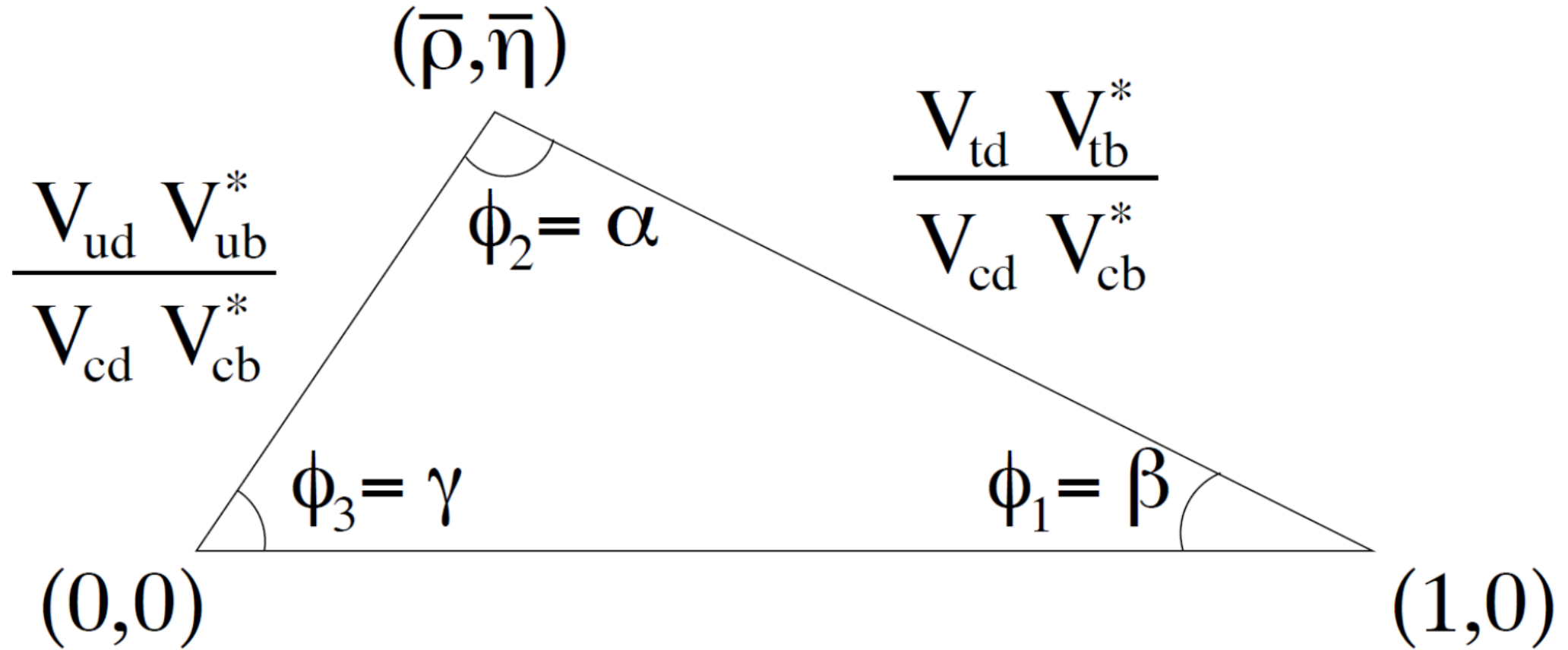


Flavour physics.

