Cygnus Project Overview

13-03-2019

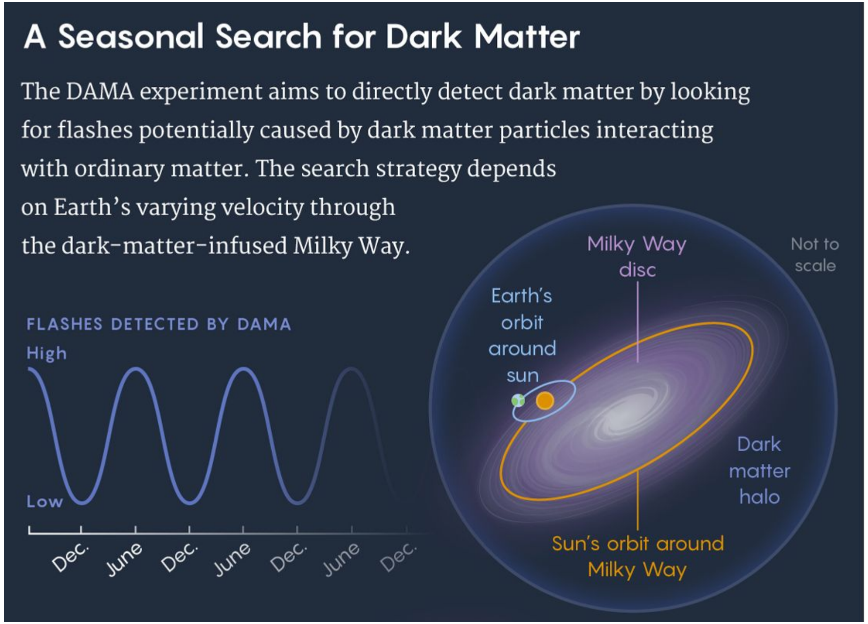
About the MAIN GOAL of the CYGNO project

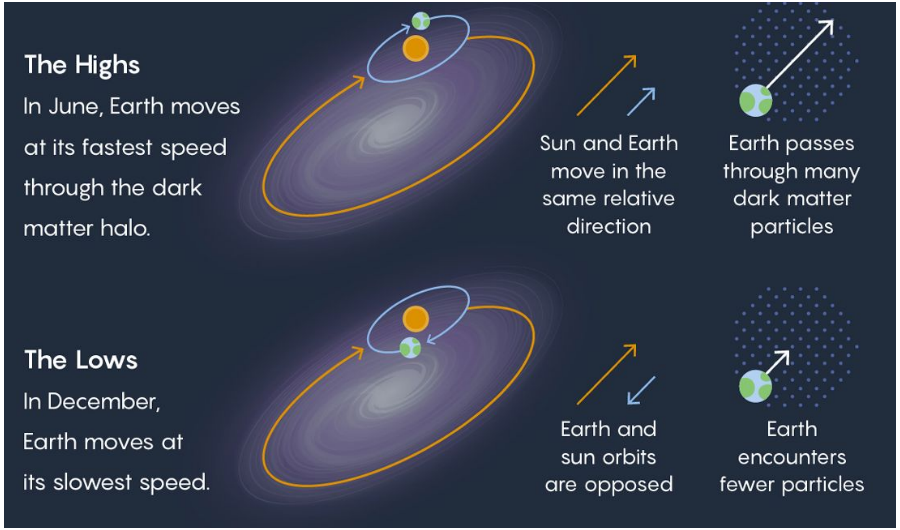
- For 20 years, an experiment in Italy known as **DAMA** has detected an oscillating signal that could be coming from dark matter;
- One of the oldest and biggest experiments hunting for dark matter particles, DAMA is alone in claiming to see them;
- But if these dalliances between the visible and invisible worlds really do produce DAMA's data, several other experiments would probably also have detected dark matter by now. They have not.
- So, If another project show the 'same' result, the **DAMA** will not be the only one and there is a chance that they will win a NOBEL PRIZE.
(https://www.nature.com/articles/d41586-018-03991-y)

