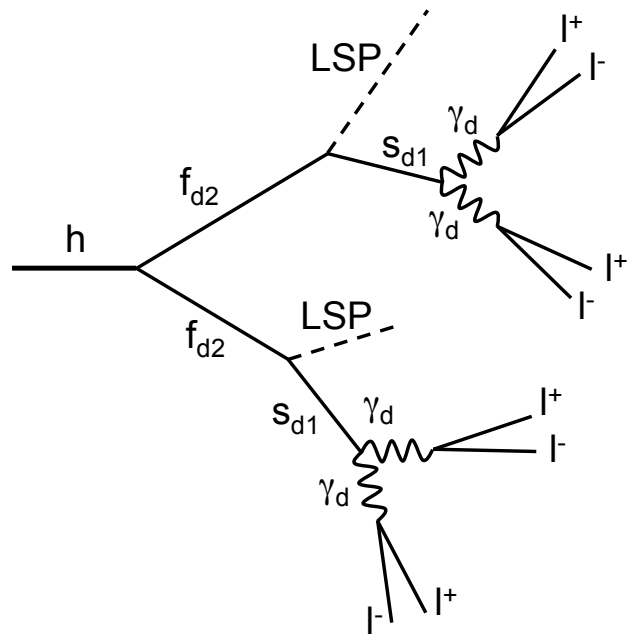


# **HIGGS DECAYS TO DISPLACED LEPTONJETS: MCI2 VALIDATION - STATUS REPORT**

**Antonio Policicchio**  
INFN Cosenza

# DECAY MODEL



**Discussed with Volansky and Ruderman:**

- high particle multiplicity
- low visible energy

## **MODEL PARAMETERS**

- Standard Higgs production cross section
- $m_h = 100 / 140$  GeV
- $m_{fd2} = 5$  GeV
- $m_{sd1} = 2$  GeV
- $m_{LSP} = 2$  GeV
- $m_{\gamma_d} = 400$  MeV
- $BR(\gamma_d \rightarrow ee) = 45\%$
- $BR(\gamma_d \rightarrow \mu\mu) = 45\%$
- $BR(\gamma_d \rightarrow \pi\pi) = 10\%$
- $c\tau(\gamma_d) = 78.8 / 59.7$  mm

**Particles masses consistent with experimental constraints, theoreticians prejudice, and results from dark matter experiments (e.g. PAMELA)**

**Lifetime chosen to get enough decays in each detector region**

**MCI DATASETS:**

**115705.PythiaMadGraph\_H100toLJ\_4zd\_mixed\_MET**

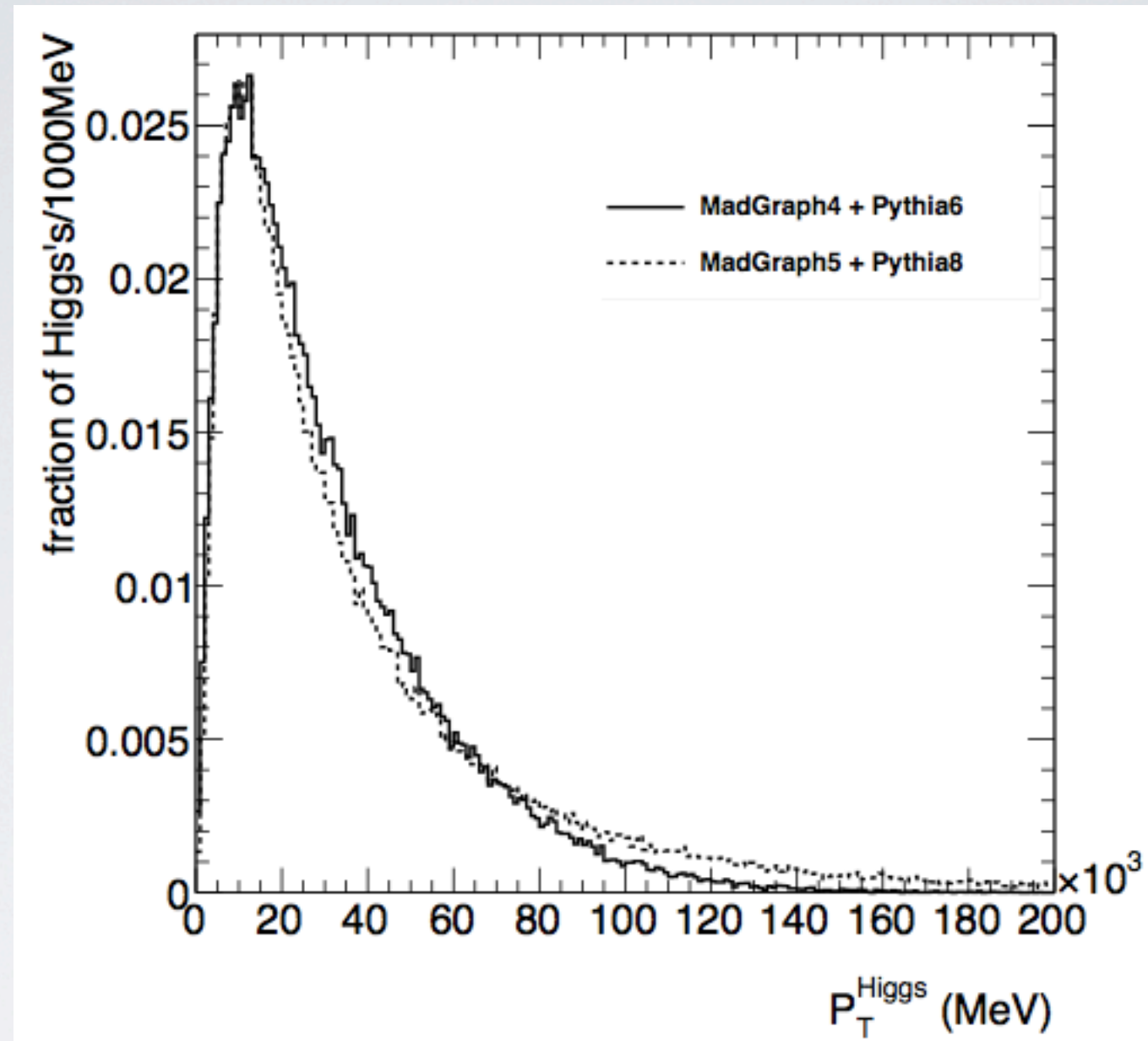
**115712.PythiaMadGraph\_H140toLJ\_4zd\_mixed\_MET**



# MCI2 VALIDATION

- **MCI2 requires MadGraph5 + Pythia8**
- **Strategy for validation of MCI2**
  - **generate a sample of events for 140GeV Higgs channel at 7TeV with MadGraph5**
  - **Process them using Pythia6 (MCI1) and Pythia8 (MCI2)**
    - **Athena 17.2.0.4.1, TAGProd**
  - **Compare relevant variables at the parton level**
- **We have found differences mainly in the  $\varphi$  distribution of the MadGraph produced particles**

