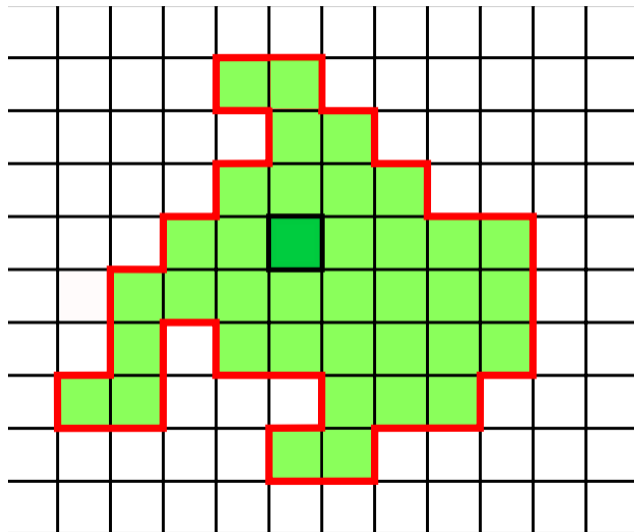


Split-Off recognition for the EMC

Jonas Kohlen

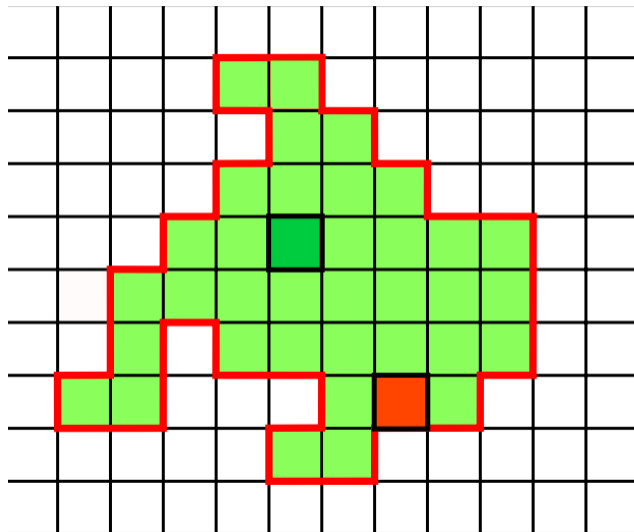
Helmholtz-Institut für Strahlen- und Kernphysik

What are Split-Offs? - In-Cluster Split-Offs



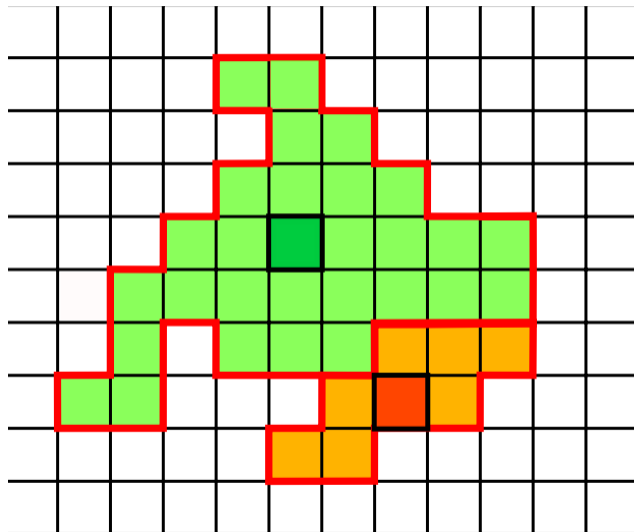
- statistical fluctuations cause additional maxima

What are Split-Offs? - In-Cluster Split-Offs



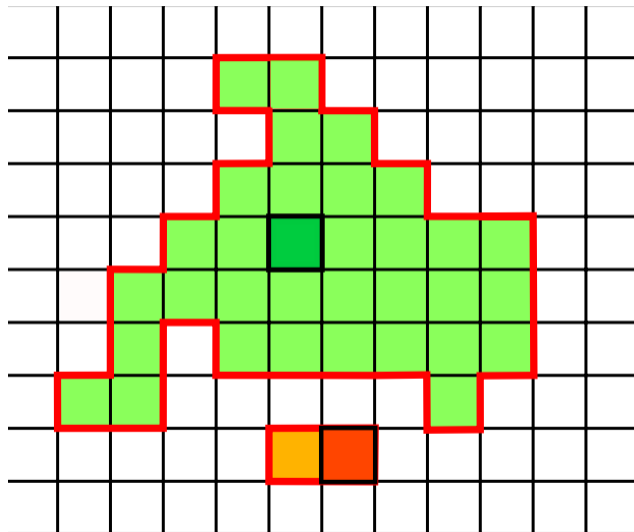
- statistical fluctuations cause additional maxima
- energy is split between maxima

