A Tau - Charm - Factory at Argonne

Workshop on the Tau - Charm - Factory
in the
Era of B - Factories

SLAC, August 15 and 16, 1994

JOSE REPOND

Argonne National Laboratory

Argonne, IL 60439, U.S.A.
Argonne High Energy Physics

Ed Berger
Dave Grosnick
Tom Fields
Jim Norem
Jose Repond
Paul Schoessow

Argonne Advanced Photon Source

Ed Crosbie
Fred Mills
Lee Teng
PLAN VIEW OF THE ADVANCED PHOTON SOURCE

PLAN VIEW OF THE ADVANCED PHOTON SOURCE

MULTI-FUNCTION BUILDING

CENTRAL LAB/OFFICE BUILDING

UTILITY BUILDING

COOLING TOWERS

EARLY ASSEMBLY AREAS

EXISTING WETLAND "D"

EXISTING WETLAND "P"

ATTENDANCE BARN "P"

ATTENDANCE BARN "D"

LAB/OFFICE MODULES

400 ft

1/63

RF/EXTRACTION BUILDING

BOOSTER/INJECTOR SYNCHROTRON

POSITRON ACCUMULATOR RING

INJECTION WING

EXPERIMENT HALL

STORAGE RING

7 GeV

450 TeV

7 GeV e+ SYNCHROTRON RADIATION FACILITY

OPERATIONAL 1995
Argonne High Energy Physics Division

- Involvement in experiments outside ANL: FNAL, DESY, ...

- Currently NO in-house project

- Studies of different projects for the future: ATLAS, Long Baseline, ...

- Tau - Charm Factory $\Rightarrow$ Attractive project

  Collider: Expertise available from the ANL Advanced Photon Source
  Detector: Expertise in the HEP Division
## Comparison of Measurements and Sensitivities in τ Physics

<table>
<thead>
<tr>
<th>Measurement</th>
<th>1993 Cornell (Dallas)</th>
<th>τcF 1993</th>
<th>SLAC BF 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Properties</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m_\tau$</td>
<td>± 0.3 MeV</td>
<td>± 0.1 MeV</td>
<td>?</td>
</tr>
<tr>
<td>$\tau_r$</td>
<td>± 1.0%</td>
<td>-</td>
<td>± 0.3%</td>
</tr>
<tr>
<td>$m_{\mu_\tau}$</td>
<td>&lt; 3.2 MeV CL=95%</td>
<td>&lt; 1 MeV CL=95%</td>
<td>&lt; 5.5 MeV CL=95%</td>
</tr>
<tr>
<td>$\rho$</td>
<td>± 3.9%</td>
<td>± 0.02%</td>
<td>± O(0.1)%</td>
</tr>
<tr>
<td>$d_\tau$</td>
<td>± 10%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Universality</td>
<td>$O(0.5)%$</td>
<td>0.1%</td>
<td>0.5%</td>
</tr>
<tr>
<td><strong>Branching Ratios</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$e\nu\nu$</td>
<td>± 0.8%</td>
<td>± 0.1%</td>
<td>± 0.5%</td>
</tr>
<tr>
<td>$\mu\nu\nu$</td>
<td>± 0.9%</td>
<td>± 0.1%</td>
<td>± 0.5%</td>
</tr>
<tr>
<td>$\pi\nu$</td>
<td>± 2.2%</td>
<td>± 0.1%</td>
<td>± 0.5%</td>
</tr>
<tr>
<td>$K\nu$</td>
<td>± 10%</td>
<td>± 0.8%</td>
<td>?</td>
</tr>
<tr>
<td>$\rho\nu$</td>
<td>± 1.3%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$3\pi\nu$</td>
<td>± 2.4%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$2\pi^0\nu$</td>
<td>± 3.6%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$5\pi\nu$</td>
<td>± 16%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>$5\pi^0\nu$</td>
<td>± 43%</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Rare Decays</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\pi^0\eta\nu$</td>
<td>&lt; $1.1 \times 10^{-2}$ CL=95%</td>
<td>&lt; $10^{-7}$</td>
<td>&lt; $10^{-6}$</td>
</tr>
<tr>
<td>$e\gamma$</td>
<td>&lt; $1.7 \times 10^{-4}$ CL=90%</td>
<td>&lt; $10^{-7}$</td>
<td>&lt; $10^{-6}$</td>
</tr>
<tr>
<td>$\mu\gamma$</td>
<td>&lt; $4.2 \times 10^{-6}$ CL=90%</td>
<td>&lt; $10^{-7}$</td>
<td>&lt; $10^{-6}$</td>
</tr>
<tr>
<td>$3\mu$</td>
<td>&lt; $1.7 \times 10^{-8}$ CL=90%</td>
<td>&lt; $2 \times 10^{-8}$ CL=90%</td>
<td>&lt; $5 \times 10^{-7}$ CL=90%</td>
</tr>
<tr>
<td>$\pi\eta\nu$</td>
<td>&lt; $0.9 \times 10^{-2}$ CL=95%</td>
<td>~ $1 \times 10^{-5}$</td>
<td>&lt; $5 \times 10^{-5}$ CL=95%</td>
</tr>
</tbody>
</table>

