Analyzing dark matter with new models

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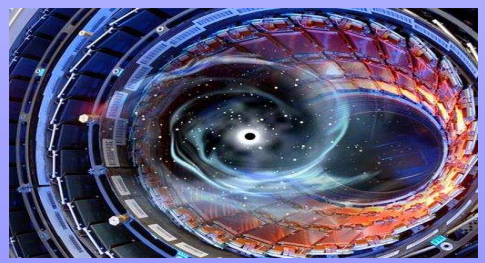

Waking up with the idea

Moving around the plan.....

Pre-requisites

☺ A laptop/Desktop in working conditions...

- Pick up your favourite OS.....



- Basic knowledge of your favourite programming language... **FORTRAN, C/C++**
- To edit your code you need... **f77/g77/gfortran, gcc/g++**....
- Basic knowledge of your favourite editor... **vi, emacs, gedit....**
- Basic knowledge of your favourite plotting software **XMgrace, Gnuplot, ROOT....**. We chose to work with **Gnuplot**.
- We have planned to use a Linux platform based tutorial.. Window users need to install Virtual Box..see next

Making Virtual Linux Machines with VirtualBox

- Please download and install the appropriate binary of VirtualBox for your operating system:

▸ Download VirtualBox

- It is available for Windows, OS X, Solaris and various Linux distributions
- Download the Linux installation file, e.g. Ubuntu 12.04 LTS:

▸ Download Ubuntu

- Start VirtualBox and install Ubuntu on a virtual hard disk
- Be sure to allocate at least 1 GB of RAM if you can spare it
- In case of doubt, have a look at the VirtualBox User Manual:

▸ VirtualBox User Manual

- Be sure to install the Guest Additions so that Ubuntu runs more properly in the VirtualBox:

▸ Guest Additions for Linux

Installing packages..

• Use **synaptic package manager** or **yumex** or **yast** for graphical installation and **apt-get install** <**package-name**> or **yum -y install** <**package-name**> for command based installation..

You can find handful of help materials in the web...☺

• To learn basics of Gnuplot please visit ▸ Gnuplot-Homepage..
you can also see the manual ▸ Gnuplot-manual

There are other useful pages too....

⋆ If you love ROOT.. go to ▸ ROOT-Homepage

Installing LanHEP

- A software for transcript your particle physics model from the Lagrangian to latex, CalcHEP model file. The latter is needed by MicrOmegas to calculate DM phenomenology!
- Also it makes consistency checks like hermiticity, charge conservation, etc. useful for finding mistakes
- To install go to ▸ LanHEP-Homepage
- The manual for versions 3.x at ▸ LanHEP-Manual
- If you are addicted to `Mathematica` you can also use `FeynRules` ▸ FeynRules-Homepage
- but `Mathematica` is not **FREE** ☹☹

Installing MicrOMEGAs

- A `C/C++` code for the calculation of DM properties including the relic density, direct and indirect rates for general supersymmetric model as well as your favorite or customized models
- You can install `MicrOMEGAs` from ▸ micrOMEGA-Homepage
- The model should be in CalcHEP model file format, LanHEP can generate it
- Model's parameters (like masses, couplings, etc.) can be varied if you want to do an scan of the space of parameters

Stay tuned for the LanHEP/MicrOMEGAs session!

Installing Pythia

• You need showering and hadronization of your signal in a real experimental ambiance...

It is useful to go through the manuals.. ▸ Pythia6-manual or ▸ Pythia8-manual

You can also see the journal version in case you have an access ▸ Pythia6J-manual or ▸ Pythia8J-manual

• To install the latest version go to ▸ Pythia6-install or ▸ Pythia8-install

Pythia-Dark Matter

• Annihilating/decaying DM will produce SM particles which also decay and/or hadronize until final stable SM particles

• Let's focus on gamma-rays i.e. photons at the end of the whole process

• The photon spectrum is obtained by doing the histogram of photons produced

Pythia-Collider

- A glimpse of real collider phenomenon with Monte Carlo analysis.. ▸ MC-wiki
- Main uses.. event generation with initial and final state radiation.. hadronization..
- Followed by calling **PYCELL** (Pythia-6) or **CALLJET** (Pythia-8) to identify final state leptons/jets/photons/Missing energy...
- Get familiar with sample main programs... ▸ sample-programs
- Most important thing... **know your switches....** go through ▸ Pythia6-manual or ▸ Pythia6J-manual

Pythia-Collider... the switches... ☹

• It's all there in **last four pages..Appendix B** of ▸ Pythia6-manual.. second **last four pages..Appendix A** contains list of all processes...

• Some of the important ones.. for **ISR**, **FSR**, **Multiple Interaction**, **Hadronization**.. **Choice of scale** and **Parton distribution functions**

• It is also better to know about.. **particle properties**, **decay specification** and **controlling decays**

• Know about **K(I,1,..,5)** (to study a event..to know a mother and a daughter) , **P(I,1...5)** and **V(I,1,...,5)**.. momentum and position of any particle.. **I** is the line number in a event.. take a **look**..and also in section 5.2 of ▸ Pythia6-manual

• A sample simple-most (for $t\bar{t}$ in the SM, no ISR, FSR, MI or hadronization) event **file**..

Pythia-Collider... the switches... ☹

• Learn how to get the process of your choice from a list of processes given in Appendix A of ▸ Pythia6-manual. Know about **MSEL-MSUB**. See section 9.2 for more details...

• A few more... **PYSTAT(2)** for decay properties.. same for **PYLIST(12)**.. good to know each decay channel.. in-case you need to turn off some of them.. and also **PYSTAT(1)** for Cross section table

• There are **more**.... go through the ▸ Pythia6-manual and wait for the school.....

Pythia-Collider... Making Histogram

- You need to look at various distributions.. say P_{T}, missing E_{T}.. lepton/jet multiplicity... η... and many more....
- You can collect entries for each event using loops... but not quite economic...
- use a simple `FORTRAN` code **hist.f** with **hist.i** to generate histogram data...
- Use your favourite plotting software.... (Gnuplot/Paw/Root...)

Pythia-Collider... Making Histogram

• hist.f and hist.i are coupled with Pythia through three simple steps... (for details.. wait for the school)

1. After initial steps and `CALL PYINIT('CMS','p','p',ECM)` `with p ≡ proton and ECM ≡ CM energy` (see ▸ sample-codes)
   call hist(underscore)init('name of the histogram',minimum,maximum,steps)
2. Just before the event loop (wait for the school) call hist(underscore)fill('name of the histogram',DBLE(name of the entity you want to plot.. say number of μ))
3. Just after the event loop (wait for the school) call hist(underscore)plot('name of the histogram')

Pythia-Collider.. a few steps forward

- A better approach is to generate a **LHE** or a **HeP-MC** output ▸ HeP-MC
- Then go through fast detector simulation package like ▸ PGS4 (see also ▸ particle-id) or ▸ Delphes
- The output is with standard **LHCO** format.. and you are ready for your dream analysis
- You can link Pythia with ▸ LHAPDF to use your favourite PDF...
- You can try also ▸ HERWIG++ which also calculates spin-correlations.. see **installation-guide**....

To do list

Anything more for LanHEP, micrOMEGA parts ? Roberto

Anything you want to add in Pythia-DM.. or any suggestion for Pythia-collider