What are Split-Offs? - In-Cluster Split-Offs



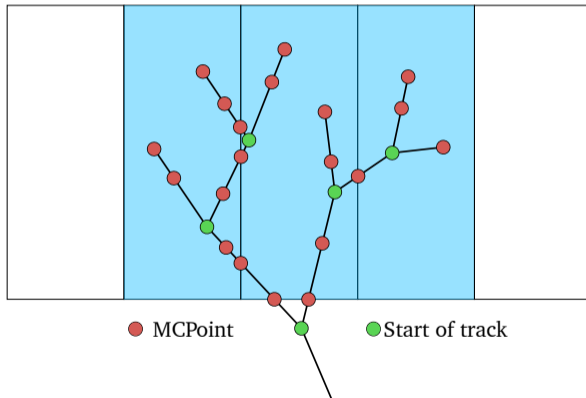
- statistical fluctuations cause additional maxima
- energy is split between maxima
- too many particles are reconstructed

What are Split-Offs? - Out-Of-Cluster Split-Offs



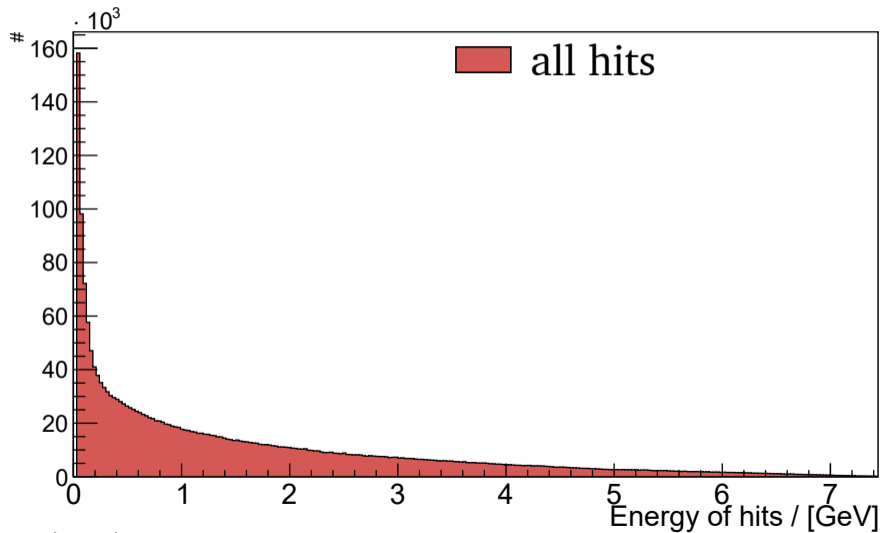
- statistical fluctuations cause additional maxima
- energy is split between maxima
- too many particles are reconstructed

How to find Split-Offs - MC track matching

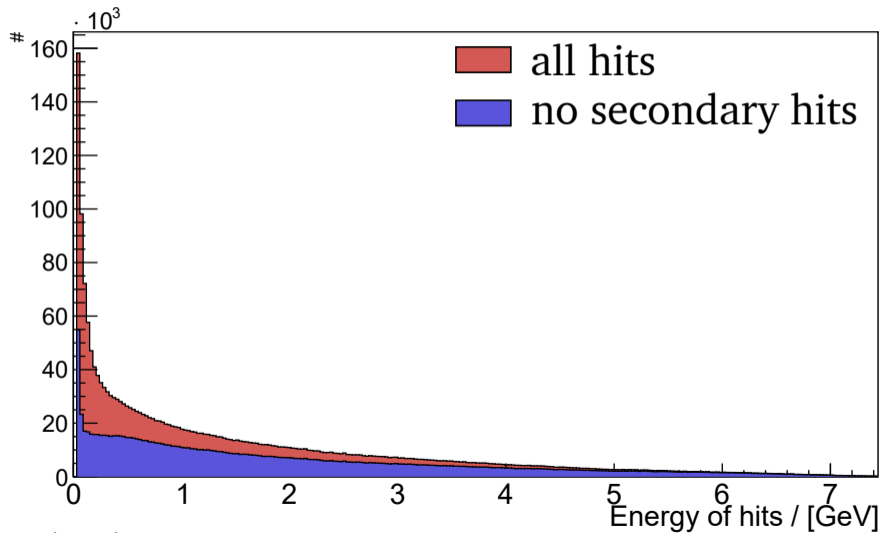


- track interactions in crystals create MCPoint objects
- MCPoints tracked back to **external track** responsible for shower
- **external tracks** are matched to maxima

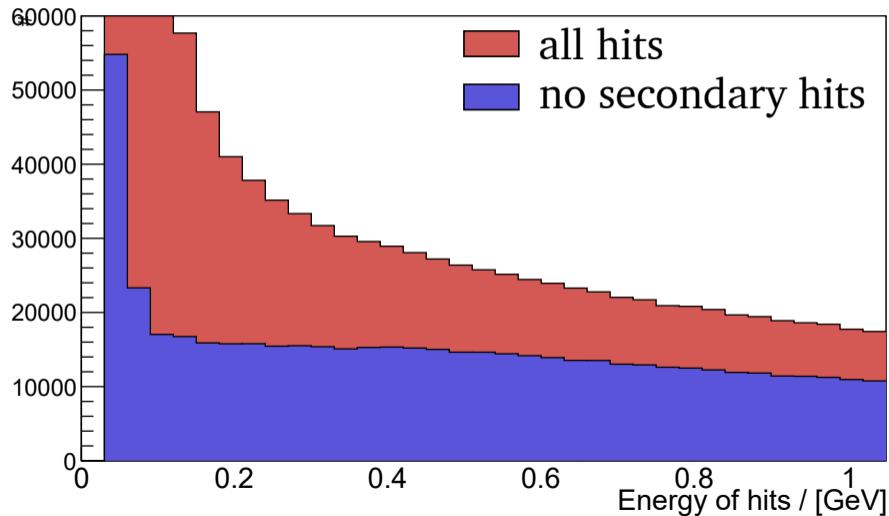
What is the impact of Split-Offs? - Energy distribution - $\eta \pi^0 \rightarrow 4\gamma$



