Low energy electron reconstruction for background calibration

17/04/24 Emile LAVAUT

SingleHit module
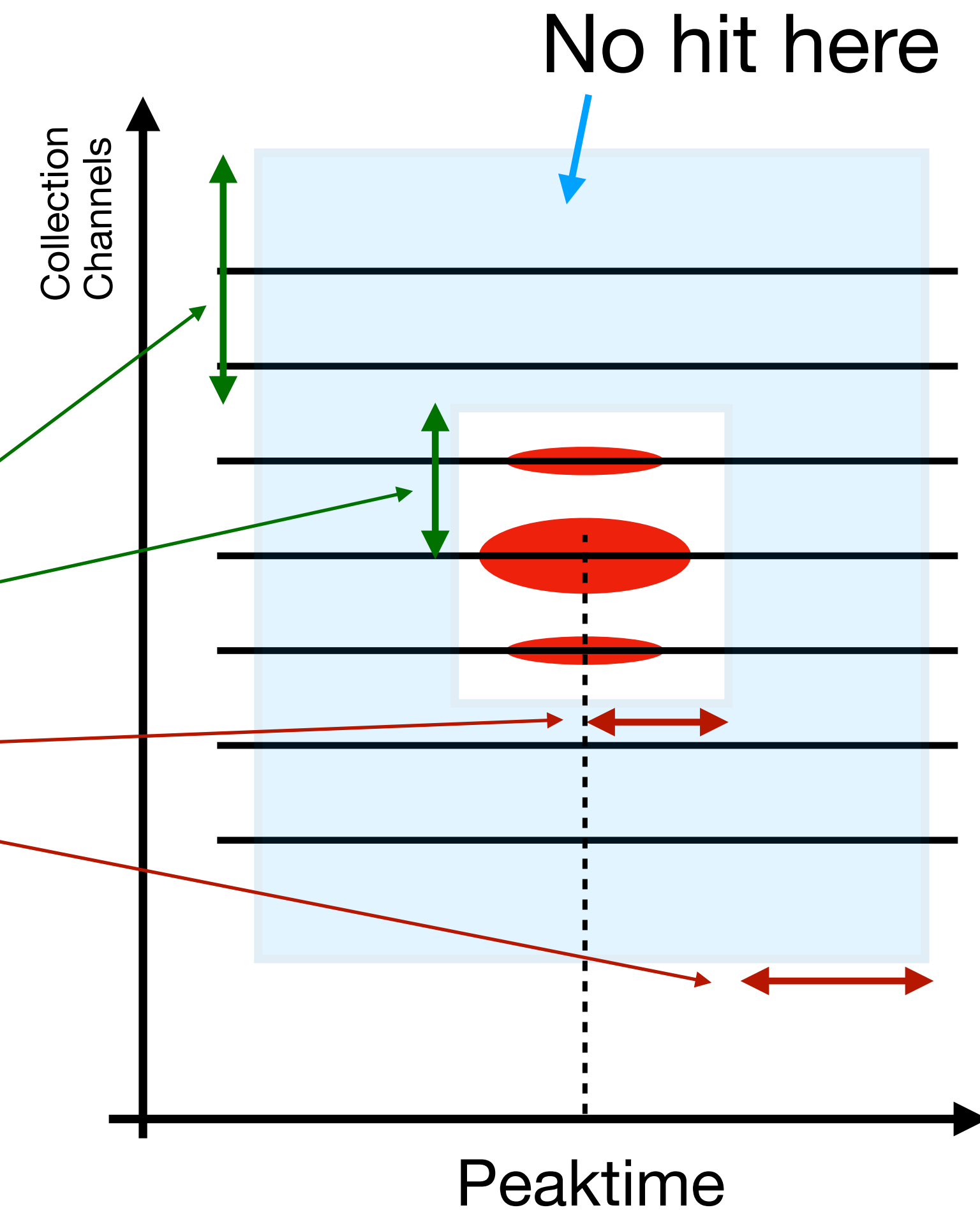
- Available in the last version of LArSoft

- Search for single **isolated** hits candidate for beta decay (Ar39, K40, radiological …)

```
services.Geometry.Name: "protodunevd_v4"
physics:
{
  analyzers:
  {
    ana:
    {
      module_type: "SingleHit"
      LogLevel:       5

      SpacePointLabel:     "reco3d"
      ClusterLabel:        "pandora"
      TrackLabel:          "pandoroTrack"
      HitLabel:            "gaushit"

      ChannelWindowInt:       1
      ChannelWindowExt:       2
      HitMultiplicity:        3
      PeakTimeWindowInt:     20
      PeakTimeWindowExt:     20
      CoincidenceWindow:     10
      Pitch:                0.9 #in cm
      PitchMultiplier:      1.2
    }
  }

  analysis: [ ana ]
  end_paths: [ analysis ]
}
```

