Tau Polarimetry Update

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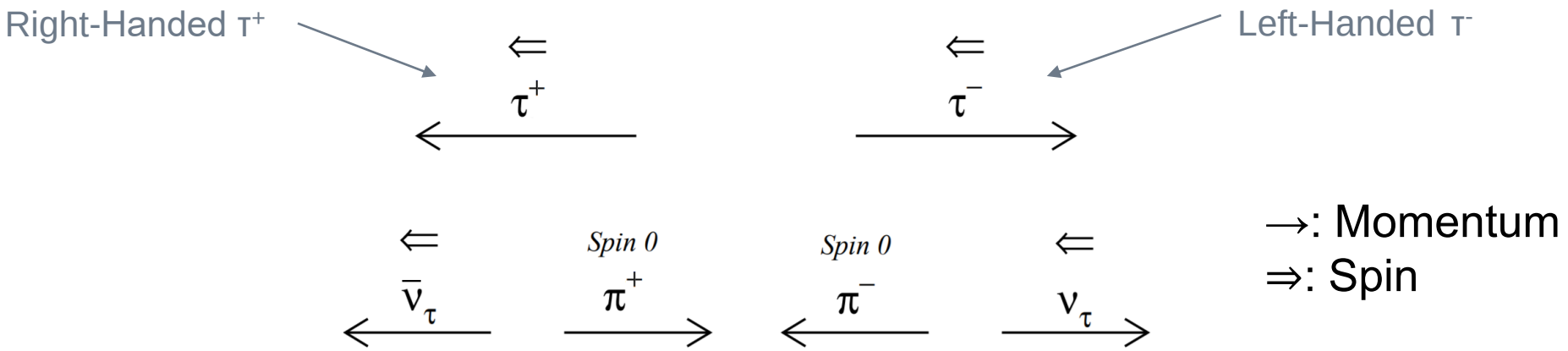
Tau Polarimetry

- The polarization of tau's (P_τ) produced in e^+e^- collisions at 10.58 GeV is related to the electron beam polarization (P_e) through:

$$P_{\tau^-} = P_e \frac{\cos\theta}{1+\cos^2\theta} - \frac{8G_F s g_V^\tau}{4\sqrt{2}\pi\alpha}\left(g_A^\tau \frac{\overrightarrow{|p|}}{p^0} + 2g_A^e \frac{\cos\theta}{1+\cos^2\theta}\right)$$

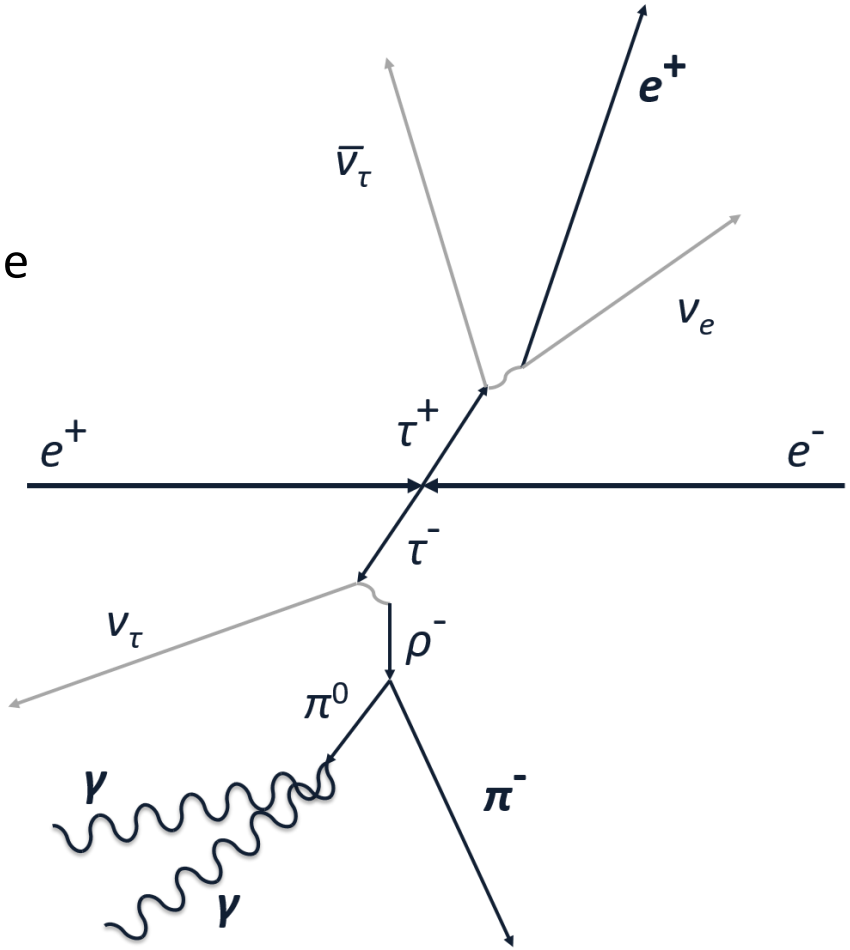
Note: cosθ defined as the polar angle of the τ^- with respect to the electron beam

