# KLOE-2 Data Quality: Summary and open issues

*A. De Santis*
*for the DQ task force*

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# Introduction

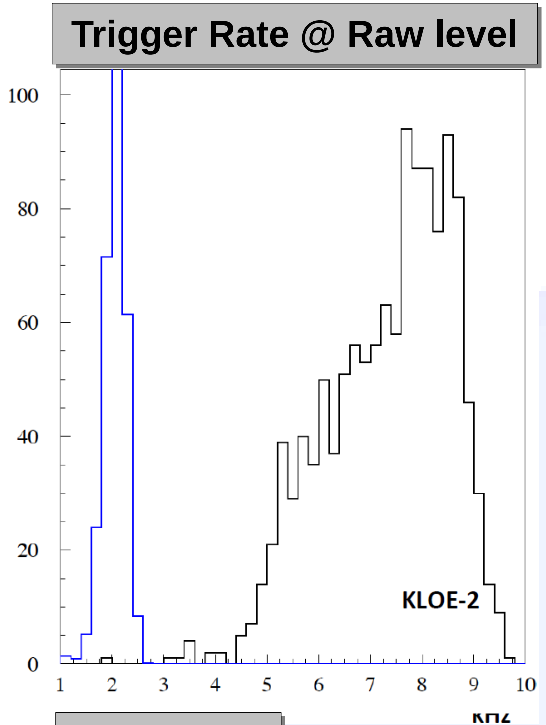
KLOE-2 experimental conditions are strongly different from those experienced in the old KLOE data-taking campaign. Higher level of background is observed and has several implications:

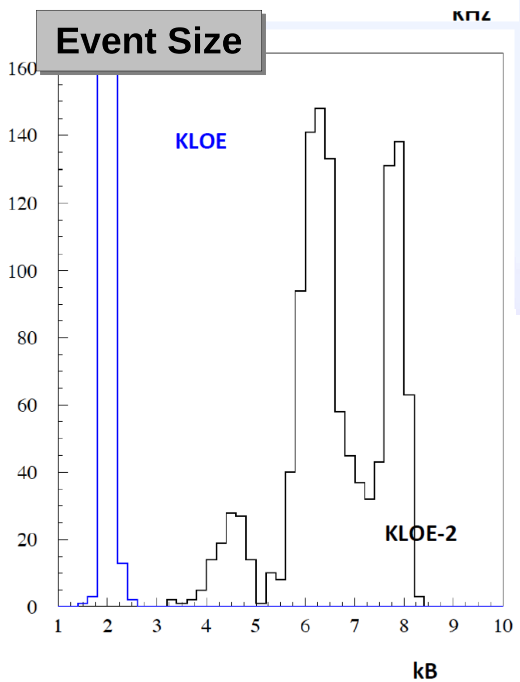
- Trigger rate & Data volume
- Event classification capabilities
- Effective luminosity collected

Are we able to do "good" physics with these data?

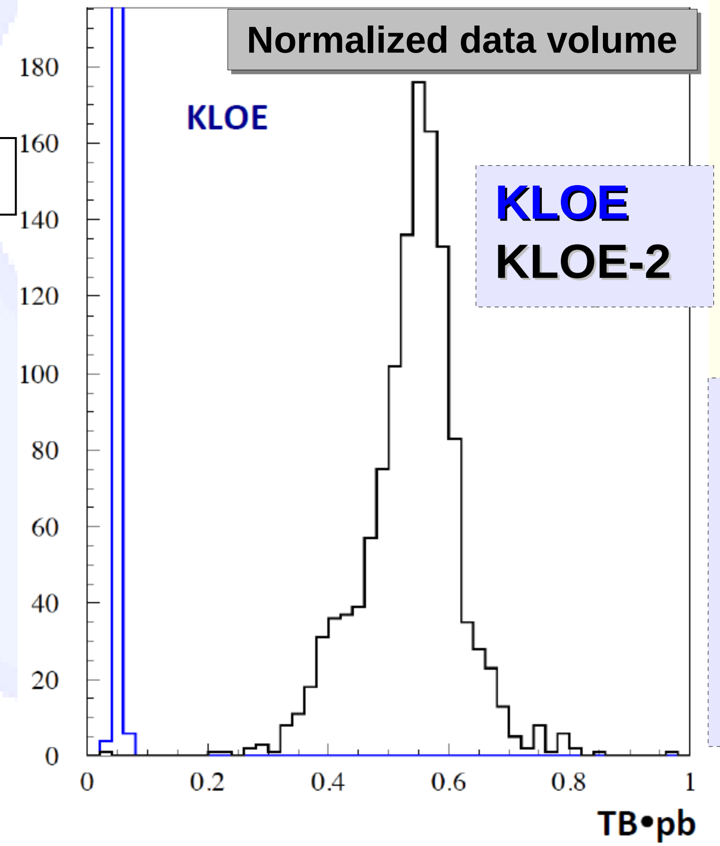
# Trigger Rate
# &
# Data volume

# Event rates & Data volumes




Higher trigger rate (even if normalized to the luminosity) and larger event size (not only because of the new detectors) leads to a big increase in the data volume.
Reduce it is mandatory both because of tape consumption and data throughput towards L3 farms.
Larger data volume has also impact on the data reconstruction performance.

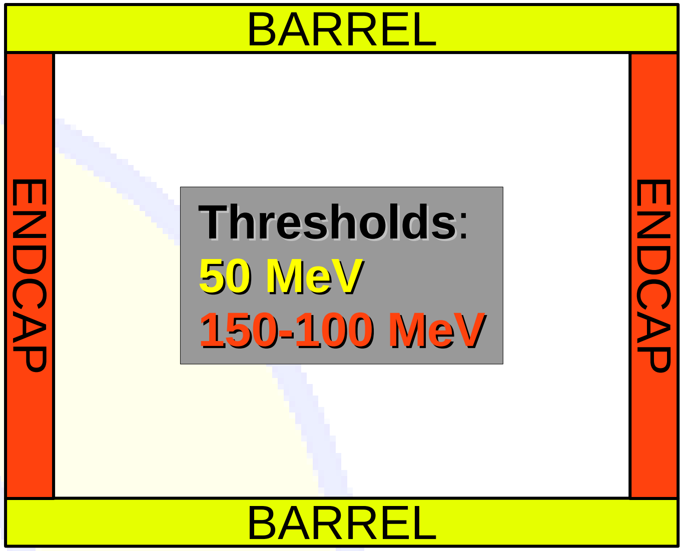


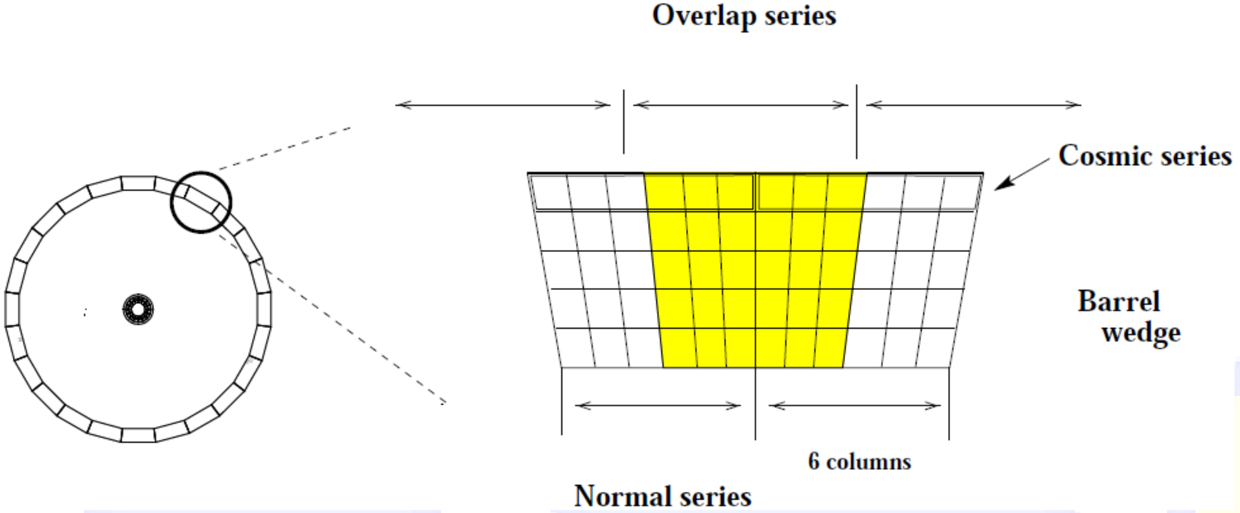

Largely due to "neutral" component. The relative increase of EMC cluster related size is larger than the increase related to the DC hits.

# Trigger logic and event time structure

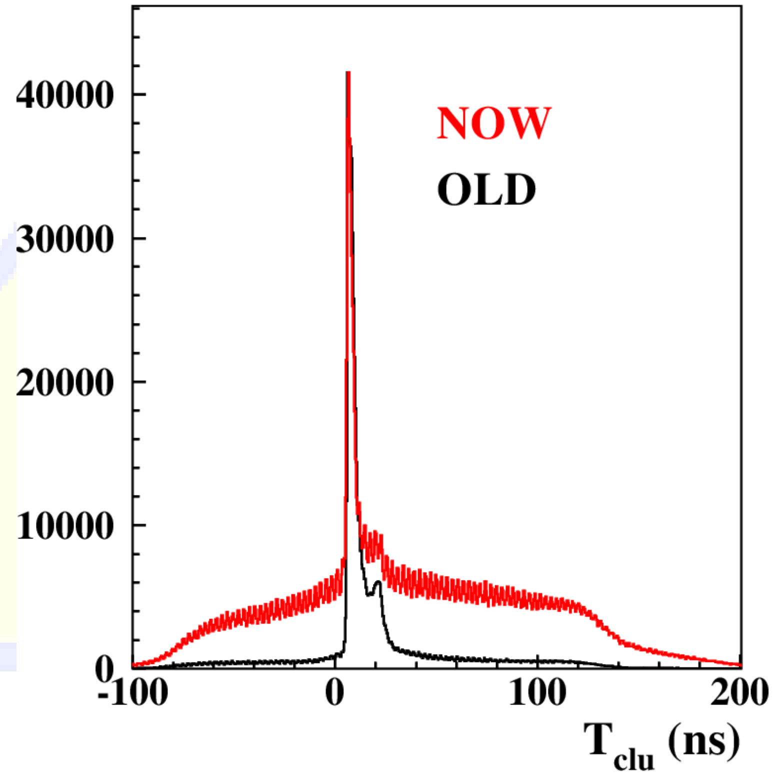
Trigger logic is very simple:
2 fired sectors within 70 ns
Two different series are defined (Normal and Overlap) to avoid inefficiencies close to the sector borders.

Time window is so large to allow for late decays of $K_L/K^{\pm}$ to trigger when needed (e.g. $T_{clu}(K_L^{crash})$~40 ns).



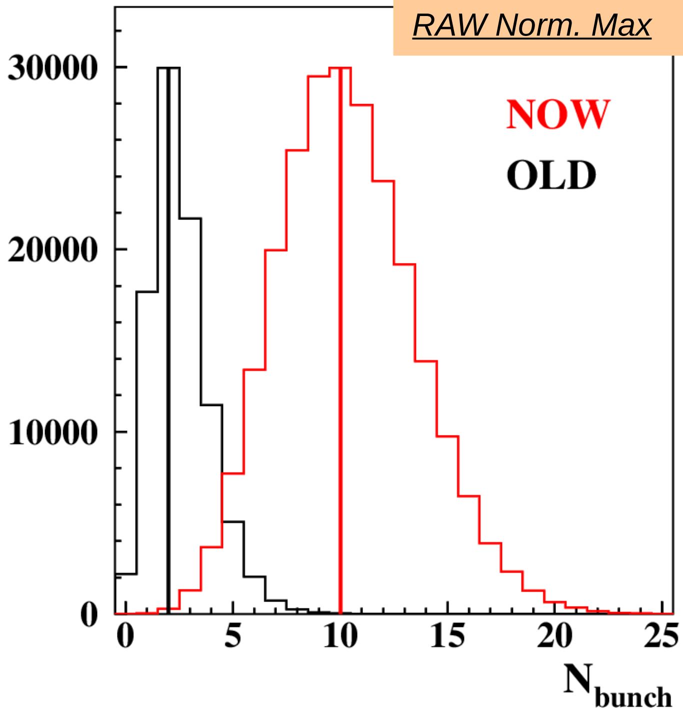

Time span of events acquired now with respect to the past has a very different shape. The time range in unchanged (since the time buffer is the same), but “out of time” clusters have a larger (x10) relative weight than in the past.



