

Diffraction dissociation in proton-proton collisions at $\sqrt{s} = 0.9$ TeV, 2.76 TeV and 7 TeV, with ALICE at the LHC.

Martin Poghosyan

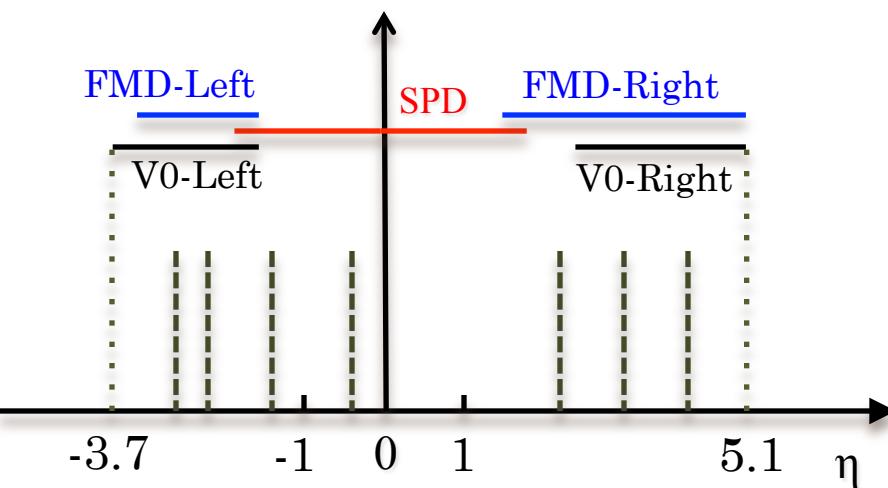
Torino University, Italy

ALICE Collaboration

Quark Matter 2011
Annecy, France
May 23-28, 2011

Detectors used to measure pseudorapidity gaps

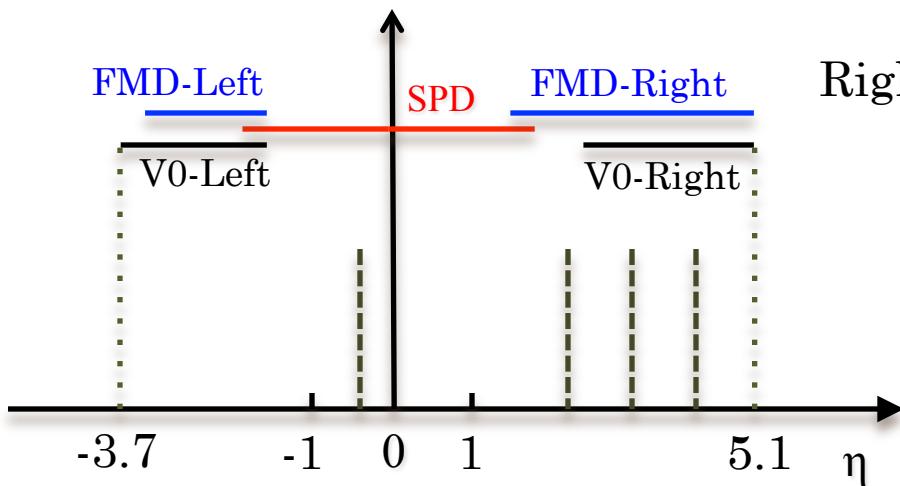
- Silicon Pixel Detector (**SPD**) corresponds to the two innermost layers of the ALICE Inner Tracking System and covers pseudorapidity range $|\eta| < 2$.
- **V0** scintillator hodoscopes are placed on both sides of the interaction point covering the pseudorapidity ranges $-3.7 < \eta < -1.7$ and $2.8 < \eta < 5.1$.
- Forward Multiplicity Detector (**FMD**) is made of silicon strip sensors placed on either side of the interaction point covering the pseudo-rapidity range $-3.4 < \eta < -1.7$ and $1.7 < \eta < 5.1$.



MC generators: PYTHIA(-perugia0 tune) and PHOJET

Detectors used to measure pseudorapidity gaps

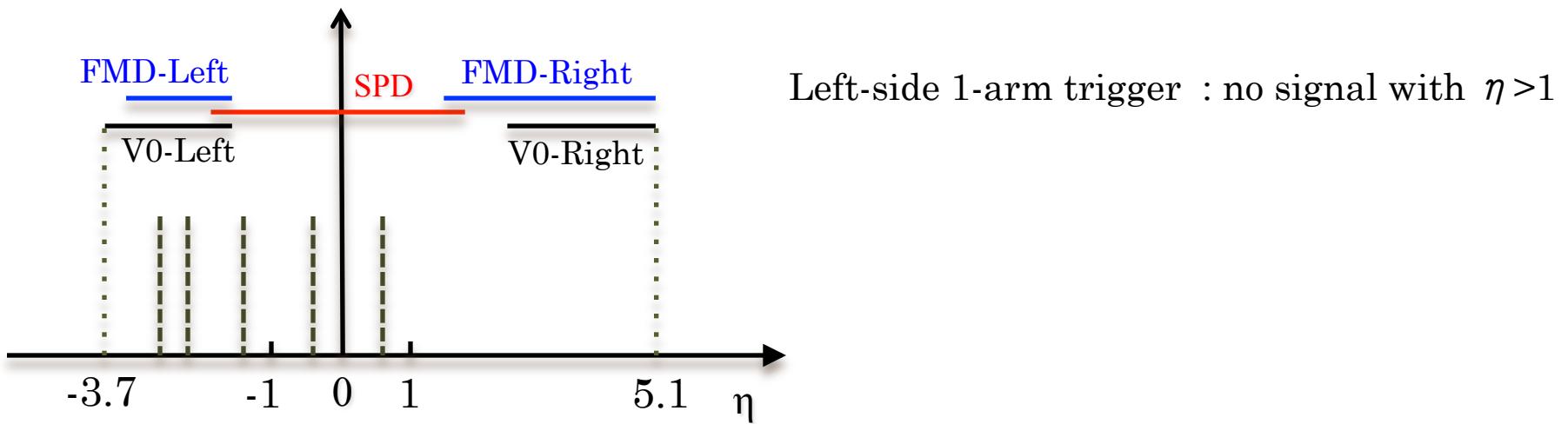
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Right-side 1-arm trigger: no signal with $\eta < -1$

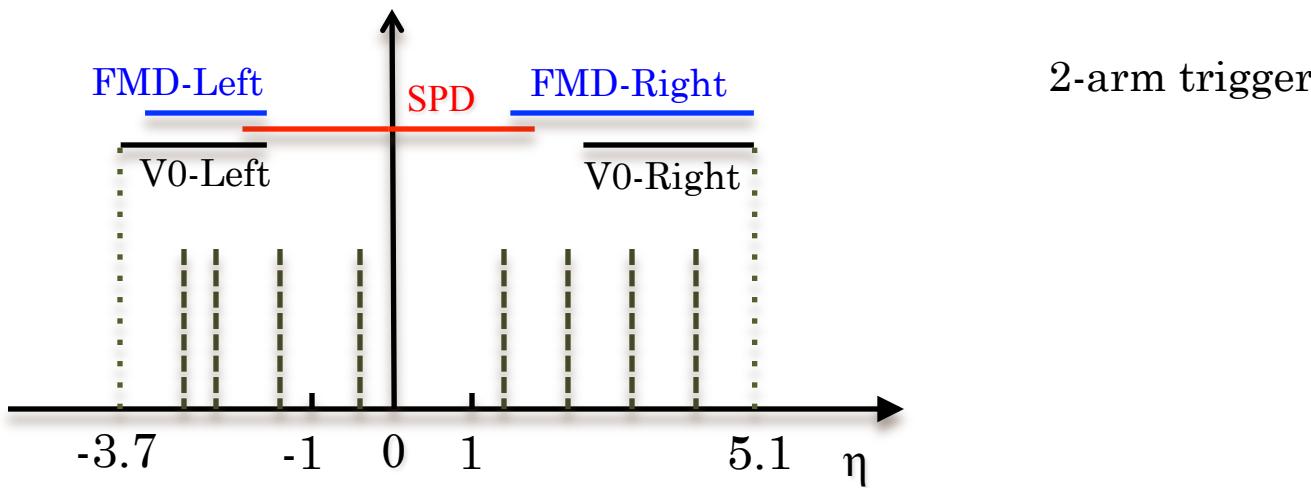
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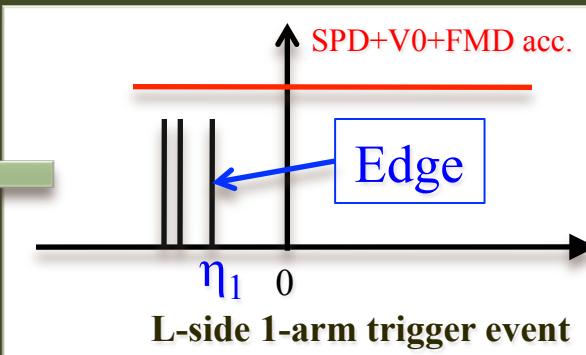
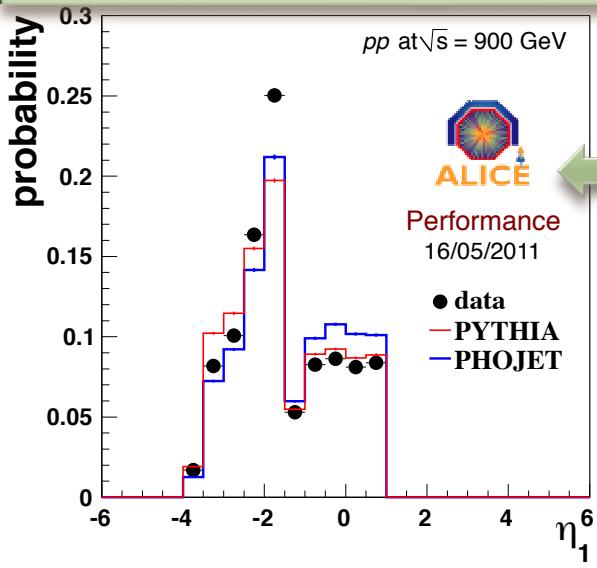
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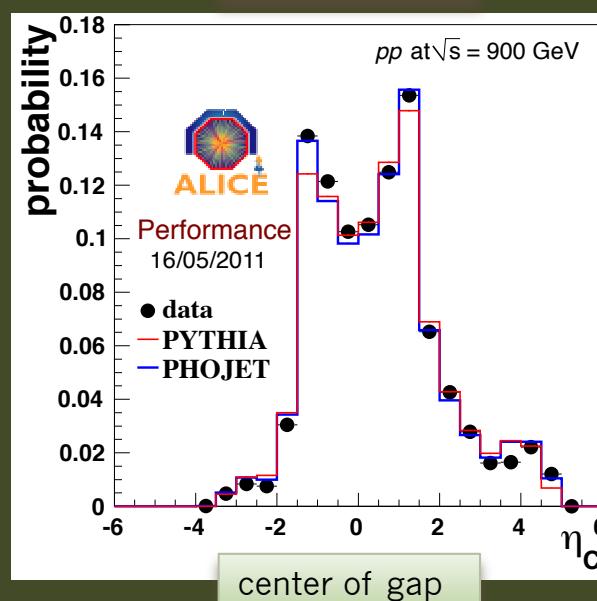


