

Measurement of η, η' decay widths into e^+e^-

- Motivation for $P \rightarrow l+l^-$ decays
- ND η' measurement
- Can one improve?...

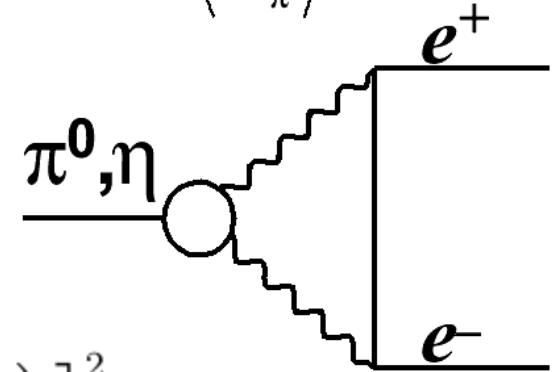
Andrzej Kupść
Uppsala University



$P \rightarrow l+l-$ Motivation

- Suppressed: intermediate $\gamma\gamma$

$$BR \approx \alpha^2 \left(\frac{m_e}{m_\pi} \right)^2 \approx O(10^{-8})$$

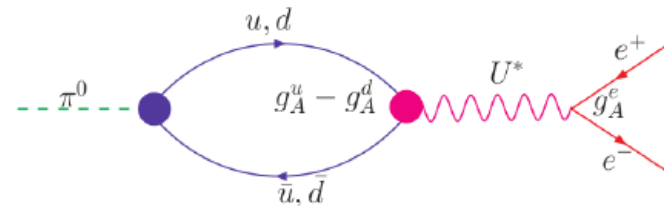


$$\mathcal{B}_{UB}(P \rightarrow e^+e^-) \approx 2\mathcal{B}(P \rightarrow \gamma\gamma) \left(\frac{\alpha m_e}{m_P} \right)^2 \left[\ln \left(\frac{m_e}{m_P} \right) \right]^2$$

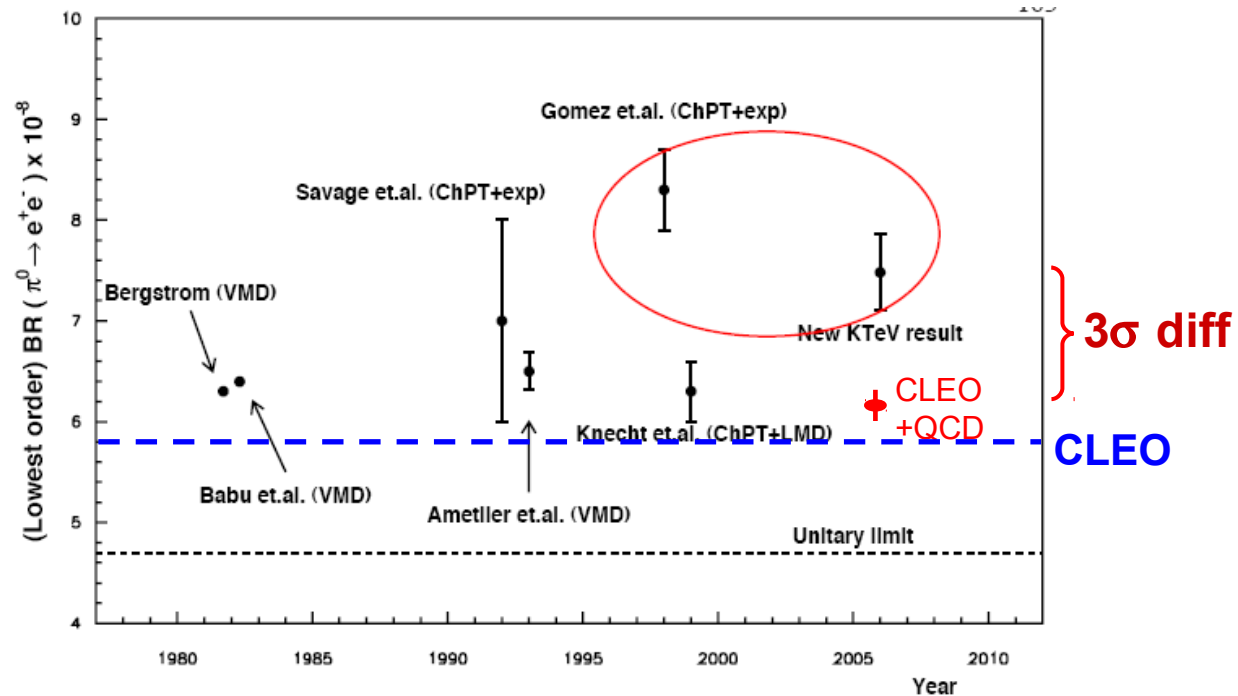
- Sensitive to $F_P(q_1^2, q_2^2)$

$$\Rightarrow \text{LbL } a_\mu$$

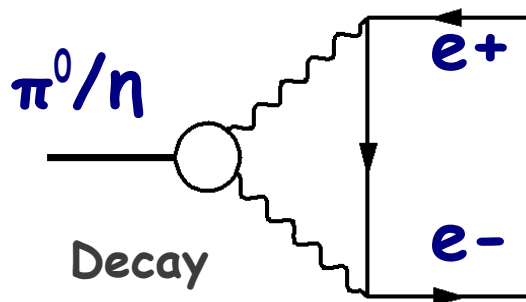
- BSM physics...
- $BR(\pi \rightarrow e^+e^-) \ 3\sigma > BR_{SM}$



