New Physics effects on leptonic decays of $D^{\pm}/D_s^{\pm}$ mesons

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Collaborator: S. Recksiegel (Munich)

$\boxed{\text{CLEO-c Charm factory}}$

Until 2002 CLEO was a $\sqrt{s} = 10.6$ GeV B factory

$\rightarrow$ converted to charm physics programme CLEO-c

- Charm threshold region: $3\,GeV < \sqrt{s} < 5$ GeV
- Started operation in September 2003
- CLEO-c complements charm physics studies at hadron colliders and $e^{+}e^{-}$ B factories
- Advantages of lower backgrounds

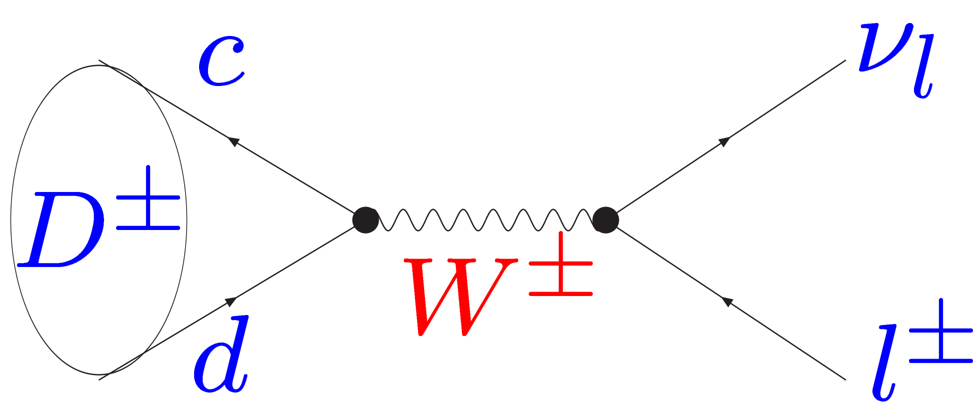
Target

- $\sqrt{s} = 3.77$ GeV: 3×10^7 D^+D^- and $D^0\overline{D}^0$ (2004)
- $\sqrt{s} = 4.14$ GeV: 1.5×10^6 $D_s^+D_s^-$ (2005)
- More than 100 times larger than existing data samples in the charm threshold region
- By June 2004 had accumulated 1×10^6 $D^{\pm}, D^0$ mesons

Purely leptonic decays of $D^{\pm}$ and $D_s^{\pm}$ mesons

CLEO-c suitable to search for $D^{\pm}/D_s^{\pm} \to l^{\pm}\nu$

No spectator quark. Meson is annihilated via $W^{\pm}$



Other examples are $\pi^{\pm} \to \mu^{\pm}\nu, e^{\pm}\nu$ and $K^{\pm} \to \mu^{\pm}\nu, e^{\pm}\nu$

Decay rate

$$\Gamma(D_q^+ \to \ell^+ \nu_\ell) = \frac{G_F^2 m_{D_q} m_l^2 f_{D_q}^2}{8\pi} |V_{cq}|^2 \left(1 - \frac{m_l^2}{m_{D_q}^2}\right)^2$$

- Helicity suppression: proportional to m_l^2
- Expect $\Gamma(\tau^\pm \nu) >> \Gamma(\mu^\pm \nu) >> \Gamma(e^\pm \nu)$
- f_D and f_{D_s} induces uncertainty of $\approx 30\%$ in SM prediction

