A first extraction and test of new association cuts

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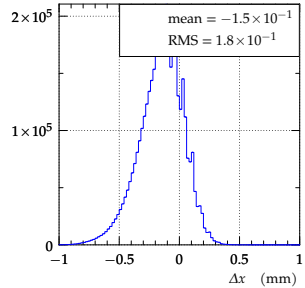
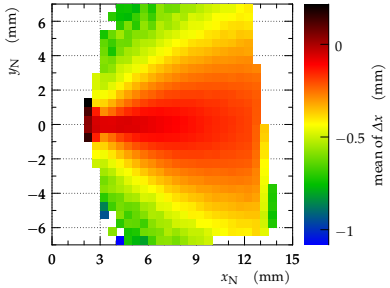
- association cuts = rules how to associate local tracks in the near RP with those fro the far RP
- in Run2
  - form of cuts: associate if $|\Delta x - \text{mean}| < \text{threshold}$ (and similarly for y)
  - $\Delta \equiv \text{far} - \text{near}$
  - two parameters per quantity: mean and threshold (cannot depend on event kinematics)
- plan for Run3
  - man and threshold: any function of xangle and track position in the near RP (x_N, y_N)
  - functions described by a string (TF1 notation) and stored in DB
- CMSSW implementation $\rightarrow$ see Grzegorz's talk
- this presentation:
  - first attempt to derive the cuts for Run3 (in no way the final)
    - step 1: simulate hit distribution with MC $\rightarrow \Delta x$ and Δy distributions
    - step 2: parametrise the distributions with an analytic function/model
  - check if exploiting the new flexibility does lead to improvement (efficiency comparison):
    - "model 1": Run2-like tuning, i.e. mean and threshold constant
    - "model 2": Run3-like tuning, i.e. mean and threshold function of x_N and y_N

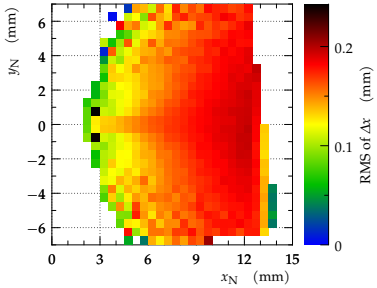
- with “direct” simulation, CMSSW_12_1_0_pre2, profile “profile_2021_default”
  - before the bug-fix of isPixelHit → acceptance (artificially) limited at high x
  - with “2021” optics, while “2022” is (being) prepared
  - 2021 optics symmetric 45 wrt. 56 → extraction for sector 56 only
  - due to a recent update of Run3 geometry, the distance beam–RPs on the optimistic side → the lowest x bin or two most likely not accessible with LHC data
- hit distributions (including near-far differences): module CTPPSTrackDistributionPlotter (included in CMSSW)
- run simulations
  - for discrete xangles: 100, 130 and 160 → to establish also xangle dependence of the cuts
  - statistics: 1E7 events

