Computing at Belle II

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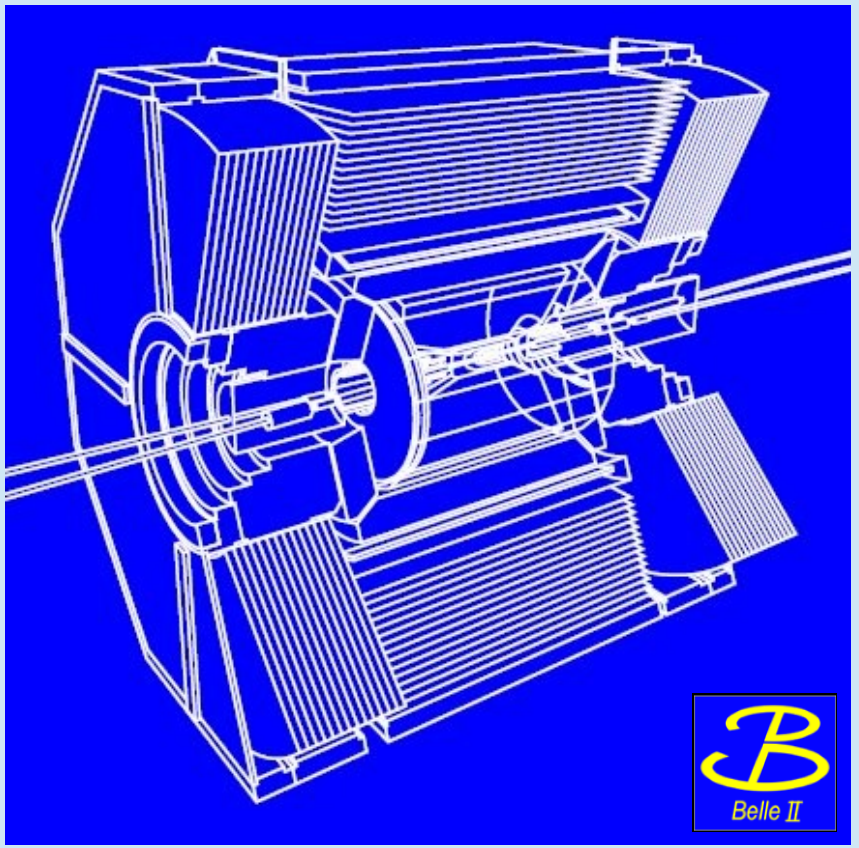
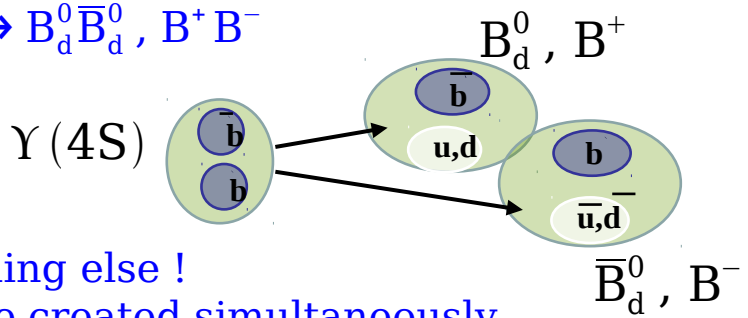


2019/05/09

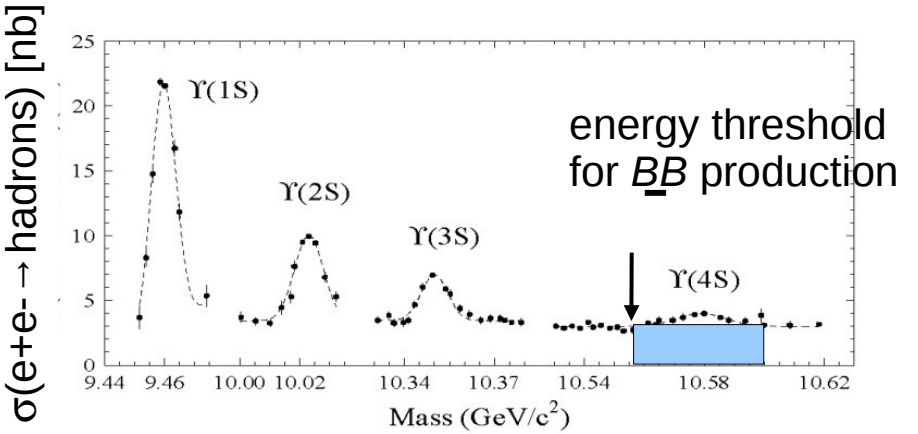
Belle II, a flavour-factory, a rich physics program...

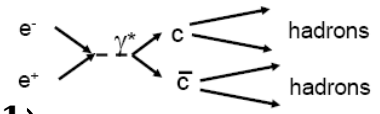
- We plan to collect (**at least**) **50 ab^{-1}** of e^+e^- collisions at (or close to) the $\Upsilon(4S)$ resonance, so that we have:
  - **a (Super) B-factory ($\sim 1.1 \times 10^9$ $B\bar{B}$ pairs per ab^{-1})**

''on resonance'' production
$e^+e^- \to \Upsilon(4S) \to B^0_d\bar{B}^0_d$, B^+B^-



- 2 B's and nothing else !
- 2 B mesons are created simultaneously in a L=1 coherent state

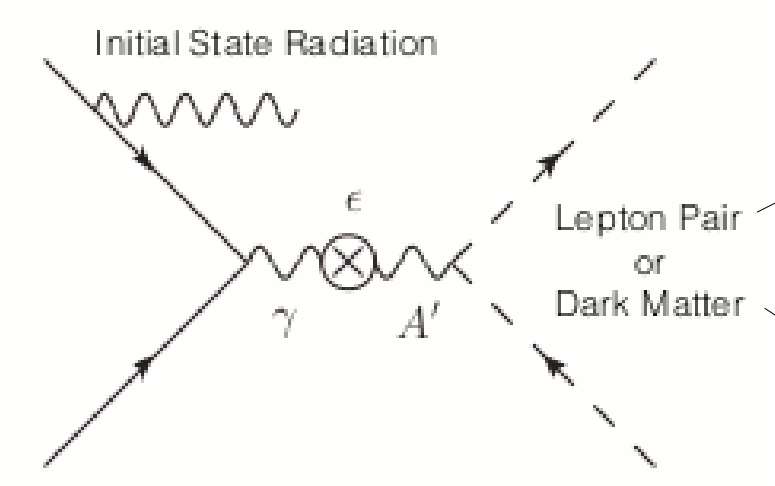




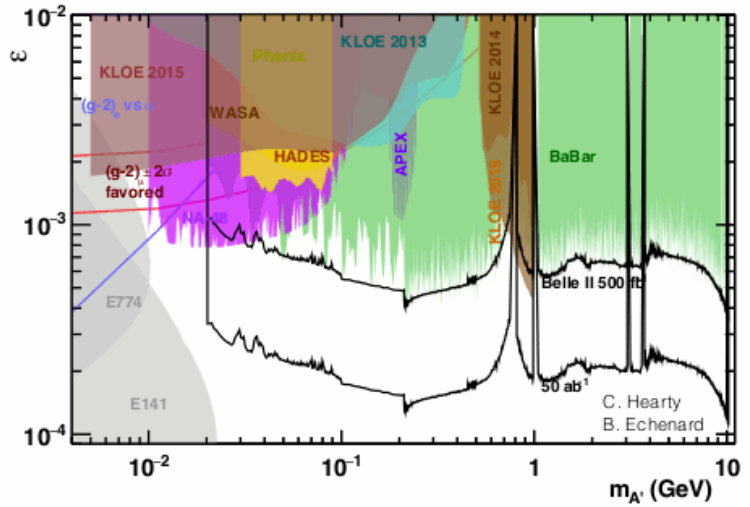
  - **a (Super) charm factory ($\sim 1.3 \times 10^9$ $c\bar{c}$ pairs per ab^{-1})**
  - **a (Super) τ factory ($\sim 0.9 \times 10^9$ $\tau^+\tau^-$ pairs per ab^{-1})**
  - with Initial State Radiation, effectively scan the range [0.5 – 10] GeV and measure the $e^+e^- \to$ light hadrons cross section very precisely
  - exploit the clean e^+e^- environment to probe the existence of exotic hadrons, dark photons/Higgs, light Dark Matter particles, ...

