

The Belle II Computing System

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Soongsil University

January 29, 2018
AFAD 2018



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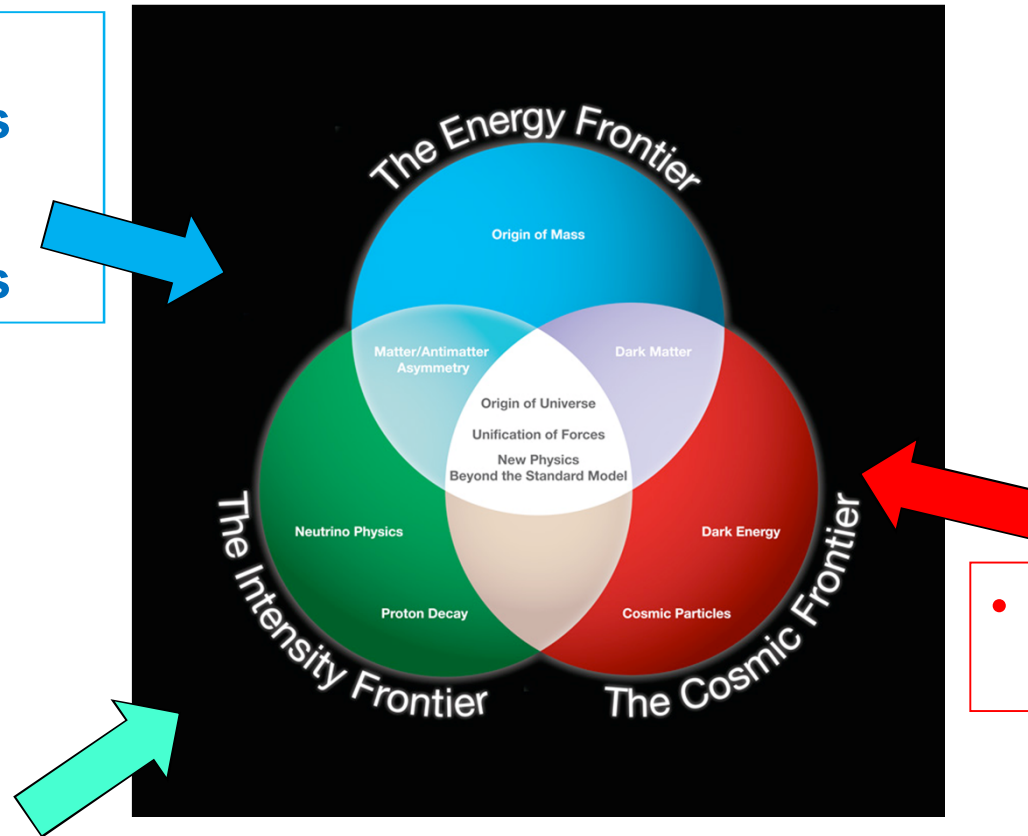
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Introduction

The B Factory

Three Frontiers of Particle Physics

- LHC experiments
- Neutrino experiments

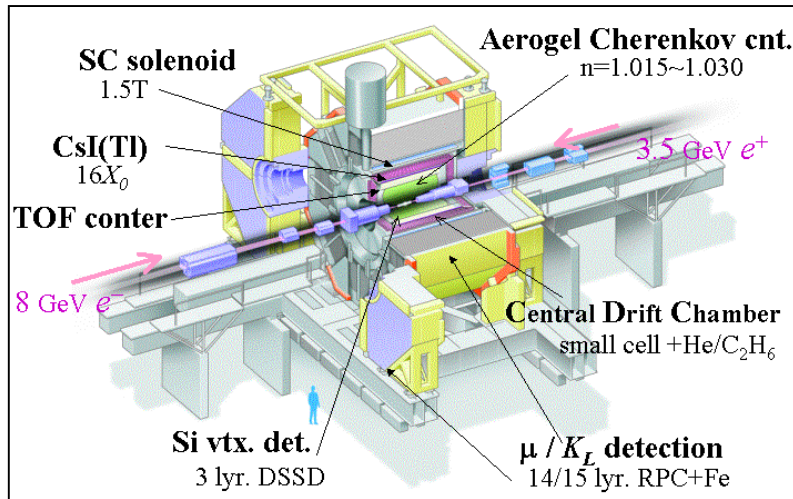


- Astroparticle experiments

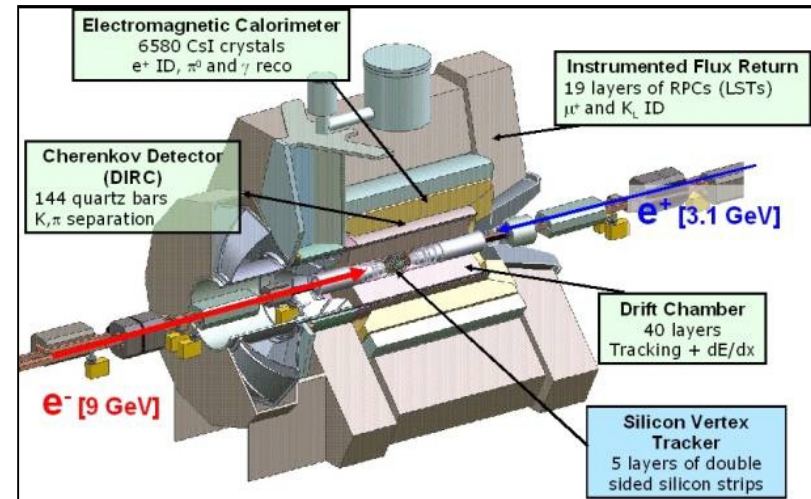
- particle factories such as Belle (II) and tau-charm factories

Two B Factories from 1999

Belle / KEKB



BABAR / PEP II

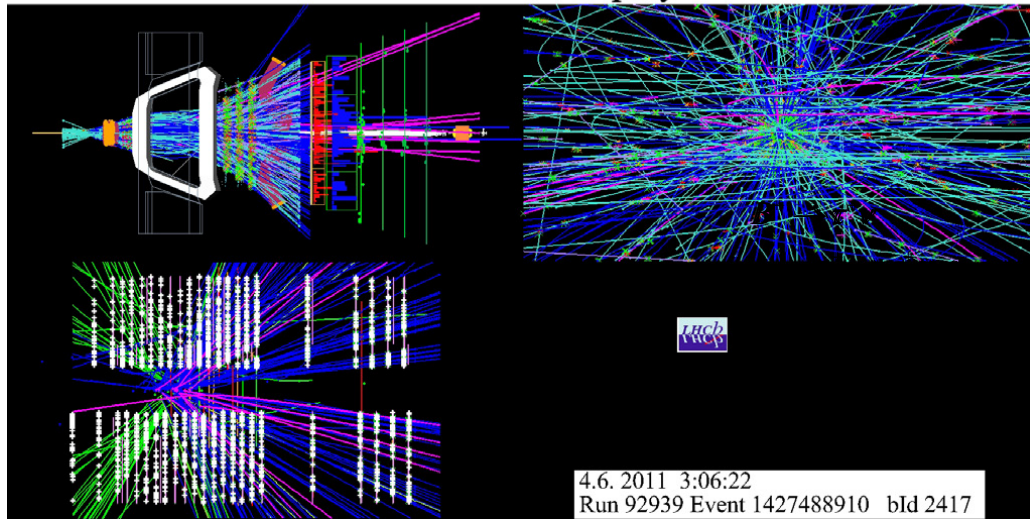


- **CP Violation in the B section confirmed.**
- **Precision measurement of the CKM matrix. X(3872) and exotic particles.**
- **2008 Nobel Prize, Kobayashi-Maskawa**
- **2017 Hoam Prize (Korea), Sookyung Choi**

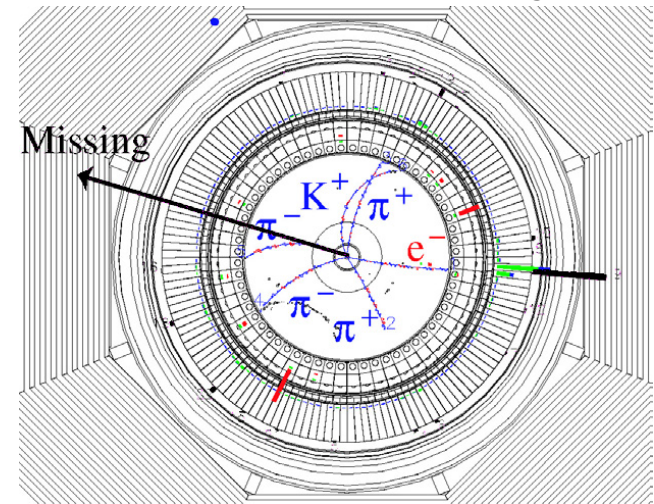


Two B Factories: Current/Next Generation

LHCb Event Display



Belle Event Display



ere.

