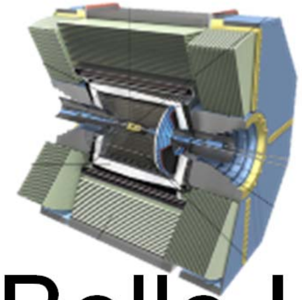


Status of SuperKEKB and Belle II

T. Browder (University of Hawaii)

- A few comments on physics motivation
- SuperKEKB Accelerator
- Belle II Detector (a few highlights)
- Schedule

Many thanks to Akai-san for SuperKEKB slides and Phil Urquijo for physics performance slides and many other Belle II collaborators.

2008:

Critical Role of the B factories in the verification of the KM hypothesis was recognized and cited by the Nobel Foundation

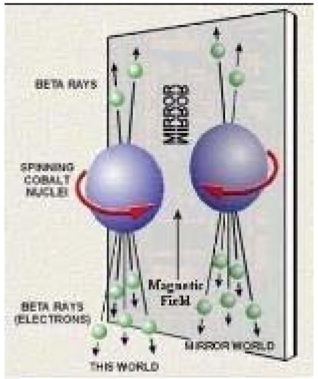
A single irreducible phase in the weak interaction matrix accounts for most of the CPV observed in kaons and B's.

CP violating effects in the B sector are O(1) rather than O(10^{-3}) as in the kaon system.

Nobel Prizes from Surprising Discoveries about *Weak Interactions of Quarks*

T.D. Lee

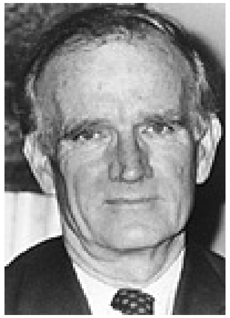
C.N. Yang



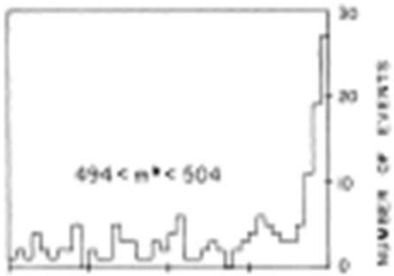
Maximal P violation

1957

J. Cronin



V. Fitch

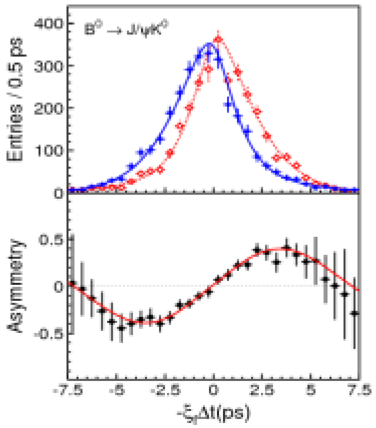


Small CP violation

1980

M. Kobayashi

T. Maskawa

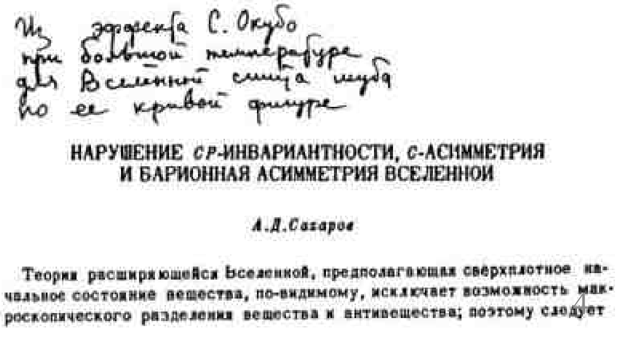


O(1) CP violation and 3 generations

2008

Are we done ? (Didn't the B factories accomplish their mission, recognized by the 2008 Nobel Prize in Physics ?)

BAU: KM (Kobayashi-Maskawa) mechanism still short by 10 orders of magnitude !!!



Из эффекта С. Окубо
при большой температуре
для Вселенной сшита шуба
по ее кривой фигуре

НАРУШЕНИЕ *CP*-ИНВАРИАНТНОСТИ, *C*-АСИММЕТРИЯ
И БАРИОННАЯ АСИММЕТРИЯ ВСЕЛЕННОЙ

А.Д.Сахаров

Теория расширяющейся Вселенной, предполагающая сверхплотное начальное состояние вещества, по-видимому, исключает возможность макроскопического разделения вещества и антивещества; поэтому следует

<u>New physics amplitudes 10-20% the size of the Standard Model contributions allowed by data</u>

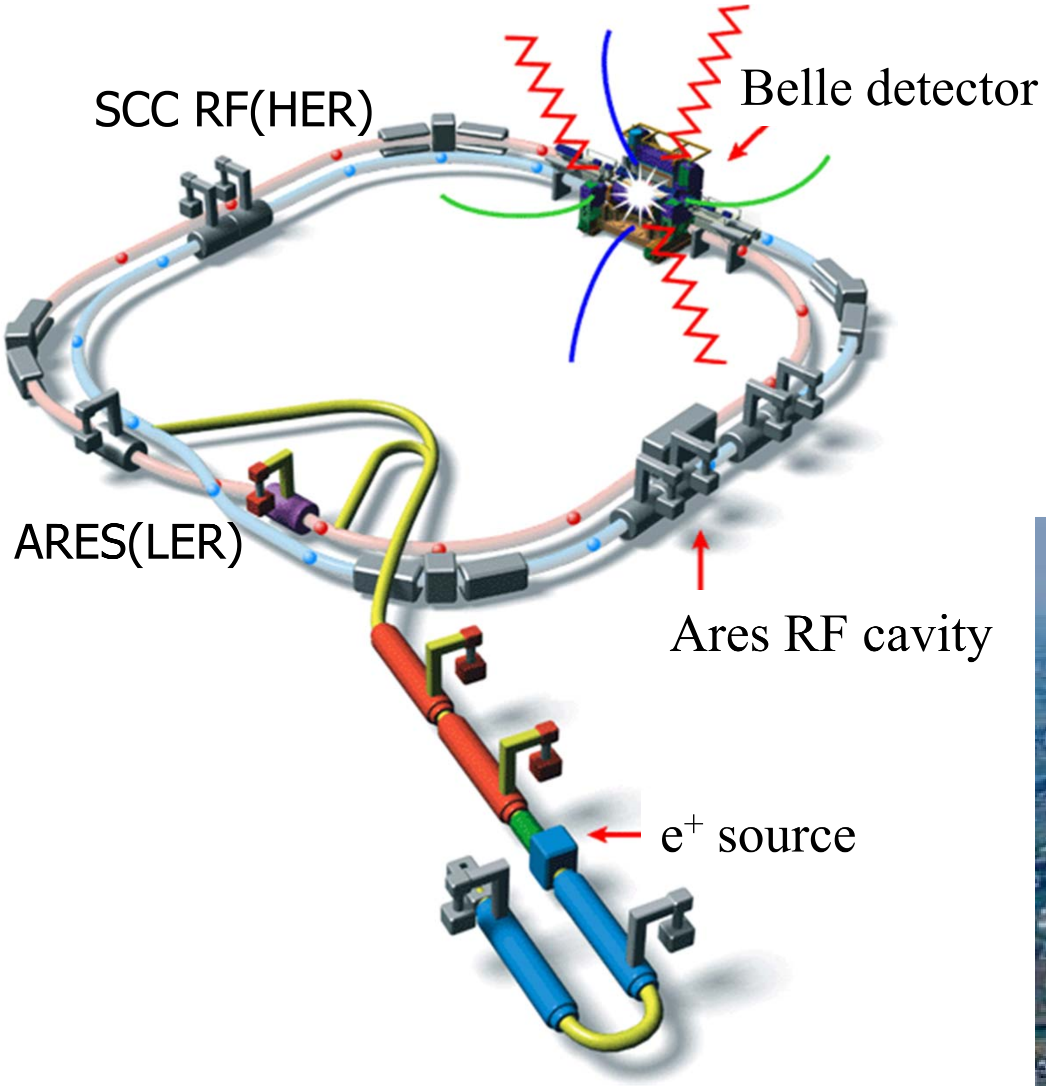
Belle II/SuperKEKB Motivation

As extensively discussed at this conference SuperKEKB/Belle II is *the new intensity frontier facility* for B mesons, charm mesons and tau leptons.

Unique new physics capabilities and unique detector capabilities ("single B meson beam", neutrals, neutrinos), clean environment with good systematics, which are critical for the next round of NP searches e.g. charged Higgs.)

Photo credit: R. Lipton

Upgrade The KEKB Collider
(Tsukuba, Japan)



8 x 3.5 GeV
22 mrad crossing angle

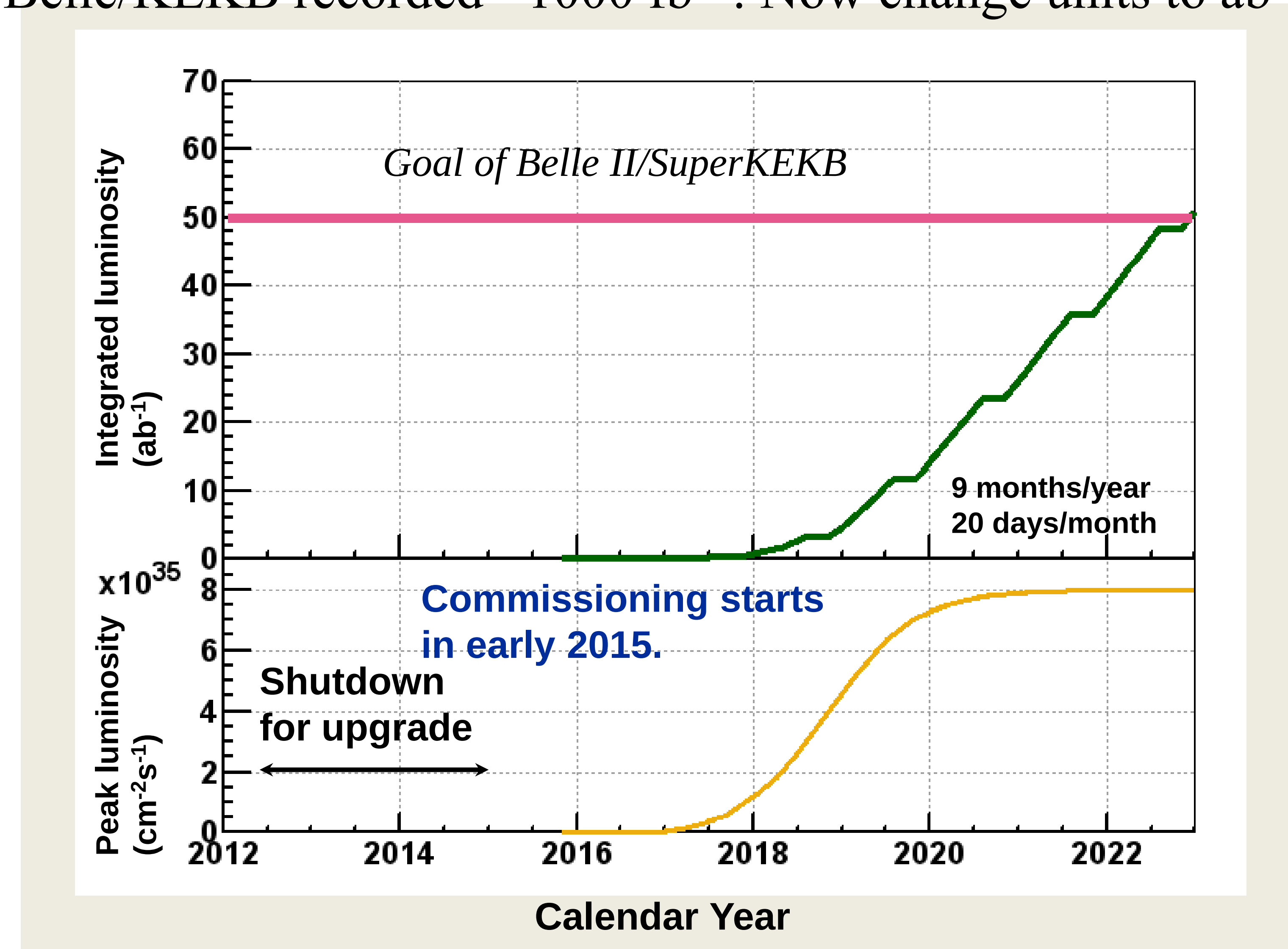
World record:

$L = 2.1 \times 10^{34}/cm^2/sec$

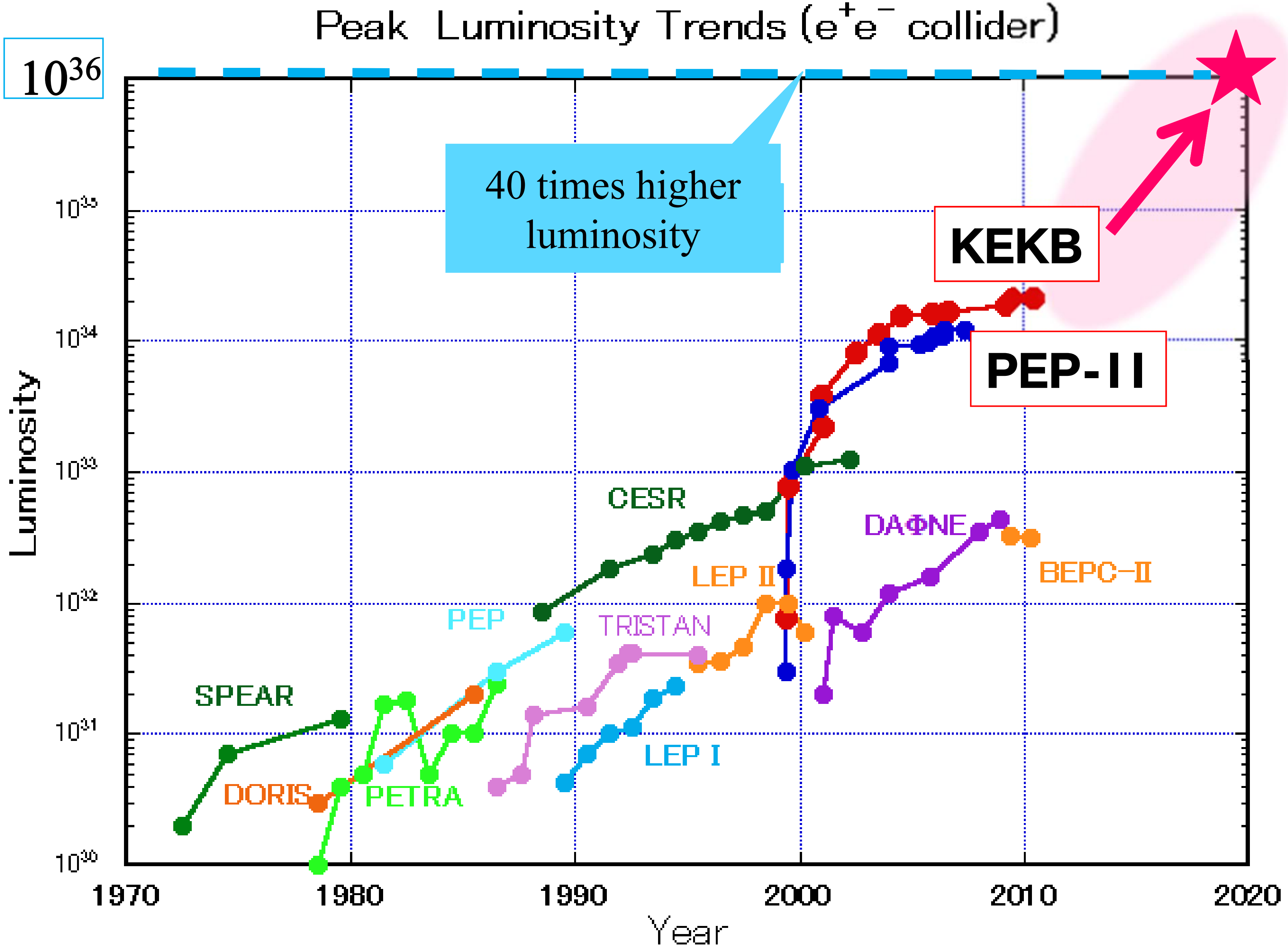
Downtown Tsukuba, Izakayas

SuperKEKB luminosity projection

Belle/KEKB recorded ~1000 fb^{-1} . Now change units to ab^{-1}



SuperKEKB is the e⁺e⁻ intensity frontier



Compare the Parameters for KEKB and SuperKEKB

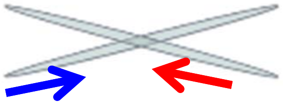
	KEKB Design	KEKB Achieved : with crab	SuperKEKB Nano-Beam
Energy (GeV) (LER/HER)	3.5/8.0	3.5/8.0	4.0/7.0
β_y^* (mm)	10/10	5.9/5.9	0.27/0.30
β_x^* (mm)	330/330	1200/1200	32/25
ε_x (nm)	18/18	18/24	3.2/5.3
$\varepsilon_y/\varepsilon_x$ (%)	1	0.85/0.64	0.27/0.24
σ_y(μm)	1.9	0.94	0.048/0.062
ξ_y	0.052	0.129/0.090	0.09/0.081
σ_z (mm)	4	6 - 7	6/5
I_{beam} (A)	2.6/1.1	1.64/1.19	3.6/2.6
$N_{bunches}$	5000	1584	2500
Luminosity (10^{34} cm^{-2} s^{-1})	1	2.11	80

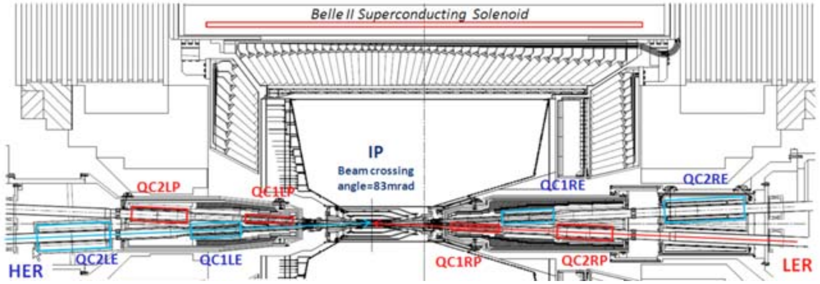
Nano-beams are the key (vertical spot size is ~50nm !!)

This is not a typo

Y. Ohnishi et al.

Colliding bunches





New superconducting final focusing magnets near the IP

e^+ 3.6A

e^- 2.6A

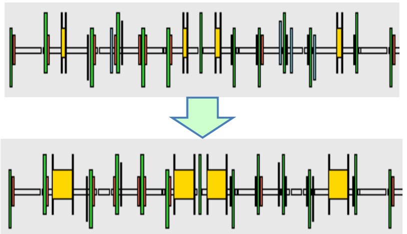
KEKB to SuperKEKB

- ◆Nano-Beam scheme
  - extremely small β_y^*
  - low emittance
- ◆Beam current X 2

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

40 times higher luminosity
2.1x10^{34} --> 8x10^{35} $cm^{-2}s^{-1}$

Redesign the lattice to reduce the emittance (replace short dipoles with longer ones, increase wiggler cycles)



Reinforce RF systems for higher beam currents

Improve monitors and control system

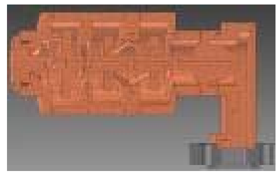
Replace beam pipes with TiN-coated beam pipes with antechambers

DR tunnel

Injector Linac upgrade

Upgrade positron capture section

Low emittance RF electron gun

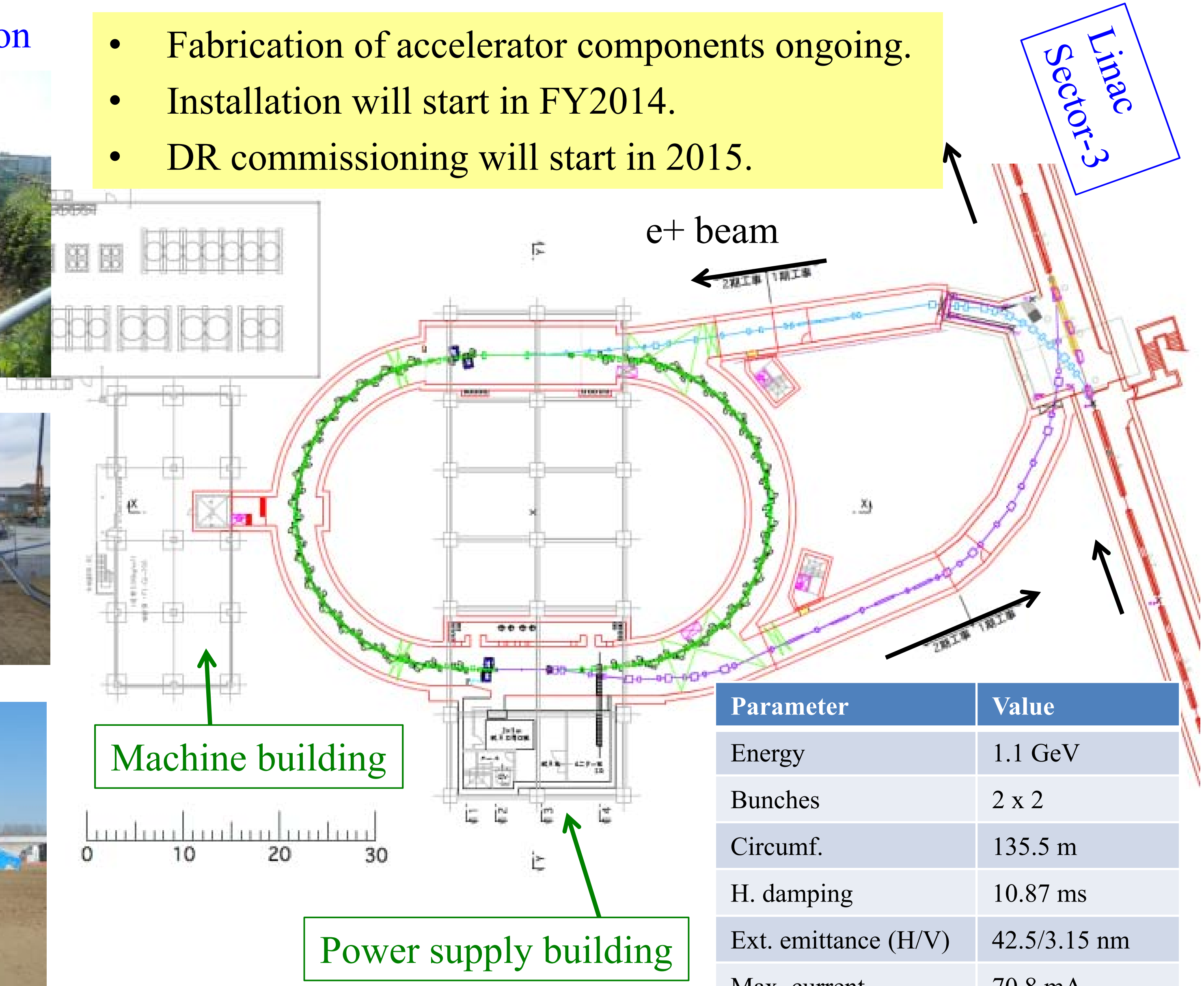


New e+ Damping Ring

New Damping Ring for positrons

DR tunnel construction

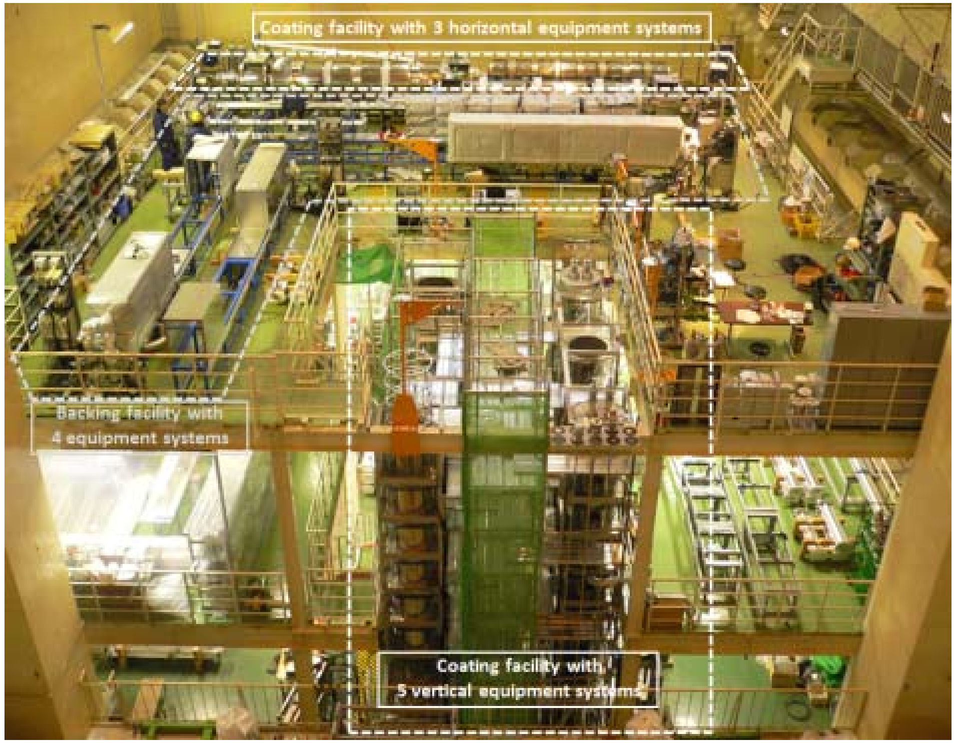
- Fabrication of accelerator components ongoing.
- Installation will start in FY2014.
- DR commissioning will start in 2015.



