LFV in τ decays with Polarized beams

Alberto Cervelli
Universita' Di Pisa

Outline

- News since Frascati meeting
- The BaBar analysis with polarized beams
- Helicity angles and scatter plots for the selected events
- Ongoing work
- Conclusions

News since Frascati

- Reproduced BaBar analysis on V0.2.6 generated Fast sim ntuples
- Efficiency of the selection compatible with BaBar analysis
- Redid analysis on angular distribution for reconstructed and selected events.

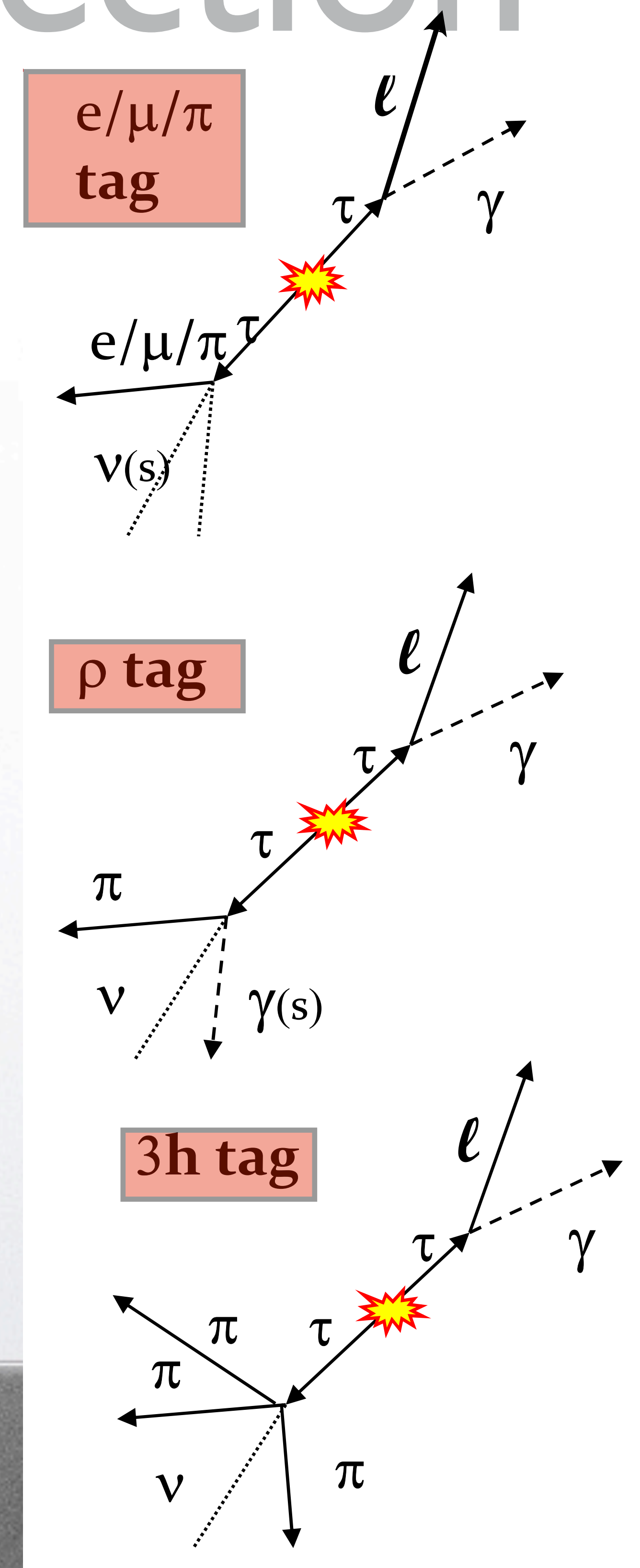
BaBar Signal selection

Reproduced BaBar Analysis:

- Signal tau has 1-1 topology and both signal muon and gamma should lay in the same hemisphere ✔
- events to be in ΔE, M_{ec} signal box ✘
- signal track identified as an e ($e\gamma$) or μ ($\mu\gamma$) ✔
- Signal candidates are divided in 2 categories, depending on decay in tag side and different selection is applied for each category ✔

π-tag:
tag track ID neither e nor μ, ✘
neutral energy in tag side < 200 MeV (e/μ) ✔

ρ-tag:
tag track ID neither e nor μ, ✘
one π^0 candidate in tag side $m_\pi \in [90, 165]$ MeV ✔
use also merged π^0 ✘

