CP measurement in $H \rightarrow \tau\tau$

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Today's topic:

Ntuples for 2018 are ready

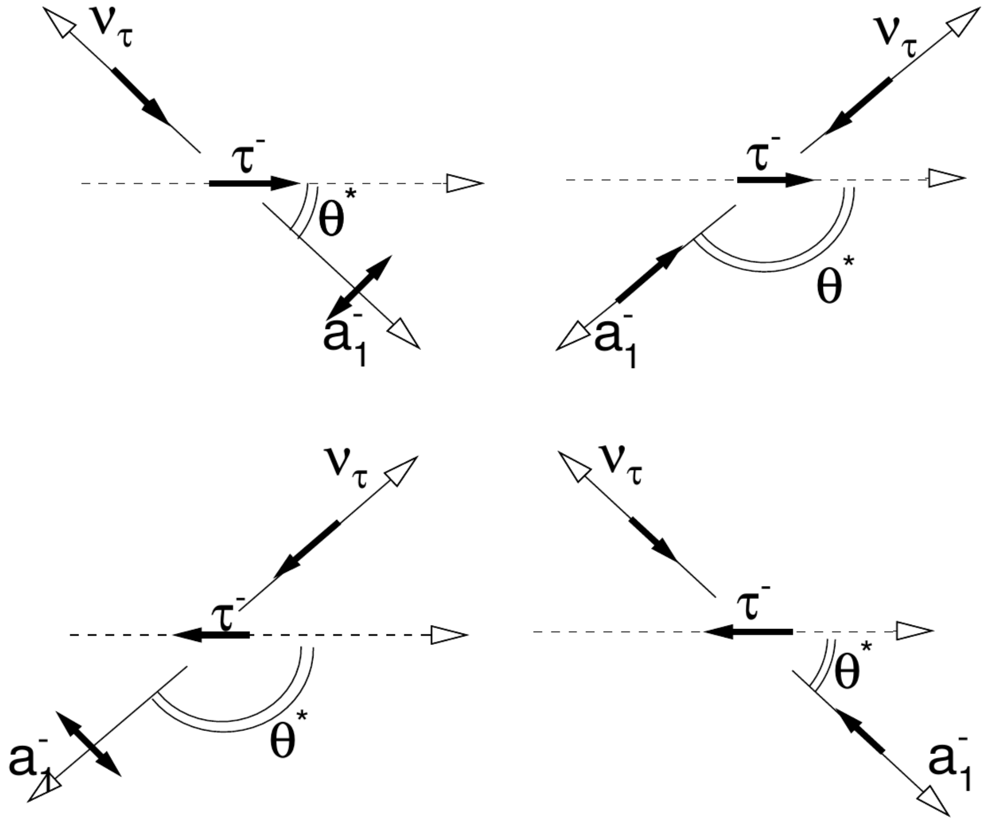
Update on 3 prong channel

2018 NTuples

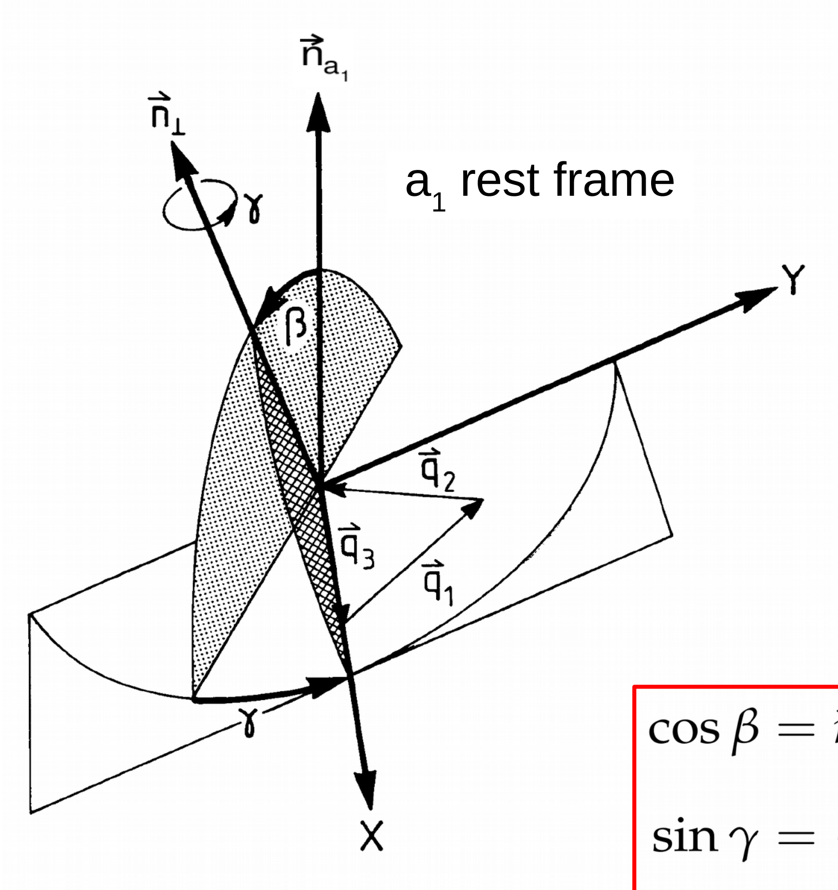
- DATA:
  - Egamma: /nfs/dust/cms/user/cardinia/gridjobs/2018/Ntuples/DATA/Run2018-17Sep2018/
  - SingleMuon: /nfs/dust/cms/user/ywen/Storage/SingleMuon/
- MC:
  - DY and tt-bar: /nfs/dust/cms/user/ywen/Storage/MC
  - W+jets, single Top, VV: /nfs/dust/cms/user/cardinia/gridjobs/2018/NTuples/MC/RunIIAutumn18

Quick recap for 3-prong

