STATUS OF U2UT BASED ALGORITHMS

- INTRODUCTION
- FIRST RESULTS FOR VELO-UT AND UT-MT MATCHING
- OUTLOOKS

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General Introduction

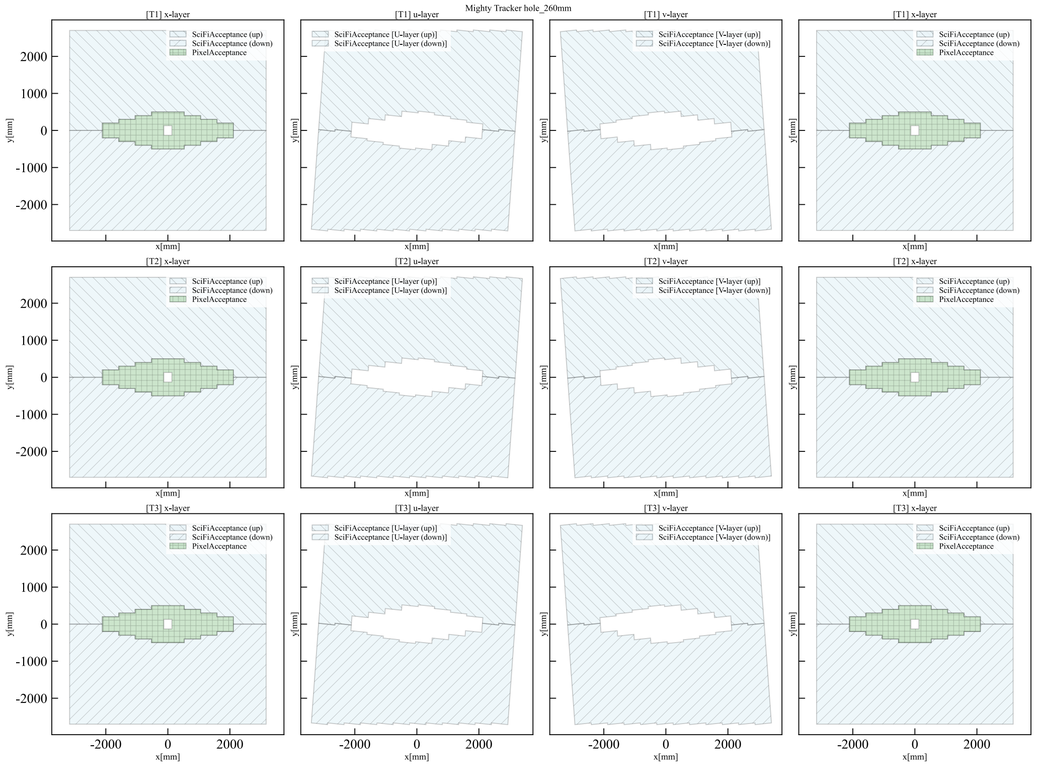
- The early results presented in the following slides are coming from:
  - The Pr_python (a.k.a Renato's python framework)
  - Early MC studies made within our working package.
- Other results can be found in Xuhao's presentation earlier today.
- **Short term goal**: developed/tune the new algorithms based on the new U2UT pixel design.
  - **Quick performance results** to test the various scoping scenarios with the different U2UT geometry (see Xuhao's presentation for more details).
  - Later, these algorithms will be integrated to the U2 proto-framework.
- Results are all **work-in-progress** and includes:
  - Standalone UT algorithms with different U2UT scoping geometries (see Carlos' presentation next).
  - Matching-based UT algorithms (with VeloTrack and MTTrack).

First results with the Pr_python framework

- General strategy of the Pr_python framework:
  - Take MCHits from gauss-on-gaussino simulation.
  - Emulated digitization via a (tunable) smearing strategy.
  - Run the algorithms and compute the efficiency/ghost rate with a PrChecker tool similar to the one in the LHCb framework.
- Simulations use Run 3 geometry with minimum bias pp@13TeV collisions with $\mathscr{L}_{inst.} = 1.3 * 10^{34} cm^{-2} s^{-1}$
  - 16 MCEvents (i.e bunch crossing) are used.
- Configuration for this presentation:

Smearing parameters

```
"VP" : {    "x_pitch_size" : 0.030,
            "y_pitch_size" : 0.030,
            "t_reso"       : 0.050,
            "hiteff"       : 0.99
},
"UT"   : { "x_pitch_size"   : 0.030,
           "y_pitch_size"   : 0.030,
           "t_pix_reso"     : 25.0,
           "hiteff"         : 0.99
},
"FT"   : { "x_scifi_pitch"     : 0.250,
           "t_scifi_reso"      : 1.2,
           "x_pix_pitch"       : 0.052,
           "y_pix_pitch"       : 0.150,
           "t_pix_reso"        : 1.2,
           "hiteff_pix"        : 0.96,
           "hiteff_fibre"      : 0.98,
           "speed_fibre_mm_per_ns"   : 150
}
```

