Background & Trigger studies

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Presented by V. Avati

Disclaimer

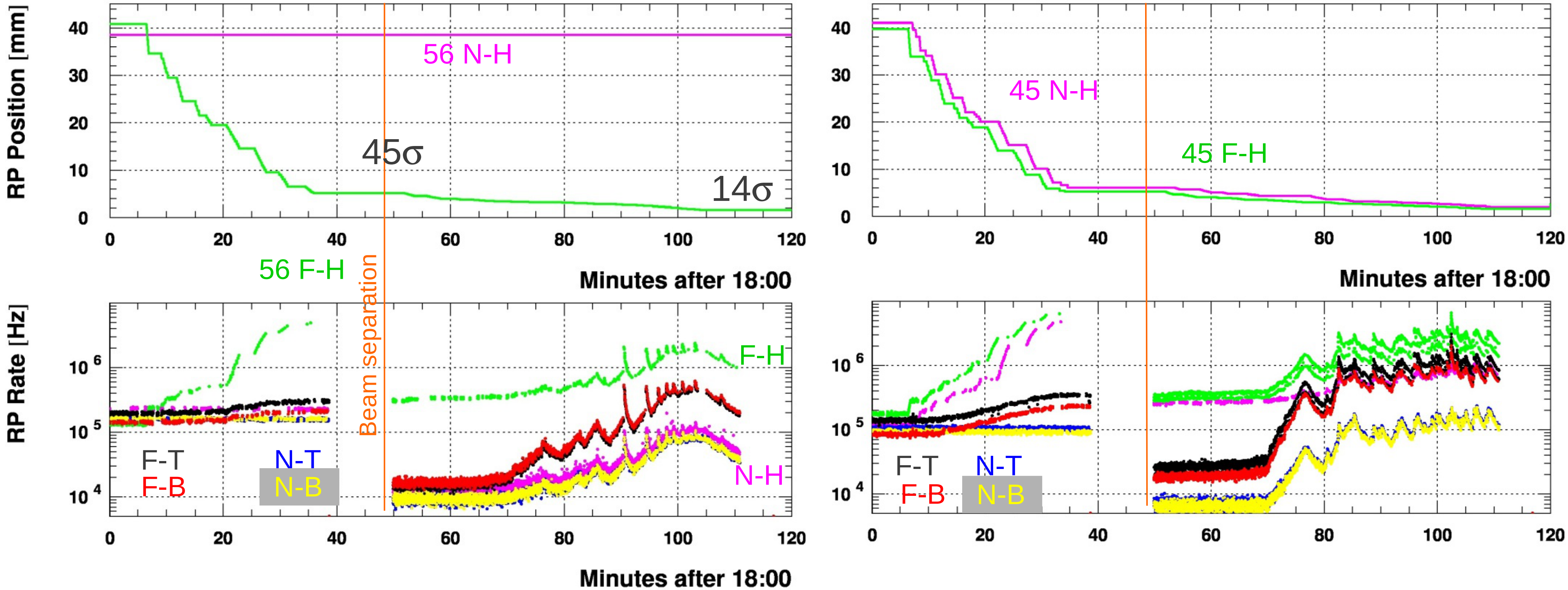
- The results presented in this talk are preliminary
- It is challenging to simulate or extrapolate the conditions in the accelerator for high luminosity
- The background and the trigger rate will be very much dependent on the beam conditions, which are difficult to predict
- The goal of this presentation is:
  - make you aware of the difficulties of proton detection in RP at high luminosity
  - propose some ideas on how to overcome some problems

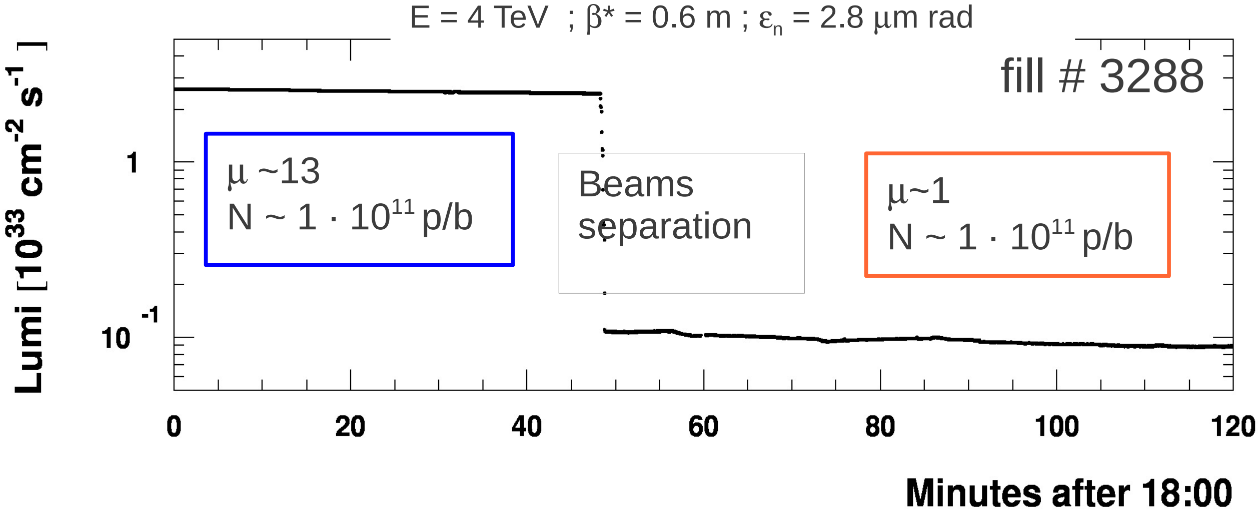
What can we learn from data?

