E08-025 Deuterium results

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To get Deuterium results … (my work so far)

Calorimeter calibration :

→ results using the $\pi°$ method
→ comparison with Malek's results

Run quality :

→ HRS and Calorimeter problems during the data taking
(= discarding some runs)

Deuterium analysis :

→ Contamination subtraction
→ Including the fermi motion for the LH2 target's proton
→ LD2 – LH2 targets subtraction
→ Comparison with Malek's results (in applying the same cuts)

Calorimeter calibration using the π° method

Elastic calibration (ep → e'p') :

→ 3 Elastics calibrations (October 26th, November 17th, December 14th)
→The **polarity of HRS is reversed** to detect the proton, the Elastic calibration **<u>is not possible</u>** during the data taking (= dedicated runs)

π° calibration (ep → e'p'π° → e'p'γγ) :

→ π° Calibration **<u>is possible</u>** during the data taking (= same experimental setup as the DVCS runs)
→ π° Calibration allows to calibrate the calorimeter **for each day of the experiment** (= Monitoring)

Minimization of χ^2 :

Calibration coefficients

$$\chi^2 = \sum_{j=1}^{N} \left(E_j - \sum_{i} (C_i \cdot A_j^i) \right)^2$$

Theoretical energy   Signal amplitude

Theoretical energy calculation from :

→ **Electron energy**
→ **π° position**
→ **Assuming exclusive event (Mx2 cut)**

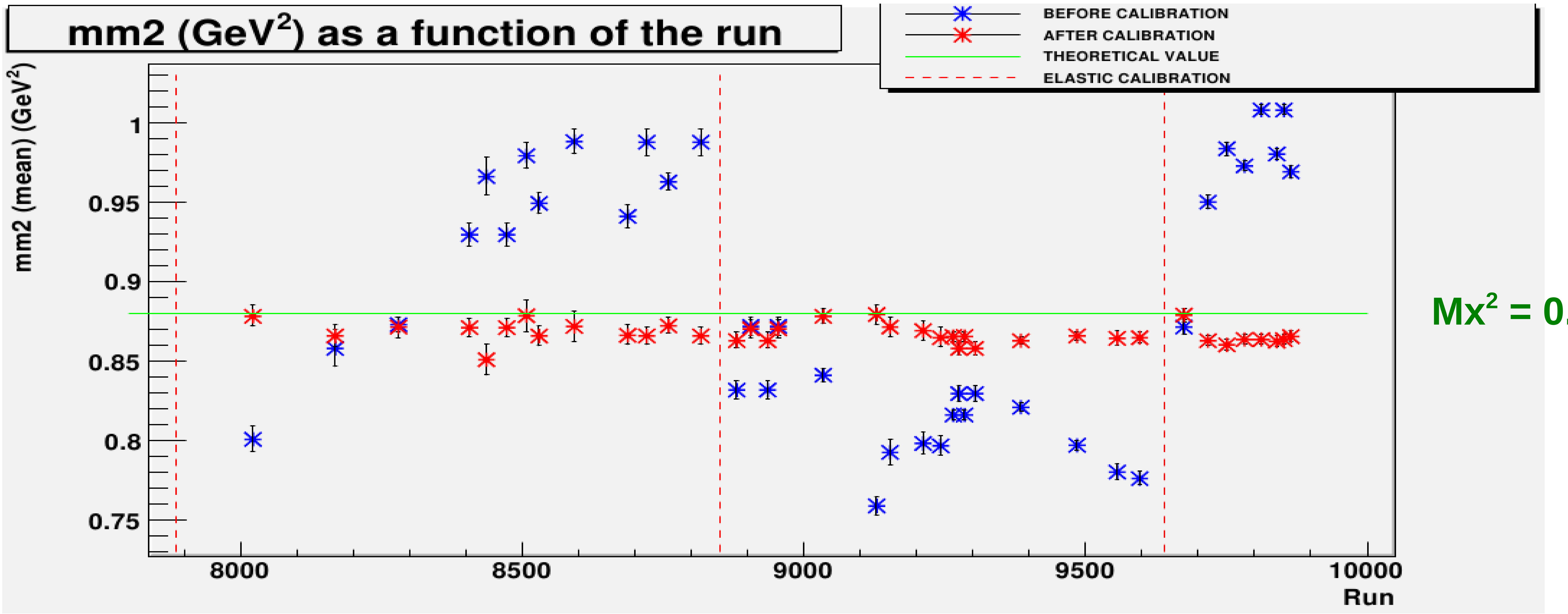
We perform several iterations of calibration to stabilize the results

Calorimeter calibration using the π° method

If the calibration works, we expect to see an improvement on :

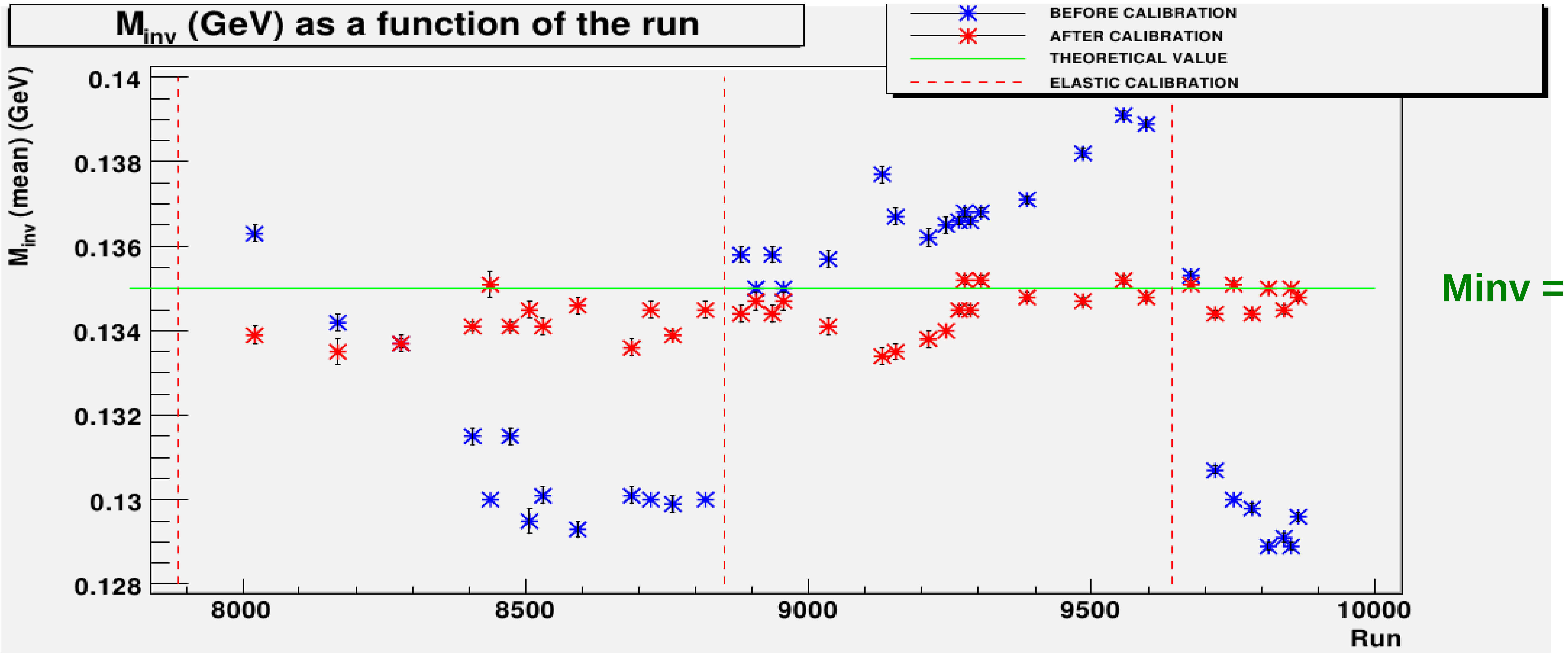
→ **Mx2** (closer to the theoretical value : Mp^2 = 0.88 GeV^2)

→ **Minv** (closer to the theoretical value : Mπ° = 0.135 MeV)



Mx2

Mx^2 = 0.88 GeV^2



Minv = 0.135 MeV

Blue dots :
Before calibration

Red dots :
After calibration

Red dotted lines :
Elastic calibrations

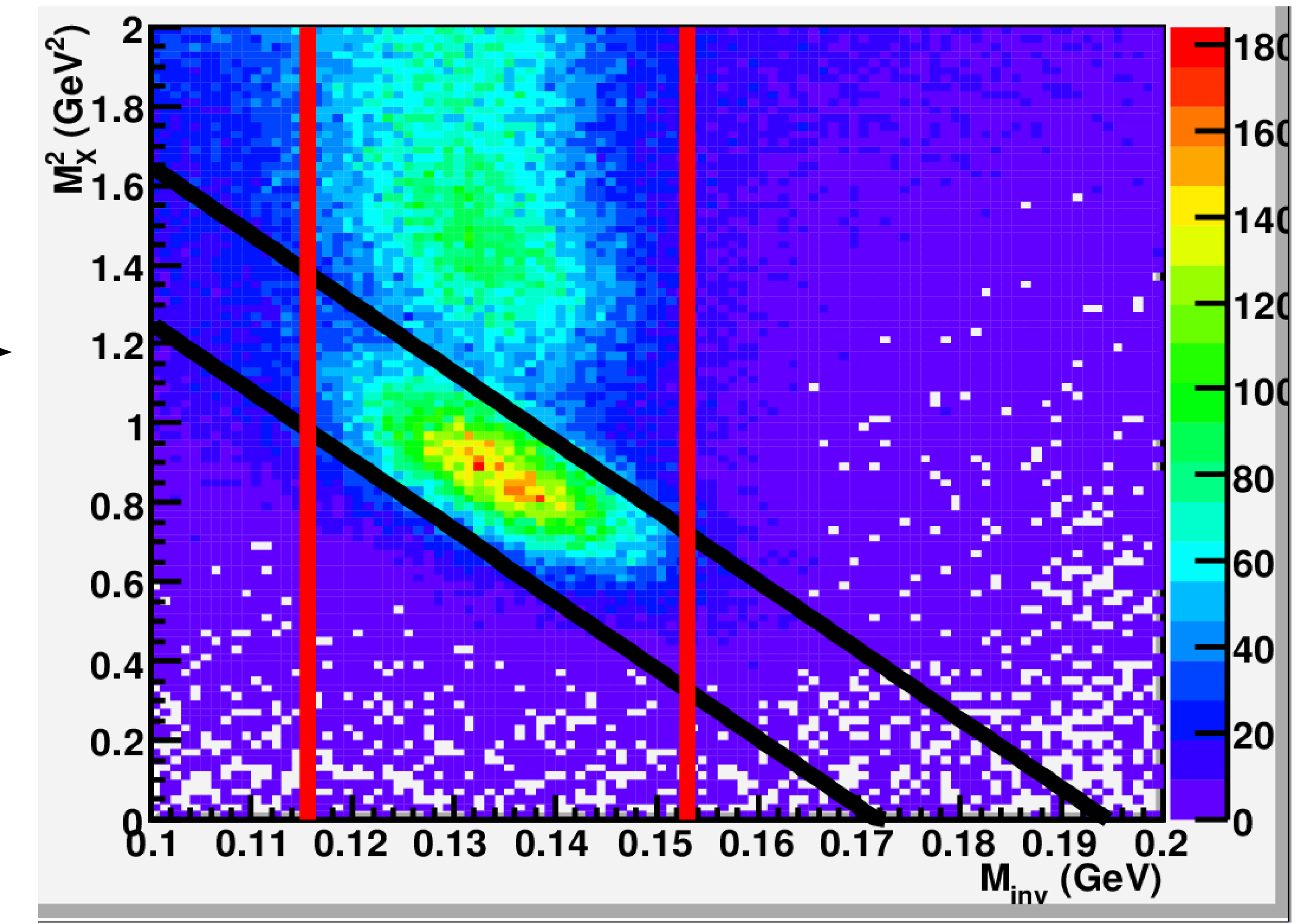
Minv

Calorimeter calibration (Comparison with Malek's results)

Difference in the cut applied for the comparison :

→ **My cut :**

A fixed 2-Dimensions cut in Mx2 vs Minv :
*0.5 < Mx2 + 17.5 * Minv - 2.31 < 1.2*

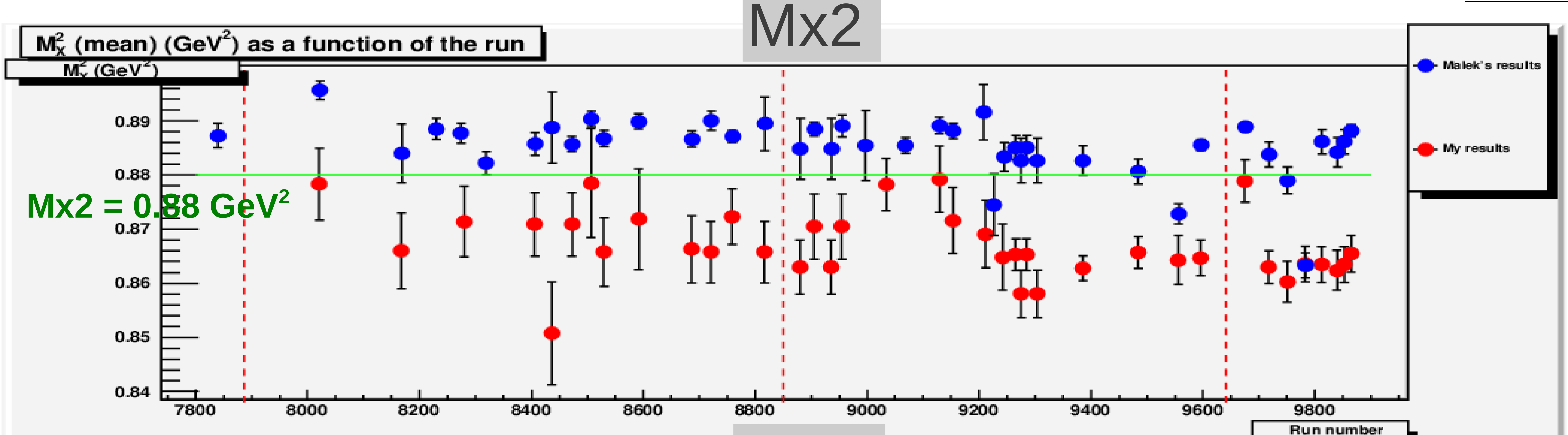


→ **Malek's cut :**

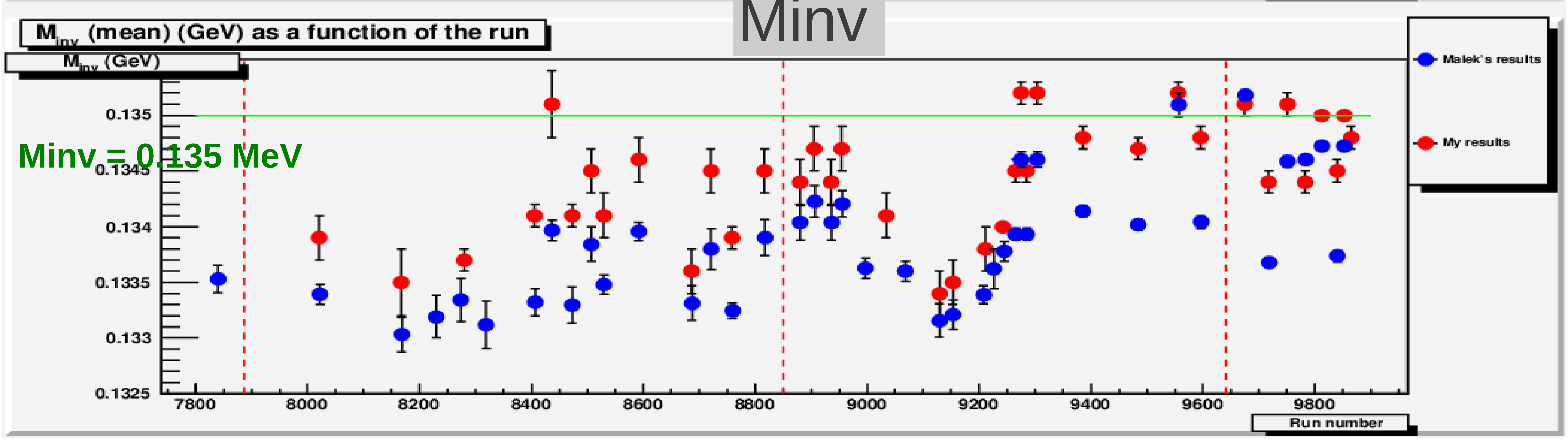
A variable 2-Dimensions cut in Mx2 vs Minv as a function of σ_{Mx2} and σ_{Minv} at each iteration

Difference on the groups of runs used for the calibration

Mx2



Minv



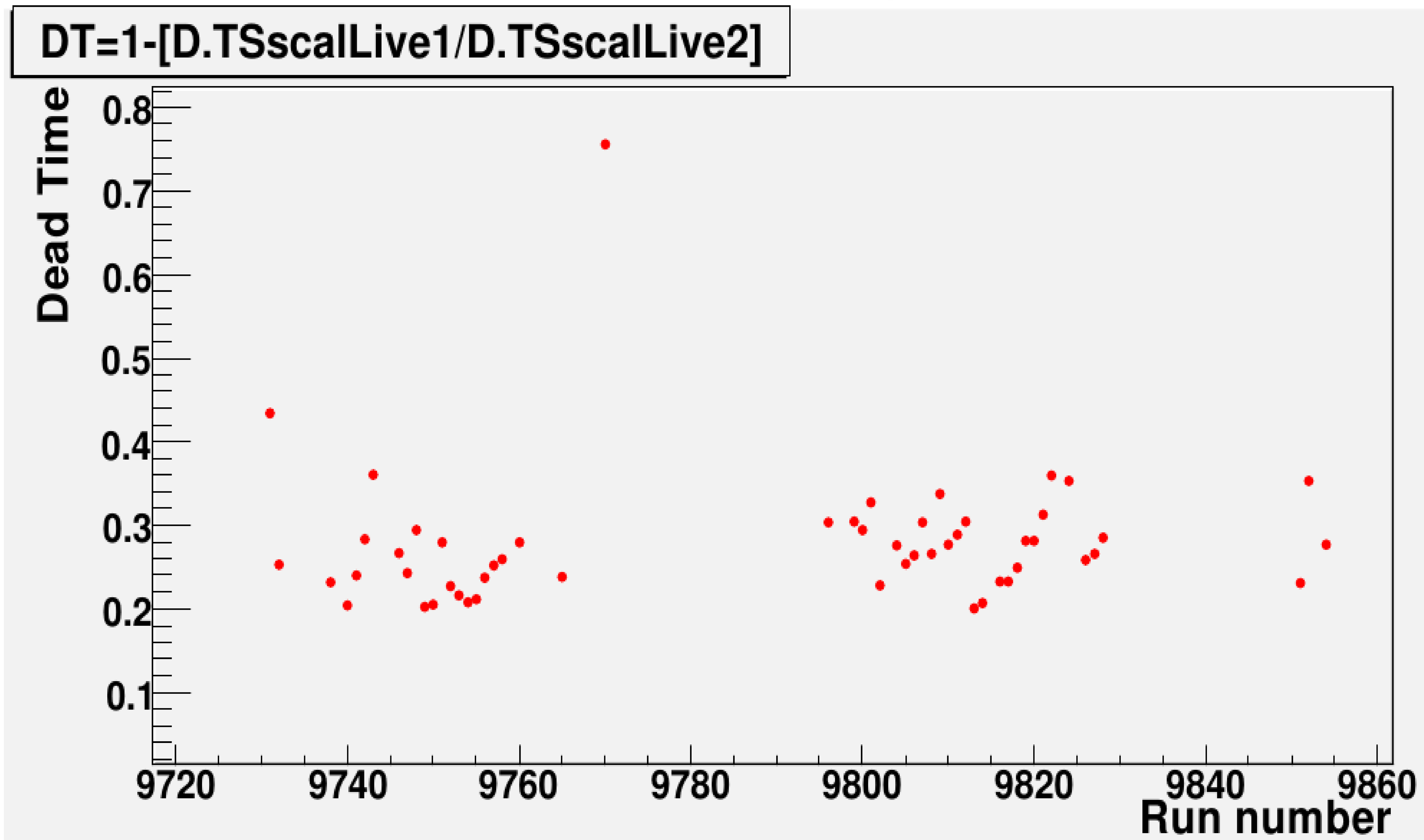
Conclusion :

