How to Generate a MC sample

Shuo Han, Yanping Huang, Shan Jin

Institute of High Energy Physics
Chinese Academy of Sciences

Outline

◆ Generation (JO-EVNT)

◆ Simulation (EVNT–HITS)

◆ Digitalization (HITS-RDO)

◆ Reconstruction (RDO-ESD-AOD)

Job-options

- Find the job-options here:

- https://svnweb.cern.ch/trac/atlasoff/browser/Generators/MC15JobOptions/trunk/share

- **Example: Particle-Gun, Single Photon (423001)**

```python
evgenConfig.description = "Single egamma particles (photons) with ET spectrum shaped for MVA calibration"
evgenConfig.keywords = ["singleParticle","egamma","photon"]
evgenConfig.contact  = ["ocariz@in2p3.fr"]

include("MC15JobOptions/ParticleGun_Common.py")
# include("GeneratorUtils/StdEvgenSetup.py")     # sets EvtMax to 100 in production. Zach Marshall suggested removing this include

def dbnFermiDirac(x,mu,kT):
    import math
    arg = (x-mu)/kT
    if arg < -20 :         # avoid numerical underflows
        result = 1
    elif arg > 20 :        # avoid numerical overflows
        result = 0
    else :
        div = math.exp(arg)+1
        result = 1/div
    return result

import ParticleGun as PG

class ETSpectrumParticleSampler(PG.ParticleSampler):

    def __init__(self, pid, num=1):
        self.pid = PG.mksampler(pid)
        self.numparticles = num

        # Parameters for the MVA-shaped spectrum : higher density in the < 100 GeV range
        mu1 = 0.5              # mu1,kT1 : smooth but steep ramp-up from 0 to 1 GeV (requested by TauCP)
        kT1 = 0.1
        mu2 = 200              # mu2,kT2 : smooth, slow ramp-down in the 100-300 GeV range
        kT2 = 20
        y0 = 0.005             # y0 : baseline for low-density at high ET up to 3 TeV

        # Create and fill a very fine-grained histogram
        from ROOT import TH1D
        etSpectrumFullRange = TH1D("ETSpectrumFullRange" , "Reference ET spectrum for egamma MVA calib" , 30000 , 0 , 3000)
        for i in xrange(etSpectrumFullRange.GetNbinsX()):
            x = etSpectrumFullRange.GetBinCenter(i+1)
            y1 = dbnFermiDirac(x,mu1,kT1)
            y2 = dbnFermiDirac(x,mu2,kT2)
            y = y0 - y1 + y2
            etSpectrumFullRange.SetBinContent(i+1,y)
        self.hist = PG.TH1(etSpectrumFullRange) #< wrap *after* populating

    def shoot(self):
        "Return a vector of sampled particles from the provided ET-histogram"
        particles = []
        for i in xrange(self.numparticles):
            ptrand = self.hist.GetRandom()
            ptrand *= 1000 # NB. This _particular_ histogram is in GeV, but Athena needs MeV
            pid = self.pid()
            m = PG.MASSES[abs(pid)]
            mom = PG.PtEtaMPhiSampler(pt=ptrand, eta=[-2.5, 2.5], mass=m)
            p = PG.SampledParticle(pid, mom())
            p.mass = m
            particles.append(p)
        return particles

topSeq += PG.ParticleGun()
topSeq.ParticleGun.sampler = ETSpectrumParticleSampler(22)

evgenConfig.minevents = 5000
```

Generation (JO-EVNT)

◆ Generation
  ◆ asetup 19.2.5.26, here
  ◆ Generate_tf.py'--ecmEnergy=13000' '--firstEvent=1001''--jobConfig=MC15.423001.ParticleGun_single_photon_egammaET.py''--maxEvents=100''--randomSeed=15' '--runNumber=423001''--outputEVNTFile=ParticleGun.EVNT.root'

◆ Example on rucio:
  ◆ mc16_13TeV.423001.ParticleGun_single_photon_egammaET.merge.EVNT.e3566_e5984

◆ Speed: Very fast (<1s for 1 event)

◆ Size: Very small (3.4G for 40M events)

◆ Output: EVNT with only truth info

```
======> EVENT:0
 EventInfo_p4_McEventInfo = (EventInfo_p4*)0x2a6d430
 McEventCollection_p5_GEN_EVENT = (McEventCollection_p5*)0x2a9f360
```

Simulation (EVNT-HITS)

