DEEP UNDERGROUND NEUTRINO EXPERIMENT

Stitching in Pandora

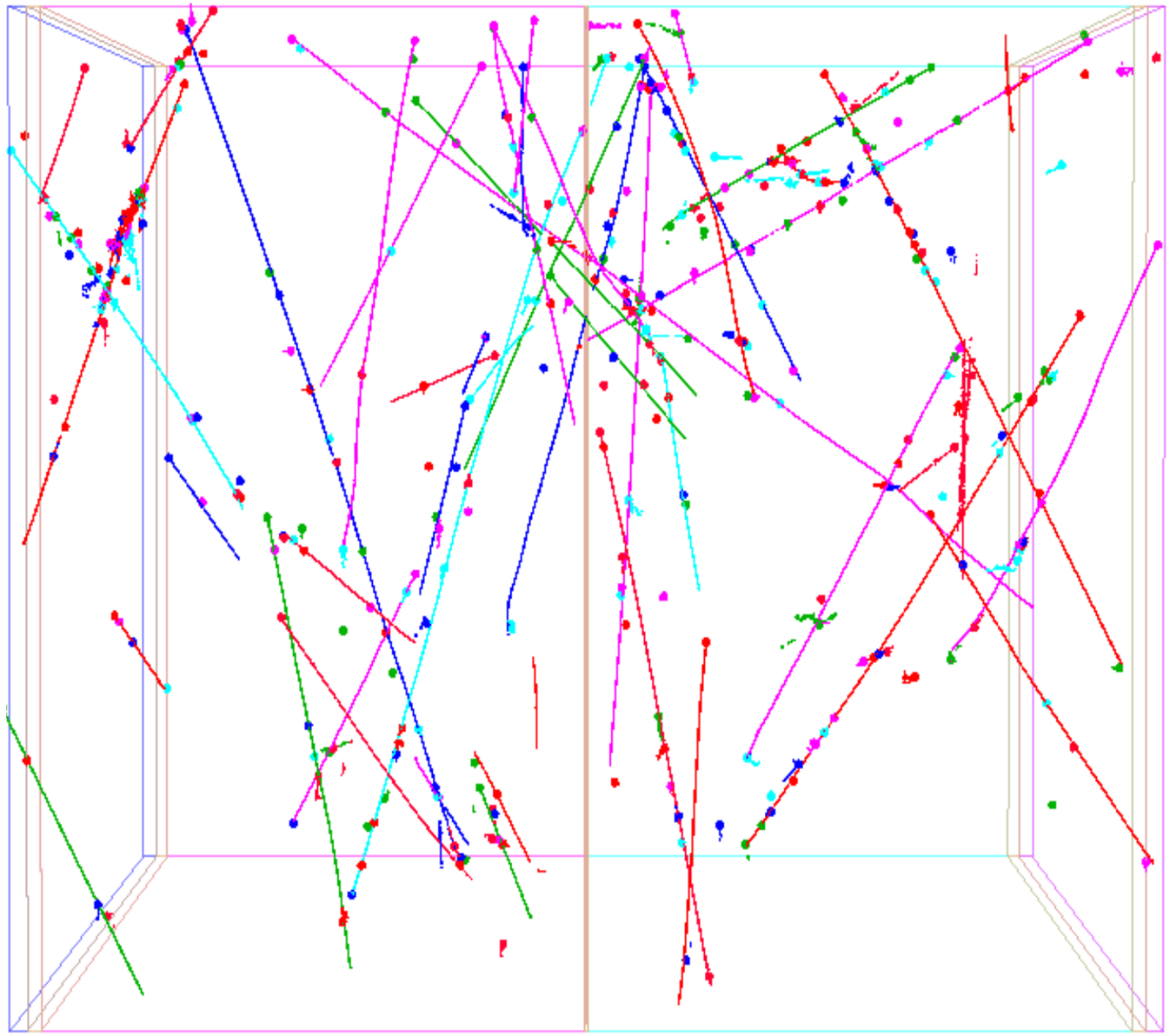
Steven Green on behalf of the Pandora team

7th March 2019

Stitching in Pandora

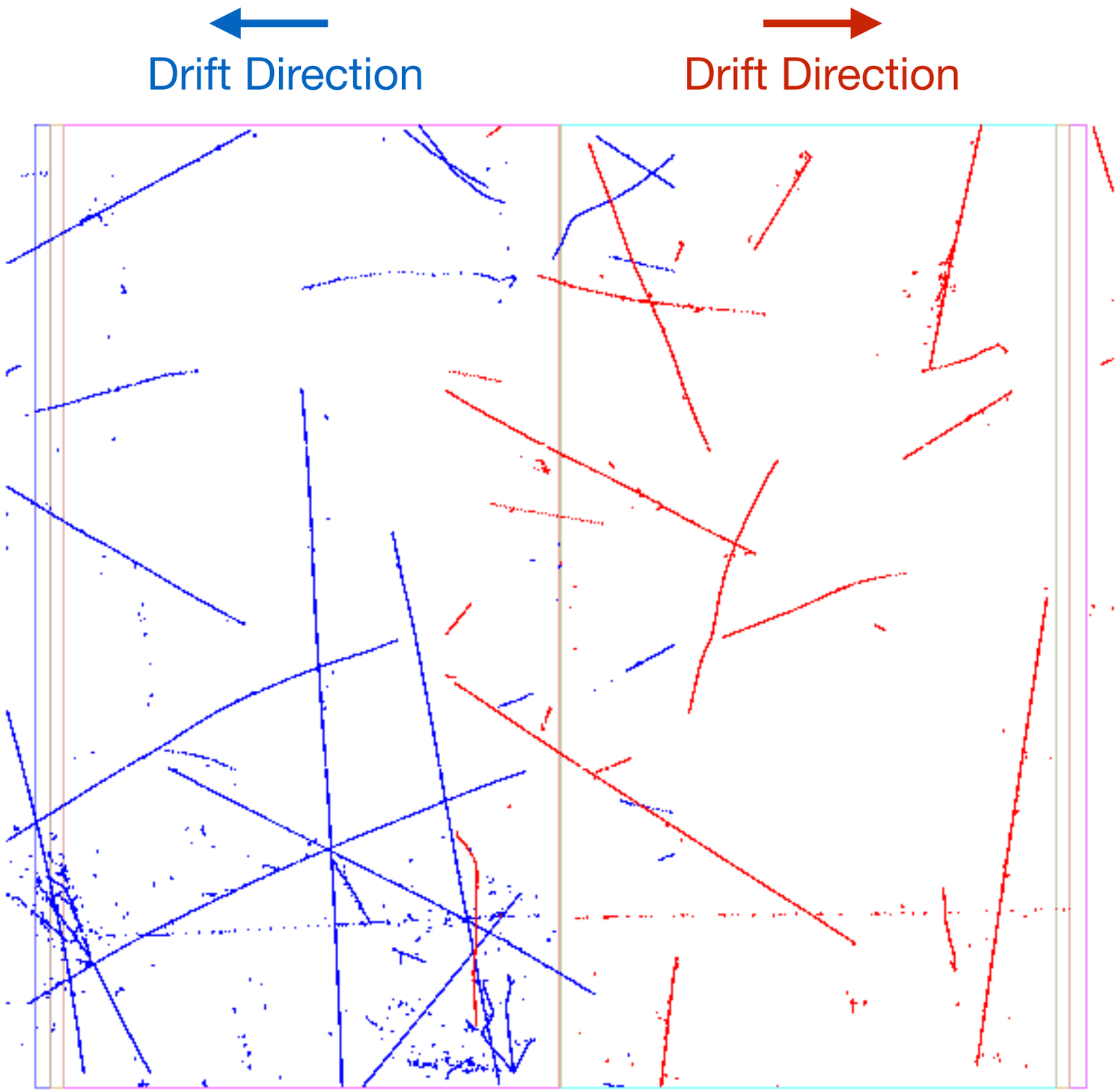
Aim:

- Give a brief overview of the stitching process in Pandora.