→ **the two calibrations improve the Mx2 and the Minv**

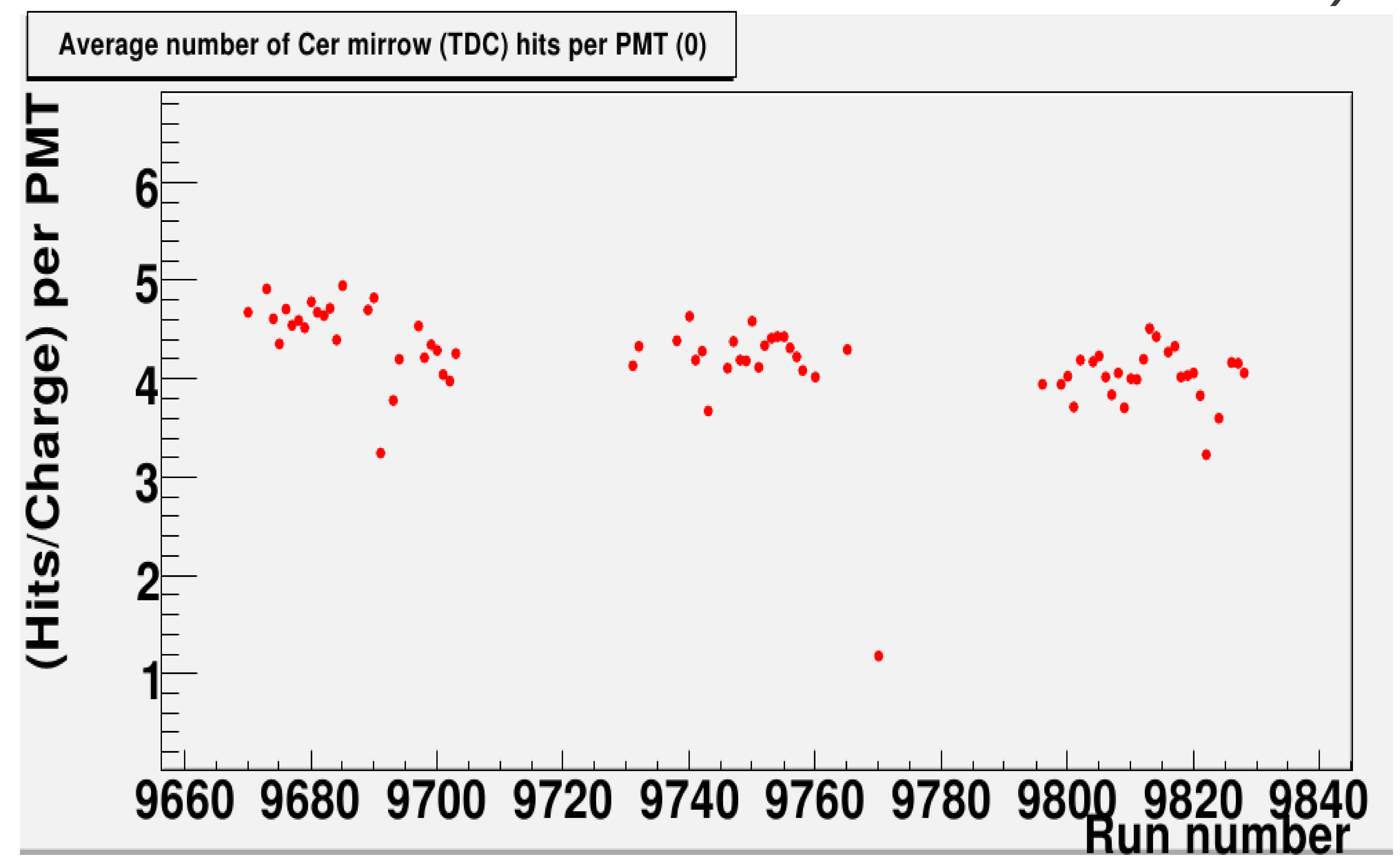
→ **the two calibrations are close to each other**

Run quality (= discarding the problematic runs)

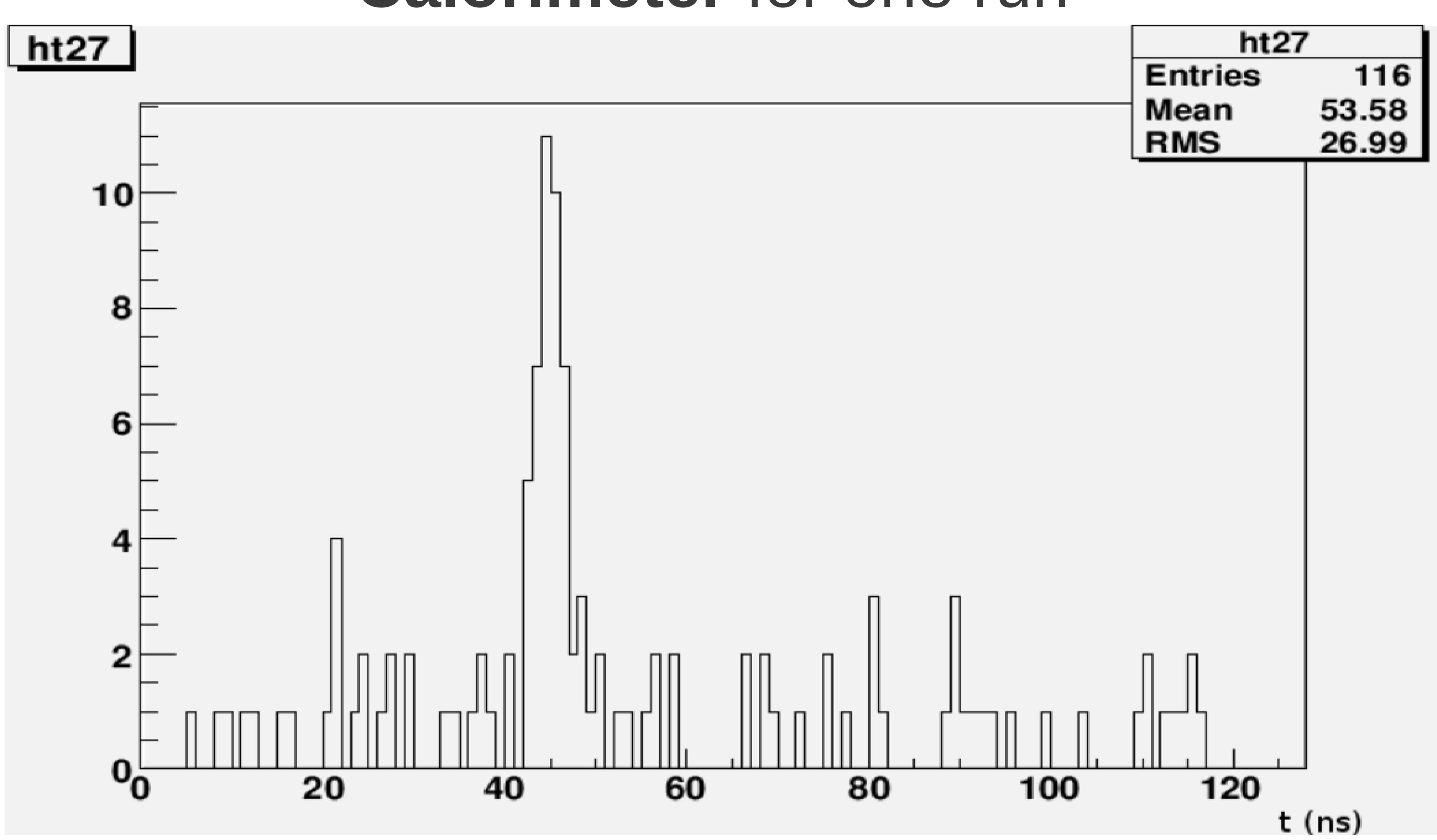
Acquisition system problem (Dead Time problem for one run)



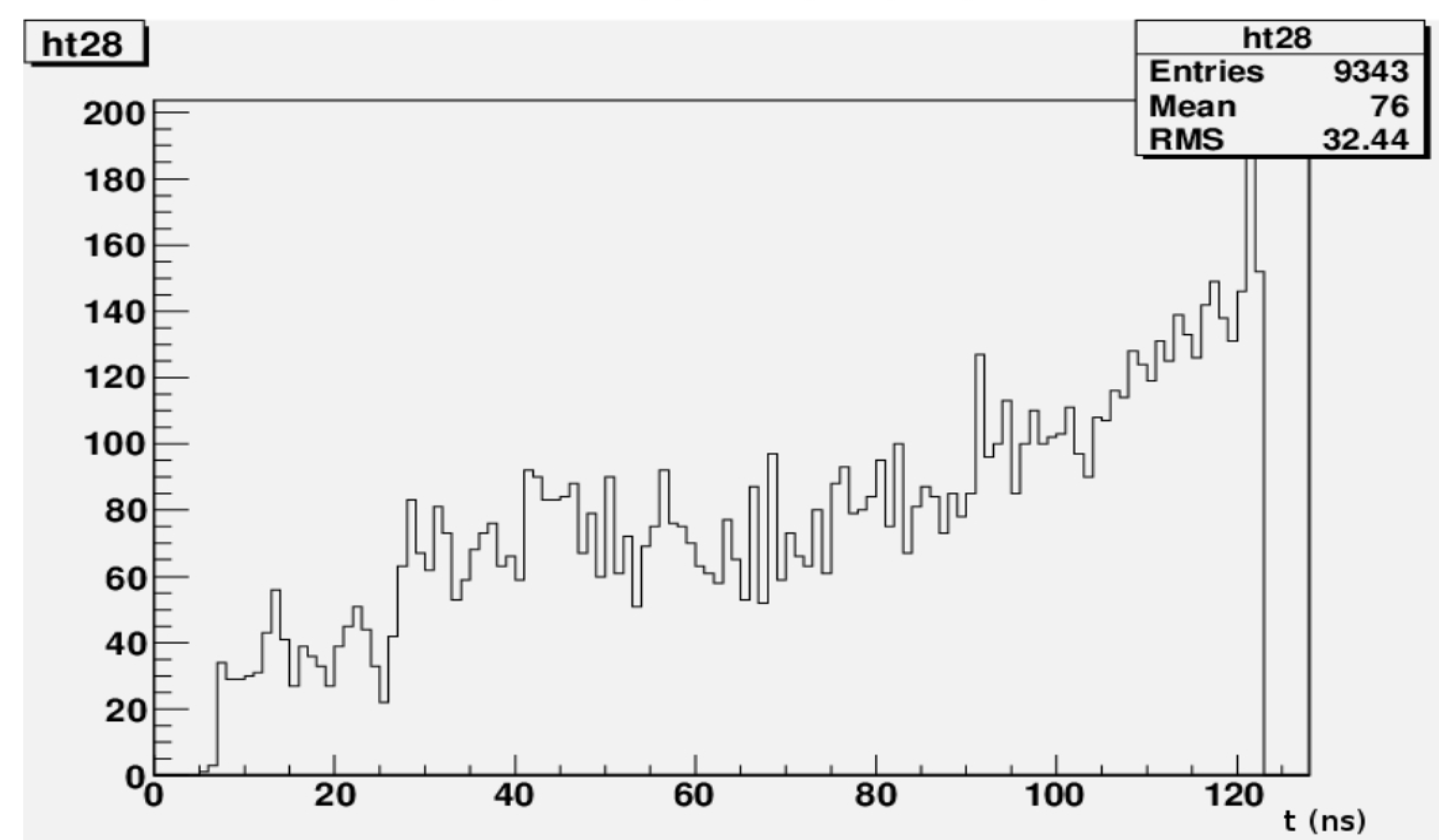
HRS problem (Low number of hits in one of the PMT of the Cerenkov detector for one run)



Normal arrival times of signals in one block of the **Calorimeter** for one run



Abnormal arrival times of signals in one block of the **Calorimeter** for one run



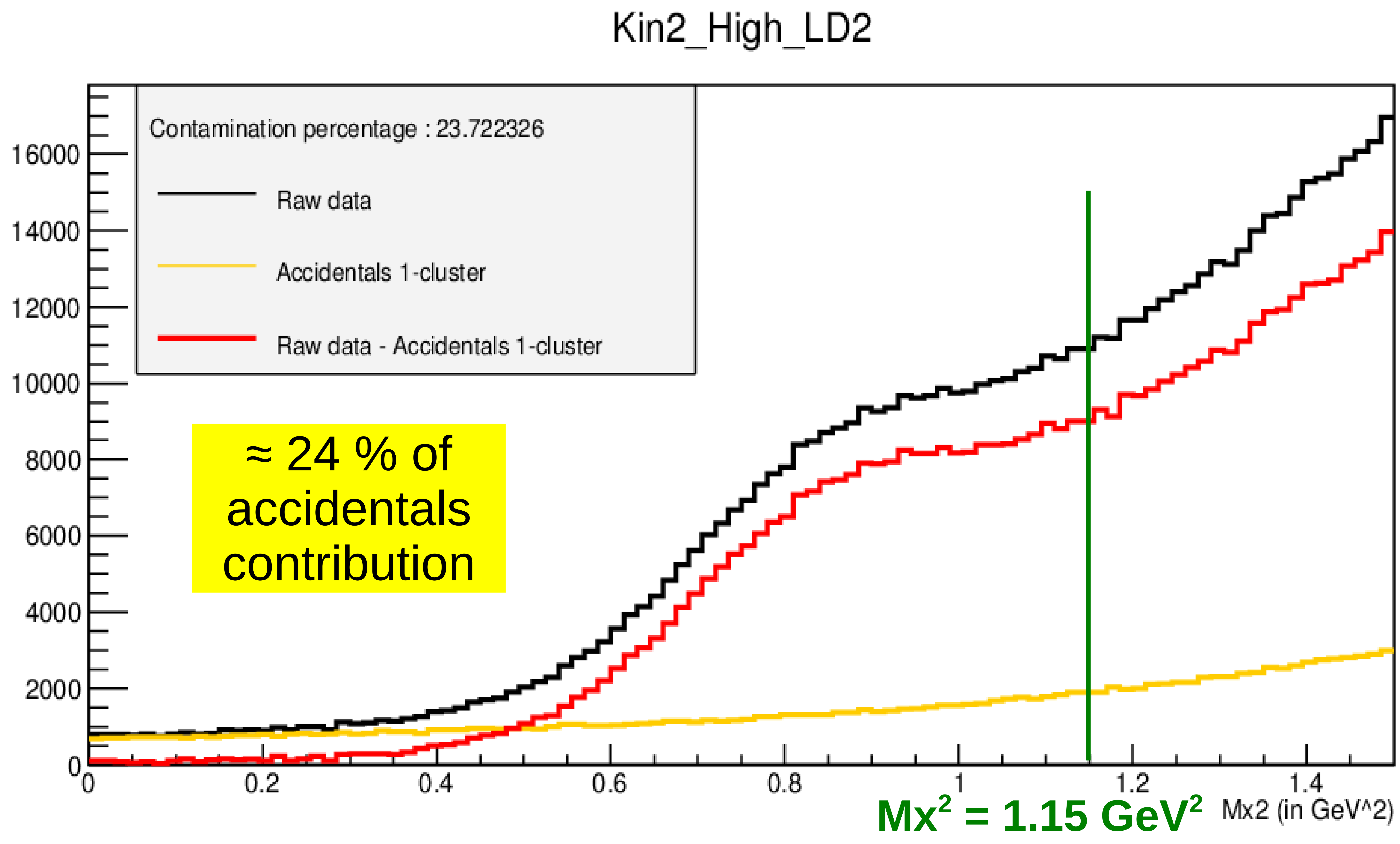
Conclusion : 10% from the totality of the runs affected

Contamination subtraction : accidentals 1 cluster contribution

Accidentals are :

→ Photons **not related to the trigger electron** detected in the [-3, 3] ns clustering window (= not coming from the vertex)
→ **Uniform contribution in the time** on the 128 ns of the acquisition window

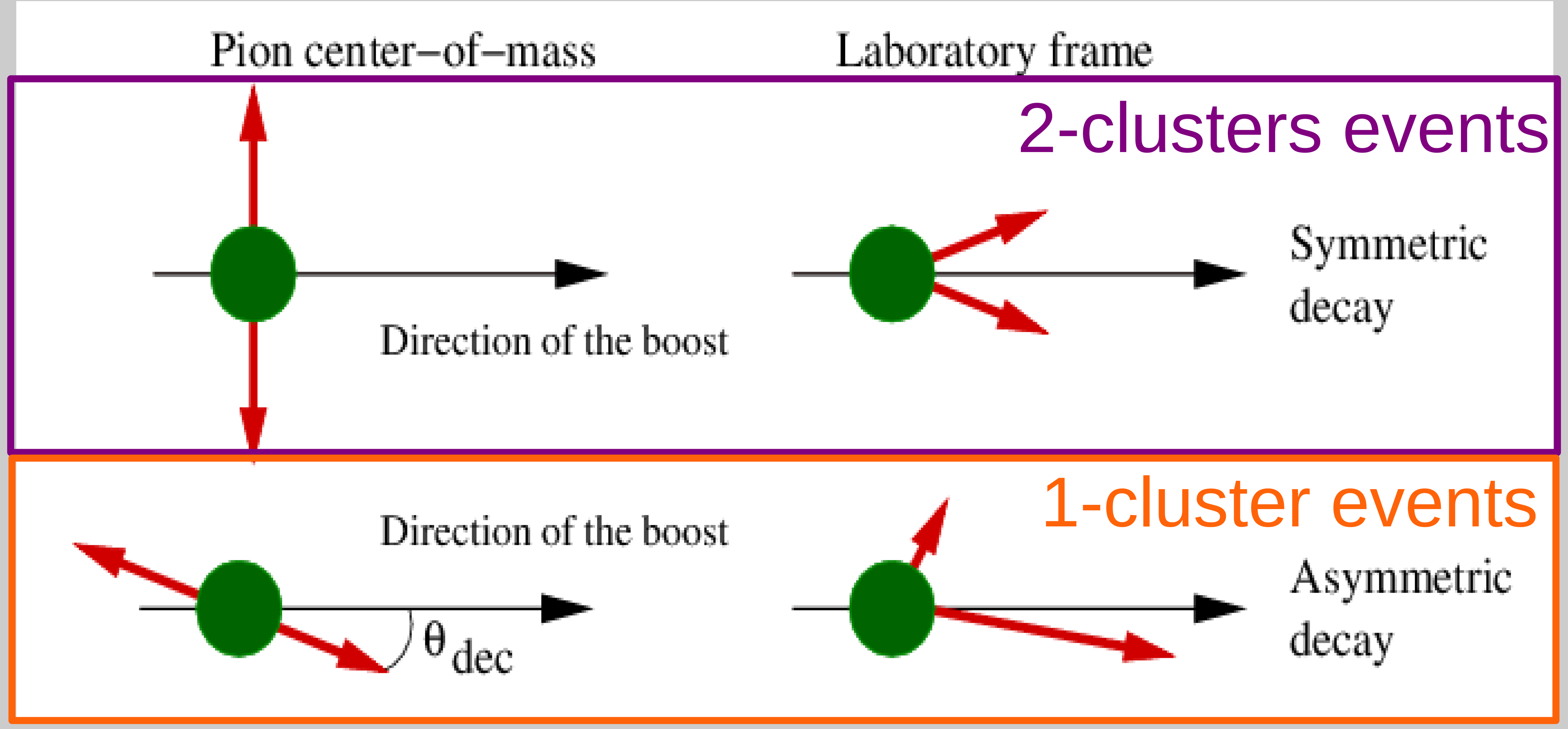
To remove the accidentals contribution, we shift in time the clustering window : from [-3, 3] ns to [-11, 5] ns (and [5, 11] ns)



Contamination subtraction : π° contamination

Raw data = DVCS + Accidentals + π° → **Contamination**

π°(ep→ e'p'π° → e'p'γγ) :



Contamination when only **1 of the two photons from the π° decay** is detected by the calorimeter

Raw data

1-cluster events (DVCS + π°)

2-clusters events (π° data)

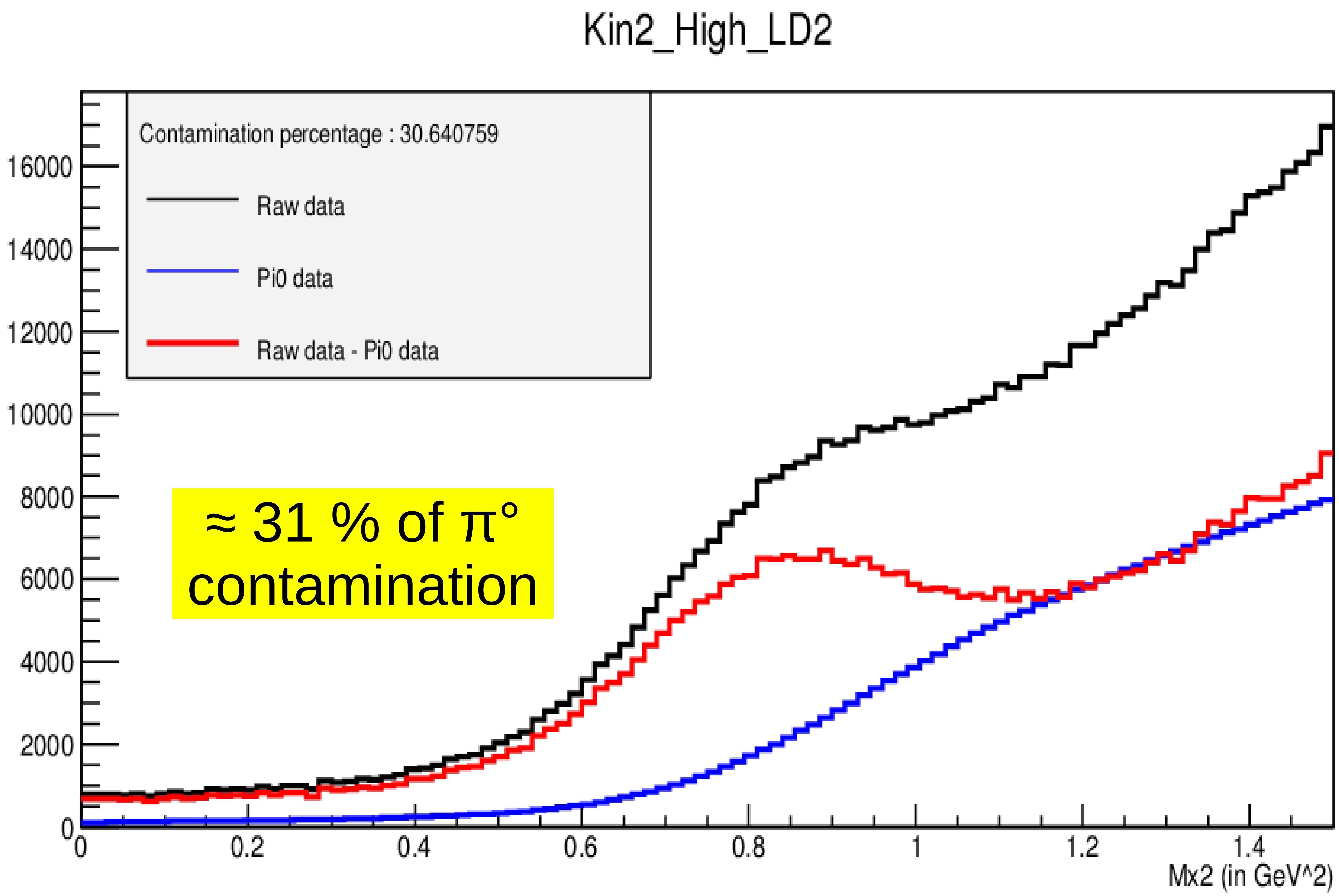
π° random decays

Projection of the photons on the calorimeter surface

N0 : 0 cluster
N1 : 1 cluster
N2 : 2 clusters

1-cluster events (DVCS + π°) − **N1** : 1 cluster

Example of π° contamination subtraction



In the **Blue curve** :
we have the **real π°** but also **accidentals π°**

We have **to remove the accidentals π° contribution to the real π°** to subtract only the real π° from the raw data

