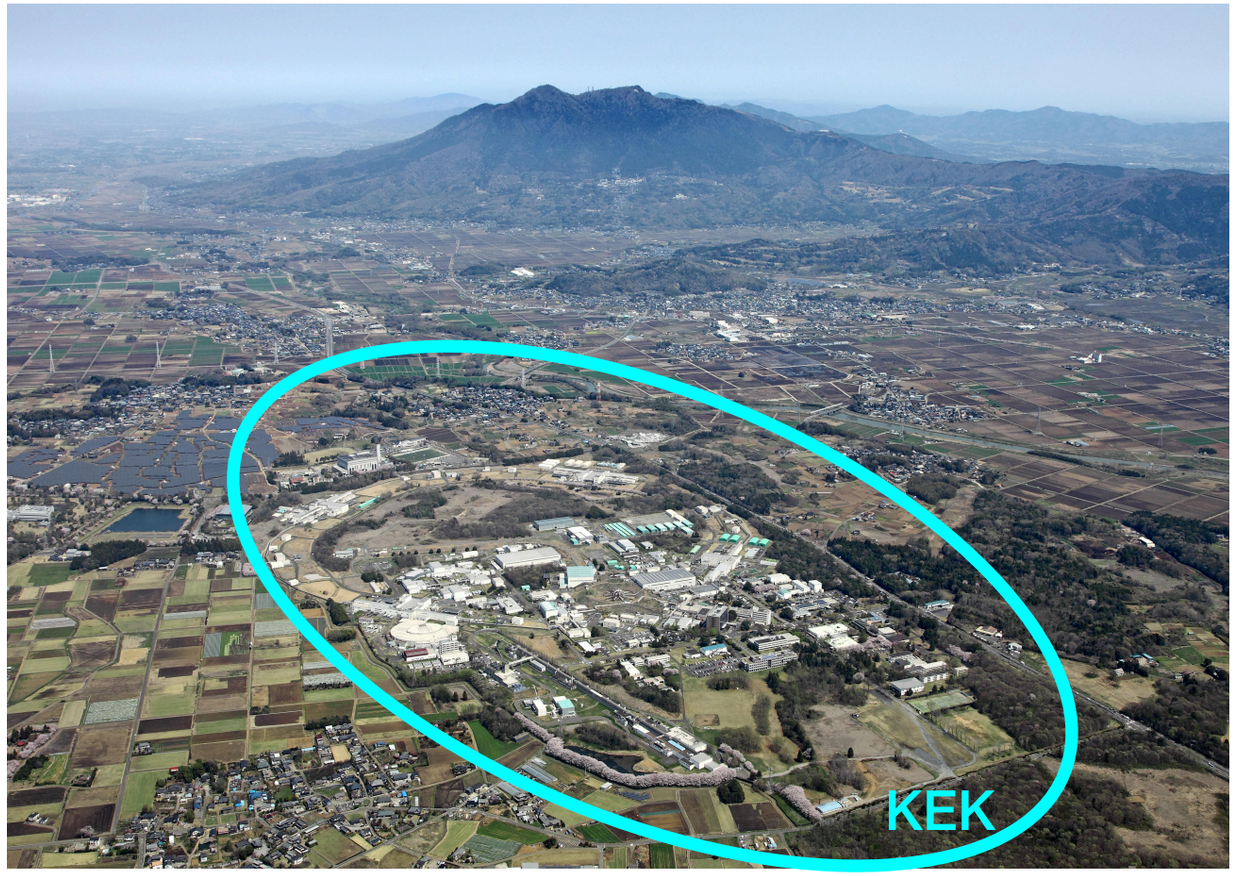
# The Belle II Experiment

Thomas Kraetzschmar

Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Belle II?

- Located in Japan at KEK, the Japanese High-Energy Accelerator Research Organisation
- Belle II is a Detector at the (super) *B*-Factory SuperKEKB




Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Motivation for *B* Factories

- 1964, Cronin and Fitch:
  Discovery of CP violation in $K^0$ system ( $O(10^{-3})$ )

- 1972, Kobayashi and Maskawa:
  CP violation possible if there are 6 quark flavours

- 1995, CDF, DO:
  Discovery of the top quark

  ➡ CP violation?