$\pi^0, \eta, \eta' \rightarrow l^+l^-$

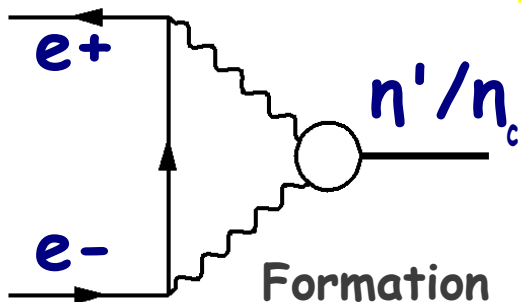


| | UB | CLEO bound | CLEO+OPE | This work | Experiment |
|---|-------------|----------------------------------|-----------------------------------|-------------|--|
| $\mathcal{B}(\pi^0 \rightarrow e^+e^-) \times 10^8$ | ≥ 4.69 | $\geq 5.85 \pm 0.03$ | 6.23 ± 0.12 | 6.26 | 7.49 ± 0.38 KTeV2007 |
| $\mathcal{B}(\eta \rightarrow \mu^+\mu^-) \times 10^6$ | ≥ 4.36 | $\leq 6.23 \pm 0.12$ | 5.12 ± 0.27 | 4.64 | 5.8 ± 0.8 SATURN1994 |
| $\mathcal{B}(\eta \rightarrow e^+e^-) \times 10^9$ | ≥ 1.78 | $\geq 4.33 \pm 0.02$ | 4.60 ± 0.09 | 5.24 | $\leq 5.6 \cdot 10^3$ HADES2012 |
| $\mathcal{B}(\eta' \rightarrow \mu^+\mu^-) \times 10^7$ | ≥ 1.35 | $\leq 1.44 \pm 0.01$ | 1.364 ± 0.010 | 1.30 | — |
| $\mathcal{B}(\eta' \rightarrow e^+e^-) \times 10^{10}$ | ≥ 0.36 | $\geq 1.121 \pm 0.004$ | 1.178 ± 0.014 | 1.86 | $\leq 2.1 \cdot 10^3$ ND1988 |
| $\mathcal{B}(\eta_c \rightarrow e^+e^-) \times 10^{14}$ | ≥ 4.2 | Dorokhov, PLB667(2009)145 | | | — |



HADES
WASA
Cball
NA48/NA62

| | UB | SM 3σ diff | EXP |
|---|-------------|----------------------|---------------------------------|
| $\mathcal{B}(\pi^0 \rightarrow e^+e^-) \times 10^8$ | ≥ 4.69 | 6.23 ± 0.12 | 7.49 ± 0.38 KTeV2007 |
| $\mathcal{B}(\eta \rightarrow e^+e^-) \times 10^9$ | ≥ 1.78 | 5.2 ± 0.3 | $\leq 5.6 \cdot 10^3$ HADES2012 |
| $\mathcal{B}(\eta' \rightarrow e^+e^-) \times 10^{10}$ | ≥ 0.36 | 1.9 ± 0.3 | $\leq 2.1 \cdot 10^3$ ND1988 |
| $\mathcal{B}(\eta_c \rightarrow e^+e^-) \times 10^{14}$ | ≥ 4.2 | Dorokhov, PLB667,145 | |



Searches using formation:
 $e^+e^- \rightarrow \eta'$, $L=0.5\text{pb}^{-1}$
 $\Rightarrow B < 2.1 \cdot 10^{-7}$ 90% CL

Vorobev SJNP 48(1988)273



Formation: $e^+e^- \rightarrow P$ ($\sqrt{s}=m_P$)

Peak cross section:

$$\sigma_0 = \frac{4\pi}{m_P^2} \mathcal{B}_{ee} \mathcal{B}_{out}$$

$$N_S = L \cdot \epsilon \cdot \langle \sigma \rangle = L \frac{4\pi}{m_P^2} \mathcal{B}_{ee} \epsilon \mathcal{B}_{out} \omega$$

| Meson | m_P [GeV] | Γ_P [MeV] | ω | $\frac{4\pi}{m_P^2}$ [mb] |
|----------|----------------|---------------------|-------------------|------------------------------|
| η | 0.5479 | $1.3 \cdot 10^{-3}$ | $4 \cdot 10^{-3}$ | 16.3 |
| η' | 0.9578 | 0.2 | 0.3 | 5.3 |
| η_c | 2.981 | 29.7 | 1 | 0.55 |

$$\omega \equiv \frac{\langle \sigma \rangle}{\sigma_0} = \int_{-\infty}^{\infty} N(E; m_P, \Delta E) \cdot BW_P(E) dE$$



