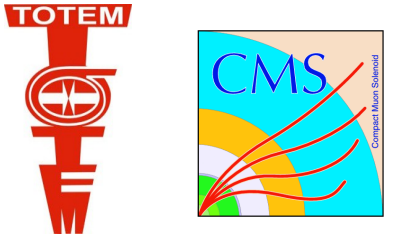
Report of the High Beta run campaign
October 2015



Overview


Beam intensity and Energy
← Alignment Run 13/10/2015
15/4/2015
Atlas Access
Loss maps
Physics
Day 1
15/10/2015
Fill 4495
42b
Fill 4496
240b
Fill 4499
671b
Day 2
16/10/2015
Fill 4505
Day 3
17/10/2015
Fill 4509
Fill 4510
Fill 4511

Alignment Run

Roman Pots at 5σ : scraping of the beam to align the pots

After alignment, quiet beams for data taking.

TOTEM alone: 11.6 M triggers (x 5 statistics 8TeV RunI)

RP Double Arm
T1, T2 inelastic trigger

Luminosity independent total cross section measurement
Low-t elastic scattering
Inelastic cross section (direct measurement)

Physics runs: some statistics…..

Bunches	Duration (h)	Luminosity $(\mu b\ s)^{-1}$	Pileup
42	3.6	0.7	0.15
240	2.6	3.9	0.09
671	4.2	6.9	0.065
“	2.7	10.6	0.095
“	8.8	9.0	0.085
“	3.3	7.6	0.07
“	5.5	9.8	0.096