Belle II Experiment

- **B meson pairs at $\Upsilon(4S)$**
- **High tagging efficiency of B particles**
- **Direct detection of γ , π^0 , K_L .**
- **Detection of neutrinos as missing energy**

Upgrade from KEK/Belle to SuperKEKB/Belle II

	KEKB	→	SuperKEKB	
Luminosity:	2.1×10^{34}	→	$8 \times 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$	(x 40)
Integrated Luminosity:	1 ab^{-1}	→	50 ab^{-1}	(x 50)
Runtime	1998 to 2010		2017 started	
Detector:	Belle	→	Belle II	
Raw Data:	1 PB		100 PB (projected 2 sets of raw data)	(x 100)

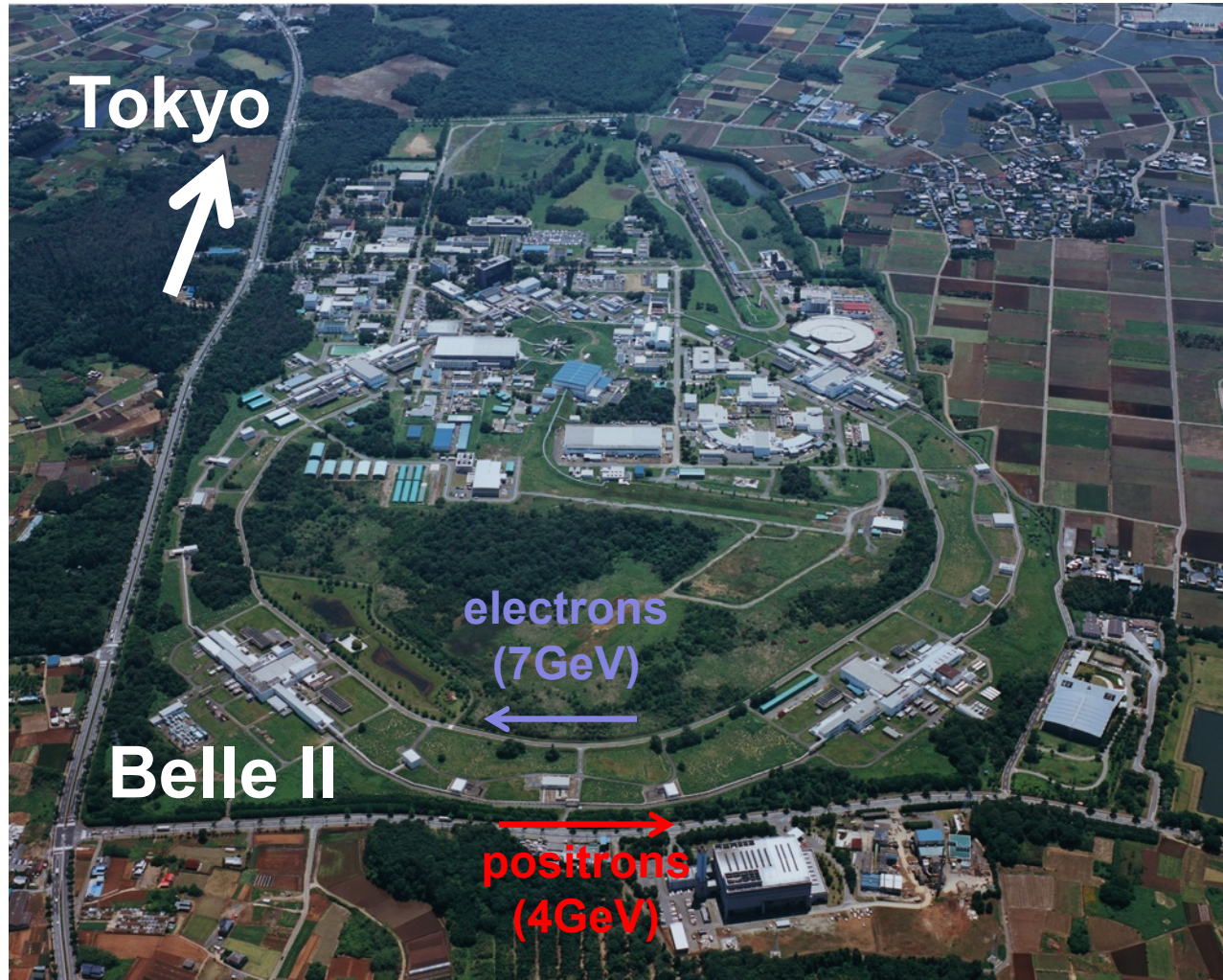


Belle II Collaboration

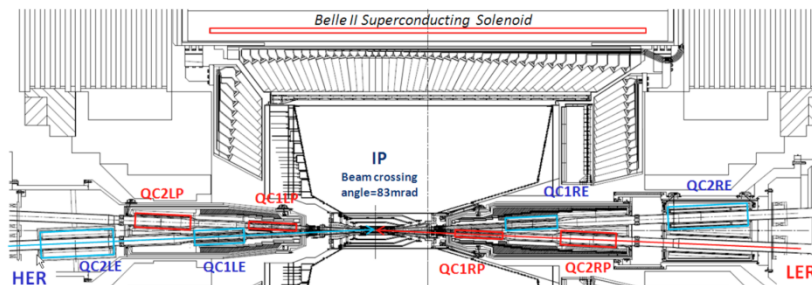


SuperKEKB Belle II

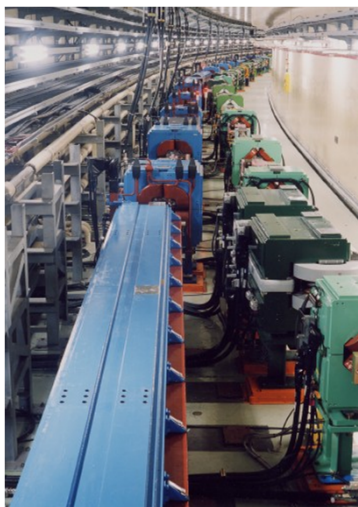
SuperKEKB Collider



SuperKEKB Construction Finished

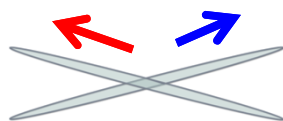


New superconducting final focusing magnets near the IP



e^+ 3.6A

e^- 2.6A

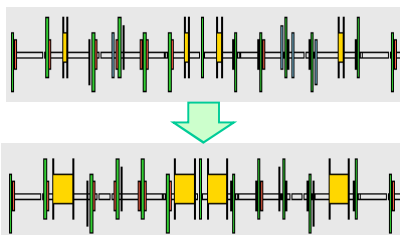


Nano-Beam scheme
extremely small β_y^*
low emittance

Reinforce RF systems for higher beam currents