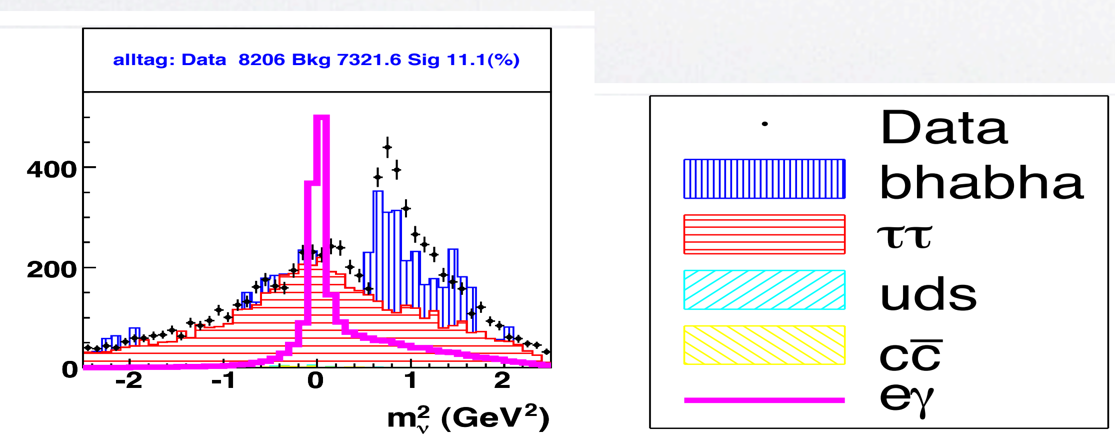


Signal Selection II

Further selection is applied using three groups of selectors and a Neural Network ✘

Tag side selection:

- m_ν in the hypothesis that the signal side is fully reconstructed. ✔
- $2\Sigma P^{CM}/\sqrt{s}$ ✔
- Pseudomass: reconstructed mass in the hypothesis ν is colinear with signal τ and has a cutoff at m_τ ✔



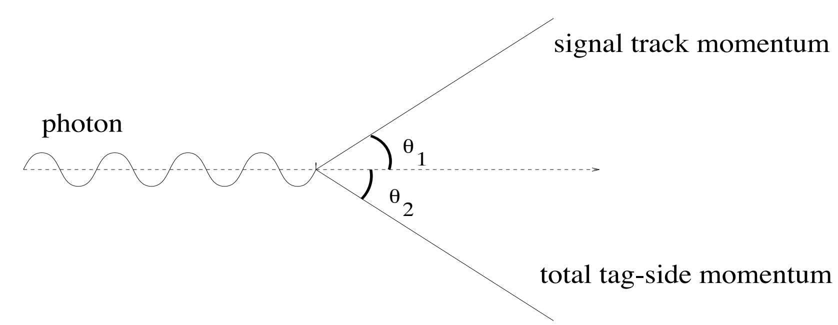
Signal Side selection

- $\cos\theta_{opening}$: opening angle between lepton and track ✔
- π^0 reconstruction consistency ✘
- E_γ >1 GeV & no further γ over 100 MeV ✔
- $2\Sigma P^{CM}/\sqrt{s}$ <0.77 ✔

