The “old” Beijing Electron Positron Collider BEPC

$L \sim 5 \times 10^{30} / \text{cm}^2 \cdot \text{s} @ J/\psi$ peak

$E_{cm} \sim 2-5 \text{ GeV}$

A unique $e^+e^-$ machine in the $\tau$–charm energy region since 1989.
### BEPCII Design Goals

<table>
<thead>
<tr>
<th>Category</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy range</strong></td>
<td>1 – 2 GeV</td>
</tr>
<tr>
<td><strong>Optimum energy</strong></td>
<td>1.89 GeV</td>
</tr>
<tr>
<td><strong>Luminosity</strong></td>
<td>$1 \times 10^{33}$ cm$^{-2}$s$^{-1}$ @ 1.89 GeV</td>
</tr>
<tr>
<td><strong>Injection</strong></td>
<td>Full energy injection: 1.55 - 1.89 GeV</td>
</tr>
<tr>
<td></td>
<td>Positron injection speed &gt; 50 mA/min</td>
</tr>
<tr>
<td><strong>Synchrotron mode</strong></td>
<td>250 mA @ 2.5 GeV</td>
</tr>
</tbody>
</table>
BEPCII: a high luminosity double–ring collider
BEPCII Status

- BEPCII linac installation completed in 2005; most design specifications reached.
- Storage ring: Major magnets, superconducting RF cavities and quadrupole magnets, as well as the cryogenics system have been completed, and their installation is complete.
- Beam collisions expected in summer/fall 2007.
Expected Event statistics at BESIII

<table>
<thead>
<tr>
<th>Physics Channel</th>
<th>Energy (GeV)</th>
<th>Luminosity (10^{33} \text{ cm}^{-2}\text{s}^{-1})</th>
<th>Events/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>J/(\psi)</td>
<td>3.097</td>
<td>0.6</td>
<td>1.0(\times10^{10})</td>
</tr>
<tr>
<td>(\tau)</td>
<td>3.67</td>
<td>1.0</td>
<td>1.2(\times10^{7})</td>
</tr>
<tr>
<td>(\psi')</td>
<td>3.686</td>
<td>1.0</td>
<td>3.0 (\times10^{9})</td>
</tr>
<tr>
<td>D</td>
<td>3.77</td>
<td>1.0</td>
<td>2.5(\times10^{7})</td>
</tr>
<tr>
<td>D_s</td>
<td>4.03</td>
<td>0.6</td>
<td>1.0(\times10^{6})</td>
</tr>
<tr>
<td>D_s</td>
<td>4.14</td>
<td>0.6</td>
<td>2.0(\times10^{6})</td>
</tr>
</tbody>
</table>

Average \(\mathcal{L} = 0.5\times\text{Peak } \mathcal{L}\); One year T = 10^7s
**This Decade**

Flavor Physics: “the sin2\(\beta\) era” Precision!
Over constrain CKM matrix with precision measurements. Limiting factor: non-pert. QCD.

---

**The Future**

LHC may uncover strongly coupled sectors in the physics that lies beyond the Standard Model
The ILC will study them. Strongly-coupled field theories are an outstanding challenge to theoretical physics. Critical need for reliable theoretical techniques & detailed data to calibrate them.

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**The Lattice**

Complete definition of pert & non. Pert. QCD. Matured over last decade, can calculate to 1-5% B, D, Y, \(\psi\), ...

Charm at threshold can provide the data to calibrate QCD techniques
Goal for the decade: high precision measurements of $V_{ub}$, $V_{cb}$, $V_{ts}$, $V_{td}$, $V_{cs}$, $V_{cd}$, & associated phases.

Over-constrain the “Unitarity Triangles”

Inconsistencies   New physics!

