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Number of muons in HI generators

Problem

- The single muons from 2 different HYDJET samples, from HYDJET and AMPT, from pp data scaled and pp PYTHIA scaled are not consistent. The numbers, presented here collected by Raphael. I stole the below table, to show the issue.

Reference	µ of p_T > 10 GeV/c
AN2009-126 (10 TeV sim)	14 Rec / N_{coll} kevts
MUO-10-002 (7 TeV data)	6 Glb / N_{coll} kevts
Hydjet, Nov. (4 TeV)	150 Gen / kevts ?
Hydjet, Today (2.8 TeV)	0.4 Gen / kevts
AMPT, July ex (2.8 TeV)	0.03 Gen / kevts
(B dominated, p+p approx. scaled to 2.8 TeV)	

Preliminary thoughts

- pp->PbPb, not compare apple to apple (one reconstructed mu other gen, also different energy);
- HYDJET1-HYDJET2 : probably different settings; also 4TeV is produced in cMSSW_21X, the second in 3XY
- HYDJET-AMPT : allowed decay region (at gen or by GEANT?); HYDJET has the CMSSW PYTHIA default, everything with ctau<10mm will be decayed by PYTHIA/HYDJET

- pp: data_MC comparison (CMSSW_3_5_6 reprocessing of 7 TeV minimum-bias sample PYTHIA D6T tune, CTEQ6L PDF): CMS DP-2010/020 -- this is minbias comparison;
    - the used config file;
    - which actually uses this file;
    - same file, with different name for CMSSW>3_8_x) ...same processes

- HI: HYDJET minbias setting
    - HYDJET-4TeV : cfg, Dongho's twiki with location of files and plots
    - HYDJET-2.76TeV:
        - production cfg from DBS, which calls Hydjet_Quenched_MinBias_2760GeV_cfi.py

