News from B-Factories

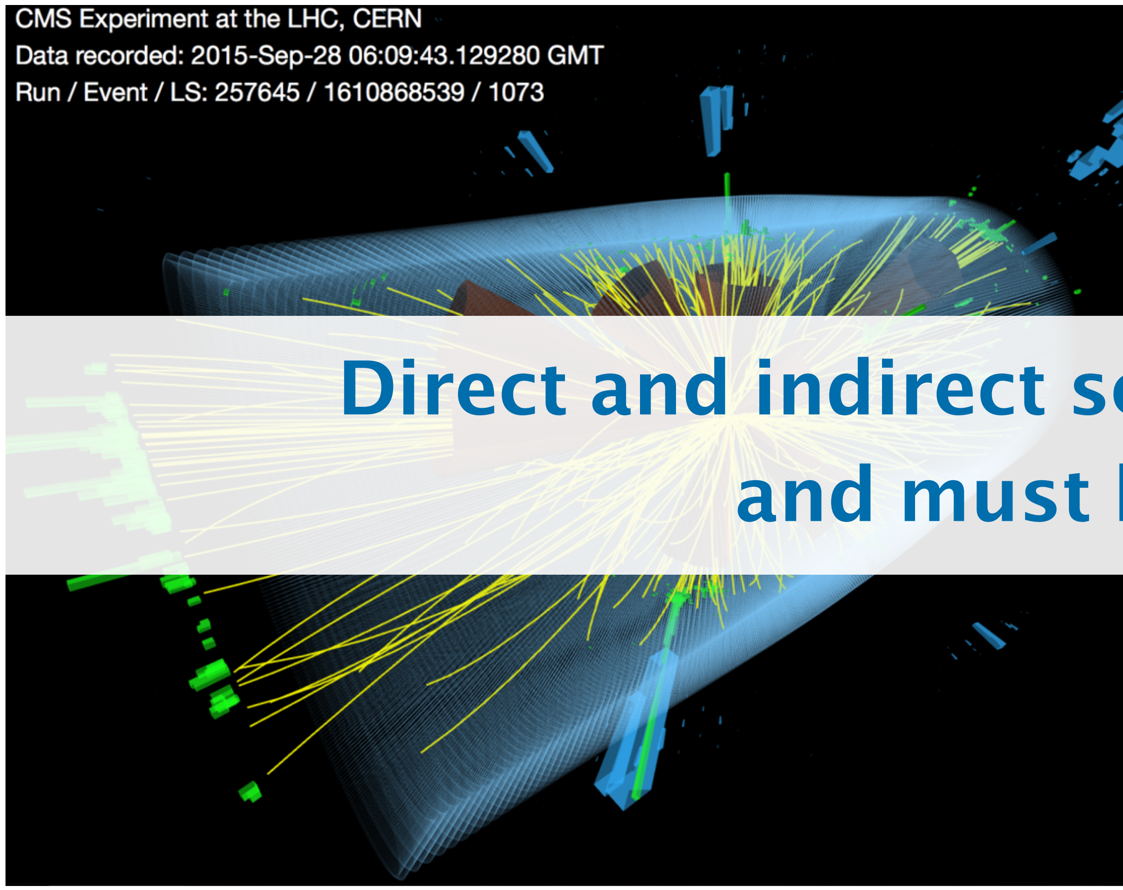
Recent results + Belle II status

Maiko Takahashi (DESY)

DESY Seminar / Helmholtz Allianz meeting
28 November 2017

Pathways to New Physics

Energy Frontier



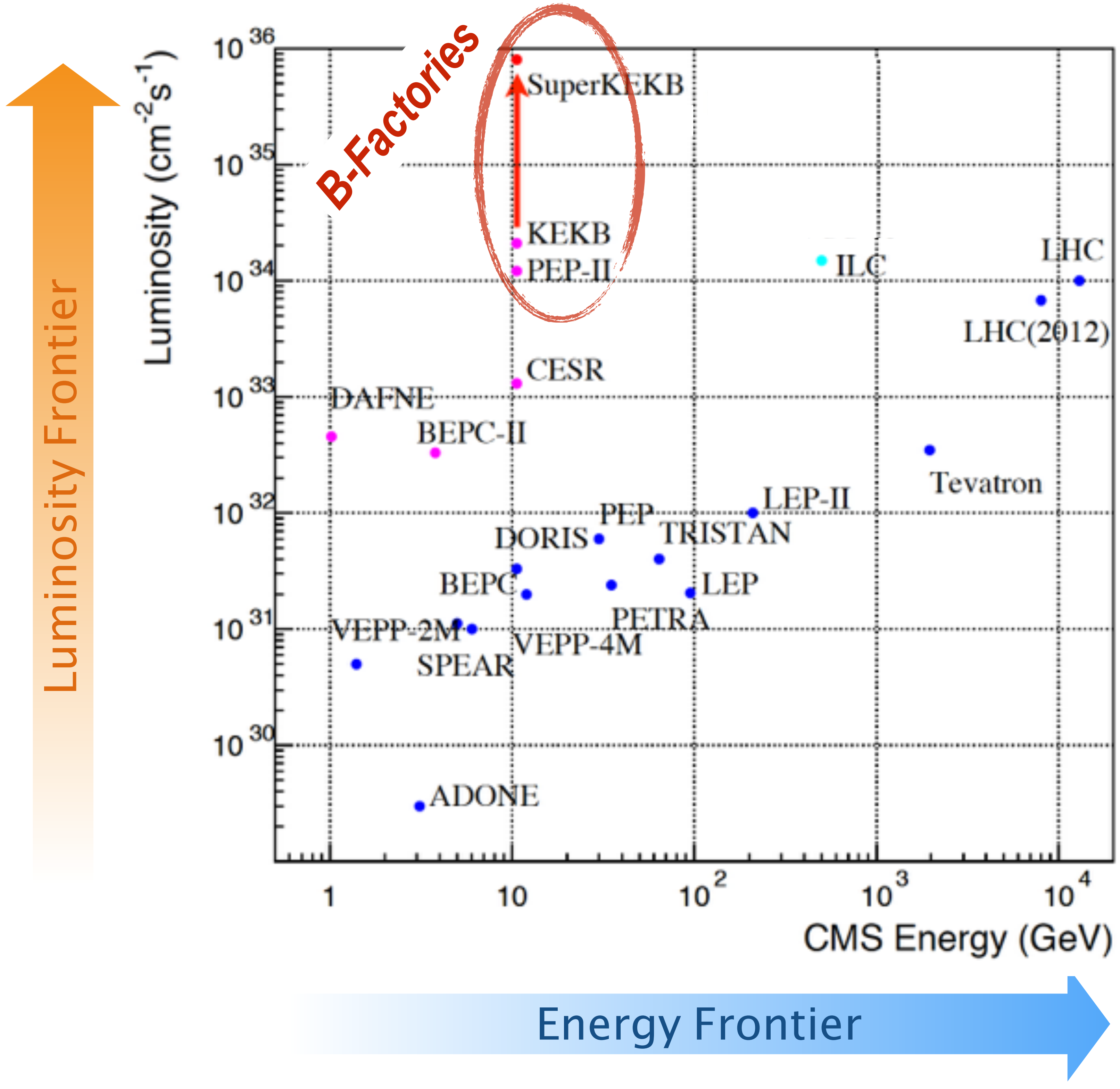
Luminosity Frontier

Direct and indirect searches are complementary and must both be pursued!

- Direct production of new particles
- New Physics reach limited by beam energy
- Energy scale O(10TeV)

- New "virtual" particles may occur in quantum loops
- Generic amplitude $\mathcal{A}_{BSM} = \mathcal{A}_0 \left(\frac{c_{SM}}{m_W^2} + \boxed{\frac{c_{NP}}{\Lambda^2}} \right)$
- Sensitivity to mass scale O(100TeV)

Luminosity Frontier



Towards B-Factory

Primary goal of 1st generation B-Factory to examine the principles of CP violation

Quark-flavour mixing explained via weak interaction → "CKM" matrix (1970s)

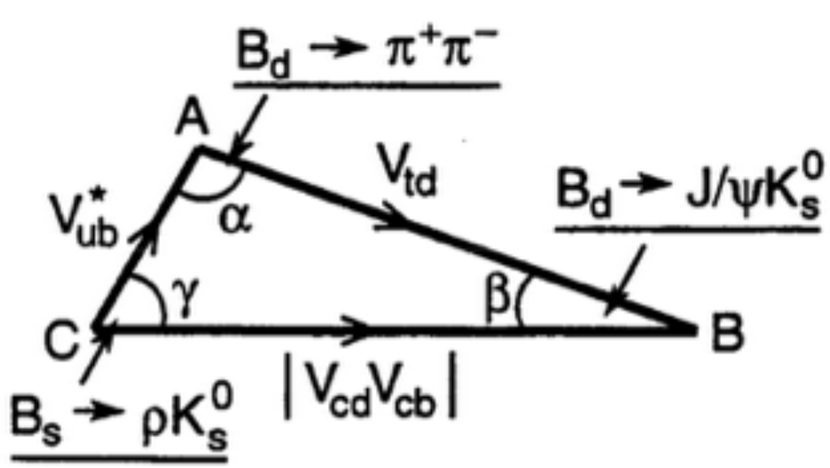
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

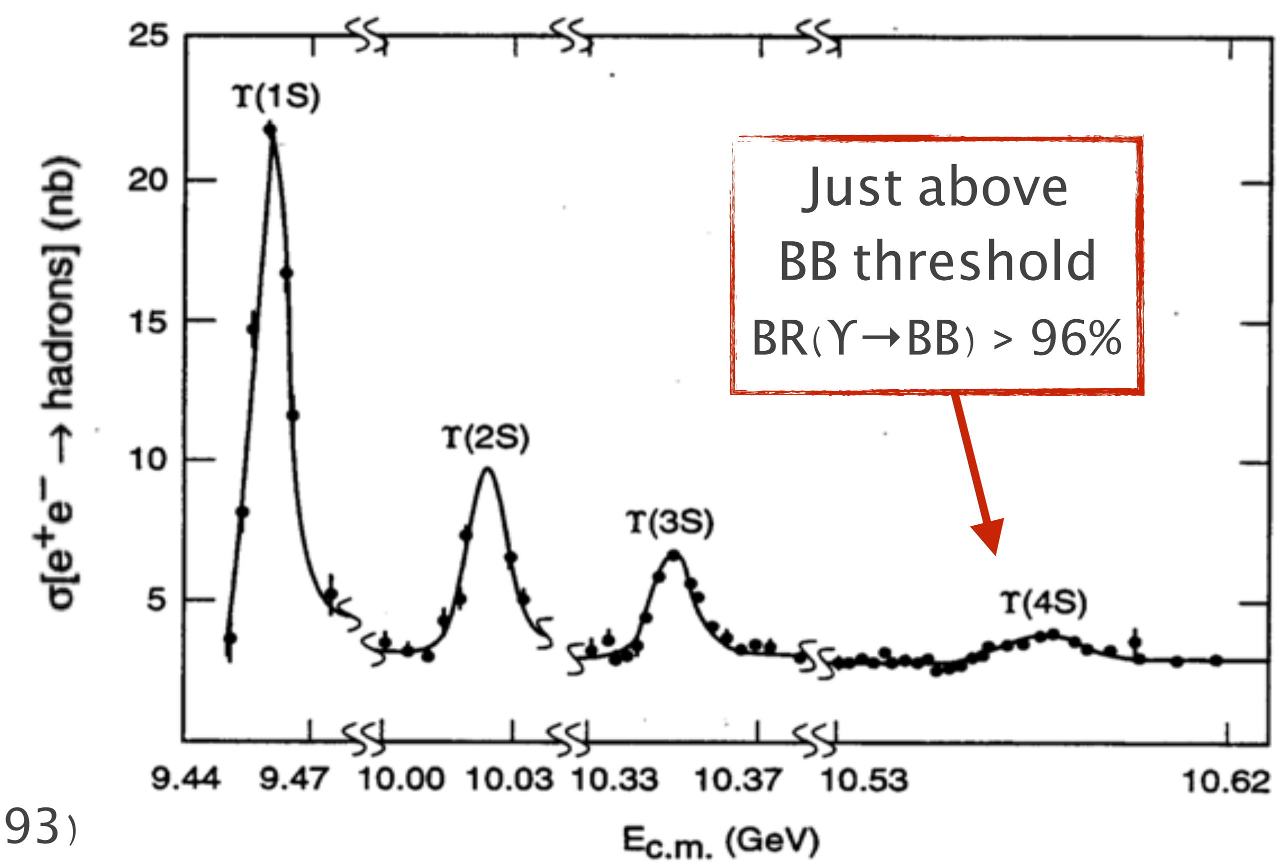
Experimental observations in B-meson physics:

- long B-meson life time (SLAC, 1983)
- B^0–$\bar{B}^0$ mixing (DESY, 1987)

Advancement of e^+e^- collider and detector technology & performance

B-mesons produced in Υ resonance
to measure CKM parameters

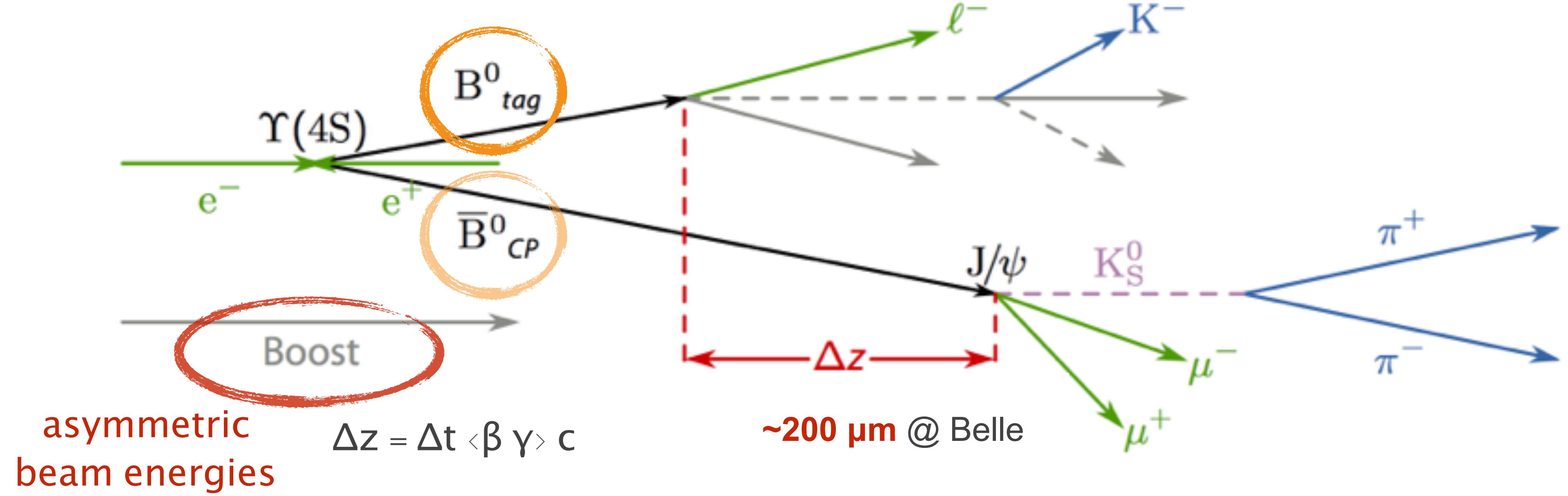




PEP II Conceptual Design Report (1993)

Physics of the B-Factories

Measure time dependent decay asymmetry of pair produced B's

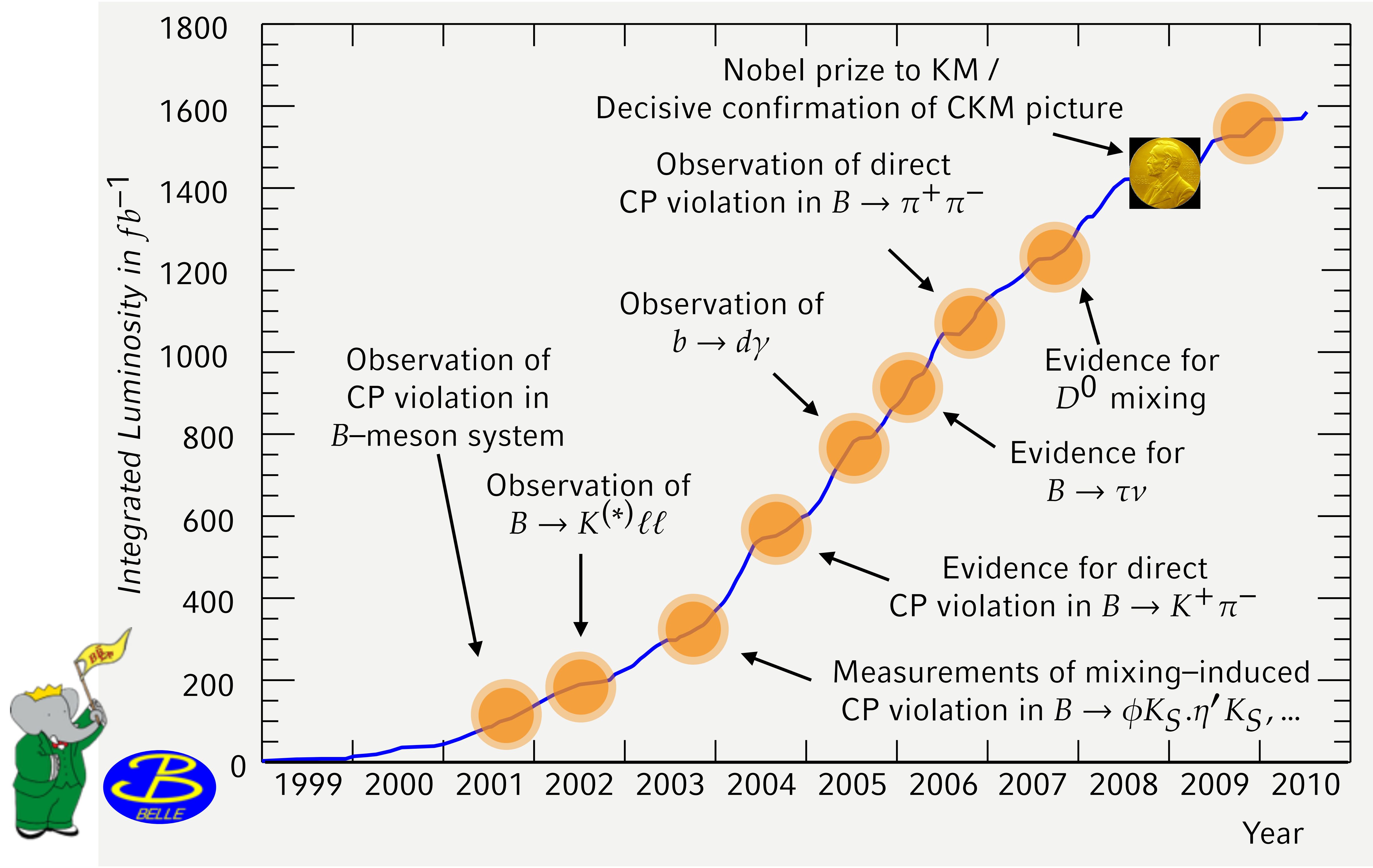


Advantages of B-factories

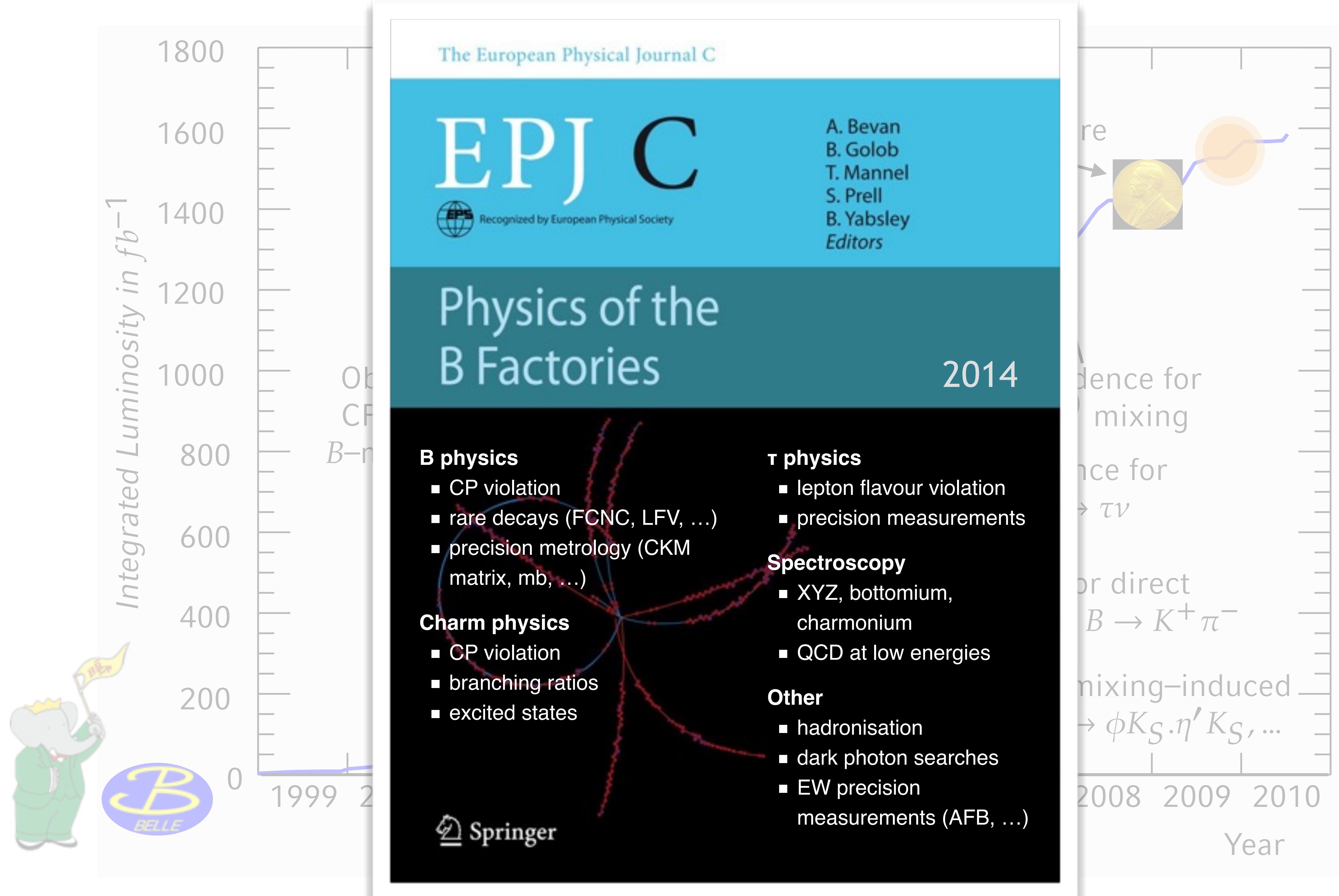
- High luminosity
- Complete knowledge of the initial state
- No underlying events and low background
- Large production of C's and τ's → diverse flavour physics

⇒ New Physics via precision measurements & missing E signature

Achievements of 1st Generation

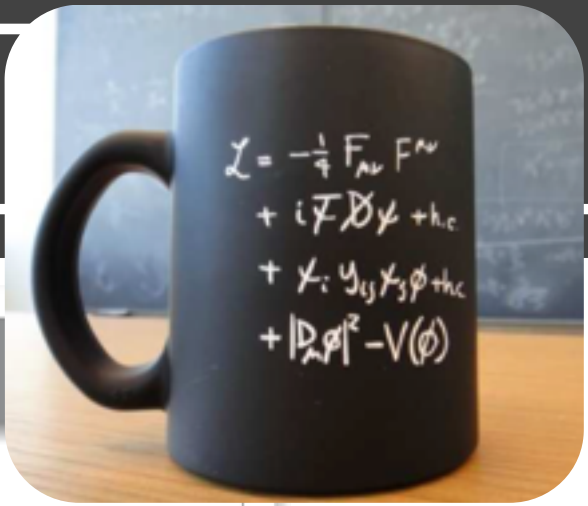


Achievements of 1st Generation



Recent Results in Flavour Physics

Flavour Physics



Flavor and the Proliferation of Parameters

gauge sector

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + i \bar{\psi} \not{D} \psi + h.c.$$

describes the gauge interactions of the quarks and leptons

parametrized by
3 gauge couplings
g_1, g_2, g_3

Higgs sector

$$+ |D_\mu \phi|^2 - V(\phi)$$

breaks electro-weak symmetry and gives mass to the $W^\pm$ and Z bosons

2 free parameters
Higgs mass
Higgs vev

flavor sector

$$+ \bar{\psi}_i y_{ij} \psi_j \phi + h.c.$$

leads to masses and mixings of the quarks and leptons

22 free parameters
to describe the masses and mixings of the quarks and leptons

the flavor sector is the most puzzling part of the Standard Model

Wolfgang Altmannshofer | The Flavor Puzzle | June 26, 2014 | 9 / 40

Experimental Status

Turn of the last decade…

- End of operation for B-Factories
- Start of the LHC(b)

Publications since 2010

- LHCb ~400
- Babar ~160
- Belle ~190

New results in 2017

The Helmholtz Alliance meeting this week

11th Annual Meeting of the Helmholtz Alliance "Physics at the Terascale"

B-physics

Place
Location: DESY Hamburg

Date: **28 Nov 09:00 - 12:40 PM**

B-Physics session this morning!

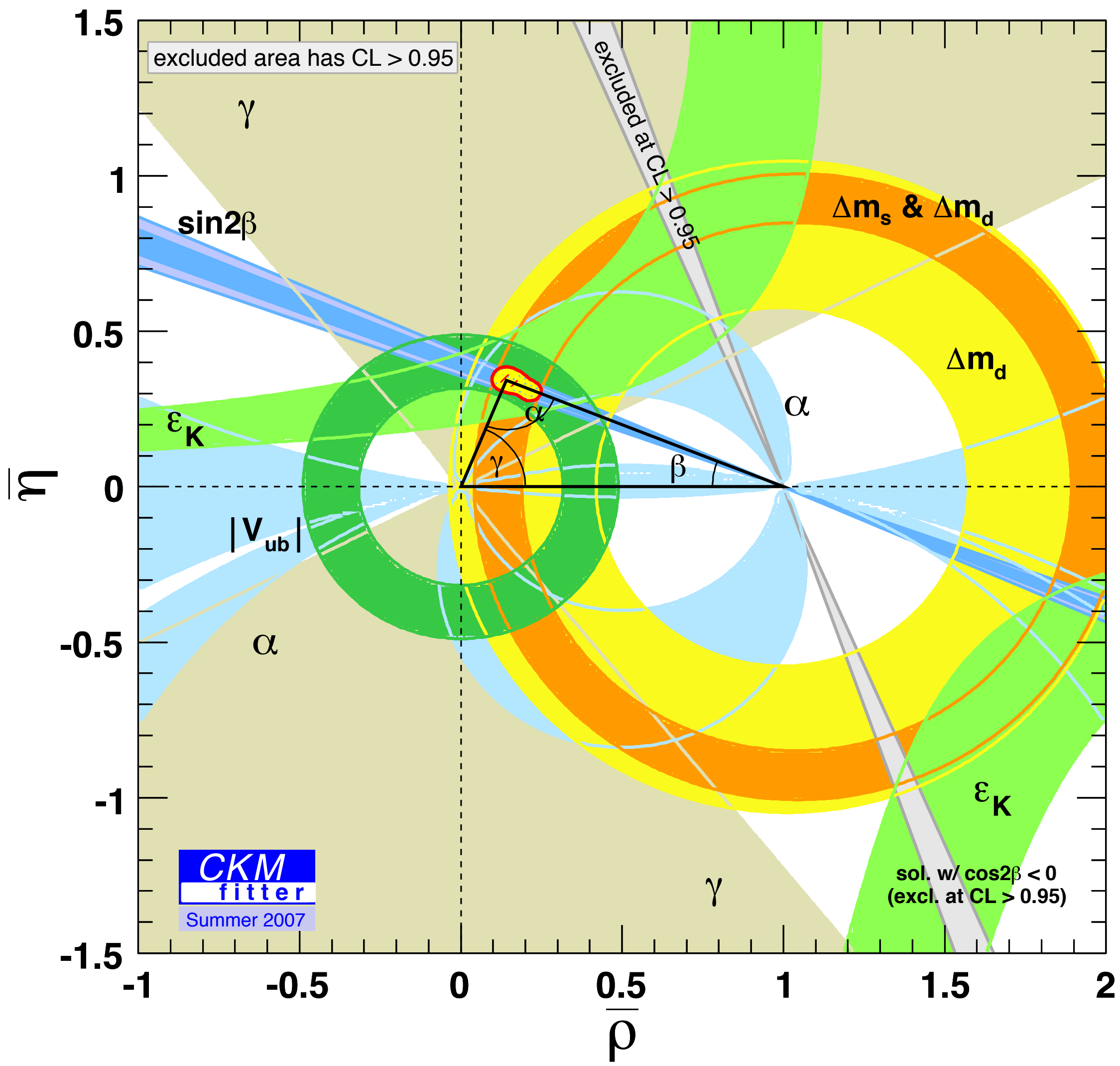
I picked a few recent results which show hints of anomalies, with some emphasis on B-Factories

CKM

Great understanding of CKM parameters over the past years

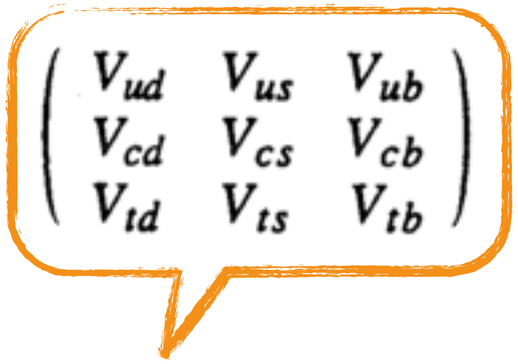
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

