



CONTUR: a tutorial

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for the →[CONTUR](#) team

Tools 2020, 2-6 November 2020

for introduction to CONTUR see overview talk

→[Review on collider recasting tools](#) by Benjamin Fuks, Tue 10:00

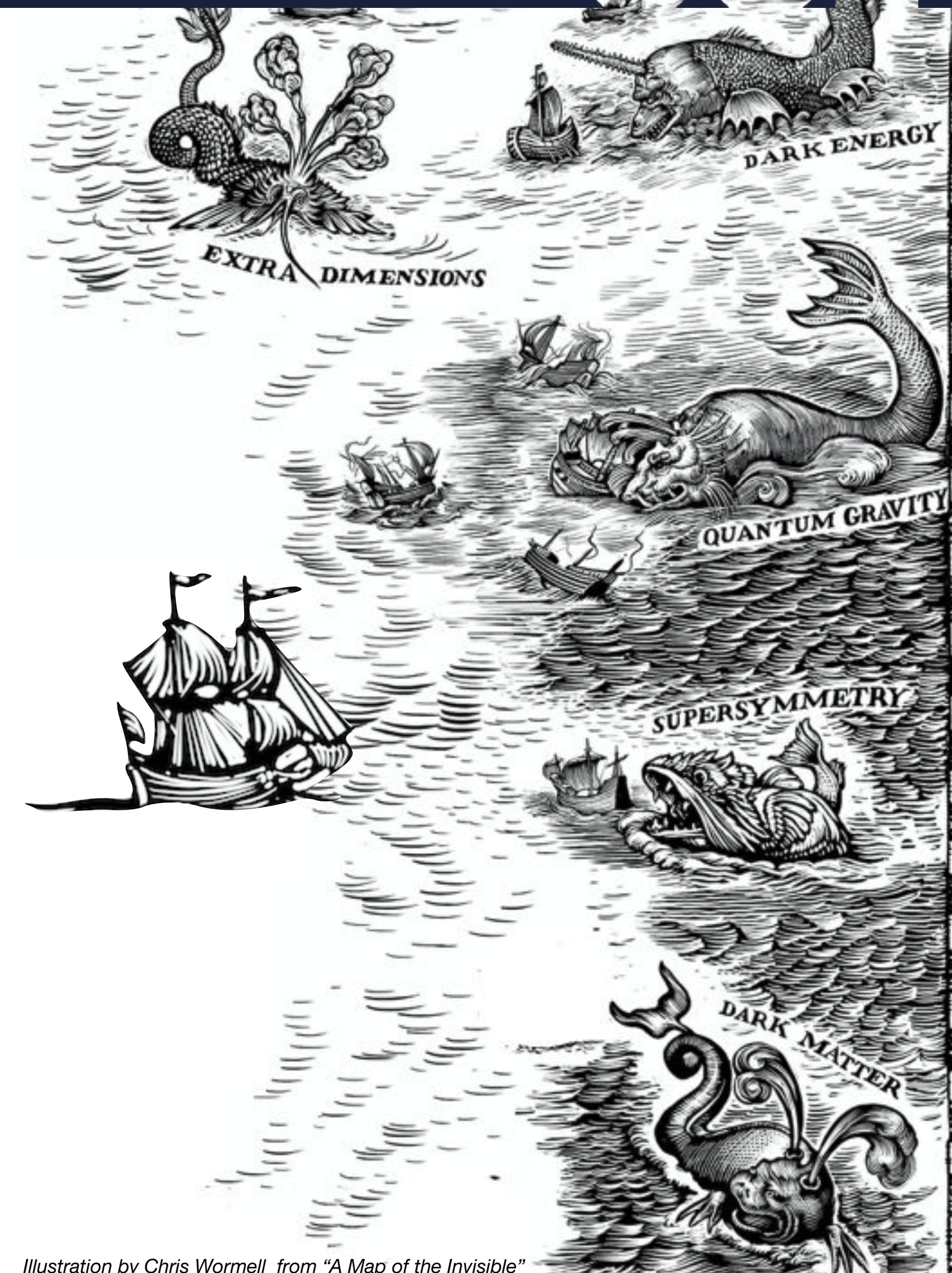


Illustration by Chris Wormell from "A Map of the Invisible"



Getting started



```
$ docker pull hepstore/contur-herwig:1.2.x
1.2.x: Pulling from hepstore/contur-herwig
d51af753c3d3: Already exists
[...]

$ unzip contur_tutorial.zip
$
$ docker run -it -v $PWD:/contur_tutorial hepstore/contur-herwig:1.2.x
Successfully found tqdm python module
Successfully found numpy python module
Successfully found future python module
Successfully found YODA python module
Successfully found Rivet python module
Successfully found scipy python module
Successfully found configobj python module
Successfully found sqlite3 python module
Successfully found matplotlib python module
Successfully found pylha python module

All python module dependencies appear to be accessible.

-----
Environment to run Contur successfully set up
-----
root@820d6f3781f0:/contur#
```

pull docker image (we're going to generate events as well, so use `contur-herwig:1.2.x` instead of `contur:1.2.x`)

(download and) extract tutorial files

run docker image, binding directories

CONTUR starting

ready to go!



Outline

1. Using UFOs

UFO describing BSM model

2. Single parameter point:
preparation

**Herwig: event generation for
all new 2->2 processes**

**Rivet+HEPdata to determine
effect of BSM on existing
measurements**

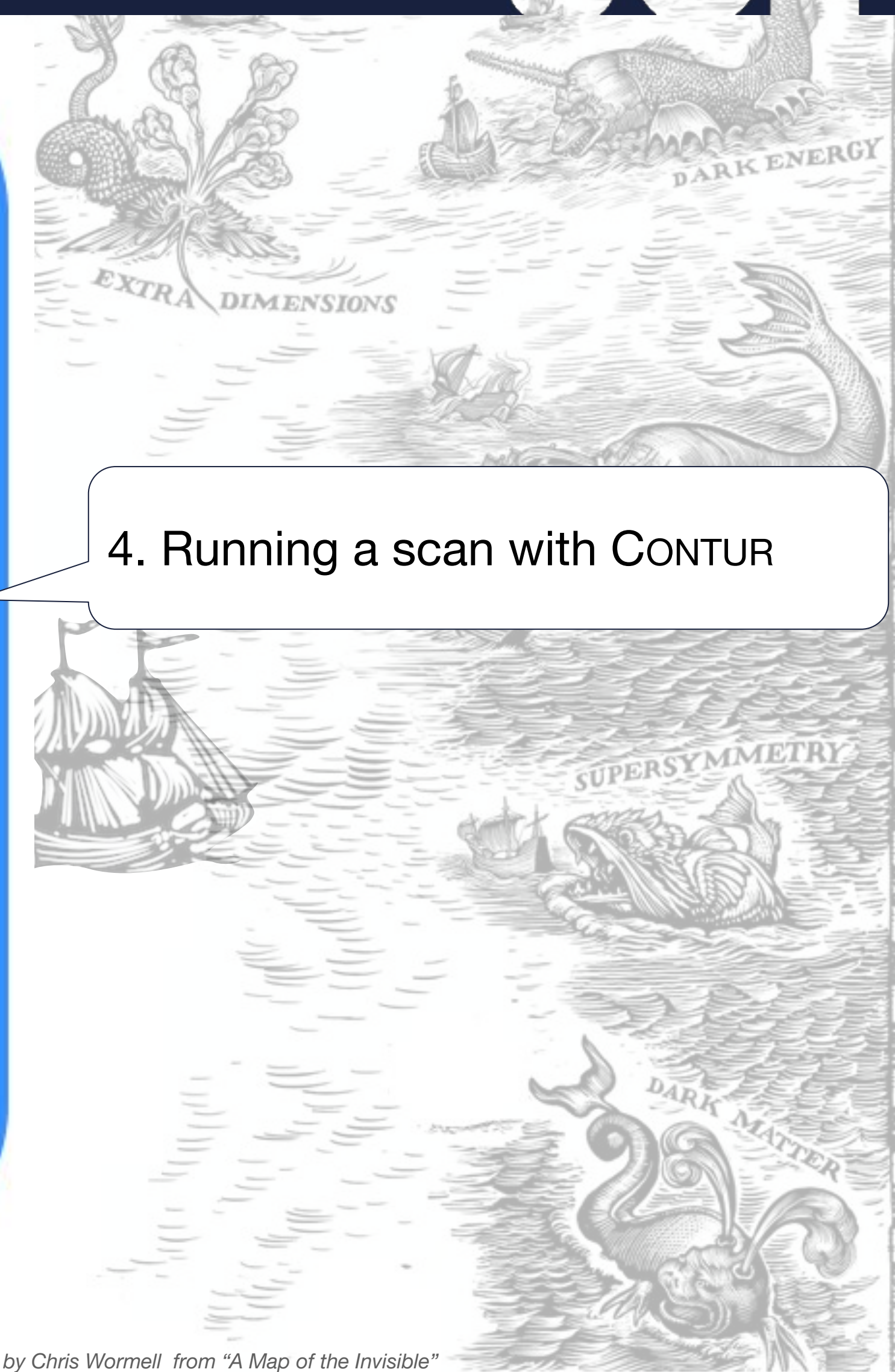
3. Single parameter point:
running CONTUR

