Update on divergent pointing with ctapipe

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Where were we?

- Performed some preliminary cross-checks between ctapipe and EventDisplay, showing some bugs in the latter.
- I had to move from the 2D reconstruction method to the 3D method present in ctapipe
- We have now more data
  - More files with same layout (divergent MSTs and parallel LSTs in La Palma)
  - Small production made by Alice: same CORSIKA, just different telescopes configurations. This allows an event-by-event comparison.
  - Another small production from Alice with a bigger divergent angle
  - Protons not already done…they will come soon…

An update:

- It was decided to use the reference curves for sensitivity, angular and energy resolution to compare with the ctapipe output: EventDisplay analysis discarded to use only ctapipe.
- Better to focus on the development than try to debug EventDisplay

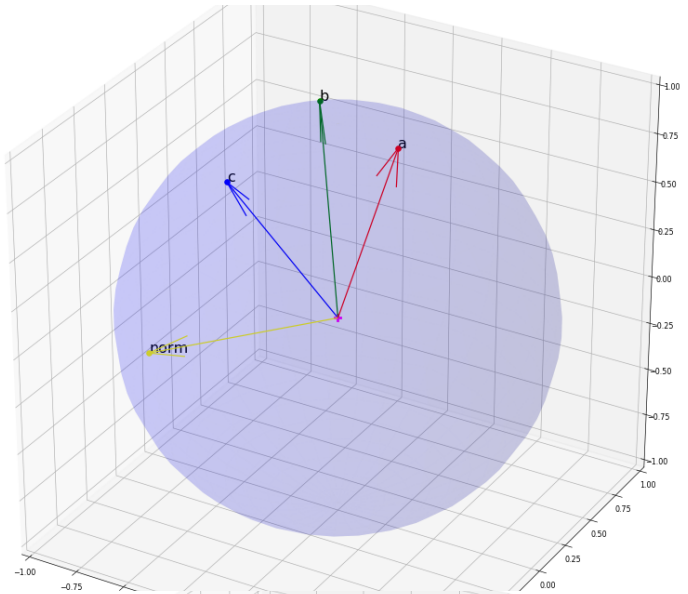
The reco method

- I’ve changed the pipeline from using the 2D method to the 3D one.
  - 2D is less performant and a bit more complicated to use
  - 3D was not “ready” for divergent pointing analysis
- The 3D method for divergent pointing (PR #946 is WIP):
  - The reconstruction of the position in the sky works.
  - The reconstruction of the impact point is done in 2D and it has to be corrected for the divergent pointing
  - I’m also missing the h_max reco

IMPORTANT:

- The results are not bad for divergent pointing for both the position in the sky, impact poing and h_max…this is **not** because the code was written for divergent pointing but because the deviation from parallel pointing is so small that the result has a slightly higher error.