~10 years ago



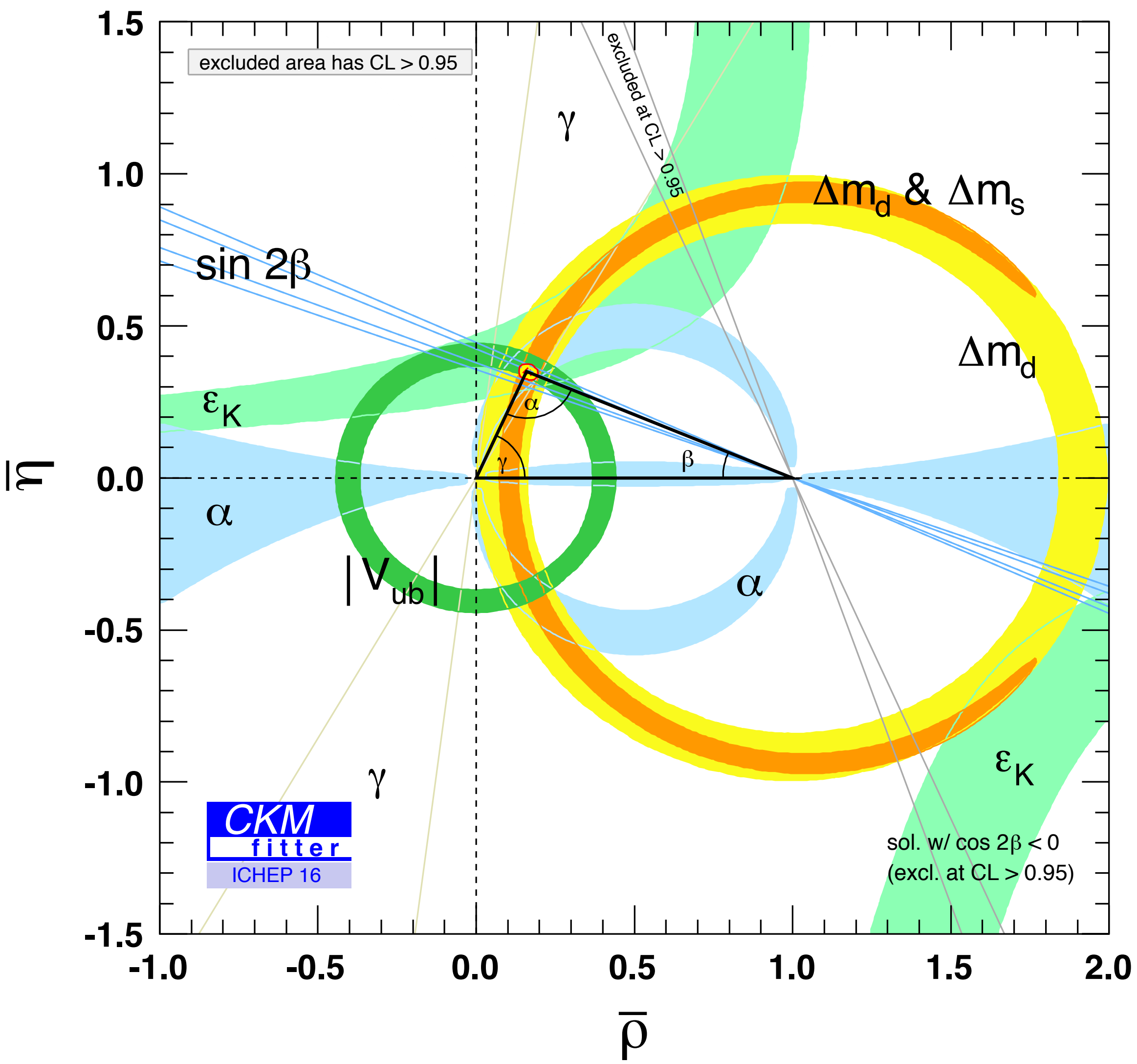
CKM

Great understanding of CKM parameters over the past years



$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

Now



CKM

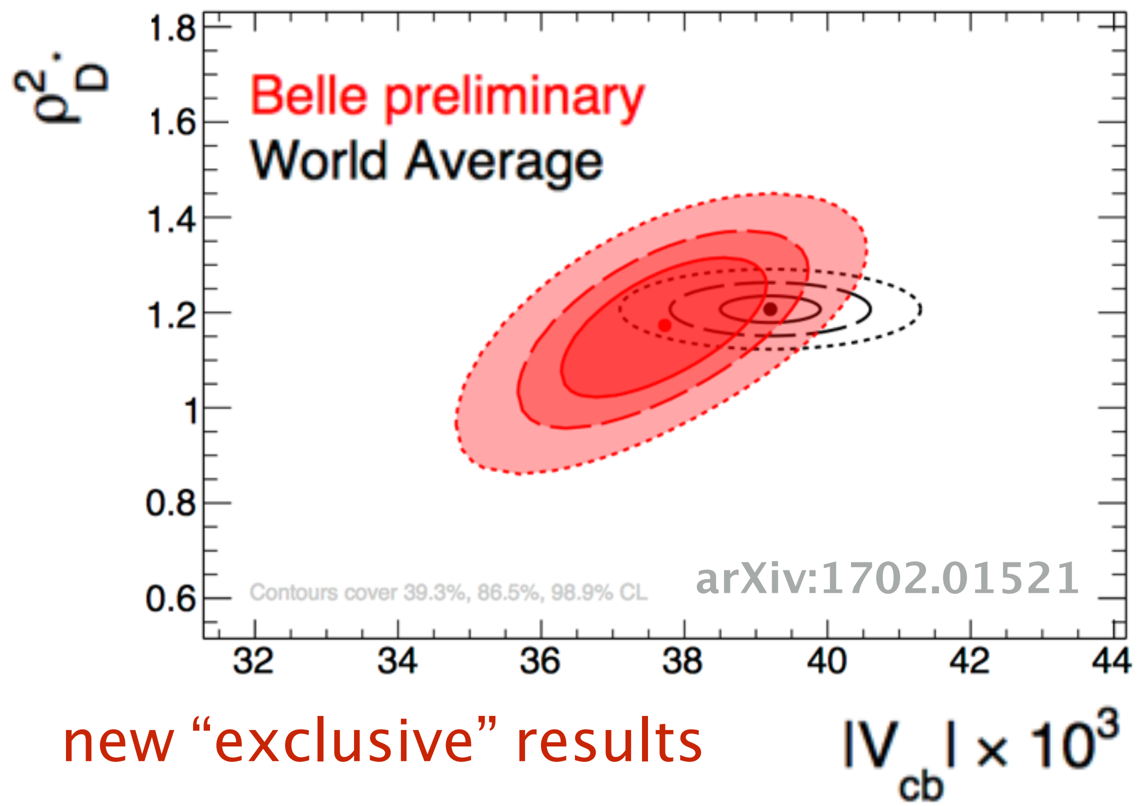
Great understanding of CKM parameters over the past years

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

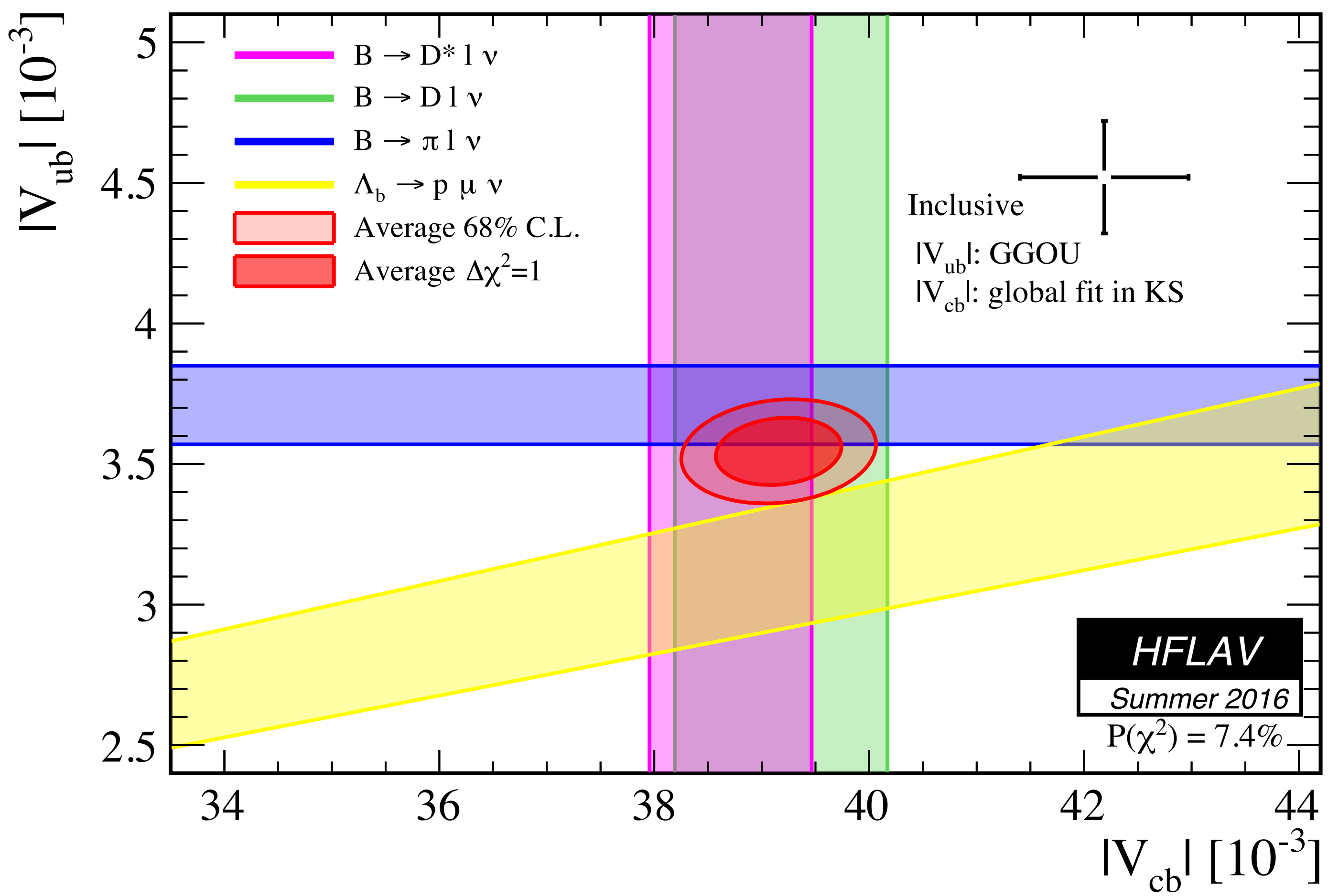
V_{cb} & V_{ub} from semileptonic B decays

- "exclusively" in different decays
- "inclusively" without explicit identification of X
  → possible only at e^+e^- collider

2-3σ tension between "inclusive" and "exclusive"



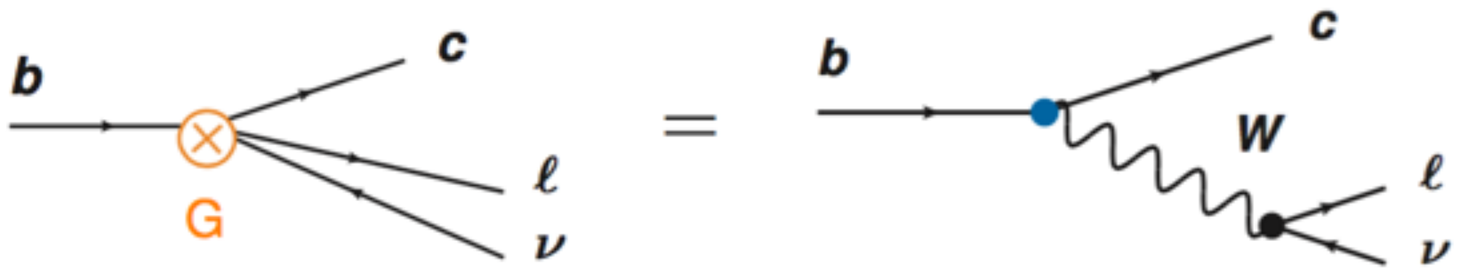
new "exclusive" results

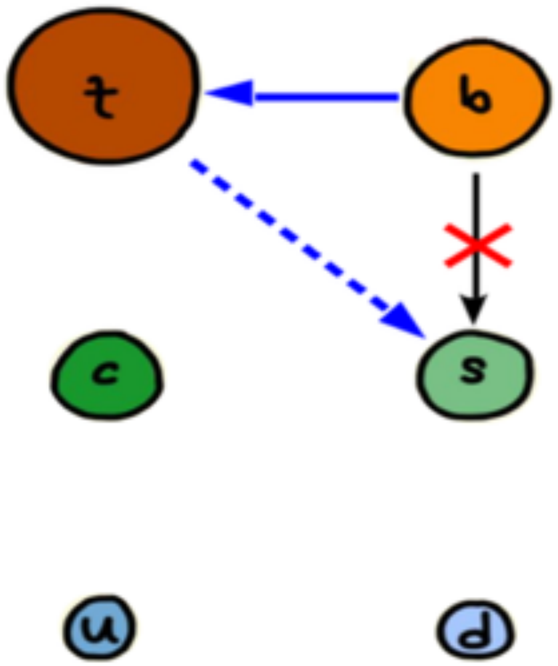


Flavour Changing Neutral Current

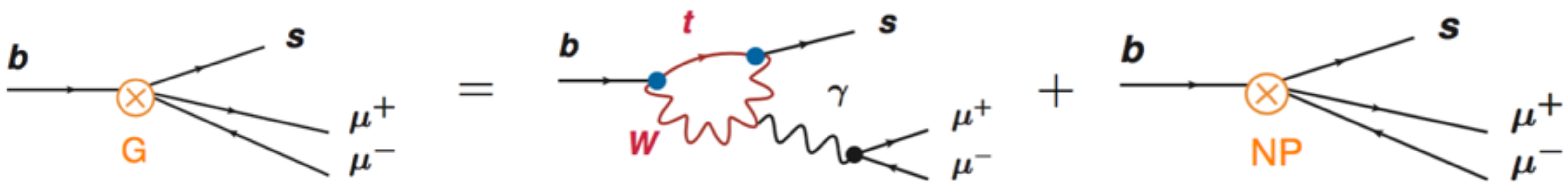
In the Standard Model,

Flavour changing “charged” currents arise at tree level;
rates are suppressed by small CKM elements





Flavour changing “neutral” currents arise at loop level;
they are suppressed by loop factors and small CKM elements



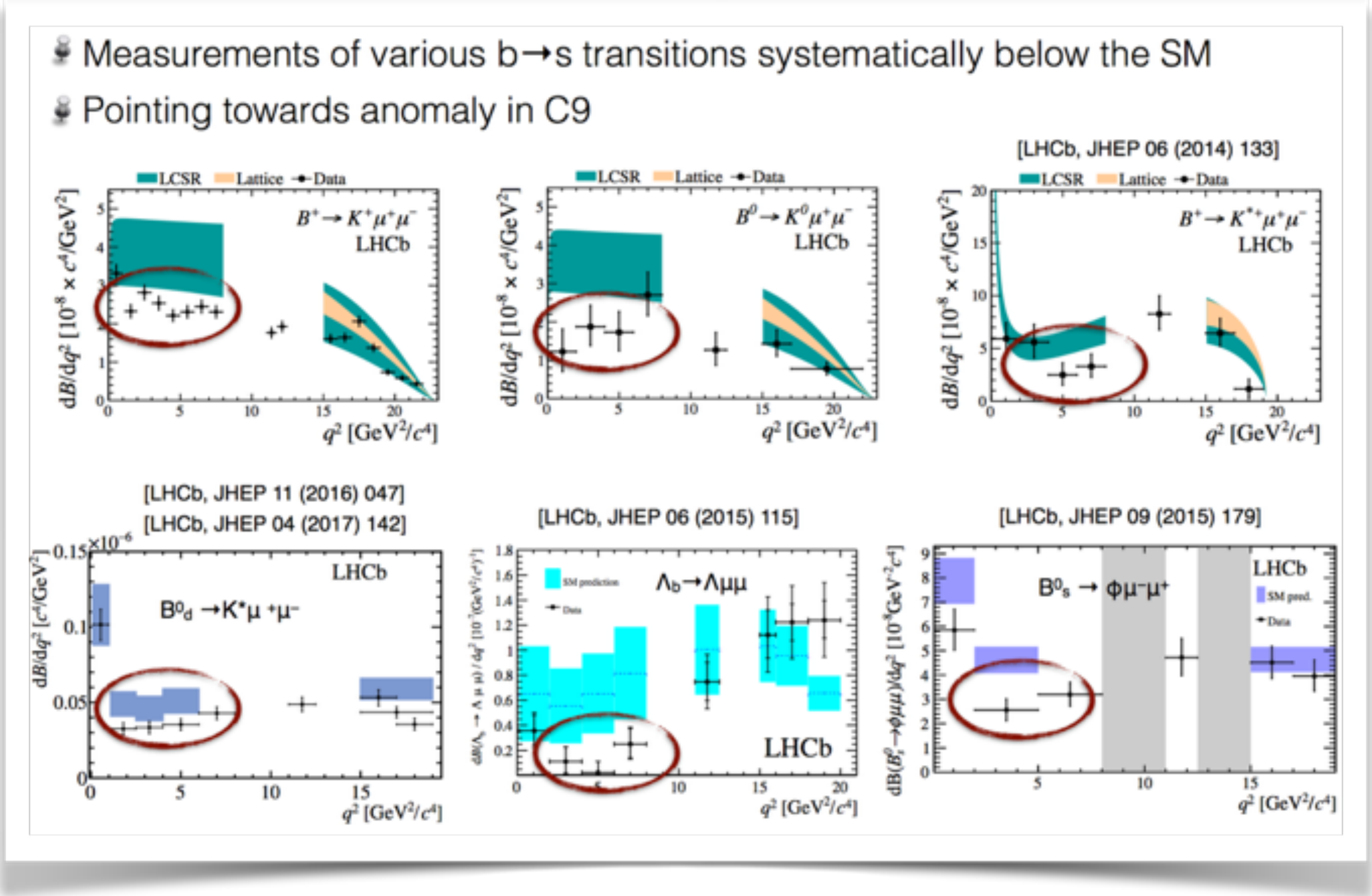
“Anomalies in B decays could establish a new scale in particle physics”

Adapted from W. Altmannshofer, DPF 2017

b → s Transition, B → K*..

Many experimental measurements show similar deviation

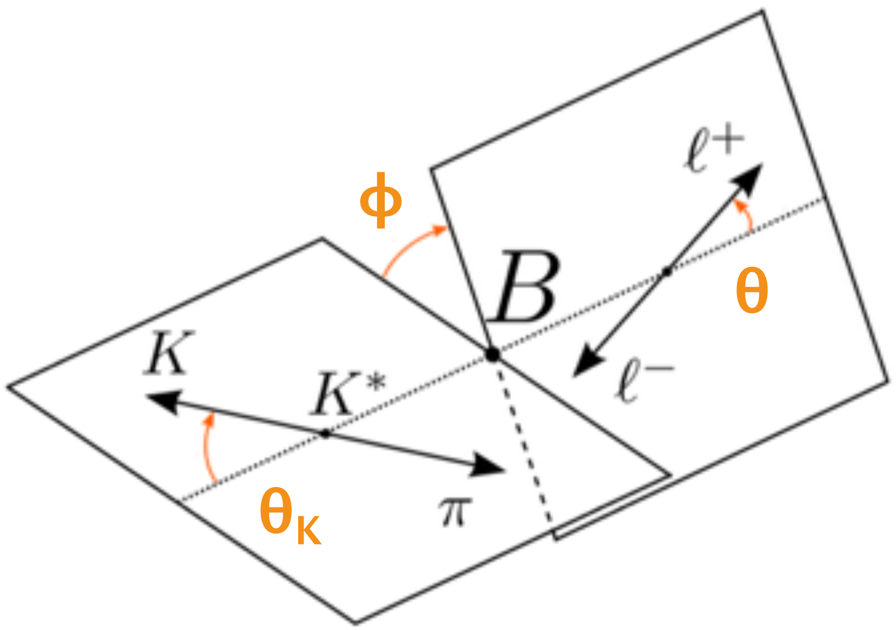
J. Prisciandaro, FPCP 2017



b → s Transition, B → K*..

Many experimental measurements show similar deviation

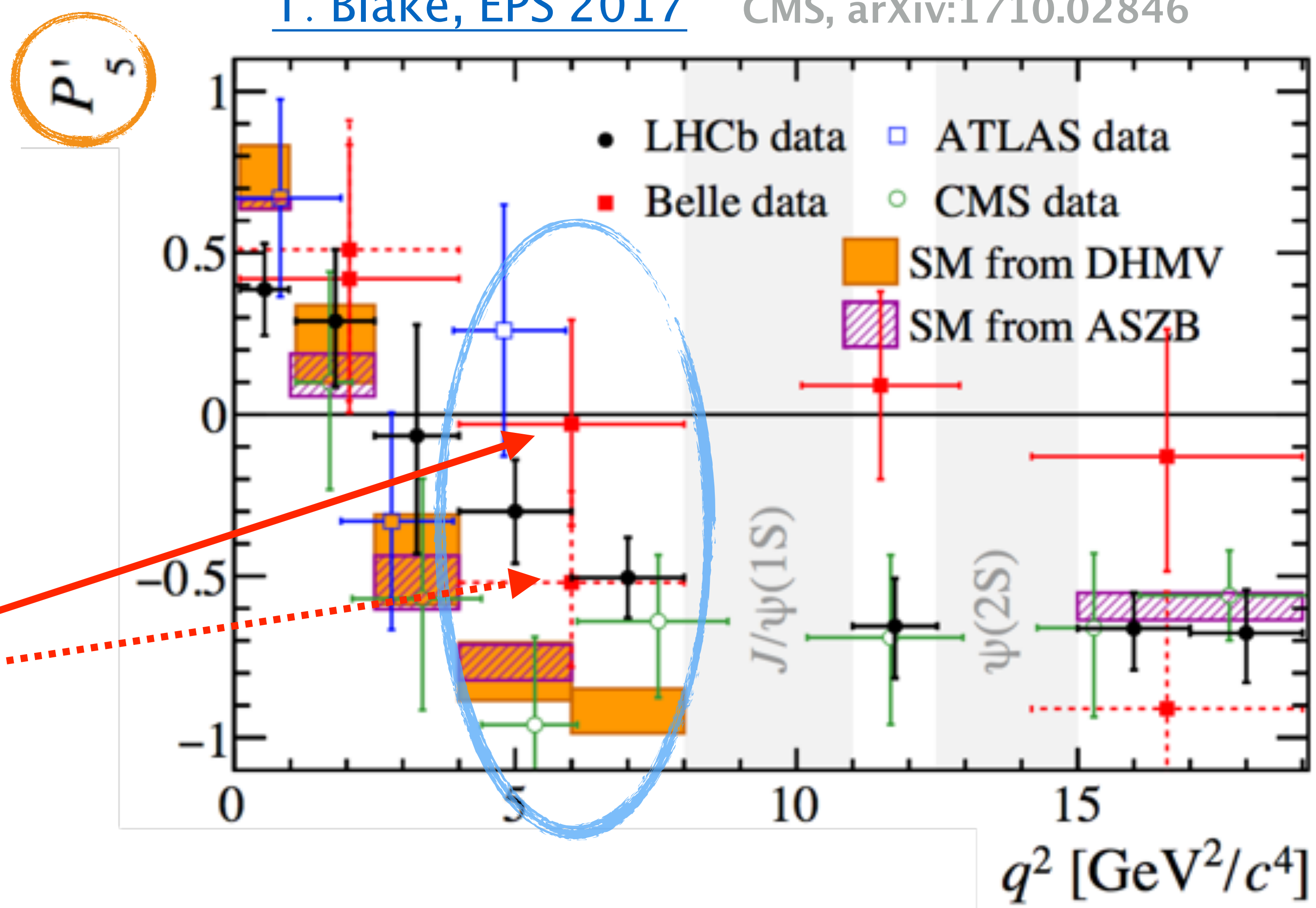
… in particular, angular analysis of B → K*ll decay



"Form-factor free" observable

T. Blake, EPS 2017

LHCb, JHEP 02 (2016) 104
Belle, PRL 118 (2017) 111801
ATLAS-CONF-2017-023
CMS, arXiv:1710.02846



Belle analysis separates measurements in lepton flavour
2.6σ (μμ) and 1.1σ (ee) from SM

Lepton Flavour Universality

In the Standard Model, charged and neutral current interactions are “universal”
→ electrons/muons/taus couple to W and Z bosons with equal strengths

Test LFU in B meson decays using ratios of BR’s

$$R_{D^{(*)}} = \frac{BR(B \to D^{(*)}\tau\nu)}{BR(B \to D^{(*)}\ell\nu)}$$

LFU ratios of
charged current decays

$$R_{K^{(*)}} = \frac{BR(B \to K^{(*)}\mu\mu)}{BR(B \to K^{(*)}ee)}$$

LFU ratios of
neutral current decays

where uncertainties cancel out

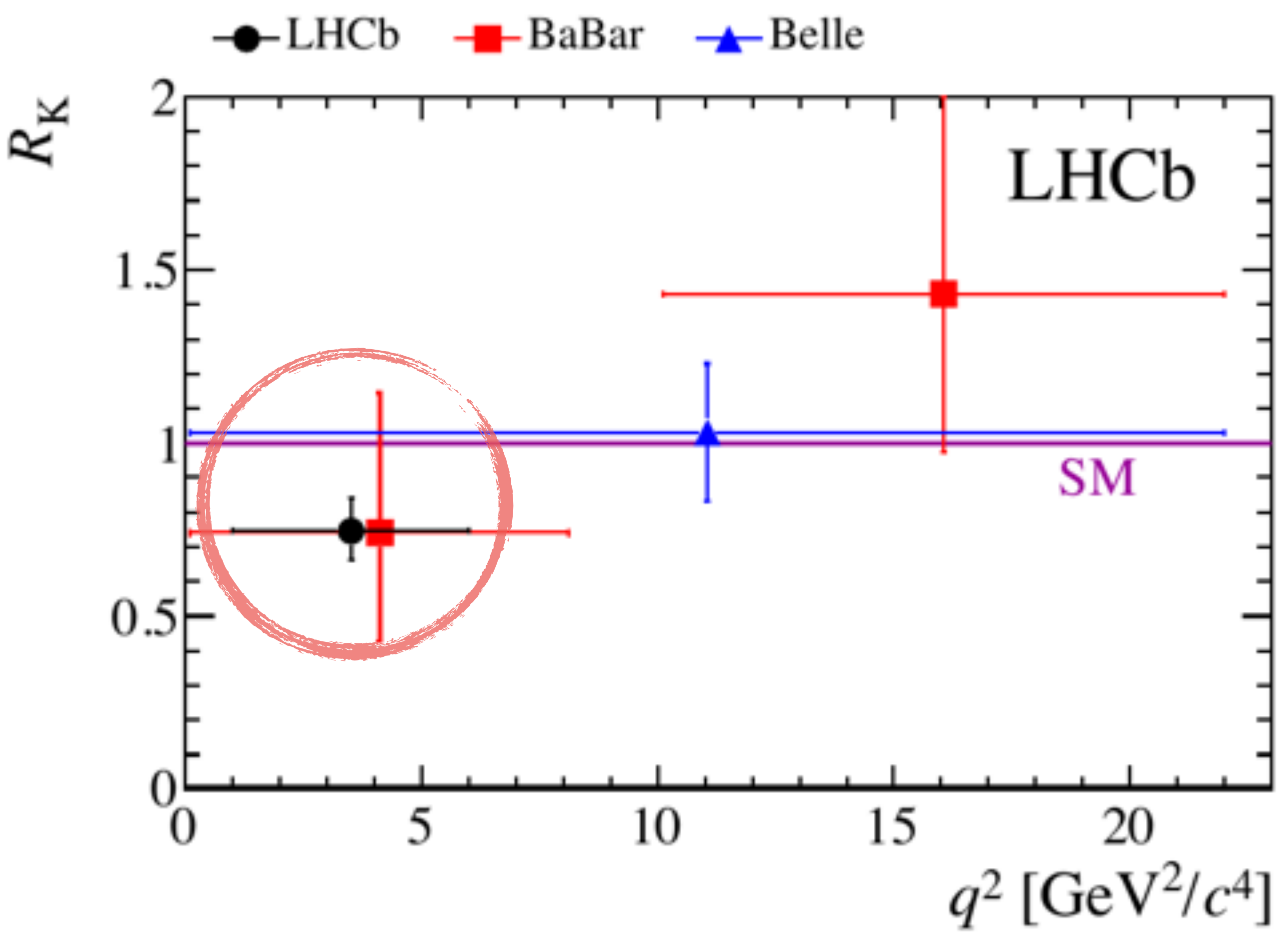
Lepton Flavour Universality

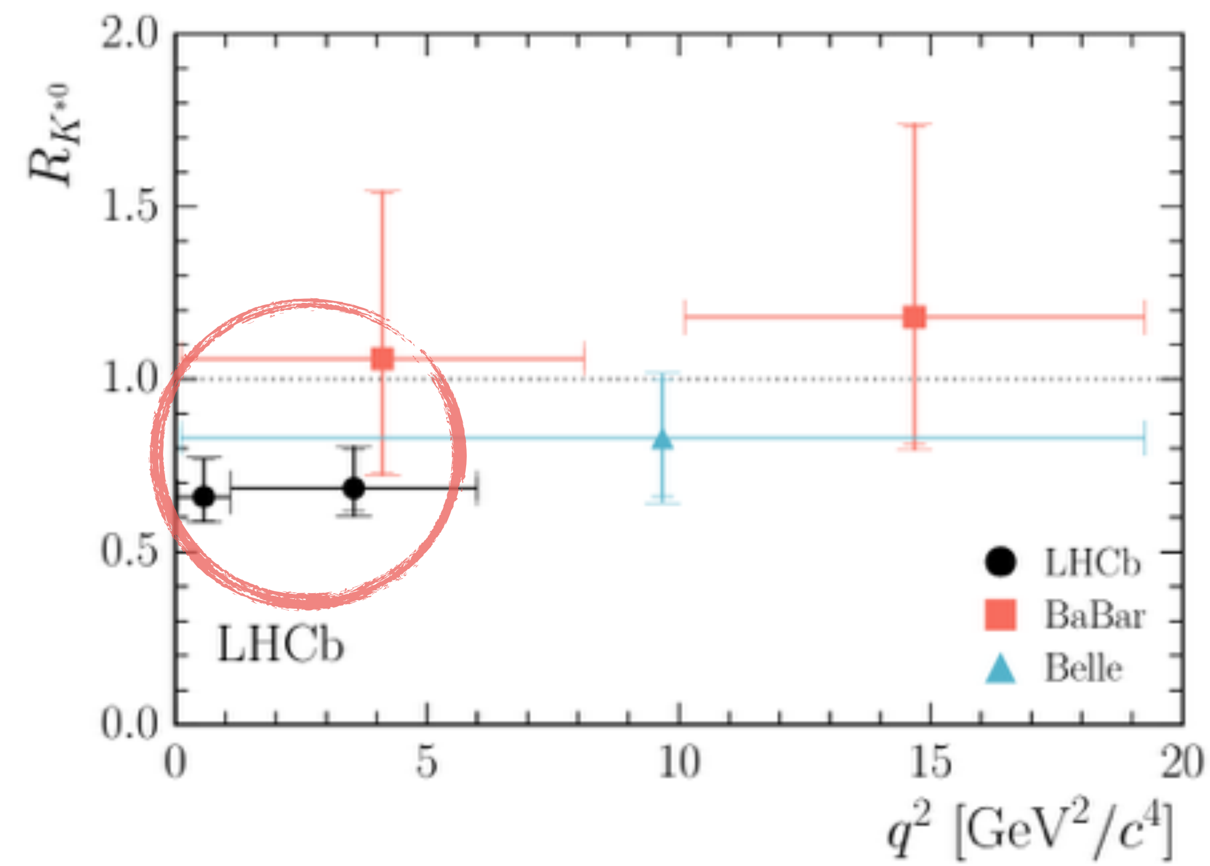
In the Standard Model, charged and neutral current interactions are “universal”
→ electrons/muons/taus couple to W and Z bosons with equal strengths

