TRACKING AND SOFTWARE PACKAGE DEVELOPED FOR BONuS

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On behalf of the BONuS tracking group

CLAS Collaboration Meeting-
Deep Processes Working Group
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- Track Finder
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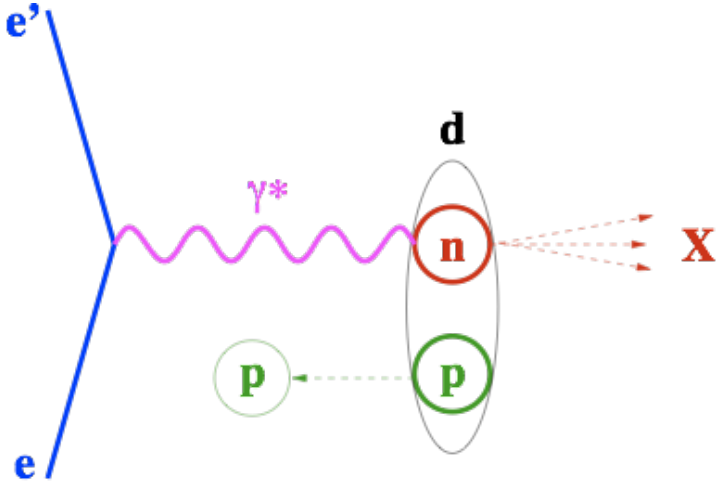
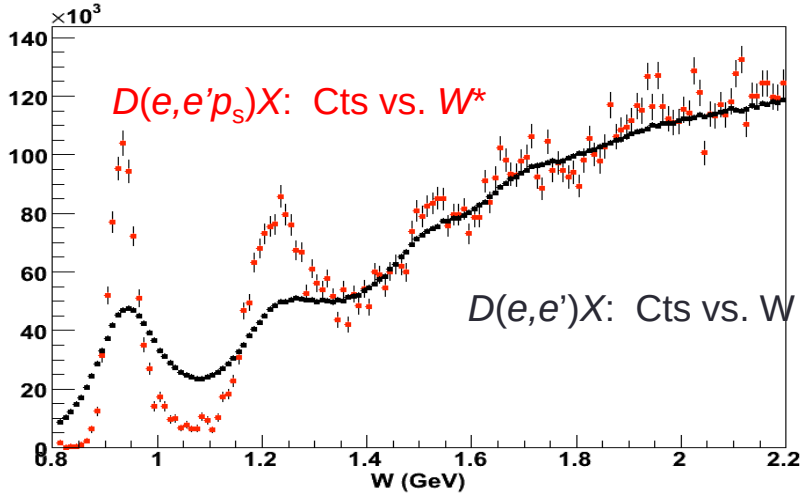
BONuS Experiment

- Barely Off-Shell Nucleon Structure experiment E12-06-113
- Measurement of neutron SF: Q^2 1 to 14 GeV^2/c^2

and $x \approx 0.1$ to 0.8.

- "Spectator tagging" technique.
  - Detection of low momentum recoil proton (down to 70 MeV/c) in coincidence with scattered electrons.

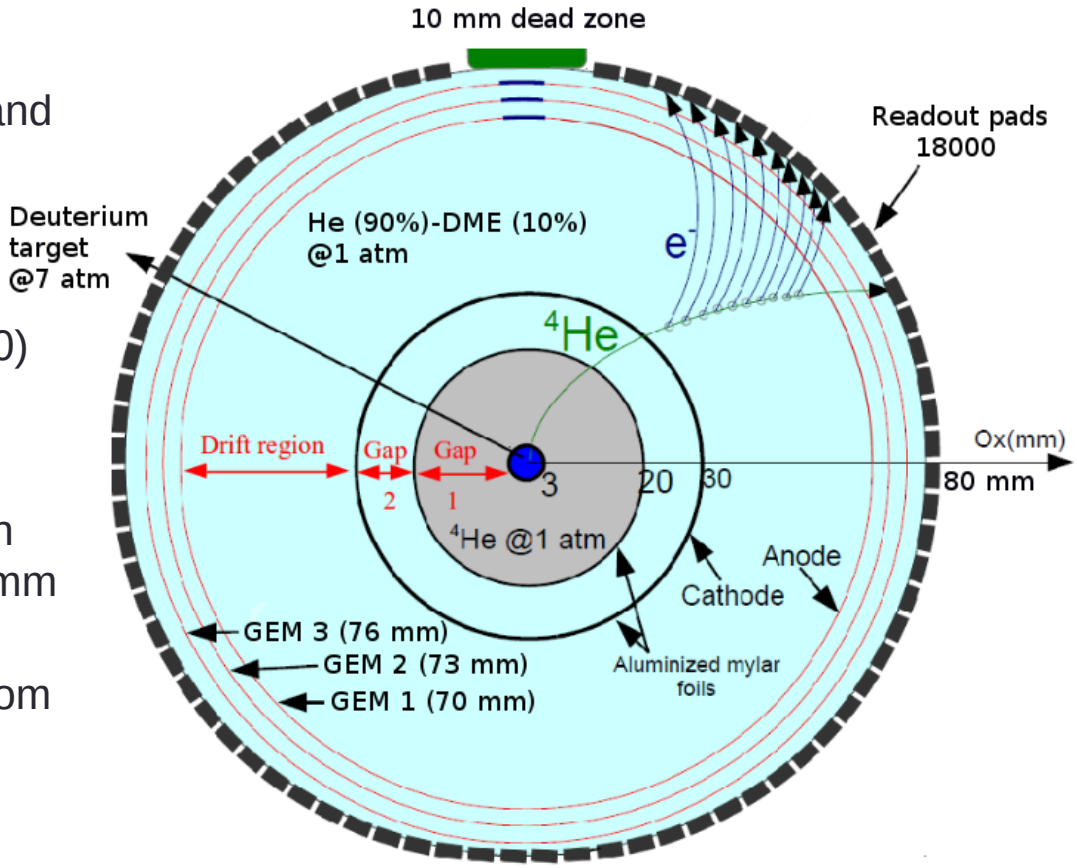




BONuS RTPC

- Recoil detector based in the RTPC design

- Target D2, 293K, 7atm, 3mm radius and 40 cm long.
- Target wall 28 μm kapton.
- Drift region: 3<R<7cm
- Drift gas: 293K, 1atm, He/DME (90/10)
- Phi coverage: 360°
- 3 GEM layers separated 3 mm.
- Readout through 100x200 pads. Each pad 4 mm long (Z-direction) and 2.5 mm (Phi-direction).
- Pad signal read by “DREAM” chips from Saclay.



