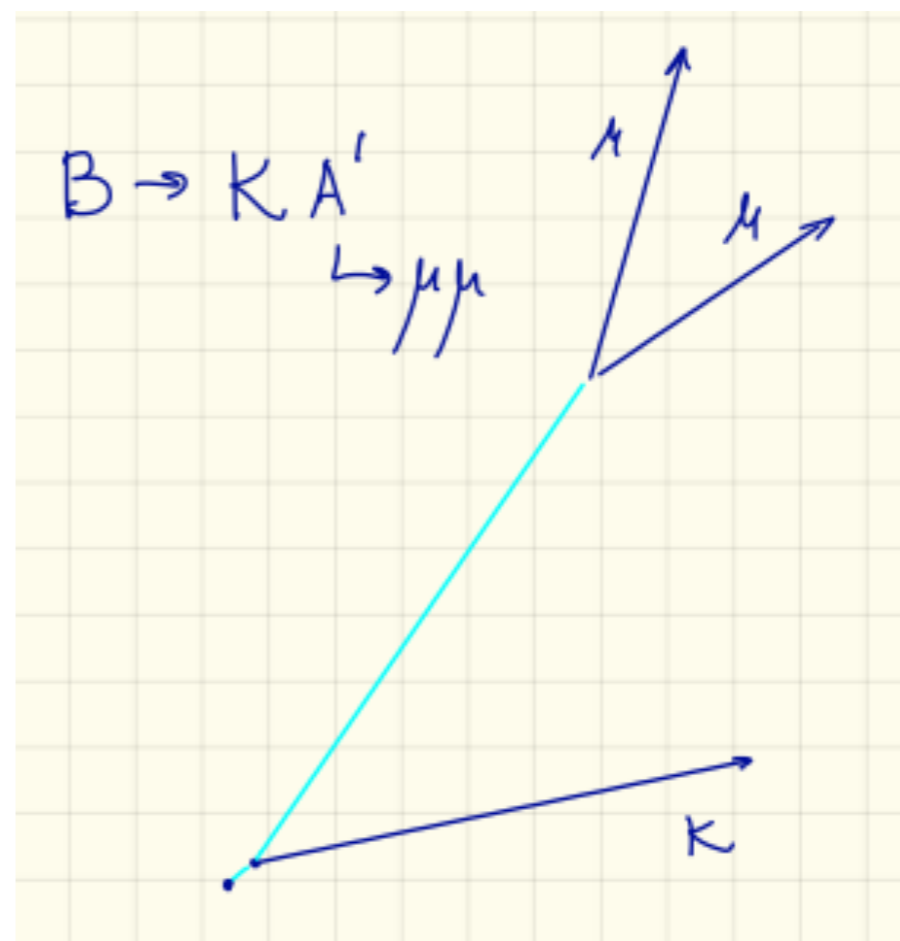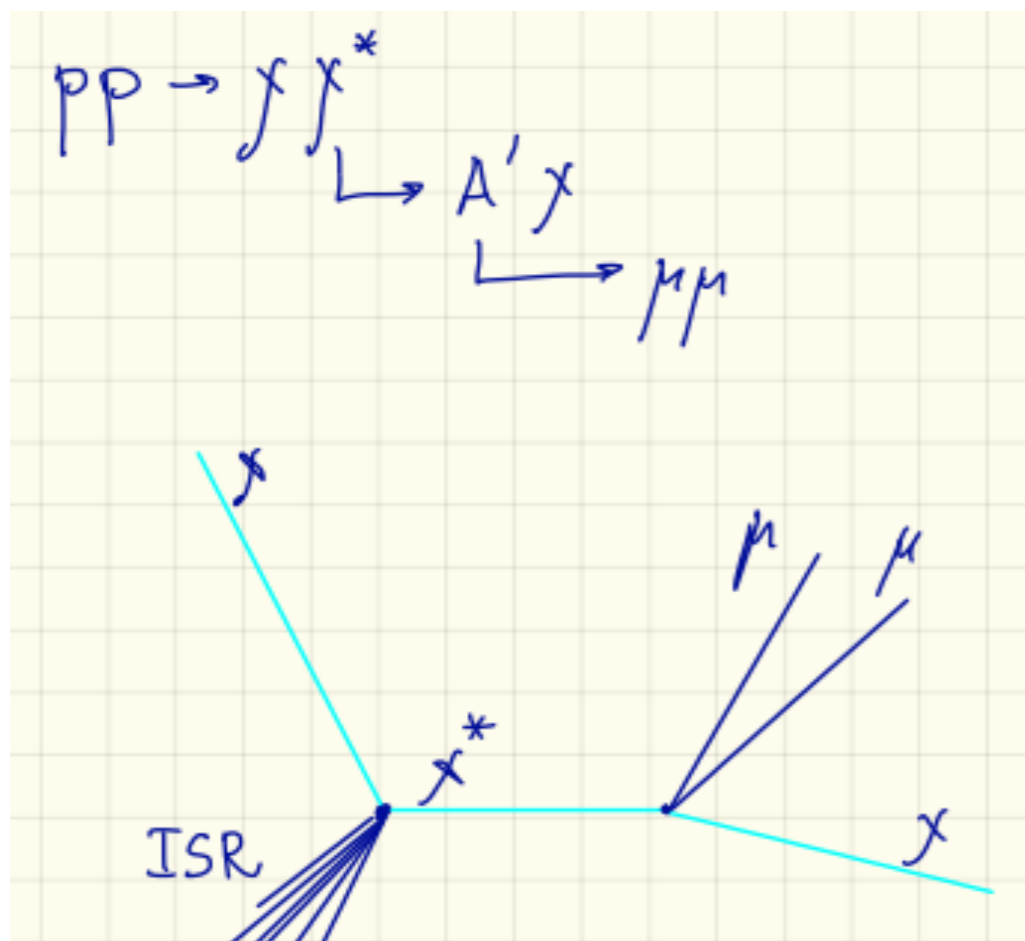# low mass dimuon (pion?) resonances

