



JENNIFER2 General Meeting

17–18 Nov 2022
Charles University
Europe/Prague timezone

Belle II Status and LS1

SuperKEKB accelerator Japan

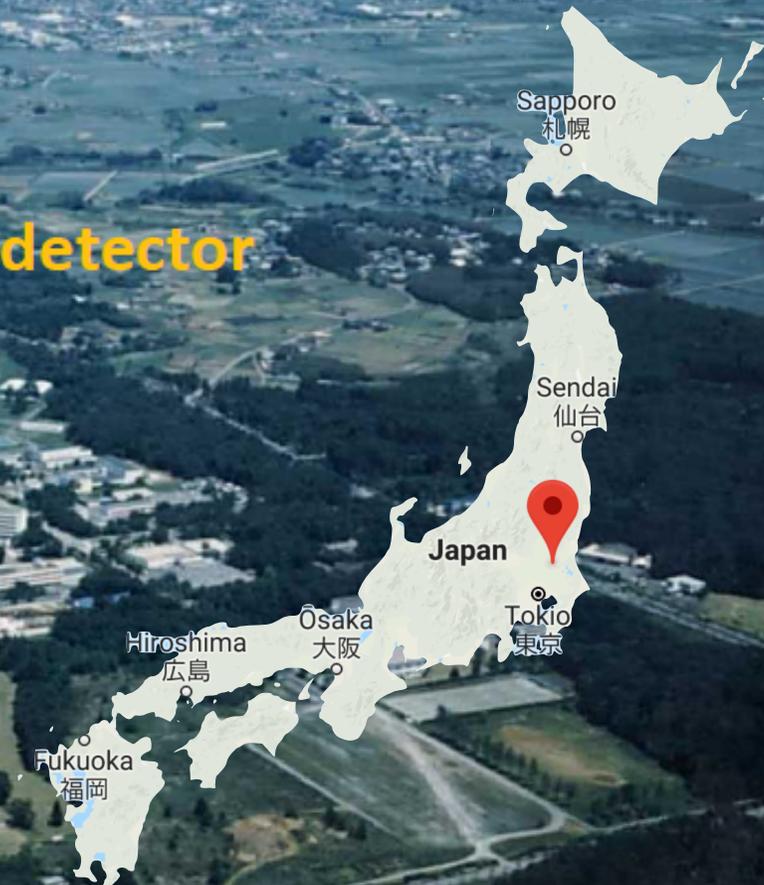
Mt. Tsukuba

SuperKEKB rings (HER+LER)

Belle II detector

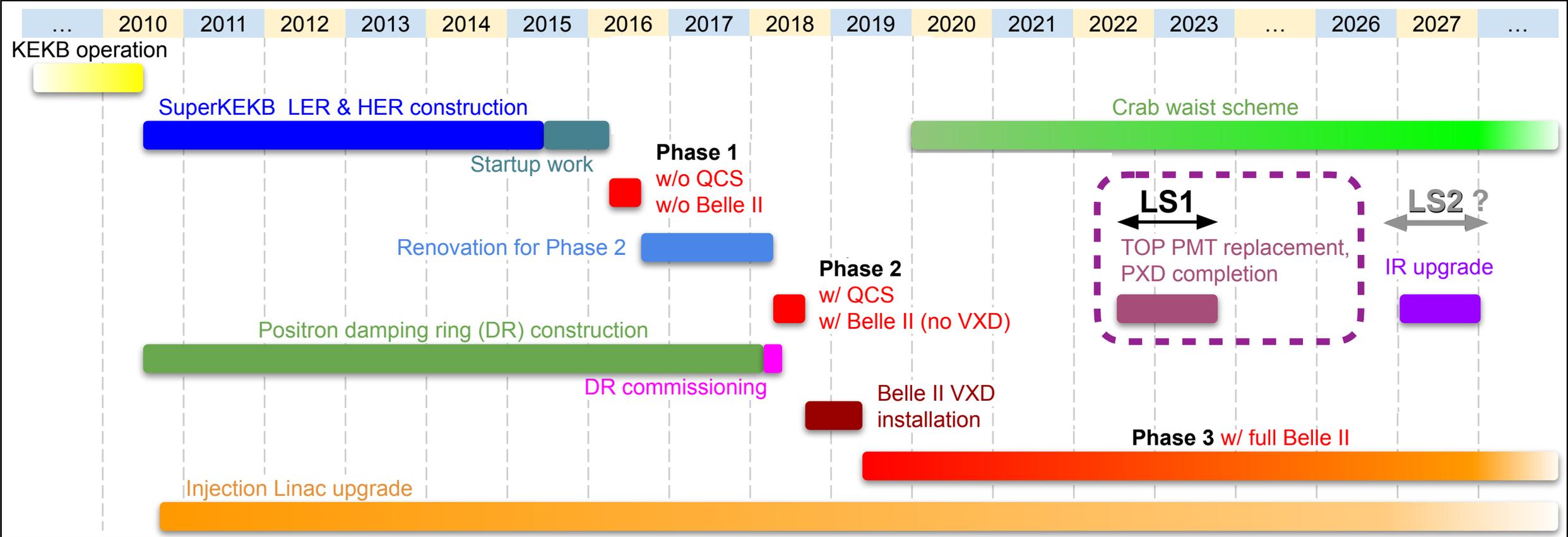
Damping ring (e⁺)

Linac



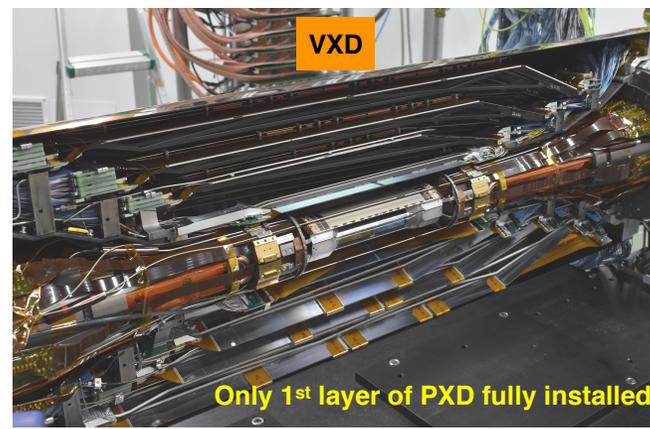
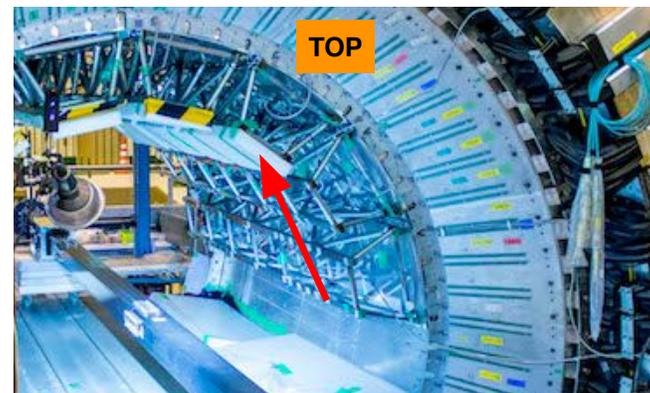
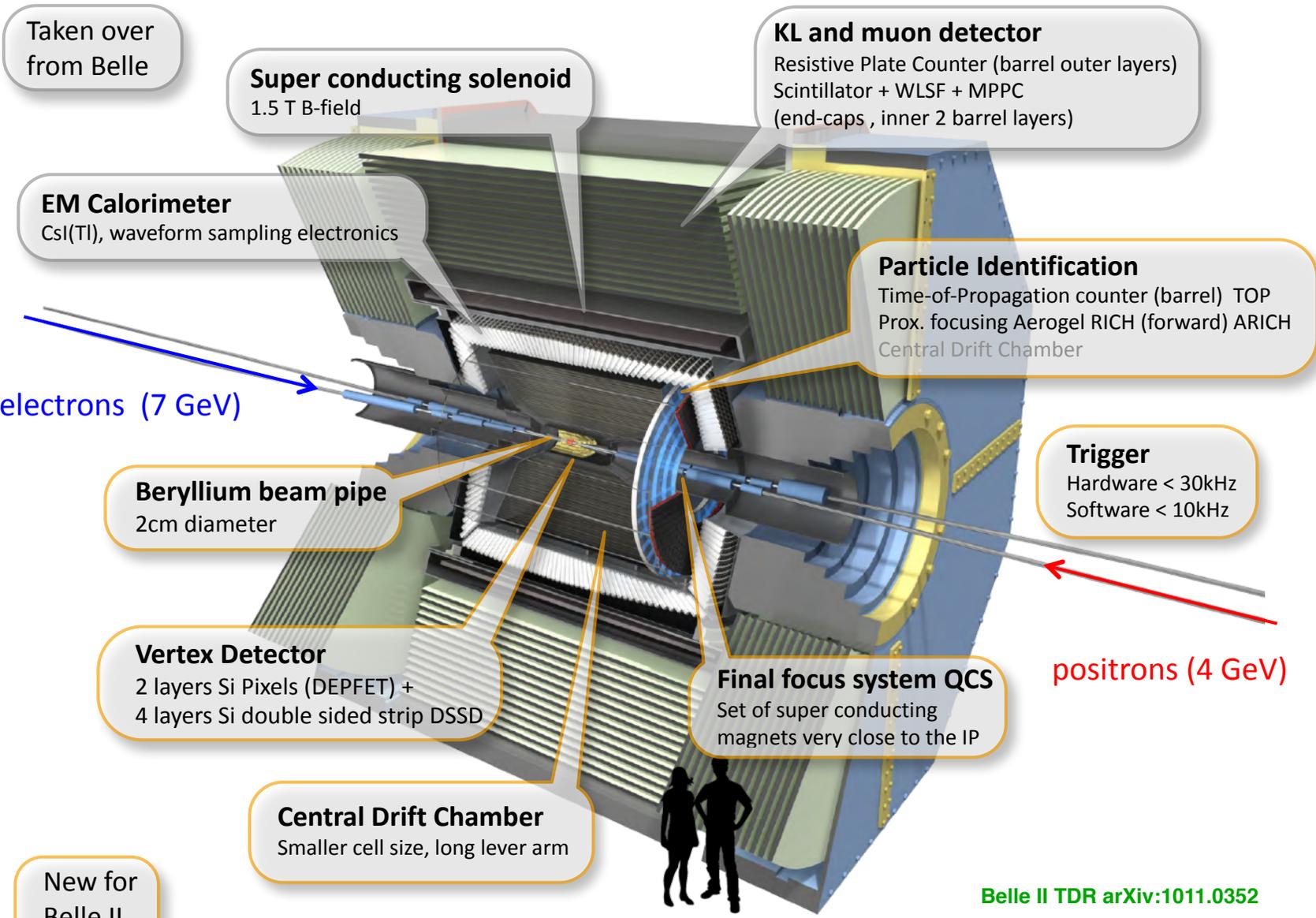
KEK - Tsukuba

