QCD background rejection for the ttbar all-hadronic channel

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MARIE CURIE ACTIONS

ATLAS

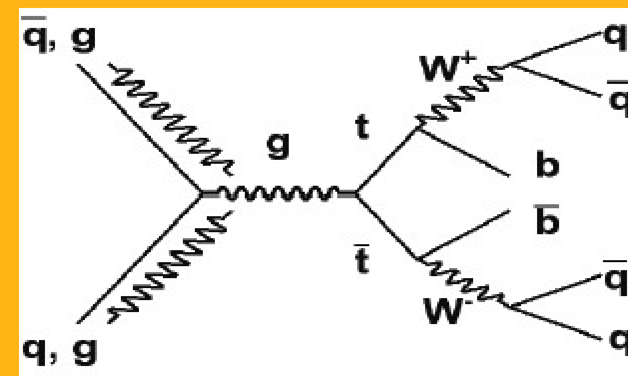
OUTLINE

- all-hadronic ttbar channel and multi-jet QCD events
- preliminary studies at event generator level with Pythia
- forthcoming steps : ALPGEN and detector effects

All-Hadronic ttbar Channel

I'm looking into the all hadronic channel:

- all had has the highest BR (46 %) ==> large statistics
- full event reconstruction
- large combinatorial background: 90 combination/event without b-tagging
- **huge QCD background**



6 high pT jets in the Final State

TRIGGER

↓

first step to achieve a good separation
of the signal from the background

QCD Multi jet background

events with 6 high pT jets in the final state are a background to the all hadronic ttbar signal

in case of available b-tagging at a trigger level as well, the signal from background separation will become easier

AT THE MOMENT only jet trigger are available as well as no b-tagging is foreseen for the first data off-line selection

↕

NEED TO UNDERSTAND THE SIGNAL AND BACKGROUND EVENT TOPOLOGY && DYNAMICS IN DETAIL, IN ORDER TO OPTIMISE CUTS ON JET PT AND ETA

QCD Multi jet background

DISCLAIMER: APOLOGIES FOR THE LEVEL OF SIMPLIFICATION

How can we get 6 high pT jets in the final state from QCD?

APPROACH 1:

- considering the matrix element (ME) of the HARD process at a LO, ONLY for 2->2 parton scatter (like qq-> qq, gg-> qq, qg-> qg ecc..) (pert. QCD)
- “running” parton showering on the two outgoing partons, till the hadronisation scale is reached (pert. QCD)
- hadronisation is performed on the final state partons (non pert. QCD)

QCD Multi jet background

COMMENTS ON APPROACH 1:

- (+) the so called "parton shower" is taking into account that the probability of **soft** or **collinear** emission is highly ***enhanced*** in QCD, this means that running a parton shower implies taking into account higher terms than LO, in specific phase space regions, where they could not be neglected ==> LO 2->2 ME + parton shower is much better than LO, it is called **Leading Log LL** order (the parton shower probability is calculated with large log re-summation)
- (**+**) parton showers provide the most **complete description** of the final state in terms of hadrons ==> **indispensable**
- (**-**)the parton shower works under two approximation : it considers the emission of **SOFT gluons** or the splitting of light quarks into **collinear** partons.

Concerning soft gluon emission, this is suppressed at high angles by theory, so a so called "angular ordering" prescription can be introduced (quantum coherence effects). This is **suppressing HARD gluon emission at large angle** as well, thus **underestimating** the rate of multi-jet final state.

[Mangano, hep-ph/0312117 and Ellis "Pink Book"]

QCD Multi jet background

APPROACH 2:

- calculating the matrix element ME of the scattering process: 2-> n partons (n=8) at LO **IF** the n outgoing partons are **WELL separated** (no collinear phace space)
- this implies an enormous number of Feymann diagrams (see LO gg-> ng)

n	2	3	4	5	6	7	8
# of diagrams	4	25	220	2485	34300	559405	10525900

==> **feasible** with more recent techniques (see Zanderighi part 3 at HCP school)

COMMENTS ON APPROACH 2:

-(**+**)have all diagrams interferences among hard partons taken into account==> provide the **best tool to describe multi jets final state**

