



Muon reconstruction in the $H \rightarrow \mu\mu$ channel with BIB

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- In the $H \rightarrow \mu\mu$ analysis (A. Montella's Master's thesis) the reconstruction and identification of muons was based on Conformal Tracking (CT) + Pandora PFA.
- Due to the computational difficulties of performing CT tracking with BIB, the BIB was not superimposed to the physical events with the assumption that its effects were minor and negligible for muons.
- To test such an assumption and quantify the effect of the BIB on the $H \rightarrow \mu\mu$ yield, in view of a future publication, I re-reconstructed 10k events of Alessandro's sample $\mu\mu \rightarrow H\nu\nu \rightarrow \mu\mu\nu\nu$ using the CKF implemented in ACTS with and without the BIB overlay, and Pandora PFA to identify the muons.

The $H \rightarrow \mu\mu$ analysis in a nutshell

- Signal and background samples generated with MadGraph5 and processed with the detector full simulation + MARLIN reconstruction w/o BIB.

- Analysis strategy:

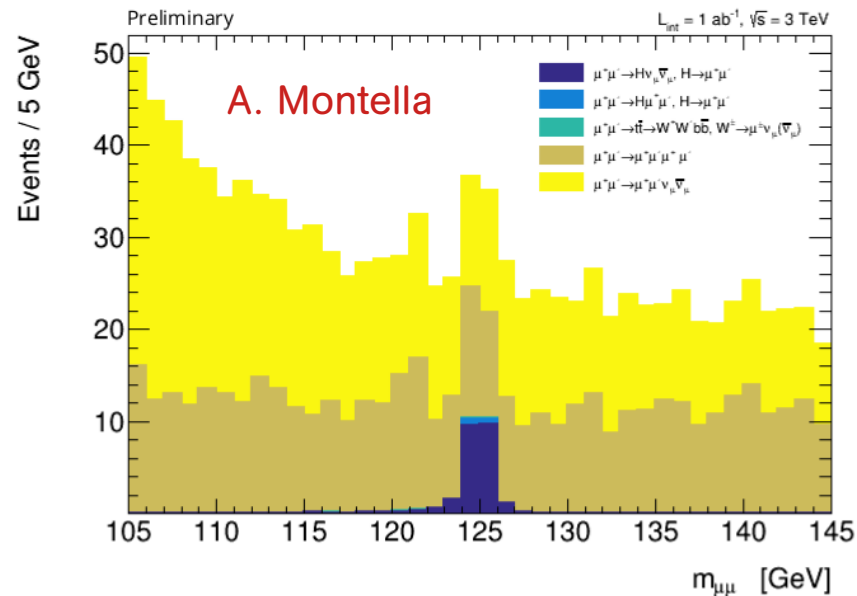
- ▶ loose preselection of events with two opposite-charge muons:

$$\begin{aligned} p_T &> 5 \text{ GeV}; \\ 10^\circ < \theta_\mu < 170^\circ; \\ p_{T1} + p_{T2} &> 50 \text{ GeV}; \\ p_T(\mu\mu) &> 30 \text{ GeV}; \\ 115 < m_{\mu\mu} &< 135 \text{ GeV}; \end{aligned}$$

- ▶ two BDTs to separate the signal from the dominant backgrounds.