Contamination subtraction : accidentals π° contribution

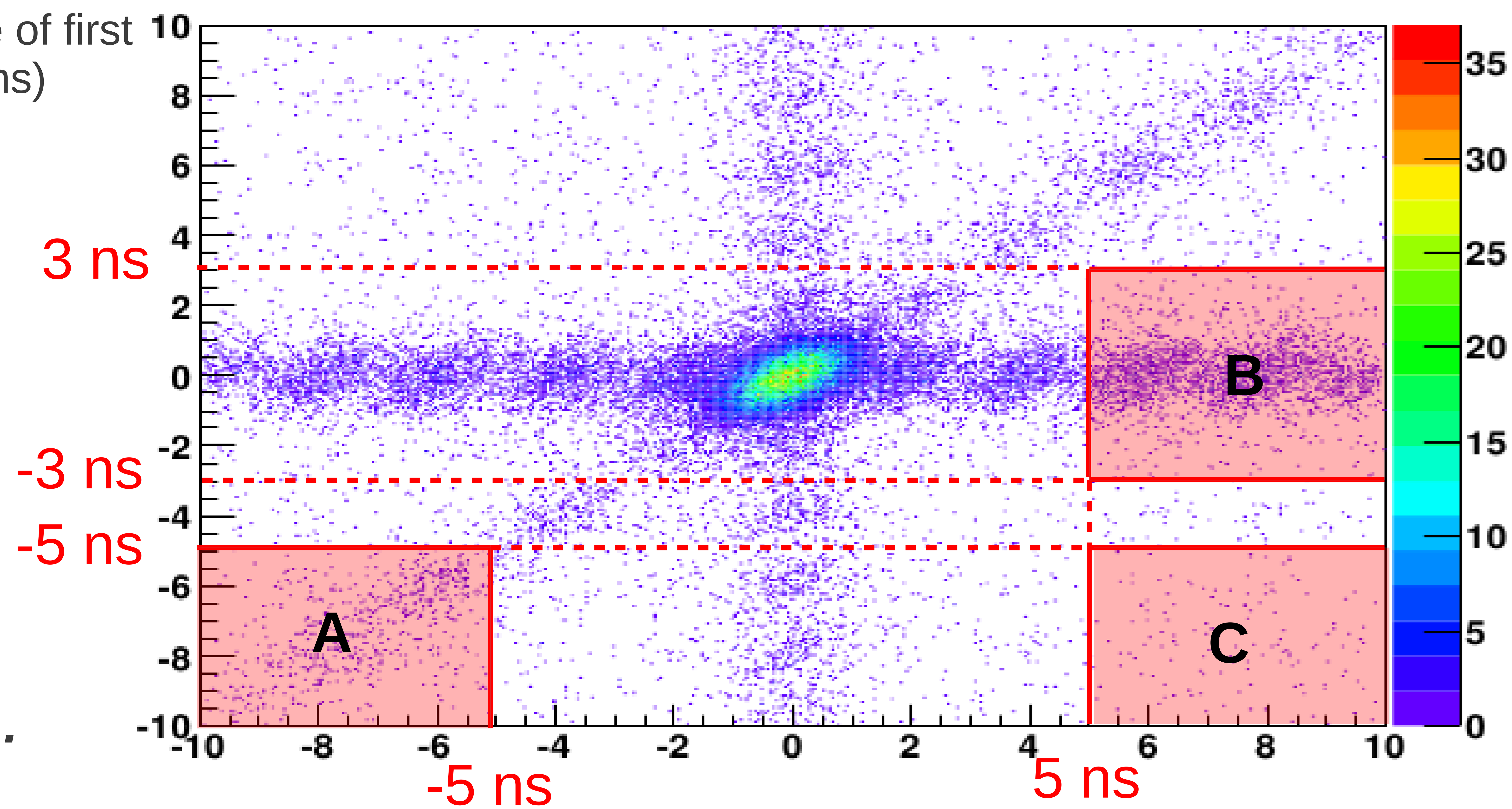
<u>Accidentals π° (3 types)</u> :

→ **A**) 2 photons **related** to a π°, so the both in coincidence with themselves but not in coincidence with the trigger electron
→ **B**) 2 photons **not related** to a π°, with one of them in coincidence with the trigger electron
→ **C**) 2 photons **not related** to a π°, and none of them in coincidence with themselves or with the trigger electron

<u>To remove the accidentals contribution, we select the clustering windows to</u> :

A) [-11, -5] ns and [-11, -5] ns
B) [-3, -3] ns and [5, 11] ns
C) [-11, -5] ns and [5, 11] ns

Arrival time of first cluster (in ns)



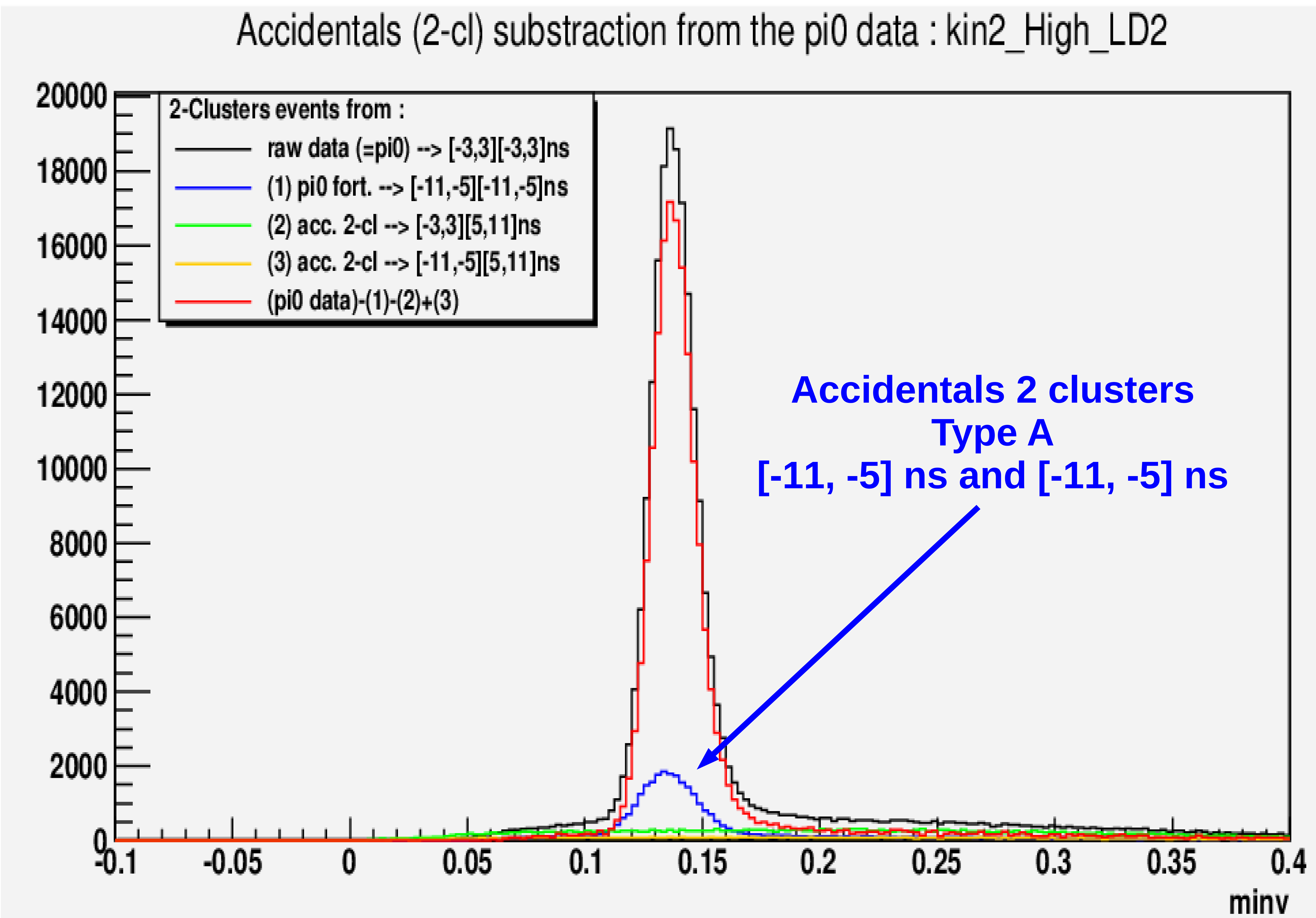
Arrival time of second cluster (in ns)

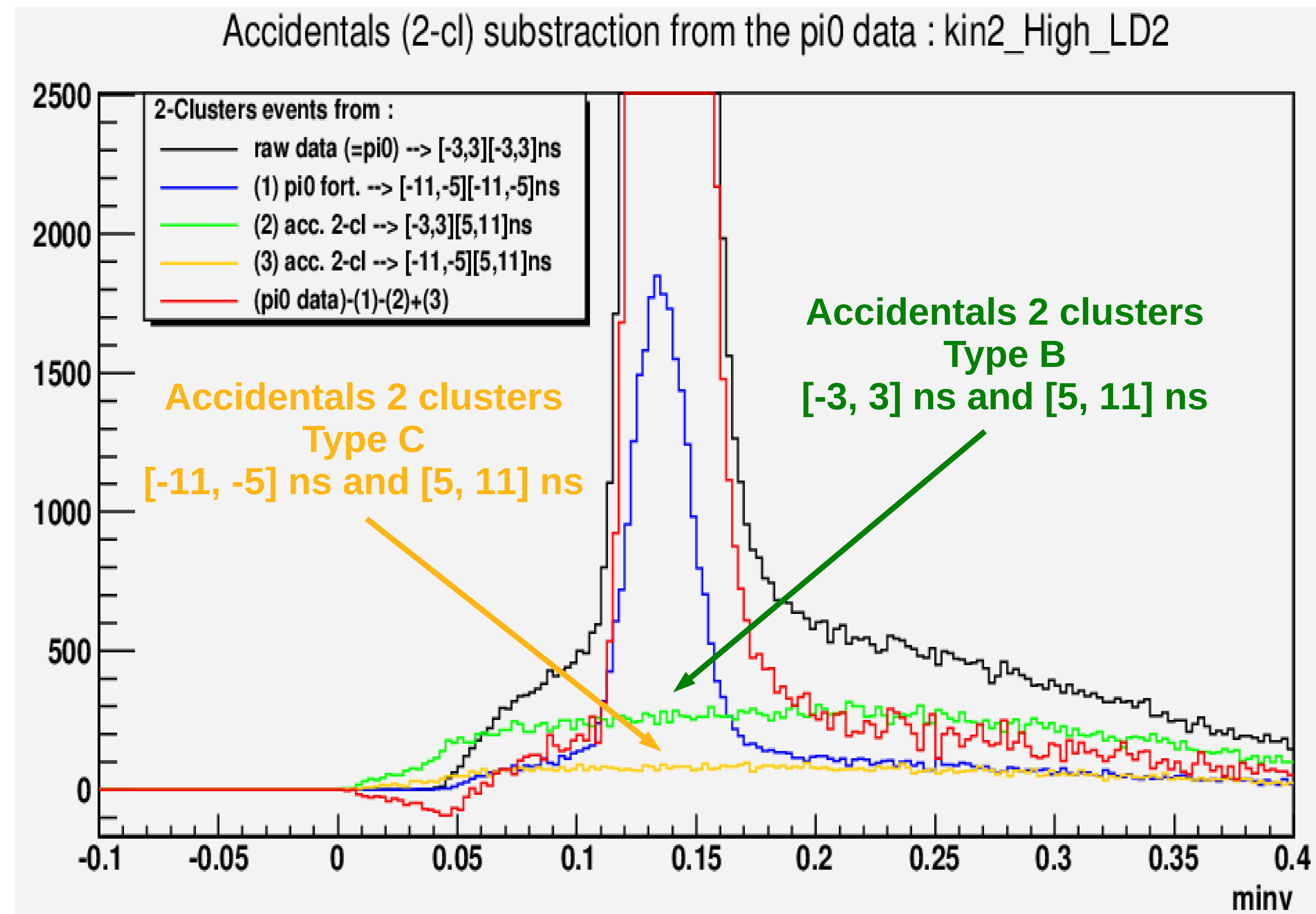
To subtract the total accidentals π° contribution :

A + B - C

Camsonne A.

Example of the accidentals π° contribution with the Minv

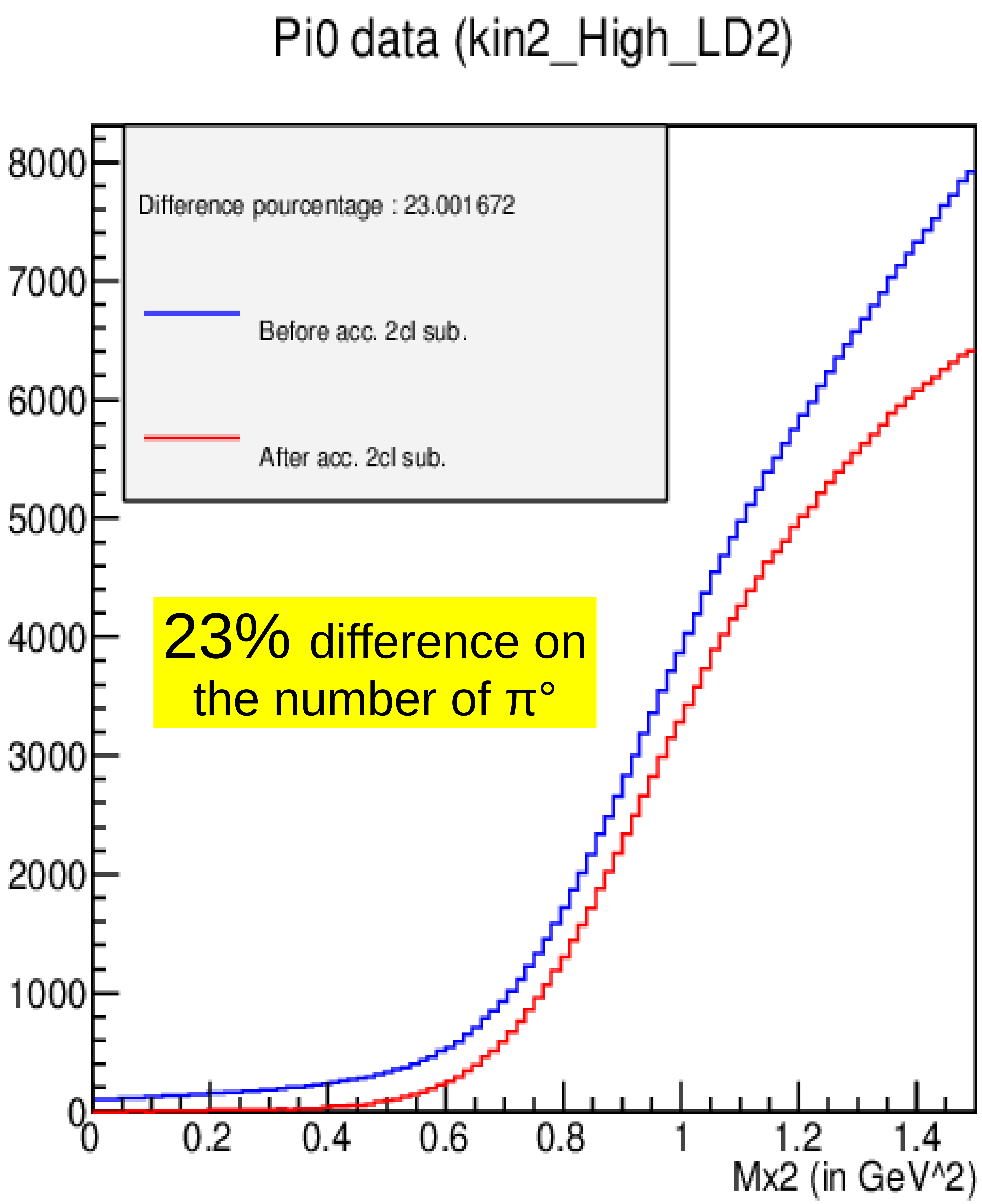


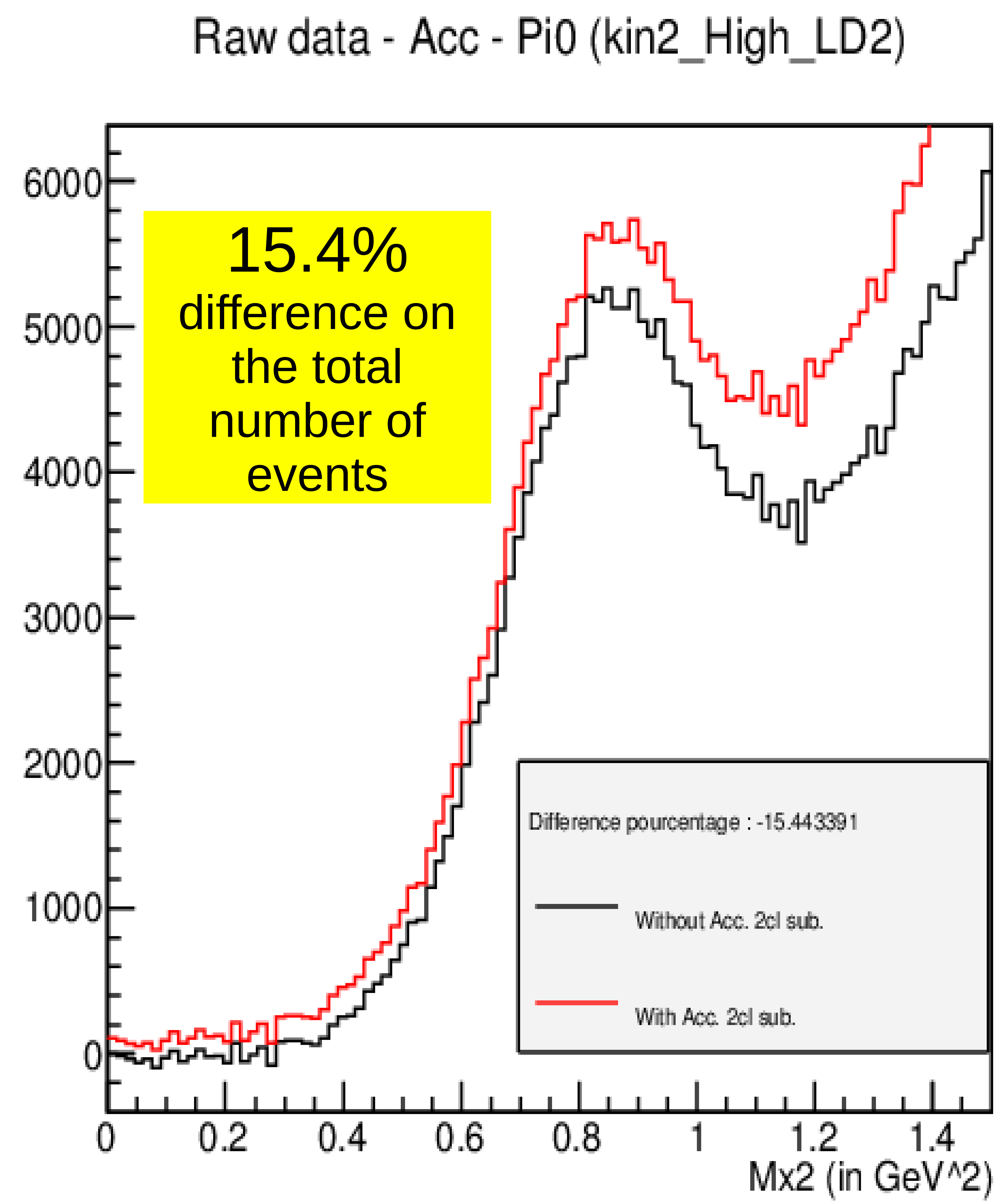


→ LD2 target : **20% to 30%** accidentals π° contribution
→ LH2 target : **13 %** accidentals π° contribution

Accidentals π° contribution is *not negligible*, so it's necessary to subtract this contribution to the total 2-clusters events.

