THEORIST'S ANALYSIS TOOL

Roberto Franceschini

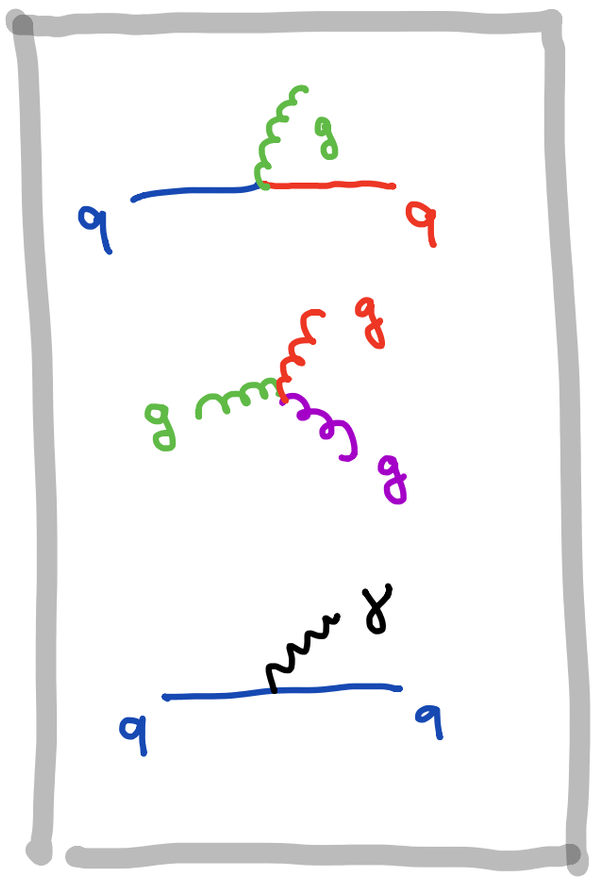
(franceschini@fis.uniroma3.it Stanza 114)

