FP420 Backgrounds

Andrew Brandt (UT-Arlington)

Marta Ruspa, Univ. Piemonte Orientale & INFN-Torino, Italy

- Much of what is known about pileup background (combination of more than one proton-proton interaction in same bunch crossing) comes from CMS/TOTEM

  trigger studies aimed at reducing rates to O(1 khz) to get events on tape
- This WG's concern is how to reduce these backgrounds to acceptable level offline
- Goal: to evaluate current understanding, prioritize and coordinate work, and enable new manpower

Trigger Note

http://cms.cern.ch/iCMS/jsp/openfile.jsp?type=NOTE&year=2006&files=NOTE2006_054.pdf

Triggering on forward physics at the LHC

M. Arneodo, V. Avati, R. Croft, F. Ferro, M. Grothe[1) 2)], C. Hogg, F. Oljemark, K. Österberg, M. Ruspa

ADD affiliations

Abstract

In this note, we investigate the feasibility of a dedicated trigger stream in the CMS trigger menu, with an output rate of $\mathcal{O}(1)$ kHz on the First Level Trigger and $\mathcal{O}(1)$ Hz on the Higher Level Trigger. By combining jet trigger information from the CMS calorimeter with information from the TOTEM Roman Pot detectors at 220 m distance from the interaction point, the default dijet trigger thresholds foreseen in the CMS trigger tables can be lowered substantially while respecting the CMS trigger bandwidth limits. We demonstrate the efficiency of the dedicated diffractive trigger stream for hard single diffractive and double-Pomeron exchange events.

Highlights to follow

Table 1

Table 1: Reduction of the rate from standard QCD processes for events with at least 2 central L1 jets with $E_T >$ 40 GeV, achievable with requirements on the tracks seen in the RP detectors. Additional rate reductions can be achieved with the H_T condition and with a topological condition (see text). Each of them yields, for all luminosities listed, an additional reduction by about a factor 2.

Luminosity $[\mathrm{cm}^{-2}\mathrm{s}^{-1}]$	# Pile-up events per bunch crossing	L1 2-jet rate [kHz] for $E_T > 40$GeV per jet	Total reduction needed	Reduction when requiring track in RPs				
				at 220 m		at 420 m	at 220 & 420 m (asymmetric)	
					$\xi < 0.1$			$\xi < 0.1$
1×10^{32}	0	2.6	2	370				
1×10^{33}	3.5	26	20	7	15	27	160	380
2×10^{33}	7	52	40	4	10	14	80	190
5×10^{33}	17.5	130	100	3	5	6	32	75
1×10^{34}	35	260	200	2	3	4	17	39

Pile-up: numbers

From Phojet:			
	all diffractive processes	110	mb
	non diffractive processes	51	mb
	elastic processes	33	mb
	single diffractive processes (1)	7.66	mb
	single diffractive processes (2)	7.52	mb
	DPE	1.96	mb
	double diffractive processes	9.3	mb

Number of pile-up events per bunch crossing =
Lumi x cross section x bunch time width x LHC bunches/filled bunches =

$10^{34}cm^{-2}s^{-1}$ x 10^{4} cm^2/m^2 x 10^{-28} m^2/b x 110 mb x 10^{-3} b/mb x 25 10^{-9} s
x 3564/2808 ~ 35

$2\ 10^{33}cm^{-2}s^{-1}$ ~ 7

$10^{33}cm^{-2}s^{-1}$ ~ 3.5

$10^{32}cm^{-2}\ s^{-1}$ ~ 0.35

Why is this linear with luminosity?

Pile-up in RPs

Pile-up sample:

- 500k PYTHIA reweighted to adjust the rate of leading protons to HERA data.

– TOTEM acceptance table used: assume a distance from the beam of

1.3 mm for 220m and 4 mm for 420m

– Sample **does not** contain DPE events.

