

-- BingxuanLiu - 2017-03-28

Heavy Resonance Search with Associated B-Jets

Four-b Resonance Search Top Priorities:

[Arxives...](#) [Fold me...](#)

Core functionalities are in place and full analysis chain has been tested. In migration to Argonne currently.

Leading two jets 260~270 GeV should do the work. Need some extra checks.

EXOT2 has all the info needed. If we explore b-trigger in the future we need to make sure trigger matching is available in the derivation.

Theory models identified.

Exotics official MC production requests procedures

Simple steps:

1. **Validation plots**
2. **Submit a jira ticket for exotics & PMG aproval**
3. **Monitor production process**

More ditail is given in this twiki page.

Pythia 8 examples:

One can find instructions on $Z^1 \rightarrow bb$ samples and the MC15/16 joboption files [☞](#)

Signal Models and Theory

Flavor physics anomalies [☞](#) have drawn lots of attentions. Models with lepton flavor violation are proposes to incorporate them. NP with enhanced or exclusive couplings to third generation are often enforced in those models.

Simplified Models with Enhanced/Exclusive Couplings to Third Generation

1. On the breaking of Lepton Flavor Universality in B decays [☞](#)

In the above model the third generation couplings of ZPrime are enhanced. We can generate such models based on the existing ZPrime models in ATLAS. A recipe is given below:

[☞ Recipes to generate ZPrime->4b evngen samples](#) [☞ Fold me...](#)

```
mkdir ZPrimeto4bSignal
cd ZPrimeto4bSignal
git clone https://:@gitlab.cern.ch:8443/biliu/ANLAnalysis.git
mv ./ANLAnalysis/SignalProduction/ .
rm -rf ANLAnalysis/
cd SignalProduction
source setup_athena.sh
mkdir Zprime4b_500GeV
cd Zprime4b_500GeV
source ../run.sh 320500 123 50 /path/to/your/output/dir

#argument 1: runnumber, runnumber - 320000 is the zprime mass
#argument 2: seed, random seed
#argument 3: maxevent
#argument 4: output directory, make sure it exists first

echo "const double n2f=1000000.; grep "cross" Zprime4b_*GeV/log.generate |sed 's/Zprime4b_//g' |
```

▣ Produce TRUTH3 xAOD ▣ Fold me...

```
# setup athena release
asetup 20.7.8.19,AtlasDerivation,here

#Run reconstruction for TRUTH3

Reco_tf.py --inputEVNTfile=test_Zprime_4b.EVNT.POOL.root
           --outputDAODFile=test_Zprime_4.AOD.TRUTH3.root --reductionConf=TRUTH3
```

2HDM Models

1. Heavy Higgs Search: Flavor Matters [↗](#)

MadGraph Recipes

We might have to run MadGraph by ourselves using the UFO files produced by the model builders. Instructions on MadGraph and MadAnalysis can be found [here](#) [↗](#). FeynRules [↗](#) is a Mathematic tool for cross section, etc, calculations. Example models can be downloaded [here](#) [↗](#) for exercises.

Recently, MG5 was tested on ANL cluster, the recipes are:

▣ Recipes to install MG5 at ANL ▣ Fold me...

```
1 Download tarball from: https://launchpad.net/mg5amcnlo
2 Untar
3 Point the madgraph config file MG5_aMC_v2_6_0/input/mg5_configuration.txt to central versions
  lhpdf6 = /share/sl6/lhapdf6/bin/lhapdf-config
  fastjet = /share/sl6/fastjet/bin/fastjet-config
```

```

4 Launch MadGraph:
  ./bin/mg5_aMC

5 Install MadAnalysis5 & pythia8:
  MG5_aMC> install MadAnalysis5
  MG5_aMC> install pythia8

6 Profit.
```

Recently, MG5 was also tested on lxplus cluster (YAY), the recipes are:

▣ Recipes to install MG5 at ANL ▣ Fold me...

```

1 Download tarball from: https://launchpad.net/mg5amcnlo

2 Untar

3 Point the madgraph config file MG5_aMC_v2_6_0/input/mg5_configuration.txt to central versions
  lhpdf6 = /afs/cern.ch/sw/lcg/external/MCGenerators_lcgcm67c/lhpdf/6.2.0/x86_64-slc6-gcc48
  fastjet = /afs/cern.ch/sw/lcg/external/fastjet/3.2.0/x86_64-slc6-gcc48-opt/bin/fastjet-confi

4 Launch MadGraph:
  ./bin/mg5_aMC

5 Install MadAnalysis5 & pythia8:
  MG5_aMC> install MadAnalysis5
  MG5_aMC> install pythia8

6 Profit.
```

Signal Samples

Z' exclusively couples to b-quarks: pp->Z'bb~->bbb~b~

Three benchmark model at $m(Z') = 800\text{GeV}$, 1TeV and 2TeV with 100K, 60K and 40K events.

[Link to Jira ticket](#)

The three probe signal samples have been prepared in AOD:

▣ 2016 Signal Samples AOD... ▣ Fold me...

Name	Dataset
Zprime4b800	mc16_13TeV.309648.Pythia8EvtGen_A14NNPDF23LO_Zprime4b800.recon.AOD.e6487_e5984_s31
Zprime4b1000	mc16_13TeV.309649.Pythia8EvtGen_A14NNPDF23LO_Zprime4b1000.recon.AOD.e6487_e5984_s3
Zprime4b2000	mc16_13TeV.309650.Pythia8EvtGen_A14NNPDF23LO_Zprime4b2000.recon.AOD.e6487_e5984_s3

The three probe signal samples have been prepared in DAOD format via EXOT2 derivation:

▣ 2016 Signal Samples DAOD... ▣ Fold me...

Name	Dataset
------	---------

Zprime4b800	mc16_13TeV.309648.Pythia8EvtGen_A14NNPDF23LO_Zprime4b800.deriv.DAOD_EXOT2.e6487
Zprime4b1000	mc16_13TeV.309649.Pythia8EvtGen_A14NNPDF23LO_Zprime4b1000.deriv.DAOD_EXOT2.e6487
Zprime4b2000	mc16_13TeV.309650.Pythia8EvtGen_A14NNPDF23LO_Zprime4b2000.deriv.DAOD_EXOT2.e6487

Trigger and Data Preparation

Tri-jet trigger with asymmetric thresholds

Derivations

All the info about Exotics derivations can be found in this page. A central JIRA [🔗](#) keeps track of the process. We can start with an existing derivation and see whether a dedicated one is needed.

Use the following command to generate a list of data sample for the grid jobs, please indicate the time it is generated until it is frozen for the analysis:

[🔗](#) Command to generate 2017 data sample list.... [🔗](#) Fold me...

```
source /cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase/user/atlasLocalSetup.sh
lsetup rucio

#Replace the p-tag in the example to the latest and greatest one.

rucio ls data17_13TeV:data17_13TeV*EXOT2\.*3372 | grep "CONTAINER" | awk '{print $2}' | sed 's/da
```

Note: sometime there are datasets with similar but not exact strings so that please double check the list!

Tip: Do check a given p tag every once a while just in case (Then a diff can tell whether there are new samples.)

The text file generated should go to your MultiBTaggedAlgo/scripts/sampleLists directory as introduced in the framework section.

GRL and Luminosity

The recommendation can be found [here](#) [🔗](#). The current one used is v97-pro21-13 [🔗](#).

The luminosity is calculated via the iLumiCalc.exe tool. The recorded luminosity for the trigger being used (HLT_2j225_gsc250_boffperf_split_0eta240_j70_gsc120_boffperf_split_0eta240) is 43.4344 fb⁻¹. The input arguments for the online lumical tool is listed below.

