Double diffractive cross-section measurement at TOTEM experiment

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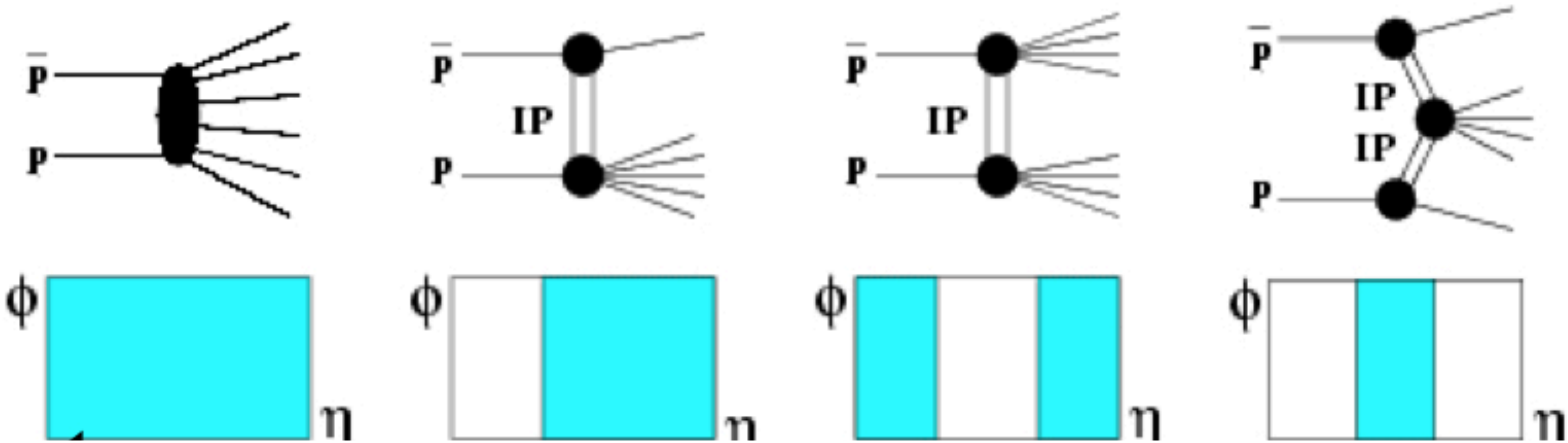
Motivation

Why to measure double diffractive cross-section?

- Contributes to understanding of proton structure
  - Size and opacity of proton
- Tests non-perturbative QCD models
- Important part of the pp inelastic cross-section
- No precise measurements at high η ($|\eta|>4.2$) and $\sqrt{s}>2$ TeV
- Important step on understanding background for central diffractive Higgs measurements