- Tau polarization information can be extracted from the kinematics of the tau decay



Tau Event Selection

- As a proof of concept, we have developed Tau Polarimetry at *BABAR* using $\tau^{\pm} \rightarrow \rho^{\pm}\nu_{\tau} \rightarrow \pi^{\pm}\pi^{0}\nu_{\tau}$ decays
- We expect uncertainties to be highly correlated between detectors due to similar designs
- Final measurement performed on total 424.18 fb^{-1}
- Selected tau events in a 1v1 topology, (ρ vs. e or mu)
  - ρ has large branching fraction, e or mu for clean tag
- Signal candidates are defined as a charged particle with a π^0
- $q\bar{q}$ events are eliminated with the lepton requirement
- Angular cuts and a minimum p_T of 350 MeV reduce two photon and Bhabha contamination



- Achieve a 99.9% pure tau-pair sample (0.05% Bhabha,0.05% $\mu^+\mu^-$)
- 88% of selected events contain a $\tau^{\pm} \rightarrow \pi^{\pm}\pi^{0}\nu_{\tau}$ decay
  - 10% a1 decays, 2% other hadronic

Status from Oct CM

- Measurement being extended to include low p_T events and muon tag

$$\langle P \rangle = -0.0010 \pm 0.0036_{\text{stat}} \pm 0.0030_{\text{sys}}$$ Preliminary

$$\langle P \rangle = -0.0002 \pm 0.0025_{\text{stat}} \pm 0.0023_{\text{sys}} \pm 0.\text{xxxx}_{\text{sys}}$$ w/ new criteria

- Not sure if -0.002 is correct, initially around 1% and slides talk about tension with zero
- Initial results showing signs of improvement in statistics and systematics
- Added a number of new criteria to clean up the selection

- Quality Improvements
  - ⇒ Minimum Track p_T
  - ⇒ Minimum Track EMC Deposit
  - ⇒ Event p_T > 0.25 MeV -> 0.35 MeV
  - ⇒ Rho decay product angular separation

- Other Improvements/Investigations
  - ⇒ cosθ definition
  - ⇒ charge asymmetry in fits
  - ⇒ cancellation of systematic effects in charge asymmetry
  - ⇒ polarization dependence on Event p_T

e-Tag Old Systematics

- 15 contributions
- Neutrals dominate 4/6 top systematics

Study	Run 1	Run 2	Run 4	Run 5	Run 6	Final
π^0 Likelihood	0.0032	0.0012	0.0009	0.0010	0.0020	**0.0015**
Hadronic Split-off Modelling	0.0035	0.0012	0.0015	0.0011	0.0005	**0.0011**
$\cos\psi$	0.0022	0.0012	0.0006	0.0008	0.0010	**0.0010**
Angular Resolution	0.0010	0.0015	0.0012	0.0002	0.0007	**0.0009**
Minimum Neutral Energy	0.0006	0.0009	0.0005	0.0006	0.0016	**0.0009**
π^0 Mass	0.0018	0.0005	0.0009	0.0006	0.0014	**0.0009**
$\cos\theta^\star$	0.0012	0.0007	0.0012	0.0009	0.0007	**0.0008**
Electron PID	0.0022	0.0008	0.0007	0.0014	0.0010	**0.0007**
Tau Branching Fraction	0.0007	0.0006	0.0010	0.0006	0.0005	**0.0006**
Event Transverse Momentum	0.0013	0.0006	0.0006	0.0002	0.0005	**0.0005**
Momentum Resolution	0.0005	0.0008	0.0004	0.0003	0.0006	**0.0005**
π^0 Minimum Photon Energy	0.0008	0.0008	0.0009	0.0003	0.0010	**0.0004**
Rho Mass	0.0007	0.0002	0.0002	0.0004	0.0005	**0.0003**
Background Modelling	0.0027	0.0002	0.0002	0.0007	0.0009	**0.0003**
Boost	0.0000	0.0002	0.0001	0.0005	0.0004	**0.0002**
Total	0.0070	0.0033	0.0032	0.0027	0.0038	**0.0030**

