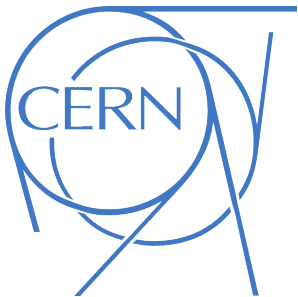
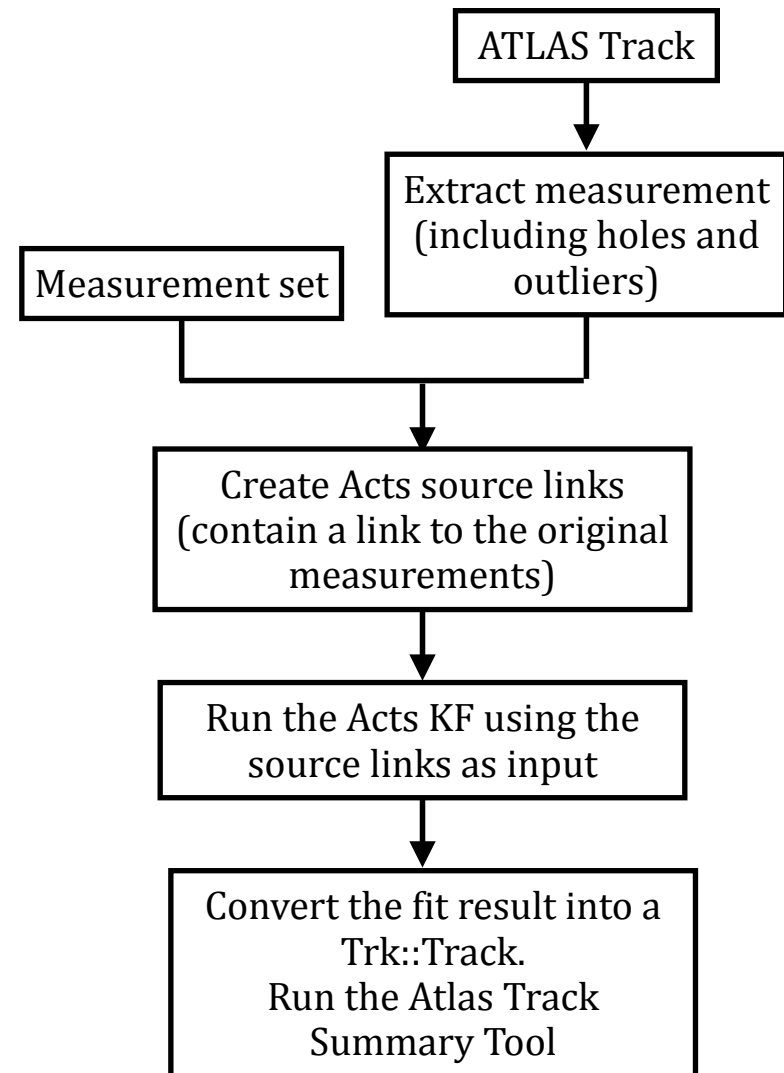

Lessons from the implementation of the KF in Athena

 Corentin Allaire



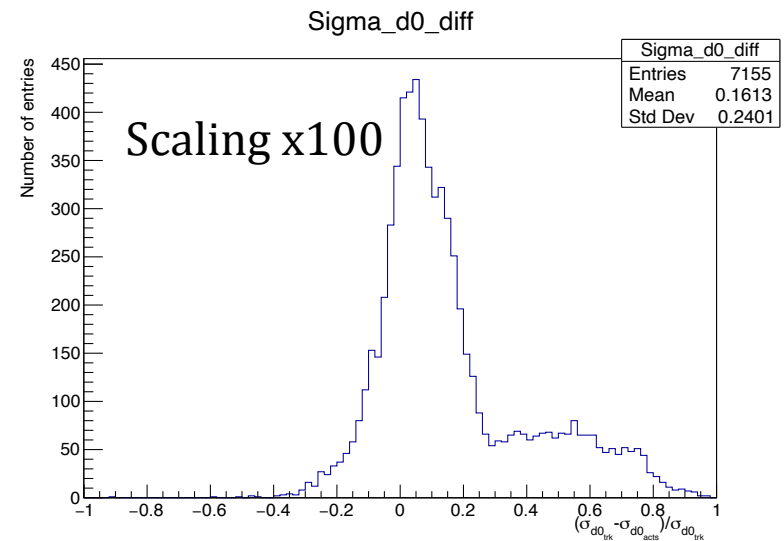
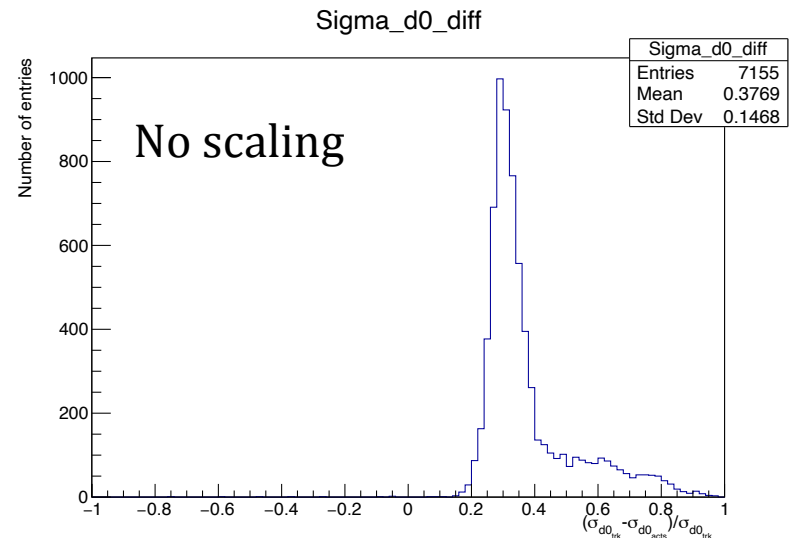
Acts Track Refitting in athena

