What can we do as intermediate steps until the global fit is ready ?

(a.k.a. Diffuse numu + HESE consistency checks and combined fit)
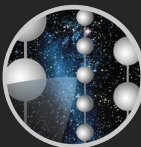
Jöran Stettner + Erik Ganster

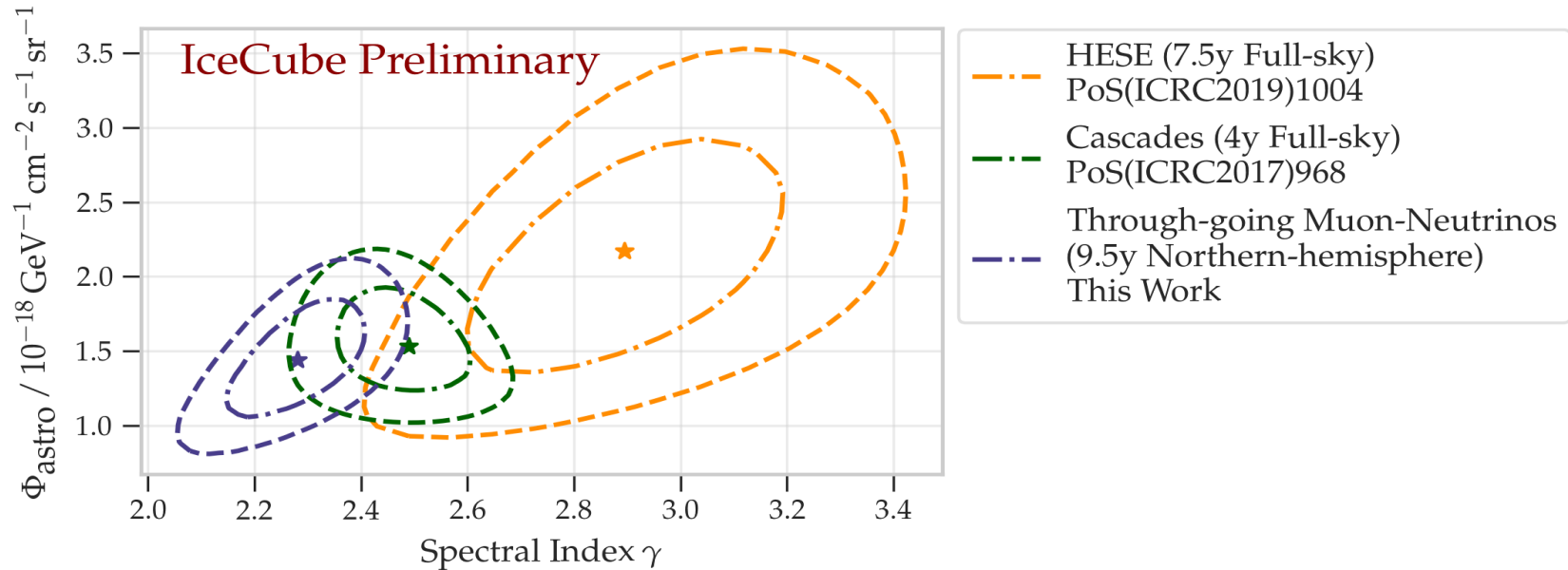RWTH AACHEN UNIVERSITY

Status of Diffuse

IceCube Preliminary

Legend:
- HESE (7.5y Full-sky) PoS(ICRC2019)1004
- Cascades (4y Full-sky) PoS(ICRC2017)968
- Through-going Muon-Neutrinos (9.5y Northern-hemisphere) This Work

- HESE:
  - 7.5 years of data (Pass2), rather soft best-fit single power-law (SPL)
  - Latest update shown at ICRC/Neutrino2018. paper draft just circulated
- Hans' cascade analysis:
  - 6 years of data (Pass1+charge correction), best-fit SPL in between
  - Paper draft is out (plot above shows only 4 years, because this is what was presented at ICRC2017 and was citable)
- DiffuseNuMu:
  - 9.5 years of data (Pass2), harder best-fit SPL

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Short-term: What can we do as intermediate step ?