ND experiment '88

Final state:

Vorobev SJNP 48(1988)273

$$\eta' \rightarrow \eta \pi^+ \pi^- \quad \epsilon \mathcal{B}_{\text{out}}^- = 0.010 \quad \Rightarrow \quad \epsilon \approx 0.1$$

Beam spread:

$$\Delta E = 0.38 \text{ MeV}$$

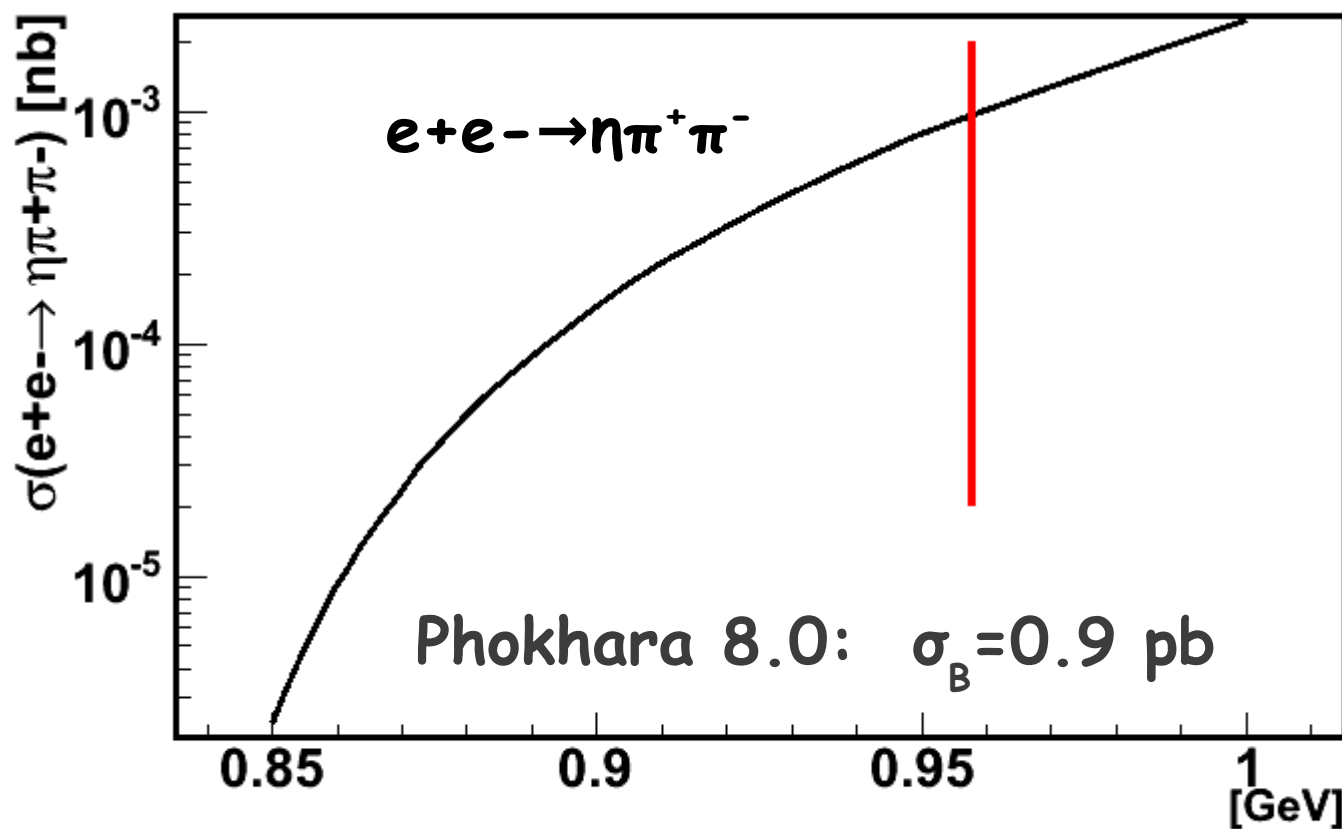
$$0.534 \text{ pb}^{-1}$$

No events
observed:

$$\mathcal{B}_{ee} < 2.1 \cdot 10^{-7} \quad 90\% \text{ CL}$$



Improvement of the ND result?



$$N_B = L \cdot \epsilon \cdot \sigma_B$$

Selection of FS:

σ_B , ϵ , Bout

- $\eta\pi^+\pi^-$: $N_B = 0$ up to 10 pb^{-1} (VEPP-2000)

- SM: $N_S/N_B = 3\%$

- Use $C=+1$ FS

even # γ
 $\eta' \rightarrow \eta\pi^0\pi^0$