SuperKEKB Timeline



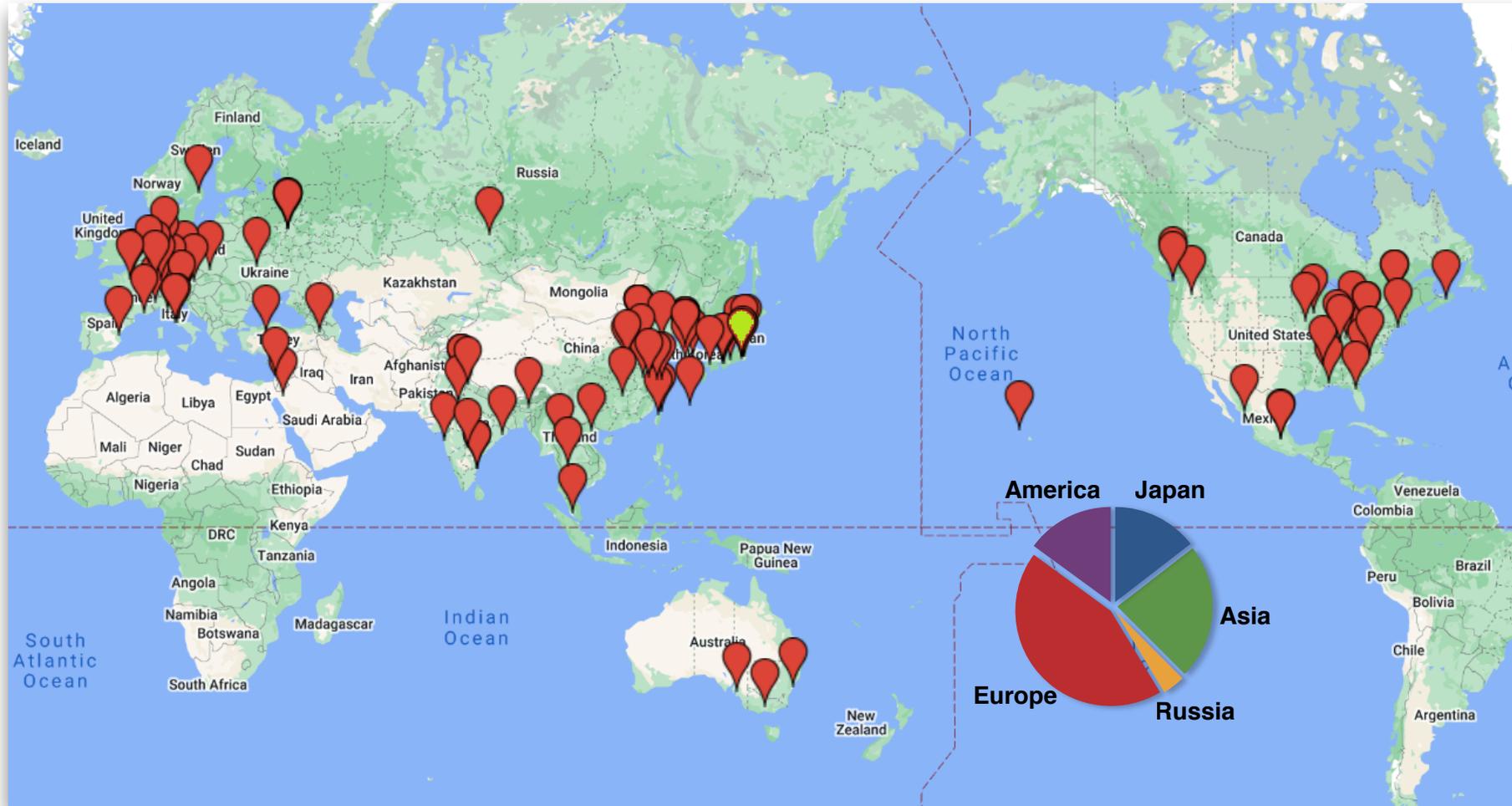
LS1: Long Shutdown 1

Belle II Detector



Belle II TDR arXiv:1011.0352

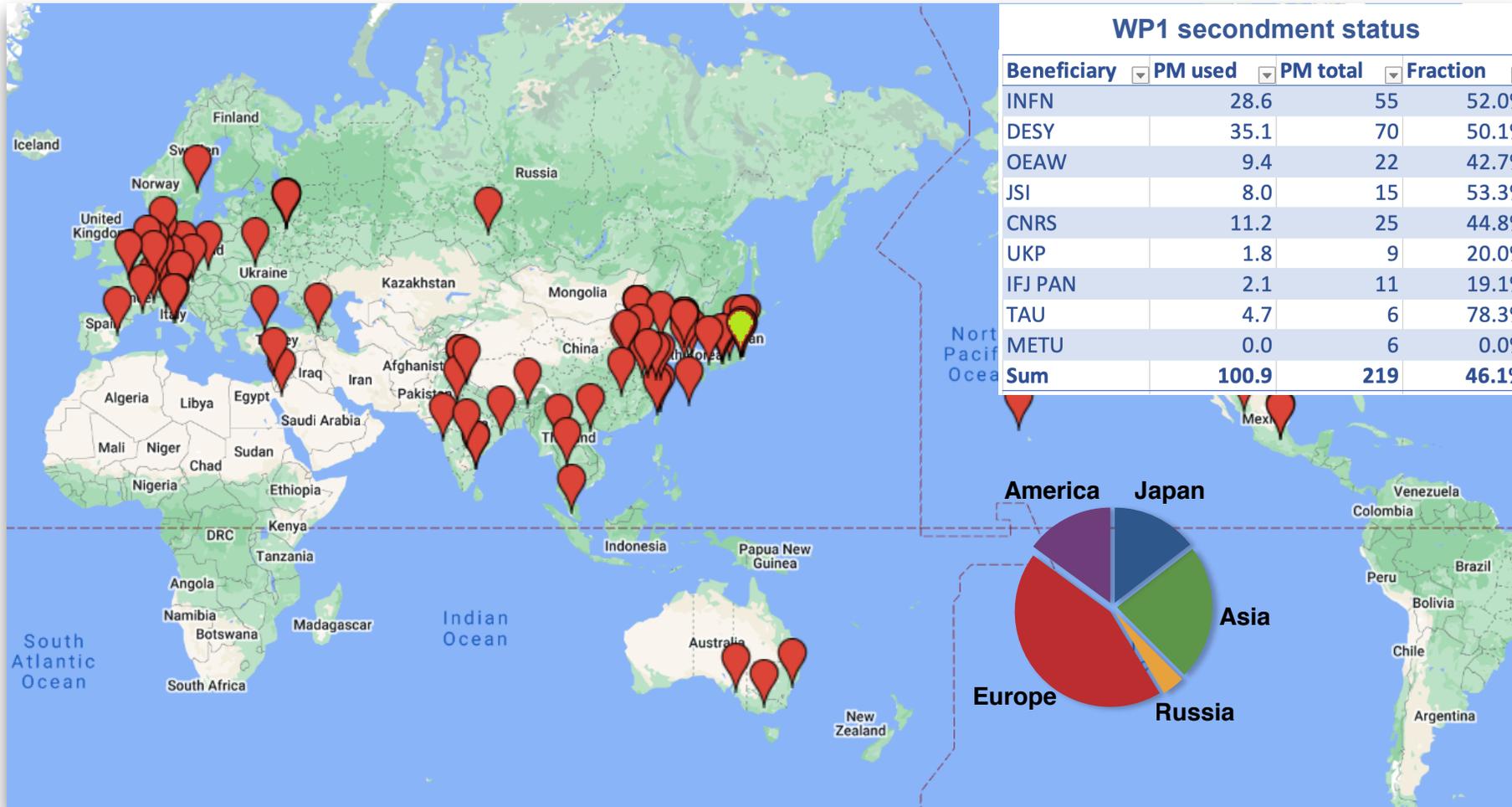
Status of Belle II Collaboration



- 27 countries
- 123 institutions
- 1151 members

Country	Members
Germany	236
Japan	171
U.S.A.	119
Italy	109
China	73
India	64
France	60
Canada	41
South Korea	41
Taiwan	40
Russia	40
Austria	33
Australia	26
Slovenia	25
Mexico	14
Israel	10
Czechia	8
Poland	7
Armenia	7
Ukraine	6
Spain	5
Thailand	5
Viet Nam	4
Turkey	4
Saudi Arabia	4
Sweden	2
Malaysia	1
Gesamtergebnis	1155

Status of Belle II Collaboration



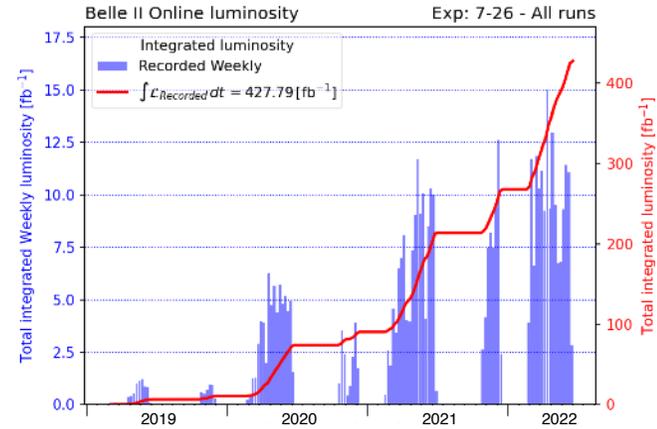
WP1 secondment status			
Beneficiary	PM used	PM total	Fraction
INFN	28.6	55	52.0%
DESY	35.1	70	50.1%
OEAW	9.4	22	42.7%
JSI	8.0	15	53.3%
CNRS	11.2	25	44.8%
UKP	1.8	9	20.0%
IFJ PAN	2.1	11	19.1%