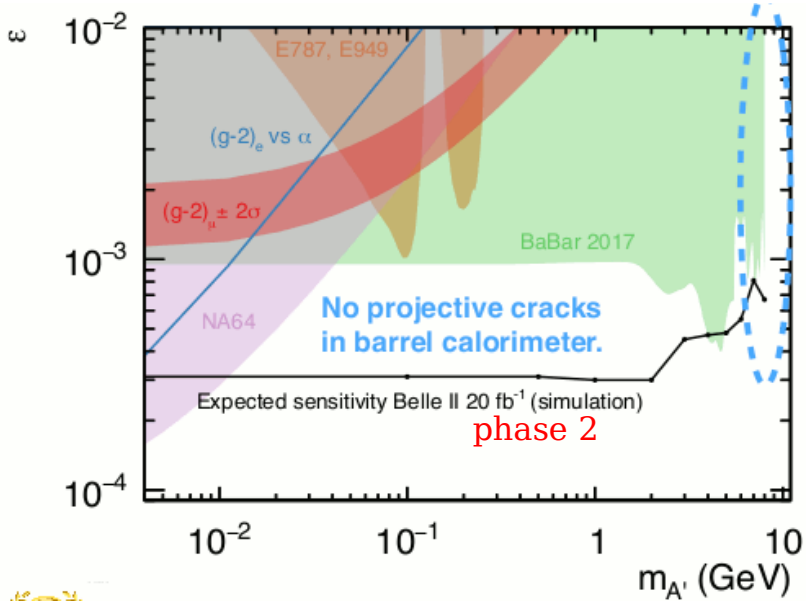
Dark Sector Physics

exploit the clean e^+e^- environment to probe the existence of exotic hadrons, dark photons/Higgs, light Dark Matter particles, …



dark photon A' mixes with SM photon γ with strength ϵ

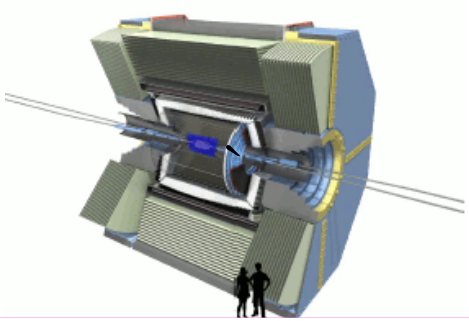


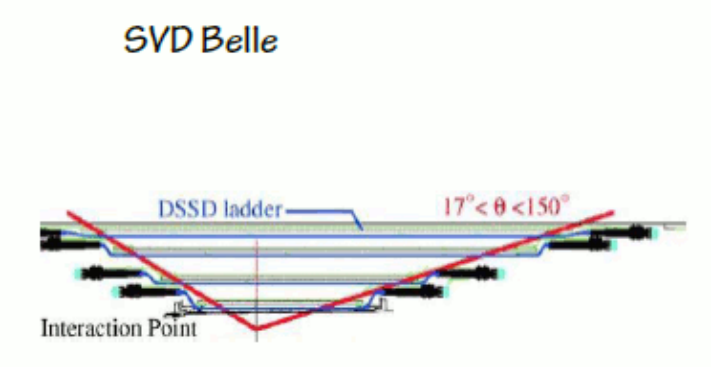


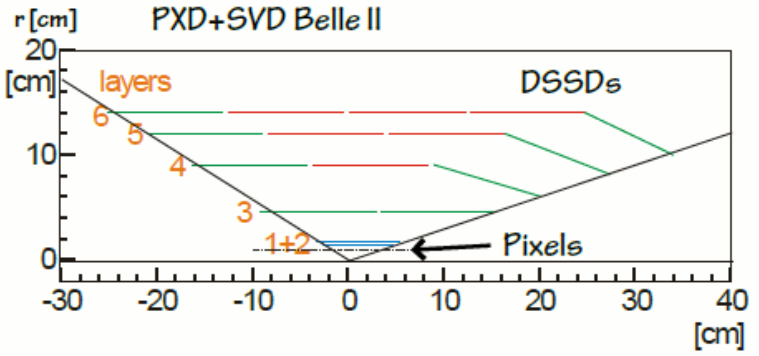
search for a dark photon decaying invisibly, and search for an axion-like particle may be possible even in early phase of data taking ⇒ **high trigger rate**

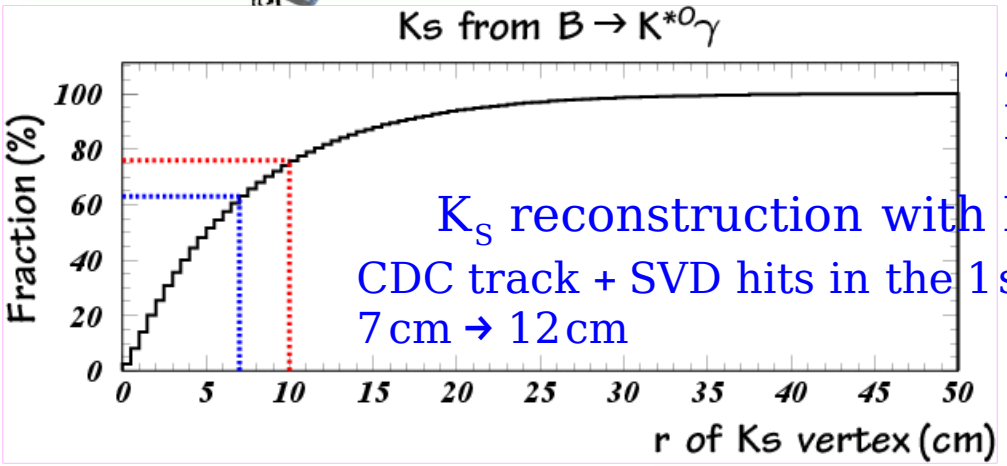
Few words on Belle II detector

- collecting 50 ab^{-1} from 2019 to 2027…(or until we get 50 ab^{-1} ?)



