Quinto Convegno Nazionale sulla Fisica di ALICE
Trieste, 12 – 14 Settembre 2009

Selezione di eventi diffrattivi in p-p mediante gli ZDC

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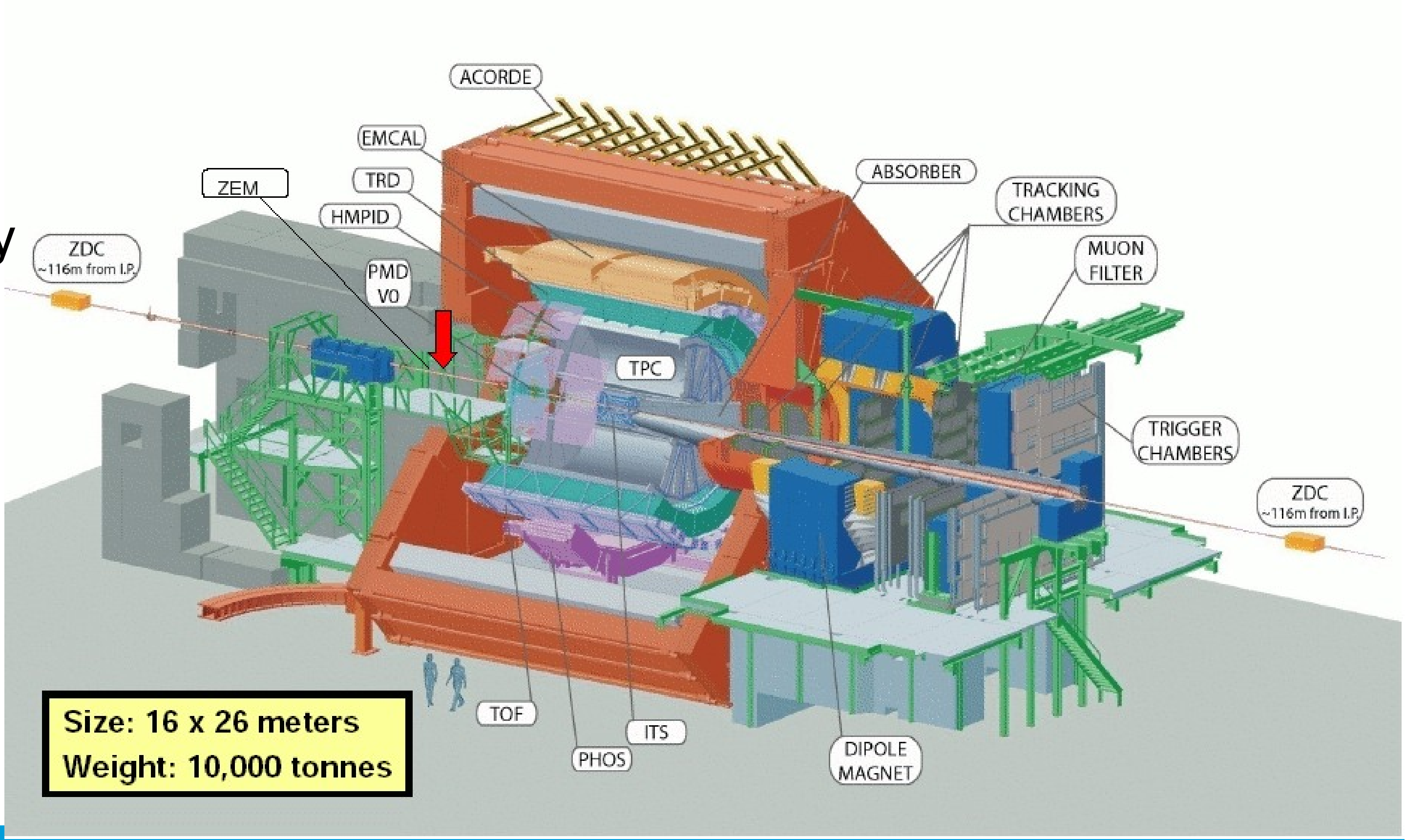
Outline

- Detector description
- Simulation ingredients
  - First Physics Production (@ 3.5+3.5 TeV and @ 450+450 GeV)
- ZDC efficiency for the selection of different types of events
- ZDC efficiency vs. N_{ch} particles produced
- Trigger selectivity for single diffractive events
- Conclusions

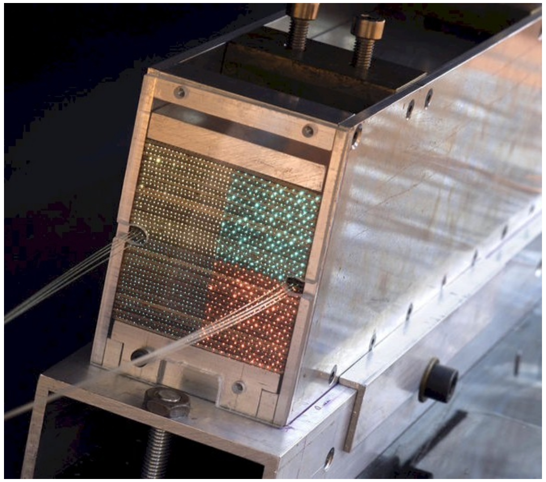
ZDC Detector (I)

- 2 sets of calorimeters located at the opposite side w.r.t. the IP, 114m away from it
- Spectators neutrons and protons are separated by LHC beam optics
- Each set consists of:
  - 1 Neutron calorimeter (ZN)
  - 1 Proton calorimeter (ZP)
- 1 forward electromagnetic calorimeter (ZEM) located at 7,5m away from the IP, only on one side



ZDC Detector (II)

- ZDC are "spaghetti" calorimeters with quartz fibers (active material) embedded in a dense absorber
- The principle of operation is based on the detection of Cherenkov light produced in the quartz fibers by charged particles of the shower generated by the hadrons
- Quartz fibers are placed at 0° with respect to the incident particle direction, come out from the rear face of the calorimeter and bring the light to 5 PM
- The charge of the PM analogical signals is converted by ADCs



Simulation Ingredients

Evaluate the ZDC efficiency for the selection of different types of events.
(Minimum Bias, non diffractive and diffractive)

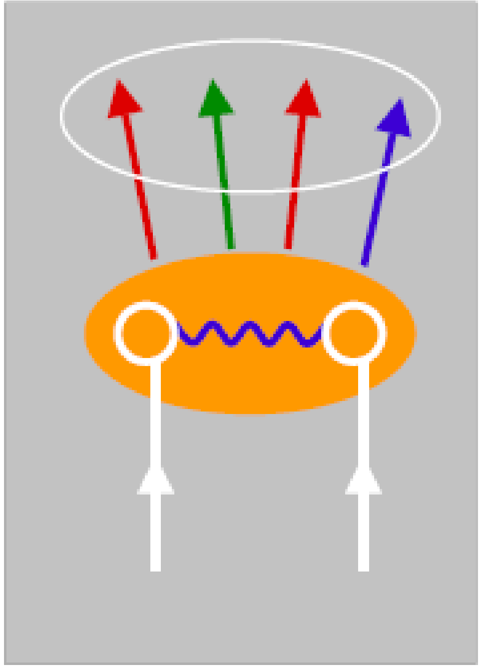
- Two generators: Pythia 6.214 and Phojet 1.12
- First Physics Productions @ 3.5 + 3.5 TeV (B=0.5 T)
  - LHC09b12 (Pythia), LHC09b14 (Phojet)
- First Physics Productions @ 450 + 450 GeV (B=0.5 T)
  - LHC09b8 (Pythia), LHC09b10 (Phojet)