Example of the accidentals π° contribution with the Mx2

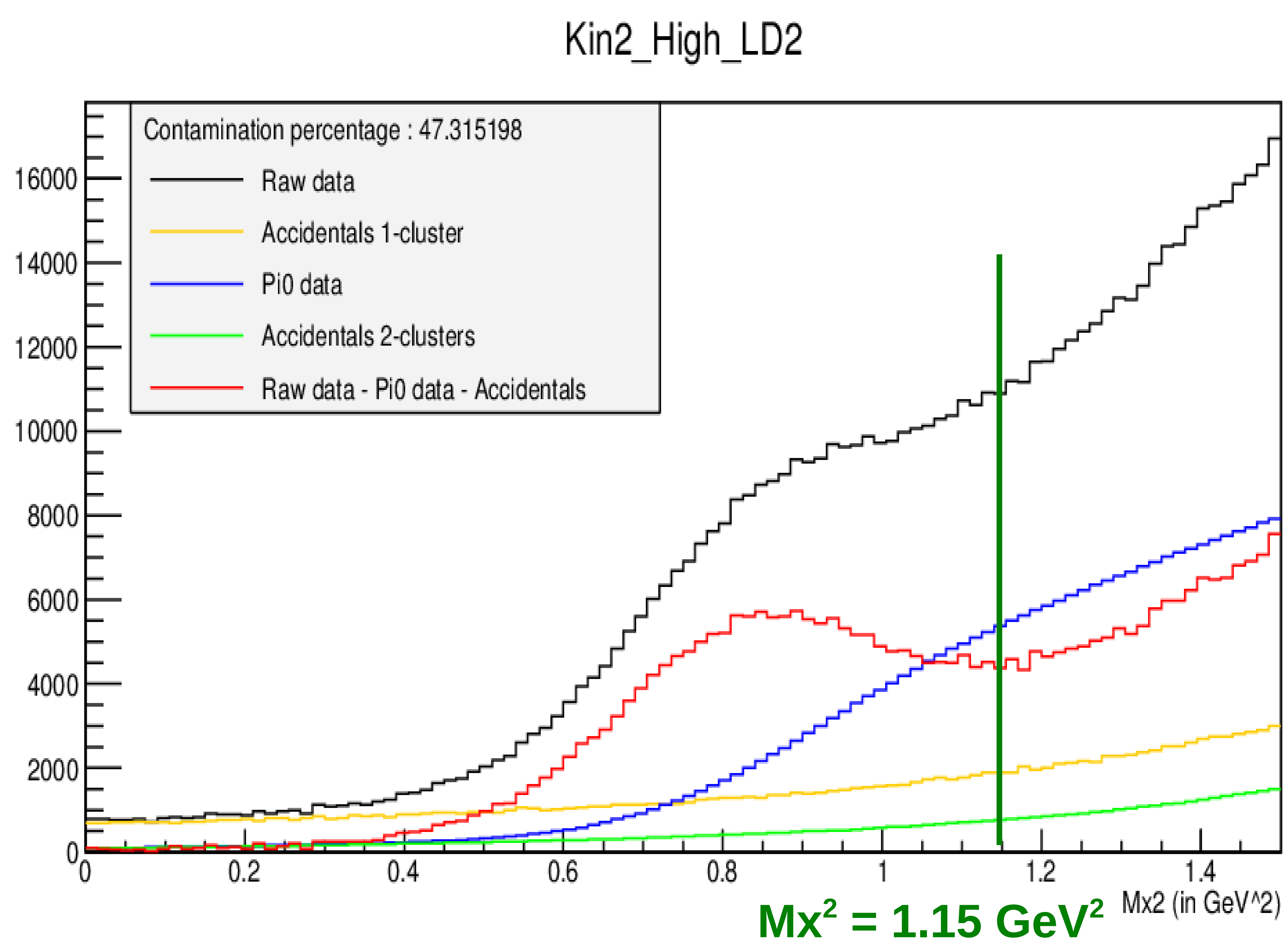


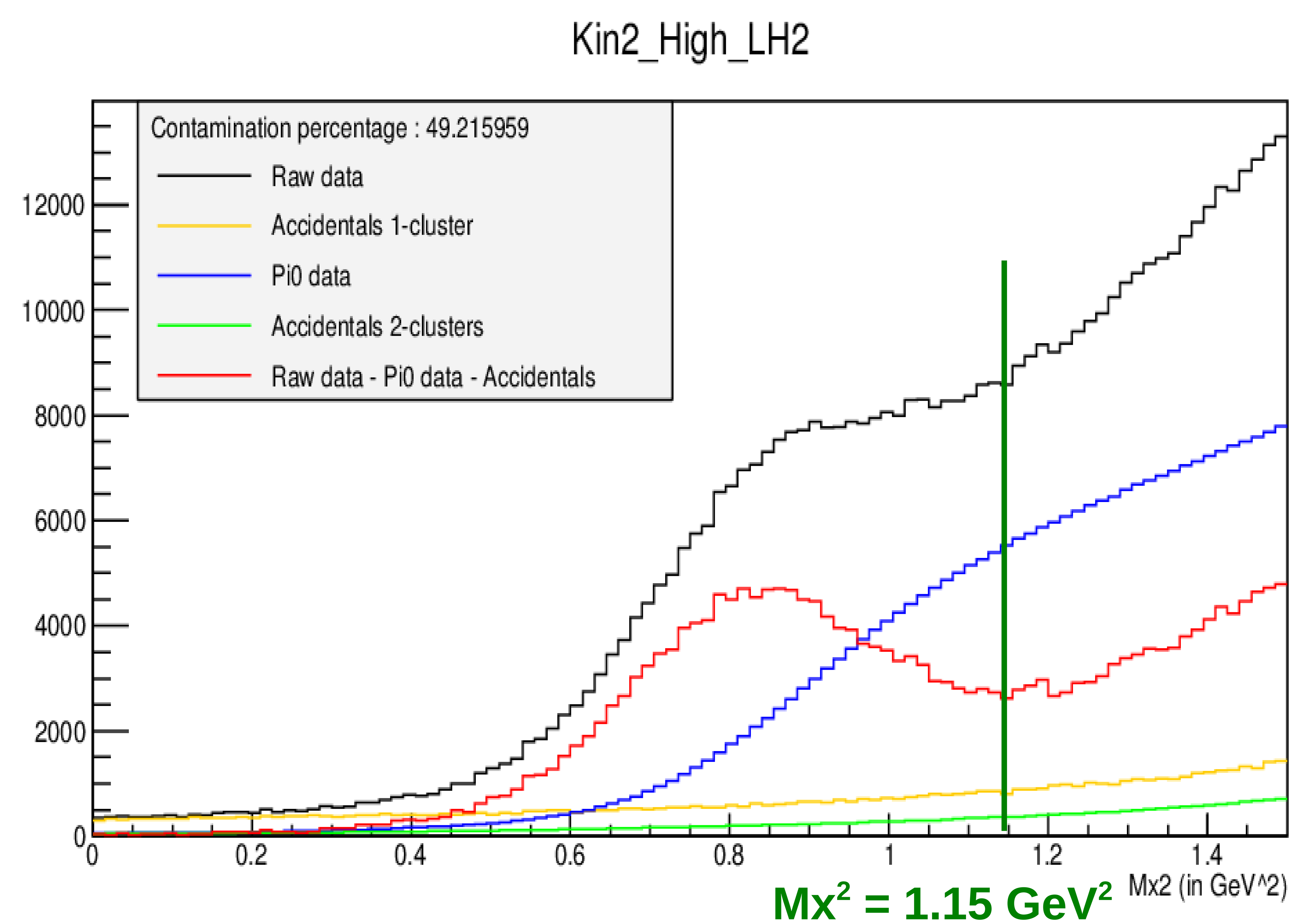


We can see the difference on the number of events when we apply the accidentals π° subtraction

Global results after contamination subtraction for each target

DVCS = Raw data - Accidentals 1 cluster - (π° - Accidentals 2 clusters)





≈ 47 % of accidentals contribution + π° contamination

≈ 49 % of accidentals contribution + π° contamination

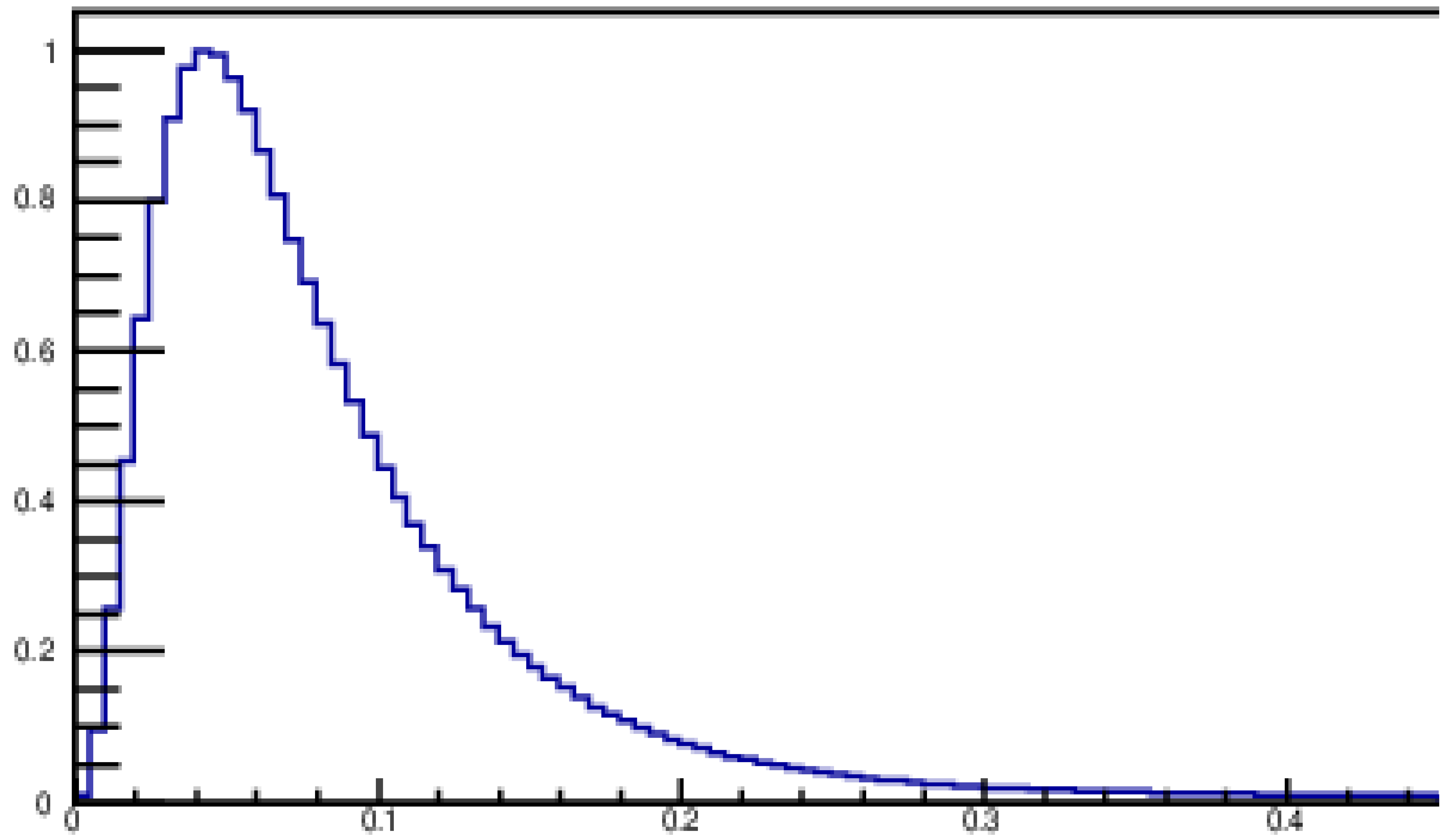
Fermi motion added to the LH2 target

→ **Proton at rest in the LH2 target but not in the LD2 target**

→ necessity to add the **fermi motion** to the LH2 target's proton for the target subtraction

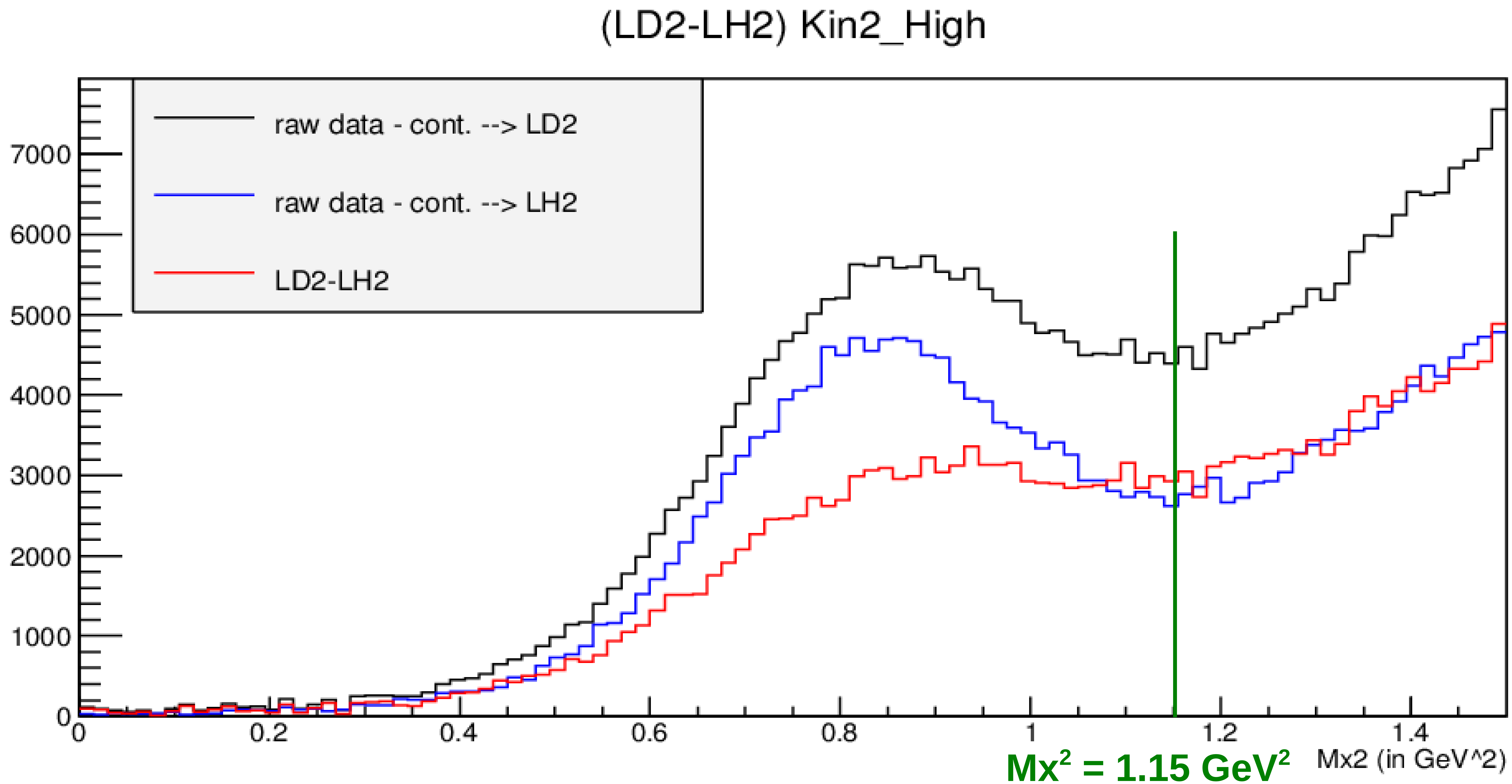
→ The fermi motion is a **smearing** on the **proton momentum** and the **proton mass** to take into account the **initial motion** of the proton in the nucleus

Distribution of fermi momentum



Fermi momentum (in GeV)

Global results after LD2-LH2 targets subtraction



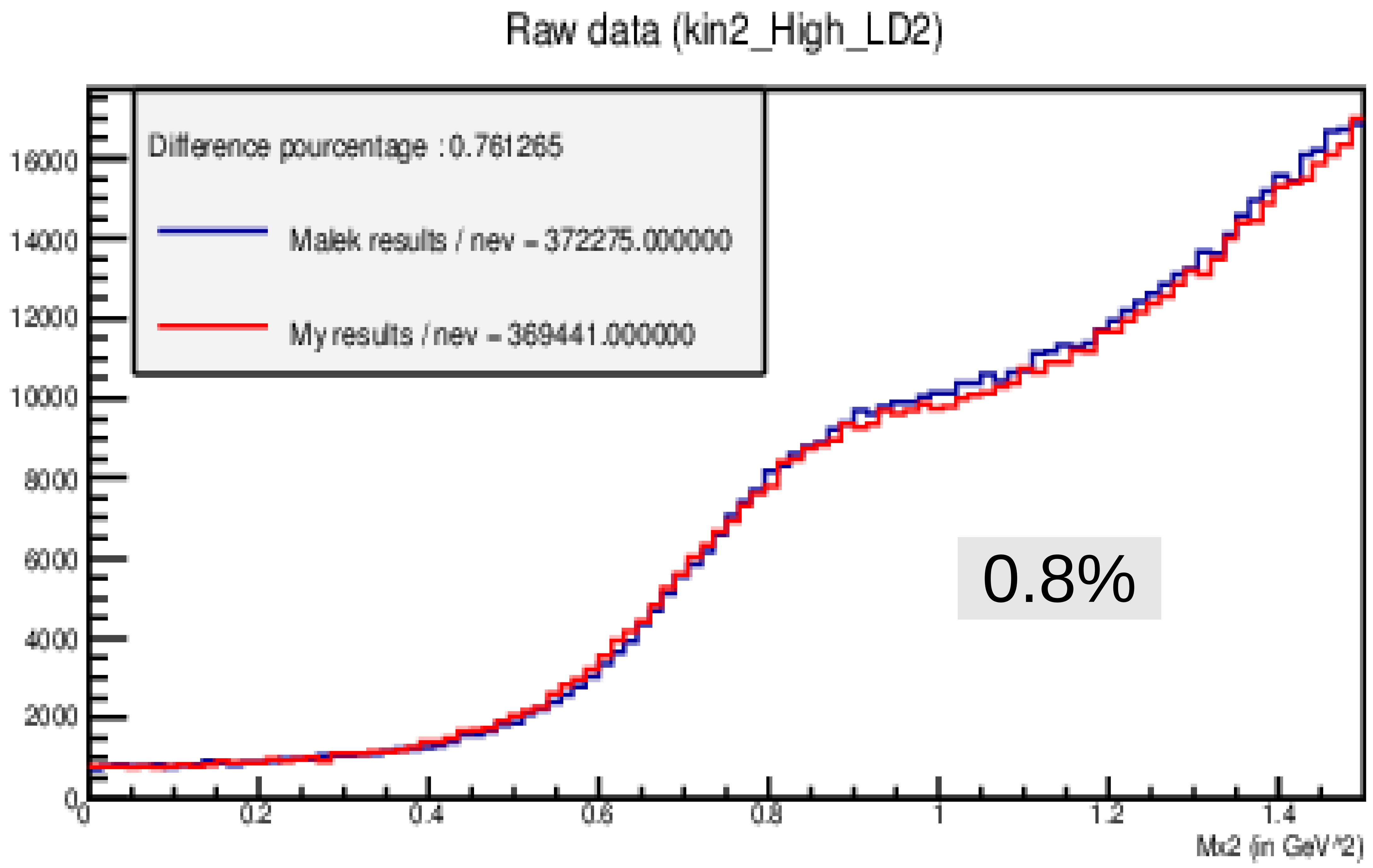
<u>Conclusion</u> :

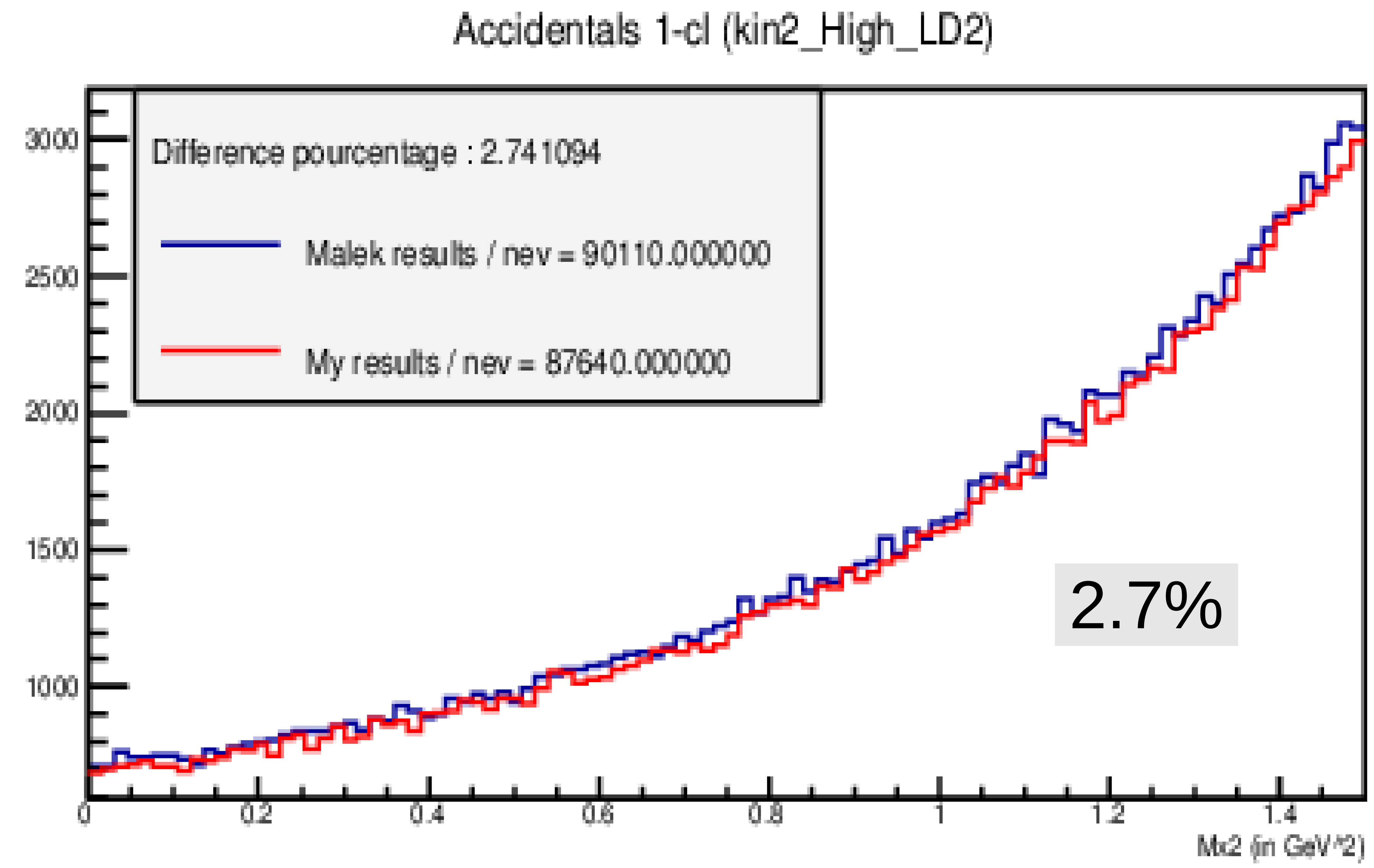
→**Normalization** by the **charge of each run** was performed to subtract the targets
→**Fermi motion** was included to the LH2 target data

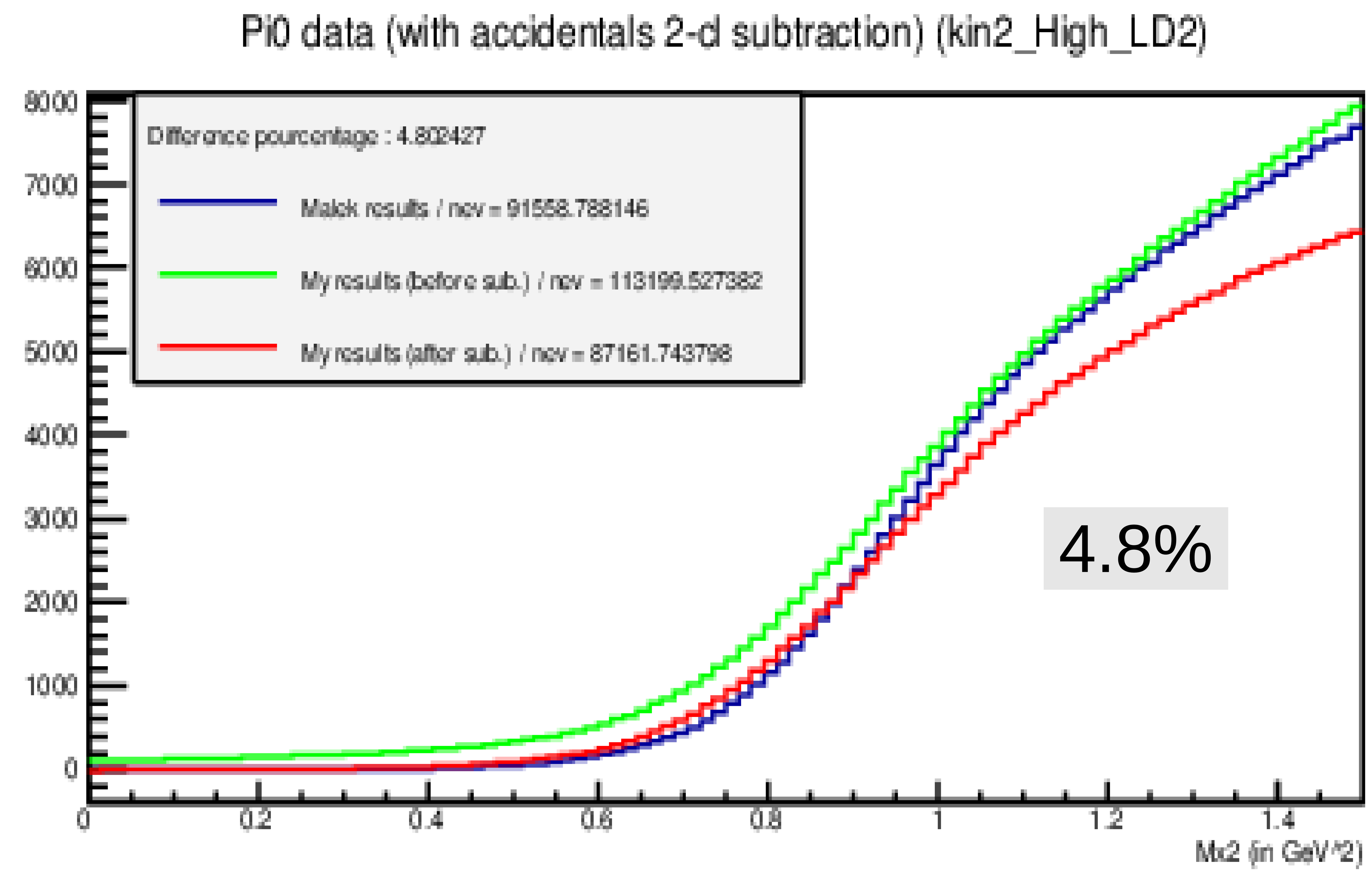
We notice a shift of the Mx2 peak between the LD2 target and the LH2 target :
→ due to the calorimeter calibration, fermi motion, π° subtraction method … ?