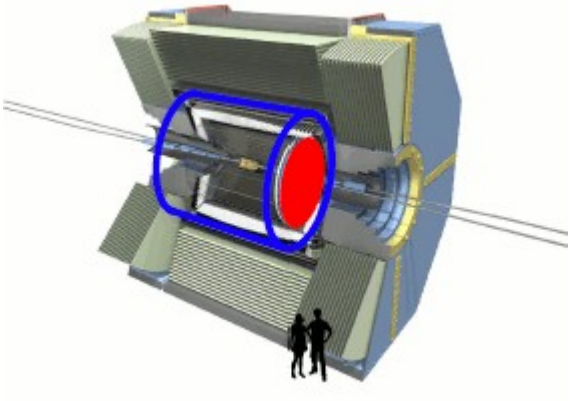


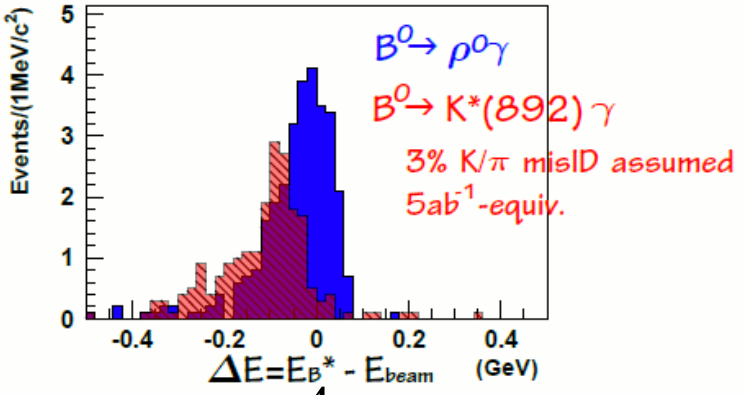


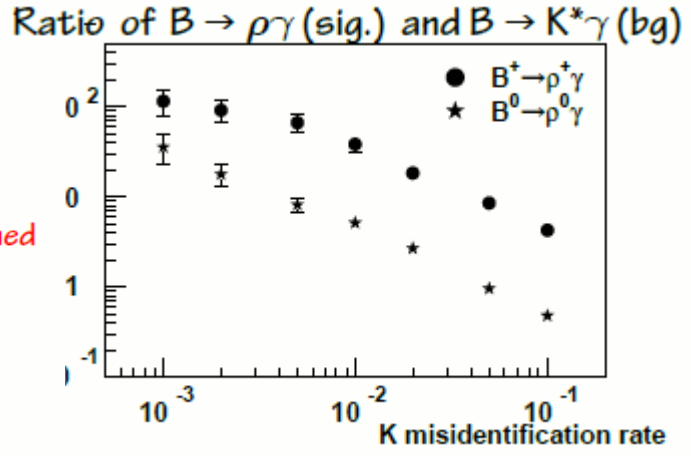


4 DSSD layers → 2 pixel layers + 4 DSSD layers
larger radius outermost layer (8.8 cm → 14 cm)

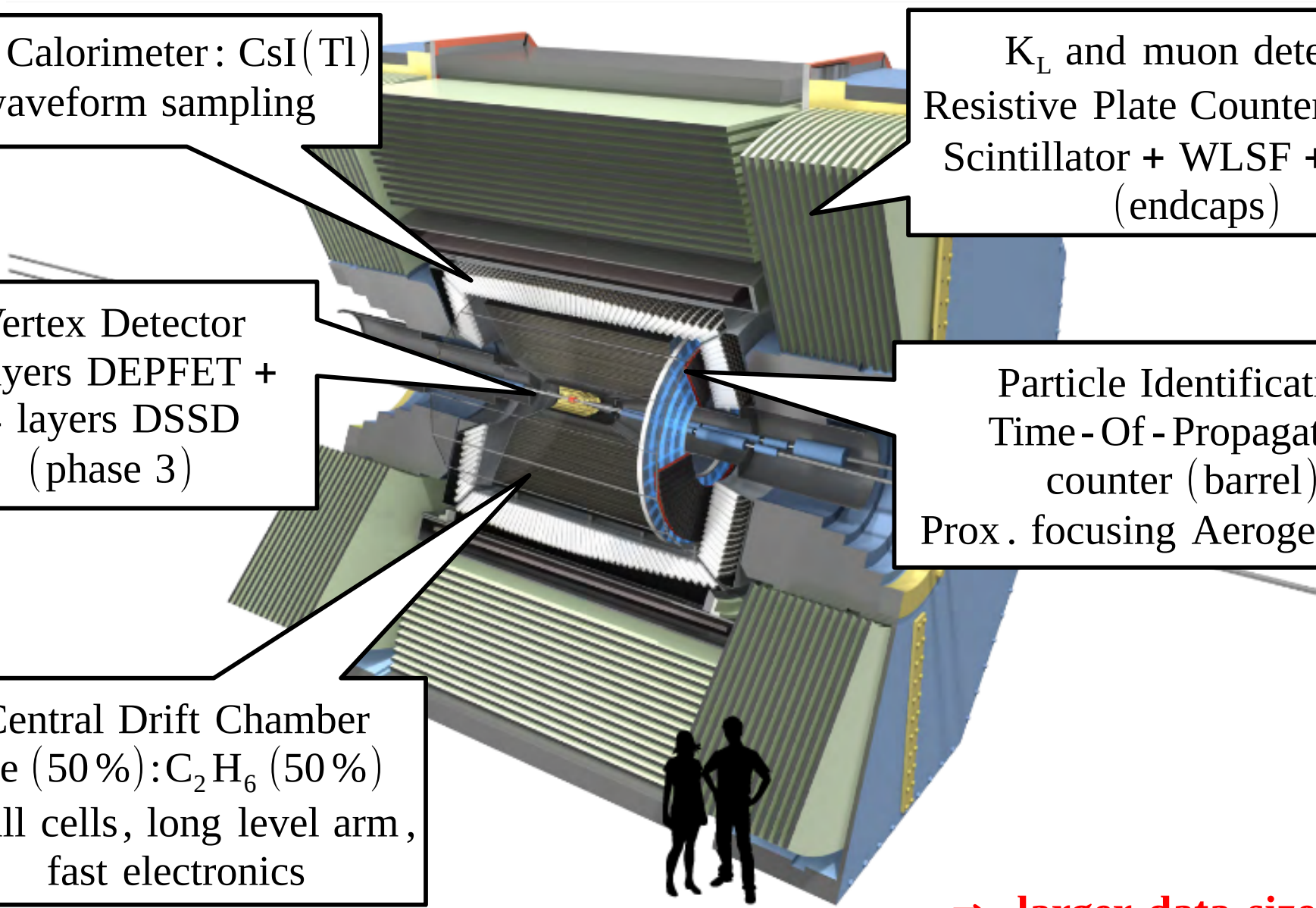
K_S reconstruction with PXD/SVD: $K^{*0}\gamma$ TCPV
CDC track + SVD hits in the 1st and 2nd outermost layers
7 cm → 12 cm







Belle II detector



EM Calorimeter: CsI(Tl)
waveform sampling

K_L and muon detector
Resistive Plate Counter (barrel)
Scintillator + WLSF + MPPC
(endcaps)

Vertex Detector
2 layers DEPFET +
4 layers DSSD
(phase 3)

Particle Identification
Time-Of-Propagation
counter (barrel)
Prox. focusing Aerogel RICH

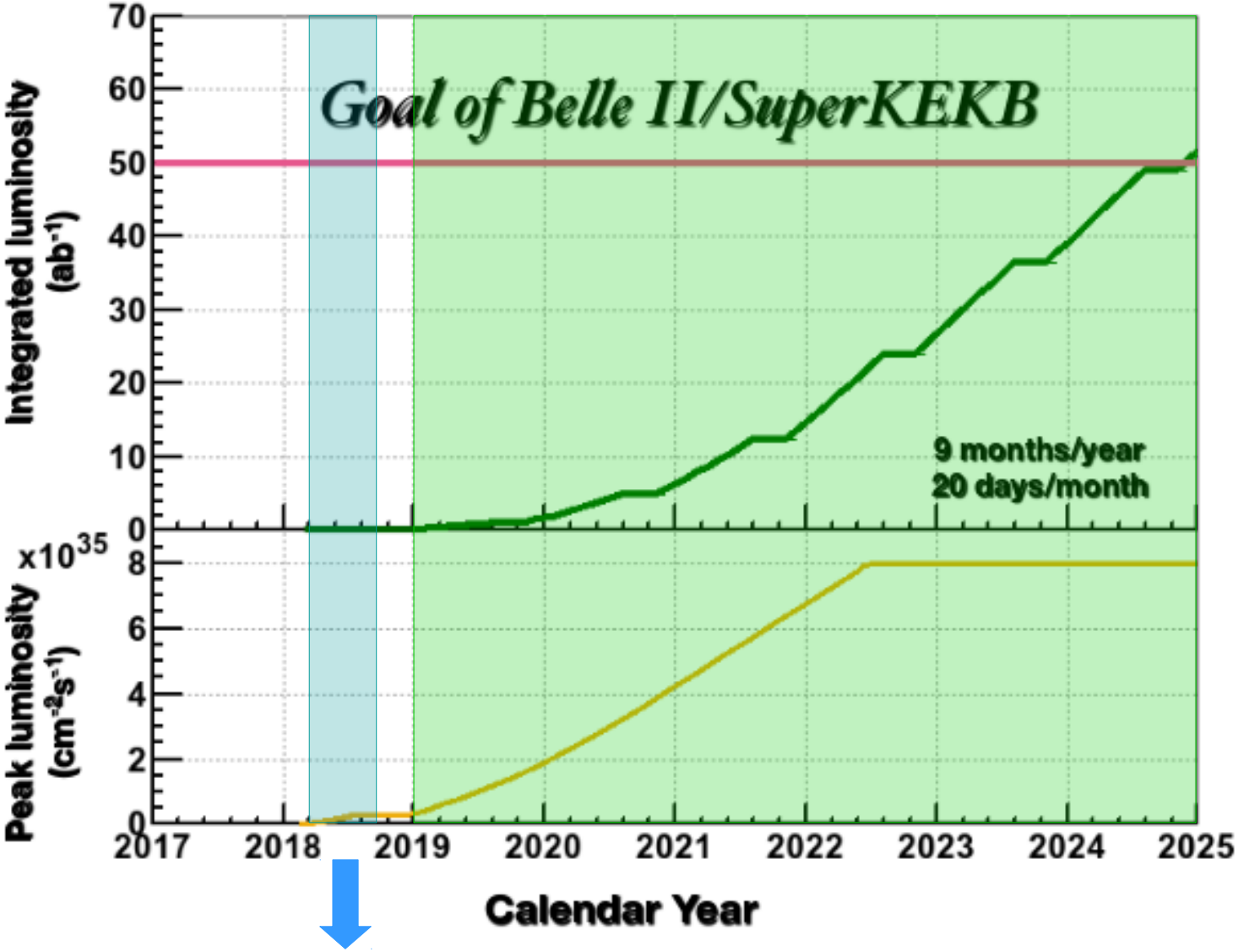
Central Drift Chamber
He (50%):C_2H_6 (50%)
small cells, long level arm,
fast electronics

⇒ larger data size/event
(larger beam background also)