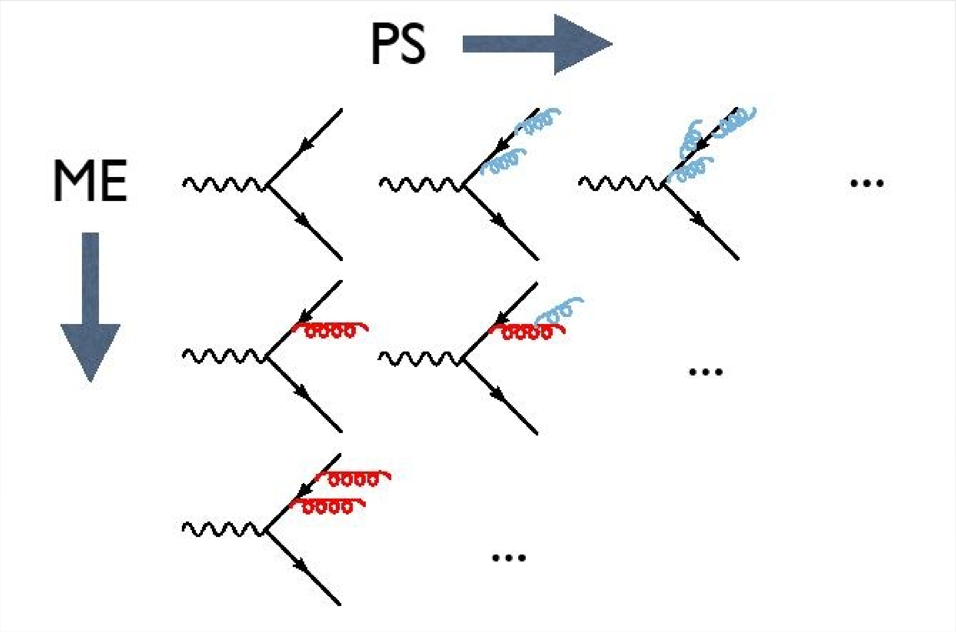
- (**-**) does not provide description of the physics at a soft/collinear regime: it is **not usable ALONE in** realistic detector **simulation**

QCD Multi jet background

Yes, one can "run" parton showering on the outgoing partons from the 2p-> np ME calculation

BUT has to be VERY careful with double counting:

There are different matching scheme that take care of avoiding the double counting!!! like MLM and CKKW
Those are efficient, BUT hard to control and implement....



QCD rejection studies

Preliminary studies at an event generator:
- used **Pythia** for both parton shower and hard process (**APPROACH 1**)
- run jet algorithm on outgoing HADRONS (Kt4)
- applies **multi-jet filters on the truth jets** (|eta|< 3.2 as feasible at trigger level)
- simulate both QCD and ttbar production in this way, applying the same filters

- running Pythia in ATLAS is quite easy
- different parameters are easily tunable
- no "a priori" filter applied
- all the previous studies have been performed with Pythia at 14 TeV ==> useful comparison at 10 TeV

- no detector description is included: vital for trigger studies
- APPROACH 1 is not providing the best theoretical description of multi-jet final states==> ALPGEN samples

QCD rejection studies

Please, look at the tables I have printed out :-):

- the low pT limit of the outgoing parton has been set to 18 GeV (shown to be a "safe choice")
- every row is a different sample, where the efficiency is calculated as how many events survive the multi-jet filter/total number of events generated;
- the first 6 rows, highlighted in **yellow**, are the multi-jet **TRIGGER filters.** The rows in **blue** are the filters that are applied at a truth particle level to the **ALPGEN** samples.

