Preparing for Electromagnetic ME/PS Matching

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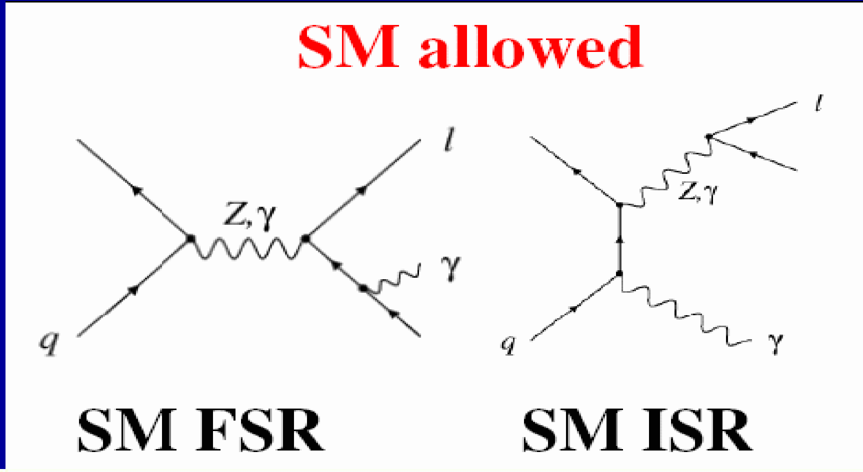
Motivation and Goals

- Monte Carlo generation of physics processes increasingly involves:
  - Generation of 'hard event' with a ME generator (ALPGEN , MadGRAPH…)
  - Fragmentation and hadronisation with a PS program (PYTHIA. Herwig…)
- Problem of double-counting of ME and PS jets is being addressed by 'QCD matching' prescriptions applied at the particle level (CKKW, MLM) (as explained in Fabio's and Simon's talks)
- What about double-counting of ME and PS photons?
- Historically people have either 1) Allowed double-counting keeping both ME and PS ISR/FSR 2) Used PHOTOS (Barberio, van Eijk, Was) which cannot do ISR while suppressing PS photons or 3) Used only ME photons suppressing all PS photons. None of these is ideal especially for studies considering a wide range of photons in E_t
- Ideal would be: Allow PS and ME to produce photons in parts of kinematic phase space where most relevant, avoiding double-counting

Sample Physics Case: Z (+γ)→μμ + γ

- Interest: Use 'inner bremstrahhlung' to measure with real data:
  - **Efficiency of photon triggers**
  - **Determination of photon energy scale**
  - **Determination of photon id efficiency**
  - **Determination of photon energy corrections**
- Relevant range of Et from ~5-200 GeV (range relevant from ECAL energy calibration with pi0 to Higgs photon range)
- Use of MC important to
  - Prepare selection and analysis
  - Predict event rates and measurement precision as function of acquired integrated luminosity