Track Finder I

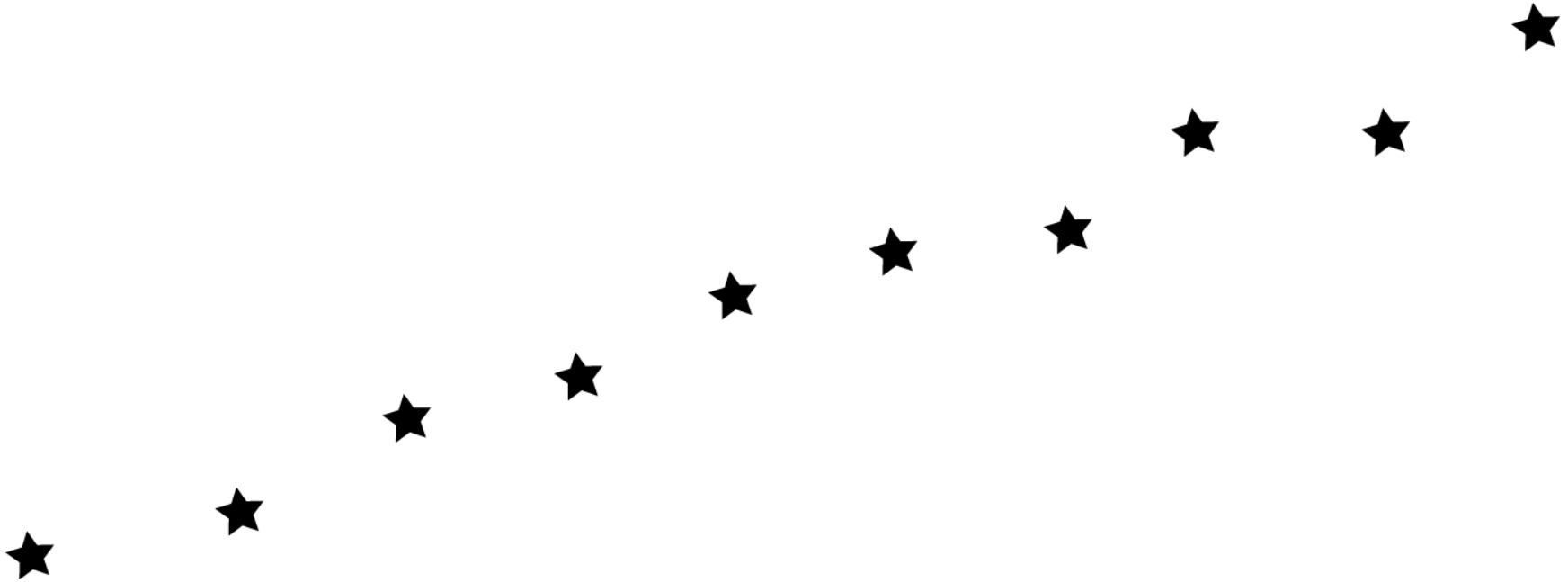
- Naïve Track Following method (**R.Mankel arXiv:physics/0402039v1**), and based on H. Fenker code for BONuS6.
- Works well but it can’t resolve crossing tracks.

- BONuS 12:
  - Higher luminosity increases the probability of crossing tracks.
  - An angular constrain is used in the search code to improve the search .
  - Need of sorting the hits in the candidate chain, in distance from cathode –> GEM in order to feed the Kalman Filter properly.

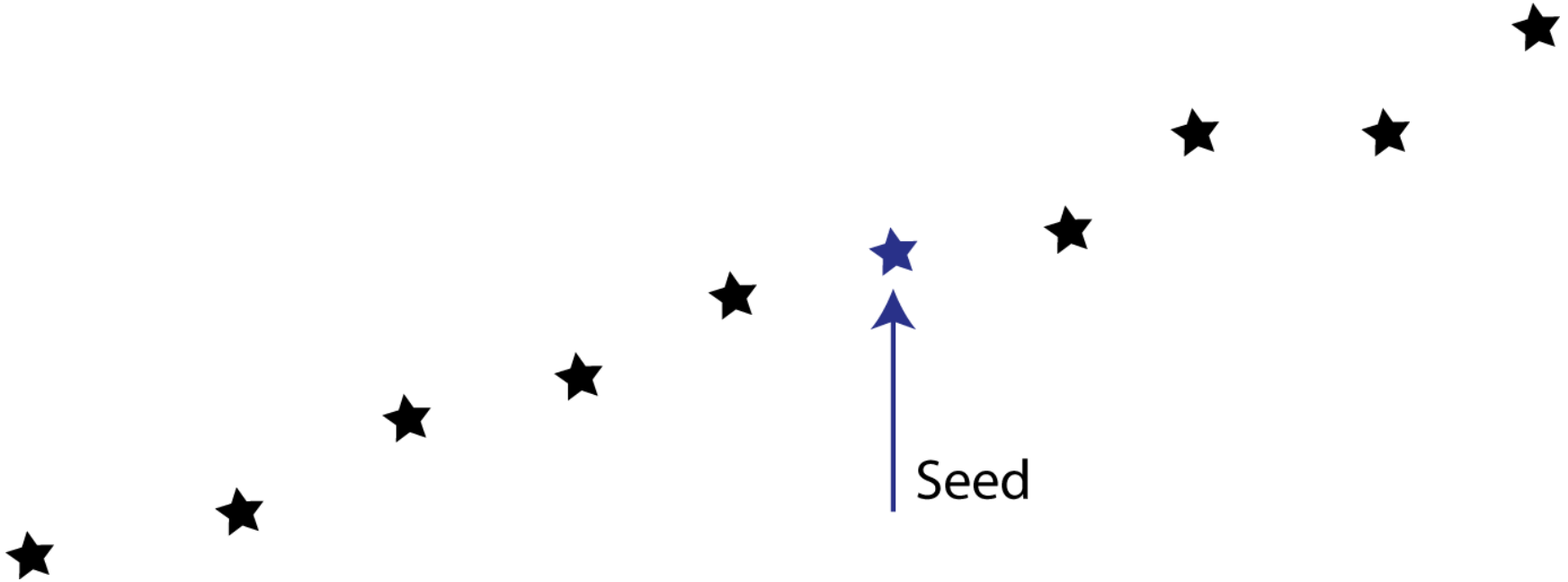
Track Finder Algorithm

- From all hits in a given event (hits pool):
  - First step
    - Take a hit (anchor and 1st seed) and calculates its distance to ALL hits in the pool.
    - Those who accomplish the condition to be under the distance stipulated are marked as part of the chain.
  - Second step
    - Moving the pivot to the marked hits in the first step, the search is repeated as before.
    - Considering a vector formed from the first hit in the chain (original seed) and the next hit in the chain (present pivot), the angle formed between such vector and the one formed by the present pivot and the temporary accepted hit is calculated.
    - If the angle calculated is within the stipulated cone, the hit is marked as part of the chain.
- Following steps
  - Move the pivot to one of the accepted hits and repeat from second step