Uncorrected data vs Simulation (900 GeV)

edge of left-side 1-arm trigger event

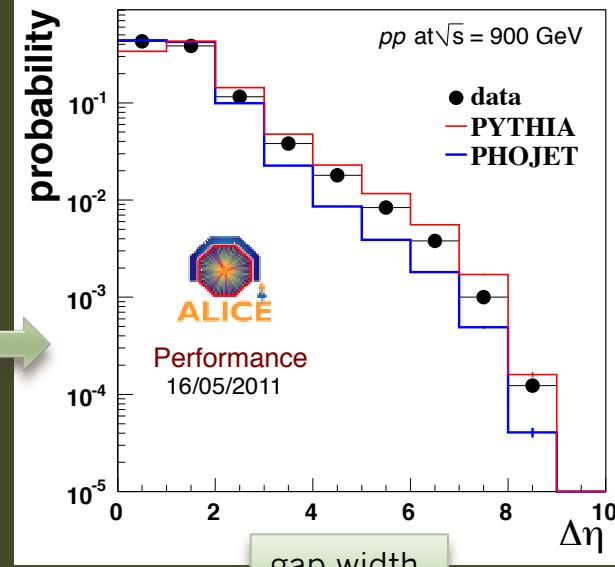
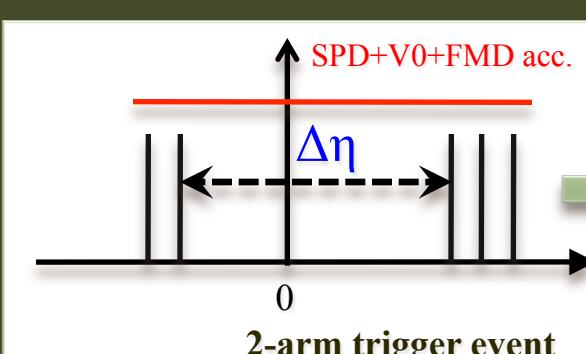
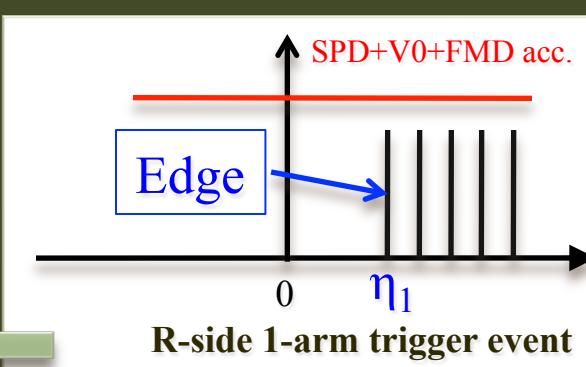
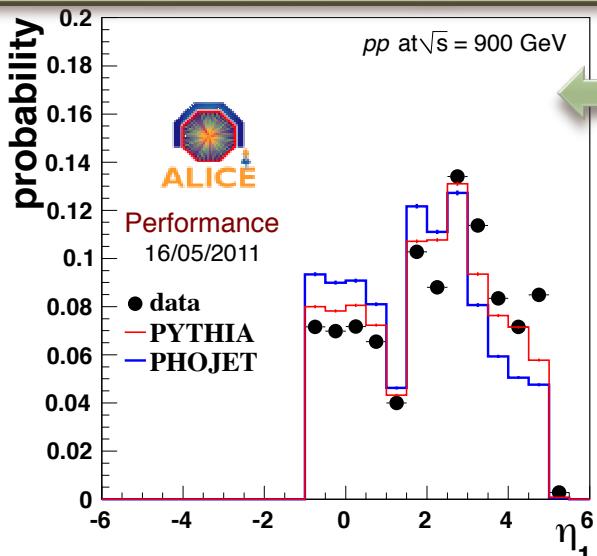


2-arm trigger



center of gap

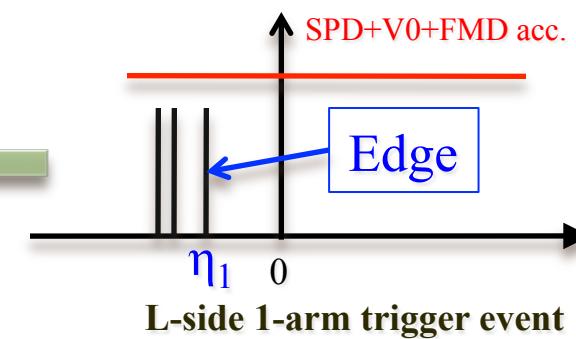
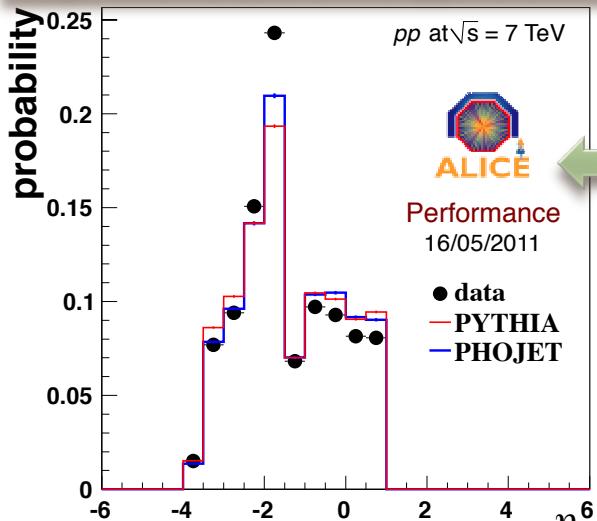
edge of right-side 1-arm trigger event