Many experiments will contribute. Measurement of absolute charm branching ratios will enable precise 1st column unitarity test & new measurements at B-factories/Tevatron/LHC to be translated into greatly improved CKM precision.
### Semi-leptonic Decays

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Input Br(%)</th>
<th>Eff.</th>
<th>Stat. Errors</th>
<th>CKM Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0 \to K^- e^+ \nu_e$</td>
<td>3.4%</td>
<td>54.6%</td>
<td>0.6%</td>
<td>$V_{cs}$</td>
</tr>
<tr>
<td>$D^0 \to K^- \mu^+ \nu_\mu$</td>
<td>30.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^0 \to \pi^- e^+ \nu_e$</td>
<td>0.4%</td>
<td>62.2%</td>
<td>1.6%</td>
<td>$V_{cd}$</td>
</tr>
<tr>
<td>$D^0 \to \pi^- \mu^+ \nu_\mu$</td>
<td>44.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$D^+ \to \bar{K}^0 e^+ \nu_e$</td>
<td>8.5%</td>
<td>6.7%</td>
<td>1.6%</td>
<td>$V_{cs}$</td>
</tr>
<tr>
<td>$D^+ \to \bar{K}^0 \mu^+ \nu_\mu$</td>
<td>3.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$$\Delta V_{cs} / V_{cs} = 1.6\%,$$

$$\Delta V_{cd} / V_{cd} = 1.8\%$$
Importance of measuring absolute charm leptonic branching ratios: $f_D$ & $f_{Ds} \rightarrow V_{td}$ & $V_{ts}$

\[ \Delta M_d = 0.50 \text{ps}^{-1} \left[ \frac{\sqrt{B_{B_d} f_{B_d}}}{200 \text{MeV}} \right]^2 \left[ \frac{|V_{td}|}{8.8 \times 10^{-3}} \right]^2 \]

\[ \sigma(\rho) = 0.5 \frac{\sigma(\Delta M_d)}{\Delta M_d} \oplus \frac{\sigma(f_B \sqrt{B_{B_d}})}{f_B \sqrt{B_{B_d}} (LP03) 1.2\%} \sim 15\% (\text{LQCD}) \]

\[ \frac{\Delta M_d}{\Delta M_s} \propto \left[ \frac{\sqrt{B_{B_d} f_{B_d}}}{\sqrt{B_{B_s} f_{B_s}}} \right]^2 \left[ \frac{|V_{td}|}{|V_{ts}|} \right]^2 \]

Lattice predicts $f_B/f_D$ & $f_{Bs}/f_{Ds}$ with small errors.

If precision measurements of $f_D$ & $f_{Ds}$ existed, we could obtain precision estimates of $f_B$ & $f_{Bs}$ and hence precision determinations of $V_{td}$ and $V_{ts}$.

Similarly $f_D/f_{Ds}$ checks $f_B/f_{Bs}$.

\[ \frac{\delta f_{Dc}}{f_{Dc}} \sim 14\% \]

\[ \frac{\delta f_{Dc}}{f_{Dc}} \sim 100\% \]
Pure Leptonic decays

<table>
<thead>
<tr>
<th>Decay Modes</th>
<th>Decay Constant</th>
<th>Branching ratios</th>
<th>Lifetime</th>
<th>CKM Elements</th>
<th>Precision of decay constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^+ \rightarrow \mu^+ \nu$</td>
<td>$f_D$</td>
<td>2.4%</td>
<td>1.2%</td>
<td>1.8%</td>
<td>3.0%</td>
</tr>
<tr>
<td>$D^+_s \rightarrow \mu^+ \nu$</td>
<td>$f_{D_s}$</td>
<td>1.7%</td>
<td>1.8%</td>
<td>0.1%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>
DDbar Mixing at BESIII

- $D^0 \leftrightarrow D^0$ mixing in SM $\sim 10^{-3} - 10^{-10}$
- $D^0 \leftrightarrow D^0$ mixing sensitive to “new physics”
- Our sensitivity: $\sim 10^{-4}$
- $D^0 \leftrightarrow D^0 \gamma_\circ (K^-\pi^+)(K^+\pi^-)$
  - Acceptance: $\sim 40\%$
  - Background: $\sim 10^{-4}$
QCD and hadron production

- R-value measurement
- pQCD and non-pQCD boundary
- Measurement of $\alpha_s$ at low energies
- Hadron production at $J/\psi$, $\psi'$, and continuum
- Multiplicity and other topology of hadron event
- BEC, correlations, form factors, resonance, etc.
R-value measurement

<table>
<thead>
<tr>
<th>Error on R</th>
<th>$\Delta \alpha^{(S)}_{\text{had}} (M_Z^2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.9%</td>
<td>0.02761 ±0.00036</td>
</tr>
<tr>
<td>3%</td>
<td>0.02761 ±0.00030</td>
</tr>
<tr>
<td>2%</td>
<td>0.02761 ±0.00029</td>
</tr>
</tbody>
</table>

