Flip mode emittance analysis update

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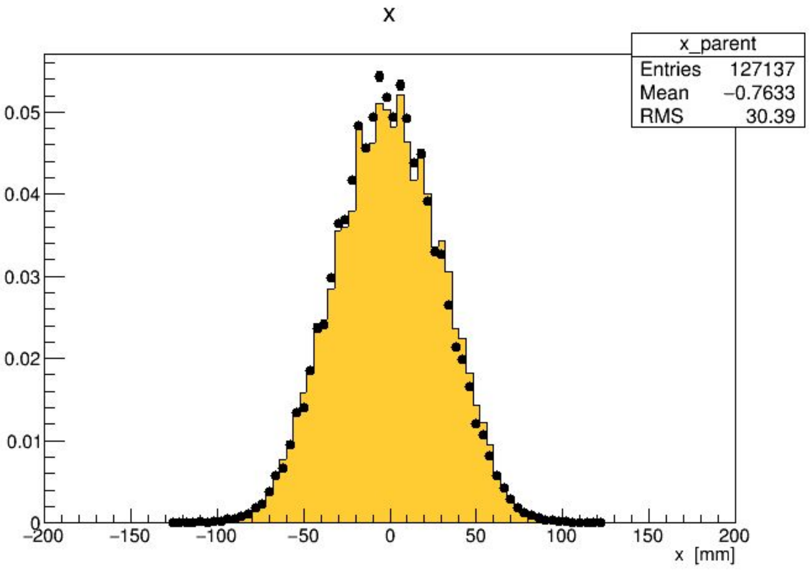
Empty vessel analysis

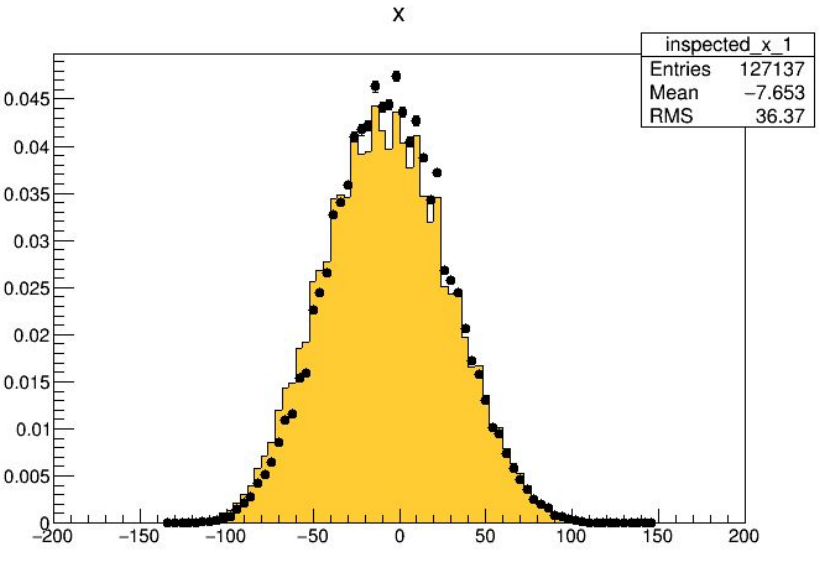
- Current status of the Empty vessel analysis (6 mm, 140 MeV/c)
  - Data vs MC comparisons
  - TKU and TKD reference plane phase space
  - Absolute emittance change (Data vs MC and comparisons with LH2 and No Absorber cases)