p-p Interactions

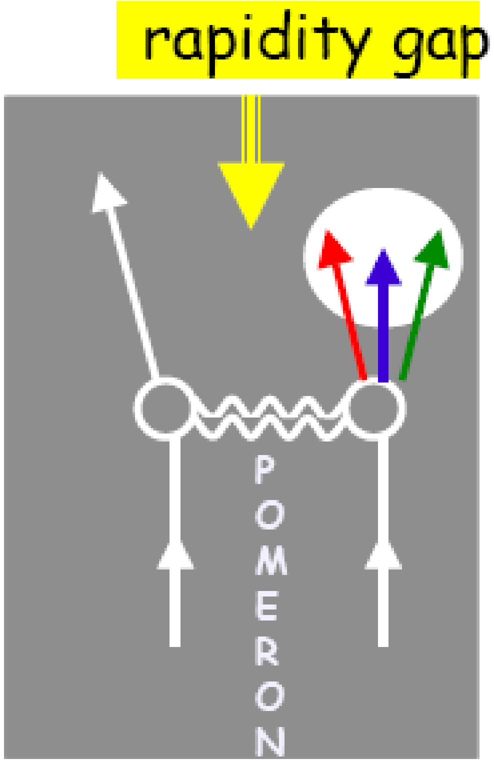
No elastic events generated

Non diffractive

Incident hadrons acquire colour and break apart

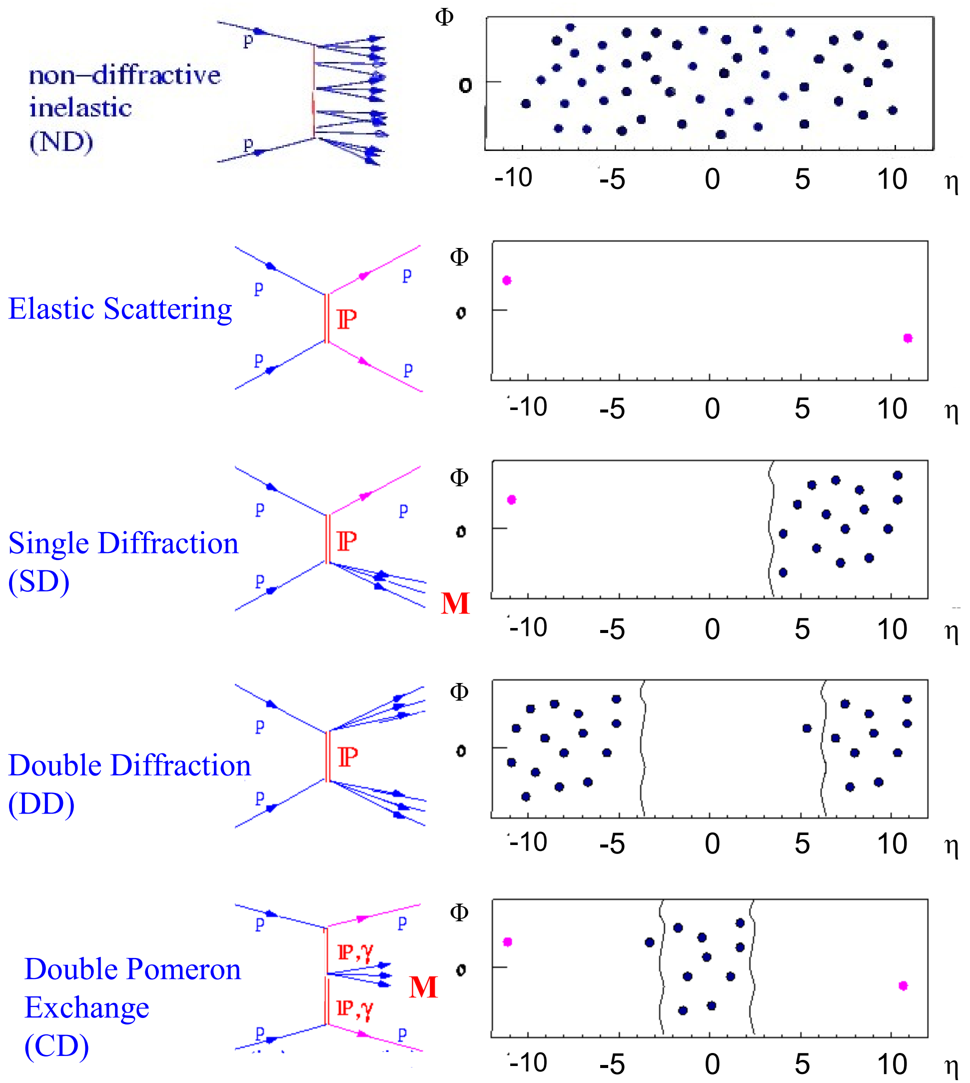


Diffractive



Incident hadrons retain their quantum numbers remaining colourless

Inelastic and Diffractive Processes



~65 mb

~30 mb

~10 mb

~7 mb

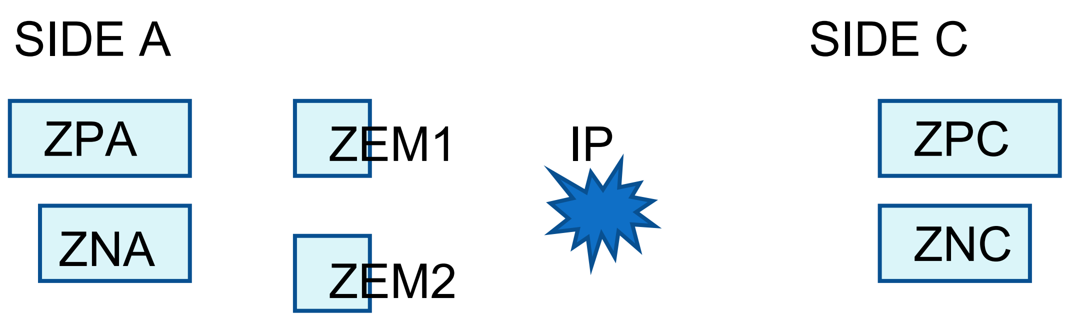
~1 mb

Fired detector pattern

- In order to study the ZDC efficiency for different type of events in the offline code a 32 bits word has been implemented in the ESD
  (fESDQuality in the class AliESDZDC.cxx)

- The right most 6 bits give information about the fired sub-detectors
- Bit - detector correspondance:

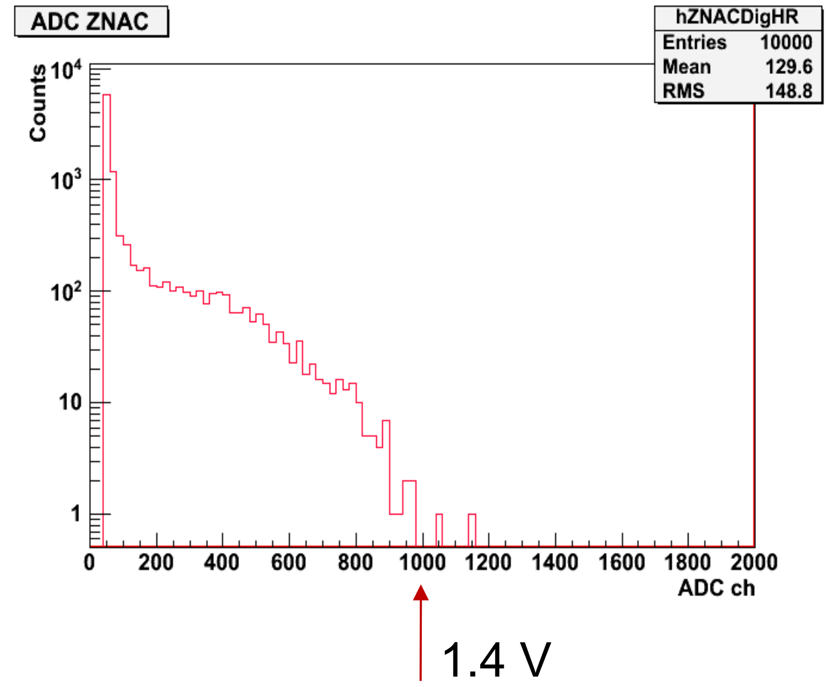
bit5	bit4	bit3	bit2	bit1	bit0
ZPC	ZNC	ZEM1	ZEM2	ZPA	ZNA



Threshold definition

- Starting point: ADC spectra obtained after digitization (AliZDCDigitizer.cxx)
- The PM gains are tuned in order to obtain the end point of the ADC spectra at the channel 1000 independently from beam energy

- Ch. 1000 corresponds to analogical signal amplitude of 1.4 V that is the maximum signal handled by our electronics (200pC)



- Minimum threshold on the signal amplitude fixed at 10 mV (ch. 7 in the ADC spectra)

→ It corresponds to a 7 ‰ cut w.r.t. the beam energy

1. ZDC efficiency vs. Event Type

Efficiency vs. event type

Some naming conventions:

Non Diffractive Inelastic Events	ND
Single Diffractive pp->Xp (Side A: Diffractive Mass, Side C: Proton)	SD1
Single Diffractive pp->pX (Side A: Proton, Side C: Diffractive Mass)	SD2
Double Diffractive	DD
Central Diffractive	CD
Minimum Bias ND+SD1 (pp->Xp) + SD2 (pp->pX)+ DD + CD	MB

Efficiency: Pythia 3.5+3.5 TeV, B=0.5T

(LHC09b12- 50000Ev)

The ZDCs can detect the leading baryons from the proton that breaks up
-> The scattered proton is not detected

	ND	SD1 (pp->Xp)	SD2 (pp->pX)	DD	MB
ZNA	34.1 ± 0.3%	53.2 ± 0.7%	1.1 ± 0.1%	54.3 ± 0.6%	35.2 ± 0.2%
ZPA	13.0 ±0.2%	24.0 ± 0.6%	2.2 ± 0.2%	24.3 ± 0.5%	14.4 ± 0.2%
ZEM	76.9 ± 0.2%	47.3 ± 0.7%	19.9 ± 0.6%	40.4 ± 0.6%	64.0 ± 0.2%
ZNAorZPA	41.7 ± 0.3%	65.2 ± 0.7%	2.8 ± 0.2%	65.6 ± 0.6%	43.1 ± 0.2%
ZNAorZPAorZNC orZPC	64.9 ± 0.3%	65.9 ± 0.7%	66.9 ± 0.7%	88.3 ± 0.4%	68.1 ± 0.2%
ZNAorZPAorZNC orZPCorZEM	94.3 ± 0.1%	83.3 ± 0.5%	73.5 ± 0.6%	93.4 ± 0.3%	91.1 ± 0.2%