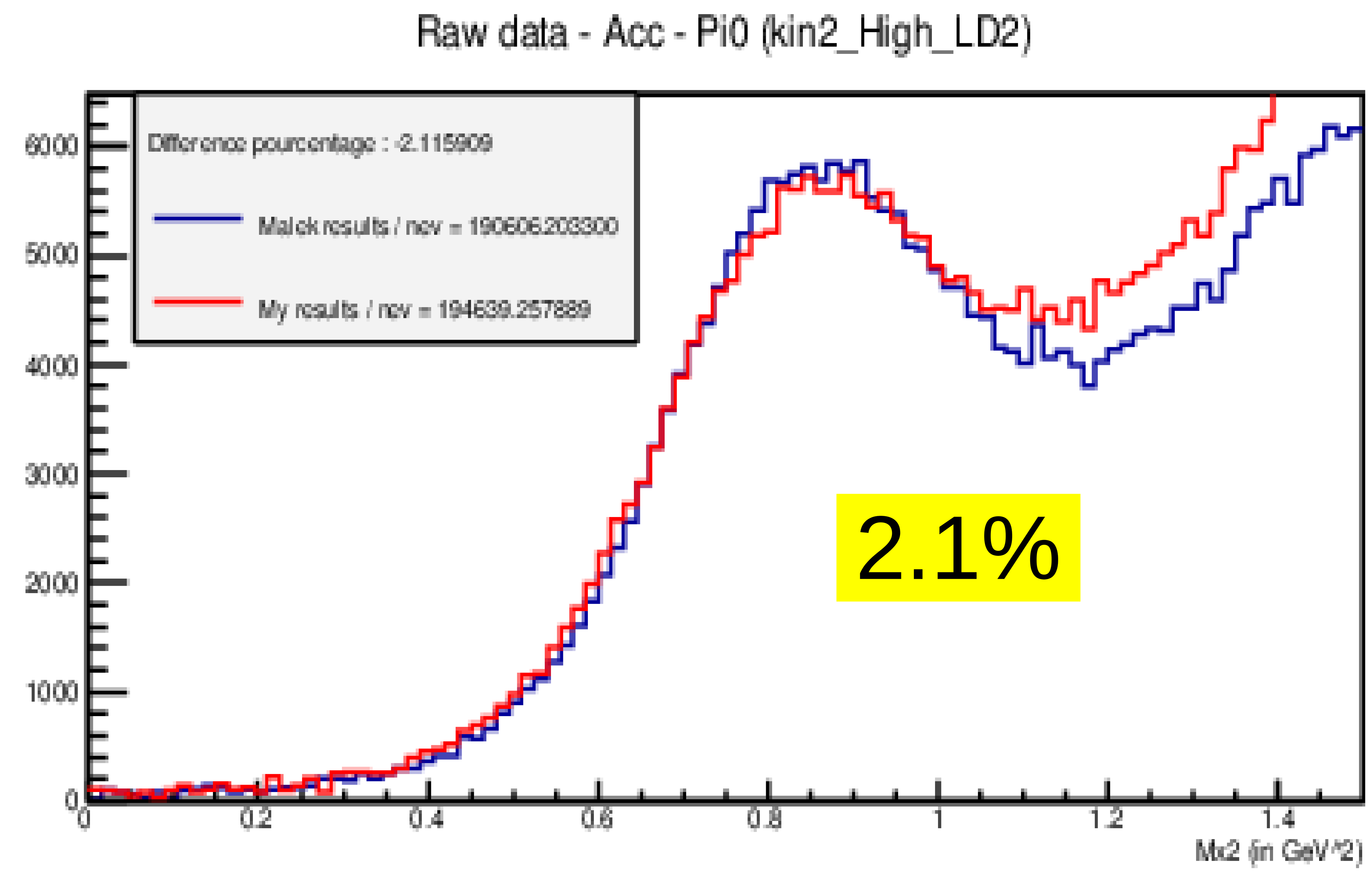
Comparison of 2 parallel analysis for the contamination subtraction
(same cuts applied)

LD2 Target : Malek results (blue) / My results (red)



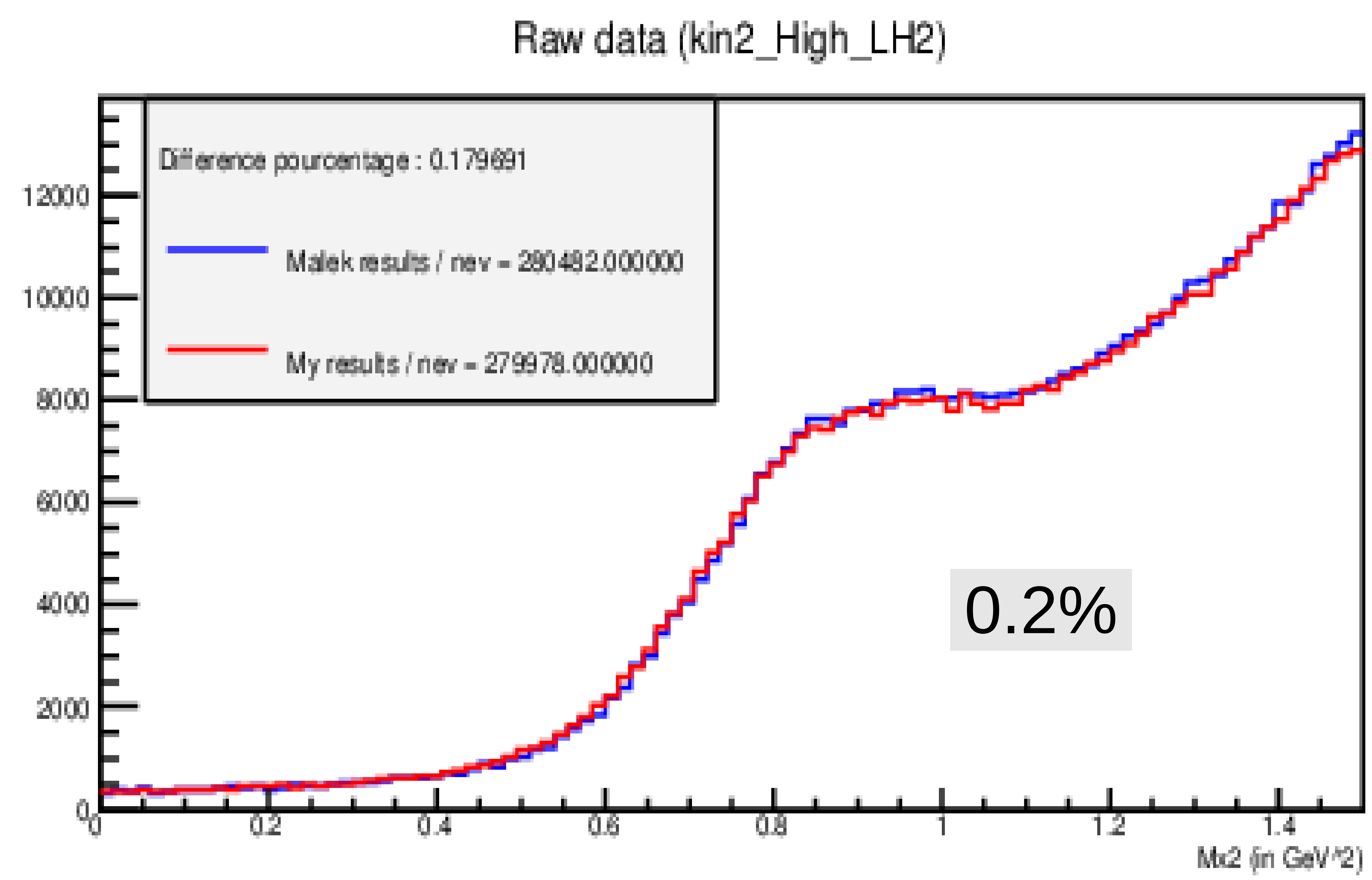


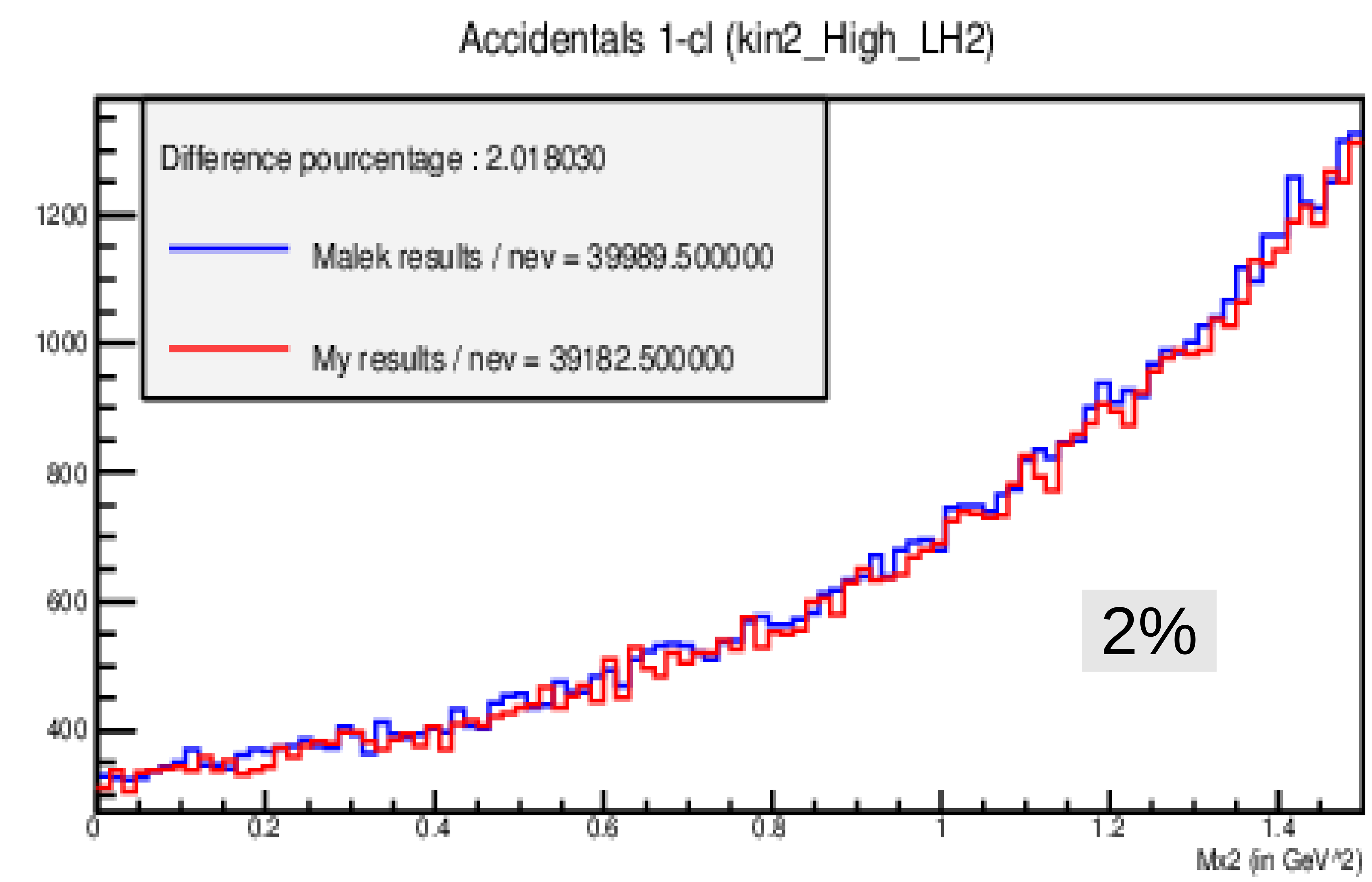


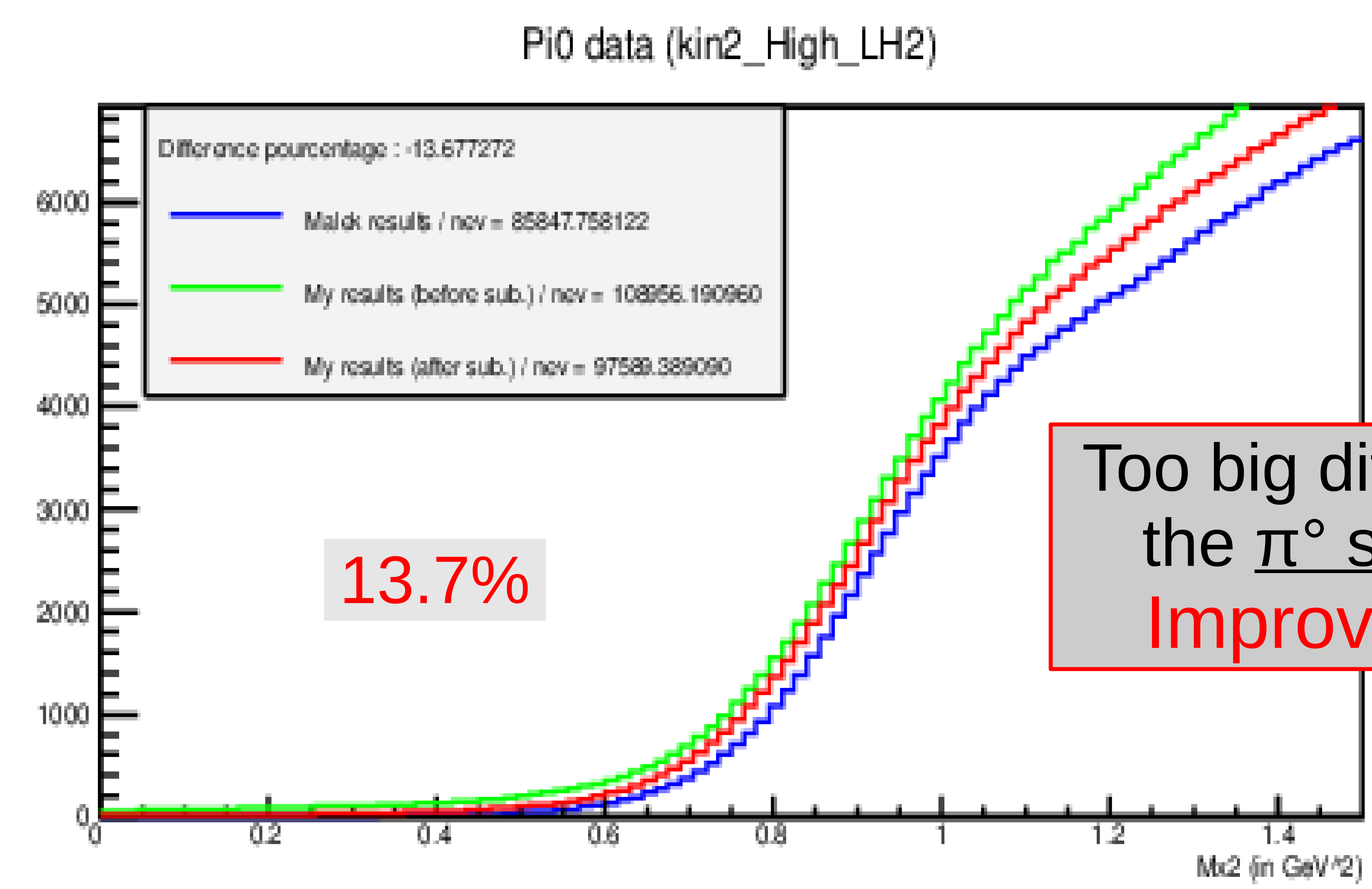


Comparison of 2 parallel analysis for the contamination subtraction
(without fermi motion)

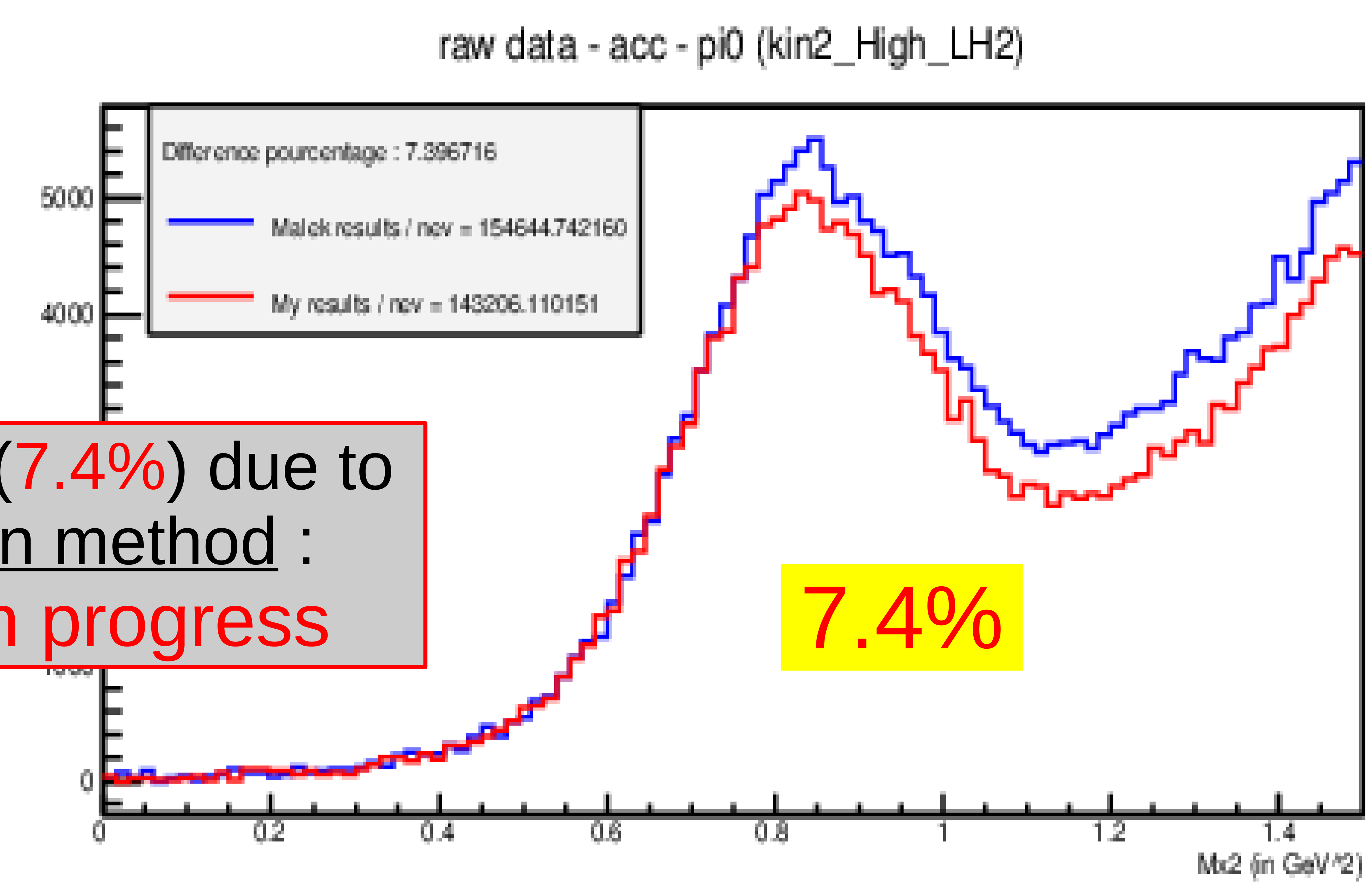
LH2 Target (*without* fermi motion) : Malek results (blue) / My results (red)