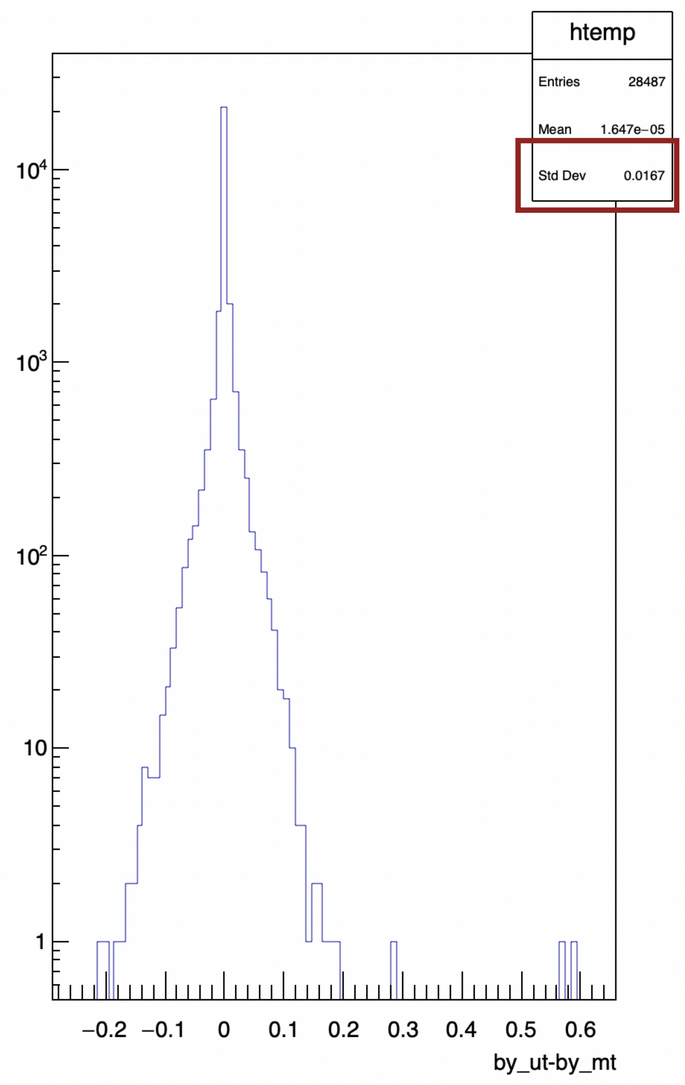


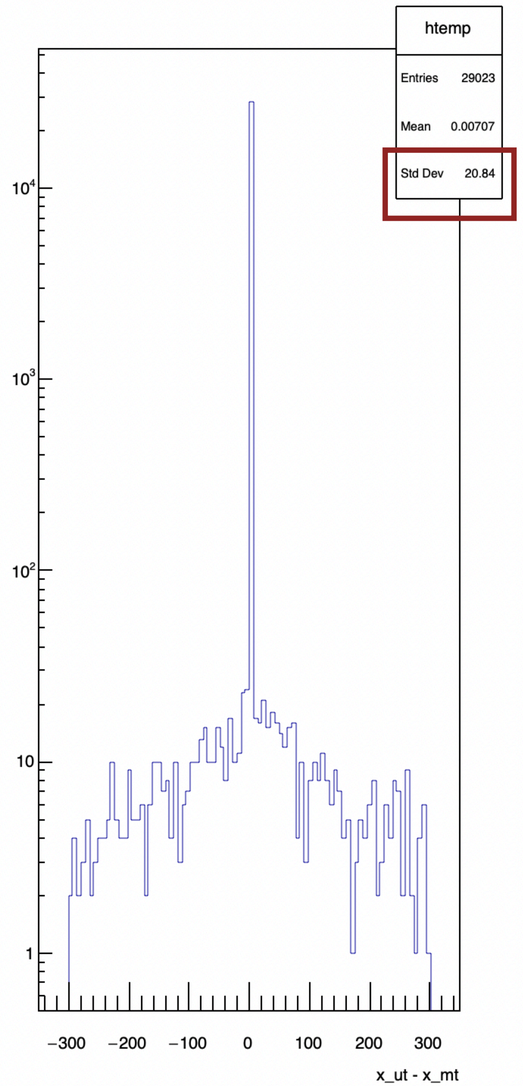
Baseline geometry for the MIGHTY

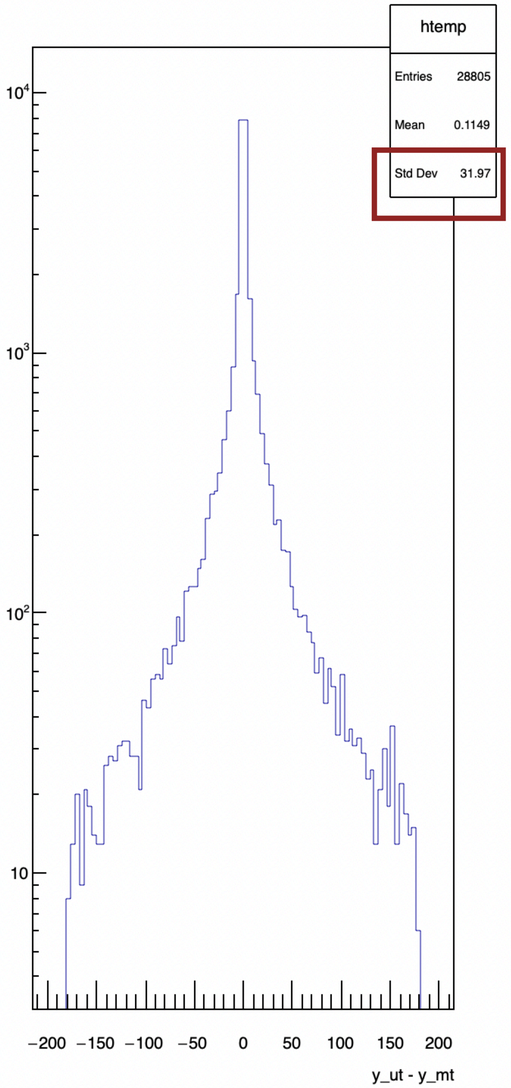
Velo-UT/UT-MT strategy

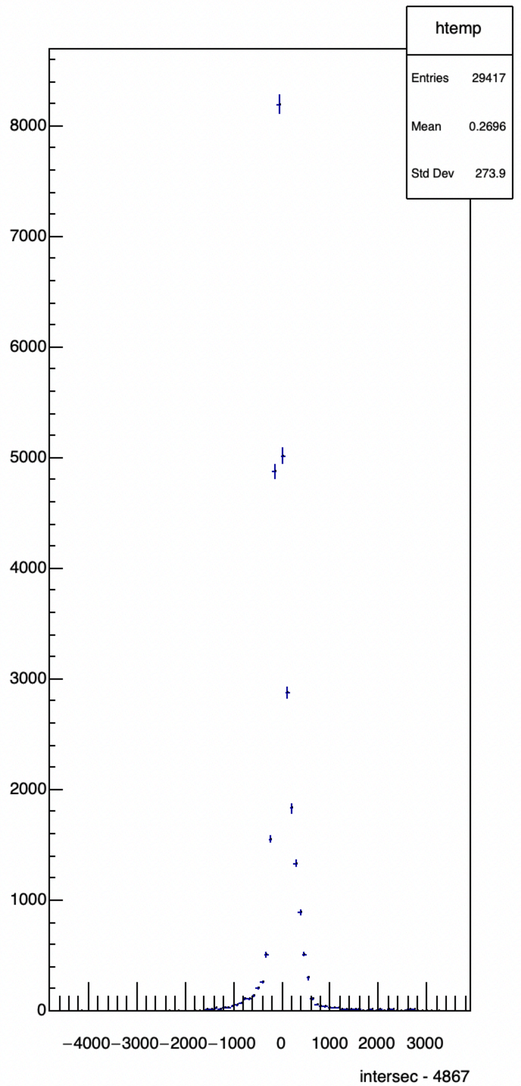
- Same strategy used for the two algorithms:
  - « cheated » algorithms are used for both the VeloTracks and UTTracks:
    - i.e. tracks are reconstructed with hits belonging to the same MCTrack.
    - Fit model is a straight line for Velo (x and y component) and a pol2 (pol1) for the UT x-component (y-component).
    - Inefficiency comes from fit instability and a χ^2/ndof cut at 100.
  - TTracks: realistic algorithms written by Renato, fitting the x-component (y-component) with a pol2 (pol1).
  - Velo-UT (UT-MT) tracks are extrapolated to the point of convergence
  - The value $\chi^2 = \frac{(x_{up} - x_{down})^2}{\sigma_x} + \frac{(y_{up} - y_{down})^2}{\sigma_y} + \frac{(by_{up} - by_{down})^2}{\sigma_{by}} (+ \frac{(bx_{up} - bx_{down})^2}{\sigma_{bx}})$
    - Last bit is for VELO-UT only
  - Track combination with the lowest χ^2 is kept for the matching.