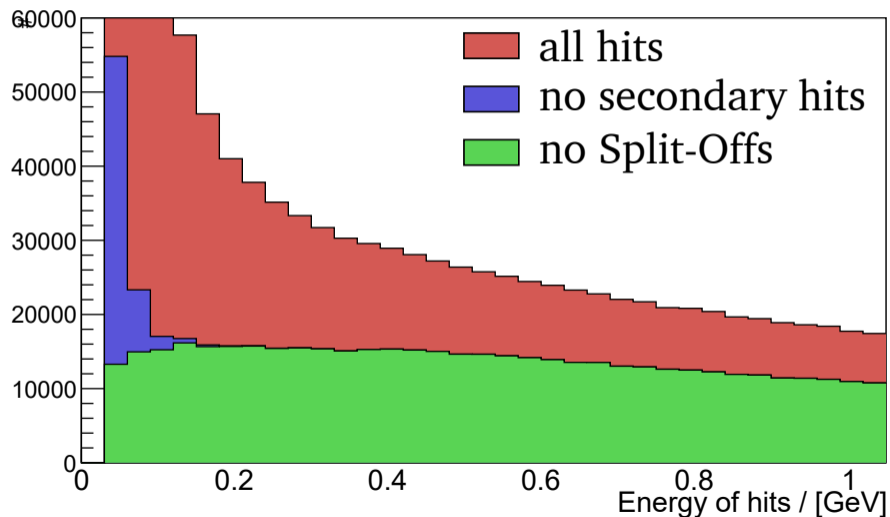
What is the impact of Split-Offs? - Energy distribution - $\eta \pi^0 \rightarrow 4\gamma$



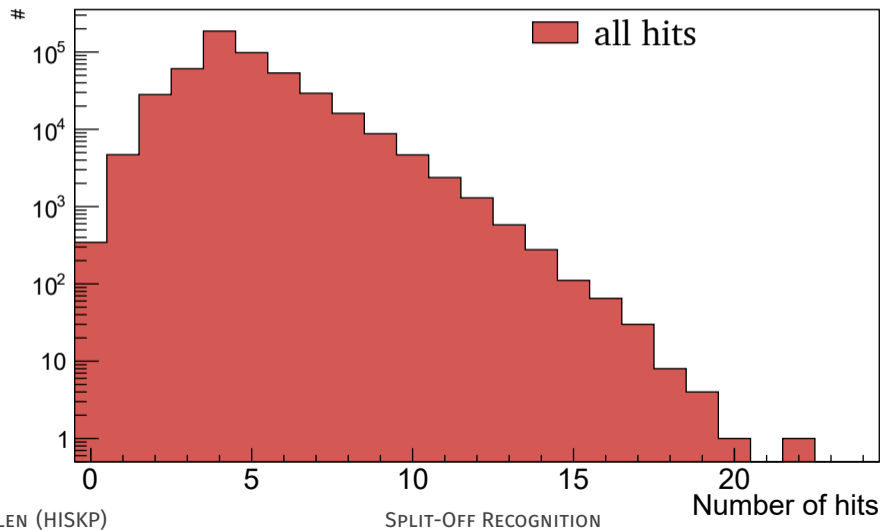
What is the impact of Split-Offs? - Energy distribution - $\eta \pi^0 \rightarrow 4\gamma$



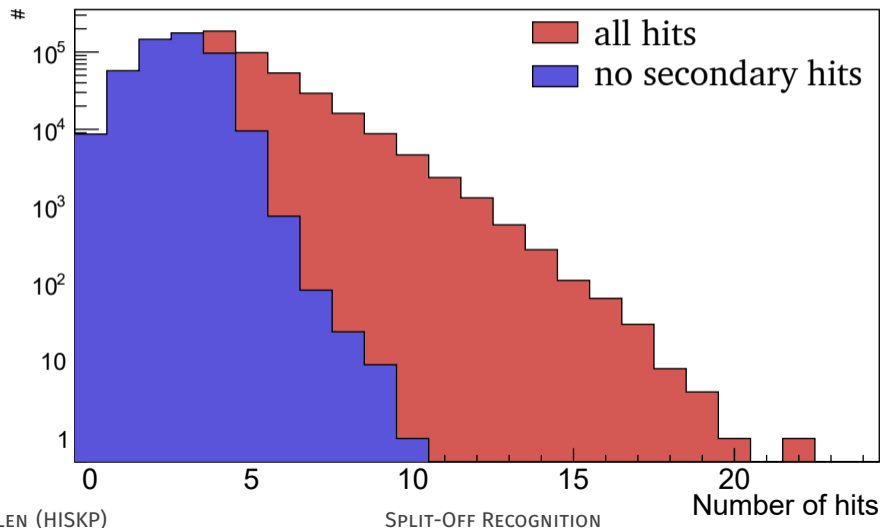
What is the impact of Split-Offs? - Energy distribution - $\eta \pi^0 \rightarrow 4\gamma$