About the MAIN GOAL of the CYGNO project

A little explanation about the DAMA experiment

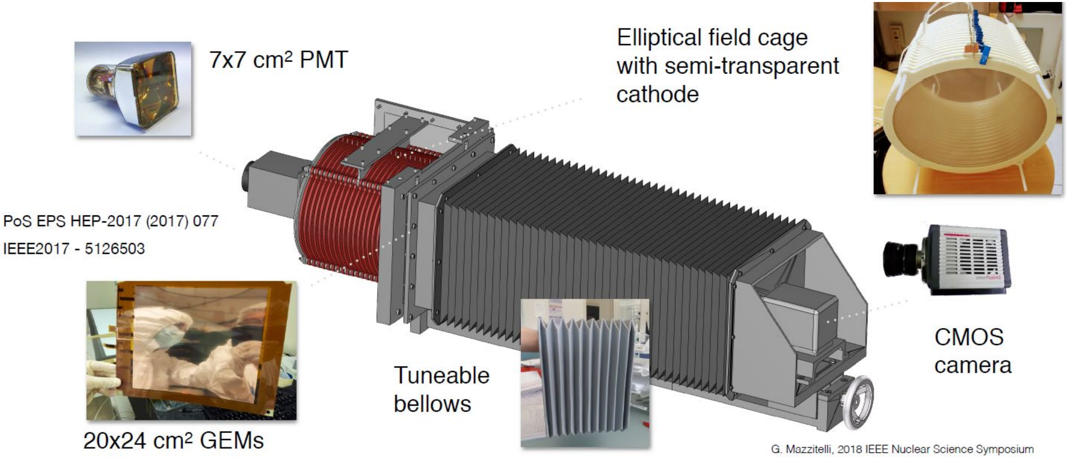
https://www.quantamagazine.org/trouble-detected-in-infamous-dark-matter-signal-20180412/





About the MAIN GOAL of the CYGNO project

- So the main goal of the CYGNO project is building a detector based on a optical readout (using a CMOS camera) with a Triple-GEM to be capable to see the Dark Matter;
- The name CYGNO is based on the CYGNUS (Cisne) constellation, there is where we believe that the WIMP (Weakly Interacting Massive Particles) comes from;
- So while the DAMA Project 'only' count the amount data of dark matter, the CYGNO will be capable to identify their directions too;

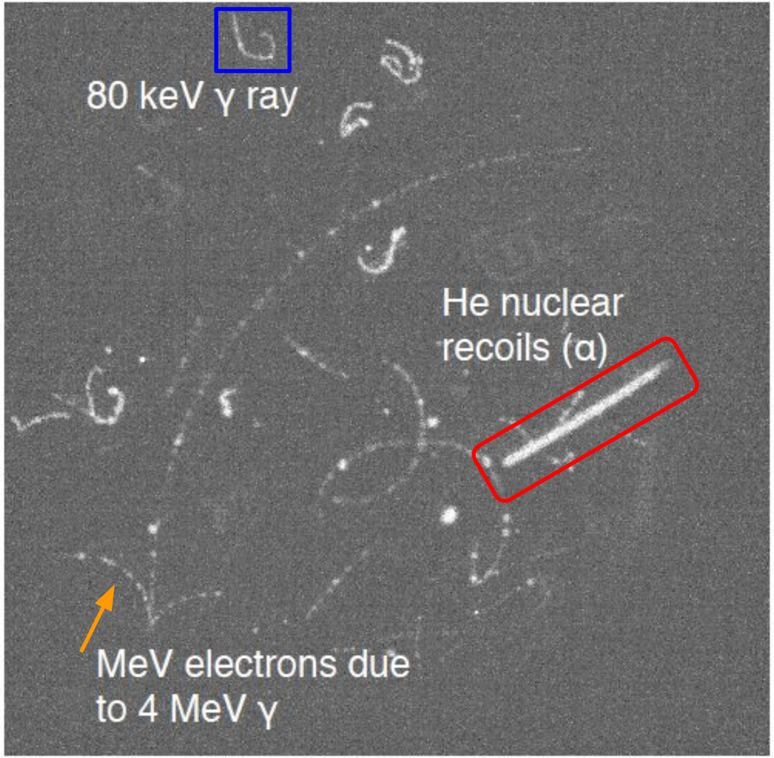


Setup used to took this data

- ❑ Took using the ORANGE detector;
- ❑ AmBe Neutron source

Using this configuration we expect to see three types of signals:

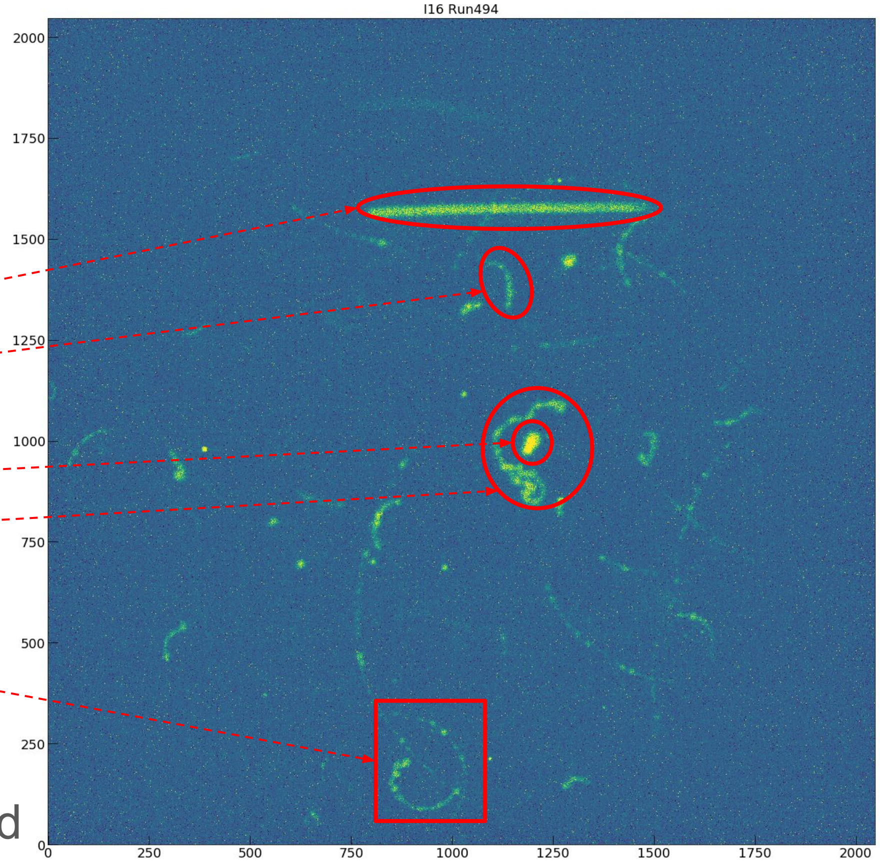
- He nuclear recoils (α);
- Low energy electrons due to X rays;
- MeV electrons due to 4 MeV γ.



Example of data

This image is a example of what we can have using a specific source and what we need to identify:

- ❑ Brighter and long tracks
- ❑ Lighter tracks
- ❑ Brighter and rounded tracks
- ❑ Close tracks
- ❑ Overlapped tracks
- ❑ etc..



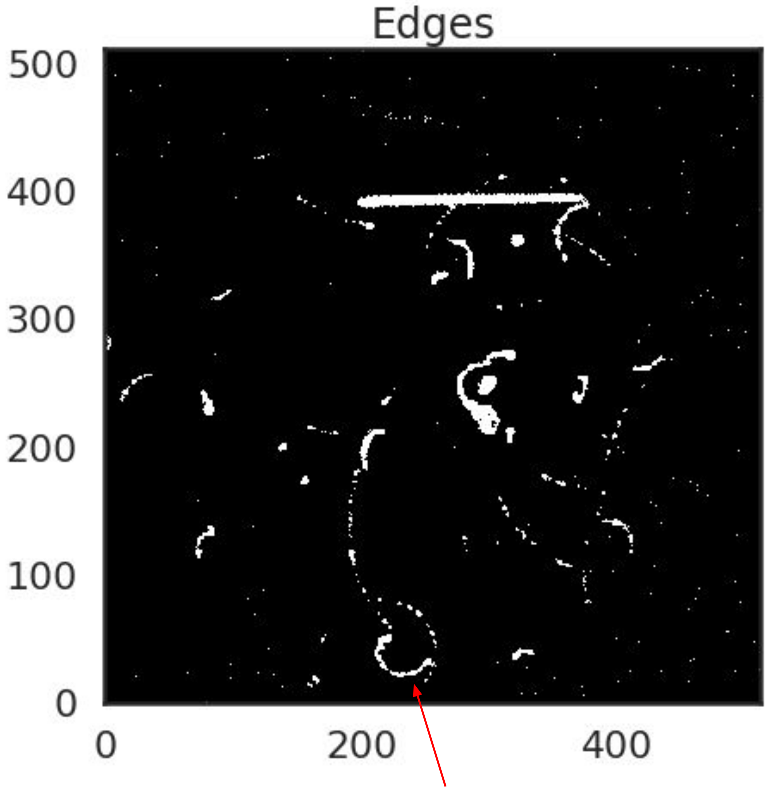
In order to recognize these differents kinds of tracks we tried a few clusterization methods and one works better to one kind like was expected.