# Event time structure

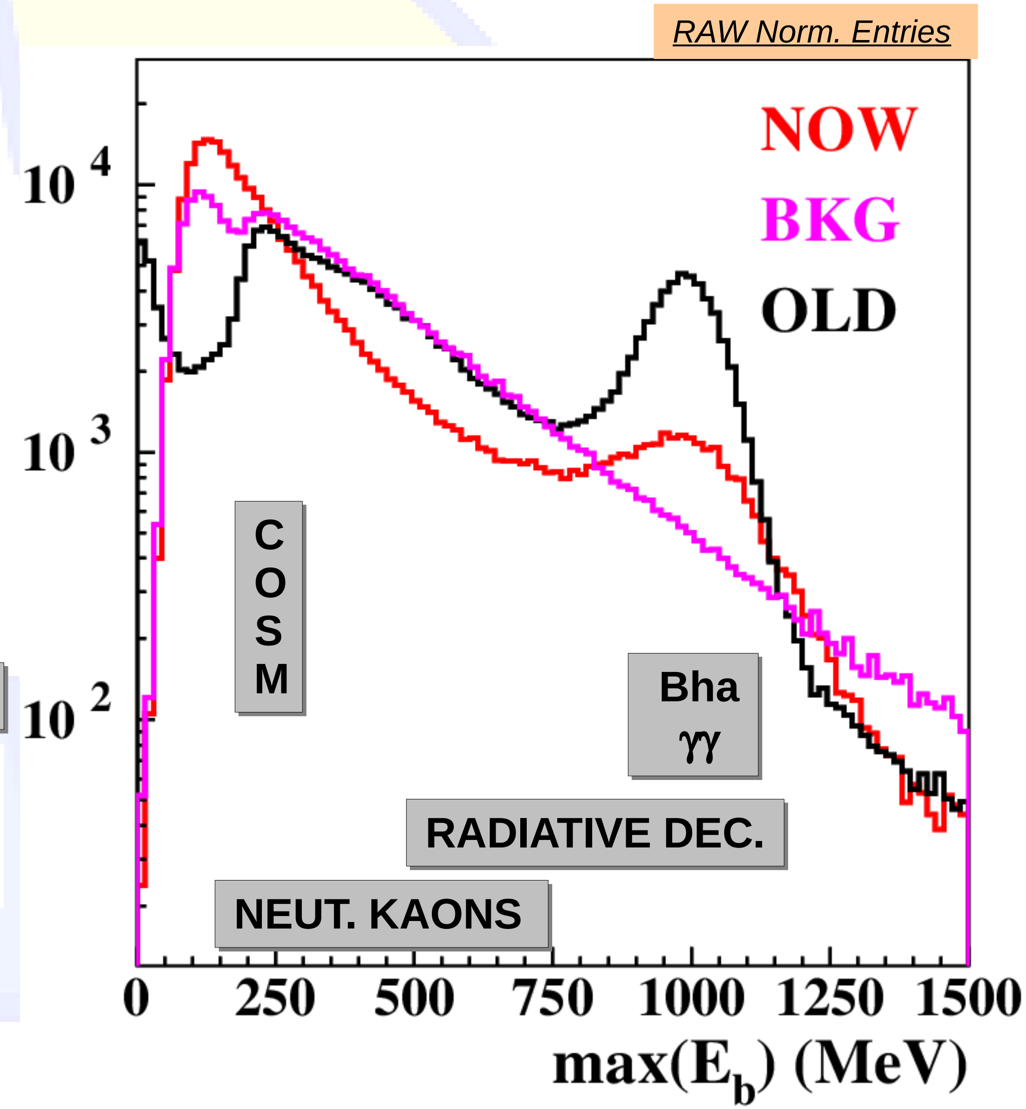
Relate every cluster to is own "bunch crossing" assuming is a photon coming from IP. Many "bunches" can be found in a single trigger (70 ns $T_W$ vs 2.7 ns $T_{RF}$):

$$b_j = NINT\left(\frac{t_j - R_j/c}{T_{RF}}\right)$$




**Bunch energy**

$$E_{\bar{b}} = \sum_j E_{(j|b_j=\bar{b})}$$




**NOW: Run 76024 (May 2015)**
**BKG: Run 76943 (w/o collisions Jun 2015)**
**OLD: Run 30300 (Jun 2004)**

# Definitions for "bunching"

To deal with bunches and their topology it is needed to define a special class of variables:

**Cluster bunch**

$$b_j = NINT\left(\frac{t_j - R_j/c}{T_{RF}}\right)$$

**Bunch energy**

$$E_b = \sum_{j|b_j=b} E_j$$

**Bunch time**

$$T_b = \frac{\sum_{j|b_j=b} t_j E_j}{E_b}$$

**Bunch CoG**

$$\vec{X}_b = \frac{\sum_{j|b_j=b} \vec{X}_j E_j}{E_b}$$

**Bunch "angles"**

$$\vartheta_b[\varphi_b] = \frac{\sum_{j|b_j=b} \vartheta_j[\varphi_j] E_j}{E_b}$$

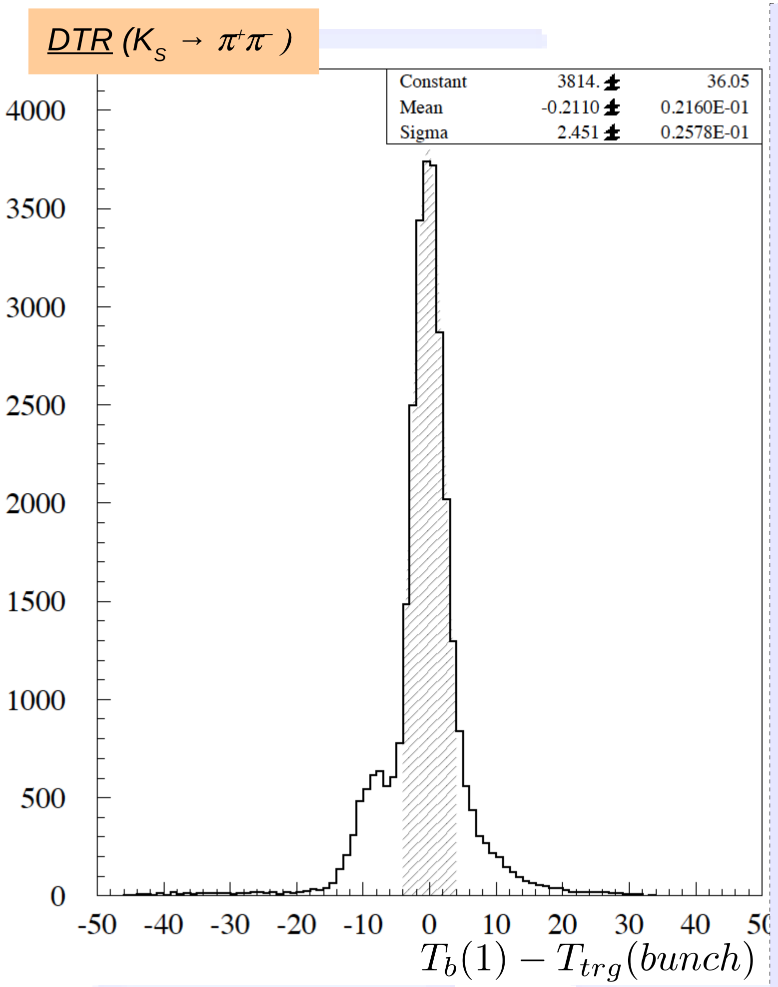
Bunches can be energy-ordered:

$$E_b(1) > E_b(2) > ...$$

and time-ordered:

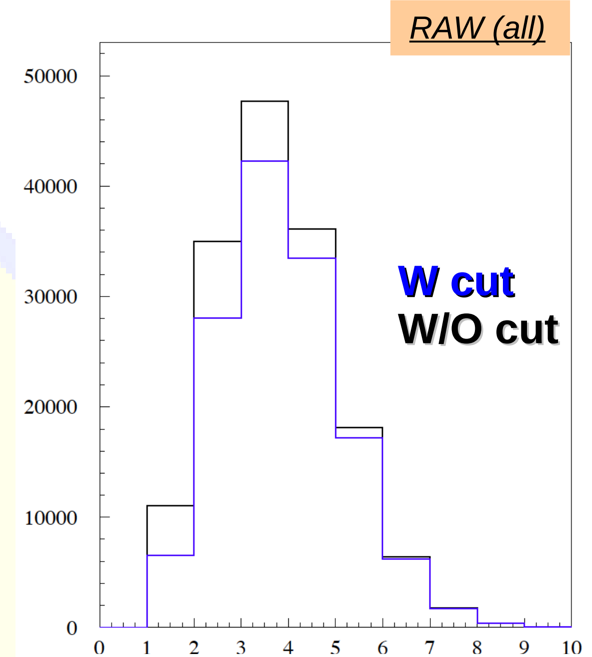
$$\tau(x_b(1) - x_b(2)) = \begin{cases} x_b(1) - x_b(2), T_b(1) < T_b(2) \\ x_b(2) - x_b(1), T_b(1) > T_b(2) \end{cases}$$

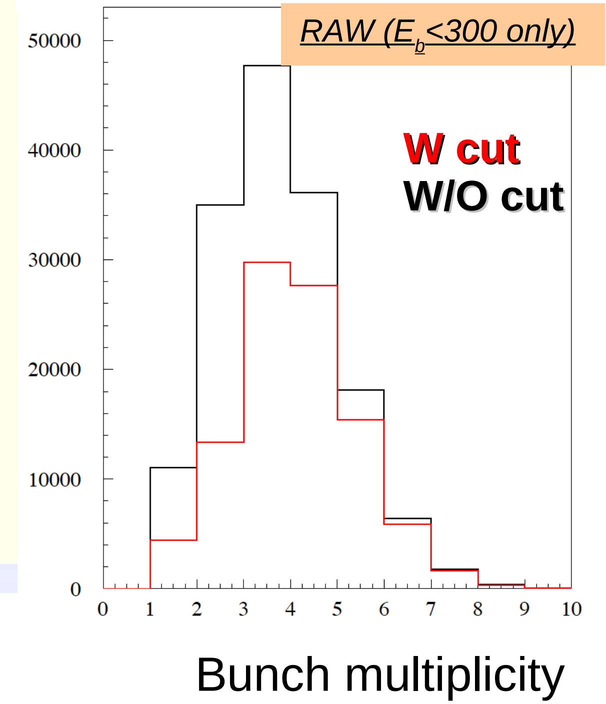
# Data reduction exploiting trigger time




Trigger: **two cluster within 2.45 bunch crossings (σ) for physics**
Wider distribution for Touschek's

Selection:
Only for events with
$E_b(1)$<300 MeV require:
at least one bunch ($E_b$>50 MeV) within 7 bunches from the trigger




For one-bunch events (prompt physics) $E_b$>100 MeV
For multi-bunch events (delayed $K_L$, $K^\pm$)
$T_b(1)-T_{trg}$ < 1.3 x $K_L$ flight-time to calorimeter