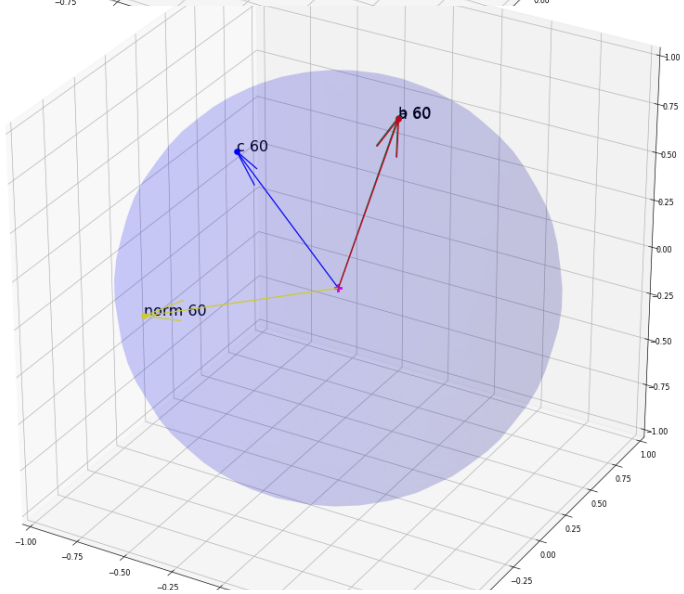
The 3D method



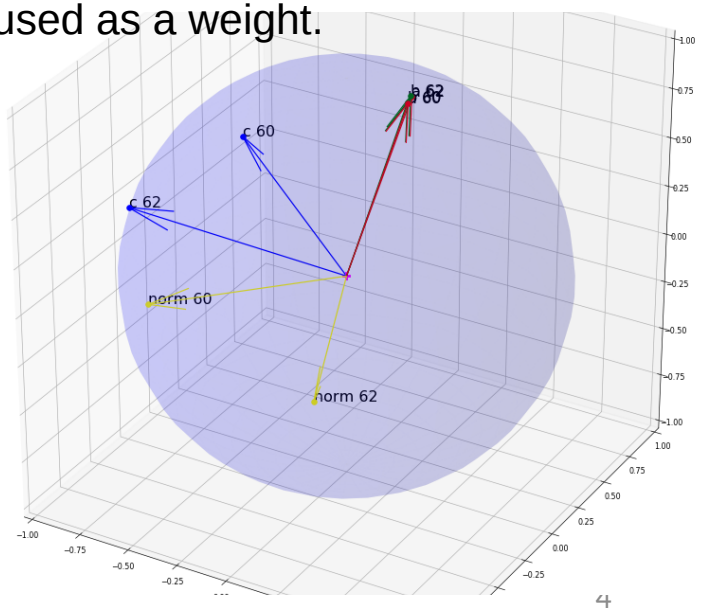
How the 3D method works. For each camera:

- take c.o.g. (a) plus a point along the major axis of the ellipse (b) [here their distance is enlarged just for visualization, but everything still holds]
- those two points in the camera are projected in the sky: CameraFrame → astropy AltAz (once “on the sky” their distance is ideally infinite→ not taking into account telescope positions)
- find the plane passing through a, b and the center:
  - (a x b) x a = c, which resides in the plane
  - c x a = normal vector (norm)

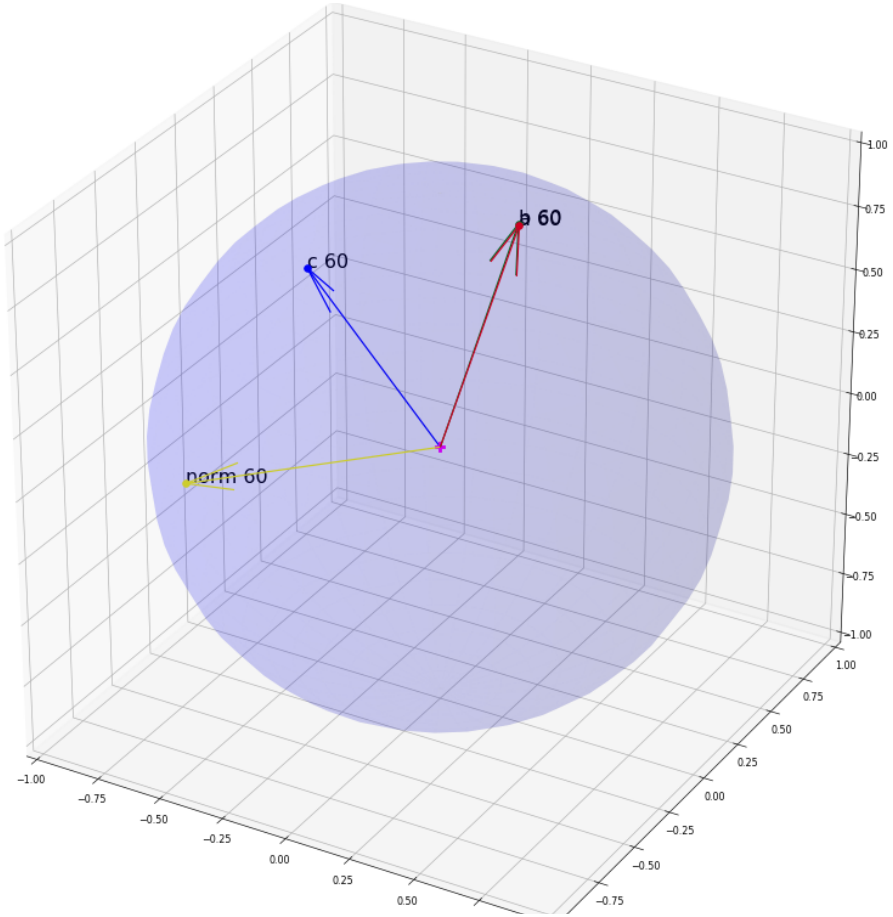
Then the intersection is performed pair-wise and the angle between the planes is used as a weight.