-

Show the different generator configurations used Hide settings

PYTHIA	

`processParameters = cms.vstring(`
`'MSEL=0 ! User defined processes',`
`'MSUB(11)=1 ! Min bias process f_i f_j -> f_i f_j',`
`'MSUB(12)=1 ! Min bias process f_i fb_i -> f_k _fb_k',`
`'MSUB(13)=1 ! Min bias process f_i fb_i -> gg,`
`'MSUB(28)=1 ! Min bias process f_i g -> f_i g',`
	`process.GlobalTag.glob`
	`process.generator = cms`
	`aBeamTarget = cms.`
	`allowEmptyEvents =`
	`bFixed = cms.doubl`
	`bMax = cms.double(`

```
        'MSUB(53)=1     ! Min bias process gg       -> f_k fb_k',
        'MSUB(68)=1     ! Min bias process gg->gg',
        'MSUB(92)=1     ! Min bias process, single diffractive XB',
        'MSUB(93)=1     ! Min bias process, single diffractive AX',
        'MSUB(94)=1     ! Min bias process, double diffractive',
        'MSUB(95)=1     ! Min bias process low-pT productions'),
    # This is a vector of ParameterSet names to be read, in this order
    parameterSets = cms.vstring(
        'pythiaUESettings',
        'processParameters')
```

```
    bMin = cms.double(0
    cFlag = cms.int32(1
    comEnergy = cms.dou
    doCollisionalEnLoss
    doRadiativeEnLoss =
    firstEvent = cms.un
    firstRun = cms.untr
    fracSoftMultiplicit
    hadronFreezoutTempe
    hydjetMode = cms.st
    maxEventsToPrint =
    maxLongitudinalRapi
    maxTransverseRapidi
    nMultiplicity = cms

    pythiaPylistVerbosi
    qgpInitialTemperatu
    qgpNumQuarkFlavor =
    qgpProperTimeFormat
    rotateEventPlane =
    shadowingSwitch = c
    sigmaInelNN = cms.d

    PythiaParameters =
            pythiaDefau
            'MSEL=0',
            'CKIN(3)=7
            'MSTJ(11)=3
            'MSTJ(22)=2
            'MSTP(81)=0
            'MSTU(21)=1
            'PARJ(71)=1
            'PARP(67)=1
            'PARP(82)=1
            'PARP(85)=0
            'PARP(86)=0
            'PARP(89)=1
give the pTmin and pT0
            'PARP(91)=1
            'PARU(14)=1
            'PMAS(5,1)=
            'PMAS(6,1)=
            ),
        pythiaBottomoni
            'MSUB(461)
            'MSUB(462)
            'MSUB(463)
            'MSUB(464)
            'MSUB(465)
            'MSUB(466)
            'MSUB(467)
            'MSUB(468)
            'MSUB(469)
            'MSUB(470)
            'MSUB(471)
            'MSUB(472)
            'MSUB(473)
            'MSUB(474)
            'MSUB(475)
            'MSUB(476)
            'MSUB(477)
            'MSUB(478)
            'MSUB(479)
        pythiaCharmoniu
            'MSUB(421)
            'MSUB(422)
            'MSUB(423)
```

```
    'MSUB(424)
    'MSUB(425)
    'MSUB(426)
    'MSUB(427)
    'MSUB(428)
    'MSUB(429)
    'MSUB(430)
    'MSUB(431)
    'MSUB(432)
    'MSUB(433)
    'MSUB(434)
    'MSUB(435)
    'MSUB(436)
    'MSUB(437)
    'MSUB(438)
    'MSUB(439)
pythiaQuarkonia
    'BRAT(861)=
    'BRAT(862)=
    'BRAT(1501)
    'BRAT(1502)
    'BRAT(1555)
    'BRAT(1556)
    'MSTP(145)=
    'MSTP(146)=
    'MSTP(147)=
    'MSTP(148)=
    'MSTP(149)=
    'PARP(141)=
    'PARP(142)=
    'PARP(143)=
    'PARP(144)=
    'PARP(145)=
    'PARP(146)=
    'PARP(147)=
    'PARP(148)=
    'PARP(149)=
    'PARP(150)=
    'PARJ(13)=0
    'PARJ(14)=0
    'PARJ(15)=0
    'PARJ(16)=0
   ),
pythiaWeakBoson
    'MSUB(1)=1
    'MSUB(2)=1
pythiaJets = cr
    'MSUB(11)=1
    'MSUB(12)=1
    'MSUB(13)=1
    'MSUB(28)=1
    'MSUB(53)=1
    'MSUB(68)=1
pythiaPromptPho
    'MSUB(14)=1
    'MSUB(18)=1
    'MSUB(29)=1
    'MSUB(114)=
    'MSUB(115)=
parameterSets =
    'pythiaDefa
    'pythiaJets
    'pythiaProm
    'pythiaWeak
    'pythiaChar
    'pythiaBott
    'pythiaQuar
```

	))

So:

- PYTHIA_ : jets, , difractive processes, lop_pT
- HYDJET_4: jets, prompt photons, Z, W, charmonium, botomonium
- HYDJET_2: jets, prompt photons

Tackle

HYDJET_4 vs HYDJET_2:

- does charmonium/botomonium/quarkonia overlaps with 'jets' part?
    - ◊ pythia read: nope; processes 421->479, have the closed heavy prod in the NRQCD frame
- make 4 data samples: same basic settings, and just different channels in;
    - (eliminate energy scaling, kinematic cuts differences, same channels): run PYTHIA & HYDJET @ 2760, 4000GeV, same eta, pT_hat cut, PYTHIA settings.
        - ◊ Quarqonia+Boson:in vs out
        - ◊ Collisional En Loss: false vs true
    - generator settings
        - ◊ pythia settings for hydjet: pythiaDefault vs UESettings --- <0.6% effect
        - ◊ longitudinal rapidity (3.75-- 4.5) -- no effect
        - ◊ multiplicity (21500 -- 26000) -- 0.1% effect
- can NOT reproduce the ~9mu/event ....
- check changes in hydjet/pyquen code from 21X->3XY:
    - moved from old structure of the interface to the new one (should not have any impact)
    - change to hydjet 1.6 with CMSW_3_1_0_pre10 and up was made here. Igor's documentation of v1.6; no change that should affect (just a handle to decay wanted particles)
    - some changes in pyquen also here
    - digging into checks done for muons between CMSSW_229 and 310_pre7"Cath&Dongho
- there is a counting issue in the Dongho's 4TeV plot!! the original presentation (for JPsi) is here; details in the Results/last_results

