Tracking in Calorimeters Reloaded

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Highly Granular Calorimetry

CALICE Calorimeter prototypes

highly granular structure (here: Analog HCal)

New possibilities of looking into physics

e.g. tracks of MIPs in hadronic showers

	13		25	79	37	7 9	49	7 9	61				
	13/73	19 _{/73}	25 _{/73}	31/73	37 _{/73}	43 _{/73}	⁴⁹ ⁄73	55 _{/73}	в1 _{/73}	67 _{/73}	73 _{/73}	79	
1/	13 _{/67}	19 _{/67}						55 _{/87}					
⁷ 61	13 _{/61}	19 _{/81}	25 _{/β1}	31/ ₆₁	37 _{/81}	43 _{/81}	49 _{/81}	55 _{/β1}	В1 _{/В1}	67 _{/61}	73 _{/β1}	79	/
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1/49	13/49	19/49	25 _{/49}	31/ ₅₂ 34/ ₅₂ 31/49 ³⁴ /49 31/.34/.	37/52 ⁴⁰ /52 37/46 ⁴⁰ /40	⁴³ /52 ⁴⁸ /52 ⁴³ /40 ⁴⁸ /40	49/52 ⁵² /52	55/52 ⁵⁸ /52	81/49	B7/49	73 ₄₉		/
	13/	19/	25/	746 746	746 746	⁴³ / ₄₈ ⁴⁸ / ₄₈ ⁴³ / ₄₃ ⁴⁸ / ₄₃	49/48 ⁵² /48 49/43 ⁵² /43	55/46 ⁵⁸ /46 55/43 ⁵⁸ /43	⁶¹ /43	67 _{/43}	73 _{/43}	>	43
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¹ ⁄ ₂₅	13/25	19/25	25 _{/25}	31/25	37/25	43/25	49/25	55/25	B1/25	67 _{/25}	73/ ₂₅	79	_
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13	13/13	19/13	²⁵ ⁄13	31/13	37/13	⁴³ ⁄13	49/13	55 _{/13}	⁶¹ /13	⁶⁷ /13	73/ ₁₃		
≜ y	¥	19	1	31	1	43	1	55	1	67	1		



Tracking in the AHCal

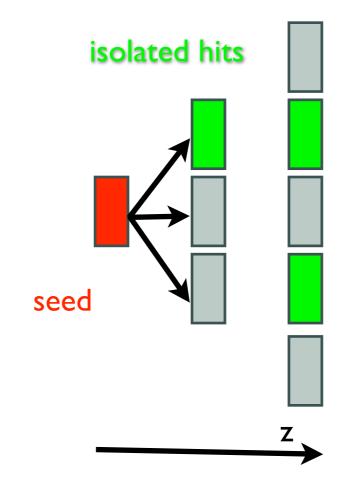
Already presented in CAN-022

- Nearest Neighbour algorithm
- Needs I hit per layer
- Based on layer isolated hits,
 i.e. hits with no adjacent hits in the same layer

Plan: Publication (JINST?)

Rewrite of code

- No fundamental changes
- Usage of official geometry classes
- Made algorithm more general
 - Completely recursive implementation
 - With simplification: No need for special treatment of certain geometric cases
 - Improving identification of inclined tracks with gaps





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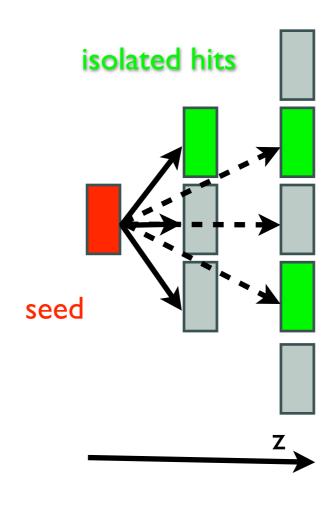
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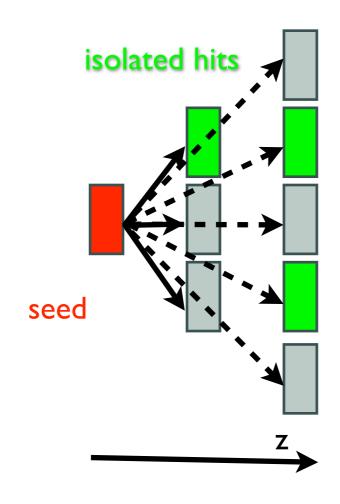




