Diffraction Studies at the LHC

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CERN

Standard Model Physics at the LHC
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INTRODUCTION

- Diffraction is an old field [Leonardo **Da Vinci** (~1500); F. Grimaldi (1665)) that moved from electromagnetic waves to particle physics in the 1950's [R. Serber; R.J. Glauber; E.L. Feinberg and I. **Pomeranchuk** (1956); M.L. Good & W.D. Walker (1960); Donnachie & Landshoff (1998); etc.].
- **Both elastic and inelastic diffraction processes are being studied at LHC.**
- Why do we (all LHC experiments) care about diffraction at LHC?
  - "**Because it's there!**": more than 25% of σ_{inel}

$$\sigma_{Tot} = \sigma_{elastic} + \sigma_{Non-Diffractive} + \sigma_{SD} + \sigma_{DD} + \text{etc.}$$

  - Information on the proton structure and interaction mechanism
  - Access to non-perturbative QCD processes*
  - In practice, one cannot ignore diffraction when normalizing data to specific event classes!

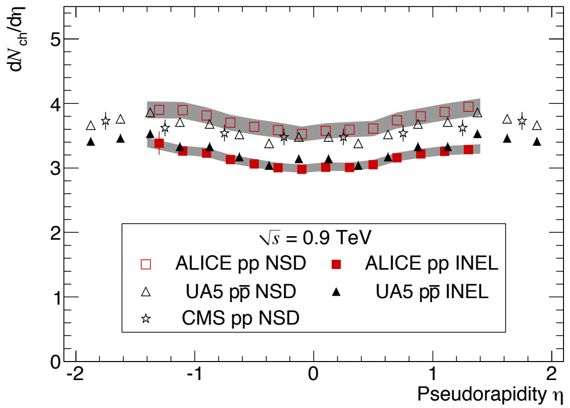
$$a + b \rightarrow c + X: \ E^c \frac{d^3\sigma}{d^3 p_c} = \frac{F_{ab}(s, p_c)}{\sigma}$$

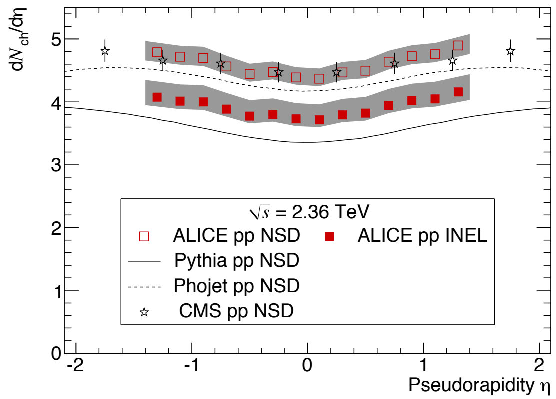
* Even though there is also hard diffraction which may belong to the perturbative regime

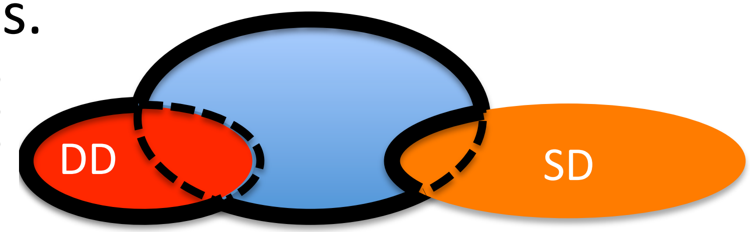
A practical issue for experiments

- NSD and INEL event classes defined to compare data between experiments. Corrections are largest contribution to systematic uncertainty in multiplicity measurements.

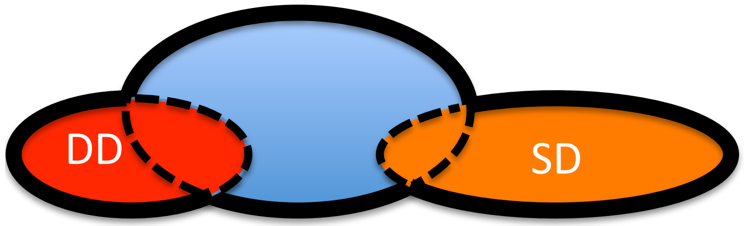
Uncertainty	$dN_{ch}/d\eta$ analysis		$P(N_{ch})$ analysis	
	0.9 TeV	2.36 TeV	0.9 TeV	2.36 TeV
Tracklet selection cuts	negl.	negl.	negl.	negl.
Material budget	negl.	negl.	negl.	negl.
Misalignment	negl.	negl.	negl.	negl.
Particle composition	0.5–1.0 %	0.5–1.0 %	included in detector efficiency	
Transverse-momentum spectrum	0.5 %	0.5 %	included in detector efficiency	
Contribution of diffraction (INEL)	0.7 %	2.6 %	3–0 % (0–5)	5–0 % (0–5)
Contribution of diffraction (NSD)	2.8 %	2.1 %	24–0 % (0–10)	12–0 % (0–10)
Event-generator dependence (INEL)	+1.7 %	+5.9 %	8–0 % (0–5)	25–0 % (0–10)
Event-generator dependence (NSD)	−0.5 %	+2.6 %	3–5–1 % (0–10–40)	32–8–2 % (0–10–40)
Detector efficiency	1.5 %	1.5 %	2–4–15 % (0–20–40)	3–0–9 % (0–8–40)
SPD triggering efficiency	negl.	negl.	negl.	negl.
VZERO triggering efficiency (INEL)	negl.	n/a	negl.	n/a
VZERO triggering efficiency (NSD)	0.5 %	n/a	1 %	n/a
Background events	negl.	negl.	negl.	negl.
Total (INEL)	$^{+2.5}_{-1.8}$ %	$^{+6.7}_{-3.1}$ %	9–4–15 % (0–20–40)	25–0–9 % (0–10–40)
Total (NSD)	$^{+3.3}_{-3.3}$ %	$^{+3.7}_{-2.7}$ %	24–5–15 % (0–10–40)	32–8–9 % (0–10–40)







NSD



INEL

To reduce uncertainties (cross-sections and kinematics): measure SD and DD processes at LHC, as precisely as possible

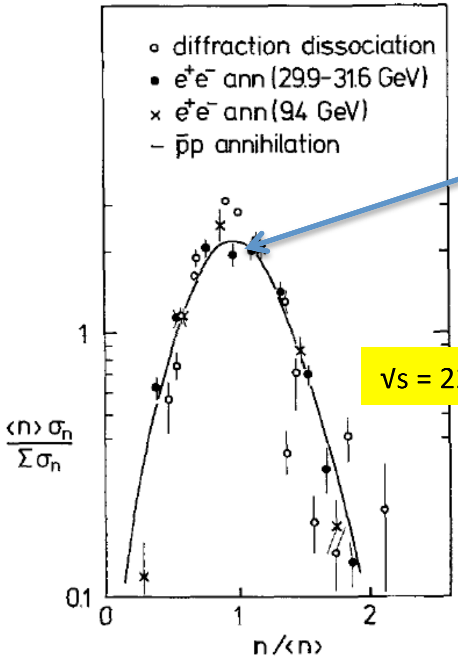
Experimental challenge!

Diffractive processes

Cross sections at 7 TeV relative to σ_{tot} (QGSM)

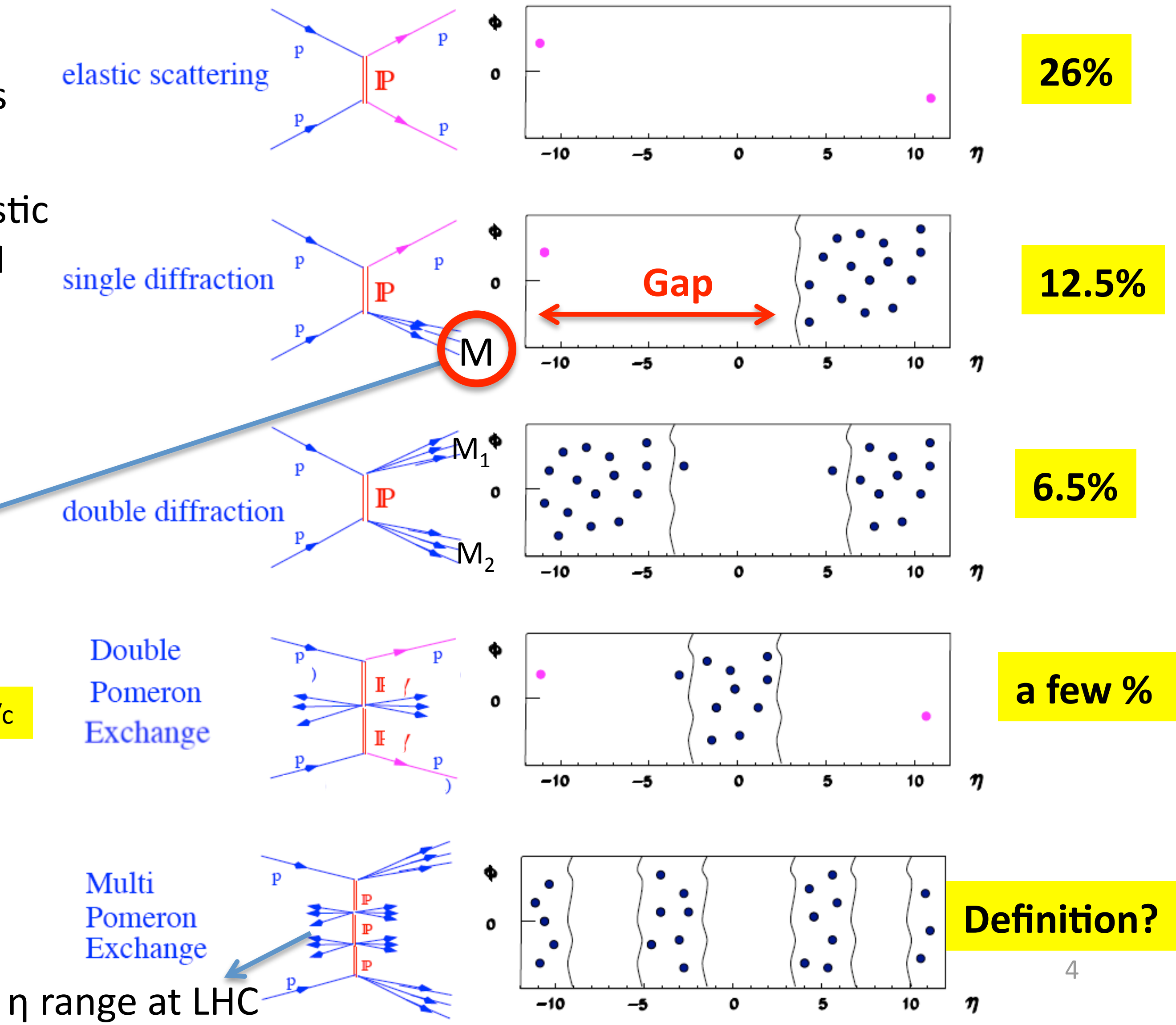
- **Cross-sections** and **Kinematic** are the main issues
- Indication that M fragments as inelastic system with $\sqrt{s}$ = M

E.G. Boos et al., Z. Phys. C Particles and Fields 17, (1983)



$\sqrt{s}$ = 22.4 GeV/c

+UA4, Phys. Lett. B116 (1986) 459

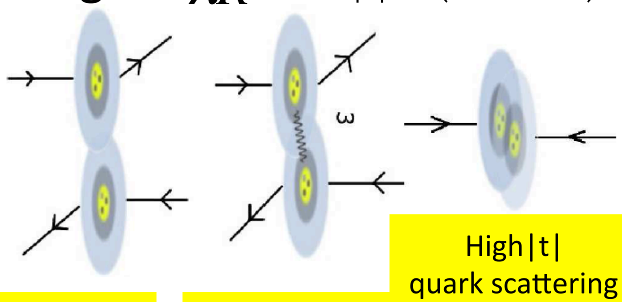


M.M. Islam et al. the proton as "condensate enclosed chiral bag?"
Proton-Proton Elastic Scattering at LHC and Proton Structure, Blois Workshop 2009s

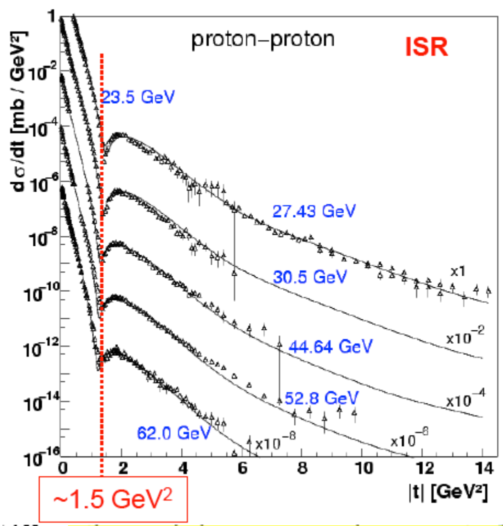
pp elastic scattering

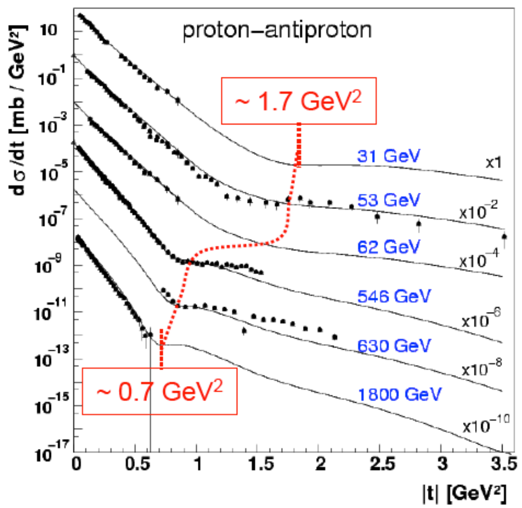
- Diffraction pattern analogous to Fraunhofer diffraction of light $\frac{a^2}{\lambda R} \ll 1$ $|\mathbf{t}| \equiv (\mathbf{p}_f - \mathbf{p}_i)^2$
  - Exponential slope B at low |t| increases with √s
  - Minimum (dip) moves to lower |t| as $1/\sigma_{tot}$
  - Interaction region grows (as also seen from rising σ_{tot})
  - Depth of minimum differs between **pp and p$\bar{p}$** different mix of processes? (Donnachie & Landshoff, introduced 3-gluon exchange ➔ no dip in p$\bar{p}$)