Clustering Task

Therefore we thought about using DBSCAN (which is a density based clustering algorithm that divides a dataset into subgroups of high density regions) in a iterative approach:

1. Run DBSCAN on a image to look to ‘noise’ clusters and remove them from the image;
2. Search first for tracks with **high** density of pixels;
    a. Remove them from the image;
3. Search first for tracks with **medium** density of pixels;
    a. Remove them from the image;
4. Search for others tracks;
5. Go to next image

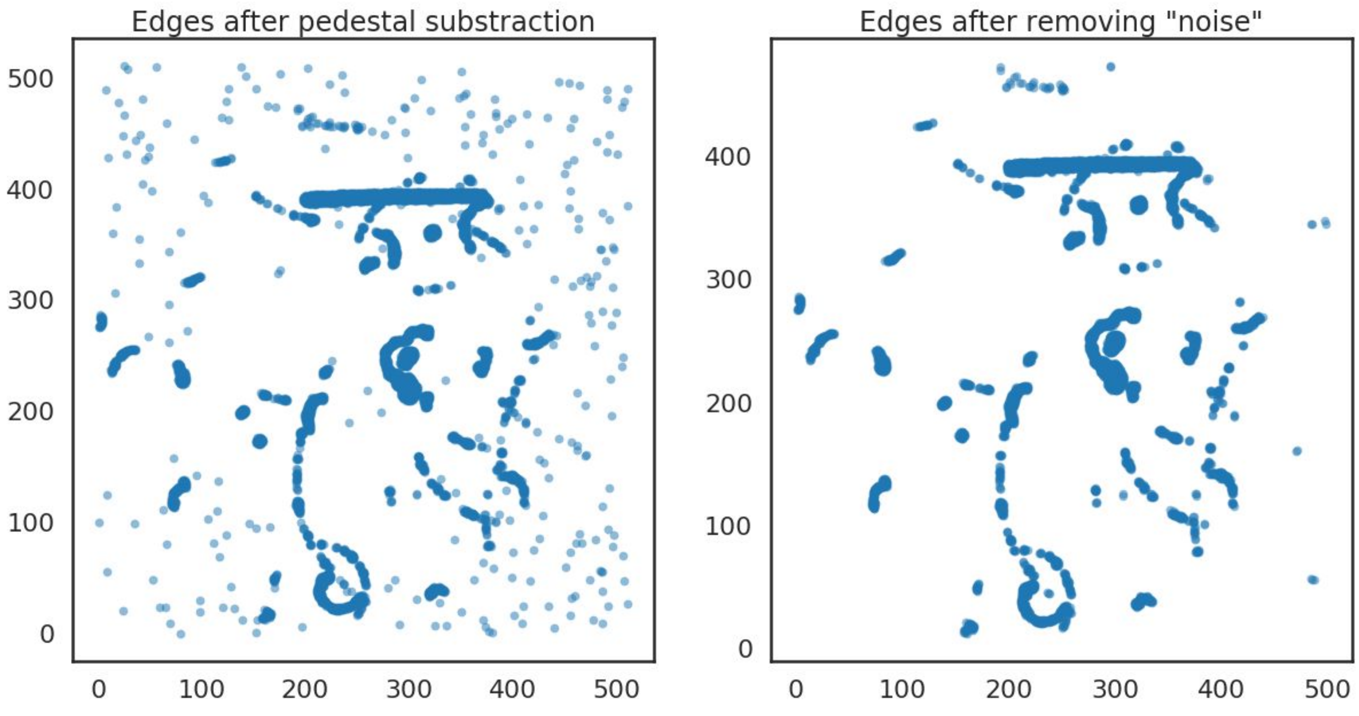
The parameters was decided looking through ~20 different images and many DBSCAN settings.



Theses X and Y are the input for the clustering algorithm.

Iterative DBSCAN Method - Step Zero

Remove ‘noise’ clusters (don’t have any near neighbors)