© The Nobel Foundation Photo: U. Montan

Makoto Kobayashi

© The Nobel Foundation Photo: U. Montan

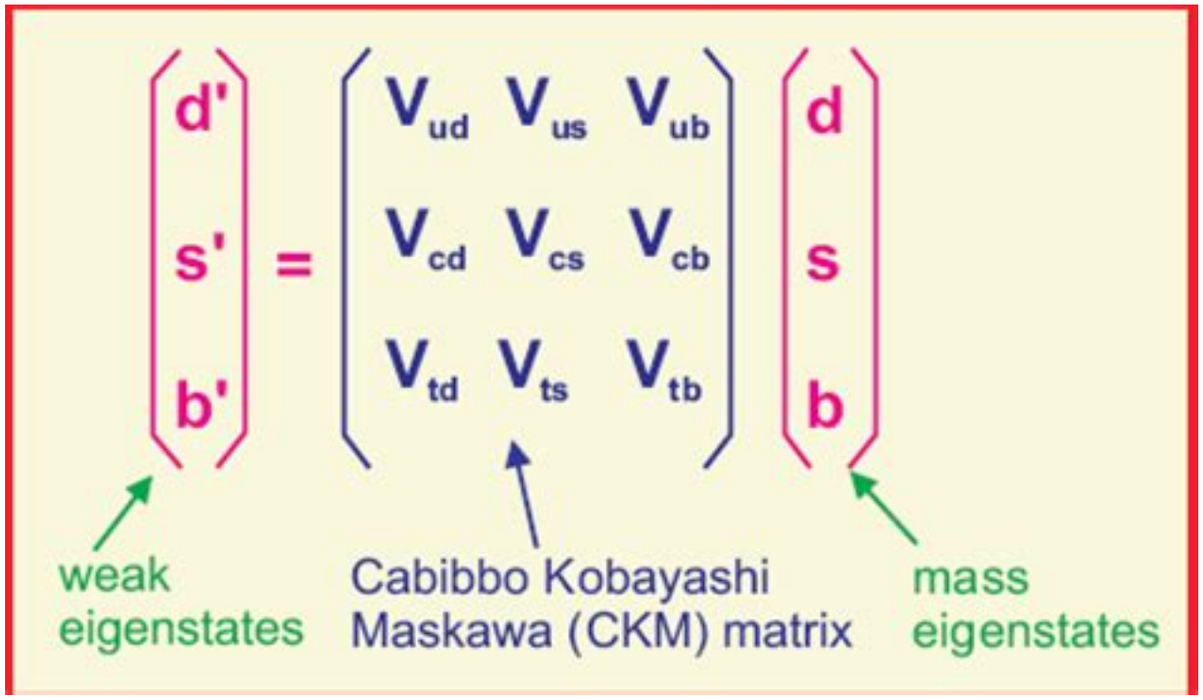
Toshihide Maskawa



Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# The CKM-Matrix

- 4 Free parameters:
  - 3 angles $\phi_1$, $\phi_2$, $\phi_3$
  - 1 CP violating phase
- Prediction of large CP violation in $B^0$ system

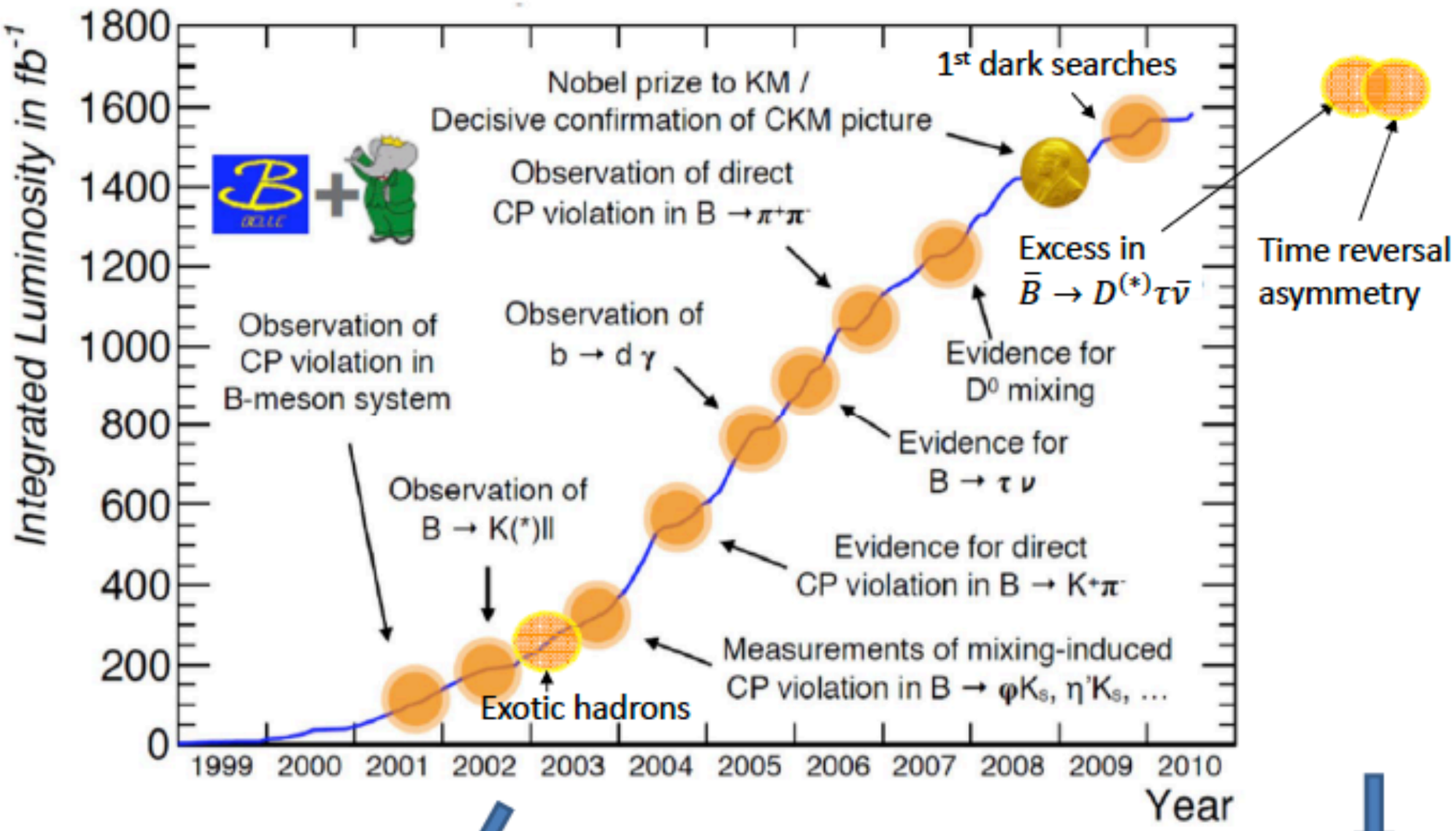




Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# B-Factories Legacy

- 1241 papers (14 Oct. 2018) and counting
  - 670 from BaBar @ PEP-II + 571 from Belle @ KEKB




>100 unique CPV results

~350 papers published after shutdown, 21 in 2018

# But Why Belle II?

- We observe an Barion asymmetry
- Sakarov requirements:
  - Baryon number violation
  - Departure from thermal equilibrium
  - C and CP violation
- CP violation in SM is not sufficient
- Other sources of CP violation?


Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

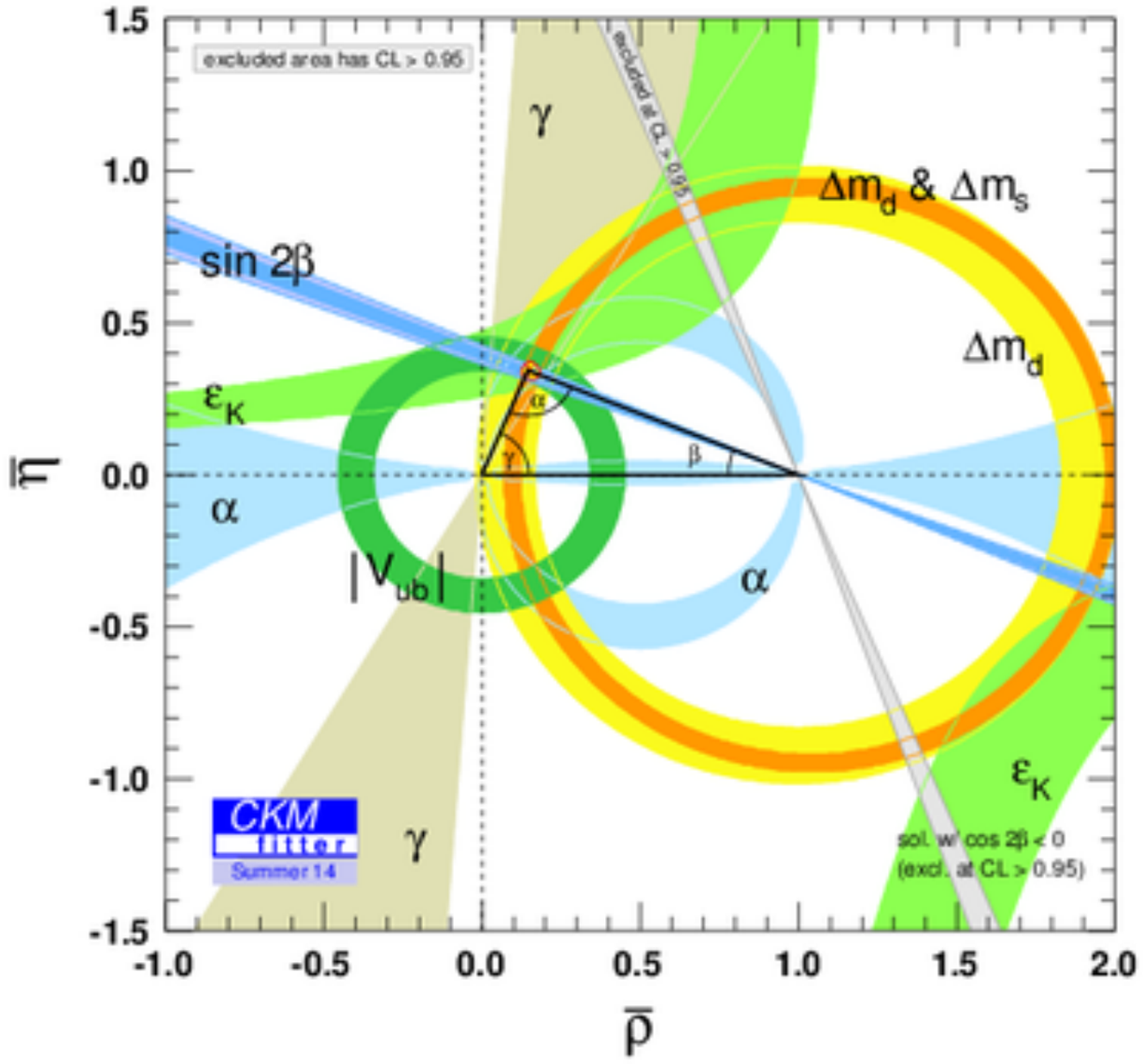
# B decays

- Precision measurements of CKM matrix
  - Time dependent CP violation:

    $B \to \pi^0\pi^0$

    - Phi3 to a precision of up to 1 degree
- Charges Higgs?: $B \to \tau\nu$
- Lepton flavour universality violating processes?