R-value below 2 GeV is important, via radiative return.
Scan of the resonance region @ 3.7 - 4.6 GeV

Test isospin symmetry far away from open charm threshold! Since the EM effect may be significant far away from DD threshold!

$$f(E_{cm}) = \frac{\sigma(e^+e^- \rightarrow D^+D^{*-})}{\sigma(e^+e^- \rightarrow D^0\bar{D}^{0(*)})}$$

Could possible EM contribution affect the ratio? Interference effect:

$$\sigma \propto \left| A(e^+e^- \rightarrow \gamma^* \rightarrow DD^*) + A(e^+e^- \rightarrow c\bar{c} \rightarrow DD^*) \right|^2$$

If a relatively narrow glueball or exotic state $I = 0$ with a vector $1^{--}$ occurs somewhat above the DD* threshold, it would manifest itself via variation or deviation from QCD prediction.

scan @ 3.7 - 4.6 GeV may indicate existence of $1^{--}$ exotic states.

It will be very helpful to make a fine scan of the ratio @ 3.7 - 4.6 GeV, so that one can understand the formation of DD system near or above the threshold.
Scan of the resonance region @ 3.7 - 4.6 GeV

\[ \sigma(e^+e^- \rightarrow DD^{(*)}), \sigma(e^+e^- \rightarrow D_s^+D_s^{(*)}), \]
\[ \sigma(e^+e^- \rightarrow J/\psi\pi^+\pi^-), \sigma(e^+e^- \rightarrow \chi_{cJ}\rho(\omega)) \]
\[ \sigma(e^+e^- \rightarrow \phi\pi\pi), \sigma(e^+e^- \rightarrow \eta'J/\psi) \]
\[ \sigma(e^+e^- \rightarrow \phiKK), \sigma(e^+e^- \rightarrow \eta'\phi) \]

Test QCD @ 3.7 ÷ 4.6 GeV

Search for exotic c\(\not{\rho}\), Y(4260)

Probe gluon enhanced hidden c\(\not{\rho}\) states

But! CLEO-c will not scan and BESIII is unable to reach masses above 4 GeV

p\(\not{\Delta}\)-annihilation @ PANDA @ FAIR

K. Peters - BESIII@BEPCII
Light hadron spectroscopy

- Baryon spectroscopy
- Charmonium spectroscopy
- Glueball searches, rad. $J/\psi$
- Search for non-$q\bar{q}$ states

- Not forgetting the huge field of $\tau$-Physics
QCD and e^+e^- → B\overline{B} 1.88-2.8 GeV

Experimental data from FENICE collaboration near the threshold:

\[
\frac{\sigma(e^+e^- \rightarrow pp)}{\sigma(e^+e^- \rightarrow nn)} = 0.66^{+0.16}_{-0.11}
\]

However, exact QCD predict:

\[
\frac{\sigma(e^+e^- \rightarrow pp)}{\sigma(e^+e^- \rightarrow nn)} \approx \frac{Q_u^2}{Q_d^2} = 4
\]

Precise measurements of e^+e^- pΔ, n⇔, n(p) n(K) will be very useful at BESIII.

BESII R measurement 1σ above the pQCD predictions above the BB open threshold.
## Errors on R at BESIII

<table>
<thead>
<tr>
<th>Error sources</th>
<th>BESII (%)</th>
<th>BESIII (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminosity</td>
<td>2 - 3</td>
<td>1</td>
</tr>
<tr>
<td>Detection efficiency</td>
<td>3 - 4</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Trigger efficiency</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Radiative corrections</td>
<td>1 - 2</td>
<td>1</td>
</tr>
<tr>
<td>Hadron decay model</td>
<td>2 - 3</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Statistics</td>
<td>2.5</td>
<td>--</td>
</tr>
<tr>
<td>Total</td>
<td>6 – 7</td>
<td>2 - 3</td>
</tr>
</tbody>
</table>
BESIII Detector

Muon counter
SC magnet
TOF
Be beam pipe
Drift chamber
CsI(Tl) calorimeter
Main Drift Chamber

