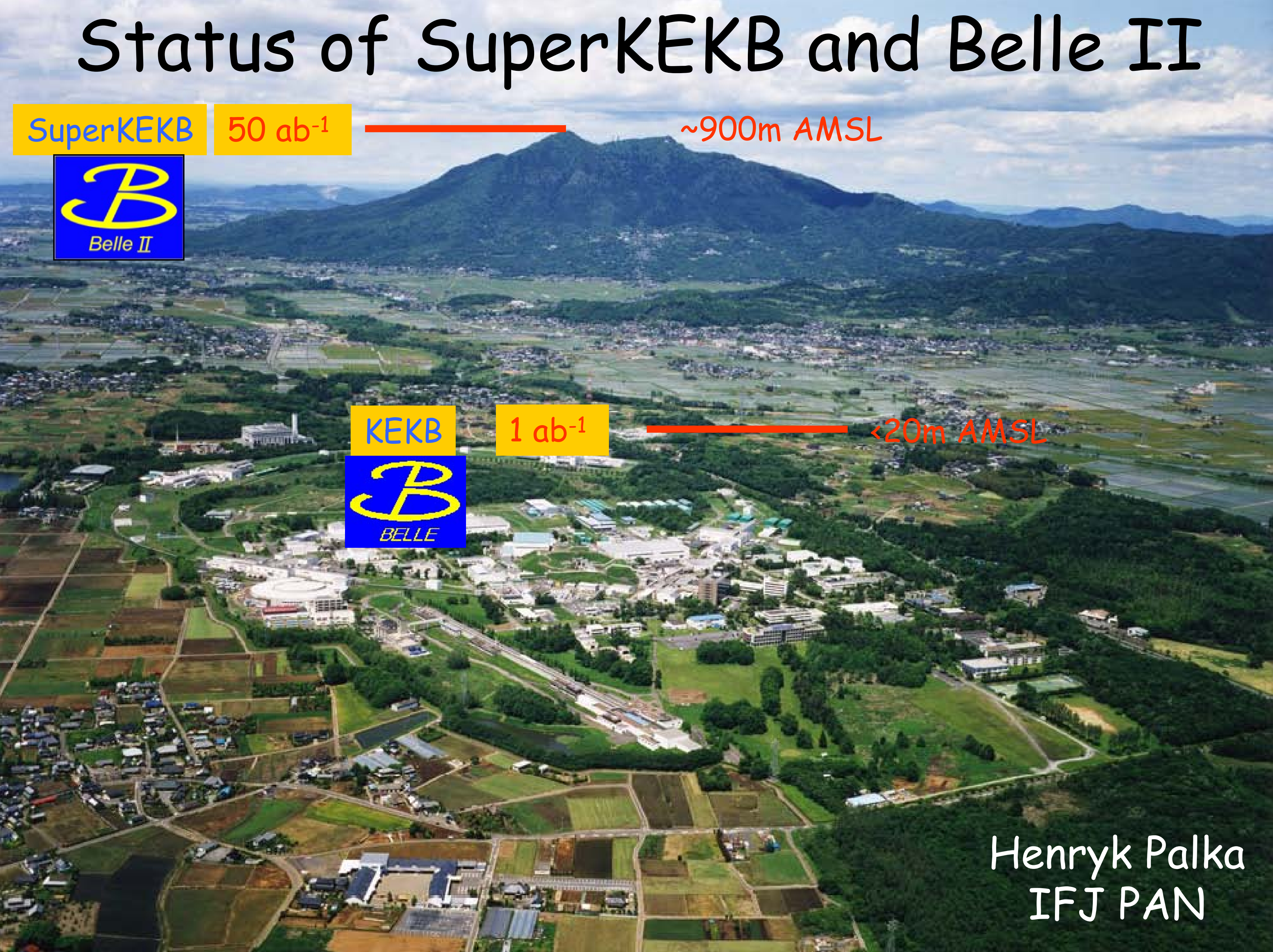
Status of SuperKEKB and Belle II



Henryk Palka
IFJ PAN


Beautiful physics needs beautiful enviroments
Ski resorts 80 km
Sightseeing 80km
Pacific ocean 50km
Tsukuba
Spa (Onsen) 120 km
Restaurant 2km
Tsukuba is nice place to study charm and beauty

Outline

- Why SuperKEKB / Belle II
- Belle and KEKB legacy
- SuperKEKB upgrade
- Belle II detector
- Background expectations
- Distributed computing for Belle II (Grids, Clouds)
- Belle II Collaboration
- Conclusions

Why we need SuperKEKB & Belle II

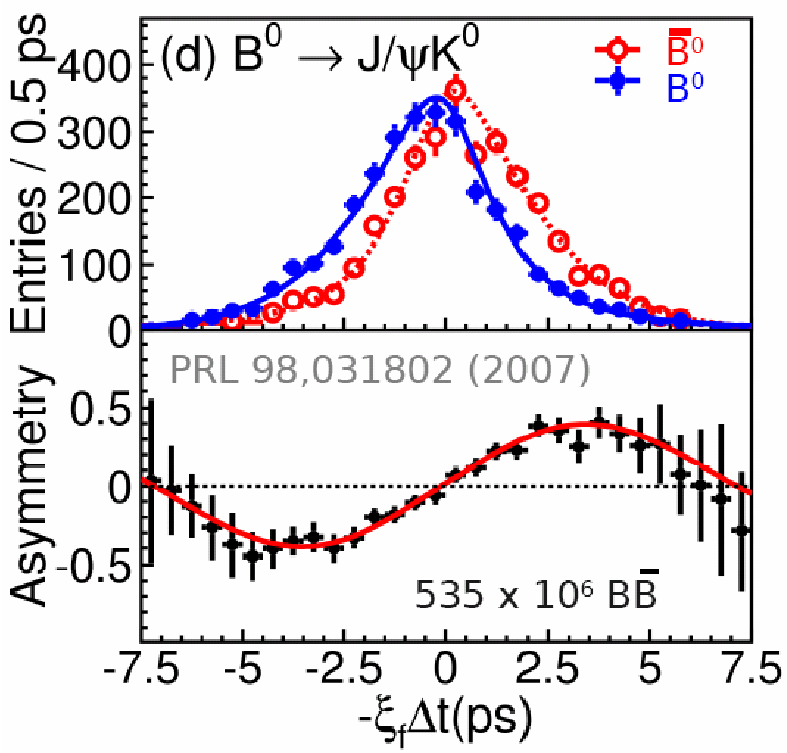
- Flavour physics is experimentaly driven field:
  e.g. the SM : only organisational principles and consistency relations

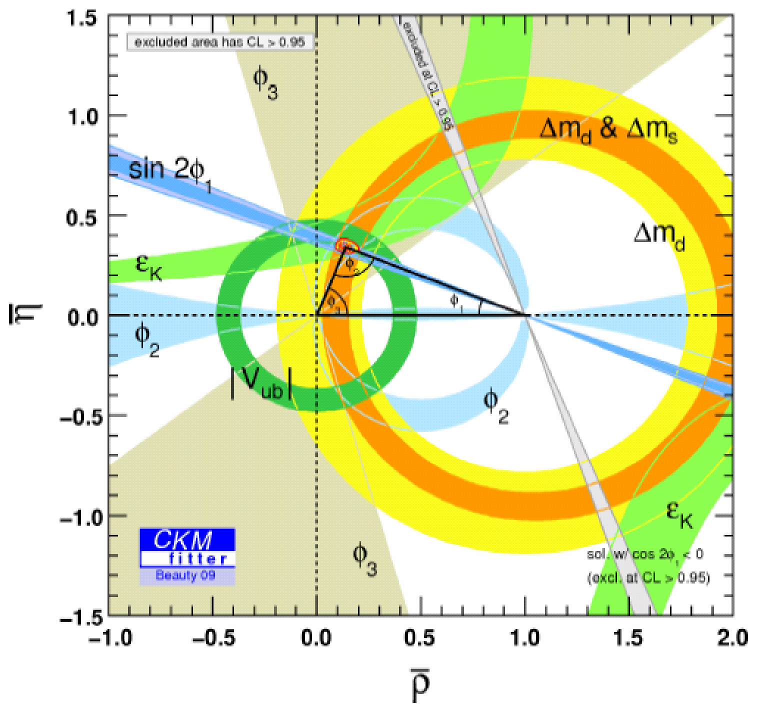
- Most of the KEKB/Belle CPV measurements (~1ab^{-1}) are statisticaly limited → improve them for further scrutiny of theory predictions
  e.g. some of the measurements suggest 'tensions' w.r.t the SM values (too low stat. significance to claim discovery)

- Clean, low multiplicity experiment, with complete final state reconstruction, many direct measurements with no ref. to MC → good chance to see the 'unexpected'

Belle Legacy

$\bar{\rho} + i\bar{\eta} = -(V_{ud}V_{ub}^*)/(V_{cd}V_{cb}^*)$



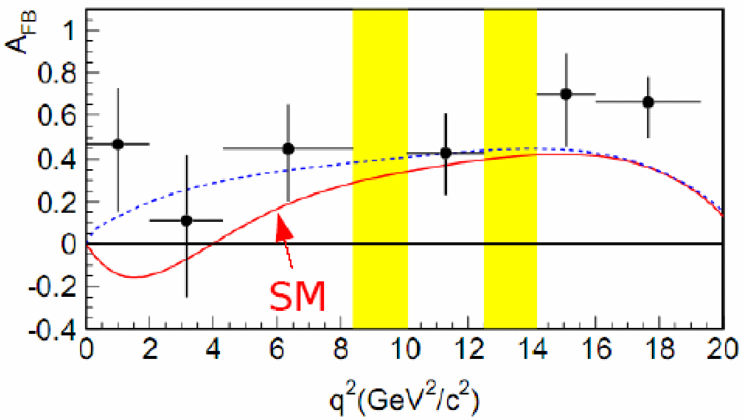


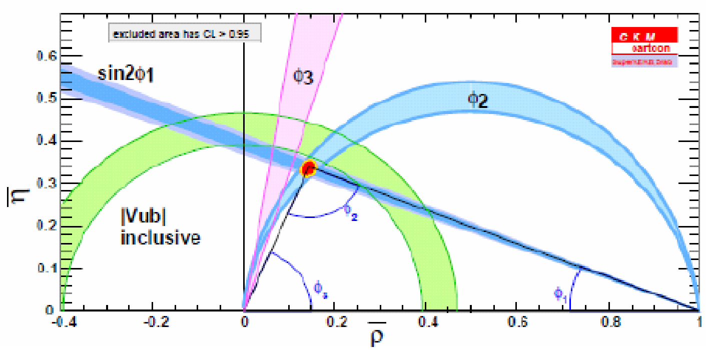
- Confirmed the SM Kobayashi-Maskawa mechanism of CP violation

Examples of measurements to look for NP

$B \to K^{(*)} l^+ l^-$ FB asymmetry

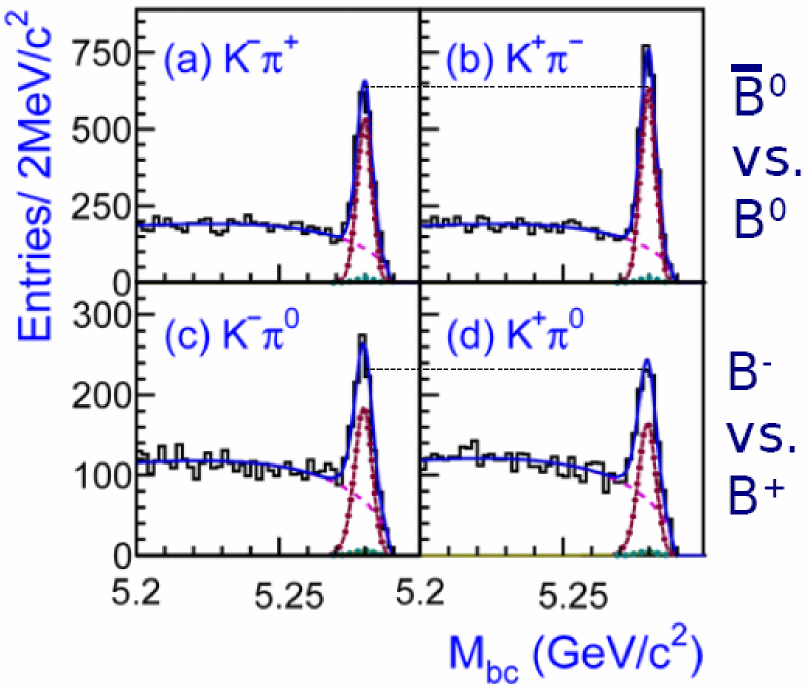
→ Zero crossing with 5% precision at 50 ab^{-1}





Direct CP violation $\Delta A(K^0\pi^0)$: 0.15 (~0.5 ab^{-1})

→ 0.042 (50 ab^{-1})