Redesigned the lattice to reduce the emittance



Replaced beam pipes with TiN-coated beam pipes with antechambers



January 29, 2018

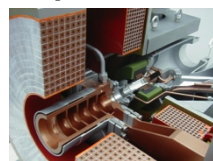


DR tunnel

Doris Y Kim, Soongsil University



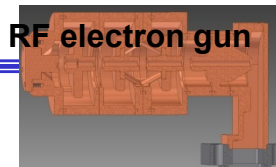
Improve monitors and control system



Upgrade positron capture section

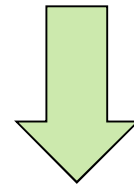
Injector Linac upgrade

Low emittance RF electron gun

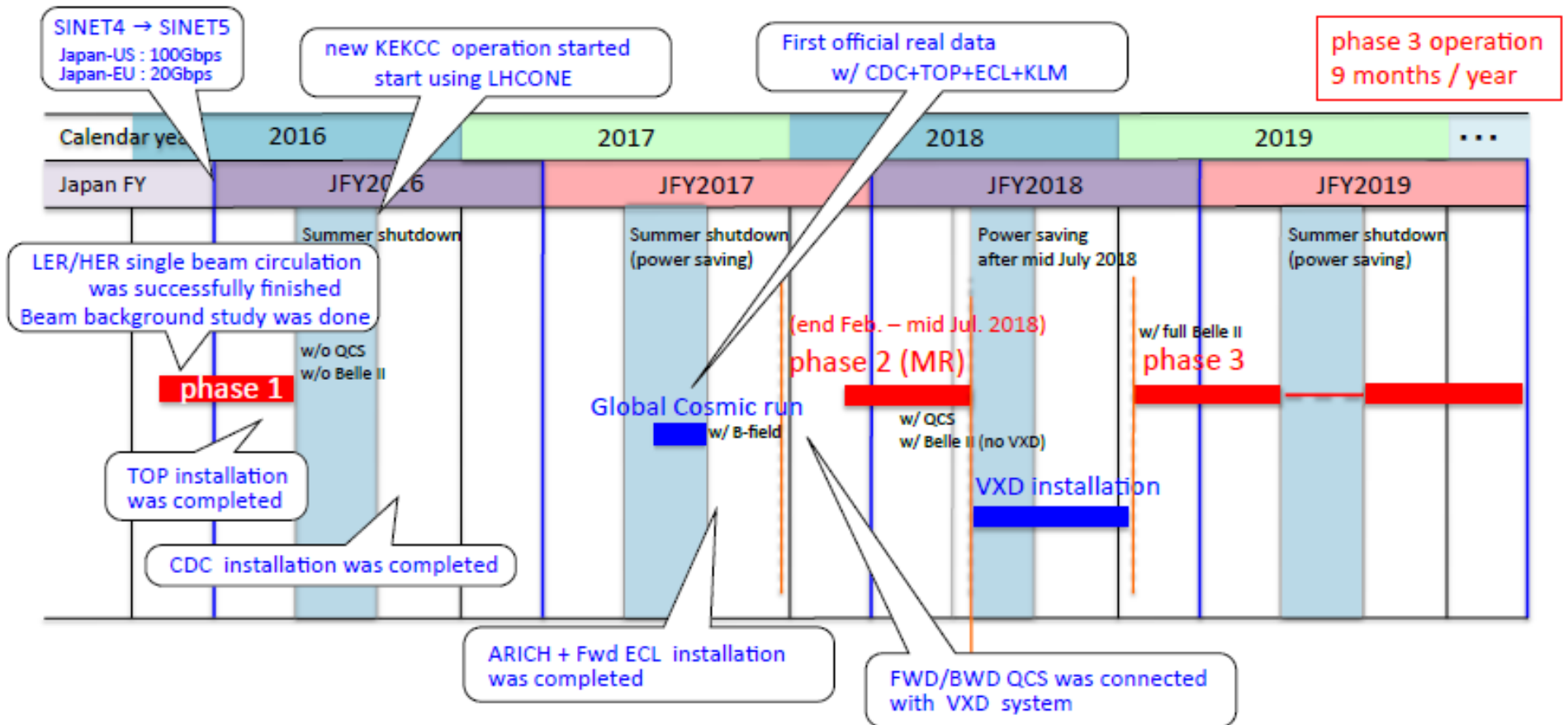


Beam Commissioning Phases

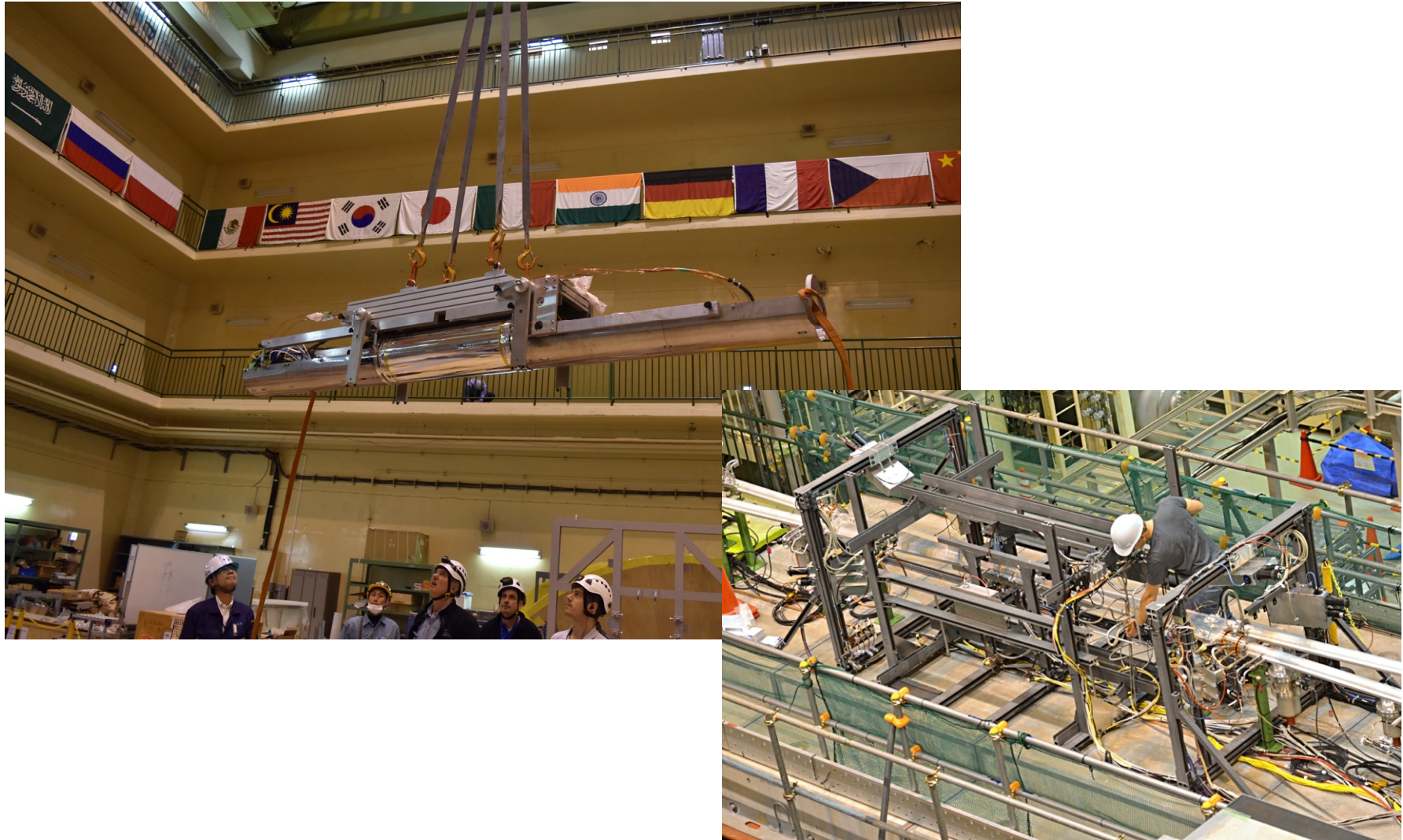
- BEAST Phase I in 2016.
 - Simple background measuring detector (diodes, diamonds TPCs, crystals)
 - Only single beam circulated for LER/HER.
- BEAST Phase II in 2018.
 - More precise inner background measuring detector +
 - Full Belle II outer detector
 - Two beams (e^+ , e^-) will collide!
- Belle II Phase III at the end of JFY 2018.
 - The most precise silicon inner detector included.
 - Physics mode with the full Belle II detector.