Experimental searches for $D^{\pm}_{(s)} \to l^{\pm}\nu$

i) Observed

ii) No limits

Decay	SM Rate	Current Exp.	CLEO-c
$D^+ \to e^+\nu_e$	8.2×10^{-9}	×	YES
$D^+ \to \mu^+\nu_\mu$	3.5×10^{-4}	$(12\,^{+9.2}_{-6.3}\,^{+1.0}_{-0.9}) \times 10^{-4}$	4%
$D^+ \to \tau^+\nu_\tau$	9.3×10^{-4}	×	NO
$D_s^+ \to e^+\nu_e$	1.2×10^{-7}	×	YES
$D_s^+ \to \mu^+\nu_\mu$	5.2×10^{-3}	$(5.3 \pm 0.9 \pm 1.2) \times 10^{-3}$	3%
$D_s^+ \to \tau^+\nu_\tau$	5.1×10^{-2}	$(6.1 \pm 1.0 \pm 1.3) \times 10^{-2}$	3%

Prospects at CLEO-c

- CLEO-c plans to measure 3 of the 6 decays to $< 4\%$:

$D^{\pm} \to \mu^{\pm}\nu,\ D_s^{\pm} \to \tau^{\pm}\nu, \mu^{\pm}\nu$

- Direct measurements of f_D and f_{D_s}
- important check of Lattice calculations

Question: Can new physics affect these decays?

YES: Tree level contributions from sleptons $\tilde{l}^{\pm}$

(R parity violating MSSM)

The decays $D^{\pm}/D_s^{\pm} \to e^{\pm}\nu$

Cleanest channels to look for new physics are:

$$D^{\pm} \to e^{\pm}\nu, D_s^{\pm} \to e^{\pm}\nu$$

- SM Branching ratio $< 10^{-7}$
- Mere observation would be a clear sign of new physics
- No experimental limits
- CLEO-c ideal place to search for these decays

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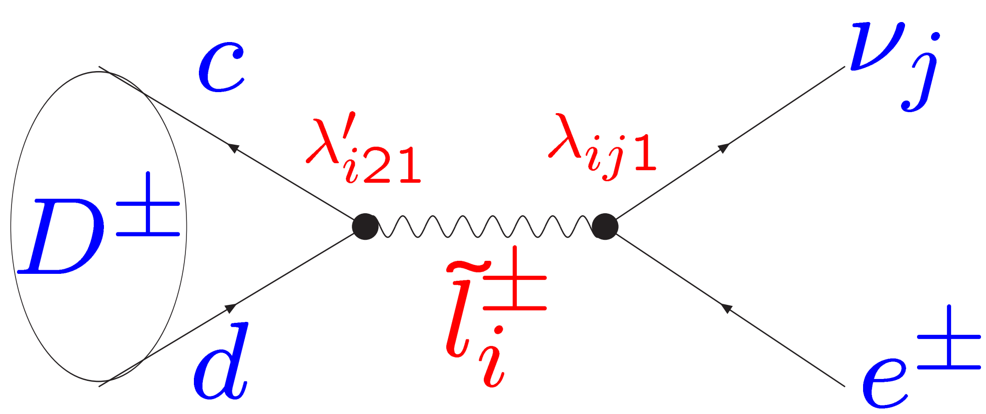
The decay $D^\pm \to e^\pm \nu$



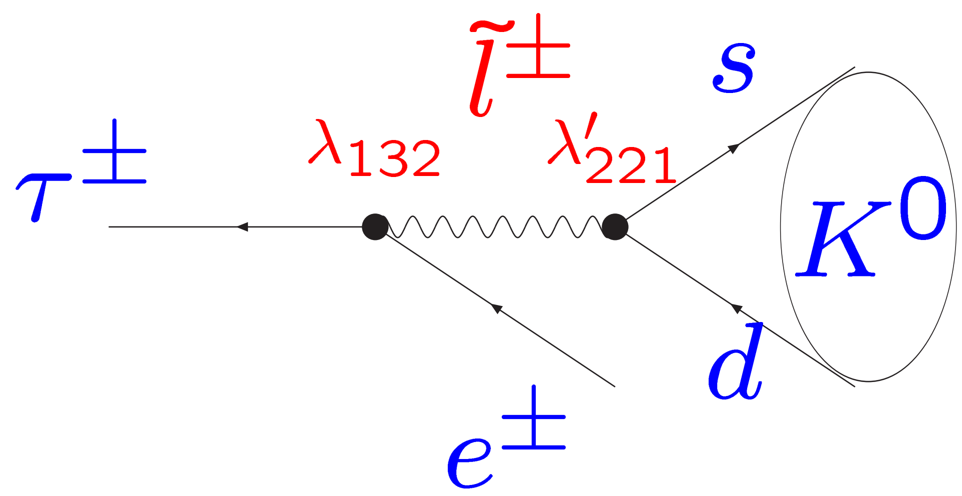
- Slepton $\tilde{l}_i^\pm$ contributions in R parity violating MSSM
- $W^\pm$ contribution negligible $\sim m_e$
- SM suppression of $G_F m_e$ is replaced by: $\lambda'_{i21}\lambda_{ij1}/m^2_{\tilde{l}_i}$

