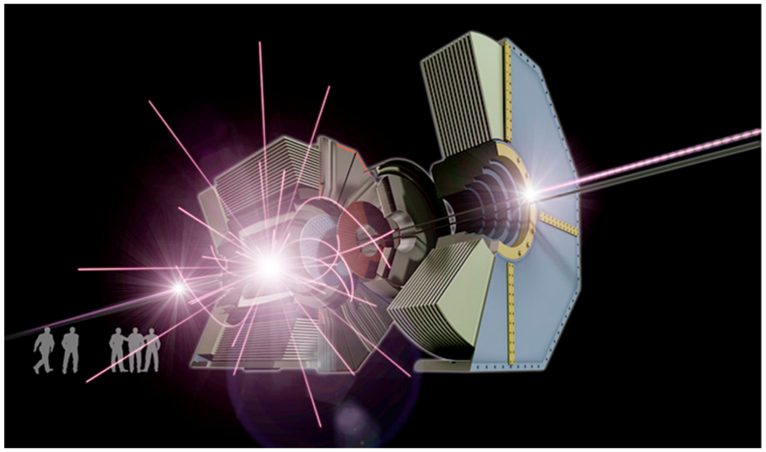
Seminar, CPPM, November 12, 2018

Belle II - status and potential



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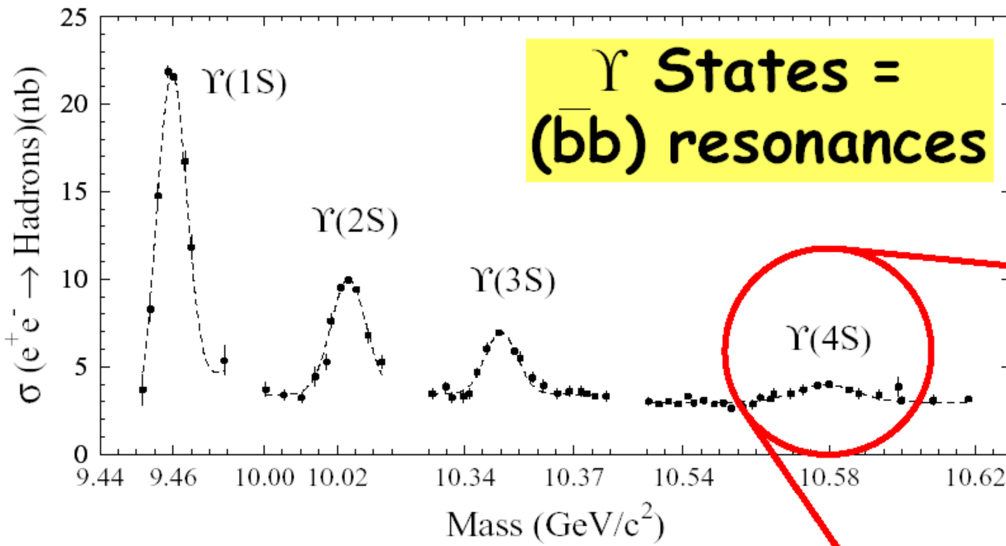
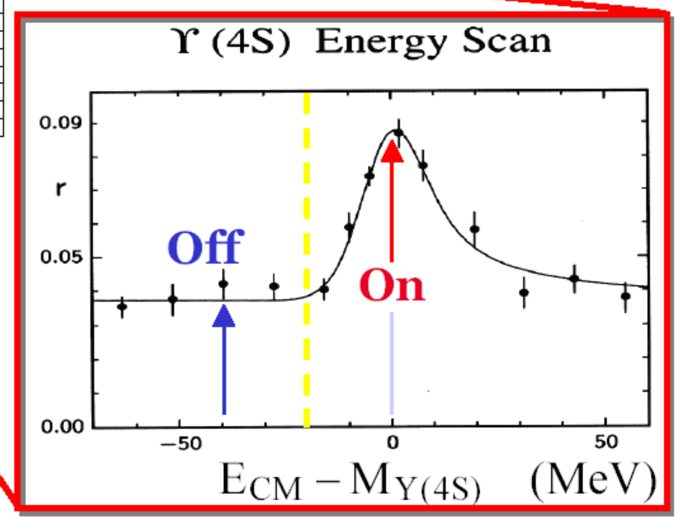
Jožef Stefan Institute

Contents

- Introduction
- SuperKEKB and Belle II: status and outlook
- Belle II physics

B meson production at ϒ(4S)





Cross Sections at ϒ(4S):

$b\bar{b} \sim 1.1$ nb

$c\bar{c} \sim 1.3$ nb

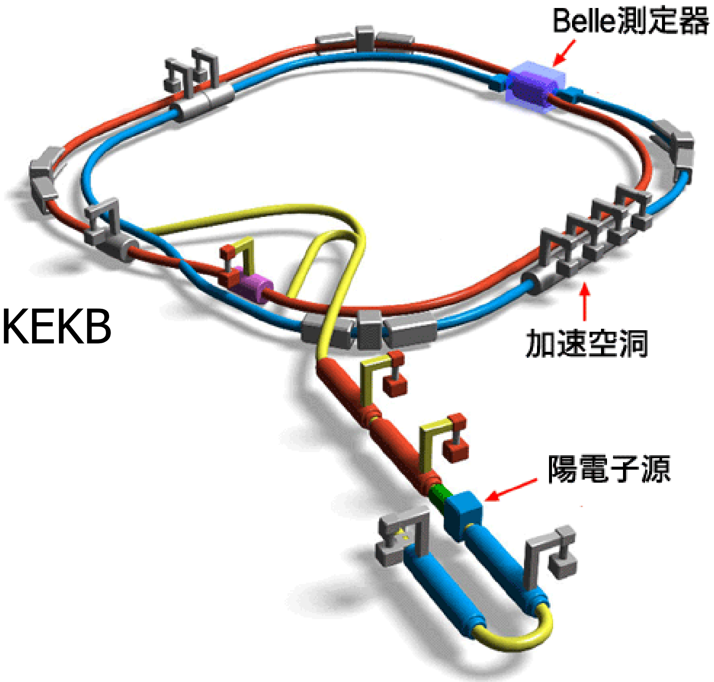
$d\bar{d}, s\bar{s} \sim 0.3$ nb

$u\bar{u} \sim 1.4$ nb

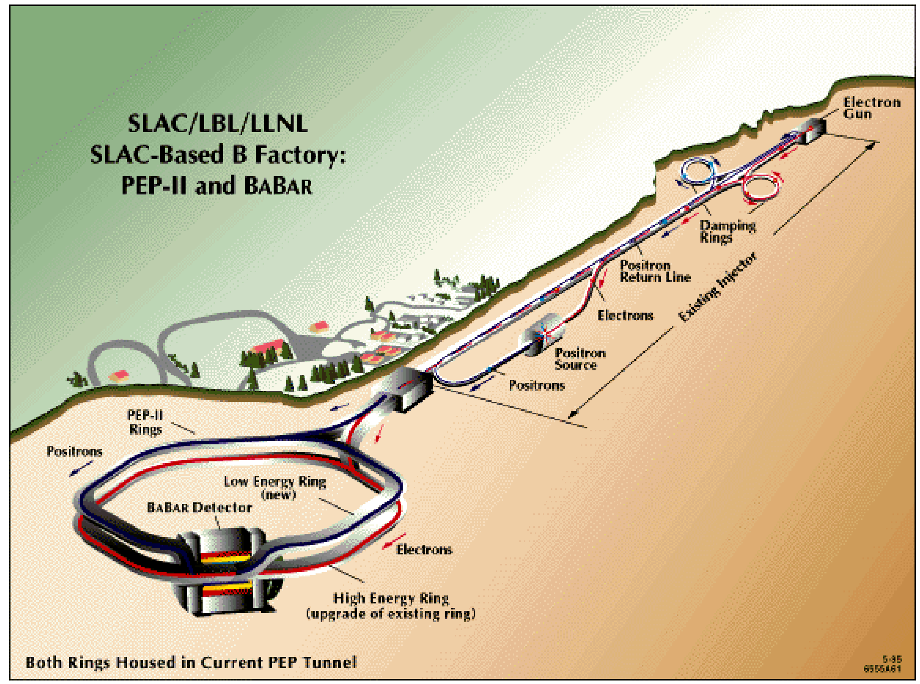
$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$

$L = 1$ state

Flavour physics at the luminosity frontier with asymmetric B factories



KEKB



$\sqrt{s}=10.58$ GeV

$e^+ \rightarrow \Upsilon(4S) \leftarrow e^-$

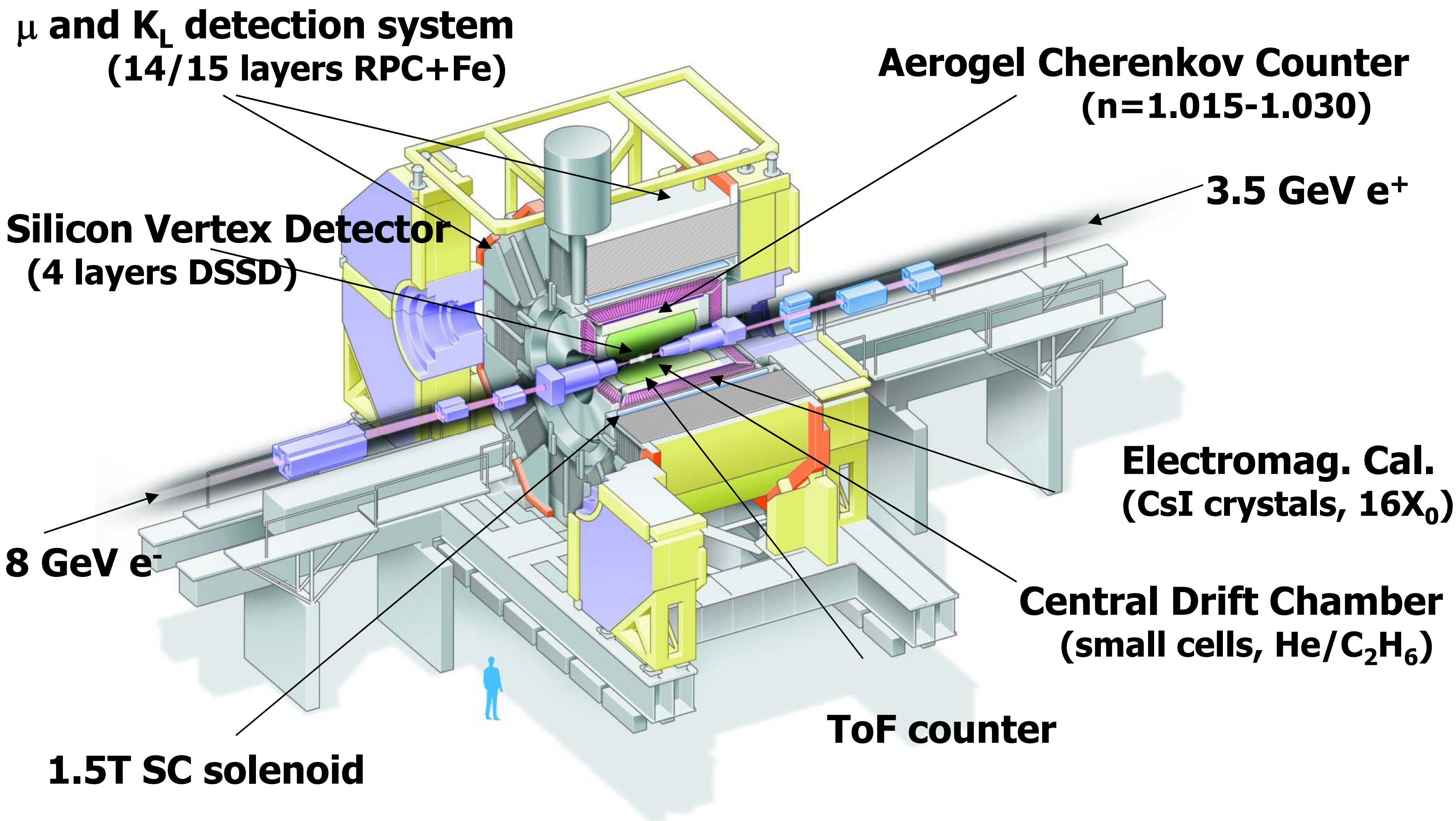
$\Upsilon(4S) \rightarrow B\,\bar{B}$

$\Delta z \sim c\beta\gamma\tau_B \sim 200\mu m$

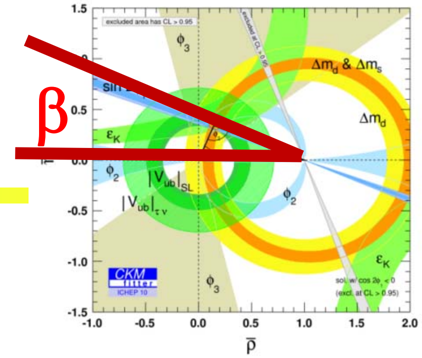
BaBar	$p(e^-)=9$ GeV	$p(e^+)=3.1$ GeV	$\beta\gamma=0.56$
Belle	$p(e^-)=8$ GeV	$p(e^+)=3.5$ GeV	$\beta\gamma=0.42$

To a large degree shaped flavour physics in the previous decade

Belle spectrometer at KEK-B

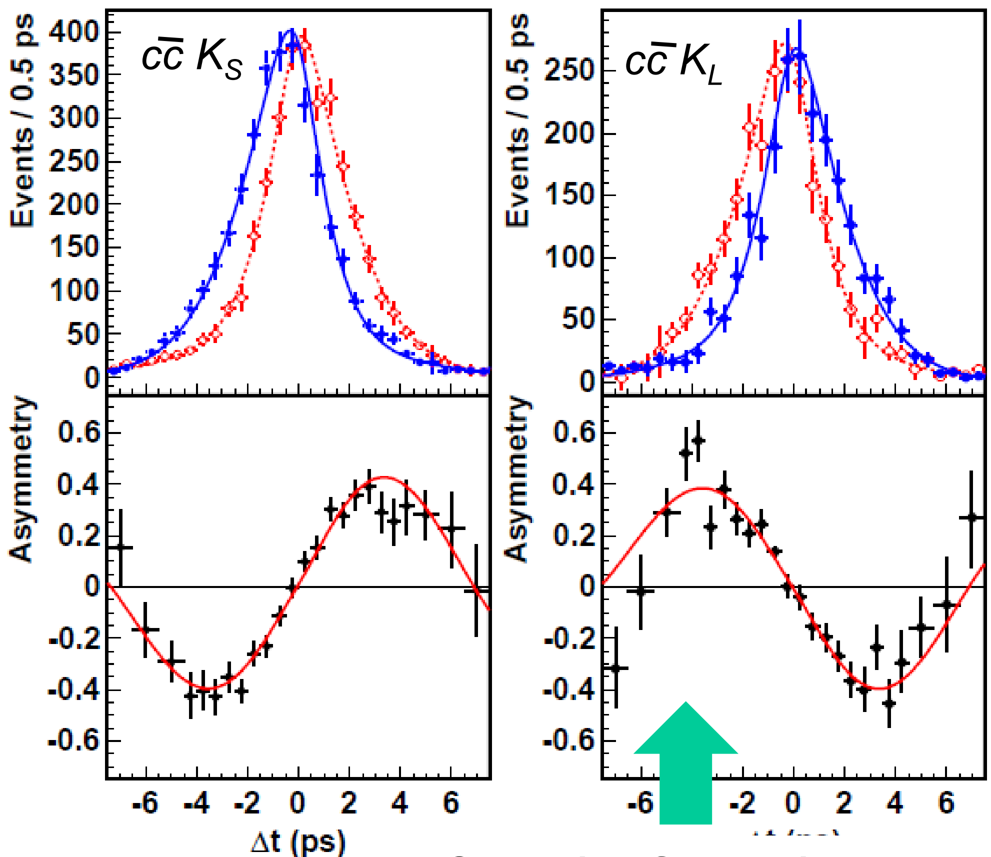


CP violation in the B meson system: measurement of the CKM phase



ϕ_1 from CP violation measurements in $B^0 \to J/\psi K^0$

$$a_{f_{CP}} = -\mathrm{Im}(\lambda_{f_{CP}}) \sin(\Delta m t) = \sin 2\phi_1 \sin(\Delta m t)$$



Opposite CP → sine wave with a flipped sign

$\sin 2\phi_1$ (=$\sin 2\beta$)

Belle:	0.668 ± 0.023 ± 0.012
BaBar:	0.687 ± 0.028 ± 0.012

Belle, PRL 108, 171802 (2012)

BaBar, PRD 79, 072009 (2009)

with a single experiment precision of ~4%!

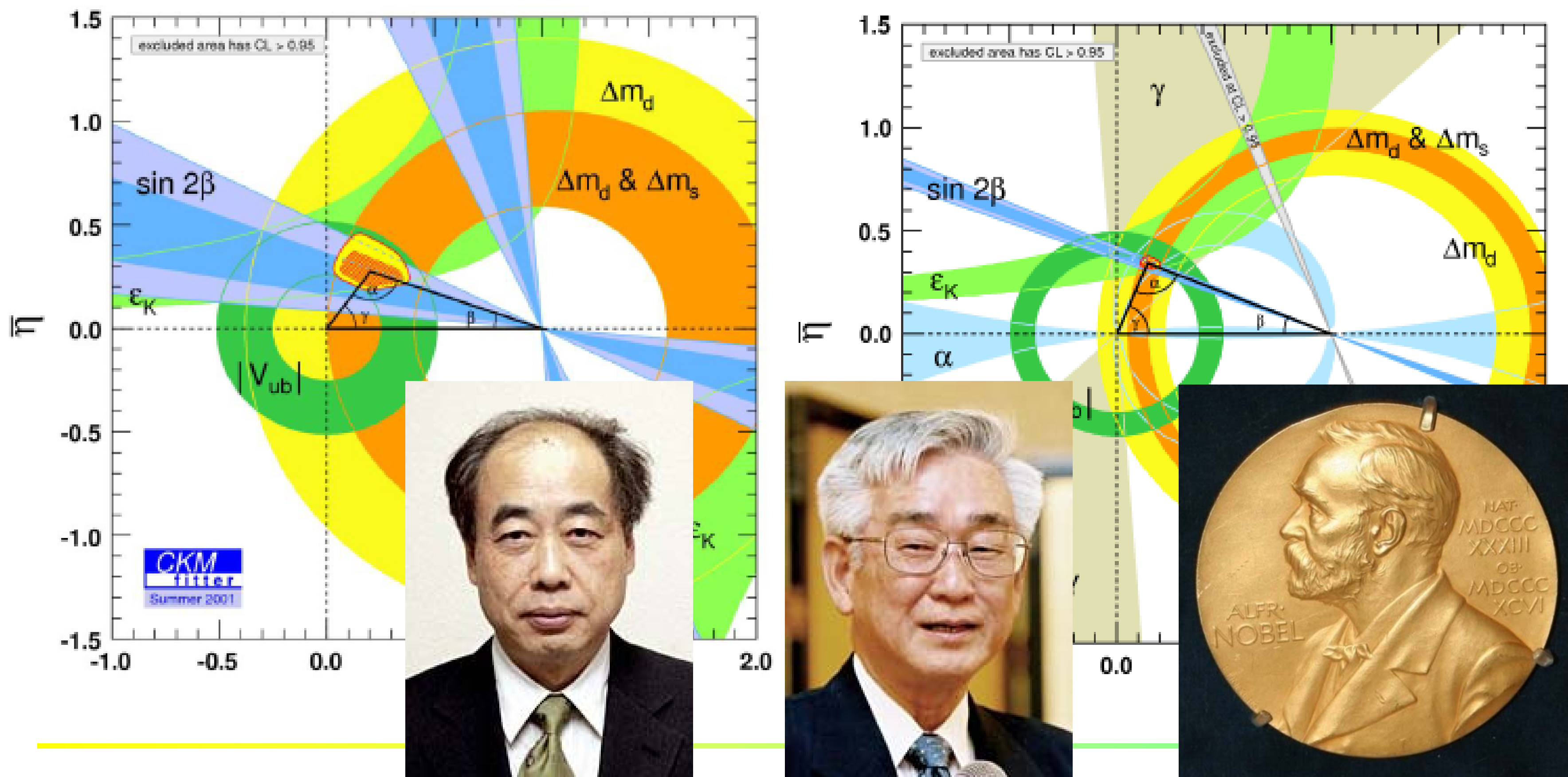
$\phi_1 = \beta = (21.4 \pm 0.8)^0$

CP violation in the B system

B factories: CP violation in the B system: from the discovery (2001) to a precision measurement (2011) → remarkable agreement with the Kobayashi-Maskawa prediction!

EPS 2001

EPS 2011



What next?

Next generation: Super B factories → Looking for NP

→ Need much more data (almost two orders!)

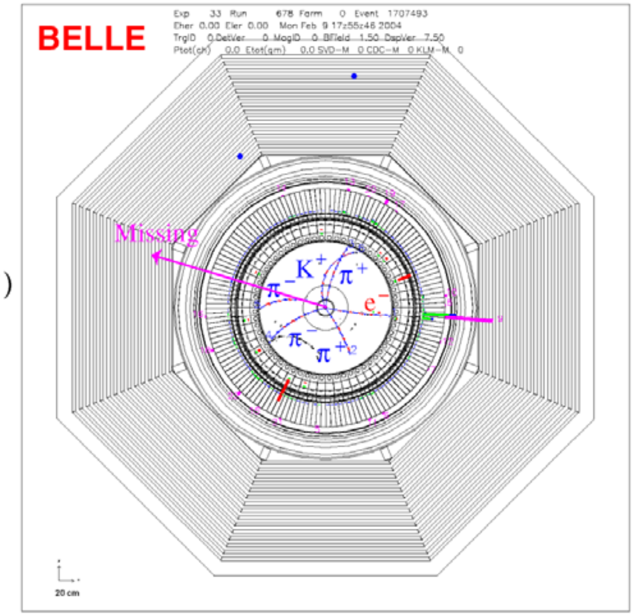
However: a hard competition from LHCb and BESIII

Still, an e^+e^- machine running at (or near) Υ(4s) will have considerable advantages in several classes of measurements, and will be complementary in many more

→ Physics at Super B Factory, arXiv:1002.5012 (Belle II)
→ SuperB Progress Reports: Physics, arXiv:1008.1541 (SuperB)
→ Physics at B Factories, Eur. Phys. J. C74 (2014) 3026
→ Belle II Theory Interface Platform (B2TiP), arXiv:1808.10567, to be published in PTEP **New!**

Advantages of B factories in the LHC era

$$B^+ \to D^0 \pi^+$$
$$(\to K\pi^-\pi^+\pi^-)$$
$$B^- \to \tau(\to e\nu\bar{\nu})\nu$$



Unique capabilities of B factories:

→ Exactly two B mesons produced (at Υ(4S))

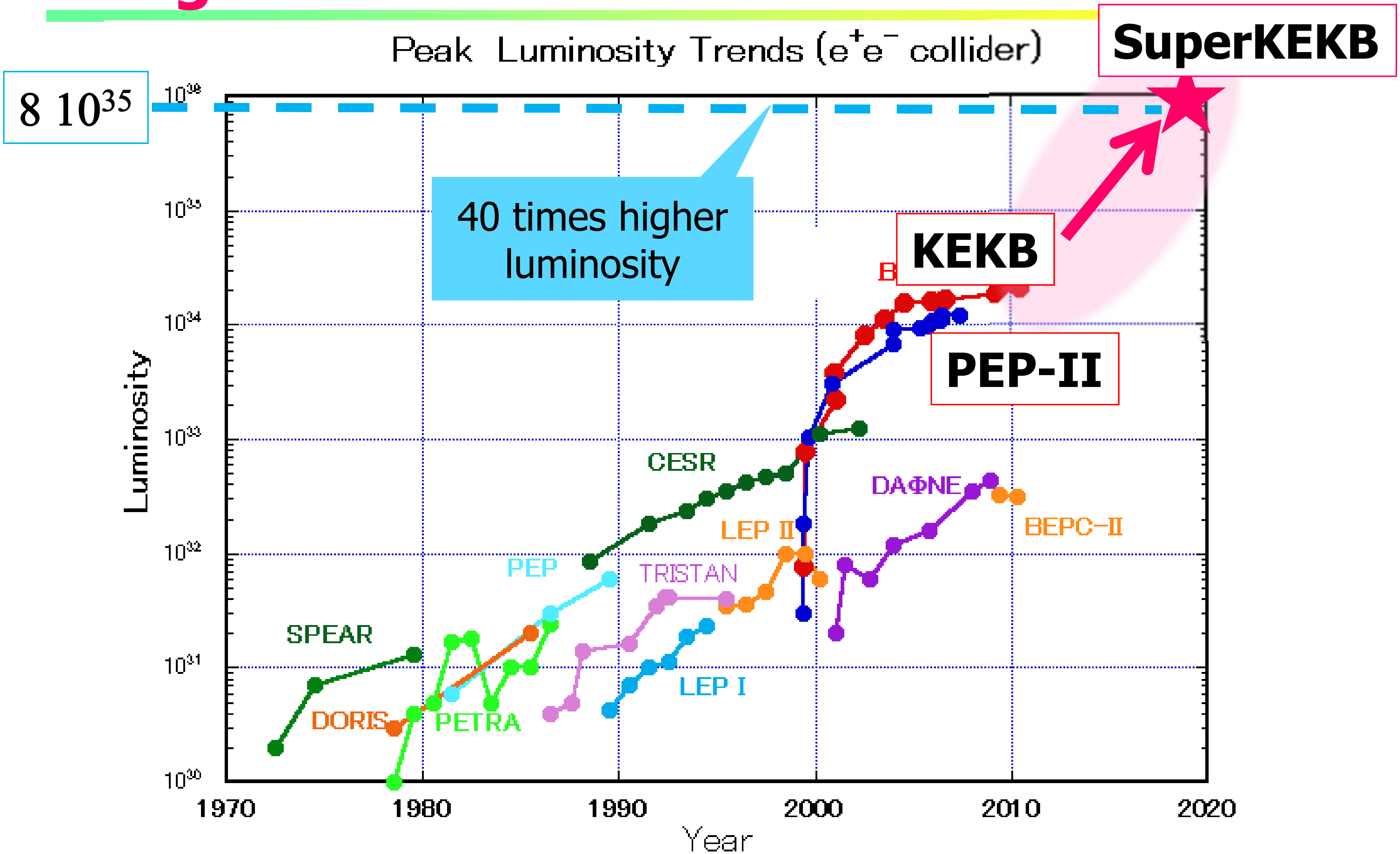
→ High flavour tagging efficiency

→ Detection of gammas, π^0s, K_Ls

→ Very clean detector environment (can observe decays with several neutrinos in the final state!)

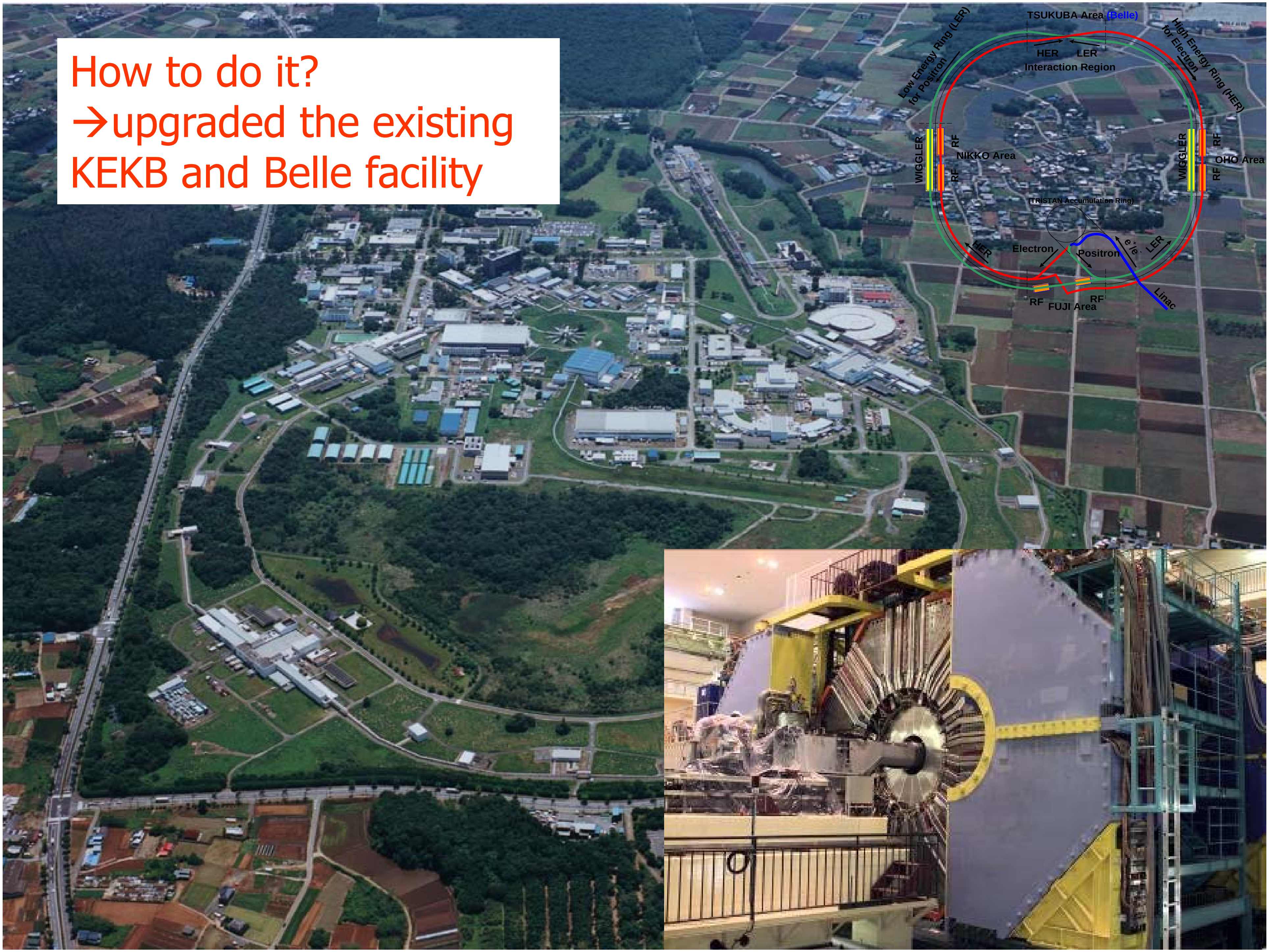
However, need a two-orders-of-magnitude larger data sample!

Need O(100x) more data →Next generation B-factories



N.B. KEKB peak L: 2.11 10^{34} cm^{-2} s^{-1} , LHC peak L: 2.06 10^{34} cm^{-2} s^{-1}

How to do it?
→upgraded the existing KEKB and Belle facility



How to increase the luminosity?

Lorentz factor

Beam current

Beam-beam parameter

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

Lumi. reduction factor (crossing angle)&
Tune shift reduction factor (hour glass effect)
0.8 - 1
(short bunch)

Classical electron radius

Beam size ratio@IP
1 - 2 % (flat beam)

Vertical beta function@IP

(1) Smaller β_y^*
(2) Increase beam currents
(3) Increase ξ_y

← **"Nano-Beam" scheme**

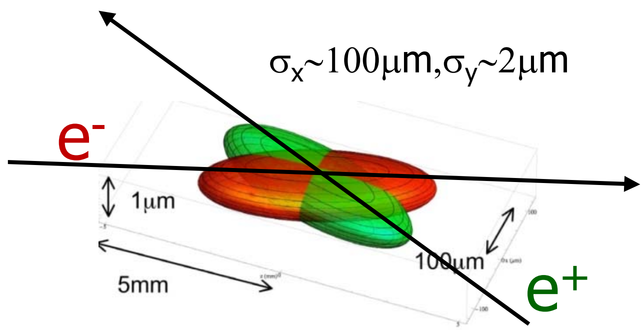
Collision with very small spot-size beams

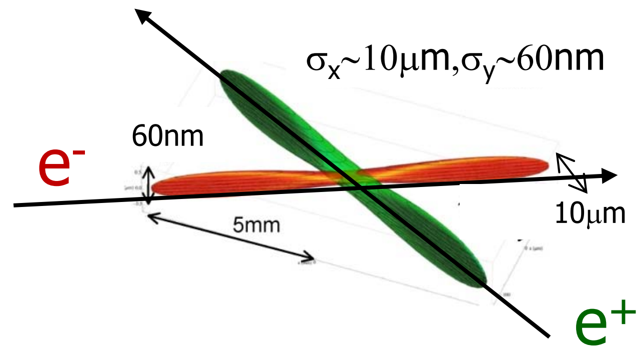
Invented by Pantaleo Raimondi for SuperB

How big is a nano-beam ?

How to go from an excellent accelerator with world record performance – KEKB – to a 40x times better, more intense facility?

