DVCS collaboration meeting

January 26th 2018

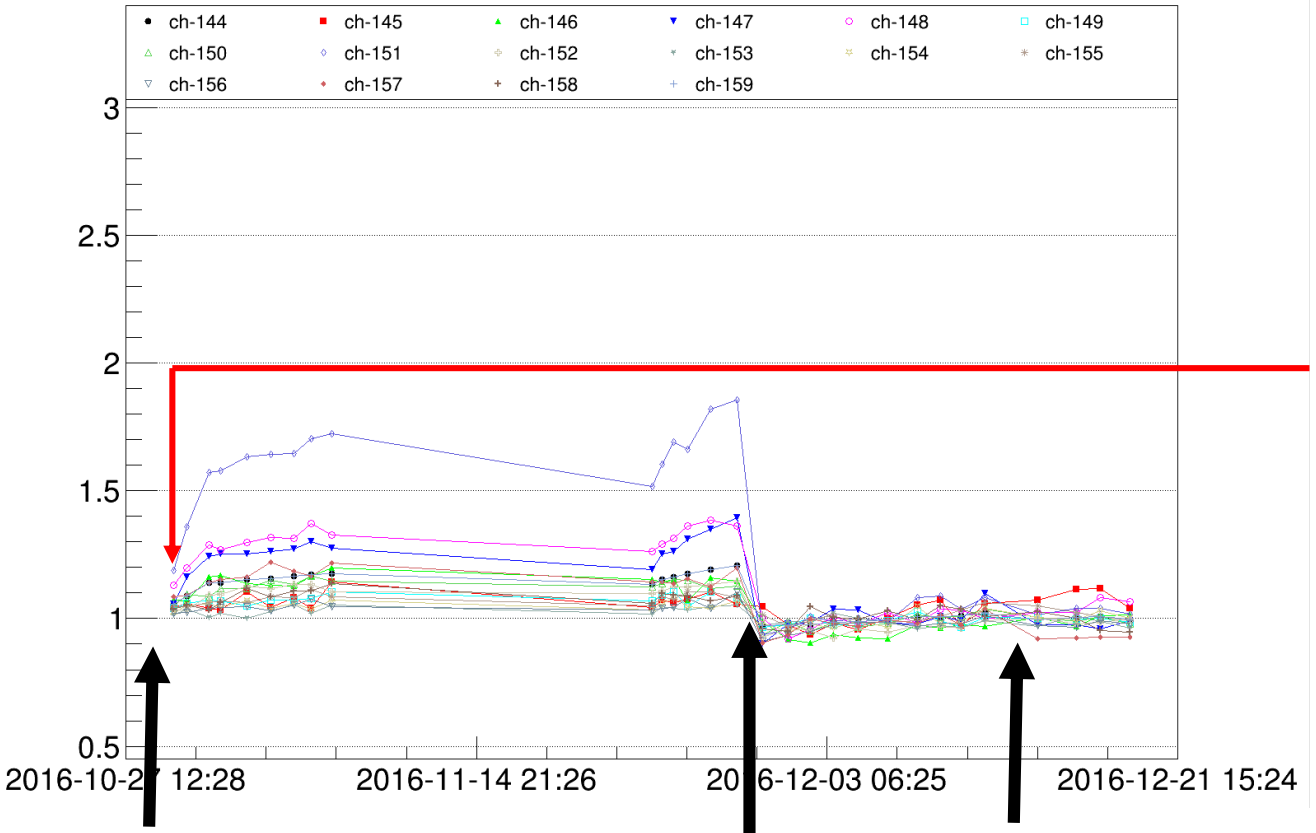
Calorimeter analysis update

Frédéric Georges

π^0 calibration

π^0 calibration

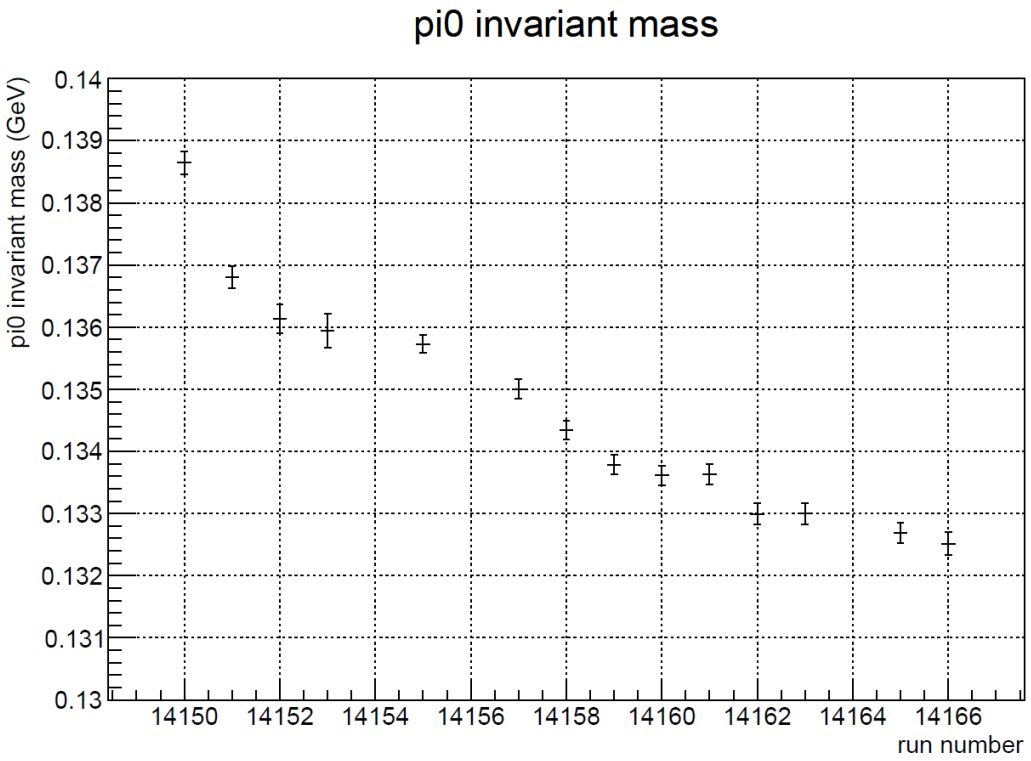
- Done for all kinematics (Fall 2014, Spring 2016, Fall 2016)



elastic calibration

elastic coefficients changed

elastic calibration



- Issue : loss of gain sometime too fast for π^0 calibration (usually : after long down time, or at the start of a run period)

