

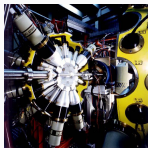
## Gamma spectroscopy challenges in PANDORA

---

Alain Goasduff - INFN - Legnaro National Laboratories

2<sup>nd</sup> PANDORA Progress Meeting December 16<sup>th</sup>-17<sup>th</sup> 2021

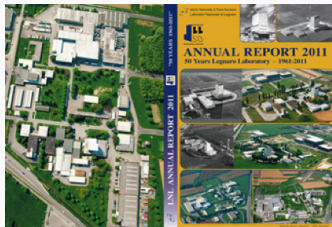
# $\gamma$ -spectroscopy at LNL - A long story (short)



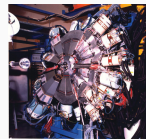
GASP



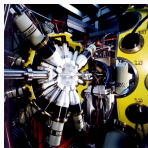
CLARA



- 80 % of nuclear physics research
- 50 %  $\gamma$ -ray spectroscopy



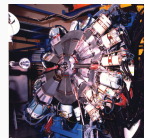
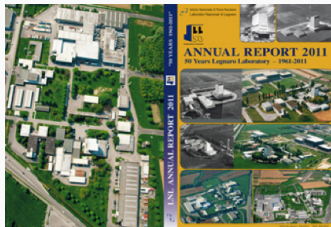
EUROBALL



GASP

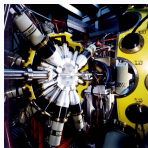


CLARA



EUROBALL

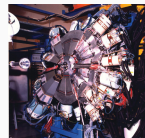
- 80 % of nuclear physics research
- 50 %  $\gamma$ -ray spectroscopy
- Neutron-deficient and neutron-rich nuclei



GASP

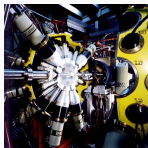


CLARA

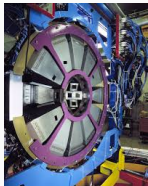


EUROBALL

- 80 % of nuclear physics research
- 50 %  $\gamma$ -ray spectroscopy
- Neutron-deficient and neutron-rich nuclei



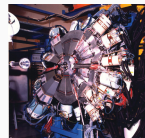
GASP



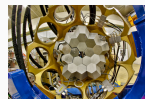
CLARA



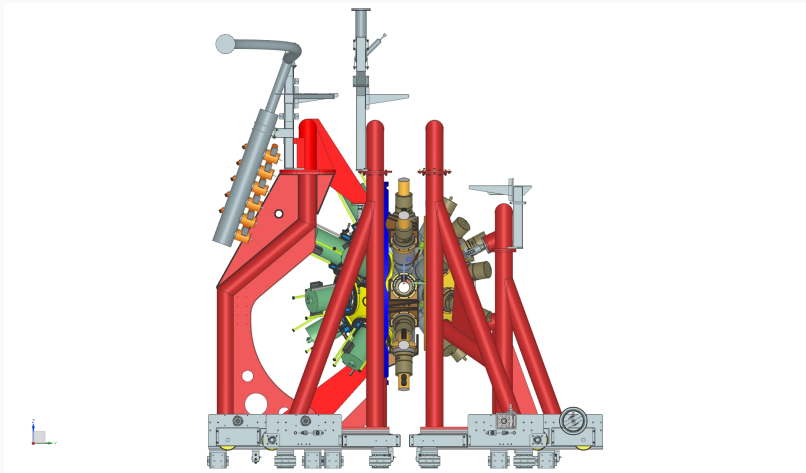
- 80 % of nuclear physics research
- 50 %  $\gamma$ -ray spectroscopy
- Neutron-deficient and neutron-rich nuclei



EUROBALL



AGATA



- 10 Triple Clusters + **25 Single crystals**
- Home made differential pre-amplifiers (up to 20 kHz)
- AGATA-like readout electronics

