Search for $CP/T$-violation in the tau sector at a superb $\tau$ factory

$\tau$ Electric Dipole Moment

Eugenio Paoloni

on behalf
of the
I.N.F.N. Pisa group

Flavour In The Era Of The LHC
Outline

1. The collider and the detector
   - The linear super-B factory

2. $\tau$ electric dipole moment
   - Motivation and present status
   - How to improve it in a significant way?

3. $T$ violation in $\tau$ decays

4. conclusions and plans
Linear Super B Factory: the concept

- $e^+ e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
Linear Super B Factory: the concept

- $e^+ e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
**Linear Super B Factory: the concept**

- $e^+e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
Linear Super B Factory: the concept

- $e^+ e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
- $e^+e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
Linear Super B Factory: the concept

- $e^+ e^-$ bunches are injected in the cooling rings
- they stay in the cooling rings lowering their emittance
- they are spilled, focused, polarized and collided
- they are recirculated in the cooling rings
Linear Super B Factory: the pros

- Low currents at the interaction point:
  - Low beam debris related background,
  - Possibility to extend at lower angle the calorimeter acceptance

- Head on collision, large distance among the bunches at the IP:
  - No separating dipole magnet inside the detector,
  - Possibility to extend the tracking at lower angle

A more hermetic detector w.r.t. BABAR(Belle)
Linear Super B Factory: the pros

- Low currents at the interaction point: low beam debris related background, possibility to extend at lower angle the calorimeter acceptance
- Head on collision, large distance among the bunches at the IP: no separating dipole magnet inside the detector, possibility to extend the tracking at lower angle

A more hermetic detector w.r.t. BABAR(Belle)
Linear Super B Factory: the pros

- Low currents at the interaction point:
  - Low beam debris related background,
  - Possibility to extend at lower angle the calorimeter acceptance
- Head on collision, large distance among the bunches at the IP:
  - No separating dipole magnet inside the detector,
  - Possibility to extend the tracking at lower angle

A more hermetic detector w.r.t. BABAR(Belle)
low currents at the interaction point:
low beam debris related background,
possibility to extend at lower angle the calorimeter acceptance

head on collision, large distance among the bunches at the IP:
no separating dipole magnet inside the detector,
possibility to extend the tracking at lower angle

A more hermetic detector w.r.t. \textit{BABAR}(Belle)
A super B-factory is also a superb $\tau$ factory!

**Luminosity**

\[ \mathcal{L} \sim 10^{36} \text{ cm}^{-2} \text{s}^{-1} \]

\[ \sigma(e^+ e^- \rightarrow \tau^+ \tau^- @ \Upsilon(4S)) \sim 1 \text{ nb} \]

\[ f_{\text{prod.}} \sim 1 \text{ KHz} \Rightarrow \frac{10 \text{ billions } \tau^+ \tau^-}{\text{Snowmass Year}} \]
Motivation of the search

The electric dipole moment interaction

\[ \mathcal{H}_i = i e \frac{F_\tau}{2m_\tau} \bar{\psi} \sigma^{\mu\nu} \gamma^5 \psi F_{\mu\nu} \]

is the lowest dimension gauge invariant T odd operator that couple the photon (Z0) with the \( \tau \) current.

SM generates such interaction only at a very high order of the perturbative expansion (i.e. \( F_\tau \ll 1 \)).

Possibility for the “New Physics” to stay on the stage.

**PDG 2004 \( e, \mu \)**

\[
\begin{align*}
d_e &= (0.07 \pm 0.07) \times 10^{-26} \text{ e cm} \\
d_{\mu\nu} &= (3.7 \pm 3.4) \times 10^{-19} \text{ e cm}
\end{align*}
\]

**PDG 2004 \( \tau \)**

\[
\begin{align*}
\Re (d_\tau) &= (-0.22 \text{ to } 0.45) \times 10^{-16} \text{ cm} \\
\Im (d_\tau) &= (-0.25 \text{ to } 0.01) \times 10^{-16} \text{ cm}
\end{align*}
\]
Belle measurement of the $\tau$ EDM (hep-ex/0210066)

