SuperKEKB/Belle II

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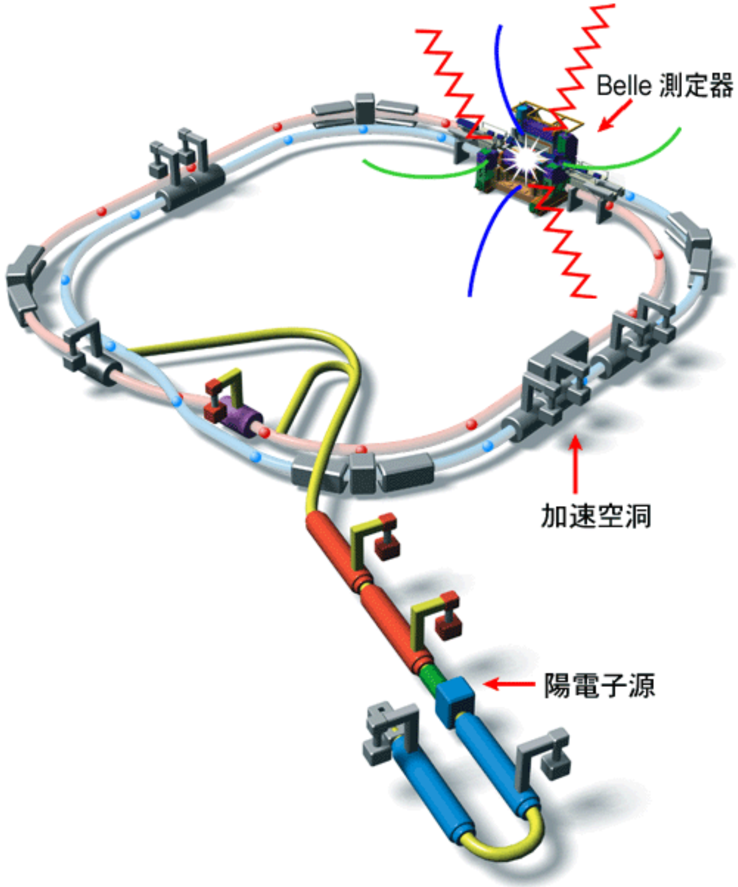
Hadron2013, Nara

2013 Nov. 8th

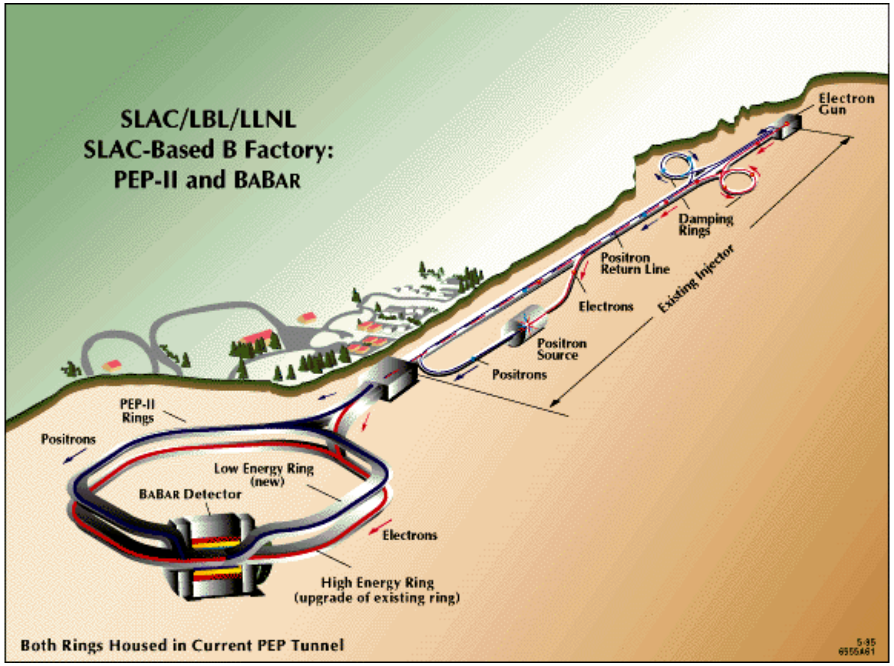
Outline

- Lessons from B-factories
- What we can expect with higher luminosity
- SuperKEKB accelerator and Belle II detector construction status/schedule
- Summary

B-factories

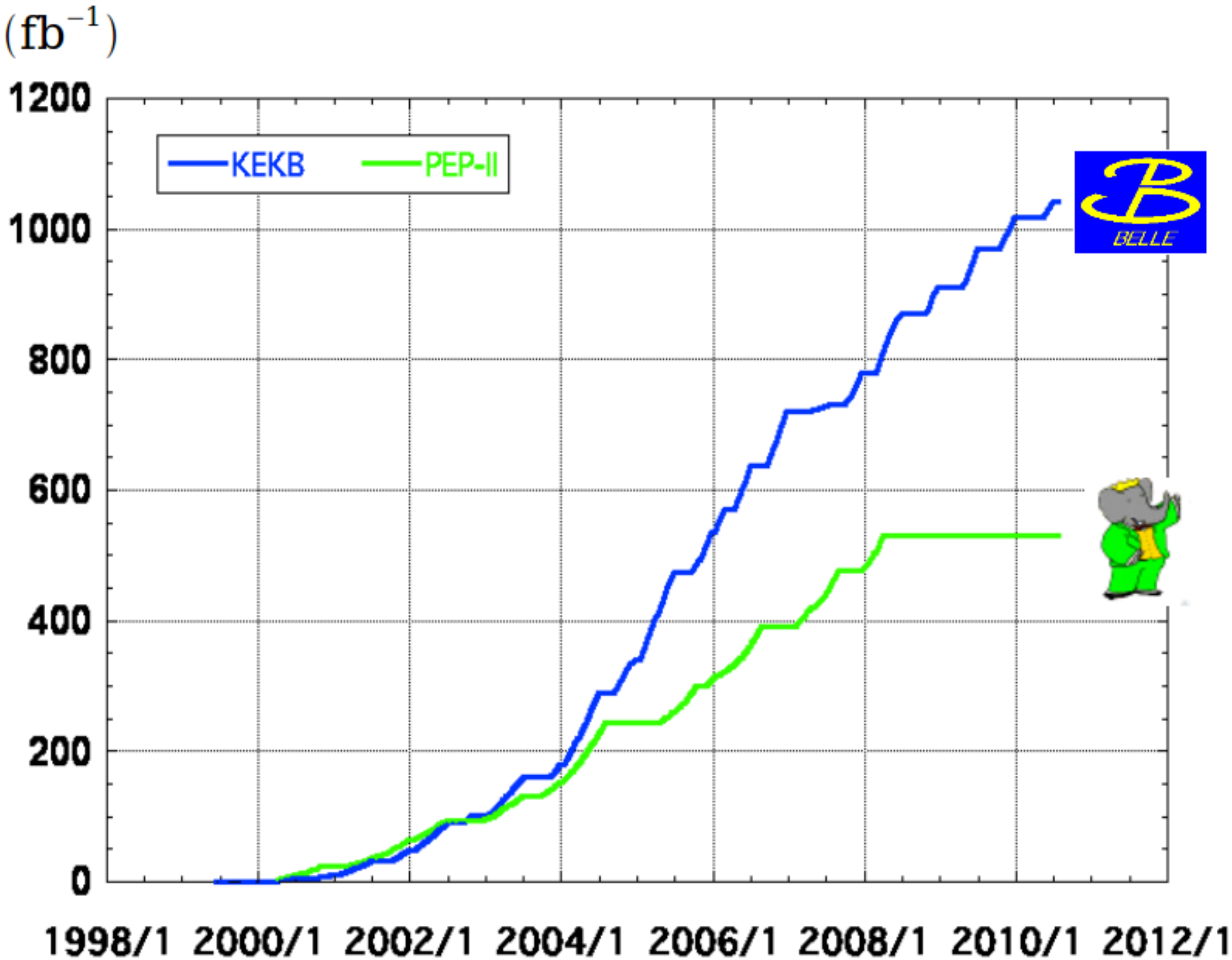


KEKB&Belle 8GeV×3.5GeV



PEP II&BaBar 9GeV×3.1GeV

Integrated luminosity of B factories



$> 1\ ab^{-1}$

On resonance:

$\Upsilon(5S)$: 121 fb^{-1}

$\Upsilon(4S)$: 711 fb^{-1} 772M $B\overline{B}$

$\Upsilon(3S)$: 3 fb^{-1}

$\Upsilon(2S)$: 25 fb^{-1}

$\Upsilon(1S)$: 6 fb^{-1}

Off reson./scan:

$\sim 100\ fb^{-1}$

$\sim 550\ fb^{-1}$

On resonance:

$\Upsilon(4S)$: 433 fb^{-1} 470M $B\overline{B}$

$\Upsilon(3S)$: 30 fb^{-1}

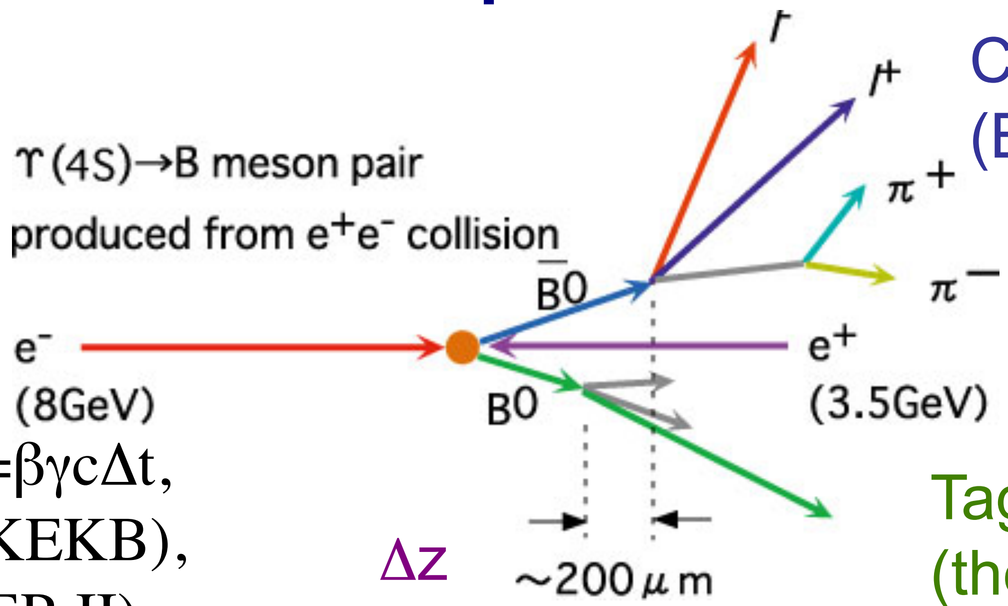
$\Upsilon(2S)$: 14 fb^{-1}

Off resonance:

$\sim 54\ fb^{-1}$

In total, more than 1.5 ab^{-1} including 1G $B\overline{B}$ pairs are recorded at B-factories

Originally in order for time-dependent CPV



CP side
(B to f_{CP})

Tag side
(the other B)

Δz
measurement

$\Delta z = \beta\gamma c \Delta t$,
$\beta\gamma = 0.425$(KEKB),
0.56(PEP-II)

$$A_{CP}(\Delta t) = \frac{\Gamma(\overline{B}^0(\Delta t) \to f_{CP}) - \Gamma(B^0(\Delta t) \to f_{CP})}{\Gamma(\overline{B}^0(\Delta t) \to f_{CP}) + \Gamma(B^0(\Delta t) \to f_{CP})} = S_{f_{CP}} \sin(\Delta m \Delta t) + A_{f_{CP}} \cos(\Delta m \Delta t)$$

This is very demanding measurement, requires sophisticated detector and analysis methodology!