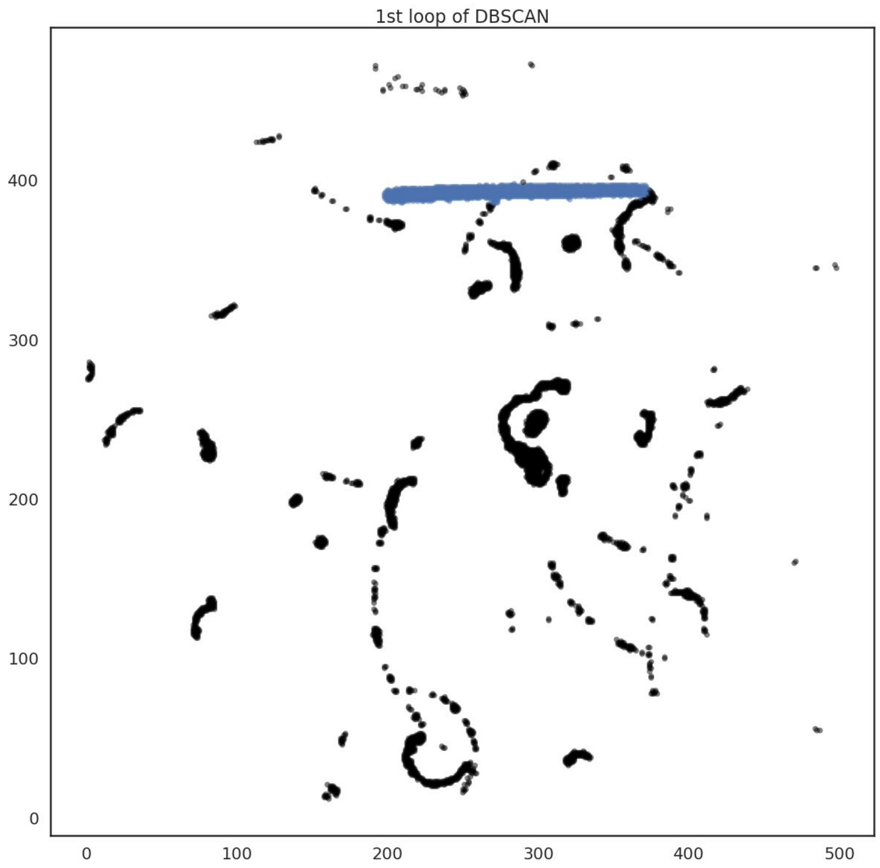
Iterative DBSCAN Method - Step One

In this loop DBSCAN was set to look for groups of pixels that have **high** density.

When the algorithm find a cluster in this step it is labelled as ‘long’.

Then, the found clusters are removed from the image to proceed to the next step.

(In the image at right different colors means different clusters and the black ones represents the not found clusters)

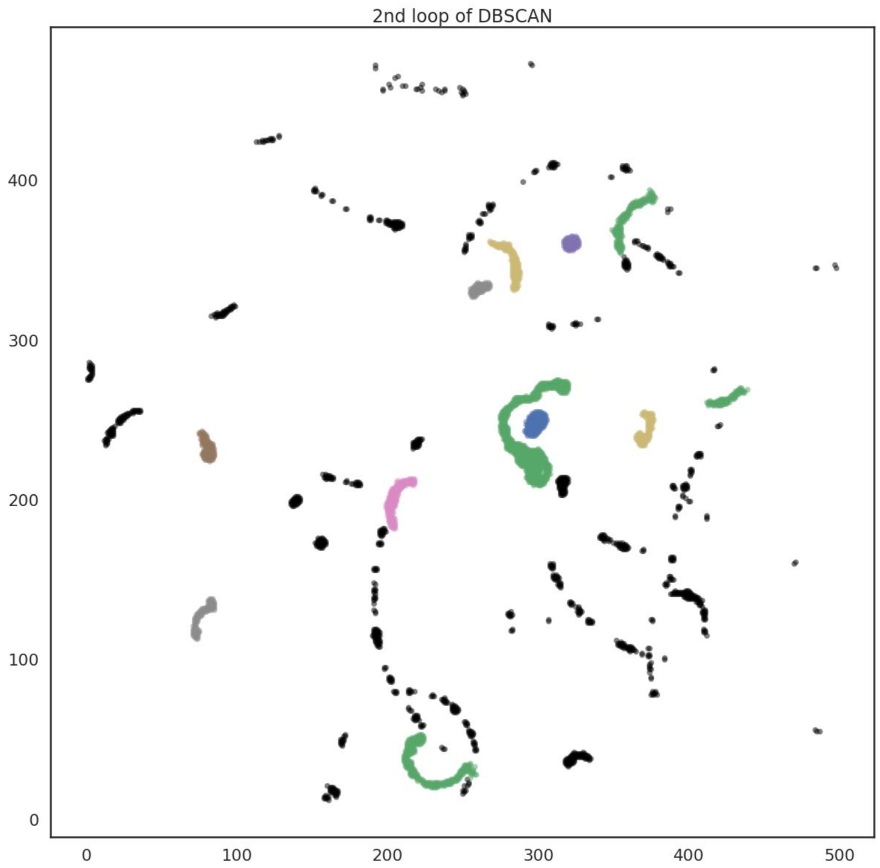


Iterative DBSCAN Method - Step Two

The second loop try to find groups of pixels with not so high density, let's say **medium** density.

And, as in the first step the found clusters are labelled as 'medium' and removed from the image to proceed to the next step.