- The Acts track fitting included into the ATLAS framework Athena (code available [here](#))
- We test the fitting by **refitting** ATLAS tracks
- We use ATLAS Resolved tracks as input :
 - Extract the measurement from them
 - **Convert** them into Acts source link
 - Use the fitted track perigee parameter as initial parameter for the fitter
- Convert the resulting track back to ATLAS track and use ATLAS tool to extract the performances
- The performance of the Acts fitting can then be compared to the original ATLAS fitting (Chi2)
- The plots I will show are with 1000 ttbar events



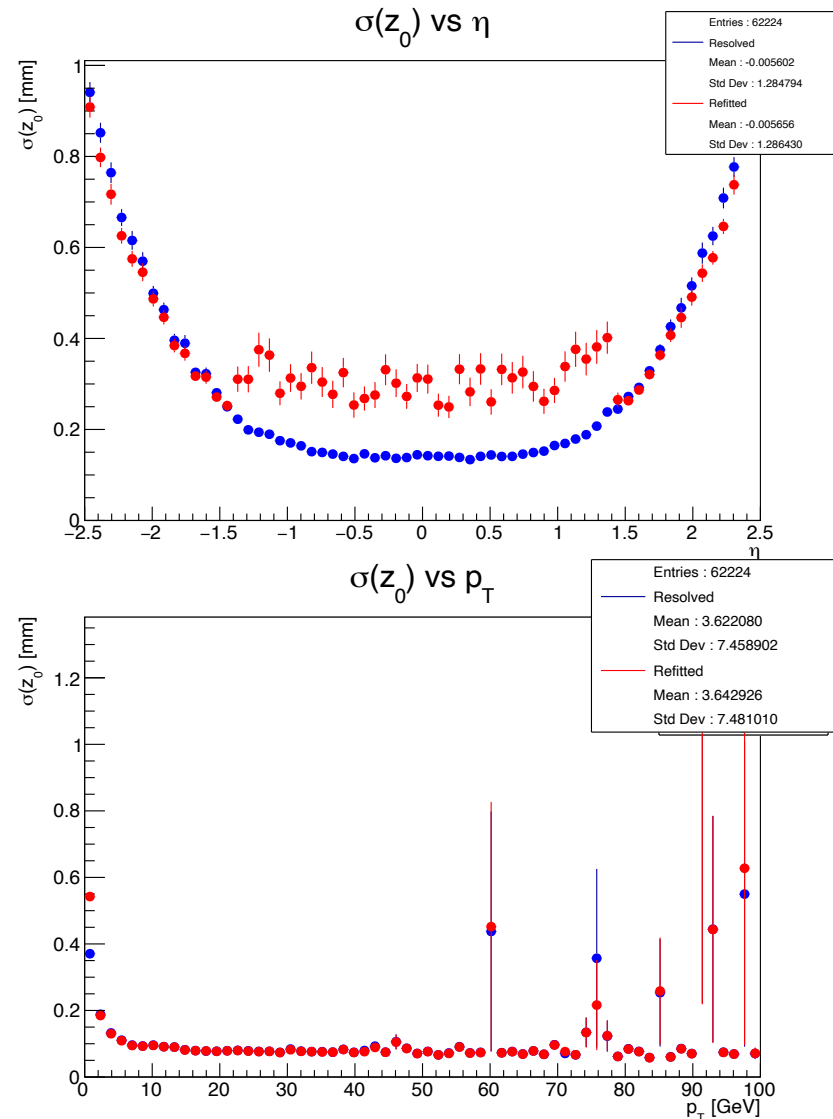
First issue : Initial covariance

- **Input** covariance -> greatly affect the resulting covariance matrix
- If your input covariance is **too small**, your starting parameters start to be interpreted as an additional measurement -> sigmas smaller than expected
- Since we use the perigee of ATLAS tracks as input; the input covariance need to be **scaled** by a **factor 100** (same thing should be done when using truth information)
- On the right, difference between the ATLAS sigma Z0 and Acts refitted sigma Z0 with and without the scaling (ignore the weird features : old plots)



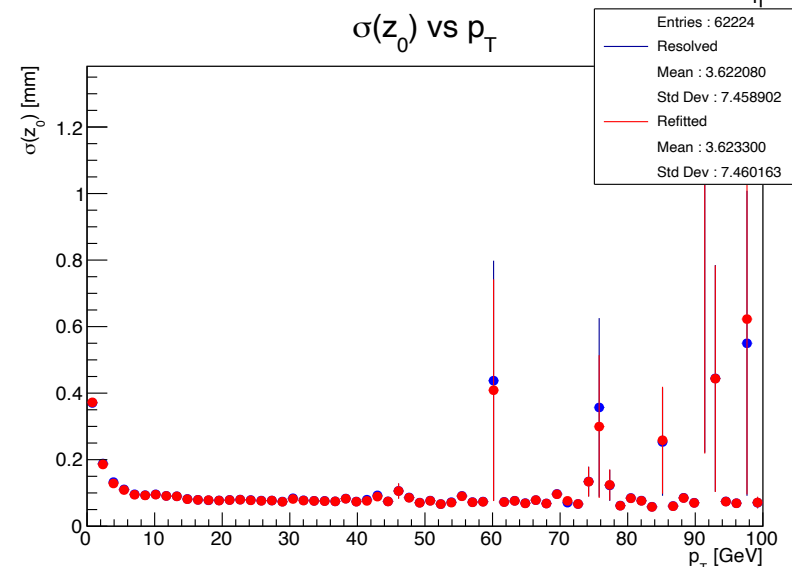
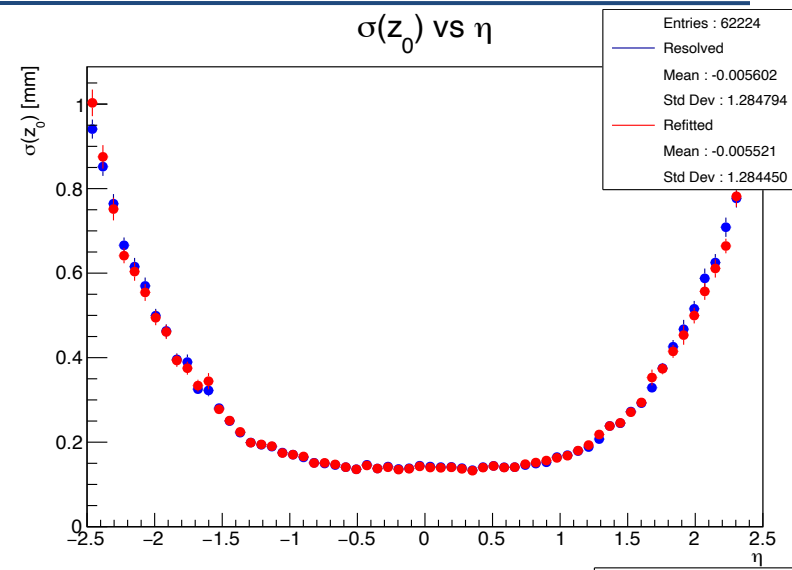
Second issue : performance at low Pt