Test LFU in B meson decays using ratios of BR’s

LHCb results show up to ~2.5σ in low q^2 region

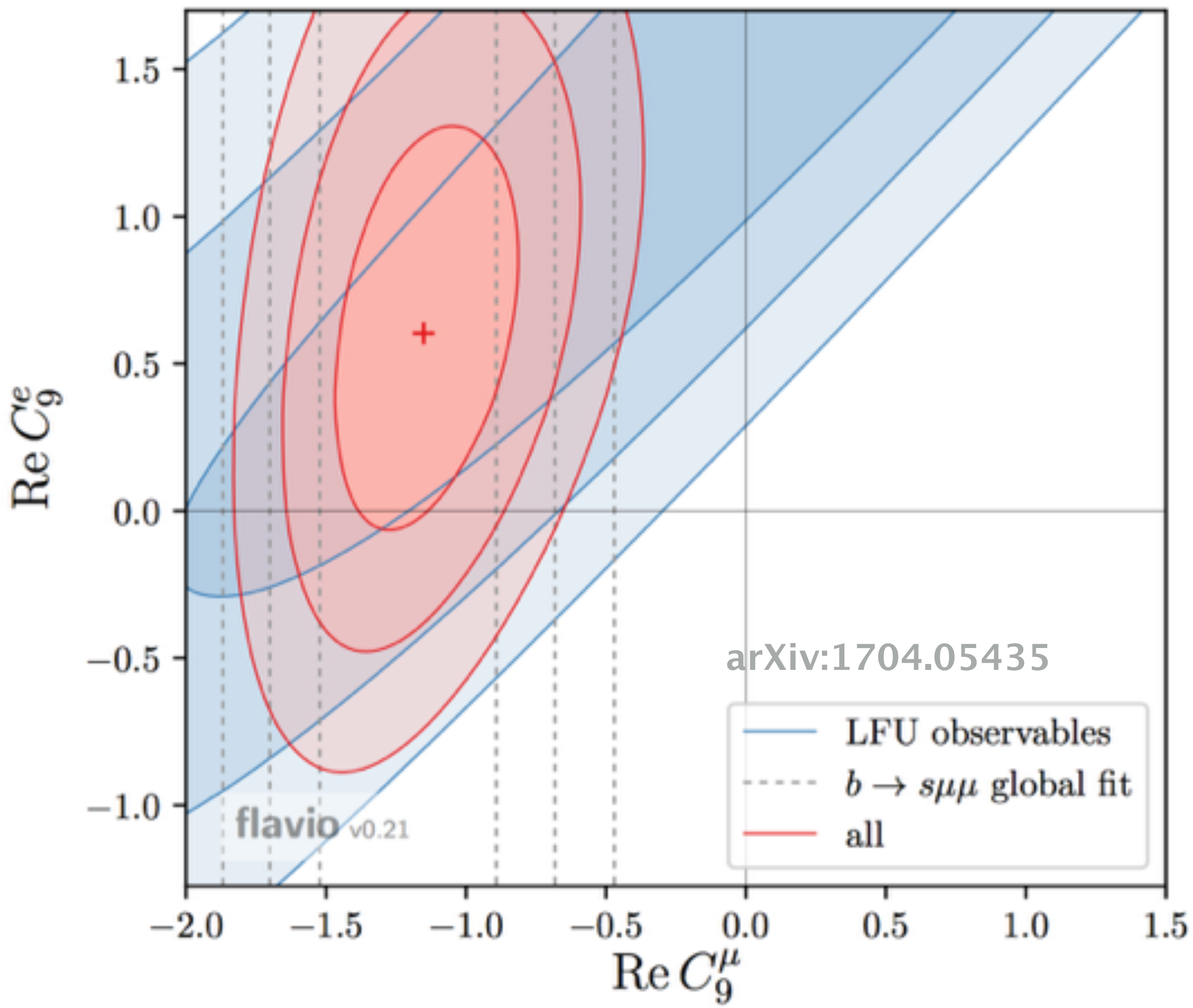
Belle, PRL 103 (2009) 171801
BaBar, PRD 86 (2012) 032012
LHCb, PRL113 (2014) 151601
LHCb, JHEP 08 (2017) 055





Lepton Flavour Universality

Fit to various experimental LFU measurements involving FCNC b → s transition for a possible presence of New Physics



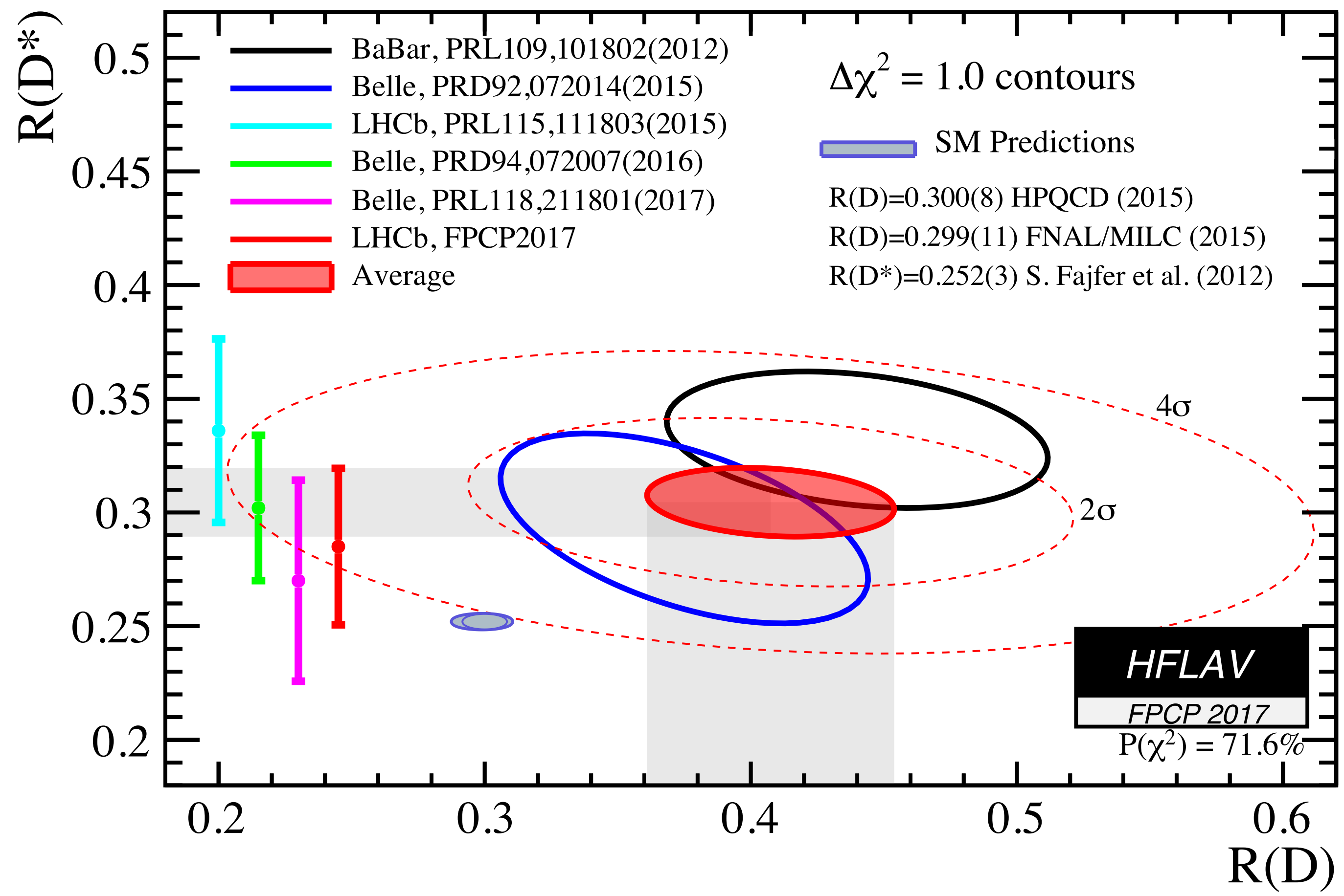
Anomalies seen in R(K) & R(K*) and angular measurements are compatible

Lepton Flavour Universality

$$R_{D^{(*)}} = \frac{BR(B \to D^{(*)}\tau\nu)}{BR(B \to D^{(*)}\ell\nu)}$$

LFU ratios of charged current decays

2.3σ / 3.4σ deviation in R(D) / R(D*)
> 4σ combined



LFU & FCNC

nature

International journal of science

Two review articles on Nature

REVIEW

doi:10.1038/nature22346

A challenge to lepton universality in B-meson decays

Gregory Ciezarek[1], Manuel Franco Sevilla[2], Brian Hamilton[3], Robert Kowalewski[4], Thomas Kuhr[5], Vera Lüth[6] & Yutaro Sato[7]

One of the key assumptions of the standard model of particle physics is that the interactions of the charged leptons, namely electrons, muons and taus, differ only because of their different masses. Whereas precision tests comparing processes involving electrons and muons have not revealed any definite violation of this assumption, recent studies of B-meson decays involving the higher-mass tau lepton have resulted in observations that challenge lepton universality at the level of four standard deviations. A confirmation of these results would point to new particles or interactions, and could have profound implications for our understanding of particle physics.

More than 70 years of particle physics research have led to an elegant and concise theory of particle interactions at the sub-nuclear level, commonly referred to as the standard model[1,2]. On the basis of information extracted from experiments, theorists have combined the theory of electroweak interactions with quantum chromodynamics, the theory of strong interactions, and experiments have validated this theory to an extraordinary degree. Any observation that is proven to be inconsistent with standard model assumptions would suggest a new type of interaction or particle.

In the framework of the standard model of particle physics, the fundamental building blocks, quarks and leptons, are each grouped in three generations of two members each. The three generations of charged leptons—the electron (e^-), the muon (μ^-) and the tau (τ^-)—are each paired with an electrically neutral lepton, a very low mass neutrino, ν_e, ν_μ and ν_τ, respectively. The electron, a critical component of matter, was discovered by Thomson[3] in 1897. The discovery of the muon in cosmic rays by Anderson and Neddermeyer[4] in 1937 came as a surprise. Similarly surprising was the first observation of $\tau^+\tau^-$ pair production by Perl et al.[5] at the SPEAR e^+e^- storage ring in 1975. As far as we know, all leptons are point-like particles, that is, they have no substructure.

The three generations are ordered by the mass of the charged lepton, which ranges from 0.511 MeV for $e^\pm$ to 105 MeV for $\mu^\pm$ and to 1,777 MeV for $\tau^\pm$ (ref. 6). These different masses lead to vastly different lifetimes, from the stable electron to 2.2 μs for muons, and to 0.29 ps for taus. Charged leptons participate in electromagnetic and weak interactions, but not in strong interactions, whereas neutrinos only undergo weak interactions. The standard model assumes that these interactions of the charged and neutral leptons are universal, that is, the same for the three generations.

Precision tests of lepton universality have been performed over many years by many experiments. To date no definite violation of lepton universality has been observed. Among the most precise tests is a comparison of the decay rates of K mesons, that is, $K^- \to e^-\bar{\nu}_e$ versus $K^- \to \mu^-\bar{\nu}_\mu$ (ref. 7). (Unless stated otherwise, the inclusion of charged-conjugate states and decay modes is implied here and in the following.) Furthermore, taking into account precision measurements of the tau and muon masses and lifetimes and the decay rates $\tau^- \to e^-\bar{\nu}_e\nu_\tau$ and $\mu^- \to e^-\bar{\nu}_e\nu_\mu$, the equality of the weak coupling strengths of the tau and muon was confirmed[6]. On

difference are underway[9]. They are aimed at a better understanding of the proton radius and structure, and may reveal details of the true impact of muons and electrons on these interactions.

Recent studies have focused on purely leptonic decays of B mesons of the form $B^- \to \tau^-\bar{\nu}_\tau$ and semileptonic B decays such as $\bar{B} \to D^{(*)}\ell^-\bar{\nu}_\ell$, with $\ell = e$, μ or τ, and where $D^{(*)}$ refers to a low-mass charm meson, D or D^*. These studies have resulted in observations that seem to challenge lepton universality. These weak decays involving leptons are well understood in the framework of the standard model, and therefore offer a unique opportunity to search for unknown phenomena and processes involving new particles: for instance, a yet undiscovered charged partner of the Higgs boson[10]. Such searches have been performed on data collected by three different experiments: the LHCb experiment at the pp collider at CERN in Europe, and the BaBar and Belle experiments at e^+e^- colliders in the USA and in Japan, respectively.

Measurements by these three experiments favour larger than expected rates for semileptonic B decays involving τ leptons. Currently, the combined significance of these results is at the level of four standard deviations, and the fact that all three experiments report an unexpected enhancement has drawn considerable attention. A confirmation of this violation of lepton universality and an explanation in terms of new-physics processes would be very exciting. In the following, we present details of the experimental techniques and preliminary studies to understand the observed effects, along with prospects of improved sensitivity and complementary measurements at current and future facilities.

Standard model predictions of B-meson decay rates

According to the standard model, purely leptonic and semileptonic decays of B mesons are mediated by the W^- boson, as shown schematically in Fig. 1. B mesons are assumed to be composed of a b-quark and an antiquark (anti-u or anti-d), either $B^-(b, \bar{u})$ or $\bar{B}^0(b, \bar{d})$, whereas charm mesons (the spin-0 D and spin-1 D^* state) contain a c-quark and an antiquark (anti-u or anti-d), $D^{0(*)}(c, \bar{u})$ or $D^{+(*)}(c, \bar{d})$.

For purely leptonic B^- decays, the standard model prediction of the total decay rate Γ, which depends critically on the lepton mass squared m_ℓ^2, is:

REVIEW

doi:10.1038/nature21721

Flavour-changing neutral currents making and breaking the standard model

F. Archilli[1], M.-O. Bettler[2], P. Owen[3] & K. A. Petridis[4]

The standard model of particle physics is our best description yet of fundamental particles and their interactions, but it is known to be incomplete. As yet undiscovered particles and interactions might exist. One of the most powerful ways to search for new particles is by studying processes known as flavour-changing neutral current decays, whereby a quark changes its flavour without altering its electric charge. One example of such a transition is the decay of a beauty quark into a strange quark. Here we review some intriguing anomalies in these decays, which have revealed potential cracks in the standard model—hinting at the existence of new phenomena.

The standard model of particle physics has been a spectacularly successful theory for explaining the properties and interactions of fundamental particles, with many measurements confirming its predictions to extraordinary precision. However, cosmological observations of the apparent dark-matter content of the Universe, and of the dominance of matter over antimatter, suggest that the standard model is an incomplete theory. In addition, the standard model does not provide an explanation for the observed patterns of masses of elementary particles. Therefore, one of the current goals of experimental particle physics is to discover new particles and interactions—commonly referred to as 'new physics'—that could provide an explanation for these observations.

Searches for such new particles are performed in two ways. The first requires the production of a new particle directly from the collisions of highly energetic beams of protons or electrons. The new particle subsequently decays to a set of known standard model particles, whose properties are measured in particle physics detectors. The ATLAS[1] and CMS[2] collaborations at the Large Hadron Collider[3] (LHC) at CERN are examples of experiments that search directly for new particles produced through the collisions of proton beams at unprecedented energies and intensities.

The second method involves performing precise measurements of the properties of known decays of hadrons (composites of quarks) that are accurately described by the standard model. In this case, processes that occur via the weak force—such as the decay of a kaon (a hadron containing a strange quark) or of a b hadron (which contains a beauty quark)—are particularly interesting. As a consequence of quantum-field theory, such decays can occur through transient particles that have a physical mass larger than the amount of mass-energy available from the decaying particle. These transient particles are referred to as 'virtual'. Heavy new particles can cause large deviations from the standard model predictions of the decay rate and of the dynamics of the decay products. Precise measurements of such quantities are sensitive to particles beyond the standard model that have masses far exceeding the available collision energy of the LHC. The LHCb experiment[4] operating at the LHC is an example of an experiment that is searching for new physics through precision measurements of the properties of known decays.

neutral-current processes. There are six types (flavours) of quarks: down (d), up (u), strange (s), charm (c), beauty (b) and top (t). These quarks can change their flavour by interacting with the W^+ or W^- bosons, but cannot by interacting with the Z^0 boson.

Flavour-changing neutral currents (FCNCs)

By the end of the 1960s, the charged-current process that occurs when a charged kaon decays into a muon and a neutrino ($K^+ \to \mu^+\nu_\mu$) had been well established, but the neutral-current counterpart of this process, $K_L^0 \to \mu^+\mu^-$, had not been observed, posing a major puzzle in particle physics. At the time, only three different flavours of quark were known to exist, and while the existence of a fourth had been postulated[5], there was no experimental evidence for it. In 1970, Glashow, Iliopoulos and Maiani[6] provided an explanation (the GIM mechanism) behind the suppression of the neutral-current process relative to the charge-current process, by proposing the existence of a fourth type of quark with specific couplings to the known quarks. The contribution from this fourth quark would cancel out the contribution from other quarks involved in the $K_L^0 \to \mu^+\mu^-$ decay. In today's language, the strange quark and the down quark that make up the K_L^0 particle interact via a quantum-loop transition involving predominantly a W boson and either an up quark or a charm quark, as shown in Fig. 1a. Given the limitation that the quarks have the same mass, the diagram involving the up quark exactly cancels that of the charm quark, explaining the suppression of the $K_L^0 \to \mu^+\mu^-$ decay relative to the $K^+ \to \mu^+\nu_\mu$ decay.

The combination of experimental measurements and the proposed GIM mechanism provided an indirect observation of the charm quark, four years before it was observed directly[7,8], with the discovery of the J/ψ hadron (a bound state of a charm quark and an anticharm quark). Such interplay between experimental measurements and theoretical predictions of quark flavours has shaped the standard model over the past 50 years.

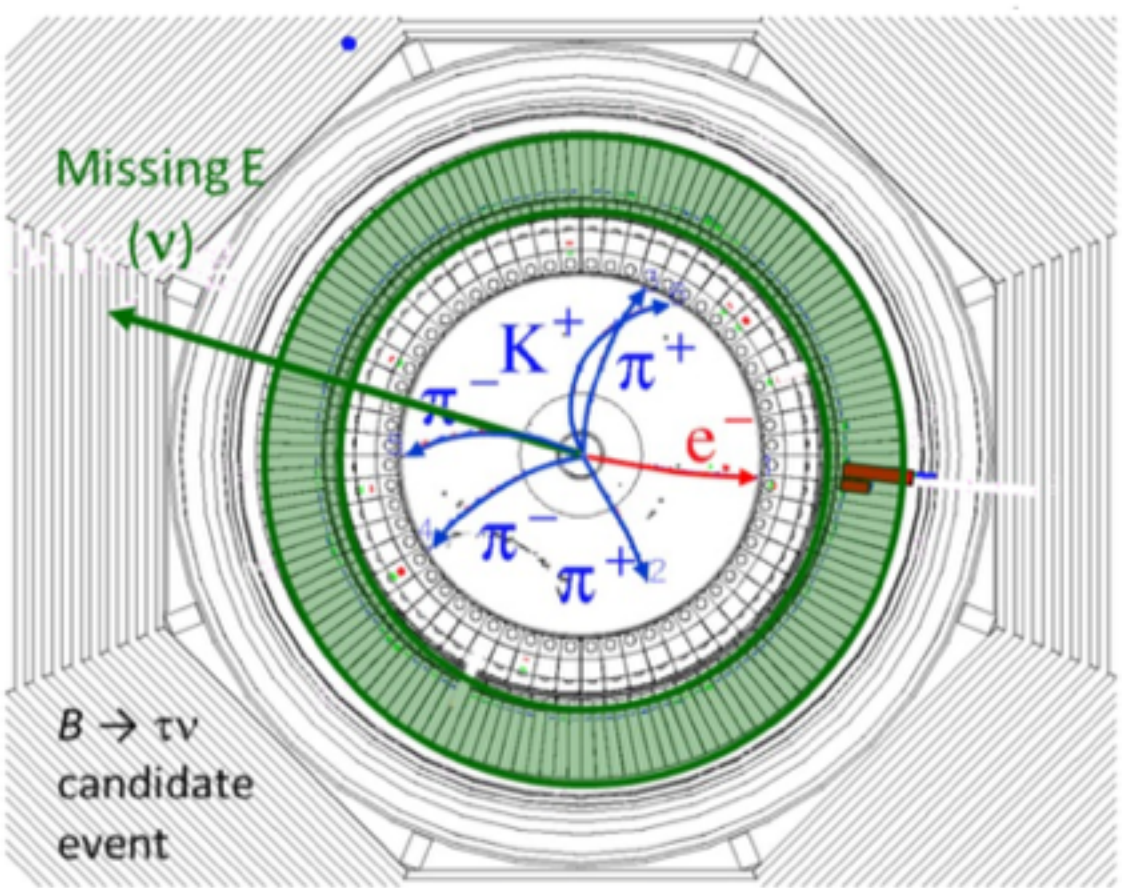
FCNCs in decays of beauty quarks

Another example of a FCNC process involves the transition of a beauty quark into a strange quark. This process can occur through the same

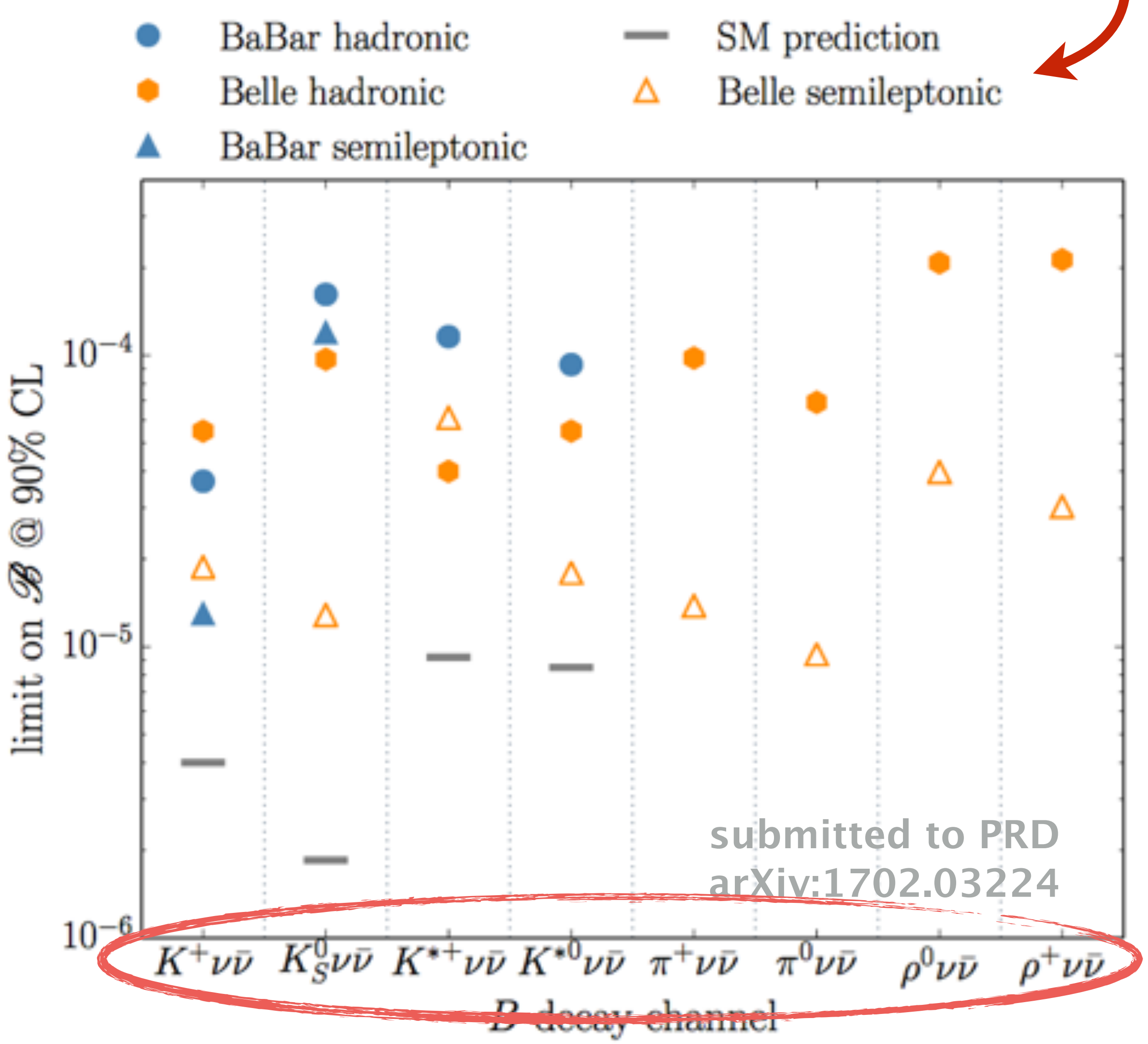
B → "K"νν

b → s transition with neutrinos in final state

- missing momentum signature
  + veto on additional tracks
  → possible only at e⁺e⁻ collider
- sensitivity to New Physics



Most stringent limit by Belle using semileptonic tag (2017)



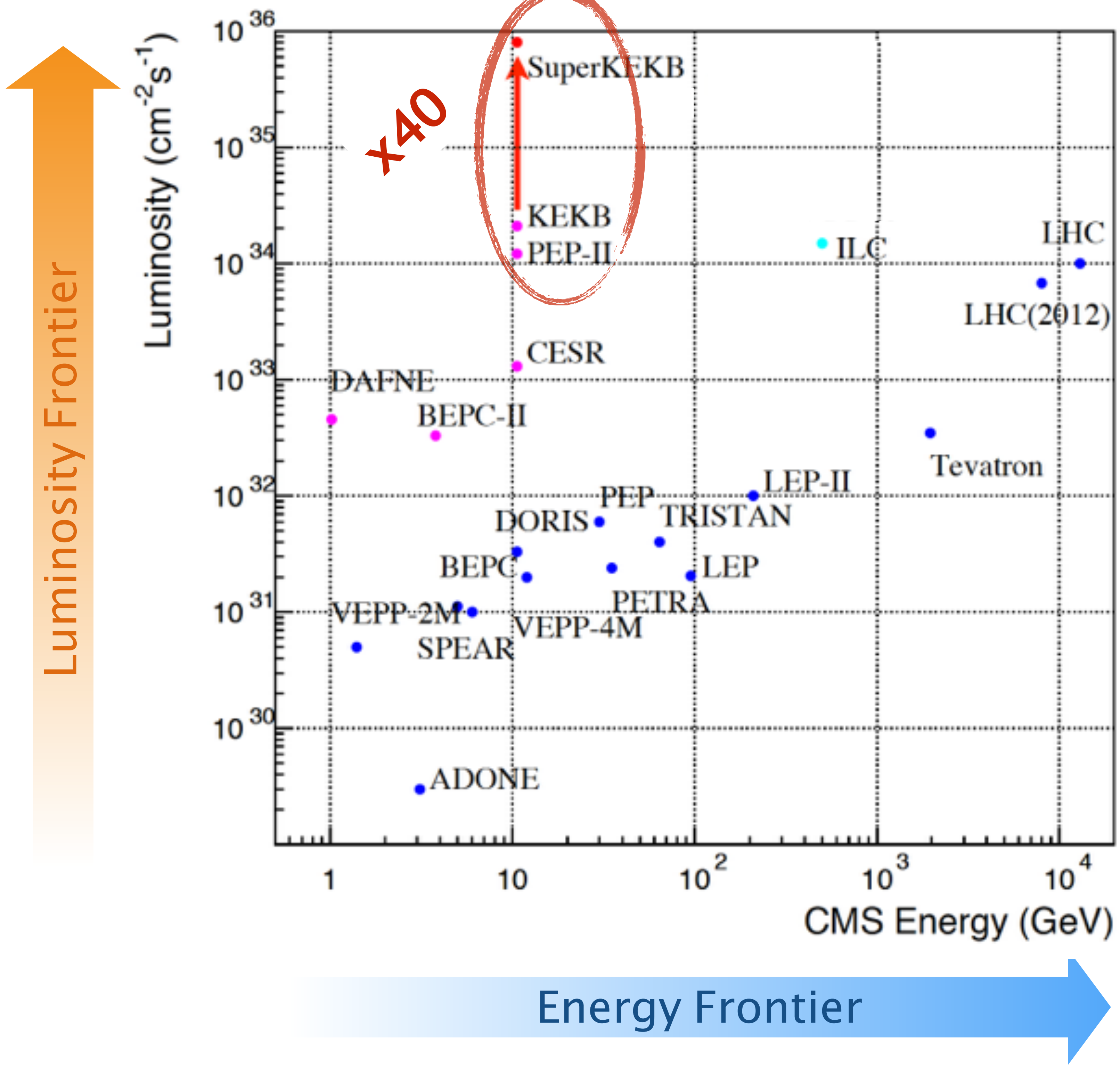
Status of Belle II

Belle II Experiment

775 members, 106 institutions, 25 countries/regions

(110 members from 12 German institutions)

From KEKB to SuperKEKB



From KEKB to SuperKEKB

Luminosity x40

x2 beam current

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

vertical β at IP x1/20

Vertical beam size ~50nm @ collision

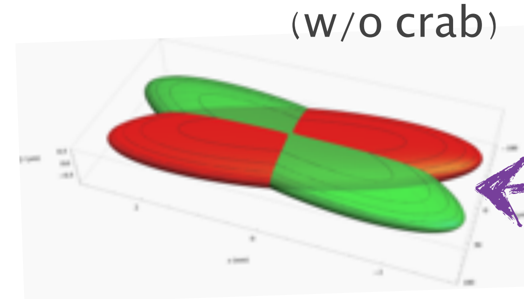
Low emittance beams

+

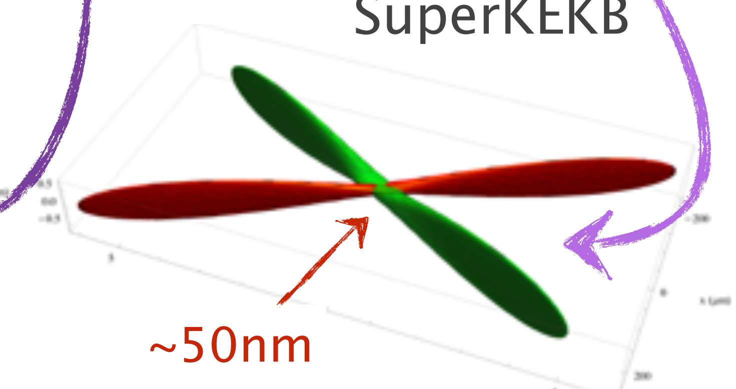
Strong focusing at interaction point using very sophisticated final focus quadrupole magnets

e^+ / e^-	KEKB	SuperKEKB
E [GeV]	3.5 / 8.0	4.0 / 7.0
I [A]	1.6 / 1.2	3.6 / 2.6
ξ	0.13 / 0.09	0.09 / 0.09
β^*_y [mm]	5.9 / 5.9	0.27 / 0.30
β^*_x [mm]	120 / 120	3.2 / 2.5
angle [mrad]	22	83
L [$cm^{-2}s^{-1}$]	2.1 x 10^{34}	80 x 10^{34}

