Status Report: Run 3 Electron Reconstruction Studies

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Motivation

- electrons heavily emit bremsstrahlung
- electron track-finding underperforms compared to other particles

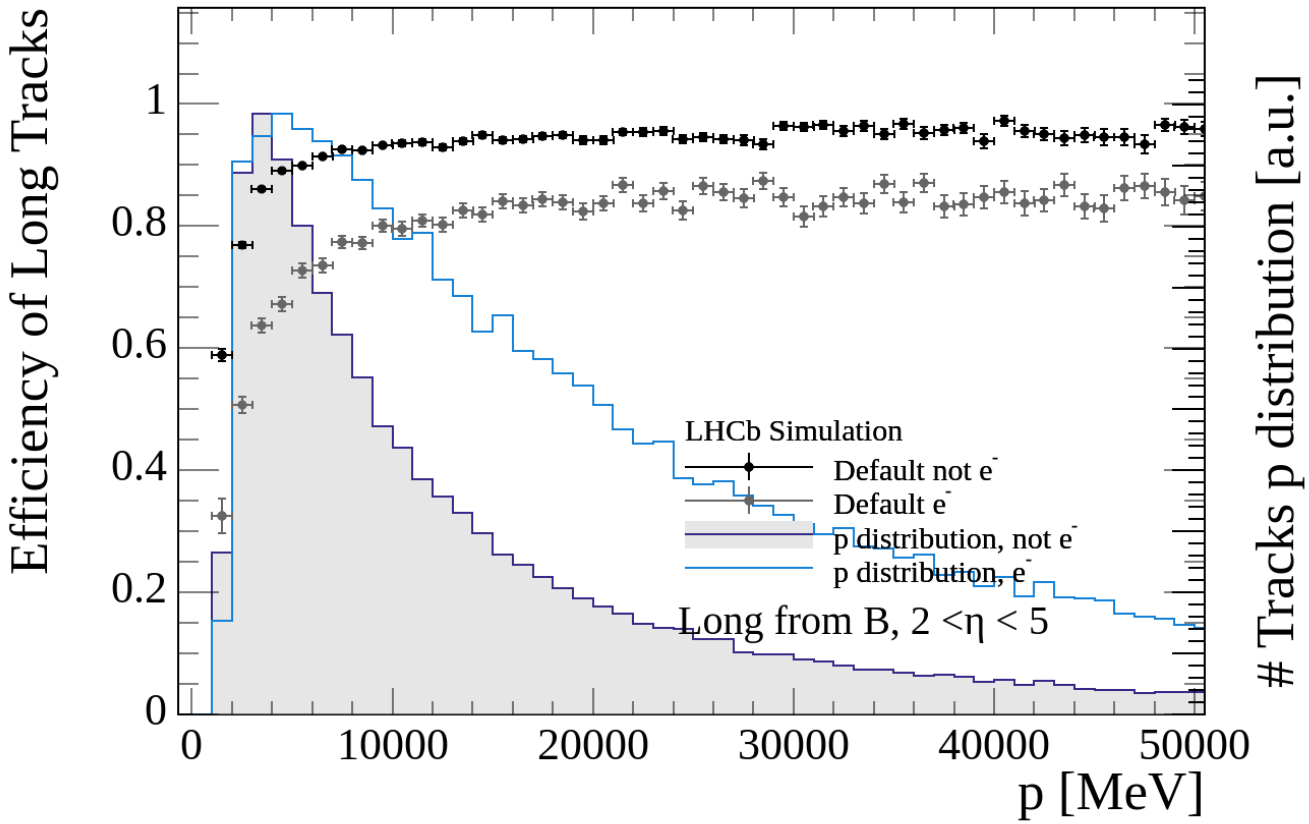


Figure: BestLong Efficiency for electrons and not-electrons using baseline reco for the $B^0 \to K^* e^+ e^-$ decay

