Professor

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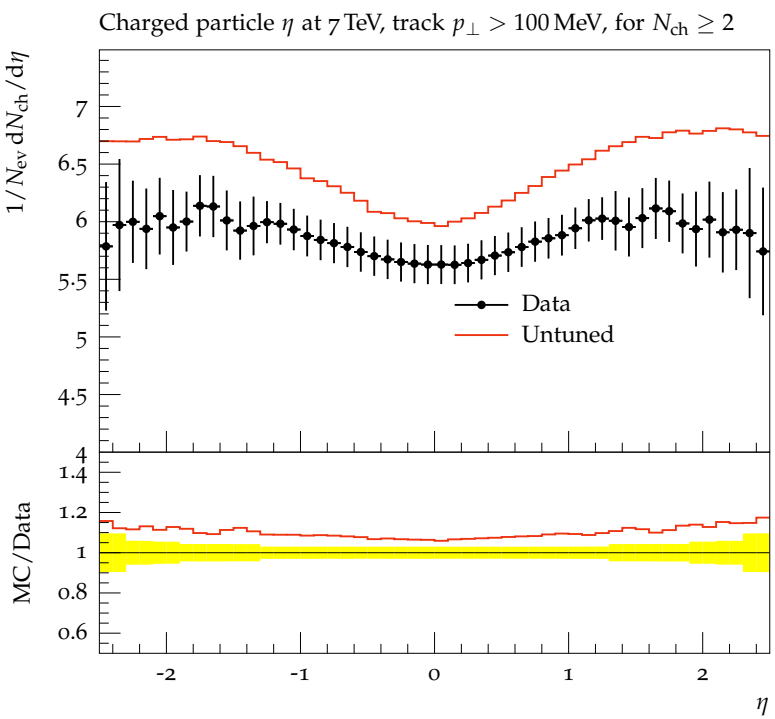
15th MCnet meeting, CERN

Professor so far

- Established tool for MC generator tuning, heavily taylored to Rivet
- Replace MC generator response with polynomials in χ^2 minimisation using `Minuit`
- $\chi^2(\vec{p}) = \sum_b^{\text{Nbins}} w_b \cdot \left(\frac{I_b(\vec{p}) - D_b}{\Delta(\vec{p})} \right)^2$