Global Selection

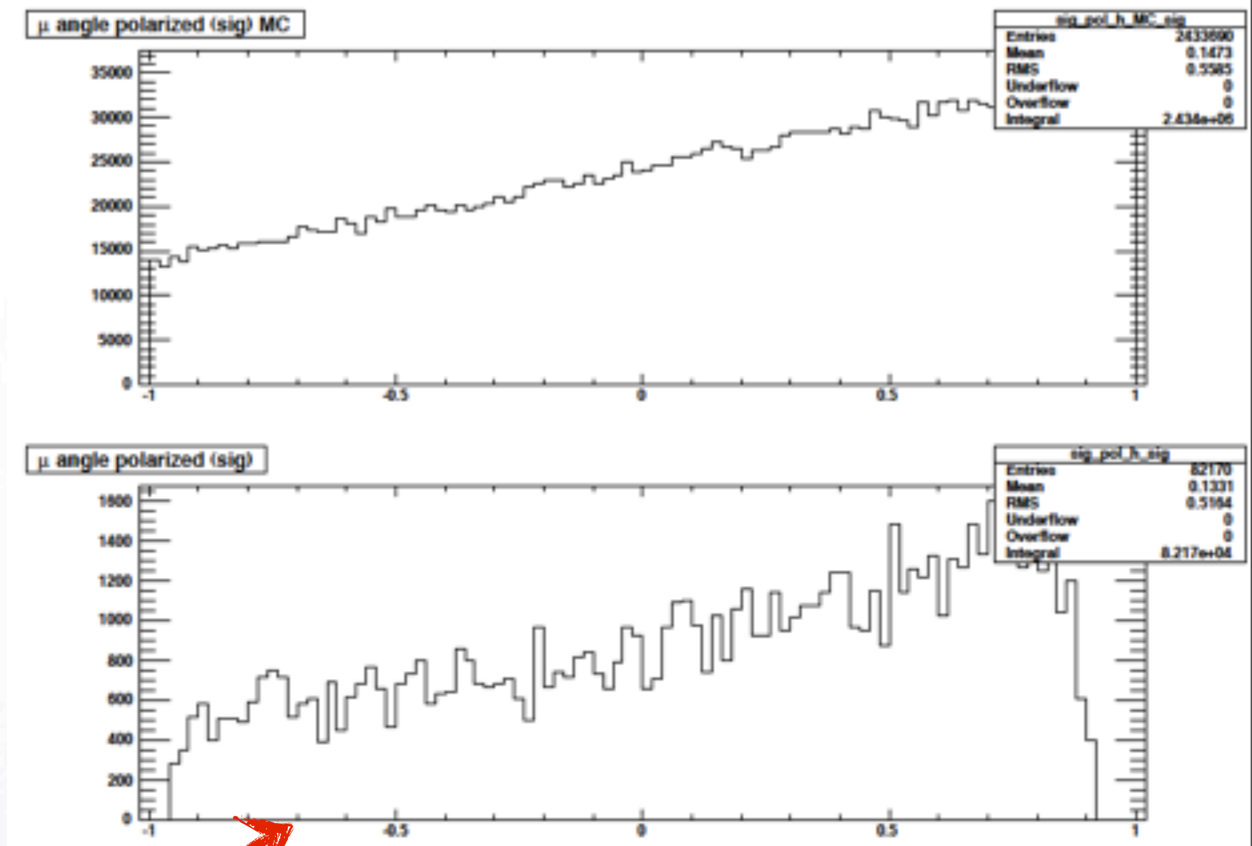
- $\cos\theta_{miss}$ & p^T_{miss} are used to reduce QED bkg ✔
- $\cos\theta_{recoil}$:angle between reconstructed tau directions. ✔
- ΔE_γ : neglecting track masses ✘

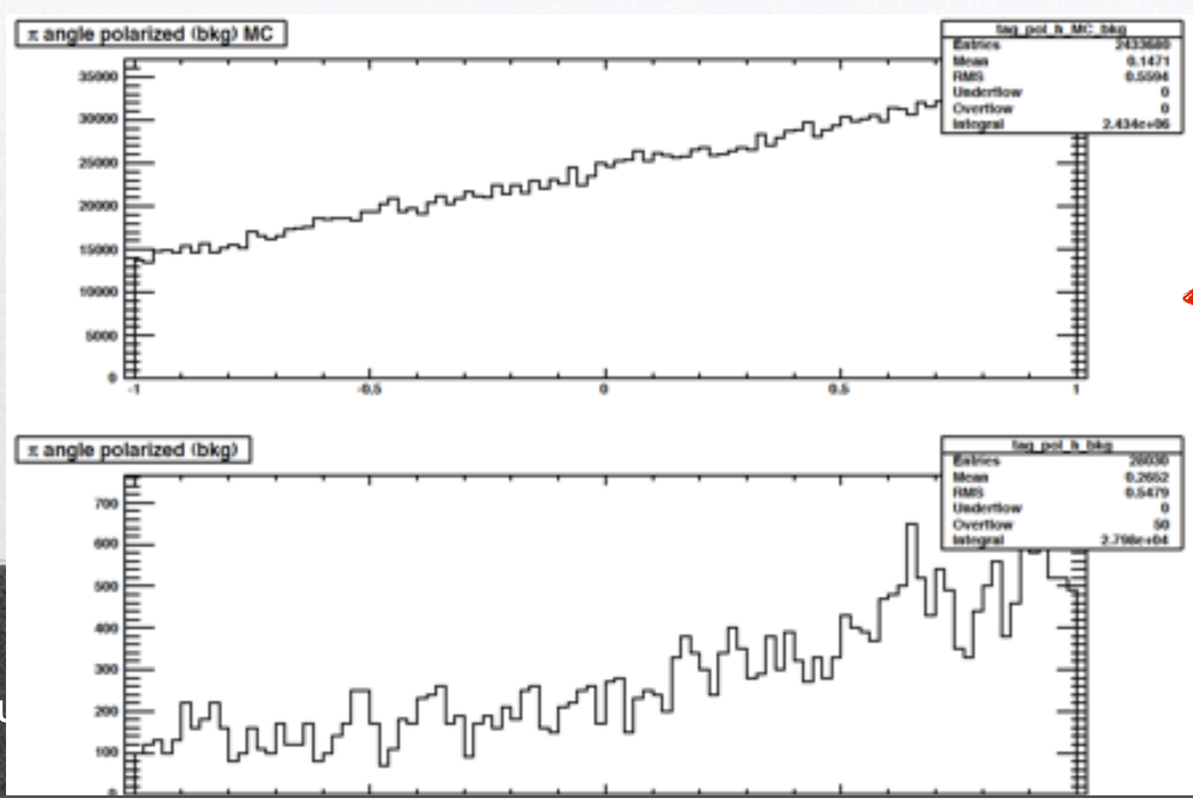
$$\Delta E_\gamma = \frac{E_\gamma^{CM}}{\sqrt{s}} - \frac{|\sin(\theta_1+\theta_2)|}{\sin(\theta_1)+\sin(\theta_2)+\sin(\theta_1+\theta_2)}$$