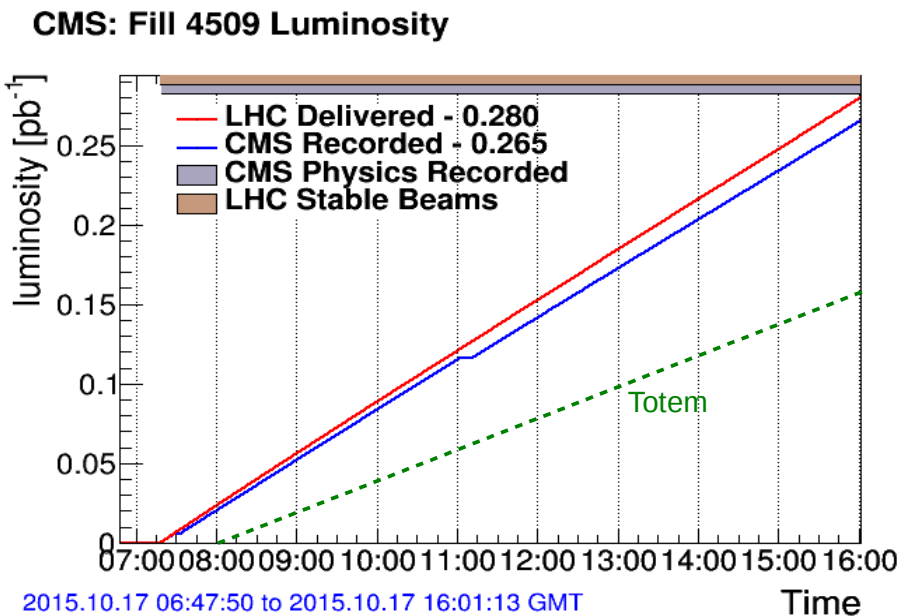
Integrated Luminosity

LHC delivered : 0.74/pb

CMS recorded : 0.68/pb

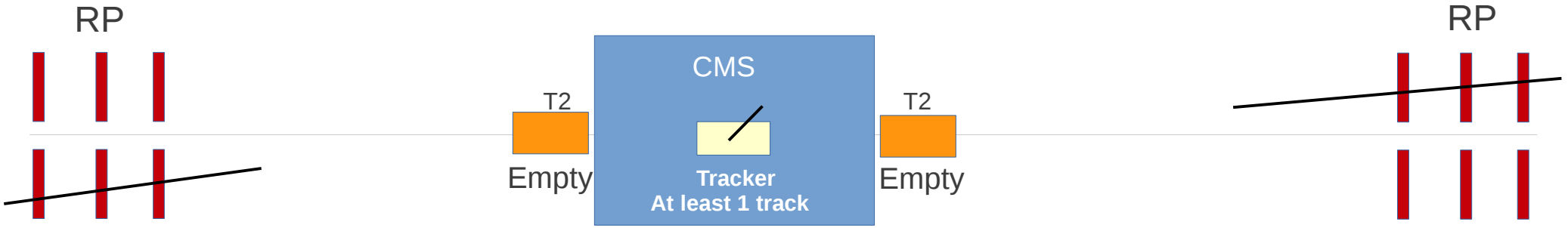
Totem recorded : 0.4/pb

Effective luminosity
Totem Trigger & CMS data : 0.55/pb



CMS-TOTEM : Trigger Menu - 1

RomanPots Double arm & T2 Veto + at least 1 track in CMS-Tracker



New in 2015:
3 RP Units/arm !
Improved acceptance

Totem Rate ~ 45 Khz

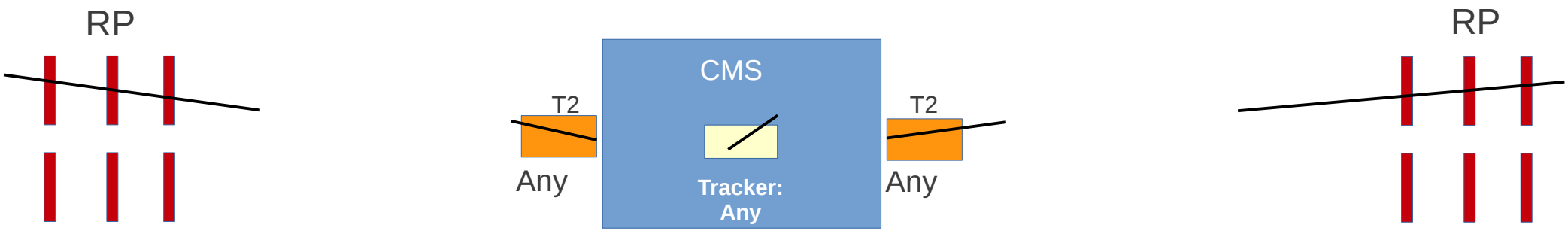
CMS HLT rate ~ 1.5-2 Khz

Right topology for low mass central diffraction, glueballs searches

In Totem very high statistics of elastic scattering!

CMS-TOTEM : Trigger Menu - 2

RomanPots Double Arm TopTop OR BottomBottom



Totem Rate ~ 5 Khz

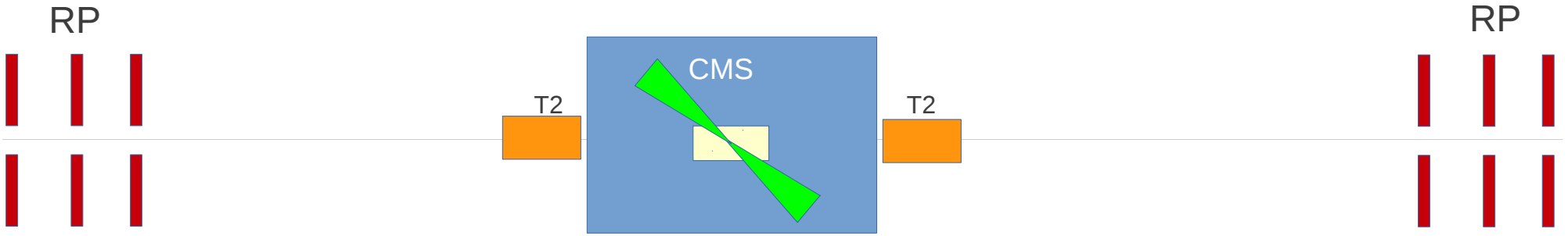
CMS HLT rate ~ 5 Khz

Right topology for high mass central diffraction, missing mass searches

Elastic scattering “background” is excluded

CMS-TOTEM : Trigger Menu - 3

Dijets pT~ 20 GeV – pT ~ 32 GeV

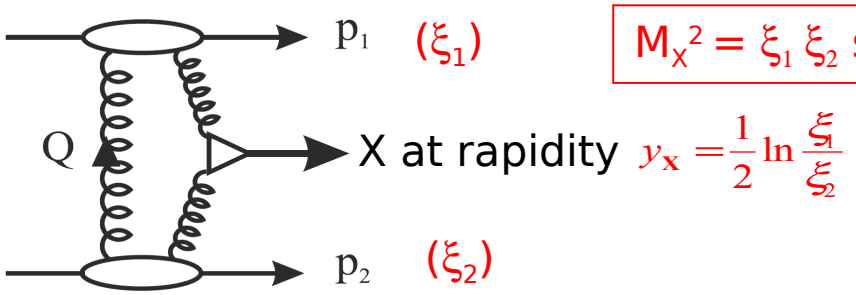


CMS HLT rate ~ 500 hz

Right topology for Single Diffractive Dijets, Exclusive Dijets

And also : Double muon, Single Muon with HF gap, Min Bias (T2), ZeroBias

(Exclusive) Central Diffraction



$M_X^2 = \xi_1 \xi_2 s$

Exchange of colour singlets with vacuum quantum numbers

⇒ selection rules for system X: $J^{PC} = 0^{++}, 2^{++},...$

Double-arm proton detection

$\beta^* = 90$ m runs: all M_X for $t \gtrsim 0.04$ GeV^{-2}

Comparison of prediction from forward to central system:

M(pp) =? M(central), $p_{T,z}$(pp) =? $p_{T,z}$(central), vertex(pp) =? vertex(central)

Prediction of rapidity gaps from protons : $\Delta\eta_{1,2} = -\ln\xi_{1,2}$

Examples:

Low mass resonances and glueball studies *(see next slides)*

Exclusive charmonium production *(see next slides)*

Missing Mass & Momentum (large mass) : x 100 statistics(2012)

Low mass (non-exclusive) central diffractive dijets ($p^T_{jet} > 30, 40$ GeV) : x 100 statistics(2012)

