Belle II Construction and Schedule

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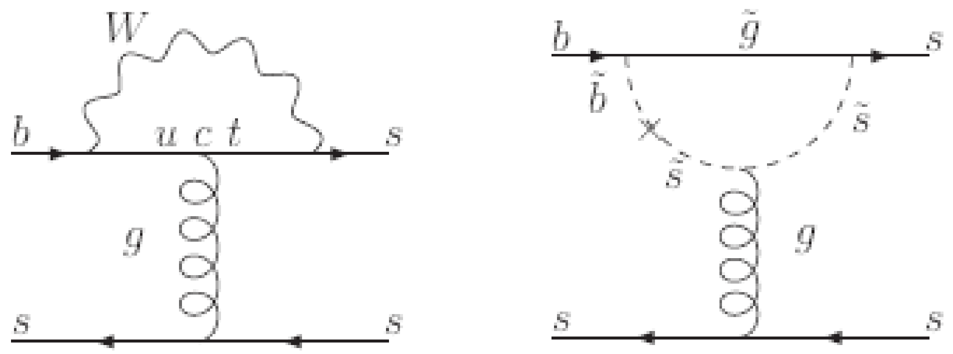
KEK

2015.Feb.23

Physics Motivation

SuperKEKB Project : Motivation

- Many good reasons to investigate an underlying theory beyond the SM ("New Physics").
  - Origin of flavor structure
  - Naturalness
  - Dark matter & dark energy
  - Baryon asymmetry in Universe
  - …



However, it has not yet been discovered.

Ultimate Precision

Quantum Effect

Many Measurements

SuperKEKB

is the unique laboratory to isolate new signals from SM predictions.

SuperKEKB Project : Motivation

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  - Baryon asymmetry in Universe
  - …

However, it has not yet been discovered.

If new finding at energy frontier experiments (LHC)

SuperKEKB

is the place to get deep understanding in new physics with ultimate precisions.

SuperKEKB Project : Motivation

- Many good reasons to investigate an underlying theory beyond the SM (“New Physics”).
  - Origin of flavor structure
  - Naturalness
  - Dark matter & dark energy
  - Baryon asymmetry in Universe
  - …

However, it has not yet been discovered.

If no new finding at LHC

SuperKEKB

is the only alternative to explore new physics with ultimate precisions.

SuperKEKB Project : Motivation

- Many good reasons to investigate an underlying theory beyond the SM (“New Physics”).
  - Origin of flavor structure
  - Naturalness
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  - Baryon asymmetry in Universe
  - …

However, it has not yet been discovered.

If new finding at LHC

If no new finding at LHC

SuperKEKB

is essential to open up new window for new physics independent of LHC program.

Physics of Our Interests

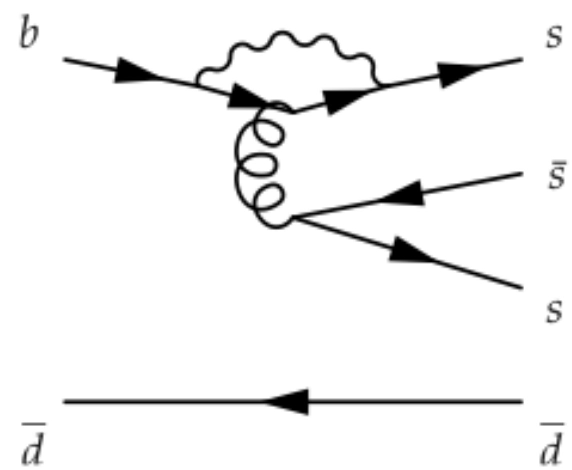
- New CP violating phase

"penguin mode"

$B^0 \to \phi K^0$

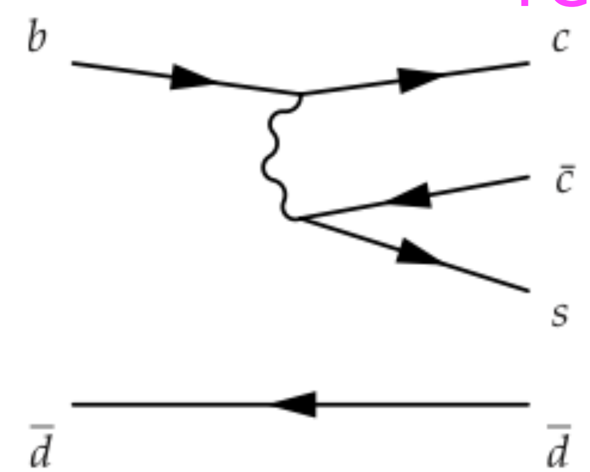
$B^0 \to \eta' K^0$

$B^0 \to K^0 K^0 K^0$



VS

"reference mode"

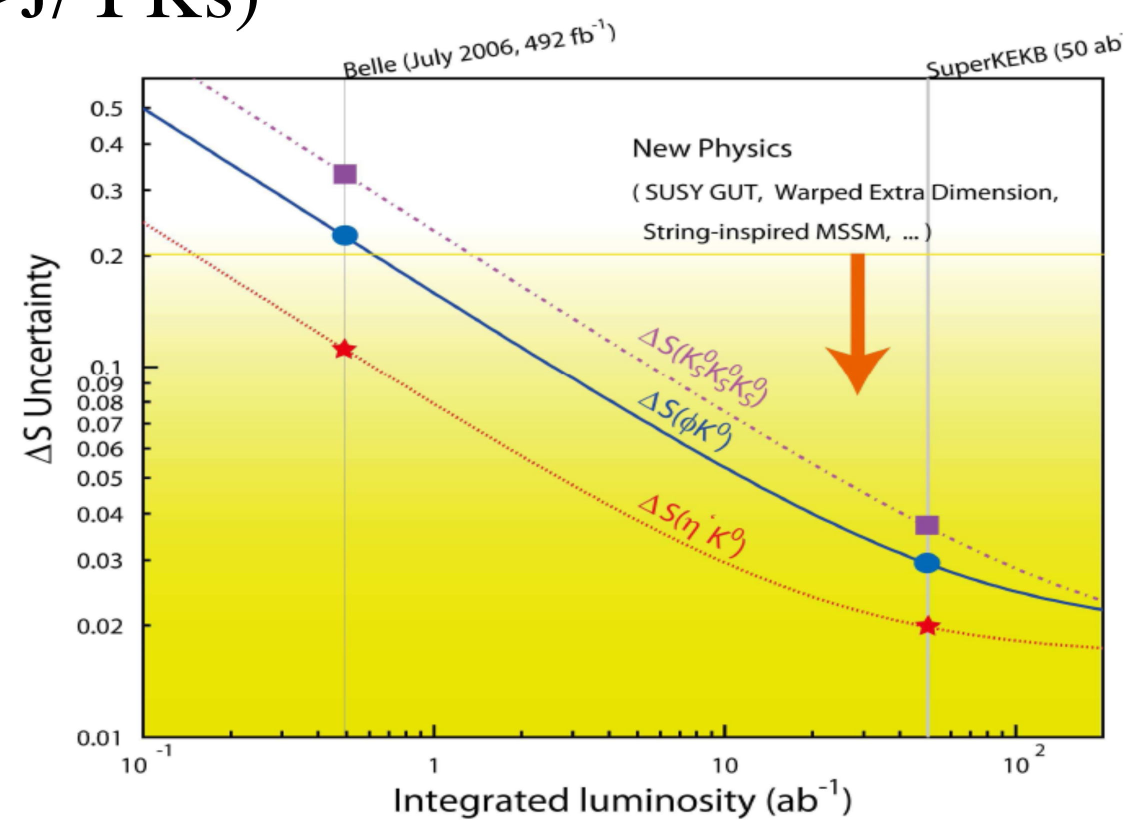


$B^0 \to J/\psi K^0$

$\Delta S = \sin 2\phi_1(B \to \phi Ks) - \sin 2\phi_1(B \to J/\Psi Ks)$

$\Delta S \simeq 0$ at SM

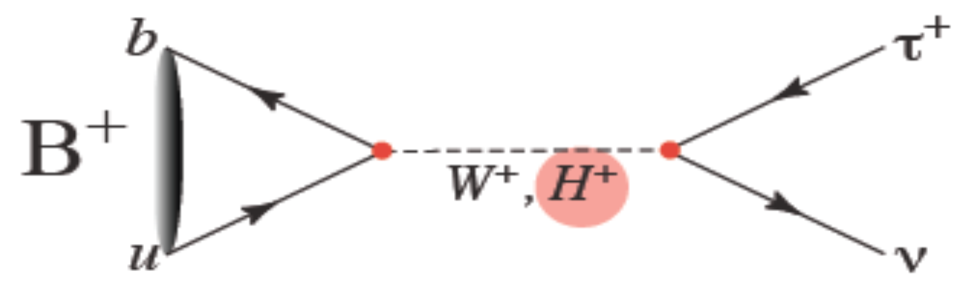
Non zero value indicates a sign from NP, and precise measurements allow us to distinguish NP models.



Physics of Our Interests

- Charged Higgs

  Annihilation process of B→τν

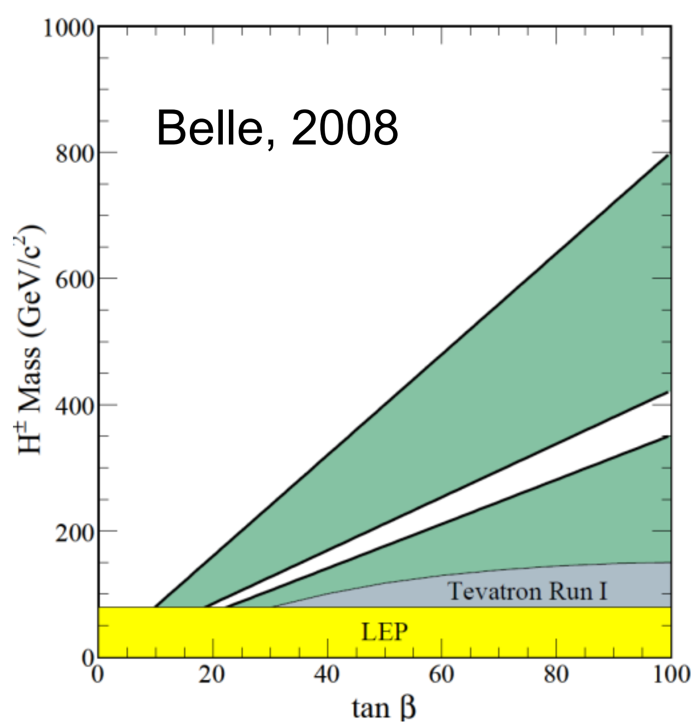


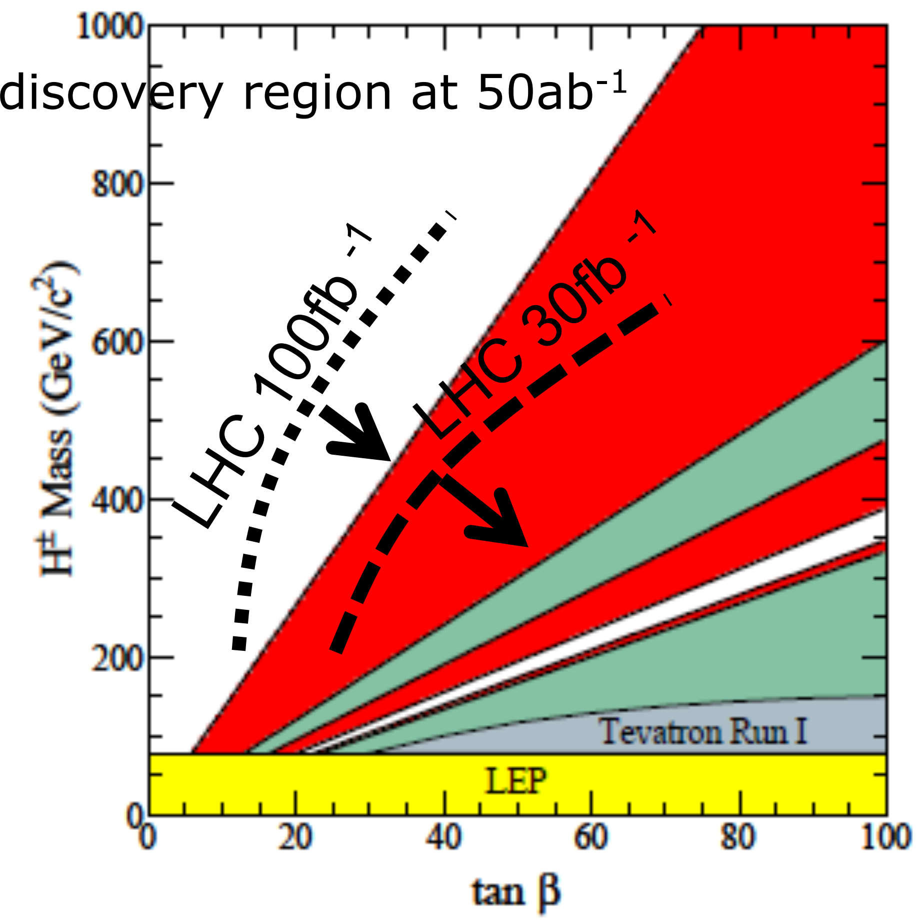
Br(B→τν) = $(1.14\pm0.27)\times10^{-4}$ from PDG2014

↔ Br(B→τν) = $(0.73\pm0.21)\times10^{-4}$ from SM prediction

Effect from charged Higgs can contribute to excess of BF.

B→D$^{(*)}$τν as well…





Only place to investigate *b-H±-u*/*b-H±-c* couplings

Belle II Theory interface Platform (B2TiP)

Coherent interactions between theorists and experimentalists to study physics impact from Belle II are now organized in a systematic way.

KEK where Belle II is hosted is the natural gathering point where flavour physics experts meet to discuss and develop topics of flavour physics for Belle II.

What's new in Belle II compared to Babar/Belle?

- ➡ Efficiencies and precision of the new hardware
- ➡ New analysis softwares and methods

What's new in theory after Babar/Belle & LHCb result?

- ➡ Progresses in QCD
- ➡ New physics models and their constraints
- ➡ New observables

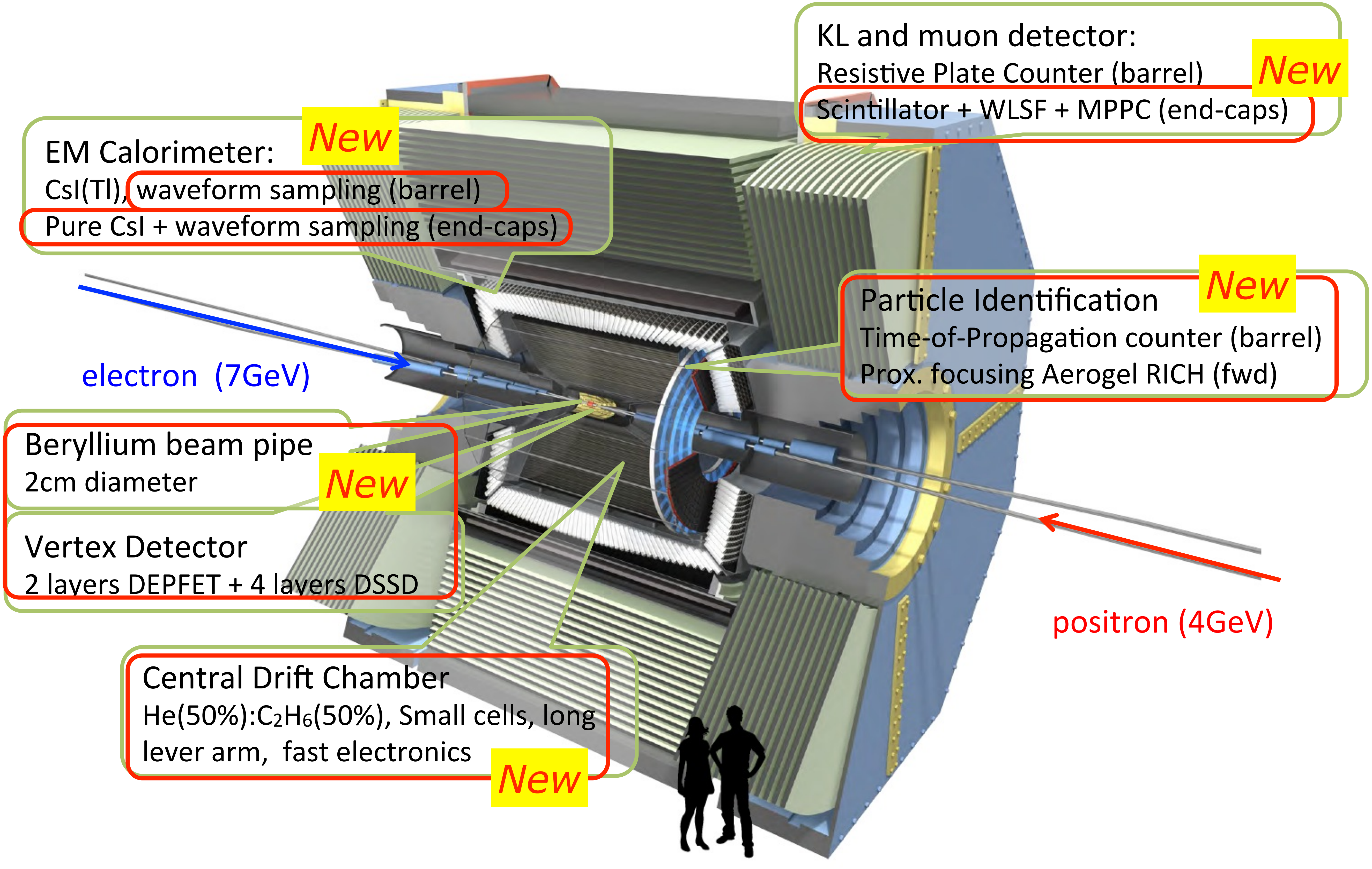
NEW IDEAS

Deliverable: "KEK yellow report" by the end of 2016

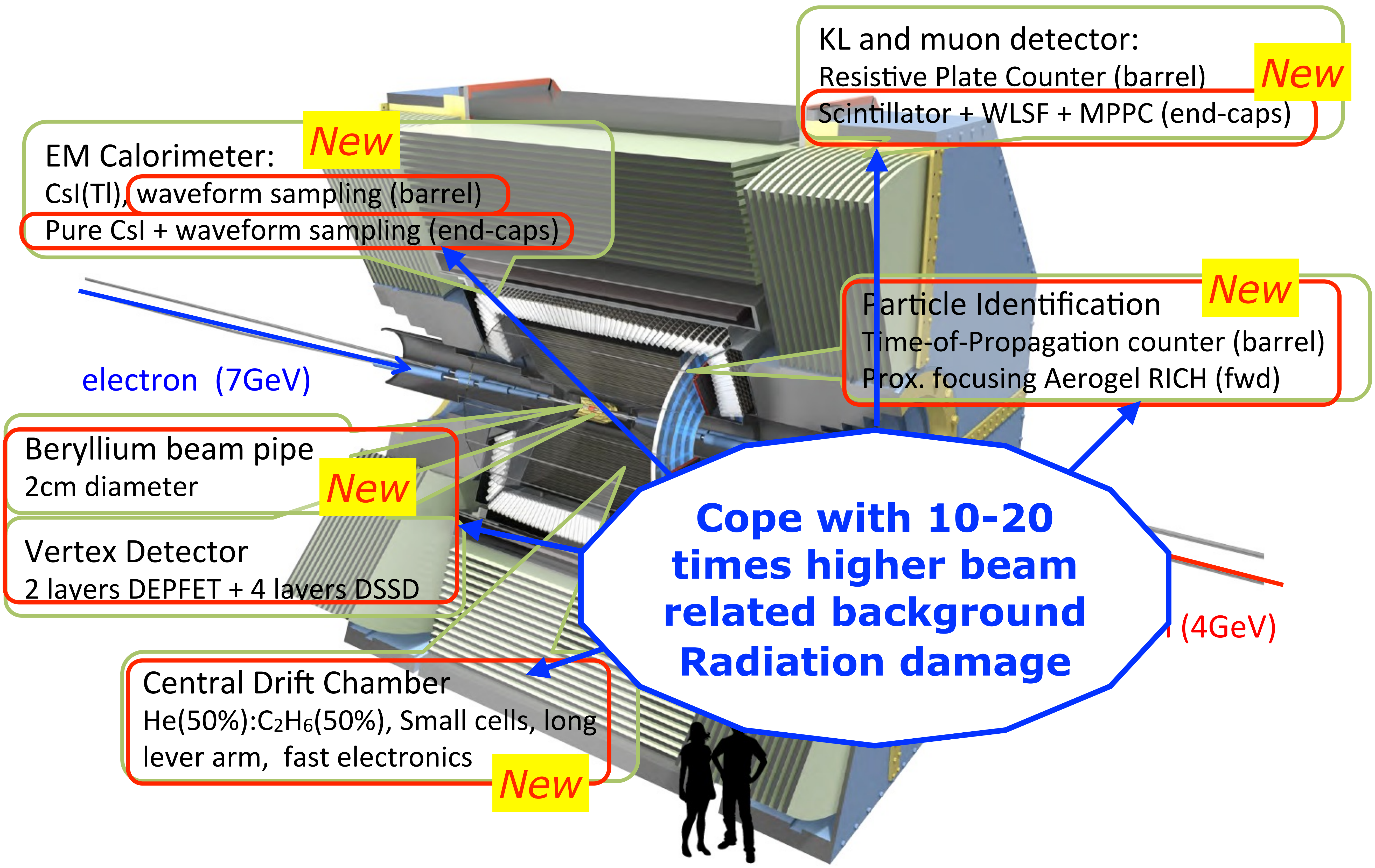
Working groups have been set up.

