Karlsruher Institut für Technologie

Physical MC-Matching based on χ^2

B2GM.

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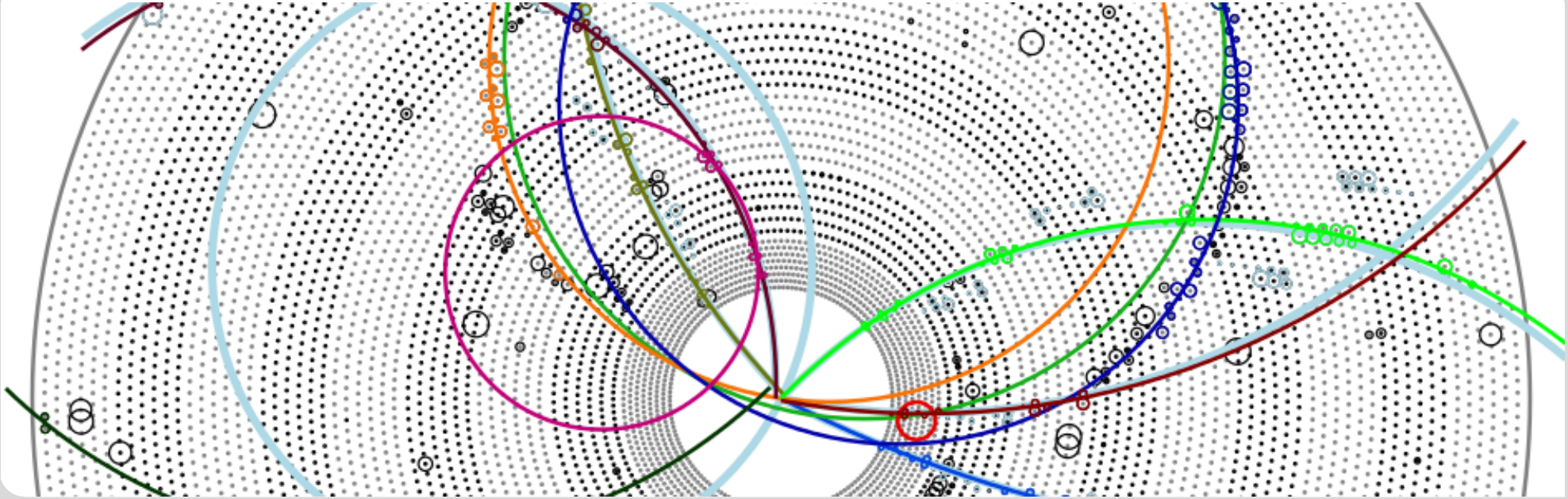
IEKP - KIT



Motivation for additional MC-Matcher

- Current matcher is based on hit-information - which is perfectly well for tracking studies, but may not be the information we (as the tracking group) want to “deliver” in the end to the analysis people.
- An additional matching based on the extracted tracking parameters may (?!) be better suited to the analysis workflow.
- New matcher uses the fitted tracks (`Belle2::Track`), which is our final result.
- *In principle, the same theory can also be applied for other object types, e.g. clusters etc.*

How does it work?

- Get the `TrackFitResult` for each PR track and extract a 5d-state (d_0, z_0, ϕ_0, ω, $\tan\lambda$). If the fit failed, classify as “background”.
- Extract the 5d-state also from the MC Reco Tracks.
- Calculate the corresponding entry in a confusion matrix with

$$\chi^2 = (s_{\mathrm{MC}} - s_{\mathrm{PR}})^T C^{-1} (s_{\mathrm{MC}} - s_{\mathrm{PR}})$$

  (precisely use the probability calculated from this χ^2 with NDF = 5.)
- Cut on the minimal probability.
- Look for the best matching MC track for each PR track and vice versa.

This setup has the advantage, that it directly probes the variables, that are used in the analysis together with their uncertainties.