arm 1

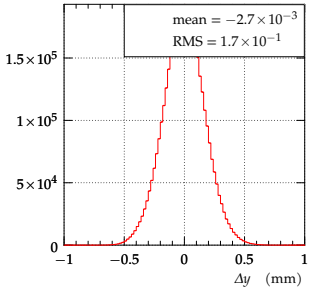
$\Delta x \equiv x^F - x^N$

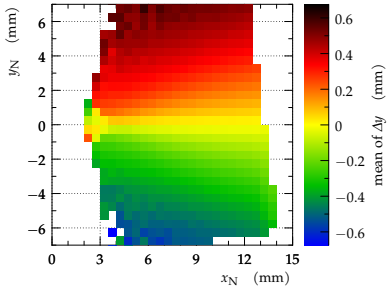


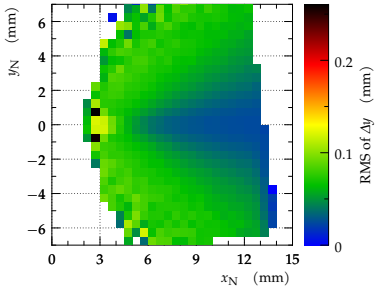




$\Delta y \equiv y^F - y^N$



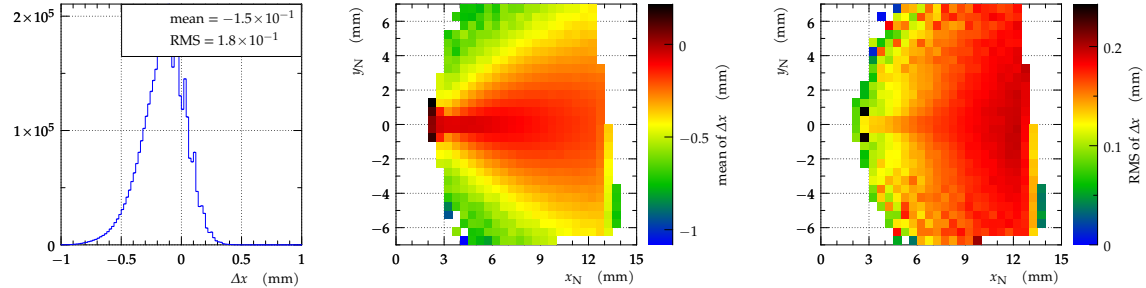




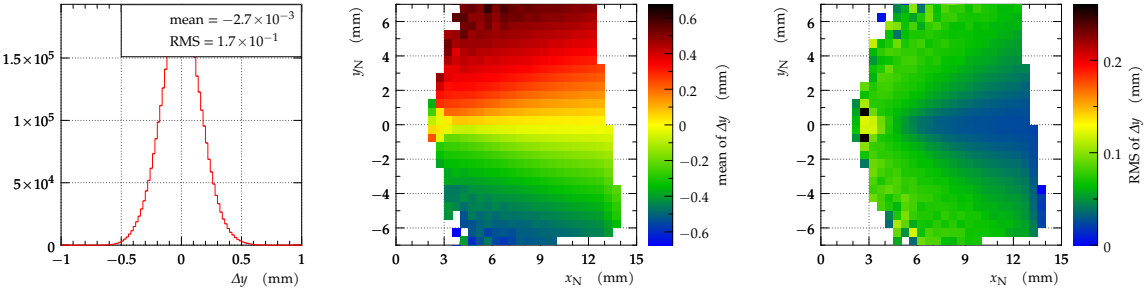
- left column: histograms of Δx and Δy
  - mean and RMS define “model 1” (threshold = 4× RMS)

arm 1

$\Delta x \equiv x^F - x^N$

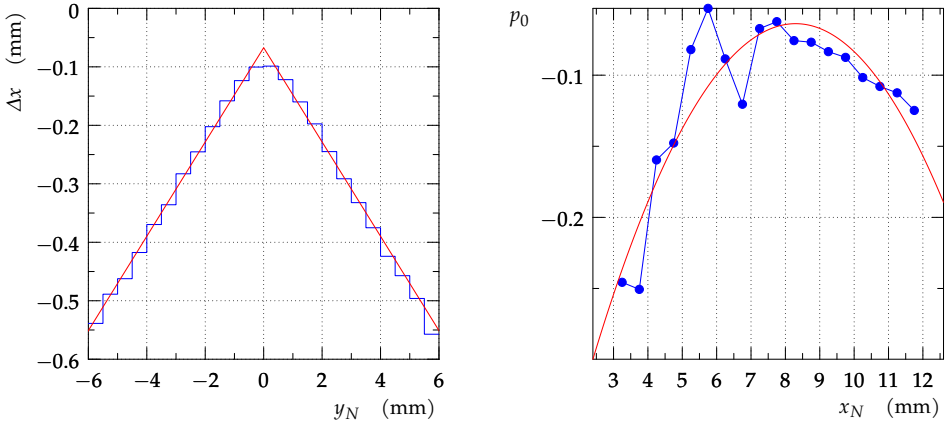


$\Delta y \equiv y^F - y^N$



- other columns: histograms of Δx and Δy as functions of track position in the near RP – NB: non-trivial dependence!
  - define “model 2”: central column mean, right column RMS (threshold = 4× RMS)
  - needs parametrisation expressible as a string

