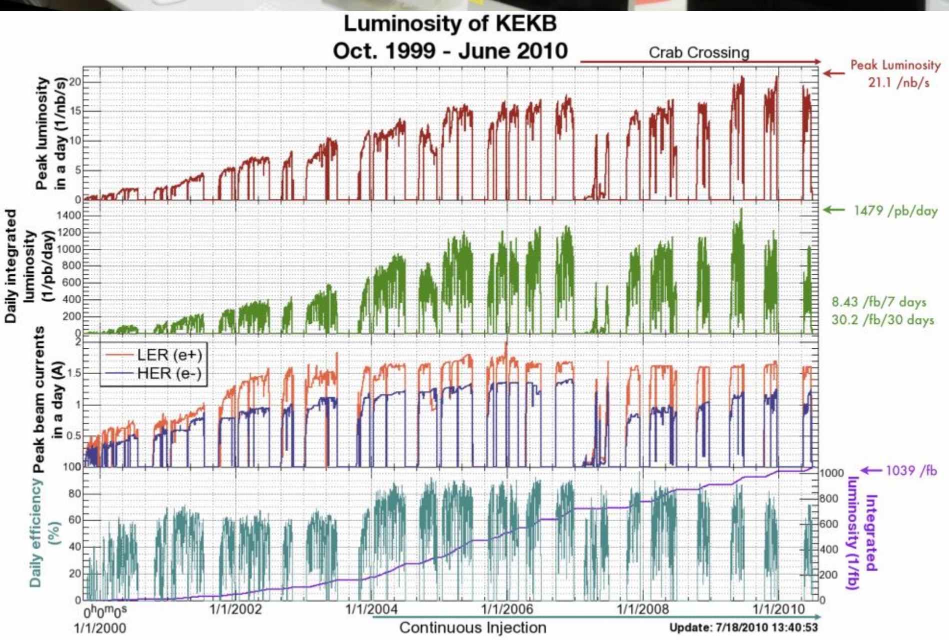
Status and Prospects of SuperKEKB and Belle II

July 24, 2010
Yutaka USHIRODA (KEK)
for the Belle II Collaboration

The last beam abort of KEKB on June 30, 2010



First physics run on June 2, 1999
Last physics run on June 30, 2010
L_{peak} = 2.1x10^{34}/cm^2/s
L > 1ab^{-1}

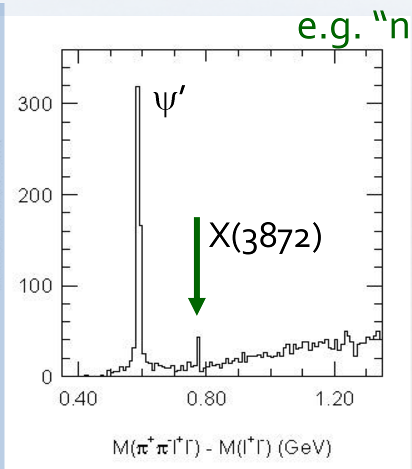
Physics

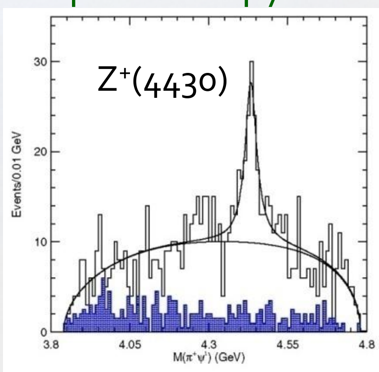
Current Measurements:

- Omissions in SM (possible in SM):

e.g. “new spectroscopy”

Belle, PRL 91, 262001 (2003), 140fb⁻¹

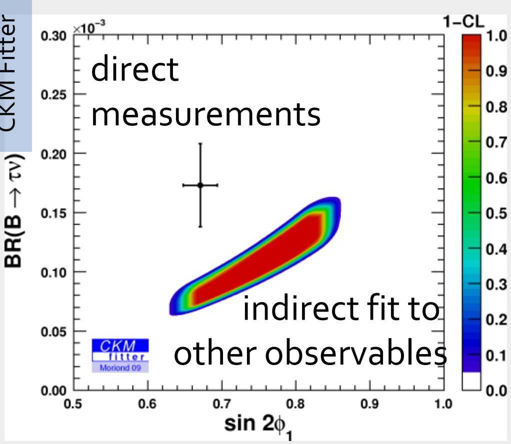


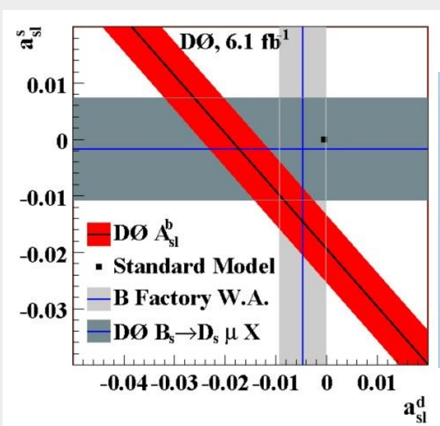


Belle, PRL 100, 142001 (2008), 605fb⁻¹

- Hints of discrepancies with SM (impossible in SM):

CKM Fitter





DØ, arXiv:1005.2757

$\mathcal{B}(B \to \tau\nu)$, A_{SL}^{B}, …

Future Measurements:

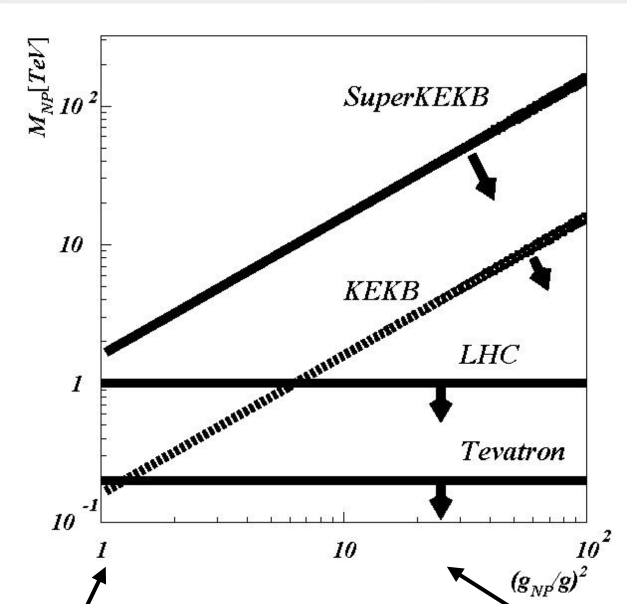
Precision frontier / Energy frontier

Flavor Factories / LHC

complementary quest for New Physics

Super *B* factories: $\mathcal{O}(10^2)$ larger $\int\mathcal{L}dt$

NP scale reach:



Belle II, Technical Design Report, in preparation

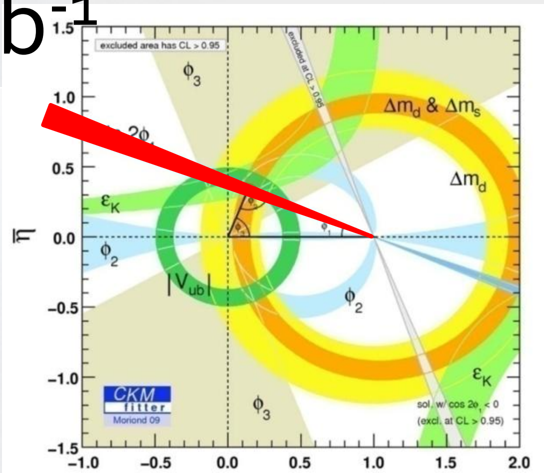
- Minimal Flavor Violation
- Enhanced flavor violating couplings

Physics with 50ab^{-1}

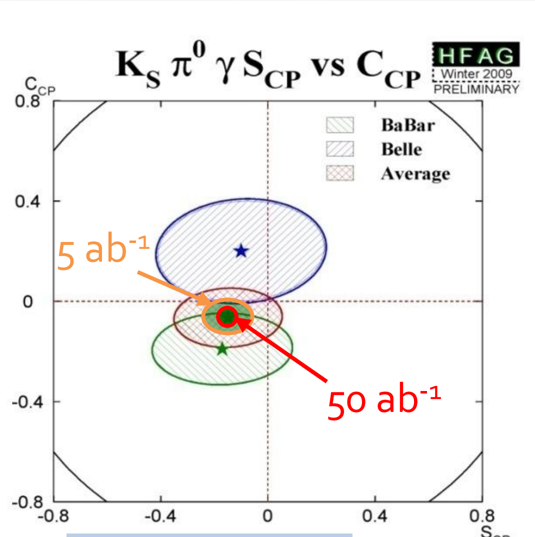
"bread & butter":

- *B* factory:
  $B \to J/\psi K_S$, $\mathcal{B} \sim 4.5 \cdot 10^{-4}$
  $\delta S \sim 0.03$

- Super *B* factory:
  $B \to K^*\gamma$, $\mathcal{B} \sim 4.0 \cdot 10^{-5}$
  $\delta S \sim 0.2 \to \sim$a few %



CKM Fitter

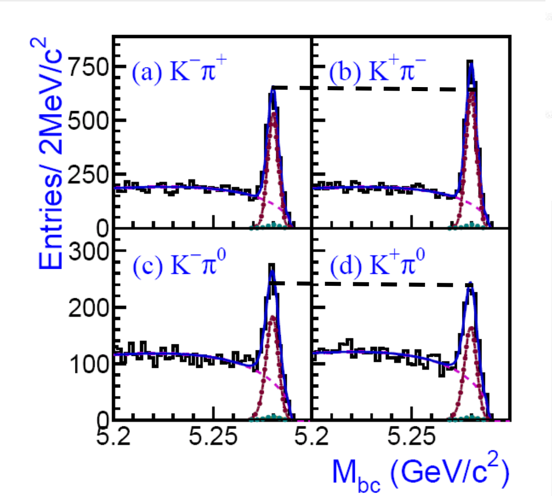


adopted from HFAG

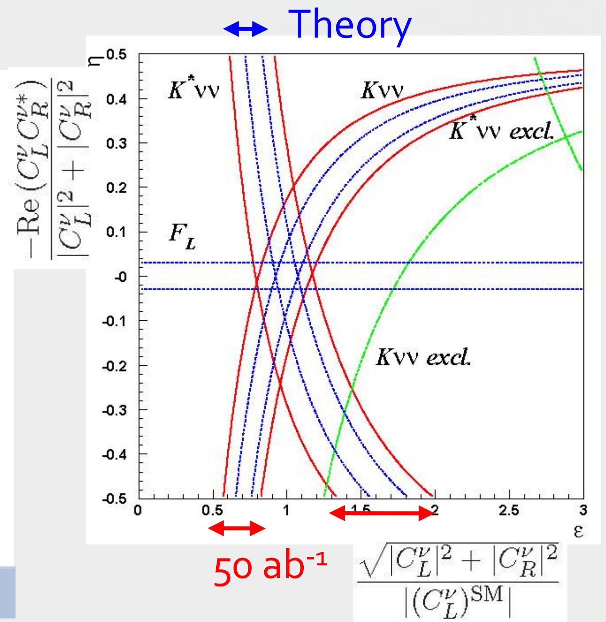
Interesting modes for NP:

- *B* factory:
  $B \to K\pi$, $\mathcal{B} \sim 1.9 \cdot 10^{-5}$

- Super *B* factory:
  $B \to K\nu\nu$, $\mathcal{B} \sim 4 \cdot 10^{-6}$



Belle, Nature 452, 332 (2008), 480 fb^{-1}

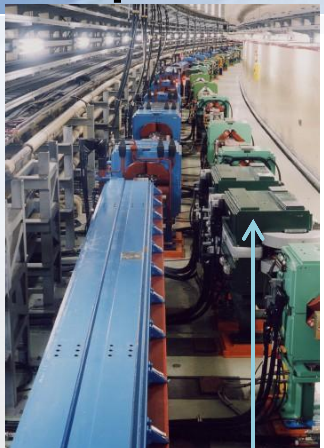


adopted from W. Altmannshofer et al., JHEP 0904, 022 (2009)

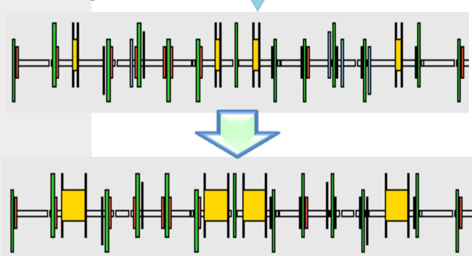
$S(K_S\pi^0\gamma)$, $K\nu\nu$, $\tau\nu$, ... are not possible @ LHCb

Contribution ID: 561
The SuperKEKB accelerator status

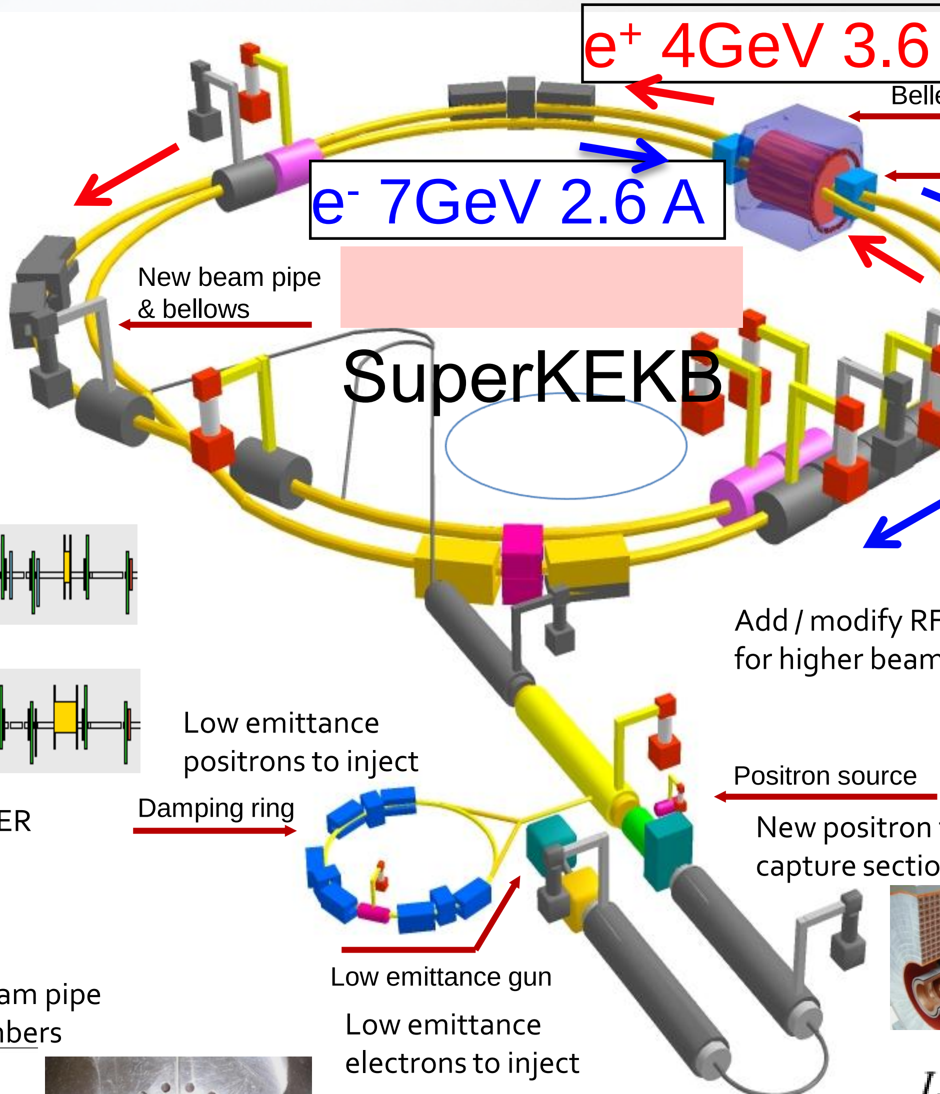
SuperKEKB collider

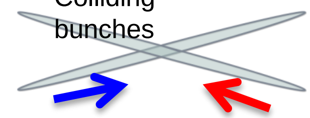


Replace short dipoles with longer ones (LER)



Redesign the lattices of HER & LER to squeeze the emittance

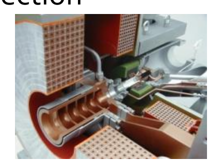




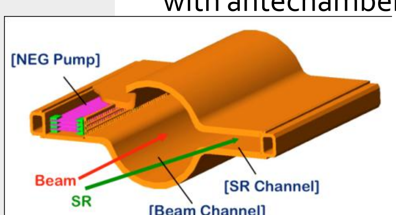
New superconducting /permanent final focusing quads near the IP