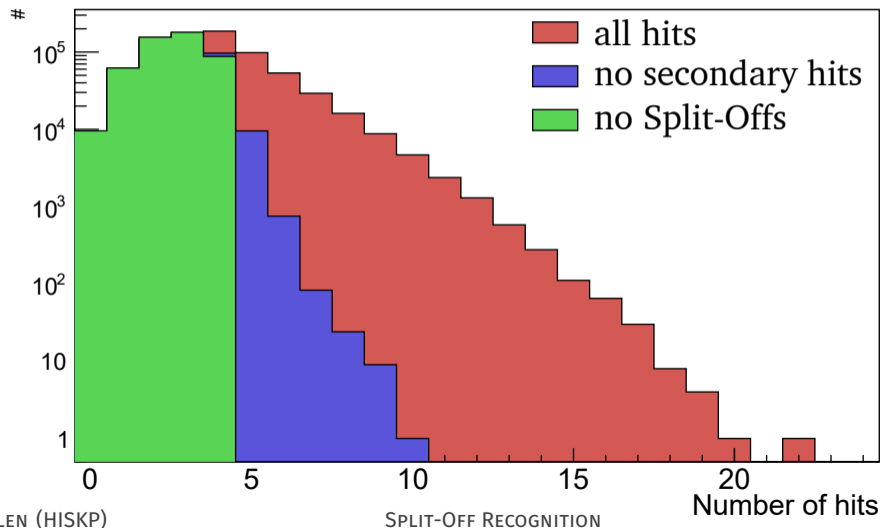
What is the impact of Split-Offs? - Hit multiplicity - $\eta \pi^0 \rightarrow 4\gamma$



What is the impact of Split-Offs? - Hit multiplicity - $\eta \pi^0 \rightarrow 4\gamma$



What is the impact of Split-Offs? - Hit multiplicity - $\eta \pi^0 \rightarrow 4\gamma$



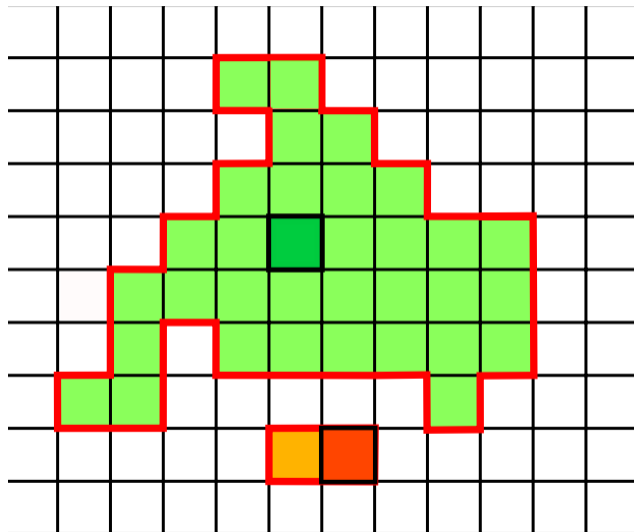
Split-Off recognition

- find **Split-Offs** based on MC information
- look for properties that separate **Split-Offs** from **real hits**
- develop **cuts** that can identify **Split-Offs** in real data

Simulation

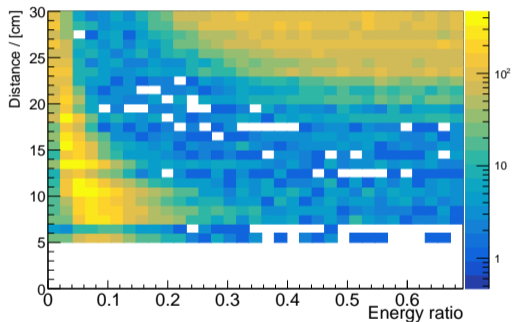
- $\bar{p}p \rightarrow \eta \pi^0 \rightarrow 4\gamma$ 8 GeV beam - full PANDA detector setup - 500k events

Split-Off recognition - Out-Of-Cluster Split-Offs

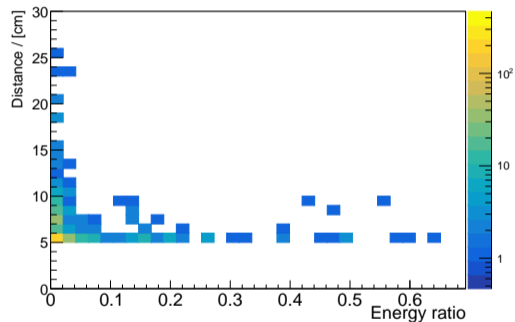


- Split-Offs carry low energy
- out-of-cluster Split-Offs are created close to cluster
- distance and ratio of energies are considered