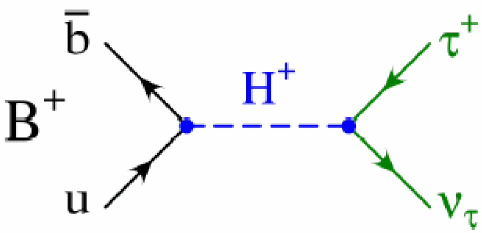


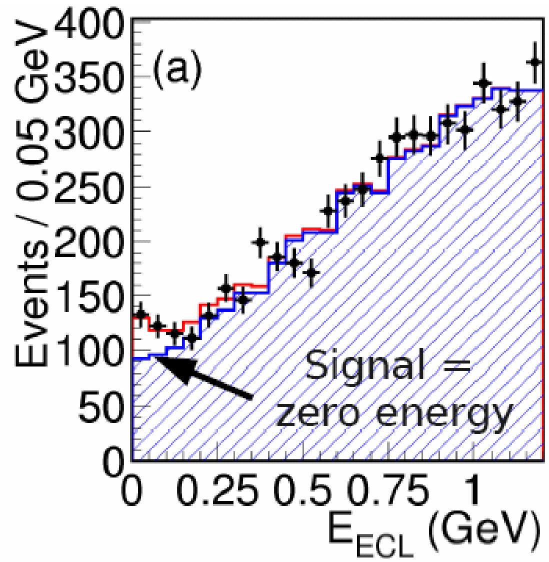
Precision angle measurements

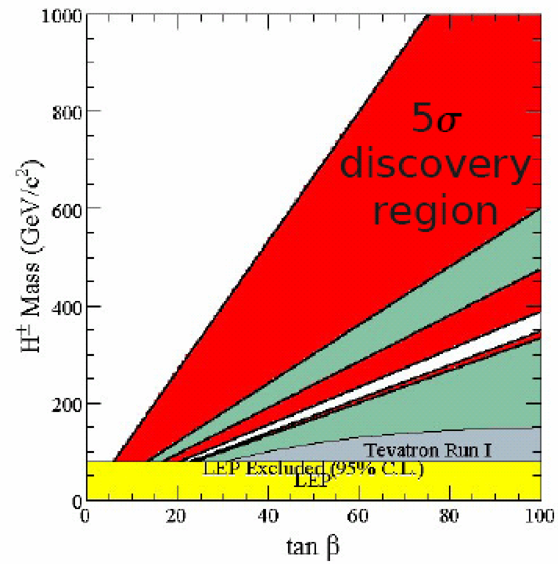
→ Precision at 50 ab^{-1}: $\varphi_2 \simeq 1°$, $\varphi_3 = 1.5°$

Examples of measurements to look for NP

Charged Higgs:
$B \rightarrow \tau\nu$



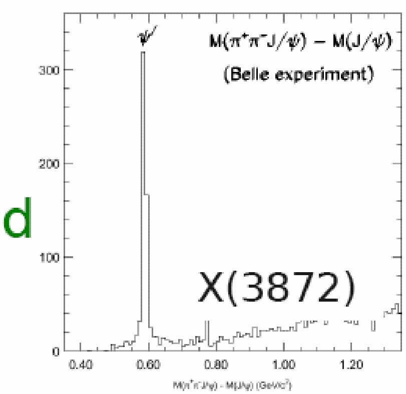




Lepton flavor violation

$B(\tau \rightarrow \mu\gamma)$ 90% CL UL [10^{-9}]: 45 (~0.5 ab^{-1}) → 5 (50 ab^{-1})

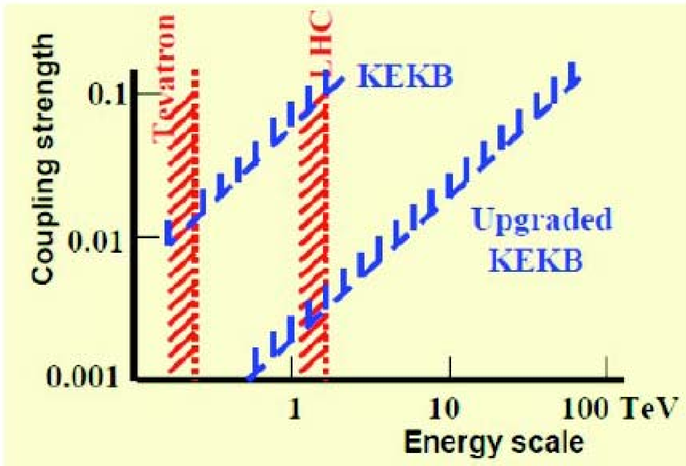
The unexpected



CP violation in D^0 mixing

Precision of |q/p|: 0.16 (~0.5 ab^{-1}) → 0.05 (50 ab^{-1})

Flavour Physics in the LHC Era



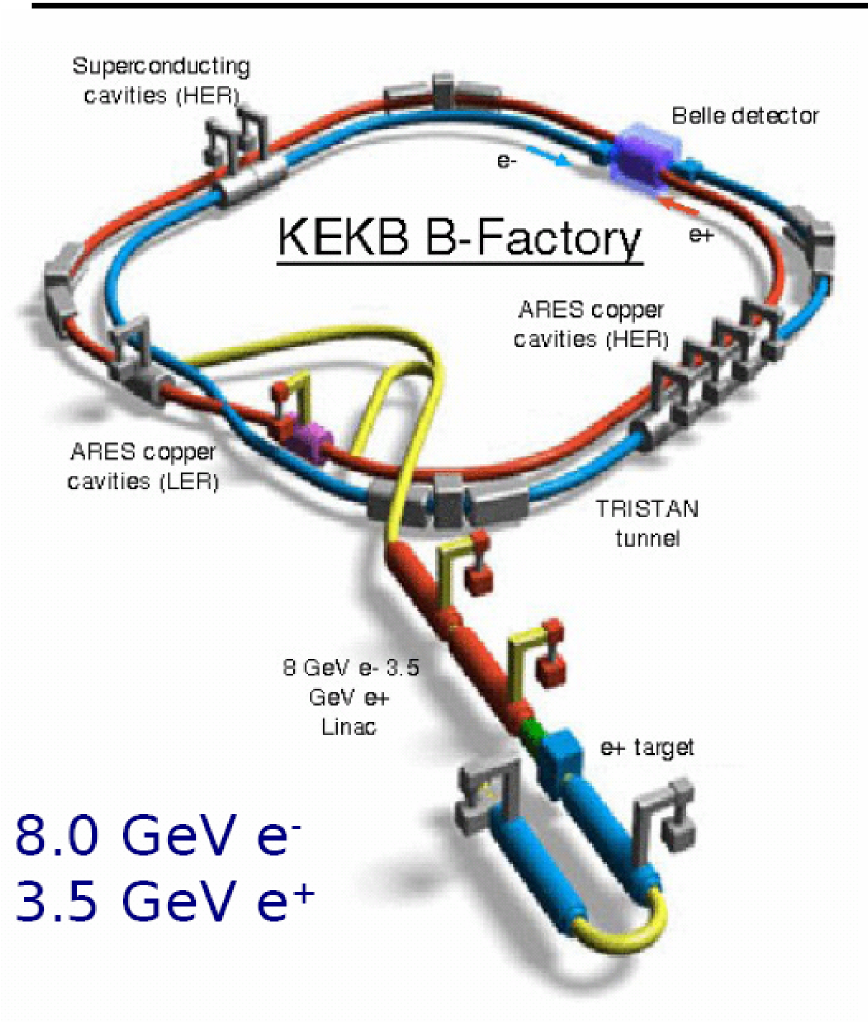
SuperKEKB measurements are complementary to direct searches for NP at the LHC

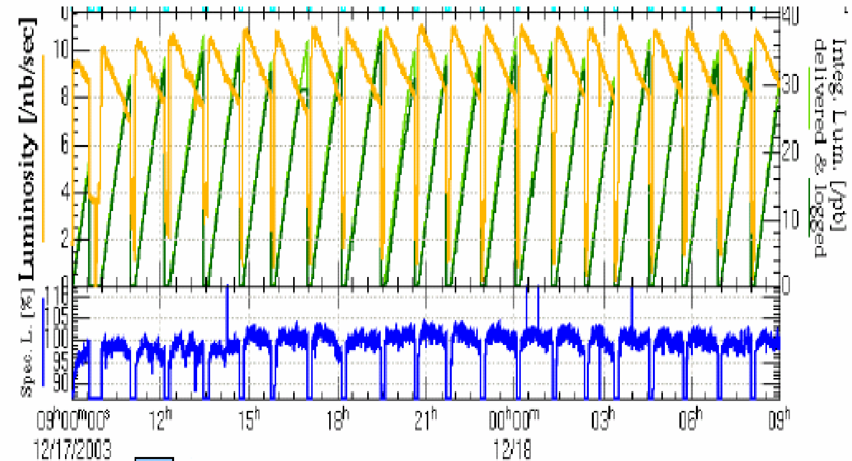
'DNA test' of NP

	AC	RVV2	AKM	δLL	FBMSSM	LHT	RS
$D^0 - \bar{D}^0$	★★★	★	★	★	★	★★★	?
ϵ_K	★	★★★	★★★	★	★	★★	★★★
$S_{\psi\phi}$	★★★	★★★	★★★	★	★	★★★	★★★
$S_{\phi K_S}$	★★★	★★	★	★★★	★★★	★	?
$A_{CP}(B \to X_s\gamma)$	★	★	★	★★★	★★★	★	?
$A_{7,8}(B \to K^*\mu^+\mu^-)$	★	★	★	★★★	★★★	★★	?
$A_9(B \to K^*\mu^+\mu^-)$	★	★	★	★	★	★	?
$B \to K^{(*)}\nu\bar{\nu}$	★	★	★	★	★	★	★
$B_s \to \mu^+\mu^-$	★★★	★★★	★★★	★★★	★★★	★	★
$K^+ \to \pi^+\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$K_L \to \pi^0\nu\bar{\nu}$	★	★	★	★	★	★★★	★★★
$\mu \to e\gamma$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
$\tau \to \mu\gamma$	★★★	★★★	★	★★★	★★★	★★★	★★★
$\mu + N \to e + N$	★★★	★★★	★★★	★★★	★★★	★★★	★★★
d_n	★★★	★★★	★★★	★★	★★★	★	★★★
d_e	★★★	★★★	★★	★	★★★	★	★★★
$(g-2)_\mu$	★★★	★★★	★★	★★★	★★★	★	?

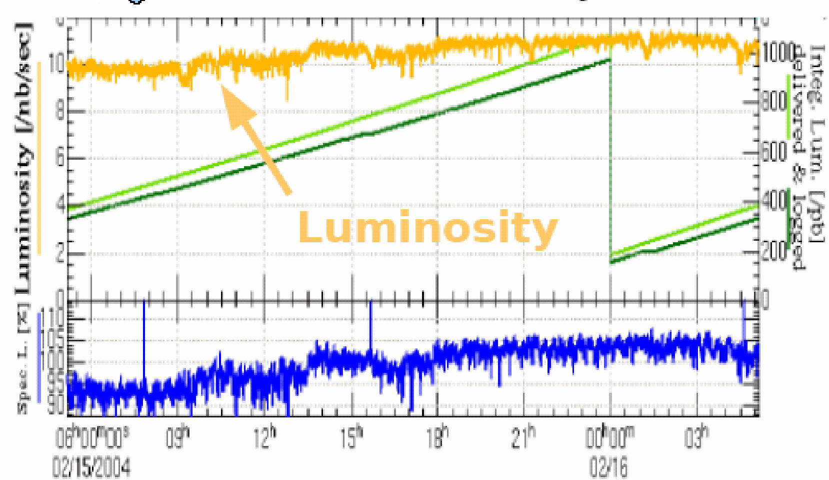
Altmannshofer, Buras, Gori, Paradis and Straub
Nucl.Phys.B830, 17-94, 2010

