The Belle II Upgrade Program

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Belle II Collaboration

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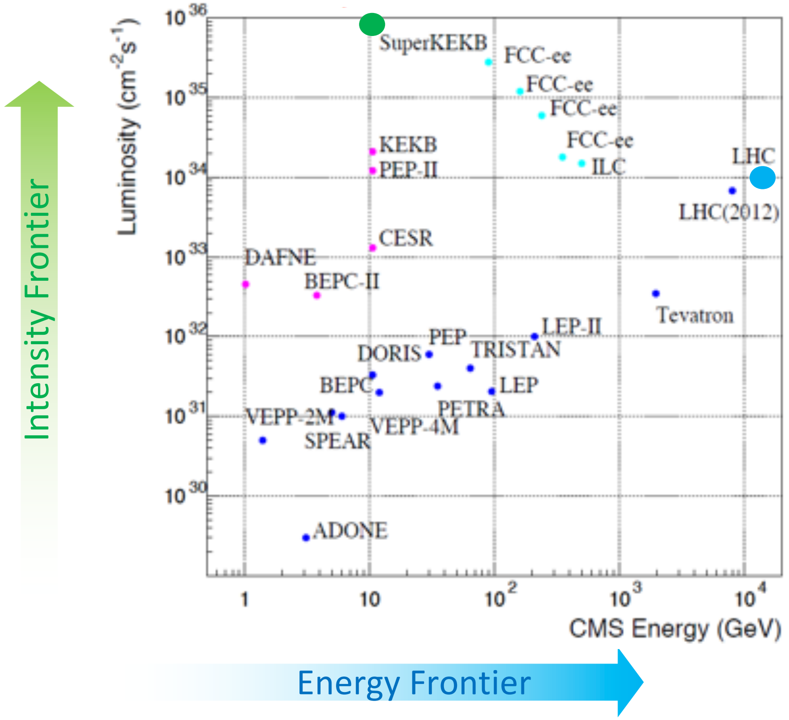
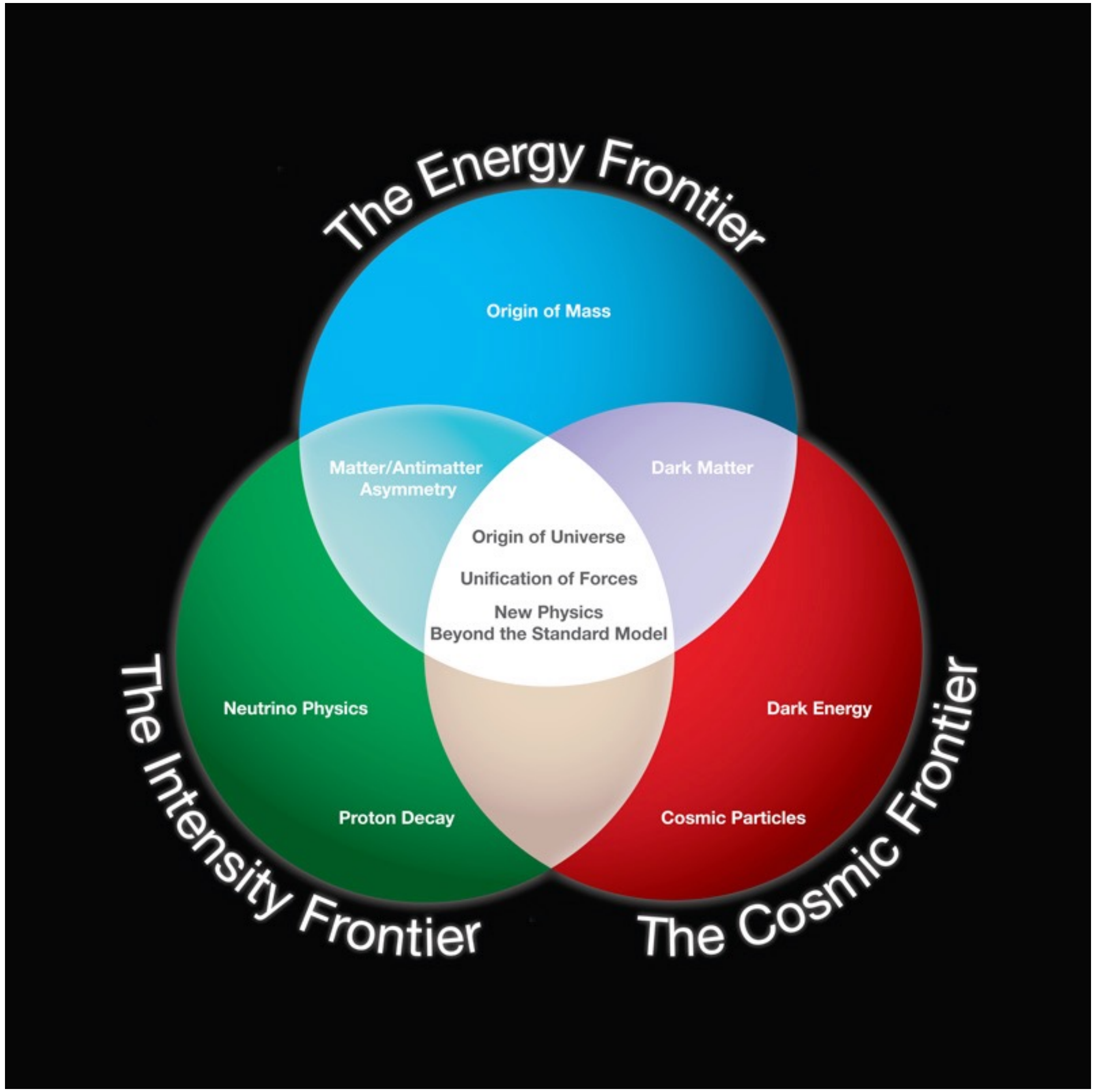
The Three Frontiers



- The **Intensity Frontier**: Search for rare new phenomena using *medium-energy high-luminosity* machines

Belle II

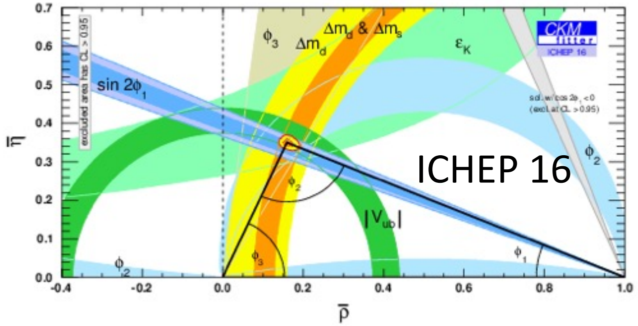


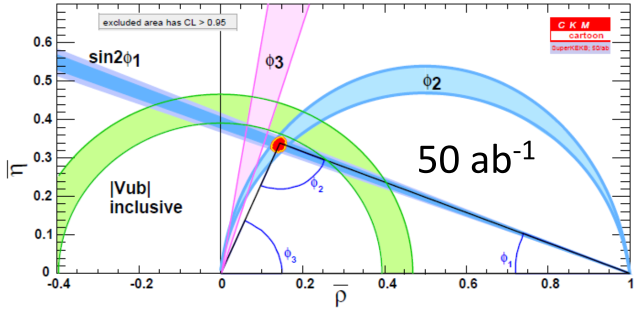
Super Flavor Factory

- Search for physics phenomena beyond SM in B, D and τ decays through precision measurements of the CKM sector and studies of rare or forbidden processes
- Many potential NP sources:
  - Flavor changing neutral currents
  - Lepton flavor violating decays
  - B → τ tree level new physics
  - New sources of CPV

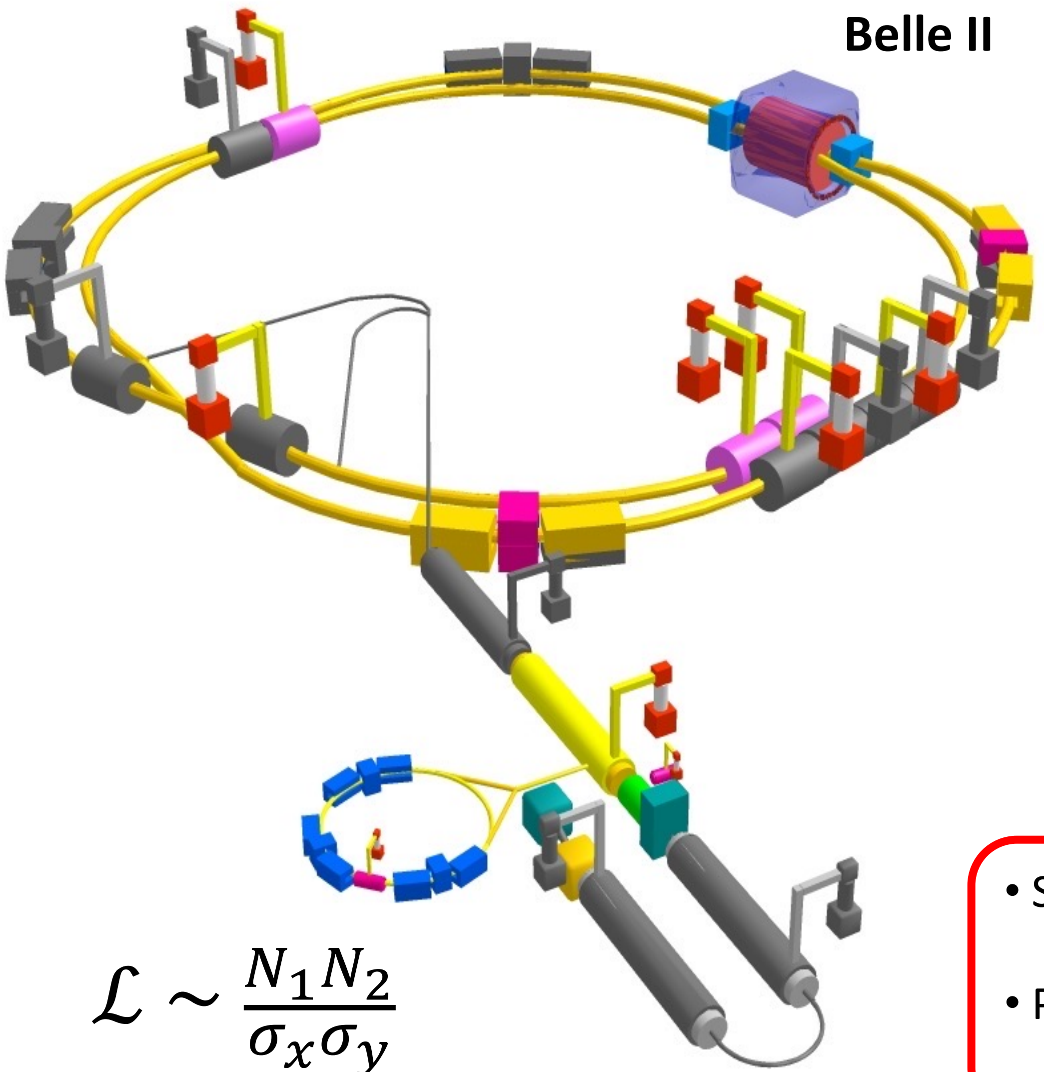
1. High luminosity accelerator
   SuperKEKB
2. High-resolution and large-coverage detector
   Belle II

Observable	SM theory	Current measurement (early 2013)	Belle II * (50 ab^{-1})
$S(B \to \phi K^0)$	0.68	0.56 ± 0.17	± 0.018
$S(B \to \eta' K^0)$	0.68	0.59 ± 0.07	± 0.011
α from $B \to \pi\pi, \rho\rho$		$\pm 5.4°$	$\pm 1°$
γ from $B \to DK$		$\pm 11°$	$\pm 1.5°$
$S(B \to K_S \pi^0 \gamma)$	< 0.05	-0.15 ± 0.20	± 0.035
$S(B \to \rho\gamma)$	< 0.05	-0.83 ± 0.65	± 0.07
$A_{CP}(B \to X_{s+d}\gamma)$	< 0.005	0.06 ± 0.06	± 0.005
A_{SL}^d	-5×10^{-4}	-0.0049 ± 0.0038	± 0.001
$\mathcal{B}(B \to \tau\nu)$	1.1×10^{-4}	$(1.64 \pm 0.34) \times 10^{-4}$	$\pm 3\%$
$\mathcal{B}(B \to \mu\nu)$	4.7×10^{-7}	$< 1.0 \times 10^{-6}$	$\gg 5\sigma$
$\mathcal{B}(B \to X_s\gamma)$	3.15×10^{-4}	$(3.55 \pm 0.26) \times 10^{-4}$	$\pm 6\%$
$\mathcal{B}(B \to K^{(*)}\nu\bar{\nu})$	3.6×10^{-6}	$< 1.3 \times 10^{-5}$	$\pm 30\%$
$\mathcal{B}(B \to X_s \ell^+\ell^-)$ $(1 < q^2 < 6\,\mathrm{GeV}^2)$	1.6×10^{-6}	$(4.5 \pm 1.0) \times 10^{-6}$	$\pm 0.10 \times 10^{-6}$
$A_{FB}(B^0 \to K^{*0}\ell^+\ell^-)$ zero crossing	7%	18%	5%
$\lvert V_{ub} \rvert$ from $B \to \pi\ell^+\nu$ $(q^2 > 16\,\mathrm{GeV}^2)$	9% → 2%	11%	2.1%





SuperKEKB



$$\mathcal{L} \sim \frac{N_1 N_2}{\sigma_x \sigma_y}$$

- SuperKEKB: Asymmetric energy e^+e^- collider
  $E_{cm} = m(\Upsilon(4S)) = 10.58$ GeV
- Peak luminosity: $\mathcal{L} = 6 \cdot 10^{35}$ cm^{-2} s^{-1} (x30 than KEKB)
  Beam size reduction. Higher current (x2 higher).