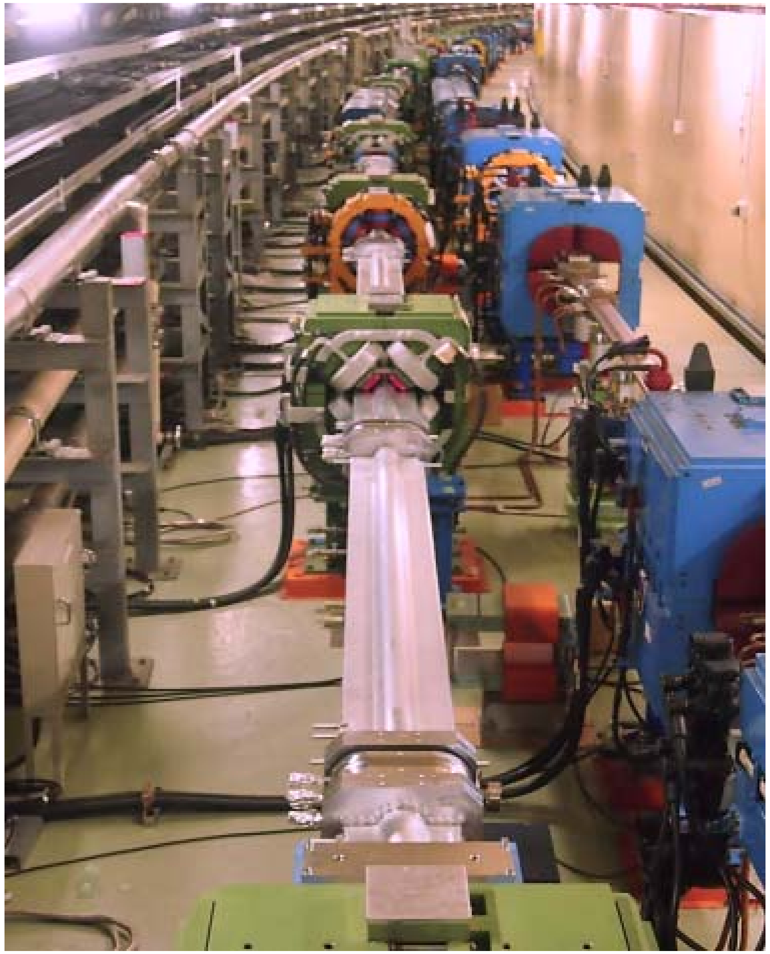
Parameter	Value
Energy	1.1 GeV
Bunches	2 x 2
Circumf.	135.5 m
H. damping	10.87 ms
Ext. emittance (H/V)	42.5/3.15 nm
Max. current	70.8 mA

The new LER (with antechambers and TiN coating)

Ti-N beampipe coating and baking facility in the Oho Hall

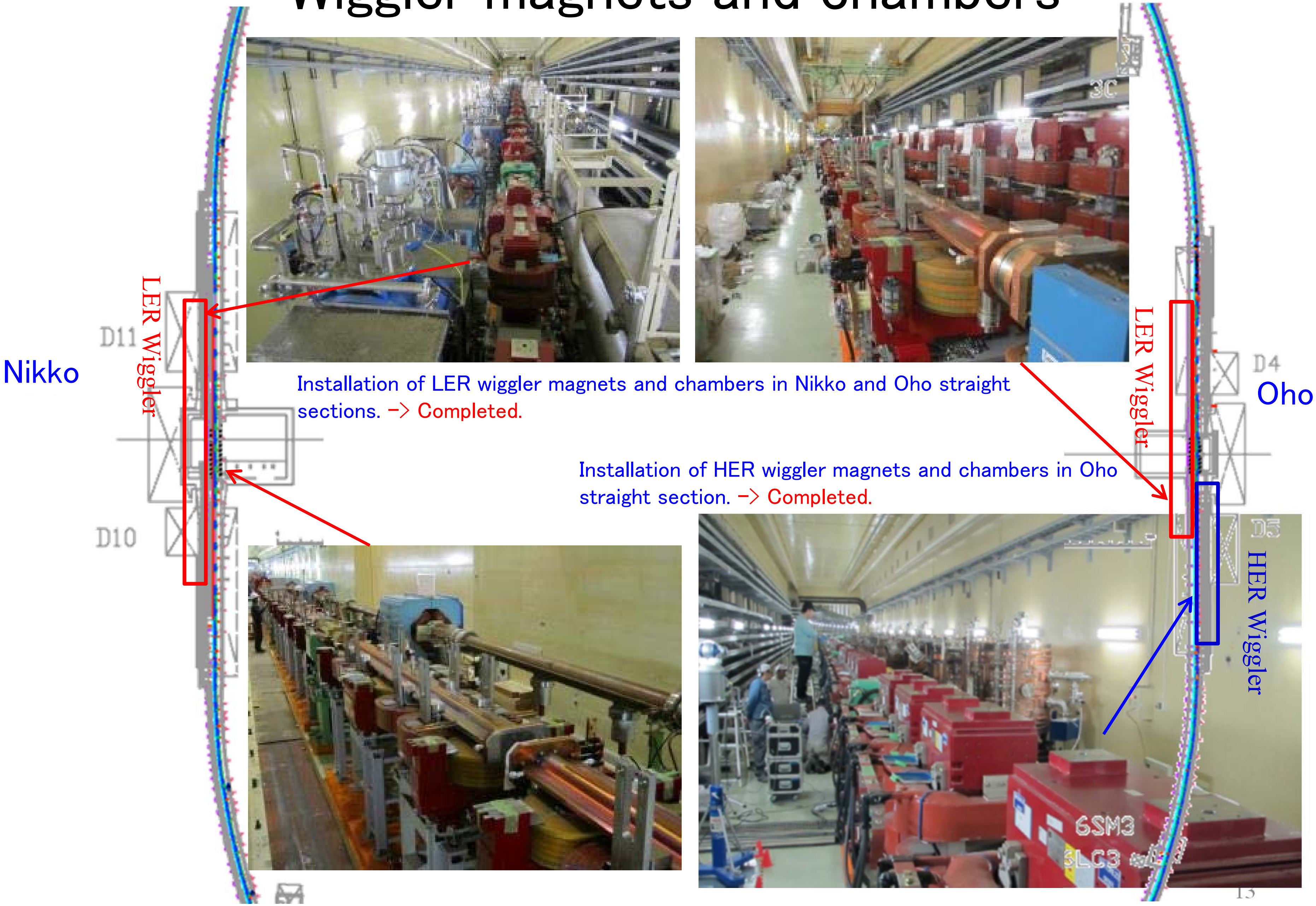


A new LER section installed



Photoelectrons in the LER blow up the beam size and were a persistent problem at the B factories.

Wiggler magnets and chambers



Installation of LER wiggler magnets and chambers in Nikko and Oho straight sections. -> Completed.

Installation of HER wiggler magnets and chambers in Oho straight section. -> Completed.

Before 2013

(2)KEKB電磁石撤去済
新ビームライン用測量・罫描き 済
ベースプレート設置進行中

Tsukuba straight section

電磁石搬入・据え付けは来年度から
一部の電磁石は新規製作予定

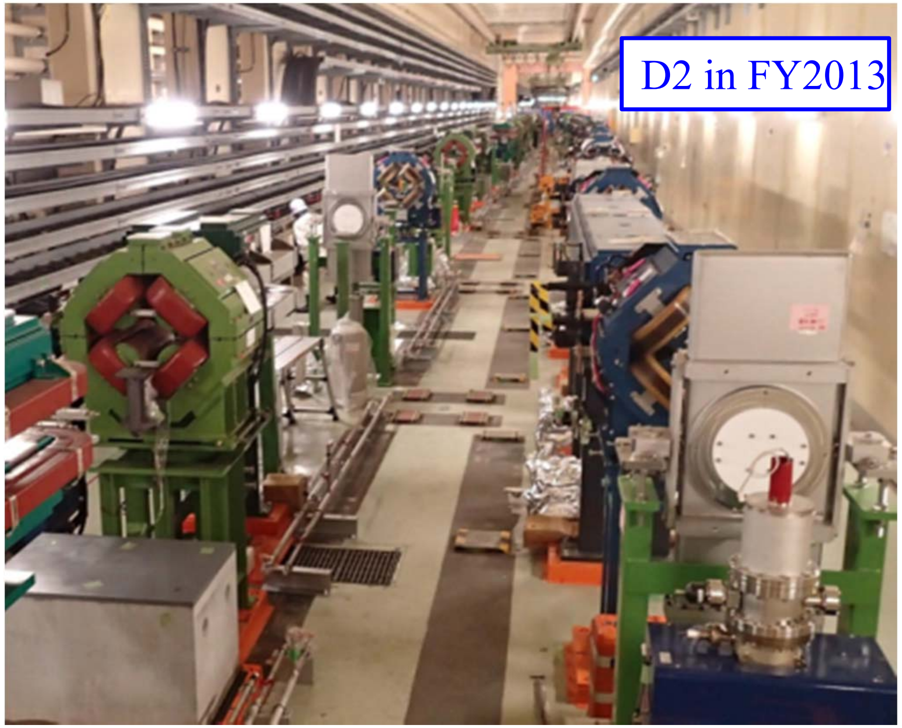
Done

- Dismantling all magnets, beam pipes, cables, etc.
- Belle rotation, roll-out
- Installation of magnets (except close to IP)

On going 2014

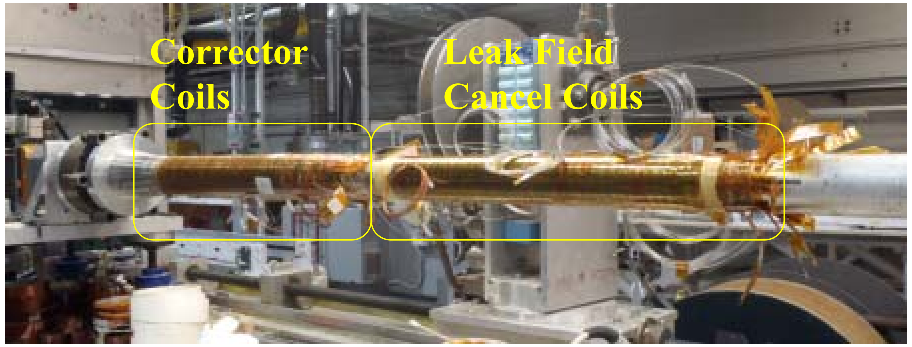
- Beam pipe fabrication
- Magnets close to the IP being fabricated
- Cabling and piping
- Floor modification and moveable stage
- Radiation shielding

Tsukuba section waiting for beam pipes

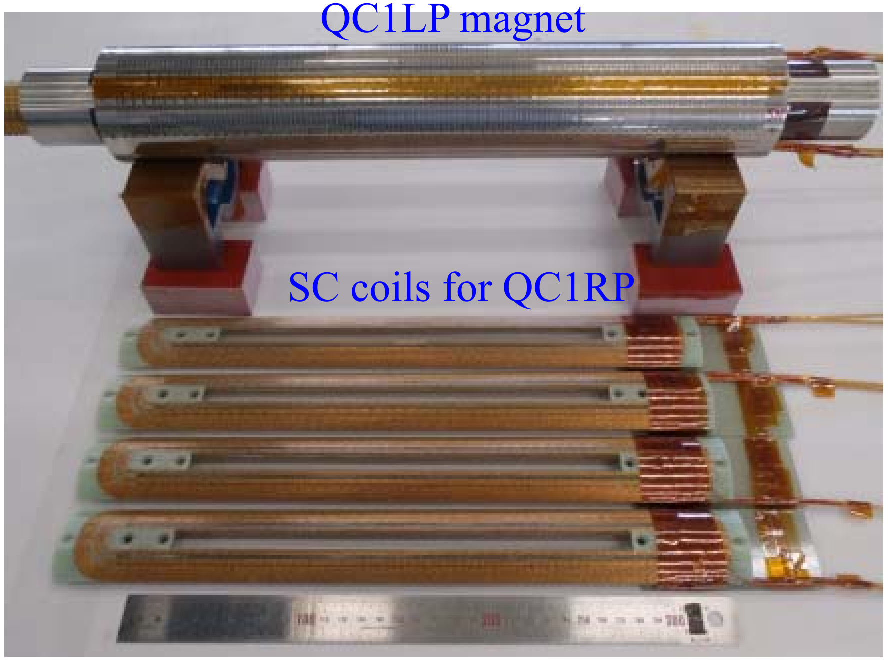


Superconducting IR Magnets

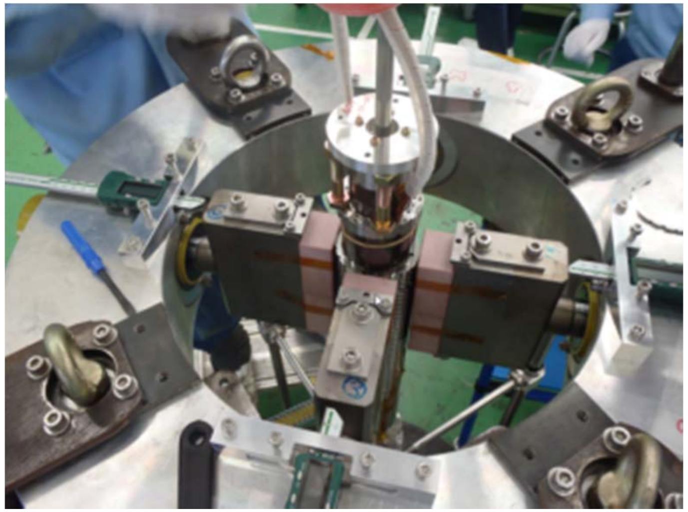
- Fabrication of QC1/QC2 magnets and cryostats in Mitsubishi
- Fabrication of SC corrector coils by Brookhaven National Lab (BNL)
- Excitation tests and field measurements underway



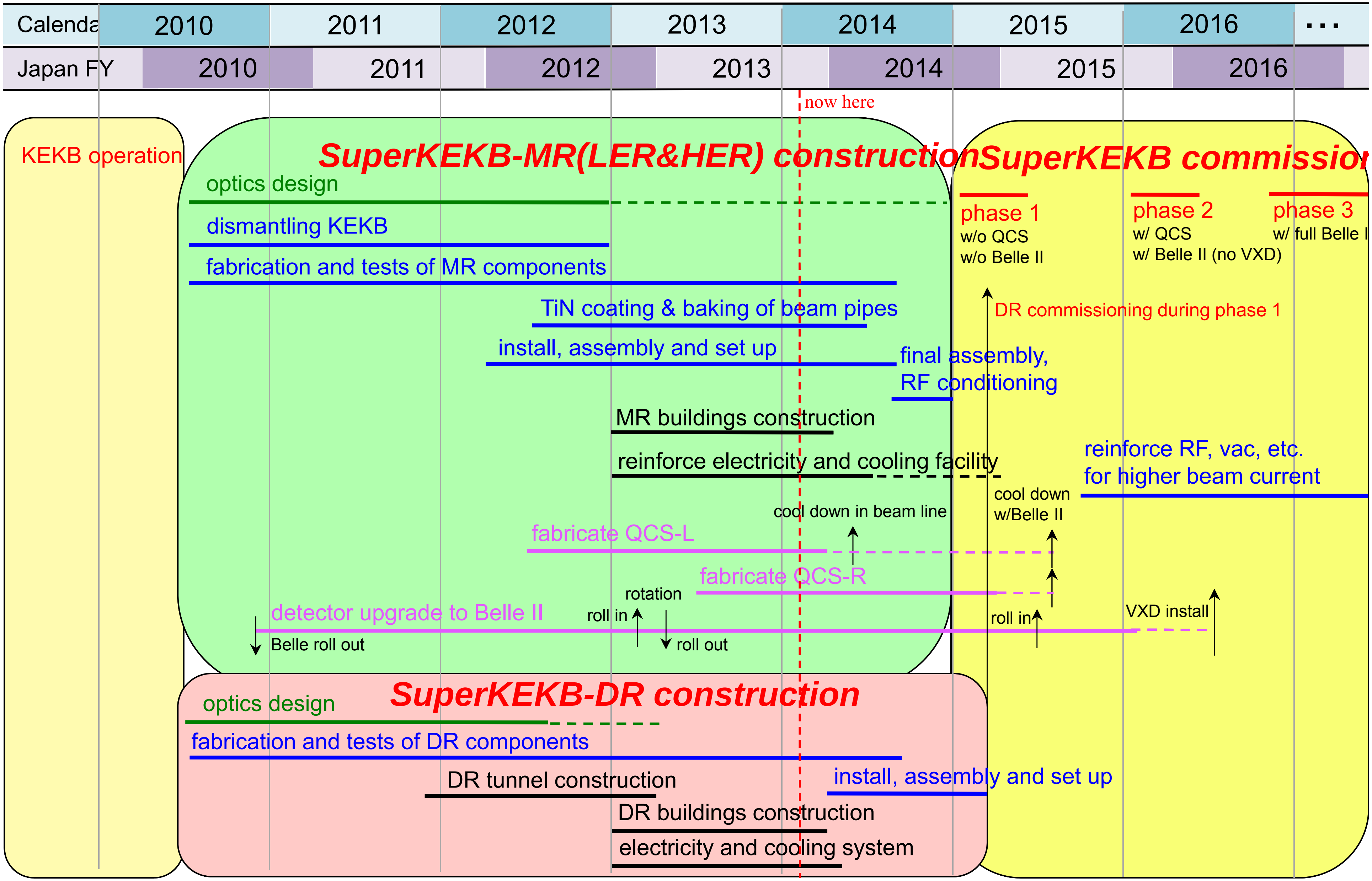
QC1LE correctors coils at BNL, November 2013



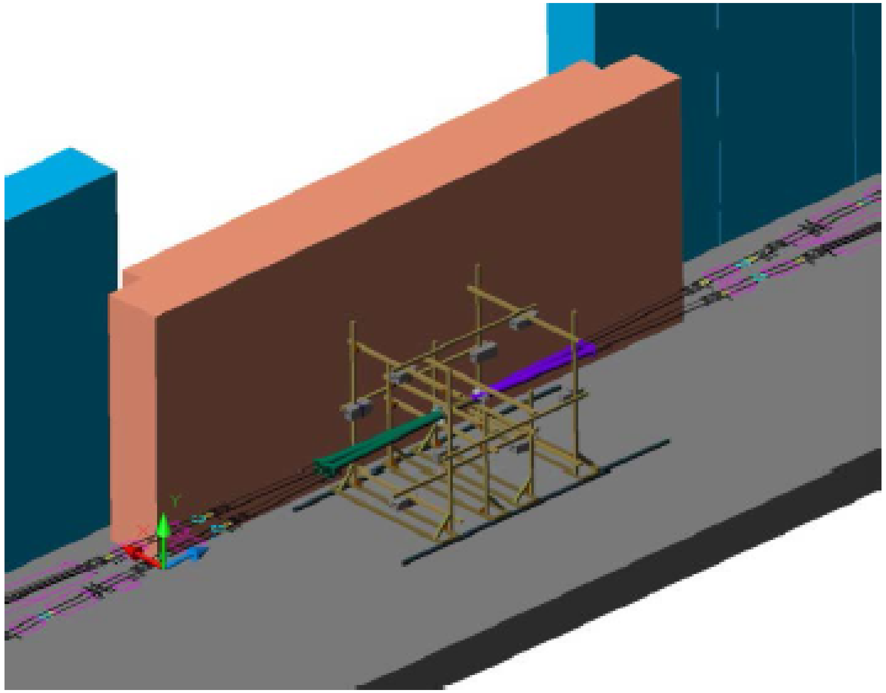
Completed collared QC1LP magnet and SC coils for QC1RP

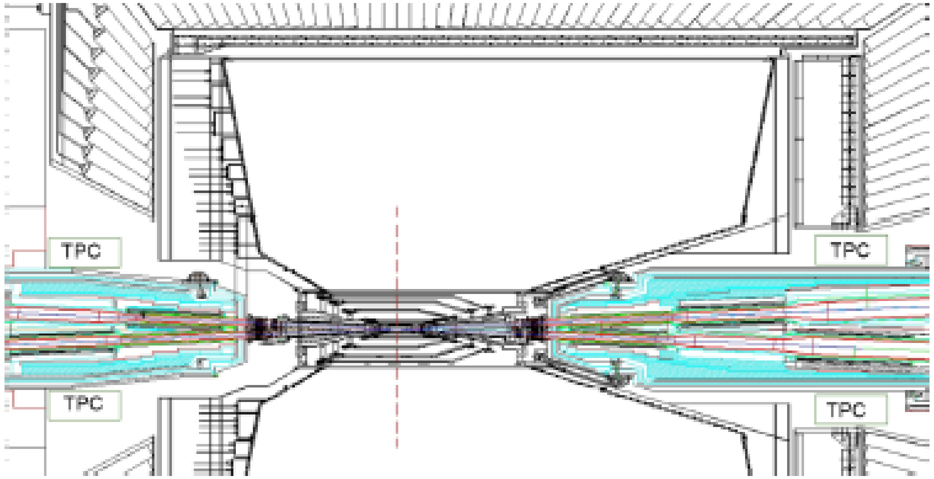

Collaring work in Mitsubishi

SuperKEKB master schedule



SuperKEKB: Two Commissioning Phases





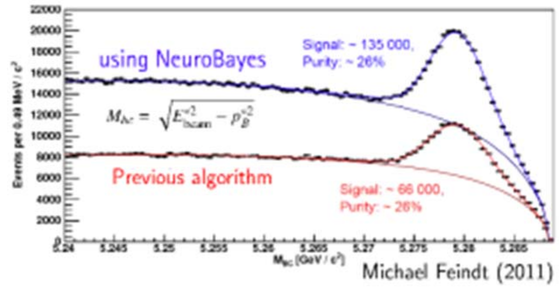
Phase 1: >Jan 2015
Vacuum scrubbing of beam pipe.
No QCS. No collisions. Belle will not roll-in.

Phase 2: > Feb 2016
Belle rolled in.
No VXD detectors.

BEAST II Background commissioning experiment to measure bkgs, check simulation and determine if Belle II vertex detectors will be safe.