TAU	4.7	6	78.3%
METU	0.0	6	0.0%
Sum	100.9	219	46.1%

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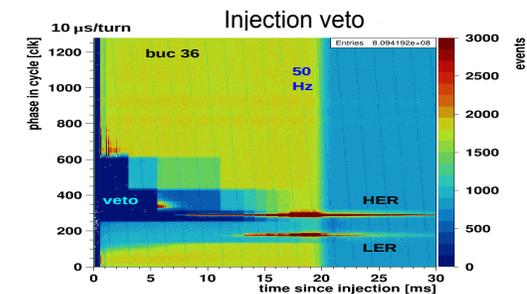
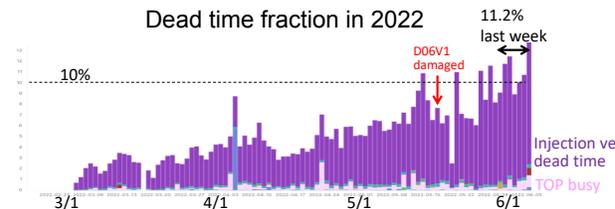
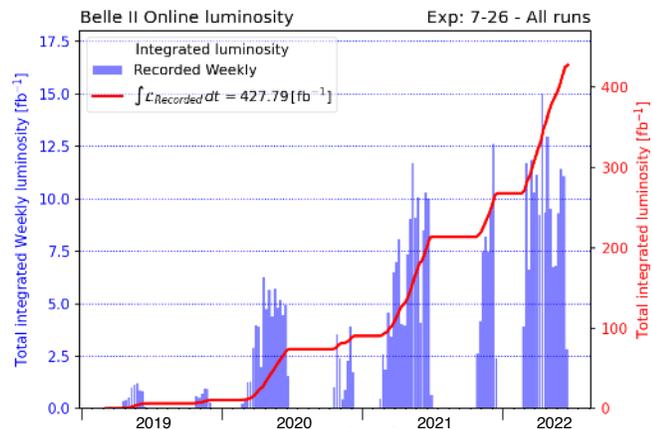
Belle II Data Taking before LS1

- Total integrated luminosity of 428 fb⁻¹
 - roughly corresponding to entire BaBar dataset
 - premature run end due to budget limitations
 - $L_{\text{peak}} = 4.65 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$



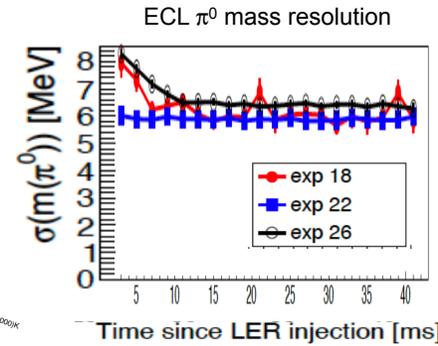
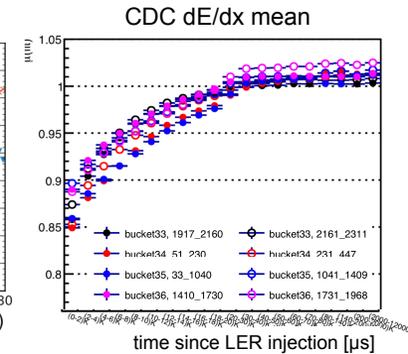
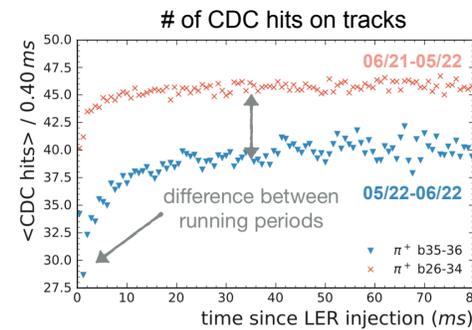
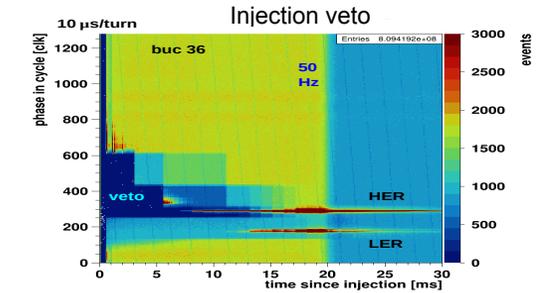
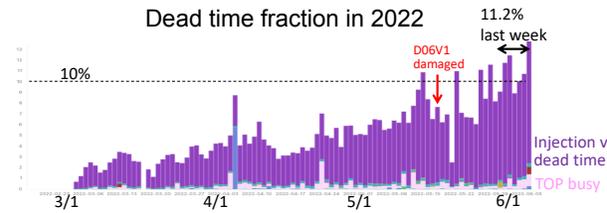
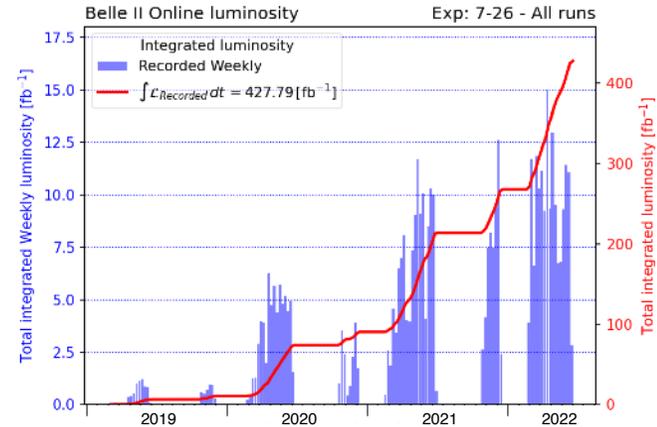
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- Impact of injection background
 - increasing dead time due to injection veto