phase 2, phase 3…

Phase 2, BEAST II
collision + partial Belle II

Phase 3, physics run

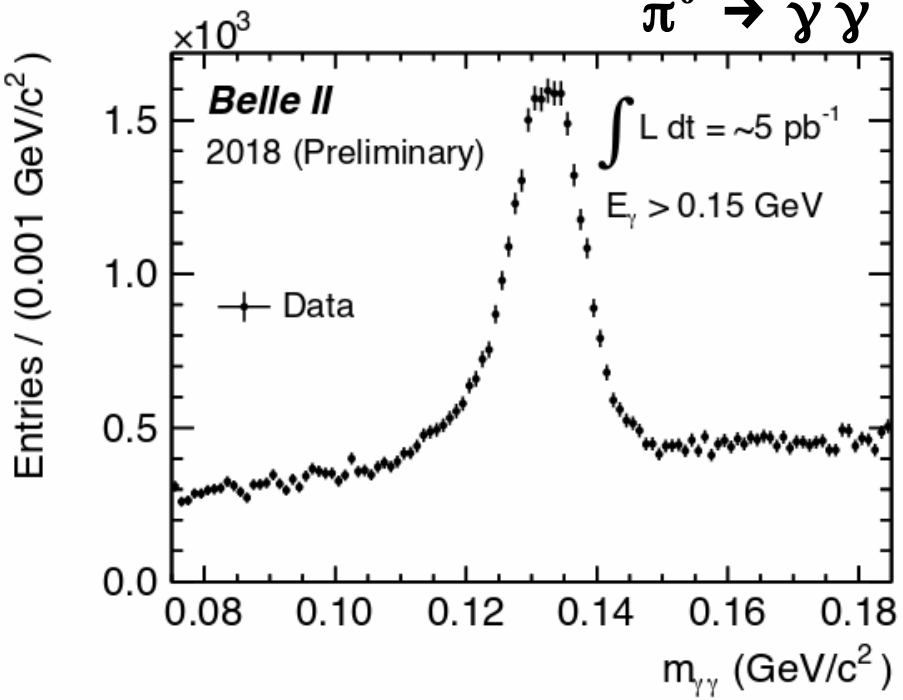


First collisions May to July

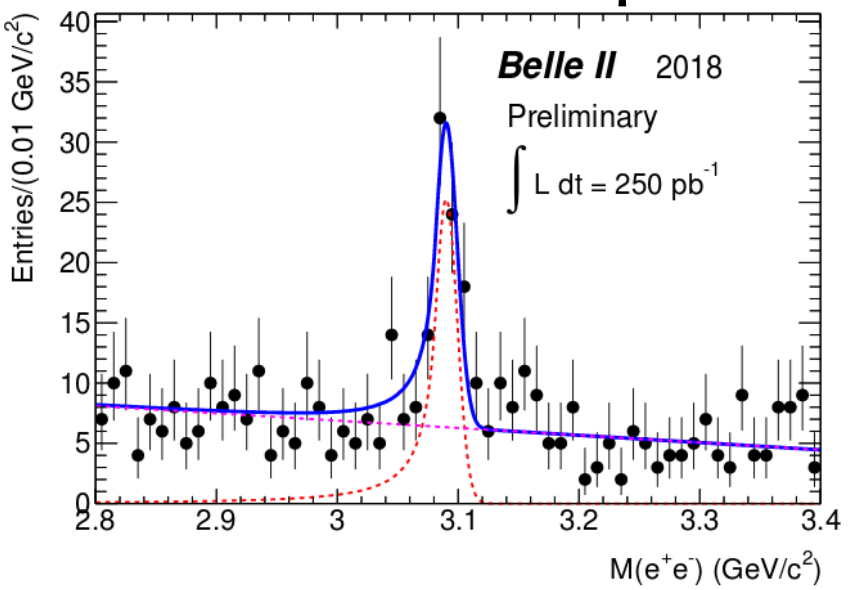
$\sim 500\ \mathrm{pb}^{-1}$

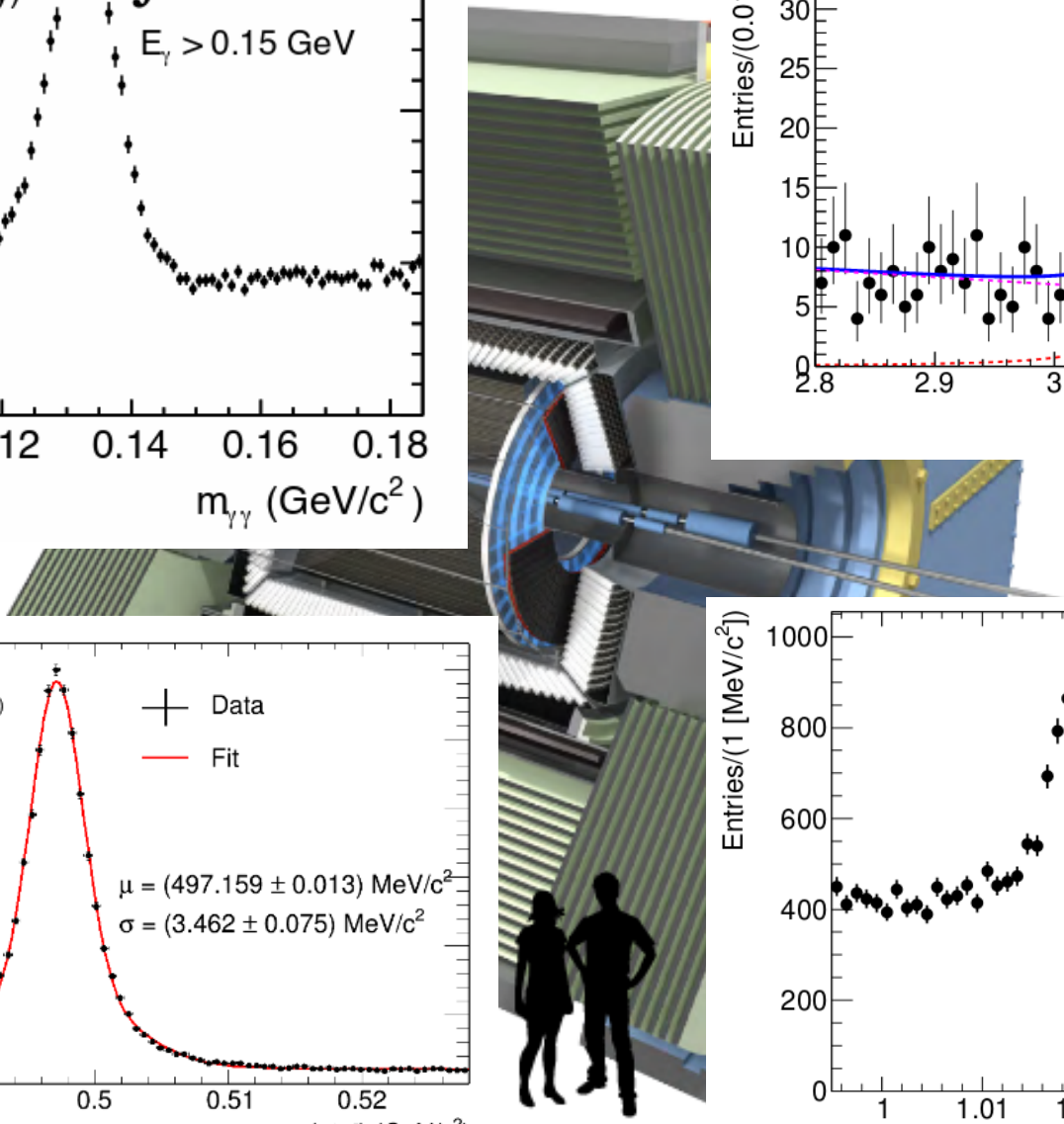
Phase 2 performances (May to July 2018)

