# Flavour Factories
# -a personal view-

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- **Some energy frontier machines also function as or even become “factories”.**

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- B factories (KEKB and PEP II)
  - With all the data available, observed CPV phenomena in the kaon system, described by a single complex parameter, $\varepsilon_K$, were "compatible" with the SM, but could not exclude that CPV was outside of the SM.
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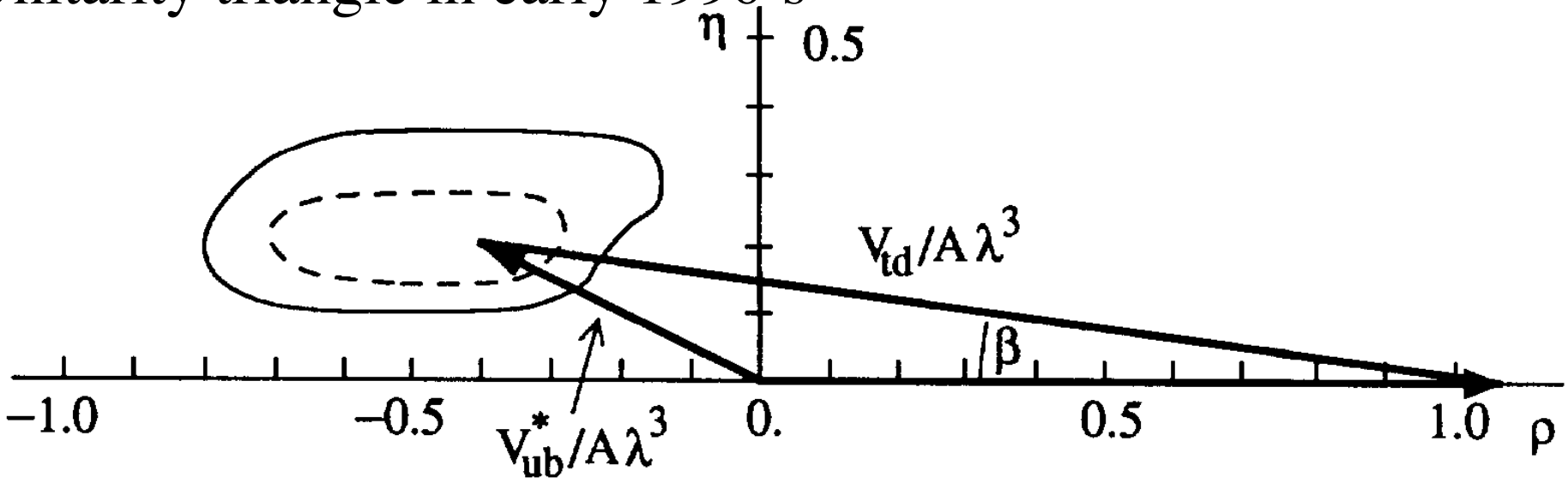


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"If the SM is the origin of CPV, an asymmetric B factory with $L \approx 10^{33}$ cm$^{-2}$s$^{-1}$ CPV in $B \rightarrow J/\psi K_S$ should be observed within a few years of data taking.": **a strong justification!**