New Systematics

- 21 contributions
- Neutrals dominate 6/7 top systematics
- pi-0 efficiency is a new correction to attempt to correct few % discrepancy between Data/MC that's persisted in the analysis
- Neutral Energy Scale has replace 50,100 MeV cuts
- Angular cuts, and momentum dependence has gotten small

Source	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Combined
π^0 Efficiency	0.0025	0.0016	0.0013	0.0018	0.0006	0.0017	**0.0013**
Muon PID	0.0018	0.0018	0.0029	0.0011	0.0006	0.0016	**0.0012**
Photon Split-off Modelling	0.0015	0.0017	0.0016	0.0006	0.0016	0.0020	**0.0011**
Neutral Energy Scale	0.0027	0.0012	0.0023	0.0009	0.0014	0.0008	**0.0010**
π^0 Mass	0.0018	0.0028	0.0010	0.0005	0.0004	0.0004	**0.0008**
$\pi - \pi^0$ Angular Separation	0.0015	0.0009	0.0016	0.0007	0.0005	0.0005	**0.0007**
π^0 Likelihood	0.0015	0.0009	0.0015	0.0006	0.0003	0.0010	**0.0006**
Electron PID	0.0011	0.0020	0.0008	0.0006	0.0005	0.0001	**0.0005**
Particle Transverse Momentum	0.0012	0.0007	0.0009	0.0002	0.0003	0.0006	**0.0004**
Boost Modelling	0.0004	0.0019	0.0003	0.0004	0.0004	0.0004	**0.0004**
Momentum Scale	0.0001	0.0014	0.0005	0.0002	0.0001	0.0003	**0.0004**
Max EMC Acceptance	0.0001	0.0011	0.0008	0.0001	0.0002	0.0005	**0.0003**
τ Direction Definition	0.0003	0.0007	0.0008	0.0003	0.0001	0.0004	**0.0003**
Angular Resolution	0.0003	0.0008	0.0003	0.0003	0.0002	0.0003	**0.0003**
Background Modelling	0.0005	0.0006	0.0010	0.0002	0.0003	0.0003	**0.0003**
Event Transverse Momentum	0.0001	0.0013	0.0005	0.0002	0.0002	0.0004	**0.0003**
Momentum Resolution	0.0001	0.0012	0.0004	0.0002	0.0001	0.0005	**0.0003**
Rho Mass Acceptance	0.0000	0.0011	0.0003	0.0001	0.0002	0.0005	**0.0003**
Tau Branching Fraction	0.0001	0.0007	0.0004	0.0002	0.0002	0.0002	**0.0002**
$\cos\theta^\star$ Acceptance	0.0002	0.0006	0.0004	0.0001	0.0001	0.0004	**0.0002**
$\cos\psi$ Acceptance	0.0002	0.0003	0.0002	0.0002	0.0002	0.0003	**0.0002**
Quadratic Sum	0.0058	0.0062	0.0054	0.0030	0.0026	0.0038	**0.0029**

Conclusions

- Final (pre-preliminary) measurement:

$$\langle P \rangle = 0.0035 \pm 0.0024_{\text{stat}} \pm 0.0029_{\text{sys}}$$

- Significant improvement in statistics compared to e-tag only:

$$\langle P \rangle = -0.0010 \pm 0.0036_{\text{stat}} \pm 0.0030_{\text{sys}}$$

- Systematics about the same but much more well understood
- pi-0 efficiency is the only systematic dominated by statistical fluctuations
- Paper in the BaBar review process now

Thank You!