Belle II Detector Requirements

Build a full-capability magnetic spectrometer with excellent vertexing, tracking, PID, neutral and hermeticity capabilities

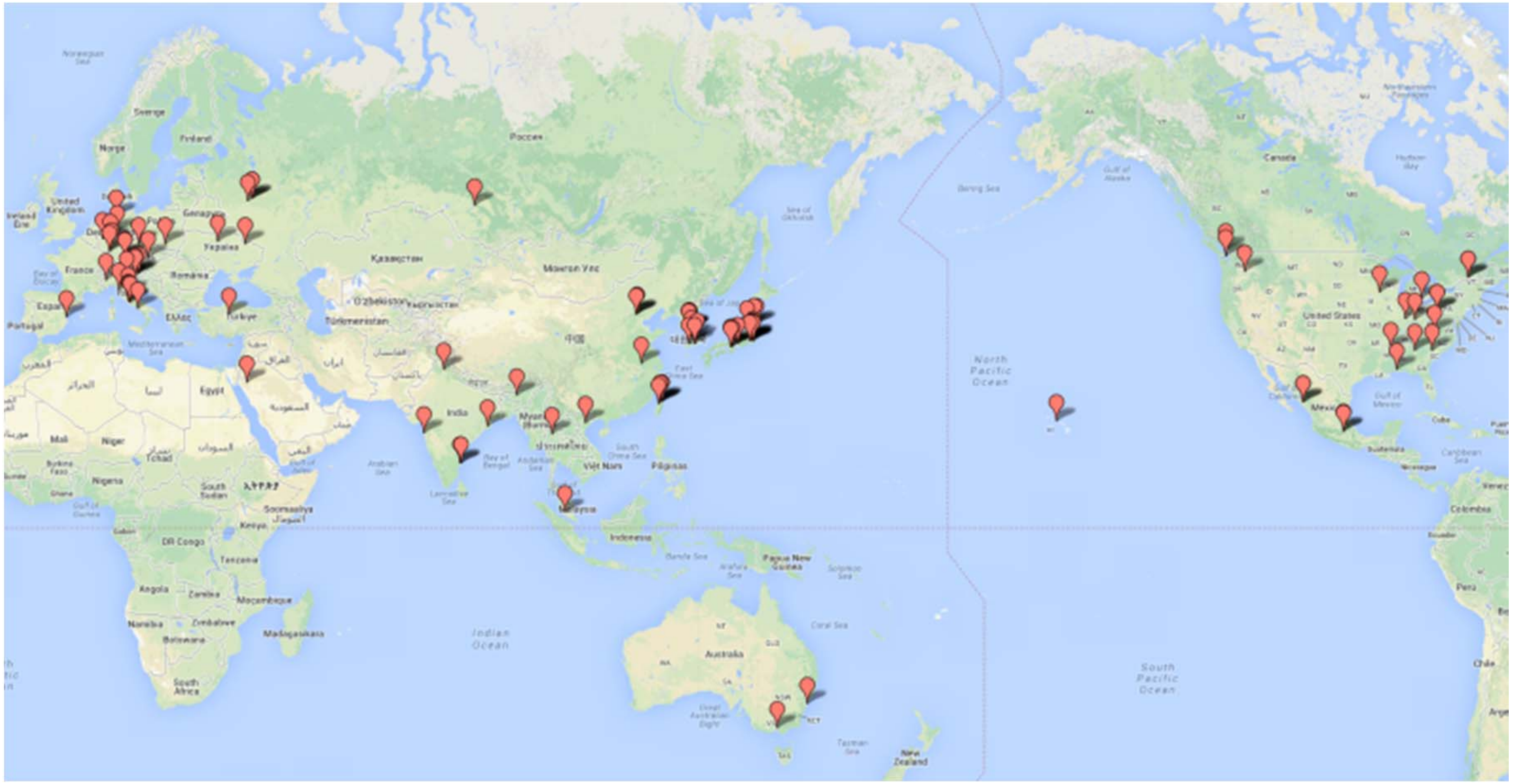


Belle I tags

<u>Performance must be preserved when beam-related backgrounds are 10-20 times larger than in Belle</u>. Such backgrounds are associated with Super B factory level luminosity.

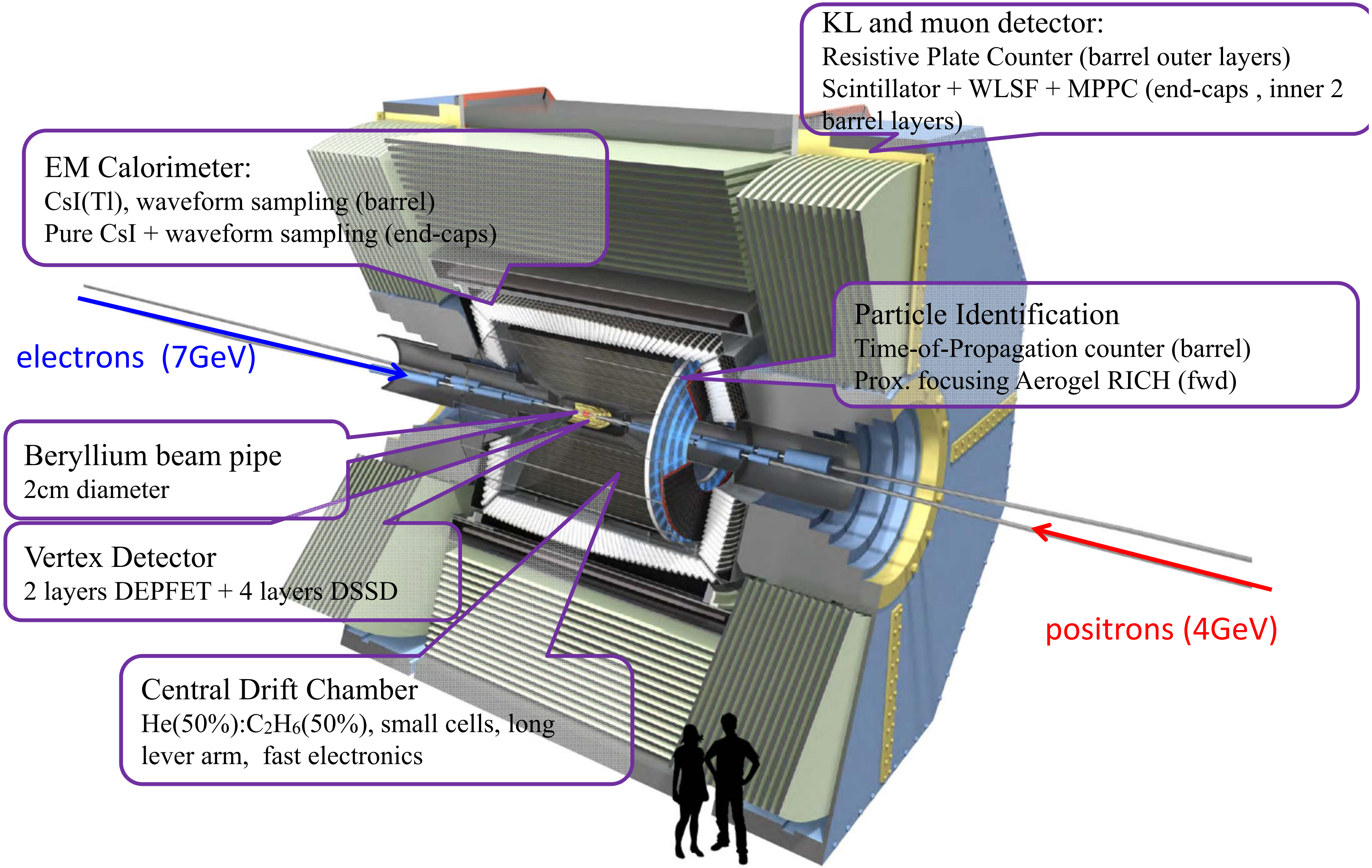
Reuse as much of Belle as possible. Introduce new technological developments (pixel vertex detectors, pixelated photosensors, "oscilloscope on a chip" electronics etc.)

Belle II: A Truly International Team



599 Collaborators, 97 institutes, 23 countries

Belle II Detector



In e+e- scattering at 10-11 GeV, a critical issue for vertexing is multiple scattering.

$$\sigma = a + \frac{b}{p\beta \sin^{\nu}\theta}$$

Beampipe r= 10 mm

DEPFET pixels
- Layer 1 r=14 mm
- Layer 2 r= 22 mm

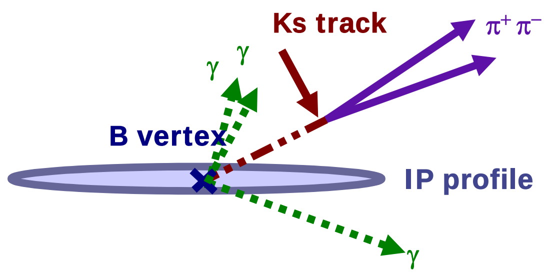
DSSD (double sided silicon detectors)
- Layer 3 r=38 mm (Australia)
- Layer 4 r=80 mm (India)
- Layer 5 r=115 mm (Austria)
- Layer 6 r=140 mm (Japan)

+Italy

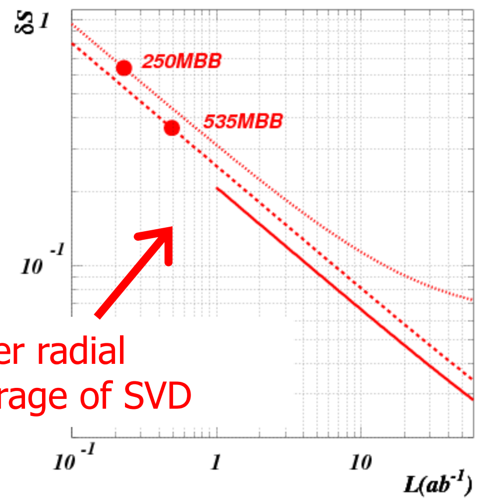
Belle: r(beampipe) 2 cm→1.5 cm
Belle II: r(beampipe) 1cm

Improved resolution and nano-beams will open new possibilities for vertex analysis

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



B decay point reconstruction
Using the K_S trajectory

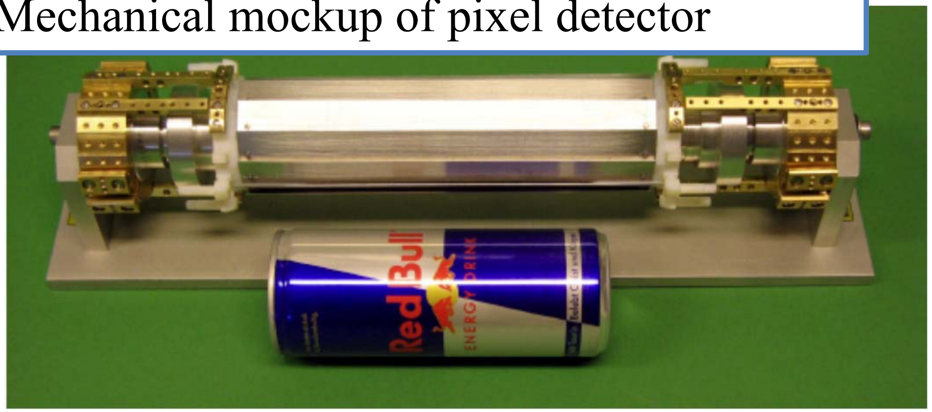


Larger radial coverage of SVD

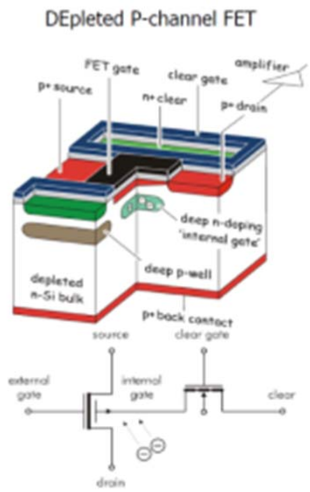
Pixel Detector

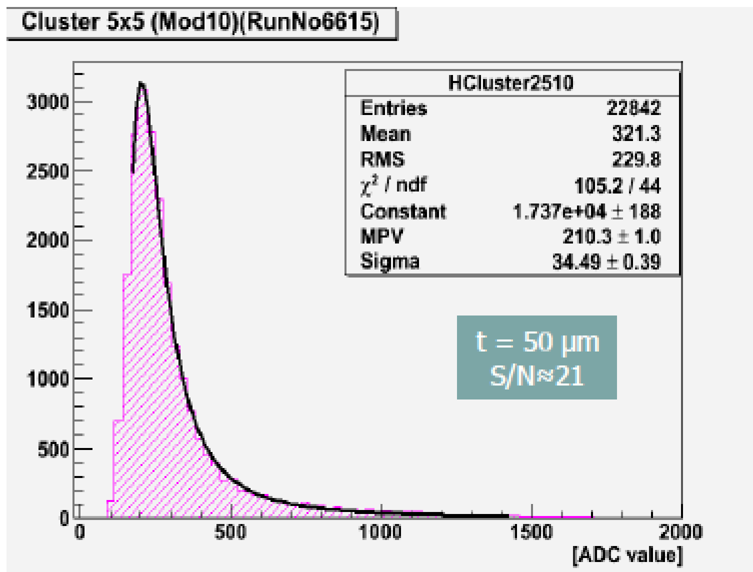
DEPFET:
http://aldebaran.hll.mpg.de/twiki/bin/view/DEPFET/WebHome

Mechanical mockup of pixel detector



DEPFET pixel sensor



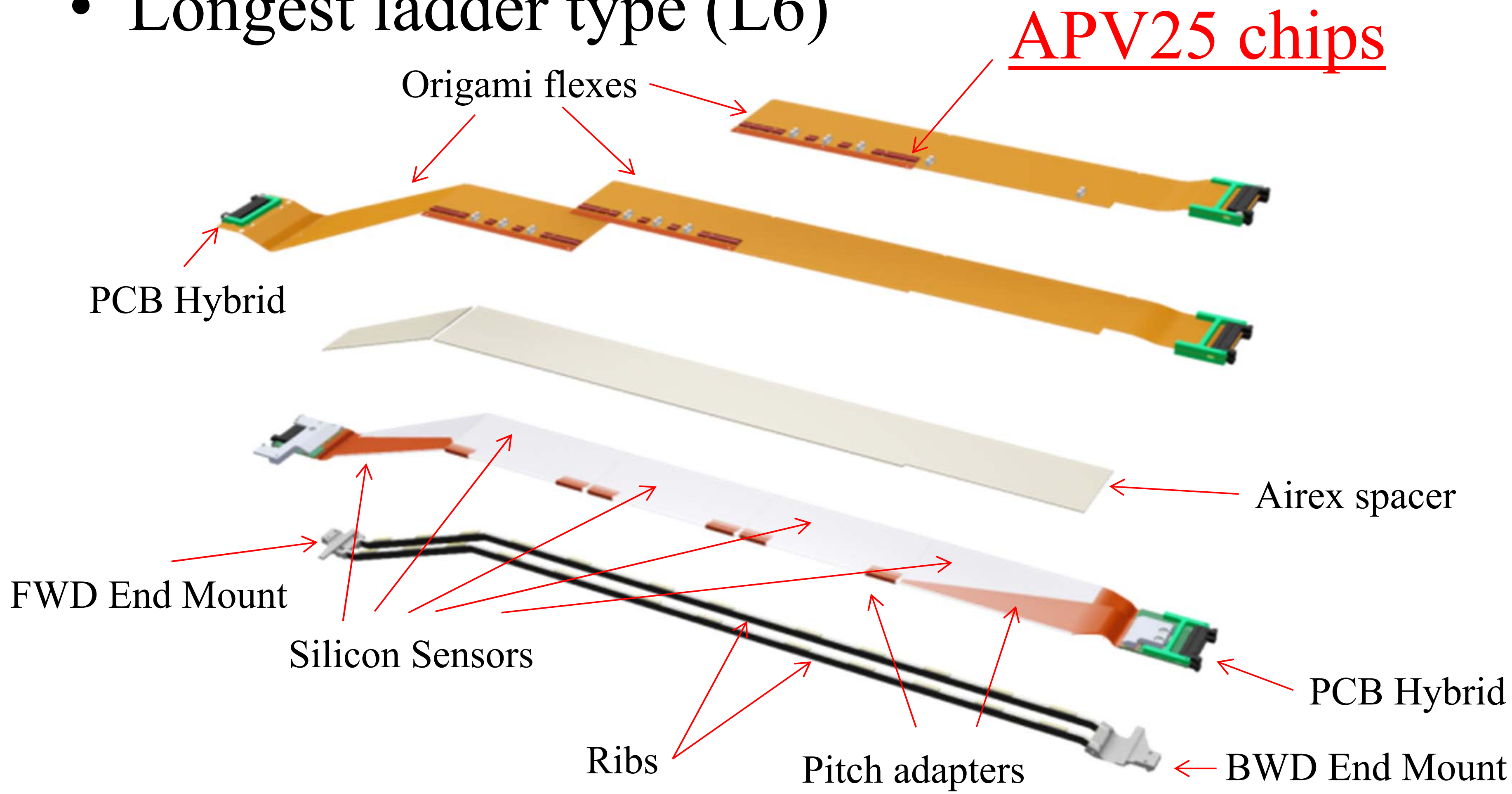


DEPFET sensor: very good S/N

Exploded view of an SVD detector

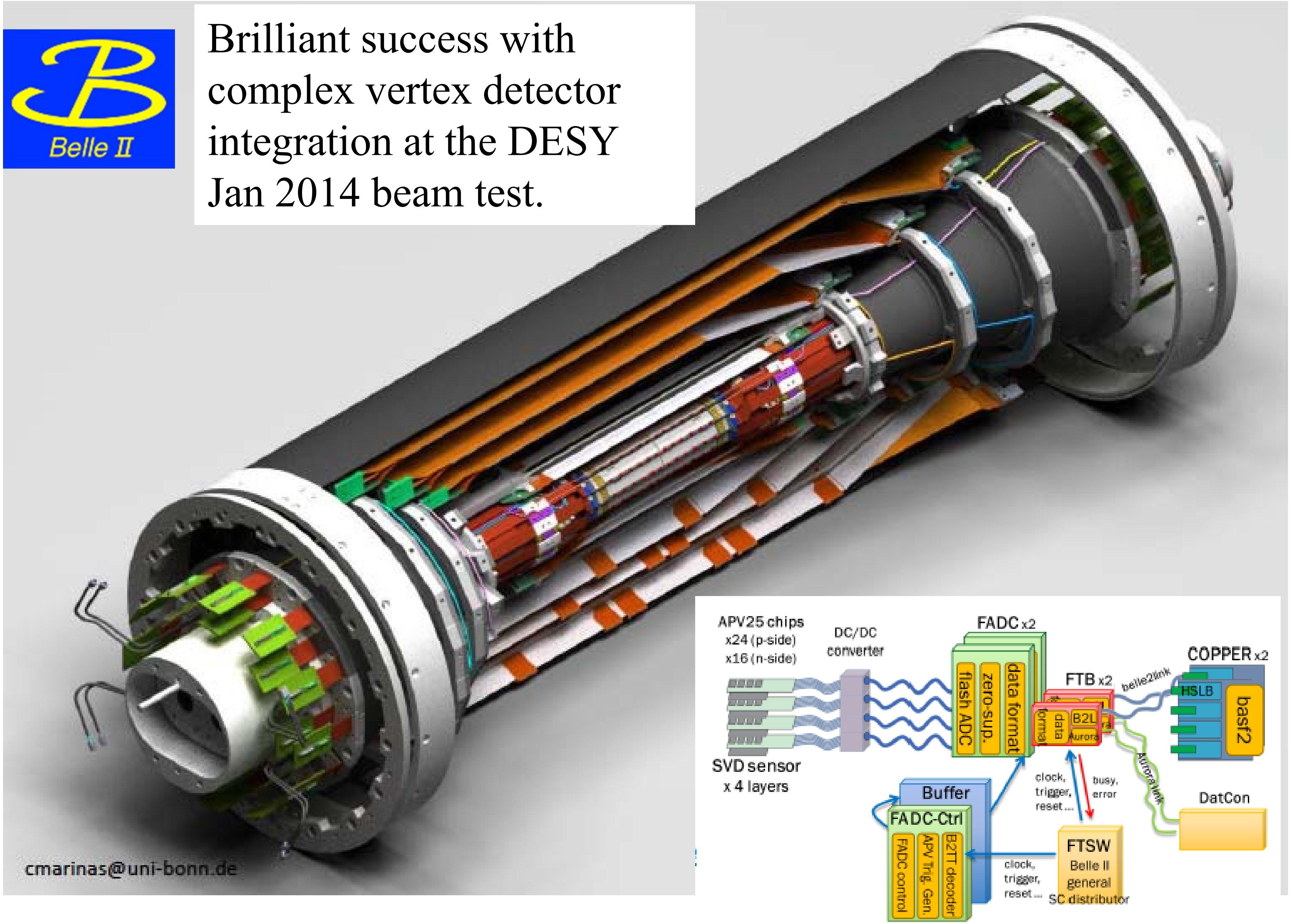
http://www.hep.ph.ic.ac.uk/cms/tracker/apv2
chip.html

- Longest ladder type (L6)

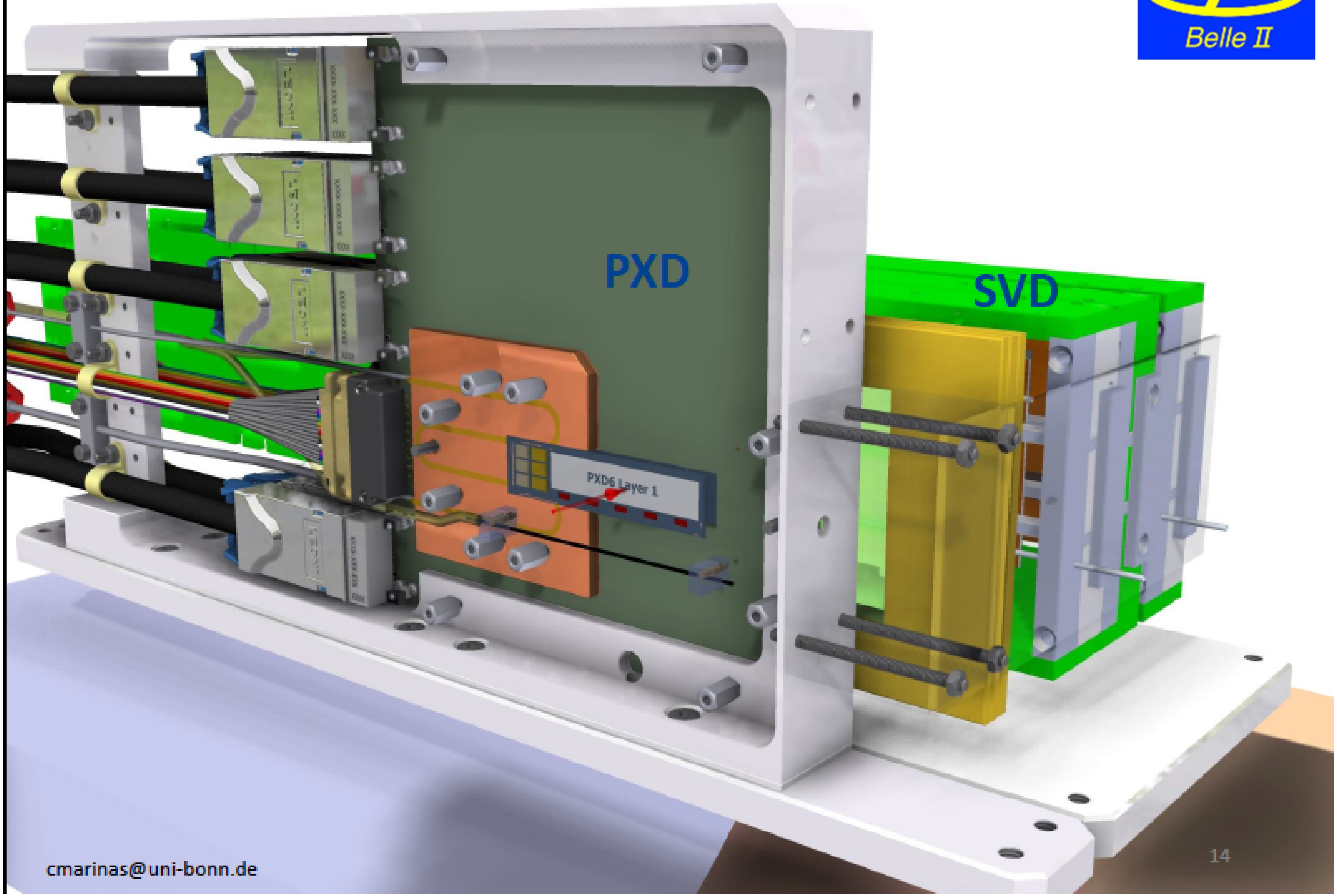


Belle II

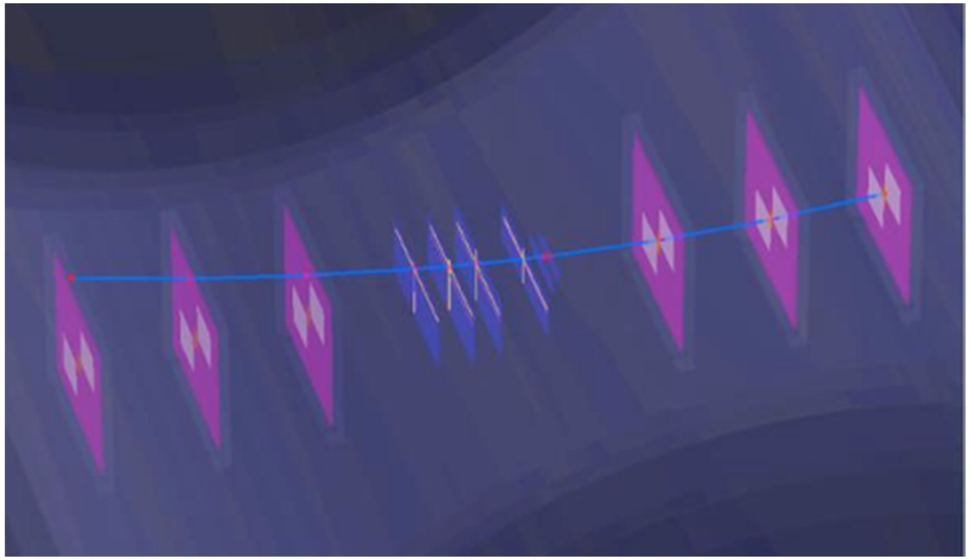
Brilliant success with complex vertex detector integration at the DESY Jan 2014 beam test.