Beam Position: X

Upstream

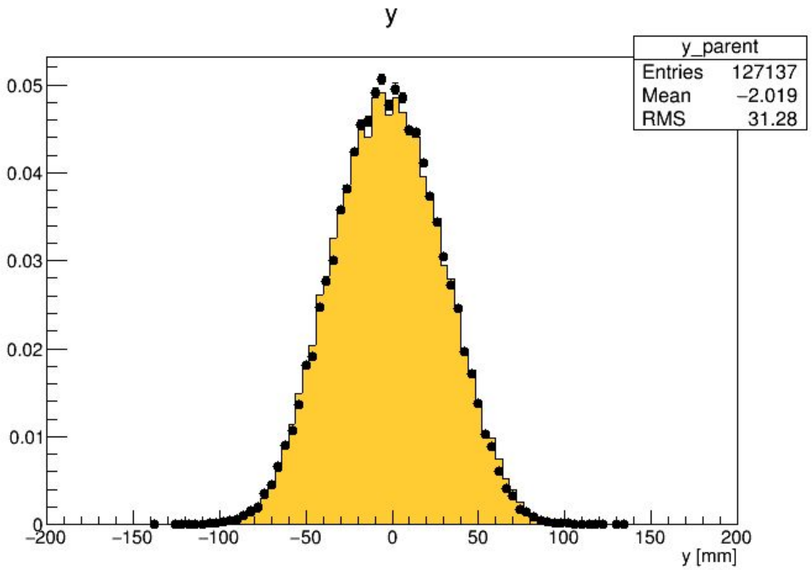


Downstream

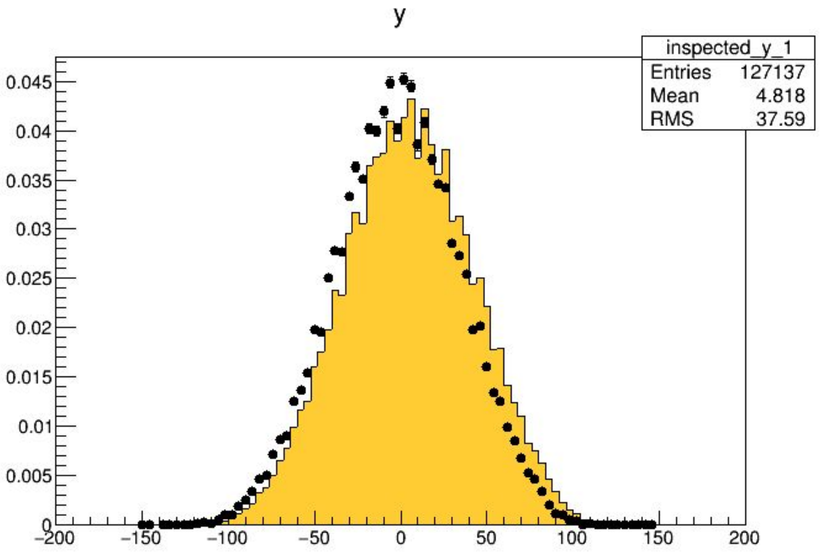


Beam Position: Y

Upstream

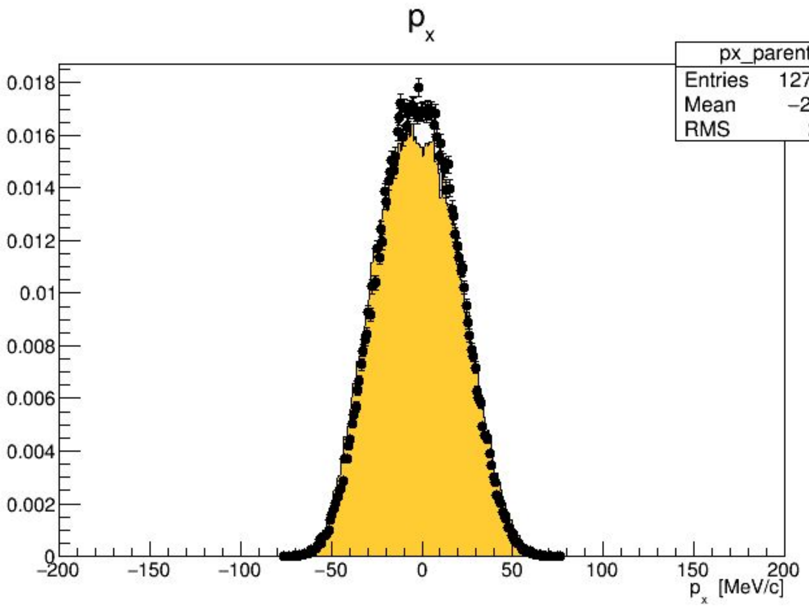


Downstream

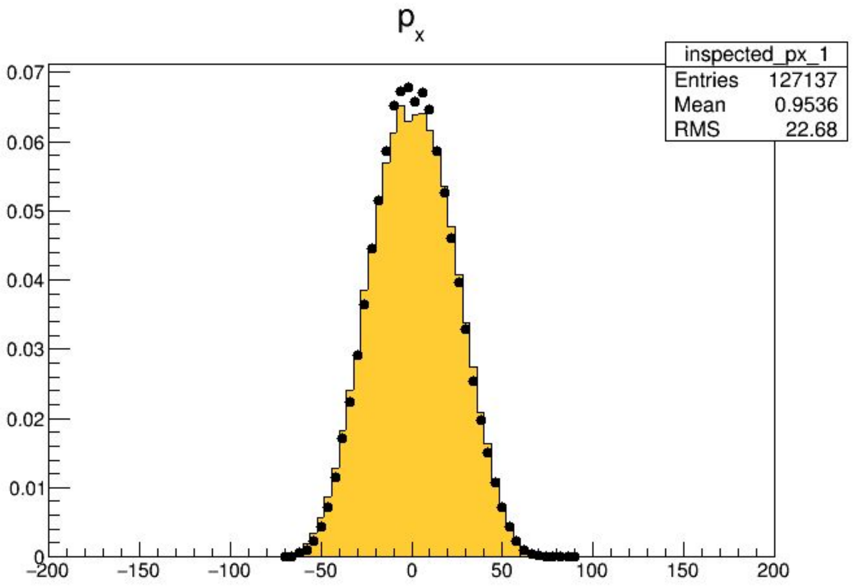


Beam Momentum: P_x

Upstream

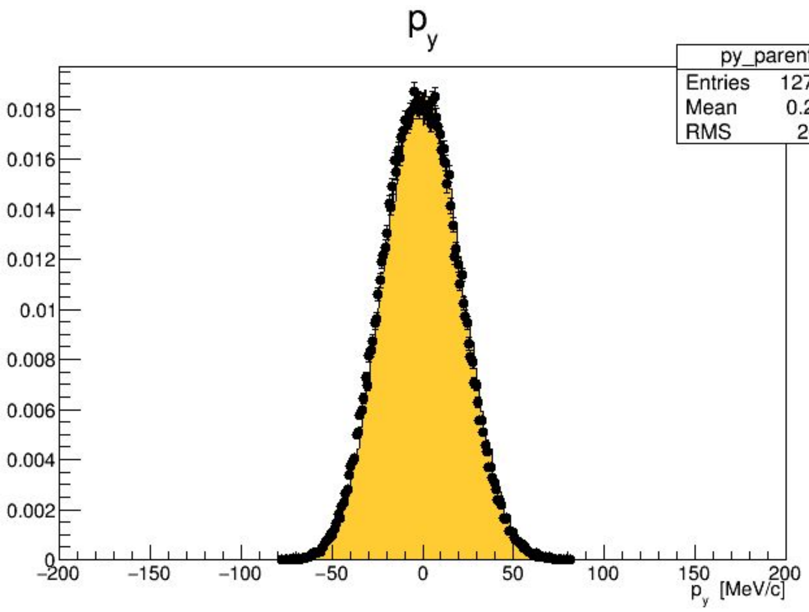