MT-UT - extrapolation constraints



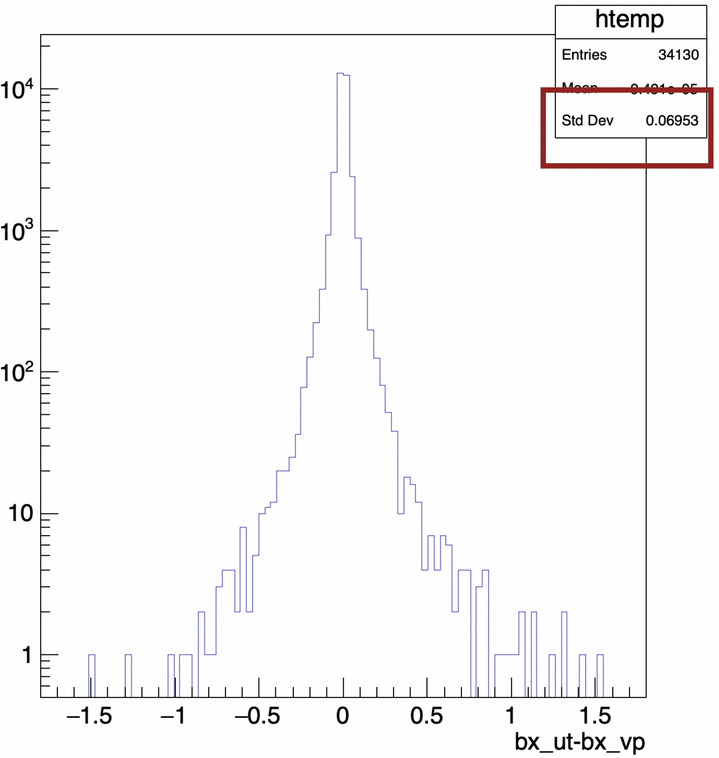


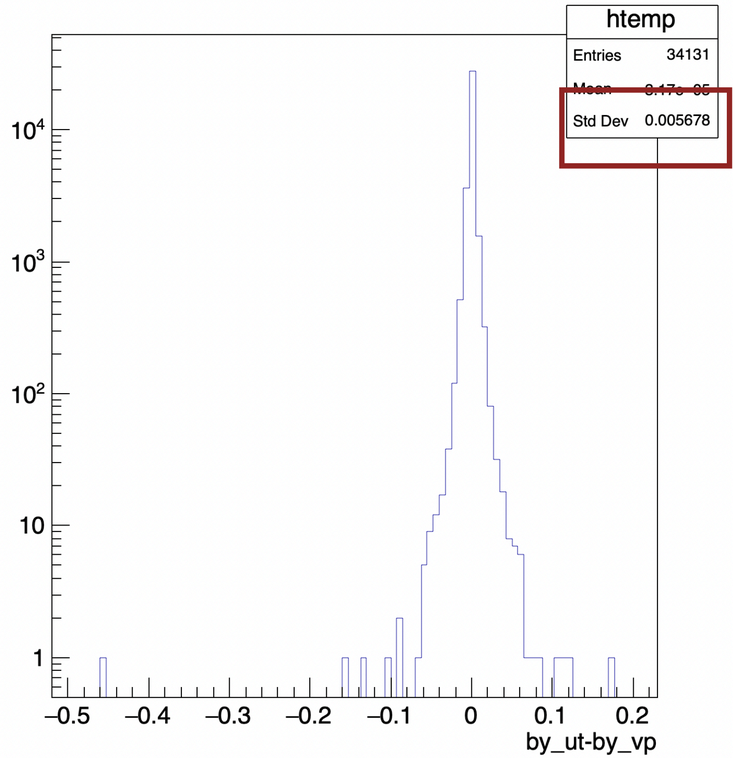


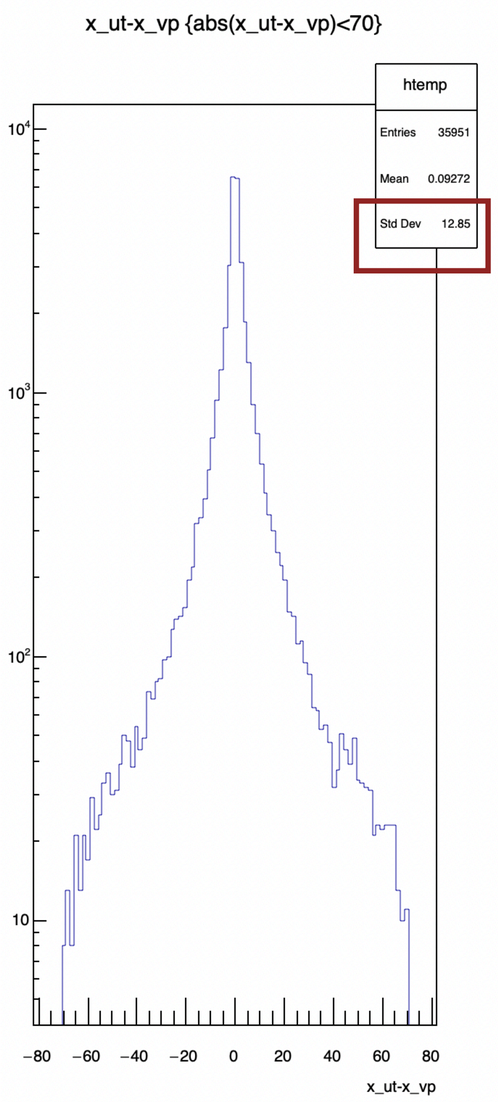


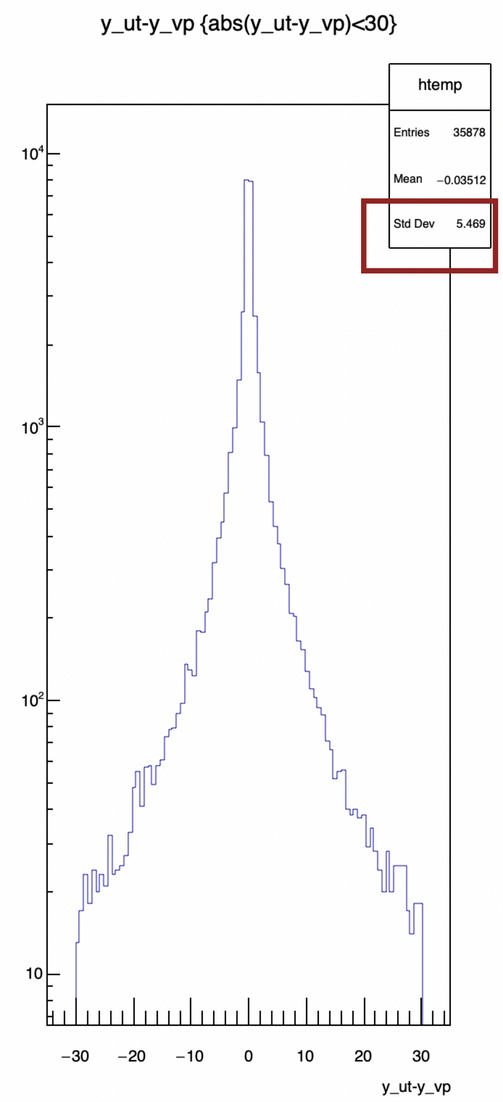
Studied down by fitting MCTrack only

VeloUT - extrapolation constraints









Studied down by fitting MCTrack only

« Tracklets » reference

Velo Tracks PrChecker

Category	# Recoed / # Recoble	Efficiency (%)	Clones (%)
HasVelo (all)	27505 / 30139	91.26 %	0 (0.00 %) [nTotMatch = 27505]
(!e) HasVelo (all)	25407 / 26268	96.72 %	0 (0.00 %) [nTotMatch = 25407]
HasVelo (all), eta>0	16847 / 18956	88.87 %	0 (0.00 %) [nTotMatch = 16847]
HasVelo (all), eta<0	10658 / 11183	95.31 %	0 (0.00 %) [nTotMatch = 10658]
HasVelo (all), eta[2,5]	12343 / 13938	88.56 %	0 (0.00 %) [nTotMatch = 12343]
HasVelo (all), eta[2,5], p > 5 GeV	6091 / 6139	99.22 %	0 (0.00 %) [nTotMatch = 6091]
Long eta[2,5]	6897 / 6994	98.61 %	0 (0.00 %) [nTotMatch = 6897]
Long eta[2,5], p>5GeV	4382 / 4419	99.16 %	0 (0.00 %) [nTotMatch = 4382]