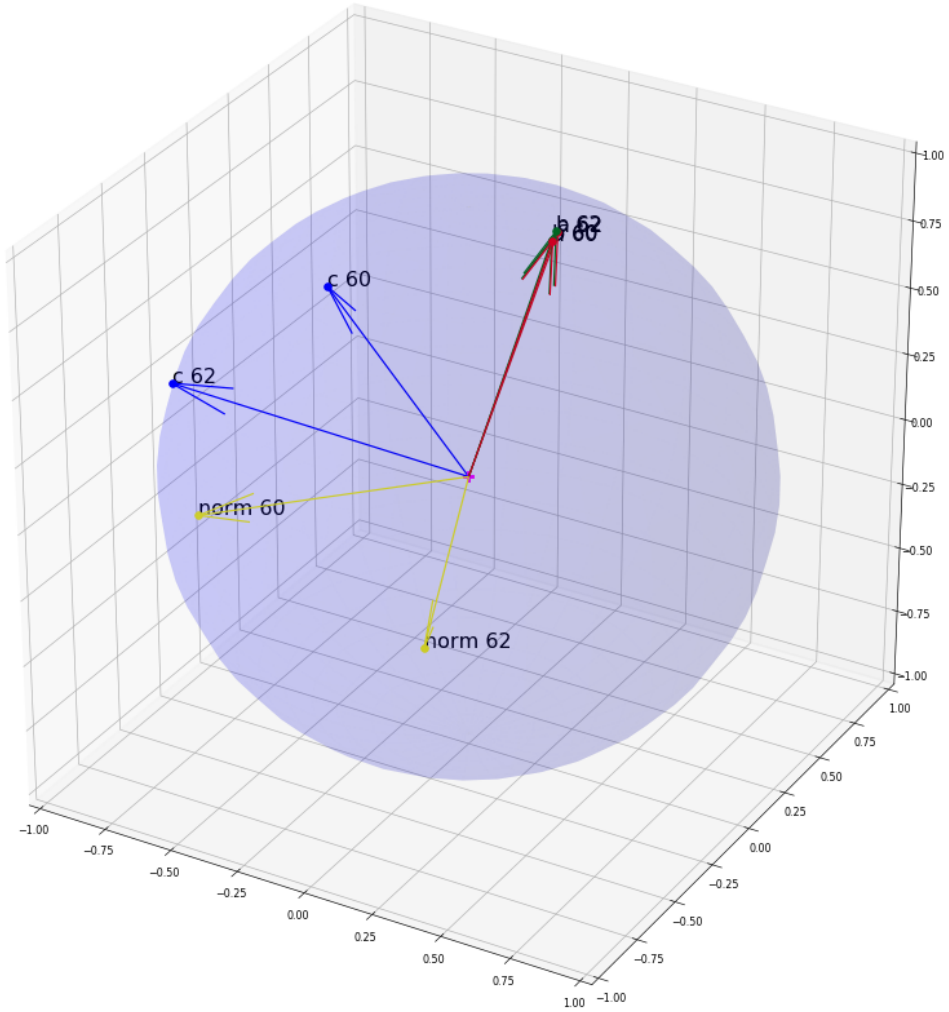


This works also for Divergent pointing

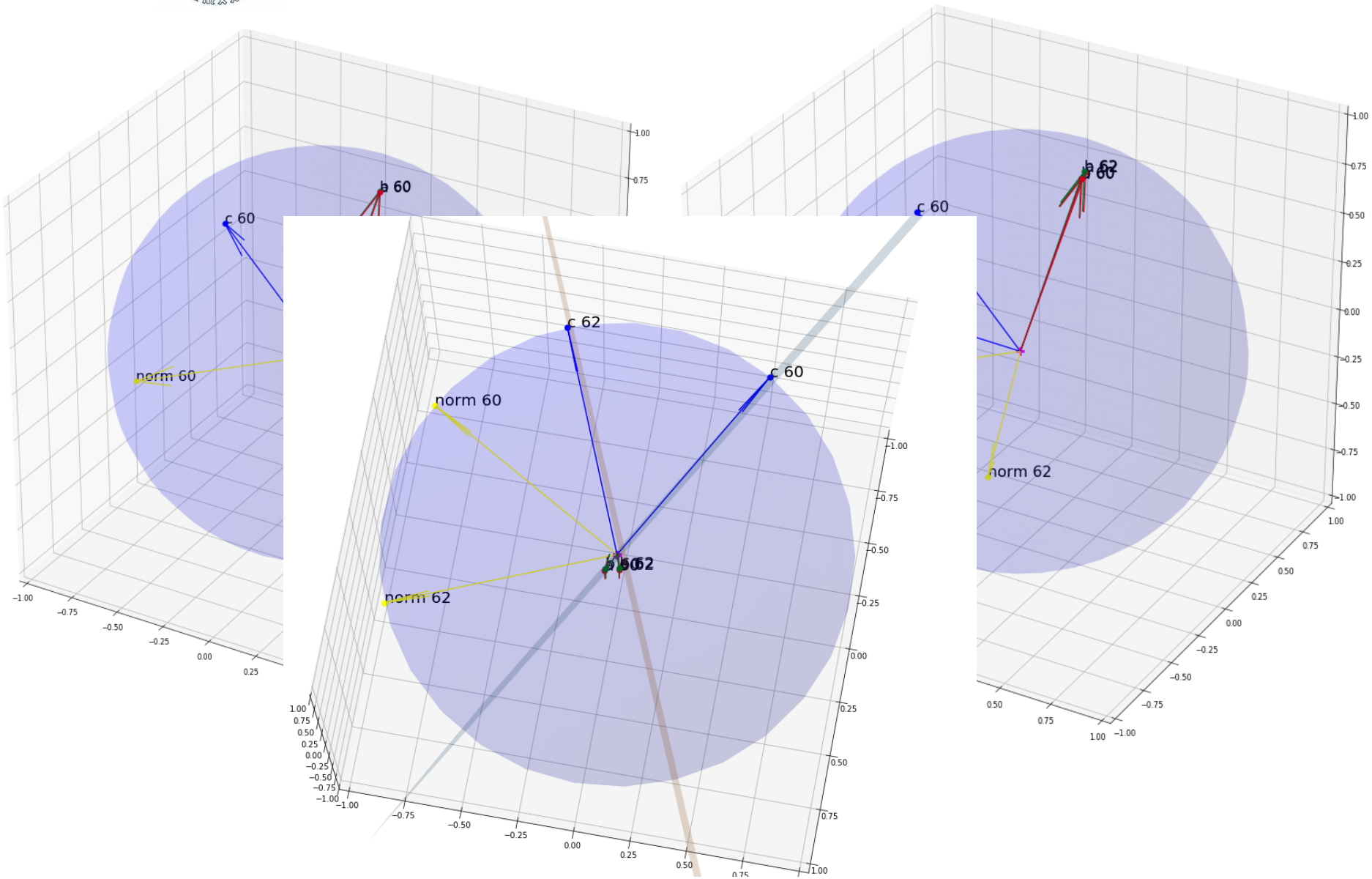