# Effect of data reduction with trigger time only

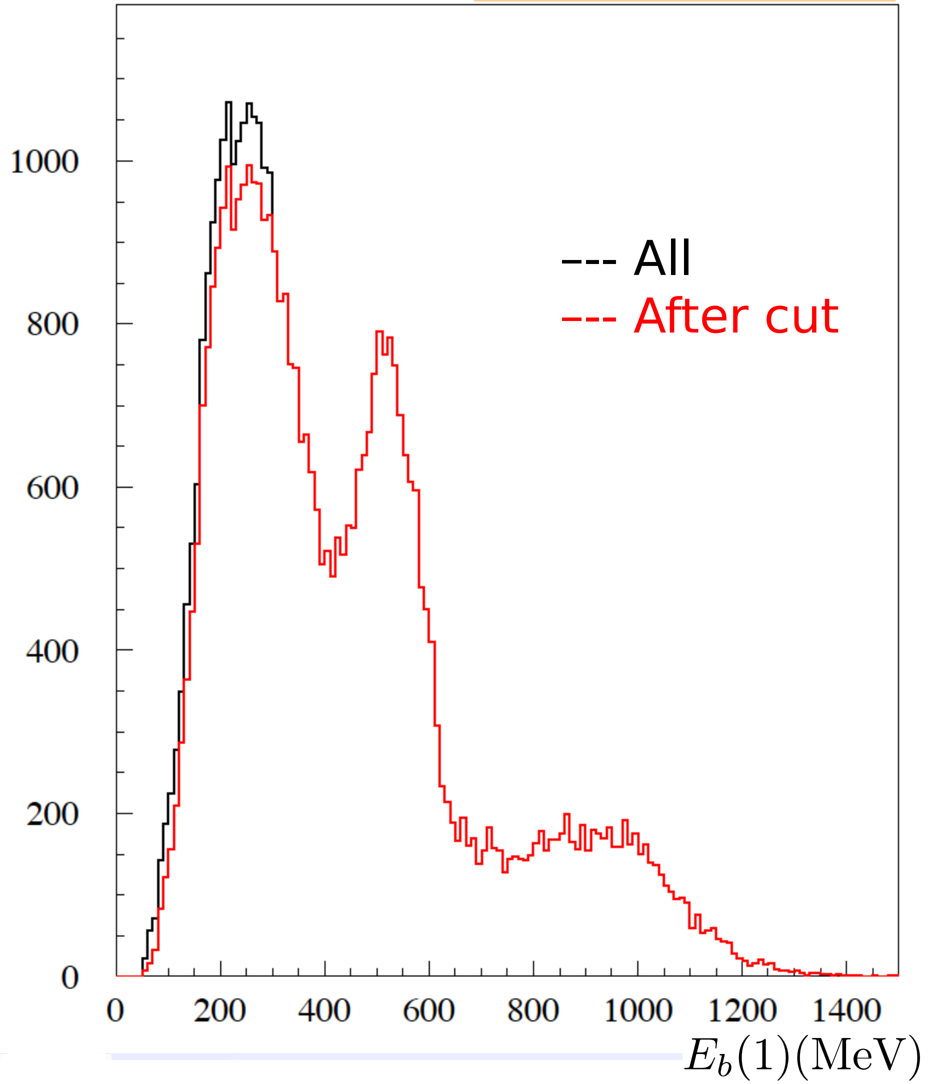
Raw data reduction factor:
37% of triggers – 3 kHz

Prompt physics channels unaffected (continuum, radiative phi decays, events with early decay of KL)

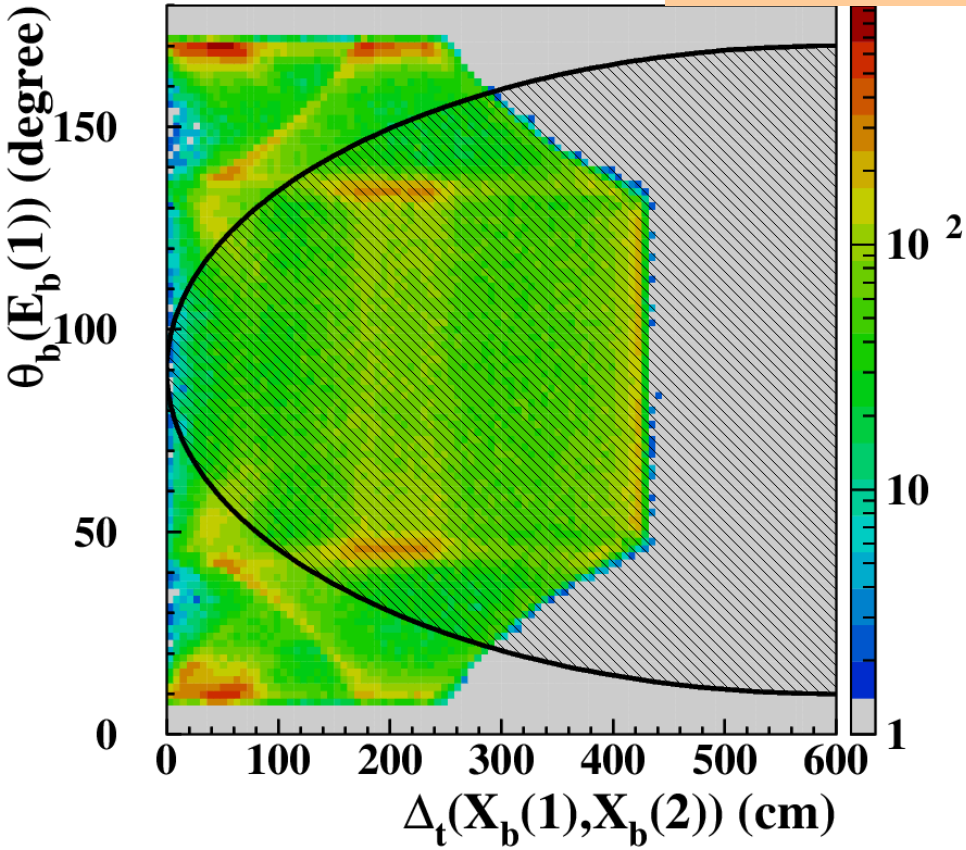
4% reduction of the neutral Kaon sample ($K_L$ interactions in the calorimeter excluded) under study

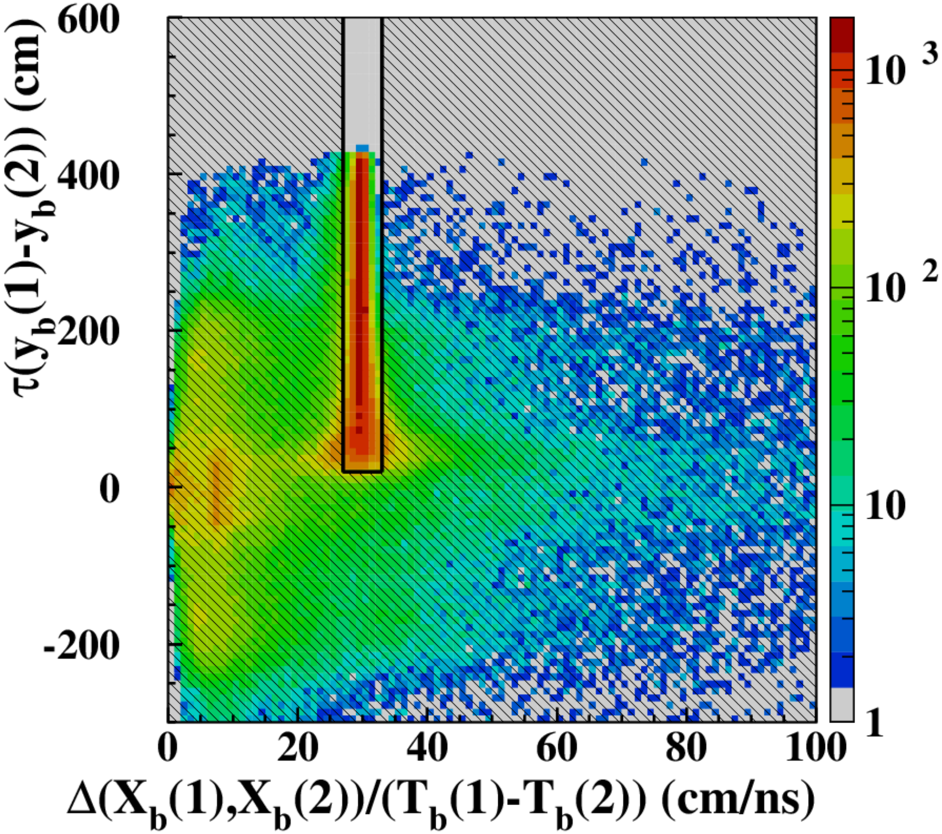
Charged kaon sample to be analyzed

KSL stream (no $K_L$ crash)



# Bunching cuts using topology (beams w/o collisions)




Machine background and cosmic ray only
Shaded region are retained

Transverse distance between two most energetic bunches CoG

$$\Delta_t(\vec{X}_b(1), \vec{X}_b(2))$$

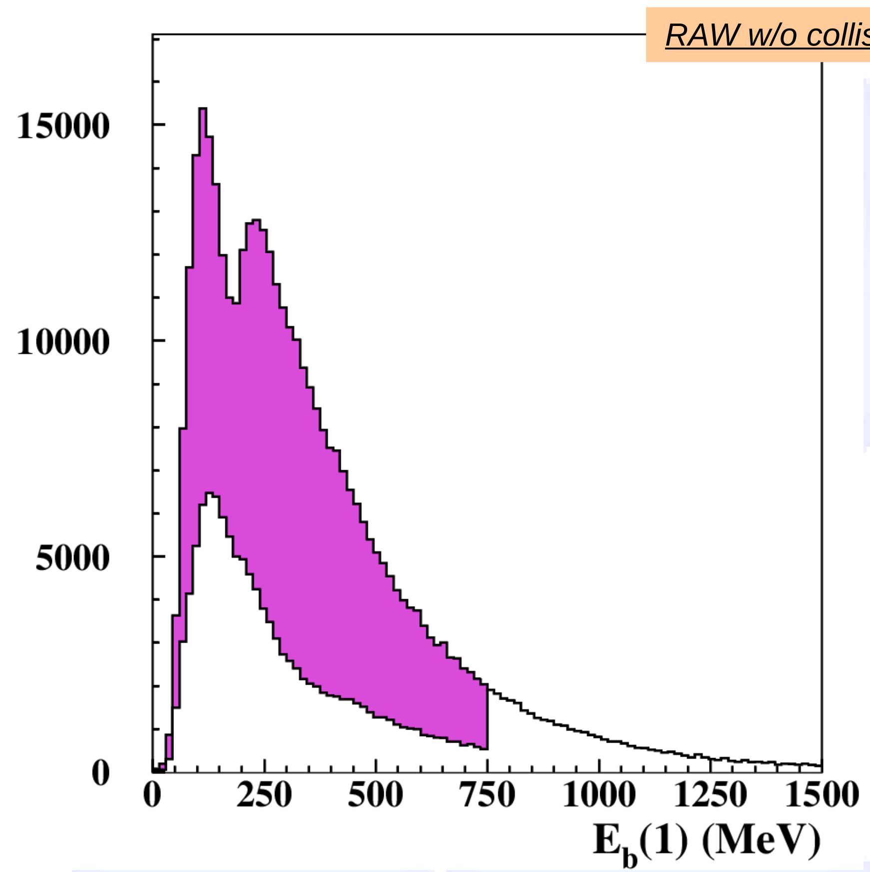
$$\Delta(\vec{X}_b(1), \vec{X}_b(2))$$

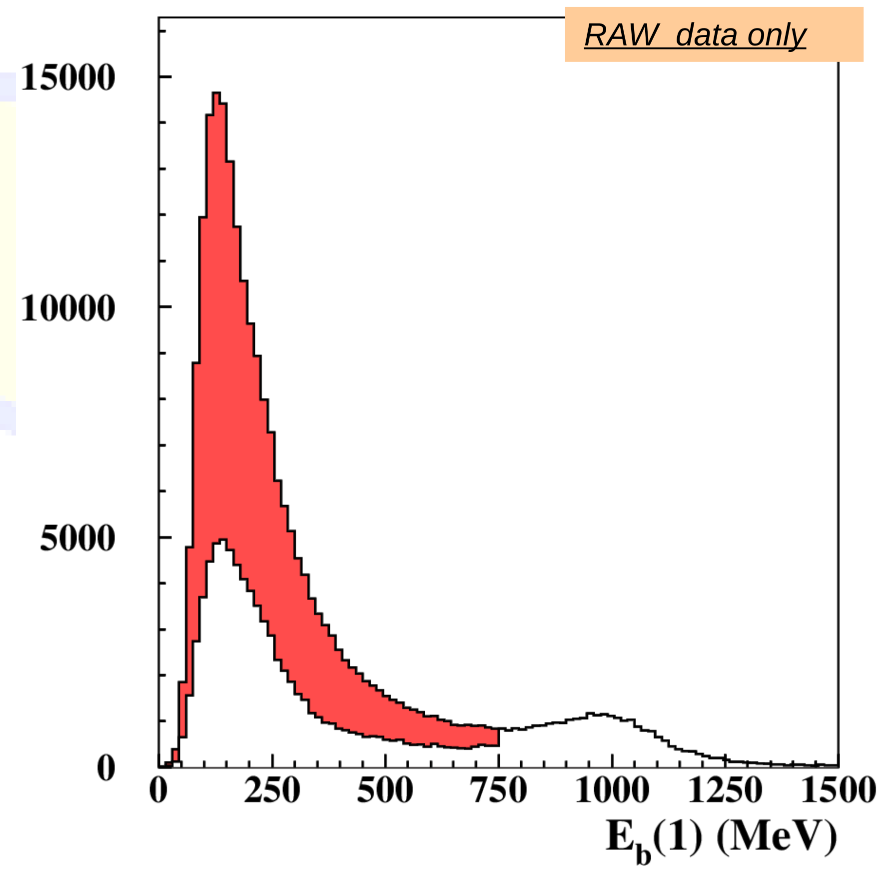
Distance between two most energetic bunches CoG

$$\tau(y_b(1) - y_b(2))$$

Time ordered distance between vertical focal point coordinate

# Bunching cuts using topology




Previous cut have been applied only to the events with $E_b(1)<750$.