1

<sup>1</sup>A. Goasduff et al., NIM A 1015 (2021) 165753



- 16 Single crystals have been unmounted
- Average FWHM at 1.3 MeV: 2.3 keV
- HV from 2.5 to 4.5 kV,  $I \leq 1\mu\text{A}$
- CAEN SY4527 + 2 boards A1561H
- Home made LVPS
- Automatic bias shutdown from LN2 system + signal from detector
- Some detectors present tail due to n-damage

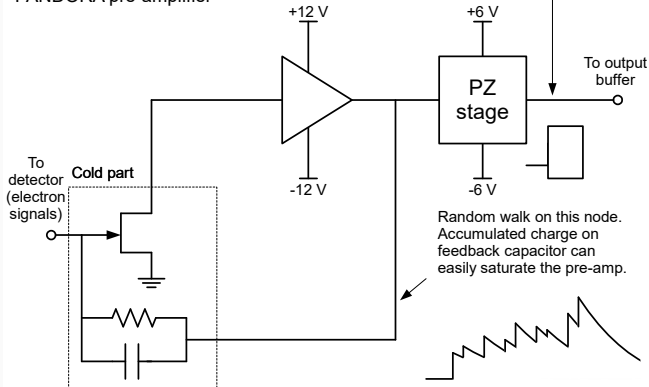
## Front-end electronics

---



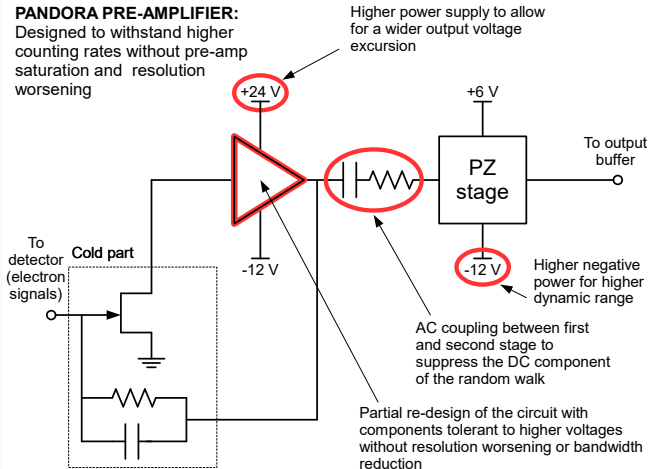
## GALILEO PRE-AMPLIFIER:

Starting point for the development of the PANDORA pre-amplifier



# GALILEO pre-amplifier for PANDORA

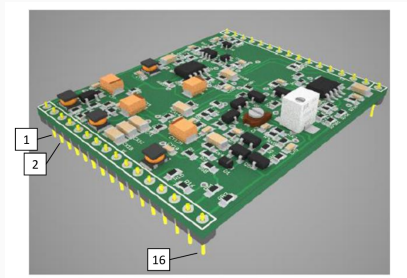
**PANDORA PRE-AMPLIFIER:**  
Designed to withstand higher counting rates without pre-amp saturation and resolution worsening



# Modification of the pre-amplifier

The modified pre-amplifiers require:

- LVPS with +24, -12V, +6V, -6V
- Modification of the pre-amplifier motherboard (new capacitor with 35V)
- new LVPS cable between the motherboard and the detector patch-panel.