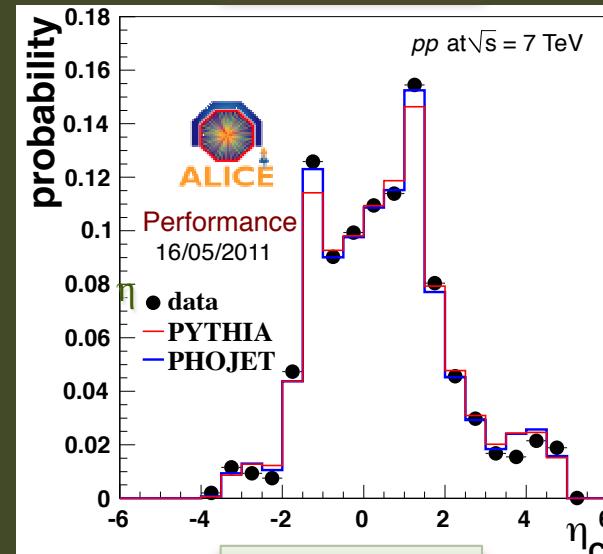
gap width

Uncorrected data vs Simulation (7 TeV)

edge of left-side 1-arm trigger event

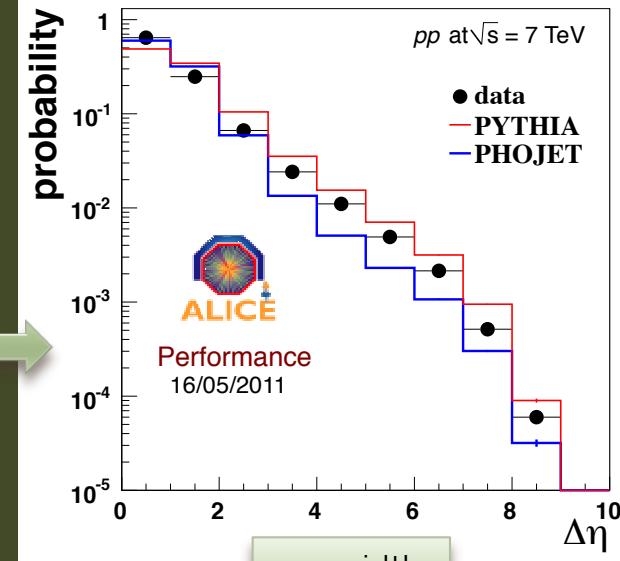
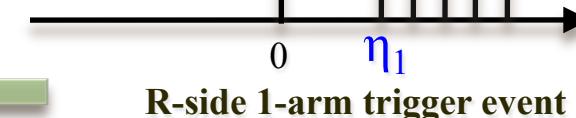
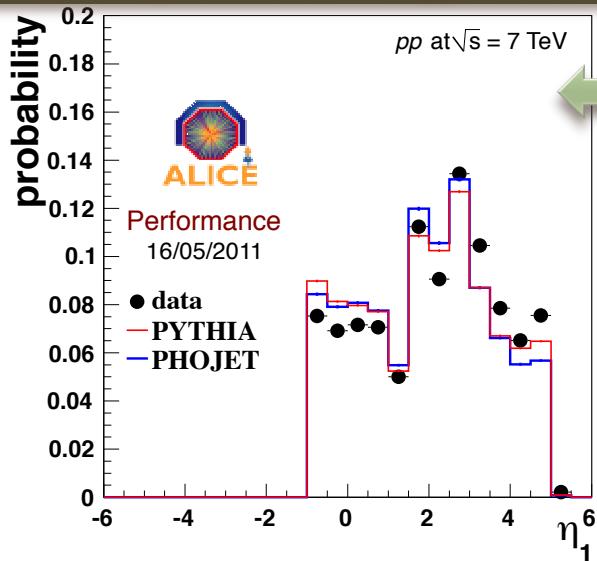


2-arm trigger



center of gap

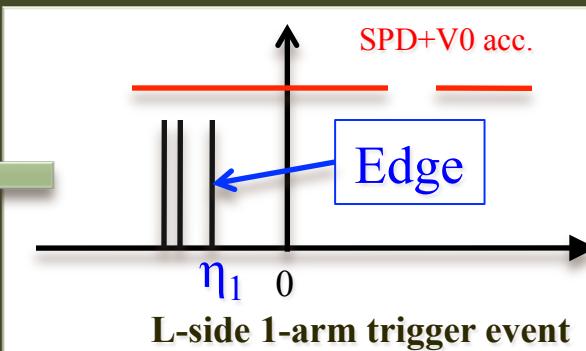
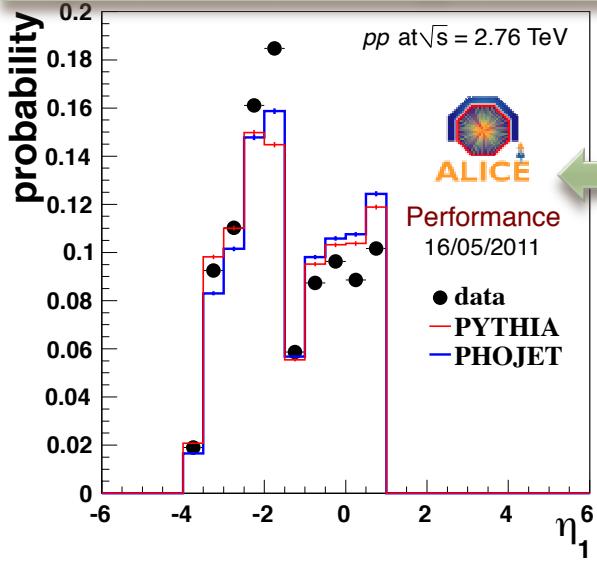
edge of right-side 1-arm trigger event



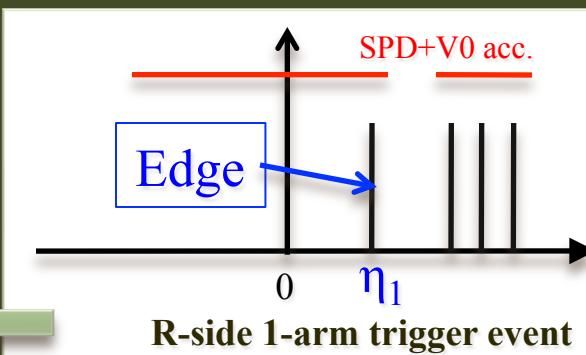
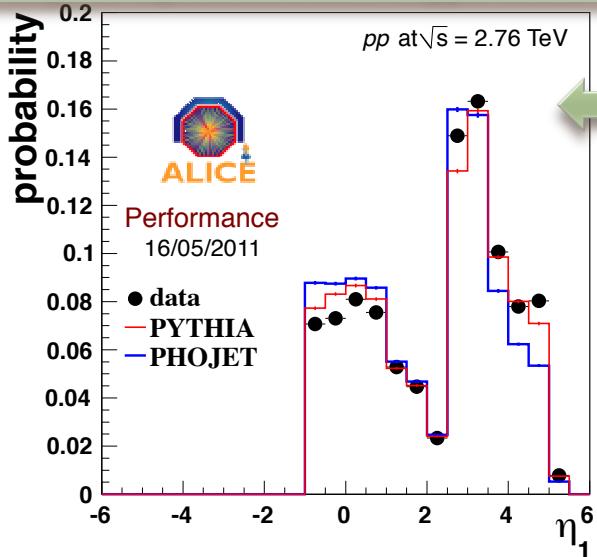
Uncorrected data vs Simulation (2.76 TeV)