  $\bar{b} \to \bar{c}l\nu$

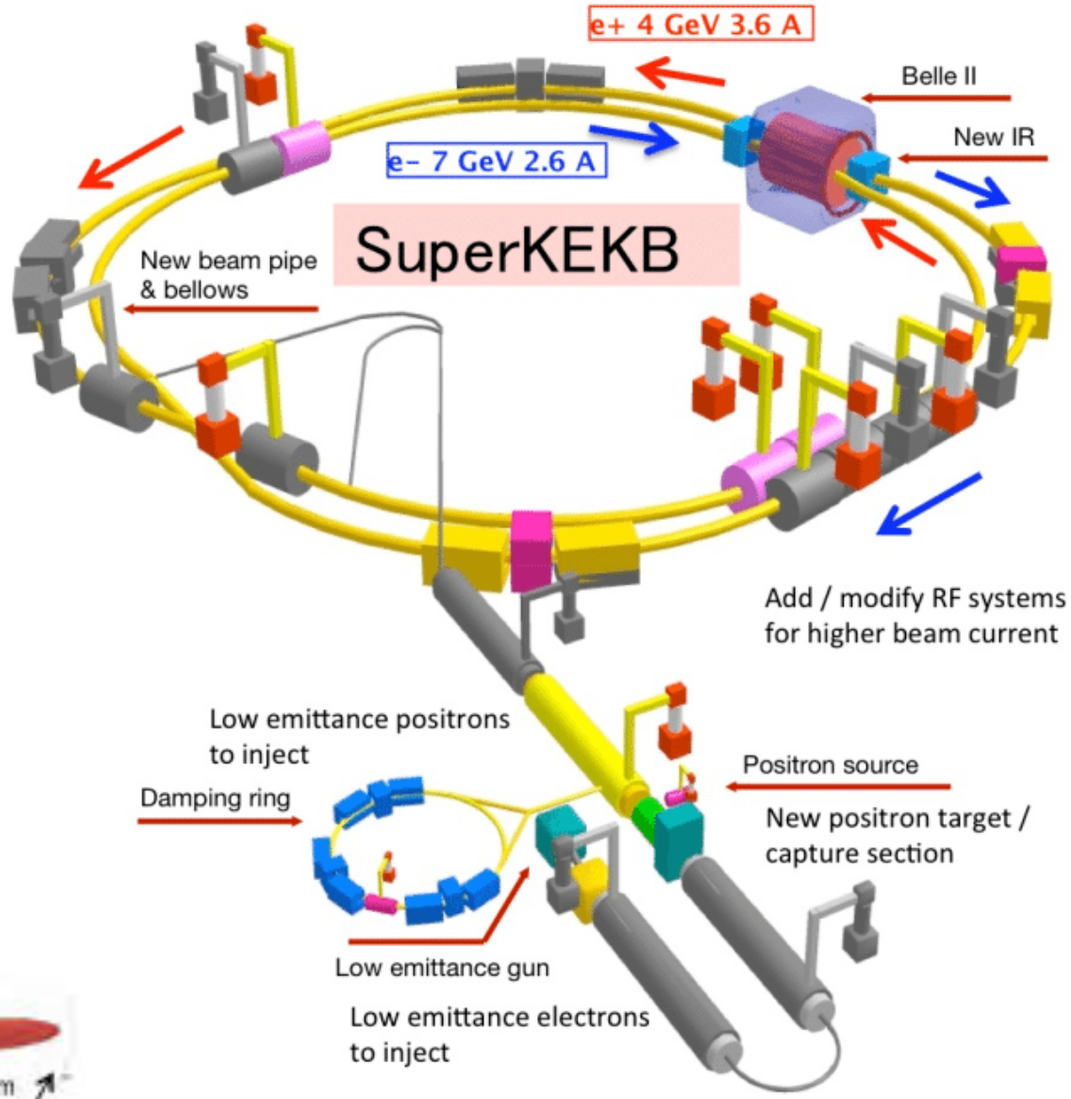


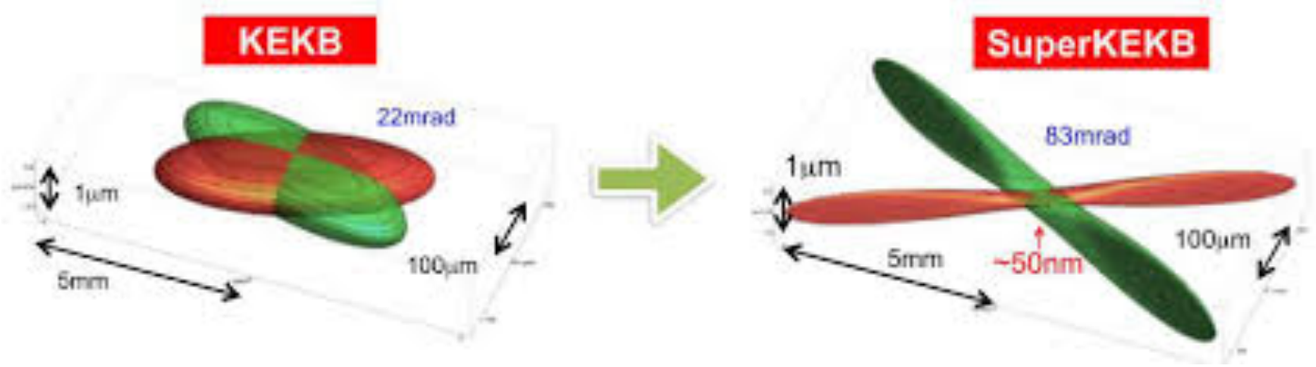



Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# SuperKEKB

- Electron - Positron Asymmetric Accelerator:
  $\sqrt{s} = \Upsilon(4) = 10.58$ **GeV**
- Increased Integrated Luminosity:
  1 ab$^{-1}$(KEKB) ->  50 ab$^{-1}$
- Nano-beam Scheme:

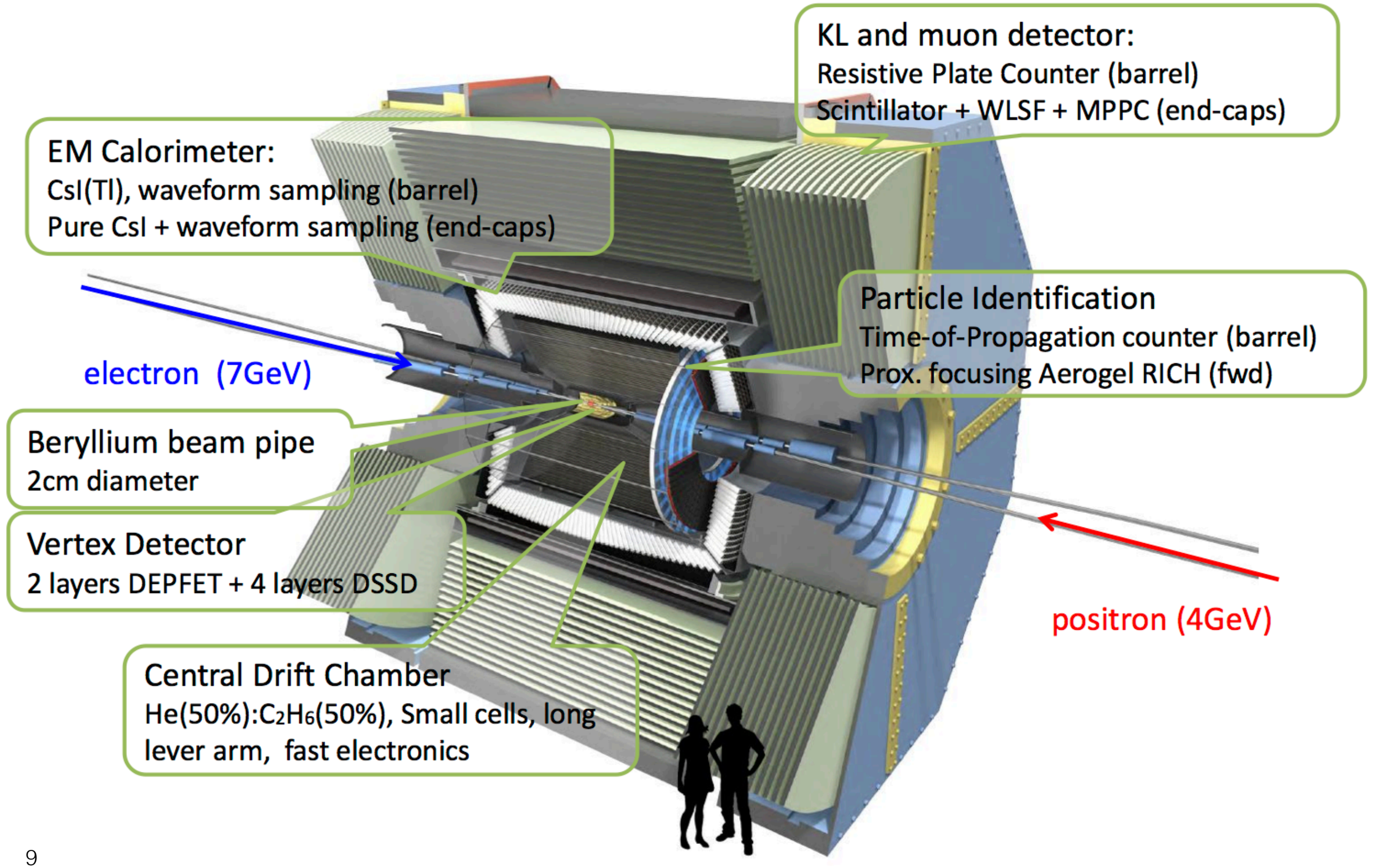


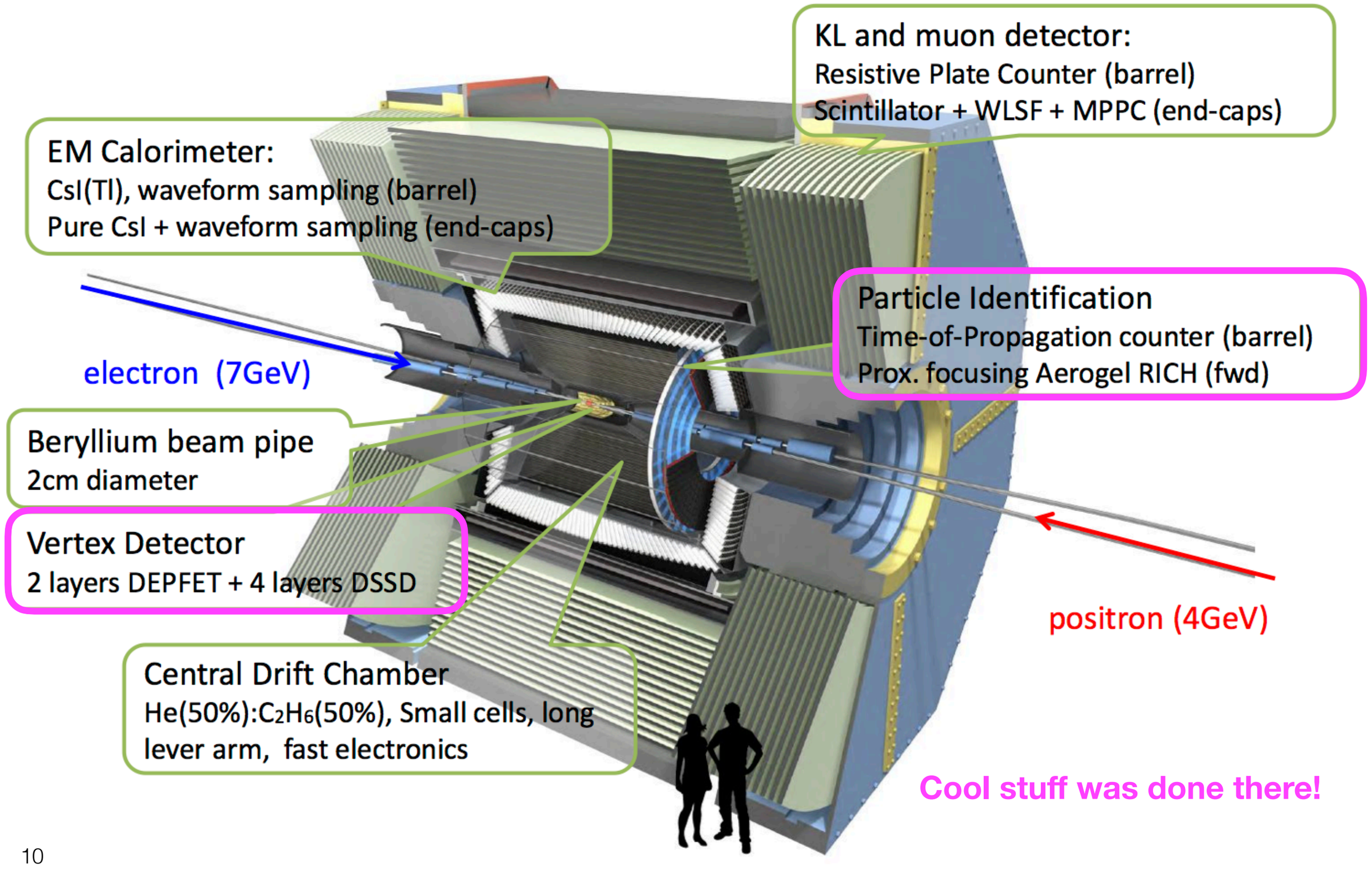



Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Belle II Detector

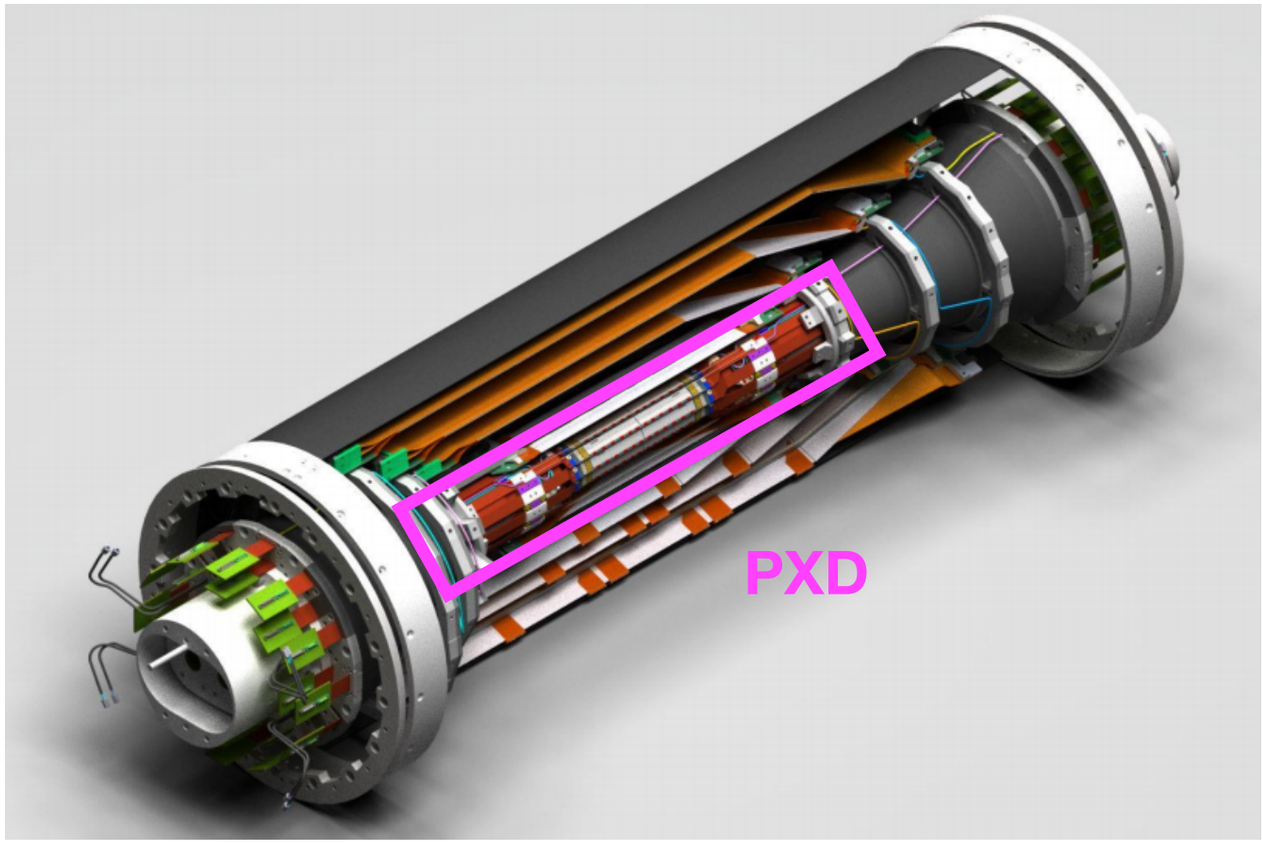


# Belle II Detector



# VXD

- PXD
  - Pixeld Silicon Detector
  - Higher spatial resolution; important for Time dependent CP violation!
  - More about that from Philipp
- SVD
  - Double Sided Silicon Strip detector used to improve vertexing