LongUT (all)	6958 / 7055	98.63 %	0 (0.00 %) [nTotMatch = 6958]
LongUT eta[2,5]	6795 / 6891	98.61 %	0 (0.00 %) [nTotMatch = 6795]
LongUT eta[2,5], p>5GeV	4299 / 4335	99.17 %	0 (0.00 %) [nTotMatch = 4299]
(!e) Long (Pix-Pix)	3913 / 3956	98.91 %	0 (0.00 %) [nTotMatch = 3913]
(!e) Long (Pix-Pix), eta[2,5]	3522 / 3565	98.79 %	0 (0.00 %) [nTotMatch = 3522]
(!e) Long (Pix-Pix), eta[2,5], p>5GeV	2992 / 3016	99.20 %	0 (0.00 %) [nTotMatch = 2992]
(!e) LongUT (Pix-Pix)	3460 / 3502	98.80 %	0 (0.00 %) [nTotMatch = 3460]
(!e) LongUT (Pix-Pix), eta[2,5]	3435 / 3477	98.79 %	0 (0.00 %) [nTotMatch = 3435]
(!e) LongUT (Pix-Pix), eta[2,5], p>5GeV	2915 / 2938	99.22 %	0 (0.00 %) [nTotMatch = 2915]
HasVeloUT (all)	11504 / 12648	90.96 %	0 (0.00 %) [nTotMatch = 11504]
(!e) HasVeloUT (all)	10224 / 10683	95.70 %	0 (0.00 %) [nTotMatch = 10224]
HasVeloUT (all), eta[2,5]	10839 / 11939	90.79 %	0 (0.00 %) [nTotMatch = 10839]
HasVeloUT (all), eta[2,5], p > 5 GeV	5323 / 5365	99.22 %	0 (0.00 %) [nTotMatch = 5323]