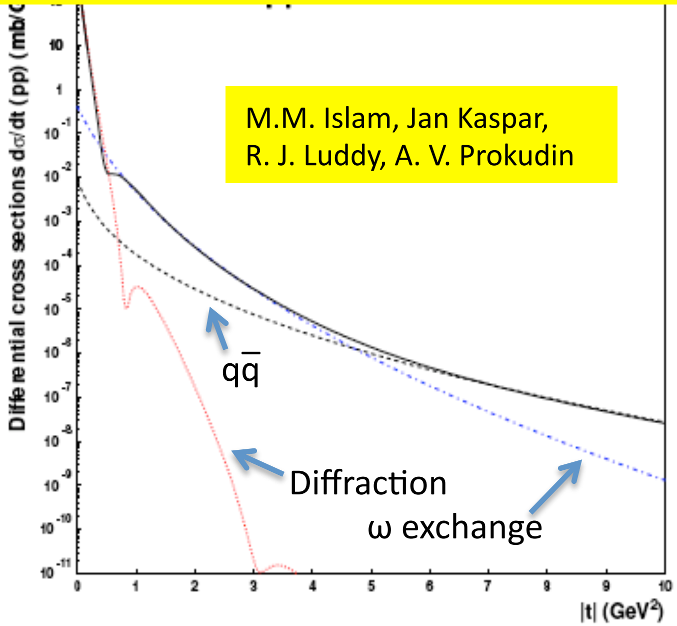
(associated to exchange of Oderon in Regge theory)



ATLAS ALFA detector (0.0006 < |t| < 0.1 GeV²)



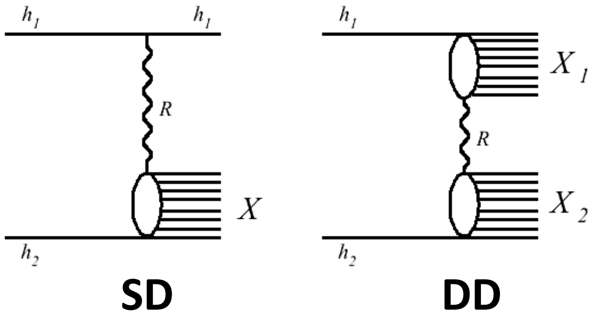




M. Bozzo / LHCC/ Nov. 17, 2010

Modeling particle production

$$h_1 + h_2 \to h_1 + X_2;$$
$$h_1 + h_2 \to X_1 + h_2;$$



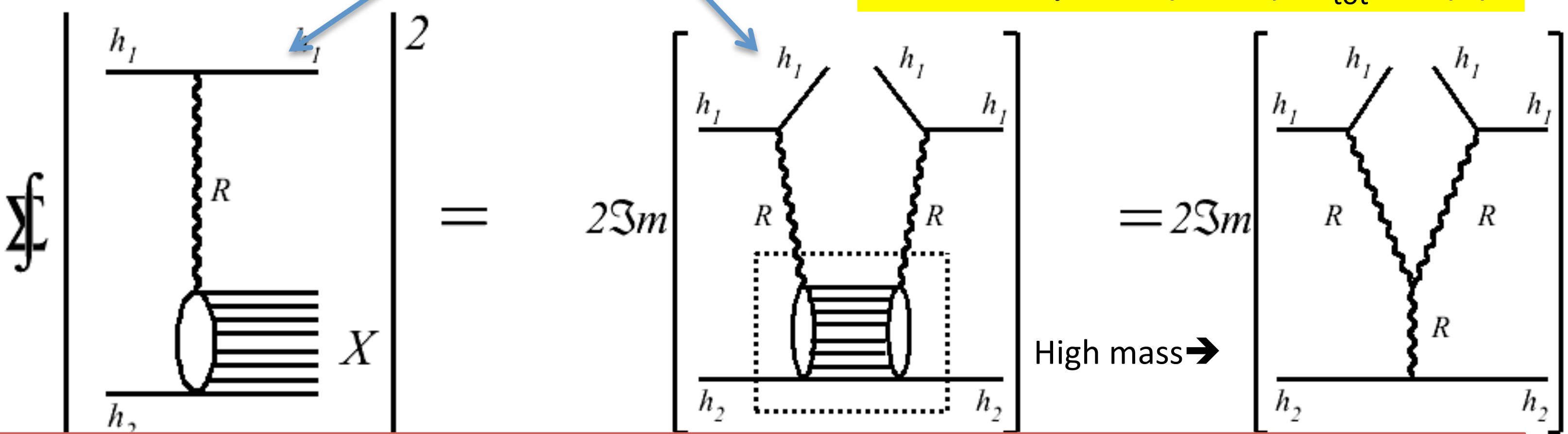
$$h_1 + h_2 \to X_1 + X_2$$

Example of single diffraction

- Analogous to the ***optical theorem***, Muller– Kancheli's theorem relates the inclusive cross-section for the reaction: *$h_1+h_2 \to h_1+X$ to the forward scattering amplitude of the three-body hadronic* process: $h_1+h_2+\underline{h}_1 \to h_1+h_2+\underline{h}_1$.

$$\sum_c T_{ac} T^*_{ac} = 2\Im m T_{aa}$$

Elastic amplitude ⟷ T = –i(S-I)
+ unitarity of S ($SS^+=I$); $\sigma_{tot}=Im(T)$

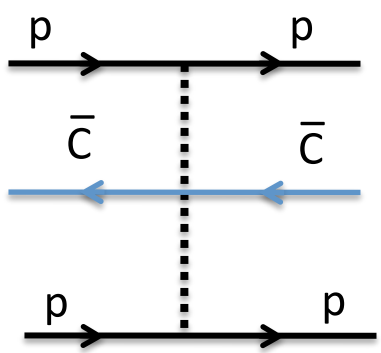


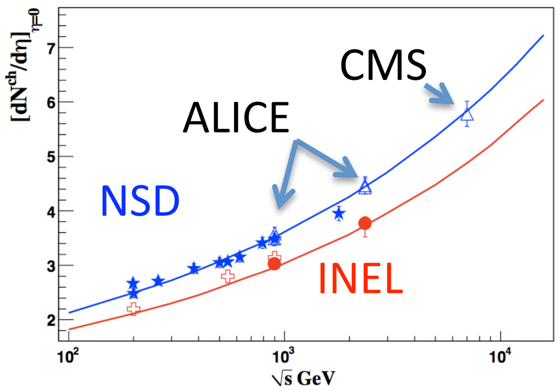
Direct information on interacting Reggeons: First determination of triple Pomeron by A. B. Kaidalov, V. Khoze et al., [P.L. B45, 493-496 (1973)]

Particle production at LHC

p + p ➔ c+ X

- At high energy, simple Mueller-Kancheli graph should dominate





$$\left(\frac{d\sigma^{incl.}}{dy}\right)_{y=0} \sim s^{\Delta} \Rightarrow \left(\frac{dN}{d\eta}\right)_{\eta=0} \sim \frac{1}{\sigma_{int.}} \frac{p_T}{m_T} s^{\Delta}$$

Alice 0.9 & 2.36 TeV ➔ $\Delta = (\alpha_P - 1) = 0.2$

Martin Poghosyan

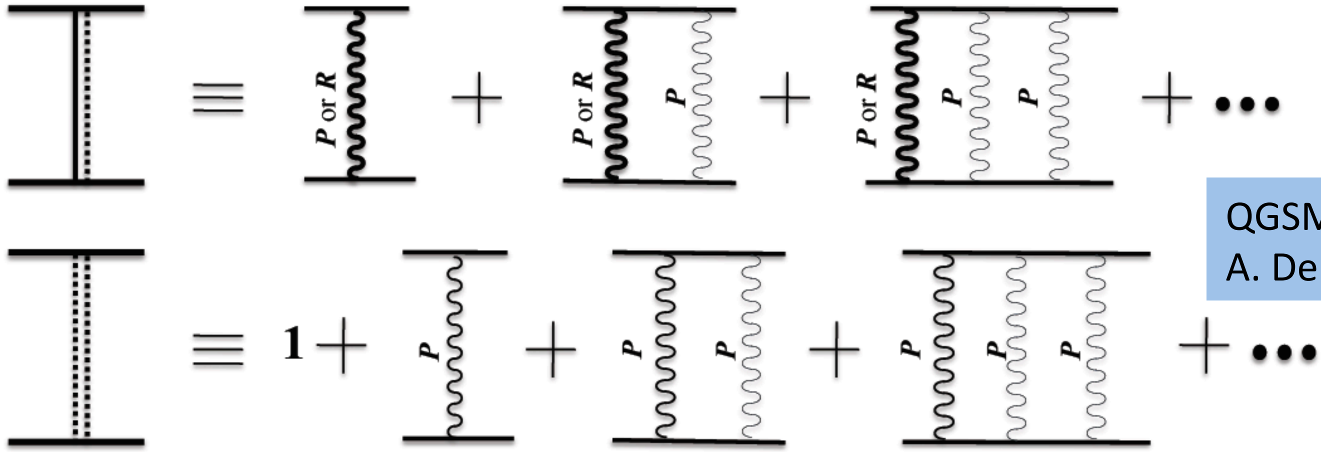
Predicted correctly the NSD CMS point at 7 TeV

- **A more precise test requires higher order calculations and more precise measurements (importance of diffraction).**
  ➔ LHC clearly entered the realm of **non-perturbative QCD** and of **Pomerons, towards a better understanding of the nature of the Pomeron.**

Modelling particle production

- Higher orders needed for many reasons (high energy behaviour, unitarity, etc.). After adding ordinary Reggeons (Dressed triple-Reggeon and loop diagrams), and a lot of hard work …
(A. Kaidalov and M. Poghosyan)

where



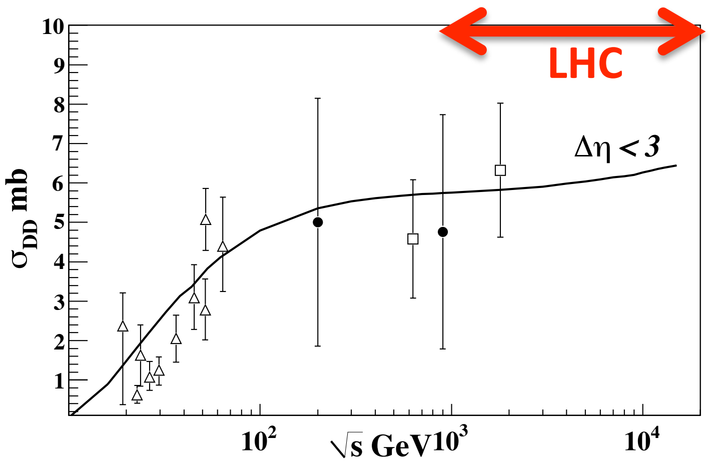
Alexei B. Kaidalov 1940–2010

QGSM: “Immorally succesful model”
A. De Rujula, Evian, 1992

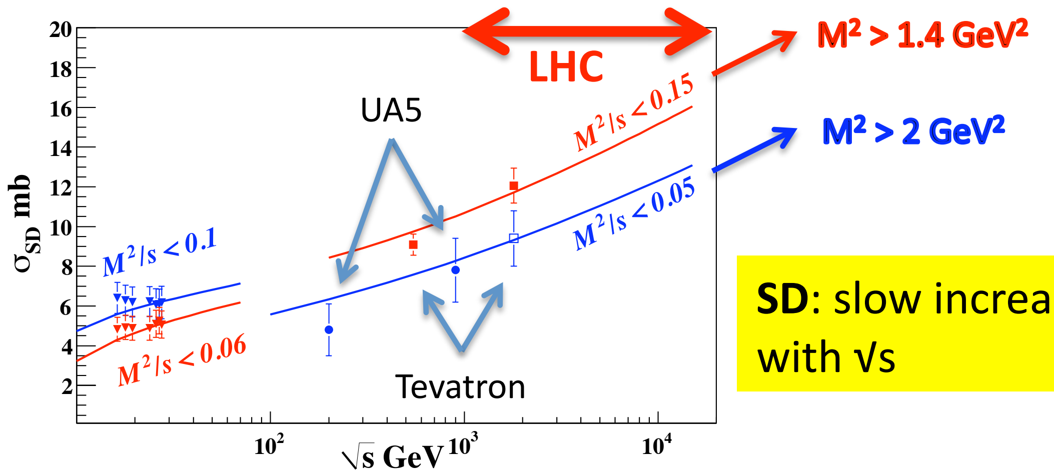
SD and DD cross sections

- **Resulting predictions (not a fit) for integrated SD and DD cross-sections: needs more precise measurements!**

DD: Little increase with √s



Details in:
M. Poghosyan EDS Blois(2009)



SD: slow increase with √s

√s (TeV)	σ_{tot} (mb)	$\sigma_{elastic}$ (mb)	$\sigma_{inelastic}$ (mb)	σ^*_{SD} (mb)	σ^{**}_{DD} (mb)
0.9	66.8	14.6	52.2	9.3	5.7
7	96.4	24.8	71.6	13	6.2
14	108	29.5	78.5	14.3	6.4

- * SD: $M^2/s < 0.05$
- ** DD: $\Delta\eta > 3$

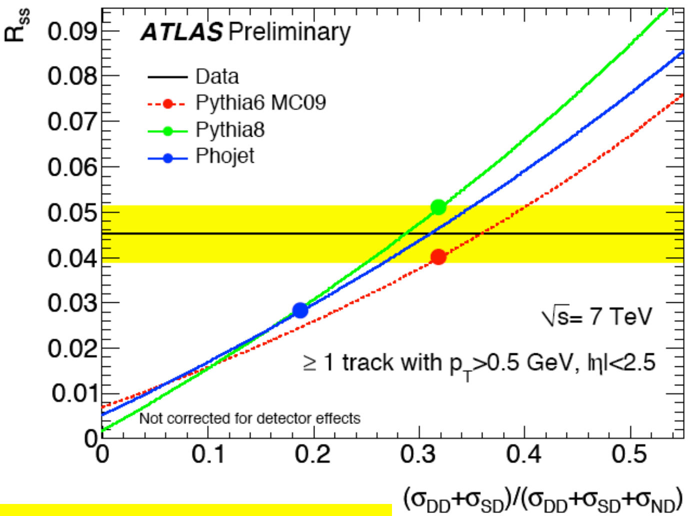
Diffraction studies with ATLAS

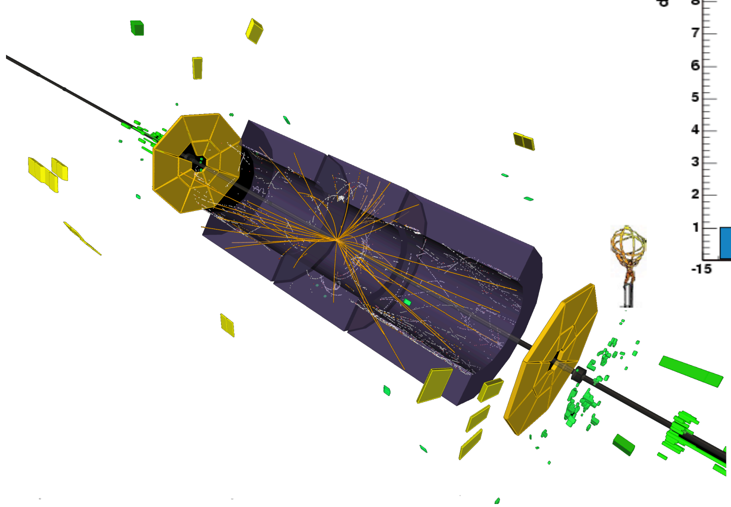
- Observing SD and DD, using Minimum Bias Trigger Scintillators (MBTS) selection: require activity only on one side of the MBTS (2.09 < |η| < 3.84 and at least one track $p_T \geq 0.5$ GeV/c in |η| < 2.5.
- No correction for detector effects