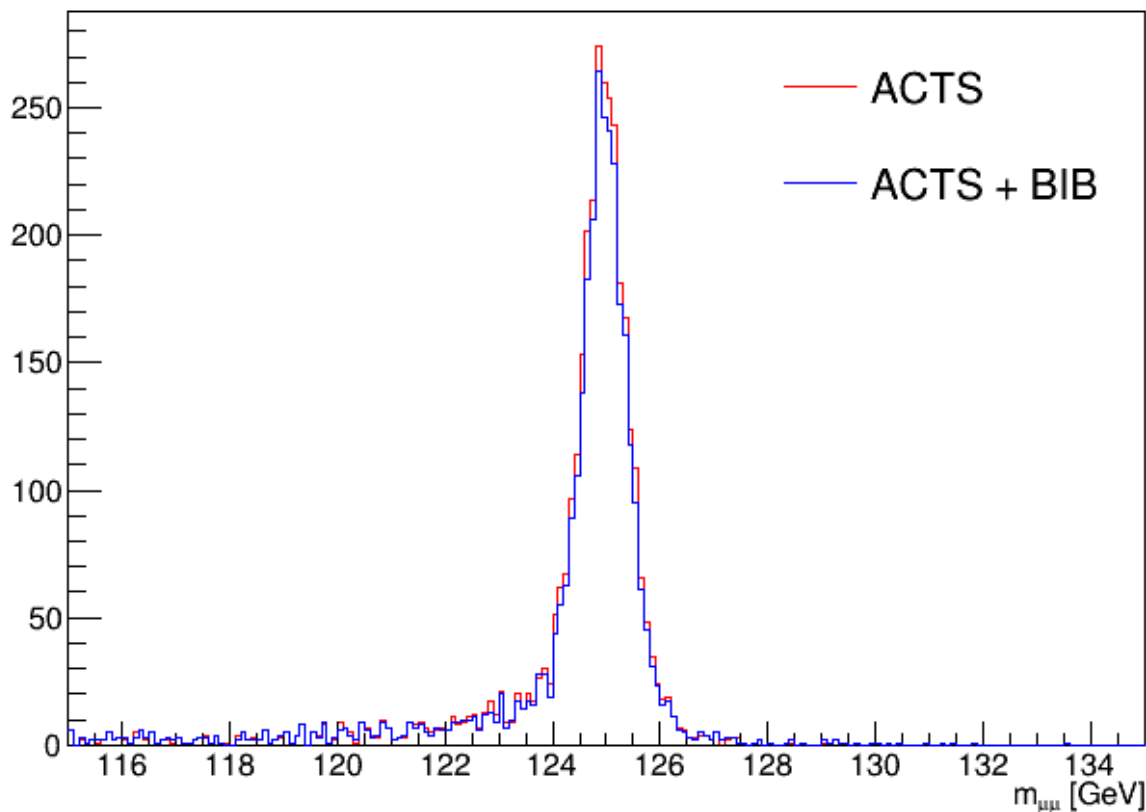
- Result:

$$\frac{\Delta \sigma_{H \rightarrow \mu\mu}}{\sigma_{H \rightarrow \mu\mu}} \sim 38\%$$



Process	Expected events with $105 < m_{\mu\mu} < 145 \text{ GeV}$
$\mu^+ \mu^- \rightarrow H \nu_\mu \bar{\nu}_\mu, H \rightarrow \mu^+ \mu^-$	24.2
$\mu^+ \mu^- \rightarrow H \mu^+ \mu^-, H \rightarrow \mu^+ \mu^-$	1.6
$\mu^+ \mu^- \rightarrow \mu^+ \mu^- \nu_\mu \bar{\nu}_\mu$	636.5
$\mu^+ \mu^- \rightarrow \mu^+ \mu^- \mu^+ \mu^-$	476.4
$\mu^+ \mu^- \rightarrow t \bar{t} \rightarrow W^+ W^- b \bar{b}, W^\pm \rightarrow \mu^\pm \nu_\mu (\bar{\nu}_\mu)$	1.1

$\mu\mu$ invariant mass



Event selection:

$$p_T > 5 \text{ GeV};$$

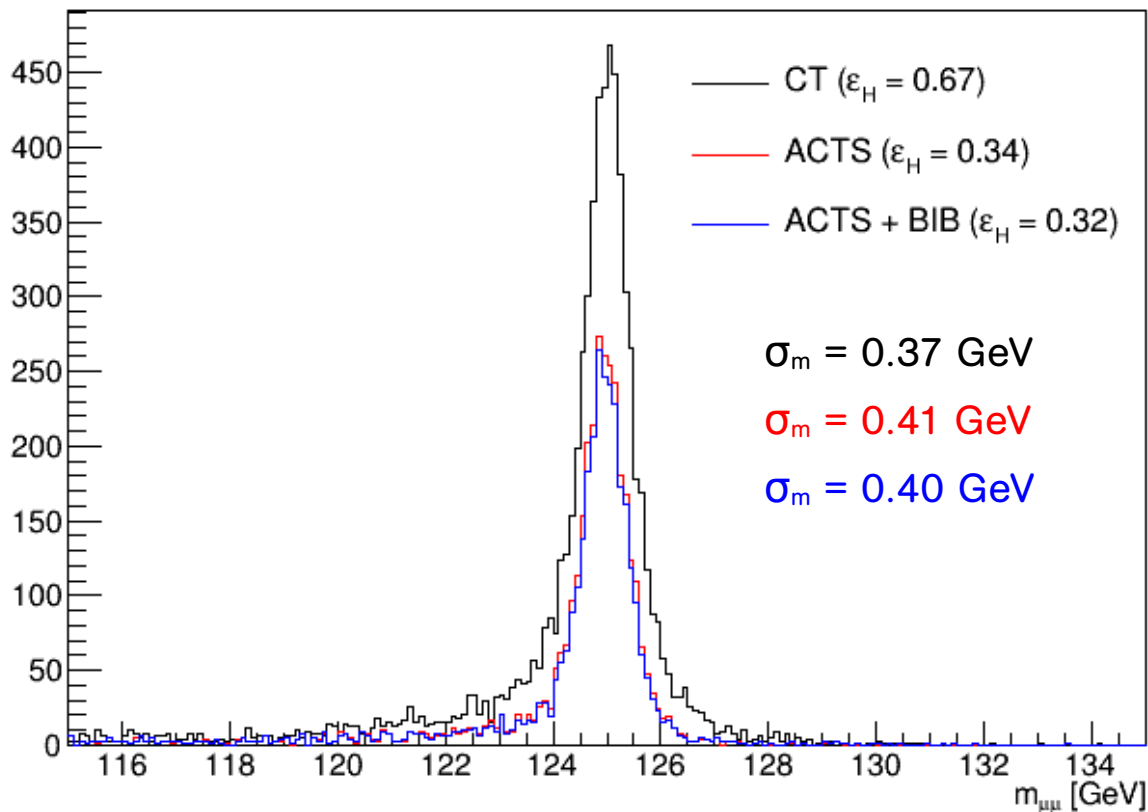
$$10^\circ < \theta_\mu < 170^\circ;$$

$$p_{T1} + p_{T2} > 50 \text{ GeV};$$