- Current strategy: MET trigger, reconstruct displaced pair offline (HLT?)
- How many more events can we write out if we also trigger on the displaced pair?
  - Efficiency hit from pair reconstruction
  - Cross-section increase from smaller ISR jet requirement
- MIP timing? muon chambers?
- Note: the pair does not point back to PV

- Current strategy for HL-LHC
  - Dimuon trigger? CMS would likely do much worse then LHCb
- How many more events can we write out if we also trigger on the displaced pair?
  - Efficiency hit from pair reconstruction
  - Cross-section increase from smaller muon pT
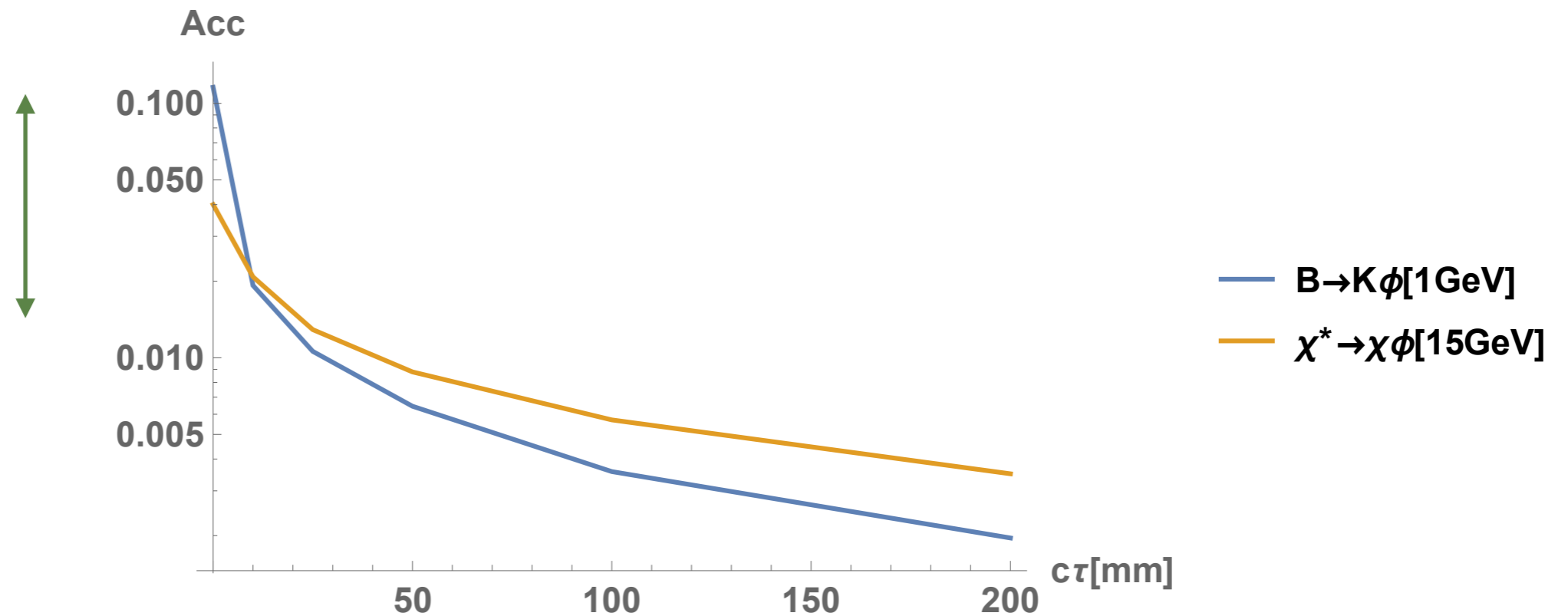- MIP timing? muon chambers?
- Note: the pair points back to PV

Pipeline

1. Signal generation (pythia -> Hepmc -> root)   ✔

2. Find stubs & smear stubs   ✔

3. Find vertex   (✔)

4. Estimate BG by throwing fake tracks   (✔)

5. Matching tracks with muon chamber & timing layer

# Stub finding efficiency

Demand at least 6 stubs

factor of ~ 10 loss over
decent lifetime range

(Benchmarks likely too aggressive)

Toy MC

- Propagate MC truth tracks through cylindrical tracker layers
- Calculate the number of stubs per track
- Smear the hit position according to pixel/strip sizes (assume 1 strip/pixel per hit), and fit with a helix
  - Fit parameters are correlated, but the covariance matrix is approximately the same for all tracks with the same number of hits

