Bump hunt form 2016 data

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HPS collaboration meeting at JLab, May 29-31, 2019

Status

Event selection

- Most of it is done in pass1 data.
- Needs to be re-obtained w/ pass4 data.

cl. Δt, d_0, χ^2/NDF, trk-cl time diff, ESum.

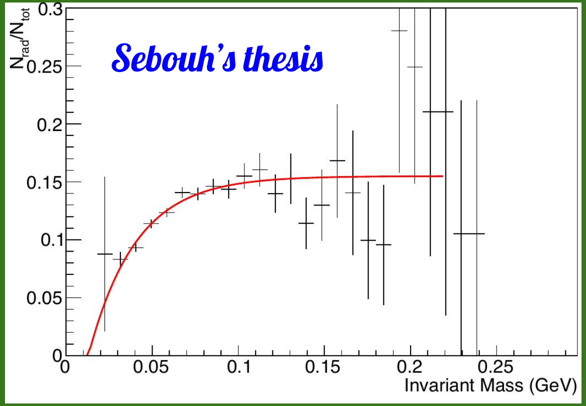
Cuts are obtained by maximizing figure of merit: e.g. S/Sqrt(Bgr)

Mass resolution

This was parametrized by Sebouh.
Codes are available.

Though the Moeller mass was obtained from Carbon data which gives smaller sigma 1.7 MeV vs 2.2 MeV

Radiative fraction



Unlike to 2015, it is not flat

Bump hunting

Omar has released the code, although some features needs to be added

Systematic uncertainties

- frad
- Mass resolution
- fitting

Has not started yet.

Heavy Photon Search Group / ... / Data Analysis Working Group

2016 Resonance Search Task list

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Created by Rafayel Paremuzyan, last modified by Omar Moreno on Feb 10, 2019

Task	Subtask	Comment	Document
MC and Data agreement	[ ] Check the tracking efficiency (Matt, Omar) [ ] Check single hit efficiency? (Matt, Omar) Mat has progress, see his talk [x] MG5 cross section converges? (Bradley) [ ] Any significant discrepancy between MC and data selection cut? (Matt)	Unlike to 2015 data, we see that the Normalized data is about 30% higher than the normalized MC	
Event Selection	[ ] Optimize event selection cuts (Rafo) Done for pass1, needs to be revalidated with pass4 [ ] Optimize energy/momentum sum cut (Rafo? Omar?) Done for pass1, needs to be revalidated with pass4 [ ] Generate final e+e- invariant mass spectrum (Rafo)		
Determine mass resolution with the pass4 data	[ ] Generate A'-beam MC at several different masses along with Moller-beam MC (Bradley). Done [ ] Check data-MC agreement for Moller data (Matt? Omar?) [ ] Develop a cutflow to isolate Moller peak and fit using a Crystal Ball function to extract the mass resolution (Rafo? Omar?) [ ] Isolate A' invariant mass peaks and fit each using a Crystal Ball function to extract mass resolution (Rafo) [ ] Fit A' mass resolution as a function of A' mass to obtain mass parametrization. (Rafo) [ ] Determine mass scale correction (Kyle)	Is done for paas1, need to run codes over new MC data	
Bump Hunting	[ ] Run the BumpHunter (Kyle) [ ] Use Crystal-Ball instead of the Gauss for the signal shape (Omar) [ ] Add CLs limit calculation [ ] Import mass resolution parametrization (Kyle) [ ] Optimize fitting function and window size. Requires knowledge of the mass resolution (Kyle) [ ] Incorporate mass resolution and scale systematic. [ ] Add "Pulls to exclusion limits" conversion in the BumpHunter?		
Systematics	[ ] fRad (Matt) [ ] Mass resolution (Moeller mass fit, different target positions) (Rafo) [ ] fits (Kyle)		