Exclusive central diffractive dijets ($p^T_{jet} > 40$ GeV) ~ O(10) events

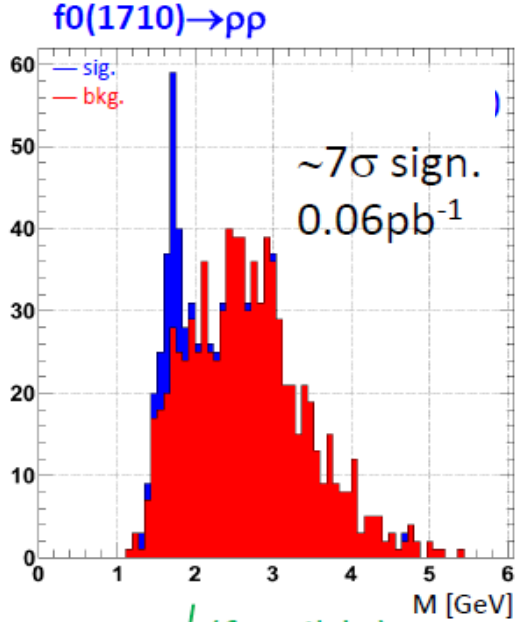
Low mass resonances & Glueballs studies

Pomeron ≈ colourless gluon pair/ladder ⇒ fusion likely to produce glueballs

CD@LHC: x ~ 10^{-3} – 10^{-4} gluons ⇒ pure gluon pair ⇒ M_X ~ 1 – 4 GeV (X = $\pi^+\pi^-$, K^+K^-, $\rho^0\rho^0$, $\pi^+\pi^-K^+K^-$...)

CMS+TOTEM data from 2012 (L ~ 1 nb^{-1} of double arm RP trigger)
show sensitivity to $f_0(1710) \rightarrow \rho^0\rho^0 \rightarrow 4\pi^{\pm}$ (channel not yet reported in PDG)

Sensitivity to the invariant mass



Generator Level study : signal & non-resonant $\rho^0\rho^0$ background [DIME MC]
(RP and CMS tracker acceptance included)

CMS-TOTEM advantages:
→ particle ID using CMS tracker dE/dx
→ RP protons assure exclusivity ($p_{T,RP}$ ~ $p_{T,tracker}$)
→ σ(M) ~ 20 – 30 MeV

Data 2015:
L ~0.4 pb^{-1} [double arm RP & T2 veto & tracks in CMS tracker] ⇒ × 500-750 statistics (2012)
⇒ should allows to some extent the full decay characterization

Full spin analysis would require L ~ 5 pb^{-1}

Exclusive charmonium states

SuperChic/Durham predictions $\sqrt{s}$ = 13 TeV

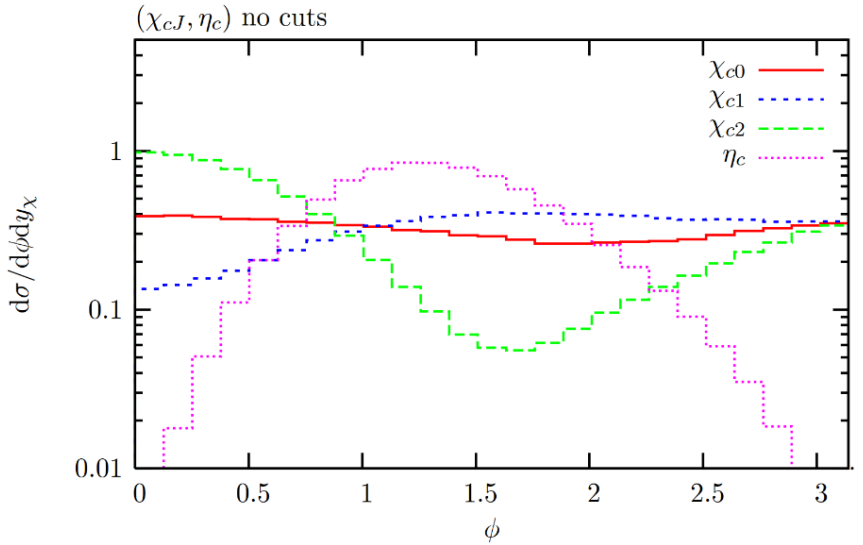
	$J/\psi\,(\to \mu^+\mu^-)\gamma$	$2(\pi^+\pi^-)$	$3(\pi^+\pi^-)$	$\pi^+\pi^-K^+K^-$
χ_{c0} :	264 pb	**7.6 nb**	**4.1 nb**	**6.0 nb**
χ_{c1} :	166 pb	61 pb	46 pb	45 pb
χ_{c2} :	53 pb	49 pb	38 pb	40 pb

All existing observations (LHCb & CDF) based on rapidity gap tagging

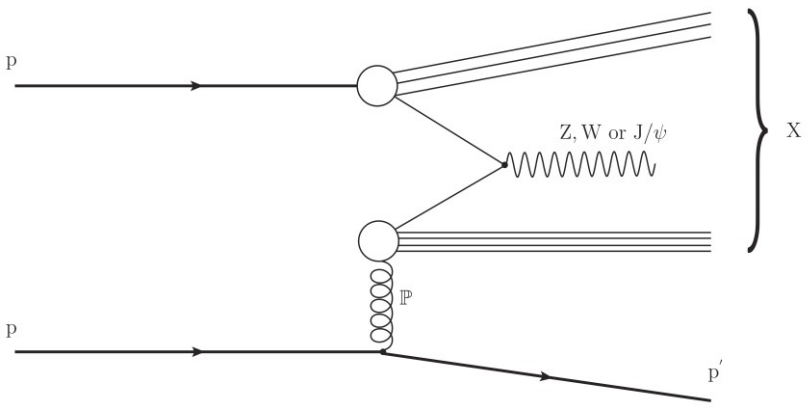
χ_c (σ_{mass} = 20-30 MeV, Γ < 10 MeV): selection identical to low mass resonances

In 0.4 pb^{-1}, expect ≥ few hundred χ_{c0} in all-hadronic decay modes.