- A proper treatment of all datasets requires new simulations etc…
    - → that's why we are all here
- On a shorter time-scale: What can we do to give an approximate answer of the global picture in diffuse?

- Idea that came up during HESE and DiffuseNuMu unblindings:
    - We have multiple analyses, each with its own MC / systematics treatment / fitting tools...
    - The datasets are mostly independent (or can be separated easily)
        - → The likelihoods per analysis are independent

        - → **Global LLH can be obtained as sum of the per-analysis-LLHs**

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→ **Global LLH can be obtained as sum of the per-analysis-LLHs**

"It's a bit ugly, but it could work.."   + has the advantage that we can start
right away and use the existing
analyses/samples we have

HESE

Diffuse-Numu

Cascades

PEPE

+more..
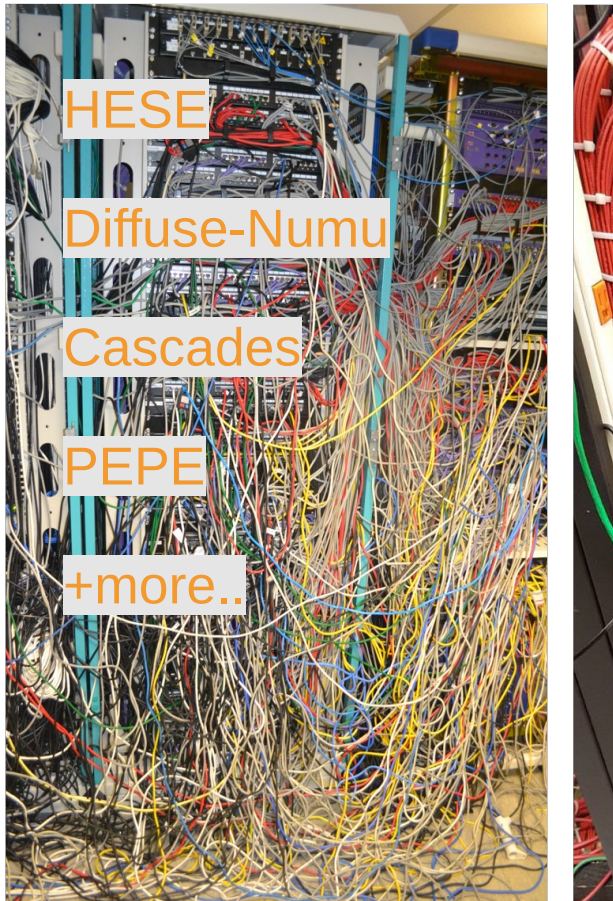
Short-term: What can we do as intermediate step ?

→ How the globalfit will hopefully look like!