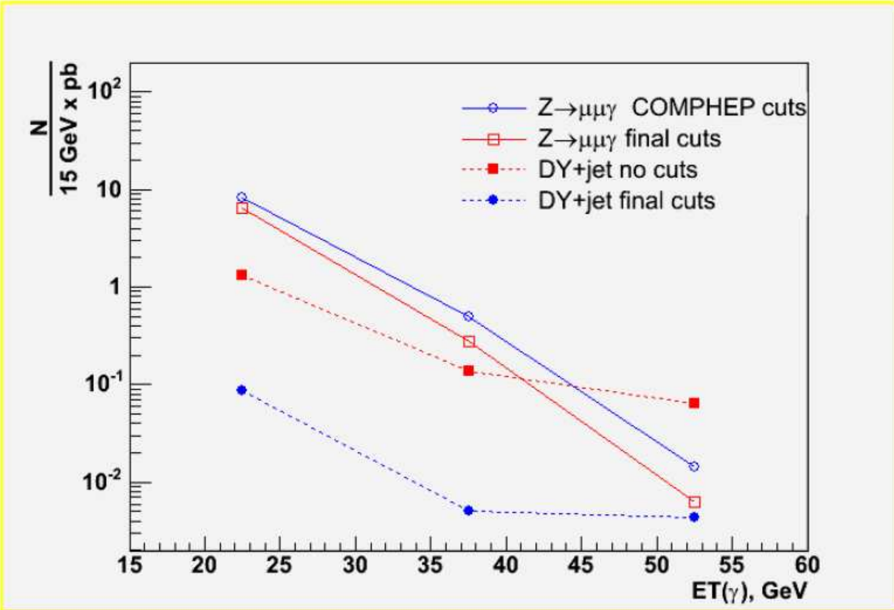


Figure 3: Signal and background yields before and after the cuts on event kinematics

Prescription from ALPGEN team (I)

- Determine phase space of observables where ME/PS descriptions differ:
  For us: $\Delta R(\gamma,\mu)$, $p_t\gamma$
- Determine PS/ME boundary range from which cutoff can be chosen (zone of agreement between PS/ME descriptions)
- Check if PS/ME boundary range is robust: Total effective cross-section and overall shape of observable distributions after veto procedure (described later) should be fairly insensitive to choice of cutoff point within boundary range
- If ok, set final generation cutoff point as high as possible within the boundary range to maximize generation efficiency.

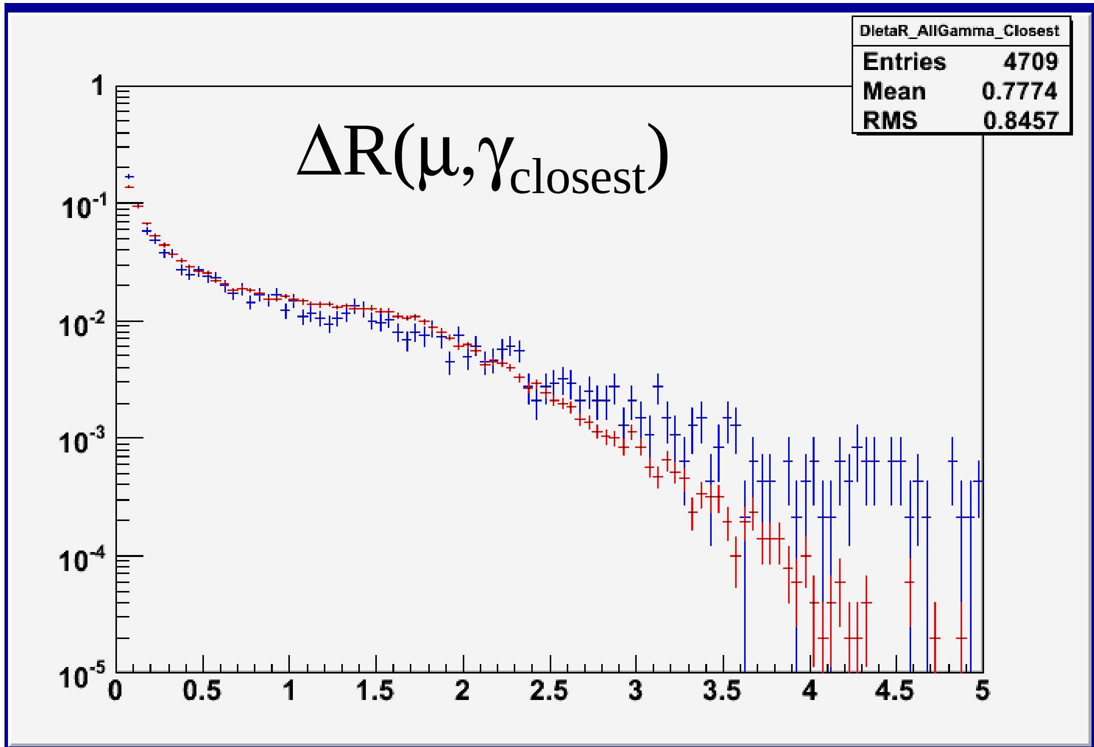
Event Generation for ME/PS Boundary study