Classification of inelastic events

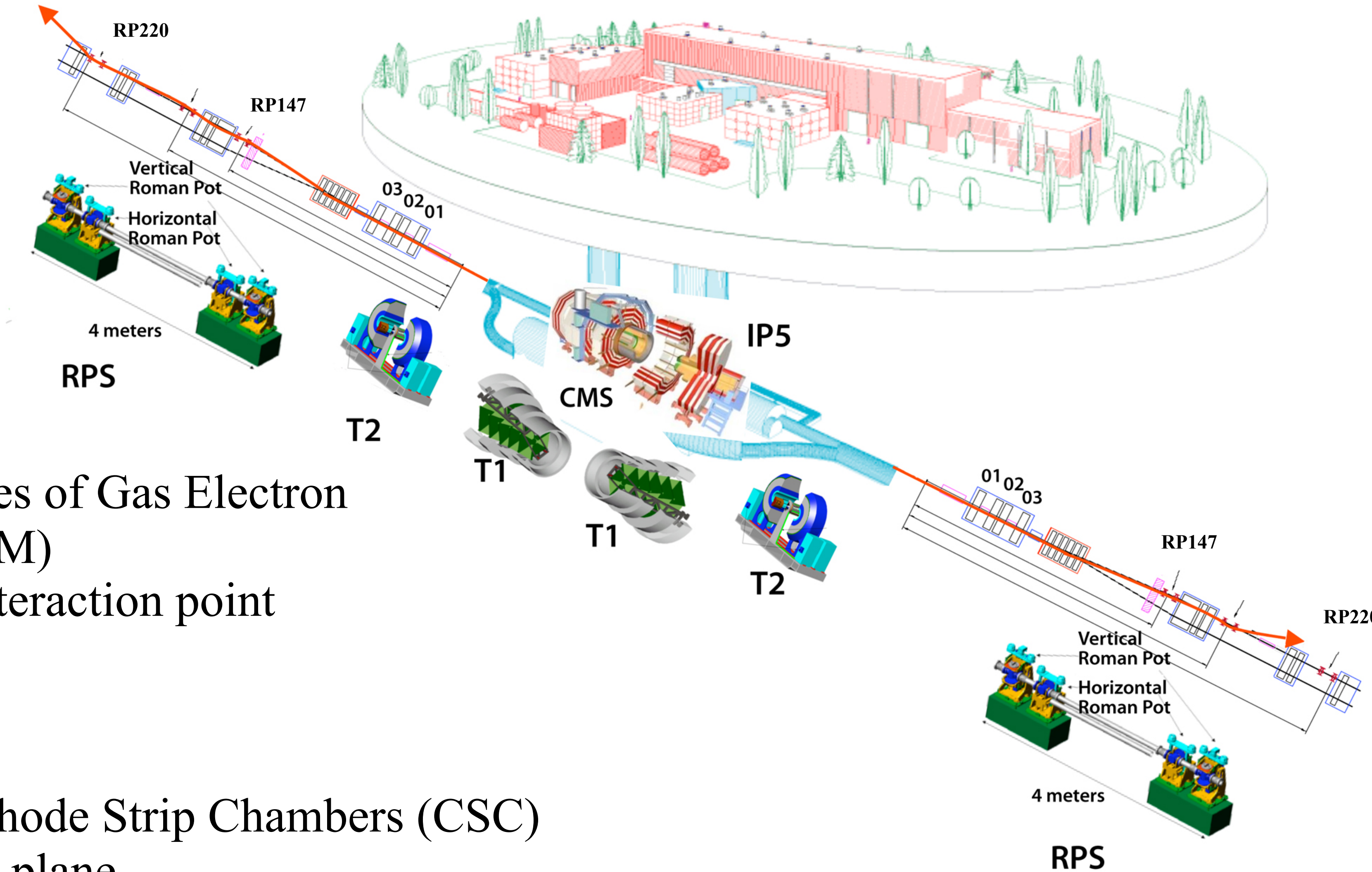


Non-Diffractive (ND) | **Single Diffractive (SD)** | **Double Diffractive (DD)** | **Central Diffractive (CD)**

$$\sigma_{TOT} \equiv \sigma_{EL} + \sigma_{ND} + \sigma_{SD} + \sigma_{DD} + \sigma_{CD}$$

Note: Non-diffractive events will be called minimum bias (MB) later in the presentation