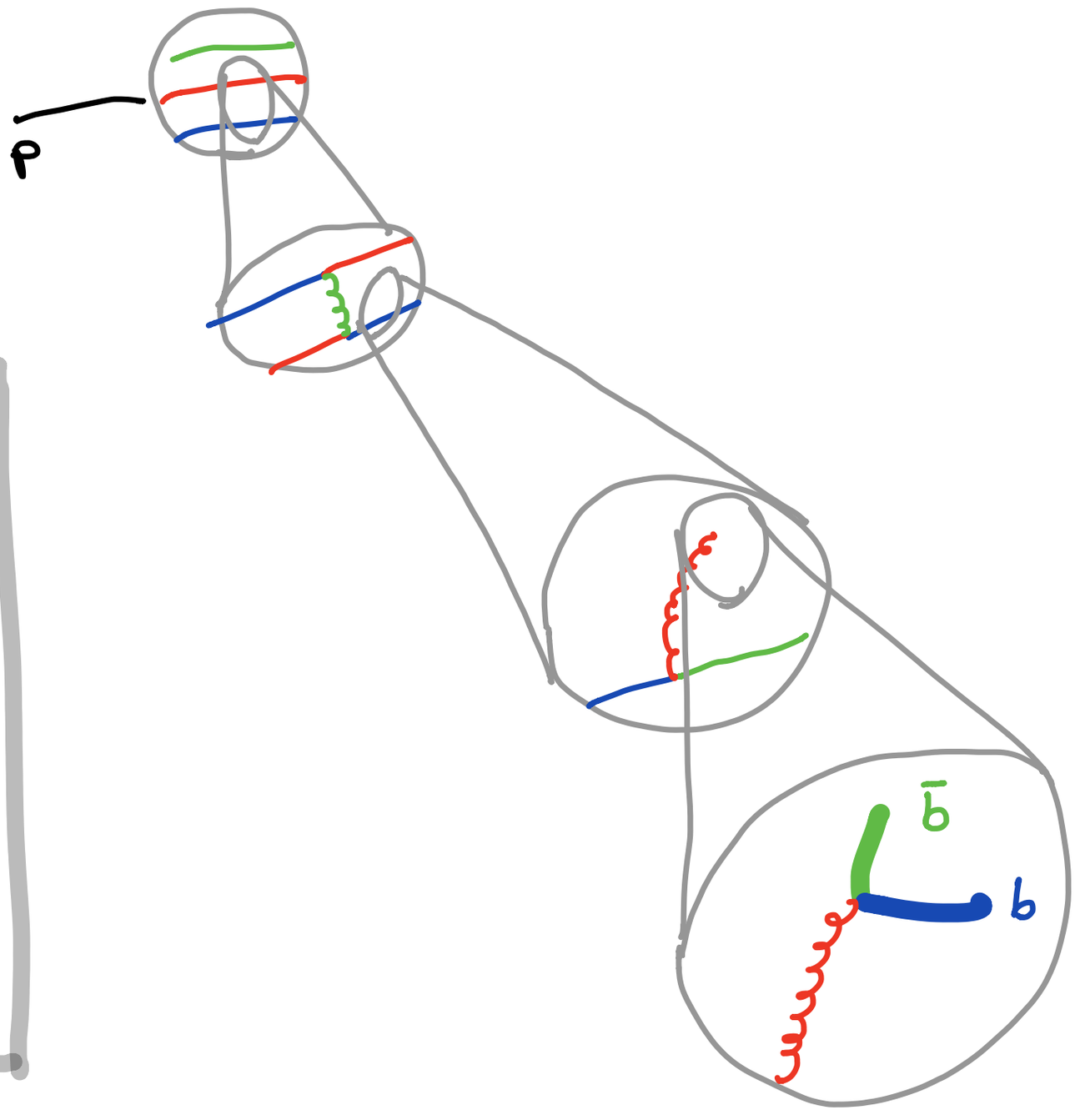
THE BIG PICTURE

Separation of scales

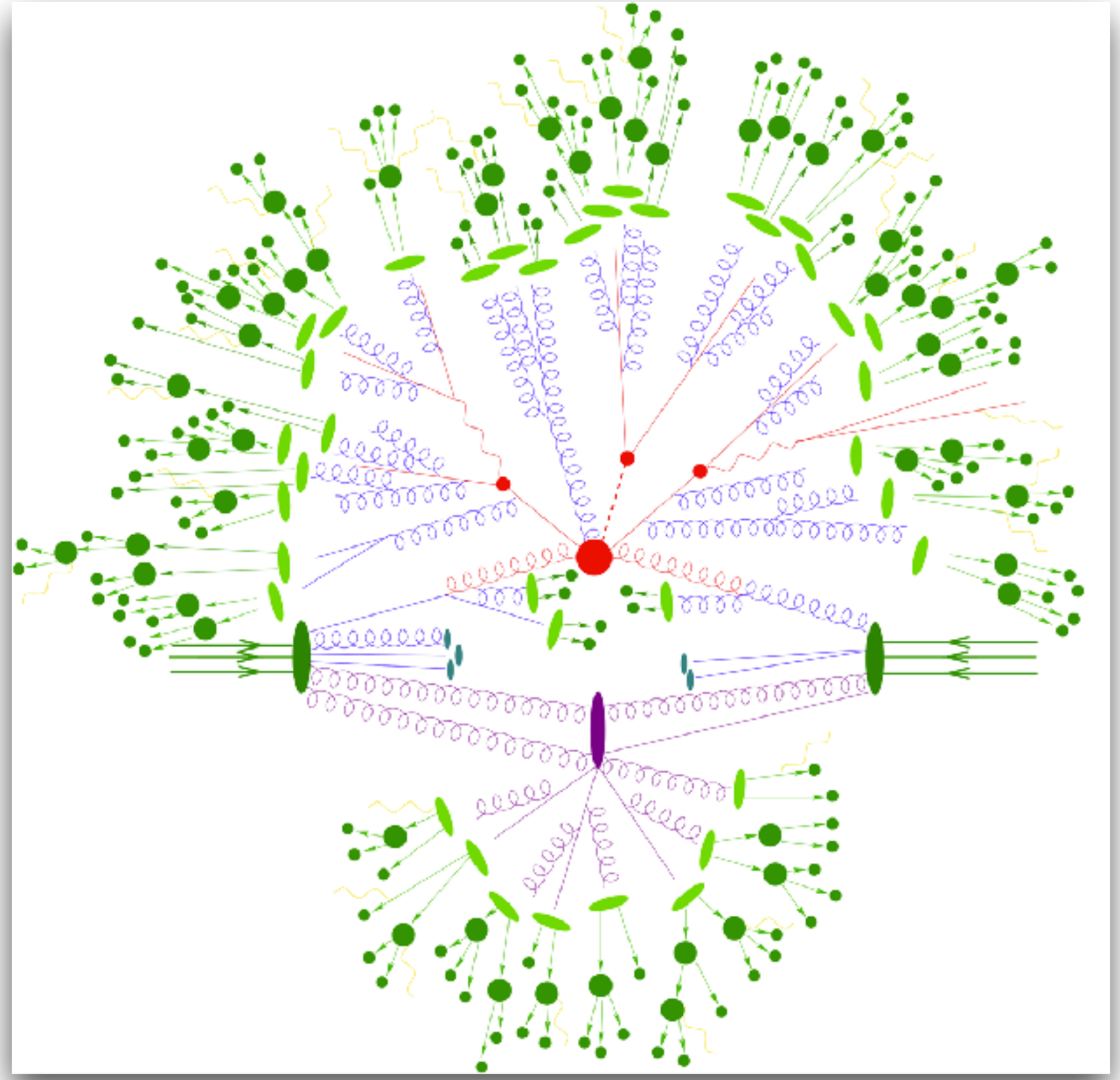
Just Living Like This with Lyme

DIFFERENT PHENOMENA HAPPEN AT DIFFERENT TIME-SCALES





DIFFERENT PHENOMENA HAPPEN AT DIFFERENT TIME-SCALES



DIFFERENT PHENOMENA HAPPEN AT DIFFERENT TIME-SCALES

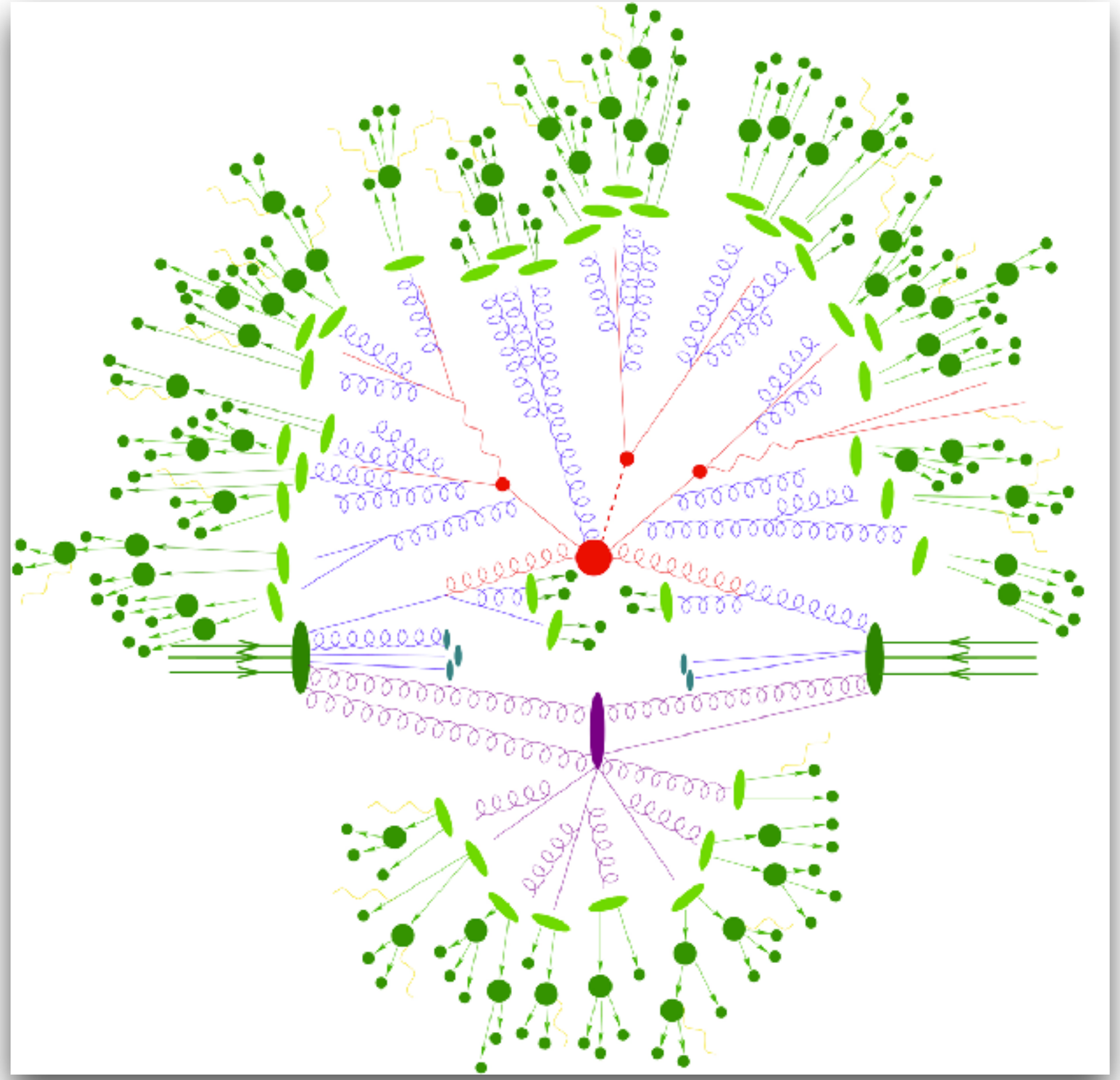
Red: Hard Scattering

Blue: Parton Shower

Purple: softer Underlying Event

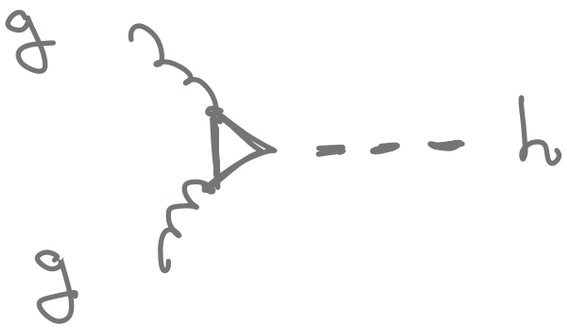
Green: Hadronization

Dark Green: Hadron Decays