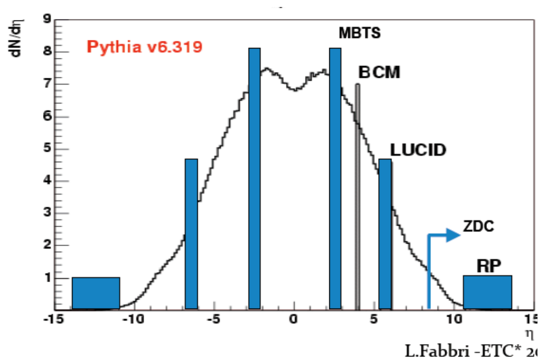
$$\mathbf{R}_{\mathbf{SS}} = \frac{\mathbf{N}_{\text{single side}}}{\mathbf{N}_{\mathbf{any}}} \equiv \frac{\mathbf{N}_{\mathbf{ss}}}{\mathbf{N}_{\mathbf{any}}} = \frac{\mathbf{A}_{\mathbf{ss}}^{\mathbf{SD}}\sigma_{\mathbf{SD}} + \mathbf{A}_{\mathbf{ss}}^{\mathbf{DD}}\sigma_{\mathbf{DD}} + \mathbf{A}_{\mathbf{ss}}^{\mathbf{ND}}\sigma_{\mathbf{ND}}}{\mathbf{A}_{\mathbf{any}}^{\mathbf{SD}}\sigma_{\mathbf{SD}} + \mathbf{A}_{\mathbf{any}}^{\mathbf{DD}}\sigma_{\mathbf{DD}} + \mathbf{A}_{\mathbf{any}}^{\mathbf{ND}}\sigma_{\mathbf{ND}}}$$

ATLAS Note
ATLAS-CONF-2010-048

$$\mathbf{R}_{\mathbf{SS}} = \frac{52{,}801}{1{,}169{,}508} = [4.52 \pm 0.02(\mathbf{stat}) \pm 0.61(\mathbf{syst})]\%$$







Discrepancies between generators imply a high systematic uncertainty ≥ 40%!

Diffraction studies with ATLAS

- Recent publication of the measurement of the inelastic cross section (arXiv:1104.0326v1)

$$\sigma\left(\xi > \frac{m_p^2}{s}\right) = 69.4 \pm 2.4(\exp.) \pm 6.9(extr.); \xi \equiv \frac{M_X^2}{s}$$

No p_T cut in this case, gives higher sensitivity to diffraction
ATLAS sensitivity down to $\xi > 5\text{x}10^{-6}$
$M_X > 15.6$ GeV)

$$\mathbf{R_{SS}} = [10.02 \pm 0.03(\mathbf{stat})^{+0.1}_{-0.4}(\mathbf{syst})]\%$$

$$\frac{\mathbf{d}\sigma_{\mathbf{SD}}}{\mathbf{d}\xi} \propto \frac{1}{\xi^{1+\Delta}}(1+\xi); \quad \Delta \equiv \alpha(0) - 1;$$

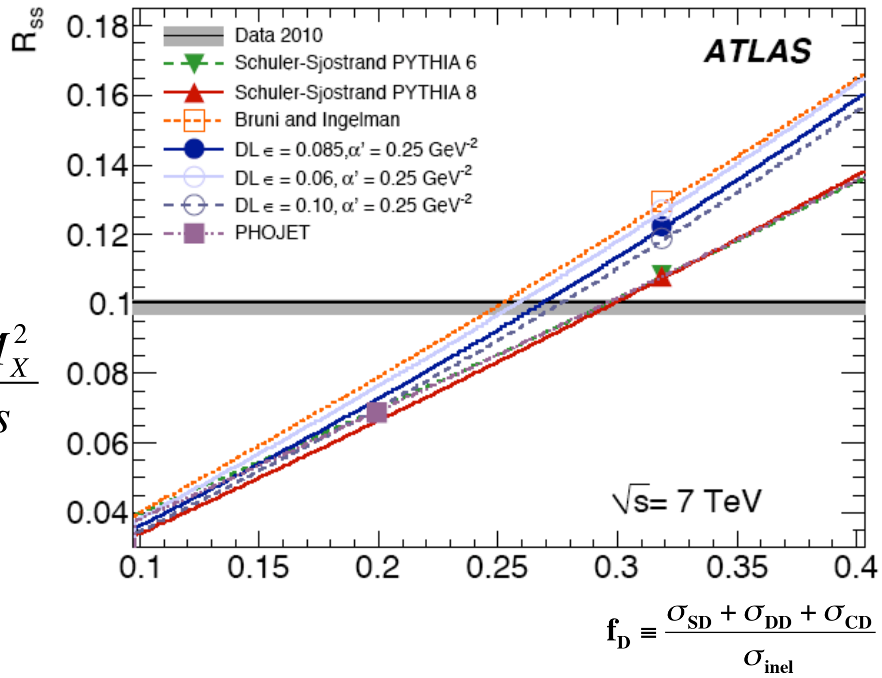
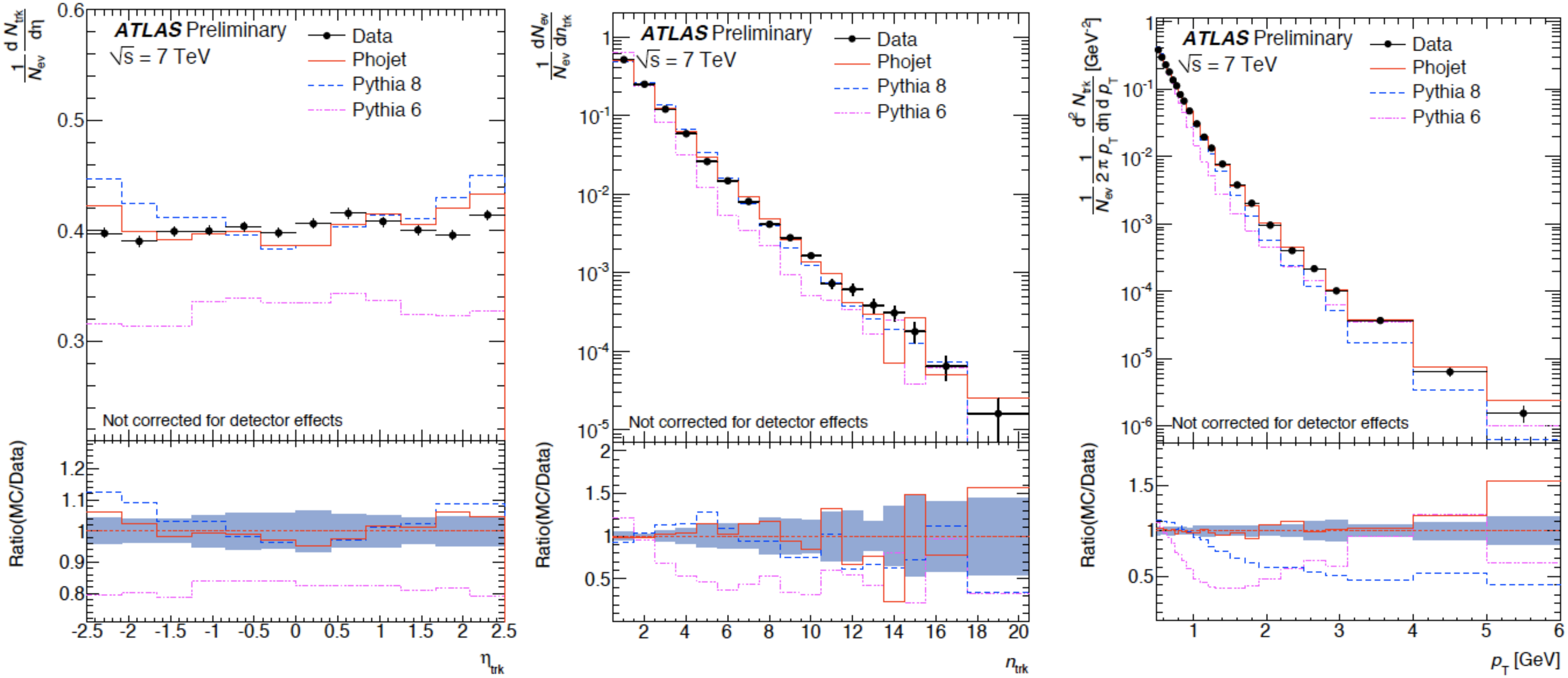


Figure 1: The ratio of the single-sided to inclusive event sample R_{ss} as a function of the fractional contribution of diffractive events to the inelastic cross-section f_D. The data value for R_{ss} is shown as the horizontal line with its systematic uncertainties (grey band). Also shown are predictions of several models as a function of an assumed value of f_D. The default f_D value (32.2% for all models but PHOJET which is 20.2%) is indicated by the markers.

Diffraction studies with ATLAS

Track distributions for the single-sided MBTS requirement

ATLAS Note
ATLAS-CONF-2010-048



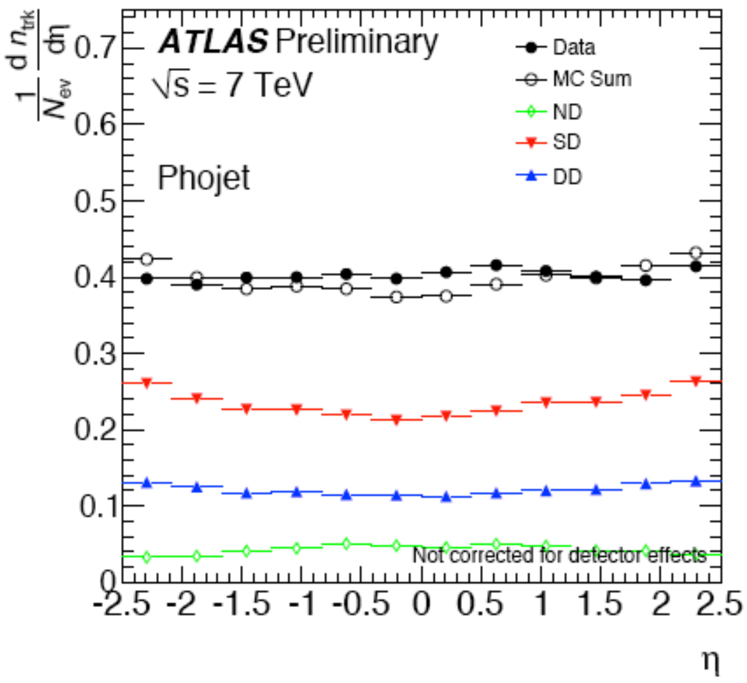
Pseudorapidity

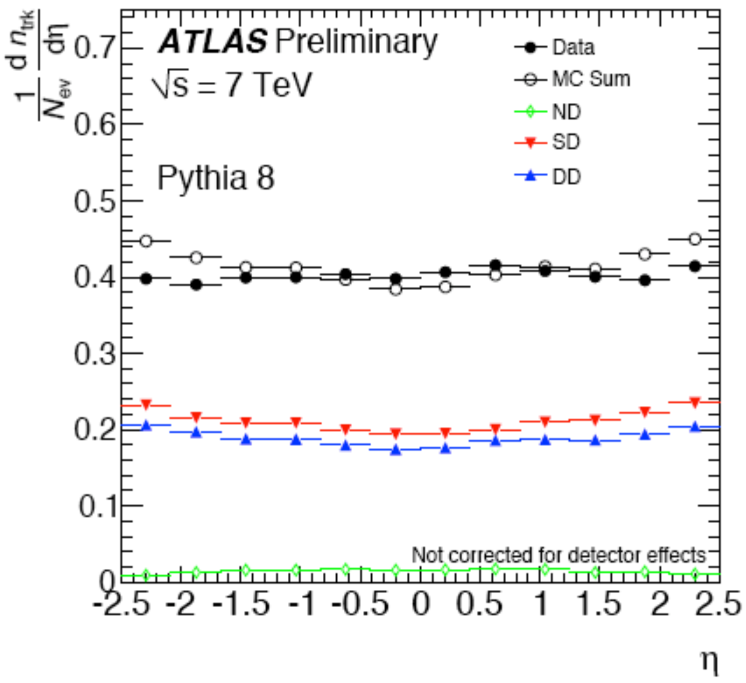
Multiplicity

p_T

Diffraction studies with ATLAS

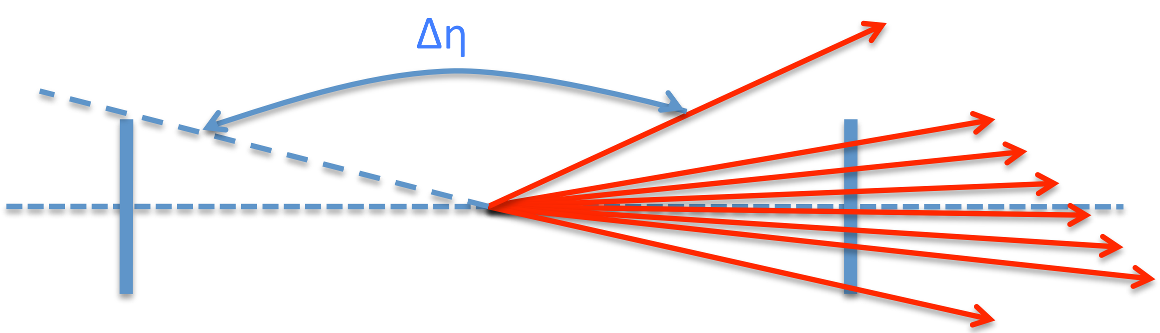
- Even though PYTHIA 8 and PHOJET are globally similar, they differ in the contribution mix!