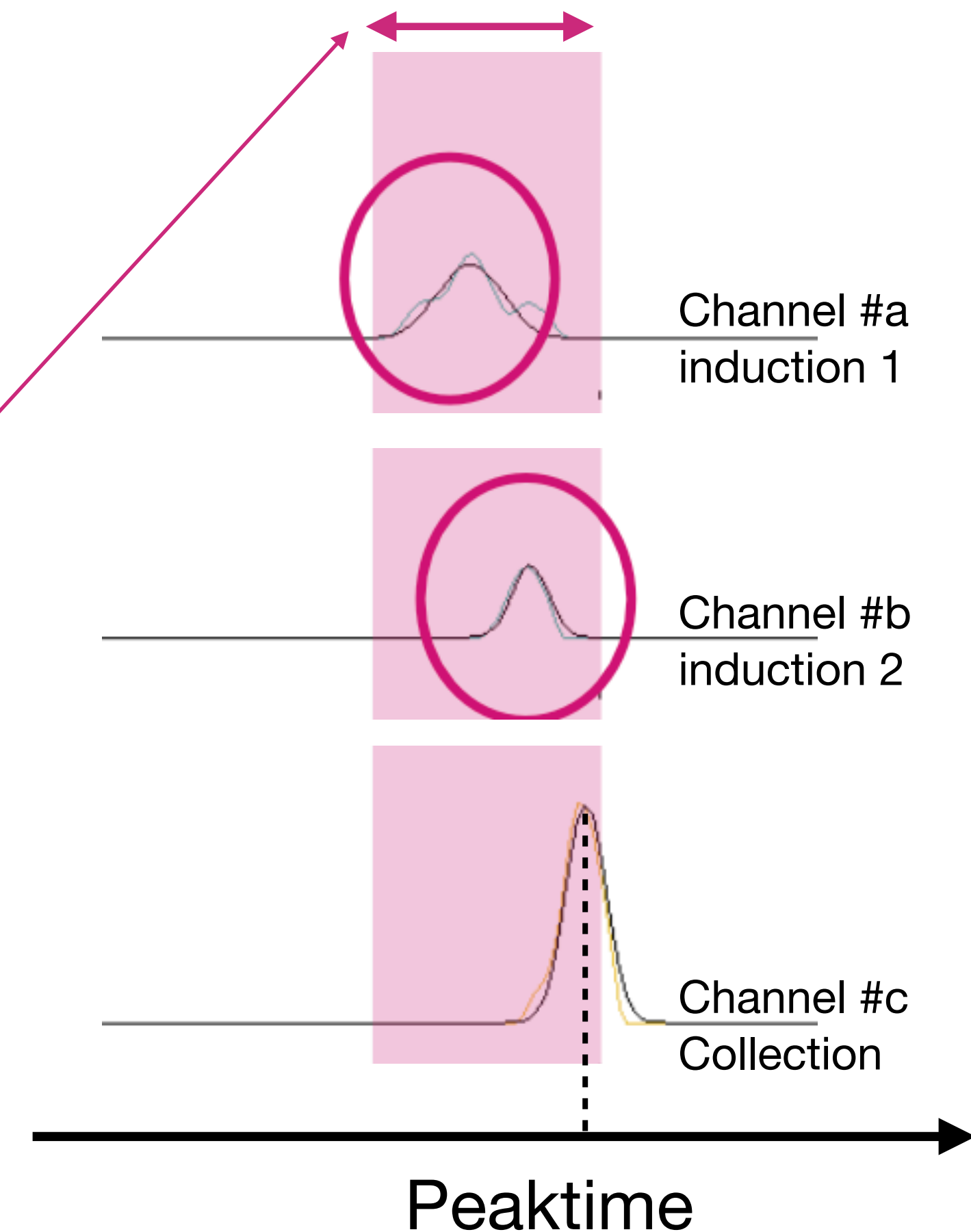No hit here

Collection Channels

Peaktime

SingleHit module

- Available in the last version of LArSoft

- Search for **single** isolated hits candidate for beta decay (Ar39, K40, radiological …)

- Time coincidence (tt) tuned for PDVD → mean time for an electron to travel from induction 1 to collection

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services.Geometry.Name: "protodunevd_v4"
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      ChannelWindowInt:   1
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      PeakTimeWindowInt:  20
      PeakTimeWindowExt:  20
      CoincidenceWindow:  10
      Pitch:              0.9  #in cm
      PitchMultiplier:    1.2
    }
  }

  analysis: [ ana ]
  end_paths: [ analysis ]
}
```

Channel #a
induction 1

Channel #b
induction 2

Channel #c
Collection

Peaktime

3

SingleHit module

- Available in the last version of LArSoft

- Search for single isolated hits candidate for beta decay (Ar39, K40, radiological …)

- Time coincidence (tt) tuned for PDVD $\rightarrow$ mean time for an electron to travel from induction 1 to collection

- Spatial coincidence $\rightarrow$ want a signal in the **3 views**

- SpacePoint is a **barycentre** of the intersection point (with ind. energy)

```
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  {
    ana:
    {
      module_type: "SingleHit"
      LogLevel:      5

      SpacePointLabel:    "reco3d"
      ClusterLabel:       "pandora"
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      ChannelWindowInt:    1
      ChannelWindowExt:    2
      HitMultiplicity:     3
      PeakTimeWindowInt:   20
      PeakTimeWindowExt:   20
      CoincidenceWindow:   10
      Pitch:               0.9  #in_cm
      PitchMultiplier:     1.2
    }
  }