Tracking in the AHCal

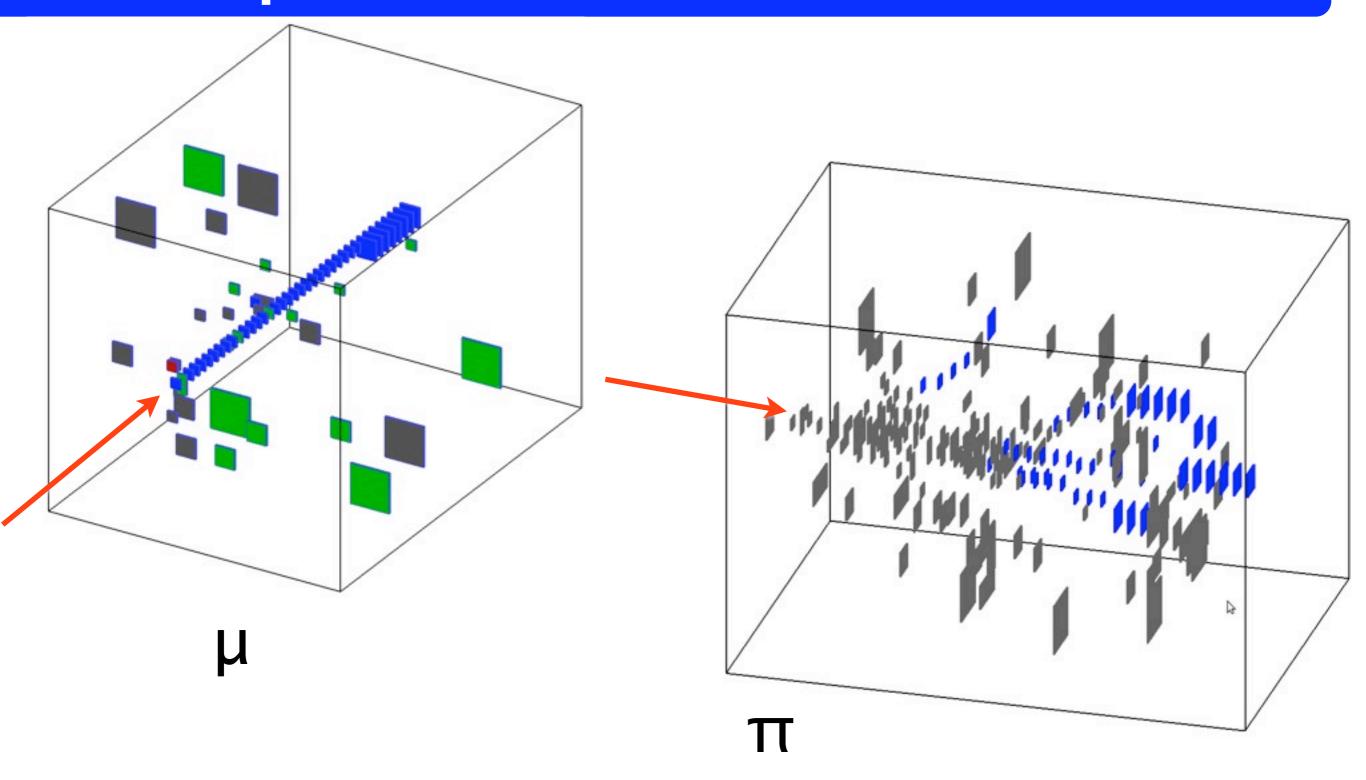
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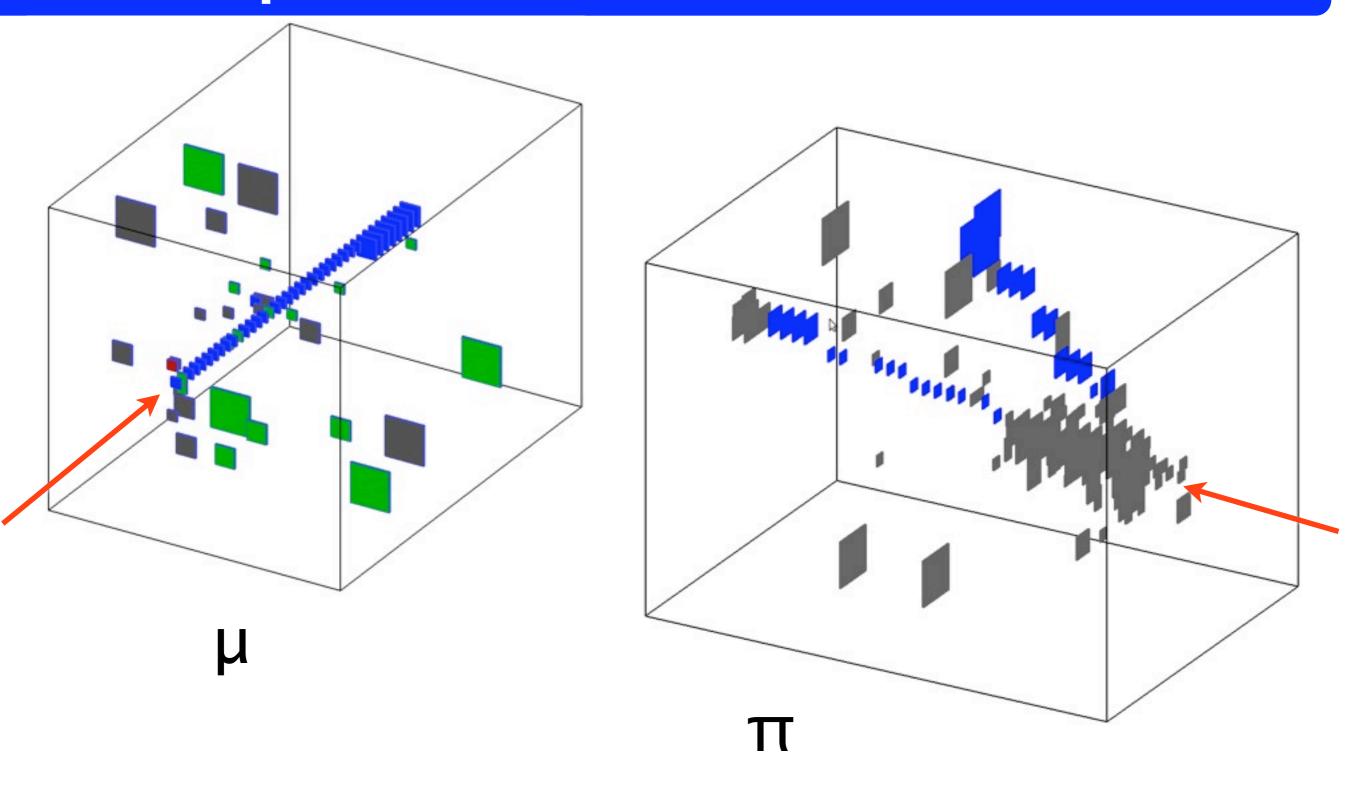