KEKB Legacy

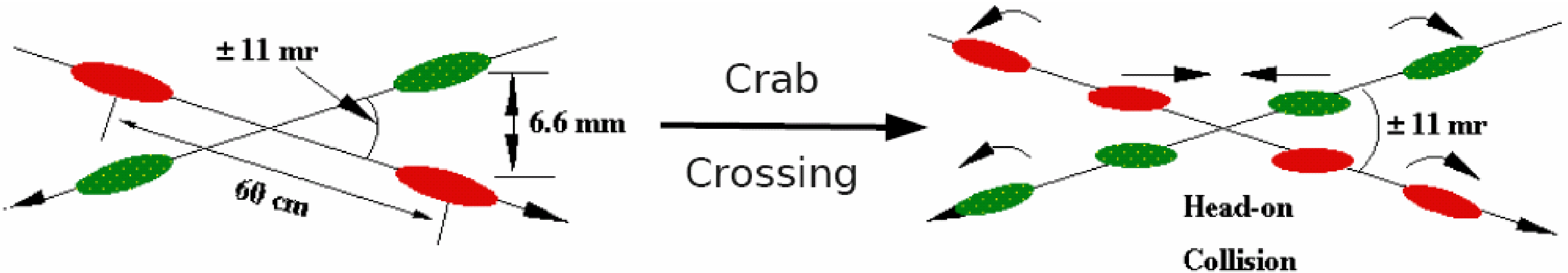


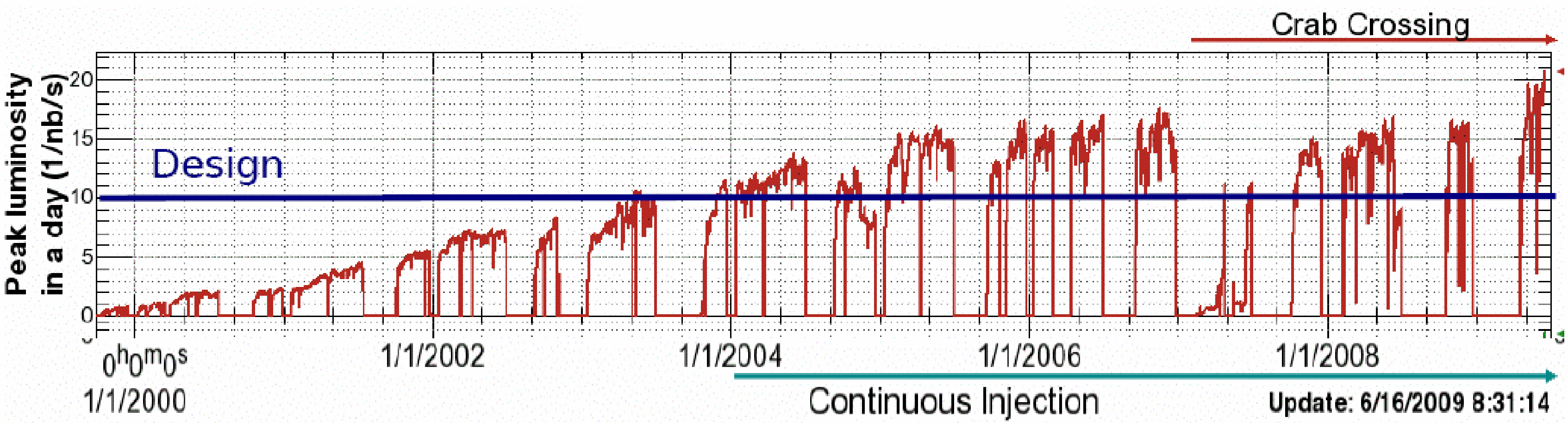


Continuous injection



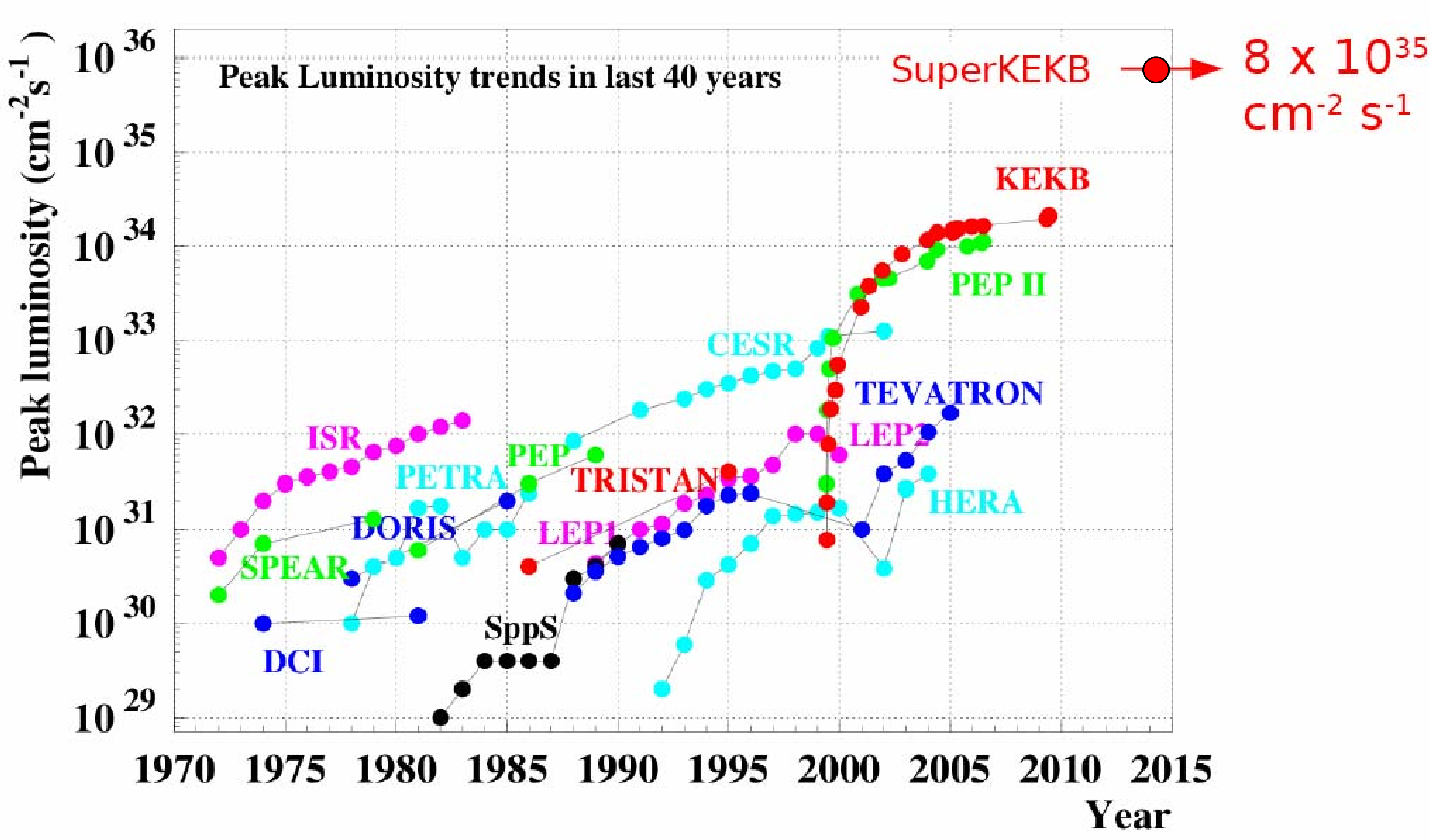
KEKB performance





- World record luminosity: 2.1 x 10^{34} $cm^{-2}s^{-1}$, twice the design value
- 1 ab^{-1} of integrated luminosity
- Still 'kicking' till end o June 2010

SuperKEKB goal: x40 luminosity increase



SuperKEKB: nano-beams collision scheme

Lorentz factor

Beam current

Beam-Beam parameter $\xi_y \propto \sqrt{(\beta_y^*/\varepsilon_y)}$

$$L = \frac{\gamma_\pm}{2er_e}\left(1 + \frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_\pm \xi_{y\pm}}{\beta_{y\pm}^*}\left(\frac{R_L}{R_{\xi_y}}\right)$$

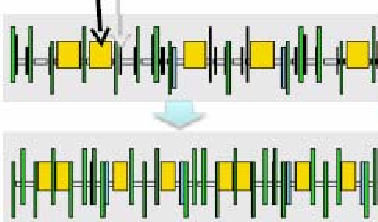
Geometrical reduction factors (crossing angle, hourglass effect)

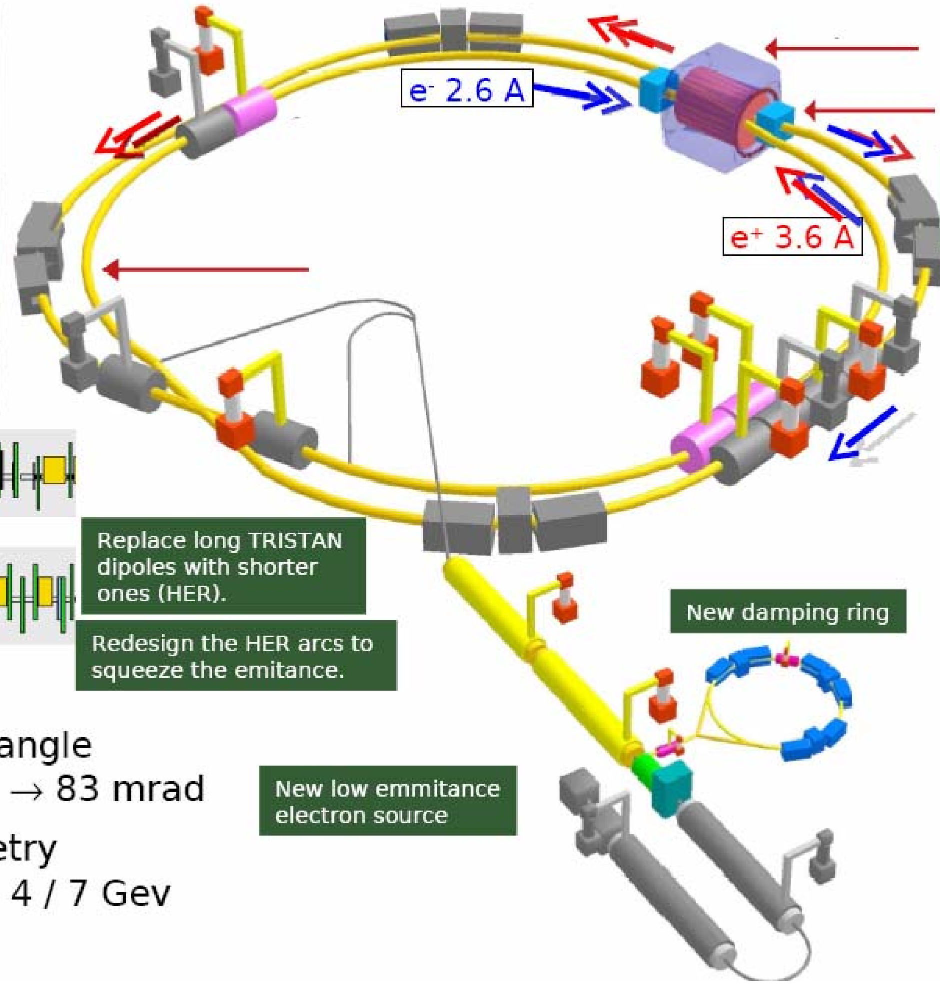
Beam aspect ratio at IP

Vertical beta function at IP

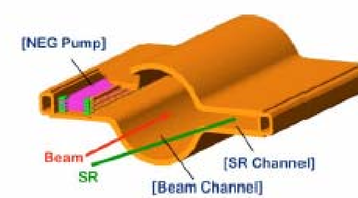
	β_x^* (cm)	β_y^* (mm)	ξ_y	ϵ_x (nm)	I_{beam} (A)	L ($cm^{-2}\ s^{-1}$)
KEKB w/ crab	120/120	5.9/5.9	0.13/0.09	18/24	1.6/1.2	2.11×10^{34}
SuperKEKB	3.2/2.5	0.27/0.42	0.09/0.09	3.2/1.7	3.6/2.6	**80×10^{34}**

SuperKEKB upgrade





TiN coated beam pipe with antechambers



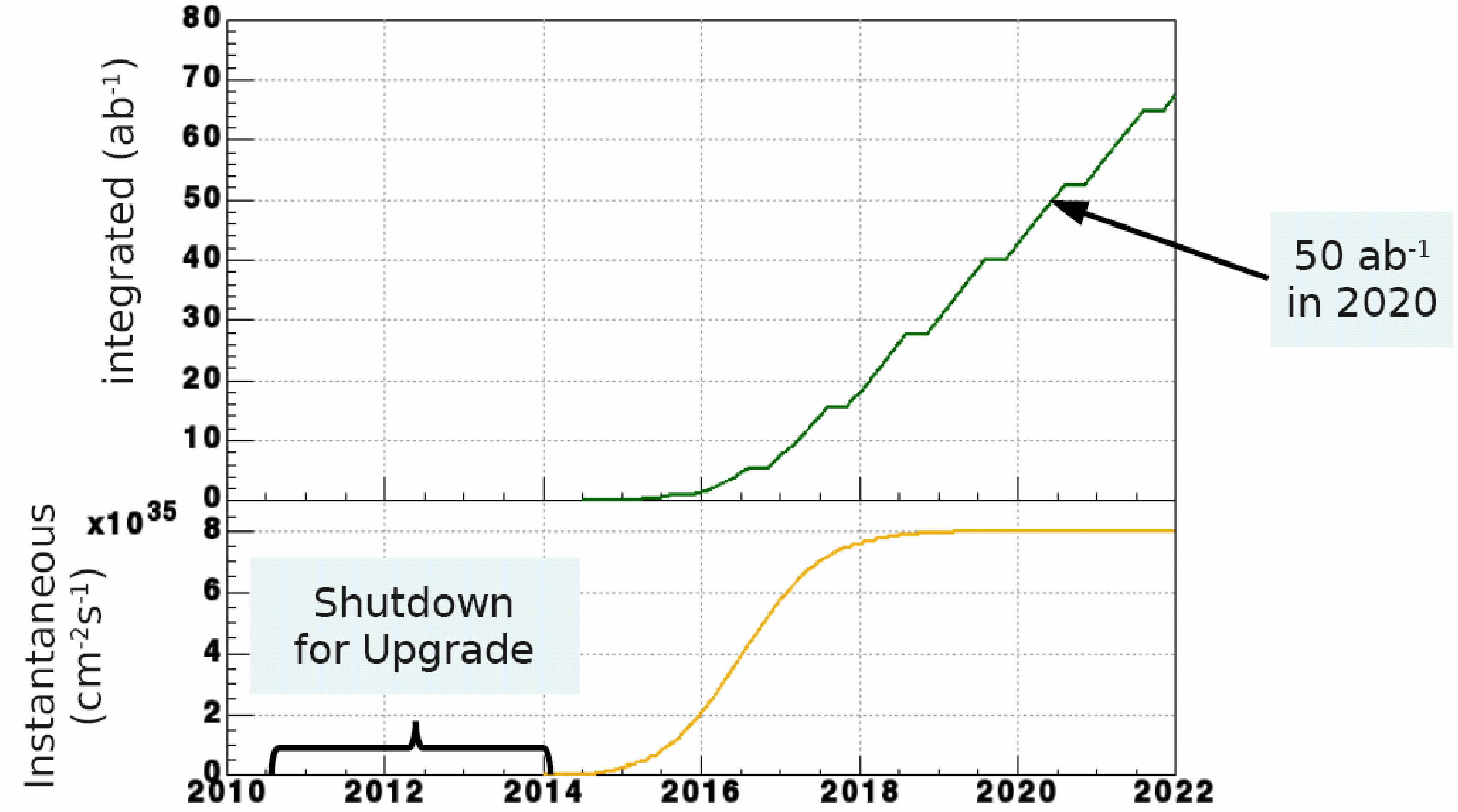
Larger crossing angle

$2\phi = 22$ mrad $\rightarrow$ 83 mrad

Smaller asymmetry

3.5 / 8 GeV $\rightarrow$ 4 / 7 Gev

S-KEKB Luminosity Projection



Belle II Detector

Designed for improved performance and to cope with higher event rates and backgrounds

