DaMaSCUSv1.0 Manual

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1 Quick Introduction

- DaMaSCUS is a MC simulator of dark matter particles as they move through the Earth and scatter on terrestrial nuclei.
- It allows to compute the local distortions of the DM density and velocity distribution caused by collisions with nuclei.
- The distorted distribution functions and redistributed densities are used to give precise estimates of time-dependent signal rates for direct detection experiments and diurnal modulations.
- A full, realistic model of the Earth is implemented as well as the Earth's time-dependent velocity and orientation in the galactic frame.
- DaMaSCUS is written in C++ and fully parallelized (openMPI).

2 Getting started

2.1 Requirements

These are the dependencies of DaMaSCUS:

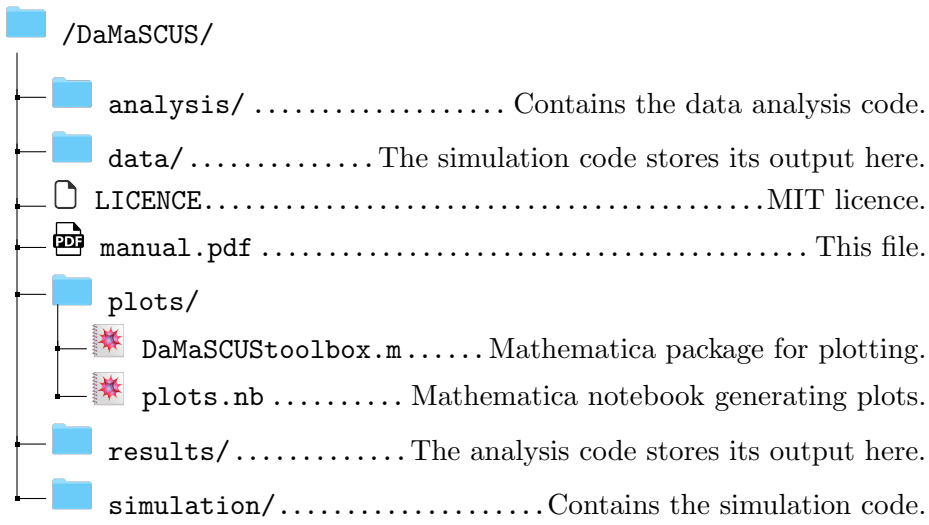
- *libconfig*: To handle the input configuration files we use the *libconfig* library. Available at `http://www.hyperrealm.com/libconfig/`
- *Eigen*: DaMaSCUS relies heavily on this linear algebra C++ library. Available at `http://eigen.tuxfamily.org/`
- *open MPI*: For the parallelization we implemented DaMaSCUS using the open *Message Passing Interface*. Available at `https://www.open-mpi.org`.

2.2 Installation

The DaMaSCUS code is available at

`https://github.com/temken/DaMaSCUS/`.

The content:



The DaMaSCUS code consists of two independent C++ sub-programmes. The first simulates the trajectories and generates data, the second analyzes the data and creates readable and plot-able output. The source files are located in `/simulation/` and `/analysis/` respectively.
In each of these folders you will find a `Makefile`, where you might have to adjust the compiler lines

```
appname := DaMaSCUS_simulation

CXX := mpic++
CXXFLAGS := -Wall -std=c++11 -I /path/to/libraries/ -O2 -lconfig++
(...)
```

to match your local setup. Then the code is simply being compiled by running

`make`

in the respective folder.

3 Usage

The work flow of DaMaSCUS is the following.

1. Adjust the input parameter of the next simulation run, such as the DM mass or cross-section, and assign it a simulation ID in the `/simulation/input.cfg` file. Here is an example:

```
//DaMaSCUS Configuration File

//Simulation input parameter
     simID   =  "exampleID";       //MC Simulation ID
     initialruns = 1000000000L;    //Number of particles in
         the initial MC run
     samplesize =  100000;       //velocity sample size per
         isodetection ring
     vcutoff    =  1e-1;      //velocity cutoff in cm/sec


//Simulation Time:
     date    =  [15,02,2016]; //Date [dd,mm,yyyy]
     time    =  [0,0,0];   //Universal time [h,m,s]


//Dark Matter Data
   //Particle data
     mass    =  500.0;        //in MeV
     sigma      =  1.0;       //in pb
     formfactor =  "None";       //Options: "None",
         "HelmApproximation"

   //DM Halo
     halomodel  =  "SHM";        //Options: Standard Halo
         Model "SHM",...
     rho        =  0.3;       //DM halo energy density in
         GeV/cm^3

//Detector depth:
     depth   =  1000.0;       //in meter

//Analysis parameter
     experiment =  "CRESST-II";       //Options: "LUX" for
         heavy DM,"CRESST-II" for light DM
```

2. Run the simulation from the `/simulation/` folder with

   ```
   mpirun -n N DaMaSCUS_simulation input.cfg
   ```

   where N is the number of used MPI processes.