4

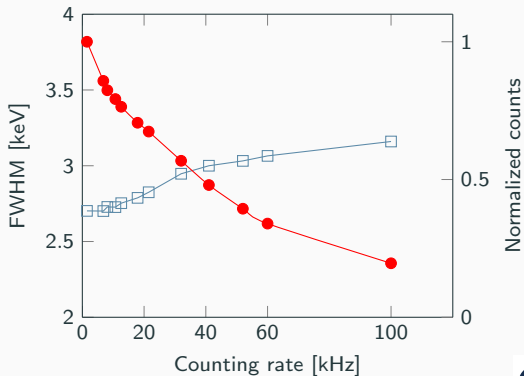
---

<sup>4</sup>Courtesy of S. Capra & A. Pullia UniMI - INFN Mi

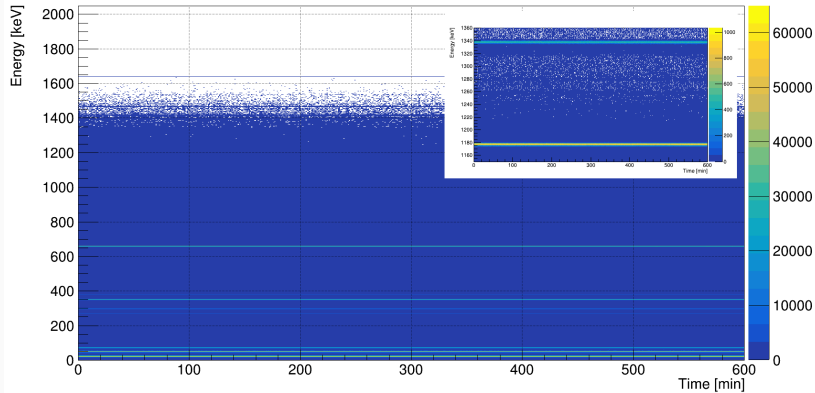
# Test of the new pre-amplifier

Multi-sources test:

1. fixed  $^{60}\text{Co}$  - with a fix rate of 1.5 kHz
2.  $^{241}\text{Am}$  +  $^{133}\text{Ba}$  +  $^{137}\text{Cs}$  movable to simulate the background
3. 10-min acquisition time



# Stability check



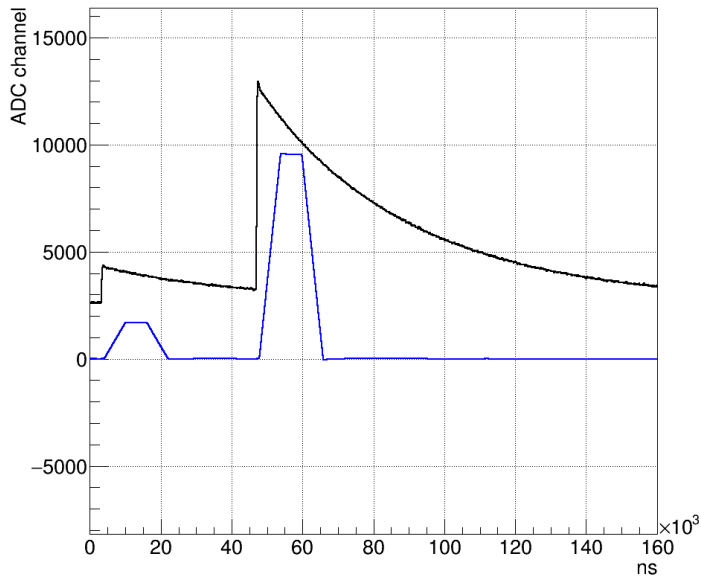
## Readout electronics

---



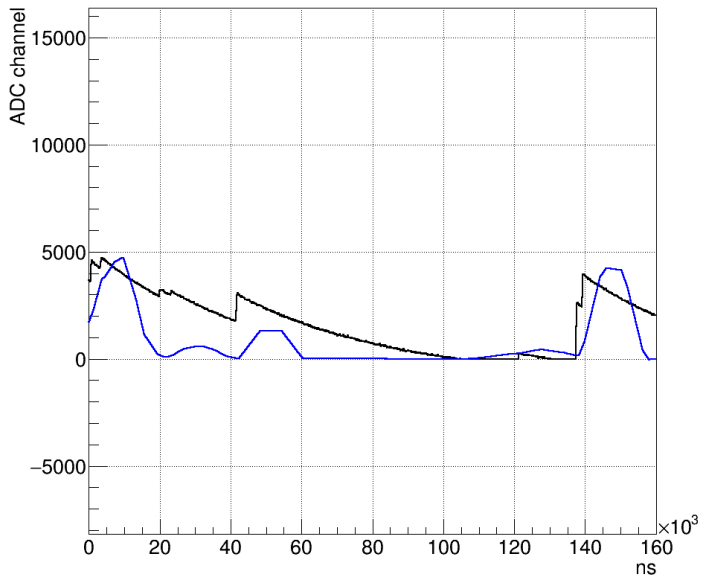
- Mesytec MDC-8 Differential to single-ended converter
- CAEN VX1725S: 16 channels, 14 bit, 250 Msps, 2 Vpp - DPP-PHA
- CAEN A3818: PCIe bridge
- SuperMicro 2U-server: 6029U-E1CR4