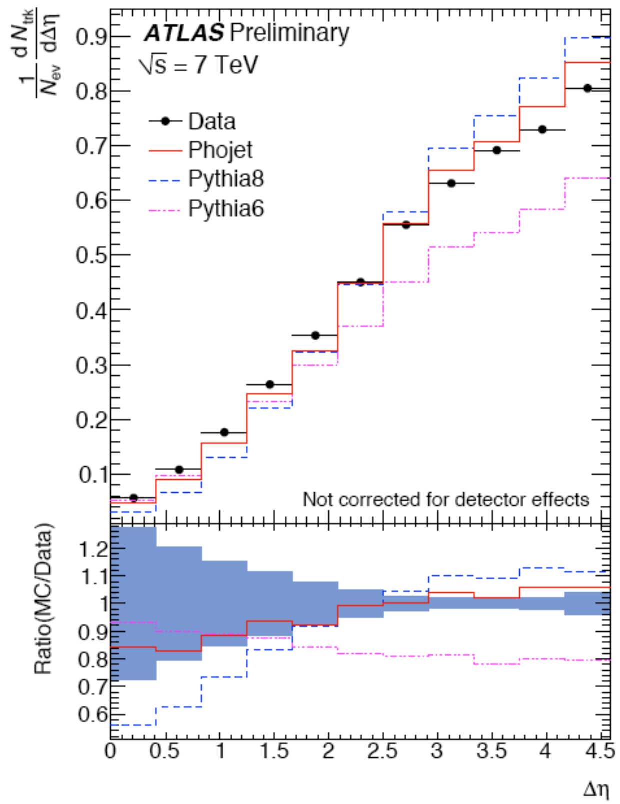




Diffraction studies with ATLAS

- Pseudorapidity gap (Δη) study study (with respect to edge of MBTS which has no hit)
  - $\Delta\eta = |\eta_{MBTS} - \eta_{track}|$
  - In all cases PYTHIA 6 not doing as well as PHOJET. PYTHIA 8 underpredicting at small Δη (sensitive to kinematics).

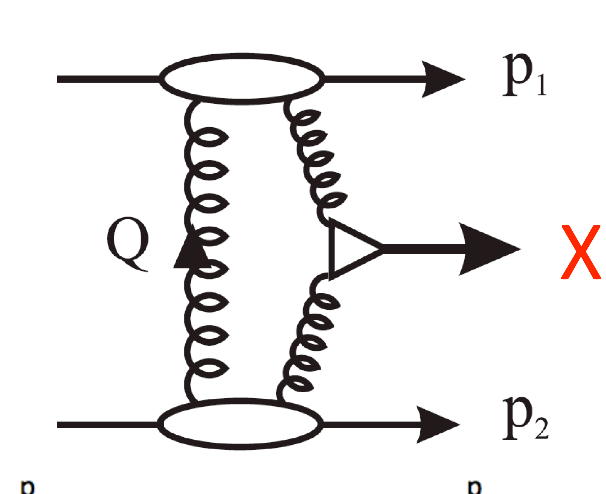




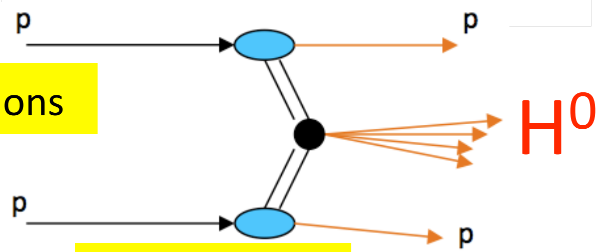
ATLAS future diffraction programme

- **Diffractive measurements using future ALFA (4 Roman Pots on each side – installation completed in January)**
  - Prime motivation is precise measurement of the luminosity (optical theorem) ($t \sim 6x10^{-4}$ GeV^2) interestingly small!
  - Contribution to diffraction in elastic scattering of protons 6.3 < E_{proton} < *7 TeV SD for* $\xi < 0.01$; ND proton for $0.01 < \xi < 0.1$.

- **Diffractive measurements at high luminosity?**
  - AFP project under discussion in the ATLAS Collaboration to detect protons with additional proton taggers at 220 m and 420 m from the interaction point.
    3-D Si detector (10 µm) and TOF (5-10 ps)



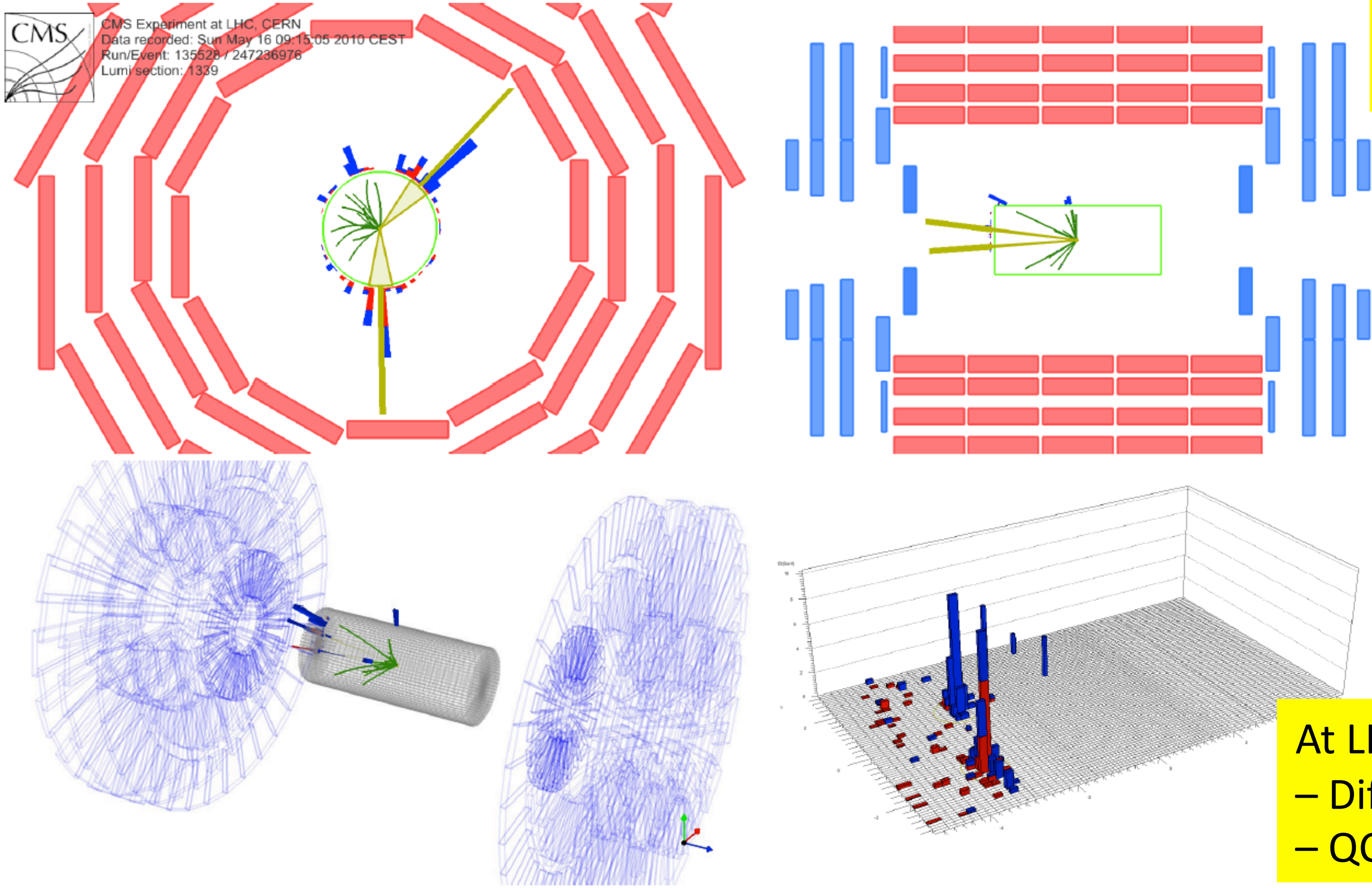
The challenge is to cope with high rate to be sensitive to small cross sections



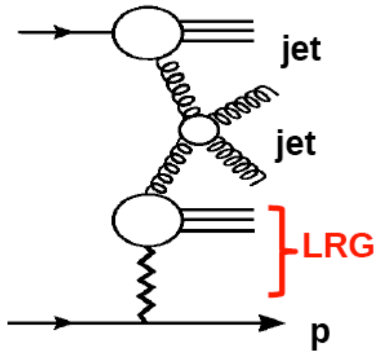
X = H➔bb; H➔ττ; triplet Higgs,
SUSY CP-X (i.e. CP viol. Ang.) Higgs, etc.

Unification?

CMS diffractive di-jet candidate



Selecting events with large rapidity gaps

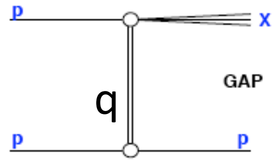


At LHC
– Diffraction topology
– QCD perturbative regime

$E(\eta < 3.0) > 1.5$ GeV $p_T(\text{track}) > 0.5$ GeV
$E(\eta \geq 3.0) > 2.0$ GeV

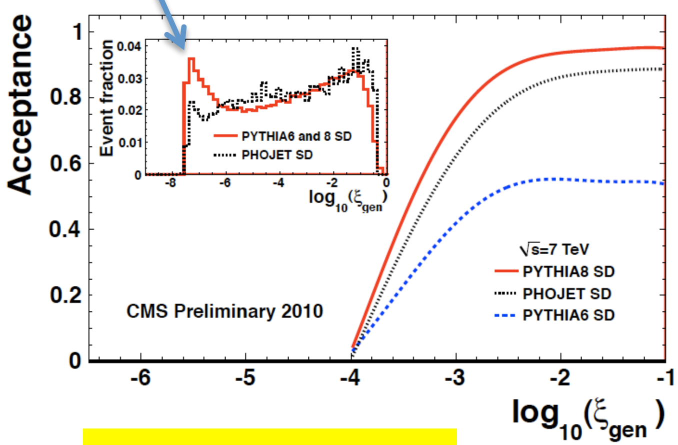
p_T (jet1) = 41.2 GeV, p_T (jet2) = 31.9 GeV
η (jet1) = -2.8, η (jet2) = -3.3

Diffraction studies with CMS



- Event selection:
  - Signals from both BPTX detectors and Logical OR of Beam Scintillator Counters (BSC) (±10.86m) (|η|:3.23-4.65)
  - Vertex: |z| < 15cm, r < 2cm + backrgound rejection

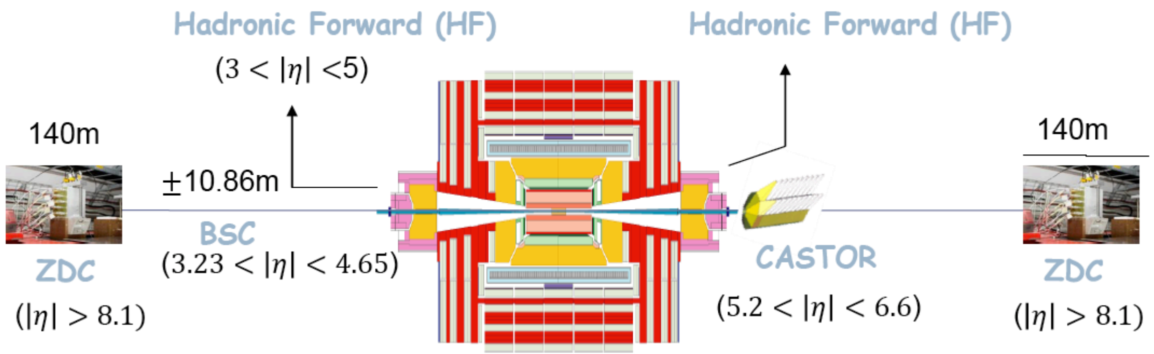
Note!



CMS PAS FWD-10-007

$$\xi \equiv \frac{M^2}{s}$$

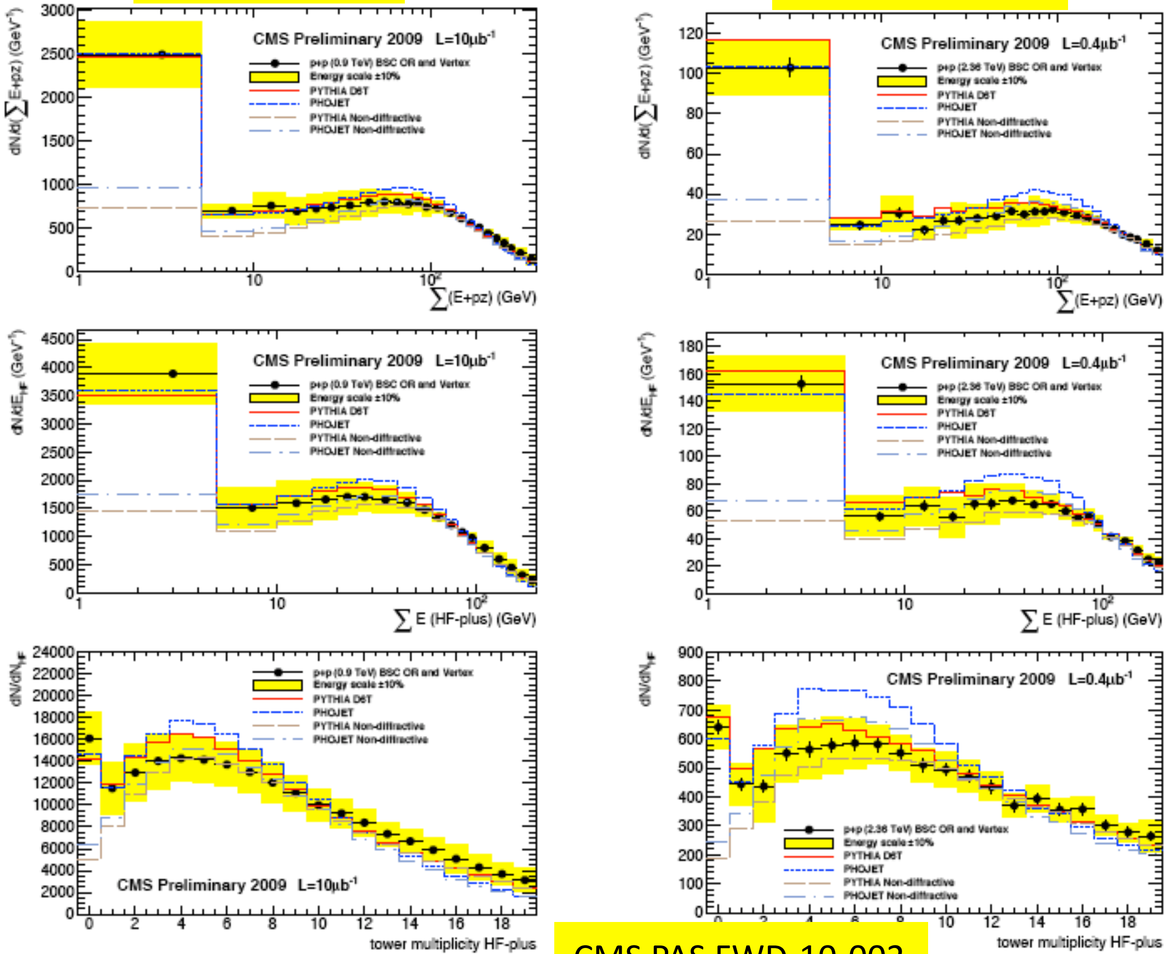
Forward detectors - CMS



Diffraction studies with CMS

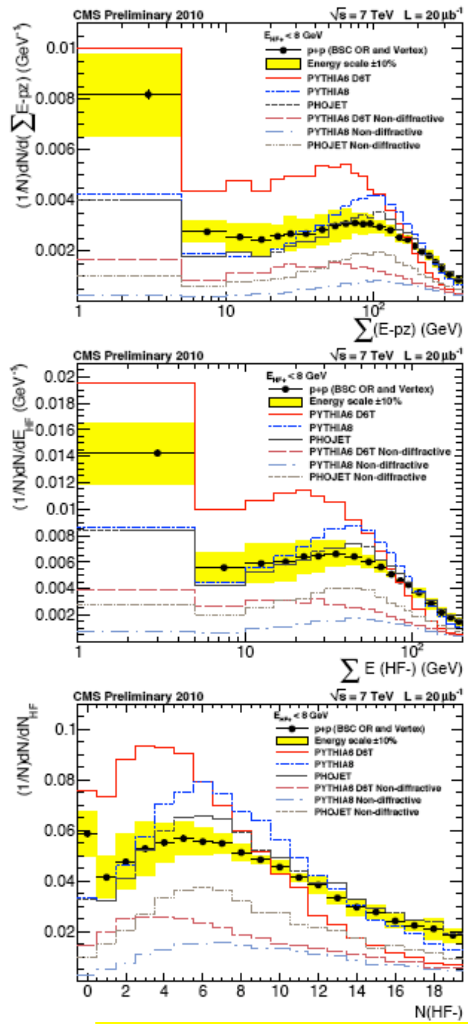
√s = 0.9 TeV

√s = 2.36 TeV



CMS PAS FWD-10-002

√s = 7 TeV; E_{HF+}<8 GeV



Enhanced single diffraction

CMS PAS FWD-10-007

$$\sum_{i}(E_i \pm p_{zi}) \approx 2q_0$$ (related to the energy of the diffracted system)