SPD+V0

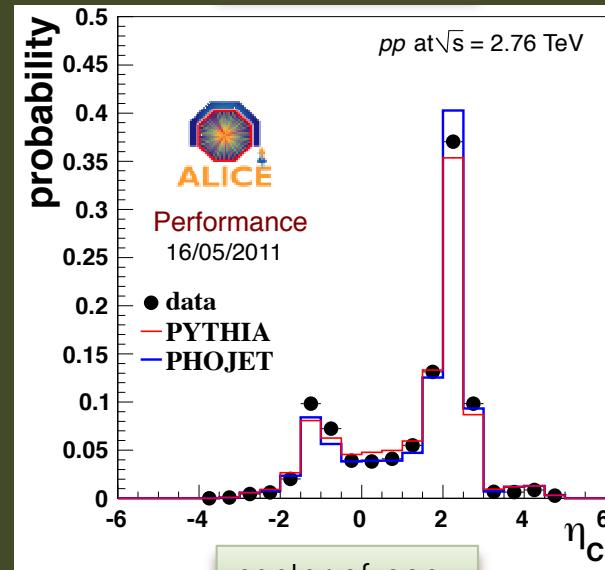
edge of left-side 1-arm trigger event



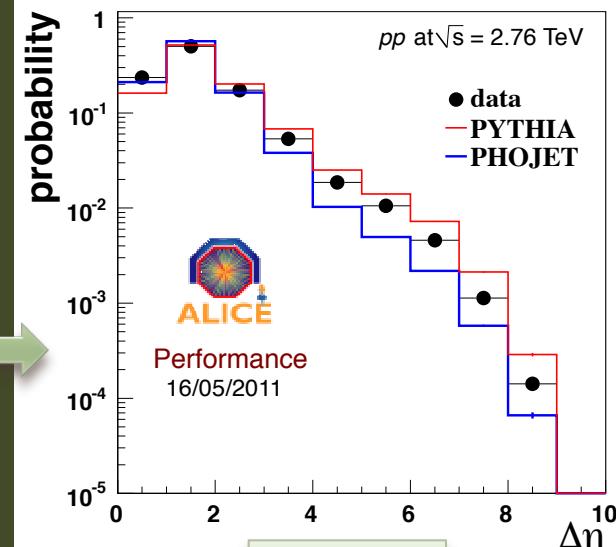
edge of right-side 1-arm trigger event



2-arm trigger



center of gap

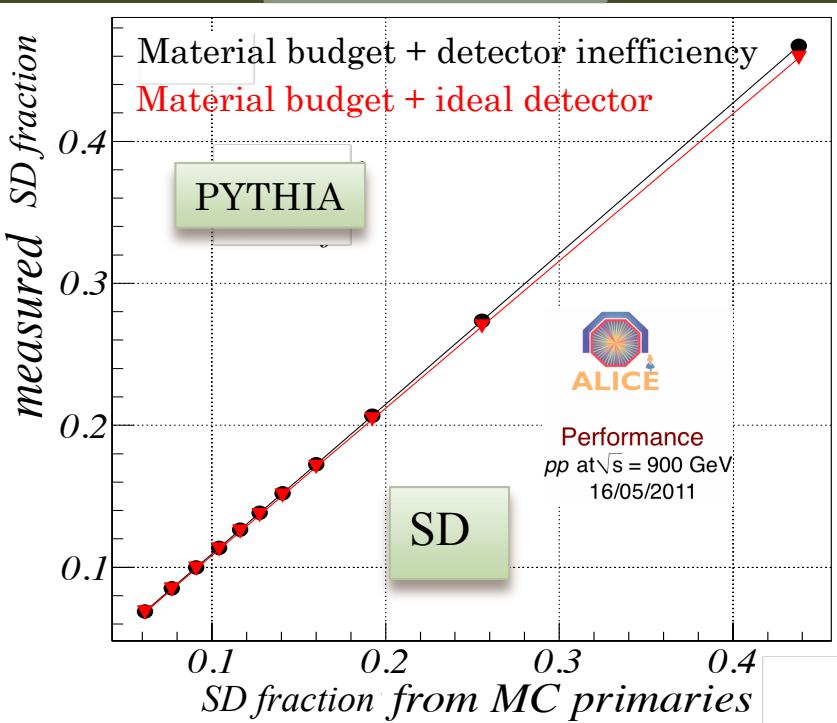


gap width

Varying the fraction of single- and double-diffractions in MC generator

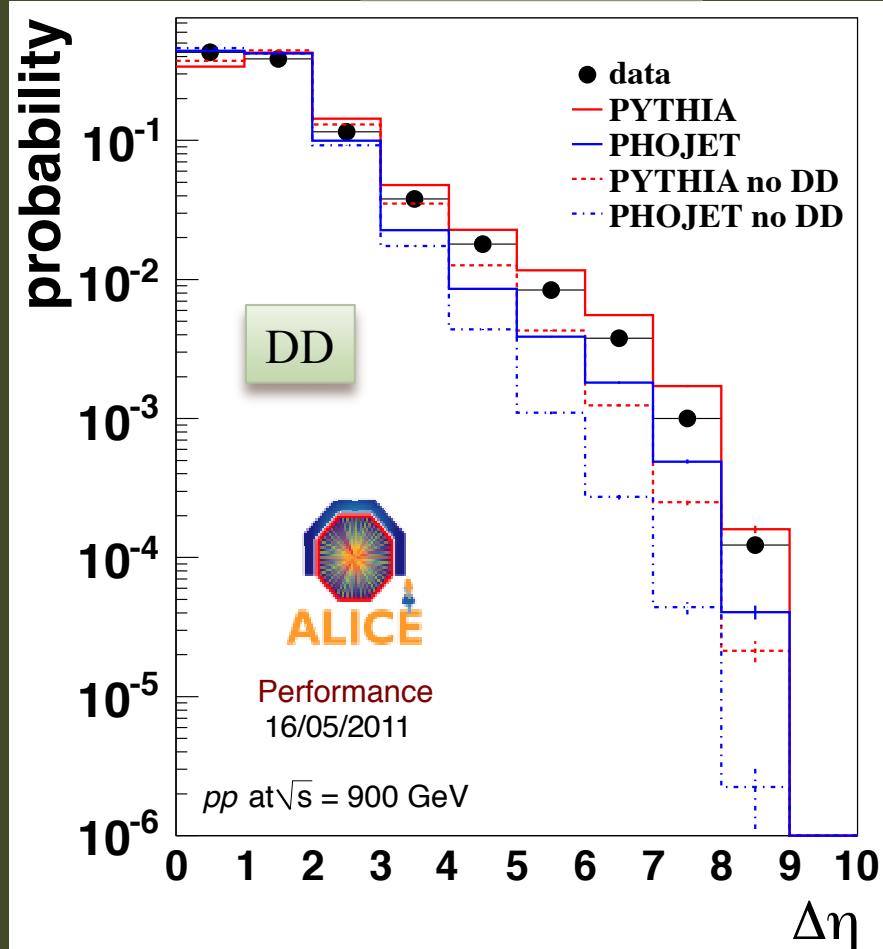
900 GeV

1-arm triggers



Material budget + simulation of detector response do not spoil the sensitivity to SD

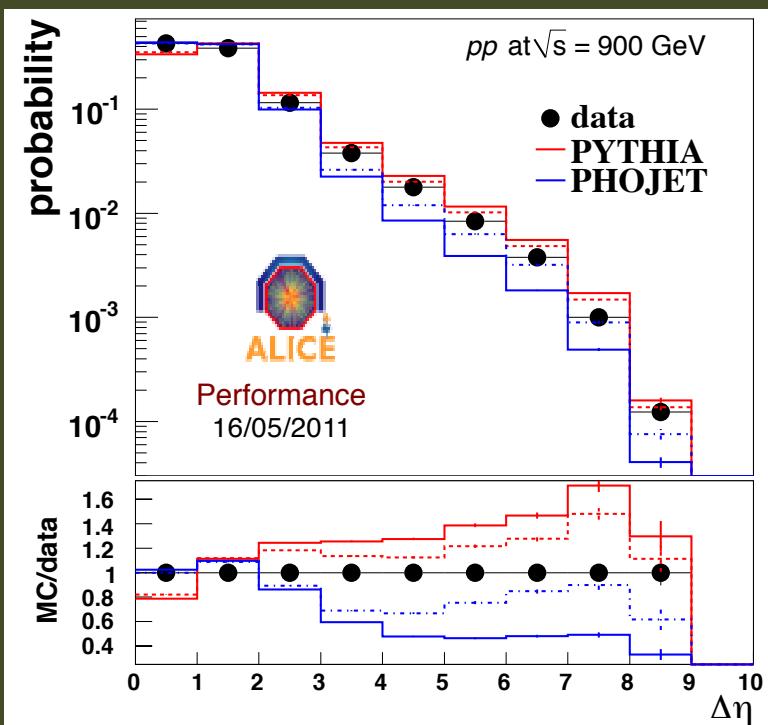
2-arm triggers



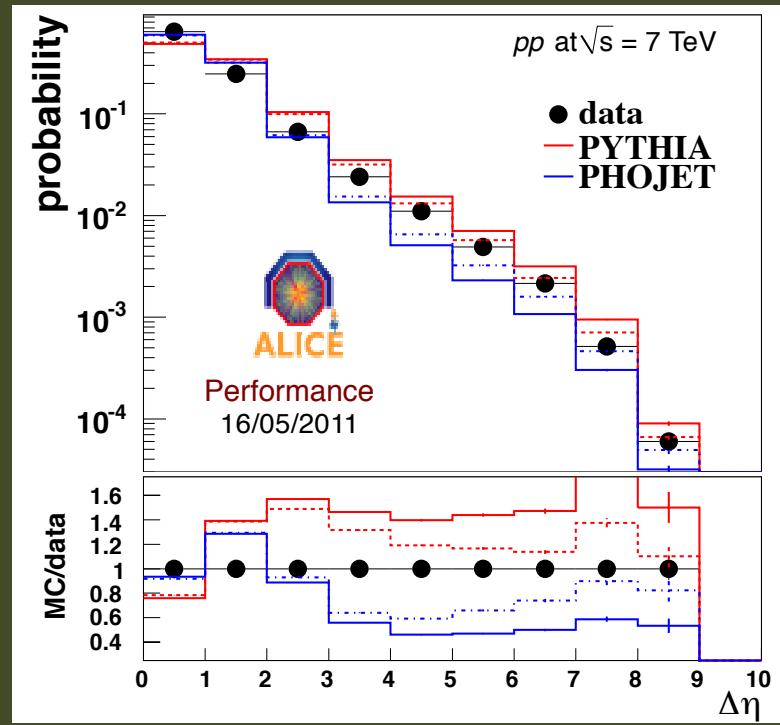
gap width distribution is sensitive to DD

Fixing the fraction of DD in Monte Carlo

Use the measured width distribution from two-arm triggers to constrain the contribution of double-diffraction.