$$p_T(\mu\mu) > 30 \text{ GeV};$$

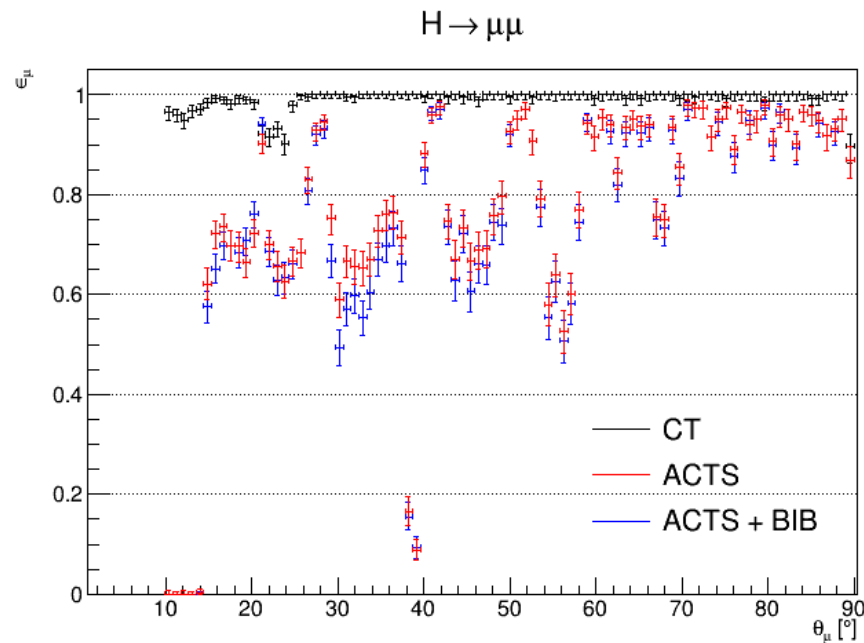
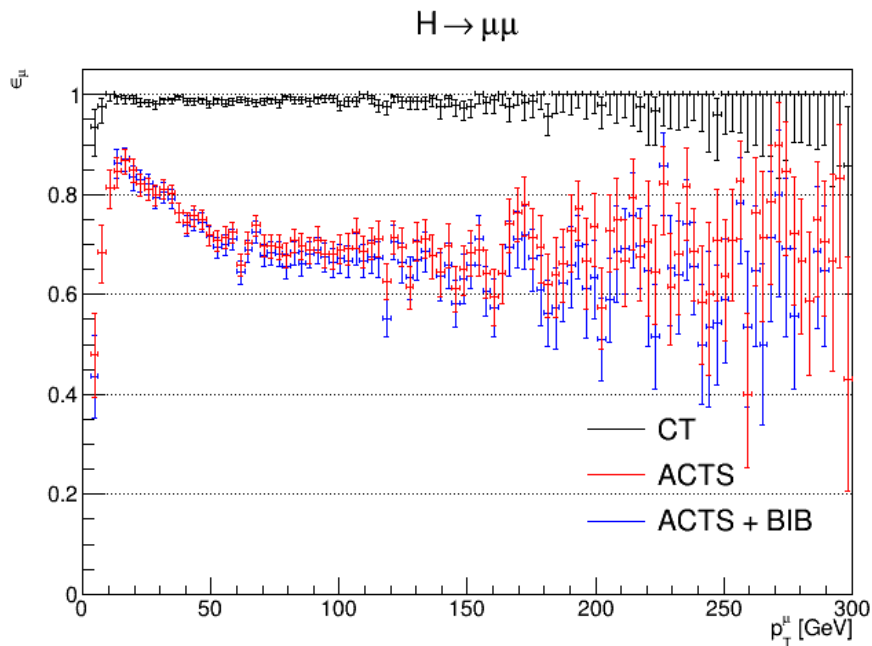
$$115 < m_{\mu\mu} < 135 \text{ GeV}.$$