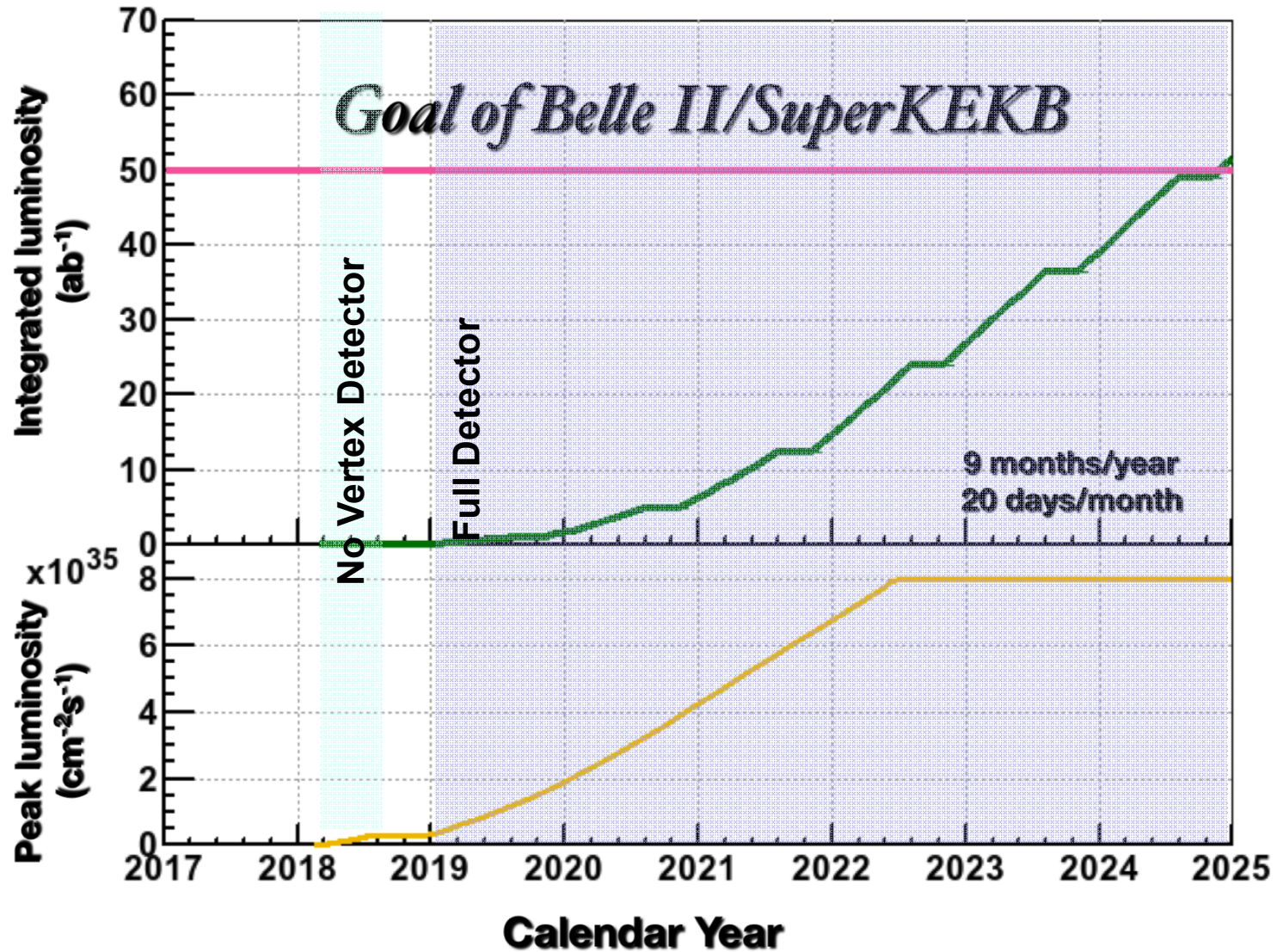
SuperKEKB/Belle II Schedule



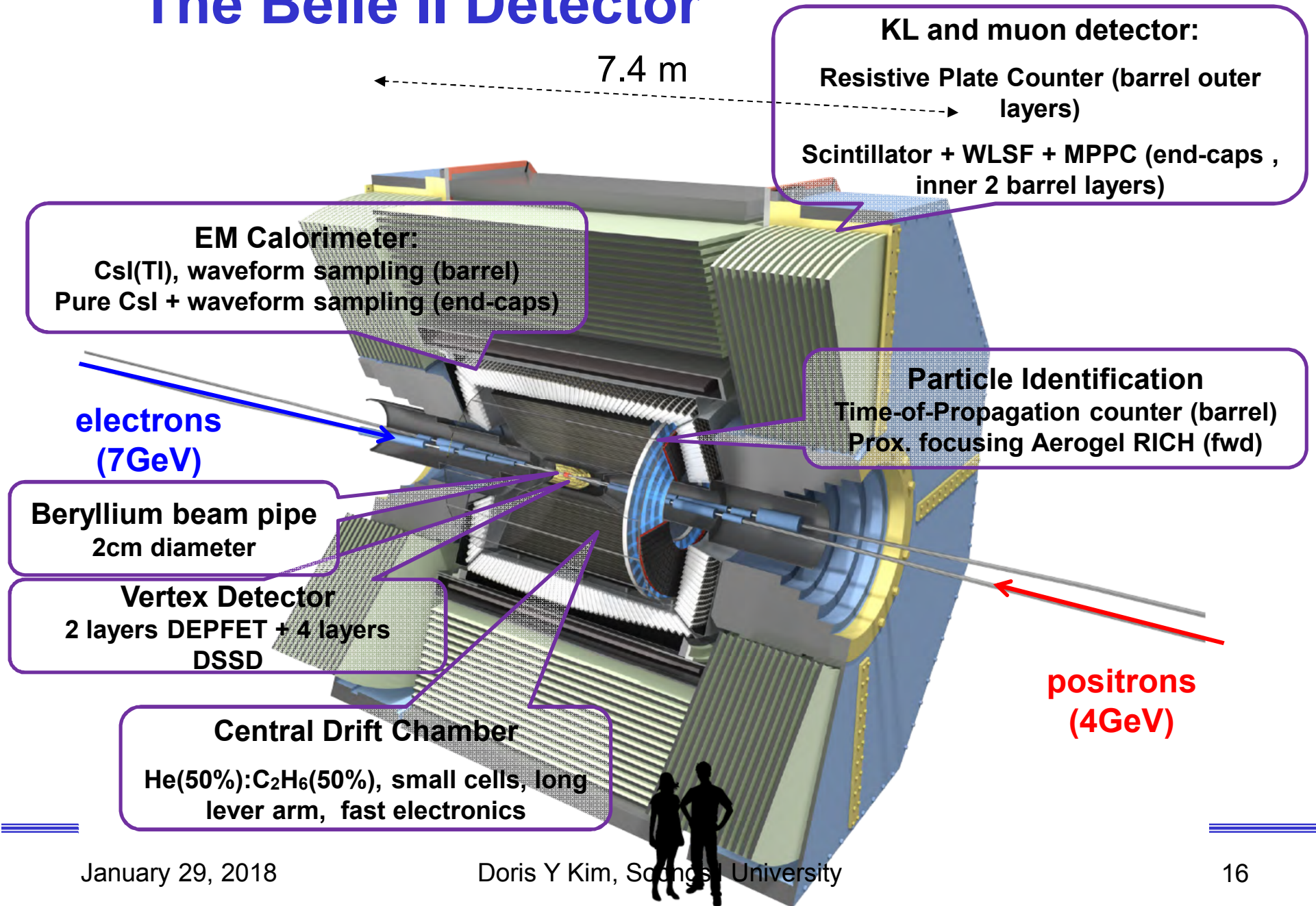
The BEAST Phase II Vertex Detector



SuperKEKB/Belle II Luminosity Plan

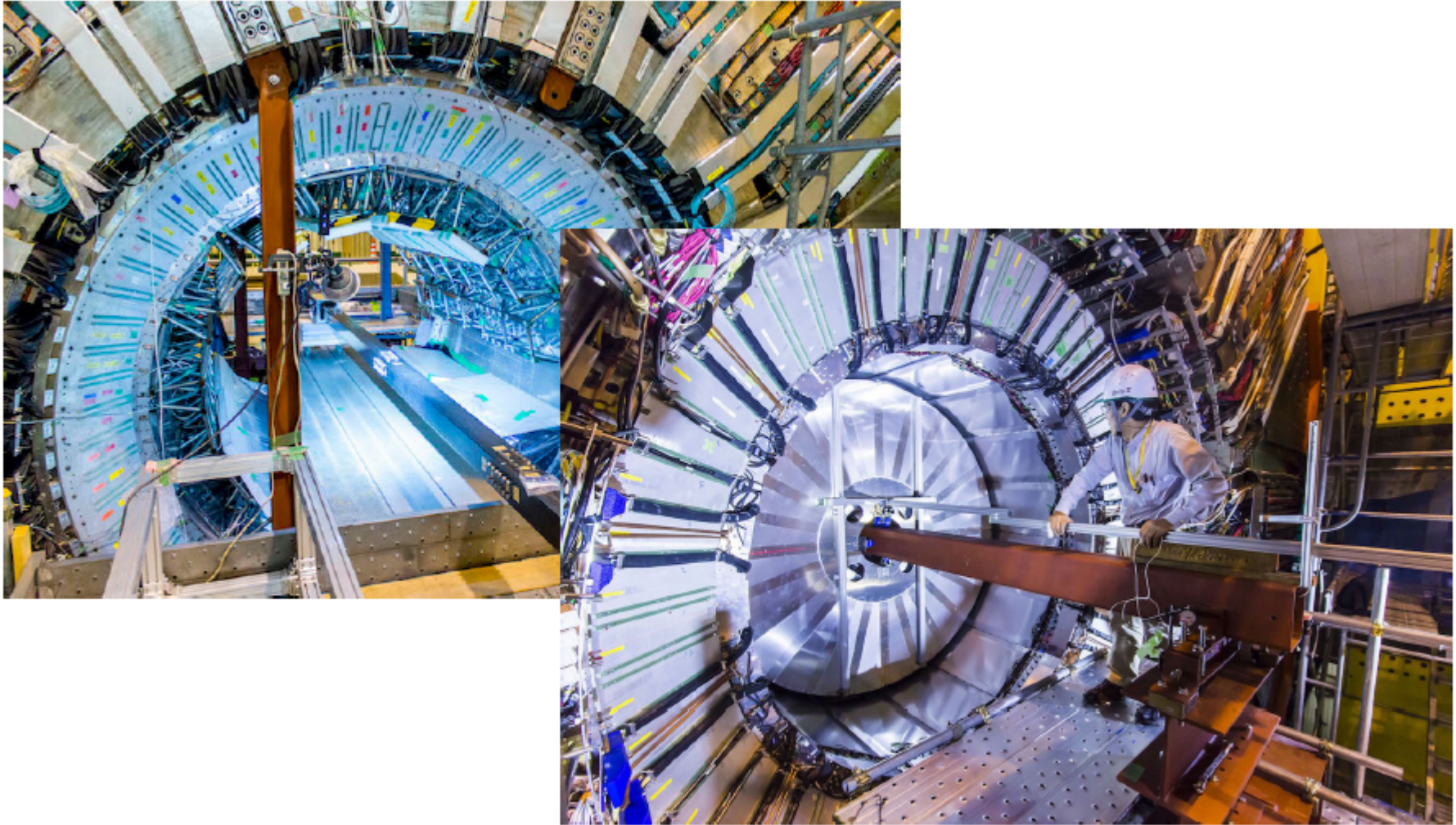


The Belle II Detector



Installation of Belle II Detectors

May 2016 TOP installed: <https://www2.kek.jp/ipns/en/post/2016/05/belle2-top-detector-installation/>



October 2016 CDC Installed: <https://www2.kek.jp/ipns/en/post/2016/10/belle2-cdc-installation/>