CLs method for exclusion

Repeat for
each point
in
parameter
space

4. Running a scan with CONTUR

Constraints On New Theories Using Rivet





A look at the directory contents



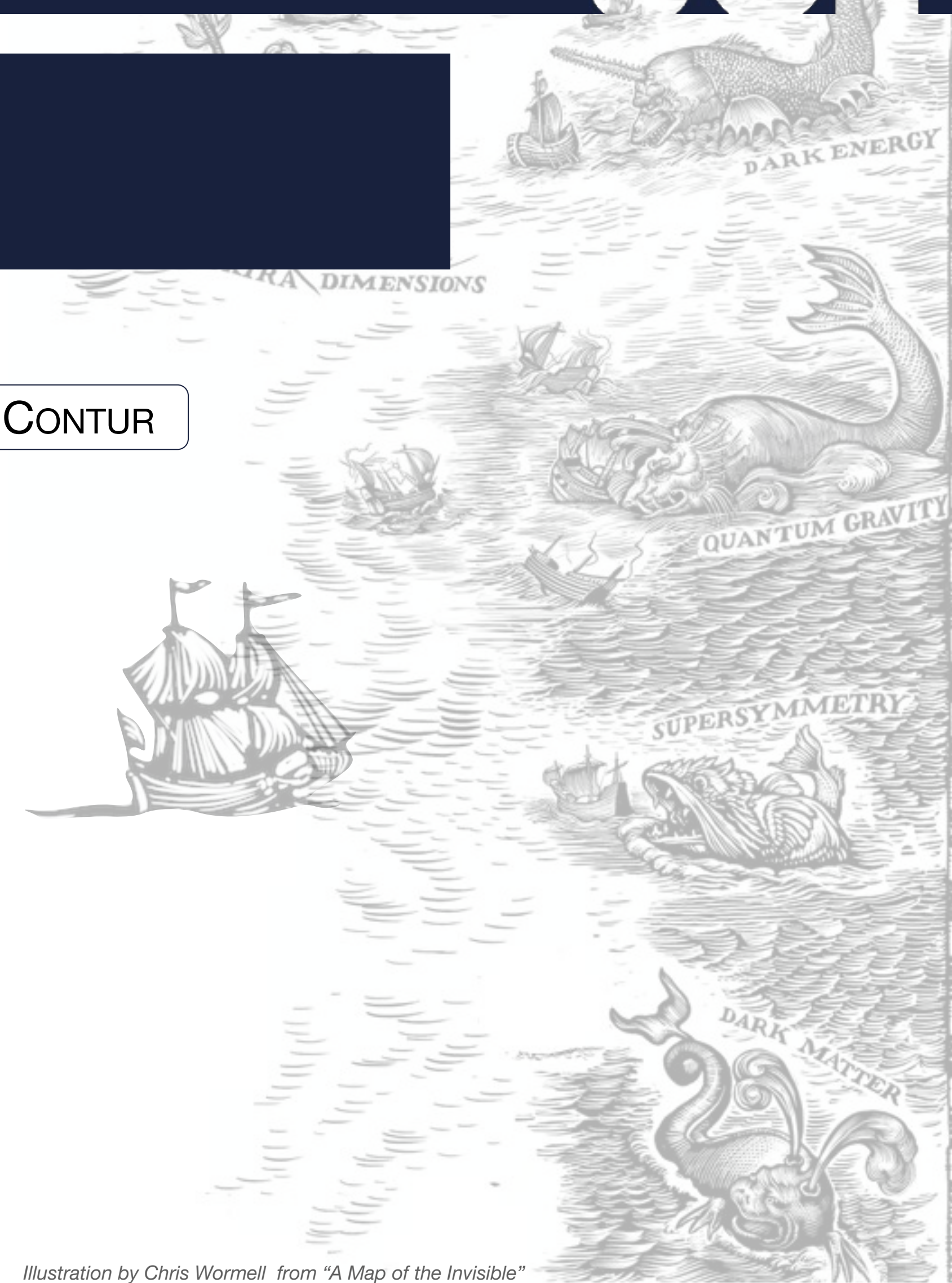
```
# cd /contur_tutorial
# ls
LHC.in  LHC_example.in  myscan00  param_file.dat
```

command file for Herwig
when running a scan

command file for Herwig
for a single grid point

signal grid

scan file for CONTUR





1. Using UFOs

```
# cp -r /contur/AnalysisTools/GridSetup/GridPack/ .
# cd GridPack/
# cp -r /contur/Models/DM/DM_vector_mediator_UFO/ .
# . $HERWIG_ENV/bin/activate
# ufo2herwig DM_vector_mediator_UFO/
```

```
=====
LENGTH 1
finished generating model:   FRModel
model directory:           DM_vector_mediator_UFO/
generated:                  122 vertices
=====
```

```
library:      FRModel.so
input file:   LHC-FRModel.in
model file:   FRModel.model
=====
```

```
To complete the installation, compile by typing "make".
An example input file is provided as LHC-FRModel.in,
you'll need to change the required particles in there.
```

```
DONE!
```

```
=====
# make
g++ -std=c++11 -fPIC -I/herwig/include -I/herwig/include -I/herwig/include -Wall -Wextra
-pedantic -O2 -DBOOST_UBLAS_NDEBUG -c FRModel.cc -o FRModel.o
[...]
```