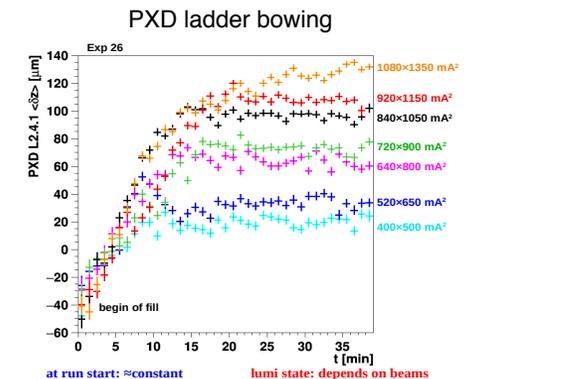
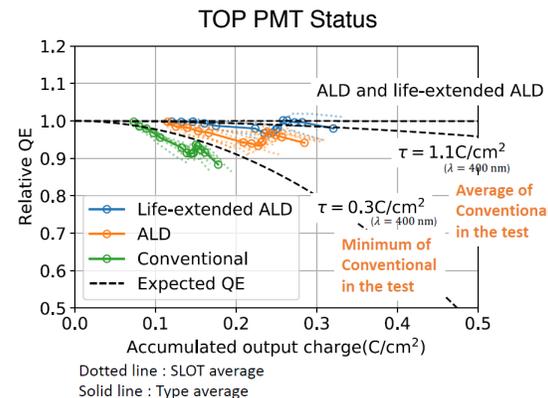
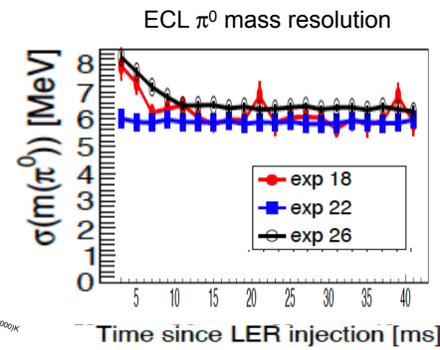
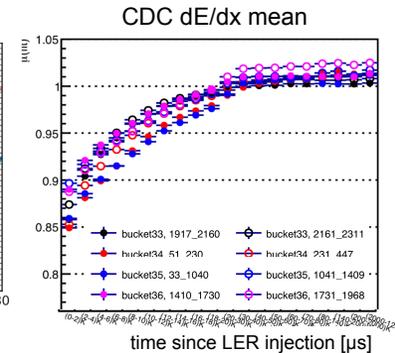
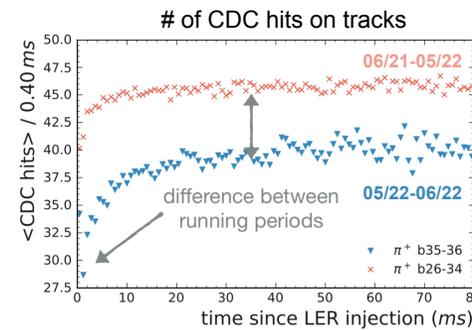
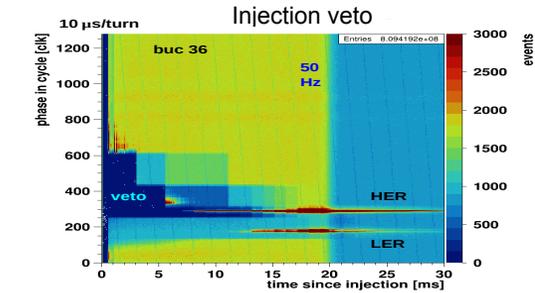
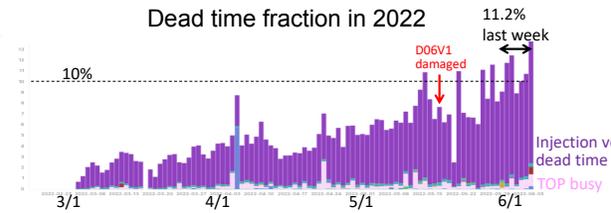
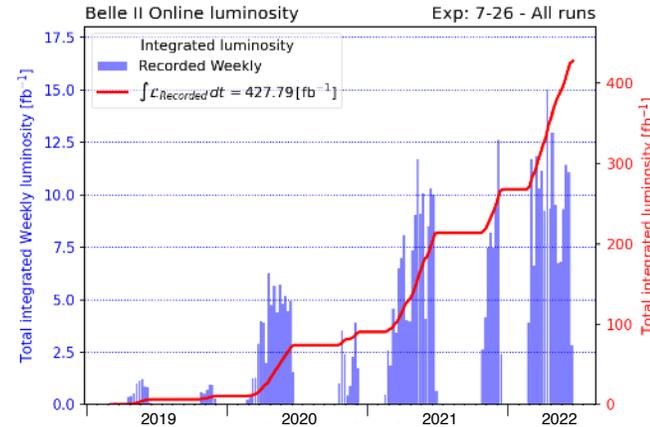
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 - performance degradation as a function of time since last injection in
 - ▶ CDC (hit efficiency, dE/dx (μ, σ), trigger efficiency)
 - ▶ ECL (e.g. π^0 mass resolution)



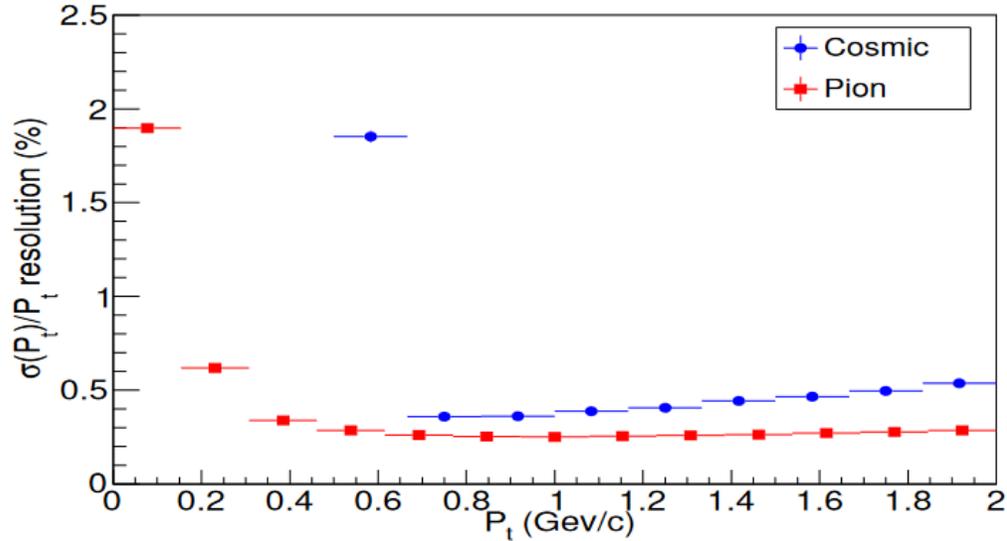
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 - ▶ CDC (hit efficiency, dE/dx (μ, σ), trigger efficiency)
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- Other detector issues
 - CDC: steady decrease of gain / efficiency
 - TOP: degrading QE of PMTs (\rightarrow replace in LS1)
 - KLM: efficiency drop in one sector (gas problem)
 - PXD: beam current-dependent ladder deformation
 - increasing rate of SEUs in several detectors