PYTHIA: $w_{DD} = 0.12 \rightarrow 0.1$
PHOJET: $w_{DD} = 0.06 \rightarrow 0.11$



PYTHIA: $w_{DD} = 0.13 \rightarrow 0.09$
PHOJET: $w_{DD} = 0.05 \rightarrow 0.07$

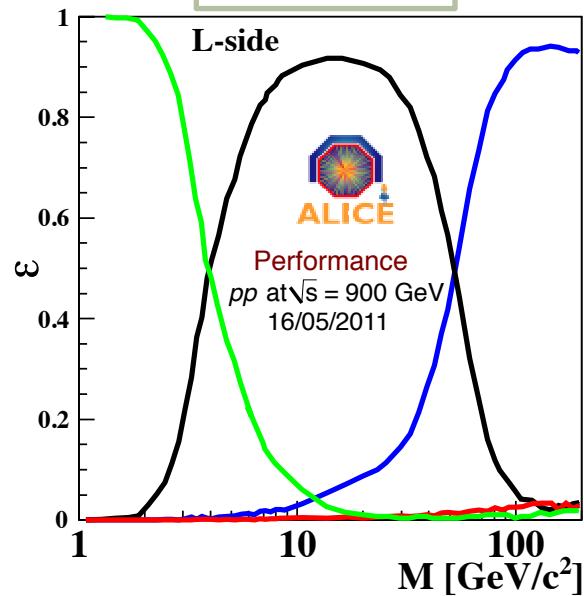
Fractions of DD events converging to same value in the two MC

For 2.76 TeV the FMD is not used and the fraction of DD is not changed.

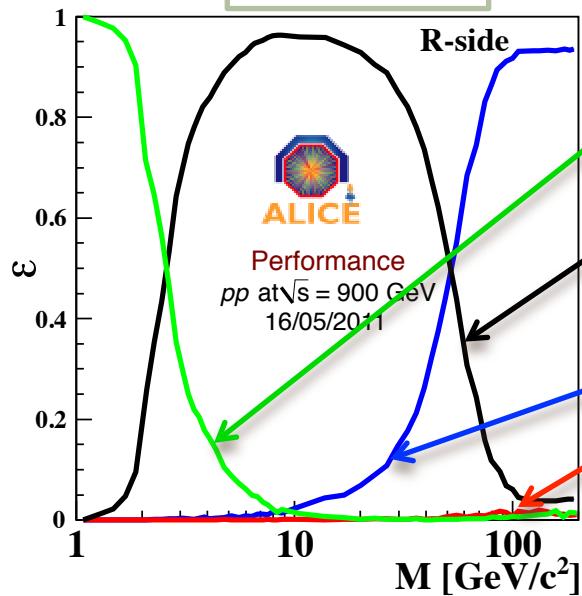
Efficiency/Inefficiency vs mass for SD (900 GeV)

PYTHIA

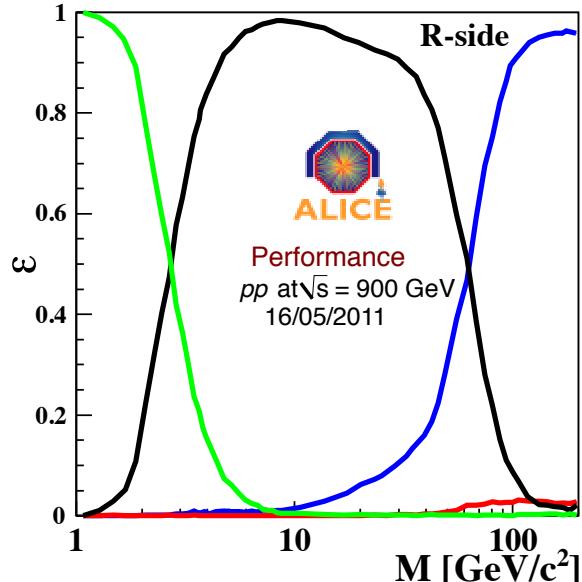
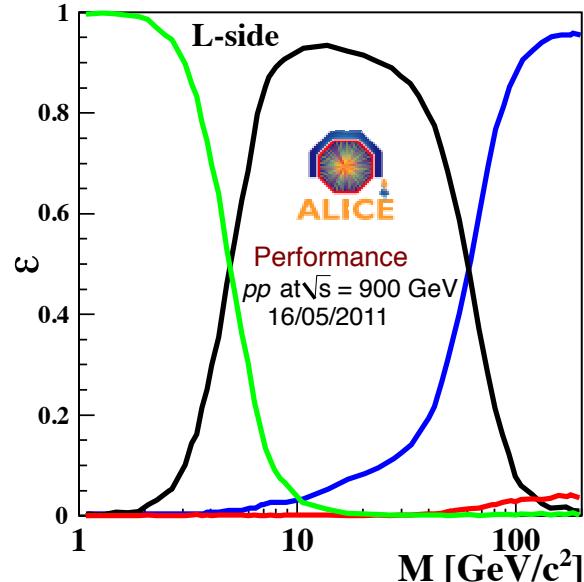
L-side SD



R-side SD



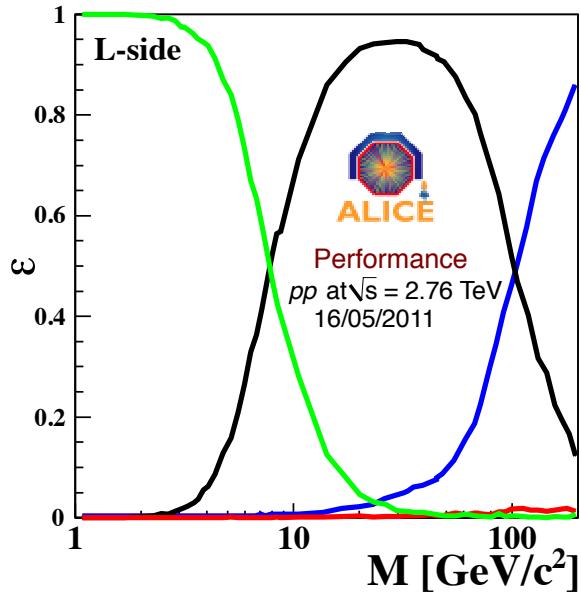
PHOJET



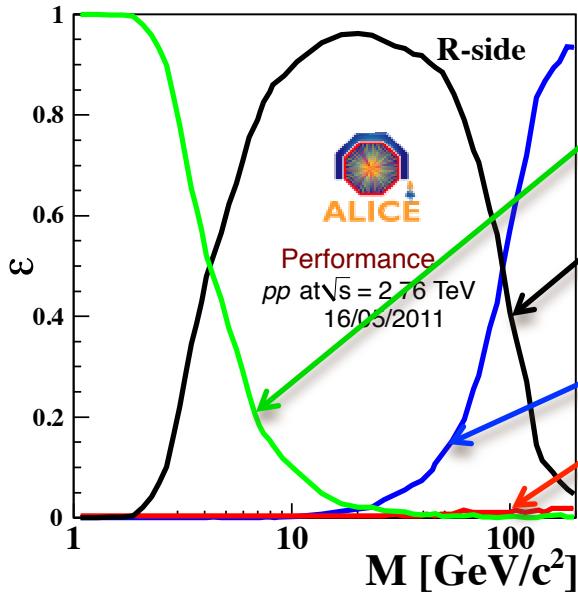
Efficiency/Inefficiency vs mass for SD (2.76 TeV)

PYTHIA

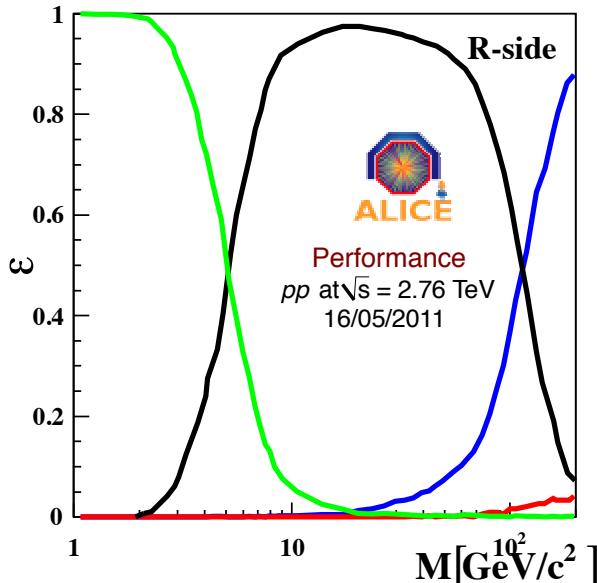
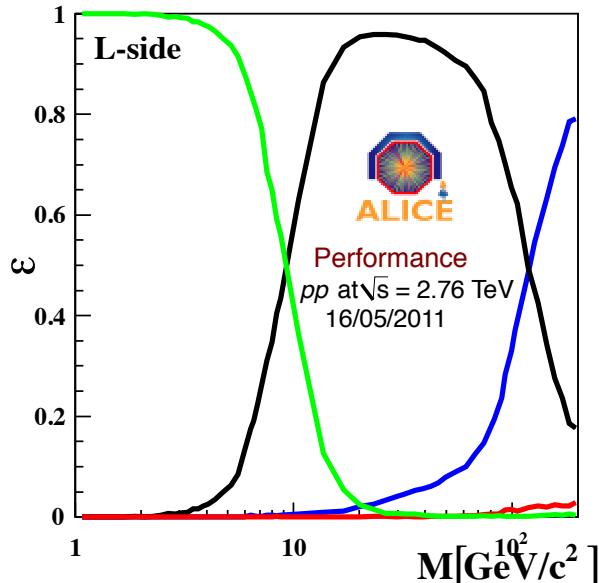
L-side SD