  analysis: [ ana ]
  end_paths: [ analysis ]
}
_
```


Intersection points

Z

Channel #a
induction 1

Channel #b
induction 2

Channel #c
Collection

Space-point

Y
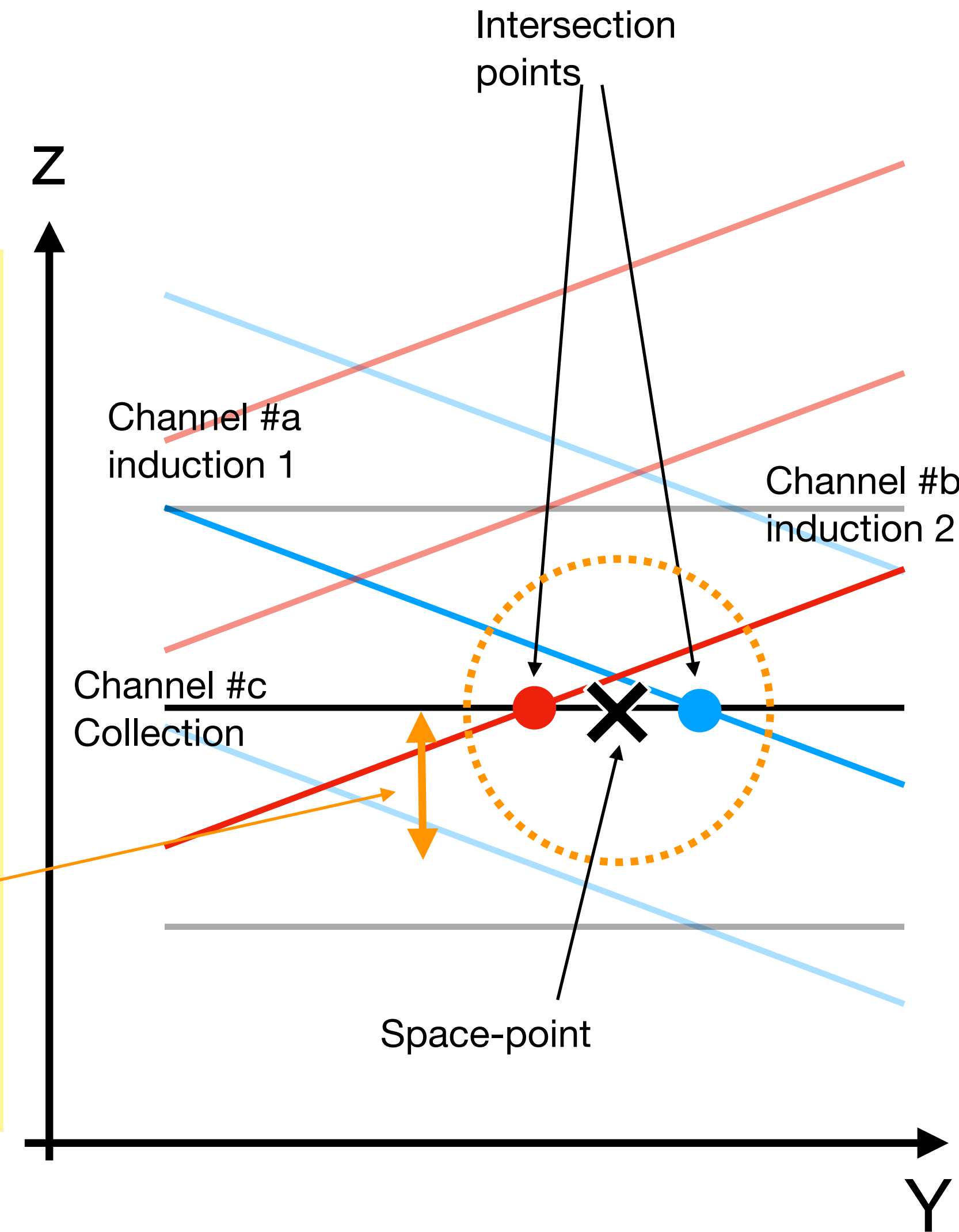
- Simulated 1MeV electron in PDVD

- Next step : clustering all this SpacePoint for energy comparison

- 1 cluster by decay

- **Cluster position is a barycentre of SpacePoint (with collection energy)**


1 MeV

○ SingleHit SpacePoint
★ True SpacePoint
● Induction 1 Point