Downstream

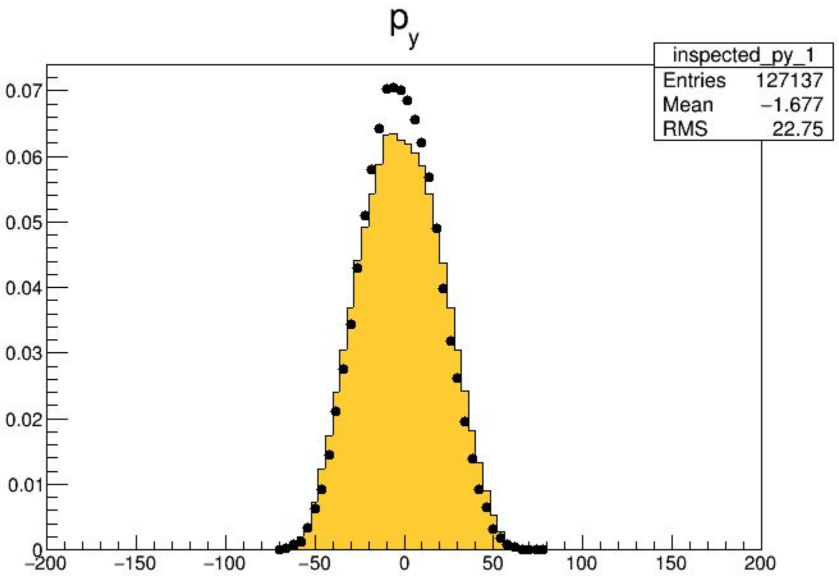


Beam Momentum: P_y

Upstream



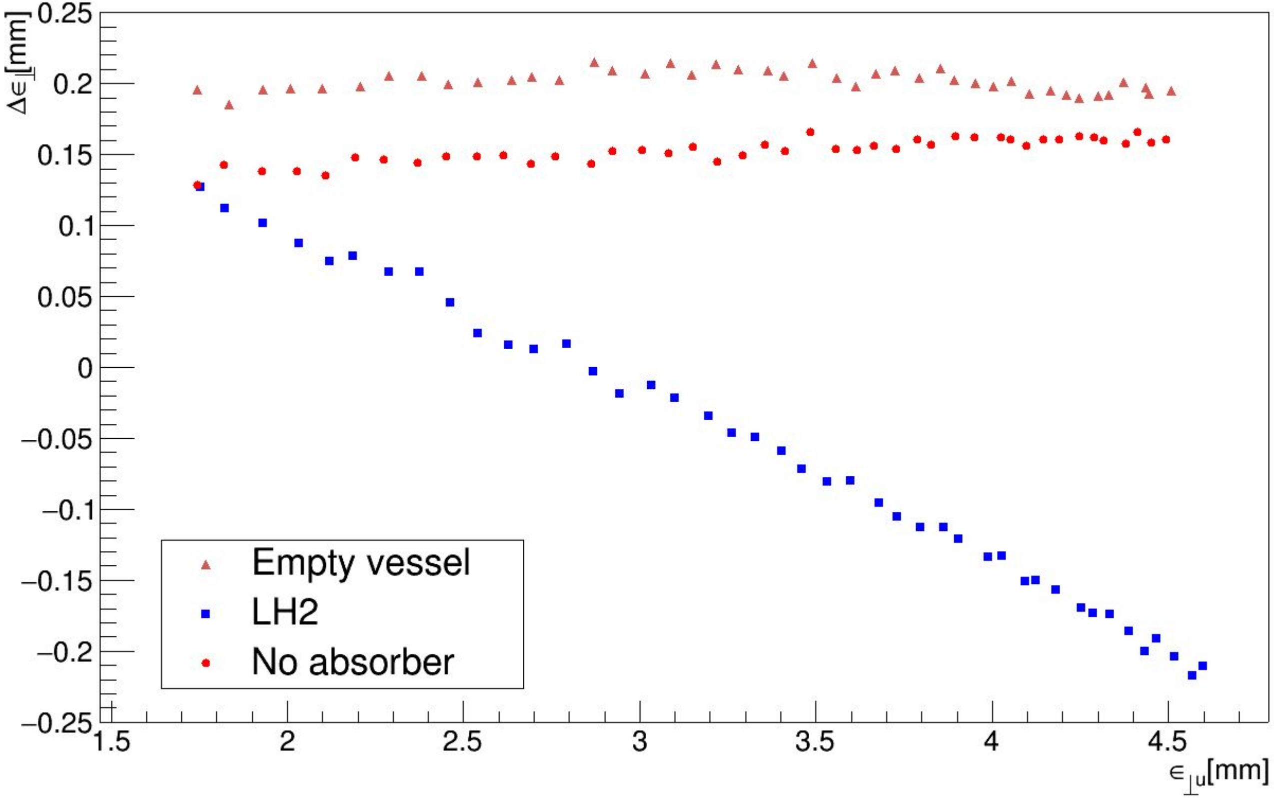
Downstream



Emittance change (Data)

More heating observed than in the *No absorber* case due to scattering from the vessel windows.

Heating ~ constant with respect to the emittance of