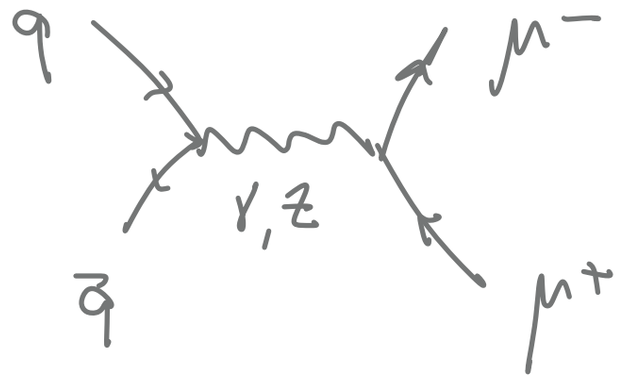


HARD SCATTERING

Typically a $2 \to 1$ or $2 \to 2$ process



$2 \to 1$

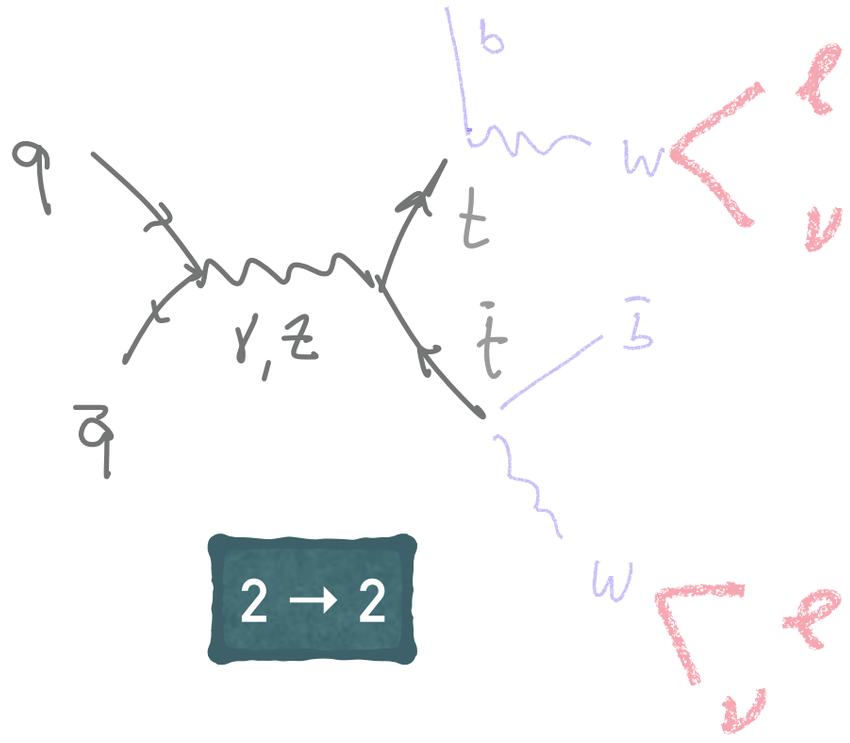


$2 \to 2$

$\sigma_{n\text{-}bodies} \sim \alpha^n \Rightarrow$ *start considering process with lowest number of interactions*

HARD SCATTERING

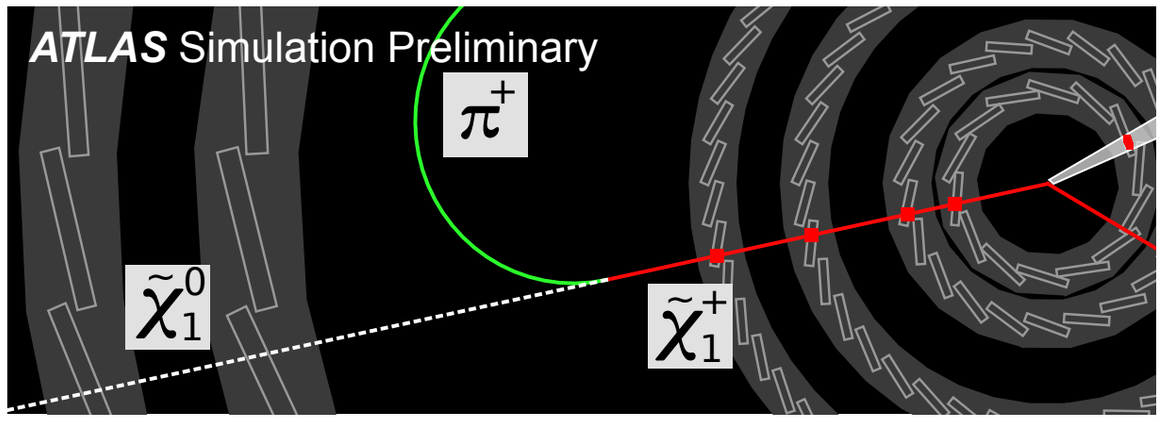
Typically a 2 → 1 or 2 → 2 process



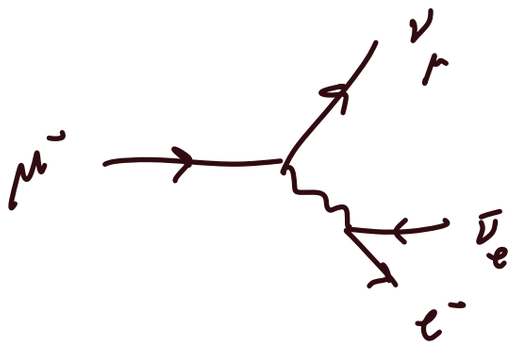
$\sigma_{n\text{-}bodies} \sim \alpha^n \Rightarrow$ *start considering process with lowest number of interactions*