Possible to measure azimuthal angular correlation (ϕ) between leading proton for exclusive χ_{c0}

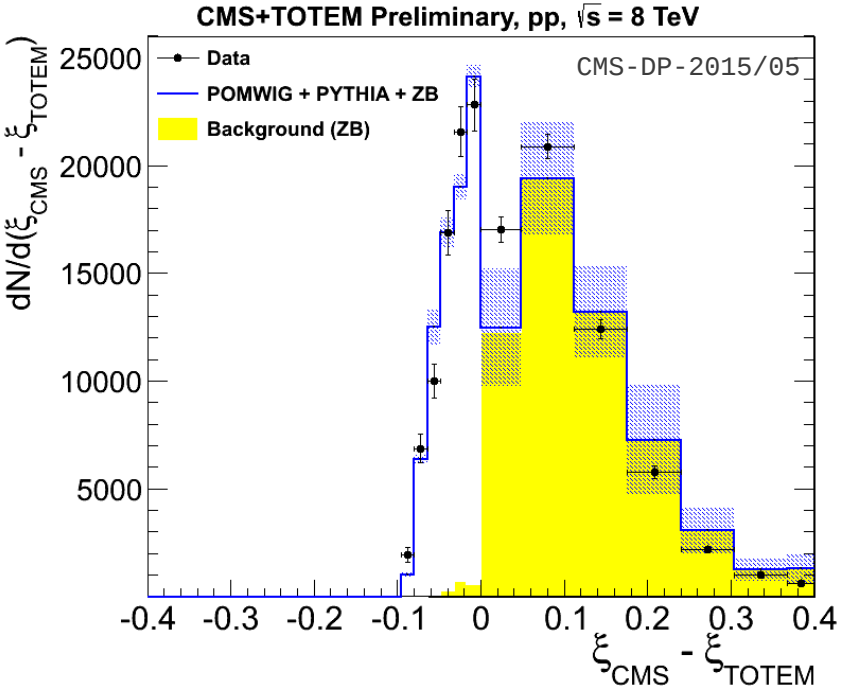


Hard Diffraction



Trigger: CMS lepton & jet triggers

Background removal demonstrated on common CMS+TOTEM β* = 90 m data at √s = 8 TeV (SD dijets)



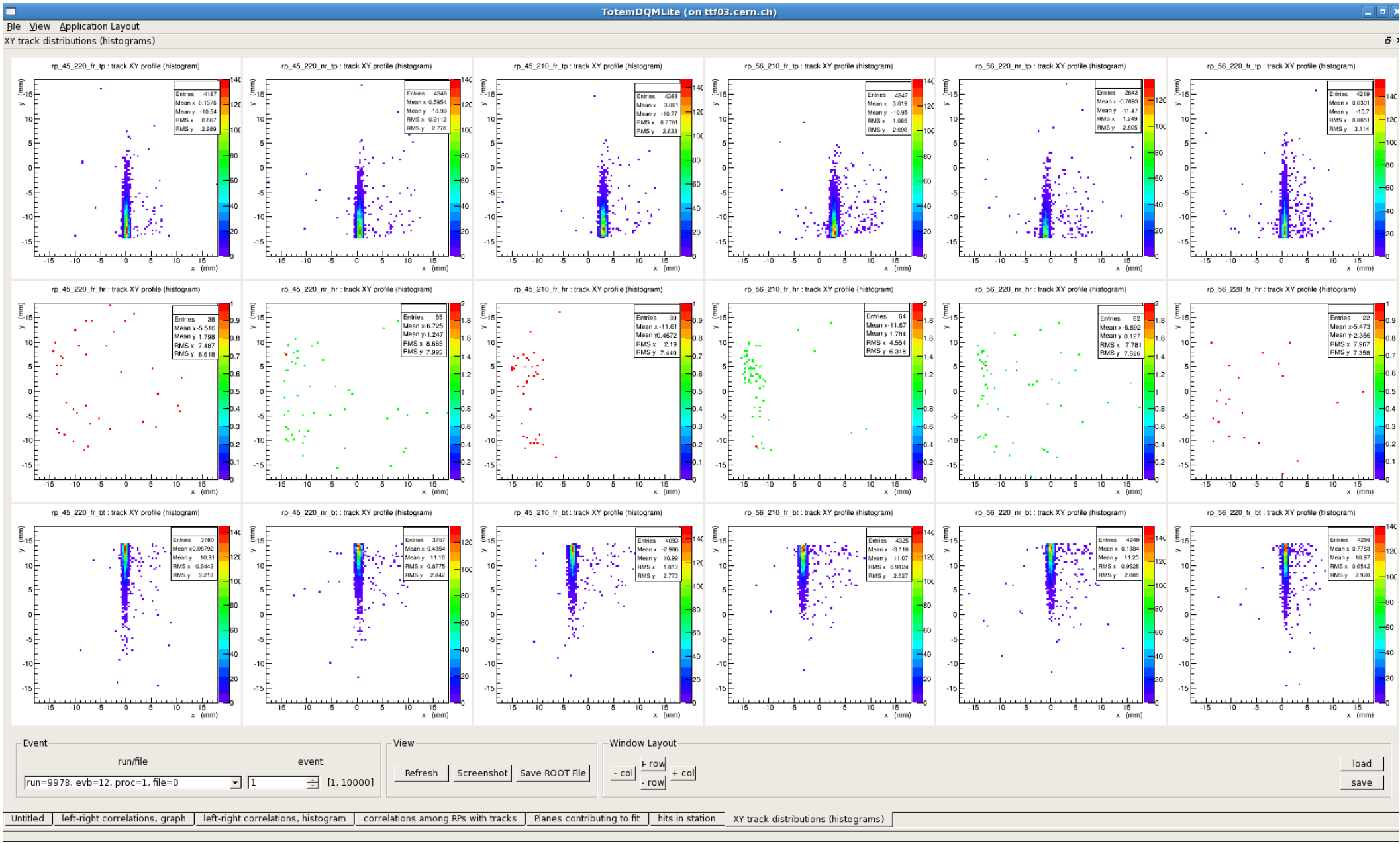
Estimate visible σ at √s = 13 TeV & L~0.4 pb^{-1} (both proton + central object)