[🔗](#) iLumiCalc.exe command.... [🔗](#) Fold me...

```
Luminosity DB tag: Of1Lumi-13TeV-010

Live fraction trigger: L1_EM24VHI

Physics trigger: HLT_2j225_gsc250_boffperf_split_0eta240_j70_gsc120_boffperf_split_0eta240

LAr EventVeto Tag: LARBadChannelsOf1EventVeto-RUN2-UPD4-08

GRL file: data17_13TeV.periodAllYear_DetStatus-v97-pro21-13_Unknown_PHYS_StandardGRL_All_Good_25n
```

The output is:

Z' exclusively couples to b-quarks: pp->Z'bb~->bbb~b~

[iLumiCalc.exe output...](#) [Fold me...](#)

```

--- LumiCalculator      : Livetime      : 23710.3 [0m
--- LumiCalculator      : Prescale Weighted Livetime: 23710.3 [0m
--- LumiCalculator      : Good LBs       : 406 [0m
--- LumiCalculator      : Bad LBs        : 0 [0m
--- LumiCalculator      : IntL delivered (ub^-1) : 1.01535e+08 [0m
--- LumiCalculator      : IntL after livefraction (ub^-1): 1.00076e+08 [0m
--- LumiCalculator      : IntL after LAr fraction (ub^-1): 1.00071e+08 [0m
--- LumiCalculator      : IntL recorded after prescale (ub^-1) : 1.00071e+08 [0m
--- LumiCalculator      : L1 Prescales: [1107,1195]:1, [1196,1310]:1, [1311,1427]:1, [1428,1562]:1
--- LumiCalculator      : HLT Prescales: [1107,1195]:1, [1196,1310]:1, [1311,1427]:1, [1428,1562]:1
--- LumiCalculator      : ----- [0m
--- LumiCalculator      : LumiCalculator summary [0m
--- LumiCalculator      : ----- [0m
--- LumiCalculator      : Total      L1-Acc      L2-Acc      L3-Acc      LiveTime      IntL rec.(ub^-1)
--- LumiCalculator      :              4157394338              0              04.81438e+06              4.34344e+10
--- LumiCalculator      : Total L1/2/3 accept: 41573943380              0 [0m
--- LumiCalculator      : Total L1 livetime trigger accept: 60709860 [0m
--- LumiCalculator      : First Run: 325713 [0m
--- LumiCalculator      : Last Run: 340453 [0m
--- LumiCalculator      : Total L1BeforePresc: 296026634 [0m
--- LumiCalculator      : Total Livetime      : 4.81438e+06 [0m
--- LumiCalculator      : Total prescale weighted Livetime: 4.81438e+06 [0m
--- LumiCalculator      : Total Good LBs      : 88225 [0m
--- LumiCalculator      : Total Bad LBs       : 0 [0m
--- LumiCalculator      : Total IntL delivered (ub^-1) : 4.54655e+10 [0m
--- LumiCalculator      : Total IntL after livefraction (ub^-1): 4.34513e+10 [0m
--- LumiCalculator      : Total IntL after LAr fraction (ub^-1): 4.34344e+10 [0m
--- LumiCalculator      : Total IntL recorded (ub^-1) : 4.34344e+10 [0m
--- CoolQuery          : Closing database 'CONDBR2 [0m
--- CoolQuery          : Closing database 'CONDBR2 [0m
--- CoolQuery          : Closing database 'CONDBR2 [0m
--- iLumiCalc           : ----- [0m
--- TGoodRunsListWriter : GoodRunsList stored as : ilumicalc_merged_grl_325713.97-340453.1
--- iLumiCalc           : Real time: 1658.05 s [0m
--- iLumiCalc           : CPU time: 348.2 s [0m
Done
Tue Feb 20 17:37:18 CET 2018

```

Background Studies

Background MC Samples

QCD multijet process contribute the most to this final state. 2016 JZ slice MC EXOT2 derivations have been finished, the list of samples is:

[2016 JZ Slice Samples...](#) [Fold me...](#)

Name	Dataset
JZ0W	mc16_13TeV.361020.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ0W.deriv.DAOD_EXOT2.e3569_s3126_r5
JZ1W	mc16_13TeV.361021.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ1W.deriv.DAOD_EXOT2.e3569_s3126_r5
JZ2W	mc16_13TeV.361022.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ2W.deriv.DAOD_EXOT2.e3668_s3126_r5
JZ3W	mc16_13TeV.361023.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ3W.deriv.DAOD_EXOT2.e3668_s3126_r5
JZ4W	mc16_13TeV.361024.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ4W.deriv.DAOD_EXOT2.e3668_s3126_r5
JZ5W	mc16_13TeV.361025.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ5W.deriv.DAOD_EXOT2.e3668_s3126_r5