All these are great benefit

4π general purpose spectrometer with

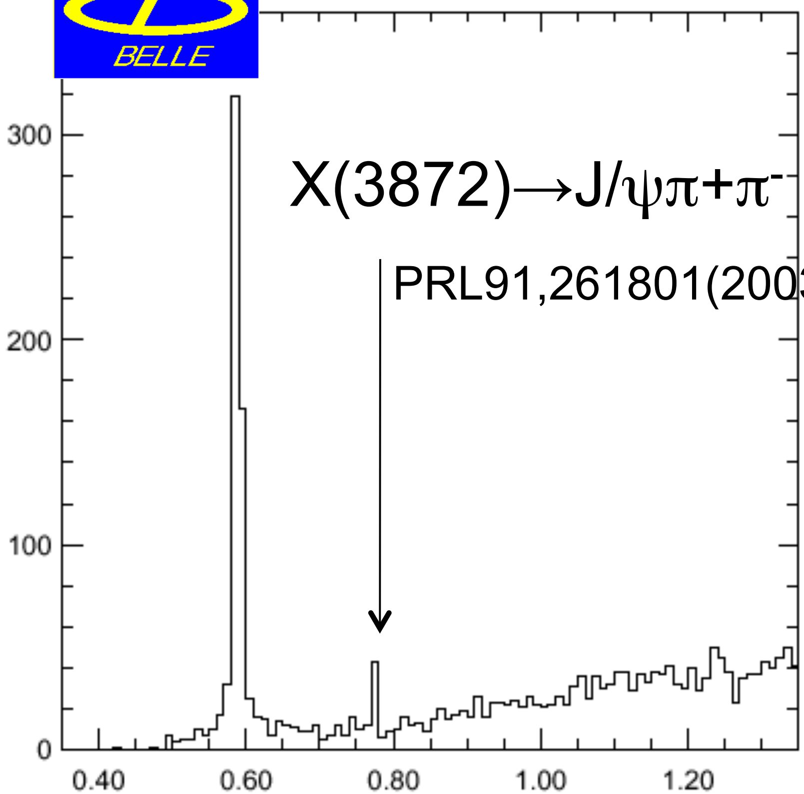
- High momentum resolution, σ_p/p = 0.3%@1GeV/c.
- Ability to detect γ down to 30 MeV.
- Good γ energy resolution, σ_M =5MeV for $\pi^0 \to \gamma\gamma$.
- Lepton identification capability, ε>0.9, fake<0.01.
- K/π/p separation capability, ε~0.9, fake<0.1.
- Excellent B decay vertex reconstruction, $\sigma_{\Delta z}$ =80μm.

+

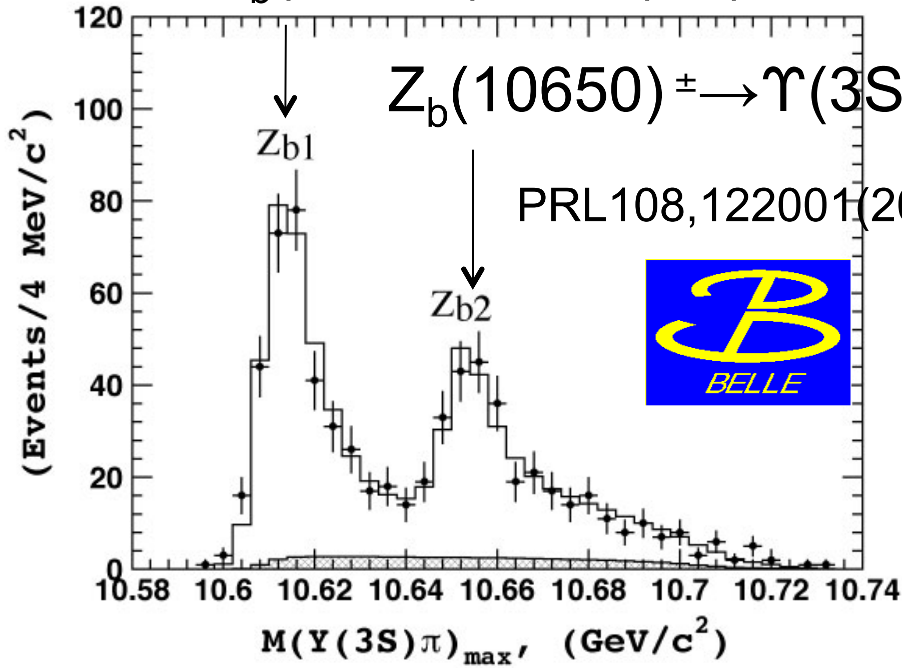
- World highest luminosity

Then, we have had …

A lot of discoveries!



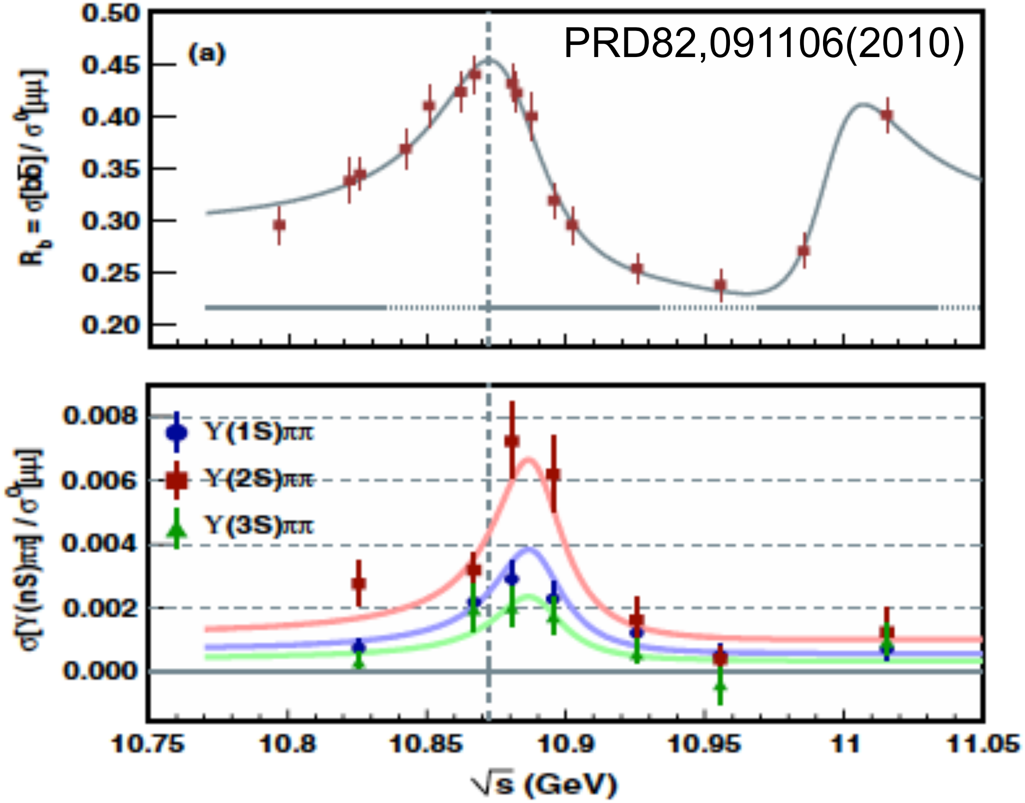
$M_{l+l-\pi+\pi-}$ - M_{l+l-} (GeV)

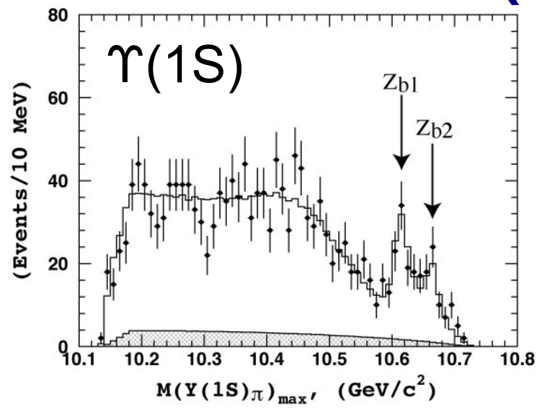


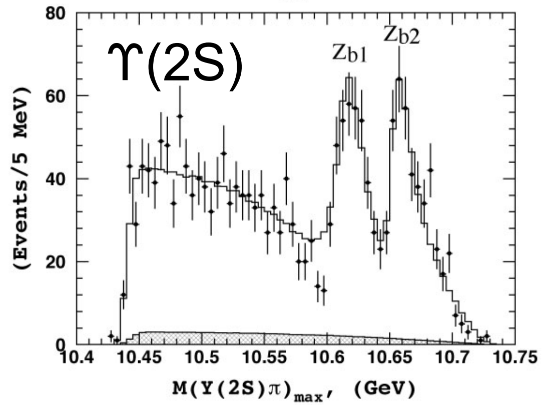
M(ϒ(3S)π±) (GeV)

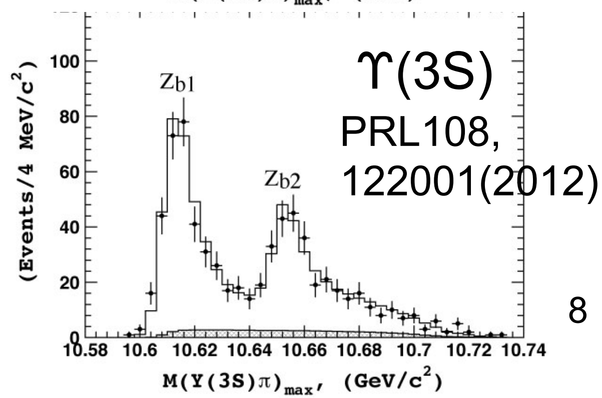
… and more!

Synergy among measurements (I)





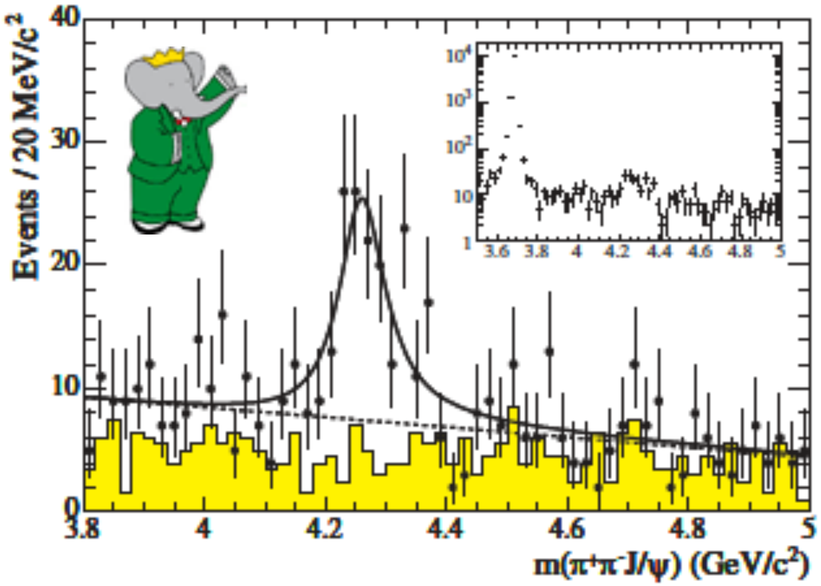




Anomalous $\Upsilon(nS)\pi^+\pi^-$ production at $\Upsilon(5S)$

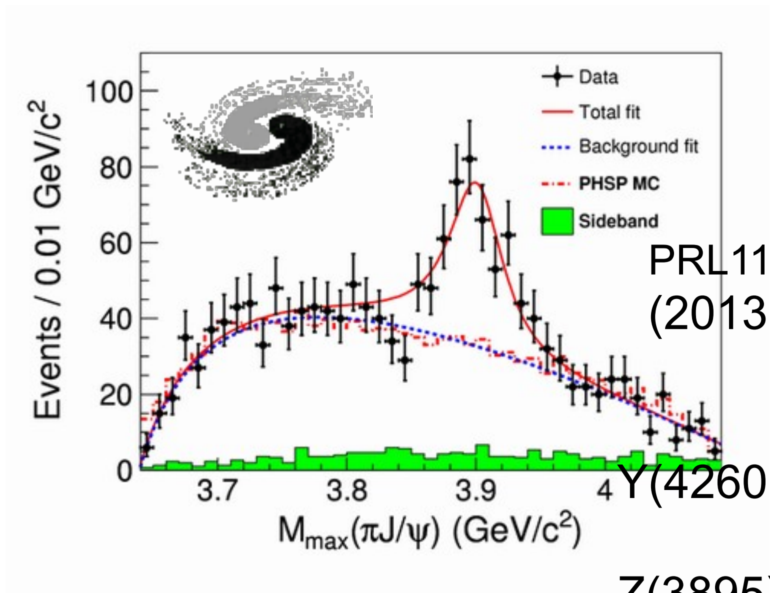
$\rightarrow Z_b^+$ in $\Upsilon(nS)\pi^+$