Helicity Angle after Reconstruction

- Main Concern: will the polarization information be propagated in the selection?
- BaBar analysis have many cuts affecting angular distribution:
    - requirement to have the signal track and photon in the same hemisphere
    - opening angle between signal track and photon
    - Rho reconstruction due to photons laying in signal side





After reconstruction the slopes of the helicity angles are slightly modified due to smearing

But mantain the same slopes of the MC distribution before selection

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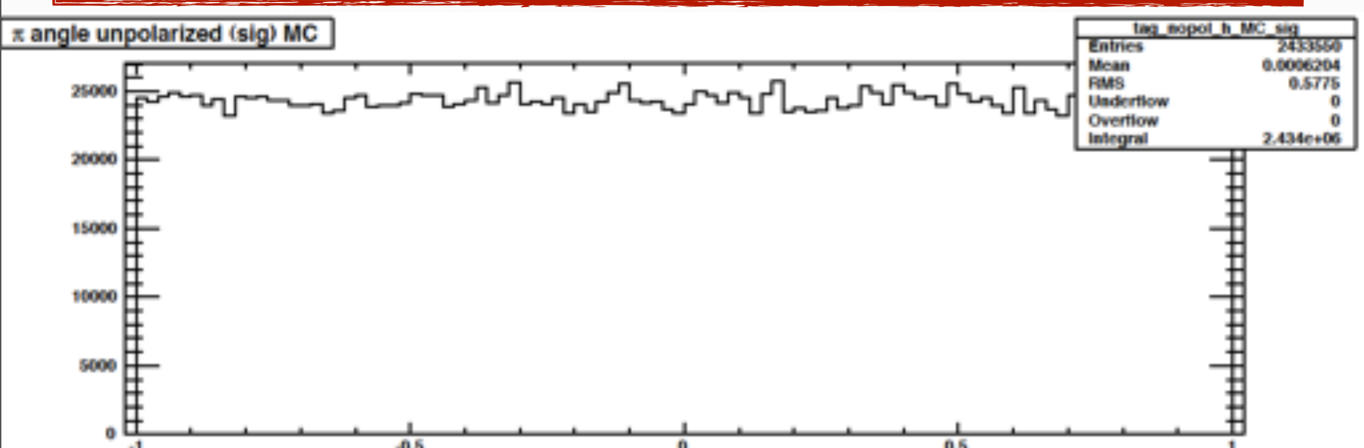
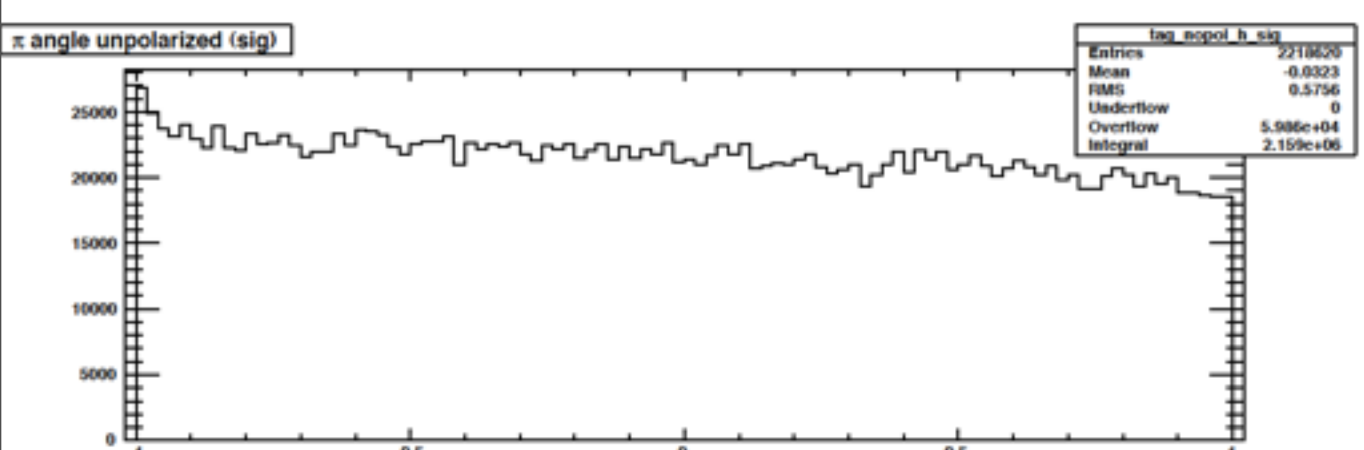
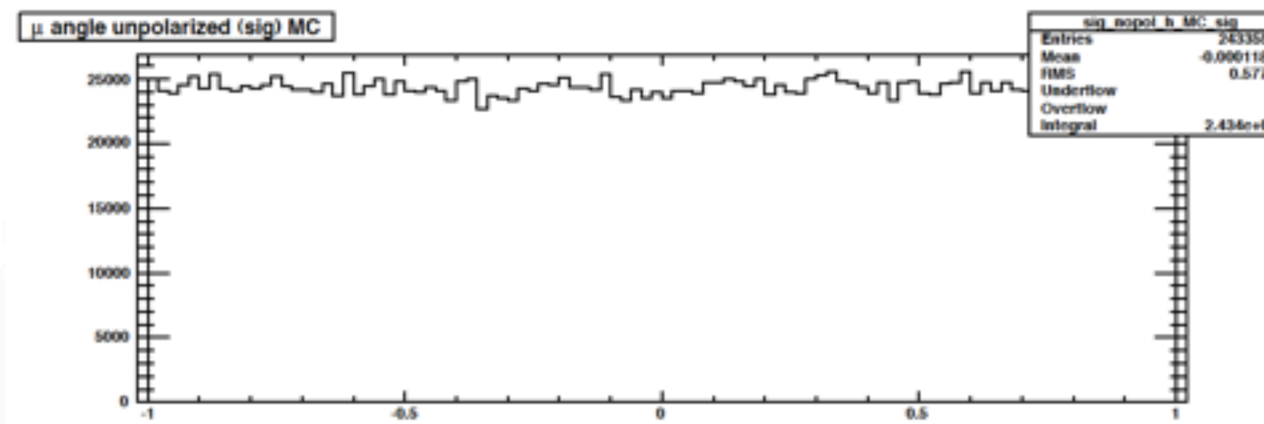
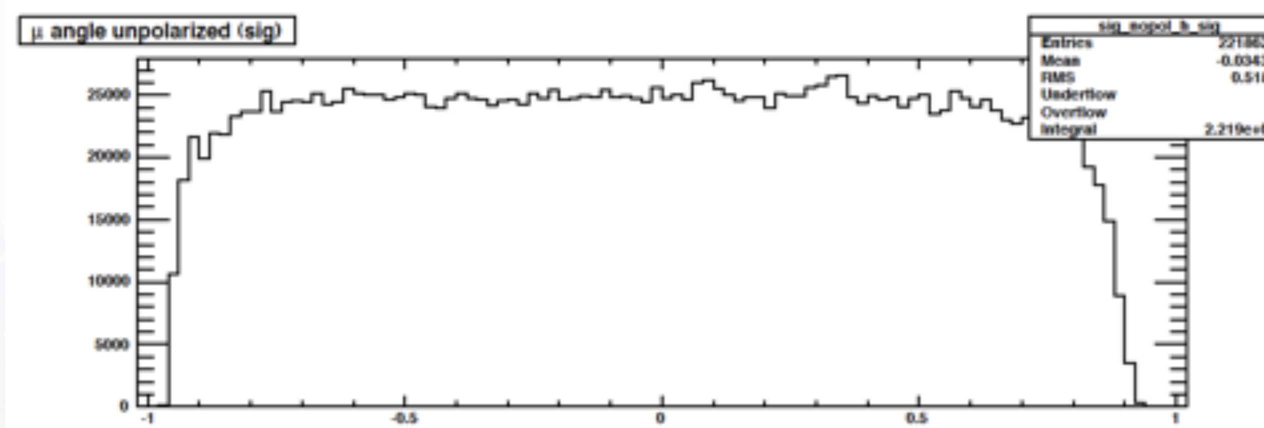
Unpolarized helicity angle

Efficiency for the analysis comparable with babar
The helicity angles of signal and track tag shows a similar behavior, with the same left unaltered by reconstruction