Graphic Example

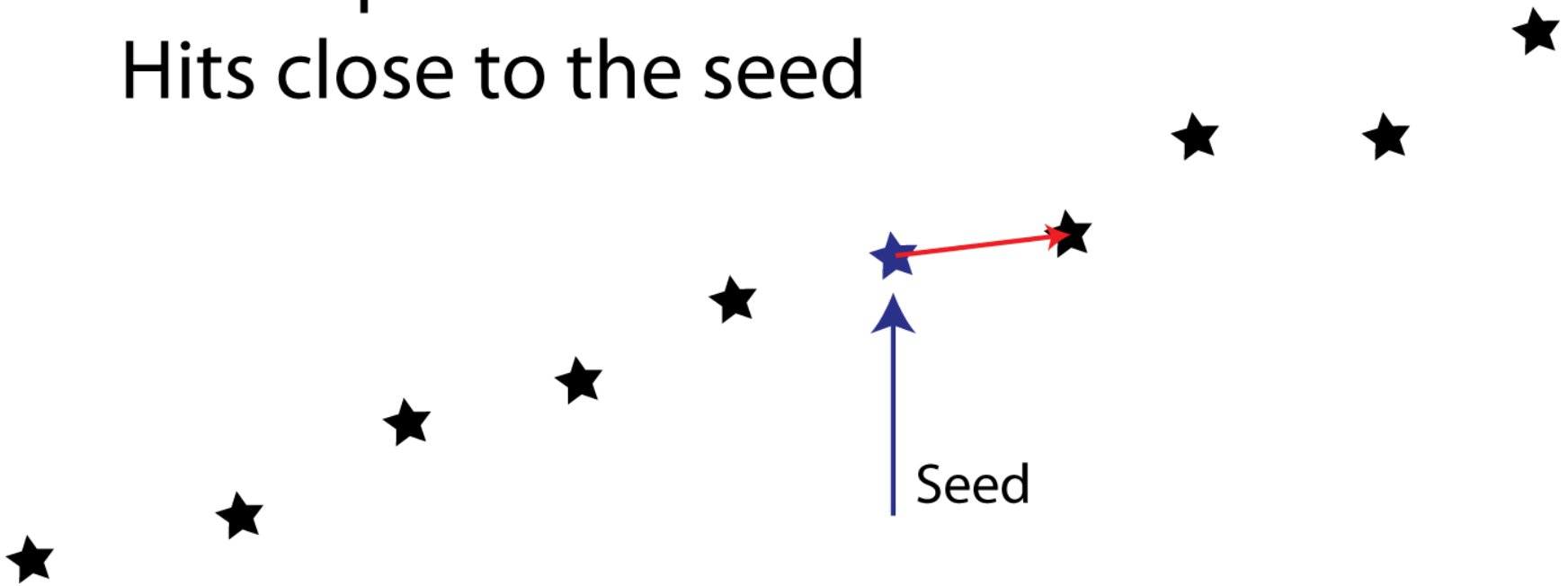


Graphic Example



Graphic Example

1st Step
Hits close to the seed



Graphic Example

1st Step
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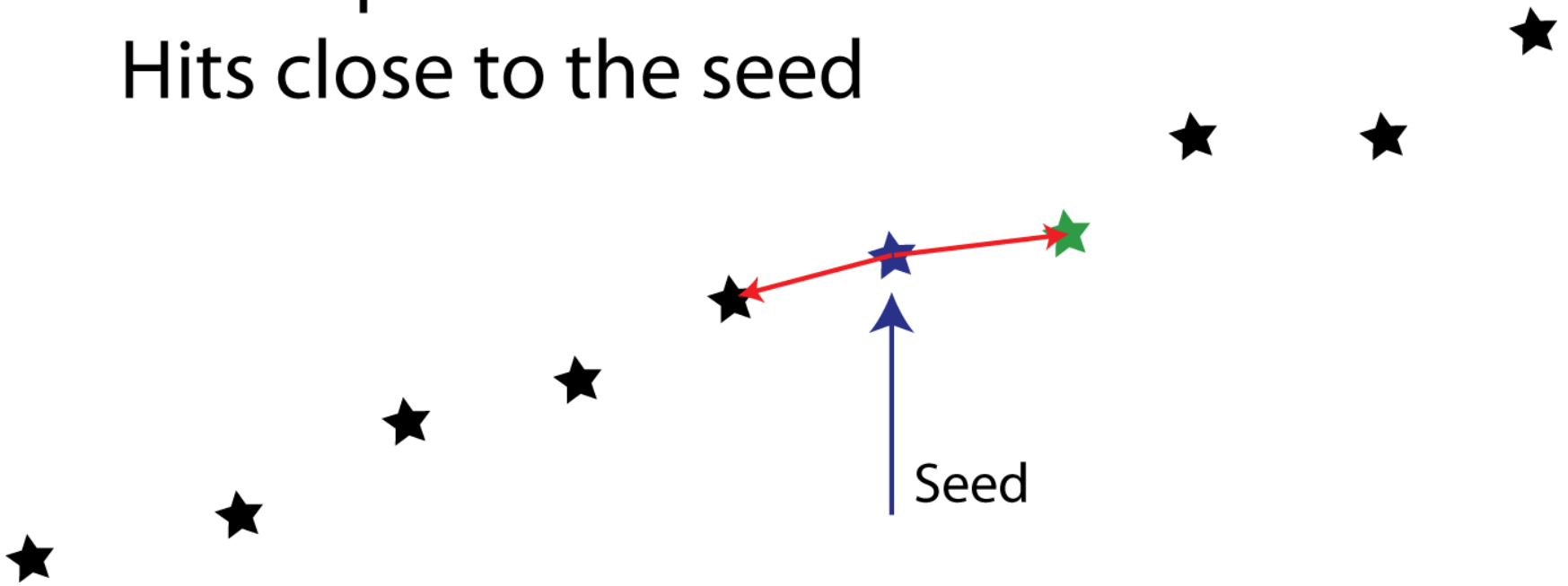
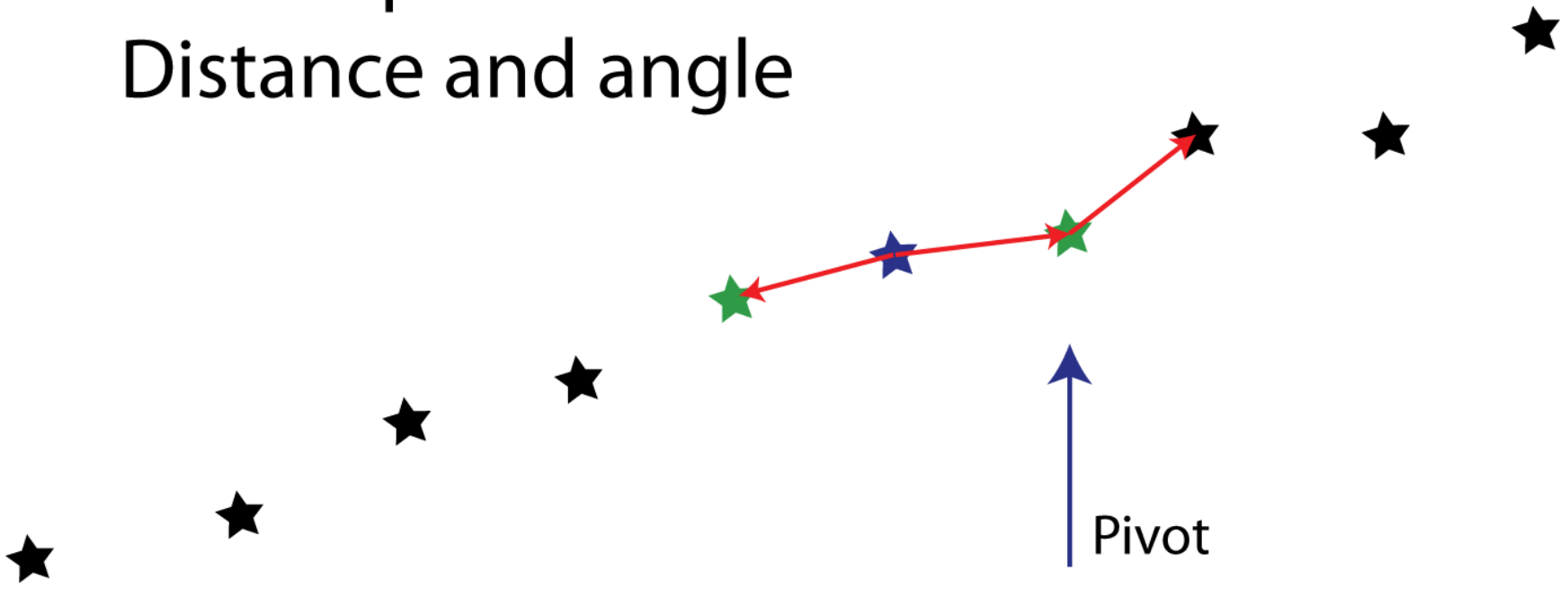