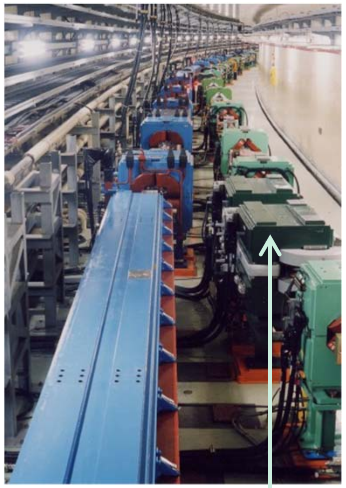
In KEKB, colliding electron and positron beams were already much thinner than a human hair...



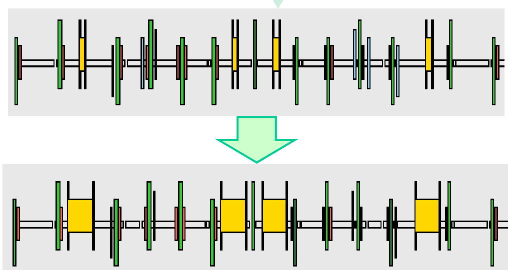


... For a 40x increase in intensity you have to make the beam as thin as a few x100 atomic layers!

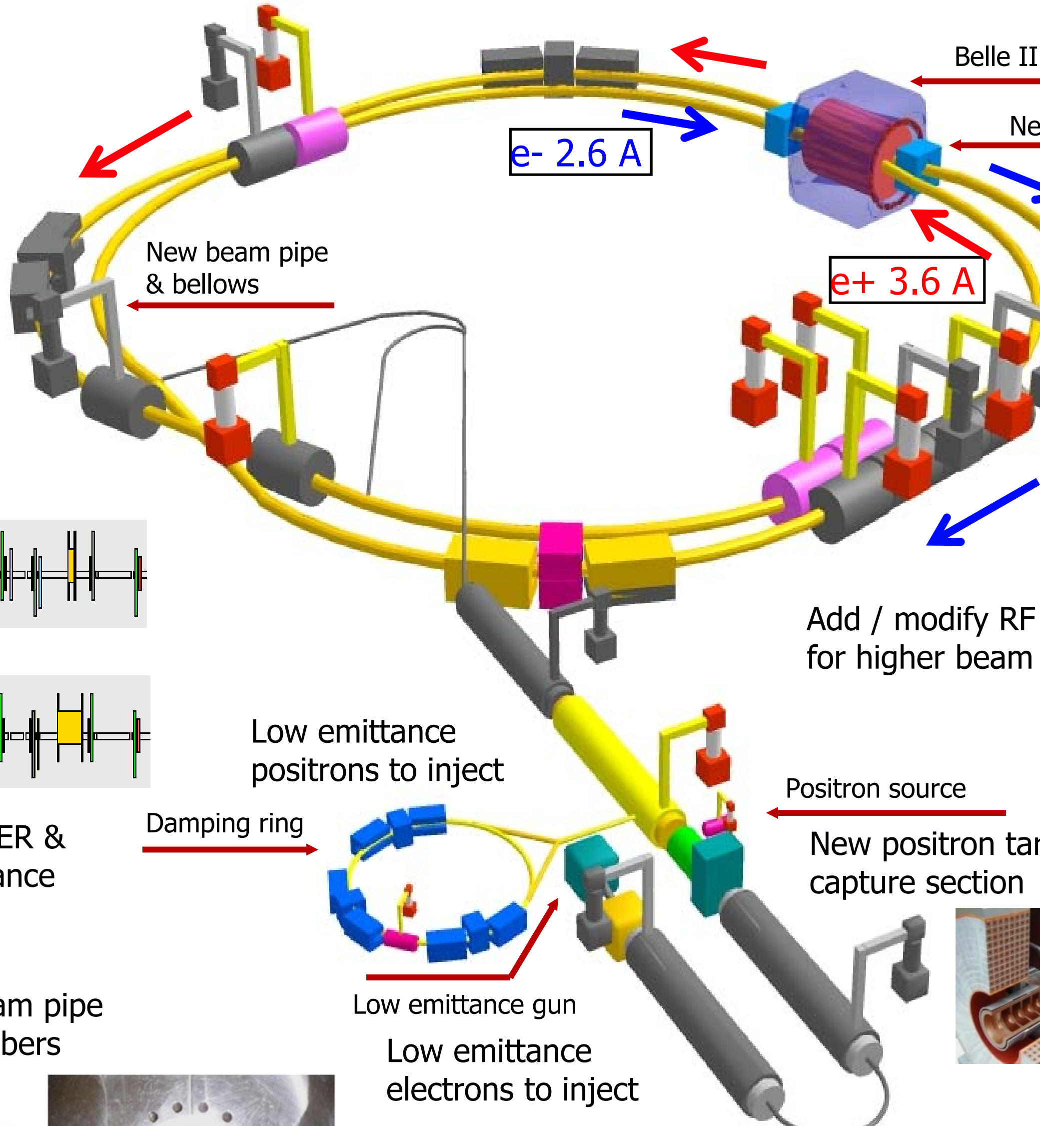
KEKB → SuperKEKB

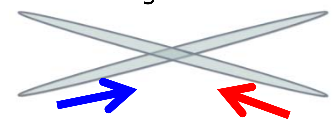


Replace short dipoles with longer ones (LER)

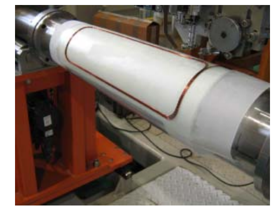


Redesign the lattices of HER & LER to squeeze the emittance





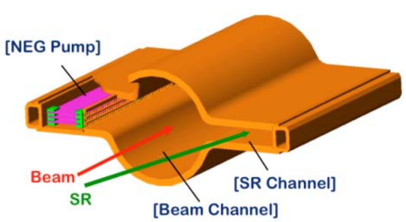
New superconducting /permanent final focusing quads near the IP

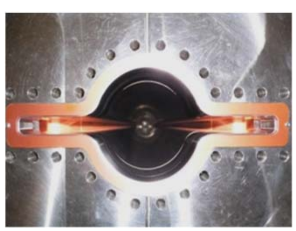


Add / modify RF systems for higher beam current

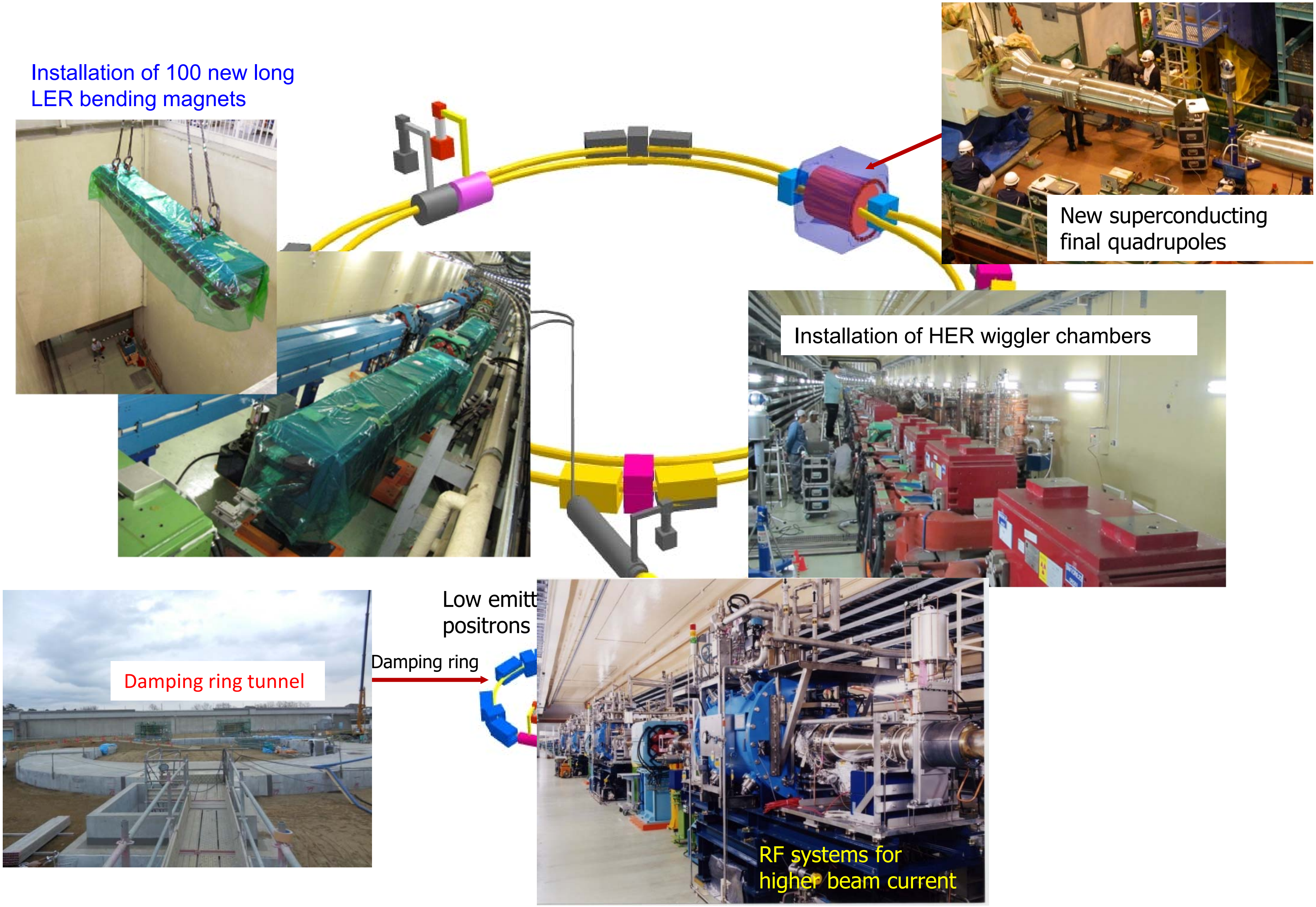
New positron target / capture section

TiN-coated beam pipe with antechambers



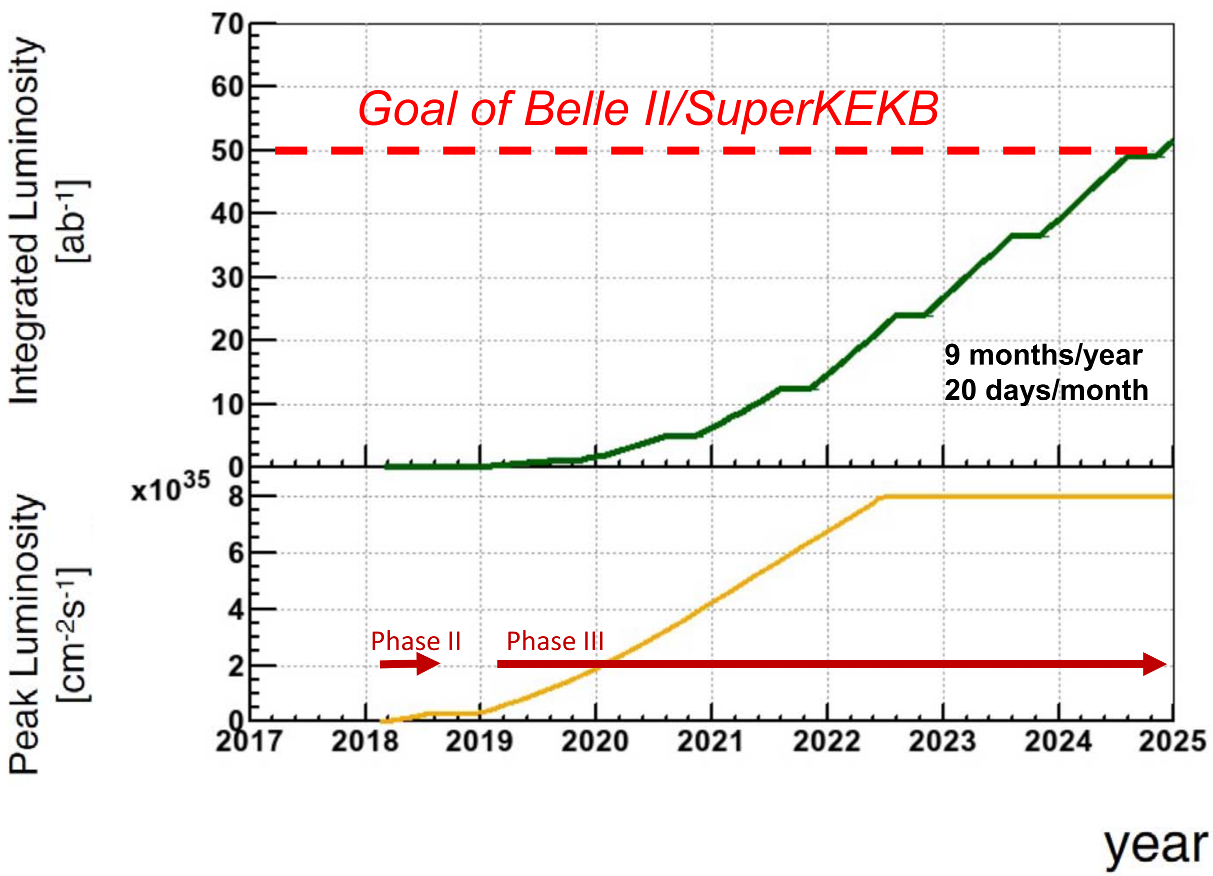


To get x40 higher luminosity



Installation of 100 new long
LER bending magnets
New superconducting
final quadrupoles
Installation of HER wiggler chambers
Low emitt
positrons
Damping ring
Damping ring tunnel
RF systems for
higher beam current

SuperKEKB phases and luminosity projection



Phase I (2016)

- NO final focus; NO damping ring
- Circulated both beams but no collisions;
- Tune accelerator optics, etc.; vacuum scrubbing
- Beam Background studies with dedicated BEAST II/1 detector

Phase II (2018)

- First collisions
- Beam Commissioning
- Background measurements with BEAST II/2
- Physics run with Belle II without Vertex Detector

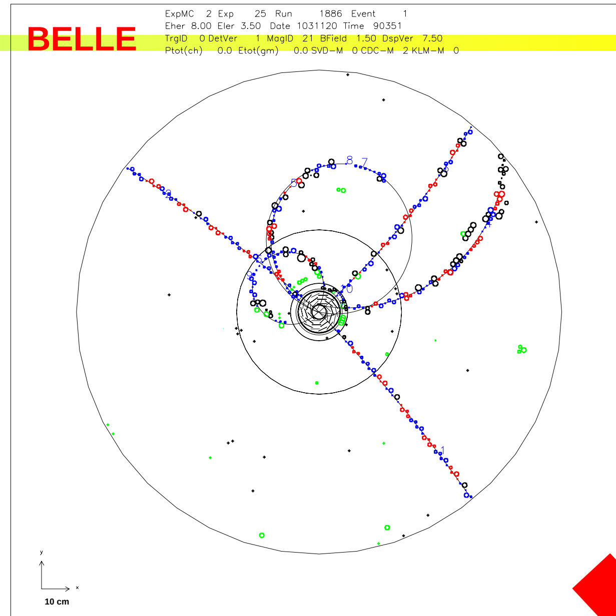
Phase III (2019→)

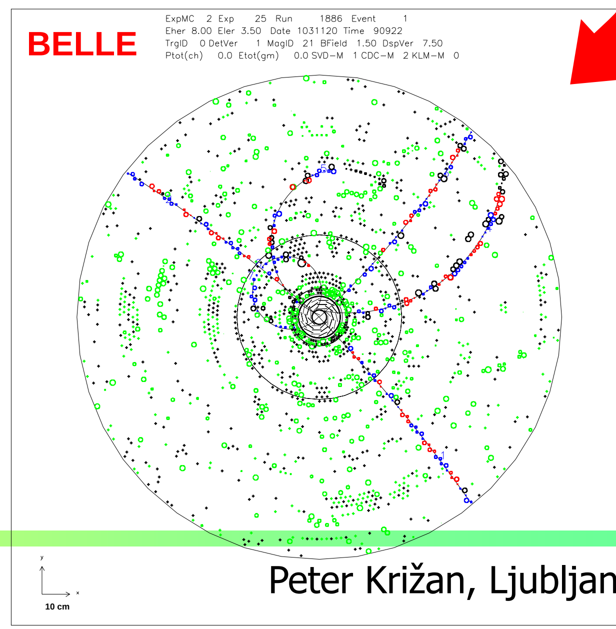
- Physics run

Requirements for the Belle II detector

Critical issues at L= 8 x 10^{35}/cm^2/sec

- **Higher background (×10-20)**
  - radiation damage and occupancy
  - fake hits and pile-up noise in the EM
- **Higher event rate (×10)**
  - higher rate trigger, DAQ and computing
- **Require special features**
  - low p μ identification ← $s\mu\mu$ recon. eff.
  - hermeticity ← ν “reconstruction”



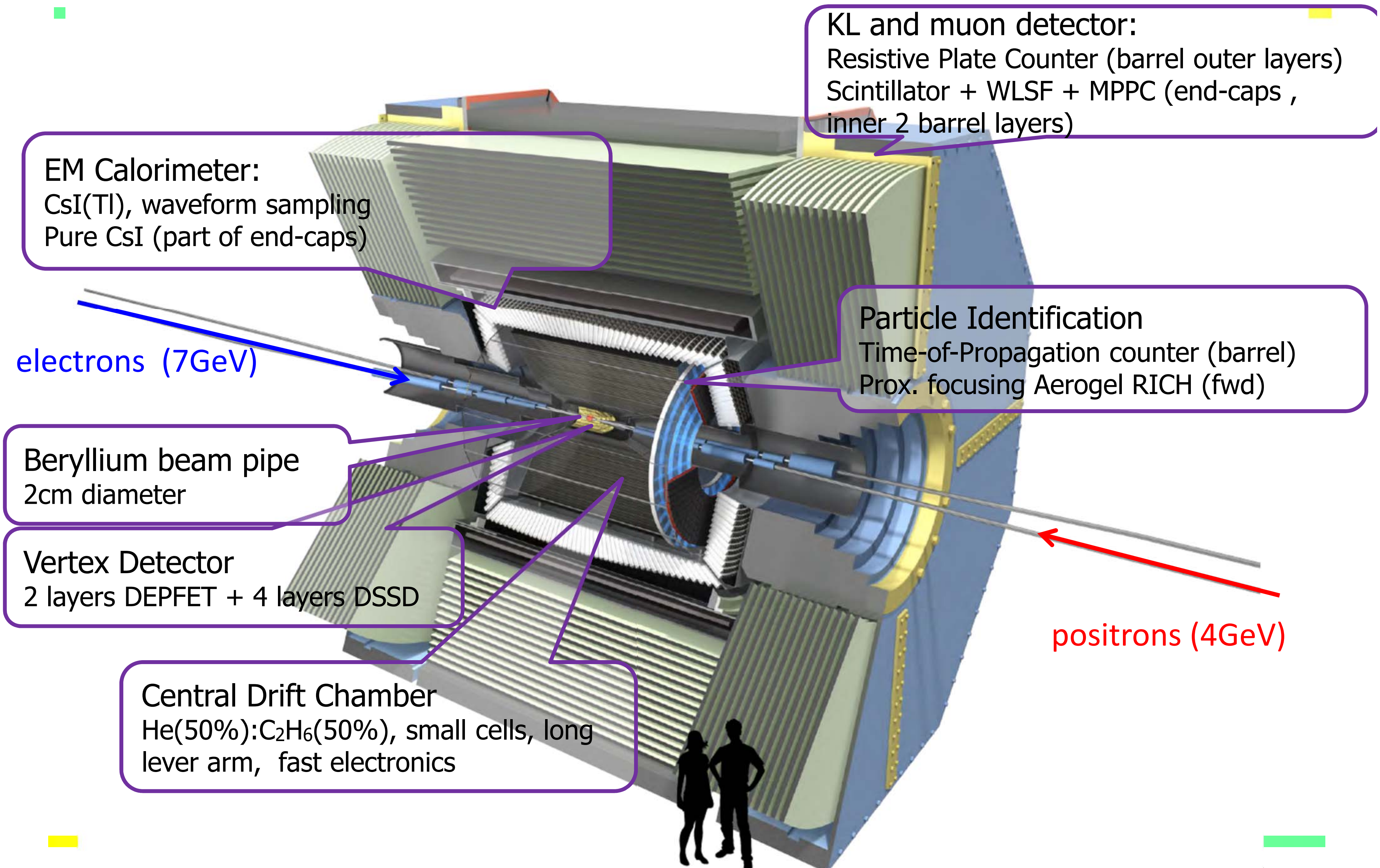


Solutions:

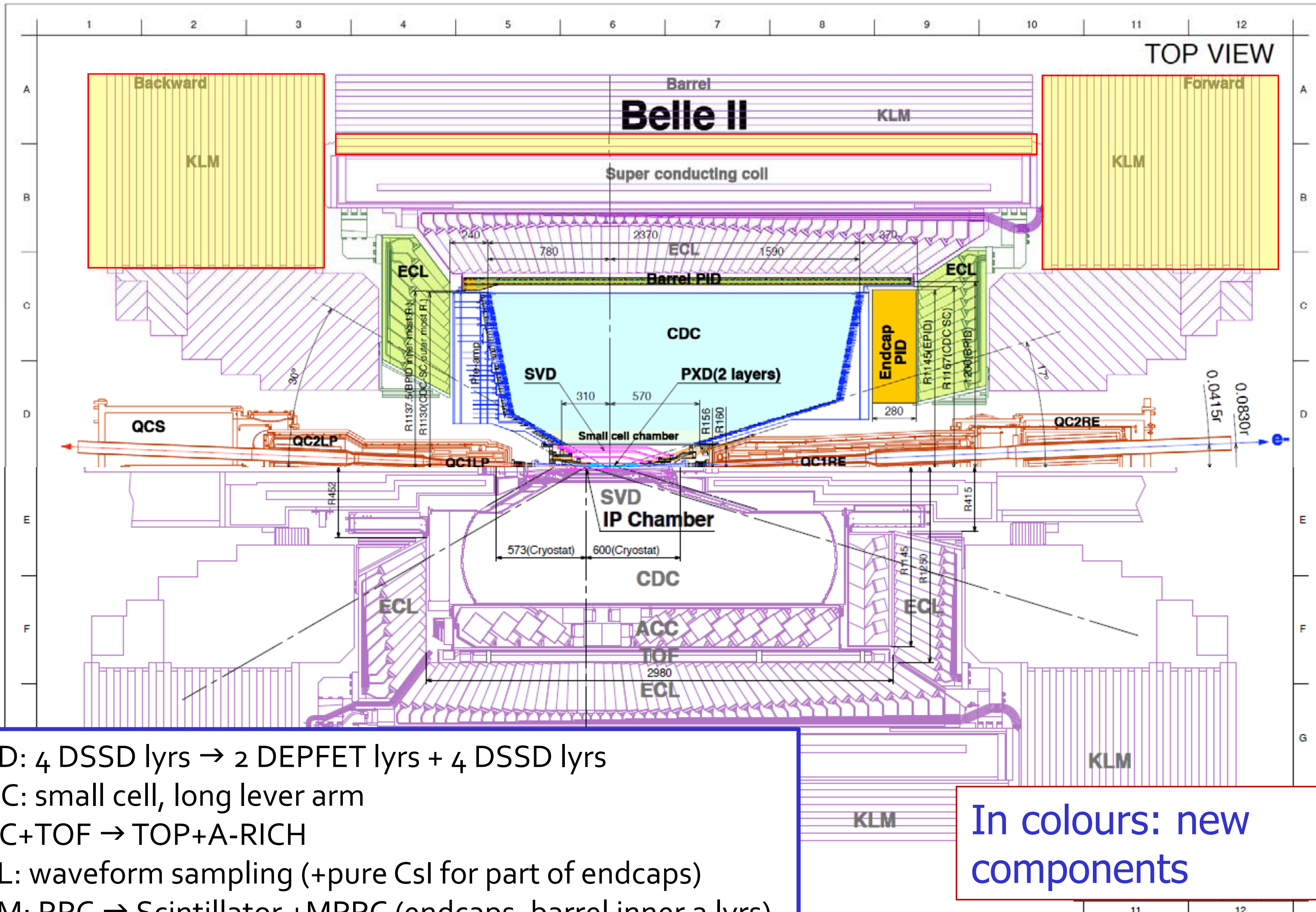
- Replace inner layers of the vertex detector with a pixel detector.
- Replace inner part of the central tracker with a silicon strip detector.
- Better particle identification device
- Replace part of endcap calorimeter crystals
- Faster readout electronics and computing system.

Belle II TDR, arxiv:1011.0352v1[physics.ins-det]

Belle II Detector



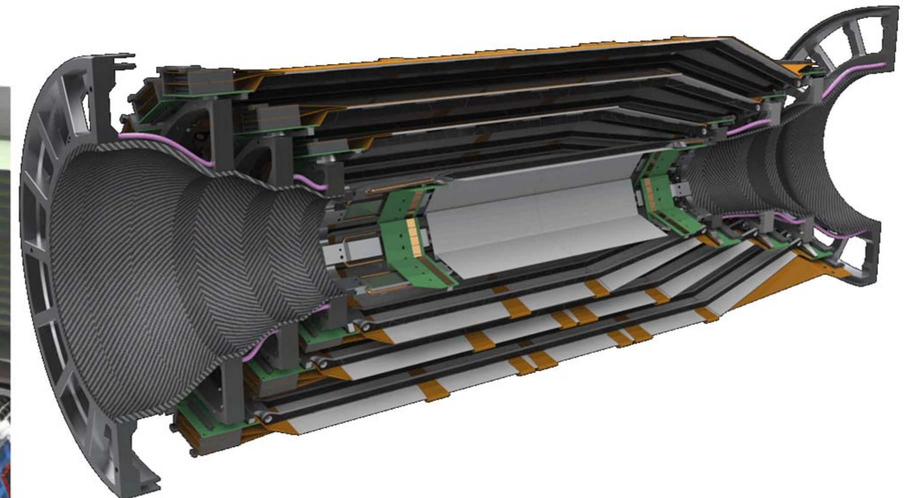
Belle II Detector (in comparison with Belle)

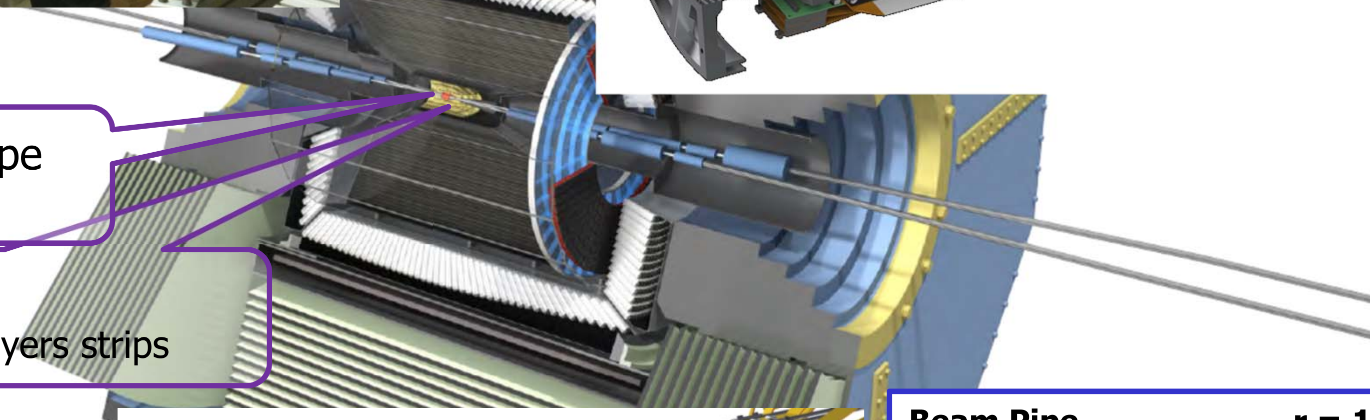


SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling (+pure CsI for part of endcaps)
KLM: RPC → Scintillator +MPPC (endcaps, barrel inner 2 lyrs)

In colours: new components

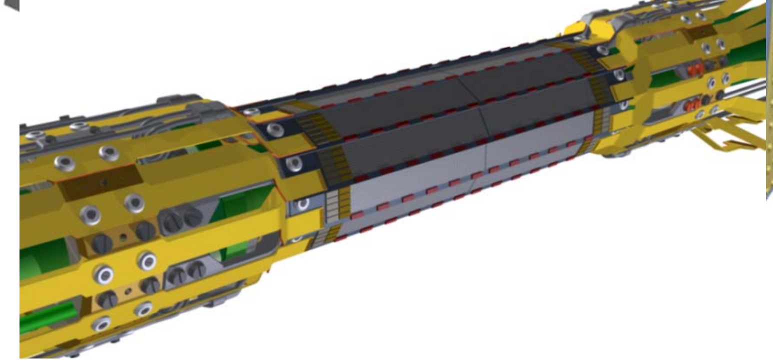
Belle II Detector – vertex region





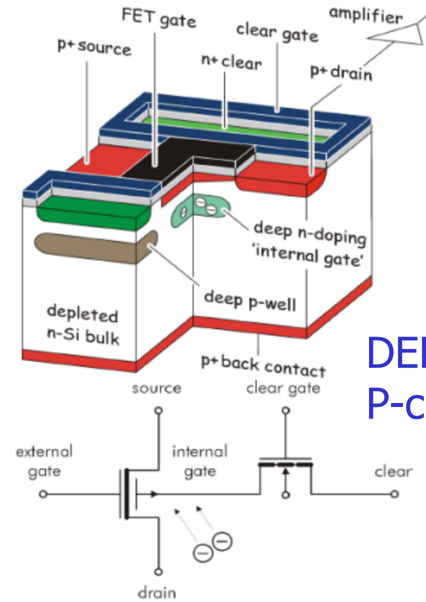
Beryllium beam pipe
2cm diameter

Vertex Detector
2 layers pixels + 4 layers strips



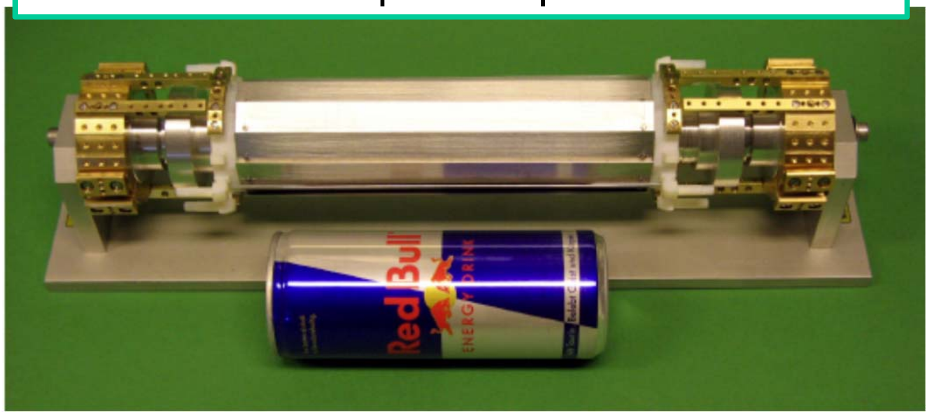
Beam Pipe		**r = 10mm**
DEPFET pixels		
	Layer 1	**r = 14mm**
	Layer 2	**r = 22mm**
DSSD silicon strips		
	Layer 3	**r = 39mm**
	Layer 4	**r = 80mm**
	Layer 5	**r = 104mm**
	Layer 6	**r = 135mm**

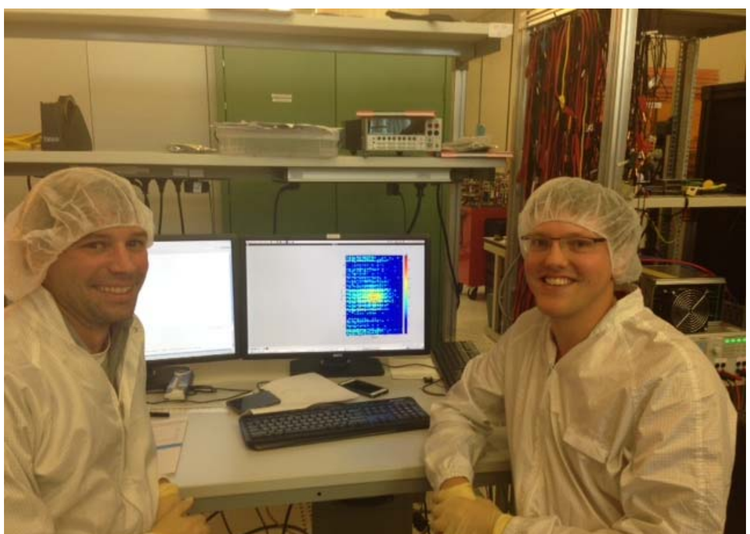
Pixel detector: 2 layers of DEPFET sensors



DEPFET sensor (Depleted P-channel FET)