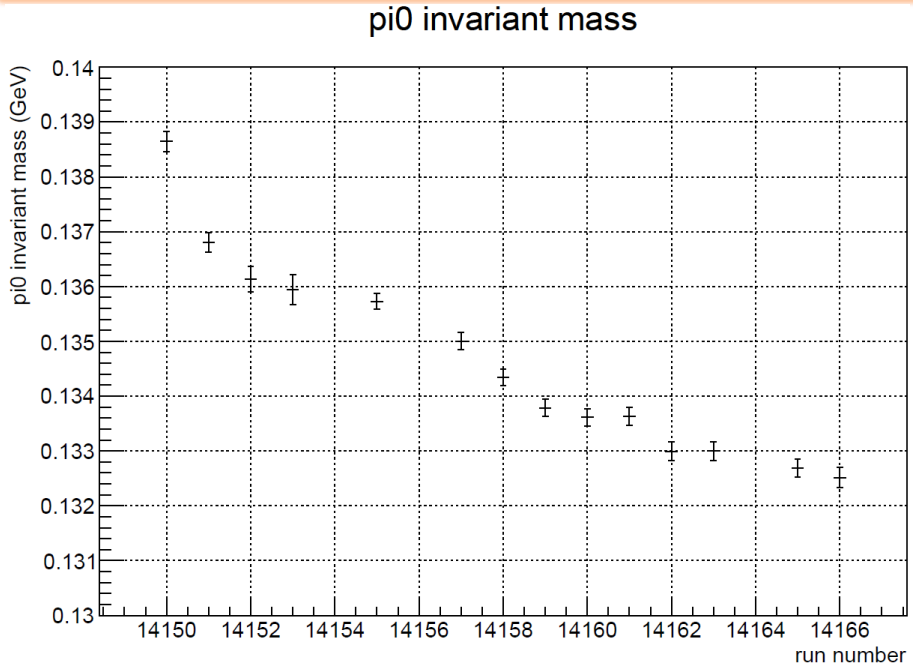
π^0 calibration

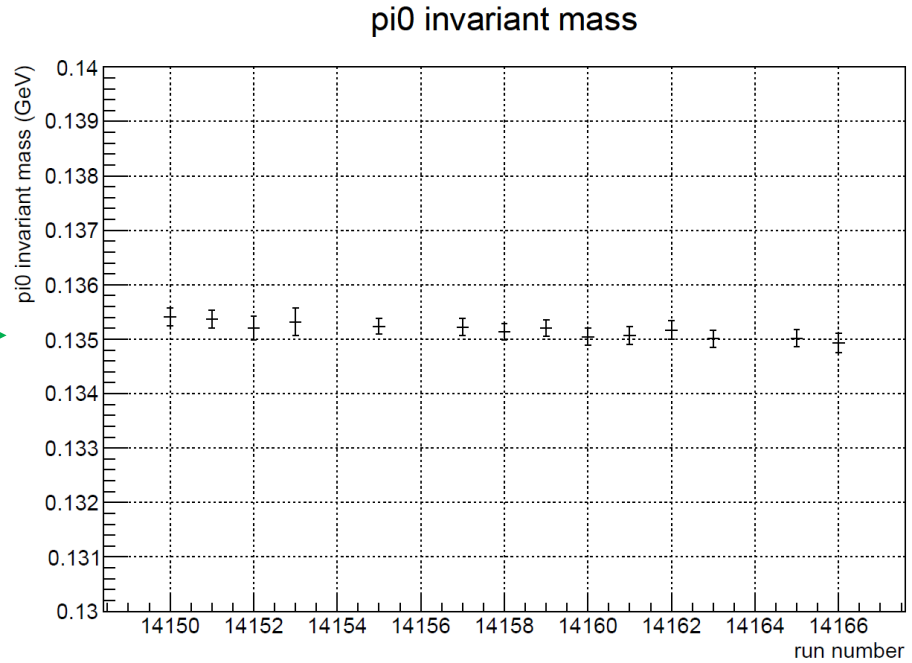
- Linear interpolation/extrapolation : did not work
- Exponential fit : did not work (Later realized I made a mistake in my formula. Might have worked.)
- Empirical correction :
  - **Approximation** : loss of gain similar for all (most of) the blocks

  → Variation of π^0 invariant mass proportional to the variation of π^0 calibration coefficients

  → **Correction run by run of π^0 calibration coefficients** by a factor $\frac{0.134977\ \mathrm{GeV}}{\text{reconstructed } \pi^0 \text{ mass}}$

SQL DB updated (France & Jlab)

