EIC Crossing Angle: Crab Cavities and FF Detectors

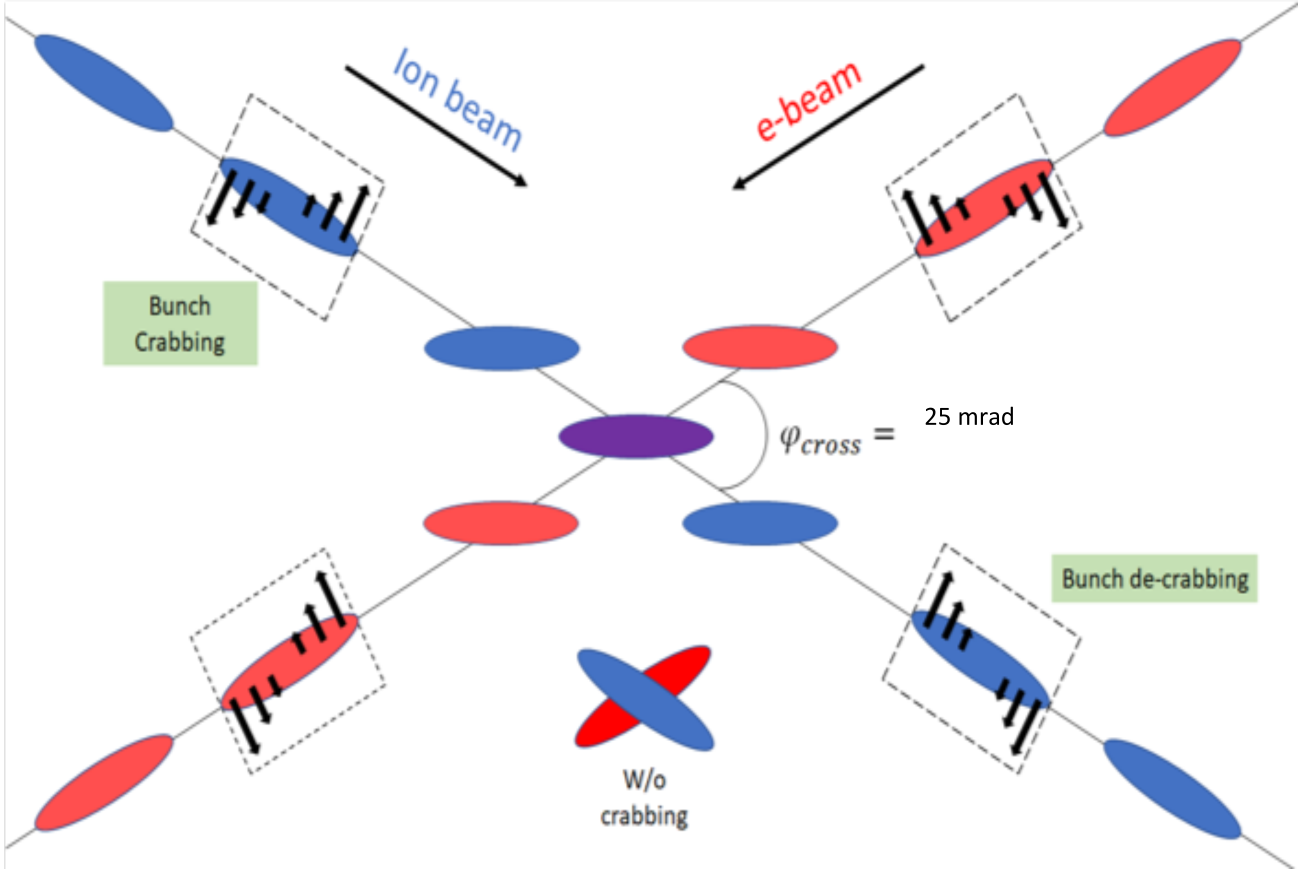
Alex Jentsch

Yellow Report DWG+PWG Joint Meeting

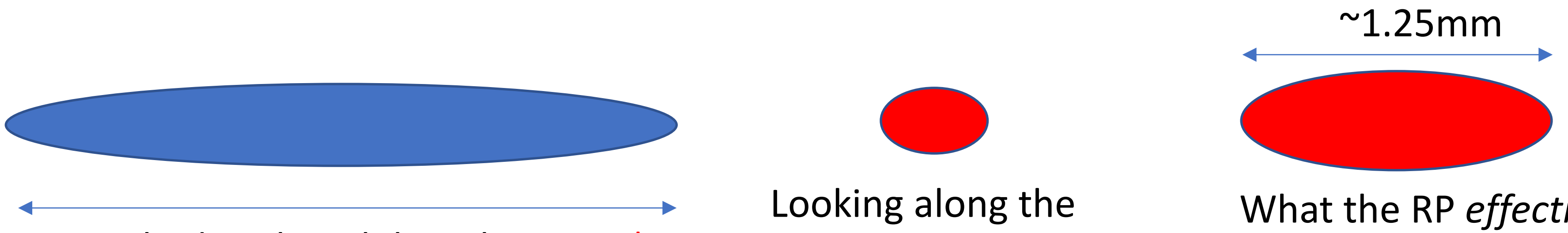
10/21/2020

What do crab cavities do?

- Crab cavity rotation
  - Can perform rotations of the beam bunches in 2D.
  - Used to account for the luminosity drop due to the crossing angle – allows for head-on collisions to still take place.
  - The rotation induces effective vertex smearing.



Crab Cavity Induced Vertex Smearing (25 mrad)



RMS hadron bunch length ~10cm*.
*based on "ultimate" machine performance.

Looking along the beam with no crabbing.