HESE

Diffuse-Numu

Cascades

PEPE

+more..
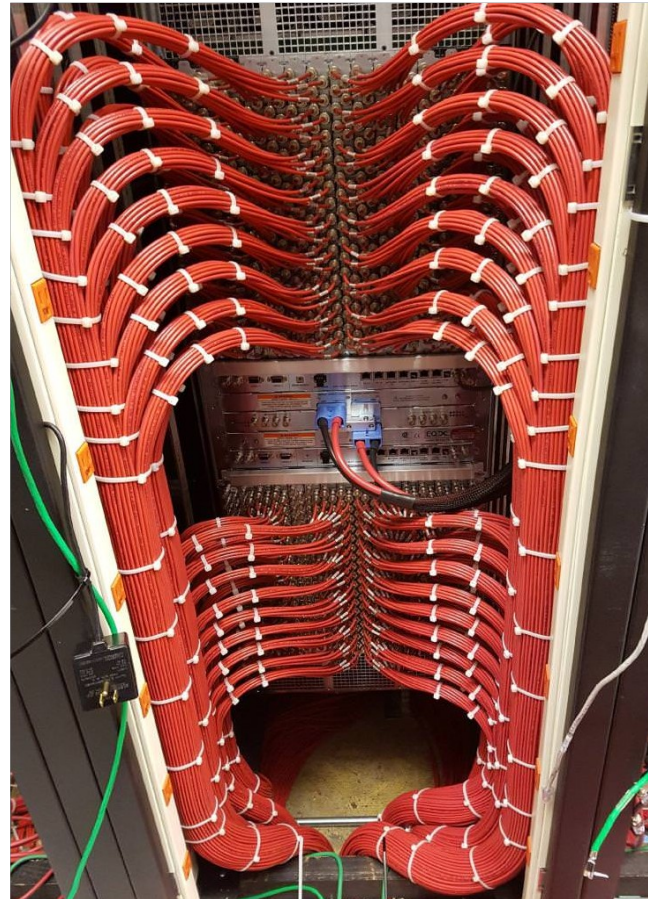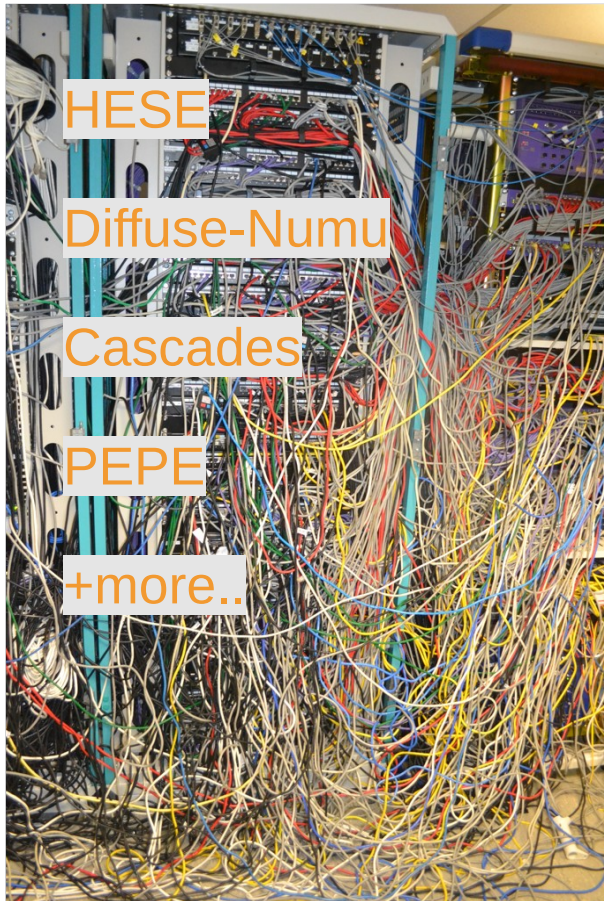
1) Make samples and MCs disjunct

- Only then, the per-analysis-LLHs are independent and can be summed up
- Easiest way:
  - Keep HESE MC and sample as it is
  - Apply HESE cuts to the other sample to remove overlap

  For DiffuseNuMu:
  - Removed 4655 events from baseline MC
  - Removed 10 events from Pass2-dataset:

3 examples for these starting tracks:
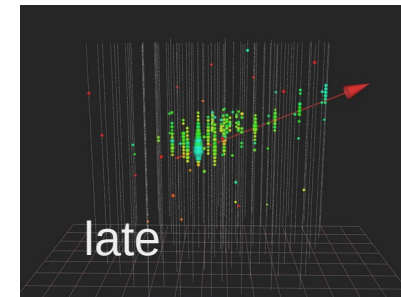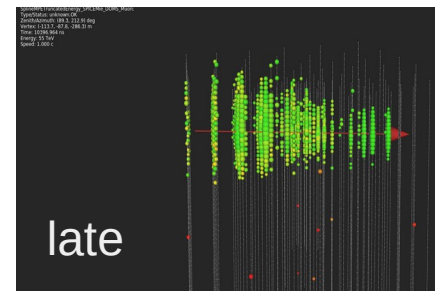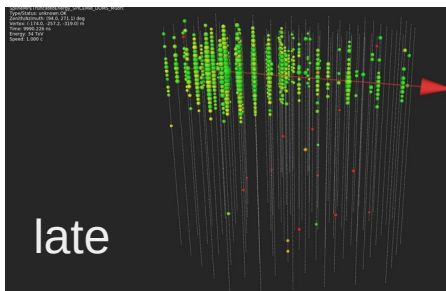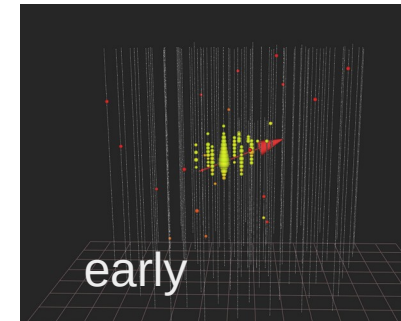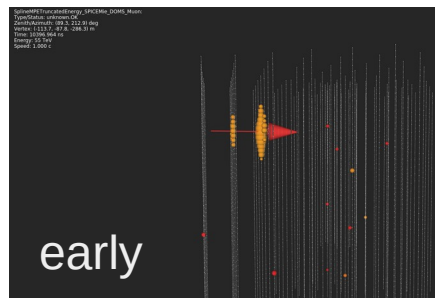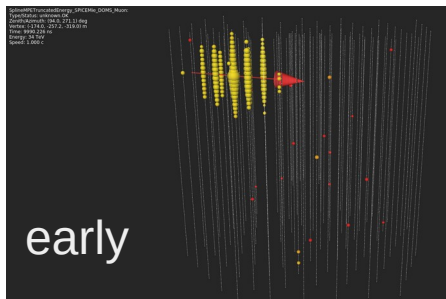
2) Build a Meta-Fitter to optimize all parameters simultaneously

- Idea is to keep things simple and build on existing code/knowledge/tweaks as much as possible:
  - Each analysis stays in it's own sandbox
    - → GolemFit (github) for HESE
    - → NNMFit (github) for DiffuseNuMu
    (load MC, tweaks+tricks, systematics handling etc..)

  - Communication between meta-fitter and analyses via python-redisqueue (https://python-rq.org/)

Meta-Globalfitter

Analysis A   +   Analysis B   +   ☐   +....

- In more detail / the current setup:

Disclaimer: Focus on HESE and DiffuseNuMu for now!

Meta-Globalfitter
- Minimizer
- Knows which parameters are shared

In each minimizer step:
Request LLH for full set of current parameters

Redis Database

Distribute LLH-calls for...