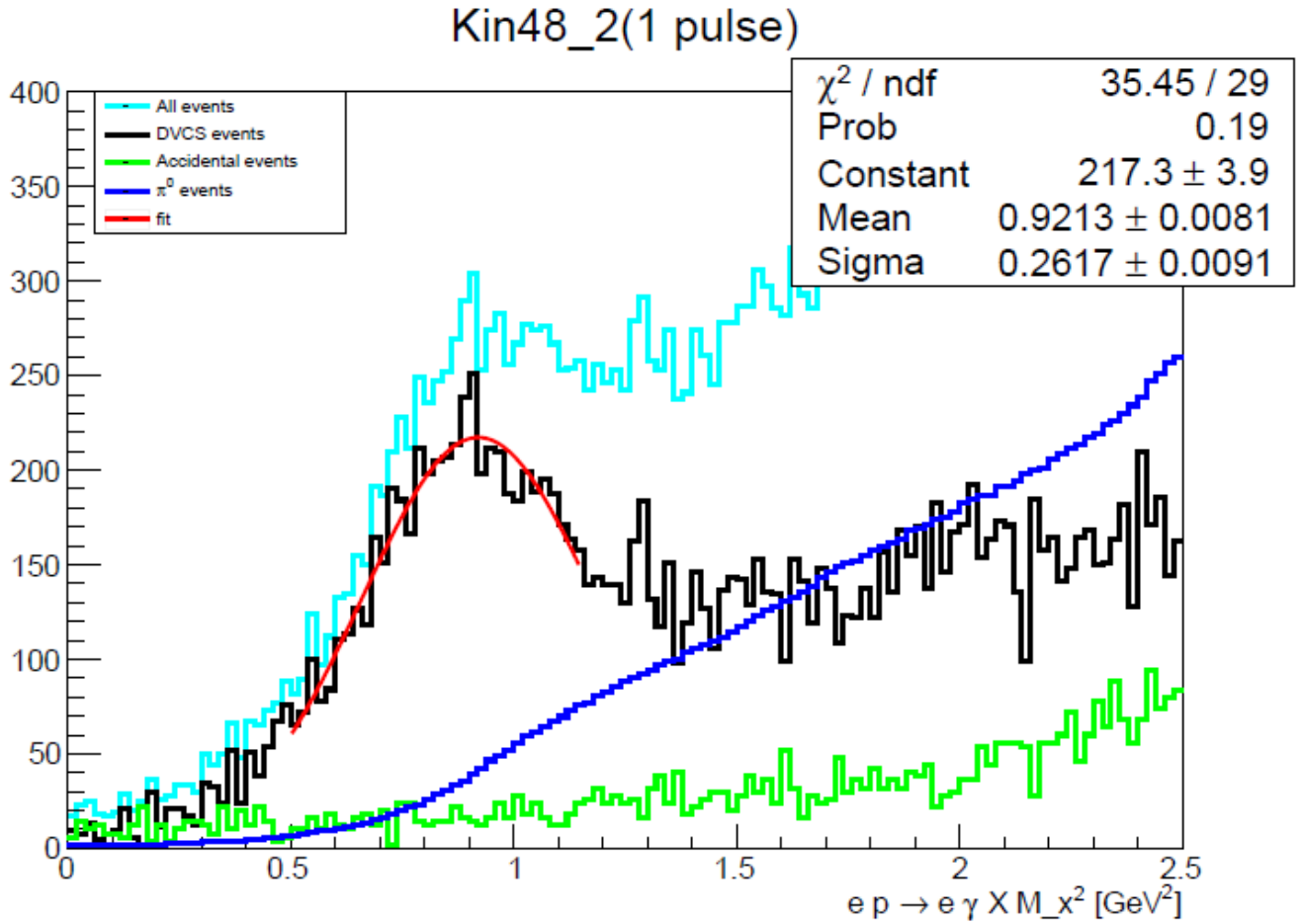




π^0 contamination subtraction

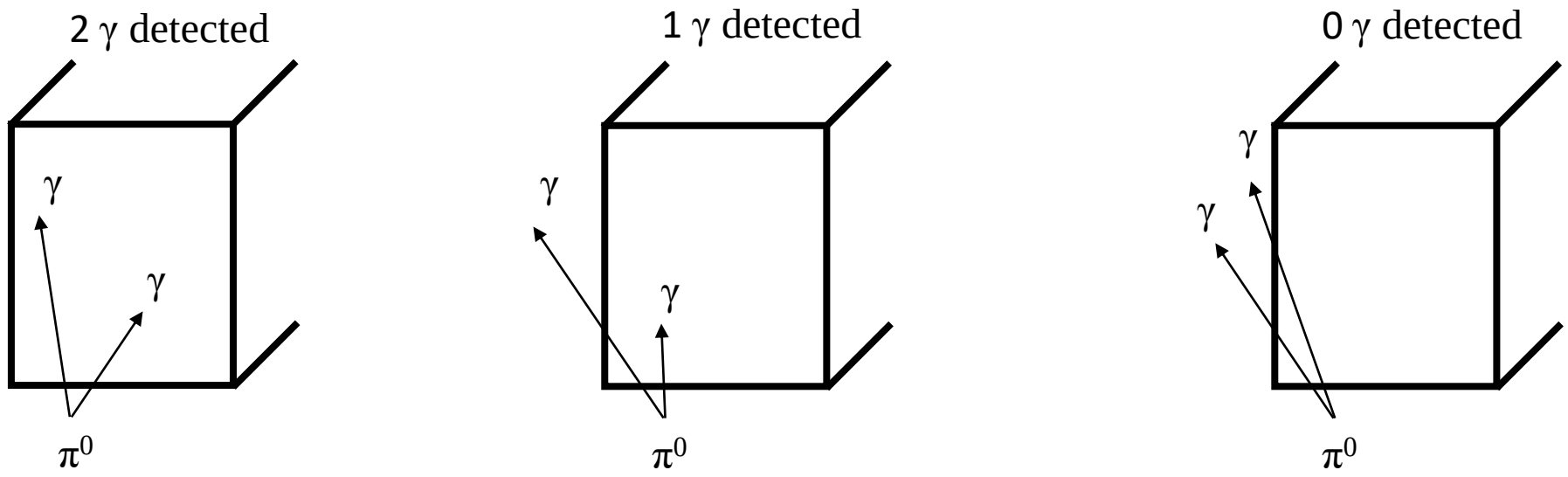
reminder

- DVMP event : ep → epπ^0
- π^0 → $\gamma\gamma$
- If 1 single γ is detected in the calorimeter : looks like a DVCS event ep → epγ
- Missing mass can be compatible with DVCS if missed γ had low energy
- Contamination must be removed



principle

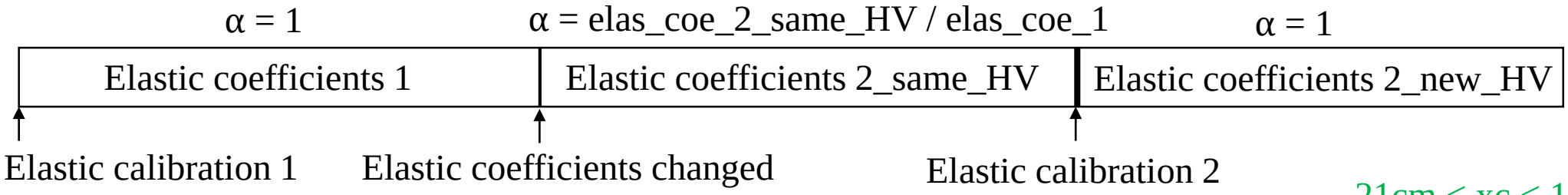
- Real data : ep → epπ^0 events identification : 2 γ in the calorimeter & invariant mass compatible with π^0
- For each detected π^0 : simulation of 5000 decays $\pi^0 \rightarrow \gamma\gamma$ (Monte-Carlo generates random γ directions and energies, projections on calorimeter surface)
- Check if γ are detected (Energy threshold, geometrical cuts) → $0\gamma - 1\gamma - 2\gamma$ cases
- Estimation of the proportion of simulated decays where a single γ is detected
- → π^0 contamination



Description of the subtraction process

- Code basis from Camille Desnault
- Step 1 : From real data, π^0 identification
  - Reads rootfiles after clustering (ana.C).
  - Look at ntuple ntu2 : 2 clusters in the calorimeter
  - Select π^0 with "**Cut1**" :
    - Energy threshold cuts on both clusters : run by run and block by block :

$$TriggerSim * \pi^0 coefficients * \alpha$$



    - Geometrical cuts : removed edges of the calorimeter (3 cm (= 1 block)): -21cm < xc < 12cm, -21cm < yc < 21cm
    - π^0 invariant mass cut : fitted π^0 invariant mass for a few runs of the kinematic, cut at ± 3σ.

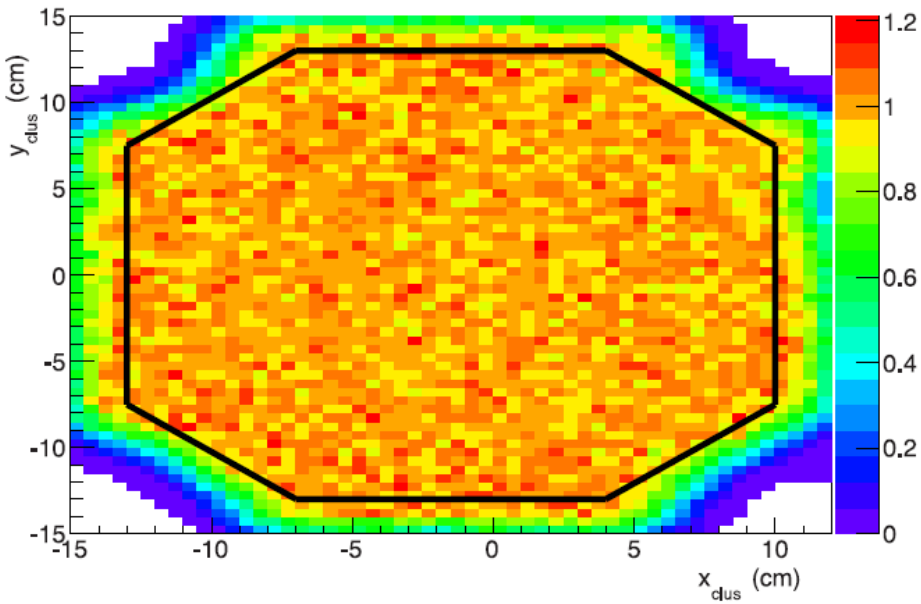
Description of the subtraction process

- Step 2 : For each identified π^0 : Monte-Carlo simulation of 5000 decays $\pi^0 \rightarrow \gamma\gamma$
  - Decay in the π^0 center of mass frame : polar angles θ and ϕ generated uniformly : θ between 0 and π, ϕ between 0 and 2π. Each γ has the energy $E_\pi/2$.
  - Lorentz boost along the π^0 momentum
  - Projection on the calorimeter (+ shower depth correction)
    - Code basis from Malek Mazouz
  - Check if γ detected : **same as "Cut1"**
    - Count the number of cases where 0 – 1 – 2 γ are detected : $N_{0\gamma}$, $N_{1\gamma}$, $N_{2\gamma}$ out of the 5000 decays
  - For each π^0, save $N_{0\gamma}$, $N_{1\gamma}$, $N_{2\gamma}$ and 1γ case as if real DVCS data (cf. ana.C)

Description of the subtraction process

- Step 3 : Subtraction.
  - Simulated data from the π^0 subtraction process must be **normalized** by $\frac{1}{5000} * \frac{1}{\frac{N_{2\gamma}}{5000}} = \frac{1}{N_{2\gamma}}$
  - "**Cut2**" : same cuts must be applied to real data and simulated subtraction data.
    - Energy threshold (preliminary : clustering energy threshold)
    - Geometrical cuts : An "octagonal" cut must be applied to account for inefficiencies of the subtraction method in the corners (to be determined)
    - Other cuts can be added…

