Event-by-Event Analysis Using muDSTs

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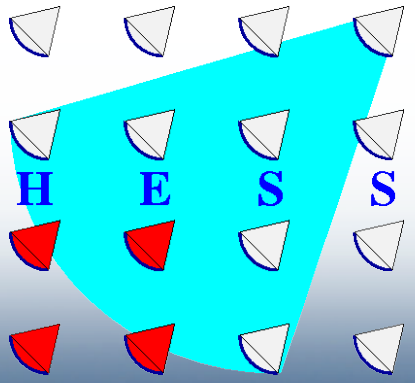
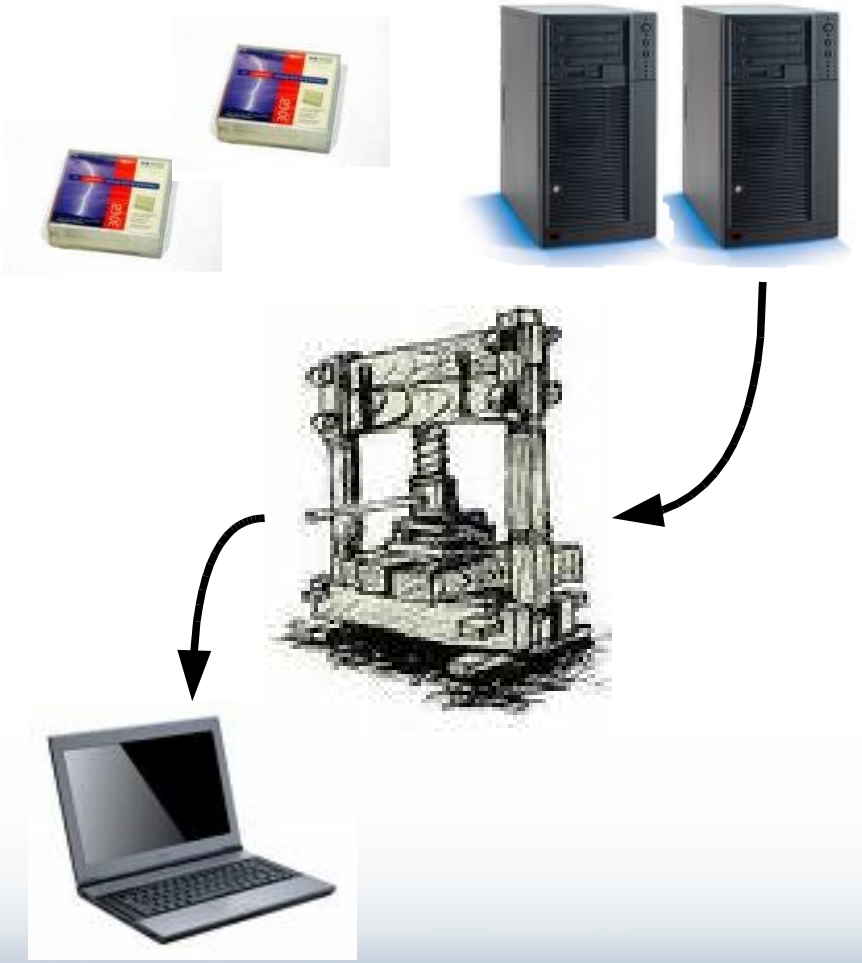
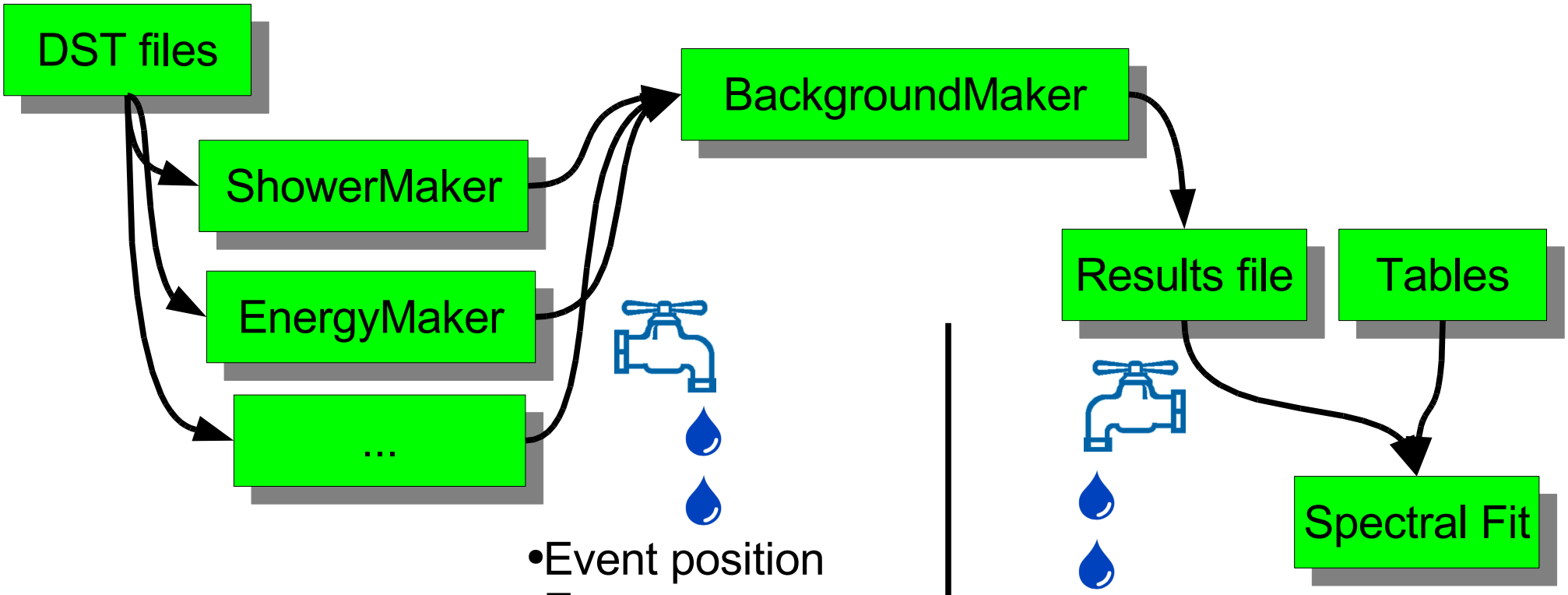