R-side SD



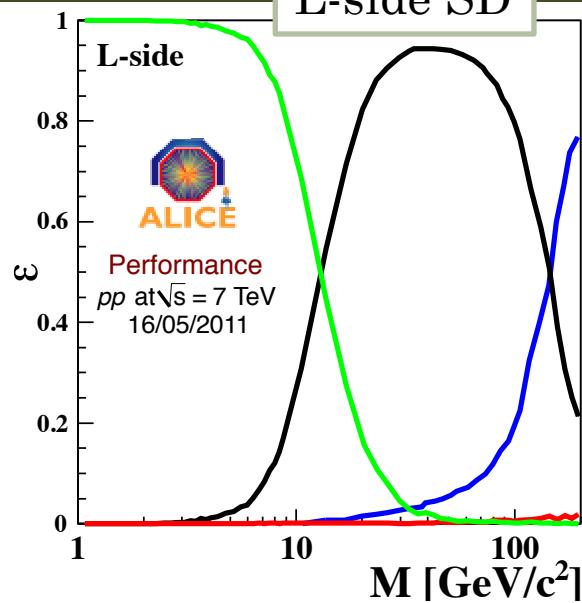
PHOJET



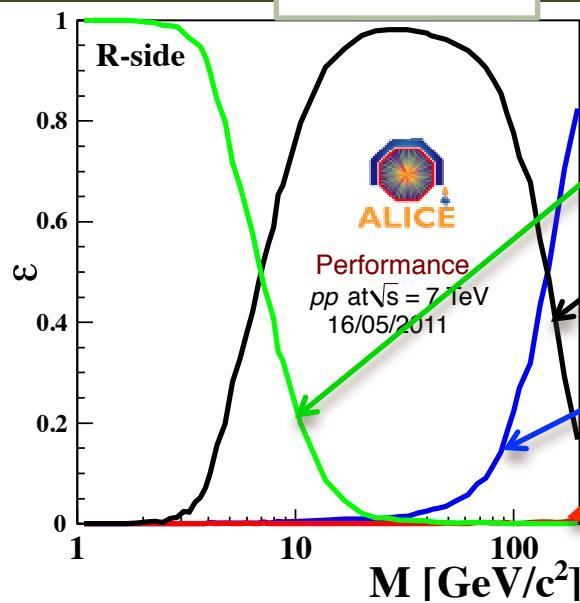
Efficiency/Inefficiency vs mass for SD (7 TeV)

PYTHIA

L-side SD



R-side SD



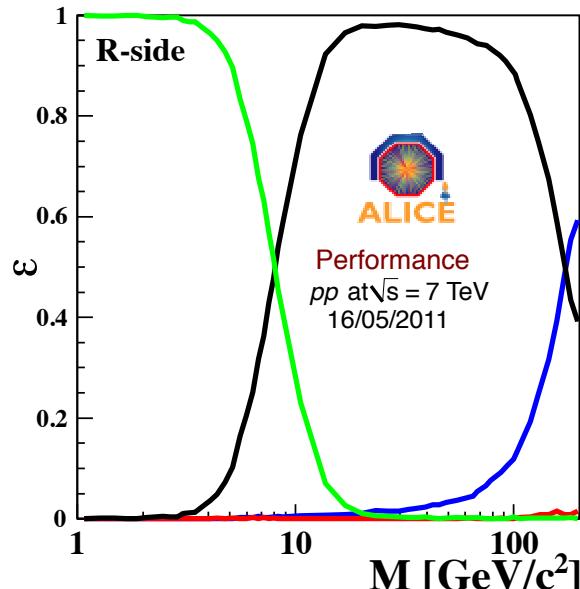
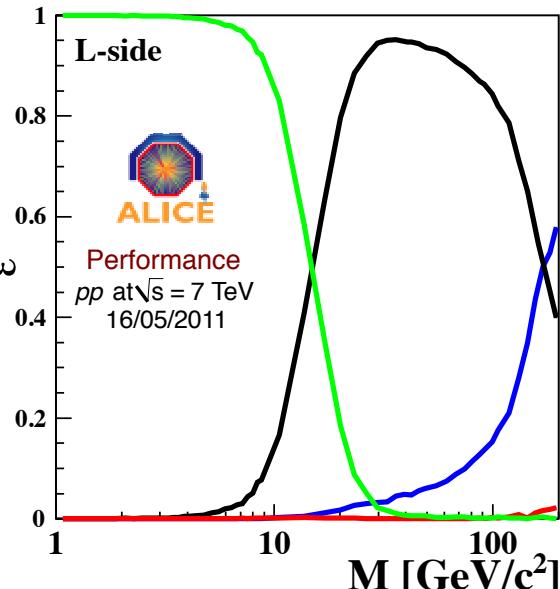
no trigger

1-arm trigger

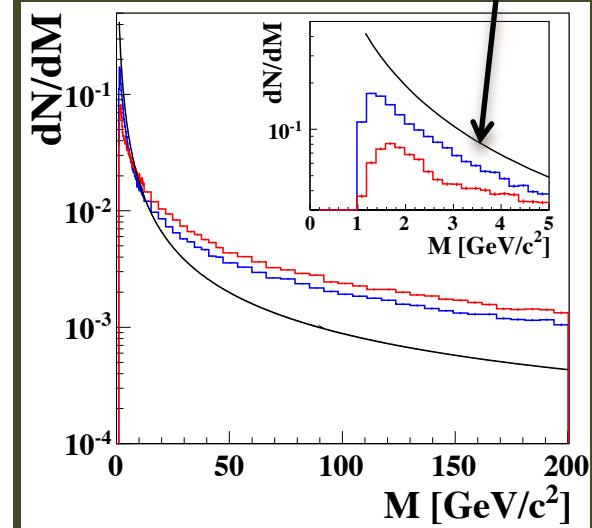
2-arm trigger

opposite side 1-arm trigger

PHOJET

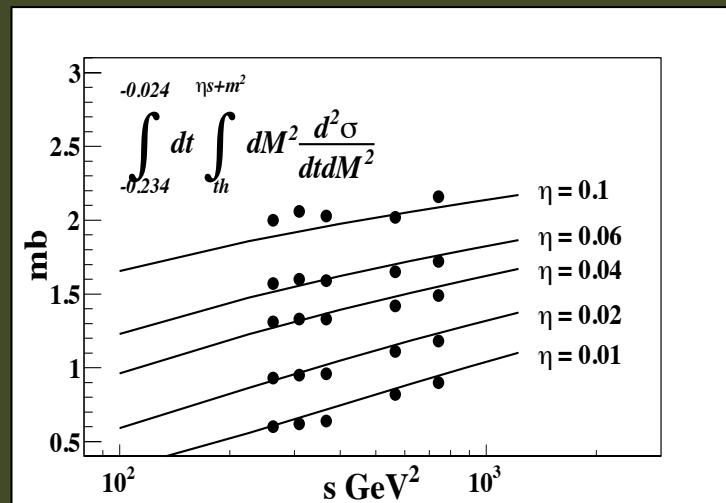
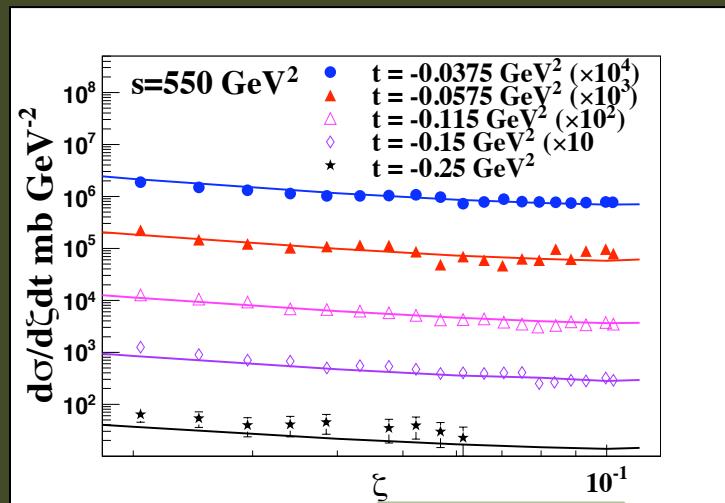
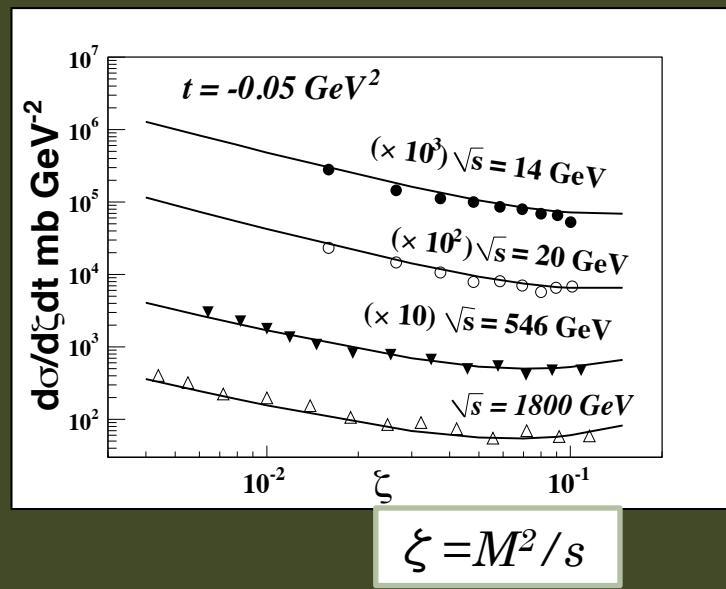
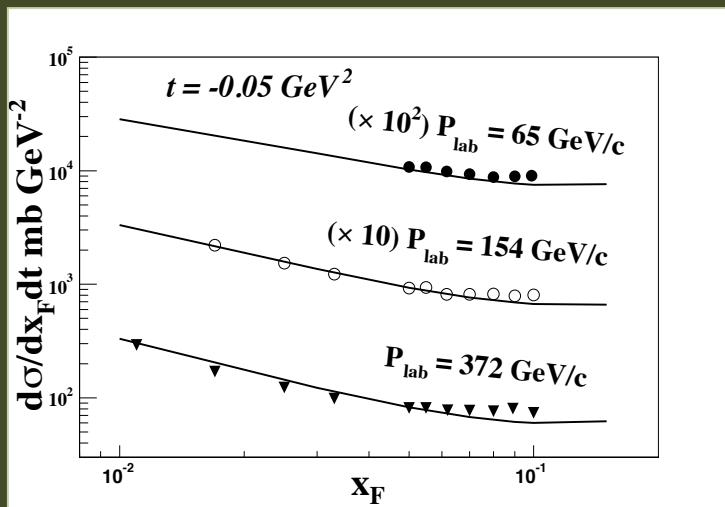


