

SARAH

- Get SARAH from <https://sarah.hepforge.org/>
- Extract it to the directory of your choosing
- Let Mathematica know where you've put it by adding to `init.m` file, located in

`~/.Mathematica/Kernel` (Linux)
`~/Library/Mathematica/Kernel` (macOS)

by adding a line similar to

```
AppendTo[$Path, $HomeDirectory <> "/HEP-software/mathematica/SARAH-4.14.3"];
```

↑
Mathematica's
\$Path (kind of like
bash's \$PATH). We don't
touch this.

↑
home dir path (in my case
'/home/wojciech'); on
macOS it'd be
'/Users/wojciech'

↑
rest of the path

- To check if it worked, open mathematica notebook and type and evaluate

```
<<SARAH`
```

Standard Model in SARAH

- Have a look at models in SARAH's Models directory
- Now have a look at SM/SM.m
- There are also files SM/parameters.m and SM/particles.m (the names should be self explanatory, we'll come back to them later)

Installing FlexibleSUSY

■ Prerequisites:

- development versions of `eigen`, `boost` and `gsl` (e.g. development version of `gls` is called `libgsl-dev` in Debian and its derivatives)
- Mathematica/Wolfram Engine (version $\gtrsim 10$)
- SARAH (version $\gtrsim 4.11.0$)
- C++ (`g++` $\geq 5.0.0$ or `clang++` $\geq 3.8.1$ or `icpc` $\geq 17.0.0$) and Fortran compilers
- there are also some optional dependencies which you might need if you want to do something fancy
- in a pinch most dependencies can be installed via [conan](#)

■ You can get FLEXIBLESUSY from [here](#) (current stable version is 2.5.0)

■ FLEXIBLESUSY works on Linux/Unix (including macOS) and Windows (through Cygwin)

Creating THDMII spectrum generator

- create model

```
./createmodel --name=SM
```

- configure (minimal example)

```
./configure --with-models=SM
```

type `./configure --help` to see extra options

- compile

```
make [-jN]
```

This will take a moment. Time for questions :)

- run

```
models/SM/run_SM.x \  
  --slha-input-file=model_files/SM/LesHouches.in.SM
```

The output is written to the screen in an SLHA format.

Create new SARAH SM model

- Copy directory SM from SARAH's Models to FlexibleSUSY's sarah folder. Changing it's name to MyModel
- Copy FlexibleSUSY's folder model_files/SM to model_files/MyModel
- Rename
 - sarah/MyModel/SM.m →
sarah/MyModel/MyModel.m
 - model_files/MyModel/LesHouches.in.SM →
model_files/MyModel/LesHouches.in.Model
- In model_files/MyModel/FlexibleSUSY.m.in replace
FSDefaultSARAHModel = SM; →
FSDefaultSARAHModel = MyModel;
- In sarah/MyModel/MyModel.m replace
Model`Name = "SM"; →
Model`Name = "MyModel";

Creating singlet extended SM

- Lagrangian

$$\mathcal{L} = \mathcal{L}_{\text{SM}} + \frac{1}{2}m_S s^2 + \frac{1}{2}\lambda_s s^4 + \frac{1}{2}K_2 H^\dagger H s^2$$

- 4 new parameters: v_s , m_s , λ_s , K_2
- we'll eliminate m_s using tadpole equation – 3 independent parameters left