$\pi^0 \rightarrow \gamma\gamma$

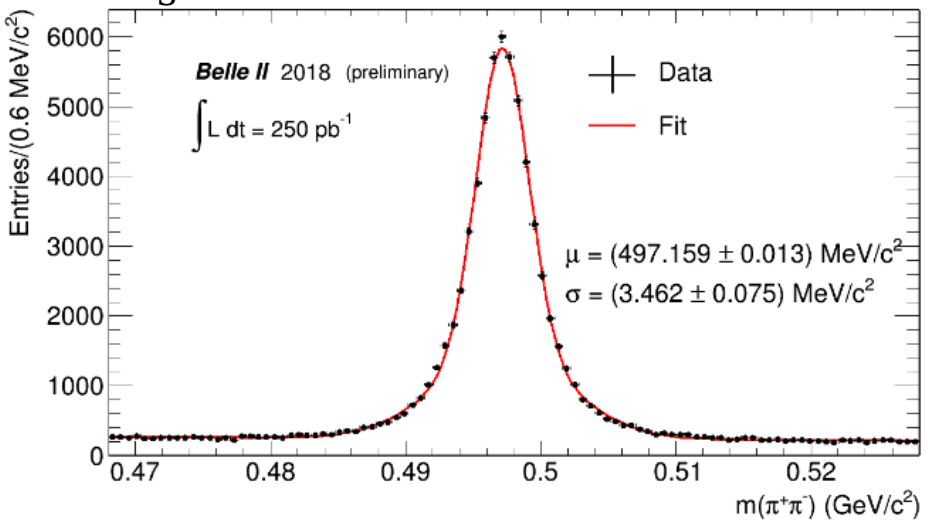


$J/\psi \rightarrow e^+ e^-$

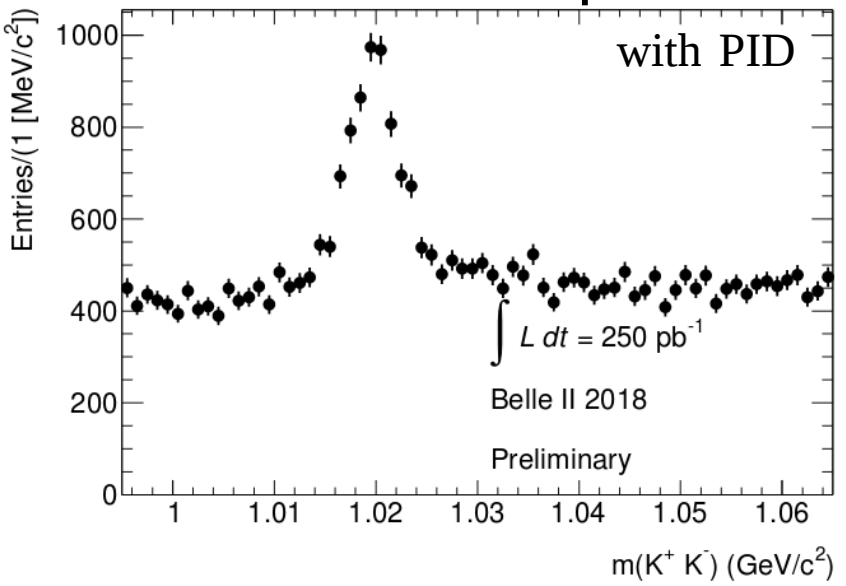




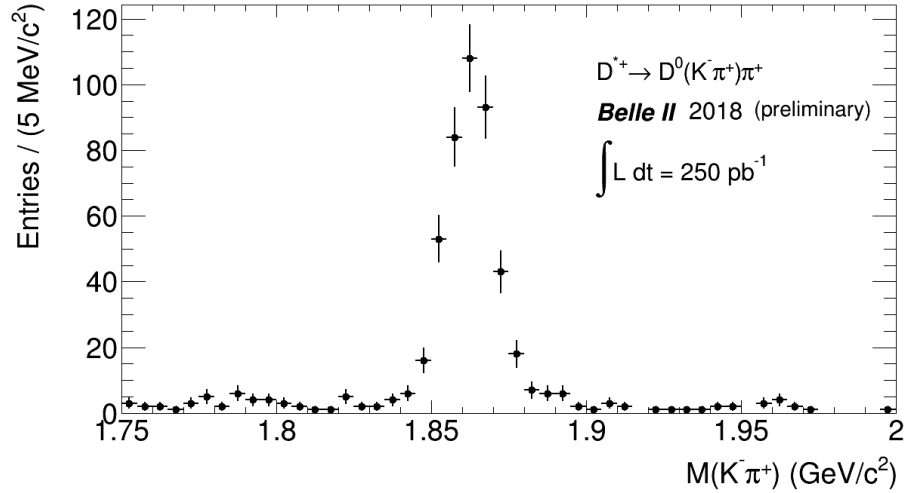
$K^0_S \rightarrow \pi^+ \pi^-$

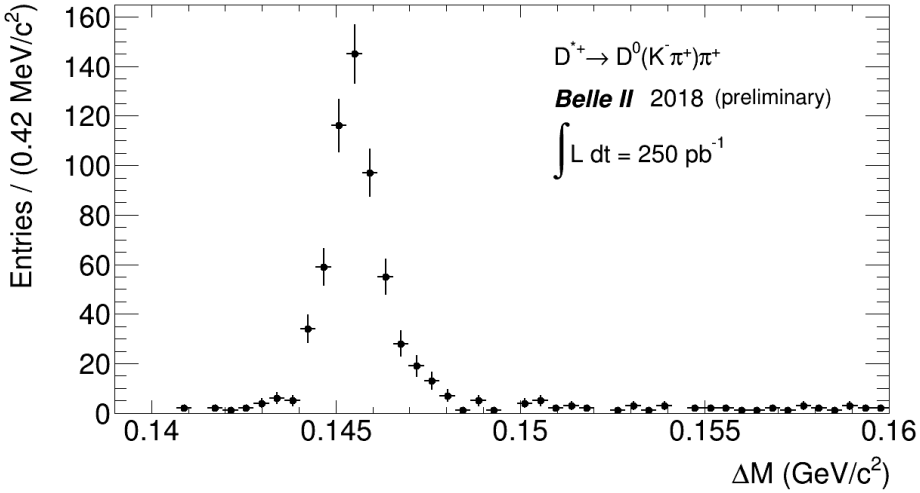


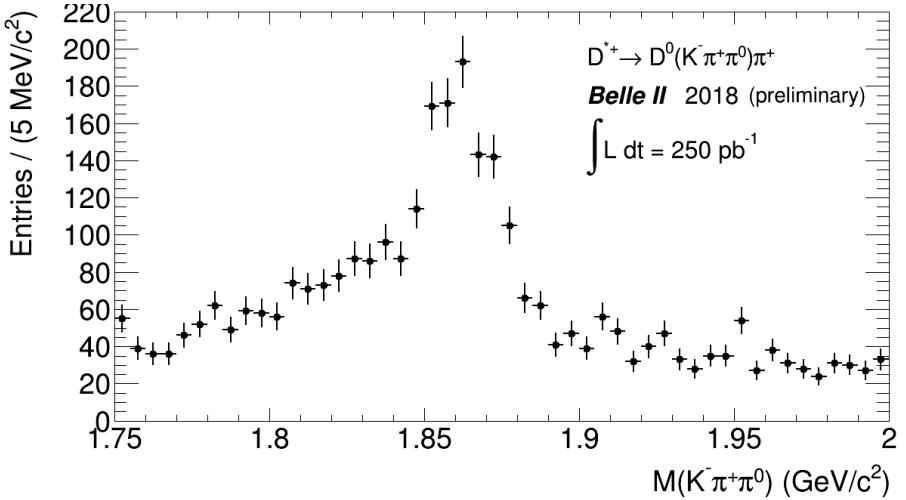
$\phi \rightarrow K^+ K^-$

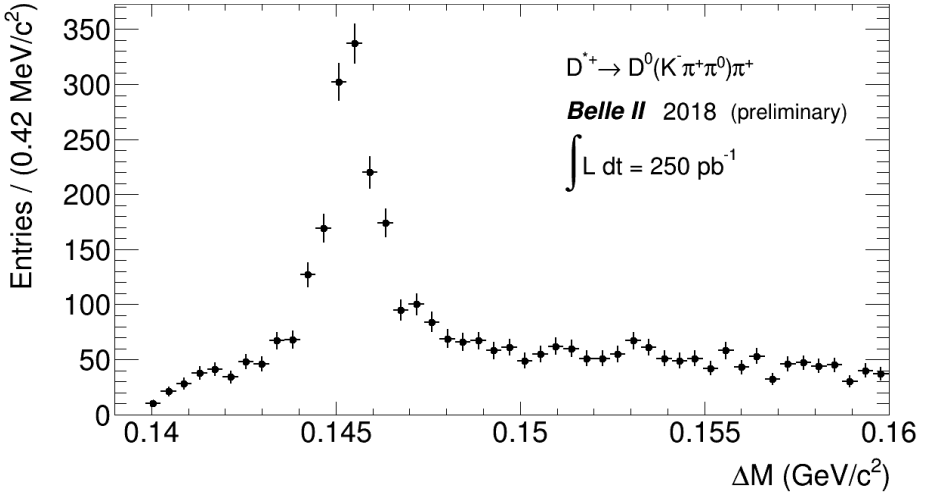


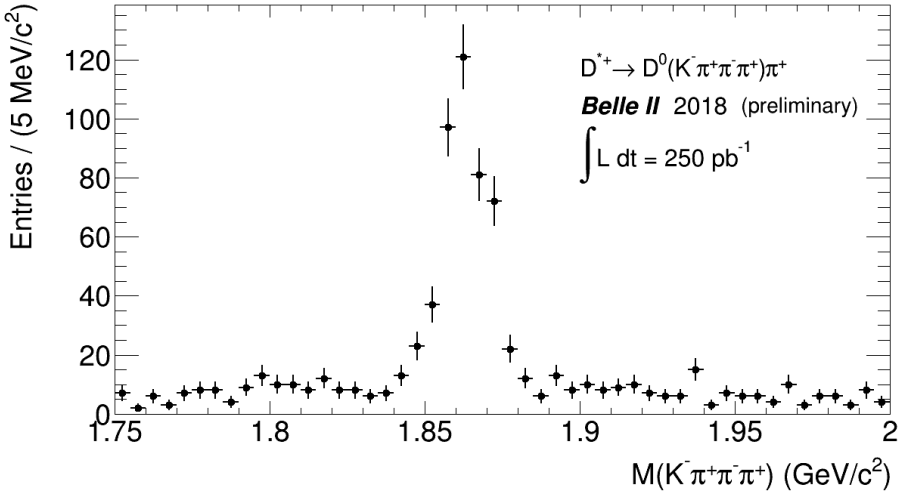
Rediscovering charm: $D^{*+} \to D\pi^+$, $D \to K^-\pi^+$, $K^-\pi^+\pi^0$, $K^-\pi^+\pi^-\pi^+$