Belle II Roll-In April 11, 2017

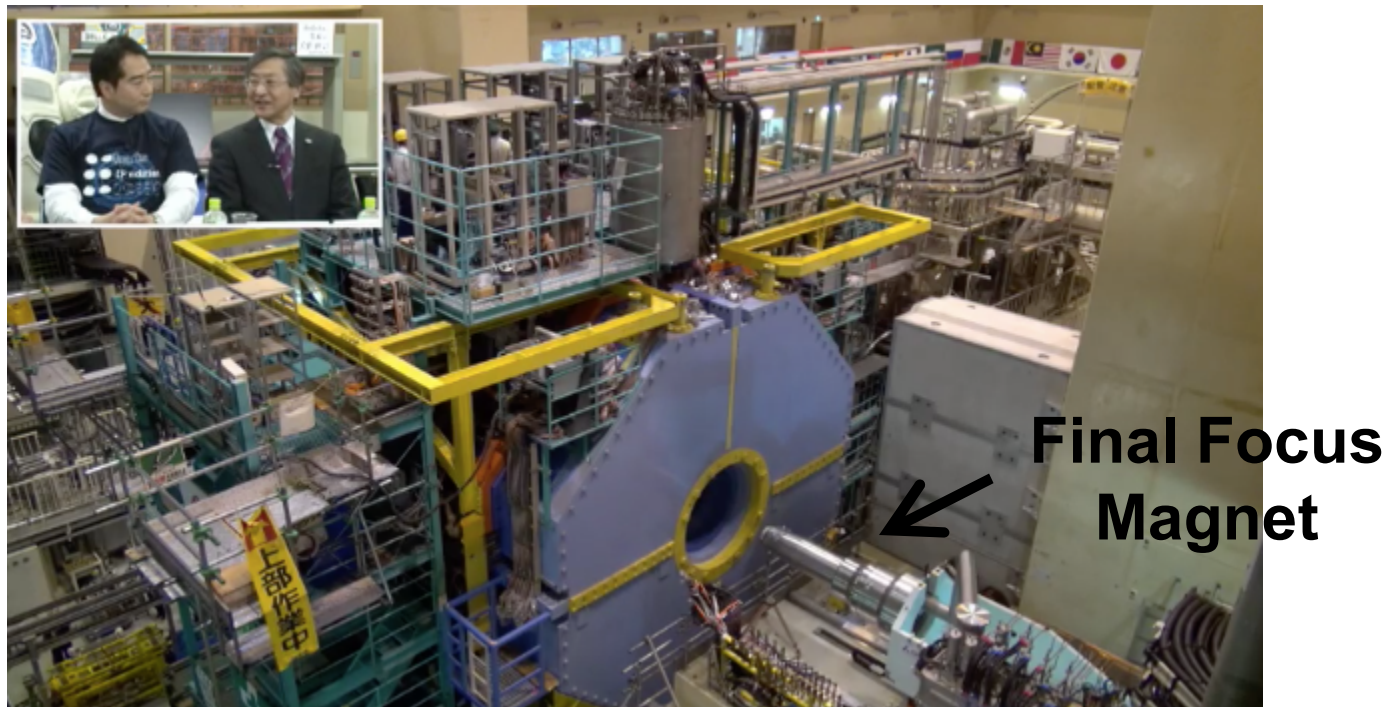


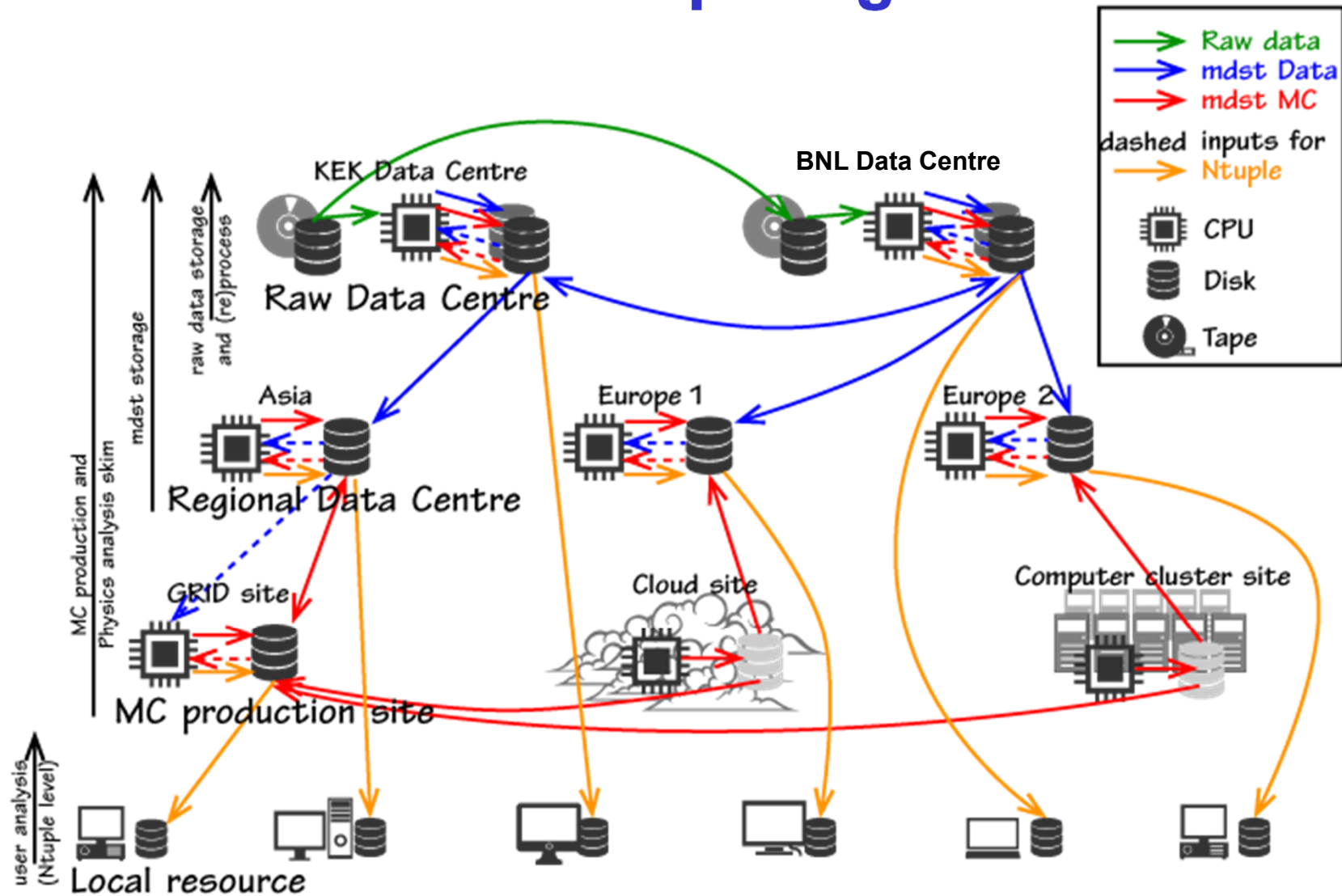
Photo taken when the detector is just 10 cm from the interaction point. Took 5 hours for the roll-in.

For more photos and news of Belle II,

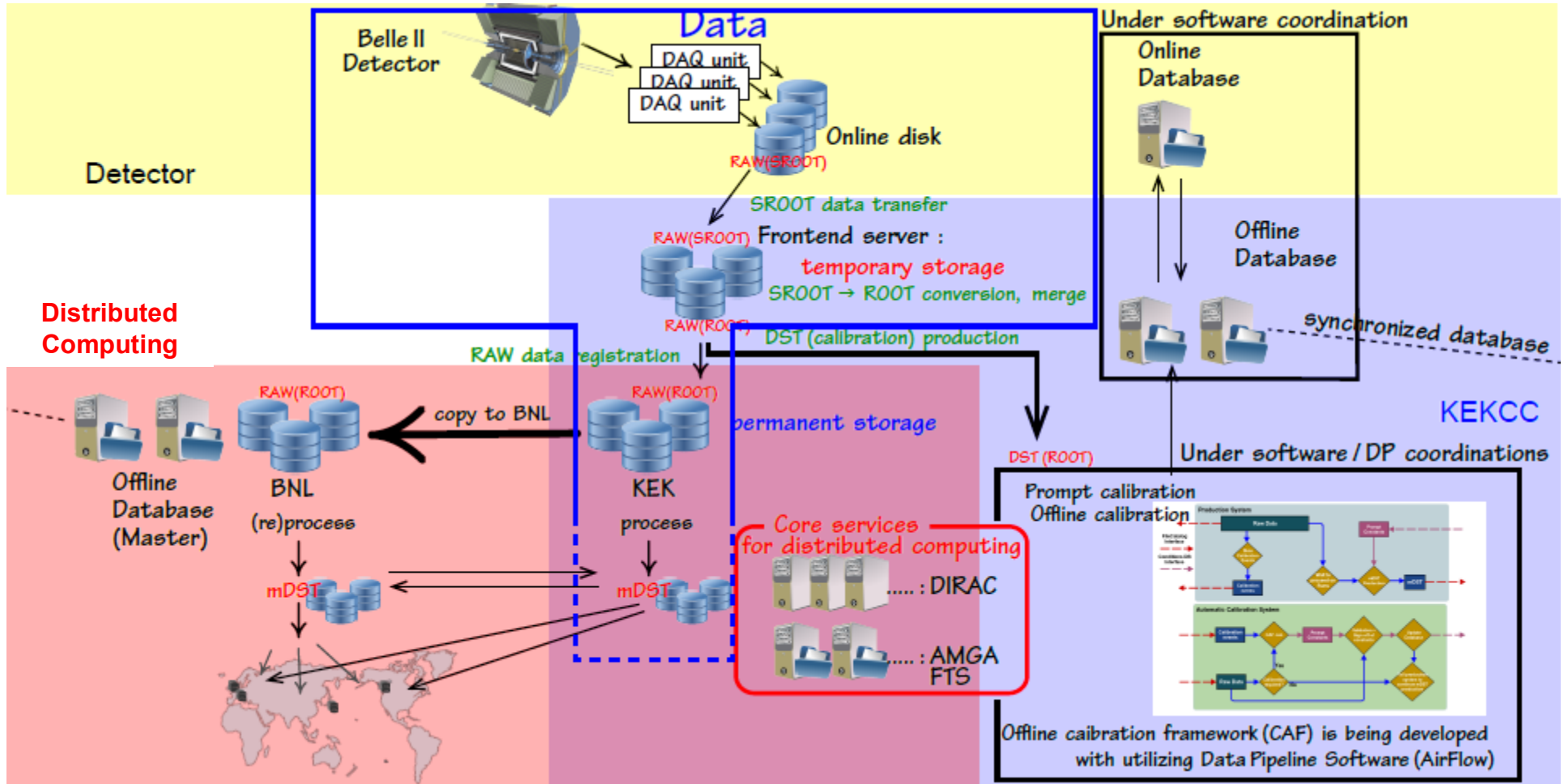
<https://www.facebook.com/belle2collab>

The Belle II Computing System

The Basic Computing Model



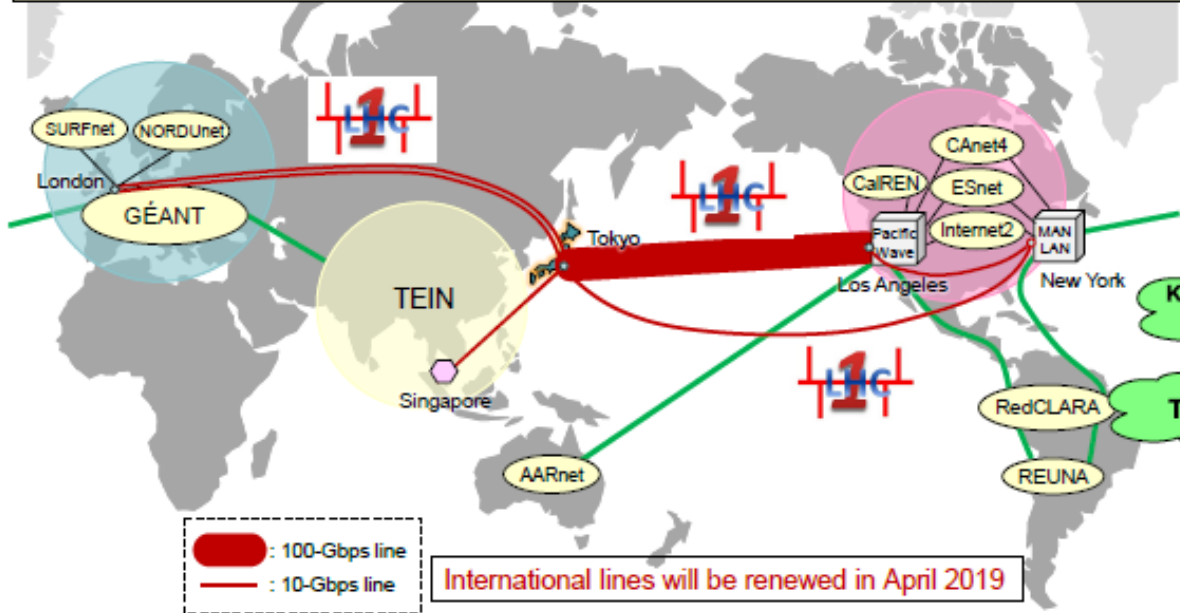
In Reality, More Details



Network Connectivity

T. Nakamura (KEKRC) @ 28th B2GM on Oct 11, 2017

- ◆ SINET5 has direct international lines to USA, Europe, and Asia.
 - USA: 100-Gbps line to Los Angeles, 10-Gbps line to New York, and 10-Gbps backup line
 - Europe: Two 10-Gbps lines to London for small latency
 - Asia: 10-Gbps line to Singapore