- ALPGEN $Z\rightarrow\mu\mu$, $Z\rightarrow\mu\mu+\gamma$ samples with loose generation cuts (process $Z+\gamma$ included in a private version of v. 2.11)
  - $pT(\mu)>15$ GeV, $|\eta|<3.0$
  - $pT(\gamma)>1$ GeV, $|\eta\gamma|<3.0$ (for $Z\rightarrow\mu\mu+\gamma$ only)
  - $\Delta R(\mu,\gamma)>0.05$
  - 150 GeV>$M(\mu\mu)$>20 GeV

- UE and hadronisation suppressed in order to deconvolute the ME/PS comparison (both samples), PYTHIA ISR/FSR suppressed in $Z\rightarrow\mu\mu+\gamma$ sample. PS done with PYTHIA 6.408 (with 'old' showers as in for ex. 6.227)

- In each event, choose the highest p_t photon such that: $\Delta R(\gamma,\mu) > 0.05$
  $p_t\gamma > 1$ GeV
- Sample statistics surviving selection (those shown in plots):
  - ALPGEN $Z\rightarrow\mu\mu$, γ from PYTHIA PS: 4709/42k (~11%)
  - ALPGEN $Z\rightarrow\mu\mu+\gamma$ (γ from ALPGEN ME): 50719/52k (~97%)

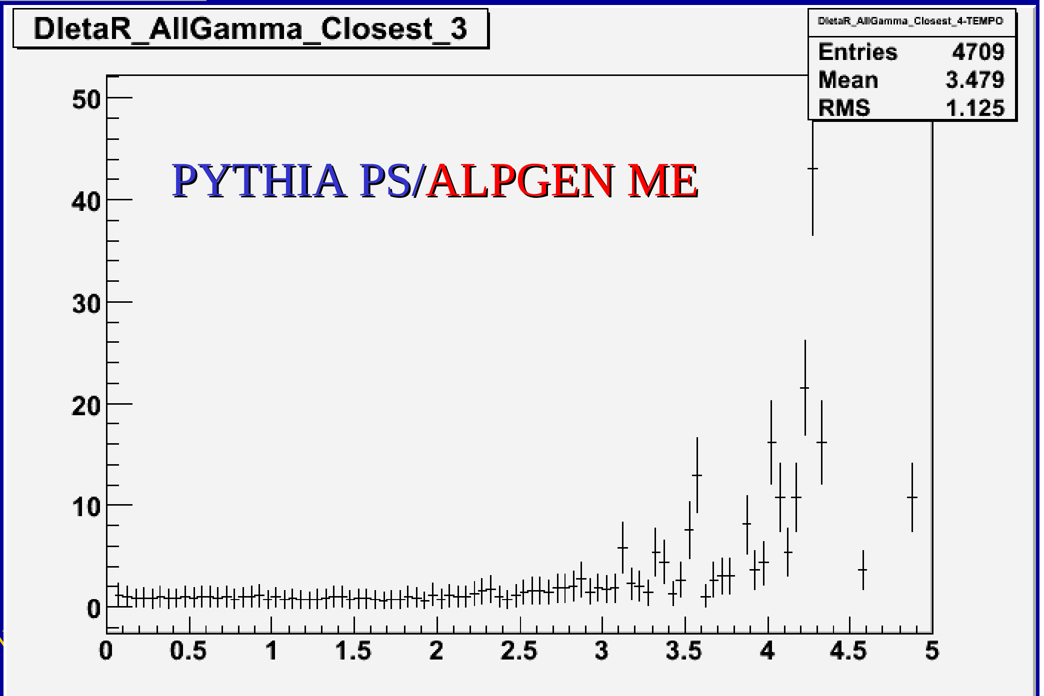
(a 10x higher-stat PYTHIA PS sample is in progress)
- Both samples normalized to 1