Belle II Detector

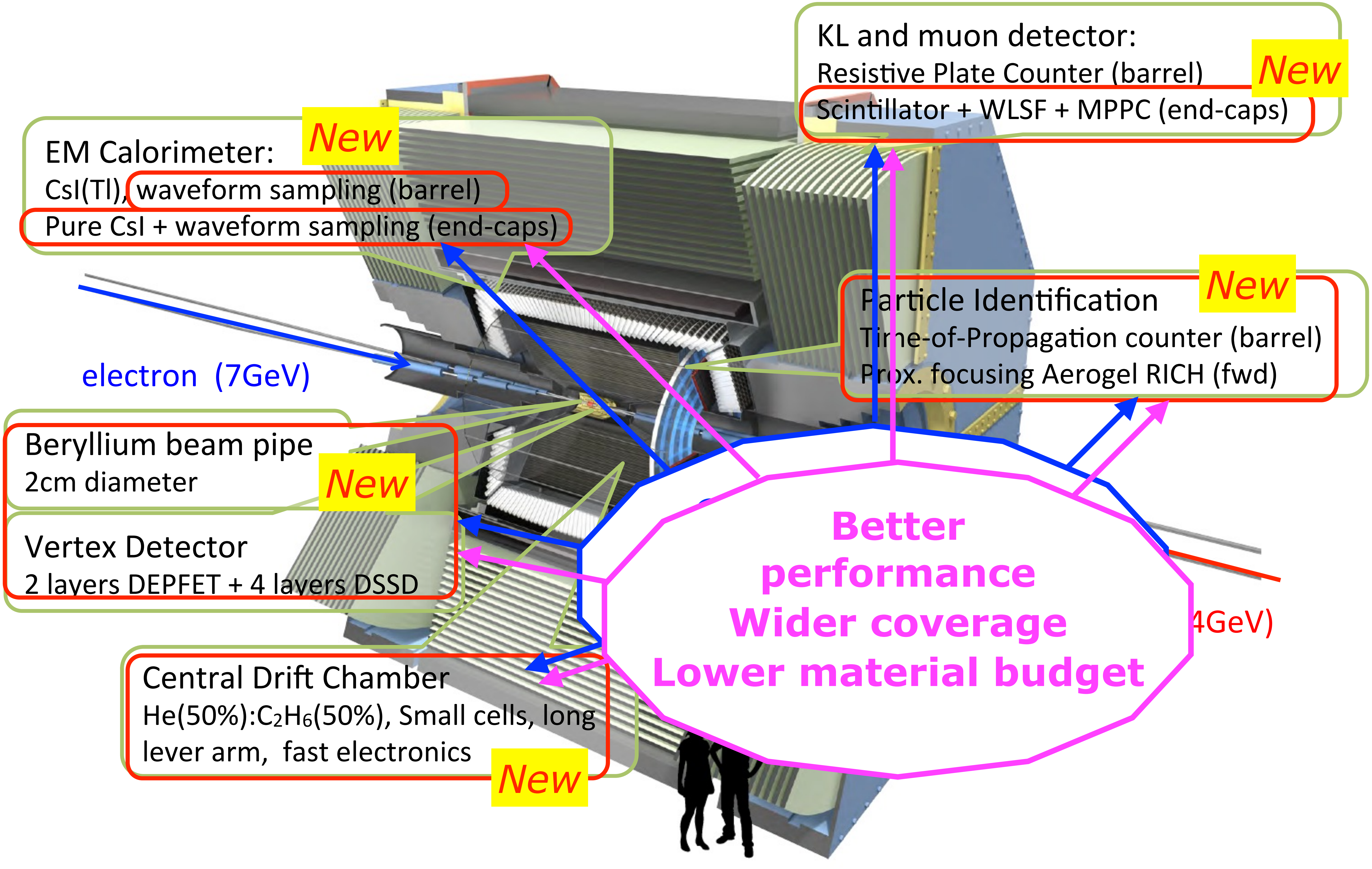
Belle II Detector



Belle II Detector



Belle II Detector



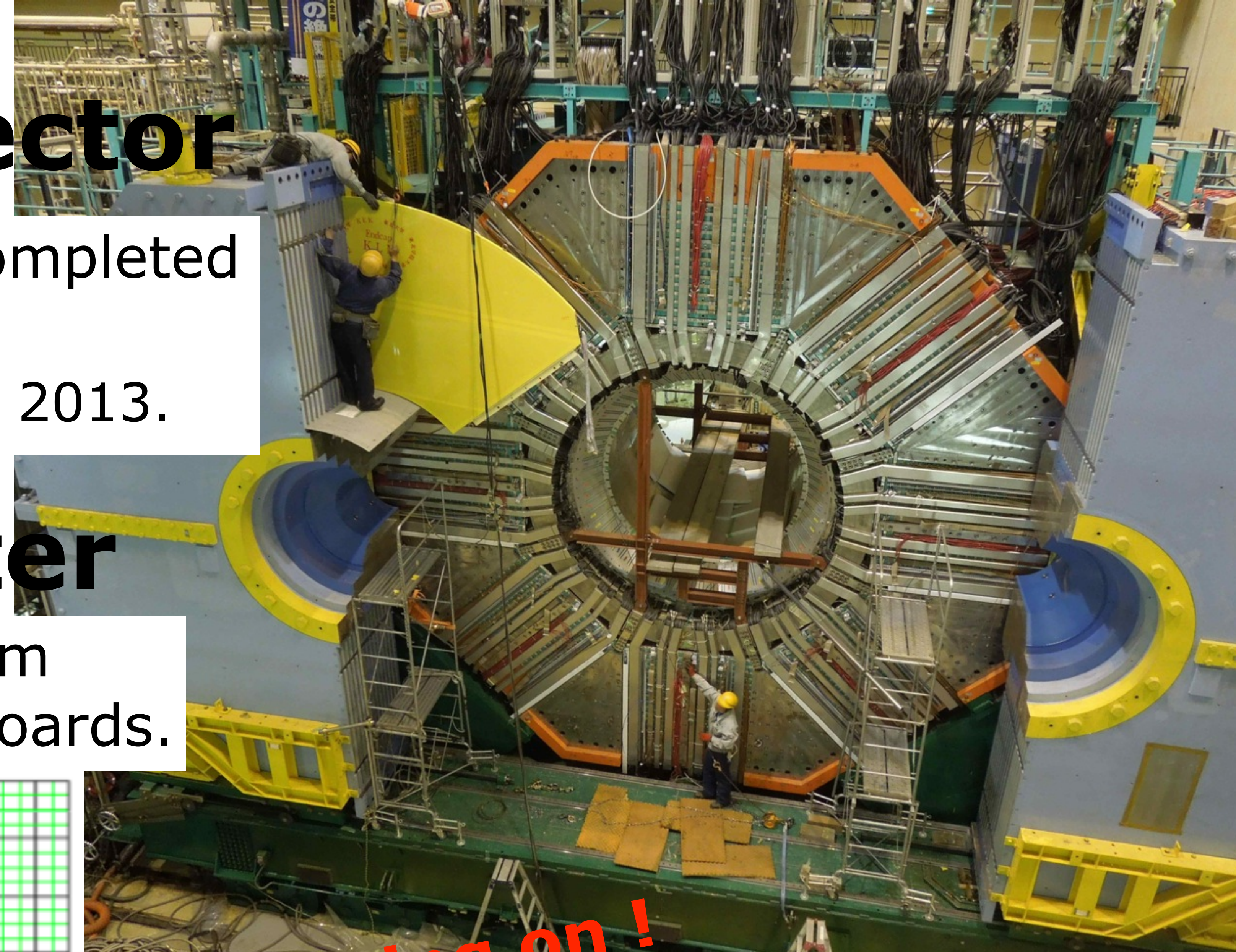
Highlights of Detector Construction 2014-2015


Important Progress !!!
New Flags at Exp. Hall !!!

K_L Muon Detector

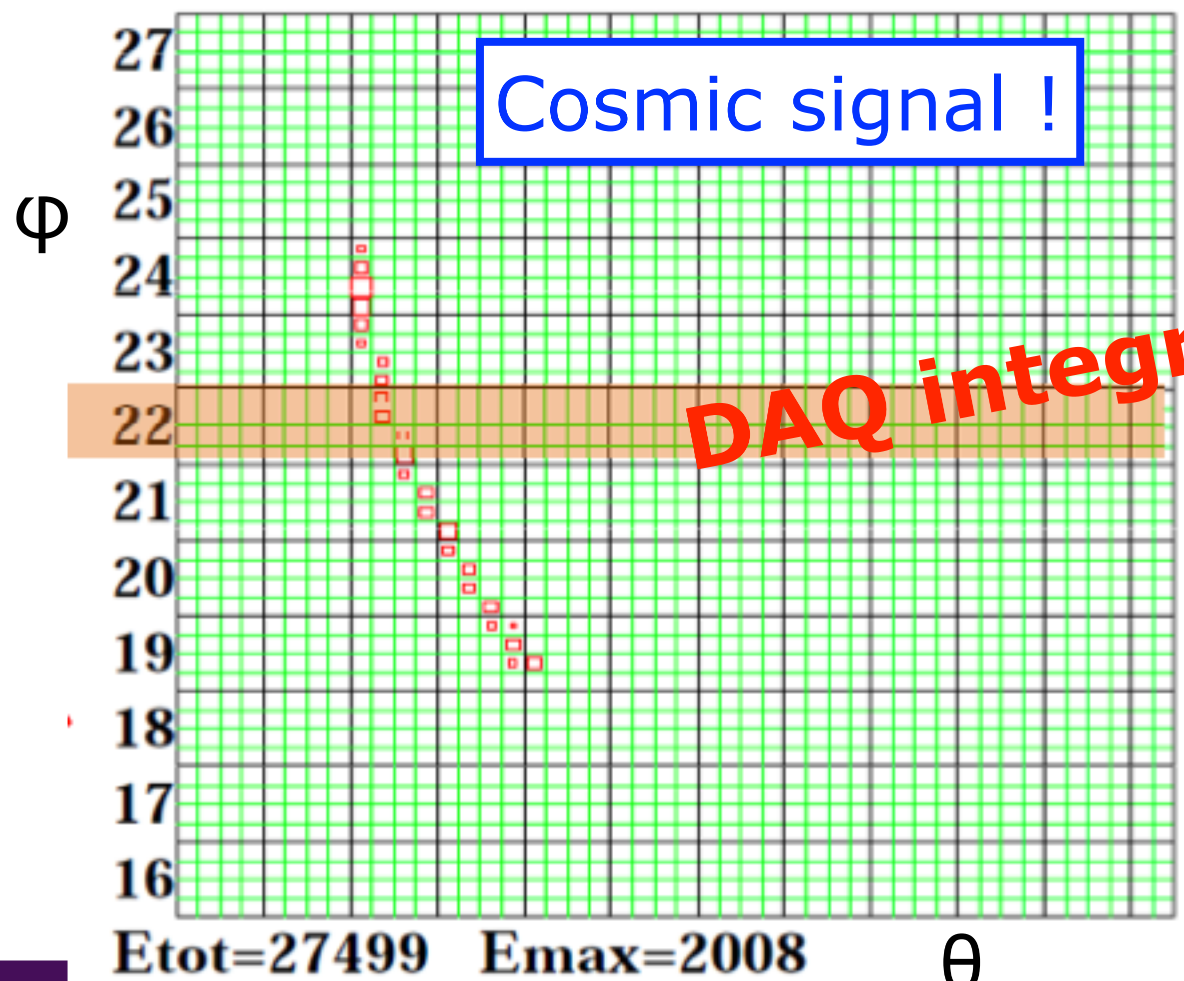
End-cap KLM installation completed in 2014 July.

Barrel KLM already done in 2013.



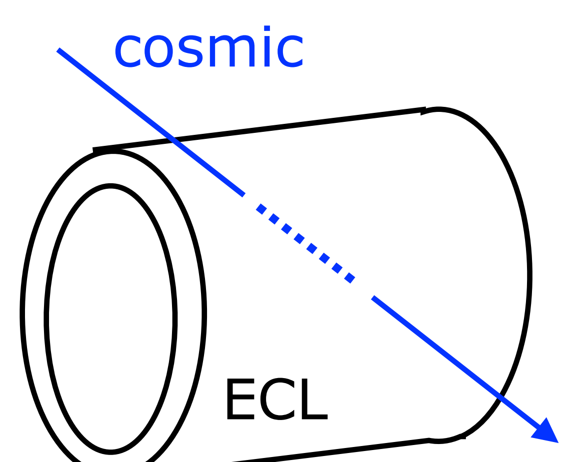
EM Calorimeter

Turn on new 2MHz waveform electronics + new trigger boards.



DAQ integration going on !

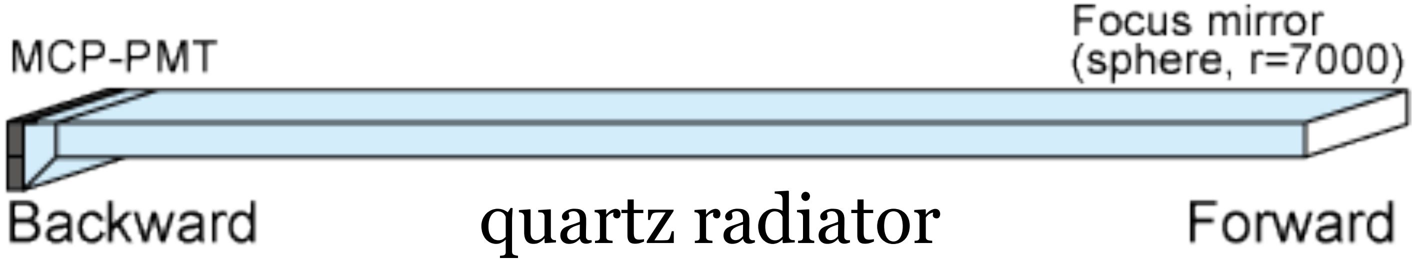
Nice work by both of sub-detector and DAQ groups