Cheated

UT Tracks PrChecker

Category	# Recoed / # Recoble	Efficiency (%)	Clones (%)
HasVelo (all)	10849 / 30139	36.00 %	0 (0.00 %) [nTotMatch = 10849]
(!e) HasVelo (all)	9811 / 26268	37.35 %	0 (0.00 %) [nTotMatch = 9811]
HasVelo (all), eta>0	10849 / 18956	57.23 %	0 (0.00 %) [nTotMatch = 10849]
HasVelo (all), eta<0	0 / 11183	0.00 %	nan
HasVelo (all), eta[2,5]	10434 / 13938	74.86 %	0 (0.00 %) [nTotMatch = 10434]
HasVelo (all), eta[2,5], p > 5 GeV	5342 / 6139	87.02 %	0 (0.00 %) [nTotMatch = 5342]
HasUT (all)	15397 / 26244	58.67 %	0 (0.00 %) [nTotMatch = 15397]
(!e) HasUT (all)	12218 / 14366	85.05 %	0 (0.00 %) [nTotMatch = 12218]
HasUT (all), eta[2,5]	14191 / 20971	67.67 %	0 (0.00 %) [nTotMatch = 14191]
HasUT (all), eta[2,5], p > 5 GeV	6196 / 6242	99.26 %	0 (0.00 %) [nTotMatch = 6196]
HasVeloUT (all)	10849 / 12648	85.78 %	0 (0.00 %) [nTotMatch = 10849]
(!e) HasVeloUT (all)	9811 / 10683	91.84 %	0 (0.00 %) [nTotMatch = 9811]
HasVeloUT (all), eta[2,5]	10434 / 11939	87.39 %	0 (0.00 %) [nTotMatch = 10434]
HasVeloUT (all), eta[2,5], p > 5 GeV	5342 / 5365	99.57 %	0 (0.00 %) [nTotMatch = 5342]
Long (all)	6995 / 7643	91.52 %	0 (0.00 %) [nTotMatch = 6995]
Long eta[2,5]	6844 / 6994	97.86 %	0 (0.00 %) [nTotMatch = 6844]
Long eta[2,5], p>5GeV	4328 / 4419	97.94 %	0 (0.00 %) [nTotMatch = 4328]
LongUT (all)	6995 / 7055	99.15 %	0 (0.00 %) [nTotMatch = 6995]
LongUT eta[2,5]	6844 / 6891	99.32 %	0 (0.00 %) [nTotMatch = 6844]
LongUT eta[2,5], p>5GeV	4328 / 4335	99.84 %	0 (0.00 %) [nTotMatch = 4328]
(!e) Long (Pix-Pix)	3497 / 3956	88.40 %	0 (0.00 %) [nTotMatch = 3497]
(!e) Long (Pix-Pix), eta[2,5]	3472 / 3565	97.39 %	0 (0.00 %) [nTotMatch = 3472]
(!e) Long (Pix-Pix), eta[2,5], p>5GeV	2936 / 3016	97.35 %	0 (0.00 %) [nTotMatch = 2936]
(!e) LongUT (Pix-Pix)	3497 / 3502	99.86 %	0 (0.00 %) [nTotMatch = 3497]
(!e) LongUT (Pix-Pix), eta[2,5]	3472 / 3477	99.86 %	0 (0.00 %) [nTotMatch = 3472]
(!e) LongUT (Pix-Pix), eta[2,5], p>5GeV	2936 / 2938	99.93 %	0 (0.00 %) [nTotMatch = 2936]
Decay Down_Exclusive_tight eta[2,5], p>5GeV	218 / 220	99.09 %	0 (0.00 %) [nTotMatch = 218]
Decay Down_tight eta[2,5], p>5GeV	4130 / 4139	99.78 %	0 (0.00 %) [nTotMatch = 4130]

Cheated

TTracks Tracks PrChecker

Category	# Recoed / # Recoble	Efficiency (%)	Clones (%)
HasMT (all)	9282 / 17786	52.19 %	4 (0.04 %) [nTotMatch = 9284]
HasMT (pix-pix)	5753 / 9803	58.69 %	2 (0.03 %) [nTotMatch = 5754]
HasMT (fib-fib)	3483 / 5435	64.08 %	2 (0.06 %) [nTotMatch = 3484]
HasMT (pix-fib)	46 / 2554	1.80 %	0 (0.00 %) [nTotMatch = 46]
Down (all)	6917 / 8901	77.71 %	0 (0.00 %) [nTotMatch = 6917]
Down Exclusive (all)	1207 / 1846	65.38 %	0 (0.00 %) [nTotMatch = 1207]
Long (all)	6196 / 7643	81.07 %	0 (0.00 %) [nTotMatch = 6196]
Long eta[2,5]	5695 / 6994	81.43 %	0 (0.00 %) [nTotMatch = 5695]
Long eta[2,5], p>5GeV	3967 / 4419	89.77 %	0 (0.00 %) [nTotMatch = 3967]
LongUT (all)	5710 / 7055	80.94 %	0 (0.00 %) [nTotMatch = 5710]
LongUT eta[2,5]	5606 / 6891	81.35 %	0 (0.00 %) [nTotMatch = 5606]
LongUT eta[2,5], p>5GeV	3890 / 4335	89.73 %	0 (0.00 %) [nTotMatch = 3890]
(!e) Long eta[2,5]	5391 / 6540	82.43 %	0 (0.00 %) [nTotMatch = 5391]
(!e) Long eta[2,5], p>5GeV	3763 / 4165	90.35 %	0 (0.00 %) [nTotMatch = 3763]
(!e) Long (Pix-Pix)	3673 / 3956	92.85 %	0 (0.00 %) [nTotMatch = 3673]
(!e) Long (Pix-Pix), eta[2,5]	3326 / 3565	93.30 %	0 (0.00 %) [nTotMatch = 3326]
(!e) Long (Pix-Pix), eta[2,5], p>5GeV	2932 / 3016	97.21 %	0 (0.00 %) [nTotMatch = 2932]
(!e) Long (Fib-Fib)	2175 / 2579	84.34 %	0 (0.00 %) [nTotMatch = 2175]
(!e) Long (Fib-Fib), eta[2,5]	2048 / 2374	86.27 %	0 (0.00 %) [nTotMatch = 2048]
(!e) Long (Fib-Fib), eta[2,5], p>5GeV	822 / 890	92.36 %	0 (0.00 %) [nTotMatch = 822]
(!e) Long (Pix-Fib)	17 / 615	2.76 %	0 (0.00 %) [nTotMatch = 17]
(!e) Long (Pix-Fib), eta[2,5]	17 / 601	2.83 %	0 (0.00 %) [nTotMatch = 17]
(!e) Long (Pix-Fib), eta[2,5], p>5GeV	9 / 259	3.47 %	0 (0.00 %) [nTotMatch = 9]
(!e) LongUT eta[2,5]	5306 / 6442	82.37 %	0 (0.00 %) [nTotMatch = 5306]
(!e) LongUT eta[2,5], p>5GeV	3690 / 4086	90.31 %	0 (0.00 %) [nTotMatch = 3690]
(!e) LongUT (Pix-Pix)	3258 / 3502	93.03 %	0 (0.00 %) [nTotMatch = 3258]
(!e) LongUT (Pix-Pix), eta[2,5]	3245 / 3477	93.33 %	0 (0.00 %) [nTotMatch = 3245]
(!e) LongUT (Pix-Pix), eta[2,5], p>5GeV	2859 / 2938	97.31 %	0 (0.00 %) [nTotMatch = 2859]
(!e) LongUT (Fib-Fib)	2134 / 2496	85.50 %	0 (0.00 %) [nTotMatch = 2134]
(!e) LongUT (Fib-Fib), eta[2,5]	2044 / 2365	86.43 %	0 (0.00 %) [nTotMatch = 2044]
(!e) LongUT (Fib-Fib), eta[2,5], p>5GeV	822 / 889	92.46 %	0 (0.00 %) [nTotMatch = 822]
(!e) LongUT (Pix-Fib)	17 / 606	2.81 %	0 (0.00 %) [nTotMatch = 17]
(!e) LongUT (Pix-Fib), eta[2,5]	17 / 600	2.83 %	0 (0.00 %) [nTotMatch = 17]
(!e) LongUT (Pix-Fib), eta[2,5], p>5GeV	9 / 259	3.47 %	0 (0.00 %) [nTotMatch = 9]
Decay Down_Exclusive_tight eta[2,5], p>5GeV	188 / 220	85.45 %	0 (0.00 %) [nTotMatch = 188]
Decay Down_tight eta[2,5], p>5GeV	3737 / 4139	90.29 %	0 (0.00 %) [nTotMatch = 3737]