What the RP *effectively* see.

- Because of the rotation, the Roman Pots+other FF detectors effectively see the bunch crossing **smeared in x**.
- Vertex smearing = 12.5mrad (half the crossing angle) * 10cm = **1.25 mm**
- If the effective vertex smearing was **for a 1cm bunch**, we would have **0.125mm** vertex smearing.

> - **For a 25mrad crossing angle – the crab smearing is the second largest smearing effect (behind angular divergence).**
> - **The contribution is about half as large compared to angular divergence at top energy.**

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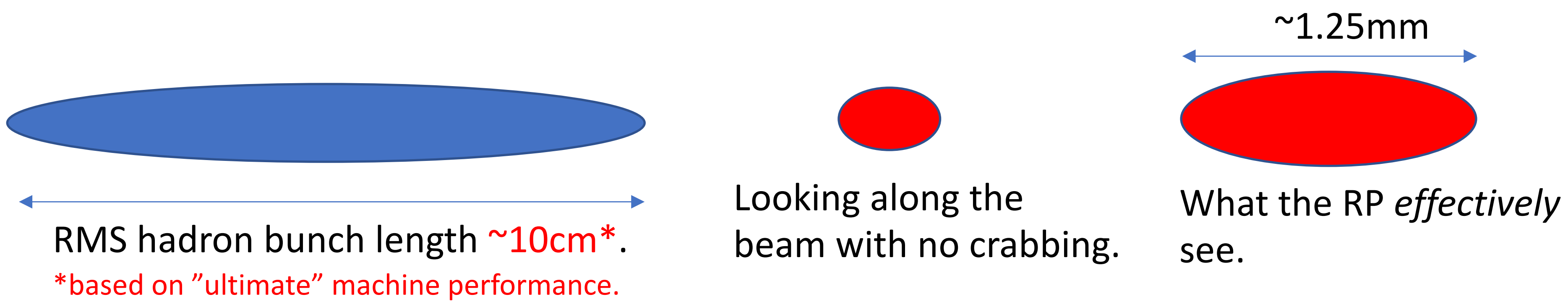