(In the image at right different colors means different clusters and the black ones represents the not found clusters)

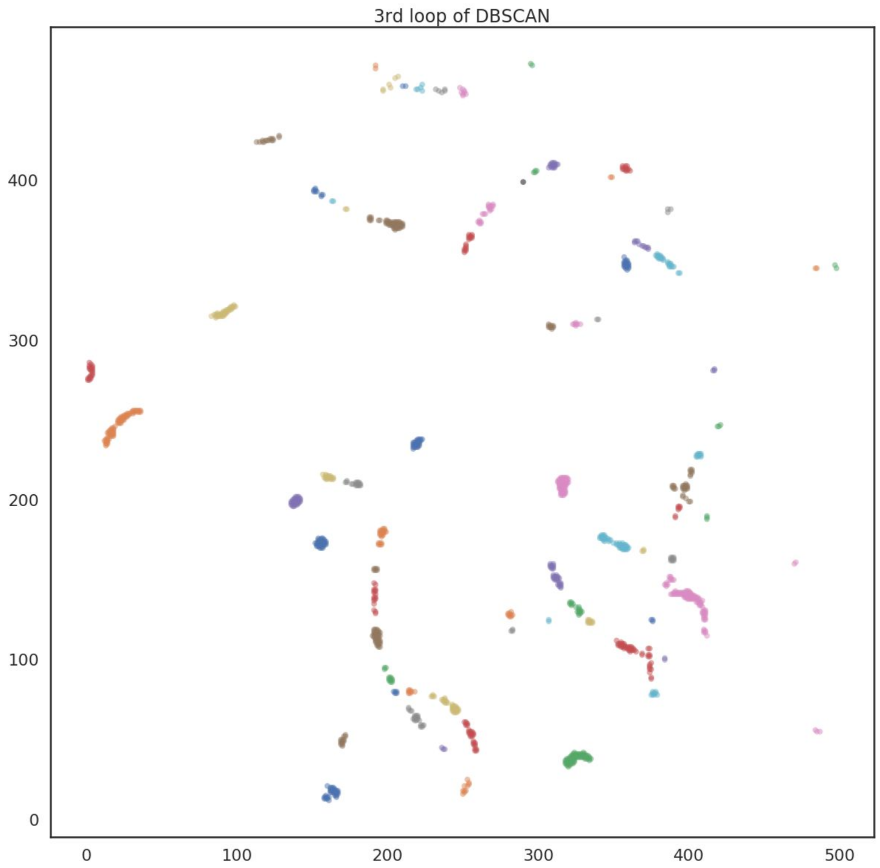


Iterative DBSCAN Method - Step Three

The last one is more flexible and the goal here is find the signals that aren't found yet.

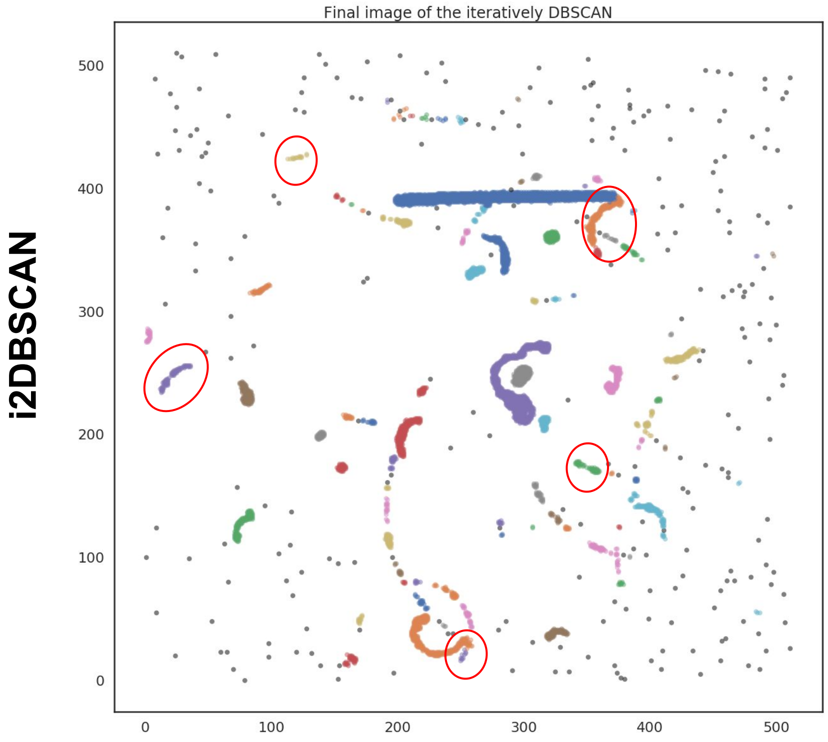
In this case the label is 'small' and the output of all steps is save for further analysis.