JZ6W	mc16_13TeV.361026.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ6W.deriv.DAOD_EXOT2.e3569_e5984_s
JZ7W	mc16_13TeV.361027.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ7W.deriv.DAOD_EXOT2.e3668_s3126_r
JZ8W	mc16_13TeV.361028.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ8W.deriv.DAOD_EXOT2.e3569_s3126_r
JZ9W	mc16_13TeV.361029.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ9W.deriv.DAOD_EXOT2.e3569_s3126_r
JZ10W	mc16_13TeV.361030.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ10W.deriv.DAOD_EXOT2.e3569_s3126_r
JZ11W	mc16_13TeV.361031.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ11W.deriv.DAOD_EXOT2.e3569_s3126_r
JZ12W	mc16_13TeV.361032.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ12W.deriv.DAOD_EXOT2.e3668_s3126_r

B-tagging Studies

Flavor Tagging Recommendation

Rel21 recommendations for 2018 winter conference is in [CDI](#). The latest CDI file is 2017-21-13TeV-MC16-CDI-2018-02-09_v1.root. Due to its large size it can not be stored in GitLab.

Four B-Jet Analysis Framework

General design philosophies and goals

The analysis framework is built based on the xAODHelpers, the DiJetFramework and the standalone analysis package developed at Argonne. The xAODHelpers is a central package for Nutple production so that there are no changes need to be made to suit this analysis. DiJetFramework is a customized package where we determine how to skim the derivations. Only a sub-package, DiJetResonanceAlgo is used here. The standalone analysis package developed at Argonne is the tool to apply analysis specific selections and make histograms or CutFlow tables.

This software model has been used successfully in the Di-BJet search. For the Four B-Jet Analysis Framework, DiJetResonanceAlgo has been updated to MultiBTaggedAlgo. The standalone ANL analysis package has been revamped to fulfill the following design goals:

1. **Flexibility:** The software should not have to be recompiled each time a cut value or histogram binning needs to be changed.
2. **Reproductivity:** The software automatically keeps track of the setup for a given job. Information to keep track includes the samples used, important cuts applied and current software version.
3. **Clarity:** The software should be written in a straightforward and modular fashion. The logic should be clearly represented by the code line by line or comments.

The above points will be illustrated in the following recipes and instructions. Any new ideas to further improve the framework is welcome. Everything is tested on lxplus.

Package recipes

All necessary packages can be installed at once on lxplus:

[▣ Lxplus recipe..](#) [▣ Fold me...](#)

```
export ATLAS_LOCAL_ROOT_BASE=/cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase
source ${ATLAS_LOCAL_ROOT_BASE}/user/atlasLocalSetup.sh
mkdir FourB
cd FourB
mkdir src build
cd src
asetup AnalysisBase,21.2.10,here
git clone https://github.com/UCATLAS/xAODAnaHelpers.git
git clone https://:@gitlab.cern.ch:8443/biliu/FourBJetAnalysis.git
git clone https://:@gitlab.cern.ch:8443/biliu/MultiBTaggedAlgo.git
cd ../build
cmake ../src
make
cd ../
source build/${CMTCONFIG}/setup.sh
```

For the time being on LCRC at ANL the CMTCONFIG variable must be set by hand to x86_64-centos7-gcc62-opt. Furthermore an additional step is needed to access GitLab on the Argonne clusters:

[▣ Argonne recipe..](#) [▣ Fold me...](#)

```
export ATLAS_LOCAL_ROOT_BASE=/cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase
source ${ATLAS_LOCAL_ROOT_BASE}/user/atlasLocalSetup.sh
kinit your_cern_username@CERN.CH
aklog
mkdir FourB
cd FourB
mkdir src build
cd src
asetup AnalysisBase,21.2.10,here
git clone https://github.com/UCATLAS/xAODAnaHelpers.git
git clone https://:@gitlab.cern.ch:8443/biliu/FourBJetAnalysis.git
git clone https://:@gitlab.cern.ch:8443/biliu/MultiBTaggedAlgo.git
cd ../build
cmake ../src
make
cd ../

#Here you may see machine name as centos7 instead of slac6. This is fine so just ignore it.
source build/x86*/setup.sh

#For test run: you can create a run directory and run analysis code under this directory
#For example mine looks like "build/ runDir/ src/".
#Under runDir/ you should create an "output/" directory.
#Here is a test command:
run_4b /users/bingxuan.liu/FourB/run/PeriodD/user.biliu.PeriodD.Run331085.physics_Main.Nominal.Pa

#(I don t know if you can read directories from atlas* machine)
#You should ignore ERROR messages related to any TBranches.
```