AN EXAMPLE

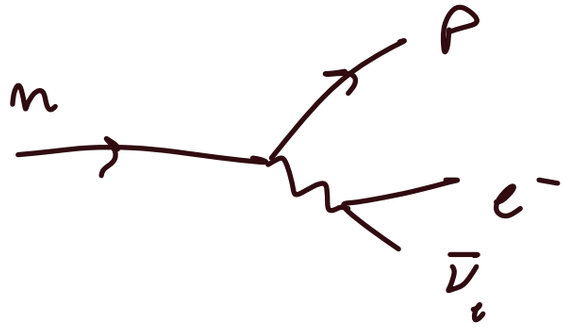
A heavy muon



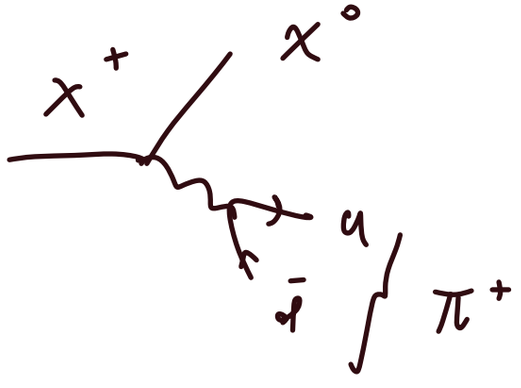
MUON AND NEUTRON LIFE-TIME



$\tau \sim 10^{-6}\ s$



$\tau \sim 900\ s$ $\qquad$ $\Gamma \sim 1/\tau \sim G_F(m_n - m_p)^5$

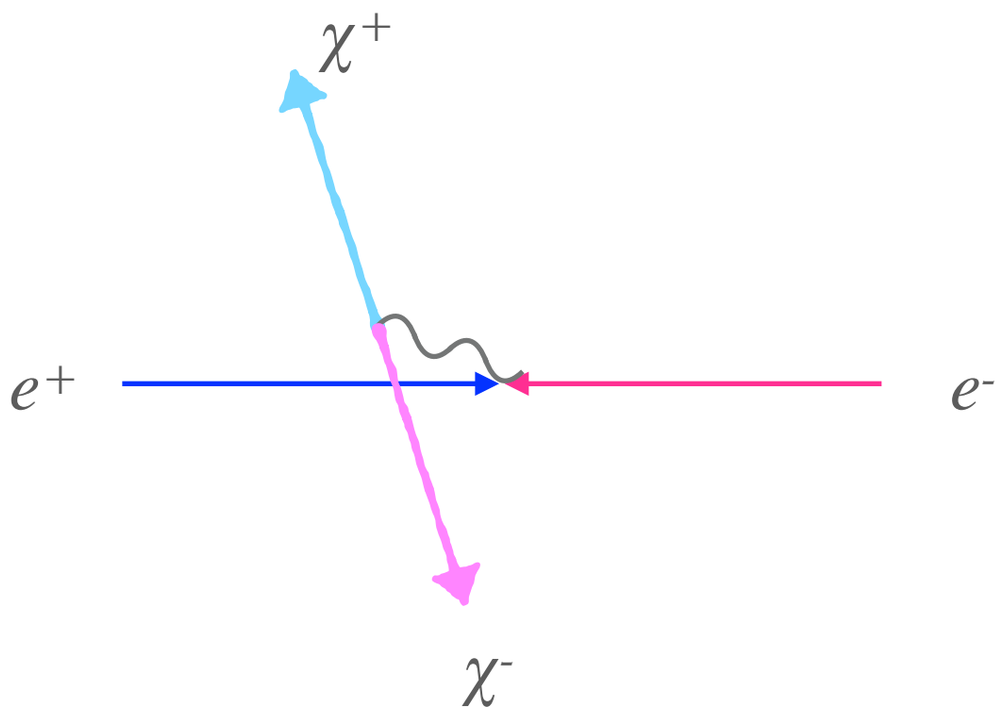


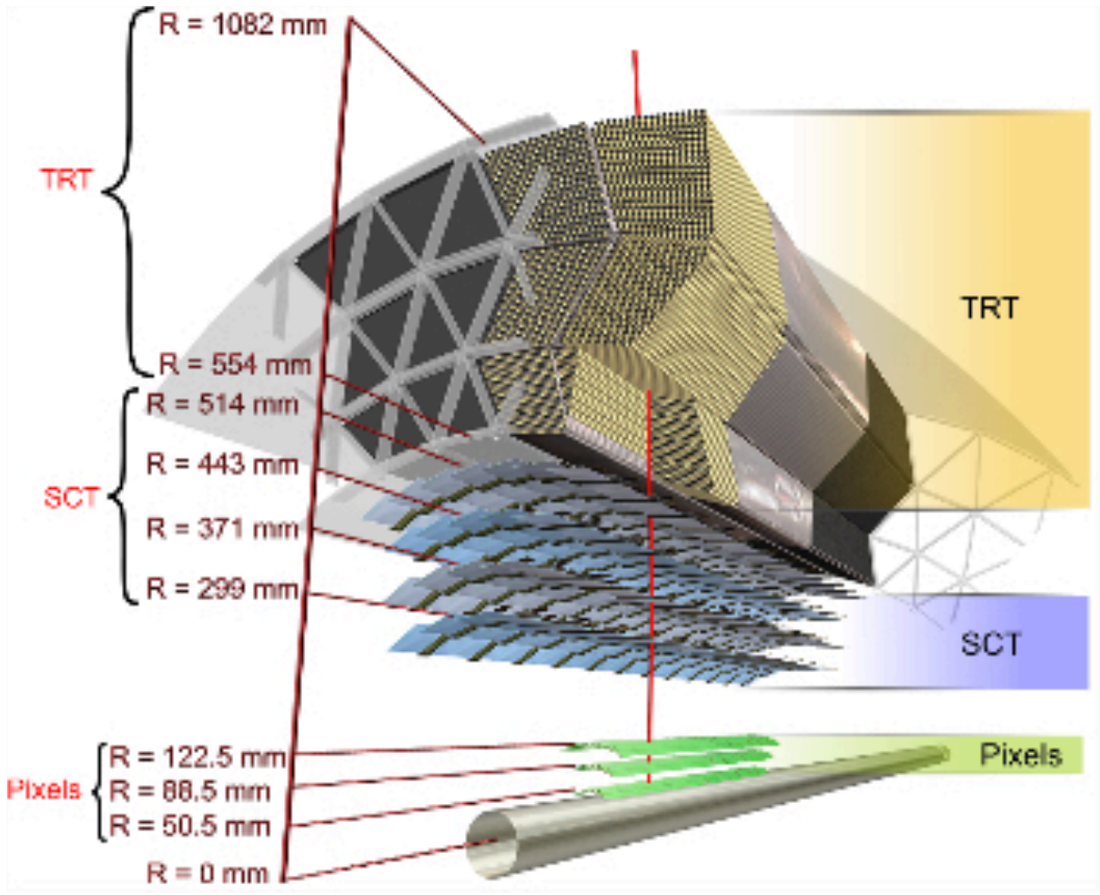
$\tau \sim 0.1\ ns \Rightarrow c\tau = 3\ cm$

Mass of $\chi^+ \sim 100\ GeV$ - $1\ TeV$

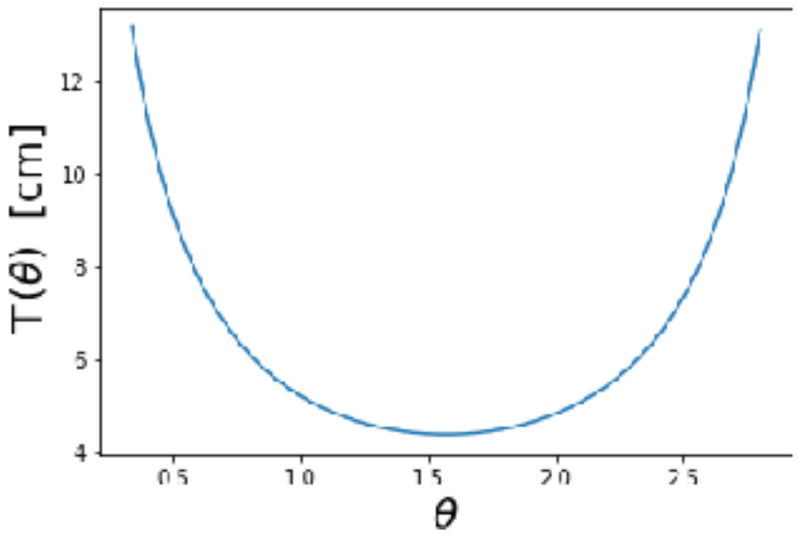
HOW TO SEARCH FOR IT?

