Data Quality Monitoring in Belle II: From Perspective Of KLM Detector

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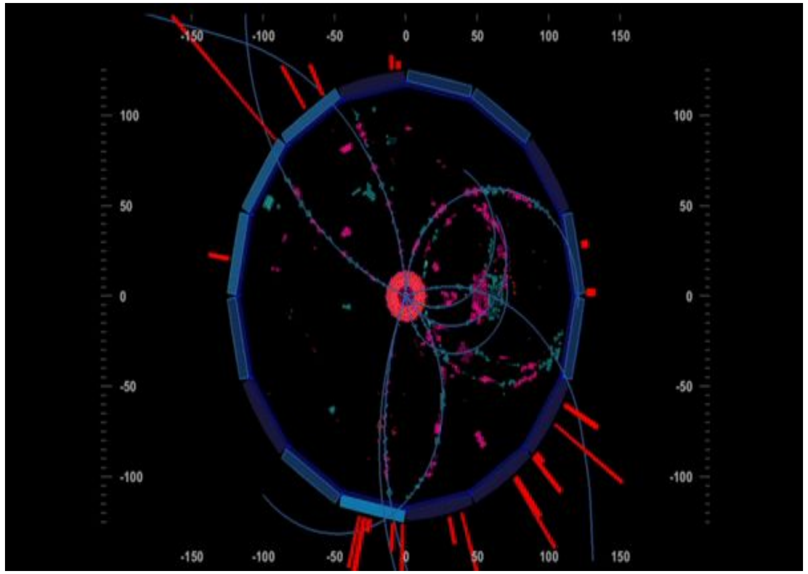
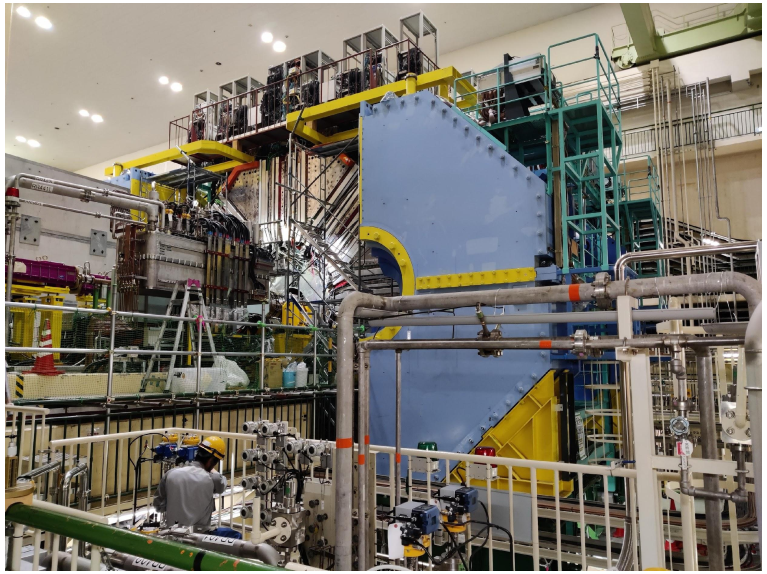
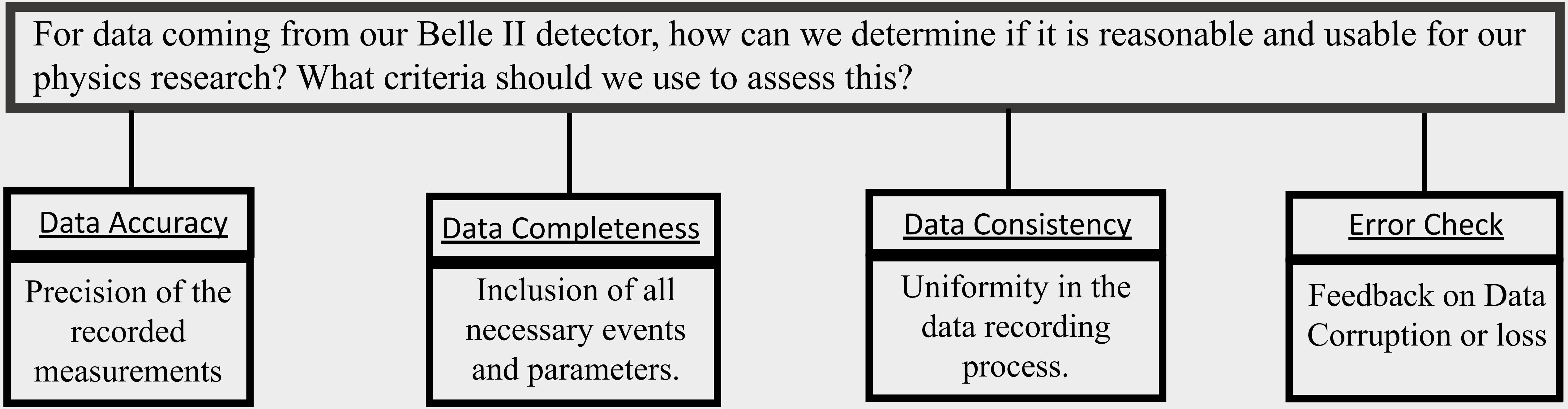




2024 US Belle II Summer Workshop

Introduction



For data coming from our Belle II detector, how can we determine if it is reasonable and usable for our physics research? What criteria should we use to assess this?

Data Accuracy

Precision of the recorded measurements

Data Completeness

Inclusion of all necessary events and parameters.

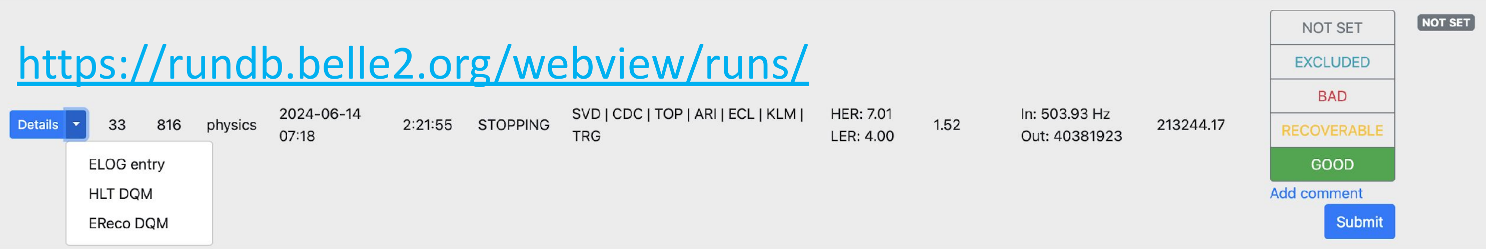
Data Consistency

Uniformity in the data recording process.

Error Check

Feedback on Data Corruption or loss

- In the Belle II experiment, each sub-system group maintains its own set of metrics and observables to evaluate the overall quality of a given run. Based on this evaluation, runs are classified as **Good**, **Bad**, or **Recoverable**.



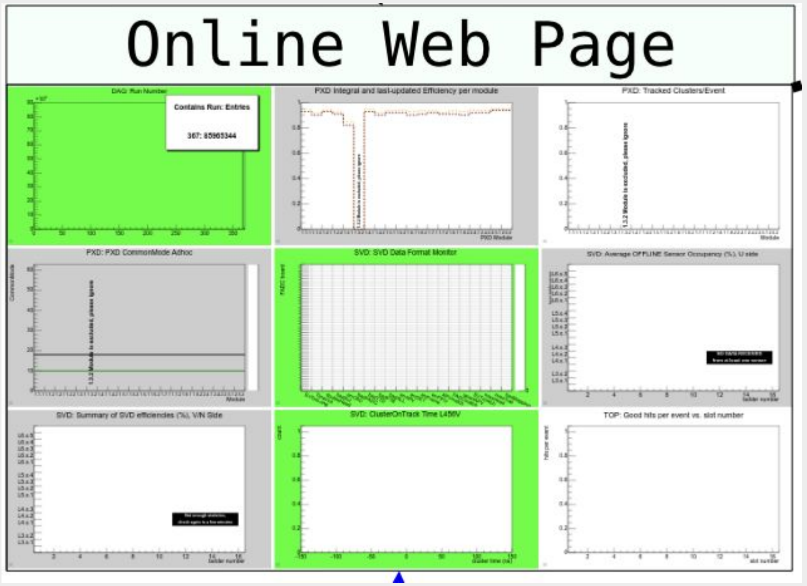
https://rundb.belle2.org/webview/runs/

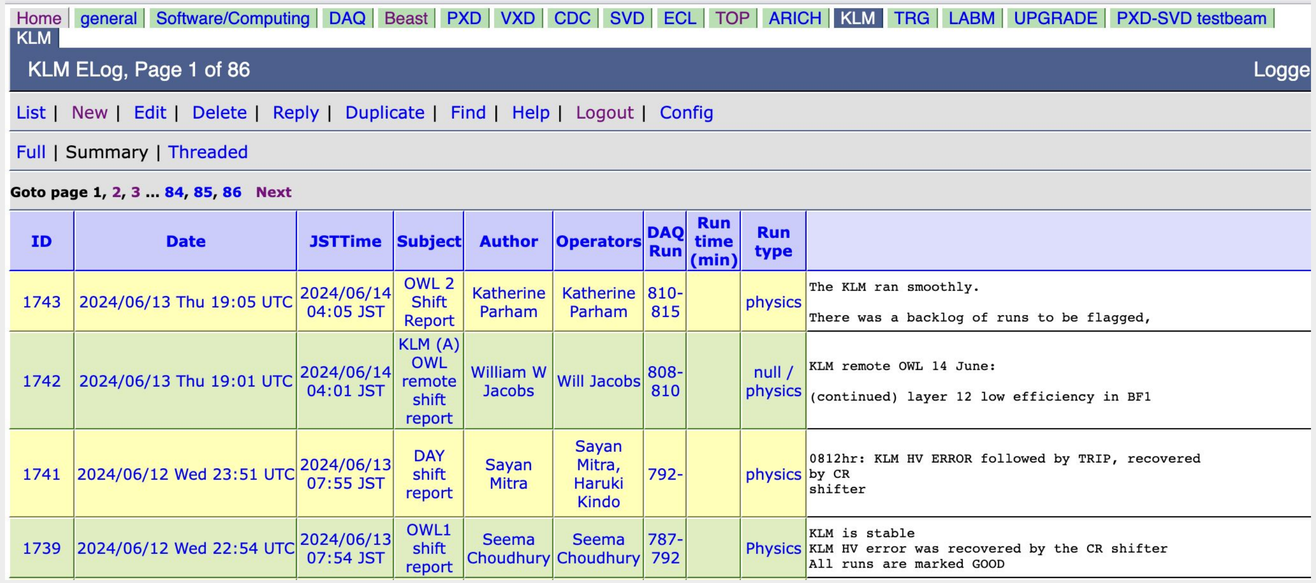
Details ▾ 33 816 physics 2024-06-14 07:18 2:21:55 STOPPING SVD | CDC | TOP | ARI | ECL | KLM | TRG HER: 7.01 LER: 4.00 1.52 In: 503.93 Hz Out: 40381923 213244.17