Reminder

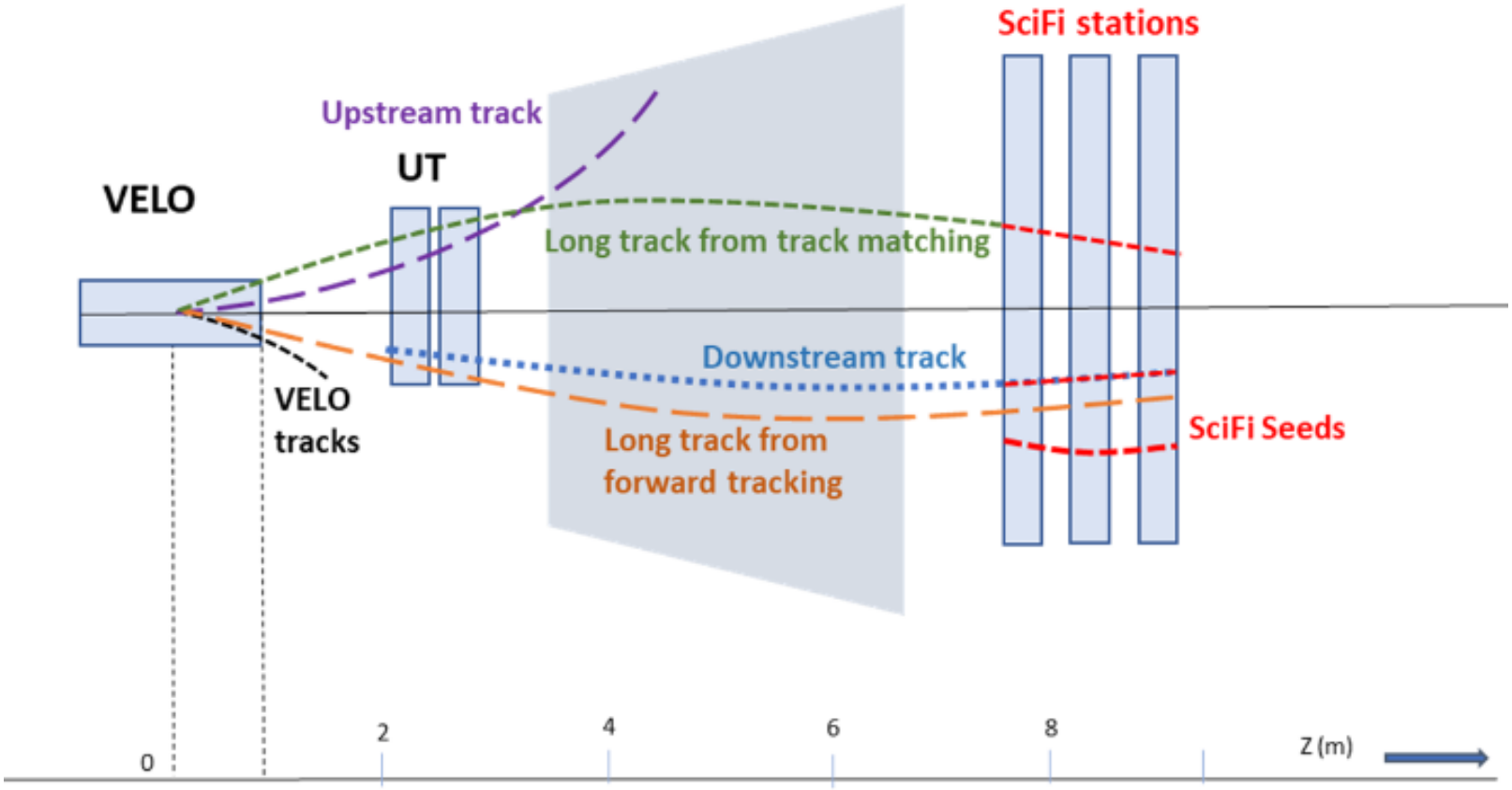


Figure: Track Types at LHCb

Idea

- we have Velo and Scifi tracks, with good $e^{\pm}$ efficiency

→ implement a Matching algorithm for electrons

- current Matching not trained for electrons
- Matching is computationally cheap → can be used in trigger

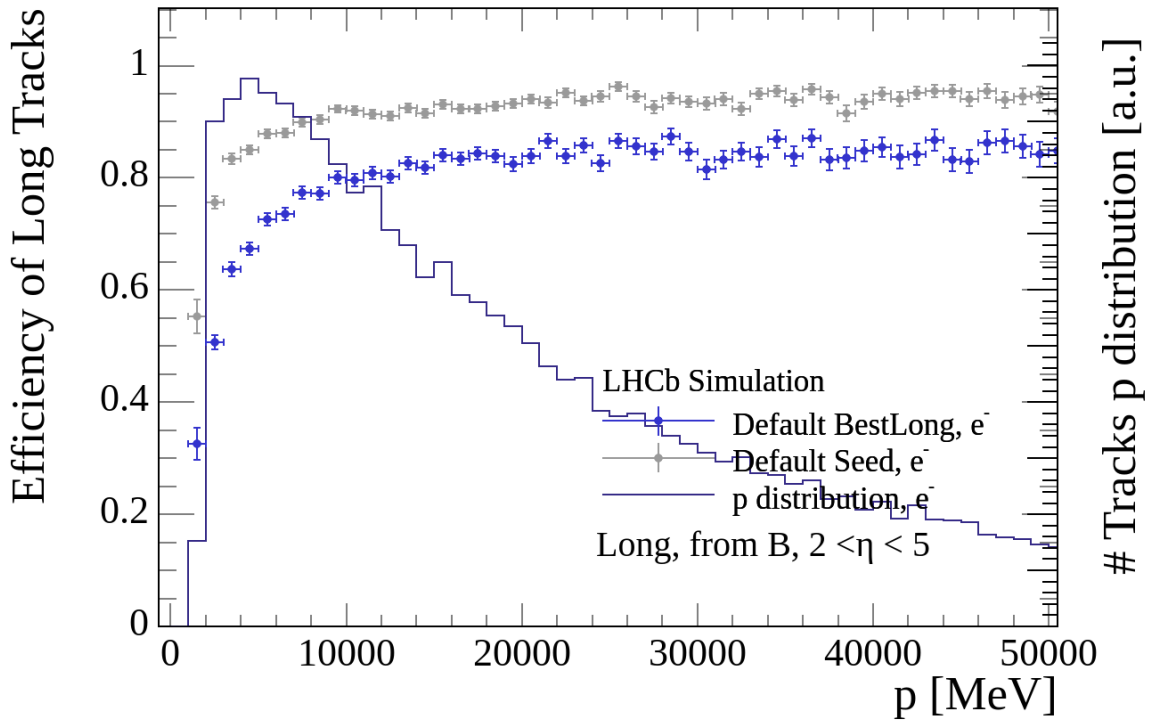


Figure: Efficiency for Electron Seed Tracks and BestLong Tracks in baseline reco

The Matching Algorithm

- use a classifier, a Multi Layer Perceptron
- quantify the level of agreement, i.e. a match

Table: Input variables of the Matching MLP

Variable	Preselection
χ^2_{match}	< 15
D_x	< 250 mm
D_y	< 250 mm
$\lvert\Delta t_x^{\text{match}}\rvert$	< 1.5
$\lvert\Delta t_y^{\text{match}}\rvert$	< 0.15
$t_x^2 + t_y^2$	