Track Classification

Same rules apply as with the current hit-based matcher:
Classify each PR track as

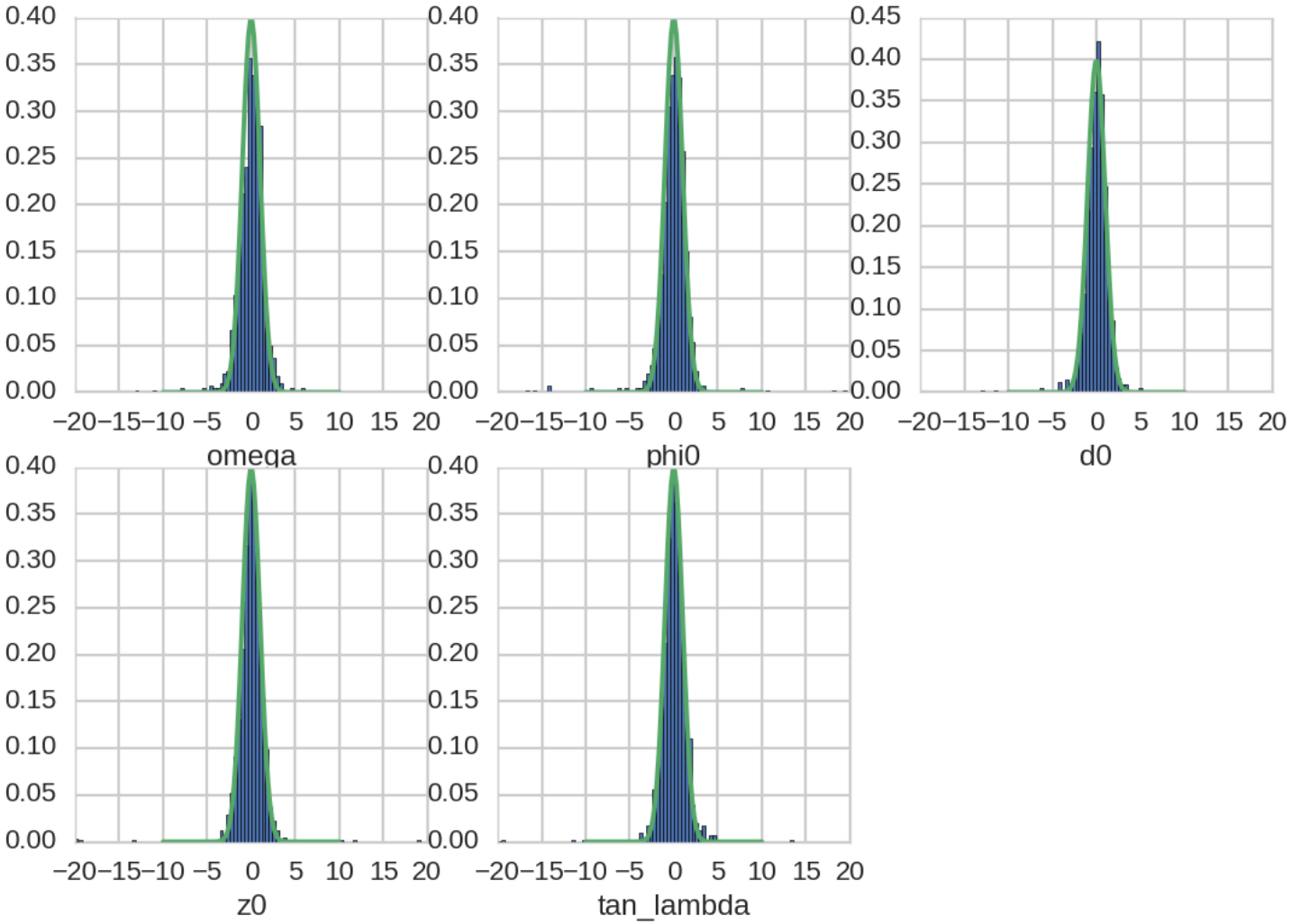
- fake (not fitted or probability is too low),
- matched (related to a MC track, which is in turn related to this PR track),
- clone (related to a MC track, which is not related to this PR track).

Classify each MC track as

- missing (no related and fitted PR track or probability is too low),
- found (related to a PR track, which is in turn related to this MC track),
- merged (related to a PR track, which is not related to this MC track).