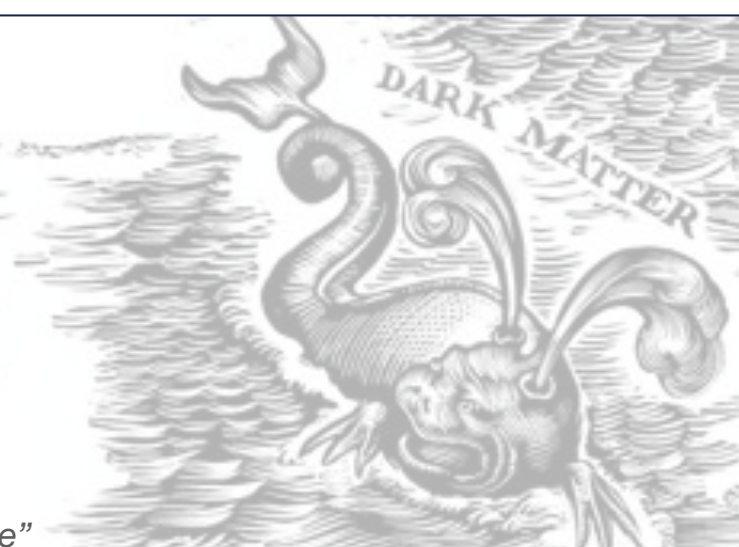
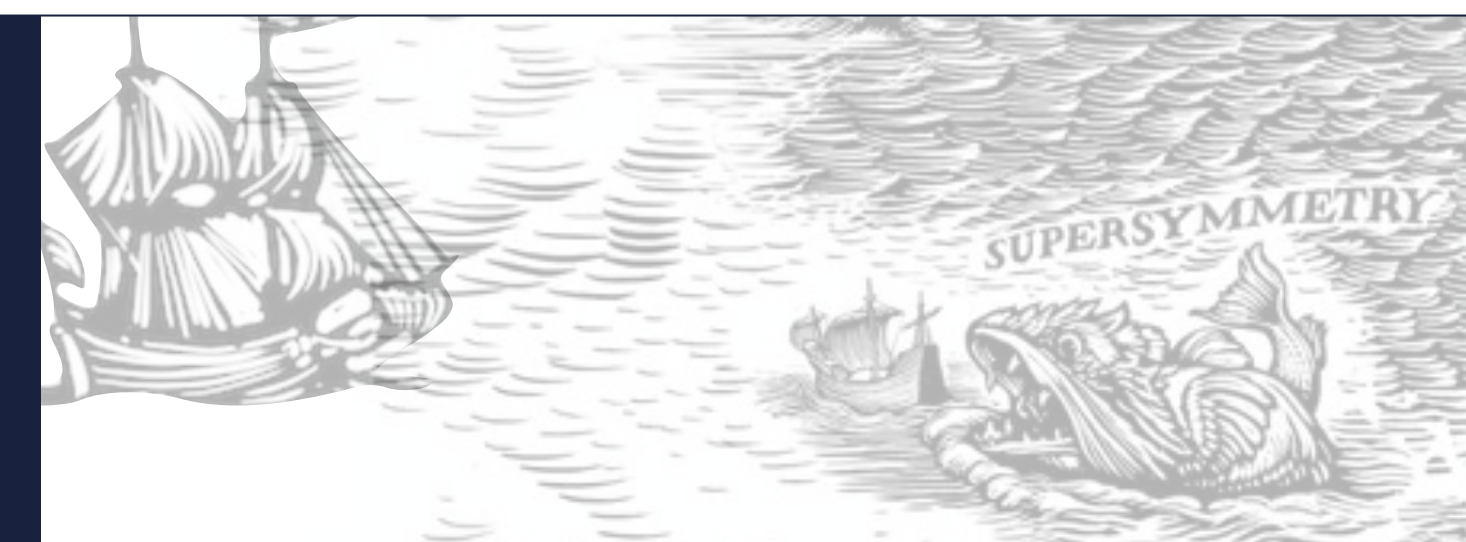
copy "GridPack" which tells CONTUR/ Rivet which analyses to use

choose and copy model UFO

we're going to use Herwig for event generation, so activate Herwig

convert UFO to Herwig-readable format

compile UFO





2. A look at LHC.in



```
$ cd /contur_tutorial
$ cat LHC.in

read FRModel.model
set /Herwig/FRModel/Particles/Y1:NominalMass {mY1}*GeV
set /Herwig/FRModel/Particles/Xm:NominalMass {mXm}*GeV
set /Herwig/FRModel/FRModel:gYXm {gYXm}
set /Herwig/FRModel/FRModel:gYq {gYq}

#####
#
# Modify the required process here
#
#####
[...]
```





2. Single point: preparation



```
# Herwig read LHC_example.in -L /contur_tutorial/GridPack/ -I /contur_tutorial/GridPack/  
# Herwig run LHC.run -N 1000  
event> 1000 1000
```

```
BasicConsistency: maximum 4-momentum violation: 0.163 MeV
```

```
HepMCFile: generated HepMC output.
```

```
# rivet -a CMS_2018_I1682495 LHC.hepmc
```

```
Rivet.AnalysisHandler: INFO Using named weights
```

```
Reading events from 'LHC.hepmc'
```

```
Event 1000 (0:00:22 elapsed)
```

```
Finished event loop at 2020-10-26 09:59:27
```

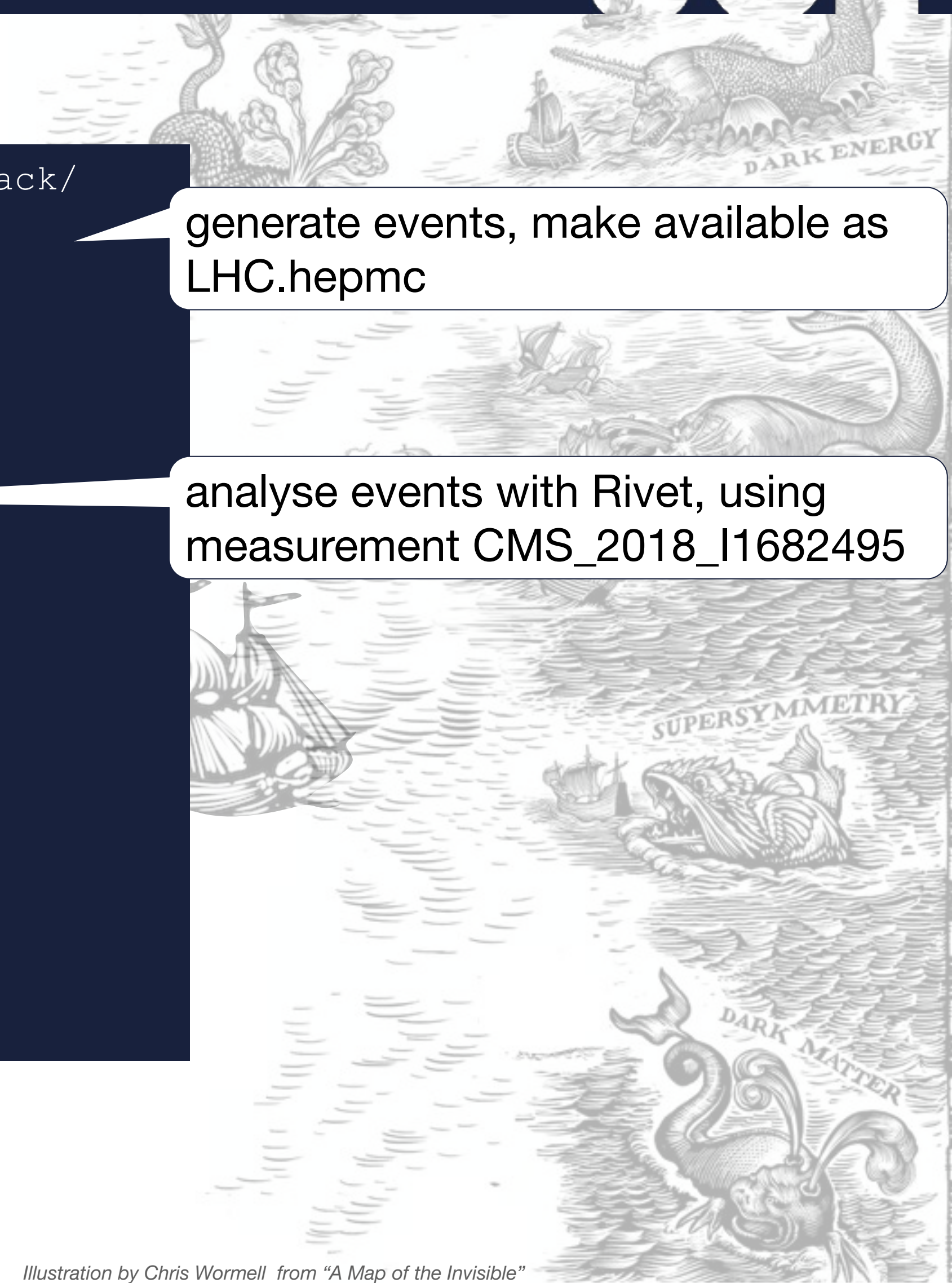
```
Cross-section = 2.996196e-01 pb
```

```
Rivet run completed at 2020-10-26 09:59:27, time elapsed = 0:00:22
```

```
Histograms written to /contur_tutorial/myscan00/13TeV/0079/Rivet.yoda
```

generate events, make available as LHC.hepmc

analyse events with Rivet, using measurement CMS_2018_I1682495





3. Single point: running CONTUR



```
# cd /contur
# source setupContur.sh
Successfully found tqdm python module
[...]
-----
Environment to run Contur successfully set up
-----
# cd /contur_tutorial
# contur --ana-match CMS_2018_I1682495 Rivet.yoda
INFO - Running Contur version 1.2.x
INFO - See https://hepcedar.gitlab.io/contur-webpage/
INFO - Run Information
Contur is running in /contur_tutorial on analysis objects in ['Rivet.yoda']
Excluding Higgs to WW measurements
Excluding secret b-veto measurements
Excluding ATLAS WZ SM measurement
No correlations being built, using single bins in tests
Building default background model from data, ignoring (optional) theory predictions
Only using analysis objects whose path includes ['CMS_2018_I1682495'].
```