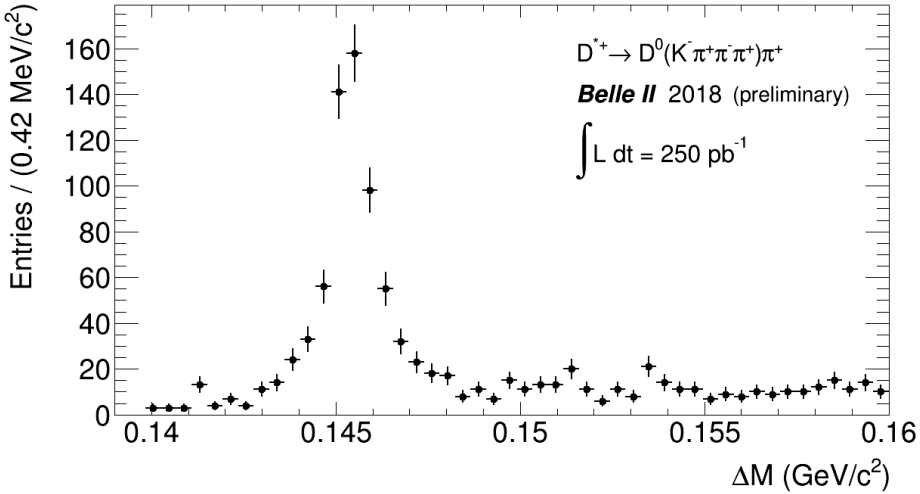






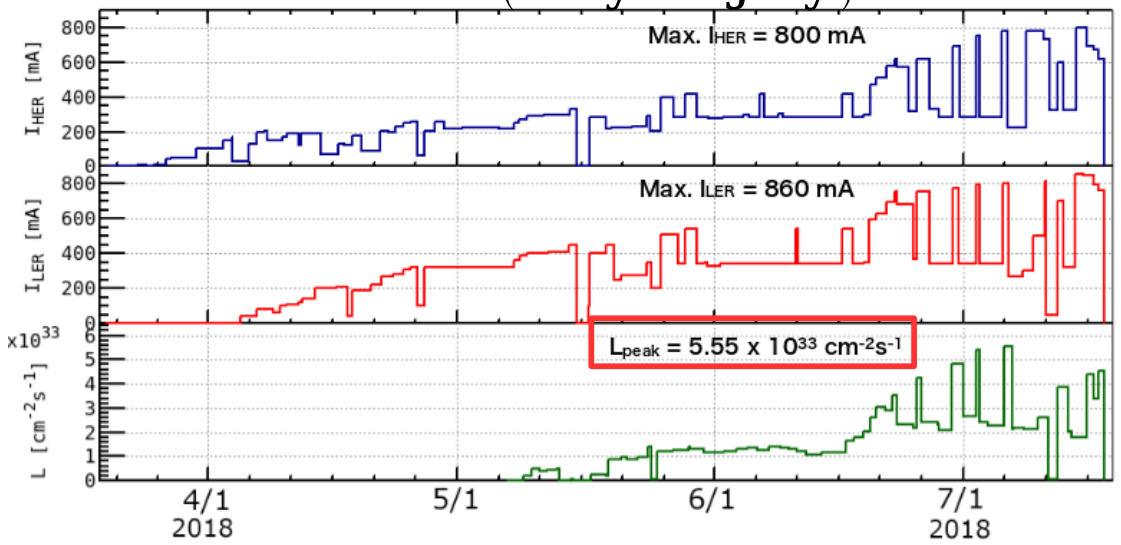


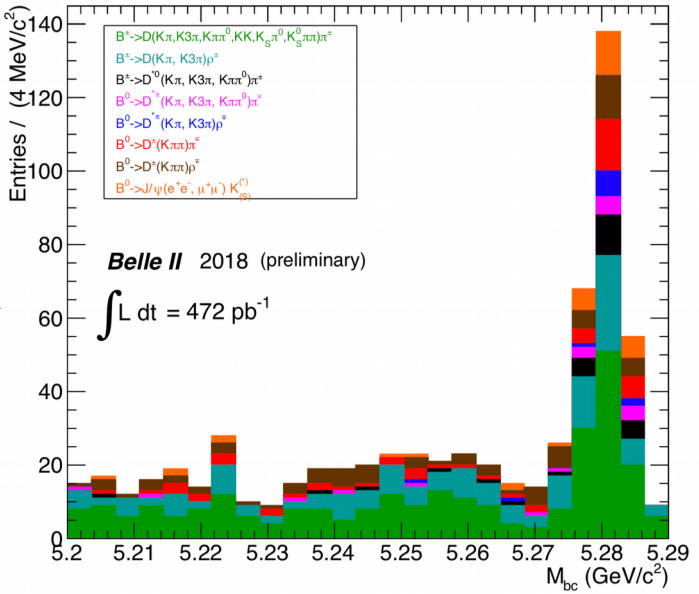




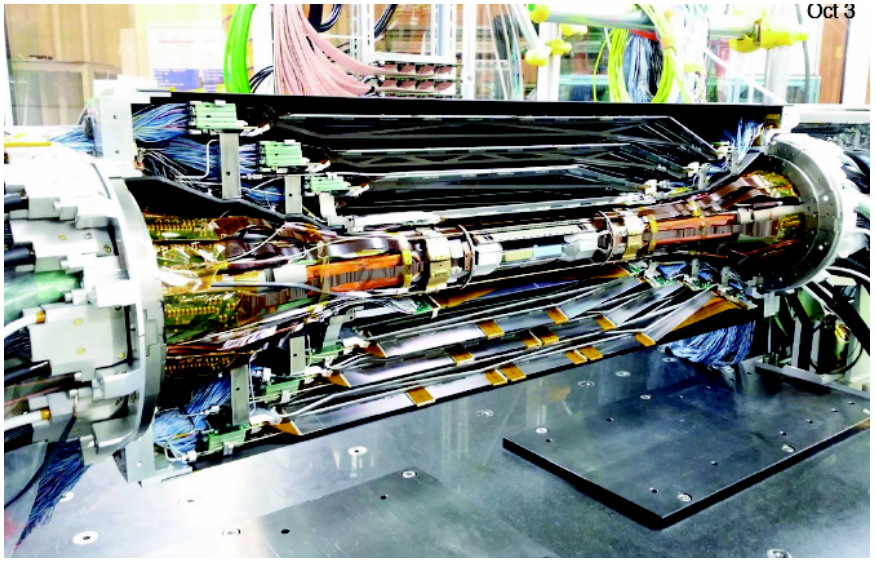
phase 2 → phase 3

2018 (May to July)

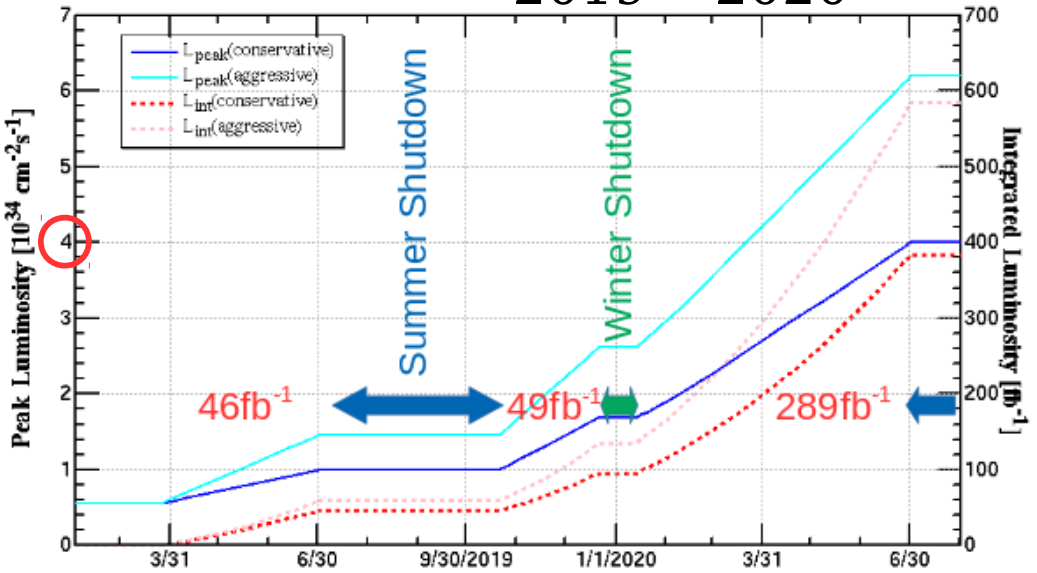




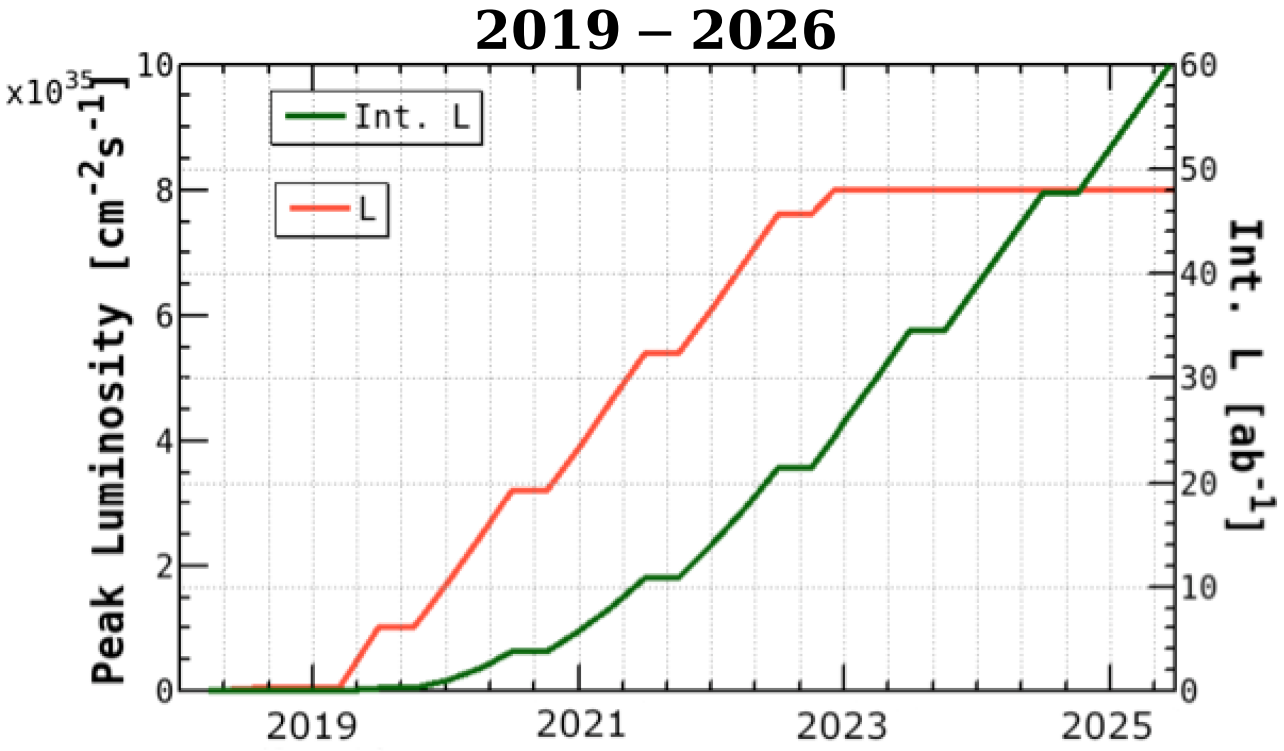
Installation of the full vertex detector in Fall 2018