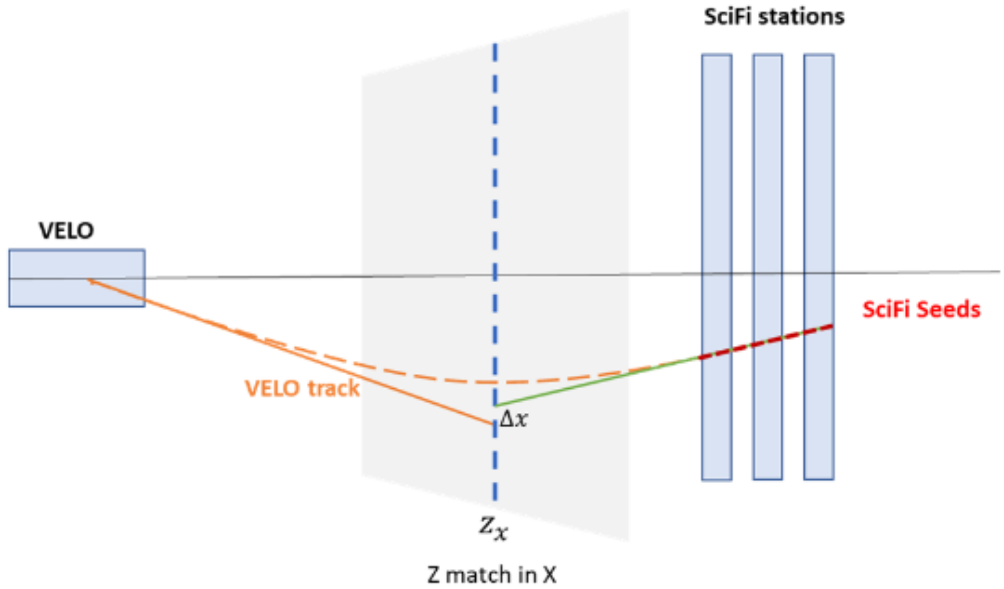


Figure: Matching Distance D_x

Matching Variables in baseline reconstruction

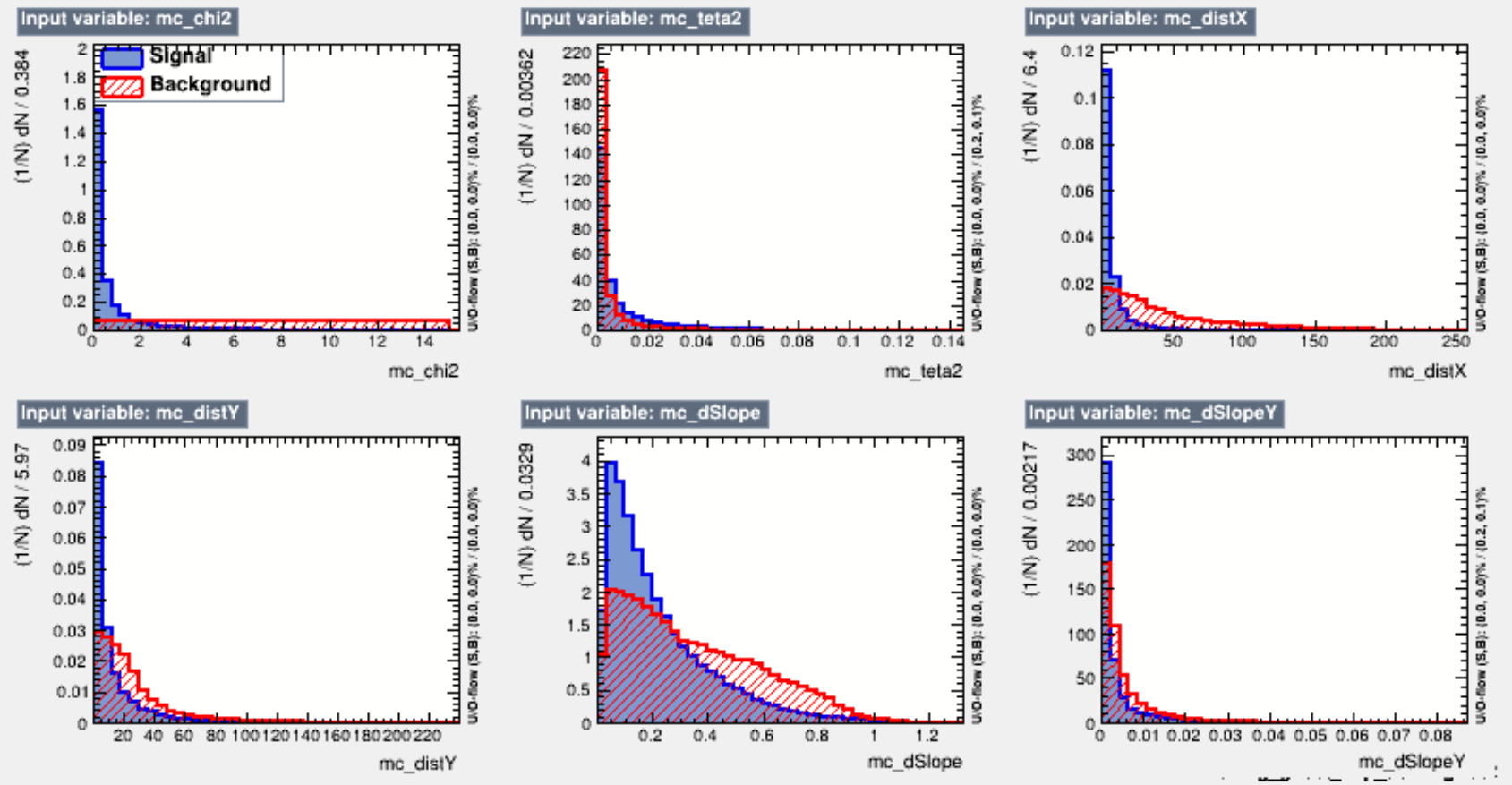


Figure: Input variables for baseline reco, i.e. explicitly excluding electrons as signal

Matching Variables in electron-specific reconstruction

Trained a NN with true long tracks of $e^{\pm}$ as signal and true ghosts of $e^{\pm}$ and not-$e^{\pm}$ as background.