## Moving window deconvolution: DPP-PHA

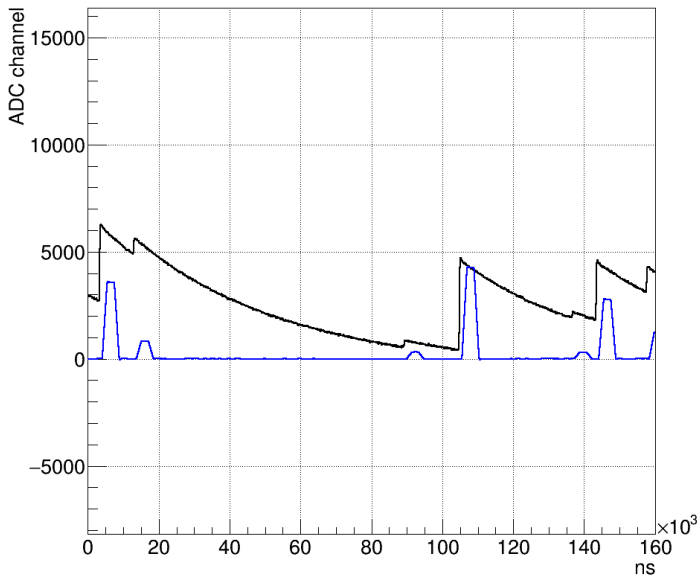




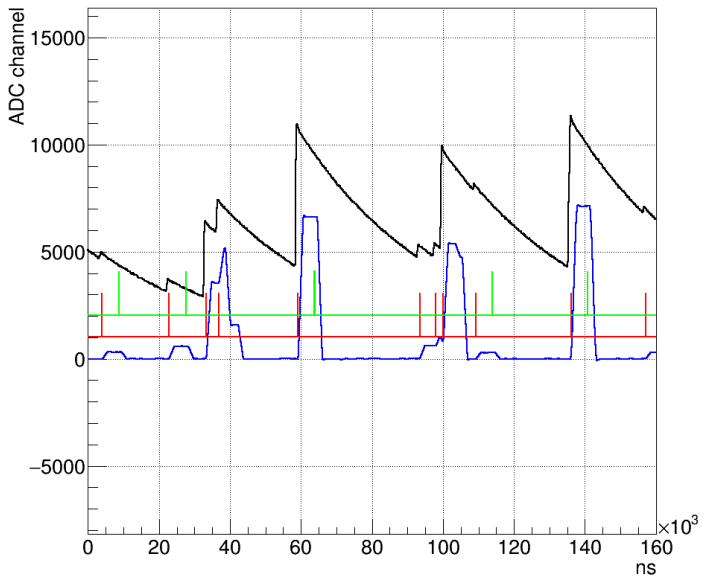
## Moving window deconvolution: DPP-PHA



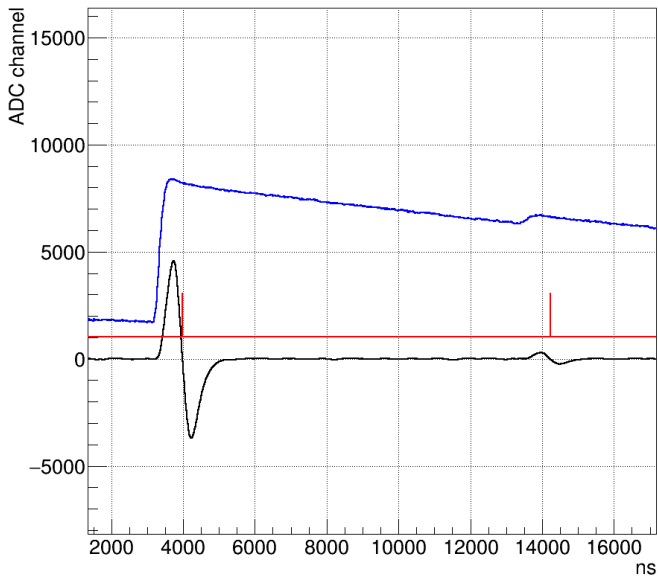
# Moving window deconvolution: DPP-PHA

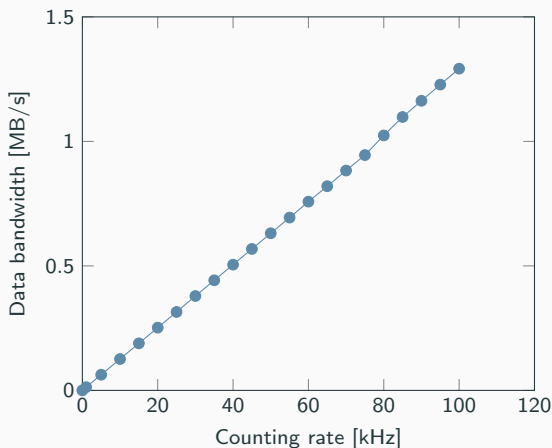


# Moving window deconvolution: DPP-PHA



## Moving window deconvolution: DPP-PHA





- Constant rate pulser
- No samples past to the DAQ
- In trigger-less mode:
  - 64 GB / day / detector
  - 900 GB for the full array / day

## **Data acquisition system**

---

- Software platform developed at CERN

- Software platform developed at CERN
- XDAQ provides:
  - Platform independent services,
  - Peer-to-peer communication between the actors
  - SOAP for configuration and control.



- Software platform developed at CERN
- XDAQ provides:
  - Platform independent services,
  - Peer-to-peer communication between the actors
  - SOAP for configuration and control.
- Main Features:
  - Device access