The 3D method

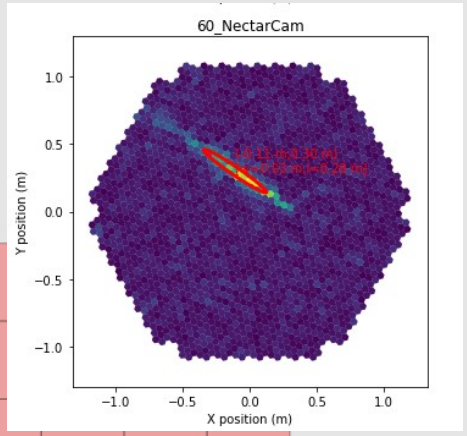


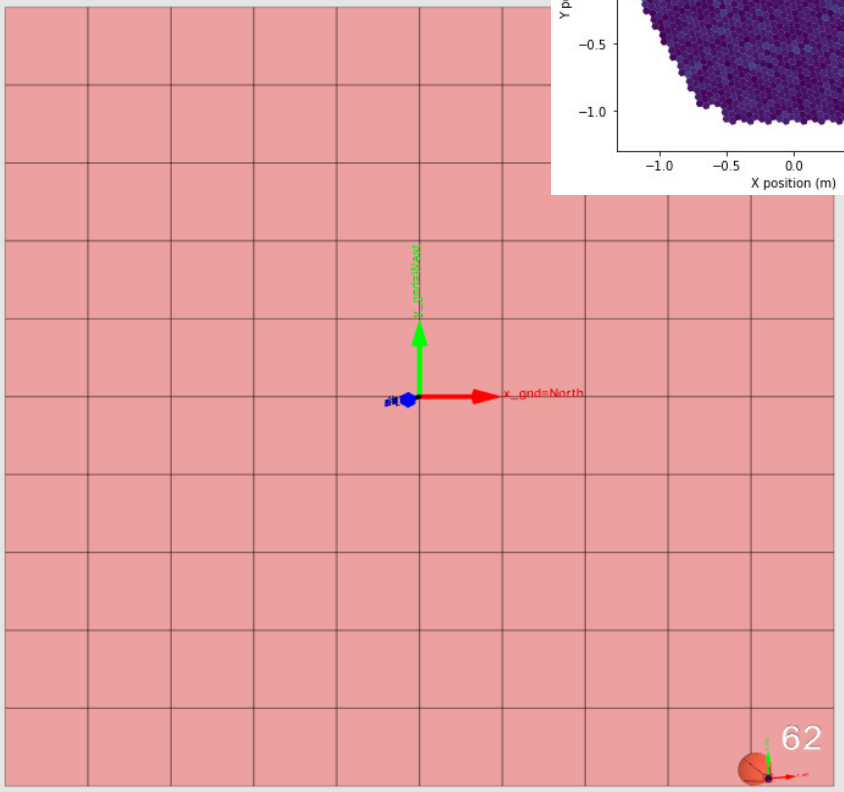