smear and fit the same truth track 1000 times

Rudimentary vertexing: **Overview**
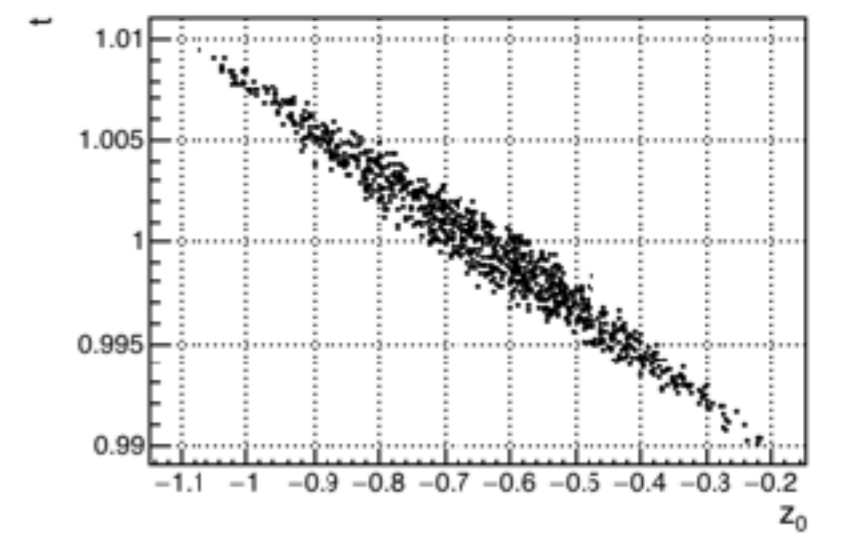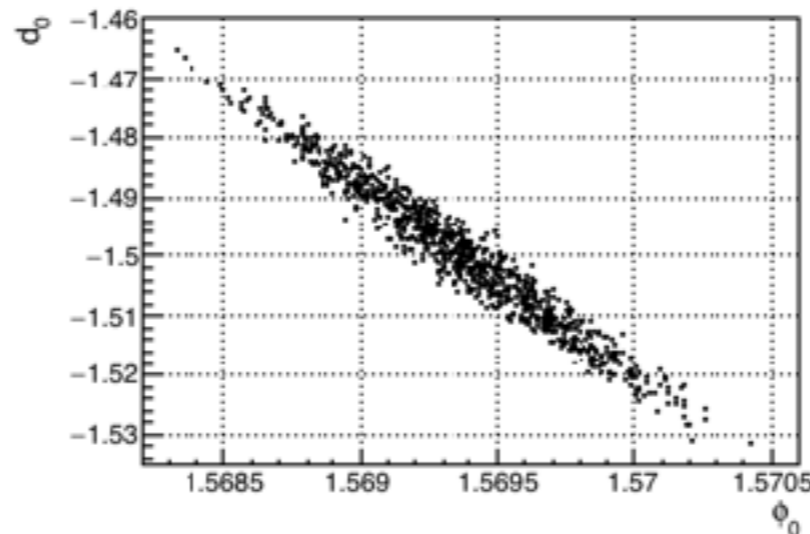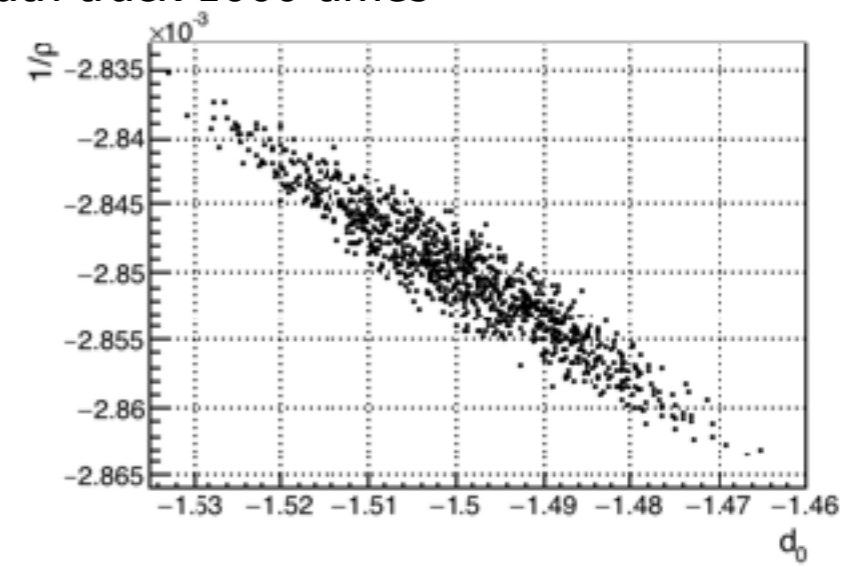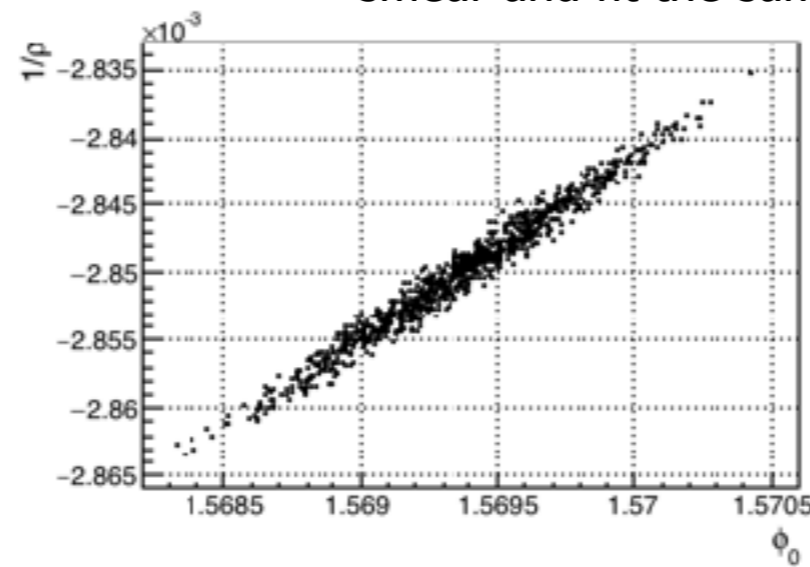