RP insertion 15/11/2012

TCL5 at 60 sigma = 21 mm

Reference time: 15 November 2012, 18:00 h





Rate for 1368 b with separ.	56F-H 2 MHz	45N-H 1 MHz	45F-H 3 MHz

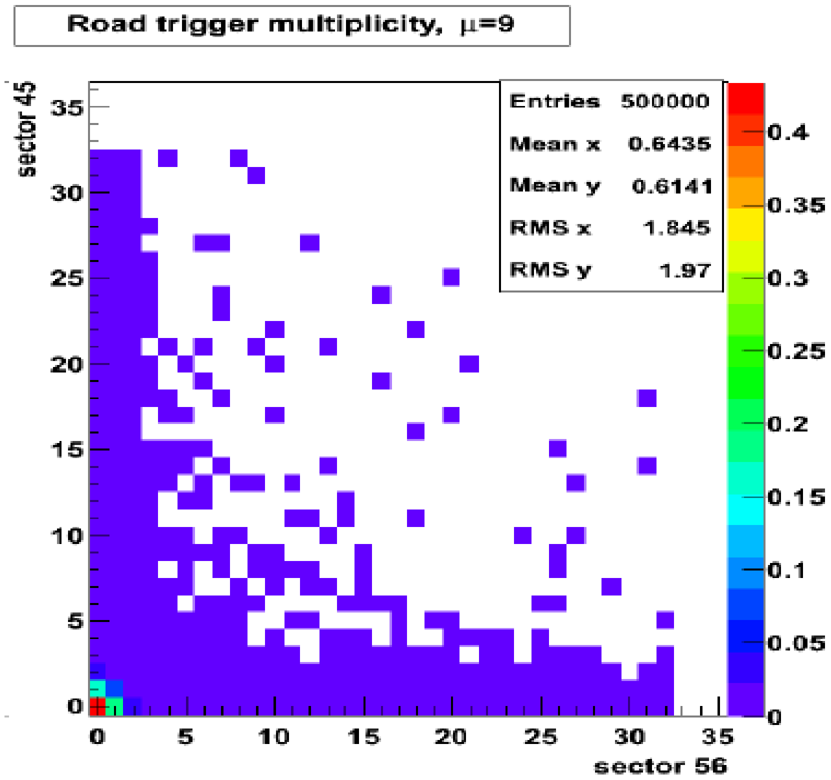
Extrapolated rate for 1368 b without separ.	56F-H 31 MHz	45N-H 19 MHz	45F-H 68 MHz

What can we learn from data?

Sample

$\beta^* = 0.6$ m ; E = 4 TeV ; $N_p \sim 0.8 \times 10^{11}$ p/b ; $\varepsilon_n \sim 2.5$ μm rad ; 1 bunch; $\mu \sim 9$; $L \sim 10^{30}$ Hz/cm^2

RP Alignment (6σ)



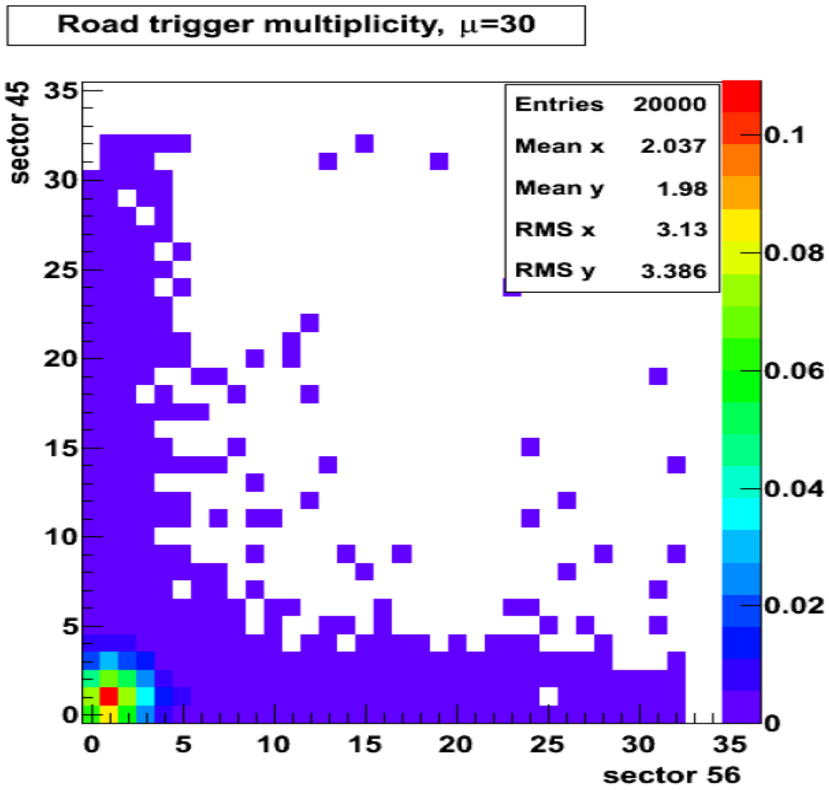
rate/bunch (khz)	DATA μ=9	
RP_45 || RP_56	RP_1arm	RP_2arms
6.6	4.3	1.4

What can we learn from data?