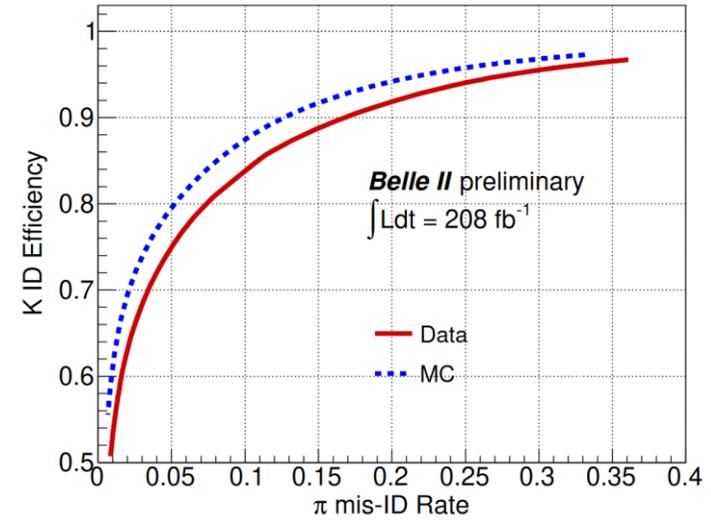


Detector Performance

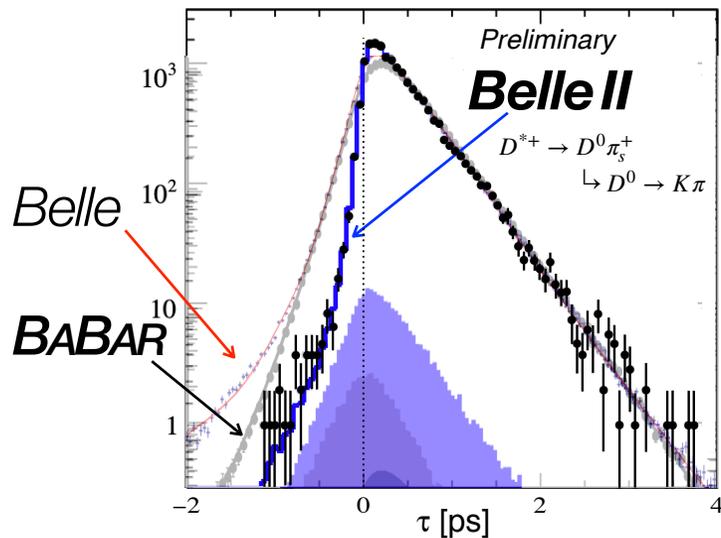
Improved P_t resolution wrt Belle



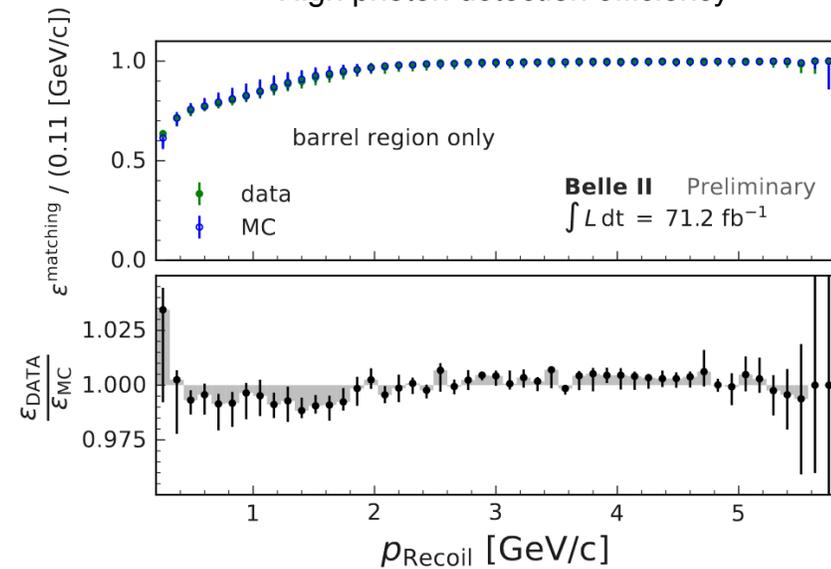
K/ π ID still slightly worse than Belle



Vertex resolution twice as good as Belle



High photon detection efficiency



New Belle II Results @ 2022 Spring and Summer Conferences

Moriond 2022

ICHEP 2022

- Lepton-mass moments — [paper](#), [world best](#)
- Λ_c^+ lifetime — [paper](#), [world best](#)
- Darkhiggstrahlung — [paper](#), [world best](#)
- B^0 lifetime and mixing — [paper](#)
- BF and A_{CP} of $B^0 \rightarrow K^0 \pi^0$
- BF, A_{CP} , and f_L of $B^+ \rightarrow \rho^+ \rho^0$
- $|V_{ub}|$ tagged
- $|V_{cb}|$ tagged
- BF of $B \rightarrow K^{(*)} \ell \ell$
- BF of $B^0 \rightarrow K^0_S \pi^0 \gamma$

$|V_{cb}|$ from untagged $B \rightarrow D \ell \nu$ decays

CONF

$|V_{ub}|$ from untagged $B \rightarrow \pi \ell \nu$ decays

CONF

BF($B \rightarrow \rho \ell \nu$) from tagged decays

CONF

LFU test in semileptonic B decays

Aiming at PRD or PRL

Inclusive $B \rightarrow X_s \gamma$ using hadronic tagging

CONF

B^0 mixing phase ϕ_1/β from $B^0 \rightarrow J/\psi K^0_S$

Aiming at PRD

CP violation in $B^0 \rightarrow K^0_S K^0_S K^0_S$ decays

CONF

BF and f_L in $B^0 \rightarrow \rho^+ \rho^-$

CONF

BF and A_{CP} in $B^+ \rightarrow h^+ \pi^0$

CONF

BF and A_{CP} in $B^0 \rightarrow \pi^+ \pi^- \rho^0$

Aiming at PRD

Measurement of $R(K)$ in resonant decays

CONF

Measurement of the Ω_c lifetime

Accepted by PRD

Observation of $e^+e^- \rightarrow \omega \chi_0$ and search for X_0 at and near 10.75 GeV

With PRL

Search for $\tau \rightarrow \ell \alpha$ (invisible)

Aiming at PRL

Search for $Z', S, ALP \rightarrow \pi\pi$ in $\mu\mu\pi\pi$ final states

Aiming at PRL

Search for an invisible Z' in $\mu\mu +$ missing energy

Aiming at PRL

SuperKEKB Activities during LS1

K. Nakamura
Assembly test with real designs
Shield mockup (3D printing)

H. Yamaoka
Tsukuba
Additional PE and concrete shields around Belle II

K. Oide
Need new magnets, converters, cabling
factory
3SM2
3LC2

quadrupole	L	# (line)
QK1OP	0.44078	-5.775222
QK2OP1	0.44078	4.701084
QK3OP	0.44078	-3.272473

S. Nakamura
38 m
Construction site of non-linear collimator

T. Ishibashi
Carbon collimator head

Y. Suetsugu
Beam pipe at HER injection point

Beam channel for injection beam

SuperKEKB

IR radiation shield modification

- For BG reduction
 - New heavy metal shields around IP bellows
 - Additional concrete & polyethylene shields around Belle II
 - Material change from W to SUS of QCS cryostat front plate

Nonlinear collimator (LER)

- For impedance and BG reduction
 - New collimation scheme less likely to cause TMCI
 - Removal of 50 wiggler magnets
 - Installation of 2 skew sextupole and 5 quadrupole magnets
 - Installation of new vertical collimator with wider aperture

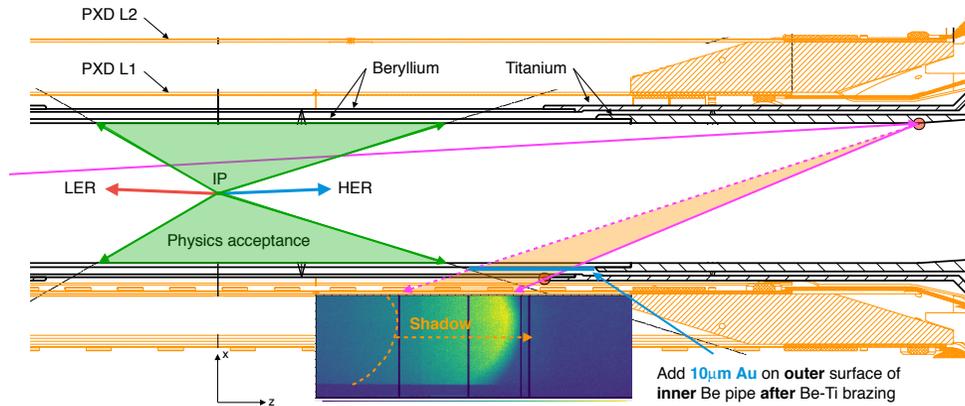
Robust collimator head (LER)

- As countermeasure against kicker-pulsar misfiring and resulting destruction of collimator
 - Replacement with carbon head of horizontal collimator D06H3

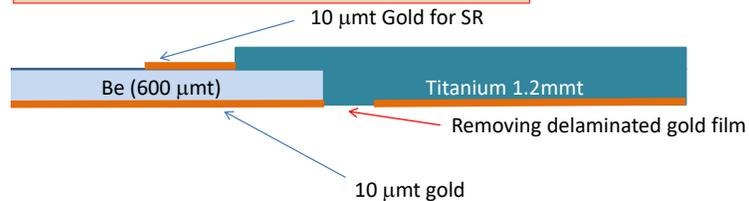
New beam pipes with wider aperture at HER injection point

- For improvement of injection efficiency
 - New beam pipes with wider aperture
 - New BPM for precise measurement of injected beam.