Example 3D Reconstruction Output From Run 5387, 1 GeV

Stitching in Pandora



W View

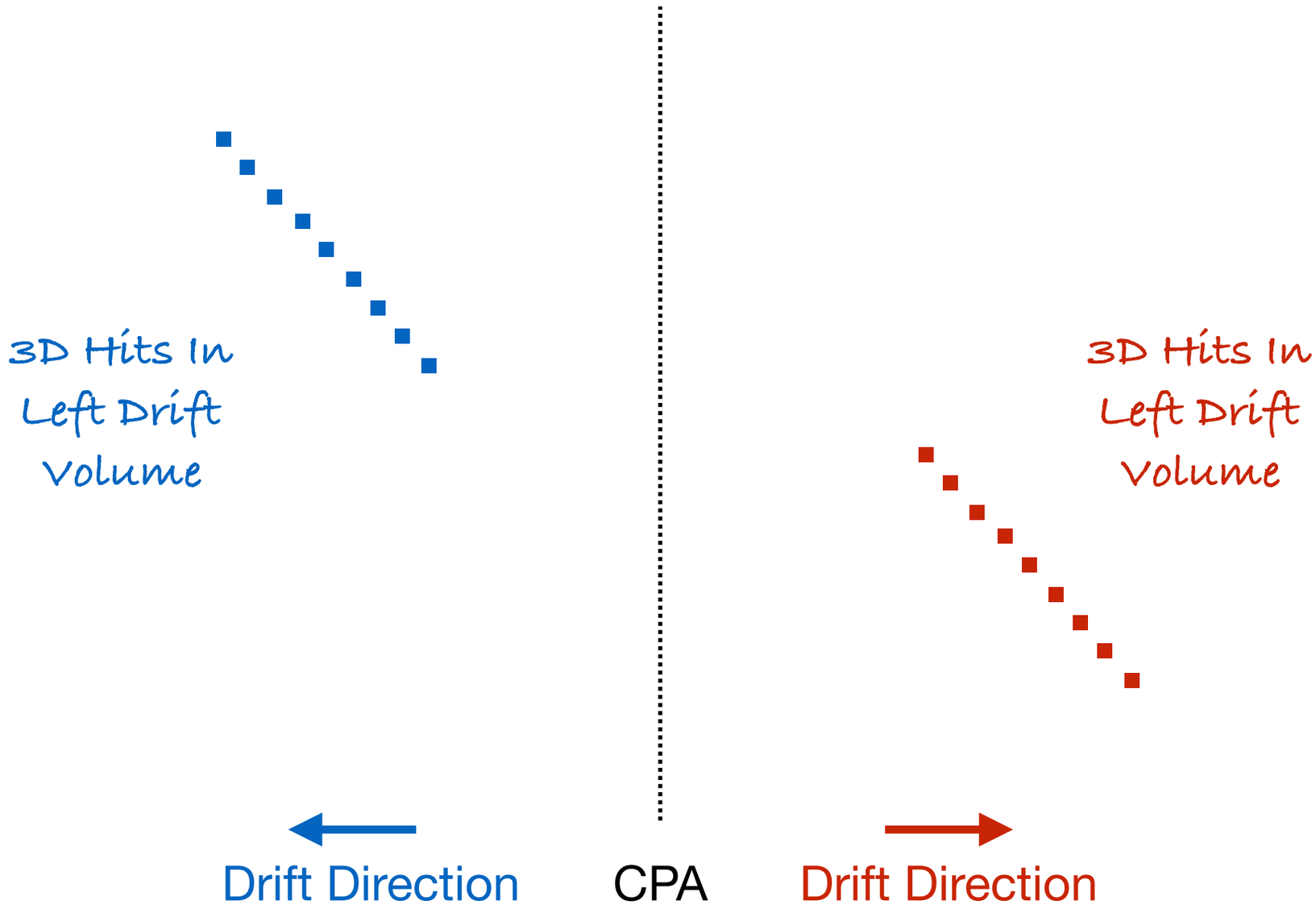
- To begin with Pandora reconstructs all hits from each drift volume independently.
- Then once each drift volume has been independently reconstructed, Pandora looks to stitch cosmic rays that cross the CPA, allowing us to tag clear cosmics.
- We can also tag across APAs using the same method, but can't tune the stitching for the cryostat side APAs yet.

Stitching in Pandora

Principle:

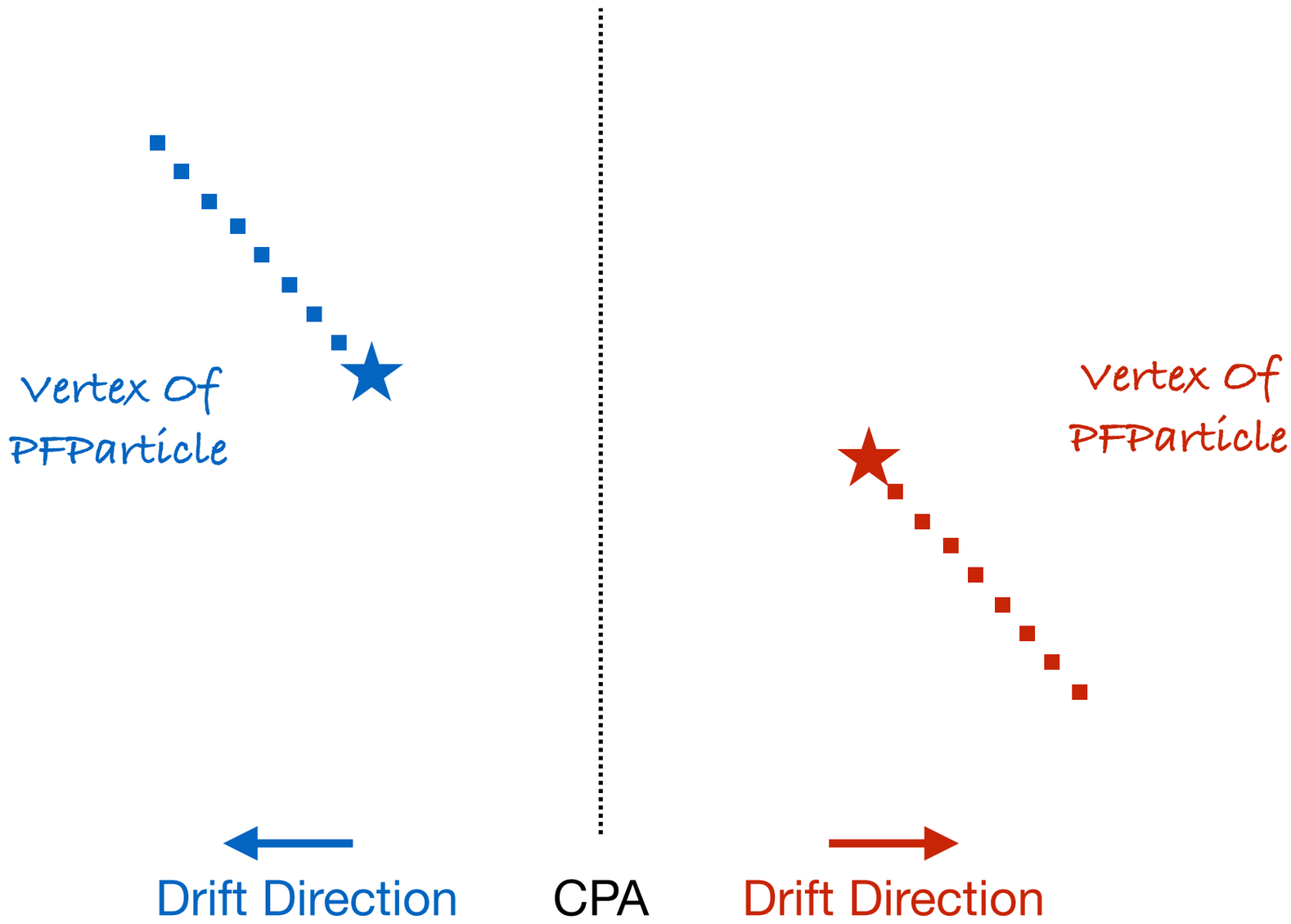
- Look at direction and position of interception of two reconstructed PFParticles in each drift volume and pair them up if they point at each other.

Cartoon example:

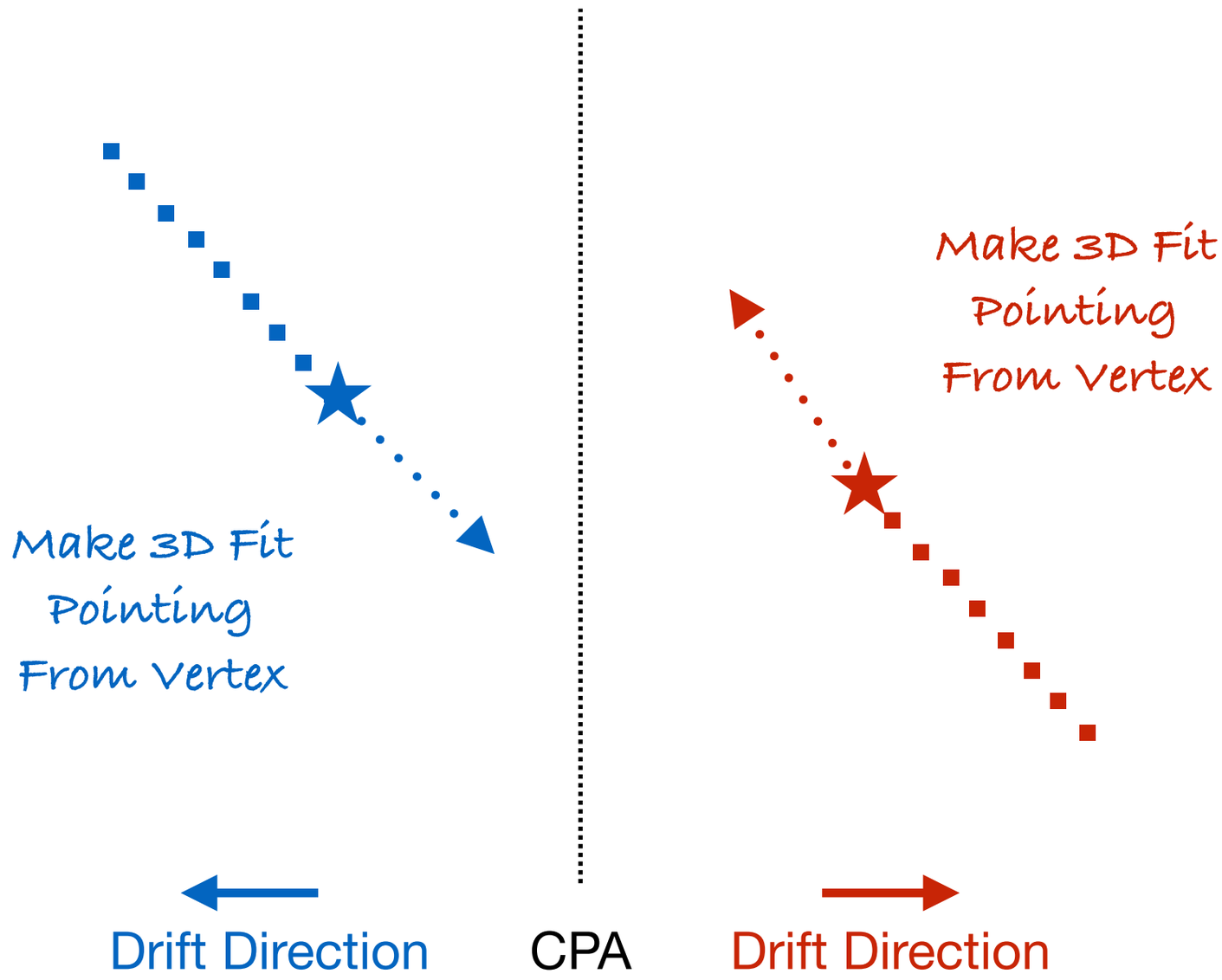


Stitching in Pandora

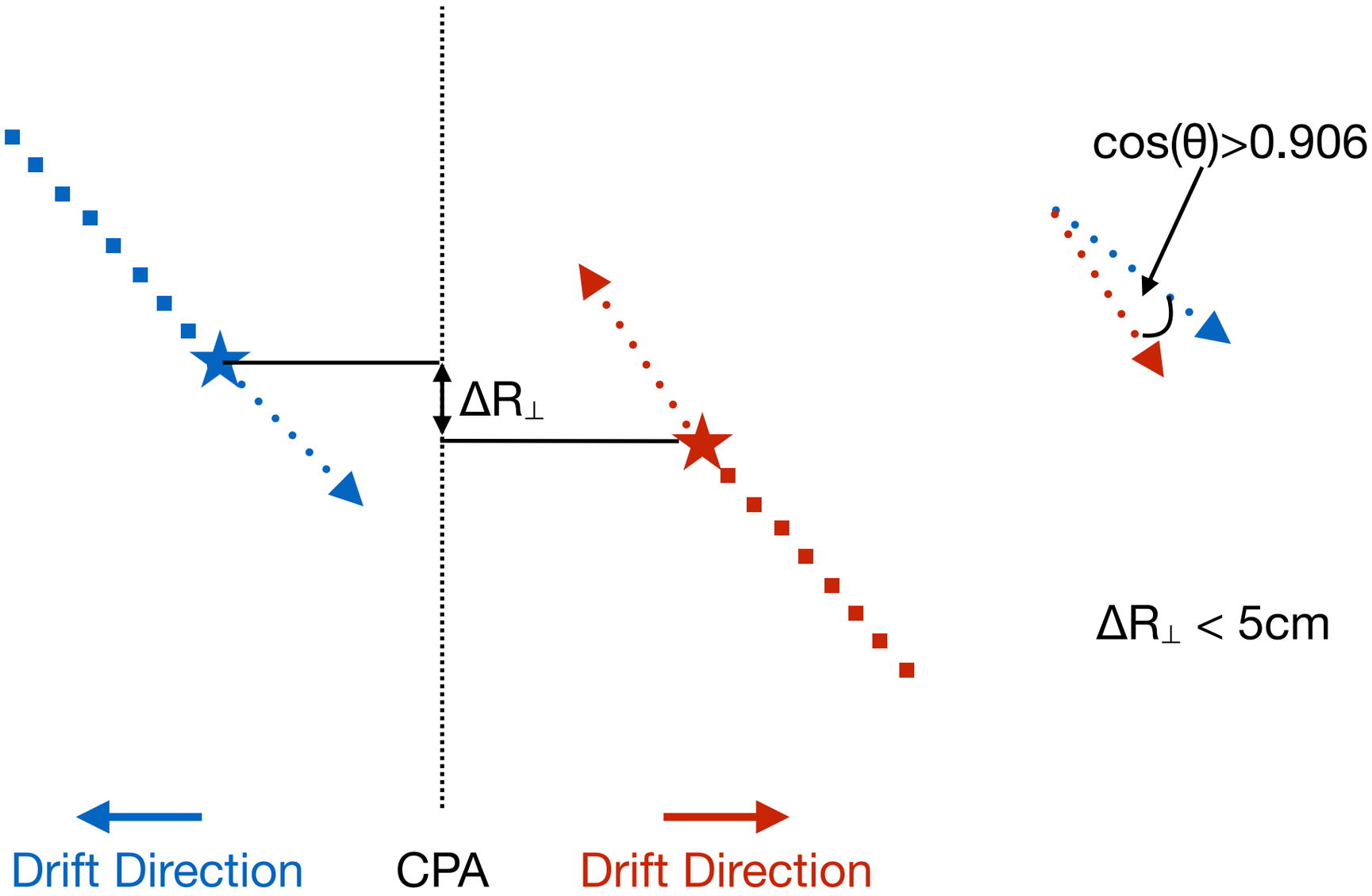
1) Find the vertices that would cross the CPA/APA when stitched



2) Perform local fit in 3D to give direction of tracks at these points

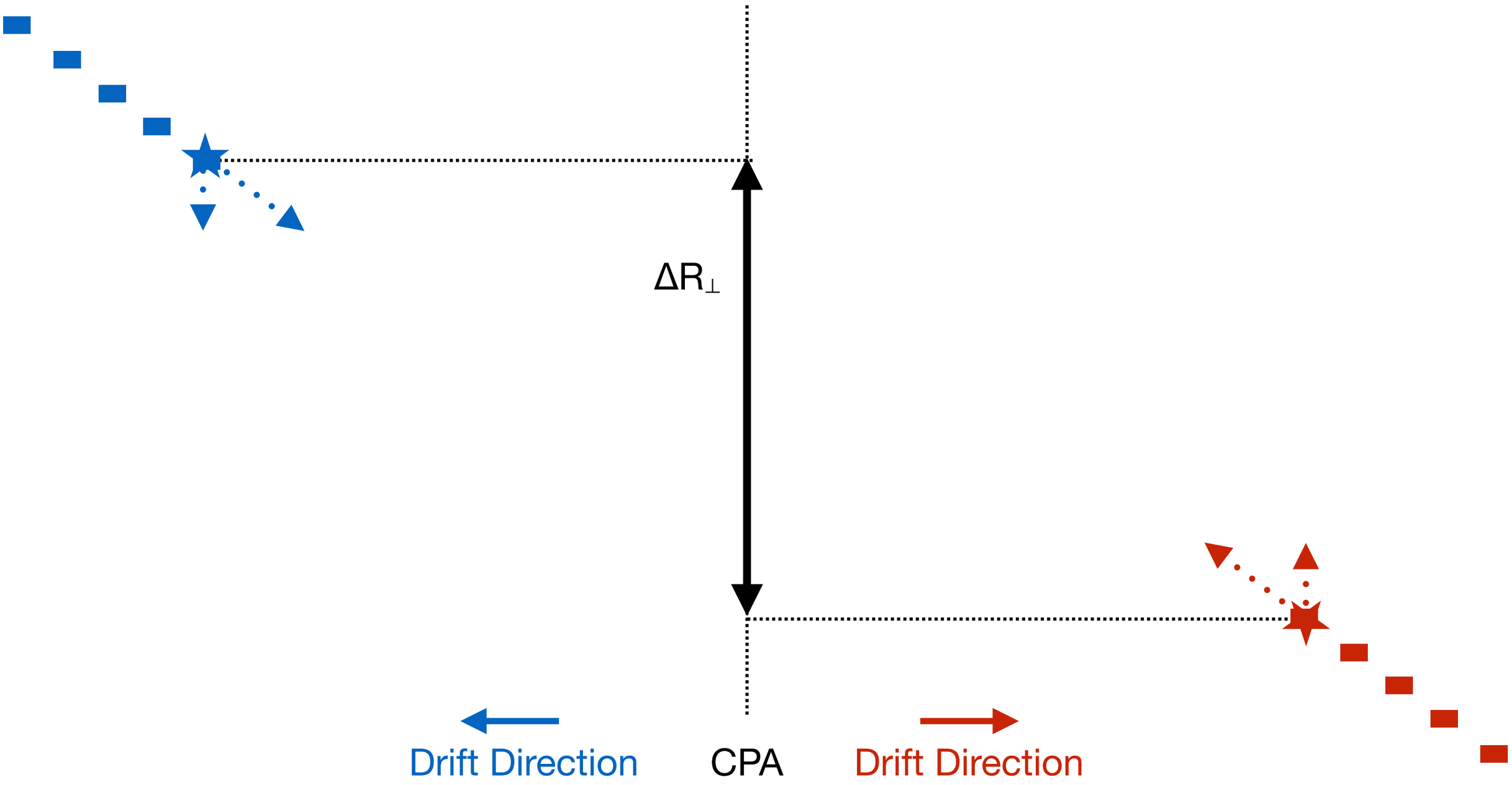


3) Compare the relative angle of the directions and the vertex offsets to see if the PFParticles should be matched.



Stitching in Pandora

4) Find X_0 by assuming the $\Delta R_\perp$ is due to the addition of vectors along the fit direction.