The ZDC have a good trigger efficiency for all the event type

Efficiency: Phojet 3.5+3.5 TeV, B=0.5T

(LHC09b14- 50000Ev)

The ZDCs can detect the leading baryons from the proton that breaks up
-> The scattered proton is not detected

	ND	SD1 (pp->Xp)	SD2 (pp->pX)	DD	CD	MB
ZNA	33.0±0.2%	39.1±0.8%	1.4±0.2%	39.9±0.9%	1.0±0.3%	31.0±0.2%
ZPA	13.4±0.2%	16.5±0.6%	4.0±0.3%	18.5±0.8%	2.7±0.6%	13.4±0.2%
ZEM	75.2±0.2%	63.4±0.8%	21.8±0.7%	60.2±0.9%	28±1%	69.1±0.2%
ZNAorZPA	41.5±0.2%	48.8±0.8%	4.5±0.4%	50±1%	3.2±0.6%	39.2±0.2%
ZNAorZPAor ZNCorZPC	65.9±0.2%	50.1±0.8%	50.4±0.8%	74.2±0.9%	4.6±0.7%	63.0±0.2%
ZNAorZPAorZNCor ZPCorZEM	92.4±0.1%	84.4±0.6%	60.6±0.8%	90.8±0.6%	31±1%	88.4±0.1%

All the event type considered can be detected by ZDC

Efficiency: Pythia 450+450 GeV, B=0.5T

(LHC09b8- 50000Ev)

	ND	SD1 (pp->Xp)	SD2 (pp->pX)	DD	MB
ZNA	0.92± 0.05%	2.4 ± 0.2%	0.07 ± 0.04%	2.5 ± 0.2%	1.16 ± 0.05%
ZPA	0.8 ±0.05%	1.3 ± 0.2%	0.8 ± 0.1%	0.9 ± 0.1%	0.84 ± 0.04%
ZEM	57.8 ± 0.3%	45.6 ± 0.7%	14.8 ± 0.5%	42.7 ± 0.7%	49.9 ± 0.2%
ZNAorZPA	1.54 ± 0.07%	3.1 ± 0.2%	0.9 ± 0.1%	3.1 ± 0.2%	1.82 ± 0.06%
ZNAorZPAorZNC orZPC	2.88 ± 0.09%	3.6 ± 0.2%	4.4 ± 0.3%	6.5 ± 0.3%	3.53 ± 0.08%
ZNAorZPAorZNC orZPCorZEM	59.1 ± 0.3%	47.6 ± 0.7%	18.7 ± 0.5%	46.7 ± 0.7%	51.9 ± 0.2%

ZN and ZP have very low efficiency (< 3%).
The overall trigger efficiencies are mainly due to the ZEM.

Efficiency: Phojet 450+450 GeV, B=0.5T

(LHC09b10- 50000Ev)

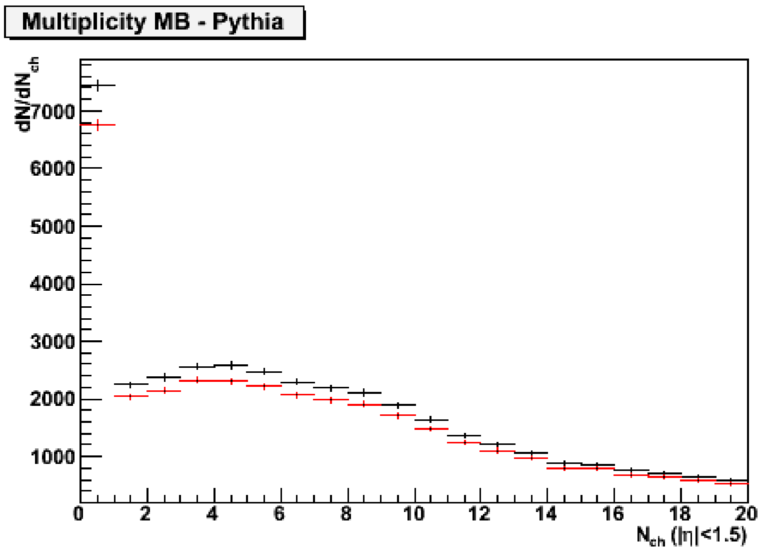
	ND	SD1 (pp->Xp)	SD2 (pp->pX)	DD	CD	MB
ZNA	0.91±0.05%	1.2±0.2%	0.08±0.04%	1.2±0.2%	0.1±0.1%	0.86±0.04%
ZPA	0.76±0.05%	0.8±0.1%	0.5±0.1%	0.5±0.1%	0.4±0.2%	0.71±0.04%
ZEM	58.5±0.3%	56.2±0.7%	15.1±0.5%	54.2±0.9%	15±1%	52.9±0.2%
ZNAorZPA	1.52±0.06%	1.8±0.2%	0.6±0.1%	1.5±0.2%	0.5±0.2%	1.43±0.05%
ZNAorZPAor ZNC orZPC	3.88±0.09%	2.2±0.2%	2.5±0.2%	4.5±0.4%	0.8±0.3%	2.84±0.07%
ZNAorZPAorZNCor ZPCorZEM	59.9±0.3%	57.5±0.7%	17.1±0.5%	56.4±0.9%	16±1%	54.4±0.2%

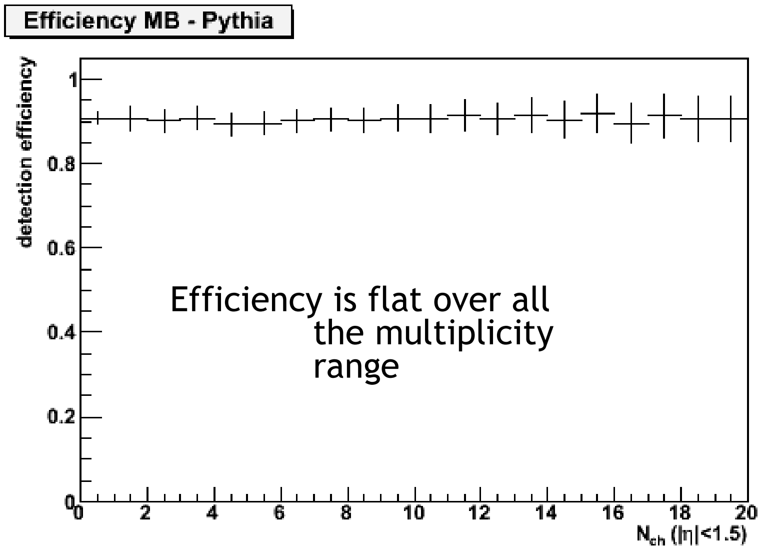
ZN and ZP have very low efficiency (< 1.5%).
The overall trigger efficiency are mainly due to the ZEM.

2. ZDC efficiency vs. N_{ch}

Efficiency vs. N_{ch} - Pythia

MB events @ 3.5+3.5 TeV





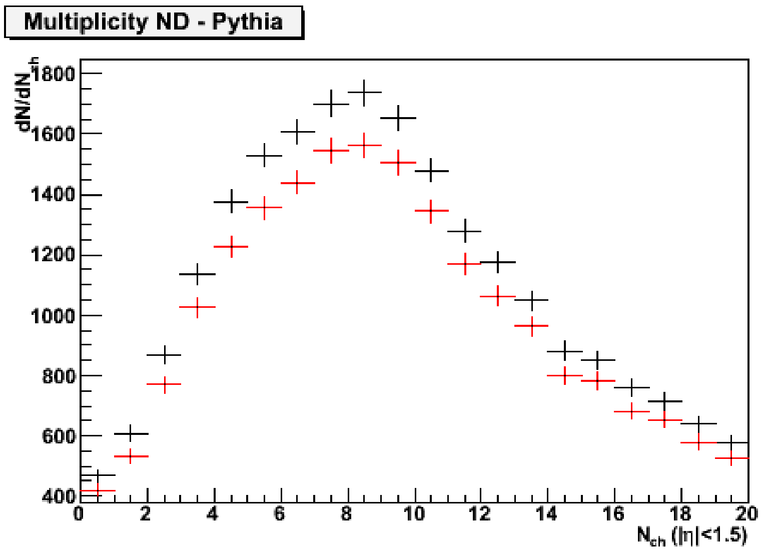
Trigger requirement:
ZNAorZPAorZNCorZPCorZEM

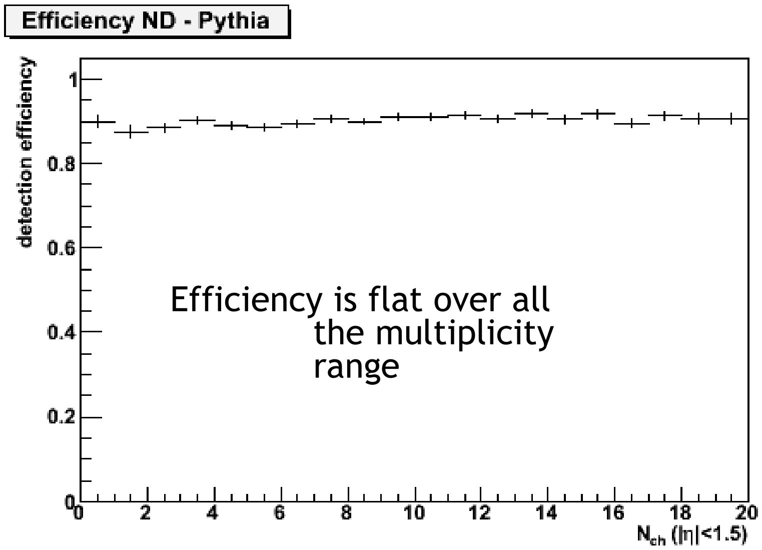
- Black: generated N_{ch} distribution
- Red: N_{ch} distribution for triggered events