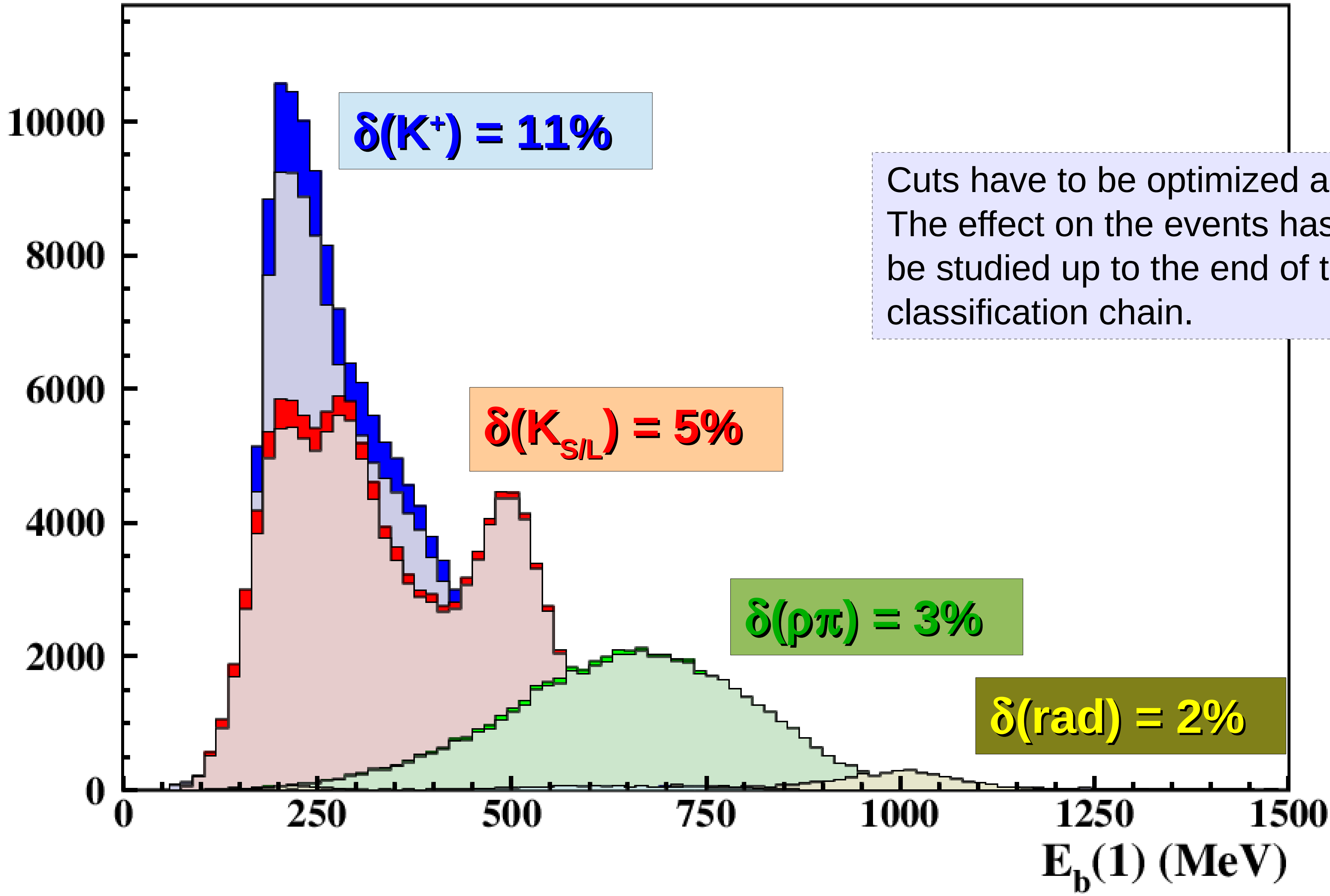
Shaded regions represents the discarded events.

RAW trigger rate reduction **61%** (on **BKG: Run 76943 (w/o collisions Jun 2015)** ) and **56%** on ( **NOW: Run 76024 (May 2015)** )

# Bunching cut on the topology effect on the MC

Only the calorimeter trigger has been used to prefilter MC events.

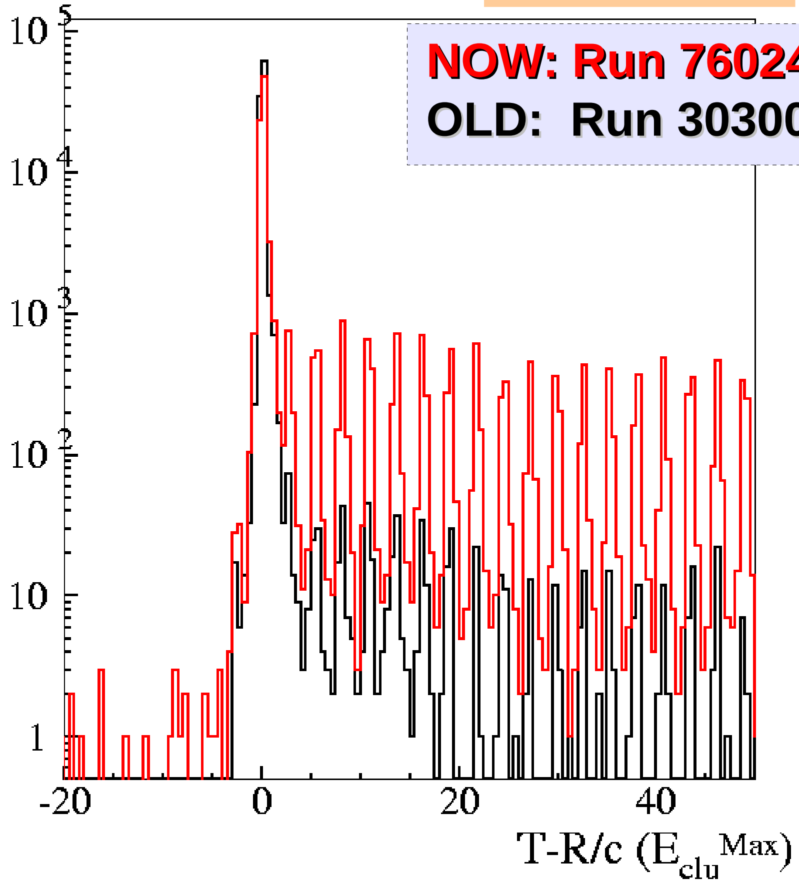
*MC "all_phys" DST*

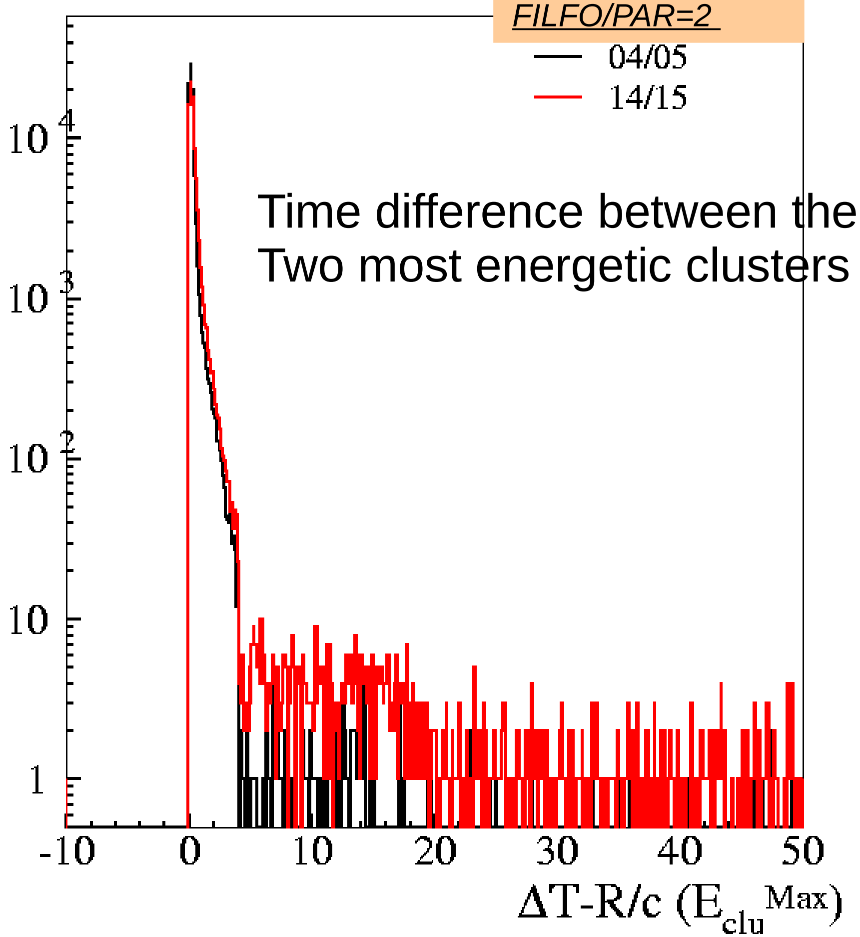



Cuts have to be optimized and The effect on the events has to be studied up to the end of the classification chain.

# *Bunching on data*

# T0 global & "bunching"



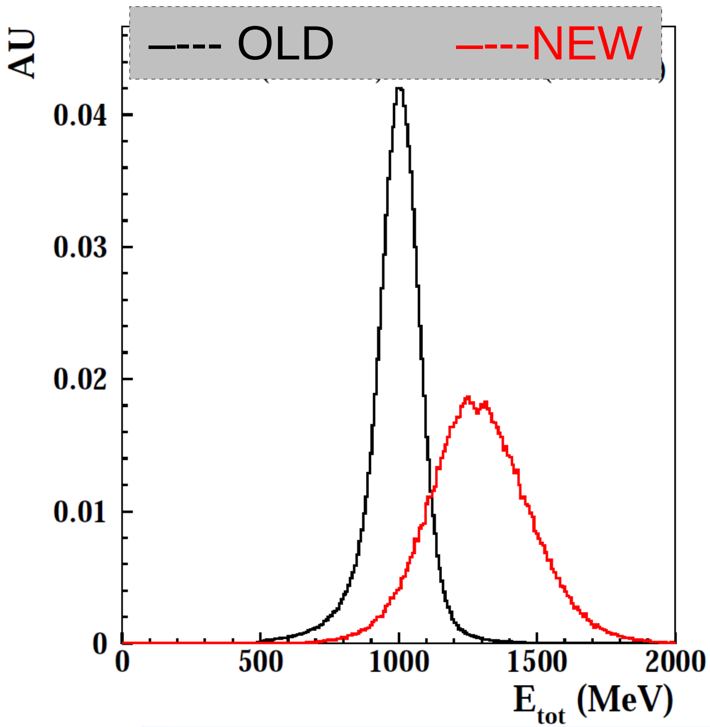



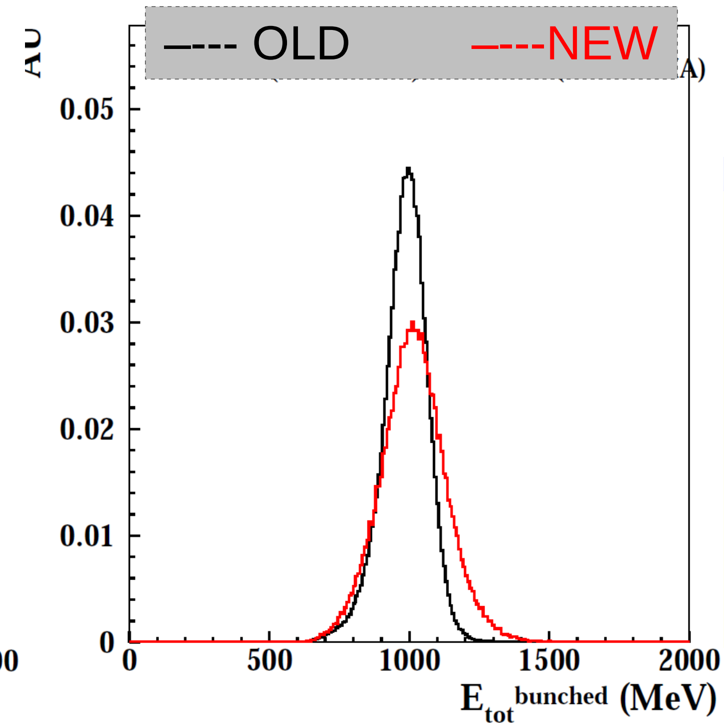

Bhabha scattering and $\gamma\gamma$ stream

The two most energetic clusters have the same time, while the $T_0$ Global is often (30%) associated to the wrong cluster because background has greater energy on average.