2019 – 2020



Belle II computing requirements

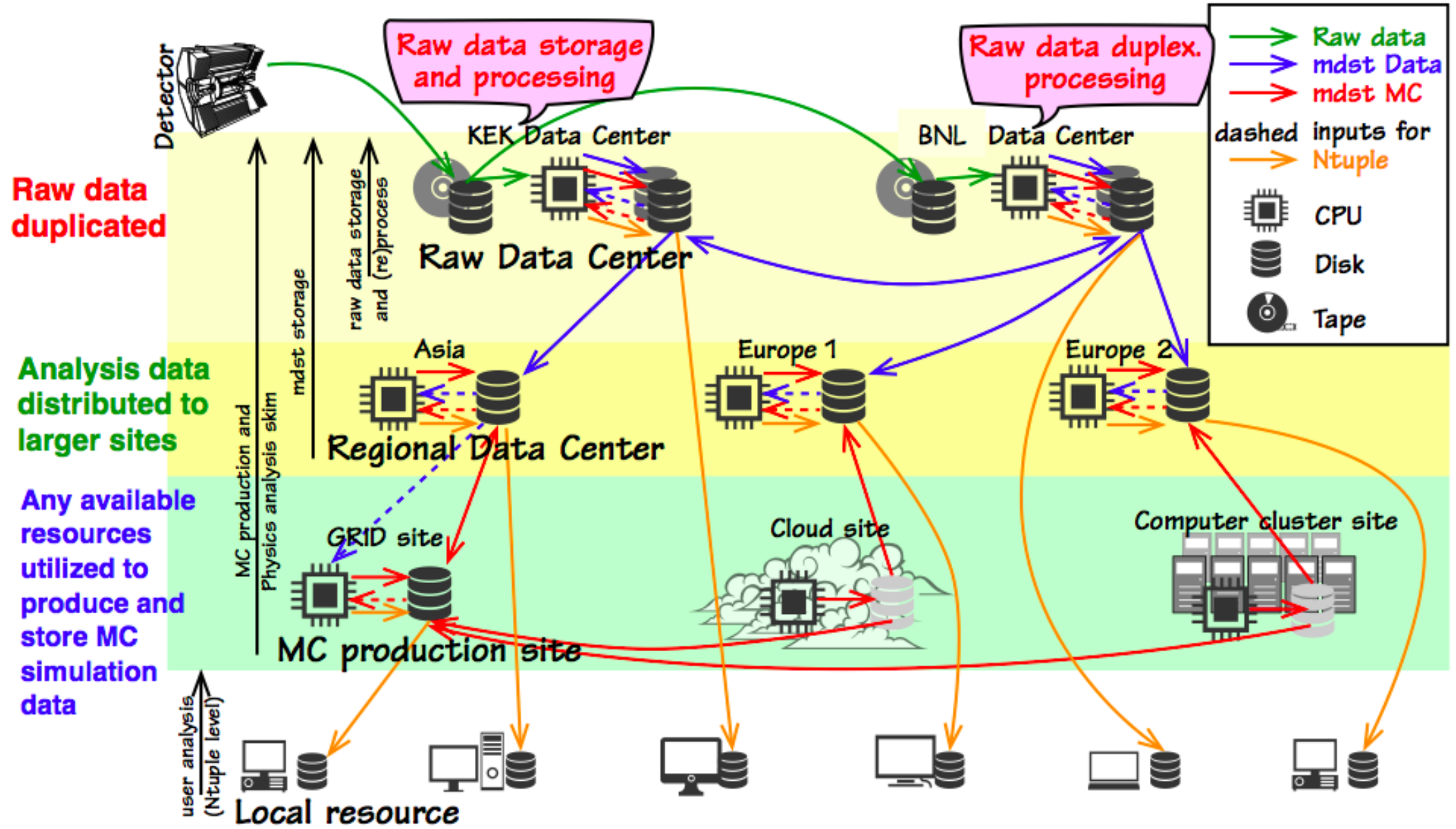


10 - 20 PB/year !

JFY		2019	2020	2021	2022	2023	2024	2025	2026	2027
Tape	(PB)	0.92	2.43	8.43	20.83	34.37	57.83	83.44	109.04	134.76
CPU for data processing	(kHEPSpec06)	13.87	22.81	78.73	109.32	119.48	207.17	226.14	226.14	227.07
CPU for data reprocessing	(kHEPSpec06)	24.18	40.72	26.38	36.53	94.05	94.05	153.79	153.79	370.44

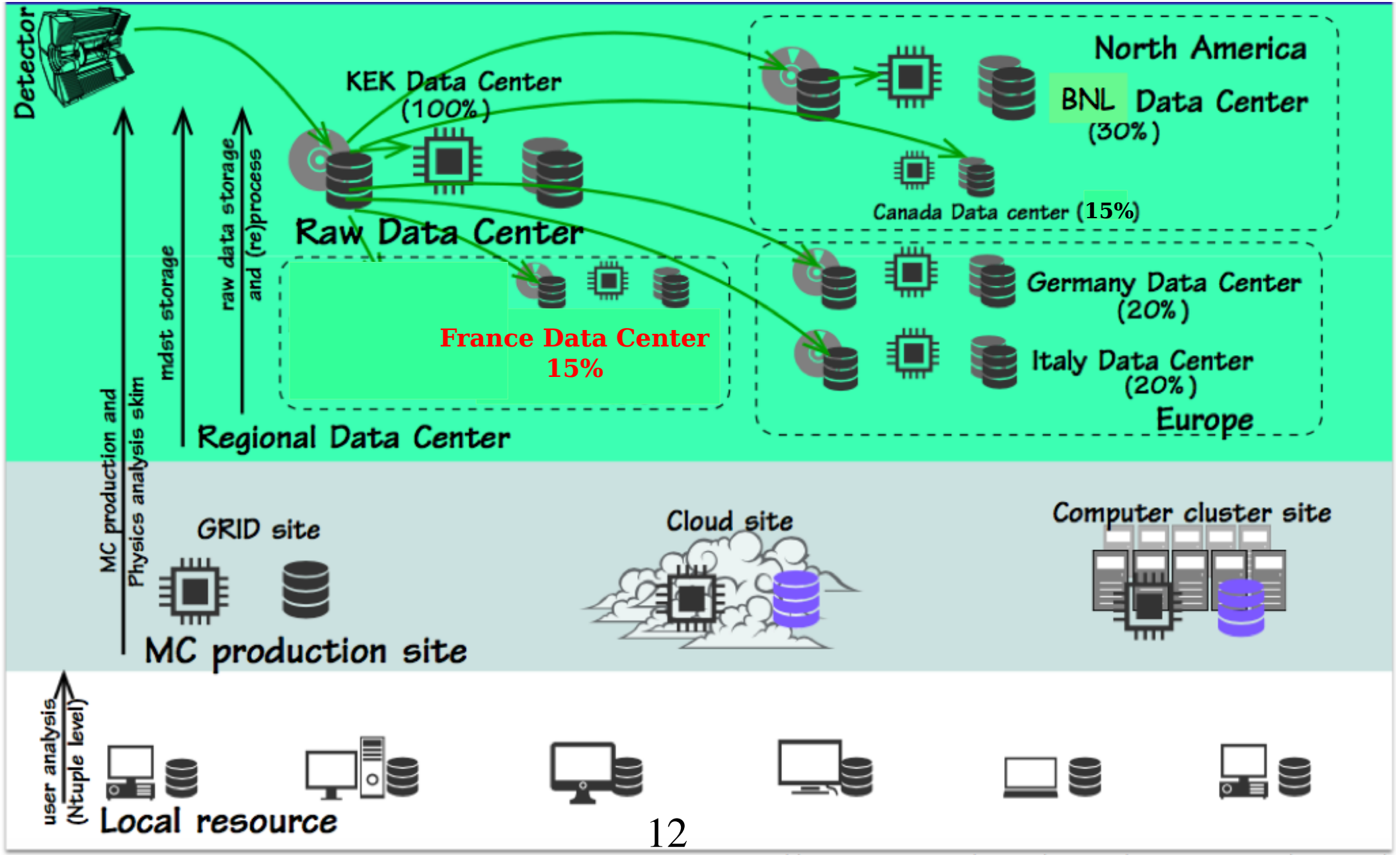
TABLE II: Estimation of the raw data size (PB) for the two replicas (one at KEK, the other distributed over the raw data centers) and CPU needed for processing and reprocessing (kHEP-Spec06).

Belle II Computing model (2019–2020)



Belle II Computing model (from 2021)

- Raw data centers vital components of Belle II computing model
- France could host one of those raw data centers…



France as Belle II Raw data center (CCIN2P3)

raw data

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+

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027
BNL	100	100	30	30	30	30	30	30	30
Canada	0	0	15	15	15	15	15	15	15
France	0	0	15	15	15	15	15	15	15
Germany	0	0	20	20	20	20	20	20	20
Italy	0	0	20	20	20	20	20	20	20

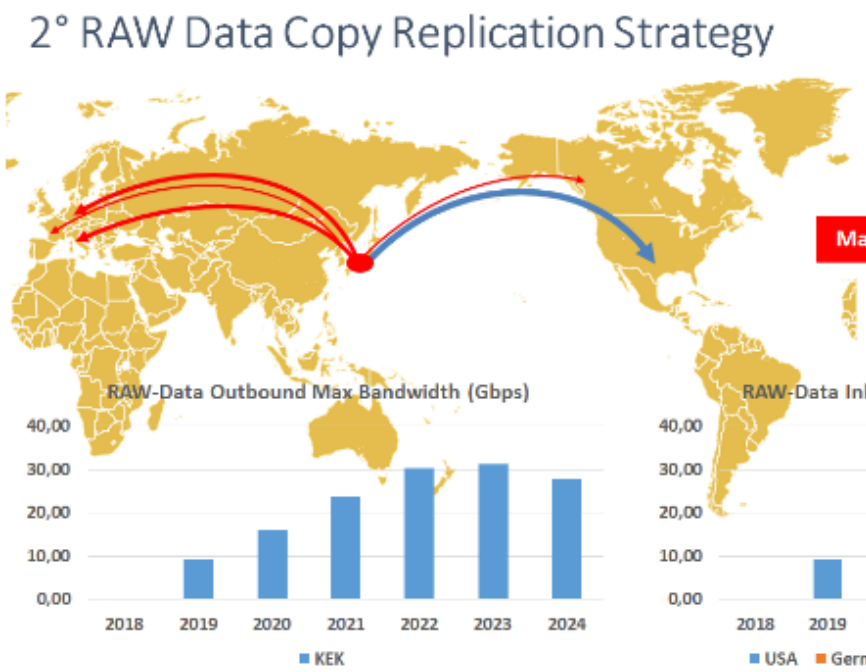
TABLE V: Sharing of the copy of raw data (%).

	2021	2022	2023	2024	2025	2026	2027
Tape (PB)	0.45	1.38	2.40	4.16	6.08	8.00	9.92
CPU (kHEPSpec06)	8.68	12.04	21.28	26.54	36.64	36.64	69.19

TABLE VI: Resources requested from 2021 for a French raw data center.