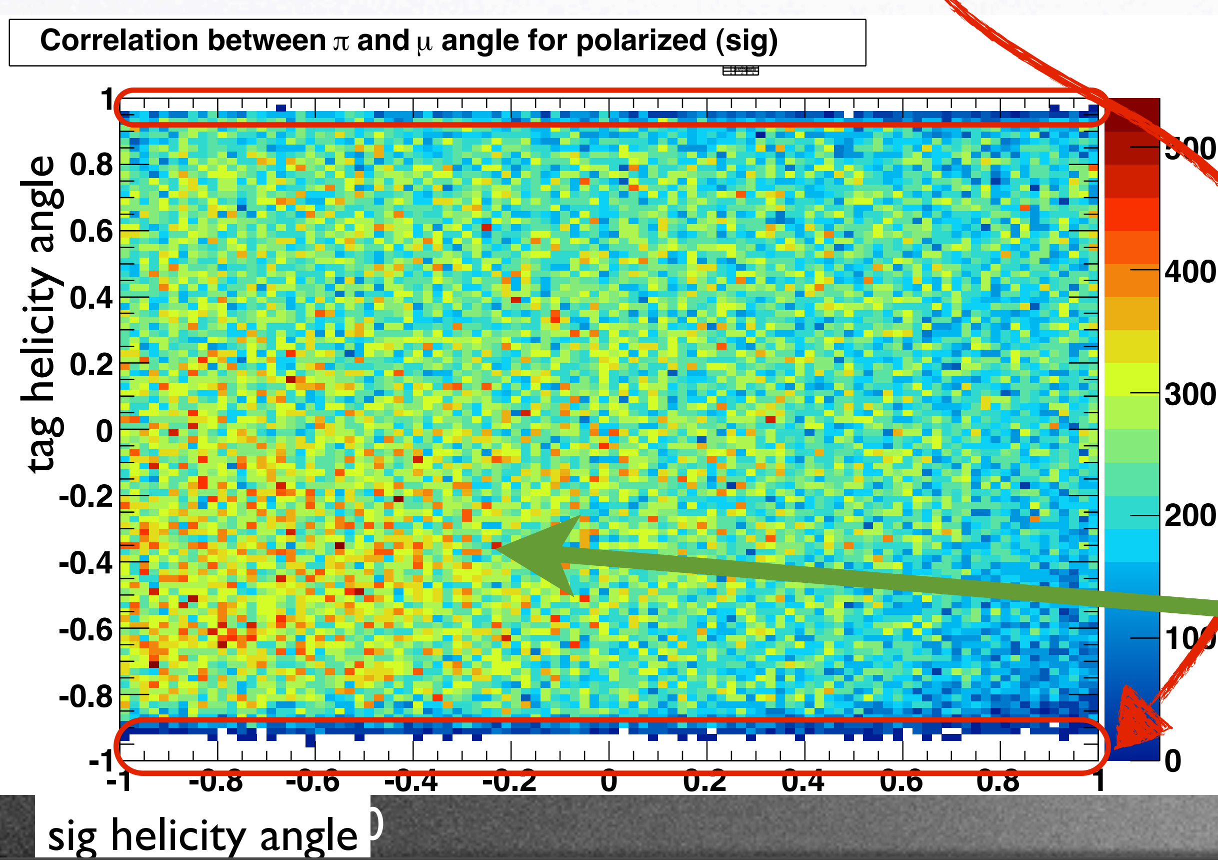


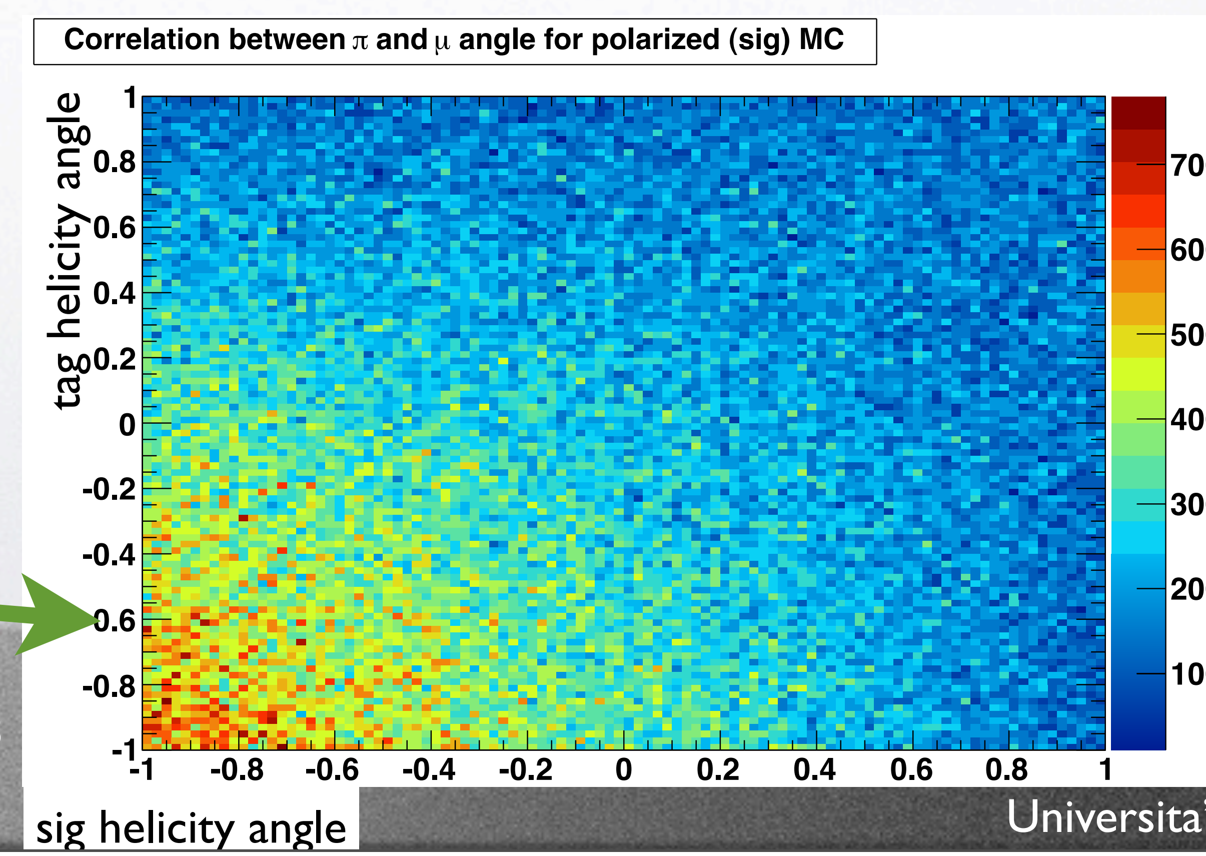
However the interesting information comes from the correlation between the signal track and helicity tag angle