Split-Off recognition - Out-Of-Cluster Split-Offs



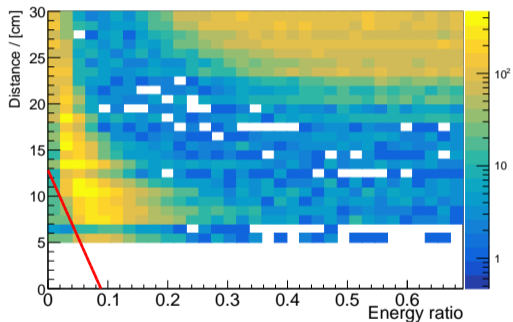
primary maxima



Split-Off maxima

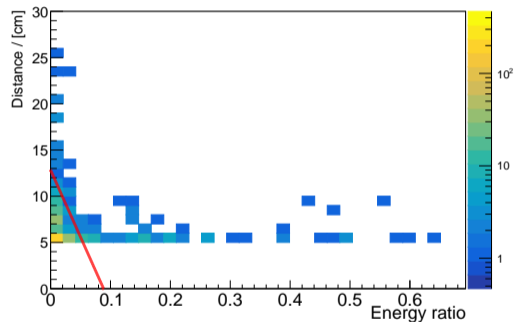
Split-Off recognition - Out-Of-Cluster Split-Offs

>99% correctly identified



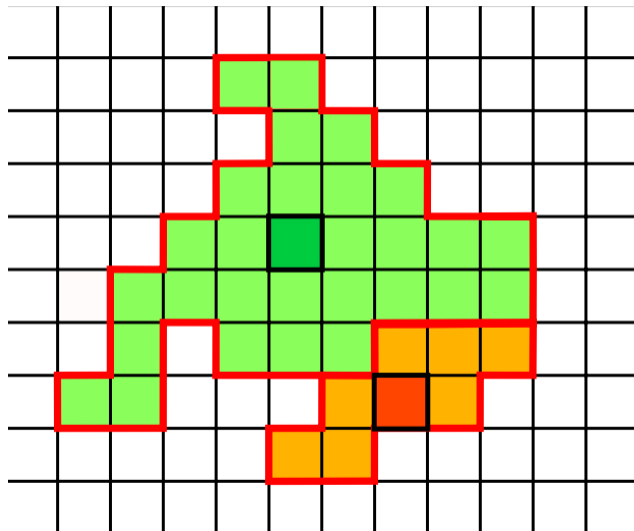
primary maxima

69% correctly identified



Split-Off maxima

Split-Off recognition - In-Cluster Split-Offs - 2 maxima



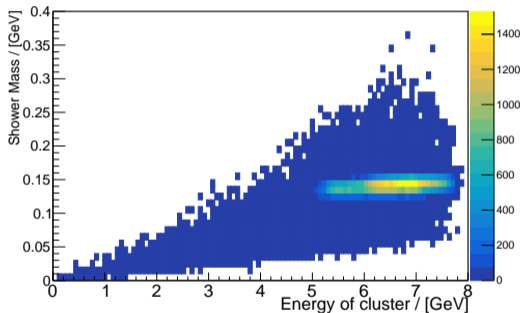
- shower mass of cluster is considered

- $$R_{mass} = \sqrt{\left(\sum_i E_i\right)^2 - \left(\sum_i \vec{p}_i\right)^2}$$

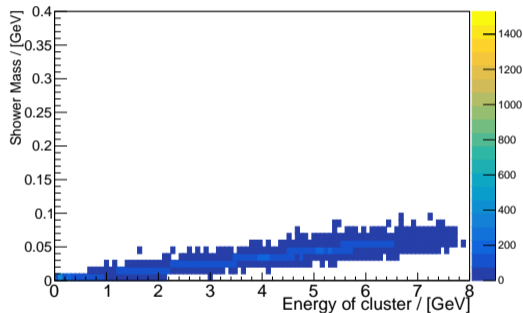
(crystal index i)

- plotted against total energy of cluster

Split-Off recognition - In-Cluster Split-Offs - 2 maxima



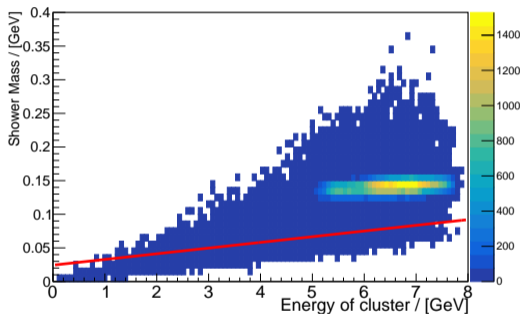
clusters not containing Split-Off maxima



clusters containing Split-Off maxima

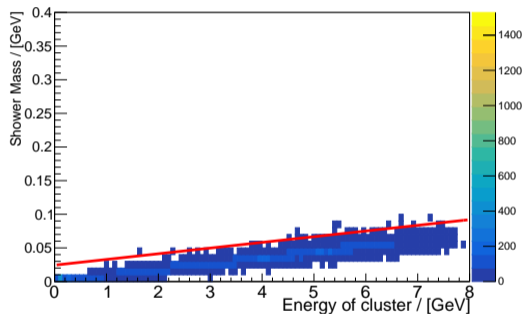
Split-Off recognition - In-Cluster Split-Offs - 2 maxima