- Resources needed: storage (tapes, disks), CPU... but also network...
- participated to the Data Network Challenge, Belle II is now a group at CCIN2P3 (Belle II network challenge organized by Silvio Pardi)

Belle II Data Network Challenge

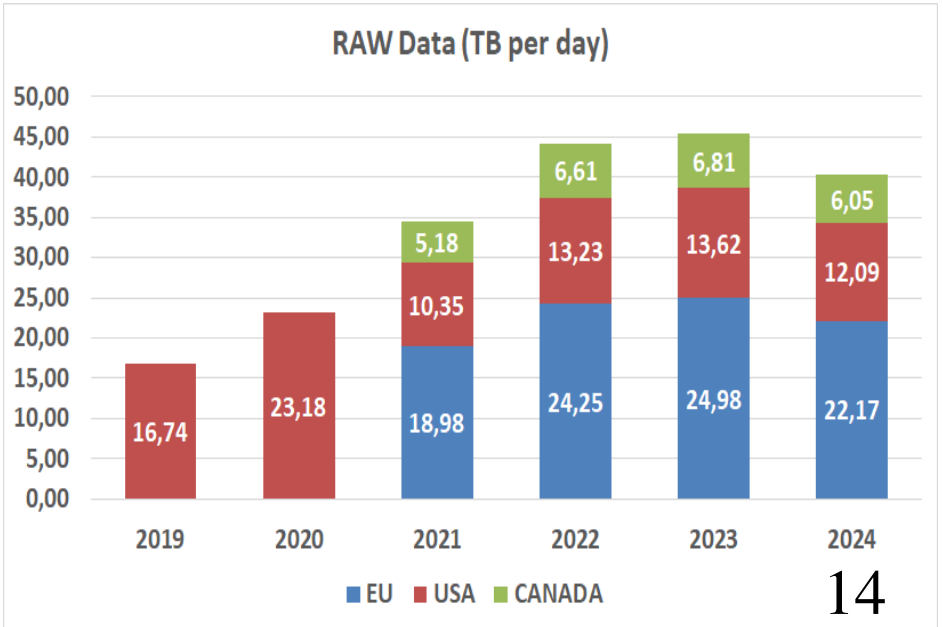


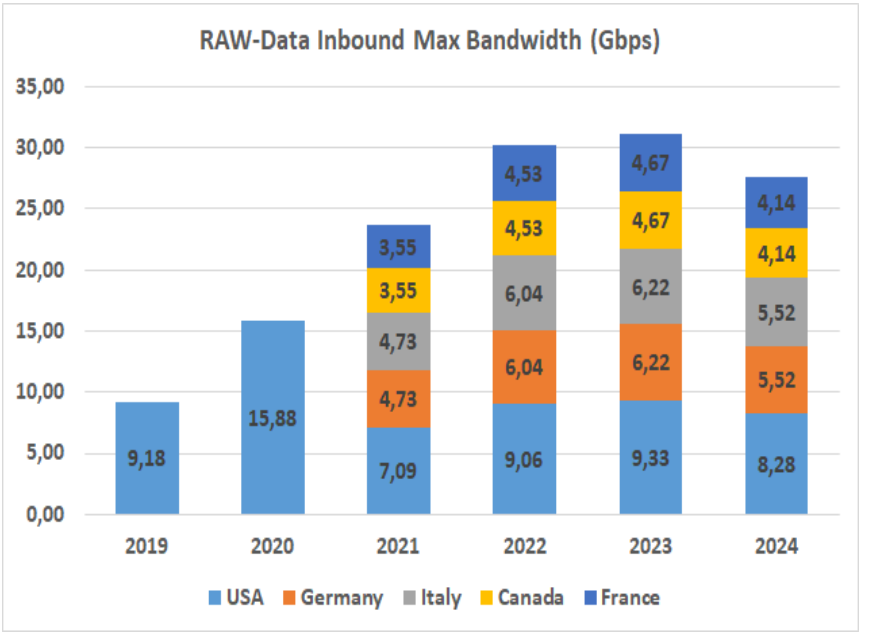
Year	2018-2020	2021-2024
USA	100%	30%
Italy	0%	20%
Germany	0%	20%
Canada	0%	15%
France	0%	15%

Max 8.5 Gbps Throughput/year (2023)

In 2023 the expect the maximum Raw data rate will be about 45TB for day : 55% in Europe, 30% USA 15% Canada.

GOAL FOR DATA CHALLENGE 5xAnnual Throughput

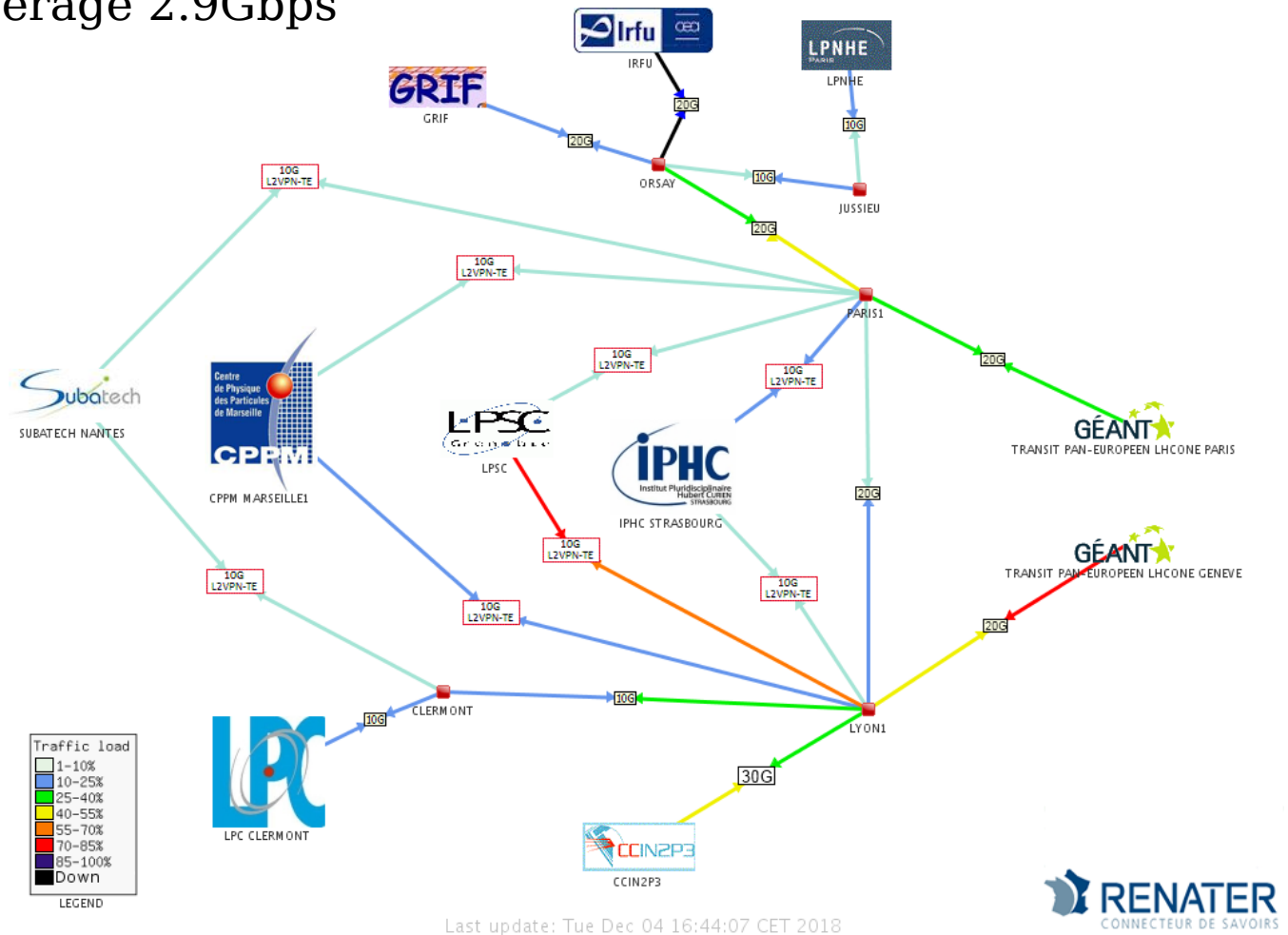




Belle II Data Network Challenge

Tests occured the week of Nov 26, discussion with experts the following week
Belle II (Silvio Pardi), CCIN2P3 (David Bouvet, L.Caillat-Vallet, Adrien ...)

not able to reach same performances in both directions
KEK→IN2P3 Max 2 Gbps average 0.7Gbps
IN2P3→KEK Max 8.5Gbps average 2.9Gbps



- bottleneck seems to occur in one direction from Geneva to Lyon
- link has been updated (×2) in February (Laurent Gydé, RENATER)

⇒ will resume the DNC test soon (coming days)

FJPPL project proposed

- study solutions for the Belle II computing in France
- prepare efficiently for a raw data center in France

French Group		**Japanese Group**	
K. Trabelsi	(LAL)	I. Ueda	(KEK)
S. Watanuki	(LAL)	H. Miyake	(KEK)
M. Jouvin	(LAL)	T. Hara	(KEK)
G. Philippon	(LAL)		
D. Bouvet	(CCIN2P3)		
J. Pansanel	(IPHC)		

- experienced KEK team
- main actors of Belle II computing group

''French Belle II computing group''

- share experience on DDM (CCIN2P3 experience at LHC)
- DIRAC system (Data Management System) originally developed at CPPM for LHCb
  ⇒ discuss further development for Belle II needs
- code optimization → speed up reprocessing
- development of more efficient skims...

⇒ mini-workshop in Nov/Dec 2019