Sample

β^* = 0.6 m ; E = 4 TeV ; N_p ~ 0.8 x 10^{11} p/b ; ε_n ~ 2.5 μm rad ; 1 bunch; μ ~ 9 ; L ~ 10^{30} Hz/cm^2

RP Alignment (6σ)



rate/bunch (khz)	DATA μ=9	
RP_45 || RP_56	RP_1arm	RP_2arms
6.6	4.3	1.4

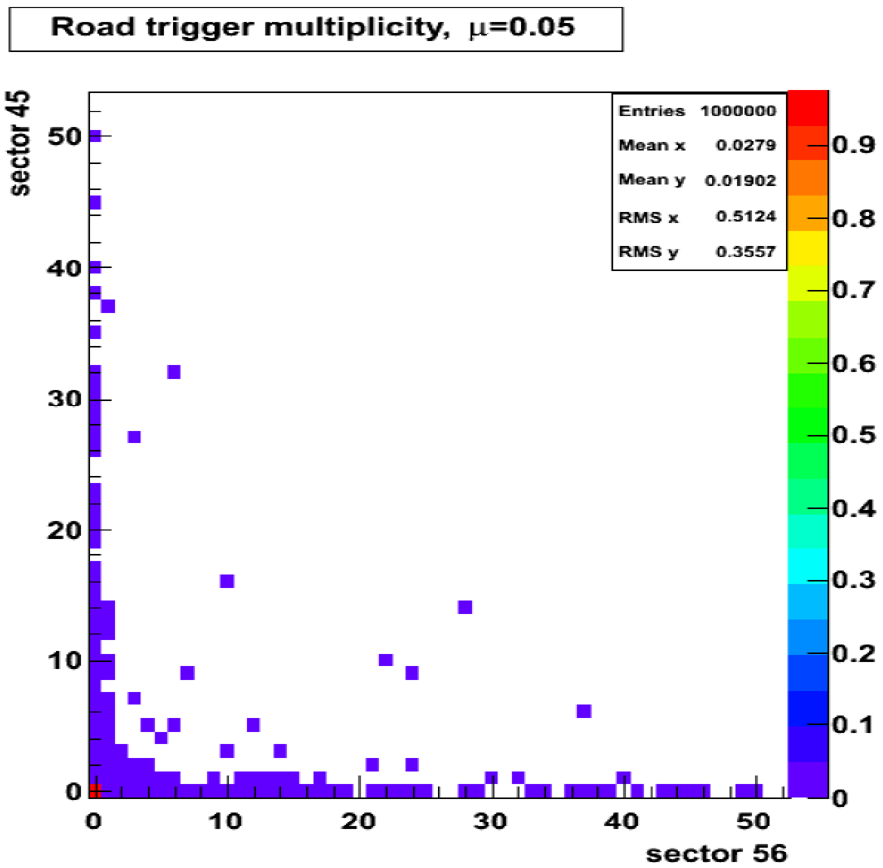
rate/bunch (khz)	EXTRAPOLATED μ=30	
RP_45 || RP_56	RP_1arm	RP_2arms
10	4	6.5

What can we learn from data?

Sample

$\beta^* = 90$ m ; E = 4 TeV ; $N_p \sim 0.8 \times 10^{11}$ p/b ; $\varepsilon_n \sim 2.5$ μm rad ; 112 b; $\mu \sim 0.05$; $L \sim 10^{30}$ Hz/cm^2

Physics data taking (10σ)



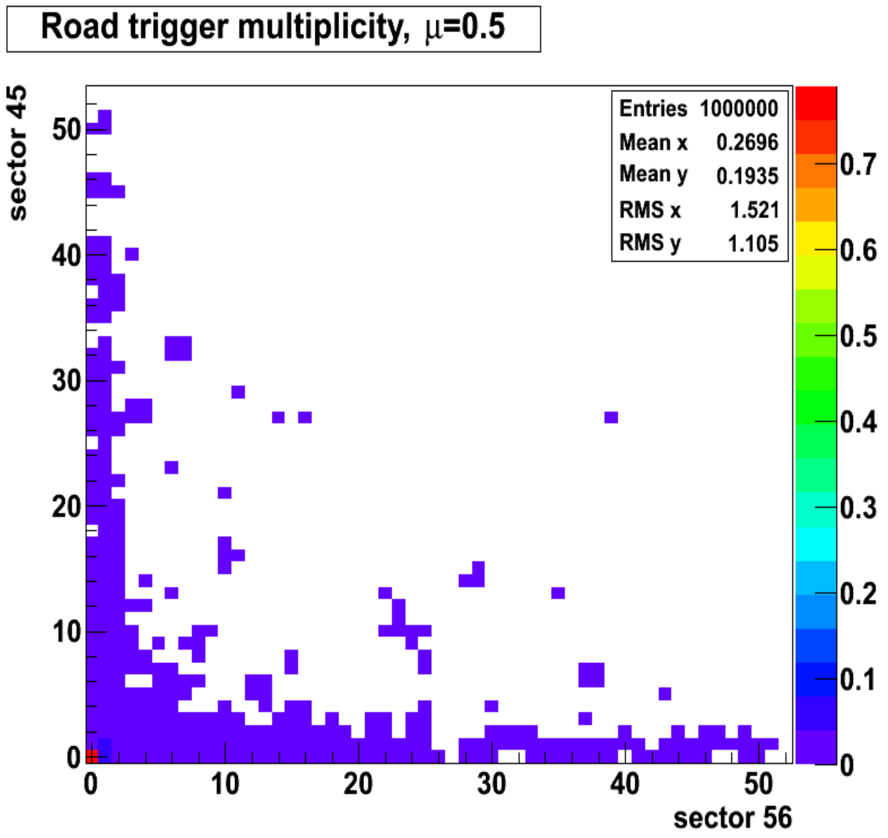
rate/bunch (hz)	DATA μ=0.05	
RP_45 || RP_56	RP_1arm	RP_2arms
1100	150	100

What can we learn from data?