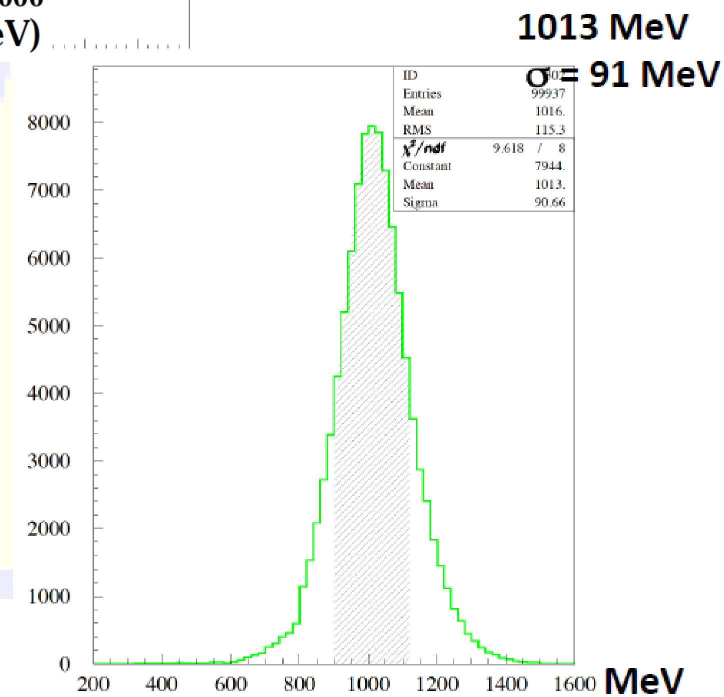
Selecting the proper bunch crossing will allow to get rid of this problem.

# Bunching with Bhabha scattering




Bunching, as implemented right now, allows to consider only a portion of the event (the interesting bunch[es]) shrinking the EMC clusters. Comparison look very different when bunching is applied.

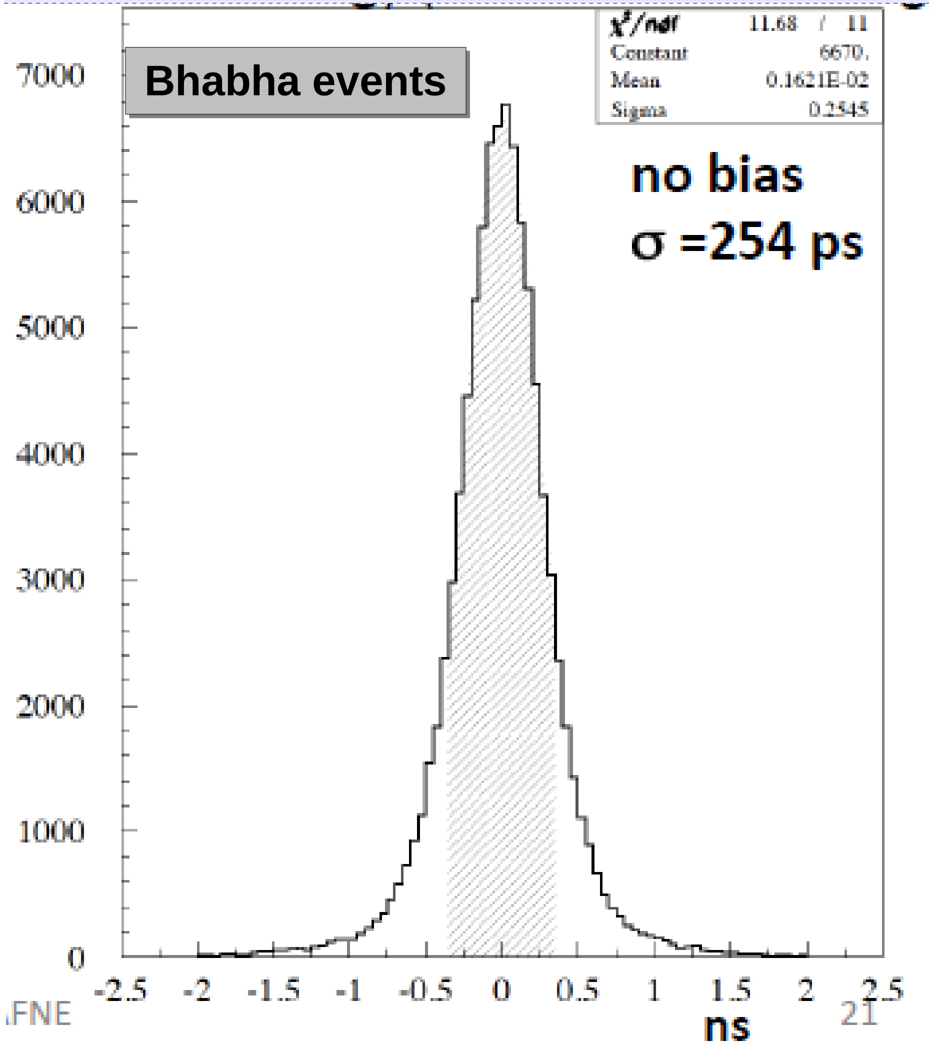


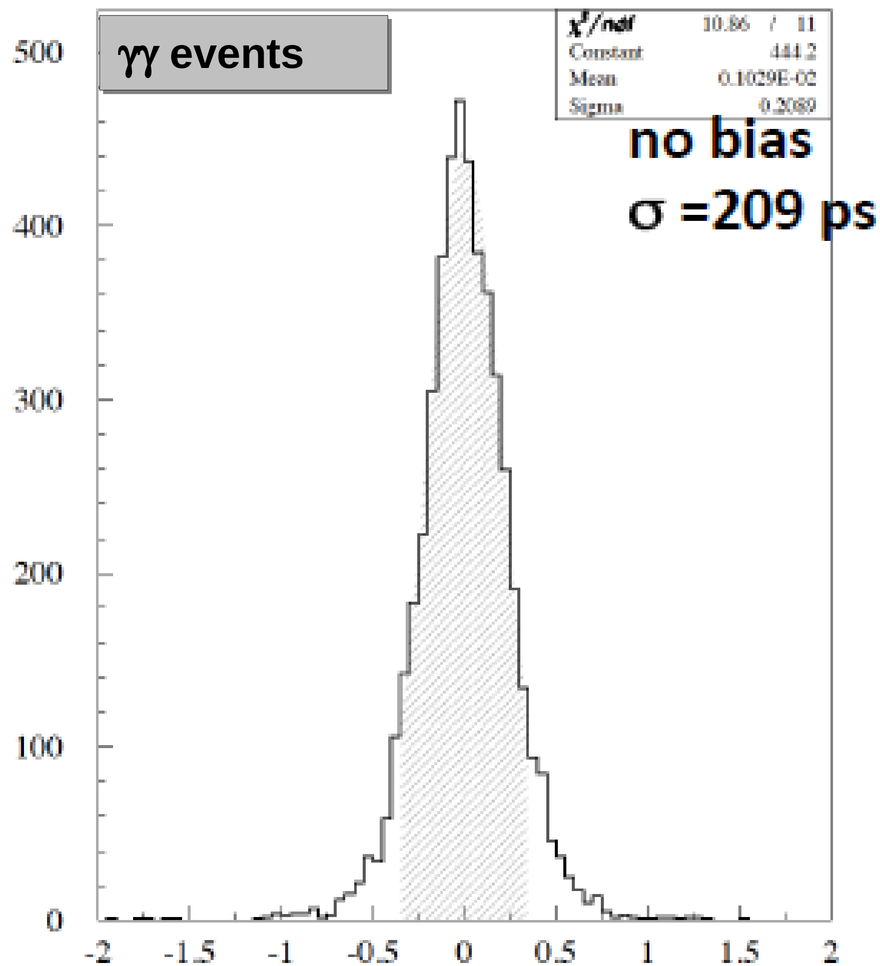

Differences in calorimeter related distributions (total energy, cluster multiplicity, etc.) appear if the whole event is considered.
When only the “interesting” bunch is considered the comparison between new and old data is strongly improved.

The calorimeter performances, when judged on the right “time scale”, are fully restored.

# Bunching: time resolutions

Difference of time between the two cluster with higher energy in the same bunch for Bhabha scattering and γγ events using only EMC reconstruction.




Selecting the clusters for two body events in the right bunch only the time resolution of the calorimeter is the one expected.

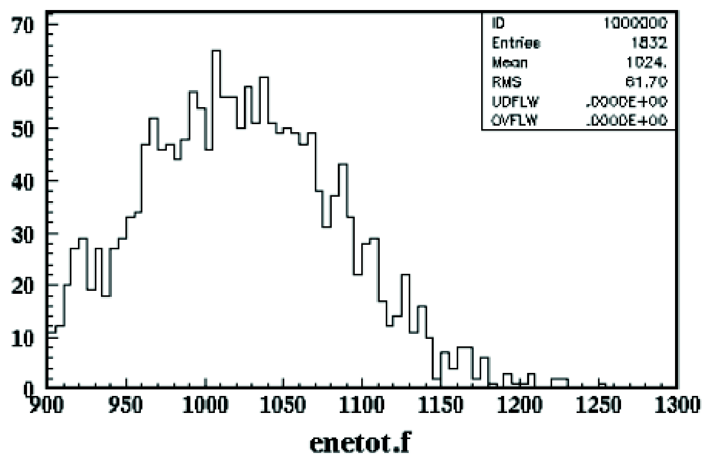
# Radiative decay: $\phi \rightarrow \eta\gamma \rightarrow 5\gamma$

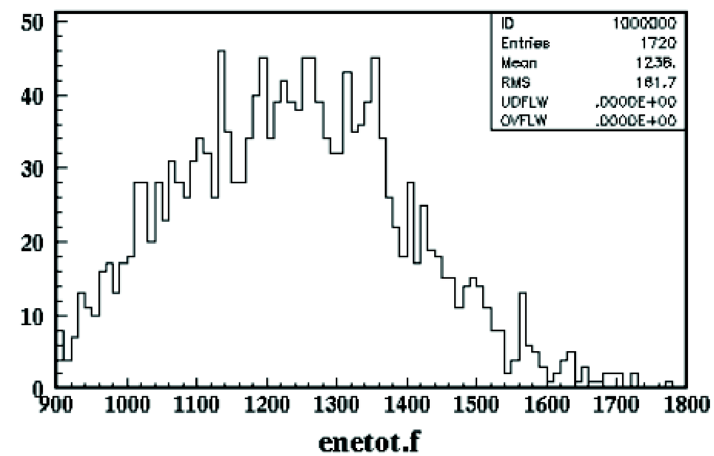
Special $T_0$ correction applied also on old data.