source CONTUR because Herwig changed environment variables

do statistical analysis with Contur, only using measurement CMS_2018_I1682495 for now

information about CONTUR run



3. Single point: running CONTUR



(continued)

```

100 analysisobjects in Rivet.yoda
INFO - Loading reference and theory data from all yoda files in
$RIVET_DATA_PATH matching paths in input yoda
Processing reference/theory YODAs: 0it [00:00, ?it/s]
[...]

INFO - Combined exclusion for these plots is 64.71 %
# contur-mkhtml Rivet.yoda
Making 24 plots
Plotting contur-plots/CMS_13_JETS/CMS_2018_I1682495/d08-x01-y01.dat
(24/24 remaining)
[...]

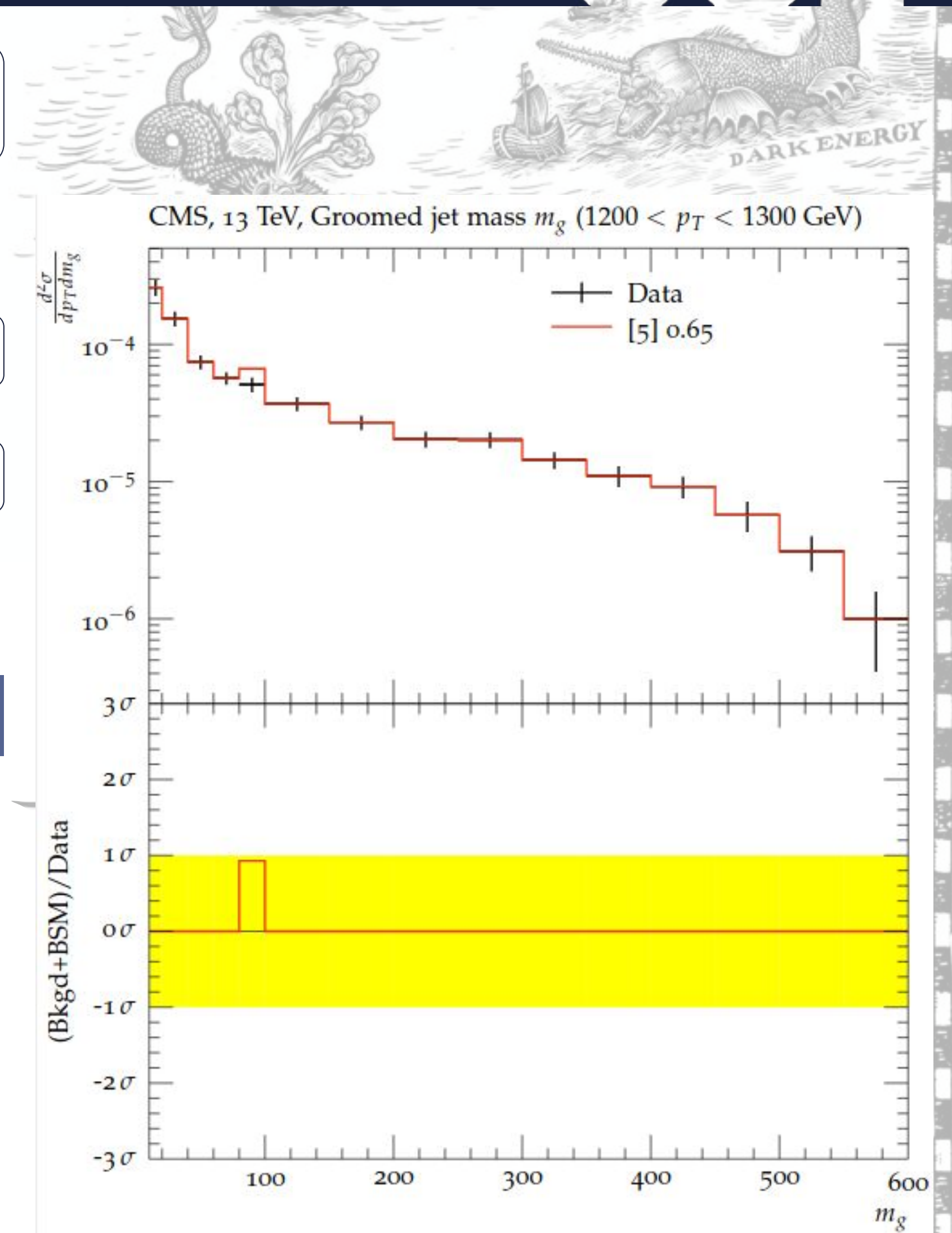
```

loading histograms and theory inputs

exclusion of ~65%!

wrapper for rivet-mkhtml

open contur-plots/index.html in a browser of your choice:





4. A look at param_files.dat



```
# cat param_file.dat
```

```
[Run]
generator = '<path to Herwig>/Herwig-7.2.1/bin/activate'
[...]
```

tell CONTUR which generator etc. to use and where to find them

```
[Parameters]
[[mXm]]
mode = LIN
start = 10.0
stop = 1500.0
number = 10
```

tell CONTUR to vary dark matter mass from 10 to 1500 GeV in ten equidistant steps

```
[[mY1]]
mode = LIN
start = 10.0
stop = 3500.0
number = 10
```

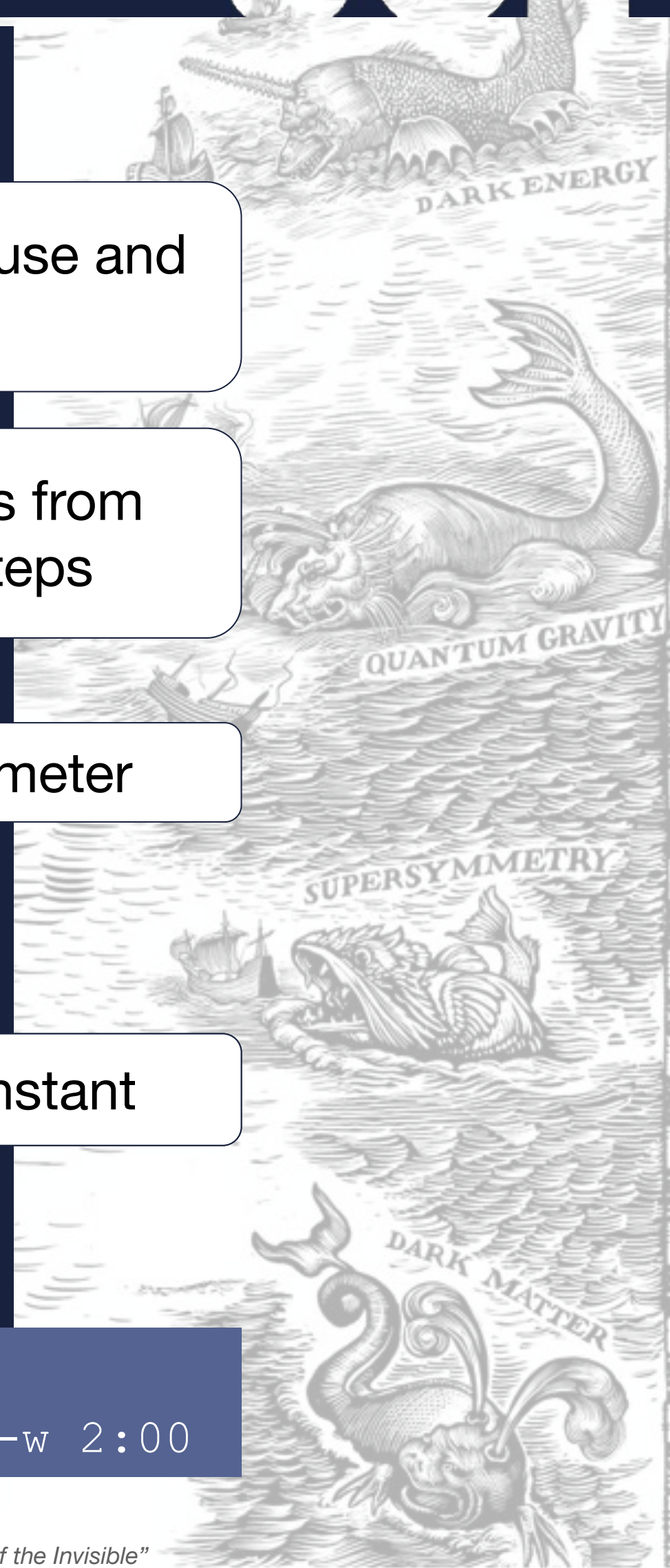
mediator mass is second scan parameter

```
[[gYXm]]
mode = CONST
value = 1.0
```

tell CONTUR to treat couplings as constant

```
[[gYq]]
mode = CONST
value = 0.25
```

with this setup, signal grid generated with
`$ contur-batch -p param_file.dat -P -b 13TeV -w 2:00`