✔ *Ensuring these aspects are maintained involves continuous calibration, real-time monitoring, efficient data filtering, and robust error-checking mechanisms within the DQM system*

Features of DQM

- Feedback to accelerator & sub-systems group
- Good detector performance
- Helps in fixing hardware & software problems
- Sets a good baseline for offline analysis
- Tuning based on physics performance
- Eventually serves for good data



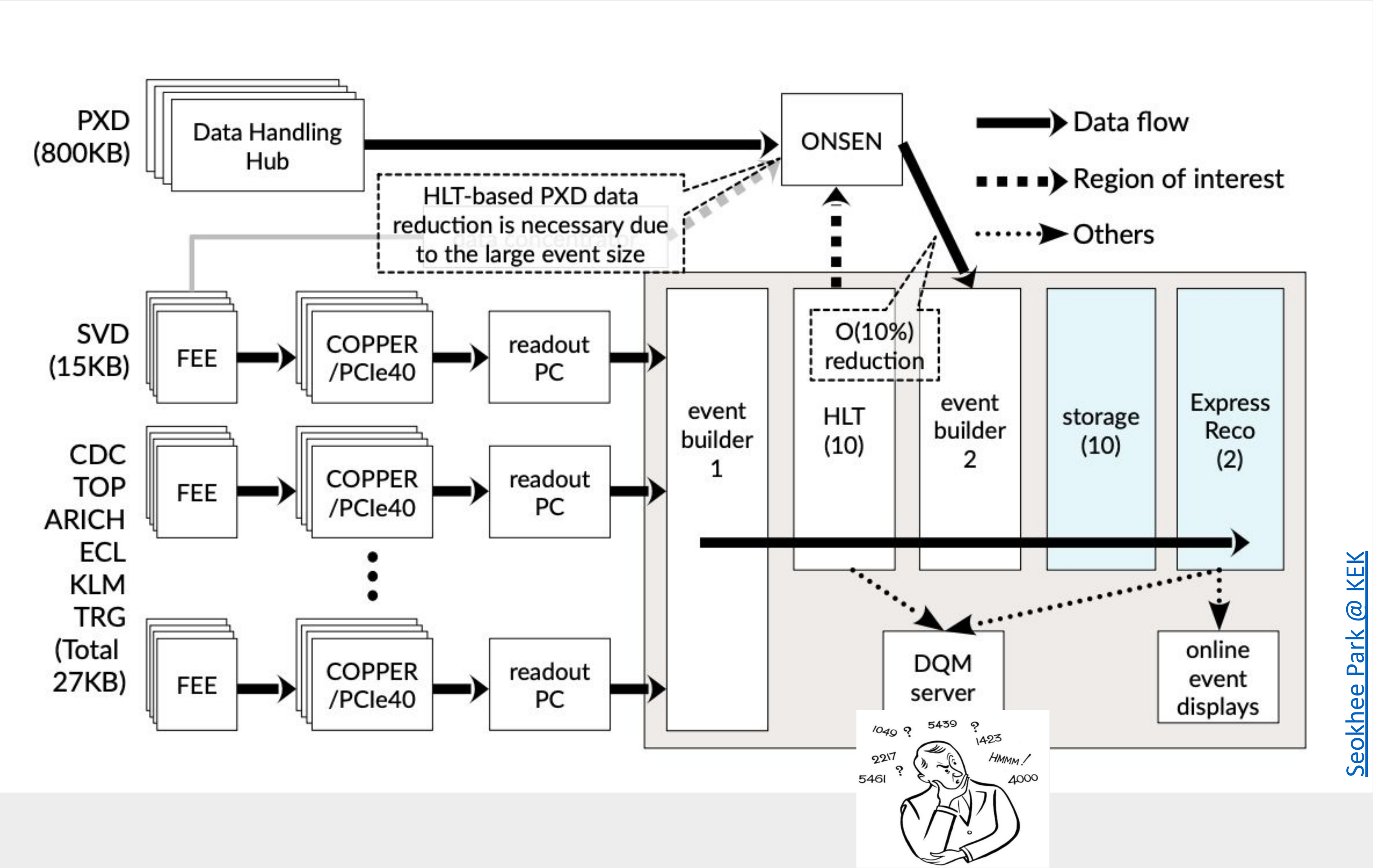

Home | general | Software/Computing | DAQ | Beast | PXD | VXD | CDC | SVD | ECL | TOP | ARICH | KLM | TRG | LABM | UPGRADE | PXD-SVD testbeam
KLM
Logge
List | New | Edit | Delete | Reply | Duplicate | Find | Help | Logout | Config
Full | Summary | Threaded

KLM ELog, Page 1 of 86

Goto page 1, 2, 3 ... 84, 85, 86 Next

ID	Date	JSTTime	Subject	Author	Operators	DAQ Run	Run time (min)	Run type	
1743	2024/06/13 Thu 19:05 UTC	2024/06/14 04:05 JST	OWL 2 Shift Report	Katherine Parham	Katherine Parham	810-815		physics	The KLM ran smoothly. There was a backlog of runs to be flagged,
1742	2024/06/13 Thu 19:01 UTC	2024/06/14 04:01 JST	KLM (A) OWL remote shift report	William W Jacobs	Will Jacobs	808-810		null / physics	KLM remote OWL 14 June: (continued) layer 12 low efficiency in BF1
1741	2024/06/12 Wed 23:51 UTC	2024/06/13 07:55 JST	DAY shift report	Sayan Mitra	Sayan Mitra, Haruki Kindo	792-		physics	0812hr: KLM HV ERROR followed by TRIP, recovered by CR shifter
1739	2024/06/12 Wed 22:54 UTC	2024/06/13 07:54 JST	OWL1 shift report	Seema Choudhury	Seema Choudhury	787-792		Physics	KLM is stable KLM HV error was recovered by the CR shifter All runs are marked GOOD

Data Flow in Belle II



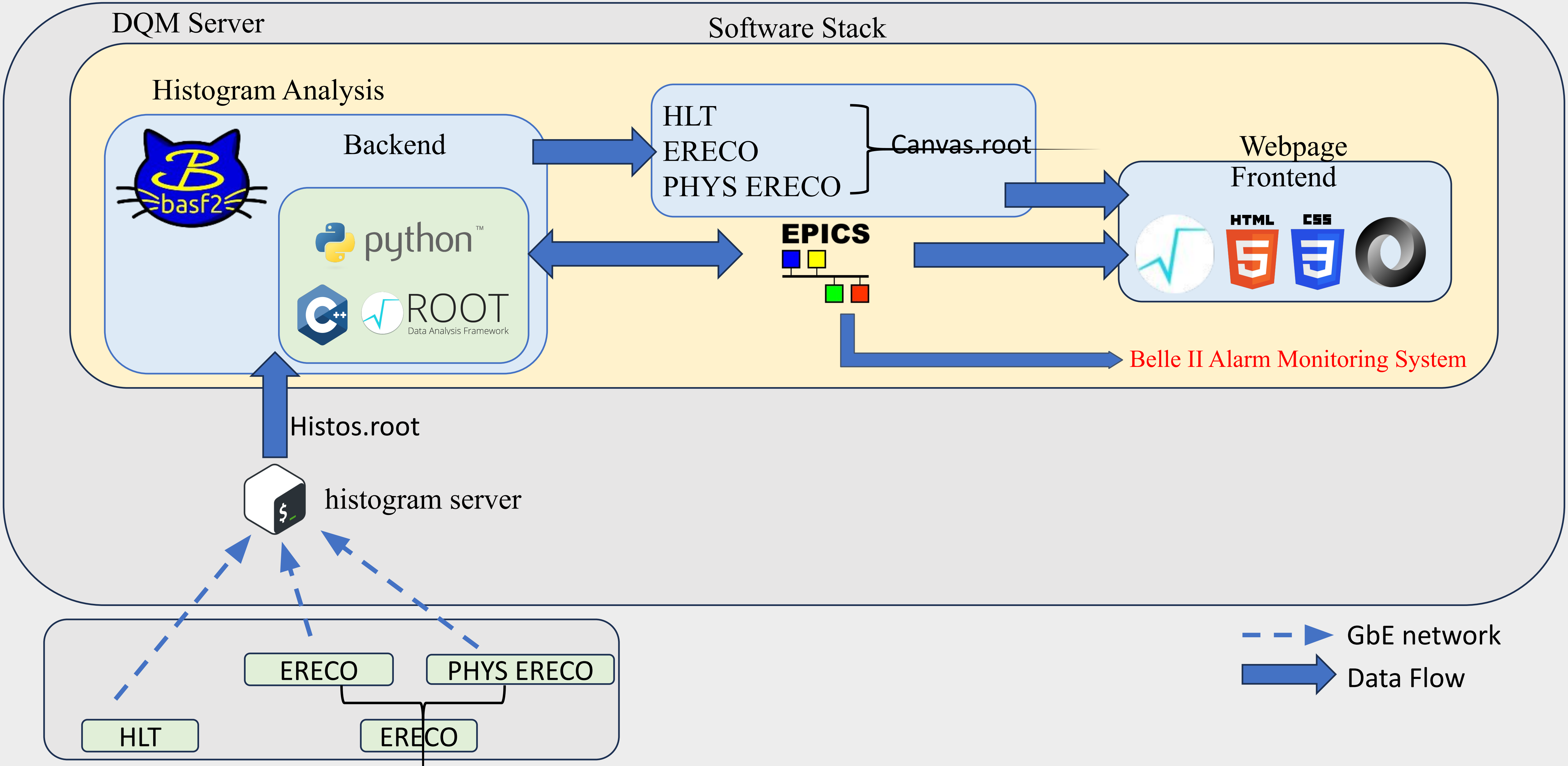
Seokhee Park @ KEK

Output of **HLT** (low-level information, timing, triggering etc.) and **Express reco** (w/ PXD and further reconstruction-related) are monitored for DQM.