the incoming beam. Possible reduction in heating at higher emittances, as the cooling effect due to the windows increases.



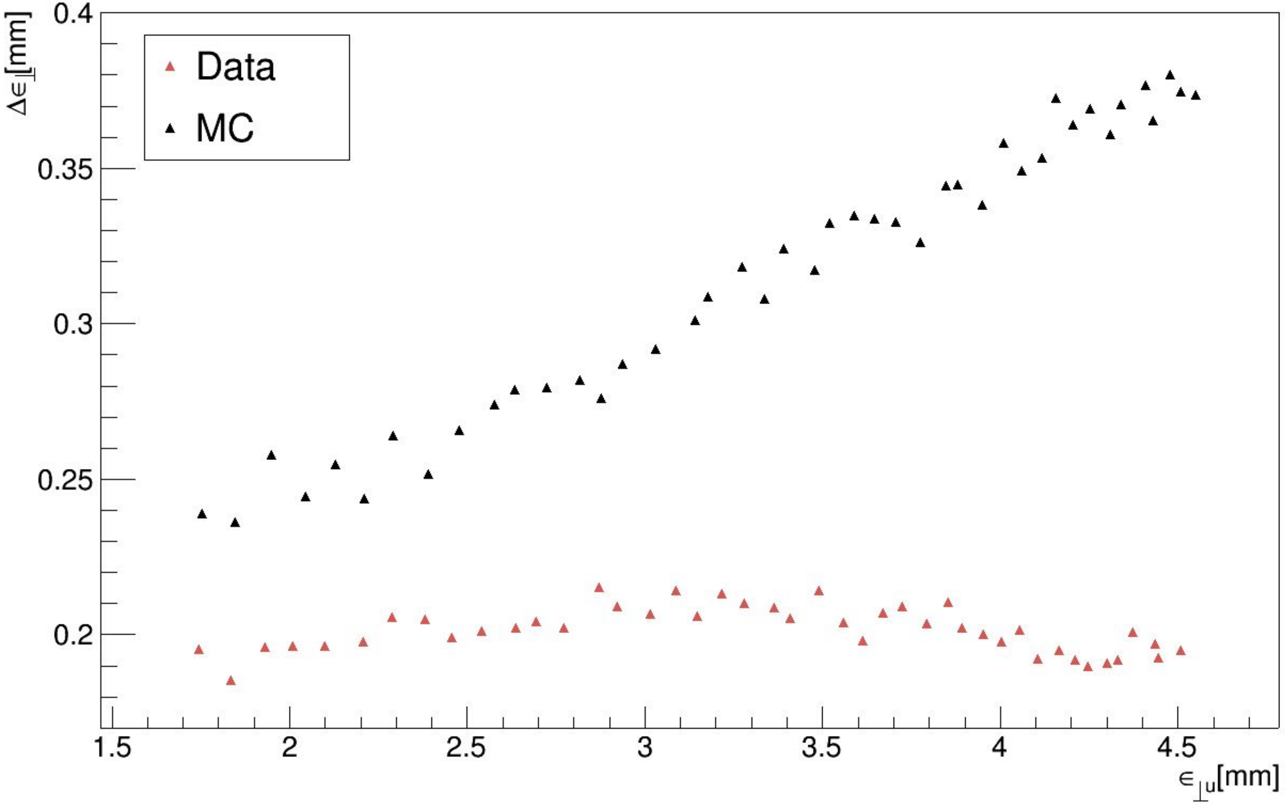
Empty vessel - Data vs MC

Similar discrepancy as in the *No Absorber* case: significantly more cooling in MC; cooling correlated with upstream emittance.