New IR Beam Pipe



Gold film partially peeled IP pipe (inner cylinder)

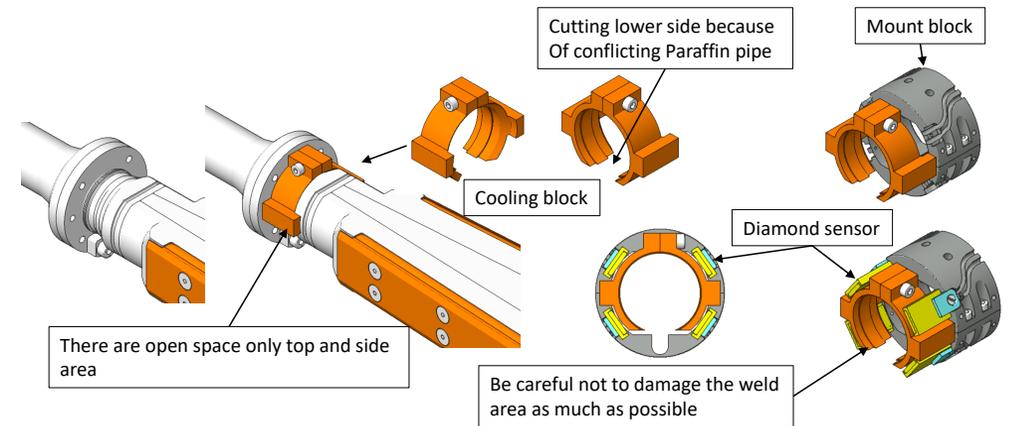


Current schedule

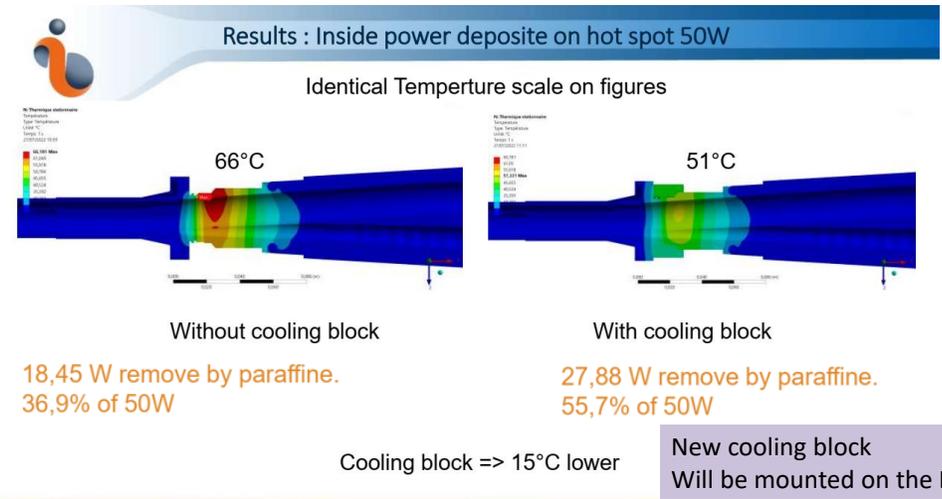
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
IP part production										
Spare cylinder plating										
Inner+outer cylinder connection										
IP part + croct part										
Beam pipe + HM shields integration										

- Production delayed due to gold delamination issue
- Beam pipe should be ready for diamond mounting in January/February

Mitigation of hot spot issue



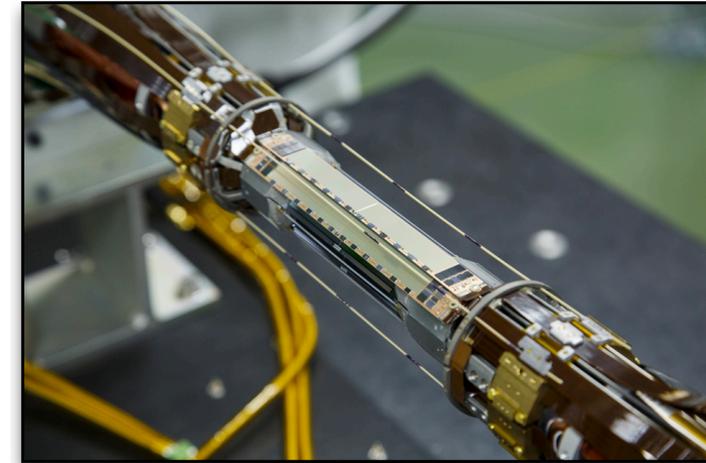
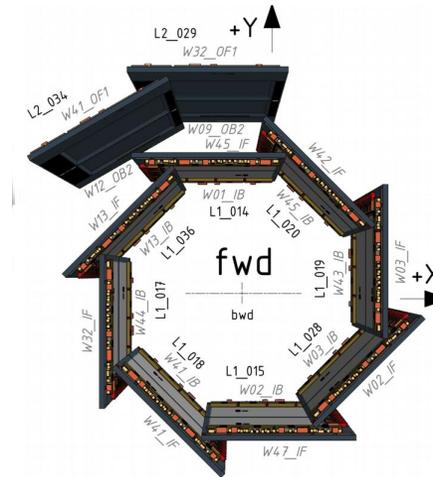
Thermal FEM simulation



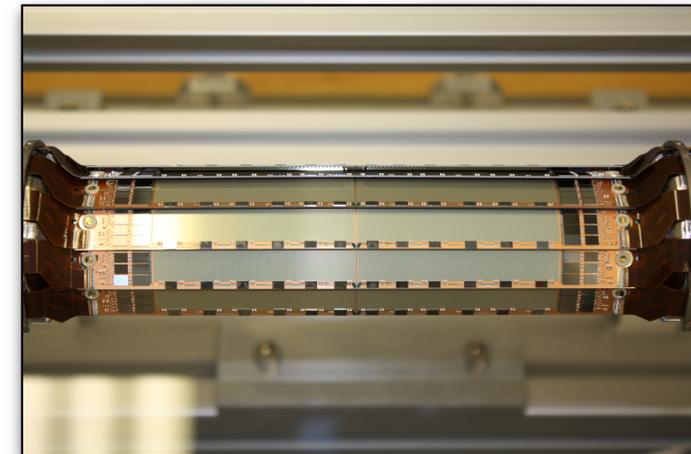
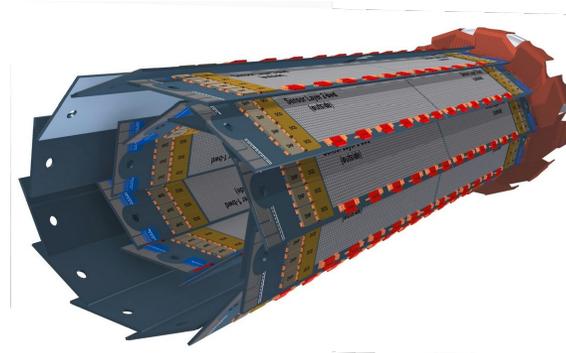
PXD Completion

- Present PXD incomplete
 - only 10/20 ladders (8/8 inner, 2/12 outer) installed
 - very good vertexing performance so far
 - ▶ but not guaranteed for future higher luminosity \Rightarrow higher background / occupancy
- Ongoing efforts to build 2nd, complete PXD2
 - same technology but improved manufacturing processes and more time
 - module production & half-shell assembly finished
 - testing ongoing (with some delays)
 - PXD2 to be installed during LS1

PXD

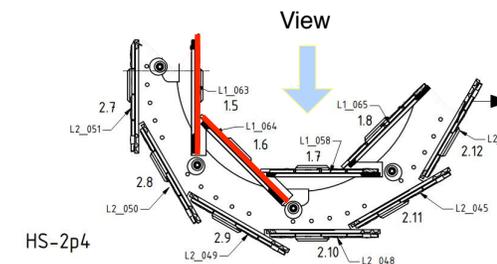
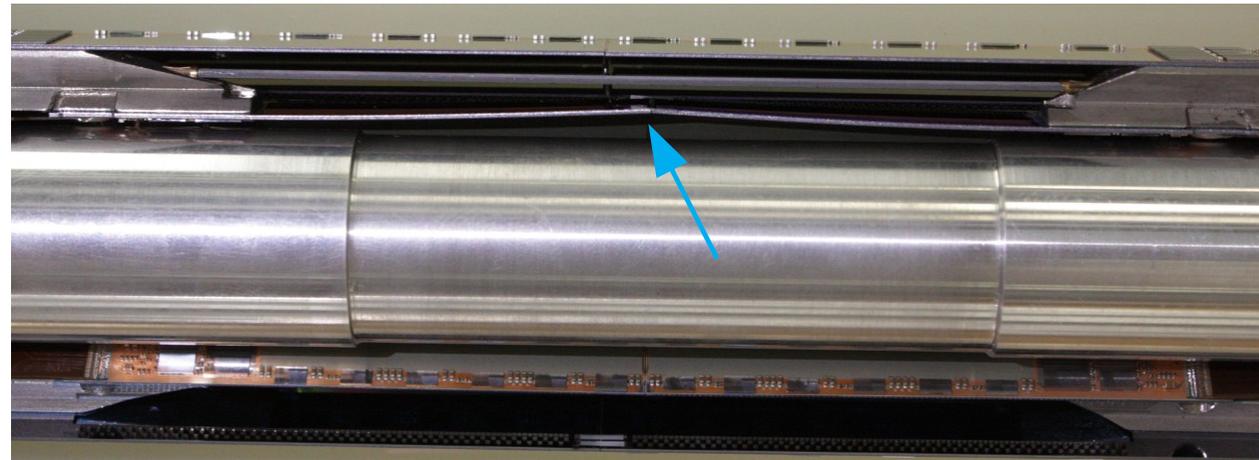
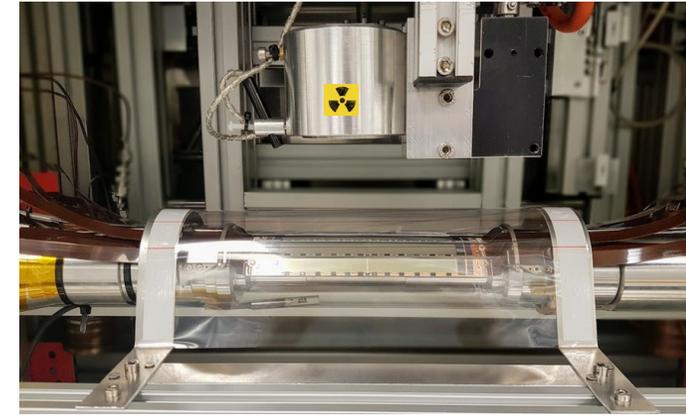