π^0 subtraction efficiency, from Maxime Defurne thesis

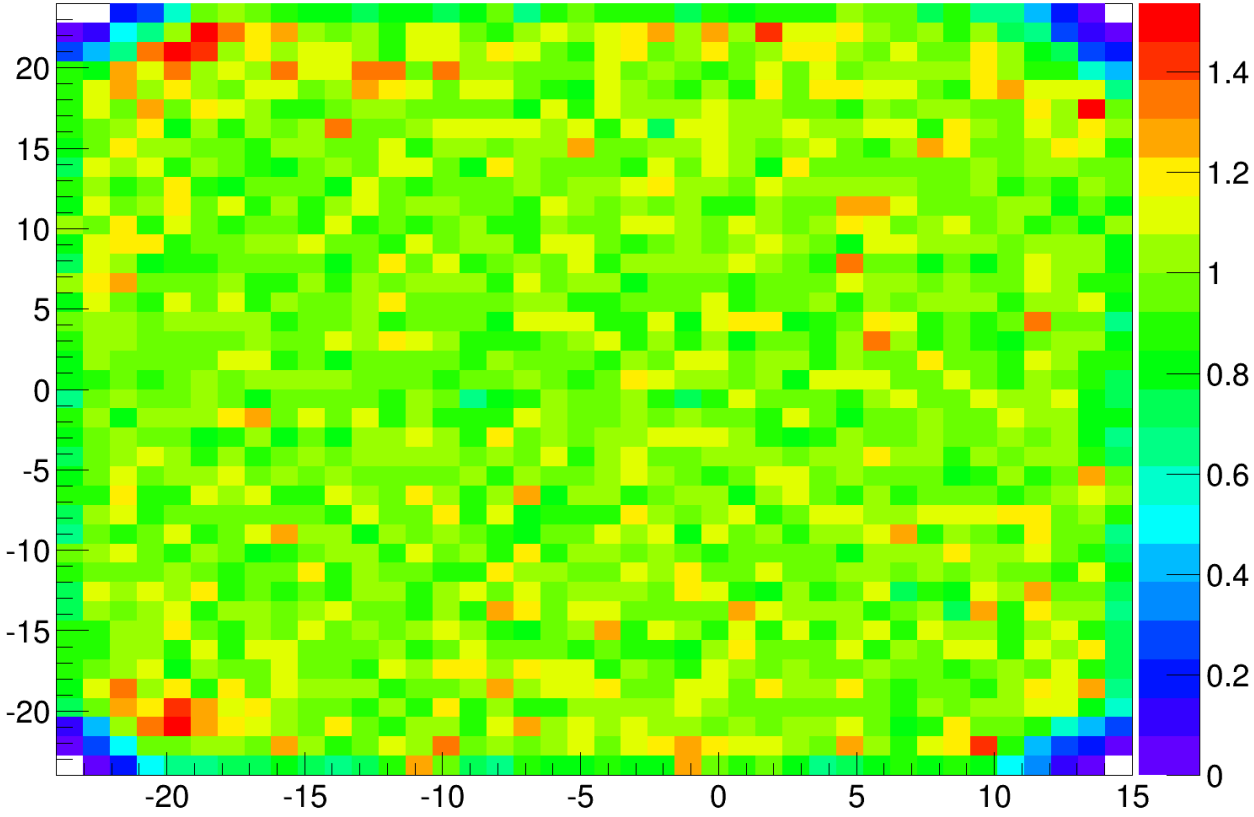


Method checking against Monte-Carlo

- Goal : reproduce the efficiency plot from Maxime Defurne's thesis to check the subtraction results against simulation.
- Used Maxime Defurne's thesis Monte Carlo simulation :
  - Generates π^0 uniformly (polar angles + energy) & simulates a decay & projection on the calorimeter
  - Ran π^0 subtraction on 2-γ events & compared results to 1-γ events
- GOOD

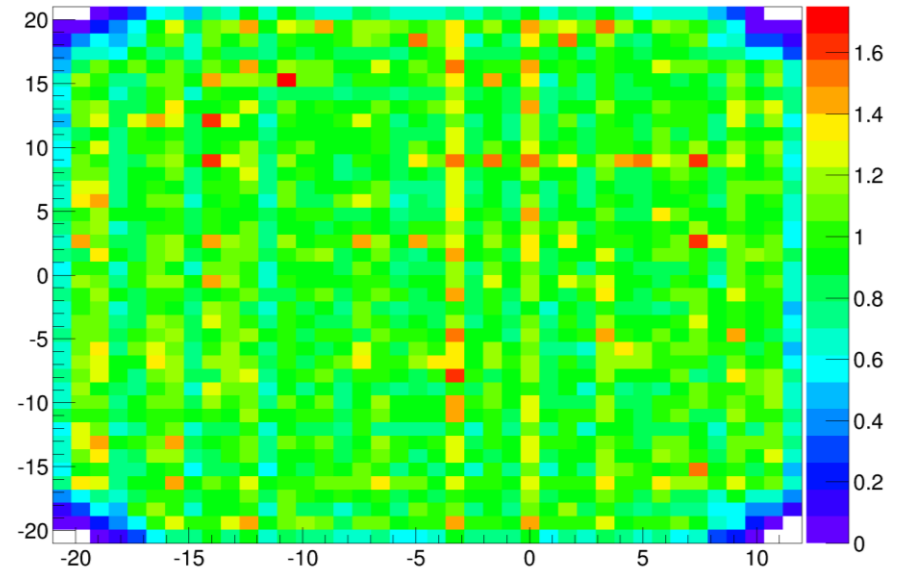
π^0 subtraction efficiency, for kin48_2 (run 13000)

(with cut $M_x^2 < 1.35$ GeV)



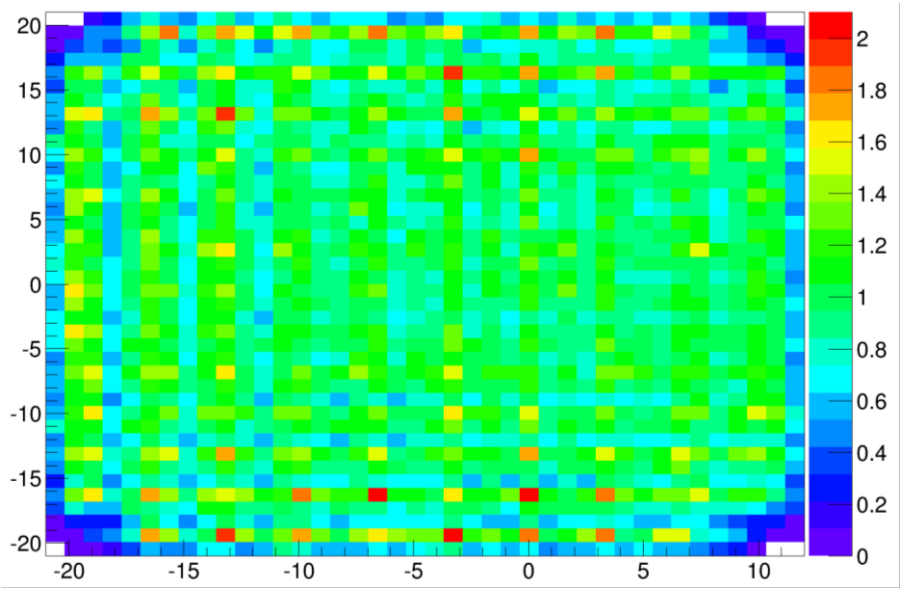
Method checking against Geant4

- Used Geant4 simulation from Rafayel (pi0_2010/no_esmear)
  - Modification to save 1-cluster events too
  - Tested a 12 GeV kinematic (run 220 ~kin48_2)
  - Tested a 6 GeV kinematic (run 9124, kin3high)
- GOOD