KEKB
(w/o crab)

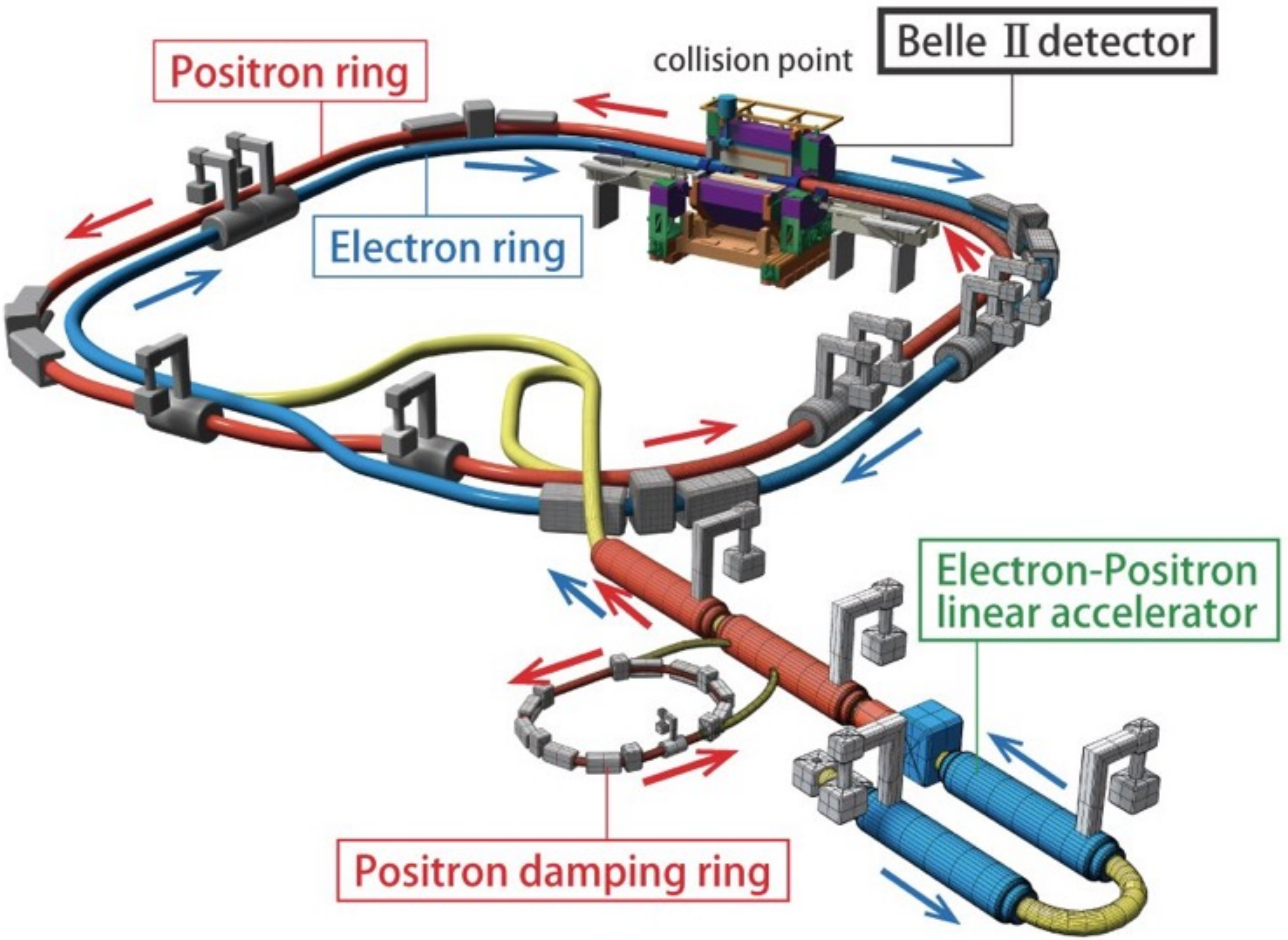


SuperKEKB



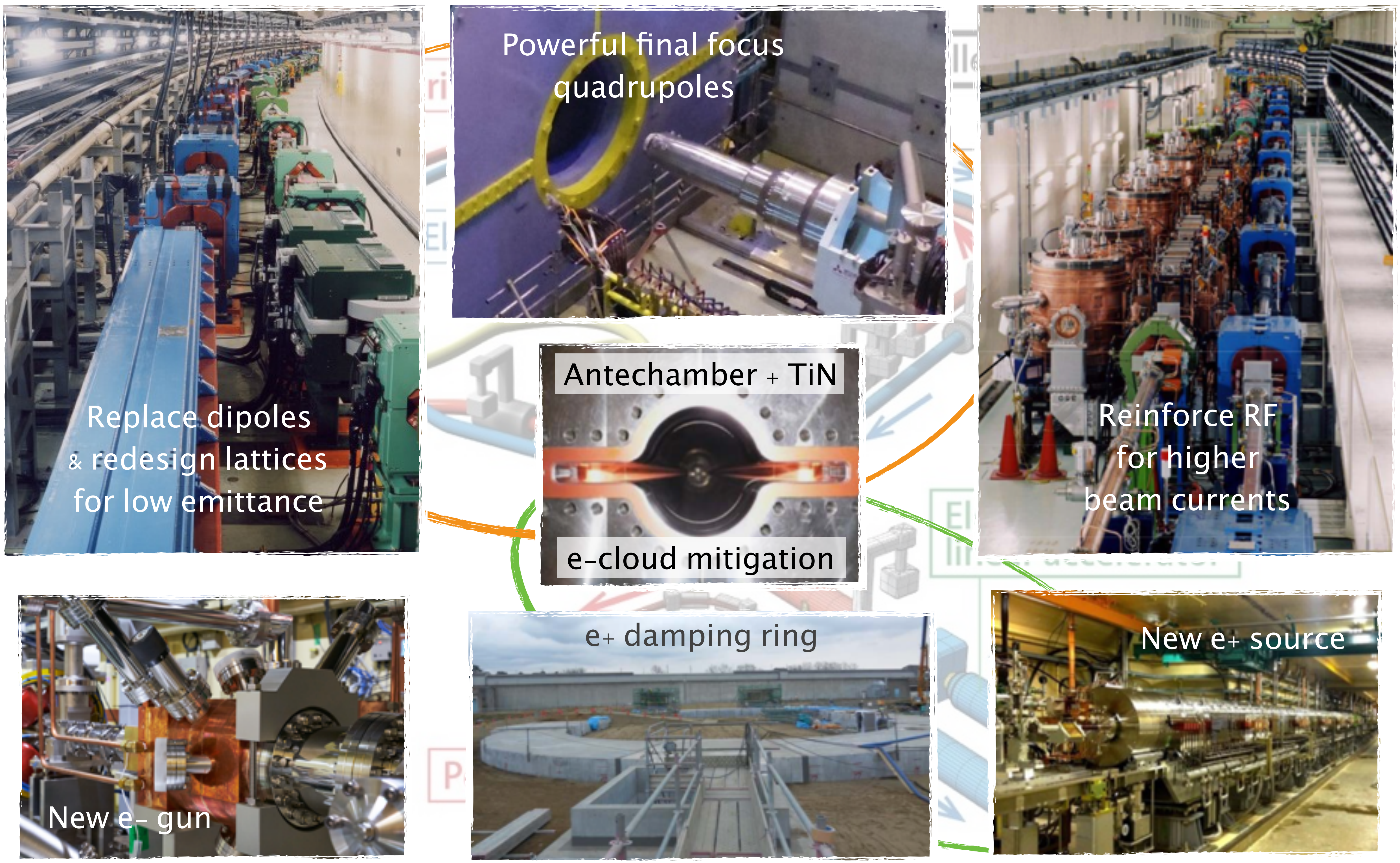
"Nano beam" (SuperB)

SuperKEKB

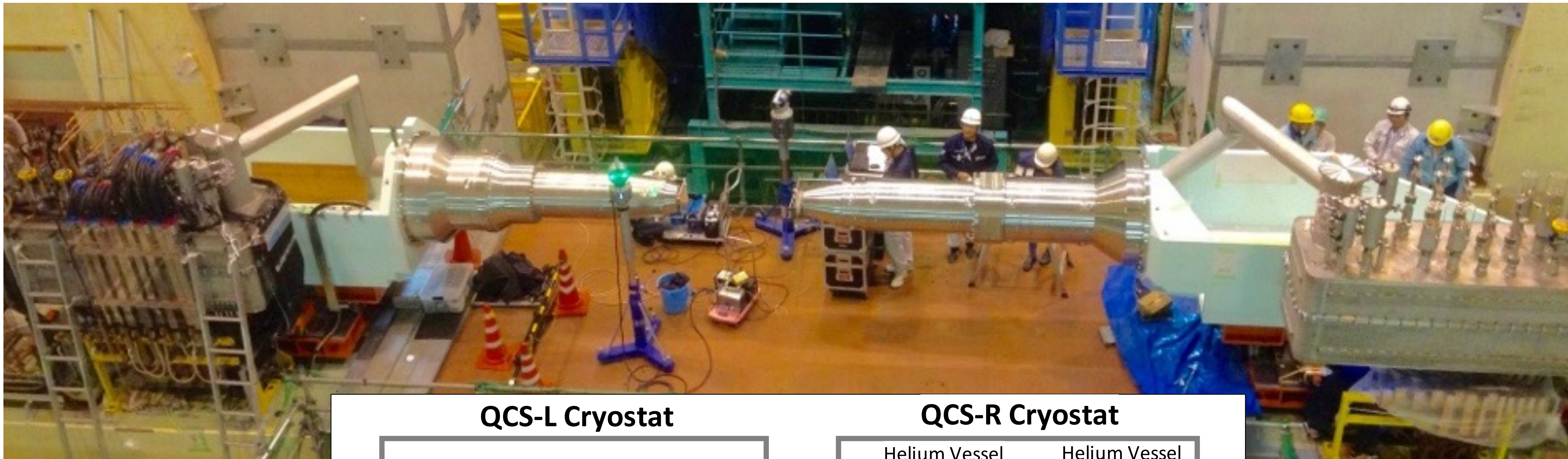


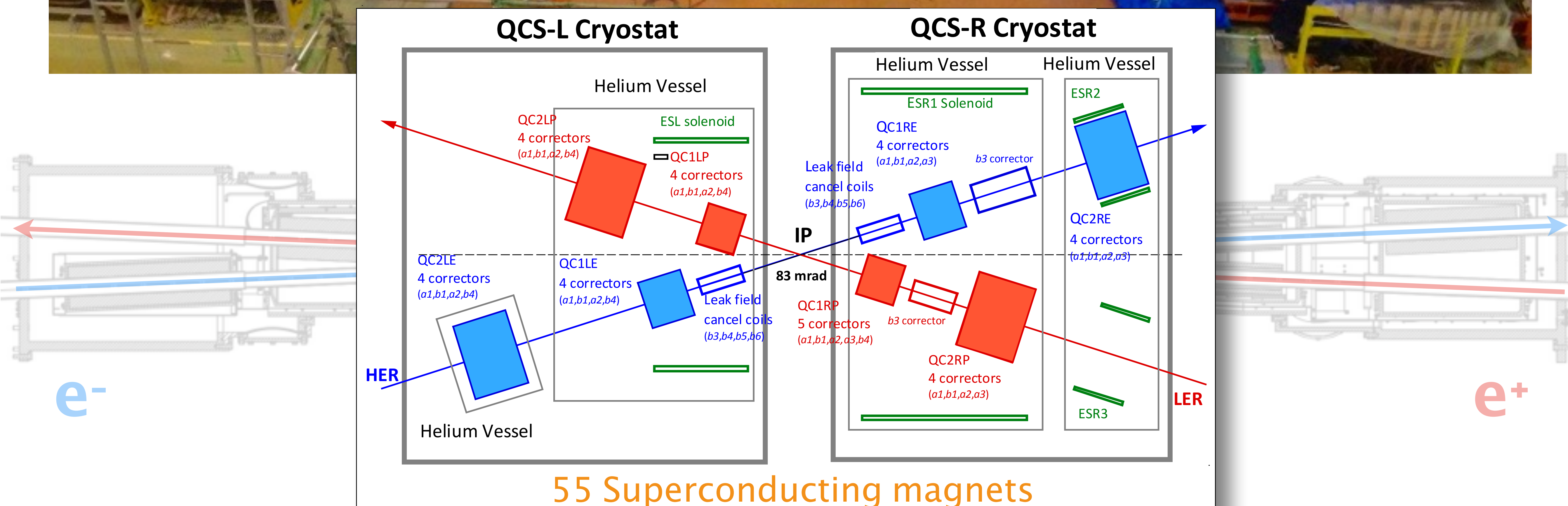
Positron ring
collision point
Belle II detector
Electron ring
Electron-Positron
linear accelerator
Positron damping ring

SuperKEKB


Powerful final focus
quadrupoles
Replace dipoles
& redesign lattices
for low emittance
Antechamber + TiN
e-cloud mitigation
Reinforce RF
for higher
beam currents
e+ damping ring
New e+ source
New e- gun

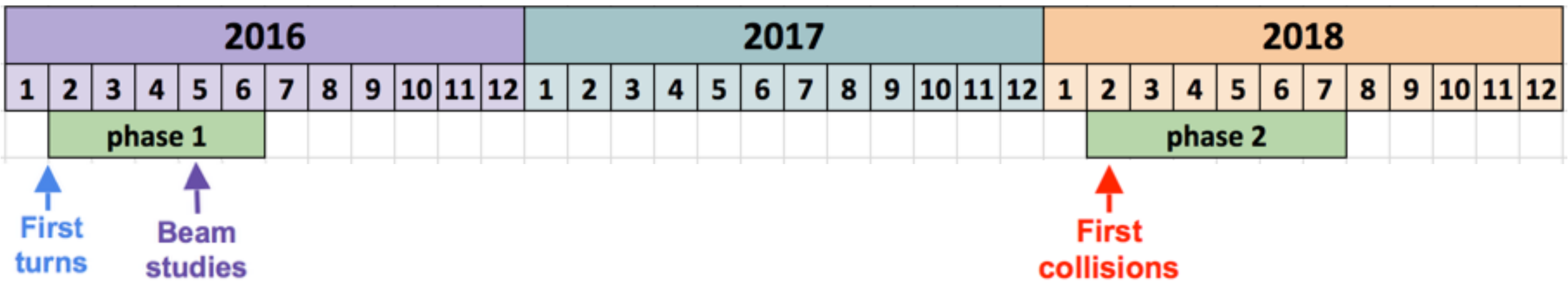
Interaction Region





55 Superconducting magnets

SuperKEKB Commissioning



SuperKEKB commissioning during first 2 phases of operation

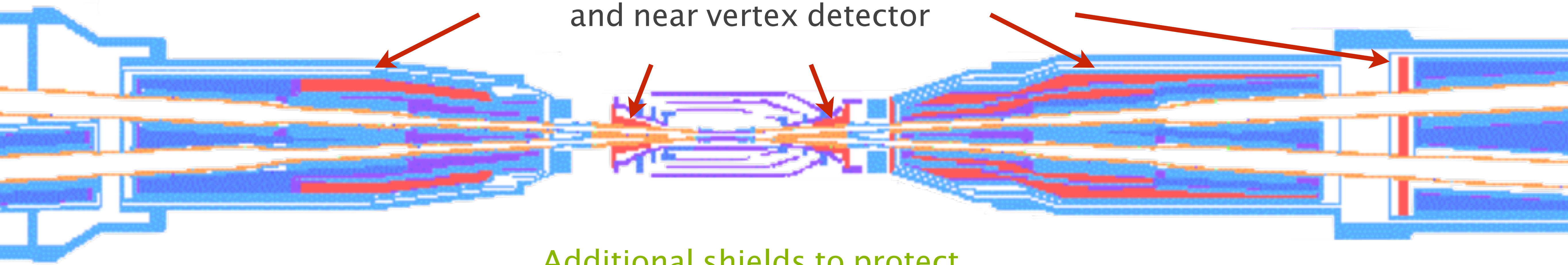
- Phase 1: single circulating beams, no collisions (without QCS)
- Phase 2: colliding beams at nominal CM energy (with QCS)

Belle II detector installed between Phase 1 & 2,
except the vertex detector only for Phase 3 physics run

Beam Background

x40 luminosity means much higher background, for which we need...

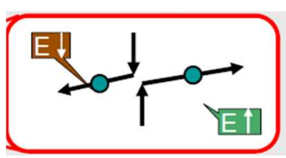
→ solid protection



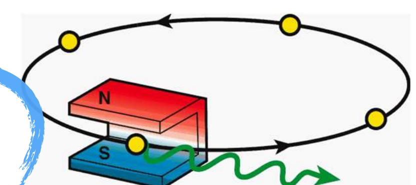
Beam Background

Beam background studied with dedicated detectors
during SuperKEKB commissioning phases
→ Beam Exorcisms for A Stable experimenT

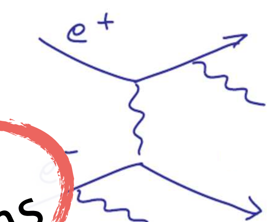
Touschek
intra-bunch scattering
rate ∝ beam size^{-1}, E^{-3}
x20 higher



Synchrotron radiation
created by QCS magnets
& scattered by beam pipe
rate ∝ E^{2}B^2



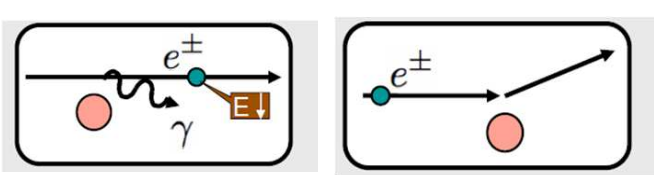
Radiative Bhabha
EM shower + neutron
rate ∝ Luminosity



Phase 1
single beam

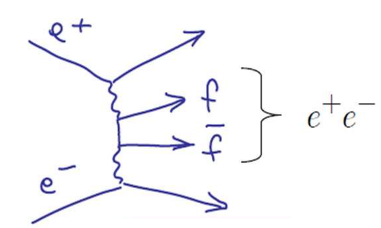
Phase 2
colliding beams

Beam-gas
scattering by remaining gas
rate ∝ I x P
up to x100

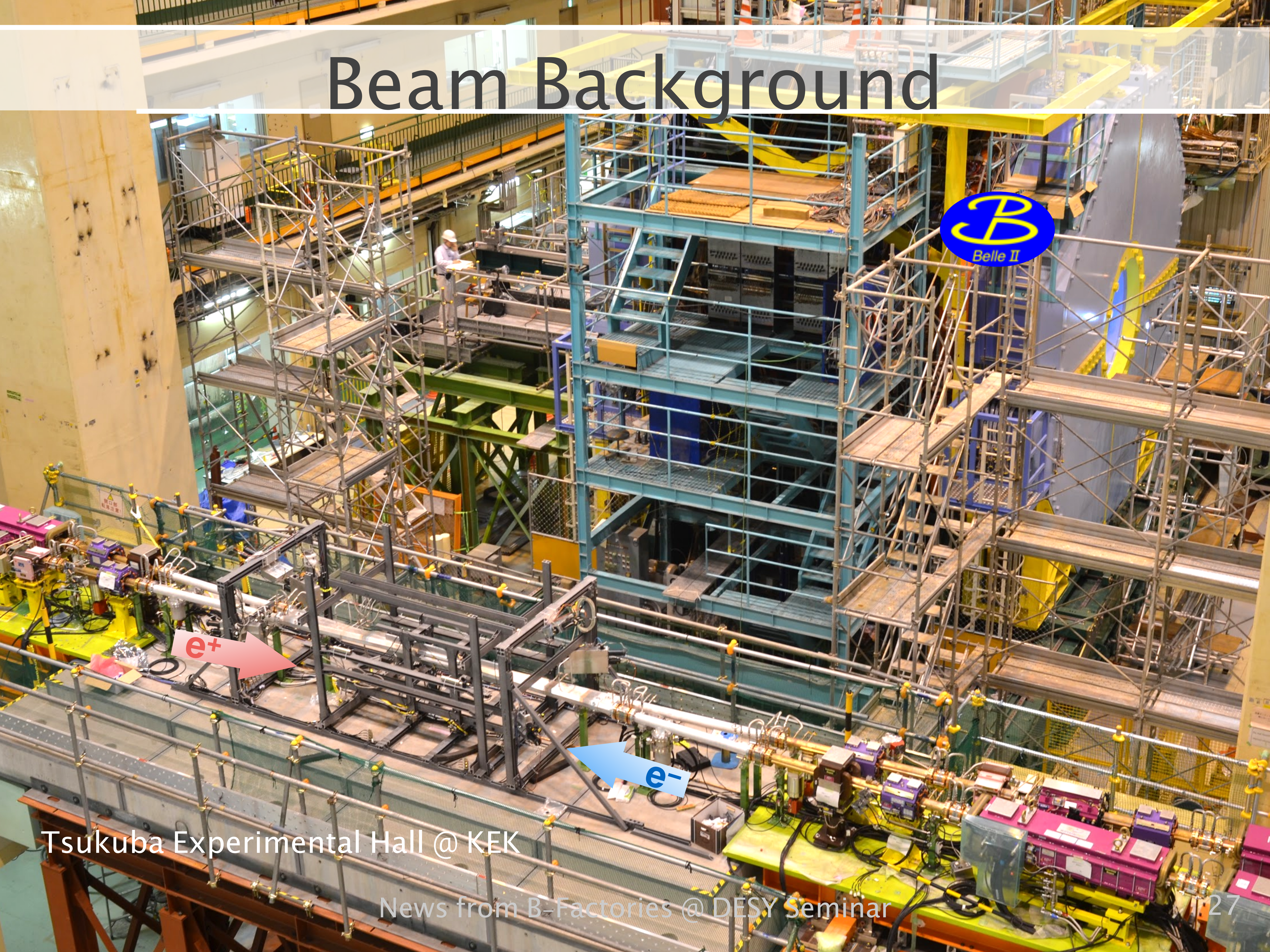


Injection background
can be x1000
at every injection @50Hz

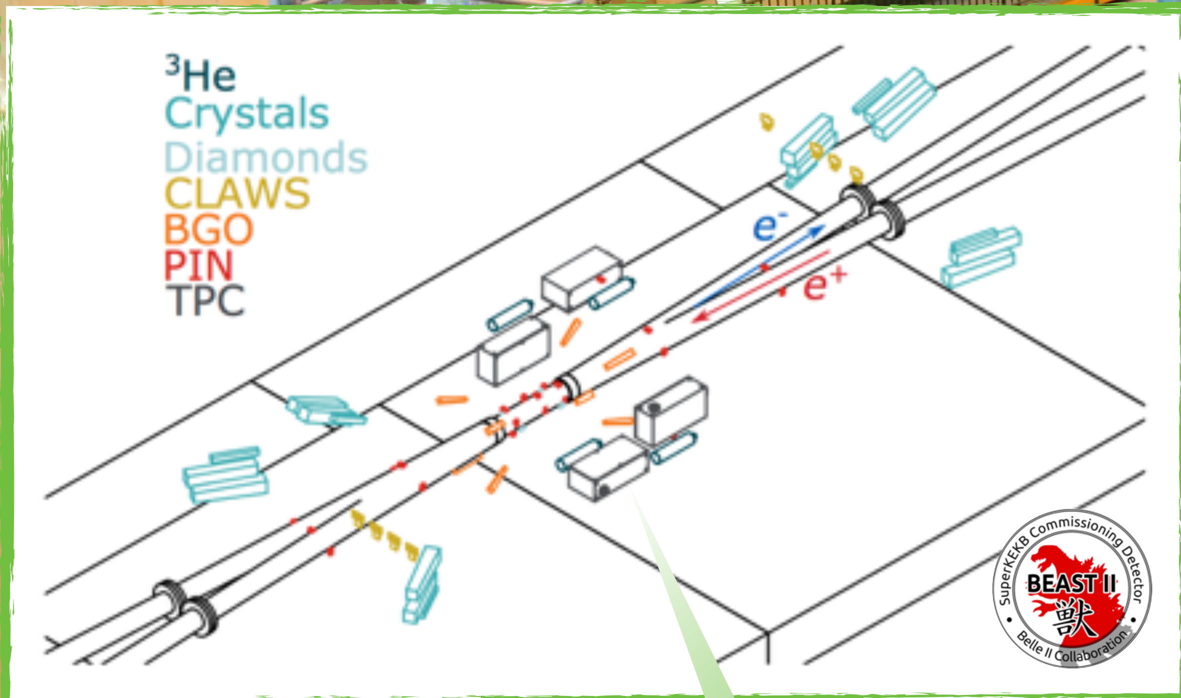
Two photon
Very low momentum
e$^+$e$^-$ pair