Pulls

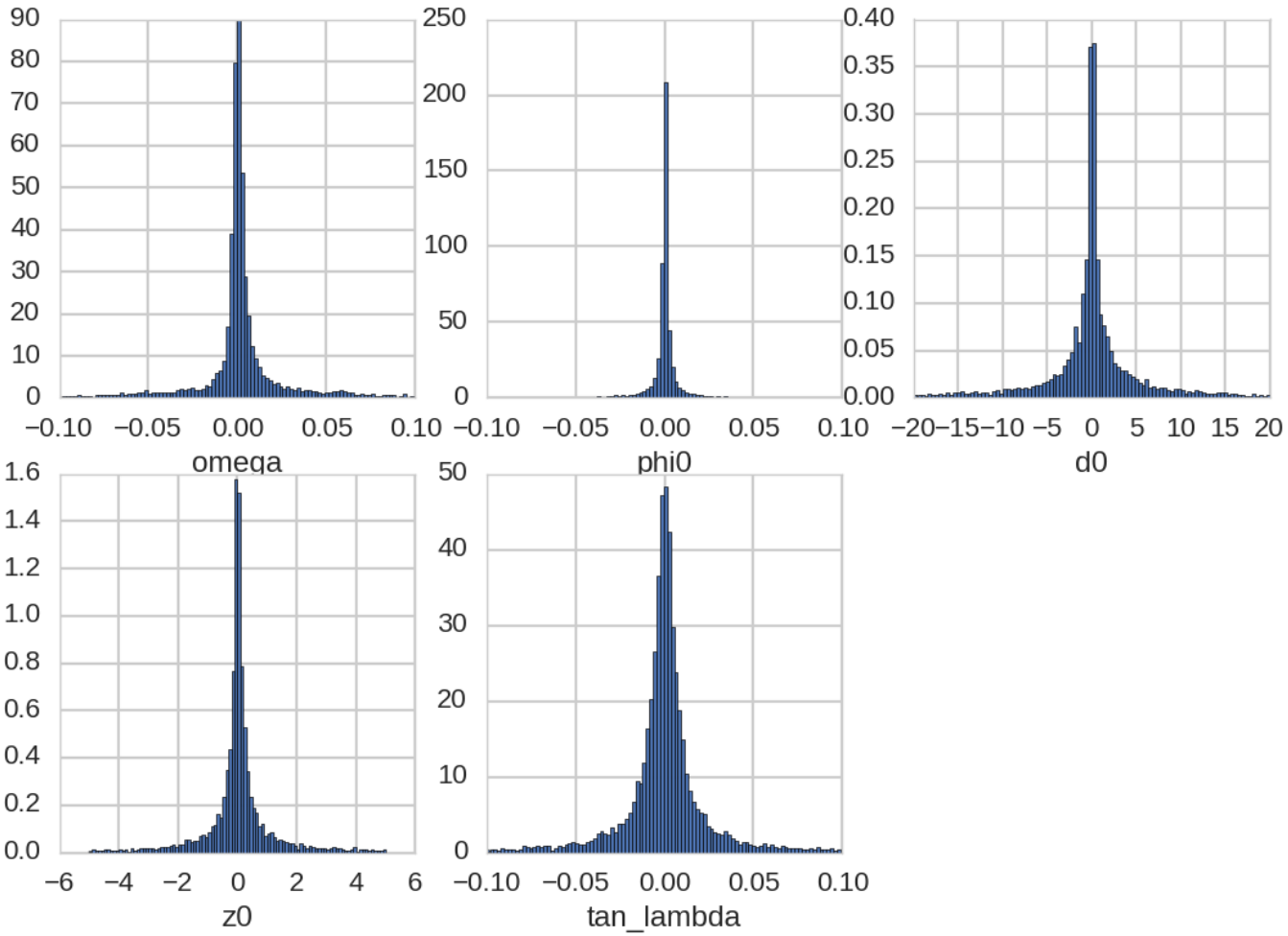
Except for correlations, the χ^2 and the probability are directly related to the pulls.