Calculate probability per pile-up event to satisfy the relevant RP condition, determined separately, and scale it by the average number of pile-up events at the lumi in question:

220m → 0.055 protons per pile-up event
@10^{34} $cm^{-2}s^{-1}$: 35 x 0.055 = 1.93 protons per bunch crossing

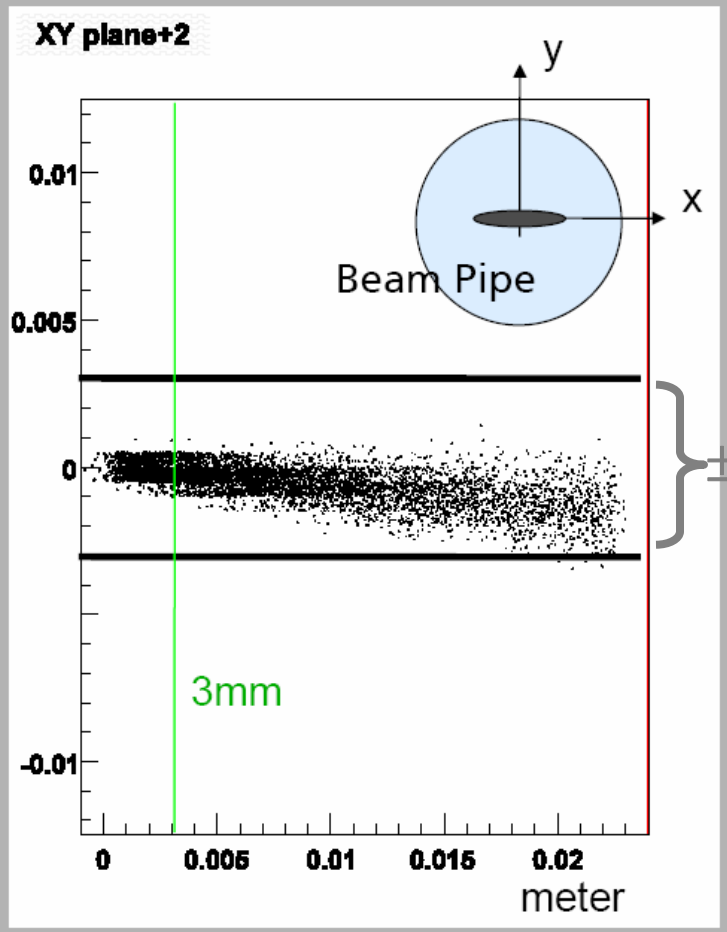
420m → 0.012 protons per pile-up event (83 pileup event needed to have a proton)
@10^{34} $cm^{-2}s^{-1}$: 35 x 0.012 = 0.42 protons per bunch crossing
Therefore:

- around 7x 1.2% = 8.4% of single diffractive interactions in the pile-up will lead a track at 420m (7 since diffractive is ~1/7 of total
- effective cross section for a proton at 420m is 1.2% of 105 mb (1.26 mb).

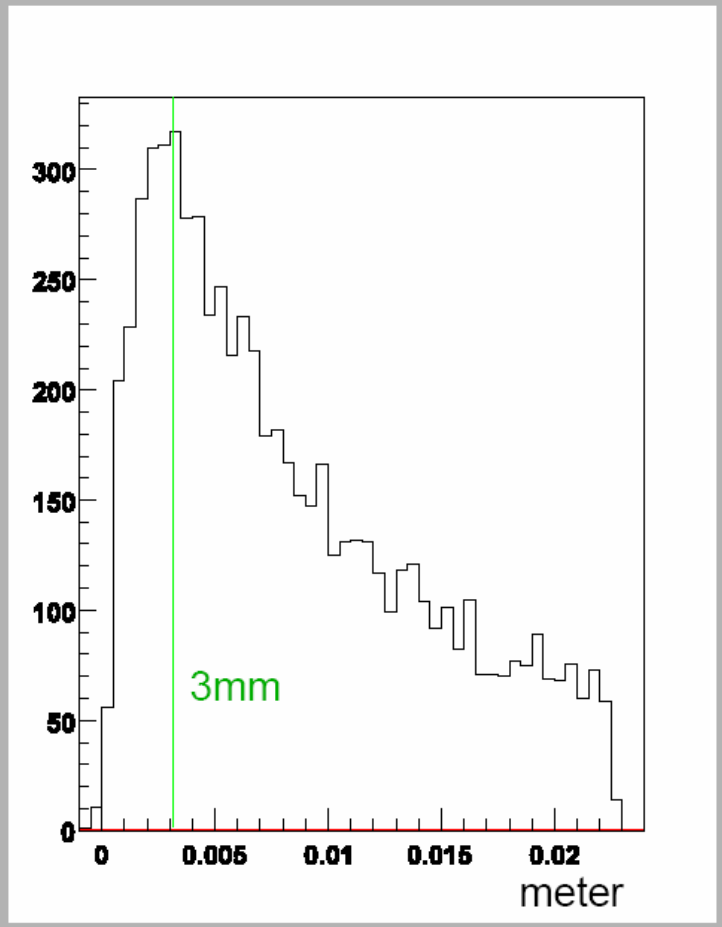
Needed: PHOJET or POMWIG sample to estimate contribution of DPE to the pile-up when double-sided 420m required.