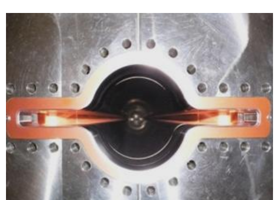
Add / modify RF systems for higher beam current

New positron target / capture section



TiN-coated beam pipe with antechambers

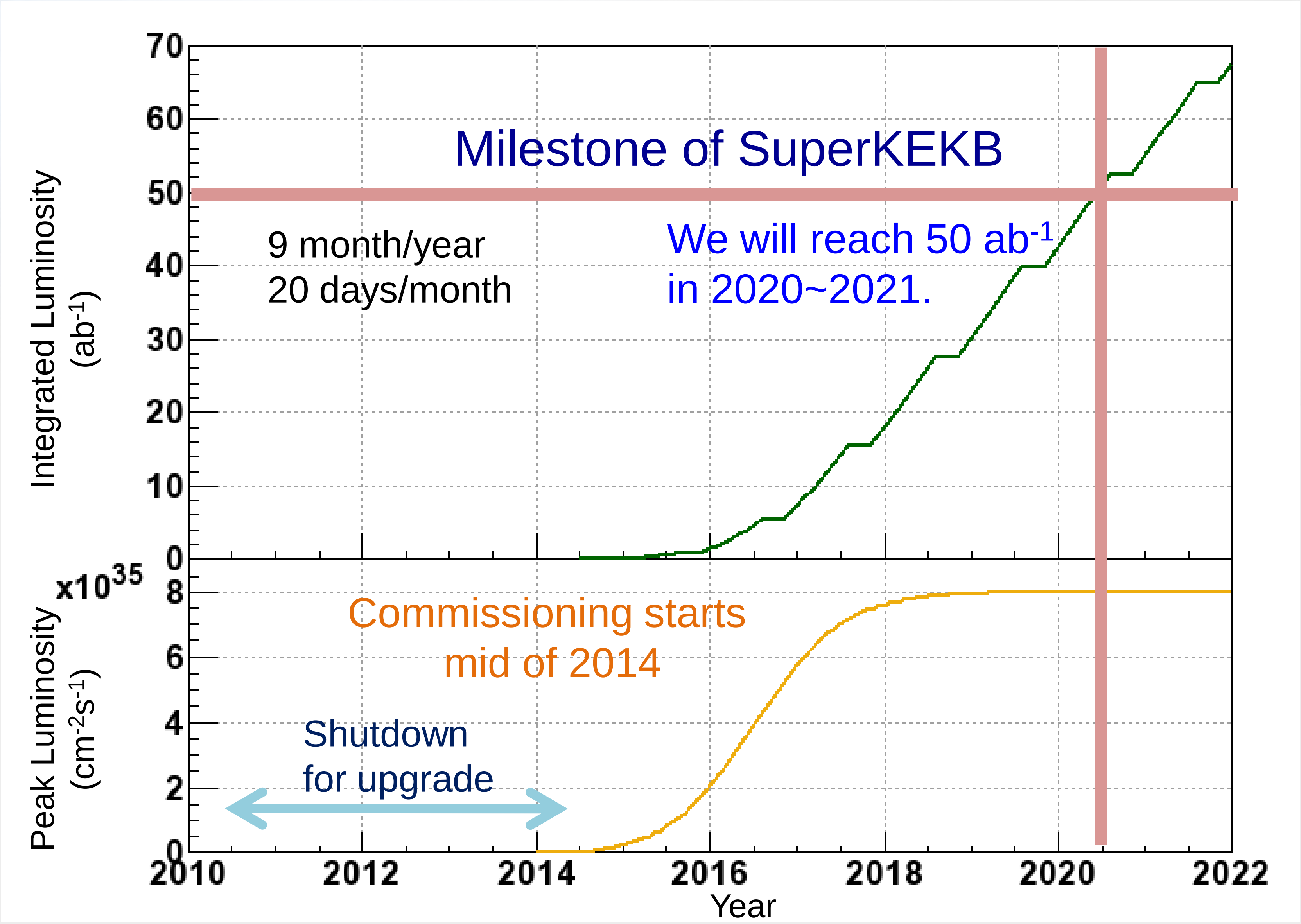




$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

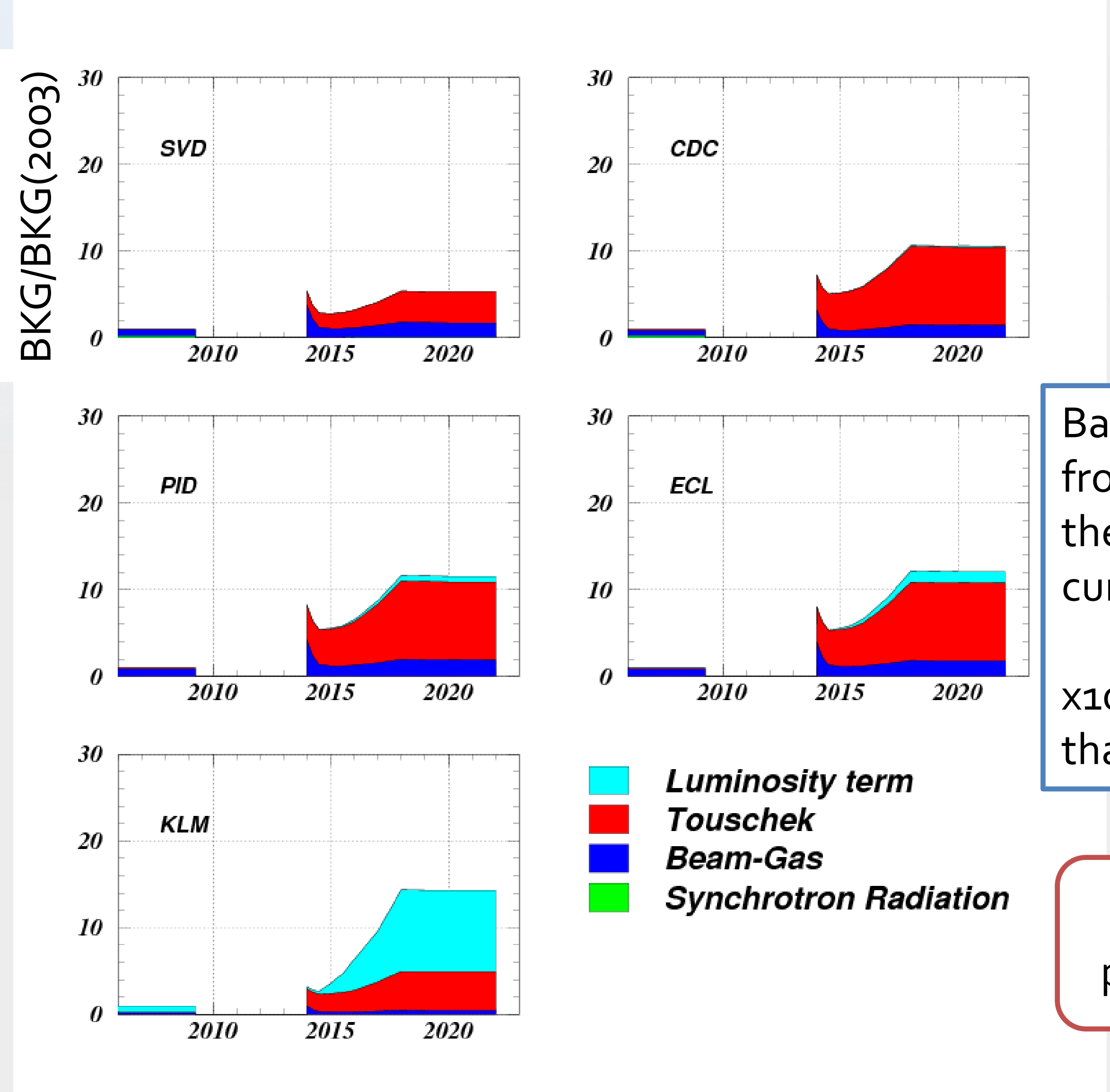
Target: L = 8x10^{35}/cm^2/s

Luminosity upgrade projection



Y. Ohnishi

Beam Background

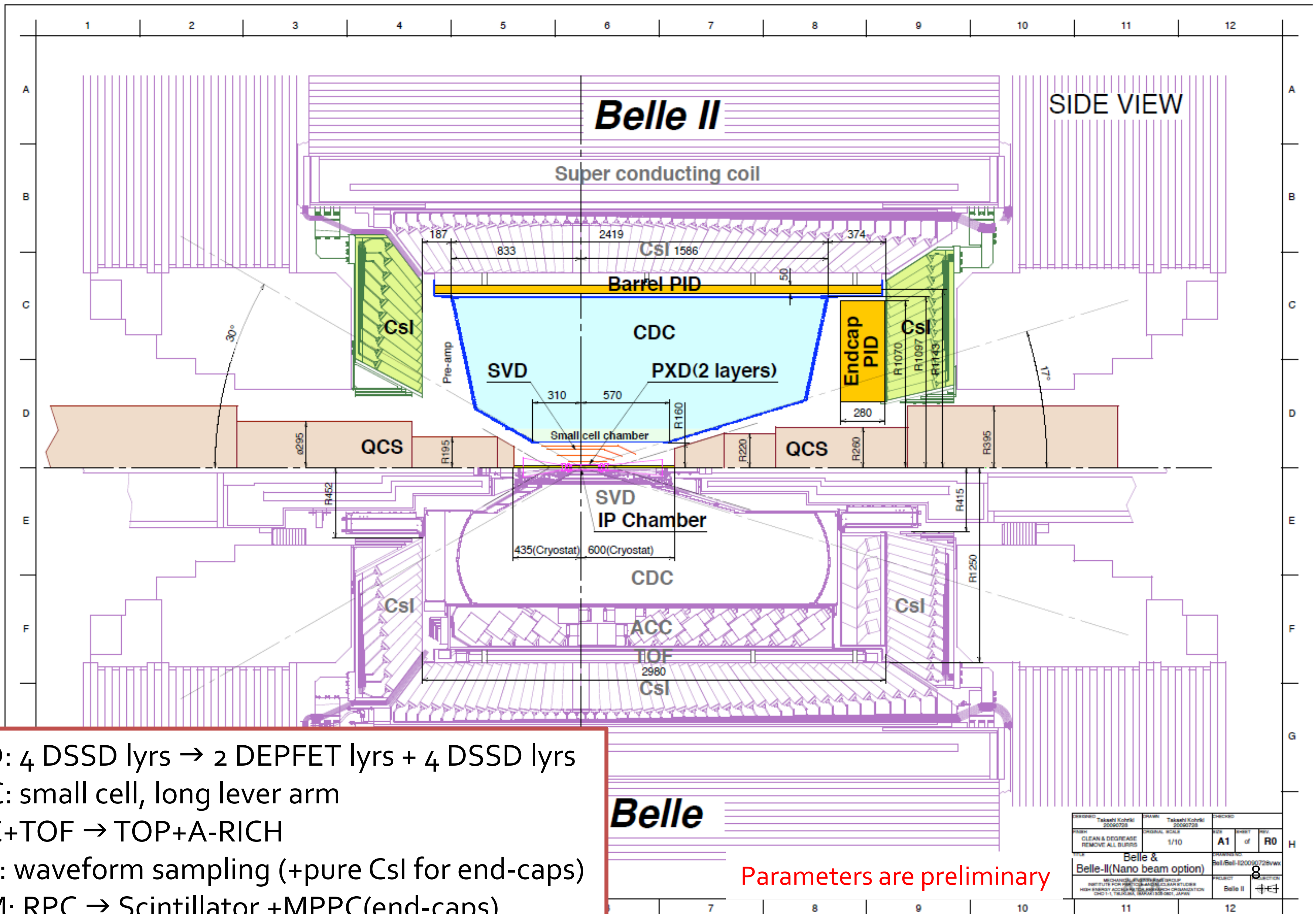


Background composition derived from background study data, which is then scaled by Luminosity, beam current etc.

x10 to x20 as large background as that of 2003 conditions (~severest)

Similar or Higher detector performance even under x20 bkg

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 end-caps)
KLM: RPC → Scintillator +MPPC(end-caps)

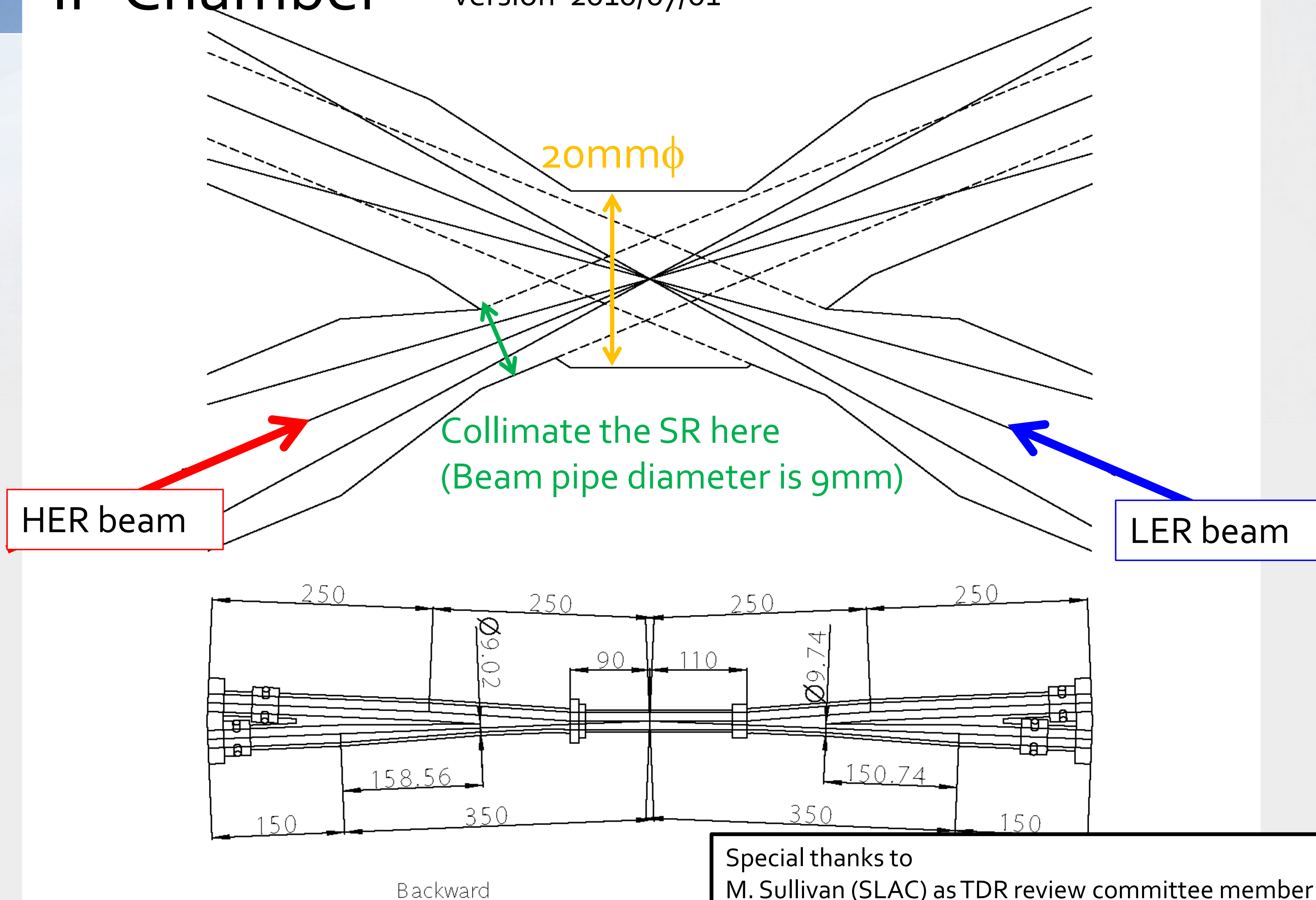
Parameters are preliminary

Outline

- Introduction
- Status of Detector Development
  - Beam Pipe, Vertex Detectors, Particle ID, ...
- Status and prospects of the Project
- Summary & Conclusion