- N_{ch} → number of primary charged particles produced by the generator (|η|<1.5)

Efficiency vs. N_{ch} - Pythia

ND events @ 3.5+3.5 TeV



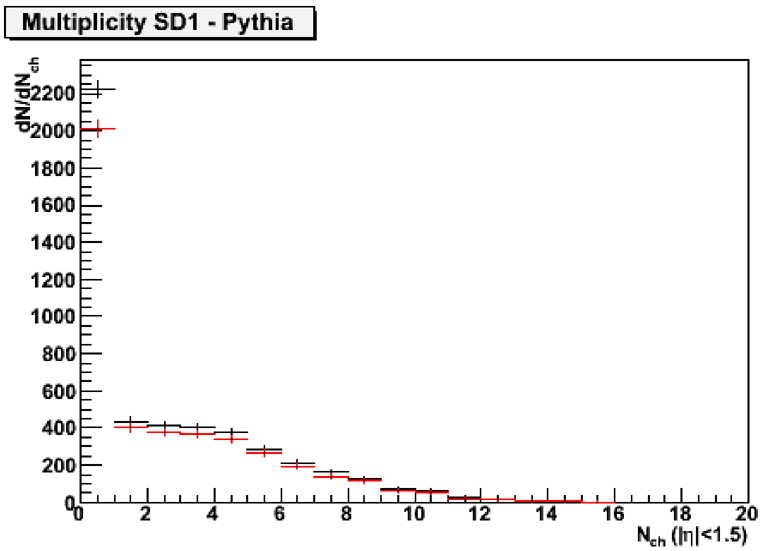


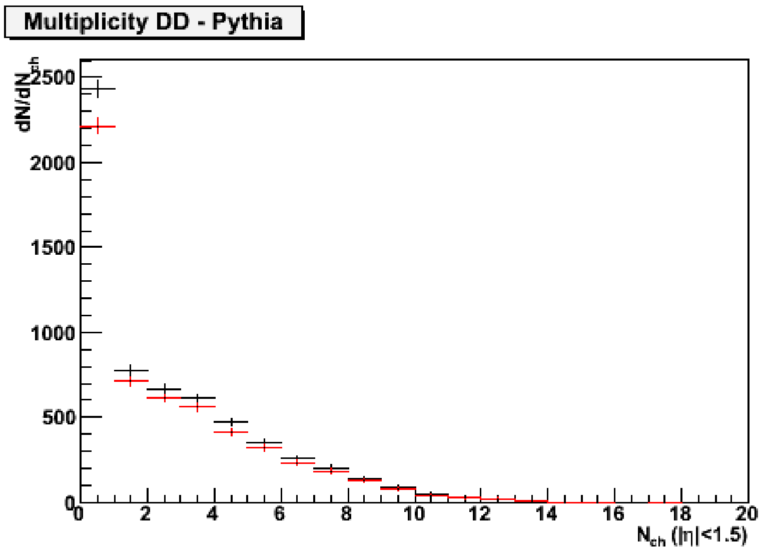
Trigger requirement:
ZNAorZPAorZNCorZPCorZEM

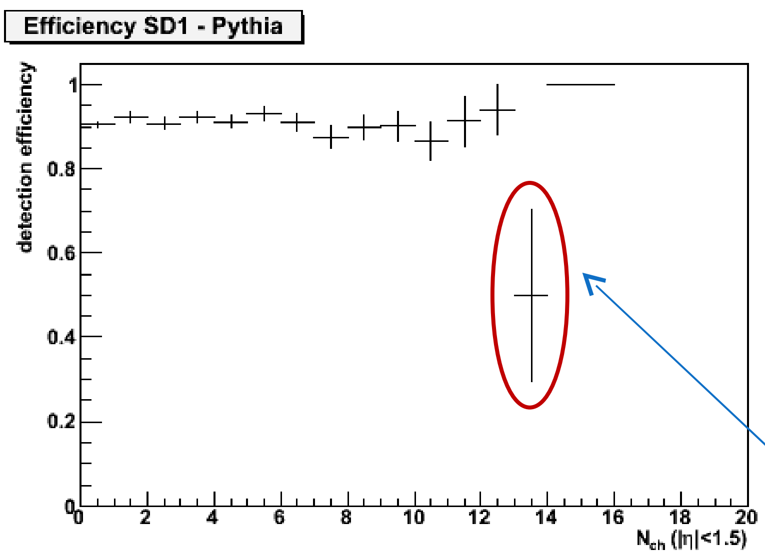
- Black: generated N_{ch} distribution
- Red: N_{ch} distribution for triggered events

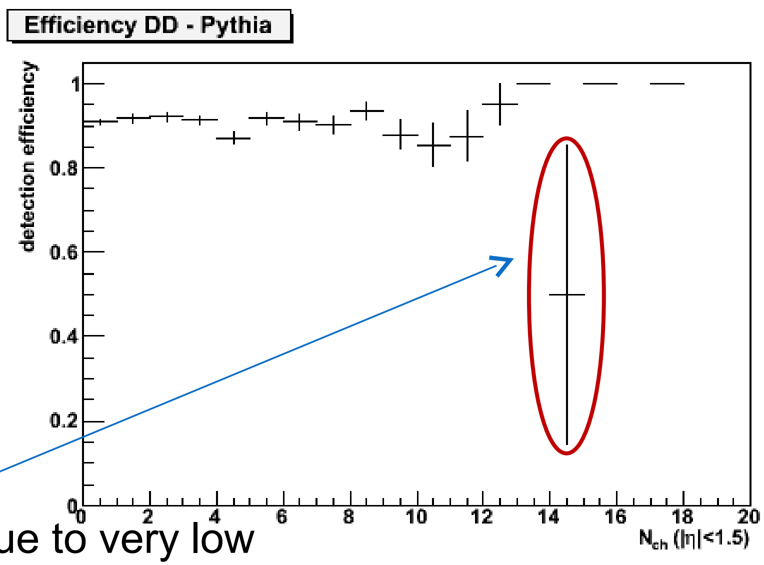
- $N_{ch} \rightarrow$ number of primary charged particles produced by the generator ($|\eta|<1.5$)