Sample

β^* = 90 m ; E = 4 TeV ; N_p ~ 0.8 x 10^{11} p/b ; ε_n ~ 2.5 μm rad ; 112 b; μ ~ 0.05 ; L ~ 10^{30} Hz/cm^2

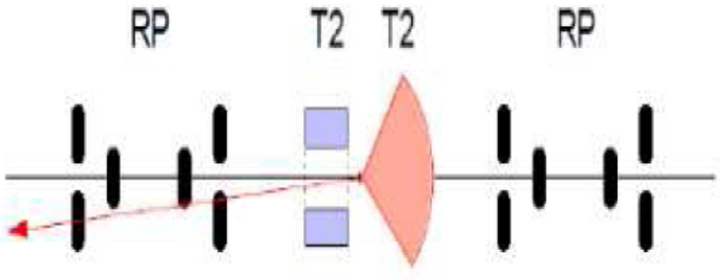
Physics data taking (10σ)



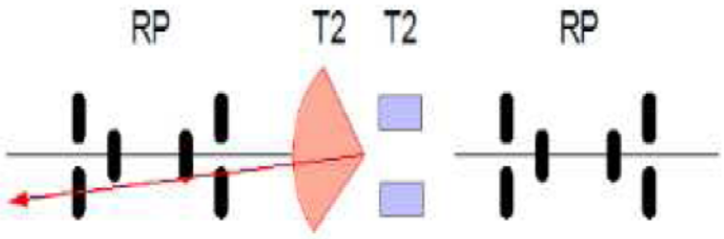
rate/bunch (hz) DATA μ=0.05		
RP_45 || RP_56	RP_1arm	RP_2arms
1100	150	100

rate/bunch (hz) EXTRAPOLATED μ=0.5		
RP_45 || RP_56	RP_1arm	RP_2arms
3000	1100	1000

Background estimate: **collision debris (low β) & beam halo (high β)**



"RPT2 Opposite" enriched of
diffractive protons



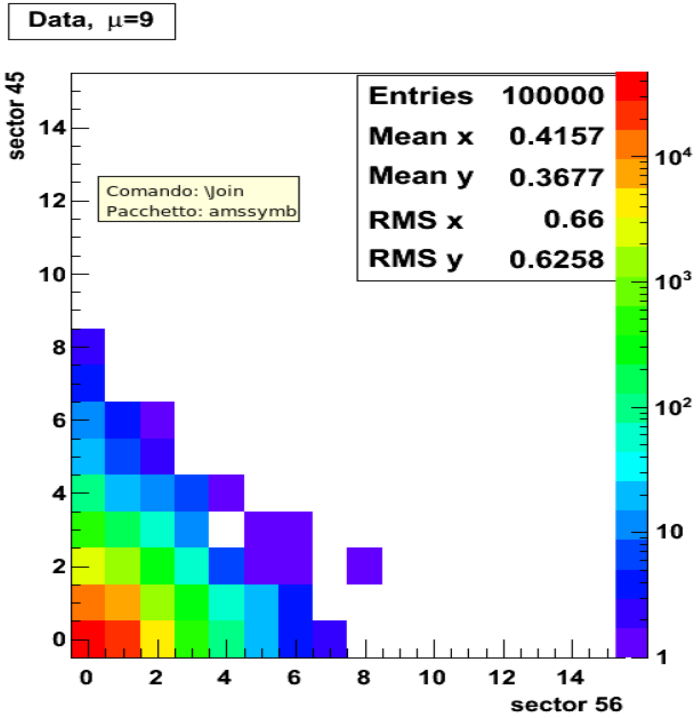
"RPT2 Same" enriched of
background protons