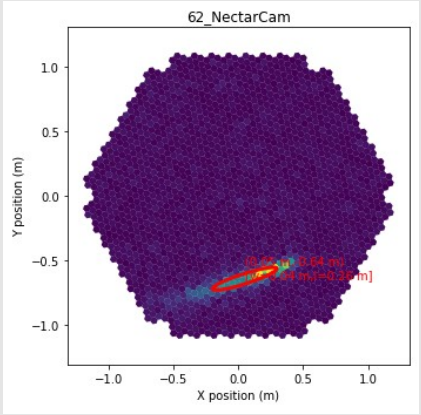
The 3D method



Visualization of two MSTs





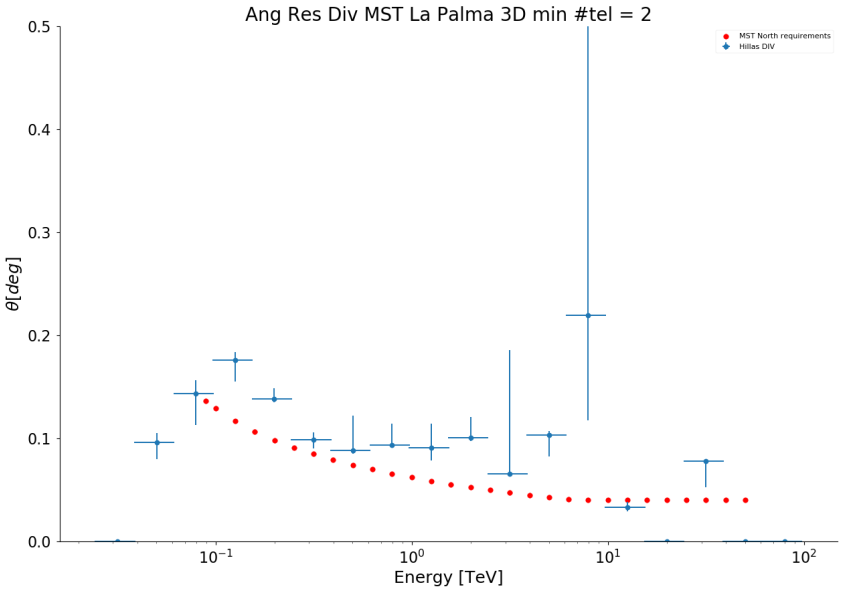