Residual

Shown is

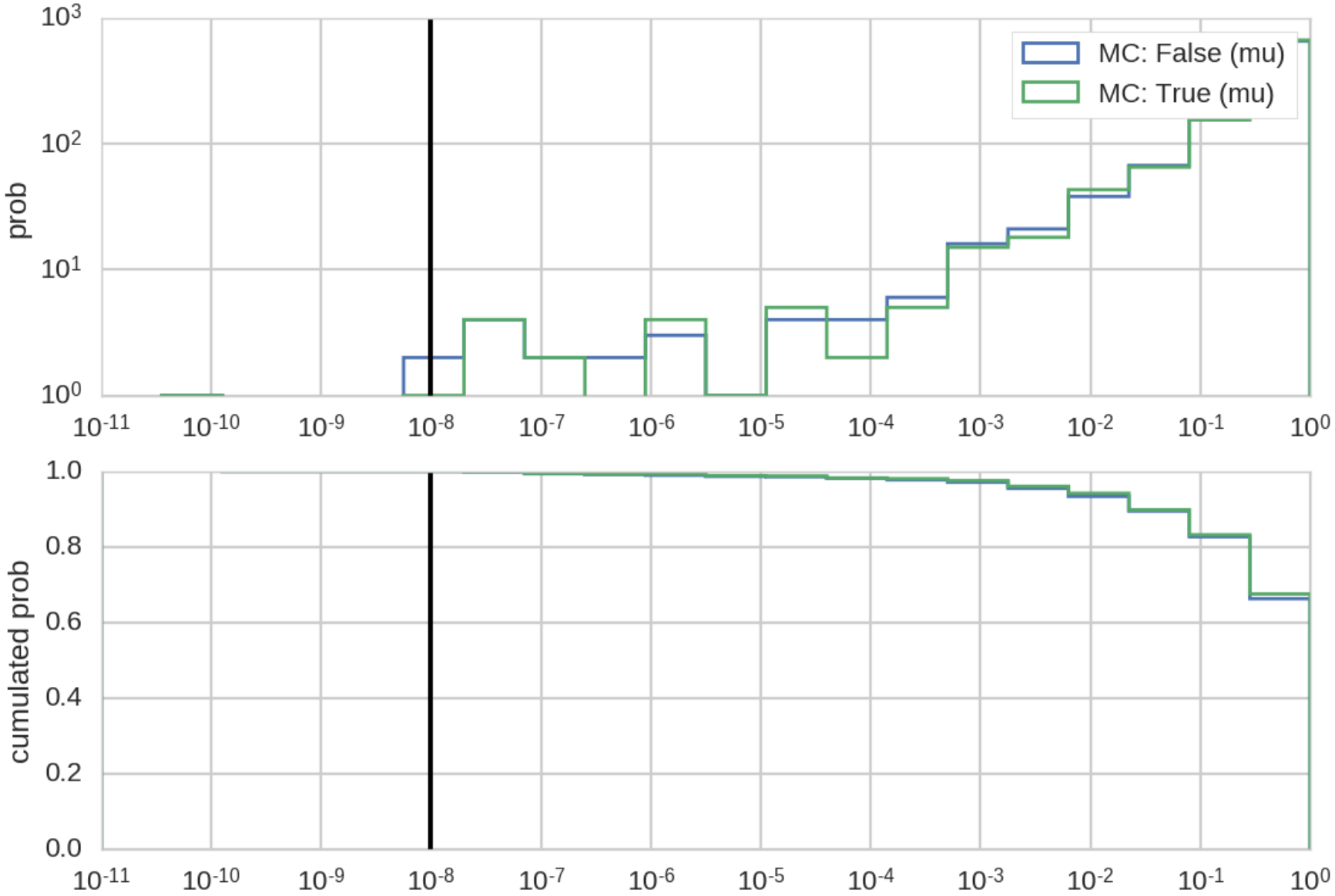
$$\frac{x - x_{\mathrm{MC}}}{x_{\mathrm{MC}}}$$