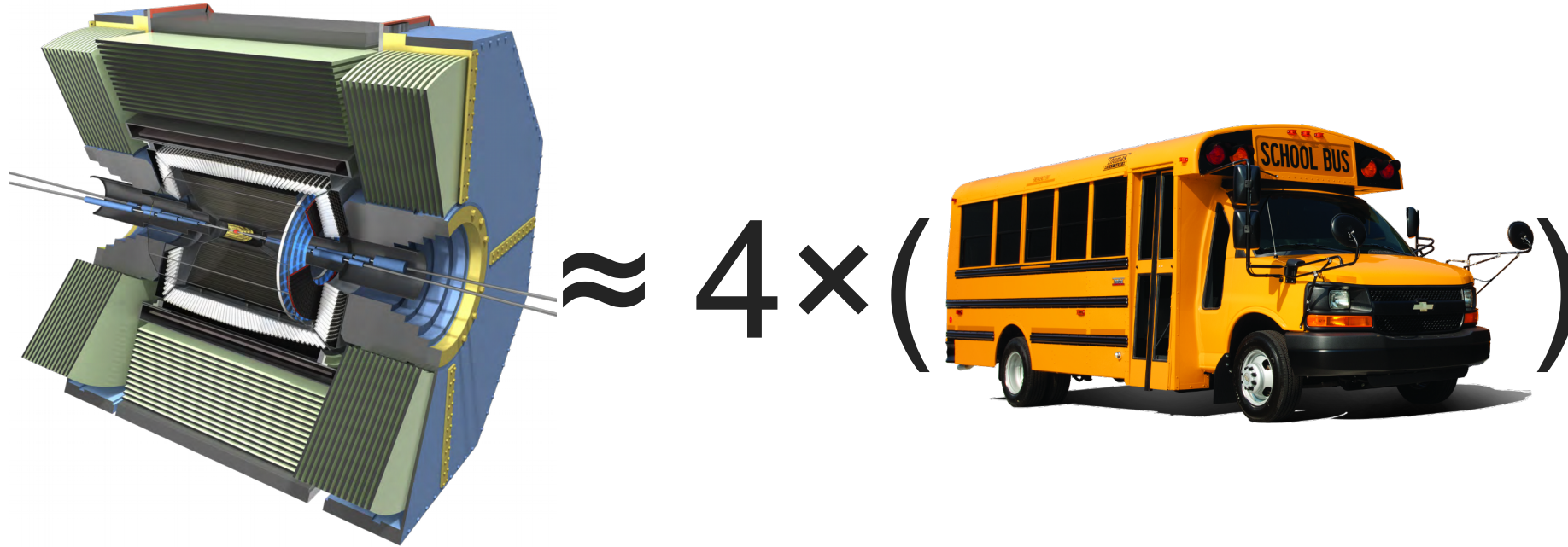
DESY Summer Student Lectures 2019
Supplimentary information

Sam Cunliffe
23.08.2019

Unitarity triangle



Size of the Belle II detector



Cherenkov effect

- A particle moving faster than the speed of light **in some medium**.