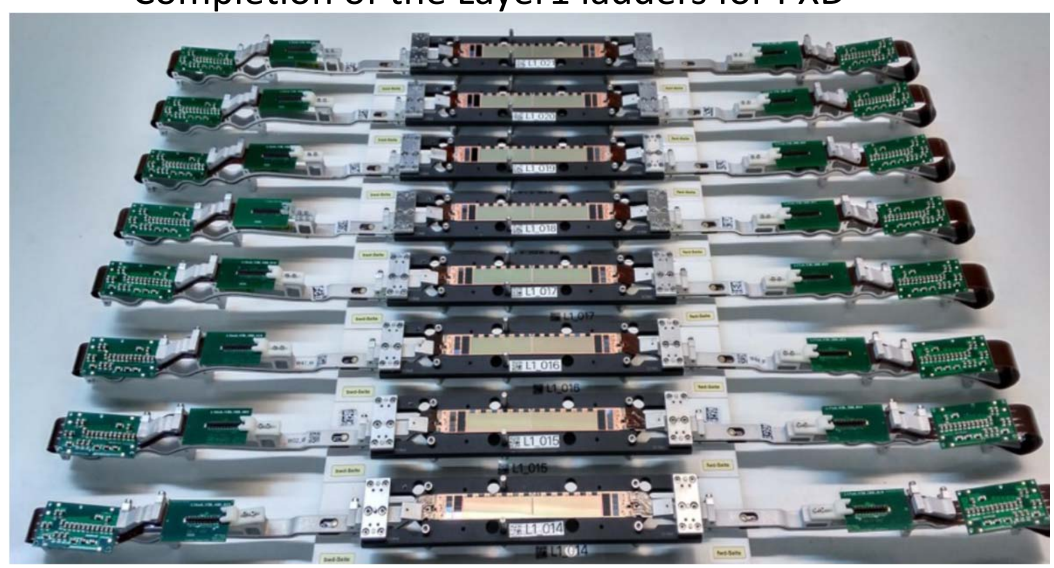
Mechanical mockup of the pixel detector





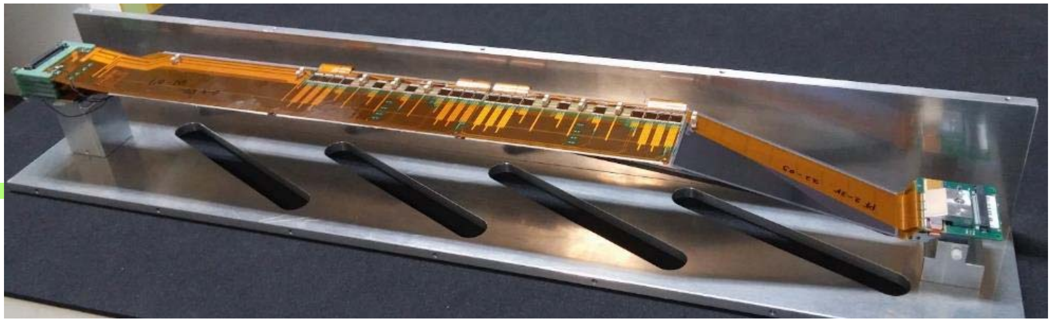
First laser light observed with the full size sensor

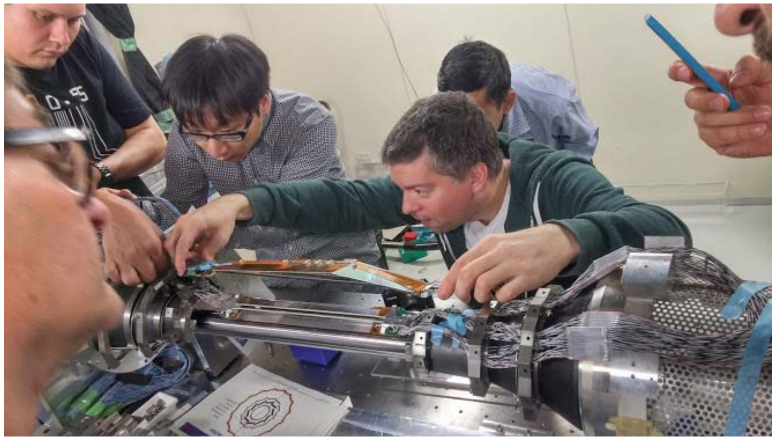
Completion of the Layer1 ladders for PXD

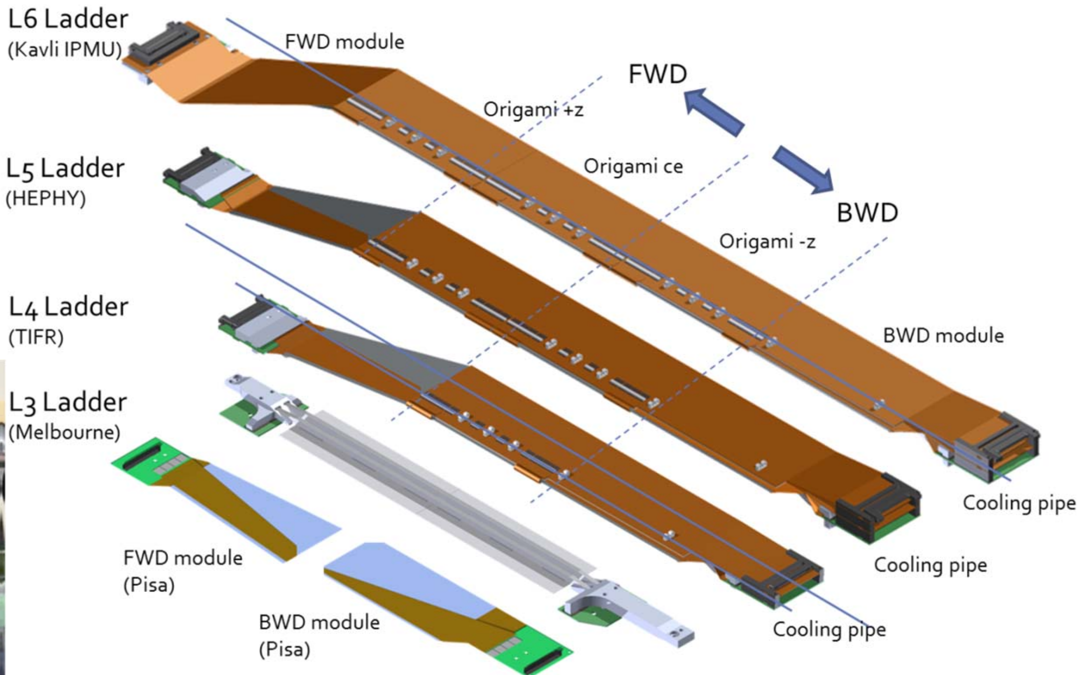


http://aldebaran.hll.mpg.de/twiki/bin/view/DEPFET/WebHome

SVD (Silicon Vertex Detector): four layers of double-sided silicon microstrip detectors.





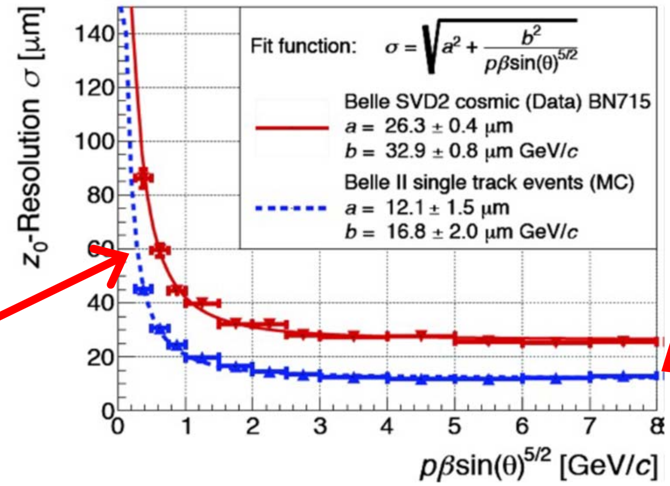


Completion of the first half of SVD on Jan 18, 2018

Expected performance

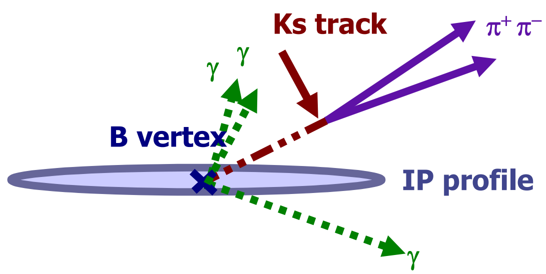
Significant improvement in vertex resolution vs Belle!

Less Coulomb scattering

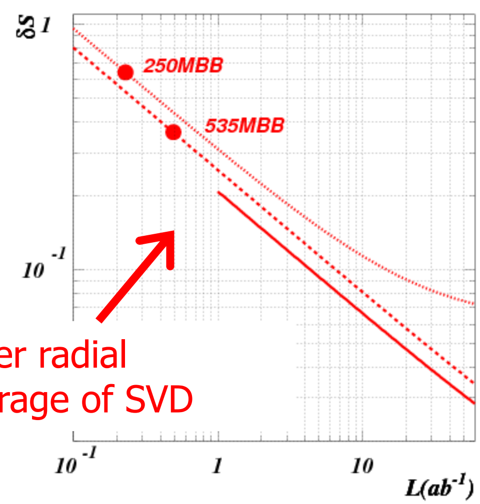


Pixel detector close to the beam pipe

Significant improvement in $\delta S(K_S\pi^0\gamma)$

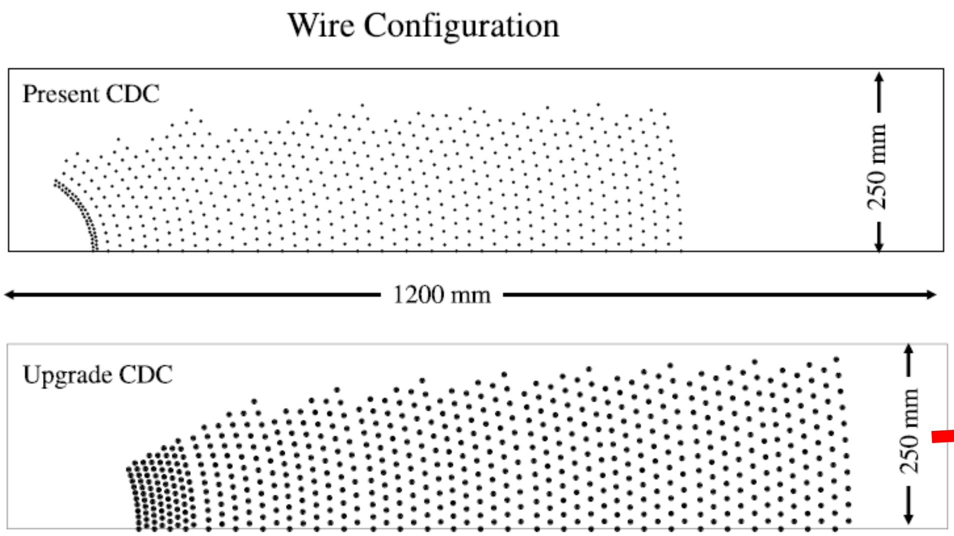


B decay point reconstruction with K_S trajectory



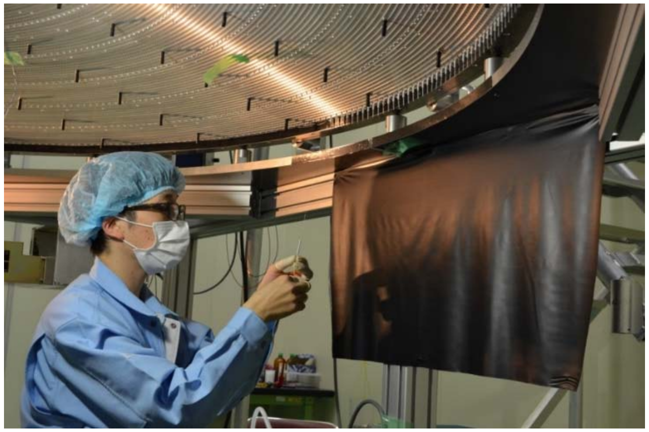
Larger radial coverage of SVD

Belle II CDC



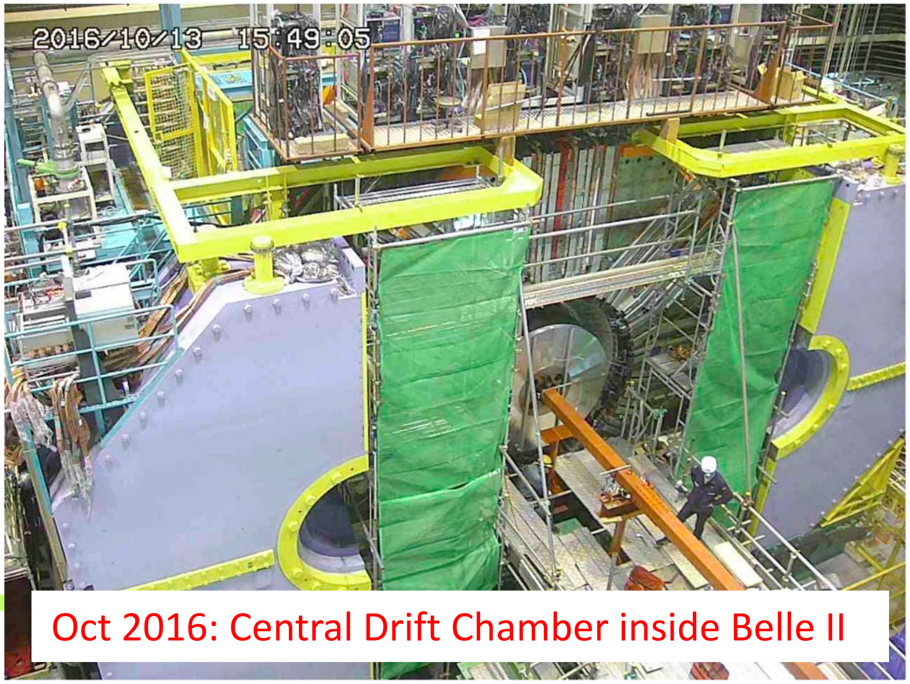
$$\frac{\sigma_{p_t}}{p_t} \sim 0.3\%/\beta \oplus 0.1\% \cdot p_t[GeV/c]$$

$$\sigma\left(\frac{dE}{dx}\right)\Big|_{MIP} \sim 5\%$$

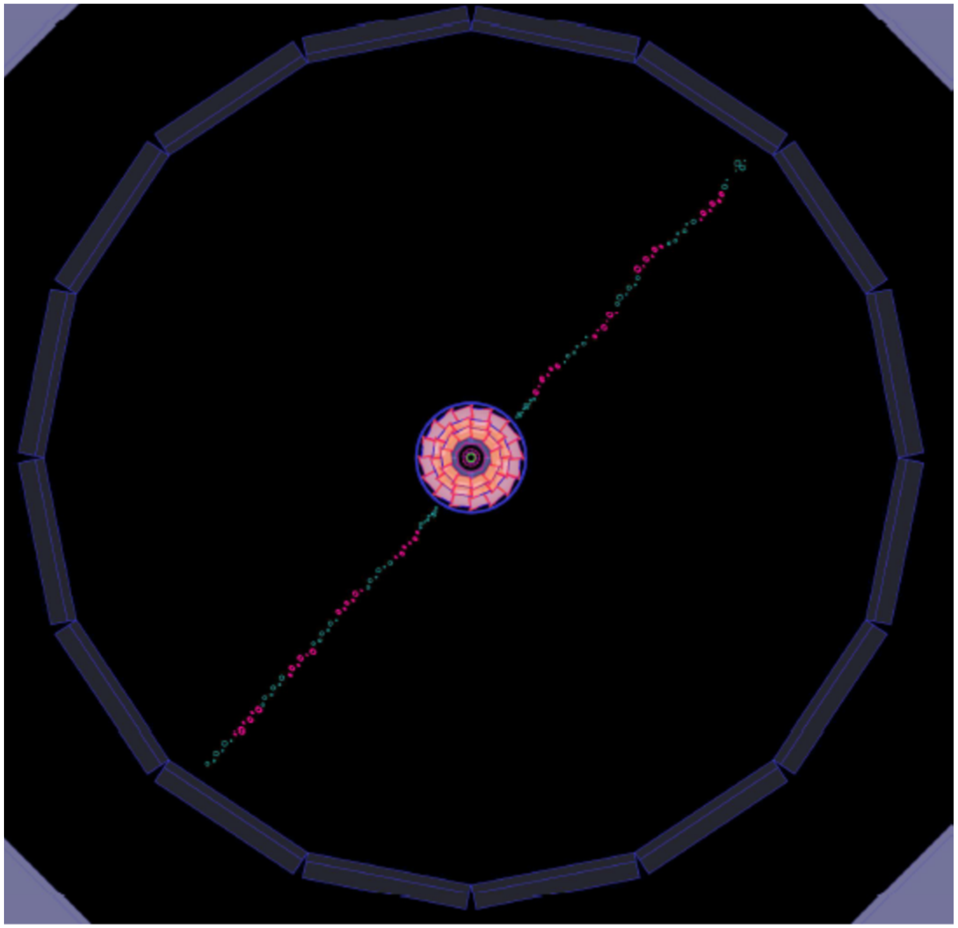


Wire stringing in a clean room

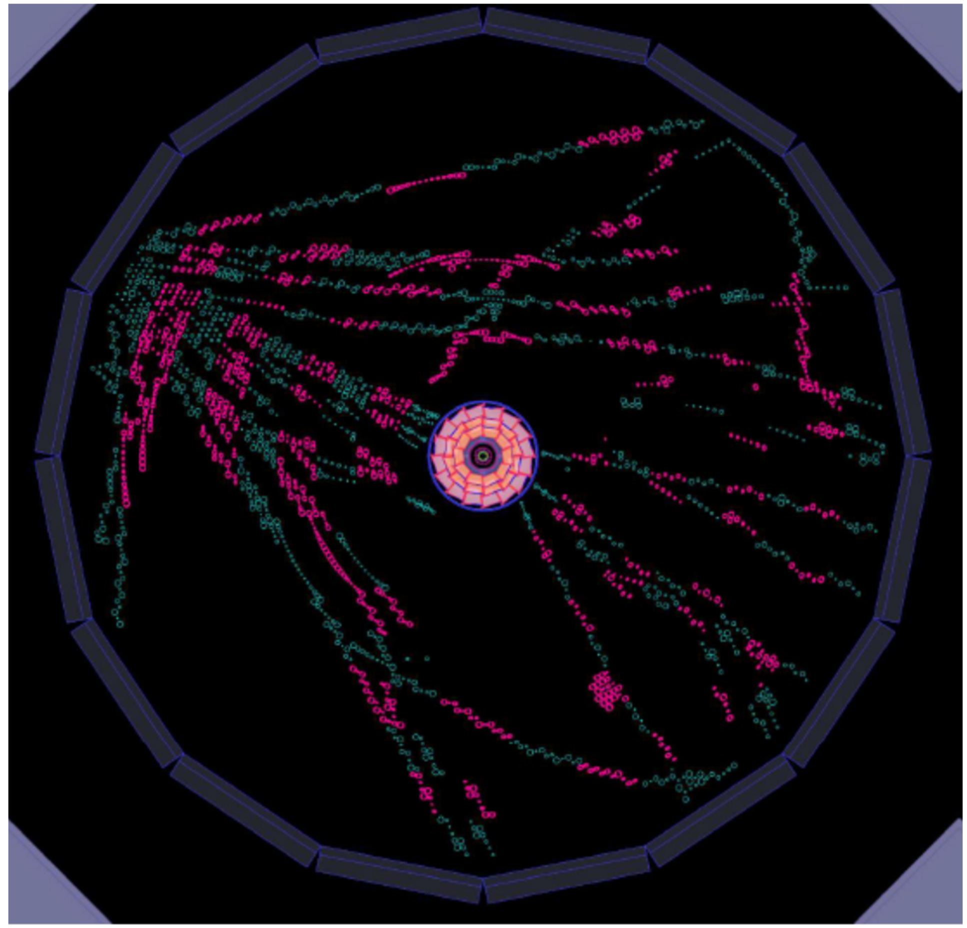
- thousands of wires,
- 1 year of work...



CDC event displays



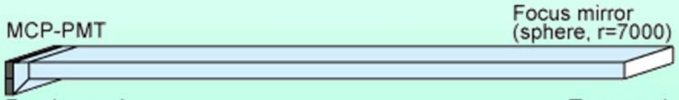
Single cosmic ray track



Multiple tracks
(showering cosmic ray event)

Particle Identification Devices

Barrel PID: Time of Propagation Counter (TOP)



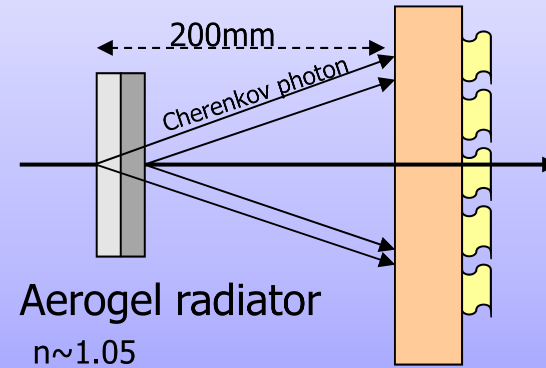
Quartz radiator

Focusing mirror

Small expansion block

Hamamatsu MCP-PMT (measure t, x and y)

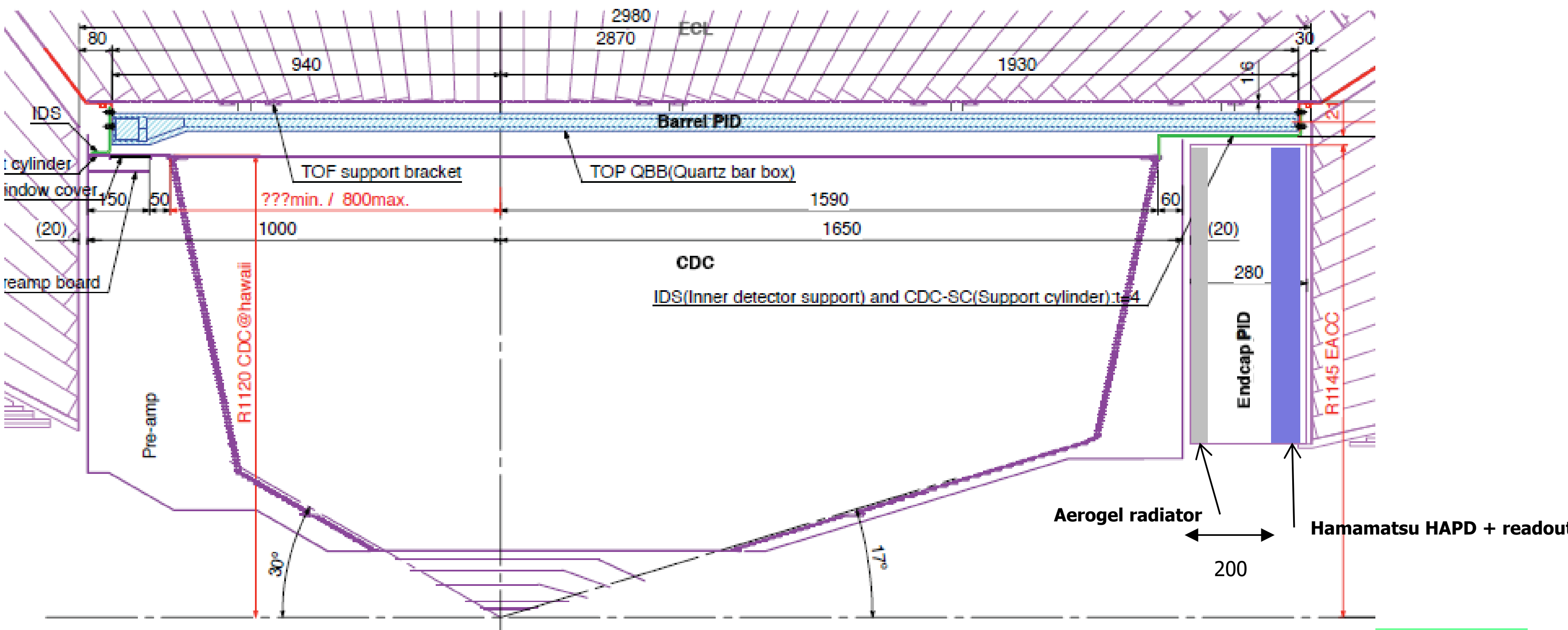
Endcap PID: Aerogel RICH (ARICH)



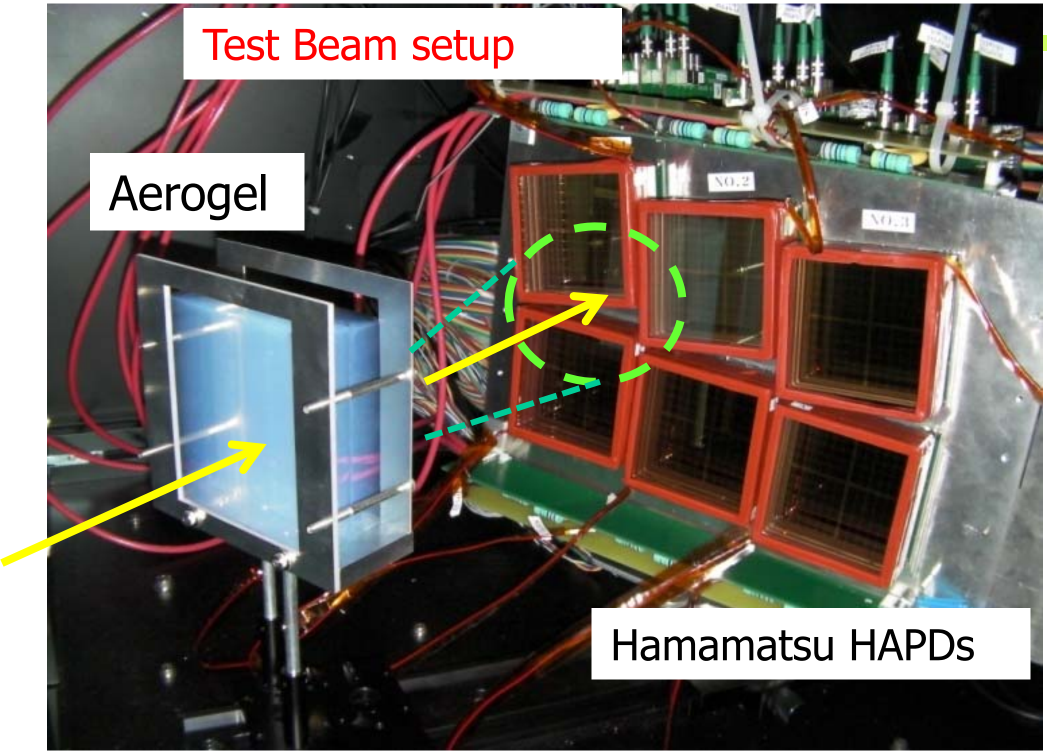
Aerogel radiator

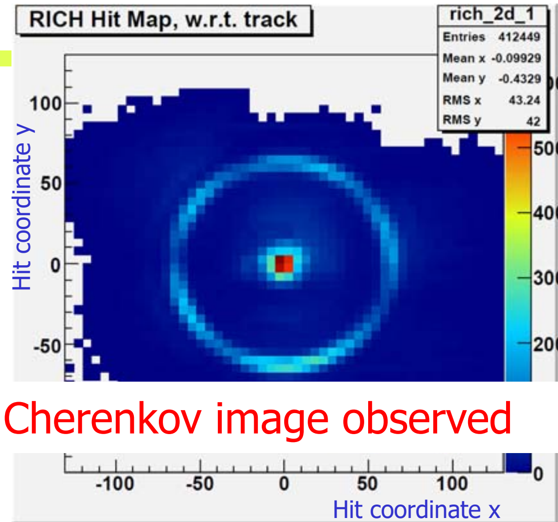
n~1.05

Hamamatsu HAPD



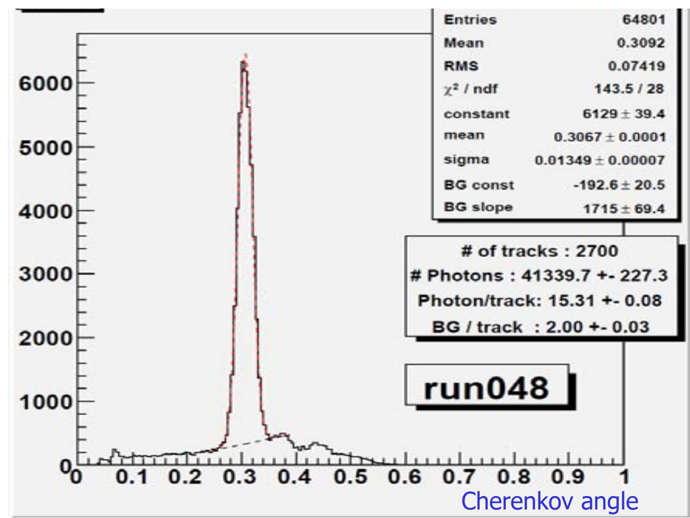
Aerogel RICH (endcap PID)





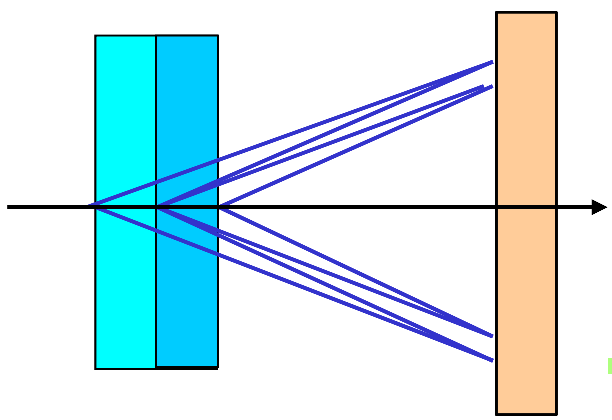
Clear Cherenkov image observed

Cherenkov angle distribution



RICH with a novel "focusing" radiator – a two layer radiator

Employ multiple layers with different refractive indices→ Cherenkov images from individual layers overlap on the photon detector.



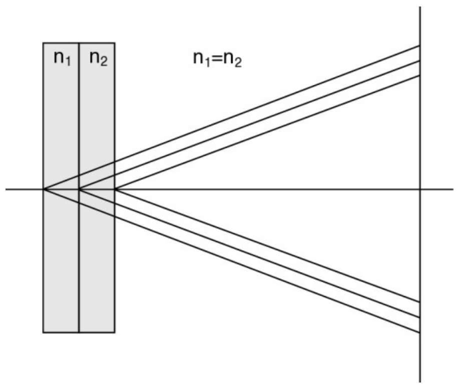
6.6 σ π/K at 4GeV/c !