The presence of diffractive processes is needed to account for the data

Diffraction studies with CMS

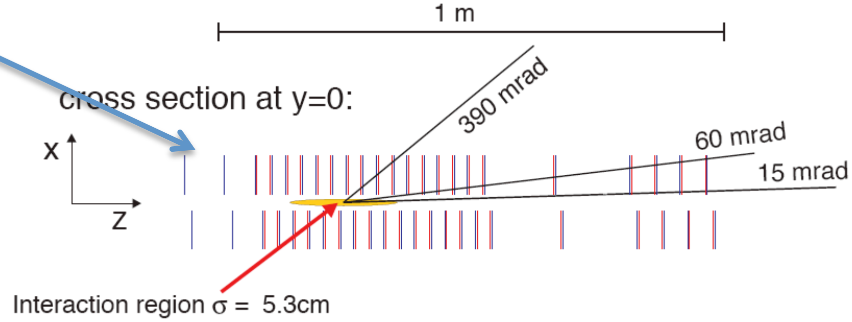
- Comparison with Monte Carlo

Quote from CMS PAS FWD-10-007

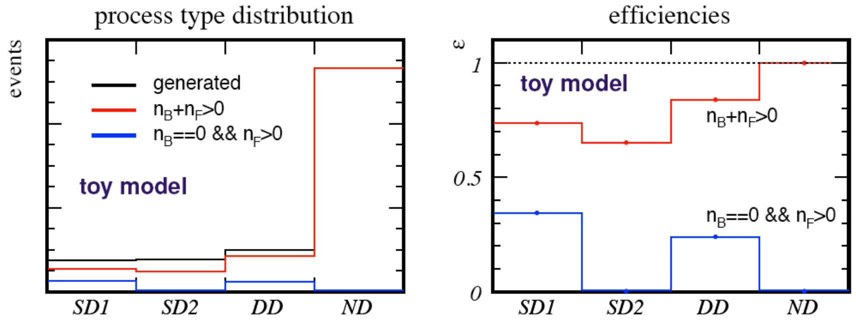
  - *The uncorrected data have been compared to PYTHIA6 (tunes D6T, DW, CW, P0 and Z1), PYTHIA8 (tune 1) and PHOJET after simulation of the detector response.*
  - *None of the PYTHIA6 tunes considered reproduces the diffractive component of the data, which is instead described to a fair degree by PHOJET and PYTHIA8; PHOJET performs better in the forward region and PYTHIA8 in the central region.*
  - *Conversely, the inclusive distributions presented are described well by PYTHIA8 and PYTHIA6, notably tune Z1, in the central region; in the forward region, PYTHIA6 tunes D6T, DW and CW reproduce the data best.*
  - ***None of the simulations considered describes all features of the data.***

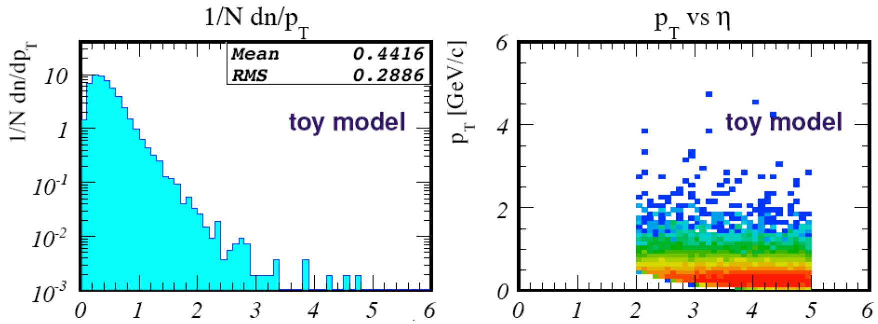
Diffraction studies with LHCb

- Demanding no track in the backward planes of LHCb VELO detector enriches the MB data sample with SD and DD events:
  - pseudorapidity coverage with PID and momentum measurement $2 < \eta < 5$
  - momentum acceptance starting at $p = 2$ GeV/c
  - VELO angular coverage $-4 < \eta < +1.5$ and $1.5 < \eta < 5$



Michael Schmelling, May 31st, 2010 (proof of interest in diffraction)

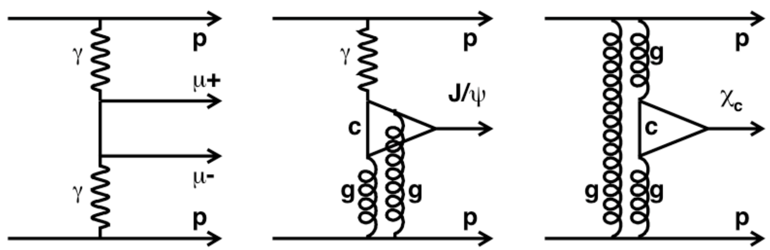




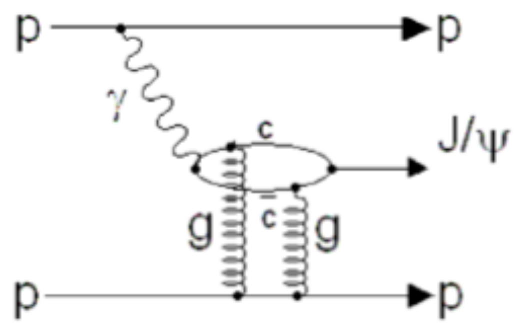
- Future study of possible 'exclusive' onia events, which could occur through double Pomeron exchange (p+p➔p+p+X) as well as central exclusive production

Perhaps, unique acceptance at LHC, because of LHCb tracking performance in forward region!

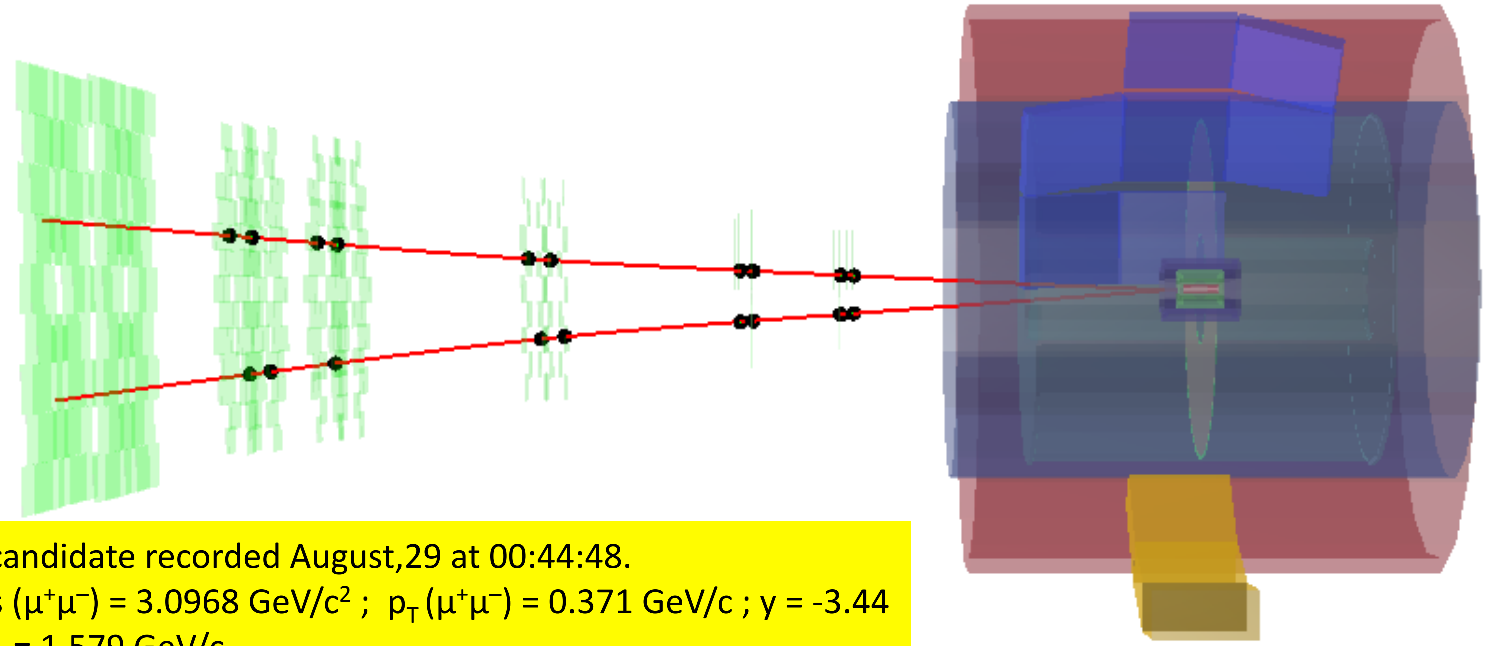
New results on central exclusive production of di-muon final states by Ronan McNulty at this workshop



ALICE event



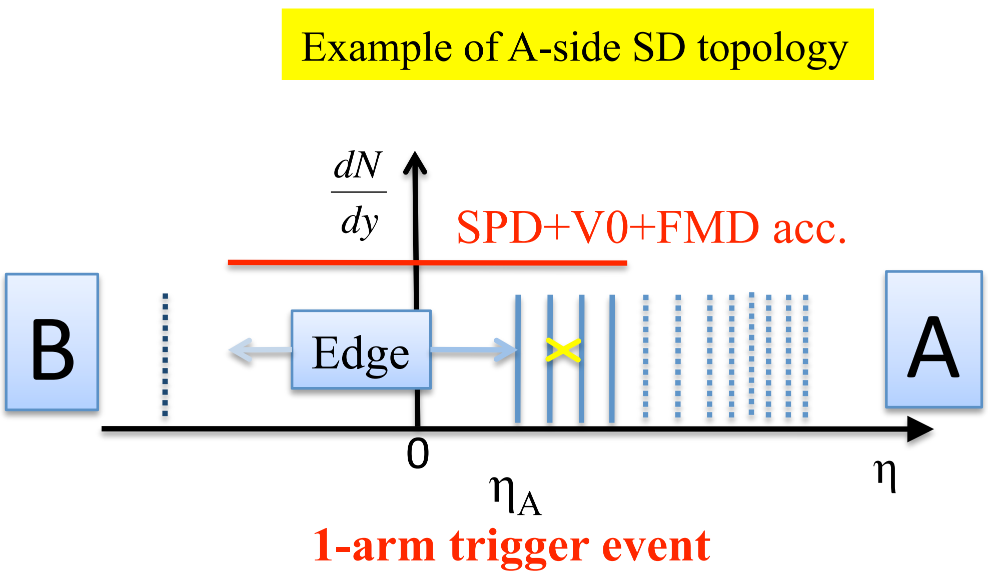
- **Exclusive J/Psi candidates in the muon arm:**
  - No pixel trigger; No V0A trigger (opposite to muon arm)
  - V0C trigger with ≤ 2 hits in the two inner rings (overlap with the muon spectrometer) and no hits in 2 outer rings ($-2.7 < \eta < -1.7$).
  - No FMD hits in $1.7 < \eta < 5.0$ and $-2.4 < \eta < -1.7$. Allow hits in $-3.4 < \eta < -2.4$
  - No ZDC hit; No TPC tracks (if TPC is available in the run).