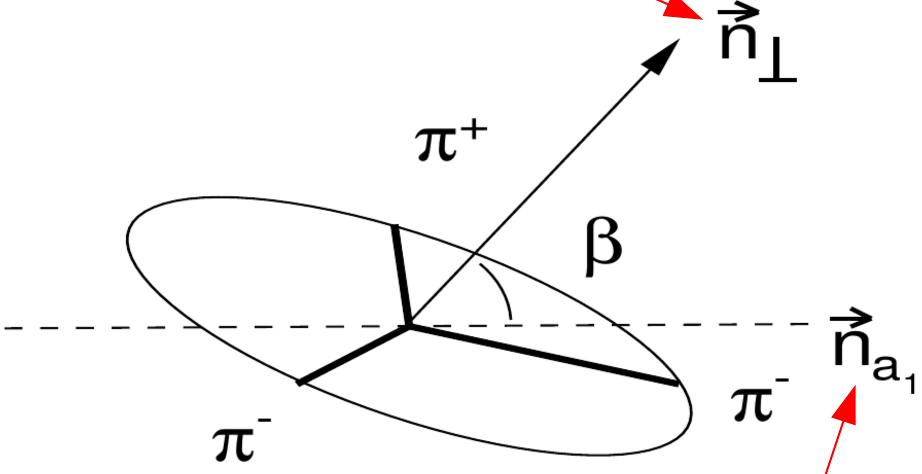
- The 3-prong channel is dominated by the a_1 resonance
- Investigating this channel can be interesting because of the presence of a secondary vertex that can improve the sensitivity for the CP observable
- However the a_1 meson has spin 1 ⇒ L and T polarization have opposite spin correlation with the τ



$a_1 \rightarrow 3\pi$



normal to the π decay plane in the a_1 f.o.r.



direction of motion of a_1

$$\cos\beta = \vec{n}_{\perp}\vec{n}_{a_1}$$

$$\sin\gamma = \frac{(\vec{n}_{\perp} \times \vec{n}_{a_1})\vec{q}_3}{|\vec{n}_{\perp} \times \vec{n}_{a_1}|}$$