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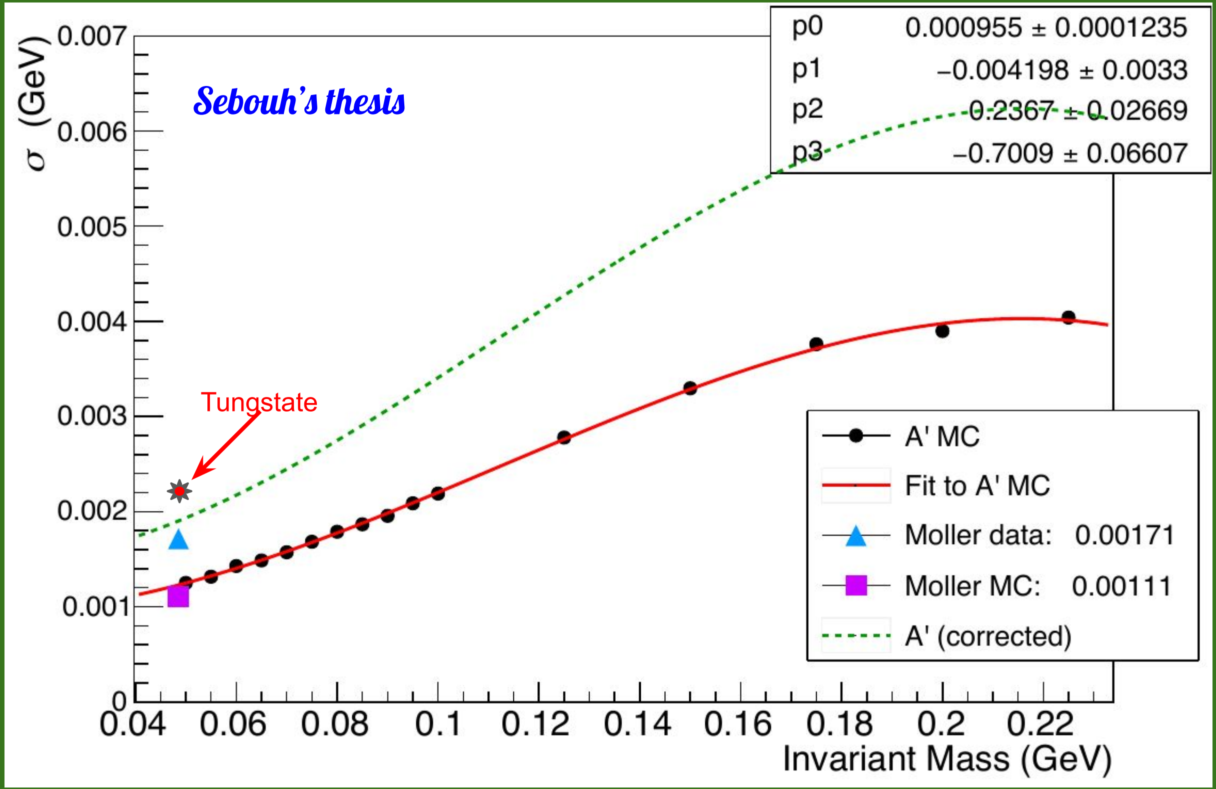
Backup slides

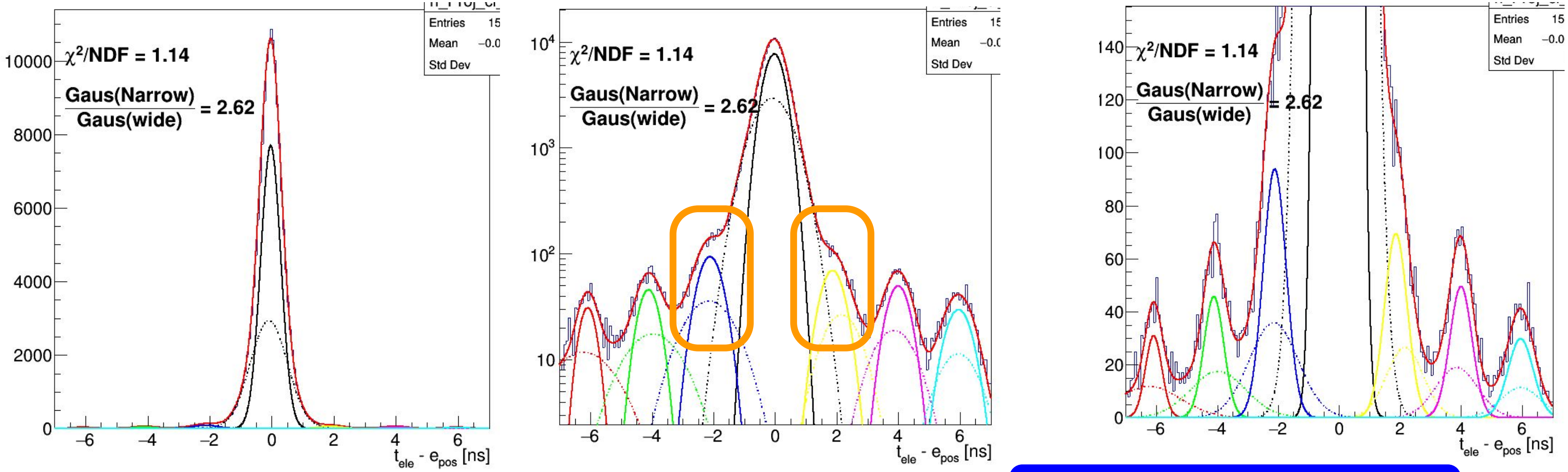
Moeller mass resolution is obtained from Carbon data.
Mass parametrization needs to be scaled wrt Tungstate mass resolution



Peak = A*(Gaus(x, μ^1,σ^1) + d*Gaus(x, μ^2,σ^2))

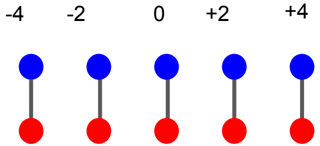
The fit function is a sum of 7 Peak functions: F = $\Sigma^7_{i=1}$ Peak(i)