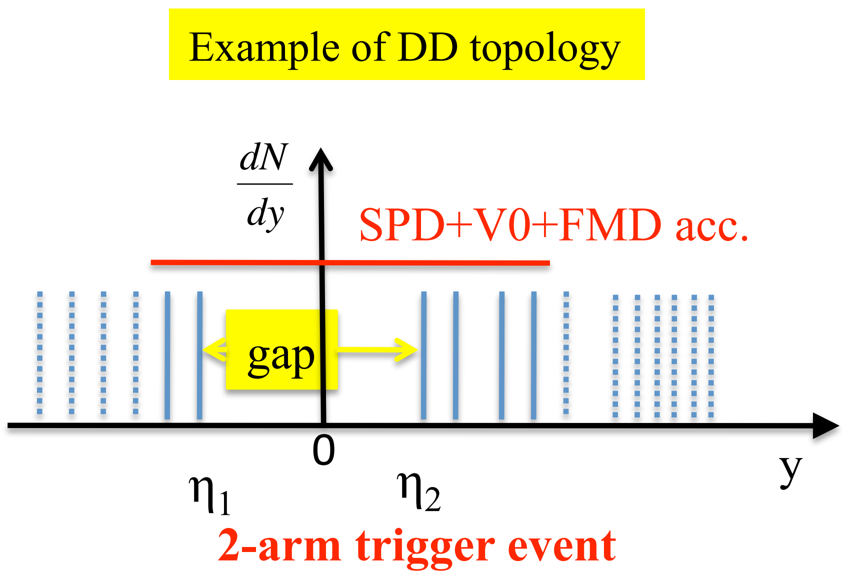


J/Ψ candidate recorded August,29 at 00:44:48.
Mass ($\mu^+\mu^-$) = 3.0968 GeV/c^2 ; p_T ($\mu^+\mu^-$) = 0.371 GeV/c ; y = -3.44
μ^+: p_T = 1.579 GeV/c
μ^-: p_T = 1.444 GeV/c

SD and DD studies with ALICE

- Within the acceptance of SPD + V0 + FMD (9 units of pseudorapidity) study the pseudorapidity distribution of "tracks", on an event per event basis
- **Classification of events into 1-arm or 2-arm triggers**

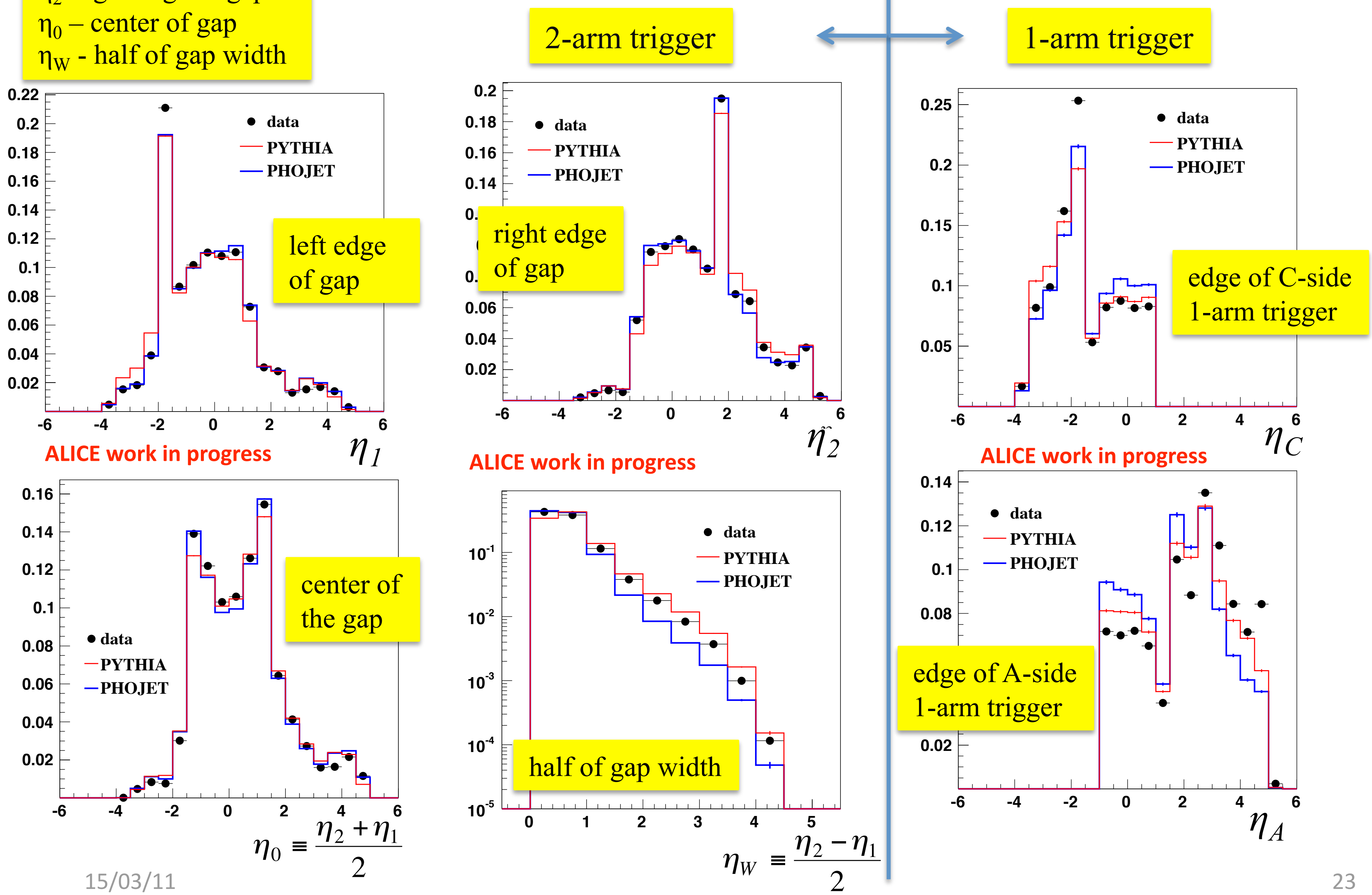




SD and DD studies with ALICE

η_1 - left edge of gap
η_2 - right edge of gap
η_0 – center of gap
η_W - half of gap width

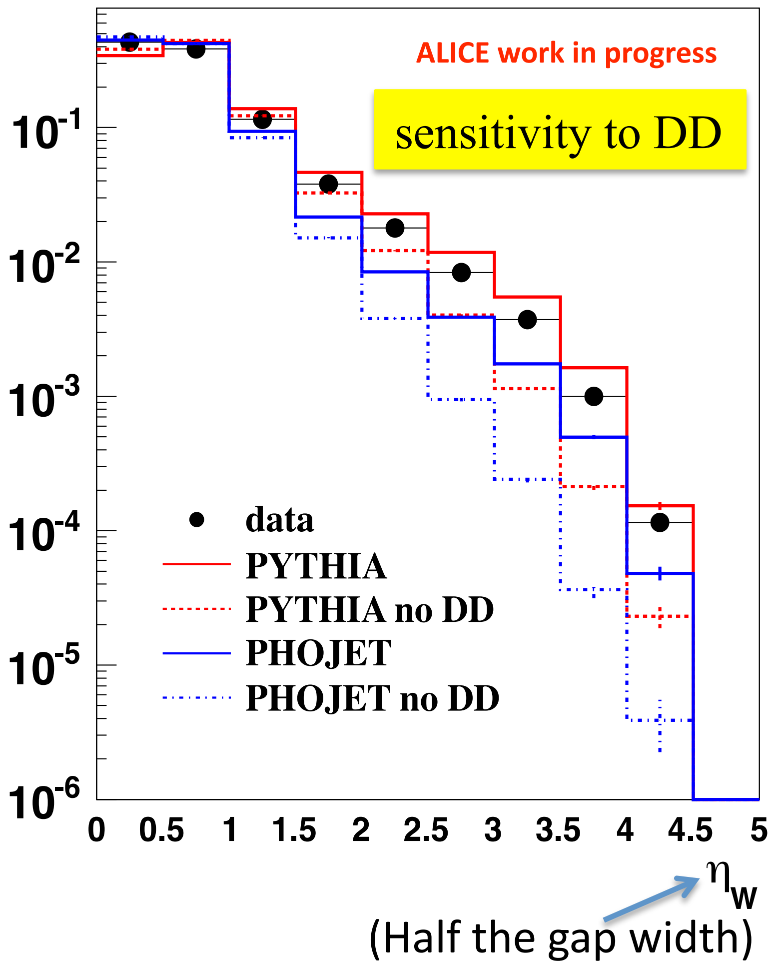
Uncorrected data compared to simulation



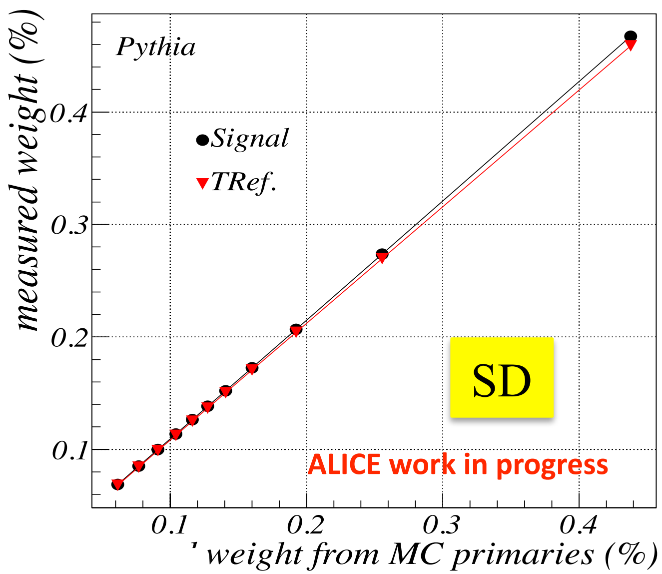
SD and DD studies with ALICE

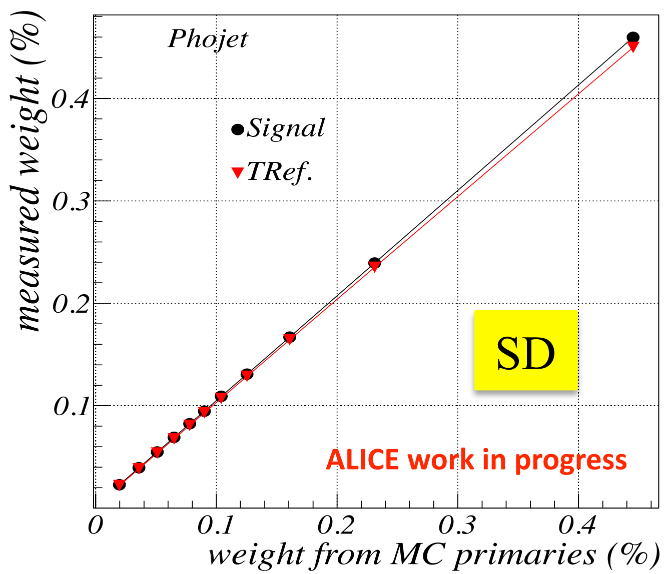
Response to varying SD and DD rates

2-arm triggers



1-arm triggers

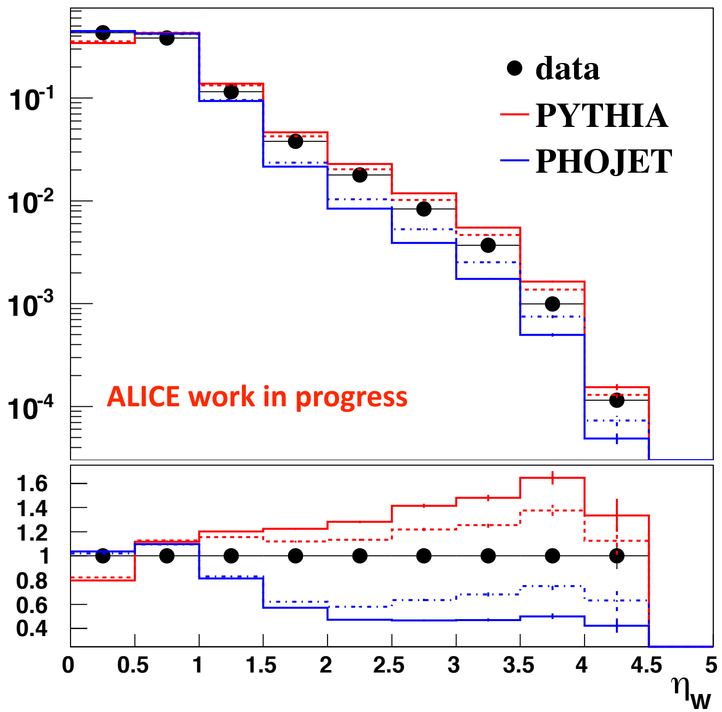




The simulation of detector response is not affecting the result

Tuning DD in Monte Carlo

Tune DD fraction (doted lines) to get ratios on average ±10% of the data



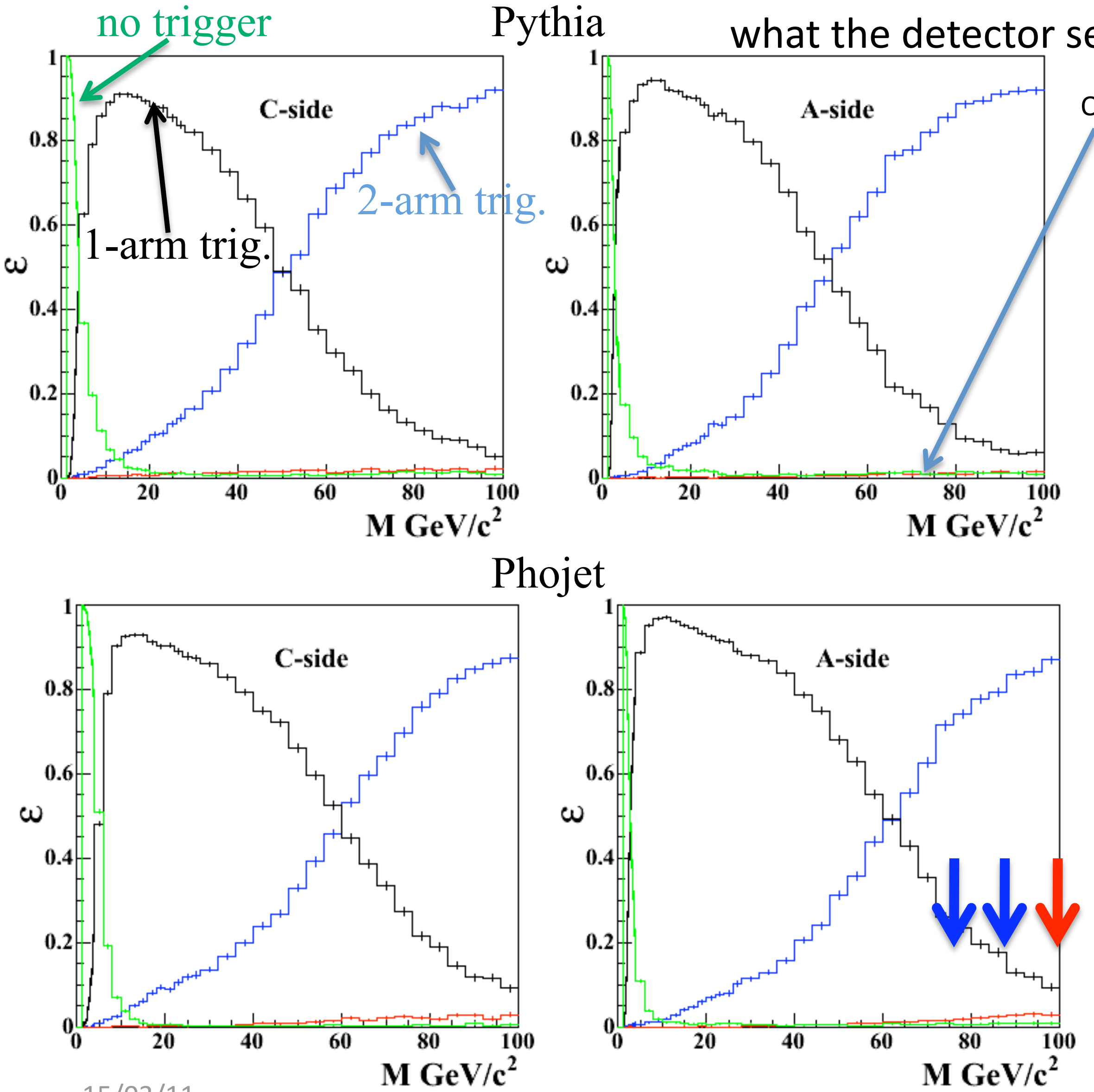
PYTHIA: $w_{DD} = 0.12 \rightarrow 0.1$
PHOJET: $w_{DD} = 0.06 \rightarrow 0.09$

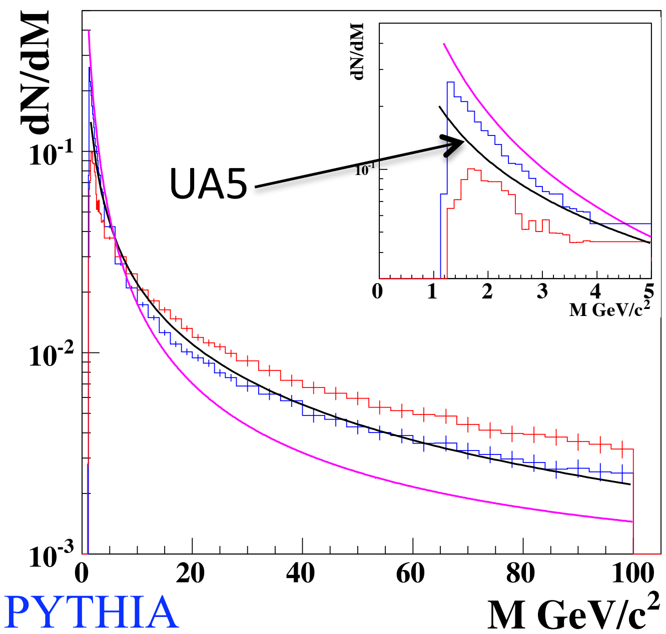
Tuned weights

Still limited by the statistics for the last bins
but 4 times more statistics available!