- Size ø 63 mm - 810 mm length: 2400 mm
  - inner cylinder: 1 mm Carbon fiber
  - outer cylinder: 10 mm CF with 8 windows
- End flange: 18 mm thick Al 7075 (6 steps)
- 7000 Signal wires: 25 (3% Rhenium) um gold-plated tungsten
- 22000 Field wires: 110 um gold-plated Aluminum
- Small cell: inner 6*6 mm², outer 8.2 *8.2 mm²,
- Gas: He + C₃H₈ (60/40)
- Momentum resolution (@ 1 GeV/c)
  \[ \frac{\sigma_{P_t}}{P_t} = 0.32\% \oplus 0.37\% \]
- dE/dX resolution: 6-7%
Main Drift Chamber
MDC Status: Wire stringing complete
Preamp installation complete
Cosmic ray running in progress
Beam test at KEK

Prototype tested in a 1T magnetic field at KEK 12GeV PS.

Results:
- spatial resolution better than 130 µm
- cell efficiency over 98%
- dE/dX resolution better than 5% (3σπ/K separation exceeding 700MeV/c).
EMC: CsI(Tl) crystals

- 6300 crystals, (5.2 x 5.2 – 6.4 x 6.4) x 28 cm$^3$ (15 $X_0$)
- PD readout, noise $\sim$ 1100 ENC
- Energy resolution: 2.5% @ 1 GeV
- Position resolution: 5 mm @ 1 GeV
- Tiled angle: theta $\sim$ 1.3°, phi $\sim$ 1.5°
- Minimum materials between crystals
**CsI(Tl) crystal detector cell**

Readout: Two Hamamatsu S2744-08 10 mm x 20 mm photodiodes
Testing:
- Size
- Source tests (\(^{137}\)Cs)
- LED tests
- PD tests
- Preamp tests
- Cosmic ray tests
- Beam tests (6 x 6 array):

Energy resolution (1GeV)
\[ \sigma_E = 2.62 \% \]

Position resolution (1GeV)
\[ \sigma_{x-y} = 6 \text{ mm} \]
Mechanical structure

A 1/60 prototype

Status:
- Assembly starts soon
- Barrel completed by April 07

Mechanical structure now at IHEP
Super-conducting magnet

- Al stabilized NbTi/Cu conductor from Hitachi
- 1.0 T, <5% non-uniformity
- 921 turns, 3150A @4.5K
- \( R = 1.475 \, \text{m}, \, L=3.52\, \text{m}, \, \text{cold mass} \equiv \) 
- Thickness: 1.92 \( X_0 \)
- Inner-winding method

![Diagram of superconducting magnet with voltage by quench plot](image)
BESIII Magnet Progress

- **wiring**
- **thermal insulation**
- **assembly**
- **transportation**
- **installation**
The super-conducting magnet in place
Voltage curve shows that the magnet is in super-conducting state. Magnetic field 10029.8 Gauss.
Particle ID: TOF system

- 392 pieces BC408, 2.4 m long, 5cm thick
- Time resolution 100-110 ps/layer
- PMT: Hamamatsu R5942
TOF

• TOF electronics (USTC):
  – Whole system reached a resolution of < 25 ps in the beam test
  – Preamp. under mass production
  – The third version of FEE board under design
  – Fast clock system almost completed
• PMT are under testing in Tokyo Uni.
• Scintilator are ordered and to be delivered in May.
• Monitoring system under preparation in Hawaii
• By the end of the year, complete all the testing and be ready for the installation next year.
TOF Performance

- Time resolution 1-layer (intrinsic):
  - Belle: 70 to 80 ps
  - Beam tests: < 90 ps
  - Simulation: < 90 ps

- Time resolution of two layers is 100ps to 110ps for kaon and pions.

- $K/\pi$ separation: $2\sigma$ separation up to 0.9 GeV/c.
Muon Chamber

- 9 (8) layers, 2000 m$^2$
- Bakelite, no linseed oil
- 4cm strips, 10000 channels
- Tens of prototypes (up to 1*0.6 m$^2$)
- Noise less than 0.2 Hz/cm$^2$
μ system : RPC

- 9 layers, 2000 m²
- Bakelite, no linseed oil
- 4cm strips, 10000 channels
- Tens of prototypes (up to 1*0.6 m²)
- Total of 64 endcap modules, 72 barrel modules;
- Gas: \( \text{Ar}:\text{C}_2\text{H}_2\text{F}_4:\text{Isobutane} = 50:42:8 \)
- HV voltage: 8000V;
- One module contains two RPC layers and one readout layer.
Test Result after installation - Endcap