Motivation

- each event comes with a lot of information
  - "raw" information: number of telescopes, Hillas parameters, telescope pointing, ...
  - reconstructed information: direction, energy, gamma or background, ...
  - several reconstruction algorithms
- compress the information, put it into small files
- → systematic studies, development of cuts and algorithms



Tapping the Analysis Chain



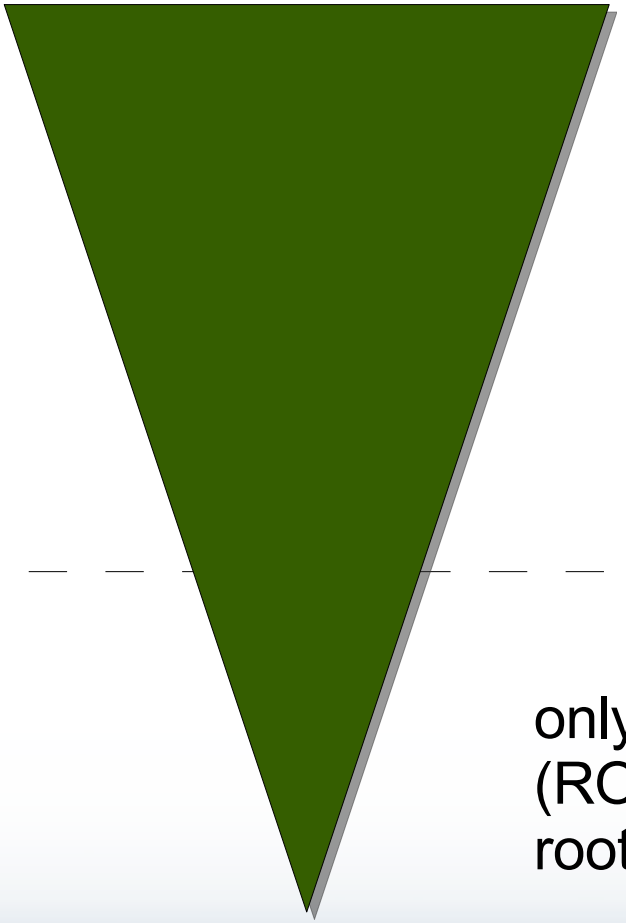
μ-DST ⇒

- Event position
- Energy
- Hillas parameters
- Goodness of Fit
- ...

- on or off
- (effective area)
- ...