- **~3800** histograms from HLT, 41 MB (6.5 MB in file)
- **~7900** histograms from ERECO, 88 MB (16 MB in file)

The numbers here are from end of Run 1 (2022).
The number of histograms have been increased to >10k from ERECO after LS1!

DQM Pipeline



DQM Server

Software Stack

Histogram Analysis

Backend

basf2

python™

ROOT

Data Analysis Framework

HLT

ERECO

PHYS ERECO

Canvas.root

Webpage

Frontend

HTML

CSS

EPICS

Belle II Alarm Monitoring System

Histos.root

histogram server

ERECO

PHYS ERECO

HLT

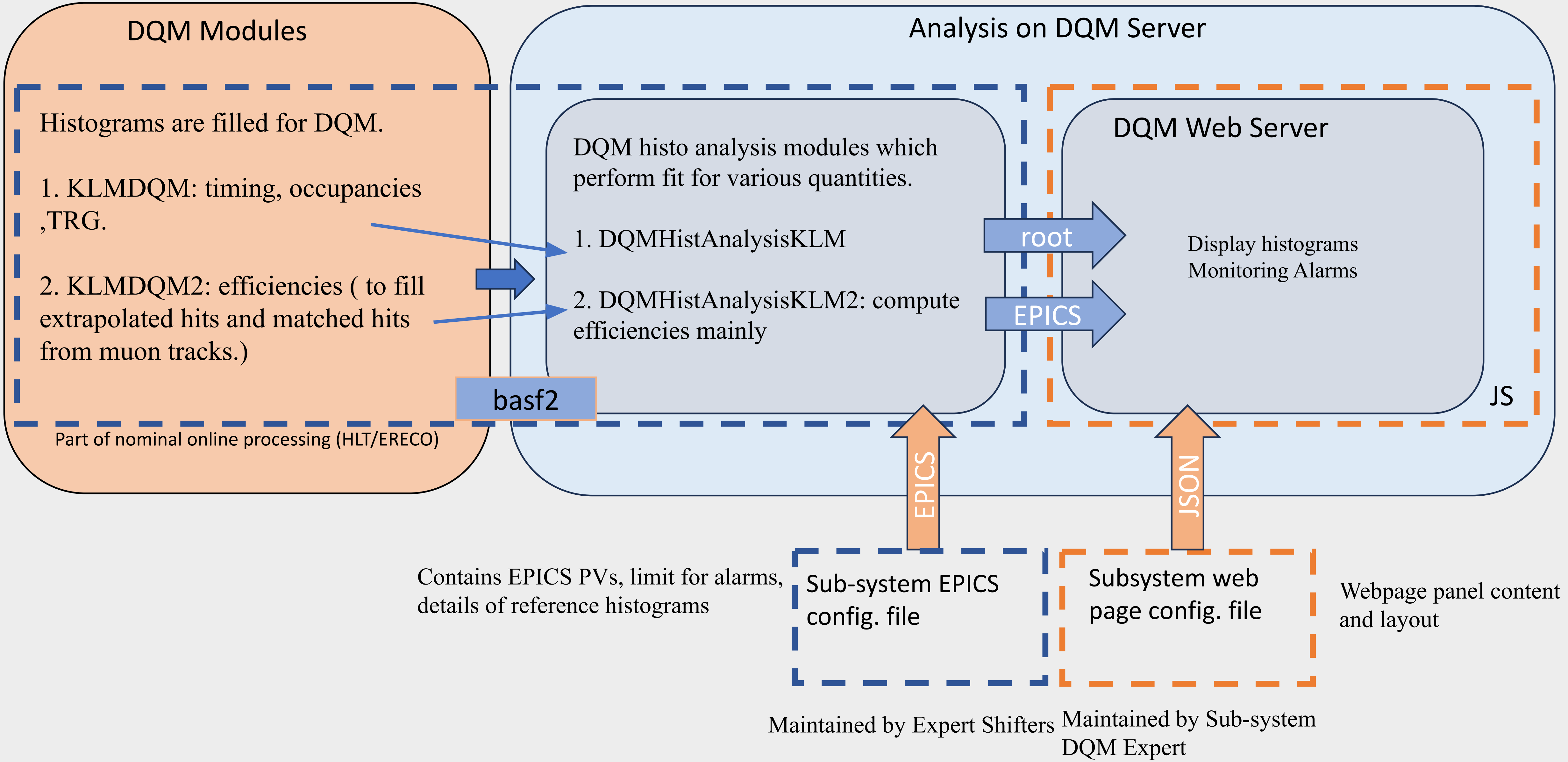
ERECO

GbE network

Data Flow

DQM for the KLM Detector of Belle II

Data Processing & Analysis for KLM



DQM Modules

Histograms are filled for DQM.

1. KLMDQM: timing, occupancies ,TRG.

2. KLMDQM2: efficiencies (to fill extrapolated hits and matched hits from muon tracks.)

Part of nominal online processing (HLT/ERECO)

Analysis on DQM Server

DQM histo analysis modules which perform fit for various quantities.

1. DQMHistAnalysisKLM

2. DQMHistAnalysisKLM2: compute efficiencies mainly

DQM Web Server

Display histograms
Monitoring Alarms

Contains EPICS PVs, limit for alarms, details of reference histograms

Sub-system EPICS config. file

Maintained by Expert Shifters

Subsystem web page config. file

Webpage panel content and layout

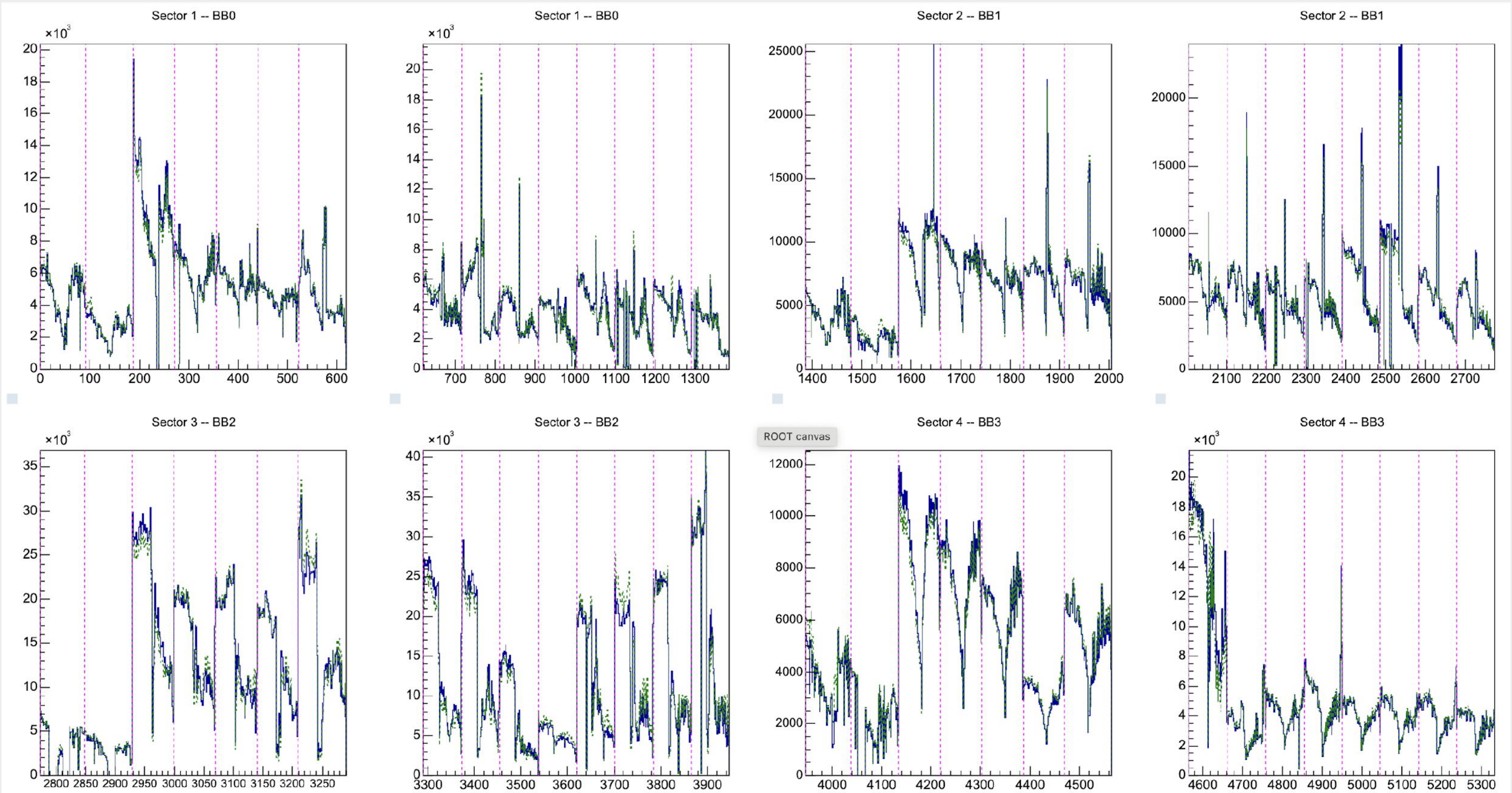
Maintained by Sub-system DQM Expert

Observables

What **observables** should be included in KLM DQM to effectively monitor hundreds of readout channels and the changing detector conditions on a minute-by-minute basis?