Efficiency vs. N_{ch} - Pythia
SD and DD events @ 3.5+3.5 TeV





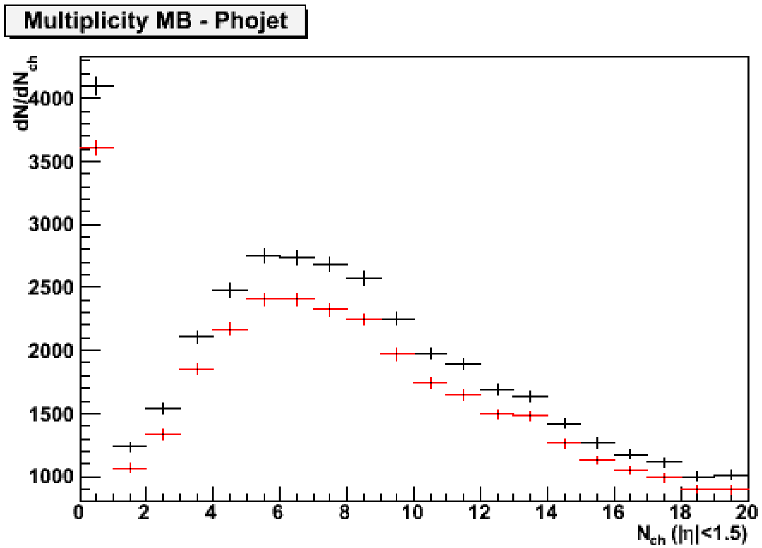


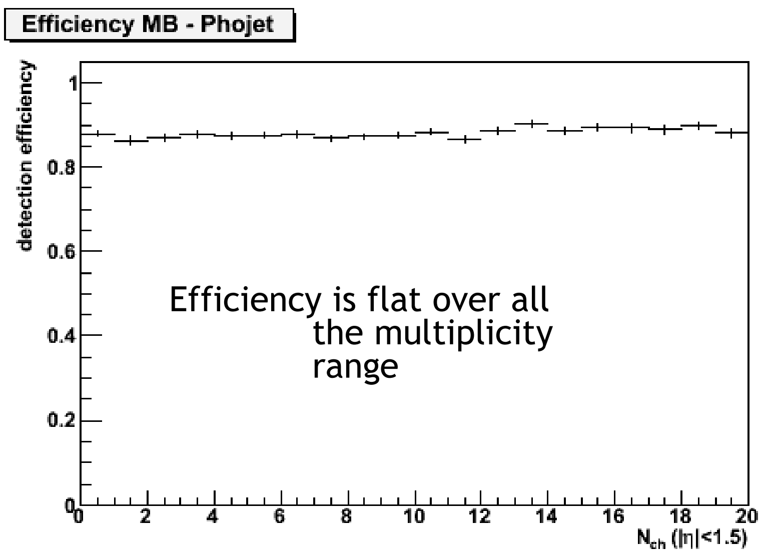


Errors are due to very low statistics in the bin

Efficiency vs. N_{ch} - Phojet

MB events @ 3.5+3.5 TeV



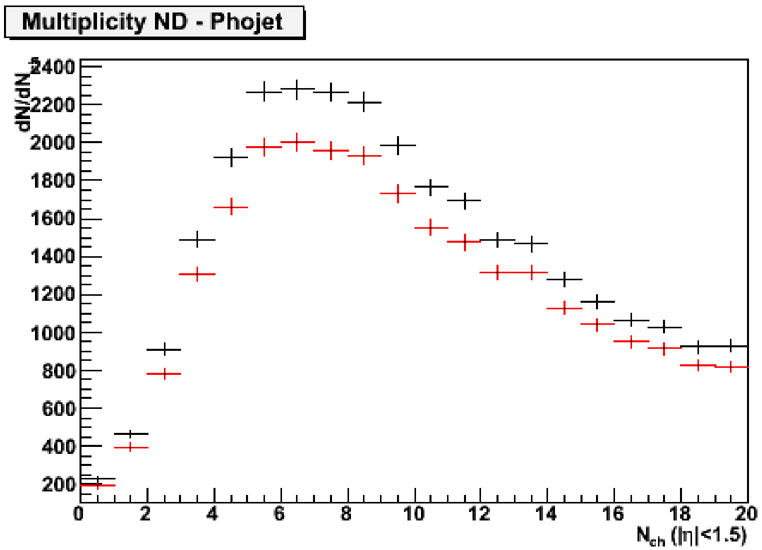


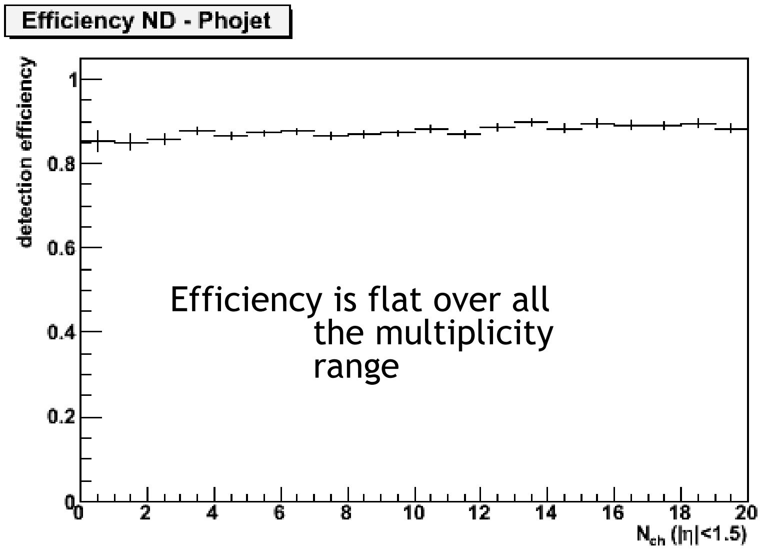
Trigger requirement:
ZNAorZPAorZNCorZPCorZEM

- N_{ch} → number of primary charged particles produced by the generator ($|\eta|<1.5$)
- Black: generated N_{ch} distribution
- Red: N_{ch} distribution for triggered events

Efficiency vs. N_{ch} - Phojet

ND events @ 3.5+3.5 TeV



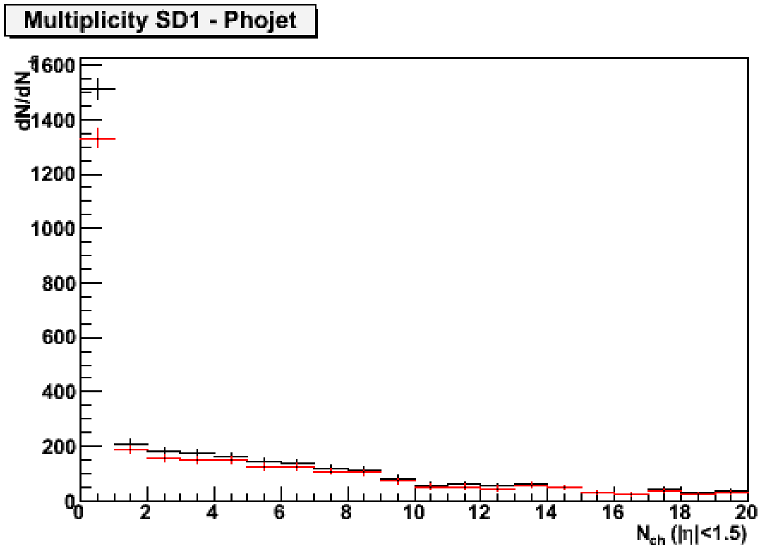


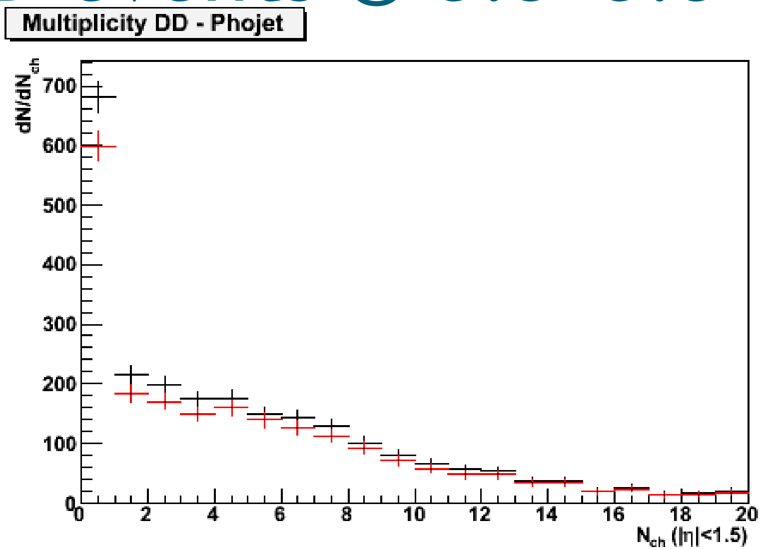
Trigger requirement:
ZNAorZPAorZNCorZPCorZEM

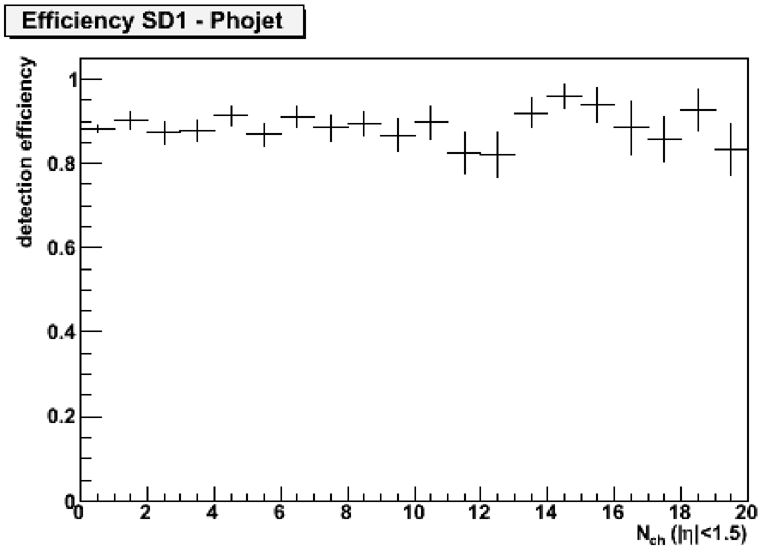
- N_{ch} → number of primary charged particles produced by the generator ($|\eta|<1.5$)

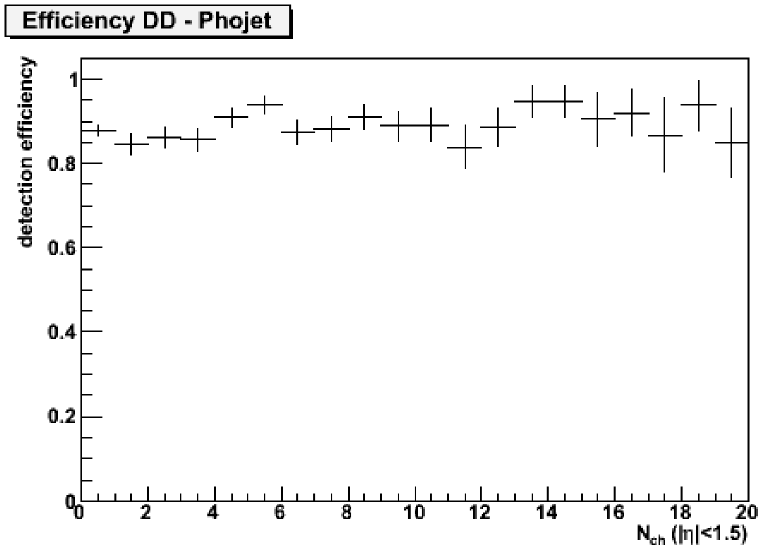
- Black: generated N_{ch} distribution
- Red: N_{ch} distribution for triggered events