4. Running a CONTUR scan

now run CONTUR by calling

```
# contur -g myscan00
INFO - Running Contur version 1.2.x
INFO - See https://hepcedar.gitlab.io/contur-webpage/
INFO - Run Information
Contur is running in /Contur_tutorial
on files in myscan00 Excluding Higgs to WW measurements
Excluding secret b-veto measurements
Excluding ATLAS WZ SM measurement
No correlations being built, using single bins in tests
Building default background model from data, ignoring (optional) theory predictions

INFO - Removing unnecessary files from grid
INFO - Merging yoda files (myscan00/13TeV)
-----
WARNING - NO YODA FILES FOUND IN DIRECTORY 13TeV
WARNING - runpoint_0000.yoda.gz already exists.

[...]

INFO - Found valid yoda file Contur_tutorial/myscan00/13TeV/0000/runpoint_0000.yoda.gz
INFO - Sampled at:
gYXm: 1.0
gYq: 0.25
mXm: 10.0
mY1: 10.0
```

(this will take some time)

information about CONTUR run

files would be compressed (but that was already done when preparing the tutorial)

information about current grid point



4. Running a CONTUR scan

(continued)

```
INFO - Found 1474 analysisobjects in /Contur_tutorial/myscan00/13TeV/0000/runpoint_0000.yoda.gz
INFO - Loading reference and theory data from all yoda files in $RIVET_DATA_PATH matching paths in input yoda
Processing reference/theory YODAs: 0it [00:00, ?it/s]
```

loading histograms (and theory inputs, but only once)

[...]

```
WARNING - Negative CLs -0.002172, setting to zero for /ATLAS_2017_I1609448/d01-x01-y01. BSM+SM is in better agreement with data.
```

if CLs negative, ignore those histograms

[...]

```
INFO - Added yodafile with reported exclusion of: 0.7404989651618201
INFO - Found valid yoda file Contur_tutorial/myscan00/13TeV/0001/runpoint_0001.yoda.gz
```

report exclusion for grid point and go to next one

[...]

[...]

```
INFO - Found 100 yoda files
INFO - Merging maps
INFO - Writing output map to : ANALYSIS/contur.map
```

summarise run and output



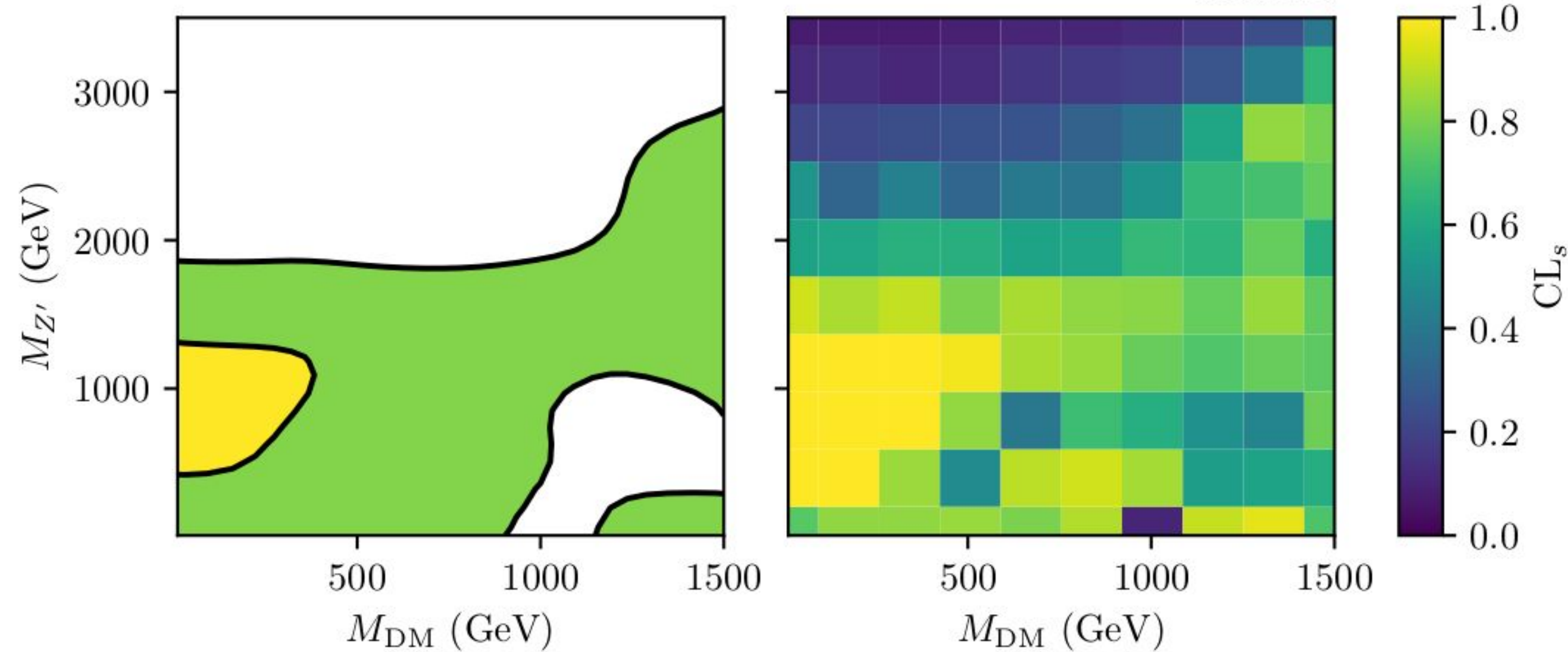
4. Plotting with CONTUR

to plot do

```
# cd ANALYSIS
# contur-plot contur.map mXm mY1
Starting plotting engine, outputs written to conturPlot
plot combined exclusion limit grid
plot dominant pools level 0 (1/1)
Done
```