'd' is unique for all peaks

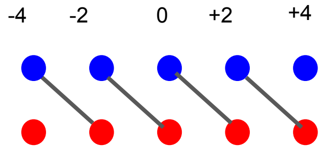


Shoulders on "-2 ns" and "+2 ns" are not symmetric, Not sure why

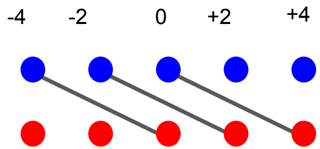
Will be checked with pass2



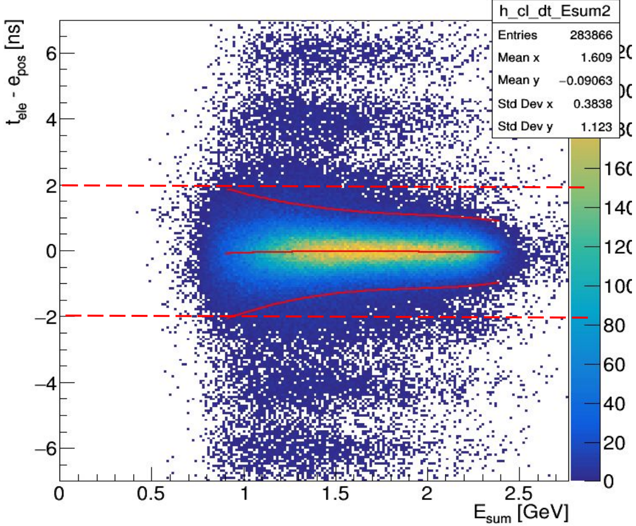
Δt = 0ns: 5 samples



Δt = 2ns: 4 samples

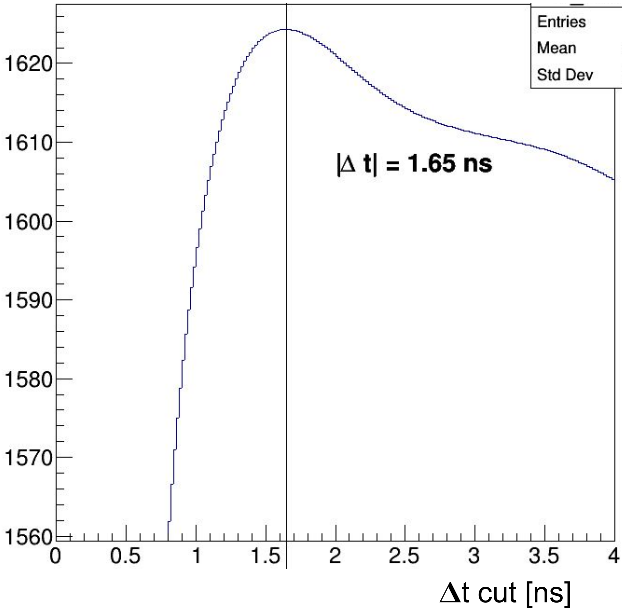


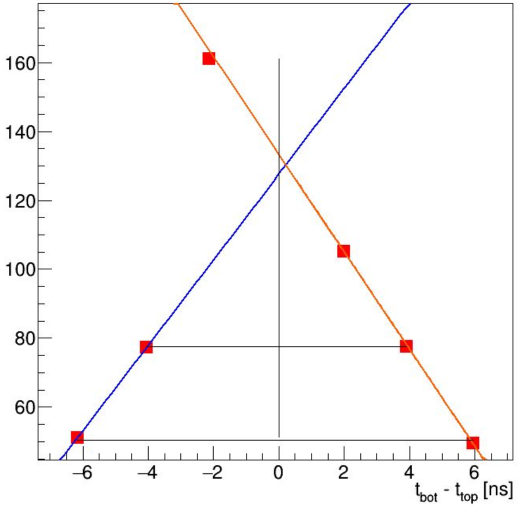
Δt = 4ns: 3 samples



There is an asymmetry here

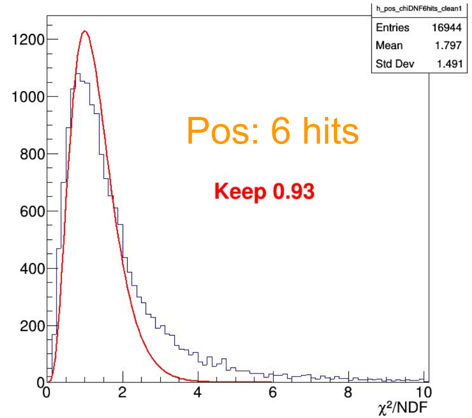
Events at **Δ**t = -2ns are more than at **Δ**t = +2ns





Δt cut is optimized by maximizing “Core/sqrt(total)” function as a function of cut value