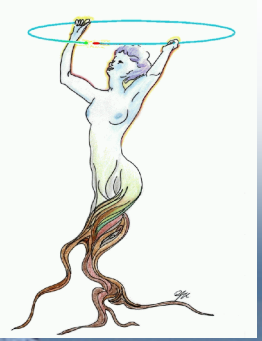
Time and Space

- DST files:
  - size: 300 MB
  - analysis time: ~ 5 min
- Results file:
  - size: 13 MB
  - analysis done
- muDST:
  - size: 2 – 3 MB
  - analysis: ~ 5 sec
  - but: they need to be produced!!



H.E.S.S. analysis software needed

only standard software (ROOT) needed
root.cern.ch



What is in a muDST file?

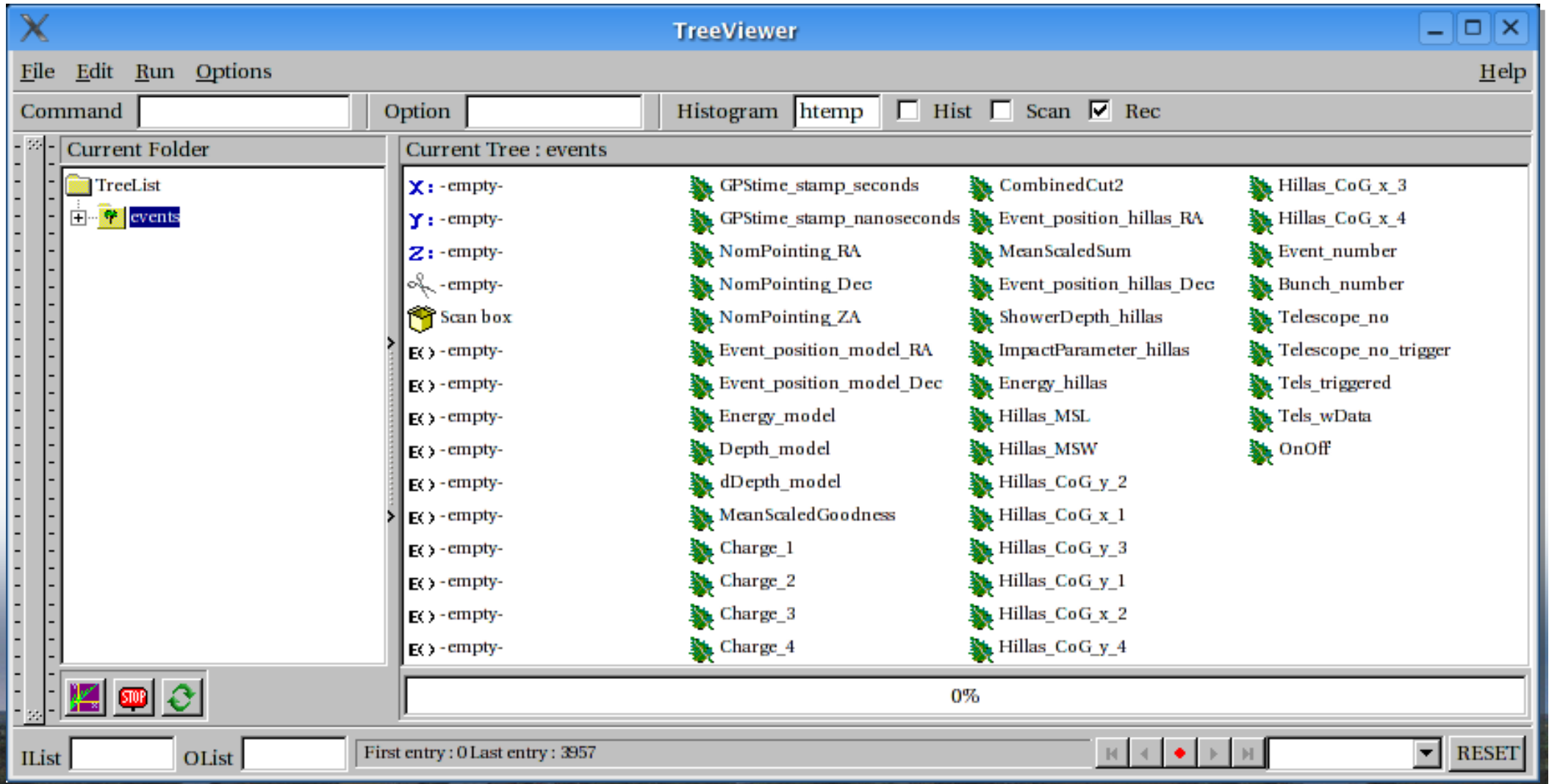
- plain ROOT file
- contains Header
  - a `TList` of `TNamed` objects
  - run related information
- contains events tree
  - a `TTree`
- If you don't know TWhatever, don' worry about the details.

```
> root run018406.muDST.root
root [0] .ls
TFile**         run018406.muDST.root
 TFile*         run018406.muDST.root
  KEY: TList    Header;1        Doubly
  KEY: TTree    events;1        events
root [1] Header->Print()
OBJ: TNamed     RunNumber       18406
OBJ: TNamed     ObservationPosition_RA  83.6333
OBJ: TNamed     ObservationPosition_Dec 24.5144
OBJ: TNamed     TargetPosition_RA       83.6333
OBJ: TNamed     TargetPosition_Dec      22.0144
...
root [2]
```