$\mu\mu$ invariant mass

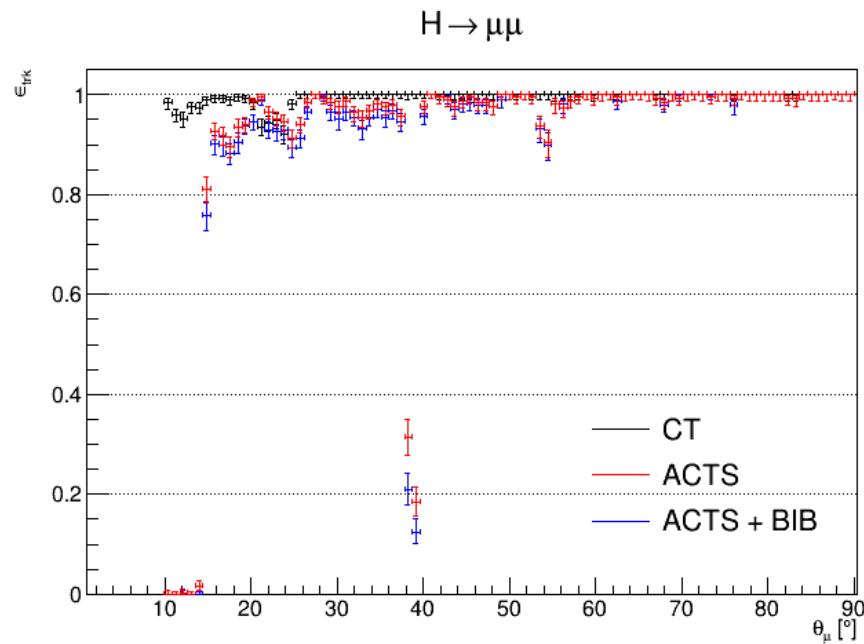
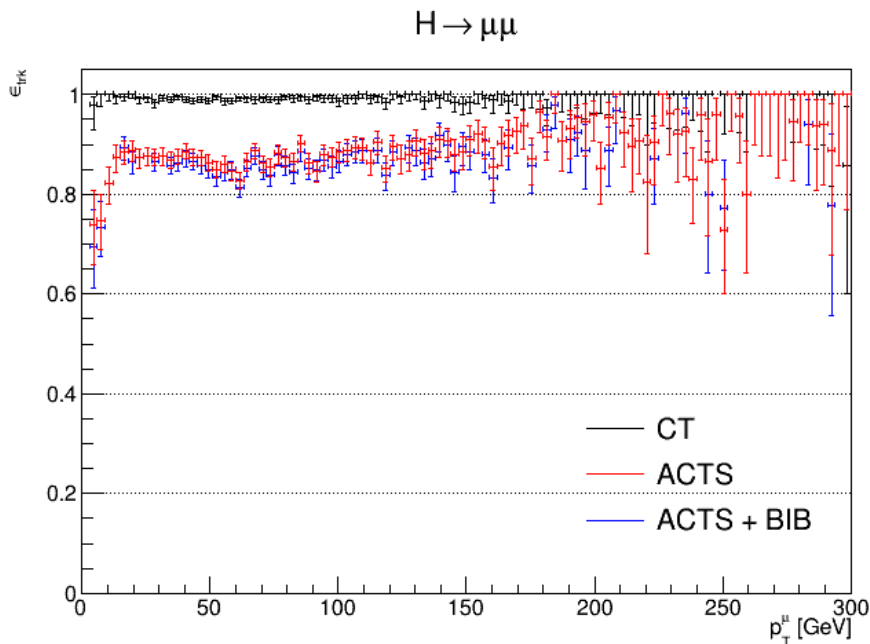


Event selection:

- $p_T > 5$ GeV;
- $10^\circ < \theta_\mu < 170^\circ$;
- $p_{T1} + p_{T2} > 50$ GeV;
- $p_T(\mu\mu) > 30$ GeV;
- $115 < m_{\mu\mu} < 135$ GeV.



- ▶ Denominator: generated muons with $p_T > 3$ GeV and $10^\circ < \theta_\mu < 170^\circ$.
- ▶ Numerator: generated muons matching a reconstructed muon with $\Delta R < 0.05$.