● Induction 2 Point
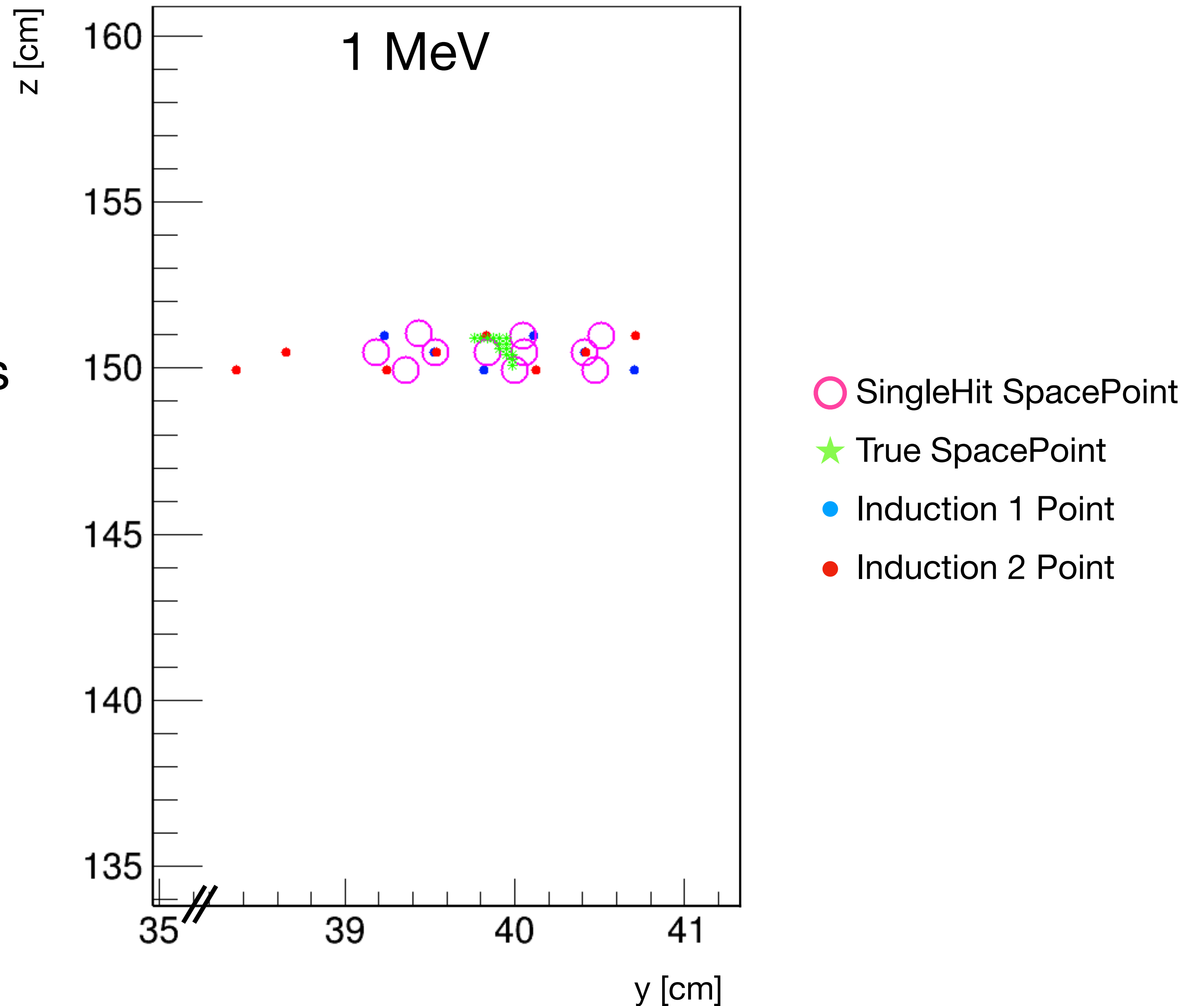
Simulated event in PDVD

- 8 electrons in same X = 50 cm but energy = { 0.5 MeV , 1 MeV , 2 MeV , 3 MeV , 4 MeV , 5 MeV , 10 MeV , 20 MeV }
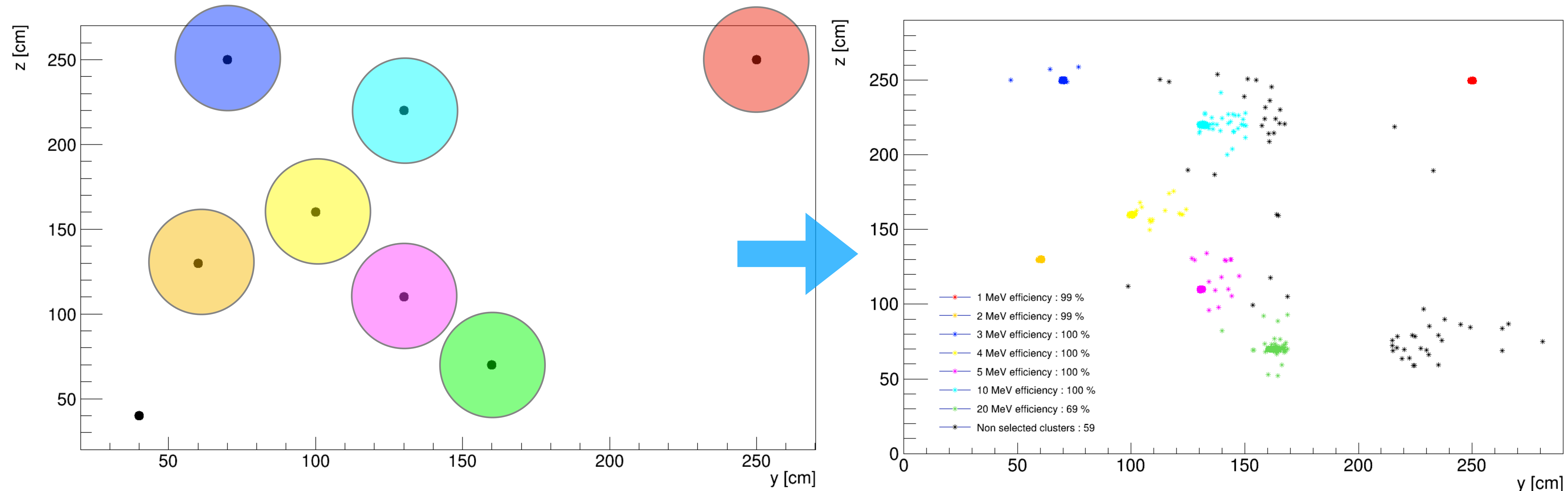
- 250 events like that were simulated
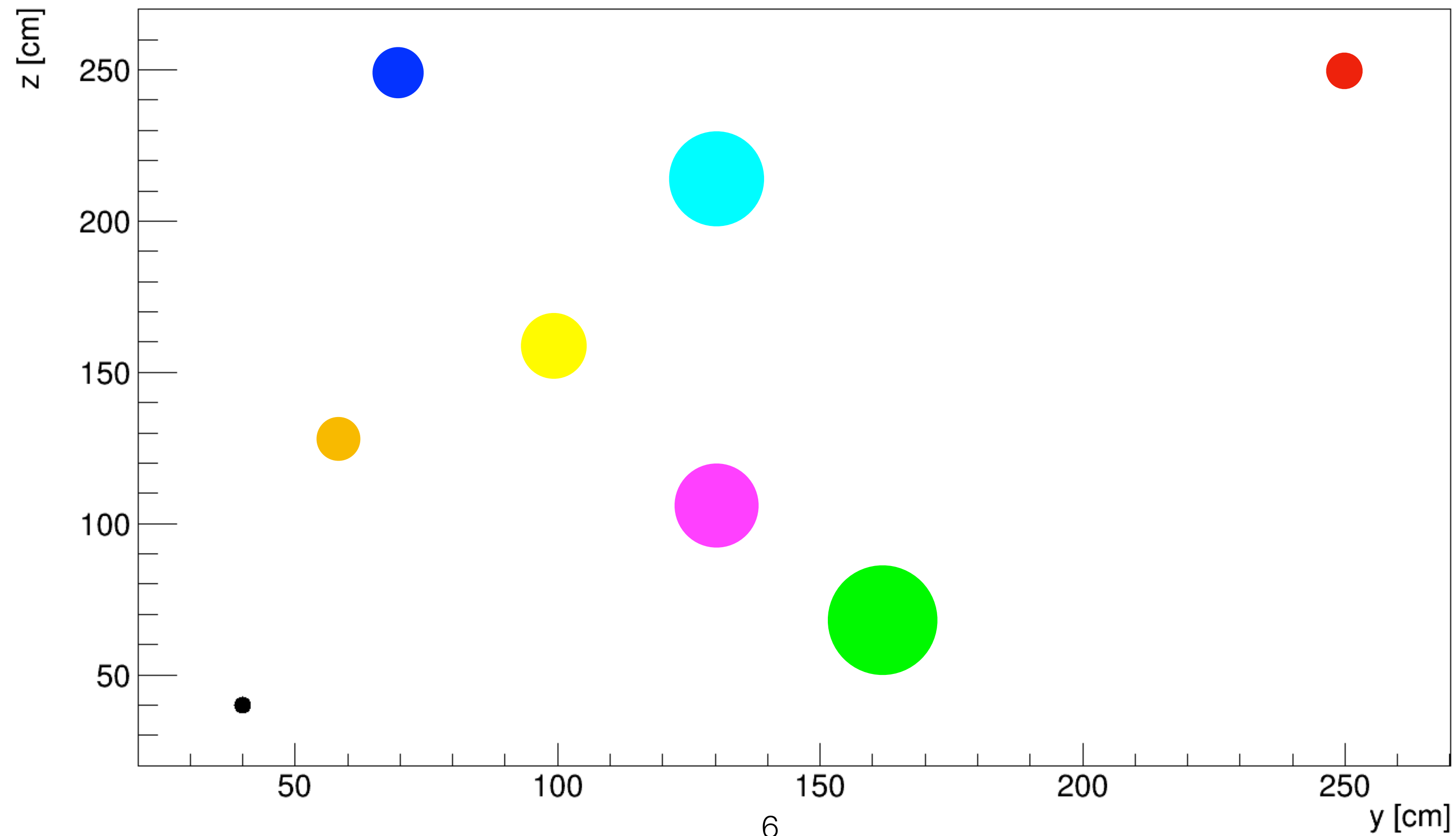
Reconstructed Cluster

- Here selection with **windowChannel_int = $\pm$ 3**

- We reconstruct 1727 clusters for 250 event $\to$ ~ 6.9 clusters/events