Could occur due to different optics.

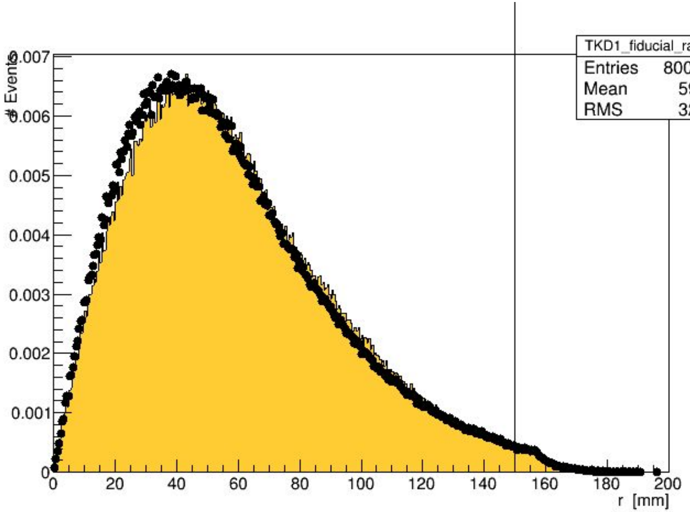
Significant tails in (x,y) sub-space observed downstream.

To be investigated

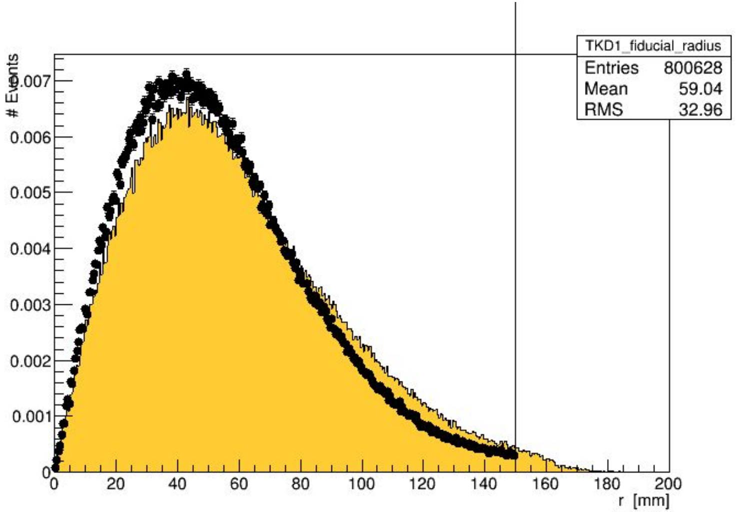


TKD fiducial cut

No momentum cut applied on data



With momentum cut applied

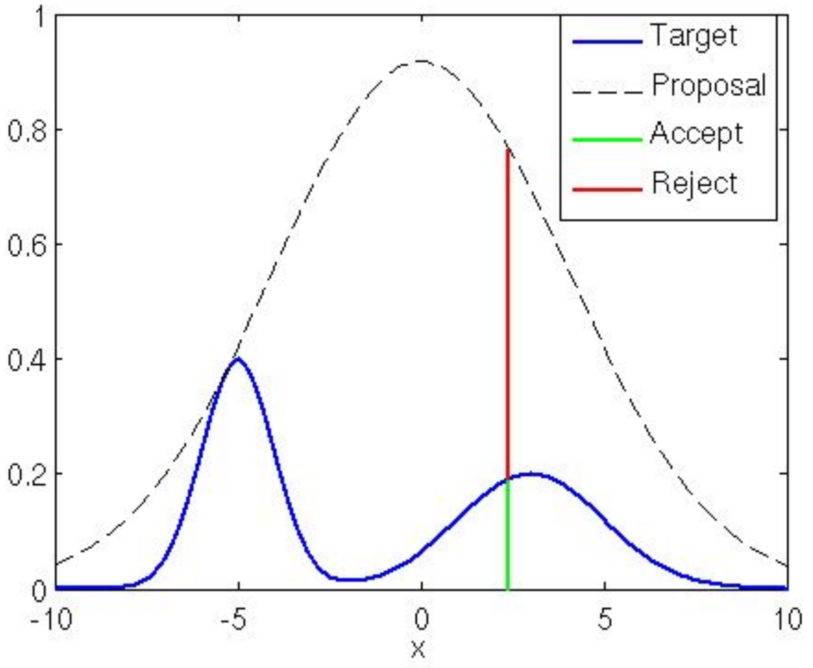


LHS: Bug in data cut (no 135 -145 MeV momentum cut applied). Cut applied on MC.