- The value of sigma for Z0 and D0 seem to be overestimated for $\eta < 1.5$ (same for D0)
- The sigma value appears to be greatly overestimated for some ($\sim 8\%$) low pt track ($< 1\text{GeV}$)
- The issue was at first thought to be related with the Acts smoothing
- The default Acts smoothing only use the **Jacobian** between states to update the filtered track parameters -> Greatly increase speed (50% faster) but could causes issue at low Pt



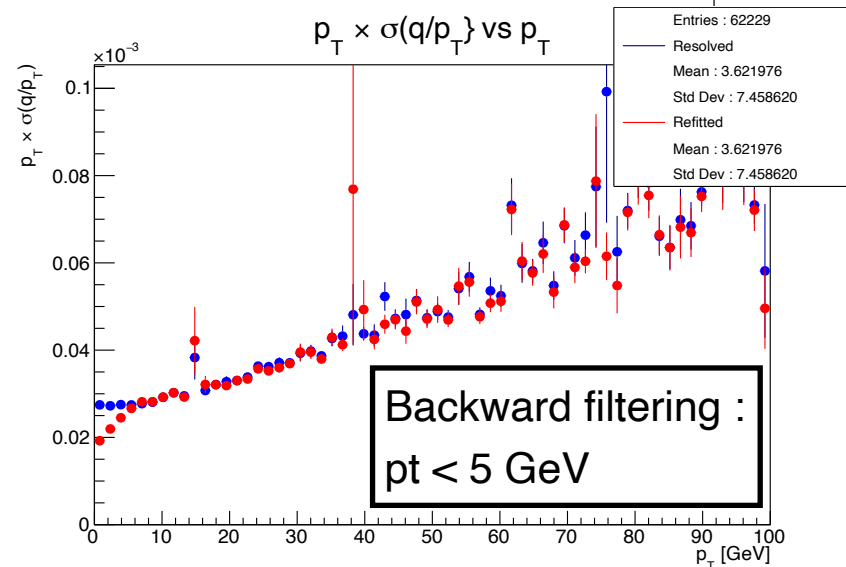
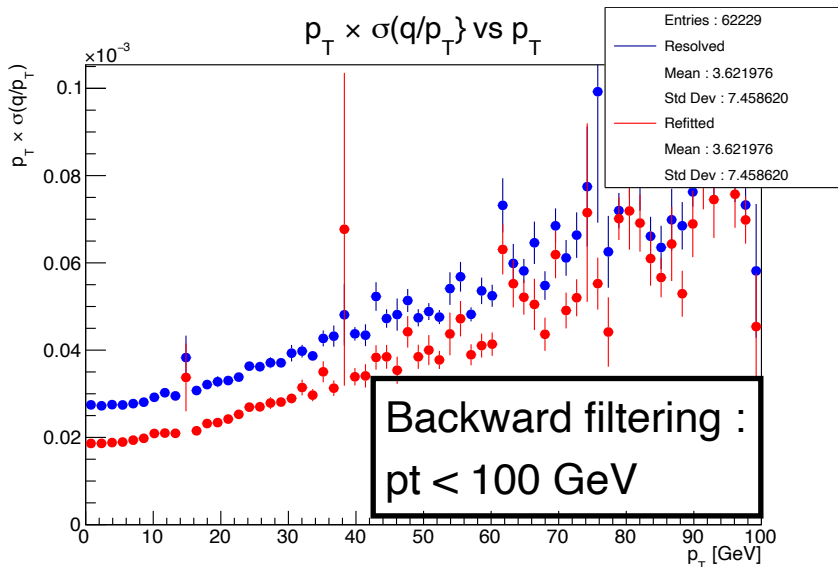
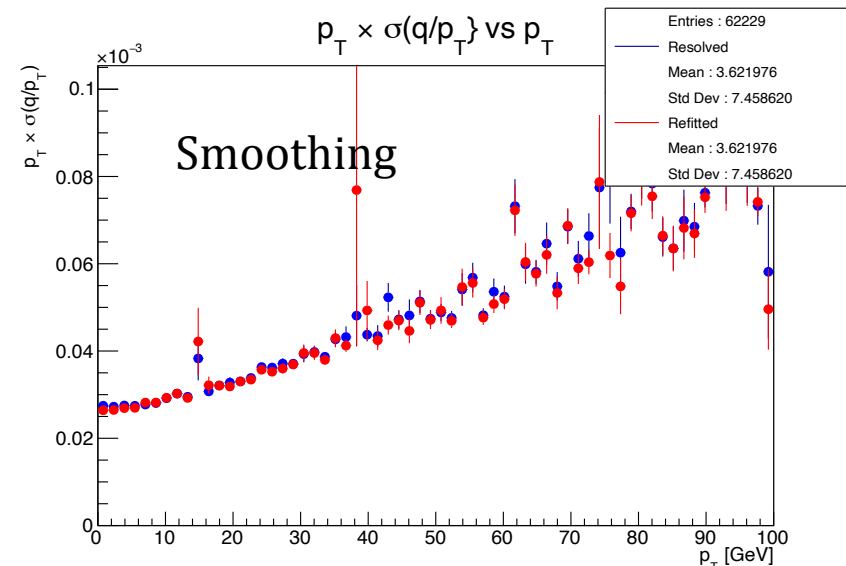
Solution : Backward filtering ?