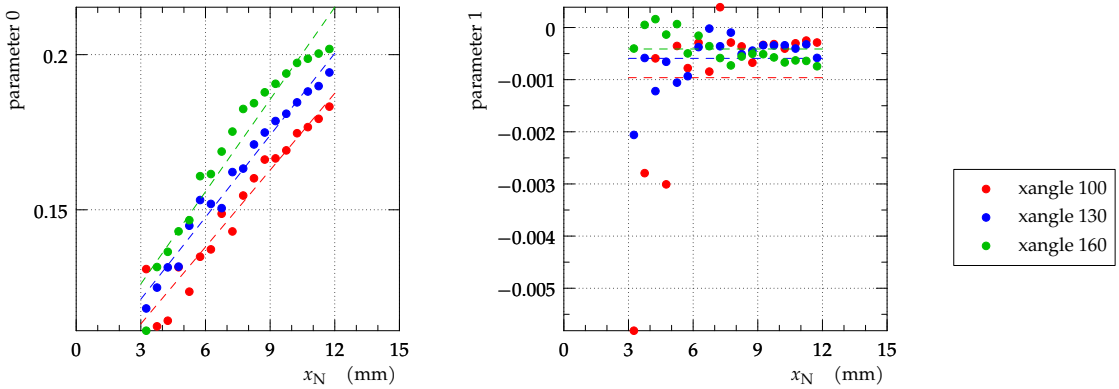
- for example consider mean of Δx (see backup for more complete set of plots)
- step A: consider slices at const x_N, thus functions of $y_N \to$ left plot
  - blue: simulation
  - identify shapes, parametrise: $p_0 - p_1\,|y_N|$, fit (red)



- step B: consider fitted parameters as function of $x_N \to$ right plot
  - blue: parameters extracted in step A
  - fit with an appropriate function (red), here a parabola $p_1 \approx a_0 + a_1\,x_N + a_2\,x_N^2$
- step C: put everything together
  - mean of $\Delta x = (-0.462076 + 0.100746 * x_N - 0.005906 * x_N * x_N) - (0.036128 + 0.333544/x_N) * abs(y_N)$

- for example consider RMS of Δx (see backup for more complete set of plots)

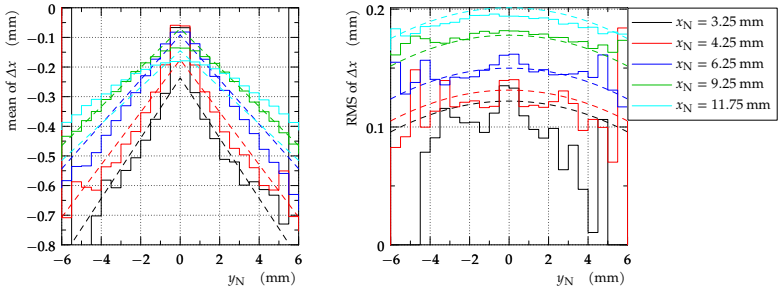
RMS of Δx



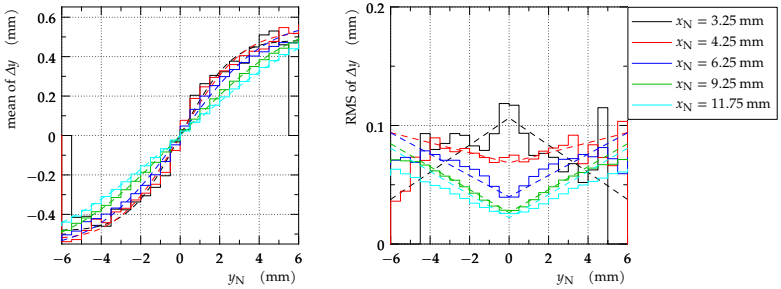
- parameter 0 (left plot)
  - xangle dependence straight-forward ($\sim$ vertical shift)
  - can be included to the model (CMSSW framework prepared for it), not yet done
- parameter 1 (right plot)
  - xangle dependence not obvious