[CMS PAS FSQ-14-001, TOTEM-NOTE-2014-002]

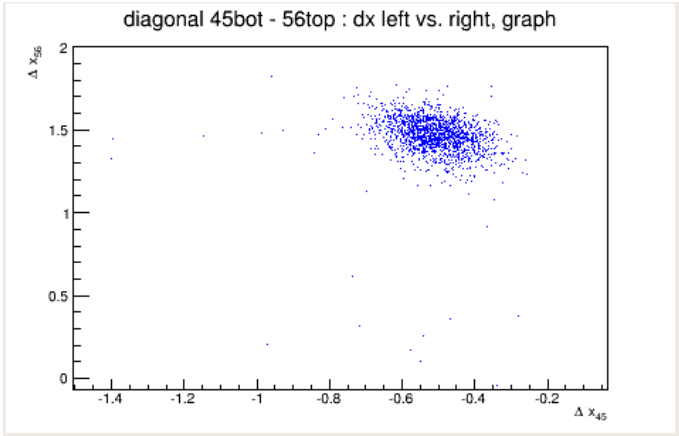
- SD jet production: $p_{T,jet} > 40$ GeV ⇒ O(10k) events
- J/ψ production (POMPYT): $\mu^+\mu^-$ $3.05 < M_{\mu\mu} < 3.15$ GeV ⇒ O(100) events
- W production (POMWIG): $\mu^\pm/e^\pm$ ($p_T > 20$ GeV), $60 < M_T < 110$ GeV ⇒ O(10) events

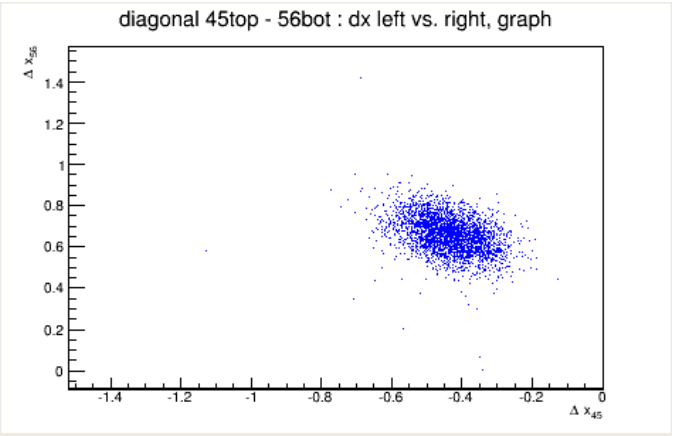
Some performance plots….