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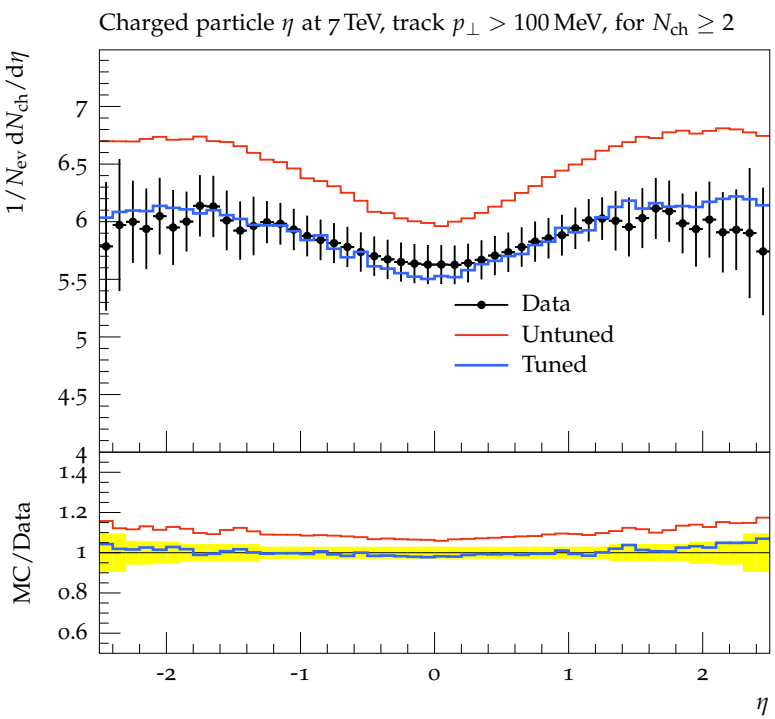
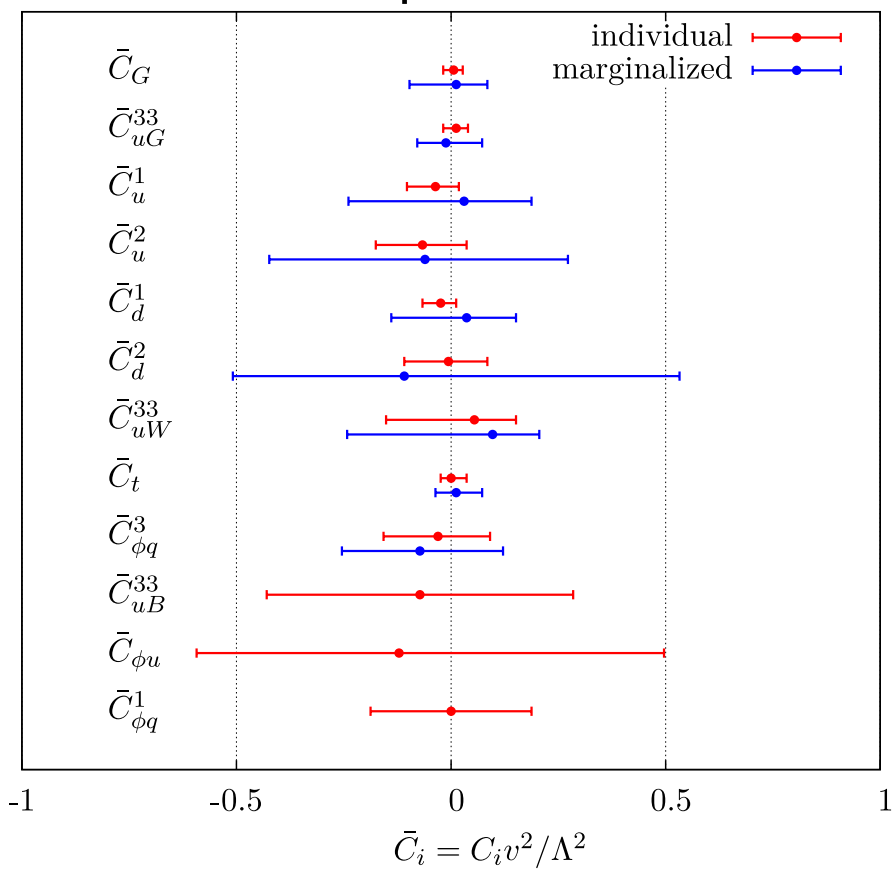


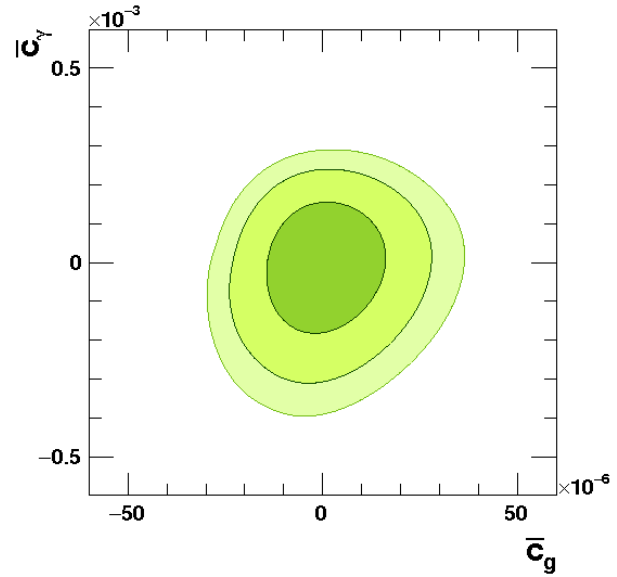
Professor beyond tuning

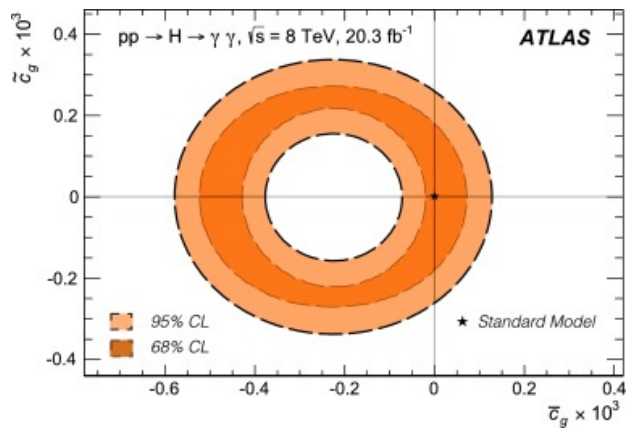
- Instead of fiddling with say hadronisation model parameters, explore BSM parameter space