Optimal combination: $i = 2, j = 3$

$\to$ $D^\pm \to e^\pm \nu_\tau$ mediated by $\lambda'_{221}\lambda_{231}$

Correlation with lepton number violating decay

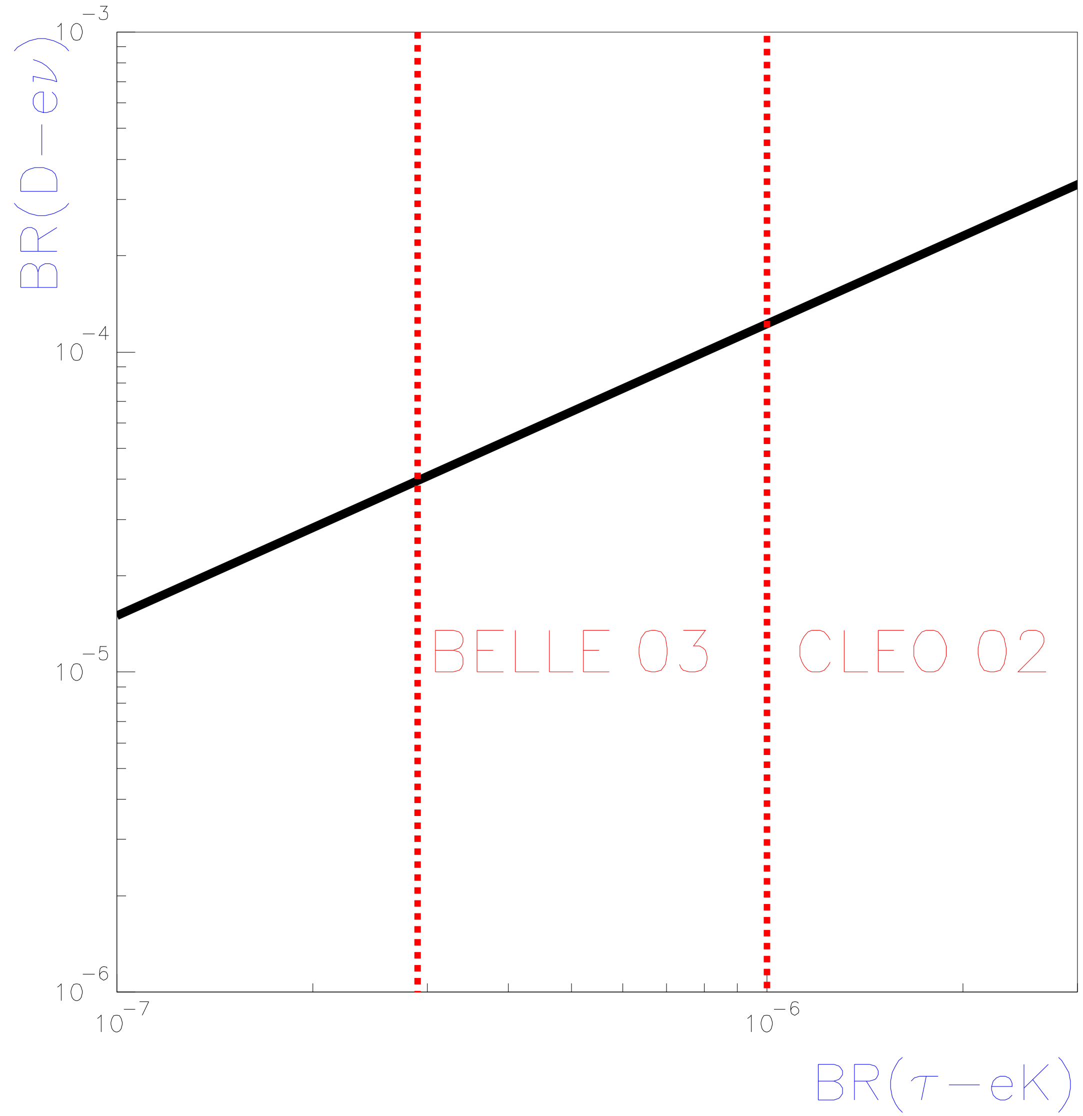
$\tau^{\pm} \to e^{\pm} K_S^0$



This decay is currently being searched for

at e^+e^- B factories BELLE and BABAR