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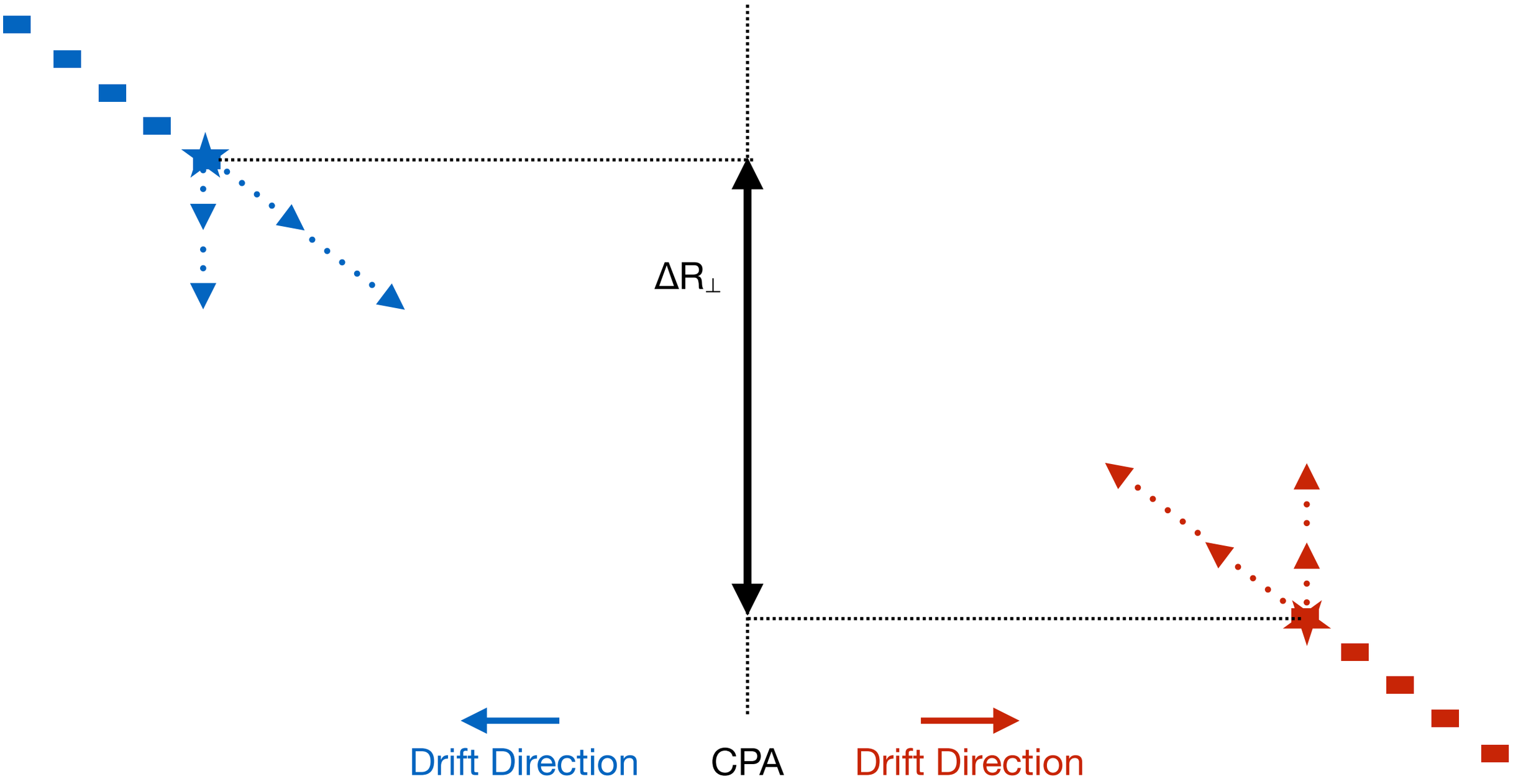

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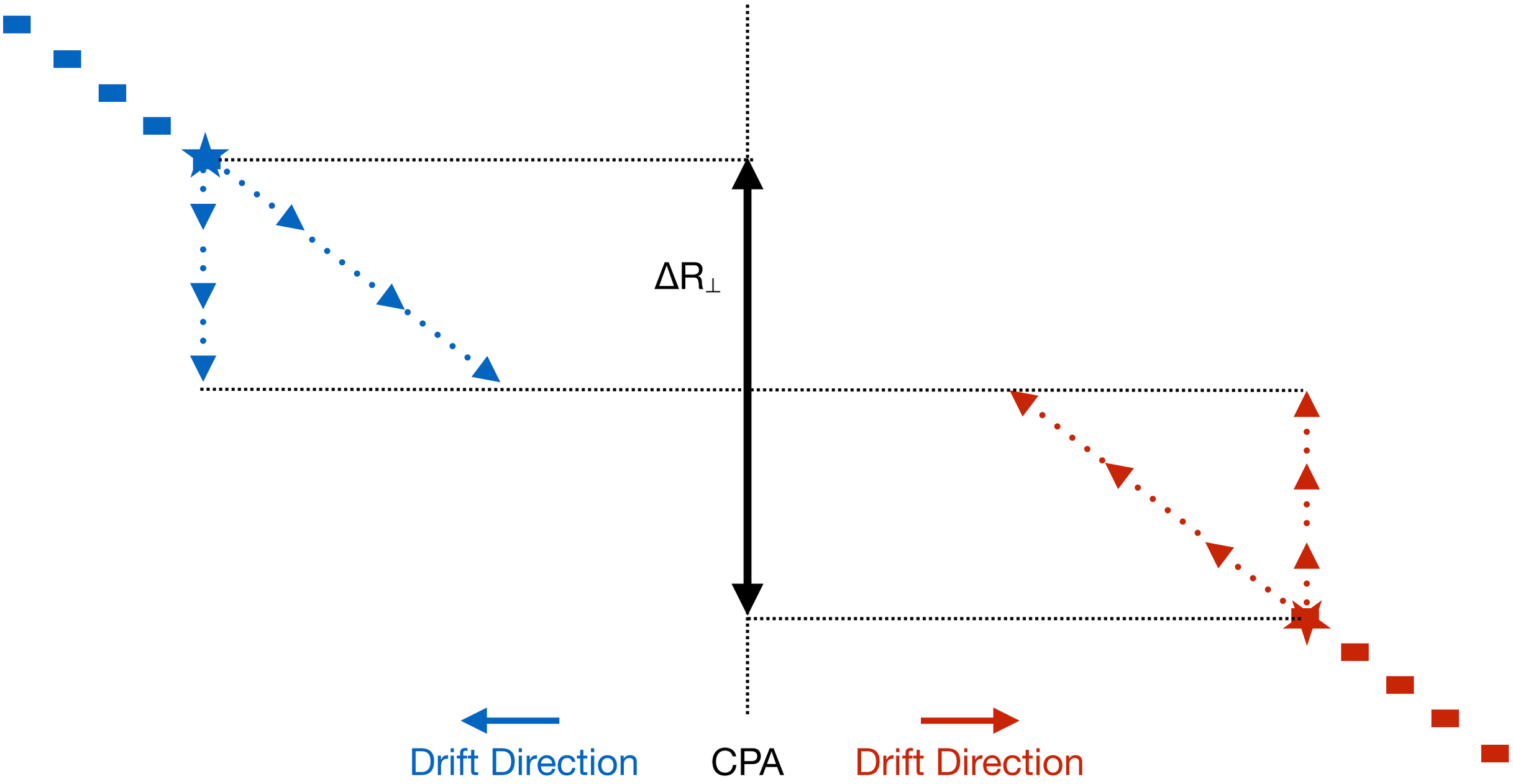