RHS: Bug fixed. Momentum cut applied to both data and MC. However, worse agreement. More particles at larger radius seen in MC.

Rejection Sampling

- $P_{selection}(x) = Norm * Target(x) / Parent(x)$
- Draw *u* from *U[0,1]*. If $u < P_{selection}(x)$ then accept event. Otherwise reject it.
- Normalisation calculation:
  - for a large number of times randomly draw a sample *x* from the target distribution and take the minimum of *Parent (x) / Target (x)*
  - **OR** draw samples from the parent beam and take the minimum of *Parent (x) / Target (x)*
  - Normalisation ensures that $P_{selection}(x) <= 1$
  - **# of particles in the daugher beam ~ Norm**



Event likelihood

Draw an particle from the parent distribution.

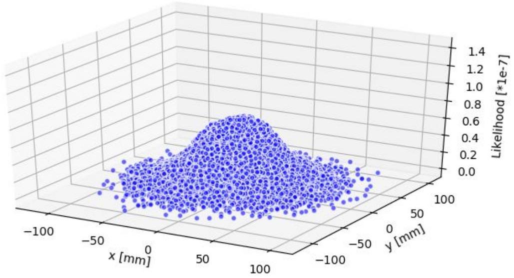
Calculate its likelihood of being sampled from the parent (KDE) and target (analytical 4D Gaussian) PDFs.

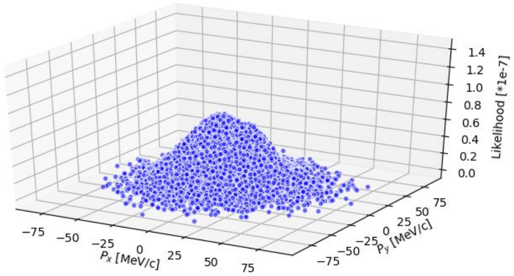
Here, likelihoods projected on the (x,y) and (p_x, p_y) subspaces.

Beam parameters:

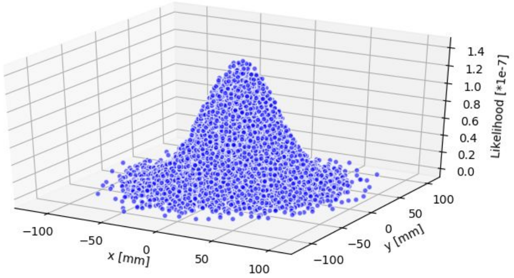
- Parent: [ϵ=4.85 mm, β = 282 mm, α = 0.36, L = 1.1]
- Target: [ϵ=4 mm, β = 310 mm, α = 0, L = 1.1]

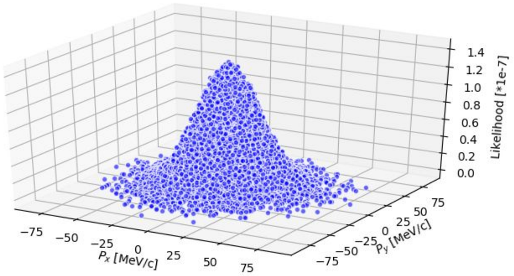
Parent (KDE)