BETTER by $\sim x 10$ and $\sim x 5$
Topics in Charm and Charmonium Physics

- **CKM Matrix Elements** $V_{ub}/V_{cb}$ to $\sim 1\%$

  **SEMILEPTONIC $D^0$ DECAYS**

- **Weak Decay Constants** $f_D, f_{D^*}$ to $2\%$

  **PURELY LEPTONIC $D$ DECAYS**

- **New Physics** Sensitivity to BR's $O(10^{-8})$

  **RARE DECAYS**

- **$D - D$ Mixing** $\tau_D < 2.0 \times 10^{-8}$ in 1 year
  No confusion with DCSD

  **SEMI-LEPTONIC DECAYS**

  **HADRONIC DECAYS**

- **CP Violation** Reach $\sim 1\%$ in 1 year

  $D^{*0} \overline{D}^0$ EVENTS
  $J/\psi^* \rightarrow (\text{SEMILEPTONIC})(\text{CP EIGENSTATE})$
  $J/\psi^* \rightarrow (\text{CP EIGENSTATE})(\text{CP EIGENSTATE})$

- **Absolute Branching Ratios**

  $D$ MESONS: $O(1\%)$
  $D_s, \Lambda_c, \Xi_c, ...$ $O(5\%)$

- **Charmonium** $O(3)$ more statistics

  **SPECTROSCOPY**
  **ELECTROMAGNETIC COUPLINGS**
  **GLUONIUM SEARCH**
Design of the Collider

- Collaboration with APS accelerator physicists
- Based in part on CERN/Spanish design
- Optimization of the lattice
- Vacuum chamber design
- Preliminary list of parameters
- The ideal injector system
- Cost estimate:
  
  Not complete yet

  Expected to be similar to CERN design

- Written document(s) in preparation
- CDR

  Approximately 2 years

  5 - 10 people
Optimization of Lattice

- Monochromatic and Standard High Luminosity options were compared.

- The monochromatic option, along with a standard FODO arc, produced comparable luminosity, for a given tune shift with less modification of the arc lattice.

- We adopted the monochromatic mode as the primary option, with $\beta_x = 0.01 \text{ m}$, $\beta_y = 0.037 \text{ m}$, $D_y = 0.5 \text{ m}$ and $\varepsilon_x = 247 \text{ nm} @ 1.5 \text{ GeV}$.

- This leads to large charge/bunch.
  $$I = 0.95 \text{ A}, \quad N = 2 \cdot 10^{11} /\text{b}, \quad \xi_x \sim \xi_y \sim 0.25$$

- Higher currents require minimal impedance. Assume superconducting Cornell type cavities which should dominate the impedance of the ring.
Vacuum Chamber

- Cost has driven the design.
- Vacuum chambers in arcs would be extruded Copper (or Aluminum).
- Pumping would be with non-evaporable getter (NEG) strips.
- Slots would be machined in extrusions, or cut using EDM.
- Chamber sections would be bent like the APS vacuum chamber.
Initial Parameters

General

Center of mass energy 3.0 - 5.0 GeV
Luminosity 10^{33} /s /cm^2
Current 0.96 A /beam
Electrons (positrons) 2 \times 10^{11} /bunch
Approximate circumference 360 m
Bend radius 11.71 m
Bunch spacing \sim 10 m
Natural emittance, \varepsilon_x, \varepsilon_y 247 / 5 nm
Bunch length 0.01 m
Momentum compaction 0.094

Interaction Point

\beta_x^*, \beta_y^* 0.010 / 0.037 m
Dispersion, D_y^* 0.5 m
Beam beam tune shifts. \xi_x, \xi_y 0.025 / 0.026

RF System

RF frequency \sim 500 MHz
Required RF voltage 3. MV
Radiated power 280 kW /beam
Cavities 1 /ring
Injector Options

- An ideal high current injector would consist of
  - ~200 MeV electron linac
  - 450 MeV positron linac
  - Positron accumulator ring
  - Rapid cycling synchrotron

- The choice between reversing the synchrotron or building extra lines has been studied. Reversing seems cheaper.

- We have also studied the option without the positron accumulator ring and lower energy linacs.
General Considerations

- Strong support and interest within ANL HEP & APS divisions
- Interest by ANL management

HEP community support?

- Proposal for Laboratory Directed R & D Funds submitted
- Recently, cancellation of ANL Integral Fast Reactor program

Effect on new proposals at ANL?
Conclusions

- In our view: Physics motivation for a τcF is strong
  
  Despite B-factories, LEP

- ANL preliminary design of the collider almost complete

- Next steps:

  - Initiation of detector studies
  - Conceptual design report of collider

- Go ahead dependent:

  - HEP community interest
  - Support by ANL management

  DOE