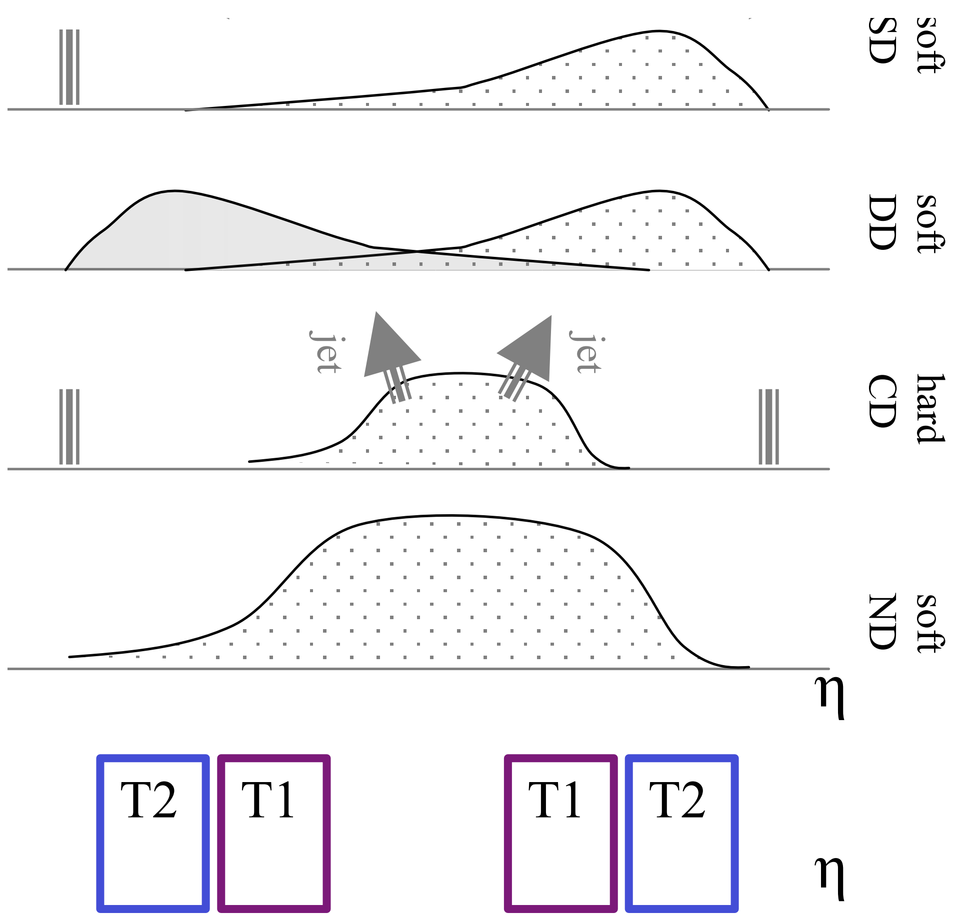
TOTEM has two charged particle trackers



T2 telescopes
- 10 double planes of Gas Electron Multipliers (GEM)
- 13.5 m from interaction point
- $5.3<|\eta|<6.5$

T1 telescopes
- 5 planes of Cathode Strip Chambers (CSC)
- 6 chambers per plane
- 9 m from interaction point
- $3.1<|\eta|<4.7$

Pure event sample of DD events



Event selection (2T2+0T1)

- At least one T2 track on both positive and negative sides
  - No cut on Z_{impact} to select events with neutral particles hitting beam pipe
- No tracks on T1s

Trigger requirement

- At least one track in T2

Pure event sample of DD events: MC predictions

Pythia 8

	Cross-section (mb)	Acceptance (%)	Example integrated luminosity (μb^{-1})	Number of events
DD	8.1	2.4%	40	7614
SD	12.4	0.06%	40	288
MB	50.9	0.04%	40	774

S/(S+B)=~0.9
➔clean sample

Phojet

	Cross-section (mb)	Acceptance (%)	Example integrated luminosity (μb^{-1})	Number of events
DD	3.9	2.9%	40	4524
SD	10.7	0.02%	40	64
CEP	1.3	0.01%	40	5
MB	61.6	0.02%	40	370

Cross section from counting experiment

$$\sigma_{DD} = \frac{cN_{data}^{raw} - N_{background}}{AL}$$

- N_{data}^{raw} = Raw number of data events passing event selection
- $N_{background}$ = Estimate of number of background events passing event selection
- c = Experimental efficiency (trigger efficiency, reconstruction inefficiency, pile-up correction)
- A = Acceptance of double diffractive events with the selection
- L = Integrated luminosity

MB background estimation method

- Select control sample that is dominated by MB: tracks in both T2s and both T1s
- Calculate amount of MB in control sample (csample)

$$N_{MB}^{csample} = N_{data}^{csample} - N_{DD}^{csample} - N_{SD}^{csample} - N_{CEP}^{csample}$$