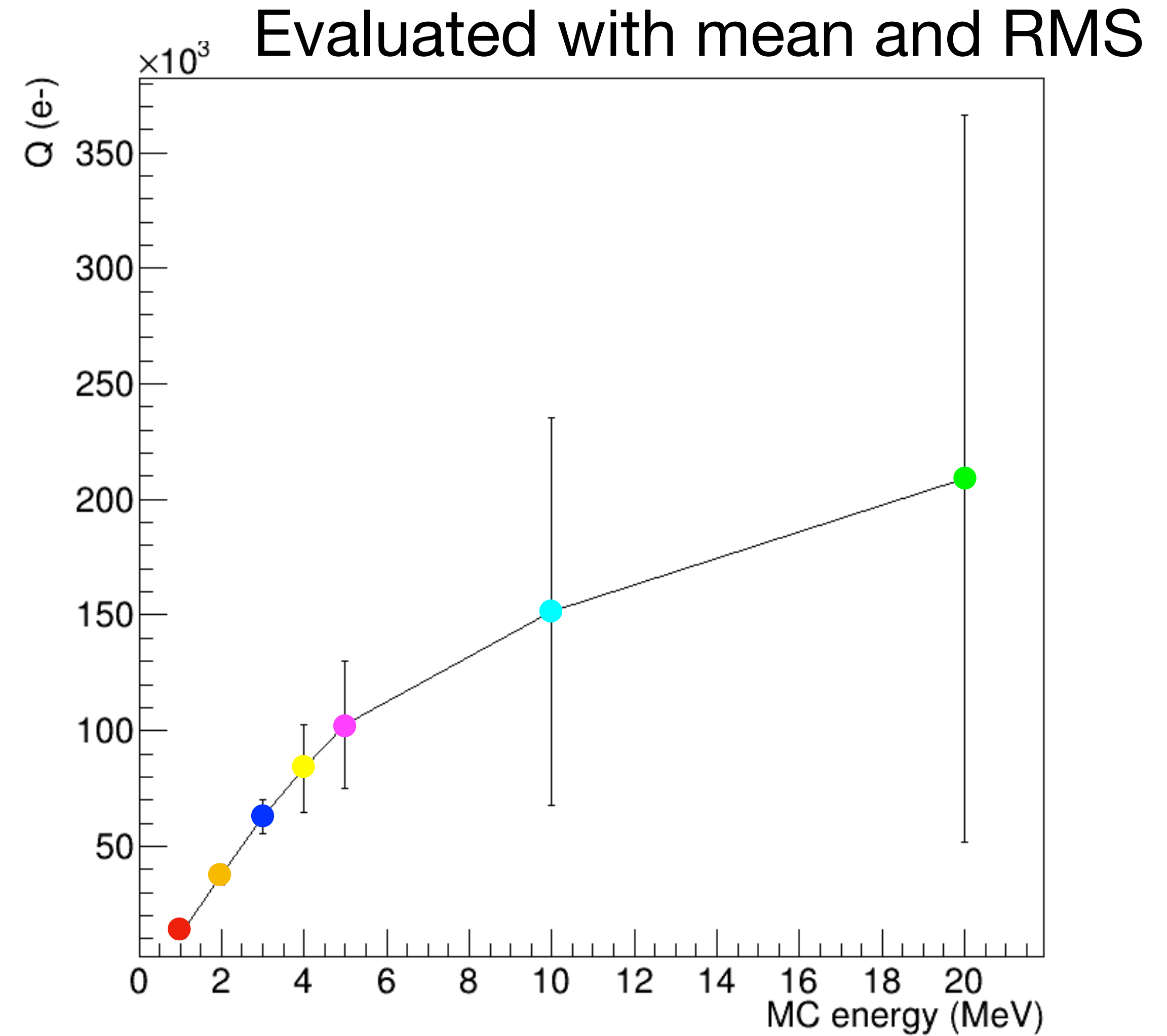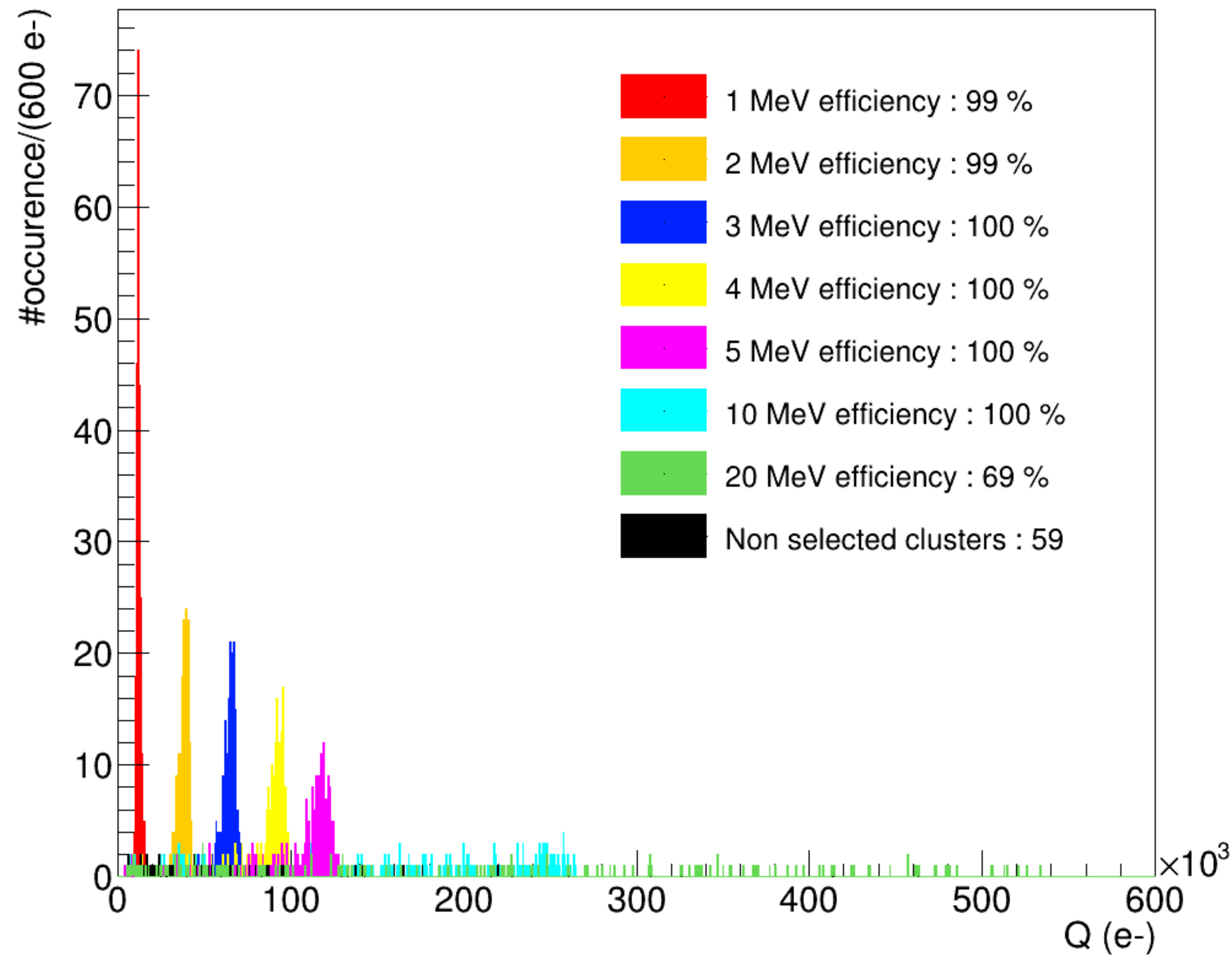- We never reconstruct 0.5 MeV electron

- Start to see some **patterns**
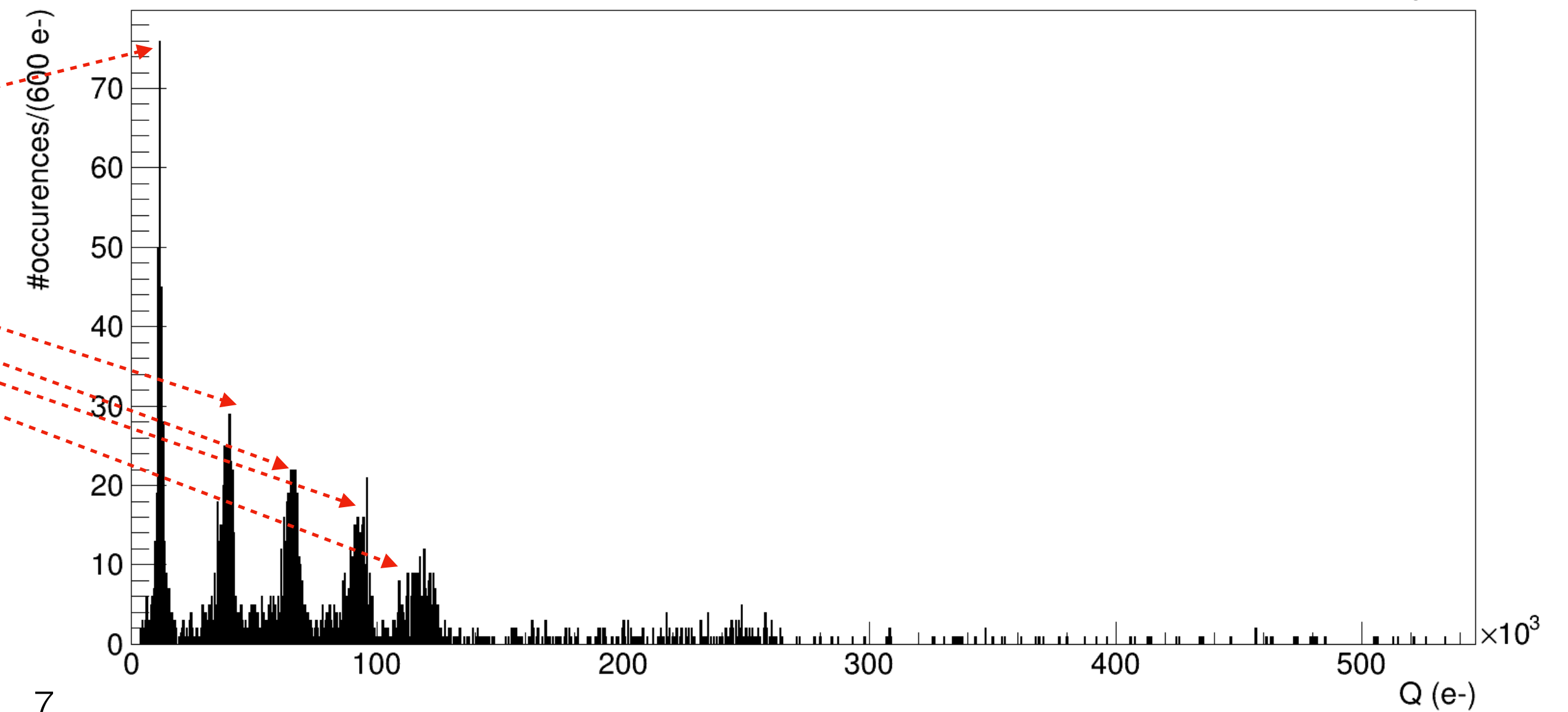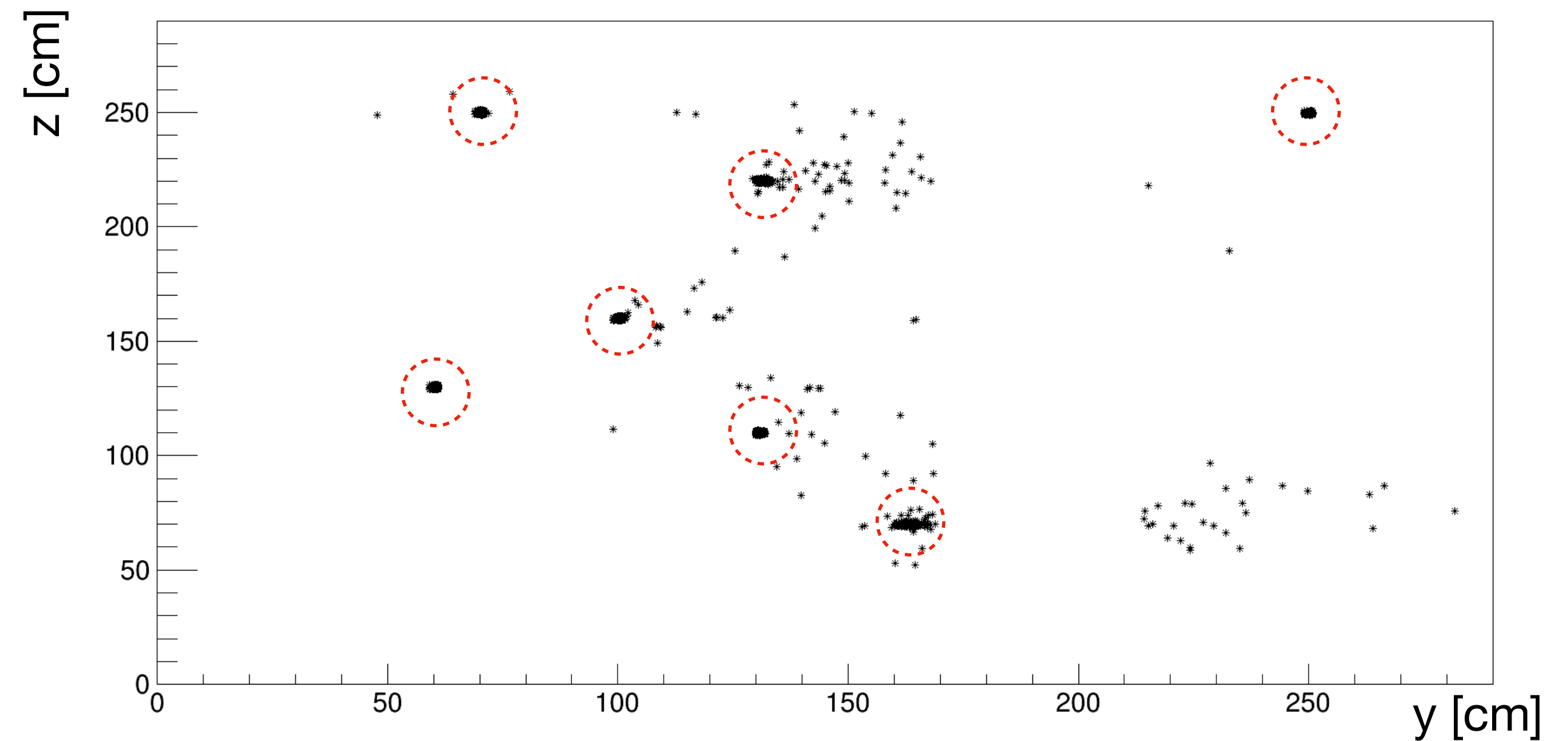
Efficiency estimation

- efficiency $= \dfrac{\text{Number of cluster(d < 25 cm)}}{\text{Number of simulated events}}$

- with d the distance to the origin MCTruth electron

Energy Spectrum

Evaluated with mean and RMS

Legend:
- 1 MeV efficiency : 99 %