TopFitter



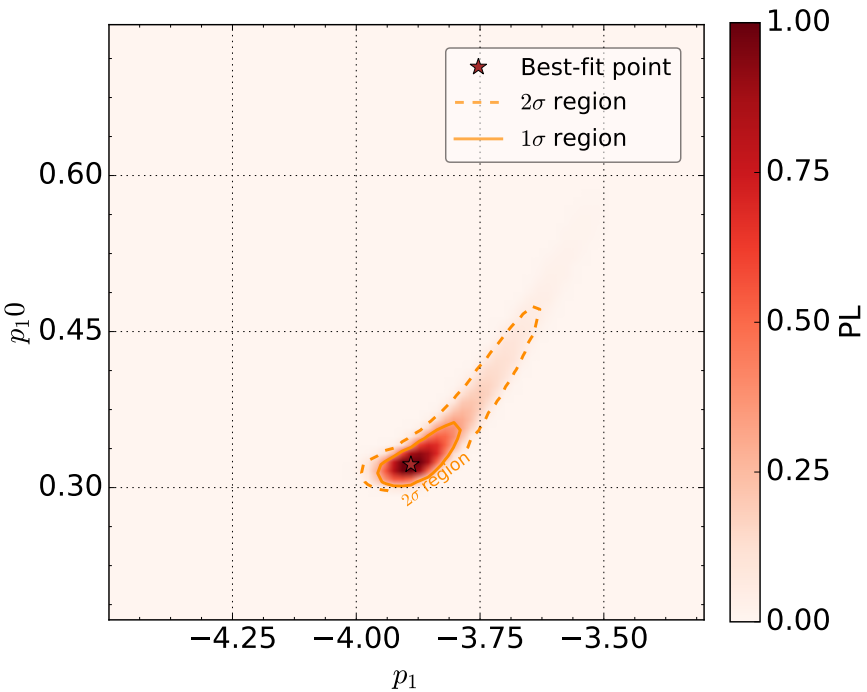
HEFT





Professor beyond collider physics

- Recently got foothold in neutrino MC community, `Genie`
- Needed to open up to support ROOT input files
- That triggered containerisation of Professor with Docker
- Similarly, Dark Matter direct detection community is hooked



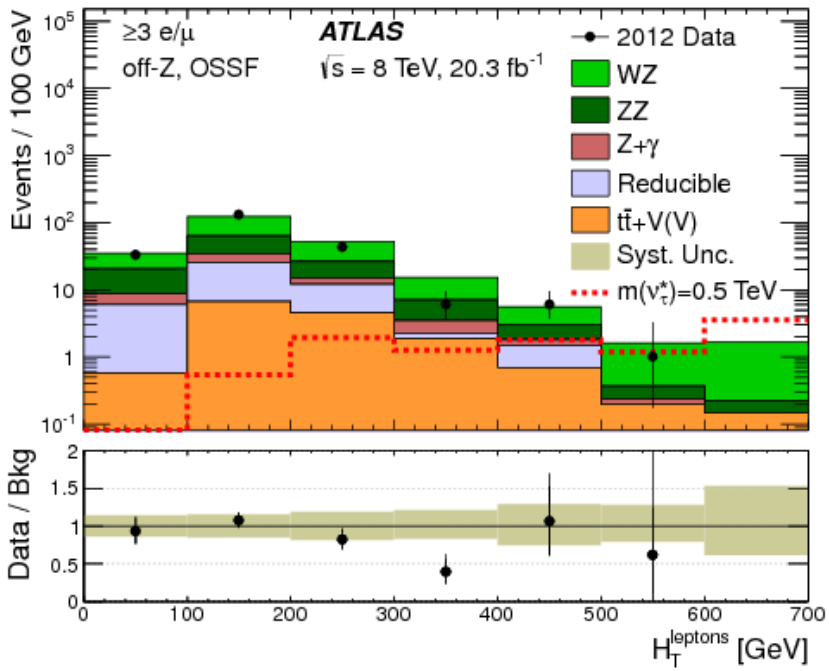
- Nice technology transfer
- Likelihood evaluation