	efficiency	*sigma Pythia*	*eff. * sigma*	*S/B*
5J10_4J35_3J45_J60 ttbar	5.46 10^-1	0.230 * 0.44 nb	5.5 10^-2 nb	**3.7 * 10^-4**
5J10_4J35_3J45_J60 QCD	2 10^-4	751619 nb	1.5 10^2 nb	
4J35_3J45_2J50_J60 ttbar	5.5 10^-1	0.228 * 0.44 nb	5.5 10^-2 nb	**3.3 * 10^-4**
4J35_3J45_2J50_J60 QCD	2.2 10^-4	751978 nb	1.7 10^ 2 nb	
4J45_J60 ttbar	4.1 10^-1	0.231 * 0.44 nb	4.1 10^-2 nb	**5.5 * 10^-4**
4J45_J60 QCD	1.0 10^-4	751305	7.5 10^ 1 nb	
4J17_3J35 ttbar	8.22 10^-1	0.230 * 0.44 nb	8.4 10^-2 nb	**7.5 * 10^-5**
4J17_3J35 QCD	1.45 10^-3	751682 nb	1.1 10^3 nb	

QCD rejection studies

a one-jet filter (1J100) is not efficient ,cause in QCD events, the highest Pt jet has an higher Pt than in ttbar events

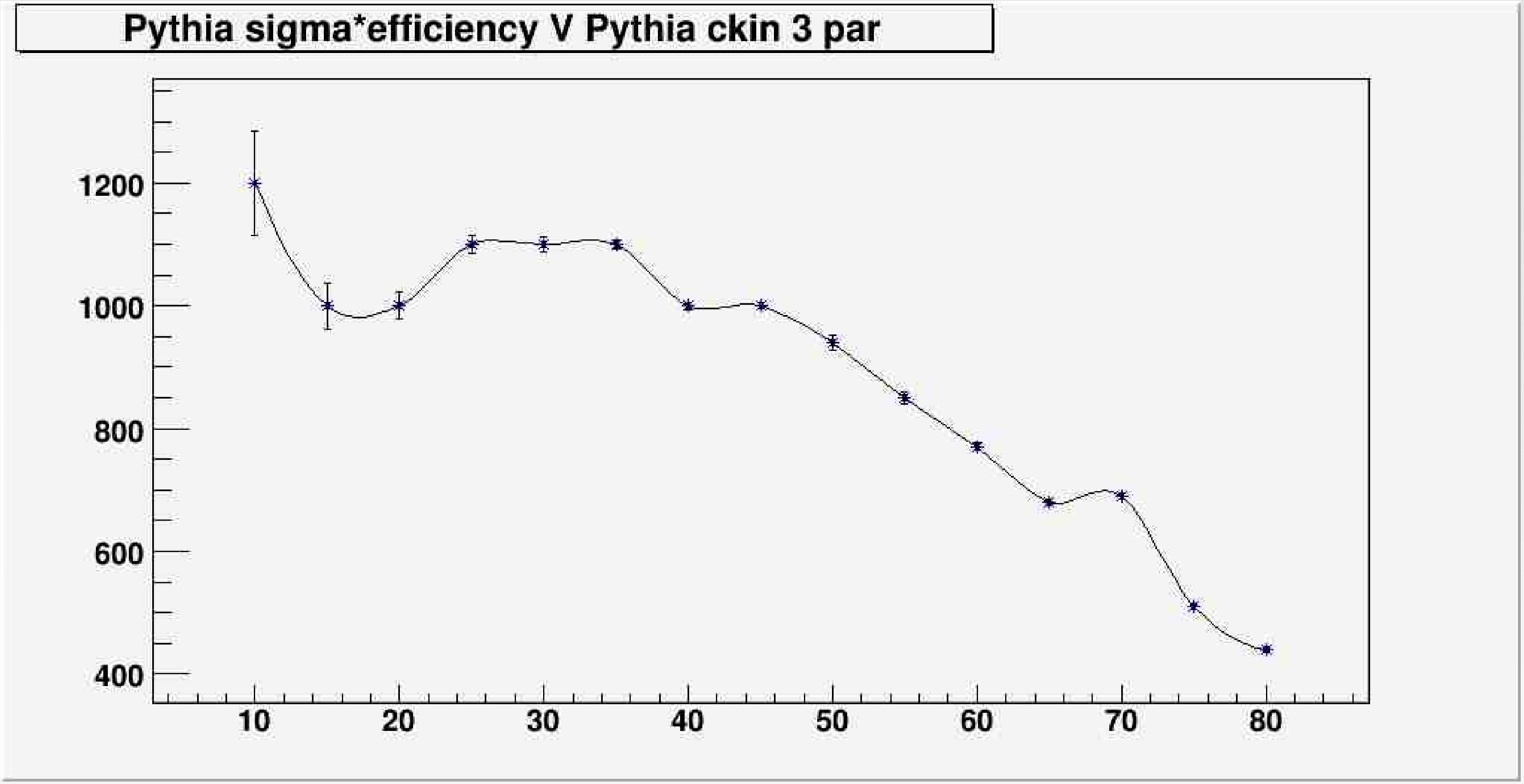
"flat multi-jet" filter (like 6J40) show a better S/B ratio, but a smaller signal efficiency...!!!

