calibrations

- Cross talk calibrations and corrections

- Time calibrations

Details on the configuration files

- The Conf directories contain, for each used actor, one file with "keyword value" pairs to control the details of the actual analysis.
- The name of the configuration file is always **actorName.conf**
- If the actor is organized as a mother-class/daughter-class the daughter can also have its configuration files (e.g for energy calibrations, xTalk corrections, description of ATCA and VME hardware ...), but these are specific and, unfortunately, the names are not standardized
- The configuration files for the crystals are very similar; the changes to adapt them to the specific experiment/analysis have been done often using tools like sed → error prone
- Clearly, we need some graphics interface
- As a temporary solution there is now a python script "gen_conf.py" which simplifies the job
- For energy calibrations, xTalks, n-damage, ..., there are (or there should be) dedicated programs which should produce and copy to the target directories the proper files
- The Narval API puts constraints on how some of the parameters are passed to the system

The Grid Search algorithm
implemented in Narval as **PSAFilterGridSearch**

- Signal decomposition **assumes one interaction per segment**

- The decomposition uses the transients and a differentiated version of the net charge pulse

- Proportional and differential cross-talk are included using the xTalk coefficients of the preprocessing.

- The minimum energy of the "hit" segments is a parameter in the PreprocessingFilter → 10 keV

- No limit to the number of fired segments (i.e. up to 36)

- The number of used neighbours is a compile time parameter (usually 2 as Manhattan distance)

- The algorithm cycles through the segments in order of decreasing energy;
  the result of the decomposition is removed from the remaining signal
  → subtraction method at detector level

- Presently using ADL bases (Bart Bruyneel) with the neutron-damage correction model
  (the n-damage correction is not yet fully implemented in this actor)

- Using 2 mm grids → ~48000 grid points in a crystal; 700-2000 points/segments

- Speed is
  - → **150 events/s/core for the Full Grid Search**
  - → **1000 events/s/core for the Adaptive Grid Search**

- To speedup execution, parallelism has been implemented (using boost:threads) with blocks of ~100 events passed to N parallel threads of execution

Speed does not increase linearly with the number of threads

Amdahl's law $\quad T = T_{serial} + T_{parallel}/N_{threads}$

Expected from profiler results for 1 thread

10 % serial
90 % parallel

30 % serial
70% parallel

Actual speed of Adaptive Grid Search

Events/s

Number of threads