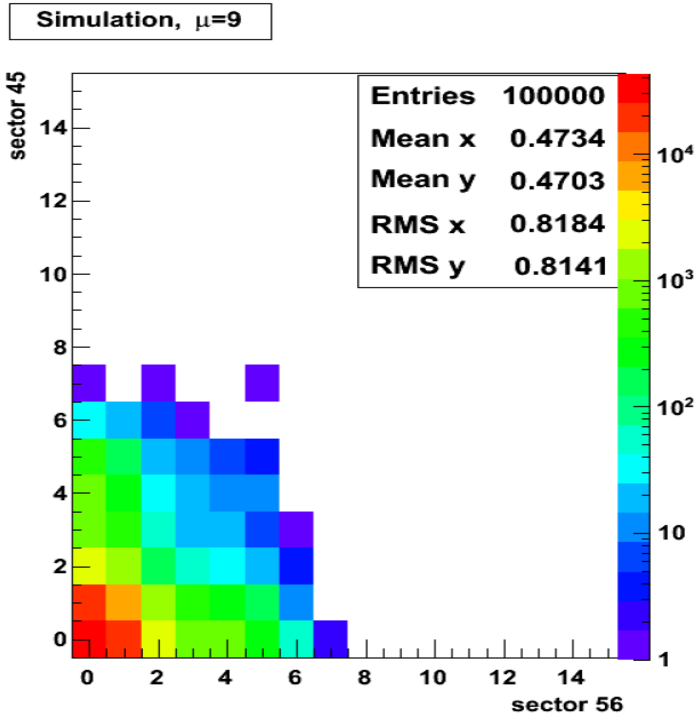
From data: background probability ~ 17%

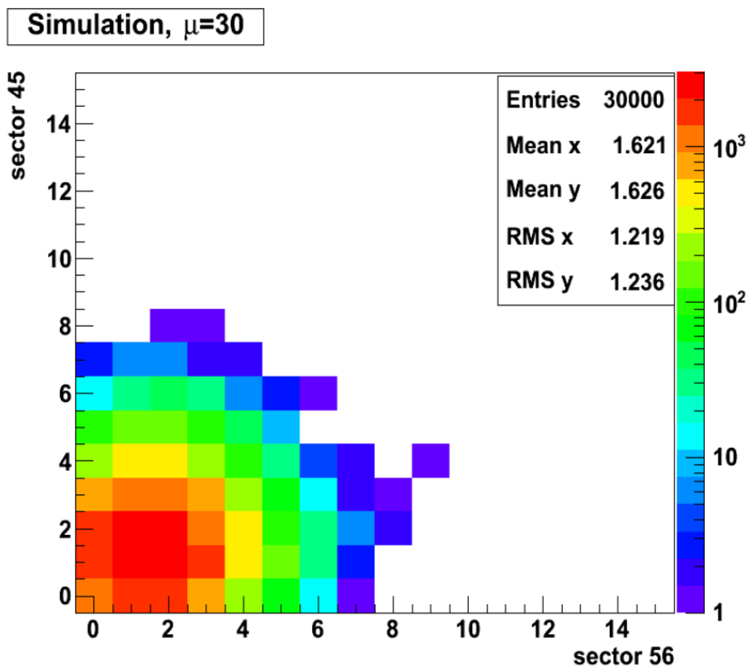
Strategy to extrapolate the background cross checked with simulation in order to reproduce the track multiplicity in data (some rescale factor needs to be applied!)

Estimate of the collision debris for high-β in progress

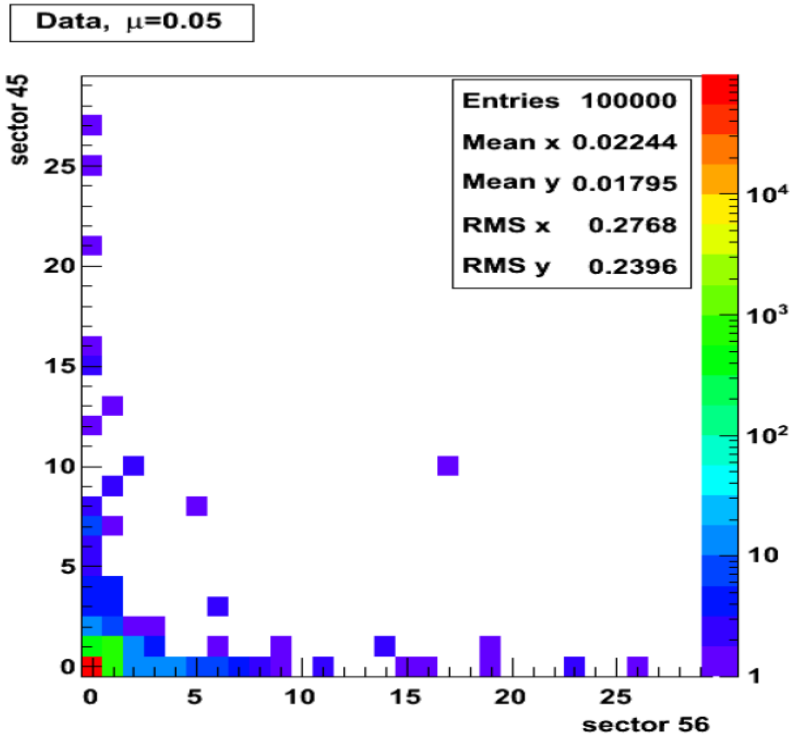
Simulation vs Data : Track multiplicity – low β