Average strip efficiency: 0.97    Spatial resolution: 16.6mm

Mean of 64 endcap RPC = 0.95
Other systems

- Electronics design have been almost finished, several prototypes have been successfully tested
- Trigger system largely based on FPGA technology have been designed, prototypes underway
- DAQ system based on VME/PowerPC and PC farm have been designed, mini-version setup, software underway
- Offline computing environment based on a large scale PC farm is under study
- MC based on GEANT4, first reconstruction framework released, sub-detector reconstruction code underway
Trigger and DAQ

- Using the latest technology of FPGA, the trigger design is almost finalized.
- No. of types of trigger boards are reduced from 23 to 17
- All the boards are tested, some for several prototyping.
- By the end of the year, all the boards should be tested and installed.
- The whole DAQ system tested to 8K Hz for the event size of 12Kb, a factor of two safety margin
- The whole DAQ system tested during beam test with MDC and EMC
## The detectors of BES III and CLEO-c

<table>
<thead>
<tr>
<th>Subdetector</th>
<th>BES III</th>
<th>CLEOc</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDC</td>
<td>$\sigma_{XY} (\mu m) = 130$</td>
<td>90 $\mu m$</td>
</tr>
<tr>
<td></td>
<td>$\Delta P/P (0/0) = 0.5 % (1 \text{ GeV})$</td>
<td>0.5 %</td>
</tr>
<tr>
<td></td>
<td>$\sigma_{dE/dx} (0/0) = 6 - 7 %$</td>
<td>6%</td>
</tr>
<tr>
<td>EMC</td>
<td>$\Delta E/\sqrt{E} (0/0) = 2.5 % (1 \text{ GeV})$</td>
<td>2.0%</td>
</tr>
<tr>
<td></td>
<td>$\sigma_z (\text{cm}) = 0.5 \text{cm}/\sqrt{E}$</td>
<td>0.3 cm/$\sqrt{E}$</td>
</tr>
<tr>
<td>TOF</td>
<td>$\sigma_T (\text{ps}) = 100-110/\text{layer}$</td>
<td>Rich</td>
</tr>
<tr>
<td></td>
<td>Double layer</td>
<td></td>
</tr>
<tr>
<td>$\mu$ counter</td>
<td>9 layers</td>
<td>----</td>
</tr>
<tr>
<td>magnet</td>
<td>1.0 T</td>
<td>1.0 T</td>
</tr>
</tbody>
</table>
Future

In US:
- Fermilab stops collider physics in 2009.

In China:
BESIII commissioning in fall 2007.
BESIII will be a unique facility.

In Germany:
FAIR finished construction 2015.
Hadron Spectroscopy – Leading Labs
Summary

- BEPCII linac installation complete.
- Installation of collider nearly complete; ready for **synchrotron running**.
- BESIII hardware and software progressing rapidly, although still much to do.
- Commissioning **ongoing**.
Thank you！谢谢！
• BACKUP
  – Comparison BESIII/CLEO
  – Resolution studies
BESIII: (8M, M.C.)

\[ m(\chi_{c1}) = 3.508 \text{GeV}, \]
\[ m(\chi_{c2}) = 3.553 \text{GeV}; \]
\[ \sigma(\chi_{c1}) = 8.1 \text{MeV}, \]
\[ \sigma(\chi_{c2}) = 9.4 \text{MeV}. \]

\[ \Psi' \; \gamma \chi_{cJ} , \; \chi_{cJ} \; \gamma J/\psi \]

\[ \psi' \; J/\psi(\pi^0, \eta), (\pi^0, \eta) \; \gamma \gamma \]

\[ m(\eta) = 549 \text{MeV}, \]
\[ m(\pi^0) = 135 \text{MeV} \]

\[ \chi_{c0} \]
\[ \gamma \gamma \]

\[ m(\chi_{c-}) = 3.413 \text{GeV}, \]
\[ \sigma(\chi_{c0}) = 9.0 \text{MeV}. \]

\[ \chi_f \]

\[ \chi_f \]

\[ \chi_f \]

\[ \chi_f \]
Performance of State-of-the-Art BESIII detector

Neutral object

$\pi^0$ from $J/\psi \rho\pi$

$\sigma = 5.8$ MeV

$\sigma = 5.1$ MeV

Inclusive $\pi^0$ from $(3770)$ decays

$\sigma = 2.4$ MeV

Inclusive $K_s$ from $(3770)$ decays

length/error_length $> 2$

from Vertex fit

New muon counter
(9 layers) RPC for KL
and $\mu$ ID,
double layers TOF for PID
Physics Simulations

50,000 $\psi''$ Inclusive event sample.