The Events Tree

- easy use: the TreeViewer, a graphical interface

```
root [2] events->StartViewer()
```



General Information

- Bunch_number, Event_number
- GPStime_stamp_seconds, GPStime_stamp_nanoseconds
- Telescope_no, Telescope_no_trigger
- Tels_triggered, Tels_wData
  - bitmaps to identify the telescopes, e.g. tels 2+3+4: 14 $\sum 2^{tel}$
- NomPointing_RA, NomPointing_Dec, NomPointing_ZA

Information from Model Analysis

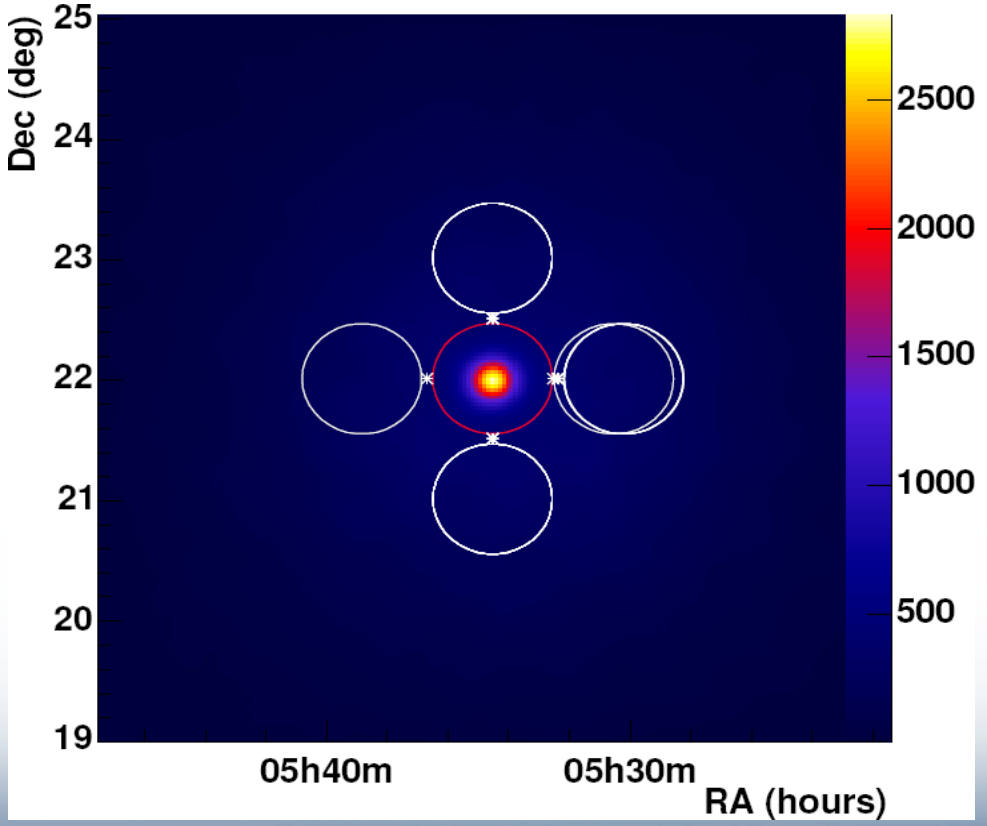
- Event_position_model_RA, Event_position_model_Dec
- Energy_model
- Depth_model, dDepth_model
- Charge_1, Charge_2, Charge_3, Charge_4
- MeanScaledGoodness, MeanScaledSum, CombinedCut2

Information from Hillas Analysis

- Event_position_hillas_RA, Event_position_hillas_Dec
- ShowerDepth_hillas, ImpactParameter_hillas
- Energy_hillas
- Hillas_MSL, Hillas_MSW
- Hillas_CoG_x_t, Hillas_CoG_y_t t = 1...4