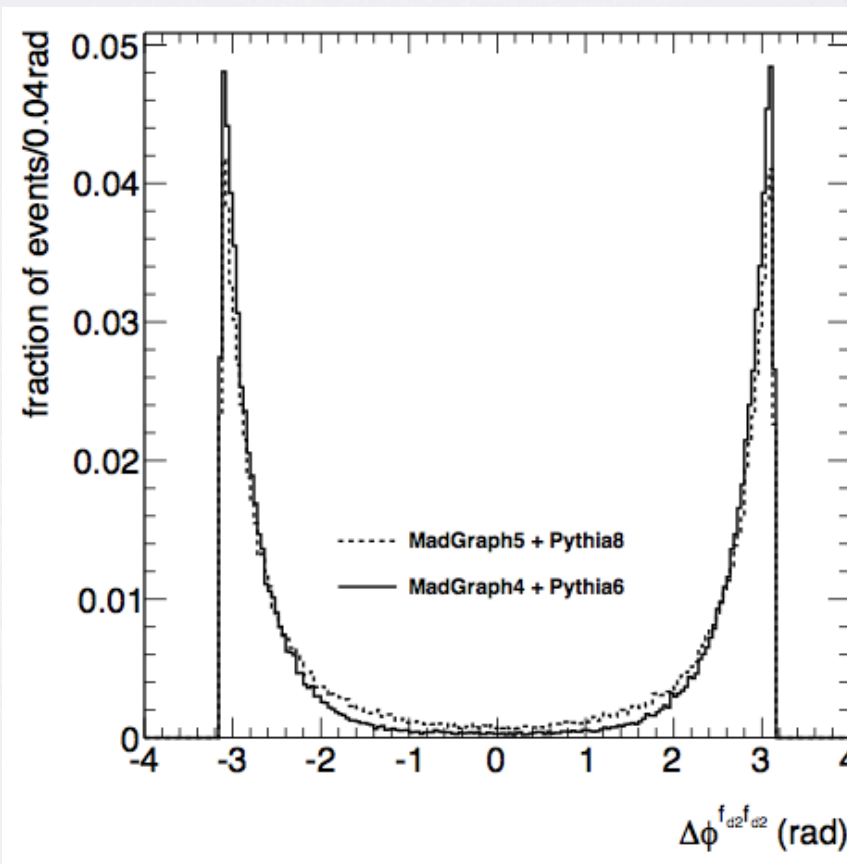
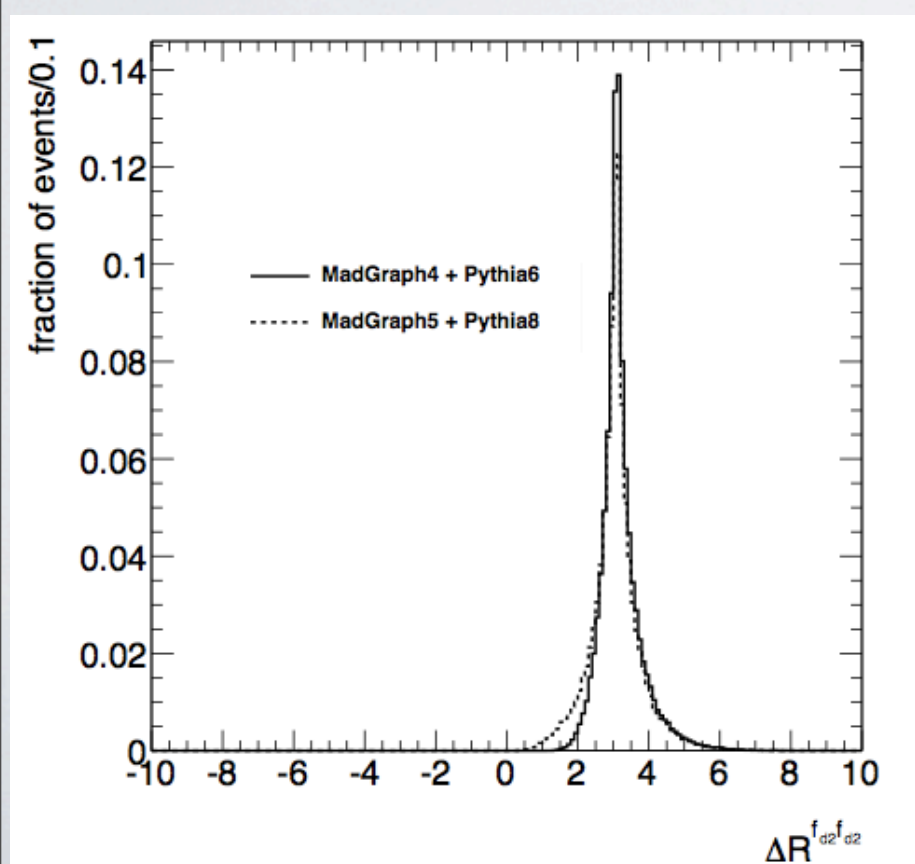
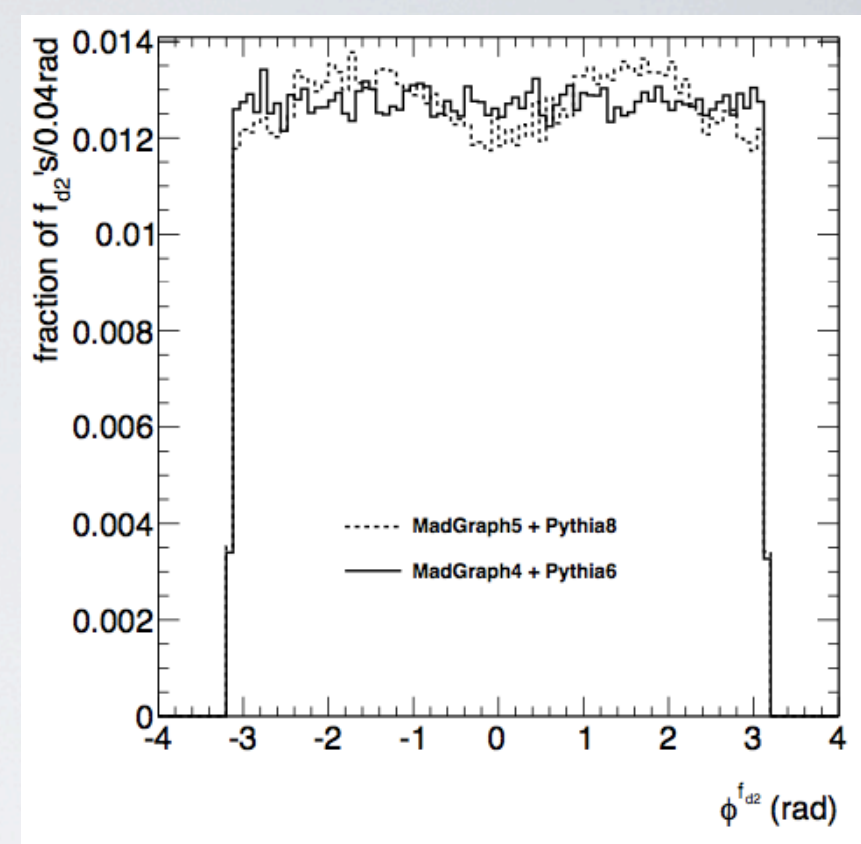