Belle searched for $CP$ violating effects in

$$e^+ e^- \rightarrow \gamma^* \rightarrow \tau^+ \tau^-$$

analyzing $26.8 \cdot 10^6 \tau$ pairs. Sample composition:

<table>
<thead>
<tr>
<th></th>
<th>Yield</th>
<th>Purity (%)</th>
<th>Background mode (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e\mu$</td>
<td>250,948</td>
<td>96.6 ± 0.1</td>
<td>$2\gamma \rightarrow \mu\mu(1.9)$, $\tau\tau \rightarrow e\pi(1.1)$.</td>
</tr>
<tr>
<td>$e\pi$</td>
<td>132,574</td>
<td>82.5 ± 0.1</td>
<td>$\tau\tau \rightarrow e\rho(6.0)$, $eK(5.4)$, $e\mu(3.1)$, $eK^*(1.3)$.</td>
</tr>
<tr>
<td>$\mu\pi$</td>
<td>123,520</td>
<td>80.6 ± 0.1</td>
<td>$\tau\tau \rightarrow \mu\rho(5.7)$, $\mu K(5.3)$, $\mu\mu(2.9)$, $2\gamma \rightarrow \mu\mu(2.0)$.</td>
</tr>
<tr>
<td>$e\rho$</td>
<td>240,501</td>
<td>92.4 ± 0.1</td>
<td>$\tau\tau \rightarrow e\pi\pi^0\pi^0(4.4)$, $eK^*(1.7)$.</td>
</tr>
<tr>
<td>$\mu\rho$</td>
<td>217,156</td>
<td>91.6 ± 0.1</td>
<td>$\tau\tau \rightarrow \mu\pi\pi^0\pi^0(4.2)$, $\mu K^*(1.6)$, $\pi\rho(1.0)$.</td>
</tr>
<tr>
<td>$\pi\rho$</td>
<td>110,414</td>
<td>77.7 ± 0.1</td>
<td>$\tau\tau \rightarrow \rho\rho(5.1)$, $K\rho(4.9)$, $\pi\pi\pi^0\pi^0(3.8)$, $\mu\rho(2.7)$.</td>
</tr>
<tr>
<td>$\rho\rho$</td>
<td>93,016</td>
<td>86.2 ± 0.1</td>
<td>$\tau\tau \rightarrow \rho\pi\pi^0\pi^0(8.0)$, $\rho K^*(3.1)$.</td>
</tr>
</tbody>
</table>
| $\pi\pi$ | 28,348  | 70.0 ± 0.2 | $\tau\tau \rightarrow \pi\rho(9.2)$, $\pi K(9.2)$, $\pi\mu(4.7)$, $\pi K^*(2.0)$.
Systematic $\sim$ statistical with only 25 millions $\tau$-pairs

Belle measured T-odd correlations among the momenta of the decay products of the $\tau^+\tau^-$. 

$$-0.22 < \Re(d_\tau) < 0.45(10^{-16}\text{ e cm}) \quad 95\%\text{C.L}$$

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic errors for $Re(d_\tau)$ and $Im(d_\tau)$ in units of $10^{-16}\text{ e cm}$.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$Re(d_\tau)$</th>
<th>$e\mu$</th>
<th>$e\pi$</th>
<th>$\mu\pi$</th>
<th>$e\rho$</th>
<th>$\mu\rho$</th>
<th>$\pi\rho$</th>
<th>$\rho\rho$</th>
<th>$\pi\pi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mismatch of distribution</td>
<td>0.80</td>
<td>0.58</td>
<td>0.70</td>
<td>0.11</td>
<td>0.15</td>
<td>0.21</td>
<td>0.16</td>
<td>0.06</td>
</tr>
<tr>
<td>Charge asymmetry</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Background variation</td>
<td>0.43</td>
<td>0.12</td>
<td>0.07</td>
<td>0.07</td>
<td>0.08</td>
<td>0.03</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Momentum reconstruction</td>
<td>0.16</td>
<td>0.09</td>
<td>0.24</td>
<td>0.04</td>
<td>0.06</td>
<td>0.06</td>
<td>0.04</td>
<td>0.45</td>
</tr>
<tr>
<td>Detector alignment</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Radiative effects</td>
<td>0.09</td>
<td>0.04</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.16</td>
</tr>
<tr>
<td>Total</td>
<td>0.93</td>
<td>0.60</td>
<td>0.74</td>
<td>0.14</td>
<td>0.18</td>
<td>0.22</td>
<td>0.17</td>
<td>0.48</td>
</tr>
</tbody>
</table>