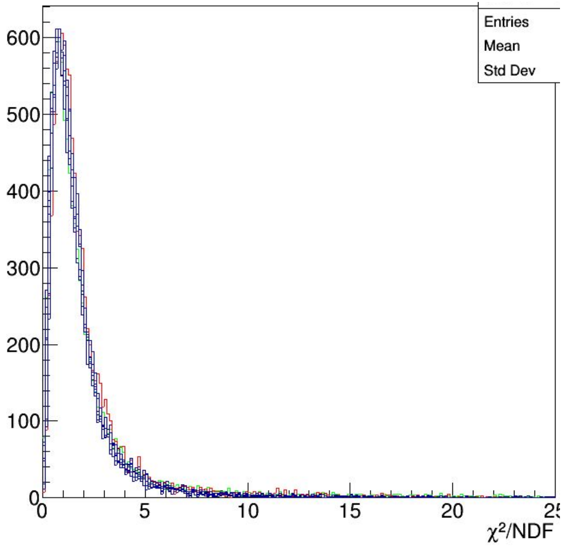
Track chi2/NDF

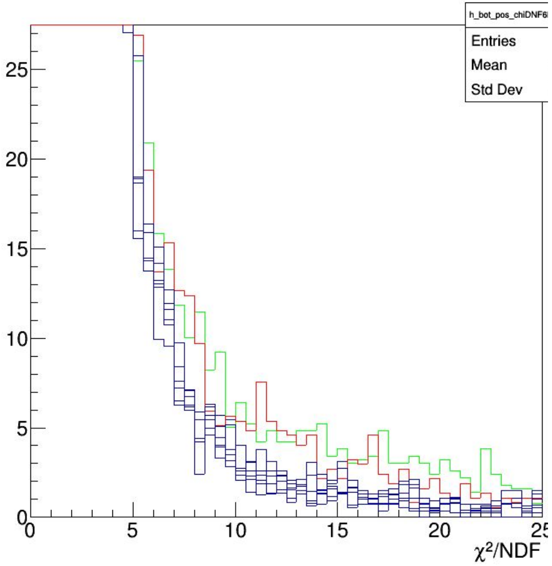


The chi2/NDF distribution is not described by the chi2/NDF PDF, but there are reasons for that: uncertainty in the geometry, not right material model etc.

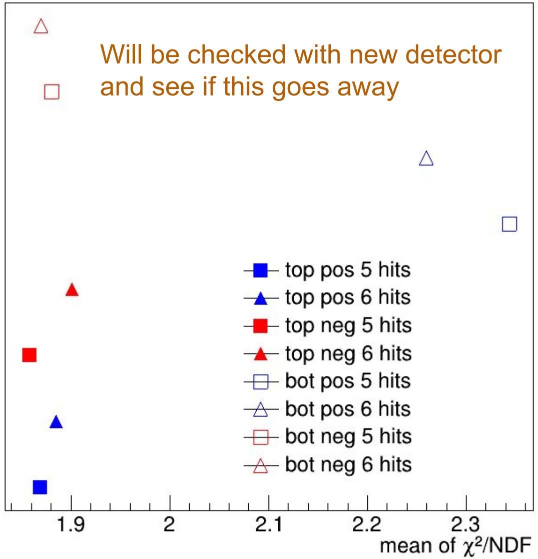
Subdividing into top/bot/neg/pos/5hits/6hits, distributions keep their shape, which is a good sign, only positrons at the bottom show slightly more tail

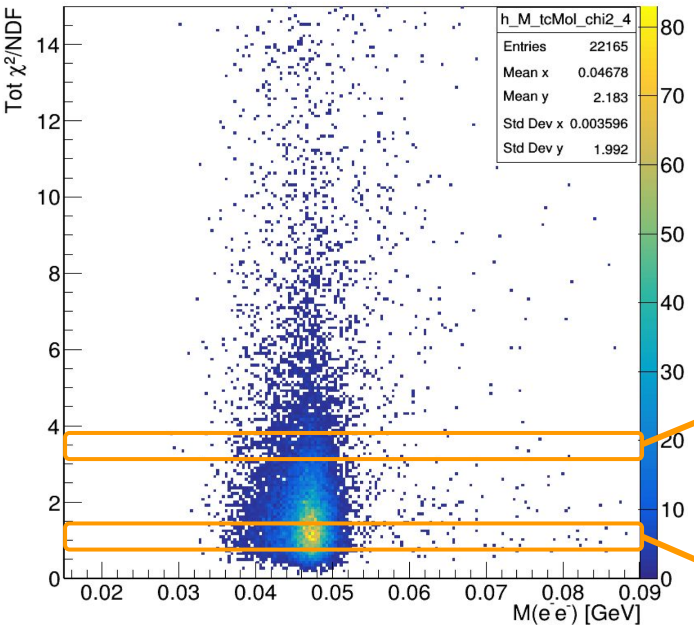
Select cleanest events: only 1 track in in detector half, and no extra hit is present in SVT