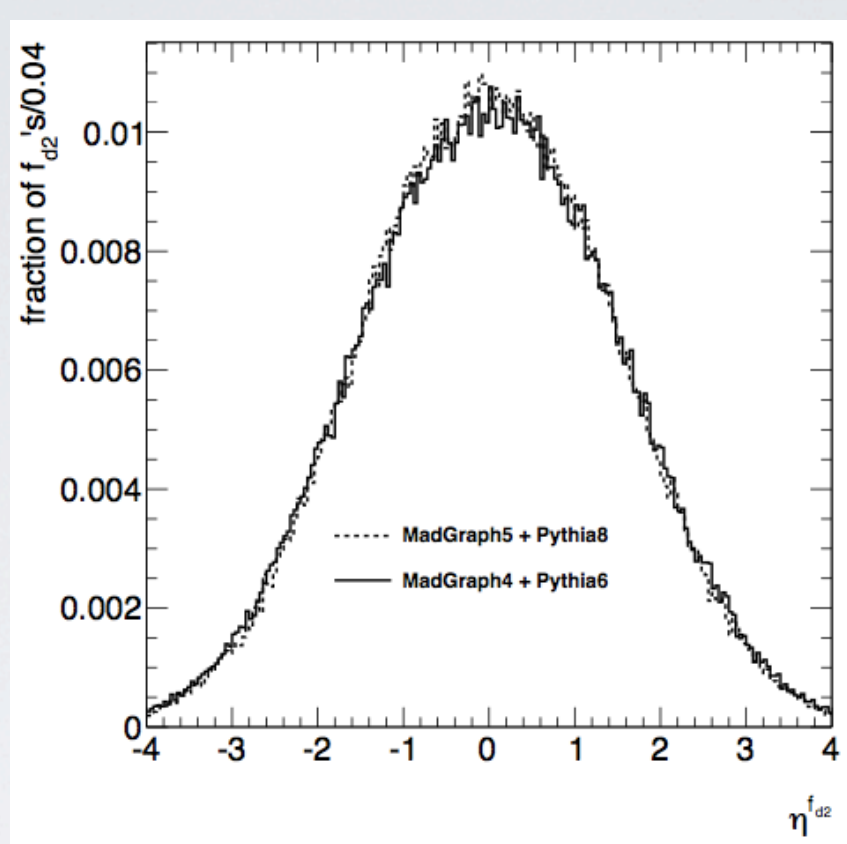
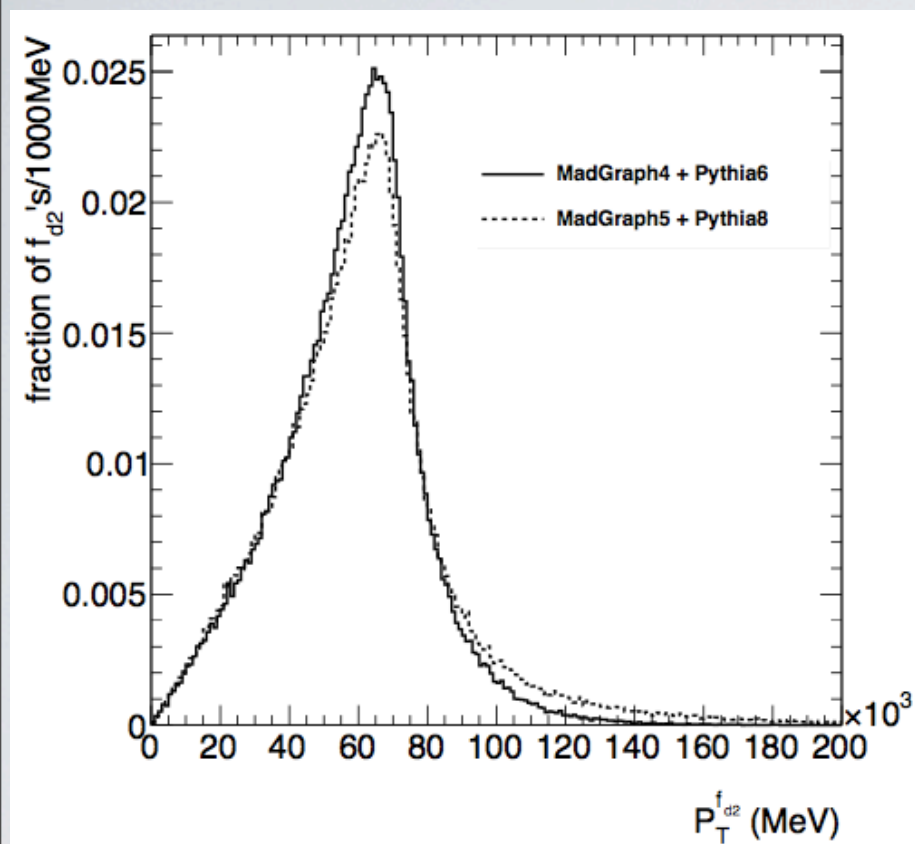
# MC TRUTH: HIGGS