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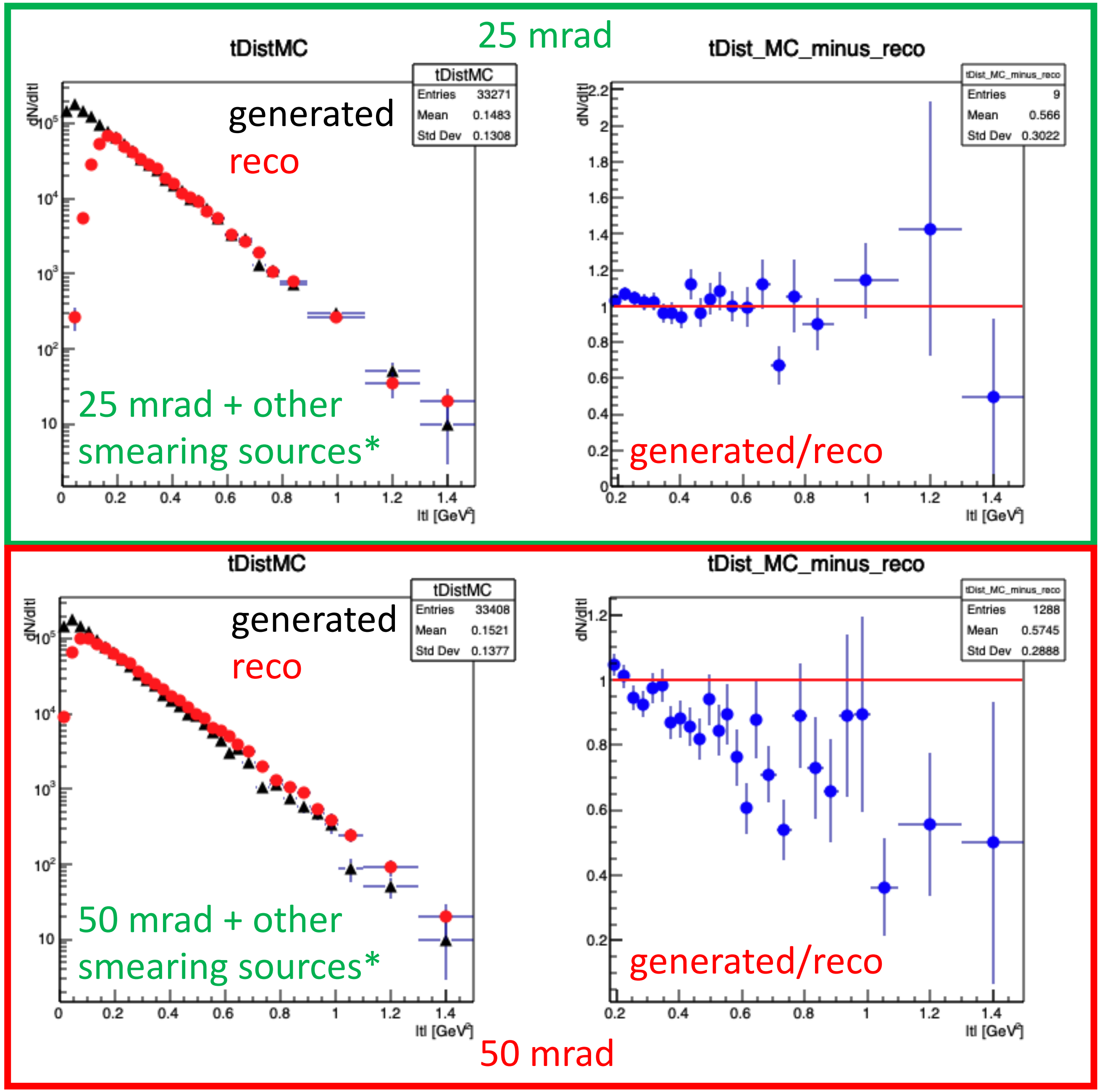
> - **Reducing the effective vertex smearing to that of an effective 1cm bunch length reduces this smearing contribution to a negligible amount.**
> - **This can be achieved with timing of ~ 35ps (1cm/speed of light), with 70ps still being okay to reduce the effect to much less than the angular divergence contribution.**
>   - **Allows us to pinpoint the Z-coordinate in the bunch coordinate system (i.e. where the collision takes place within the bunch).**

What about 50 mrad?

- A larger crossing angle would increase the needed crab cavity rotation.
- As a result, it also doubles the effective vertex smearing.
- In this case, the crab cavity induced vertex smearing becomes dominant over the angular divergence.
- Without correction, the crab effect for 50mrad becomes the dominate smearing source.
  - Places a tighter constraint on the detector timing (i.e. would need the 35ps timing or better to reduce the smearing below that of the angular divergence).



*Angular divergence + detector smearing (i.e. pixel size)

Takeaways

- Crab cavity induced effective vertex smearing is correctable with fast timing.
- With a larger crossing angle, this requirement becomes more strict -> the contribution from the vertex smearing becomes the dominant source of smearing.