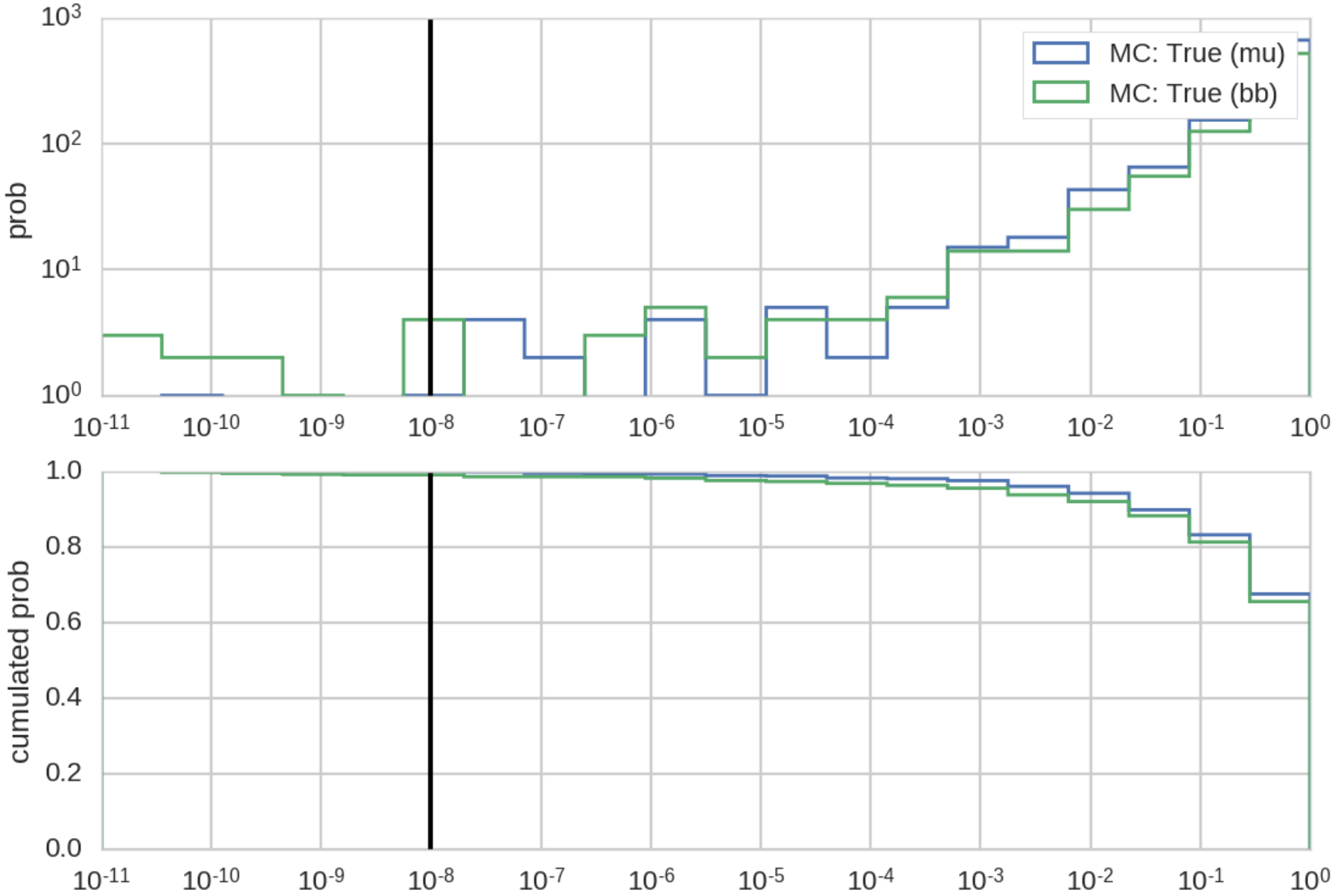
Results and Problems

- Problem: One has to define a minimal probability.
- We will look into a very “simple” example, to get some feeling.
- In the following plots you will always see:
  - 1000 single μ between 0.1 and 4 GeV momentum.
  - Mostly all of the tracks could be fitted (so there are no background tracks).
  - Only a very small amount of events do not have exactly one found track (so more or less no clones).
- After that you will see:
  - 1000 $B\bar{B}$ events.
  - Roughly 1 % of the tracks could not be fitted.
  - Clone rate is larger (number depending on the matching routine).