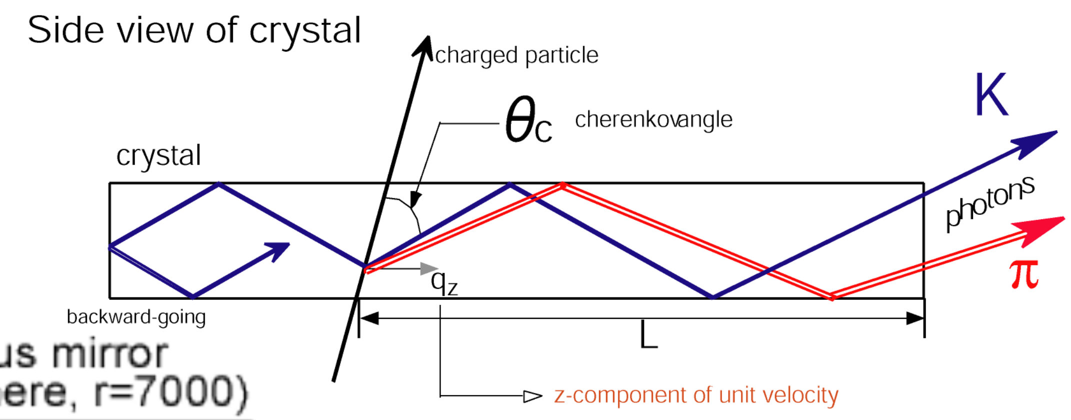


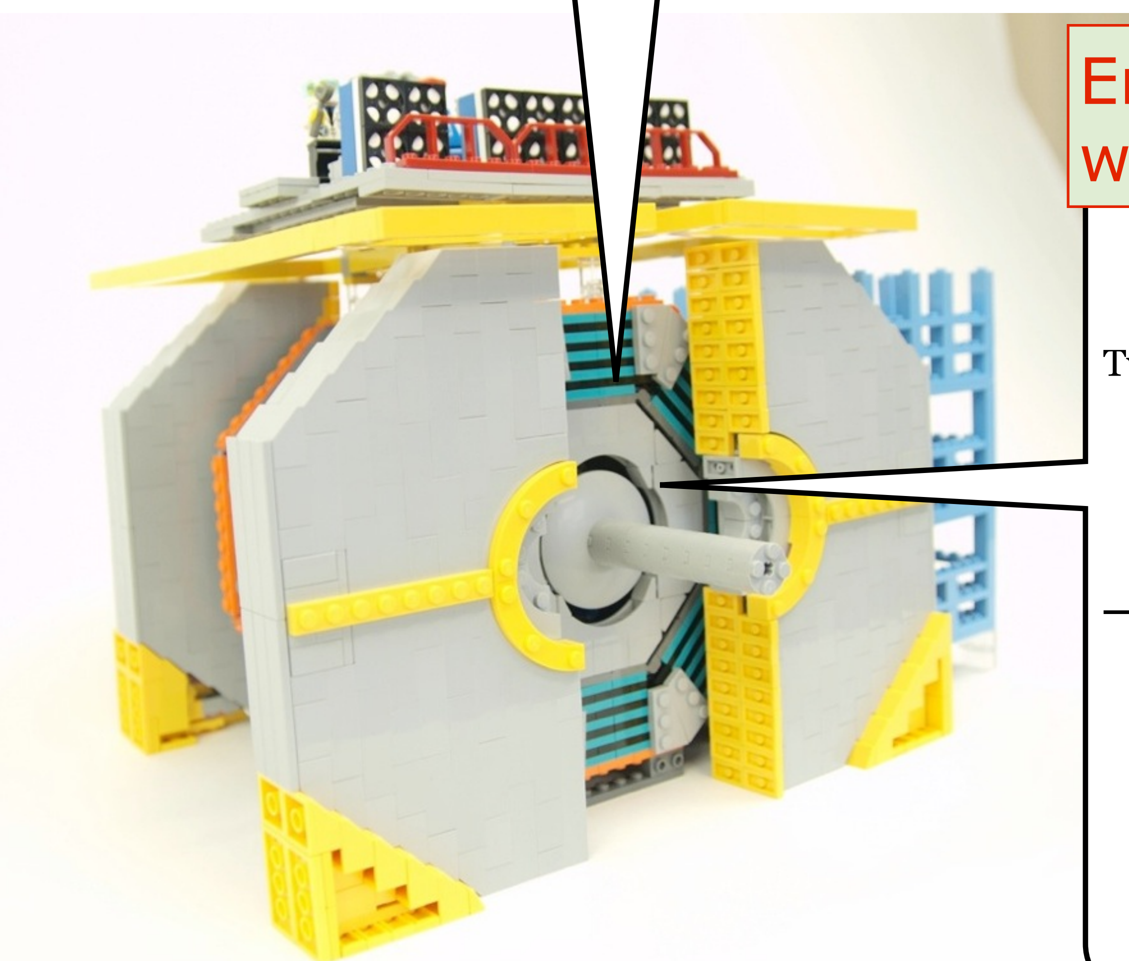
Particle Identification Devices

Barrel : Time-of-Propagation (TOP) counter

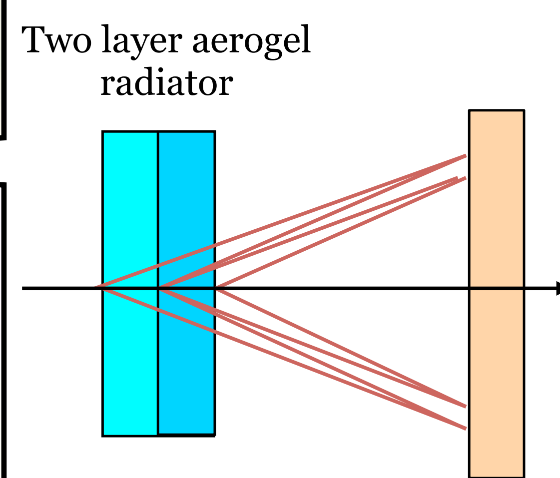
MCP-PMT+expansion block

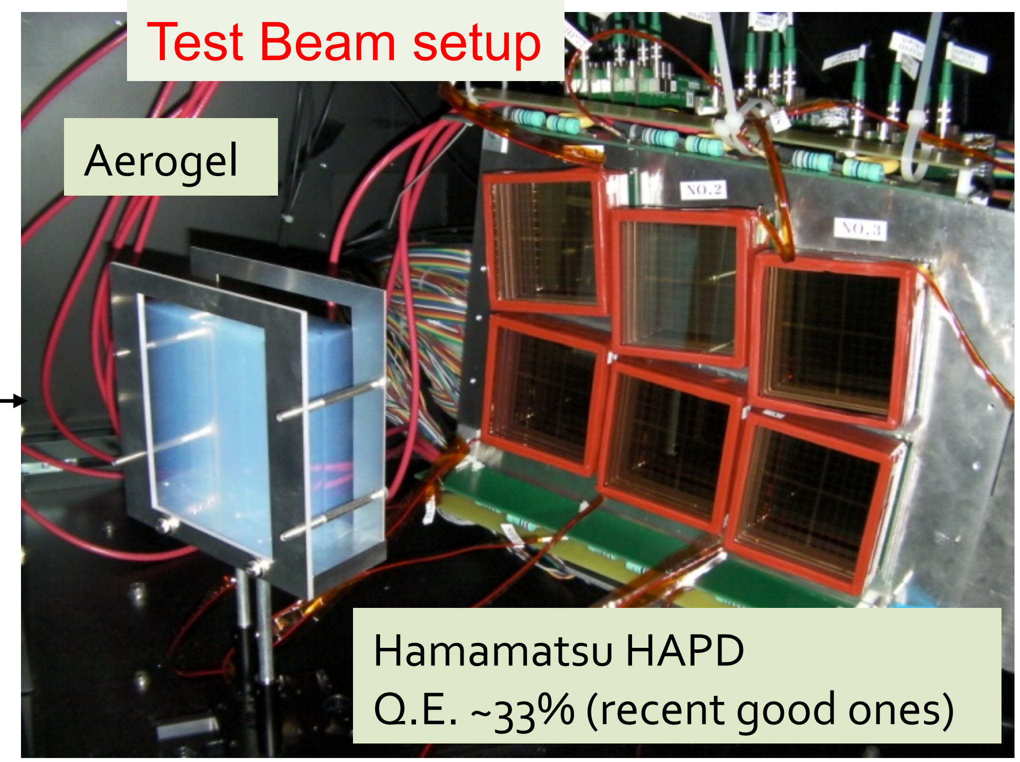




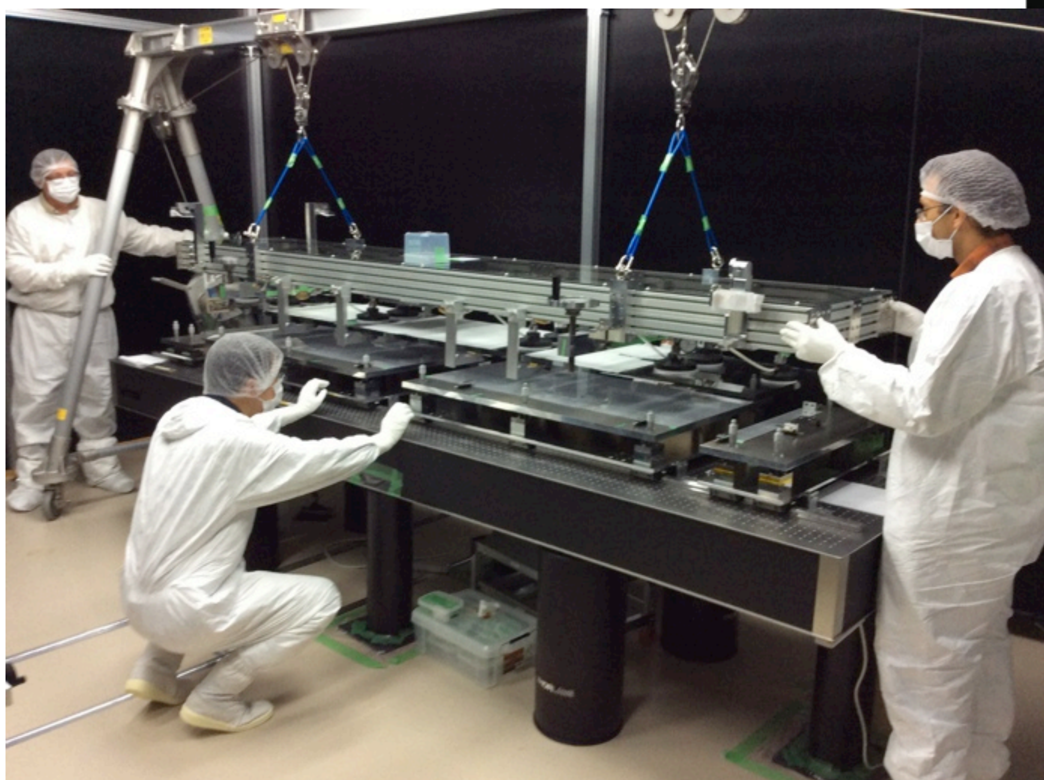


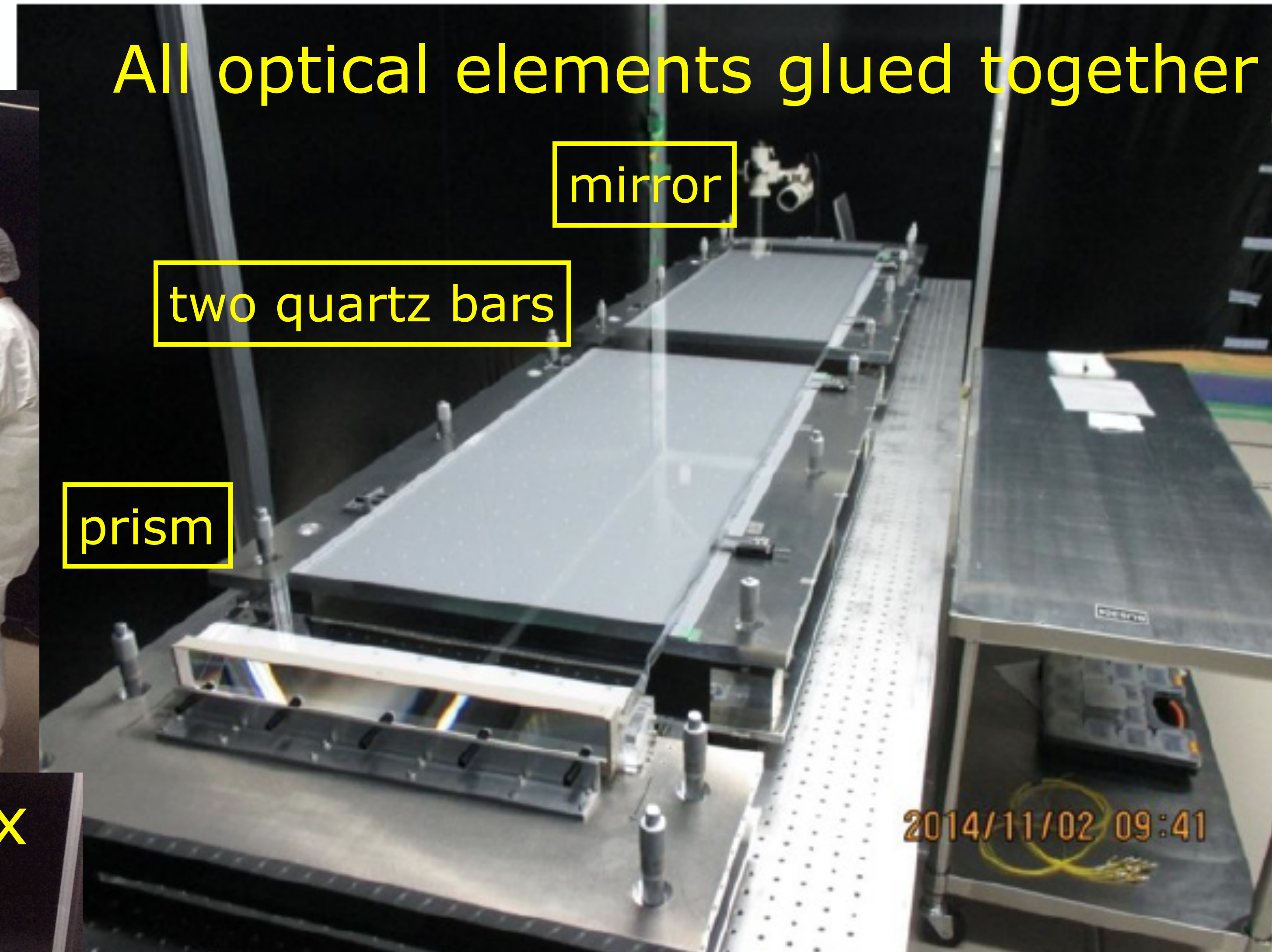
End-cap : Ring Imaging Cherenkov counter with Aerogel radiator (ARICH)





Time-of-Propagation(TOP) Counter



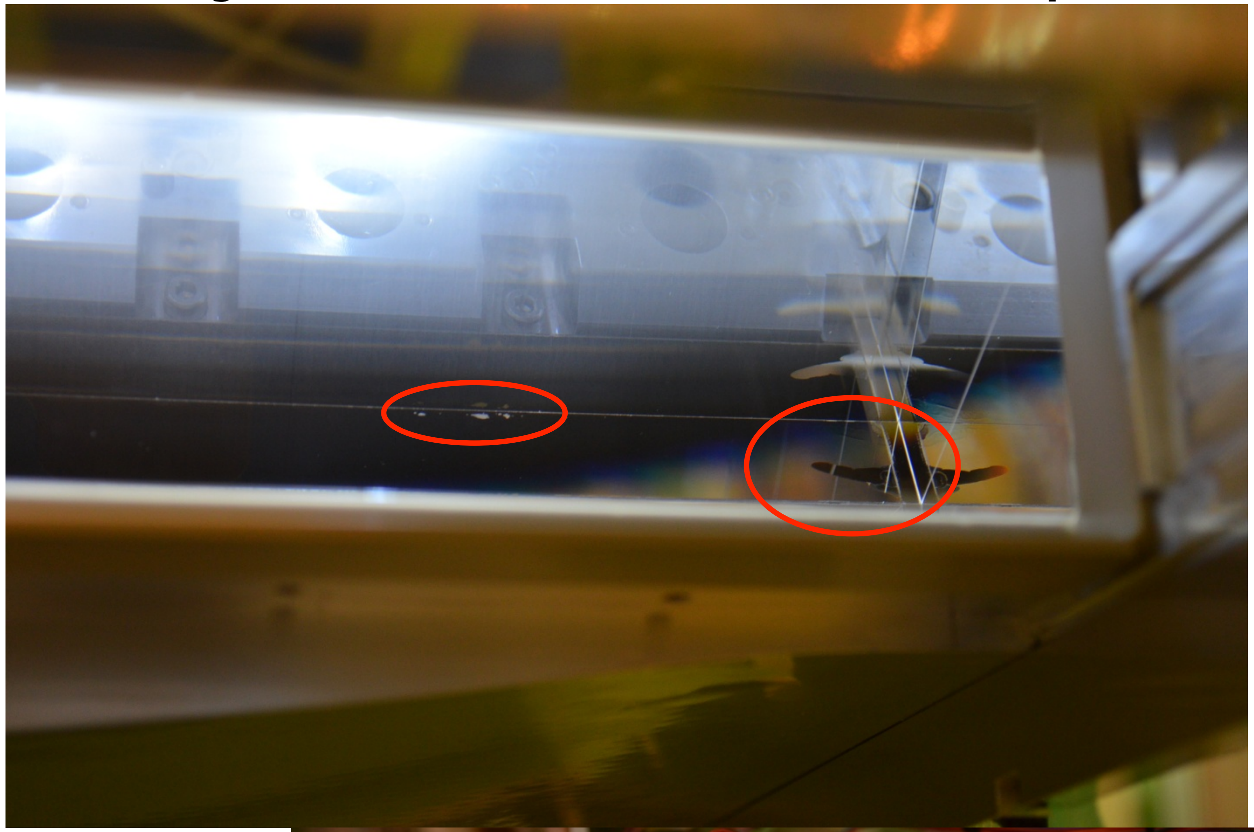


Critical path for Belle II

1st module produced.

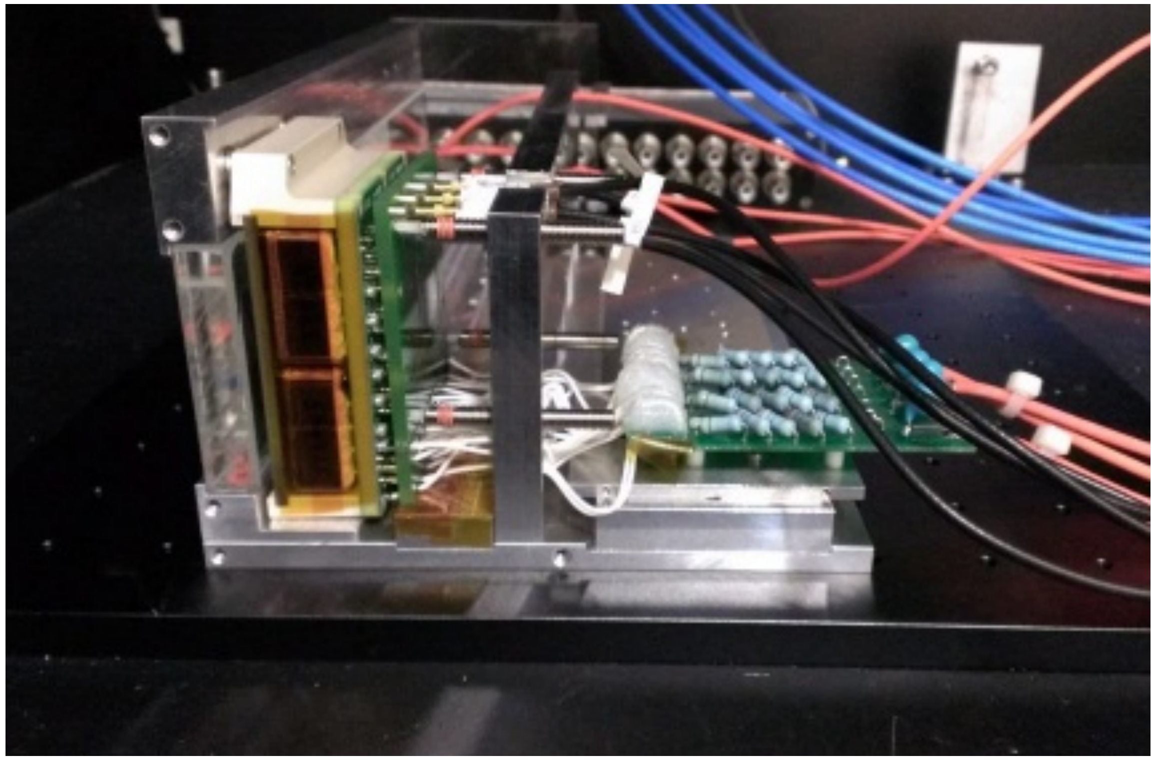
Time-of-Propagation(TOP) Counter

Glue joint failure between quartz bar and prism.