Multinest and Superplot

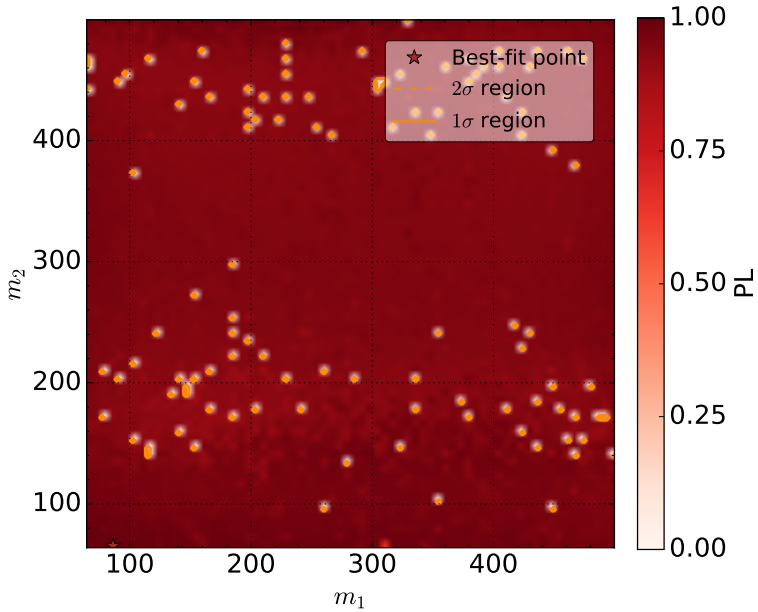
- Multinest is a likelihood evaluator with importance sampling
- Widely used in gamma ray and dark matter communities
- Many likelihood evaluations, computationally too expensive for MC generators
- Python bindings available
- Solution: in log-likelihood, replace signal contribution with fast Professor parametrisation
- Integrates seamlessly with Rivet's BSM efforts

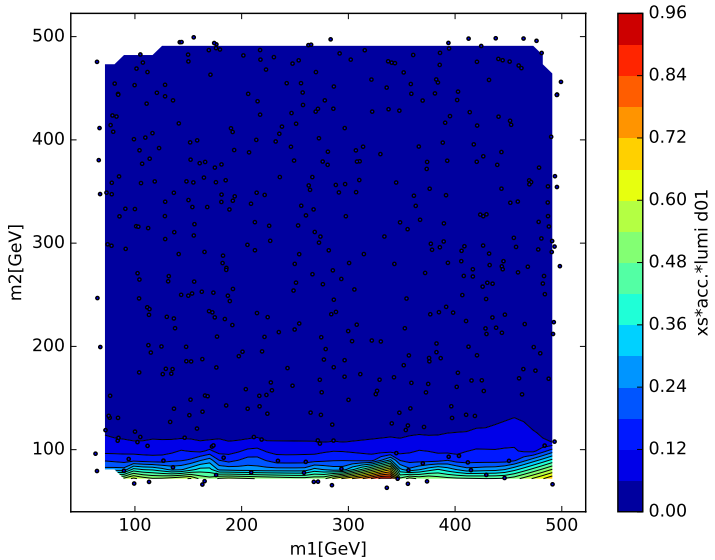
BSM workflow and tools

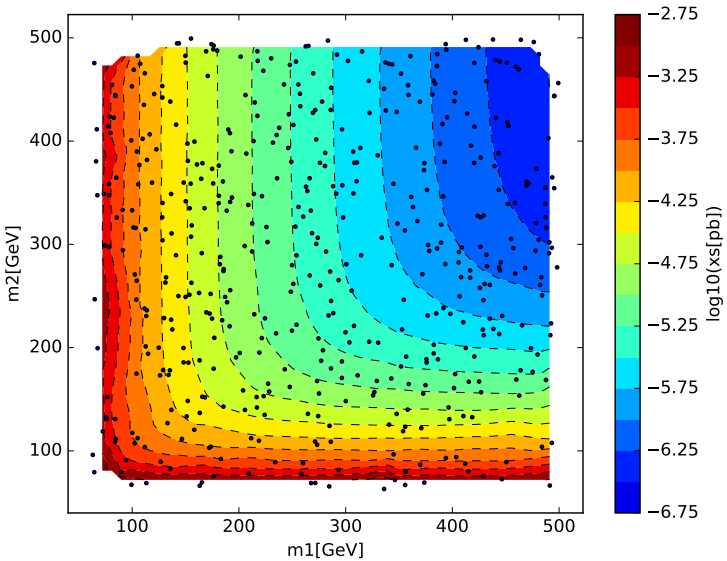
- UFO model for BSM physisc
- MC generator for events that reads UFO (H7,Sherpa,MG5)
- Find suitable Rivet analysis
- Sampling the model space and write runcards
- Run generator, run Rivet, get histograms
- Run professor, get parametrisation of histograms
- Run Multinest, get plot
- Start over