Polarization measurement

$$cos\beta = \frac{\vec{p}_3(\vec{p}_1 \times \vec{p}_2)}{|\vec{p}_{3\pi}|T}$$

where:

$$T = \frac{1}{2}\sqrt{-\lambda(B_1, B_2, B_3)}$$

$$\lambda(B_1, B_2, B_3) = B_1^2 + B_2^2 + B_3^2 - 2B_1B_2 - 2B_1B_3 - 2B_2B_3$$

$$B_i = \frac{(E_iE_{3\pi} - \vec{p}_{3\pi}\vec{p}_i)^2 - Q^2m_\pi^2}{Q^2}$$

Polarization measurement

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where:

$$T = \frac{1}{2}\sqrt{-\lambda(B_1, B_2, B_3)}$$

$$\lambda(B_1, B_2, B_3) = 2\left(B_1^2 + B_2^2 + B_3^2\right) - \left(B_1 + B_2 + B_3\right)^2$$

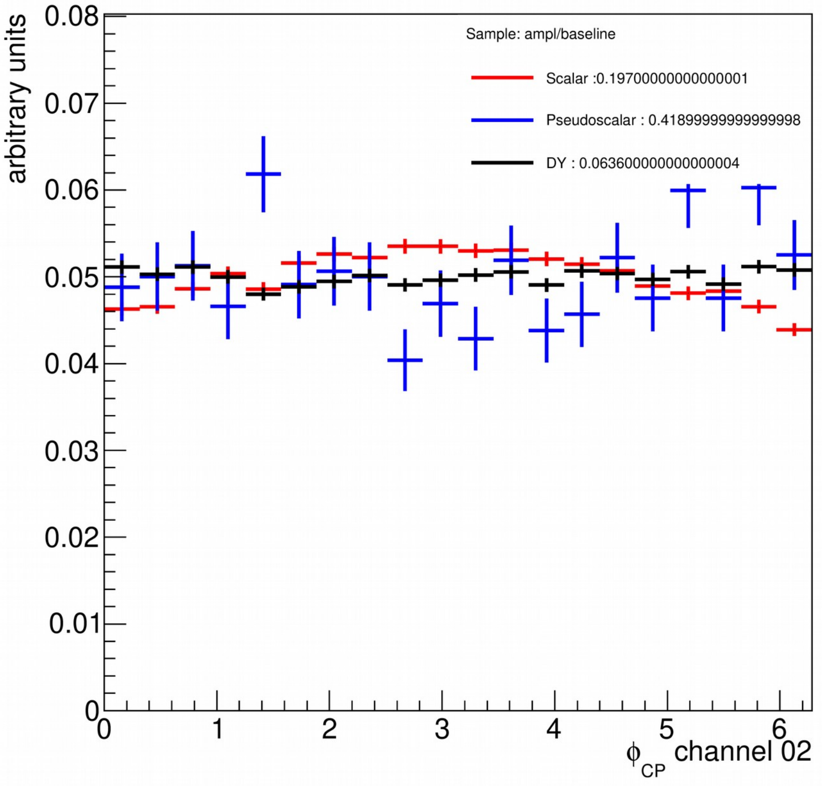
$$B_i = \frac{(E_i E_{3\pi} - \vec{p}_{3\pi}\vec{p}_i)^2 - Q^2 m_\pi^2}{Q^2}$$

Problems

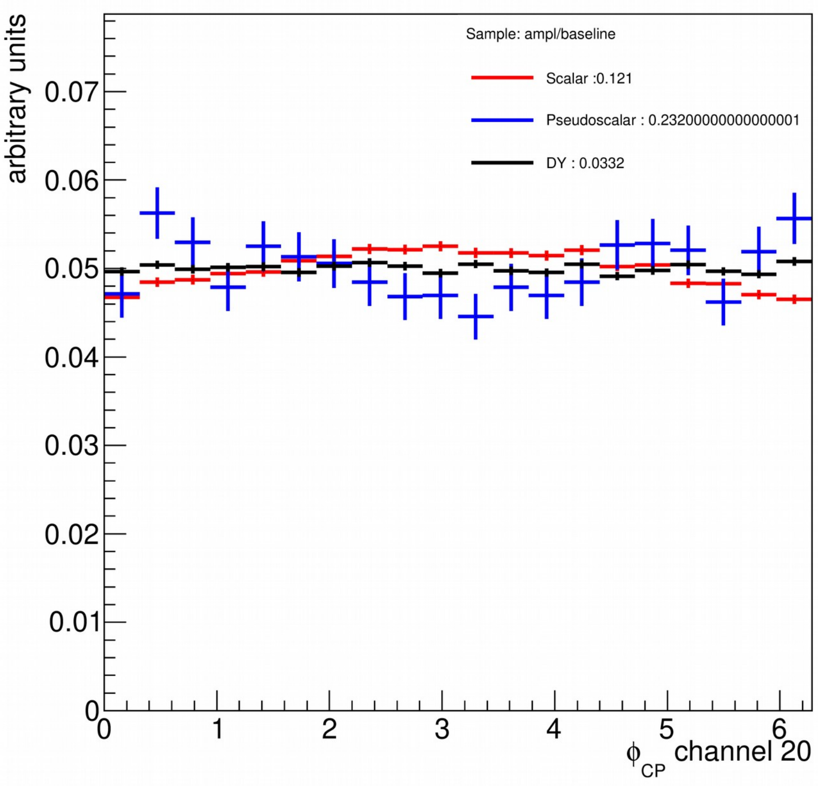
- For some gen level tau with decayMode 4 (3-prong + 0 pi0s) a different number of charged pions is found:
  - 1 pi: ~2%
  - 2 pi: ~4%
  - 4 pi: ~0.2%
  - 6 pi: 1 event in ~14'000
- The λ function in the previous slide returns a positive value in ~0.3% of the cases → there is a negative factor under the square root