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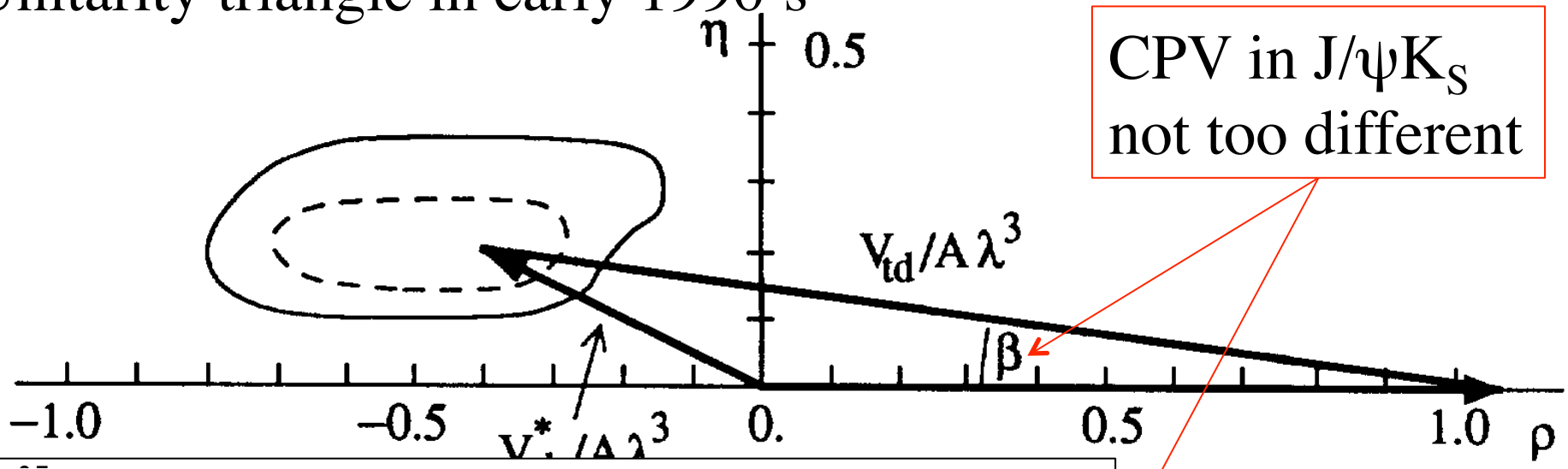
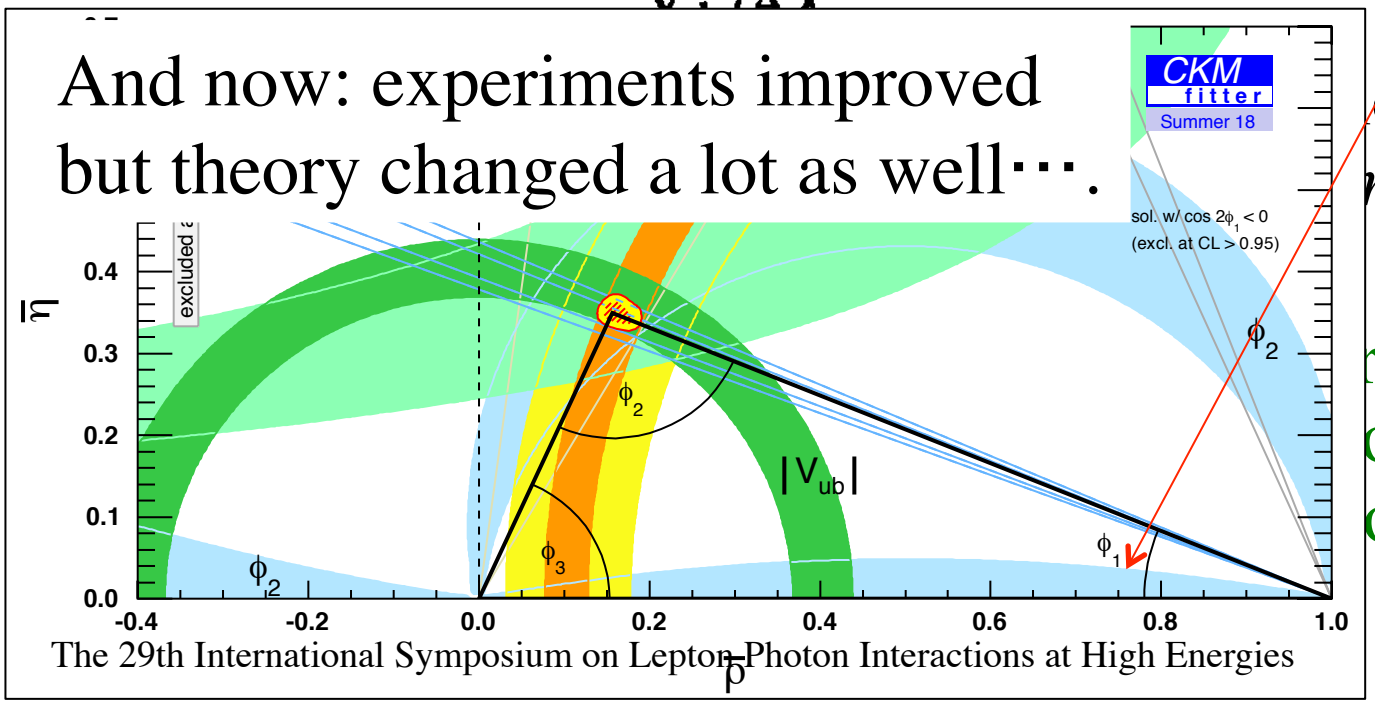