- Simulation
  - asetup 21.0.20.1,AtlasProduction,here
  - Sim_tf.py--inputEvgenFile='../SinglePhoton_Test1_EVNT/ParticleGun.EVNT.root'--outputHitsFile='ParticleGun.HITS.root'--maxEvents='100' --DataRunNumber='284500'--geometryVersion='ATLAS-R2-2016-01-00-01'

- Example on rucio:
  - mc16_13TeV.423001.ParticleGun_single_photon_egammaET.simul.HITS.e3566_s3113

- Speed: Very slow (>40s for 1 event)

- Size: Large (1T for 40M events)

- Output: HITS with truth and hit info

```
EventInfo_p4_McEventInfo = (EventInfo_p4*)0x1e49d60
SiHitCollection_p2_BCMHits = (SiHitCollection_p2*)0x1e5ddd0
SiHitCollection_p2_BLMHits = (SiHitCollection_p2*)0x1e66520
SiHitCollection_p2_PixelHits = (SiHitCollection_p2*)0x1e6e4b0
SiHitCollection_p2_SCT_Hits = (SiHitCollection_p2*)0x1e76990
LArHitContainer_p2_LArHitEMB = (LArHitContainer_p2*)0x1e7f5e0
LArHitContainer_p2_LArHitEMEC = (LArHitContainer_p2*)0x1e86a80
LArHitContainer_p2_LArHitFCAL = (LArHitContainer_p2*)0x1e77f00
LArHitContainer_p2_LArHitHEC = (LArHitContainer_p2*)0x1e96a40
LArHitContainer_p2_LArHitMiniFCAL = (LArHitContainer_p2*)0x1e9d8b0
TileHitVector_p1_MBTSHits = (TileHitVector_p1*)0x1ea7140
TileHitVector_p1_TileHitVec = (TileHitVector_p1*)0x1eae510
Muon::RPCSimHitCollection_p2_RPC_Hits = (Muon::RPCSimHitCollection_p2*)0x1ebb840
Muon::TGCSimHitCollection_p3_TGC_Hits = (Muon::TGCSimHitCollection_p3*)0x1ec5aa0
Muon::CSCSimHitCollection_p2_CSC_Hits = (Muon::CSCSimHitCollection_p2*)0x1ecfd20
Muon::MDTSimHitCollection_p2_MDT_Hits = (Muon::MDTSimHitCollection_p2*)0x1ed9960
McEventCollection_p5_TruthEvent = (McEventCollection_p5*)0x1efcd90
RecoTimingObj_p1_EVNTtoHITS_timings = (RecoTimingObj_p1*)0x1f13550
TRT_HitCollection_p3_TRTUncompressedHits = (TRT_HitCollection_p3*)0x1f22300
TrackRecordCollection_p2_CaloEntryLayer = (TrackRecordCollection_p2*)0x1f2fd20
TrackRecordCollection_p2_MuonEntryLayer = (TrackRecordCollection_p2*)0x1f3a910
TrackRecordCollection_p2_MuonExitLayer = (TrackRecordCollection_p2*)0x1f41570
CaloCalibrationHitContainer_p3_LArCalibrationHitDeadMaterial = (CaloCalibrationHitContainer_p3*)0x1f47e40
```

Digitalization (HITS-RDO)

- Digitalization
  - asetup 21.0.20.1,AtlasProduction,here
  - Reco_tf.py --inputHITSFile= '../SinglePhoton_Test1_Sim/ParticleGun.HITS.root' --outputRDOFile= 'ParticleGun.RDO.root' --maxEvents= '15' --DataRunNumber= '284500' --pileupFinalBunch= '6' --numberOfHighPtMinBias= '0.0052' --numberOfLowPtMinBias= '1.9948' --inputLowPtMinbiasHitsFile= '' –inputHighPtMinbiasHitsFile= ''

- Example on rucio:
  - mc16_13TeV.423001.ParticleGun_single_photon_egammaET.recon.RDO.e3566_s3113_r9422

- Speed: Slow (~2s for low-pileup event ~40s for high-pileup event)

- Size: Even Larger (500G for 0.1M events)