Beam Background

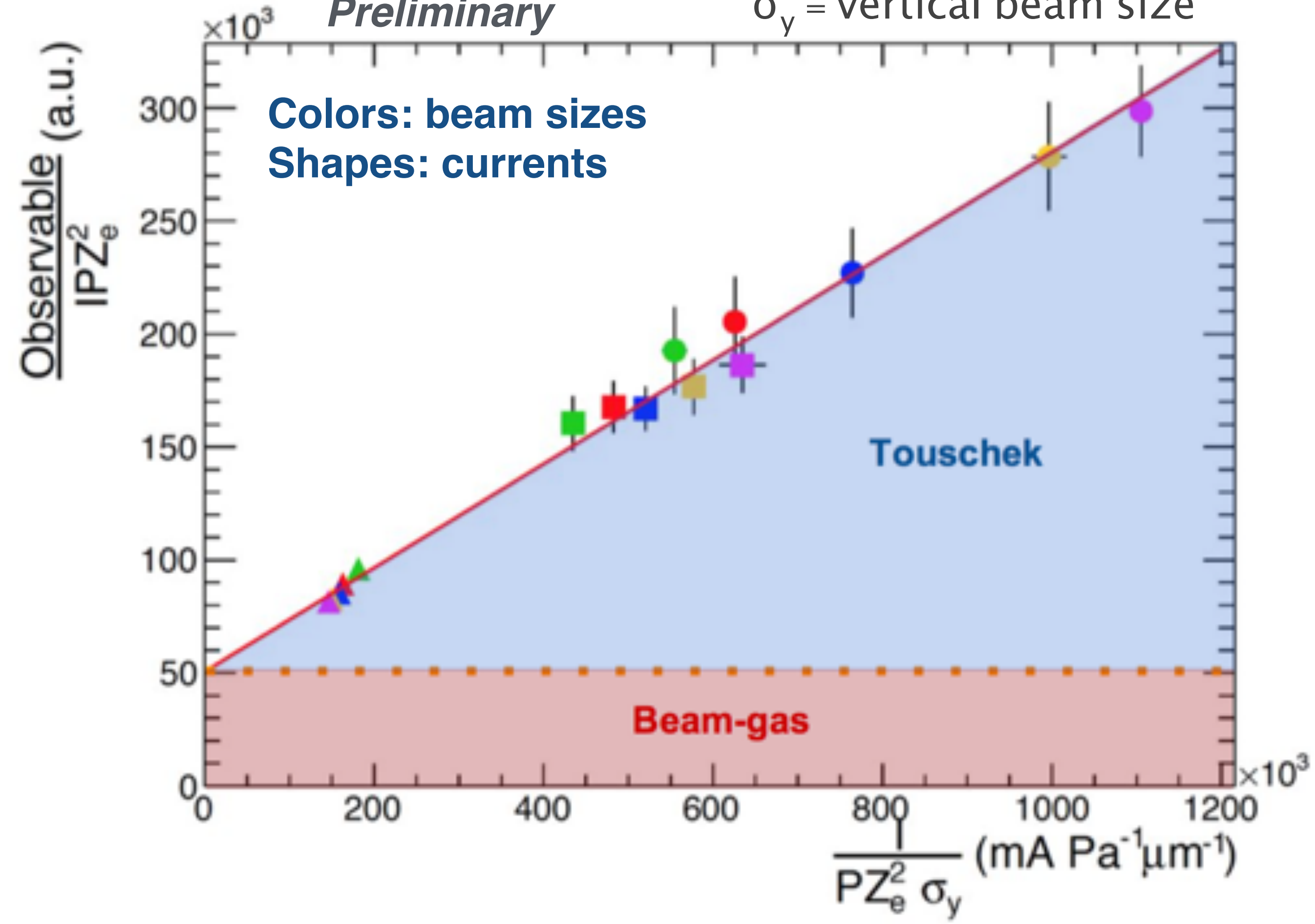


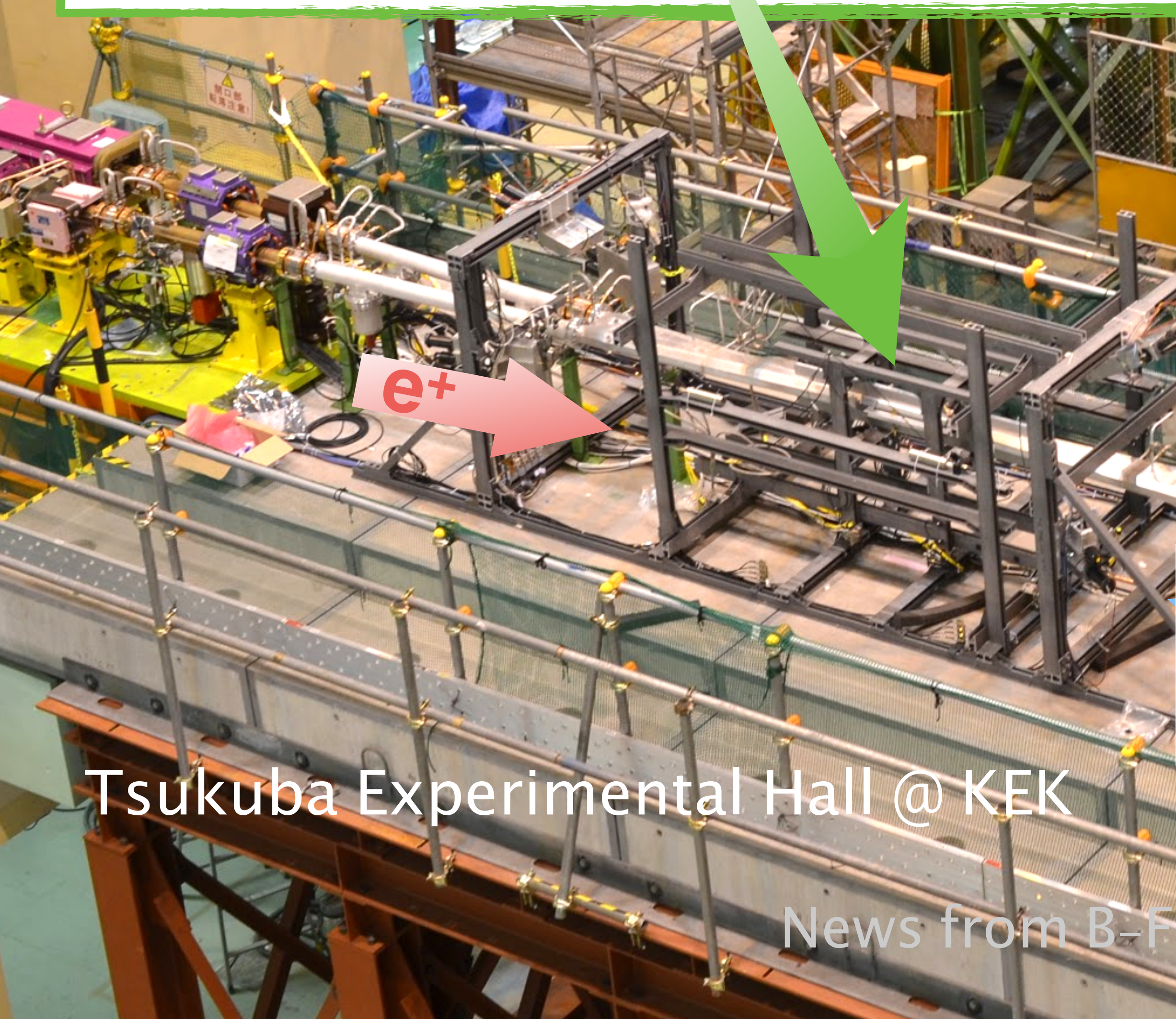
Beam Background



BGO measurements agree well with model

I = beam current
P = pressure
Z_e = effective atomic #
σ_y = vertical beam size

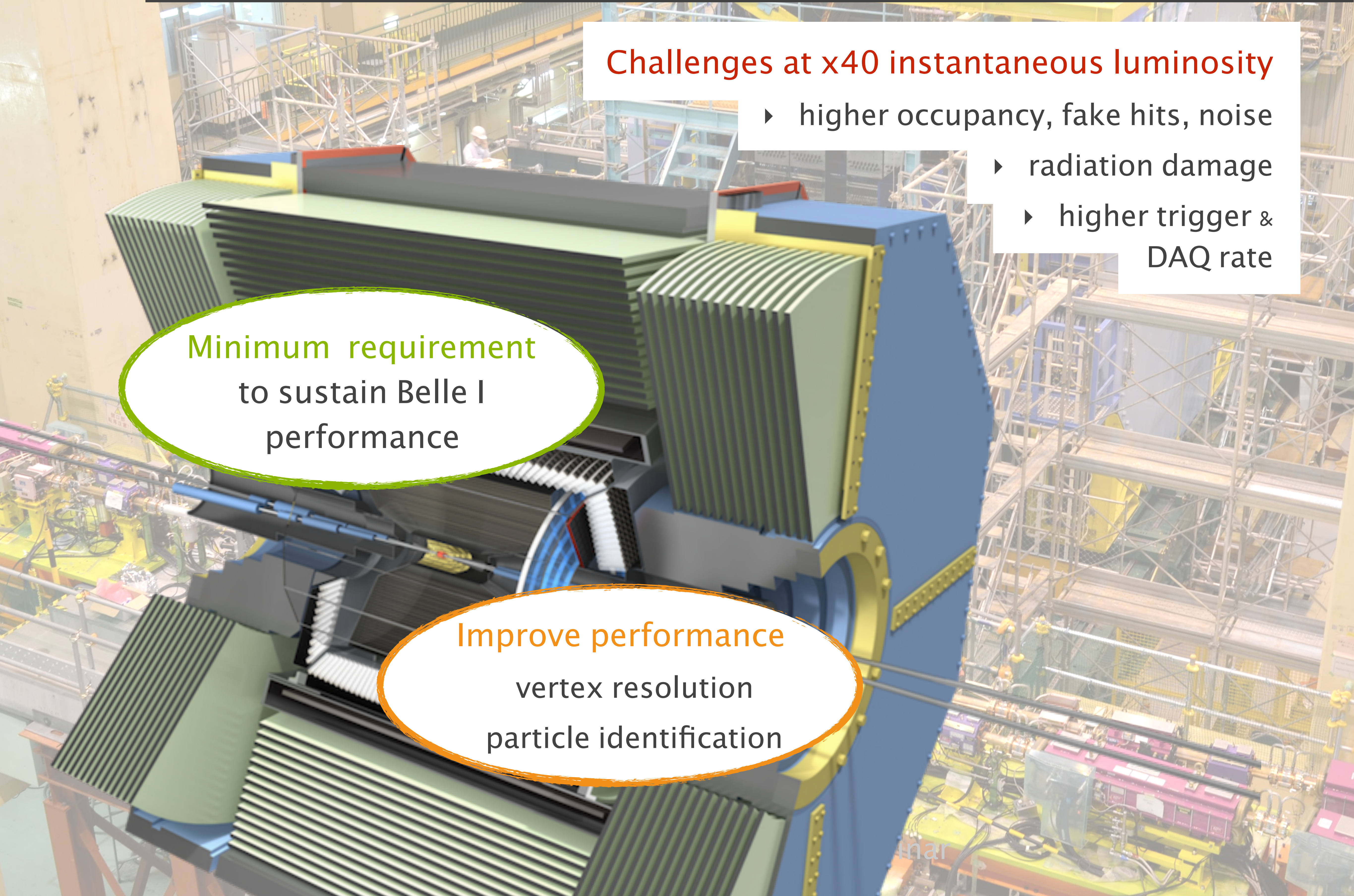




Extensive studies on various measurements
→ 100-page paper on the way

Tsukuba Experimental Hall @ KEK

Belle II Detector



Challenges at x40 instantaneous luminosity

- higher occupancy, fake hits, noise
- radiation damage
- higher trigger & DAQ rate

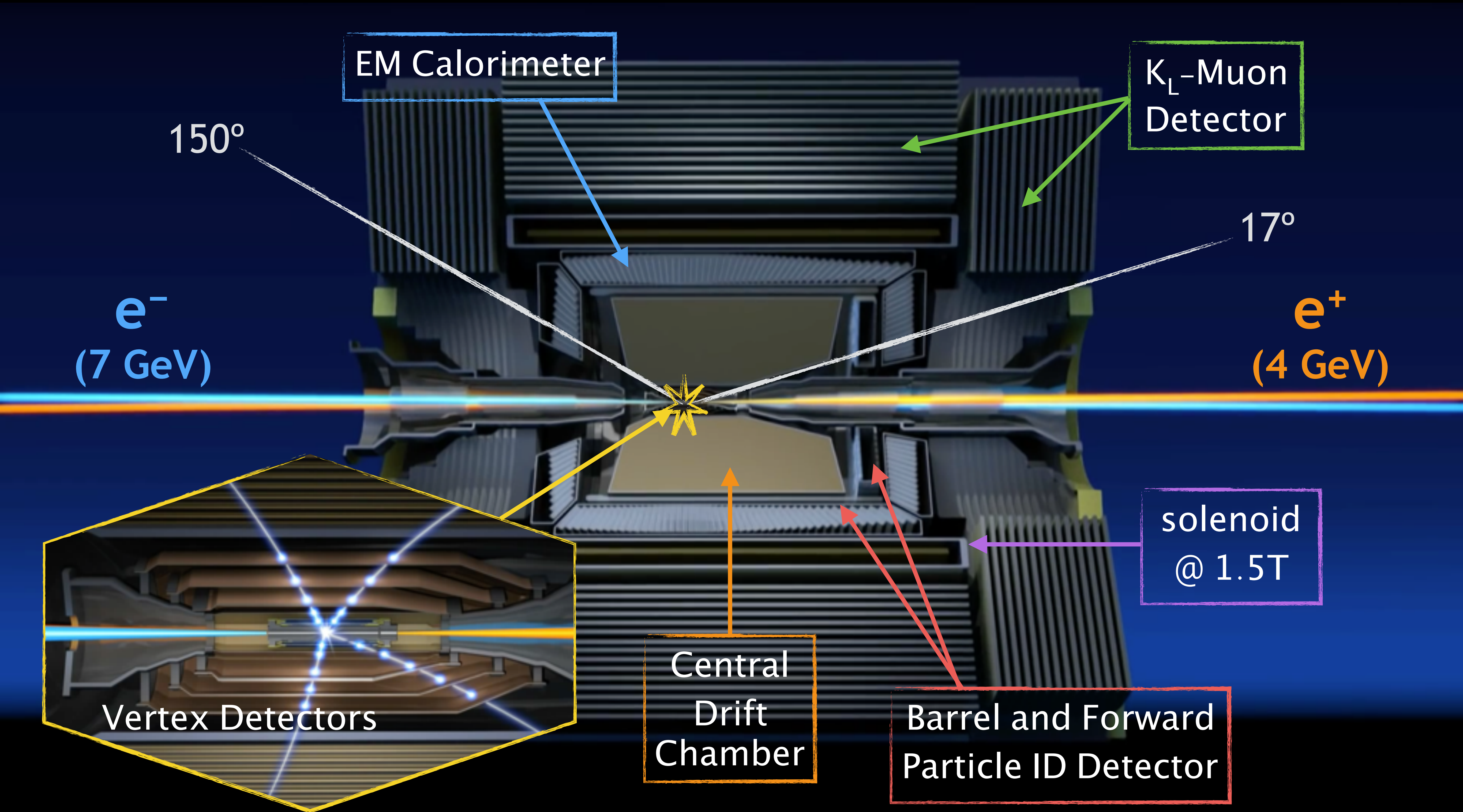
Minimum requirement to sustain Belle I performance

Improve performance

vertex resolution

particle identification

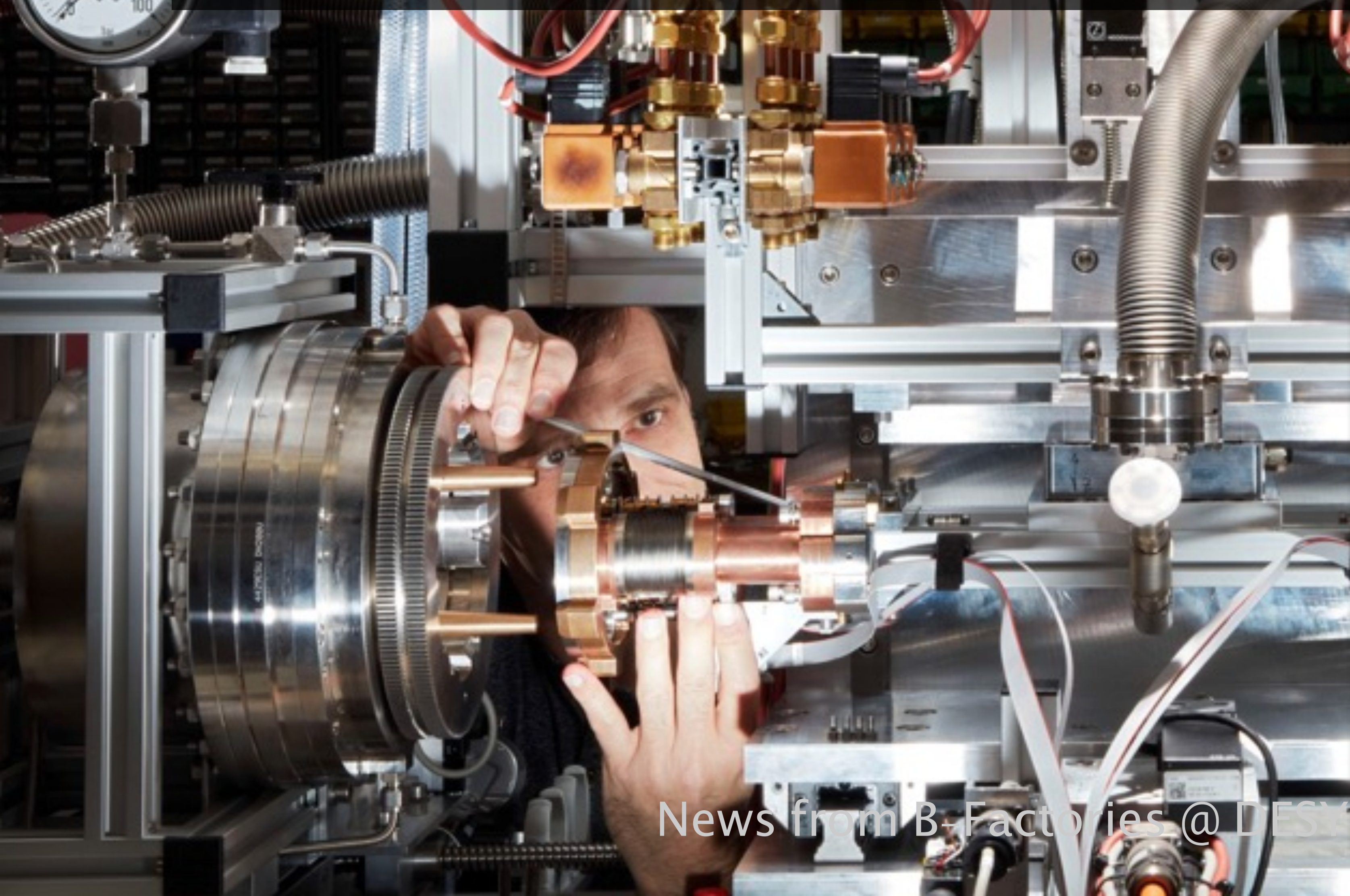
Belle II Detector

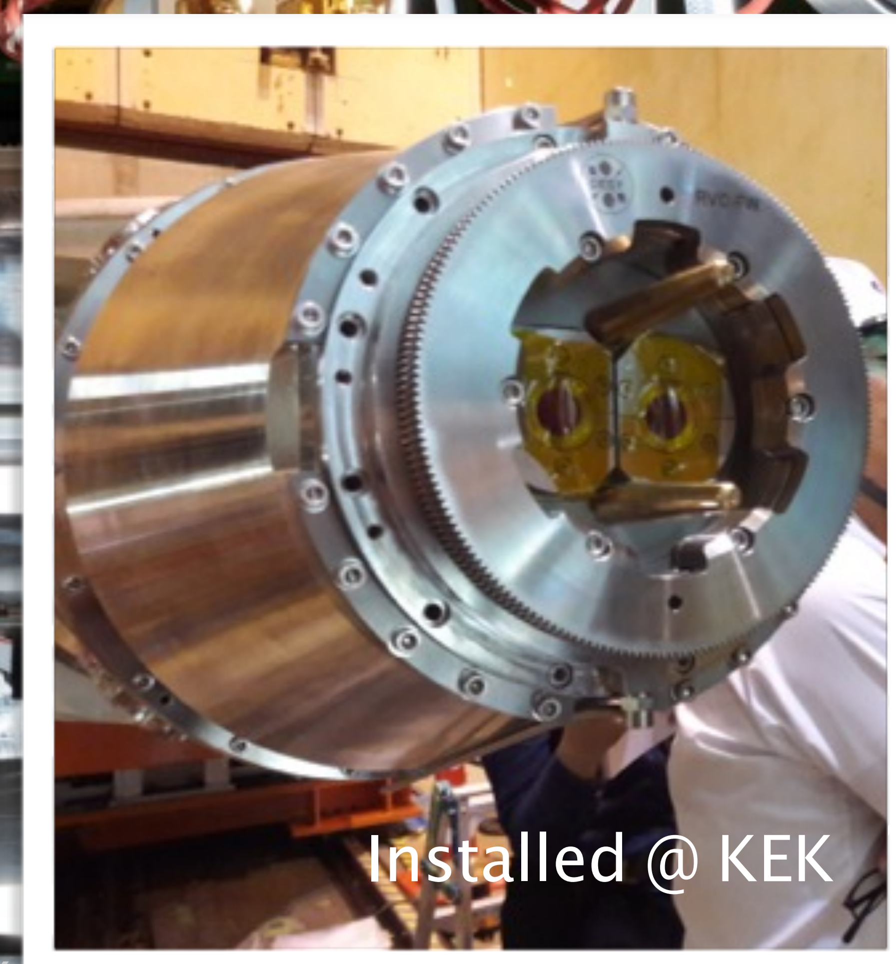


Machine-Detector Interface

- Beam pipe integrated to Vertex Detector
- Limited space around interaction region
- Very complex, remote actuated vacuum coupling joint between beam pipe and rest of the accelerator
- → Remote Vacuum Connection

Designed & built by DESY group

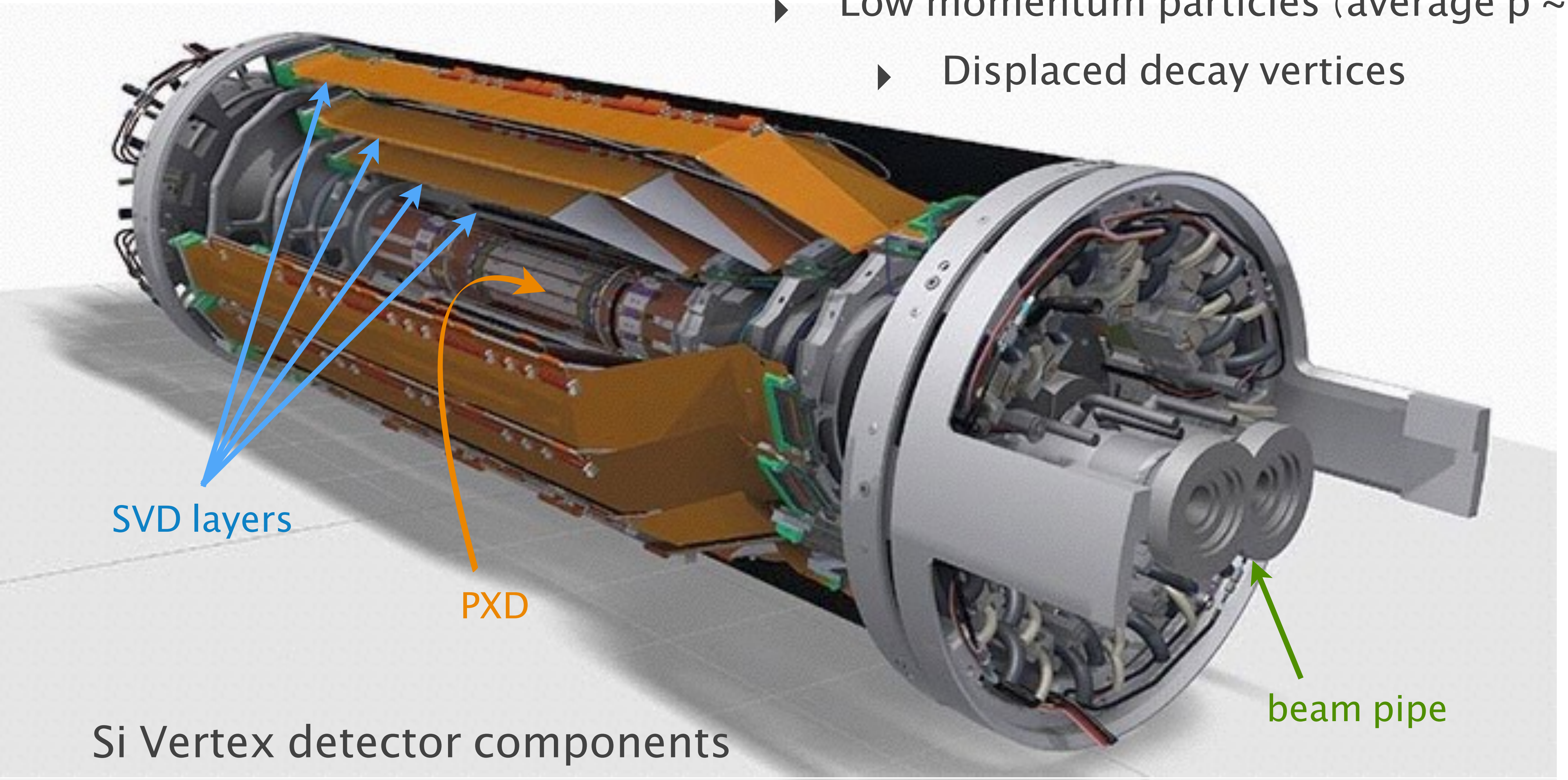




Vertex Detector

Tracking and vertexing at B-factory

- Low momentum particles (average p ~ 500 MeV)
    - Displaced decay vertices



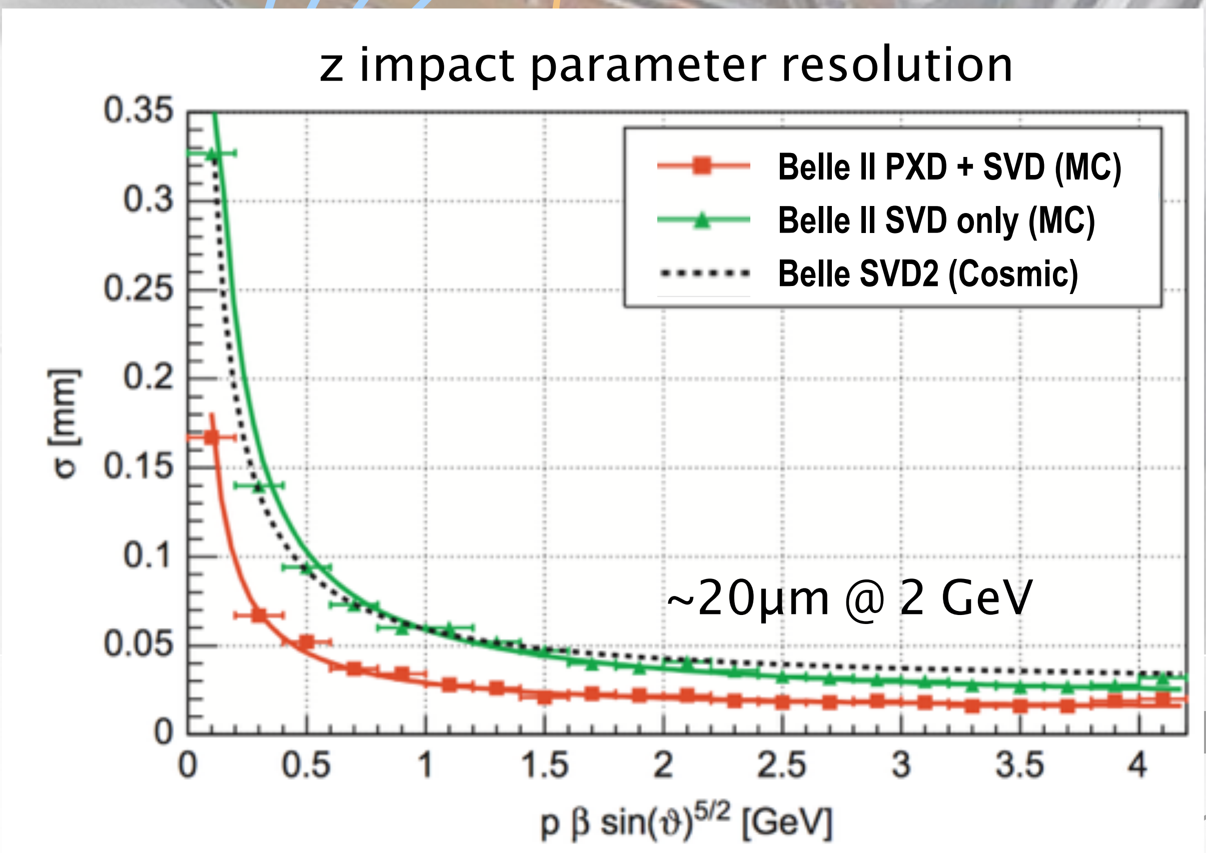
Si Vertex detector components

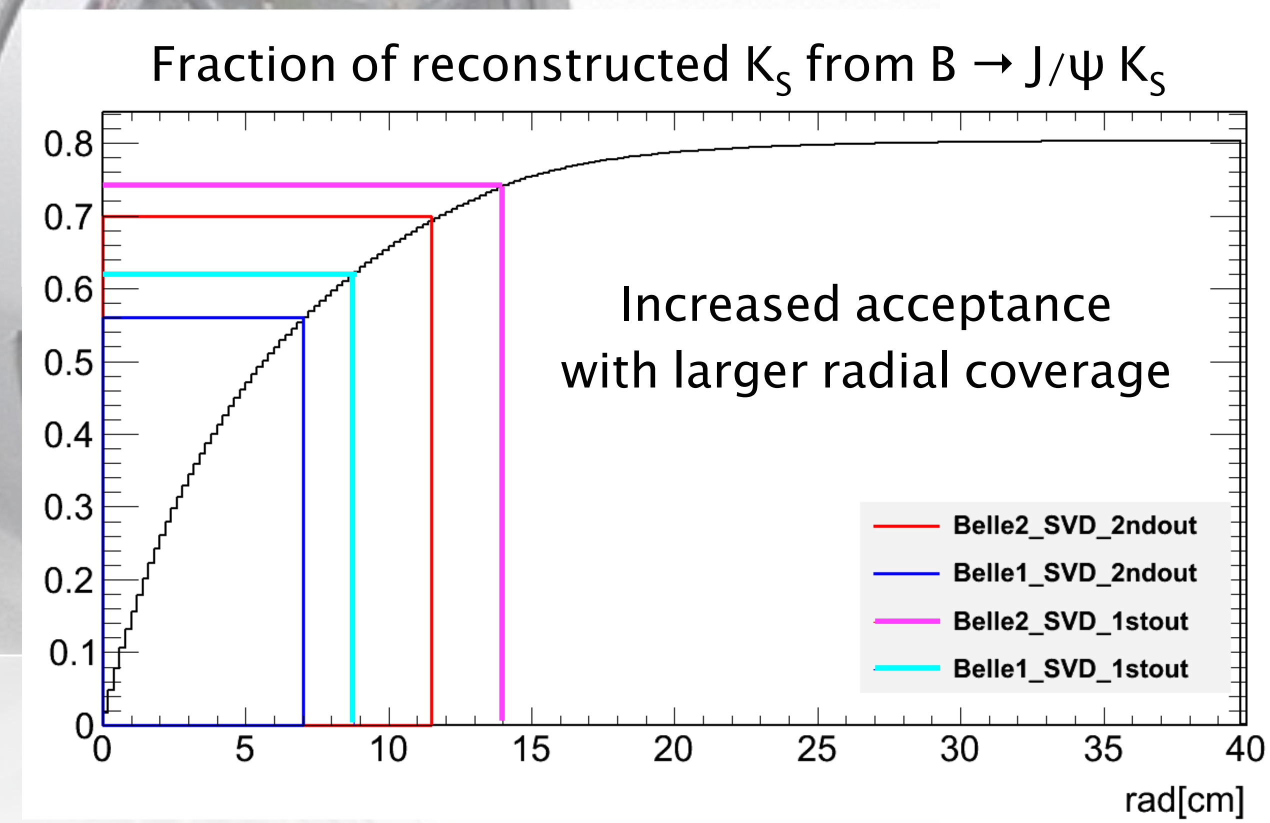
- 2 pixel layers (PXD) close to beam pipe @ r = 1.4 cm, 2.2 cm
- 4 strip layers (SVD) up to r = 140 mm

Vertex Detector

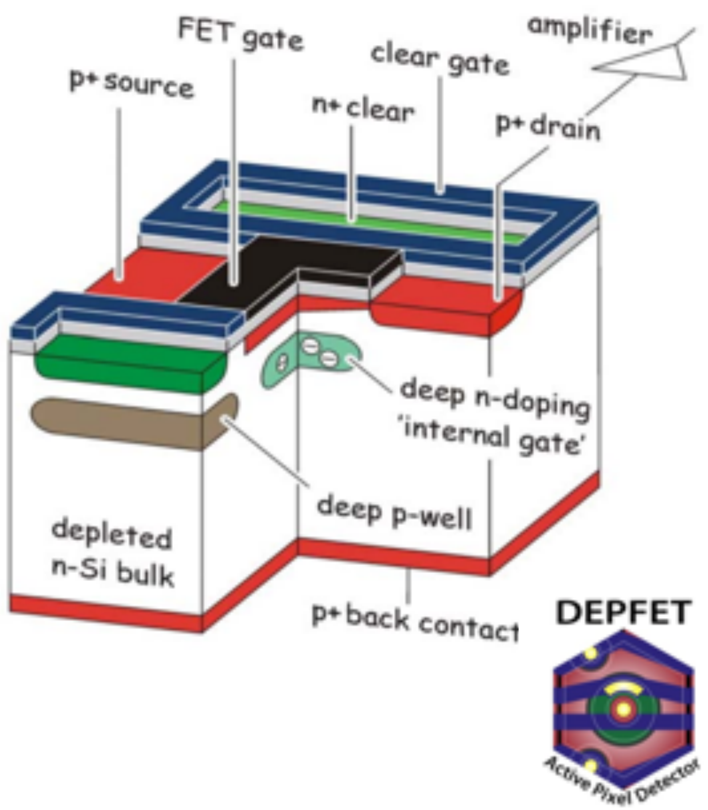
Tracking and vertexing at B-factory

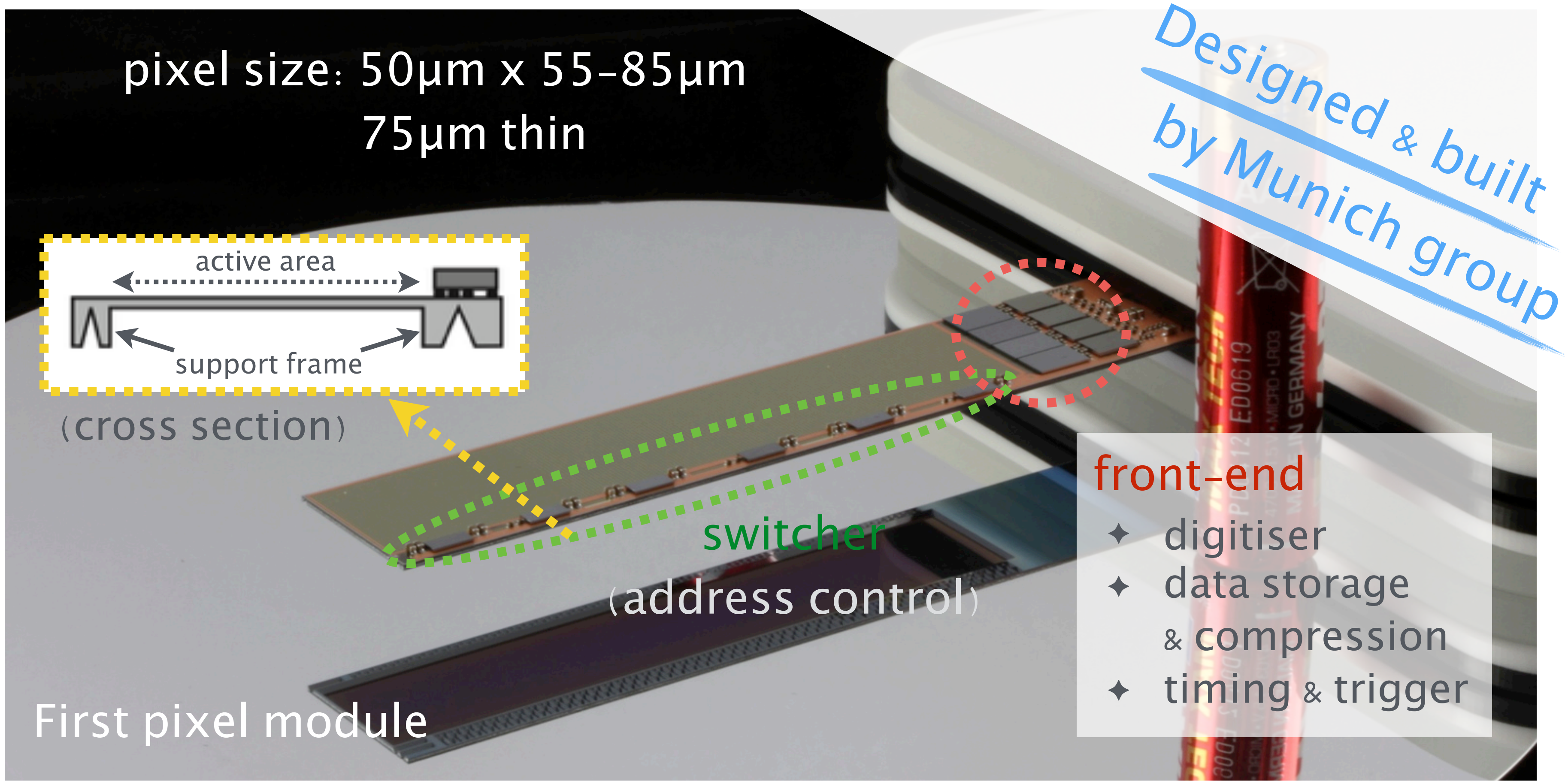
- Low momentum particles (average p ~ 500 MeV)
  - Displaced decay vertices