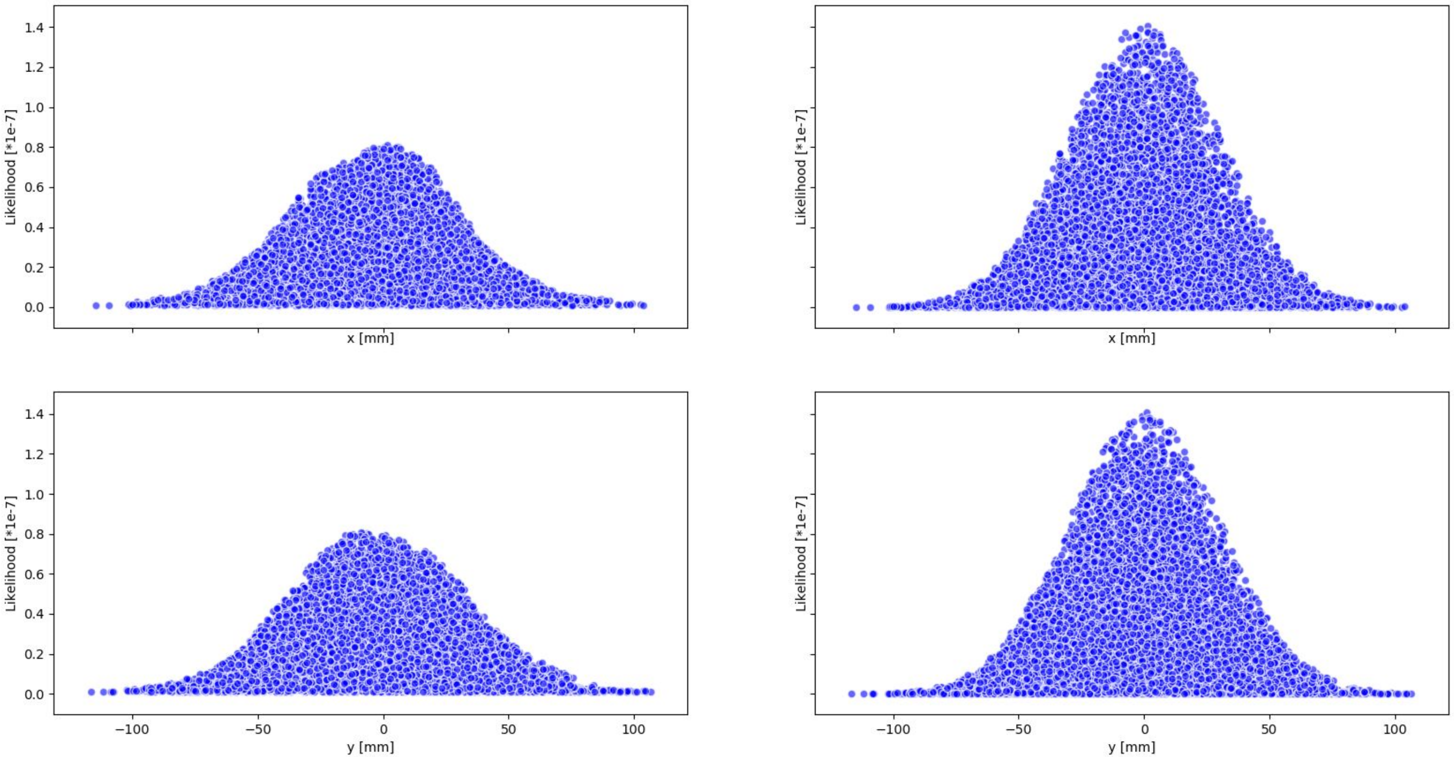
Target (4D Gaussian)





Event likelihood: 1D projections (position space)

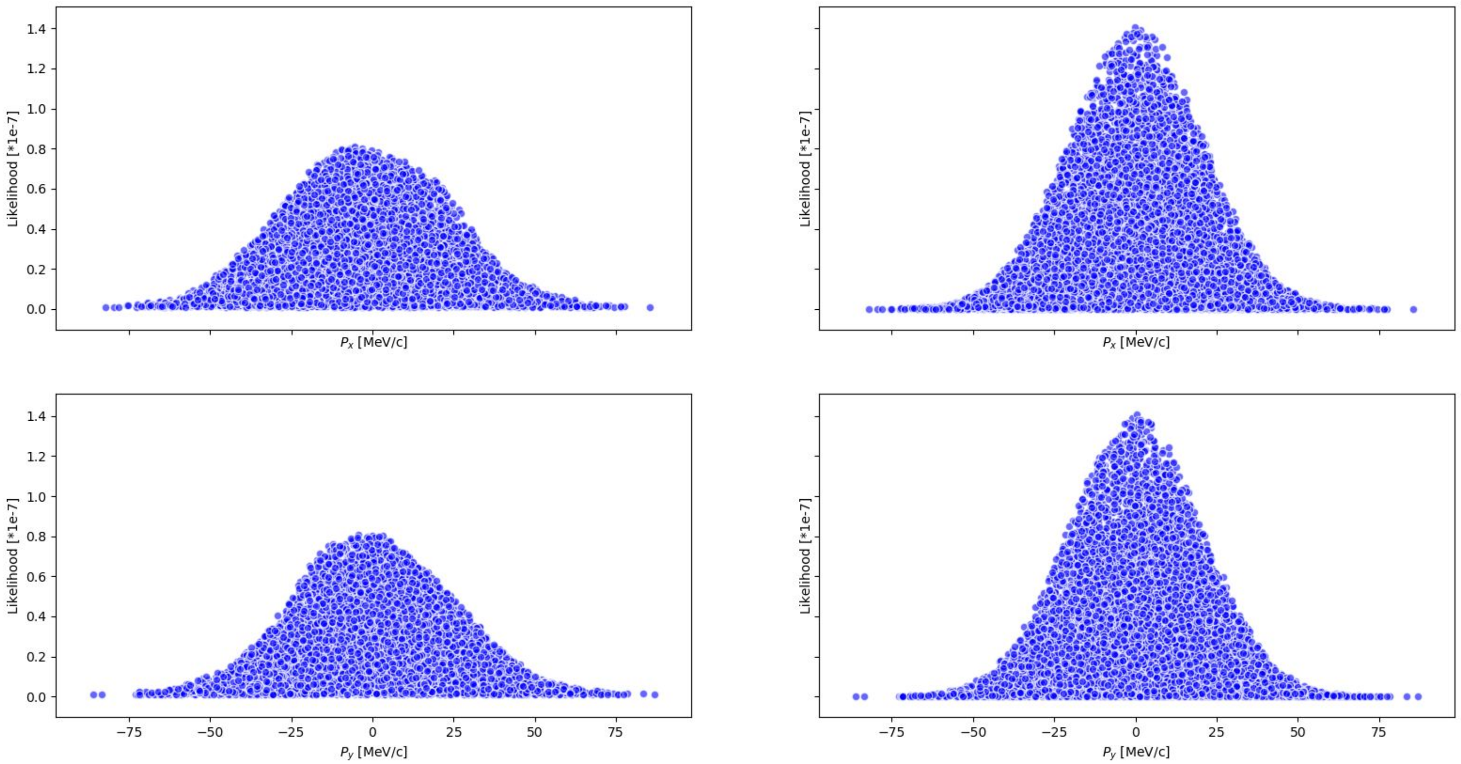
Parent (KDE) | Target (4D Gaussian)