Real-time Monitoring – Continuously monitor readout channel

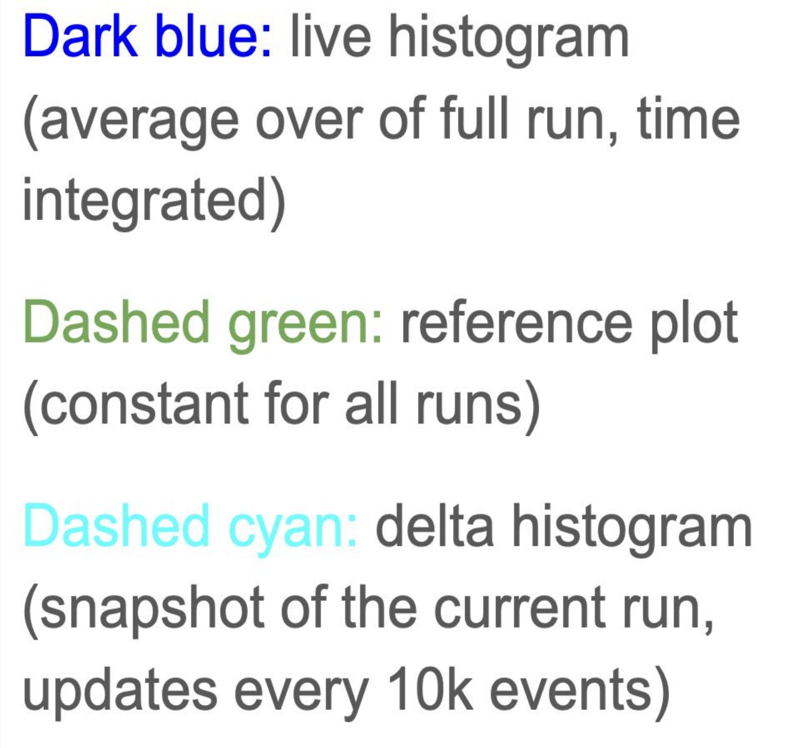
Hit maps for all KLM sectors



Observables

What **observables** should be included in KLM DQM to effectively monitor to hundreds of readout channels and changing detector conditions on a minute-by-minute basis?

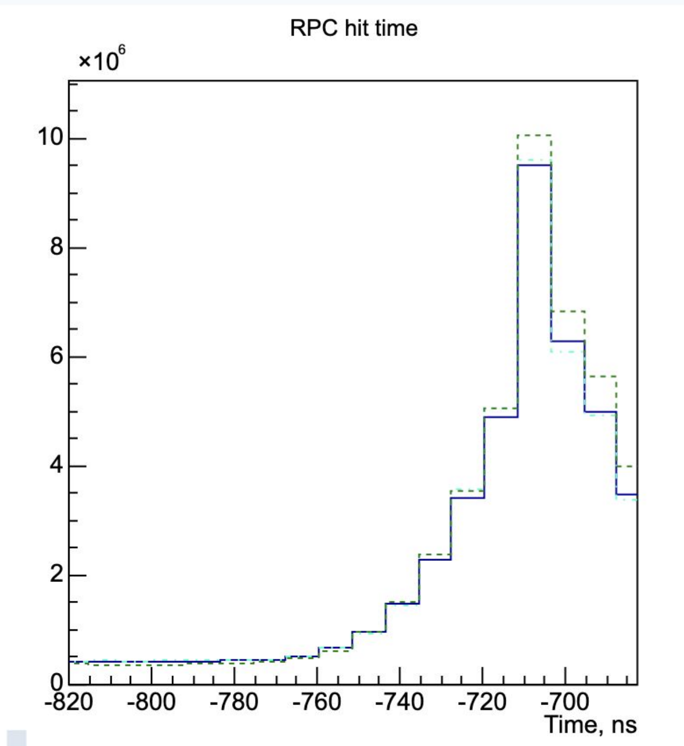
Dynamic Condition Updates – Time slice delta histogram analysis

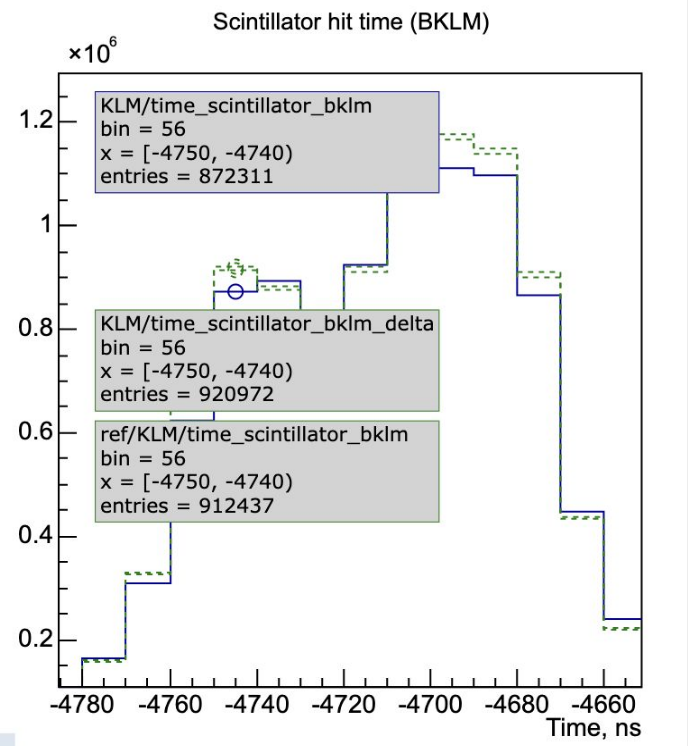


Dark blue: live histogram (average over of full run, time integrated)

Dashed green: reference plot (constant for all runs)

Dashed cyan: delta histogram (snapshot of the current run, updates every 10k events)





KLM/time_scintillator_bklm
bin = 56
x = [-4750, -4740)
entries = 872311

KLM/time_scintillator_bklm_delta
bin = 56
x = [-4750, -4740)
entries = 920972

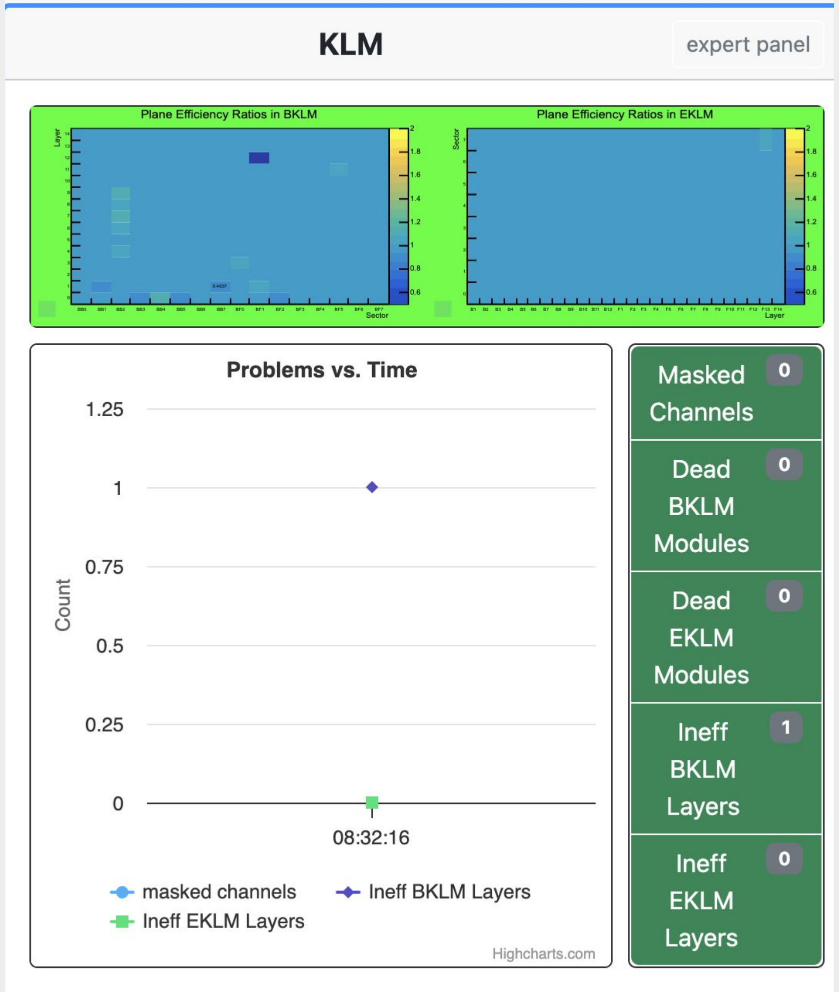
ref/KLM/time_scintillator_bklm
bin = 56
x = [-4750, -4740)
entries = 912437

Observables

What **observables** should be included in KLM DQM to effectively monitor hundreds of readout channels and changing detector conditions on a minute-by-minute basis?