- for several representative values of x_N (different colours), compare:
  - solid: original simulation (from slide 4)
  - dashed: model parametrisation

$$\Delta x \equiv x^F - x^N$$



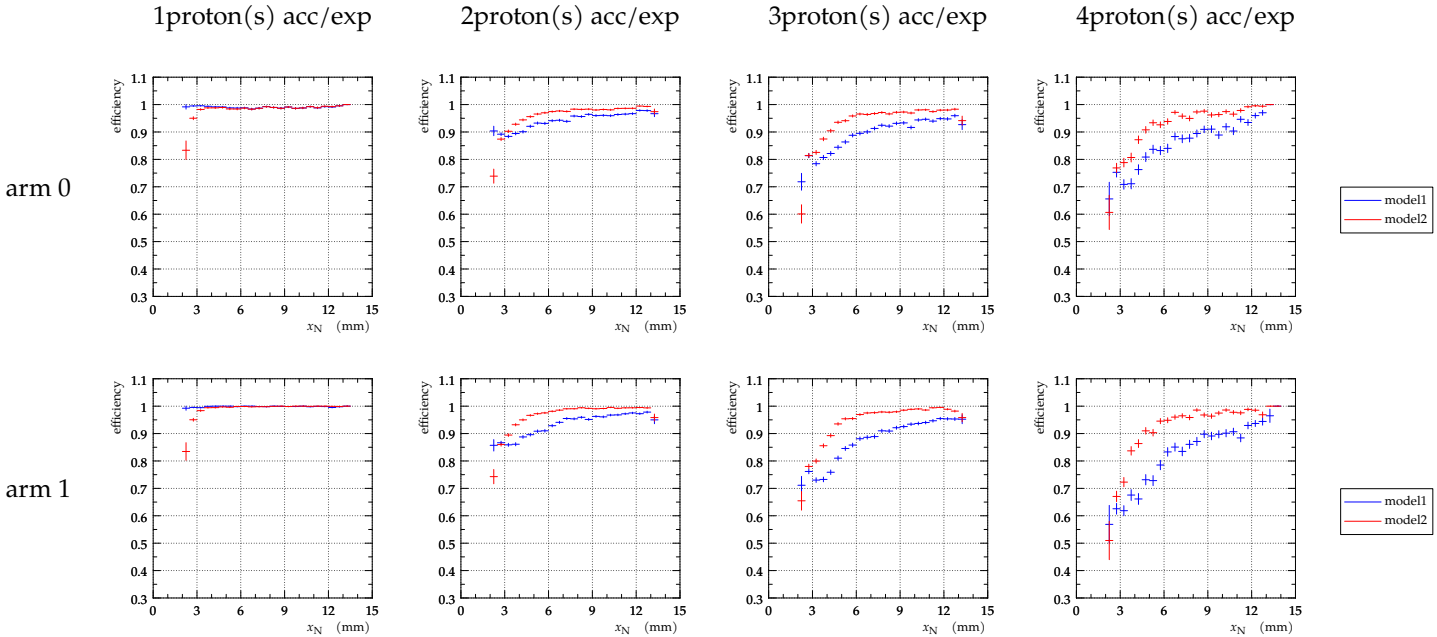
$$\Delta y \equiv y^F - y^N$$



  - relatively good overlap between dashed and solid lines

- run again “direct” simu, same conditions as on slide 3, focus on xangle 130
- efficiency estimated with module CTPPSProtonReconstructionEfficiencyEstimatorData (included in CMSSW)
  - same module used for Run2 data
  - efficiency of the near-far association, algorithm:
    - scan through local tracks in the near RP, for each
    - open a “expectation” window in the far RP $\rightarrow$ count local tracks in the far RP $\rightarrow$ denominator = number of expected protons
    - numerator = number of really reconstructed multi-RP protons
    - efficiency = numerator / denominator

