Data Analysis and Simulation with HAWC

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AERIE

- ***A***nalysis and ***E***vent ***R***econstruction ***I***ntegrated ***E***nvironment

- Event-driven framework used for online event building and offline analysis
- Branch of IceTray, for those familiar with that…
- C++ backbone with full python bindings, support for ROOT-based analysis

Data Formats

- **XCDF**: e***X***plicitly ***C***ompacted ***D***ata ***F***ormat, event data
  - Custom reduced-precision binary bit-packing library (J. Braun author, UMD)
  - C++ utility with full python support
- **FITS**: format for skymaps
  - Current maps are written in HEALPix format
  - Data, bkg, weights, masks in 6 FITS columns
  - Relative intensity & errors in 4 FITS columns

Installation in VM

- /home/fermi/software/ApeInstalled/aerie/1.23.00
- To set up environment:
  - eval `./software/ApeInstalled/aerie/1.23.00/bin/hawc-config --env-csh`
  - eval `./software/ApeInstalled/aerie/1.23.00/bin/hawc-config --env-sh`
- Exercises:
  - Event viewing demo
  - Generate fake point source & background
  - Plot simulated cosmic ray background

Important Locations

- Applications folder:
  - software/ApeInstalled/aerie/1.23.00/share/hawc/aerie-apps
- Installed binaries:
  - software/ApeInstalled/aerie/1.23.00/bin
- Configuration files (survey, catalogs, etc.):
  - software/ApeInstalled/aerie/1.23.00/share/hawc/config
- Extras (sim maps, response tables, plot scripts, etc.):
  - /home/fermi/HAWCExtras

Not Discussed By Me

- Full GEANT4 simulation of HAWC tank response with CORSIKA shower libraries (HAWCSim)
  - Plugs into AERIE, not included in distribution
  - Maintainer: Brian Baughman
- Steady source sensitivity
  - software/ApeInstalled/aerie/1.23.00/bin/hmc-analysis-*
  - Astropart. Phys. **50-52** 2013:26-32, arXiv:1306.5800
  - Questions: John Pretz

Point Source Exercise

- Enter the following command in your shell to simulate 1 day of data from the Crab Nebula (HESS spectral fit):

```
aerie-apps-pointsource
 -c $HAWC_INSTALL/share/hawc/config/TeV-src-catalog.xml
 -n "TeV J0534+220 : Crab"
-a HAWCExtras/sim-response/hawc111_389pmt_nhit17_aeff.fits.gz
-r HAWCExtras/sim-response/hawc111_389pmt_nhit17_response.fits.gz
-m 56700 -M 56701
-d $HAWC_INSTALL/share/hawc/config/HAWCRealConfig.xml
```

- Your output will be an XCDF file called test.xcd
- You can convert XCDF to ROOT as follows:
  - `xcdf-root test.xcd -o test.root`

Viewing Data with XCDF

- Print RA, Dec in test.xcd using a python script:

```
from xcdf import XCDFFile

f = XCDFFile("test.xcd")
for record in f.fields("phony.RA, phony.Dec"):
    ra,dec = [x*180./3.14159 for x in record]
    print(ra,dec)
```

- You should see output like this:

```
(85.592399999999998, 18.3887)
(83.919200000000004, 21.8337)
(84.676199999999994, 23.675500000000003)
(82.896400000000014, 25.682300000000001)
(83.512900000000002, 21.605)
...
```

Plotting Code

- See the plotVars.py script included in the workshop materials
- Sky maps in HAWCExtras/sim-maps
- Plotting pre-computed sky maps (healpy required):
  - HAWCExtras/plotMercator.py
  - HAWCExtras/plotMollweide.py