Scatter Plots

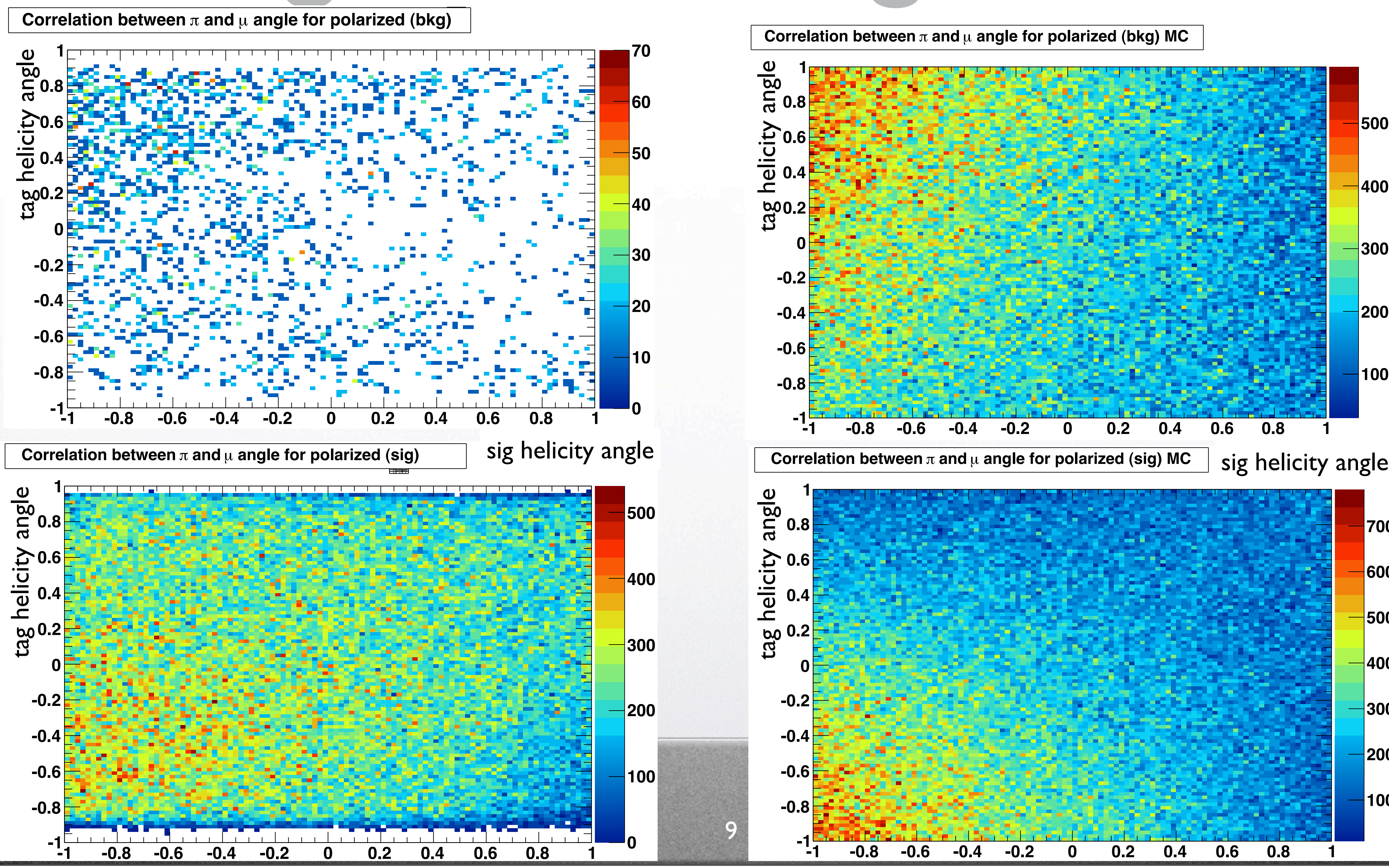
The regions at signal helicity angle near 1 and -1 are suppressed because of the requirement of muon and photon laying in the same hemisphere