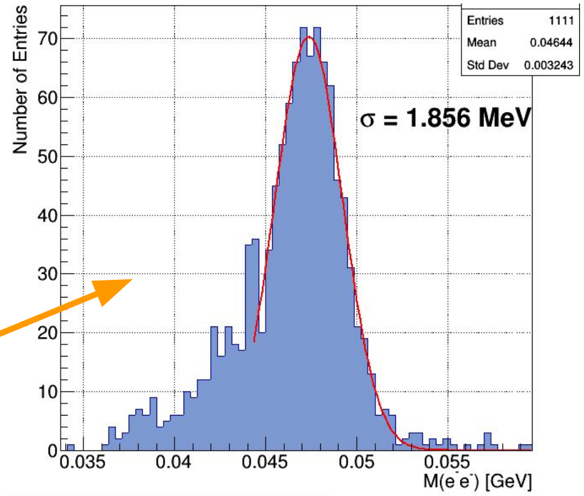


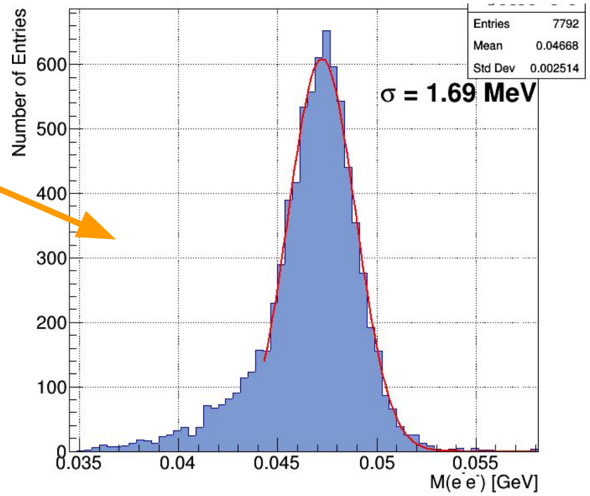


Mean of chi2/ndf







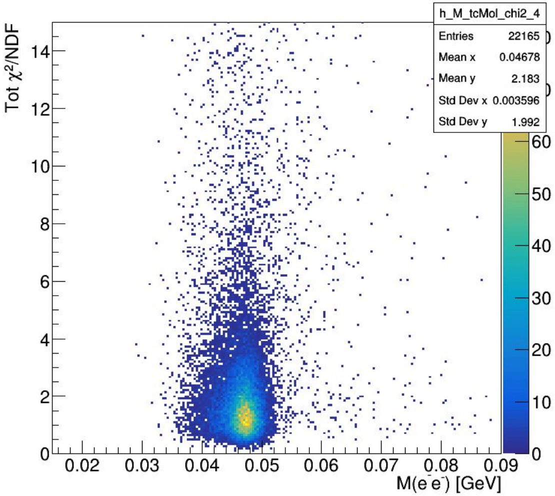


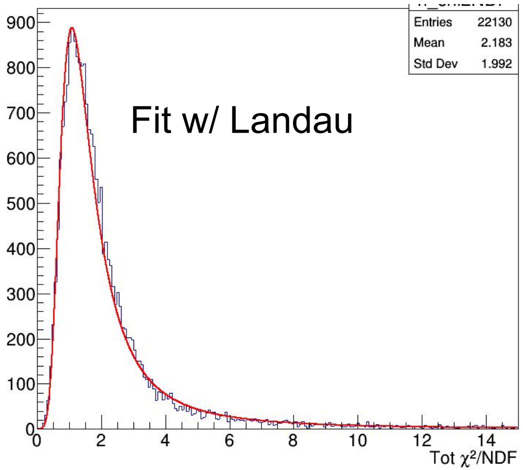
Instead of chi2/NDF of a single electron track a total (combined) chi2/NDF is used.

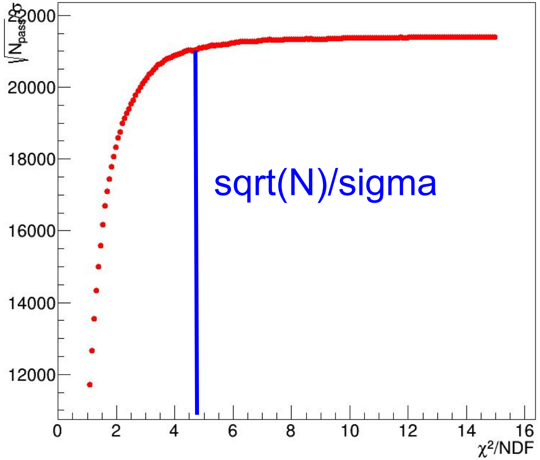
As it is expected mass depends on chi2/NDF cut.