  - Configuration, control and monitoring
  - Maintainability and portability (releases are now available via YUM)
  - Scalability.

- Software platform developed at CERN
- XDAQ provides:
  - Platform independent services,
  - Peer-to-peer communication between the actors
  - SOAP for configuration and control.
- Main Features:
  - Device access
  - Configuration, control and monitoring
  - Maintainability and portability (releases are now available via YUM)
  - Scalability.
- GALILEO DAQ based on release 11 → **SLC6**

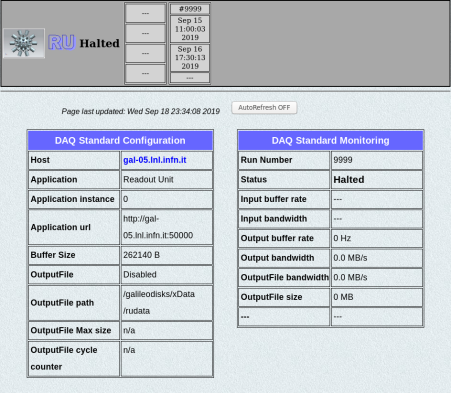
- Software platform developed at CERN
- XDAQ provides:
  - Platform independent services,
  - Peer-to-peer communication between the actors
  - SOAP for configuration and control.
- Main Features:
  - Device access
  - Configuration, control and monitoring
  - Maintainability and portability (releases are now available via YUM)
  - Scalability.
- GALILEO DAQ based on release 11 → **SLC6**
- PARIS DAQ based on release 15 → **CentOS7**