LHCONE routing

Sep. 2016
 GEANT at London (20G)
 GEANT at NY (10G, backup)
 ESnet, CANARIE at LA (100G)

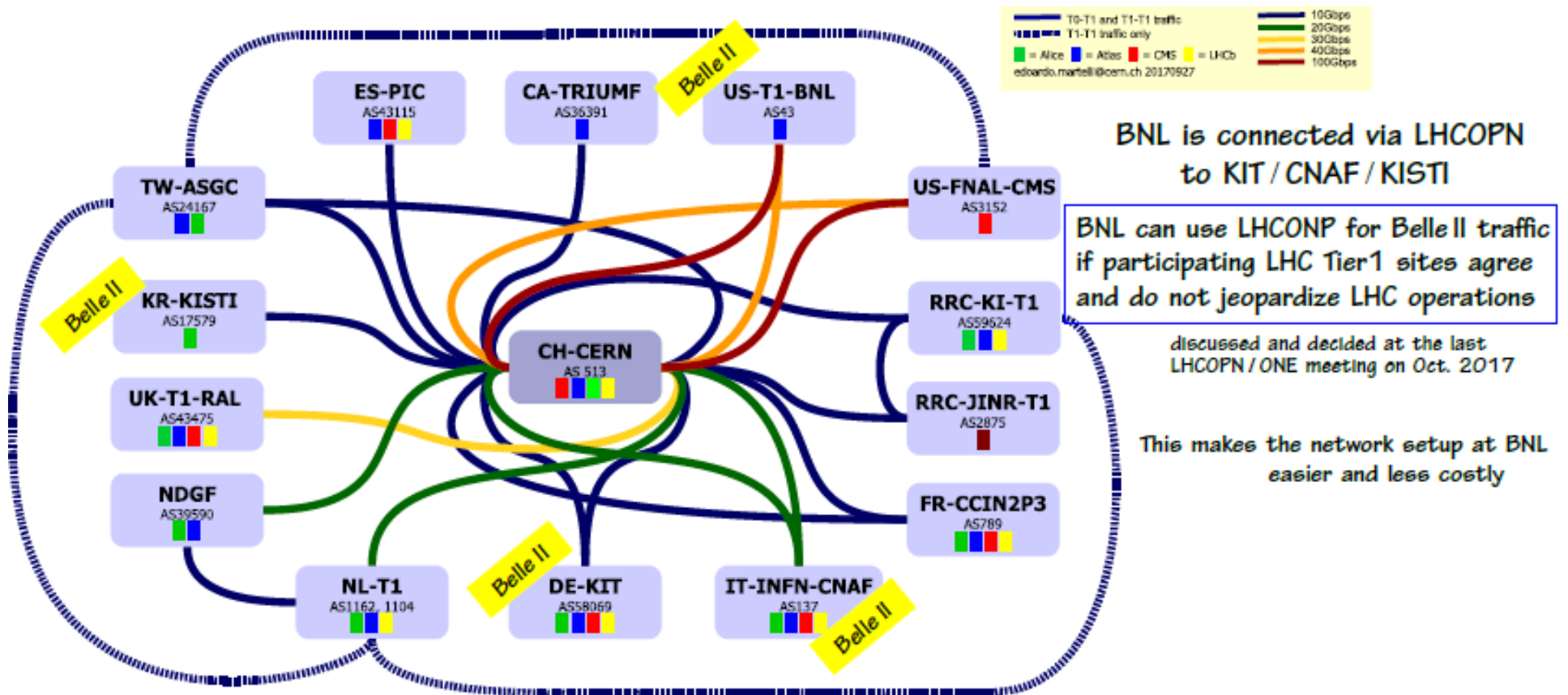
Sep. 29th 2017
 ASGC, KOREONET, (TEIN at Hong Kong (100G)



SINET International Links will be renewed in March 2019 for next period of 3 years.
 EU link will be upgraded to 100G
 NY link will be upgraded to 100G hopefully
 SG link may be upgraded to 100G

M. Nakamura (NII) @ 3rd ATCF on Oct 12, 2017

Belle II can utilize LHCOPN



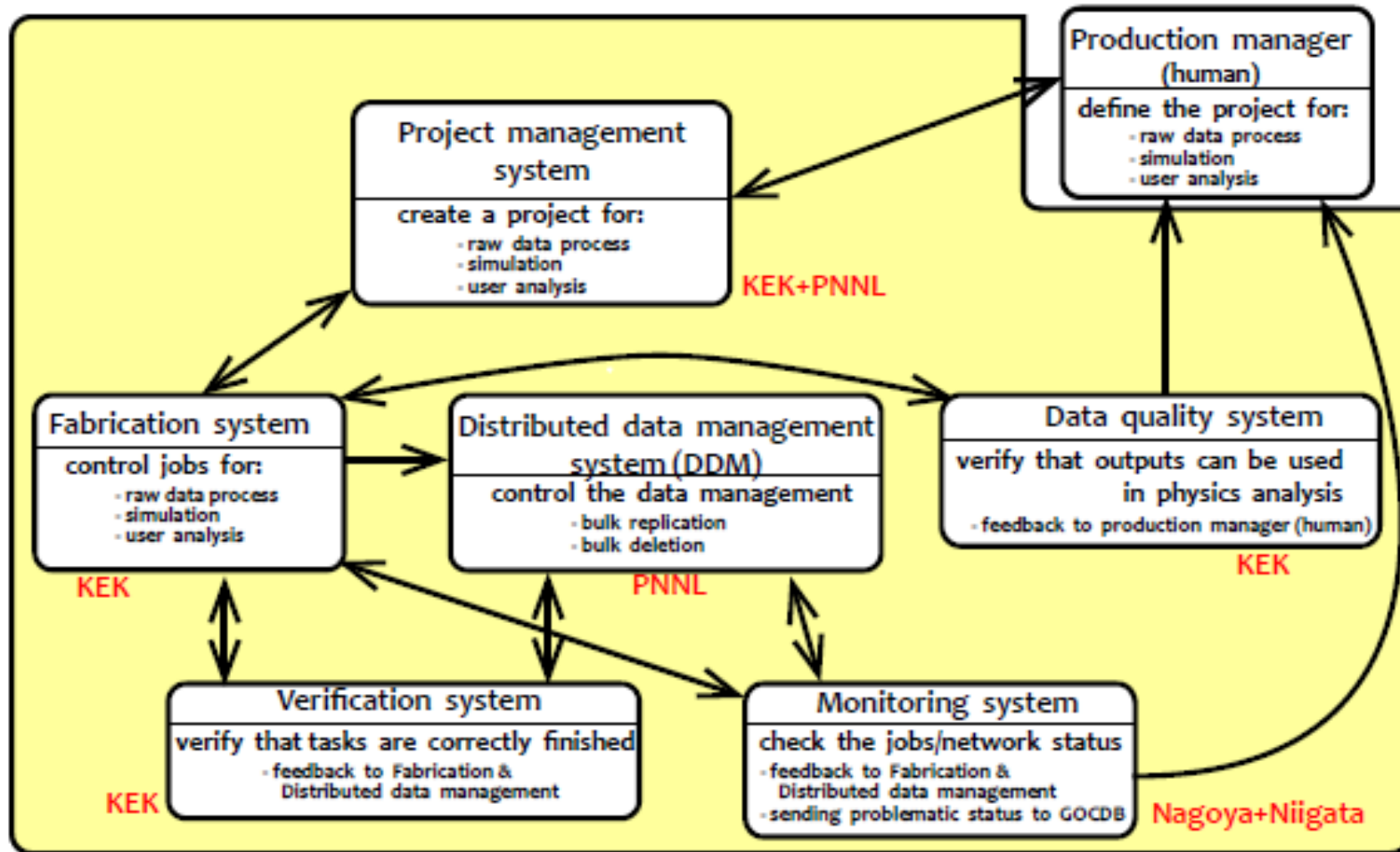
Resource Requirement for Near Future

Year	2018	2019	2020	2021	2022
Luminosity (ab^{-1} / year)	0.21	1.67	4.67	8.60	12.03
Integrated Luminosity (ab^{-1})	0.21	1.88	6.64	15.23	27.27