HYDJET vs PYTHIA*Ncoll/part scale diffrences

- is it an issue with the Ncoll scaling?
    - Interface: http://cmssdt.cern.ch/SDT/lxr/source/GeneratorInterface/HydjetInterfa :
        - ◊ 232 nsub_ = hyjpar.njet; ----->Ncoll_hard
    - http://lokhtin.web.cern.ch/lokhtin/hydro/hydjet.txt :
        - ◊ njet - number of hard parton-parton scatterings with pt>ptmin in event;
        - ◊ n_coll = hyfpar.nbcol ; mean number of nucleon-nucleon binary sub-collisions at given 'bgen'.
    - hydjet: nbcoll nucleon-nucleon on top of each other, in which ncoll_hard parton-parton scatterings take place

- PYTHIA vs PYTHIA
    - official (jets, diffractive,low_pT) vs hydjet_setting (jets, photons, MSTP(81)=0) --> more muons when no multiple interactions (initial,final) OFF
    - official (jets, diffractive,low_pT) vs hydjet_setting (jets, photons but MSTP(81)=1) --> slightly more than previous case (0.031 vs 0.028); so main diffrence from the channels
- HYDJET vsPYTHIA scaled (only with jets and photons in)
    - hydro off, quenching on nhsel = 4 (kQJetsOnly)
    - hydro off, quenching off nhsel = 3 (kJetsOnly)

- HYDJET and PYTHIA simple deal differently with the hard event generation when a pt_hat is applied
    - HYDJET recalculates the number of hard scattering
    - PYTHIA does NOT recalculate the number of hard scattering
- What does this mean?
    - if NO pt_hat cut, (0 to infinity), there will be generated:
        - in HYDJET n_hydjet hard scatterings
        - in pythia, n_pythia hard scatterings
    - if YES pt_hat cut, there will be generated
        - in HYDJET, [n_hydjet - n_hydjet_(found in the pt<pt_hat interval)] (so only what is above the cut in the (1), a subset)
        - in PYTHIA, still all n_pythia hard scatterings
- What is the effect?
    - You get more hard_scattering_probes in PYTHIA case than in HYDJET (just because you have more hard scatterings)
- How to do comparison properly?
    - when comparing the 2 one has to make a x-section correction: Nbcol*N_PYTHIA(pt>ptcut)* [sigjet/sigin]
        - **sigin** is the total inelastic NN cross section at given cms energy (=58mb, it is actually input to HYDJET in the hydjet configuration file)
        - **sigjet** is the hard scattering NN cross section at given pt min and energy (=10.5474mb for 4TeV and =6.69251 for 2.76TeV, both for a pT_hat>6GeV, as taken from printout from hyjpar)
    - These 2 are stored as output from HYDJET in

```
COMMON /hyjpar/ ptmin,sigin,sigjet,nhsel,ishad,njet
```

Results

- dilep_2sept2010_genmus.pdf: preliminary results
- dilep_8sept2010_genmus.pdf: last results
- dilep_16sept2010_genmus.pdf: last numbers