Automated Alerts – List of PVs & their alarm threshold

Data Visualization – Colorize histograms to visual alert systems, labels, & thresholds


KLM

Masked Channels 0

Dead BKLM Modules 0

Dead EKLM Modules 0

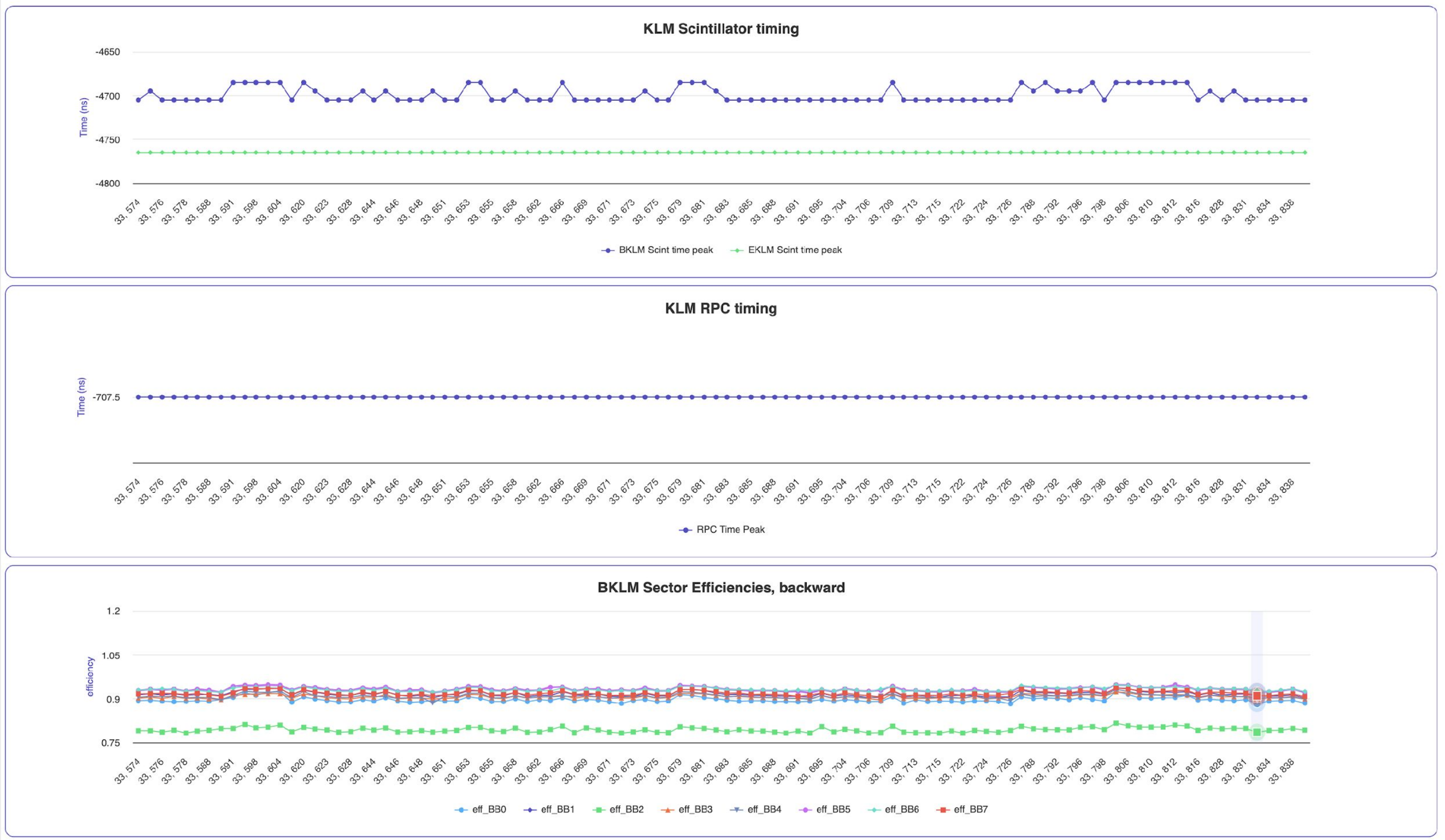
Ineff BKLM Layers 1

Ineff EKLM Layers 0

Observables

What **observables** should be included in KLM DQM to effectively monitor hundreds of readout channels and changing detector conditions on a minute-by-minute basis?

Historical Data Analysis – Trend Plots (Mirabelle)

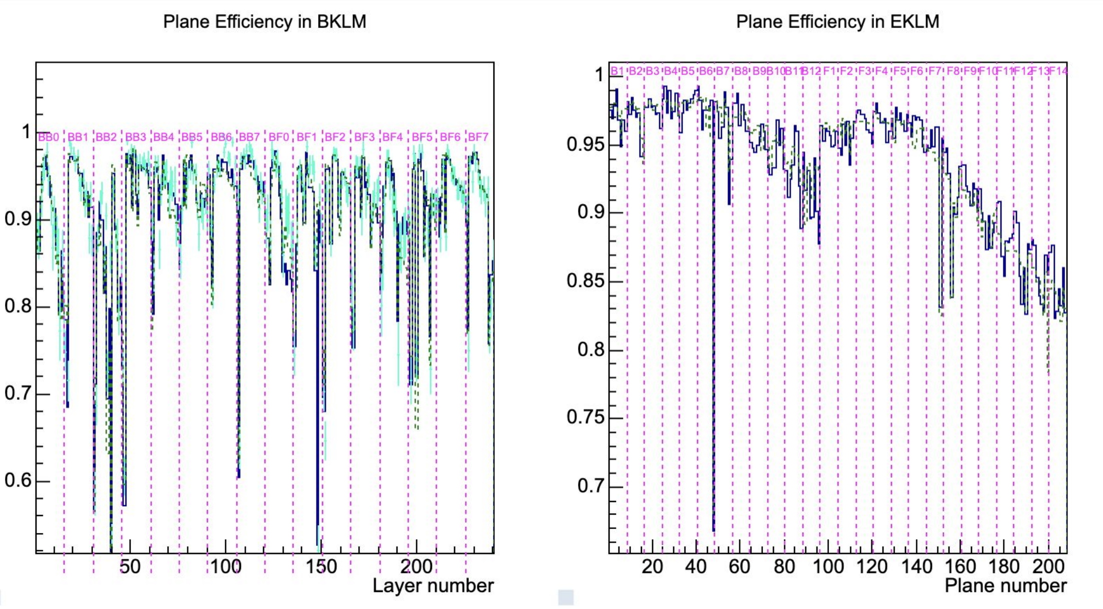


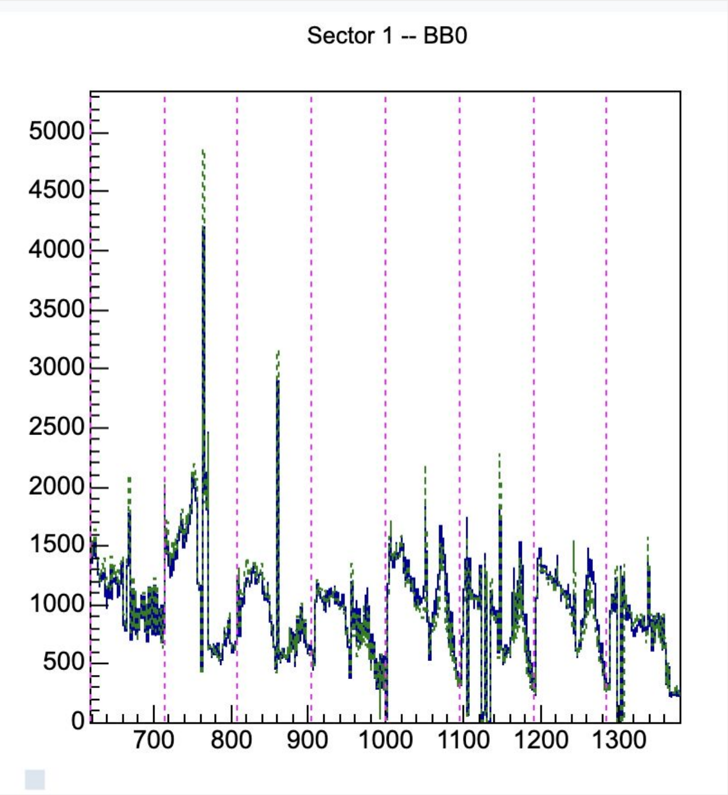
Observables

What **observables** should be included in KLM DQM to effectively monitor hundreds of readout channels and changing detector conditions on a minute-by-minute basis?

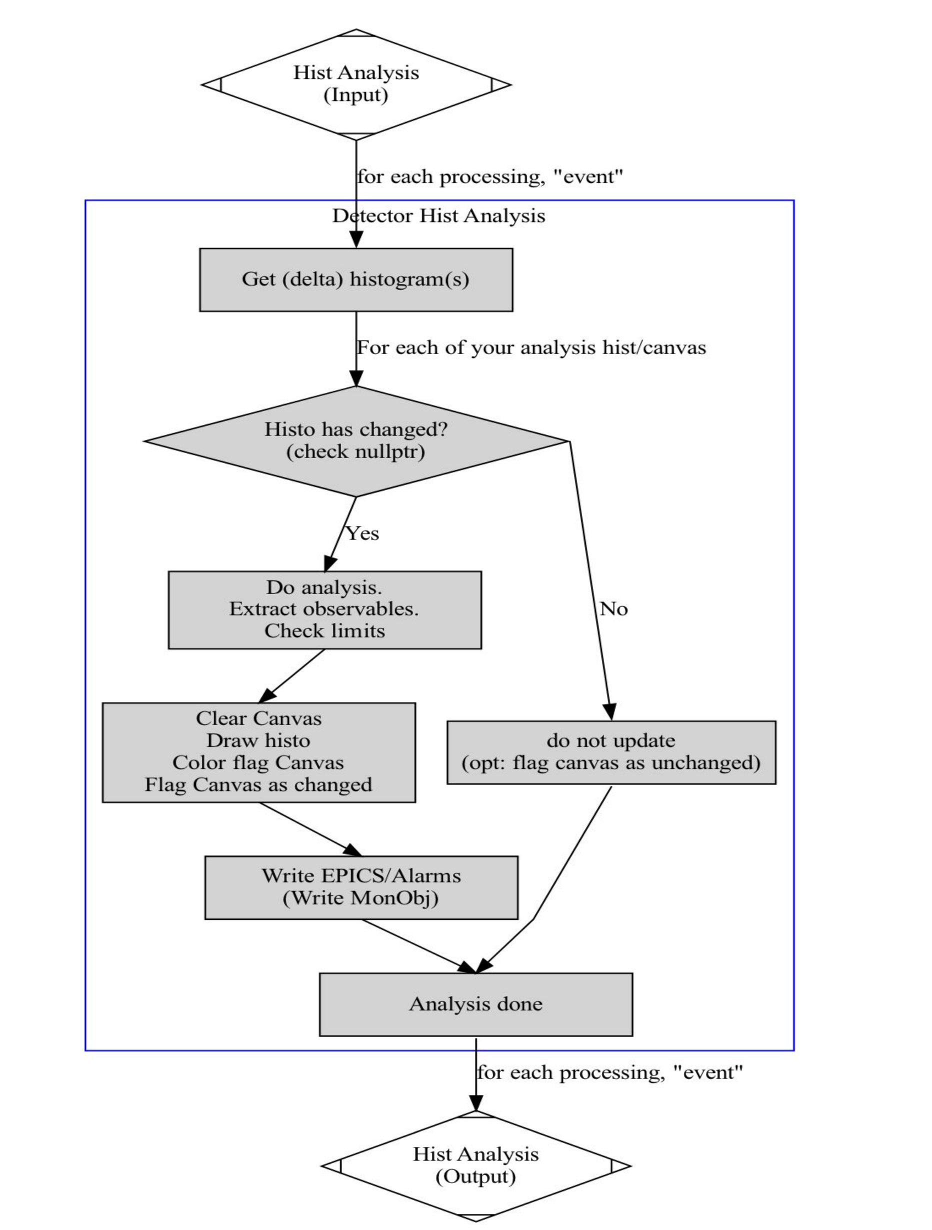
User-Friendly Interface – Simplify monitoring and interpretation