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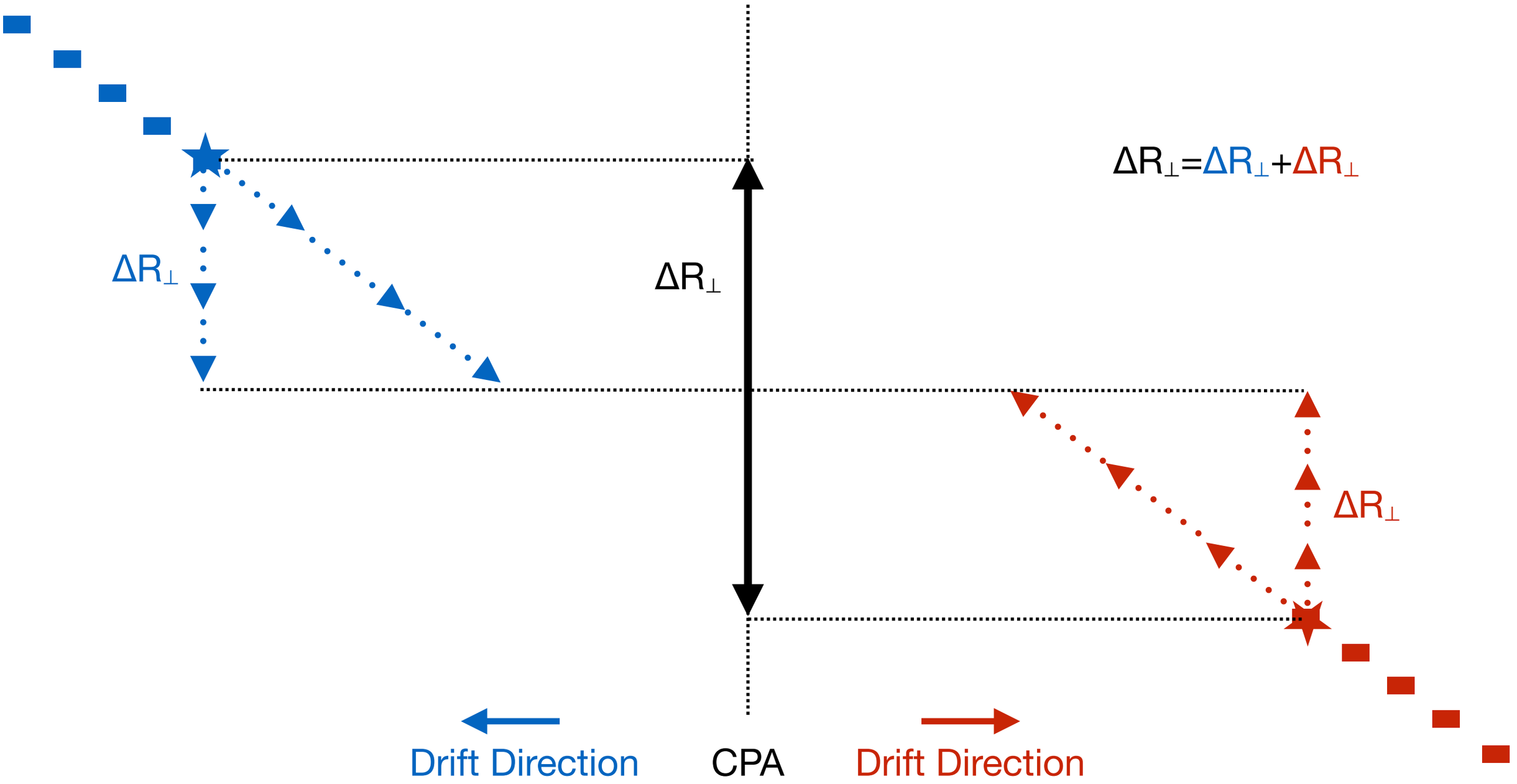
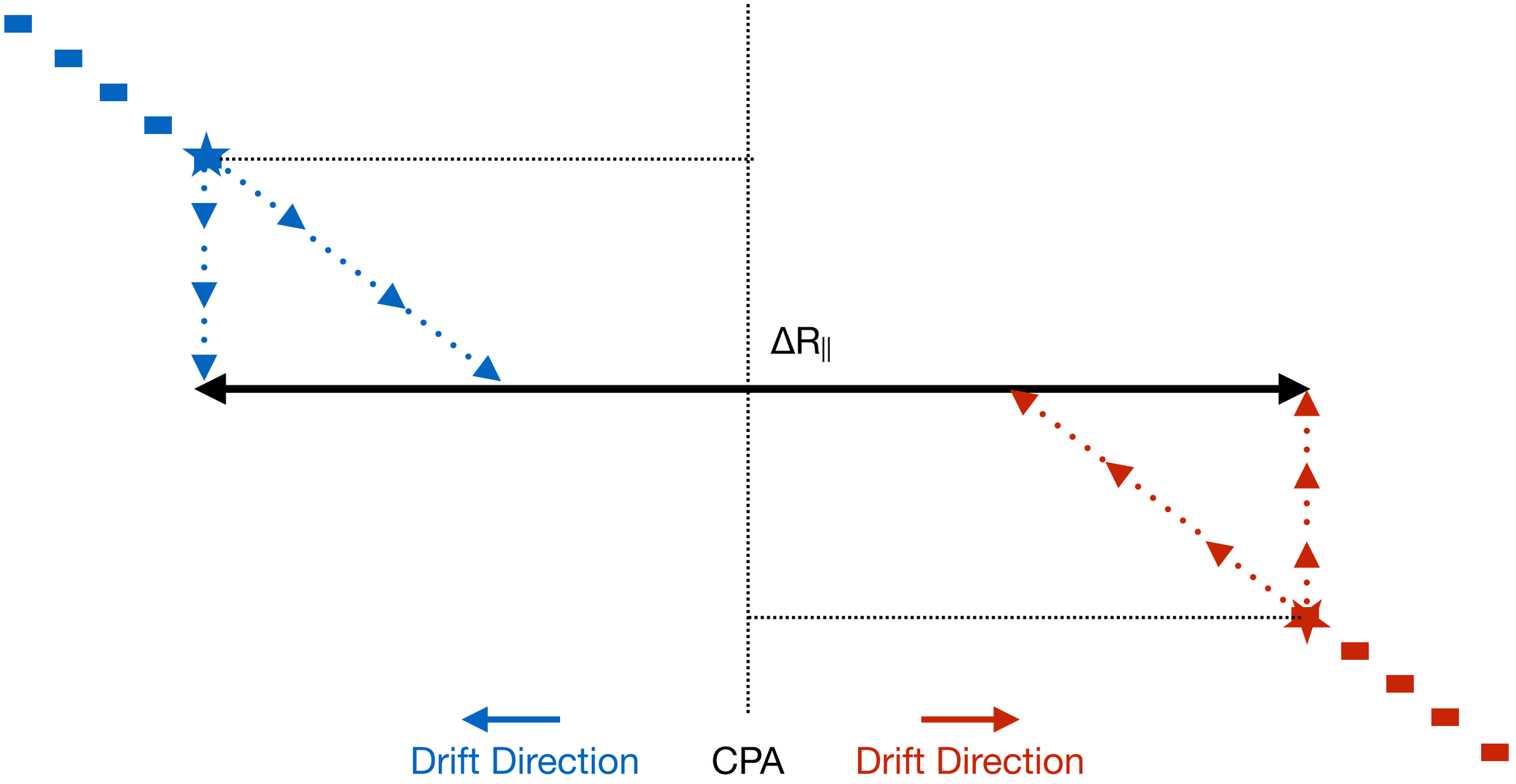


$$\Delta R_\perp = \Delta R_\perp + \Delta R_\perp$$

4) Find X_0 by assuming the $\Delta R_\perp$ is due to the addition of vectors along the fit direction.



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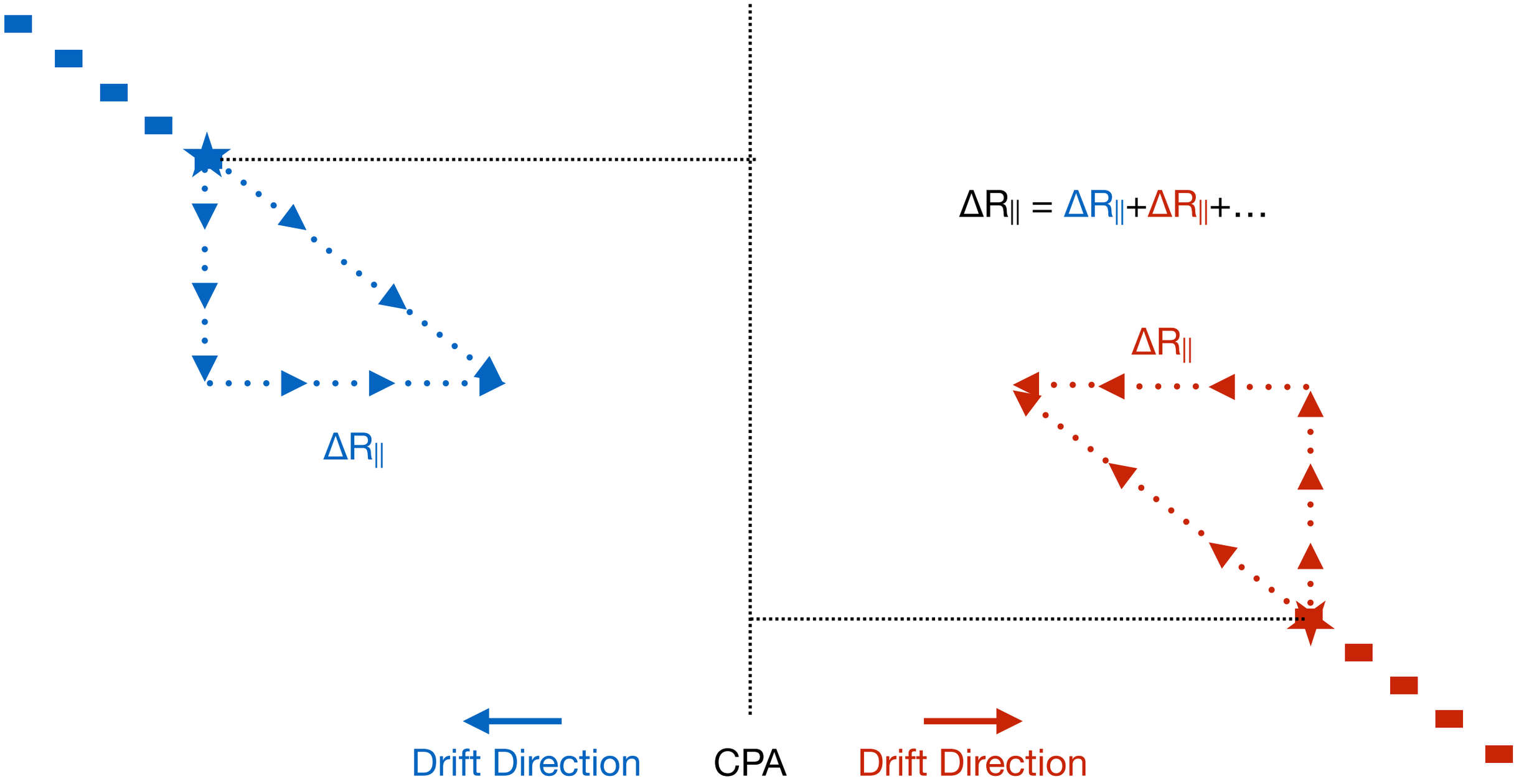