Mechanical Set-up

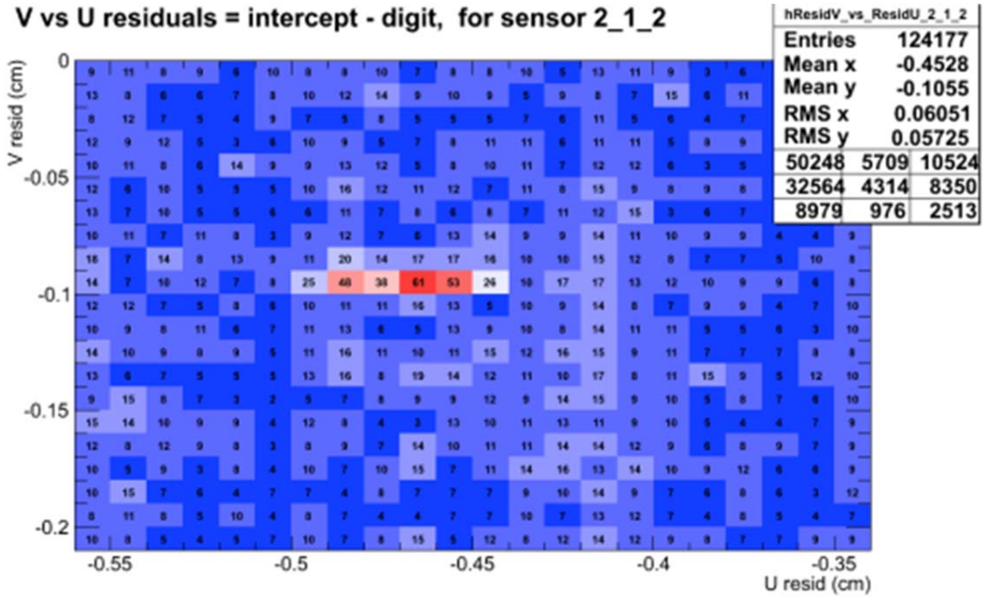


cmarinas@uni-bonn.de



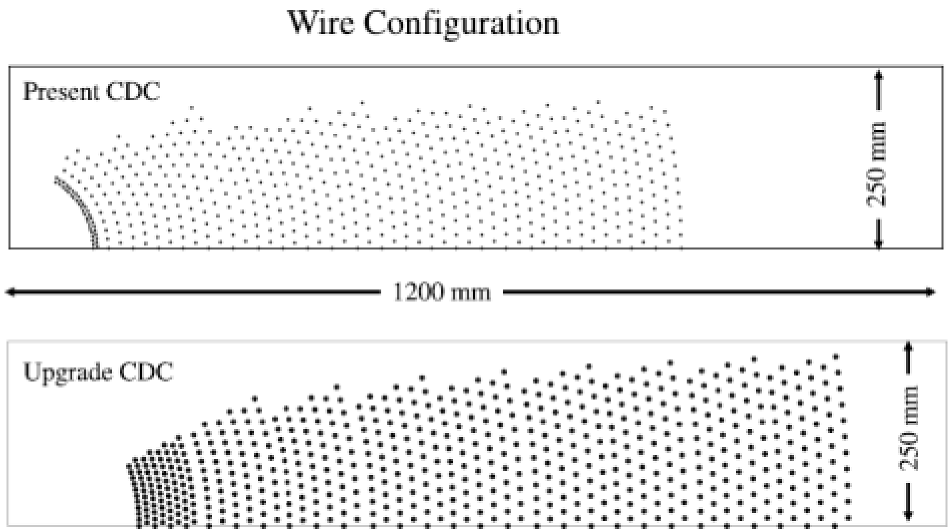
Event display with EUDET Mimosa pixels, Belle II SVD and PXD modules

To reduce the Gbit/s data volume from pixels, read out only Regions Of Interest (ROI)'s from projected SVD track segments.

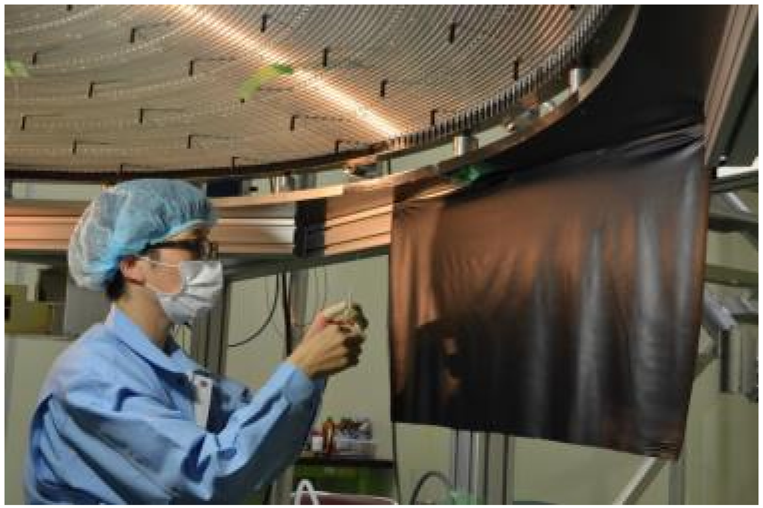


✔ SVD ROI (region of interest) finding in the PXD at the DESY beam test (plot from Jan 30, 2014)

Belle II Central Drift Chamber(CDC)

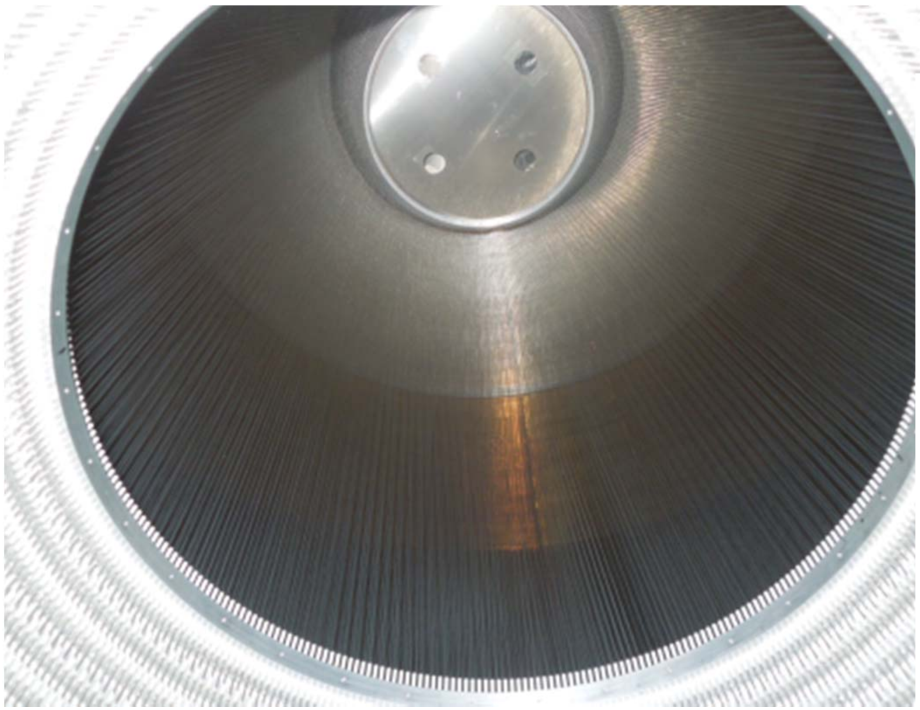


Longer lever arm than in Belle!



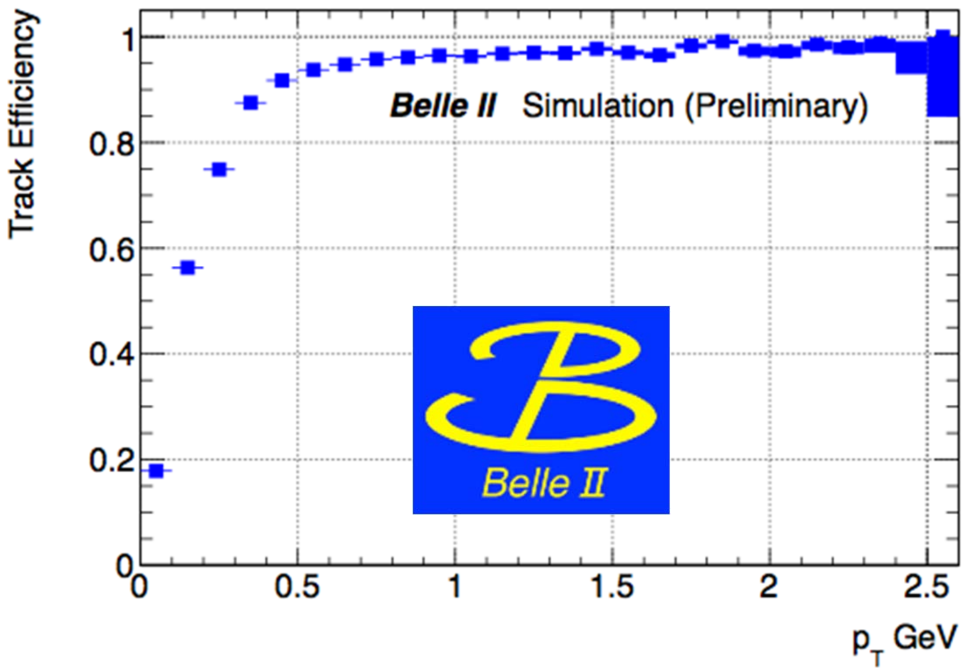
Wire stringing in a clean room in Fuji Hall

✓ CDC wire stringing is done (~51k wires done)



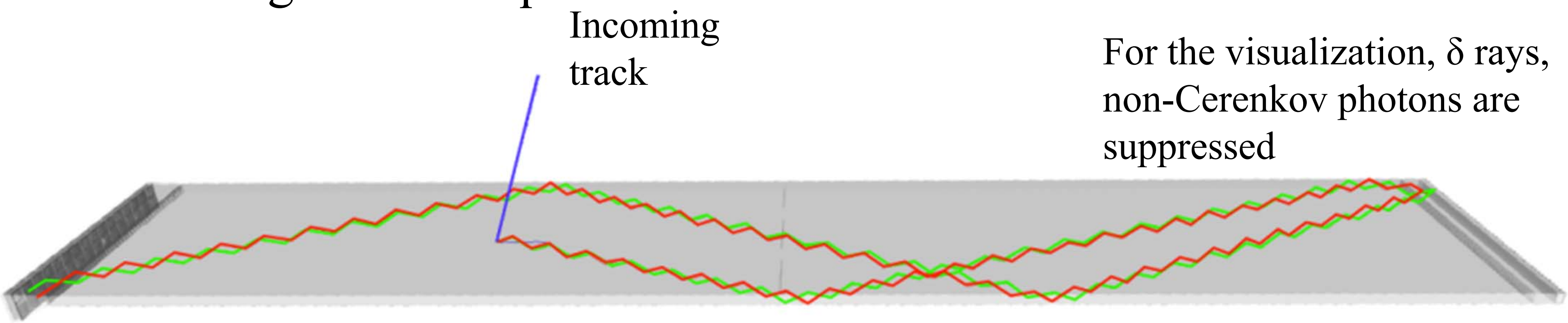
CDC viewed from the backward side

Expected performance using Kalman filter and GEANT4 simulation



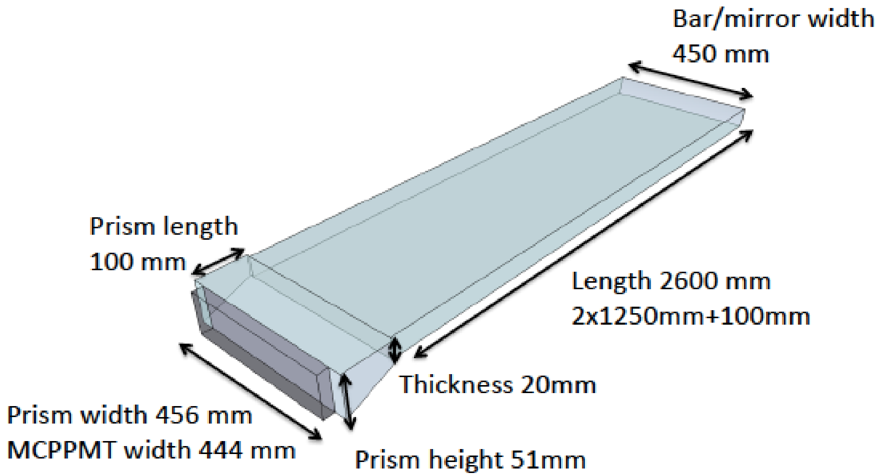
PID: Principle of operation of iTOP detector

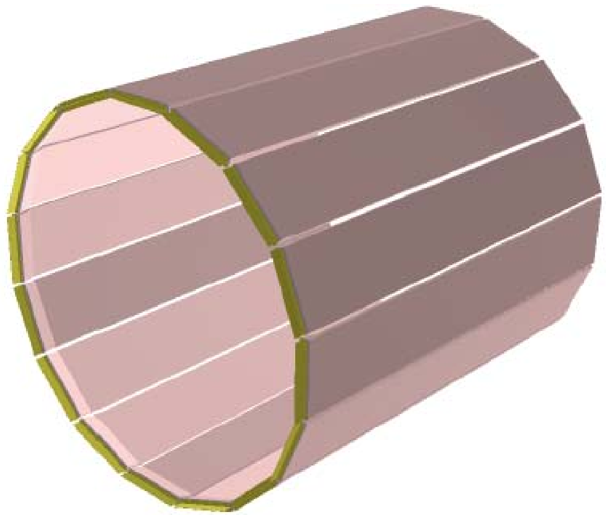
Shown below is a GEANT4 event display of a 2 GeV pion and kaon interacting in a TOP quartz bar.



For the visualization, δ rays, non-Cerenkov photons are suppressed

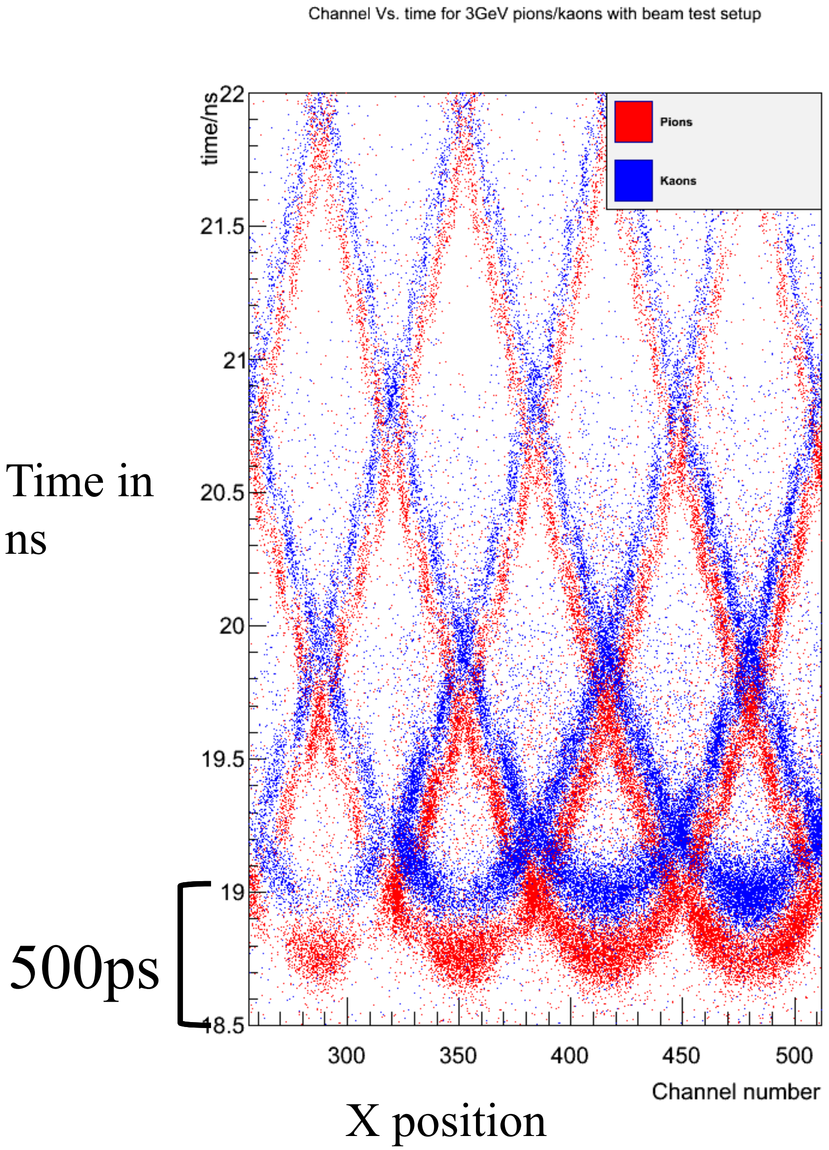
Tight tolerances on the quality of the quartz bars and optical components.





16 bar modules arranged in a "roman arch"

Kaons vs pions: Integrated MC distributions



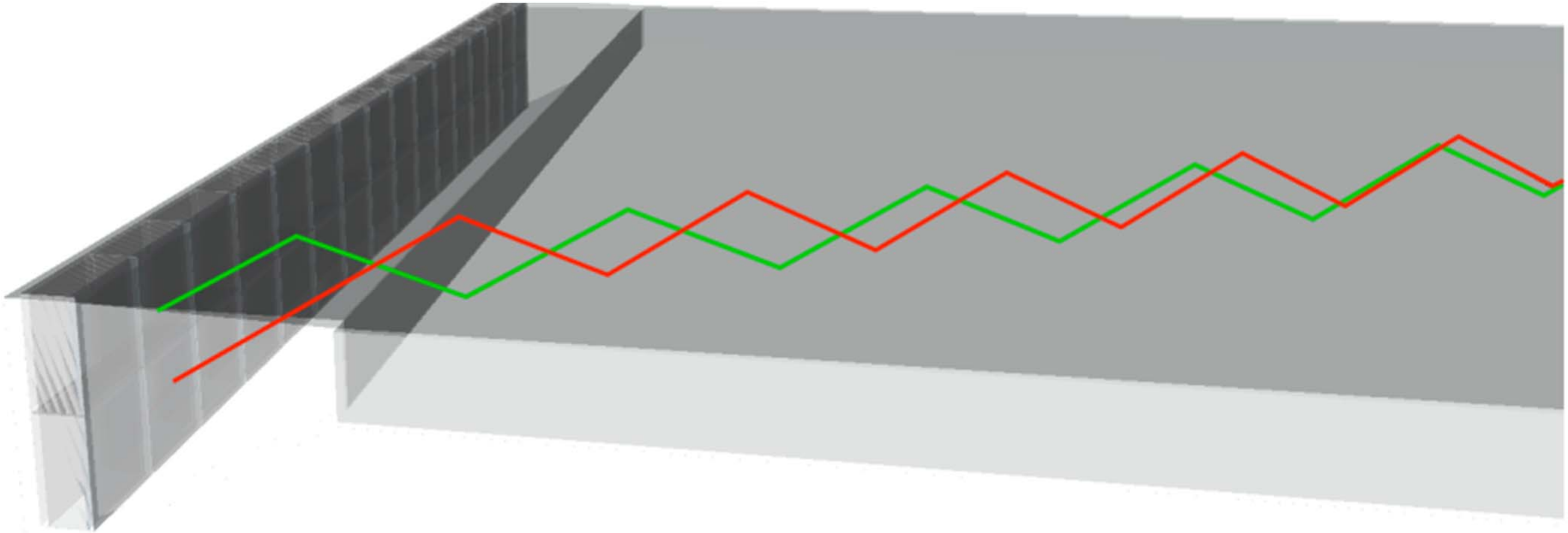
At 3 GeV, the upper end of the interesting physics range, only modest differences between kaons and pions in the x vs t distributions. *Timing at the ~100 ps level is needed.*