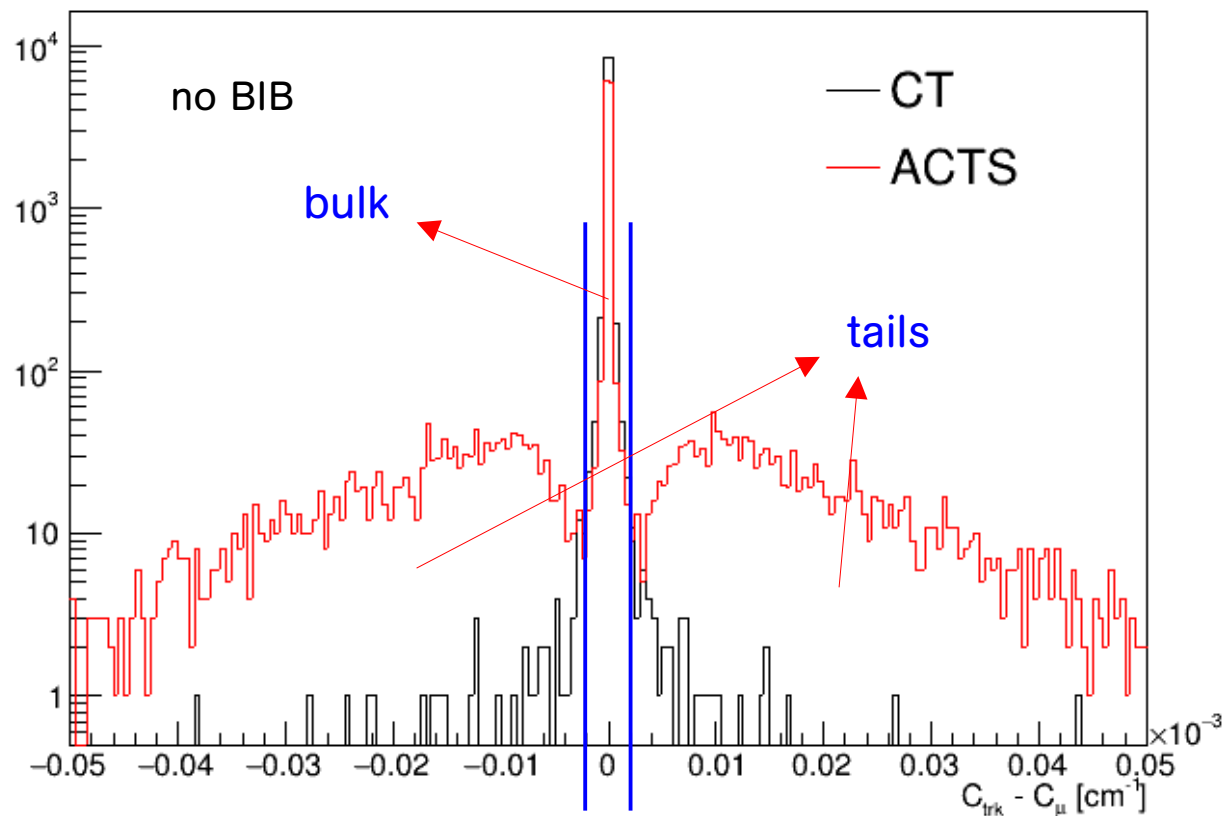
- ▶ Denominator: generated muons with $p_T > 3$ GeV and $10^\circ < \theta_\mu < 170^\circ$.
- ▶ Numerator: generated muons matching a reconstructed track with $\Delta R < 0.05$.

Track p_T measured inaccurately?

generator-level μ	→ MC	:	-13	58.6733	34.9037	49.0586
	→ RECO trk	:	1	59.1145	34.9027	49.0605
	→ RECO muon	:	-13	59.0735	34.9027	49.0605
μ reco track	→ MC	:	13	47.7156	-118.781	115.767
	→ RECO trk	:	-1	47.73	-118.782	115.767
	→ RECO muon	:	13	47.6969	-118.782	115.767
reco μ	→ MC	:	-13	55.7595	169.302	76.5328
	→ RECO trk	:	1	55.7643	169.304	76.5352
	→ RECO muon	:	-13	55.7257	169.304	76.5352
	→ MC	:	13	152.051	10.4323	24.0213
	→ RECO trk	:	-1	733.642	10.465	24.0327
	→ MC	:	13	42.4256	95.8376	148.154
	→ RECO trk	:	1	9522.72	95.9164	148.153
	→ MC	:	-13	48.967	73.3398	122.844
	→ RECO trk	:	-1	66.9087	73.2185	122.845
	→ MC	:	13	36.2433	-62.4768	43.2846
	→ RECO trk	:	-1	606.437	-62.3978	43.2836
	→ MC	:	-13	88.5644	-91.7945	121.963
	→ RECO trk	:	1	170.132	-91.8275	121.959
	→ MC	:	-13	104.235	-50.1424	20.3948
	→ RECO trk	:	-1	161.268	-50.2253	20.3941
	→ MC	:	-13	78.7789	-88.3008	132.912
	→ RECO trk	:	1	641.855	-88.3456	132.913

- It seems that Pandora fails to reconstruct a muon when the p_T of the feeding track is poorly determined.