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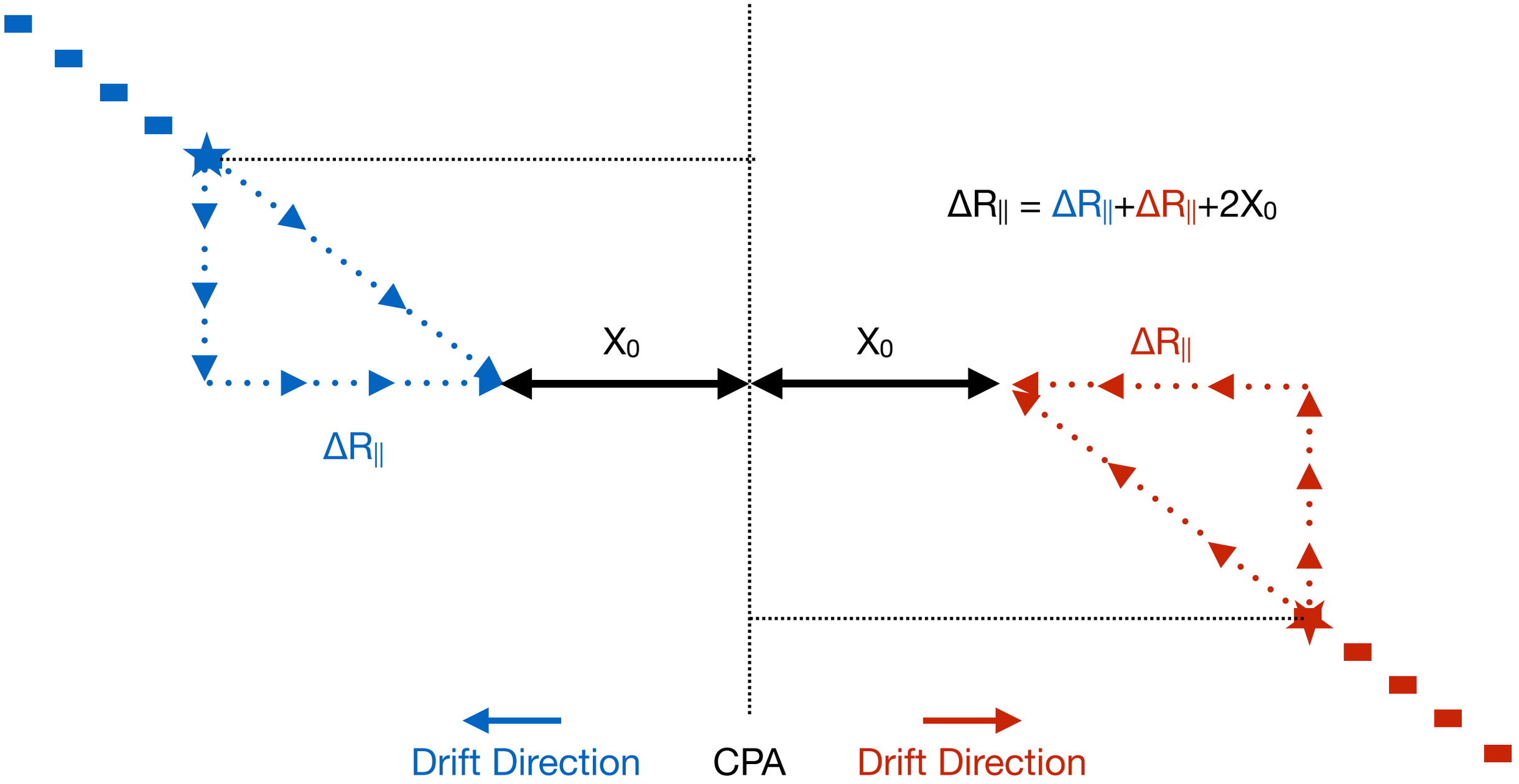
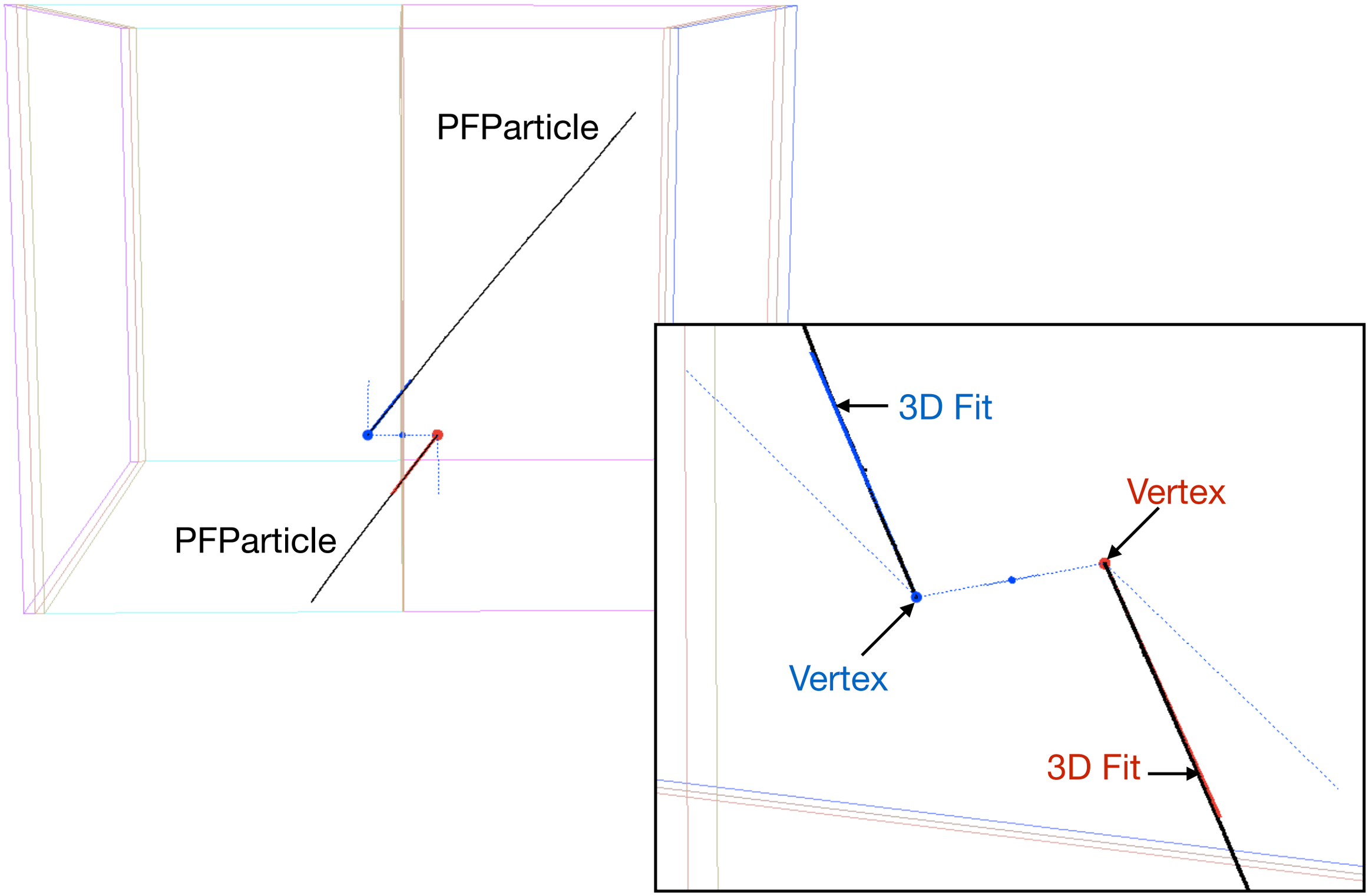


5) Convert the X_0 to a T_0. This is done using variables from the detector properties service and so no modifications are needed for different run settings if this service has been updated.

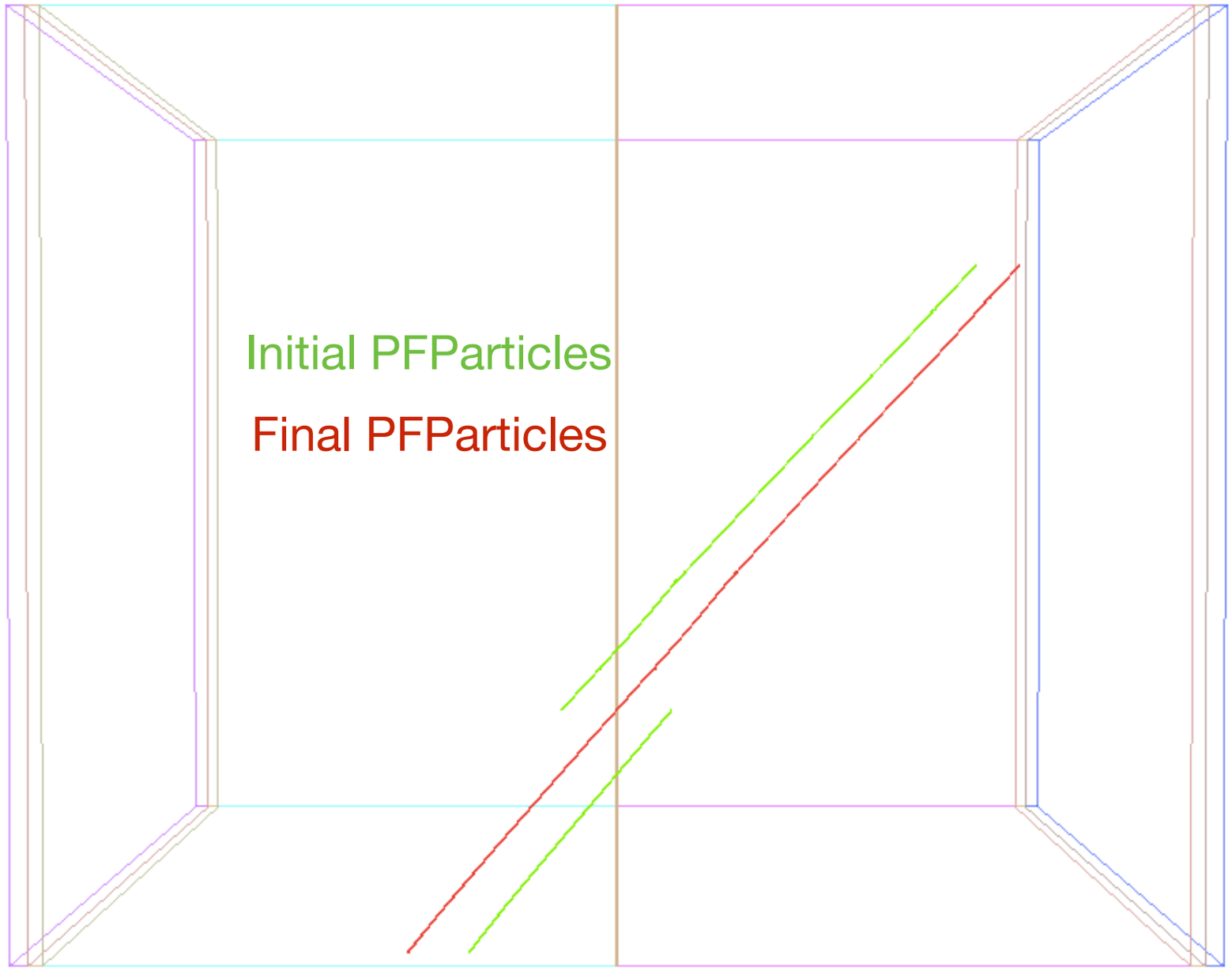
GitHub Link

```
const pandora::ParticleFlowObject *const pParent(lar_content::LArPfoHelper::GetParentPfo(pPfo));
const float x0(pParent->GetPropertiesMap().count("X0") ? pParent->GetPropertiesMap().at("X0") : 0.f);

auto const* theDetector = lar::providerFrom<detinfo::DetectorPropertiesService>();
const double cm_per_tick(theDetector->GetXTicksCoefficient());
const double ns_per_tick(theDetector->SamplingRate());

// ATTN: T0 values are currently calculated in nanoseconds relative to the trigger offset. Only non-zero
const double T0(x0 * ns_per_tick / cm_per_tick);
```