- ☑️ Fitting
- ☑️ Efficiency Checks
- ☑️ Overlay with reference plot

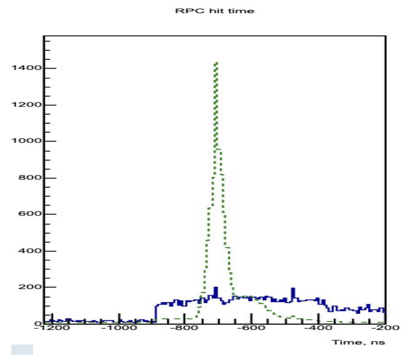


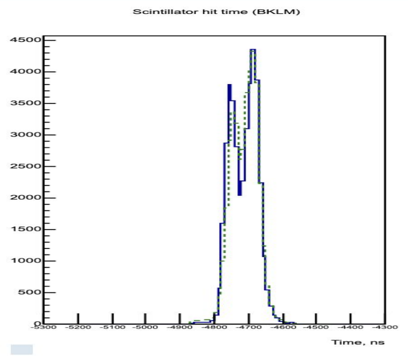


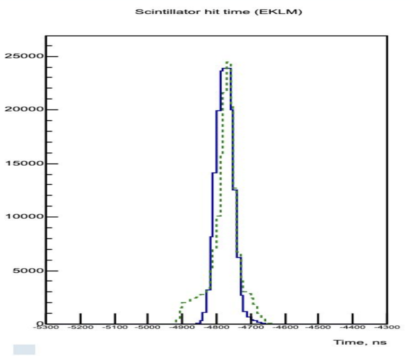
Approach

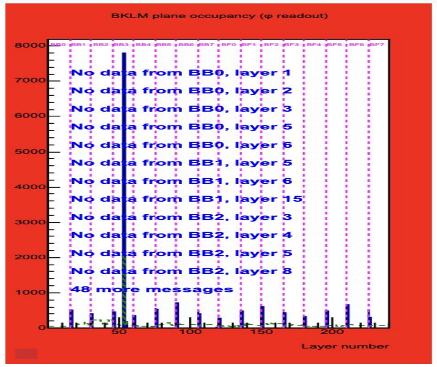

Hist Analysis
(Input)
for each processing, "event"
Detector Hist Analysis
Get (delta) histogram(s)
For each of your analysis hist/canvas
Histo has changed?
(check nullptr)
Yes
No
Do analysis.
Extract observables.
Check limits
Clear Canvas
Draw histo
Color flag Canvas
Flag Canvas as changed
do not update
(opt: flag canvas as unchanged)
Write EPICS/Alarms
(Write MonObj)
Analysis done
for each processing, "event"
Hist Analysis
(Output)

Examples

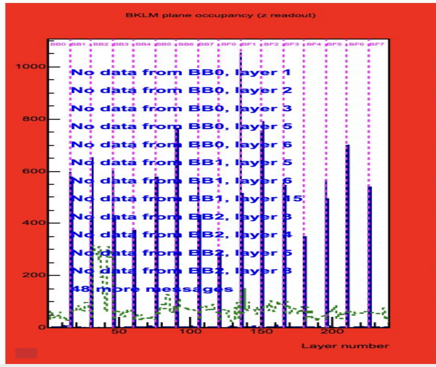




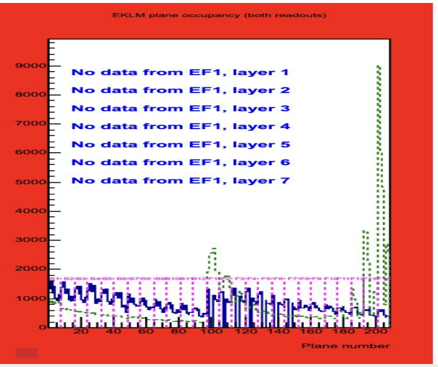




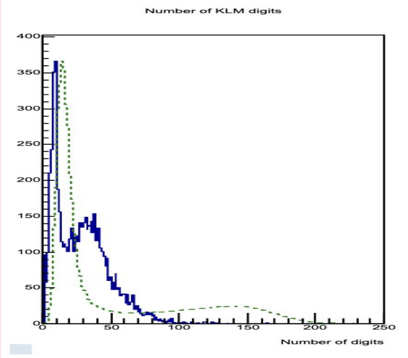
No data from BB0, layer 1
No data from BB0, layer 2
No data from BB0, layer 3
No data from BB0, layer 5
No data from BB0, layer 6
No data from BB1, layer 5
No data from BB1, layer 6
No data from BB1, layer 15
No data from BB2, layer 3
No data from BB2, layer 4
No data from BB2, layer 5
No data from BB2, layer 8
48 more messages

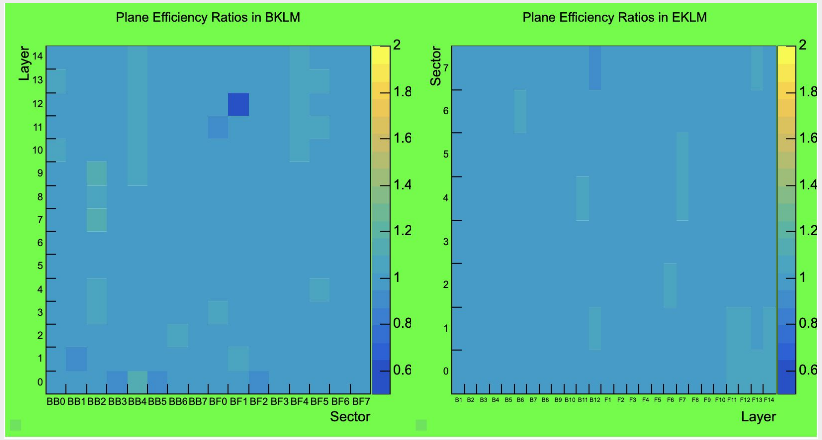


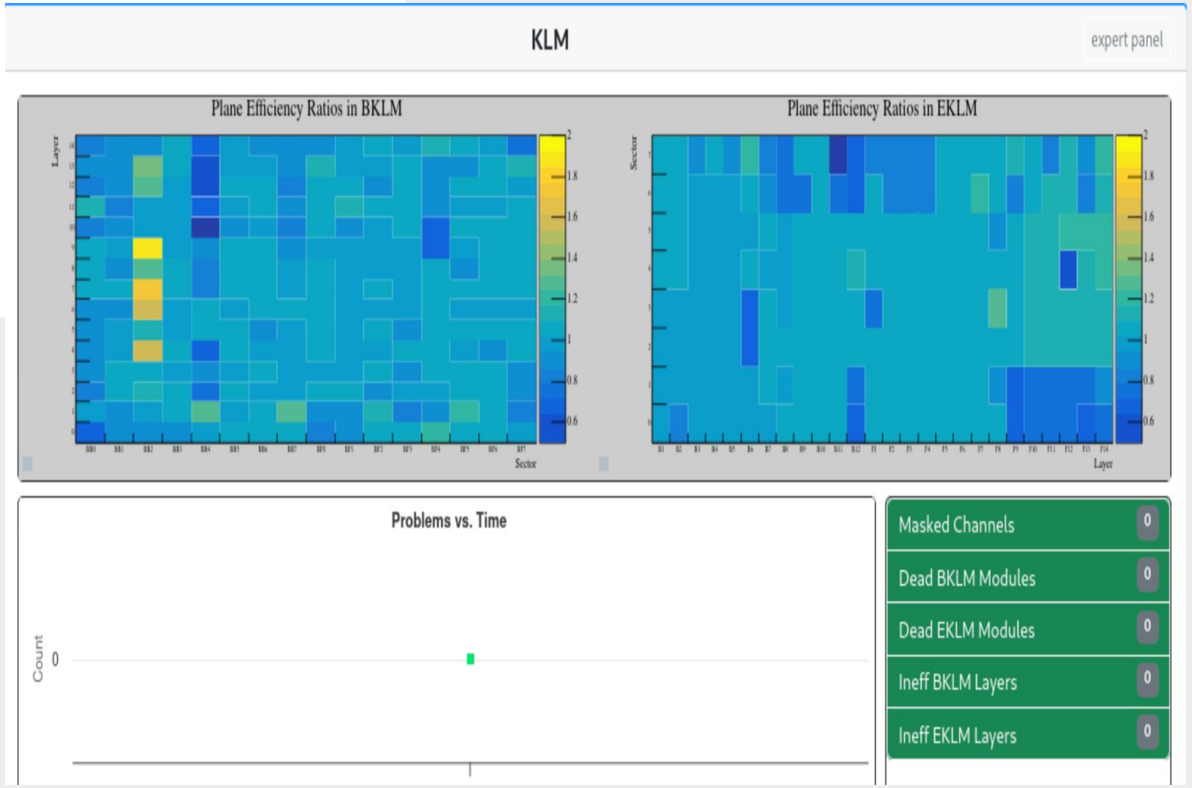
No data from BB0, layer 1
No data from BB0, layer 2
No data from BB0, layer 3
No data from BB0, layer 5
No data from BB0, layer 6
No data from BB1, layer 5
No data from BB1, layer 6
No data from BB1, layer 15
No data from BB2, layer 3
No data from BB2, layer 4
No data from BB2, layer 5
No data from BB2, layer 8
48 more messages



No data from EF1, layer 1
No data from EF1, layer 2
No data from EF1, layer 3
No data from EF1, layer 4
No data from EF1, layer 5
No data from EF1, layer 6
No data from EF1, layer 7






expert panel
Plane Efficiency Ratios in BKLM
Layer
Sector
Plane Efficiency Ratios in EKLM
Sector
Layer
Problems vs. Time
Count
0

KLM

Masked Channels	0
Dead BKLM Modules	0
Dead EKLM Modules	0
Ineff BKLM Layers	0
Ineff EKLM Layers	0

Recent Developments

- Common functionality within the framework to save work on detector developer side.
- Recent changes will enhance the ability to flag run quality directly from 2D efficiency plots.
- Use configuration file for settings, limits and EPICS (high level abstraction).
- Efforts are put to optimize plot ranges for directly obtaining significance.