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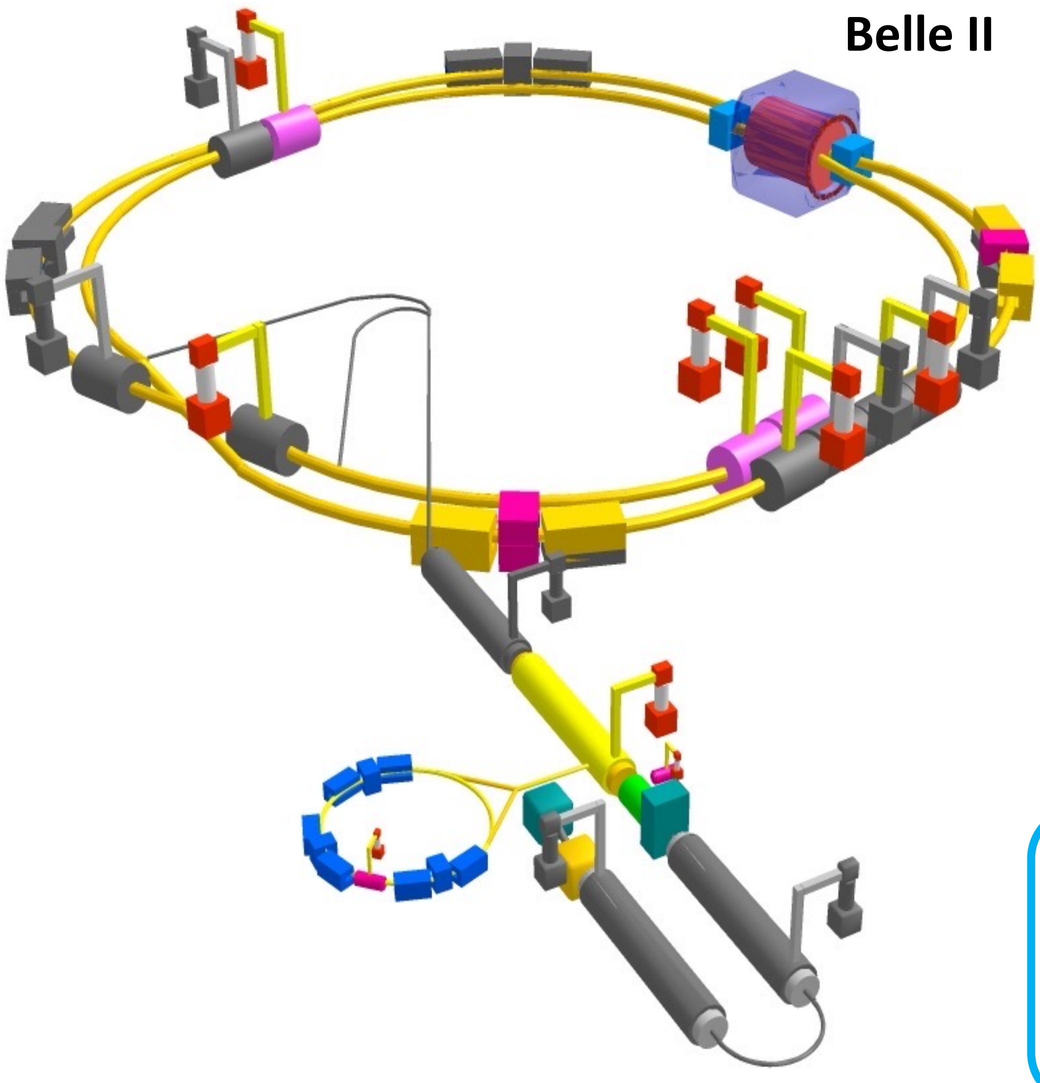
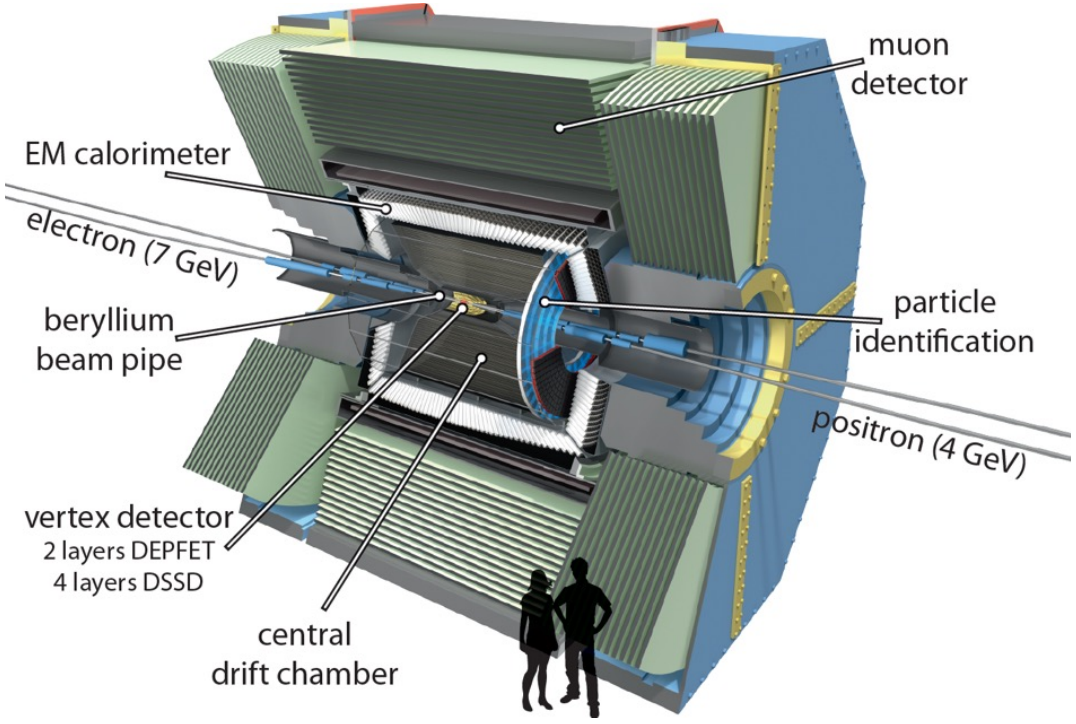
SuperKEKB and the Belle II Experiment

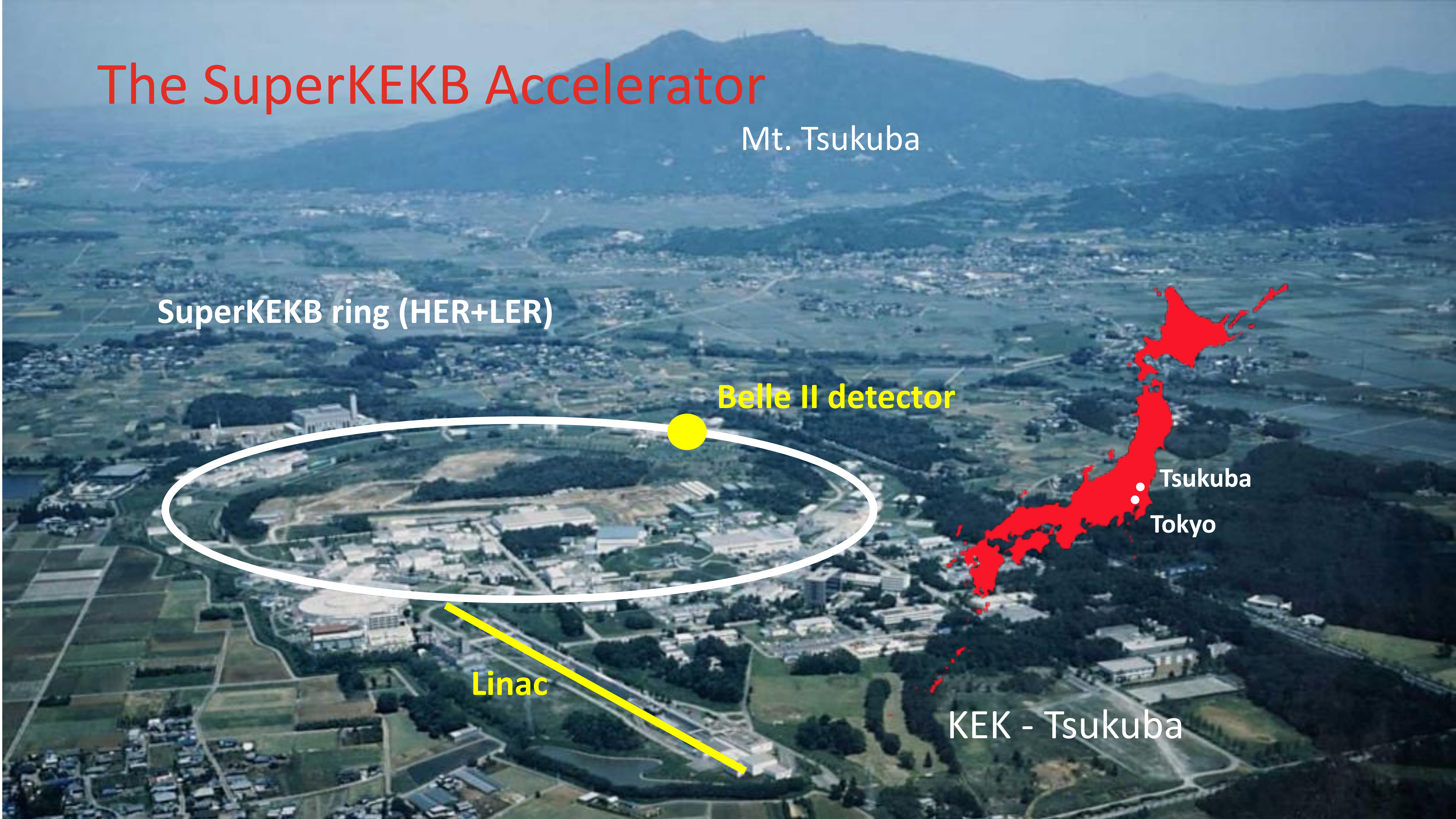




Belle II is a significant upgrade of Belle

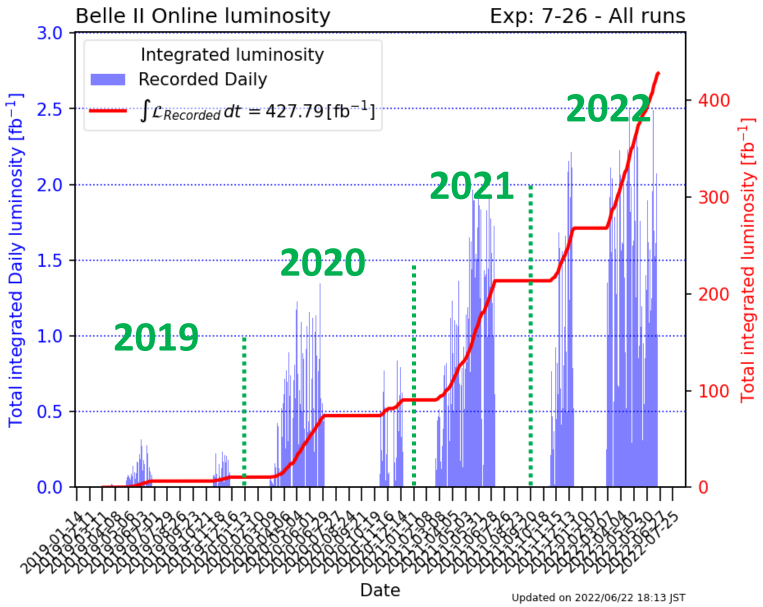
- Improved vertexing, tracking and PID
- Better background insensitivity
- Higher event rate

The SuperKEKB Accelerator



The SuperKEKB – Belle II Roadmap

- Phase 1 (2016): No detector, no collision. Machine startup and baking
- Phase 2 (2018): Pilot run. First collisions with complete accelerator
  Only partial vertex detector and background monitors (BEAST)
- Phase 3 (2019): Physics runs with complete detector
  Run 1 (2019 - 2022): Only partial PXD → 1st Physics paper in 2020
  Run 2 (2024 -): Full detector



Achievements:

- L_{peak} = 4.7x10^{34} cm^{-2}s^{-1} (x2 KEKB)
- $L_{integrated}$ = 430 fb^{-1} (~BaBar)
- Data taking efficiency >90%

- Path identified to reach 2x10^{35} cm^{-2}s^{-1}

- Ultimate goal: 50 ab^{-1} by operating at 6x10^{35} cm^{-2}s^{-1}

Advanced Technologies in Belle II

- Pixelated photosensors
  MCP-PMTs in imaging time-of-propagation detector (TOP)
  HAPDs in aerogel ring-imaging Cherenkov detector (ARICH)
  MPPCs (aka SiPMs) in KL-muon detector (KLM)

- Semiconductor technologies
  DEPFET in the pixel detector (PXD)

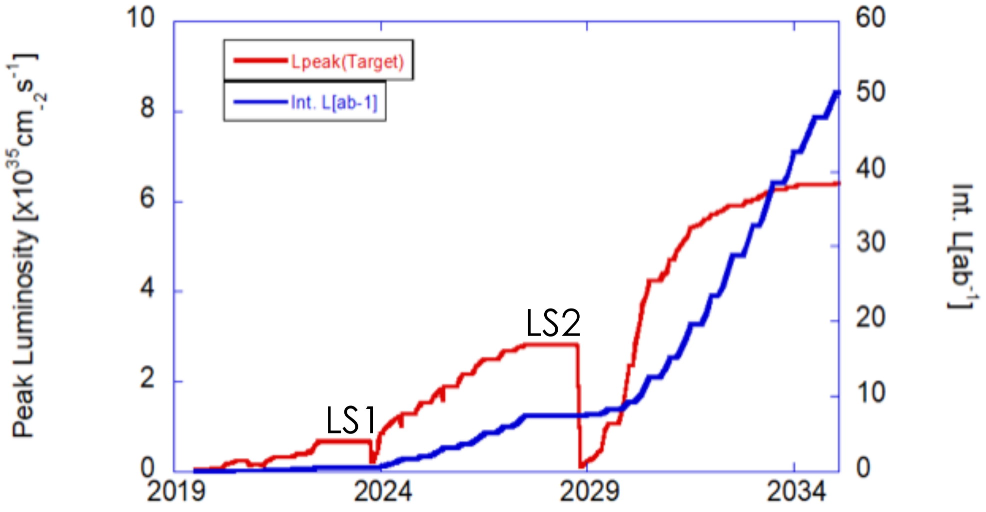
- Custom front-end ASICs for waveform sampling with precise timing
  APV25 (adapted from CMS) in silicon-strip vertex detector (SVD)
  DCD, DHP, Switcher in PXD
  TARGETX in KLM
  IRSX in TOP

- High-performance data-acquisition system
  High-throughput network switches to aggregate event data
  Large computer farm for high-level software trigger

→ Plan to keep pushing for advanced R&D in collaboration with industry

Belle II Upgrade Program

SuperKEKB **peak** & **integrated** luminosity vs time



LS1 (2022): Actual detector consolidation
LS2 (2027): IR and detector upgrades

→ Currently: CDR preparation

Path to the future:

1) Improve machine performance and stability
Beam blowup, lifetime, injection power, beam losses

2) Reduce detector backgrounds
Single beam, injection and luminosity backgrounds

3) LS1 Detector consolidation toward $2x10^{35}$ $cm^{-2}s^{-1}$
Installation of more robust components

4) LS2 Detector upgrade toward $6x10^{35}$ $cm^{-2}s^{-1}$
Including a redesign of the interaction region

→ More performant detector and robust against machine-induced backgrounds

Machine and Detector Upgrades – LS1 (2022/2023)

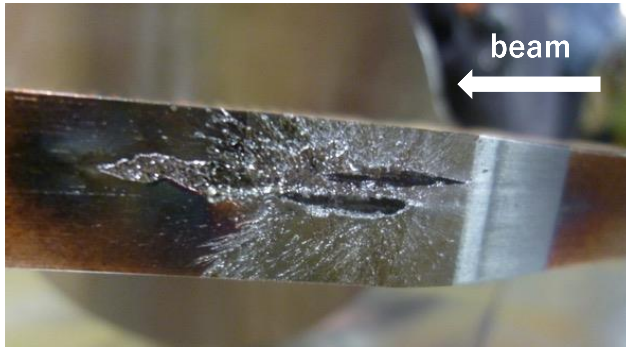
- Machine upgrades:

- Additional beam loss monitors around the ring

- New more resilient collimators

- Neutron background shielding

- RF cavity replacement, faster kicker magnets at injector



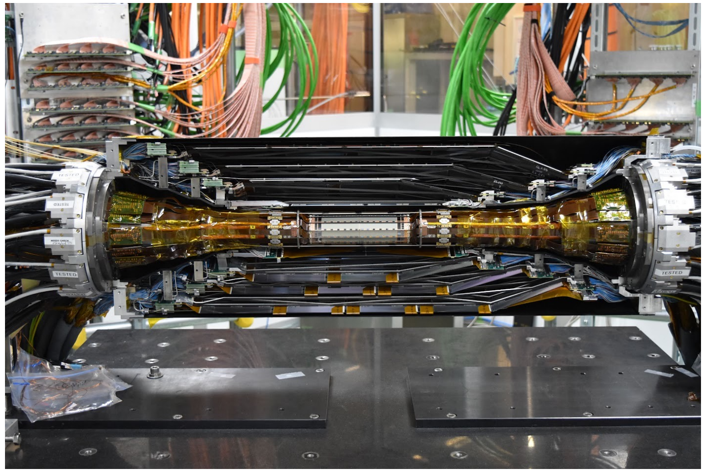
- Detector upgrades:

- Installation of complete pixel detector

- Replacement of TOP’s photomultipliers

- Improved CDC gas distribution and monitoring

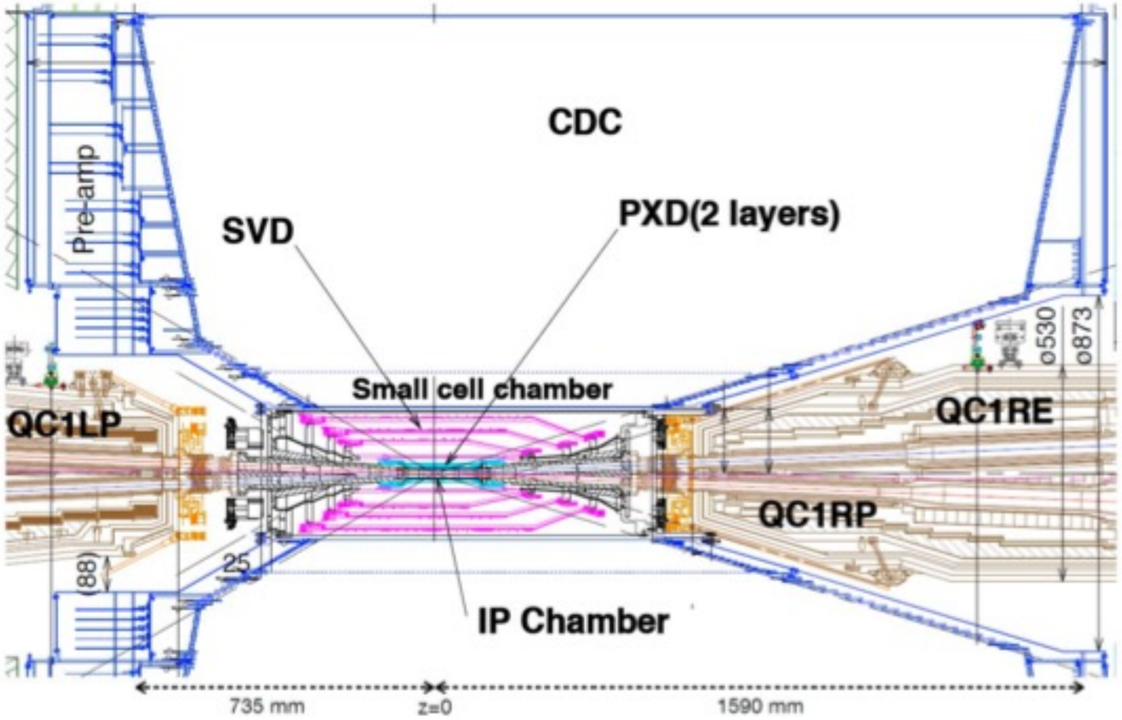
- DAQ system upgrade PCIe40



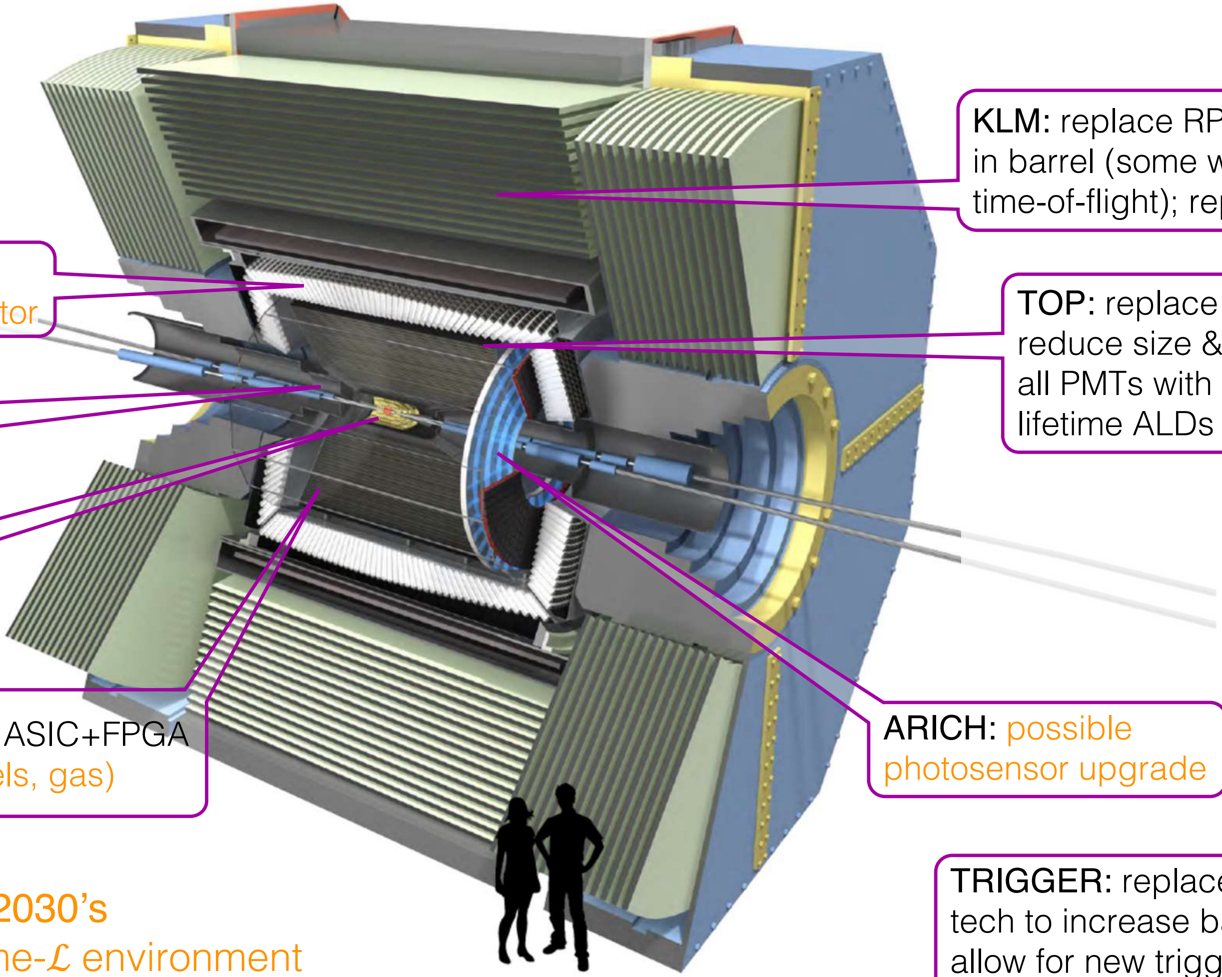
SuperKEKB Upgrades – LS2

Goal: Higher L with lower β^* and higher currents

- Limit beam-beam effects, preserve beam lifetime
- Reposition final-focus (QC) magnets closer to IP
- New design for final-focus magnets
- Additional compensating solenoid inside QC magnets
- Feasibility studies ongoing



Belle II Upgrades – LS2 and Beyond



KLM: replace RPCs with scintillators in barrel (some with fast timing for K_L time-of-flight); replace readout

ECL: replace crystals with pure CsI; APD readout; add pre-shower detector

TOP: replace readout to reduce size & power; replace all PMTs with extended-lifetime ALDs (or SiPMs?)

IR: accommodate QCS replacement and repositioning

VXD: all pixels DMAPS

CDC: replace r/o ASIC+FPGA
New tracker (pixels, gas)

ARICH: possible photosensor upgrade

TRIGGER: replace with latest tech to increase bandwidth, allow for new trigger primitives

More distant future: ~mid-2030's
✓ Detector R&D for extreme-$\mathcal{L}$ environment

Requirements for VXD Upgrade in LS2

Upgrade motivation:

- Cope with larger background activity
- Improve momentum and impact parameter resolution in low p_T region
- Simplify tracking chain with all layers involved
- Contribution to Level 1 trigger
- Operation without data reduction

Key sensor specifications:

- Pixel pitch 30-40 µm
- Integration time $\lesssim$100 ns
- Power dissipation $\lesssim 200\ \mathrm{mW/cm^2}$

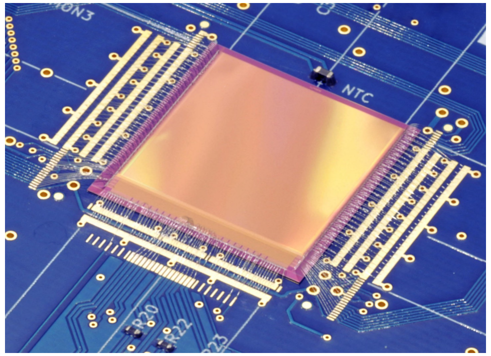
Improve physics reach per ab^{-1}

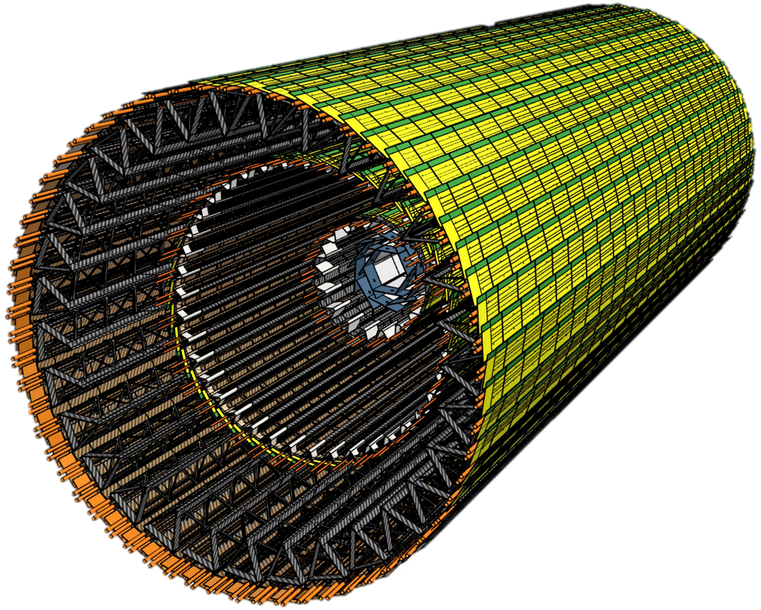
Radius range	14 – 135 mm
Tracking & Vertexing performance	
Single point resolution	< 15 µm
Material budget	0.2% X_0 / 0.7% X_0 inner- / outer- layer
Robustness against high radiation environment (innermost layer)	
Hit rate	~ 120 MHz/cm²
Total ionizing dose	~ 10 Mrad/year
NIEL fluence	~ 5e13 n_{eq}/cm²/year

Vertexing: All-layer DMAPS Pixel Detector (VTX)

Target: Belle II LS2 Upgrade

- 5 straight layers barrel, using CMOS pixel sensors
- Low material : 0.1% X_0 (L1+L2) - 0.4% (L3) - 0.8% X_0 (L4+L5)
- Moderate pixel pitch ~ 30 μm^2
- Fast integration time 50-100 ns
- iVTX: innermost 2 layers, self-supported, air cooled
- oVTX: 3 outer layers, CF structure, water cooled
- Overall service reduction and operation simplification





Tracking: CDC Front-End Electronics

Better tracking performance

- Reduce cross-talk, power consumption and increase output bandwidth
- Improve radiation tolerance

Achieved with new ASICs, new FPGA, optical modules:

- ASIC chips to measure signal timing and digitize waveform

- New FPGA for online data processing for the trigger and data acquisition systems

- QSFP for data transfer to the trigger and DAQ

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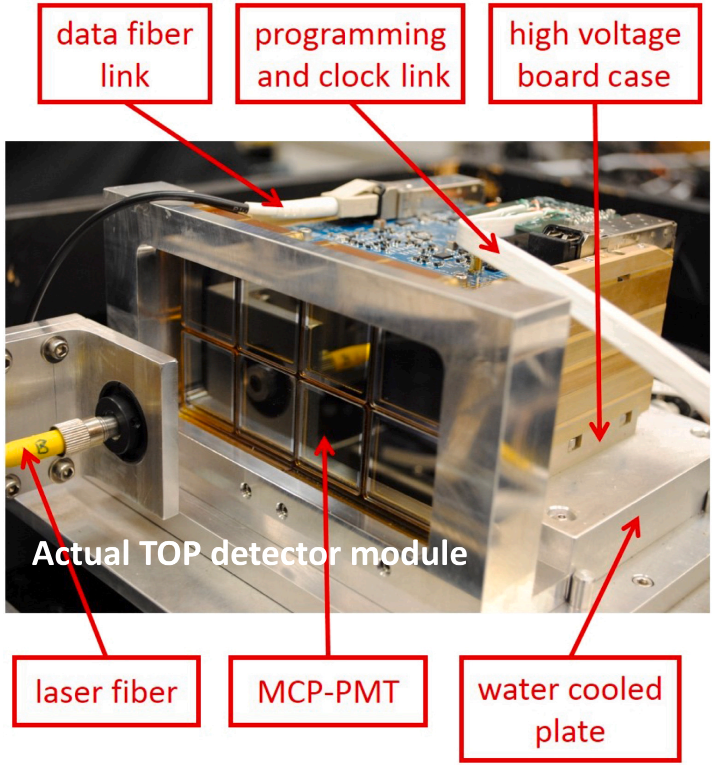
PID: Time Of Propagation Counter

- Performance improvements:

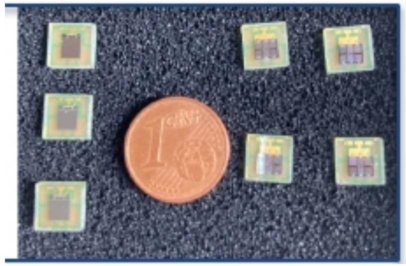
  Better particle-ID performance
  Feature extraction inside ASIC
  Reduced power consumption

- Technology implementation in LS2:

  Lifetime-extended ALD-PMTs with better radiation tolerance
  Redesign front-end boards (ASoC) with Gbps to FPGA
  Lower power budget and more compact design

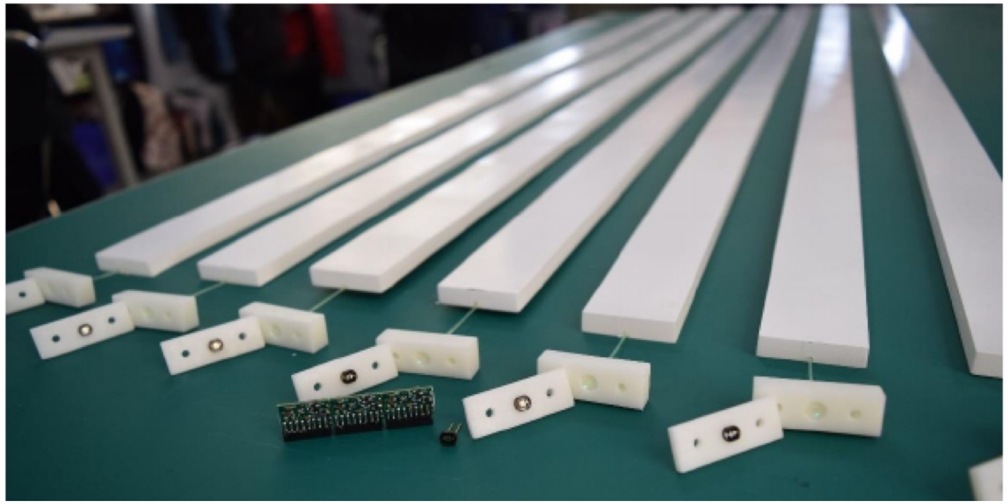


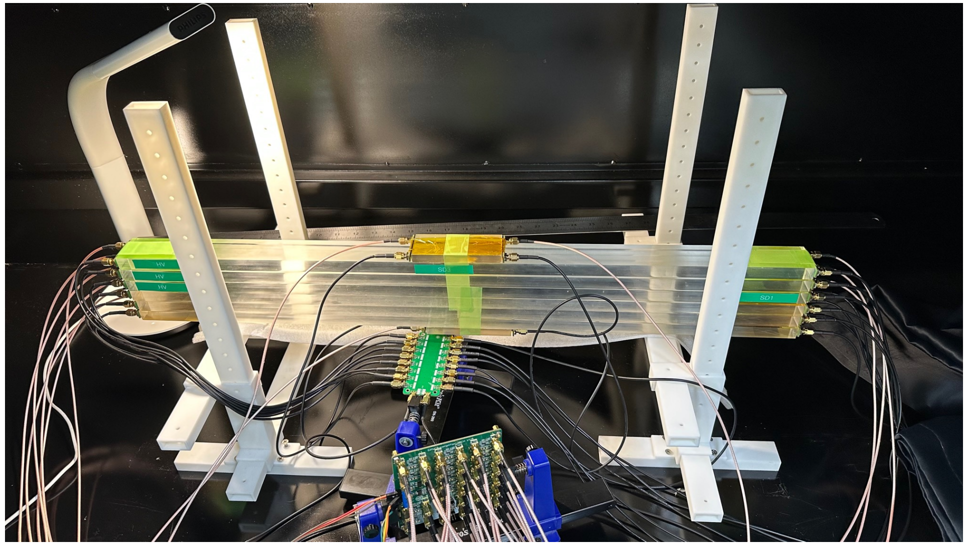
Beyond LS2: R&D for SiPM photosensors



K_L and Muon

- Replace remaining RPCs in barrel with scintillator strips
- Re-design electronics layout with feature-extraction ASIC inside panel, only digital I/O (optical)
- High-resolution timing for K_L momentum via TOF
  Solid scintillator with SiPMs





Trigger

UT generation	UT3	UT4	UT5
Main FPGA (Xilinx)	Virtex6 XC6VHX380-565	Virtex Ultrascale XCVU080-190	Varsal
Sub FPGA (Xilinx)	−−	Artex7	Artex7, Zynq
# Logic gate	500k	2000k	8000k
Optical transmission rate	8 Gbps	25 Gbps	58 Gbps
RAM	−−	DDR4	DDR4, UltraRAM
# UT boards	30	30	10
Cost per a board (k$)	15	30	50
Time schedule	2014-	2019-2026	2024-2032

- More powerful hardware UT4 and UT5 trigger boards
- Avoid merger boards, more bandwidth
  - Using all CDC TDC and ADC information → Vertex resolution improved x2 and 50% trigger rate reduction
- Keep high-efficiency on hadronic events and improve on low-multiplicity

Component	Feature	Improvement	Time	#UT
CDC cluster finder	transmit TDC and ADC from all wires with the new CDC front end	beamBG rejection	2026	10
CDC 2Dtrack finder	use full wire hit patterns inside clustered hit	increase occupancy limit	2022	4
CDC 3Dtrack finder	add stereo wires to track finding	enlarge θ angle acceptance	2022	4
CDC 3Dtrack fitter (1)	increase the number of wires for neural net training	beamBG rejection	2025	4
CDC 3Dtrack fitter (2)	improve fitting algorithm with quantum annealing method	beamBG rejection	2025	4
Displaced vertex finder	find track outside IP originated from long loved particle	LLP search	2025	1
ECL waveform fitter	improve crystal waveform fitter to get energy and timing	resolution	2026	–
ECL cluster finder	improve clustering algorithm with higher BG condition	beamBG rejection	2026	1
KLM track finder	improve track finder with 2D information of hitting layers	beamBG rejection	2024	–
VXD trigger	add VXD to TRG system with new detector and front end	BG rejection	2032	–
GRL event identification	implement neural net based event identification algorithm	signal efficiency	2025	1
GDL injection veto	improve algorithm to veto beam injection BG	DAQ efficiency	2024	–

Summary

- Belle II physics goals is steering a rich instrumental program
- The detector operates efficiently at peak luminosities just below 10^{35} $cm^{-2}s^{-1}$
- LS1 (2023): Detector consolidation for entering $L_{inst} = 10^{35}$ $cm^{-2}s^{-1}$ regime in the next years
- LS2 (2027): Introducing new technologies for running safely at $6x10^{35}$ $cm^{-2}s^{-1}$ with enhanced performance
    - More robustness against backgrounds and radiation damage
    - Better physics performance
    - Readiness for accelerator's redesign of interaction region
- Conceptual Design Report for medium-term detector upgrade ⟶ Fall 2023

The transition to a construction project is expected soon

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THANK YOU

Financiado por la Unión Europea
NextGenerationEU

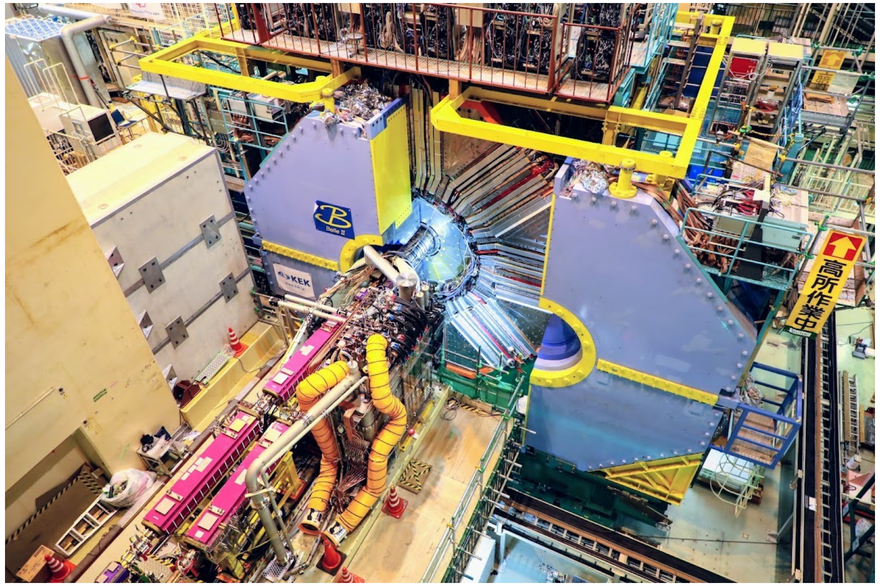
MINISTERIO
DE CIENCIA
E INNOVACIÓN

Plan de Recuperación,
Transformación
y Resiliencia

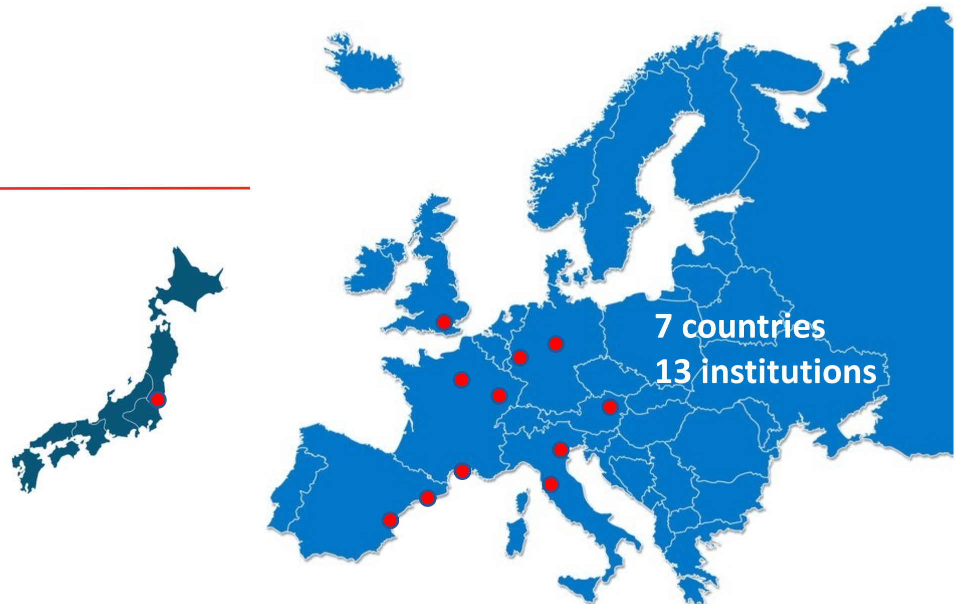
CSIC
Consejo Superior de Investigaciones Científicas

The Belle II Collaboration

- 27 countries
- 132 institutions
- 1175 members



Belle II VTX - Organization



Institutional Board

Project Leader
C. Marinas (Valencia)

WG1: Performance
B. Schwenker (Goettingen)

- Software
- Tracking
- Benchmarking

WG2: Sensor design
J. Baudot (Strasbourg)

- Analog
- Digital
- Verification
- Irradiations
- Test beam
- Lab Testing

WG3: Layer development
S. Bettarini (Pisa)

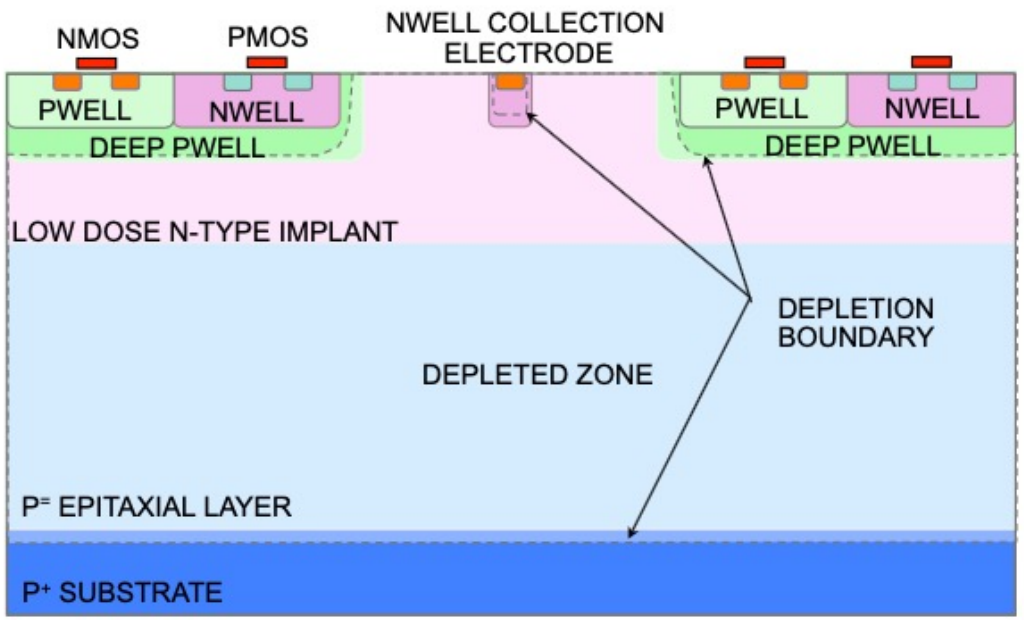
- iVTX Electrical
- oVTX Electrical
- iVTX Thermomech
- oVTX Thermomech

WG4: System integration

- Interfaces/links
- DAQ
- Power supplies
- Cooling/services
- Slow control

Small Electrode Sensor Design DMAPS

Monolithic detector: Combine sensor and readout on the same wafer



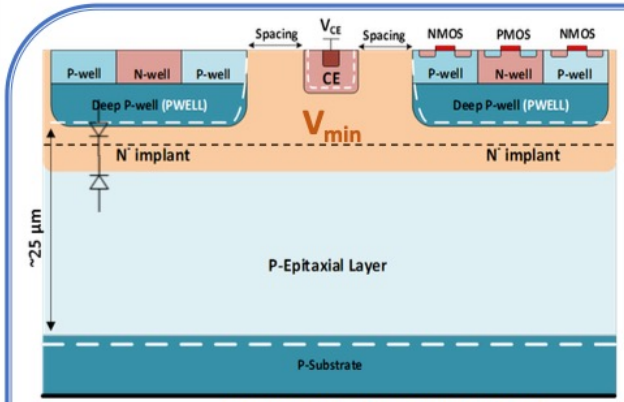
Electronics outside the collection well
Small fill factor

- Very small sensor capacitance
- Low noise and power

TowerJazz 180 nm CIS

- Deep pwell allows for full CMOS in pixel
- High resistivity epi-layer 1-8 kOhm.cm
  Epi thickness 18-40 µm
- 3 nm gate oxide for good TID
- Modified process: Additional planar n-type implant
  Full depleted volume
  Fast charge collection
- Derived from LHC developments

OBELIX: Growing the TJ-Monopix Family



W. Snoeys et al. https://doi.org/10.1016/j.nima.2017.07.046

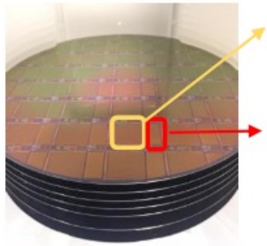
$C_d \leq 3fF$

$P \approx \frac{S}{N} \approx \frac{Q}{C_d}$

DMAPS in TJ 180 nm: Concept

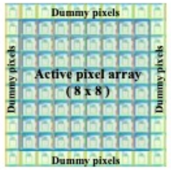
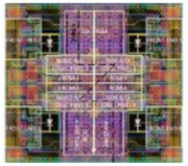
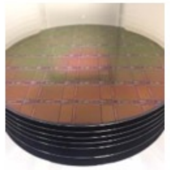
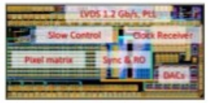
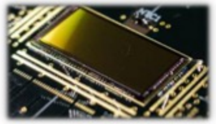
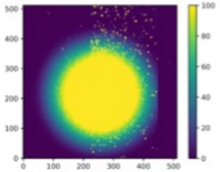
- Small sensor capacitance (Cd)
  - Key for low power/low noise
- Radiation tolerance challenges
  - Modified process
  - Small pixel size
- Design challenges
  - Compact, low power FE
  - Compact, efficient R/O