Little space for improvements...
Ananthanarayan & Rindani proposed in 1995 a very clever method:

- use an $e^-$ beam with tunable longitudinal polarization $P$

$$ e^-(p_-) + e^+(p_+) \rightarrow \gamma^* \rightarrow \tau^+ + \tau^- $$

$$ \tau^- \rightarrow H_A(q_-) + \nu_\tau \quad \tau^+ \rightarrow H_B(q_+) + \bar{\nu}_\tau $$

- under $CP$:

$$ p_+ \leftrightarrow -p_- \quad q_+ \leftrightarrow -q_- $$

- measure the mean value of the $CP$ odd observables:

$$ O_1 = \hat{p}_+ \cdot (q_+ \times q_-) \propto R(d_\tau) \quad O_2 = \hat{p}_+ \cdot (q_+ + q_-) \propto S(d_\tau) $$

- compare $\langle O_i \rangle$ measured with opposite polarizations

$$ R(d_\tau) \propto \langle O_1 \rangle_P - \langle O_1 \rangle_{-P} $$
Ananthanarayan & Rindani proposed in 1995 a very clever method:

- use an $e^-$ beam with tunable longitudinal polarization $P$

$$e^- (p_-) + e^+ (p_+) \rightarrow \gamma^* \rightarrow \tau^+ + \tau^-$$

$$\tau^- \rightarrow H_A (q_-) + \nu_\tau \quad \tau^+ \rightarrow H_B (q_+) + \bar{\nu}_\tau$$

- under $CP$:
  $$p_+ \leftrightarrow -p_- \quad q_+ \leftrightarrow -q_-$$

- measure the mean value of the $CP$ odd observables:
  $$O_1 = \hat{p}_+ \cdot (q_+ \times q_-) \propto \Re (d_\tau) \quad O_2 = \hat{p}_+ \cdot (q_+ + q_-) \propto \Im (d_\tau)$$

- compare $\langle O_i \rangle$ measured with opposite polarizations
  $$\Re (d_\tau) \propto \langle O_1 \rangle_P - \langle O_1 \rangle_{-P}$$
**τ** EDM with polarized $e^+ e^−$ beams (Phys. Rev. D51 5996)

Ananthanarayan & Rindani proposed in 1995 a very clever method:

- use an $e^−$ beam with tunable longitudinal polarization $P$

  $$e^−(p_−) + e^+(p_+) \rightarrow \gamma^* \rightarrow \tau^+ + \tau^−$$

  $$\tau^− \rightarrow H_A(q_−) + ν_\tau \quad \tau^+ \rightarrow H_B(q_+) + \bar{ν}_τ$$

- under $CP$:

  $$p_+ \leftrightarrow −p_− \quad q_+ \leftrightarrow −q_−$$

- measure the mean value of the $CP$ odd observables:

  $$O_1 = \hat{p}_+ \cdot (q_+ \times q_−) \propto \Re(d_τ) \quad O_2 = \hat{p}_+ \cdot (q_+ + q_−) \propto \Im(d_τ)$$

- compare $⟨O_i⟩$ measured with opposite polarizations

  $$\Re(d_τ) \propto ⟨O_1⟩_P − ⟨O_1⟩_{−P}$$
τ EDM with polarized $e^+e^-$ beams (Phys. Rev. D51 5996)

Ananthanarayan & Rindani proposed in 1995 a very clever method:

- use an $e^-$ beam with tunable longitudinal polarization $P$

$$e^-(p_-) + e^+(p_+) \rightarrow \gamma^* \rightarrow \tau^+ + \tau^-$$

$$\tau^- \rightarrow H_A(q_-) + \nu_\tau \quad \tau^+ \rightarrow H_B(q_+) + \bar{\nu}_\tau$$