Synergy among measurements (II)



BaBar discovered $Y(4260) \to J/\psi\pi^+\pi^-$ in Initial State Radiation

PRL95, 142001 (2005)

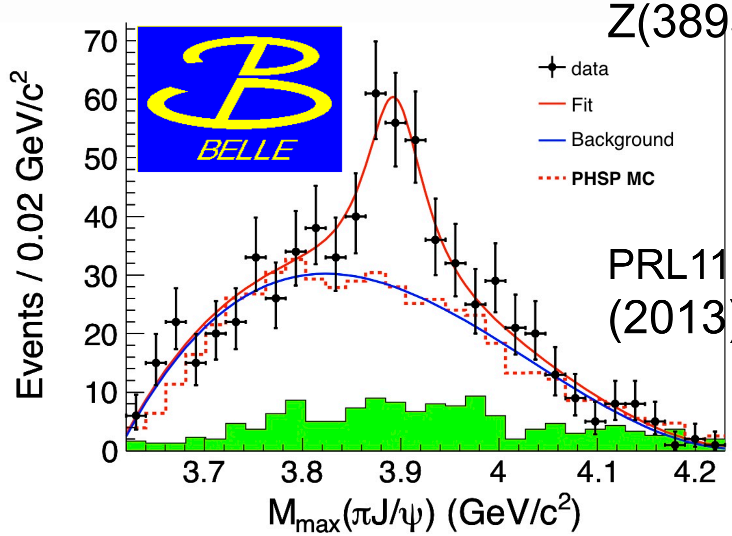


PRL110,252001 (2013)

$Y(4260) \to J/\psi\pi^+\pi^-$

↓

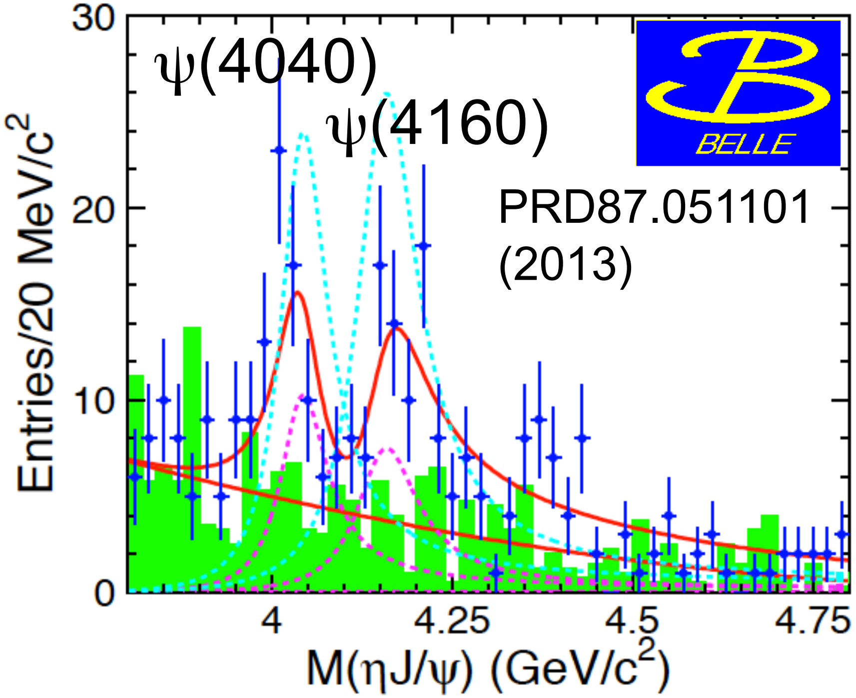
$Z(3895)^+$ in $J/\psi\pi^+$



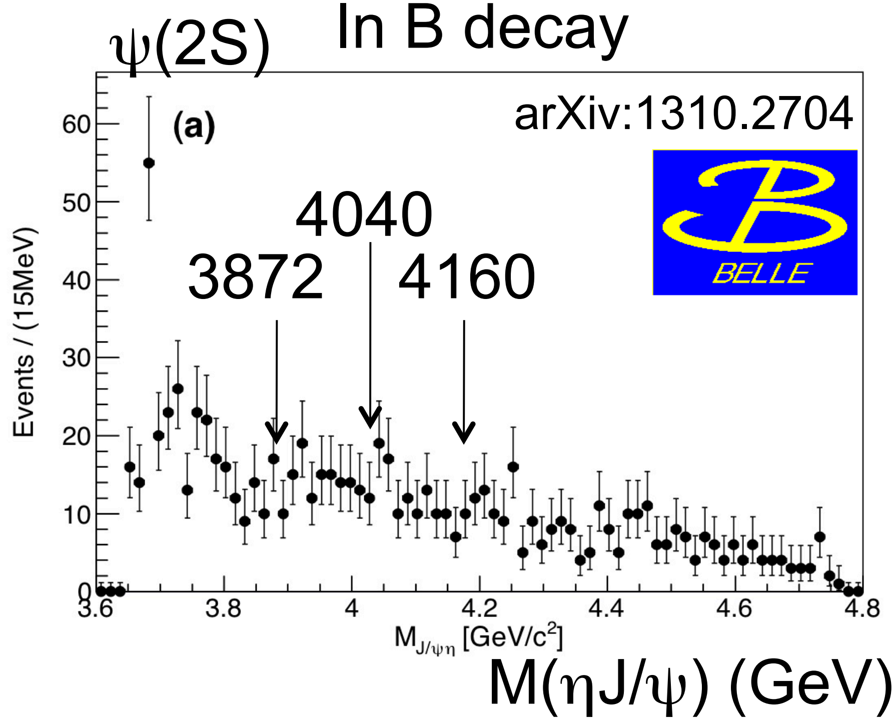
PRL110,252002 (2013)

Synergy among measurements (III)

In ISR

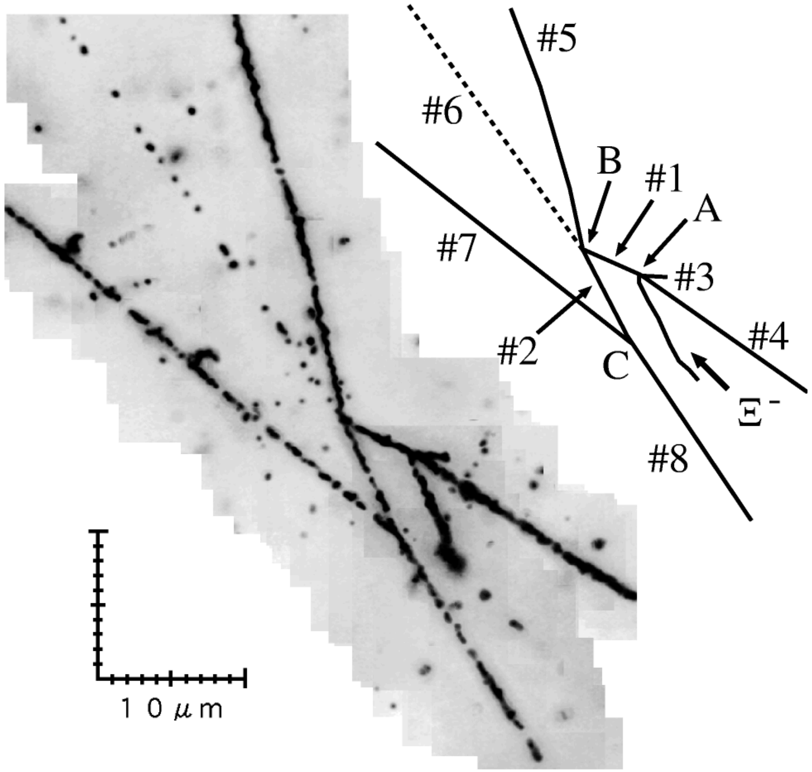


In B decay

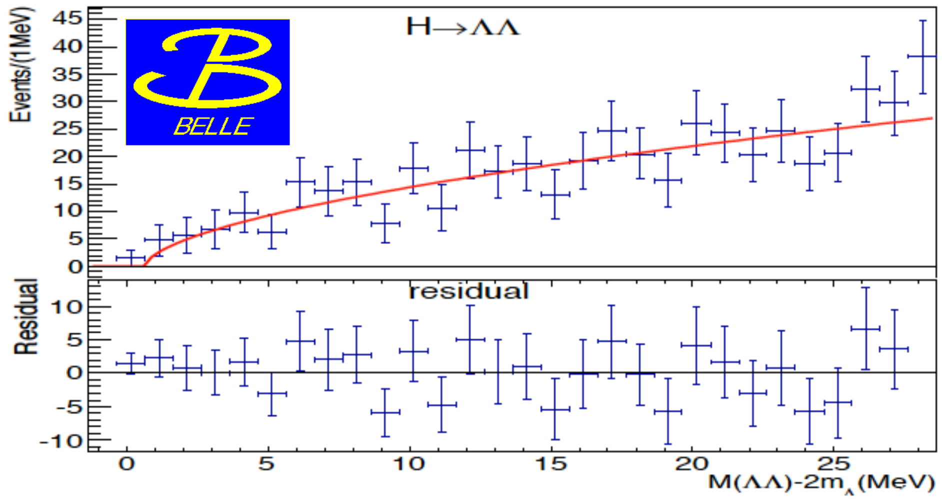


For $\psi(4040)$ and $\psi(4160)$, "seen in ISR" imply a few % branching fraction to $J/\psi\eta$, compatible with "unseen in B decay".
→comprehensive understanding.

Synergy with other exp. (I)



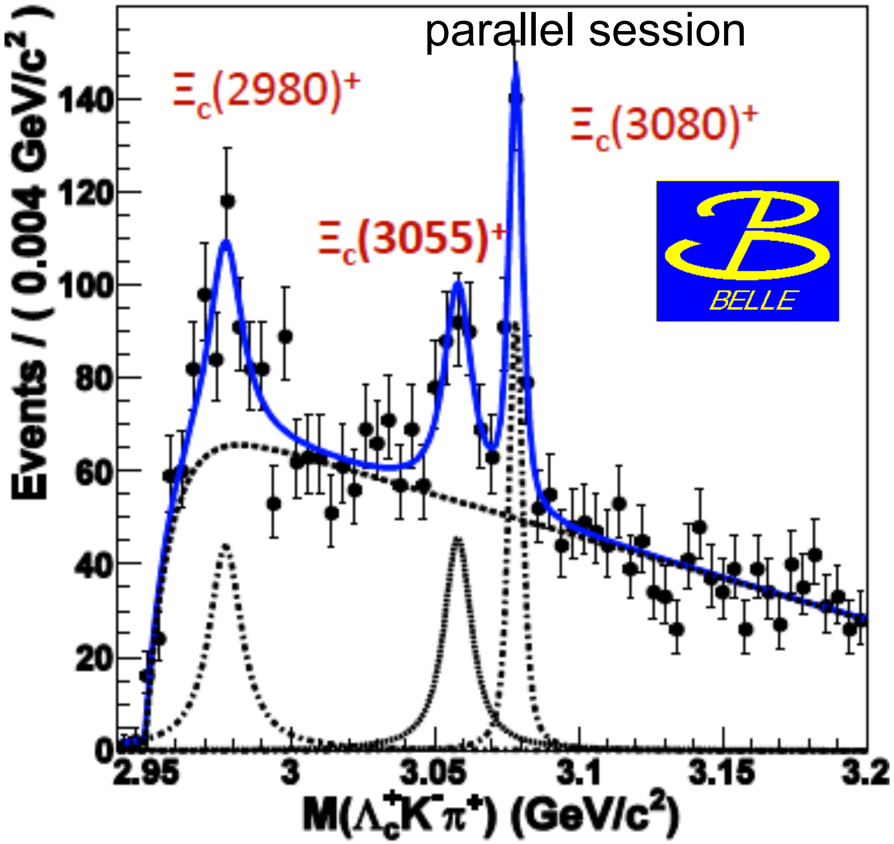
"NAGARA" event
PRL87,212502(2001)