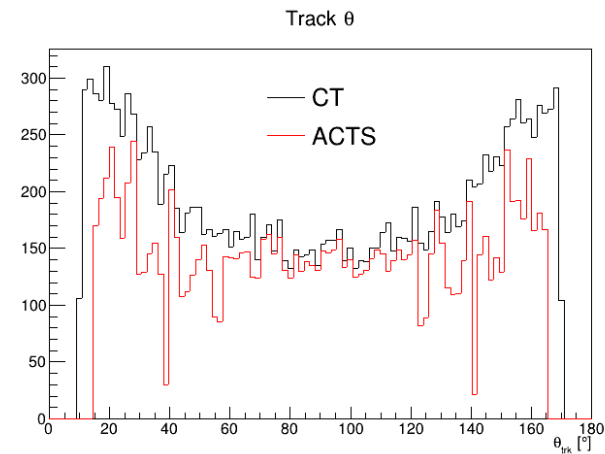
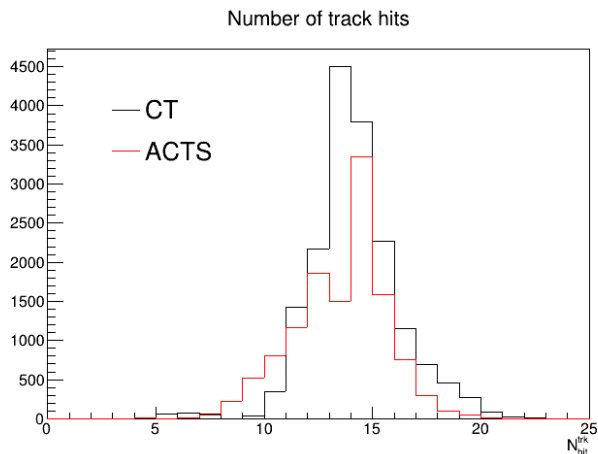
Track curvature residuals



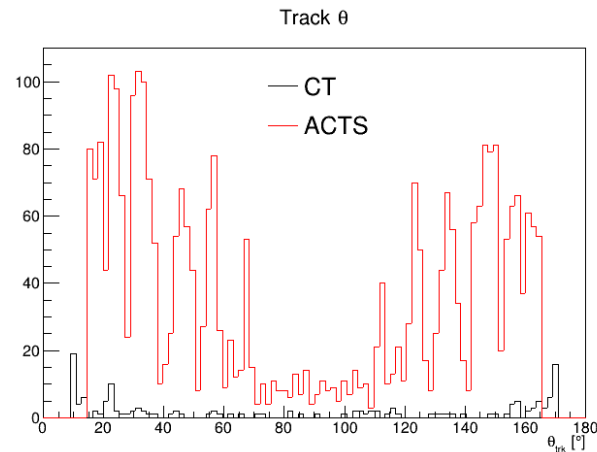
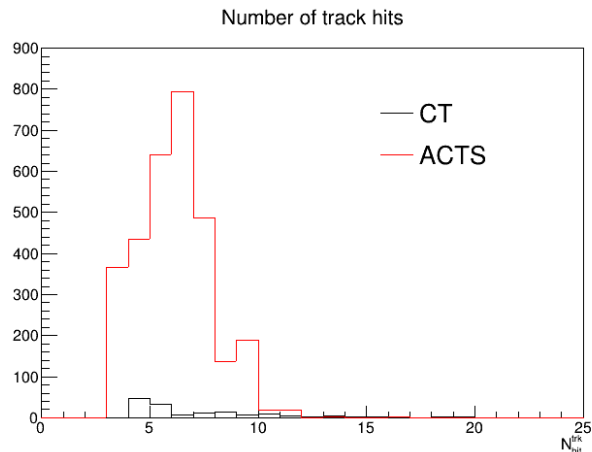
Thanks to Simone
for the suggestion!