$K_S \rightarrow \pi^+ \pi^-$

$\Lambda \rightarrow p\pi$

$\sim 3\text{MeV}$

$\sim 1.2\text{MeV}$
50,000 $\psi''$ Inclusive event sample.

A RooPlot of "D0 to Kpi"

$D^0 \rightarrow K^- \pi^+$

$\sigma(m_{BC}) \sim 1.2 \text{ MeV}/c^2$

$\sigma(\Delta E) = 7 \text{ MeV}$

A RooPlot of "D0 to K3pi"

$D^0 \rightarrow K^- \pi^+ \pi^+ \pi^-$

A RooPlot of "D0 to Kpipi0"

$D^0 \rightarrow K^- \pi^+ \pi^0$

A RooPlot of "D0 to K0bpipi"

$D^0 \rightarrow K_S \pi^+ \pi^-$

K. Peters - BESIII@BEPCII
Absolute Br measurement: clear D tagging

-D$^+ \rightarrow K^-\pi^+\pi^+

B = 1.0T

$\sigma_{MD} = 1.05\text{MeV}$

($\sigma_{Eb} = 0.9\text{MeV}$)

beam energy spread important
## Non-leptonic decays

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Input Br(%)</th>
<th>Detection efficiency</th>
<th>Statistical Error (ΔB/B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0 \rightarrow K^-\pi^+$</td>
<td>3.7</td>
<td>72.2%</td>
<td></td>
</tr>
<tr>
<td>$D^0 \rightarrow K^-\pi^+\pi^+$</td>
<td>~7.8</td>
<td>34.0%</td>
<td>~ 0.4%</td>
</tr>
<tr>
<td>$D^0 \rightarrow K^-\pi^+\pi^0$</td>
<td>~12.0</td>
<td>32.0%</td>
<td></td>
</tr>
<tr>
<td>$D^+ \rightarrow K^-\pi^+\pi^+$</td>
<td>~7.7</td>
<td>52.0%</td>
<td></td>
</tr>
<tr>
<td>$D^+ \rightarrow K^0\pi^+$</td>
<td>2.8</td>
<td>12.5%</td>
<td></td>
</tr>
<tr>
<td>$D^+ \rightarrow K^0\pi^+\pi^+$</td>
<td>~5.6</td>
<td>9.2%</td>
<td>~ 0.6%</td>
</tr>
<tr>
<td>$D^+ \rightarrow K^0\pi^+\pi^-$</td>
<td>~8.6</td>
<td>7.9%</td>
<td></td>
</tr>
<tr>
<td>$D^+ \rightarrow K^-\pi^+\pi^0$</td>
<td>~5.0</td>
<td>22.5%</td>
<td></td>
</tr>
<tr>
<td>$D^+ \rightarrow \phi\pi^+$</td>
<td>~3.0</td>
<td>60.0%</td>
<td>~ 1.2%</td>
</tr>
</tbody>
</table>

One year of running
QCD and $e^+e^- \rightarrow B\bar{B}$ 1.88-2.8 GeV

An intermediate coherent isovector state serving as an intermediary between $e^+e^-$ and BB

$$f = \frac{\sigma(e^+e^- \rightarrow pp)}{\sigma(e^+e^- \rightarrow nn)} = \frac{|A_1 + e^{i\alpha}A_0|^2}{|A_1 - e^{i\alpha}A_0|^2} = \frac{|1 + e^{i\alpha}\varepsilon|^2}{|1 - e^{i\alpha}\varepsilon|^2}$$

$A_1$ and $A_0$ are $I = 1$ and $0$ amplitudes, and dominated by single states $r^*, \omega^*, \phi^*$

J. Ellis and M. Karliner hep-ph/0108259

QCD 10^{-24} sec

Proposed mechanism by J. Ellis and M. Karliner

Experimental region

Projection