IP Chamber

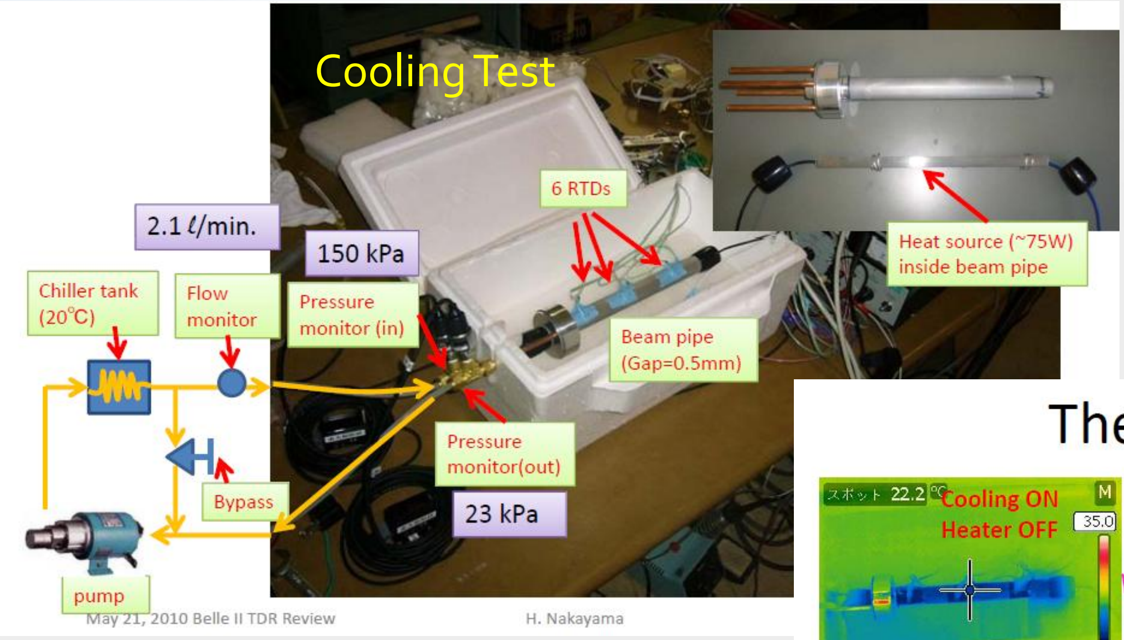
version 2010/07/01



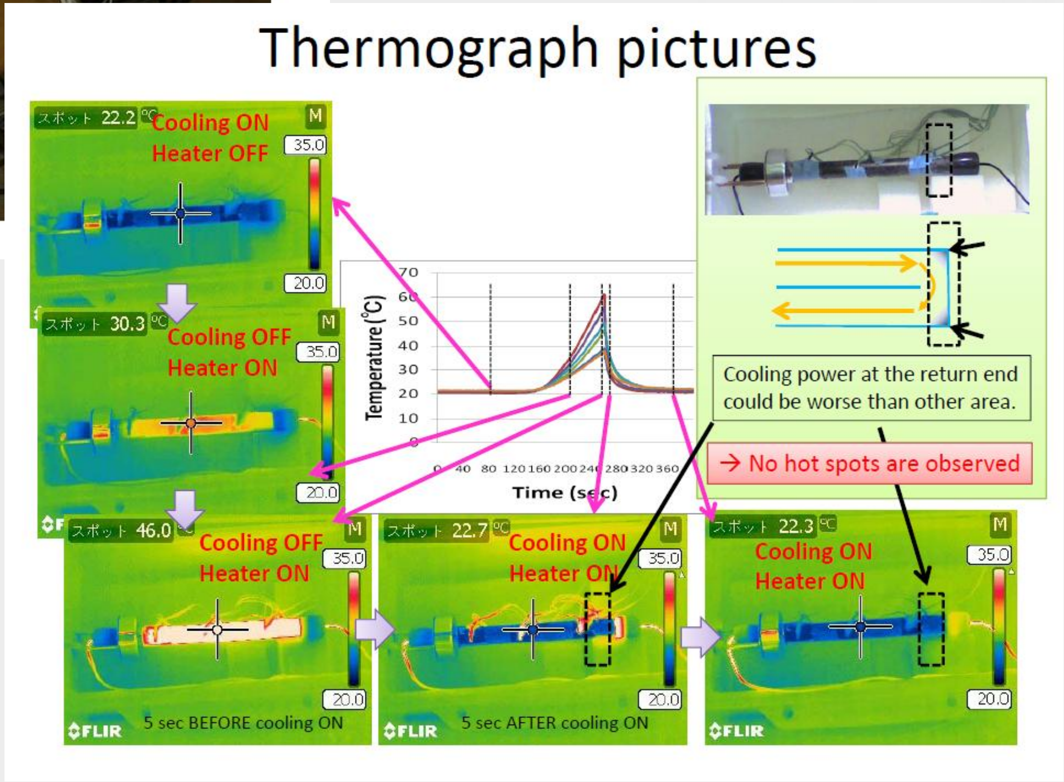
Special thanks to
M. Sullivan (SLAC) as TDR review committee member
who pointed out the SR issue.

Tests

Mechanical mock-up



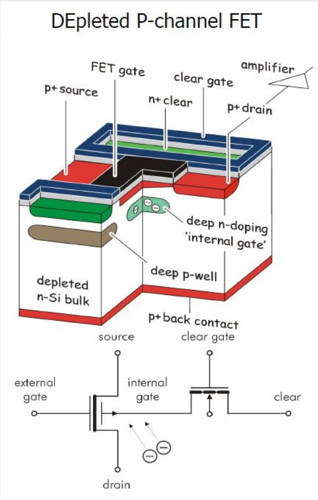
Cooling Test
6 RTDs
2.1 ℓ/min.
150 kPa
Chiller tank (20°C)
Flow monitor
Pressure monitor (in)
Beam pipe (Gap=0.5mm)
Heat source (~75W) inside beam pipe
Pressure monitor(out)
23 kPa
Bypass
pump
May 21, 2010 Belle II TDR Review
H. Nakayama

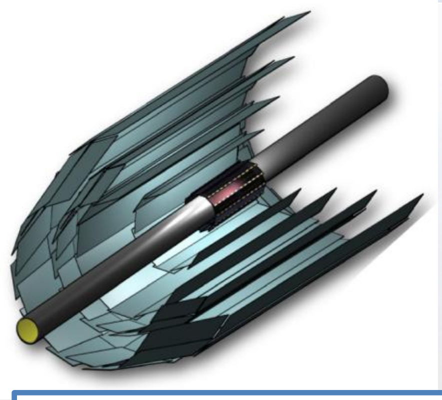


Thermograph pictures
スポット 22.2 ℃
Cooling ON
Heater OFF
スポット 30.3 ℃
Cooling OFF
Heater ON
スポット 46.0 ℃
Cooling OFF
Heater ON
5 sec BEFORE cooling ON
スポット 22.7 ℃
Cooling ON
Heater ON
5 sec AFTER cooling ON
スポット 22.3 ℃
Cooling ON
Heater ON
Temperature (°C)
Time (sec)
Cooling power at the return end could be worse than other area.
→ No hot spots are observed

Vertex Detector

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

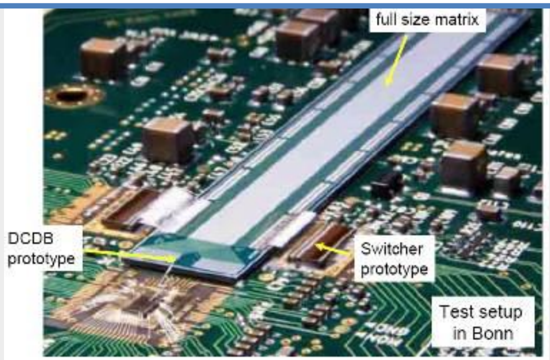


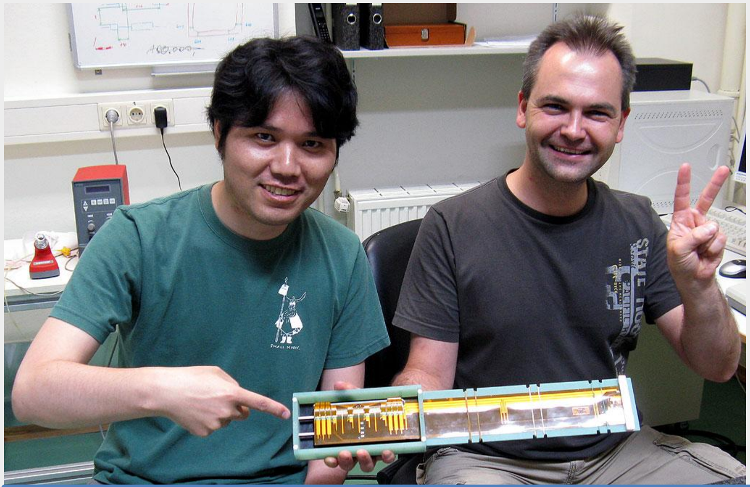


Beam Pipe		**r = 10mm**
DEPFET		
	Layer 1	**r = 14mm**
	Layer 2	**r = 22mm**
DSSD		
	Layer 3	**r = 38mm**
	Layer 4	**r = 80mm**
	Layer 5	**r = 115mm**
	Layer 6	**r = 140mm**

Mechanical mockup of pixel detector

Prototype DEPFET pixel sensor and readout



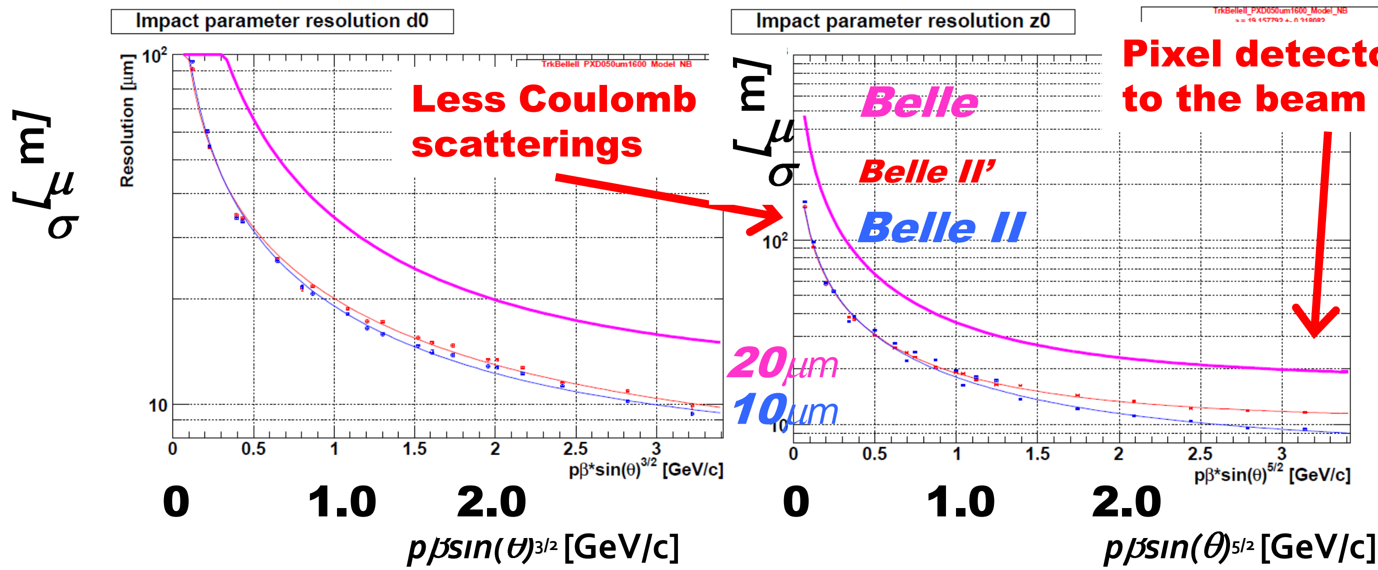


A prototype ladder using the first 6 inch DSSD from Hamamatsu has been assembled and tested.

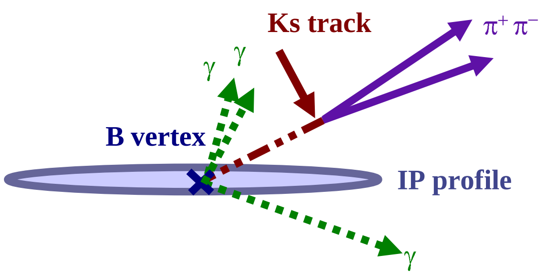
Expected performance

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

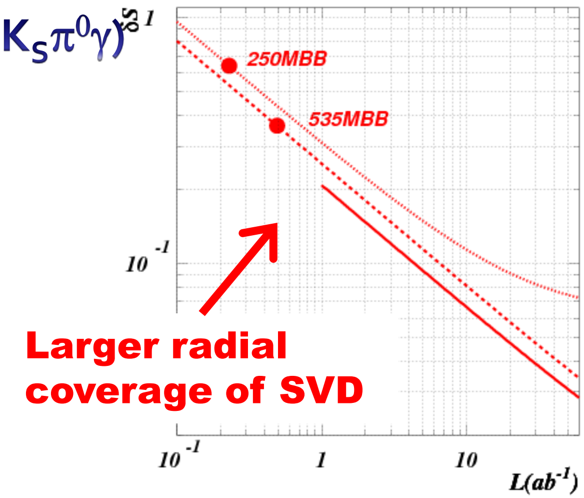
Significant improvement in IP resolution!



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

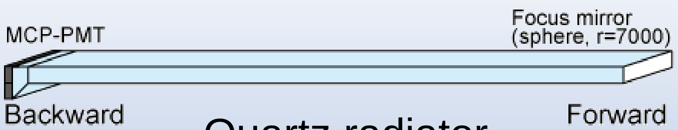


B decay point reconstruction with K_S trajectory



Particle Identification Devices

Barrel PID: Time of Propagation Counter (TOP)



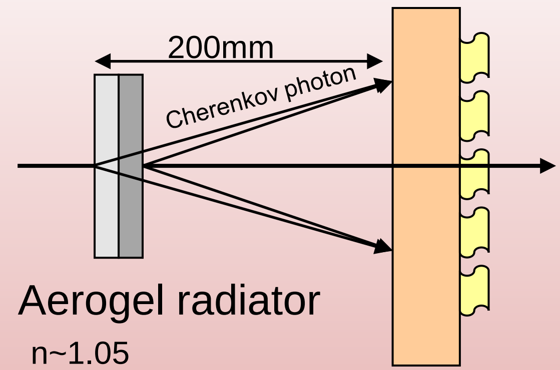
Quartz radiator

Focusing mirror

Small expansion block

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

Endcap PID: Aerogel RICH (ARICH)