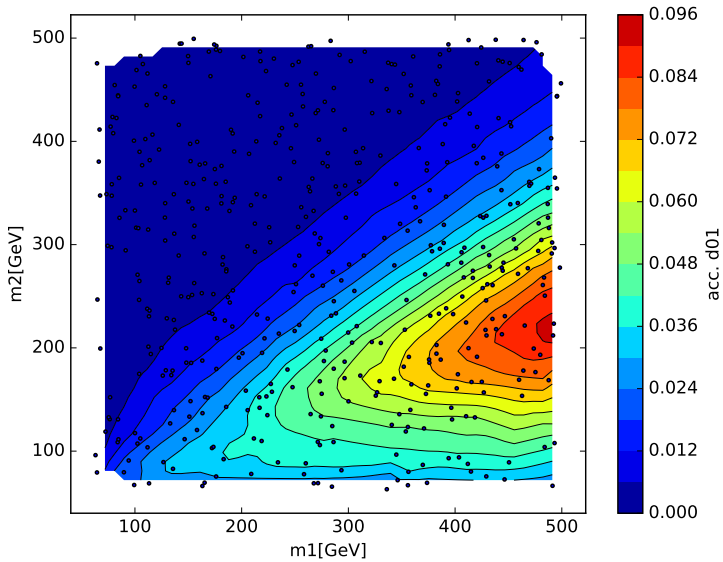


Bad luck

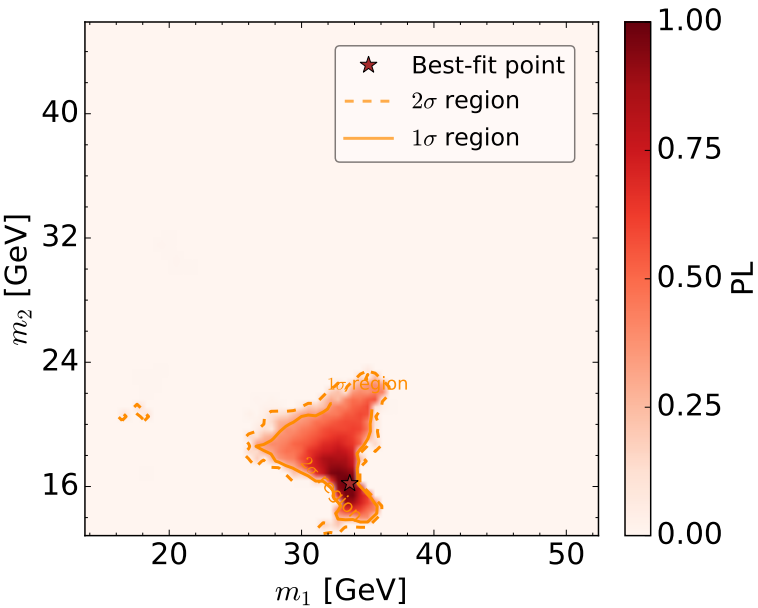

Best-fit point
2σ region
1σ region
m_2
m_1
PL
1.00
0.75
0.50
0.25
0.00

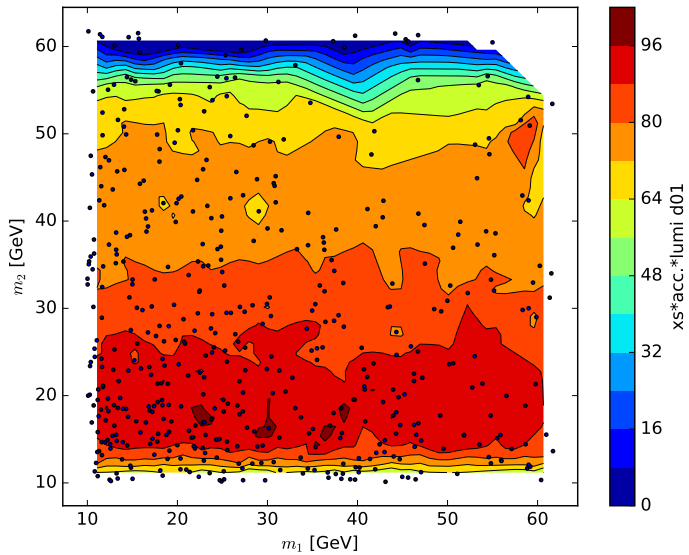

m2[GeV]
m1[GeV]
xs*acc.*lumi d01

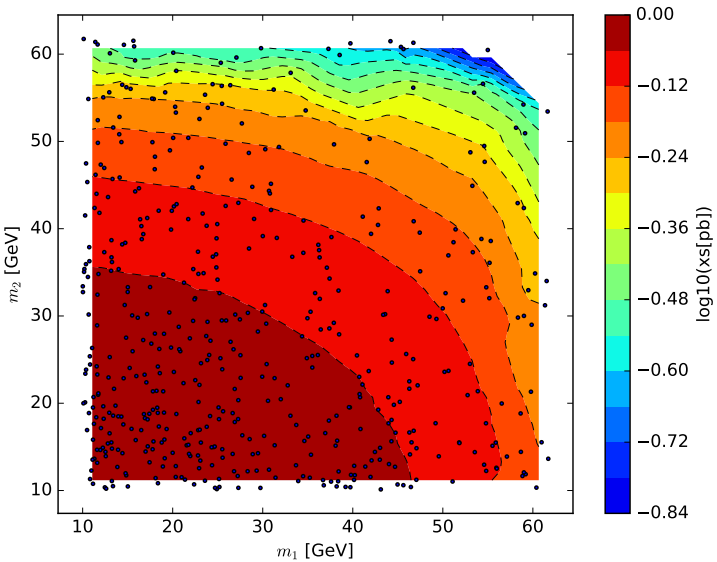