π^0 subtraction efficiency, for ~kin48_2 (run 220)

(with cut $M_x^2 < 1.2$ GeV)



π^0 subtraction efficiency, for kin3high (run 9124)

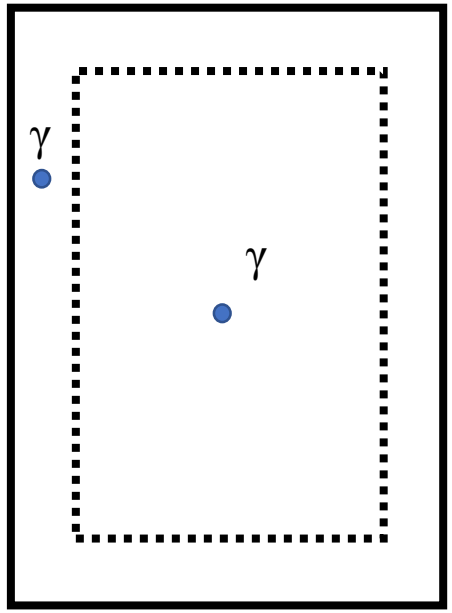
Cuts discussion

- **Discussion on Cut1 geometrical cut : Do we cut the edges of the calorimeter (3cm) or not ?**
- Pros : γ energy reconstruction on the edges of the calorimeter is biased by energy leaks.
- Cons : In the simulation, 2-γ events can be mistaken for 1-γ events

Real data :

1. 2 clusters detected : 2-γ event
2. During data analysis : 1 γ is on the edge of the calorimeter : whole event discarded.

3. **Final situation : no π^0 contamination, no event kept**



Simulated subtraction data :

1. 2 clusters : should be a 2-γ event
2. But 1 γ is on the edge of the calorimeter : γ discarded. But the other γ is kept.

3. **Final situation : 1-γ event, counted as a contaminating π^0 event**

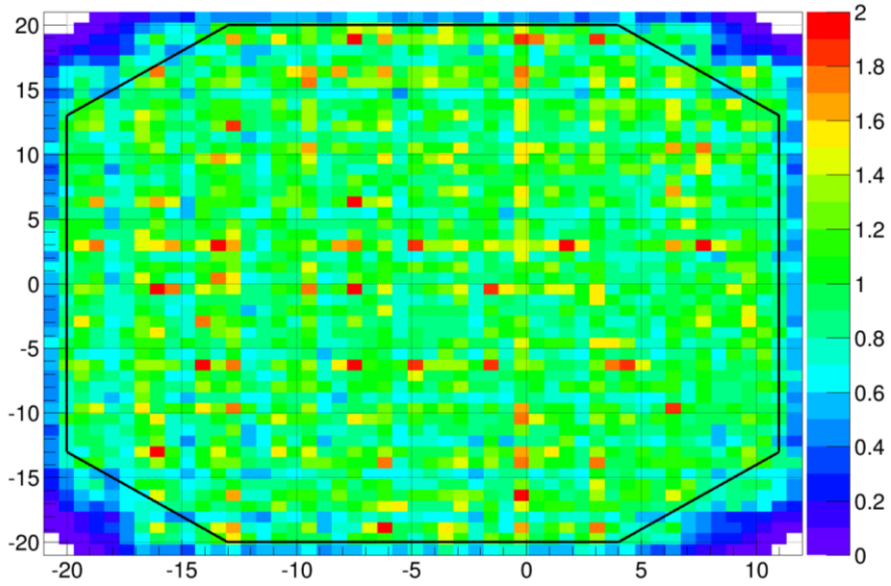
4. Cannot discard both γ and count a 0-γ event : false
5. Cannot discard whole event as if did not exist either.

- Estimation from data : 1/3 of π^0 events are in this situation
- If cut $Mx^2 < 1.35$ GeV : 0.5% only. Error seems acceptable.

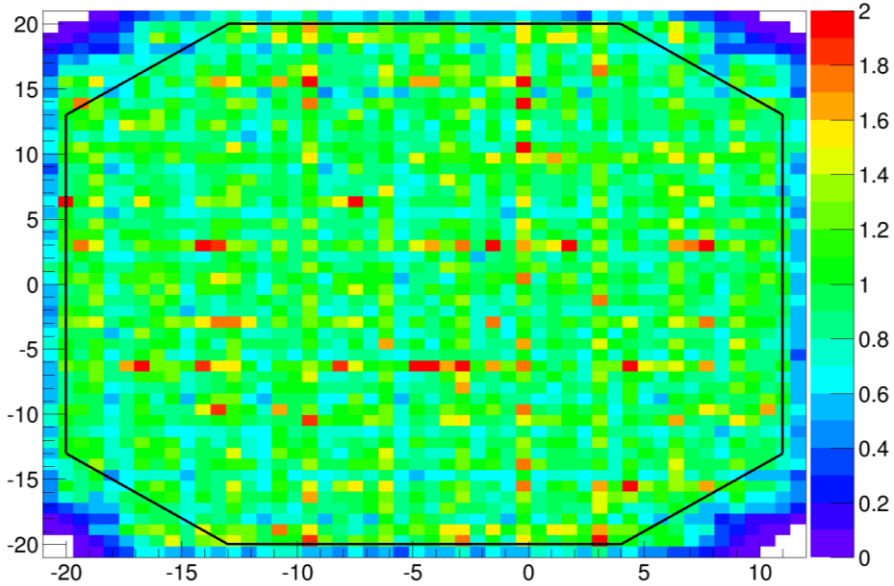
Octagonal cut

- Proposition for all kinematics:

$$\begin{cases} yc \leq 20 \\ yc \geq -20 \\ xc \leq 11 \\ xc \geq -20 \\ yc - xc \leq 33 \\ yc + xc \leq 24 \\ yc + xc \geq -33 \\ yc - xc \geq -24 \end{cases}$$

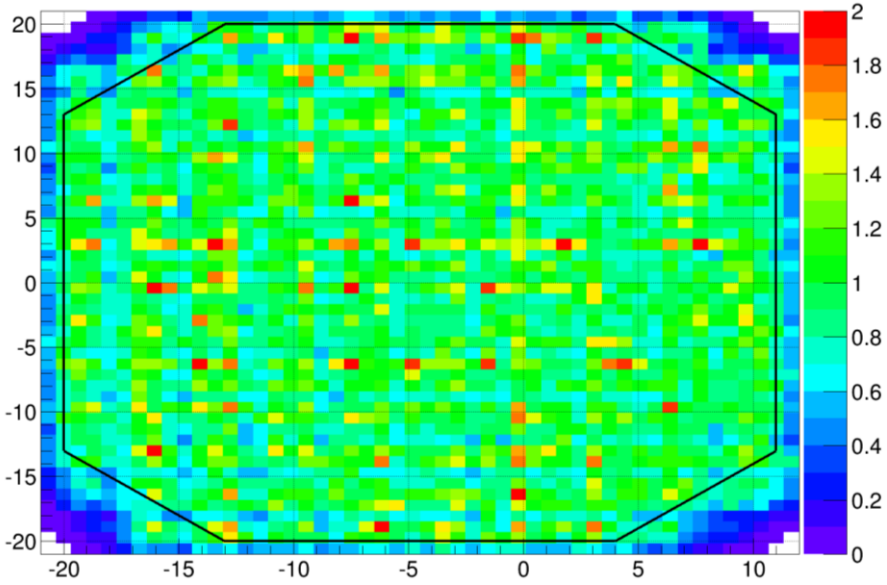


π^0 subtraction efficiency, for run 12508 (kin48_1)