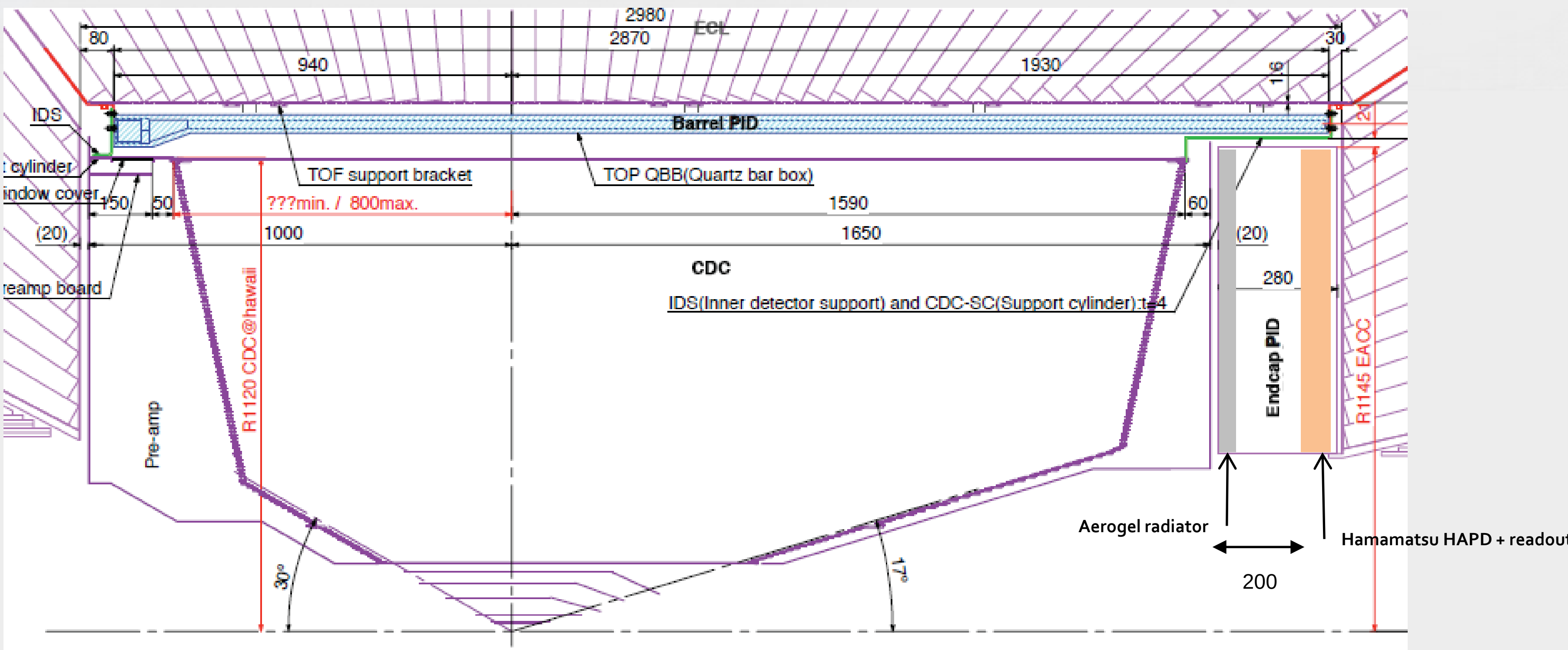


Aerogel radiator

n~1.05

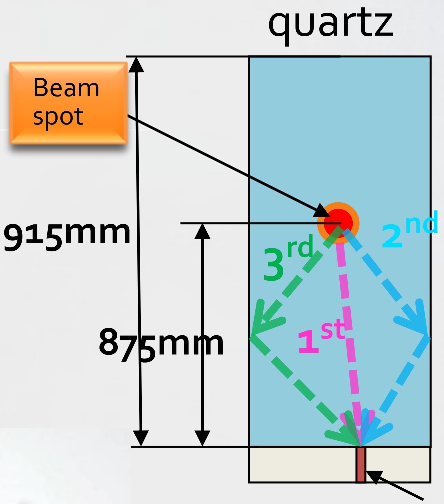
Hamamatsu HAPD

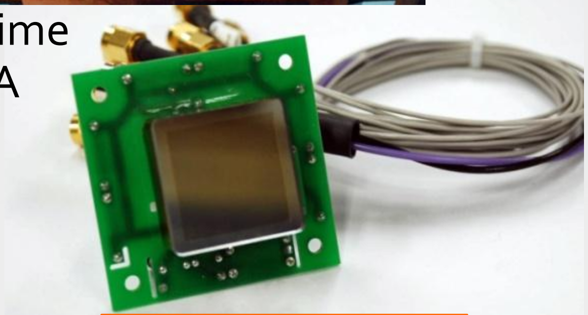
+ new ASIC

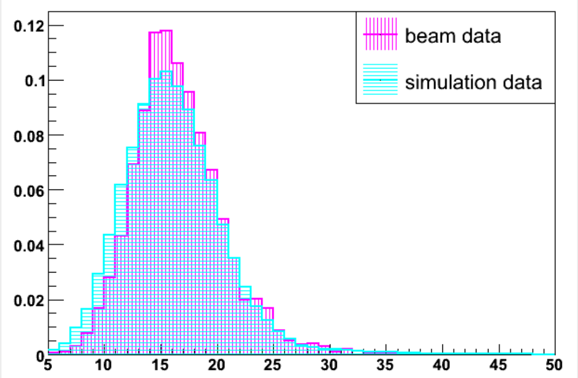


TOP (Barrel PID)

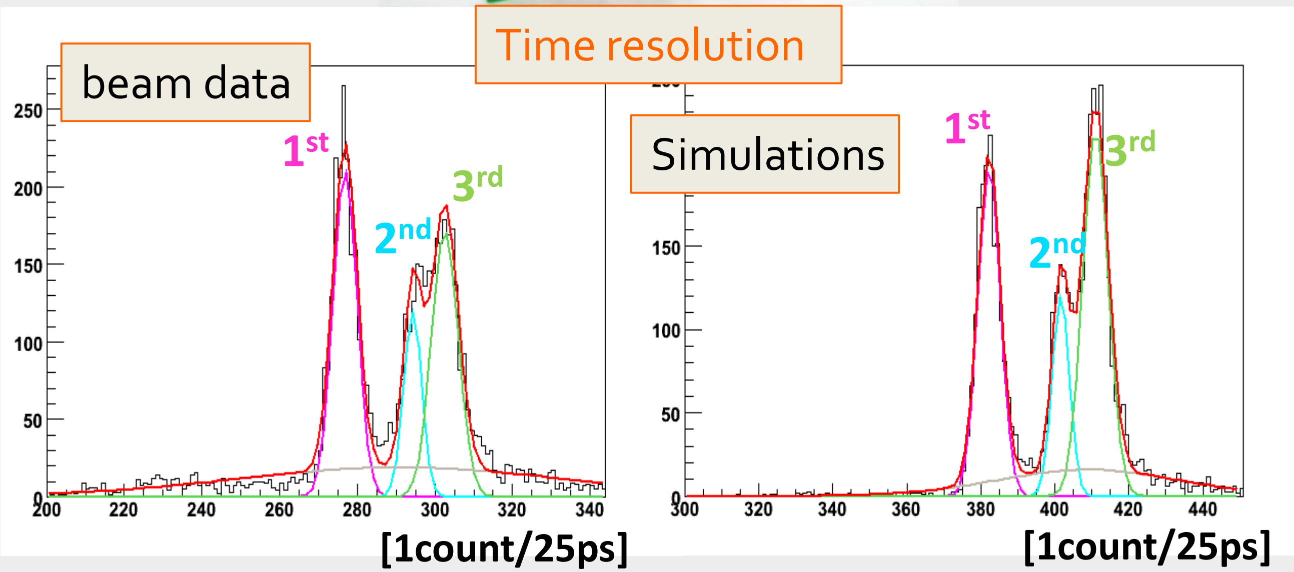
- Quartz radiator
  - $2.6m^{L} \times 45cm^{W} \times 2cm^{T}$
  - Excellent surface accuracy
- MCP-PMT
  - Hamamatsu 16ch MCP-PMT
    - Good TTS (<35ps) & enough lifetime
    - Multialkali photo-cathode → SBA
- Beam test done in 2009
  - # of photons consistent
  - Time resolution OK





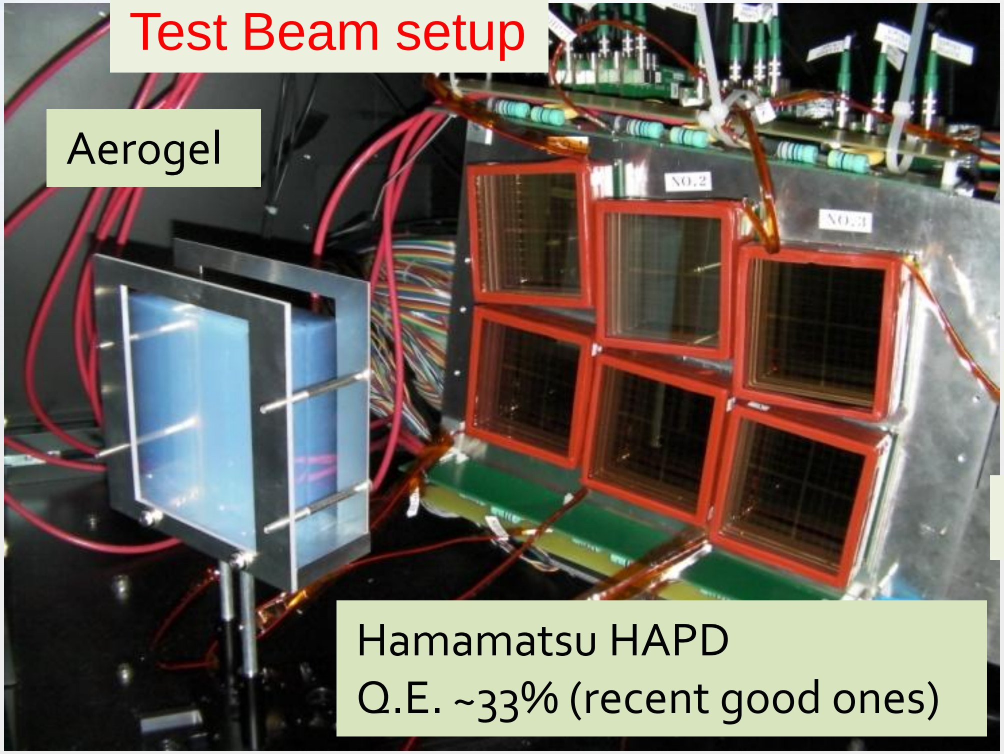


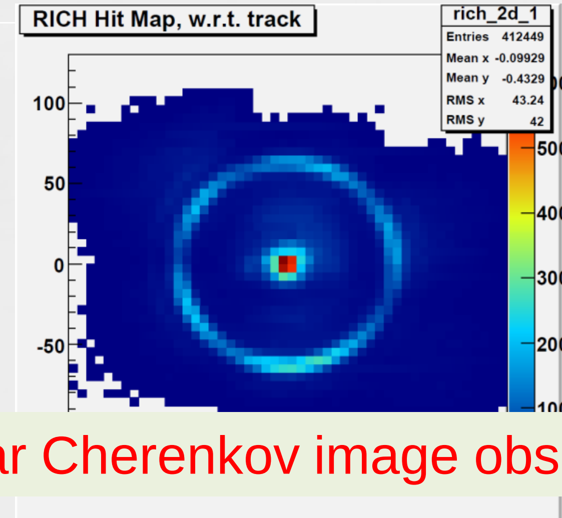
# of photons

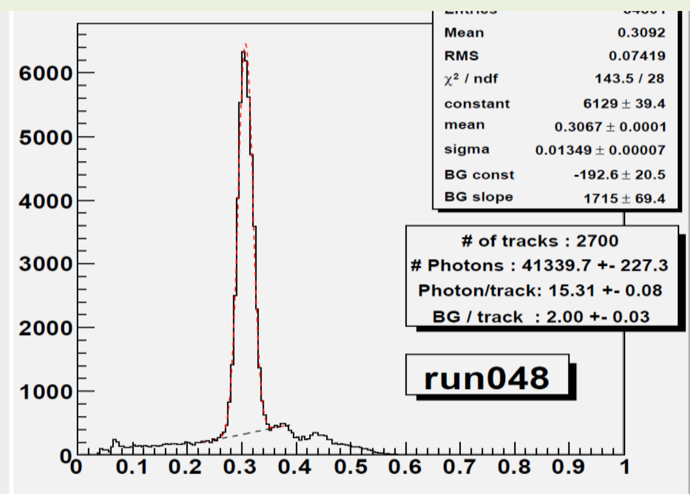


Aerogel RICH (endcap PID)

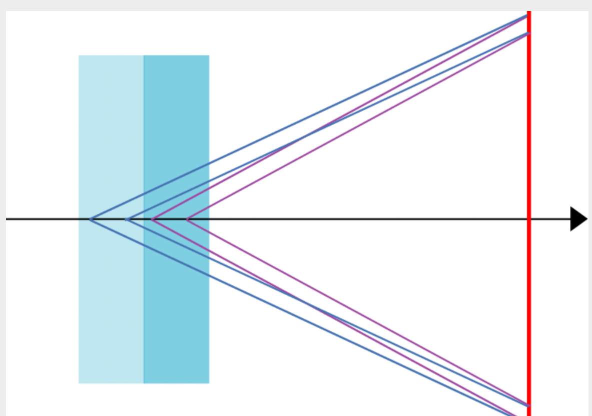
Contribution ID: 1016
Aerogel RICH for Belle II







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

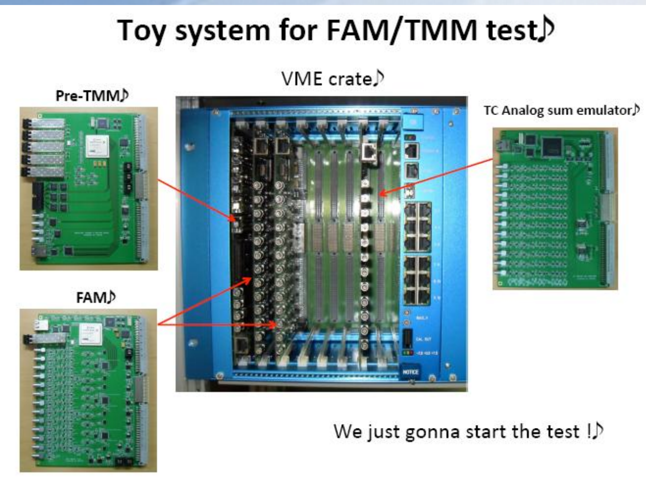


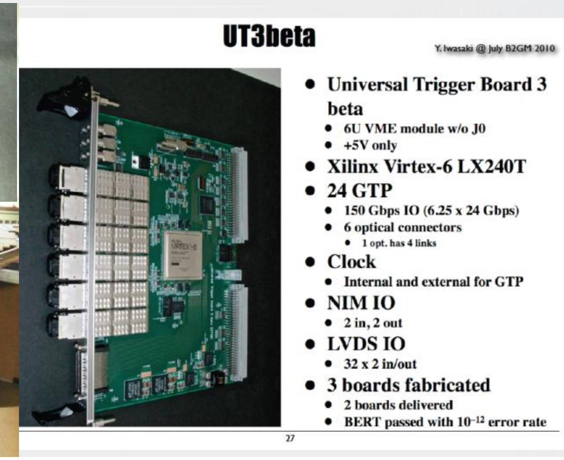
Employ multiple layers with different refractive indices→ Cherenkov images from individual layers overlap on the photon detector.

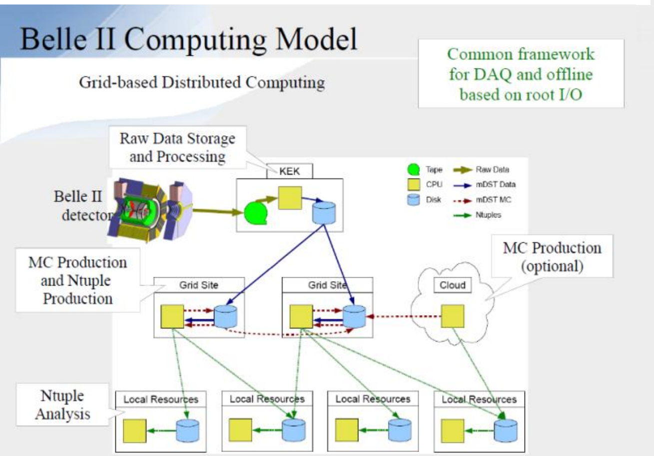
6.6 σ π/K at 4GeV/c !

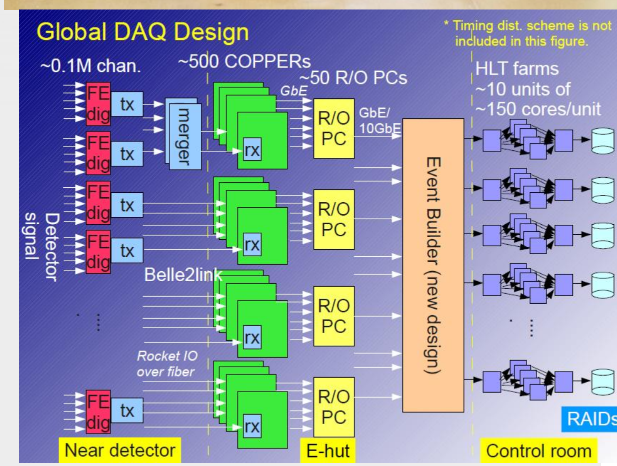
Intensively going on!

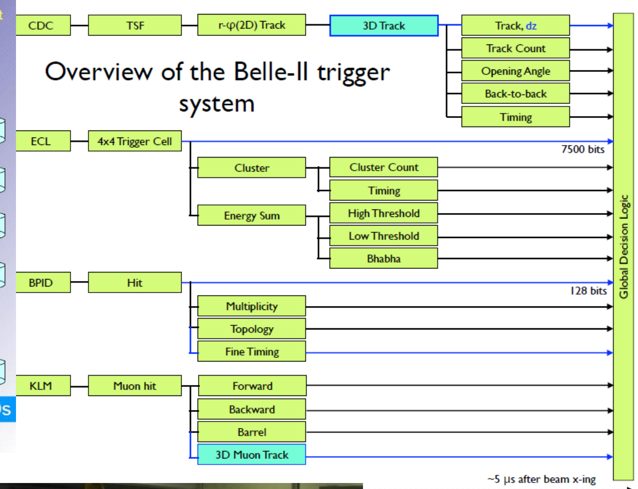
Other design & development activities











Funding Status

KEKB upgrade has been approved

- 5.8 oku yen for Damping Ring (FY2010)
- 100 oku yen for machine -- Very Advanced Research Support Program (FY2010-2012)

Continue efforts to obtain additional funds to complete construction as scheduled.