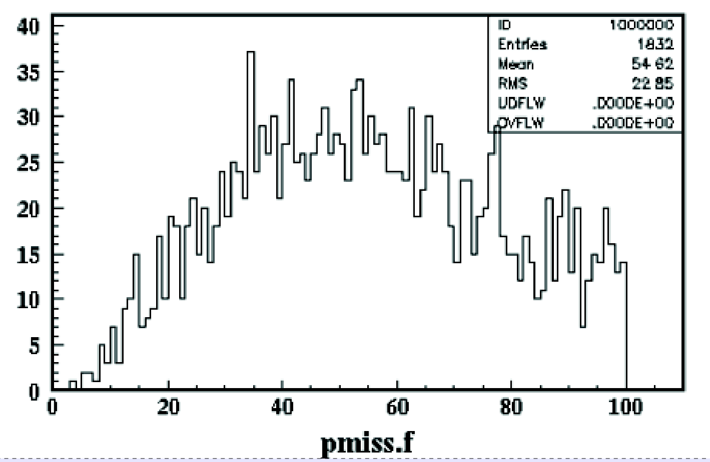
Cuts on "global" variables spoils the classification (tot energy, tot missing momentum)

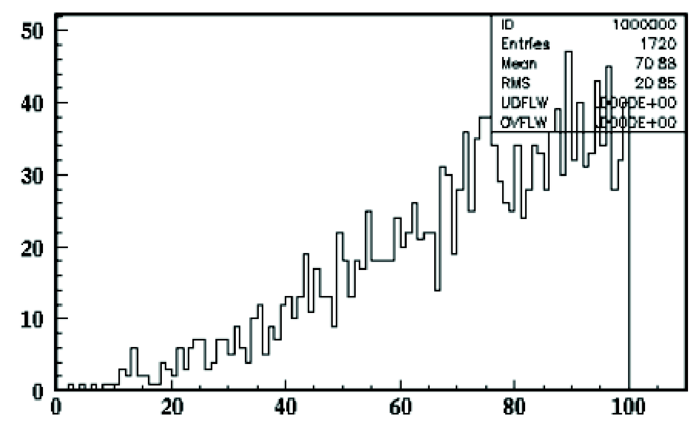
**Run 30300: 1832 / 202 $nb^{-1}$ = 9.07 nb (2004)**

**Run 76024: 1720 / 509 $nb^{-1}$ = 3.37 nb (2015)**




Revising event classification by moving the cuts from the "global" variables to the "bunched" variables ⇒ **5409 events / 509 nb-1 = 10.6 nb**

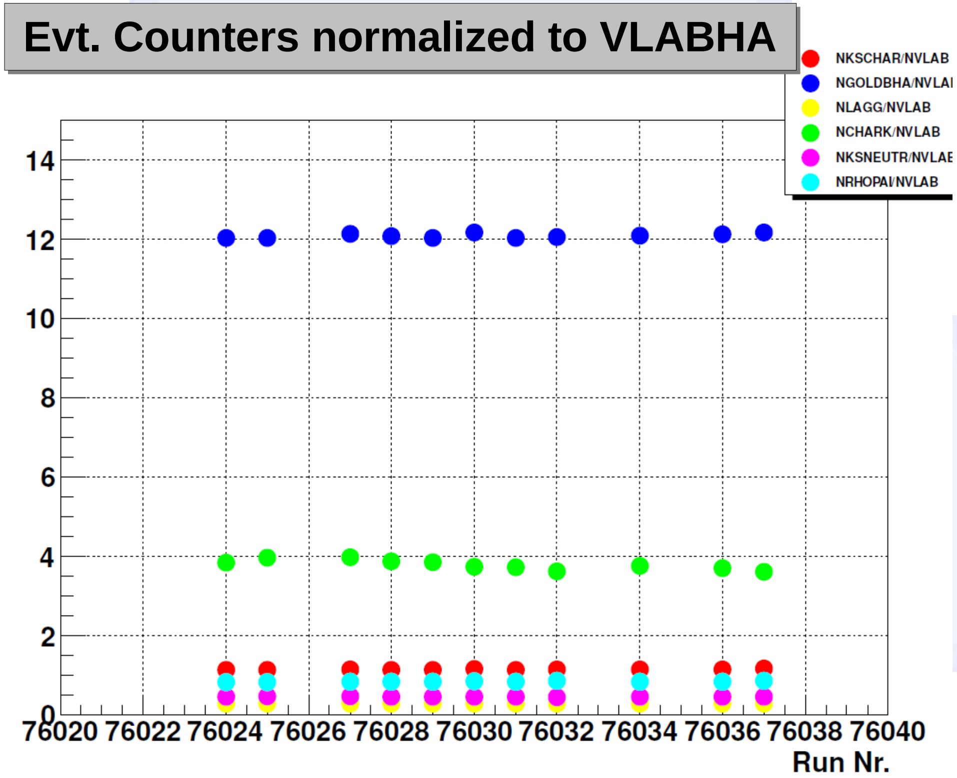
# *Event classification*
# *&*
# *Luminosity*

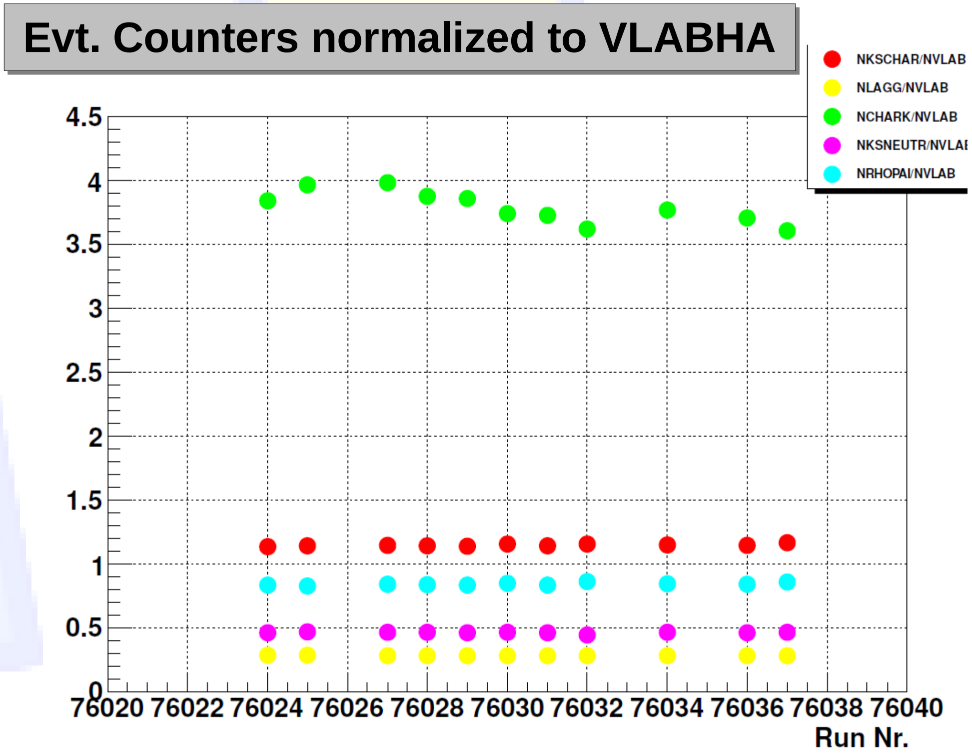
# Streaming capabilities

Event classification allows for offline checks on the data quality and stability along the time. The number of events are usually normalized to the VLABHA counter (High quality Bhabha scattering events reconstructed with EMC and DC).

**The relative cross sections, when detector is properly calibrated, are stable.**

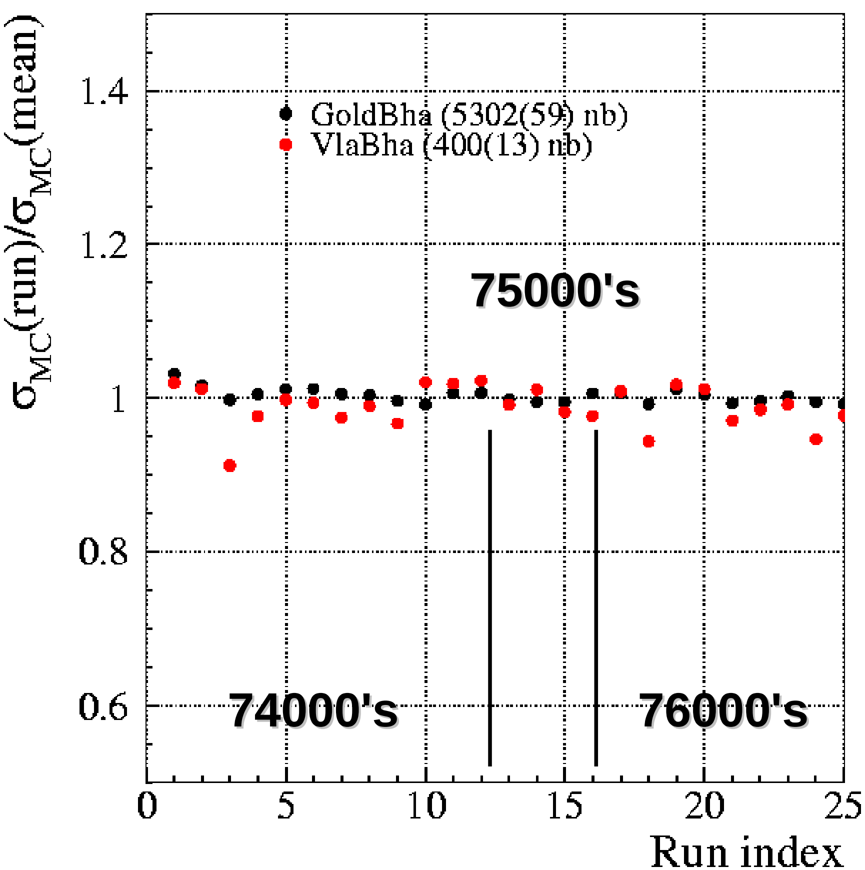
Effective acceptance, now changed because of $\phi$ momentum change, role of the background and impact of the material for the different categories are under evaluation both using data and MC, as well as the role of the normalization sample.

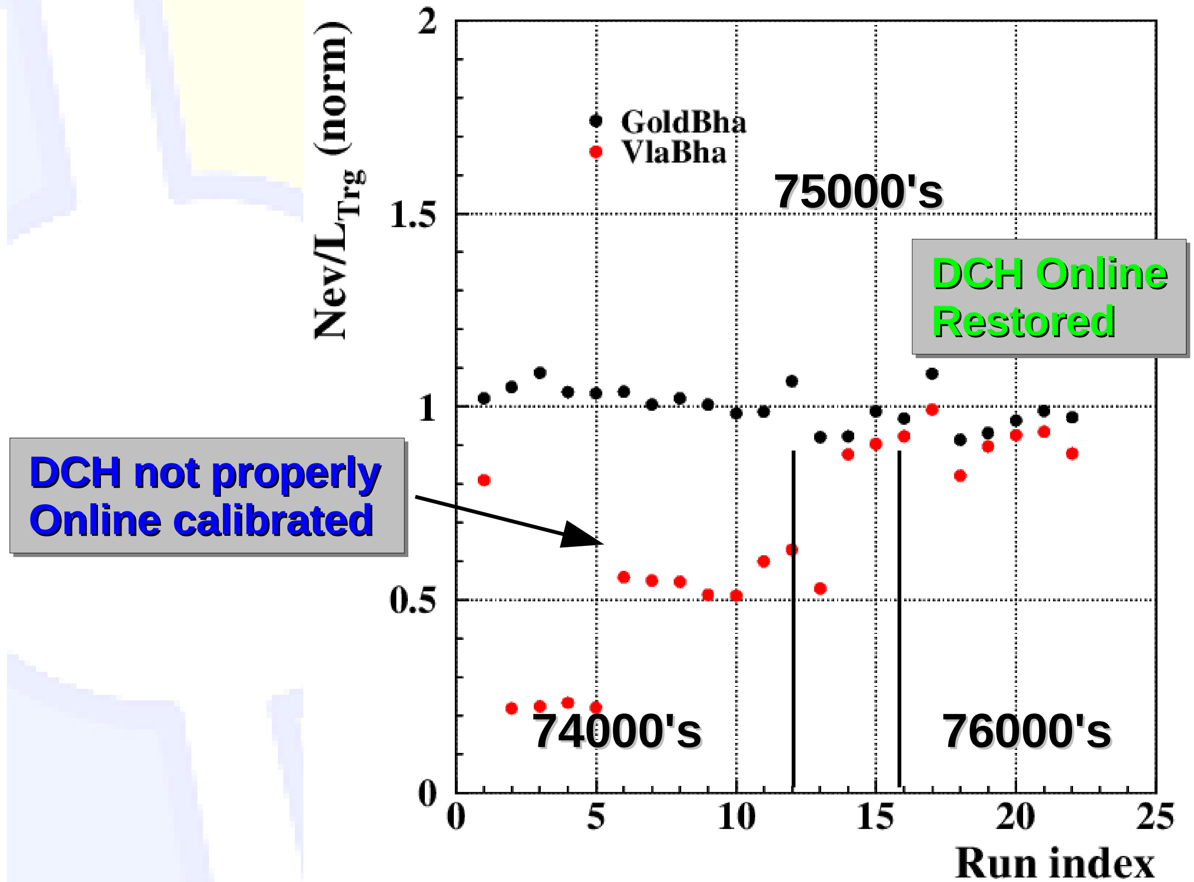


# Luminosity measurement

Luminosity measurement is performed online at the trigger level using the multiplicity of Bhabha thresholds in the barrel. The offline measurement is the ratio between the events measured in a given category and the corresponding visible cross section.




$$\sigma(VLABHA)_{05} = 430nb$$
$$\sigma(GOLDBHA)_{05} = 5.7\mu b$$
$$\sigma(VLABHA)_{15} = 400nb$$
$$\sigma(GOLDBHA)_{15} = 5.4\mu b$$

The absolute normalization scale for Offline & Online measurement seems differs of ~10%. A complete revision of both procedures is underway in order to deeply understand all the factors and make the right correction.