CPV in $J/\psi K_S$ not too different

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- Primary goal is not look for "new particles".

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- Class-A: undetectably small effect from the known physics,
  - Lepton flavour violating muon decays: $\mu \rightarrow e\gamma$:
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- Class-B: A discrepancy with the SM prediction
  - $\mu(g-2)$ (PDG 017, E821)

$$\Delta a_\mu = a_\mu^{\rm exp} - a_\mu^{\rm SM} = 268(63)(43) \times 10^{-11}\,,$$

**Improvements in both theory and experiment needed**

# Other on going examples

- Class-A:
  - Electric dipole moment: n, p, atoms, nuclei, e, μ
    (if seen only for hadron, could be due to strong CPV)
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Experimental progress makes a migration of A to B

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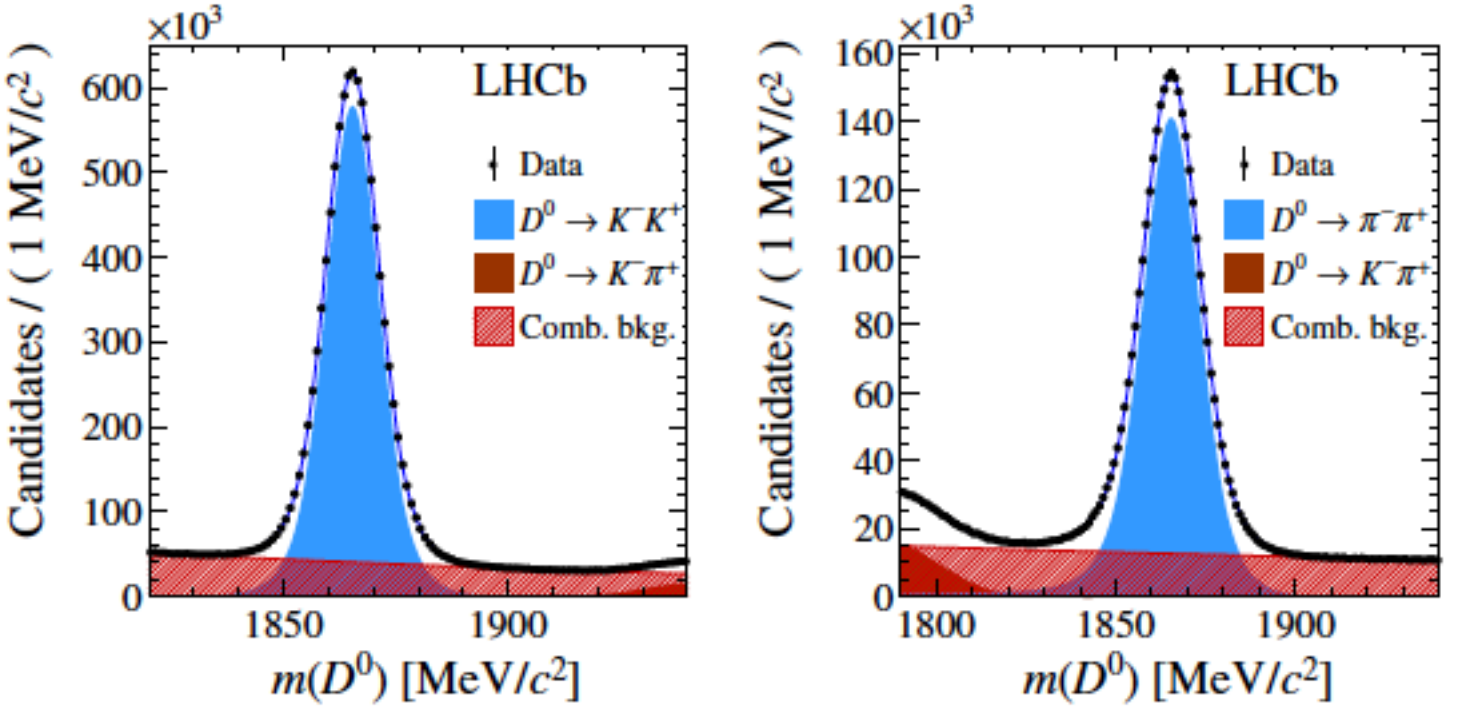