- under $CP$:

$$p_+ \leftrightarrow -p_- \quad q_+ \leftrightarrow -q_-$$

- measure the mean value of the $CP$ odd observables:

$$O_1 = \hat{p}_+ \cdot (q_+ \times q_-) \propto \Re(d_\tau) \quad O_2 = \hat{p}_+ \cdot (q_+ + q_-) \propto \Im(d_\tau)$$

- compare $\langle O_i \rangle$ measured with opposite polarizations

$$\Re(d_\tau) \propto \langle O_1 \rangle_P - \langle O_1 \rangle_{-P}$$
Experimental approach

**Event selection**
- Low multiplicity
- Missing momentum
- Missing energy
- Particle id.

Select only

\[ \tau \rightarrow \pi \nu \]
\[ \tau \rightarrow \rho \nu \]

**Observable**
- identify the positive and the negative track

\[ O_1 = |p_+^\perp| |p_-^\perp| \sin (\phi_+ - \phi_-) \]
Experimental approach

**BABAR** $e^+ e^- \rightarrow \tau^+ \tau^- \rightarrow 3 + 1$

**Event selection**
- Low multiplicity
- Missing momentum
- Missing energy
- Particle id.

Select only

$$\tau \rightarrow \pi \nu \quad \tau \rightarrow \rho \nu$$

**Observable**
- Identify the positive and the negative track

$$O_1 = |p^+_\perp| |p^-\perp| \sin(\phi_+ - \phi_-)$$
Experimental approach

**Event selection**
- Low multiplicity
- Missing momentum
- Missing energy
- Particle id.

Select only

\[ \tau \rightarrow \pi \nu \quad \tau \rightarrow \rho \nu \]

**Observable**
- Identify the positive and the negative track

\[ O_1 = |p_+^\perp| |p_-^\perp| \sin (\phi_+ - \phi_-) \]
### Sensitivities \( (10^7\tau - \text{pairs}) \)

| \( P \) | \( c_{AB} \) (GeV\(^2\)) | \( \sqrt{\left\langle O_1^2 \right\rangle} \) (GeV\(^2\)) | \( |\delta \text{Red}_\tau| \) (e cm) |
|---|---|---|---|
| 0.00 | \(-1.58 \times 10^{-5}\) | 1.78 | \(5.71 \times 10^{-15}\) |
| -0.62 | \(-8.19 \times 10^{-1}\) | 1.78 | \(1.10 \times 10^{-17}\) |
| +0.62 | \(8.15 \times 10^{-1}\) | 1.78 | \(1.11 \times 10^{-17}\) |
| -0.71 | \(-9.37 \times 10^{-1}\) | 1.78 | \(9.65 \times 10^{-18}\) |
| +0.71 | \(9.33 \times 10^{-1}\) | 1.78 | \(9.67 \times 10^{-18}\) |
| -1.00 | \(-1.32\) | 1.78 | \(6.86 \times 10^{-18}\) |
| +1.00 | \(1.31\) | 1.78 | \(6.86 \times 10^{-18}\) |

| \( P \) | \( c_{AB} \) (GeV\(^2\)) | \( \sqrt{\left\langle O_1^2 \right\rangle} \) (GeV\(^2\)) | \( |\delta \text{Red}_\tau| \) (e cm) |
|---|---|---|---|
| 0.00 | \(-3.91 \times 10^{-4}\) | 1.66 | \(1.57 \times 10^{-14}\) |
| -0.62 | \(-6.36 \times 10^{-1}\) | 1.66 | \(9.63 \times 10^{-18}\) |
| +0.62 | \(6.35 \times 10^{-1}\) | 1.66 | \(9.64 \times 10^{-18}\) |
| -0.71 | \(-7.29 \times 10^{-1}\) | 1.66 | \(8.41 \times 10^{-18}\) |
| +0.71 | \(7.27 \times 10^{-1}\) | 1.66 | \(8.42 \times 10^{-18}\) |
| -1.00 | \(-1.03\) | 1.66 | \(5.98 \times 10^{-18}\) |
| +1.00 | \(1.02\) | 1.66 | \(5.98 \times 10^{-18}\) |