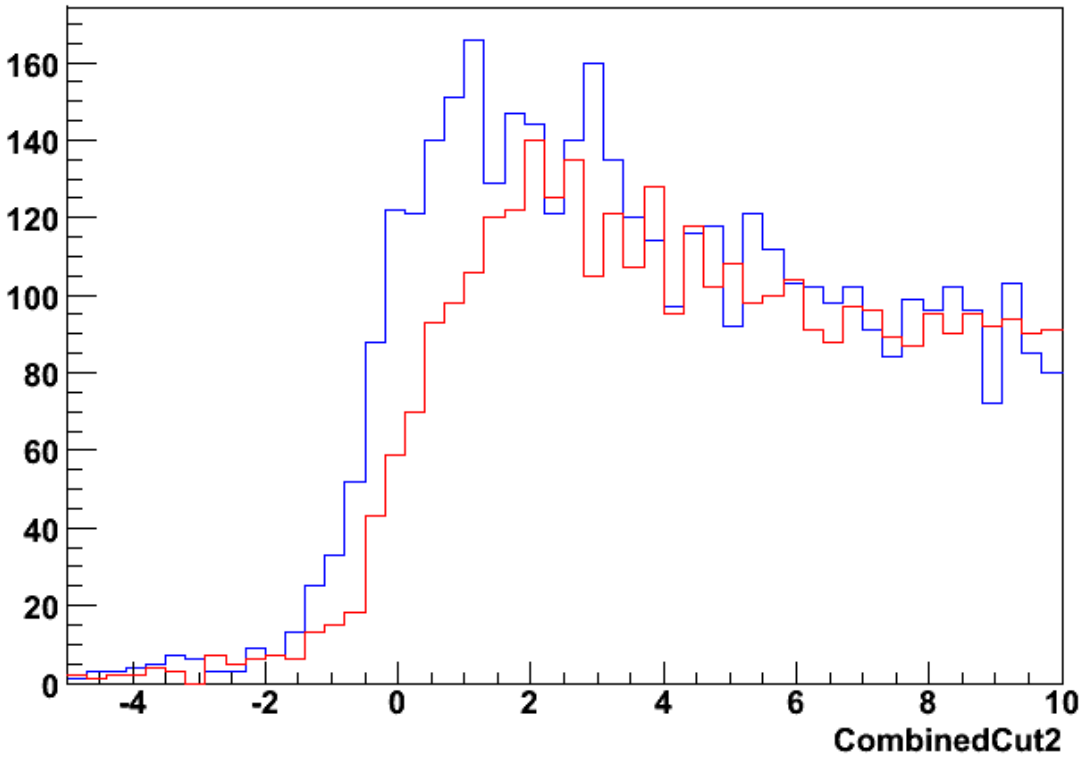
Background Determination

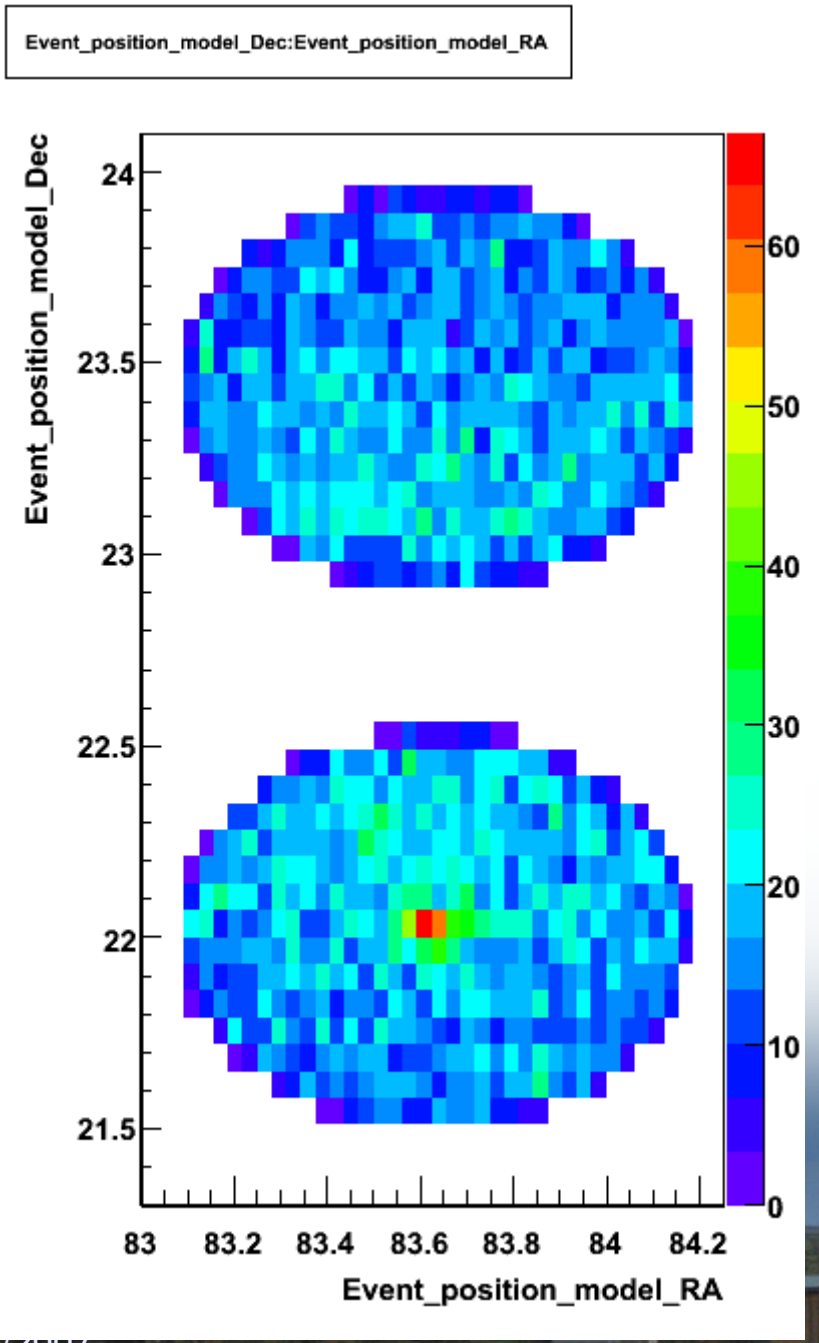
- simplest method: one region reflected at camera centre
- in muDST:
  - OnOff = 1 (event in on source region)
  - OnOff = 2 (event in off source region)



Example Plots

- tutorials after coffee...





MuDST Production

- it is done during analysis
- predefined script for ParisAnalysis
- uses very loose cuts, keeps almost all events
- Lyon:
  `$HESSROOT/muDST/scripts/makeOnOffMuDST.C`

```
root [2] makeOnOffMuDST(12345,"./",0.25)
```

run number

output directory, will produce a file ./run12345.muDST.root

squared radius of test region

More ParisAnalysis Scripts

- you are not interested in On and Off, but just the data in the camera

```
root [2] makeMuDST(12345,"./")
```