Efficiency vs diffracted mass for SD

Needs a model of diffracted mass distribution to relate what the detector sees to a given mass (M)





PYTHIA

PHOJET

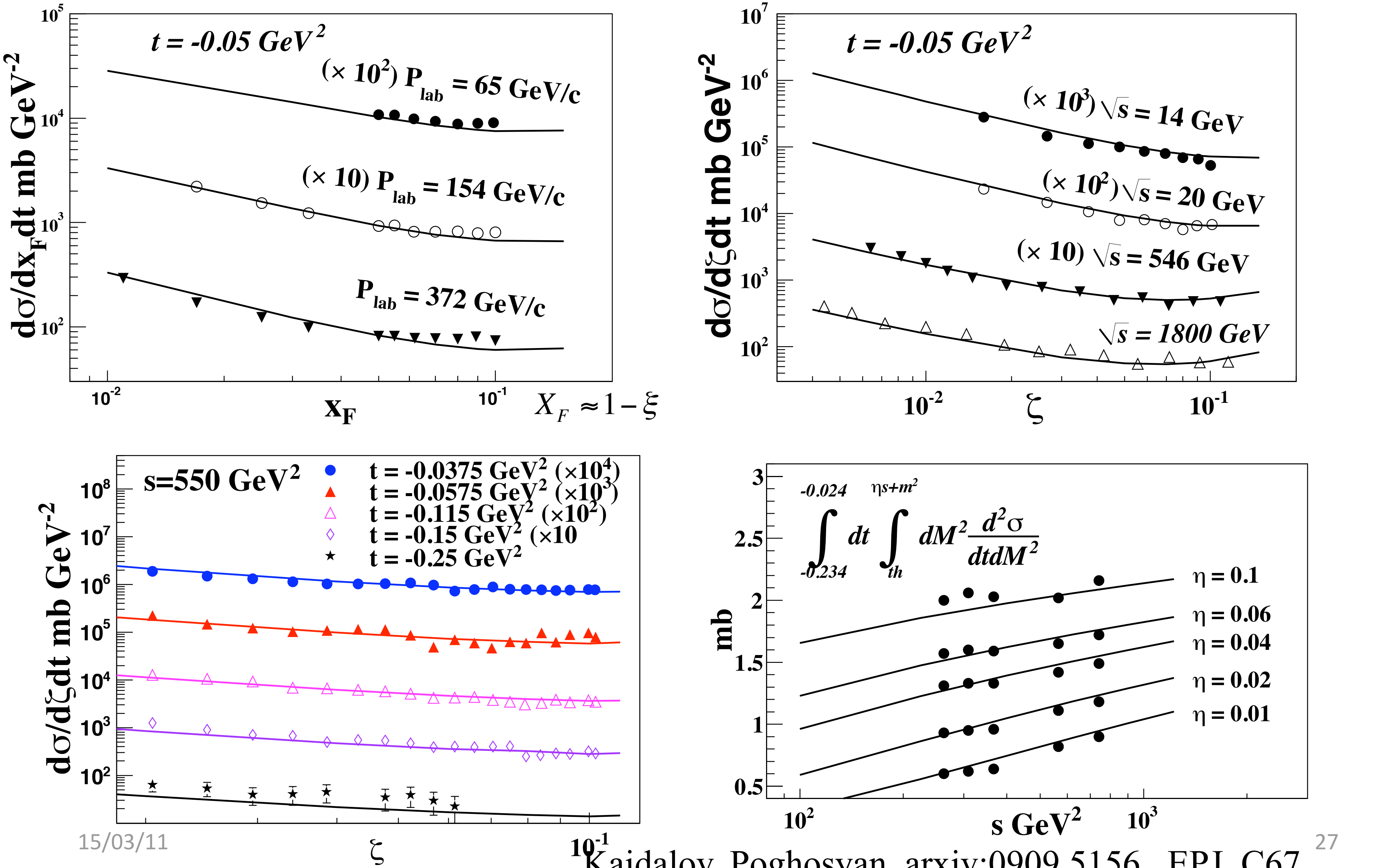
$dN/dM \sim 1/M$ (for comp. with UA5)

A. B. Kaidalov and M. Poghosyan
arxiv:0909.5156, EPJ. C67
(justified by an excellent fit to data)

In what follows: $M \leq 100$ GeV/c^2

Acceptance, efficiency and Physics Selection included

Performance of Kaidalov and Poghosyan model for SD differential cross-section



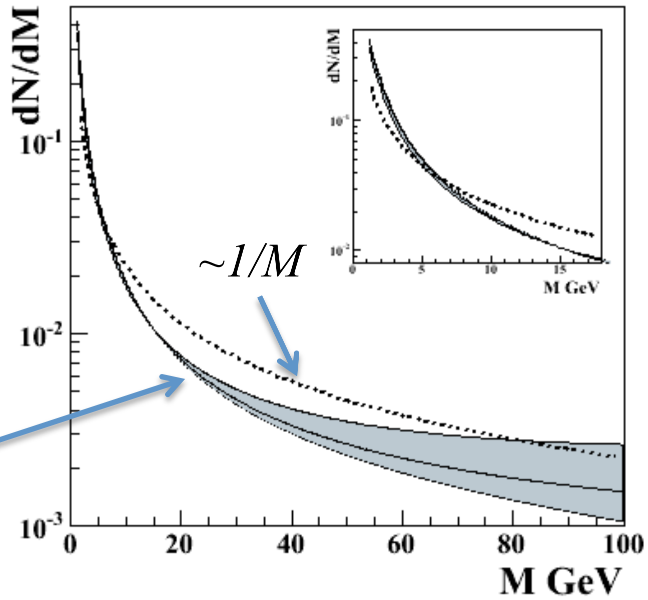
$$\int_{-0.234}^{-0.024} dt \int_{th}^{\eta s + m^2} dM^2 \frac{d^2\sigma}{dt\,dM^2}$$

Kaidalov, Poghosyan, arxiv:0909.5156, EPJ. C67

Resulting efficiencies and σ_{SD}/σ_{NSD}

Efficiencies

input \ output	A-arm trig.	C-arm trig.	2-arm trig.
A-arm SD	0.504 ± 0.018	0.002 ± 0.001	0.103 ± 0.038
C-arm SD	0.003 ± 0.001	0.382 ± 0.025	0.111 ± 0.039
NSD	0.024 ± 0.008	0.012 ± 0.005	0.956 ± 0.016



Syst. error comes from:

- Adjustment of DD in PYTHIA and PHOJET
- Changing d*N*/d*M* by ±50% at the threshold
- SD kinematic in PYTHIA and PHOJET

Corrected cross section ratios (SD: M < 100 GeV)

$$\frac{\sigma^{A}_{SD}}{\sigma_{NSD}} = 0.114 \quad \pm 0.0005(stat.) \quad \pm 0.023(syst.)$$

$$\frac{\sigma^{C}_{SD}}{\sigma_{NSD}} = 0.118 \quad \pm 0.0005(stat.) \quad \pm 0.022(syst.)$$

$$\frac{\sigma_{SD}}{\sigma_{NSD}} = 0.232 \quad \pm 0.001(stat.) \quad \pm 0.045(syst.)$$

Raw trigger ratios:

A-arm/2-arm= 0.0856 ± 0.0003(stat.)± 0.0026(syst.)

C-arm/2-arm= 0.0561 ± 0.0002(stat.) ± 0.0006(syst.)

Other systematic uncertainties:
MC simulation: 15%
Combined with background corr.: 19%.
Additional 2% from material Budget

Note, good agreement between *A*- and *C*- sides

Added linearly

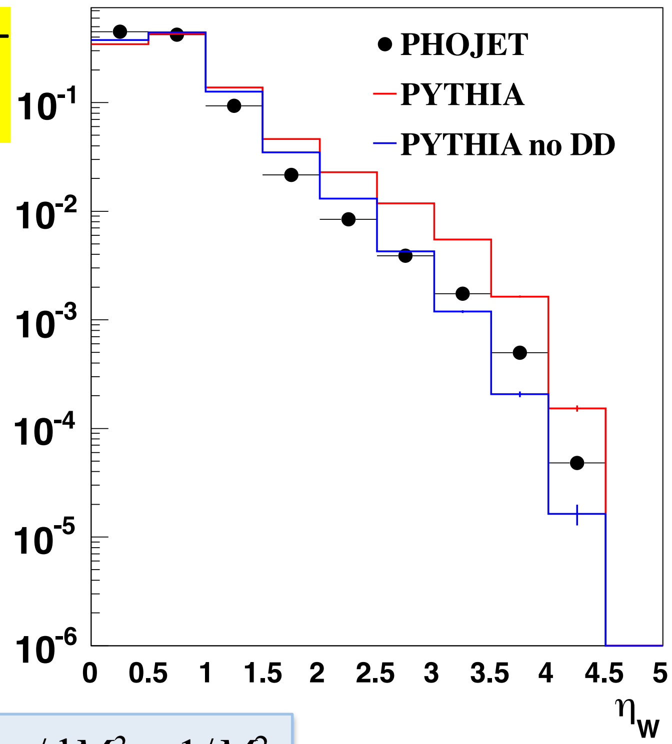
A Monte Carlo test (PHOJET as data)

In order to test the technique, consider the signal from PHOJET as data and correct with PYTHIA and PYTHIA without DD.

For wide gaps, the width distribution in PHOJET is in between PYTHIA and PYTHIA without DD.

The same situation as with data, PYTHIA and PHOJET. However, the case with data is more reliable because PHOJET and PYTHIA do not bound data only in one bin.

To have a handle to wide gaps is very important for separation SD from asymmetric DD.



True value: $\frac{\sigma_{SD}}{\sigma_{NSD}} = 0.164$

$$\frac{\sigma_{SD}^{A}}{\sigma_{NSD}} = 0.098 \quad \pm 0.0026$$
$$\frac{\sigma_{SD}^{C}}{\sigma_{NSD}} = 0.091 \quad \pm 0.0034$$
$$\frac{\sigma_{SD}}{\sigma_{NSD}} = 0.190 \quad \pm 0.060$$

Difference in diffracted mass distribution of MCs reflected in larger error

Picking a mass distr. closer to data produces smaller error

$d\sigma_{SD}/dM^2 \sim 1/M^2$

$$\frac{\sigma_{SD}^{A}}{\sigma_{NSD}} = 0.078 \quad \pm 0.0020$$
$$\frac{\sigma_{SD}^{C}}{\sigma_{NSD}} = 0.076 \quad \pm 0.0029$$
$$\frac{\sigma_{SD}}{\sigma_{NSD}} = 0.154 \quad \pm 0.049$$

Comparison with UA5: SD

UA5 used $d\sigma_{SD}/dM^2 \sim 1/M^2$ parameterization for SD
(not correct, see M.Poghosyan arXiv:1005.1806)
To compare with UA5, repeat ALICE analysis for $d\sigma_{SD}/dM^2 \sim 1/M^2$

effic.	A-arm trig.	C-arm trig.	2-arm trig.
A-arm SD	0.599 ± 0.039	0.003 ± 0.001	0.170 ± 0.071
C-arm SD	0.004 ± 0.002	0.507 ± 0.009	0.180 ± 0.068
NSD	0.024 ± 0.008	0.012 ± 0.005	0.956 ± 0.016

$$\frac{\sigma_{SD}^{A}}{\sigma_{NSD}} = 0.084 \quad \pm 0.0004 \quad \pm 0.014$$

$$\frac{\sigma_{SD}^{C}}{\sigma_{NSD}} = 0.099 \quad \pm 0.0004 \quad \pm 0.020$$

$$\frac{\sigma_{SD}}{\sigma_{NSD}} = 0.183 \quad \pm 0.0008 \quad \pm 0.033$$

UA5

$$\frac{\sigma_{SD}(M < 200\ GeV)}{\sigma_{SD}(M < 100\ GeV)} \approx 1.1$$

Using the same parameterization for SD as UA5 used

$$1.1 \times (0.183 \pm 0.033) = 0.20 \pm 0.036$$

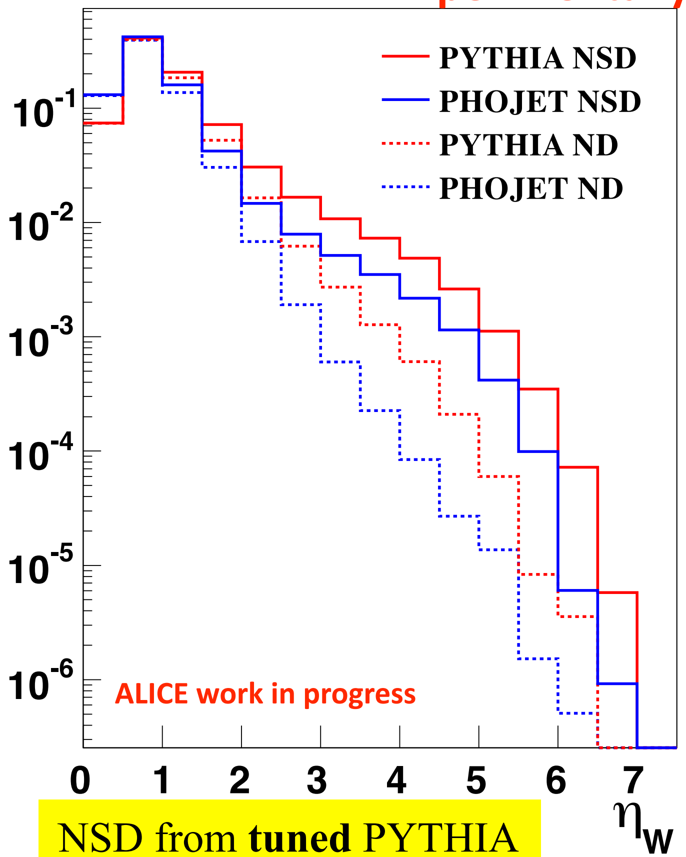
UA5: $\sigma_{SD}(M<200)/\sigma_{NSD} = 0.18 \pm 0.014 \pm 0.029$

Good agreement with UA5, however, in ALICE's case, all processes with leading protons are considered as SD, whereas UA5 separated out Ordinary Reggeon exchange (model!). Thus, the cross section obtained with the ALICE definition will be greater than the UA5 one.