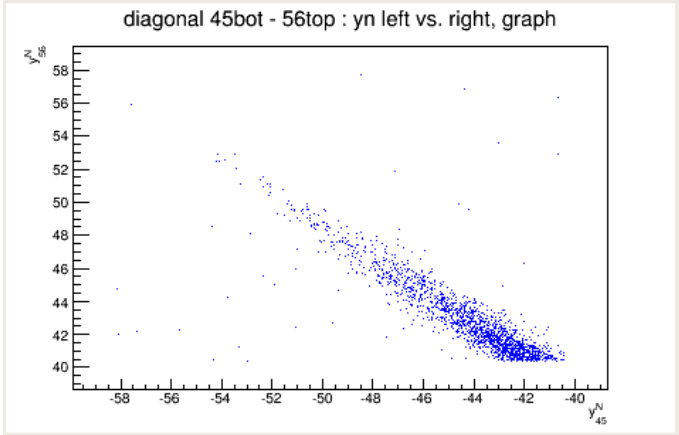
Hits distribution in all RPs

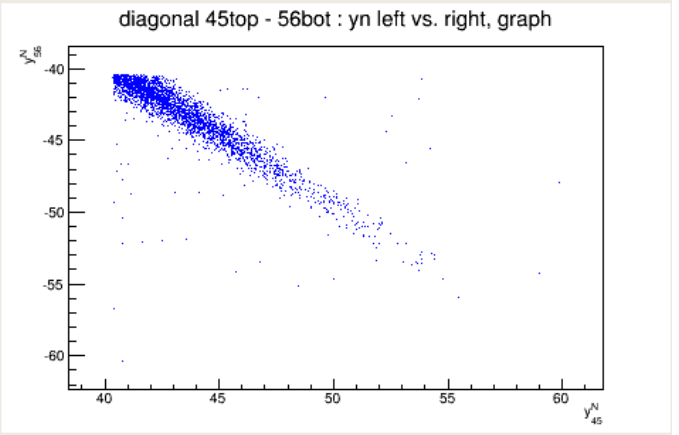


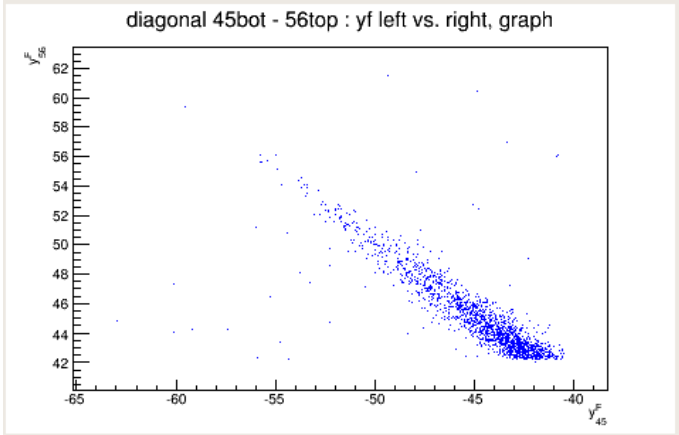
Online correlation checks

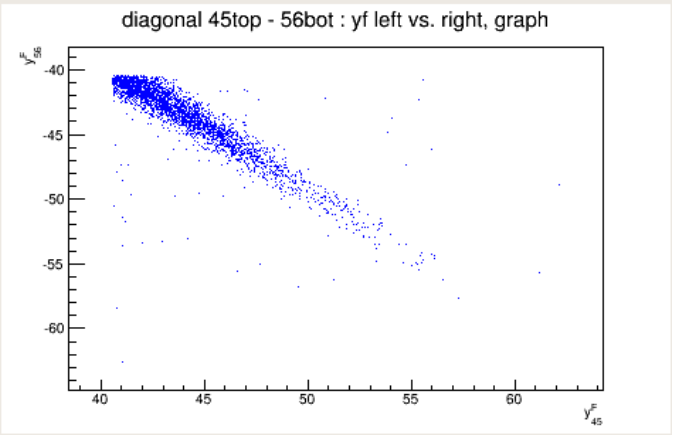












RP Alignment

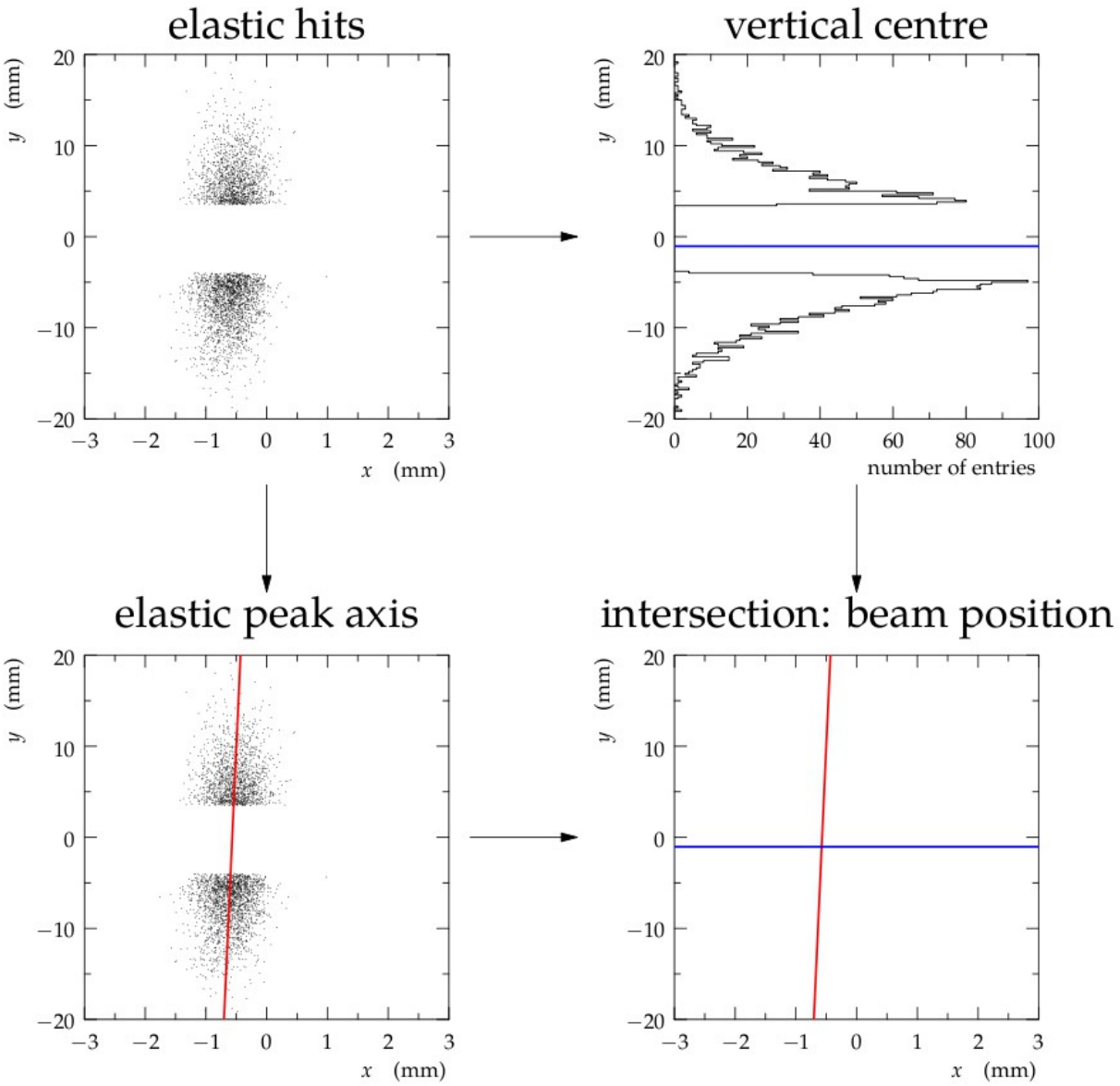
Track based alignment method (overlap of hor. and ver. pots):