- **Slight difference in Higgs  $p_T$  spectrum**

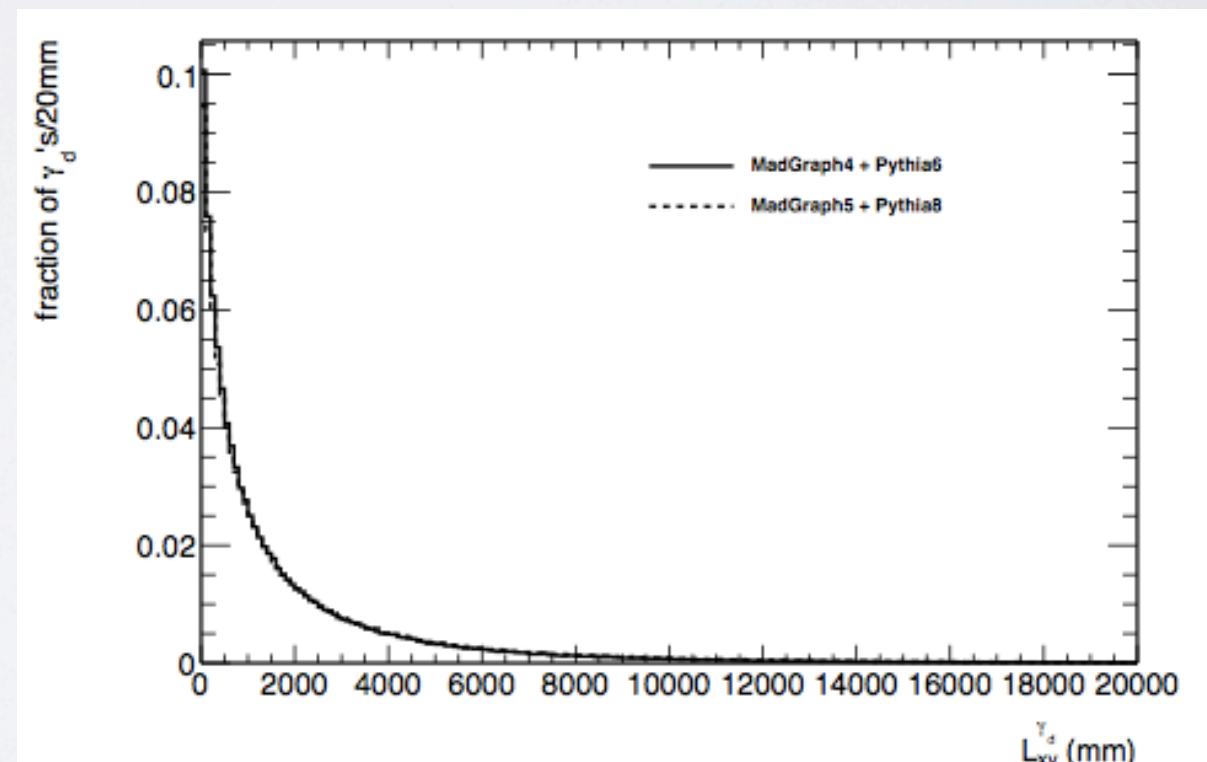
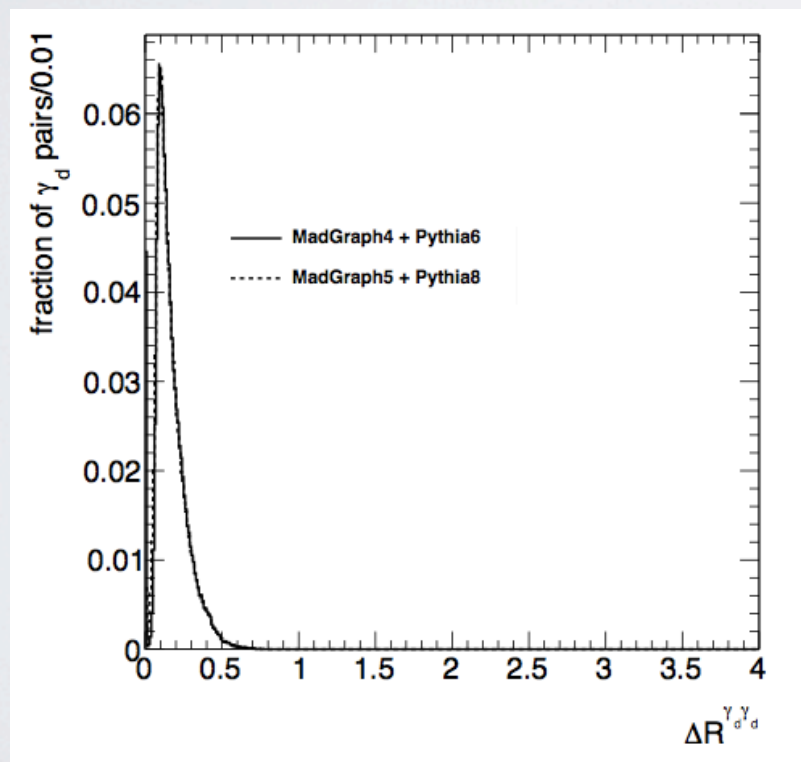