Example events





Example events





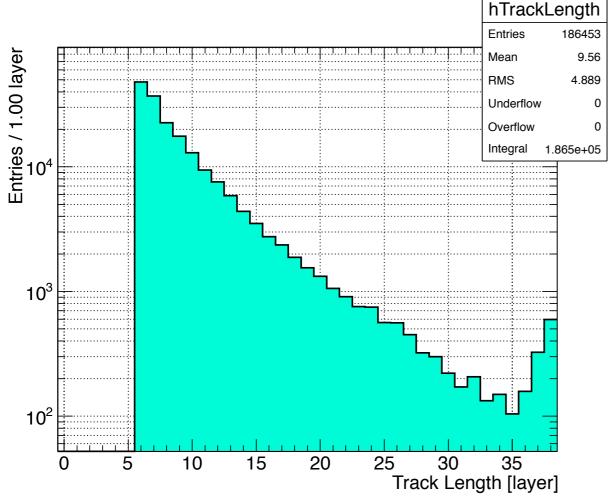
Track multiplicity / Track length

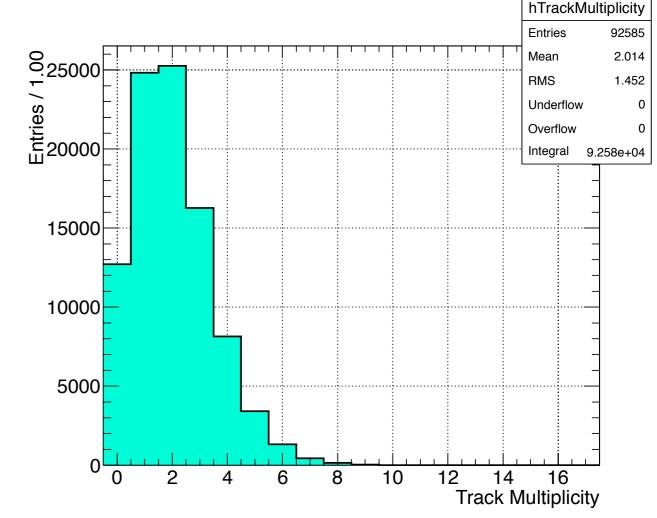
For Run 330325

— 25 GeV pi-

On average: 2.01 tracks / evt

Old tracker (different 25 GeV run):I.6 tracks / evt





Exponentially decreasing tracklength

 \rightarrow hadronic interaction length λ_0

Quick estimation of λ_0 (straight, primary tracks):

$$\lambda_0 = 8.1 \text{ layers}$$

$$\lambda_{0,PDG} = 8.88 \text{ layers}$$



Track segments by MIPs: Langau

Energy deposition of MIPs:

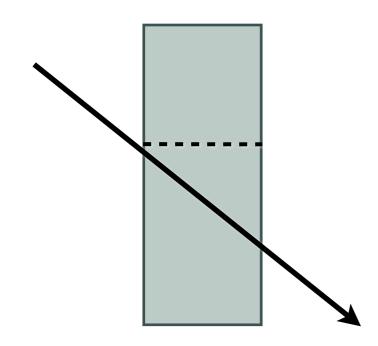
— Landau ⊗ Gauss: "Langau"

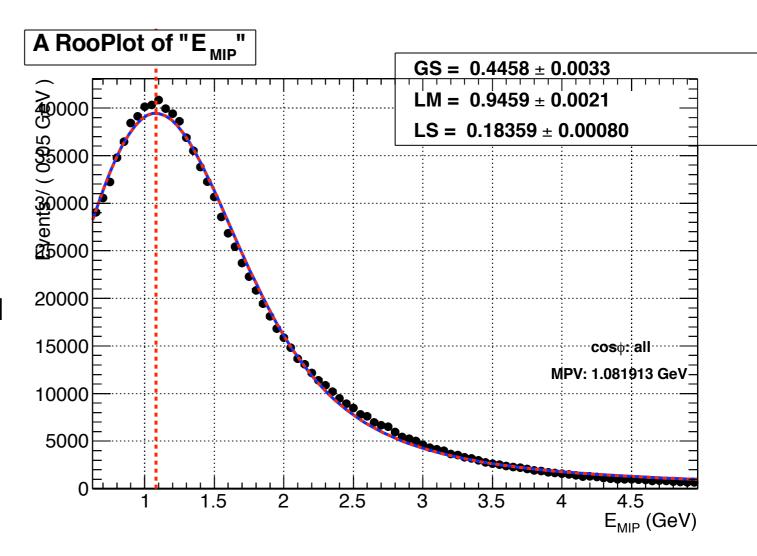
Similar Fit like in FitMip package:

- MPV = 1.08 GeV (all tracks)

Energy deposition higher for inclined tracks

MPV = 0.99 GeV (straight tracks)





Run 331333: 60 GeV Pion



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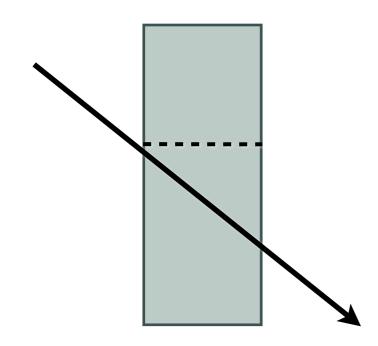
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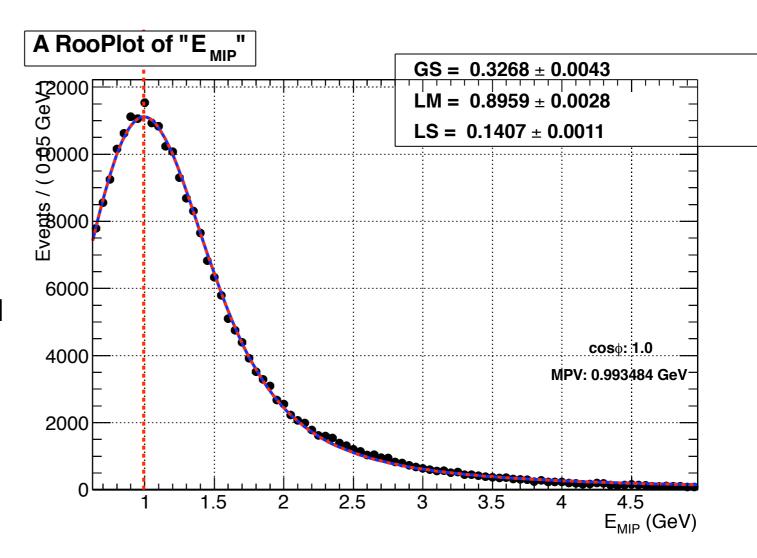
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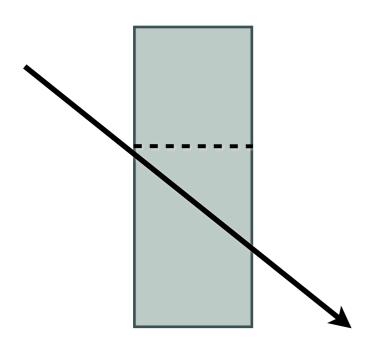