Belle II Jargon

TOP=Time Of Propagation

M. Barrett

Pixelated PMTs measure *time and position of single photons*

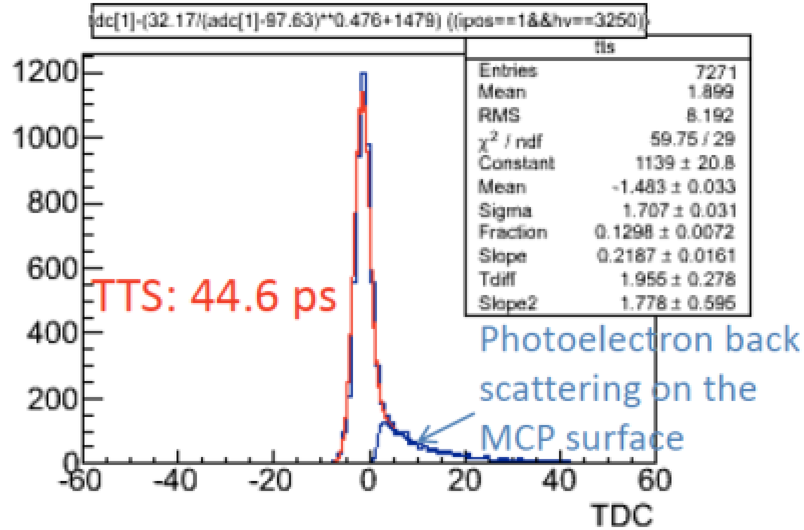


512 Hamamatsu 4 x 4 MCP-PMT needed

NaKSbCs photocathode

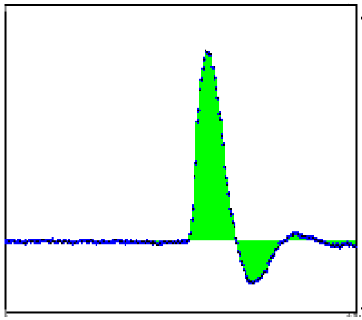
Typical QE~28% at 380 nm

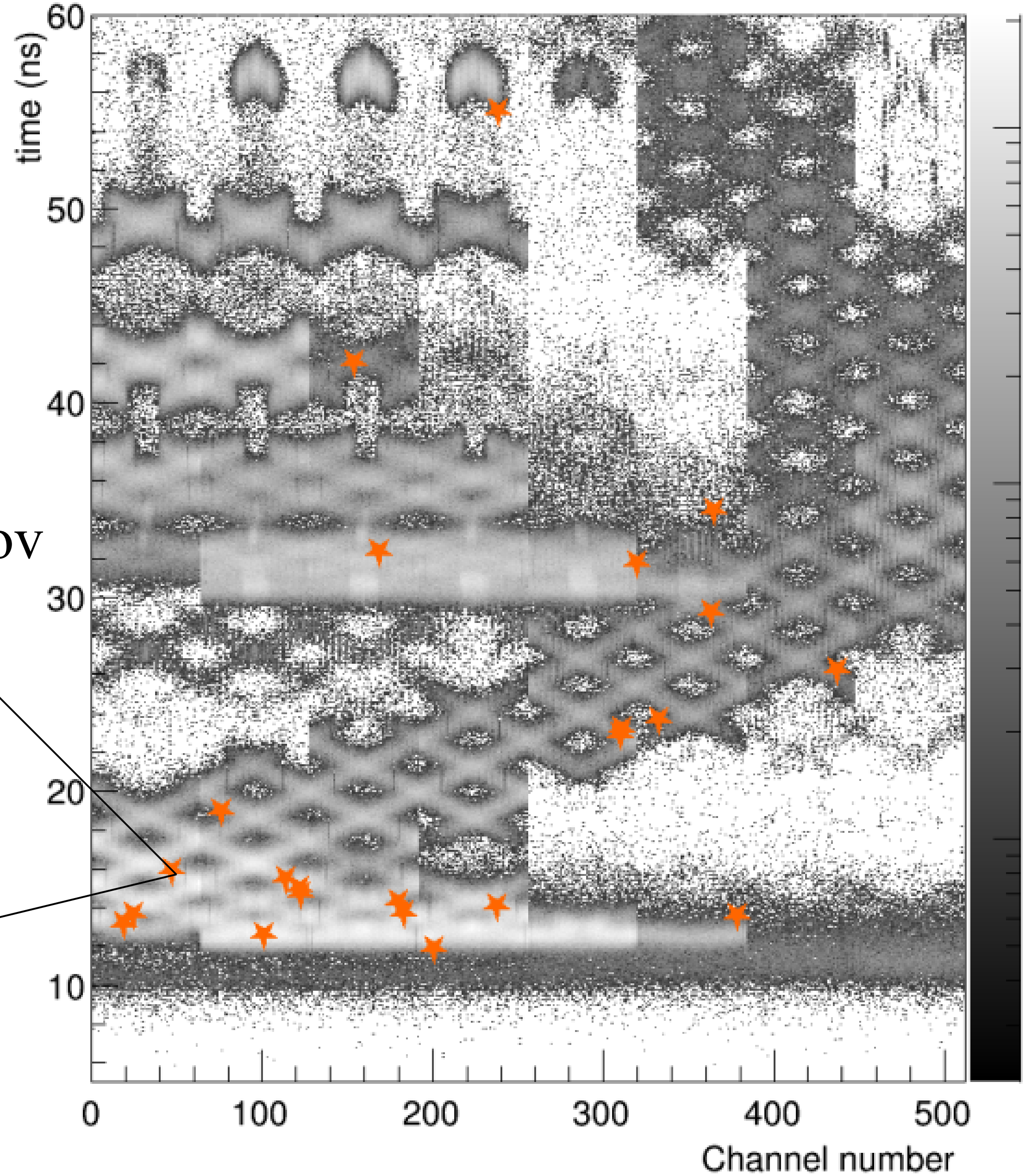
TTS 45 ps with a long

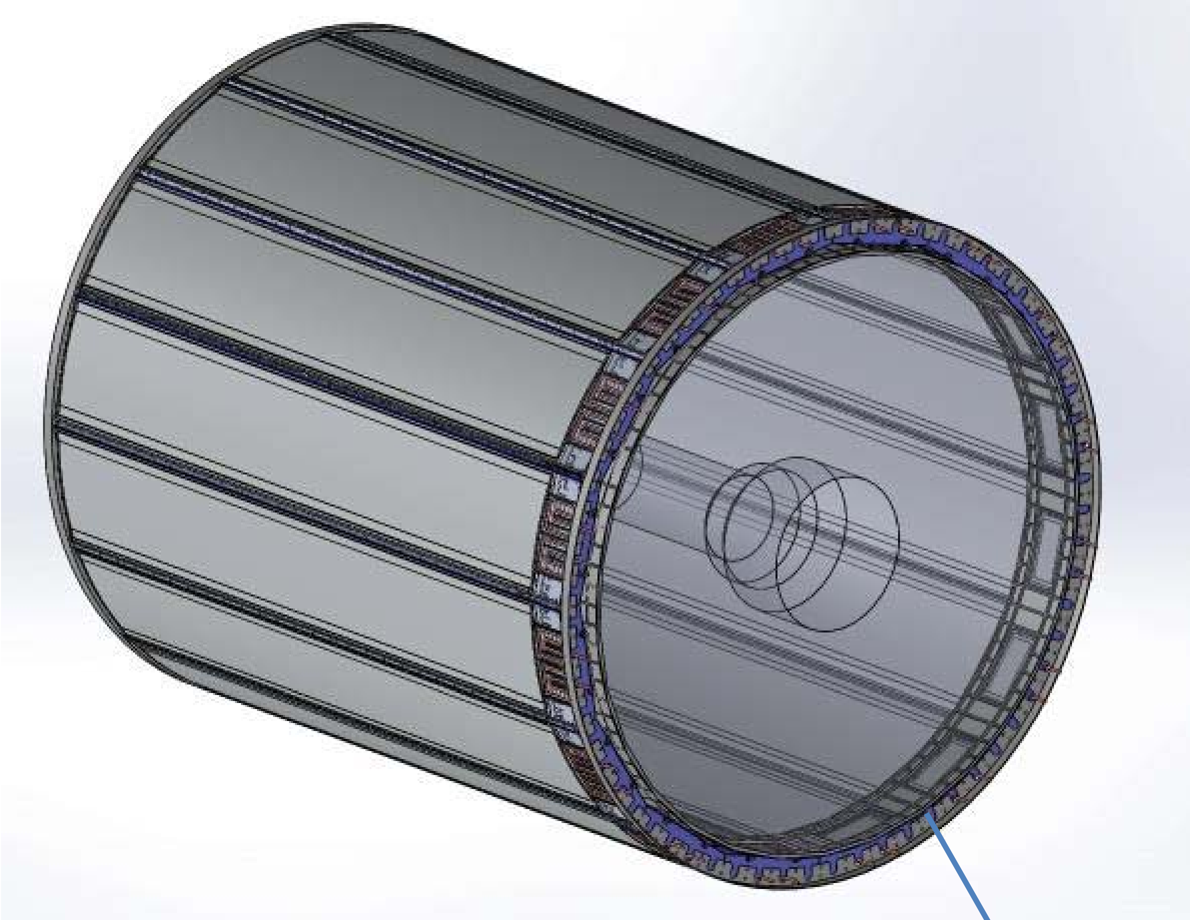


Electronics based on IRSnn "*oscilloscope on a chip*" electronics

Waveform of a Cherenkov photon



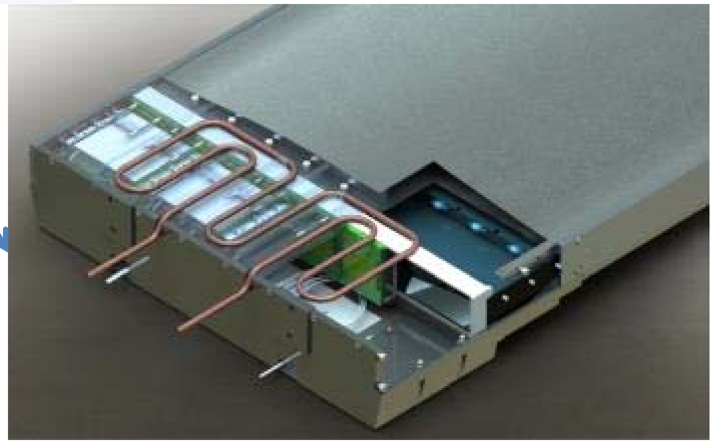




Detector subsystem of Japan, US, Slovenia and Italy.

Passed CD1 in 2012

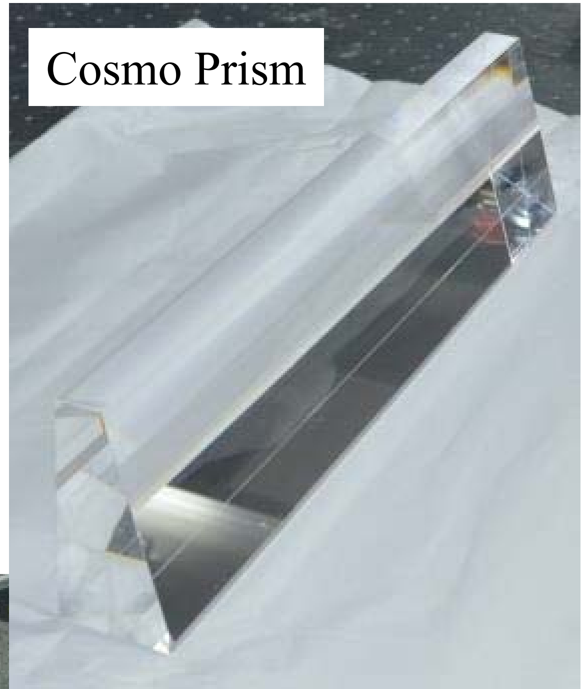
Expanded view of the readout



Proceeding to a US DOE CD2-3 (Critical Decision 2-3) review, scheduled for March 19-20 at PNNL

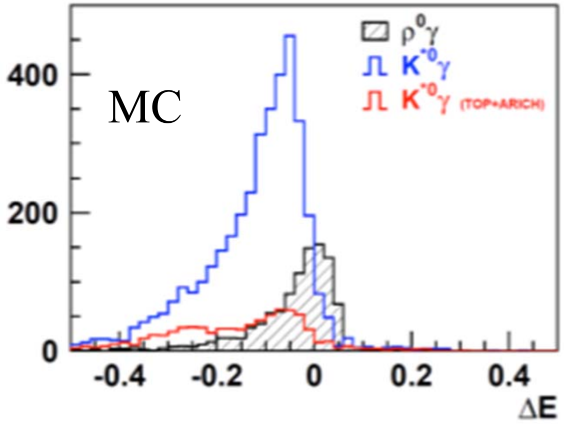
TOP optics are arriving

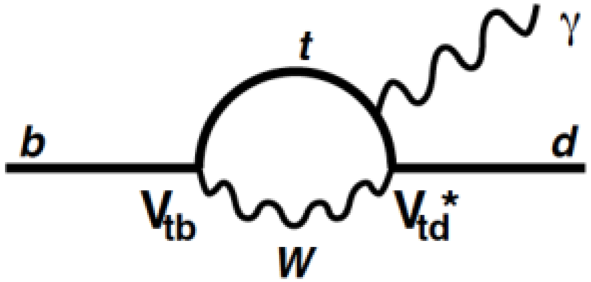
- Optics are coming in meeting specs and on or near vendor promised delivery dates (except for bars from Aperture/Okamoto)



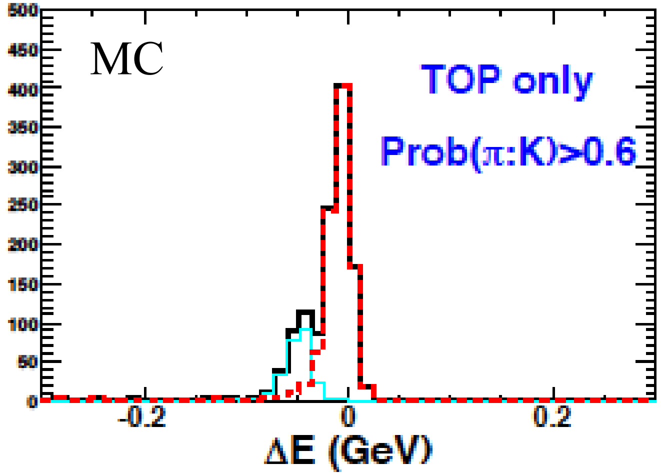
TOP impact on Rare b→d Penguins: B→ ργ, K^* γ

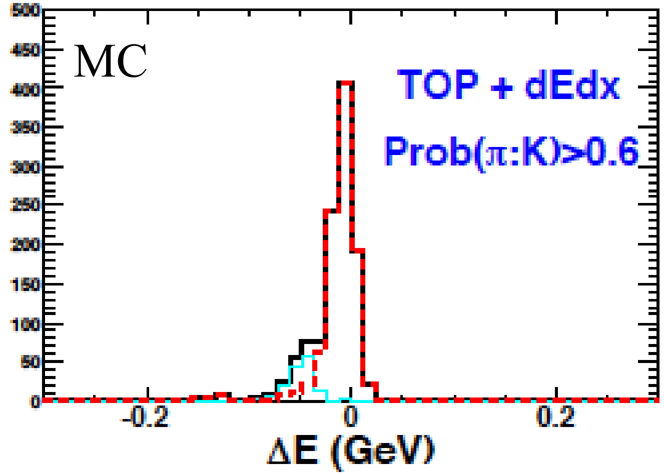
Rare white penguin, observed in a 2012 expedition



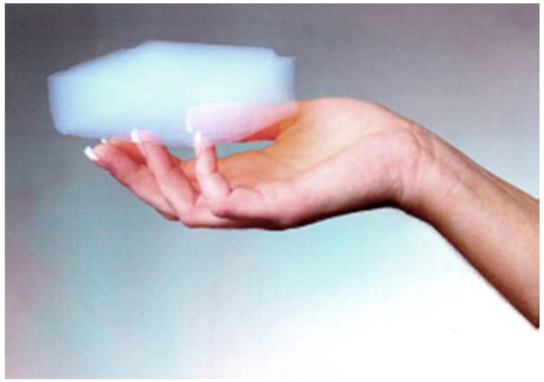


The B→K^* γ (b→s) penguin (turquoise) is ~30X more abundant than B→ργ (red).
Belle II's *improved* detector PID and statistics solve this problem (c.f. Nishida-san)

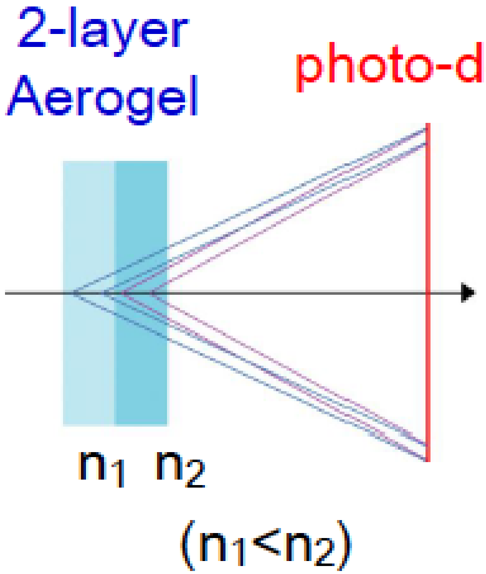




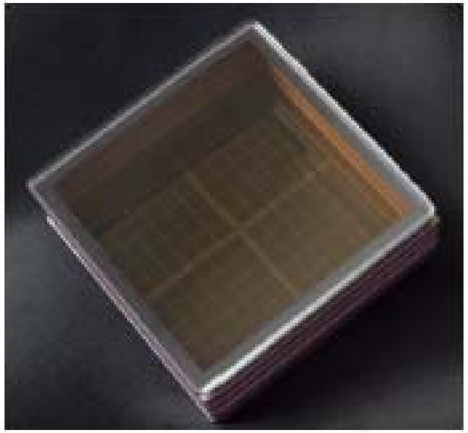
Cherenkov rings in the forward endcap



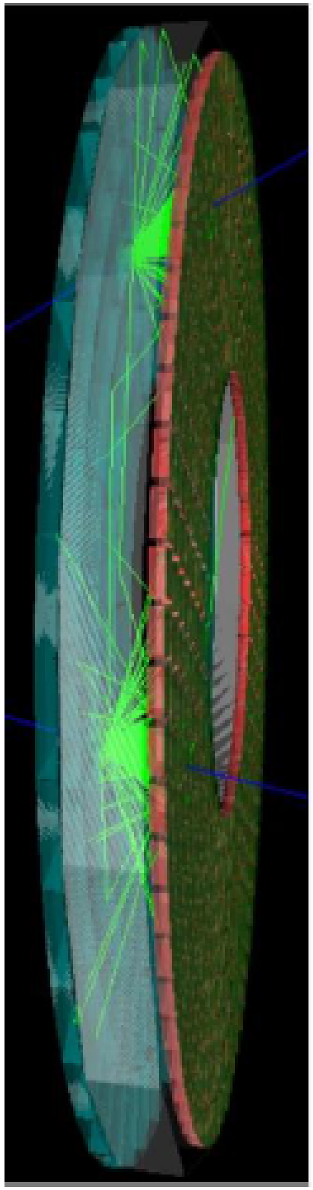
To distinguish kaons and pions in the forward endcap, use an aerogel RICH.



HAPD



- PID in forward endcap.
- Two-layer aerogel as radiator
- 420 of 144-channel Hybrid Avalanche Photo Detector (HAPD).

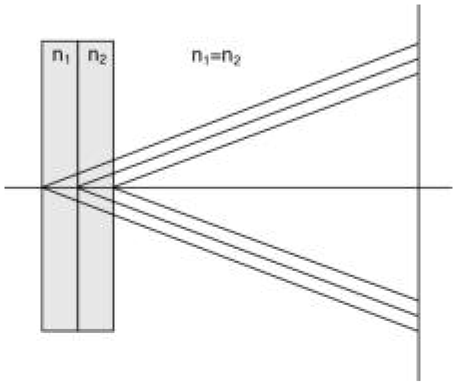


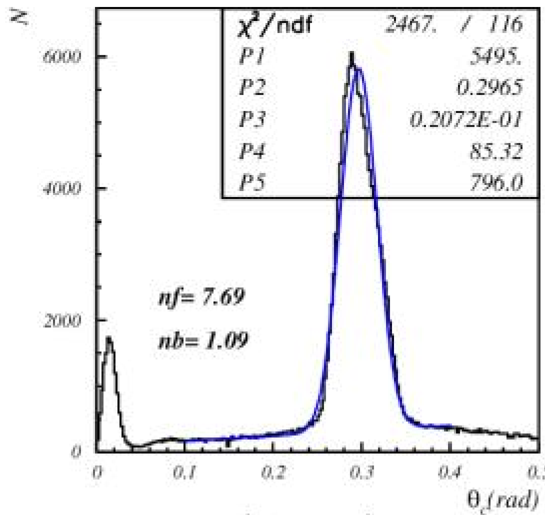
Verification of aerogel ring imaging Cerenkov counter performance in beam tests

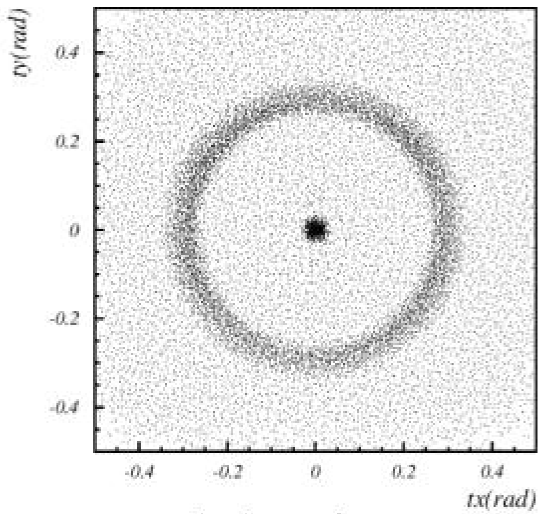
Increases the number of photons without degrading the resolution

Data

4cm aerogel single index



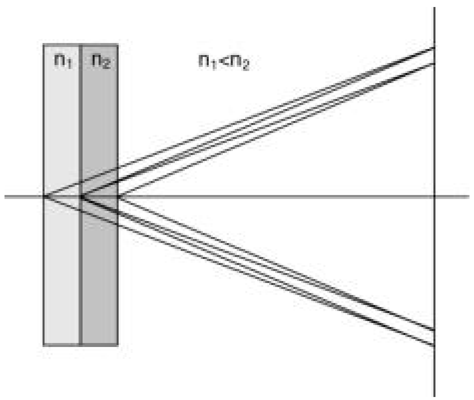


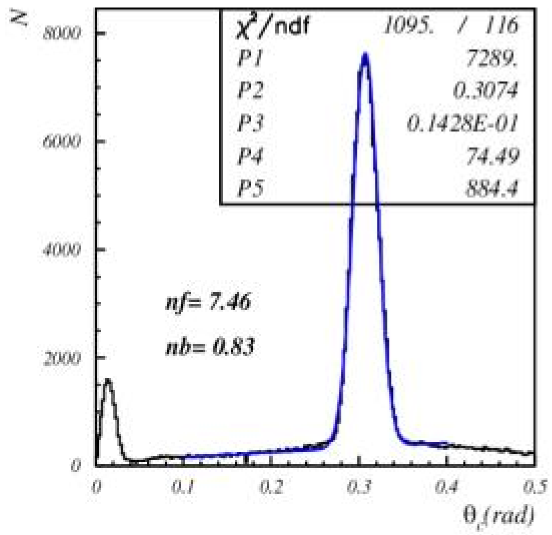


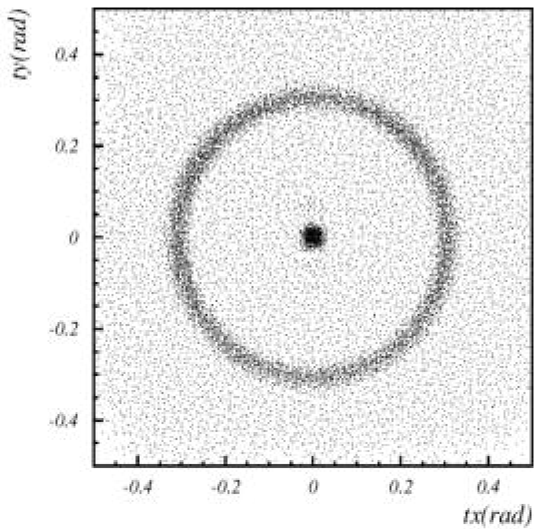
theta cerenkov

ring in cerenkov space

2+2cm aerogel



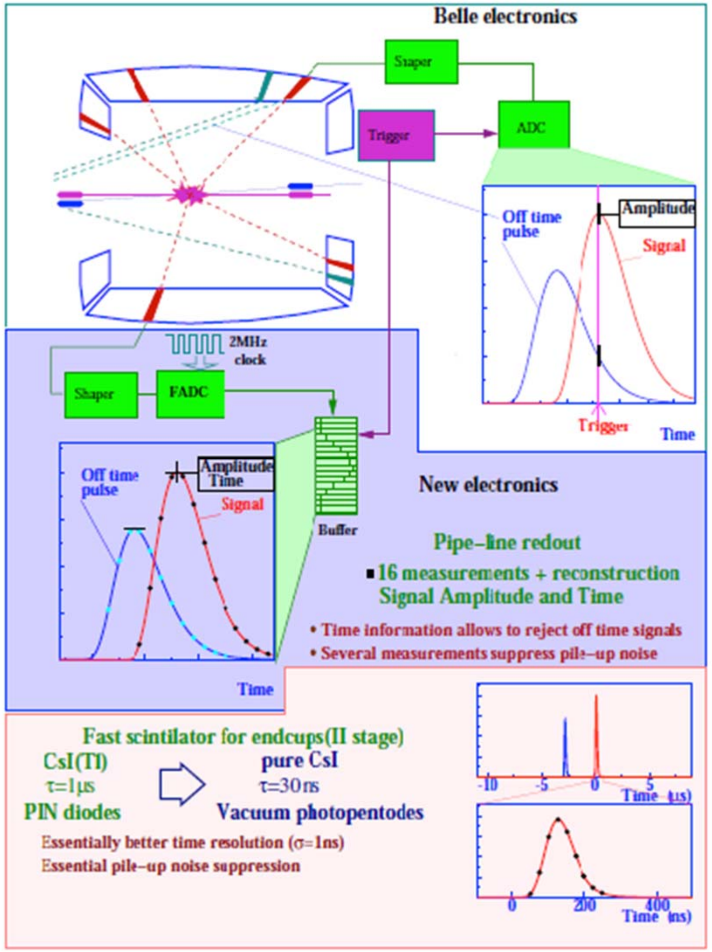




→NIM A548 (2005) 383

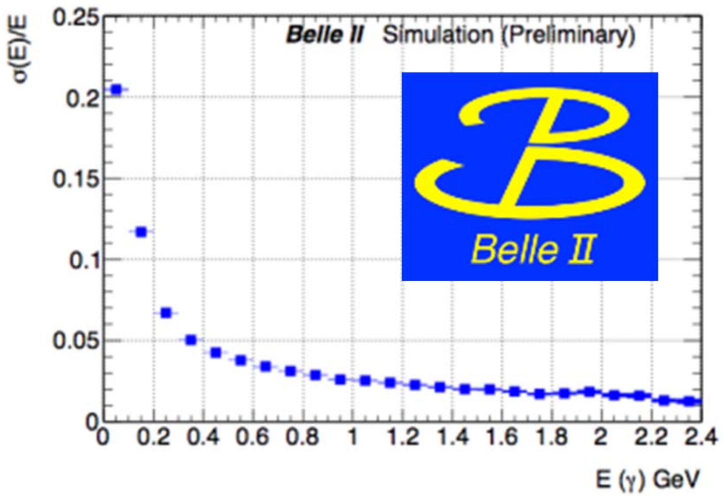
New ECL Readout Electronics Status

Waveform sampling to compensate for the larger beam-related backgrounds and the long decay time of CsI(Tl) signals.