- Simulation runs

```
root [2] makeMuMC(12345,"./",...)
```

- if you have your analysis script, you can add

```
set_MuDST_inputFolder("event_on","event_o
ff");
set_MuDST_outputFile(outputfile);
```

- you will get the same events in your Result and in the muDST
  - same preselection and number of background regions
  - event selection cut not applied

Technical Details

- it is a Maker in the Sash frame
- `include <muDST/MuDSTMaker.hh>`
- `m = new MuDST::MuDSTMaker(onfolder, offfolder);`
- `m->InitBasic();`
- `m->InitModel();`
- `m->InitParisHillas();`
- `chain->UseMaker(m);`

Technical Details

- it is a Maker in the S
- chain->UseMaker(m);

it can be plugged into other analyses
(e.g. HAP, to be done)

Dos and Don'ts

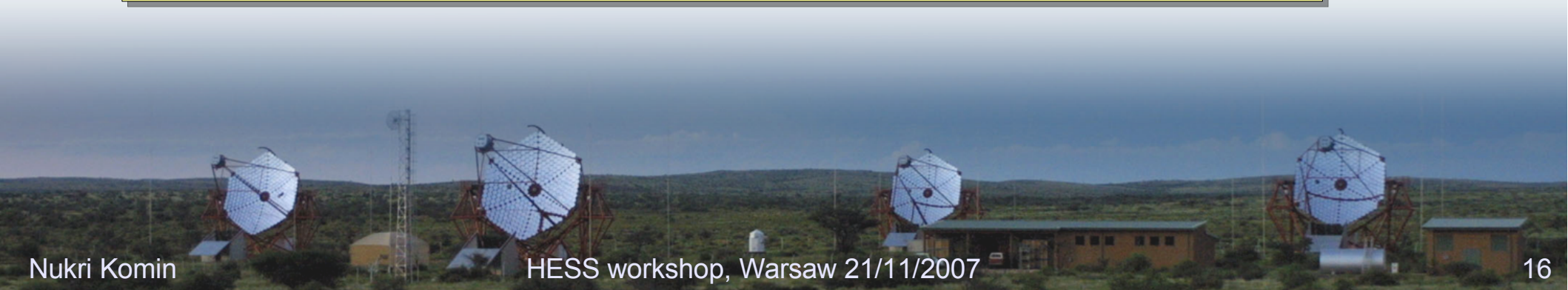
What is it good for?