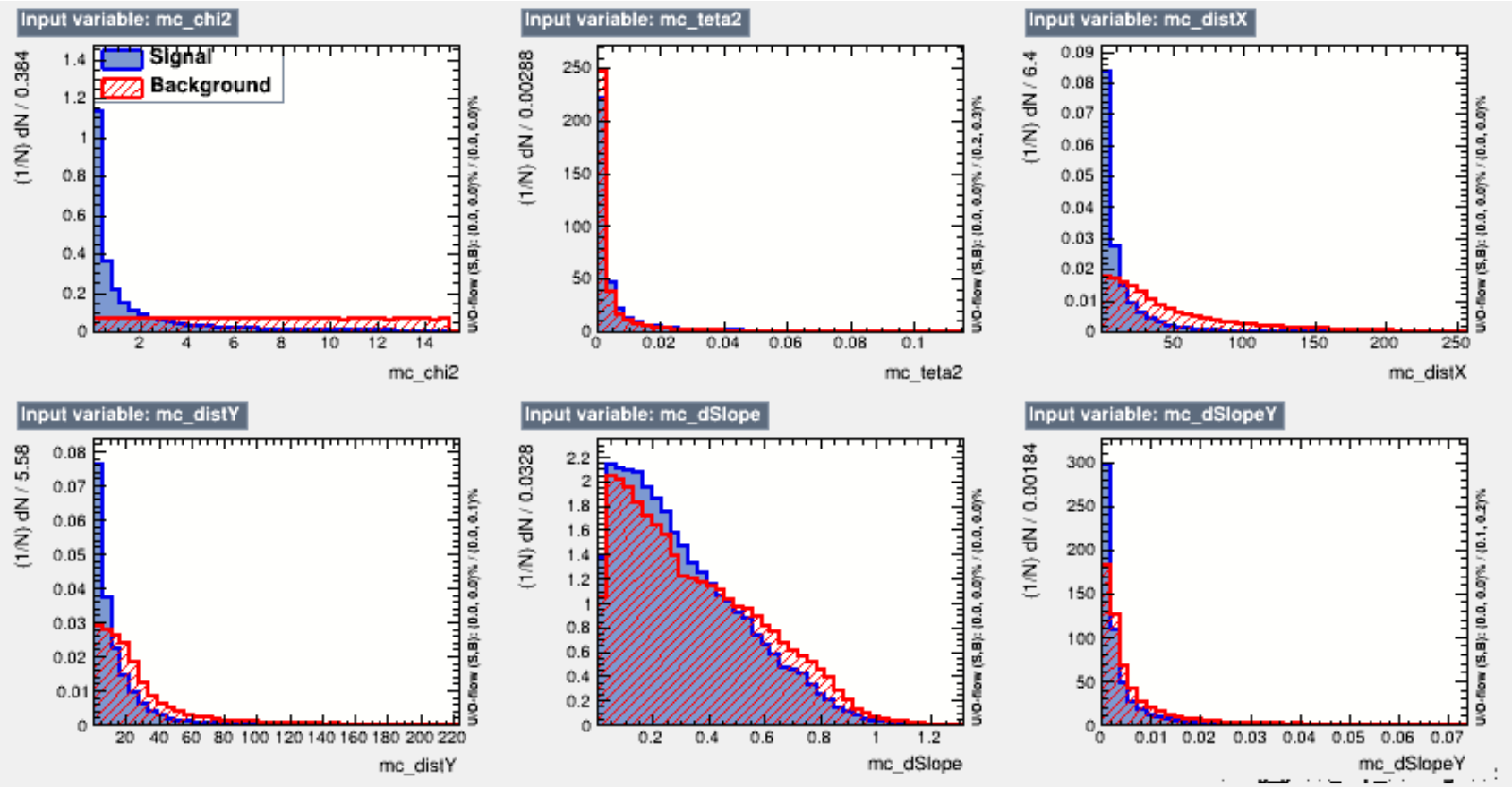
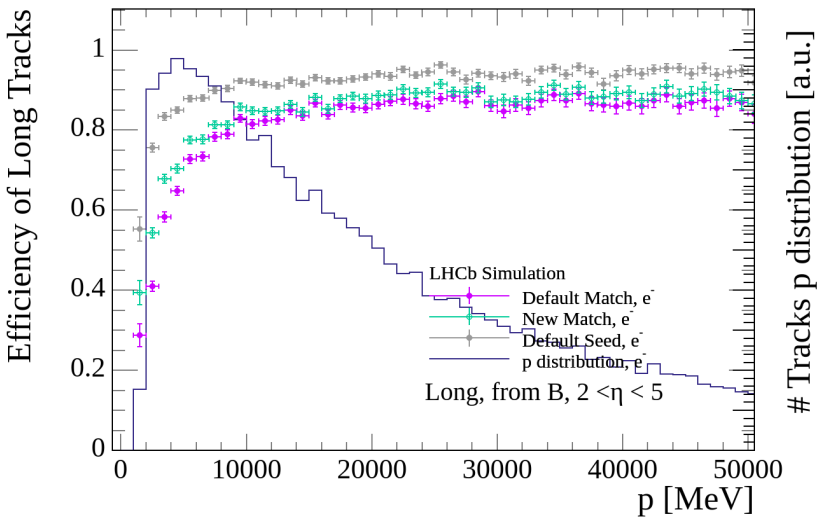
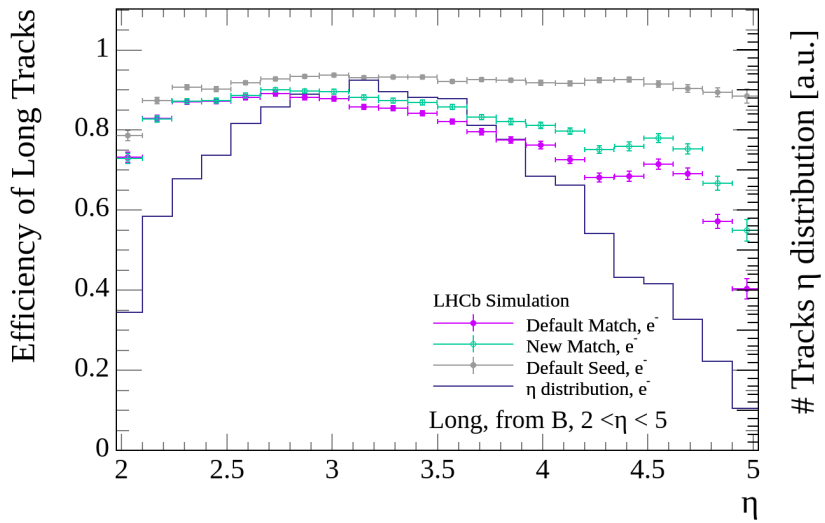
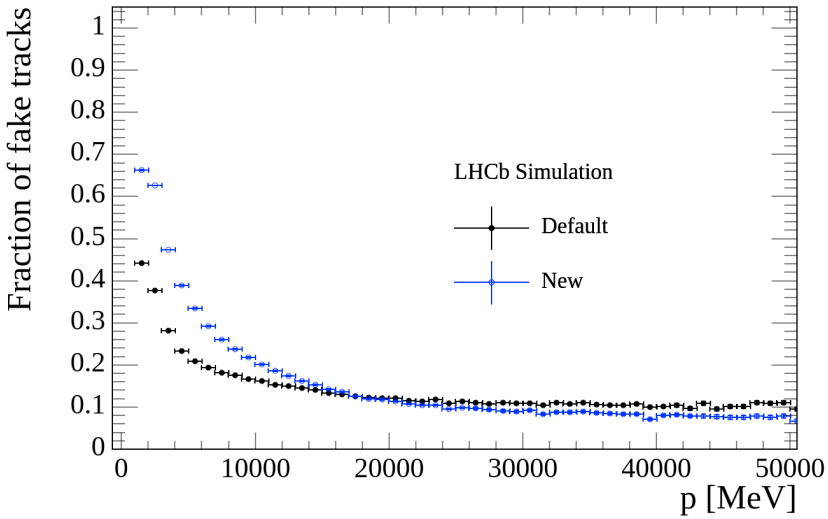