PXD2



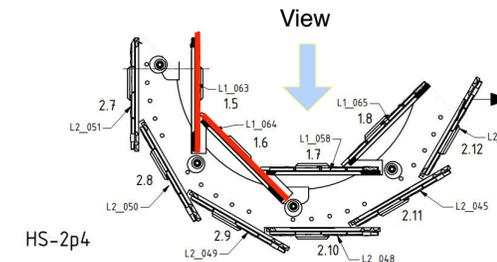
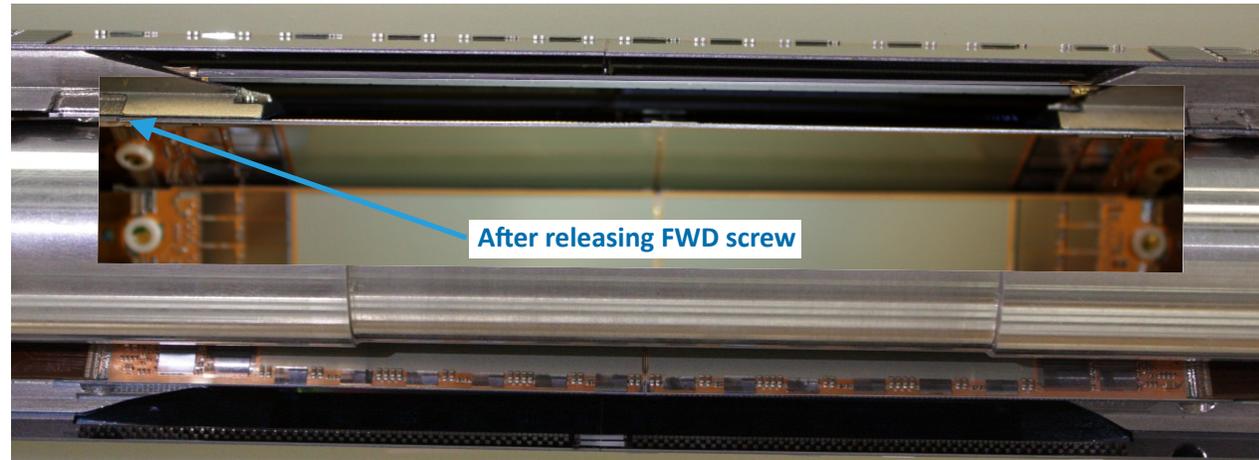
Status of PXD2 Half-Shells

- Both PXD2 half-shells successfully assembled at MPP and safely transported to DESY for commissioning
 - perform full electrical tests to ensure no damage during ladder mounting
 - perform source measurements with ^{90}Sr source to optimize working point
- After finishing first half-shell found two ladders where glue joint between modules opened \Rightarrow can't leave like this
 - testing of second half-shell presently on hold
- Main questions to be answered
 - why and how could this happen?
 - how can we prevent this to happen in Belle II?
- Input for ongoing discussion on LS1 schedule
 - PXD2 production schedule
 - status of new beam pipe
 - operation budget in JFY2023
 - expected electricity price in 2023
- Decision to be taken at collaboration meeting in February



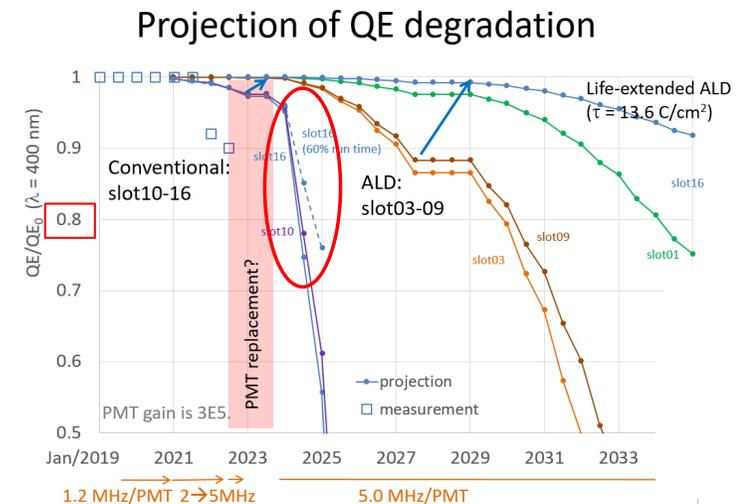
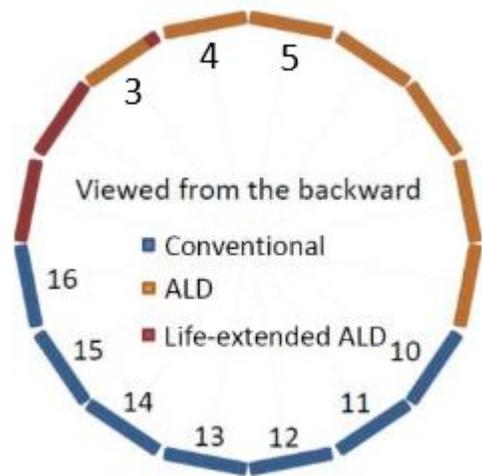
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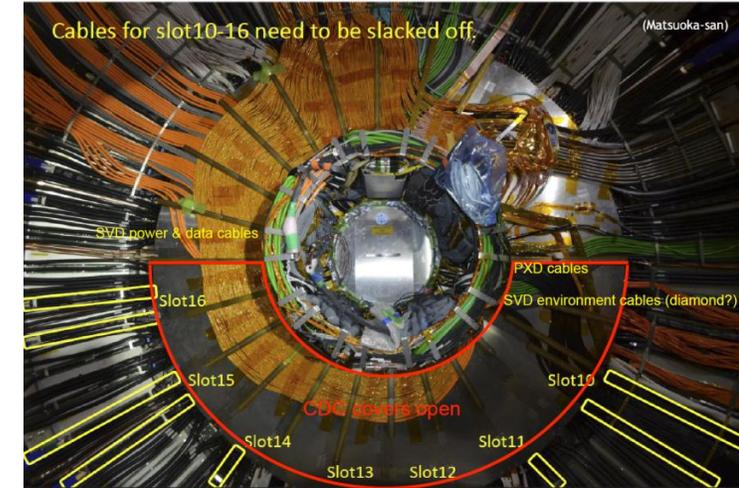
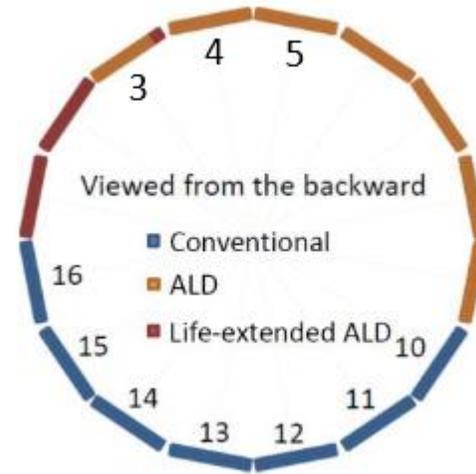
Status of TOP PMT Replacement

- Laboratory tests suggest that quantum efficiency will quickly drop after exceeding certain threshold of integrated charge on photo cathode



