

Overview of LLAMA data structure and analysis

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Data timeline

Runs do not have same length!

New LLAMA cables

Pulser in

Nat Ba:
11 runs

Ba136:
7 runs

Nat Se:
2 runs

Se76:
16 runs

Ba136:
2 runs

Oct 14 Oct 15

Oct 20 Oct 21

Oct 24 Oct 28

Nov 4 Nov 7

Co60_01

Co60_02
EuCoY_01

Co60_03
Co60_04*
Y88_01

Na22_01
Pb_01
Pb_02
Pb_03
Eu152_01

Co60_06**

Co60_05
Eu152_02*
Ba133_02*

Pb_04*
Eu152_03*

*TUM pulser used

**calibration source
directly below detector 9

Data @ TUM-server

Data location for beam time 2021

Data divided by target/calibration source

```
bossioel@monument:/data/psi2021$ ls
Ba_136  Ba_nat  Se_76   Se_nat  calibrations  pulser-test  rampup  readme
bossioel@monument:/data/psi2021$ cd Se_76
bossioel@monument:/data/psi2021/Se_76$ ls
readme  se76-02  se76-04  se76-06  se76-08  se76-10  se76-12  se76-14  se76-16
se76-01  se76-03  se76-05  se76-07  se76-09  se76-11  se76-13  se76-15
```

Multiple runs for each target/calibration source: run length highly non-uniform :)

Data scheme

```
-- ba136-07
  |-- log
  |-- raw
  |-- tier1
  |-- tier2
-- ba136-08
  |-- log
  |-- raw
  |-- tier1
  |-- tier2
-- ba136-09
  |-- log
  |-- raw
  |-- tier1
  |-- tier2
```

- **Raw:** binary files* *Size and length (in time) of files highly non-uniform :)

Example:

ba136-20211022-000600.bin

Data type

Timestamp

File key: same at all levels

- **Tier1:** root files

Example:

ba136-20211022-000600.tier1.ge.root

ba136-20211022-000600.tier1.pmt.root

Detector type

- **Tier2:** root files

Example:

ba136-20211022-000600.ge.tier2.root

ba136-20211022-000600.pmt.tier2.root

Tier level

Multi-level data structure *à la GERDA*

Tier0 Raw data: HPGe, PMTs

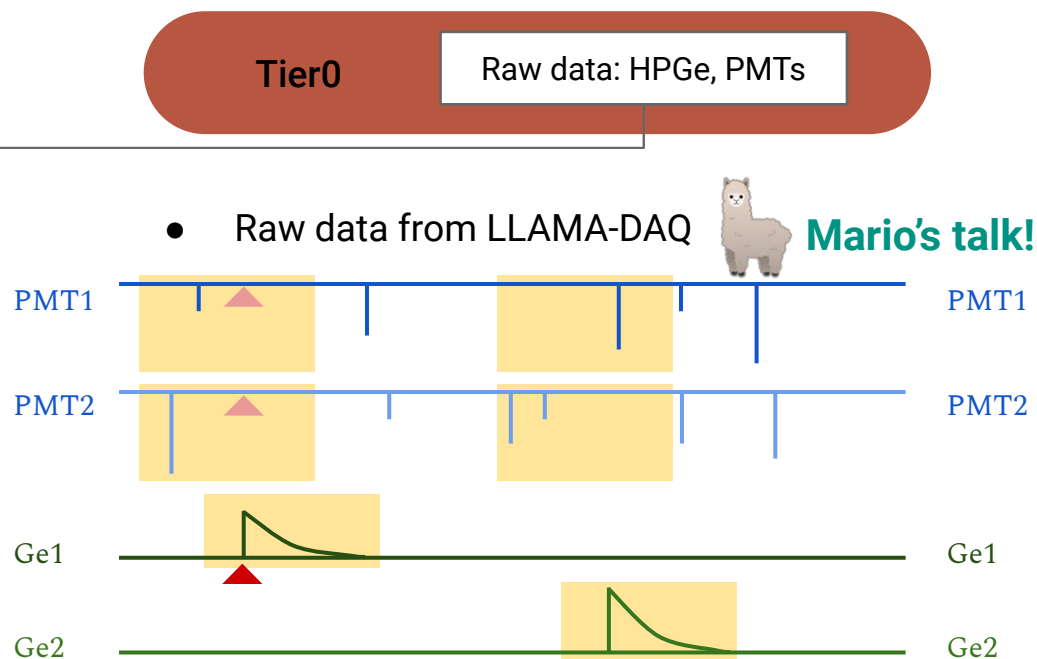
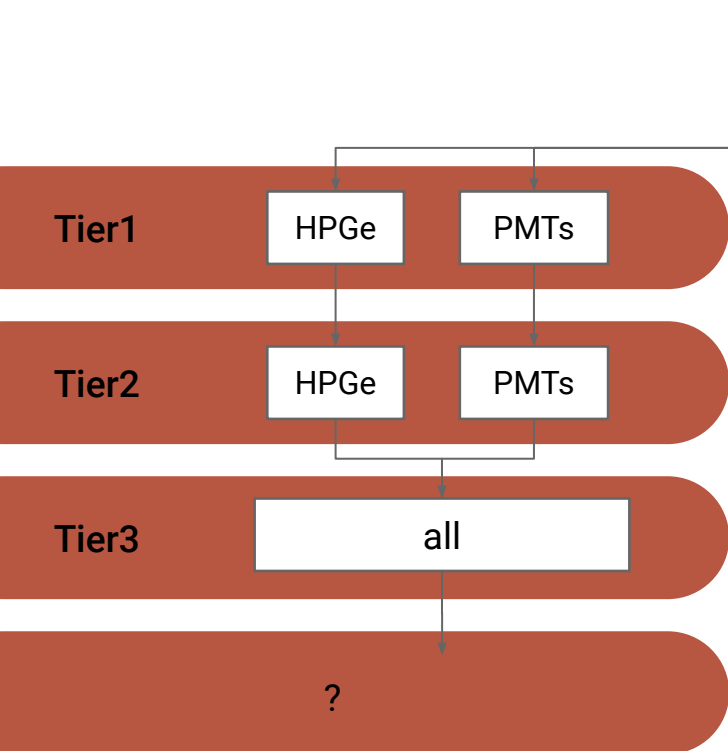
Tier1 HPGe PMTs