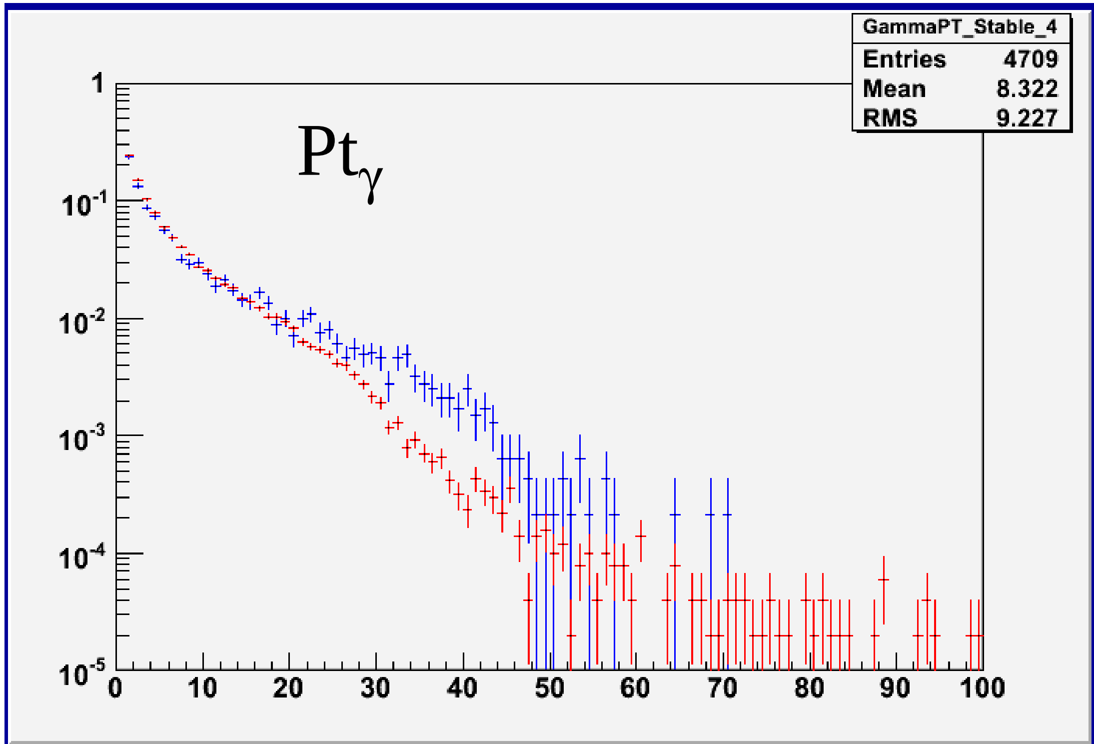


First Indications

γ from PYTHIA PS
γ from ALPGEN ME

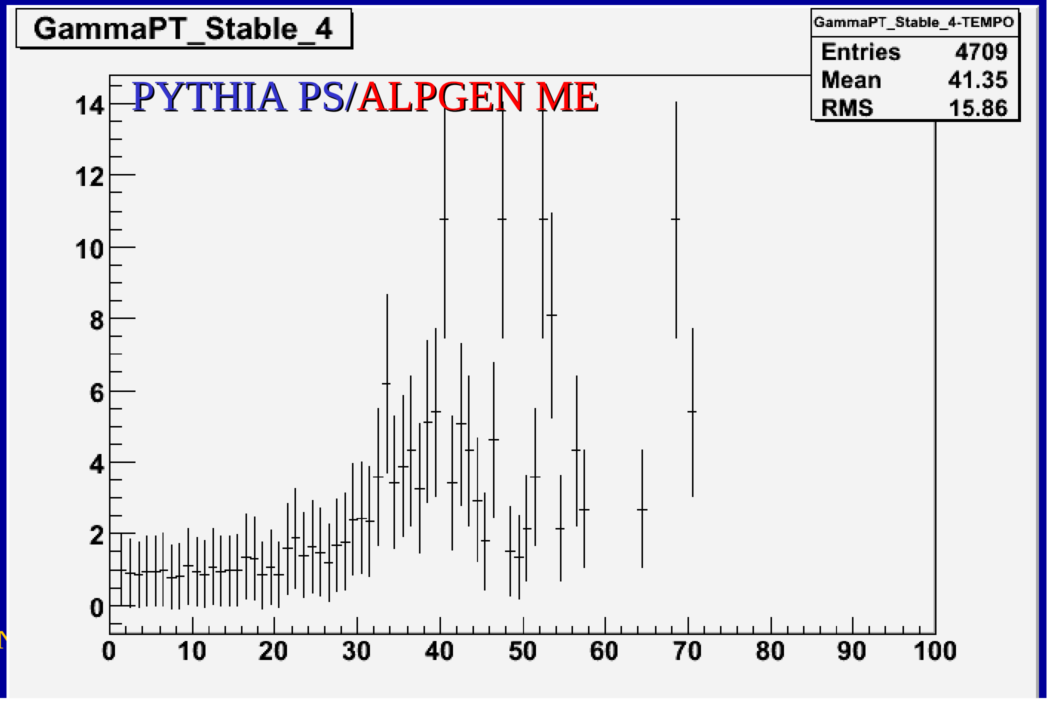
Boundary range~
$0.1<\Delta R(\mu,\gamma_{closest})<1$





γ from PYTHIA PS
γ from ALPGEN ME

Boundary range~
1 GeV< Pt_γ <15 GeV



Prescription from ALPGEN team (II): Envisaged Anti-Double-counting veto procedure

- Given a group of samples with {0, 1,……n,N} explicit photons, for the chosen boundary point (pt_match, dR_match, η_match[fid. Volume]):

- For samples including 0 explicit photons (for example Z + jets)
  veto events with at least 1 photon with:

  pt> pt_match
  AND dR> dR_match
  AND $\eta < \eta$_match
  and keep other events

- For samples including 0 < n< N explicit photons (for example Z + nγ + jets)
  keep only events having exactly n photons satisfying above condition

- For samples including N explicit photons (INCLUSIVE sample)
  keep only events having at least N photons satisfying above condition
  AND Additional condition on the highest-pt photon (γ_1):
  dR (γ_1 , γ_{parton}) < dR_match