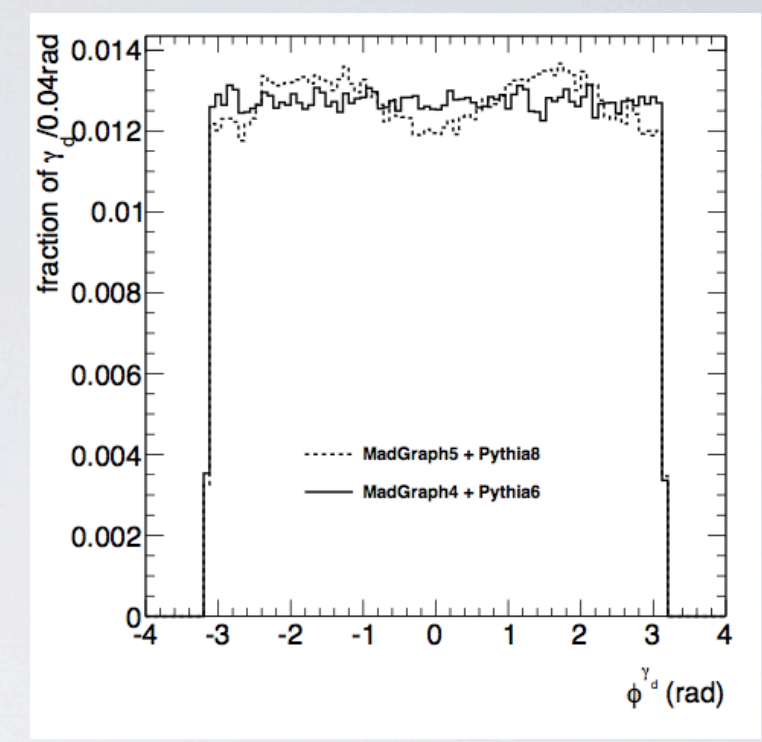
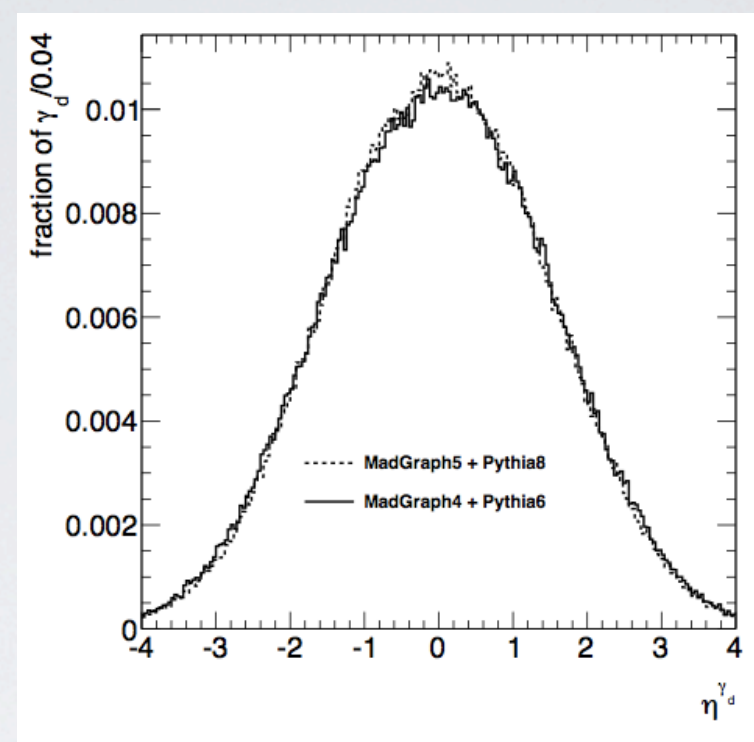
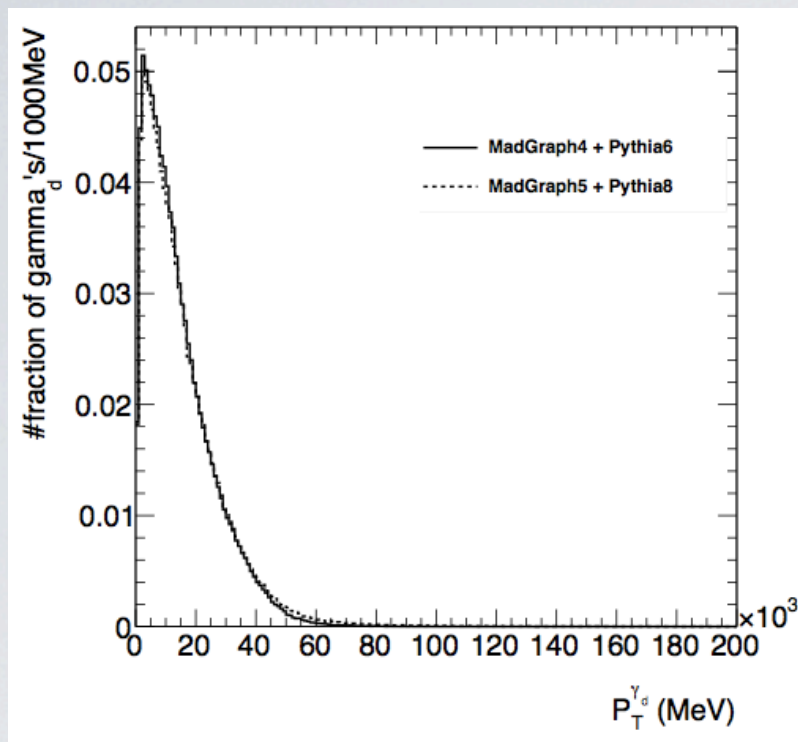