- We tried using **backward filtering** (similarly to what the ATLAS KF uses) for low Pt track
- The way material is accounted in the backward propagation had to be changed : it used to remove noise instead of adding it ([#1033](#))
- Added a reverseFilteringLogic extension to the KF ([#1021](#)) -> allows us to decide on a track per track basis if we should use the smoothing or the backward filtering
- At this point, we put a Pt threshold at 5GeV
- With this, the low pt issue is resolved for most parameters



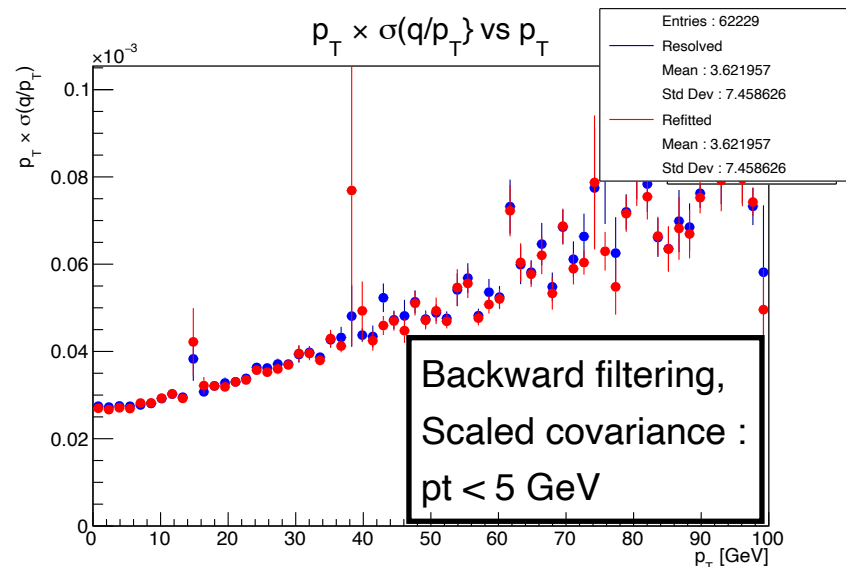
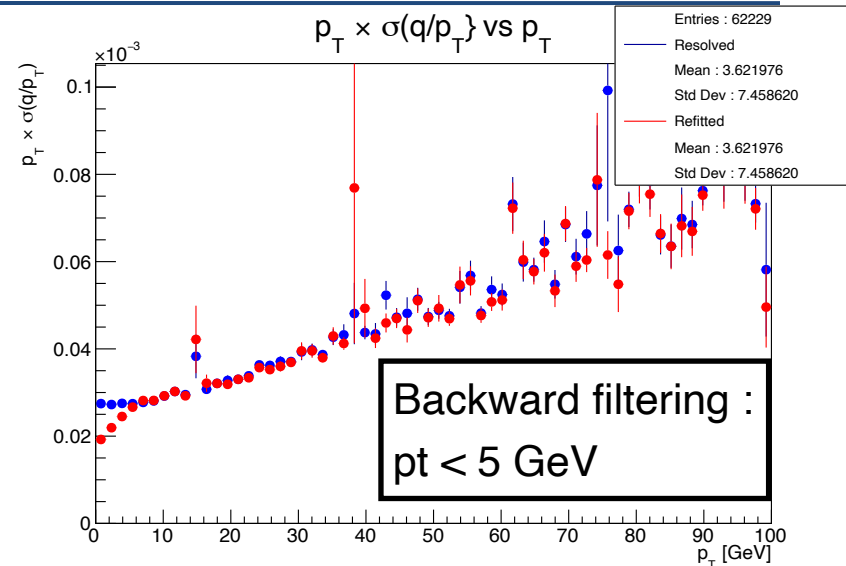
Backward filtering issue

- Unfortunately, there seem to be an issue with the backward filtering
- While it greatly improves the pull width at low p_T for most variables, it degrades the performance for q_p
- When using the backward filtering the sigma q_p seem to be greatly **underestimated**



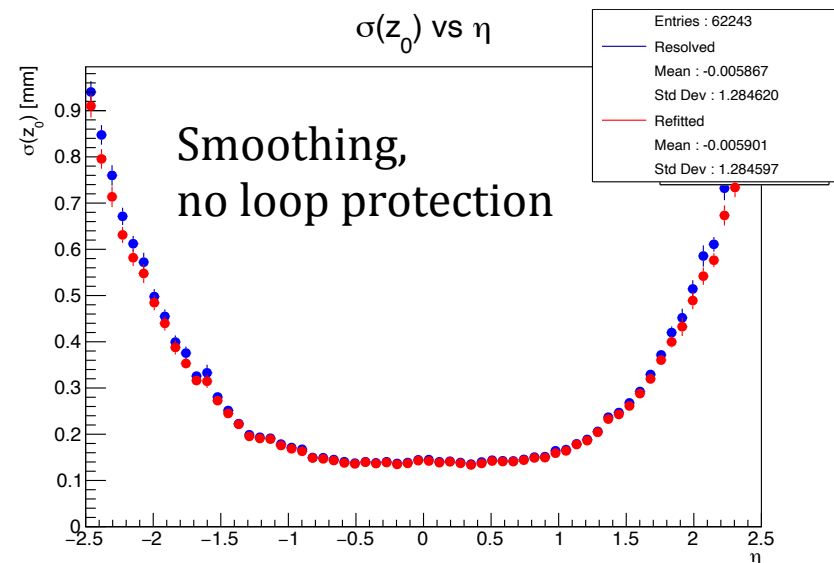
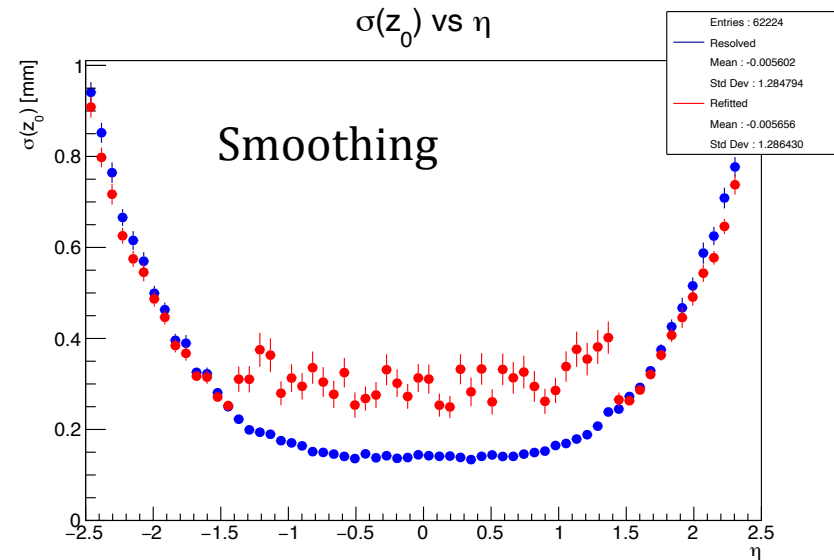
Backward filtering solution