Run 331333: 60 GeV Pion



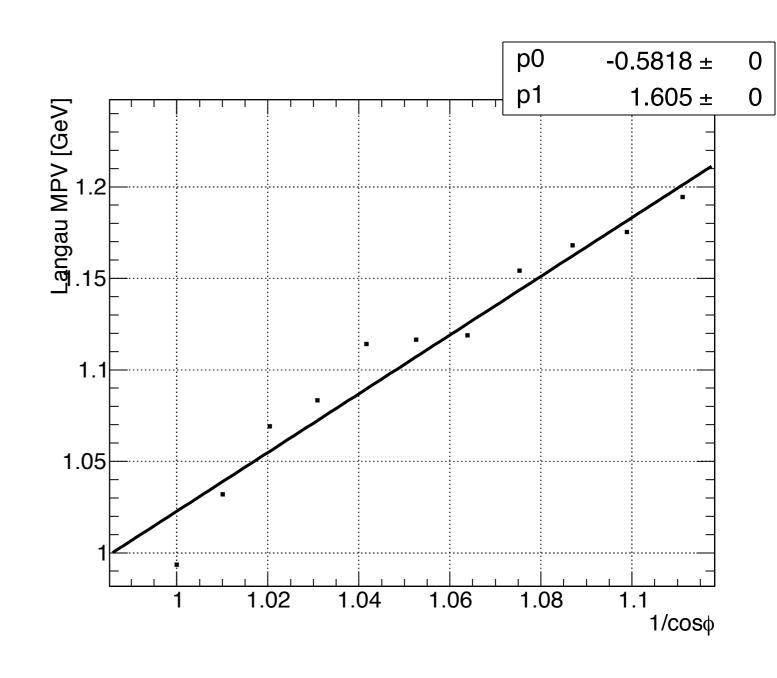
Langau MPV: Track angle dependence



Longer distance @ inclined tracks

higher E_{dep}

-[expected: E_{dep} ∝ I/cos φ





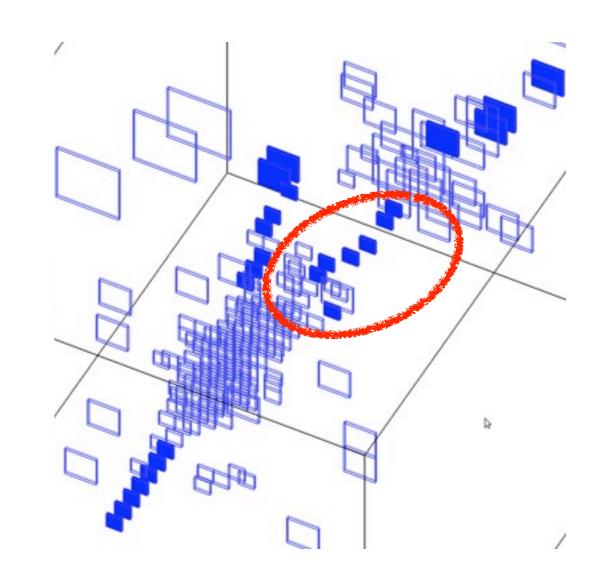
Track finding: Imperfections

Nearest Neigbour Algorithm

- No usage of physical flight trajectory
- Noise hits influence track direction

Solution:

- Track Fitting
- More advanced algorithms
- However: No/Small influence for
- Straight/primary tracks
- MC ⇔ Data comparison