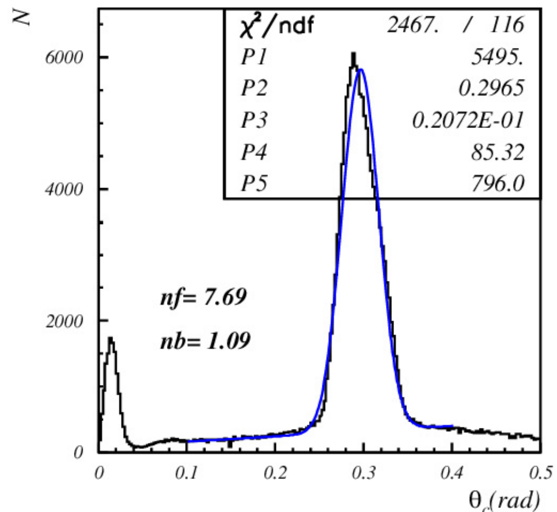
Peter Križan, Ljubljana

Focusing configuration – data

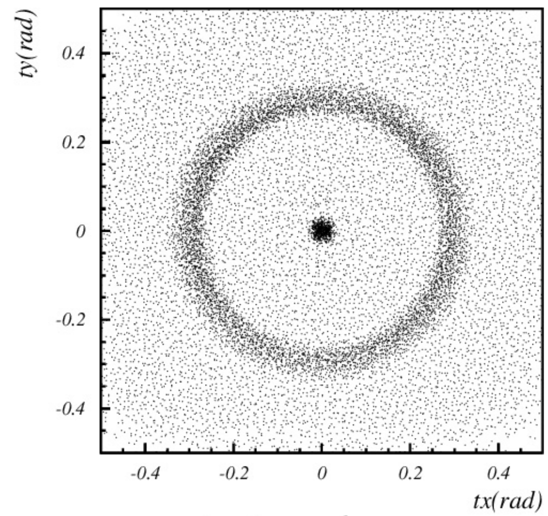
Increases the number of photons without degrading the resolution

4cm aerogel single index



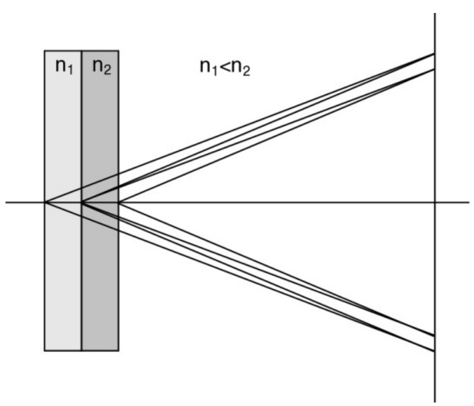


theta cerenkov

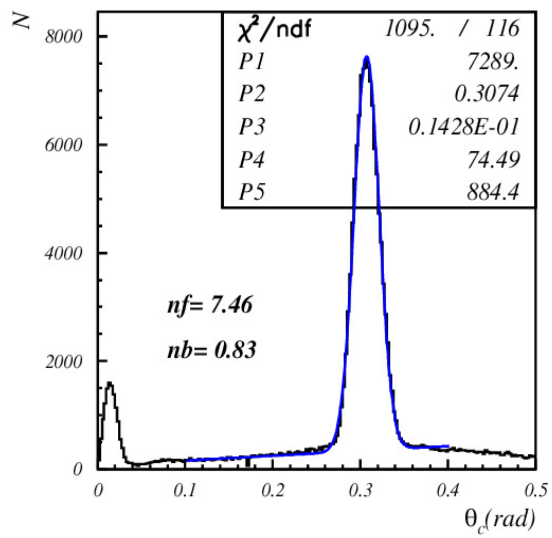


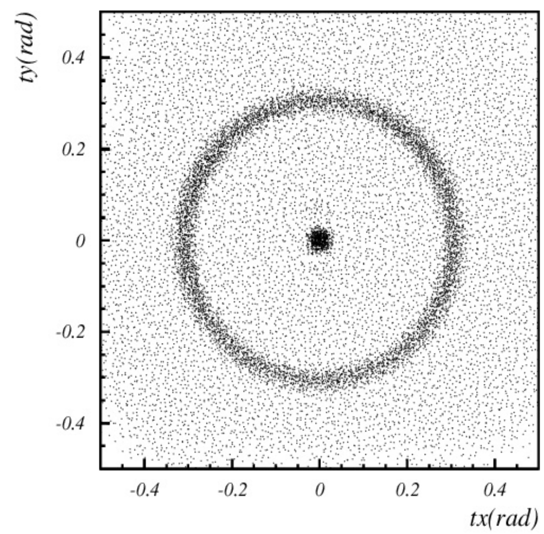
ring in cerenkov space

2+2cm aerogel

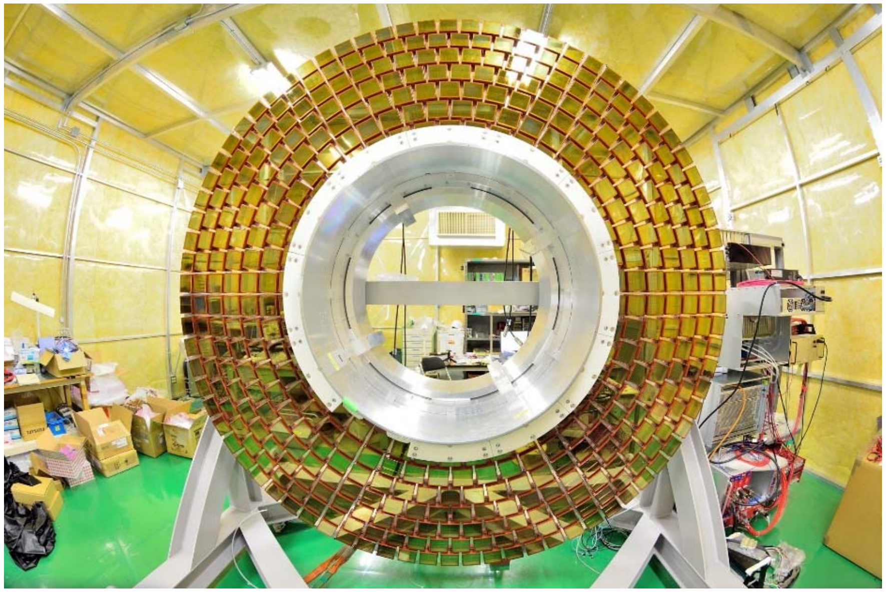


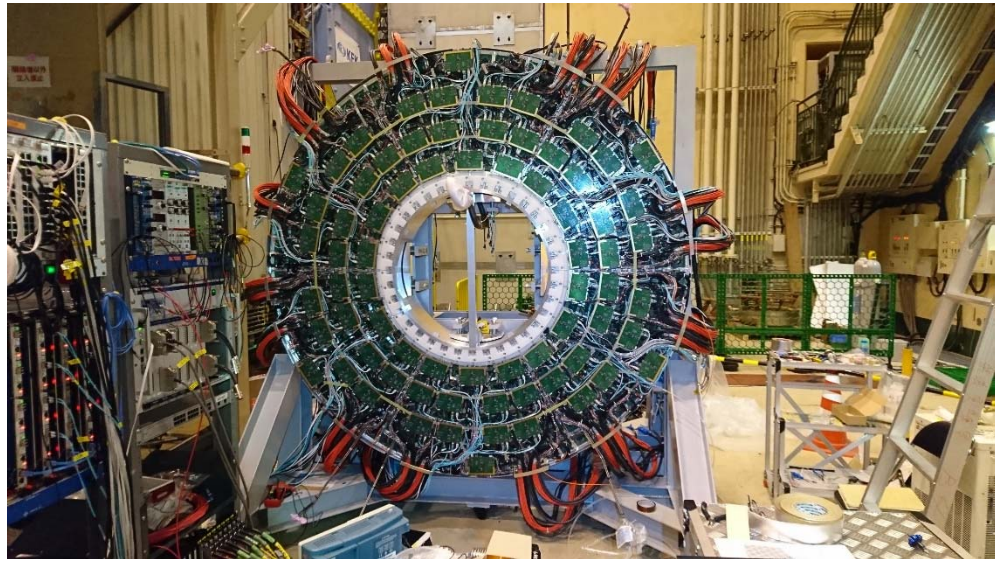
→NIM A548 (2005) 383

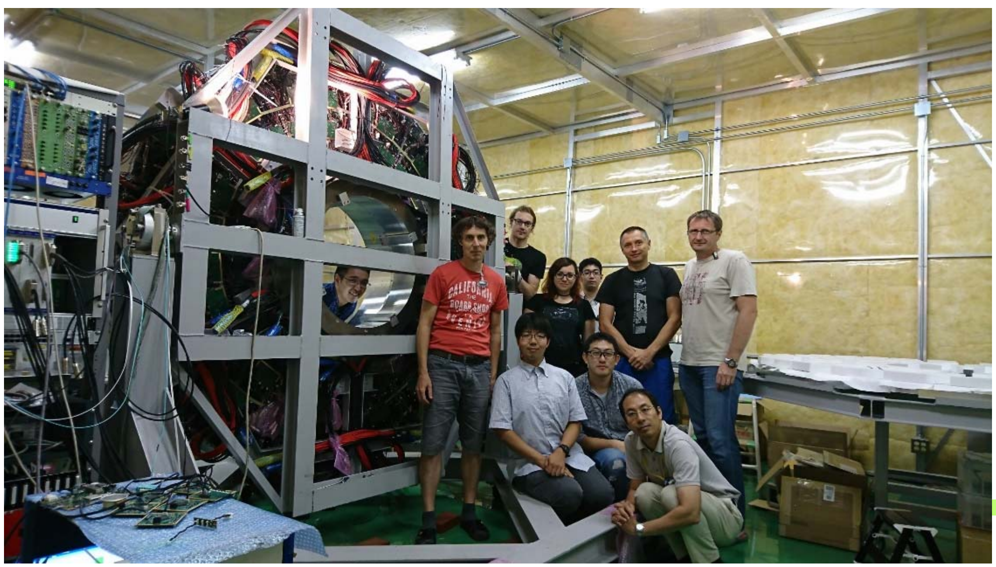


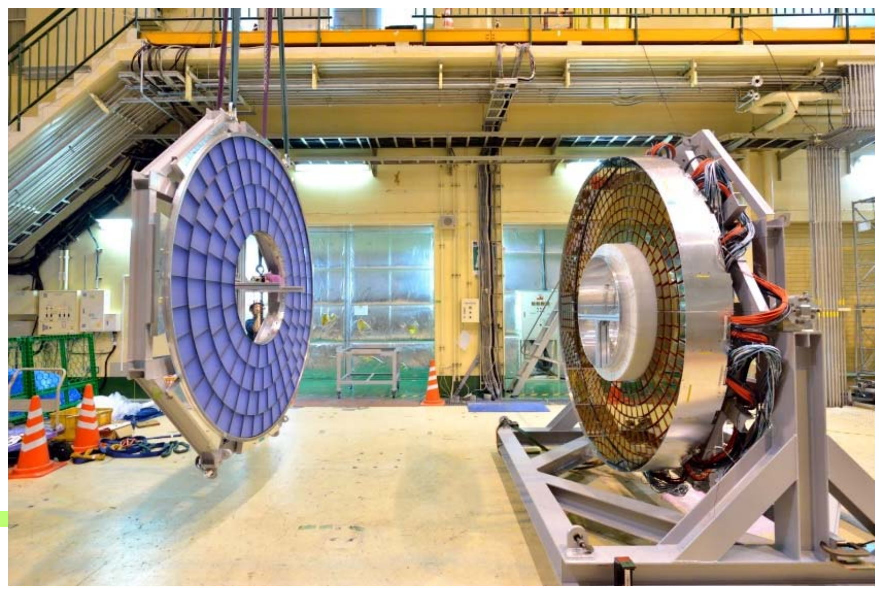


The big eye of ARICH



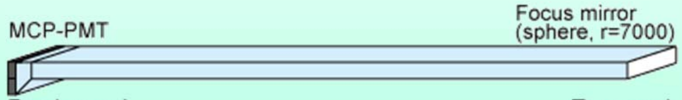






Cherenkov detectors

Barrel PID: Time of Propagation Counter (TOP)



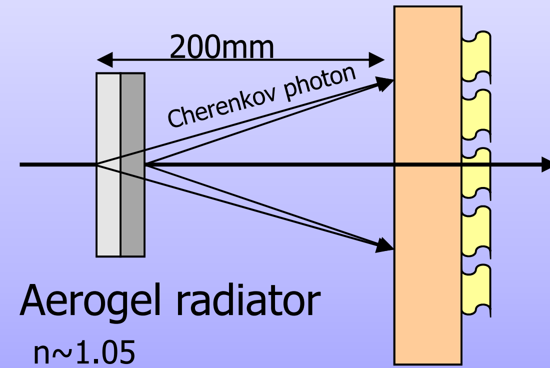
Quartz radiator

Focusing mirror

Small expansion block

Hamamatsu MCP-PMT (measure t, x and y)

Endcap PID: Aerogel RICH (ARICH)

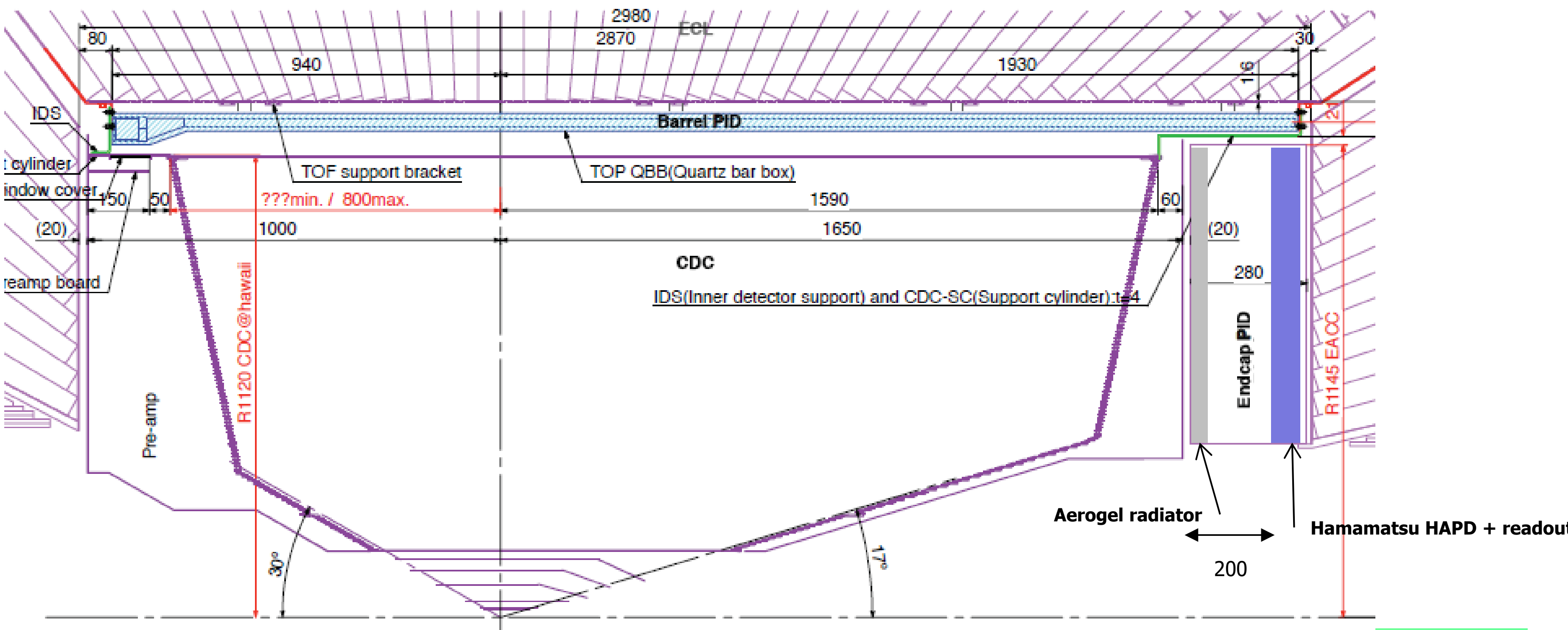


Aerogel radiator

n~1.05

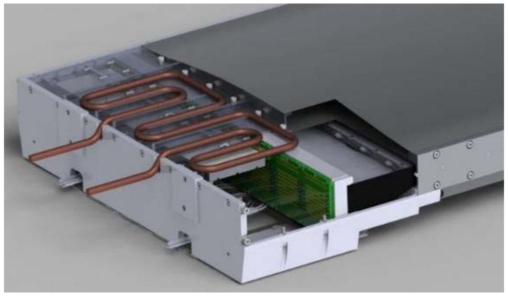
Hamamatsu HAPD

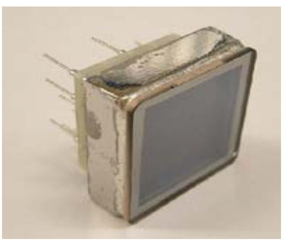
+ new ASIC

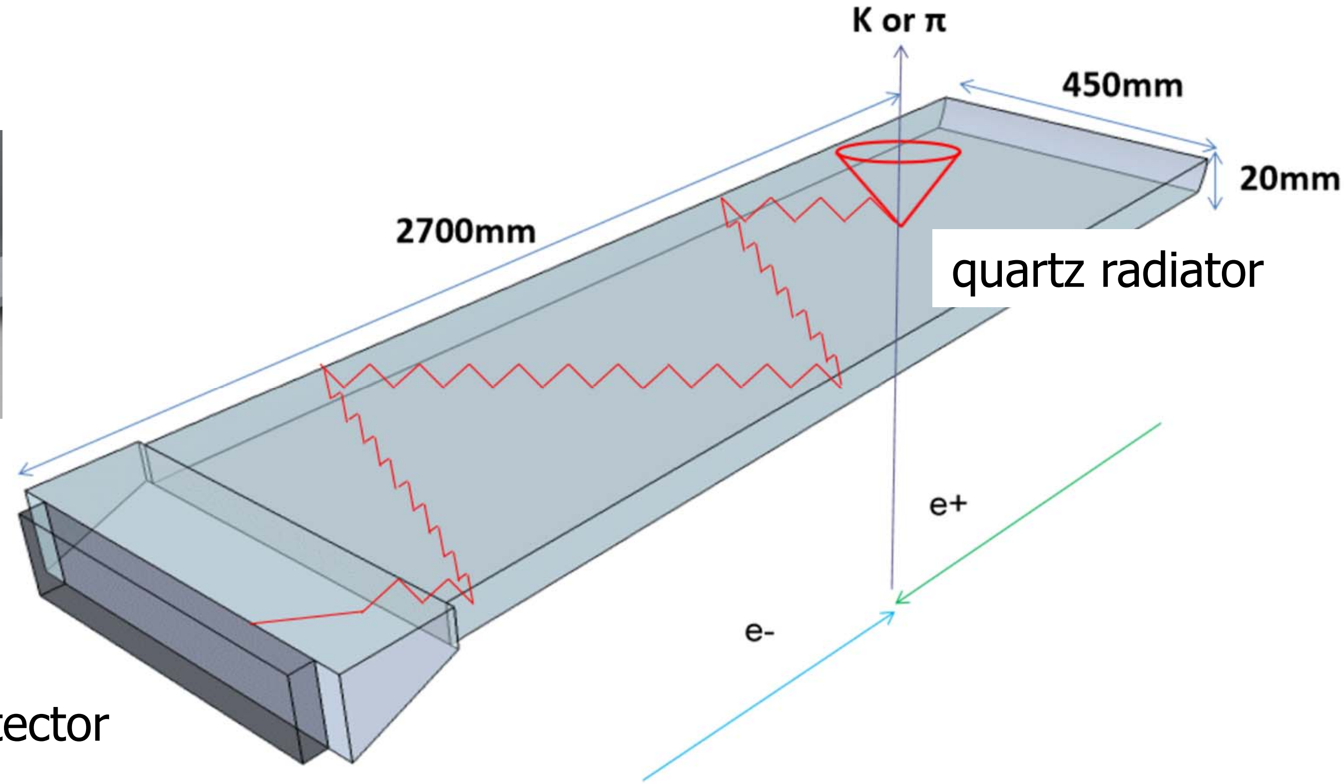


Peter Križan, Ljubljana

Barrel PID: Time of propagation (TOP) counter



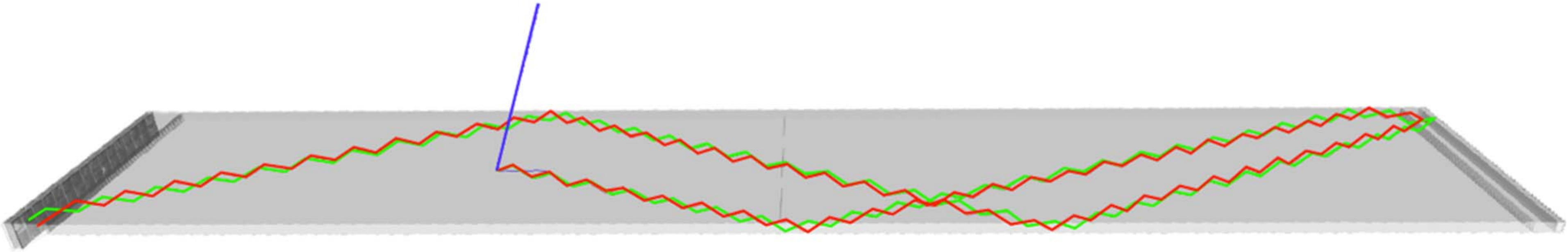




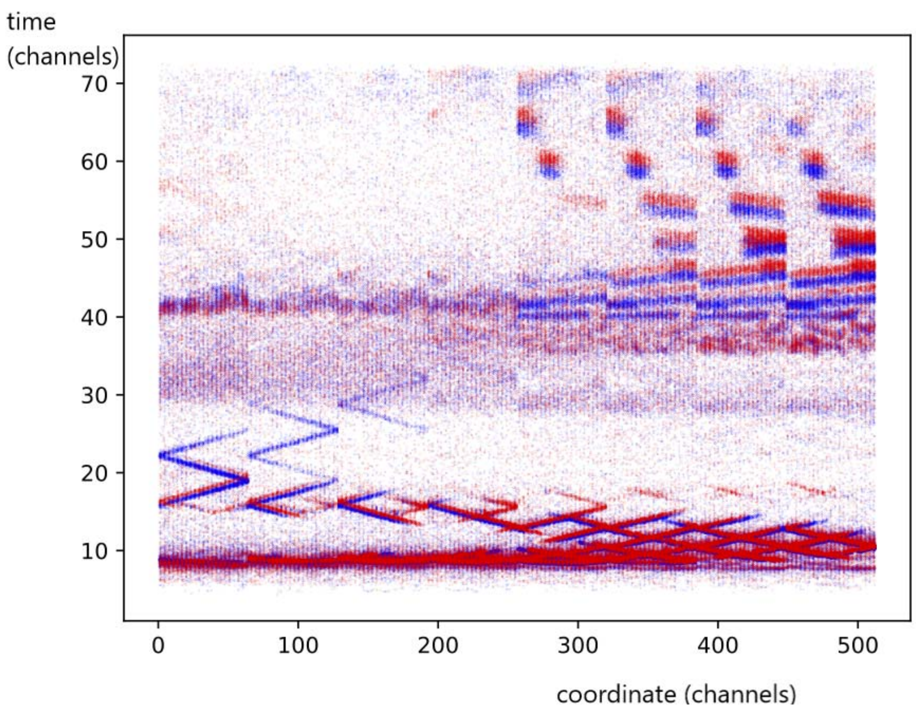
Photon detector

- Cherenkov ring imaging with precise time measurement.
- Reconstruct Cherenkov angle from two hit coordinates and the time of propagation of the photon
  - Quartz radiator (2cm thick)
  - Photon detector (MCP-PMT)
    - Excellent time resolution ~ 40 ps
    - Single photon sensitivity in 1.5 T

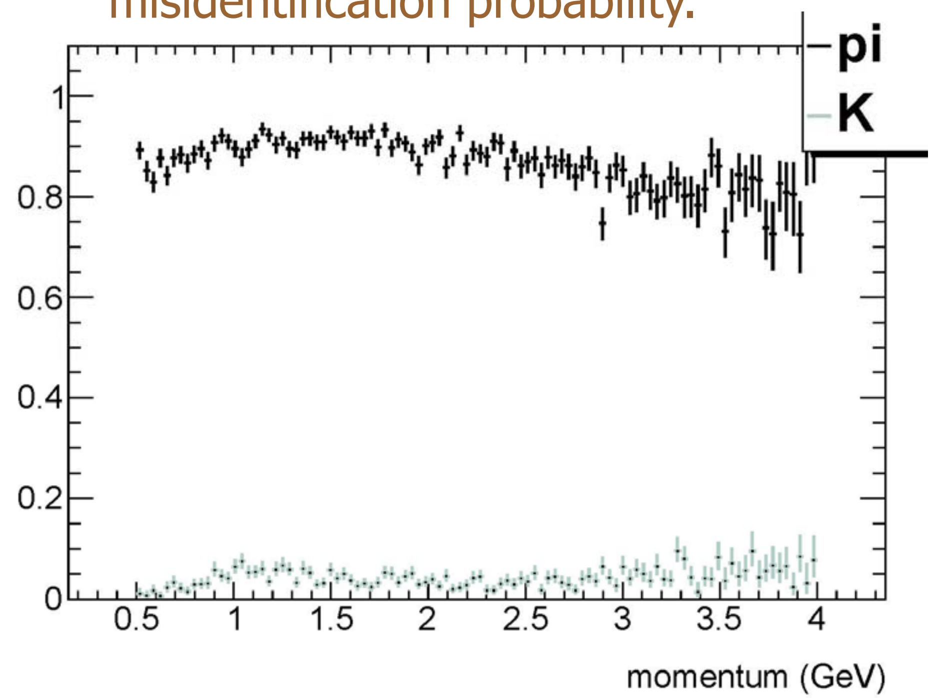
Separation of kaons and pions



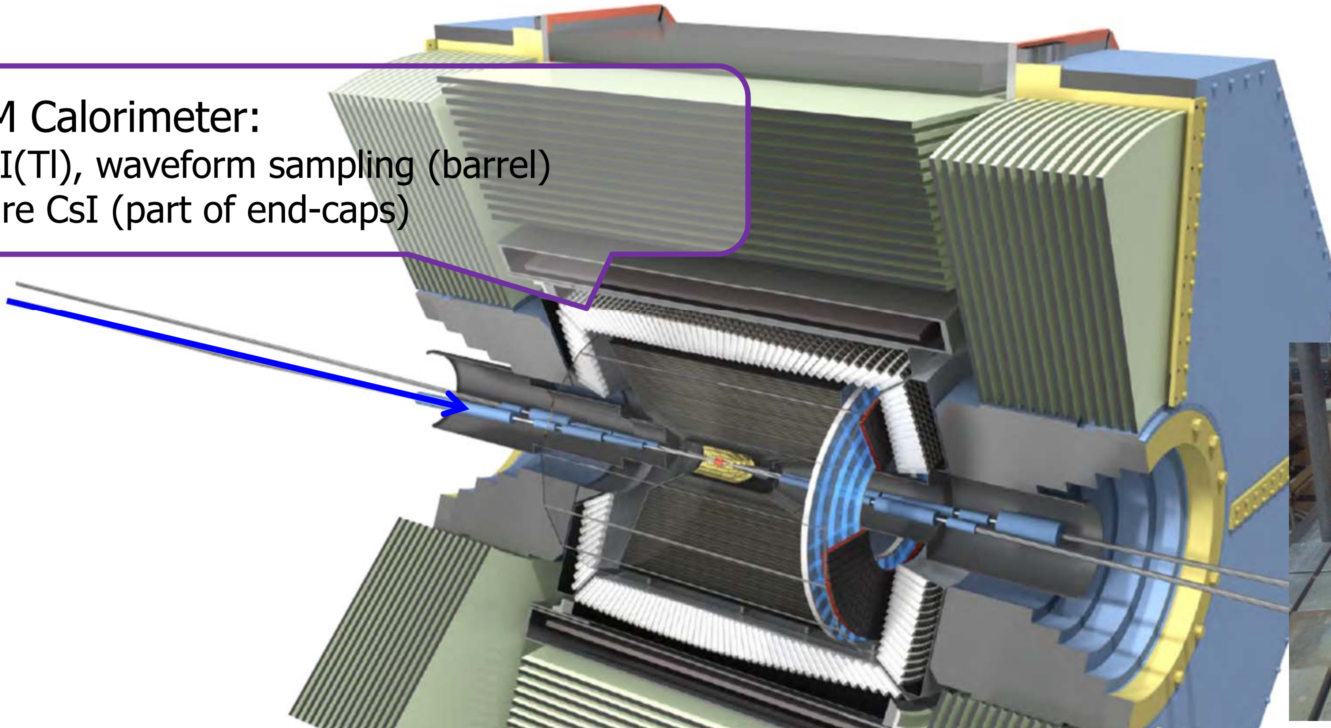
Pions vs kaons in TOP:
different patterns in the time vs PMT impact point coordinate



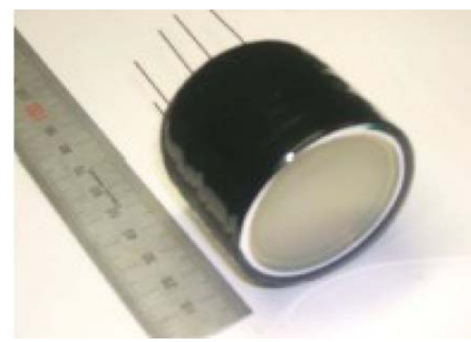
Pions vs kaons:
Expected PID efficiency and misidentification probability.



EM calorimeter: upgrade needed because of higher rates (electronics → waveform sampling) and radiation load (endcap, replace some fraction of crystals, CsI(Tl) → pure CsI)

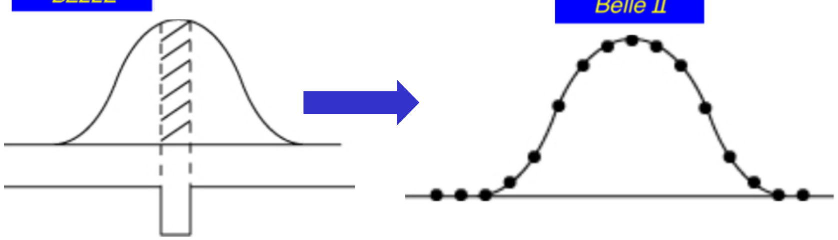


EM Calorimeter:
CsI(Tl), waveform sampling (barrel)
Pure CsI (part of end-caps)

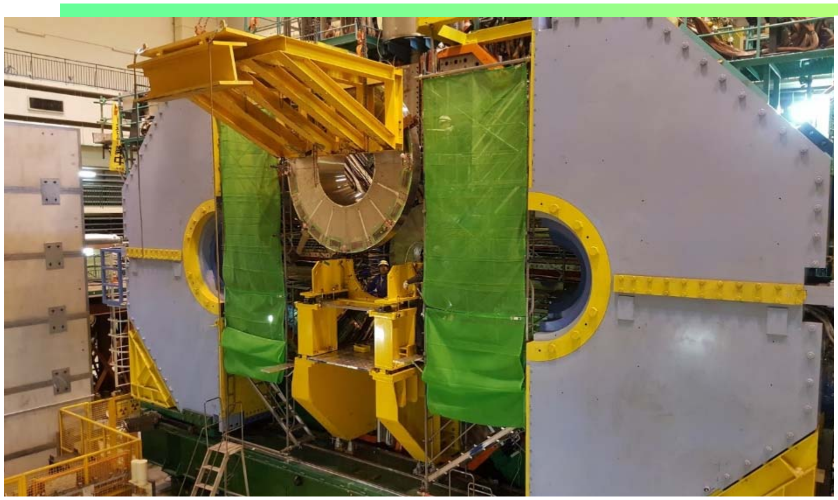


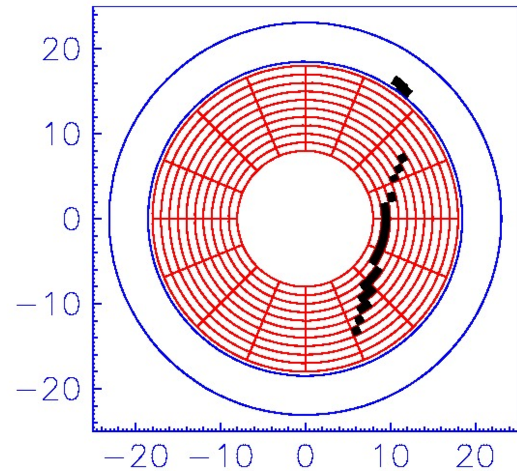
New read-out: waveform sampling

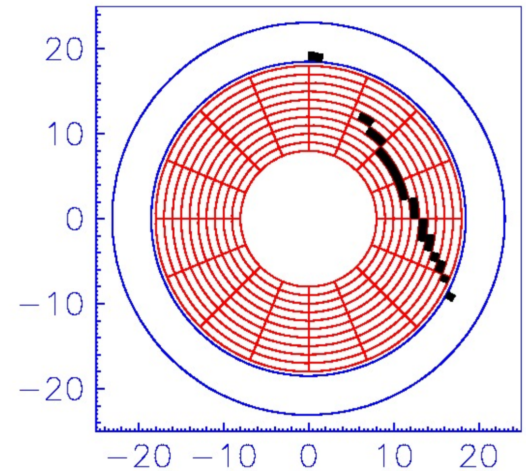
BELLE → Belle II



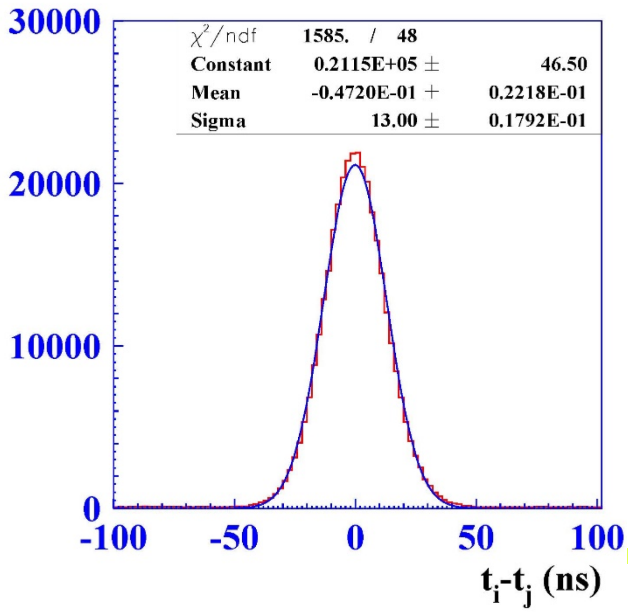
ECL: endcap installation, testing with cosmic ray tracks, expected performance