Note: Calendar year. Not JFY

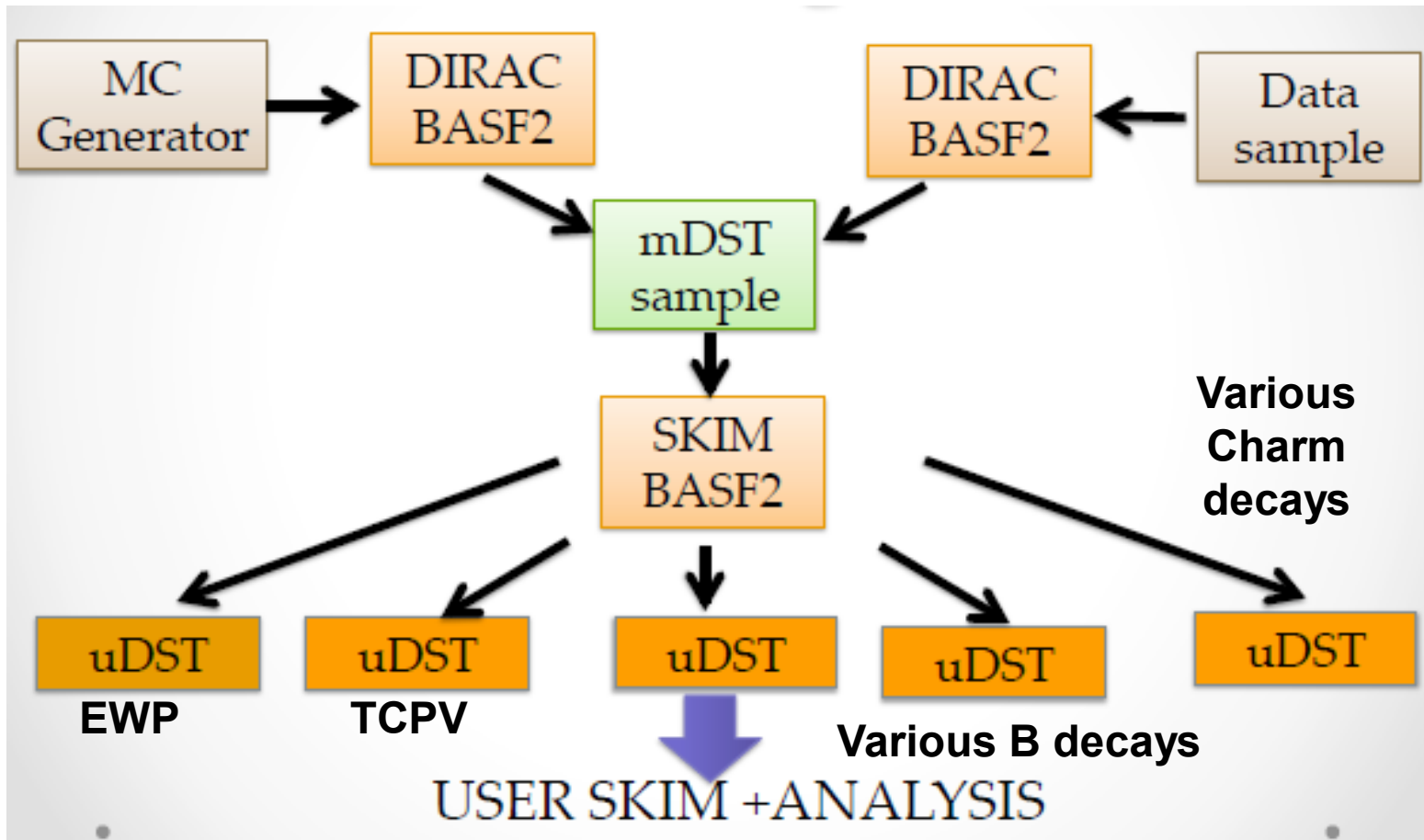
Year	2018	2019	2020	2021	2022
Total tape (PB)	1.6	6.4	17.3	36.1	62.5
Total disk (PB)	3.5	13.2	22.3	23.3	43.6
Total CPU (kHEPSpec)	175	404	431	534	733

Automated Production System Planned



Skim Strategy

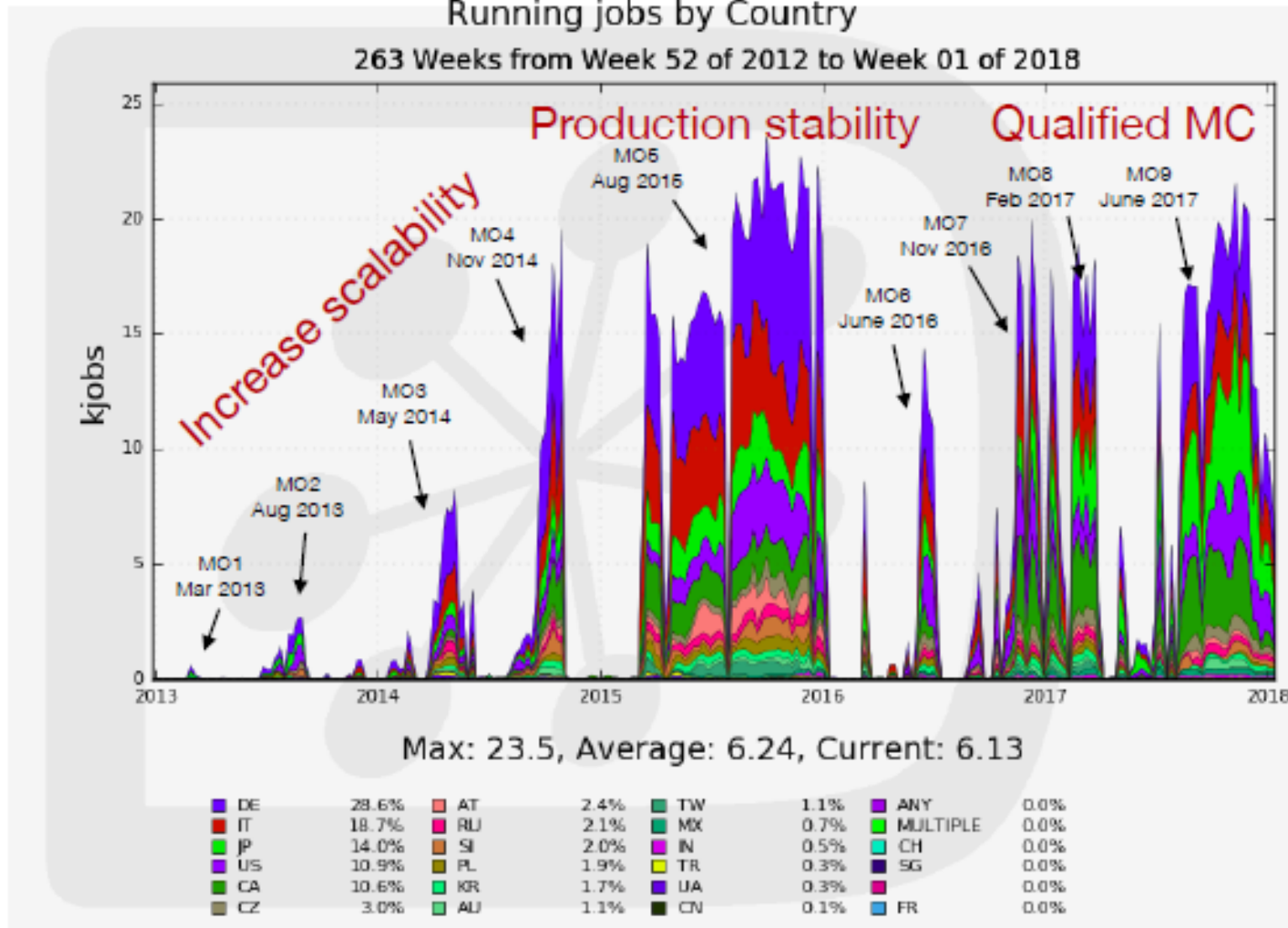
uDST files are produced and stored at Belle II Grid



More skim types are in development.

Usage of Belle II Grid System

Usage of Belle II GRID Computing Resources: Number of Jobs by Country



January 29, 2018

Courtesy: Jake Bennett @ Carnegie Melone University,
Karim Trabelsi @ KEK

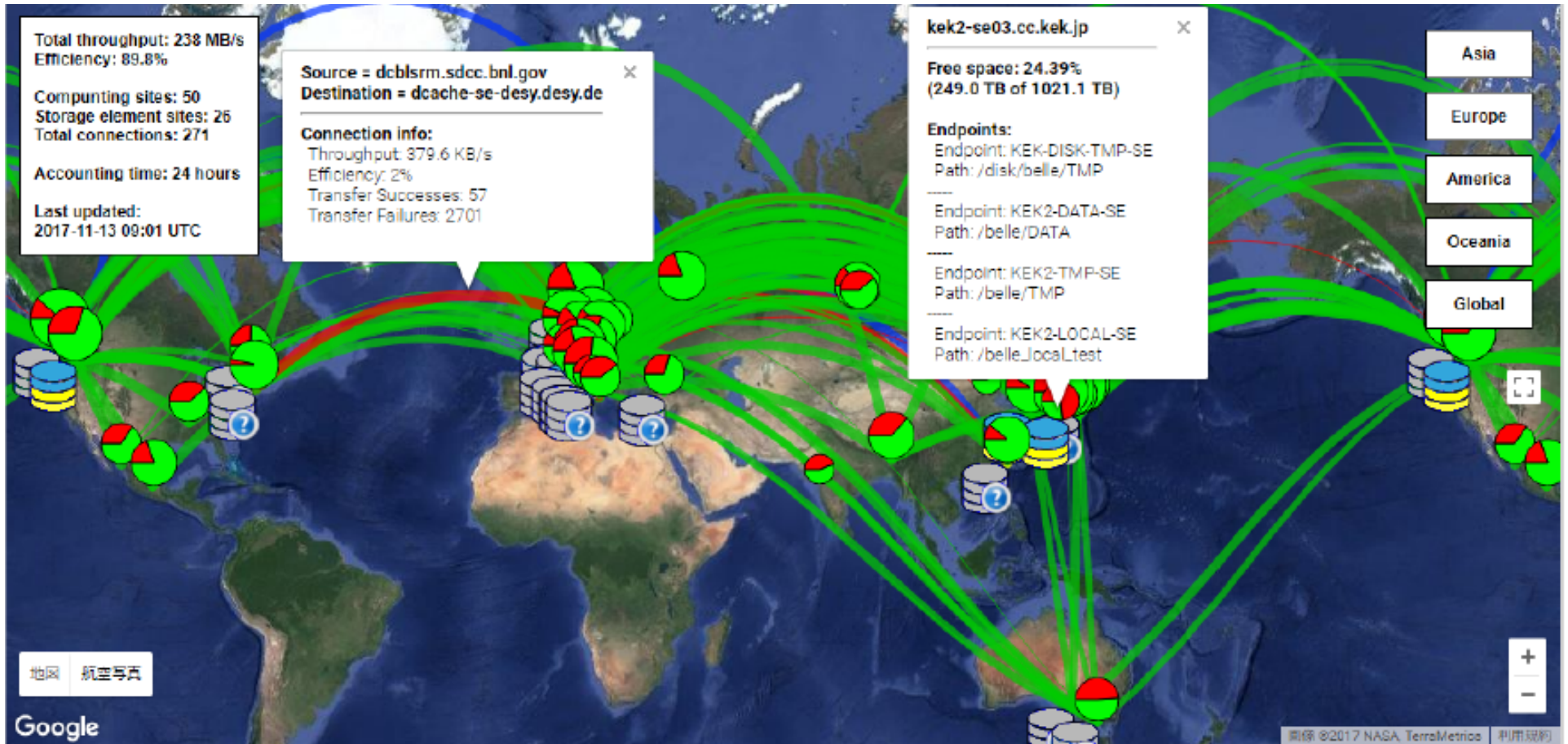
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Production on Grid Example: MC9