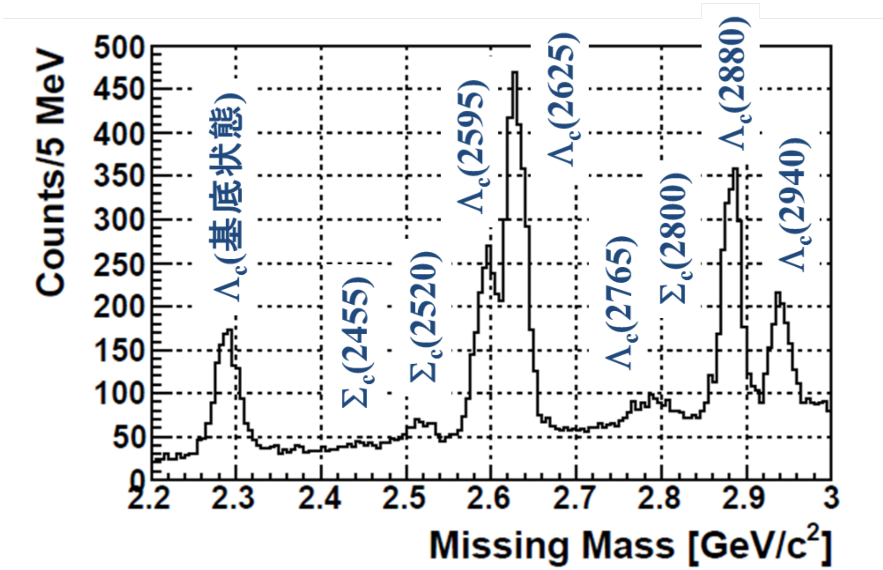
Search for H-dibaryon in ϒ(1S) and ϒ(2S) decays have been performed.
PRL110,222002(2013)

Synergy with other exp. (II)

Y.Kato, talk given in parallel session



J-PARC P50 proposal
$\pi N \rightarrow D^* Y_c$
(Y_c: charmed baryon)



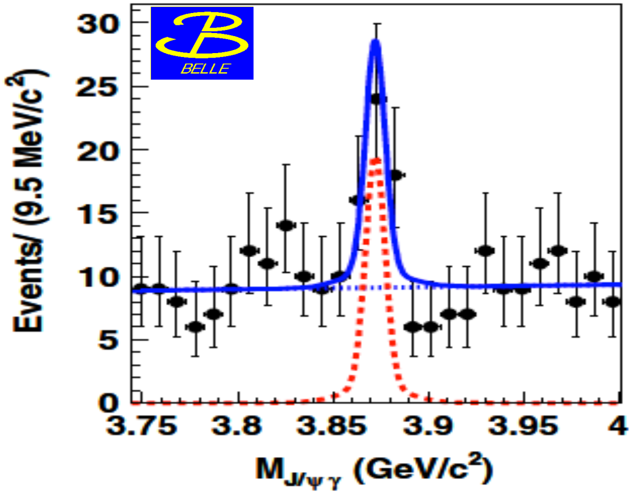
MC: assuming 1nb for Λ_c.

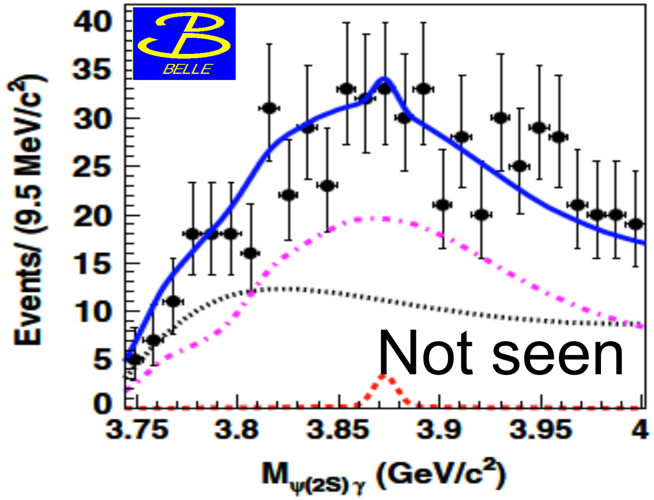
Exclusive reconstruction ⇄ missing mass technique complementary each other.

Limitation at current statistics (I)

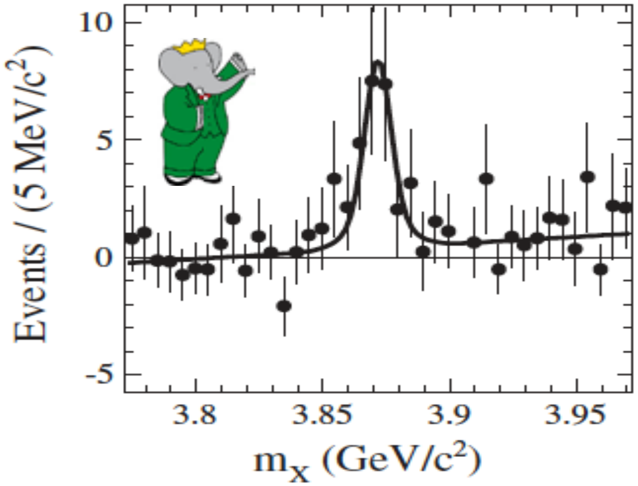
X(3872)→J/ψ γ : established

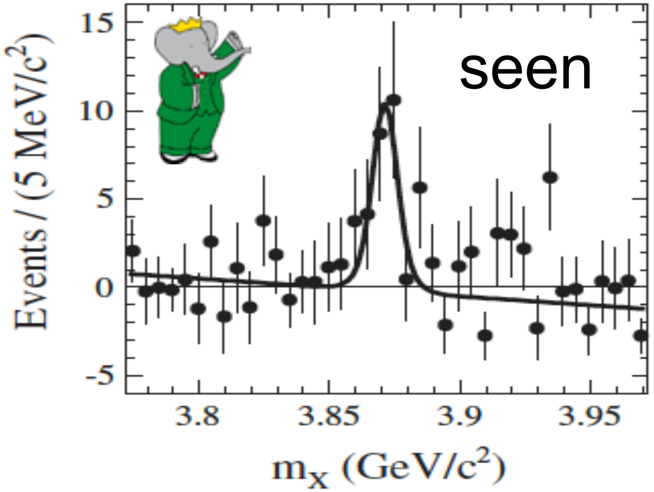
X(3872)→ψ(2S) γ : contradicting





PRL107,091803(2011)

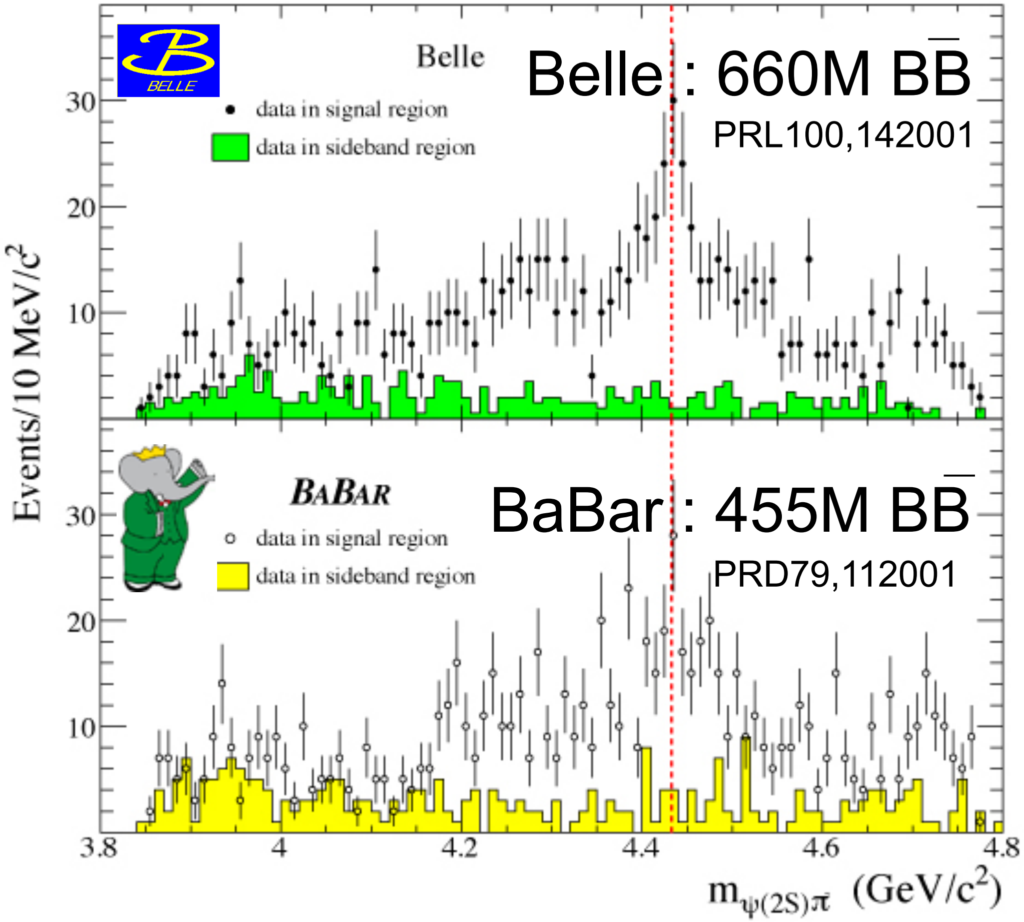




This puzzle can only be solved by a higher statistics e^+e^- machine.

PRL102,132001(2009)

Limitation at current statistics (II)