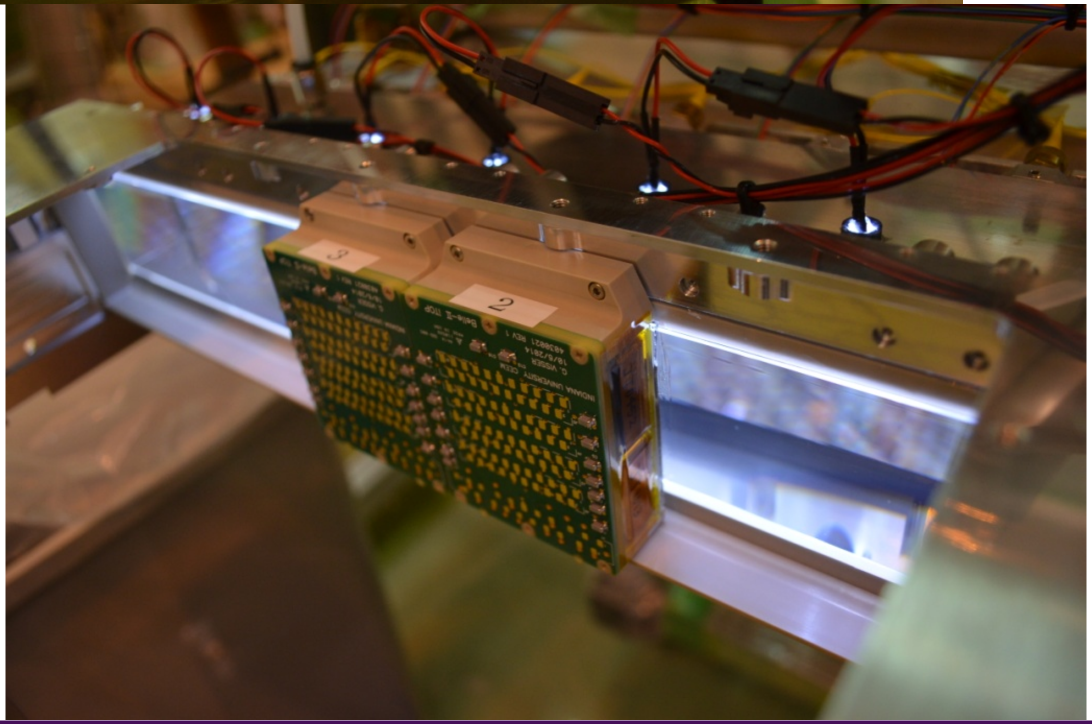


Dedicated glue tests in progress…

Will resume module production in March.

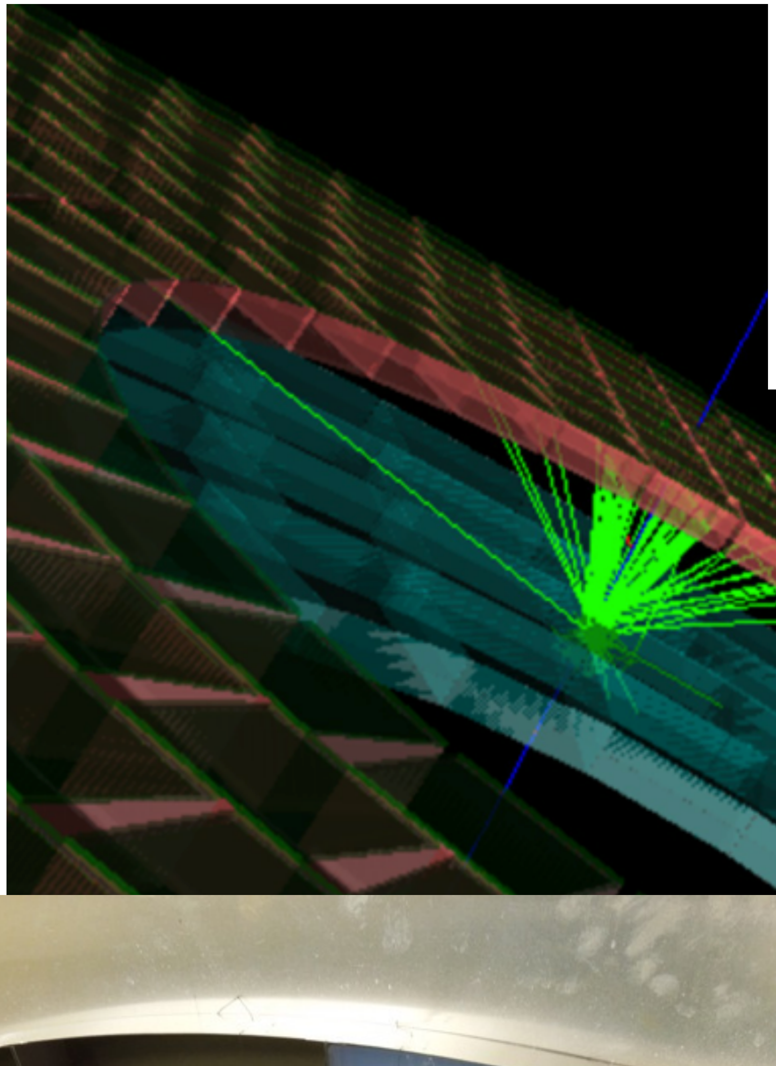


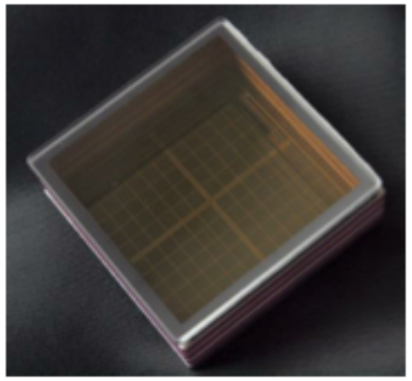
MCP-PMT mounting

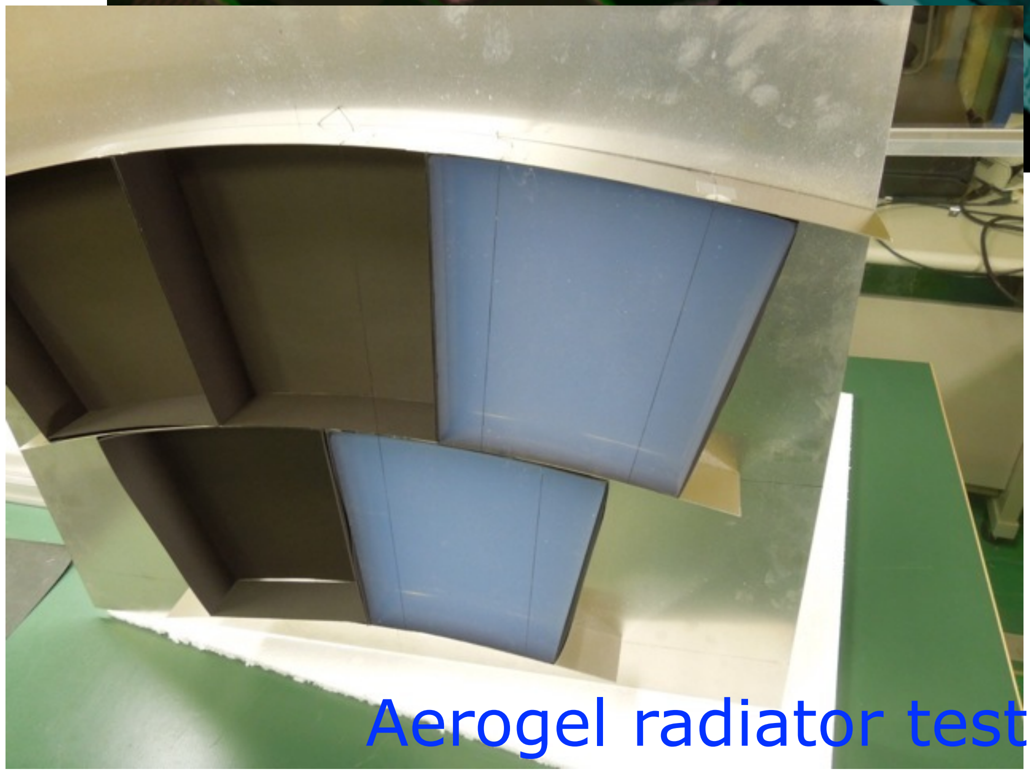


All production procedures have been examined in detail.

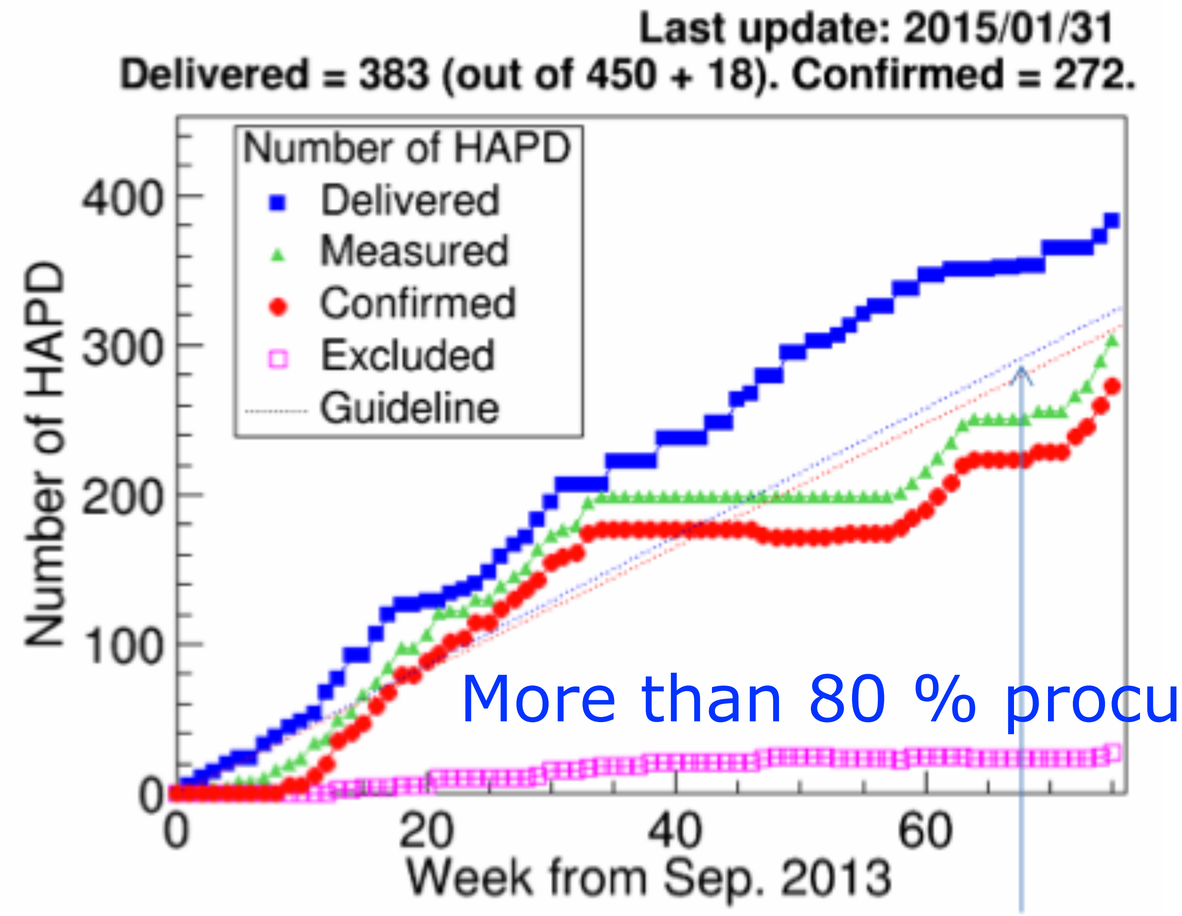
Aerogel RICH

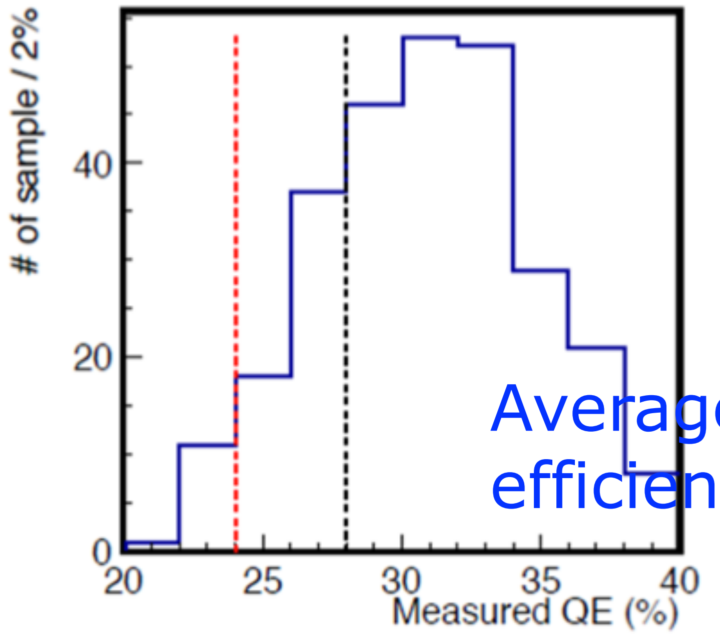






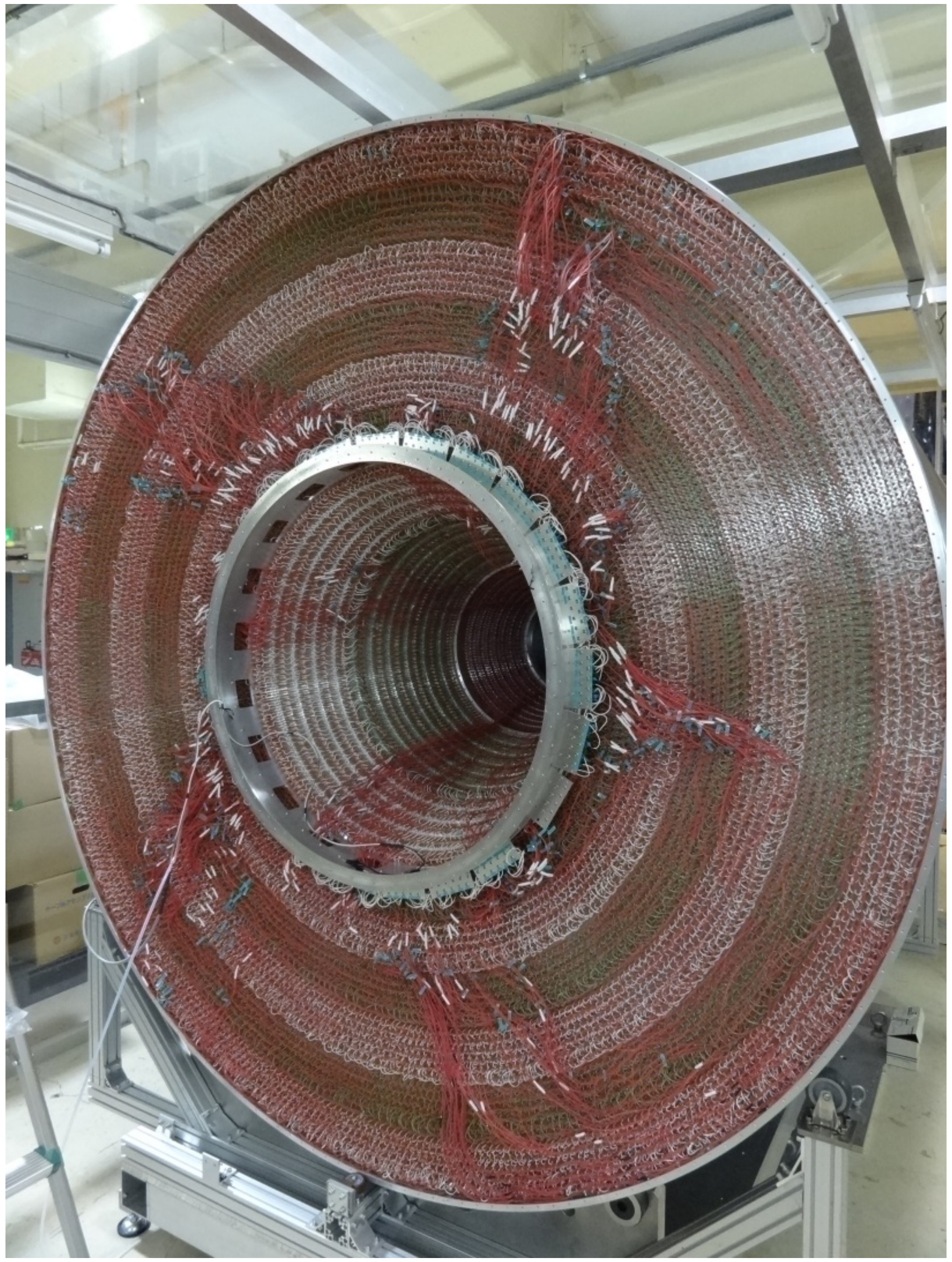
Photon sensor (Hybrid avalanche photo-detector) delivery



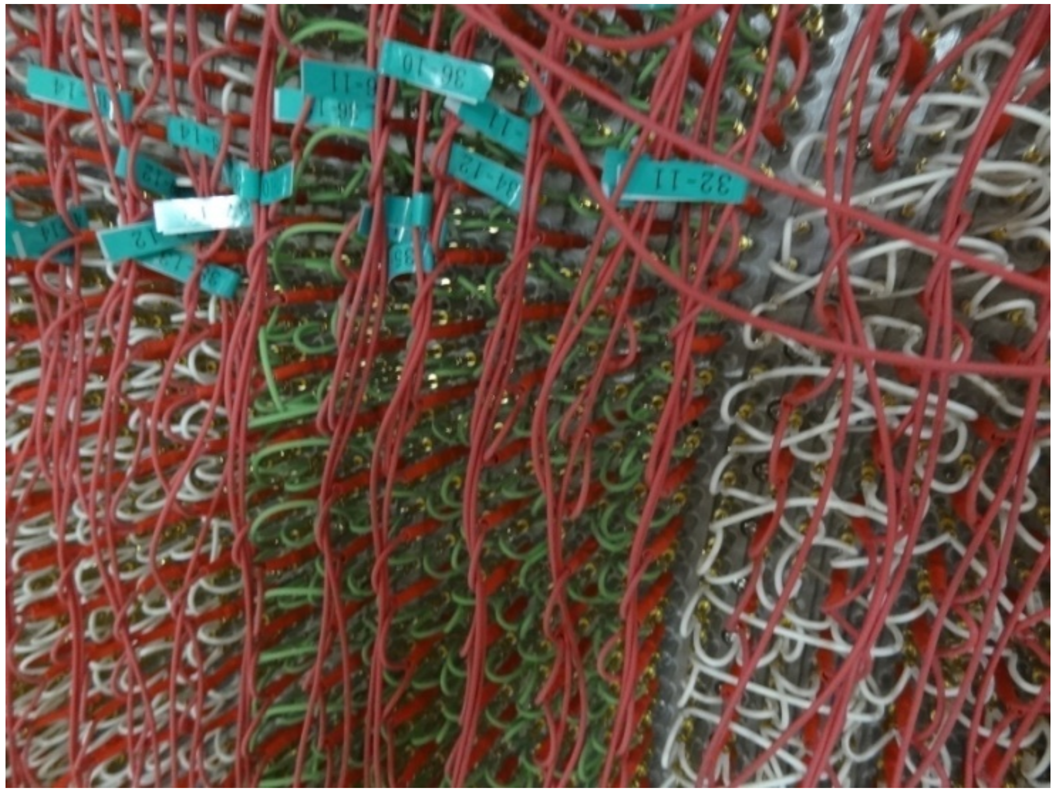


Central Drift Chamber (CDC)