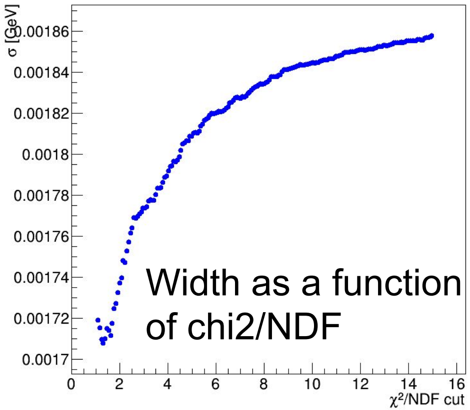
Optimize cut on chi2/NDF to get the maximum signal sensitivity

Carbon data







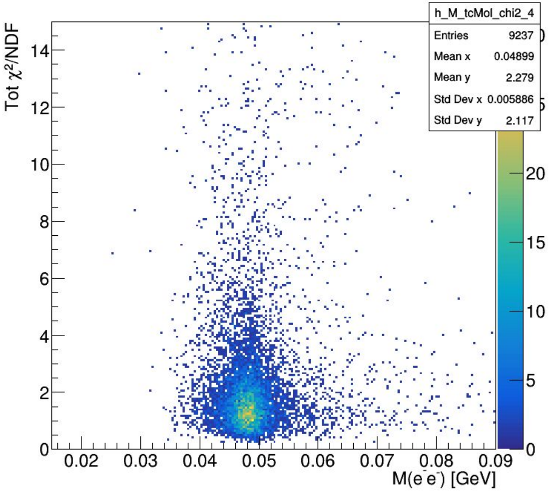


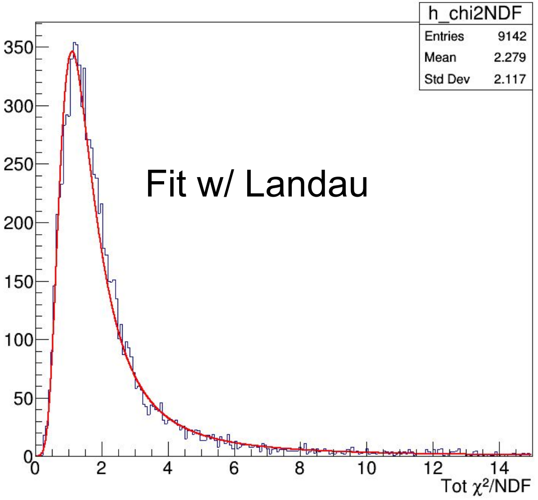
The goal: maximize sqrt(N)/sigma

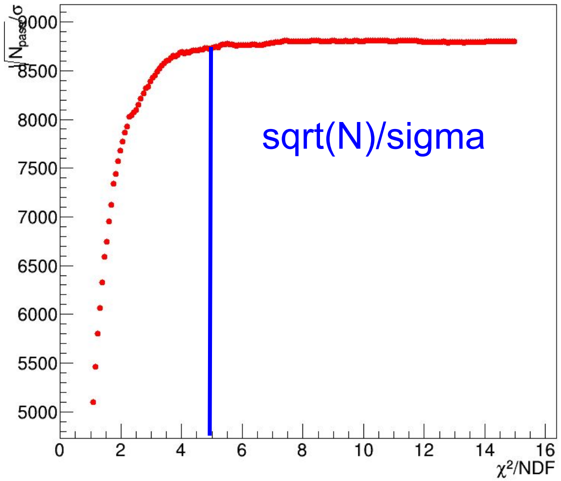
No apparent maximum, but keeping it tighter without losing significant signal sensitivity is safer.

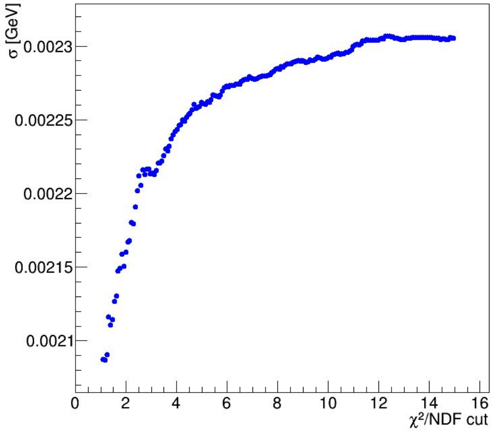
Proposal is to choose chi2/NDF < 5.

Tungsten data





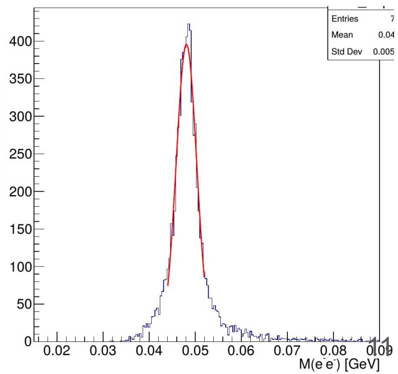




Similarities: significance doesn't converge in both cases

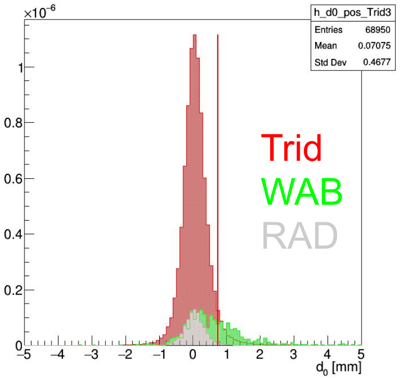
Differences:

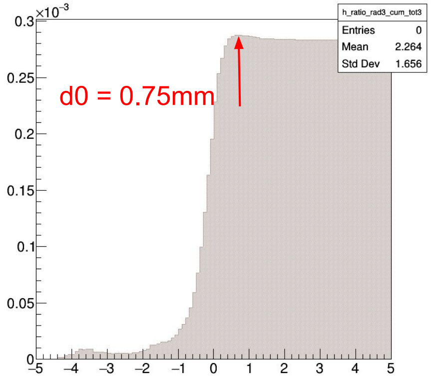
- sigma is quite a bit larger
- The tails are on the opposite side of the peak



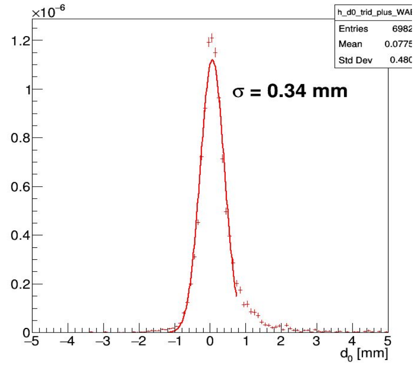
Need more digging into to understand sigma differences between C12 and W targets

d0 cut (suppressing cWABs)

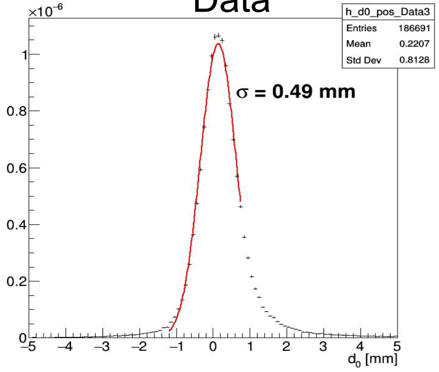


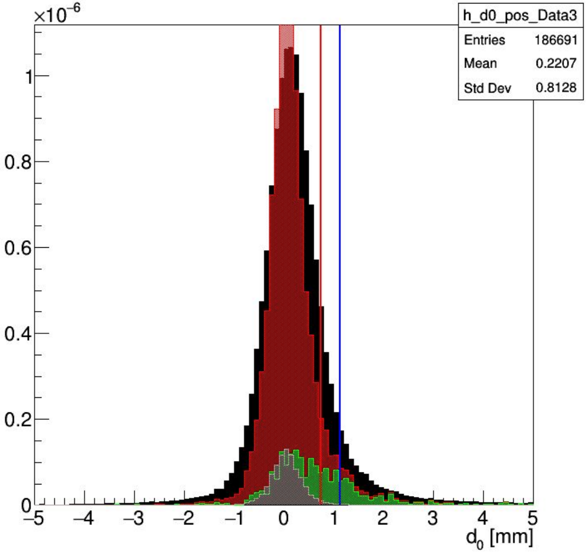


Trident + WAB



Data





Using only MC, the d0 cut is optimized as N_rad/sqrt(N_trid + N_WAB)