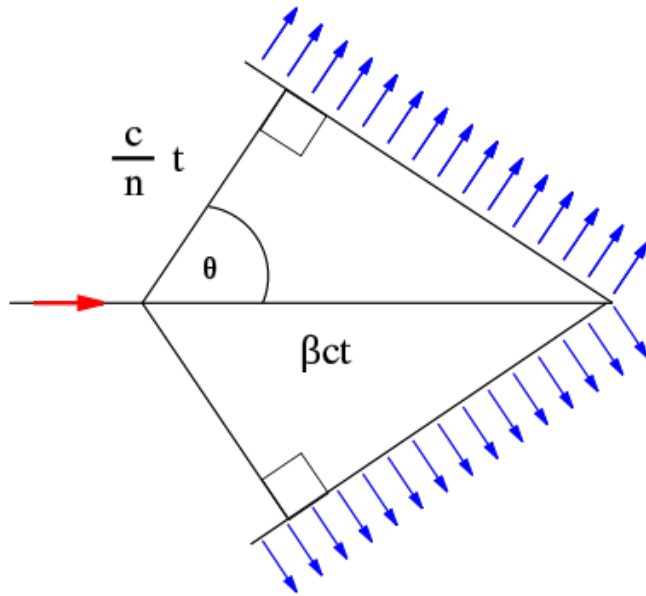
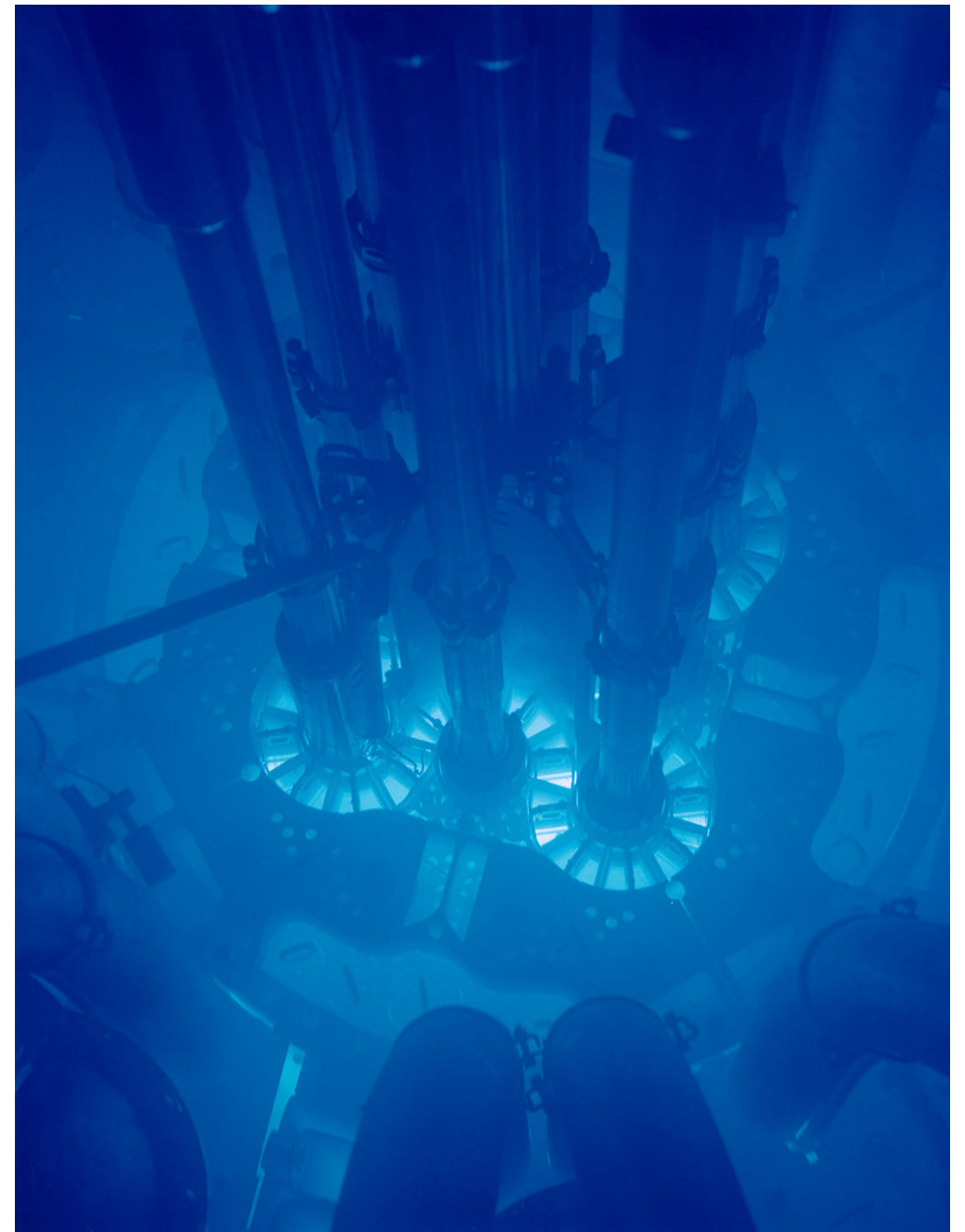