First look at 3-prong channel

Decay mode 1: $\tau^{\pm} \rightarrow \pi^{\pm}$
Decay mode 2: $\tau^{\pm} \rightarrow a_1$

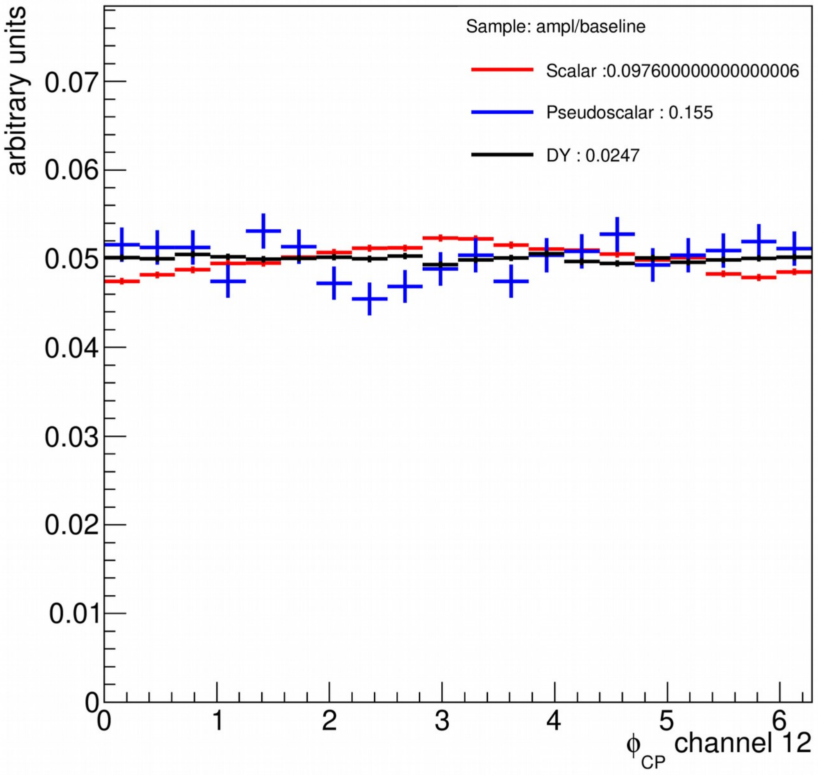


Decay mode 1: $\tau^{\pm} \rightarrow a_1$
Decay mode 2: $\tau^{\pm} \rightarrow \pi^{\pm}$



First look at 3-prong channel

Decay mode 1: $\tau^{\pm} \rightarrow \pi^{\pm} + \pi^{0}$
Decay mode 2: $\tau^{\pm} \rightarrow a_1$