- Hardware work almost completed.
  - Wire stringing done in 2014 January.
  - Gas leak check, tension measurements etc.
  - Cabling



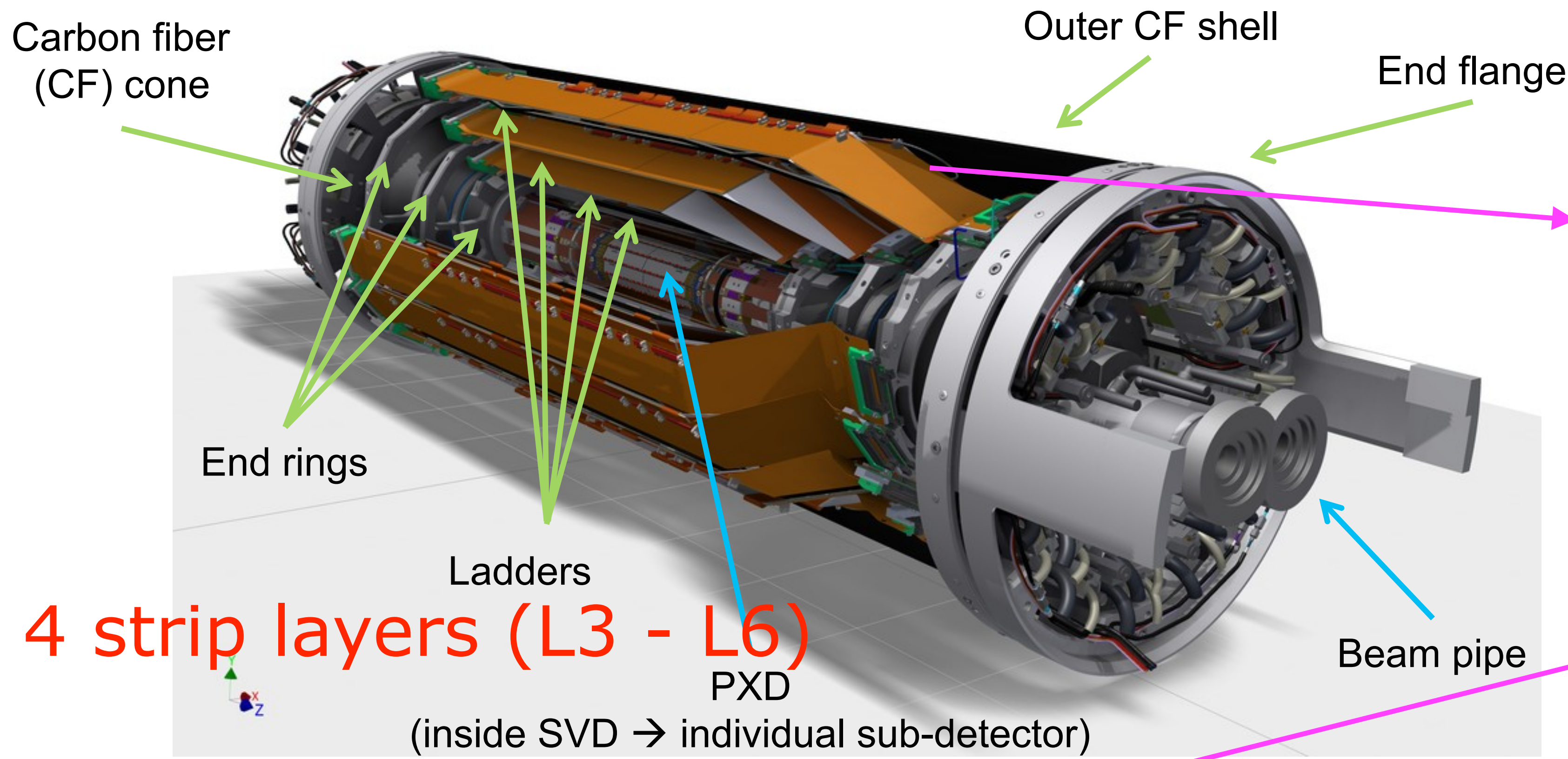
HV cabling

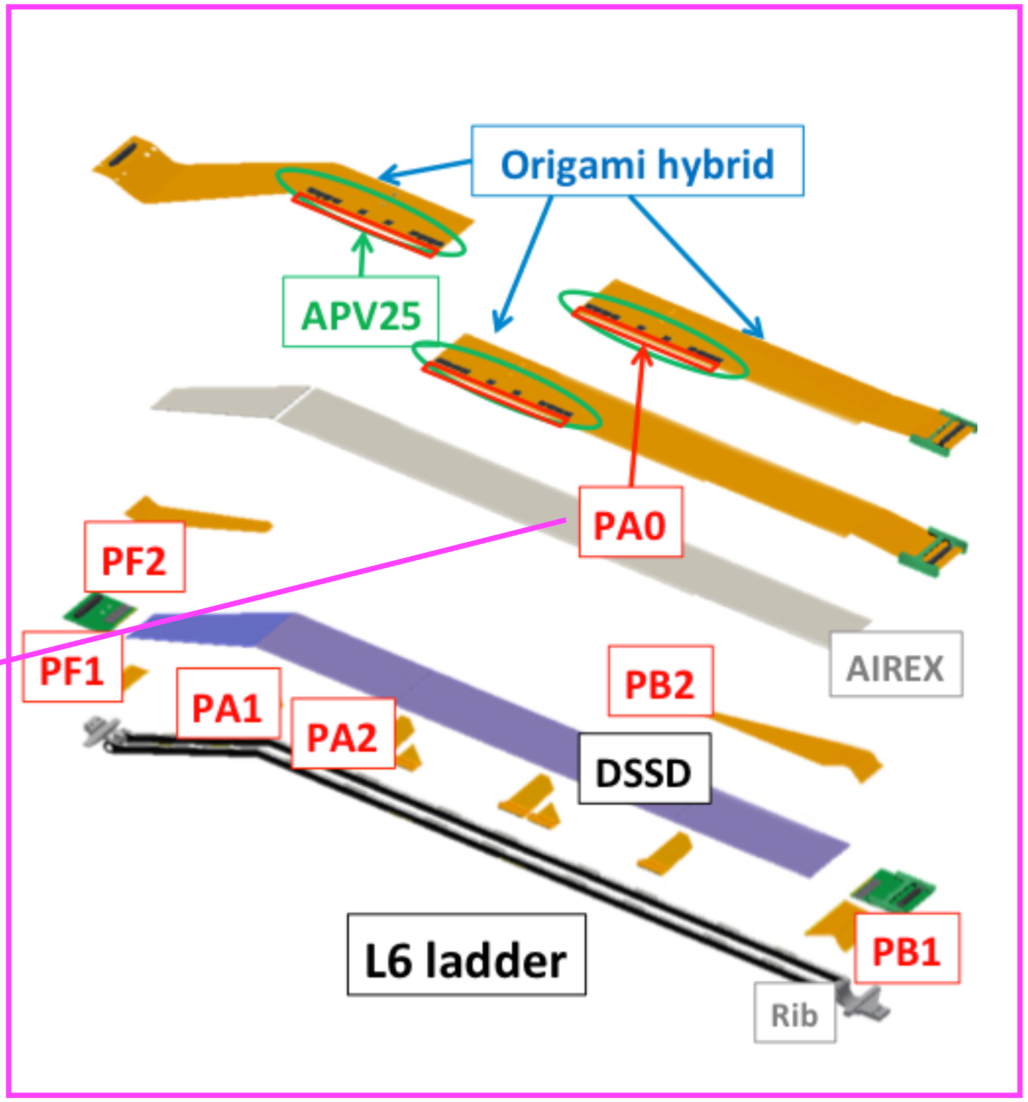


Central Drift Chamber (CDC)

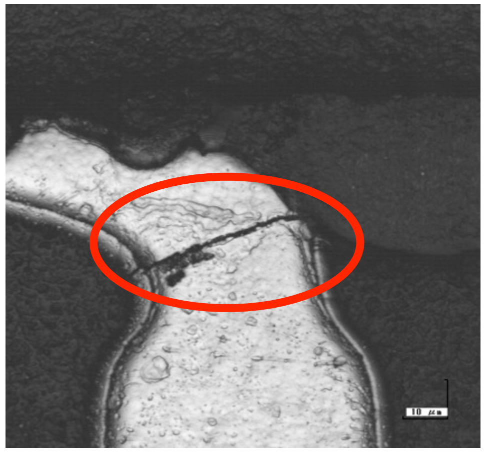
- Moved to Fuji Hall to Tsukuba Hall in 2015 January.
- DAQ test is about to start.
  - Mass-production of FE successfully completed.

Silicon Vertex Detector (SVD)





Pitch Adaptor 0 : flexible circuits to guide signals from DSSD to APV25

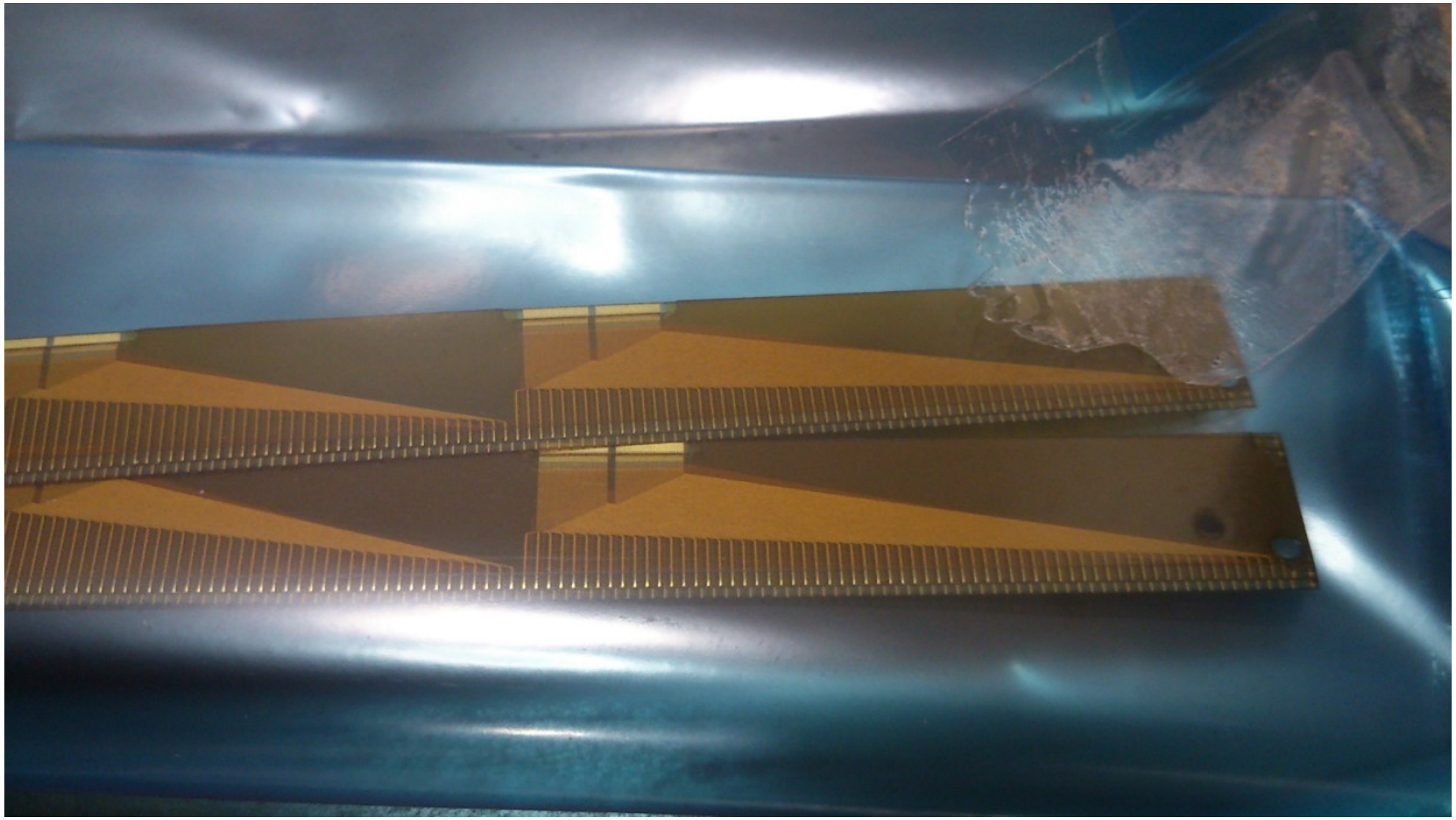


"Micro-cracks" found in last autumn. Task force was formed to solve this problem. Now improving by updating production method.

Silicon Vertex Detector (SVD)

Carbon
(CF)

New design PA0 sample.



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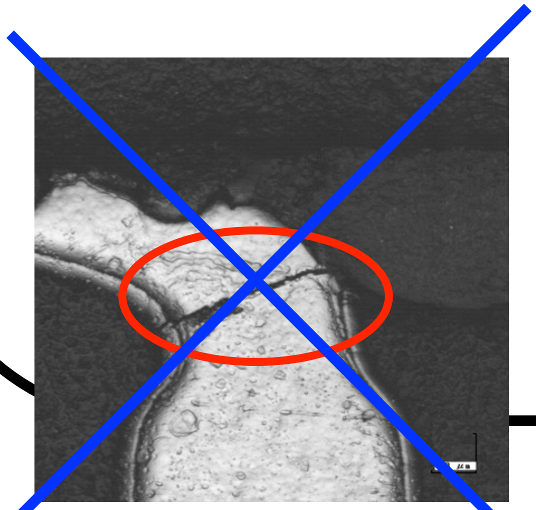
Gone !



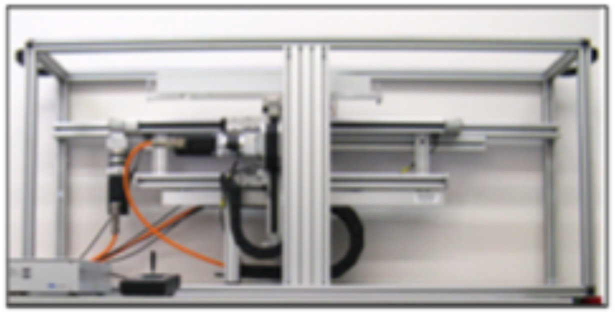
Improved sample available this spring.

Silicon Vertex Detector (SVD)

Ladder production is a one of critical paths.

Getting ready to start SVD ladder production

- **Facility**
  - L5's clean rooms are well equipped and good for the assembly:
    - Clean rooms: cleanliness=10,000.
    - CMM: δ= (2.9+0.3L/cm)μm.
    - Redundant WB machines.
  - Ladder test system is ready with dry air and CO_2 inlet and with DAQ.

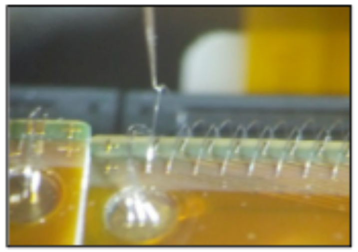


Ladder test box

- **Assembly jigs**
  - **All assembly jigs are produced.**
  - All jig precisions are measured within the tolerance.
    - ***O*(50μm) in the flatness.**
    - ***O*(20μm) in the milling precision.**

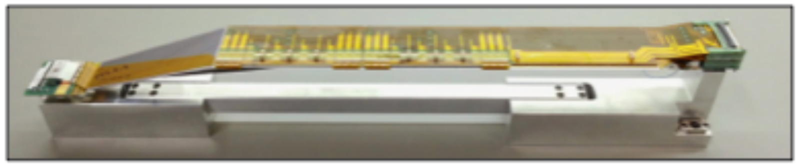
5 sites of IPMU/Pisa/TIFR/Melbourne/HEPHY engaged in this work.

- **Gluing**
  - **Gluing is well reproducible.**
    - PA1/PA2↔DSSD, DSSD↔AIREX, AIREX↔Origami, Origami↔ribs.
- **Wire bonding**
  - The WB performance suffices the QCG criteria, which is optimized with a FlexPA glued to a CMS sensor.
    - **Pull force: f > ~9.7gw, σ_f/f < 6%.**



Pull force test (DSSD-N ↔ PA0)

- **Full ladder assembly**
  - **The ladder was qualified as the class-C on Jan.19th.**
    - Optimization in the PA1/PA2 gluing at the bend was required by the reviewers.



Class-C ladder

- **Electrical test preparation**
  - Functionality for the EQA of the house-made DAQ system is as well proved as it is a de-facto standard of the SVD.

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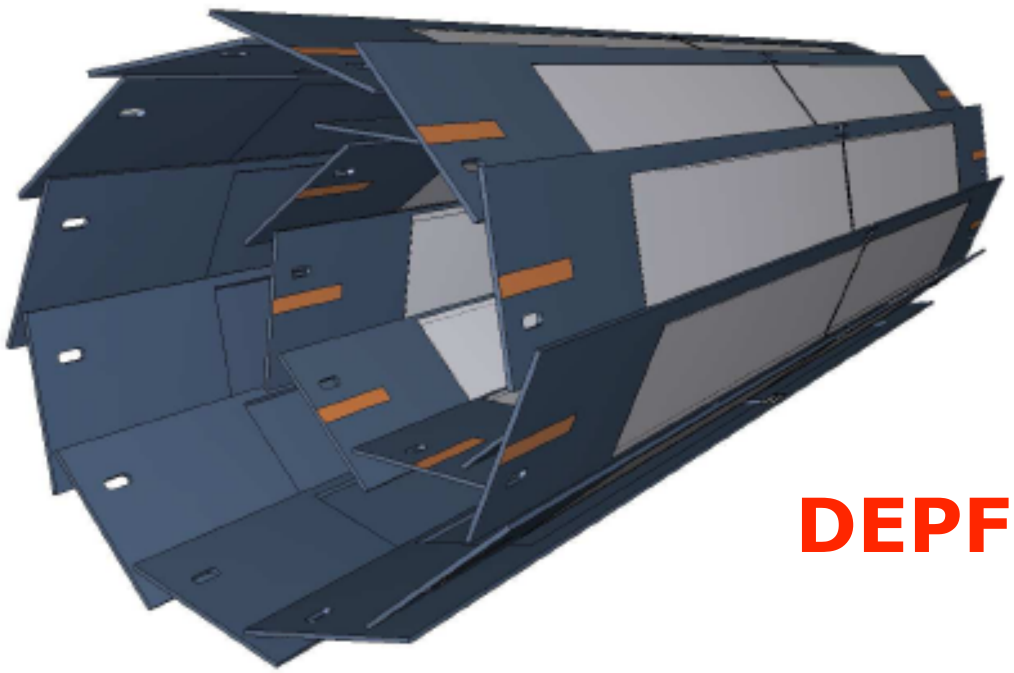
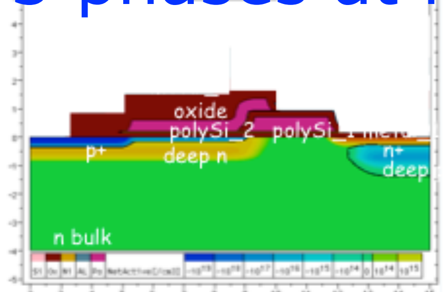
Pixel Detector (PXD)



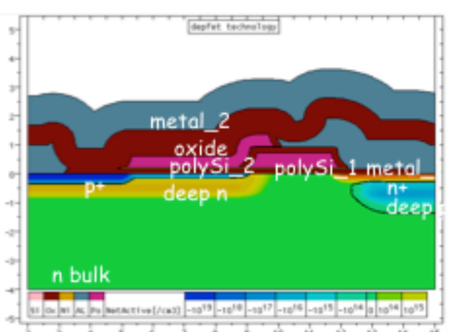
2 DEPFET layers located at the innermost position at R=14mm
(cf. 18mm at Belle)

DEPFET sensor production going smoothly.