..current parameters that exist in GolemFitter

..current parameters that exist in NNMFit

Workers

HESE

DiffuseNuMu

GolemFitter

NNMFitter
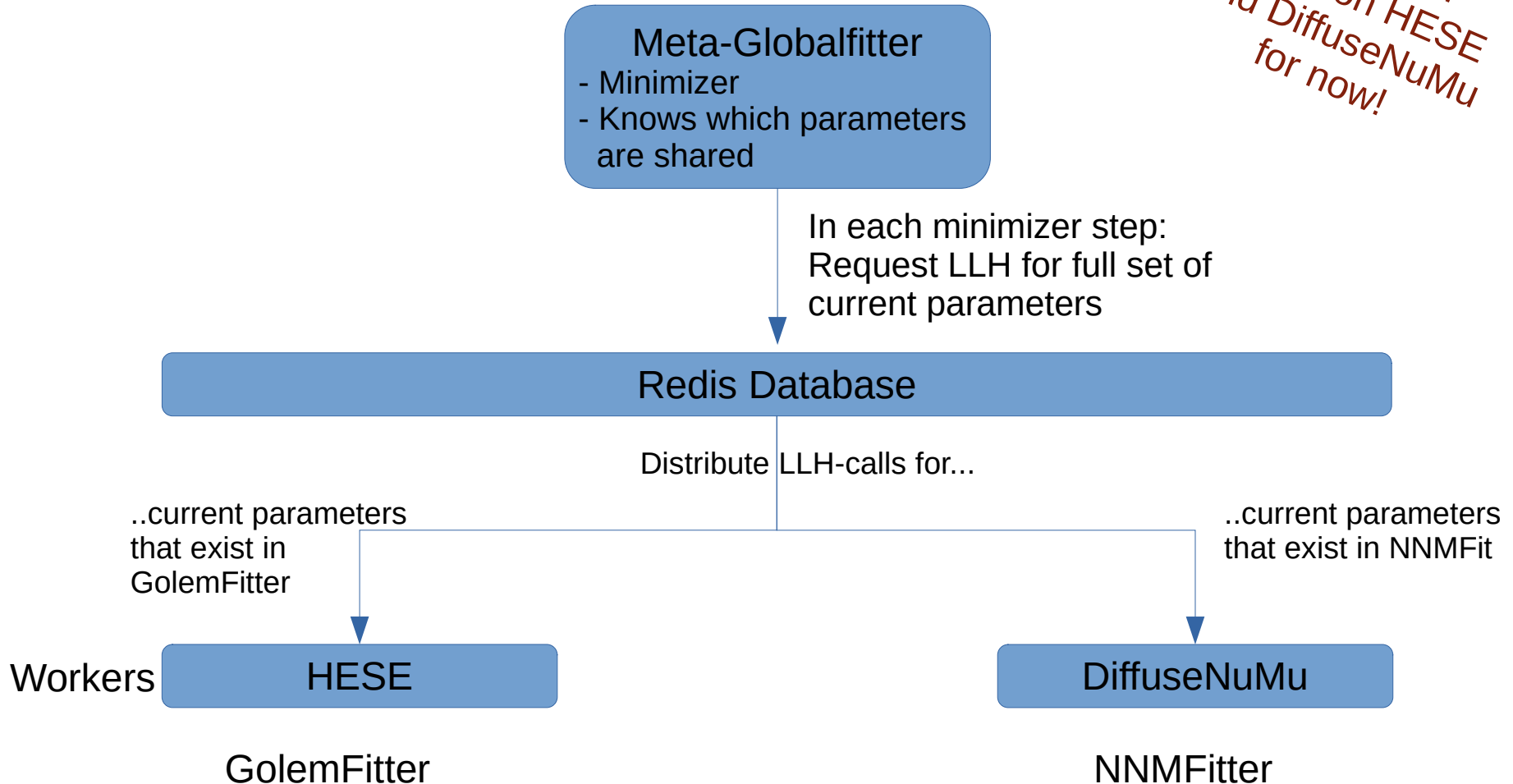
2) Build Meta-Fitter to optimize all parameters simultaneously