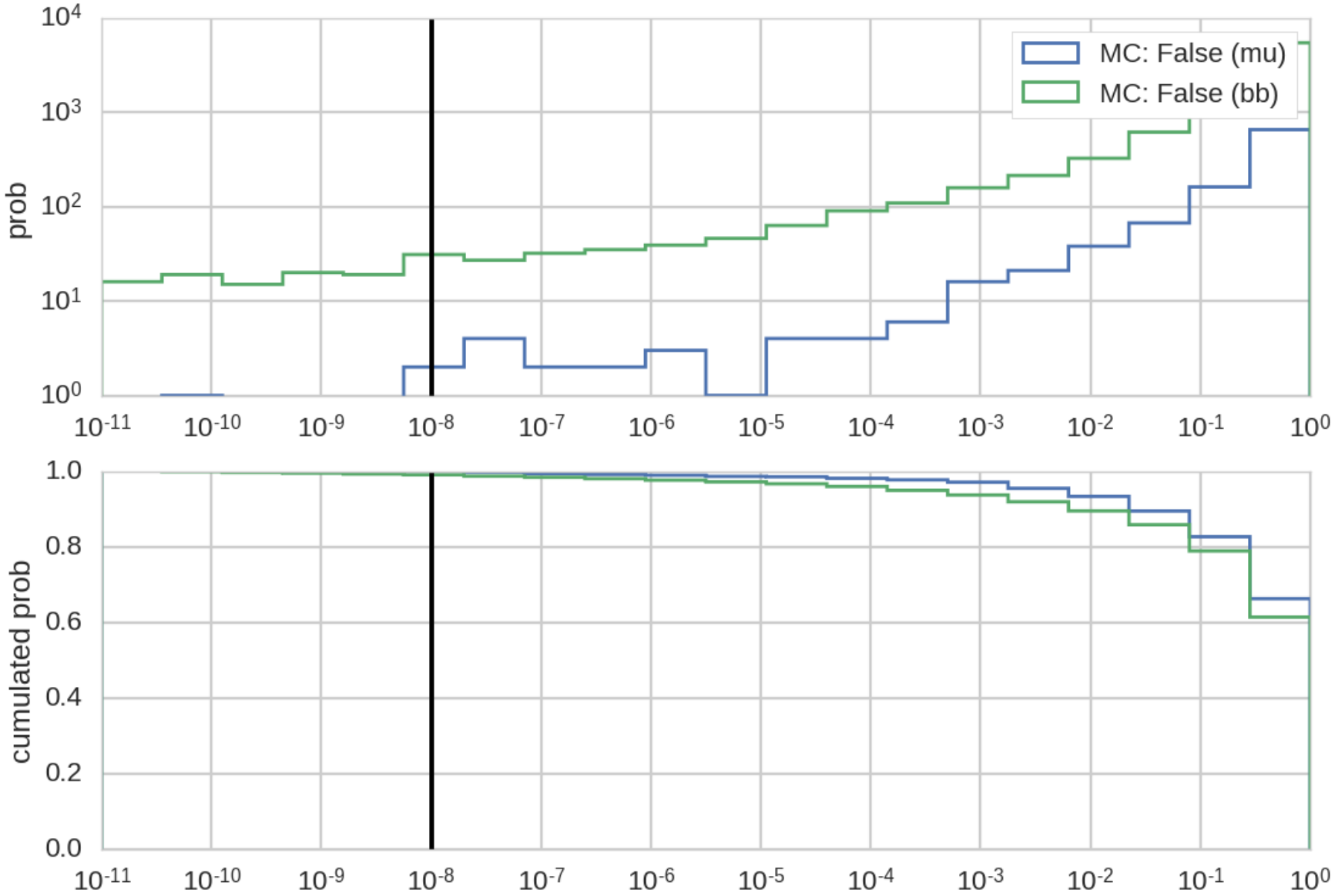
Results for myon events



Results for BB events (MC)