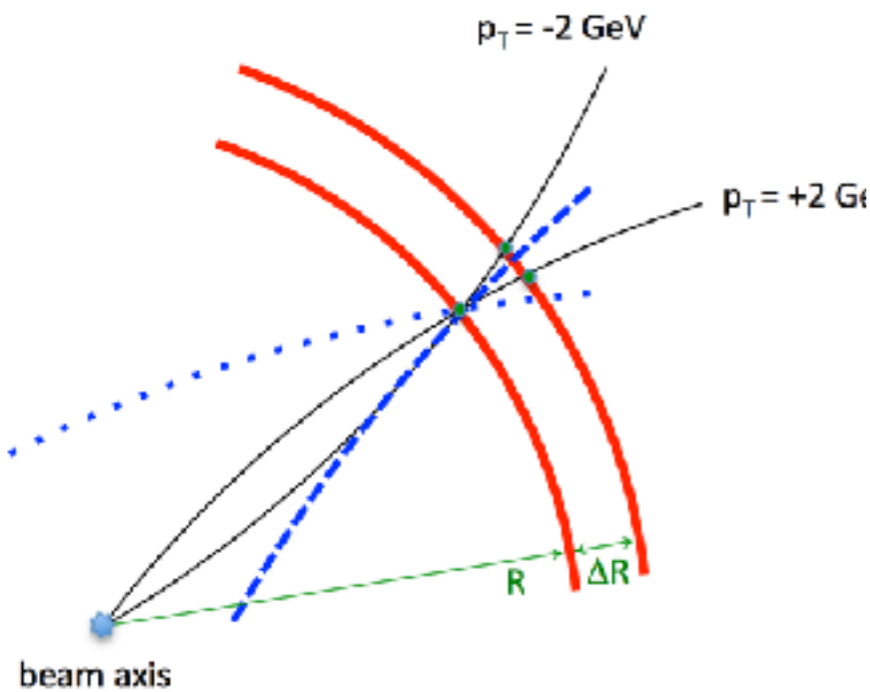
- The idea is to run very rudimentary, 2-track, vertexing to get a rough idea of where the secondary vertex is from the track parameters.
  - Is it a good vertex? If it's close to each track's d0 & z0: keep the vertex, else discard it.