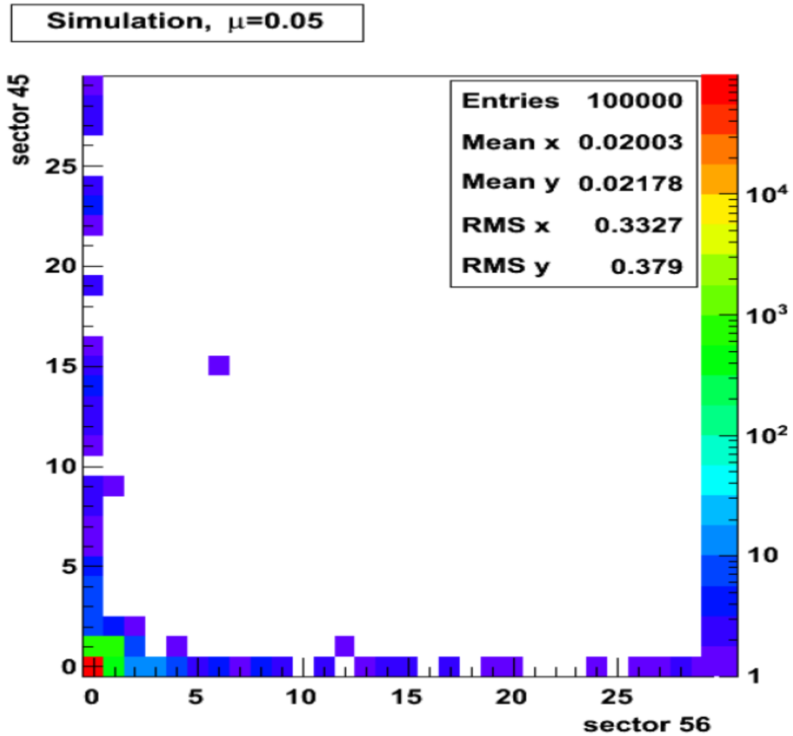


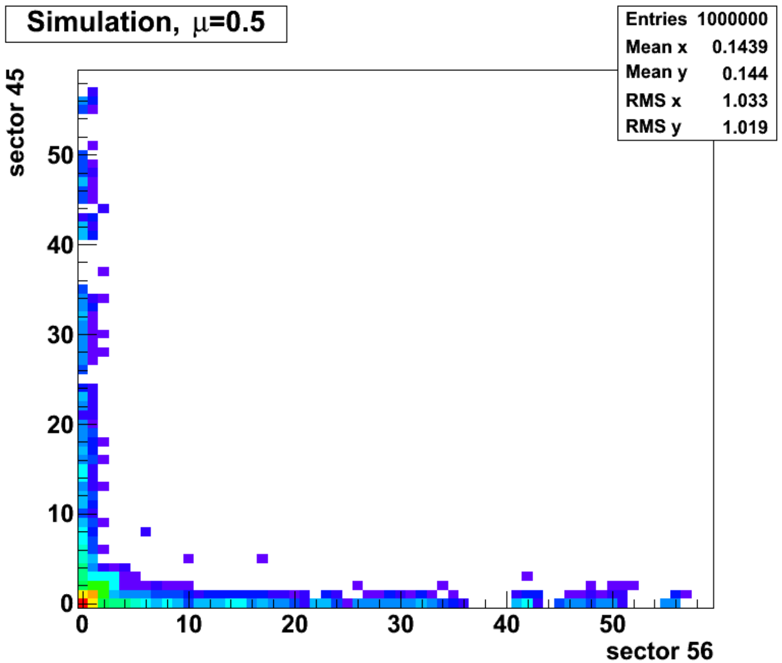




Simulation vs data : Track multiplicity – high β



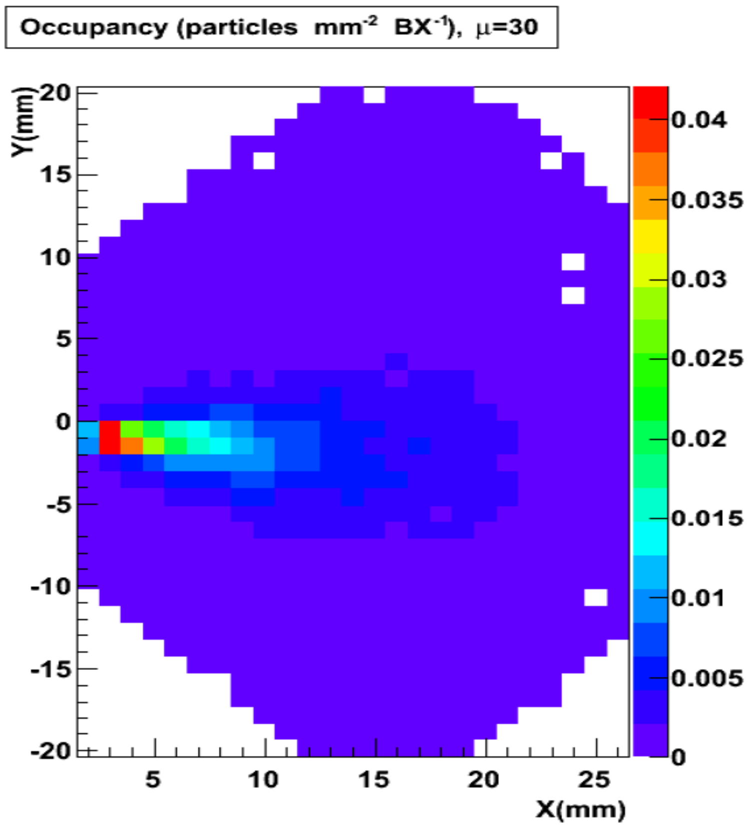


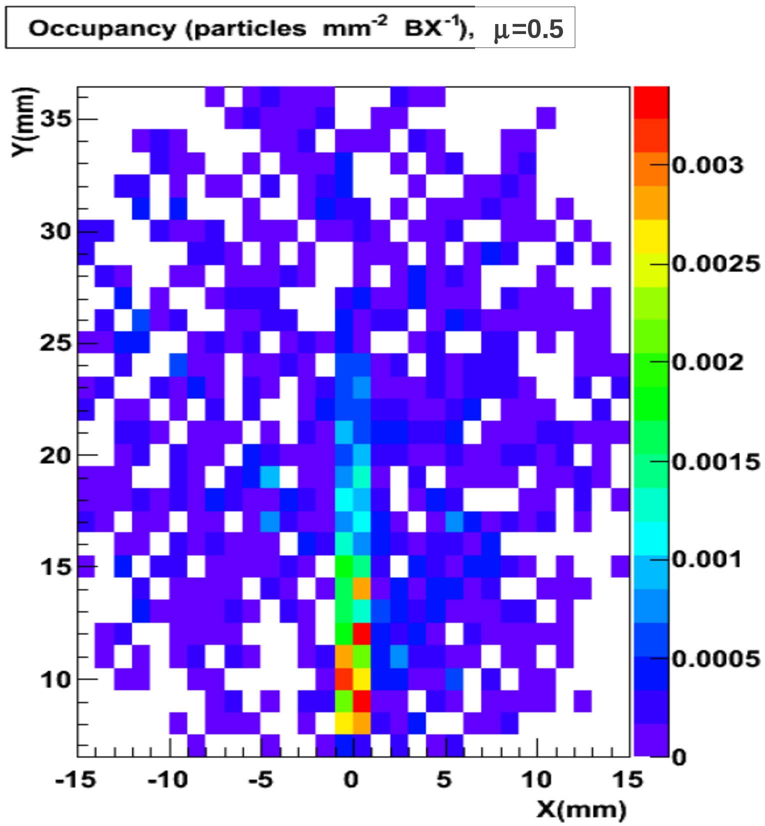


We assume we can simulate the background, also in terms of spacial coordinate.