$Z(4430)^{\pm} \rightarrow \psi(2S)\pi^{\pm}$

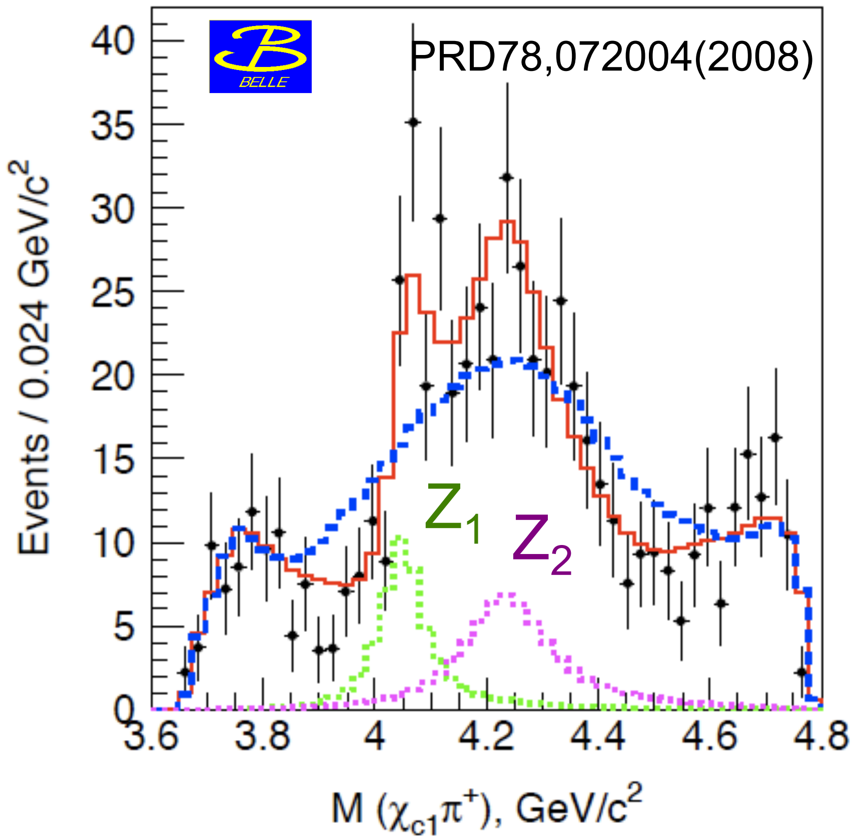
Significant signal at Belle

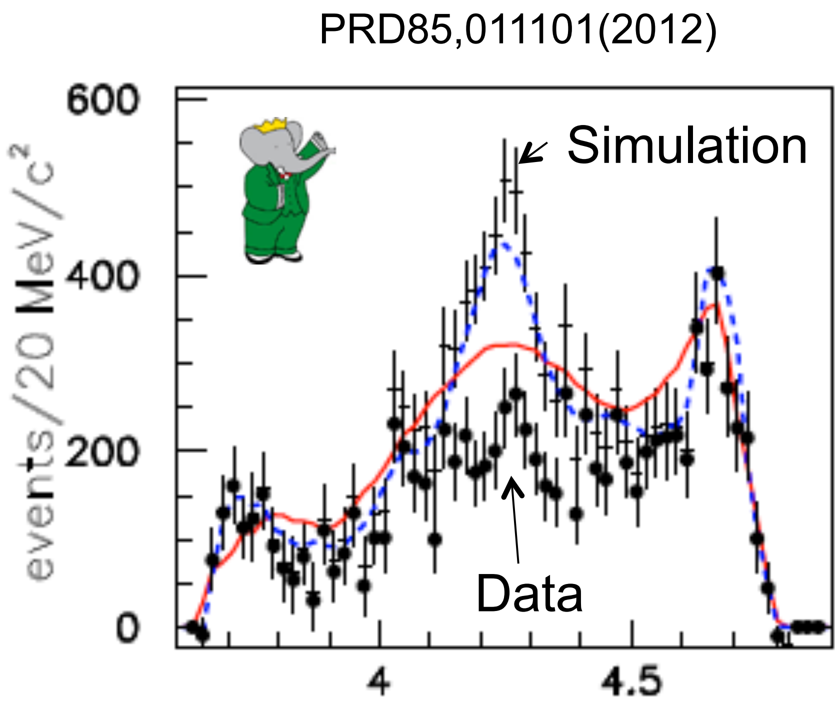
v.s.

Only hint with 1.9σ at BaBar

Statistically, both are not contradicting with each other, but clear answer is to be given by higher statistics data.

Limitation with available statistics (III)





Seen v.s. Unseen, only higher statistics e^+e^- data can give a clear answer.

Lessons from B-factories

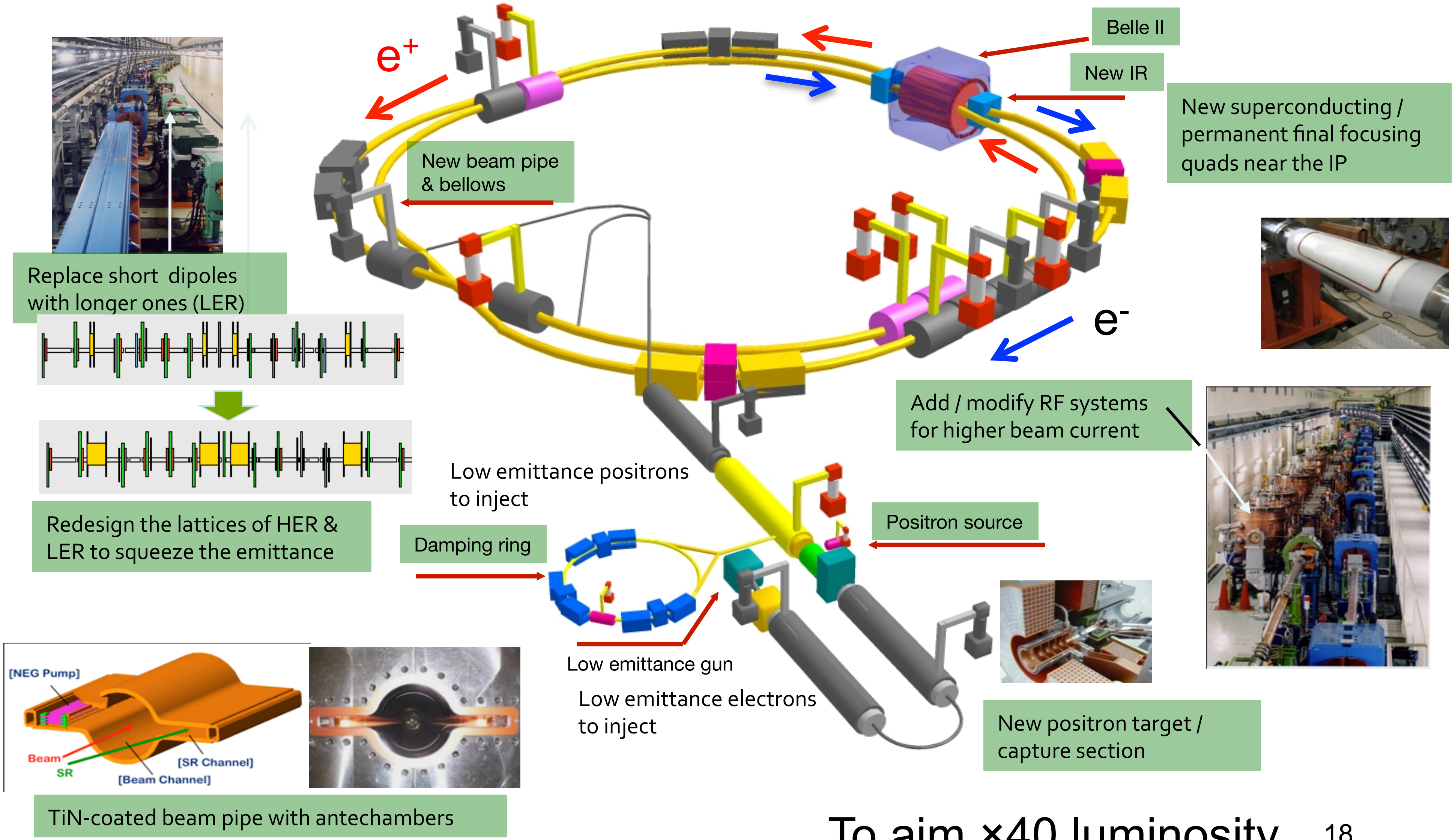
- Challenge good physics even if it looks requiring extraordinary detector performance and analysis methodology.
- It will become huge bonus for other possible topics.
- In order to solve still existing puzzles, we need higher statistics data.

What should we aim further

- Because of variety of recorded reactions, B decay, ISR, two photon collision, bottomonium decays, … B-factories have brought a lot of synergy effects.
  - Among B-factory measurements.
  - With other experiments.
- We have advantage in the detection of γ, π^0, as well as long-lived hyperons.

We want to evolve in this direction!

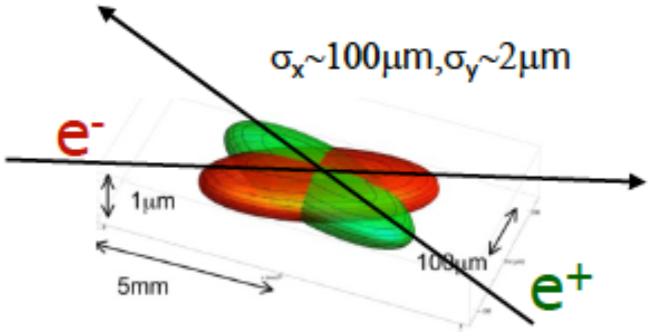
SuperKEKB



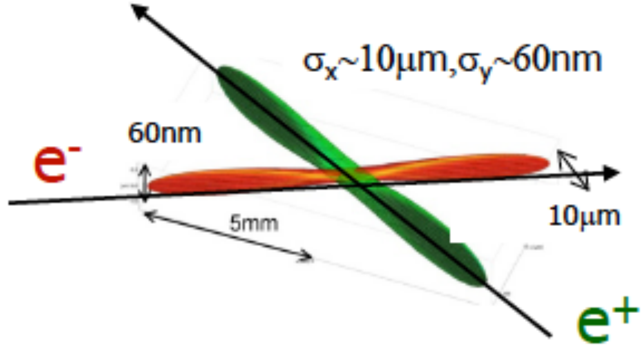
To aim ×40 luminosity

Nano-beam collision

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



KEKB



SuperKEKB

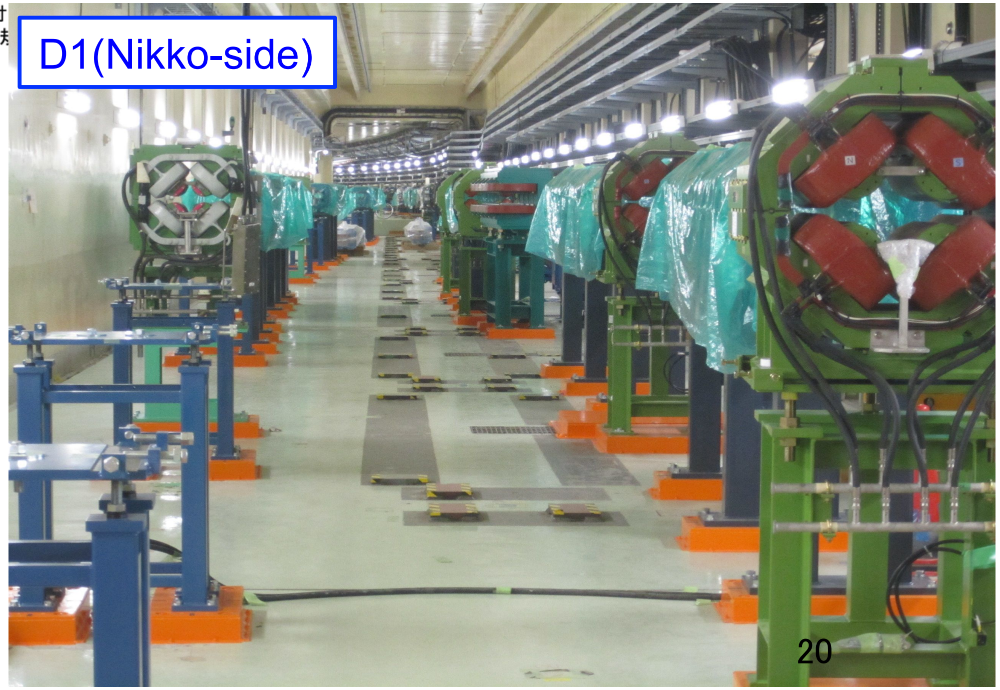
To increase luminosity, small β function is used.
To handle hourglass effect, β>size of collision spot.
→Large crossing angle, one bunch behaves as “super bunch”.