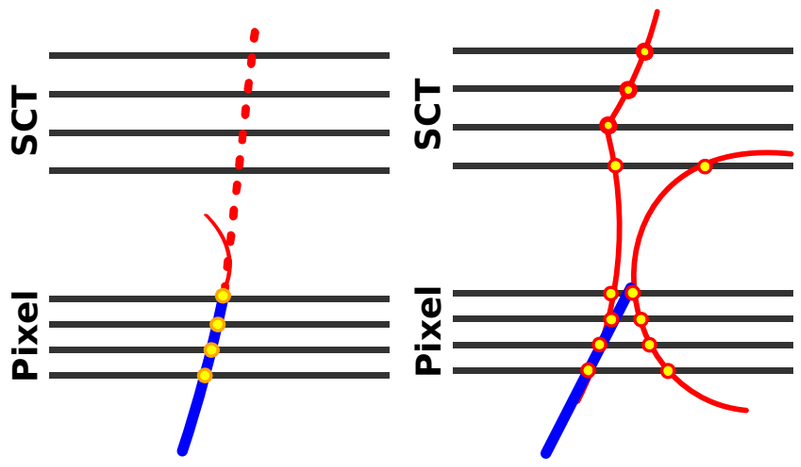
ELECTRON–POSITRON COLLISION





$$c\tau = c\tau_0\gamma \; > \top(\theta) = 4.4\ cm\ /\ sin\theta$$





EVENT GENERATION

https://launchpad.net/mg5amcnlo

HOW TO RUN THE HARD SCATTERING EVENT GENERATOR

- qsub -I -l host=wn-01-01-01.cluster.roma3
- wget https://launchpad.net/mg5amcnlo/2.0/2.6.x/+download/MG5_aMC_v3.0.0.beta.tar.gz
- tar zxf MG5_aMC_v3.0.0.beta.tar.gz
- python -V #check python version is 2.7
- cd MG5_aMC_v3_0_0
- ./bin/mg5_aMC

HOW TO RUN THE HARD SCATTERING EVENT GENERATOR

- MG5_aMC> **tutorial**
- MG5_aMC> **help import**
- MG5_aMC> **import model MSSM_SLHA2**
- MG5_aMC> **display particles x1+**

Particle x1+ has the following properties:

```
{
    'name': 'x1+',
    'antiname': 'x1-',
    'spin': 2,
    'color': 1,
    'charge': 1.00,
    'mass': 'mdl_Mch1',
    'width': 'mdl_Wch1',
    'pdg_code': 1000024,
    'line': 'straight',
    'propagator': '',
    'is_part': True,
    'self_antipart': False,
    'type': '',
    'counterterm': {}
}
```

HOW TO RUN THE HARD SCATTERING EVENT GENERATOR

- MG5_aMC> **generate e+ e- > x1+ x1-**
- MG5_aMC> **launch**

```
The following switches determine which programs are run:
/================== Description ==================|============ values ============|======== other options ========\
| 1. Choose the shower/hadronization program       |       shower = Not Avail.      |     Please install module     |
| 2. Choose the detector simulation program        |      detector = Not Avail.     |     Please install module     |
| 3. Choose an analysis package (plot/convert)     |      analysis = Not Avail.     |     Please install module     |
| 4. Decay onshell particles                       |       madspin = OFF            |     ON|onshell               |
| 5. Add weights to events for new hypp.           |      reweight = OFF            |     ON                        |
\================================================================================================================/
```

HOW TO RUN THE HARD SCATTERING EVENT GENERATOR

Do you want to edit a card (press enter to bypass editing)?