Tier2 HPGe PMTs

Tier3 all

?

Multi-level data structure *à la GERDA*



Multi-level data structure *à la* GERDA

Tier0

Raw data: HPGe, PMTs

“Rootification”

Tier1

HPGe

PMTs

[J.Phys.Conf.Ser. 375 \(2012\) 042027](#)

Tier2

HPGe

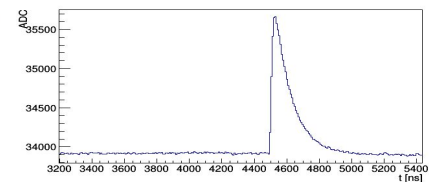
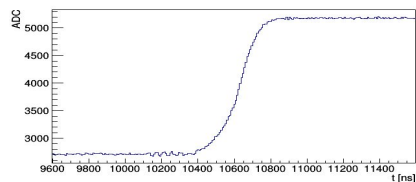
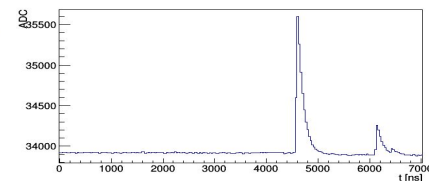
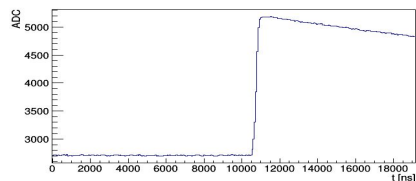
PMTs