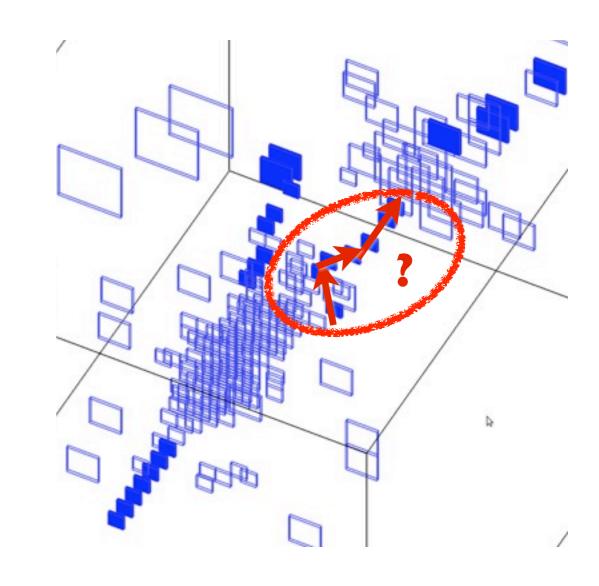
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Publication Plan

- Description of algorithm
- Monte Carlo ↔ Data comparison
- observables
 - track multiplicity / event
 - track length
 - track angle
- physics lists
 - LHEP, CHIPS
 - FTF BIC, FTFP BERT

 QGSP	BERT (TRV),	QGSP	BERT	CHIPS,	QGSP	FTFP	BERT,	QGS	BIC

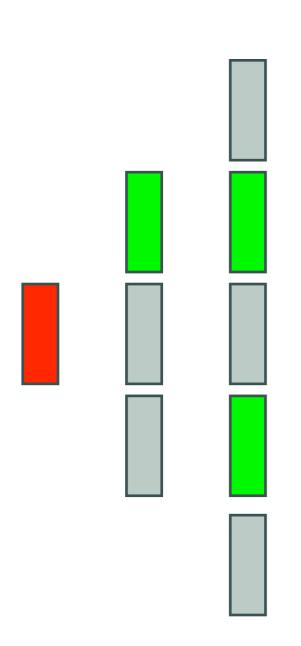
- ... (suggestions)?
- energy range: 10 to 80 GeV (same run list as software compensation paper)

maybe: track length of primary, non inclined tracks \rightarrow nuclear interaction length?



Run	energy [GeV]	particle
330777	10	π-
330328	15	π-
330327	18	π-
330649	20	π-
331340	30	π+
330551	35	π-
330412	40	π-
330559	45	π-
330391	50	π-
331655	60	π-
331567	80	π+

Backup: Tracking Algorithm

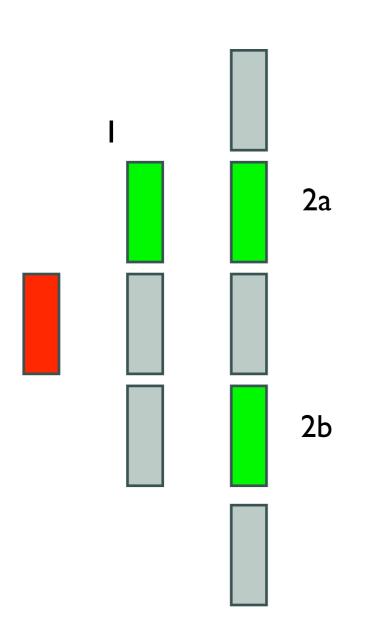


For each isolated hit as track start:

- Collect isolated hits in the consecutive 2 layers
- Sort them by distance to track start
- Search for tracks with each of these as new track start point
 - Avoid double counting of hits
 - (Here: Hit I will use Hit 2a in its track, hence there is no possibility to start an independent track from Hit 2a)
- Merge with longest track



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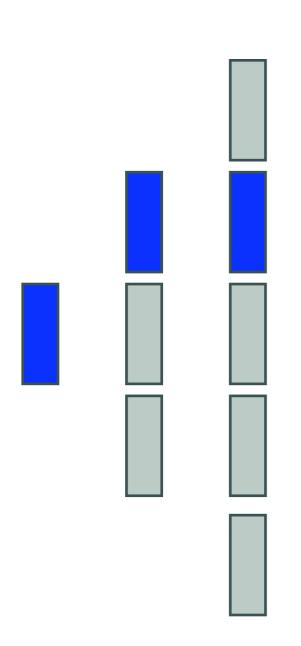


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