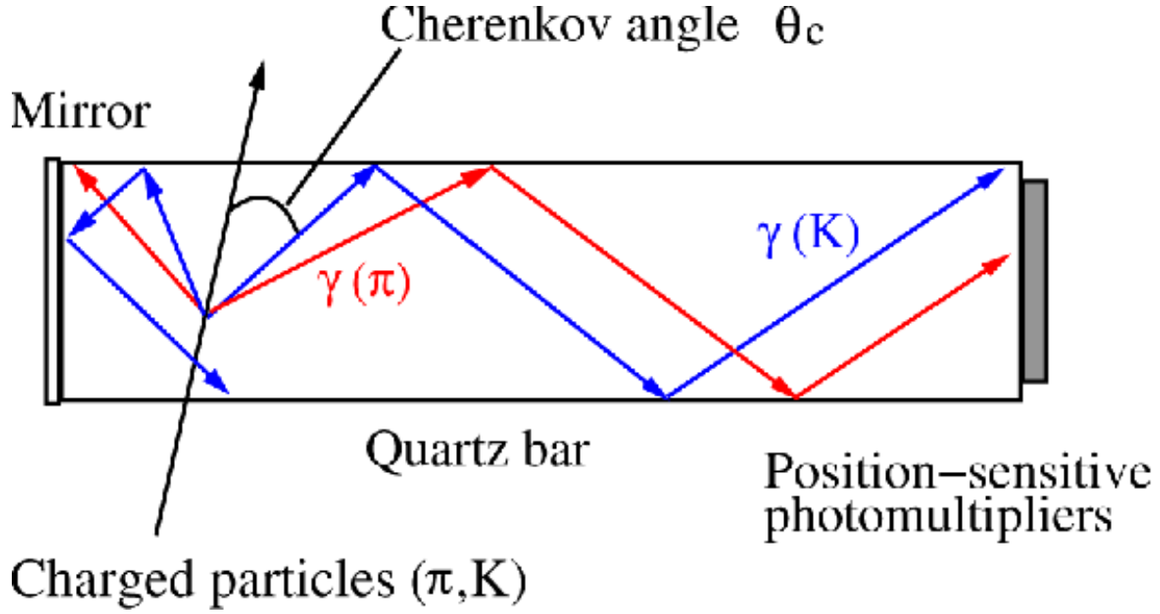





Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# TOP

- Time of Propagation counter
- Used for Particle Identification
  - Idea: *π, K* have different Cherenkov Angle
    -> propagation time $t_K \neq t_\pi$
  - Precise time measurement necessary