>99% correctly identified



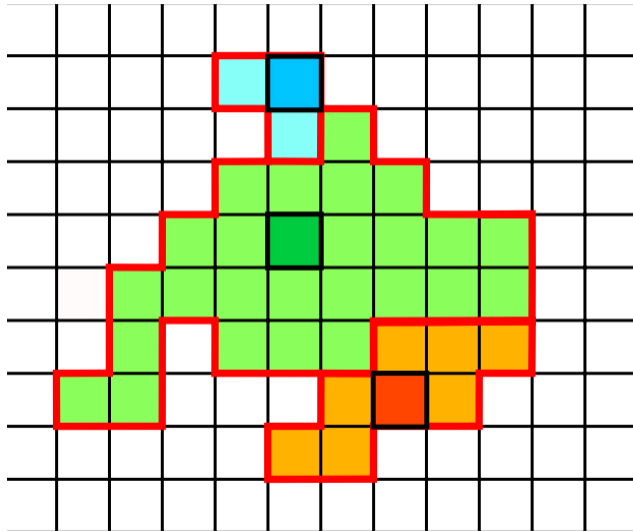
clusters not containing Split-Off maxima

>99% correctly identified



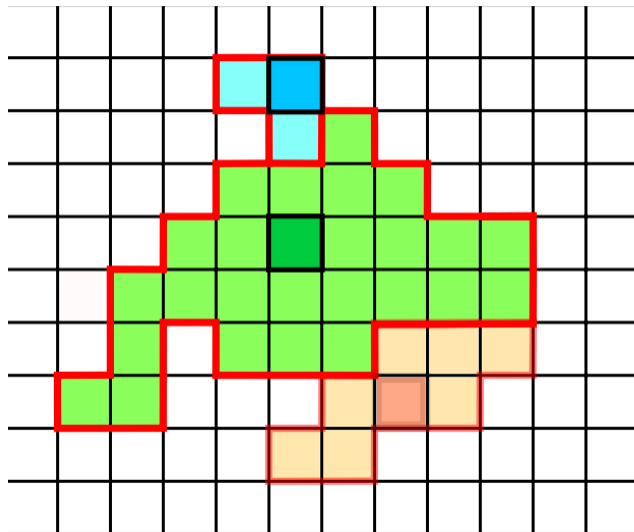
clusters containing Split-Off maxima

Split-Off recognition - In-Cluster Split-Offs - >2 maxima



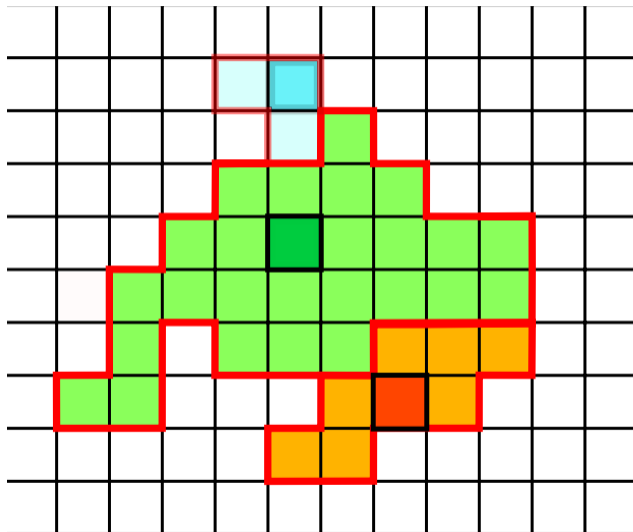
- amount of potential **Split-Offs** is ambiguous
- 2 subclusters are combined to form "pseudo clusters"
- **shower mass** is analyzed

Split-Off recognition - In-Cluster Split-Offs - >2 maxima



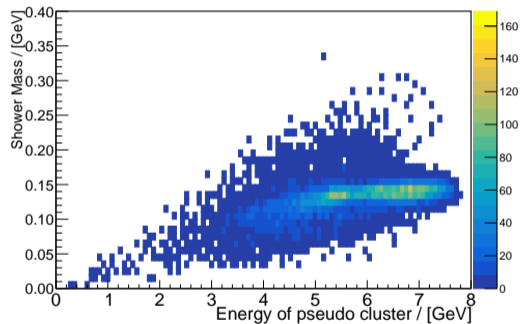
- amount of potential **Split-Offs** is ambiguous
- 2 subclusters are combined to form "**pseudo clusters**"
- **shower mass** is analyzed

Split-Off recognition - In-Cluster Split-Offs - >2 maxima

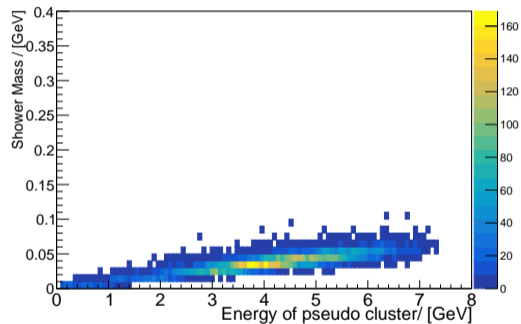


- amount of potential **Split-Offs** is ambiguous
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Split-Off recognition - In-Cluster Split-Offs - >2 maxima