Conclusion and Outlook

- We have started trying to implement a prototype electromagnetic PS/ME matching procedure developed by the ALPGEN team for the process $Z\ (+\gamma) \rightarrow \mu\mu + \gamma$
- First boundary range established, we are now starting to check robustness
- If results satisfactory we will choose a final cutoff point and start to produce events according to the proposed veto procedure
- The procedure will eventually be automatised and implemented in ALPGEN as is the case for the QCD PS/ME matching procedure is today
- Other physics cases: $m\gamma$ + njets, W+ $n\gamma$ + mjets, QQ+ $m\gamma$ + njets…

Backup: ALPGEN generation parameters

RUNNING PARAMETERS

Electroweak parameters:

iewopt= 3:

input mW, mZ, GF calculate the rest

M(W)= 80.419 Gamma(W)= 2.04807653

M(Z)= 91.188 Gamma(Z)= 2.44194427

M(H)= 120. Gamma(H)= 0.

gW= 0.65323291; sin^2(thetaW)= 0.222246533; 1/aem(mZ)= 132.50698

Quark masses:

m(top)= 174.3 m(b)= 4.7

Beams' parameters:

beam1=proton, beam2=proton

Ebeam= 7000. PDF set=CTEQ5L

as(MZ)[nloop= 1] = 0.127003172