- In more detail / the current setup:
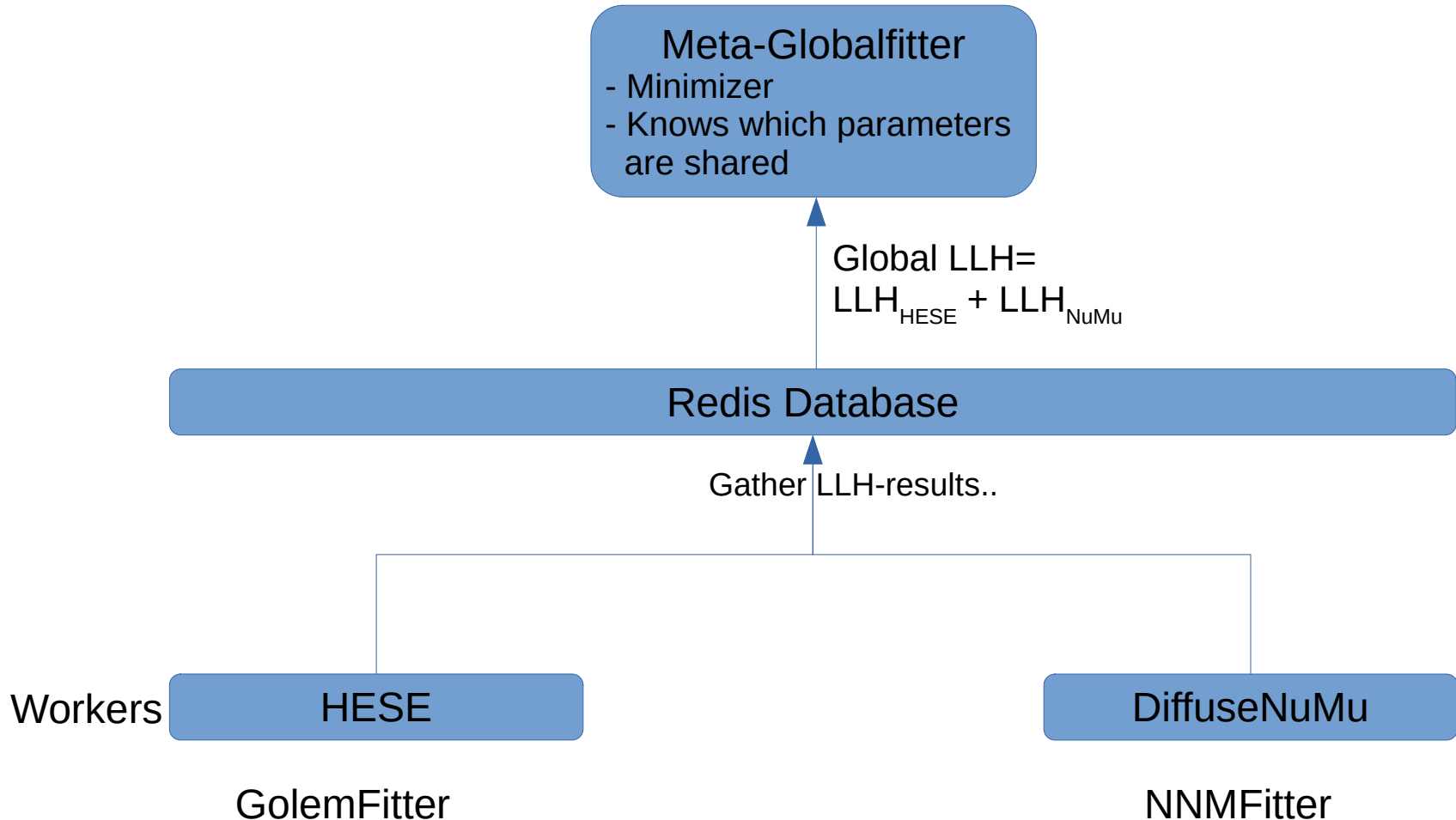
Meta-Globalfitter
- Minimizer
- Knows which parameters are shared

Global LLH=
$LLH_{HESE} + LLH_{NuMu}$

Redis Database

Gather LLH-results..

Workers | HESE

DiffuseNuMu

GolemFitter

NNMFitter

2) Meta-Fitter round-trips

- Got a running version

Big thx to Austin and Carlos for help with the Golem/HESE part!

- Round-trip tests:

a) Meta-Fitter + HESE-worker → HESE best-fit ?

HESE :::: pars=
'promptNorm': 0.0, 'astroNorm': 6.45, 'astroDeltaGamma': 2.88

→ same bestfit as HESE ICRC proceedings ✔

2) Meta-Fitter round-trips

- Got a running version

Big thx to Austin and Carlos for help with the Golem part!

- Round-trip tests:

a) Meta-Fitter + HESE-worker → HESE best-fit ? ✓
b) Meta-Fitter + NuMu-worker → NuMu best-fit ?

NuMu ::::: pars=
'astro_norm': 1.49', 'prompt_norm': 0.0, 'gamma_astro': 2.28

→ same bestfit as NuMu ICRC proceedings ✓

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2) Meta-Fitter round-trips

- Got a running version

Big thx to Austin and Carlos for help with the Golem part!

- Round-trip tests:

a) Meta-Fitter + HESE-worker → HESE best-fit ? ✔
b) Meta-Fitter + NuMu-worker → NuMu best-fit ? ✔
c) Asimov dataset created for both analyses:
   Tested with Meta-Fitter + NuMu-worker + HESE-worker

| injected	fit-result
conv. Norm(NuMu)= 1.0 conv. Norm(HESE)= 1.0 prompt Norm= 0. astro Norm= 1.0 (std. units, per flavor) astro Gamma= 2.0	conv. Norm (NuMu) = 0.99 conv. Norm (HESE) = 0.96 prompt Norm (shared) = 0.008 astro Norm (shared) = 0.98 astro Gamma (shared) = 1.99