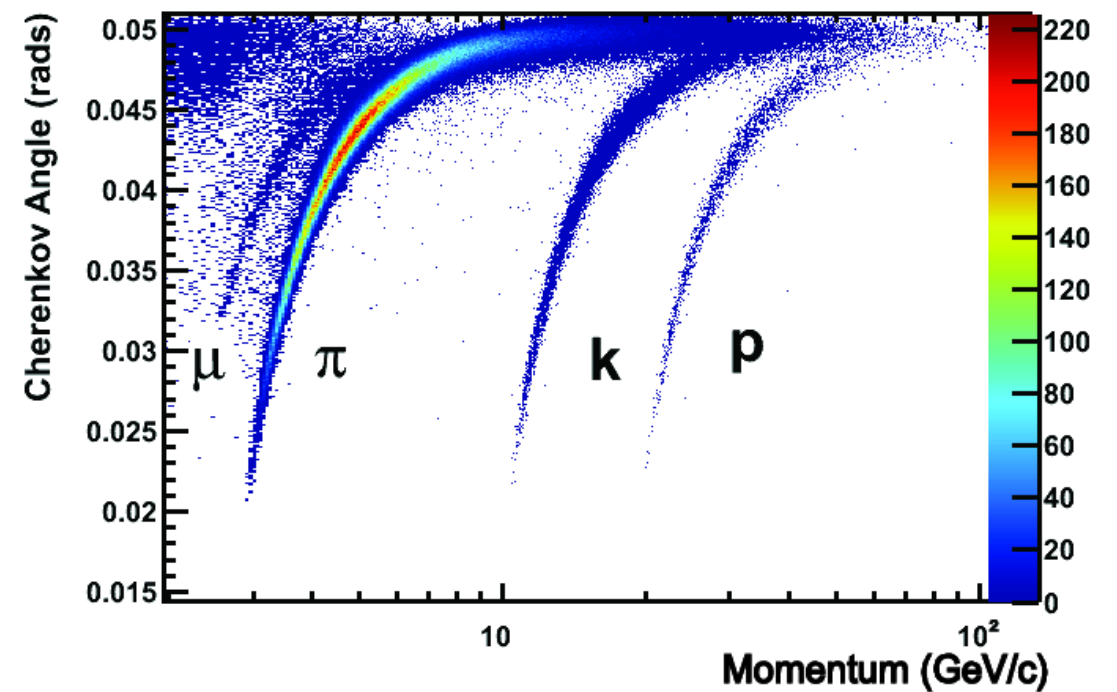
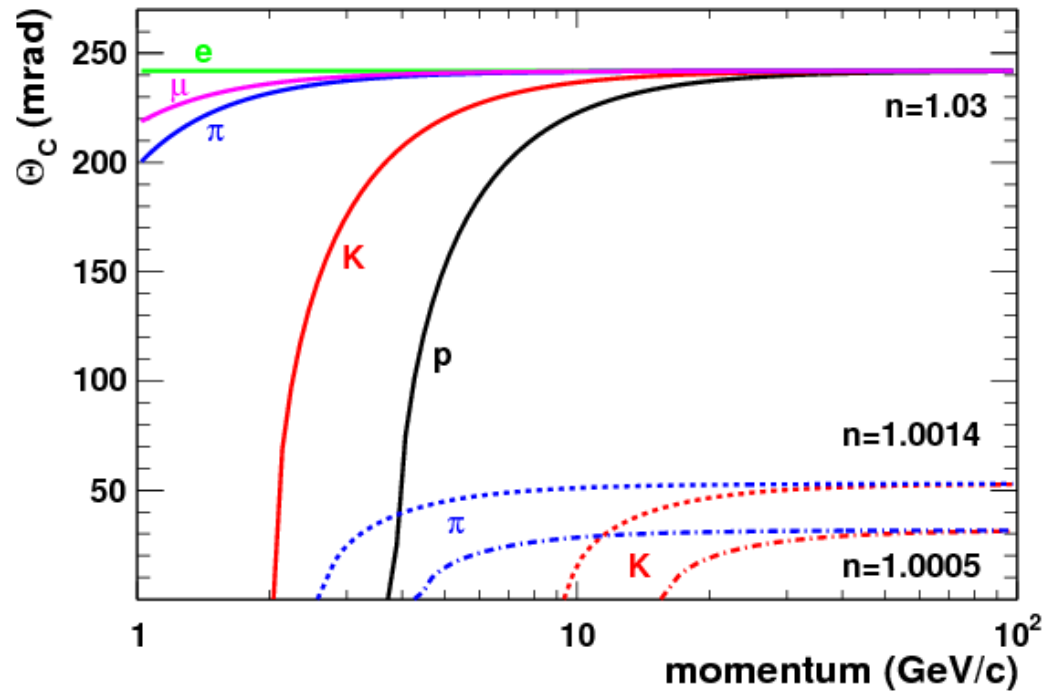