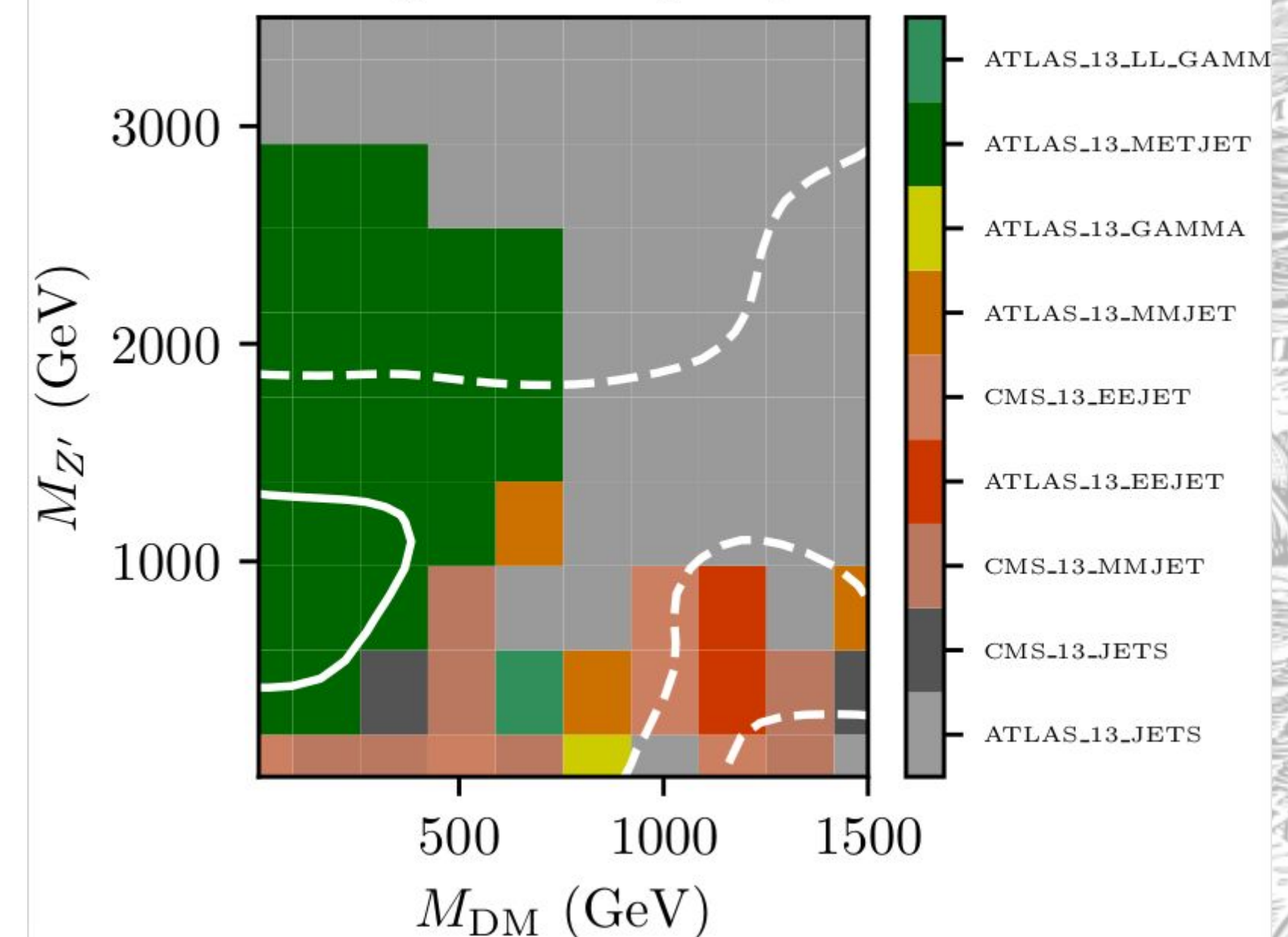
and find your plots at ANALYSIS/conturPlot

CONTUR



combinedHybrid.pdf

Leading CLs analysis pools



dominantPools0.pdf



4. Pool plots in CONTUR



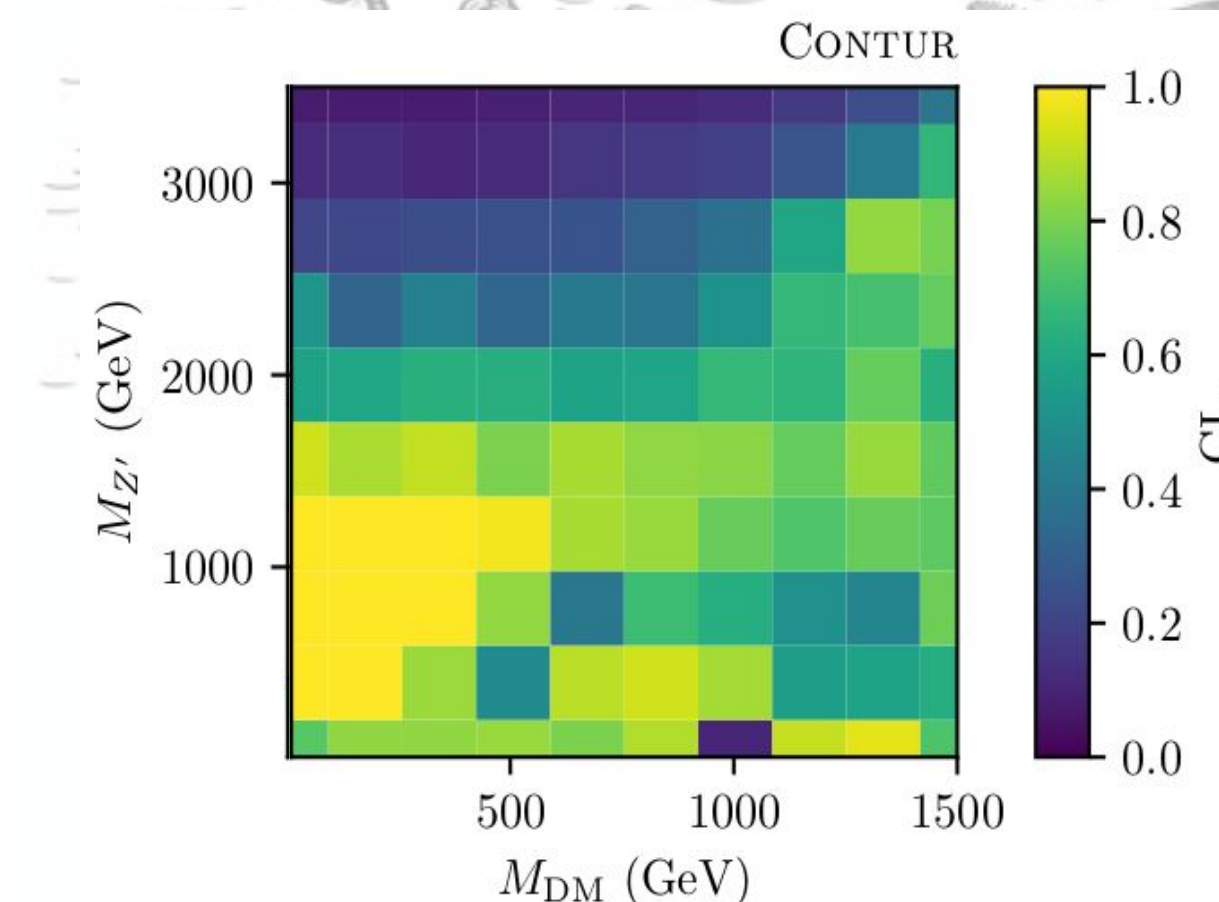
to plot the exclusion for each pool

```
# contur-plot contur.map mXm mY1 --pools
Starting plotting engine, outputs written to conturPlot
plot combined exclusion limit grid
plot dominant pools level 0 (1/1)
Requested plotting of individual analysis pools, found 16 pools to plot
plot ATLAS_13_MMJET (1/16 done)

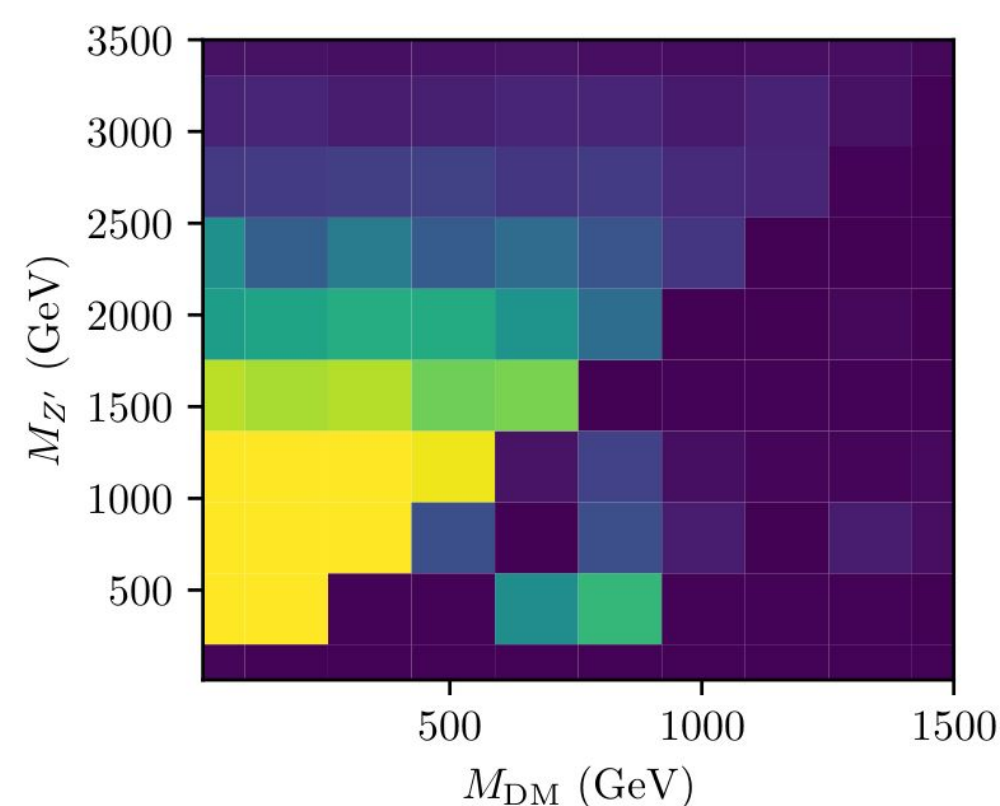
[...]

Done
```