- We were not **rescaling** the covariance matrix before starting the backward filtering
- The literature seem to imply that this might sometime be necessary (that is also what ATLAS was doing in the past)
- The covariance given to the backward filter is now the filtered covariance of the last measurement times 100 -> this seems to have **solved the issue** (and doesn't affect the smoothed parameters)
- A PR is currently open to add the option of scaling the covariance before the backward filtering ([#1147](#))



Back to the smoothing issue

- The refitting is working, but the backward filtering slowdown the fitting. **Why is the smoothing performing poorly at low Pt ?**
- Some detailed look at the logs showed that at the end of the smoothing (on the beampipe) the covariance didn't look so bad but it did after extrapolating the parameters to the perigee
- The issue appear to be the **loop protection** for the propagation, some really low Pt particles appear to be looping between the BP and the perigee -> incorrect covariance
- Turning the protection off solved the issue -> changing the max nb of loop might be enough (more test needed)

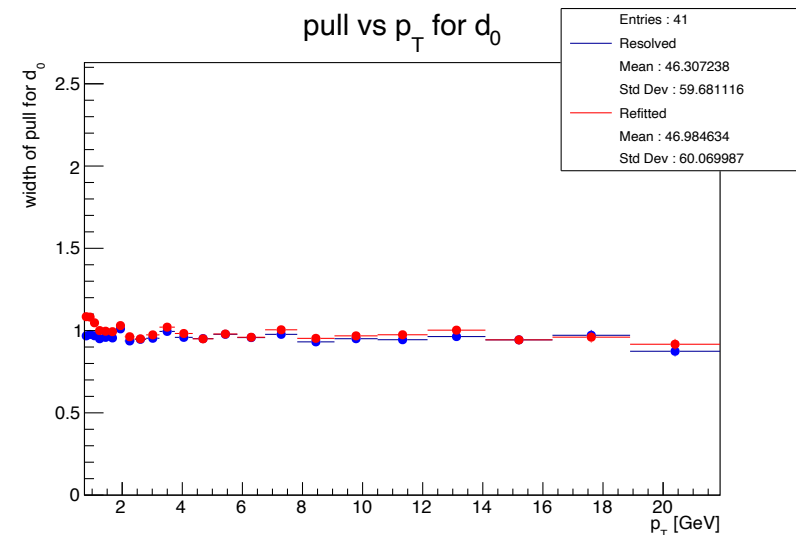
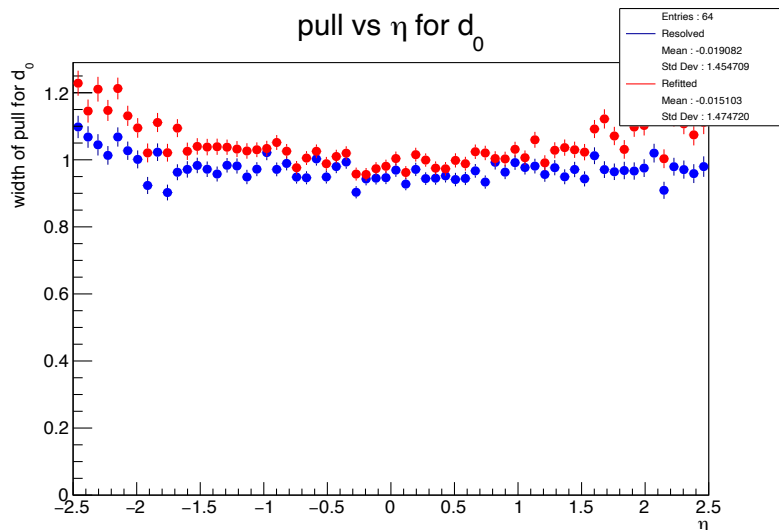
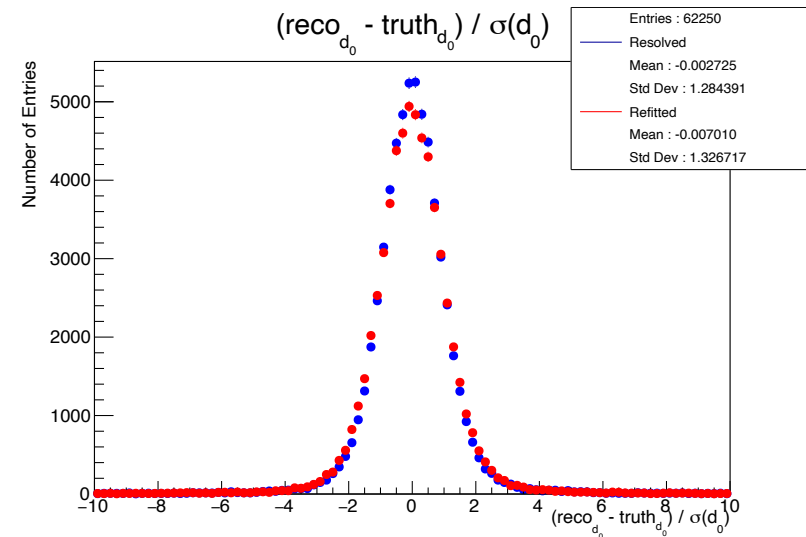


Smoothing or Backward filtering ?