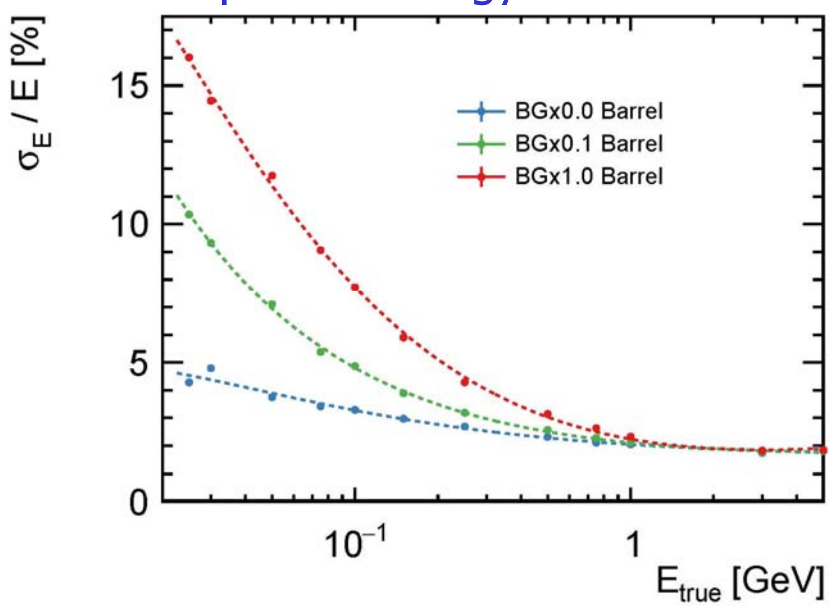




Measured time resolution

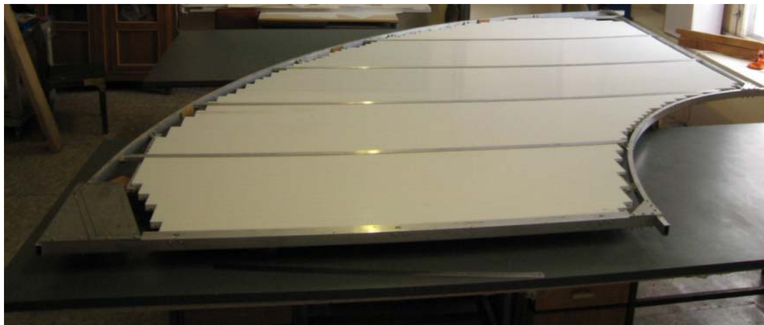


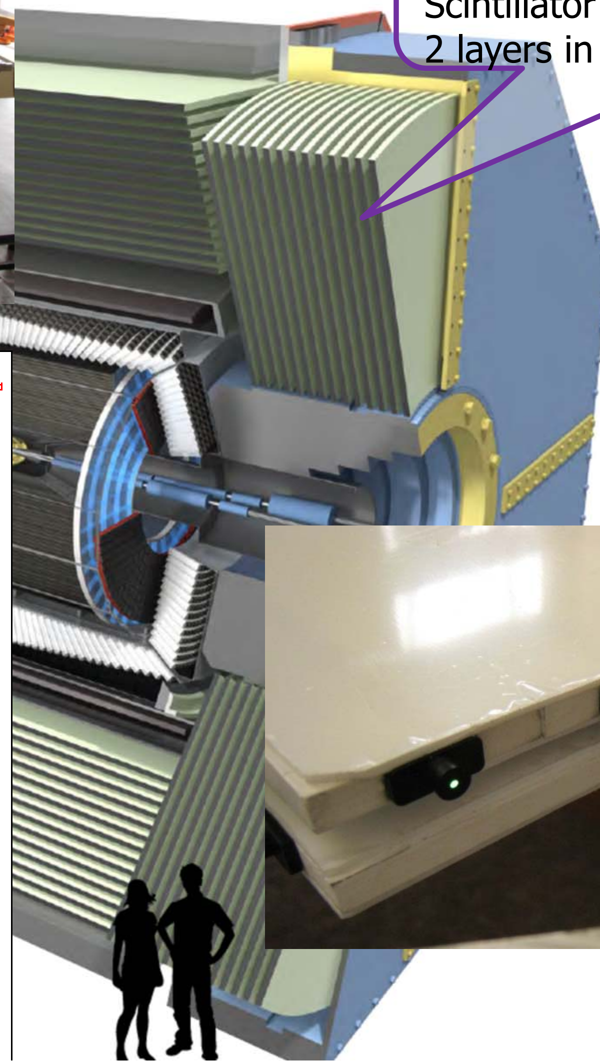
Expected energy resolution

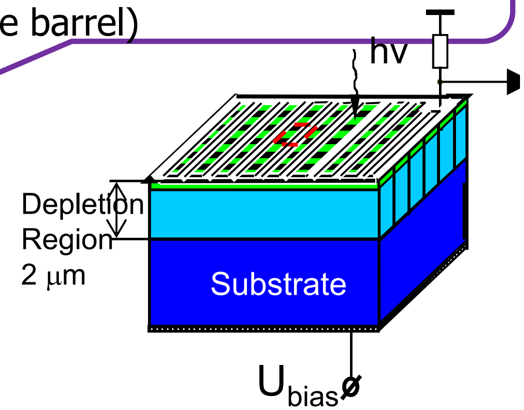


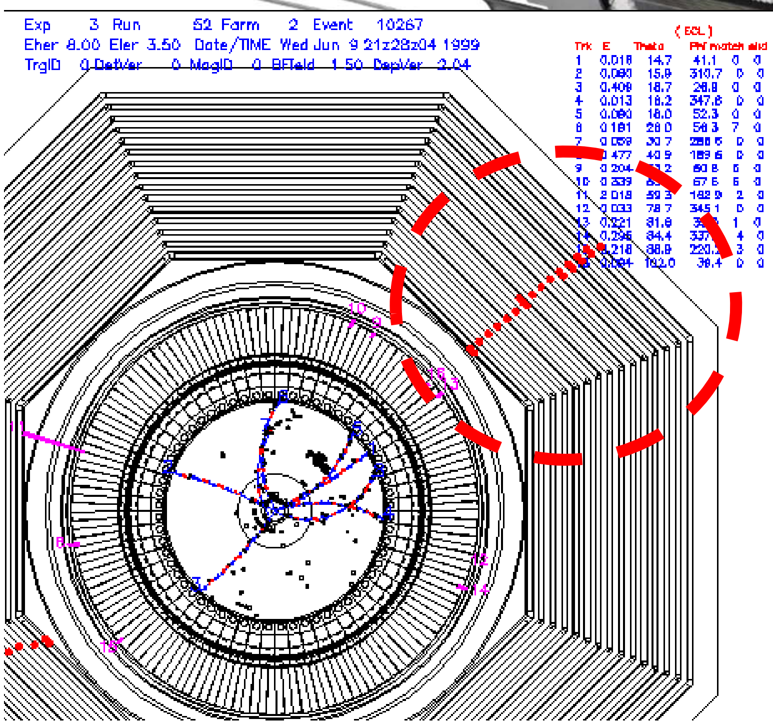
Detection of muons and K_Ls: mainly RPCs; parts of the original RPC system had to be replaced because they could not handle the high background rates (mainly neutrons)

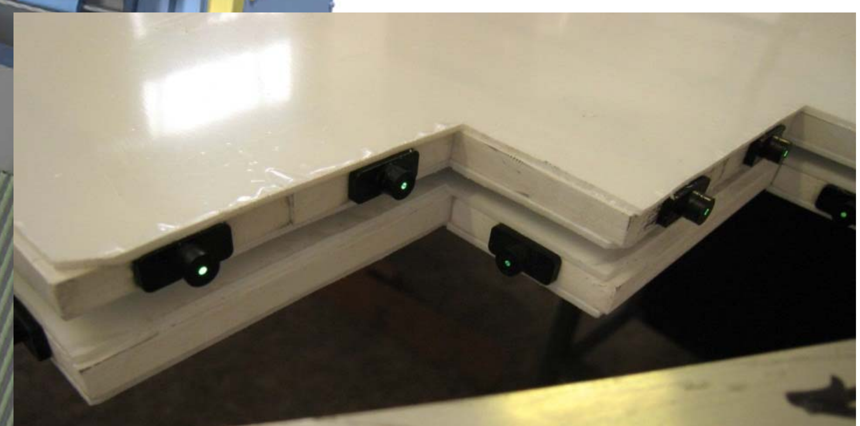
K_L and muon detector:
Resistive Plate Counter (barrel)
Scintillator + WLSF + MPPC (end-caps + 2 layers in the barrel)









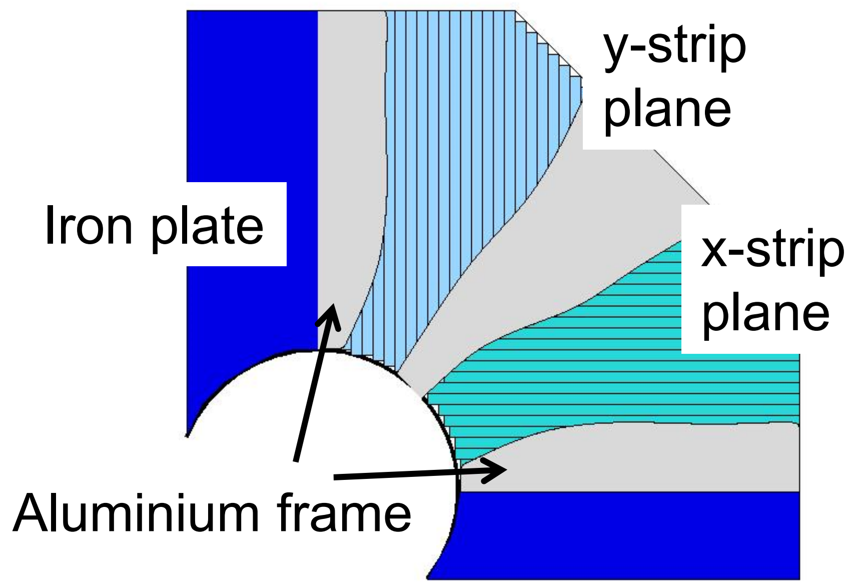


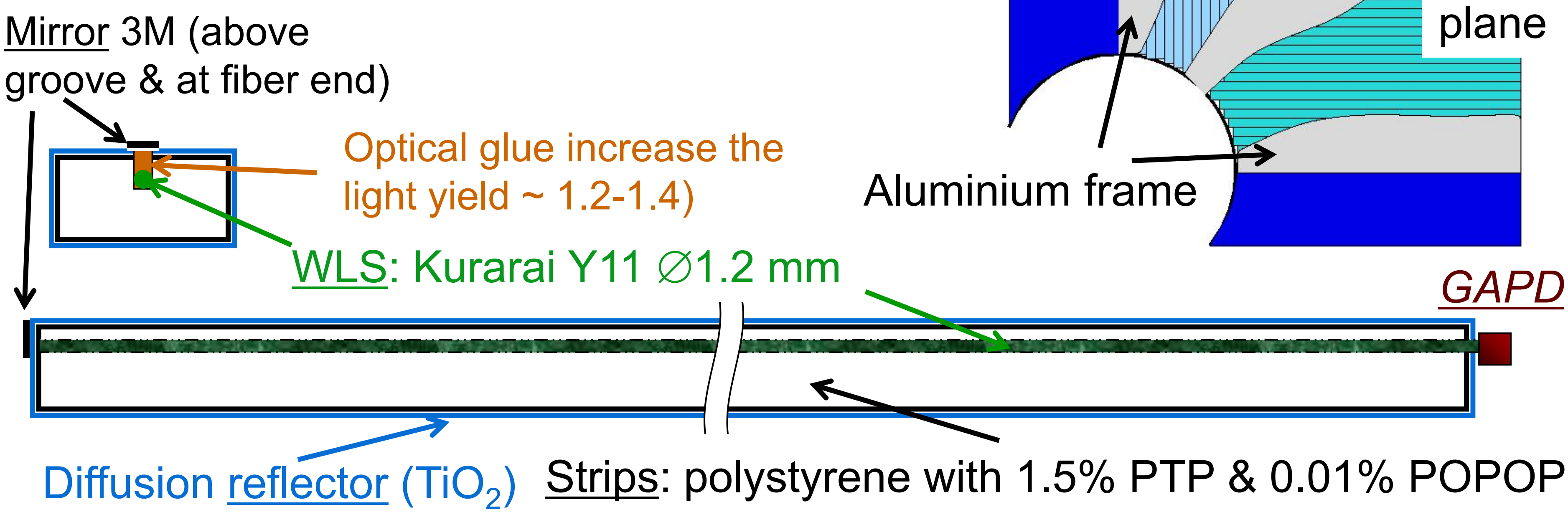
ljana

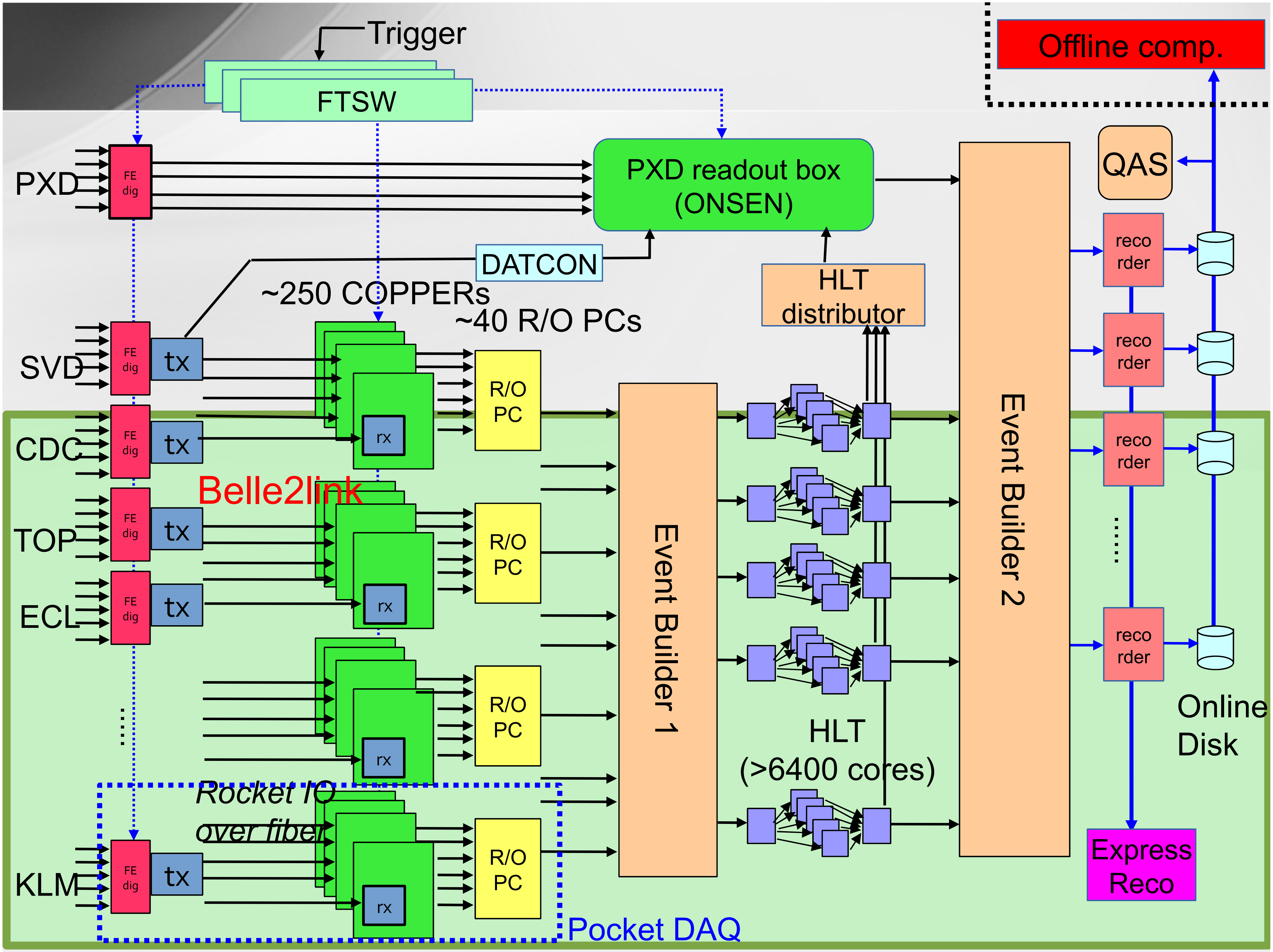
Muon detection system upgrade

Scintillator-based KLM (endcap in inner layers of the barrell part)

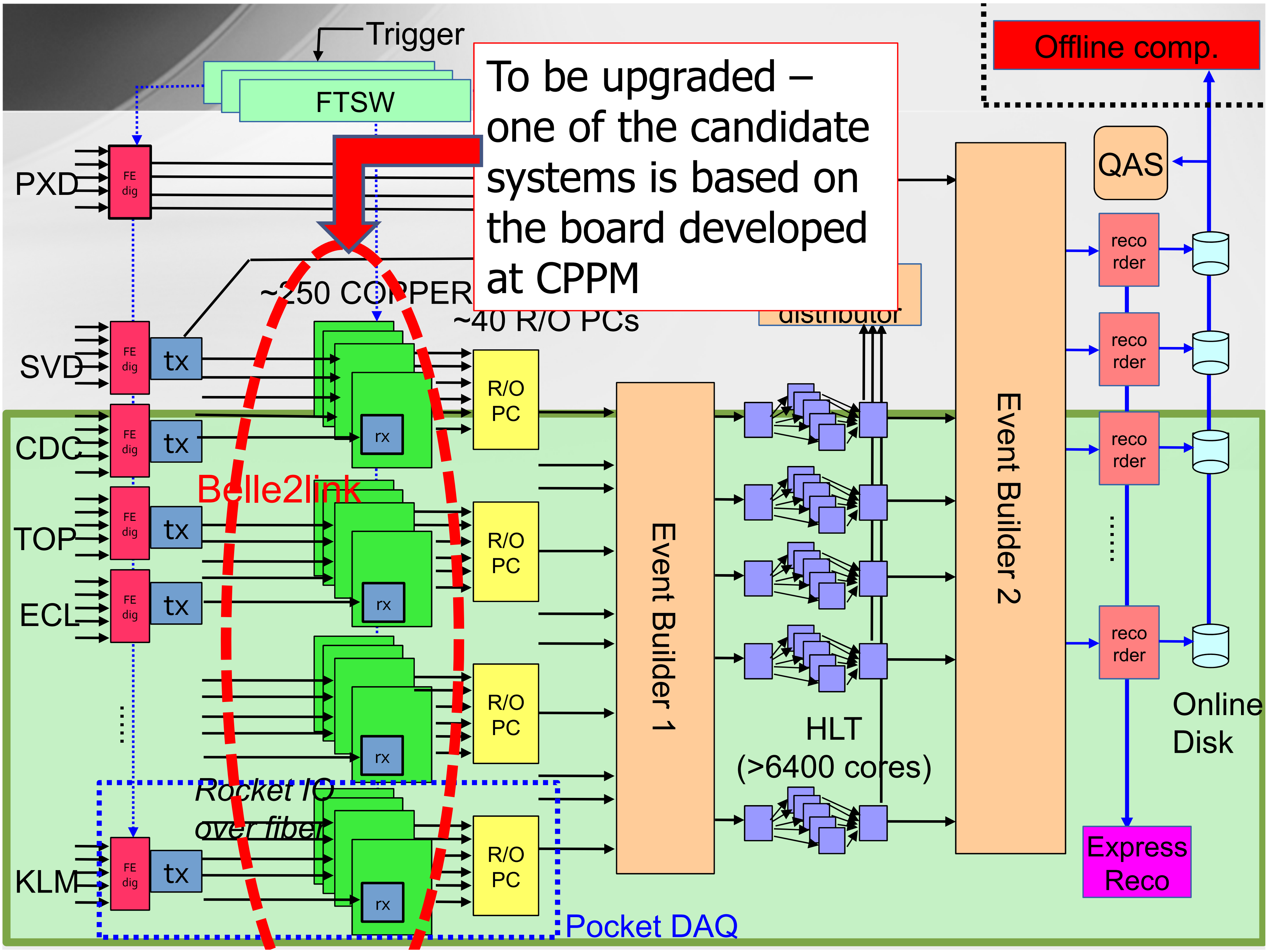
- Two independent (x and y) layers in one superlayer made of orthogonal strips with WLS read out
- Photo-detector = avalanche photodiode in Geiger mode (SiPM)
- ~120 strips in one 90º sector
  (max L=280cm, w=25mm)
- ~30000 read out channels
- Geometrical acceptance > 99%







Trigger
FTSW
Offline comp.
PXD
FE dig
PXD readout box (ONSEN)
QAS
DATCON
HLT distributor
~250 COPPERs
~40 R/O PCs
SVD
CDC
TOP
ECL
KLM
tx
rx
R/O PC
Belle2link
Event Builder 1
Event Builder 2
reco rder
HLT (>6400 cores)
Online Disk
Rocket IO over fiber
Express Reco
Pocket DAQ



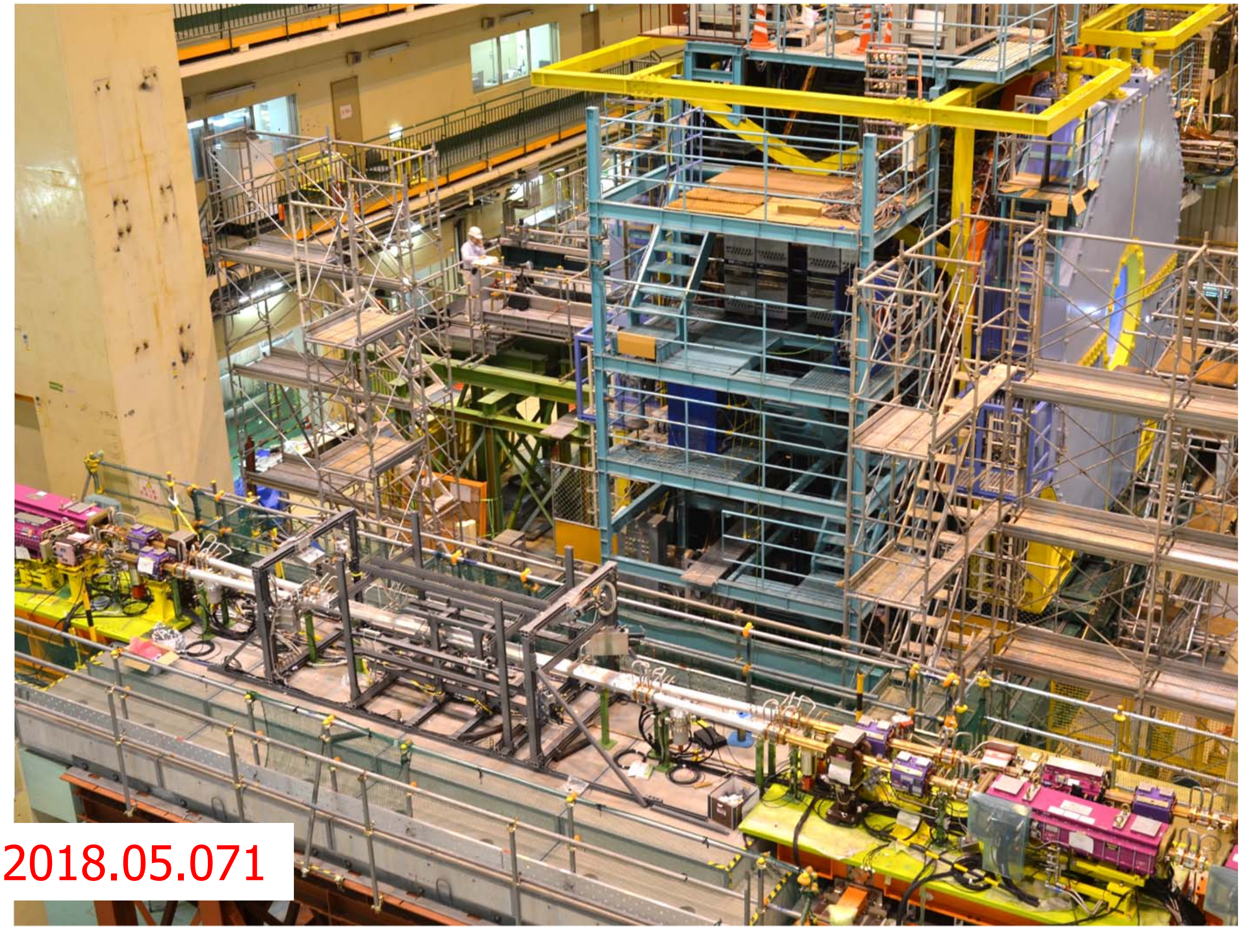
Trigger
FTSW
Offline comp.
To be upgraded – one of the candidate systems is based on the board developed at CPPM
QAS
PXD
FE dig
SVD
tx
CDC
TOP
ECL
KLM
~250 COPPER
~40 R/O PCs
distributor
R/O PC
rx
Belle2link
Rocket IO over fiber
Pocket DAQ
Event Builder 1
Event Builder 2
HLT (>6400 cores)
reco rder
Online Disk
Express Reco

Getting ready…

SuperKEKB commissioning phase 1: BEAST II commissioning detector

Commisioning (Phase 1) of the main ring (without final quads) successfully carried out from Feb 1, 2016 – end of June 2016

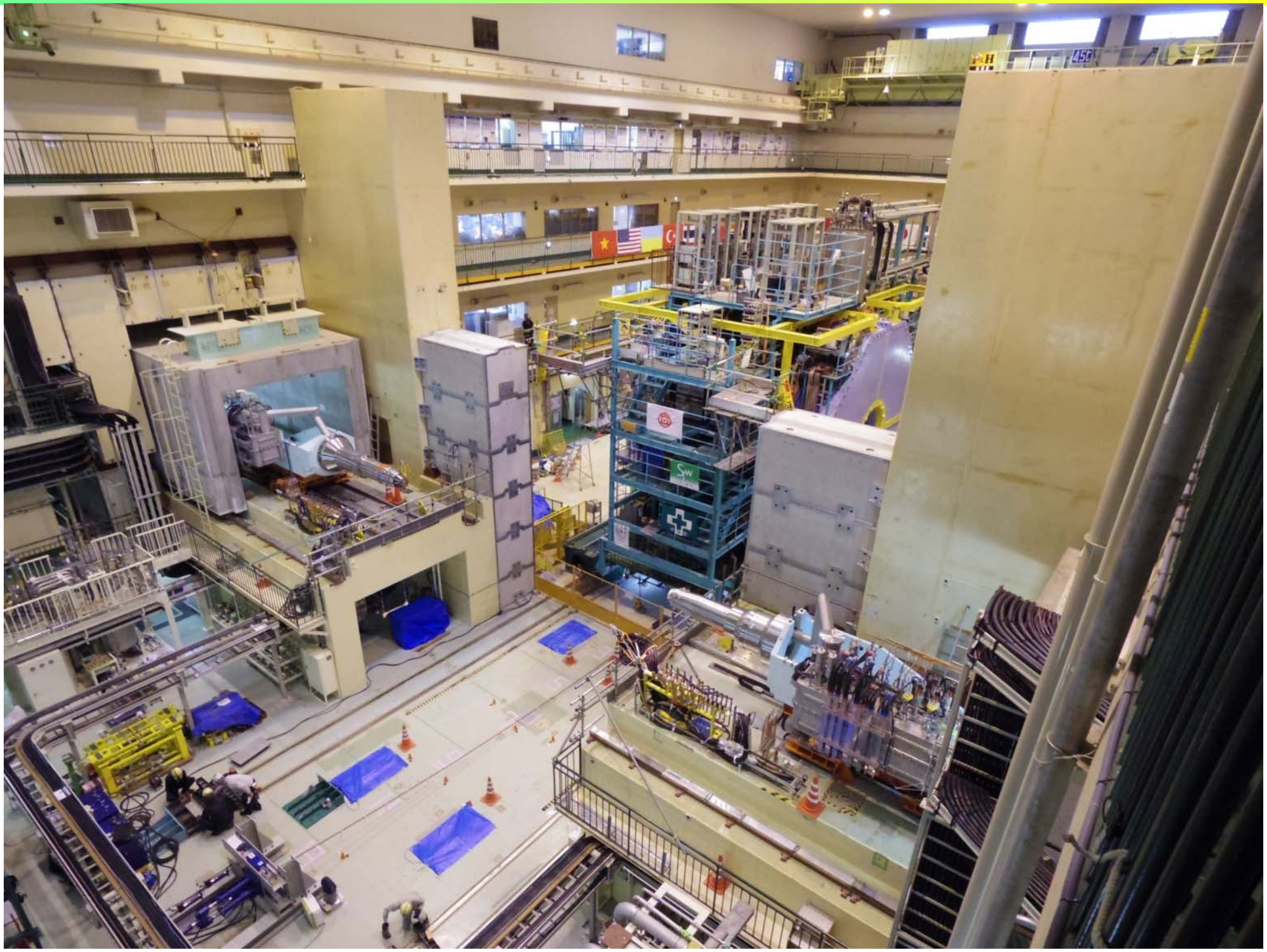
Interaction point detector: instead of Belle II, a commissioning detector – BEAST II.