Large scale demonstrator chip development

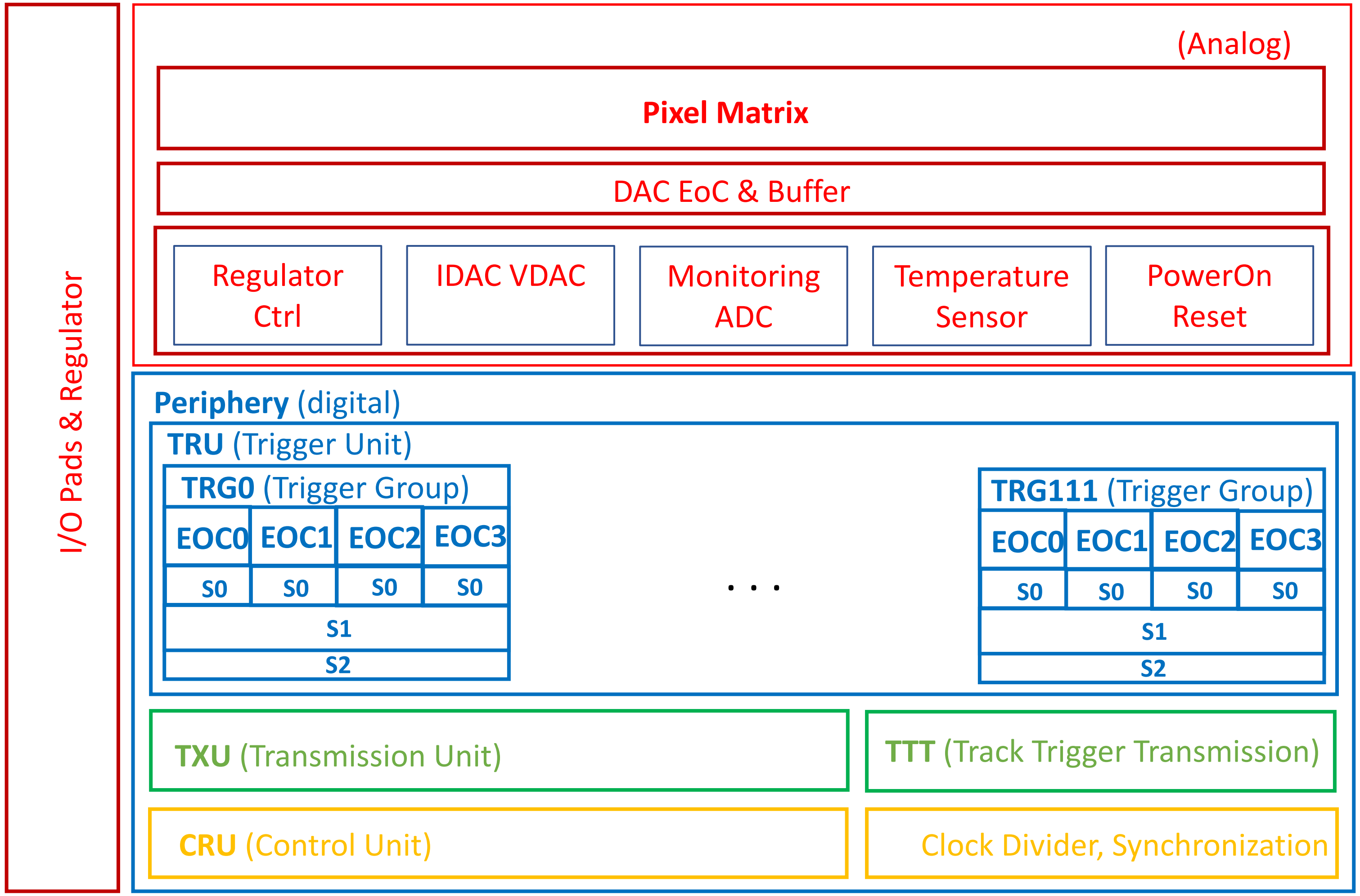


- MALTA
  - Asynchronous readout
- TJ-Monopix1
  - Synchronous column-drain R/O

- Process modification enhancements, Cz substrate ⟹ improved efficiency
- TJ-Monopix2: Improved full-scale DMAPS

TJ-Investigator characterization	*TJ-Monopix1* & MALTA Design	*TJ-Monopix1* & MALTA Submission	Mini-MALTA sub. with process fixes	*TJ-Monopix1* resub. process fixes & Cz	*TJ-Monopix2* & *MALTA2* Design	*TJ-Monopix2* & MALTA2 Submission	*TJ-Monopix2* Characterization	*"OBELIX"* Design
								Full scale System-ready: LDO, CDR, memory etc.
Q2 2016	Q4/2016	Q3/2017	Q3/2018	Q2/2019	Q2/2019	Q3/2020	Present	Future plans

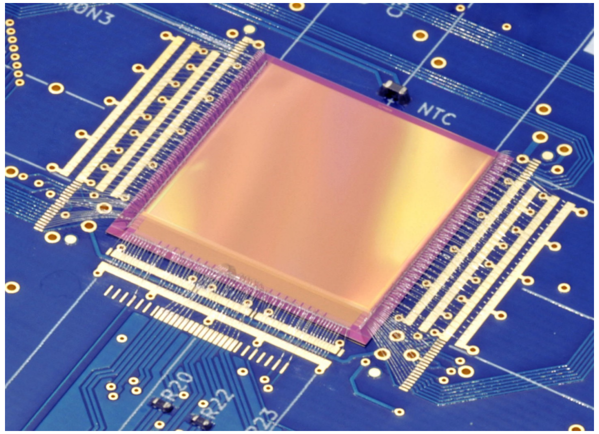
OBELIX – Design

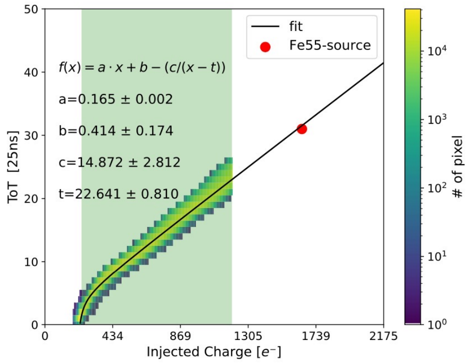


- Pixel matrix
  - Extension from TJ-Monopix2
    - Radiation tolerance granted
  - Pitch kept at 33 µm
  - Operation point (I_{bias}) tuning on-going
  - Frequency ~10-20 MHz
    - Time-stamp precision 100 - 50 ns
- Power pads
  - Power regulators
    - Simplified system integration
  - But area limited to <150 µm
- Periphery
  - New end-of-column + trigger logic adapted to Belle II trigger
  - HitOR fast transmission (20 ns)
  - Control using RD53 protocol

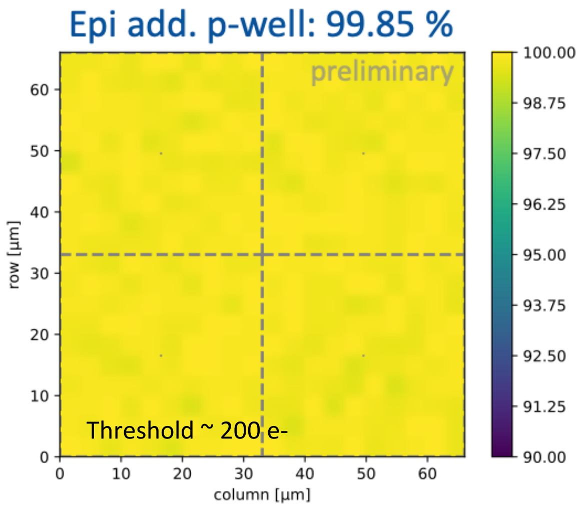
TJ-Monopix2 Characterization

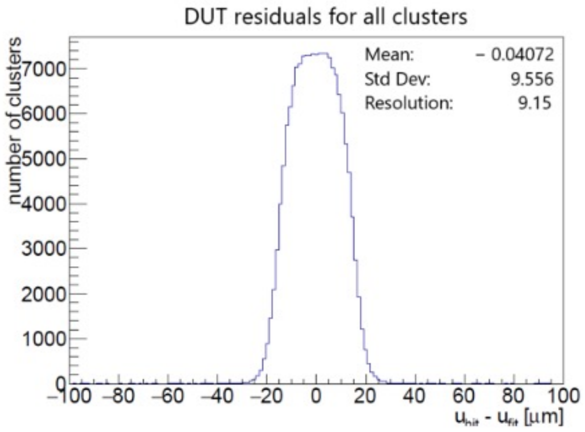
- TJ-Monopix2 as forerunner of OBELIX
  - 33x33 µm^2 pitch, 25 ns integration, 2x2 cm^2 matrix
  - 7 bit ToT information, 3 bit in-pixel threshold tuning
  - Various sensing volume thickness (CZ-bulk, epi-30 µm)





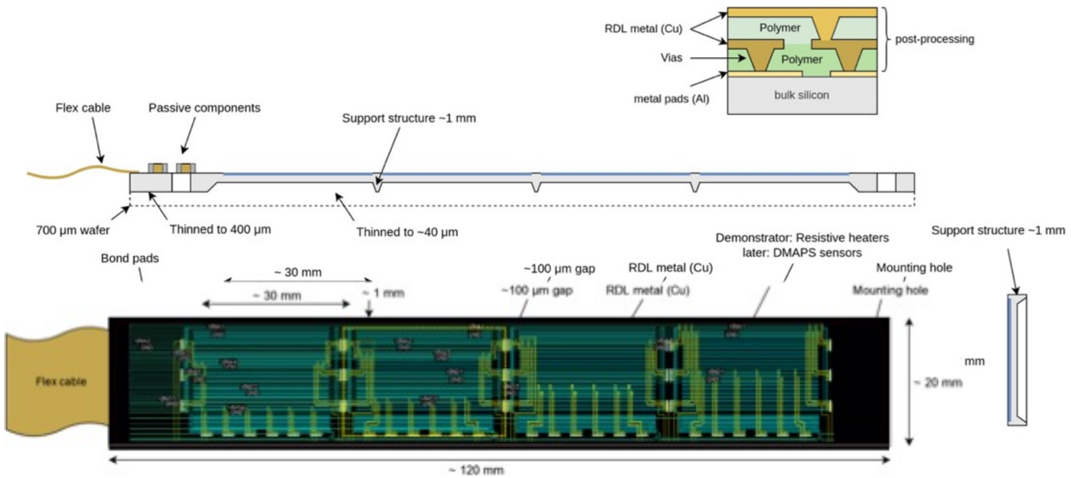
- Characterisation on-going
  - In-laboratory
    - Threshold / noise
    - ToT calibration
  - In-beam (DESY, 5 GeV electrons)
    - Efficiency ~99%
    - Position resolution ~9 µm





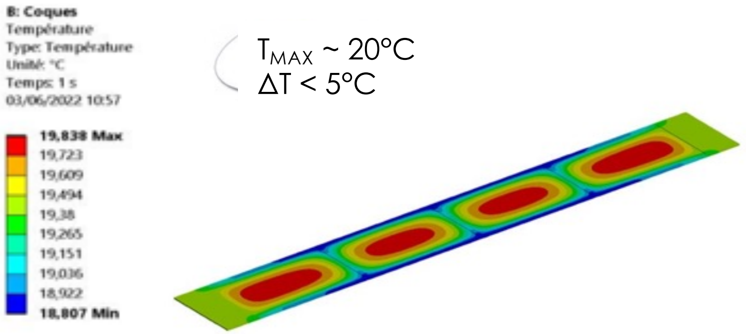
iVTX Inner Layer Concept

- All-silicon module < 0.15 % X_0
  - 4 contiguous sensors diced as a block from the wafer
  - Redistribution layer for interconnection
  - Heterogeneous thinning for thinness & stiffness



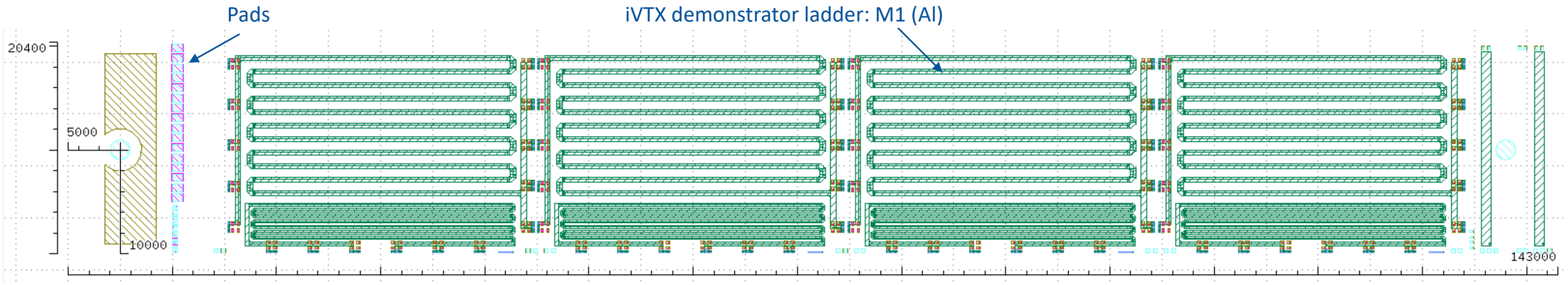
- Prototyping
  - With existing 10 cm^2 HV-CMOS ladder
    - Planarity demonstration
  - On-going at IZM-Berlin with dummy Si
    - True iVTX geometry → Summer 2023

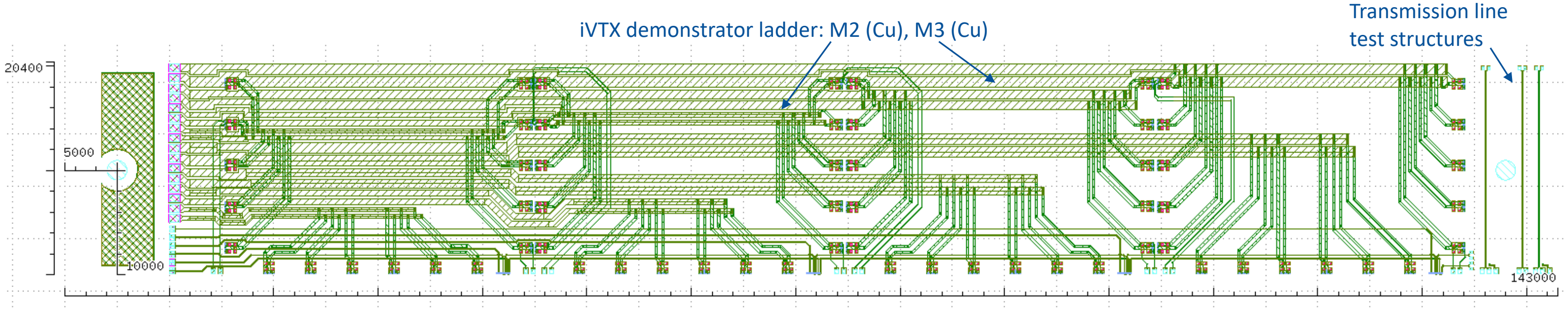
- Simulation on cooling
  - Dry air cooling 15°C
  - Assume 200 mW/cm^2