- 2 MeV efficiency : 99 %
- 3 MeV efficiency : 100 %
- 4 MeV efficiency : 100 %
- 5 MeV efficiency : 100 %
- 10 MeV efficiency : 100 %
- 20 MeV efficiency : 69 %
- Non selected clusters : 59
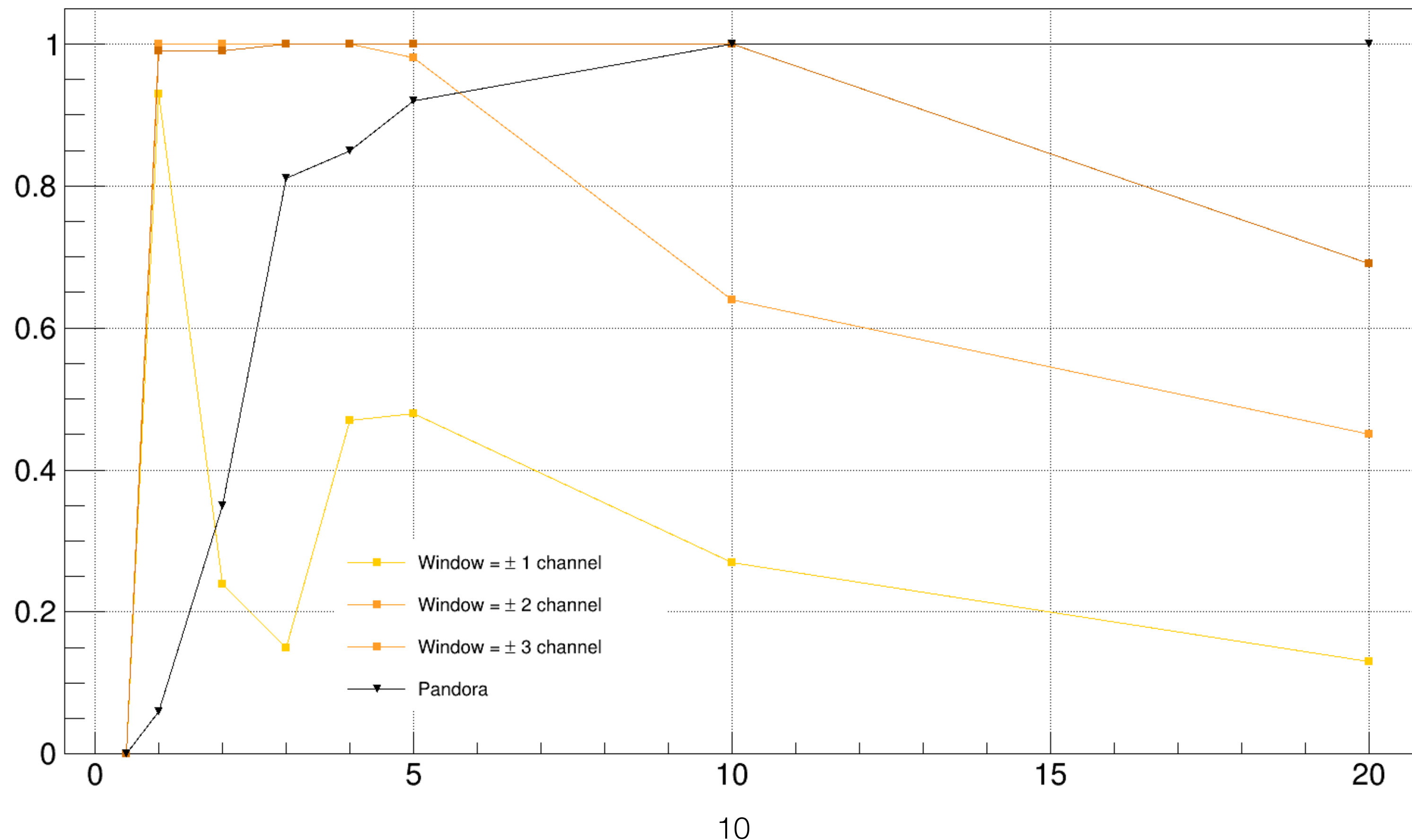
Efficiency comparison

- Made this analysis with :

  - **windowChannel_int = ± 1**

  - **windowChannel_int = ± 2**

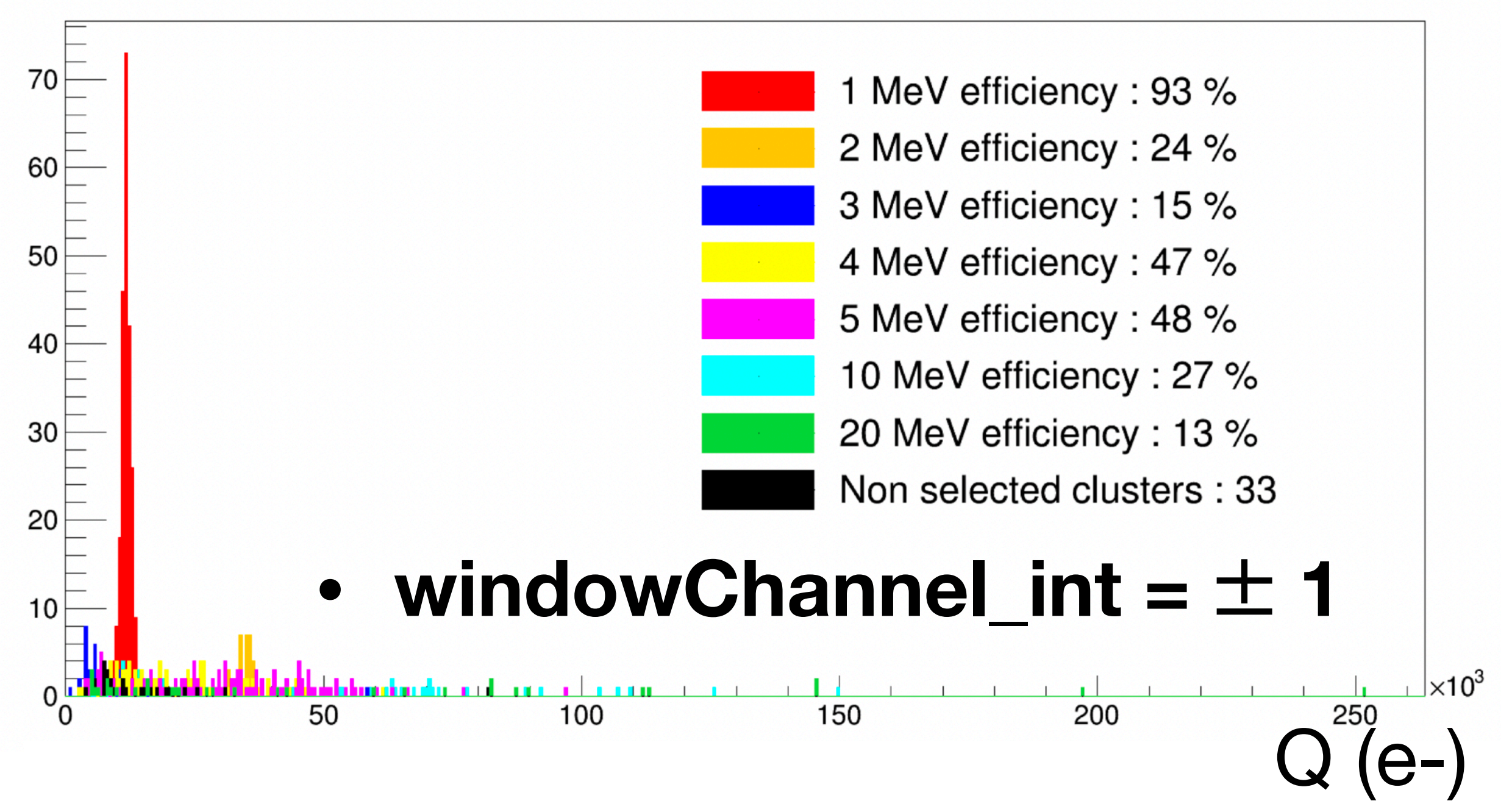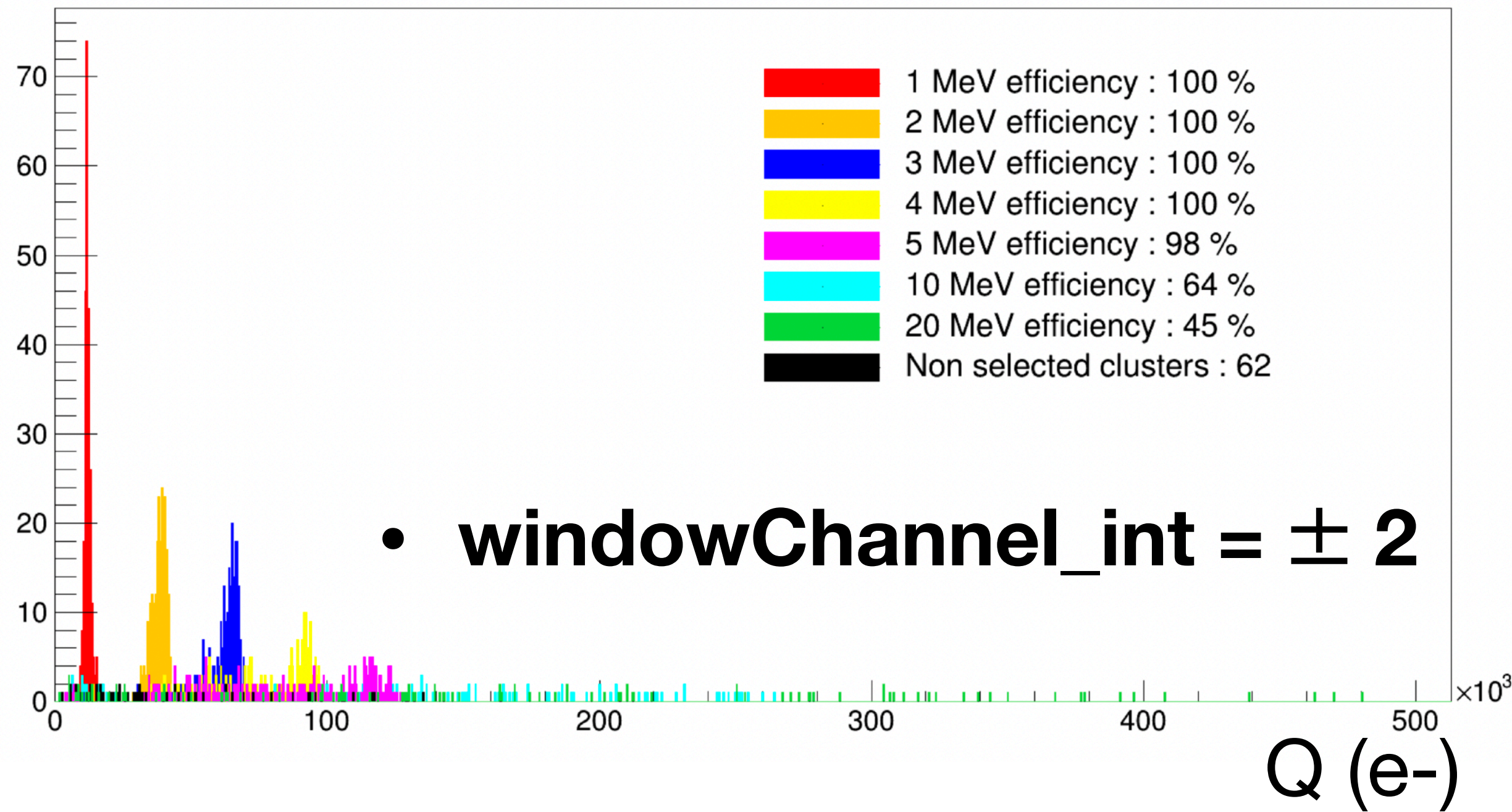- **windowChannel_int = ± 3**

- Want to compare with Pandora → I looked at the reconstructed track end point and start point

Conclusion

- The module is available for everyone (very last version need to be pushed)

- Has a **good efficiency at E < 5 MeV**

- Need more simulation on electron to evaluated purity and completeness

- Currently testing it on PDSP data

Annexe

- **windowChannel_int = ± 2**

🟥	1 MeV efficiency : 100 %
🟧	2 MeV efficiency : 100 %
🟦	3 MeV efficiency : 100 %
🟨	4 MeV efficiency : 100 %
🟪	5 MeV efficiency : 98 %
🟦	10 MeV efficiency : 64 %
🟩	20 MeV efficiency : 45 %
⬛	Non selected clusters : 62

Q (e-)

- **windowChannel_int = ± 1**

🟥	1 MeV efficiency : 93 %
🟧	2 MeV efficiency : 24 %
🟦	3 MeV efficiency : 15 %
🟨	4 MeV efficiency : 47 %
🟪	5 MeV efficiency : 48 %
🟦	10 MeV efficiency : 27 %
🟩	20 MeV efficiency : 13 %
⬛	Non selected clusters : 33

Q (e-)

Annexe

Hit in collection plane for 100 electrons at 500 keV

Hit in collection plane with a time coincidence = 1