Hard to estimate what UA5 did, but the effect is probably +3 to 4 % (in the right direction).

Comparison with UA5: DD

UA5 definition of DD is not evident ($\sigma_{DD}/\sigma_{Inel}$ = 0.08 ± 0.05)
CDF separated the DD from ND based on their MC generator.
Not obvious how to define DD for comparing with at least one of them.
Experimentally: define as DD all events with Δη > threshold



NSD from **tuned** PYTHIA and PHOJET

Fraction of gaps with $\eta_W > 1.5$: $\frac{\sigma_{DD}}{\sigma_{NSD}} = 0.112 \pm 0.034$ ALICE

Δη > 3

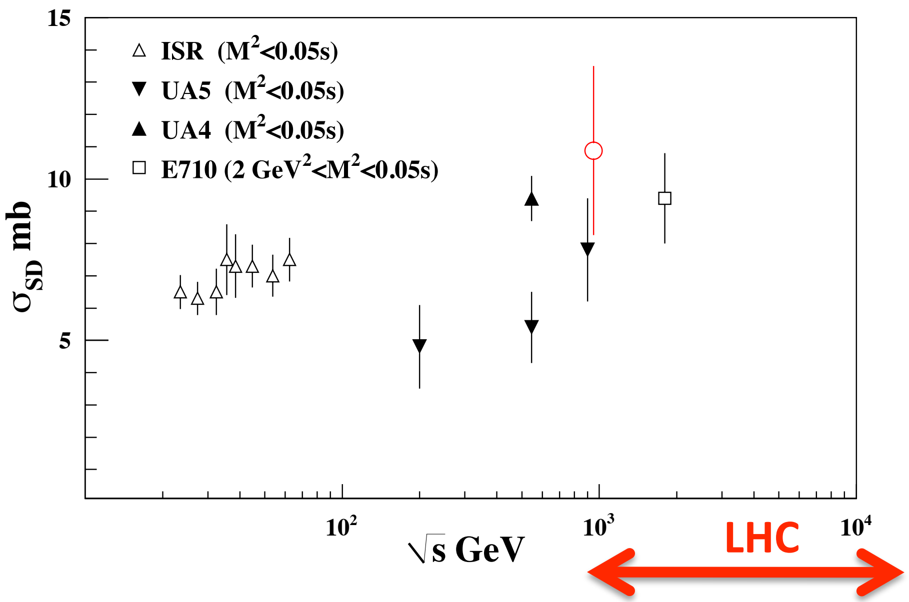
$$\frac{\sigma_{DD}}{\sigma_{NSD}} = \left(\frac{\sigma_{DD}}{\sigma_{INEL}}\right)_{UA5} \times \left(\frac{\sigma_{INEL}}{\sigma_{NSD}}\right)_{UA5} =$$

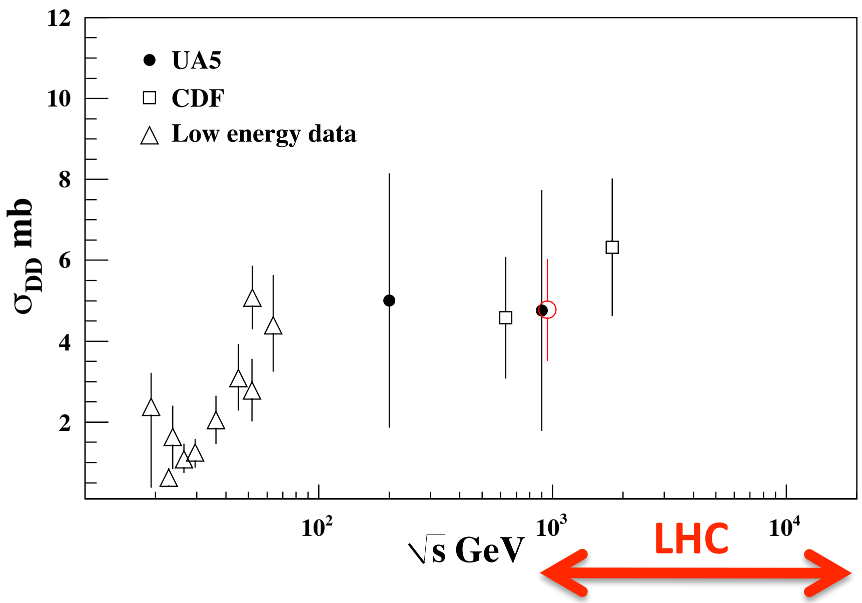
$$(0.08 \pm 0.05) \times \frac{50.3 \pm 0.4 \pm 1}{42.63 \pm 1.42} = 0.095 \pm 0.06$$

UA5

Comparison with other experiments

Using σ_{NSD} = 42.63 ± 1.42 mb from UA5 and the previous ratios:





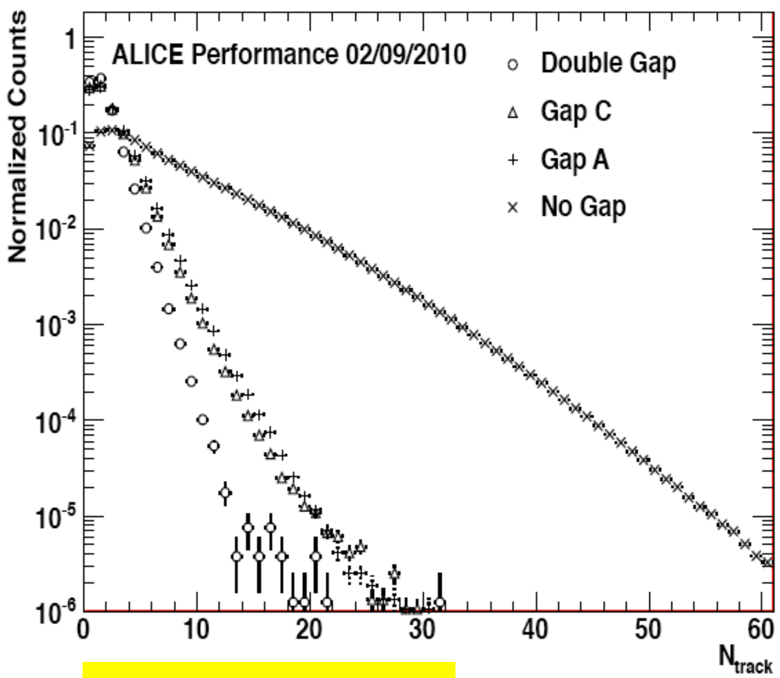
– ALICE result at 900 GeV consistent with UA5
– Note discrepancy between UA5 and UA4 at 560 GeV for SD

The ALICE errors do not reflect the ALICE best precison,
a large part comes from the corrections needed to compare to UA5!

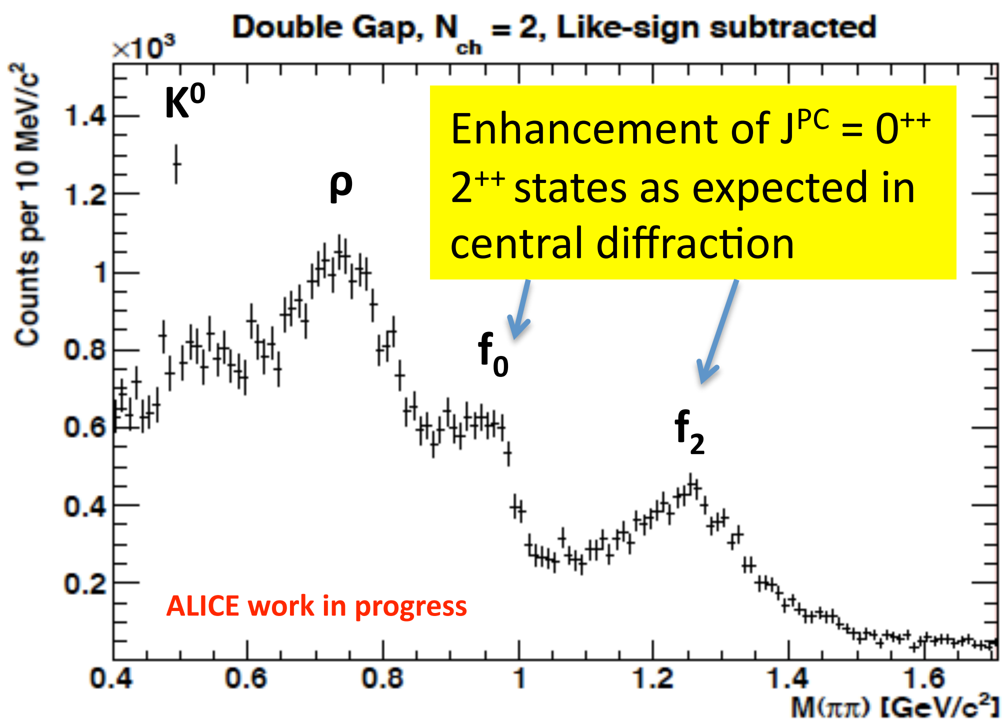
Single and double gap events

- ALICE is measuring properties of events with a gap selection (V0A, V0C gaps, no Gap, double gap)
- Trigger is logical OR of V0A, Pixel, V0C

On-going analysis, no trigger and detector corrections, qualitative only

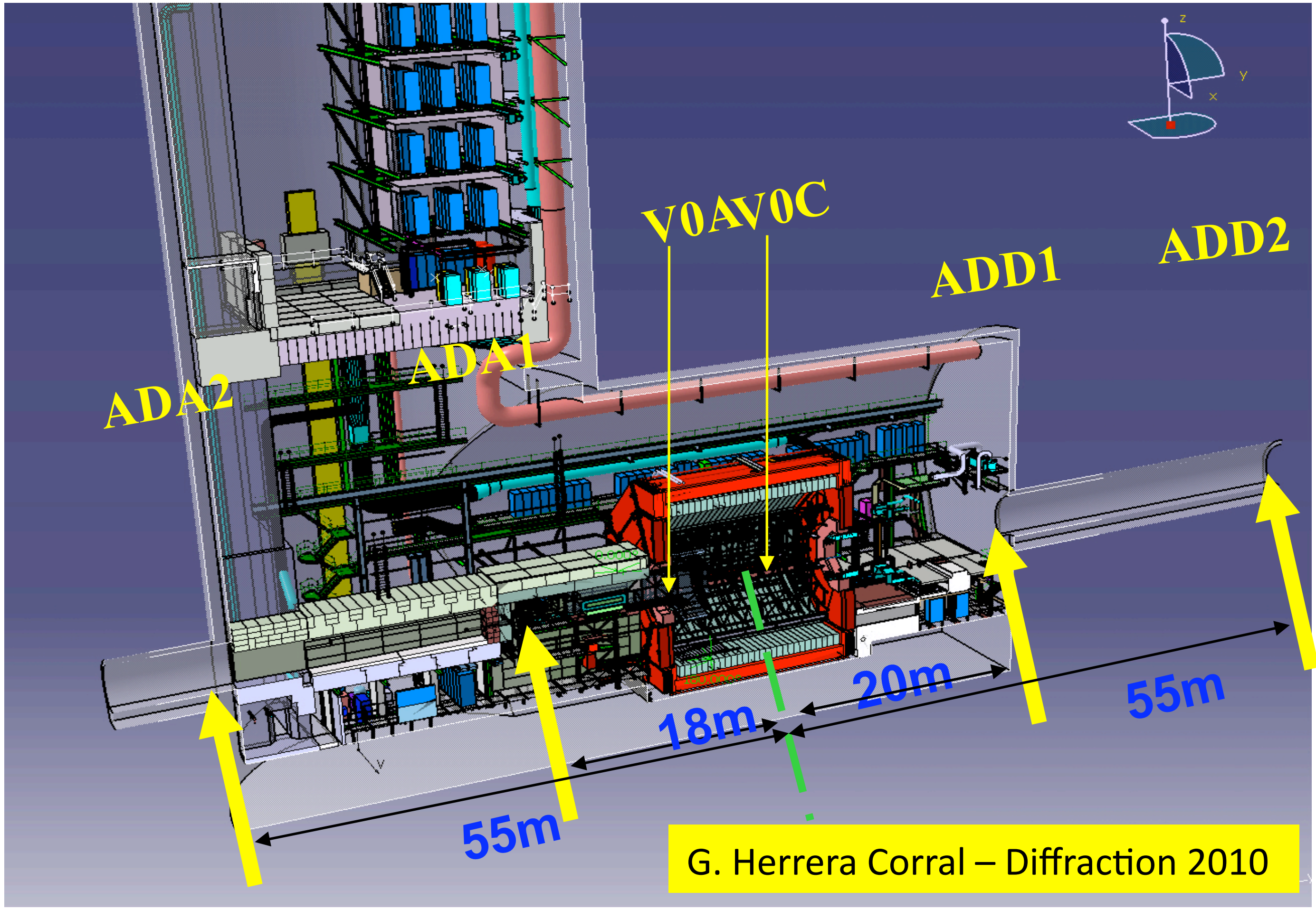


Track multiplicity



ALICE upgrade

- Discussions in the collabortion of possible addition of counters to extend the pseudorapidity coverage



ADA $5.5 \leq \eta \leq 7.5$

ADD $-7.5 \leq \eta \leq -5.5$

Would cover 15 units of pseudorapidity

Conclusion

- Diffraction is a **challenging phenomenon**, including many processes. It is a **significant part of LHC physics**. It has been observed qualitatively at LHC by ATLAS, CMS, ALICE and TOTEM.
- The next challenge is to measure precisely both cross sections and kinematic properties of diffractive processes at LHC energies. This will improve significantly the precision of measurements of global event properties.
- To be done initially without observing the outgoing proton nor the diffracted system until TOTEM/CMS and ATLAS (with ALFA detector) do it.
- LHC will contribute to a better understanding the non-perturbative domain of QCD (bulk of particle production and diffraction is part of it). **Regge theory ⇔ pQCD**