→a 100 page report published in NIMA

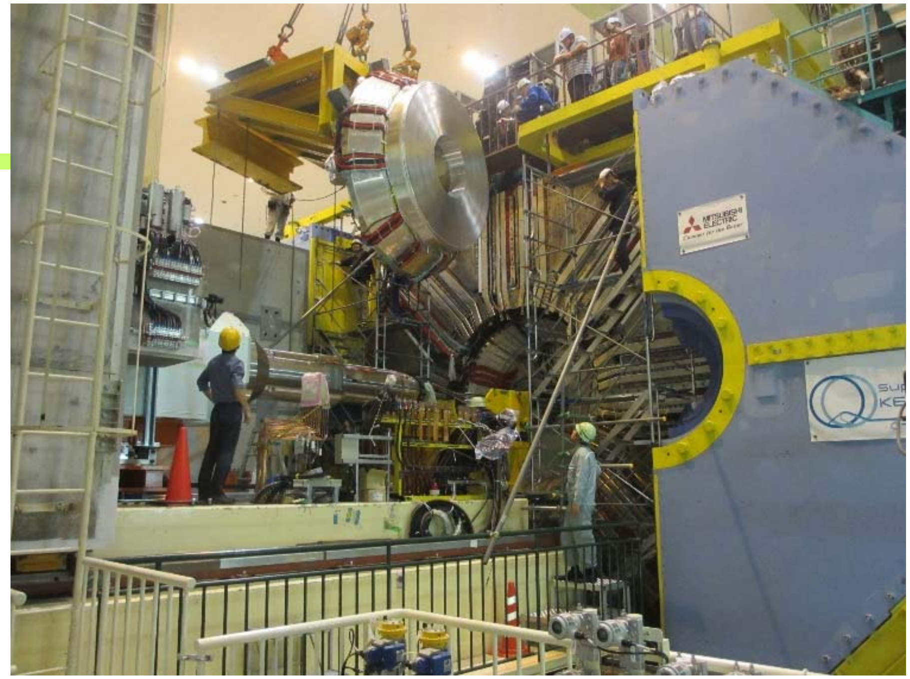
https://doi.org/10.1016/j.nima.2018.05.071

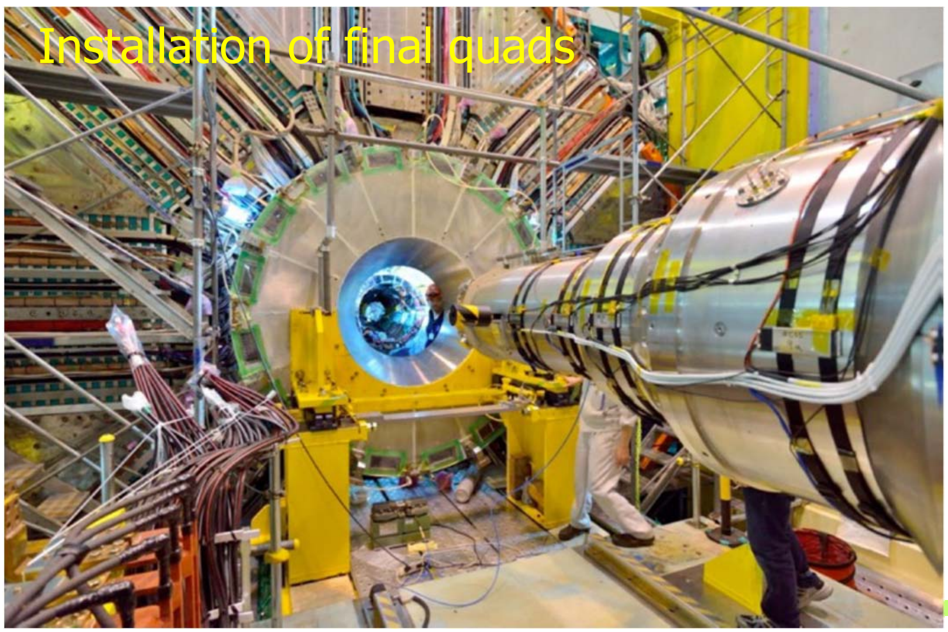
Belle II Roll-in



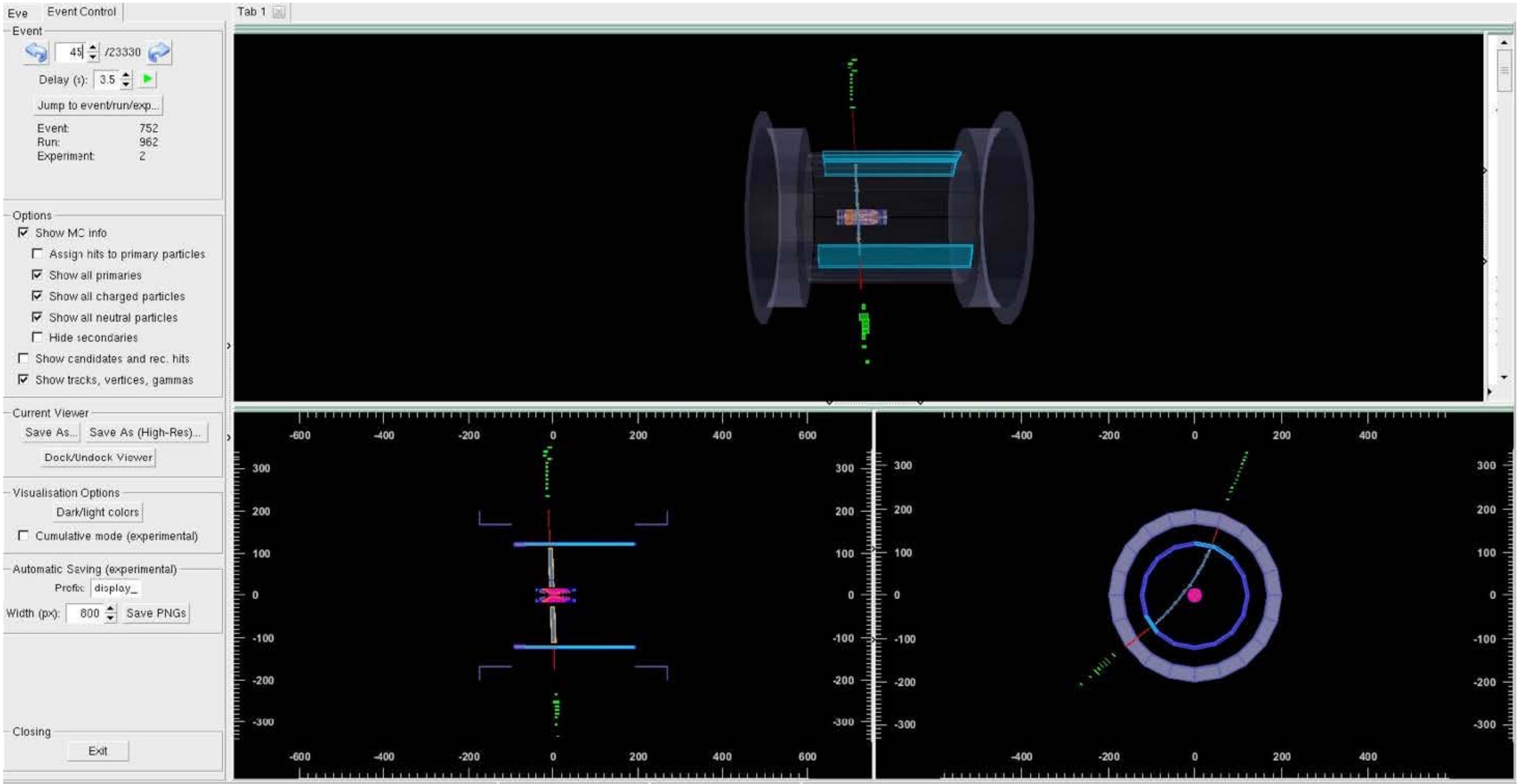
Belle II rolled-in to the beam line on April 11th, 2017
One of the most significant milestones in the construction phase
Live broadcasted by a video sharing website KEK × niconico


ARICH and forward endcap
calorimeter transport and installation

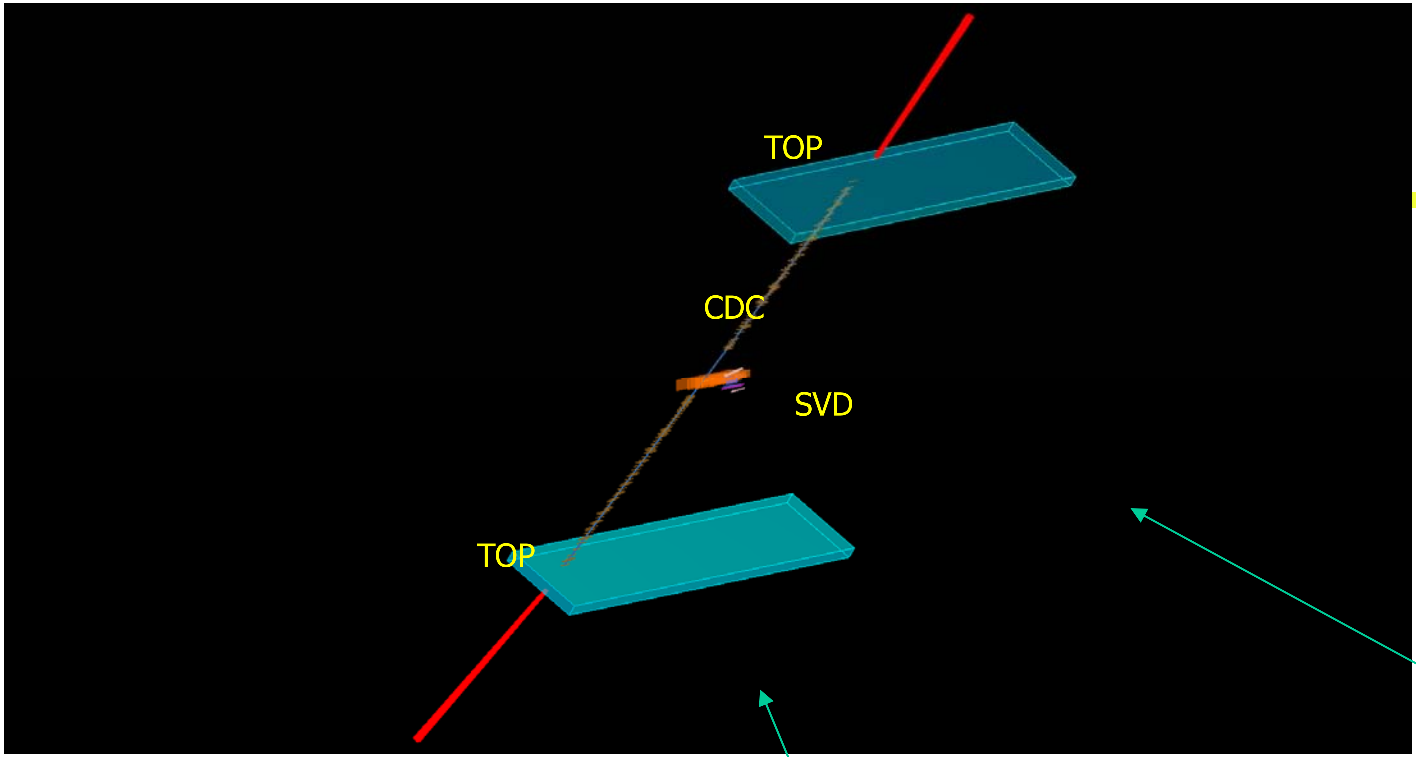



Installation of final quads

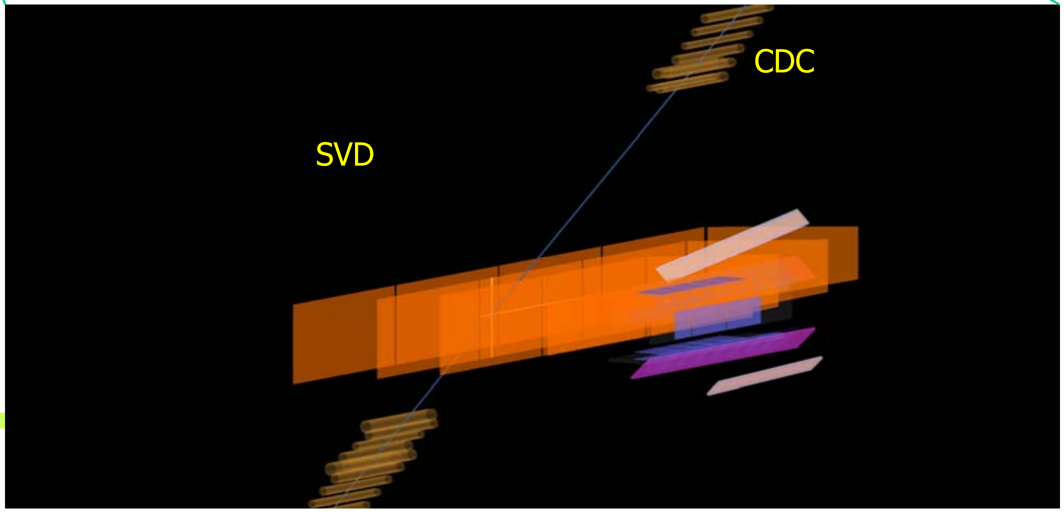

Installation of the commissioning
vertex detector



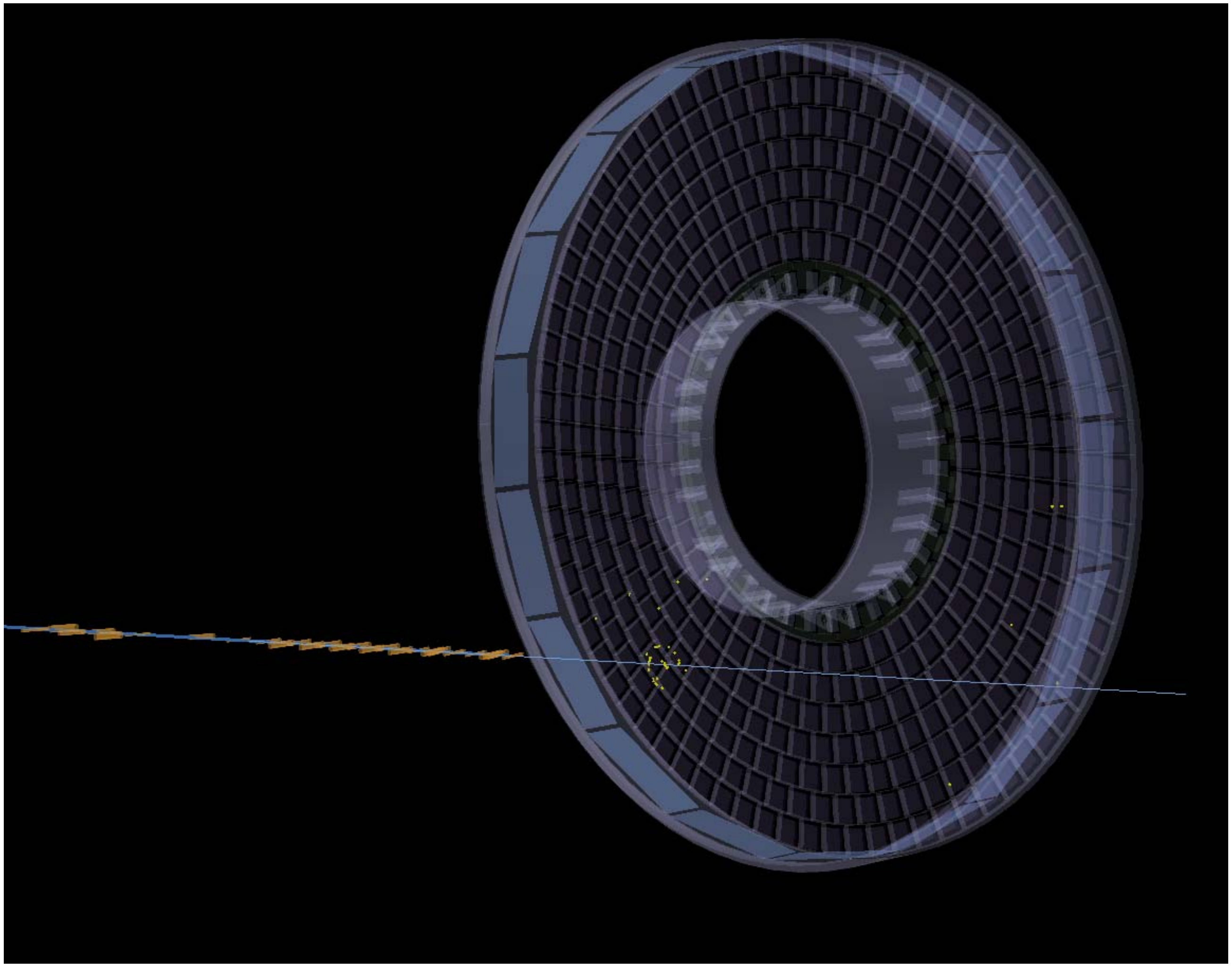
Four outer detector subsystems CDC, TOP, ECL, BKLM read out simultaneously



+ vertex
detector hits!

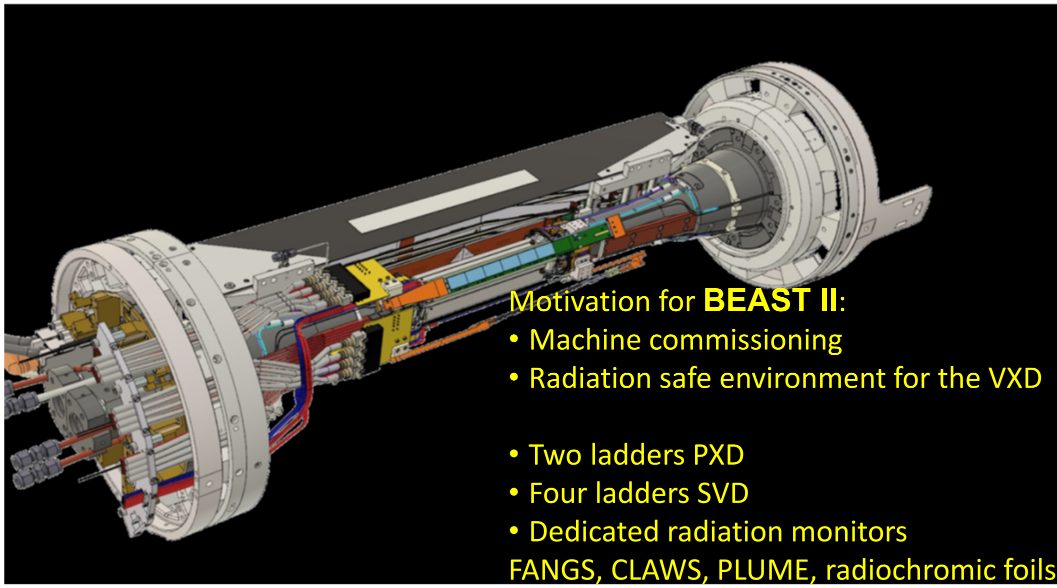


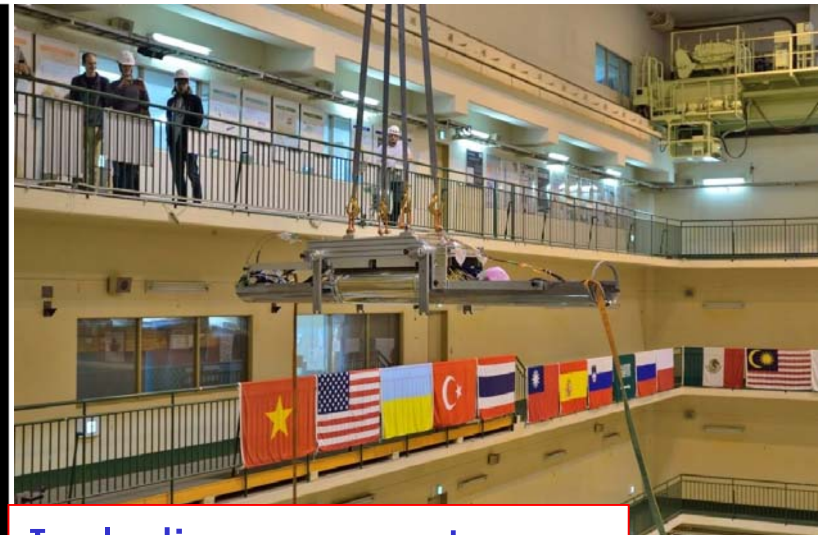
ARICH: Rings from cosmic ray muons



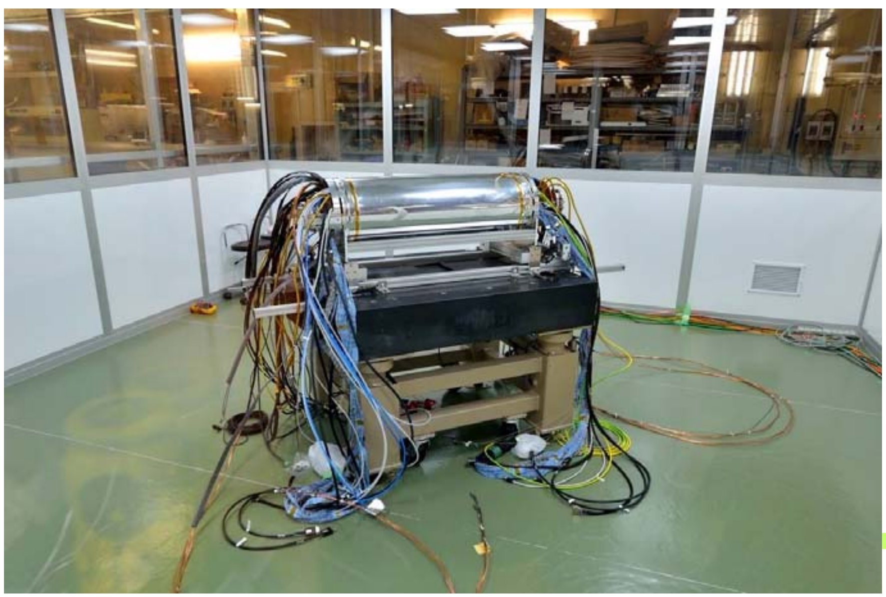
First events recorded in the fully instrumented ARICH.

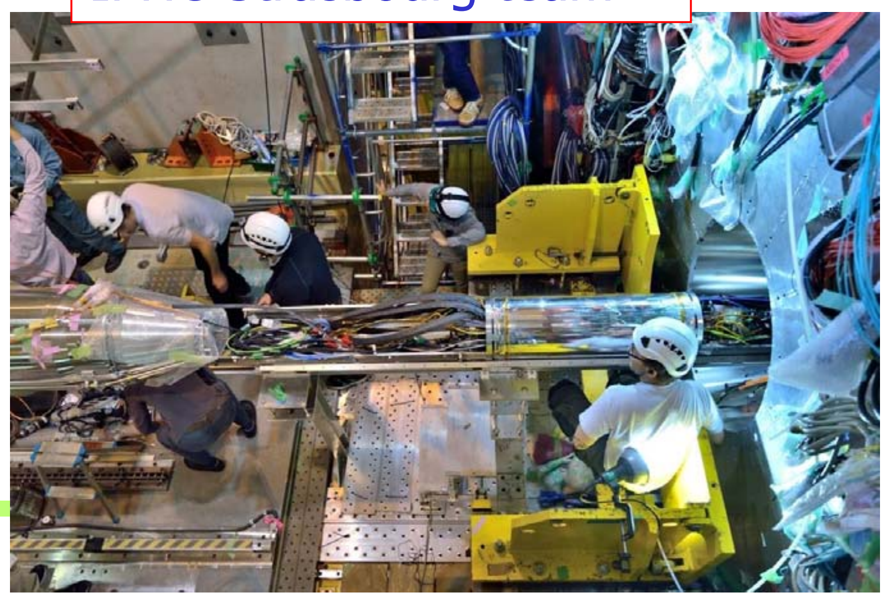
Phase 2 vertex detector (BEAST II): test the subset of final detectors and study backgrounds





Including a very strong IPHC Strasbourg team





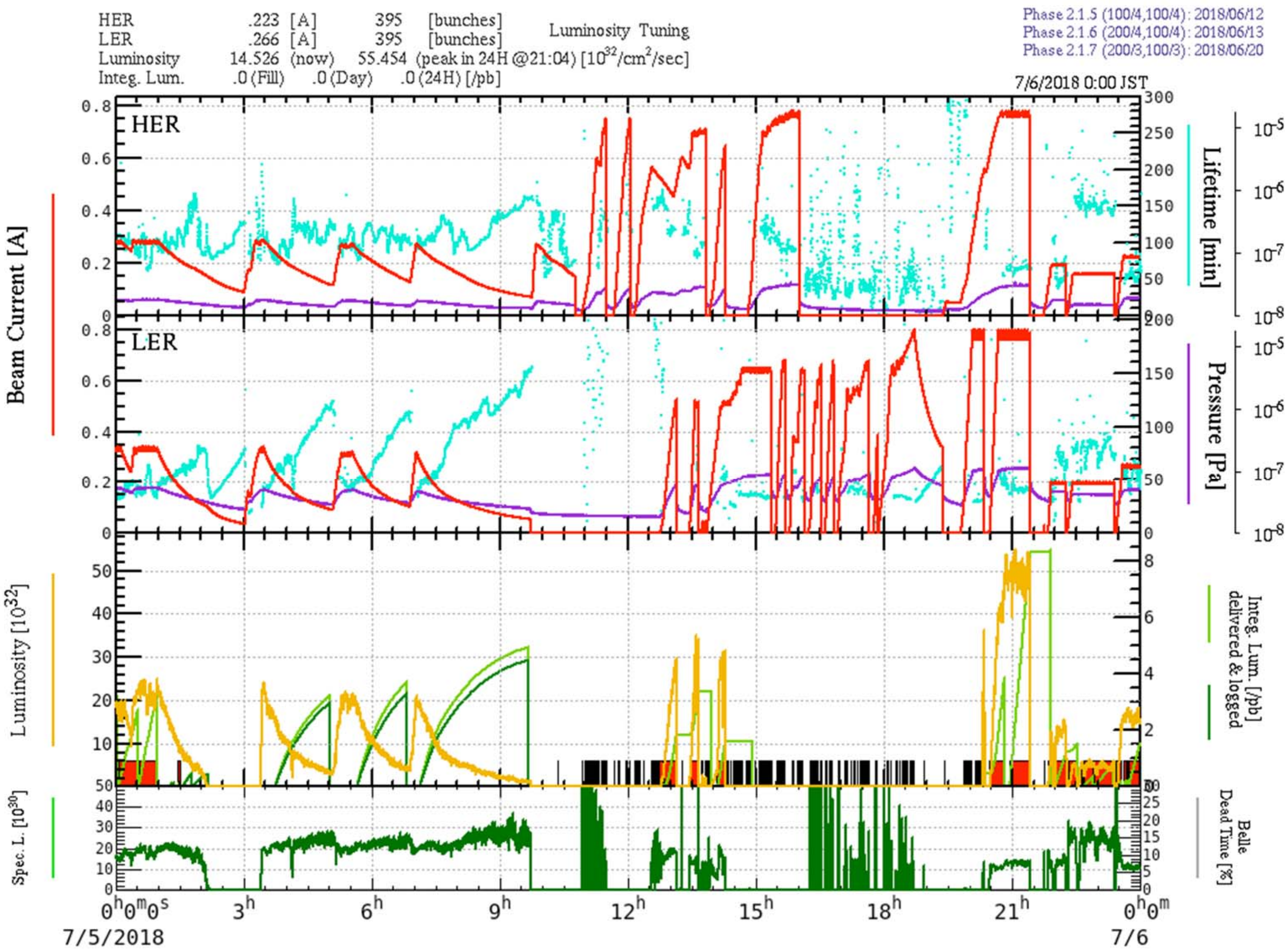
Naïve Phase 2 summary:

Keep on squeezing the two beams with the superconducting final focus down to β_y^*=3mm, making sure that the two "thin pancakes" are well aligned. One then adds beam current…..

PEP-II design luminosity 3 x 10^{33}

$$L_{peak} = 5.5 \times 10^{33} / cm^2 / \sec$$

Phase 2, July 2018

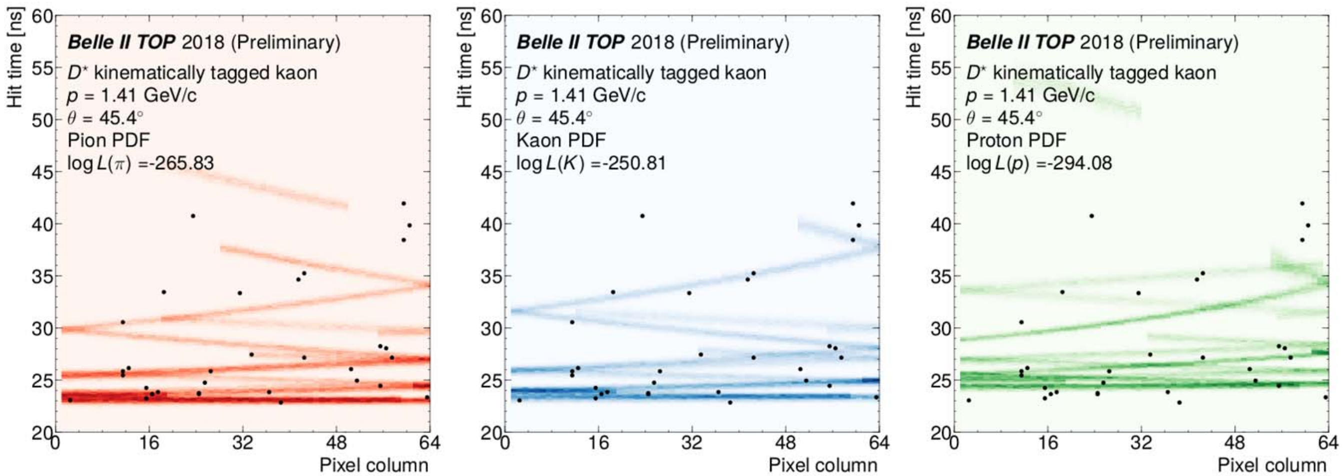


N.B. Still a long way to go with the superconducting final focus (one order of magnitude in β_y^*)

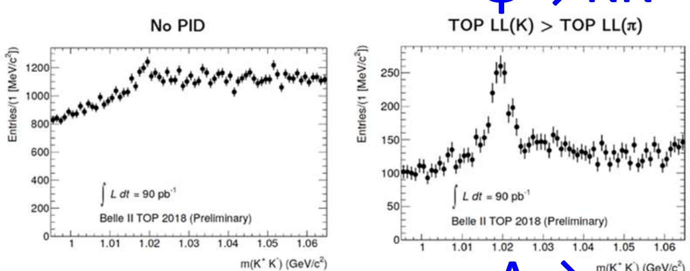
Luminosity tuning had priority. When accelerator physicists became tired, Belle II did commissioning or took data (usually owl shift only). Only able to record ~0.5 fb^{-1} during Phase 2 pilot run.

TOP in Phase 2

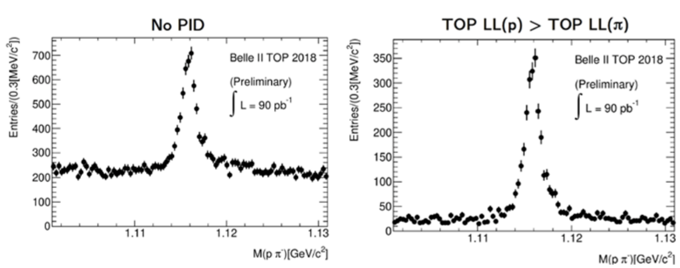
The phase 2 data demonstrates that the TOP principle is working



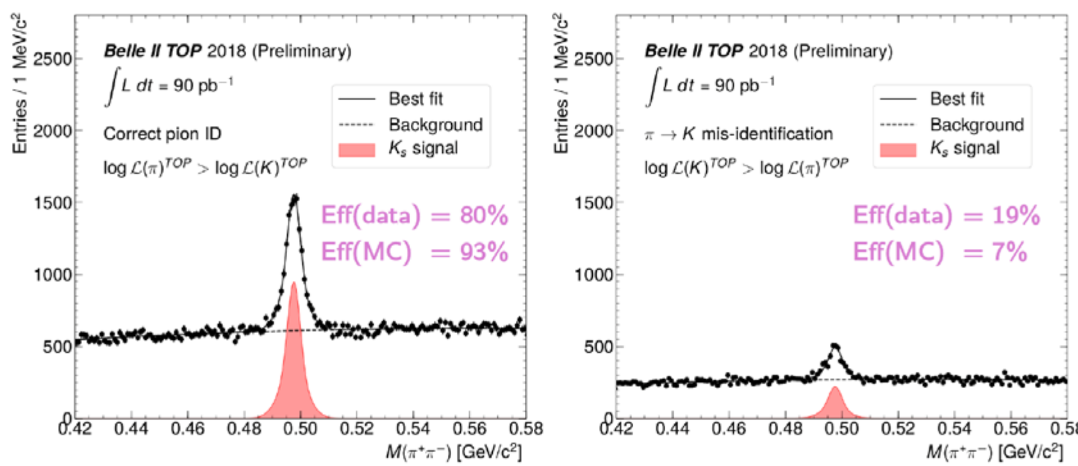
$\phi \to K^+K^-$ with both the tracks in the TOP acceptance **ϕ→KK**



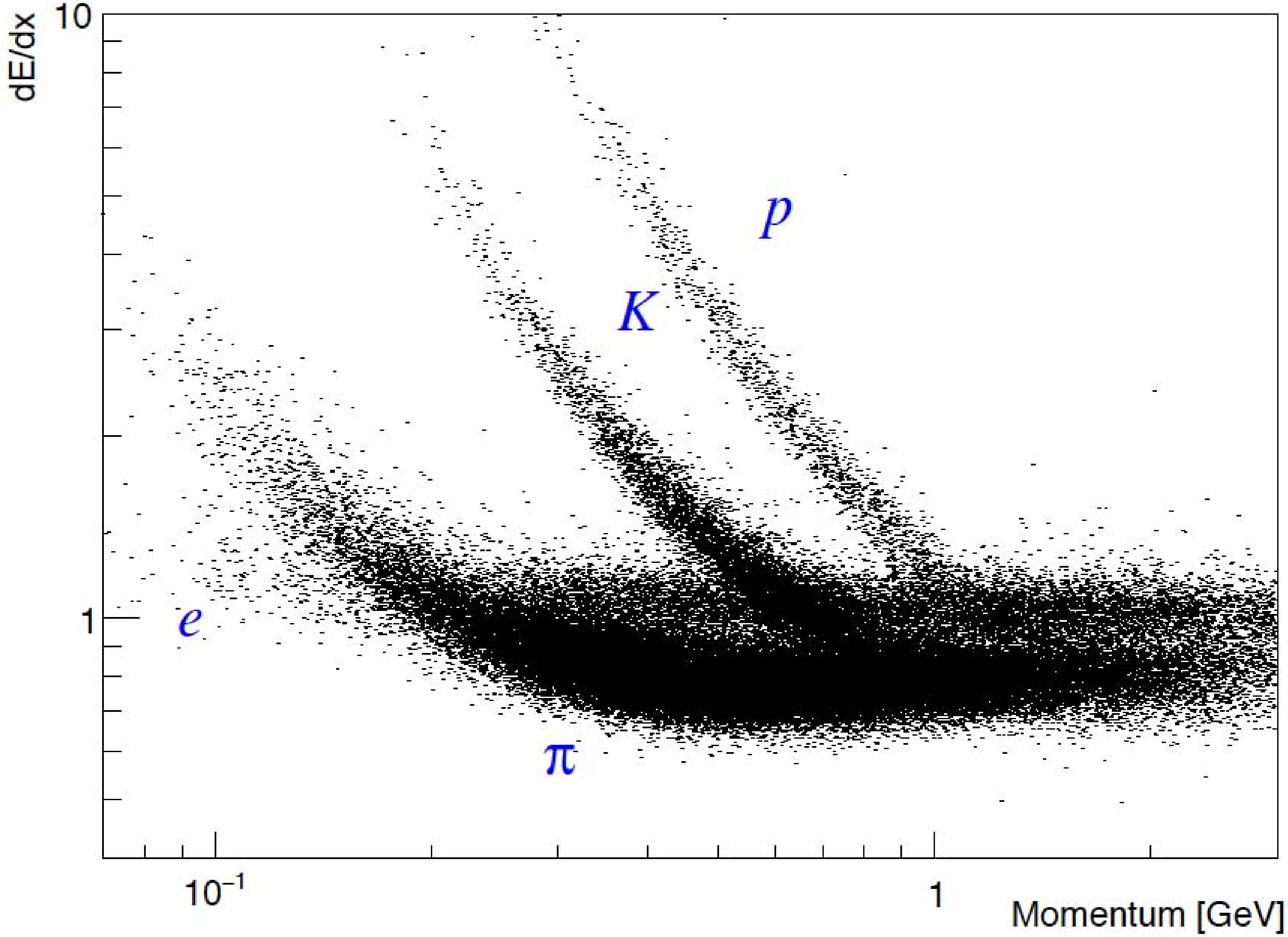
$\Lambda \to p\pi$ with the **proton candidate** in the TOP acceptance **Λ→pπ**



$K_s \to \pi\pi$

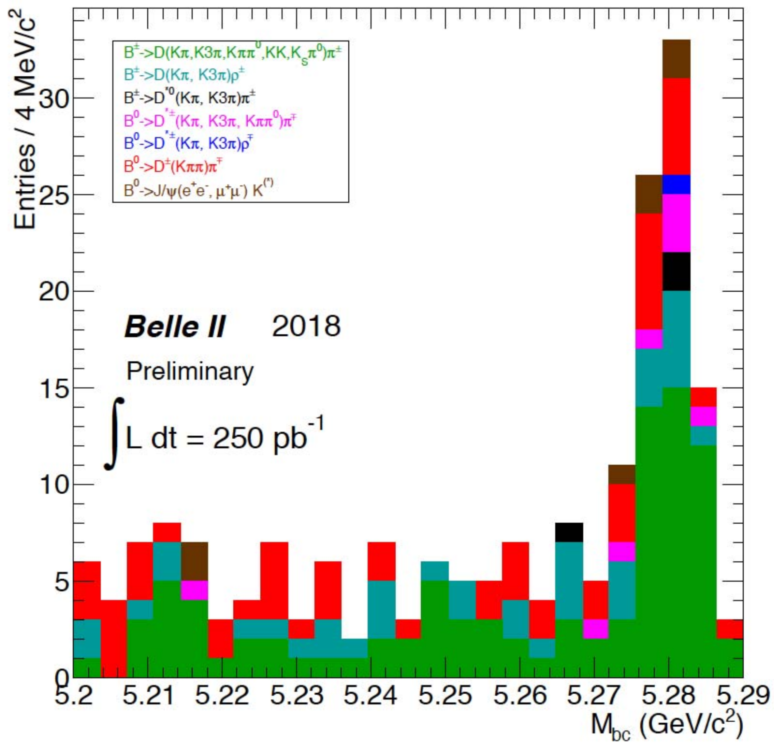


CDC: Phase 2 dE/dx performance



In June, we found our first peak in the beam-constrained mass distribution with ~88 events.