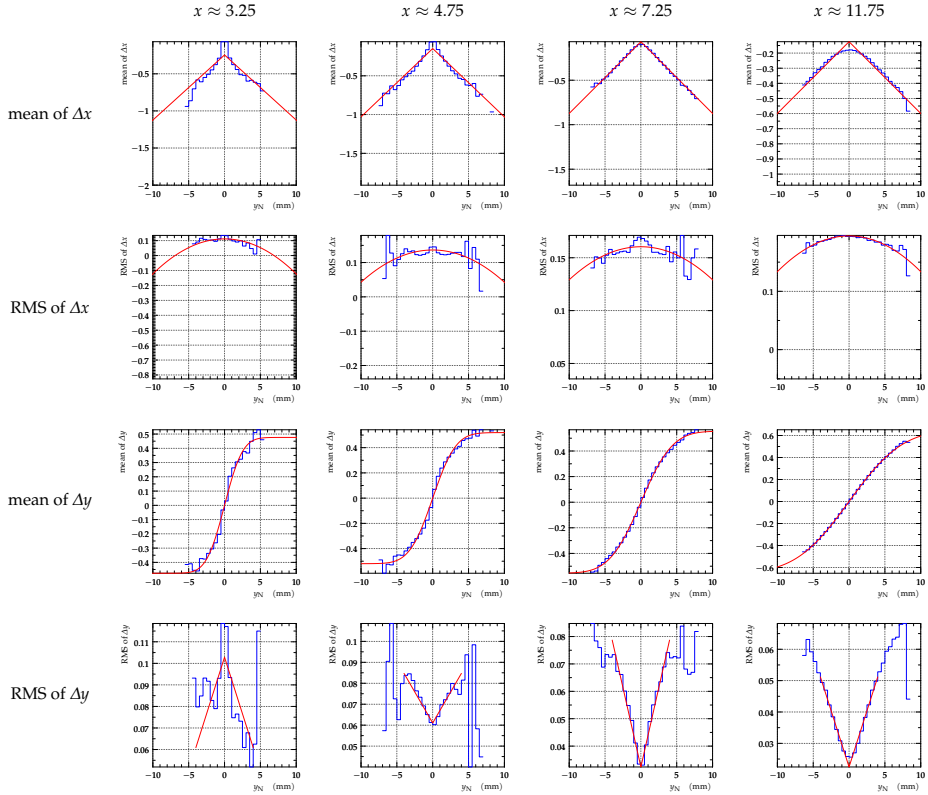
- simulation run with 4 particles per event – however not all in acceptance
  - number of accepted protons → different categories in columns
- blue = Run2-like parametrisation, red = Run3-like parametrisation



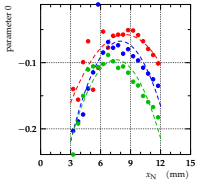
- 1 proton per event
  - almost everywhere: both models almost at 100 %
  - lowest x bins: “sacrificed” for model simplicity (can be improved), but anyway most likely inaccessible in LHC data (cf. slide 3)
- multiple protons per event
  - model 2 (with new flexibility) always better than model 1 (without the flexibility) $\rightarrow$ *justification that the new framework works as desired*
  - efficiency decrease for $x_N \lesssim 6$ mm – to be studied, possibly related to the vertical squeeze of the hit distribution (which makes disentangling multiple tracks harder)

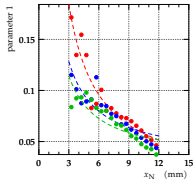
- a first simple extraction of association cuts from MC simulation of Run3-like data
- test of the extended association cut framework (cf. talk by Grzegorz)
  - model exploiting the new flexibility (kinematic dependent mean and threshold) performs better that model with constant mean and threshold
  - updated CMSSW infrastructure thus can lead to improved efficiency in Run3

Backup

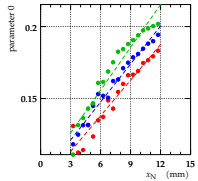

$x \approx 3.25$
$x \approx 4.75$
$x \approx 7.25$
$x \approx 11.75$
mean of Δx
RMS of Δx
mean of Δy
RMS of Δy
y_N (mm)

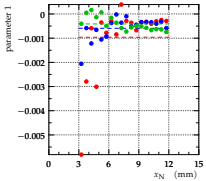
mean of Δx



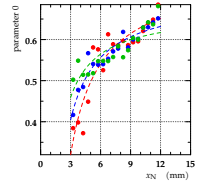


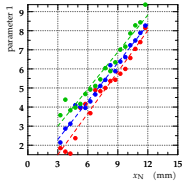
RMS of Δx





mean of Δy





RMS of Δy