PXD Technology





DEPFET sensor

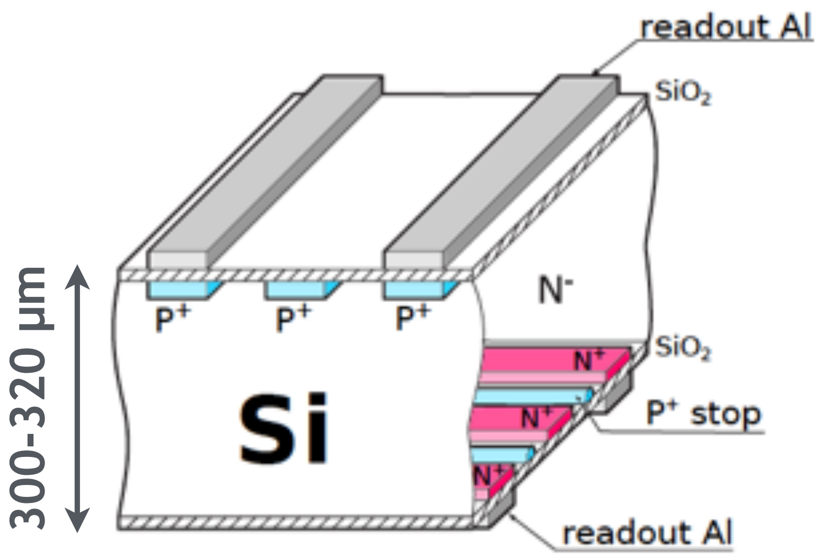
(DEpleted P- Channel Field Effect Transistor)

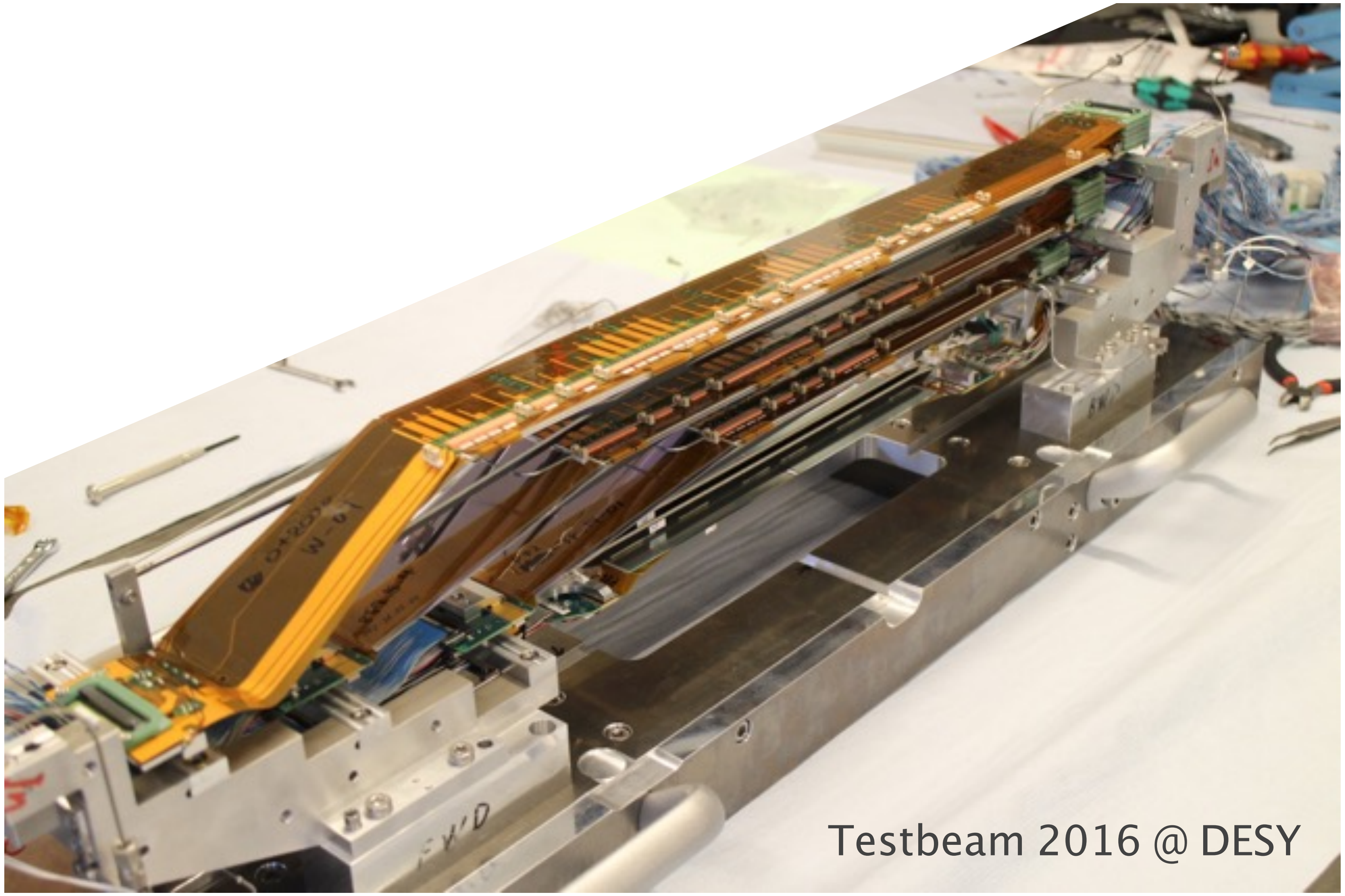
- internal amplification
- low power consumption
- low noise → thin detector possible!

Extremely low material budget

- 0.21% X_0 in the sensitive area
- frame material reduction by etching
- readout electronics outside active volume

SVD Technology





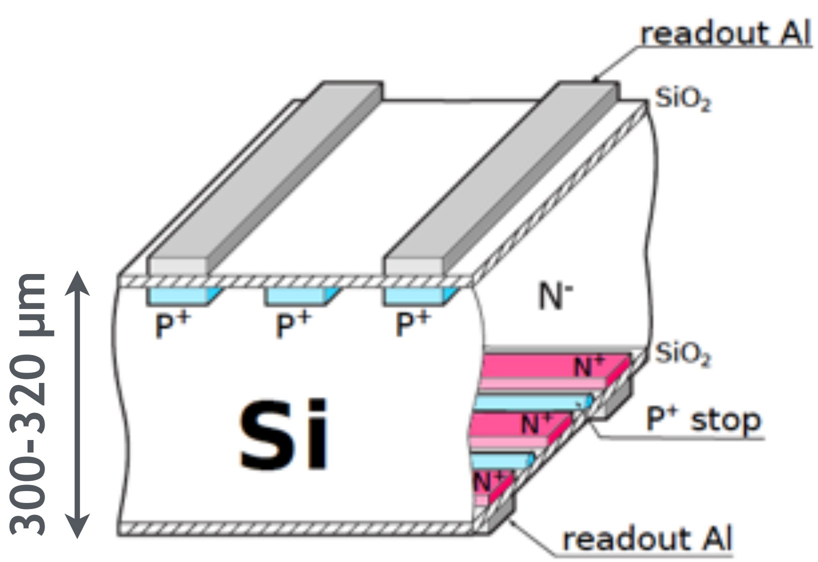
SVD Technology

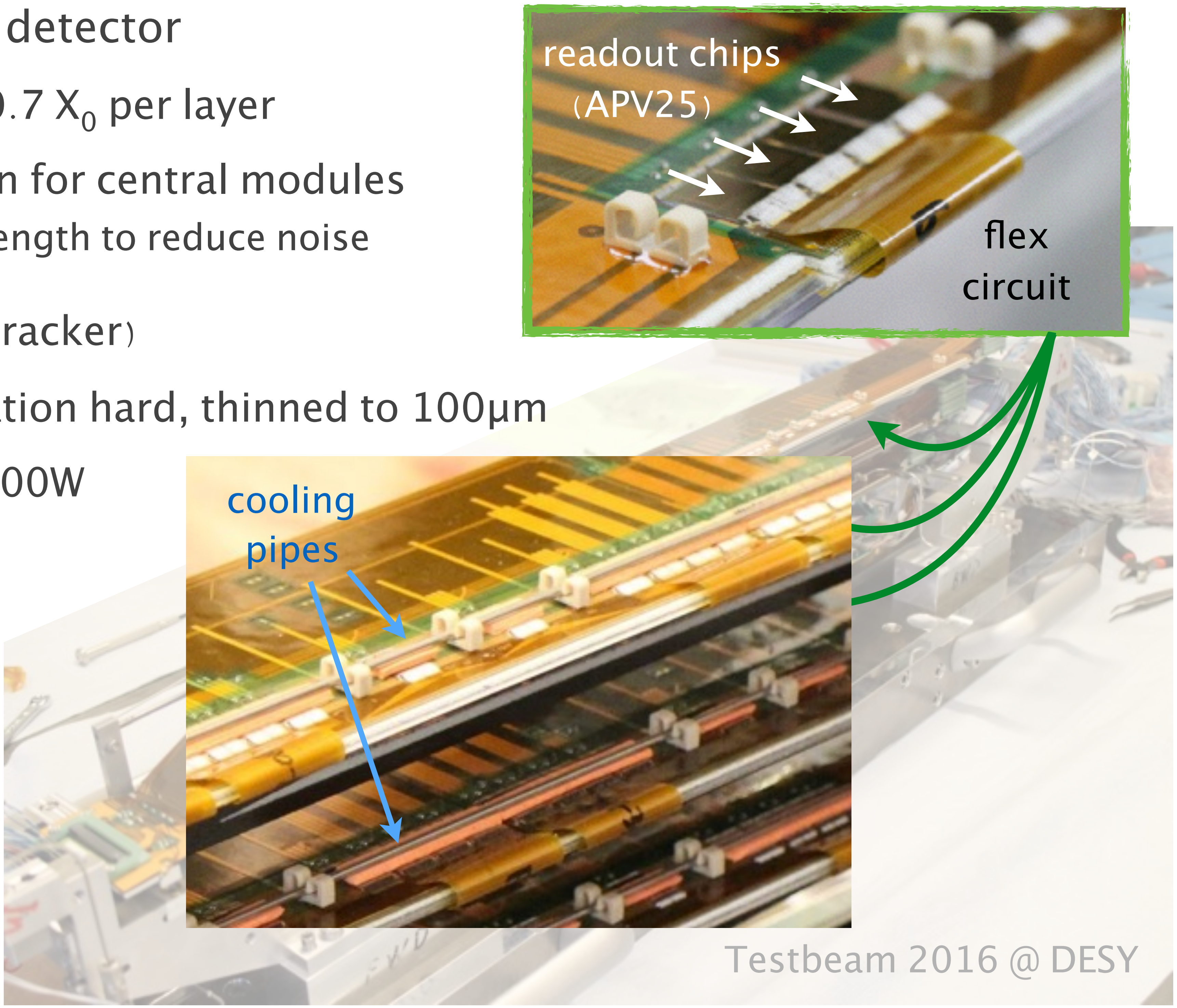
Double-sided Silicon strip detector

- Low material budget ~ 0.7 X_0 per layer
- "Chip-on-sensor" design for central modules
  → minimise analog path length to reduce noise

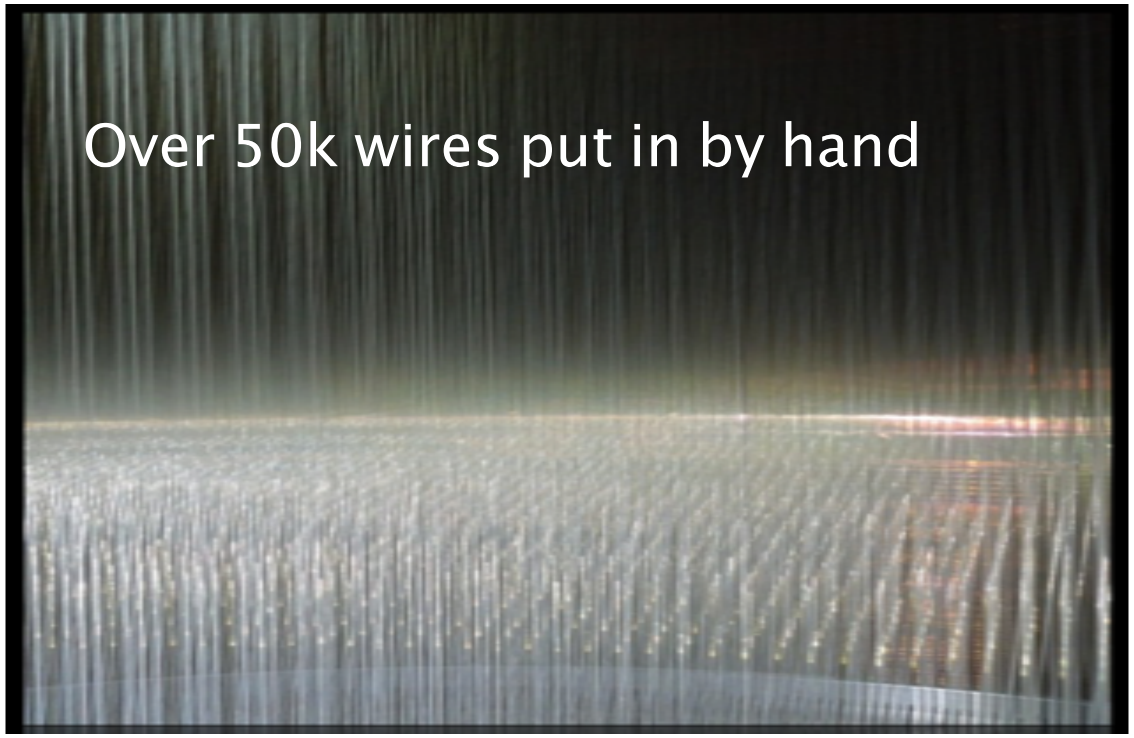
APV25 readout chip (CMS tracker)

- Fast shaping time, radiation hard, thinned to 100µm
- Heat dissipation up to 700W
  → CO_2 cooling

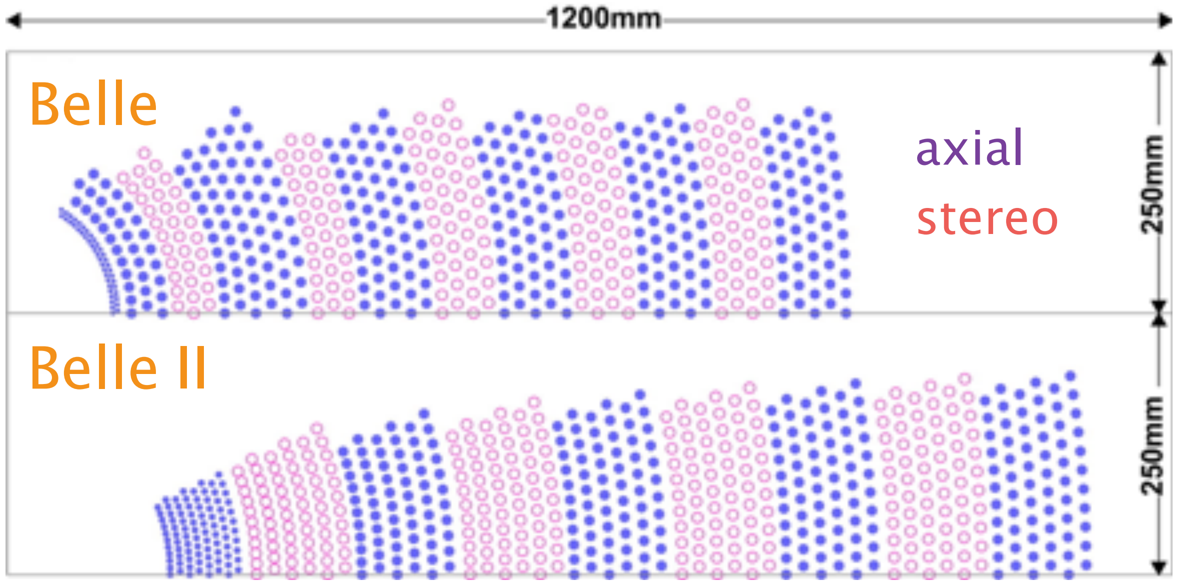




Central Drift Chamber



Inner-most "small cell" chamber and extended radial coverage



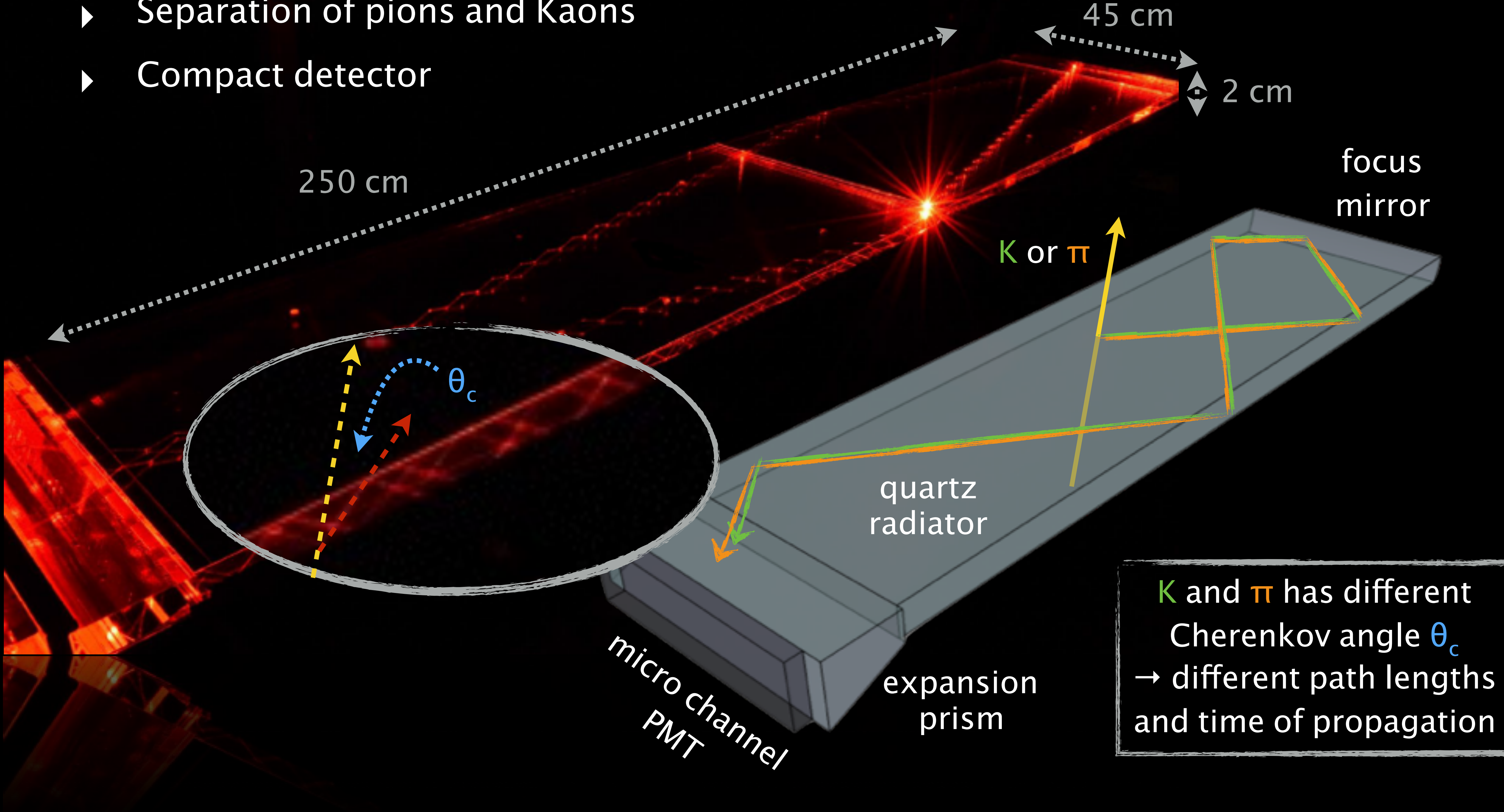
CDC performance

- momentum measurement
  $\sigma p_T/p_T = 0.1\% \cdot p_T \oplus 0.3\%/\beta$ (with VXD)
- dE/dx for particle identification ($\sigma = 5\%$)
- fast electronics (1,2μs → 200ns)

Time Of Propagation

Barrel particle identification using propagation time of Cherenkov light

- Separation of pions and Kaons
- Compact detector

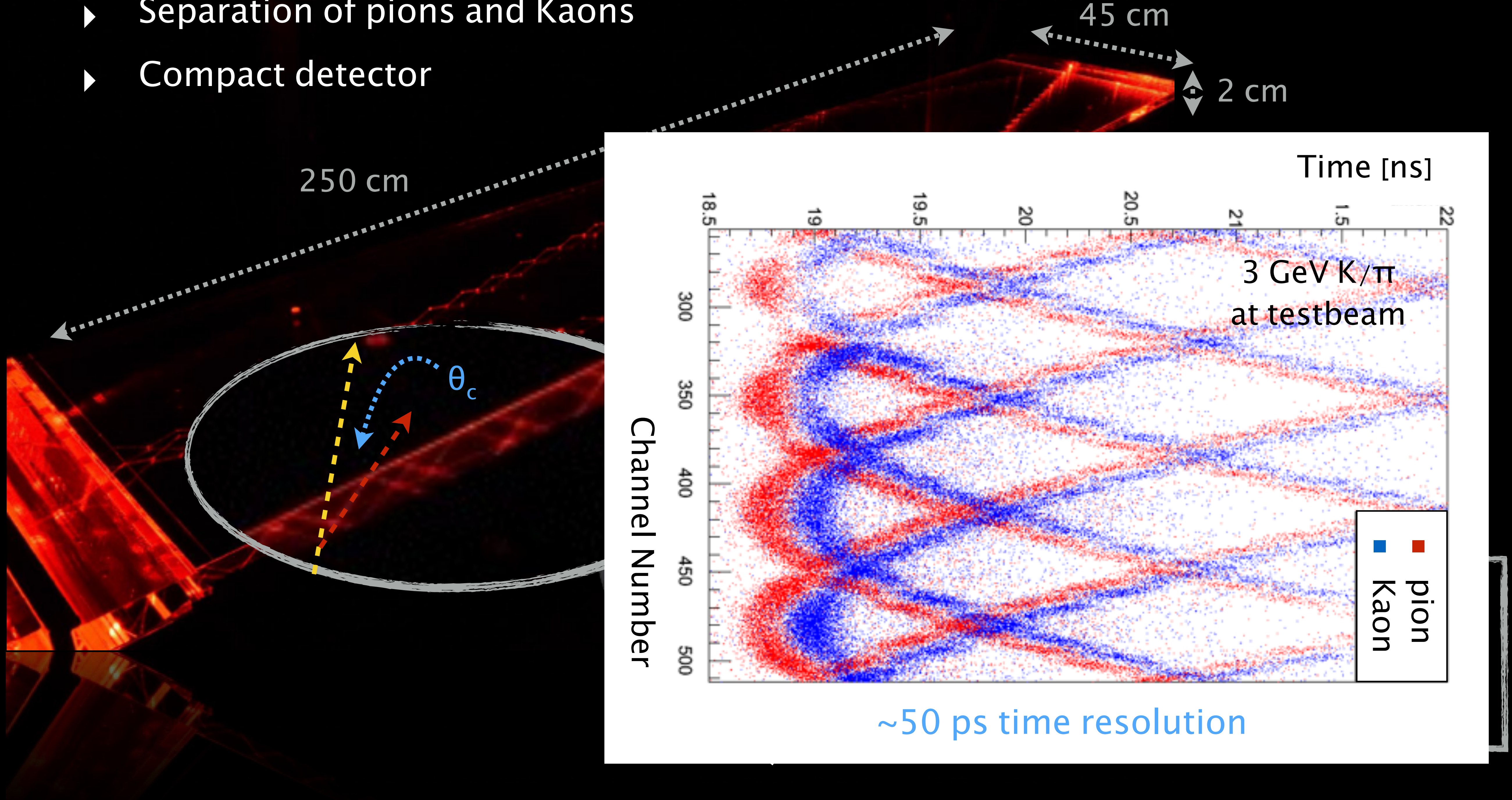


K and π has different Cherenkov angle θ_c
→ different path lengths and time of propagation

Time Of Propagation

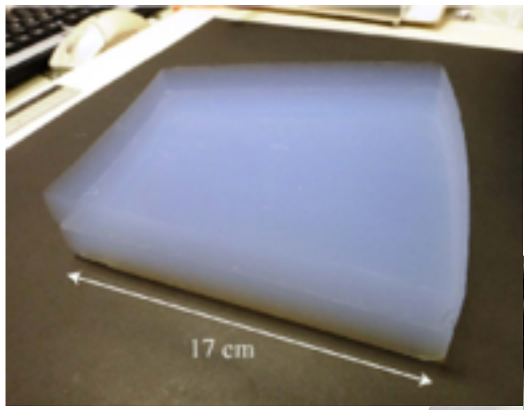
Barrel particle identification using propagation time of Cherenkov light

- Separation of pions and Kaons
- Compact detector

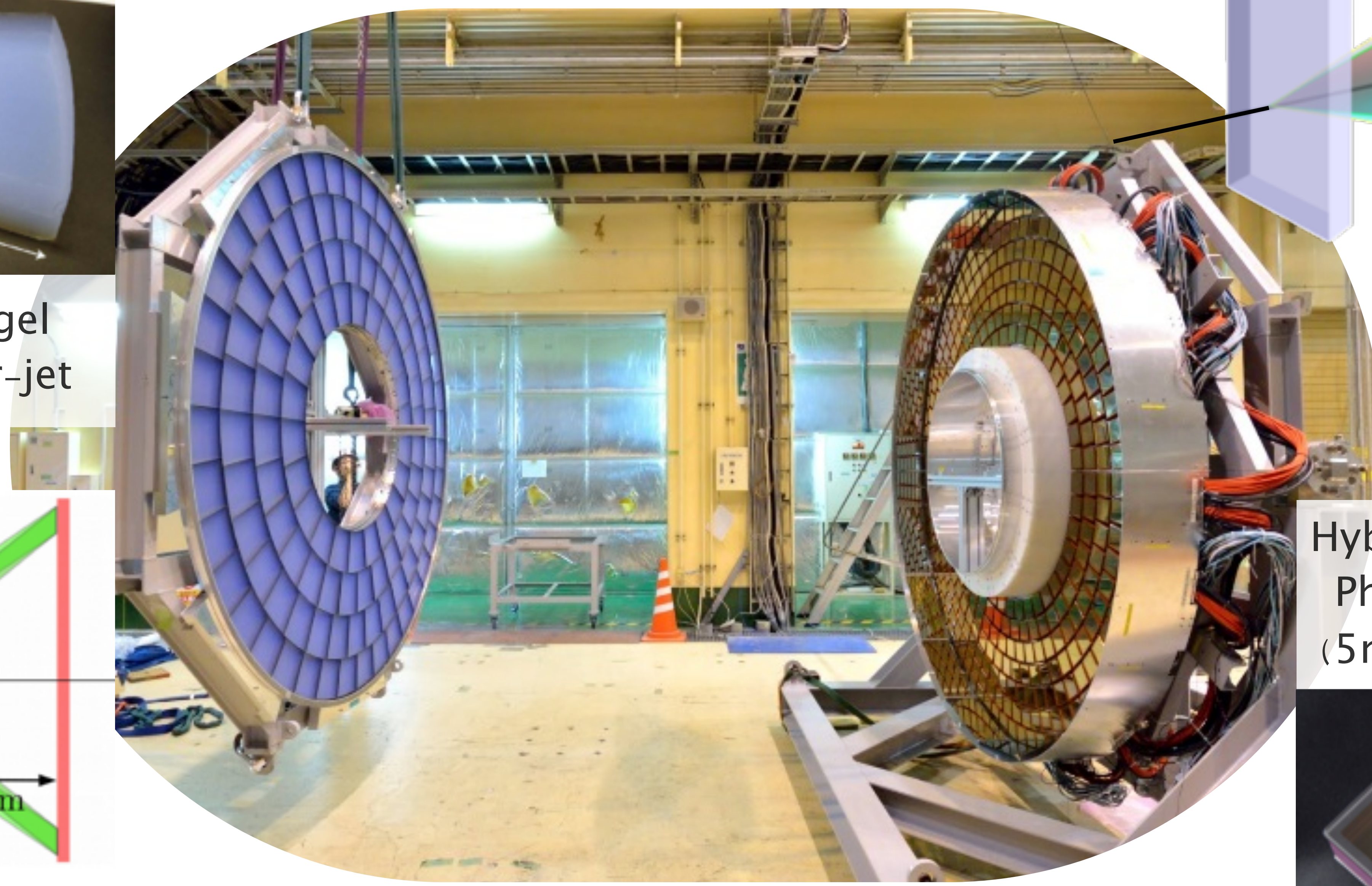


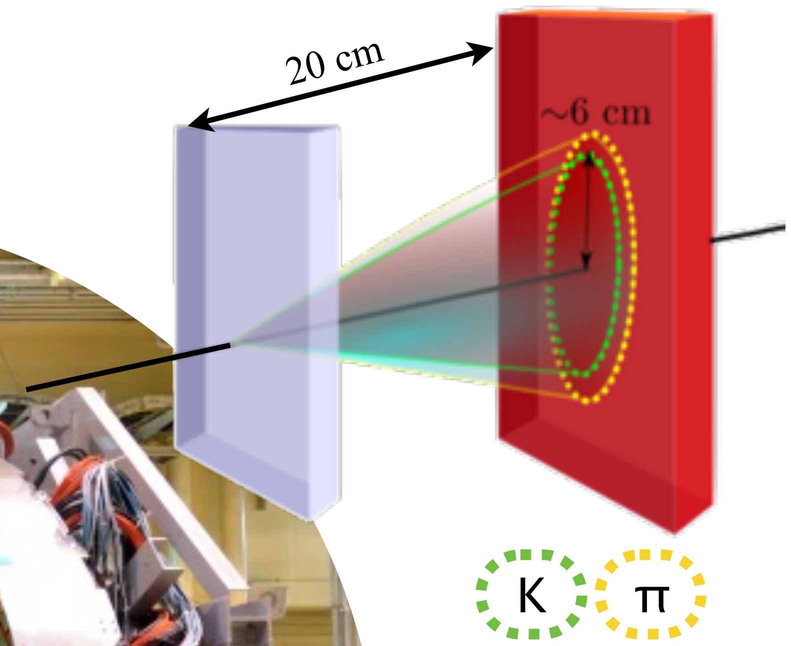
Aerogel RICH

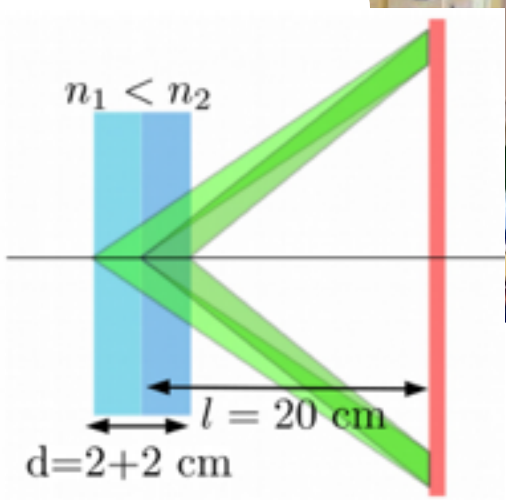
Ring Imaging Cherenkov detector for forward particle ID