- Output: RDO with raw-container (including pile-up)

```
PileUpEventInfo_p5_McEventInfo = (PileUpEventInfo_p5*)0x14a2510
InDetRawDataContainer_p2_PixelRDOs = (InDetRawDataContainer_p2*)0x3545de0
SCT_RawDataContainer_p3_SCT_RDOs = (SCT_RawDataContainer_p3*)0x14a5aa0
InDetRawDataContainer_p2_TRT_RDOs = (InDetRawDataContainer_p2*)0x5128140
InDetSimDataCollection_p2_BCM_SDO_Map = (InDetSimDataCollection_p2*)0x3552a80
InDetSimDataCollection_p2_PixelSDO_Map = (InDetSimDataCollection_p2*)0x14a9f90
InDetSimDataCollection_p2_SCT_SDO_Map = (InDetSimDataCollection_p2*)0x5112b00
InDetSimDataCollection_p2_TRT_SDO_Map = (InDetSimDataCollection_p2*)0x50fd4e0
BCM_RDO_Container_p0_BCM_RDOs = (BCM_RDO_Container_p0*)0x53ccba0
LArDigitContainer_p1_LArDigitContainer_MC_Thinned = (LArDigitContainer_p1*)0x5577280
LArRawChannelContainer_p4_LArRawChannels = (LArRawChannelContainer_p4*)0x25fdff0
```

Reconstruction (RDO-ESD-AOD)

- Reconstruction
  - asetup 21.0.20.1,AtlasProduction,here
  - Reco_tf.py--inputRDOFile='../SinglePhoton_Test1_Digital/ParticleGun.RDO.root'--outputAODFile='ParticleGun.AOD.root'--autoConfiguration='everything'--maxEvents='15'

- Example on rucio:
  - mc16_13TeV.423001.ParticleGun_single_photon_egammaET.merge.AOD.e3566_s3113_r9422_r9315

- Speed: Slow (~ 3s for RDO-ESD, <1s for ESD-AOD)

- Size: Large (81G for 0.1M events)

- Output: ESD and AOD with object containers

```
MET_Track        = (xAOD::MissingETContainer_v1*)0x78654a0
MET_Truth        = (xAOD::MissingETContainer_v1*)0x7873670
MET_TruthRegions = (xAOD::MissingETContainer_v1*)0x78818f0
HLT_xAOD__PhotonContainer_egamma_Iso_Photons = (DataVector<xAOD::Photon_v1>*)0x7890cd0
HLT_xAOD__PhotonContainer_egamma_Photons = (DataVector<xAOD::Photon_v1>*)0x789f6b0
Photons          = (DataVector<xAOD::Photon_v1>*)0x78ad820
HLT_xAOD__TrigRNNOutputContainer_TrigTRTHTCounts = (DataVector<xAOD::TrigRNNOutput_v2>*)0x78bd2a0
MuonTruthParticlesAux. = (xAOD::TruthParticleAuxContainer_v1*)0x78d2f70
```

Changing pileup while reconstruction

◆ **Changing Pileup (while processing HITS-ROD):**

◆ Mu. = 2 : --pileupFinalBunch='6'--numberOfHighPtMinBias='0.0052'--numberOfLowPtMinBias='1.9948' --inputLowPtMinbiasHitsFile= '' inputHighPtMinbiasHitsFile= ''

◆ Mu = 60 : --pileupFinalBunch='6' --numberOfHighPtMinBias='0.16' --numberOfLowPtMinBias='59.84' --inputLowPtMinbiasHitsFile= '' inputHighPtMinbiasHitsFile= ''

◆ Input Low/High pT min-bias HITS File:
  ◆ mc16_13TeV.361238.Pythia8EvtGen_A3NNPDF23LO_minbias_inelastic_low.simul.HITS.e4981_s3087_s3111
  ◆ mc16_13TeV.361239.Pythia8EvtGen_A3NNPDF23LO_minbias_inelastic_high.simul.HITS.e4981_s3087_s3111

Row	m_eventNu	m_mu	m_decayR	N_combine	N_sisp	reco_conv	reco_ph_p
0	38636007	60	542.16583	0	0	0	126.79913
1	38636011	60	51.480438	2	2	3	172.85384
2	38636026	60	58.034416	2	2	3	14.559485
3	38636051	60	418.23062	0	0	0	121.75023
4	38636085	60	51.642784	2	2	-999	-999
5	38636089	60	181.55468	1	2	0	36.548968

Row	m_eventNu	m_mu	m_decayR	N_combine	N_sisp	reco_conv	reco_ph_p
0	38636007	2	542.16583	0	0	0	127.36018
1	38636011	2	51.480438	2	2	3	170.05607
2	38636026	2	58.034416	2	2	3	12.759492
3	38636051	2	418.23062	0	0	0	122.58932
4	38636085	2	51.642784	2	2	-999	-999
5	38636089	2	181.55468	2	2	3	39.053546

Backup