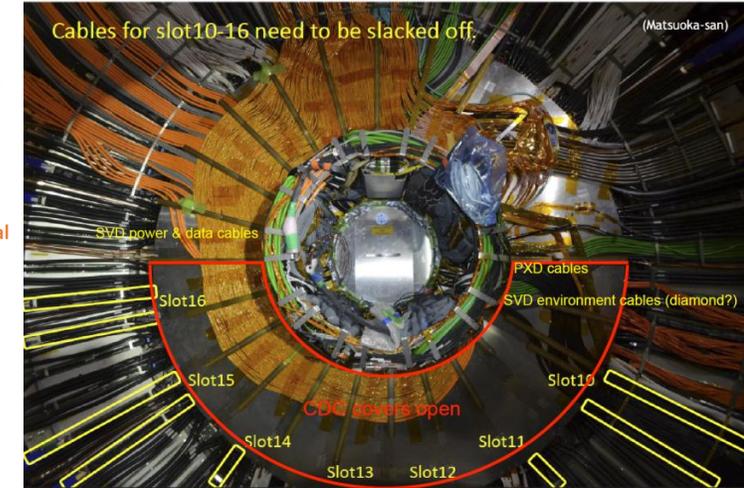
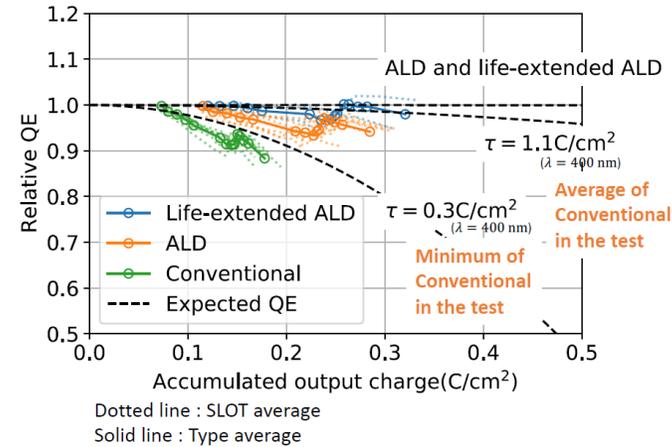
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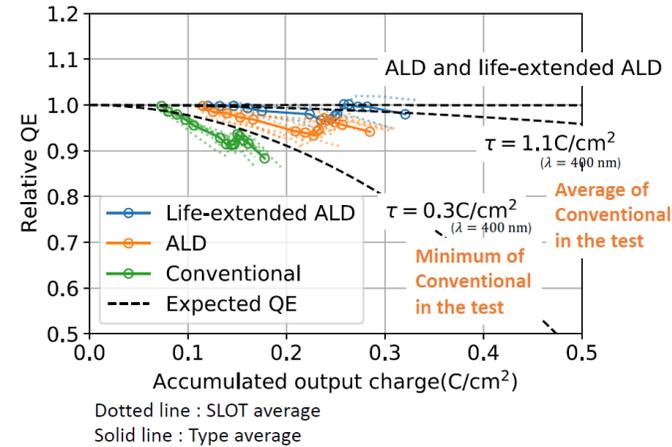
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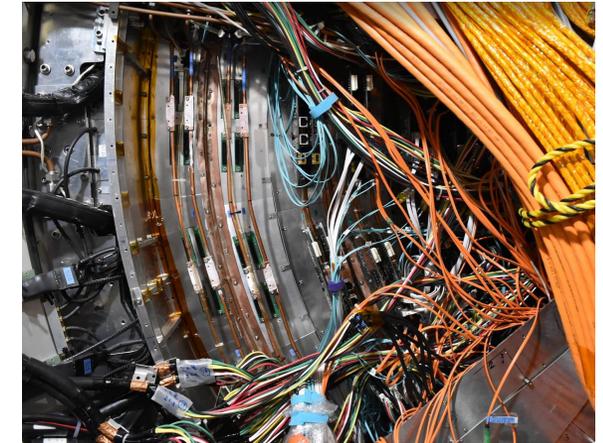
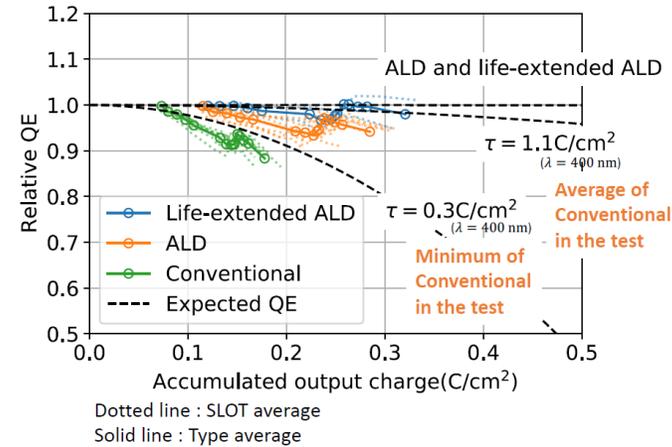
Status of TOP PMT Replacement

- Laboratory tests suggest that quantum efficiency will quickly drop after exceeding certain threshold of integrated charge on photo cathode
 - observed loss of QE not fully understood
- Ongoing: Dismounting of slot16 PMTs
 - open CDC and TOP window
 - dismount boardstacks, HV modules and PMTs

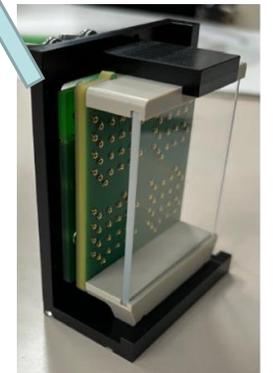
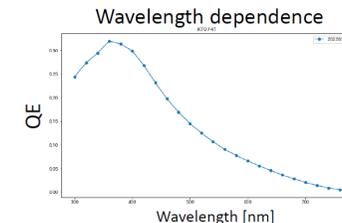
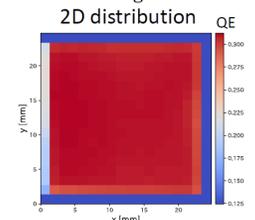
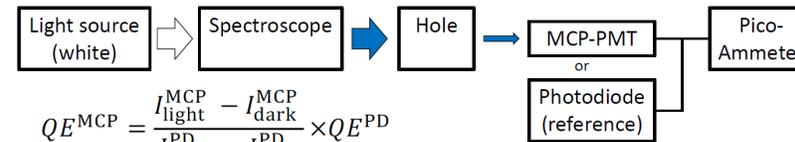


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 - dismount boardstacks, HV modules and PMTs
 - confirm QE on test bench at Nagoya

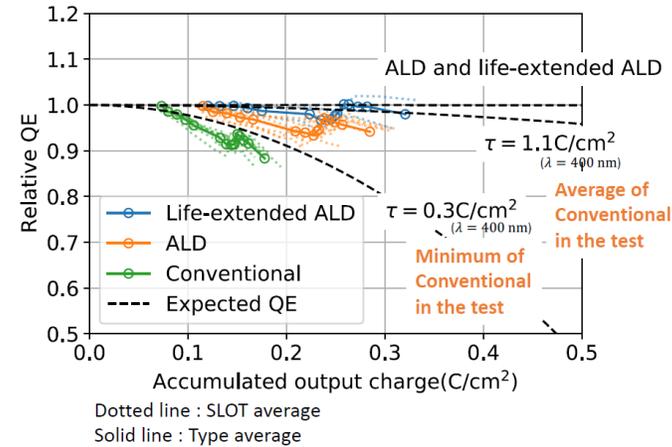


- Illuminate light on photo-diode and MCP-PMT and measure the current output, then calculate QE
- Scan light position and wavelength
- Take ~22 hours for 4 PMTs

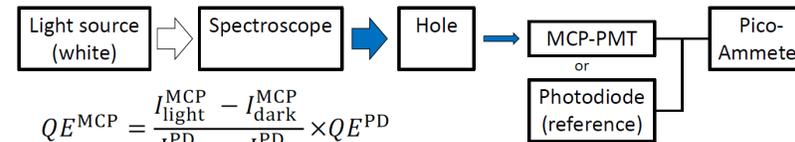


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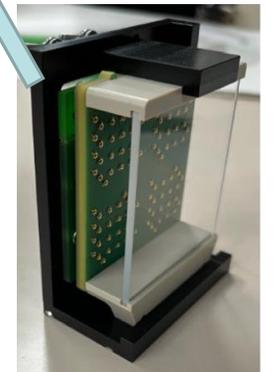
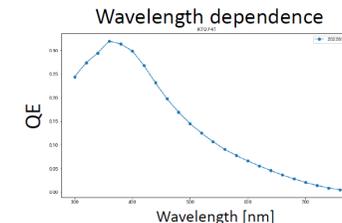
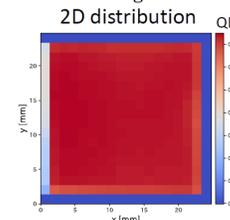
- Laboratory tests suggest that quantum efficiency will quickly drop after exceeding certain threshold of integrated charge on photo cathode
 - observed loss of QE not fully understood
- Ongoing: Dismounting of slot16 PMTs
 - open CDC and TOP window
 - dismount boardstacks, HV modules and PMTs
 - confirm QE on test bench at Nagoya
- In 2023 will replace the PMTs and electronics in 14 slots
 - 6~8 weeks for TOP PMT module replacement for 14 slots



- Illuminate light on photo-diode and MCP-PMT and measure the current output, then calculate QE
- Scan light position and wavelength
- Take ~22 hours for 4 PMTs



$$QE^{MCP} = \frac{I_{light}^{MCP} - I_{dark}^{MCP}}{I_{light}^{PD} - I_{dark}^{PD}} \times QE^{PD}$$



Conclusions

- Despite many challenges, the first years of operation of SuperKEKB / Belle II were very successful
- The machine group achieved world record specific luminosity of $4.65 \times 10^{34} \text{cm}^{-2} \text{s}^{-1}$ ($\beta_y^* = 1 \text{mm}$)
- The next big milestone after LS1 is to reach $10^{35} \text{cm}^{-2} \text{s}^{-1}$
- Belle II collected 427fb^{-1} , which is roughly the entire BaBar data size
- With this data, many results have already been obtained in a wide variety of physics areas, some of which are world best
- Several issues have been identified that will be addressed by SuperKEKB team and Belle II in the ongoing LS1