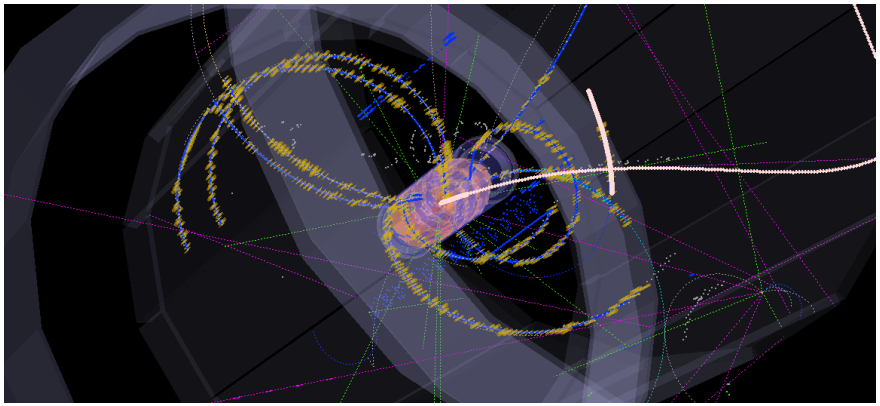
Results for BB events (PR)

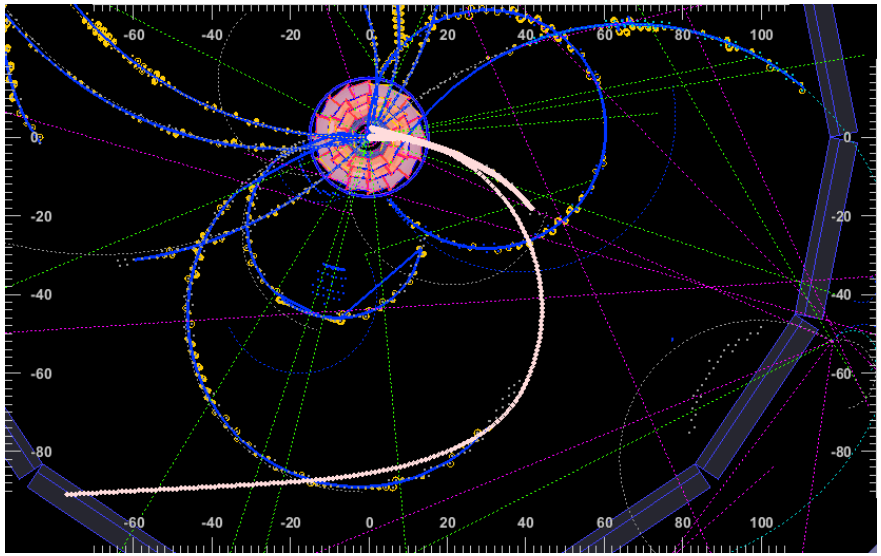


Finding efficiency

ratio		Finding Efficiency	Fake Rate	Clone Rate	Hit Efficiency
Single μ, MC	current	1	0	0	1
	0	0.996	0.003	0	-
	10^{-8}	0.982	0.017	0	-
Single μ, PR	current	1	0.0009	0.025	0.96
	0	0.997	0.019	0.008	-
	10^{-8}	0.982	0.039	0.003	-
$B\bar{B}$, MC	current	1	0	0	1
	0	0.932	0.067	0	-
	10^{-8}	0.89	0.109	0	-
$B\bar{B}$, PR	current	0.943	0.176	0.106	0.815
	0	0.887	0.281	0.036	-
	10^{-8}	0.844	0.329	0.018	-