Graphic Example

2nd step
Distance and angle



Graphic Example

2nd step
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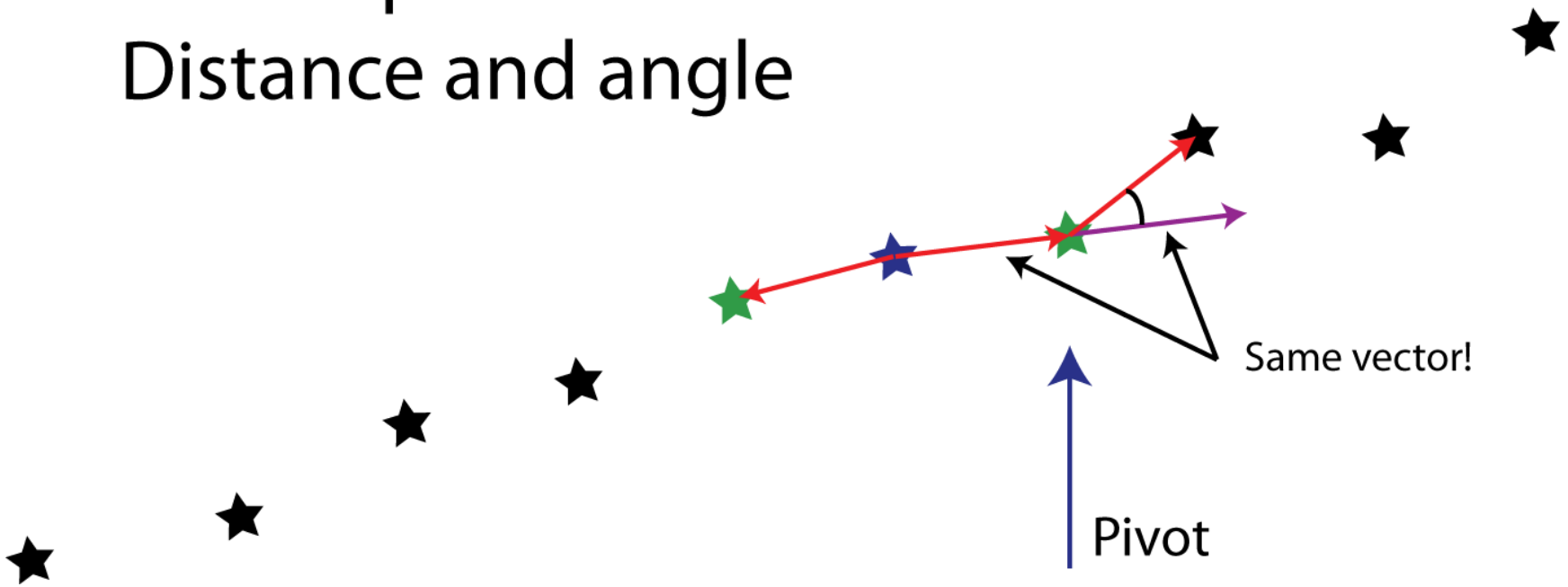