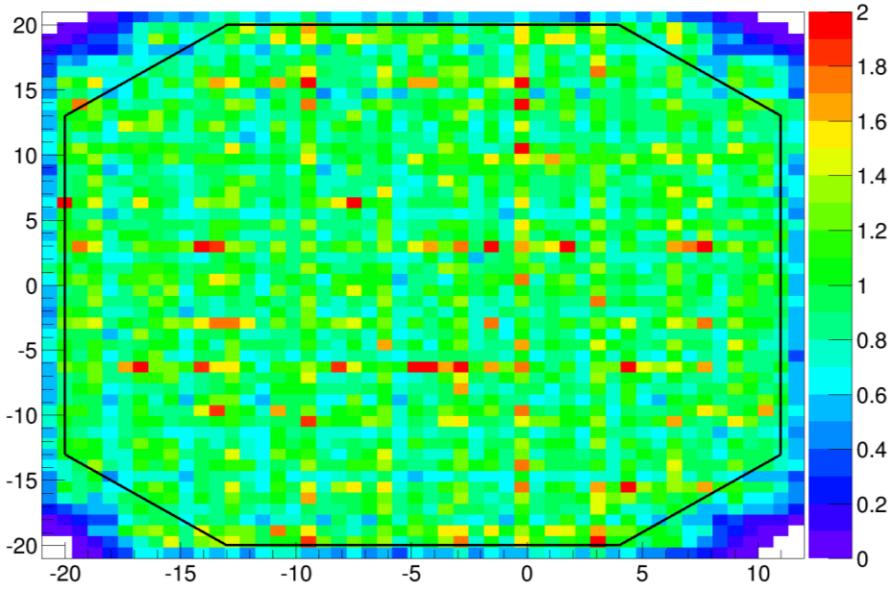


π^0 subtraction efficiency, for run 13000 (kin48_2)

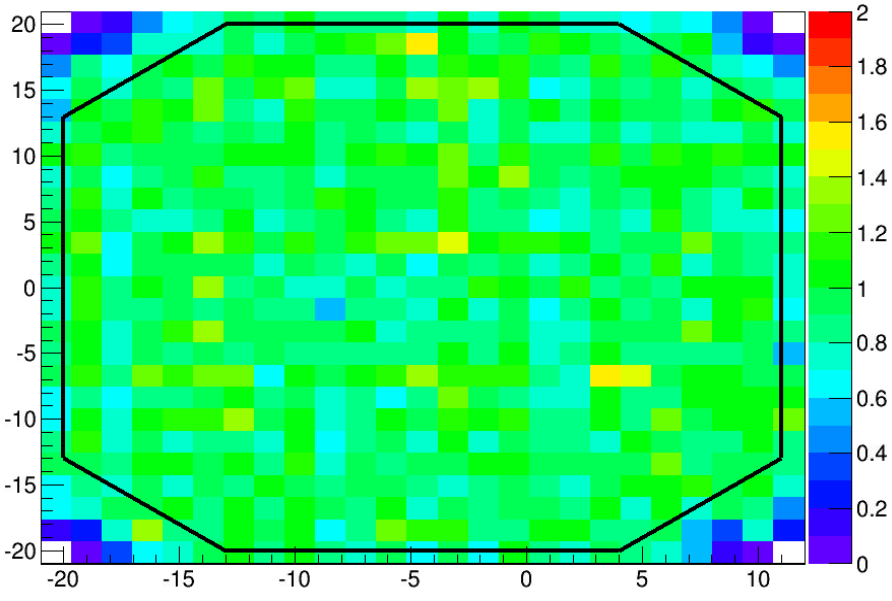
Octagonal cut



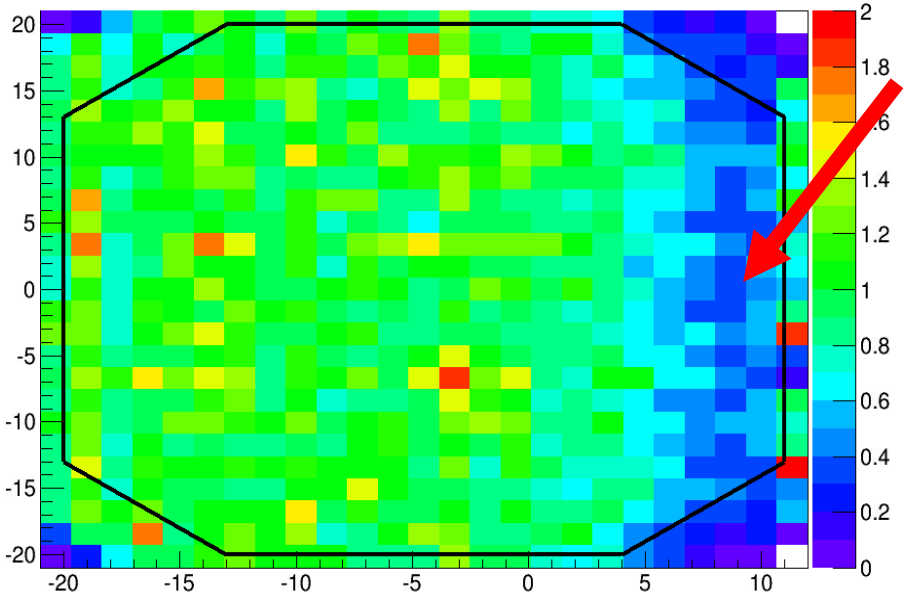
π^0 subtraction efficiency, for run 12508 (kin48_1)



π^0 subtraction efficiency, for run 13000 (kin48_2)



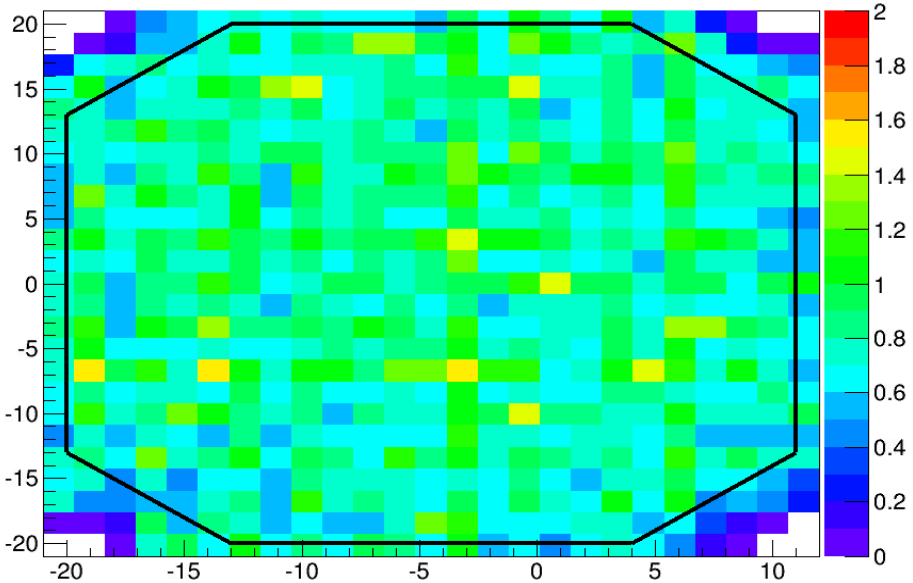
π^0 subtraction efficiency, for run 12838 (kin48_3)