KLM: RPC & Scint+SiPM

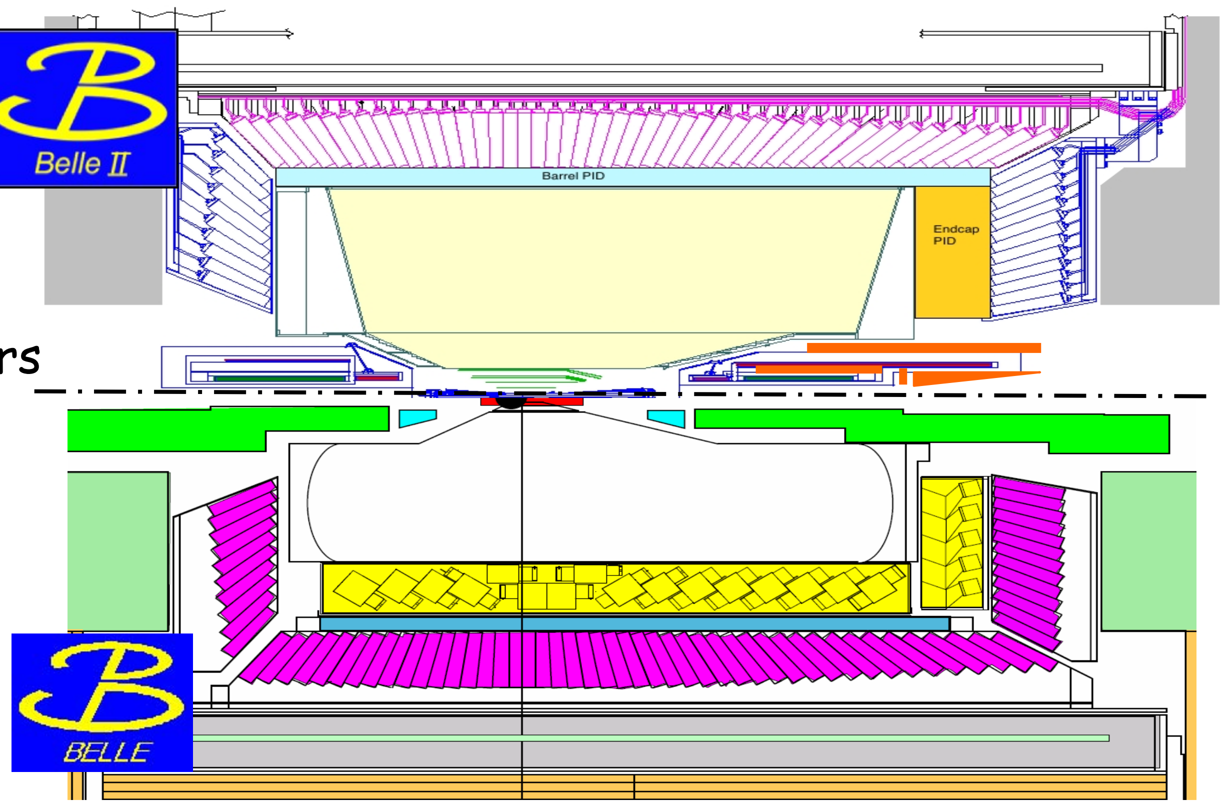
ECL: CsI(Tl) & CsI

PID: TOP & AF-RICH

CDC: larger drift chamber

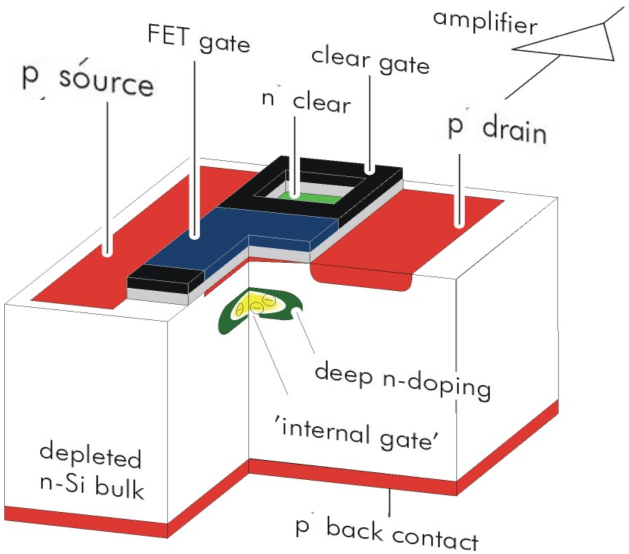
SVD: 2 DEPFET pixels layers
+ 4 DSSD layers

new DAQ: dead time free readout, high speed



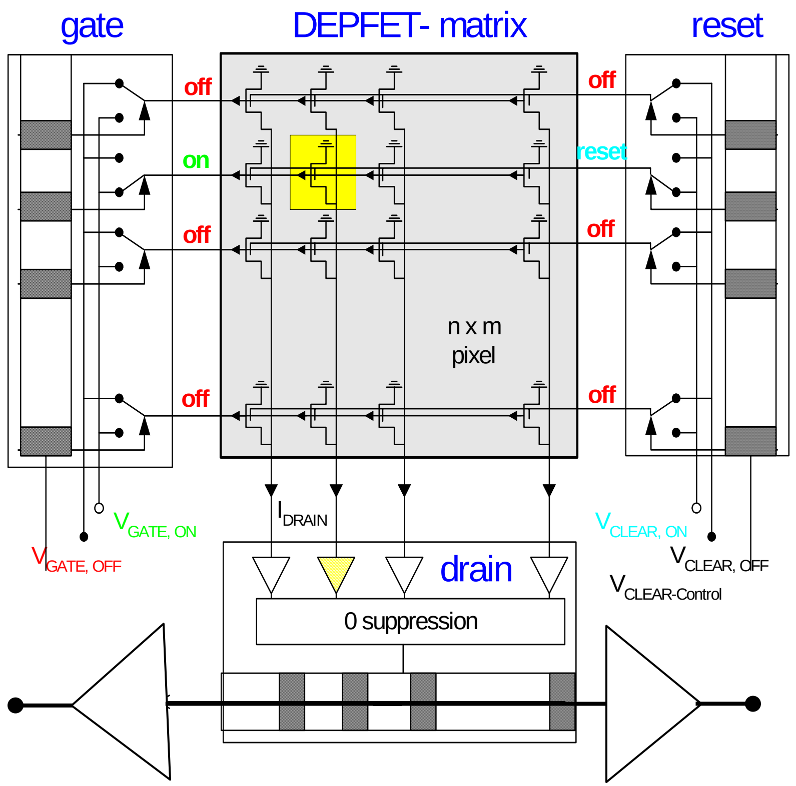
PXD based on DEPFET Sensor

Depleted P-channel FET



thin sensor, still large signal,
fast signal collection

→ low noise
→ low power



ASICs on sensor:

→ Switcher
→ DCD (drain current digitizer)

PXD Layout, Control & DAQ

2 layers: @1.4(2.2) cm

Pixels: 50 x 50(75) µm

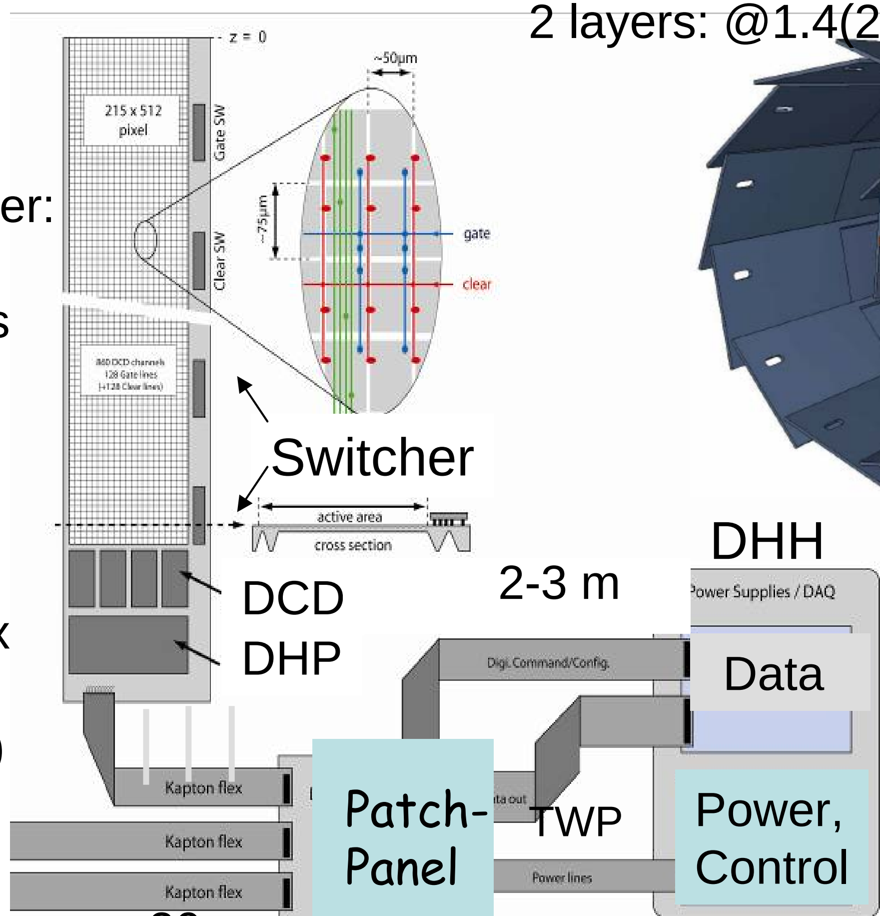
Thickness: 75 µm

total of 8 Mpx

half ladder: 800 rows

250 cols

15 x 70 (85) mm



Opt.

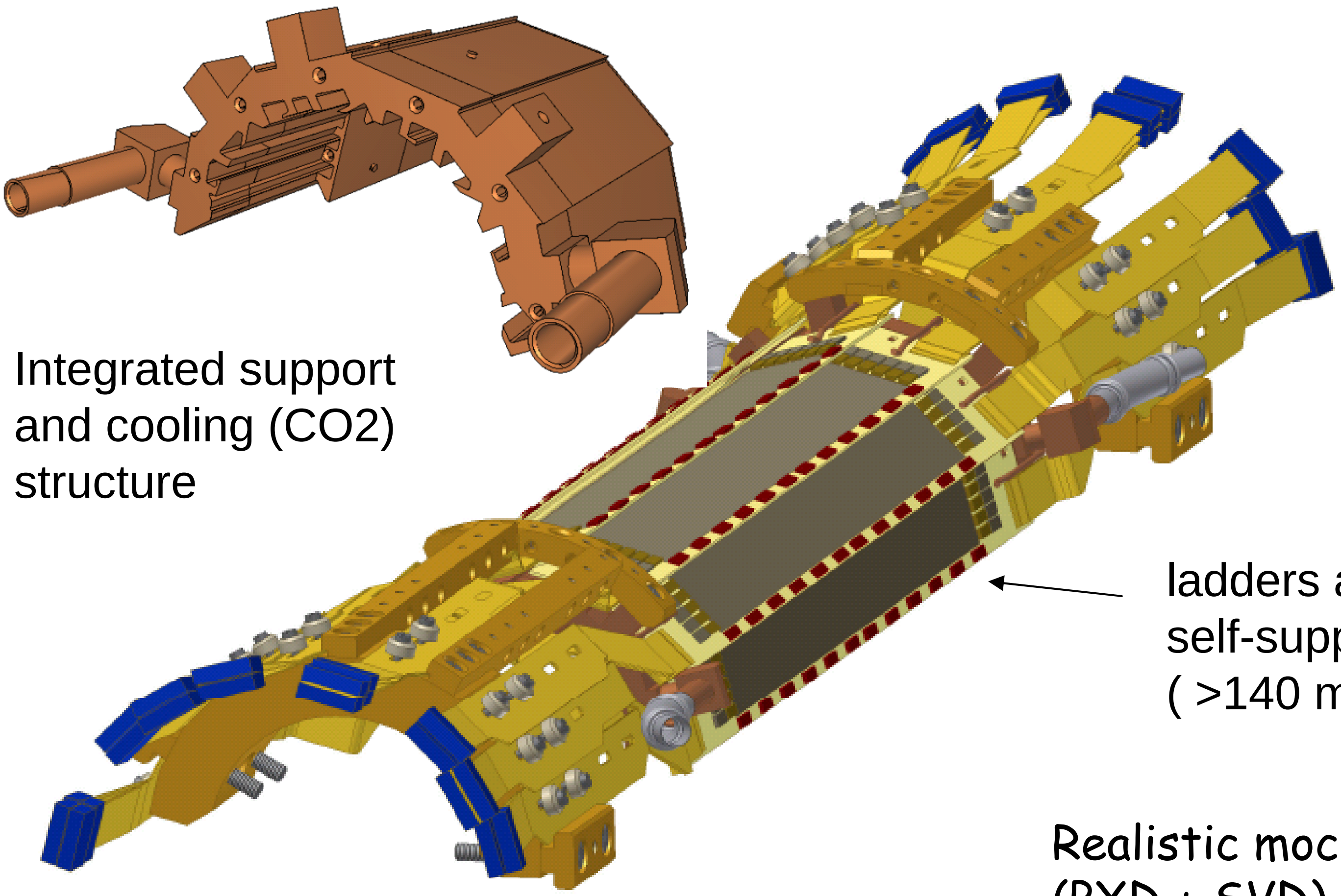
Cu

Opt.