Graphic Example

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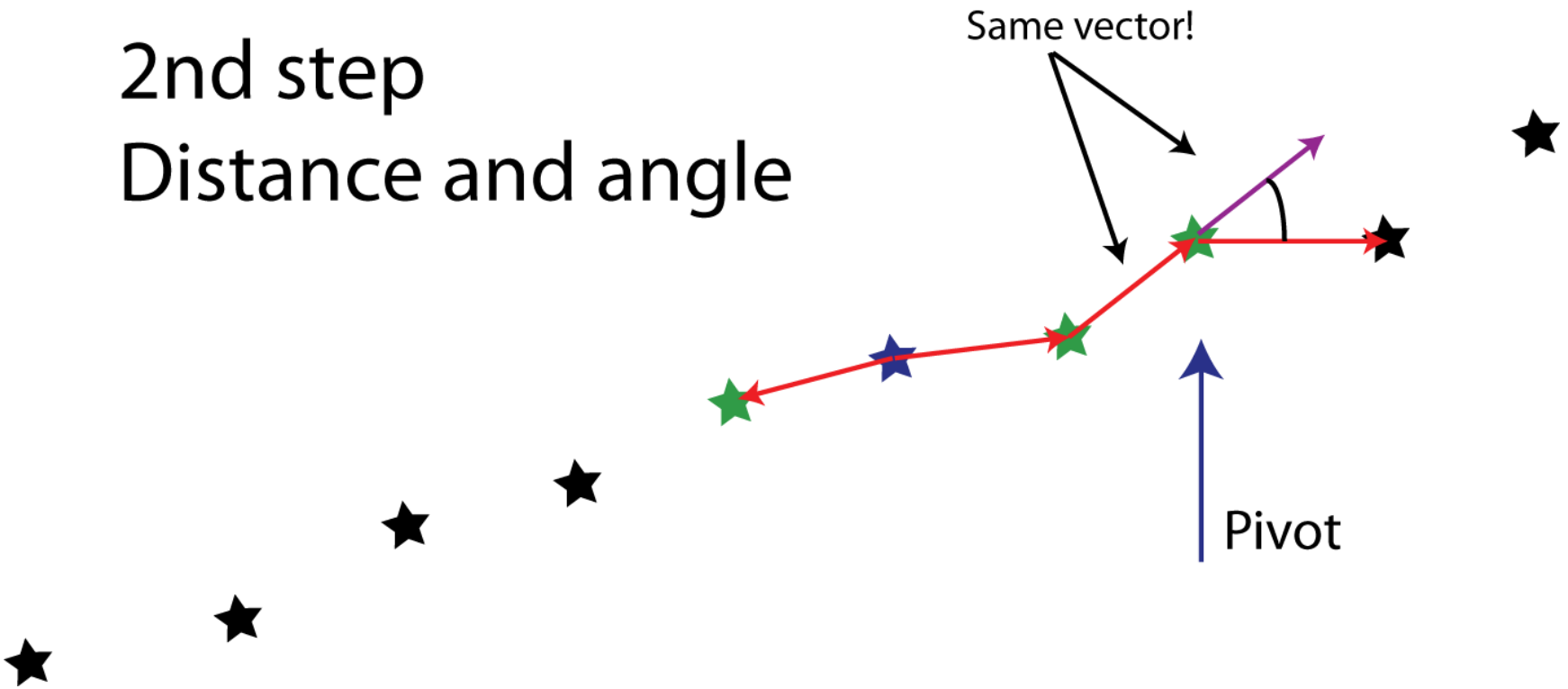
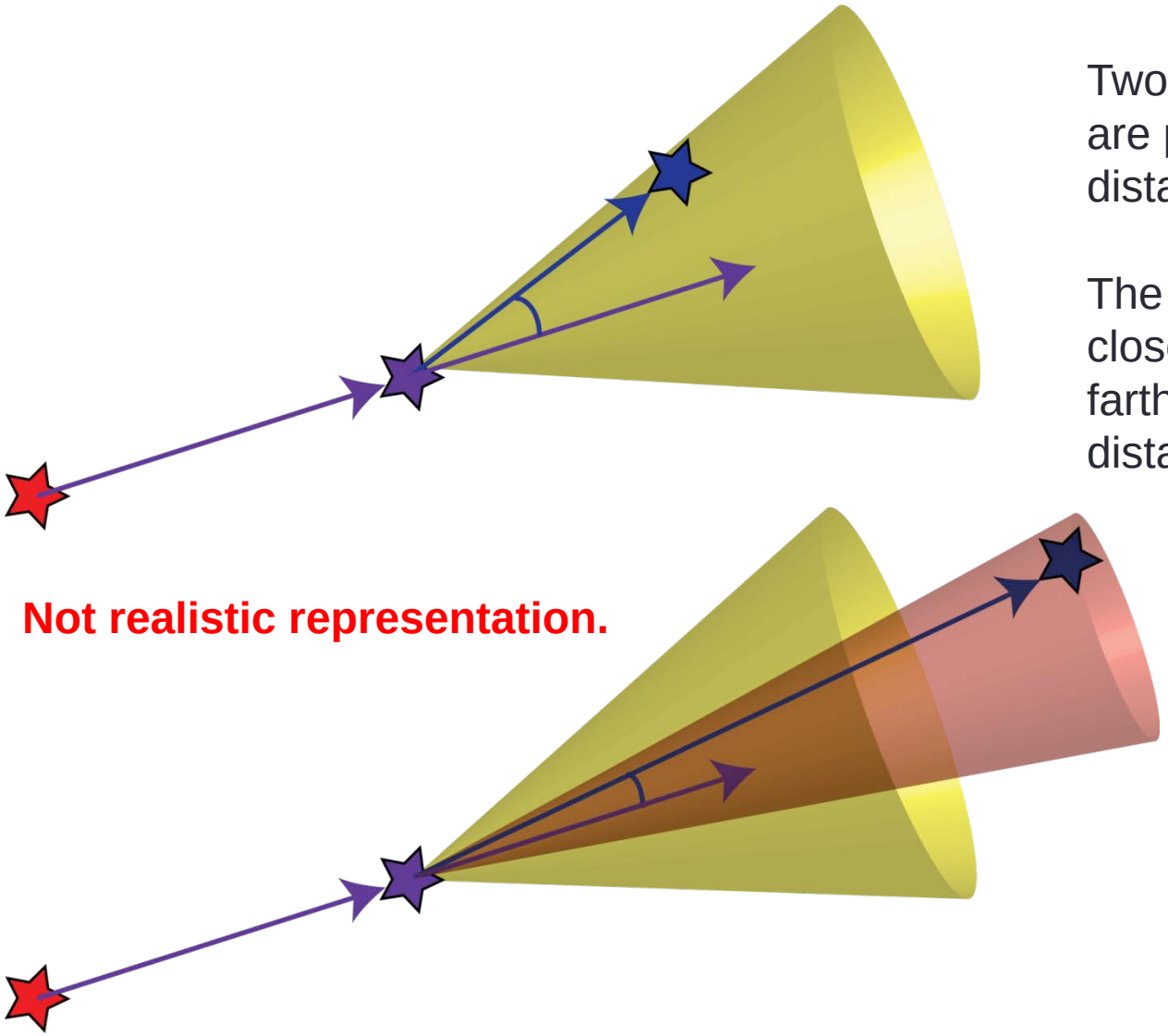


Angle constrain

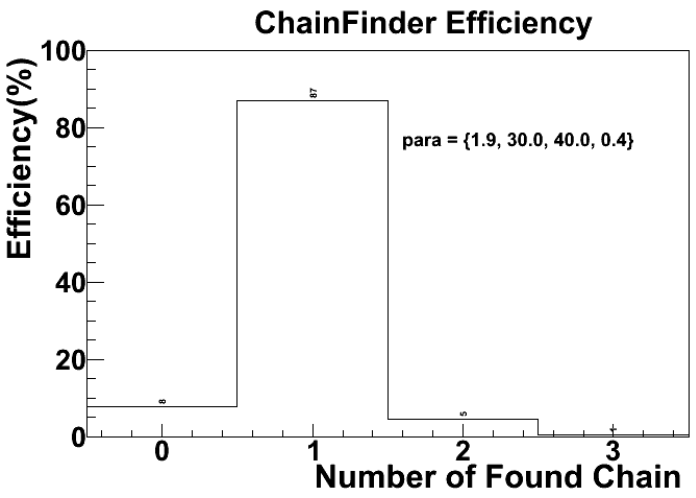


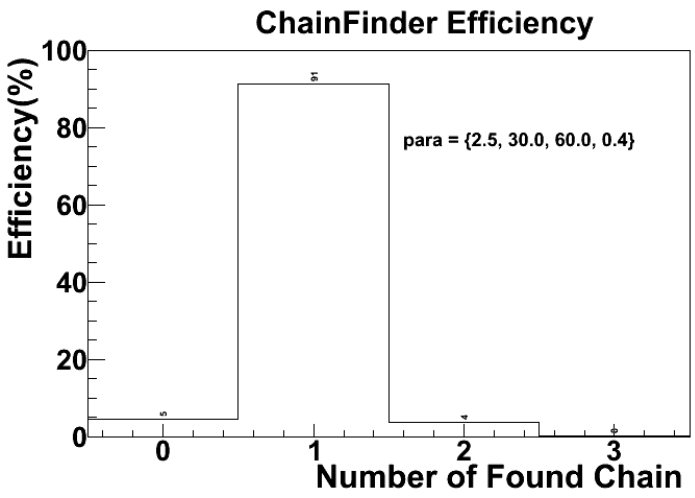
Not realistic representation.