/--

| 1. param : param_card.dat |

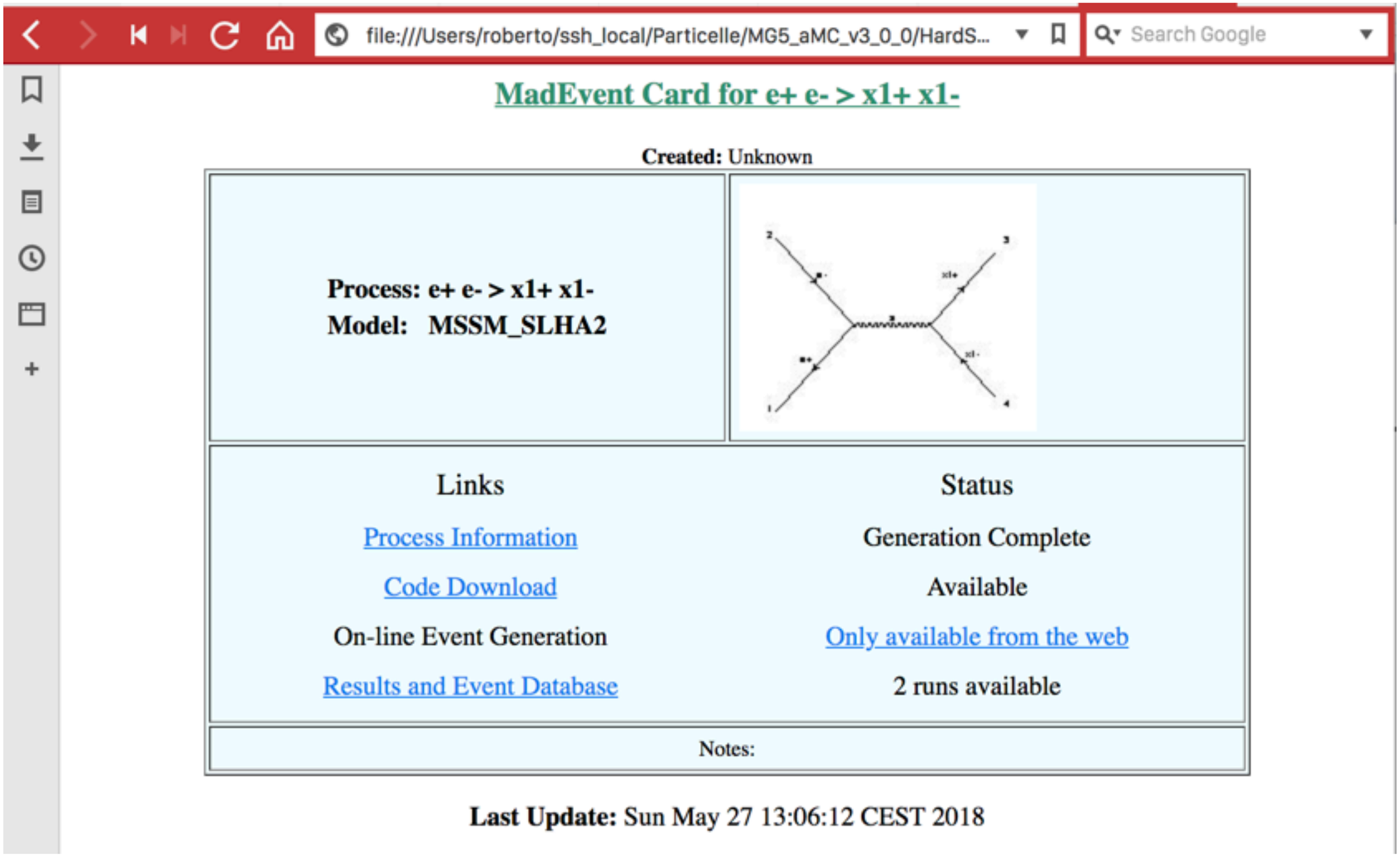
| 2. run : run_card.dat |

\--/

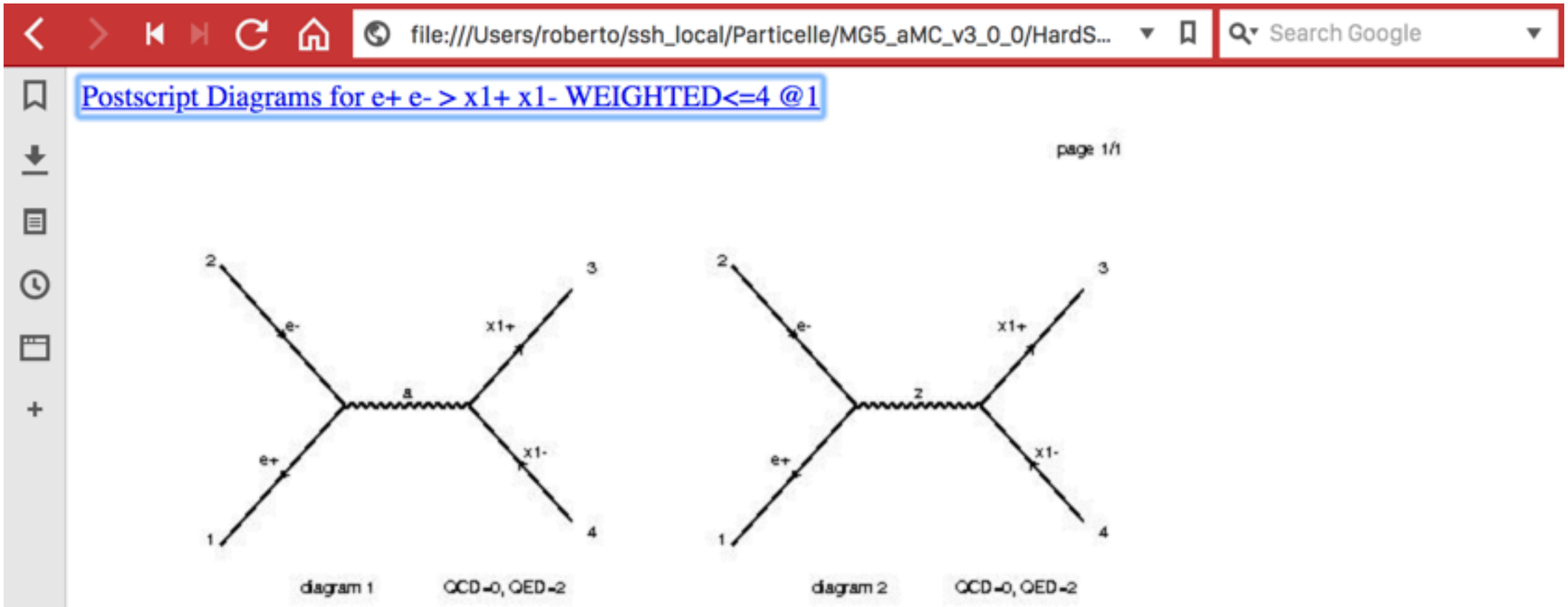
```
BLOCK MASS #
 …
 1000024 1.816965e+02 # mch1

# Running parameters

…

      1500.0     = ebeam1  ! beam 1 total energy in GeV
      1500.0     = ebeam2  ! beam 2 total energy in GeV
```

more information in /storage/DATA-05/gridrm3/franceschini/Particelle/MG5_aMC_v3_0_0/HardScattering/index.html

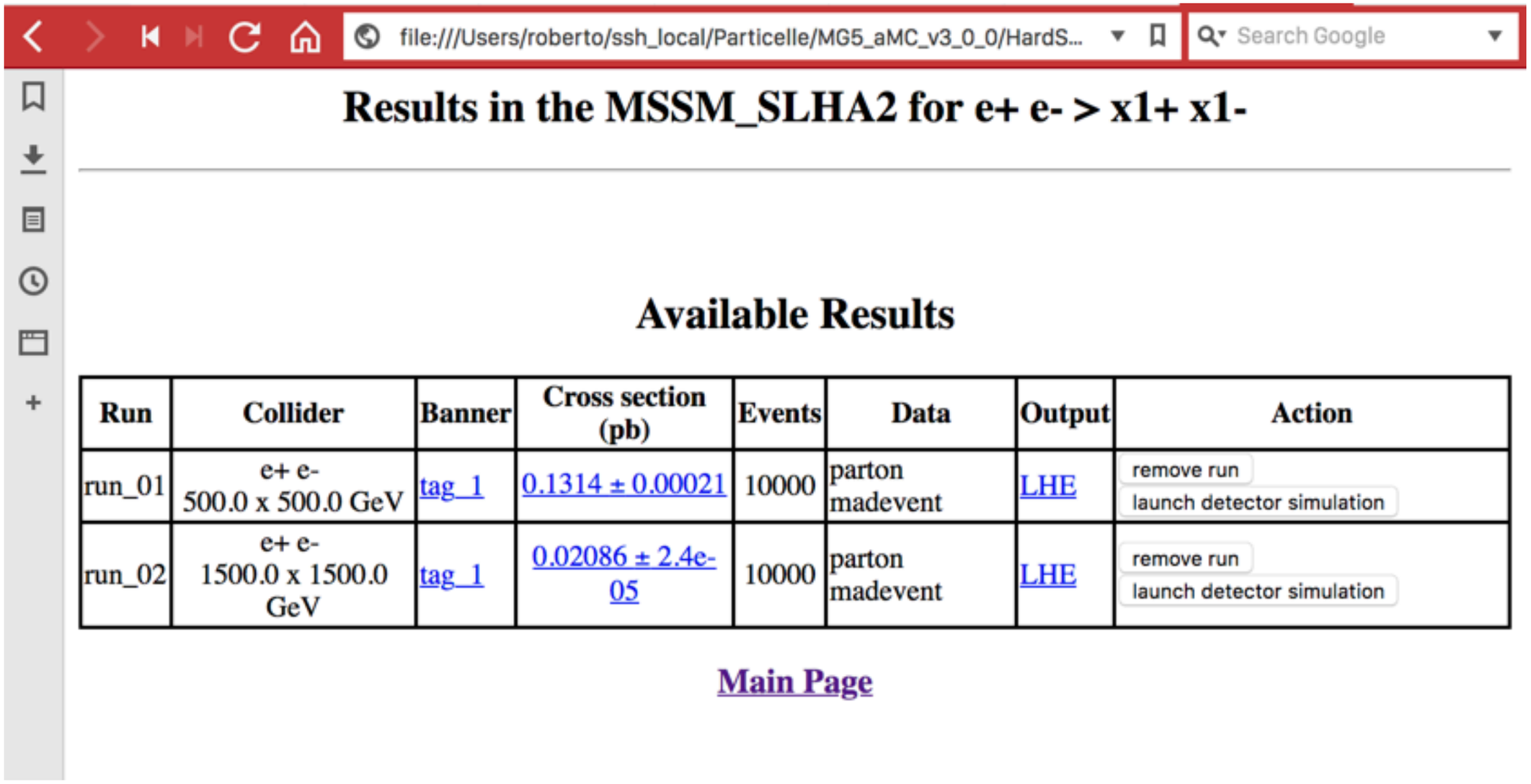
HOW TO RUN THE HARD SCATTERING EVENT GENERATOR