| \( P \) | \( c_{AB} \) (GeV\(^2\)) | \( \sqrt{\left\langle O_1^2 \right\rangle} \) (GeV\(^2\)) | \( |\delta \text{Red}_\tau| \) (e cm) |
|---|---|---|---|
| 0.00 | \(-7.03 \times 10^{-5}\) | 1.51 | \(5.76 \times 10^{-14}\) |
| -0.62 | \(-3.63 \times 10^{-1}\) | 1.51 | \(1.12 \times 10^{-17}\) |
| +0.62 | \(3.62 \times 10^{-1}\) | 1.51 | \(1.12 \times 10^{-17}\) |
| -0.71 | \(-4.15 \times 10^{-1}\) | 1.51 | \(9.77 \times 10^{-18}\) |
| +0.71 | \(4.15 \times 10^{-1}\) | 1.51 | \(9.77 \times 10^{-18}\) |
| -1.00 | \(-5.85 \times 10^{-1}\) | 1.51 | \(6.93 \times 10^{-18}\) |
### P-weighted Sensitivities \( (10^7 \tau - \text{pairs}) \)

| \(c_{AB} \) (GeV\(^2\)) | \(\sqrt{\langle O_1^2 \rangle} \) (GeV\(^2\)) | \(|\delta \text{ Real} \tau| \) (e cm) |
|--------------------------|---------------------------------|---------------------------------|
| \(\pi \pi\)               | 1.72 \times 10^3                | 3.46 \times 10^{-19}           |
| \(\pi \rho\)             | 1.34 \times 10^3                | 2.38 \times 10^{-19}           |
| \(\rho \rho\)            | 7.62 \times 10^2                | 1.48 \times 10^{-19}           |

| \(c_{AB} \) (GeV) | \(\sqrt{\langle O_2^2 \rangle} \) (GeV) | \(|\delta \text{ Imag} \tau| \) (e cm) |
|--------------------------|---------------------------------|---------------------------------|
| \(\pi \pi\)               | 2.49 \times 10^{-1}             | 1.19 \times 10^{-16}           |
| \(\pi \rho\)             | 1.71 \times 10^{-1}             | 1.28 \times 10^{-16}           |
| \(\rho \rho\)            | 9.35 \times 10^{-2}             | 1.15 \times 10^{-16}           |

\[
c_{AB} \cdot \Re(\Delta \tau) = \frac{e}{\sqrt{S}} \left[ \langle O_1 \rangle_P - \langle O_1 \rangle_{-P} \right]
\]

- Most systematic effects should cancels in \( \langle O_1 \rangle_P - \langle O_1 \rangle_{-P} \)
- With a sample in excess of \(10^{10}\tau\) pairs it seems possible to enter in the very high precision realm \(d_{\tau} \sim 10^{-20} \text{ e cm}\)
P-weighted Sensitivities \((10^7 \tau - \text{pairs})\)

| \(c_{AB} \text{ (GeV}^2\) | \(\sqrt{\langle O_1^2 \rangle} \text{ (GeV}^2\) | |\(\delta \text{ Red}_{\tau}\) | (e cm) |
|-----------------|-----------------|-----------------|-----------------|
| \(\pi\pi\) | \(1.72 \times 10^3\) | 3.46 | \(2.61 \times 10^{-19}\) |
| \(\pi\rho\) | \(1.34 \times 10^3\) | 2.38 | \(1.68 \times 10^{-19}\) |
| \(\rho\rho\) | \(7.62 \times 10^2\) | 1.48 | \(1.33 \times 10^{-19}\) |

| \(c_{AB} \text{ (GeV)}\) | \(\sqrt{\langle O_2^2 \rangle} \text{ (GeV)}\) | |\(\delta \text{ Imd}_{\tau}\) | (e cm) |
|-----------------|-----------------|-----------------|-----------------|
| \(\pi\pi\) | \(2.49 \times 10^{-1}\) | 1.19 | \(6.20 \times 10^{-16}\) |
| \(\pi\rho\) | \(1.71 \times 10^{-1}\) | 1.28 | \(7.03 \times 10^{-16}\) |
| \(\rho\rho\) | \(9.35 \times 10^{-2}\) | 1.15 | \(8.39 \times 10^{-16}\) |

\[
c_{AB} \cdot R(d_{\tau}) = \frac{e}{\sqrt{s}} \left[ \langle O_1 \rangle_P - \langle O_1 \rangle_{-P} \right]
\]