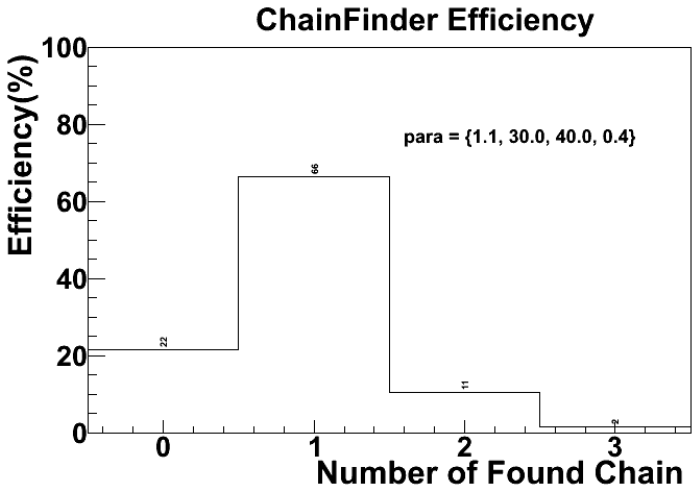
Two possible acceptances are possible depending of the distance to the candidate hit.

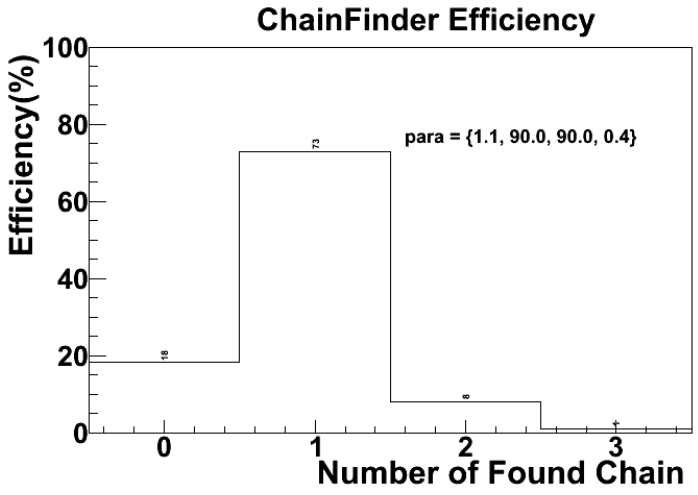
The acceptance is larger for close hits and shorter for farthest hits but within the distance condition.

Track Finder performance



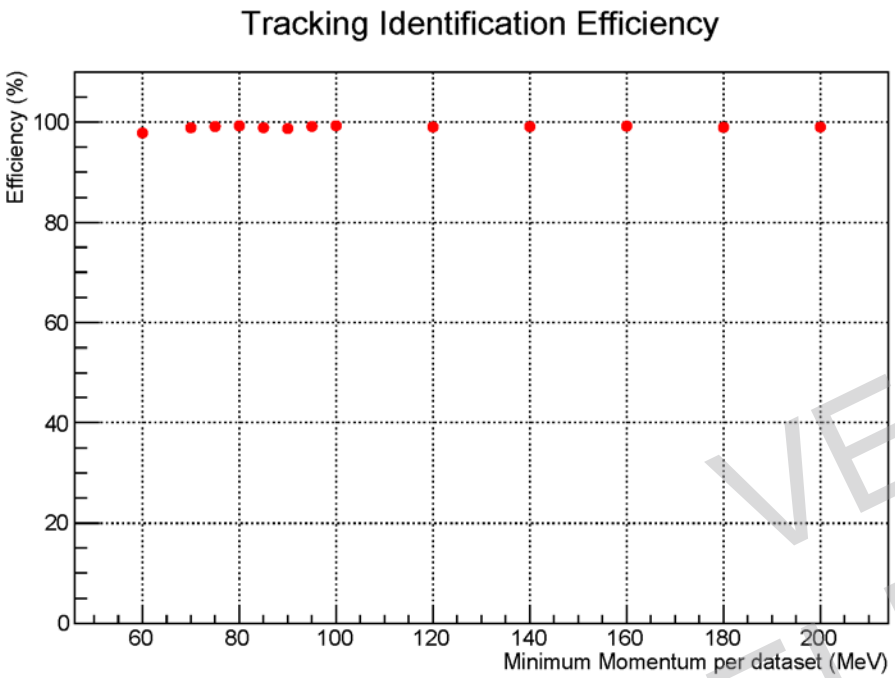






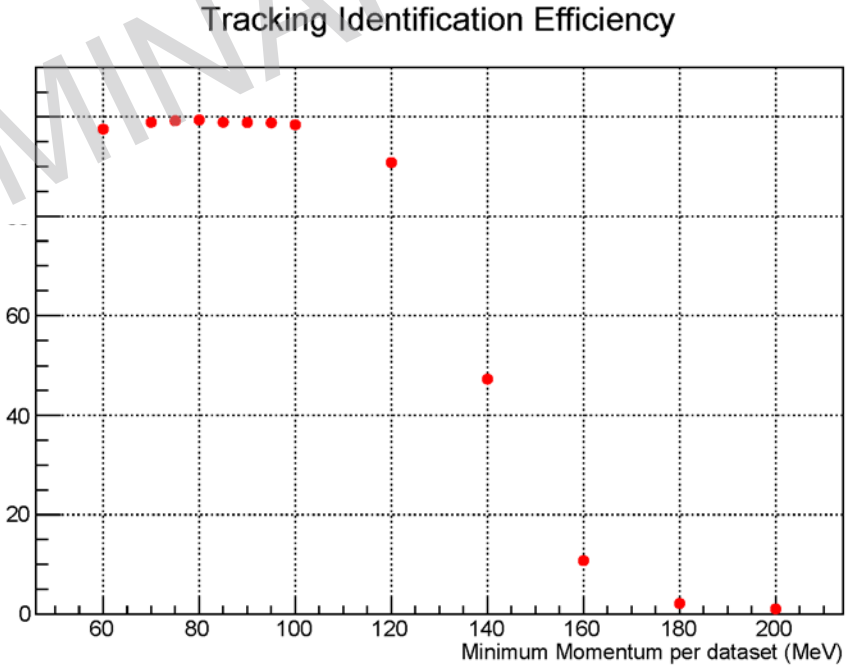
Plots courtesy Jixie Zhang

Track Finder performance



NO cut in energy deposited on every particle interaction (hit)

Energy deposited>300 eV on every particle interaction



Sorting the chain hits

- Once a candidate chain is found, the hits, that form it, are sorted in *s* (radial distance from center) and ϕ (azimuth angle of the hit).
- Different algorithms available and tested:
  - In Track Finder, two algorithms are used in parallel, Quicksort and Insertion Sort. Wikipedia has very good articles about them.
  - The use of a particular algorithm come determined by the characteristics of the candidate chain.
    - if array size$\geq$50, Quicksort is the fastest one.
    - If size<50 insertion sort is the best.