Magnets have been installed

March 2013

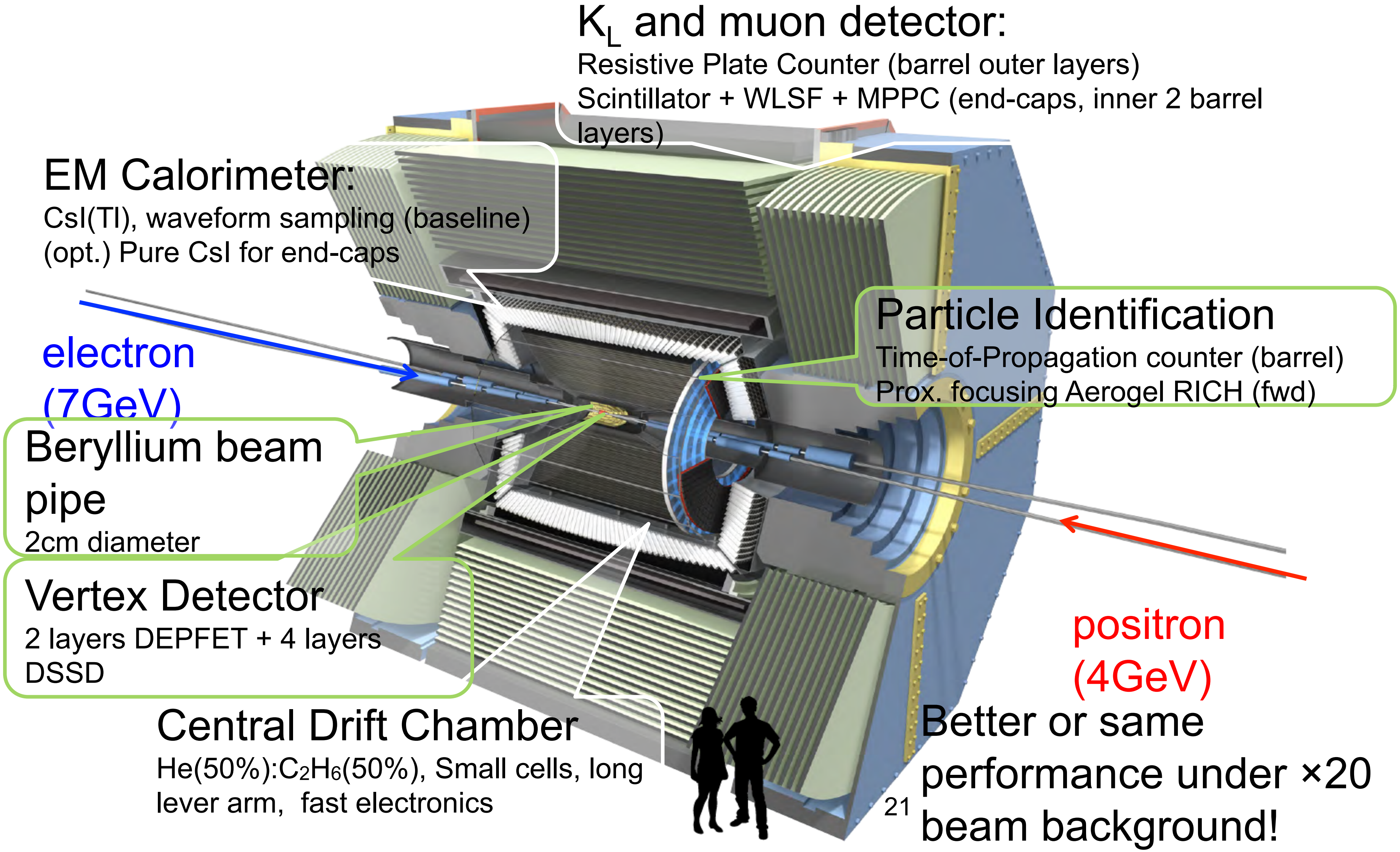
(2)KEKB電磁石撤去済
新ビームライン用測量・罫描き 済
ベースプレート設置進行中

D2(Oho-side)



D1(Nikko-side)

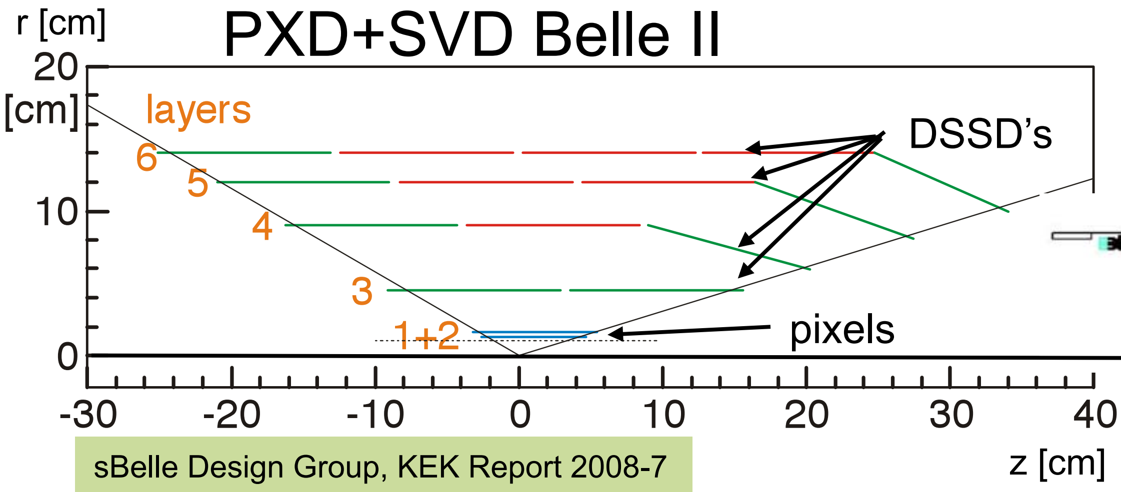
Belle II Detector



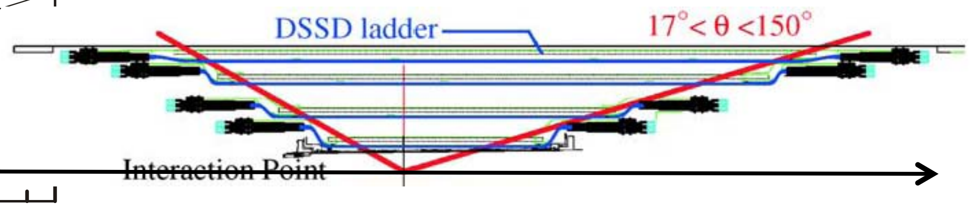
Better or same performance under ×20 beam background!

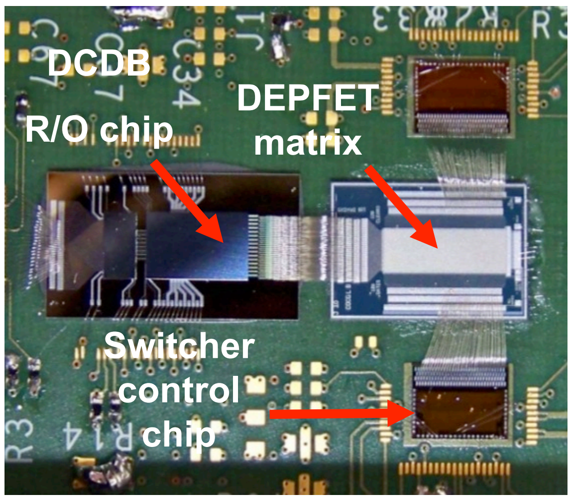
VXD=PXD+SVD

PXD+SVD Belle II



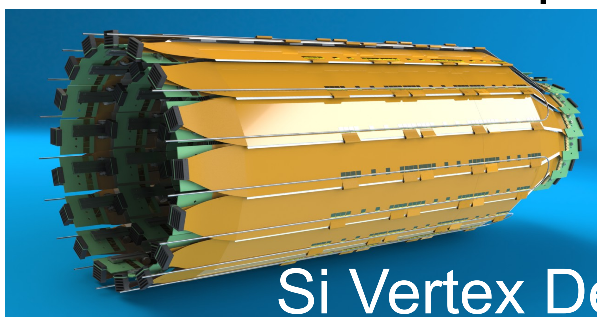
SVD Belle

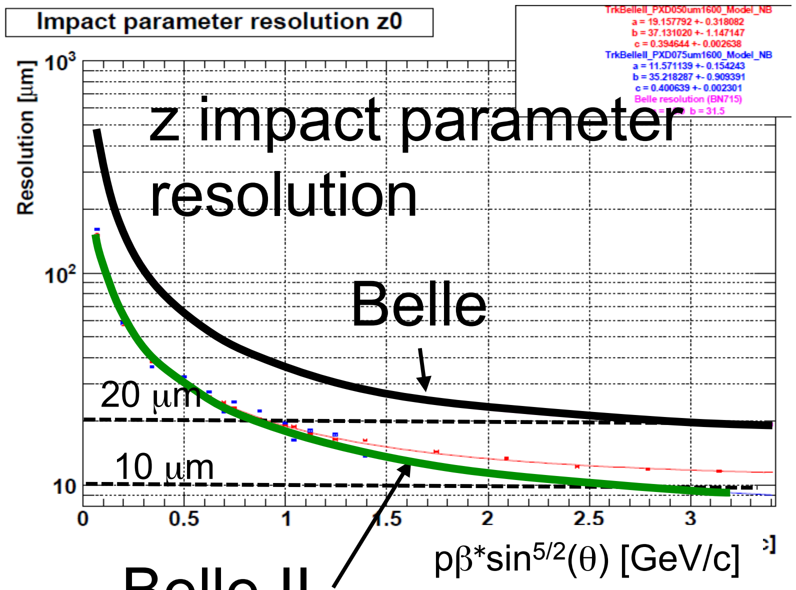




prototype DEPFET sensor

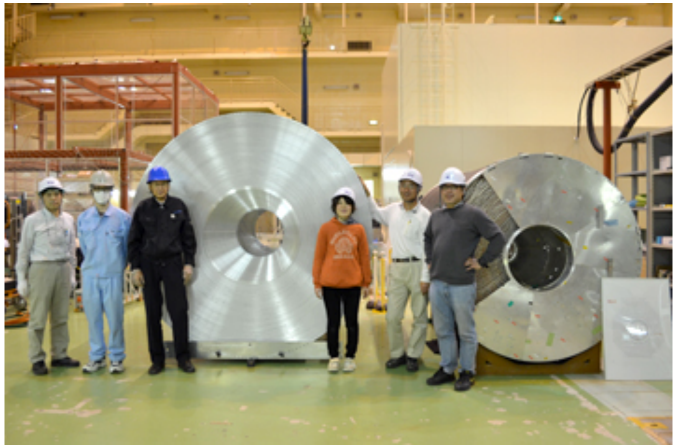
DEPFET mockup



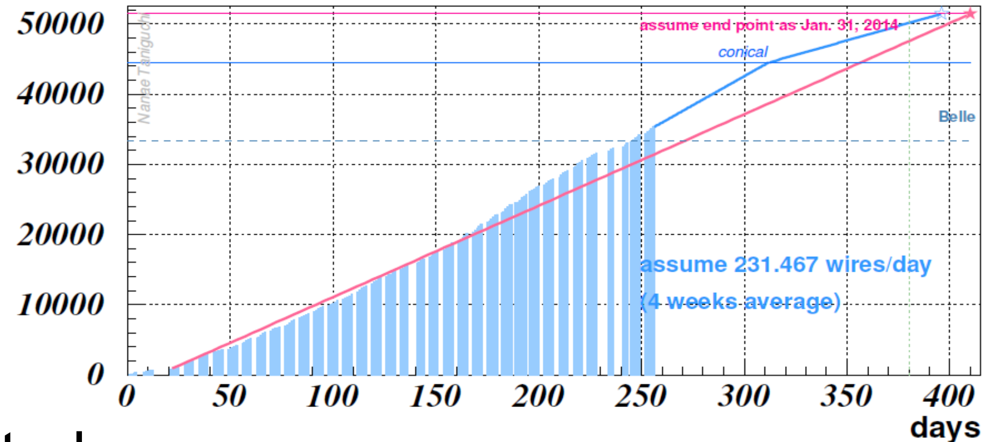


CDC

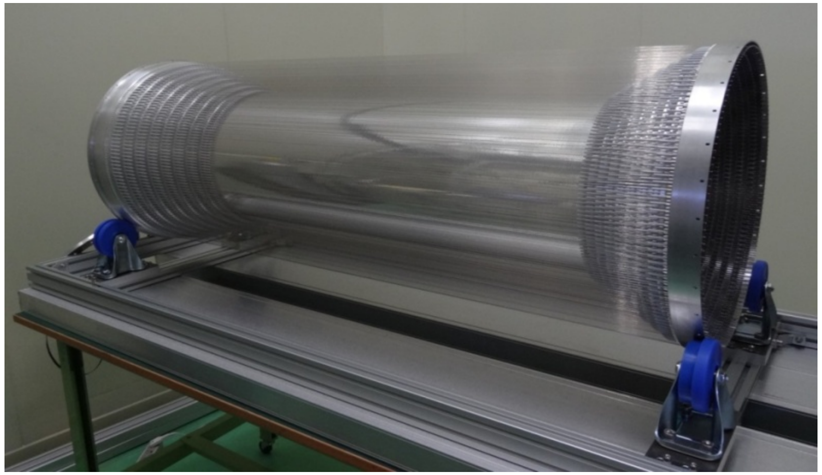
Larger diameter than Belle.