DAQ, Trigger, Timimg

PS, Slow control

PXD Mechanics, Outer Layer



Integrated support and cooling (CO_2) structure

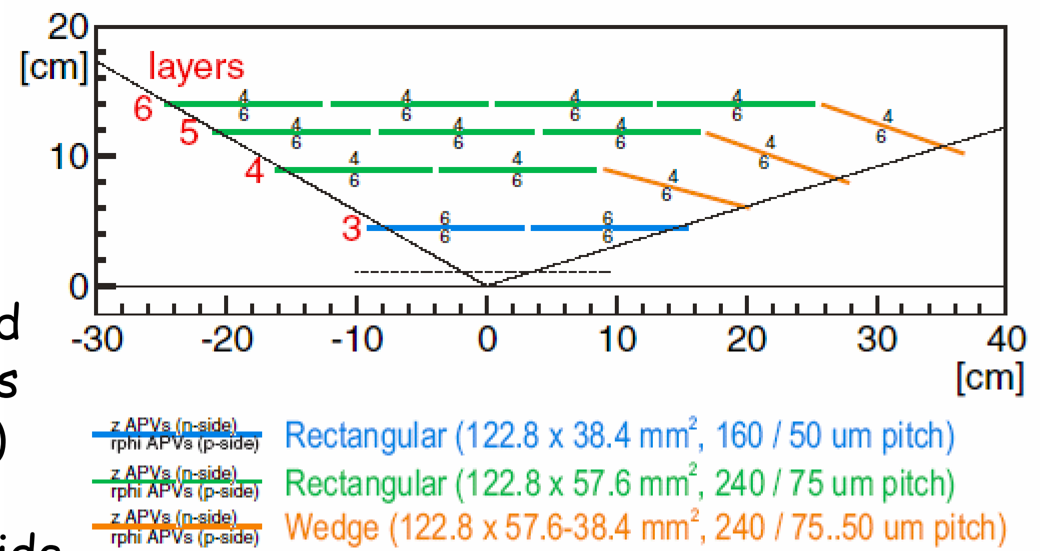
ladders are self-supporting (>140 mm)

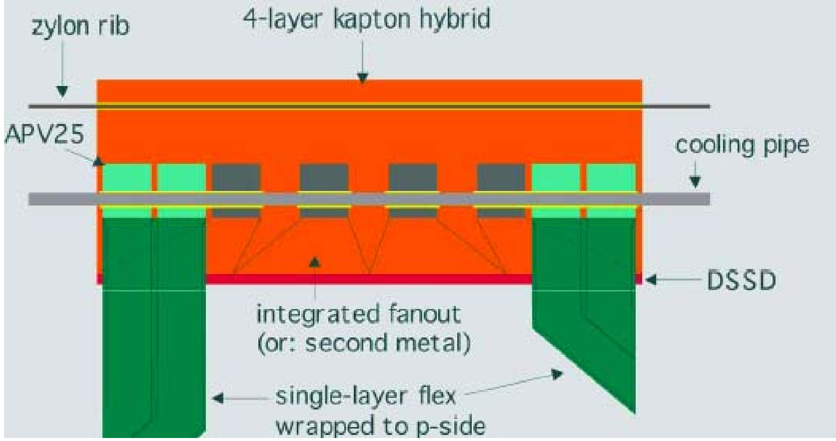
Realistic mockup is constructed (PXD + SVD) to study cooling

(construction: K. Ackermann, MPI)

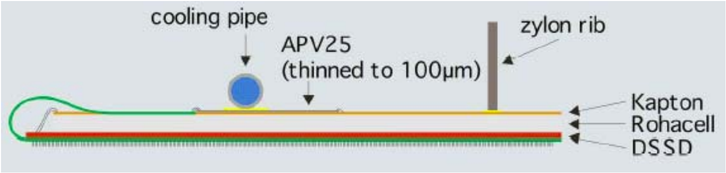
Belle II SVD

- 4 layers R=4-12cm
  (lever arm, K_s^0 eff.)
- Slanted Fwd (cluster size, less m.scatt. material)
- DSSD
- Readout chips (APV25) thinned to 100µm, bonded on detectors (small capacitance→good S/N)
- Rerouting with flex capton fan-out, wraped to opposite side

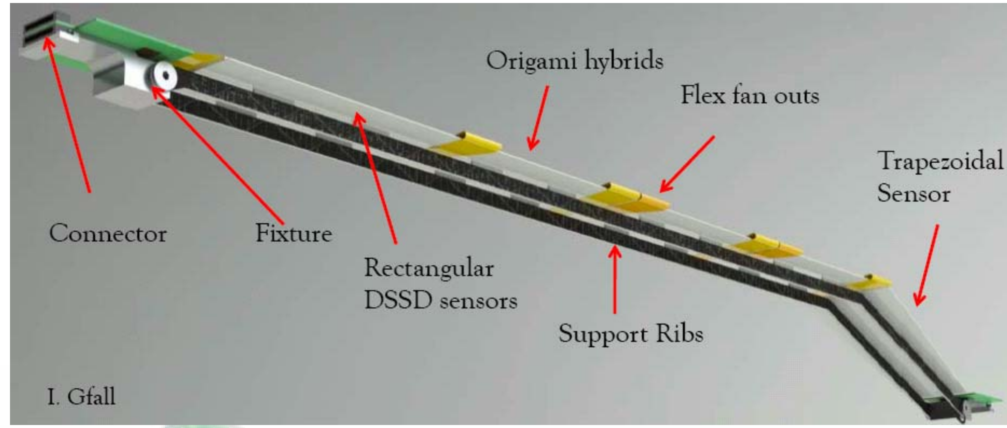




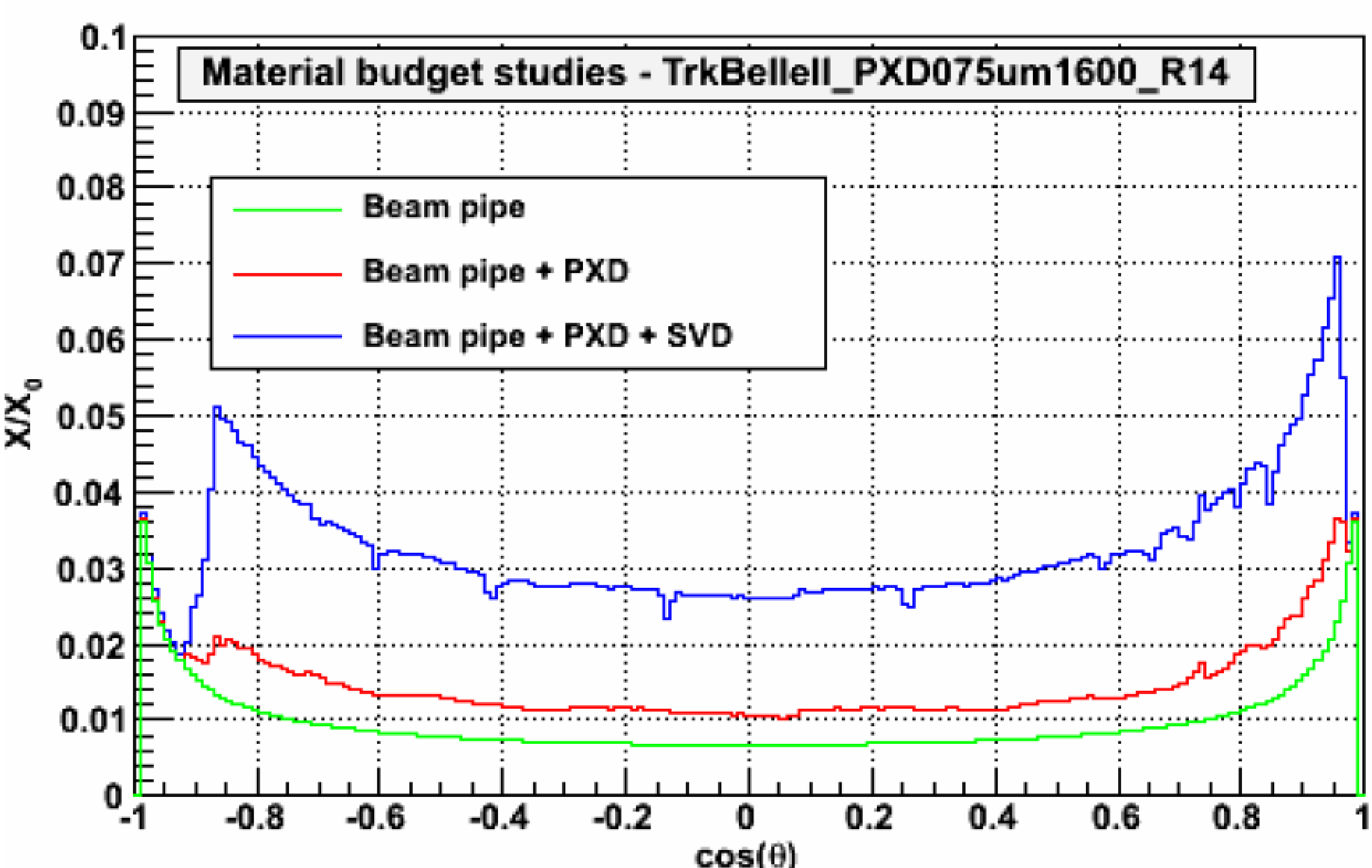
„Origami" design (HEPHY Vienna)