- Calculate ratio R from MC

$$R_{MB} = \frac{N_{signalsample}^{MB\,MC}}{N_{csample}^{MB\,MC}}$$

- Correct for difference in ratios between MC and data

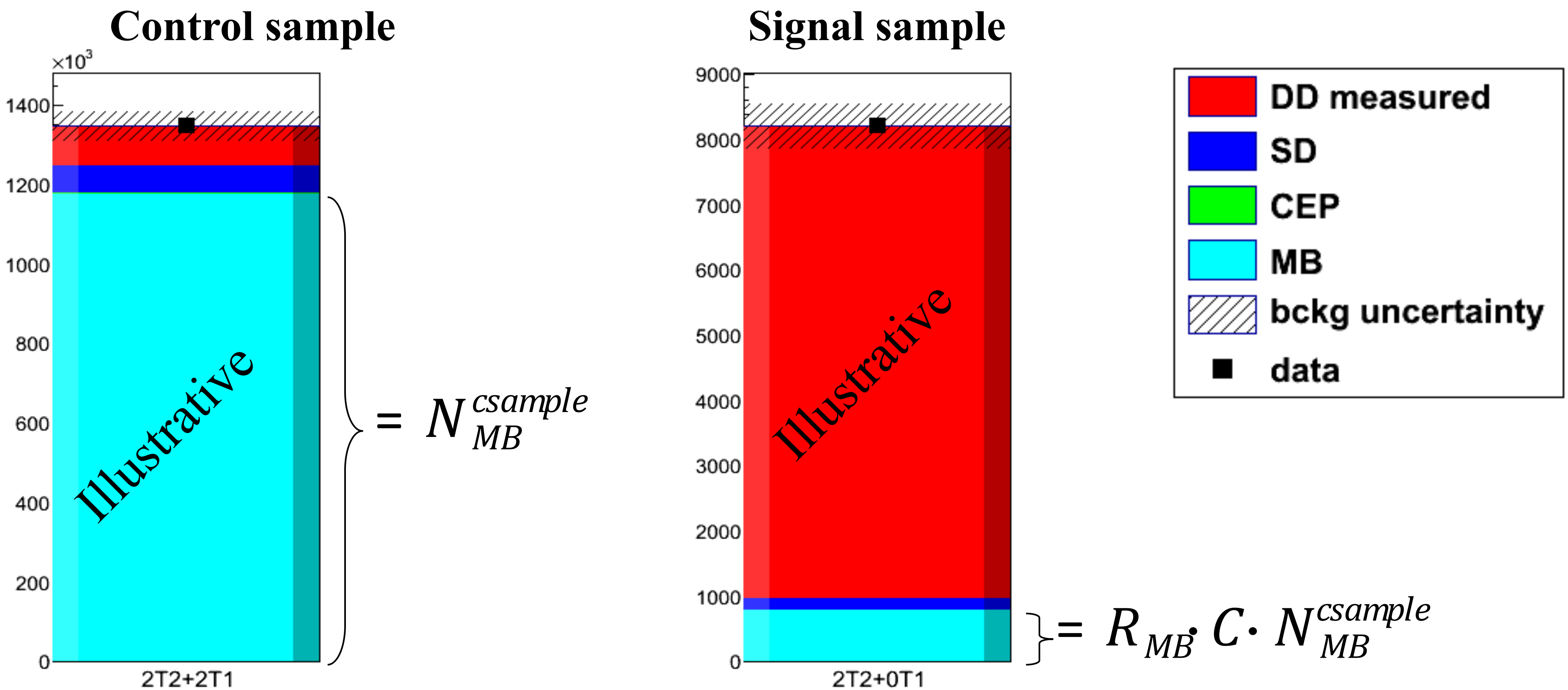
$$C = \frac{R_{total}^{data}}{R_{total}^{MC}}$$