HOW TO RUN THE HARD SCATTERING EVENT GENERATOR



HOW TO RUN THE HARD SCATTERING EVENT GENERATOR



GOODIES

- **cat /proc/cpuinfo** *#to see how many cpu you have on the node*
- **w** *#to see how many computing resources are used in the node*
- **ssh -fnNT -L 2022:ui-01.roma3.infn.it:22 USERNAME@amaldi.fis.uniroma3.it** *#to open a ssh tunnel*
- **sshfs -p 2022 USERNAME@127.0.0.1:PATH_YOU_WANT_TO_ACCESS ~/ssh_local** *#to mount locally the remote folder accessible only from ui-01, you need to install sshfs*
- **open -a Google\ Chrome.app /Users/roberto/ssh_local** *#if you use Chrome on Mac OS X*
- https://twiki.cern.ch/twiki/bin/view/CMSPublic/MadgraphTutorial

LES HOUCHES FILE FORMAT

hep-ph/0609017 - A standard format for Les Houches Event Files
http://arxiv.org/abs/hep-ph/0609017

LHEF LIBRARIES

- http://home.thep.lu.se/~leif/LHEF/ for C++
- https://github.com/lukasheinrich/pylhe for Python
- http://pdg.lbl.gov/2017/reviews/rpp2017-rev-monte-carlo-numbering.pdf

2) Event information, repeated as many times as there are events

a) one line with common event information:

NUP IDPRUP XWGTUP SCALUP AQEDUP AQCDUP

b) NUP lines, one for each particle I in the range 1 through NUP

IDUP(I) ISTUP(I) MOTHUP(1,I) MOTHUP(2,I) ICOLUP(1,I) ICOLUP(2,I) PUP(1,I) PUP(2,I) PUP(3,I) PUP(4,I) PUP(5,I) VTIMUP(I) SPINUP(I)

LHEF EVENTS

2) Event information, repeated as many times as there are events

a) one line with common event information:

NUP IDPRUP XWGTUP SCALUP AQEDUP AQCDUP

b) NUP lines, one for each particle I in the range 1 through NUP

IDUP(I) ISTUP(I) MOTHUP(1,I) MOTHUP(2,I) ICOLUP(1,I) ICOLUP(2,I) PUP(1,I) PUP(2,I) PUP(3,I) PUP(4,I) PUP(5,I) VTIMUP(I) SPINUP(I)

<event>

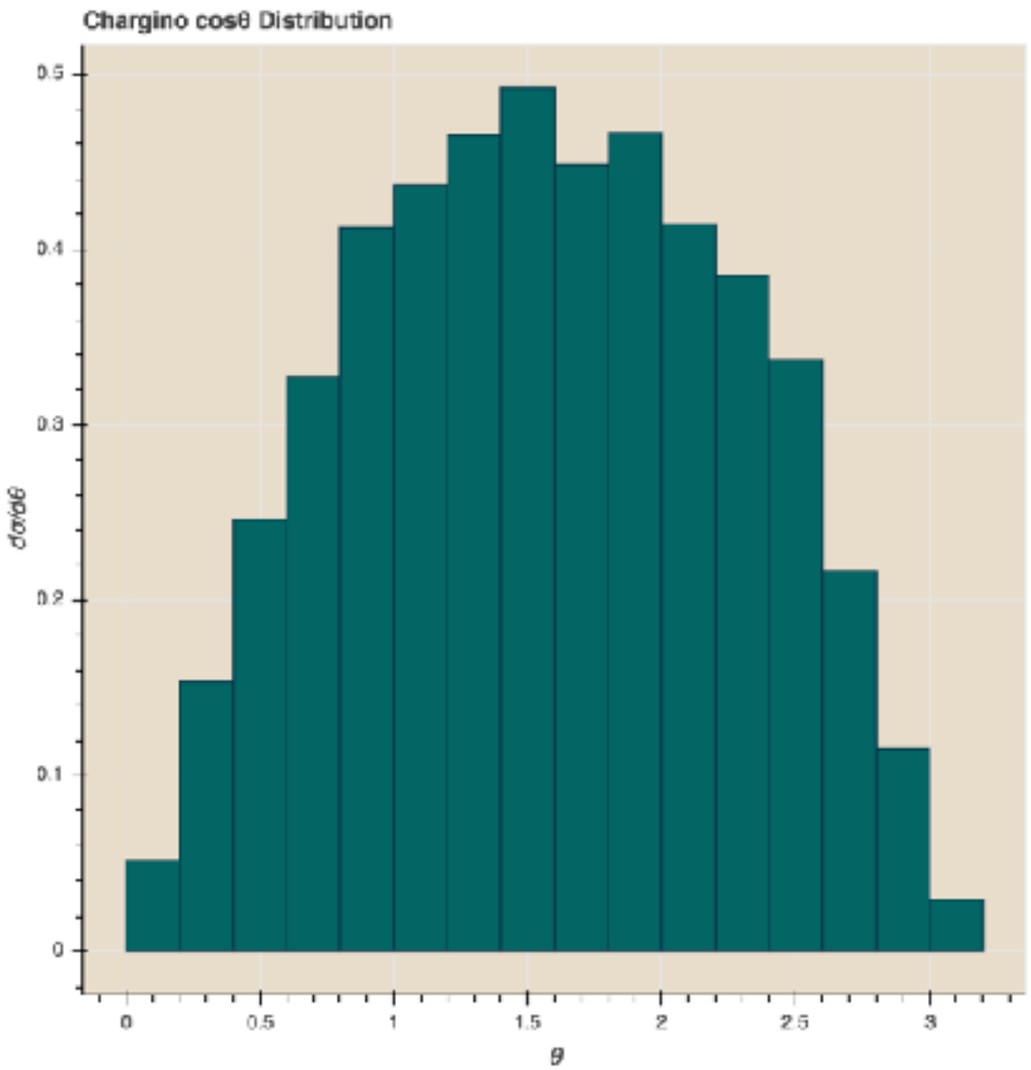
1 +2.1222900e-01 6.00000000e+02 7.81653100e-03 9.20023900e-02

ID	*status*			p_x	p_y	p_z	E	m		
-11	-1	0	0	0	0	+0.0000000000e+00	+0.0000000000e+00	+3.0000000000e+02	3.0000000000e+02	0.0000000000e+00	0.0000e+00	1.0000e+00
11	-1	0	0	0	0	-0.0000000000e+00	-0.0000000000e+00	-3.0000000000e+02	3.0000000000e+02	0.0000000000e+00	0.0000e+00	-1.0000e+00
1000024	1	1	2	0	0	-3.5774676505e+01	+6.6624747301e+01	+1.0668324877e+02	3.0000000000e+02	2.7000000000e+02	0.0000e+00	1.0000e+00
-1000024	1	1	2	0	0	+3.5774676505e+01	-6.6624747301e+01	-1.0668324877e+02	3.0000000000e+02	2.7000000000e+02	0.0000e+00	-1.0000e+00