  - Count the number of successfully reconstructed vertices. How many point back to the PV? How many do we get from random track-crossings (fake rate)?
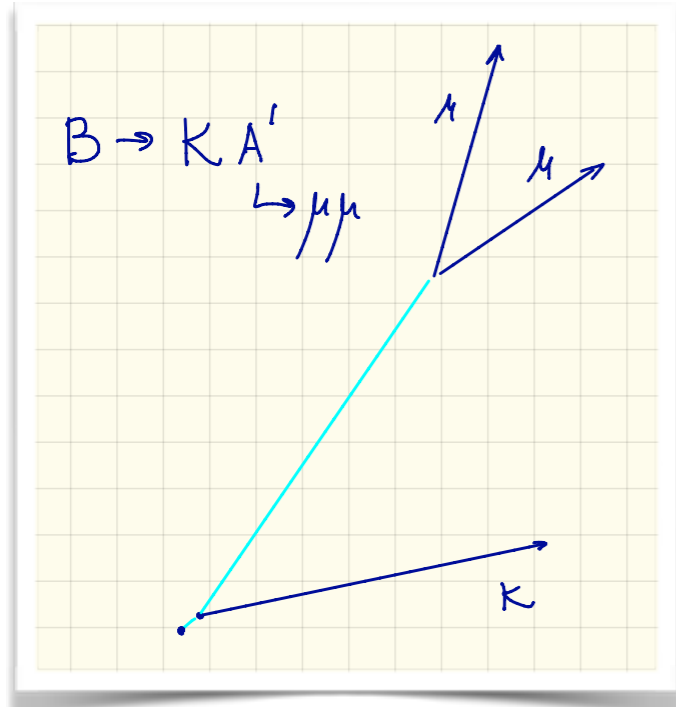
From track fit we get:

- momentum vec.
- charge (via direction of curvature)
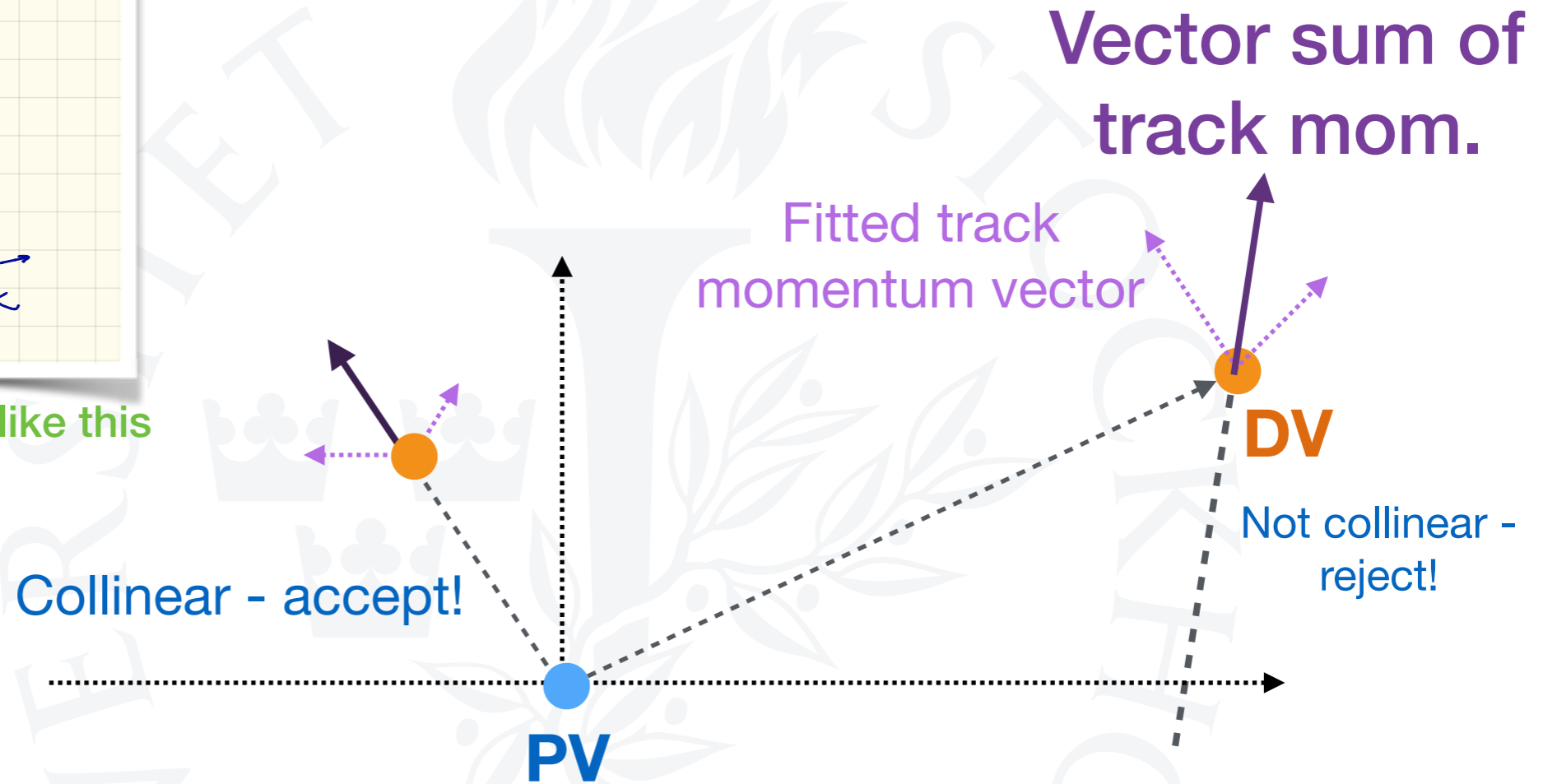