Figure: Arpad Horvath / Wikimedia Commons
Photo: Argonne National Laboratory / Wikimedia Commons



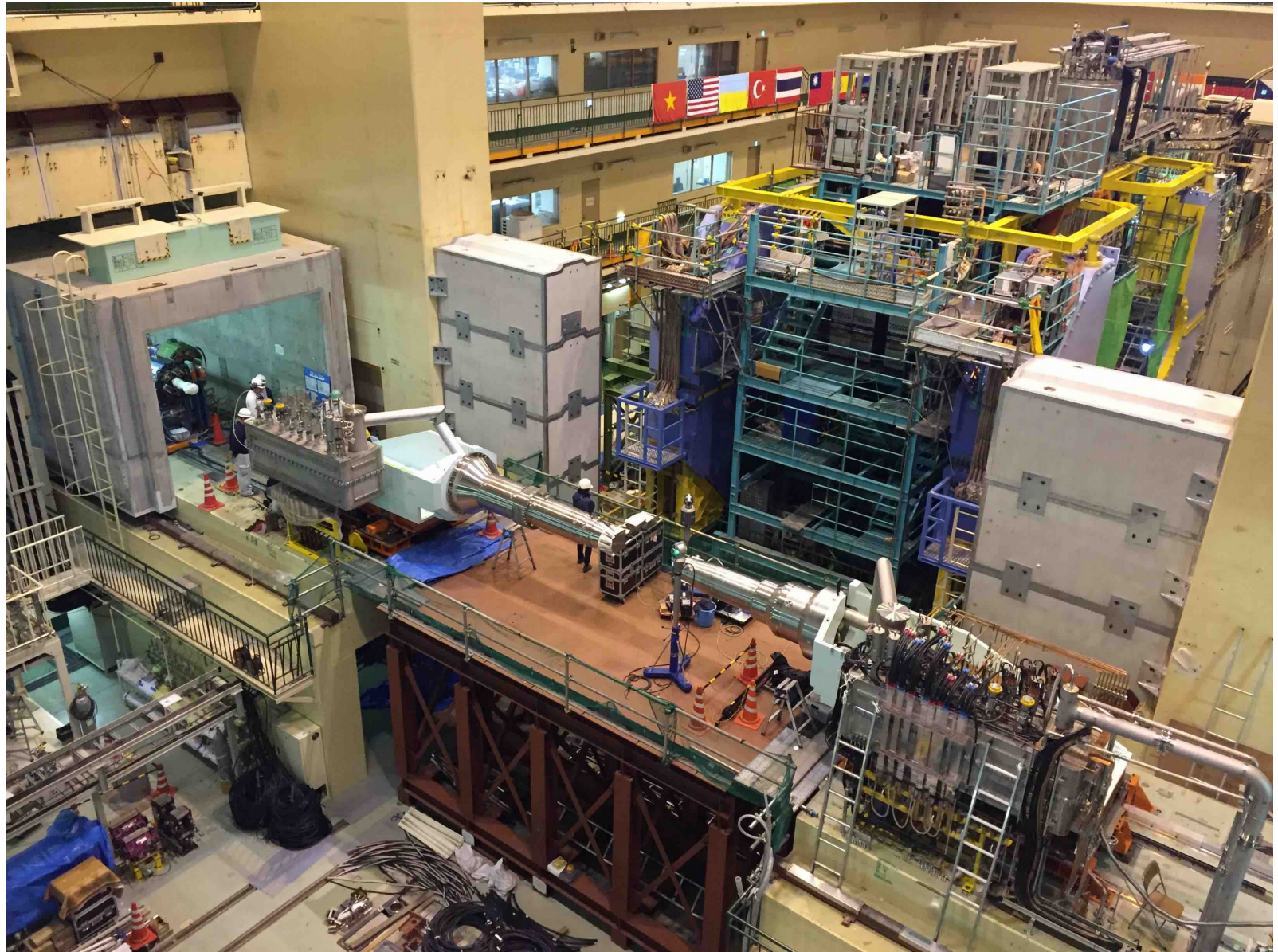
Cherenkov effect

$$\cos \theta_C = \frac{\sqrt{m^2 c^2 + p^2}}{pn},$$



SuperKEKB

Final focus magnets



Tracking

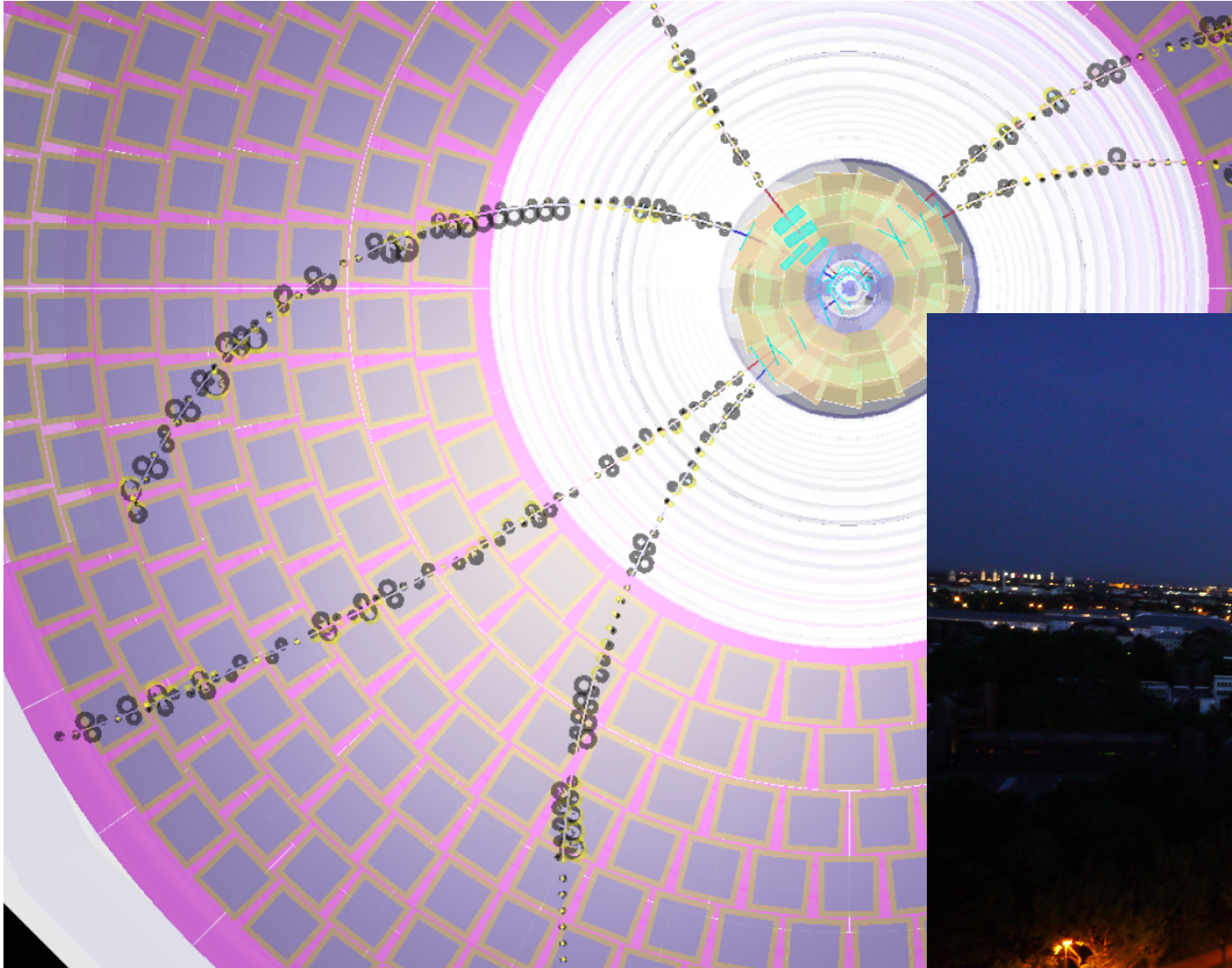


Photo: Sebastian Grünwald /
Wikimedia Commons



CP violation in $B \rightarrow K\pi$

- We want a process where:

$$i \rightarrow f \neq \tilde{i} \rightarrow \tilde{f}$$

- The amplitude for a process (the CP conjugate of a process) is:

$$\mathcal{M} = |\mathcal{M}| e^{i\phi} e^{i\theta}$$

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

$$\tilde{\mathcal{M}} = |\mathcal{M}| e^{i\phi} e^{-i\theta}$$

$$\overline{B}^0 \rightarrow K^- \pi^+$$

- The difference is subtle. θ is a CKM weak phase. ϕ is a strong phase (CP blind).

CP violation in $B \rightarrow K\pi$