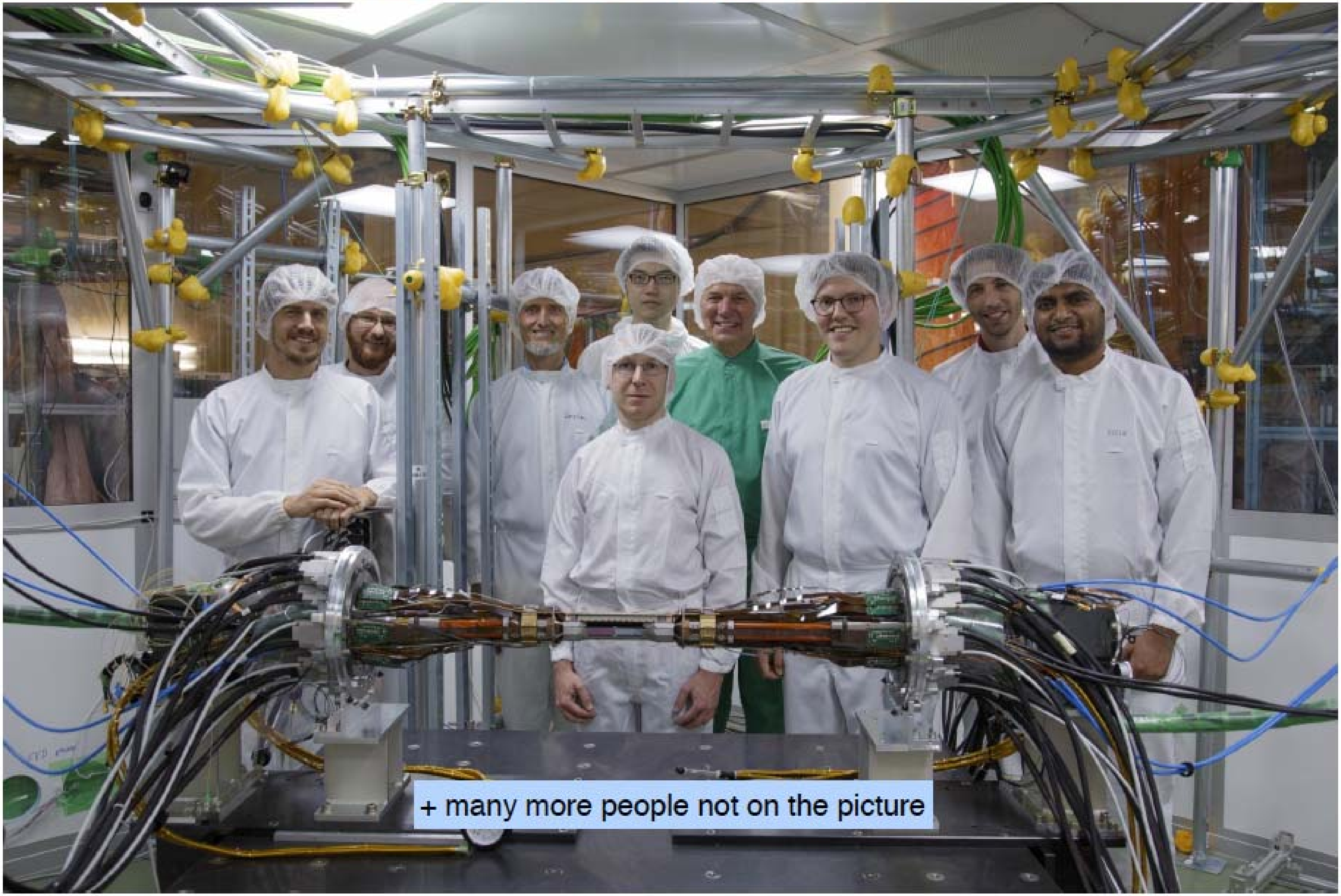
We have *rediscovered* the B meson !



With the full Phase 2 dataset and by applying the FEI (Full Event Interpretation) technique based on boosted decision trees (BDTs, a machine learning technique), we now observe ~600 fully reconstructed B mesons.

The next step: getting ready for real running (“Phase 3“)

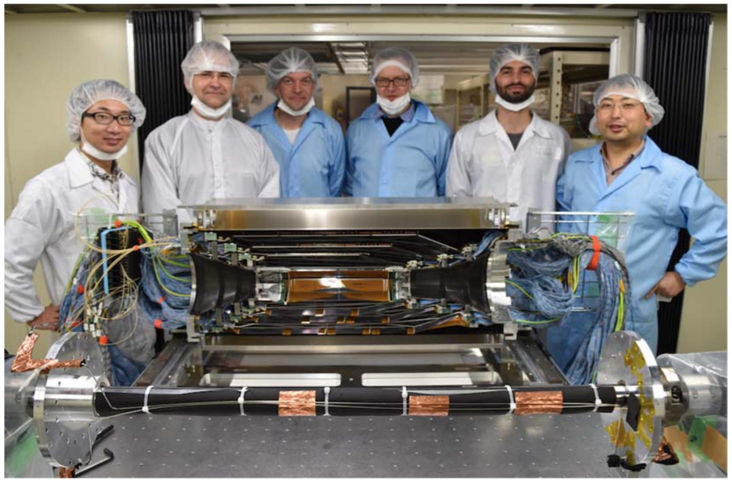
Both PXD Halfs assembled on Beam Pipe



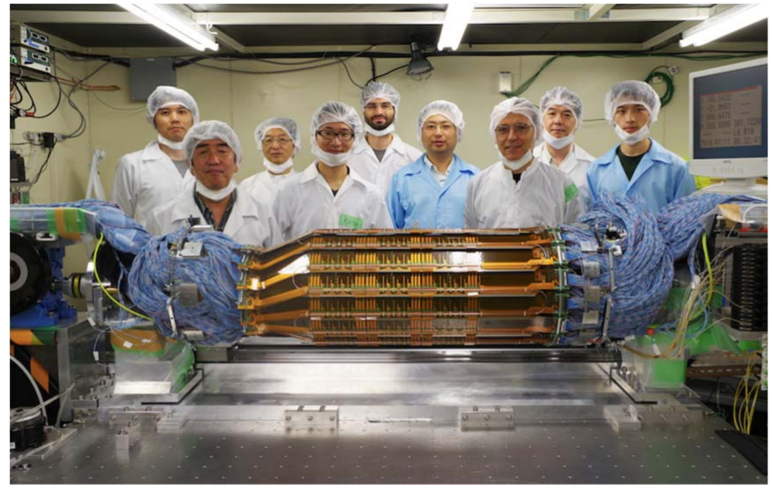
+ many more people not on the picture

SVD construction is finally done ！

SVD +X completion (Feb 2018)

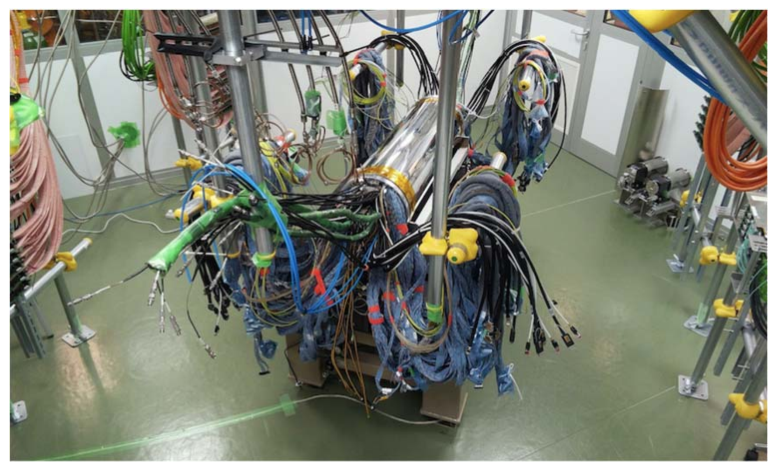


SVD -X completion (Jul 2018)



+X mount on PXD (Oct 3, 2018)

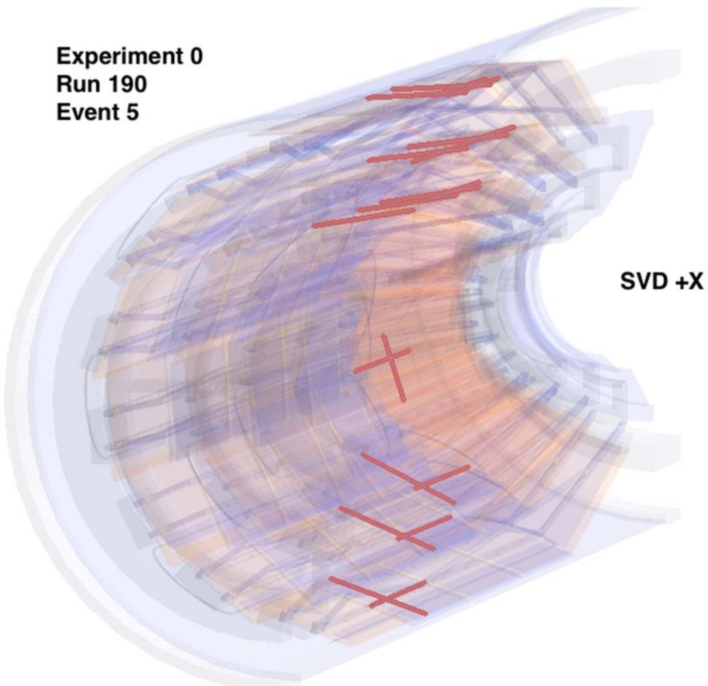
And completed… (Oct 4, 2018)



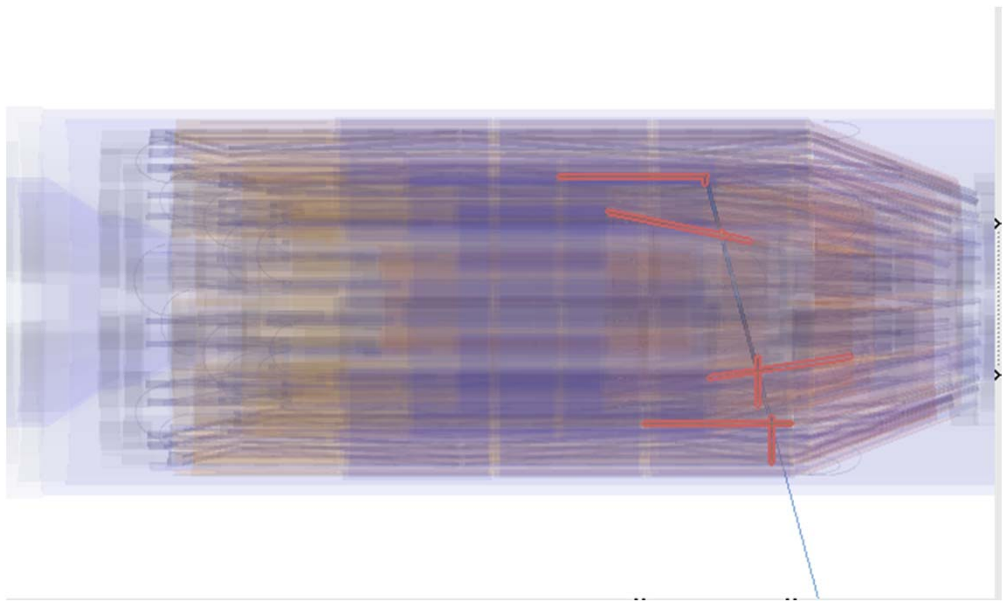
SVD standalone commissioning in B4

- The two SVD halves have operated from July to September in Tsukuba B4
- No particular issue has been encountered during this operation
- Cosmic data and special background runs were taken to understand the system prior to the start of phase 3

First cosmic event in SVD +X (Jul 10, 2018)

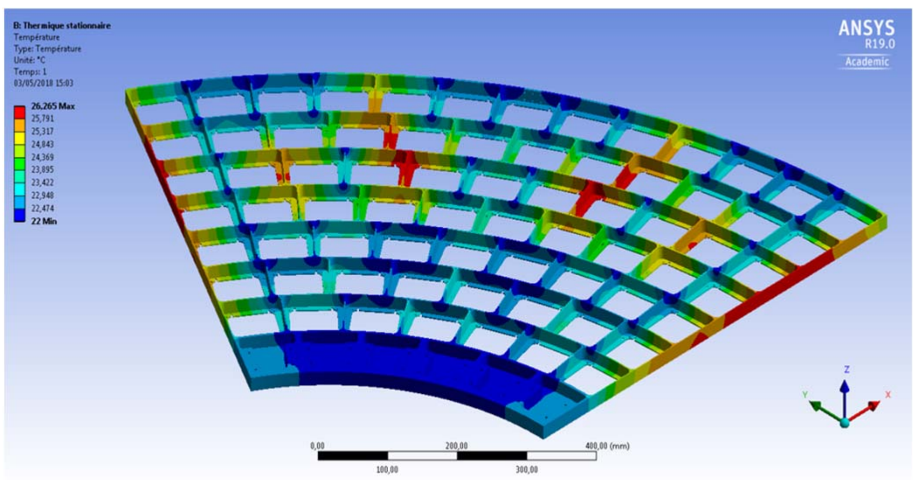


First cosmic event in full SVD (Aug 17, 2018)



Getting ready for Phase 3: mitigation of issues found in Phase 2 running

Example: the cooling system of electronics of ARICH had to be upgraded; finite element analysis at LAL, now installed and successfully tested!



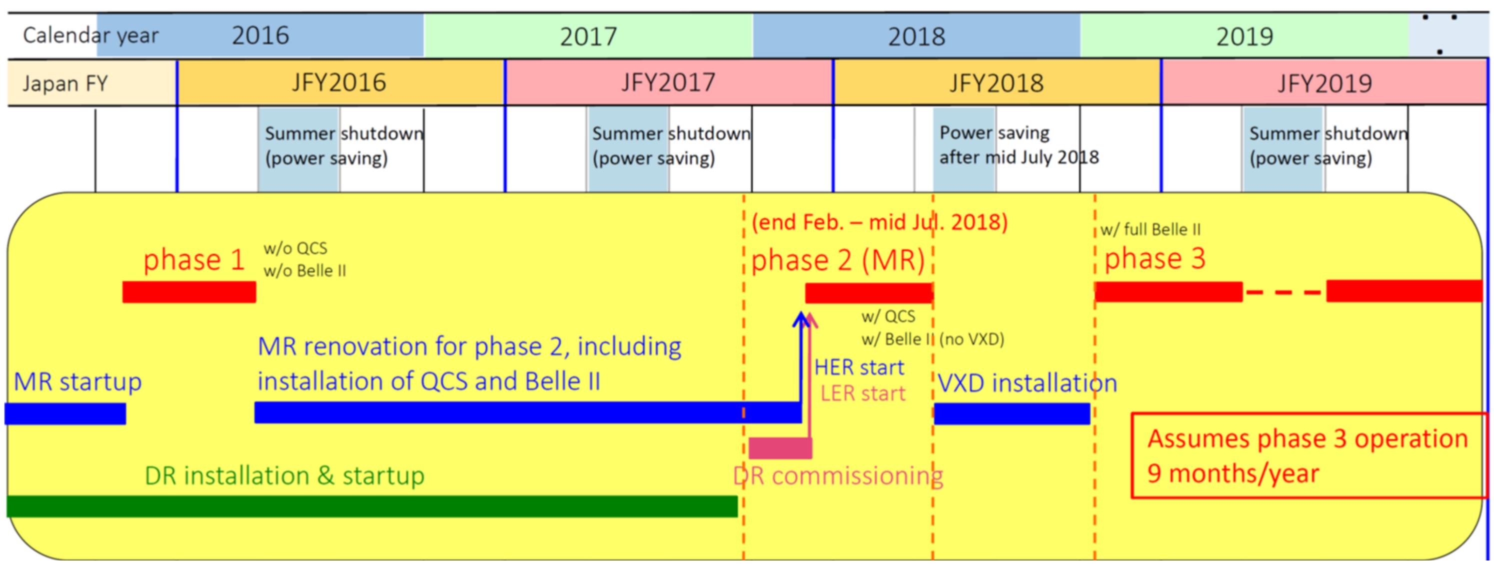
Belle II Status Summary

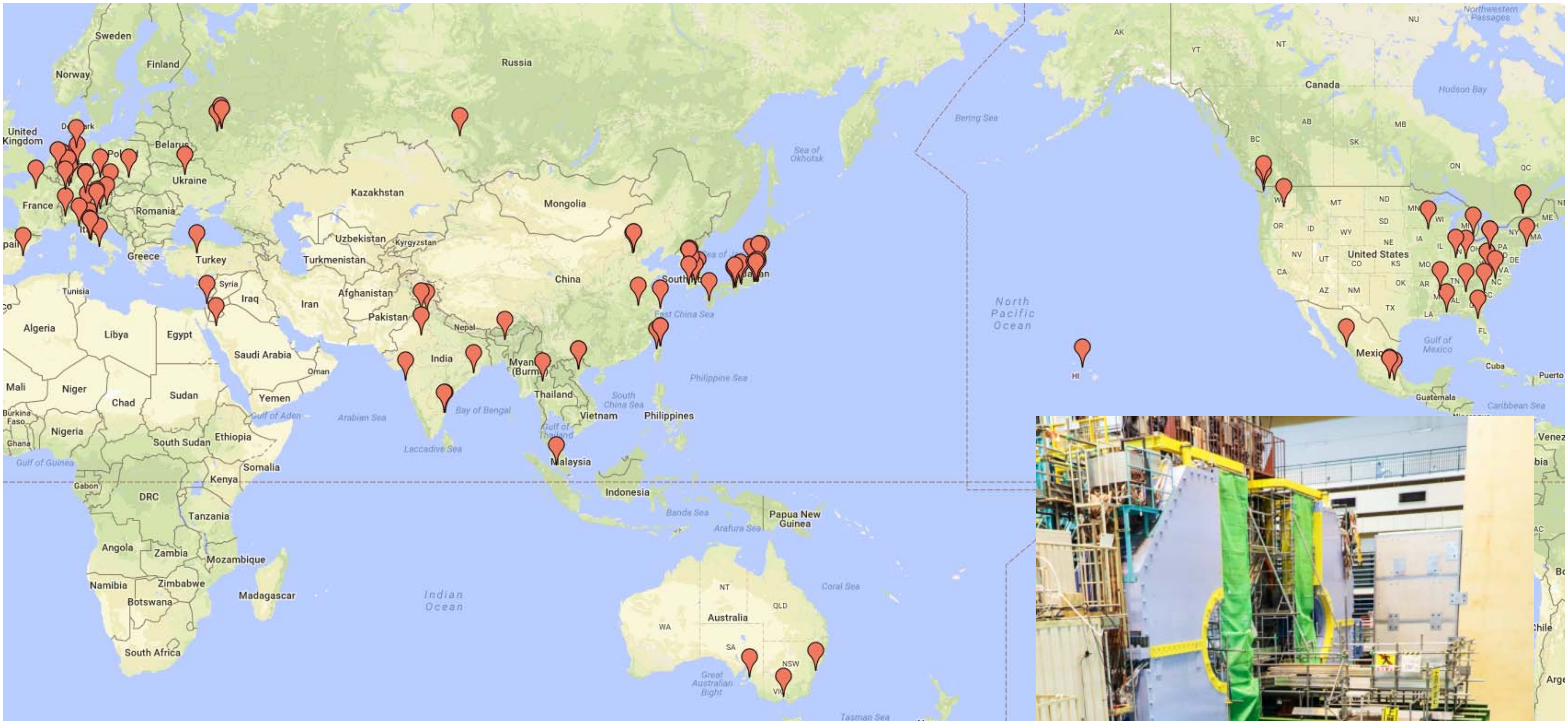
The Belle II detector is ready to accpet the final missing piece, the full vertex detector → installation starts this week.

All systems are being debugged to improve on issues we have seen in Phase 2.

Expect beam operation from March 11, then run until end of June: initial period of Phase 3.

The baseline plan: run for 9 months/year, with a target integrated luminosity of 50/ab.

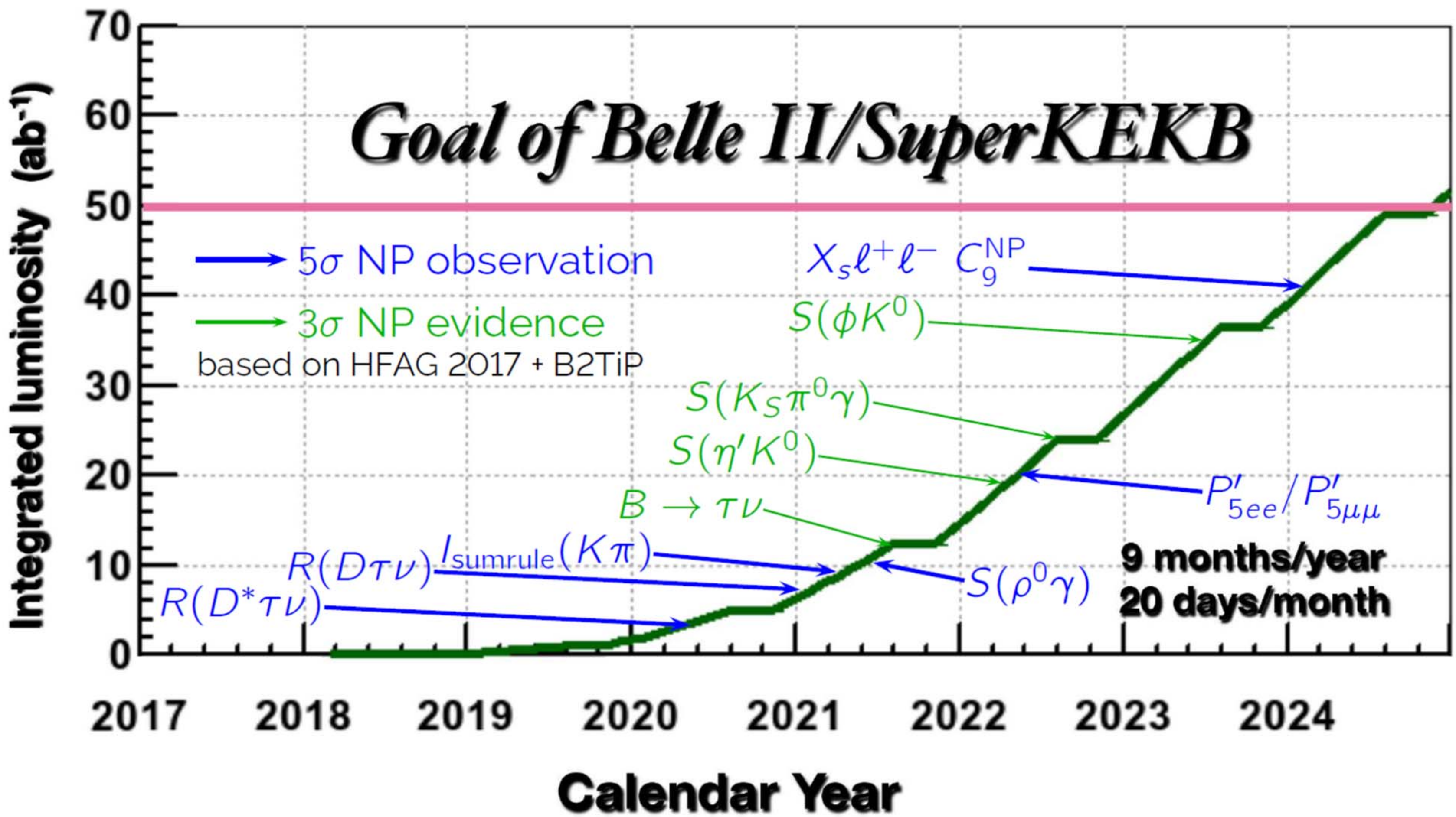




A very strong group of ~750 highly motivated scientists!

Physics prospects @ Belle II

B2TIP: Belle2 Theory Interface Platform
- A series of joint workshops with theorists
- Belle II Physics book, arXiv:1808.10567, to be published in PTEP



Physics prospects

Belle II strategy for New Physics searches:

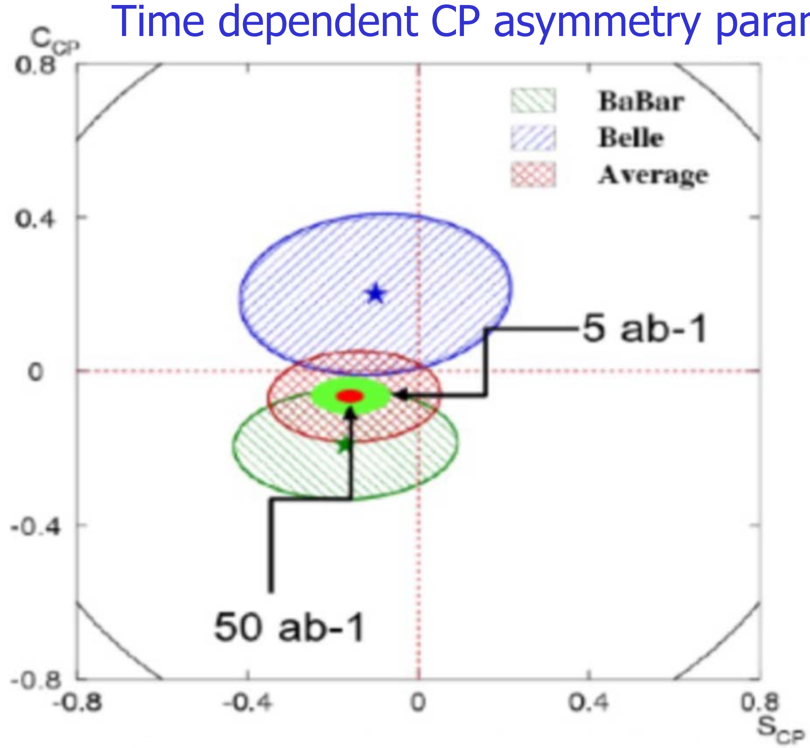
- Statistics 1 ab^{-1} (Belle) → 50 ab^{-1} (Belle II)
- Predictions of SM with small theoretical uncertainties
- Precise measurements with small systematic errors

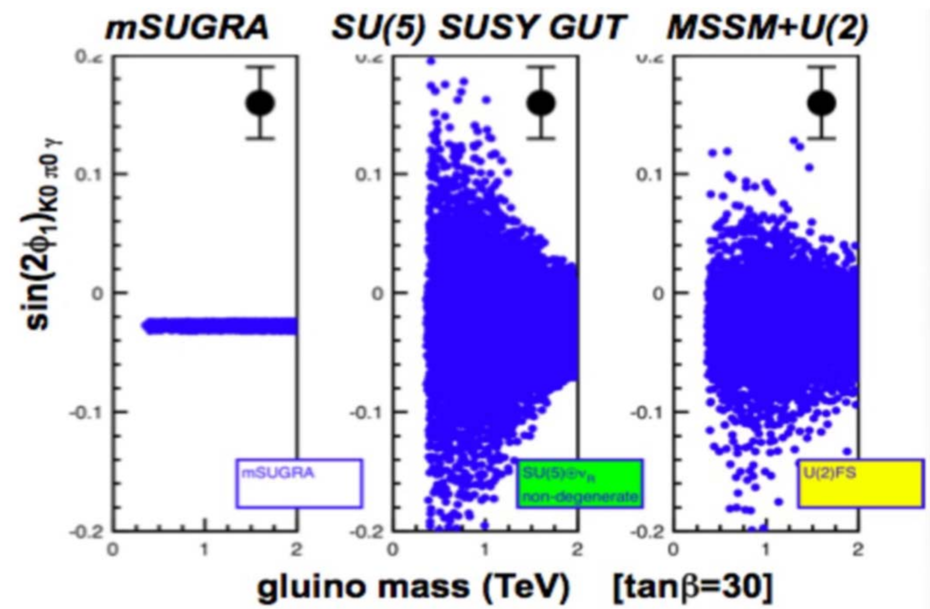
Belle II reach - a few examples

- lepton flavor universality checks
- $B \to K\nu\nu$
- CPV in $B \to K_S\pi^0\gamma$
- CPV in $B \to K\pi$
- Dark sector studies in Phase 2

Measure TDCP asymmetry in $K_S \pi^0 \gamma$

Time dependent CP asymmetry parameters





S = -016 +- 0.22, C = -0.04 +- 0.14

The value of S can discriminate among SUSY-breaking mechanisms

Mostly statistic limited, expected uncertainties

G. Buchalla et al., EPJC 57 (2008) 309

$\sigma(S) \sim 0.09$ at 5 ab^{-1}

~ 0.03 at 50 ab^{-1}

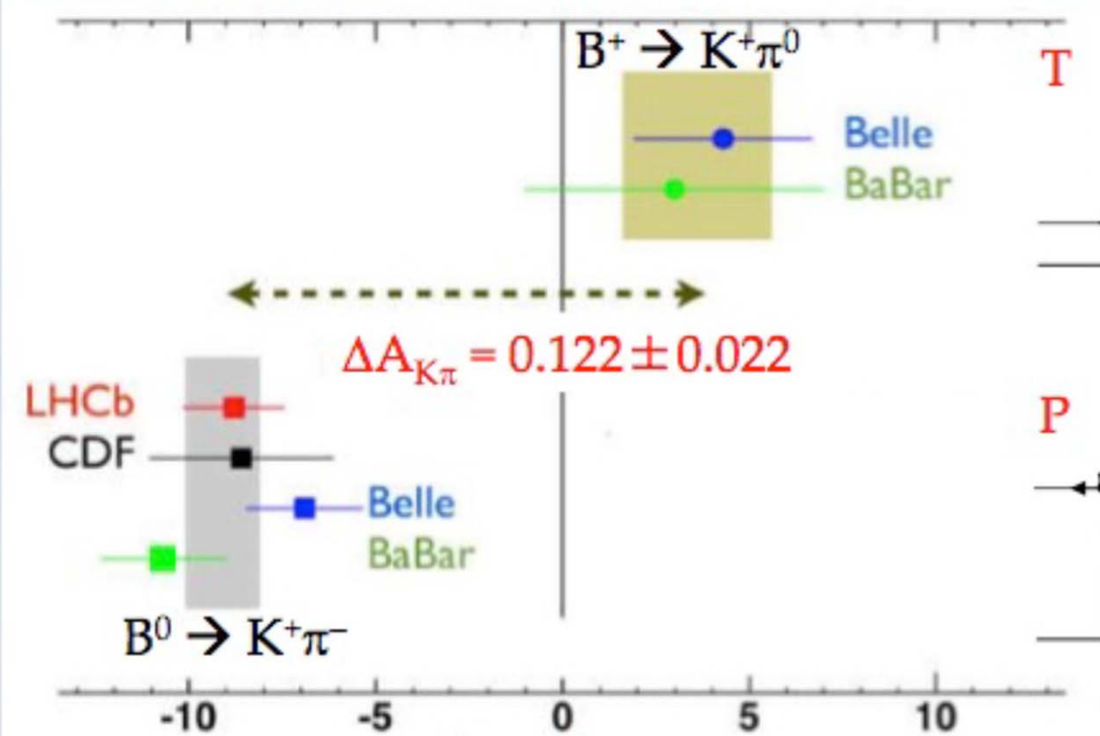
Kπ puzzle: Need to measure all the asymmetries

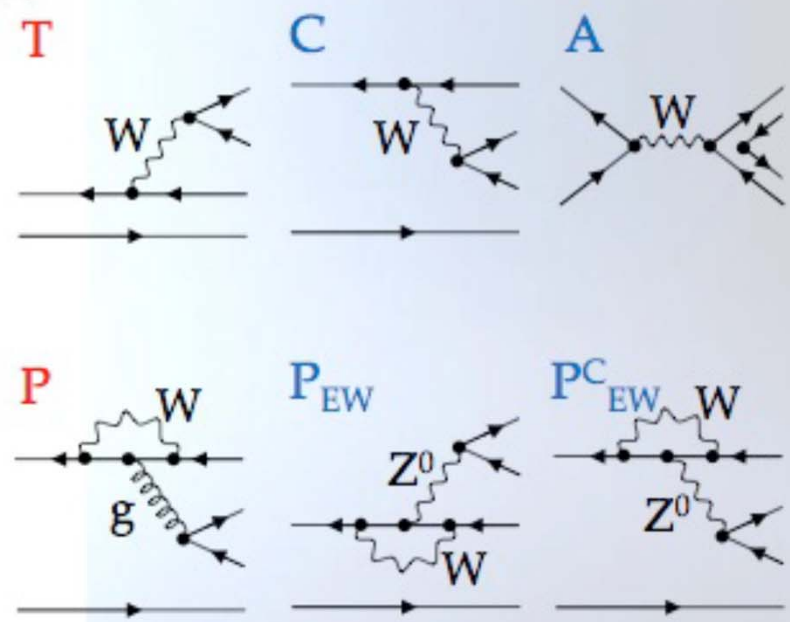
- Difference of CP asymmetry between B^0 and B^+
  - Enhanced C?
  - QCD?
  - New Physics in P_{EW}?