BR($D^{\pm} \to e^{\pm}\nu$) against BR($\tau^{\pm} \to e^{\pm}K^0$); $\lambda_{132}\lambda'_{221}$ is varied



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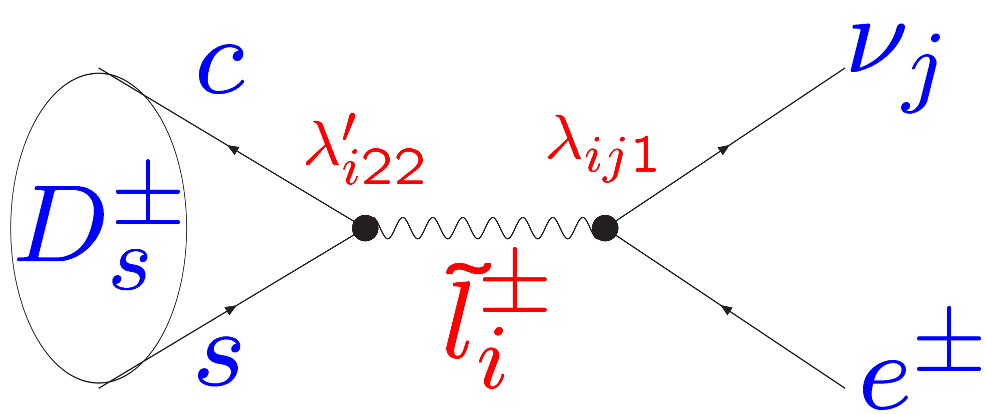
The decay $D_s^\pm \to e^\pm \nu$

$D_s^\pm$ will be produced when $\sqrt{s} = 4.14$ (2005)