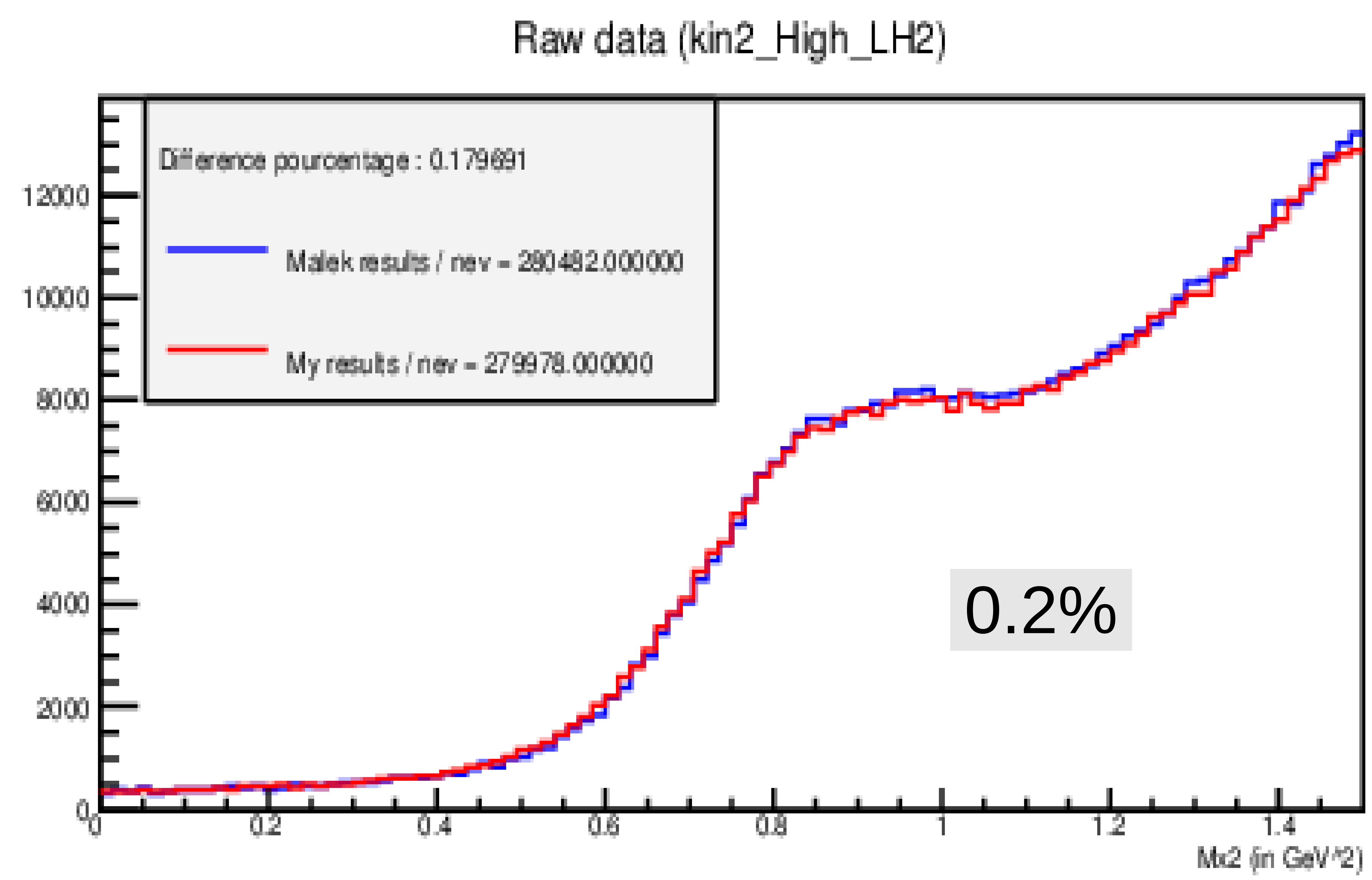


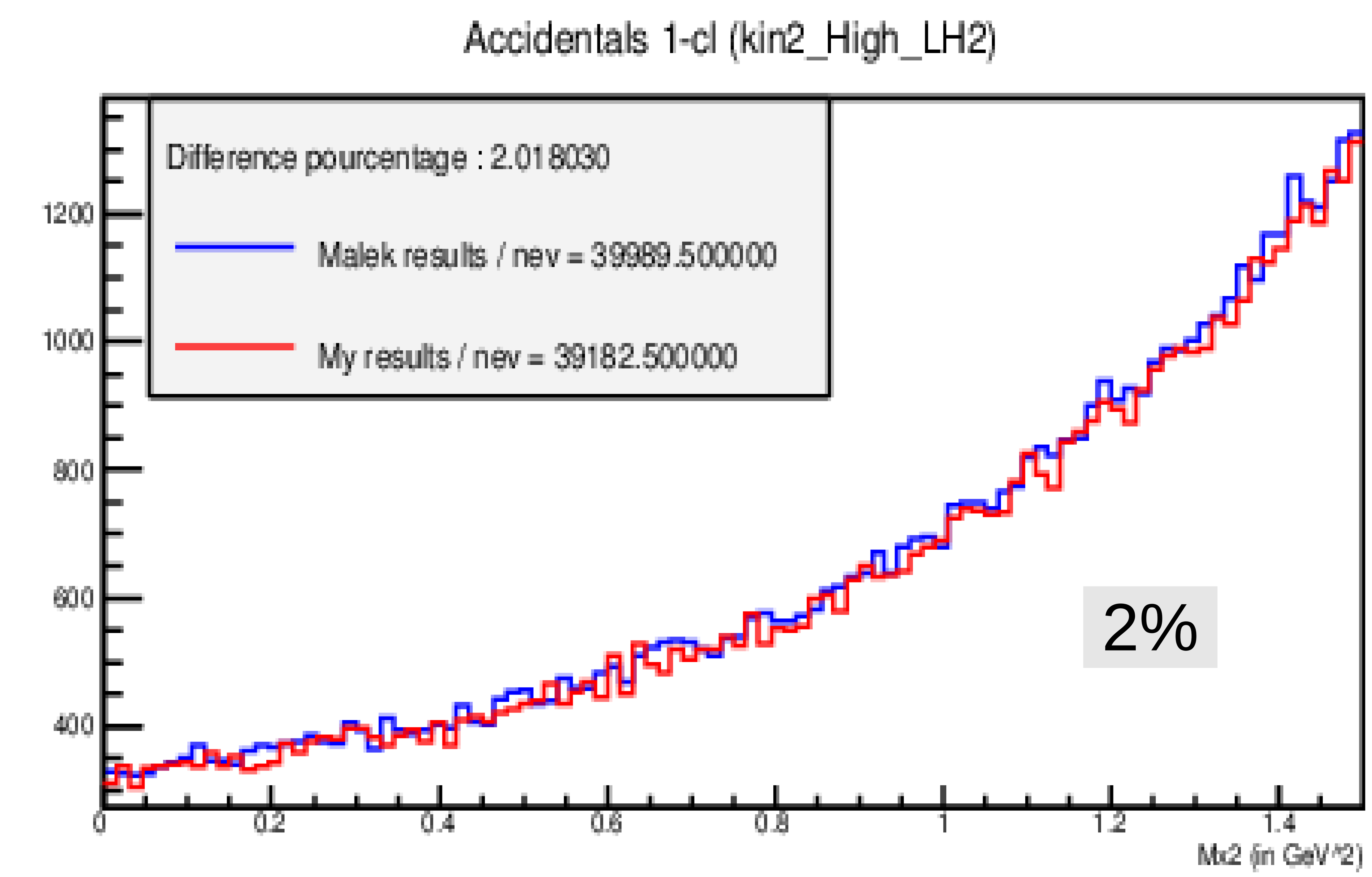
Too big difference (7.4%) due to the <u>$\pi°$ subtraction method</u> :
Improvement in progress

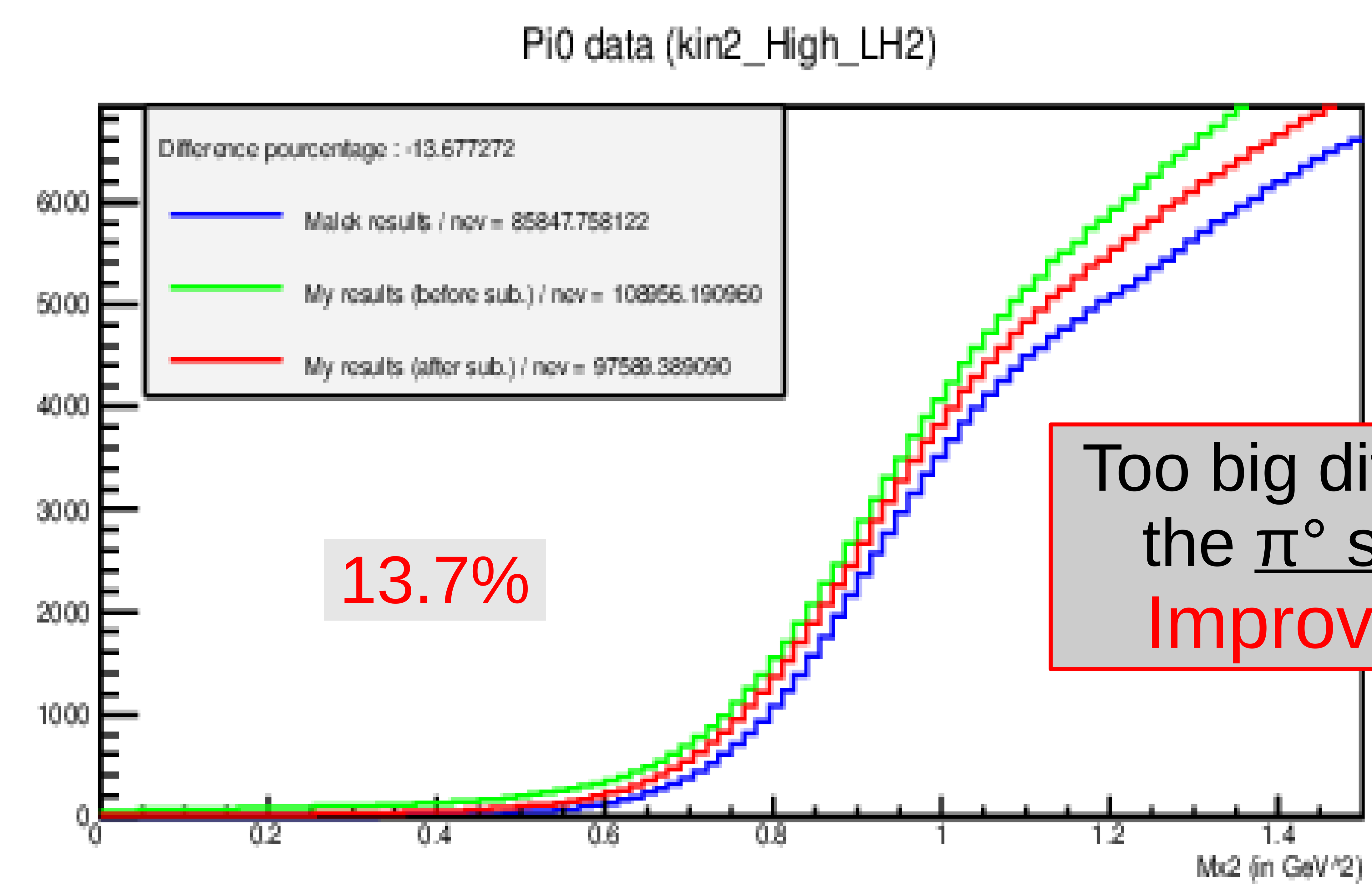


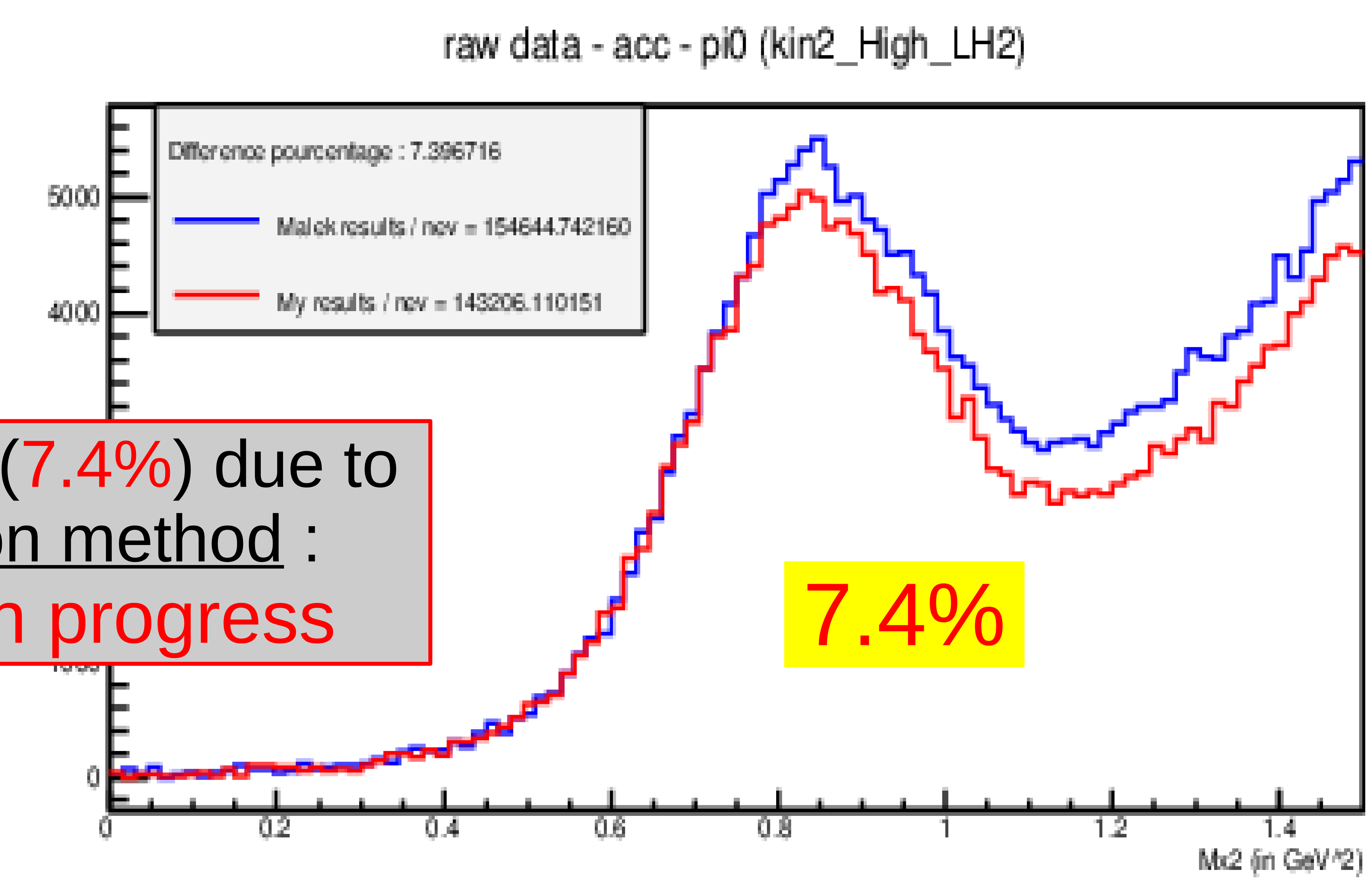
Comparison of 2 parallel analysis for the contamination subtraction
(without fermi motion)

LH2 Target (*without* fermi motion) : Malek results (blue) / My results (red)