Where do Protons go at 420m?

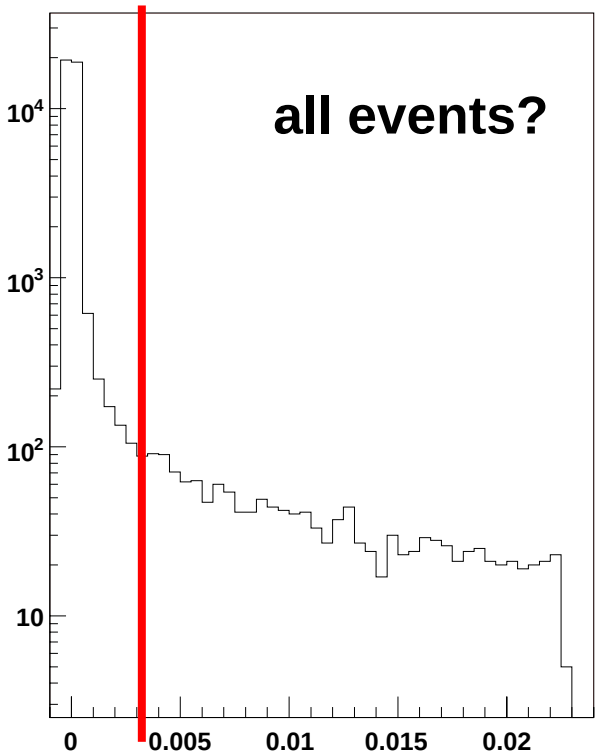
120 GeV Higgs courtesy Peter Bussey, Manchester.