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PRL2019

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    = CPV in $D^0 \leftrightarrow \overline{D}^0$ + in $A_{h^- h^+}$ + interplay of the two
  - from the known properties of $D^0 \leftrightarrow \overline{D}^0$,
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    → LHCb observation is due to CPV in decay amplitudes
- In agreement with the SM predictions:
  now this becomes Class-B search: precisions in both experiments and theory becomes necessary

# Present "factories"

- PSI p beam:
  $\pi$, n, $\mu$
- FNAL p beam:
  $\mu$, $\nu$
- J-PARC p beam:
  K, $\mu$, $\nu$
- SPS (CERN) p beam:
  K

- VEP2000 $e^+e^-$
  $\rho$, $\omega$, $\phi$, …
- BEPC $e^+e^-$
  D, $\tau$
- (VEP4M $e^+e^-$ )
- SuperKEKB $e^+e^-$
  B, D, $\tau$
- DAFNE $e^+e^-$
  K

Accelerator originally constructed as high energy frontier machine

Accelerator constructed as a "factory"

# New factories bing discussed

- Super-Tau-Charm factories: $L \approx 10^{35}$ cm$^{-2}$s$^{-1}$
  - BINP (Novosibirsk): approved but construction not funded, R&D
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- $e^+e^-$ Higgs Factories
  - Circular options: CECP (CN), FCC-ee (CERN)
  - Linear options: ILC (JP), CLIC (CERN)

Circular option

- High luminosity
- Also super Z and W factories
- High energy pp collider could be installed later
- Initial cost would be high

Linear option

- Longitudinal beam polarizations
- Statistics for Z and W less than a circular option
- Extension to higher energies possible
- Initial cost would be lower than a circular option

Within the uncertainties of uncertainties, performance in the Higgs coupling measurements are comparable (Class-B case), while for, e.g., rare decays (Class-A case), luminosities do matter.

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No longer with a moderate cost: decision will have a profound impact on the community and field

# And don't forget

- LHC and HL-LHC also a factory: c, b, τ, t, W, Z, H
- There will be upgrades of
  - existing accelerators,
    - BEPC luminosity upgrade (IHEP), PIP-II (FNAL), possible SuperKEKB upgrade (polarization)?, …
  - beam lines
    - PSI new muon beam line (HIMB) for $10^{10}$ DC $\mu^+$/sec, …
  - and experiments
    - Many plans and ideas …

A cost effective way for the diversity, which is needed now in the field and should be exploited.

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- We have not yet the Standard Model of New Physics. A guidance from "flavour physics" is seriously required and interests in "flavour physics" are rapidly expanding, with many interesting ideas (as seen in this conference).

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- And we need to support "factories" for those activities.

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- **And have a safe trip back home!**