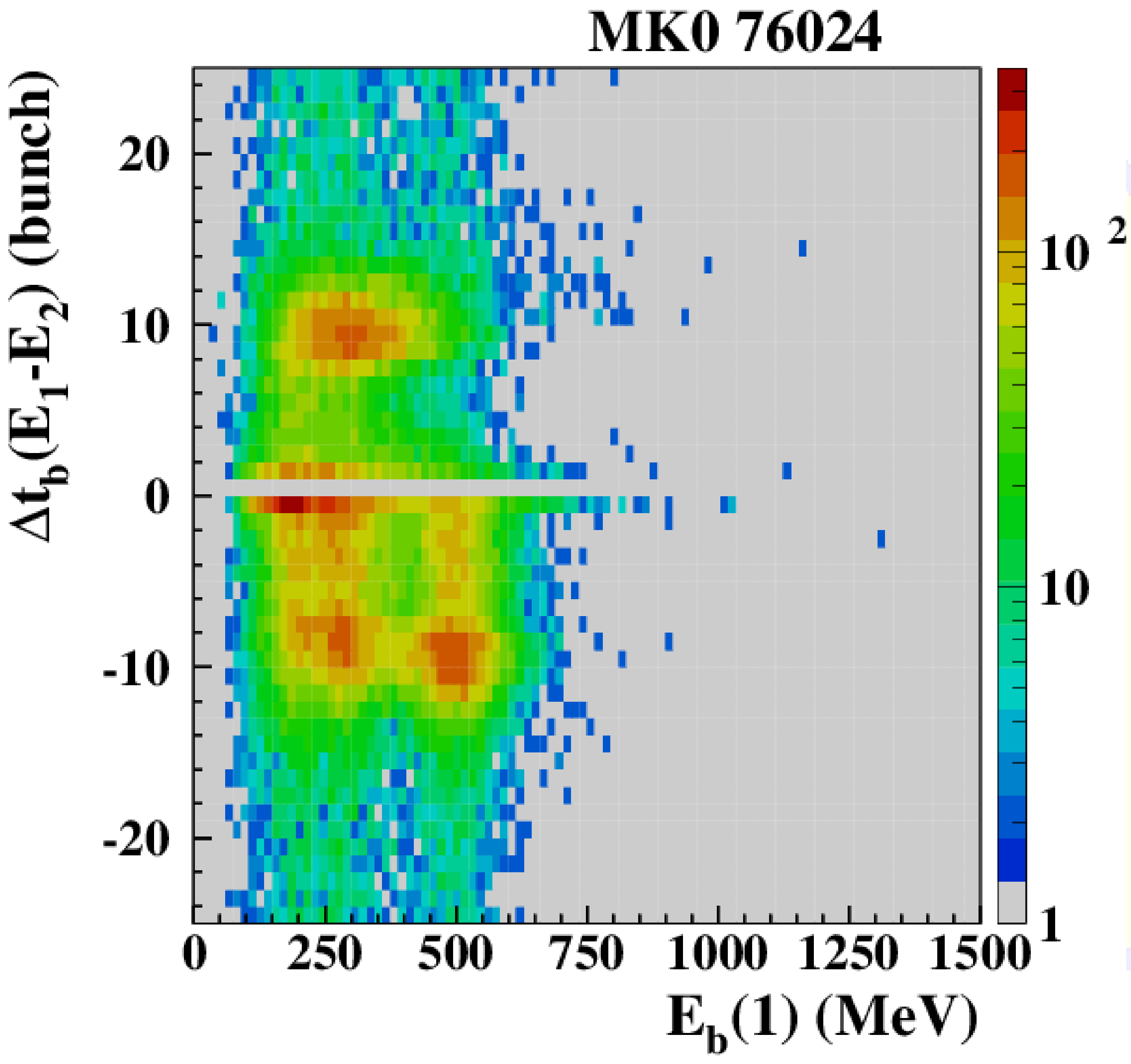
# Conclusions

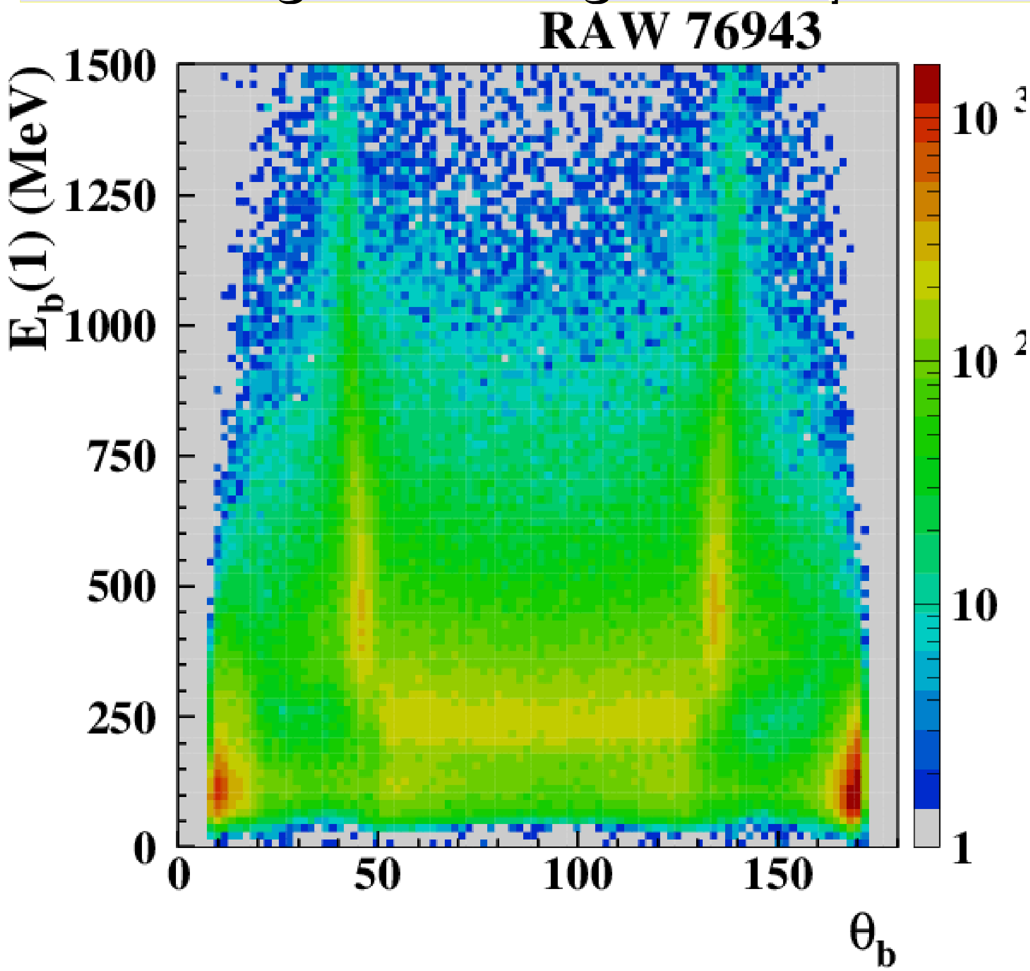
# Conclusions

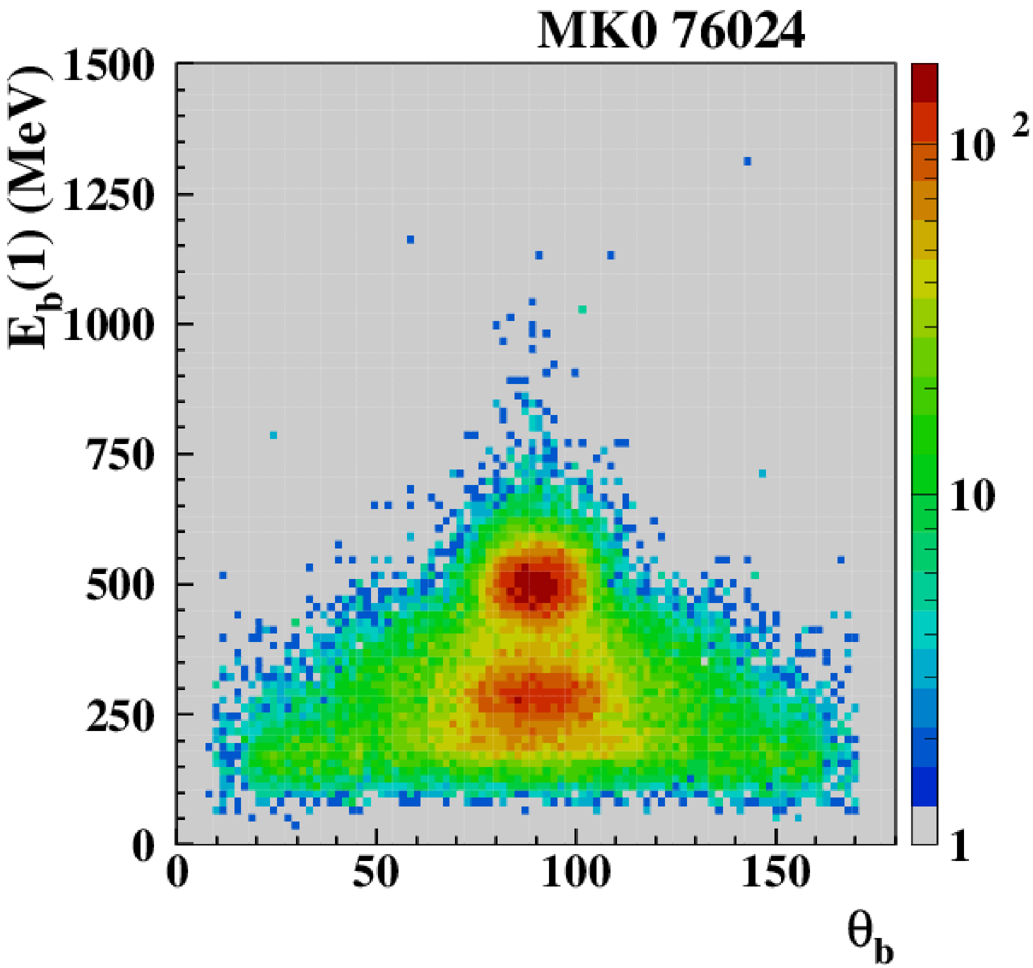
- The deeper exploitation of the EMC performance allowed to achieve a consistent data reduction (>60%), further study are needed to improves more.
- Large campaign of reconstruction software revision is underway to profit of this new approach.
- Parameters and procedures connected to the luminosity measurement, Offline and Online, need to be revised considering the changed experimental conditions (new materials, different acceptance, background impact).
- Good quality can be restored to the level of old KLOE dataset and data volume can be significantly reduced using new data reconstruction technology.