Realistic

- These numbers are used as references.
- Reconstructible criteria:

```
"hasVelo"     : 3,
"hasUT"       : 3,
"hasT_nXPerStationMin": 1,
"hasT_nYPerStationMin": 1
```

Velo-UT/UT-MT matching - results

- Results from Velo-UT matching:
  - **78% efficiency** for tracks flag « HasVeloUT ».
- Results from UT-MT matching:
  - **79% efficiency** for the « decay » category (i.e. long lived particle).
- High ghost rate for both algorithms:
  - To be studied.

VeloUT Tracks PrChecker

Category	# Recoed / # Recoble	Efficiency (%)	Clones (%)
HasVelo (all)	6479 / 30139	21.50 %	0 (0.00 %) [nTotMatch = 6479]
(!e) HasVelo (all)	6306 / 26268	24.01 %	0 (0.00 %) [nTotMatch = 6306]
HasVelo (all), eta>0	6479 / 18956	34.18 %	0 (0.00 %) [nTotMatch = 6479]
HasVelo (all), eta<0	0 / 11183	0.00 %	nan
HasVelo (all), eta[2,5]	6189 / 13938	44.40 %	0 (0.00 %) [nTotMatch = 6189]
HasVelo (all), eta[2,5], p > 5 GeV	4168 / 6139	67.89 %	0 (0.00 %) [nTotMatch = 4168]
HasUT (all)	6479 / 26244	24.69 %	0 (0.00 %) [nTotMatch = 6479]
(!e) HasUT (all)	6306 / 14366	43.90 %	0 (0.00 %) [nTotMatch = 6306]
HasUT (all), eta[2,5]	6189 / 20971	29.51 %	0 (0.00 %) [nTotMatch = 6189]
HasUT (all), eta[2,5], p > 5 GeV	4168 / 6242	66.77 %	0 (0.00 %) [nTotMatch = 4168]
HasVeloUT (all)	6479 / 12648	51.23 %	0 (0.00 %) [nTotMatch = 6479]
(!e) HasVeloUT (all)	6306 / 10683	59.03 %	0 (0.00 %) [nTotMatch = 6306]
HasVeloUT (all), eta[2,5]	6189 / 11939	51.84 %	0 (0.00 %) [nTotMatch = 6189]
HasVeloUT (all), eta[2,5], p > 5 GeV	4168 / 5365	77.69 %	0 (0.00 %) [nTotMatch = 4168]
(!e) LongUT eta[2,5]	4457 / 6442	69.19 %	0 (0.00 %) [nTotMatch = 4457]
(!e) LongUT eta[2,5], p>5GeV	3245 / 4086	79.42 %	0 (0.00 %) [nTotMatch = 3245]
(!e) LongUT (Pix-Pix)	2389 / 3502	68.22 %	0 (0.00 %) [nTotMatch = 2389]
(!e) LongUT (Pix-Pix), eta[2,5]	2378 / 3477	68.39 %	0 (0.00 %) [nTotMatch = 2378]
(!e) LongUT (Pix-Pix), eta[2,5], p>5GeV	2200 / 2938	74.88 %	0 (0.00 %) [nTotMatch = 2200]
(!e) LongUT (Fib-Fib)	1879 / 2496	75.28 %	0 (0.00 %) [nTotMatch = 1879]
(!e) LongUT (Fib-Fib), eta[2,5]	1771 / 2365	74.88 %	0 (0.00 %) [nTotMatch = 1771]
(!e) LongUT (Fib-Fib), eta[2,5], p>5GeV	834 / 889	93.81 %	0 (0.00 %) [nTotMatch = 834]
(!e) LongUT (Pix-Fib)	314 / 606	51.82 %	0 (0.00 %) [nTotMatch = 314]
(!e) LongUT (Pix-Fib), eta[2,5]	308 / 600	51.33 %	0 (0.00 %) [nTotMatch = 308]
(!e) LongUT (Pix-Fib), eta[2,5], p>5GeV	211 / 259	81.47 %	0 (0.00 %) [nTotMatch = 211]
# Events	# Recoed Tracks	# Fake Tracks	Ghost Rate
16	24866	18387	73.94 %