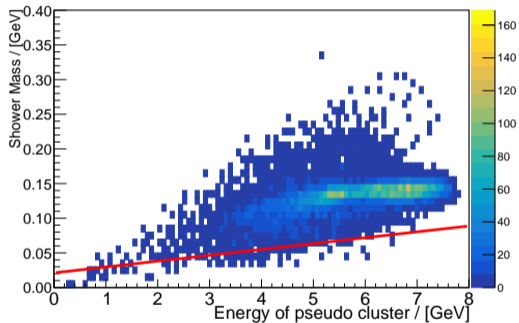
clusters not containing Split-Off maxima



clusters containing Split-Off maxima

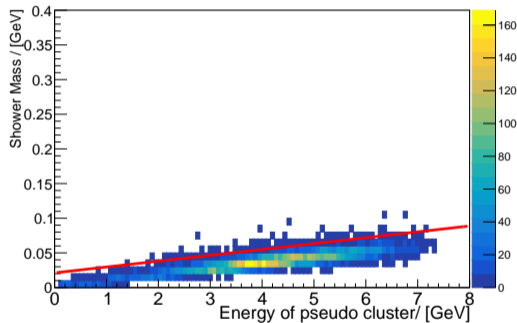
Split-Off recognition - In-Cluster Split-Offs - >2 maxima

>98% correctly identified



clusters **not** containing Split-Off maxima

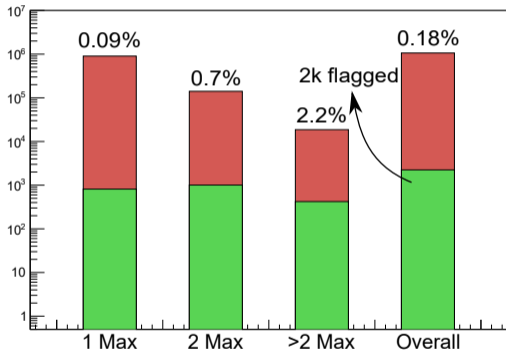
>98% correctly identified



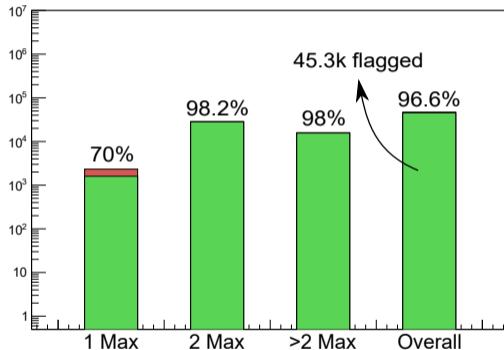
clusters **containing** Split-Off maxima