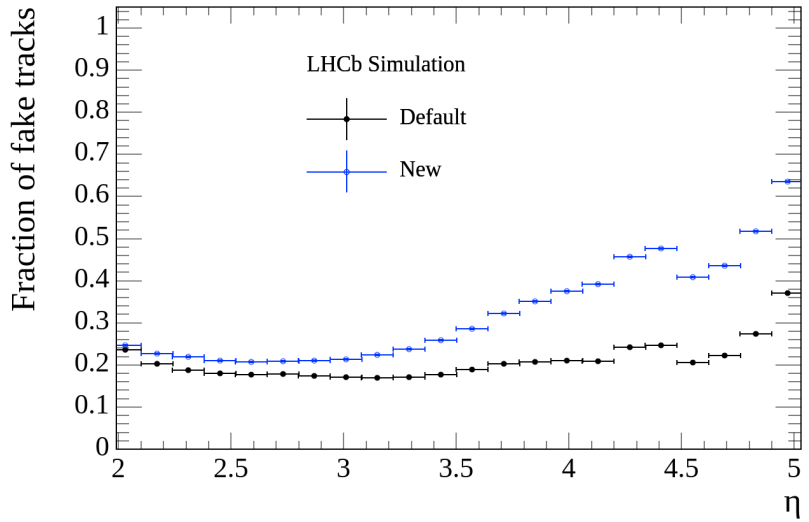
Figure: Input variables for electron-specific reco, i.e. only electrons as signal

Preliminary Efficiency and Ghost Rates









Conclusion

- Matching ansatz looks promising for electrons
- simple retraining already gains efficiency

To do:

- look into other possible input variables, exploiting the detector geometry
  - parametrisation of radiation length $\langle E \rangle = E_0 e^{z/X_0}$
  - more use of geometric variables such as ϕ
- try different NN architecture

Ideas to control ghosts:

- filter Seed tracks using calorimeter information
- use Velo and/ or Seed tracks left over after Long tracking

Backup: Baseline Reconstruction and Residual Matching

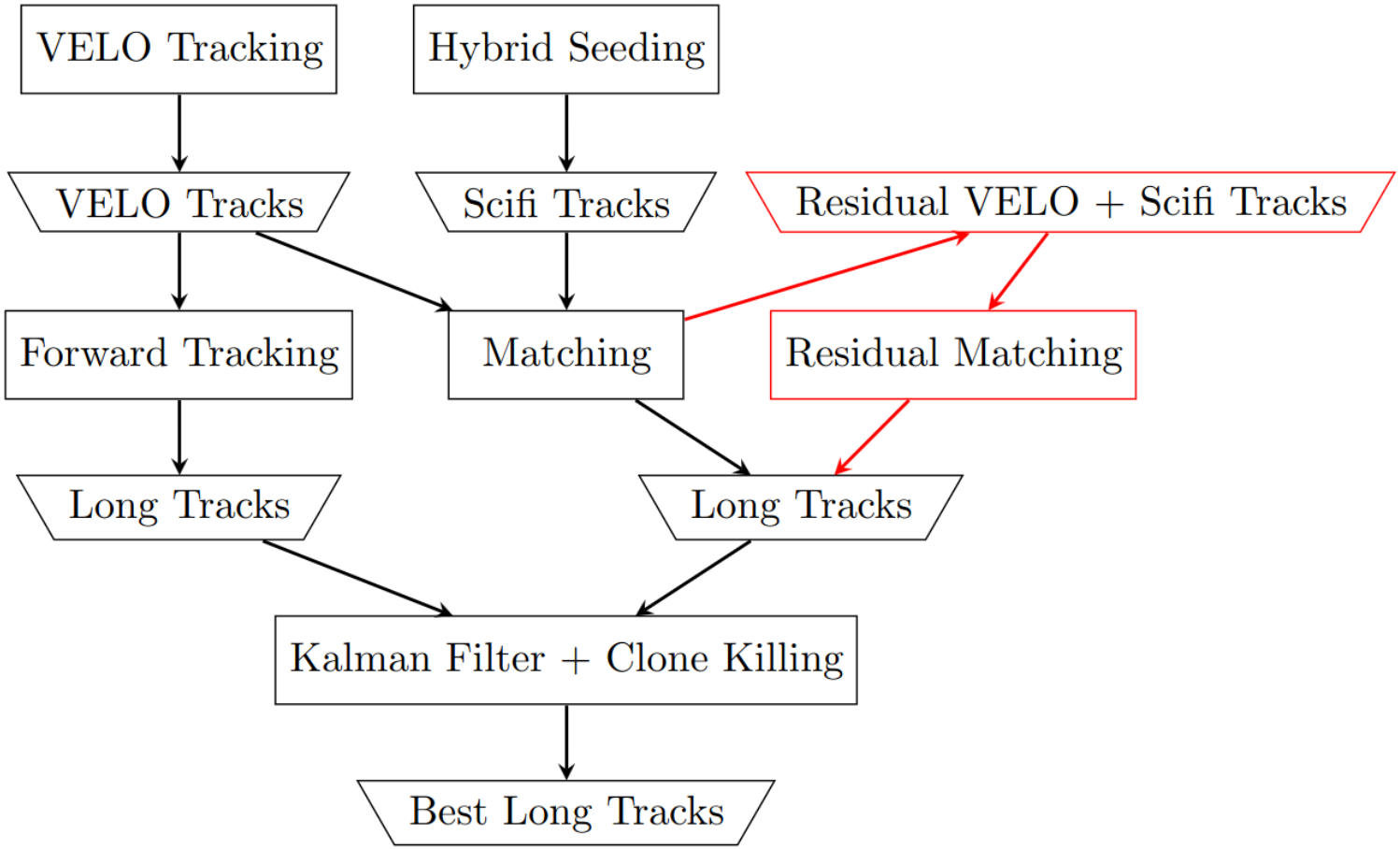
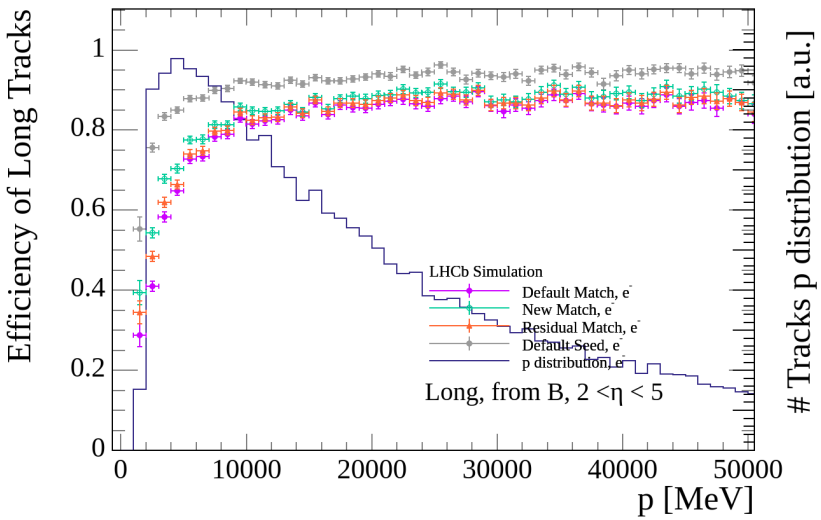