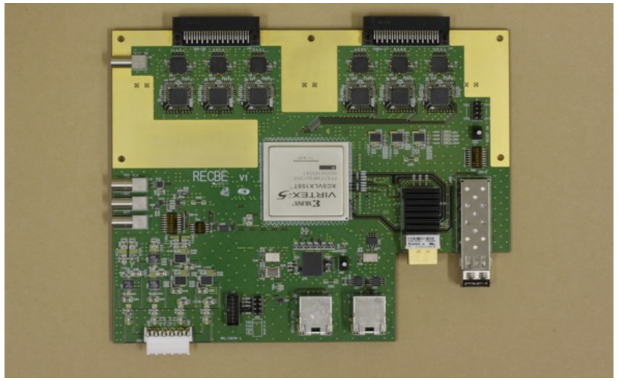


Wire stringing is on going.



Innermost part has been completed

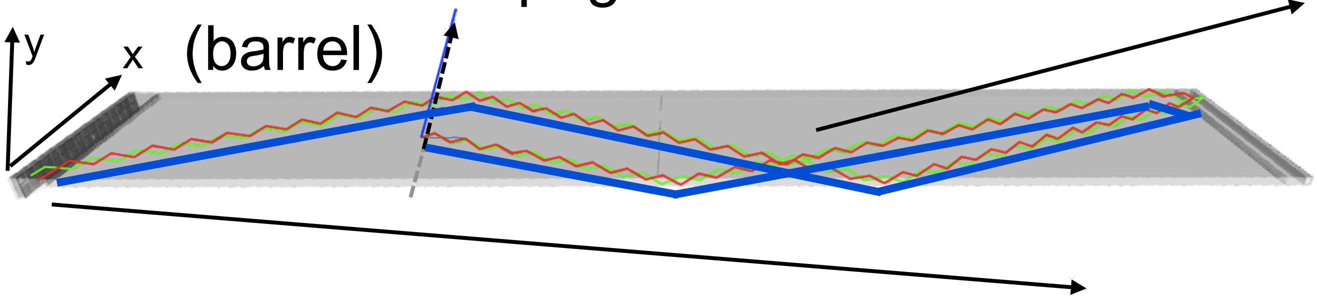


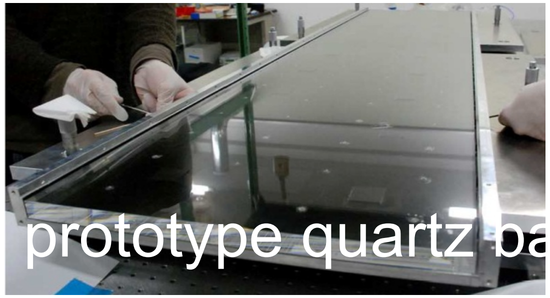


Electronics is tested by cosmic.

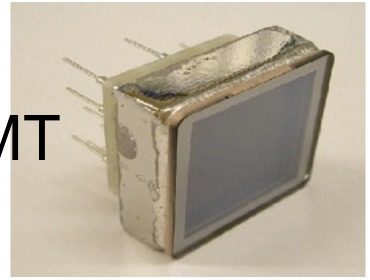
Particle identification

Time Of Propagation counter
(barrel)



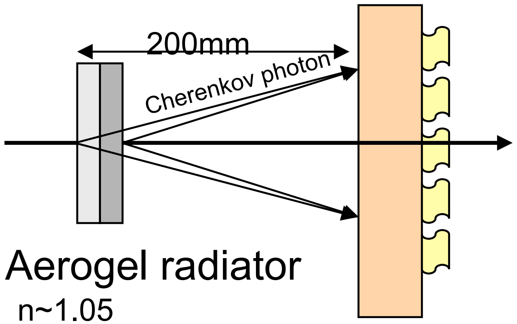


Hamamatsu
16ch MCP-PMT



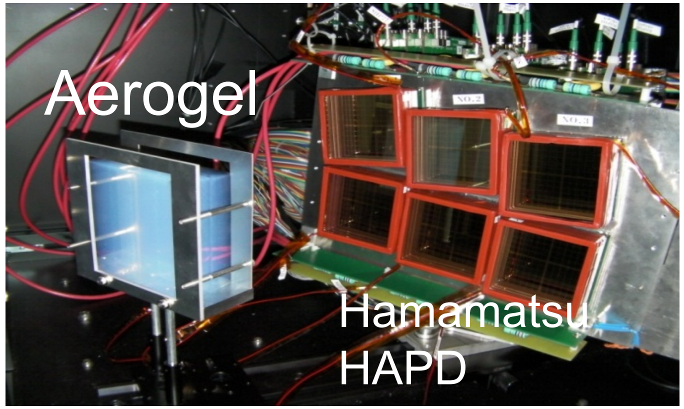
partial Cerenkov ring reconstruction
from x, y and t of propagation

Proximity focusing Aerogel RICH
(endcap)

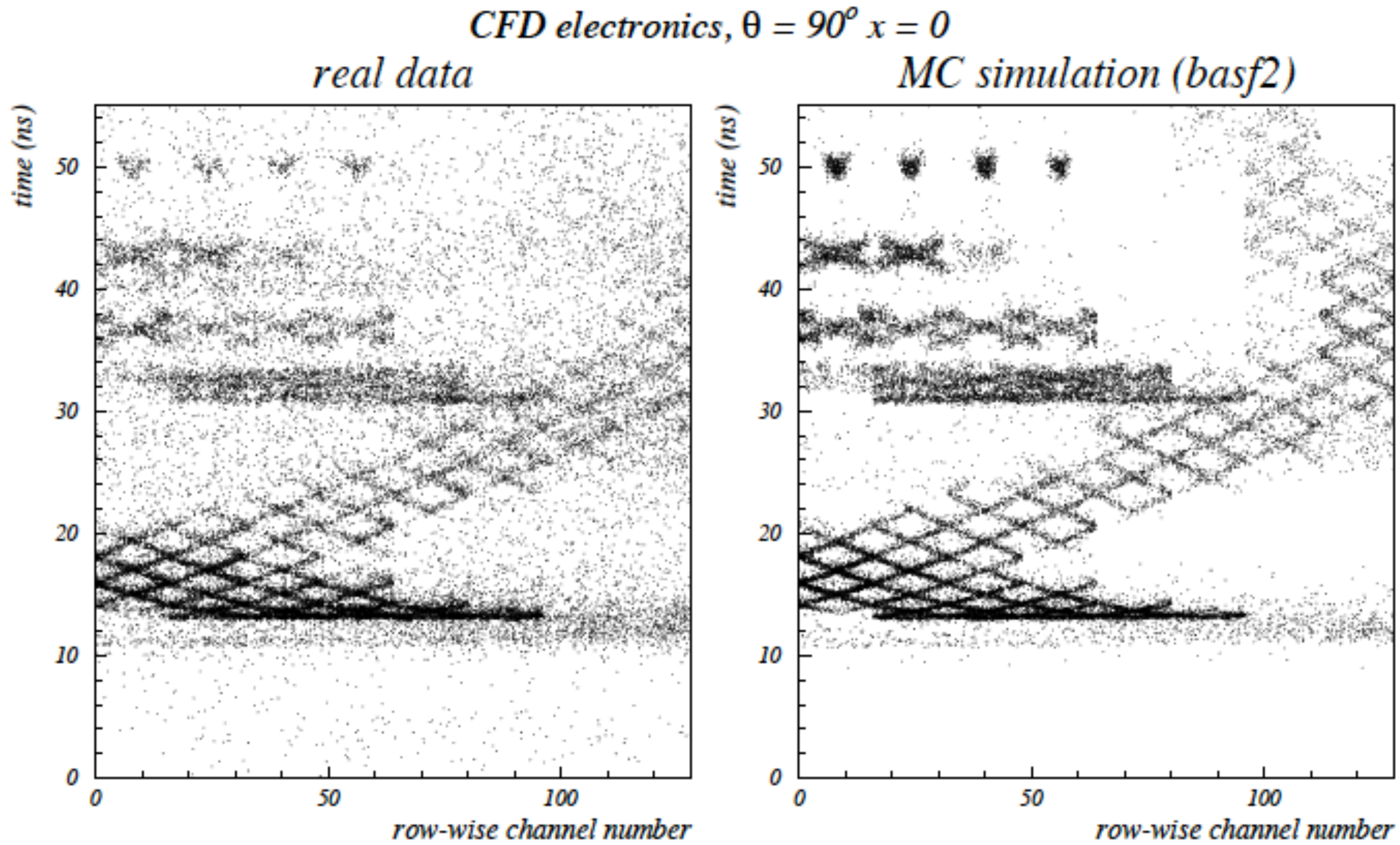


Aerogel radiator
n~1.05

Hamamatsu HAPD



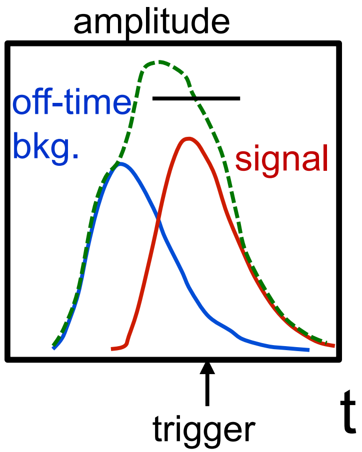
TOP test beam result

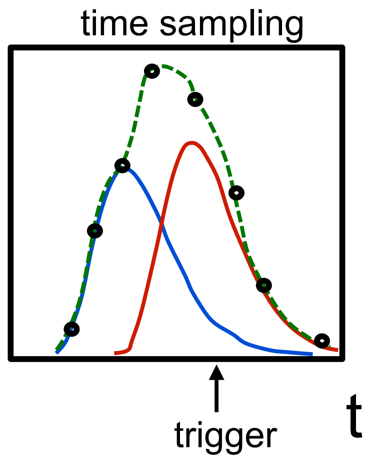


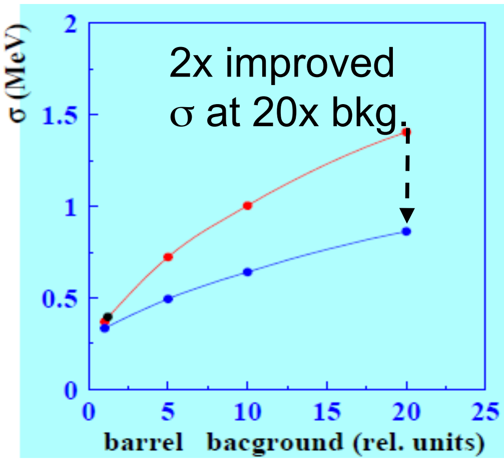
Electromagnetic calorimeter

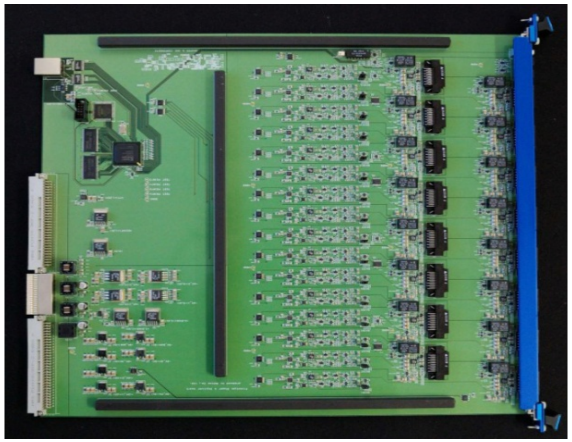
New electronics with
2MHz wave form sampling

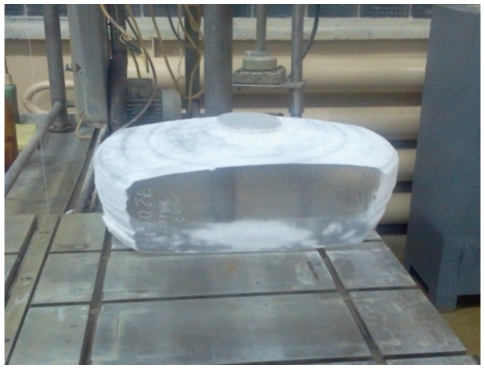
ECL (endcap):
pure CsI crystals;(not day-1)
faster performance and better
rad. hardness than CsI(Tl).