- all event information in one, simple file
- for systematic studies
- development of new cuts and algorithms

Do not use

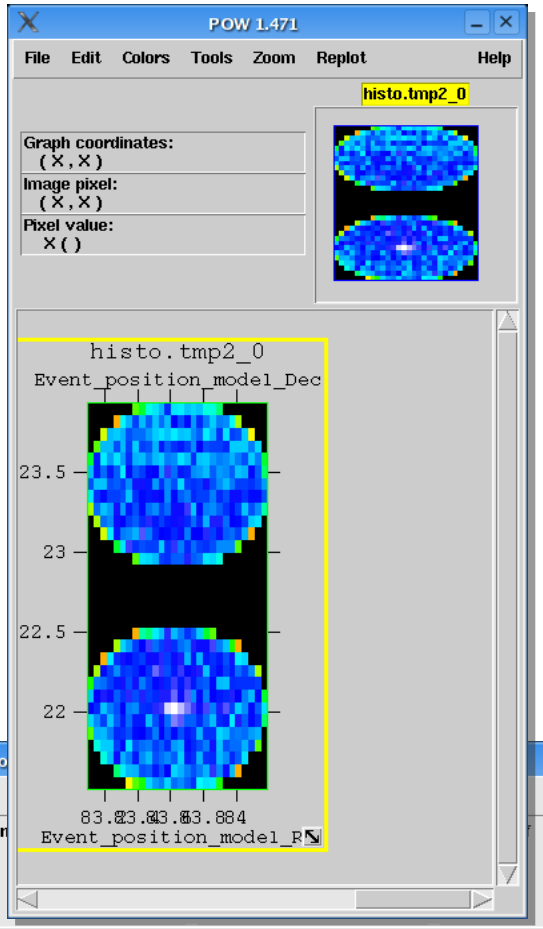
- to write a paper
- do not write long code for muDSTs
- it is not a starting point to get in touch with HESS analysis

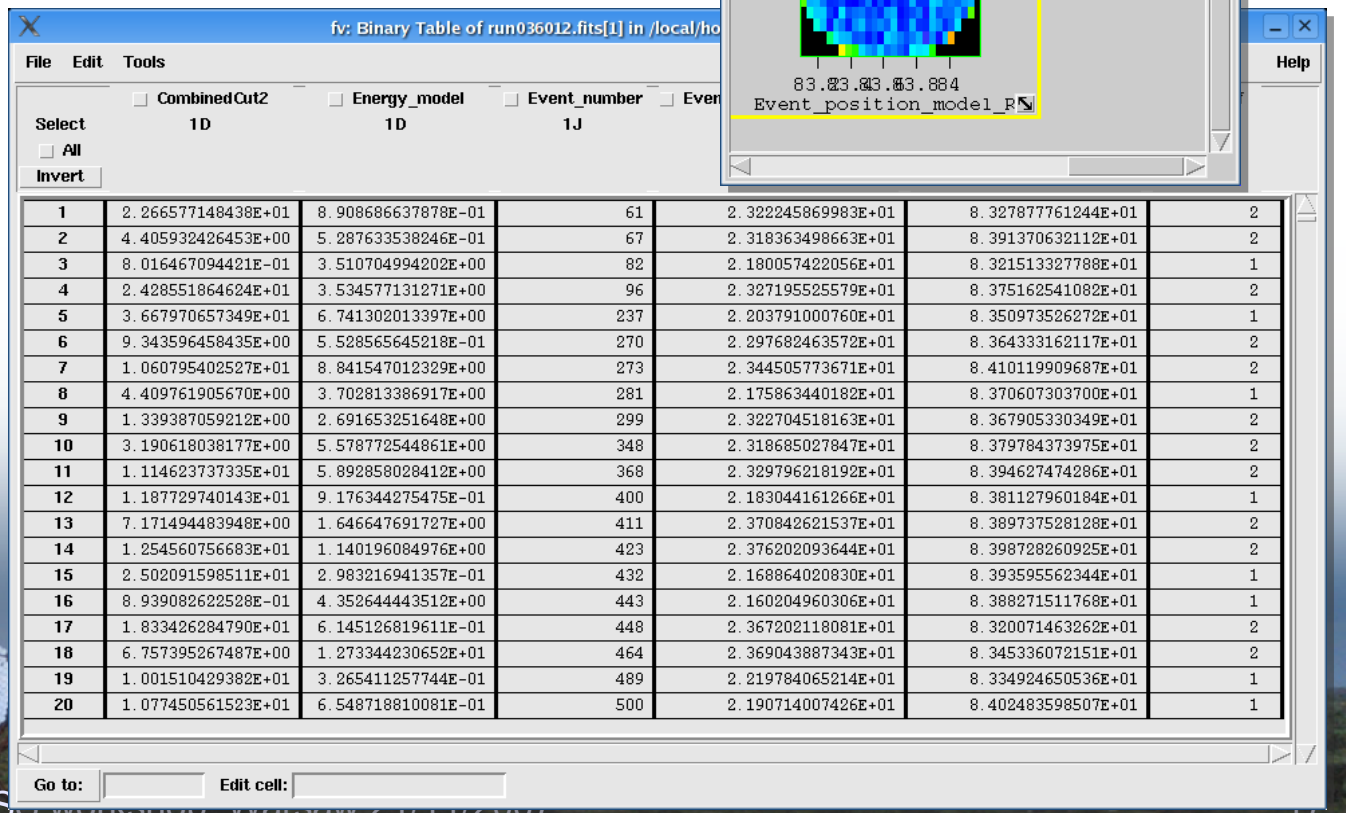
your new algorithms and cuts
should be put into a standard analysis chain