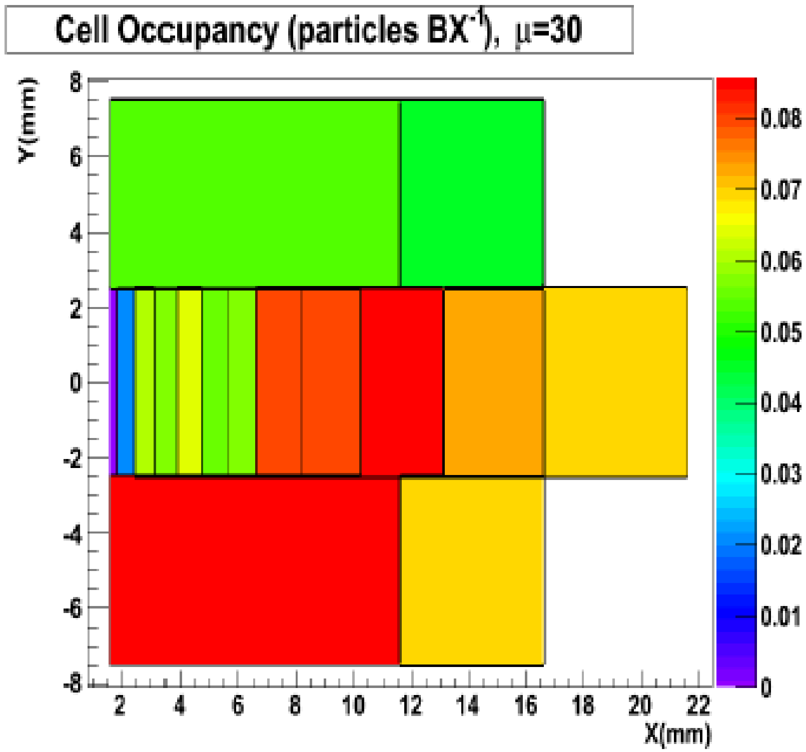
This allows to:

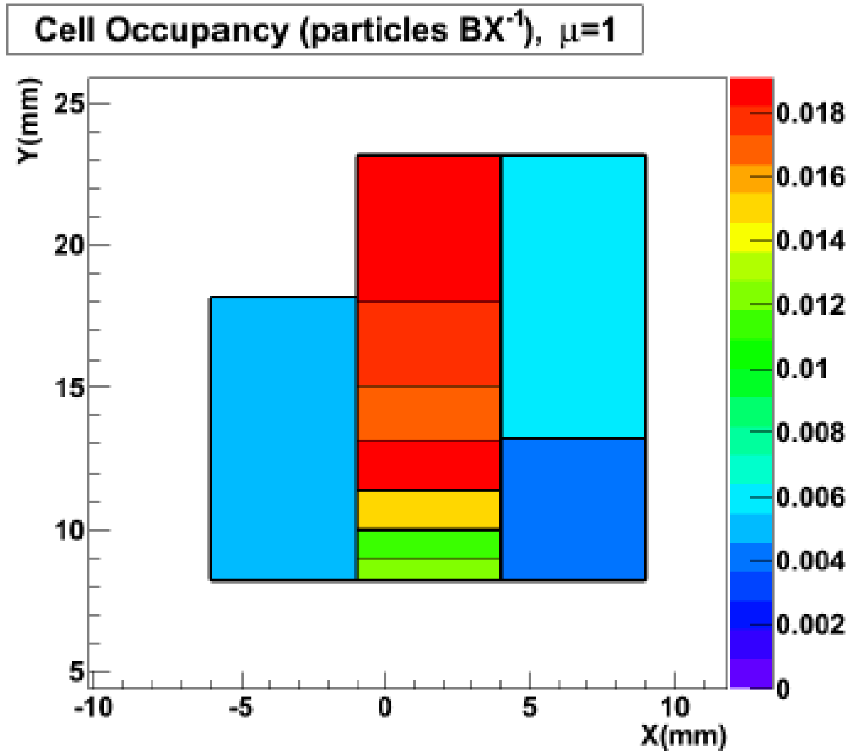
- study optimization of the read out geometry of timing detectors
- study trigger algorithms (L1, HLT) to detect central diffractive events at very high pile-up





Timing detector geometry: optimization of cell geometry





Inefficiency (CD event) due to multiple hits in one cell

	μ =30 M-Cut	μ =30, No M-Cut	μ =50, No M-Cut
Optimised geometry	9%	19%	29%
Fixed square cells	18%	36%	50%