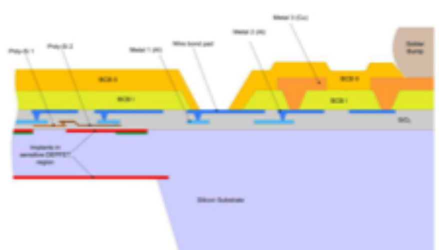
3 phases at metalization (2 Al, 1 Cu)



☑ Phase I – before metal:
↳ Process module based on PXD6 and simulation
↳ first yield estimate based on optical inspection



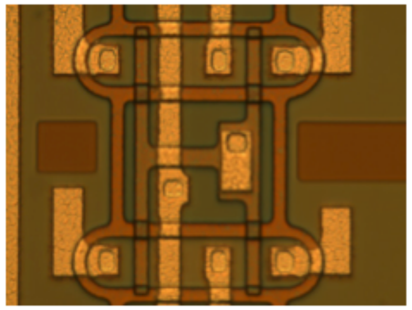
☑ Phase II – metal system (al1 and al2):
↳ Qualification parallel to Phase I
↳ Technology development on EMCM batches



☑ Phase III – Thinning and Cu
↳ Qualification on dummy level
↳ Cu on thick silicon already part of EMCM batches
↳ First test on PXD6 prototype

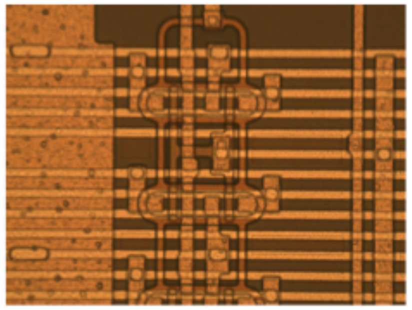
"pilot run" underway

:- status today:
:- 2nd alu structured, dummies and hot wafers being tested on probe station



:- after 1st alu
→ 1st elec. Measurements
→ Diodes, DEPFETs, test structures

1st Al : OK



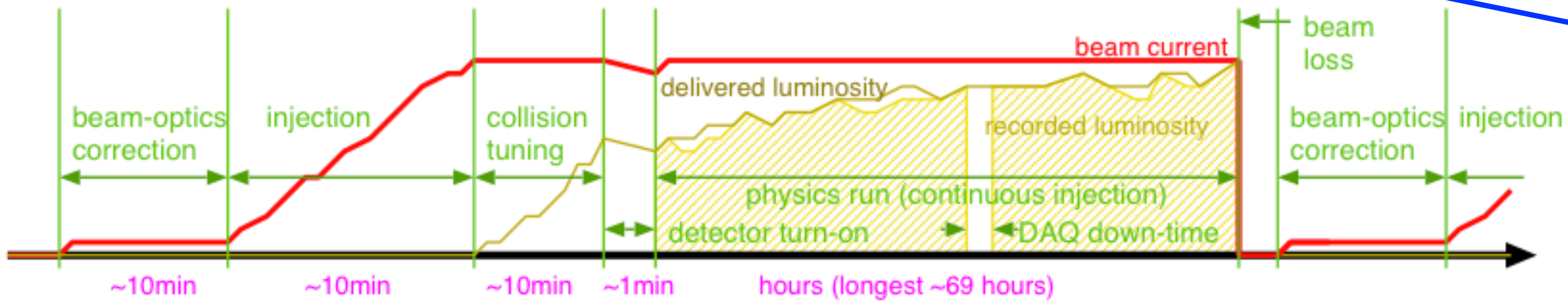
:- after 2nd alu structuring
→ Matrix testing with probe card
→ Ongoing ....

2nd Al : on-going

Slow Control

Sharing information/communication with KEKB group are essential.

Typical run cycle



Goal of slow control

(1) Smooth operation of the DAQ system when beam is ready

(2) Safe operation of the detector

(3) Shifter-friendly interface to operate with minimal training

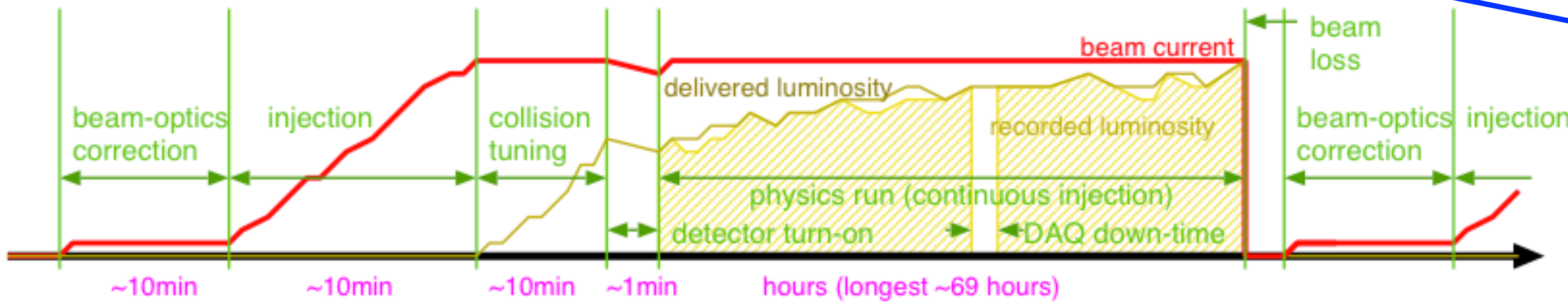
(4) Expert-friendly interface to quickly solve problems if any

(5) Logging all trends and events for later analysis / diagnosis

Slow Control

We have already started discussions with KEKB control experts.

Typical run cycle



- **Run cycle is driven by the beam status— Run and PS cycles**
  - HV power supply (PS) is turned off during injection
  - Run starts when luminosity is delivered
- **Most likely the run will stop by the beam loss**
  - To take risks to maximize the luminosity
- **Most critical part based on hardwired communication**
  - From Belle II to SuperKEKB:
    normal injection allowed / continuous injection allowed
  - From SuperKEKB to Belle II: beam is ready for physics run
  - Other information: network based communication

Slow Control

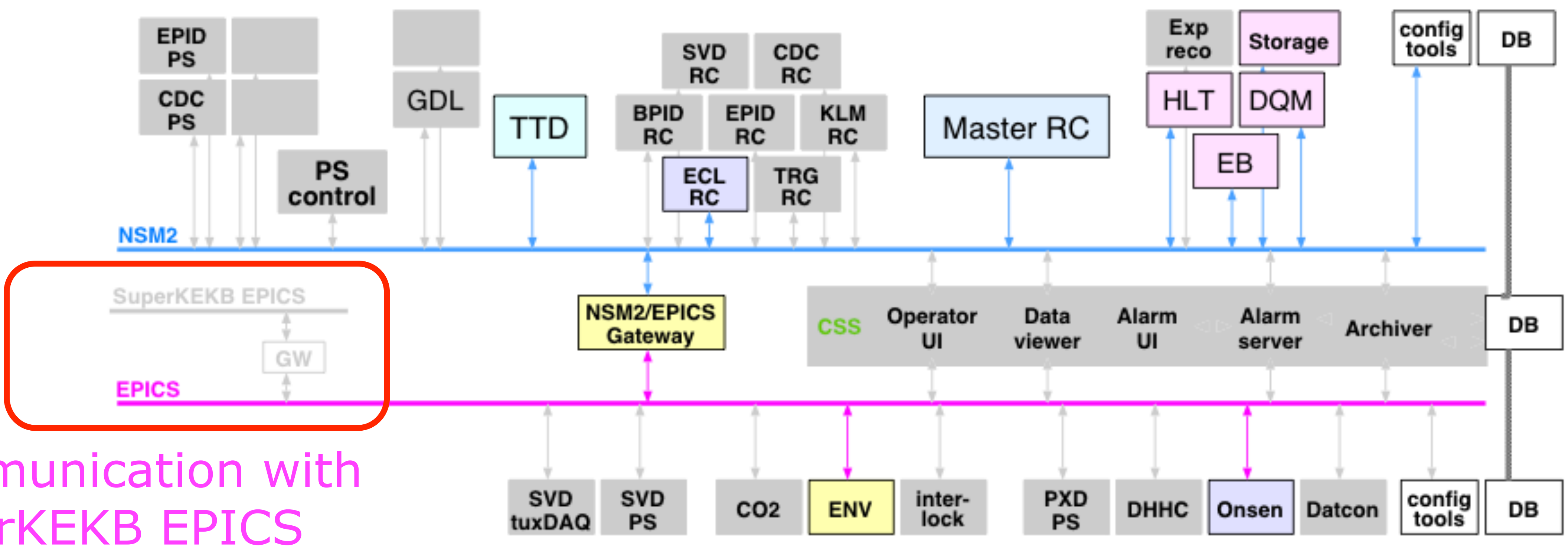
NSM (Network Shared Memory) was a basis at Belle.

CSS binds NSM2 and EPICS

- **Belle II uses both NSM2 and EPICS**
  - Both are small packages and easy to maintain
  - NSM2 is heavily used in the COPPER-based readout, HLT, and HV
  - EPICS is used in PXD, SVD, monitor systems and SuperKEKB

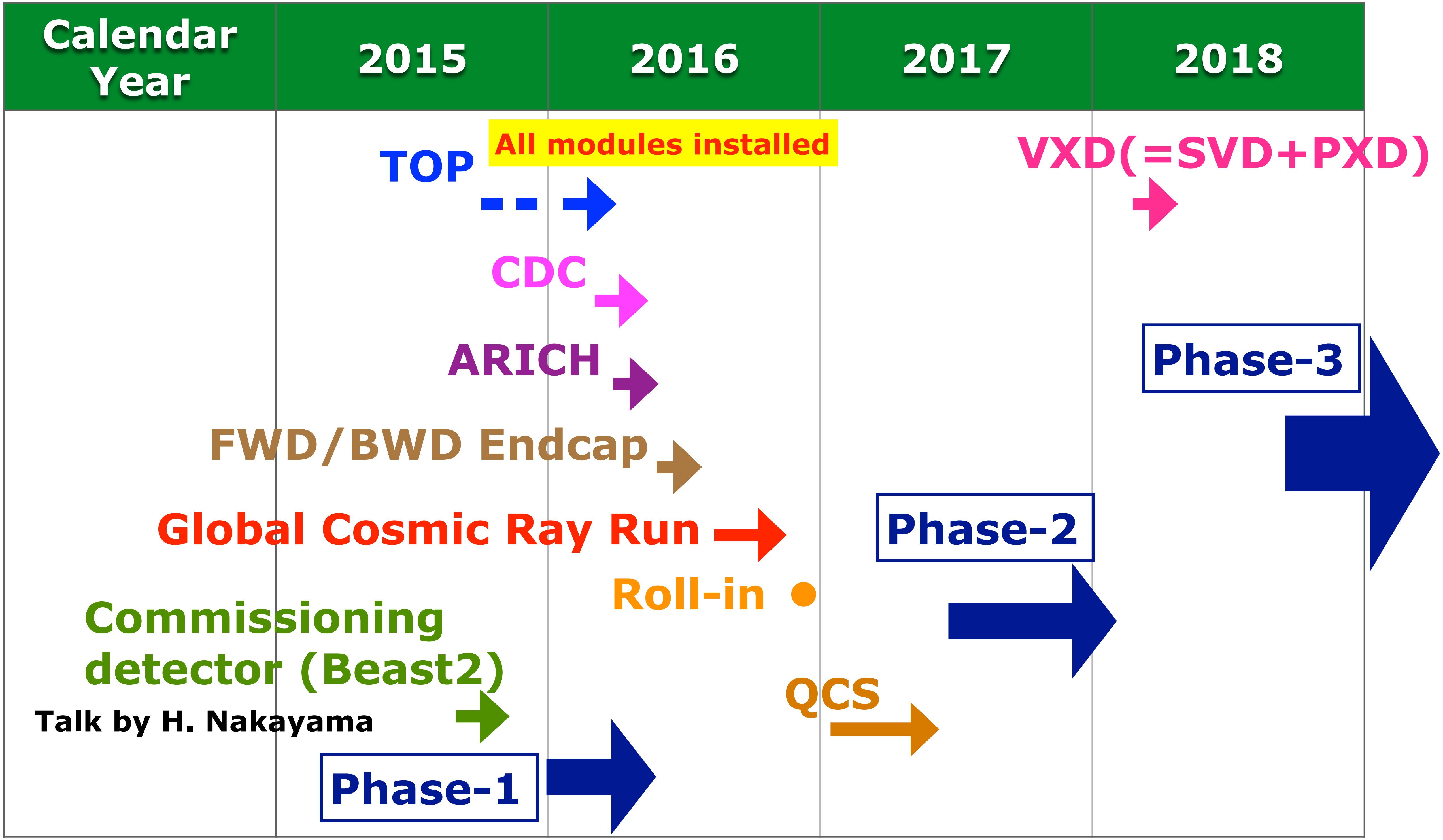
CSS (Control System Studio) can be a solution.

CSS unified control systems now



Communication with SuperKEKB EPICS

Installations & Commissioning



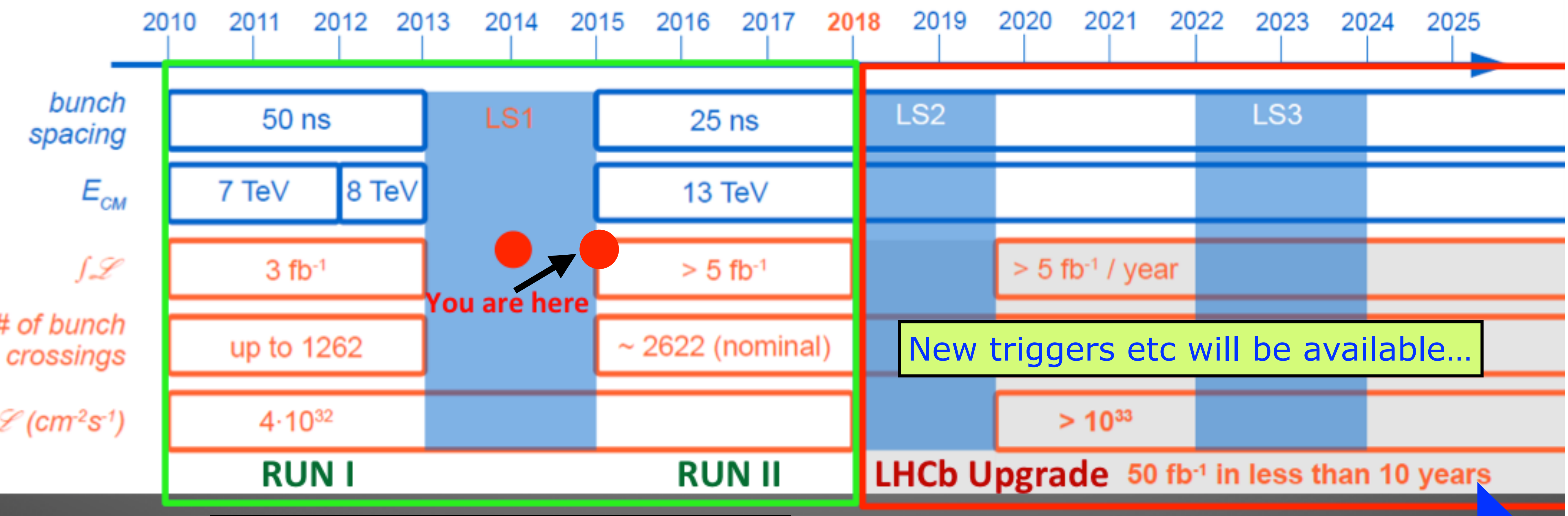
Belle II Summary

- Belle II detector construction is getting into full swing.
  - Tight schedule for TOP module assembly/SVD ladder production.
- Belle II except for VXD will get ready by mid of 2016 for phase-2.
  - All TOP modules will be installed.
  - Roll-in to the beam line is scheduled at the end of 2016.
- Physics run with full detector starts from 2018.
- For run operations, discussions with SuperKEKB group have already started and progress of slow control is in good shape.

Competition with LHCb

Our physics targets are mostly complementary.

LHCb schedule slide at 2014 Rencontres du Vietnam



Higher energy (7→14TeV) in Run2

Belle II physics run

LHCb will accumulate >5 fb^{-1} of data in Run2 (2015-2017).