# MC TRUTH: $f_{d2}$



- Slight difference in the  $p_T$  spectrum
- **Strange sinusoidal structure in the  $\phi$  distribution**
- Slightly wider  $\Delta R$  distribution
- Similar behavior observed for the  $f_{d1}$  and the  $s_{d1}$  hidden particles

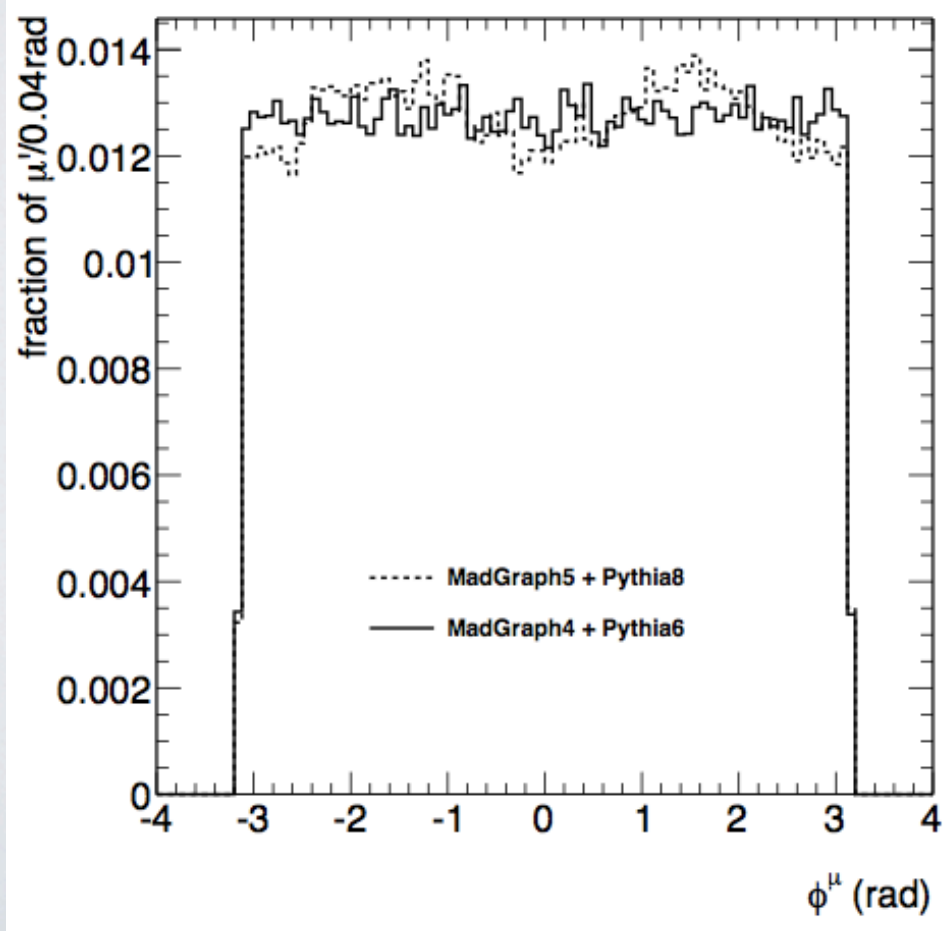
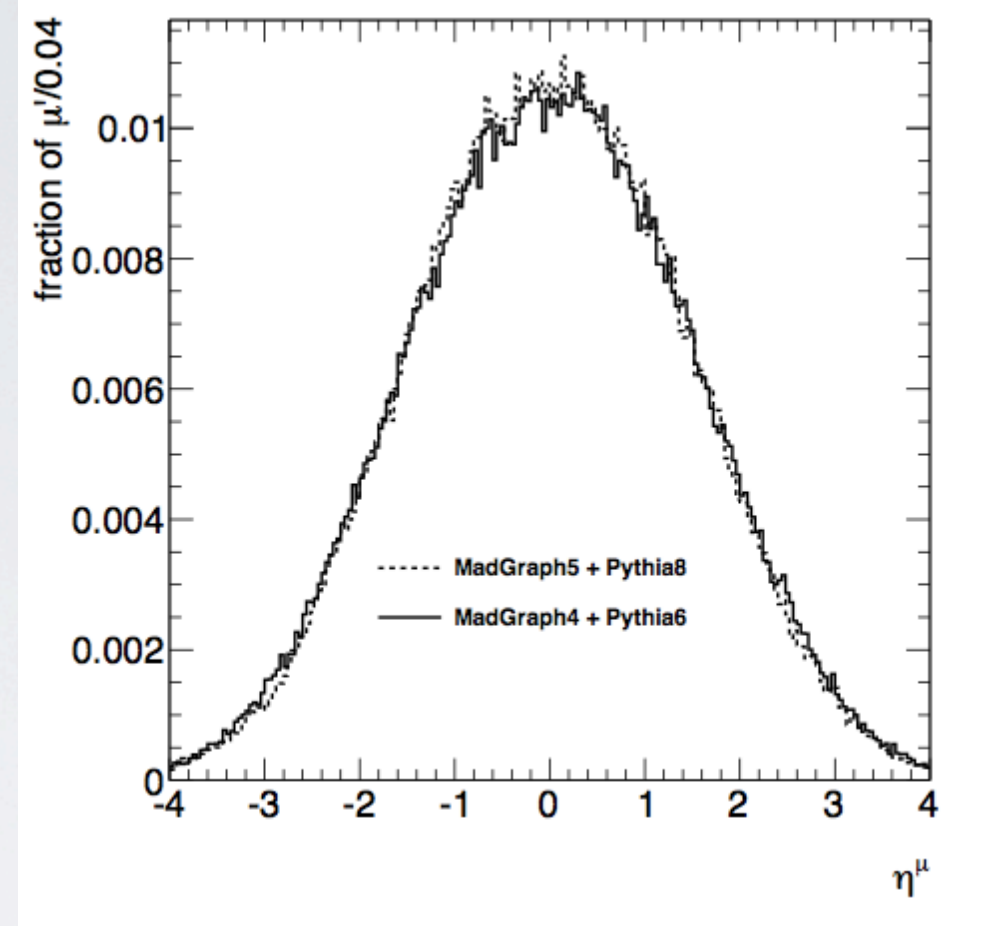
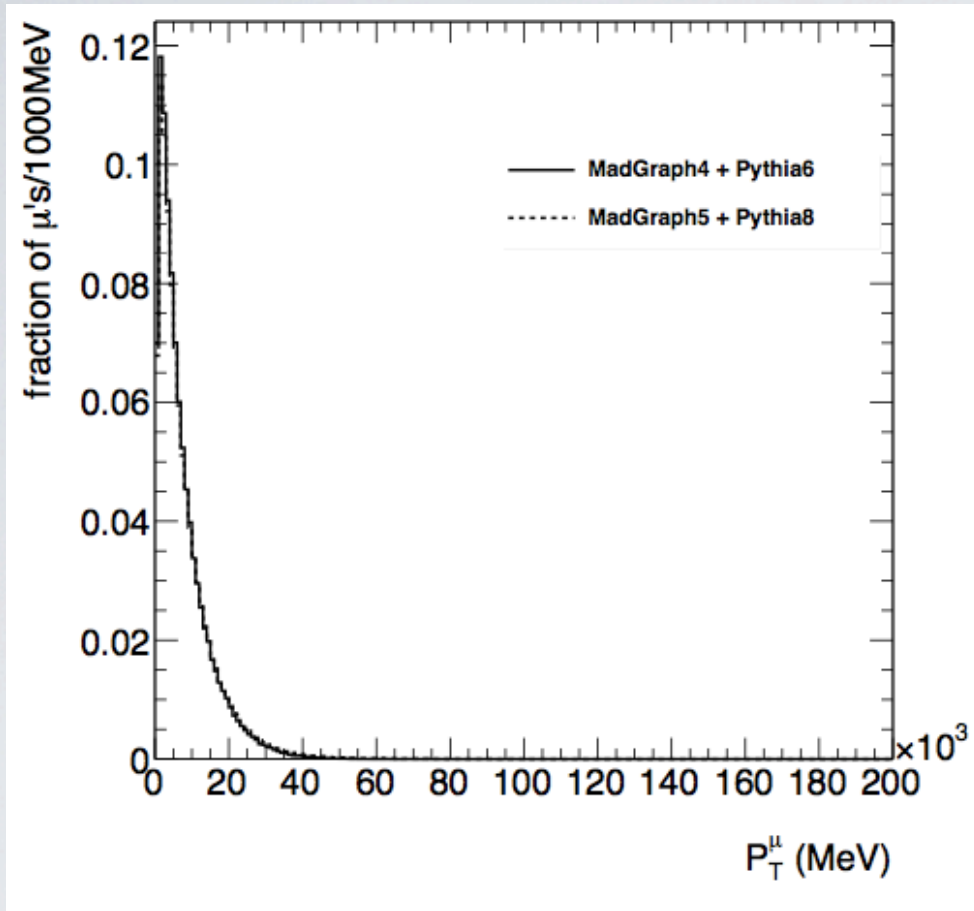
# MC TRUTH: $\gamma_d$ (DARK PHOTON)