T_{MAX} ~ 20°C
ΔT < 5°C

iVTX Ladder Demonstrator





Metal system:

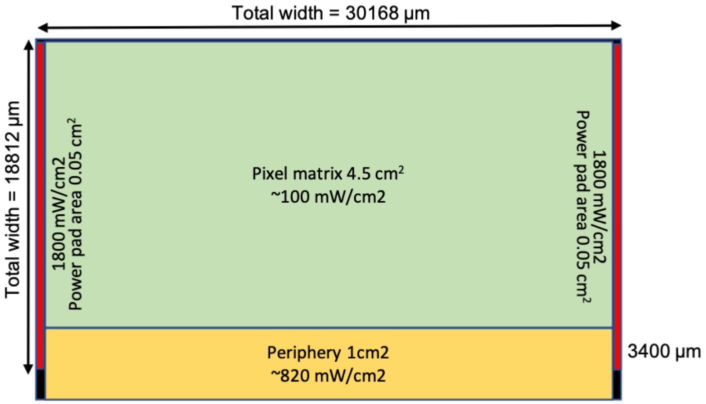
- Resistive heaters: 1.5 um Al (M1)
- 2 RDL metal layers: 3 um Cu (M2, M3)
- Top metal finish: NiAu (M4)
  Wirebonding, SMD soldering

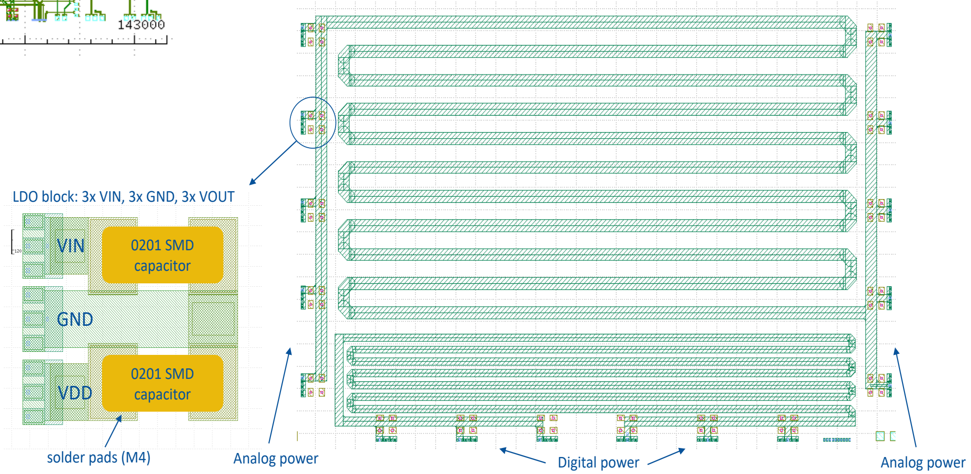
Final ladder dimension: 143 x 20.4 mm^2

Dummy heaters: 30 x 20 mm^2

Prepared for 1.7 mm mounting hole

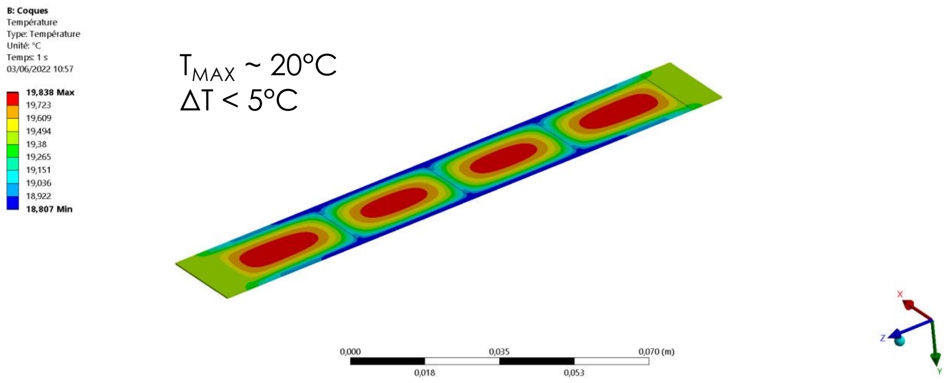
Characterization electrical, mechanical and thermal performances of iVTX ladders

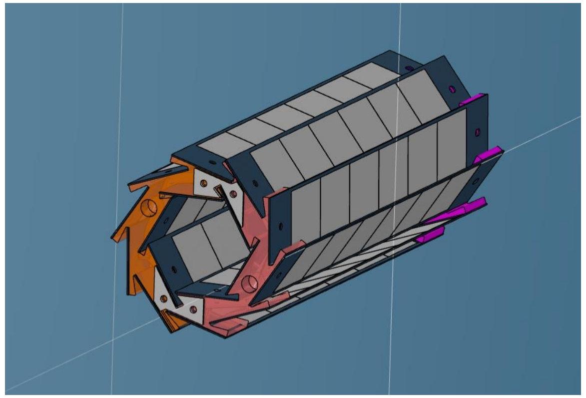




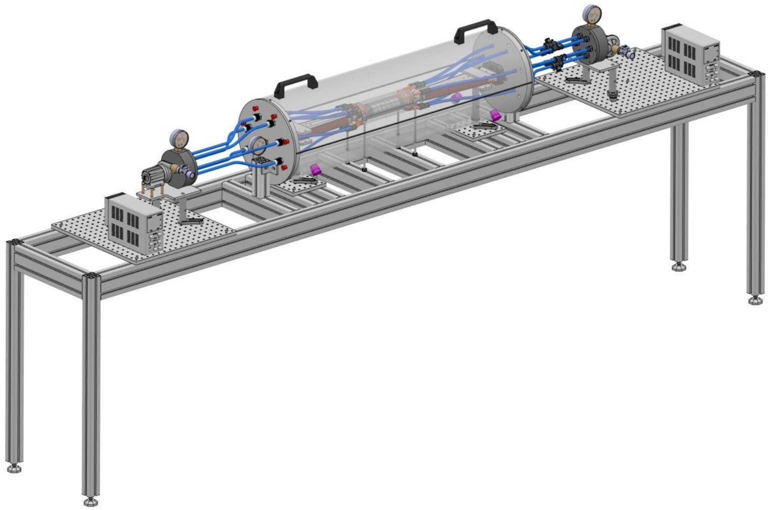
iVTX Cooling

Air cooling (10 m/s, 20 degC) seem feasible, but 9 mm tube seems necessary (3 l/s)





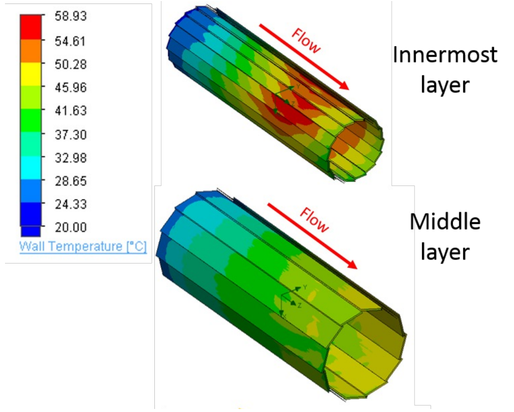
First conceptual air injector support



So far, standing single ladders with uniform power consumption.

More realism to be added on the FEM…

→ Experience from CLIC wind tunnel:



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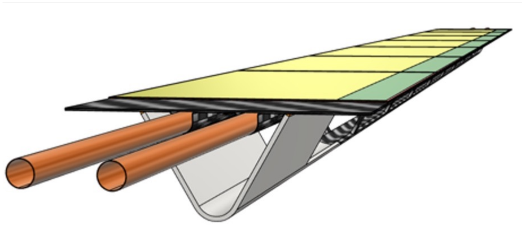
oVTX Outer Layer Concept

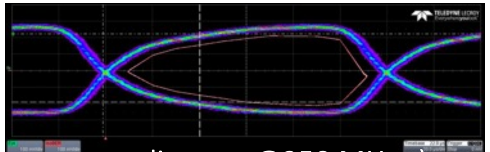
- Long ladders
  - Evolving from ALICE-ITS2
    - Carbon-fiber truss support frame
    - Cold-plate with water coolant
    - Long-flex for power & data



- L3-4, radius 4-9 cm, length < 50 cm
  - Single sensor row, ~0.5 % X_0
- L5, radius 14 cm, length 70 cm
  - Double sensor rows , ~0.8 % X_0

- Prototypes for L5 under test

  - Deformation & vibration
    - Max sagitta ~500 µm
    - First resonance f=250 Hz
  - Signal propagation



eye diagram @250 MHz s)

  - Cooling at T_{room} ~24°C
    - Leakless water flow at T_{in} = 10°C
    - Heaters dissipating 200 mW/cm^2
    - 22°C < $T_{sensors}$ < 26°C

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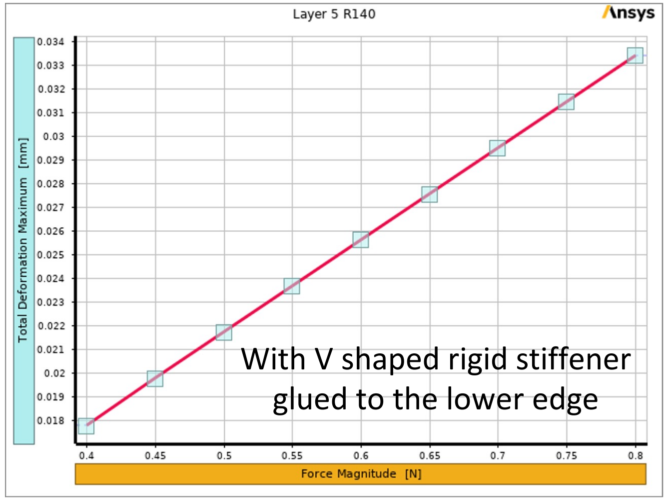
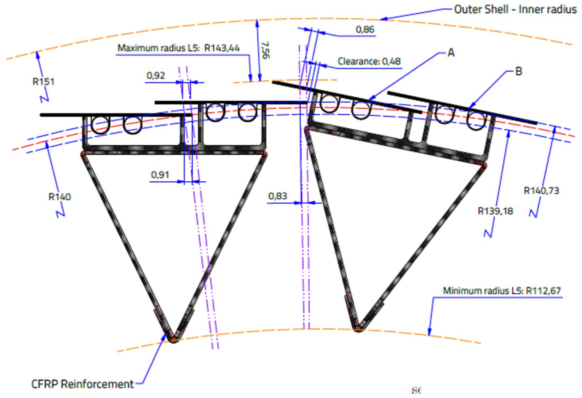
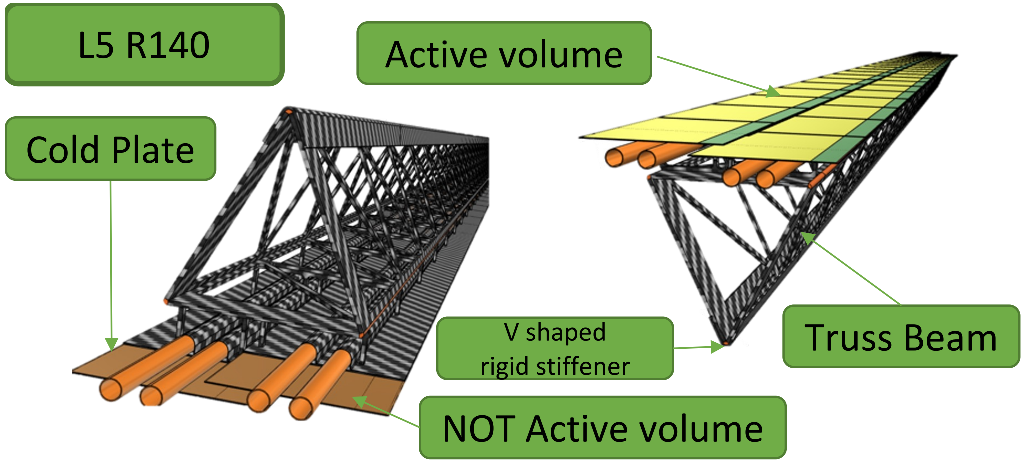
oVTX Stave Integration



Realistic CAD model, including overlap studies





Studying mechanical properties with realistic models:

Tolerable max. deflection of the structure (40 μm)

Ladder concept compatible with X/X_0 expectations (0.4-0.8%)

Layer 3 R69 Radiation length summary 2 flex from FW and BW side (6 + 6 chips) - 12 chips

COMPONENT	*X/X0 (%)*
Support Structure	0,087%
Cold Plate	0,064%
Pipes & Coolant	0,048%
Glue	0,022%
Flex (FW + BW)	0,150%
Chips	0,066%
Grand Total	0,438%

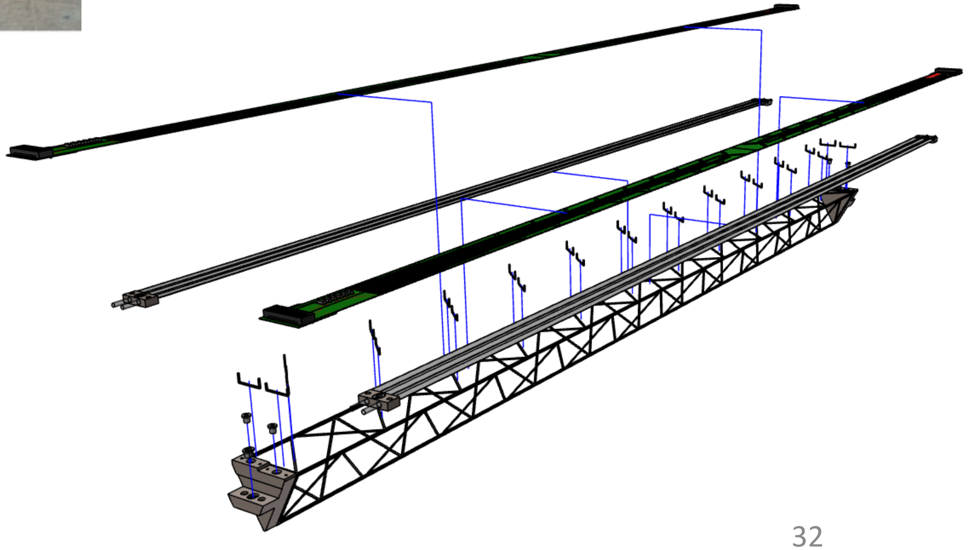
Layer 4 R89 Radiation length summary 2 flex FW and BW side (8 + 8 chips) - 16 chips