- relative (mis)alignment

Elastic scattering method:

- vertical and horizontal beam position

- arm to arm (mis)alignment

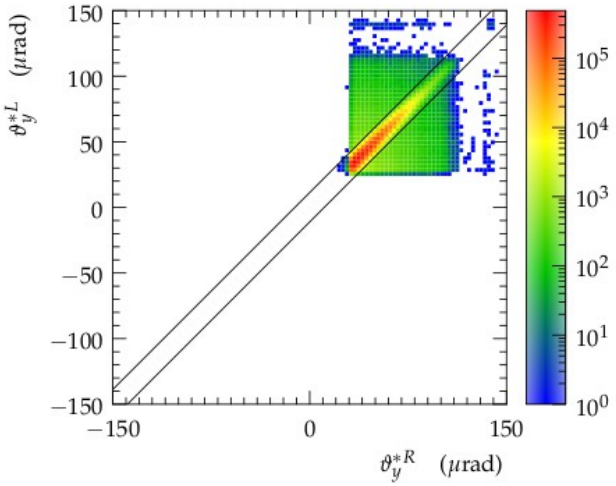


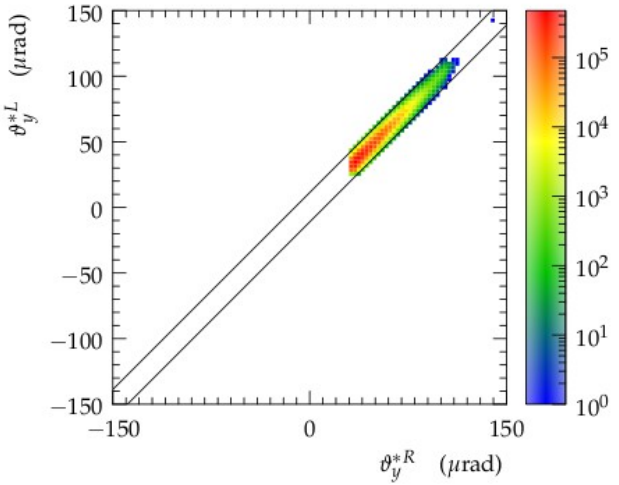
Elastic scattering selection

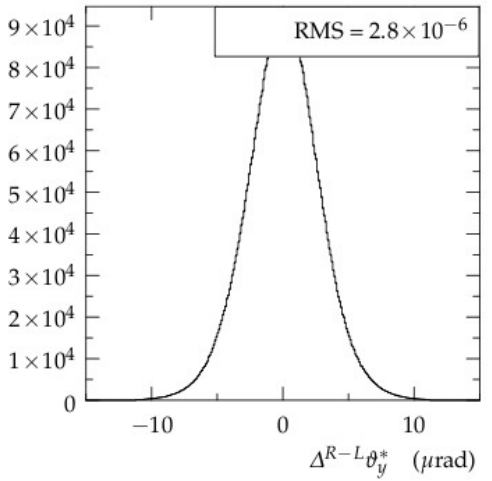
before cuts

after cuts

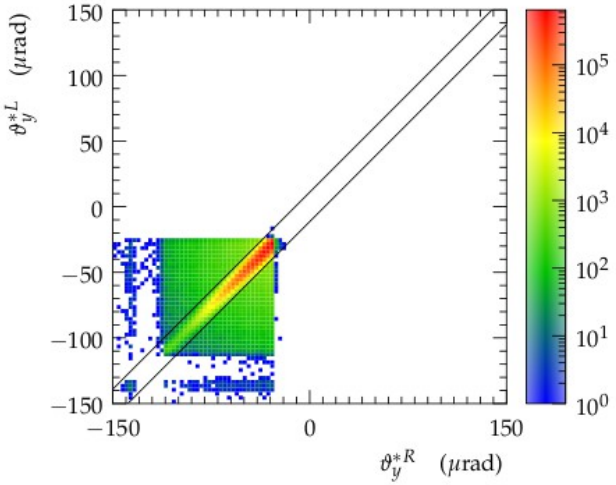
cut 2
DS4
45b–56t

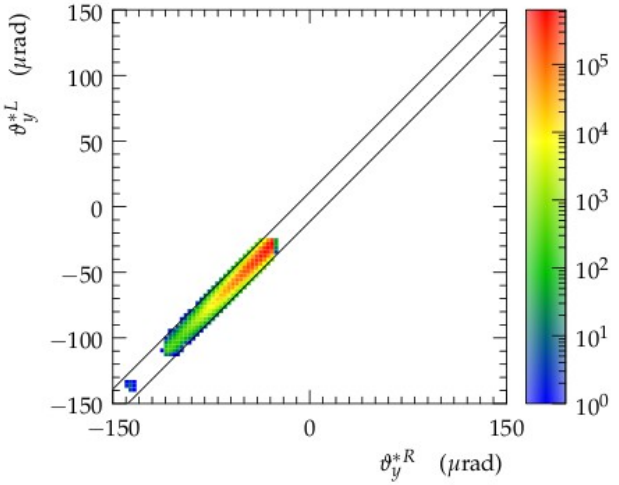


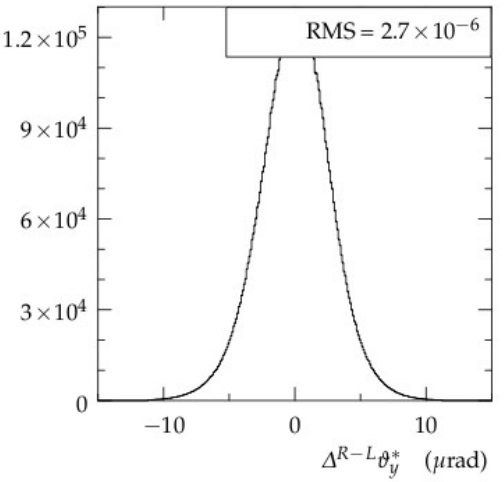




cut 2
DS4