- Most systematic effects should cancel in \(\langle O_1 \rangle_P - \langle O_1 \rangle_{-P}\)
- With a sample in excess of \(10^{10} \tau\) pairs it seems possible to enter in the very high precision realm \(d_{\tau} \sim 10^{-20} \text{ e cm}\)
P-weighted Sensitivities \((10^7 \tau - \text{pairs})\)

\[
c_{AB} \cdot \mathcal{R}(d_\tau) = \frac{e}{\sqrt{S}} \left[ \langle O_1 \rangle_P - \langle O_1 \rangle_{-P} \right]
\]

- Most systematic effects should cancel in \(\langle O_1 \rangle_P - \langle O_1 \rangle_{-P}\)
- With a sample in excess of \(10^{10} \tau\) pairs it seems possible to enter in the very high precision realm \(d_\tau \sim 10^{-20} \text{e cm}\)

| \(c_{AB} \) (GeV\(^2\)) | \(\sqrt{\langle O_1^2 \rangle}\) (GeV\(^2\)) | \(|\delta \text{ Red}_\tau|\) (e cm) |
|---|---|---|
| \(\pi\pi\) | \(1.72 \times 10^3\) | 3.46 | \(2.61 \times 10^{-19}\) |
| \(\pi\rho\) | \(1.34 \times 10^3\) | 2.38 | \(1.68 \times 10^{-19}\) |
| \(\rho\rho\) | \(7.62 \times 10^2\) | 1.48 | \(1.33 \times 10^{-19}\) |

| \(c_{AB}\) (GeV) | \(\sqrt{\langle O_2^2 \rangle}\) (GeV) | \(|\delta \text{ Im d}_\tau|\) (e cm) |
|---|---|---|
| \(\pi\pi\) | \(2.49 \times 10^{-1}\) | 1.19 | \(6.20 \times 10^{-16}\) |
| \(\pi\rho\) | \(1.71 \times 10^{-1}\) | 1.28 | \(7.03 \times 10^{-16}\) |
| \(\rho\rho\) | \(9.35 \times 10^{-2}\) | 1.15 | \(8.39 \times 10^{-16}\) |
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain the robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain the robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle...and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain the robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle ...and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain to robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle ...and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+ e^-$ machine with polarizable beams.
- A preliminary study to ascertain to robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle... and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain to robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle ...and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
Requirements

- A very high luminosity $e^+e^-$ machine with polarizable beams.
- A preliminary study to ascertain to robustness of the observables with respect to systematic effects.
- A dedicated system to measure the beam polarization?
- A tracking system with efficiency as uniform as possible in azimuthal and polar angle ...and very well aligned to reduce biases on reconstructed momenta.
- An hermetic detector to better reject backgrounds and cross-feeds.
- A Monte Carlo generator able to take into account spin correlations (Zbigniew Was can I ask you some help?)
- Psychological support and enthusiasm from the theoretical side.
$e^+ e^-$ polarization allows the search for $CP/T$ violation in $\tau$ decays. The $\tau$ pairs produced with polarized beams have a significant spin polarization along the beam line.
$T$ odd observables in $\tau$ decays (Yung Su Tsai)

One can search for $CP$ violation in the decay:

$$\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$$

Observables

$T$ odd:

$$w \cdot (q_1 \times q_2)$$

or $CPT$ violation in $\tau \rightarrow \pi \nu$

Observables

$CPT$ odd:

$$w \cdot q_\pi$$
Conclusions

- $\tau$ Electric dipole moment at a superb $\tau$ factory looks very interesting (if not exciting!)

- I plan to ascertain the robustness of the Ananthanarayan & Rindani observables against systematic effects and report at the next meeting

- $CP$ violation in $\tau$ decays needs some theoretical effort: what are the less irrelevant operators involved? What is the estimated size of the effect?