✔

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2) Meta-Fitter LLH-scan

- Asimov dataset created for both analyses:
  Tested with Meta-Fitter + NuMu-worker + HESE-worker

injected
conv. Norm(NuMu)= 1.0 conv. Norm(HESE)= 1.0 prompt Norm= 0. astro Norm= 1.0 (std. units, per flavor) astro Gamma= 2.0
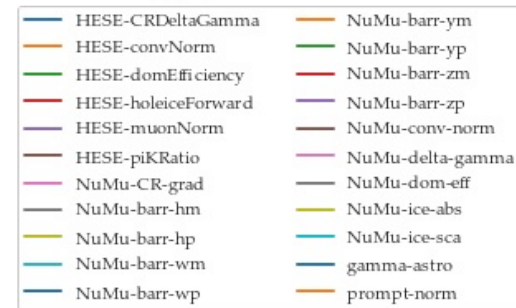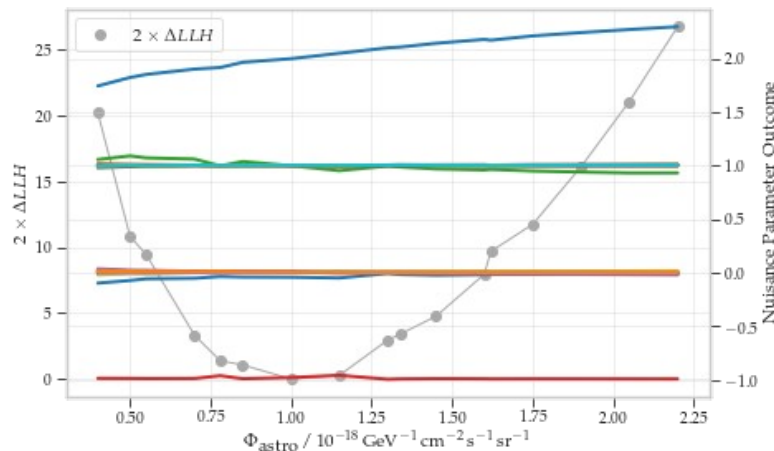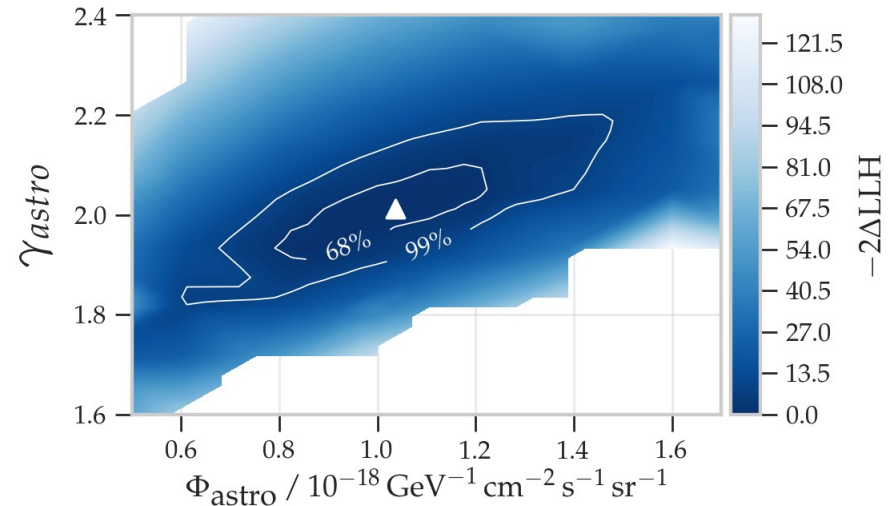
Summary and Outlook

- Short-term: What can we do as intermediate step before the global fit is ready?
- Idea: Keep all samples/analyses/tools as they are, perform meta-fit on disjunct samples
- Status: We have a running version of HESE+DiffuseNuMu
  - Minimizes all parameters at once, systematics are separated per analysis
  - Includes the gradient per analysis to help the minimizer
- Proposal:
  - No new unblinding
  - Working-Group approval? If no strong objections, we could apply it to data during the meeting...

- Outlook:
  - Get more analyses/samples into the framework
    → already talked to Hans about the cascades
  - Don't spend too much time on this, we need manpower for the actual global-fit ;-)