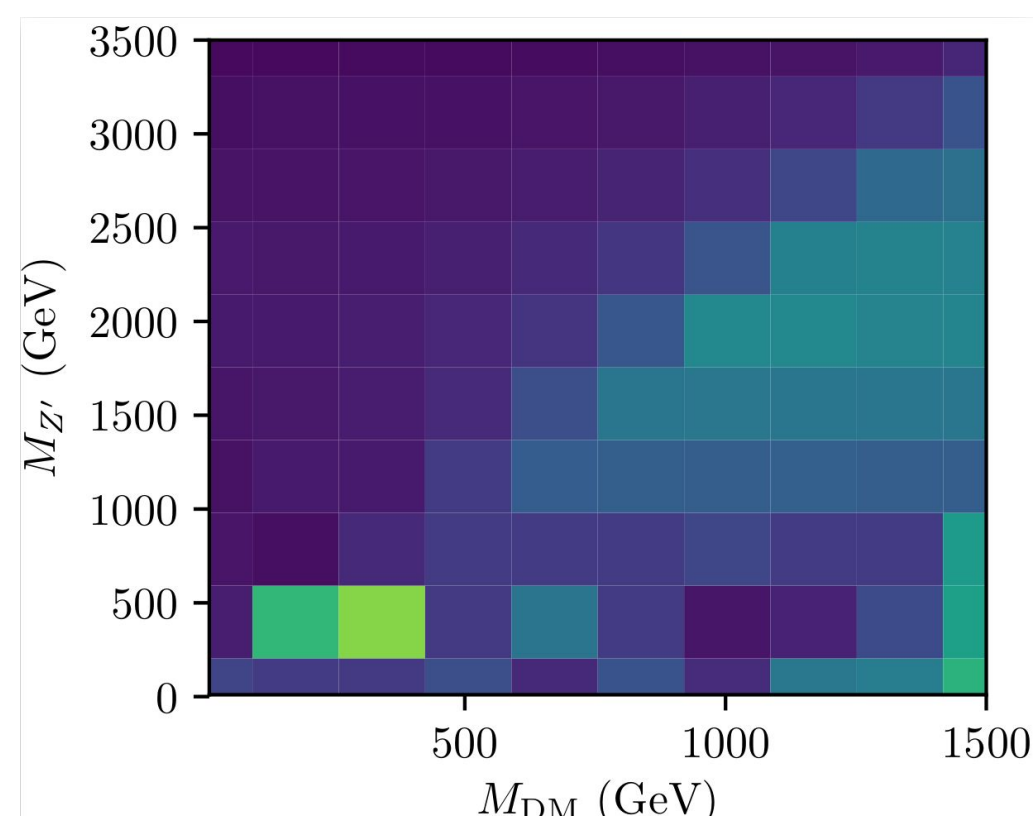
and find your plots at ANALYSIS/conturPlot/pools



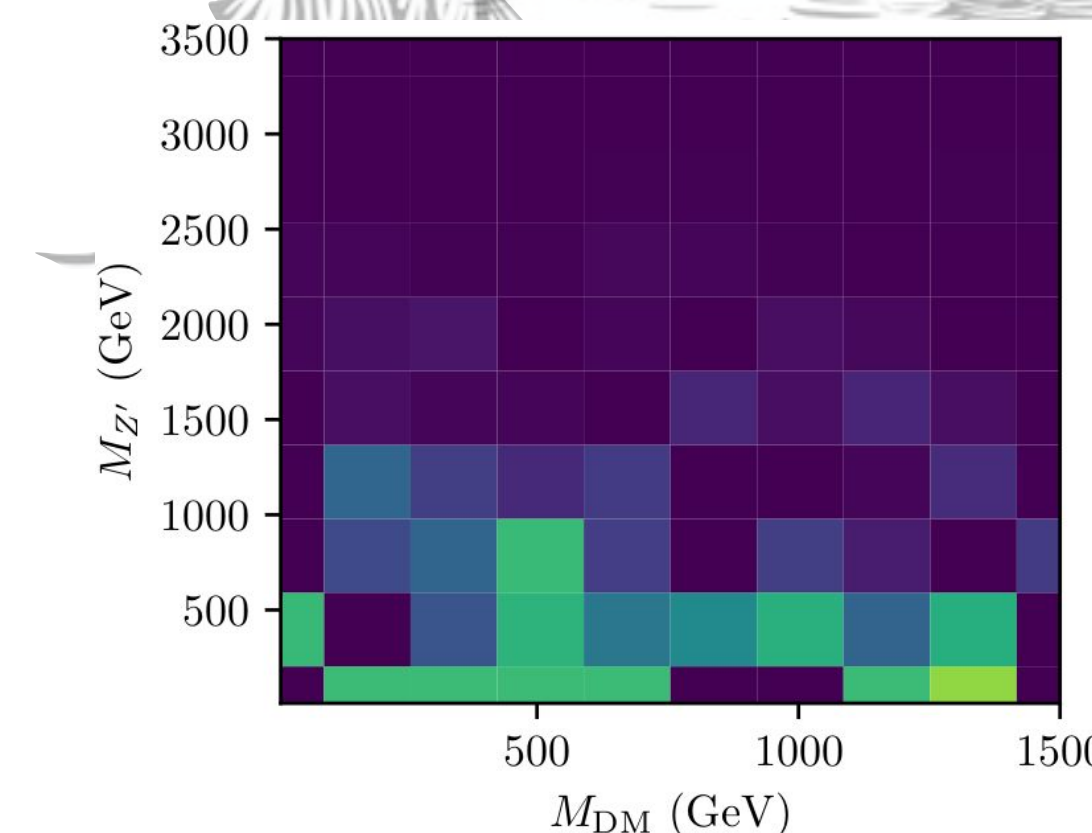
total exclusion



ATLAS_13_METJETA.pdf



CMS_13_JETSM.pdf



CMS_13_MMJETA.pdf



4. Splitting pools in CONTUR

looking at [the CONTUR website](#) we can find out which measurements contributed to CMS_13_JETS

Pool: CMS_13_JETS Inclusive hadronic final states

- CMS_2018_I1682495, Jet mass in dijet events in pp collisions at 13~TeV [148]
- CMS_2016_I1459051, Measurement of the inclusive jet cross-section in pp collisions at $\sqrt{s} = 13\text{TeV}$ [126]