- **Strange sinusoidal structure in the  $\varphi$  distribution**



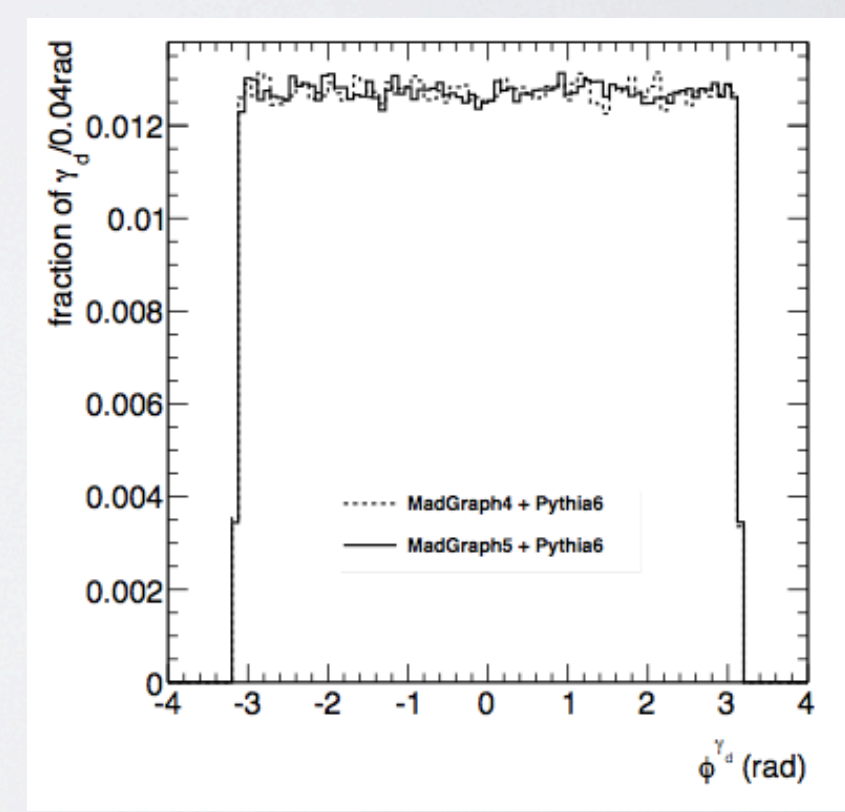
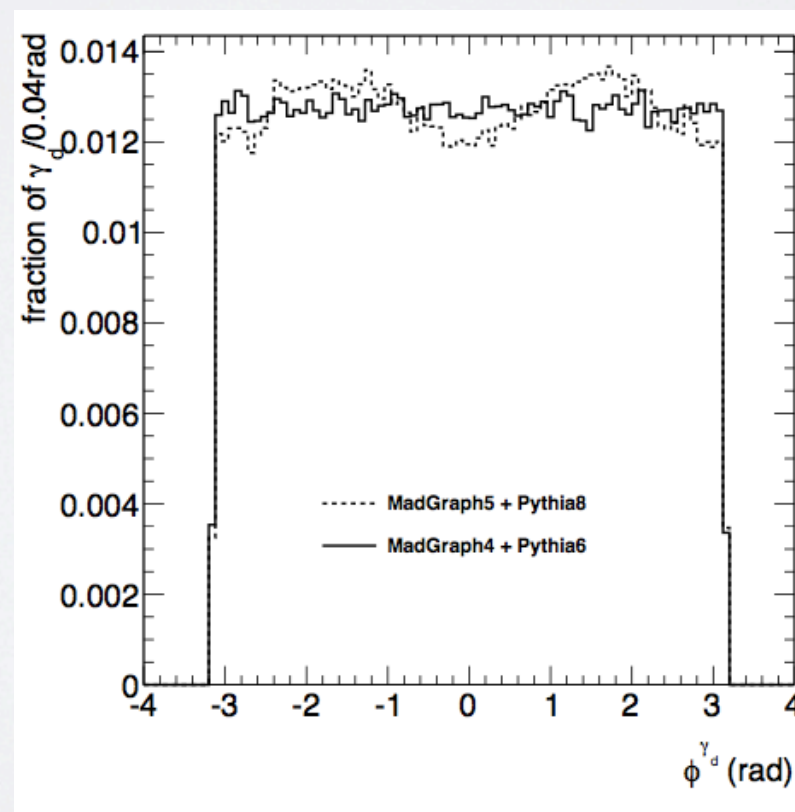
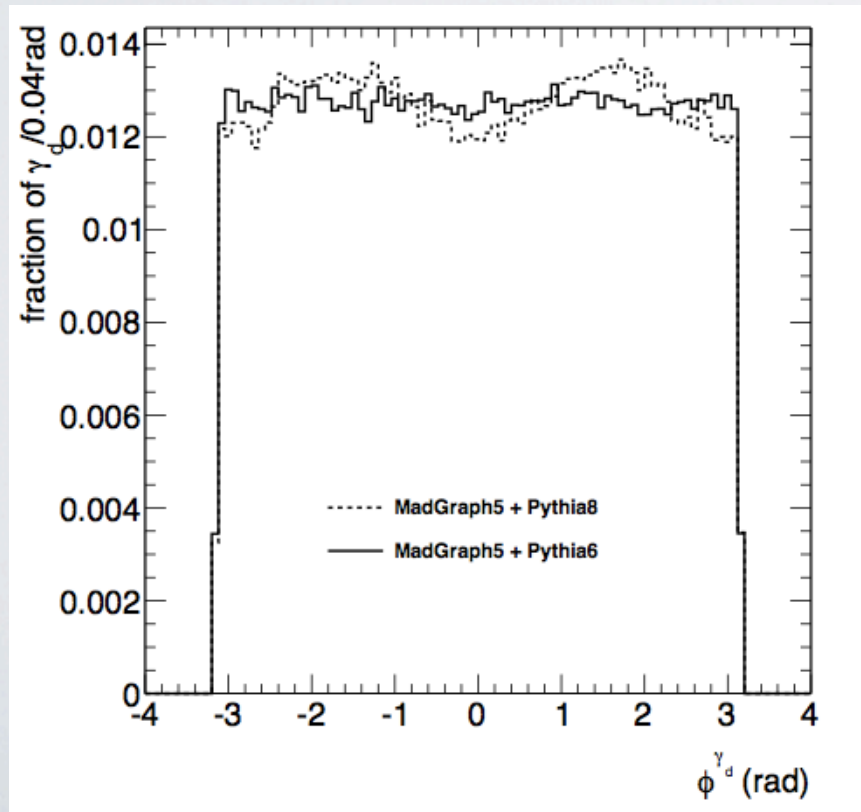
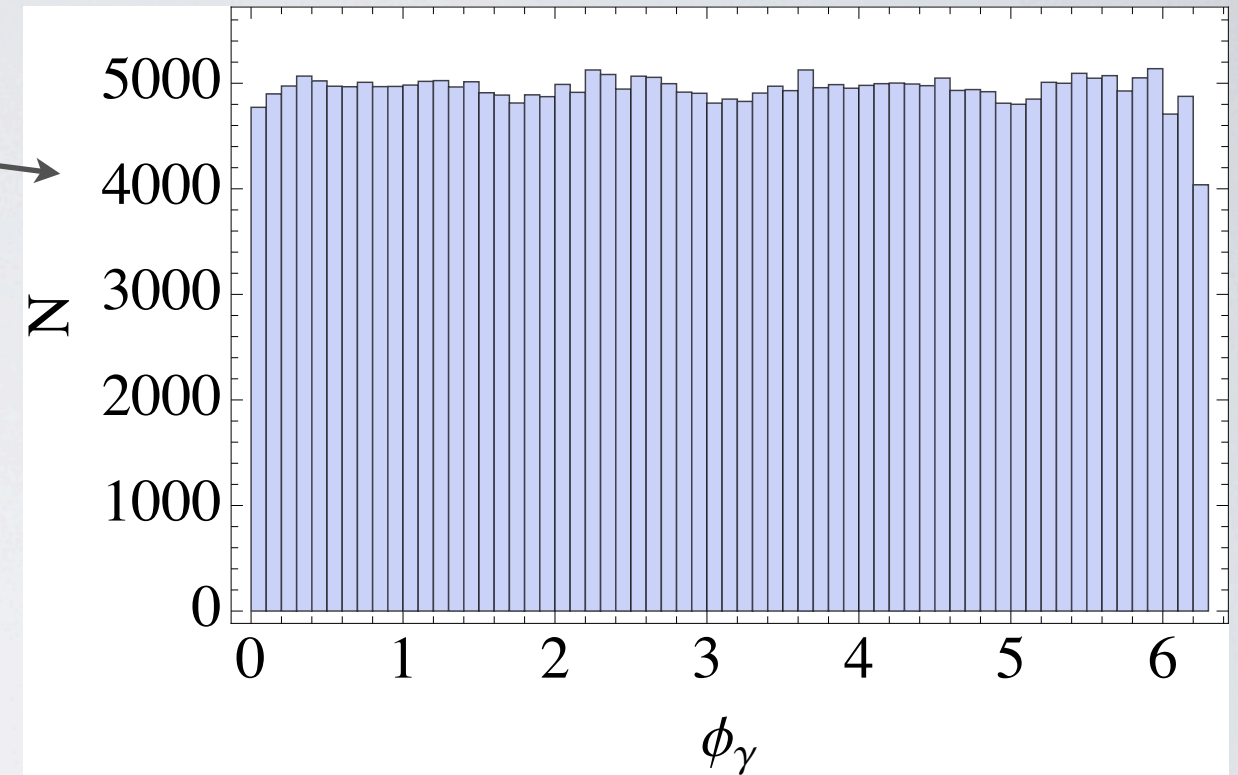
# MC TRUTH: MUONS



- **Strange sinusoidal structure in the  $\varphi$  distribution**
- **Similar behavior observed for the electrons and the pions**