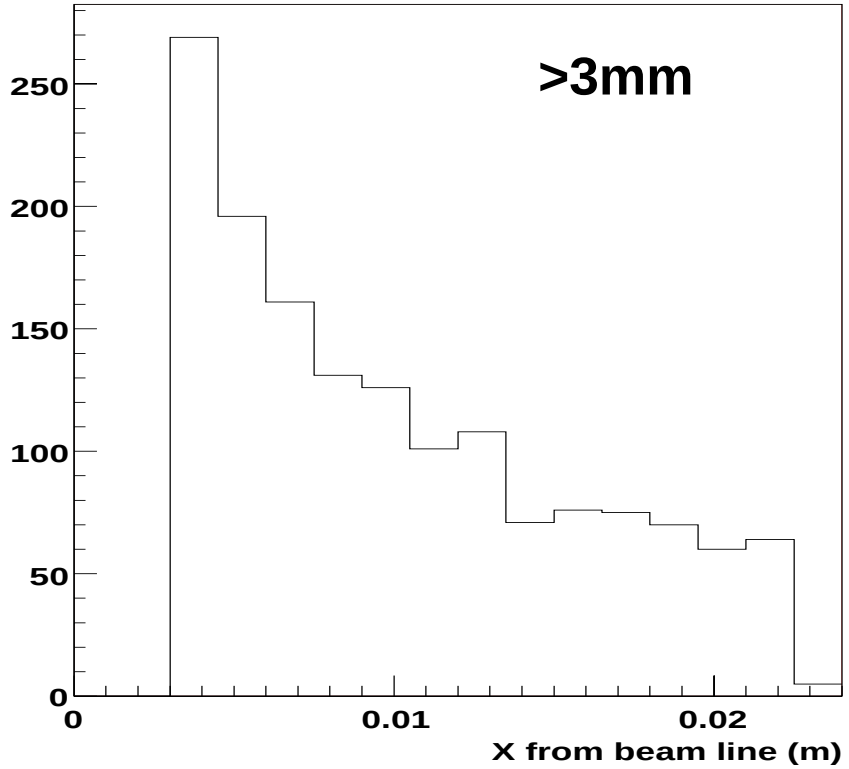


±3 mm



PYTHIA SD propagated to 420m by Peter

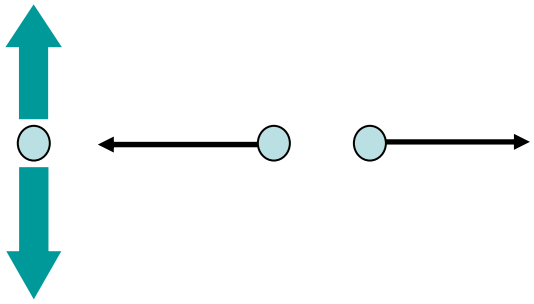




- Only 1200-1300 events with x>4mm, however it looks like whole sample of 500k not used; Peter will confirm what he did, remeasure 1.2%

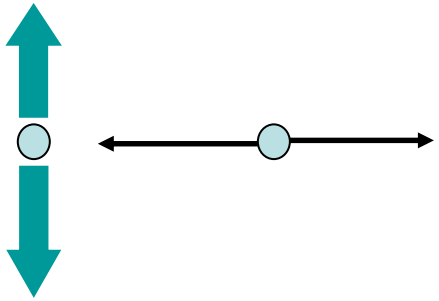
QUARTIC Background Rejection (UTA)

1) 2 single diffractive protons overlayed with a hard scatter (1% of interactions have a proton at 420m)



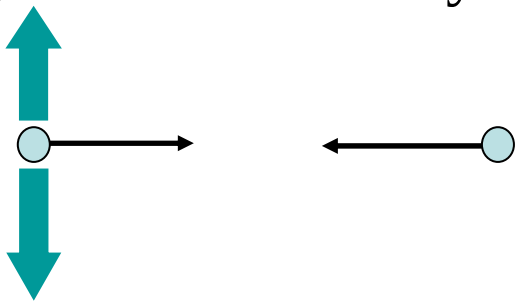
97.4% of events primary vertex and fake vertex from combining proton times more than 2.1mm (1σ) apart ; 94.8% if 20 psec

2) double pomeron overlayed with a hard scatter



97.8% of time vertices more than 2.1mm apart; 95.6% if 20 psec

3) hard SD overlayed with a soft SD



95.5% of time primary vertex and fake vertex more than 2.1mm apart; 91.0% if 20 psec

Backgrounds

Want to simulate, get magnitudes, study rejection

Note for FP420 $0.002<\xi<0.015$ so this is not really soft diffraction M(SD)> 600 GeV, propose using POMWIG with low PTmin rather than Phojet

1) pileup backgrounds with fake Higgs

B/QCD + 2 SD protons → toy MC from Andy *trigger note case

B/QCD + DPE

Hard SD + soft SD

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2) pileup backgrounds with real Higgs

H + 2 SD protons

H + DPE

SD H + SD proton

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3) physics backgrounds

Various DPE channels, including non-exclusive higgs

Andrew's Shopping List

- Peter re-checks the 1.2% number
- What new background files needed are needed? (see previous slide, should have POMWIG "soft" SD+DPE samples for pileup studies)
- Towards a full study including detector and trigger simulation for both ATLAS and CMS: show significance for H at a few different masses in a few channels, e.g. H→ b bbar, H→ WW, MSSM H → b bbar for standard lums 30, 100 fb-1 - signal/background after analysis:

  - calculation of fake CED cross section before cuts as f(lumi)

  - calculate background using fake mass obtained by picking protons at random from distribution of pile-up protons in pots and resolution parameters; include timing rejection
- see Marek's studies, let us avoid duplicating work!
- x distribution in 420m pots after other cuts to see how important x-segmentation timing is for extra protons

Wisconsin MC samples

H→b bbar (120 GeV) and H→b bbar (140 GeV):
- available either with or without the appropriate pile-up
for L=10^{33}, 2 x 10^{33}, 10^{34}, each 100K
- generators: EXHUME 1.3.1 and EDDE (for b bbar case)

Hard single diff. production of
-Dijets
-Ws decaying to anything
-Ws decaying to final states with muons
-Zs
100K each, no pile-up case

CMS full detector sim, no sim of protons

Pure pile-up, genuine minumum bias sample: 500k PYTHIA events

Generation of DPE events with PHOJET on going

Plan to generate more samples (e.g. H→ b bbar 60 GeV, 80 GeV)
More can be generated as needed.

Work in Progress

•Marek Tasevsky in CMS has done an extensive study of the light H-> b bbar at 120 GeV and H-> WW at 140GeV and the MSSM light Higgs. He works closely with the Durham group. So far he hasn't looked into the effect of pile-up, but is planning on working on that as well. In addition, he'll look into the QCD-mixed-with-pile-up background.
(help needed)

•Richard Croft has extended his L1 studies to also cover the HLT. He used Mike's xi matching method (xi from dijets and xi from RPs) to arrive at a rate estimate for HLT.
updated note?

• Andy Pilkington evaluating magnitude of pile-up problem for SD+SD+bbbar, creating pileup tools (next talk)

Studies done with PYTHIA so far; PHOJET in preparation (essential for DPE).

None of the estimates of pile-up background in RPs so far includes any detector simulation or reconstruction:

- how many protons can the detector reconstruct as separate entities?
- how well might it be able to tell pile-up protons from signal protons?

Nikolai Mokhov

- Will produce a background file at 420m for both ATLAS and CMS in the form of particle fluxes through the whole tunnel cross section.
- Similar files are already available for 220m location (some issues with this data).
- Mike Albrow can act as contact person to Nikolai.
- Brian will provide computing resources
- WG should prioritize requests

Warning from Monika about 220m backgrounds

TOTEM recently distributed the statement that the beam-beam background in their detectors is much higher than thought (around 4% per event). The number they quote would actually cause problems in using the 220m pots in the trigger already at $L=10^{33}$ This background comes from particles showering somewhere along the ring.

Andrew's comment:
About these spray backgrounds, I've been viewing them as something that just wipes out an event (maybe we can recover some), so it's just an efficiency loss when it happens during a real event. For 220m it is a trigger issue as well, but don't think this is the case for fp420, where we could remove these at the higher level trigger.

Marta's (naïve) questions

- **How do we play with that nearly half-a-proton overlaid to our signal at full lumi?**

- **How well can we tell signal protons from background protons:**
  - **need to apply kinematic cuts and timing cuts to background and see what happens (by background I mean QCD + pile-up)**
  - **need to go to reconstruction and see what happens**

- **What do the background protons do when passing through the detector in terms of multiple interactions and multiple scattering?**

- **How far are we from having a full G4 simulation of all the setup (quartic+FP420)?**

Andrew's comment on Simulations (for discussion)

1) get 4 vectors from MC then peter bussey and others can propagate them,

this can be part of a fast fp420 simulation which could then be

combined with a simple central simulation for first estimate.

a) then replace with full central detector sim

2) full mokhov mars sim combined with simple fp420

b) the whole detailed sim that marta proposes

note 1a) does not have to be from mokhov if someone else can do it faster

than mid-june.

Based on time scales it may make sense to skip some (all) of intermediate steps.

Common Meetings?

- CMS has regular diffractive meetings which we are invited to attend, but focus is broader than FP420.

- We decided for now to have parallel background meetings to deal with FP420specific issues.

New Manpower?

- UTA students will work with Andy, Athena
- Others?