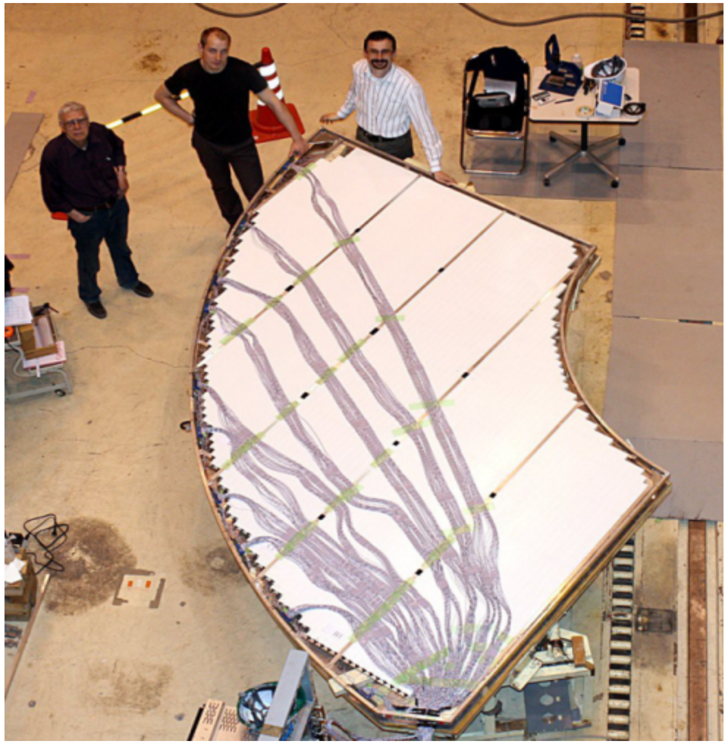


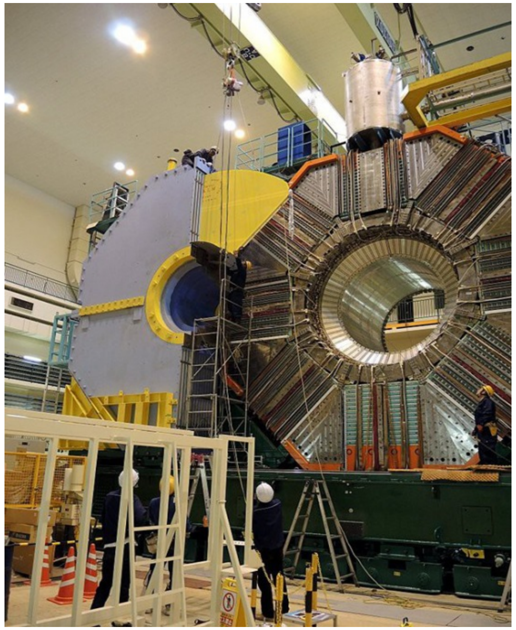


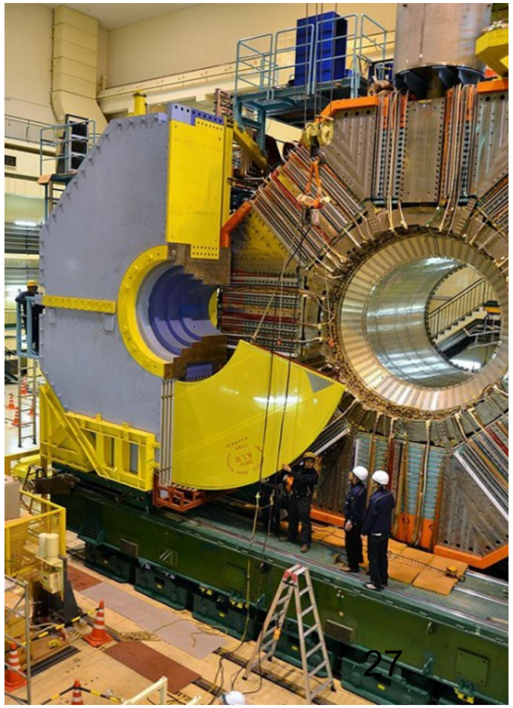


KLM status

In this FY, installation is going on.
RPC → Scintillator+MPPC readout.

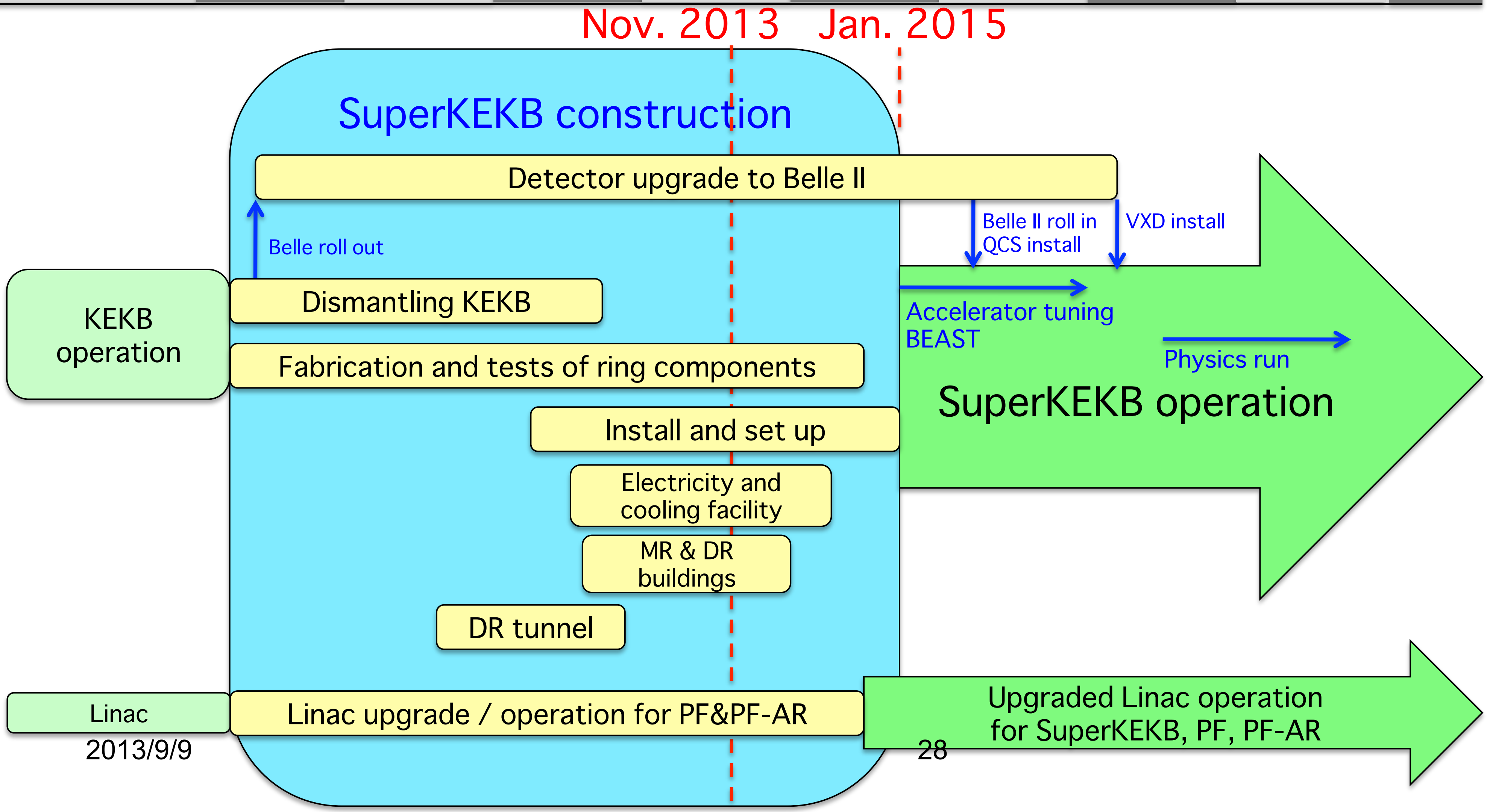




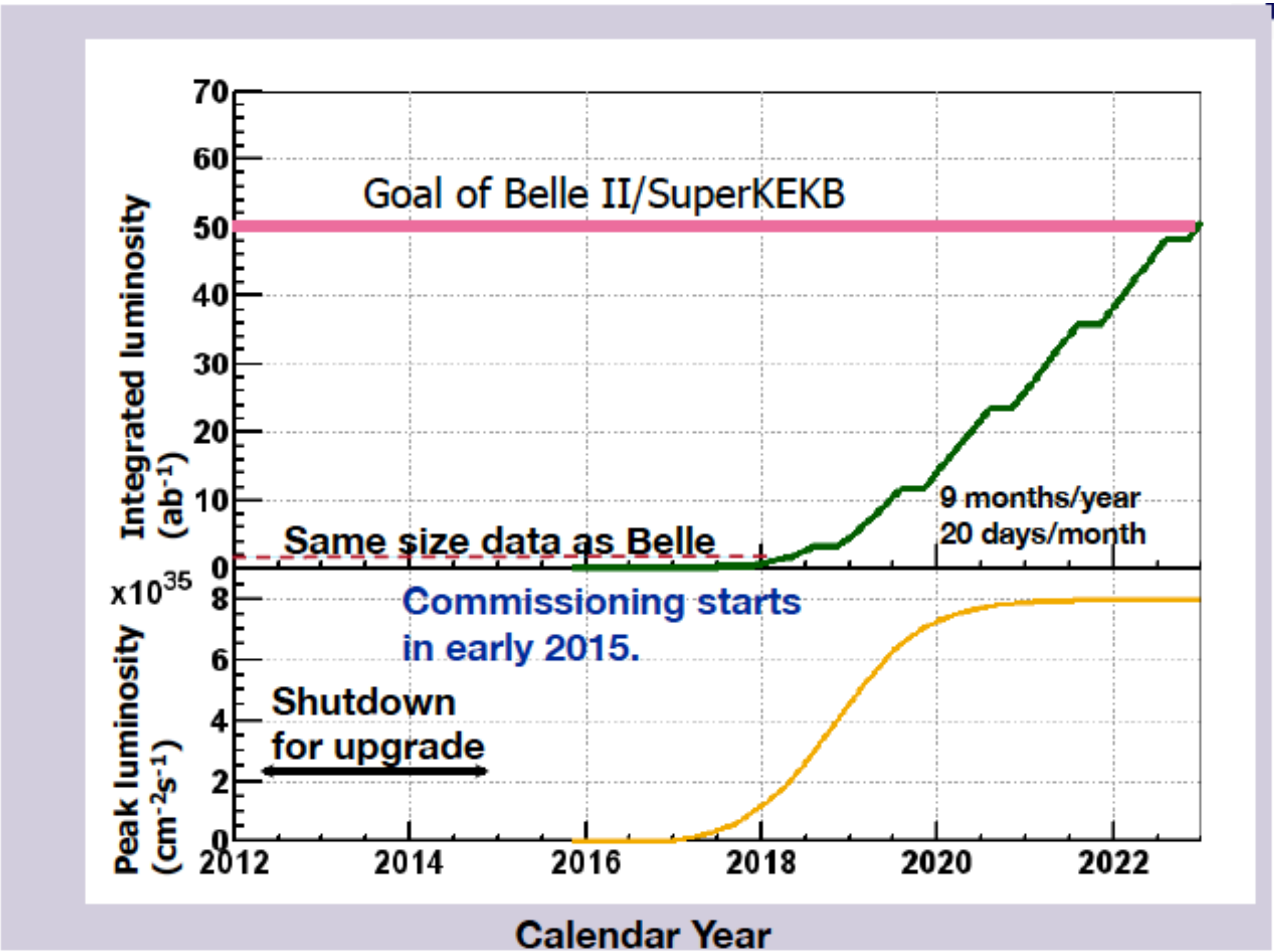


SuperKEKB/Belle II schedule

Calendar	2010	2011	2012	2013	2014	2015	2016	2017	...
Japan FY	2010	2011	2012	2013	2014	2015	2016	2017	..



Expected luminosity



50 ab^{-1} will be accumulated by 2022.

Summary

- Because of superb detector performance with excellent accelerator luminosity, B-factory experiments have been serving as the “Hub” to give a comprehensive understanding in hadron spectroscopy.
- We pursue this direction by SuperKEKB and Belle II with 50 ab^{-1} by 2022.
- Accelerator and detector construction are going on toward 2015 commisionning.