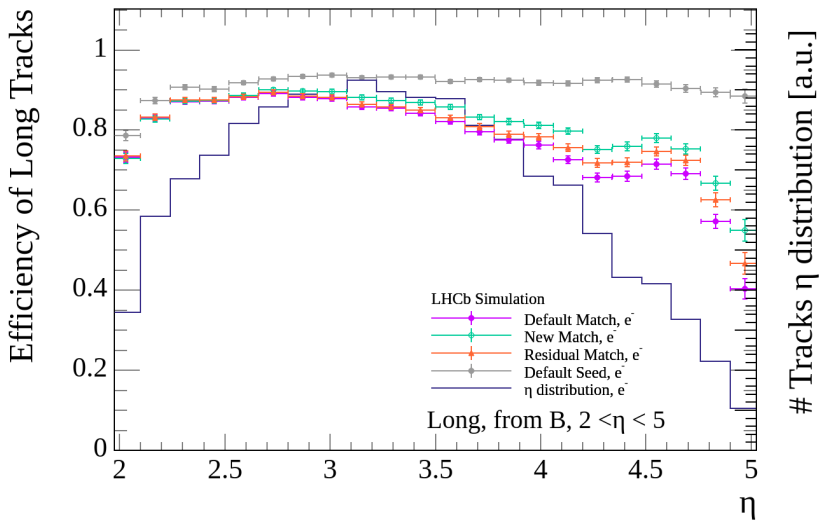
Figure: Data flow in baseline reco (black) and residual matching (red)

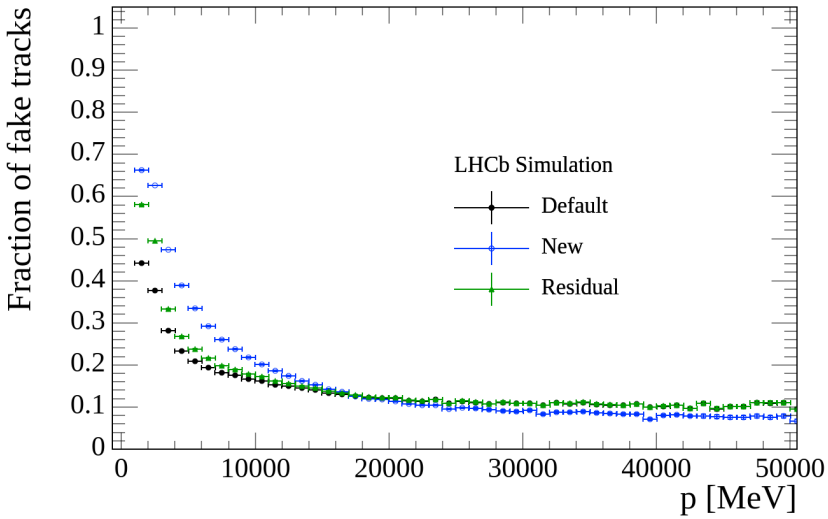
Residual Velo and Scifi tracks are given to a second Matching algorithm

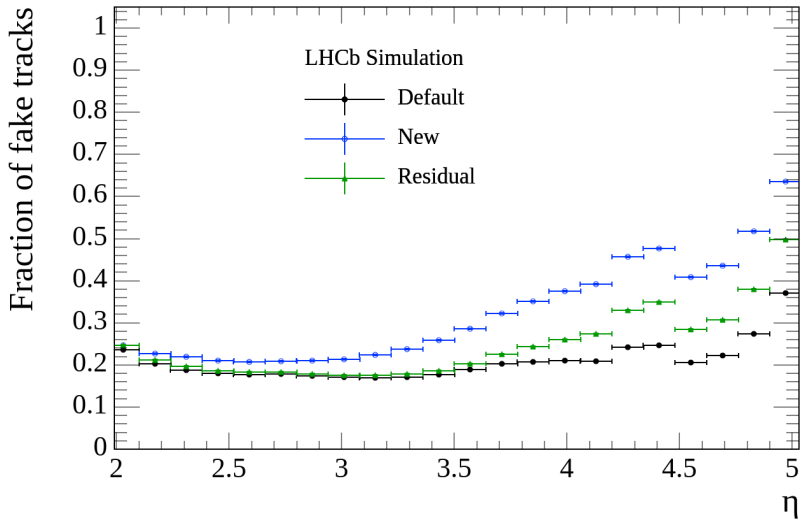
→ trained with simulated electron long tracks as signal