- But! There are two Feynman diagrams. Two ways to get to the same final state:

$$\mathcal{M}_1 = |\mathcal{M}_1| e^{i\phi_1} e^{i\theta_1} \qquad \mathcal{M}_2 = |\mathcal{M}_2| e^{i\phi_2} e^{i\theta_2}$$

$$\widetilde{\mathcal{M}}_1 = |\widetilde{\mathcal{M}}_1| e^{i\phi_1} e^{-i\theta_1} \qquad \widetilde{\mathcal{M}}_2 = |\widetilde{\mathcal{M}}_2| e^{i\phi_2} e^{-i\theta_2}$$

$$\mathcal{M} = \mathcal{M}_1 + \mathcal{M}_2$$

$$|\mathcal{M}|^2 = |\mathcal{M}_1 + \mathcal{M}_2|^2 \neq |\mathcal{M}_1|^2 + |\mathcal{M}_2|^2$$

CP violation in $B \rightarrow K\pi$

- Copy previous for CP conjugate. Then do some trigonometry:

$$|\mathcal{M}|^2 - |\widetilde{\mathcal{M}}|^2 = -4|\mathcal{M}_1||\mathcal{M}_2| \sin(\phi_1 - \phi_2) \sin(\theta_1 - \theta_2)$$

- CP violation can for this decay happen iff:
 - ▶ Two paths to the same final state.
 - ▶ A conjugated phase (weak).
 - ▶ An ordinary phase (strong).

Neutral B meson mixing