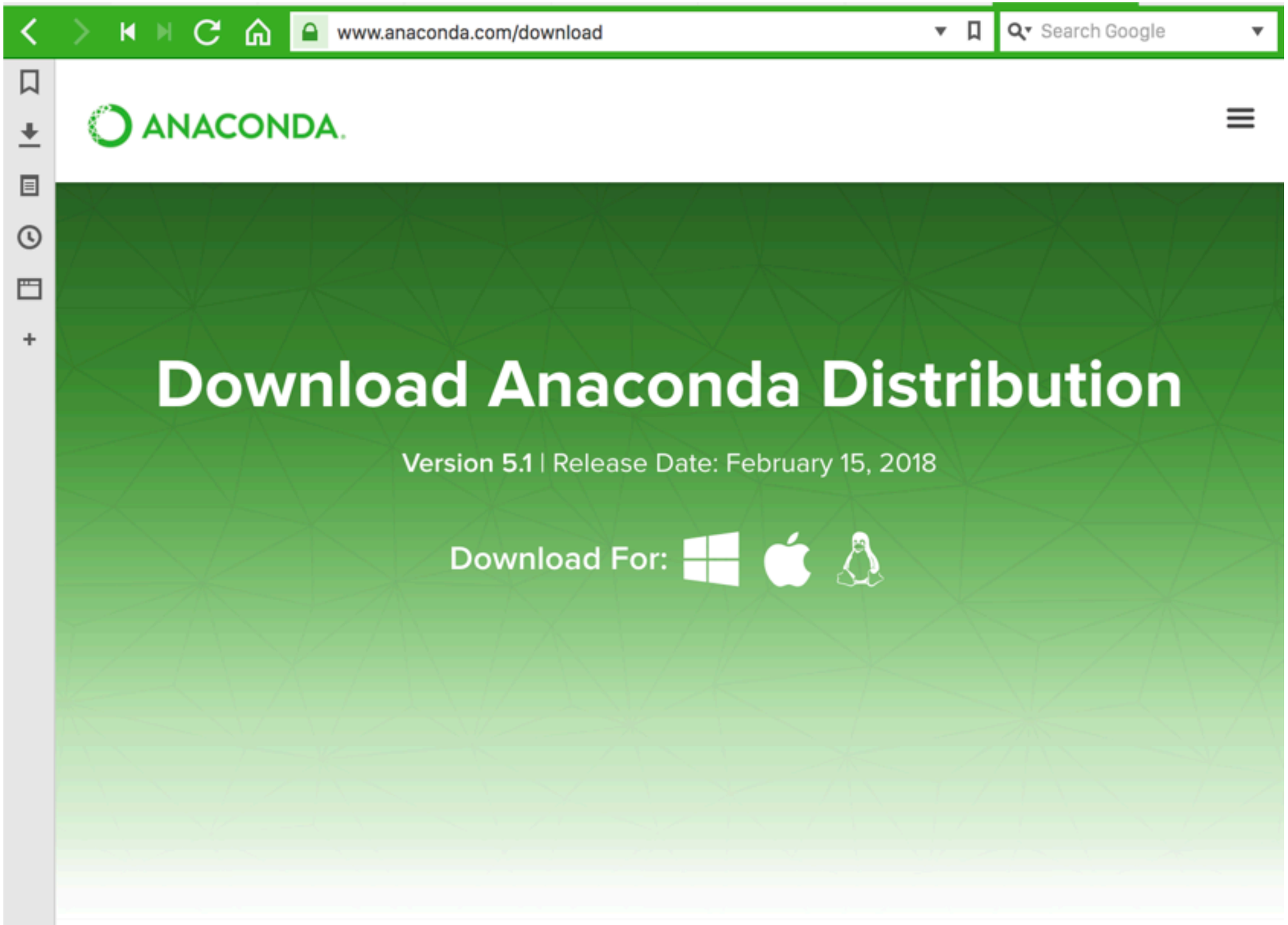
</event>

ANALYSIS

With Jupyter



ALL IN ONE SOLUTION



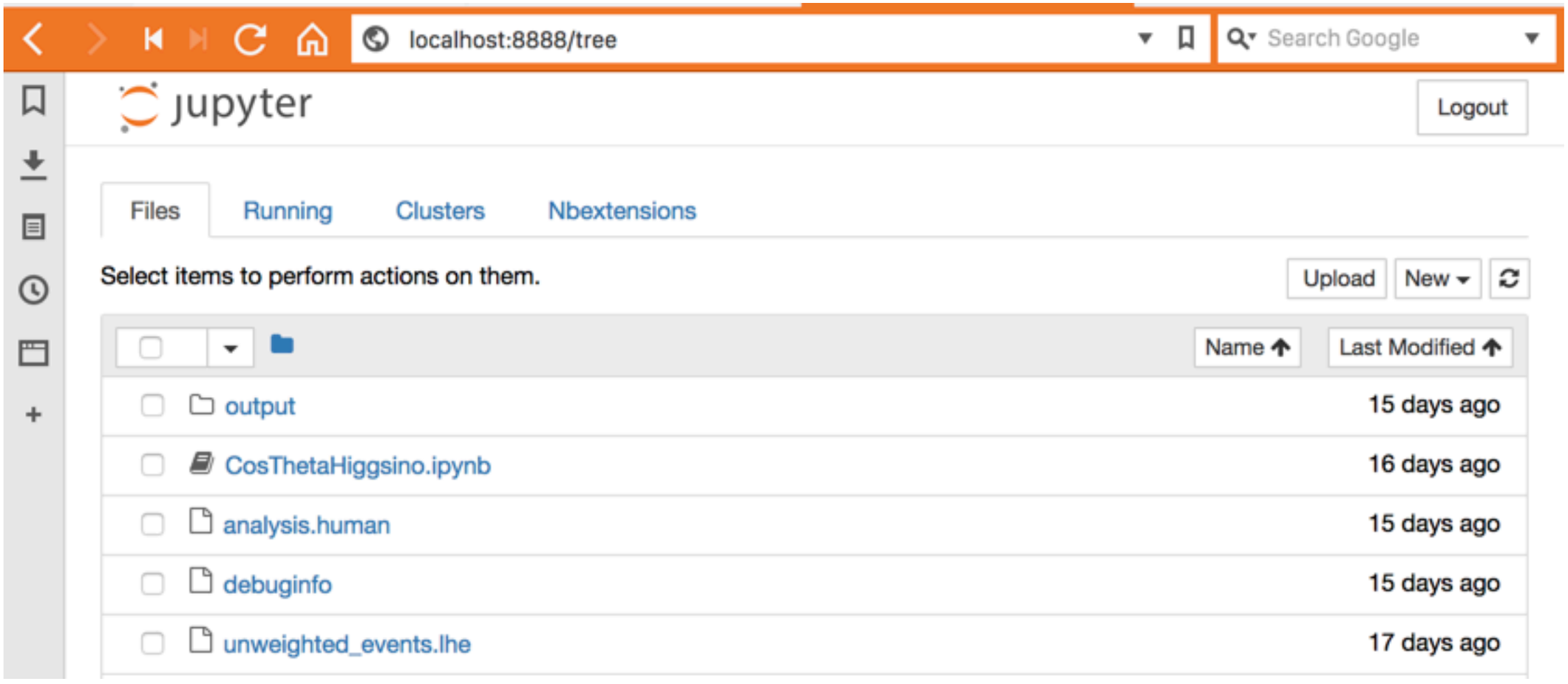
NOTEBOOKS INTERFACE

- jupyter notebook --no-browser

Copy/paste this URL into your browser when you connect for the first time,

to login with a token:

http://localhost:8888/?token=0c332205b79a1ebdc9cc80b7a890f620b96893abe1c7ffaf



PHYSICS LIBRARY

- https://github.com/lukasheinrich/lorentz/
- https://github.com/RobertoFranceschini/PyLHEAnalysis