Future Improvements

- Background Monitoring
- Finer granularity (Monitoring of each channel to better debug problems)
- Better Anomaly Detection (Use of some ML techniques).
- Faster Reactions (Automatic actions)
- Still requires improvement to defined actions clearly.

ACKNOWLEDGEMENT

Special Thanks To

- Tommy Lam
- Marcela Garcia
- Luka Santelj & Bjoern Spruck

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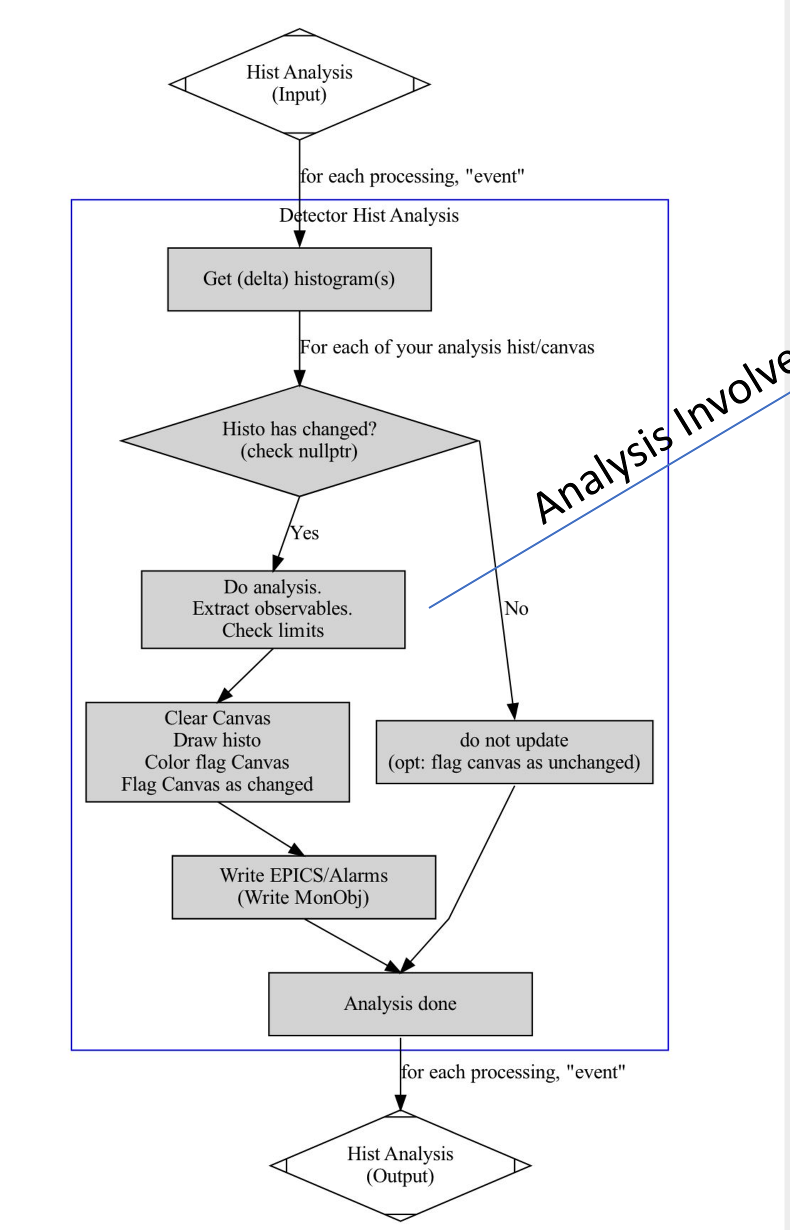
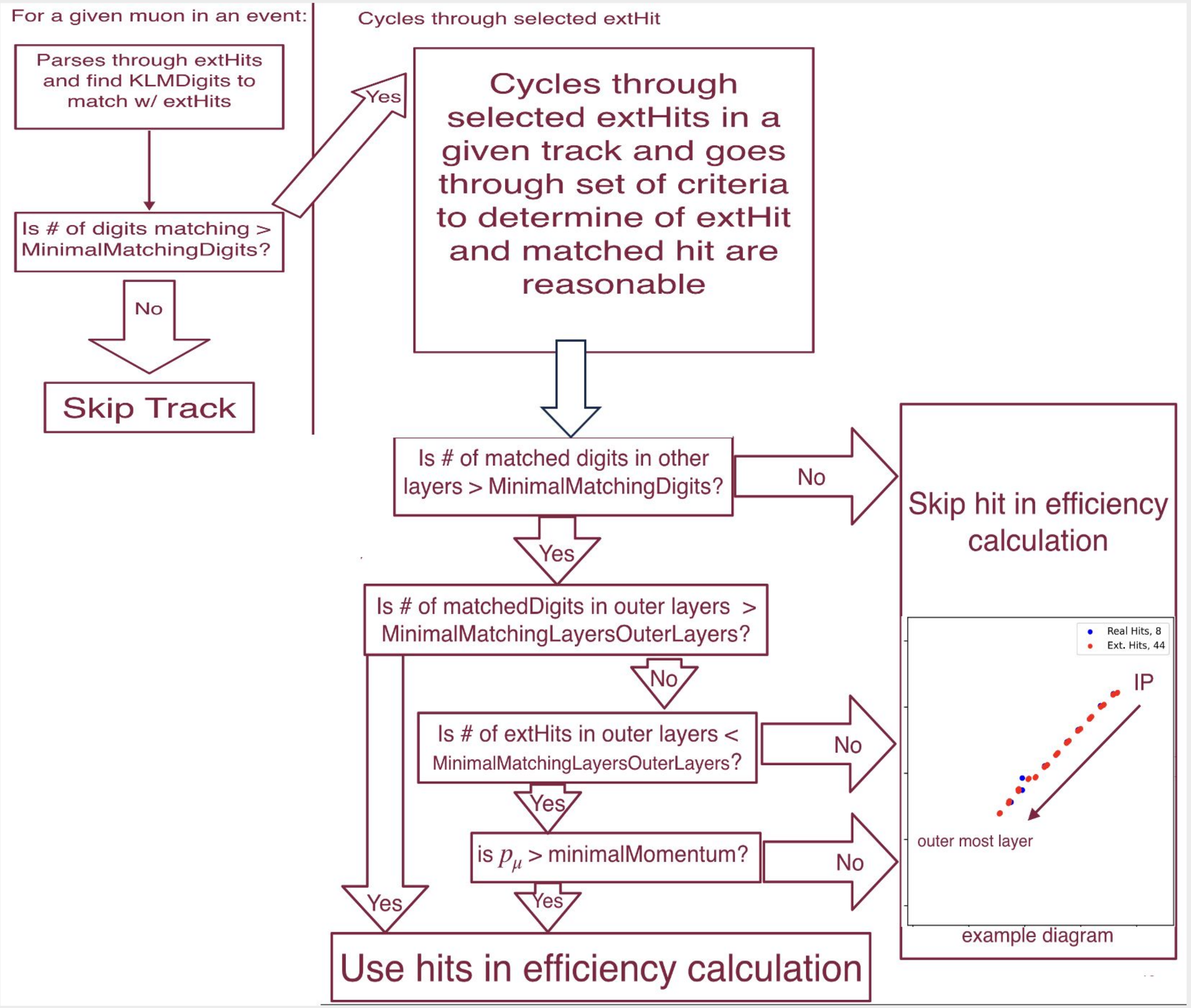
Belle II