Kalman Filter I

- The Kalman filter is an algorithm that uses a series of measurements observed which contain noise and other errors.
- It produces estimates of unknown variables (as P_t or θ) that tend to be more precise than those based on a single measurement alone and it produces a statistically optimal estimate of the underlying system state.

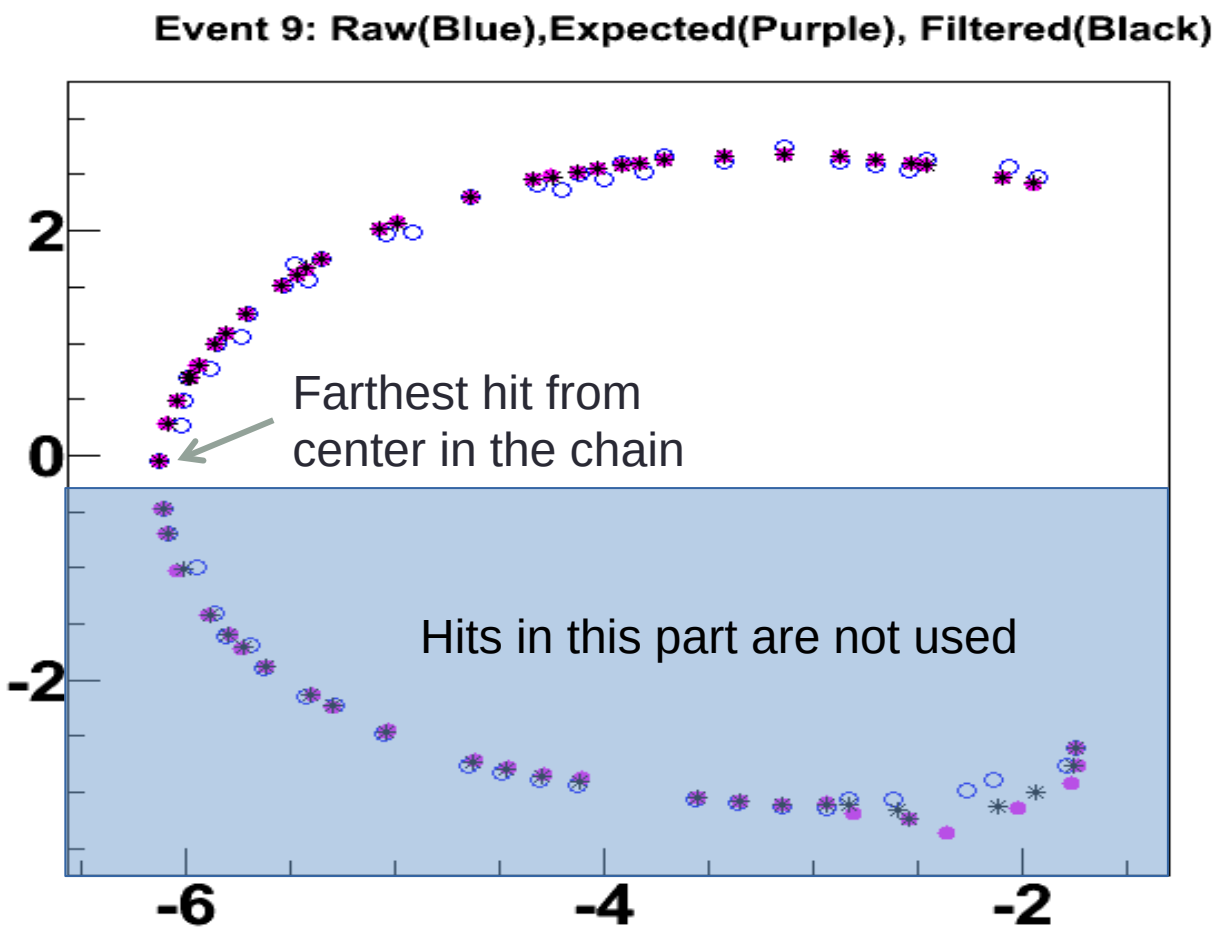
- A fine and illustrative description of the algorithm:

Tracking and Event Reconstruction

Veronique Ziegler

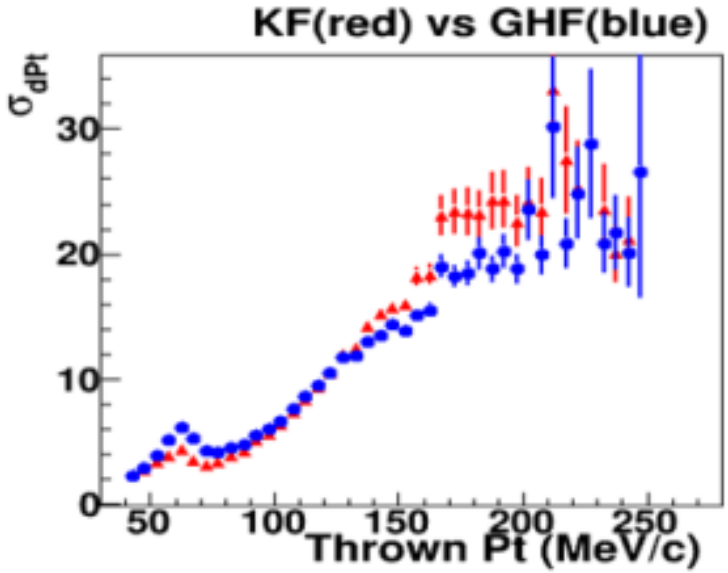
First CLAS12 Experiment Workshop, Tuesday, 28 March 2017

