3ML

The Multi-Mission Maximum Likelihood framework

for high-level analysis with SGSO

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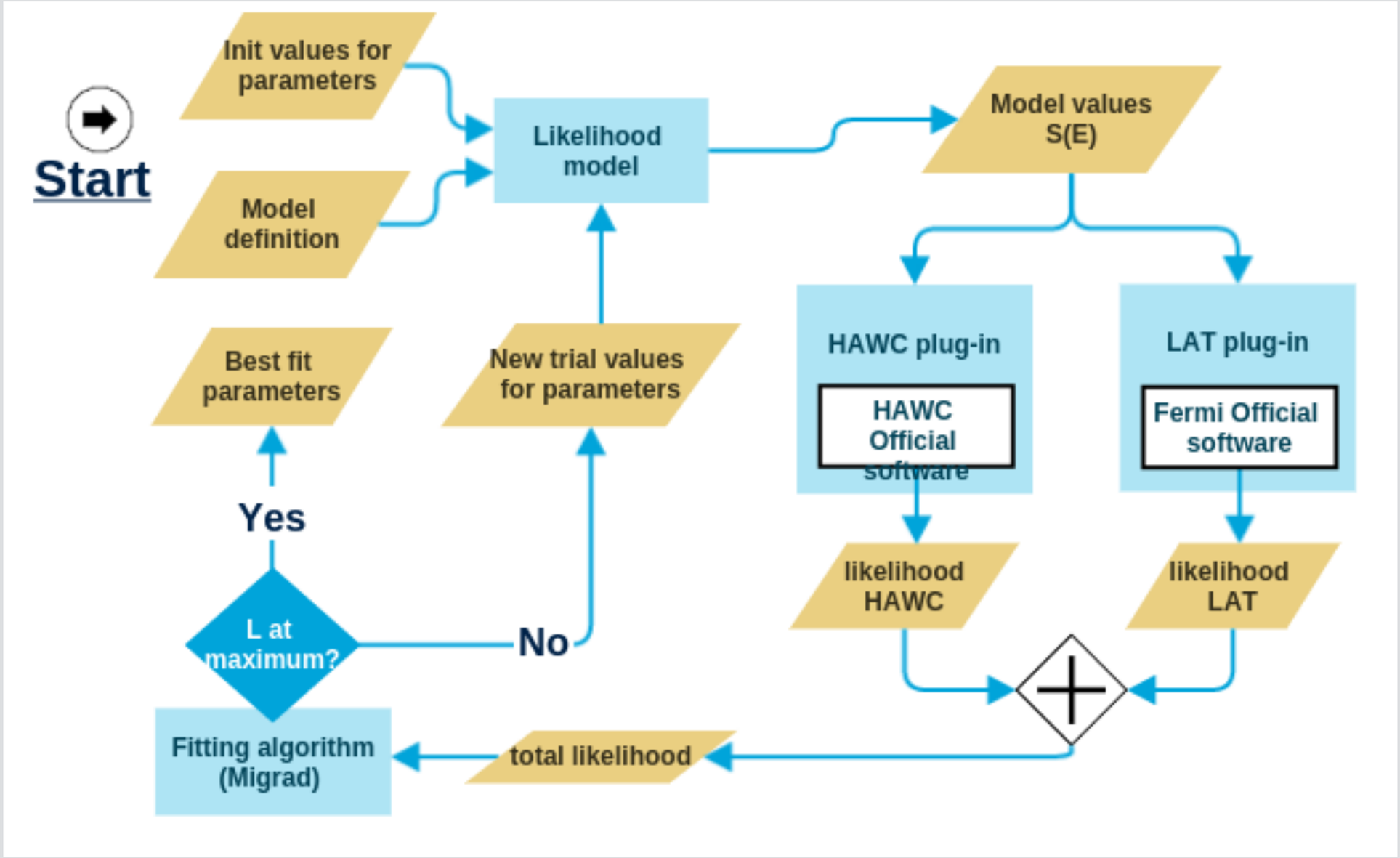
Conclusion

- Would like to make quantitative statements about SGSO's sensitivity to different kinds of sources/physics questions.
- Need to know how detector performance affects sensitivity.
- For that, need high-level analysis tools.
- I propose to use `threeML/astromodels` with the `HAL` plugin.
- Should be developed in parallel to detector design, reconstruction algorithm etc.
- Any other plans for high-level analysis yet?

threeML/astromodels

- `threeML` provides a framework for multi-instrument likelihood analysis, independent of format for data/instrument response files.
- Lots of functionality e.g. plotting, source injection, …
- `astromodels` enables detailed, complex spectral and spatial modeling of astrophysical sources.
- See https://github.com/threeML/ and https://arxiv.org/abs/1507.08343
- Actively being used/developed for HAWC analyses, X-ray, …
- Plugins available also for Fermi-LAT, VERITAS, general spectra, …
- Still growing with new plugins, bayesian samplers etc. being added.

Schematic


Start
Init values for parameters
Model definition
Likelihood model
Model values S(E)
HAWC plug-in
HAWC Official software
LAT plug-in
Fermi Official software
likelihood HAWC
likelihood LAT
total likelihood
Fitting algorithm (Migrad)
L at maximum?
Yes
No
Best fit parameters
New trial values for parameters

HAL plugin

- Likelihood calculations for different instruments are encapsulated in plugins.
- Plugins can (but don't have to) interface external software.
- HAWC data analysis: `HAL` (HAWC accelerated likelihood) plugin.
  - Data provided as healpix maps (RA, Dec) of signal and background (root or h5d)
  - One map per `analysis bin' (currently: energy and fraction of PMTs hit)
  - IRFs: point spread function (as ROOT TF1) and true energy distribution from simulations per analysis bin & declination bin.

SGSO and HAL?

- Use astromodels/threeML with HAL plugin for preliminary SGSO analysis.
- Propose to make mock SGSO instrument response files in HAL-compatible format:
  - Bin in energy and declination.
  - Use `design' PSF, detection efficiency etc.
  - Need to make some assumptions about how PSF, energy resolution, detection efficiency change with energy/declination.
- Background counts? Measured CR spectrum + design hadron suppression?
- Study impact on detector performance on sensitivity.

Why use threeML/HAL?

- Active development team.
- Lots of parallel development between HAWC and SGSO.
- Existing framework for source injection etc.
- Straightforward to extend existing features to sensitivity calculation.
- Powerful modeling: sensitivity to extended sources, spectral features etc.
- Joint analyses with HAWC, Fermi-LAT, maybe CTA in the future.
- Code is public & active development is encouraged.

Why not use theeML/HAL?

- Might be good to have an independent cross-check using a different package.
- Don’t want to lock us into decisions about high-level analysis now (inertia!).
- HAL can only handle integrated data (>1 transit) at this time, no short duration flares.
- Issues installing threeML and aerie in the same environment (under construction!)
- threeML not fully compatible with python 3.
- Lead developer (G. Vianello) has left academia.
- Sensitivity calculation not fully implemented in threeML at this time.

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