Smearing effects make the distribution in the scatter plot much wider in the selected sample with respect to the MC sample, however a denser region is clearly visible





Signal vs Backgrounds



Remarks

Polarization information is passed through the BaBar selection, but some of the requirements alter the helicity angle distribution since they act on the angular distribution of the products

Background and signal distribution substantially different even after selection applied:
Polarization offers an handle even after selection is applied

No selection on the Signal box have been applied to maintain a reasonable quantity of background events, however it is not expected to affect helicity angle distribution

To do:
Today only π channel presented, with few statistics.
Increment in statistics under way.
Rho selection is being perfected, harder to cope with photons and rho reconstruction which may affect angular distributions

Ongoing Work

- Increasing statistics for both π and ρ channels
- Implementing the rest of BaBar analysis: Neural Network and PID
- Study theoretical expectation for the tracks and taus momenta direction for polarized beam production (B. Oberhof)
- Make quantitative estimation of the effects of polarization after the selection is applied
- Reoptimize selection to better accomodate Polarization information

Conclusion

- Polarization information not used in BaBar analysis as expected
- However BaBar analysis seems to degrade the Polarization discriminating power to some extent
- Need to optimize the selection in order to use Polarization effectively, probably by releasing some cuts on the variables affecting angular distributions
- A comparison between theoretical expectation and experimental distribution is needed, work ongoing on this topic
- Polarization still seems to be a good handle to reduce backgrounds from radiative tau decays

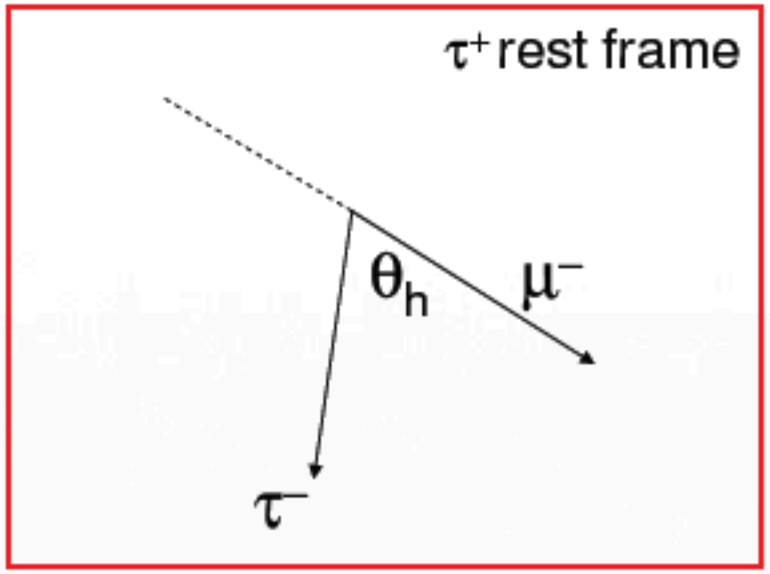
Thanks for your attention

The Physics

Using an hadron tag makes radiative di-muon events background negligible.

Main Background contribution is expected from real $\tau \to \mu\nu\nu$ decays.

Polarization may be used to reduce irreducible backgrounds using the decay dynamics



e^- beam is simulated with 80% polarization.

for $\tau \to h\nu$ decays the correlation between ν direction and the event polarization is defined.

We can observe the correlation between the helicity angles in the tag side and signal side.