ECL electronics upgrade and cabling to be installed in spring 2014

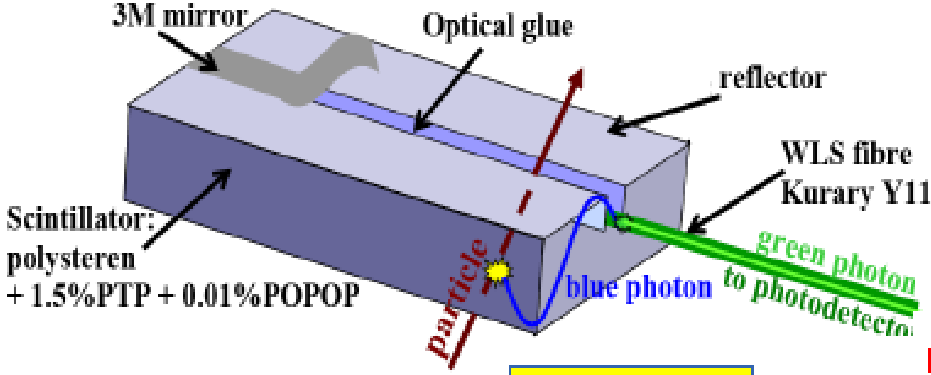
Expected performance iof CsI(Tl) system in GEANT4 simulation

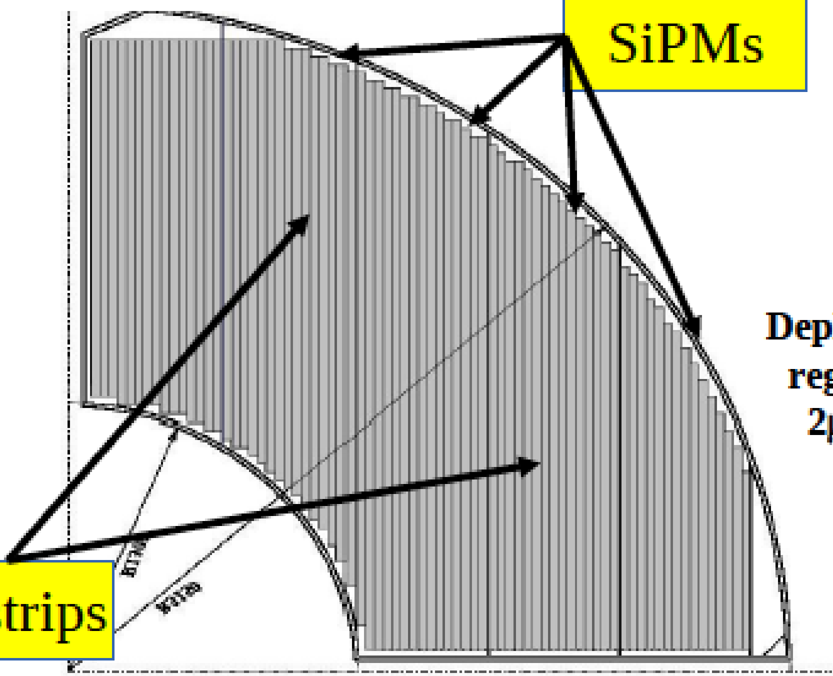


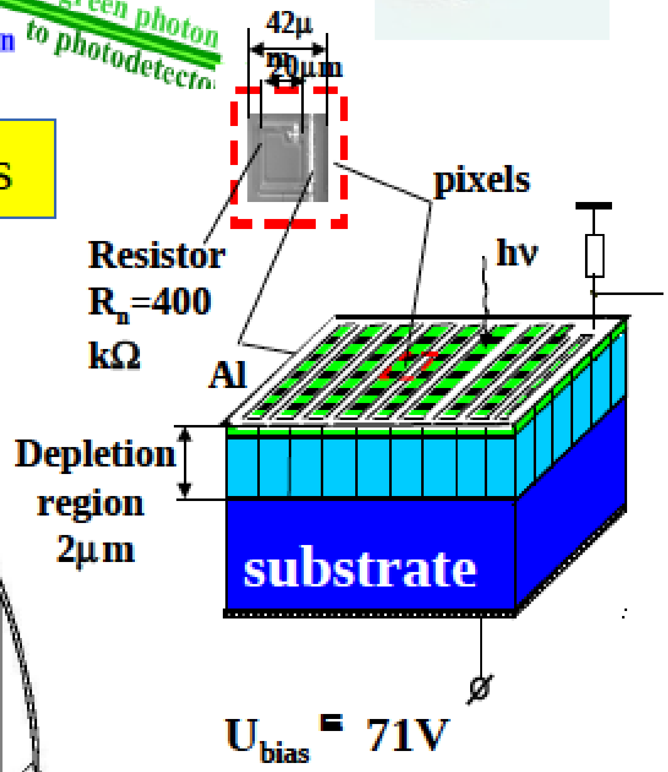
Detection of muons and KLs: Endcap RPCs and two layers of the barrel have to be replaced with scintillators to handle higher backgrounds (mainly from neutrons).

TDR efficiencies for RPC

Layer	Endcap forward KEKB	Endcap forward SuperKEKB
0	0.91	0.0
1	0.93	0.0
2	0.94	0.0
3	0.94	0.0
4	0.94	0.0
5	0.92	0.0
6	0.93	0.0
7	0.92	0.0
8	0.92	0.0
9	0.90	0.0
10	0.87	0.0
11	0.82	0.0
12	0.78	0.0
13	0.77	0.0
14	N/A	N/A

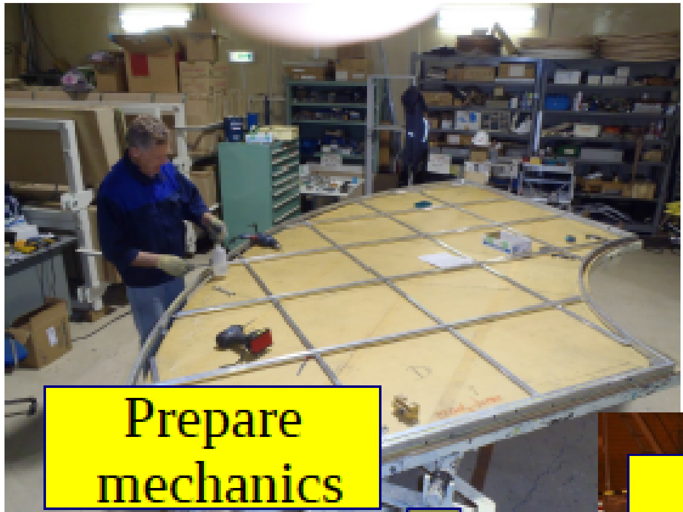




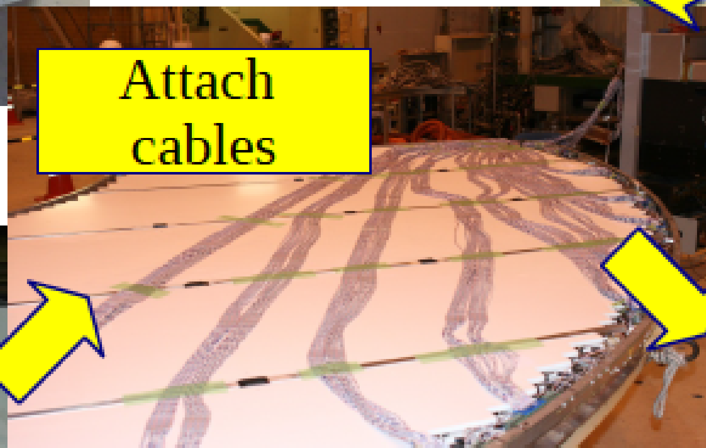


EKLM assembly by ITEP team at KEK

Expect completion by late spring 2014



Assembly speed:
<u>1 module per day</u>
(can be slightly increased with the second rotating table)



BKLM (barrel KLM - two inner layers) installation completed

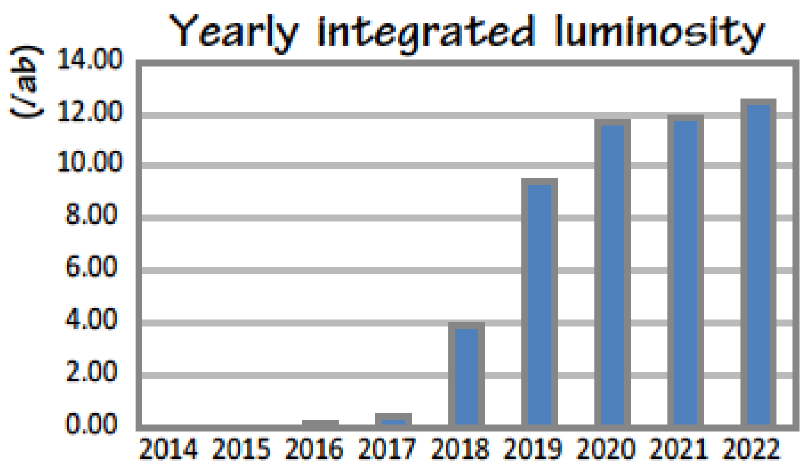
Virginia Tech crew

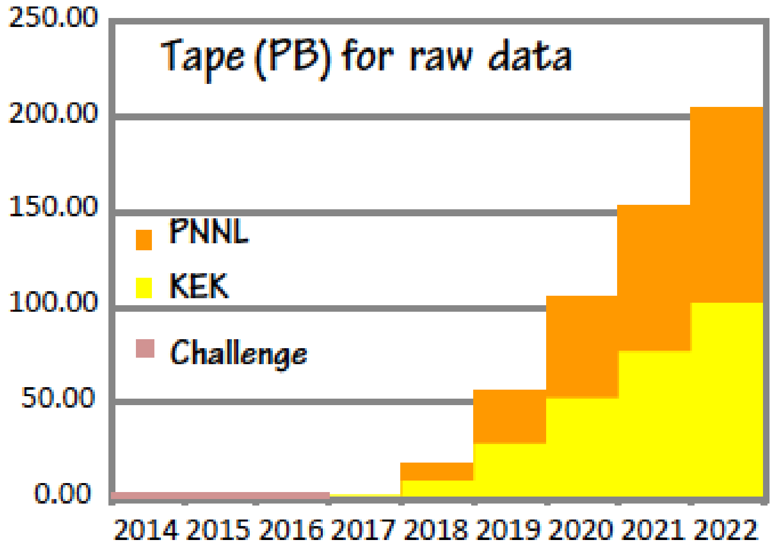
First new Belle II detector subsystem installed.

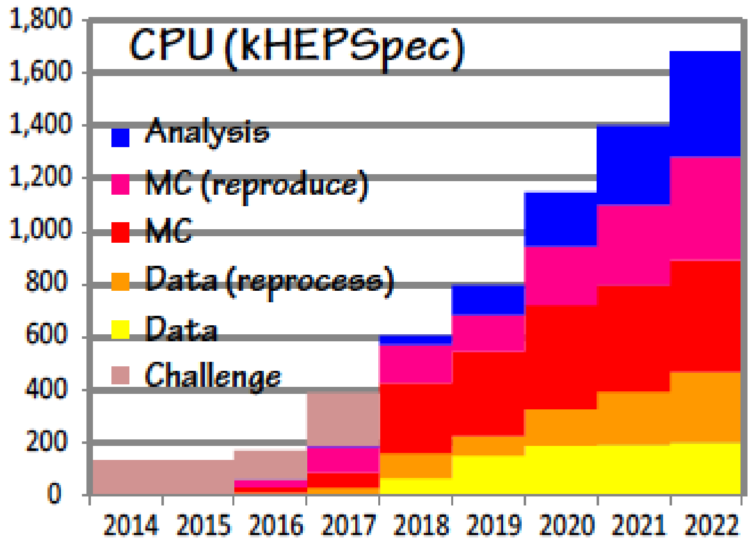
Looking forward to EKLM (endcap K_L-muon) installation in the next few months

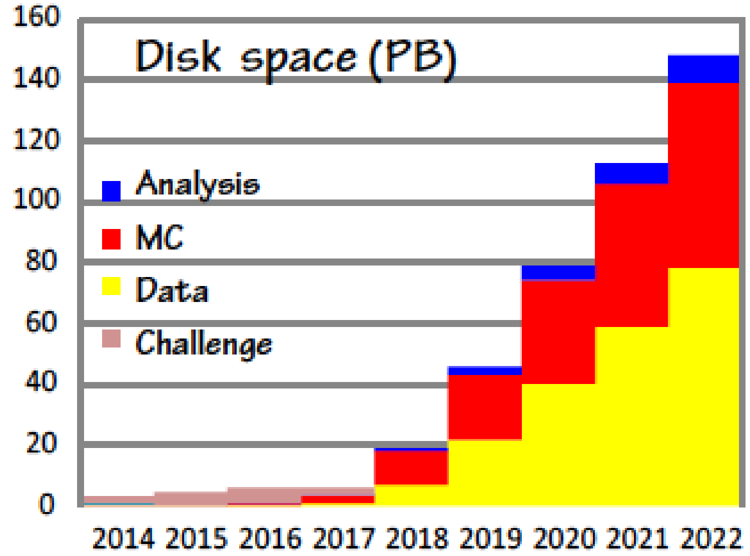
T. Hara et al. (Belle II Computing Steering Group)

Hardware Resources for Belle II

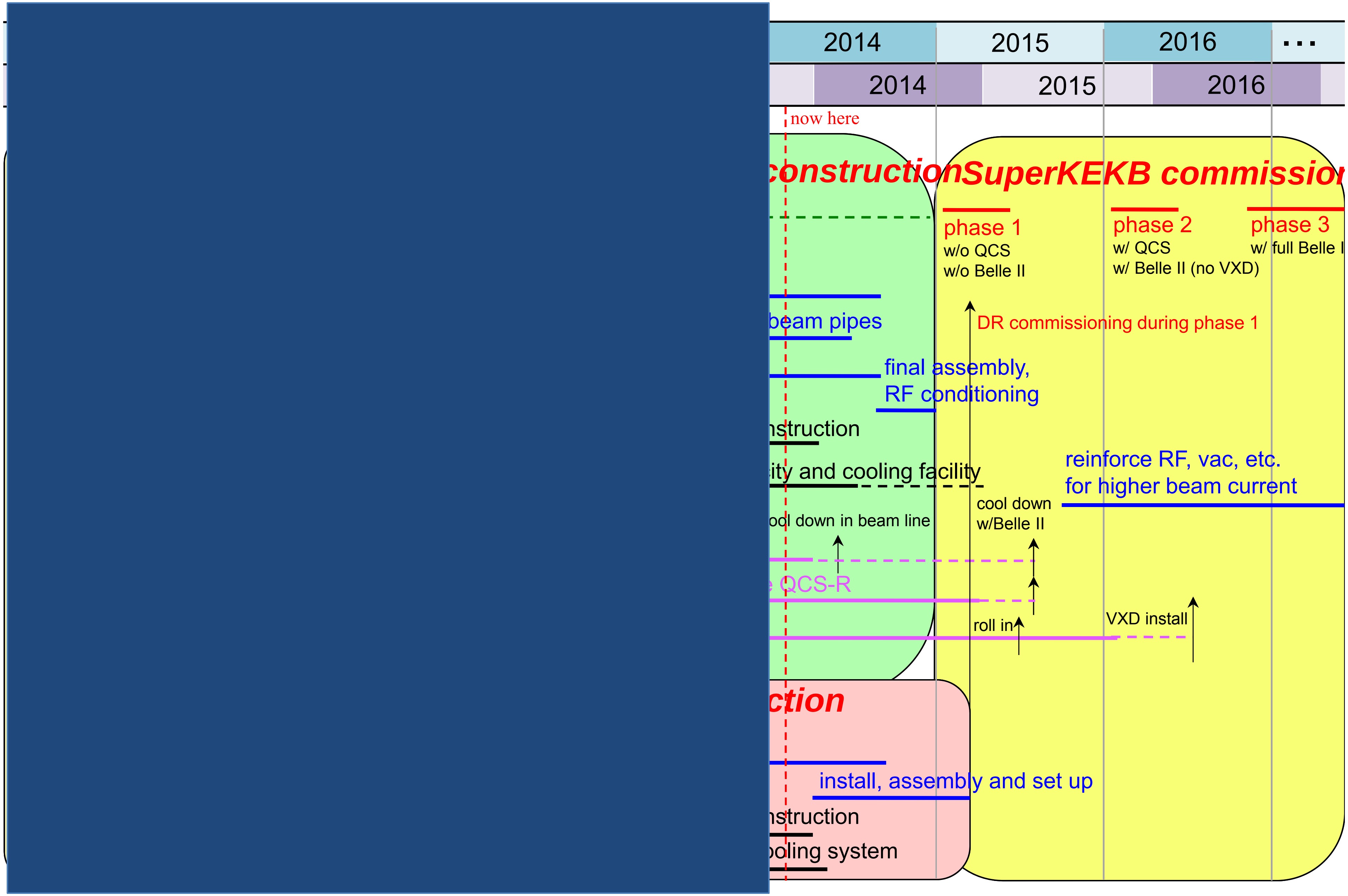








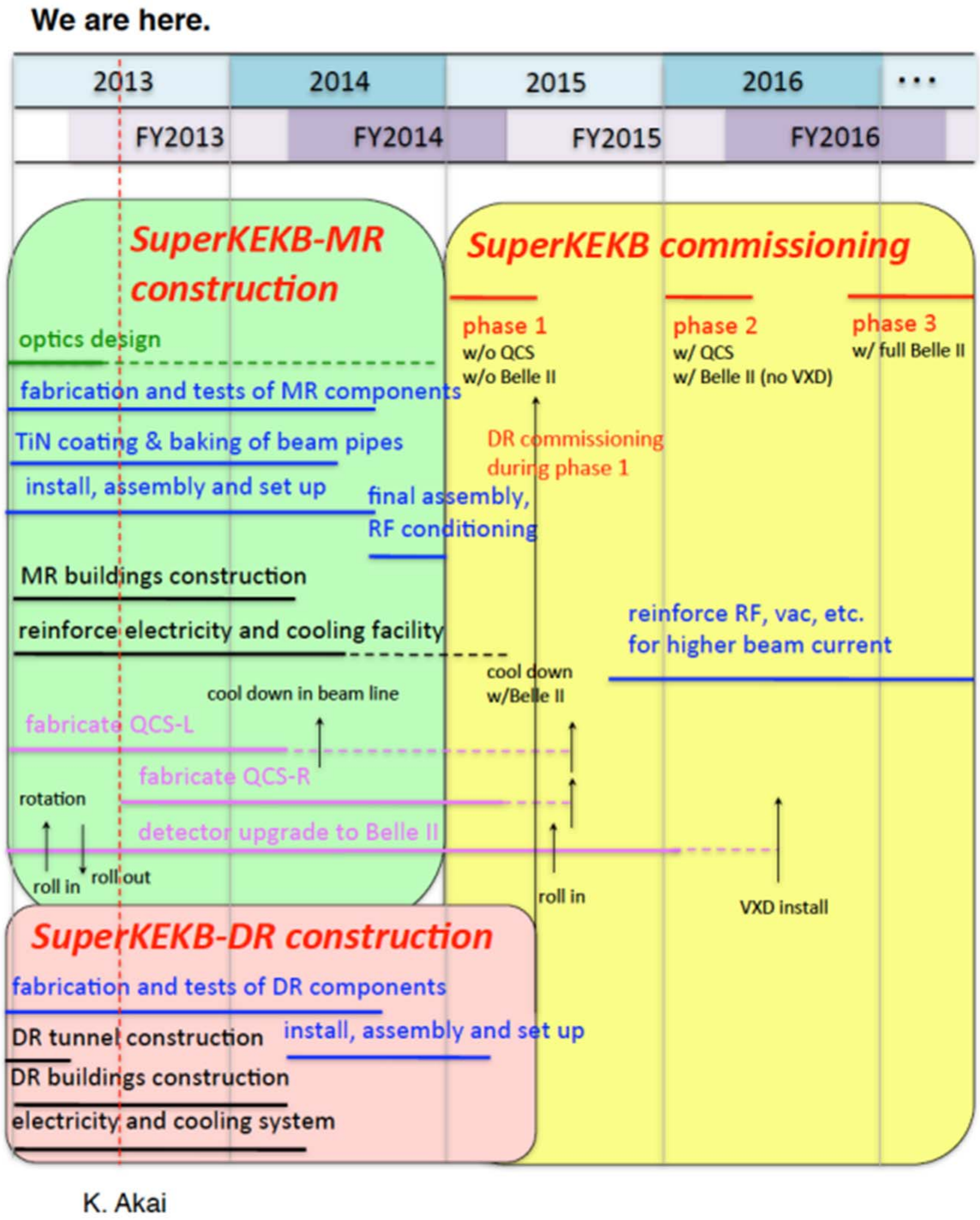
SuperKEKB schedule



Conclusion

- Belle II detector construction and integration is proceeding according to schedule.
- SuperKEKB commissioning starts in Jan 2015
- The second phase of background commissioning with the Belle II outer detector takes place starts ~Feb 2016
- *Belle II roll-ins in fall 2016 with first physics runs. This will inaugurate a new era of flavor physics.*

Backup Slides



<u>Phase I:</u>

w/o QCS and Belle II

Jan-May, 2015

<u>Phase II:</u>

with QCS and Belle II

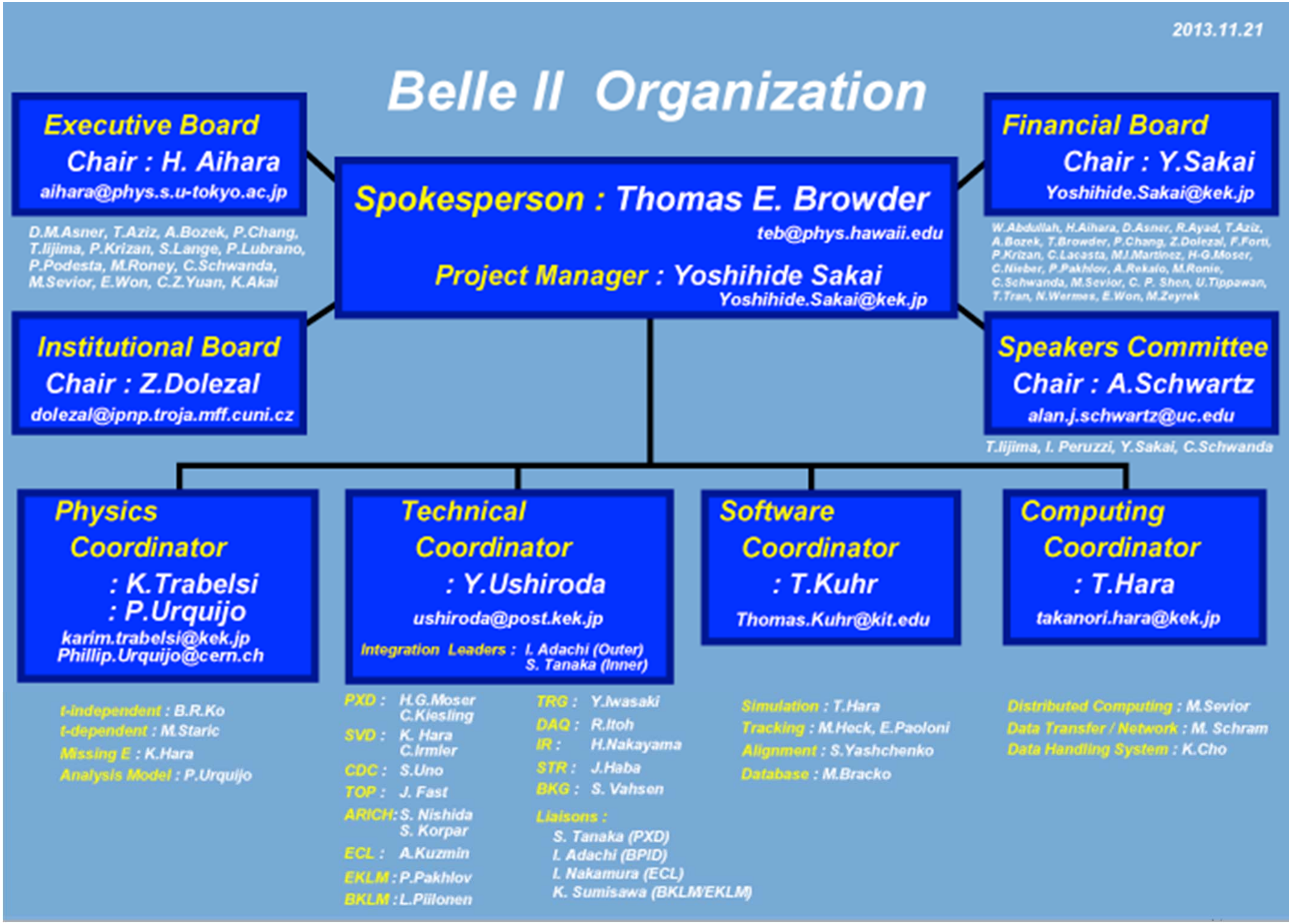
w/o inner detector

Feb-June, 2016

<u>Phase III:</u>

Physics Run with full Belle II

Starts Oct, 2016


2013.11.21
Belle II Organization
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aihara@phys.s.u-tokyo.ac.jp
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Analysis Model : P.Urquijo
PXD : H.G.Moser
C.Kiesling
SVD : K. Hara
C.Irmler
CDC : S.Uno
TOP : J. Fast
ARICH: S. Nishida
S. Korpar
ECL : A.Kuzmin
EKLM : P.Pakhlov
BKLM : L.Piilonen
TRG : Y.Iwasaki
DAQ : R.Itoh
IR : H.Nakayama
STR : J.Haba
BKG : S. Vahsen
Liaisons :
S. Tanaka (PXD)
I. Adachi (BPID)
I. Nakamura (ECL)
K. Sumisawa (BKLM/EKLM)
Simulation : T.Hara
Tracking : M.Heck, E.Paoloni
Alignment : S.Yashchenko
Database : M.Bracko
Distributed Computing : M.Sevior
Data Transfer / Network : M. Schram
Data Handling System : K.Cho

A polarized electron beam can produce polarized τ pairs. A proposal was worked out for INFN SuperB.