Efficiency vs. N_{ch} - Phojet
SD and DD events @ 3.5+3.5 TeV

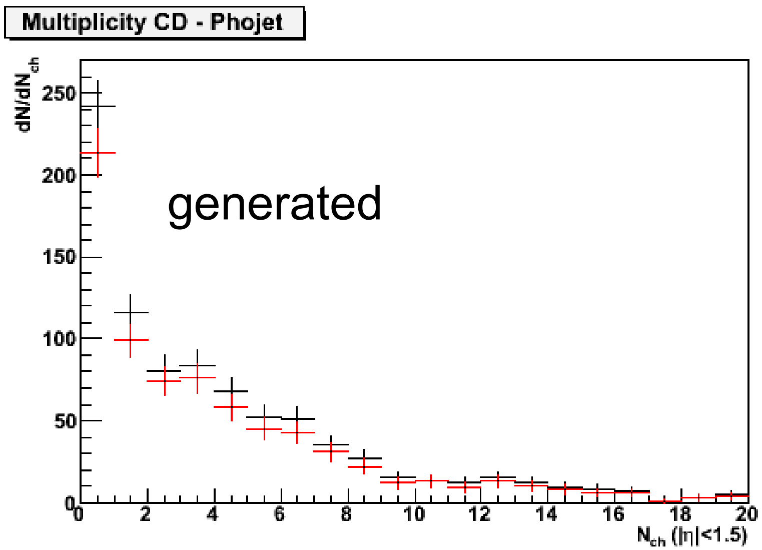


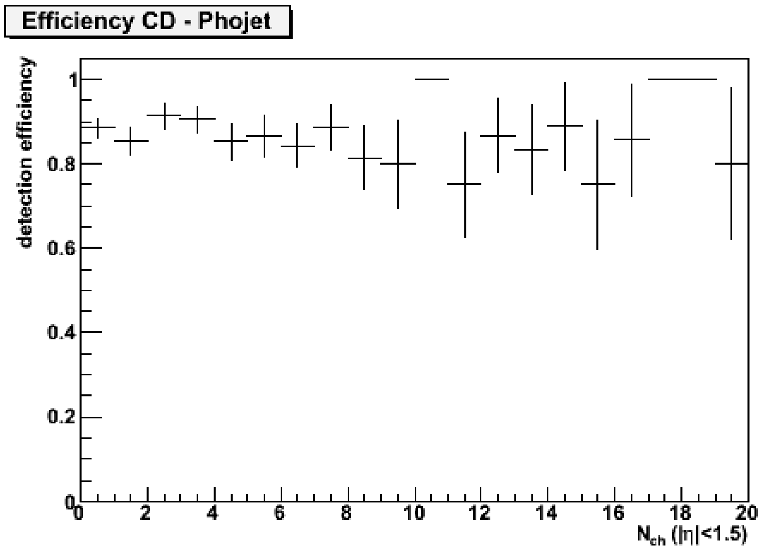






Efficiency vs. N_{ch} for CD Collisions Phojet @ 3.5+3.5 TeV





Trigger requirement:
ZNAorZPAorZNCorZPCorZEM

- N_{ch} → number of primary charged particles produced by the generator ($|\eta|<1.5$)

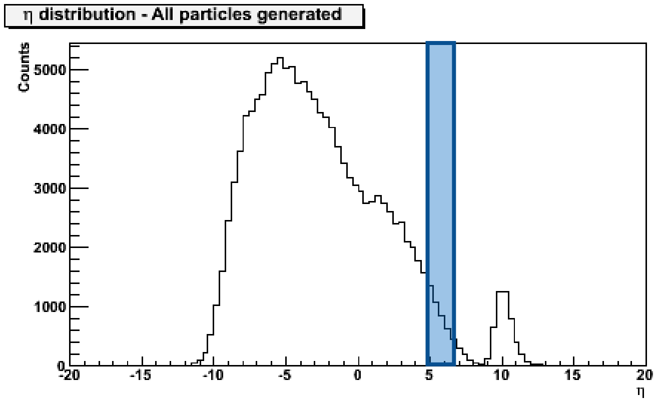
- Black: generated N_{ch} distribution
- Red: N_{ch} distribution for triggered events

3. Trigger selectivity

η distribution for SD events

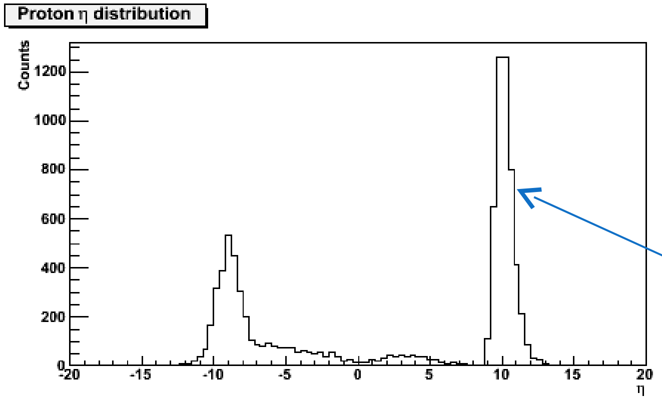
Pythia@ 3.5+3.5 TeV

Single diffractive events with diffractive mass on C side (SD2)



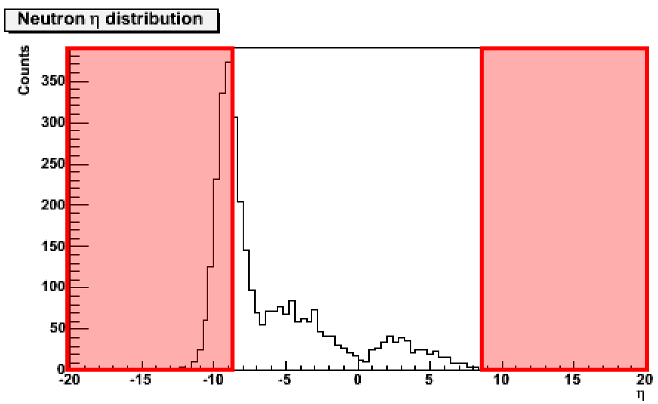
← Generated η distribution for stable particles

Low signal in ZEM



← Generated η distribution for protons

Scattered protons in beam pipe
→ No Signal in ZPA

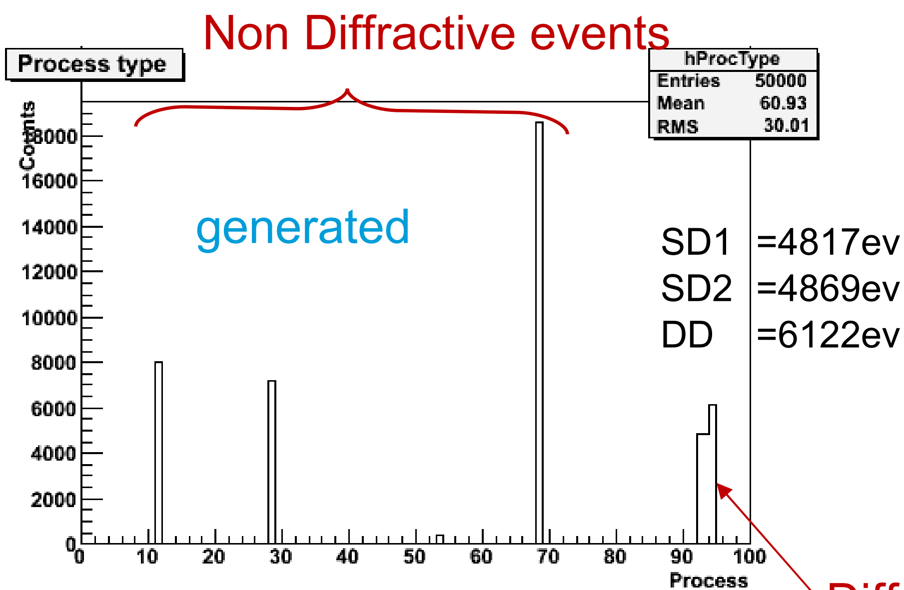


← Generated η distribution for neutrons

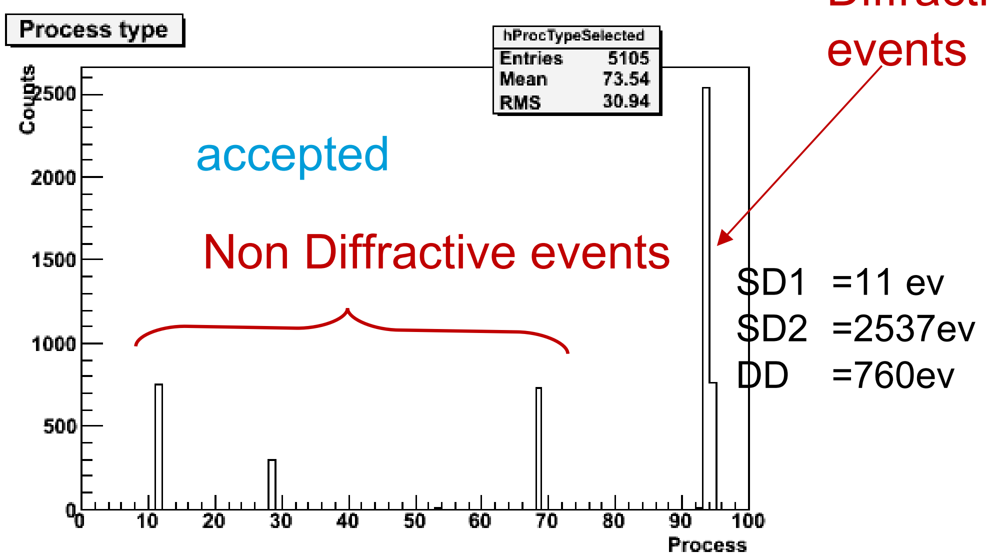
Diffractive Mass on C side
→ No Signal in ZNA, Signal in ZNC