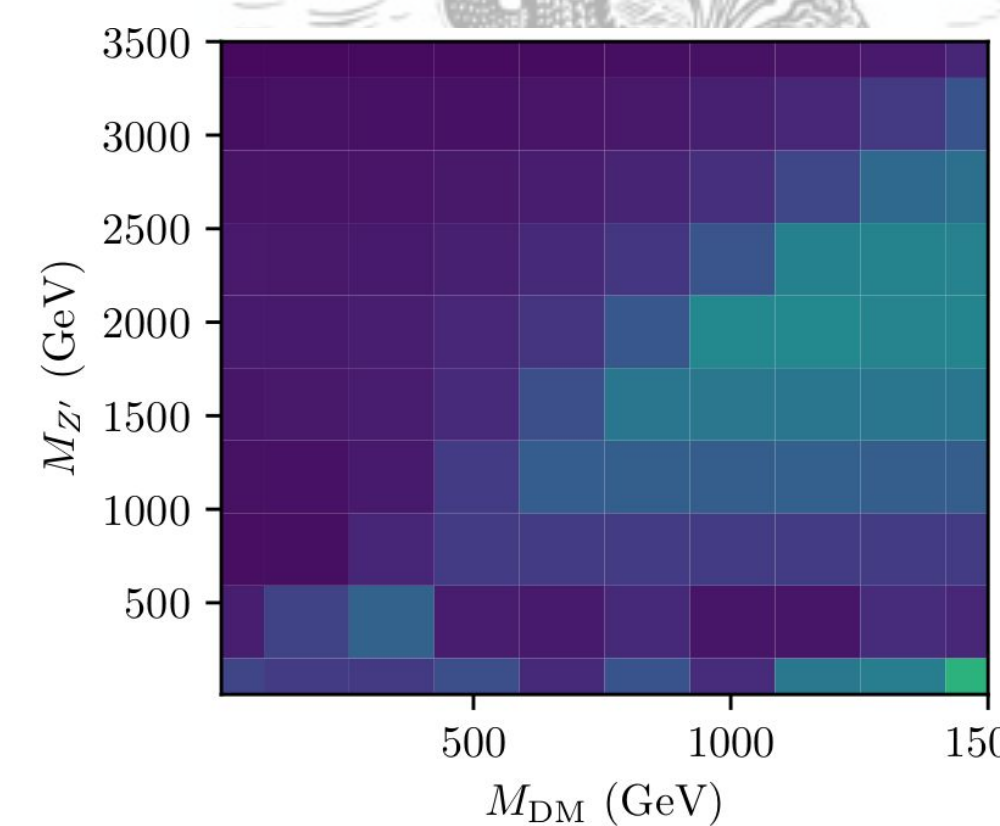
But which one contributed the most?

Rerun CONTUR, splitting the CMS_13_JETS pool

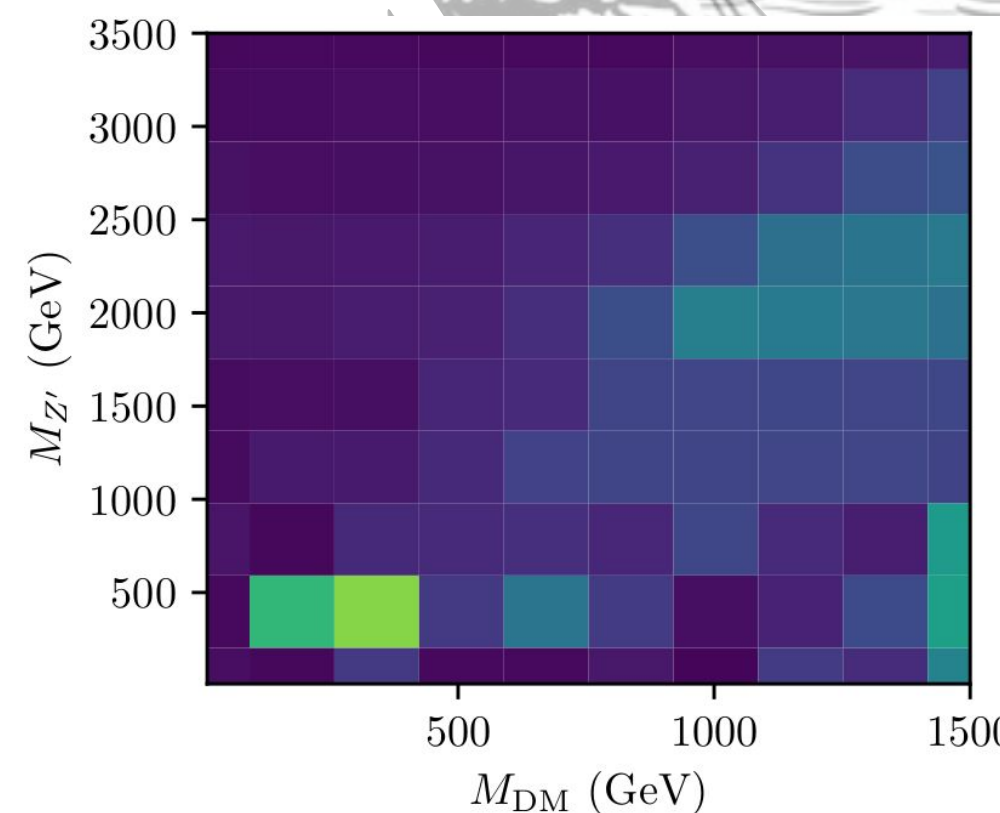
```
# cd /contur_tutorial
# contur -g myscan00 --split-pools CMS_13_JETS
# cd ANALYSIS/CMS_13_JETS
# ls
CMS_2016_I1459051  CMS_2018_I1682495
```

and plotting in both folders gives:

... both contribute in similar amounts. Off to reading the papers!



CMS_2016_I1459051



CMS_2018_I1682495

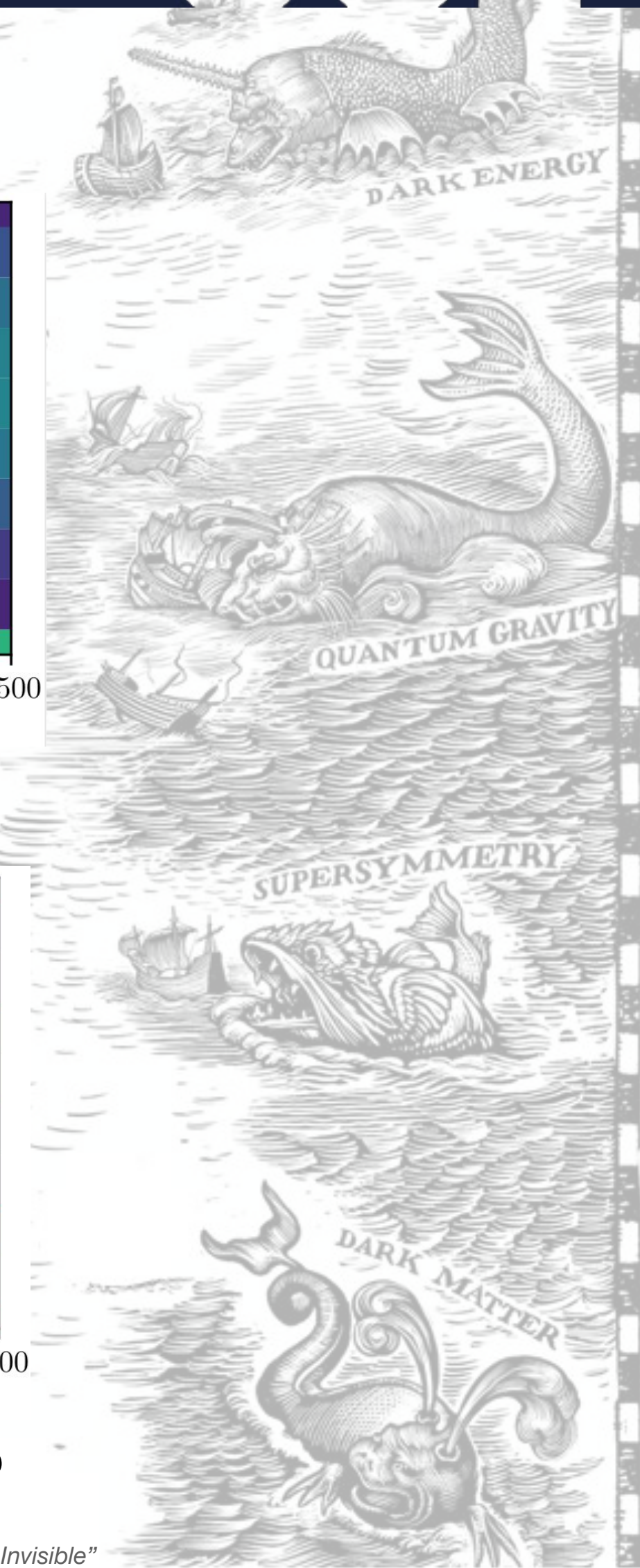


Illustration by Chris Wormell from "A Map of the Invisible"



Questions?

Join the → CONTUR drop-by session,
Tue, 3 November 2020, 14:00 - 16:00!