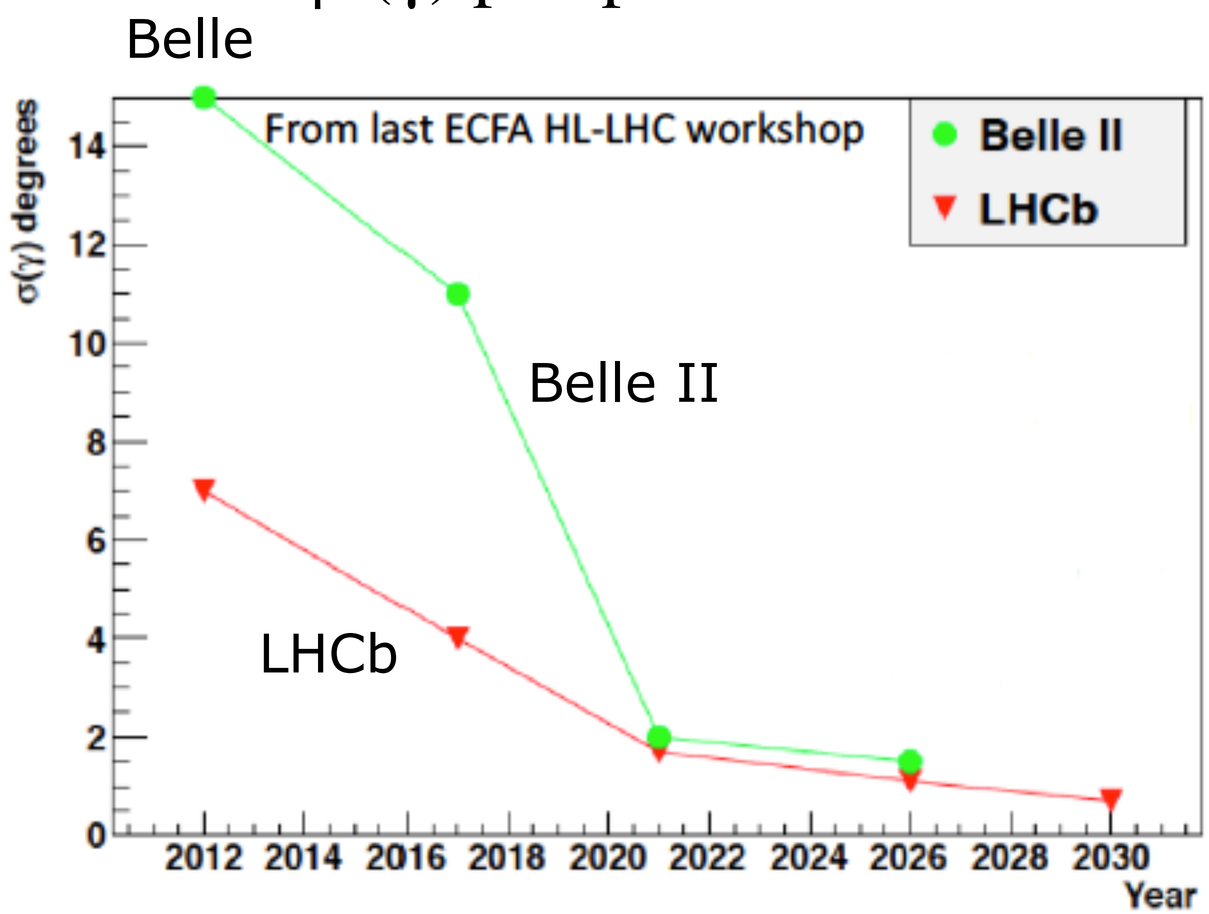
They will be ahead of us in 2018.

Competition with LHCb

We can do very good jobs in competing modes !!

- Comparable precision expected at LHCb and Belle-II
  - Sub-degree level by the end of the experimental programmes
  - Small systematic uncertainties

$\phi_3(\gamma)$ prospect



$\phi_3(\gamma)$ is one of the UT CP phases.

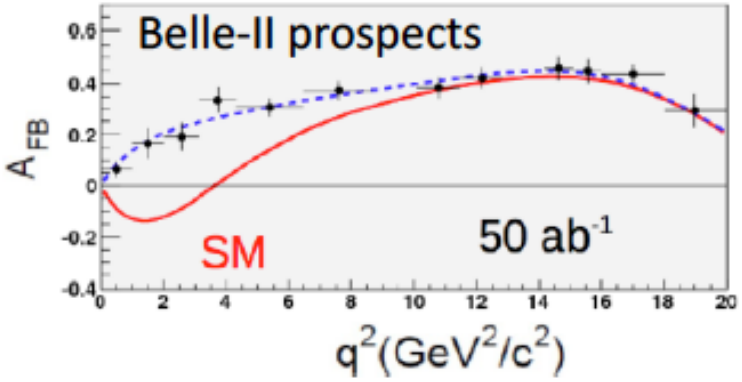
Competition with LHCb

We can do very good jobs in competing modes !!

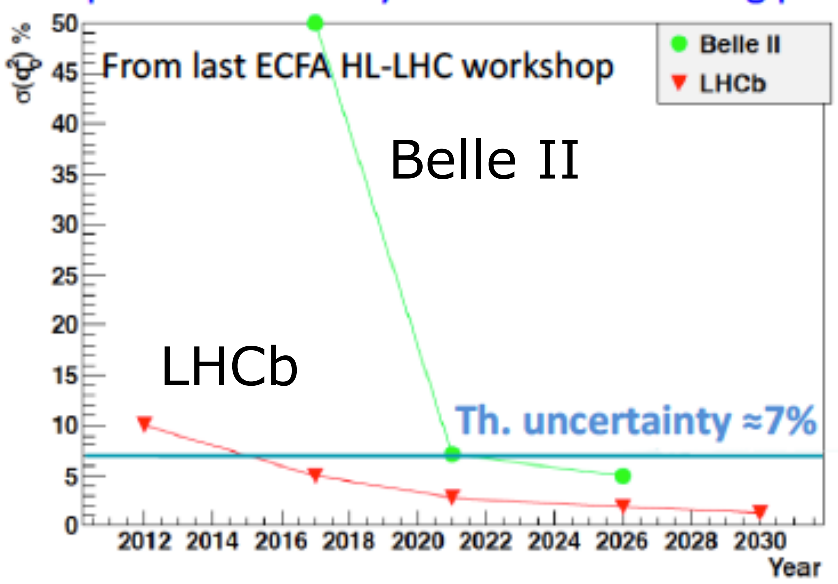
Prospects with $B \rightarrow K^* \mu^+ \mu^-$

$$A_{FB} = \frac{\Gamma(\cos\theta_{B\ell^+} > 0) - \Gamma(\cos\theta_{B\ell^+} < 0)}{\Gamma(\cos\theta_{B\ell^+} > 0) + \Gamma(\cos\theta_{B\ell^+} < 0)}$$

- LHCb expects to reach an accuracy of better than 2% in the zero-crossing of the forward-backward asymmetry
- Belle II is more limited in statistics, but can compensate with $K^* e^+ e^-$ and using an inclusive $B \rightarrow X_s l^+ l^-$ analysis



Expected sensitivity on the zero-crossing point



High sensitivity to NP.

Competition with LHCb

We can do very good jobs in competing modes !!

Aggressive commissioning and quick luminosity increase are key factors.

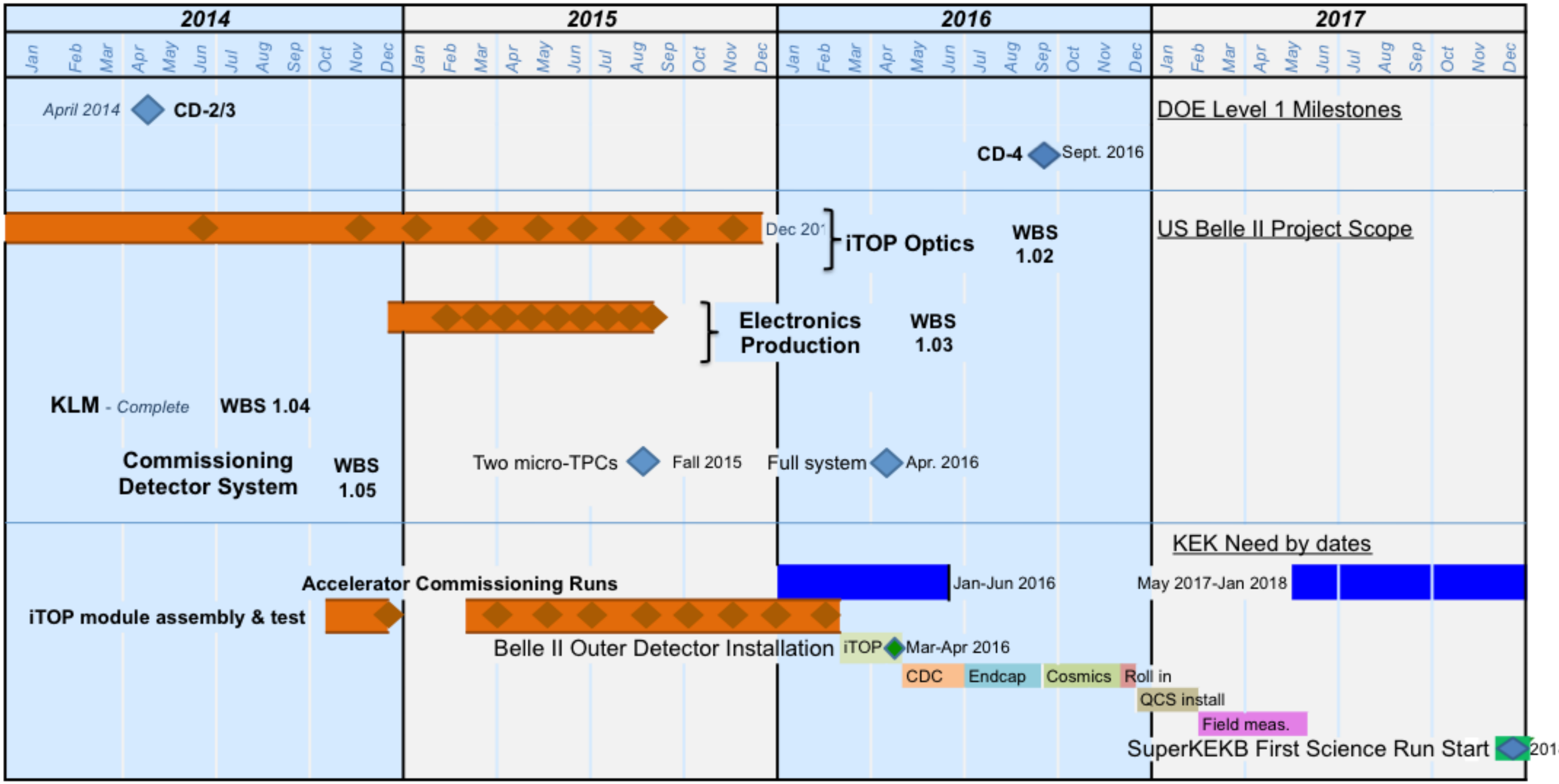
Remark from Belle II Technical Coordinator

We are not only hoping for aggressive commissioning and rapid luminosity increase, but we will be extremely supportive to make it (協力を惜しまない).

Let’s work hard together !

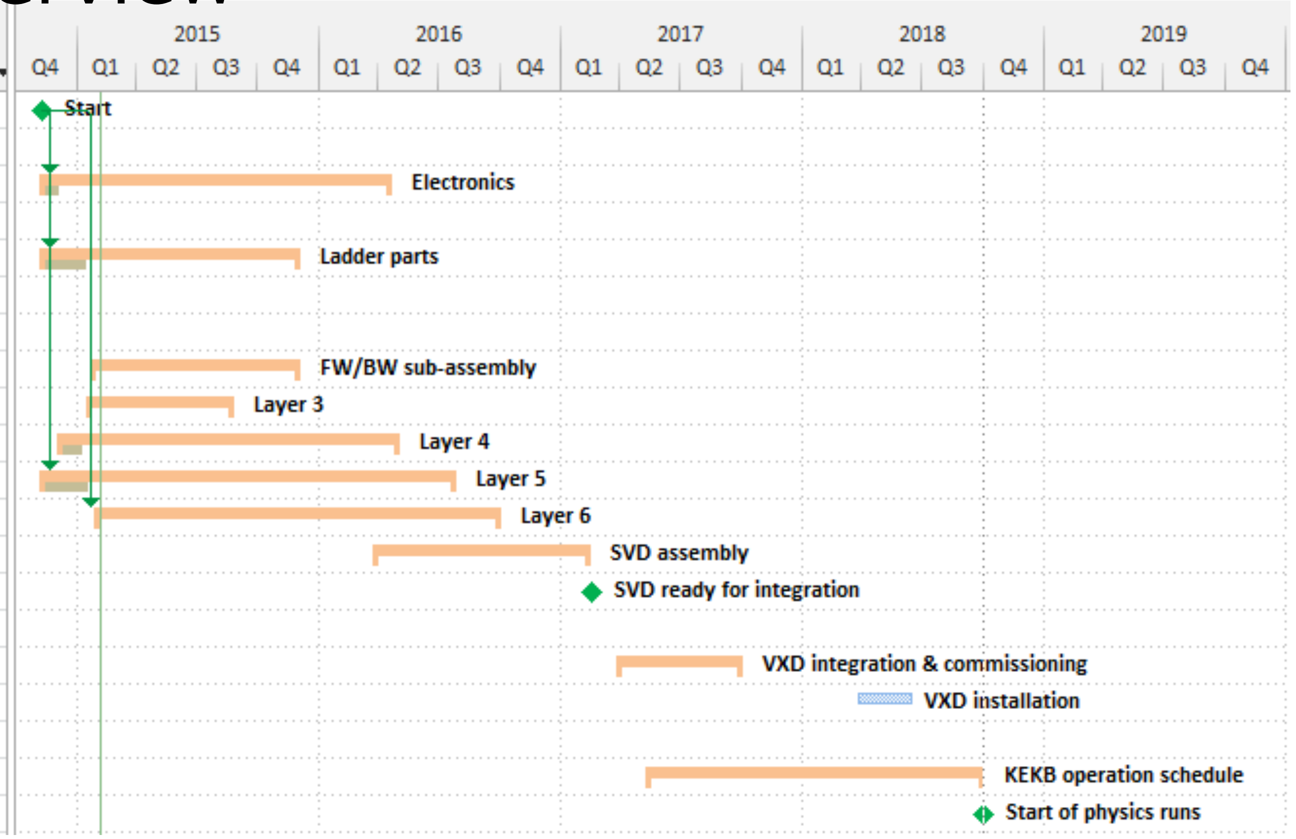
ともにがんばりましょう！

TOP Production and Installation Schedule aligned with overall Belle II schedule



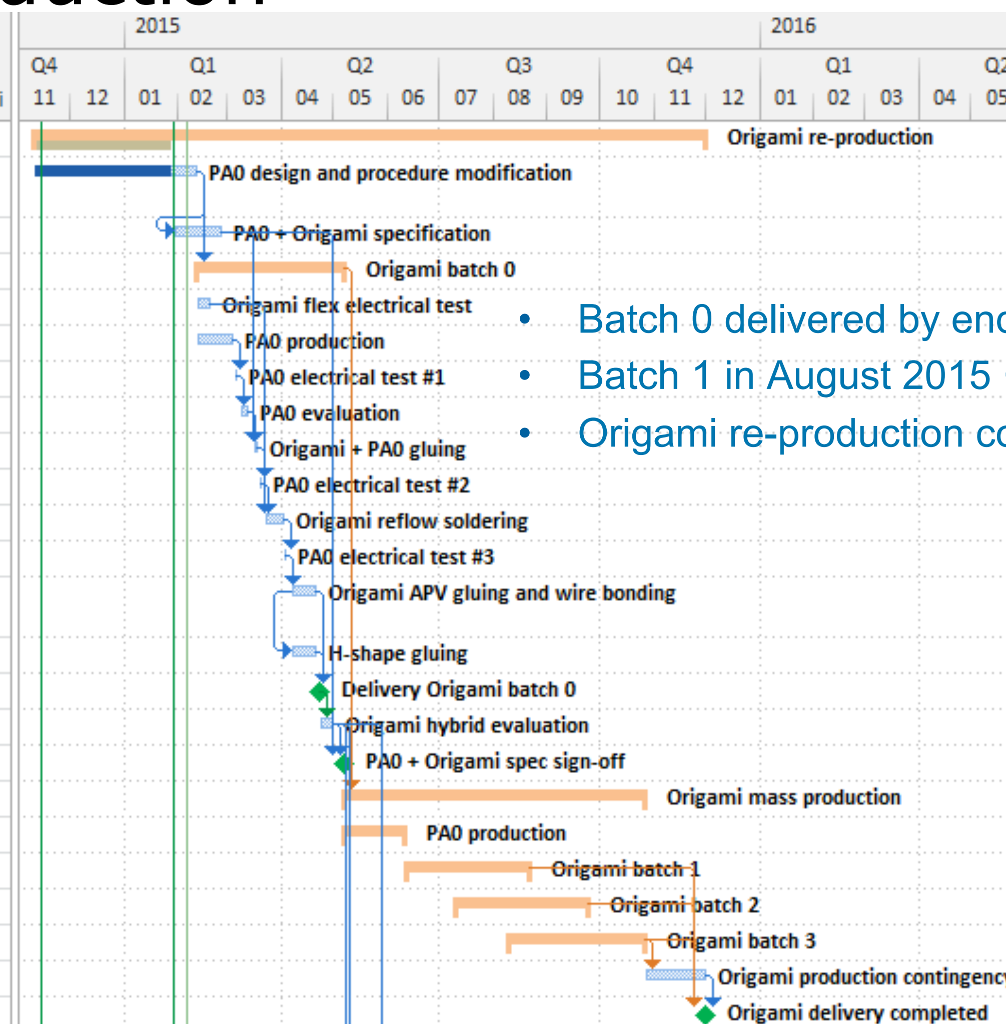
SVD schedule overview

	Name	Start	Finish	Durati
1	Start	Sun 09.11.14	Sun 09.11.14	1 d?
2				
3	**Electronics**	**Mon 10.11.14**	**Fri 15.04.16**	**375 d**
15				
16	**Ladder parts**	**Mon 10.11.14**	**Mon 30.11.15**	**276 d**
67				
105				
106	**FW/BW sub-assembly**	**Mon 26.01.15**	**Mon 30.11.15**	**221 d**
118	**Layer 3**	**Mon 19.01.15**	**Fri 21.08.15**	**155 d**
131	**Layer 4**	**Mon 08.12.14**	**Fri 29.04.16**	**365 d**
149	**Layer 5**	**Mon 10.11.14**	**Fri 22.07.16**	**445 d**
171	**Layer 6**	**Mon 02.02.15**	**Tue 27.09.16**	**432 d**
185	**SVD assembly**	**Mon 28.03.16**	**Fri 10.02.17**	**230 d**
189	SVD ready for integration	Fri 17.02.17	Fri 17.02.17	0 d
190				
191	**VXD integration & commissioning**	**Thu 30.03.17**	**Fri 29.09.17**	**132 d**
196	VXD installation	Mon 26.03.18	Fri 15.06.18	3 mo
197				
198	**KEKB operation schedule**	**Mon 15.05.17**	**Fri 28.09.18**	**360 d**
203	Start of physics runs	Tue 02.10.18	Tue 02.10.18	0 d



SVD origami re-production

	Name	Start	Finish	Durati
17	**Origami re-production**	**Mon 10.11.14**	**Mon 30.11.15**	**276 d**
18	PA0 design and procedure modification	Mon 10.11.14	Wed 11.02.15	68 d
19	PA0 + Origami specification	Thu 29.01.15	Wed 25.02.15	4 w
20	**Origami batch 0**	**Thu 12.02.15**	**Wed 06.05.15**	**60 d**
21	Origami flex electrical test	Thu 12.02.15	Wed 18.02.15	1 w
22	PA0 production	Thu 12.02.15	Tue 03.03.15	14 d
23	PA0 electrical test #1	Thu 05.03.15	Thu 05.03.15	1 d
24	PA0 evaluation	Mon 09.03.15	Thu 12.03.15	4 d
25	Origami + PA0 gluing	Mon 16.03.15	Tue 17.03.15	2 d
26	PA0 electrical test #2	Thu 19.03.15	Thu 19.03.15	1 d
27	Origami reflow soldering	Mon 23.03.15	Wed 01.04.15	8 d
28	PA0 electrical test #3	Fri 03.04.15	Fri 03.04.15	1 d
29	Origami APV gluing and wire bonding	Tue 07.04.15	Mon 20.04.15	10 d
30	H-shape gluing	Tue 07.04.15	Mon 20.04.15	2 w
31	Delivery Origami batch 0	Wed 22.04.15	Wed 22.04.15	0 d
32	Origami hybrid evaluation	Thu 23.04.15	Thu 30.04.15	6 d
33	PA0 + Origami spec sign-off	Wed 06.05.15	Wed 06.05.15	0 d
34	**Origami mass production**	**Thu 07.05.15**	**Mon 26.10.15**	**123 d**
35	**PA0 production**	**Thu 07.05.15**	**Wed 10.06.15**	**25 d**
41	**Origami batch 1**	**Fri 12.06.15**	**Fri 21.08.15**	**51 d**
49	**Origami batch 2**	**Fri 10.07.15**	**Wed 23.09.15**	**54 d**
57	**Origami batch 3**	**Mon 10.08.15**	**Mon 26.10.15**	**56 d**
65	Origami production contingency	Tue 27.10.15	Mon 30.11.15	5 w
66	Origami delivery completed	Mon 30.11.15	Mon 30.11.15	0 d



- Batch 0 delivered by end of April → for class B ladders & 1st class A
- Batch 1 in August 2015 → for class A ladders
- Origami re-production completed by December 2015

Silicon Vertex Detector (SVD)

Ladder Production Sites IPMU/Pisa/TIFR/Melbourne/HEPHY

Assembly Sites Qualification

- SVD ladders / modules will be built by 5 groups
- **Assembly groups need to be officially qualified before starting to work production level components**
- Class definition of components:

Class	Definition
A	Production quality component. Good for installation.
B	Fully functional component, but of reduced quality.
C	Mechanical, not electrically working component, but with all the features and precision of a class B (chips, sensors, wirebonds)
D	Mechanical component, possibly with missing chips, no wirebonding, aluminum sensors, reduced precision

- Qualification is foreseen in two steps:
  - Class C qualification requires all final procedures, except for an electrically working module. Site visit required
  - Final qualification (no visit) using class B or B- (with some minor differences from final module)

Internal review organized.