Tier3

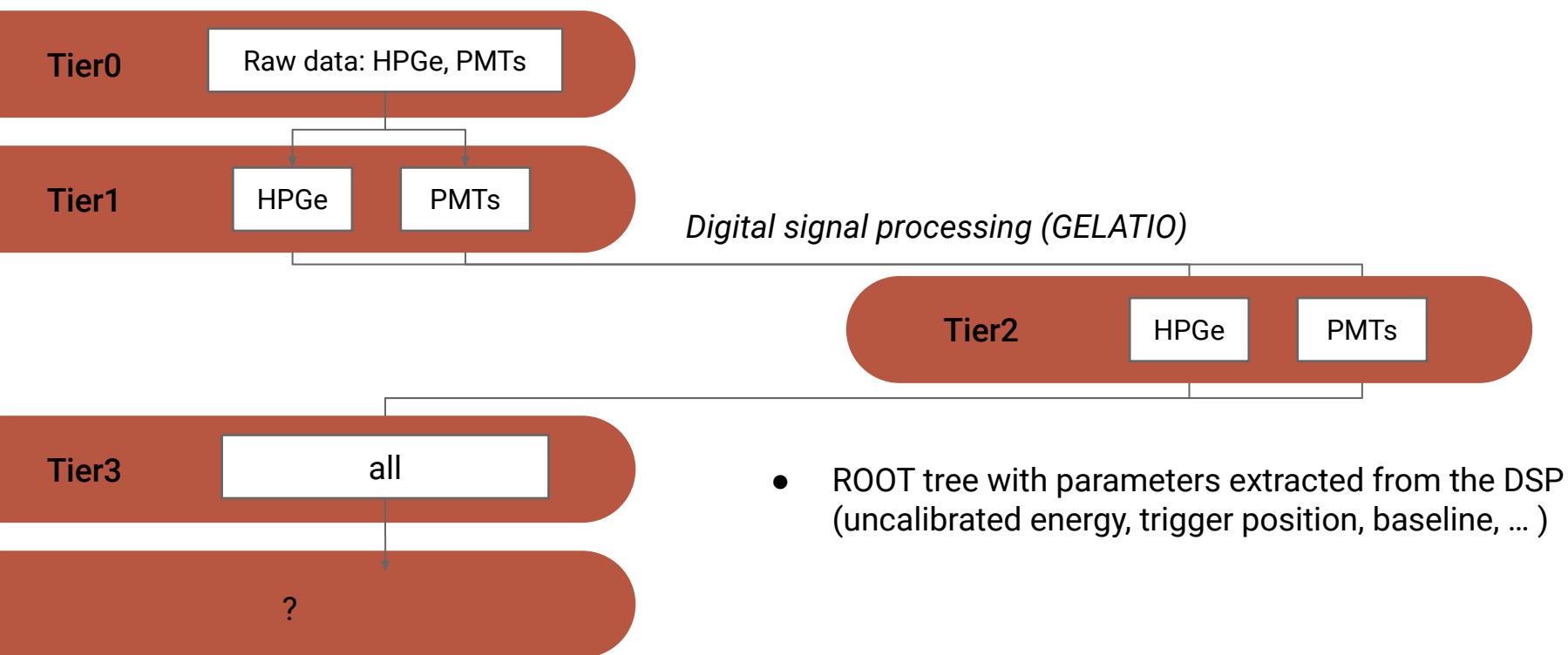
all

?

- Waveforms in ROOT format (use the MGDO libraries)
- “Almost” same content as tier0 (data cleaning)



Multi-level data structure *à la* GERDA



Multi-level data structure *à la* GERDA

Tier0

Raw data: HPGe, PMTs

Tier1

HPGe

PMTs

Tier2

HPGe

PMTs

?

Dhanurdhar and Eli's talks!

Energy calibration and Quality cuts

Tier3

all

- ROOT tree with subset of parameters (calibrated energy, quality cut flags, ...)
- Integration of information from different HPGe and PMTs (multiplicity, HPGe-PMT time difference, ...)

Data cleaning

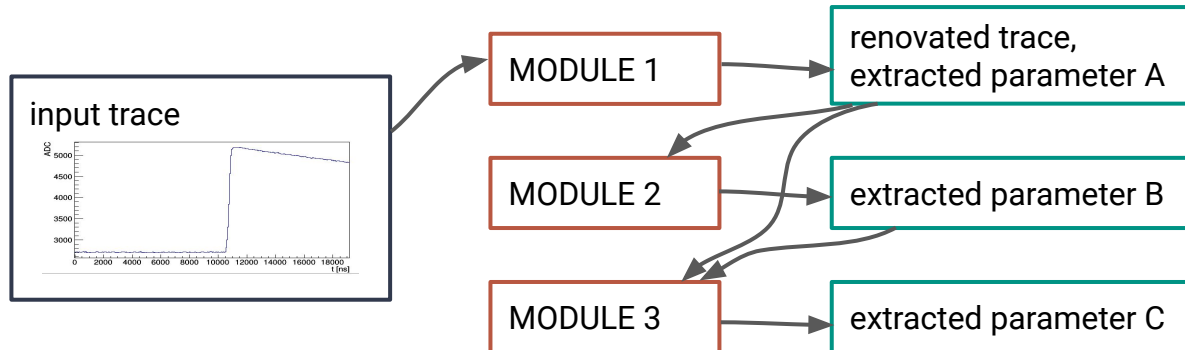
- First selection of data for analysis based on run logs
 - Main reason for data exclusion:
 - Detectors refilling
 - Beam tuning
 - Beam off/ beam down
 - Changes in the set up
 - No tier1/tier2 are produced for excluded data (raw data still available)
 - Lists of files to be used for analysis accessible via meta-data
 - All documented on GitLab
- Lesson learnt for upcoming beam times!*
- https://git.e15.ph.tum.de/monumentum/meta-data/-/merge_requests?scope=all&state=merged

Digital Signal Processing (DSP) with *GELATIO*

[JINST 6 \(2011\) P08013](#)

GELATIO (GERda **L**Ayout**T** for **I**nput/**O**utput)

- Modular approach: each module implements a unique task of the DSP
- Output information can be used as input for other modules
- Chains of modules can be created, input parameters set via ASCII files (ini files)