Decay mode 1: $\tau^{\pm} \rightarrow a_1$
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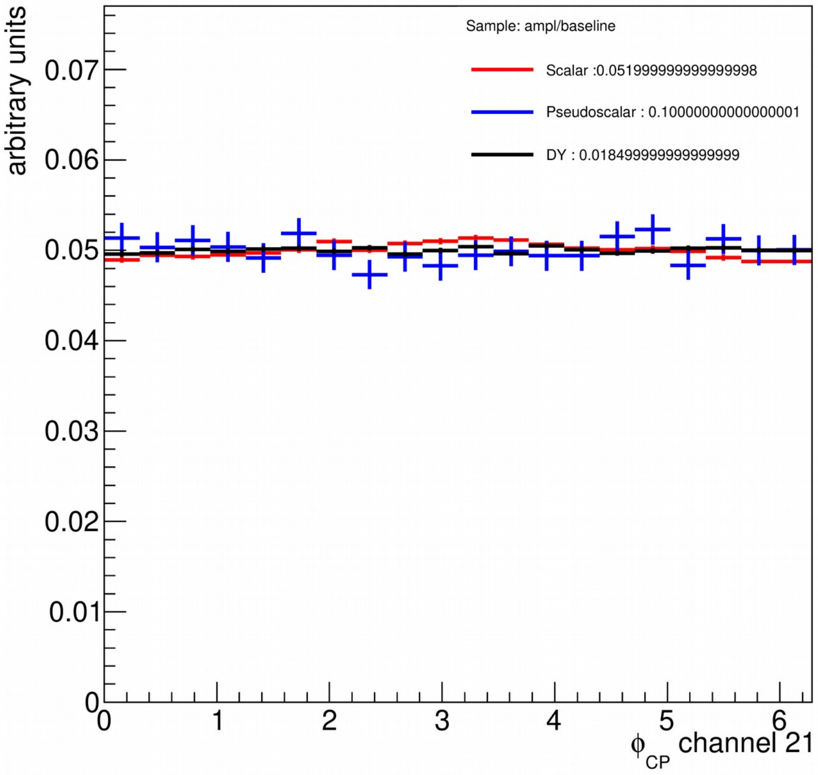

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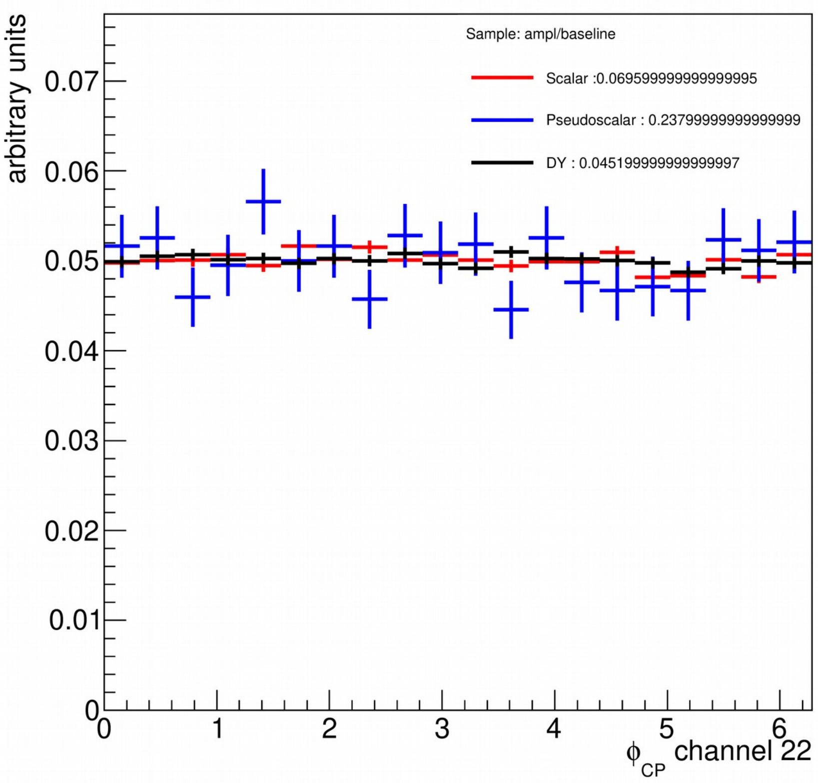

- One of the biggest limitation for the 3 prong channel is the statistic of the pseudoscalar sample
- Using the a1 polarization could improve the sensitivity in a significant way, at the cost of statistics
- More MC samples for the signal samples are required