Status of the CESR/CLEO Phase III Upgrades

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- CLEO $e^+e^- \rightarrow \gamma(4S)$ experiment upgrades to do:
  - Searches for rare $B$ meson decays
  - Accumulation of high-statistics $c$ and $\tau$ samples.

- Brief review of CESR III accelerator upgrades.

- Upgrade to CLEO Detector, featuring good particle identification (RICH)

- Impact of CESR and Particle ID upgrades on the rest of CLEO, need for
  - New central drift chamber (DRIII)
  - New inner silicon tracking detector (SiIII)
CESR/CLEO Upgrade

- CESR upgrade
  Luminosity $3 \times 10^{32} \rightarrow 2 \times 10^{33}$

- Particle identification system upgrade
  $70\% + dE/dx$ (P < 0.7, P > 2.5 GeV)
  RICH + dE/dx ≈ 4G τ/κ (P = 2.8 GeV/c)

Physics:

$D^0 \rightarrow \pi^- e^+ \nu / D^0 \rightarrow K^- e^+ \bar{\nu}$ (V_{uc} / V_{cc})
$B \rightarrow \rho \bar{\gamma} / B \rightarrow K^* \bar{\gamma}$ (V_{td} / V_{ts})

$B^+ \rightarrow \rho^+ \bar{\gamma} / B^- \rightarrow \rho^- \bar{\gamma}$
$B^- \rightarrow D^0 K^- / B^+ \rightarrow D^0 K^+$

$\{ B^- \rightarrow J^- \pi^0 / B^+ \rightarrow J^+ \pi^0 \}$

$B^- \rightarrow K^- \pi^0 / B^+ \rightarrow K^+ \pi^0$

CP

- Track system upgrade:
  Space for CESR and RICH
  Requirement: same $\delta p/\rho$ and $dE/dE$ resolution as CLEO II (while sacrificing 20 cm).
CESR parameters

Operating Energy: 4.7 - 5.0 GeV / Beam (5.3 GeV)

Circumference: 768.43 m, Trev = 2.56 μsec

Bunch length: 2.6 cm

Injector: 150 MeV LINAC, 4-8 GeV Synchrotron

Recent CESR Performance

Number of bunches: 18 e−, 18 e+

Peak luminosity: 3.5 × 10^{32} /cm²/sec

Best integrated luminosity: 18 /pb per day, 330 /pb per month

CESR phase II expectations

Number of bunches: 27 e−, 27 e+

Peak luminosity: 6 × 10^{32} /cm²/sec

CESR phase III expectations

Number of bunches: 45 e−, 45 e+

Peak luminosity: 2 × 10^{33} /cm²/sec
Si Detector

4 layer barrel-style device, 92% of the solid angle

double-sided detectors:  $z$-side, $\phi$-side

Table 1: Detector Parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Length</td>
<td>5.110 cm</td>
</tr>
<tr>
<td>Active Width</td>
<td>2.555 cm</td>
</tr>
<tr>
<td>Number of $z$ strips</td>
<td>511</td>
</tr>
<tr>
<td>Pitch of $z$ strips</td>
<td>100 $\mu$m</td>
</tr>
<tr>
<td>Number of $\phi$ strips</td>
<td>511</td>
</tr>
<tr>
<td>Pitch of $\phi$ strips</td>
<td>50 $\mu$m</td>
</tr>
<tr>
<td>Readout trace resistance</td>
<td>25 ohms/cm</td>
</tr>
</tbody>
</table>

$N$ of detectors: 447
$N$ of channels: 135, 168

(A33C)
DRIFT Chamber

DR11 Gas: to compensate for $\frac{1}{2}$ loss in $\frac{C_p}{\rho}$
In DR11, chamber gas is $\frac{1}{2}$ of total $X_0$.

Ar-Ethane (50:50): $X_0 = 178m$; $N_p = 32/cm$ ← CLEO II
He-Propane (40:60): $X_0 = 392m$; $N_p = 43/cm$ ← CLEO III

DR cells: 3:1 rectangular geometry
7mm max drift dist
Outer conical section
31 layers, 8100 cells
all stereo
Drift Chamber layers
Inner tapered section
16 layers, 1696 cells
all axial wire layers
**RICH detector:**

- **Barrel style geometry:** 30 modules (sectors)
- **Module size:** $\sim 20 \times 250$ cm, 7620 pad channels
- **Pad size:** $8.0 \times 7.5$ mm, 72 wires/module
- **Total number of channels:** \(230,000\)
- **RICH budget:**
  - $r = 80 - 100$ cm
  - $\leq 12\% \times p_0$
"Sawtooth Radiators"

- Idea for LiF radiator geometry
- Especially useful at center of CLEO detector (total internal reflection)

\[ \text{\( \Theta_e \)} \]

\[ \text{\( \# \text{photoelectrons} \)} \]

\[ \text{\( \cos \theta \)} \]

\[ \text{\( \text{Resolution per track} \)} \]

\[ \text{\( \text{False rate} \)} \]

- Gives more Čerenkov photons than leave LiF radiator
- Photons exit more at normal incidence \( \Rightarrow \) less chromatic error

- Planar LiF Radiator
- Sawtooth LiF Radiator (45° teeth)
RICII Prototype Cosmic Ray Measurements

- 80 × 15 cm² prototype
- 54 anode wires, 2000 cathode pads.
- At $U_a = +1500$ Volts, $U_w = -1300$ Volts, gain $\sim 4 \times 10^4$.
- Expansion volume is Al box flushed with N₂ (<10 ppm).
- Viking VA2 chips in readout -- noise $\sim 400$ e⁻
- Pedestals constant $\sim 24$ hrs.
- Drift chambers track cosmic ray particles $\sim 1$ mrad accuracy.
- Scintillators trigger on tracks in LiF radiators or chamber itself ($\sim 25$ hr⁻¹ $P > 500$ MeV/c)

Drift Chambers

Trigger Scintillator

LiF Radiator

Expansion Volume (Nitrogen)

Cal2 Window

Photon Detector

Cosmic Ray Muons
Cherenkov angle per photoelectron

\[ \Theta_e = 16.3 \, \text{(MC: 16.2 mrad)} \]

\[ \Theta_e = 18.8 \, \text{(MC: 15.7 mrad)} \]
Summary

* CESR III will deliver ~10 fb⁻¹/year
  CESR II ~ 1 fb⁻¹/year
  Total integ. lum. CLEO II ~ 5 fb⁻¹
  (1990 - 1996)

* Upgrade of particle ID is crucial to many physics goals, including possible observation of CP.

* CESR and all detector systems will begin Phase III data taking in early 1998.