Belle II SVD Origami module prototypes



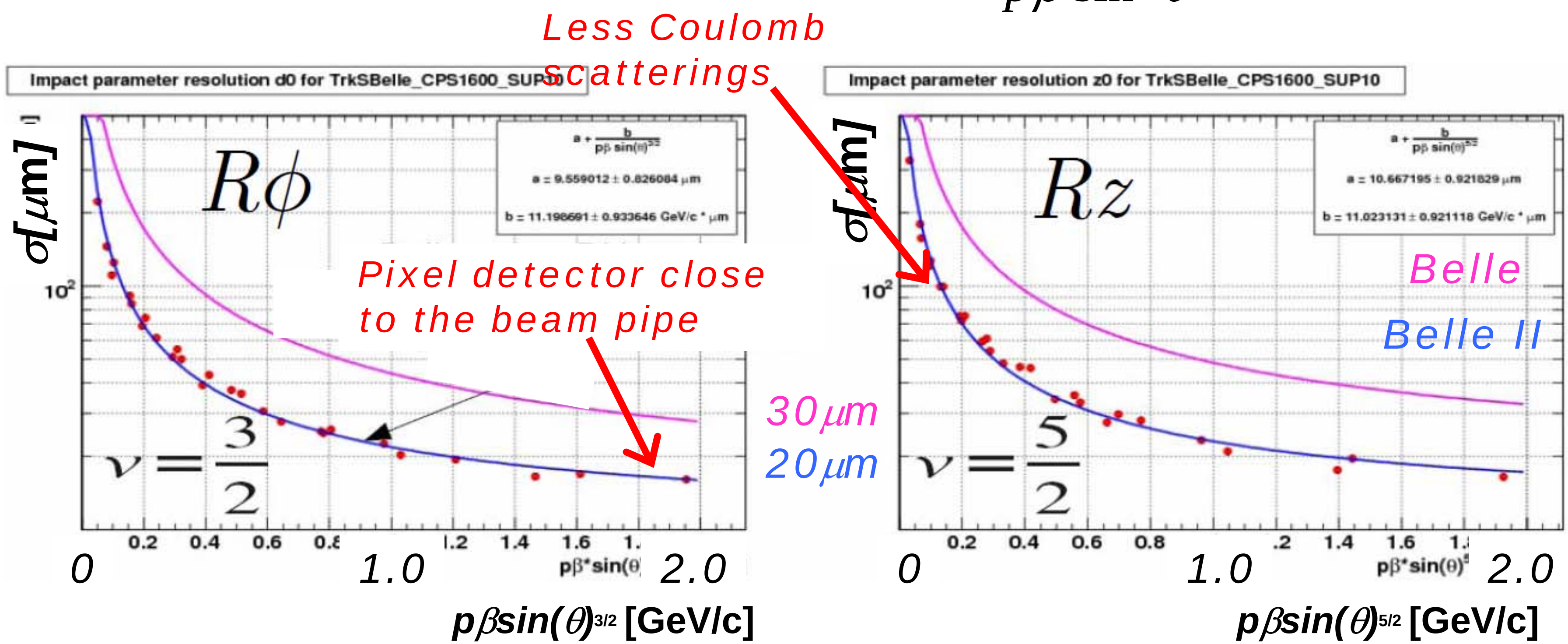
Material budget of Si-Tracking System



Vertex Detector

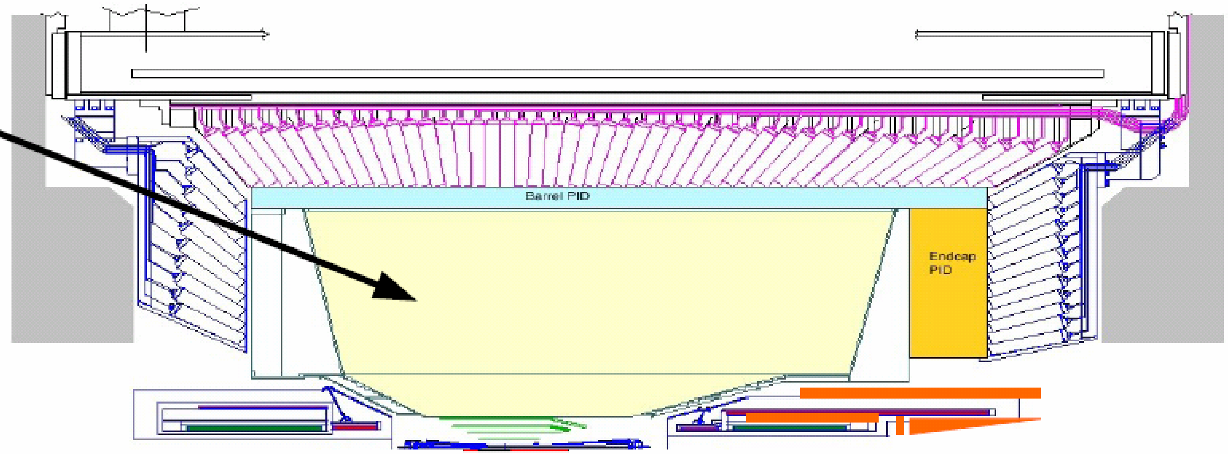
Significant improvement in IP resolution!

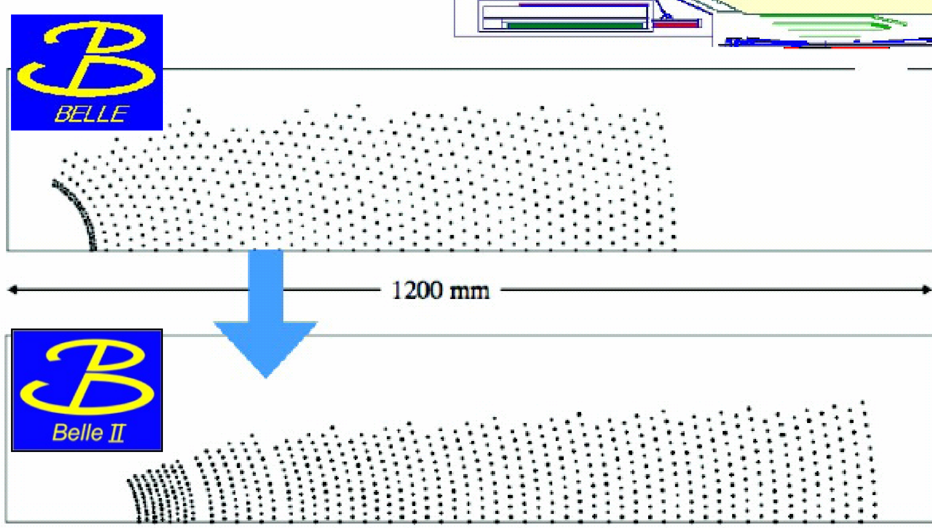
$$\sigma = a + \frac{b}{p\beta \sin^{\nu}\theta}$$



Belle II Drift Chamber

Drift chamber

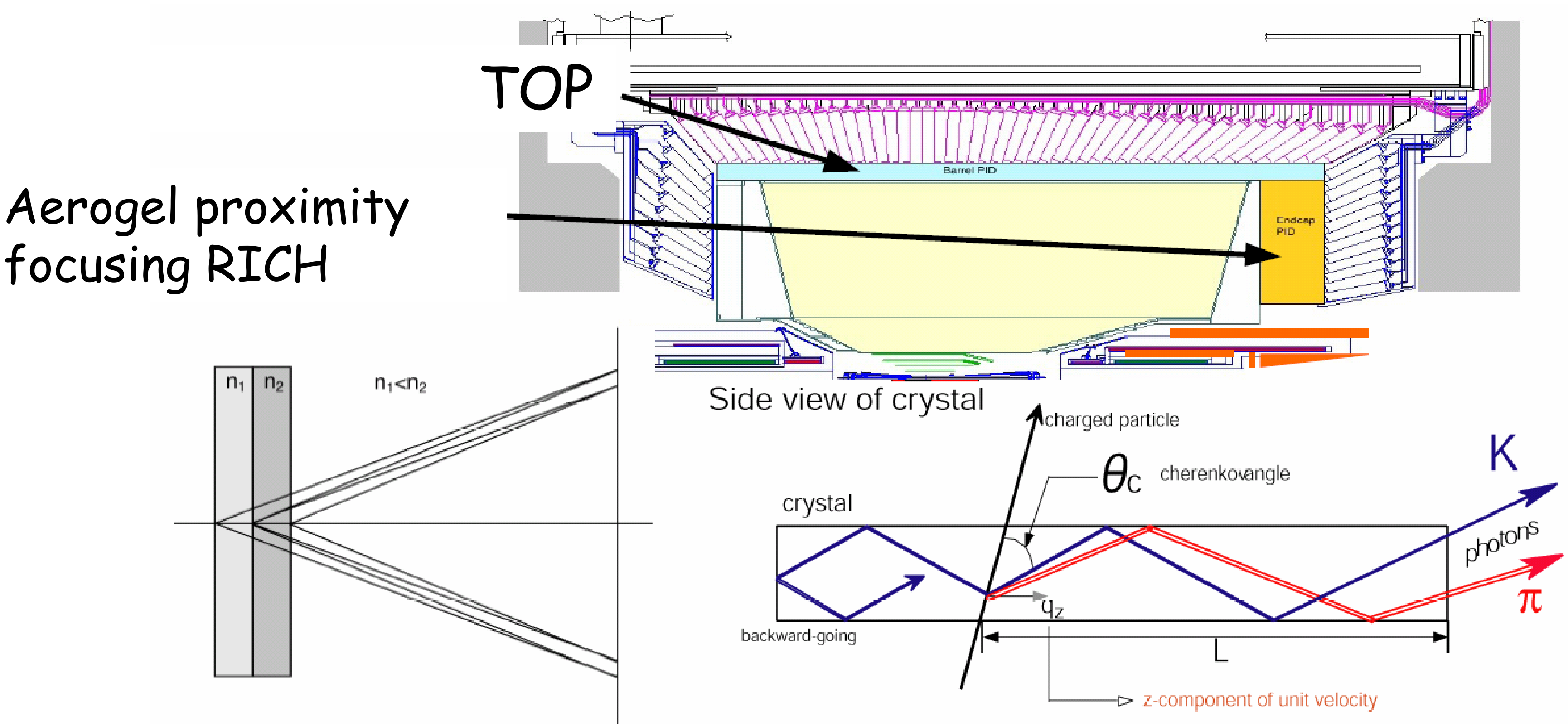




- small cell,
- longer lever arm,
- wave-form sampling

→Better momentum resol. & dE/dx measurements

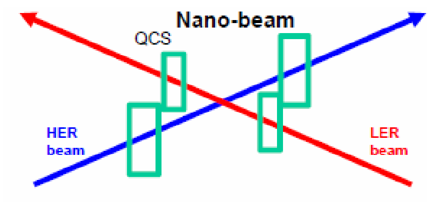
PID: Time-of-Propagation Counter & Aerogel Focusing Rich

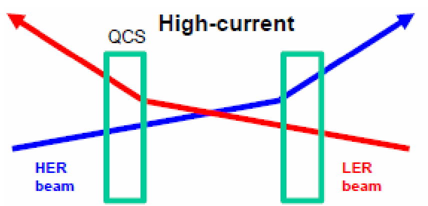


Different opening angles for particles with the same momenta → diff. propagation lengths (=propagation time, ~100ps for π/K)

Backgrounds: S-KEKB nano-beams scheme

- New scheme, no measurements, predictions are uncertain
- Expectation: independent Q magnets shall reduce background drastically compared to the shared Q





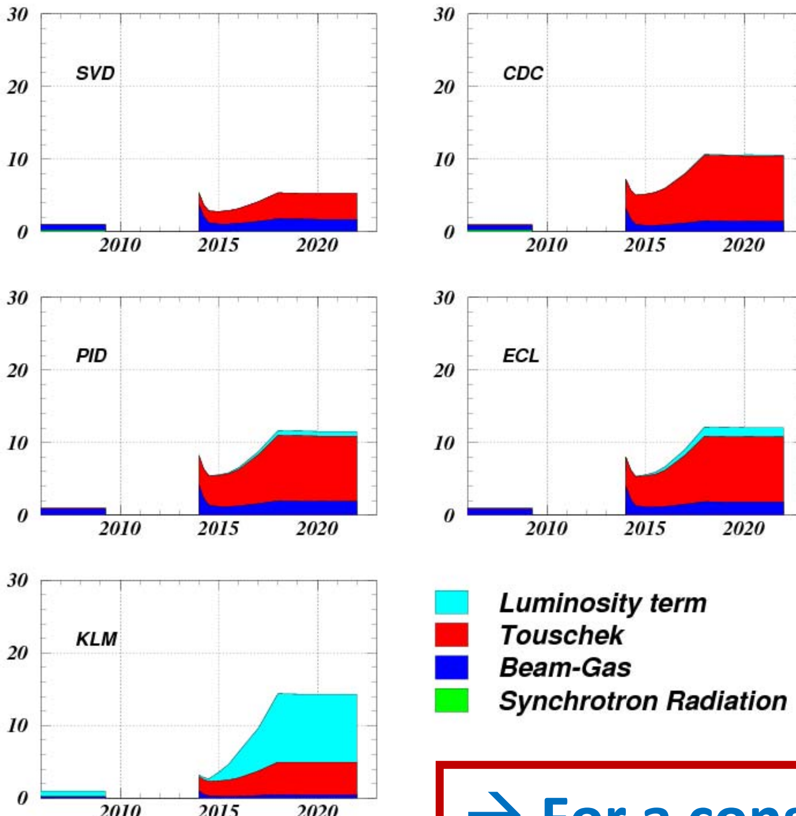
Q works also as bending magnet for the outgoing beam

Scale factors wrt Belle, based on *I, Lumi, lifetime:*

Background component	Scale factor wrt Belle
SR from upstream	v.small (prelim.:5σ beams, non-gaussian tails to be studied)
SR from final Q (backscatter)	2/1600
Beam gas	2-3
Touschek	20-30
Radiative Bhabha (charged)	40/1600
Radiative Bhabha (neutral)	40-50

Scaled with beam lifetime

Background S-KEKB nano-beams (educated guess)



Scaled according to the composition obtained a few years ago.

(Well) below x20.

Background composition will be updated.