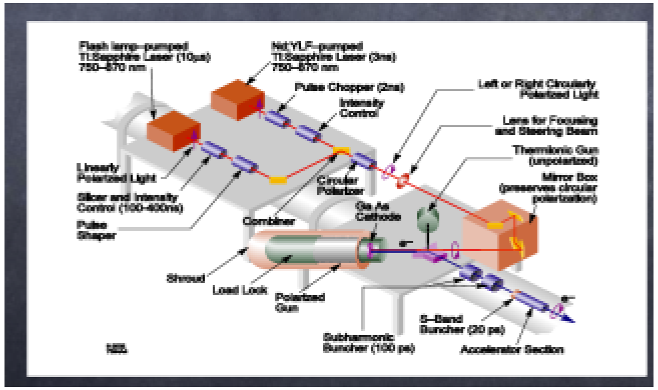
Some basic requirements:

(a)Polarized electron gun (like at SLC)

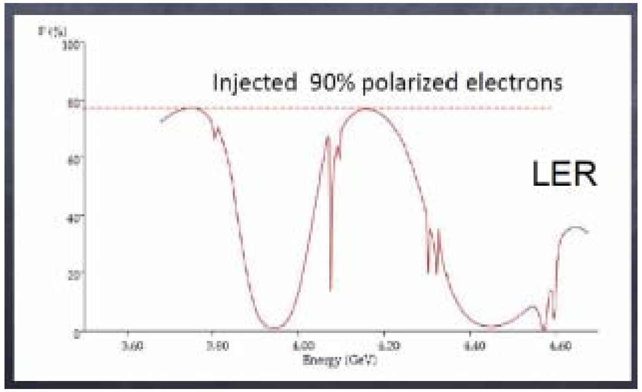
(b) Operation at beam energies away from depolarizing resonances

(c) Spin rotators to rotate the electron spin to the longitudinal direction at the IP. A machine lattice that avoids depolarizing effects from vertical bends and solenoids.

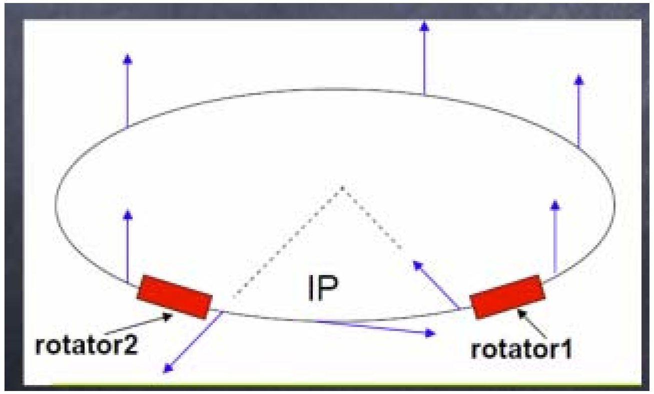
Not practical in initial operation of SuperKEKB (no space in straight sections). Upgrade may be possible (U. Wienands)



a)

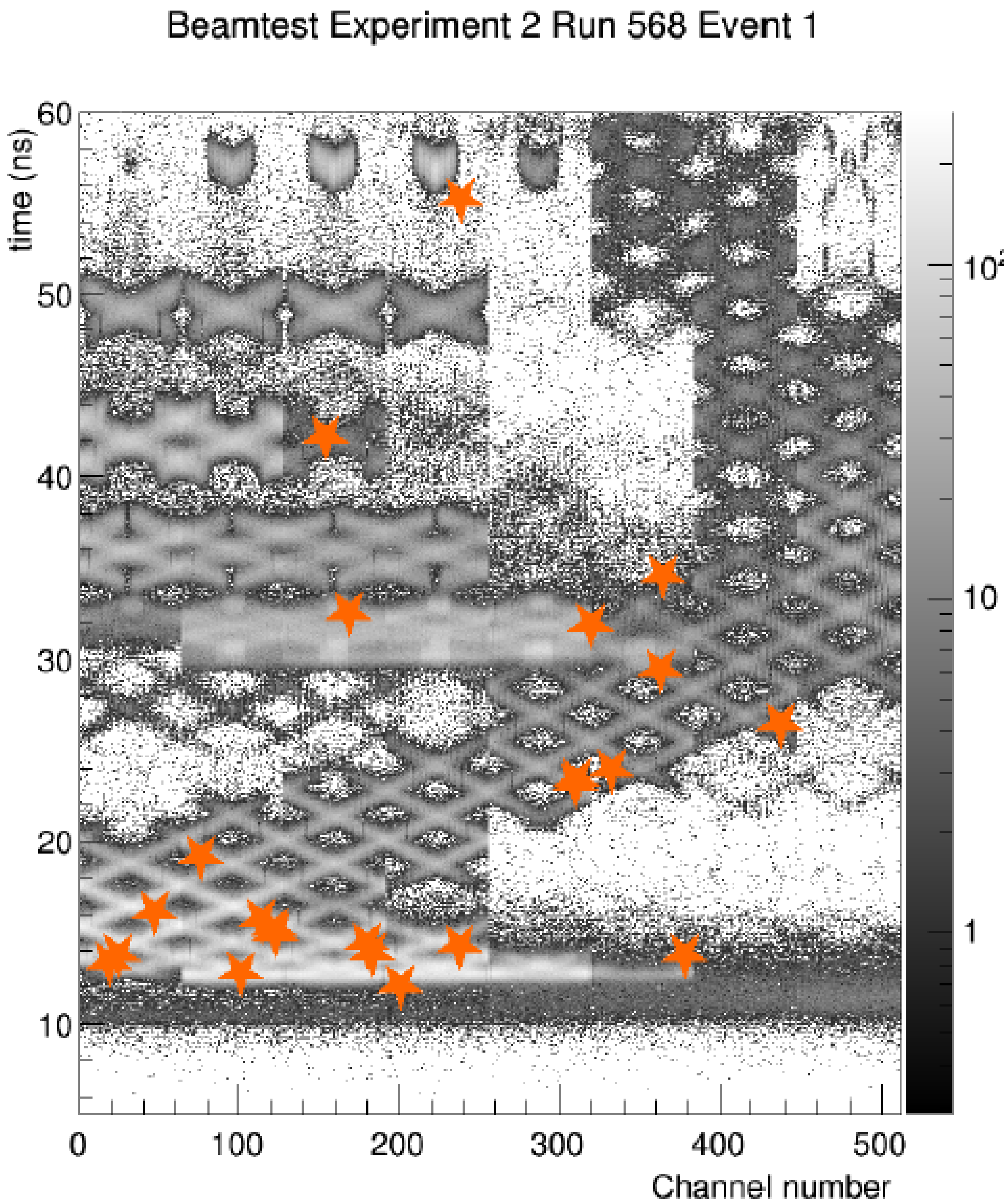


b)



c)

Slide adapated from D. Hitlin



Beamtest Experiment 2 Run 568 Event 1
time (ns)
60
50
40
30
20
10
0
100
200
300
400
500
Channel number
10²
10
1

Parameter Condition	$B^0 \to \pi^+\pi^-$ Efficiency (%)	$B^0 \to K^+\pi^-$ Fake rate (%)	$B^0 \to \rho^0\gamma$ Efficiency (%)	$B^0 \to K^{*0}\gamma$ Fake rate (%)
Baseline Performance	90.4 ± 0.3	7.1 ± 0.3	96.7 ± 0.2	4.7 ± 0.3
t resolution (50ps)				
t_0 jitter (25ps)				
t resolution (100ps)	89.2 ± 0.3	9.1 ± 0.4	96.5 ± 0.2	5.3 ± 0.2
t resolution (150ps)	86.7 ± 0.3	11.9 ± 0.4	96.1 ± 0.2	5.8 ± 0.2
t_0 jitter (50ps)	88.8 ± 0.3	8.0 ± 0.4	96.3 ± 0.2	4.9 ± 0.2
t_0 jitter (100ps)	83.8 ± 0.3	14.4 ± 0.5	95.5 ± 0.2	7.4 ± 0.2
(t resolution=50ps)				
1a. Photon yield $\times$ 0.60	86.5 ± 0.3	9.3 ± 0.4	93.7 ± 0.2	6.57 ± 0.3
2a. 10 $\times$ background	90.4 ± 0.4	6.8 ± 0.3	97.4 ± 0.2	3.78 ± 0.3
3a. $\sigma_\theta = 6.0$ mrad	82.9 ± 0.3	12.4 ± 0.4	95.9 ± 0.2	5.43 ± 0.3
4a. t_0 jitter = 50 ps	88.8 ± 0.3	8.0 ± 0.4	97.3 ± 0.2	3.89 ± 0.3
1a. + 2a.	86.2 ± 0.4	9.4 ± 0.4	93.7 ± 0.2	7.50 ± 0.3
3a. + 4a.	81.6 ± 0.3	14.3 ± 0.4	95.2 ± 0.2	6.41 ± 0.3

Luminosity Master Equation

Beam-beam parameter

Lorentz factor

Beam current

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

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

Brute force: Increase beam currents by a factor of 5-10 ! Increase the beam-beam parameter by a factor of a few (crab cavities).

Too hard, too expensive (power, melt beam pipes)

SuperKEKB TDR parameters

		LER (e+)	HER (e-)	units
Beam Energy	E	4	7	GeV
Half Crossing Angle	ϕ	41.5		mrad
Horizontal Emittance	ε_x	3.2(2.7)	2.4(2.3)	nm
Emittance ratio	$\varepsilon_y/\varepsilon_x$	0.40	0.35	%
Beta Function at the IP	β_x^*/β_y^*	32 / 0.27	25 / 0.41	mm
Horizontal Beam Size	σ_x^*	10.2(10.1)	7.75(7.58)	μm
Vertical Beam Size	σ_y^*	59	59	nm
Betatron tune	ν_x/ν_y	45.530/45.570	58.529/52.570	
Momentum Compaction	α_c	2.74×10^{-4}	1.88×10^{-4}	
Energy Spread	σ_ε	$8.14(7.96) \times 10^{-4}$	$6.49(6.34) \times 10^{-4}$	
Beam Current	I	3.60	2.62	A
Number of Bunches/ring	n_b	2503		
Energy Loss/turn	U_0	2.15	2.50	MeV
Total Cavity Voltage	V_c	8.4	6.7	MV
Synchrotron Tune	ν_s	-0.0213	-0.0117	
Bunch Length	σ_z	6.0(4.9)	5.0(4.9)	mm
Beam-Beam Parameter	ξ_y	0.0900	0.0875	
Luminosity	L	8×10^{35}		$\text{cm}^{-2}\text{s}^{-1}$

Table 2.2: Machine Parameters of SuperKEKB. Values in parentheses denote parameters at zero beam currents.

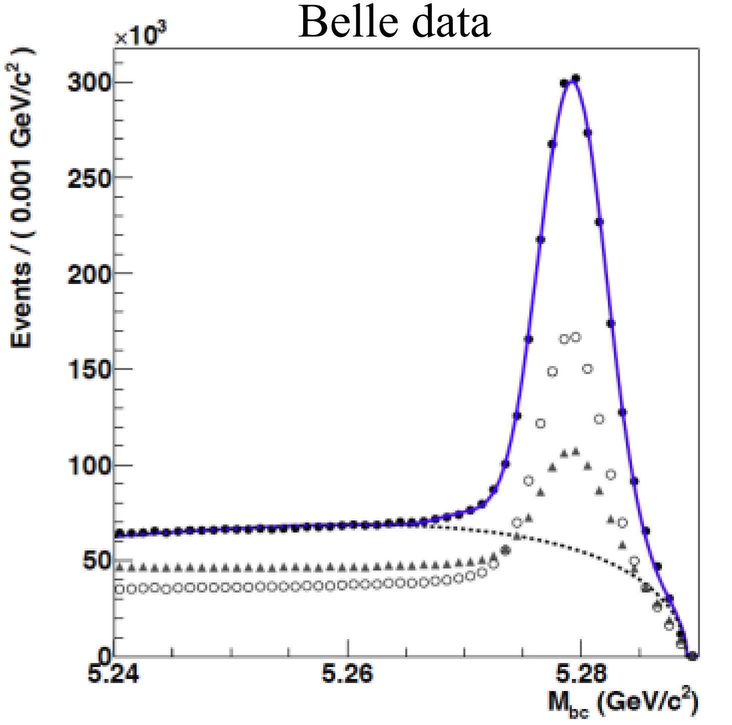
Table of Belle II detector performance parameters

Component	Type	Configuration	Readout	Performance
Beam pipe	Beryllium double-wall	Cylindrical, inner radius 10 mm, 10 μm Au, 0.6 mm Be, 1 mm coolant (paraffin), 0.4 mm Be		
PXD	Silicon pixel (DEPFET)	Sensor size: 15×100 (120) mm^2 pixel size: 50×50 (75) μm^2 2 layers: 8 (12) sensors	10 M	impact parameter resolution $\sigma_{z_0} \sim 20\ \mu$m (PXD and SVD)
SVD	Double sided Silicon strip	Sensors: rectangular and trapezoidal Strip pitch: 50(p)/160(n) - 75(p)/240(n) μm 4 layers: 16/30/56/85 sensors	245 k	
CDC	Small cell drift chamber	56 layers, 32 axial, 24 stereo r = 16 - 112 cm $-83 \leq z \leq 159$ cm	14 k	$\sigma_{r\phi} = 100\ \mu$m, $\sigma_z = 2$ mm $\sigma_{p_t}/p_t = \sqrt{(0.2\% p_t)^2 + (0.3\%/\beta)^2}$ $\sigma_{p_t}/p_t = \sqrt{(0.1\% p_t)^2 + (0.3\%/\beta)^2}$ (with SVD) $\sigma_{dE/dx} = 5\%$
TOP	RICH with quartz radiator	16 segments in ϕ at $r \sim 120$ cm 275 cm long, 2 cm thick quartz bars with 4x4 channel MCP PMTs	8 k	$N_{p.e.} \sim 20$, $\sigma_t = 40$ ps K/π separation : efficiency $> 99\%$ at $< 0.5\%$ pion fake prob. for $B \to \rho\gamma$ decays
ARICH	RICH with aerogel radiator	4 cm thick focusing radiator and HAPD photodetectors for the forward end-cap	78 k	$N_{p.e.} \sim 13$ K/π separation at 4 GeV/c: efficiency 96% at 1% pion fake prob.
ECL	CsI(Tl) (Towered structure)	Barrel: $r = 125$ - 162 cm End-cap: $z =$ -102 cm and +196 cm	6624 1152 (F) 960 (B)	$\frac{\sigma E}{E} = \frac{0.2\%}{E} \oplus \frac{1.6\%}{\sqrt{E}} \oplus 1.2\%$ $\sigma_{pos} = 0.5$ cm$/\sqrt{E}$ (E in GeV)
KLM	barrel: RPCs	14 layers (5 cm Fe + 4 cm gap) 2 RPCs in each gap	θ: 16 k, ϕ: 16 k	$\Delta\phi = \Delta\theta = 20$ mradian for K_L ~ 1 % hadron fake for muons
	end-caps: scintillator strips	14 layers of $(7-10) \times 40$ mm^2 strips read out with WLS and G-APDs	17 k	$\Delta\phi = \Delta\theta = 10$ mradian for K_L $\sigma_p/p = 18\%$ for 1 GeV/c K_L

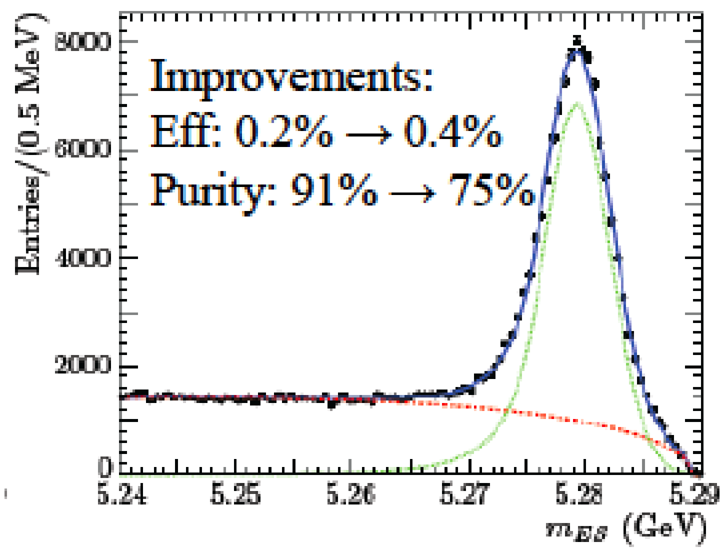
(Skip this slide) For reference only.

Unique capability

Belle data

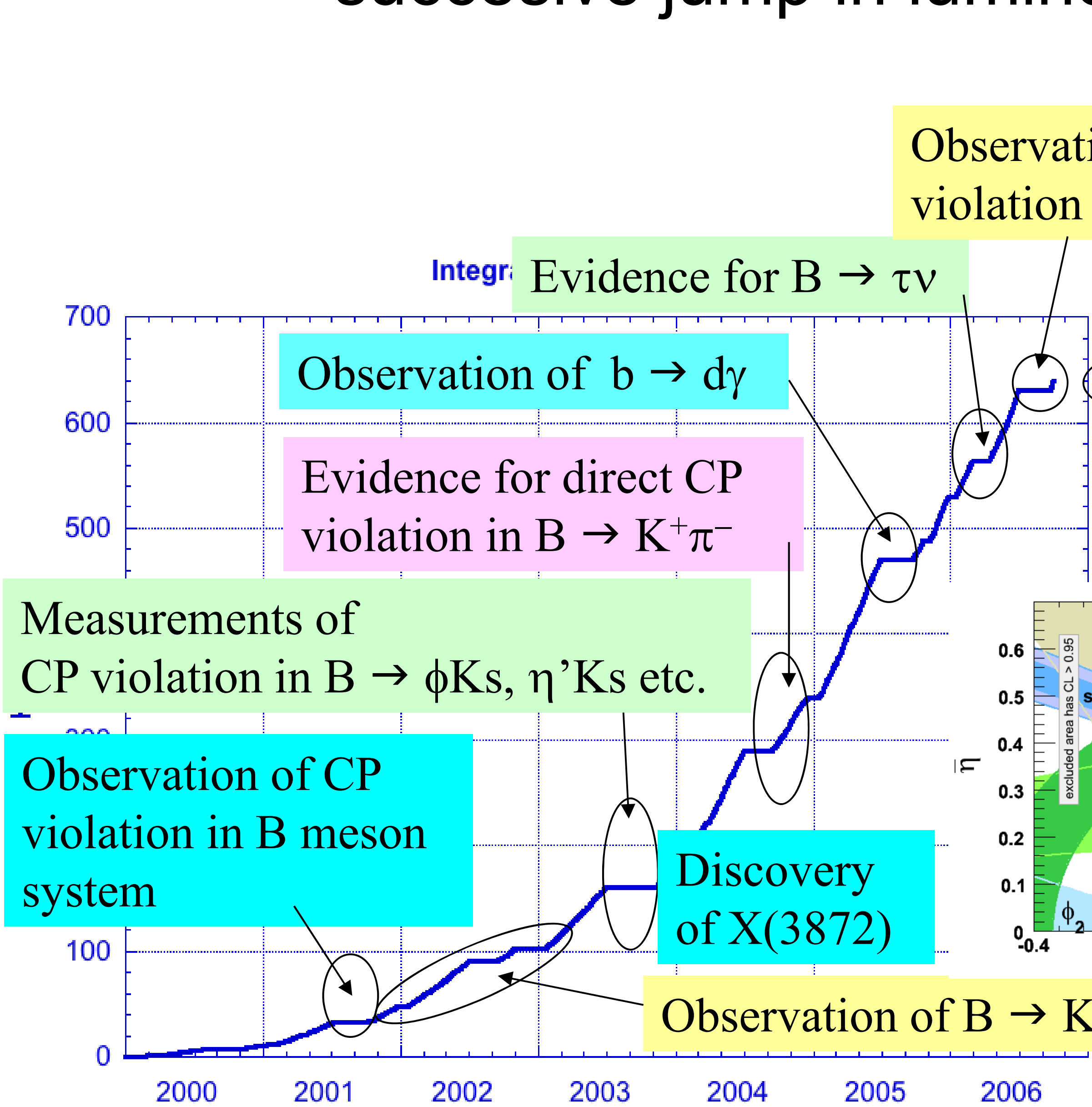


BaBar data

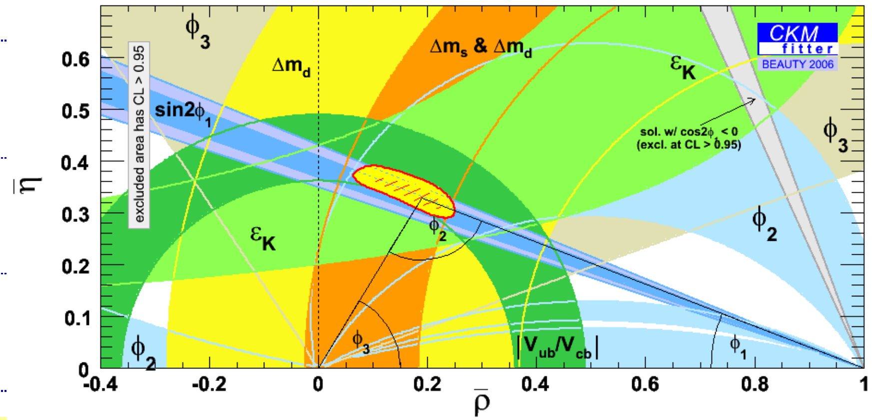


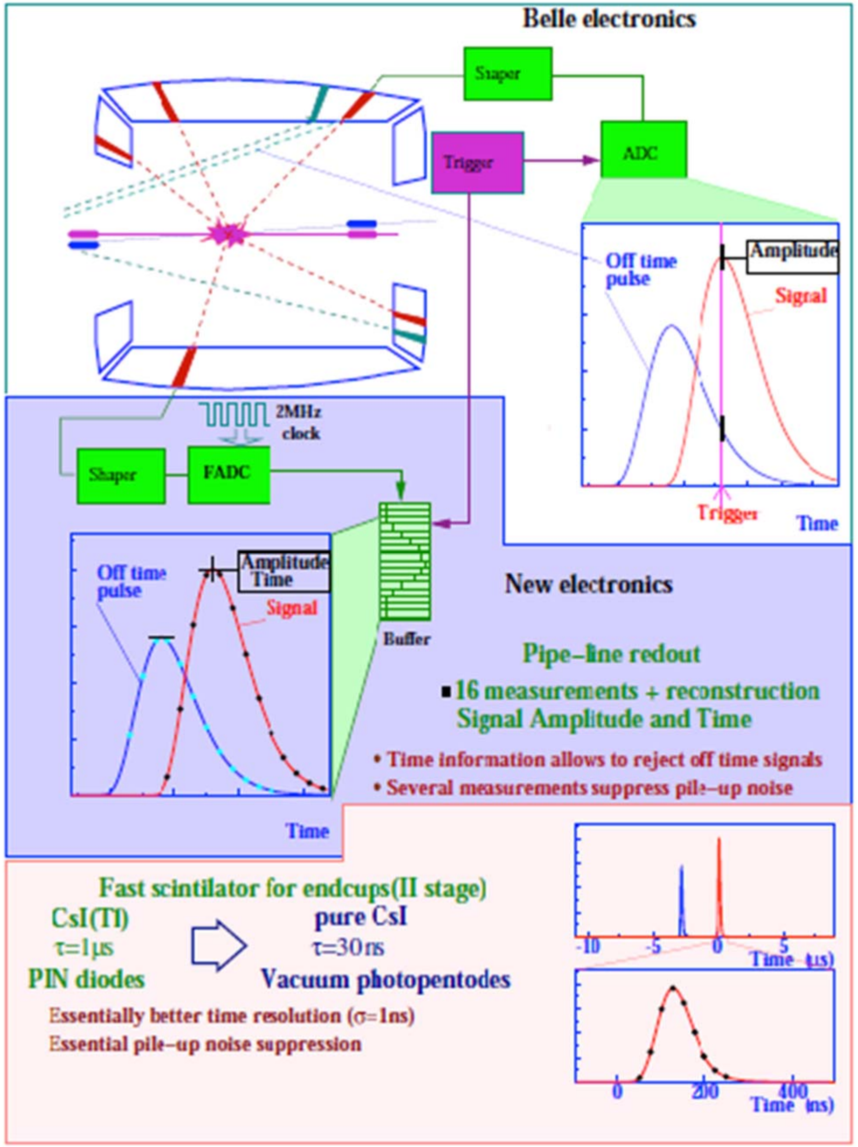
In addition to excellent neutral detection from a crystal calorimeter, and good Cerenkov particle id, (Super) B-factories can fully reconstruct one B meson. This gives the equivalent of a <u>"single B meson beam "</u>

Major achievements at Belle (enabled by each succesive jump in luminosity)



Decisive confirmation of Kobayashi-Maskawa model





Belle electronics
Shaper
Trigger
ADC
Off time
pulse
Amplitude
Signal
Trigger
Time
2MHz
clock
Shaper
FADC
Buffer
Off time
pulse
Amplitude
Time
Signal
Time
New electronics
Pipe–line redout
16 measurements + reconstruction
Signal Amplitude and Time
• Time information allows to reject off time signals
• Several measurements suppress pile–up noise
Fast scintilator for endcups(II stage)
CsI(Tl)
τ=1μs
PIN diodes
pure CsI
τ=30ns
Vacuum photopentodes
Essentially better time resolution (σ=1ns)
Essential pile–up noise suppression
-10
-5
0
5
Time (μs)
0
200
400
Time (ns)