Silica Aerogel
cut by water-jet

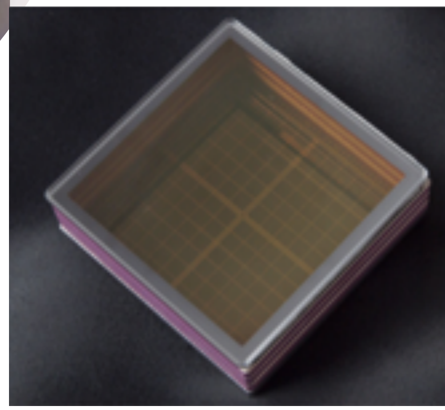






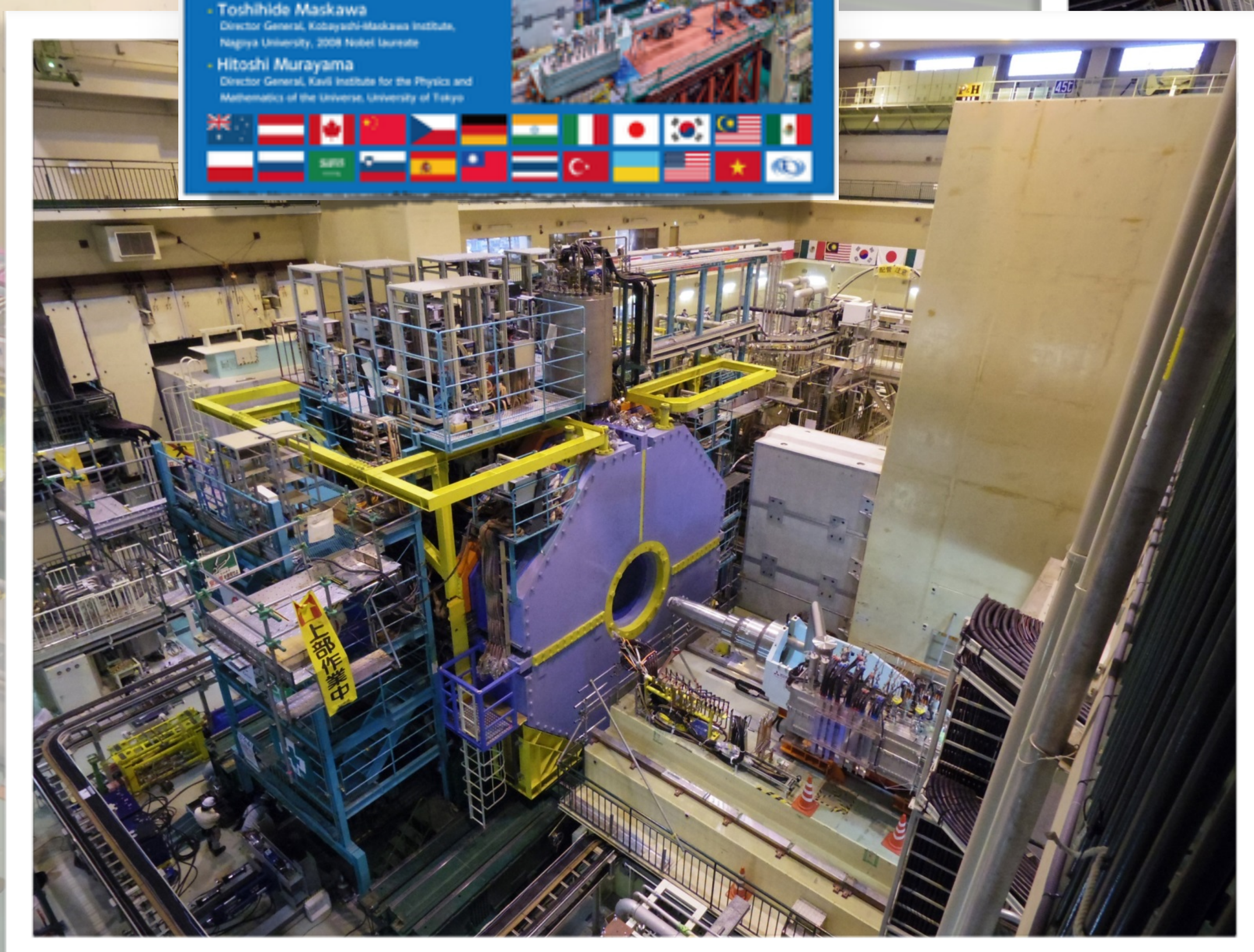
proximity focusing
to increase photon yield

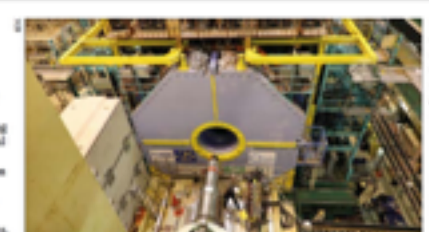
Hybrid Avalanche
Photo Detector
(5mm pixelated)



Commissioning

Belle II Roll-In





INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERNCOURIER

VOLUME 57 NUMBER 5 JUNE 2017

FACILITIES

Belle II rolls in

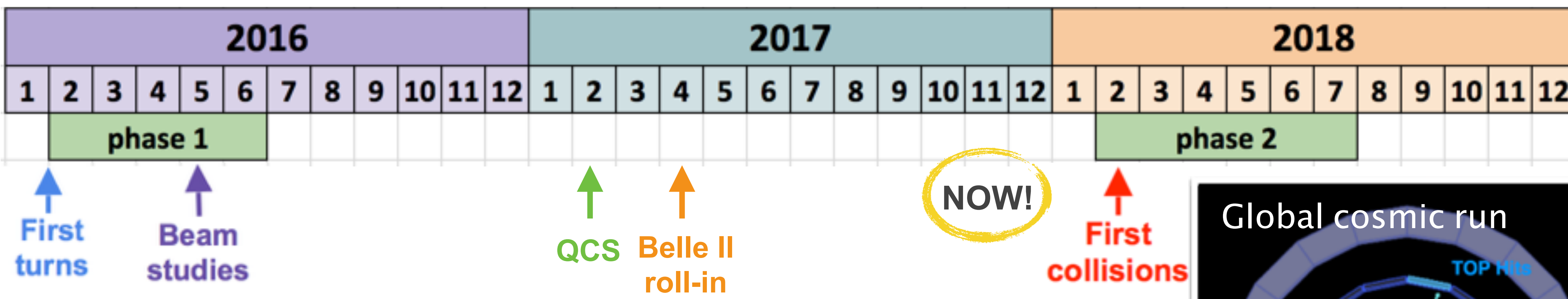
On 11 April, the Belle II detector at the KEK laboratory in Japan was successfully "rolled-in" to the collision point of the upgraded SuperKEKB accelerator, marking an important milestone for the international B-physics community. The Belle II experiment is an international collaboration hosted by KEK in Tsukuba, Japan, with related physics goals to those of the LHCb experiment at CERN but in the pristine environment of electron–positron collisions. It will analyse copious quantities of B mesons to study CP violation and signs of physics beyond the Standard Model (CERN Courier September 2016 p32).

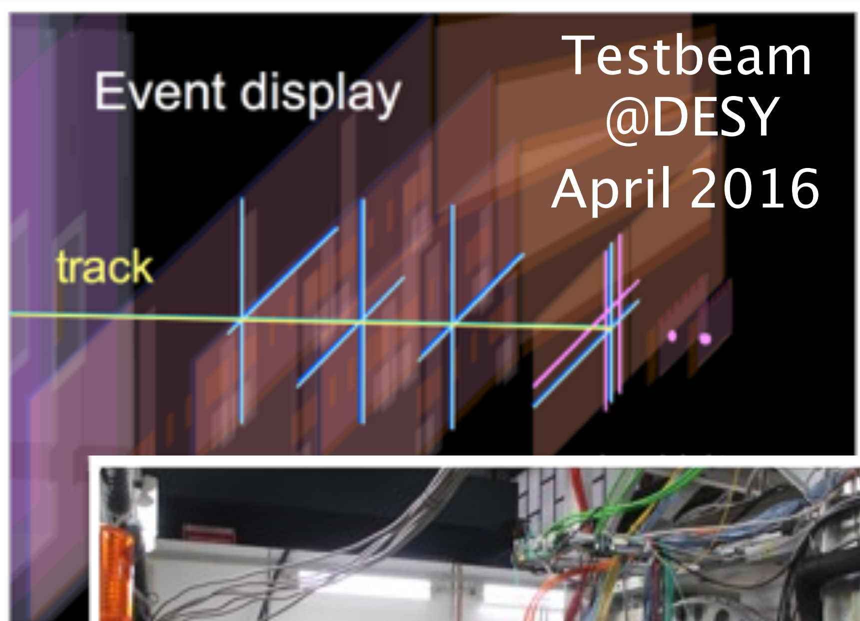
"Roll-in" involves moving the entire 8 m-tall, 1400 tonne Belle II detector system from its assembly area to the beam-collision point 13 m away. The detector is now integrated with SuperKEKB and all its seven subdetectors, except for the innermost vertex detector, are in place. The next step is to install the complex focusing magnets around the Belle II interaction point. SuperKEKB achieved its first turns in February 2016, with operation of the main rings scheduled for early spring and phase-III "physics" operation by the end of 2018.

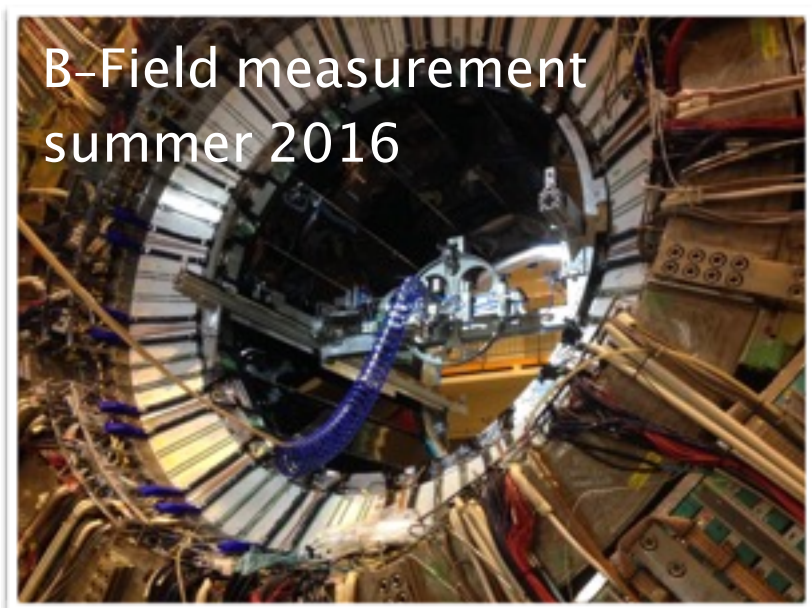
Compared to the previous Belle experiment, and thanks to major upgrades made to the former KEKB collider, Belle II will allow much larger data samples to be collected with much improved precision. "After six years of gruelling work with many unexpected twists and turns, it was a moving and gratifying experience for everyone on the team to watch the Belle II detector move to the interaction point," says Belle II spokesperson Tom Browder. "Flavour physics is now the focus of much attention and interest in the community and Belle II will play a critical role in the years to come."

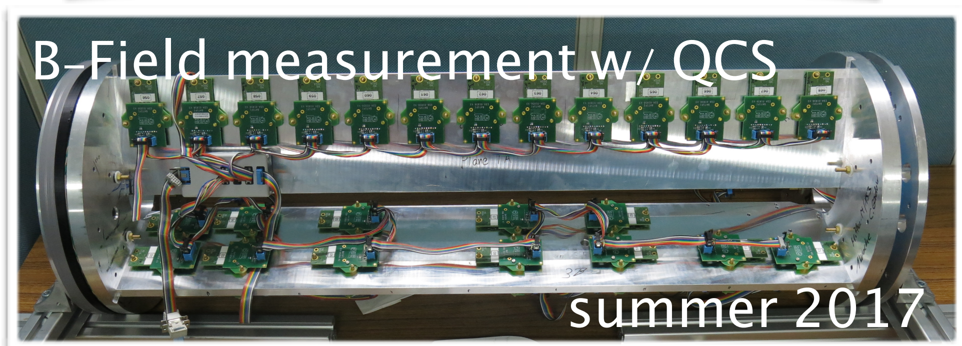
The Belle II detector is now in place at the SuperKEKB facility in Japan.

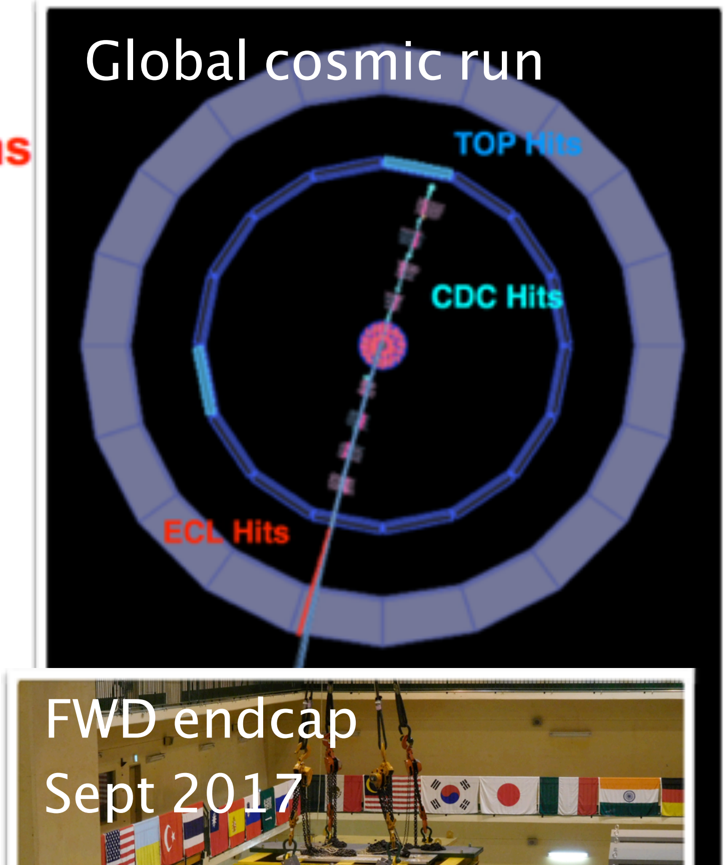
Commissioning



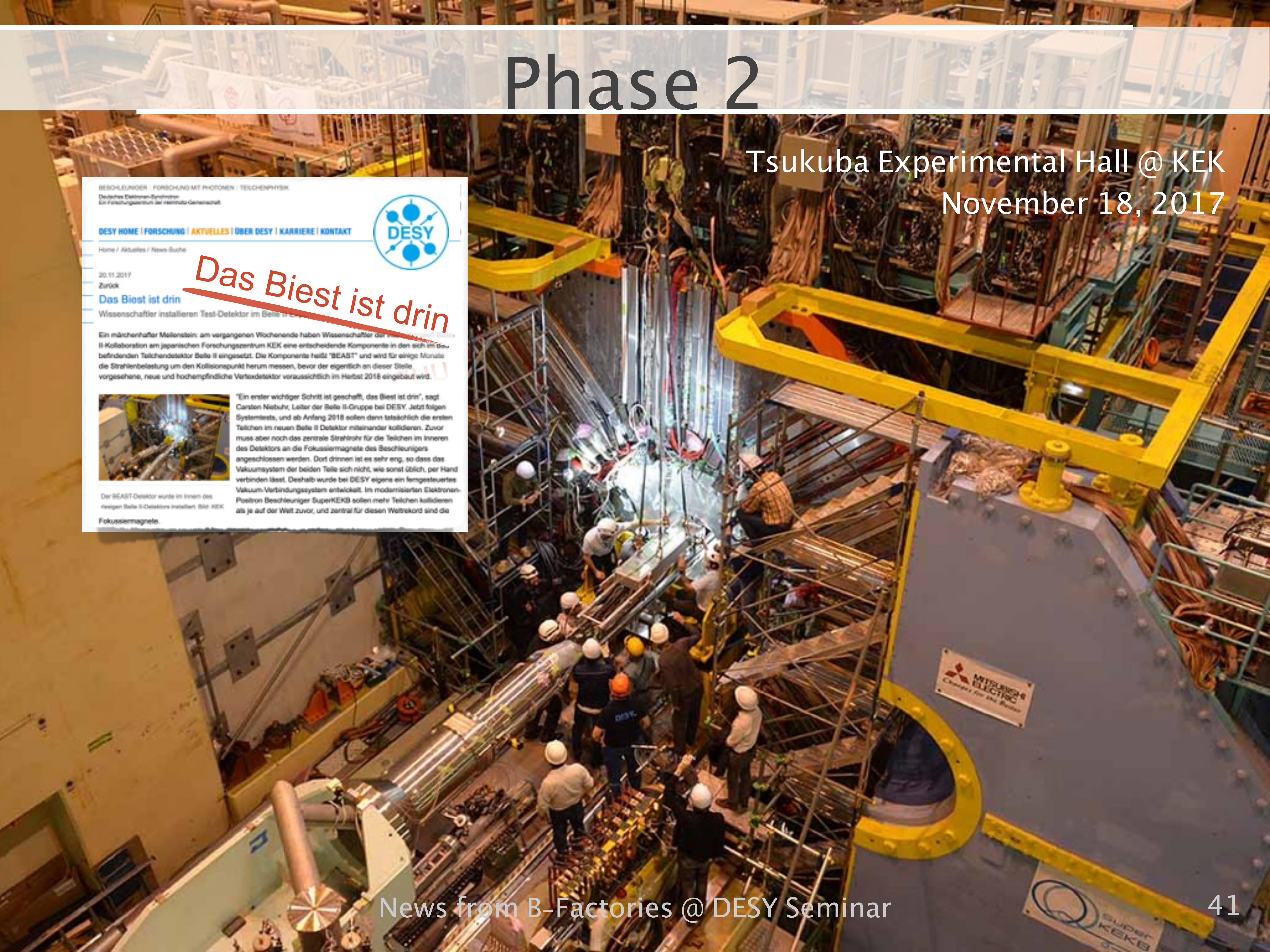








Phase 2



BESCHLEUNIGER | FORSCHUNG MIT PHOTONEN | TEILCHENPHYSIK

Deutsches Elektronen-Synchrotron
Ein Forschungszentrum der Helmholtz-Gemeinschaft

DESY HOME | FORSCHUNG | AKTUELLES | ÜBER DESY | KARRIERE | KONTAKT

Home / Aktuelles / News-Suche

20.11.2017

Zurück

Das Biest ist drin

Wissenschaftler installieren Test-Detektor im Belle [illegible]

Ein märchenhafter Meilenstein: am vergangenen Wochenende haben Wissenschaftler der [illegible] Belle II-Kollaboration am japanischen Forschungszentrum KEK eine entscheidende Komponente in den sich im Bau befindenden Teilchendetektor Belle II eingesetzt. Die Komponente heißt "BEAST" und wird für einige Monate die Strahlenbelastung um den Kollisionspunkt herum messen, bevor der eigentlich an dieser Stelle vorgesehene, neue und hochempfindliche Vertexdetektor voraussichtlich im Herbst 2018 eingebaut wird.

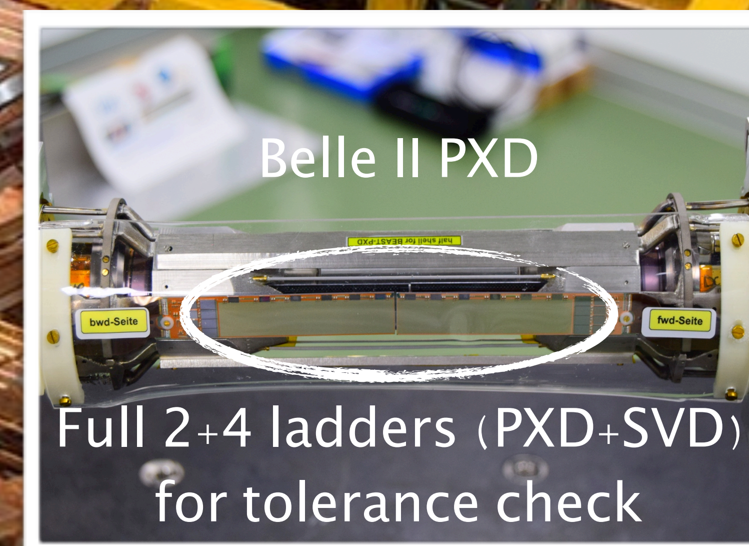
Der BEAST-Detektor wurde im Innern des riesigen Belle II-Detektors installiert. Bild: KEK

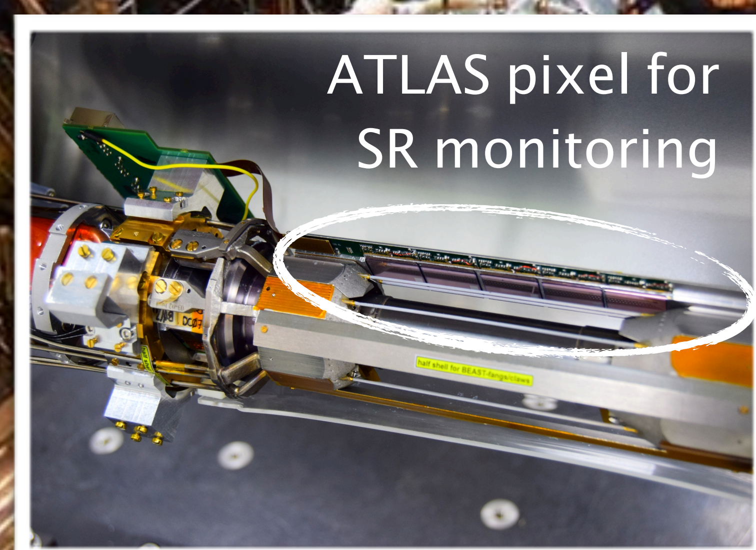
"Ein erster wichtiger Schritt ist geschafft, das Biest ist drin", sagt Carsten Niebuhr, Leiter der Belle II-Gruppe bei DESY. Jetzt folgen Systemtests, und ab Anfang 2018 sollen dann tatsächlich die ersten Teilchen im neuen Belle II Detektor miteinander kollidieren. Zuvor muss aber noch das zentrale Strahlrohr für die Teilchen im Inneren des Detektors an die Fokussiermagnete des Beschleunigers angeschlossen werden. Dort drinnen ist es sehr eng, so dass das Vakuumsystem der beiden Teile sich nicht, wie sonst üblich, per Hand verbinden lässt. Deshalb wurde bei DESY eigens ein ferngesteuertes Vakuum-Verbindungssystem entwickelt. Im modernisierten Elektronen-Positron Beschleuniger SuperKEKB sollen mehr Teilchen kollidieren als je auf der Welt zuvor, und zentral für diesen Weltrekord sind die Fokussiermagnete.

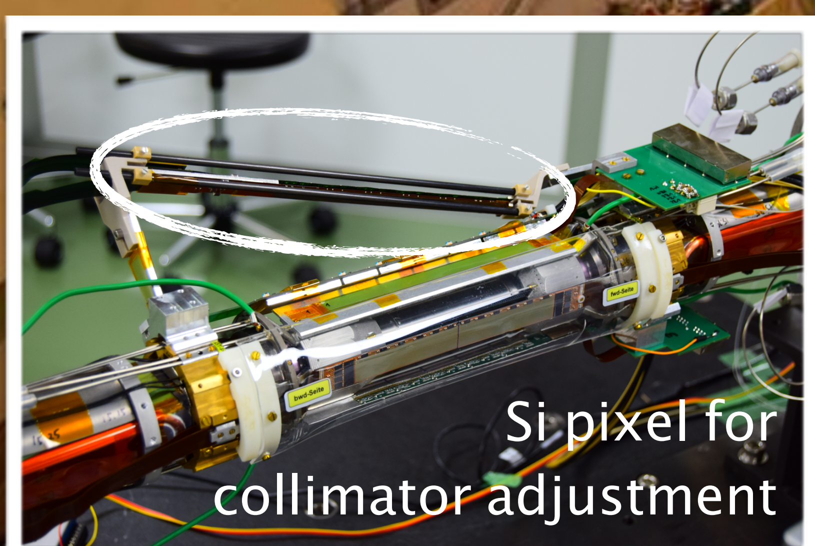
Phase 2


SuperKEKB Commissioning Detector
BEAST II
Phase II


Beam loss monitor
(diamond)