## Interface to the front-end electronic:

- GGP readout
- VME readout for ancillaries
- DPP-PHA / DPP-PSD

⇒ Application developed in C++

Accessible web interface with the key parameters

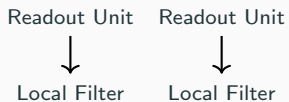


Page last updated: Wed Sep 18 23:34:08 2019    AutoRefresh OFF

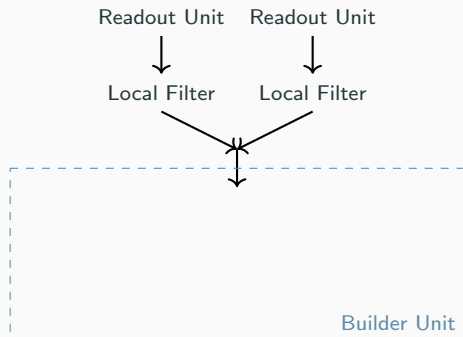
DAQ Standard Configuration	
Host	gal-05.inl.infn.it
Application	Readout Unit
Application Instance	0
Application url	http://gal-05.inl.infn.it:50000
Buffer Size	262140 B
OutputFile	Disabled
OutputFile path	/galileodisks/xData/rudata
OutputFile Max size	n/a
OutputFile cycle counter	n/a

DAQ Standard Monitoring	
Run Number	9999
Status	Halted
Input buffer rate	---
Input bandwidth	---
Output buffer rate	0 Hz
Output bandwidth	0.0 MB/s
OutputFile bandwidth	0.0 MB/s
OutputFile size	0 MB
---	---

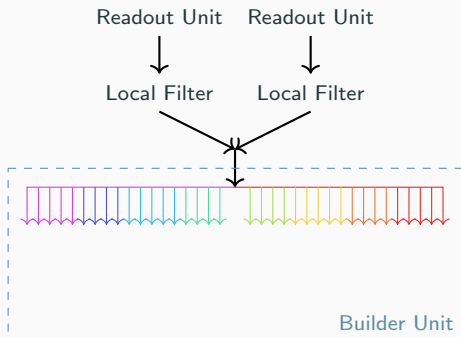
## Event reconstruction based on timestamp information



## Event reconstruction based on timestamp information

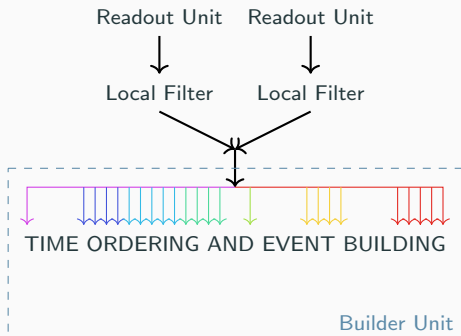


## Event reconstruction based on timestamp information



- Configurable inputs

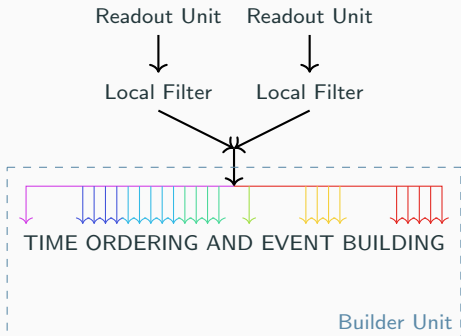
## Event reconstruction based on timestamp information