Generator settings details

-

Quarkonia extra explanations Hide settings

```
pythiaQuarkoniaSettings = cms.vstring(
          'BRAT(861)=0.202    ! BR(D*_2+   --> D*0  pi+  pi0)',
          'BRAT(862)=0.798    ! BR(D*_2+   --> D*+  pi+  pi-)',
          'BRAT(1501)=0.013  ! BR(Xi*_bb- --> ubar  d  c specflav)',
```

```
        'BRAT(1502)=0.987  ! BR(Xi*_bb- --> ubar  c  d specflav)',
        'BRAT(1555)=0.356  ! BR(Omega*_bbc0 --> ubar  d c specflav)',
        'BRAT(1556)=0.644  ! BR(Omega*_bbc0 --> ubar  c d specflav)',
        'MSTP(145)=0           ! (D = 0) polarization for NRQCD prod of charmonium or bottomo
        'MSTP(146)=0           ! (D = 1) polarization reference frame when MSTP(145) = 1.',
        'MSTP(147)=0           ! (D = 0) particular helicity or density matrix component when
        'MSTP(148)=1           ! (D = 0) possibility to allow final-state shower evolution of
        'MSTP(149)=1           !  (D = 0) if the QQ[3S(8)1 ] states are allowed to radiate, M
        'PARP(141)=1.16       ! (D = 10*1.) matrix elements for charmonium and bottomonium pr
        'PARP(142)=0.0119   ! same ',
        'PARP(143)=0.01       ! same',
        'PARP(144)=0.01       ! same',
        'PARP(145)=0.05       ! same',
        'PARP(146)=9.28       ! same',
        'PARP(147)=0.15       ! same',
        'PARP(148)=0.02       ! same',
        'PARP(149)=0.02       ! same',
        'PARP(150)=0.085     ! same',
        'PARJ(13)=0.60          ! (D = 0.75) probability that a charm or heavier meson has sp
        'PARJ(14)=0.162        ! (D = 0.) prob. that a spin = 0 meson is produced with an orb
        'PARJ(15)=0.018        ! (D = 0.) prob. that a spin = 1 meson is produced with an orb
        'PARJ(16)=0.054        ! (D = 0.) prob. that a spin = 1 meson is produced with an orb
       ),
)
```

- **MSEL = 1** : QCD high-pT processes (ISUB = 11, 12, 13, 28, 53, 68); additionally low-pT production if CKIN(3) < PARP(81) or PARP(82), depending on MSTP(82) (ISUB = 95). If low-pT is switched on, the other CKIN cuts are not used.
- **PARP(81)**: (D = 1.9 GeV) effective minimum transverse momentum pT_min for multiple interactions with MSTP(82) = 1, at the reference energy scale PARP(89), with the degree of energy rescaling given by PARP(90). The optimal value depends on a number of other assumptions, especially which parton distributions are being used. The default is intended for CTEQ 5L
- **PARP(82)=1.9** !(D = 2.0 GeV) regularization scale pT0 of the transverse-momentum spectrum for multiple interactions with MSTP(82)>=2
- **PARP(89)**: reference energy scale, at which PARP(81) and PARP(82) give the pT_min and pT_0 values directly. Has no physical meaning in itself, but is used for convenience only. (A form pT_min = PARP(81)EPARP(90)cm would have been equally possible but then with a less transparent meaning of PARP(81).) For studies of the pT_min dependence at some specific energy it may be convenient to choose PARP(89) equal to this energy.
- **PARP(90)**: (D = 0.16) power of the energy-rescaling term of the pTmin and pT0 parameters, which are assumed proportional to EPARP(90) cm . The default value is inspired by the rise of the total cross section by the pomeron term, s² = E2²cm = E2×0.08cm , which is not inconsistent with the small-x behaviour. It is also reasonably consistent with the energy-dependence implied by a comparison with the UA5 multiplicity distributions at 200 and 900 GeV [UA584]. PARP(90) = 0 is an allowed value, i.e. it is possible to have energy-independent parameters.
- **PARP(93)** : (D = 5. GeV/c) (C) upper cut-off for primordial k? distribution inside hadron.
- **PARU(14)**: (D=2.) when passing string corners, the (mis)match of transverse momentum directions may need to be compensated by using momentum fractions x outside the allowed range 0 < x < 1, by having

a slightly negative x. Occasionally the x can become quite negative, and then rarely give strange results. The new parameter sets limits how far outside the allowed range one may go before rejecting the current try and restarting the fragmentation of the current string.

Technical stuff

- all numbers used for the tables in the last presentation, numbers_differentSettings
- configuration files used to generate different samples:
  - hydjet_4tevOriginal_cfi.py.txt: 4tev w/ pythiaDefault settings
  - hydjet_4tevUEsettings_cfi.py.txt: 4TeV w/ pythiaUEsettings
  - hydjet_mbJPhin_cfi.py.txt: 2.76TeV w/o QB
  - hydjet_mbJPhQBin_cfi.py.txt: 2.76TeV w/ QB

-- CameliaMironov - 30-Aug-2010

This topic: Main > HIMuons
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