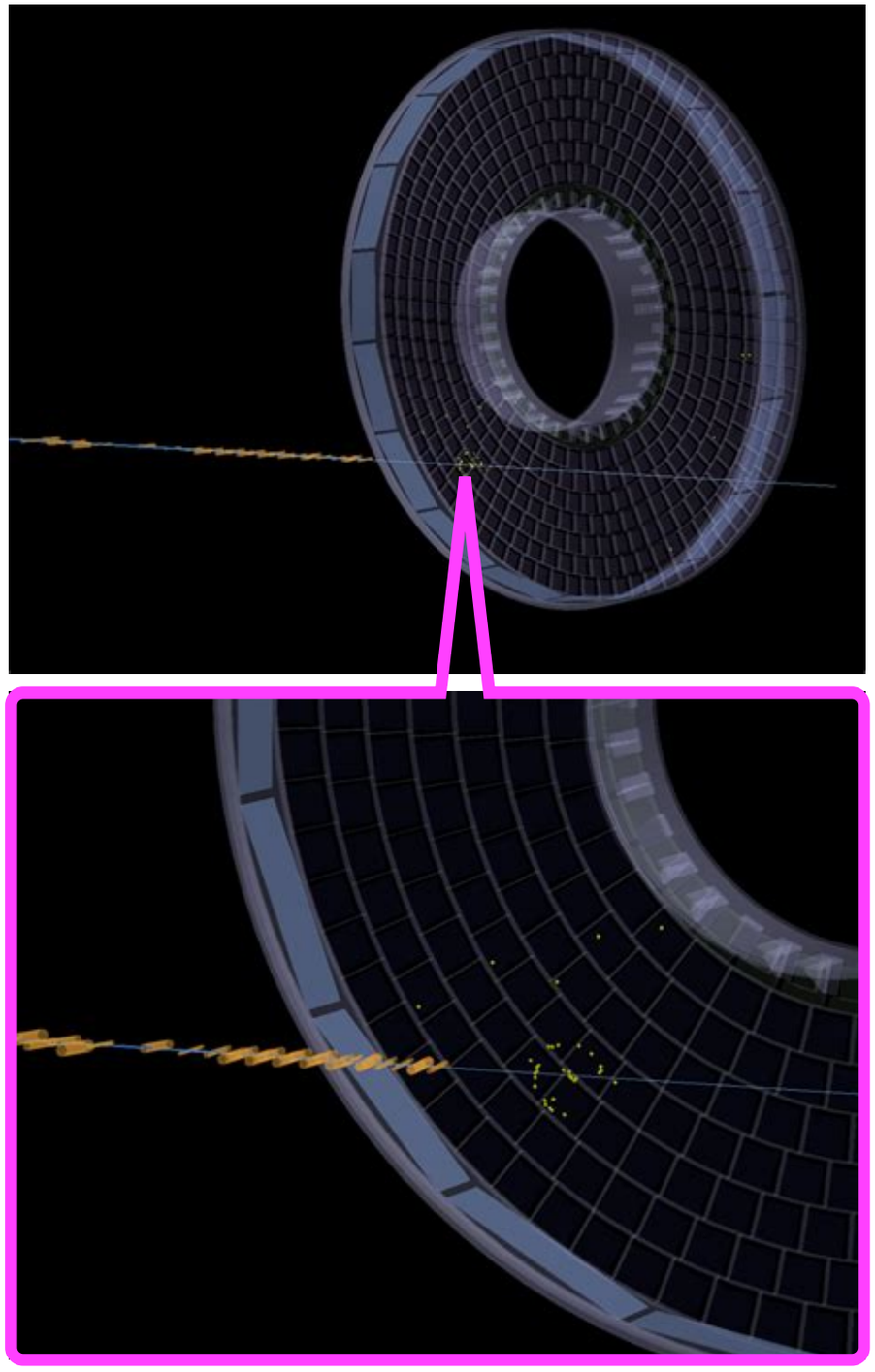




Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# ARICH

- Aerogel Ring-Imaging Cherenkov detector
- $\pi$, $K$ seperation: Important for new CP violating modes!
- discrimination between $\pi$, $\mu$, and $e$ below 1 GeV/c

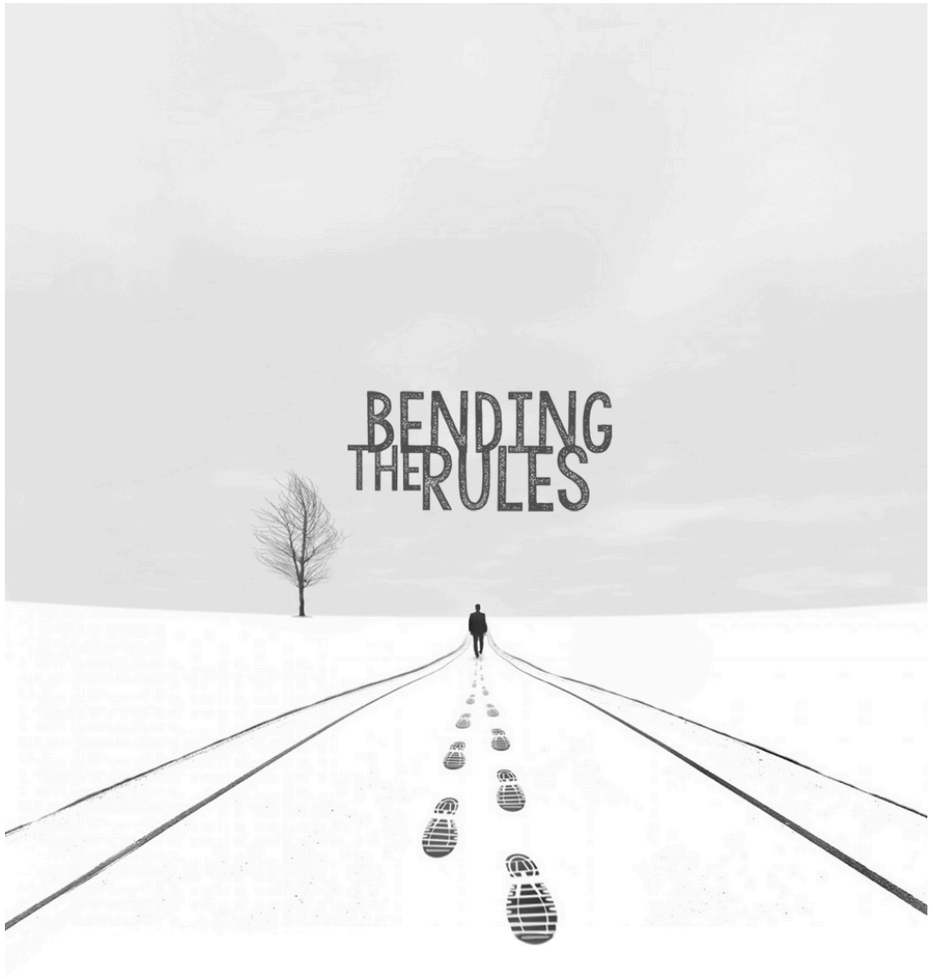




Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Physics Program

- Semileptonic and leptonic *B* decays
- Radiative and Electroweak Penguin B decays
- Time dependent CP violation in
- Measurement of the UT angle Phi3
- Hadronic *B* decays
- Charm Physics
- Quarkonium
- Tau and low multiplicity physics






Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Non *B* physics

- Charm Physics:
  - CP violation, Missing energy decay transition measurements, …
- Quarkonium
  - Charmonium, Bottonium, Light Higgs, Lepton universality violating searches, …
- Low Multiplicity Physics
  - Alps, Axions, Portals to Dark Sector, …


Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# $\tau$ Physics Prospects

- First check of SM g-2 for taus!
- CP violation in tau decays: $\tau \to K\pi\nu$
- LFV decays: $\tau \to l\gamma,\ lll$
- Look for exotic decays : $\tau \to l + \alpha$


Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)

# Outlook

- SuperKEKB and Belle II are ready to start at the end of February
- Advances in both, accelerator and detector techniques allow for super precise measurements of SM parameters.
- Hope for NP including lepton flavour violation, alps, axions …
- Stay tuned!


Thomas Kraetzschmar (kraetzsc@mpp.mpg.de)