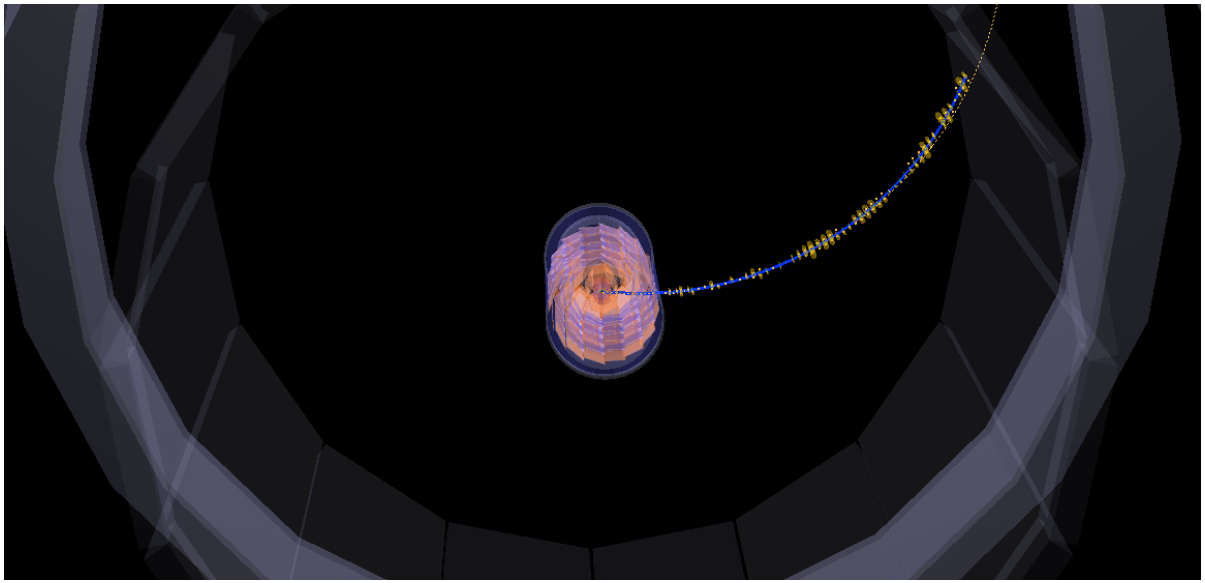
Event Displays

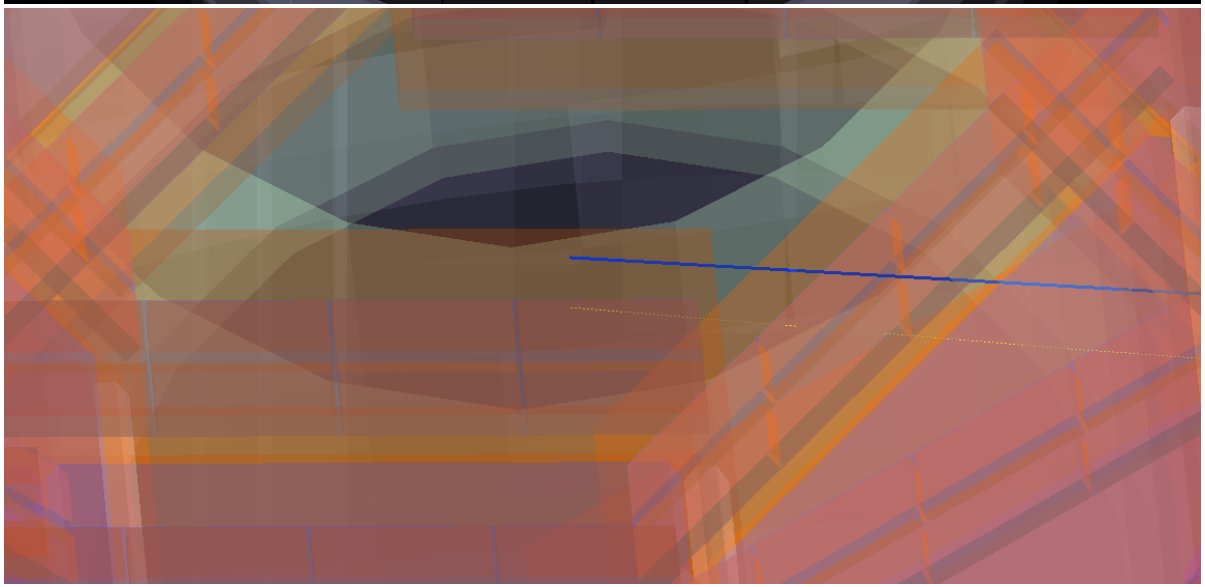




Track (short part is PR track) is matched by hit-based method, but z direction is badly fitted, so parameter based matcher does not match the track.

Event Displays (cont.)





Conclusion

- Implementation of additional physical matching routine for tracks based on χ^2 is mostly finished (still some refactoring needed).
- Results are promising, but not all are understood well.
- Question to analysis group: which matching procedure would you prefer?