一般向けページ >> 研究者向けページ >> English Pages >>

大学共同利用機関法人 KEK 高エネルギー加速器研究機構

Press Release

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last update: 10/06/23

Press Release

KEKB upgrade plan has been approved

June 23, 2010
High Energy Accelerator Research Organization (KEK)

The MEXT, the Japanese Ministry that supervises KEK, has announced that it will appropriate a budget of 100 oku-yen (approx $110M) over the next three years starting this Japanese fiscal year (JFY2010) for the high performance upgrade program of KEKB. This is part of the measures taken under the new "Very Advanced Research Support Program" of the Japanese government.

"We are delighted to hear this news," says Masanori Yamauchi, former spokesperson for the Belle experiment and currently a deputy director of the Institute of Particle and Nuclear Studies of KEK. "This three- year upgrade plan allows the Belle experiment to study the physics from decays of heavy flavor particles with an unprecedented precision. It means that KEK in Japan is launching a renewed research program in search for new physics by using a technique which is complementary to what is employed at LHC at CERN."

[Media Contact] Youhei Morita,
Head of Public Relations Office, KEK
tel. +81-29-879-6047

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1-1 Oho, Tsukuba, Ibaraki 305-0801 Japan

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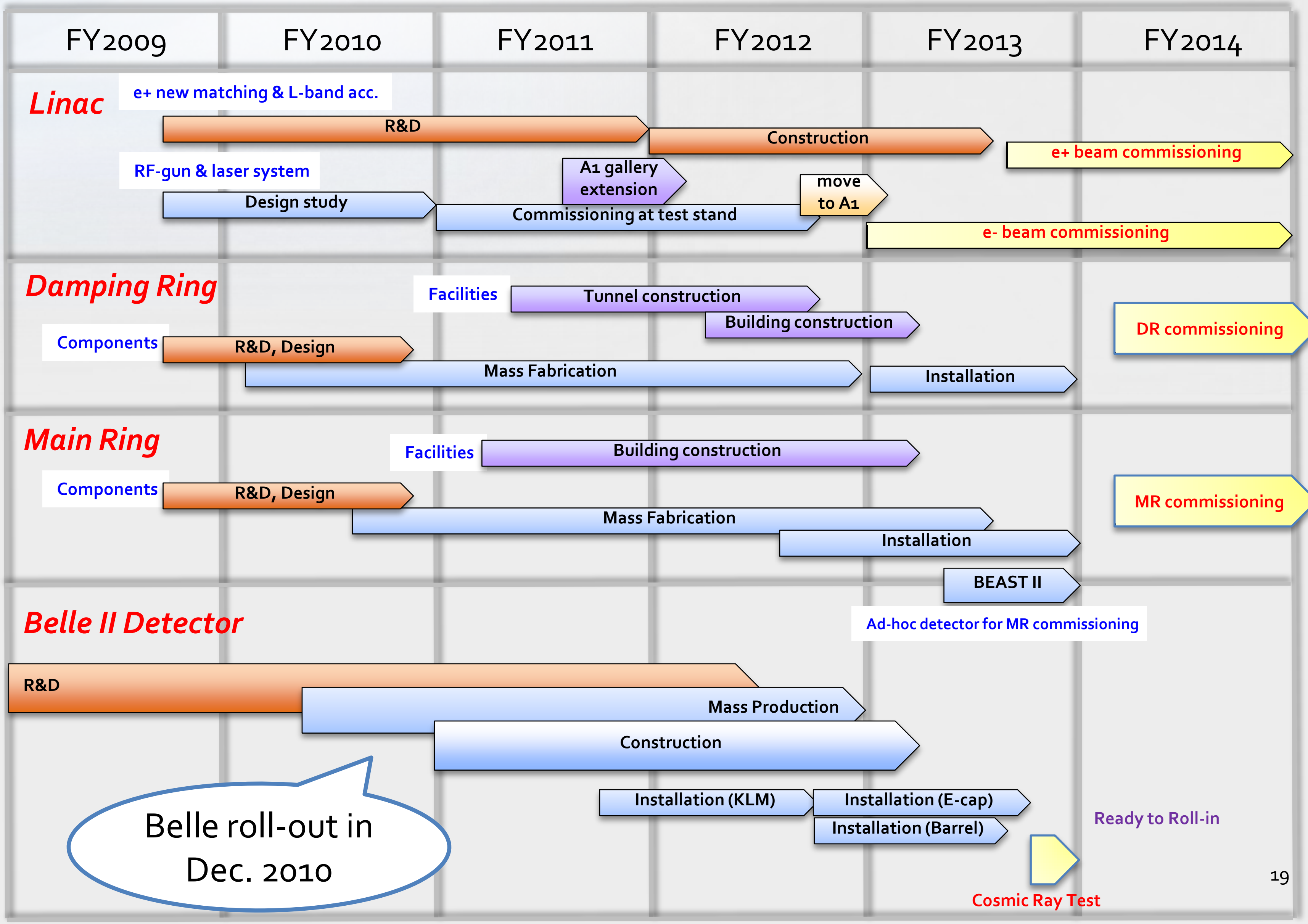
Construction Schedule of SuperKEKB/Belle II

Jun. 24, 2010



Belle II Collaboration

http://belle2.kek.jp

13 countries/regions, 53 institutes

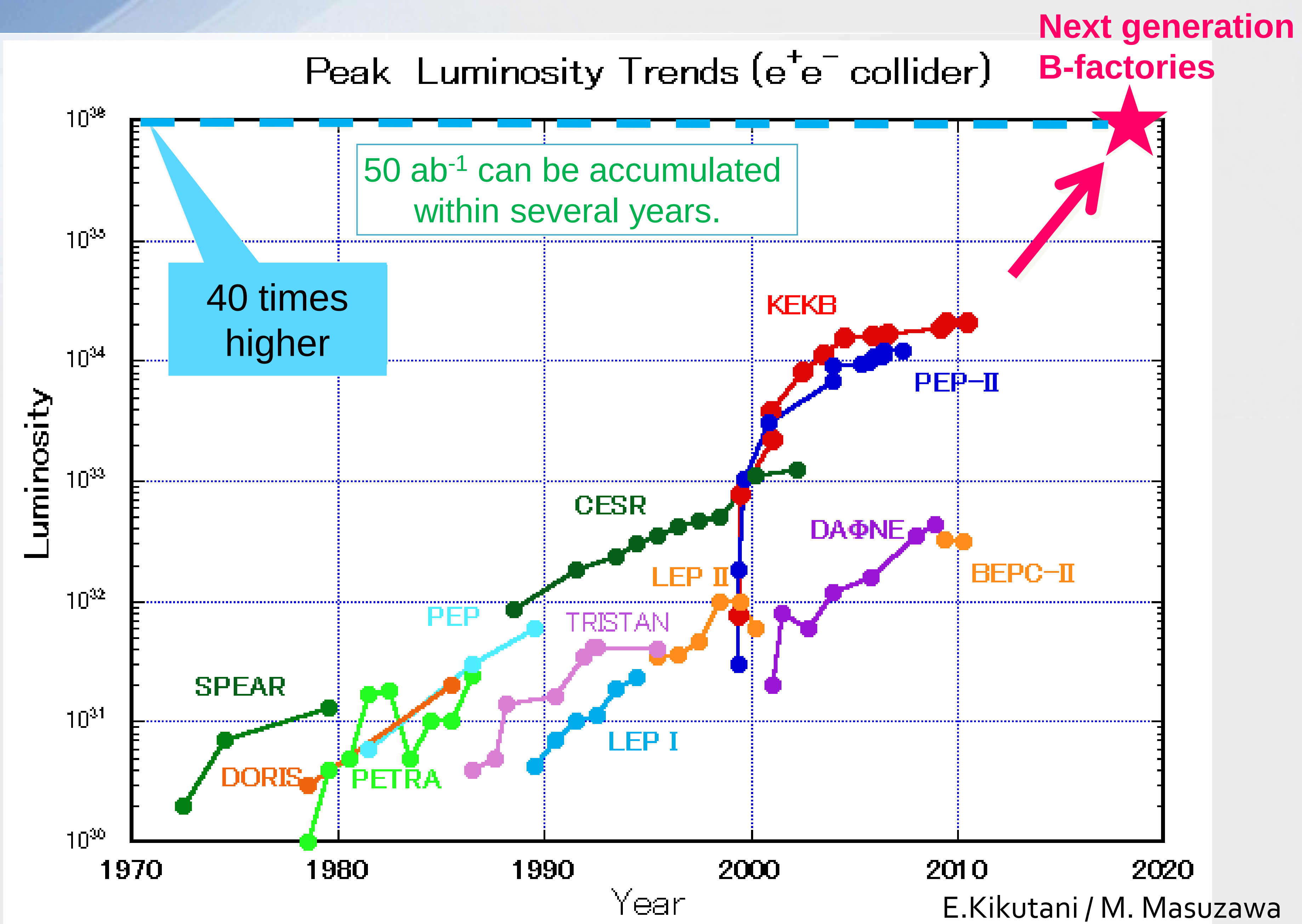
Summary and Conclusion

- SuperKEKB/Belle II aims for (discovering and) understanding the New Physics.
- Target Luminosity of SuperKEKB is $8 \times 10^{35}/cm^2/s$, will provide $50ab^{-1}$ by 2020-2021.
- Belle II gives similar or better performance than Belle even under ~20 times higher beam background.
- Project has been approved by Japanese Government in June 2010. KEKB/Belle operation has been willingly terminated. Construction starts shortly.

- Next collaboration meeting: Nov. 17-20 @KEK, still open to everyone.
- Technical Design Report will be printed very soon.

BACK-UP

Peak Luminosity History and Prospects

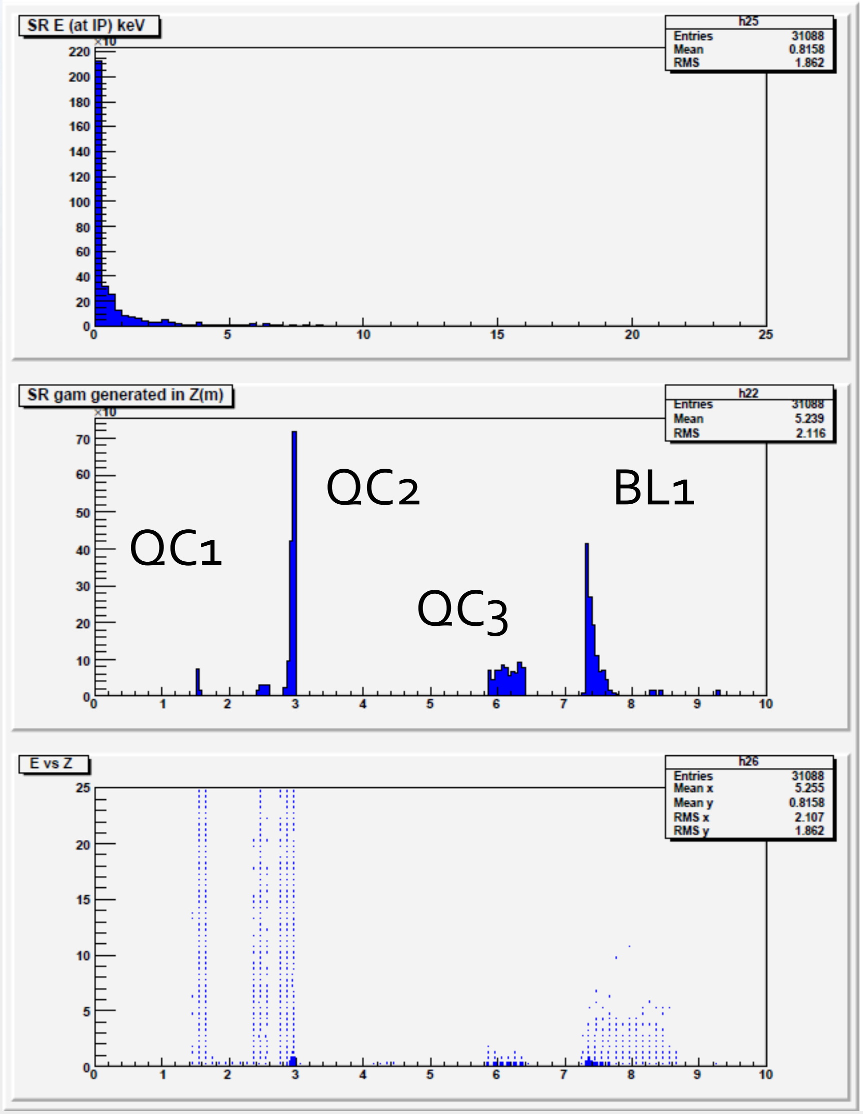


E.Kikutani / M. Masuzawa

Machine parameters

parameters		KEKB		SuperKEKB		units
		LER	HER	LER	HER	
Beam energy	E_b	3.5	8	4	7	GeV
Half crossing angle	φ	11		41.5		mrad
Horizontal emittance	ε_x	18	24	3.2	5.0	nm
Emittance ratio	κ	0.88	0.66	0.27	0.25	%
Beta functions at IP	β_x^*/β_y^*	1200/5.9		32/0.27	25/0.31	mm
Beam currents	I_b	1.64	1.19	3.60	2.60	A
beam-beam parameter	ξ_y	0.129	0.090	0.0886	0.0830	
Luminosity	L	2.1×10^{34}		8×10^{35}		$cm^{-2}s^{-1}$