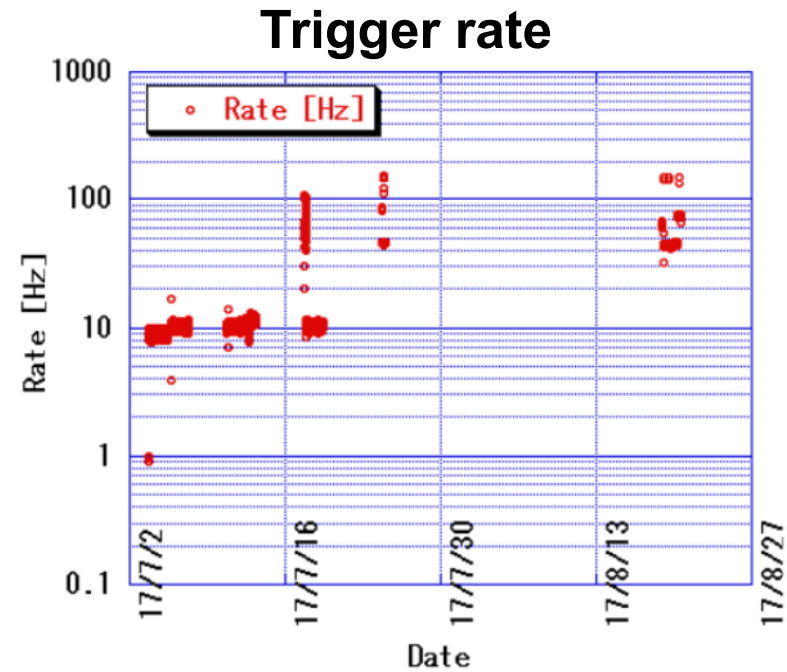
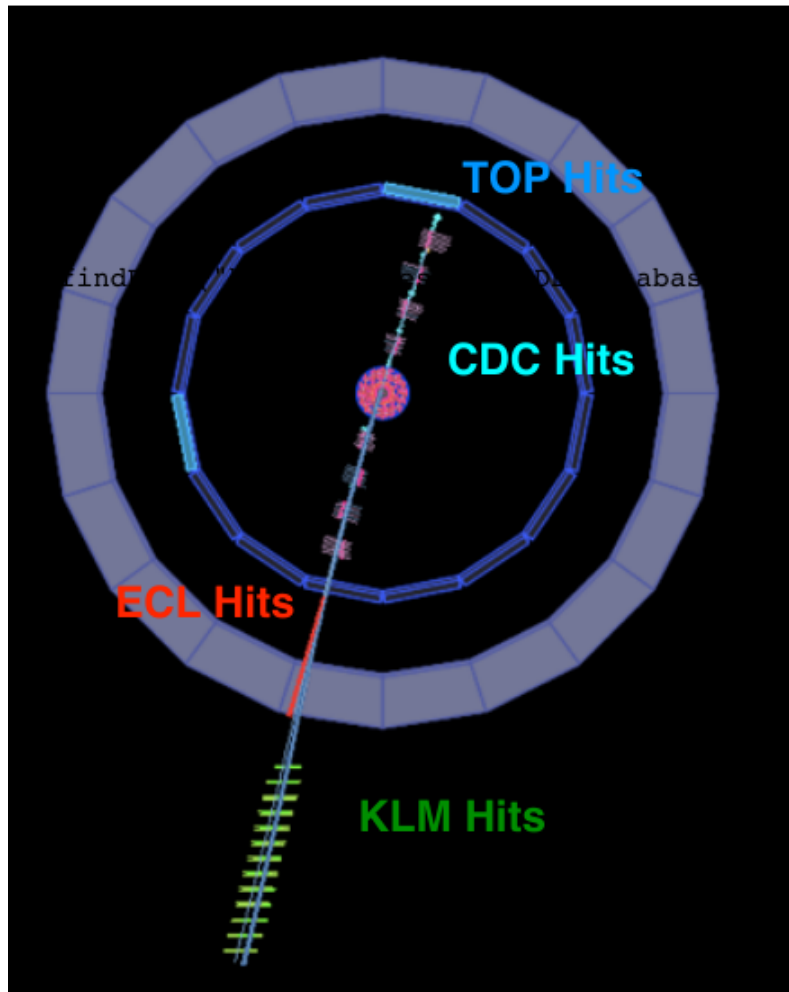
- **No. of MC events: ~ 40 billions (8 billions to be produced)**
 - **Signal events; ~ 10%**
- **Size of the final sample: ~ 353 TB**
- **Size of skimmed files: ~ 78 TB**
- **Total disk size including intermediate files: ~ 1,350 TB**

Exp. Phase	Sample Type	Size
Phase III	Y(3S) generic	300 fb ⁻¹
	Y(4S) generic	4,000 fb ⁻¹
	Y(5S) generic	1,000 fb ⁻¹
	Y(6S) generic	100 fb ⁻¹
	Signal and low multiplicity	
Phase II	Y(4S) generic	50 fb ⁻¹
	Signal and low multiplicity	

Data Transfer Map



Cosmic Particle July 2017



- Relatively low trigger rate
- ~ 10,000 2GB files.
- ~ 17TB for two months.

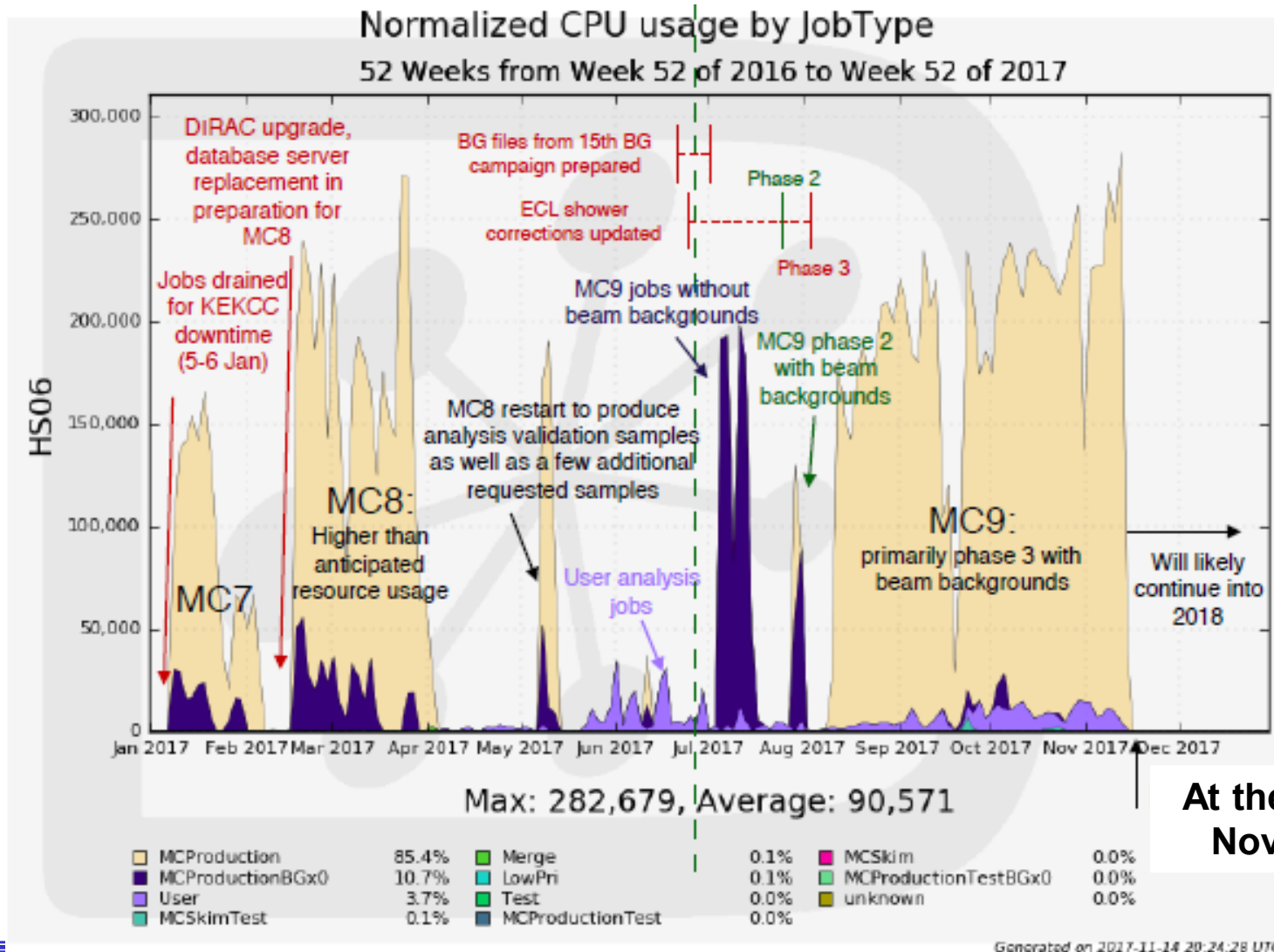
SUMMARY

Summary

- The Belle II Experiment is preparing for the beam collision events in 2018.
- The Belle II Experiment is ideal for new phenomena and precision physics.
 - Huge amount of computing resources are required.
 - Belle II grid system has been tested by periodic tests of MC production. The system passed the tests.
 - User analysis on the grid has started. Ready for physics.

Extra

Usage of Belle II GRID Computing Resources: Usage of CPU by Job Type



At the end of
Nov. 2017