→ For a conservative estimate we keep assuming 20 times Belle background level

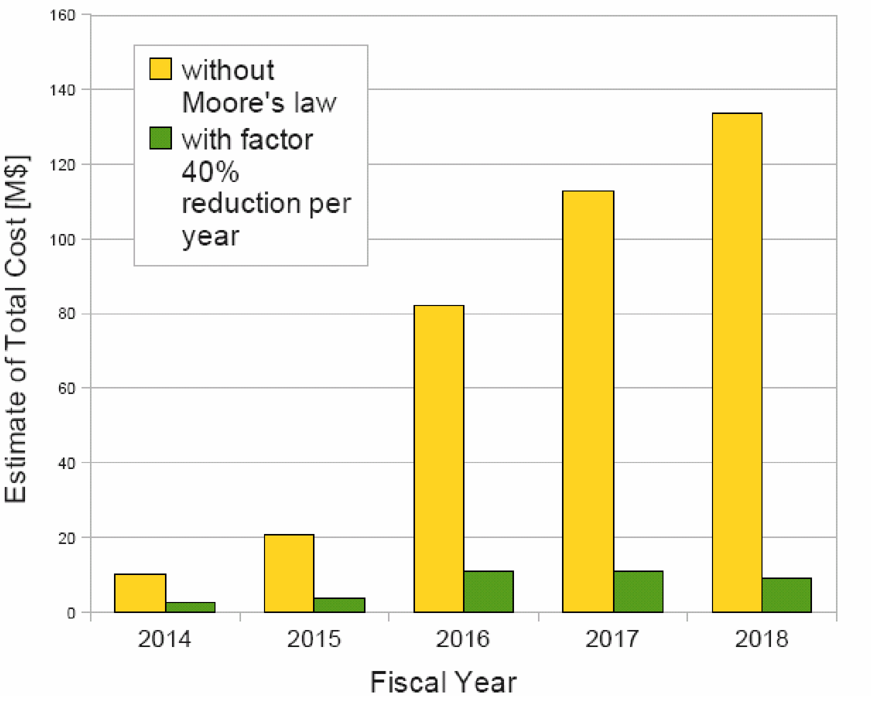
Computing resources

Table 14.9: Expected amount of storage and CPU power for DST production.

Fiscal year (Apr.1-Mar.31)	2014	2015	2016	2017	2018	2019	2020
Raw data							
size per year [PB]	6.6	13.1	52.4	72.0	85.1	85.1	72.0
Total size [PB]	6.6	19.7	72.0	144.1	229.2	314.3	386.4
mDST (per one version)							
size per year [PB]	0.3	0.6	2.3	3.2	3.8	3.8	3.2
Total size [PB]	0.3	0.9	3.2	6.4	10.2	14.0	17.2
DST (per one version)							
size per year [PB]	0.1	0.3	1.1	1.4	1.7	1.7	1.4
Total size [PB]	0.1	0.4	1.4	2.9	4.6	6.3	7.7
CPU [kHepSPEC]	15.2	30.4	121.6	167.3	197.7	197.7	167.3

Table 14.10: Expected amount of storage and CPU power for MC production.

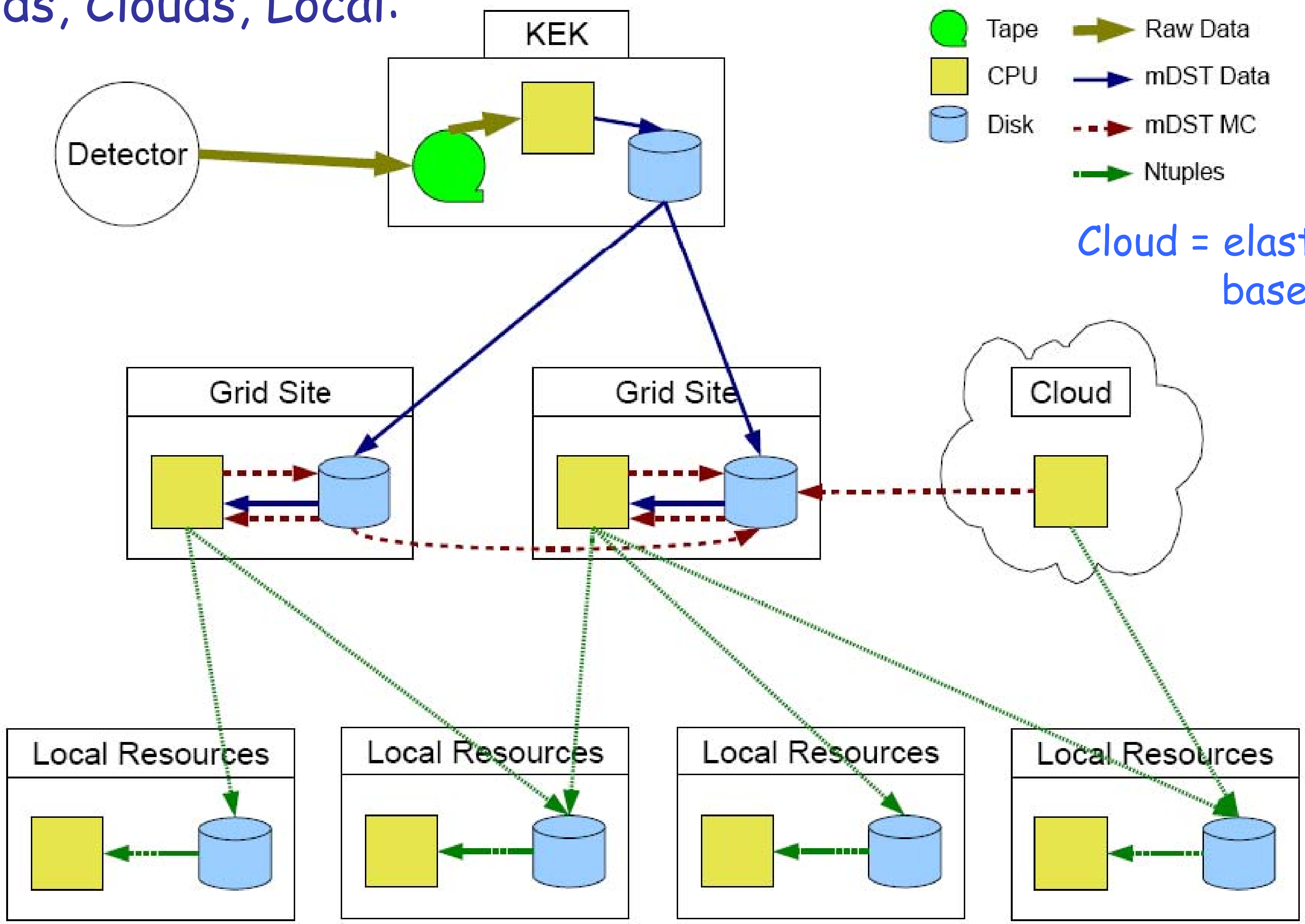
Fiscal year (Apr.1-Mar.31)	2014	2015	2016	2017	2018	2019	2020
MC data							
size per year [PB]	0.9	1.8	7.0	9.6	11.4	11.4	9.6
Total size [PB]	0.9	2.6	9.6	19.2	30.6	41.9	51.5
CPU [kHepSPEC]	30.0	60.1	240.2	330.3	390.4	390.4	330.3



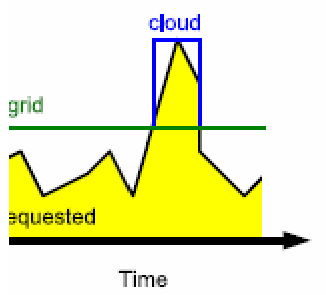
Belle II computing model

Common framework for DAQ and offline based on root I/O

Grids, Clouds, Local:

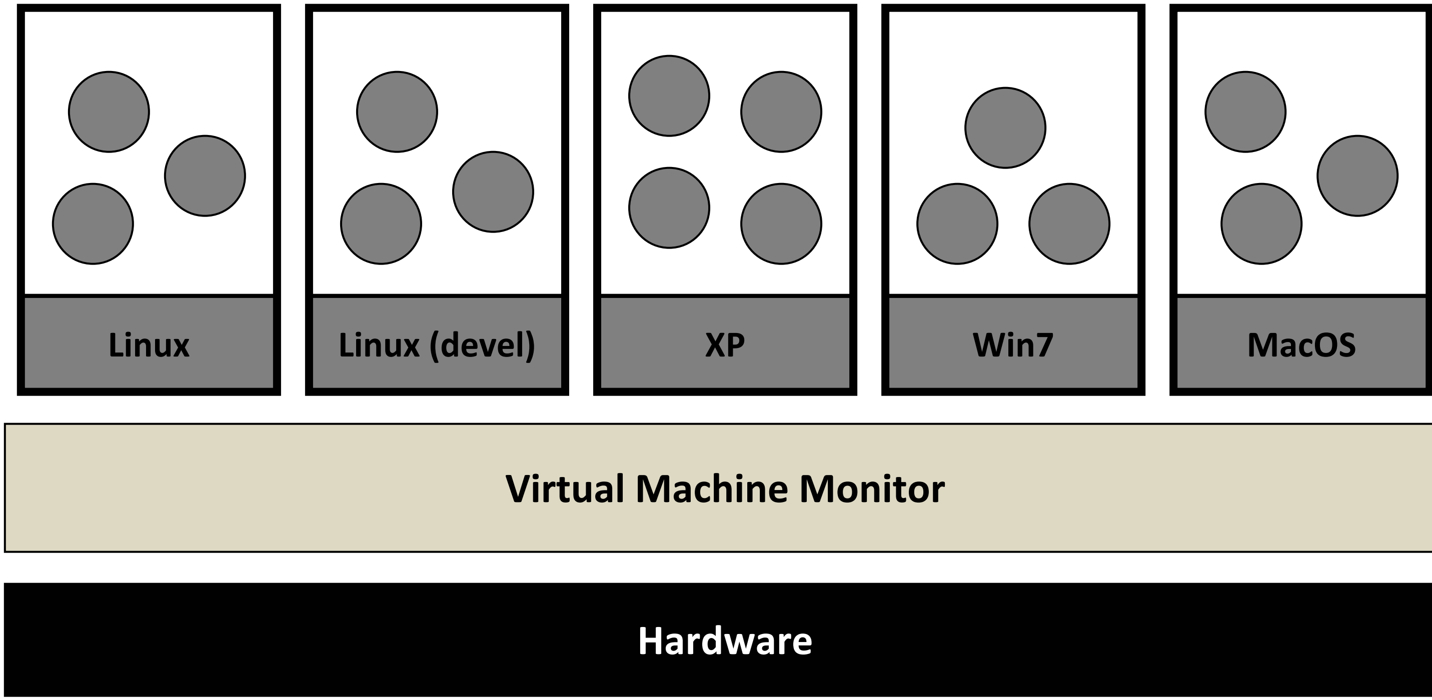


Cloud = elastic resources mgt based on virtualisation



Virtualisation basics

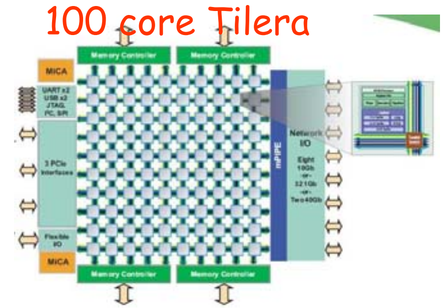
Old idea:
IBM VM/370 in 80's



CPUs:

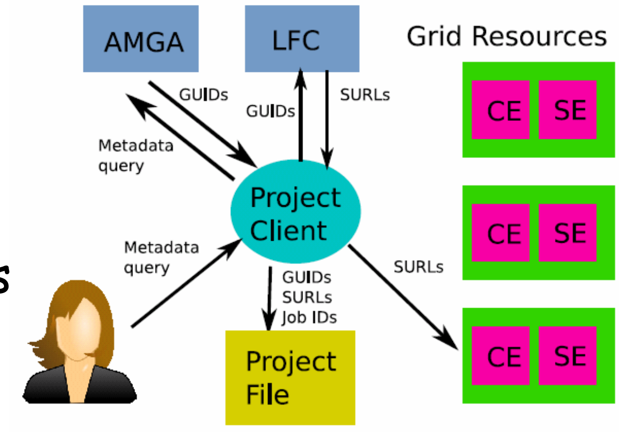
4 core Intel

100 core Tilera

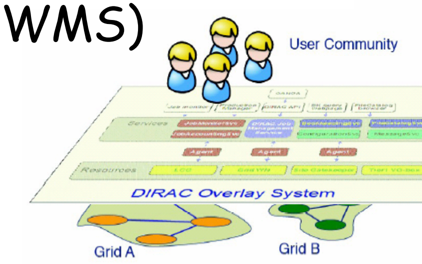


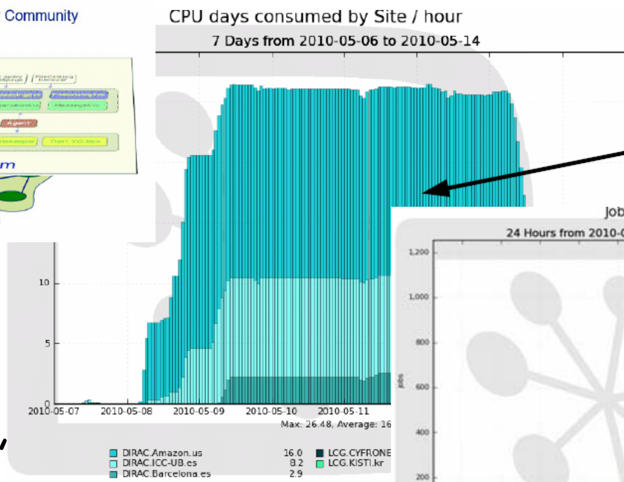
Belle II Distributed Computing

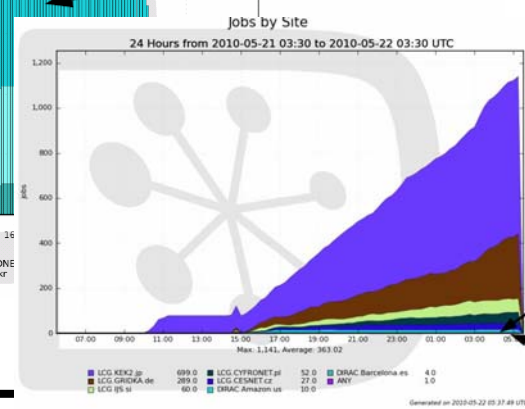
- Our own light-weight tool to submit jobs to Grid (based on CreamCE)



- Developed the framework to submit jobs to Grid(lcg), comercial Cloud (EC2) and local sites at the same time (based on DIRAC LHCb's WMS)







- Develope OpenSorce Cloud system for academic uses: the project started at IFJ PAN Krakow, ~1K cores

Belle II Collaboration

- June 2004: Letter of Intent
- March 2008: First proto collaboration meeting
- December 2008: Belle II founded

~300 members
47 institutes from 13 countries

Belle II Worldwide

You are welcome to join!