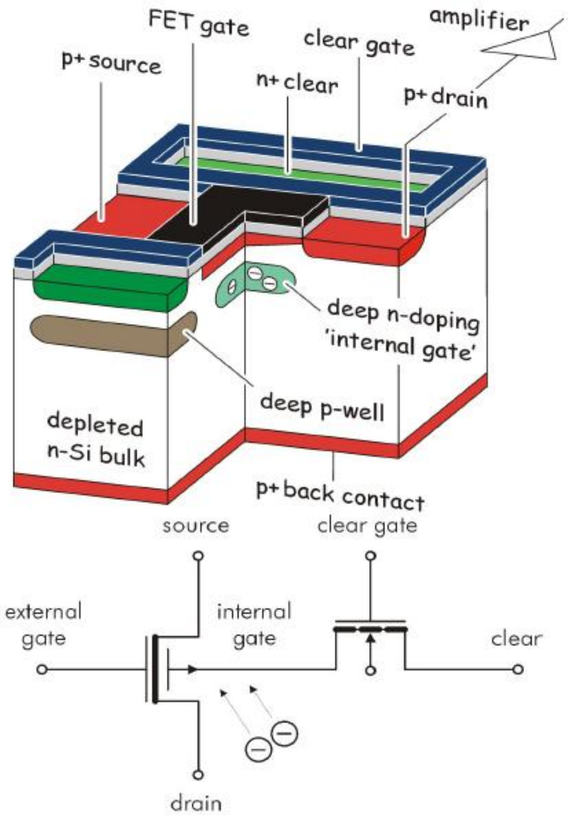
Synchrotron Radiation

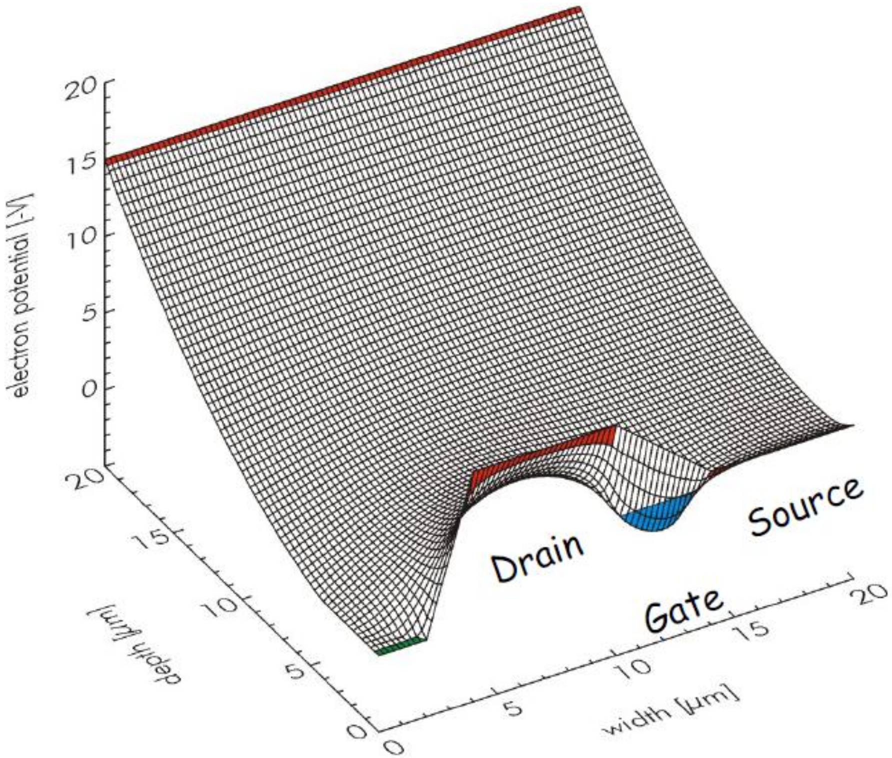


DEPFET Principle

J. Kemmer & G. Lutz, 1987

DEpleted P-channel FET



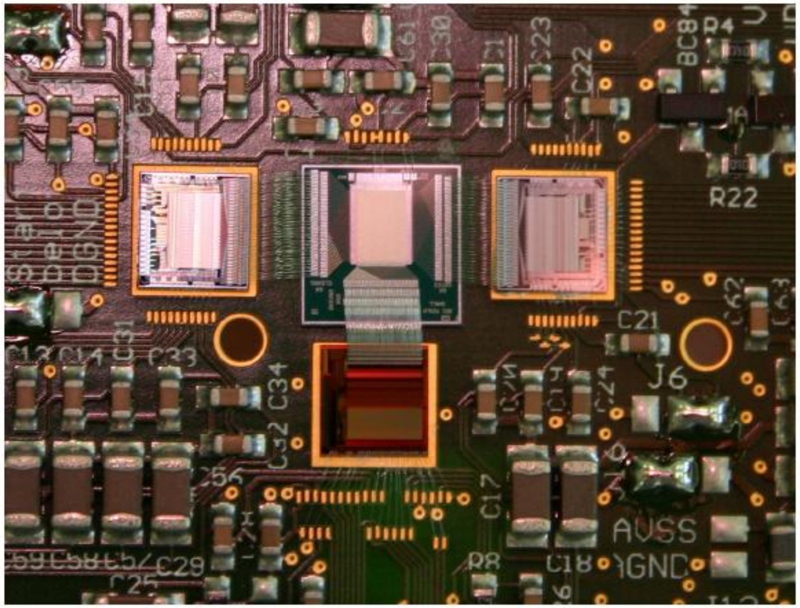


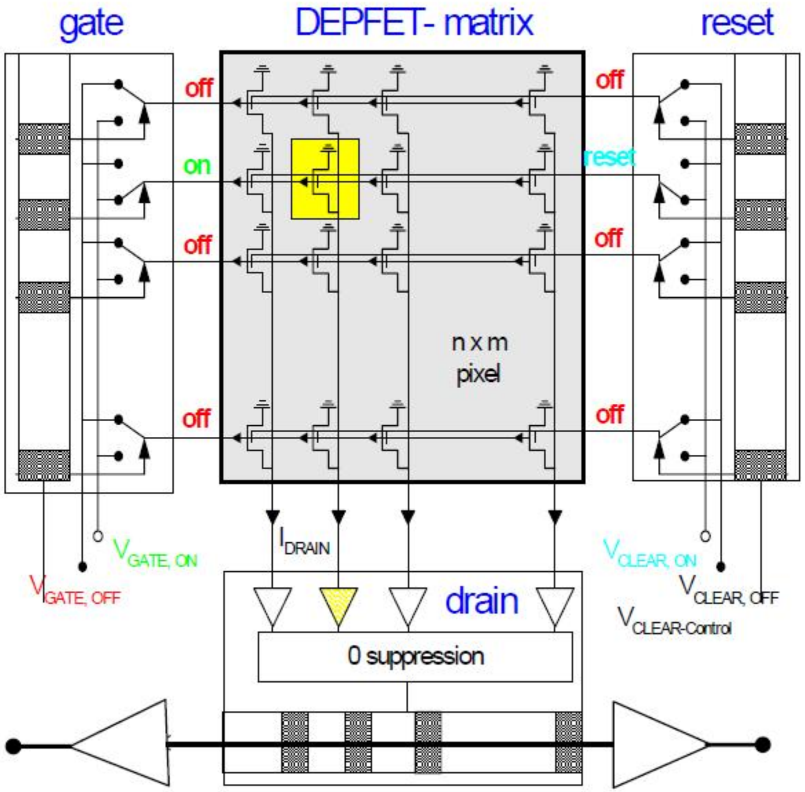
- fully depleted sensitive volume, charge collection by drift
- internal amplification → q-I conversion: 0.5 nA/e, scales with gate length and bias current
- Charge collection in "off" state, read out on demand

An Array of DEPFETs

Row wise read-out ("rolling shutter")

- select row with external gate, read current, clear DEPFET, read current again
  → the difference is the signal
- only one row active → low power consumption
- two different auxiliary ASICs needed





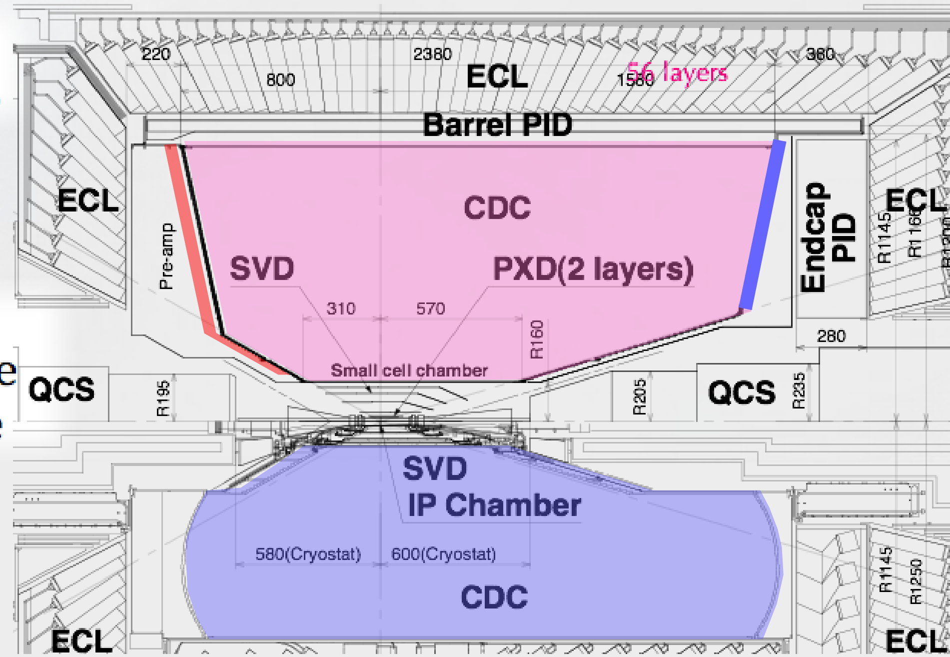
Central Drift Chamber

longer lever arm
improve resolution of momentum and dE/dx

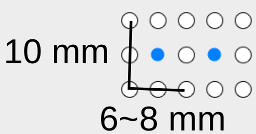
$$\sigma_{P_t}/P_t = 0.19P_t \oplus 0.30/\beta$$
$$\sigma_{P_t}/P_t = 0.11P_t \oplus 0.30/\beta$$

new readout system
dead time 1-2μs → 200ns

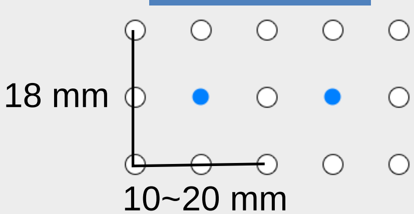
small cell
smaller hit rate for each wire
shorter maximum drift time



small cell



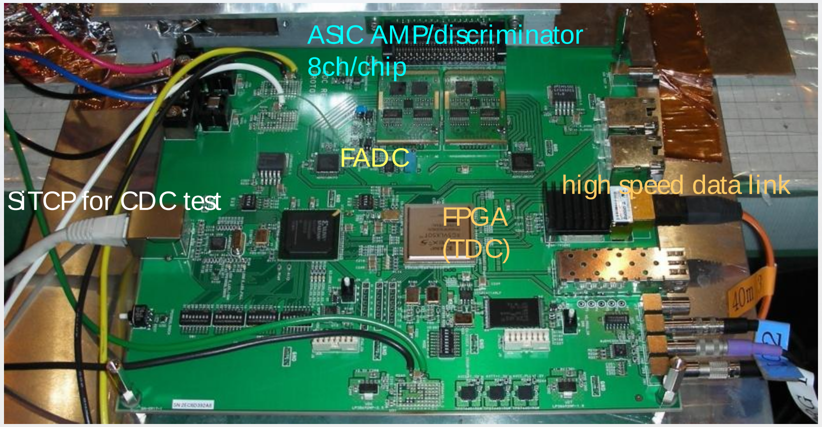
normal cell

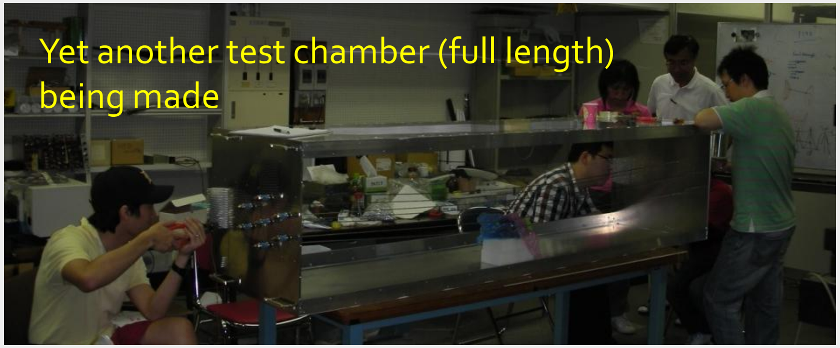


	Belle	Belle II
radius of inner most sense wire	88	168
radius of outer most sense wire	863	1111.4
Number of layers	50	56
Number of total sense wire	8400	14336
Gas	He:C_2H_6	He:C_2H_6
sense/field wire	W(Φ30μm)/Al(Φ120μm)	W(Φ30μm)/Al(Φ120μm)

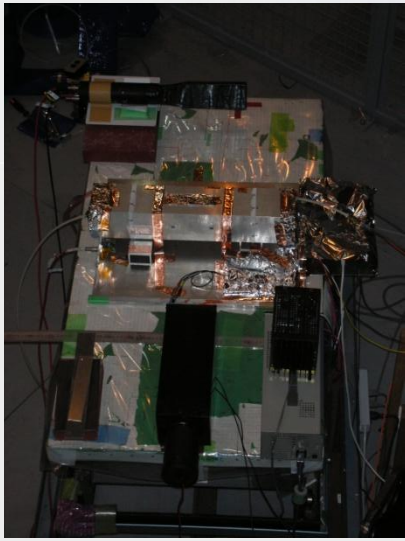
Test Chambers

Prototype readout board (will be placed behind the detector)

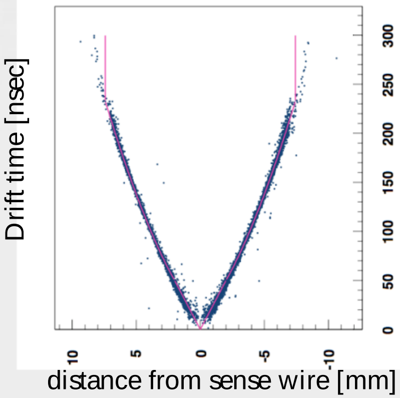




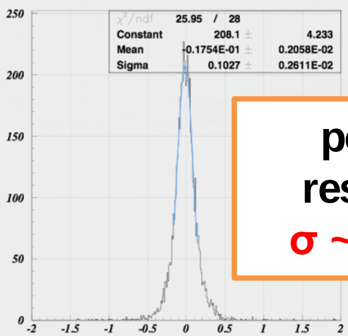
Test Beam Results with 5 Layer Test Chamber



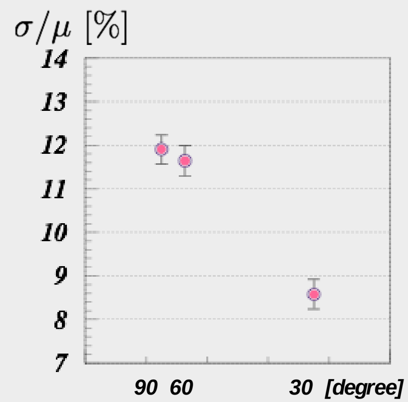
X-t relation (B=0T)