Single Diffractive event selection

Pythia@ 3.5+3.5 TeV



Diffractive events



Select SD2 events
(diffractive mass on C side)
↓
Trigger requirement:

- Signal in ZNCorZPC
- No signal in ZEMandZNAandZPA

7+7 TeV

Trigger efficiency for SD2 events:

#SD2events selected/
#SD2events generated =73.6%

Trigger purity:

#SD2events selected/total # of accepted events = 65%

Non diffractive event-rejection: 96.2%

Conclusions

- The ZDCs have a good overall efficiency for the selection of different types of events @ 3.5+3.5 TeV
  - MB overall efficiency Pythia = 91.1 ± 0.2%
  - MB overall efficiency Phojet = 88.4 ± 0.1%

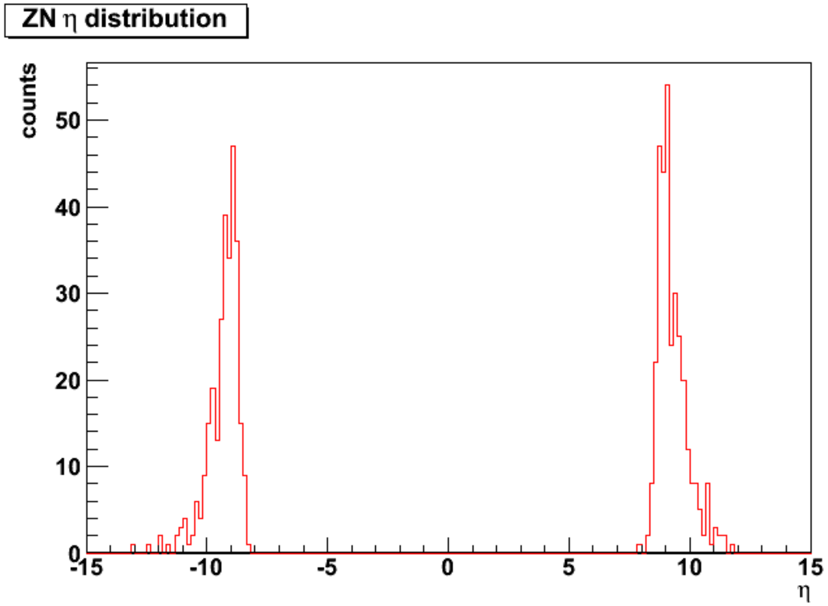
- Efficiencies values are flat over the whole N_{ch} range for all the event types considered

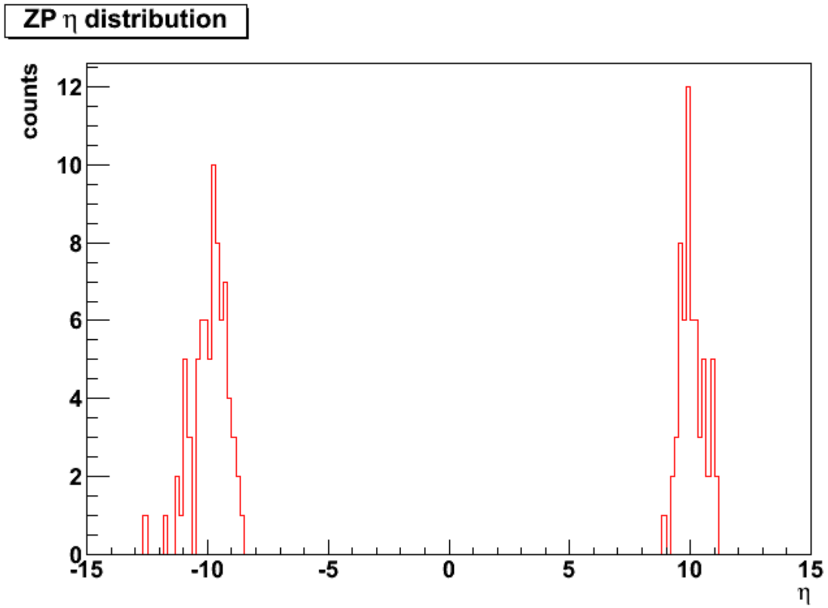
- For SD events (asymmetric), the ZDCs allow the extraction of an events sample with the 50% of purity

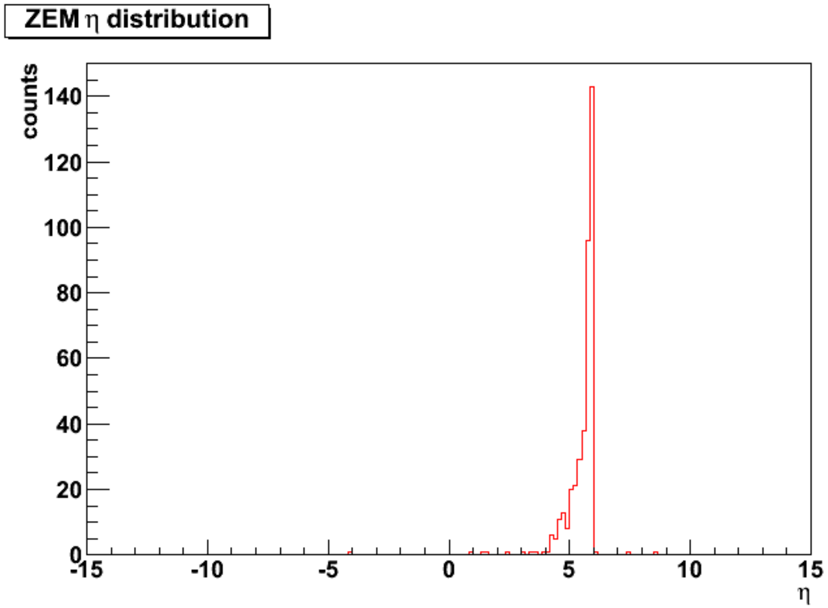
  (Trigger efficiency 52% - Non diffractive event rejection 94.8%)
  - The trigger efficiency and the purity of the sample increase at higher beam energies

That's all. Thanks!

ZDC η distribution @ 7+7 TeV



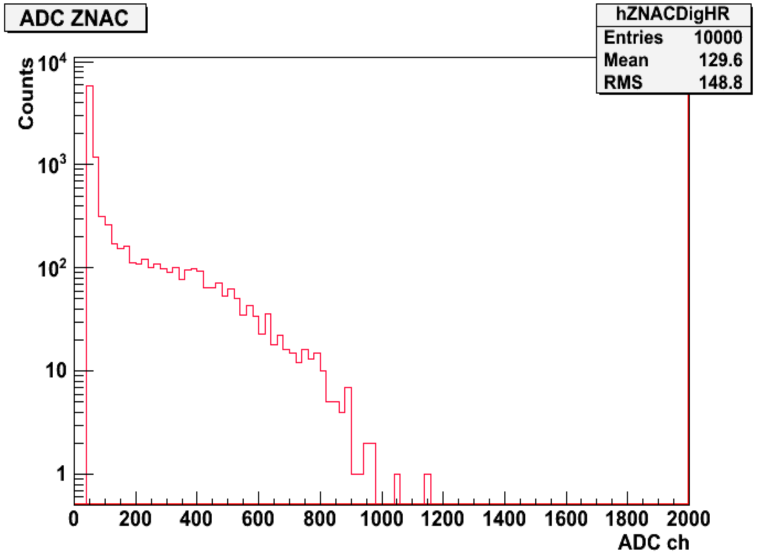




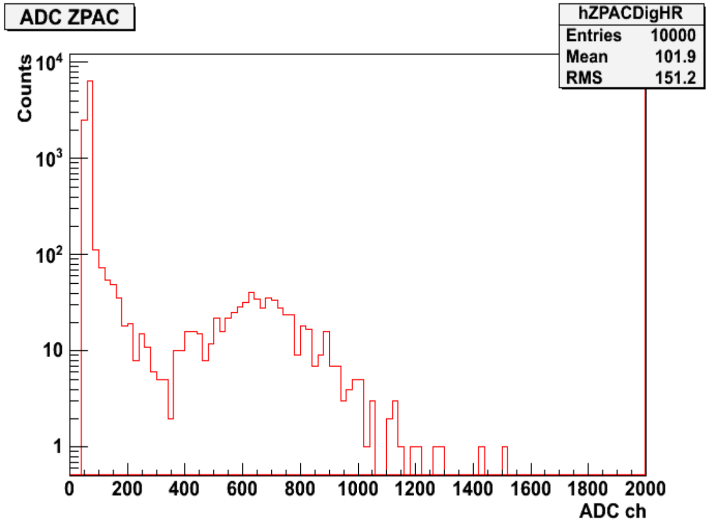
ZDC η acceptance:

- ZN -> | η | > 8.7
- ZP -> | η | > 8.4
- ZEM -> 4.8 < η < 6.7

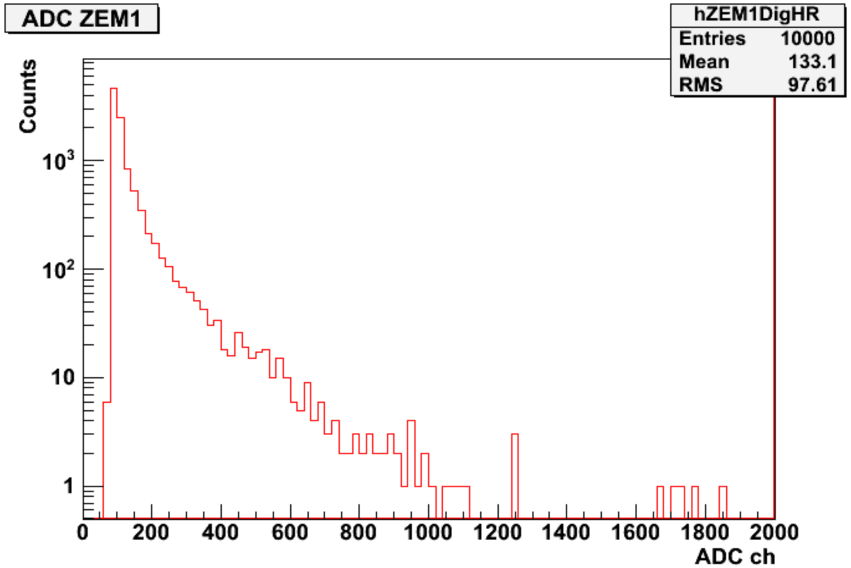
ADC spectra



ADC ZNAC
hZNACDigHR
Entries 10000
Mean 129.6
RMS 148.8
Counts
ADC ch



ADC ZPAC
hZPACDigHR
Entries 10000
Mean 101.9
RMS 151.2
Counts
ADC ch



ADC ZEM1
hZEM1DigHR
Entries 10000
Mean 133.1
RMS 97.61
Counts
ADC ch

Efficiency: Pythia @3.5+3.5 TeV, No field

(LHC09b13 – 10000ev)

	Non Diff	Single Diffr (AB->XB)	Single Diffr (AB->AX)	Double Diffr	MB
ZNA	35%	54%	1.5%	56%	35.9%
ZPA	13.6%	25.4%	3.1%	26.6%	15.2%
ZEM	75.5%	45.2%	18.2%	40.8%	62.9%
ZNAorZPA	42.9%	67.6%	3.9%	68.3%	44.3%
ZNAorZPAorZNC orZPC	66.5%	68.1%	65.5%	90%	69.2%
ZNAorZPAorZNC orZPCorZEM	94.3%	82.8%	72%	95%	90.9%

Efficiency: Pythia @450+450 GeV, No field

(LHC09b9 - 10000)

	Non Diff	Single Diffr (AB->XB)	Single Diffr (AB->AX)	Double Diffr	MB
ZNA	1.2%	3.3%	0.08%	2.8%	1.5%
ZPA	1.6%	3.1%	1.3%	2.6%	1.8%
ZEM	56.1%	44.9%	15.1%	44.4%	49.7%
ZNAorZPA	2.4%	5,3%	1.4%	4.7%	2.8%
ZNAorZPAorZNCorZPC	4.2%	6.6%	6.3%	9.3%	5.3%
ZNAorZPAorZNCorZPCorZEM	58.2%	48.9%	20.1%	50.2%	51.7%

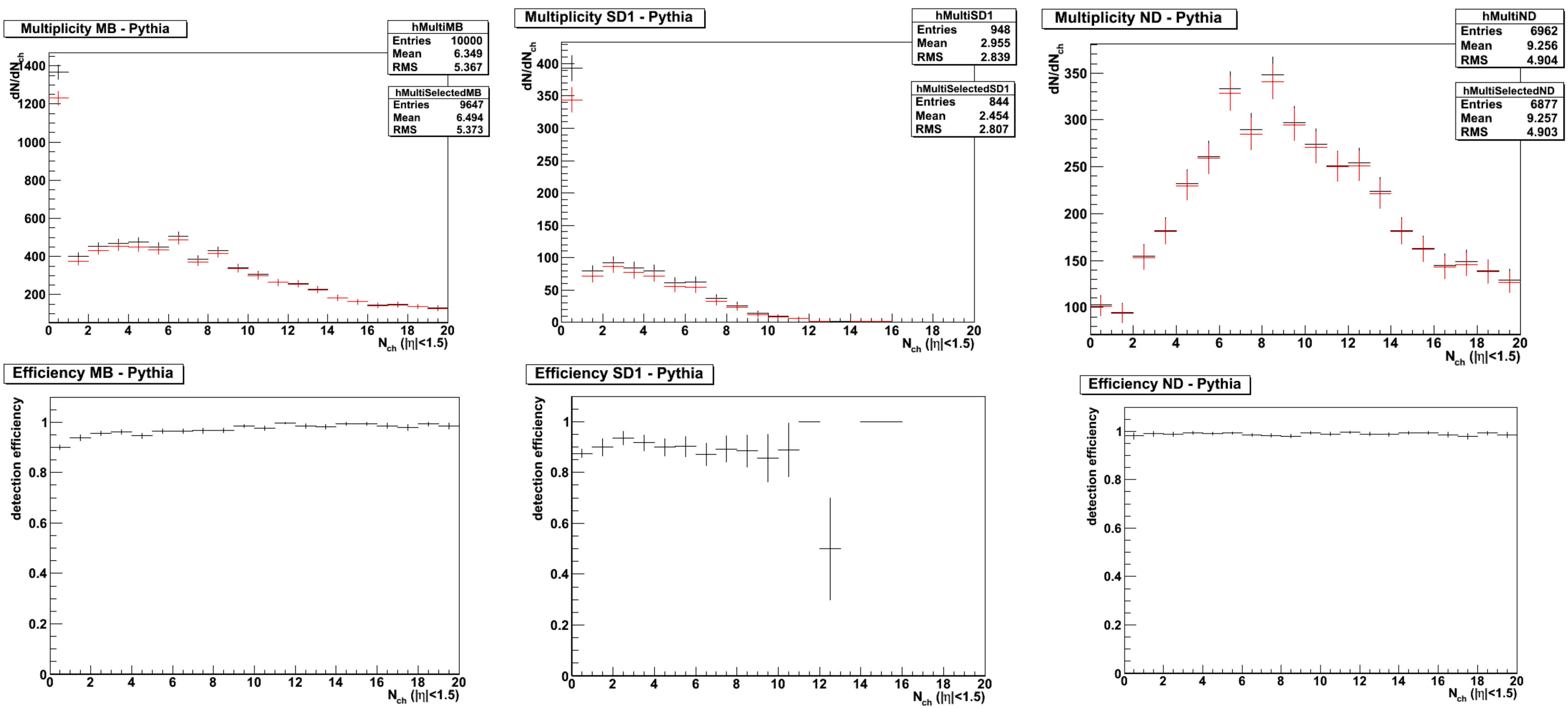
Efficiency @ 7+7 TeV

See General First Physics Meeting 24/06/2009

Pythia	Non Diff	Single Diff AB→XB	Single Diff AB→AX	Double Diff	MB
ZNA	53.7%	65.6%	1.5%	68.8%	52.2%
ZPA	15.5%	22.9%	0.7%	24.5%	16.05%
ZNAorZPA	64.3%	78.8%	2.1%	80.9%	62.4%
ZNAorZPAor ZNCorZPC	85.9%	79.5%	82.0%	96.4%	86.2%
ZNAorZPAor ZNCorZPC orZEM	98.8%	89.1%	84.1%	98.0%	96.5%

Phojet	NonDiff	SingleDiff AB→XB	SingleDiff AB→AX	DoubleDiff	CentralDiff	MB
ZNA	51.9%	56.6%	2.6%	59.9%	1.5%	48.3%
ZPA	15.9%	19.7%	3.4%	24.0%	1.0%	15.4%
ZPAorZPA	63.4%	68.8%	5.2%	76.7%	2.6%	59.4%
ZPAorZPAor ZNCorZPC	86.5%	69.8%	71.7%	93.6%	4.1%	83.1%
ZPAorZPAor ZNCorZPC orZEM	97.6%	90.6%	76.7%	98.5%	22.5%	94.3%

Efficiency vs. N_{ch} – Pythia 7+7 TeV



Plot from General First Physics Meeting – 24/06/2009