	μ =0.5 M-Cut	μ =0.5 No M-Cut	μ =1 No M-Cut
Optimised geometry	1.1%	1.1%	2.5%

Trigger studies: low β

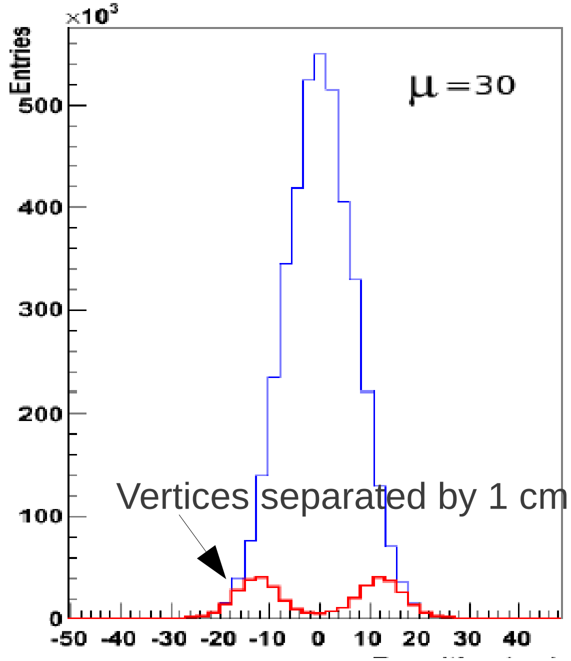
Definition of cuts:

➢ Double Arm : signal in left & right arm to tag Central Diffraction
➢ 2x2 trigger roads: max 2 roads on each arm – to exclude showers generated close to the detector

➢Timing detector resolution = 25ps

➢Observables: t_{p1} , t_{p2}
$t_{IP} = (t_{p1} + t_{p2})/2 - t_{detector}$ → time of the collision
$\Delta t = t_{p1} - t_{p2} \sim z_{vertex}$ → position of the vertex

➢ Background: a little delay is added as the path should be different from the protons in the beam



Vertex z position (cm)

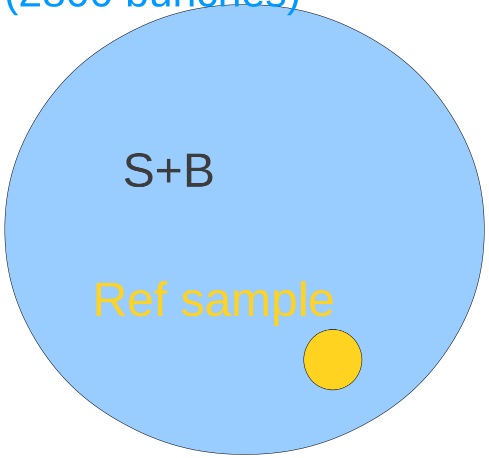
Reference sample:

Central Diffractive events
2x2 trigger roads max
vertex separated by 1cm

Trigger studies: low β

μ=30 (50)

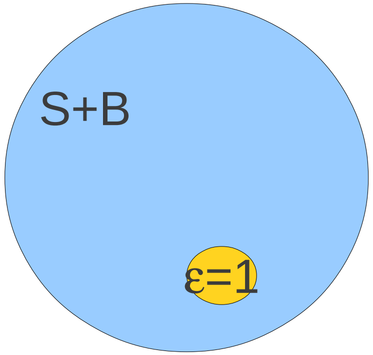
Double arm trigger: 18 (25) Mhz (2800 bunches)



Ref sample/all = 2 (0.5) %

Multiplicity cut on 2x2 trigger roads (L1)

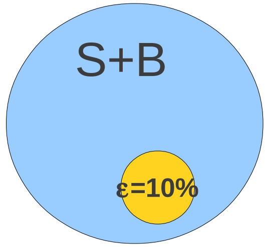
5 Mhz (3 Mhz)



Ref sample/all = 4 (3) %

Δt (L1)

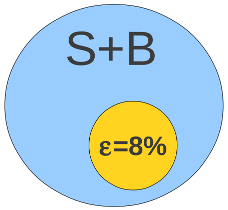
65khz (43khz)



Ref sample/all = 9 (7) %

proton_vertex & CMS_vertex match (HLT)

17khz (11 khz)



Ref sample/all = 18 (11) %

Trigger cuts allow to suppress the rate by 3 order of magnitude; further reduction can be achieved including central object selection

The purity of the reference sample is increasing

Trigger selection for CD events with an isolated vertex:

μ**=30** σ_{eff} **~ 2·10^{-4}** σ_{CD} ~ *2 · 10^{8} event/day*

μ**=50** σ_{eff} **~ 4.3·10^{-5}** σ_{CD} ~ *8 ·10^{7} event/day*

TOTEM

Trigger studies: high β

- Comparison with / without timing detectors
- Timing detectors allow the association vertex_cms & vertex_RP
- Only beam halo background included

Double arm rate
(1000 bunches)
μ=0.5   1Mhz

Multiplicity cut on
2x2 trigger roads
(L1)

Double arm rate : 0.8 Mhz

Eff	Purity
29%	71%

With timing detector

top-top/bot-bot (L1)
proton_vertex & CMS_vertex match (HLT)

Double arm rate 8.8 khz

Eff	Purity
49%	93%

Trigger selection for DPE events with correct vertex:

$\mu=0.5 \qquad \sigma_{eff} \sim 0.09 * \sigma_{CD} \sim 5 \cdot 10^{8}$ *event/day*

Summary

By exploiting the existing TOTEM-RP data we are trying to model the conditions at higher luminosity in different beam conditions

At high luminosity the L1-Trigger rate, based only on protons is very high: several strategies have been investigated to reduce the rate and increase the capability to detect interesting processes

These studies show that an optimization of the timing detectors can contribute

Future plans: finalize the estimate of the different backgrounds and establish a reference which can be used to study trigger algorithm combining forward protons with central objects