- Configurable inputs

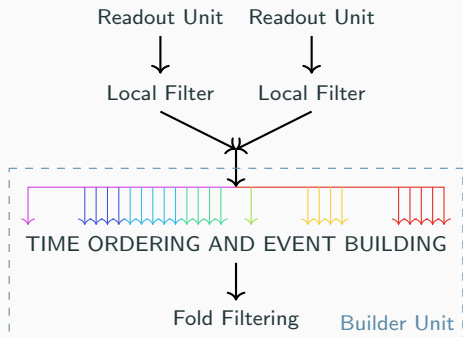


## Event reconstruction based on timestamp information



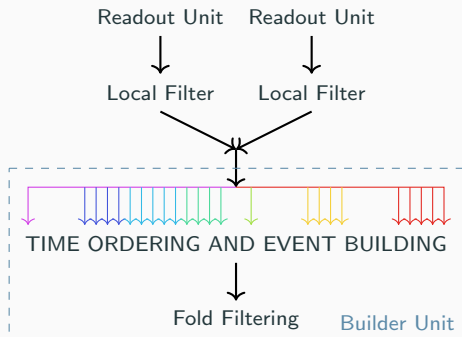
- Configurable inputs
- Configurable time window via XML file

## Event reconstruction based on timestamp information



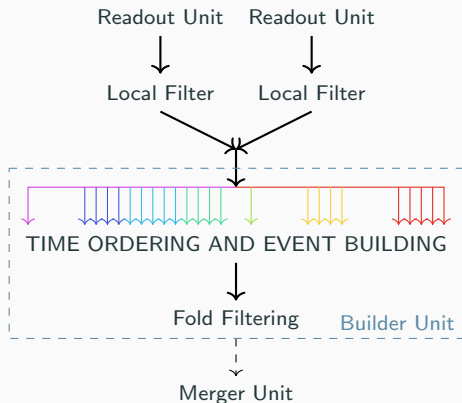
- Configurable inputs
- Configurable time window via XML file

## Event reconstruction based on timestamp information



- Configurable inputs
- Configurable time window via XML file
- Minimum fold requirement for the output

## Event reconstruction based on timestamp information



- Configurable inputs
- Configurable time window via XML file
- Minimum fold requirement for the output

- Skeleton of actor in C/C++

```
/**
 * User supplied function implementing the action to be executed on the
 * Halted->Ready transition of the application's finite state machine.
 */
void process_config(const char* file, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Ready->Enabled transition of the application's finite state machine.
 */
void process_start(uint32_t run, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Enabled->Ready transition of the application's finite state machine.
 */
void process_stop(int *error_code);

/**
 * User supplied function that is invoked on the filter application when
 * a buffer is received.
 */
void process_block(
    void *input_buffer, int input_size, int packet_ID,
    void *output_buffer, int output_size,
    int
    *used_size_of_output_buffer,
    int *error_code);
```

- Skeleton of actor in C/C++
- For GALILEO:
  - Compton-Suppression
  - CFD
  - Pile-Up Rejection
  - Zero suppression
  - Data formatting

```
/**
 * User supplied function implementing the action to be executed on the
 * Halted->Ready transition of the application's finite state machine.
 */
void process_config(const char* file, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Ready->Enabled transition of the application's finite state machine.
 */
void process_start(uint32_t run, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Enabled->Ready transition of the application's finite state machine.
 */
void process_stop(int *error_code);

/**
 * User supplied function that is invoked on the filter application when
 * a buffer is received.
 */
void process_block(
    void *input_buffer, int input_size, int packet_ID,
    void *output_buffer, int output_size,
    int
    *used_size_of_output_buffer,
    int *error_code);
```

- Skeleton of actor in C/C++
- For GALILEO:
  - Compton-Suppression
  - CFD
  - Pile-Up Rejection
  - Zero suppression
  - Data formatting
- For PARIS / LUNA:
  - Rate monitoring
  - Event formatting

```
/**
 * User supplied function implementing the action to be executed on the
 * Halted->Ready transition of the application's finite state machine.
 */
void process_config(const char* file, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Ready->Enabled transition of the application's finite state machine.
 */
void process_start(uint32_t run, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Enabled->Ready transition of the application's finite state machine.
 */
void process_stop(int *error_code);

/**
 * User supplied function that is invoked on the filter application when
 * a buffer is received.
 */
void process_block(
    void *input_buffer, int input_size, int packet_ID,
    void *output_buffer, int output_size,
    int
    *used_size_of_output_buffer,
    int *error_code);
```