With which we calculate: values in **orange**
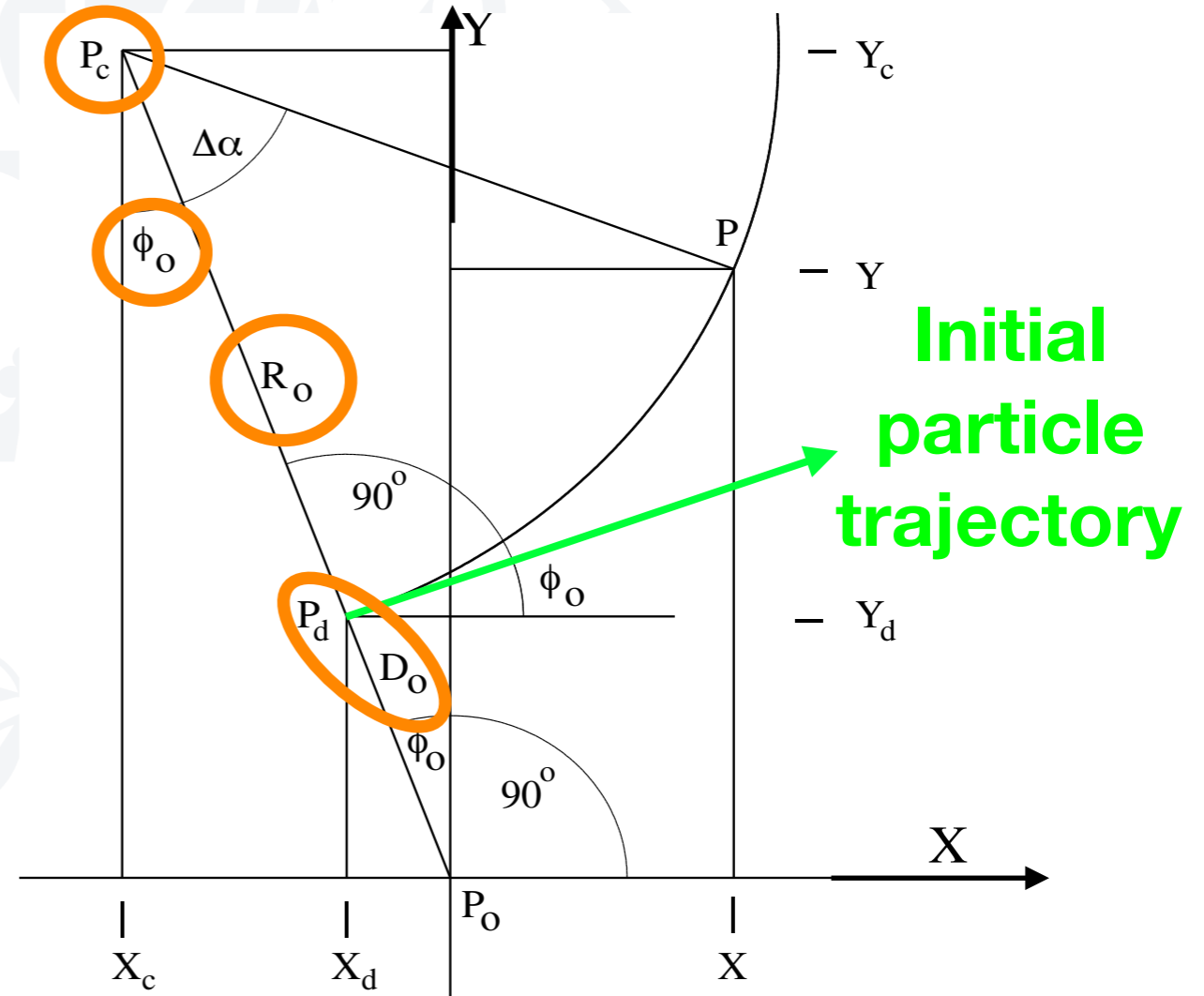
Initial particle trajectory