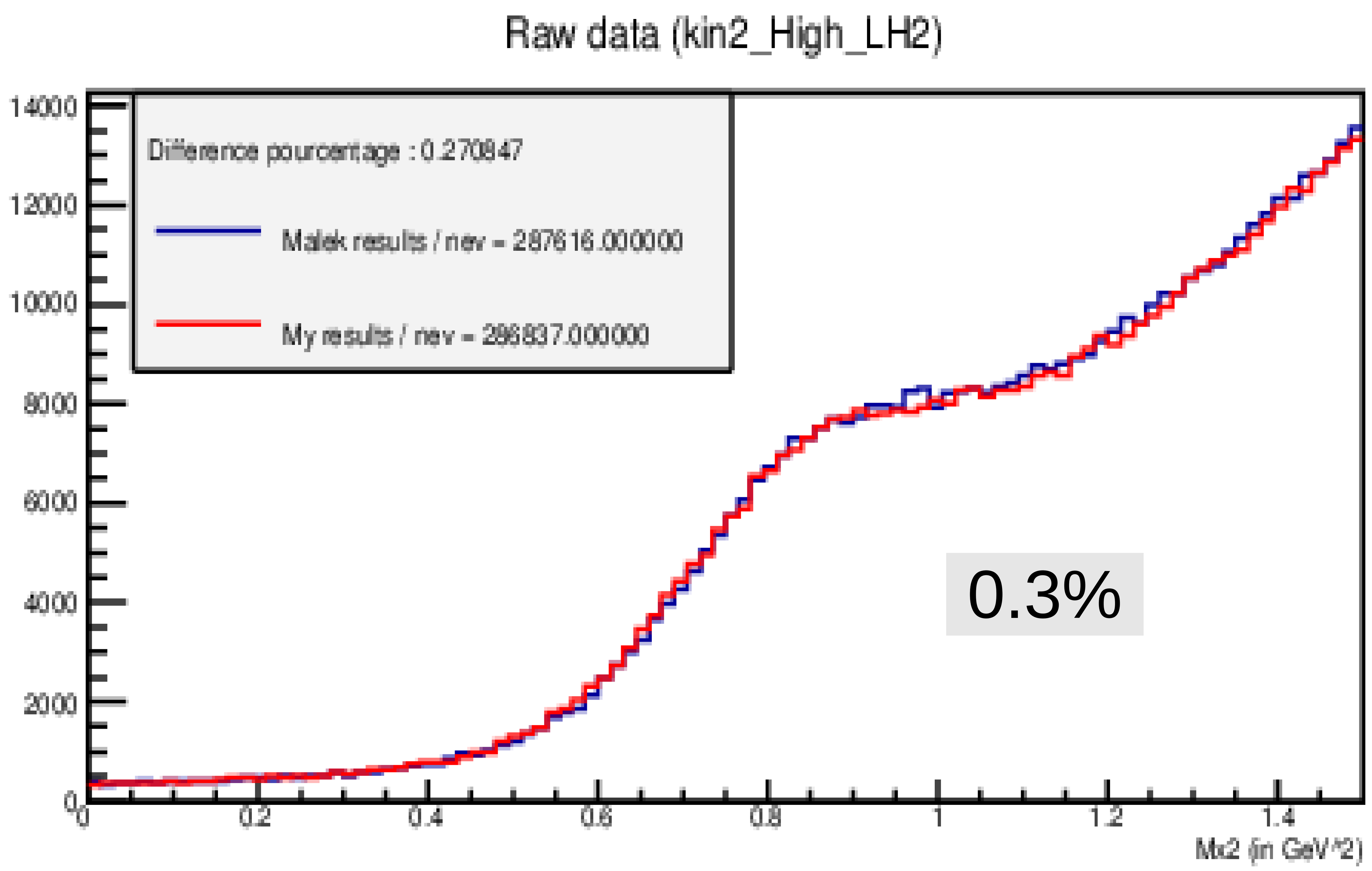


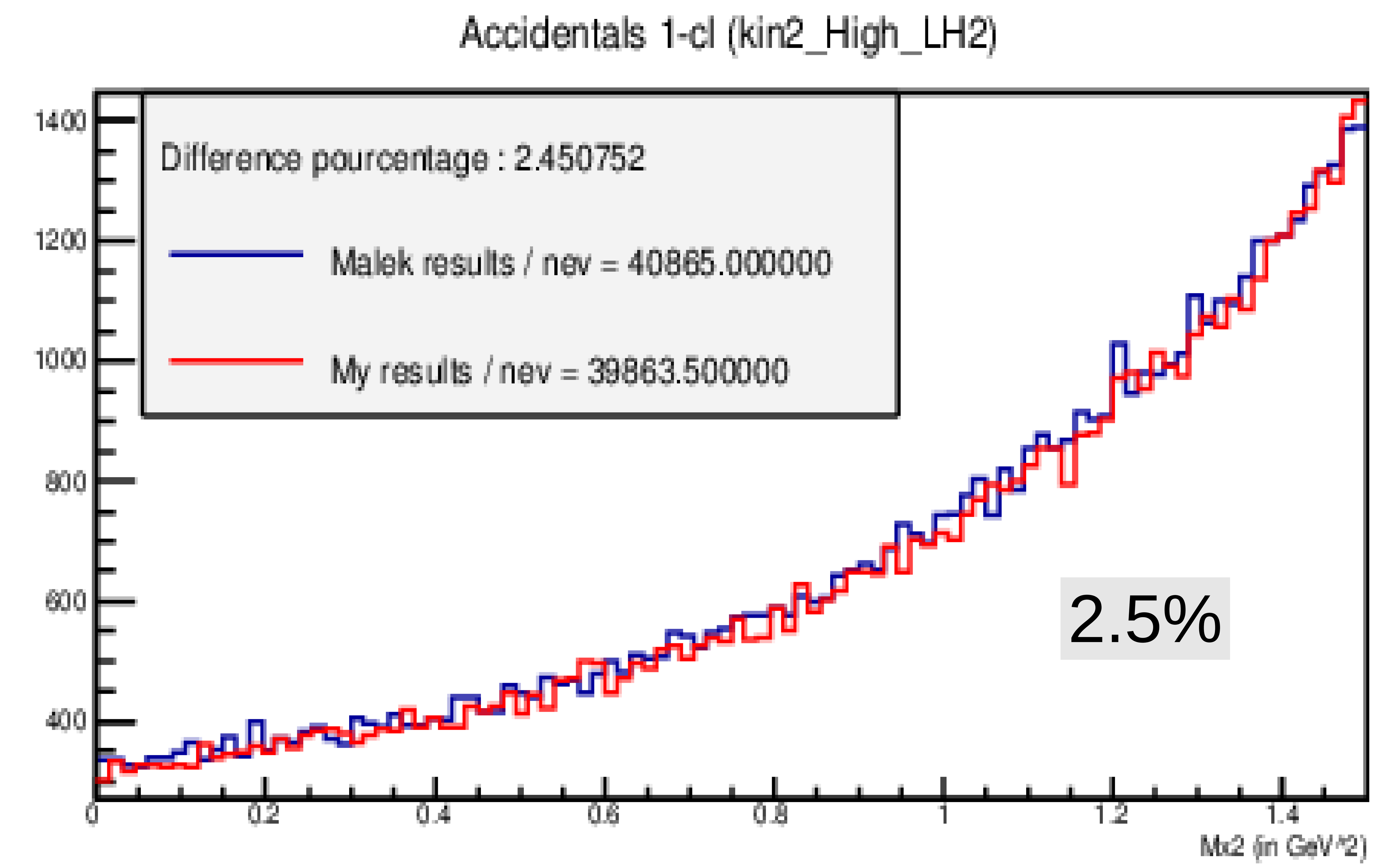


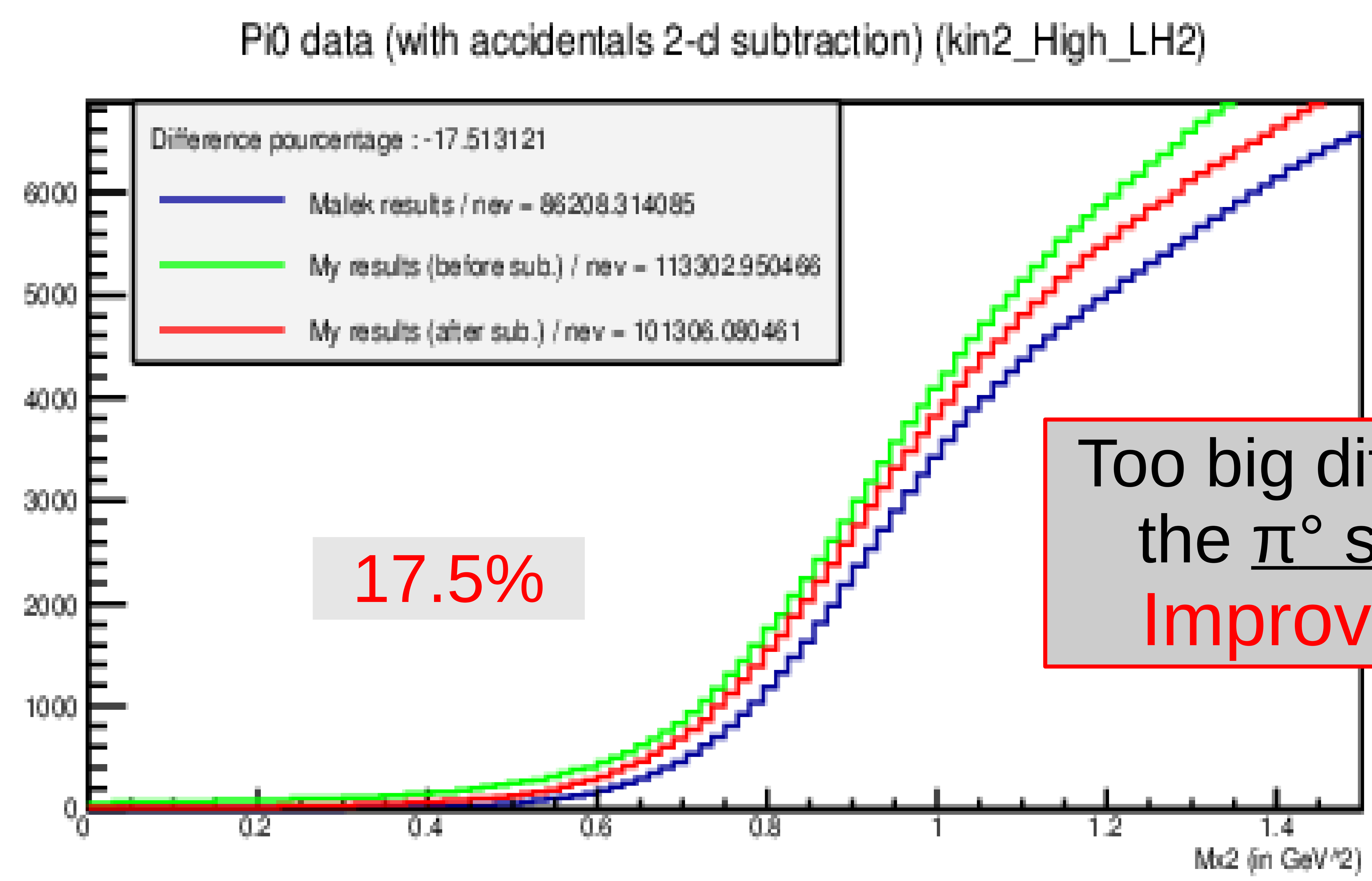
Too big difference (7.4%) due to the <u>π° subtraction method</u> :
Improvement in progress

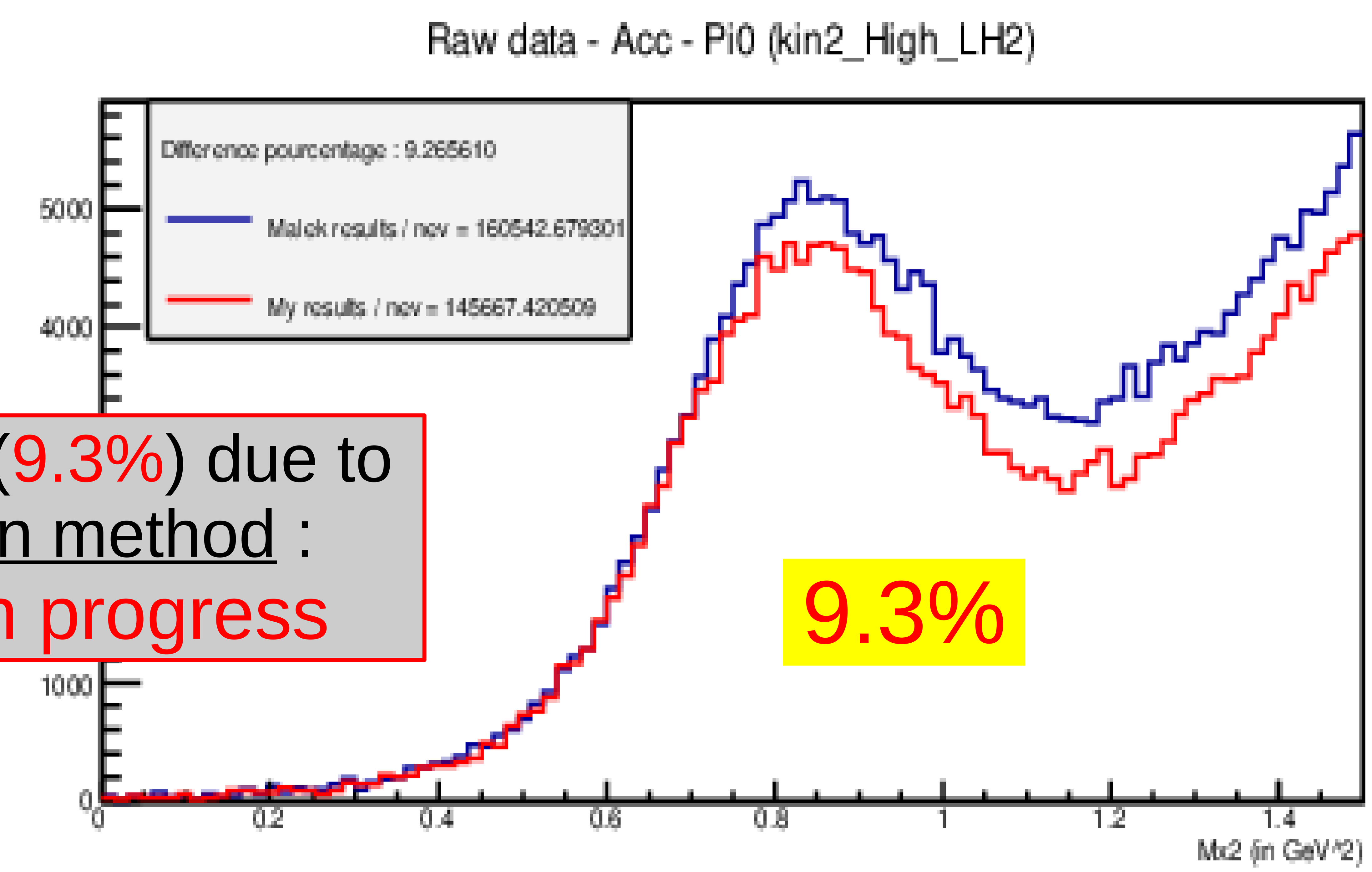
Comparison of 2 parallel analysis for the contamination subtraction
(with fermi motion)

LH2 Target (*with* fermi motion) : Malek results (blue) / My results (red)



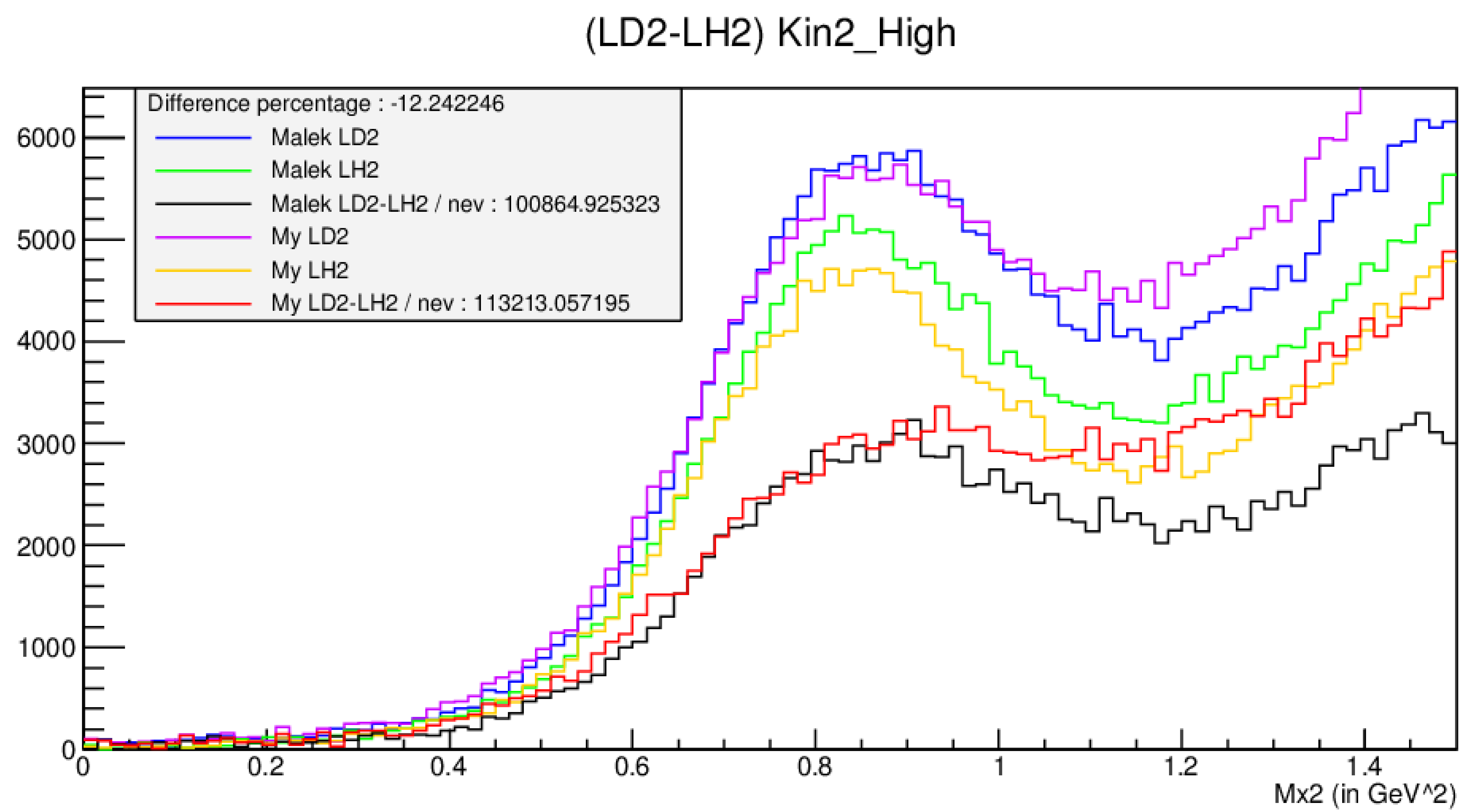






Too big difference (9.3%) due to the π° subtraction method :
Improvement in progress

Comparison of the LD2-LH2 targets subtraction



<u>Conclusion</u> :

→We notice the same shift of the Mx2 peak between the LD2 target and the LH2 target for Malek results

To get Deuterium results … (the next tasks)

Comparison of the 2 analysis for the contamination subtraction to improve

Investigation of the relative calibration of the targets (= shift of the Mx2 peak between LD2 and LH2)

Analysis of the kinematic kin2Low

Studying the impact of the cuts variations on the Mx2

Back up

Contamination subtraction to the DVCS (ep(n) → e'p'(n')γ)

Raw data = DVCS + Accidentals + π°

Exclusive (ep → e'p'° → e'p')

Inclusive (ep→ e'(X)π° → e'(X)γγ)

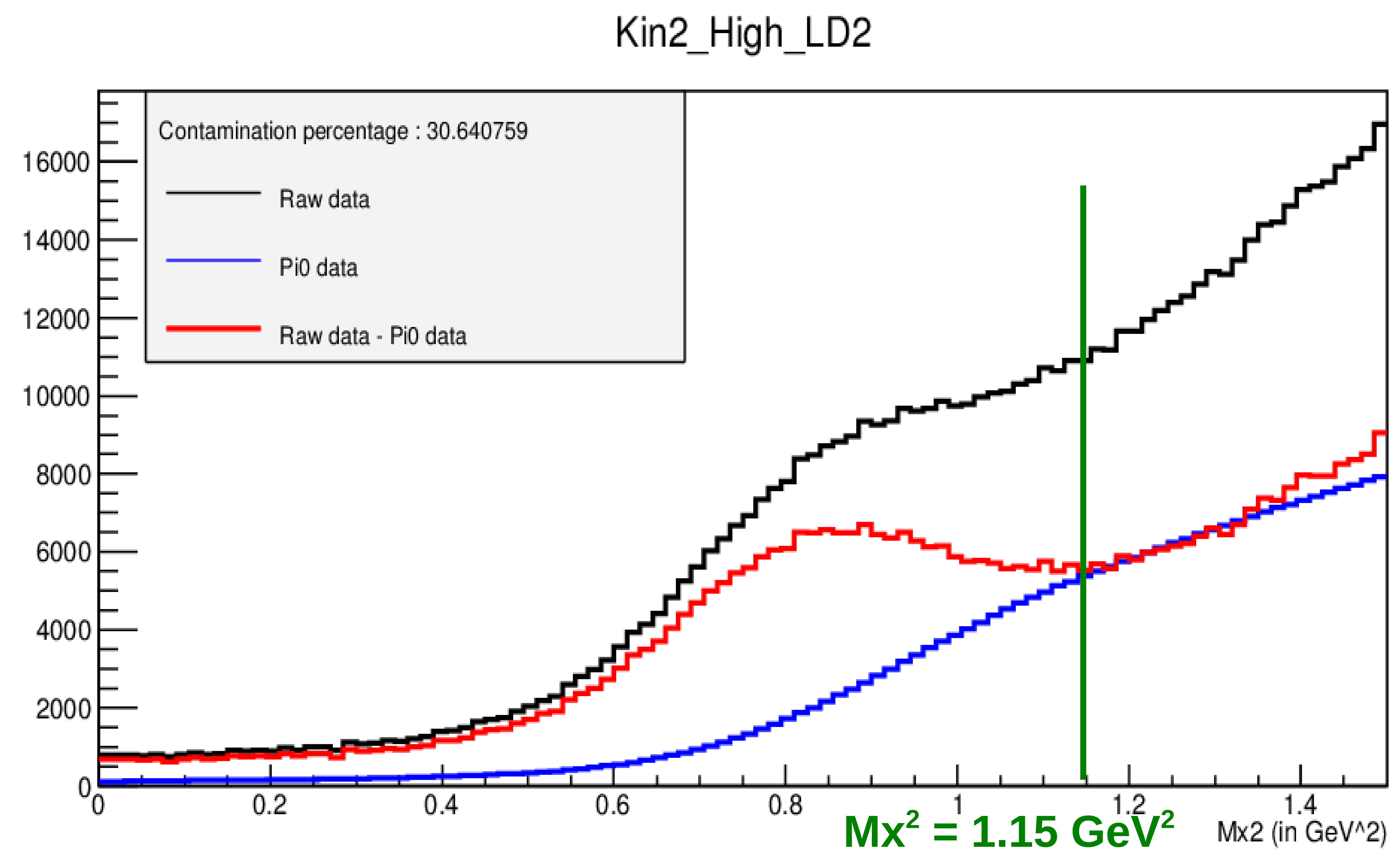
Associated-DVCS (ep → e'p'(X)γ) :

→Example : **ep → e'p'π°γ , ep → e'p'π⁺π⁻γ ...**

→First channel inclusive π° **(ep → e'p'π°γ)** with a missing mass square :

$$Mx^2 = (M_p + M_{\pi°})^2 = 1.15\ GeV^2$$

We apply a cut on the Mx2 (**$Mx^2 < 1.15 GeV^2$**) to discard the inclusive π° events from the raw data.



Contamination subtraction to the DVCS (ep(n) → e'p'(n')γ)

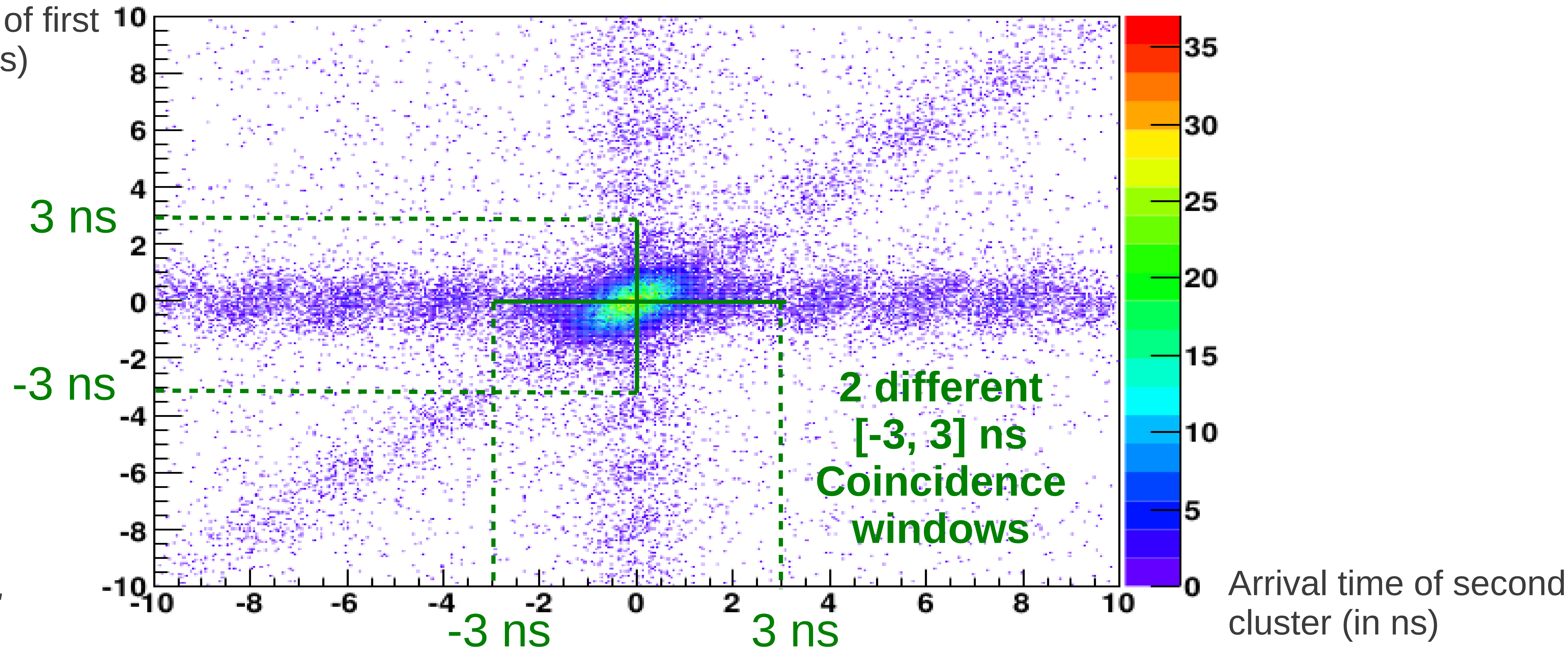
Raw data = DVCS + Accidentals + π°

Accidentals :

→ DVCS photons in the **[-3, 3] ns coincidence** window

→ Photons **not related to the trigger electron** are detected in the **[-3, 3] ns coincidence** window (= not coming from the vertex)

→ **Uniform contamination in the time** on the 128 ns of the acquisition window



Camsonne A.