NEED to be checked with an APPROACH 2 simulation

1J100 ttbar	5.46 10^-1	0.230 * 0.44 nb	5.5 10^-2 nb	**5.7* 10^-5**
1J100 QCD	1.34 10^-3	751619 nb	1 10^3 nb	
6J30 ttbar	2.5 10^-1	0.230 * 0.44 nb	2.5 10^-2 nb	**1.2 * 10^-3**
6J30 QCD	2.6 10^-5	751716 nb	20 nb	
6J35 ttbar	1.6 10^-1	0.232 * 0.44 nb	1.7 10^-2 nb	**1.9 * 10^-3**
6J35 QCD	1.2 10^-5	752344 nb	9 nb	
6J40 ttbar	1 10^-1	0.230 * 0.44 nb	1.1 10^-2 nb	**3.0 * 10^-3**
6J40 QCD	5 10^-6	752412 nb	3.8 nb	
6J45 ttbar	7.2 10^-2	0.231 * 0.44 nb	7.5 10^-3 nb	**4.9 * 10^-3**
6J45 QCD	2.1 10^-6	751994 nb	1.6 nb	
6J204J40 ttbar	3.74 10^-1	0.230 * 0.44 nb	3.8 10^-2 nb	**1.1* 10^-3**
6J204J40 QCD	5 10^-5	752050 nb	3.76 10^1 nb	

QCD rejection studies

Justification of the low PT cut at 18 GeV: the sigma*efficiency is stable up to 35 GeV!!



Conclusions

Some numbers at 10 TeV:
- integrated luminosity of 200 pb^-1
- all-hadronic cross section (NNLO) 176 pb

==> 35000 events * 0.5 multi-jet selection efficiency = 19000 signal ev

- QCD background LO after trigger = 30000000 ev ==>

LOTS OF WORK TO BE DONE!!

- playing with event generators has been lot of fun and allows to test new ideas on filters easily
- would be nice to repeat the same with ME multi scatter event generators, but it is not easy
- looking forward to the newly produced and simulated ALPGEN samples!!!

Back-up

4J17_3J35 filter:	N events	efficiency	sigma Pythia	efficiency * Pythia
QCD_10	200	2 10^-4	6 10^6 nb	1.2 10 ^ 3 nb
QCD_15	700	7 10^-4	1.46 10^6 nb	1 10 ^3 nb
QCD_20	2000	2 10^-3	509809 nb	1 10 ^3 nb
QCD_25	4900	4.9 10^-3	220078 nb	1.1 10 ^3 nb
QCD_30	9800	9.8 10^-3	109054 nb	1.1 10^3 nb
QCD_35	18000	1.8 10^-2	59508.7 nb	1.1 10^3 nb
QCD_40	30000	3 10^-2	34932.8 nb	1.0 10^3 nb
QCD_45	46000	4.6 10^-2	21727.5 nb	1.0 10^3 nb
QCD_50	6700	6.7 10^-2	14095.5 nb	9.4 10^2 nb
QCD_55	9000	9 10 ^-2	9501.97 nb	8.5 10^2 nb
QCD_60	16000	1.6 10^1	6607.67 nb	7.7 10^2 nb
QCD_65	14000	1.4 10^1	4705.84 nb	6.8 10^2 nb
QCD_70	17000	1.7 10^1	3438.86 nb	6.9 10^2 nb
QCD_75	20000	2 10^1	2549.68 nb	5.1 10^2 nb
QCD_80	23000	2.3 10^1	1935.62 nb	4.4 10^2 nb