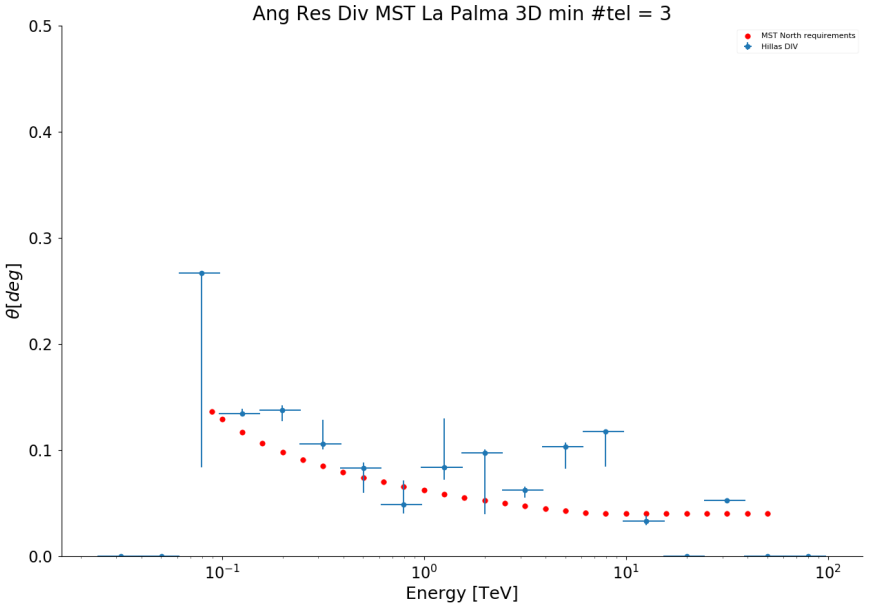
- two MSTs in La Palma
- normal pointing
- gamma diffuse
- huge 10 TeV event