Outlook

- what is missing
  - combination of different methods in one file
  - effective area per event
- muDST can be exported to FITS
- but not yet ready analysis
- (far) future:
  - spectral data in XSPEC
  - problem: effective areas





1	2.266577148438E+01	8.908686637878E-01	61	2.322245869983E+01	8.327877761244E+01	2
2	4.405932426453E+00	5.287633538246E-01	67	2.318363498663E+01	8.391370632112E+01	2
3	8.016467094421E-01	3.510704994202E+00	82	2.180057422056E+01	8.321513327788E+01	1
4	2.428551864624E+01	3.534577131271E+00	96	2.327195525579E+01	8.375162541082E+01	2
5	3.667970657349E+01	6.741302013397E+00	237	2.203791000760E+01	8.350973526272E+01	1
6	9.343596458435E+00	5.528565645218E-01	270	2.297682463572E+01	8.364333162117E+01	2
7	1.060795402527E+01	8.841547012329E+00	273	2.344505773671E+01	8.410119909687E+01	2
8	4.409761905670E+00	3.702813386917E+00	281	2.175863440182E+01	8.370607303700E+01	1
9	1.339387059212E+00	2.691653251648E+00	299	2.322704518163E+01	8.367905330349E+01	2
10	3.190618038177E+00	5.578772544861E+00	348	2.318685027847E+01	8.379784373975E+01	2
11	1.114623737335E+01	5.892858028412E+00	368	2.329796218192E+01	8.394627474286E+01	2
12	1.187729740143E+01	9.176344275475E-01	400	2.183044161266E+01	8.381127960184E+01	1
13	7.171494483948E+00	1.646647691727E+00	411	2.370842621537E+01	8.389737528128E+01	2
14	1.254560756683E+01	1.140196084976E+00	423	2.376202093644E+01	8.398728260925E+01	2
15	2.502091598511E+01	2.983216941357E-01	432	2.168864020830E+01	8.393595562344E+01	1
16	8.939082622528E-01	4.352644443512E+00	443	2.160204960306E+01	8.388271511768E+01	1
17	1.833426284790E+01	6.145126819611E-01	448	2.367202118081E+01	8.320071463262E+01	2
18	6.757395267487E+00	1.273344230652E+01	464	2.369043887343E+01	8.345336072151E+01	2
19	1.001510429382E+01	3.265411257744E-01	489	2.219784065214E+01	8.334924650536E+01	1
20	1.077450561523E+01	6.548718810081E-01	500	2.190714007426E+01	8.402483598507E+01	1

Summary

- all event information in a single, small file
  - fast production of distribution plots
  - cut and algorithm development
  - only ROOT needed
- muDST production needs one full analysis
  - scripts implemented for ParisAnalysis
  - will be done for HAP
- Future
  - FITS files with event data
  - (spectral data for XSPEC)