# DIFFERENCE IN THE $\phi$ DISTRIBUTION

- Look for example at the dark photon
- At the MadGraph5 level the distribution is flat as expected
- MadGraph5 file processed with Pythia6 gives flat  $\phi$  distributions
- **Pythia8 introduces a “sinusoidal” structure**
  - it is visible for all particles in the decay chain
- For comparison, also distributions with MadGraph4+Pythia6 (MCI0) are shown



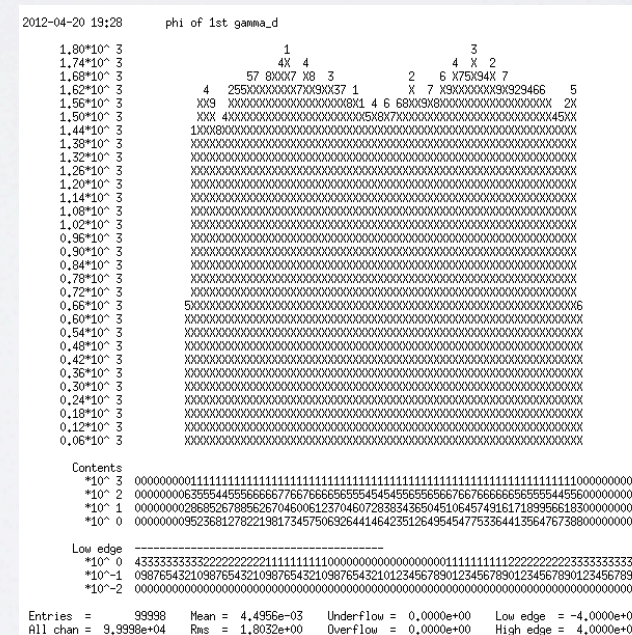
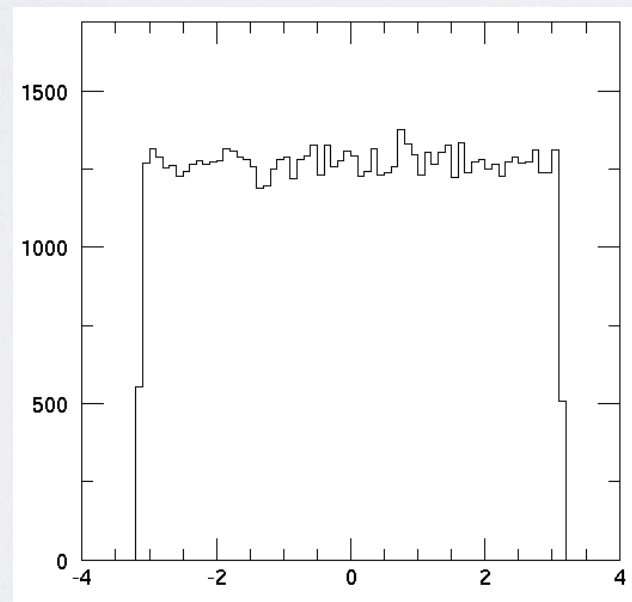


# HOW TO UNDERSTAND THE SOURCE OF THE PROBLEM?

- **Henri, Erez and the ATLAS MC group conveners are aware of this problem**
- **These slides have been shown at the MCI2 validation meeting**

<https://indico.cern.ch/conferenceDisplay.py?confId=187156>

- **All the suggestions received during the meeting have been tested (comment out Photos, run on a 8TeV sample, try other production caches) but the problem is still here**
- **Georges Azuelos and Bertrand Brelier (authors of the MadGraph-Pythia interface in ATHENA) have tested MadGraph5 + Pythia6/8 standalone (w/o Athena) observing the same funny phi effect**



- **The problem is internal to Pythia8 → talk to the Pythia authors**



# HOW TO UNDERSTAND THE SOURCE OF THE PROBLEM?

- **Torbjörn has identified the effect on  $\varphi$  as a bug in the current Pythia version**
- **The fix will go in the next Pythia version and he suggests a workaround:**

Hello Antonio,  
Thanks for pointing this out.

Indeed I also see the problem, and have tracked it to the description of gluon polarization in initial-state radiation. This should only kick in for  $2 \rightarrow 2$  processes, and I have not yet had time to figure out why Pythia fools itself into believing this should be thought of as a  $2 \rightarrow 2$  process in this particular step. Fixes for that will go in for the next version.

In the meantime I would recommend you to put

`SpaceShower:phiPolAsym = off`

to switch off the errant part of the code in your studies. Its effects on other parts of the physics should be tiny (more important for QCD  $2 \rightarrow 2$ , but small also there).

Thanks again, and all the best,  
Torbjörn



# SUMMARY

- **A comparison between MadGraph5+Pythia8 and MadGraph5+Pythia6 in order to validate MCI2 Monte Carlo generation, shows some difference in the  $\varphi$  distributions for particles at the parton level**
- **The source of the difference has been identified as a bug in the current Pythia8 version**
- **Fix will go in the new Pythia version and a **workaround** has been provided by Torbjörn**
- **We are now waiting for feedback from ATLAS MC production managers in order to go ahead with MCI2 validation and official request**

<https://savannah.cern.ch/bugs/index.php?93995>



# SUMMARY

## **1) 4 dark photons + 2 LSP**

- 100-125-140 GeV Higgs mass**
- mixed final state (45% e, 45%  $\mu$ , 10%  $\pi$ )**
- 500k events**

## **2) 2 dark photons + 2 LSP**

- 100-125-140 GeV Higgs mass**
- mixed final state (45% e, 45%  $\mu$ , 10%  $\pi$ )**
- 500k events**

<https://savannah.cern.ch/bugs/index.php?93995>



EXTRA

# JO USED FOR MC12 GENERATION

- jobOptions used for generate events in Athena (Madgrap5+Pythia8)

```
##### JO for displaced Higgs decays to leptonjets
##### 140geV Higgs, 4 dark photons + MET, mixed final state

## Config for Py8 tune AU2 with CTEQ6L1
include("MC12JobOptions/Pythia8_AU2_CTEQ6L1_Common.py")

## Configure Pythia8 to read input events from an LHEF file
include("MC12JobOptions/Pythia8_LHEF.py")

## ... Photos
include("MC12JobOptions/PhotosPythia8_Fragment.py")

evgenConfig.generators = ["MadGraph", "Pythia8"]
evgenConfig.description = "140GeV Higgs to displaced leptonjets, mixed final state, 4 dark photons + MET"
evgenConfig.keywords = ["leptonjets", "higgs"]
evgenConfig.inputfilecheck = 'group.phys-gener.MadGraph.119878.H140toLJ_4zd_mixed_MET.TXT.mc12_v1'
```

- Transformation command

```
Generate_trf.py ecmEnergy=7000 runNumber=1 firstEvent=1 maxEvents=1000 randomSeed=400010 jobConfig=MC12.119878.PythiaMadGraph_H140toLJ_4zd_mixed_MET.py outputEVNTFile=/tmp/apolici/evgen.000001.pool.root inputGeneratorFile=group.phys-gener.MadGraph.119878.H140toLJ_4zd_mixed_MET.TXT.mc12_v1._000001.events.tar.gz
```



# CURIOSITY.....

- **Perfectly fitted by a  $\cos(x)$  function**