- MB background

$$N_{MB}^{background} = R_{MB} \cdot C \cdot N_{MB}^{csample}$$

- Iterate for amount of DD in control sample

MB background estimate



$= N_{MB}^{csample}$

$= R_{MB} \cdot C \cdot N_{MB}^{csample}$

MC generator for ratio	Share of MB events in signal sample
Pythia	~9%
Phojet	~9%

MB background ~9%

Data-based SD background estimate

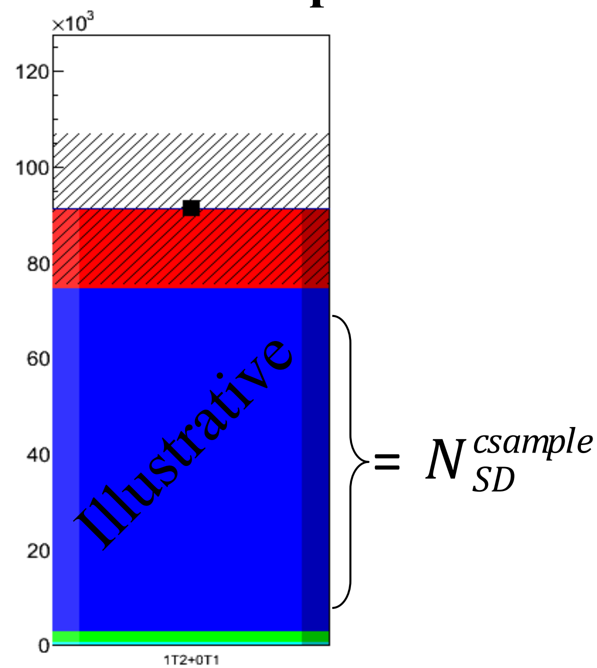
Event selection of clean SD events from data to test relative fractions of different categories

- Exactly one proton in Roman Pots
- T2 & T1 selection the same as in this analysis
  - Events triggered with T2 trigger

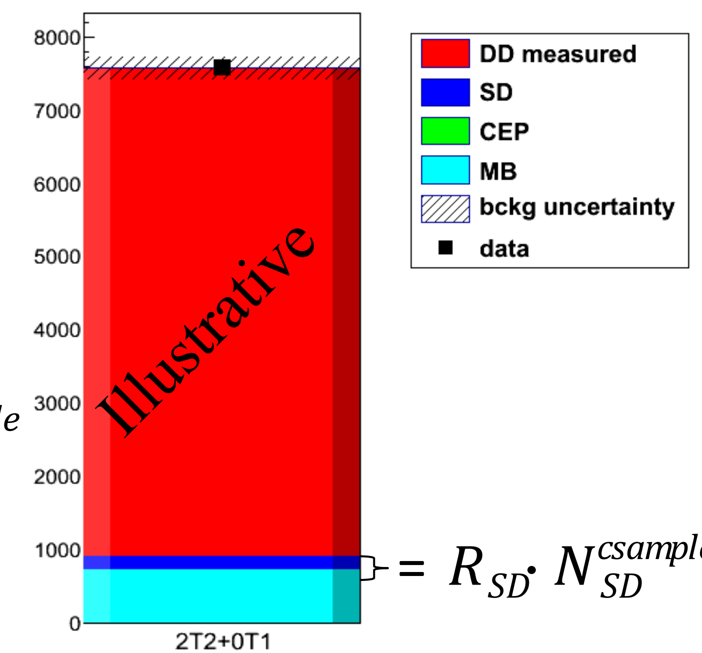
SD background estimation method

- Select control sample as 1T2+0T1
- Take ratio between control sample and wanted sample from data
- Calculate SD background based on the two numbers