How to make a Super Flavor Factory

Lorentz factor

Beam current

Beam-beam parameter

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

Classical electron radius

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

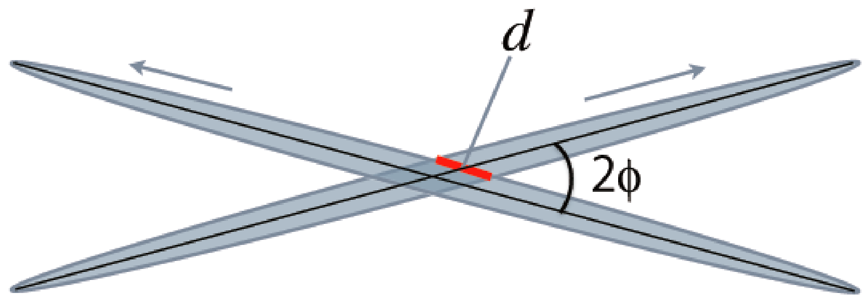
Vertical beta function@IP

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

(1) Smaller β_y^*

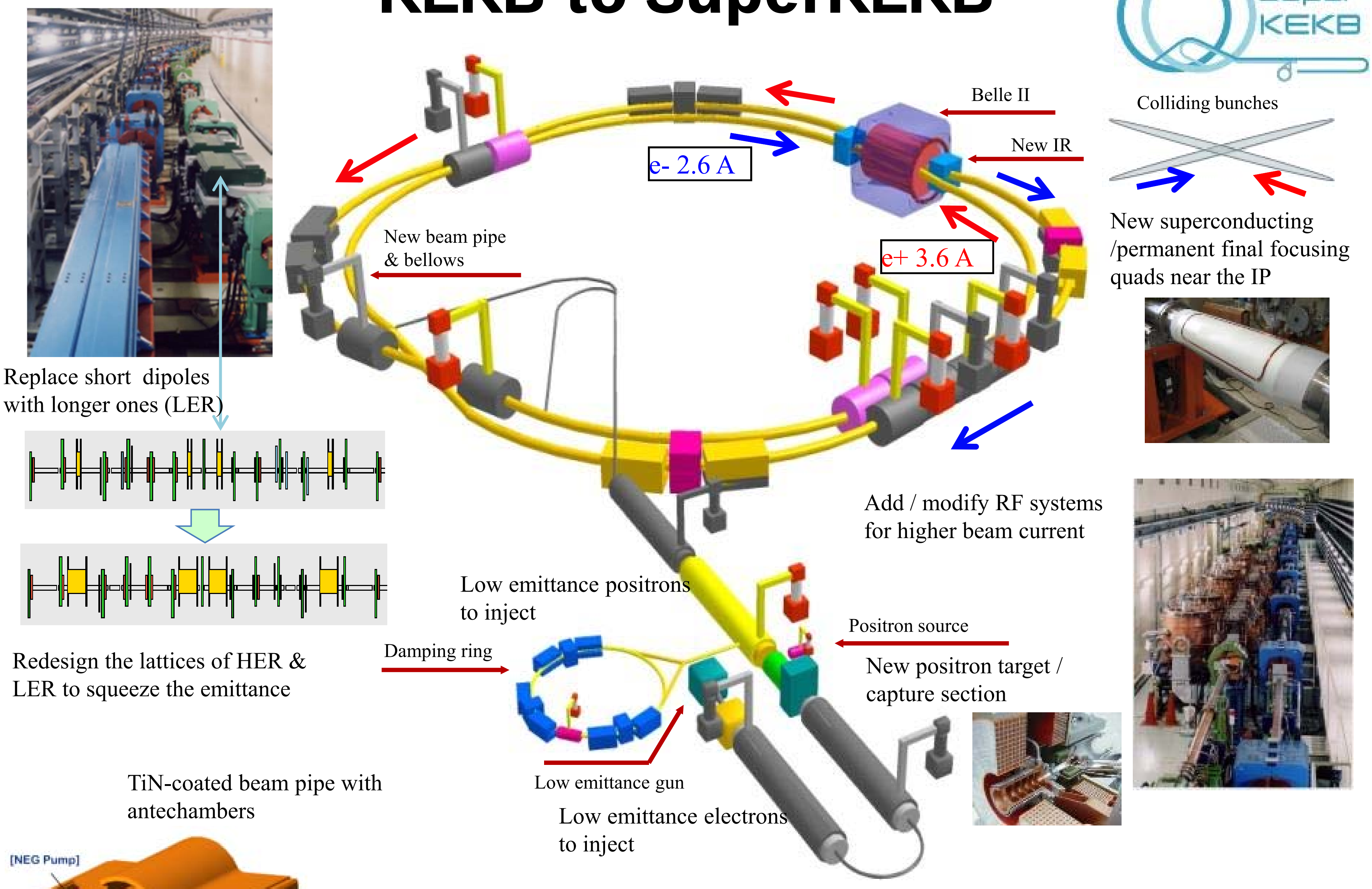
(2) Increase beam currents

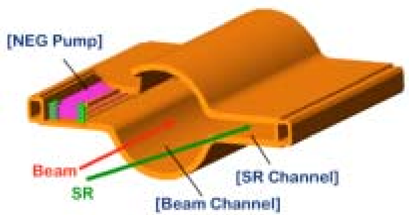
(3) Increase ξ_y



Schematic view of beam collisions with a large, 83 mrad, crossing angle.

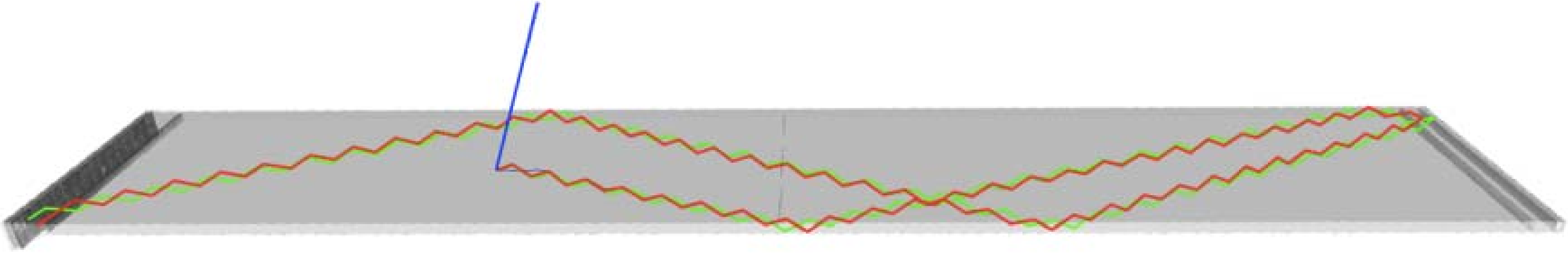
KEKB to SuperKEKB

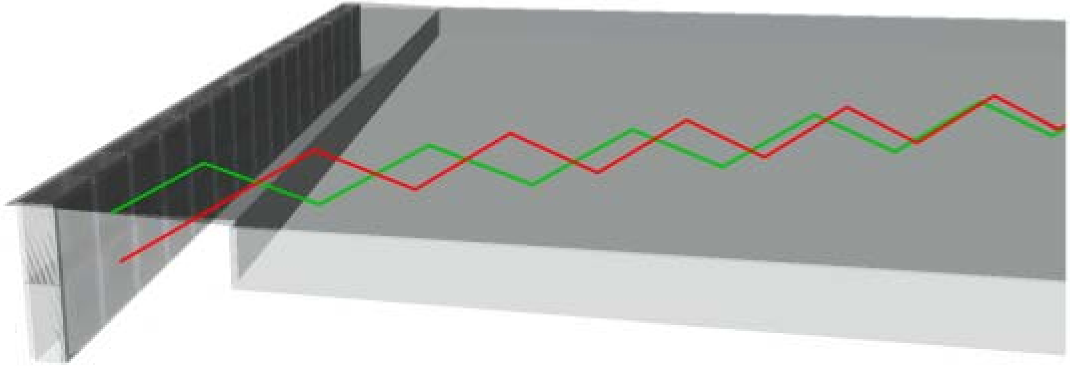




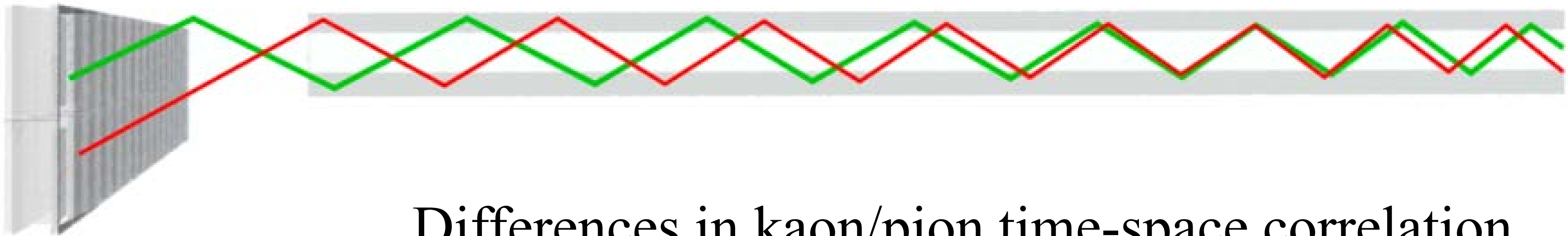
To obtain x40 higher luminosity

Kaon/Pion(s) in an iTOP GEANT4 simulation





Based on total internal reflection of Cherenkov light.



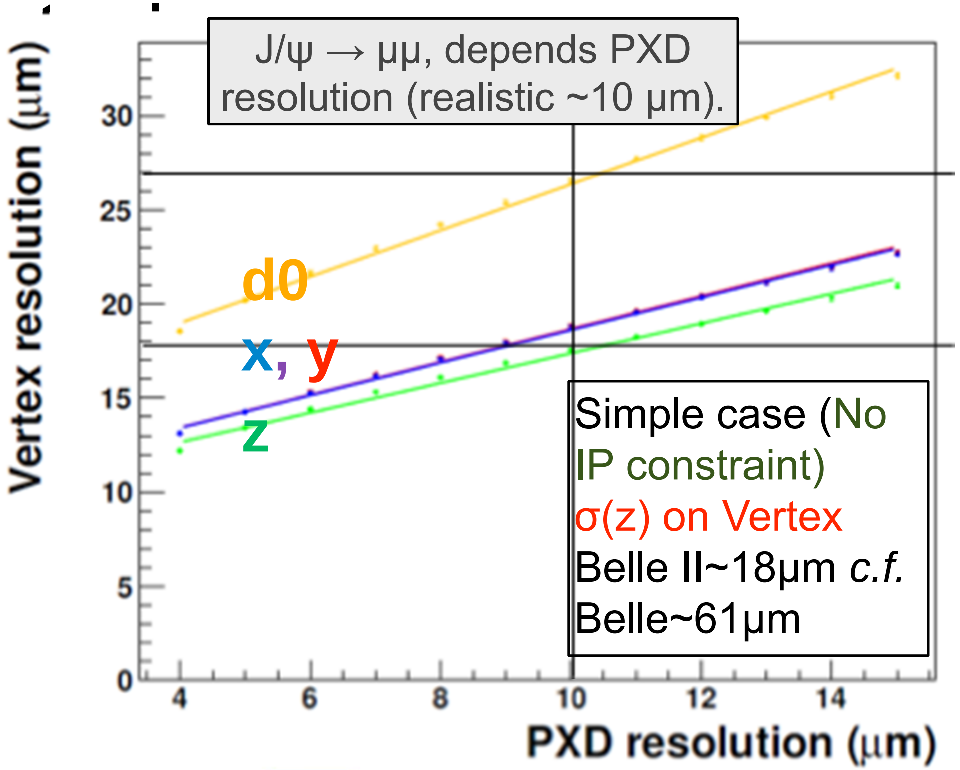
Differences in kaon/pion time-space correlation are used. (100 ps time resolution is needed for two-body modes)

Marko Petric

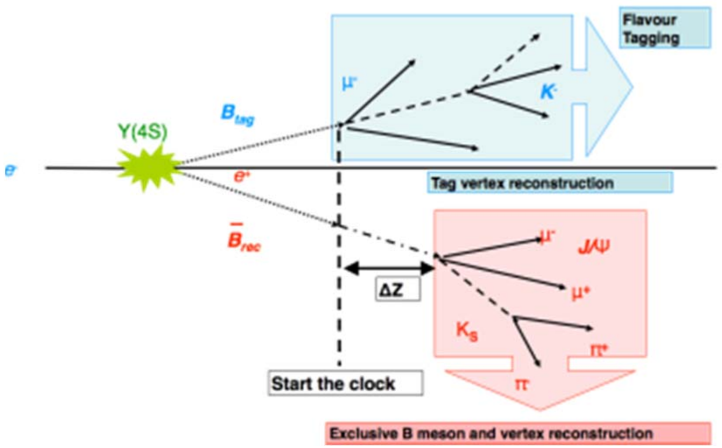
Vertex fitting & Tag ve

New Interface for various fitting techniques (e.g.):

- GF**RAVE vertexing**: active vertex refitter (based on annealing).
- Full decay chain refitting & constraints for neutrals.

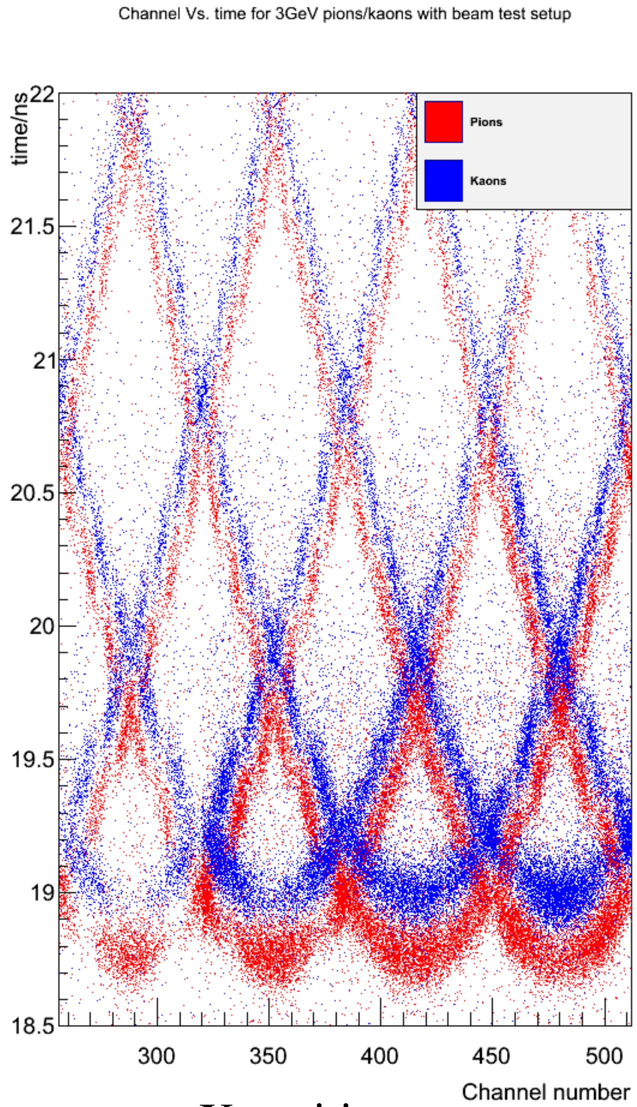


Vertex tagging prototype developed

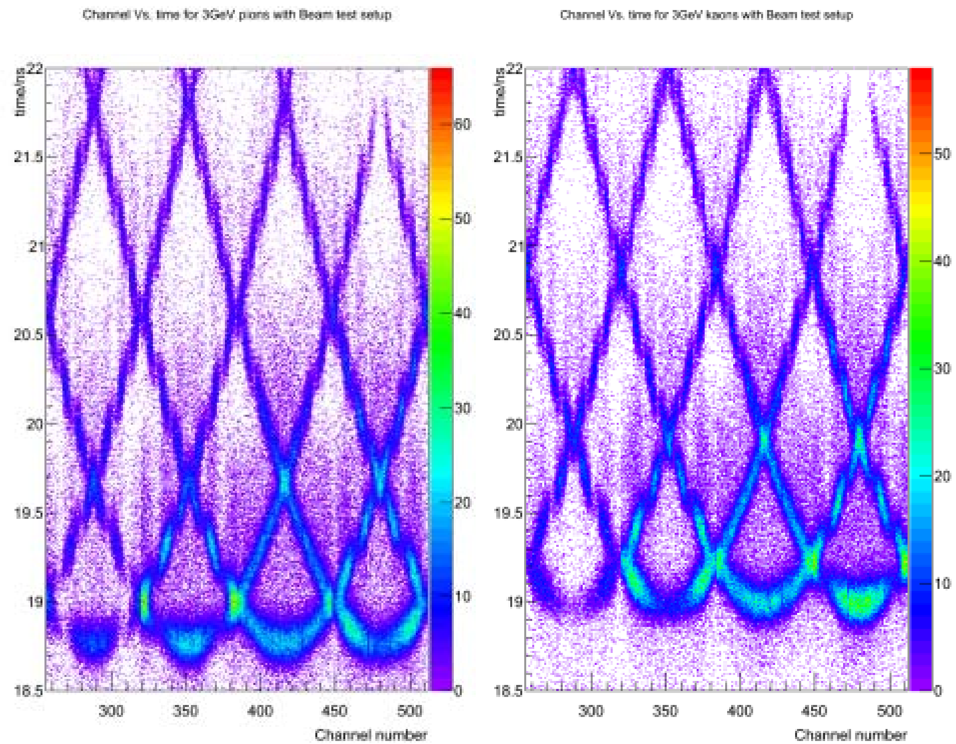


Kaons vs pions: distributions in the iTOP

Time in ns



X position



Matt Barrett


North tunnel

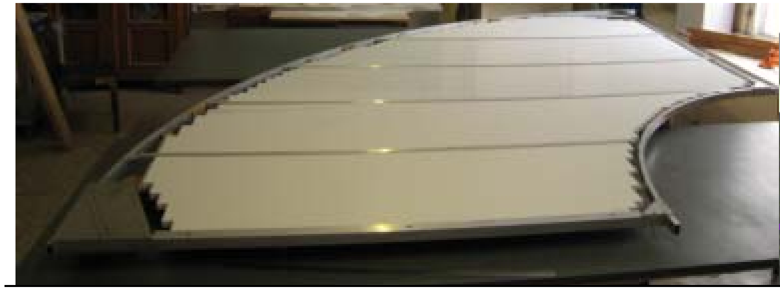

LER Gate valve in West tunnel

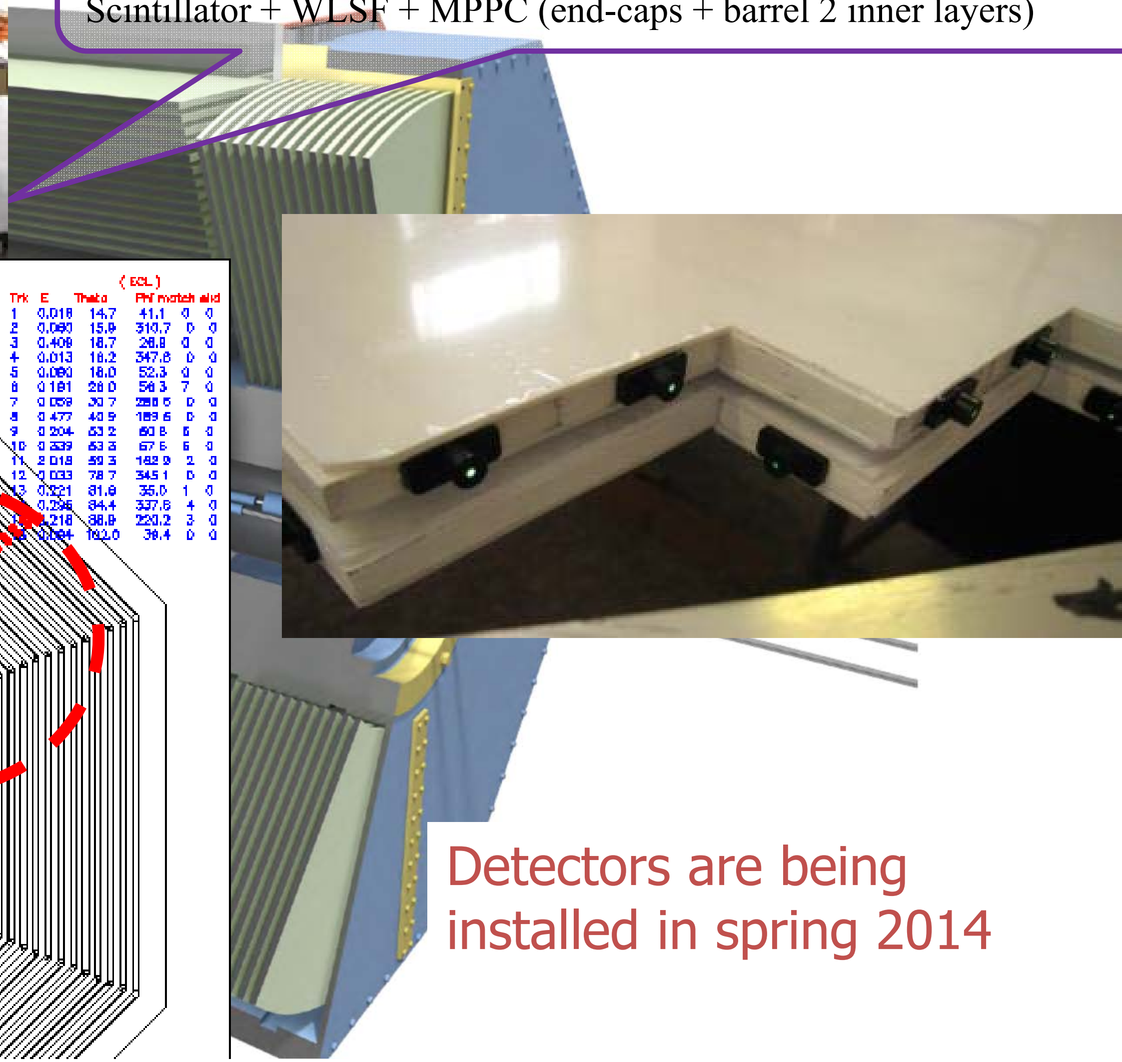

LER Oho wigger downstream

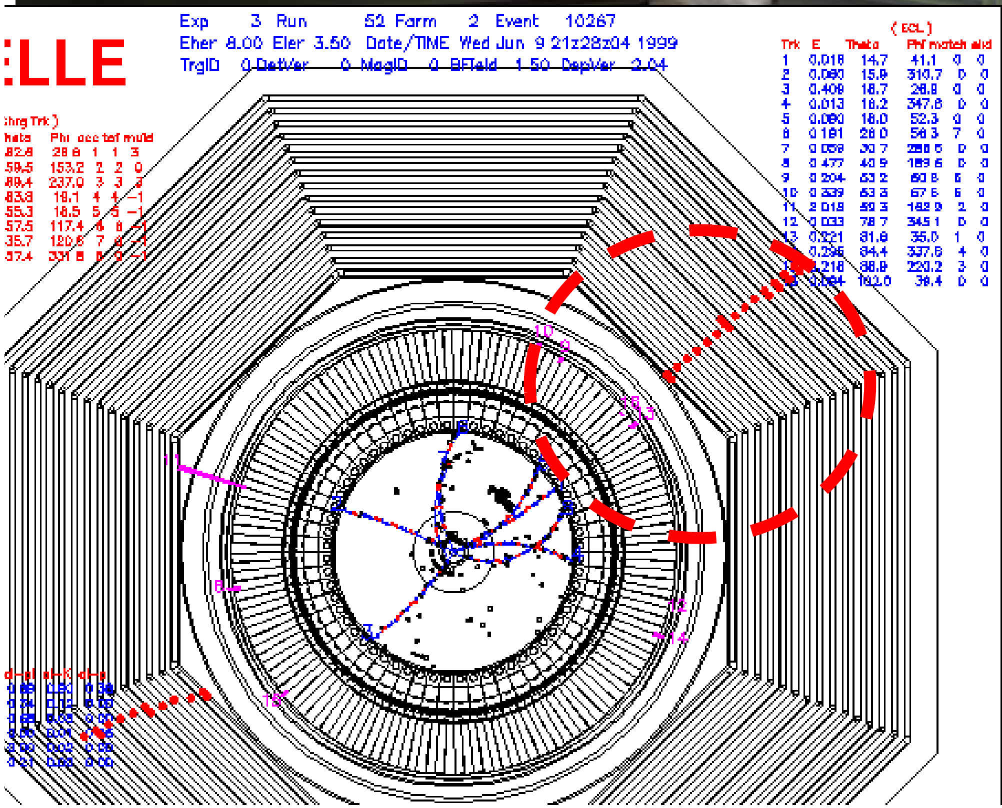

LER Nikko wigger downstream

Detection of muons and KLs: Endcap RPCs and two layers of the barrel have to be replaced with scintillators to handle higher backgrounds (mainly from neutrons).

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







Detectors are being installed in spring 2014