Contamination subtraction to the DVCS (ep(n) → e'p'(n')γ)

Raw data = <u>DVCS</u> + Accidentals + π°

Accidentals 1 cluster :

→ 1 photon detected in the coincidence window → **[-11, -5] ns or [5, 11] ns**

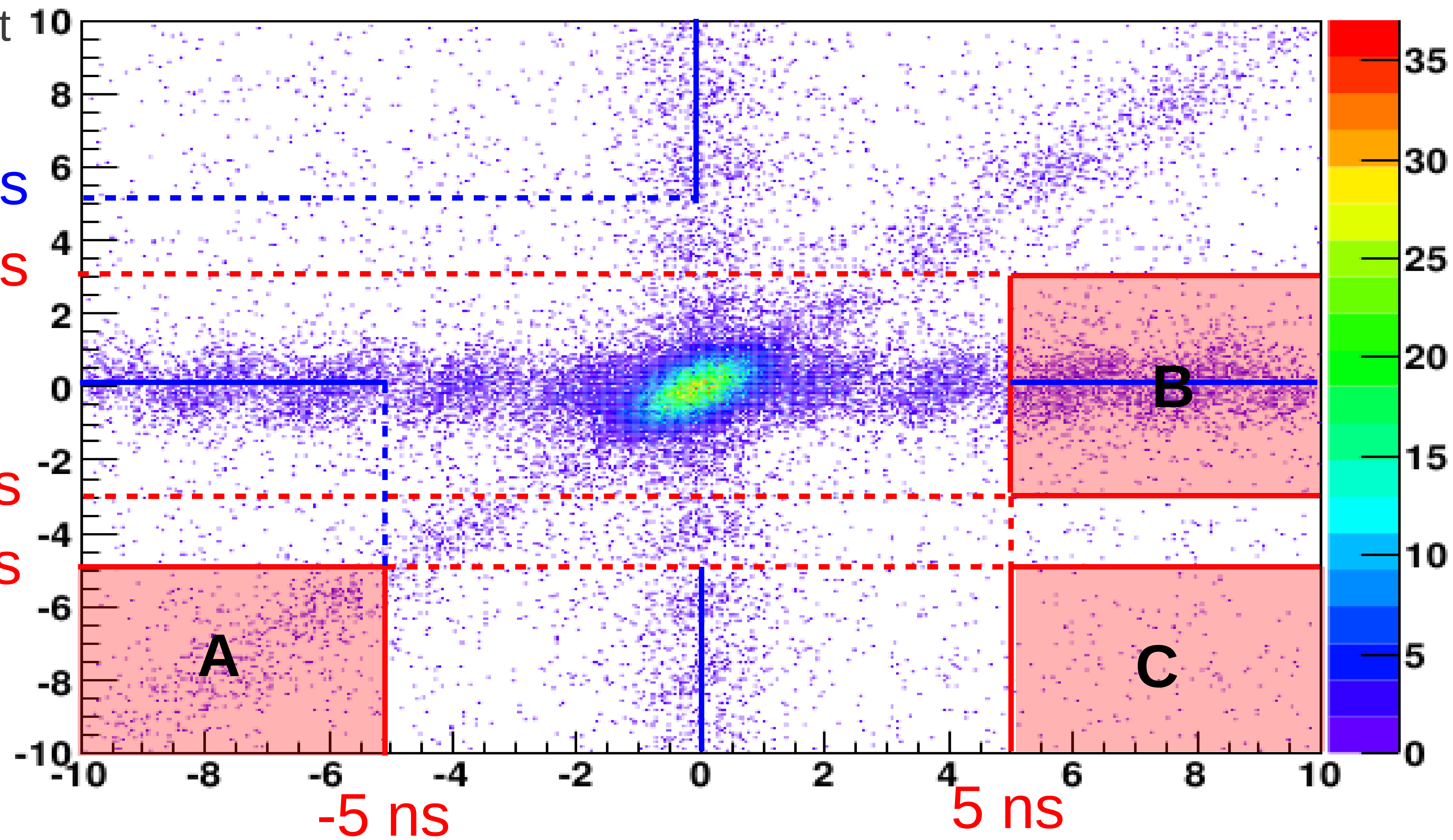
Accidentals 2 cluters (3 types) :

→ A) 2 photons related to a π°, so the both in coincidence → **[-11, -5] ns and [-11, -5] ns**

→ B) 2 photons not related to a π°, with one of them in coincidence → **[-3, -3] ns and [5, 11] ns**

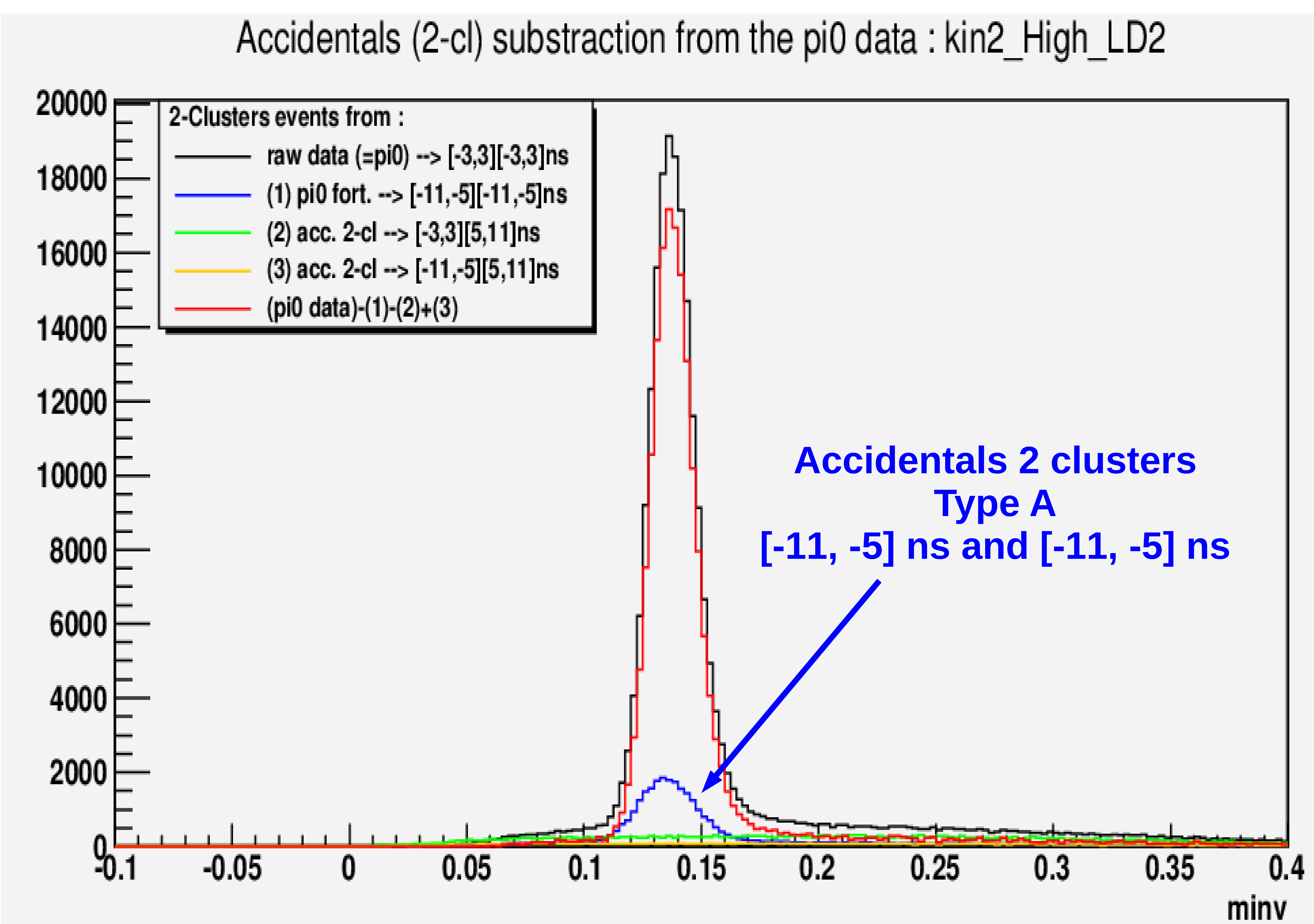
→ C) 2 photons not related to a π°, and none of them in coincidence → **[-11, -5] ns and [5, 11] ns**

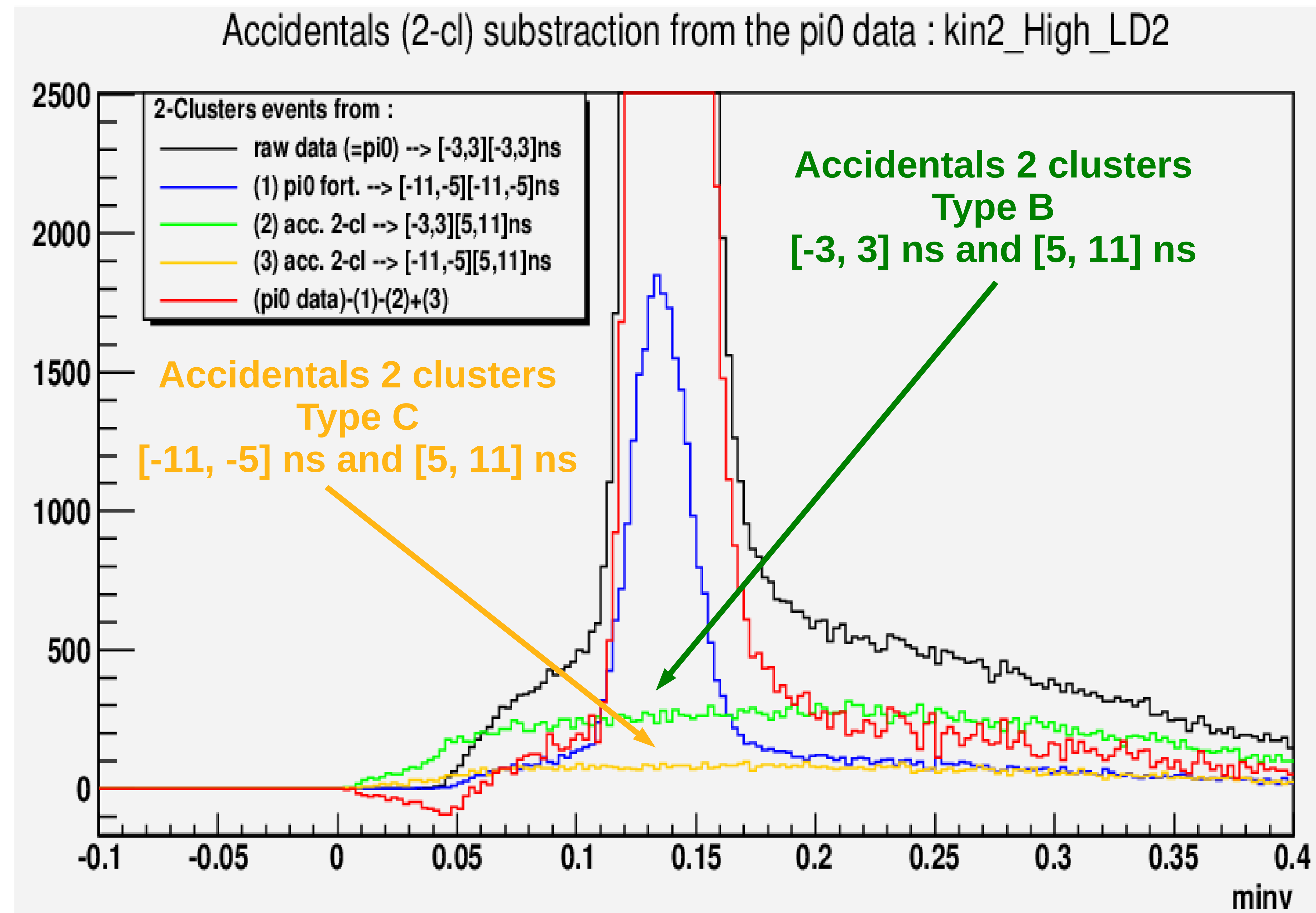
<u>**We shift in time the 6 ns acquisition window to take only accidentals events**</u>

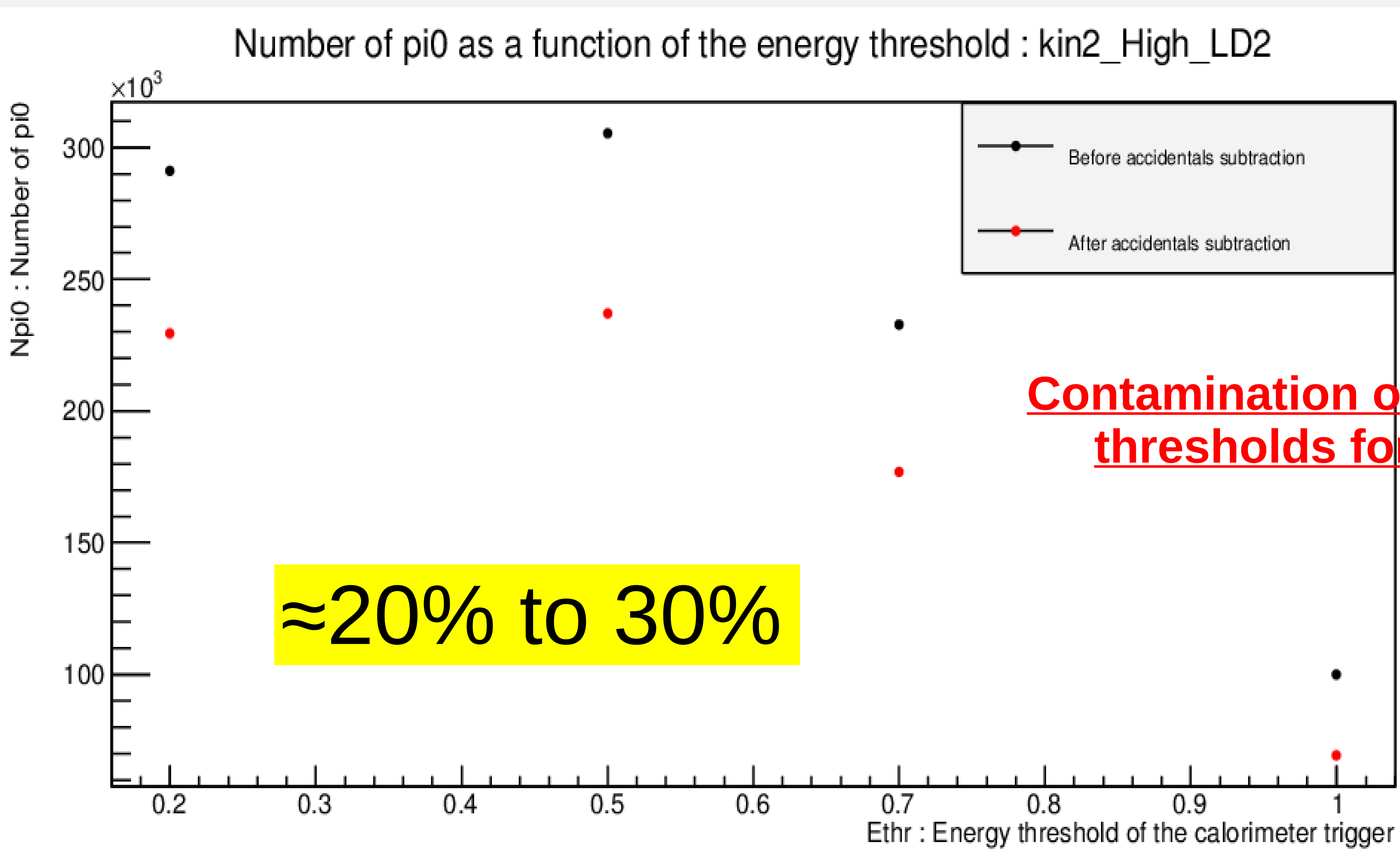


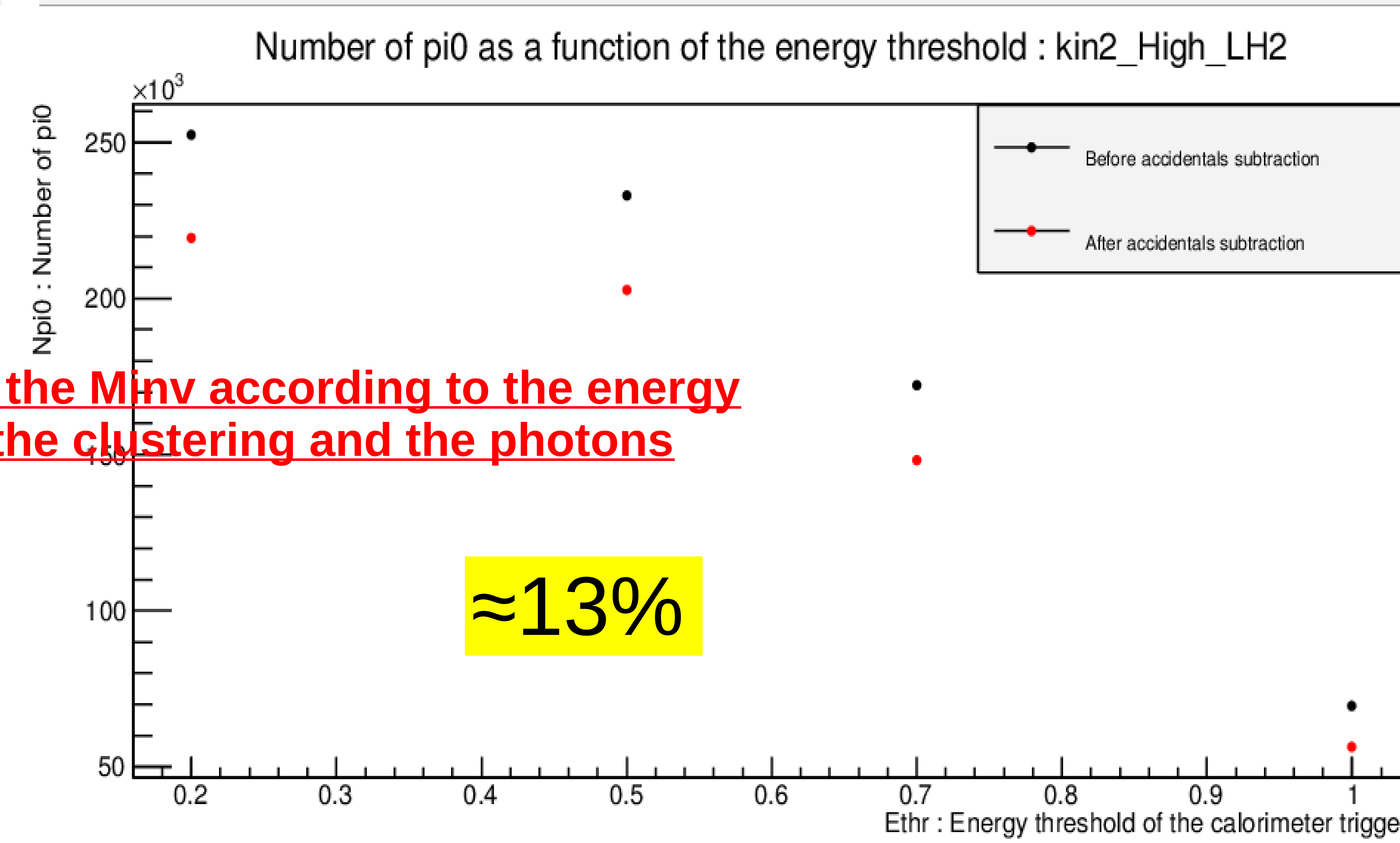
Camsonne A.

Check of the accidentals 2 clusters subtraction with the Minv





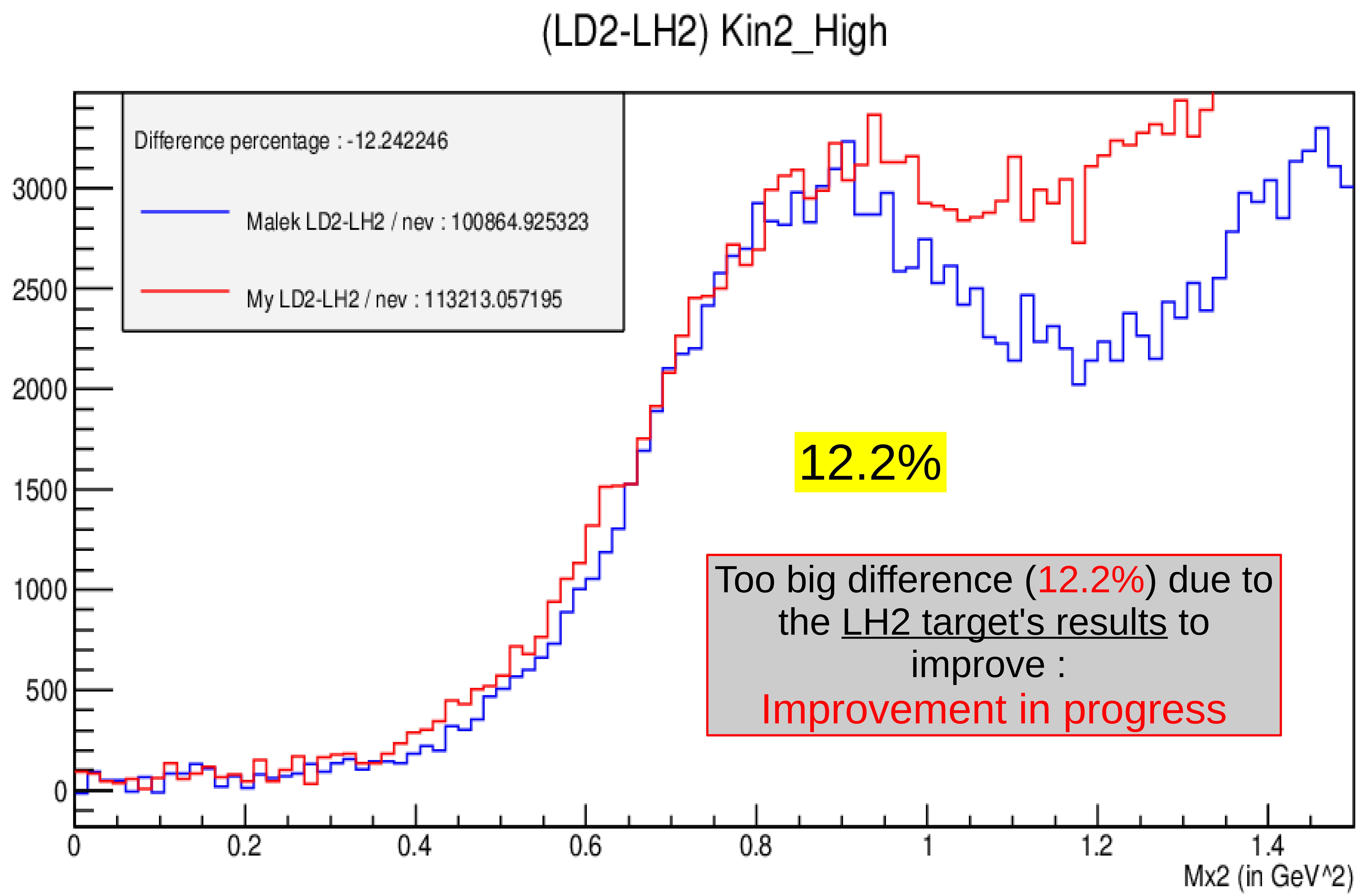




Contamination on the Minv according to the energy thresholds for the clustering and the photons

Cross check of the LD2-LH2 targets subtraction

LD2 – LH2 : M. Ben Ali results (blue) / My cross check results (red)



Too big difference (12.2%) due to the LH2 target's results to improve :
Improvement in progress