DownTracks Tracks PrChecker

Category	# Recoed / # Recoble	Efficiency (%)	Clones (%)
Long (all)	4174 / 7643	54.61 %	0 (0.00 %) [nTotMatch = 4174]
Long eta[2,5]	4103 / 6994	58.66 %	0 (0.00 %) [nTotMatch = 4103]
Long eta[2,5], p>5GeV	3323 / 4419	75.20 %	0 (0.00 %) [nTotMatch = 3323]
LongUT (all)	4174 / 7055	59.16 %	0 (0.00 %) [nTotMatch = 4174]
LongUT eta[2,5]	4103 / 6891	59.54 %	0 (0.00 %) [nTotMatch = 4103]
LongUT eta[2,5], p>5GeV	3323 / 4395	75.66 %	0 (0.00 %) [nTotMatch = 3323]
Down_loose (all)	4923 / 9181	53.62 %	0 (0.00 %) [nTotMatch = 4923]
Down_loose eta[2,5]	4821 / 8894	54.21 %	0 (0.00 %) [nTotMatch = 4821]
Down_loose eta[2,5], p>5GeV	3778 / 5280	71.55 %	0 (0.00 %) [nTotMatch = 3778]
Down_tight (all)	4921 / 8901	55.29 %	0 (0.00 %) [nTotMatch = 4921]
Down_tight eta[2,5]	4819 / 8617	55.92 %	0 (0.00 %) [nTotMatch = 4819]
Down_tight eta[2,5], p>5GeV	3777 / 5052	74.76 %	0 (0.00 %) [nTotMatch = 3777]
Decay Down_Exclusive_tight eta[2,5], p>5GeV	171 / 220	77.73 %	0 (0.00 %) [nTotMatch = 171]
Decay Down_tight eta[2,5], p>5GeV	3246 / 4139	78.42 %	0 (0.00 %) [nTotMatch = 3246]
(!e) LongUT (Pix-Pix)	2677 / 3502	76.44 %	0 (0.00 %) [nTotMatch = 2677]
(!e) LongUT (Pix-Pix), eta[2,5]	2671 / 3477	76.82 %	0 (0.00 %) [nTotMatch = 2671]
(!e) LongUT (Pix-Pix), eta[2,5], p>5GeV	2444 / 2938	83.19 %	0 (0.00 %) [nTotMatch = 2444]
(!e) LongUT (Fib-Fib)	1349 / 2496	54.05 %	0 (0.00 %) [nTotMatch = 1349]
(!e) LongUT (Fib-Fib), eta[2,5]	1284 / 2365	54.29 %	0 (0.00 %) [nTotMatch = 1284]
(!e) LongUT (Fib-Fib), eta[2,5], p>5GeV	755 / 889	84.93 %	0 (0.00 %) [nTotMatch = 755]
# Events	# Recoed Tracks	# Fake Tracks	Ghost Rate
16	13504	8578	63.52 %

Outlooks

- Points to take home:
  - **First running algorithms** for Velo-UT/UT-MT matching in Pr_python framework.
    - Good efficiency found for both algorithms (efficiency ~ 79%).
    - Significant Ghost Rate (> 60%) to be investigated.

Ideas and suggestions are welcomed

- **Next steps:**
  - Complete the « UT matching » algorithm family with the LongTrack in Pr_python.
    - Compare with the early results with the « cheated » results shown before.
  - Complete the performance studies for the various scoping scenarios.
    - Improve the algorithms (use realistic ones, better fit strategy? using momentum resolution ?).
    - Mixe MT and UT geometry.
    - Adding PbPb studies.
  - Finalize the number with Run 5 simulations.

	VELO	UT	MT	VELO-UT	UT-MT
HasVeloUT (all), eta[2,5], p > 5 GeV	99 %	99 %	-	78 %	-
Decay Down_tight eta[2,5], p>5GeV	-	99 %	90 %	-	79 %