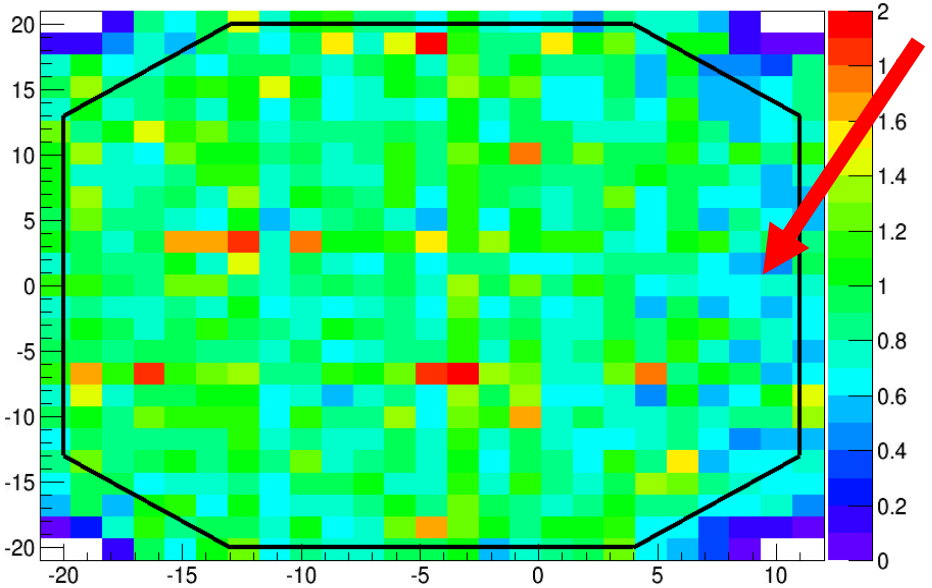
Geant4 issue ?

π^0 subtraction efficiency, for run 13100 (kin48_4)

Octagonal cut

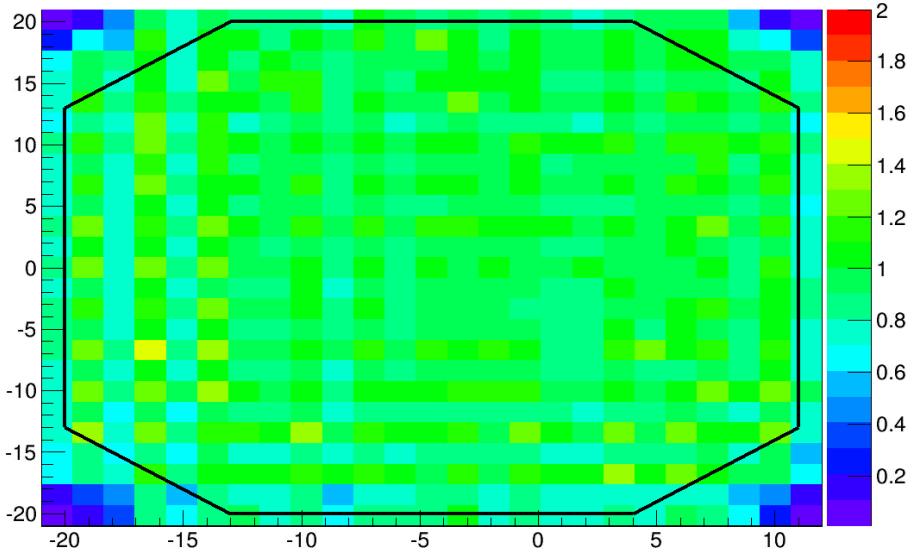


π^0 subtraction efficiency, for run 14150 (kin36_2)

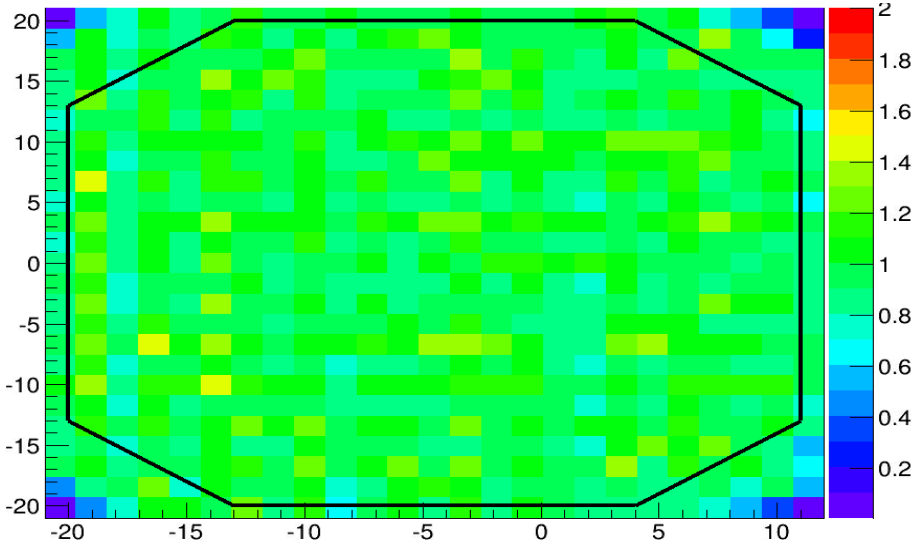


Geant4 issue ?

π^0 subtraction efficiency, for run 14476 (kin36_3)