- From the track-fit we can calculate variables shown above (details in backup). Then, for the basic vertexing:
  - In the x-y plane the helices of 2 particles will describe circles. If they came from the same vertex, the circles should overlap - solve for Vtx position in x-y.
  - Then, in the z-plane, the helices will describe a cycloid which we can approximate with a straight line at high energies: solve for Vtx in z.
- Then compare Vtx d0 & z0 values calculated. If the two are very different (outside of the track-fitting errors) we can reject the vertex - else the vertex is kept and passed on to the next stage for counting.

What do we do with the vertices?

targeting something like this

Vector sum of track mom.

Fitted track momentum vector

DV

Not collinear - reject!

Collinear - accept!

PV

- Then: is the vector pointing from the PV to the DV parallel to the vector sum of the decay-particle's momentum?
  - If yes: trigger!
  - If not: it's either a background process (discard!) or a model we're not set up for, in which case you'd have to combine it with another system to trigger.

Trigger rates (aka background)

- ~all displaced tracks are fake
  - Hadronic interactions likely much smaller
  - Generate 10 to 40 fakes / event
    - Flat in ϕ, $1/p_T$, t, z_0 and d_0
- Tracker only study:
  - Not all pairs will combine into vertices, not all will point back to PV
  - Determine the rate of "good pairs"
- Matching with inner muon layers
  - Assume occupancy of hits in inner muon layer: reduce fakes!
  - Match window is 0.05x0.05 (η, ϕ). If have N_{mu} muon stubs per event:
    - N_{mu} *0.05*0.05/(2*pi*4) ~ N_{mu} *1e-4
    - Will know a "guess" for N next week
- With MIP timing:
  - Occupancy in MTD is ~10%
  - If timing resolution is 30ps and hit distribution is 200ps, timing consistency gives random hit reduction of 0.23
  - Total reduction of 2.3e-3

Trigger "design"

- Once we know the rate reduction from the displaced vertex is calculated, we can "design a trigger"
- Can a muon+MTD+vertex be a trigger by itself?
- Current DM trigger strategy is to trigger on MET
  - Can estimate how much lower a MET cut could be with the displaced vertex requirement
- For B->K+$\mu\mu$
  - Will need to see how much rising the pT threshold for one of the muons helps...