- At first glance, the smoothing seems to be performing just **as well** as the backward filtering while being **50% faster**
- We still need to investigate if there are regions that would benefit from using it (and that would benefit enough for justifying the speed decrease)
- The infrastructure to use it properly is in place (reverseFilteringLogic, covariance scaling) but for now we won't be using it in ATLAS

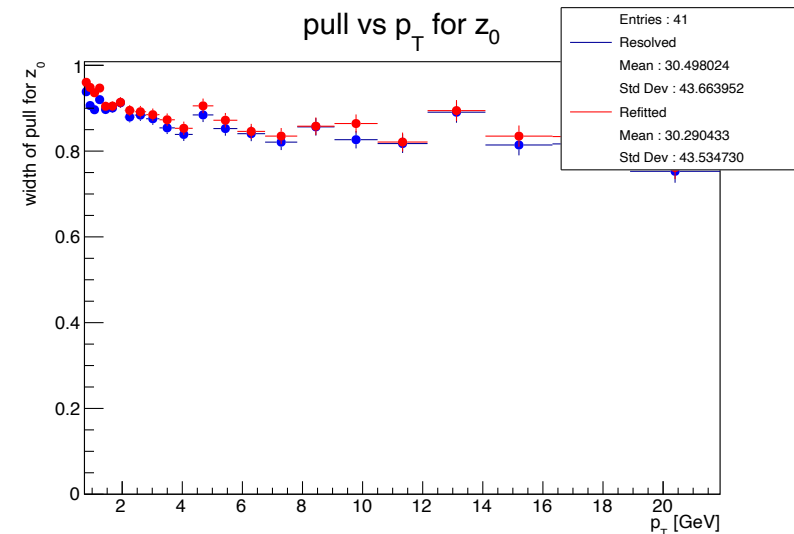
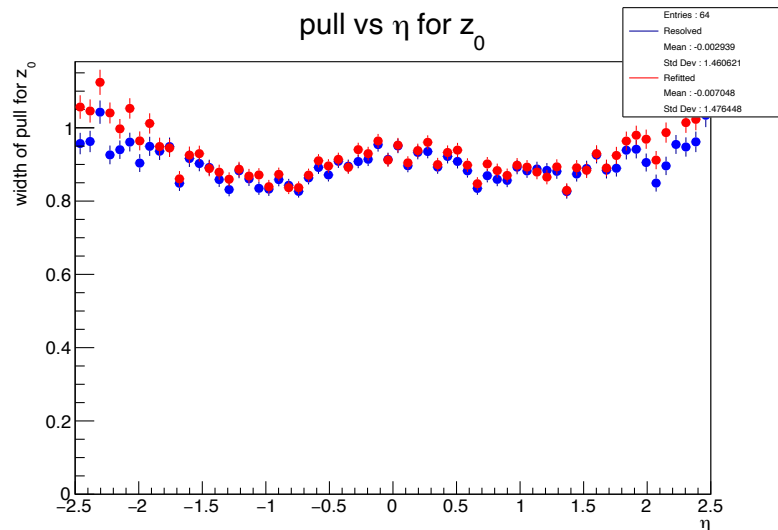
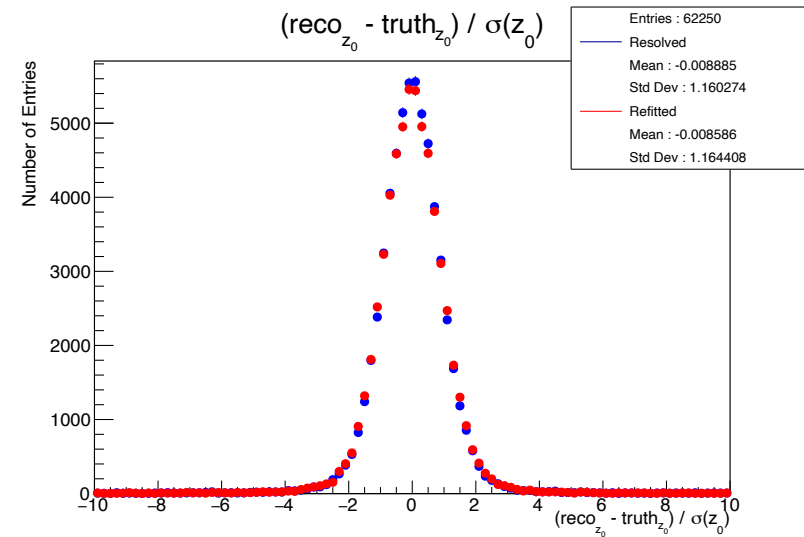
Some nice plots to conclude : d0

- Good agreement between ATLAS and Acts
- Some differences : might be **material** related
- Some optimisation is needed but we would prefer to do it with the **ITk** directly