Split-Off recognition - Overall performance

all hits flagged as Split-Off

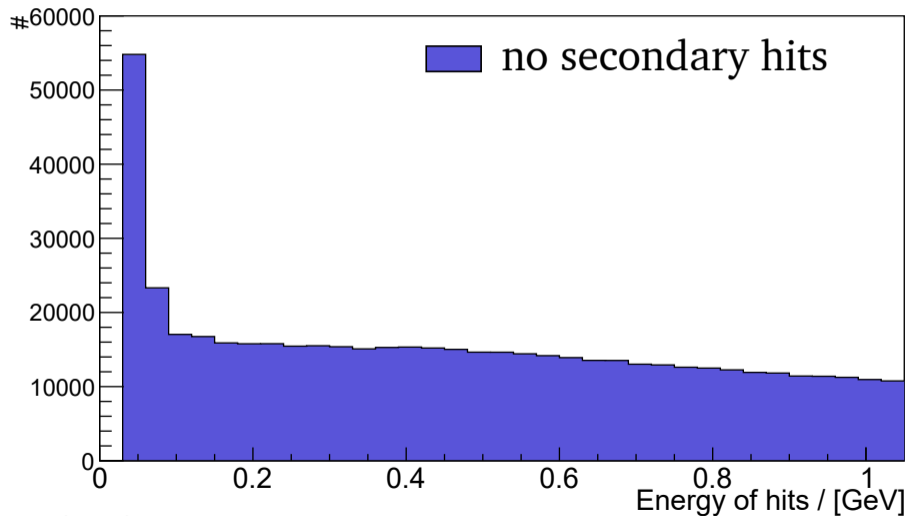


maxima caused by primary particle

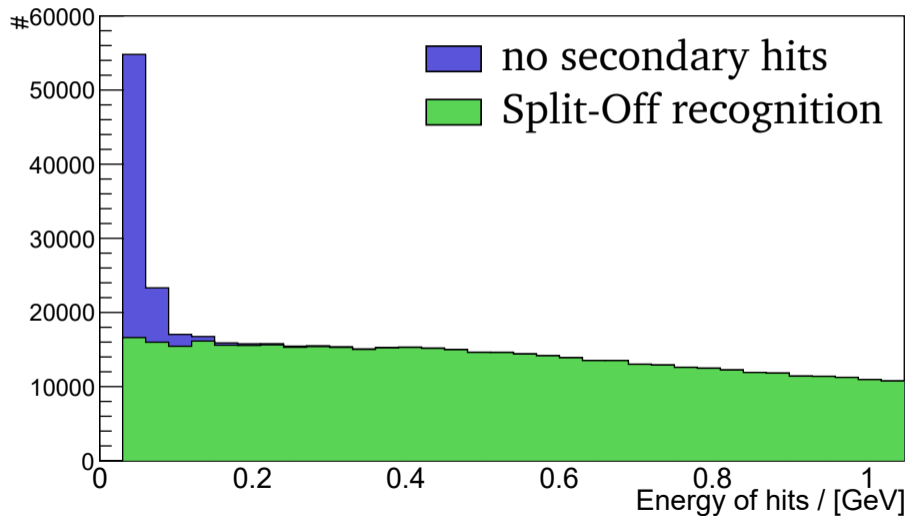


maxima caused by Split-Off

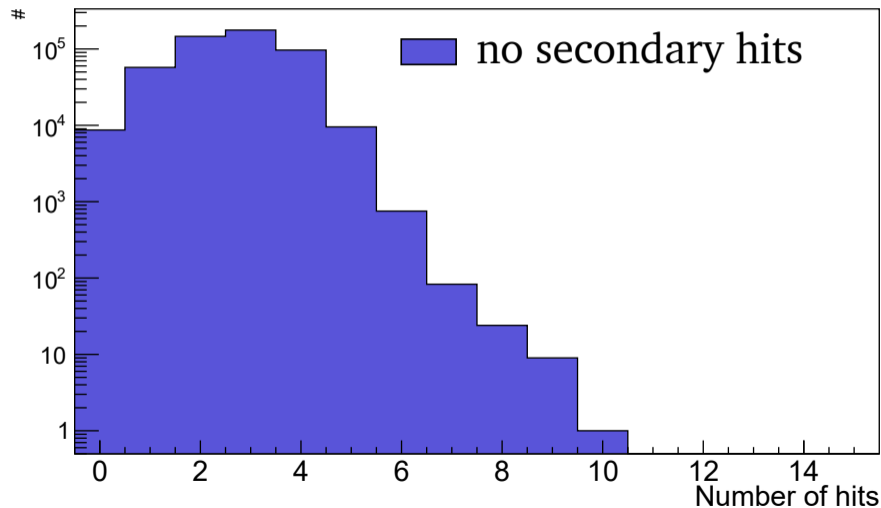
Split-Off recognition - Energy distribution



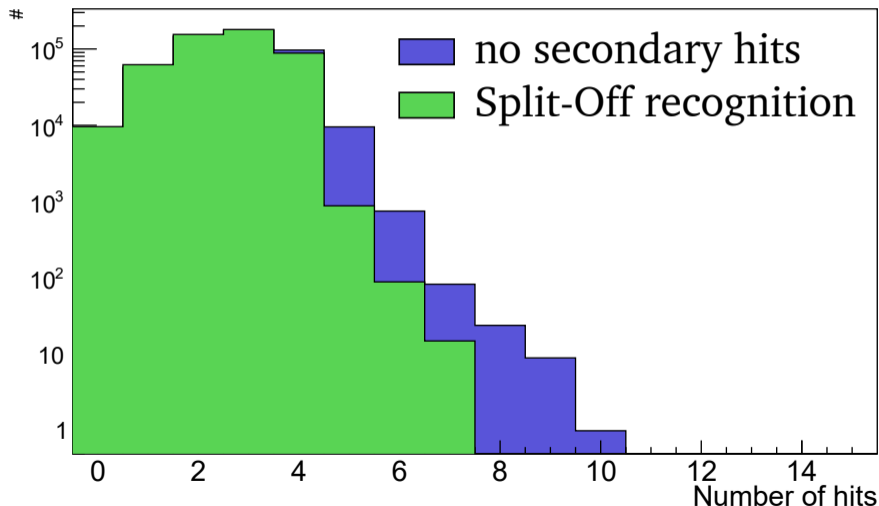
Split-Off recognition - Energy distribution



Split-Off recognition - Multiplicity



Split-Off recognition - Multiplicity



Split-Off recognition - Performance

channel	beam energy [GeV]	falsely flagged primaries [%]	falsely flagged primaries	flagged Split-Offs [%]	flagged Split-Offs
$\eta \pi^0$	8	0.18	2k	96.6	45.3k
$\eta \pi^0$	15	0.16	1.6k	94	54.8k
$\pi^0 \pi^0$	4	0.18	2.1k	97	36.2k
$\pi^0 \pi^0$	8	0.26	2.3k	96.6	44.3k
$\eta \pi^0 \pi^0$	1.94	0.22	4.6k	94.1	31.9k
$\eta \pi^0 \pi^0$	8	0.25	4.4k	96.4	56k

Summary

- Split-Offs are a cause of **increased multiplicity** and **low energy** hits
- Split-Off recognition able to **identify Split-off maxima** in **any type of cluster**
- optimized for **FwEndcap, Barrel** and **BwEndcap**
- able to identify **over 94%** of Split-Off maxima consistently
- only falsely flagging a **fraction of a percent** of "real" hits
- performance **stable** across different simulations

Thanks for your attention!