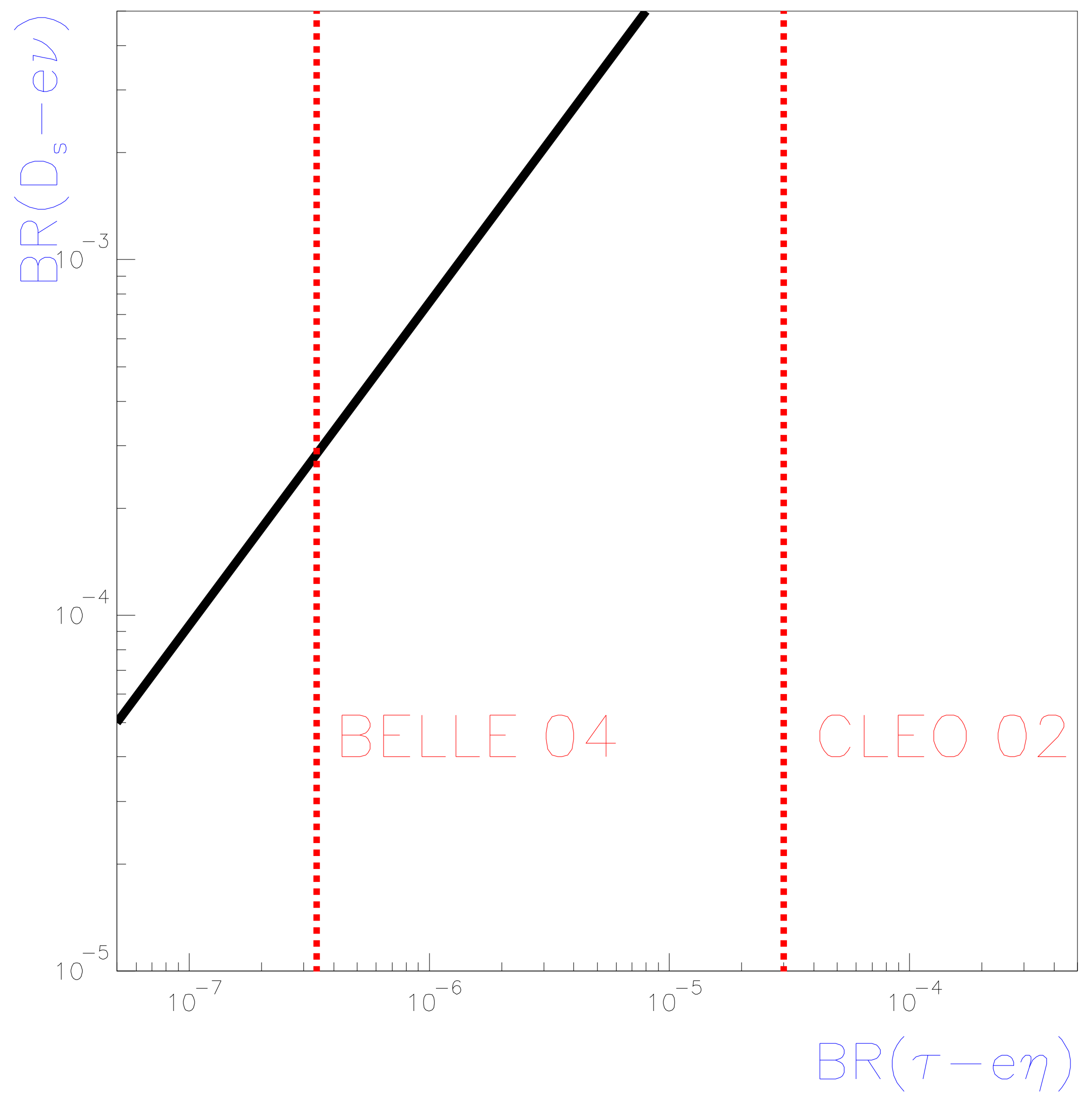


Optimal combination: $i = 2, j = 3$

$\to D_s^\pm \to e^\pm \nu_\tau$ mediated by $\lambda'_{222}\lambda_{231}$

Correlated with $\tau^\pm \to e^\pm \eta$

BR($D_s^\pm \to e^\pm \nu_\tau$) against BR($\tau^\pm \to e^\pm \eta$); $\lambda_{132}\lambda'_{222}$ is varied



Conclusions

- No experimental limits for $D^{\pm}/D_s^{\pm} \to e^{\pm}\nu$
- Mere observation would be a clear signal of new physics
- R Parity violating sleptons can enhance $D^{\pm}/D_s^{\pm} \to e^{\pm}\nu$
- BRs $\approx 10^{-4} \to 10^{-5}$
- Correlated with $\tau^{\pm} \to e^{\pm}K_S^0$ and $\tau^{\pm} \to e^{\pm}\eta$
- CLEO-c are interested in searching for $D^{\pm}/D_s^{\pm} \to e^{\pm}\nu$