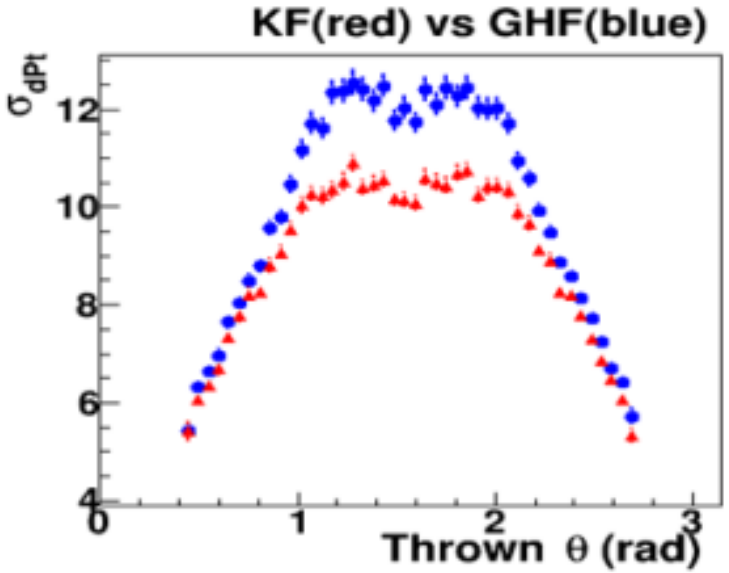
Kalman Filter II

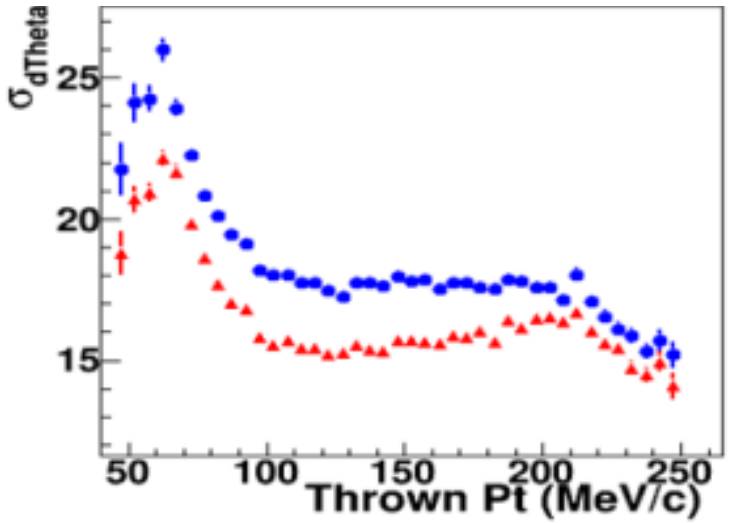


When track curves back, low momentum protons, only the forward path of the track is used in the KF, due to ambiguities in the hit position.

Kalman filter performance

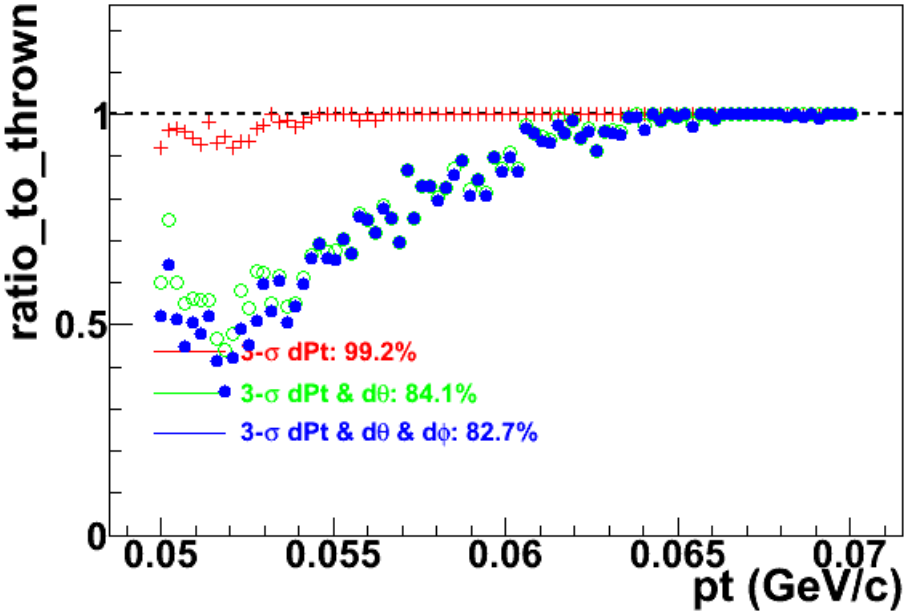




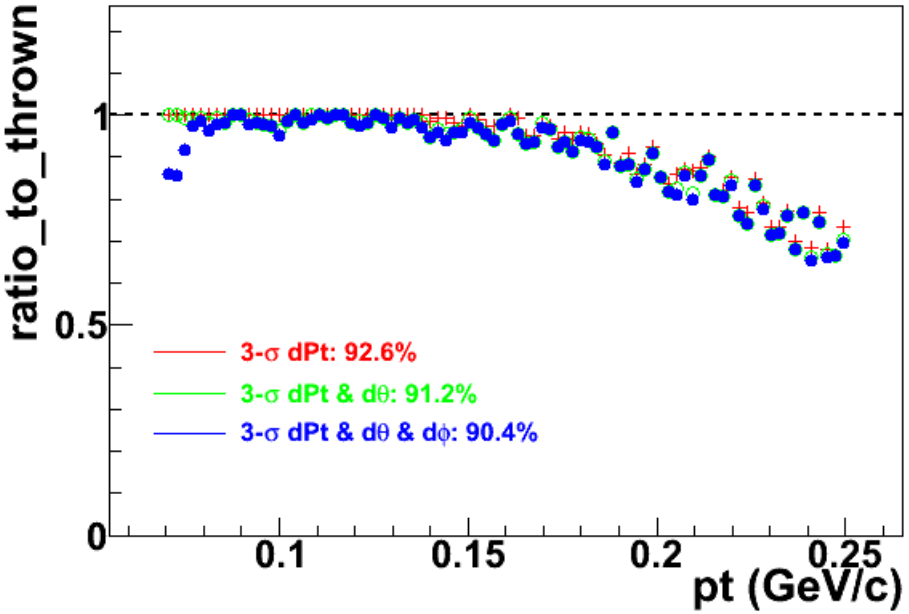


In simulated data, KF shows equal or better performance than Global Helix Fitter used previously

Kalman Filter performance



KF efficiency vs p_t for tracks with parameter resolution within 3σ (and different combination of such parameters)



Present status

- RTPC12 Tracking Software v0.97 has been released and it is being tested by the BONuS Simulation and Analysis group.

- The code is available in github:

https://github.com/jixie/KalRTPC

Summary and Outlook

- Track Finder description presented.
  - Naïve Track Following Method + angular constrain
- Sorting package for candidate found chains, in order to feed Kalman Filter.
- KF performance presented.
- Software package to be used with BONuS RTPC for tracking and fit has been developed and released.

- Improvements of the code:
  - Optimize distance and angle parameters in track finder
  - Optimize the code to improve analysis speed.
  - Realistic considerations to improve KF