Kaidalov et al.



Performance of the model used to parameterise SD

A.Kaidalov et al. model matches all existing data on single-diffraction dissociation [arxiv:0909.5156, EPJ. C67]



Resulting mean efficiencies

		trigger		
		R-side 1-arm trig.	L-side 1-arm trig.	2-arm trig.
		<i>input</i>	<i>output</i>	
900 GeV	R-side SD	0.462 ± 0.028	0.004 ± 0.002	0.198 ± 0.054
	L-side SD	0.006 ± 0.002	0.350 ± 0.015	0.200 ± 0.050
	NSD	0.026 ± 0.007	0.013 ± 0.004	0.954 ± 0.015
2.76 TeV		trigger		
	R-side SD	0.404 ± 0.011	0.003 ± 0.001	0.084 ± 0.035
	L-side SD	0.002 ± 0.001	0.308 ± 0.022	0.073 ± 0.027
7 TeV	NSD	0.026 ± 0.013	0.017 ± 0.009	0.946 ± 0.028
		trigger		
	R-arm SD	0.333 ± 0.027	0.0004 ± 0.0002	0.038 ± 0.018
	L-arm SD	0.0008 ± 0.0004	0.243 ± 0.029	0.040 ± 0.016
	NSD	0.021 ± 0.006	0.012 ± 0.003	0.954 ± 0.014

syst. error comes from:

- adjustment of DD in Pythia and Phojet
- Changing $d\sigma/dM$ by $\pm 50\%$ at the threshold
- SD kinematic in PYTHIA and PHOJET

Measurement of $\sigma_{SD}/\sigma_{Inel}$

Raw trigger ratios

900 GeV

$L\text{-side}/2\text{-arm} = 0.0563 \pm 0.0011(\text{syst.})$

$R\text{-side}/2\text{-arm} = 0.0857 \pm 0.0053(\text{syst.})$

Corrected ratios

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = 0.202 \pm 0.034(\text{syst.})$$

$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.102 \pm 0.019(\text{syst.})$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.100 \pm 0.015(\text{syst.})$$

2.76 TeV

$L\text{-side}/2\text{-arm} = 0.0535 \pm 0.0015(\text{syst.})$

$R\text{-side}/2\text{-arm} = 0.0776 \pm 0.0014(\text{syst.})$

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = 0.187 \pm 0.054(\text{syst.})$$

$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.097 \pm 0.026(\text{syst.})$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.090 \pm 0.028(\text{syst.})$$

7 TeV

$L\text{-side}/2\text{-arm} = 0.0440 \pm 0.0001(\text{syst.})$

$R\text{-side}/2\text{-arm} = 0.0653 \pm 0.0001(\text{syst.})$

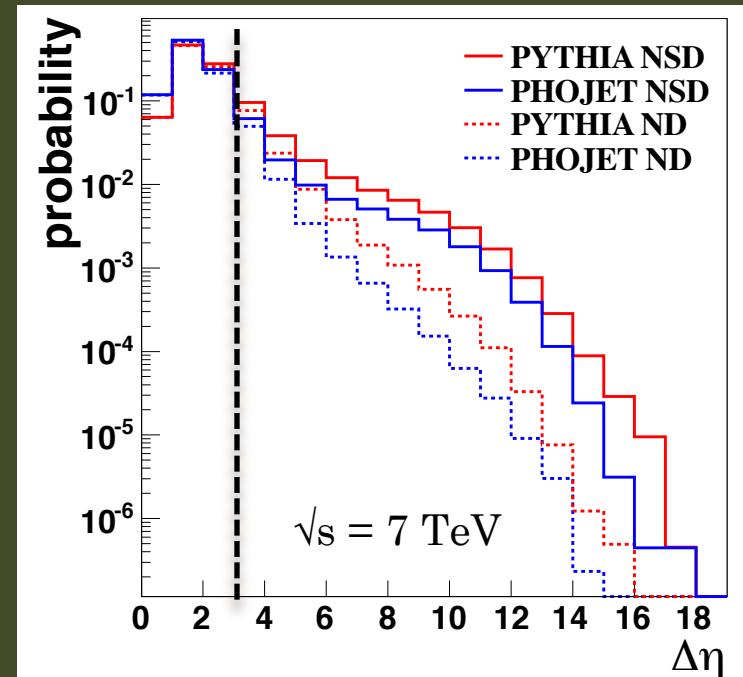
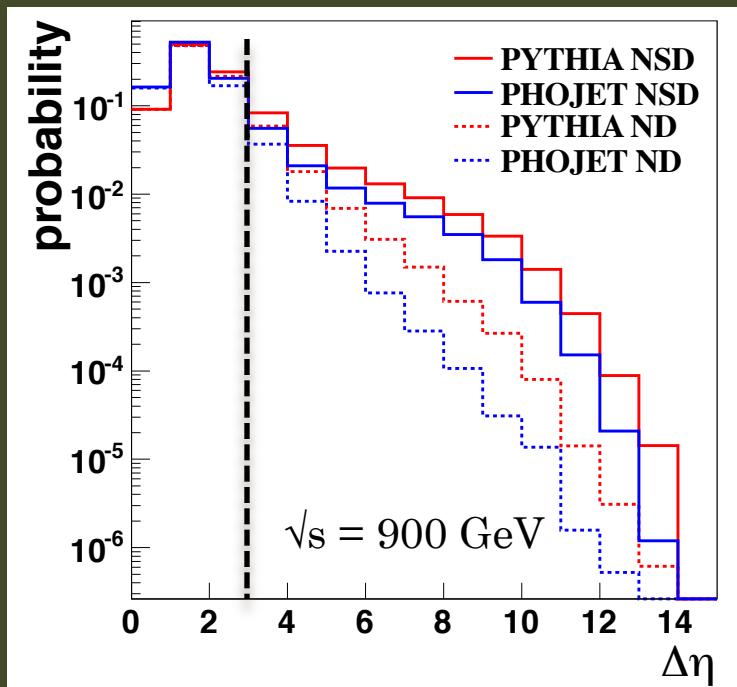
stat. errors are negligible

$$\frac{\sigma_{SD}}{\sigma_{Inel}} = 0.201 \pm 0.039(\text{syst.})$$

$$\frac{\sigma_{SD}^{left}}{\sigma_{Inel}} = 0.101 \pm 0.019(\text{syst.})$$

$$\frac{\sigma_{SD}^{right}}{\sigma_{Inel}} = 0.100 \pm 0.020(\text{syst.})$$

Despite different acceptances of the two ALICE sides, the results are symmetrical as expected from the symmetry of the physics process



Definition of DD : all events with a gap $\Delta\eta > 3$:

900 GeV

2.76 TeV

7 TeV

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.113 \pm 0.029$$

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.125 \pm 0.052$$

$$\frac{\sigma_{DD}}{\sigma_{Inel}} = 0.122 \pm 0.036$$

Triggering efficiencies

From the MC tuned with our SD and DD measurements, we can calculate the ALICE triggering efficiencies:

MB_{OR} = V0-Left or SPD or V0-Right

MB_{AND} = V0-Left and V0-Right

900 GeV

$$\text{MB}_{\text{AND}} = (77.4 \pm 0.9)\%$$

$$\text{MB}_{\text{OR}} = (91.6 \pm 1.3)\%$$

$$\text{MB}_{\text{AND}}/\text{MB}_{\text{OR}} = 0.845 \pm 0.004$$

2.76 TeV

$$\text{MB}_{\text{AND}} = (76.2 \pm 2)\%$$

$$\text{MB}_{\text{OR}} = (88.3 \pm 3)\%$$

$$\text{MB}_{\text{AND}}/\text{MB}_{\text{OR}} = 0.86 \pm 0.01$$

7 TeV

$$\text{MB}_{\text{AND}} = (74.5 \pm 1.1)\%$$

$$\text{MB}_{\text{OR}} = (85.2 \pm 2.4)\%$$

$$\text{MB}_{\text{AND}}/\text{MB}_{\text{OR}} = 0.87 \pm 0.01$$

See talk by K.Oyama:

$$\sigma_{\text{MB}_{\text{AND}}} \left(\sqrt{s} = 2.76 \text{ TeV} \right) = 47.2 \pm 3.3 \text{ mb}$$

$$\sigma_{\text{MB}_{\text{AND}}} \left(\sqrt{s} = 7 \text{ TeV} \right) = 54.2 \pm 3.8 \text{ mb}$$

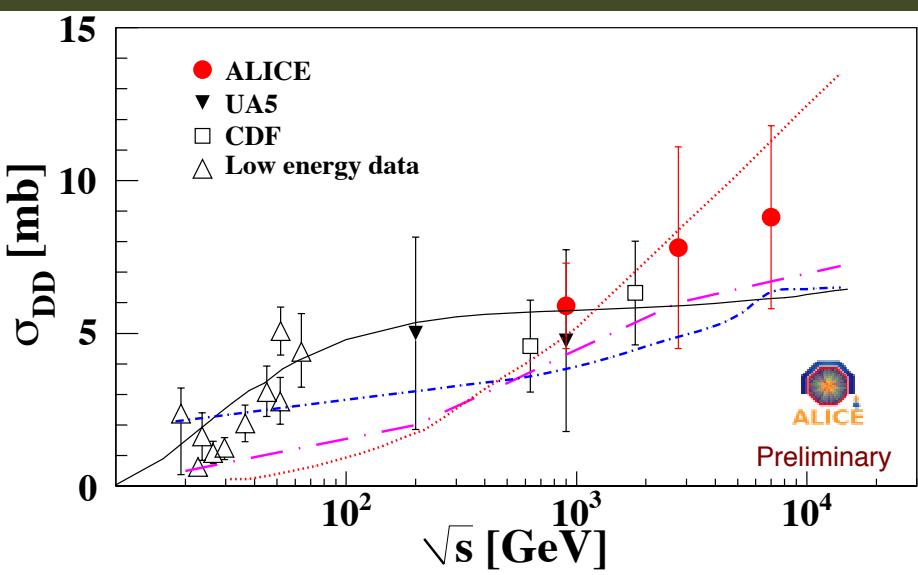
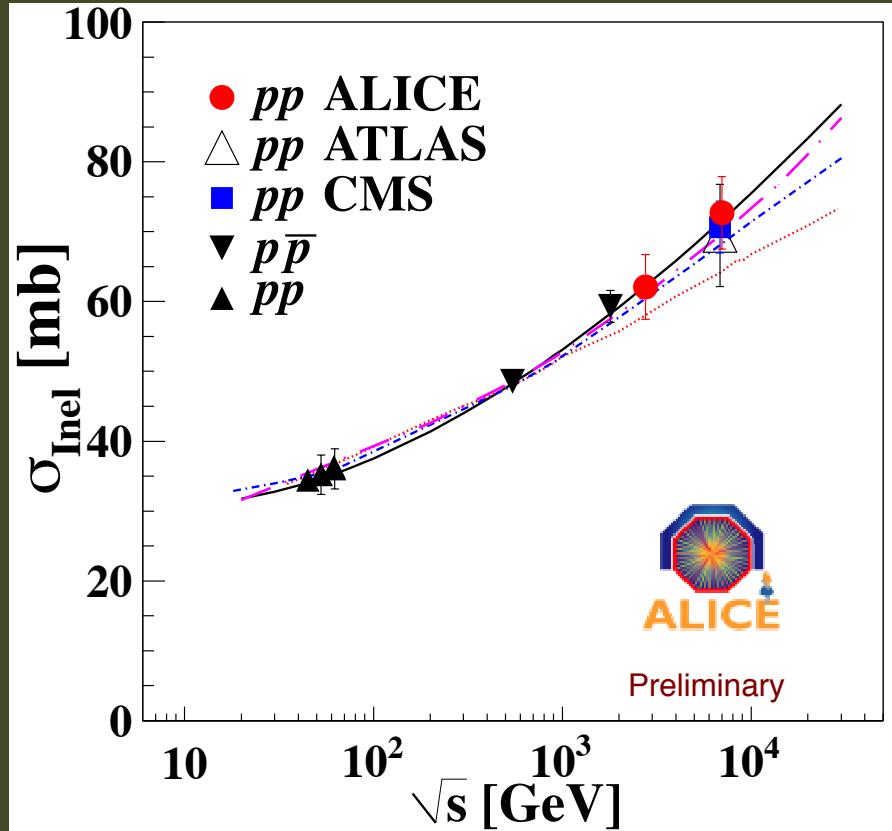
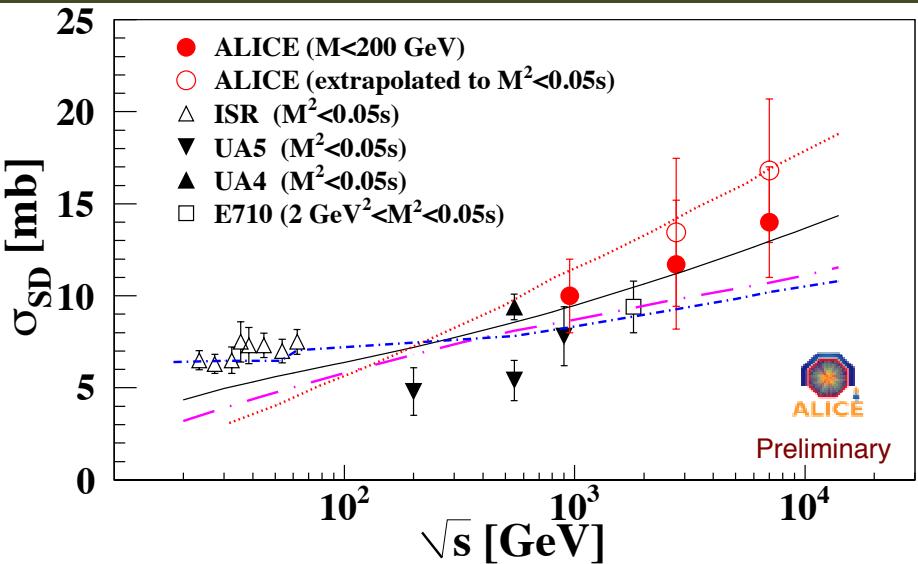


$$\sigma_{\text{Inel}} (\sqrt{s} = 2.76 \text{ TeV}) = 62.1 \pm 1.6(\text{model}) \pm 4.3(\text{lumy}) \text{ mb}$$

$$\sigma_{\text{Inel}} (\sqrt{s} = 7 \text{ TeV}) = 72.7 \pm 1.1(\text{model}) \pm 5.1(\text{lumy}) \text{ mb}$$

No van der Meer scan at 900 GeV

Comparison with other experiments and models



Gotsman et al., arXiv:1010.5323, EPJ. C74, 1553 (2011)

Kaidalov et al., arXiv:0909.5156, EPJ. C67, 397 (2010)

Ostapchenko, arXiv:1010.1869, PR D83 114018 (2011)

Khoze et al., EPJ. C60 249 (2009), C71 1617 (2011)

Model predictions:

$SD \rightarrow M^2 < 0.05s$

$DD \rightarrow \Delta \eta > 3$

Summary

Ratios of single-diffraction dissociation ($M < 200 \text{ GeV}/c^2$) to inelastic cross-sections were measured at $\sqrt{s} = 0.9, 2.76$ and 7 TeV . Within our accuracy, we do not observe variations of these ratios with energy ($\sigma_{\text{SD}}/\sigma_{\text{Inel}} \approx 0.2$).

From a determination of the inelastic cross-section (van der Meer scan) single-diffraction and double-diffraction cross-sections were obtained at $\sqrt{s} = 2.76$ and 7 TeV .

$\sqrt{s} \text{ (TeV)}$	$\sigma_{\text{Inel}} \text{ (mb)}$	$\sigma_{\text{SD}}(M < 200 \text{ GeV})/\sigma_{\text{Inel}}$	$\sigma_{\text{DD}}(\Delta \eta > 3)/\sigma_{\text{Inel}}$
0.9		0.202 ± 0.034	0.113 ± 0.029
2.76	$62.1 \pm 1.6 \pm 4.3$	0.187 ± 0.054	0.125 ± 0.052
7	$72.7 \pm 1.1 \pm 5.1$	0.201 ± 0.039	0.122 ± 0.036