- Skeleton of actor in C/C++
- For GALILEO:
  - Compton-Suppression
  - CFD
  - Pile-Up Rejection
  - Zero suppression
  - Data formatting
- For PARIS / LUNA:
  - Rate monitoring
  - Event formatting
- For PANDORA:
  - Rate monitoring
  - Event formatting
  - Data reduction
    - Energy range
    - Fold
    - ...

```
/**
 * User supplied function implementing the action to be executed on the
 * Halted->Ready transition of the application's finite state machine.
 */
void process_config(const char* file, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Ready->Enabled transition of the application's finite state machine.
 */
void process_start(uint32_t run, int *error_code);

/**
 * User supplied function implementing the action to be executed on the
 * Enabled->Ready transition of the application's finite state machine.
 */
void process_stop(int *error_code);

/**
 * User supplied function that is invoked on the filter application when
 * a buffer is received.
 */
void process_block(
    void *input_buffer, int input_size, int packet_ID,
    void *output_buffer, int output_size,
    int
    *used_size_of_output_buffer,
    int *error_code);
```



## Conclusion

---

1. GALILEO detectors have been unmounted
  - Average resolution  $\sim 2.3$  keV @ 1.3 MeV
  - Annealing of the 16 detectors could be started

1. GALILEO detectors have been unmounted
  - Average resolution  $\sim 2.3$  keV @ 1.3 MeV
  - Annealing of the 16 detectors could be started
2. Front-end electronics:
  - New pre-amplifiers adapted to PANDORA have been tested and validated
  - Production of the new pre-amplifier could be started
  - Modification of GALILEO motherboard
  - Modification of the detector LVPS cable

1. GALILEO detectors have been unmounted
  - Average resolution  $\sim 2.3$  keV @ 1.3 MeV
  - Annealing of the 16 detectors could be started
2. Front-end electronics:
  - New pre-amplifiers adapted to PANDORA have been tested and validated
  - Production of the new pre-amplifier could be started
  - Modification of GALILEO motherboard
  - Modification of the detector LVPS cable
3. Back-end electronics:
  - Digitizers of the SPES  $\beta$ -decay station delivered
  - Test with pulser and detector on-going

1. GALILEO detectors have been unmounted
  - Average resolution  $\sim 2.3$  keV @ 1.3 MeV
  - Annealing of the 16 detectors could be started
2. Front-end electronics:
  - New pre-amplifiers adapted to PANDORA have been tested and validated
  - Production of the new pre-amplifier could be started
  - Modification of GALILEO motherboard
  - Modification of the detector LVPS cable
3. Back-end electronics:
  - Digitizers of the SPES  $\beta$ -decay station delivered
  - Test with pulser and detector on-going
4. Acquisition system:
  - Recently developed a full XDAQ chain for CAEN digitizers
  - Rate capabilities tested up to 50 kHz on 12 channels using LaBr<sub>3</sub>
  - On-going optimization for the DPP-PHA

1. GALILEO detectors have been unmounted
  - Average resolution  $\sim 2.3$  keV @ 1.3 MeV
  - Annealing of the 16 detectors could be started
2. Front-end electronics:
  - New pre-amplifiers adapted to PANDORA have been tested and validated
  - Production of the new pre-amplifier could be started
  - Modification of GALILEO motherboard
  - Modification of the detector LVPS cable
3. Back-end electronics:
  - Digitizers of the SPES  $\beta$ -decay station delivered
  - Test with pulser and detector on-going
4. Acquisition system:
  - Recently developed a full XDAQ chain for CAEN digitizers
  - Rate capabilities tested up to 50 kHz on 12 channels using  $\text{LaBr}_3$
  - On-going optimization for the DPP-PHA
5. Detector support:
  - HV monitoring tools available with alert system (GRAFANA)
  - LN2 Filling system to be done.