4 sites have been already qualified up to class-C.

Expected to gear up productions.

Site Qualification Reviews

- The reviews help the groups to
  - Design stable and reliable **procedures**
  - **Document** the procedures and the QC/QA
  - **Communicate** with other sites
  - **Organize** the manpower and schedule
- **It should not be a one-time event, but rather a work method**

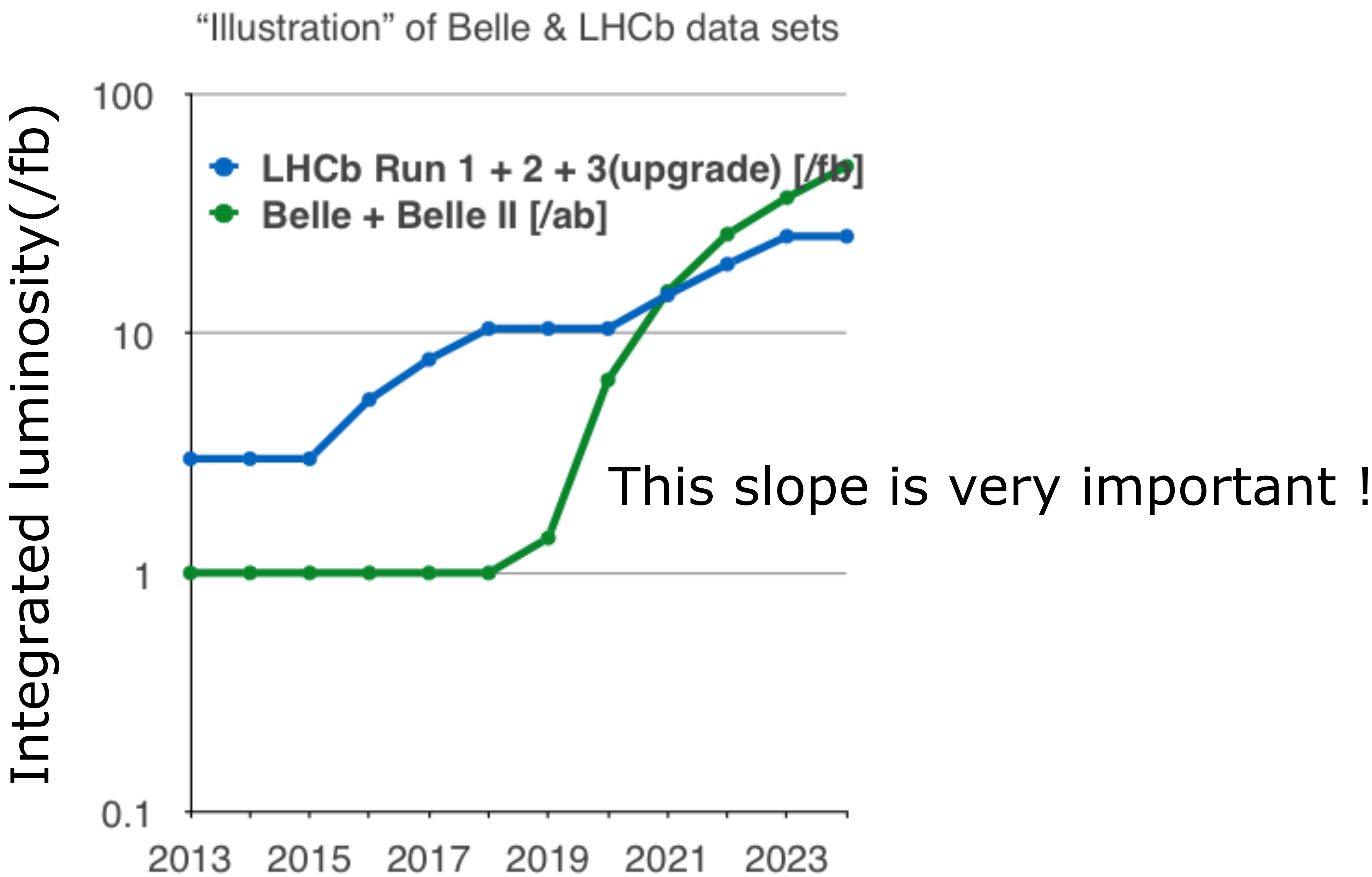
Physics Reach of Belle II and the LHCb upgrade

Observable	Expected th. accuracy	Expected exp. uncertainty	Facility
CKM matrix			
$\|V_{us}\|$ $[K \to \pi\ell\nu]$	**	0.1%	K-factory
$\|V_{cb}\|$ $[B \to X_c\ell\nu]$	**	1%	Belle II
$\|V_{ub}\|$ $[B_d \to \pi\ell\nu]$	*	4%	Belle II
$\sin(2\phi_1)$ $[c\bar{c}K_S^0$	***	$8 \cdot 10^{-3}$	Belle II/LHCb
ϕ_2		1.5°	Belle II
ϕ_3	***	3°	LHCb
CPV			
$S(B_s \to \psi\phi)$	**	0.01	LHCb
$S(B_s \to \phi\phi)$	**	0.05	LHCb
$S(B_d \to \phi K)$	***	0.05	Belle II/LHCb
$S(B_d \to \eta' K)$	***	0.02	Belle II
$S(B_d \to K^*(\to K_S^0\pi^0)\gamma))$	***	0.03	Belle II
$S(B_s \to \phi\gamma))$	***	0.05	LHCb
$S(B_d \to \rho\gamma))$		0.15	Belle II
A_{SL}^d	***	0.001	LHCb
A_{SL}^s	***	0.001	LHCb
$A_{CP}(B_d \to s\gamma)$	*	0.005	Belle II
rare decays			
$\mathcal{B}(B \to \tau\nu)$	**	3%	Belle II
$\mathcal{B}(B \to D\tau\nu)$		3%	Belle II
$\mathcal{B}(B_d \to \mu\nu)$	**	6%	Belle II
$\mathcal{B}(B_s \to \mu\mu)$	***	10%	LHCb
zero of $\mathrm{A_{FB}(B \to K^*\mu\mu)}$	**	0.05	LHCb
$\mathcal{B}(B \to K^{(*)}\nu\nu)$	***	30%	Belle II
$\mathcal{B}(B \to s\gamma)$		4%	Belle II
$\mathcal{B}(B_s \to \gamma\gamma)$		$0.25 \cdot 10^{-6}$	Belle II (with 5 ab^{-1})
$\mathcal{B}(K \to \pi\nu\nu)$	**	10%	K-factory
$\mathcal{B}(K \to e\pi\nu)/\mathcal{B}(K \to \mu\pi\nu)$	***	0.1%	K-factory
charm and τ			
$\mathcal{B}(\tau \to \mu\gamma)$	***	$3 \cdot 10^{-9}$	Belle II
$\|q/p\|_D$	***	0.03	Belle II
$arg(q/p)_D$	***	1.5°	Belle II

TABLE XLI: Expected errors on several selected flavour observables with an integrated luminosity of 5 ab^{-1} and 50 ab^{-1} of Belle II data. The current results from Belle, or from BaBar where relevant (denoted with a †) are also given. Items marked with a ‡ are estimates based on similar measurements. Errors given in % represent relative errors.

	Observables	Belle or LHCb* (2014)	Belle II 5 ab^{-1}	Belle II 50 ab^{-1}	LHCb 8 fb^{-1}(2018)	LHCb 50 fb^{-1}
UT angles	$\sin 2\beta$	$0.667 \pm 0.023 \pm 0.012 (1.4°)$	0.7°	0.4°	1.6°	0.6°
	α [°]	85 ± 4 (Belle+BaBar)	2	1		
	γ [°] $(B \to D^{(*)} K^{(*)})$	68 ± 14	6	1.5	4	1
	$2\beta_s (B_s \to J/\psi\phi)$ [rad]	$0.07 \pm 0.09 \pm 0.01^*$			0.025	0.009
Gluonic penguins	$S(B \to \phi K^0)$	$0.90^{+0.09}_{-0.19}$	0.053	0.018	0.2	0.04
	$S(B \to \eta' K^0)$	$0.68 \pm 0.07 \pm 0.03$	0.028	0.011		
	$S(B \to K^0_S K^0_S K^0_S)$	$0.30 \pm 0.32 \pm 0.08$	0.100	0.033		
	$\beta_s^{\rm eff}(B_s \to \phi\phi)$ [rad]	$-0.17 \pm 0.15 \pm 0.03^*$			0.12	0.03
	$\beta_s^{\rm eff}(B_s \to K^{*0} \bar{K}^{*0})$ [rad]	–			0.13	0.03
Direct CP in hadronic Decays	$\mathcal{A}(B \to K^0 \pi^0)$	$-0.05 \pm 0.14 \pm 0.05$	0.07	0.04		
UT sides	$\lvert V_{cb} \rvert$ incl.	$41.6 \cdot 10^{-3} (1 \pm 2.4\%)$	1.2%			
	$\lvert V_{cb} \rvert$ excl.	$37.5 \cdot 10^{-3} (1 \pm 3.0\%_{\rm ex.} \pm 2.7\%_{\rm th.})$	1.8%	1.4%		
	$\lvert V_{ub} \rvert$ incl.	$4.47 \cdot 10^{-3} (1 \pm 6.0\%_{\rm ex.} \pm 2.5\%_{\rm th.})$	3.4%	3.0%		
	$\lvert V_{ub} \rvert$ excl. (had. tag.)	$3.52 \cdot 10^{-3} (1 \pm 10.8\%)$	4.7%	2.4%		
Leptonic and Semi-tauonic	$\mathcal{B}(B \to \tau\nu)$ $[10^{-6}]$	$96(1 \pm 26\%)$	10%	5%		
	$\mathcal{B}(B \to \mu\nu)$ $[10^{-6}]$	< 1.7	20%	7%		
	$R(B \to D\tau\nu)$ [Had. tag]	$0.440(1 \pm 16.5\%)^\dagger$	5.6%	3.4%		
	$R(B \to D^*\tau\nu)^\dagger$ [Had. tag]	$0.332(1 \pm 9.0\%)^\dagger$	3.2%	2.1%	...	
Radiative	$\mathcal{B}(B \to X_s\gamma)$	$3.45 \cdot 10^{-4} (1 \pm 4.3\% \pm 11.6\%)$	7%	6%		
	$A_{CP}(B \to X_{s,d}\gamma)$ $[10^{-2}]$	$2.2 \pm 4.0 \pm 0.8$	1	0.5		
	$S(B \to K^0_S \pi^0 \gamma)$	$-0.10 \pm 0.31 \pm 0.07$	0.11	0.035		
	$2\beta_s^{\rm eff}(B_s \to \phi\gamma)$	–			0.13	0.03
	$S(B \to \rho\gamma)$	$-0.83 \pm 0.65 \pm 0.18$	0.23	0.07		
	$\mathcal{B}(B_s \to \gamma\gamma)$ $[10^{-6}]$	< 8.7	0.3	–		
Electroweak penguins	$\mathcal{B}(B \to K^{*+}\nu\bar{\nu})$ $[10^{-6}]$	< 40	< 15	30%		
	$\mathcal{B}(B \to K^+\nu\bar{\nu})$ $[10^{-6}]$	< 55	< 21	30%		
	C_7/C_9 $(B \to X_s \ell\ell)$	~20%	10%	5%		
	$\mathcal{B}(B_s \to \tau\tau)$ $[10^{-3}]$	–	< 2	–		
	$\mathcal{B}(B_s \to \mu\mu)$ $[10^{-9}]$	$2.9^{+1.1}_{-1.0}{}^*$			0.5	0.2

Data sets comparison



First Physics at Phase-2

Identify a program O(300 fb^{-1}) that maximises output from 1st year,
Allow for time to calibrate the detector at Y(4S).

No vertexing, but tracking(CDC), PID, and calorimetry are working.

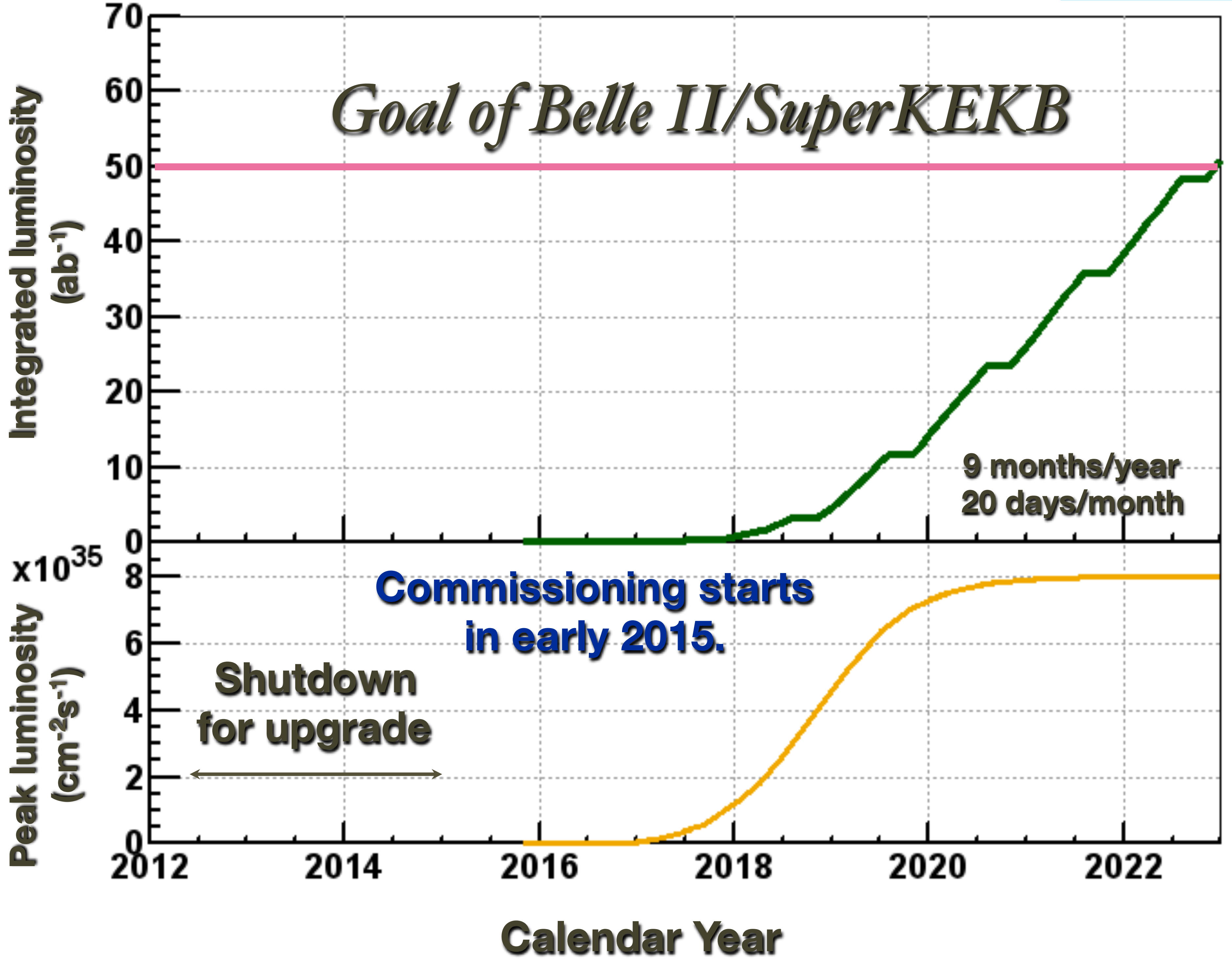
Experiment	Scans/Off. Res.	$\Upsilon(5S)$ 10876 MeV		$\Upsilon(4S)$ 10580 MeV		$\Upsilon(3S)$ 10355 MeV		$\Upsilon(2S)$ 10023 MeV		$\Upsilon(1S)$ 9460 MeV	
	fb^{-1}	fb^{-1}	10^6	fb^{-1}	10^6	fb^{-1}	10^6	fb^{-1}	10^6	fb^{-1}	10^6
CLEO	17.1	0.4	0.1	16	17.1	1.2	5	1.2	10	1.2	21
BaBar	54	R_b scan		433	471	30	122	14	99	–	
Belle	100	121	36	711	772	3	12	25	158	6	102

Experiment	Scan above $\Upsilon(5S)$
CLEO	$\sim 70\ pb^{-1}$ [49]
CUSB	$\sim 123\ pb^{-1}$ [50]
BaBar	$\sim 3.3\ fb^{-1}$ [51]
Belle	$\sim 24\ fb^{-1}$ [53, 54]

- **Y(2S)**: dark forces, light Higgs
- **Y(3S):** conventional bottomonium
- **Scan** around Y(5S) and *b* quark mass determination
- **Y(6S):** exotic bottomonium, **R_b** scan *(E_{CM} design max 11.25 GeV)*

Luminosity Projection

50/ab around 2024



Commissioning Scenario

Bistro "SuperKEKB"

Menu du Jour

Amuse-Bouche

(Phase-1)

Commissioning detector (Beast2)

No QCS

Hors D'œuvre

(Phase-2)

Belle II w/o VXD

Beast2 phase2

with QCS

Main

(Phase-3)

Physics run with full detector