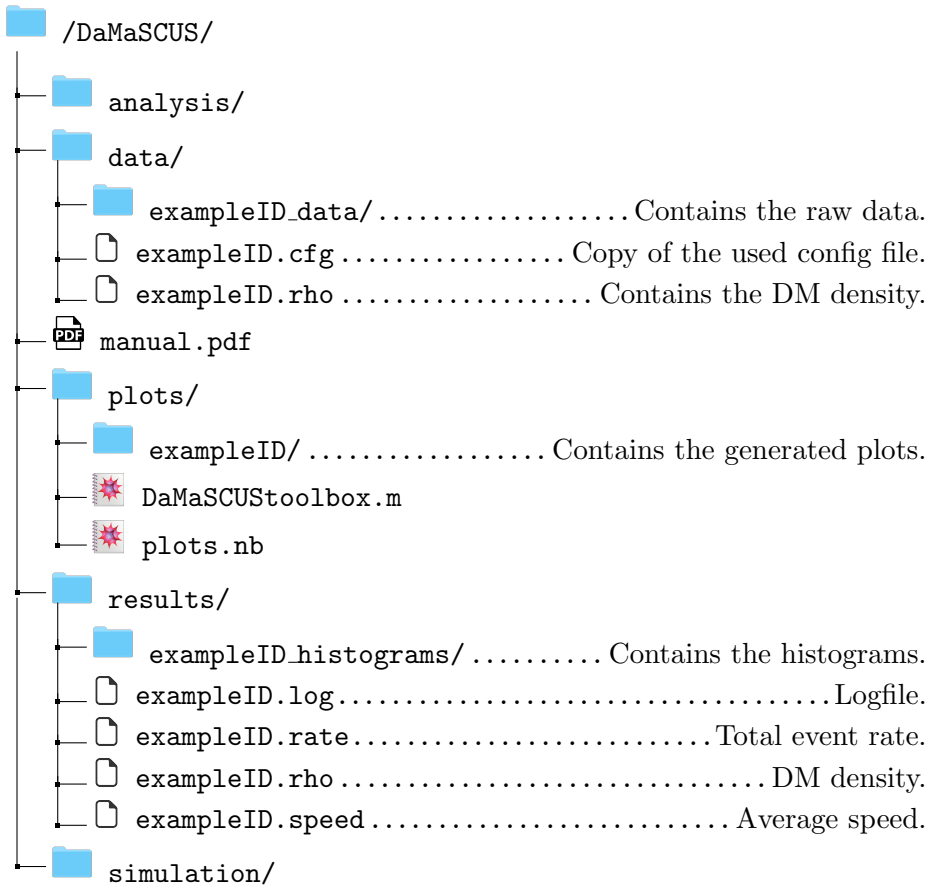
3. After the simulations are done and the data is generated, start the data processing by running

   ```
   mpirun -n N DaMaSCUS_analysis exampleID
   ```

   from the `/analysis/` folder. All results will be saved in `/results/`.

4. The output can e.g. be plotted with the included Mathematica notebook `/plots/plots.nb`.

After performing all these steps with the simulation ID 'exampleID' the file structure should like this.



4 Release History

The code is under continuous development and will be extended and updated over time.

- 06.06.2017: Release of version 1.0 of DaMaSCUS.

5 Citing DaMaSCUS

If you decide to use the DaMaSCUS code, please cite

Emken, T., Kouvaris, C.: DaMaSCUS,(2017), Astrophysics Source Code Library, record [ascl:1706.003] .

as well as the original paper,

Emken, T., Kouvaris, C.: DaMaSCUS: The Impact of Underground Scatterings on Direct Detection of Light Dark Matter, (2017), [arXiv:1706.02249] .

6 Licence

This software uses the MIT licence, see `/DaMaSCUS/LICENCE`.

7 Contact & Support

For questions, bug reports or other suggestions please contact

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