Exercise: Design your own B-meson CP Violation Experiment

- Which type of machine would you use?
  - e^+e^- or pp , pp or $p\overline{p}$ collider or fixed target? Why?
- At which energy do you want to run this machine?
- You will measure CP asymmetry in $B_s \to D_s^{\mp}K^{\pm}$ with BR=10^{-4}
  - Estimate how many collisions you need for a precision of γ=1^o
- You measure $B_s \to D_s^{\mp}K^{\pm}$ and $\overline{B_s} \to D_s^{\mp}K^{\pm}$
  - How do you determine the flavour of the B_s at production?
  - Are there intrinsic limits to this precision?
  - How would you calibrate the wrong tag fraction?
- There is a potential large background from another B_s-decay.
  - Do you know which it could be?
  - With which detector technology would you remove this background?
- What is the formula to reconstruct the B_s meson decay time in an event in observable quantities?
  - Which subdetectors would you require to measure it?

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- Points to consider:
  - e^+e^- at $\Upsilon(4S)$: electromagnetic production, clean, *no* B_s, coherent production: B^0 only time dependent CPV, requires asymmetric beams, good flavor tagging.
  - e^+e^- at $\Upsilon(5S)$: B_s, lower cross section, no resolution for time dependent CPV.
  - e^+e^- at Z-peak. Weak production, not coherent, interesting…?
  - pp collisions: Strong production and lots of stat's, "messy" events, large backgrounds requiring excellent detectors.
  - Fixed target vs collider: low cross section vs long decay distance.
    - b-quark cross section increases with high energy
  - pp vs $p\overline{p}$: "colour drag" asymmetry. Extra cross check for pp.

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- You will measure CP asymmetry in $B_s \to D_s^{\mp} K^{\pm}$ with BR=10^{-4}.
  - Estimate how many collisions you need for a precision of γ=1°
  - B_s mesons: Let's assume pp collisions at LHC using LHCb

- For ~1% measurement precision (0.01) on asymmetry:
  - Number of perfectly measured $B_s \to D_s^{\mp} K^{\pm}$ events:
  - Fraction of collisions that produce b-quarks:
  - Fraction of events where B_s meson is produced from b-quark:
  - Fraction of B_s that decay into $B_s \to D_s^{\mp} K^{\pm}$ channel
- ➔ So in total perfectly reconstructed events required

- Next, assumed measured by the LHCb experiment:
  - Acceptance x Reconstruction (background, resolution):
  - Trigger:
  - Tagging Power:

- In total pp collisions must be collected
- Assume ~10 MHz collisions, 3 x 10^6 s/year running time: of running.

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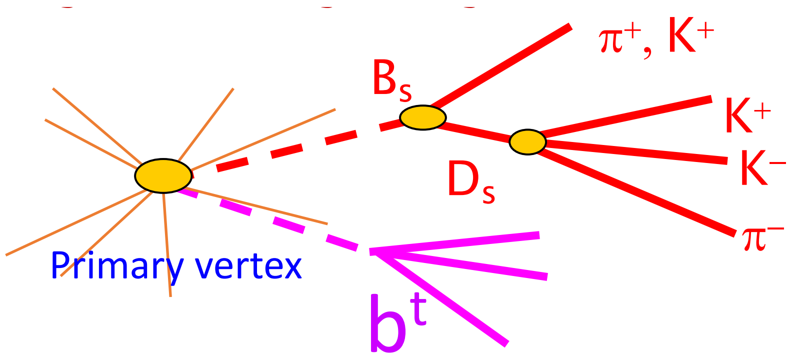

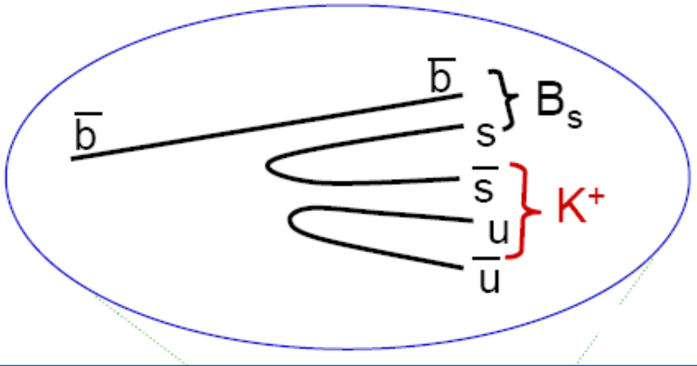

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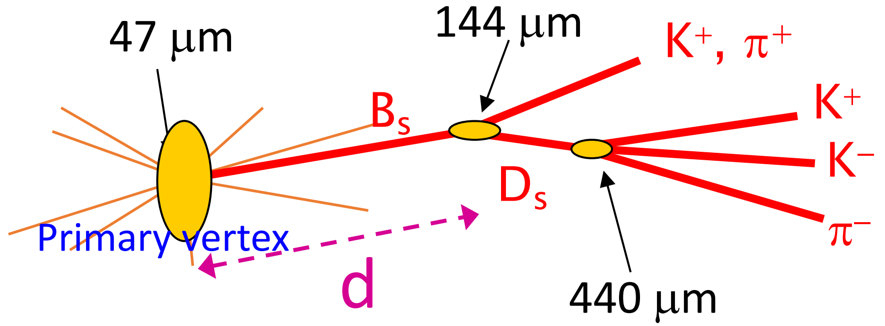

Decay time resolution = 40 fs