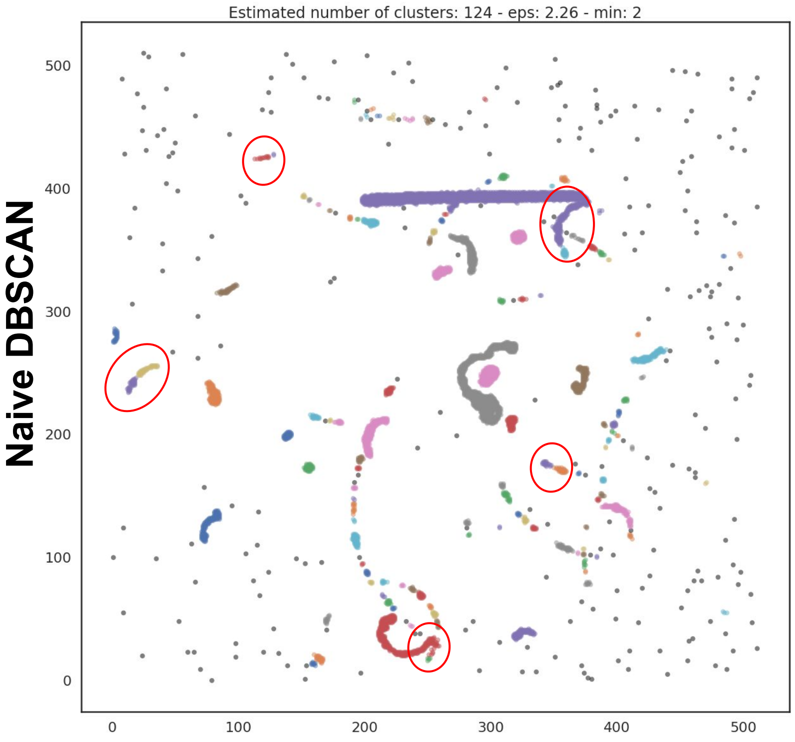
(In the image at right different colors means different clusters and the black ones represents the not found clusters)



i2DBSCAN x DBSCAN

So, the difference between the two methods are not so big by looking at one image. However, it can be a improvement considering a hundred of events.