COMPONENT	*X/X0 (%)*
Support Structure	0,086%
Cold Plate	0,069%
Pipes & Coolant	0,048%
Glue	0,021%
Flex FW + BW	0,161%
Chips	0,067%
Grand Total	0,454%

Layer 5 R140 Radiation length summary 2 flex FW and BW side (12 + 12 chips) - 24 chips

COMPONENT	*X/X0 (%)*
Support Structure	0,169%
Cold Plate	0,093%
Pipes & Coolant	0,153%
Glue	0,127%
Flex FW + BW	0,186%
Chips	0,069%
Grand Total	0,796%

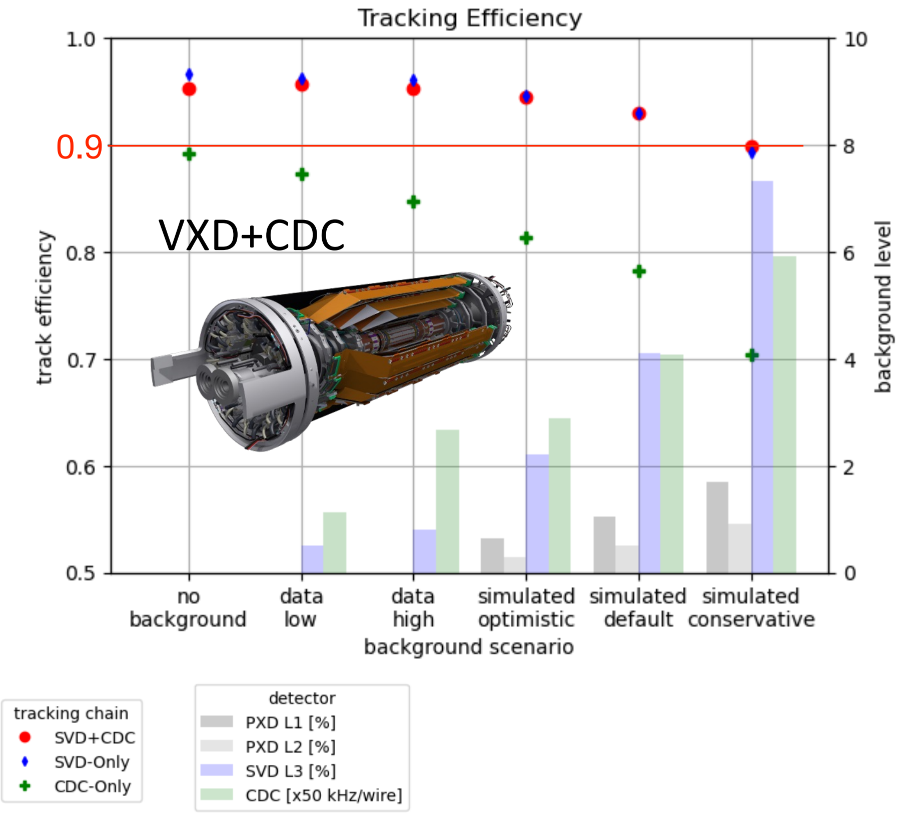
oVTX Stave Demonstrator



Completing a fully equipped L5 ladder (mechanical structure + cold plate + flex)

Assembly procedure well defined

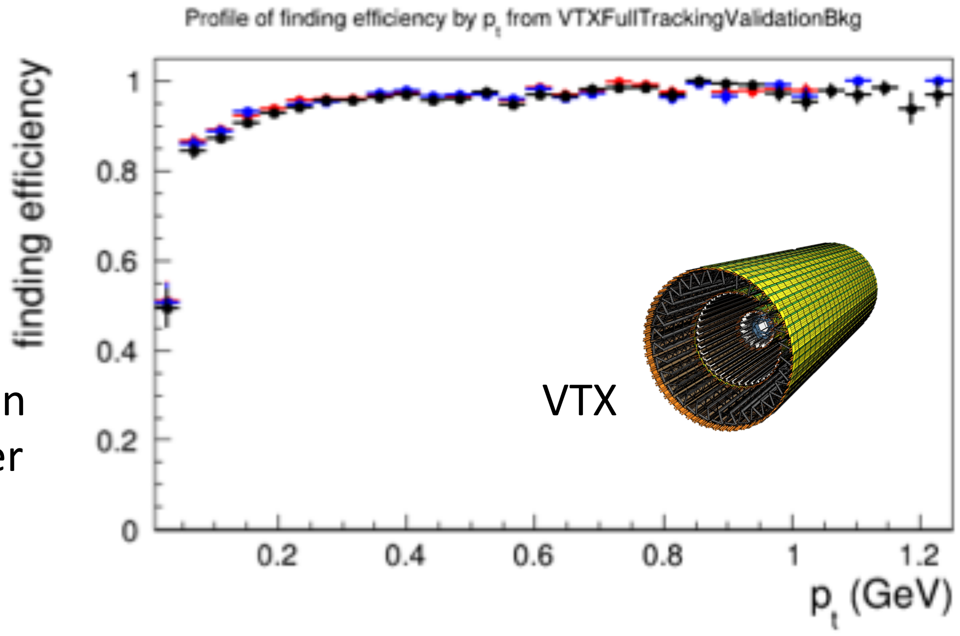
Tracking Efficiency under High Backgrounds



Tracking efficiency reaching 90% with current configuration with:

SVD at 7% occupancy
CDC at 300 kHz/wire hit rate

With new VTX: All-silicon tracking with x200 lower occupancy

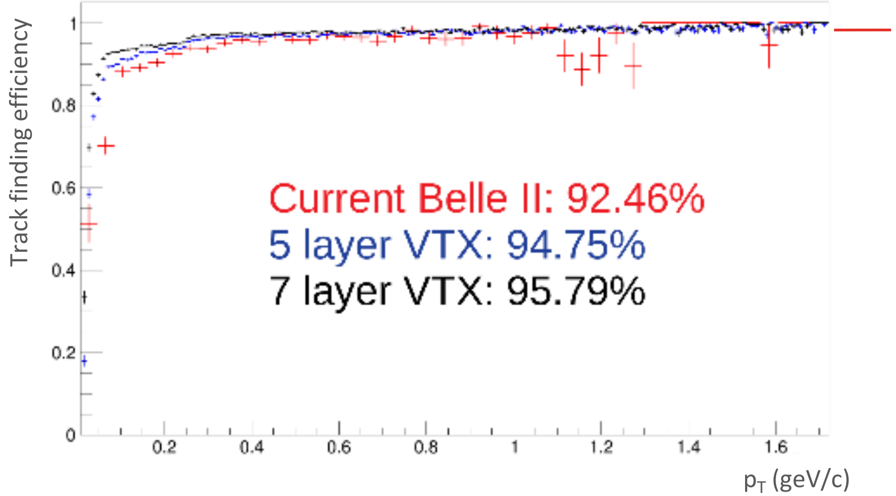


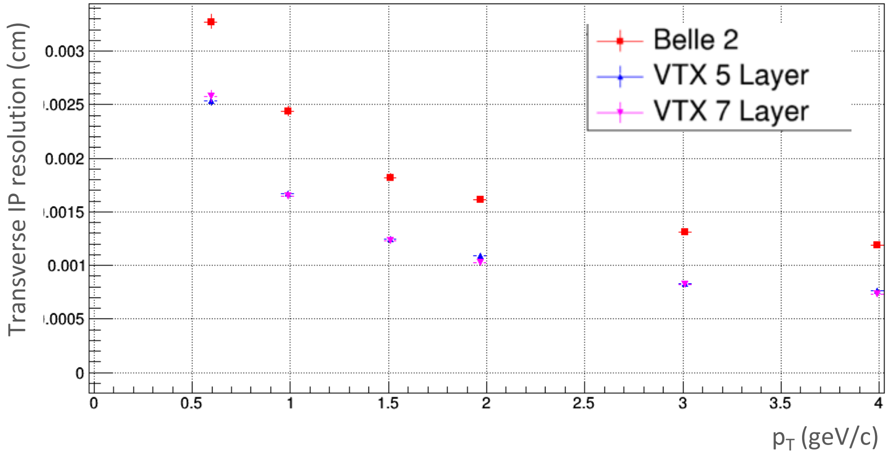
→ VTX will take over CDC tracking at large background conditions

Performance Studies

- Full simulation in Belle II analysis software
  - 5 layer geometry implemented
  - Detailed digitizer model tuned from test beam data
  - Tracking algorithms re-trained
  - Estimated backgrounds at 8x10^{35} cm^{-2}s^{-1}

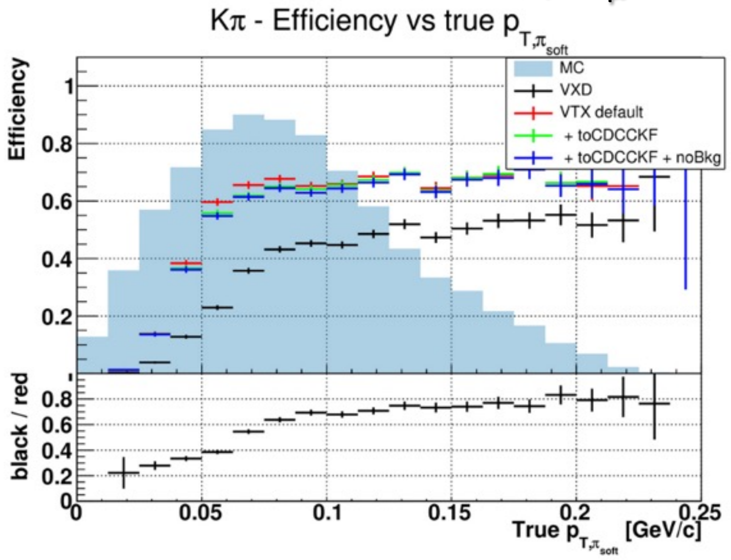
Tracking





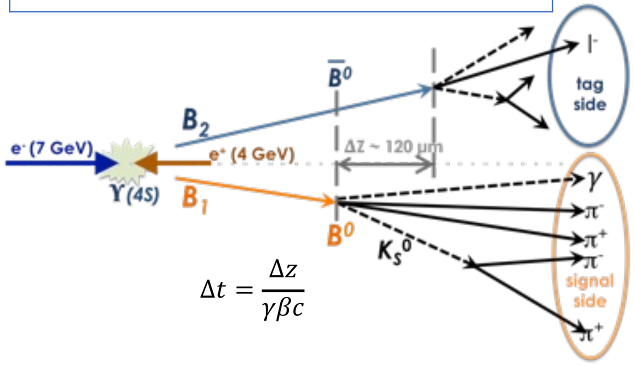
Physics Benchmarks

$B^0 \rightarrow D^{*-}(\bar{D}^0\pi^-)\,\mu^+\nu_\mu$



$B^0 \rightarrow K_S^0\,\pi^+\pi^-\gamma$

Geometry	Δt Resolution (ps)
VXD	1.12 ± 0.11
VTX 5 layers	0.82 ± 0.02



$$\Delta t = \frac{\Delta z}{\gamma\beta c}$$

→ VTX performs slightly better / current VXD

DMAPS for Belle II Beyond LS2

Starting prospective ideas on simulation beyond VTX

- **Main tracker upgrade**

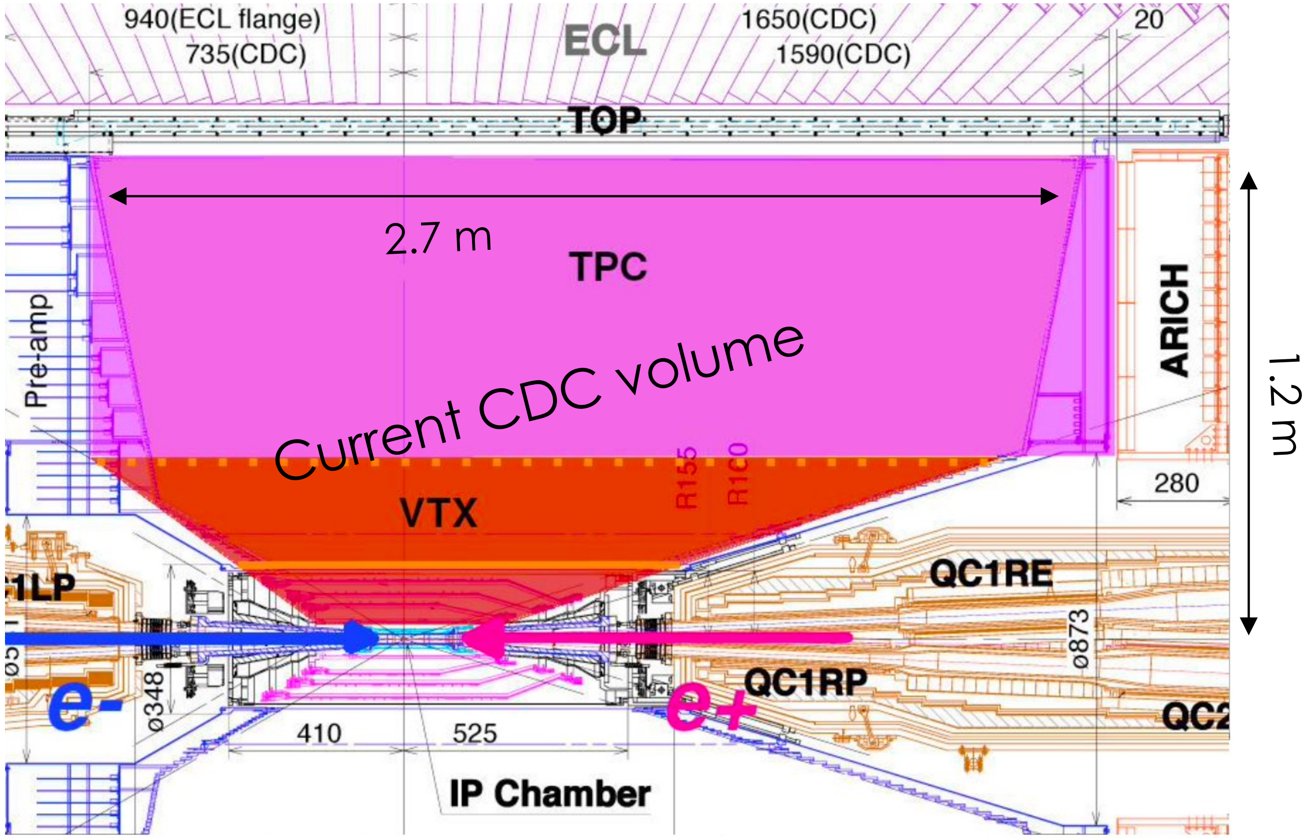
Replace totally/partially the CDC with DMAPS

Pitch 30-50 µm
1 ns time-stamping with TRG capability
50 mW/cm^2 power budget
1 MHz/cm^2 hit-rate
Low radiation hardness

- **Timing layers**

Trigger and PID (DMAPS?)