Tier2 content

HPGe detectors

- **Trigger position**, number of triggers in the trace (**GEMDFTTrigger** and GEMDTrigger)
- Baseline position, baseline slope, baseline RMS (GEMDBaseline)
- Auxiliar baseline in different region of the trace to be used in quality cuts
- Minimum and maximum value of the trace (GEMDMinMaxFinder)
- **Energy**: Gaus filter and trapezoidal filter (GEMDEnergyGauss, **GEMDEnergyGast**), plus a shorter trapezoidal filter to be considered for pile-up events (GEMDEnergyGast_pileup)
- Rise time (GEMDRiseTime)
- Trigger and Rise Time for HF trace

PMTs

- **Trigger position**, number of triggers in the trace
- Amplitude of the signal: maximum amplitude and integral
- Since the PMTs signals are quite slow, the same variables are calculated also after shaping the trace with a MW deconvolution and a MW average: we expect to get better precision
- Same story for HF trace

Towards tier3

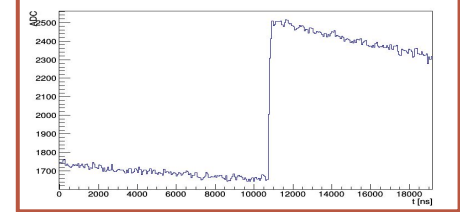
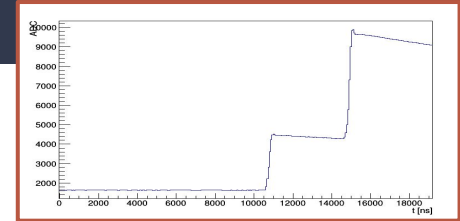
- Main analysis issue: **pile-up** due to very high event rate (~50% of the data)
- We defined a strategy: separate between two data sets:

GOLDEN DATA SET

- Stringent requirement on the slope of the baseline to cut all pile-up events
- About 50% of the statistic
- Optimal performances: energy resolution and time resolution
- Ready to be analysed (ready to move to tier3 with **calibration and quality cuts inputs**)

SILVER DATA SET (PILE-UP)

- Contains all the pile-up events cut from the GOLDEN data set
- Recover a lot of statistics
- Worse performances expected
- Not ready yet: need to find a proper pile-up correction method



Meta-data

Collection of files to be used as input for different steps of the data processing and analysis:

Tier0 ->
Tier1

- List of files:
“analysis” list to be used for all analysis steps

```
bossioel@monument:~/meta-data/psi2021/Ba_136$ ls
ba136-01-allFiles.txt  ba136-04-allFiles.txt  ba136-07-allFiles.txt
ba136-01-analysis.txt  ba136-04-analysis.txt  ba136-07-analysis.txt
ba136-02-allFiles.txt  ba136-05-allFiles.txt  ba136-08-allFiles.txt
ba136-02-analysis.txt  ba136-05-analysis.txt  ba136-08-analysis.txt
ba136-03-allFiles.txt  ba136-06-allFiles.txt  ba136-09-allFiles.txt
ba136-03-analysis.txt  ba136-06-analysis.txt  ba136-09-analysis.txt
```

Tier1 ->
Tier2

- Ini files for tier2 production:
GeDet.ini & PMT.ini

Tier2 ->
Tier3

- Results of calibration / quality cut definition for tier3 production:
To be implemented!
- ...

GitLab project @ TUM

The screenshot shows the GitLab web interface for the 'monumentum' group. The top navigation bar includes the GitLab logo, a menu, a search bar, and various utility icons. The left sidebar contains navigation links for 'monumentum', 'Group information', 'Issues' (5), 'Merge requests' (0), 'Kubernetes', 'Packages & Registries', and 'Settings'. The main content area shows the 'monumentum' group header with a notification bell, 'New subgroup', and 'New project' buttons. Below this is a tabbed interface for 'Subgroups and projects', 'Shared projects', and 'Archived projects'. A search bar and a dropdown menu are also present. The list of subgroups and projects includes:

Subgroup/Project	Description	Stars	Last Updated
data-production	collection of data production scripts and meta data	★ 1	1 week ago
meta-data	Metadata for the MONUMENT experiment	★ 0	1 month ago
monuanalysis	Analysis for monument / llama data	★ 0	4 months ago
sandbox	collection of scripts, tools or code snippets	★ 1	4 months ago

Summarizing...

- LLAMA data are available on the TUM server, organized in a multi-level data structure
- All data are available at the tier2 level: energy and time variables can be easily plotted
- With the inputs from calibration and quality cuts we are ready to move to the tier3 level for the GOLDEN data set
- The “new” LLAMA DAQ can count on well known tools and the previous successful experience with GERDA data
- We still need to think about the SILVER data set (in other words, how to handle pile-up)
- We have few lessons learnt for the upcoming beam times :)