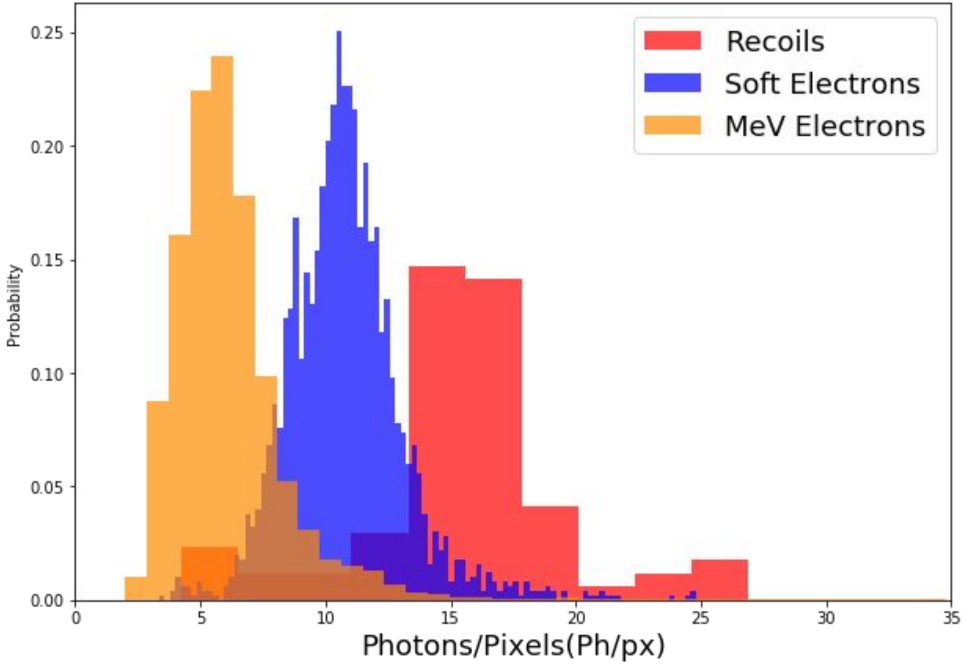




Preliminary Results

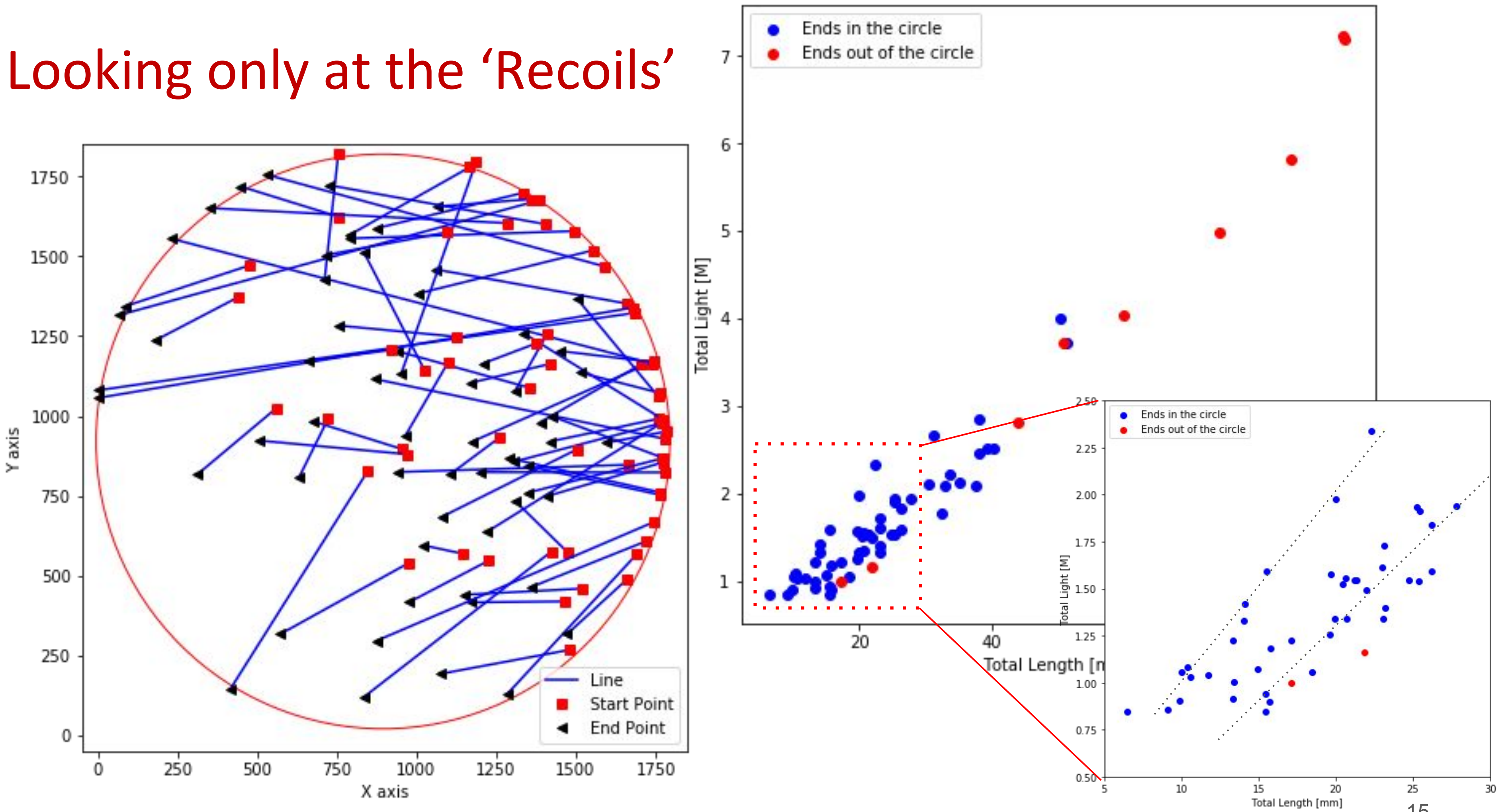
Very preliminary analysis

If we consider that the first iteration only will find 'Recoils', the second one 'Soft Electrons' and the third 'MeV Electrons', we can construct the following graphs:



- What is the expected behaviour of protons and alpha particles with an energy about few hundred keV?
- And the length?
- Where are we in the Bragg Curve?

Looking only at the ‘Recoils’



Summary

- Developed the *i2DBSCAN* algorithm:
  - Create a table with the necessary information;
  - The algorithm is taking 8-10 minutes to run over 300 images and save the **table**.
- We chose to not generate all the variables in the same time that we are doing the clusterization.
- But the 'table' has all the information needed to create the variables.

- **On Going:**
  - We are focus on characterizing first the 'long' tracks;
  - Create the needed variables;
  - And then, go to the classification task.