$B^+ \to K^+\pi^0$: $T + P + C + P_{EW} + P^C_{EW} + A$

$B^0 \to K^+\pi^-$: $T + P + P^C_{EW}$

Dominant Sub-dominant





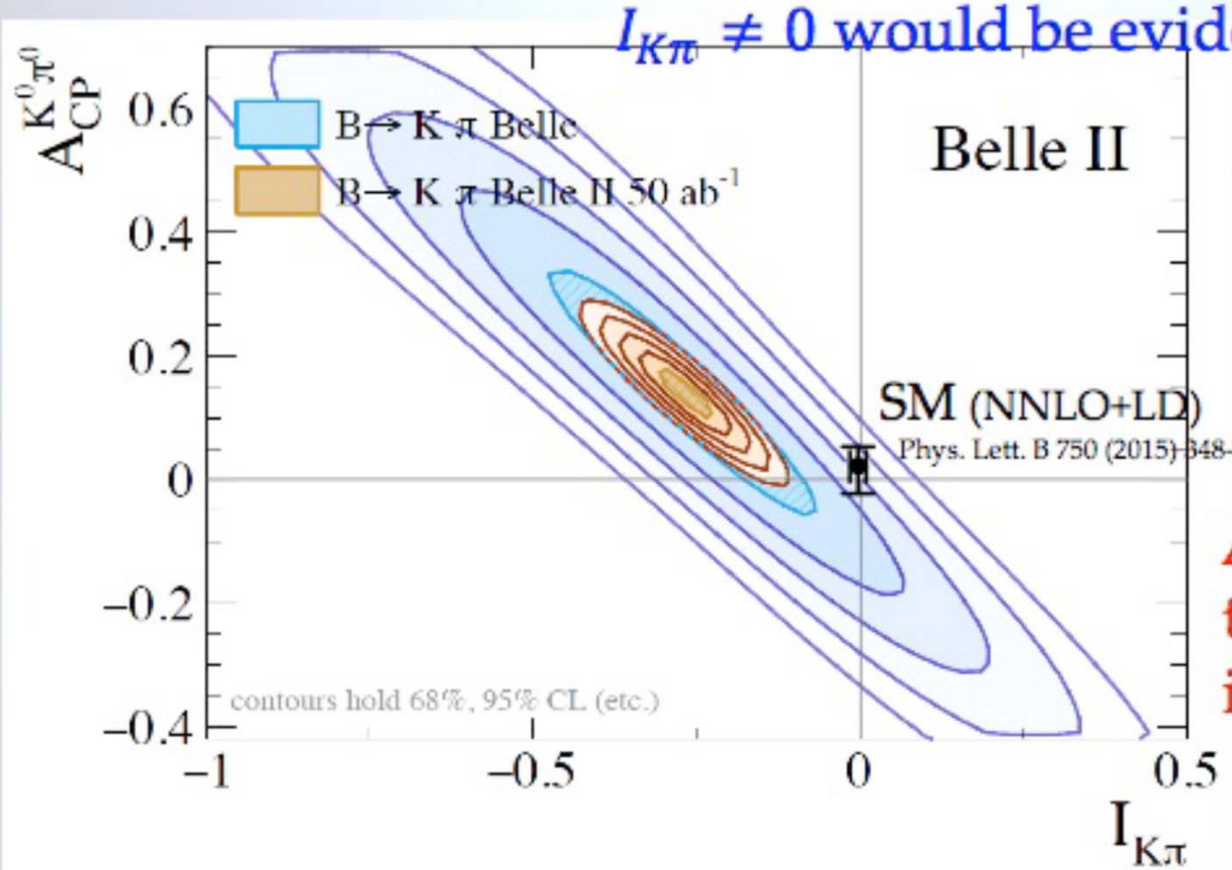
$$A_{CP}(B \to f) = \frac{\Gamma(\bar{B} \to \bar{f}) - \Gamma(B \to f)}{\Gamma(\bar{B} \to \bar{f}) + \Gamma(B \to f)} \ (\%)$$

Direct CP asymmetries in neutral states

- Sum rule of A_{CP} was proposed: [Phys. Lett. B 627 (2005) 82-88]

$$I_{K\pi} \equiv A_{CP}(K^+\pi^-) + A_{CP}(K^0\pi^+)\frac{B(K^0\pi^+)}{B(K^+\pi^-)}\frac{\tau_0}{\tau_+} - 2A_{CP}(K^+\pi^0)\frac{B(K^+\pi^0)}{B(K^+\pi^-)}\frac{\tau_0}{\tau_+} - 2A_{CP}(K^0\pi^0)\frac{B(K^0\pi^0)}{B(K^+\pi^-)} \approx 0$$

$I_{K\pi} \neq 0$ would be evidence for New Physics



$A_{CP}(K^0\pi^0)$ is one of the key measurements in Belle II

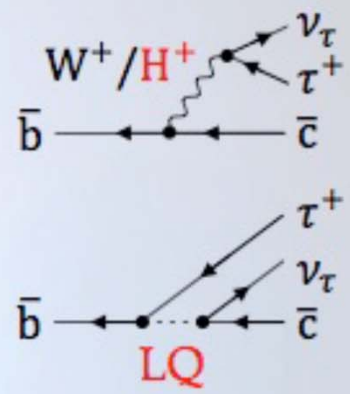
Lepton universality in B→D$^{(*)}\tau\nu$

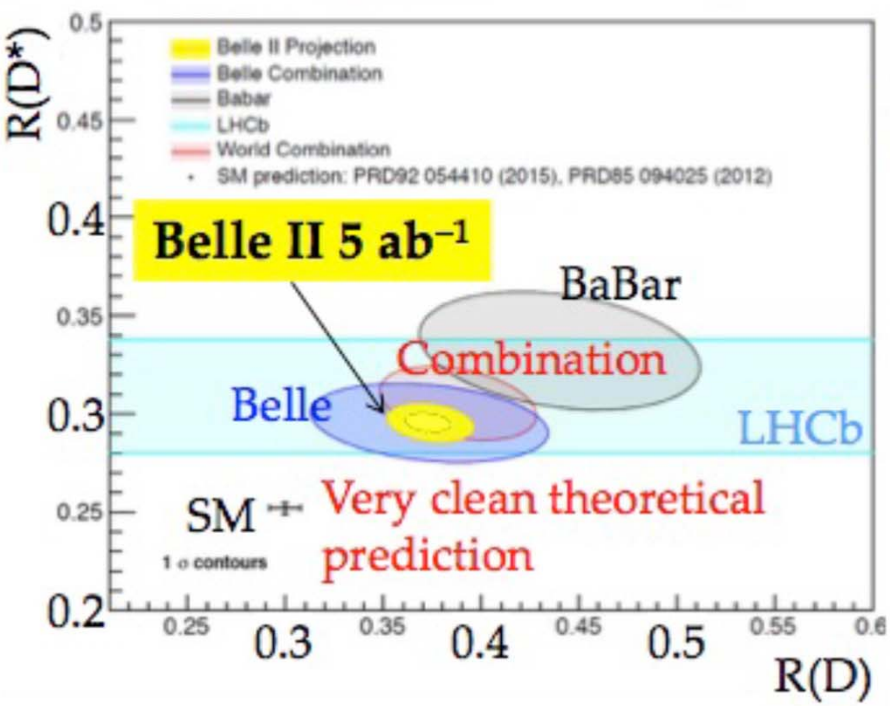
$$R(D^{(*)}) = \frac{\Gamma(B \to D^{(*)}\tau\nu)}{\Gamma(B \to D^{(*)}\ell\nu)} \quad (\ell = \mathrm{e\ or\ }\mu)$$

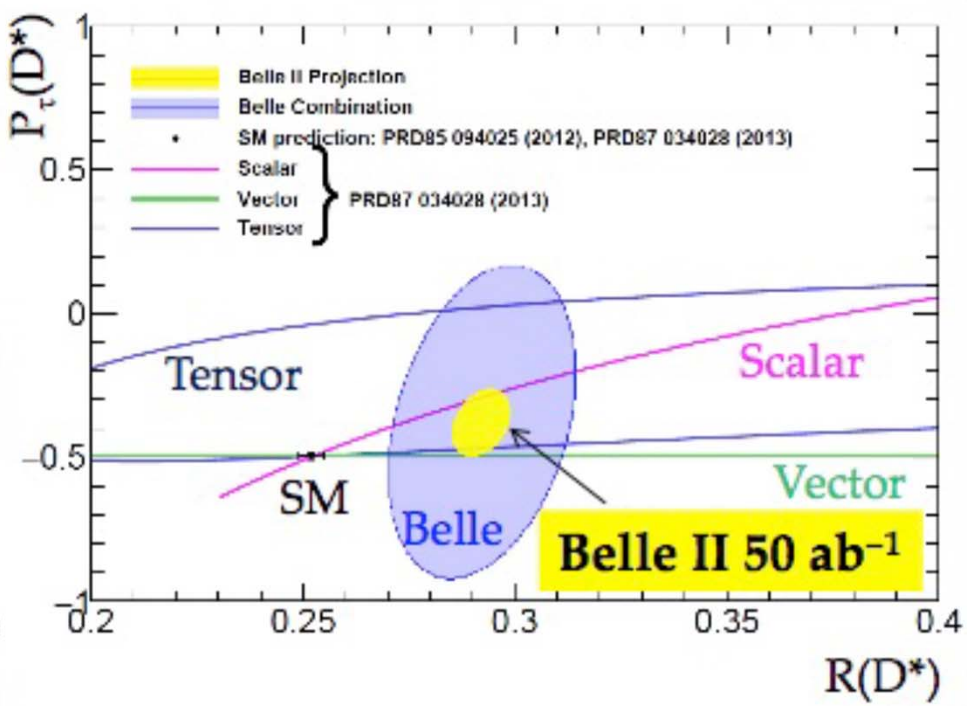
- Partial cancellation of theoretical uncertainties related to hadronic effects and measurement systematics.

$$P_\tau(D^*) = \frac{\Gamma^+ - \Gamma^-}{\Gamma^+ + \Gamma^-} \quad (\Gamma^\pm\text{: decay rate of } \pm\,\tau\text{-helicity})$$

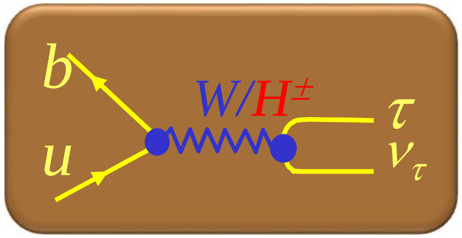
- Another probe of New Physics



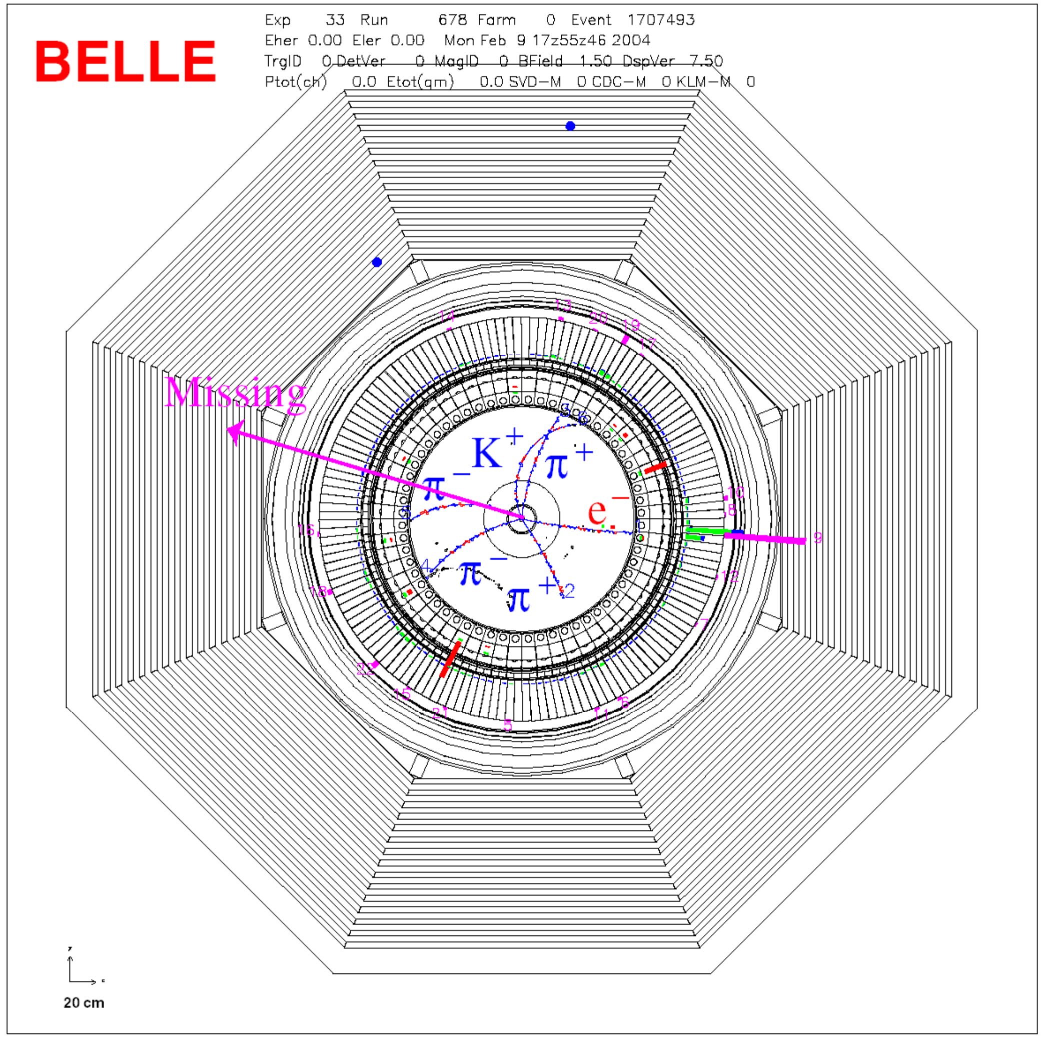




$B^- \rightarrow \tau^- \nu_\tau$



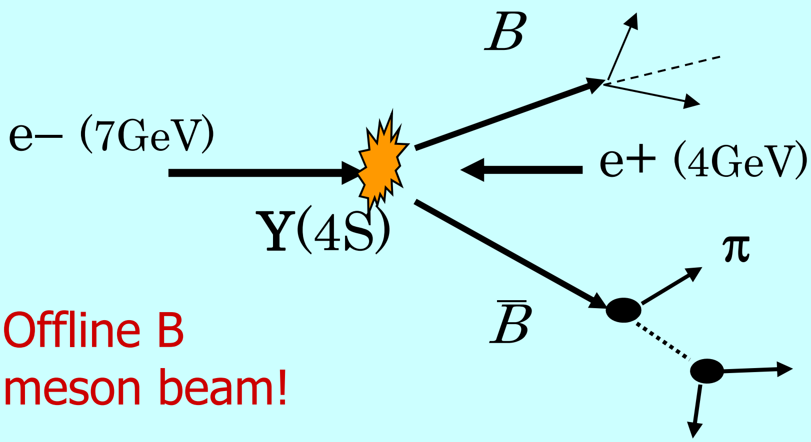
$$B^+ \rightarrow D^0 \pi^+$$
$$(\rightarrow K\pi^-\pi^+\pi^-)$$
$$B^- \rightarrow \tau(\rightarrow e\nu\bar{\nu})\nu$$



Example of a challenging rare decay

Full reconstruction tagging

Idea: fully (or partially) reconstruct one of the B's to tag B flavor/charge, determine its momentum, and exclude decay products of this B from further analysis (exactly two B's produced in $\Upsilon(4S)$ decays)



Offline B meson beam!

Decays of interest
- $B \to X_u \, l \, \nu$,
- $B \to K \nu \nu$
- $B \to D \tau \nu$, $\tau \nu$

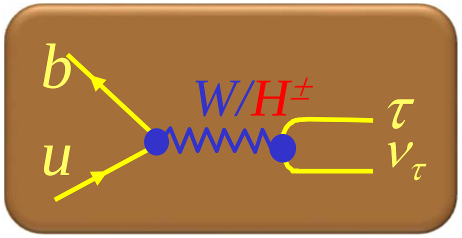
full reconstruction (0.5%):
- hadronic tagging, $B \to D\pi$ etc.

partial reconstruction (1%):
- semileptonic tagging

Powerful tool for B decays with neutrinos

→unique feature at B factories

Example for the impact of B $\rightarrow \tau^- \nu_\tau$: charged Higgs limits

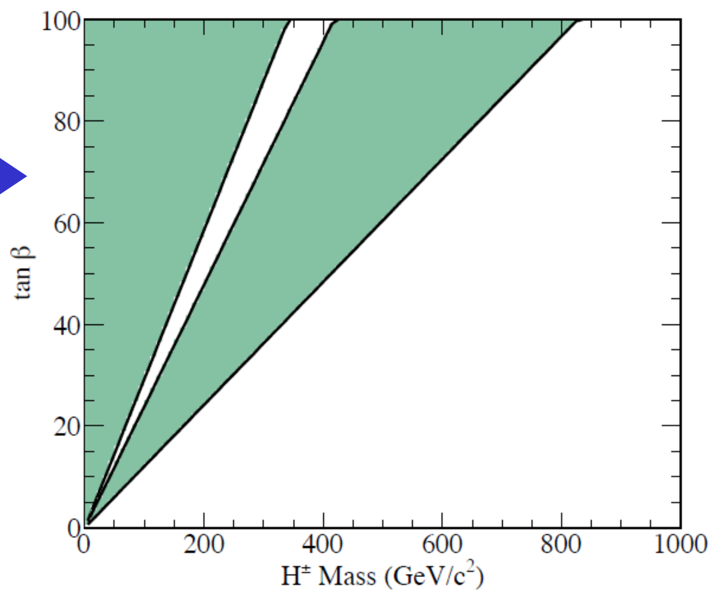


Measured value

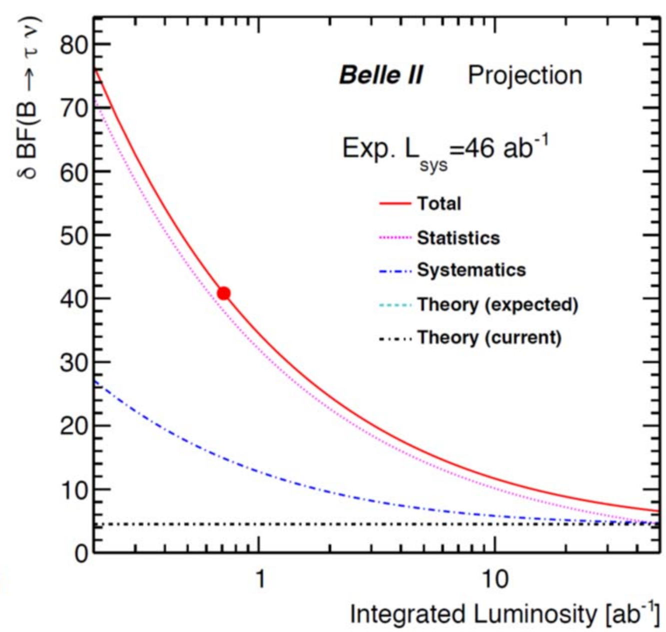
$$r_H = \frac{BF(B \to \tau\nu)}{BF(B \to \tau\nu)_{SM}} = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2$$

can be – for example - turned into a limit on charged Higgs parameters (in case of the type II 2HDM)

B factories: Exclusion plot

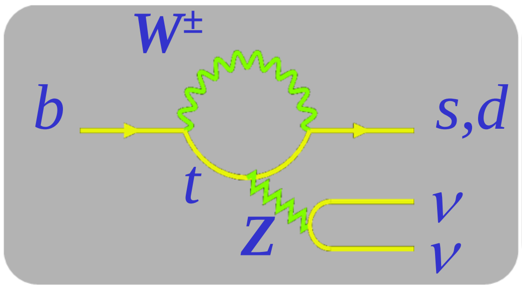


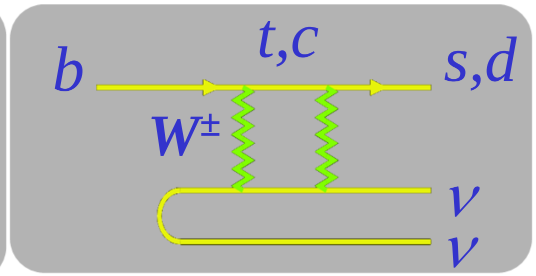
Belle II: in excellent competition with LHC!



$B \rightarrow K^{(*)}\nu\bar{\nu}$

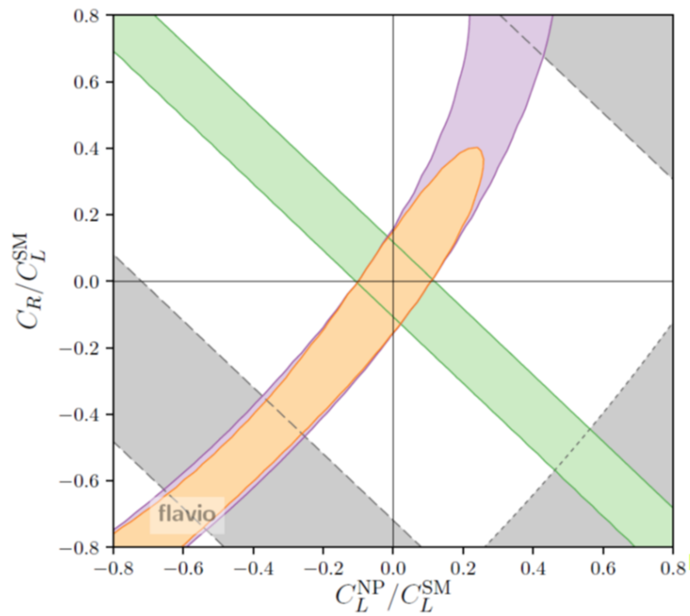
SM: penguin + box diagrams





$B \rightarrow K\nu\nu$, $\mathcal{B} \sim 4 \cdot 10^{-6}$

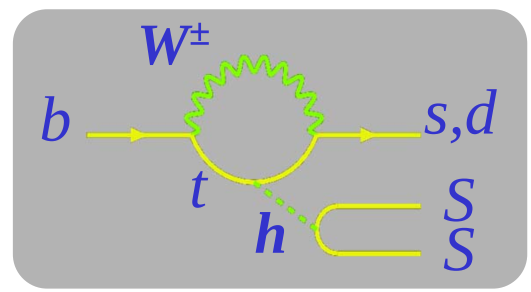
$B \rightarrow K^*\nu\nu$, $\mathcal{B} \sim 6.8 \cdot 10^{-6}$



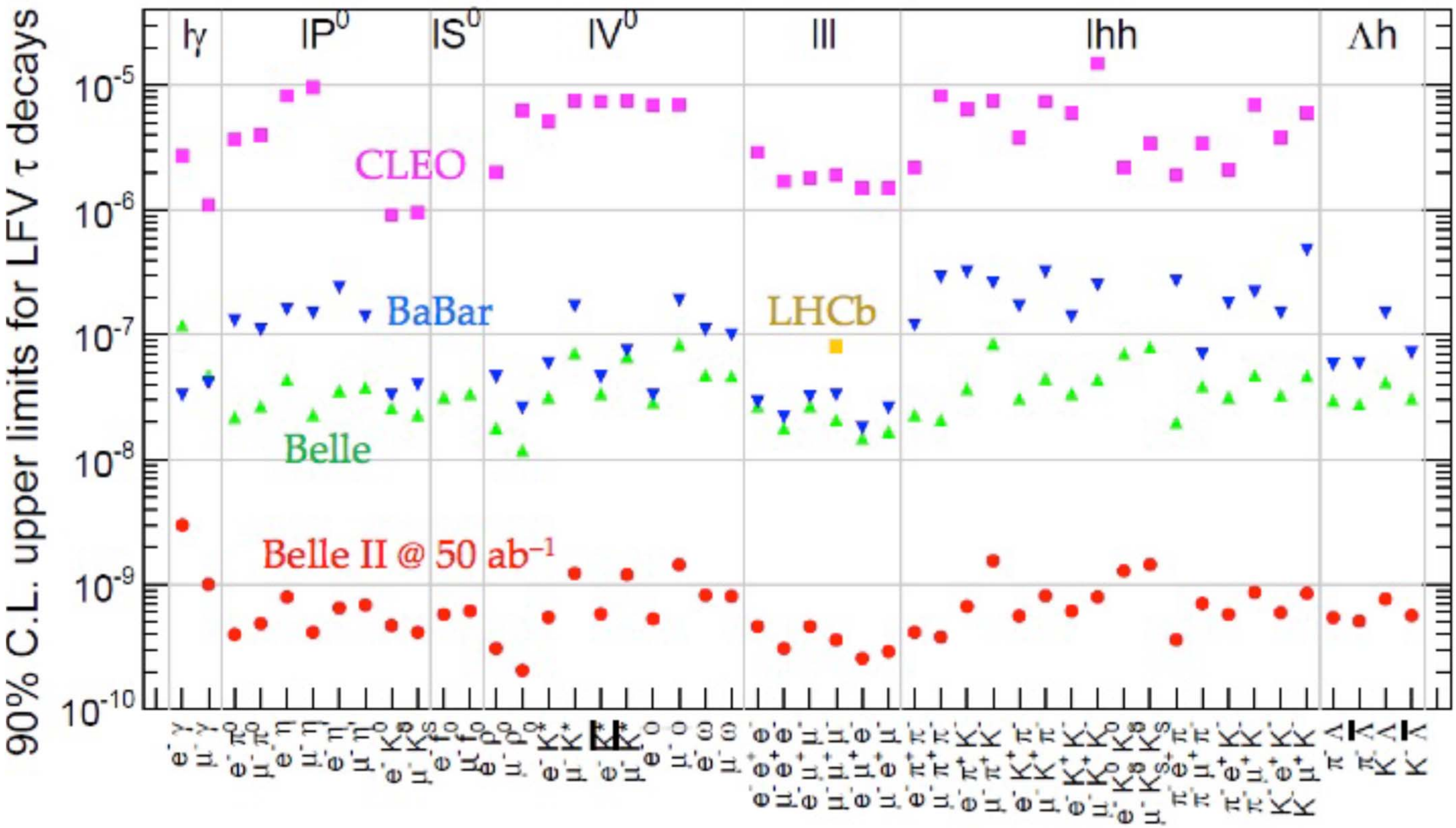
Look for deviations from the expected values → information on anomalous couplings

C^{ν}_{R} and C^{ν}_{L}

compared to the CM value $(C^{\nu}_{L})^{SM}$, coming from, e.g., processes like



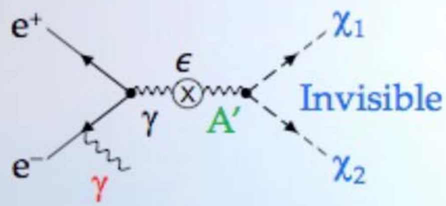
Lepton flavor violating τ decays



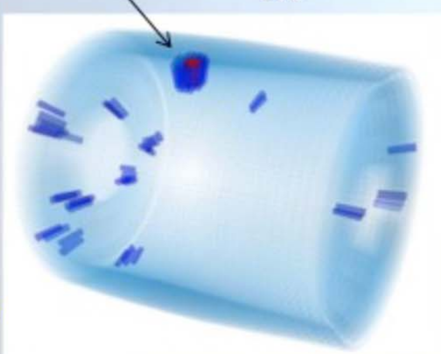
Dark sector

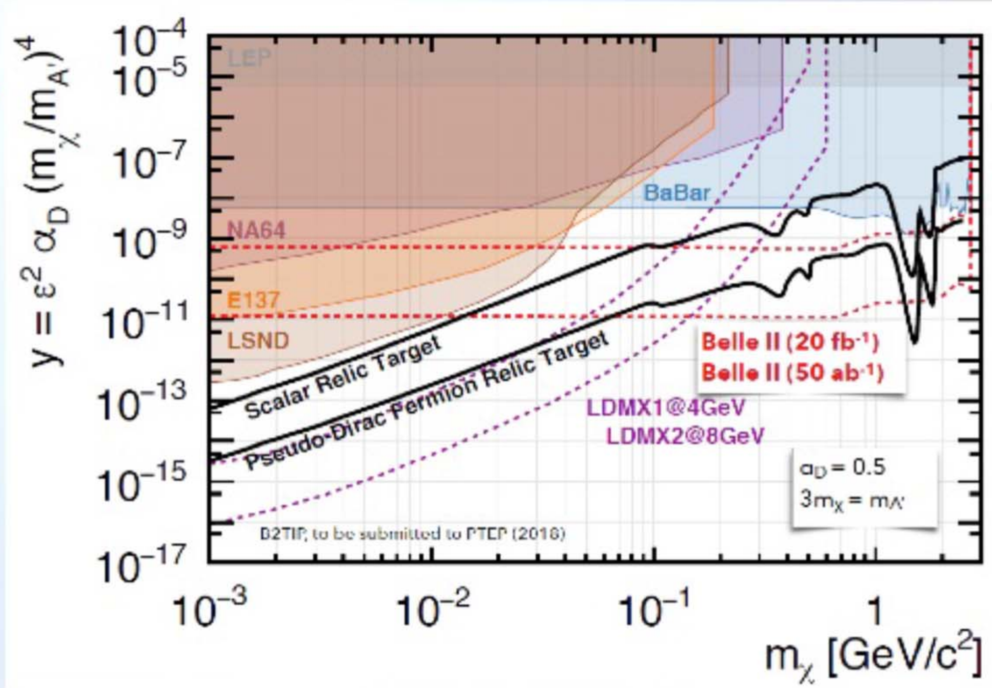
Possible to provide competitive results even with the limited statistics of the initial three months of Phase 3 running (by end of June 2019).

- New triggers will be used in Belle II to search for dark matter and dark photons.
  - Single photon trigger with ~1 GeV threshold to search for dark photon decaying into light dark matter



$$E_\gamma = \frac{E_{CM}^2 - M_{A'}^2}{2E_{CM}}$$





Summary

- Physics of B mesons has contributed substantially to our present understanding of elementary particles and their interactions
- B factories have proven to be an excellent tool for flavour physics as well for searches for new hadronic states, with reliable long term operation, constant improvement of the performance, achieving and surpassing design performance
- Super B factory at KEK, SuperKEKB+Belle II with L x40, in the final preparation phase
- In the time when LHCb is exploring anomalies in B decays, a new player is getting ready
- Expect a new, exciting era of discoveries, and a friendly competition and complementarity of Belle II, LHCb and BESIII
- We are very happy to have also French teams on board!