# SPARES

# Bunching data: neutral kaon time structure



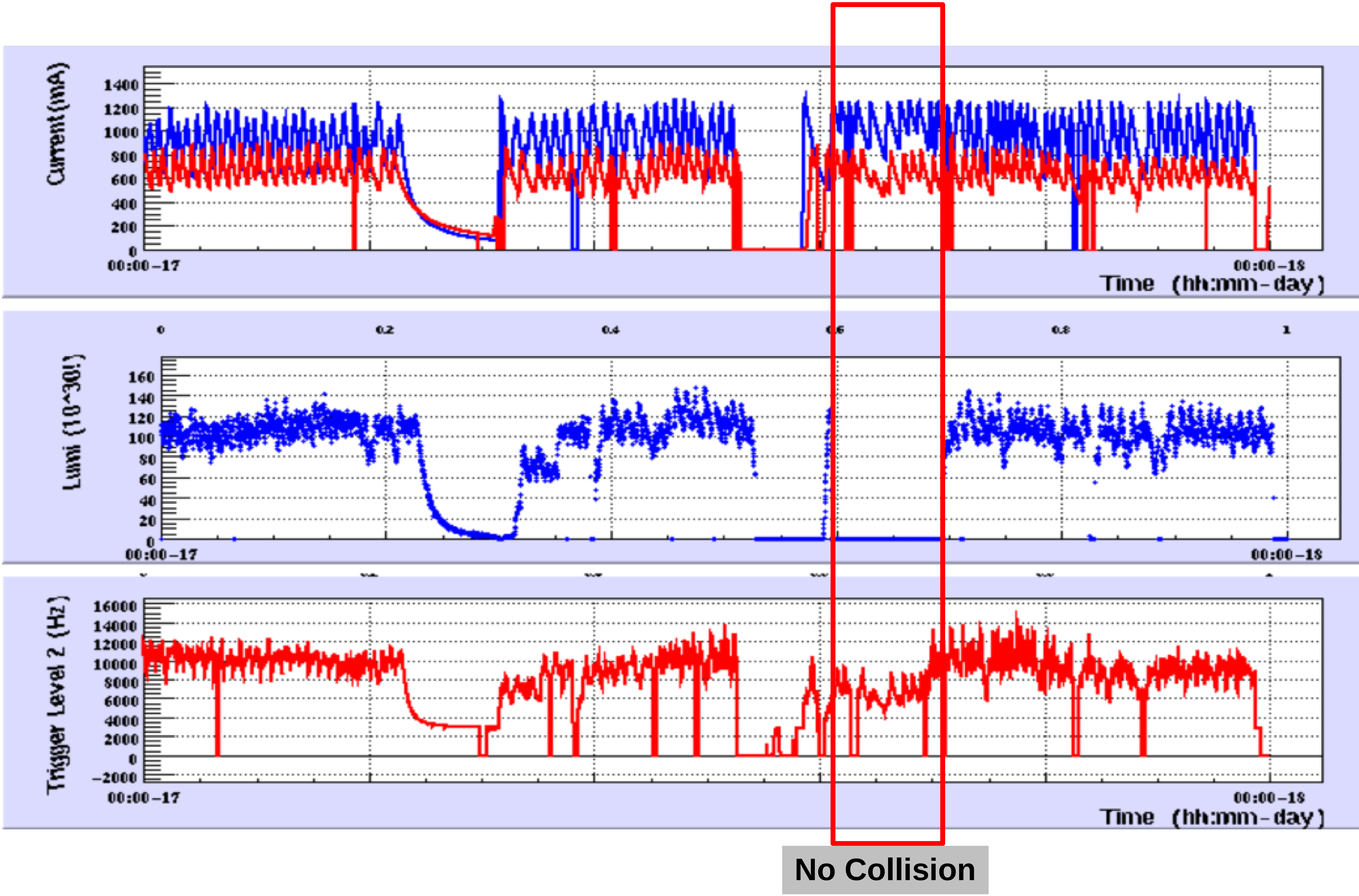



**Bunch "angles"**

$$\vartheta_b[\varphi_b] = \frac{\sum_{j|b_j=b} \vartheta_j[\varphi_j] E_j}{E_b}$$

# General conditions: trigger rates



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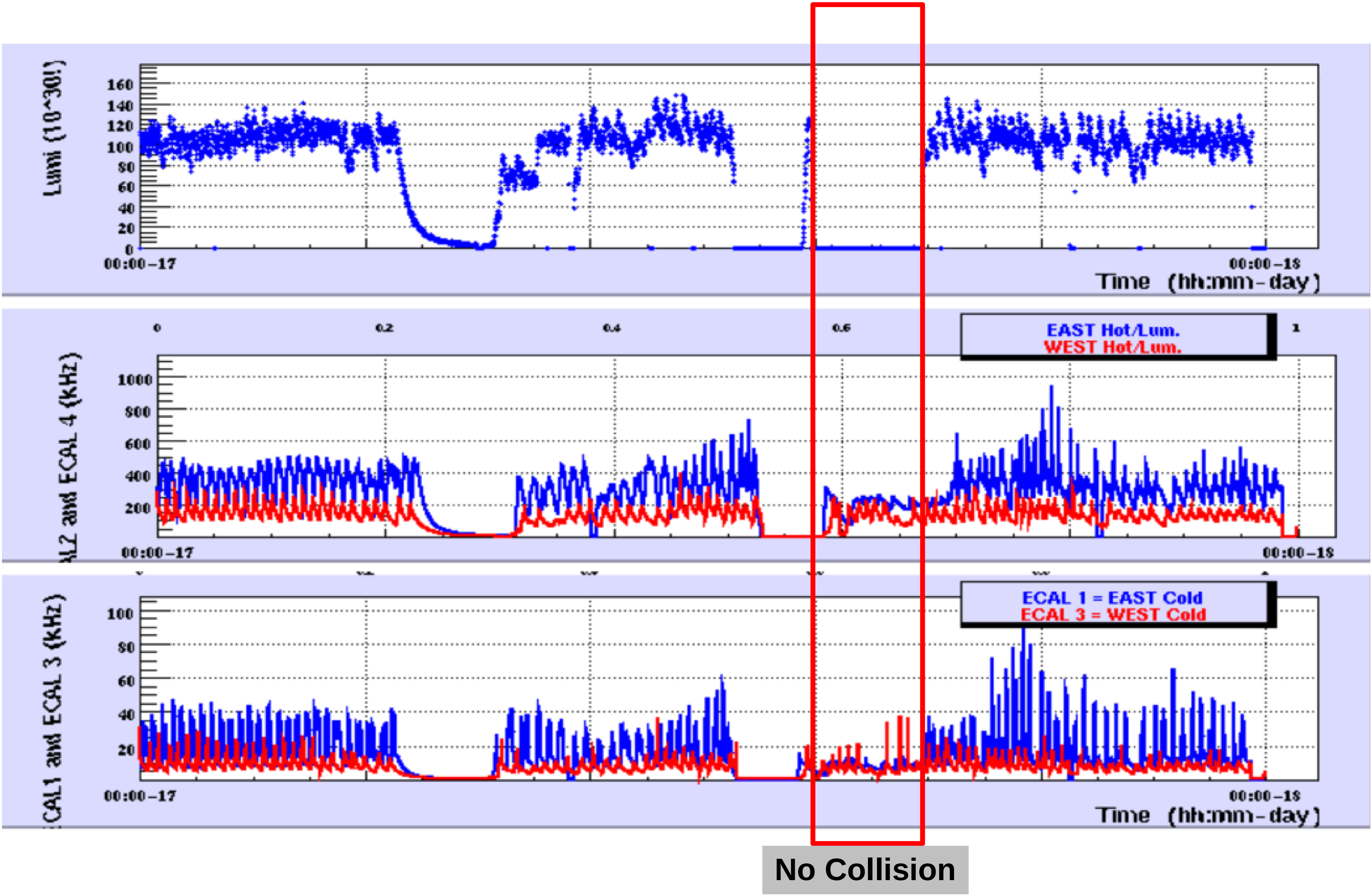

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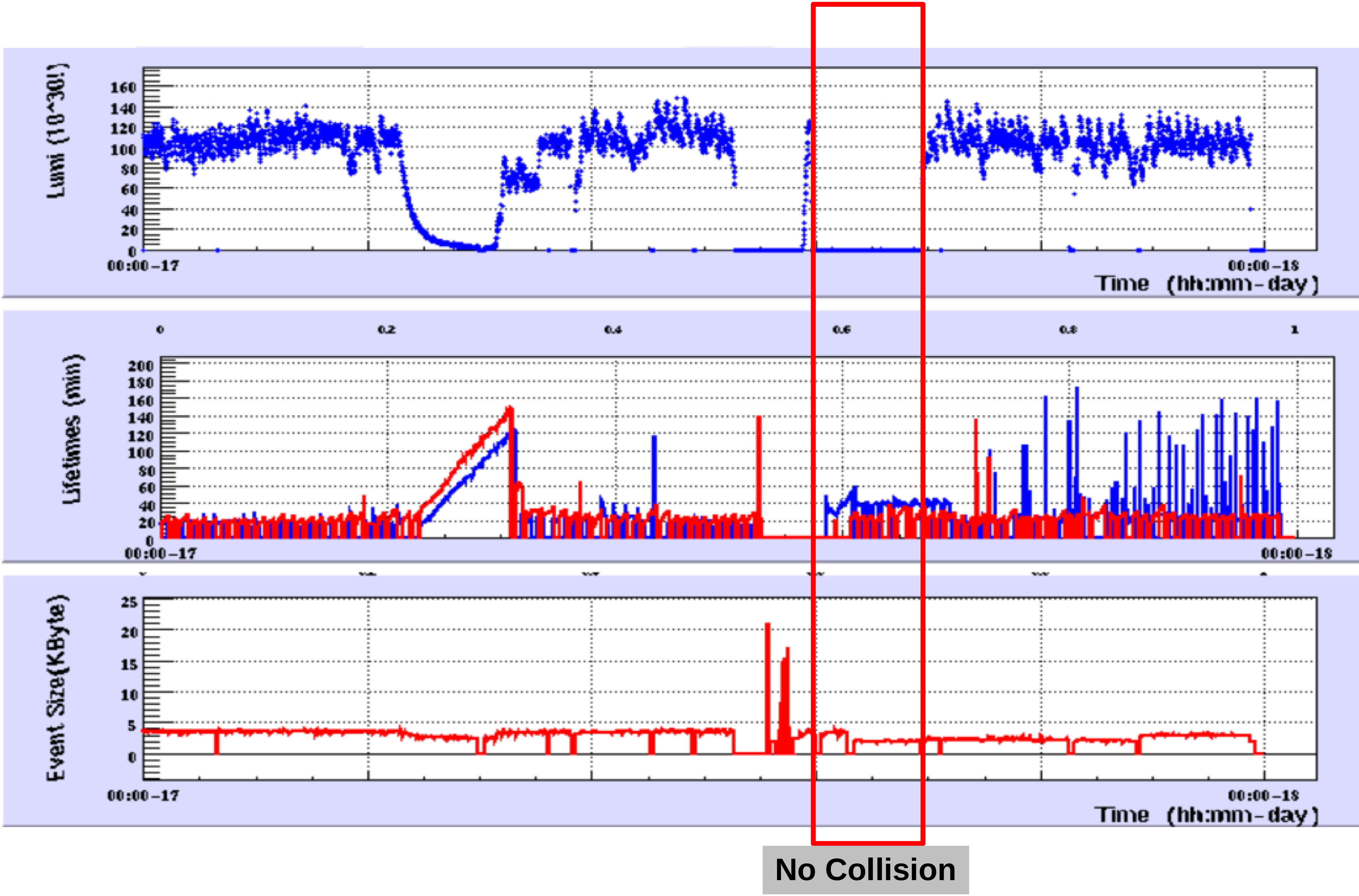
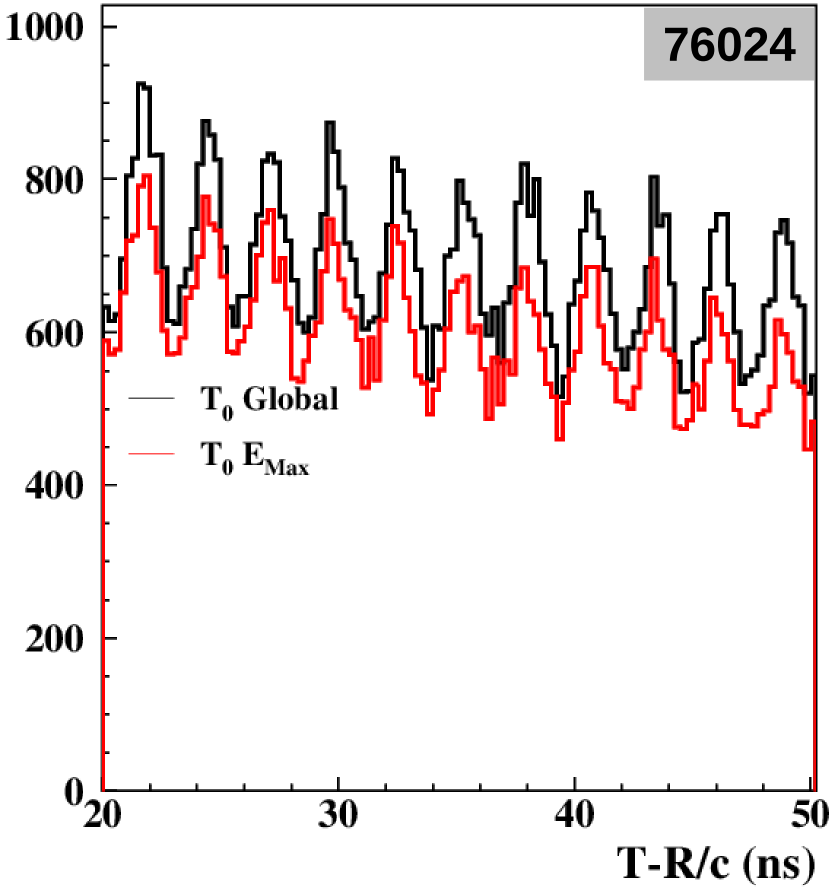


# LSB time structure in the new data




Selecting the most energetic cluster in the event as the source of $T_0$, the time structure is lowered but still remains.

As a comparison in run 76943/76944 without collisions no structure can be observed before and after the $T_0$ correction.