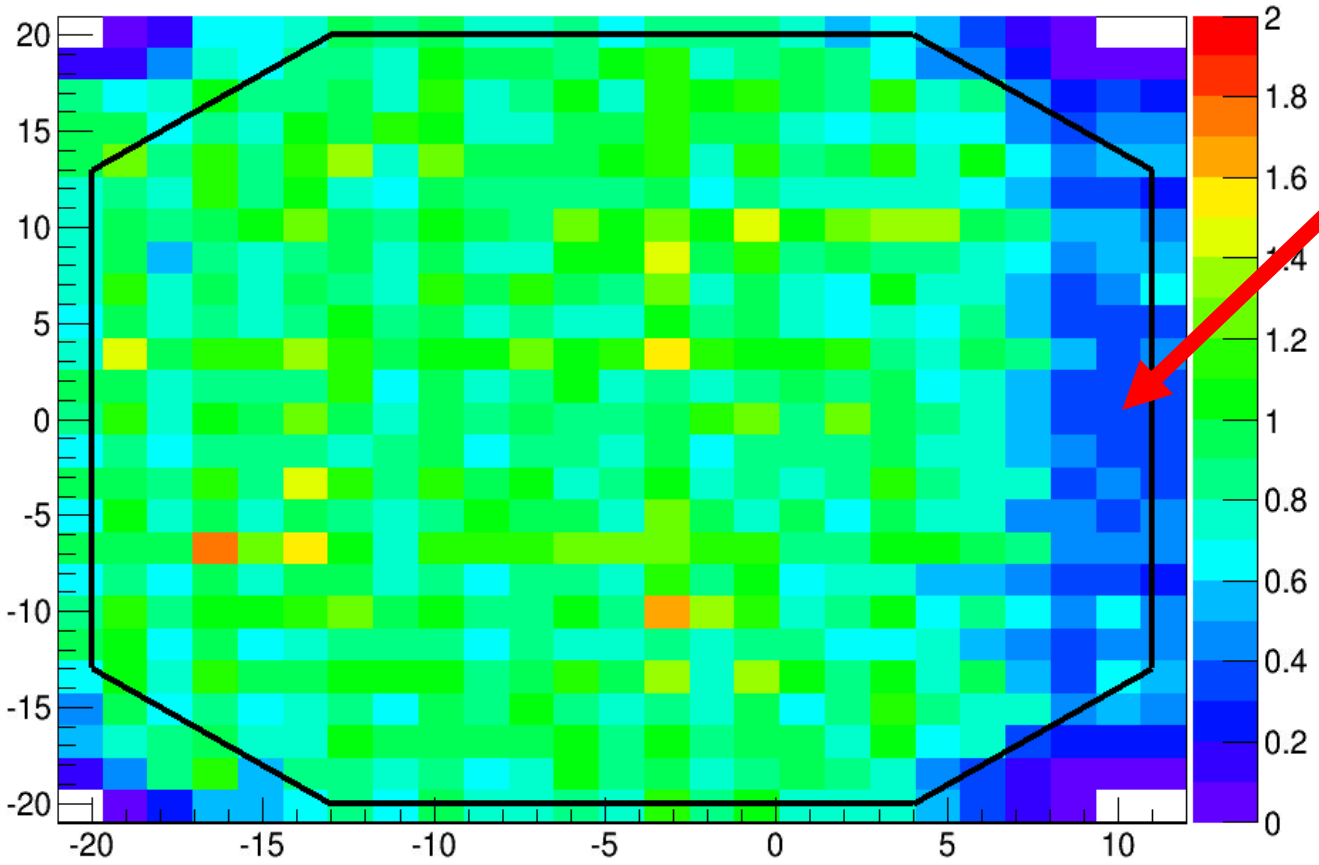


π^0 subtraction efficiency, for run 14270 (kin60_1)



π^0 subtraction efficiency, for run 14528 (kin60_3)

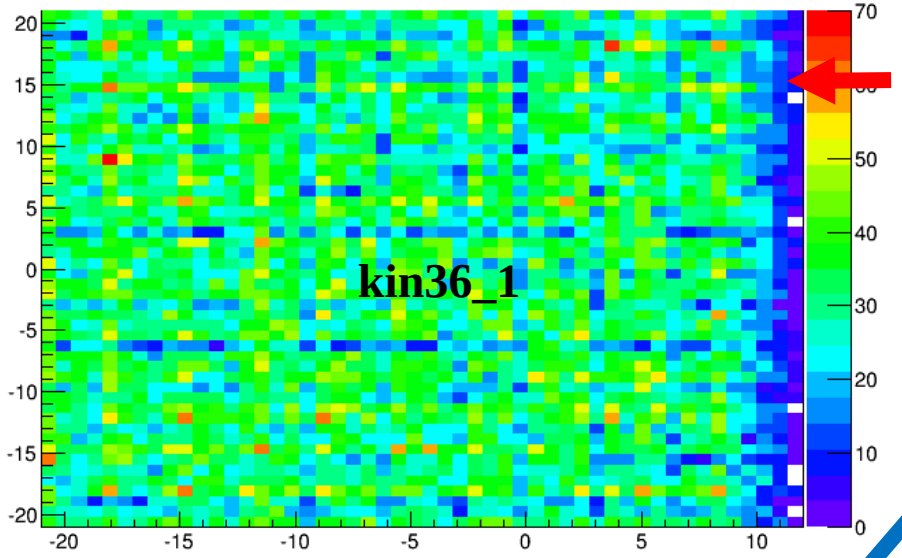
Octagonal cut



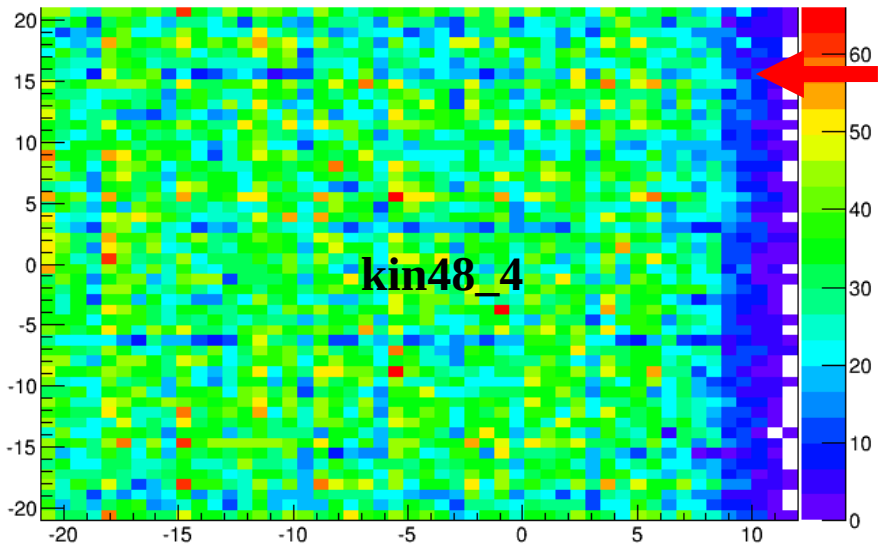
Geant4 issue ?

π^0 subtraction efficiency, for run 10553 (kin36_1)

Geant4 issue with kin36_1, kin36_3 and kin48_4

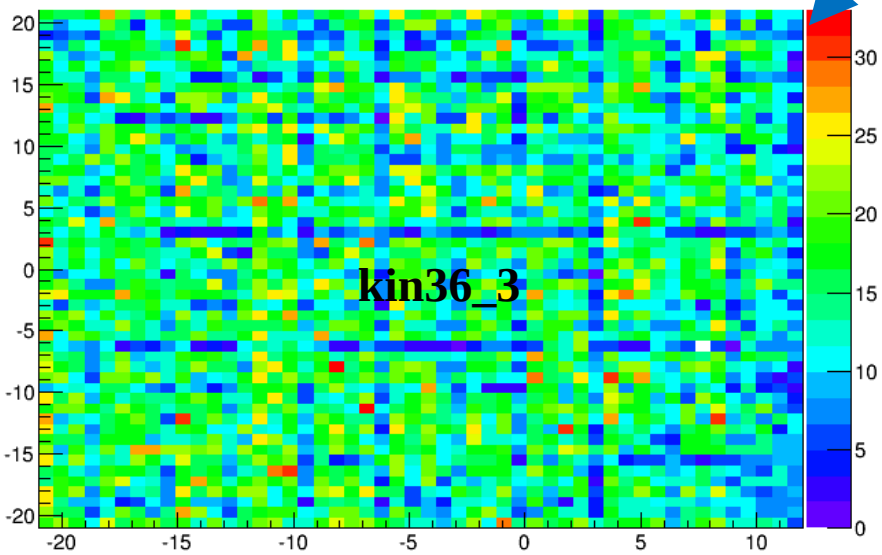


Coverage issue ?



Coverage issue ?

Coverage issue ?



Geant4 simulation (1 single photon detected case) for kin36_1 (top left)
kin48_4 (top right) and kin36_3 (bottom left) :
Photons position yc:xc in the calorimeter

Calorimeter angle / distance :

kin36_1 : 11.3 deg / 164 cm : small angle & distance combo ?

kin48_4 : 9.87 deg / 250 cm : smallest angle ?

kin36_3 : 10.46 deg / 250 cm : small angle ?

Conclusion : status and outlook

- π^0 calibration complete + SQL DB updated (France & Jlab)
- π^0 subtraction method validated with Maxime Defurne's Monte-Carlo simulation and Geant4 simulation
- π^0 subtraction done for all 12 GeV data (Fall 2014, Spring 2016, Fall 2016).
  - Subtraction rootfiles are available in France and can be copied at Jlab.

- TODO list (in progress) :
  - Define/choose octagonal cuts for every kinematics
  - Identify & Fix Geant4 calorimeter coverage issue for kin36_1 and kin48_4
    - hypothesis : generation phase space too small

- NEXT :
  - Accidentals subtraction (fast)
  - Geant4 & Monte Carlo simulation (acceptance): missing mass calibration + smearing
  - Cross-sections extraction