Event likelihood: 1D projections (momentum space)

Parent (KDE)

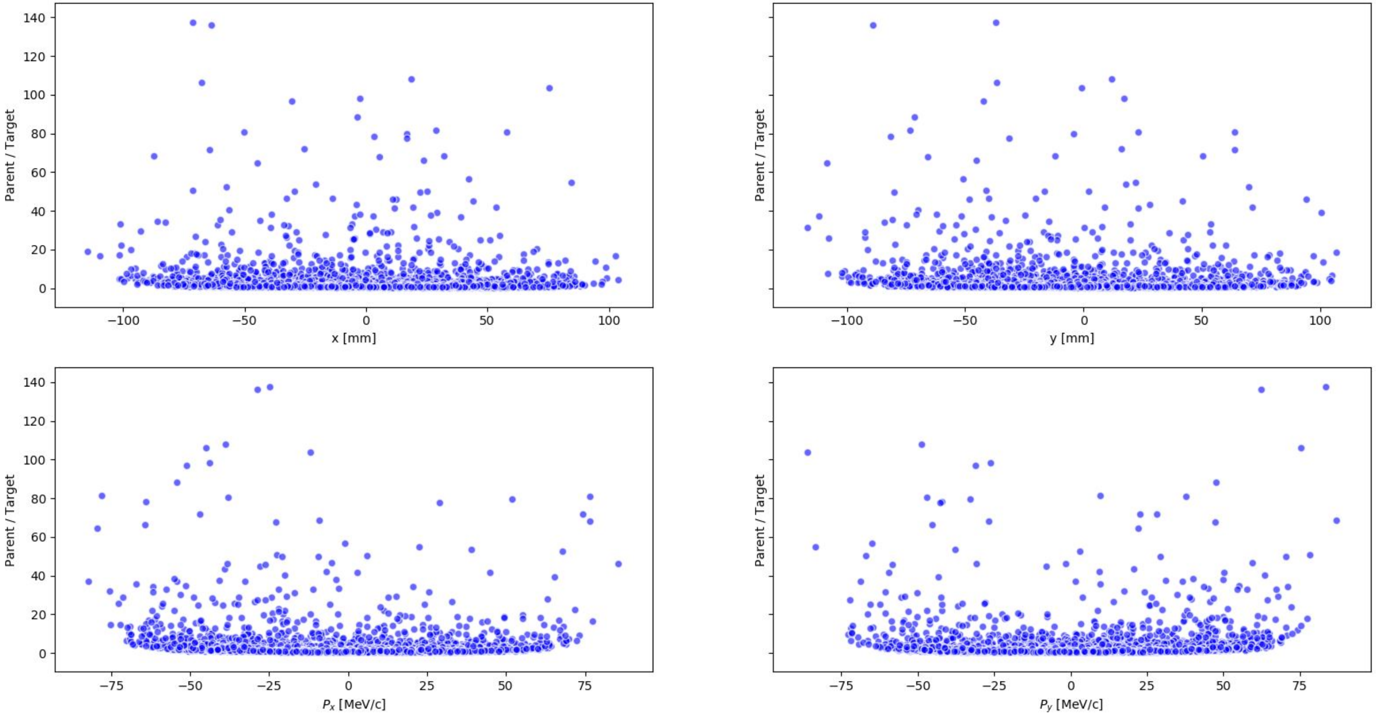
Target (4D Gaussian)



Parent (x) / Target (x)

Ratio of likelihoods projected on the 4D phase-space components.

Current procedure takes the normalisation as the minimum of these points.



Parent (x) / Target (x) (zoomed in)

The higher likelihood of particles coming from the target distribution leads to N < 1. In this case N ~ 0.5.

Tails seem not to impact the N estimation.

Seek to change N estimation method such that more particles are accepted into the daughter beam, without impacting the selection performance.