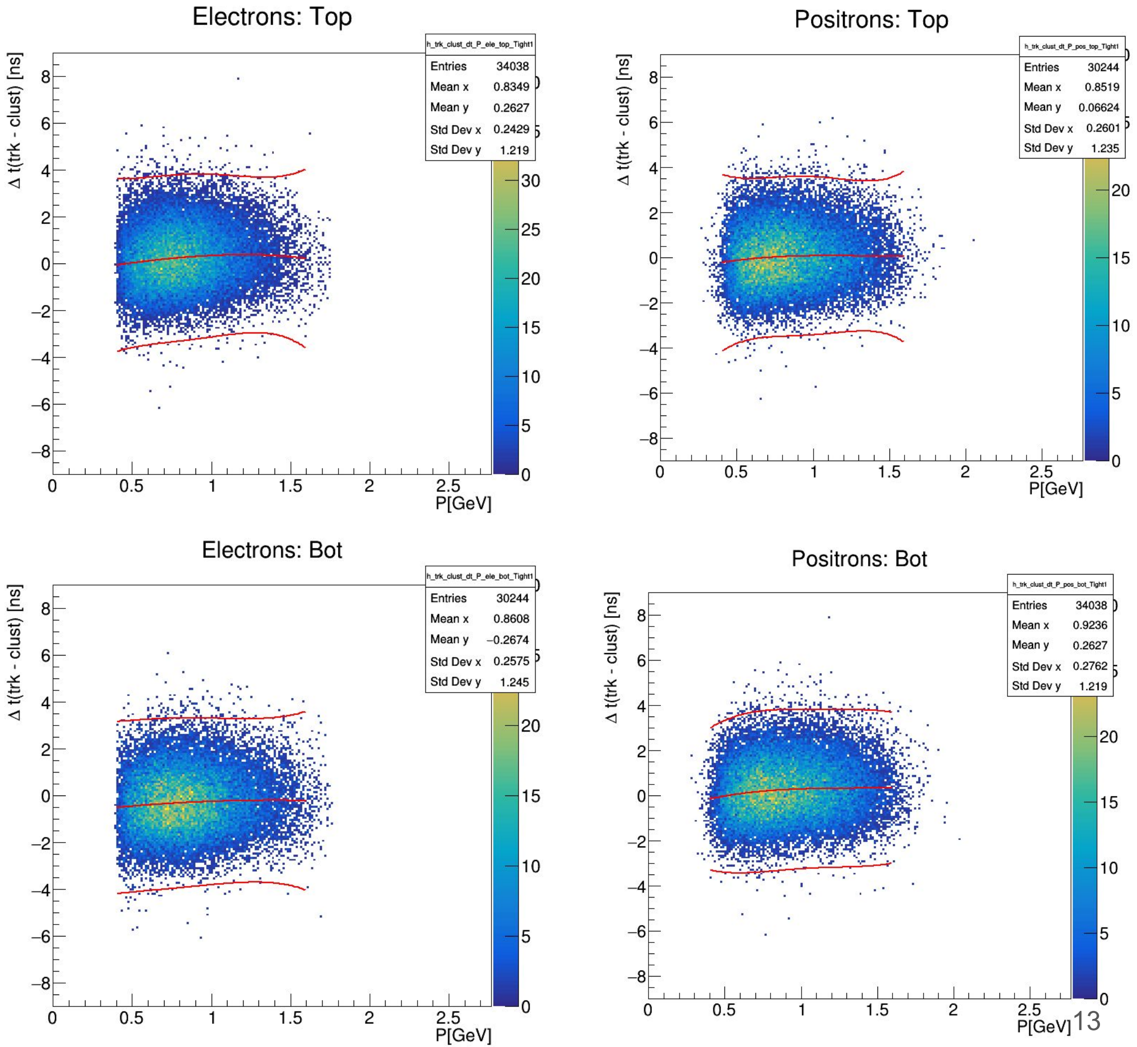
d0_cut(data) = **μ**(data) + (d0_cut - **μ**(MC))**σ**(Data)/**σ**(MC)

d0 < 1.18

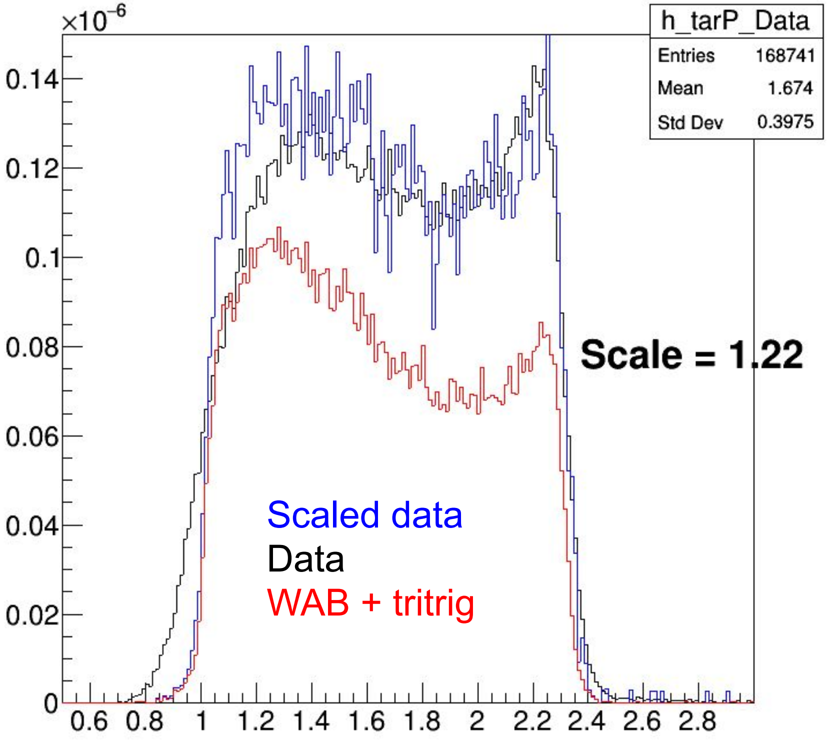
Track cluster time difference

Mean +/- 3sigma cuts can be applied
With ight cuts on other variables, essentially no bgr is present under the Gaussian.

As a systematics can be to put fixed cuts



Data MC comparison



Data and MC "shapes" agree to each other, however MC is lower the data by about 20% Data is higher than the MC.

No issue is found in the data luminosity calculation.

Will be checked with the new cooking and new MC with the new detector.