Control sample

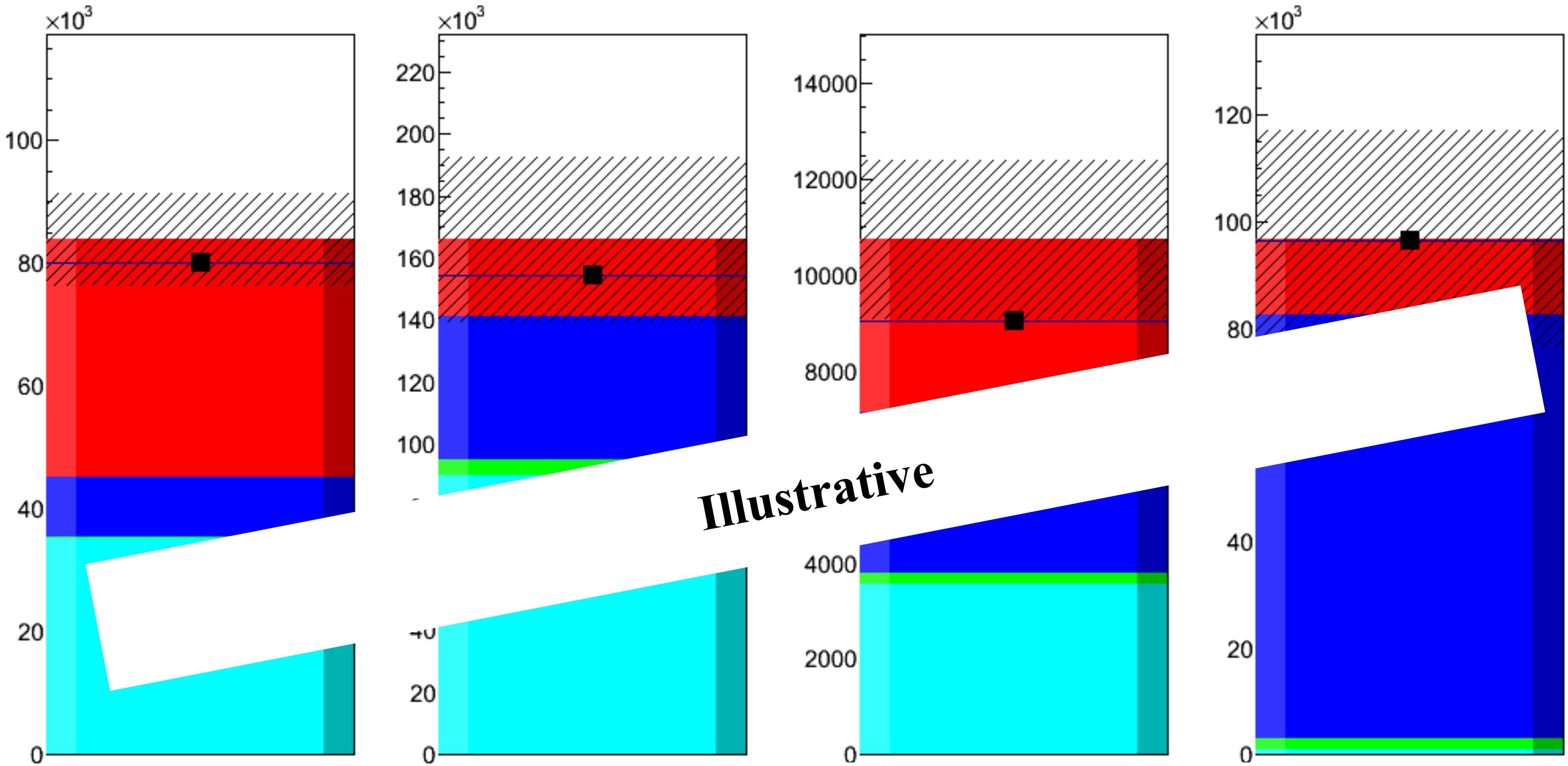


Signal sample



$$N_{SD}^{csample} = N_{data}^{csample} - N_{DD}^{csample} - N_{CEP}^{csample} - N_{MB}^{csample}$$

Background estimates will be verified with other selections



2T2+1T1 | 1T2+2T1 | 1T2+1T1 on opposite sides | 1T2+0T1

Summary

- Double diffractive cross-section measurement tests non-perturbative QCD models and it is an important step on understanding background for central diffractive Higgs measurements

- Event selection that requires tracks in TOTEM T2s and vetos for T1 tracks has high purity (>90%) for double diffractive events

- Single diffractive background can be estimated with data-based method
- Non-diffractive background estimation method a combination of data and MC

- **STAY TUNED FOR THE CROSS-SECTION MEASUREMENT FROM DATA!**