Backup

Approach

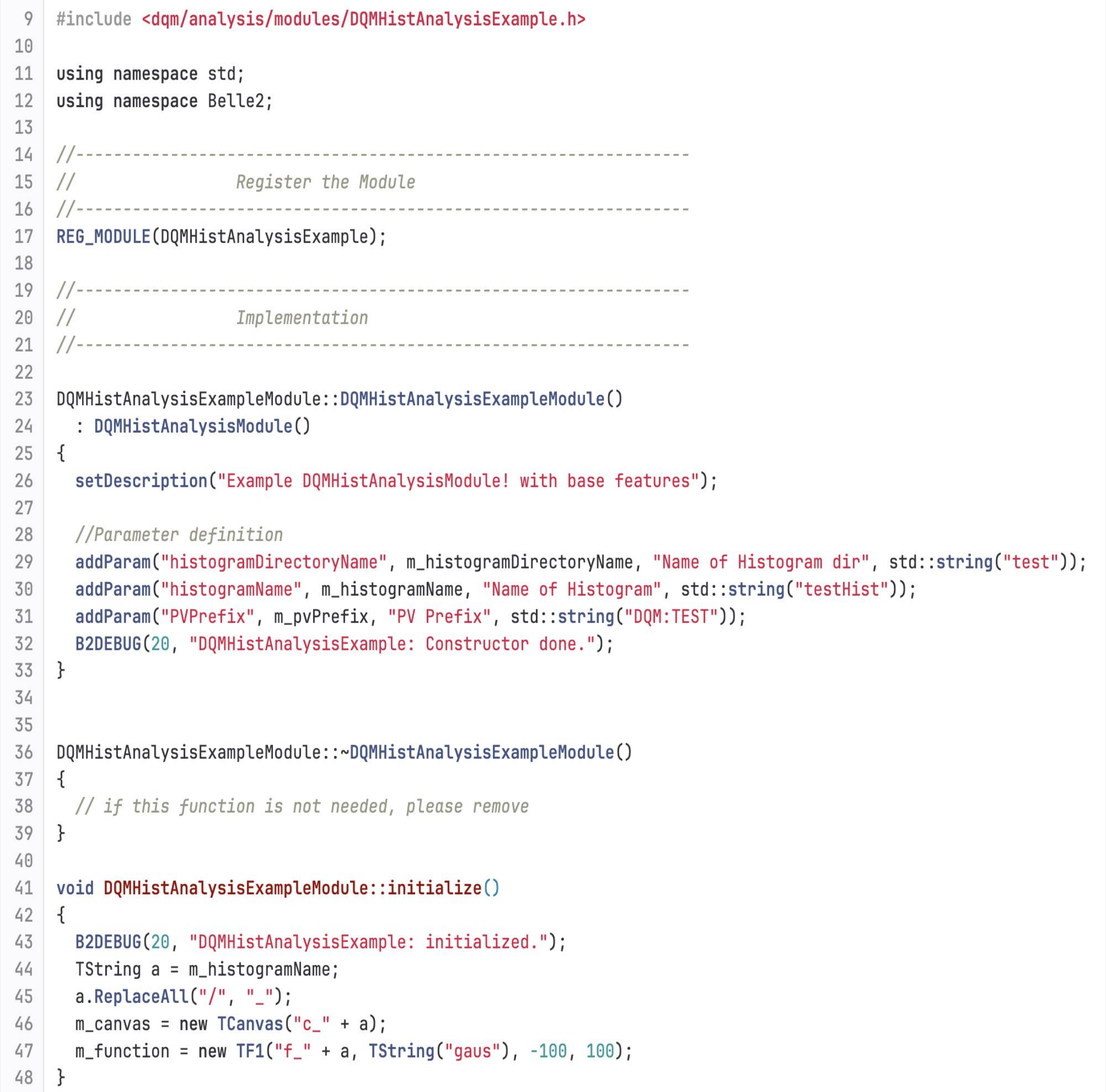

Hist Analysis (Input)
for each processing, "event"
Detector Hist Analysis
Get (delta) histogram(s)
For each of your analysis hist/canvas
Histo has changed? (check nullptr)
Yes
No
Do analysis. Extract observables. Check limits
Clear Canvas Draw histo Color flag Canvas Flag Canvas as changed
do not update (opt: flag canvas as unchanged)
Write EPICS/Alarms (Write MonObj)
Analysis done
for each processing, "event"
Hist Analysis (Output)

Analysis Involved

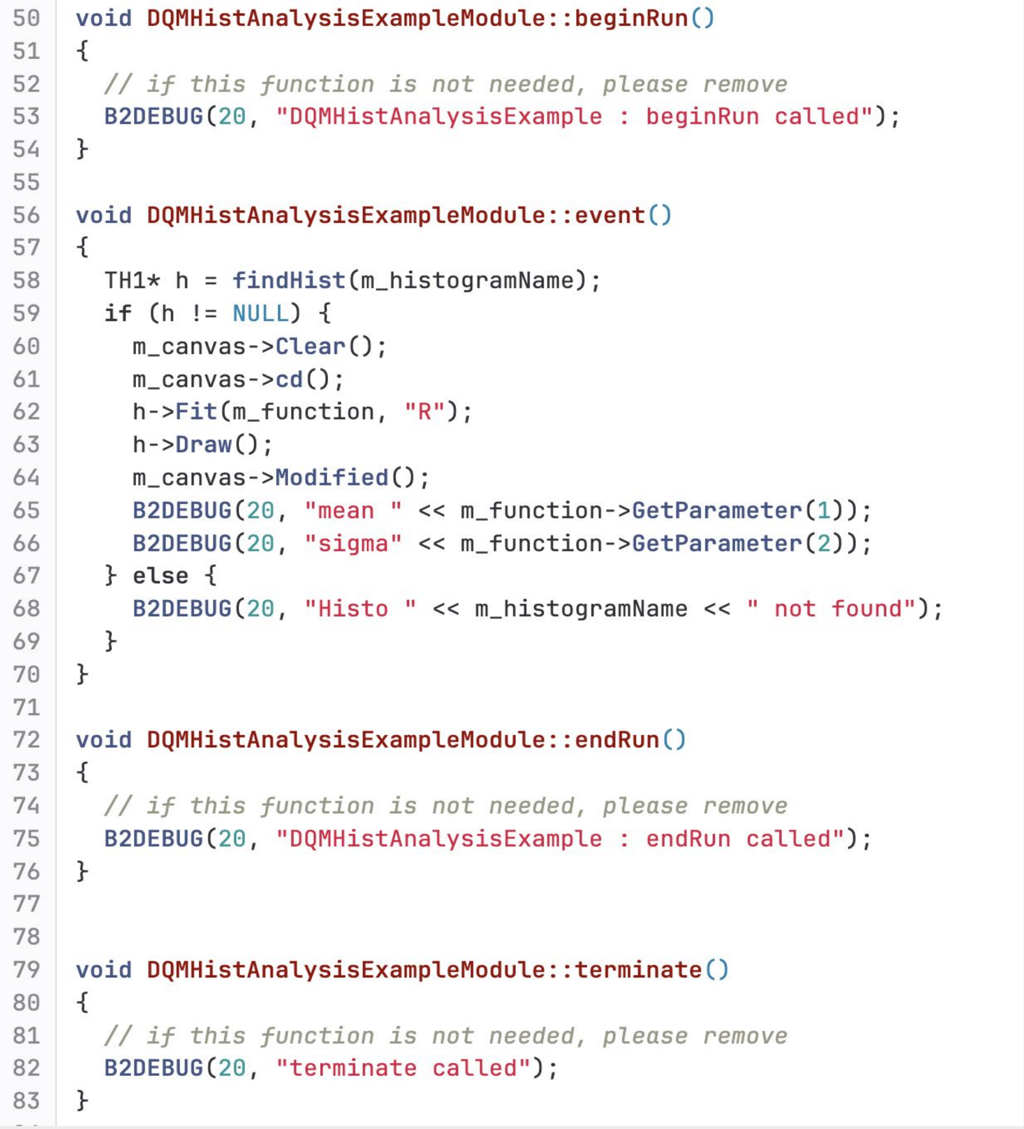

For a given muon in an event:
Parses through extHits and find KLMDigits to match w/ extHits
Is # of digits matching > MinimalMatchingDigits?
Yes
No
Skip Track
Cycles through selected extHit
Cycles through selected extHits in a given track and goes through set of criteria to determine of extHit and matched hit are reasonable
Is # of matched digits in other layers > MinimalMatchingDigits?
No
Skip hit in efficiency calculation
Yes
Is # of matchedDigits in outer layers > MinimalMatchingLayersOuterLayers?
No
Is # of extHits in outer layers < MinimalMatchingLayersOuterLayers?
No
Yes
is p_μ > minimalMomentum?
No
Yes
Yes
Use hits in efficiency calculation
Real Hits, 8
Ext. Hits, 44
IP
outer most layer
example diagram

Example

dqm/analysis/modules/src/DQMHistAnalysisExample*.cc



```cpp
#include <dqm/analysis/modules/DQMHistAnalysisExample.h>

using namespace std;
using namespace Belle2;

//-----------------------------------------------------------------
//                 Register the Module
//-----------------------------------------------------------------
REG_MODULE(DQMHistAnalysisExample);

//-----------------------------------------------------------------
//                 Implementation
//-----------------------------------------------------------------

DQMHistAnalysisExampleModule::DQMHistAnalysisExampleModule()
  : DQMHistAnalysisModule()
{
  setDescription("Example DQMHistAnalysisModule! with base features");

  //Parameter definition
  addParam("histogramDirectoryName", m_histogramDirectoryName, "Name of Histogram dir", std::string("test"));
  addParam("histogramName", m_histogramName, "Name of Histogram", std::string("testHist"));
  addParam("PVPrefix", m_pvPrefix, "PV Prefix", std::string("DQM:TEST"));
  B2DEBUG(20, "DQMHistAnalysisExample: Constructor done.");
}


DQMHistAnalysisExampleModule::~DQMHistAnalysisExampleModule()
{
  // if this function is not needed, please remove
}

void DQMHistAnalysisExampleModule::initialize()
{
  B2DEBUG(20, "DQMHistAnalysisExample: initialized.");
  TString a = m_histogramName;
  a.ReplaceAll("/", "_");
  m_canvas = new TCanvas("c_" + a);
  m_function = new TF1("f_" + a, TString("gaus"), -100, 100);
}
```



```cpp
void DQMHistAnalysisExampleModule::beginRun()
{
  // if this function is not needed, please remove
  B2DEBUG(20, "DQMHistAnalysisExample : beginRun called");
}

void DQMHistAnalysisExampleModule::event()
{
  TH1* h = findHist(m_histogramName);
  if (h != NULL) {
    m_canvas->Clear();
    m_canvas->cd();
    h->Fit(m_function, "R");
    h->Draw();
    m_canvas->Modified();
    B2DEBUG(20, "mean " << m_function->GetParameter(1));
    B2DEBUG(20, "sigma" << m_function->GetParameter(2));
  } else {
    B2DEBUG(20, "Histo " << m_histogramName << " not found");
  }
}

void DQMHistAnalysisExampleModule::endRun()
{
  // if this function is not needed, please remove
  B2DEBUG(20, "DQMHistAnalysisExample : endRun called");
}


void DQMHistAnalysisExampleModule::terminate()
{
  // if this function is not needed, please remove
  B2DEBUG(20, "terminate called");
}
```