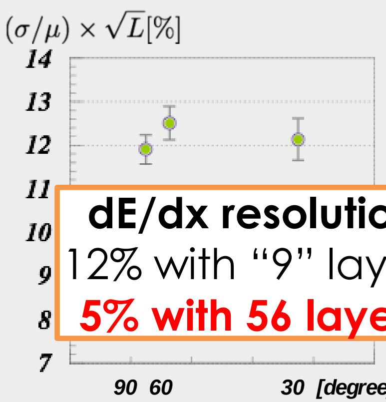


Residual distribution



position resolution
σ ~ 100μm

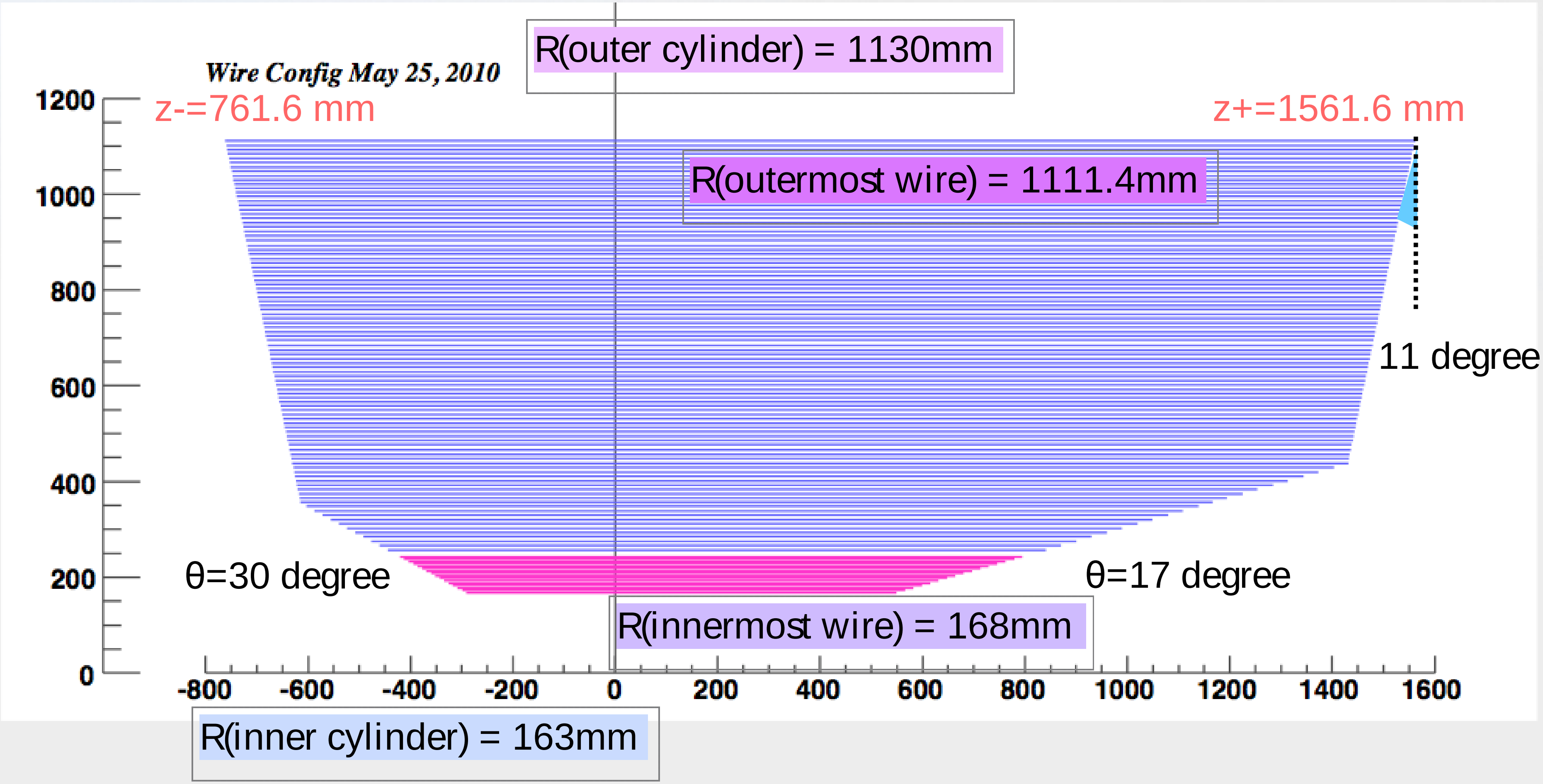




incident angle

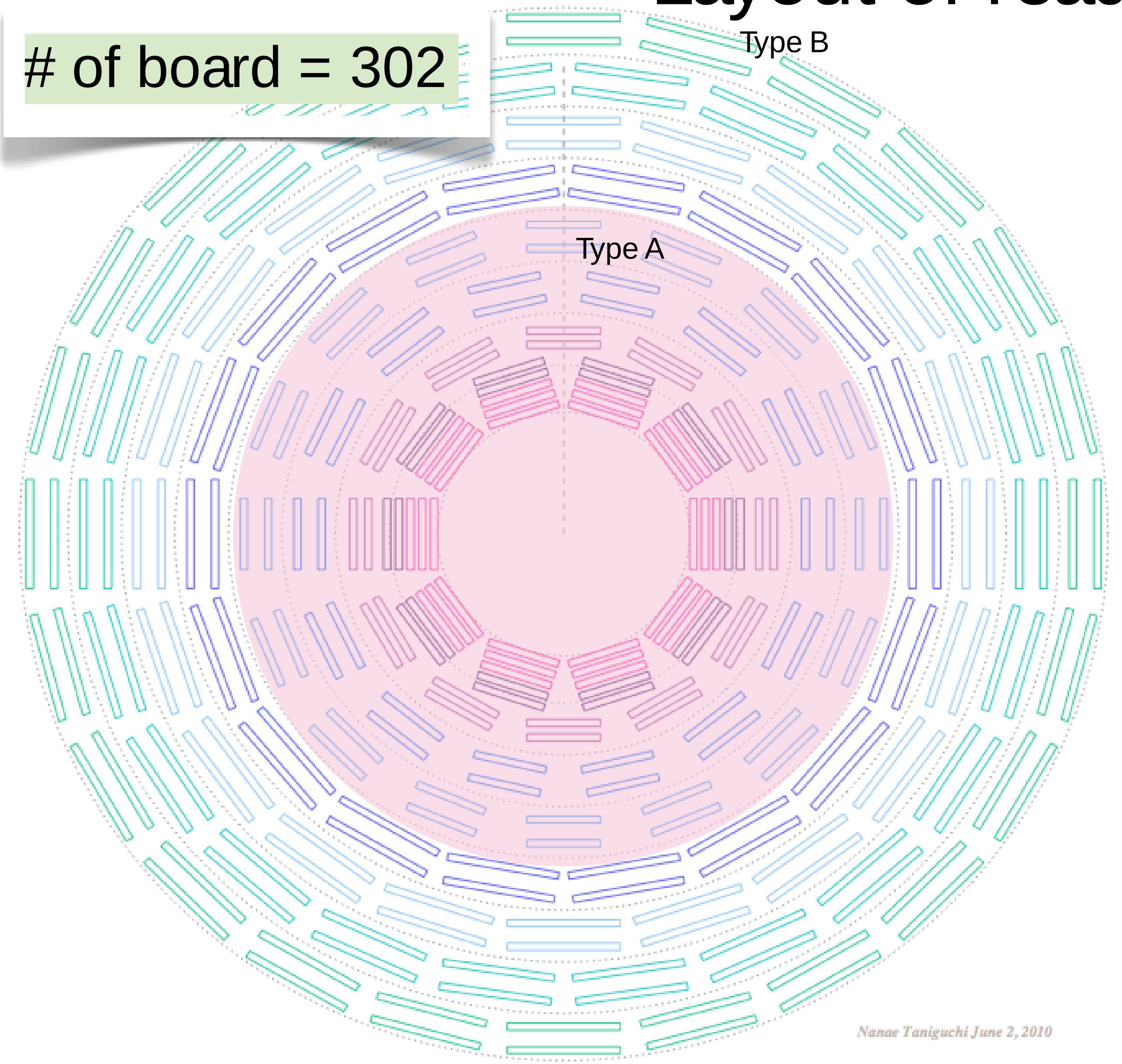
dE/dx resolution
12% with "9" layers
5% with 56 layers

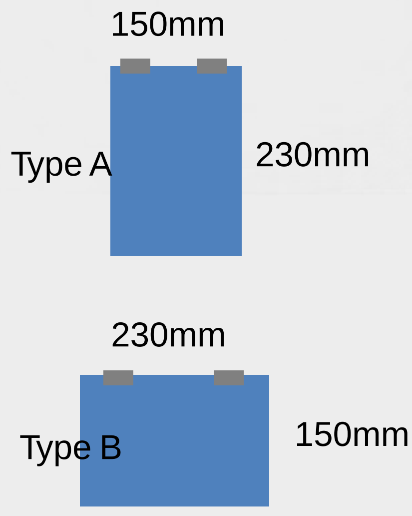
wire configuration



Layout of readout board

of board = 302



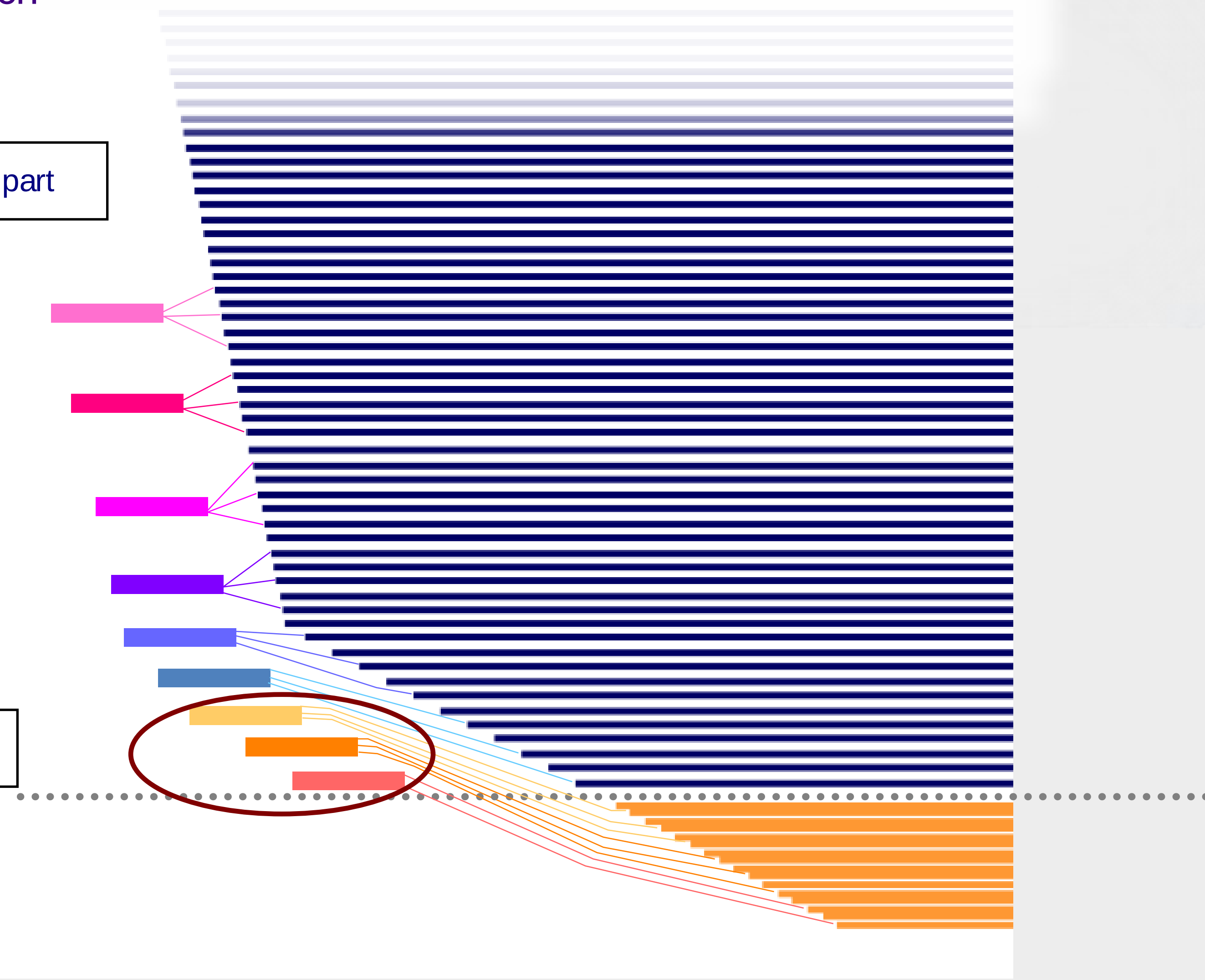


Layout of readout board

48 ch/board = 3 layers x 16ch

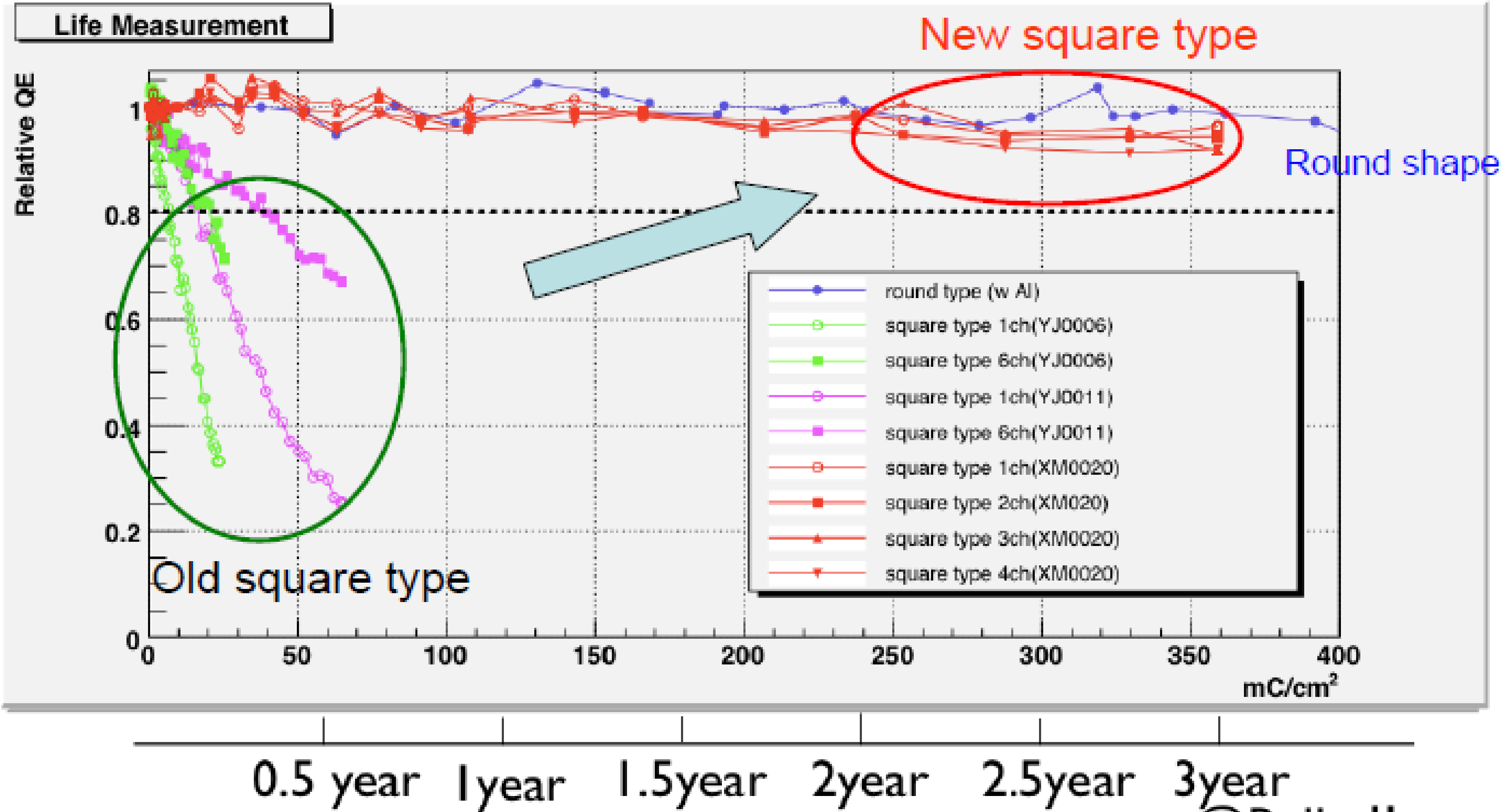
readout board for conical and main part

readout board for small cell



MCP-PMT lifetime result

- QE variation
  - <10% drop at 350mC/cm^2 ; <u>sufficient lifetime</u>



@Belle-II

Key points of ECL upgrade

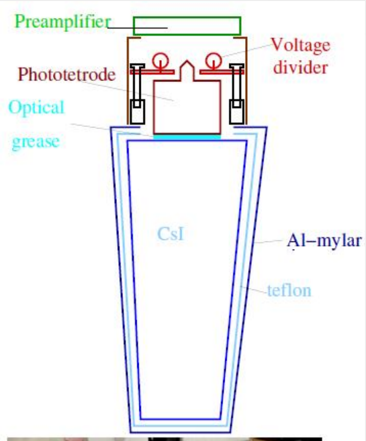
End caps

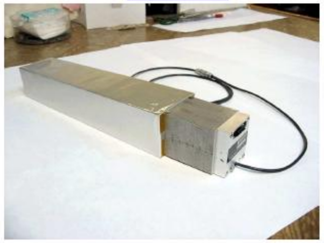
Background is the biggest issue → Faster crystal CsI(Tl) $\tau \sim 1\mu s \rightarrow$ pure CsI $\tau \sim 30ns$ → Small light yield UV → PMT

Barrel

Background is the biggest issue, but not as bad as end caps → Waveform sampling & fitting

One more issue:
Material inside ECL changes (reduces)

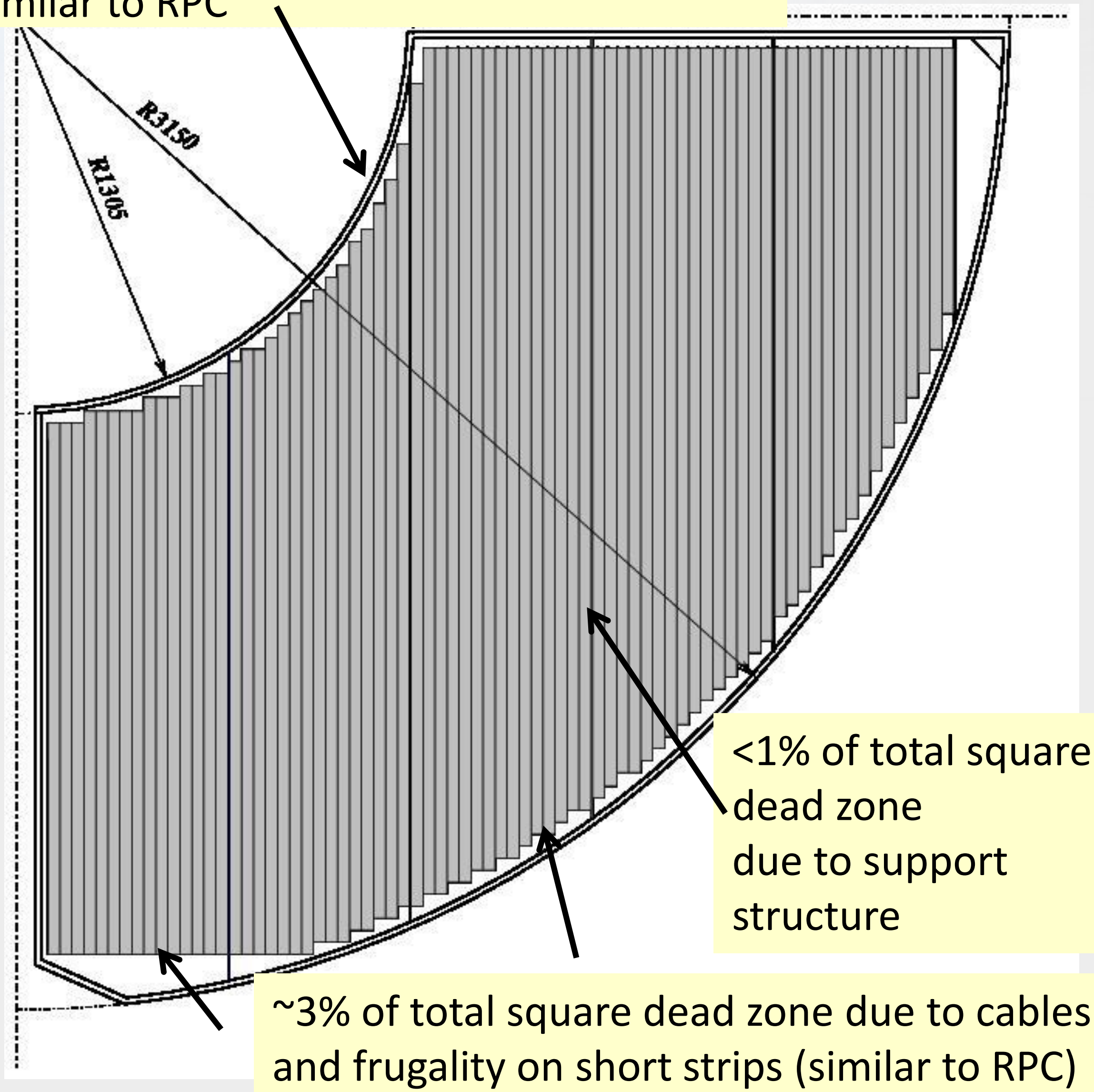




by P. Pakhlov

progress on scintillator KLM

~0.3% of total square dead zone due to inscription of rectangular strips in circle similar to RPC