m2[GeV]
m1[GeV]
log10(xs[pb])

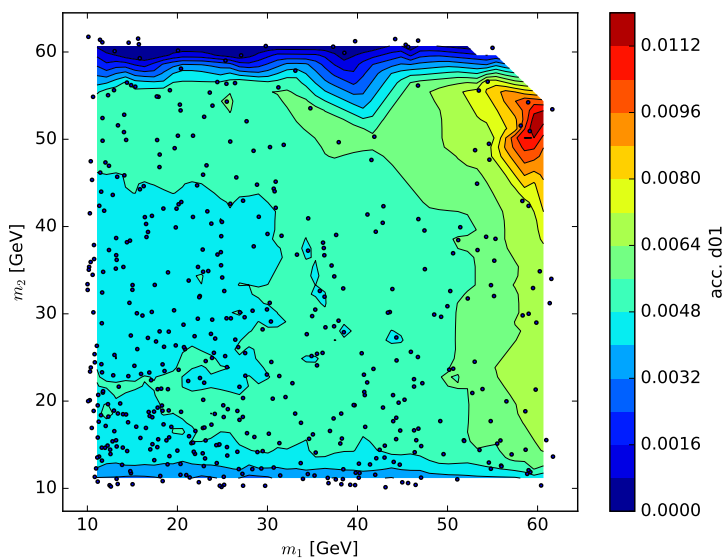

m2[GeV]
m1[GeV]
acc. d01

Better luck


Best-fit point
2σ region
1σ region
1σ region
m_2 [GeV]
m_1 [GeV]
PL


m_2 [GeV]
m_1 [GeV]
xs*acc.*lumi d01


m_2 [GeV]
m_1 [GeV]
log10(xs[pb])