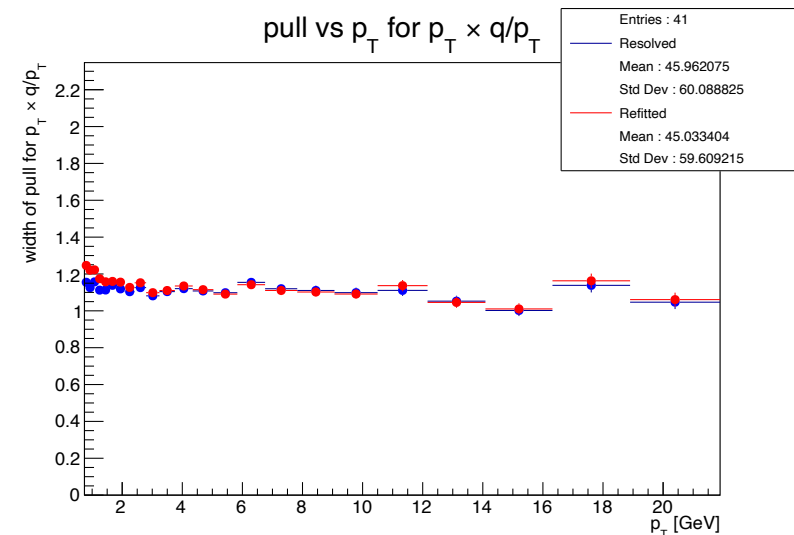
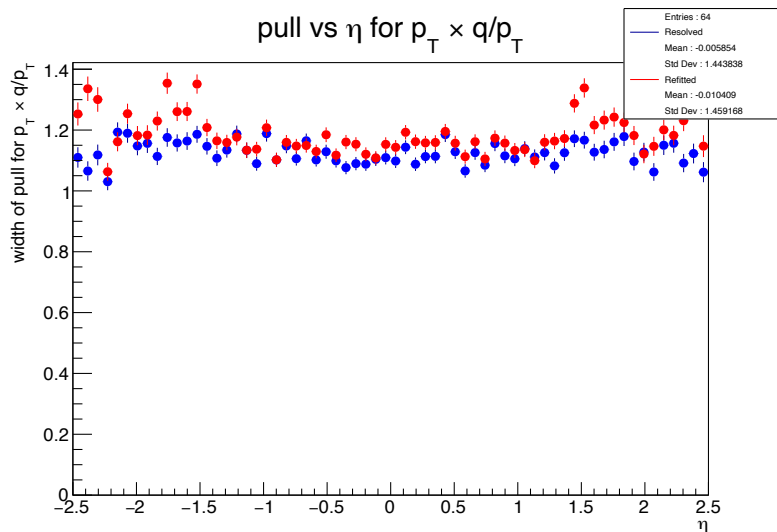
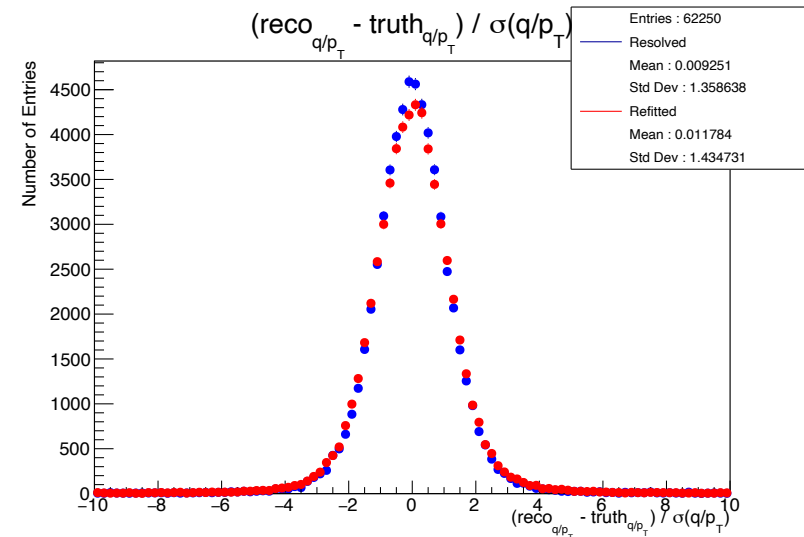
Some nice plots to conclude : z0

- Good agreement between ATLAS and Acts
- Some differences : might be **material** related
- Some optimisation is needed but we would prefer to do it with the **ITk** directly



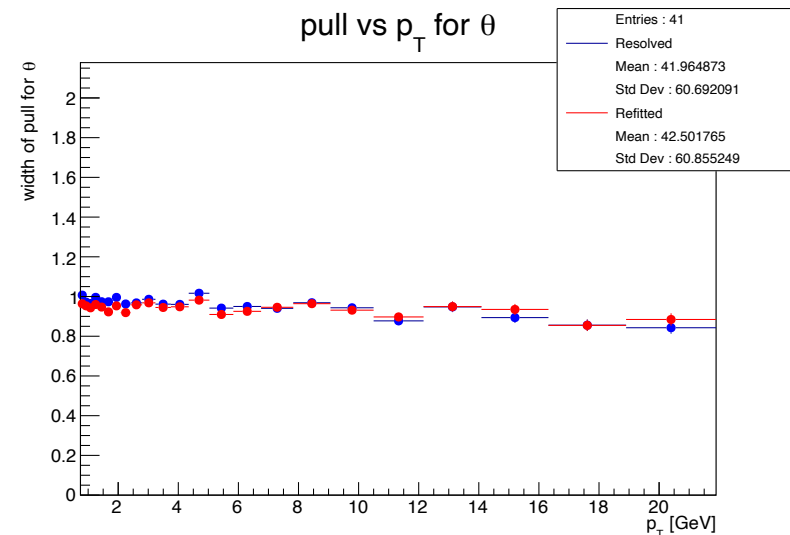
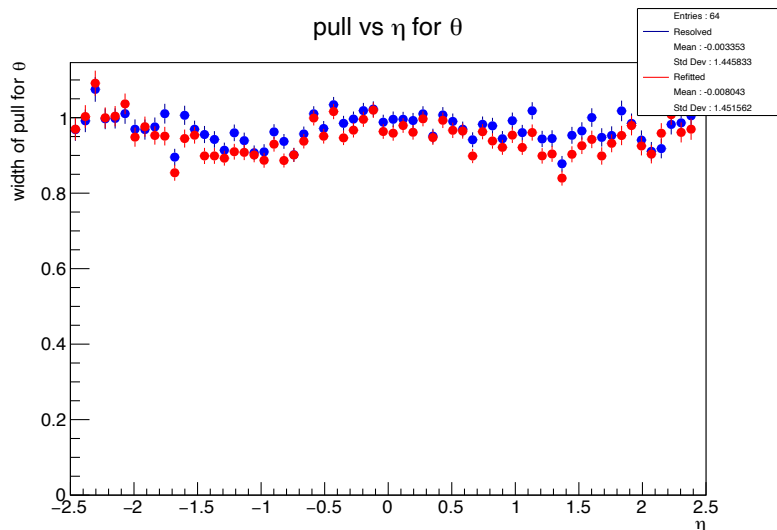
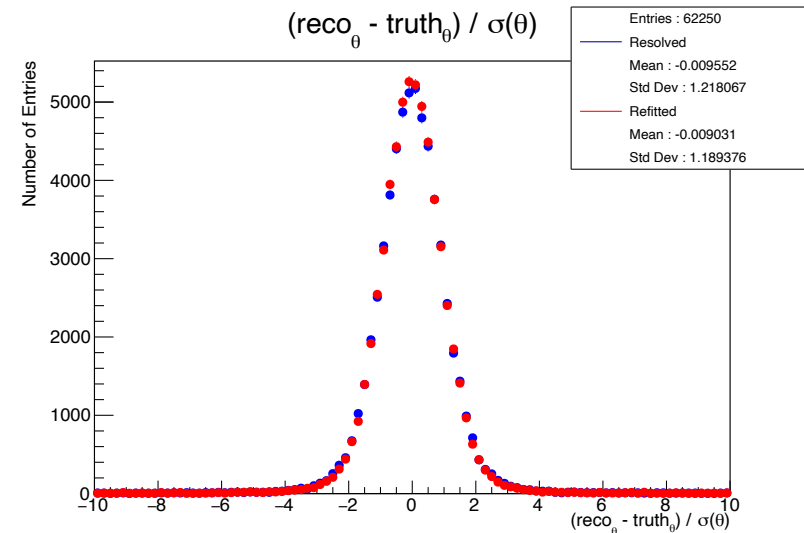
Some nice plots to conclude : qop