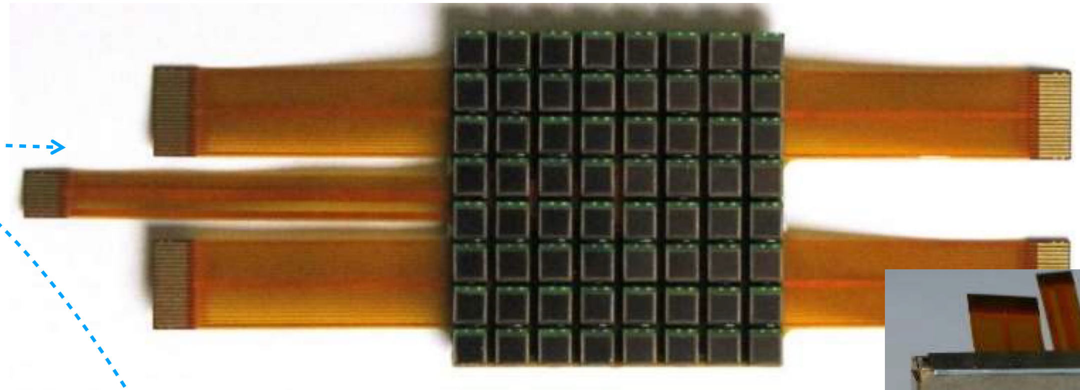
Time resolution 10-100 ps
Pad-like pixels

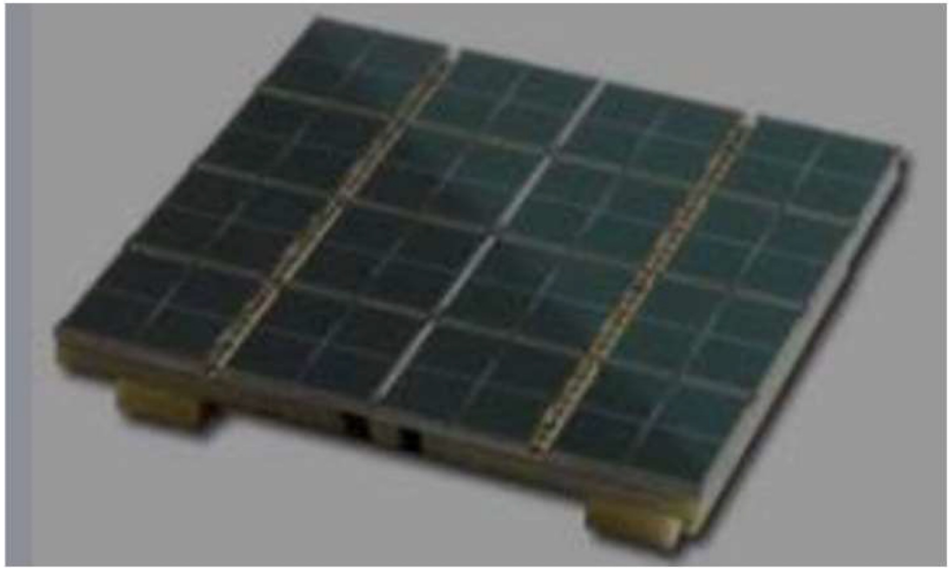


Aerogel Ring-Imaging Cerenkov Counter Upgrade

✓ **beyond LS2 …**

- R&D for SiPM photosensors or MCP-PMTs / LAPPD
- R&D for compatible readout (custom or FASTiC from LHCb)
- R&D for aerogel upgrade

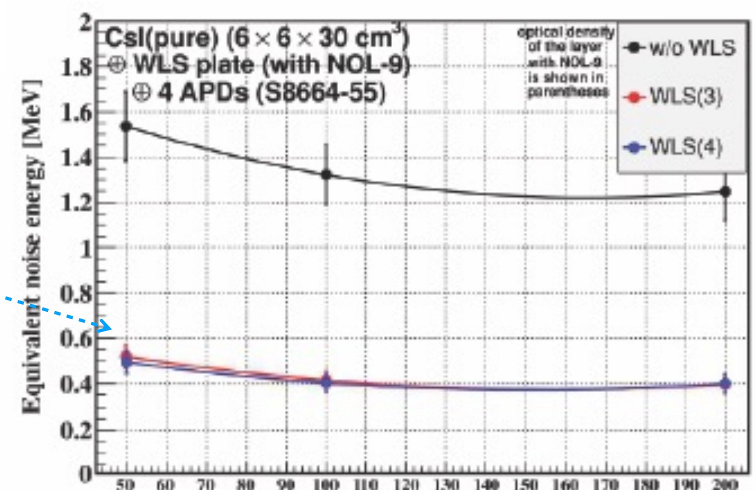


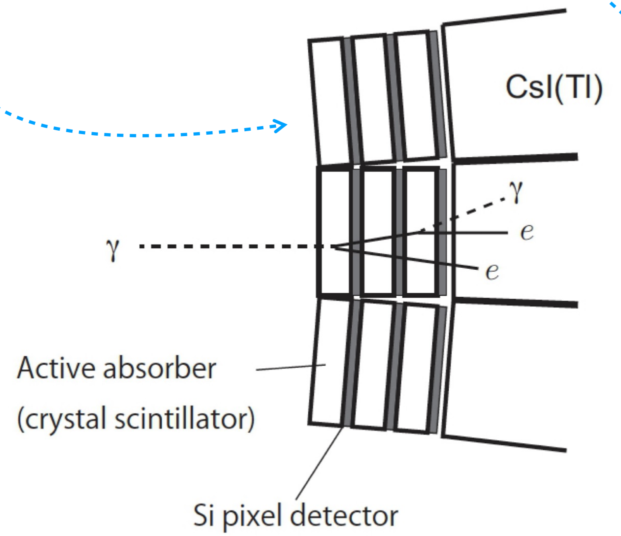


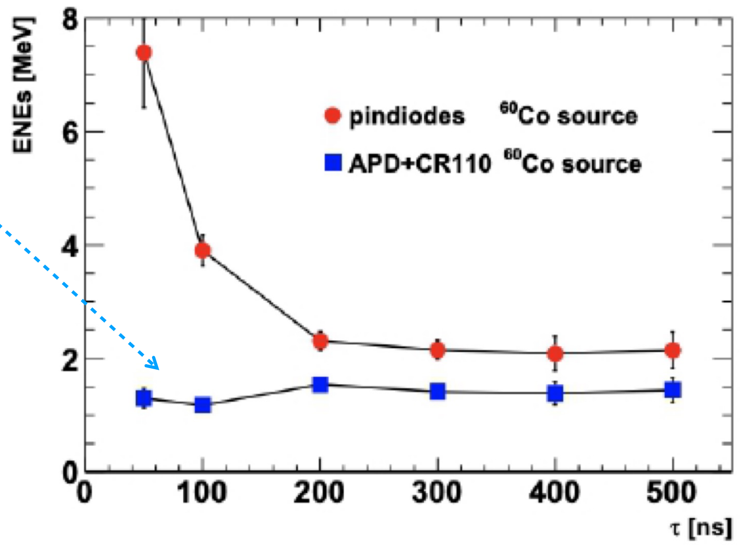
Electromagnetic Calorimeter Upgrade

✓ **beyond LS2 …**

- replace CsI(Tl) with pure CsI (or LYSO or $LaBr_3$) for shorter pulses & less pile-up
- add wavelength-shifting plate for better energy resolution
- replace PIN-diode sensors with APDs (or SiPMs) for better energy resolution
- front-end readout re-design
- add pre-shower detector

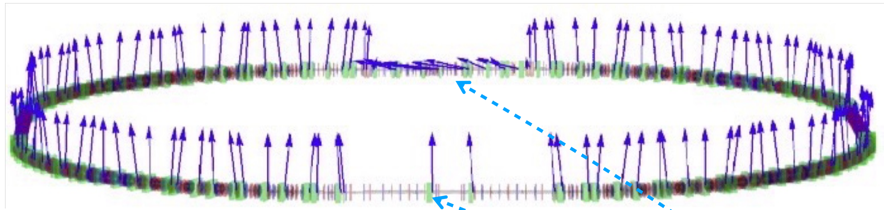






Beam Polarization and Chiral Belle

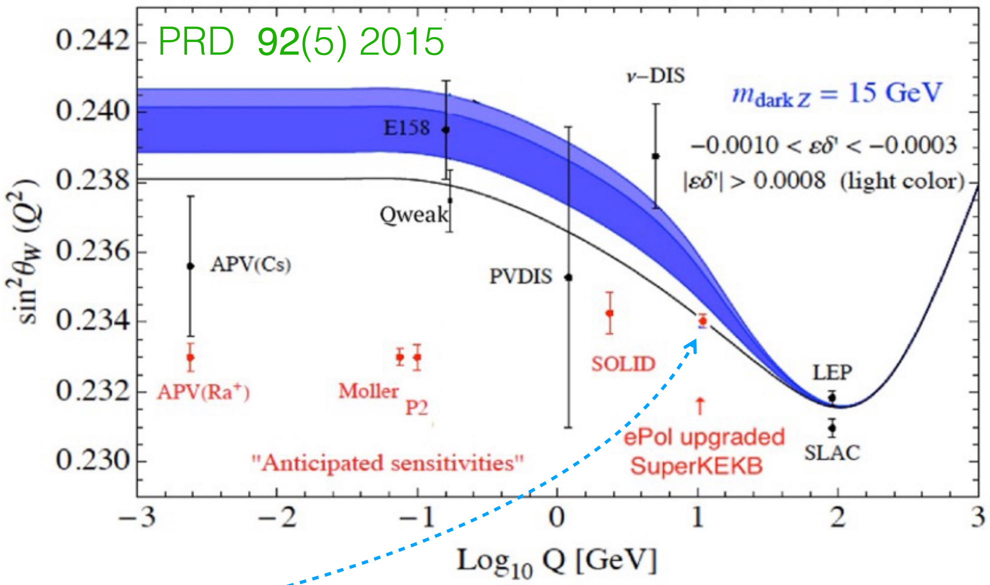
See Snowmass white paper arXiv:2205.12847



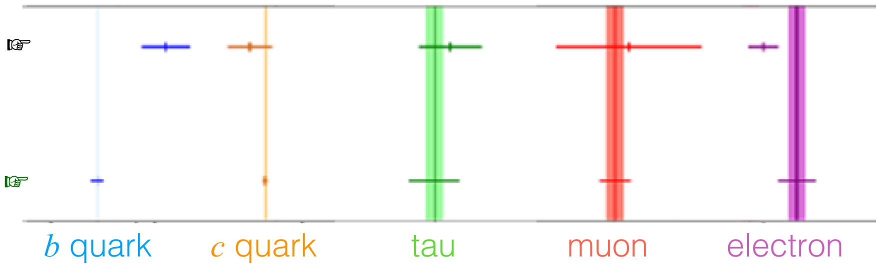
e^- spin vector in SuperKEKB

- ✓ **Polarized electrons (70%)**
  - Transverse polarization at injection
  - Rotate to longitudinal at interaction point
  - Compton polarimeter for 0.5% precision

- ✓ **with polarized electrons …**
  - sensitivity to EW neutral vector current
  - sensitivity to light Z_{dark} via $\sin^2\theta_W$
  - left-right asymmetries with 5 fermions
  - tau g–2: sensitivity of $\mathcal{O}(10^{-5})$ w/50 ab^{-1}
  - background suppression in $\tau \to \ell\,\gamma$ using helicity distributions



Uncertainties on g_V^f



World average ☞

Chiral Belle ☞
(projected)

Belle II Vertex and Tracker: European Strategic Project

- Belle II upgrade identified as a strategic project on flavor collider experiments

Different environmental constraints

Strategic Projects	Tracking Vertex Detector (VD) Central Tracker (CT)	Timing Layer (TL) + Calorimeter
Heavy Ion	ALICE-3, EIC	ALICE-3 (LS4+), EIC
Flavour collider	BELLE-3	BELLE-3
Lepton collider	ILC, CLIC FCCee, Muon Collider	ILC, CLIC FCCee, Muon Collider
pp collider	LHCb-2, ATLAS, CMS FCC-hh	LHCb-2, ATLAS, CMS FCC-hh

DRD3 Workshop
22nd March 2023
CERN
D. Contardo

Milestone 1, 2028-2029
Strategic programs ALICE-3, LHCb-2, Belle-3, EIC: VD/CT
Highest position precision at lowest power dissipation up to large wafersize

New groups applying for joining Belle II Vertex Upgrade

European Strategy and Belle II (KEK)

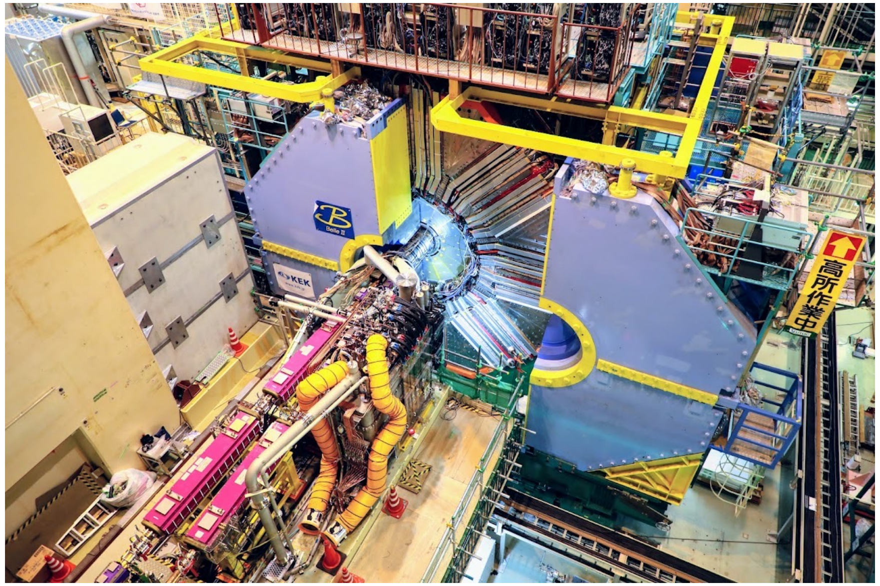
4

European Strategy Update

Other essential scientific activities for particle physics

A. The quest for dark matter and the exploration of flavour and fundamental symmetries are crucial components of the search for new physics. This search can be done in many ways, for example through precision measurements of flavour physics and electric or magnetic dipole moments, and searches for axions, dark sector candidates and feebly interacting particles. There are many options to address such physics topics including energy-frontier colliders, accelerator and non-accelerator experiments. A diverse programme that is complementary to the energy frontier is an essential part of the European particle physics Strategy. ***Experiments in such diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world.***

European Strategy recommends participation in flavor experiments outside Europe → Belle II



MEXT Report on SuperKEKB/Belle II

Comprehensive Assessment

The SuperKEKB project is very urgent and strategic, and is highly ranked as a plan that can obtain the consensus of the domestic and international research community and the support of society and the public.

Three scientific goals:

1. Continuation of operation, performance improvement, and data accumulation
2. Maintenance and *improvement of apparatus*
3. Experimental data analyses and presentations of scientific outputs

- SuperKEKB/Belle II promoted as a large scale academic frontier project
- 10 years plan
- Long term support from hosting lab >2032