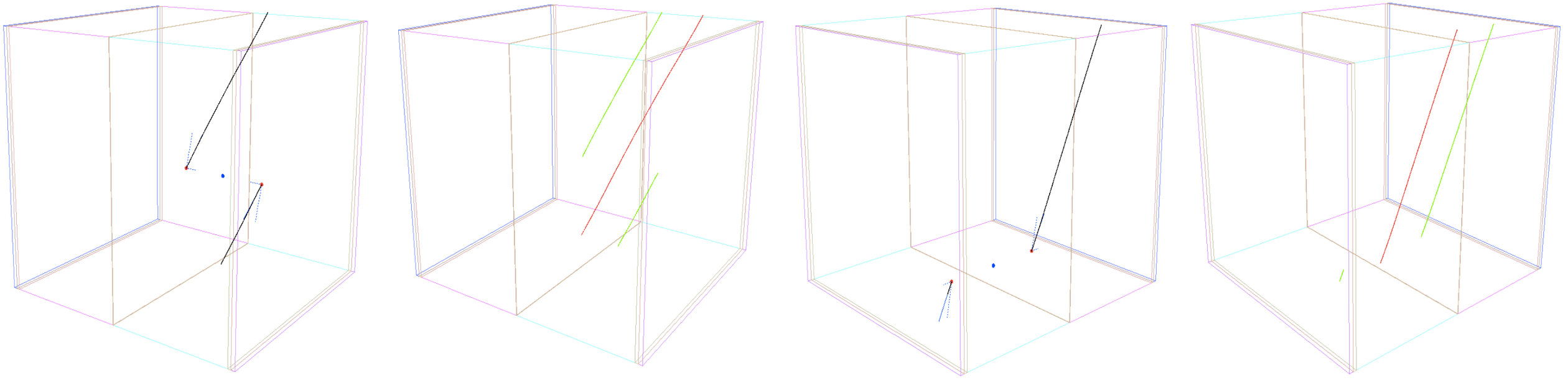
Stitching in Pandora

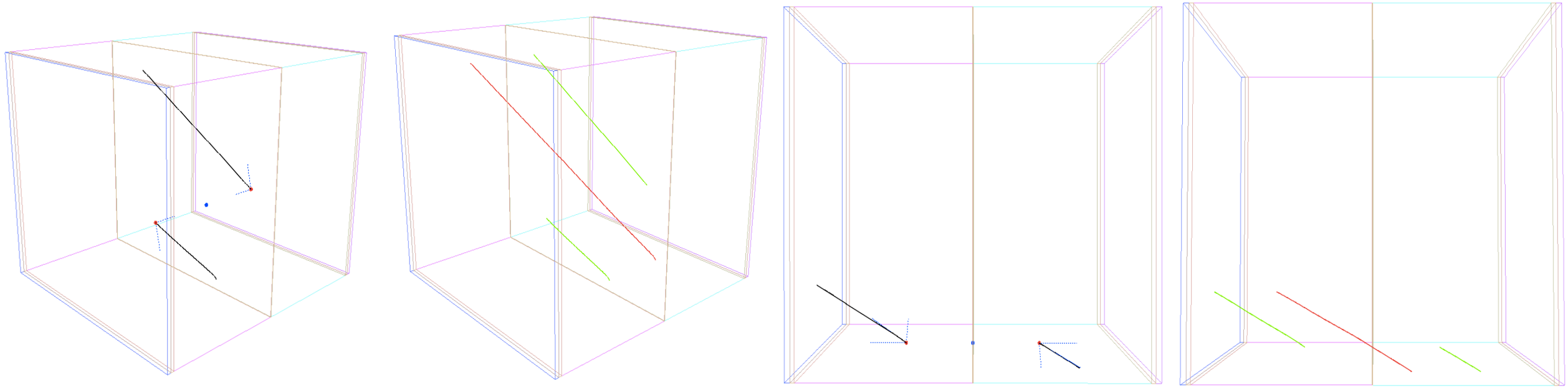


Stitching in Pandora



Stitching in Pandora





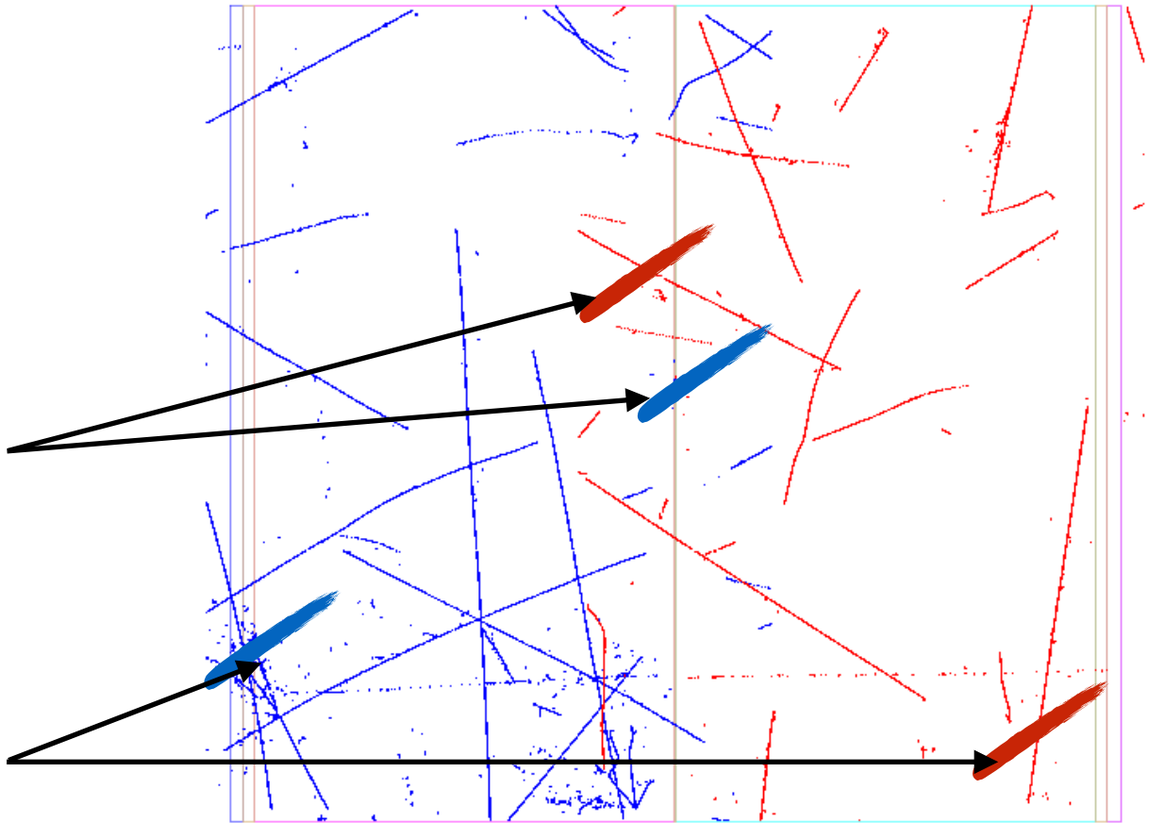
- This happens many times in an event (13 in this example event alone)!

Stitching in Pandora

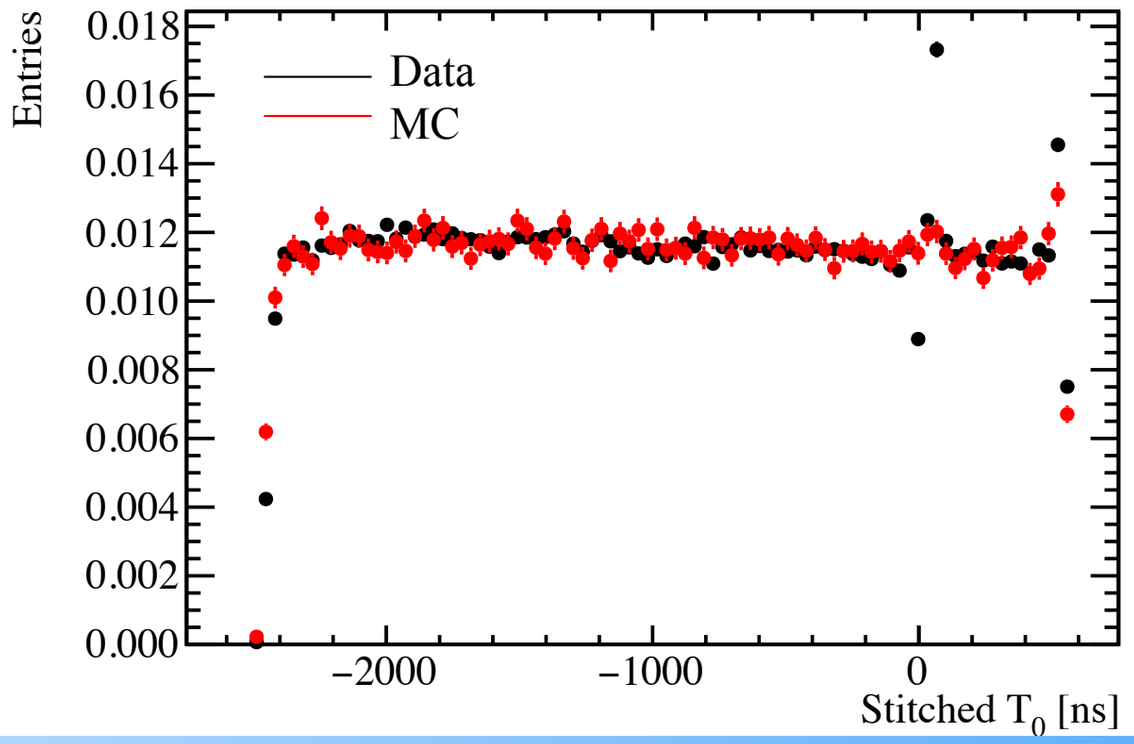
- The range of the T_0 distribution is determined by the readout time and drift time:

Latest T_0
= Readout Window$_{End}$ - Drift Time
= 2750μs - 2250μs = 500μs

Earliest T_0
= Readout Window$_{Start}$ - Drift Time
= -250μs - 2250μs = -2500μs



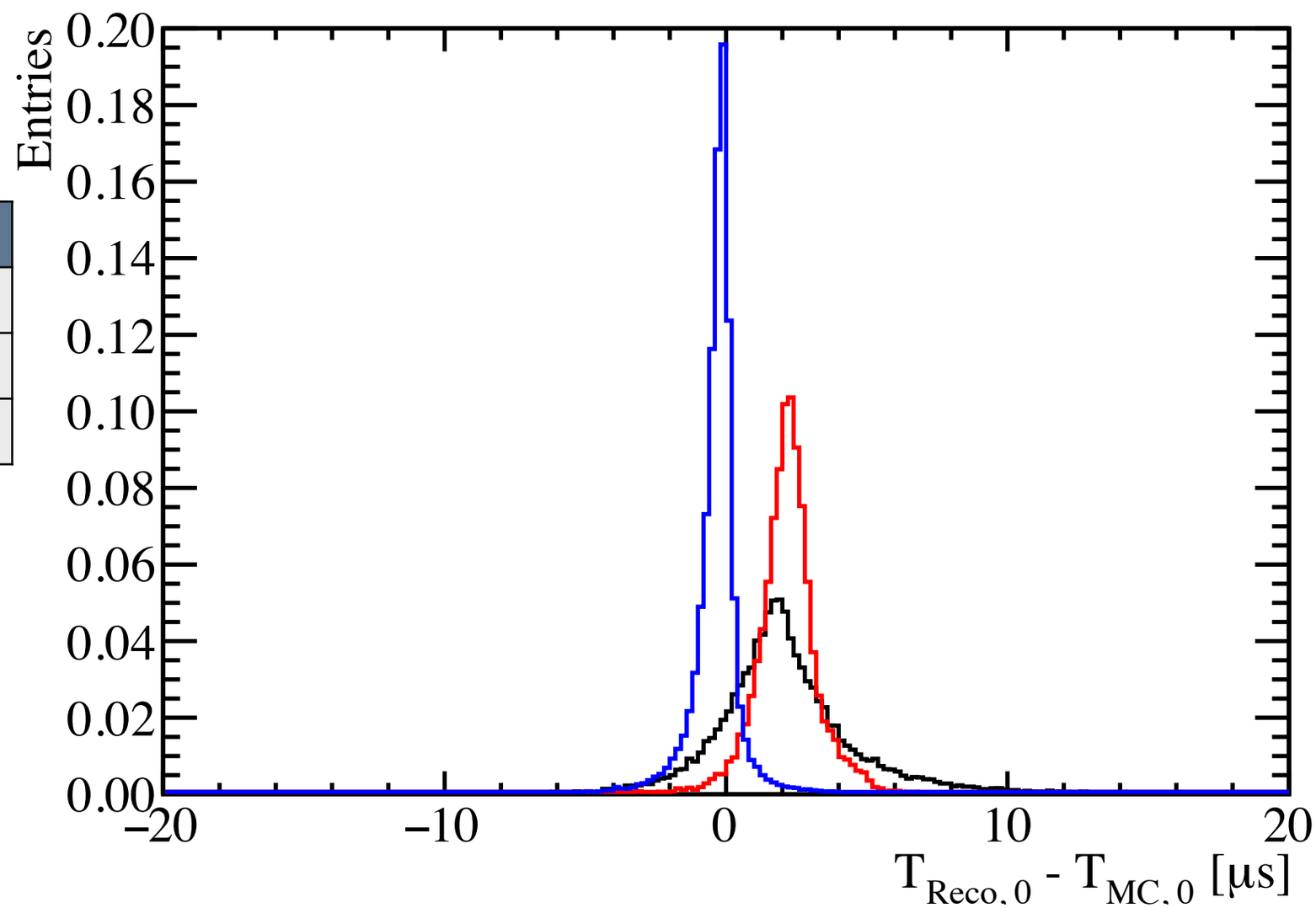
- These are reflected in the width of the stitched T_0 distributions in both data and MC



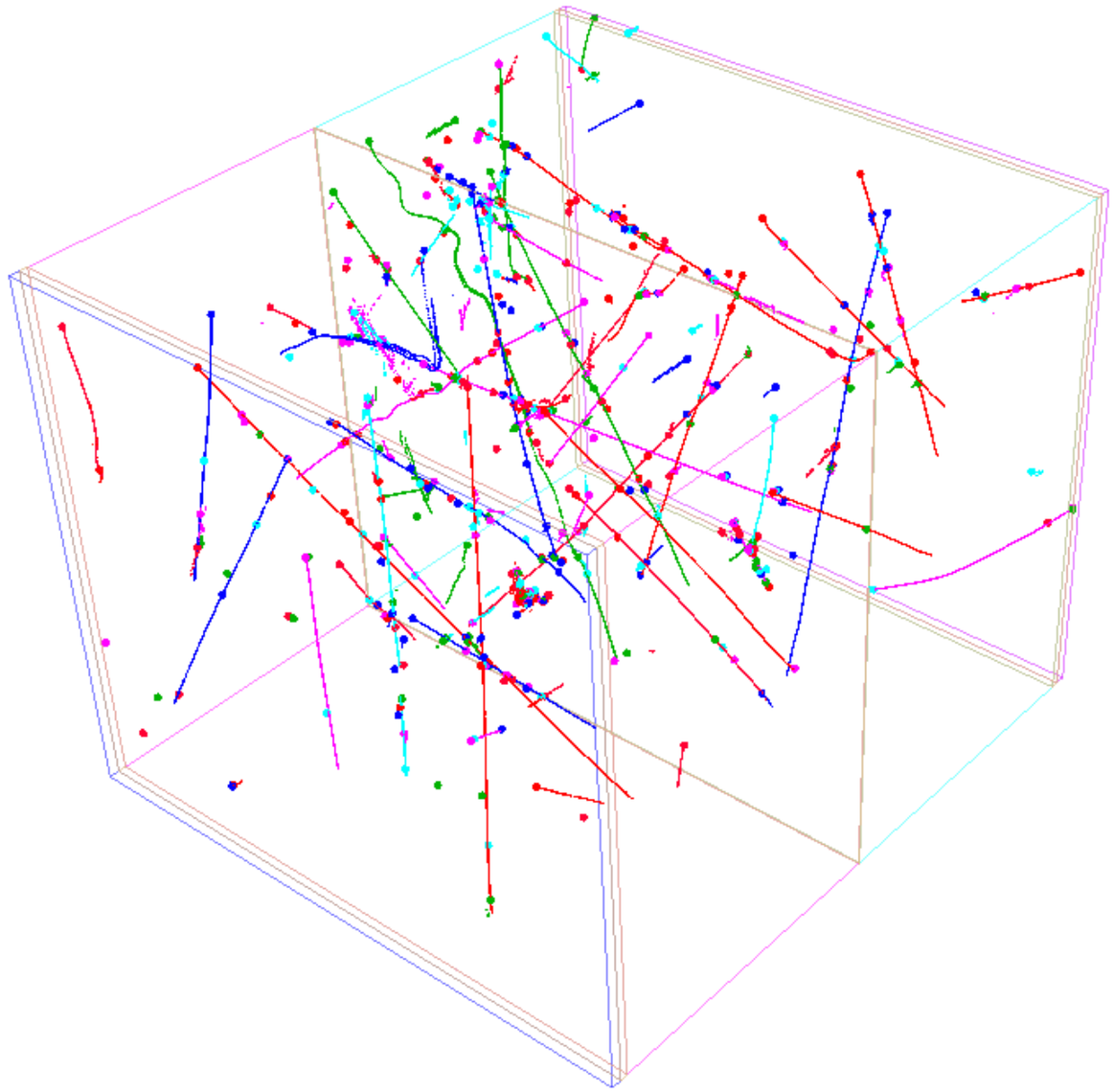
Stitching in Pandora

- There has been discussions regarding whether the stitching procedure is robust against biases other than the effect of space charge.
- While there will be several factors affecting the stitching, it is clear from MC studies that the T_0 resolution is significantly affected by space charge effects and so I believe that these T_0 tagged tracks can be used for calibration.

	Mean [μs]	FWHM [μs]
Fluid Flow	2.16	2.80
Space Charge	2.18	1.40
No Space	-0.33	0.60



Conclusions



Conclusions:

- Given a brief overview of the stitching process in Pandora.

Thank you for your attention!

Questions?

Pandora Pattern Recognition

Pandora is an open project and new contributors would be extremely welcome. We'd love to hear from you and we will always try to answer your questions.

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https://github.com/PandoraPFA

https://pandorapfa.slack.com

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