Backup: Residual – New

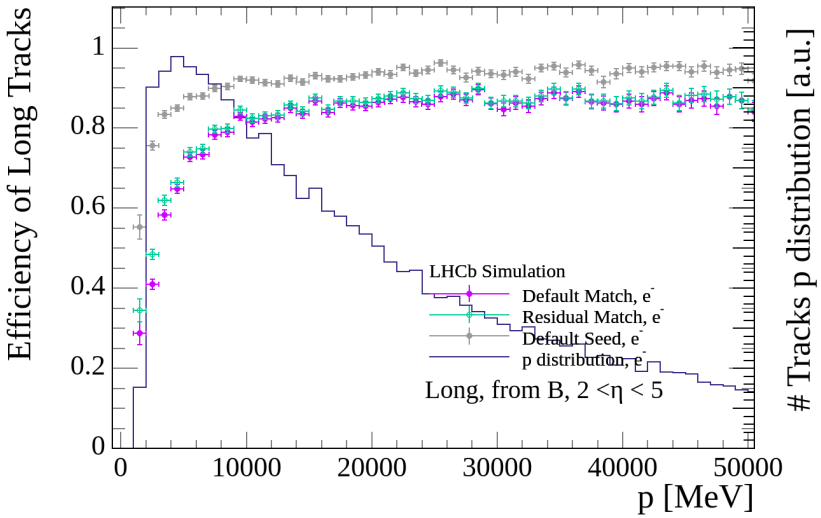


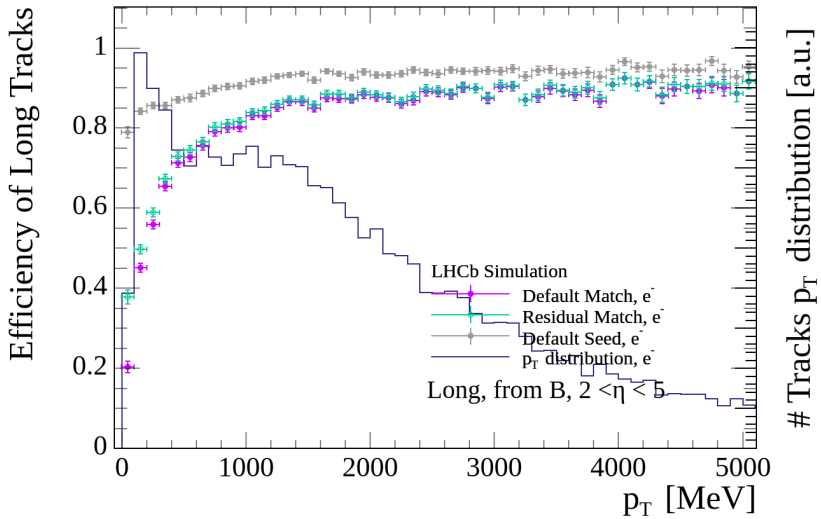


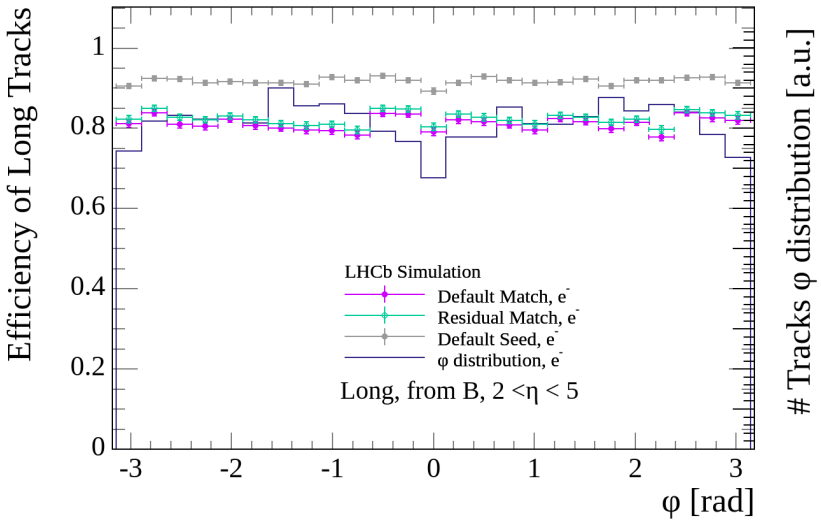


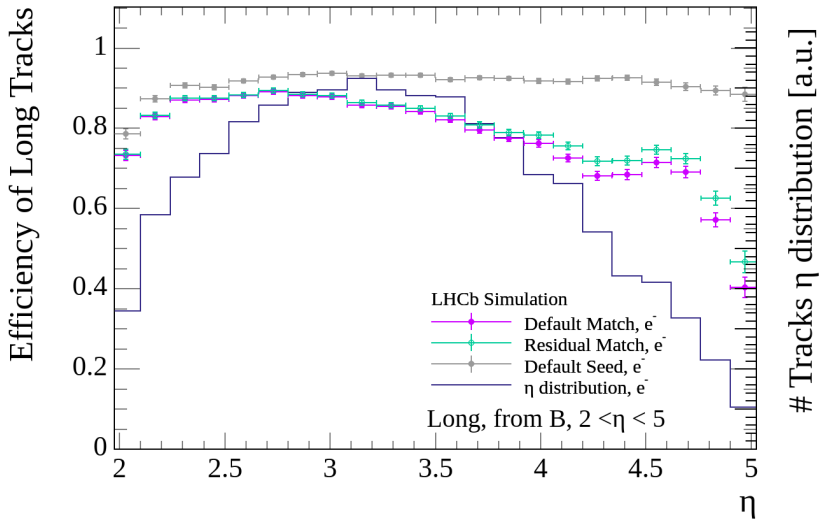


Backup: Residual Matching

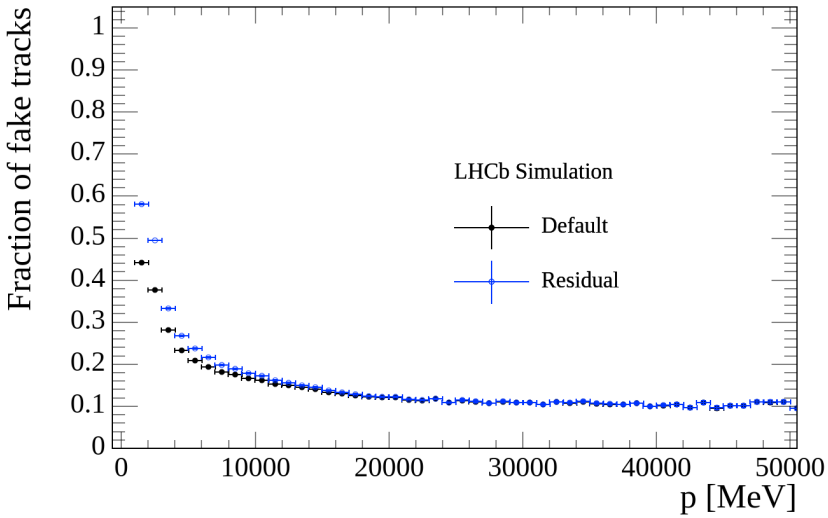


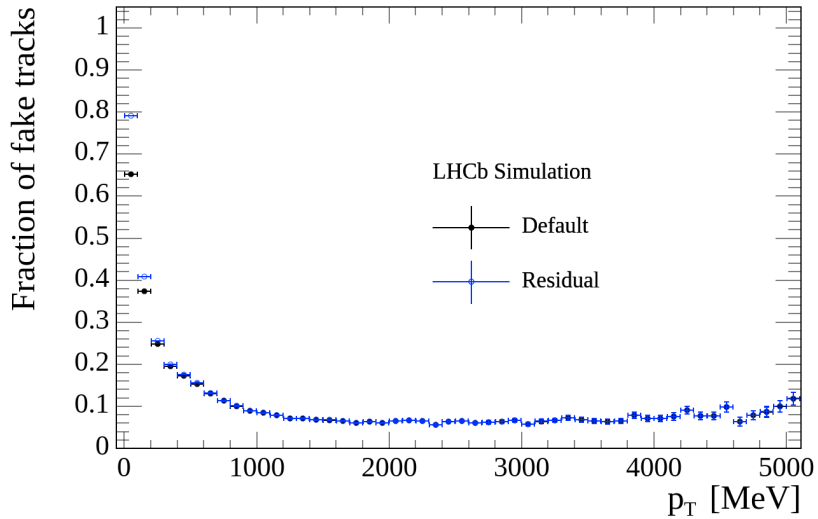


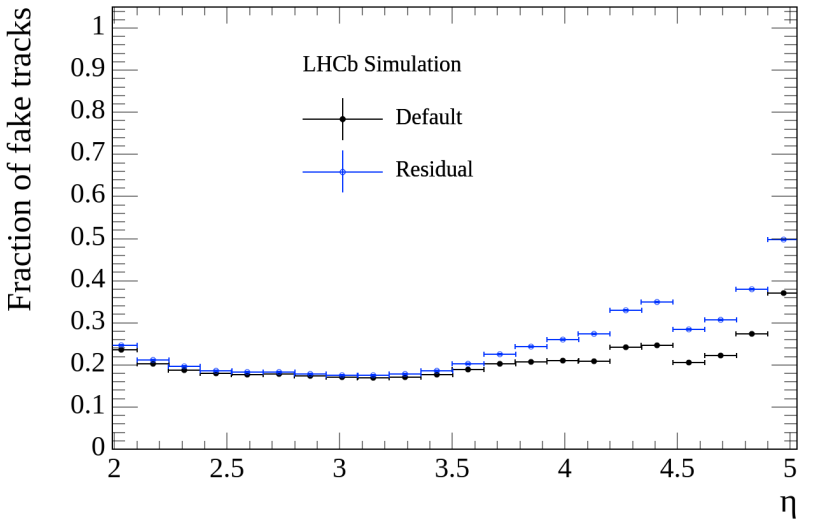


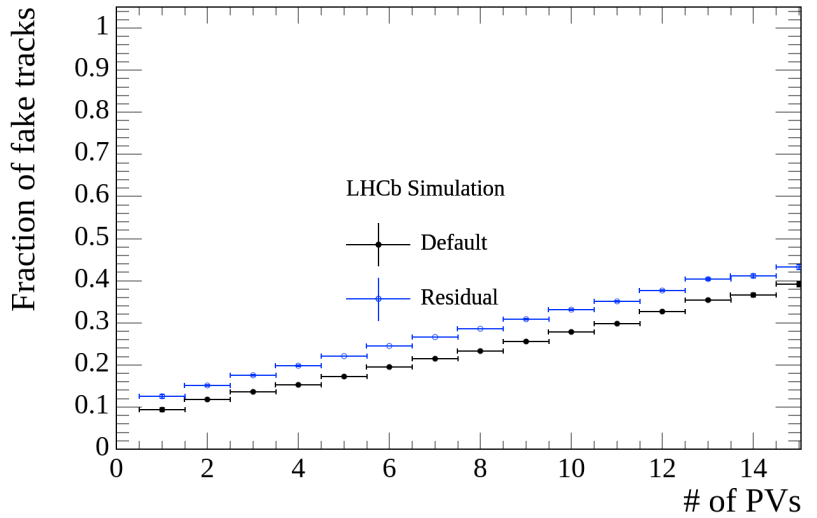


Backup: Residual Matching









Backup: Residual Weights

```
const auto ResfMin = std::array<simd::float_v, 6>{
    {2.32376150961e-05, 1.20999845876e-06, 3.0517578125e-05, 0.000152587890625,
    5.18634915352e-05, 3.16649675369e-08}};
const auto ResfMax = std::array<simd::float_v, 6>{{29.999835968, 0.448848098516,
                                                   490.75402832, 499.918823242,
                                                   1.29696559906, 0.148829773068}};
const auto ResfWeightMatrix0to1 = std::array<std::array<simd::float_v, 7>, 8>{
    {{0.972643778287334, 0.945437530240695, -1.40069143935294,
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     {1.99177578845469, -13.3678019612632, 8.38118795560118, 1.73988710441318,
      -4.61454323644065, 5.29554800958296, 1.796743670204},
     {0.154471209290507, -6.25196675947653, 5.03239643950246, 17.3659761341648,
      -6.54695139344376, -13.0321058473978, -2.79459536100855},
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      1.12938262301514, 0.122157098634831, -0.887283402159991}}};
const auto ResfWeightMatrix1to2 = std::array<std::array<simd::float_v, 9>, 6>{
    {{-2.73702380879827, 1.22468365009789, 2.40149928694528, 0.276654711632341,
      -0.947460759127638, -0.94795299724562, 1.63438201788813,
      -1.41515589667229, -0.708508928627869},
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      -0.507220427829013, 0.533181686353704, -0.0512849135791123,
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     {0.601790057732671, -2.70865568575877, -0.949516903771233,
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      1.63899587513312, 3.18360564985773}}};
const auto ResfWeightMatrix2to3 = std::array<simd::float_v, 7>{
    {-0.468166794846483, 0.905418443044577, 0.345720533590786,
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    -2.29725166588317}};
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