After everything is compiled, you can create a setup script inside FourB directory:

[▣ Setup script..](#) [▣ Fold me...](#)

```
cd src
export ATLAS_LOCAL_ROOT_BASE=/cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase
```

FourBJetResonanceSearch < Sandbox < TWiki

```
source ${ATLAS_LOCAL_ROOT_BASE}/user/atlasLocalSetup.sh
asetup AnalysisBase,21.2.10,here
cd ../
source build/${CMTCONFIG}/setup.sh
```

Instructions on each package are listed below.

xAODHelpers and <nop>MultiBTaggedAlgo Packages

xAODHelpers is well documented here [↗](#). This package is maintained by a lot of people, please become an watcher of the central GitHub repository, xAODHelpers [↗](#). Update this package frequently and make sure our framework is compatible with it. MultiBTaggedAlgo is an algorithm developed to run with the default algorithms in xAODHelpers. It applies additional cuts and calculate additional variables.

An example to run the full chain locally is listed below:

▣ Recipes to produce nTuple.. ▣ Fold me...

```
source /cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase/user/atlasLocalSetup.sh

lsetup rucio

rucio download mc16_13TeV.361027.Pythia8EvtGen_A14NNPDF23LO_jetjet_JZ7W.deriv.DAOD_EXOT2.e3668_s3
xAH_run.py --config ../src/MultiBTaggedAlgo/data/config_MultiBTaggedAlgo_Nominal_2017.py --files
```

GRL is defined in config_MultiBTaggedAlgo_Nominal_2017.py, use the one recommended.

More often we run this step on the grid, before submitting a big queue to the grid, it is better to try a probe job first. an example is given below:

▣ Recipes to produce nTuple on the grid.. ▣ Fold me...

```
source /cvmfs/atlas.cern.ch/repo/ATLASLocalRootBase/user/atlasLocalSetup.sh
voms-proxy-init -voms atlas
lsetup rucio
lsetup panda
echo data17_13TeV.00333650.physics_Main.deriv.DAOD_EXOT2.f857_m1855_p3372 > test
xAH_run.py --inputRucio --inputList --files test.txt --config $WorkDir_DIR/data/MultiBTaggedAlgo/
```

Samples

The preselection skims for data and QCD have been transferred to eos here:

/eos/atlas/user/b/biliu/FourBNtuples/. The events are required to pass a set of preselections defied as below:

The raw tuples are located in the ATLAS AFS area at Argonne: /atlasfs/atlas/local/bingxuan.liu/FourJetNtuple

Statistical Framework

Use HistFitter package: <https://gitlab.cern.ch/HistFitter/HistFitter> [↗](#)

Tutorial: <https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HistFitterTutorial>

Advanced tutorial: <https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HistFitterAdvancedTutorial>

Input to HistFitter

▣ Recipes to produce nTuple.. ▣ Fold me...

We use TTree (Ntuple) as input format to Histfitter.

Root file format:

```
sample_dir/root_file.root:
                                NomonalTreeName
                                NomonalTreeName _Sys1Up
                                NomonalTreeName _Sys1Down
                                .....
```

In the Hist Fitter config file define systimatics: jes as an example
 jes = Systematic("JES", "_NoSys", "_JESup", "_JESdown", "tree", "overallSys")

Analysis Meetings

Date	Highlights Reminders	Link to Agenda
Mar 7, 2017	ASC: Summary on the 4-b Search Efforts	Link to agenda
Mar 31, 2017	JDM: Initial Discussion on 4-b Search	Link to agenda
Dec 15, 2017	JDM: Rel21 on the 4-b Search Efforts	Link to agenda

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