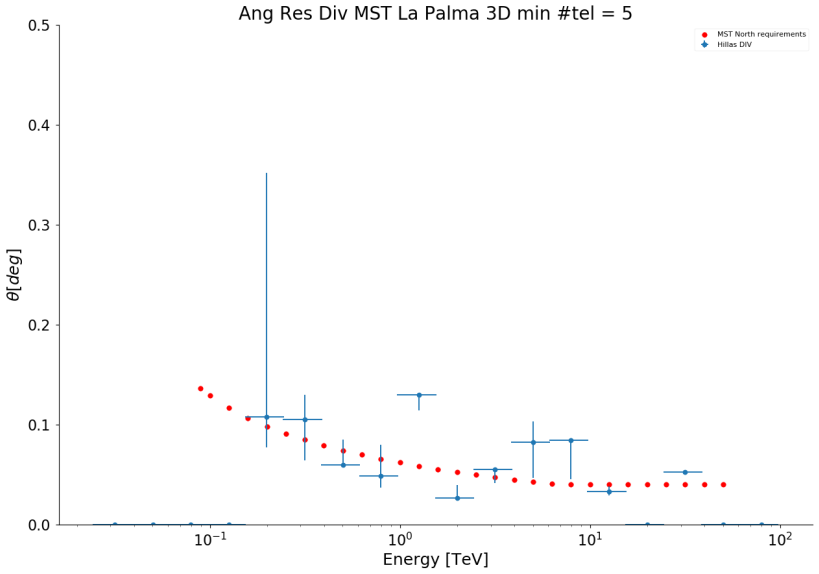
+ reco

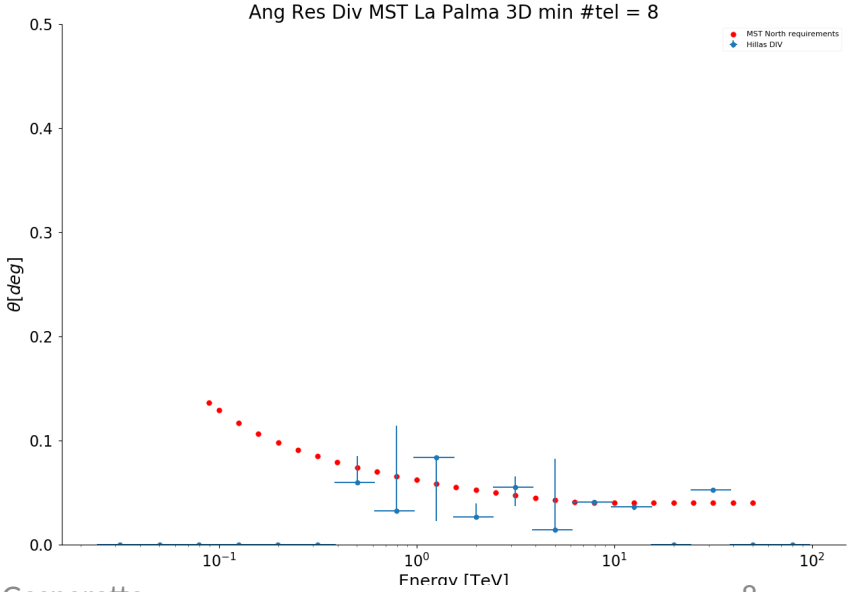
X mc

Some angular resolution plots









Next steps…

- Make the full reconstruction work for the divergent pointing
  - Sky position reconstrunction is OK
  - Impact point position has to be adjusted according to the offset between the telescope pointing and the array direction…should be easy
  - I will the impact point in tilted frame in the 3D displayer, plus a line to display if the the impact point reconstruction really works well
  - h_max (it works?)
- Test on more data:
  - Test on the new data that Johan made (100 x than first small production)
- Then test on other dataset:
  - Small MC productions: some data to play with with different pointing strategies
  - Perform full analysis in order to understand sensitivity & angular resolution & energy resolution

…then we need the full IRF chain in ctapipe to produce IRFs…