- Good agreement between ATLAS and Acts
- Some differences : might be **material** related
- Some optimisation is needed but we would prefer to do it with the **ITk** directly



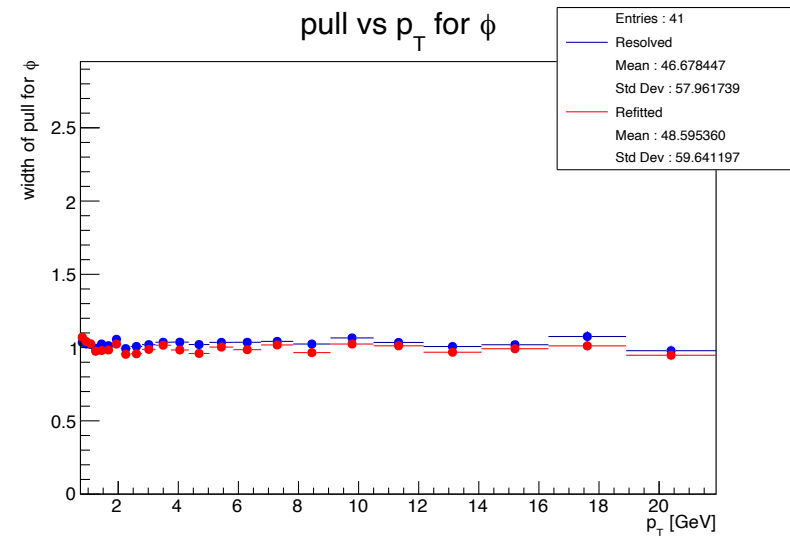
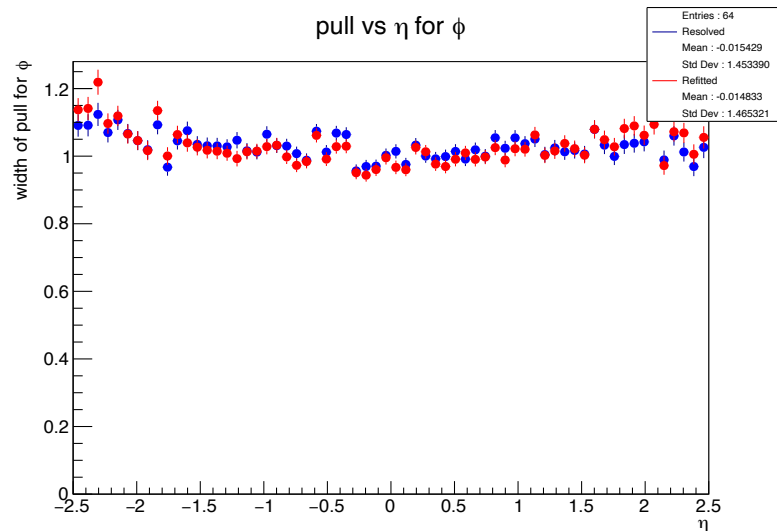
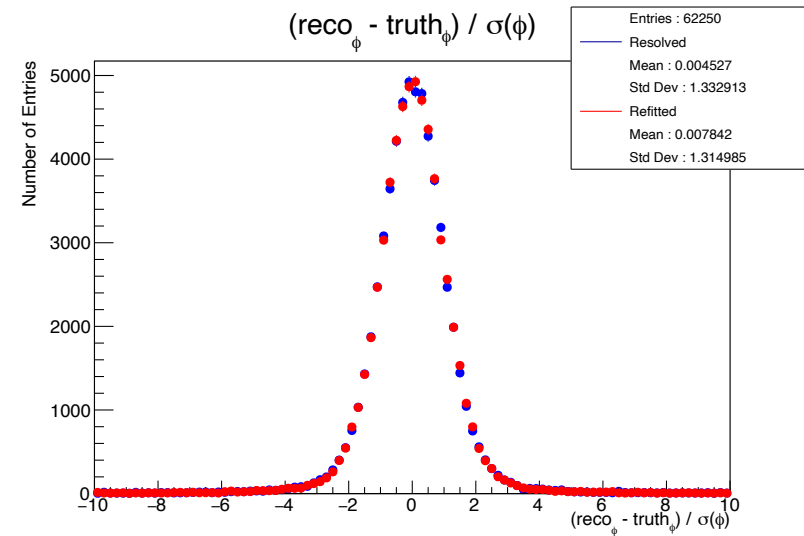
Some nice plots to conclude : theta

- Good agreement between ATLAS and Acts
- Some differences : might be **material** related
- Some optimisation is needed but we would prefer to do it with the **ITk** directly



Some nice plots to conclude

- Good agreement between ATLAS and Acts
- Some differences : might be **material** related
- Some optimisation is needed but we would prefer to do it with the **ITk** directly



Conclusion / Next Steps

- The integration of the Acts KF in ATLAS has been a big learning experience -> helped us to solve many issue with the Acts KF.
- Very soon we will perform some speed comparison between ATLAS and Acts
- The refitting was performed with ATLAS run 2 geometry, we want to then do it with ITk
- More optimisation of the fitting will then be performed using the ITk

BACKUP