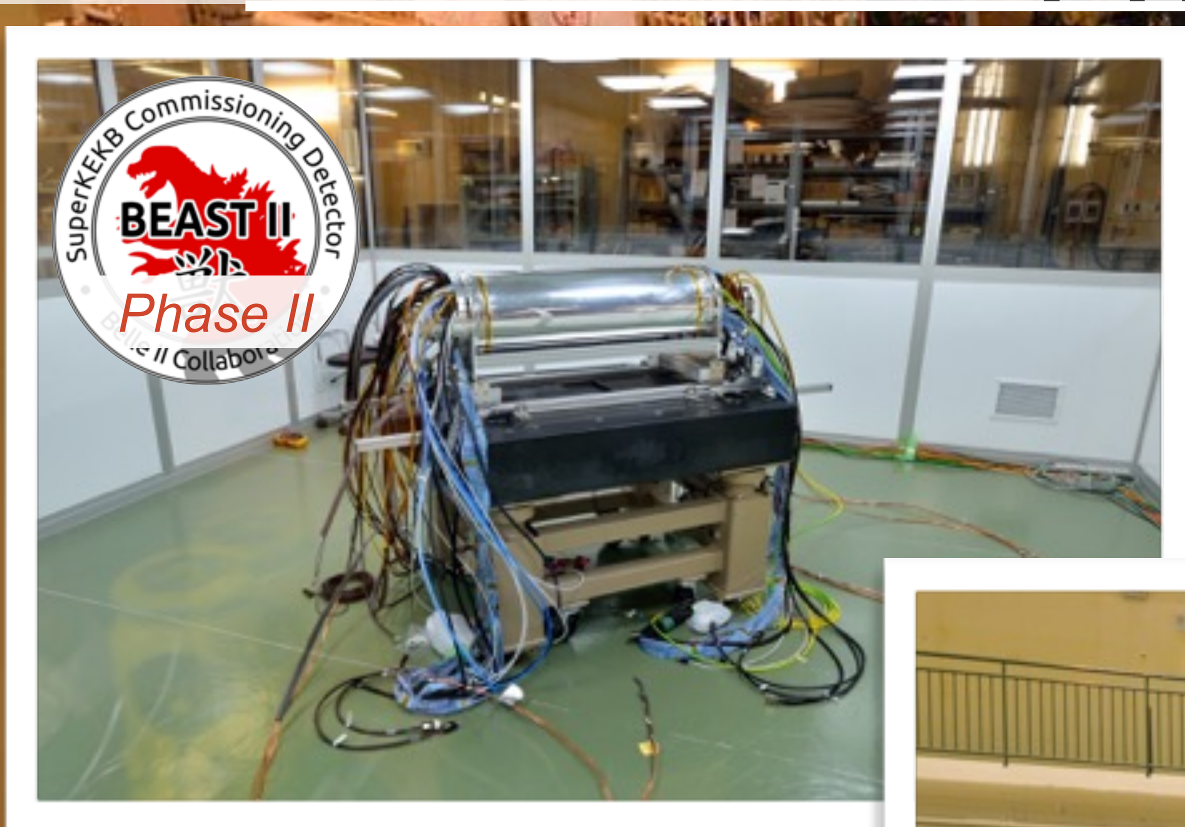

Belle II PXD
Full 2+4 ladders (PXD+SVD)
for tolerance check


ATLAS pixel for
SR monitoring

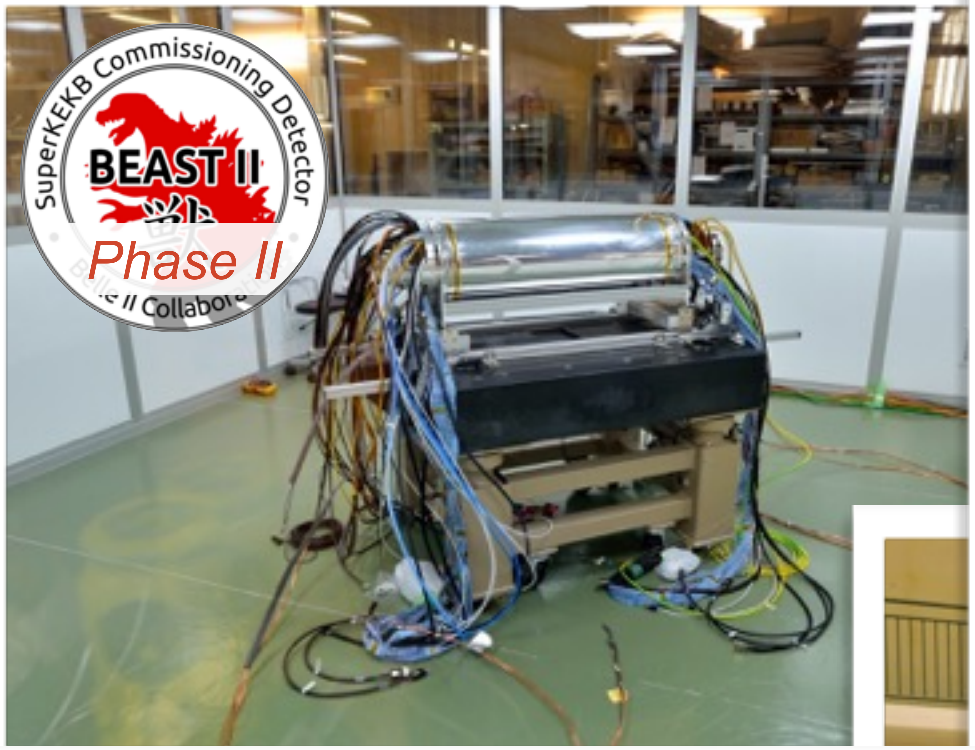

Si pixel for
collimator adjustment

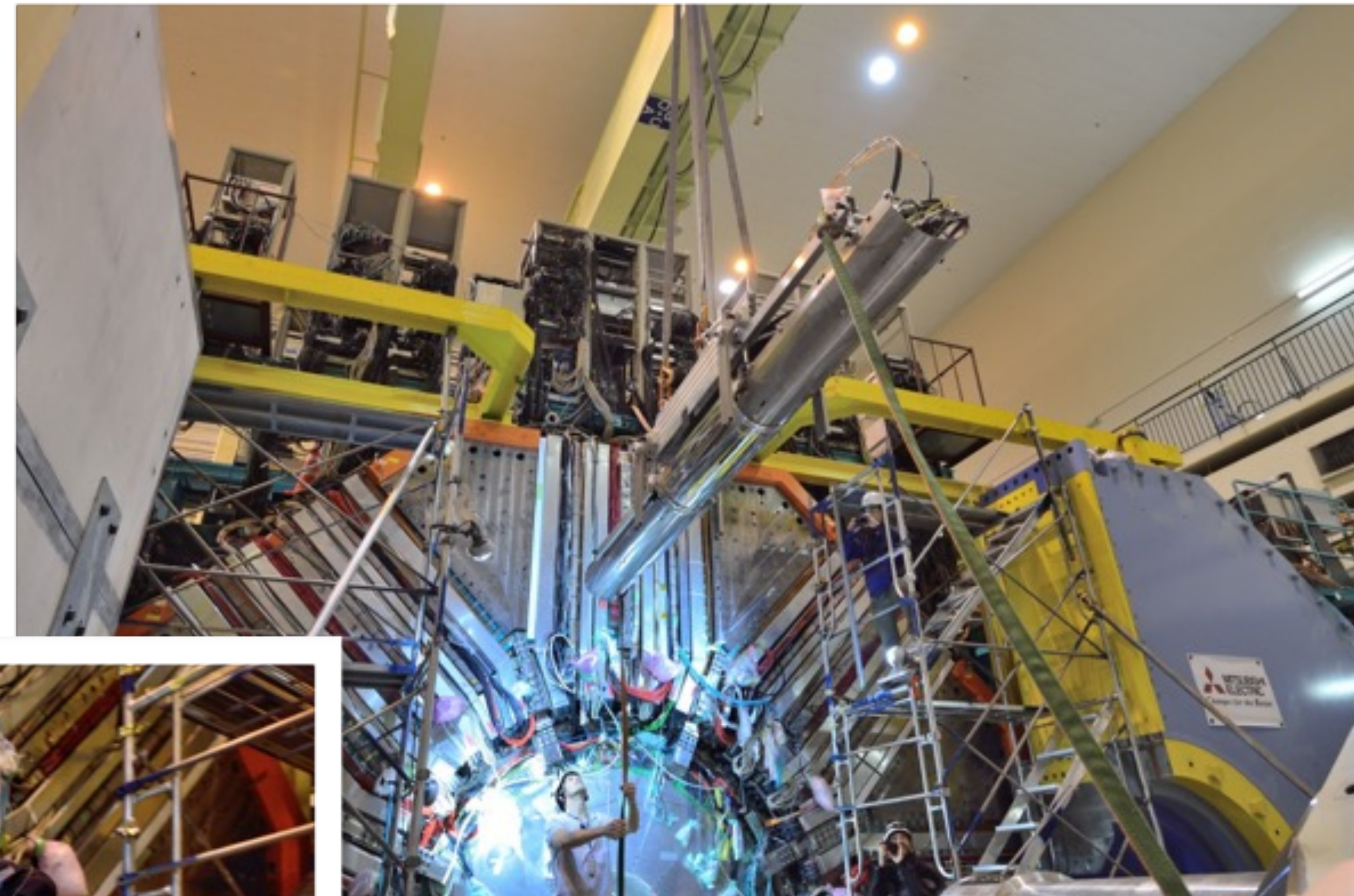

Scintillators for
injection background

Phase 2

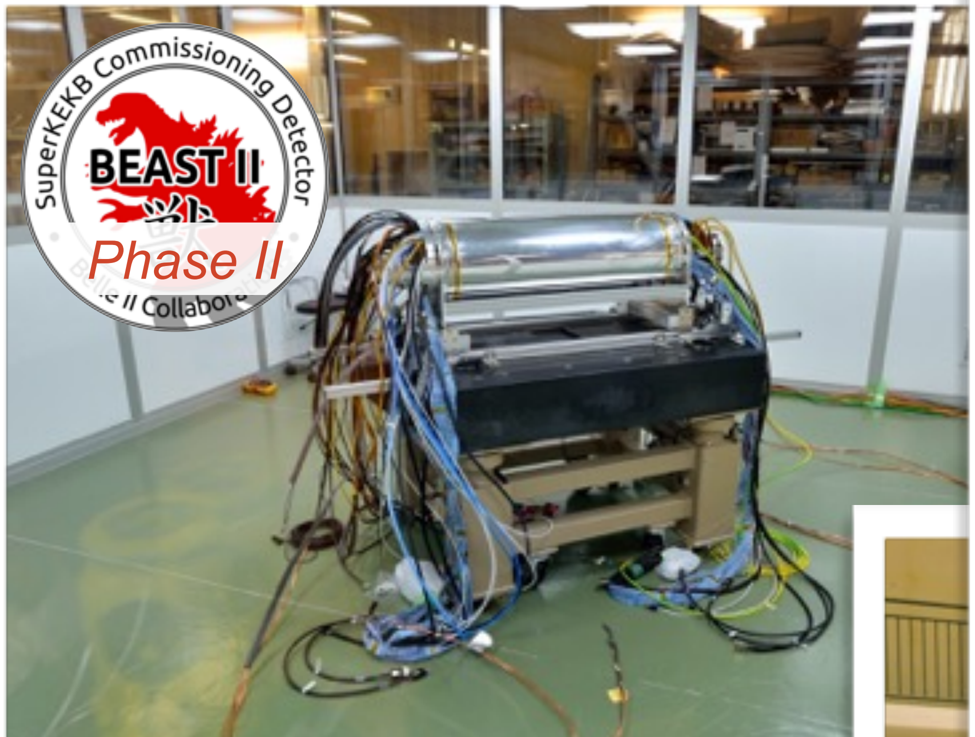


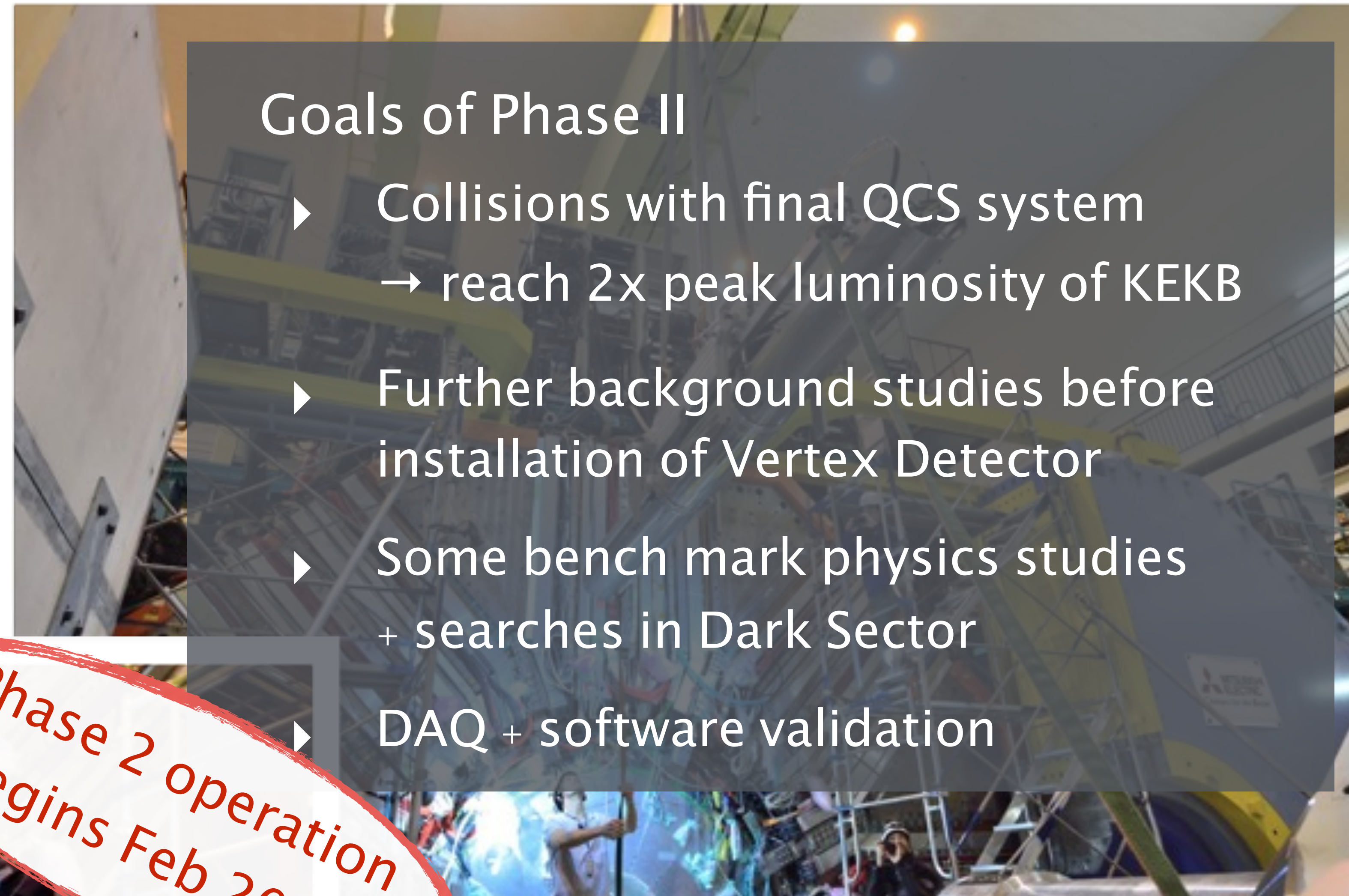
Phase 2





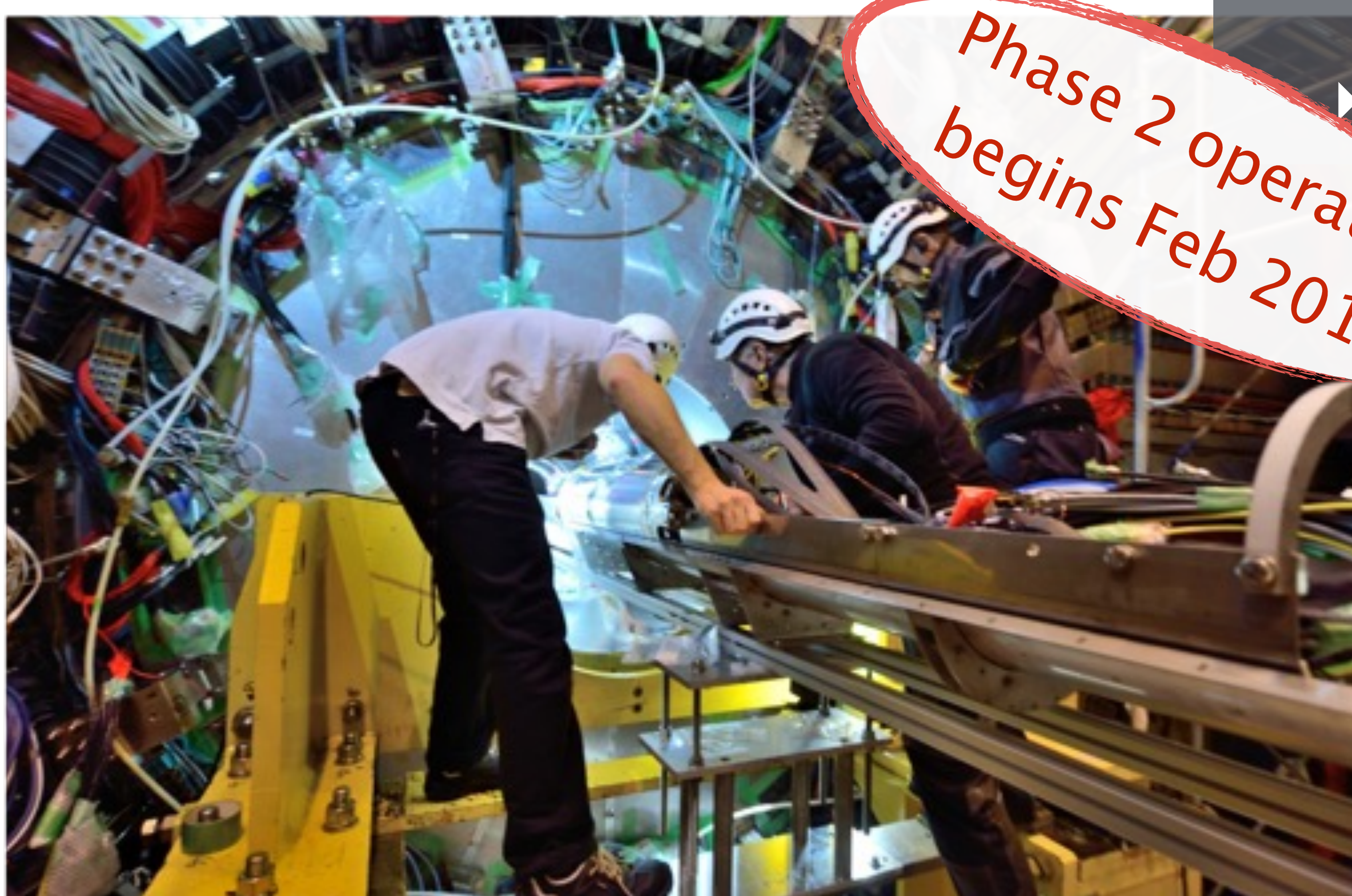
Phase 2





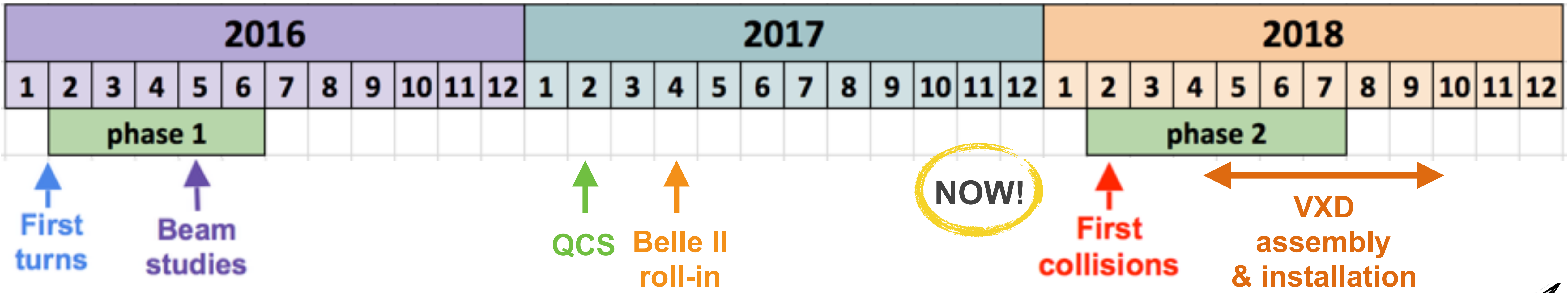
Goals of Phase II

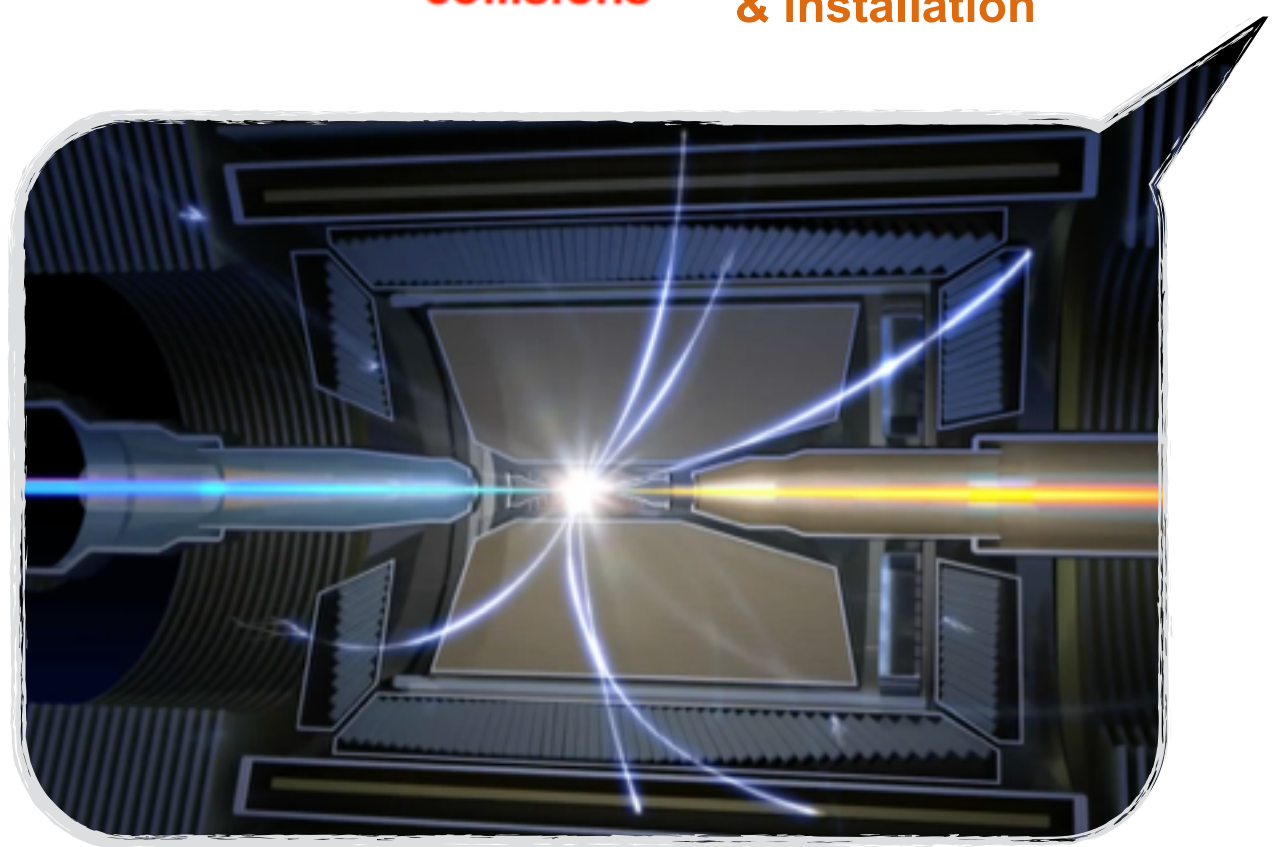
- Collisions with final QCS system
  → reach 2x peak luminosity of KEKB
- Further background studies before installation of Vertex Detector
- Some bench mark physics studies
  + searches in Dark Sector
- DAQ + software validation



Phase 2 operation begins Feb 2018

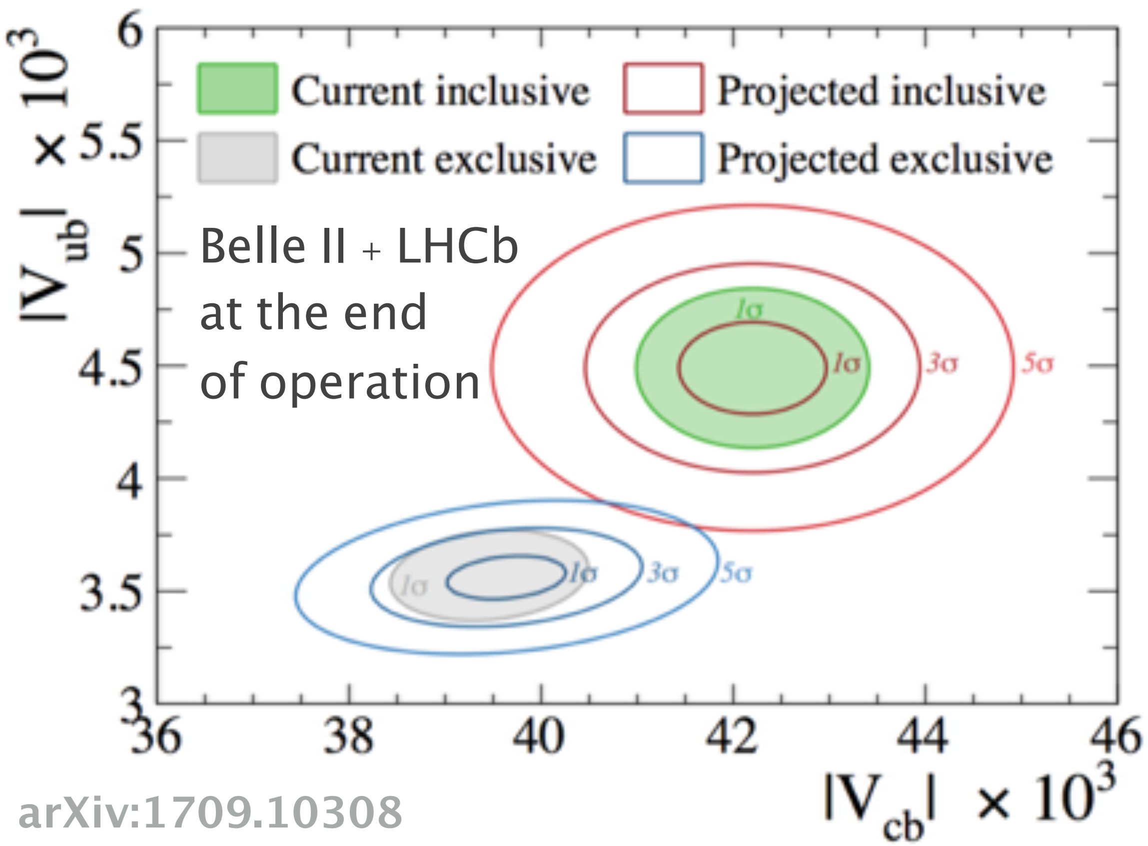
Towards Phase 3



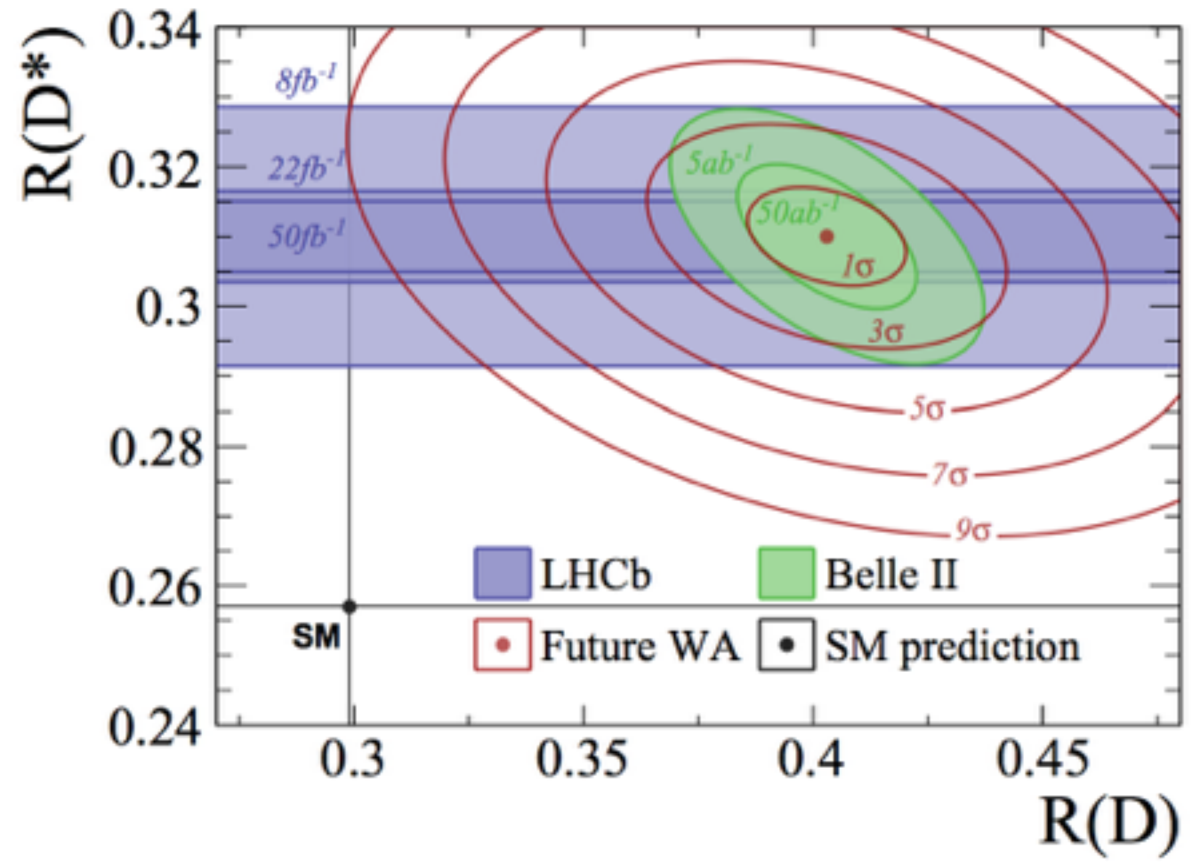


Physics run with complete detector starts early 2019

Flavour Physics Prospects



arXiv:1709.10308



Current experimental results limited by statistics

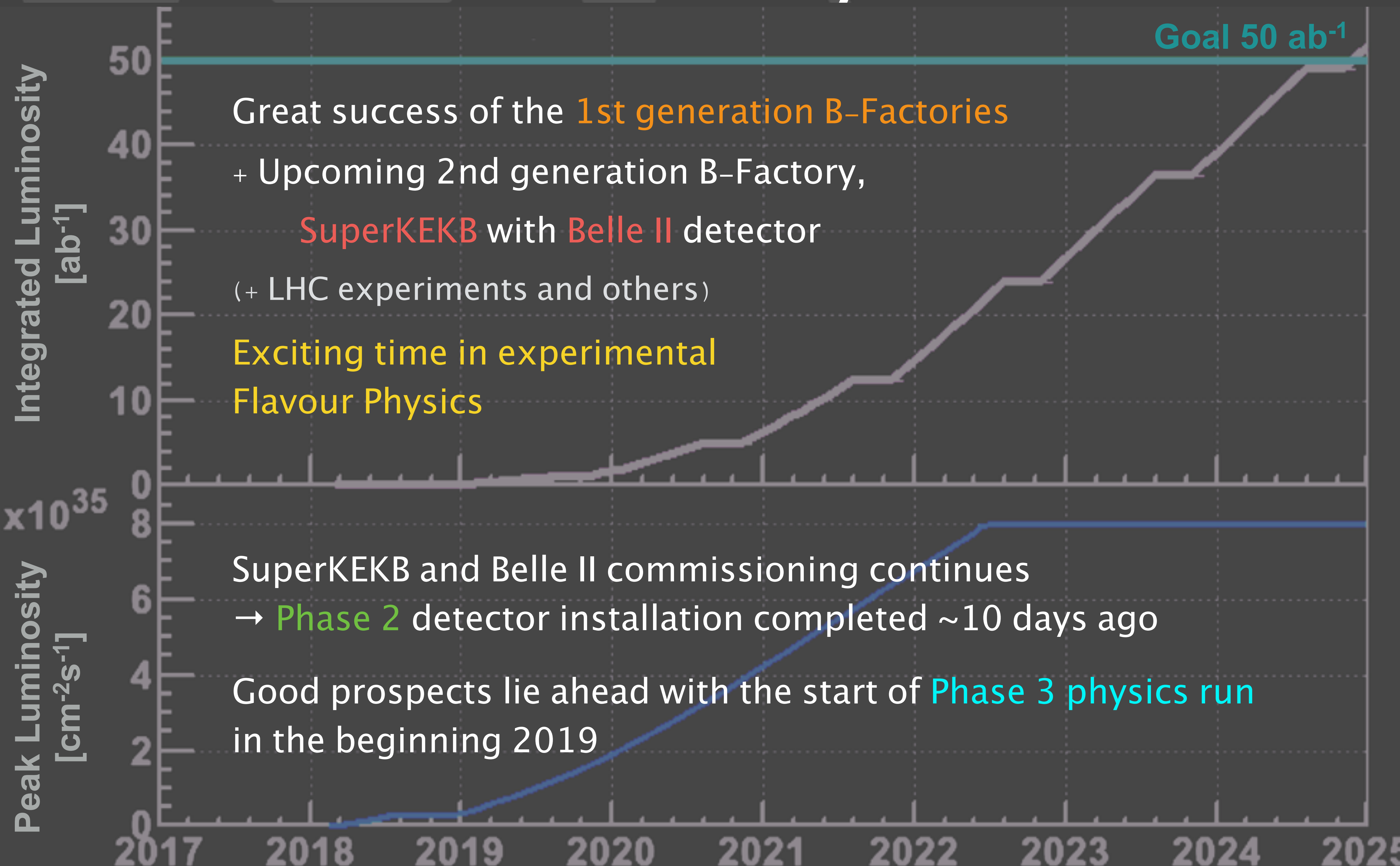
1/ab (KEKB) → 50/ab (SuperKEKB)

+ LHC experiments continue in parallel

Belle II – Theory Interface Platform

- Series of workshops from mid 2014 until end of 2016
- Report in final stage → to be on arXiv soon

Summary



Great success of the 1st generation B-Factories

+ Upcoming 2nd generation B-Factory,

SuperKEKB with Belle II detector

(+ LHC experiments and others)

Exciting time in experimental Flavour Physics

SuperKEKB and Belle II commissioning continues
→ Phase 2 detector installation completed ~10 days ago

Good prospects lie ahead with the start of Phase 3 physics run in the beginning 2019

FIN