Tracks in the bulk vs tracks in the tails

tracks in the bulk

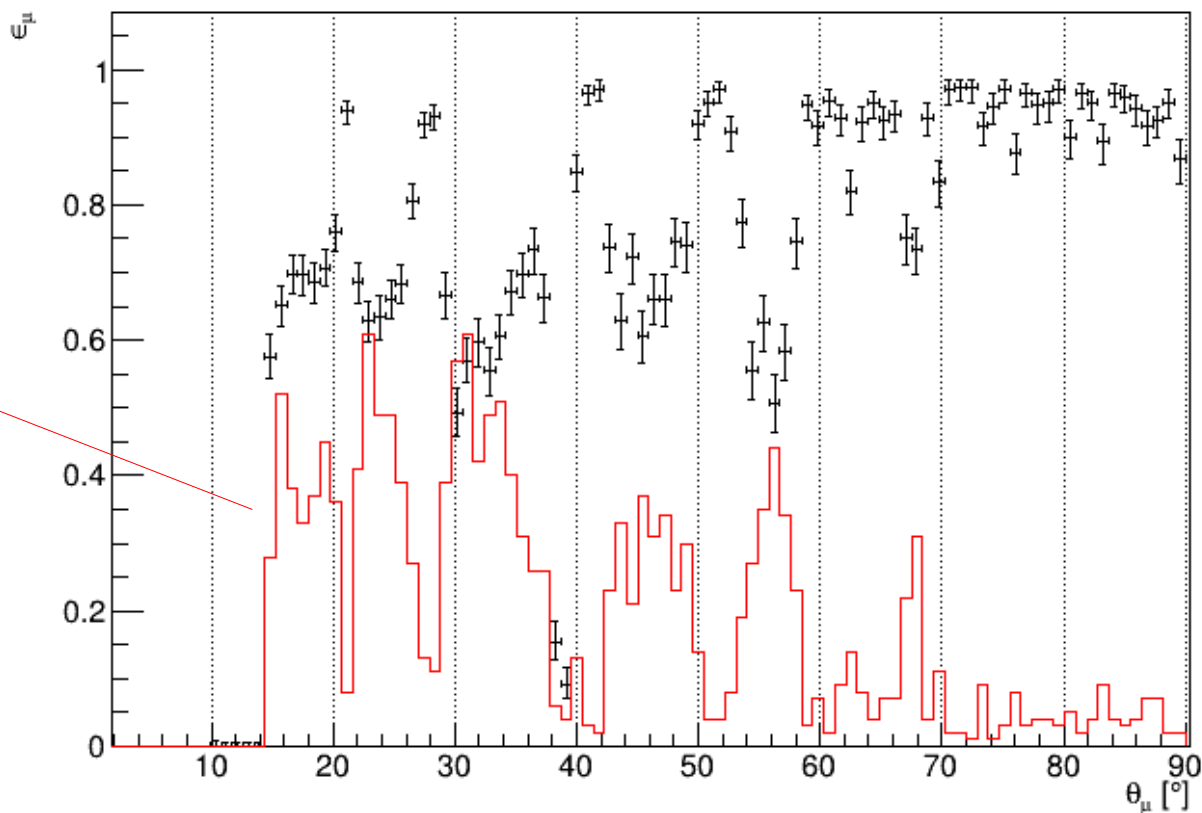


tracks in the tails



$H \rightarrow \mu\mu$

tracks in the tails of the curvature residuals



Tentative conclusion

- When comparing the samples reconstructed with ACTS + Pandora PFA with and without the BIB, the BIB effect on the $H \rightarrow \mu\mu$ yield results very small, around 2%.
- But the overall muon reconstruction efficiency is significantly affected, at least in the muon momentum range in interest for these analysis, by tracks that have been inaccurately reconstructed with fewer hits and need further investigation.