45t–56b

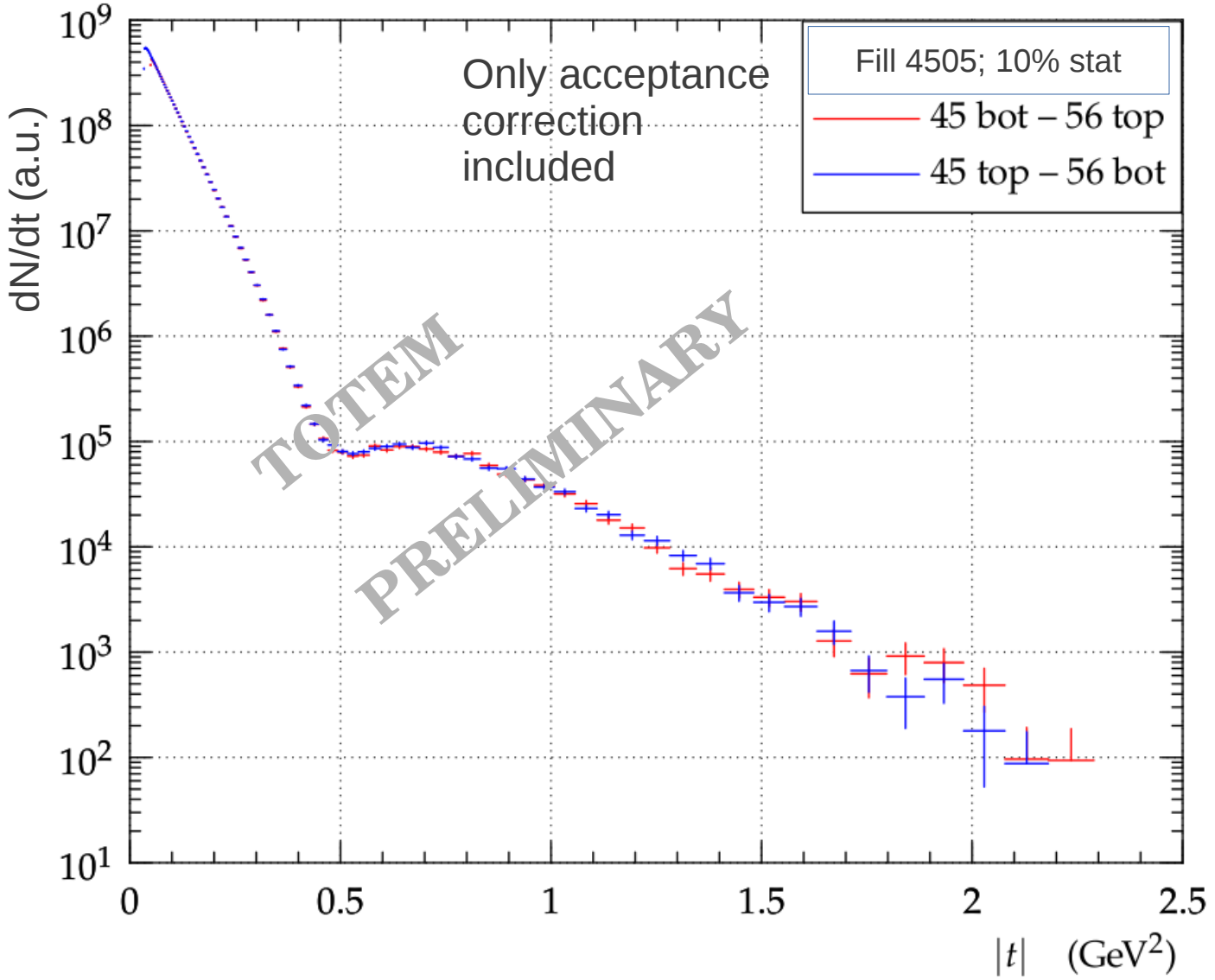






Elastic scattering selection II

Check consistency between diagonals to validate the alignment procedure



Summary

The high beta run campaign has been extremely successful !

CMS-TOTEM are reconstructing the data and merging offline the events.

CMS-TOTEM have collected within a factor 2, the statistics to accomplish the first stage of the physics programme.

Data analysis will start soon, stay tuned!