m_2 [GeV]
m_1 [GeV]
acc. d01

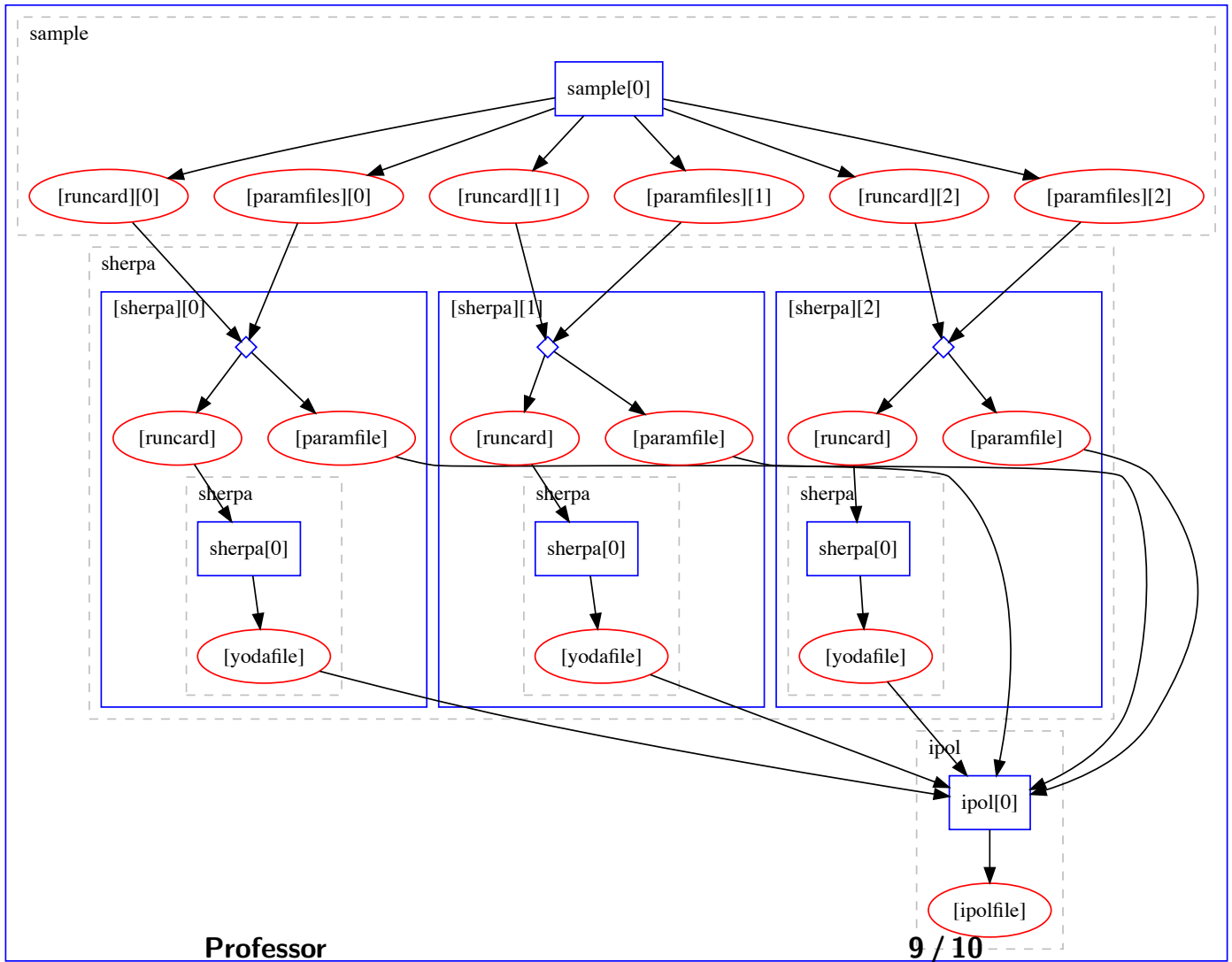
Professor near future developments

- More machine learning techniques to overcome polynomial restrictions
- Already provide some `scikit-learn` functionality (SVM)
- Toying with `gp` and `tensorflow`

- Better parametrisation validation
- More `jupyter` notebooks (`Binder`)
- Sobol sampling
- `yadage` workflow

YADAGE

- Programmable workflow
- Organises, monitors and controls steps in workflow



Summary

- Strengths of Professor:
  - Parametrisation of computationally expensive functions
  - Inputs can always be parallelised in a trivial way
  - Seamless integration into numerical tools `iminuit`, `pymultinest` through python bindings
  - Immediately available through `docker`
- Professor development used to be driven by Rivet/YODA and MC tuning needs.
- Now diversifying.
- Maybe we can establish Professor+Multinest as first stage to recast effort.