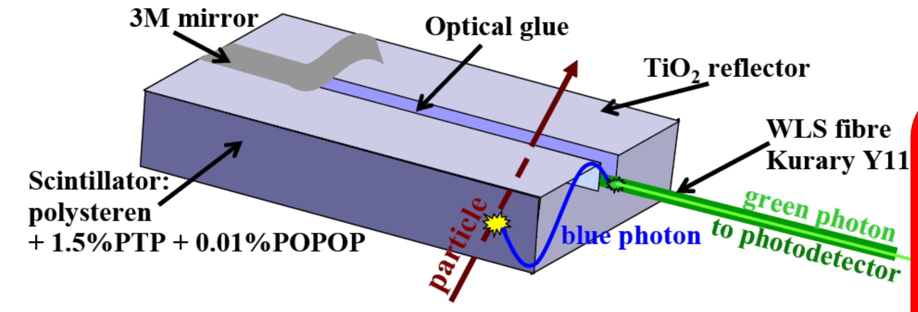


<1% of total square dead zone due to support structure

~3% of total square dead zone due to cables and frugality on short strips (similar to RPC)

GENERAL LAYOUT

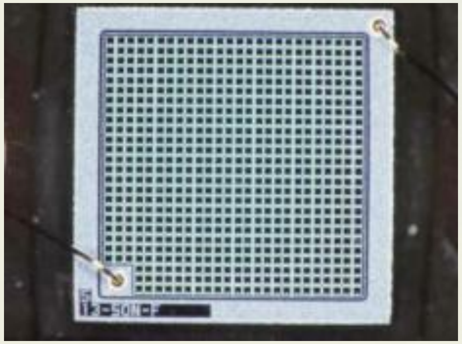
- One layer: 75 strips (4 cm width)/sector
- 5 segments
  1 segment = 15strips
- Two orthogonal layer = superlayer
- F&B endcap KLM:
  - Total area ~1400 m^2
  - 16800 strips
  - the longest strip 2.8 m; the shortest 0.6 m
- WLS fiber in each strip
- SiPM at one fiber end
- mirrored far fiber end



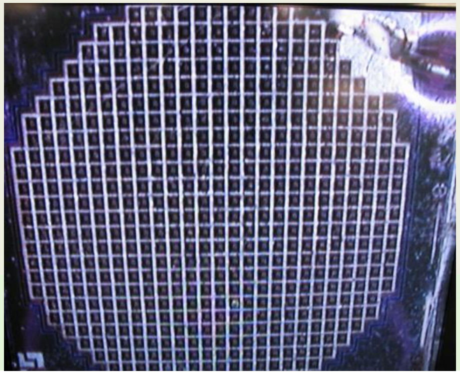
MPPC

by P. Pakhlov

Hamamatsu
1.3×1.3 mm 667 pixels
specially designed for
T2K 60k produced



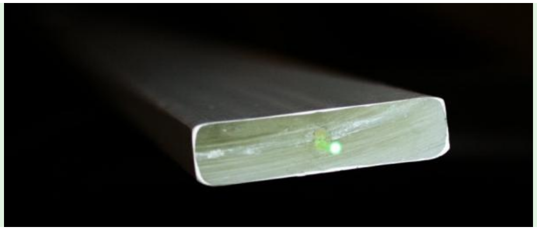
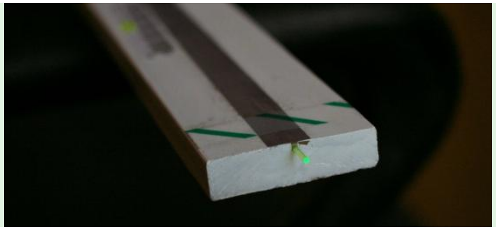
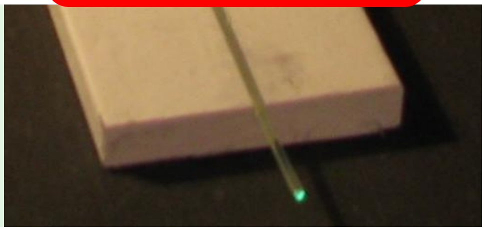
CPTA, Moscow
1.25×1.25 mm 720 pixels
10k produced (used in
few small experiments)



Fiber

Kuraray Y11 MC
No other competative option
High efficiency; long atten. length

Scintillator

Fermilab (USA) (used in T2K ND)	Kharkov (Ukraine) (used in OPERA)	Vladimir (Russia) (used in T2K ND)
		
1 m prototype tested; 100 strips 3m are produced is being transported to ITEP	1 m prototype tested (produced 3 years ago); 200 strips 3m ordered; Producer still can not reproduce previous quality	1 m prototype tested (T2K scintillator); 200 strips 3m ordered; To be produced in Dec09-Jan10

Support structure

Full size aluminum frame prototype was produced in ITEP,

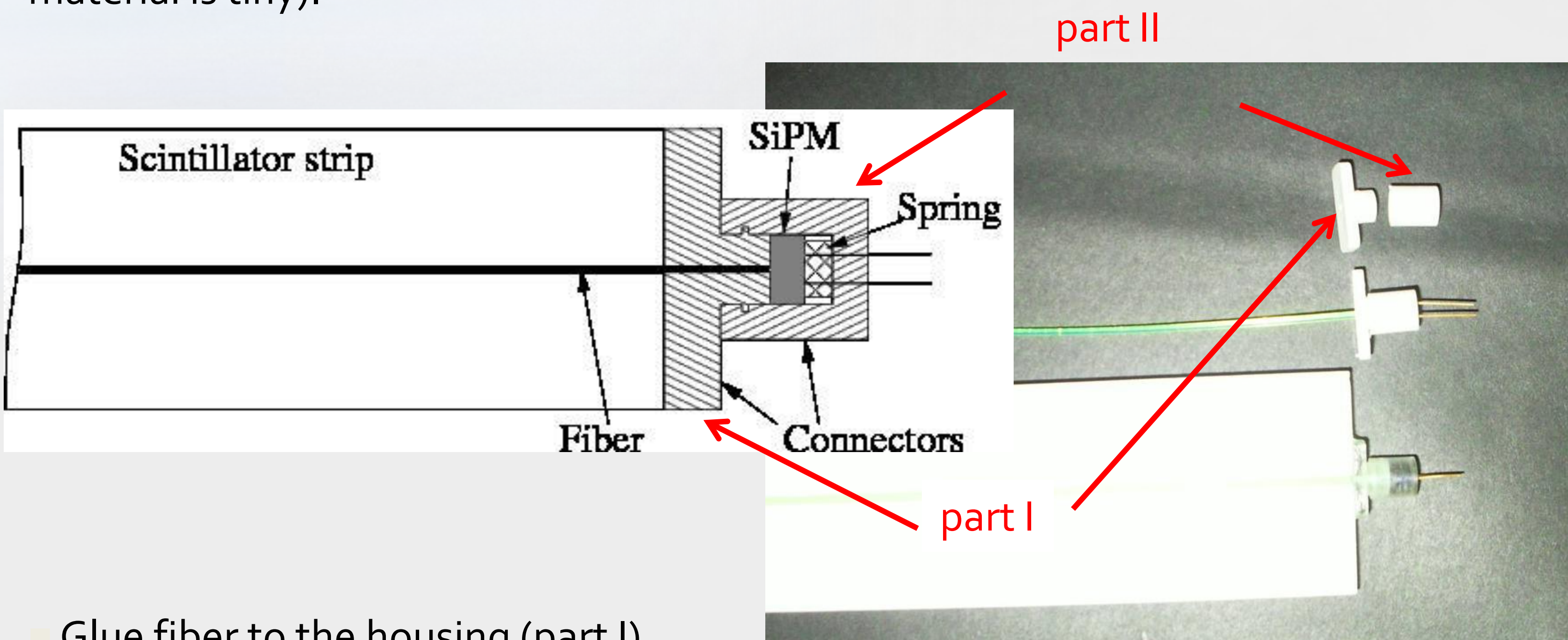
I-profiles net is screwed to the frame

filled with plywood mockup of scintillator segments edges.

The rigidity of the construction was checked by adding extra weight and trying to rotate the frame

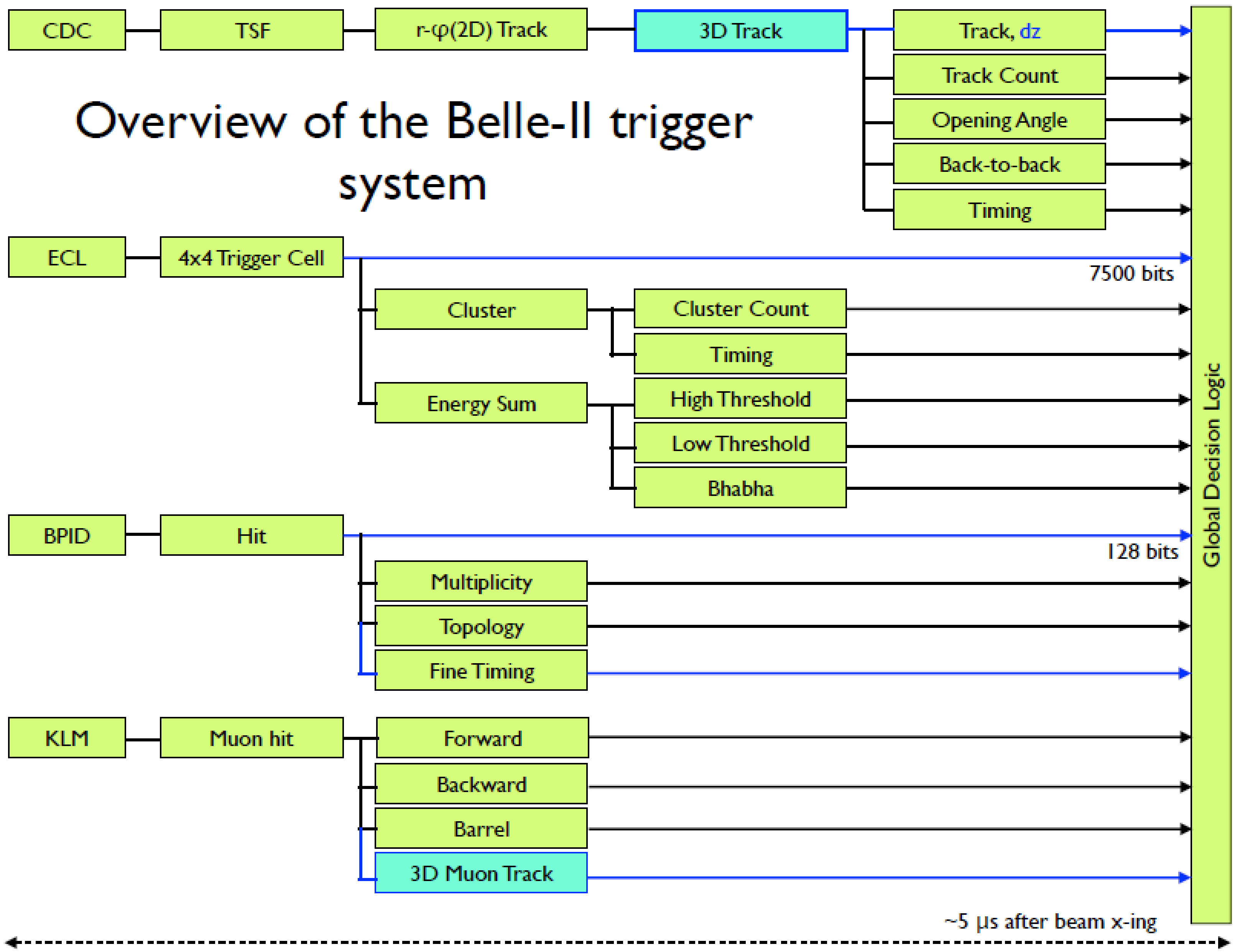
SiPM housing

Should fix MPPC to fiber and strip (with 100 micron alignment between MPPC and fiber). Produced after several iterations by Vladimir. It is checked that it provides strong fixation. (Important! MPPC's pins are made of magnetic material, though the amount of this material is tiny).

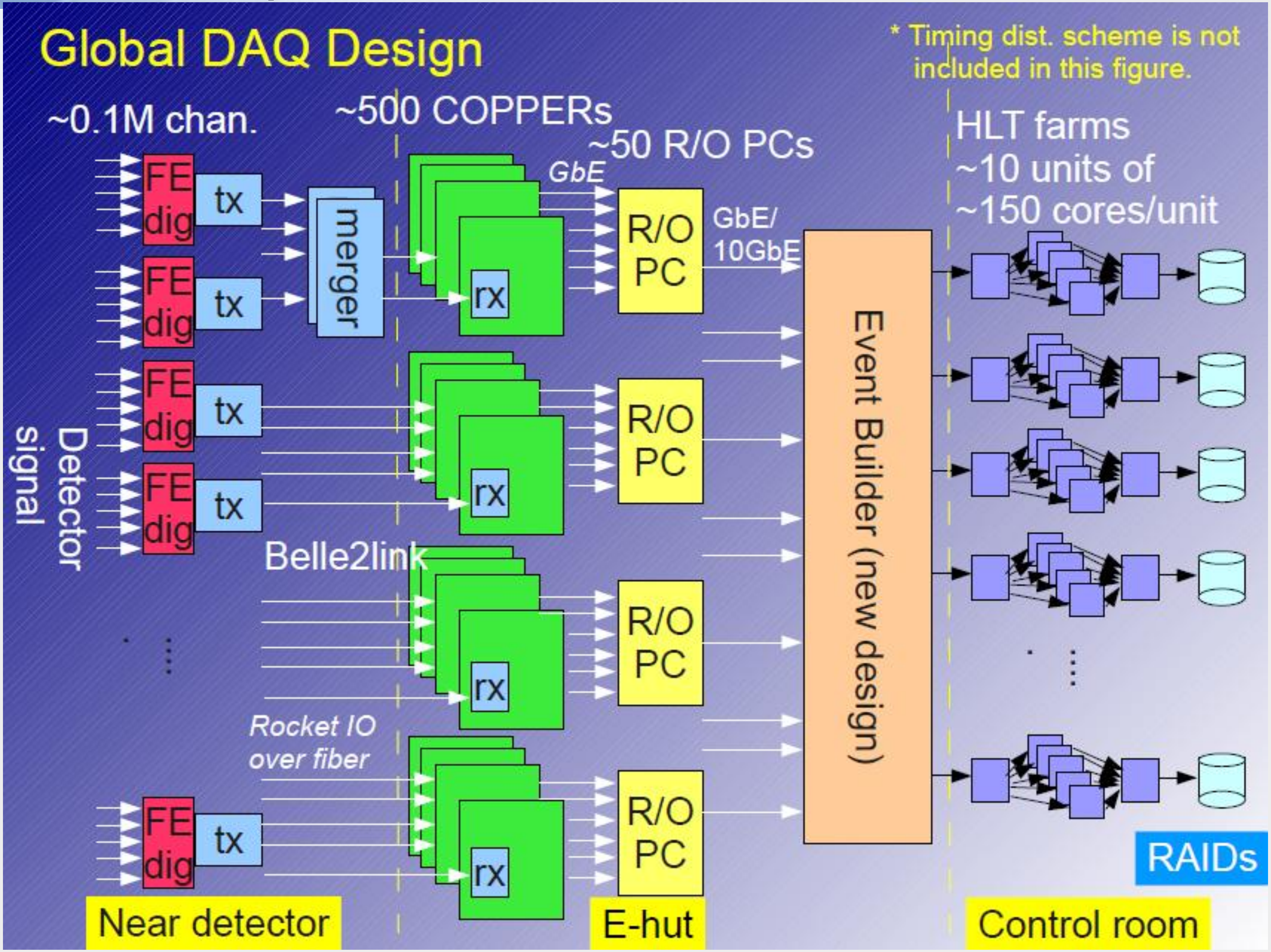


- Glue fiber to the housing (part I)
- Polish fiber end together with housing edge.
- Glue part I to the strip end (no good alignment required).
- Put rubber spring and MPPC to part II.
- Fasten part II to part I.

Level 1 Trigger



Data Acquisition



Belle II Computing Model

Grid-based Distributed Computing

Common framework
for DAQ and offline
based on root I/O