Conclusions: The status of the project

- The project obtained preliminary approval by Japanese government in January 2010. Final (funding) decision expected soon

- Technical Design Report: has been completed (~480 pages), reviewed 2 weeks ago by external int. Comm., will be published in July

- Belle finishes data taking at end of June, thus permitting the KEKB upgrade work

- We are well on track to resume data taking in 2014 and looking forward to friendly competition with SuperB and LHCb


Belle II

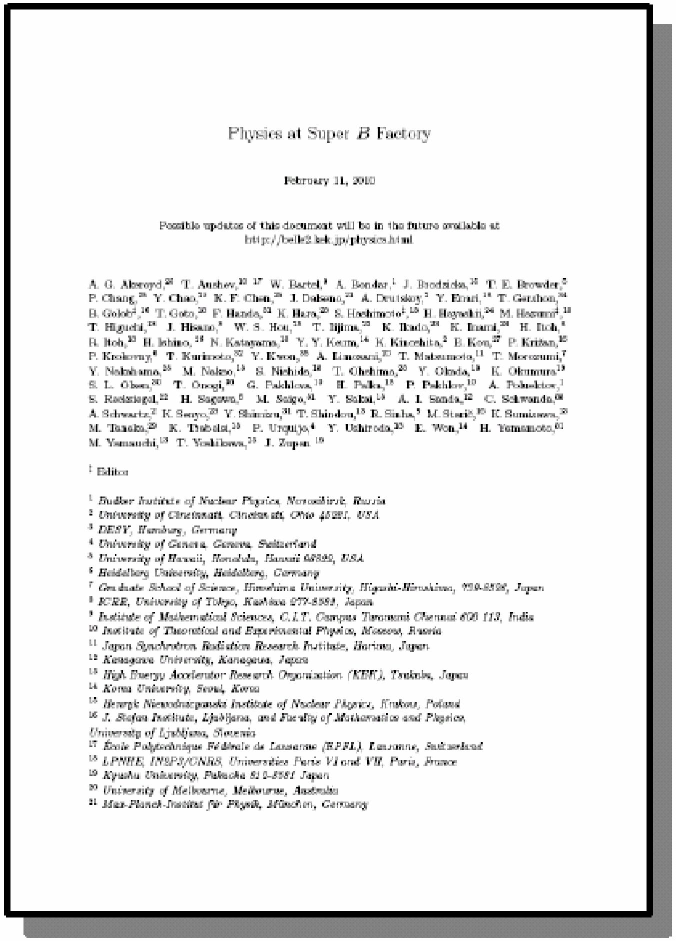
Technical Design Report

Version: 1.1
May 7, 2010

Int. Rev. Comm.:
Marcel Demarteau, Andrey Golutvin, Yuval Grossman, Yoshitaka Kuno, PereMato, Tatsuya Nakada, Niko Neufeld, Tomasz Skwarnicki, Mike Sullivan, and William Trischuk

Backup

Physics at Super B Factory



Physics at Super *B* Factory

February 11, 2010

Possible updates of this document will be in the future available at
http://belle2.kek.jp/physics.html

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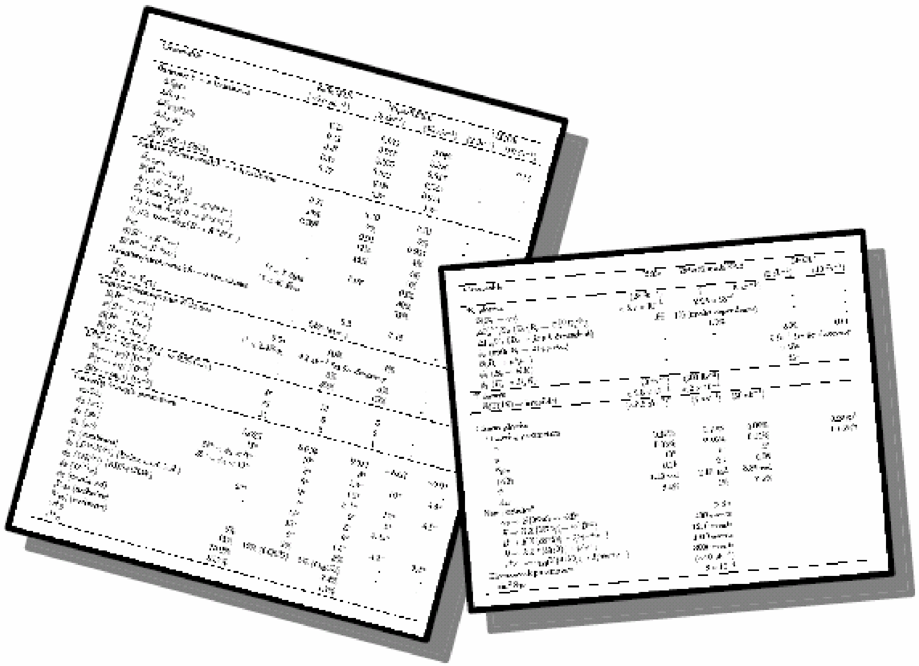
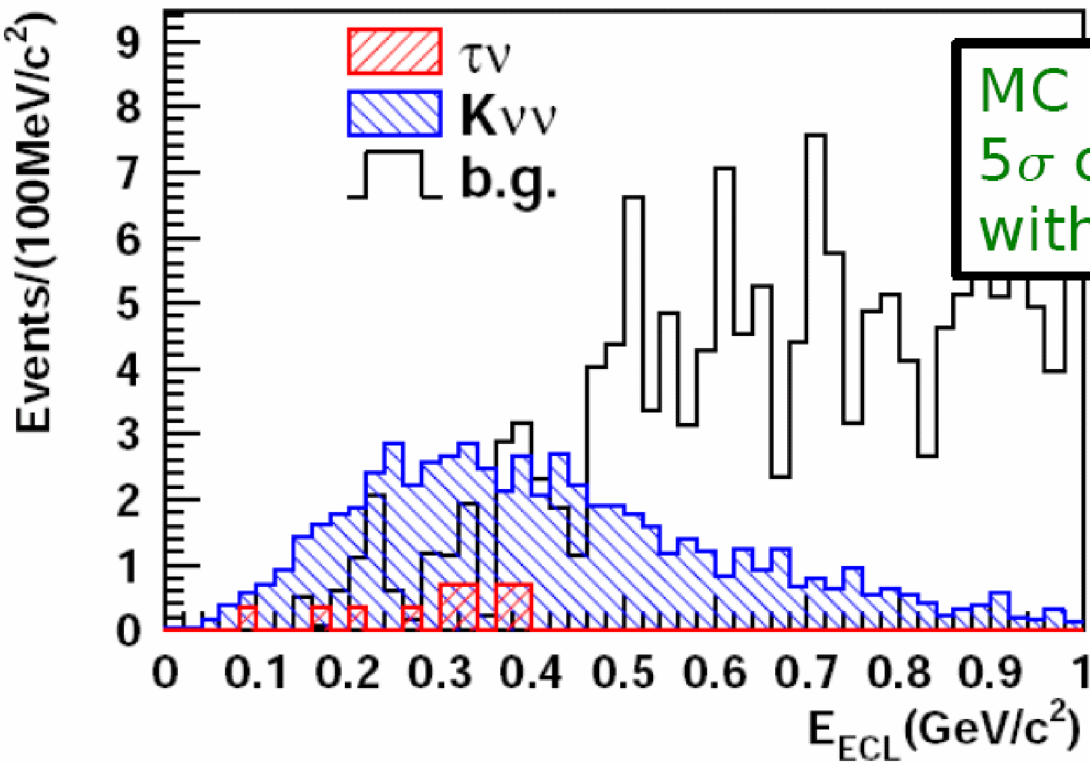
KEK-REPORT-2009-12, Feb 2010,
arXiv:1002.5012 [hep-ex]



$B \to K\nu\nu$

- Theoretically clean mode

→ SM: $B(B^+ \to K^+\nu\nu) = (3.8\ ^{+1.2}_{-0.6}) \times 10^{-6}$

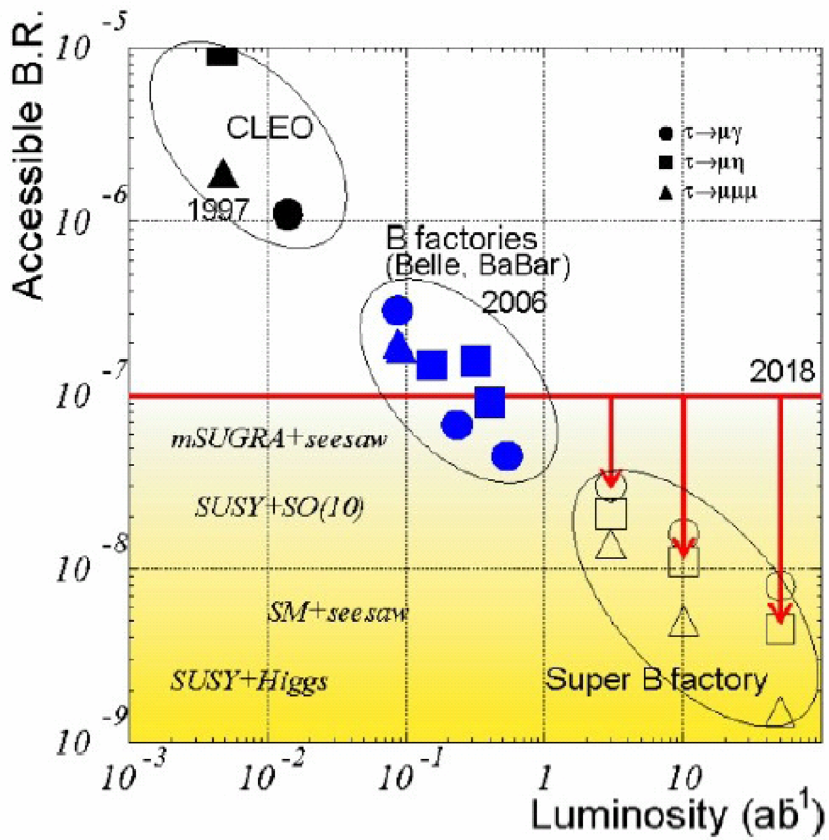


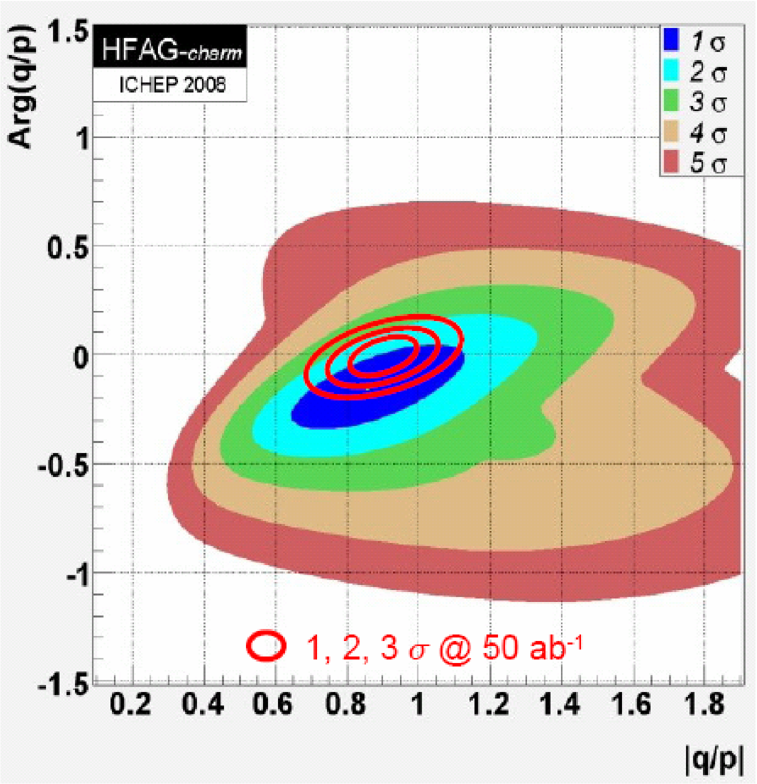
MC study:
5σ observation
with 50 ab^{-1}

Signature
sensitive to
light dark matter

Physics at Belle II

Lepton flavor violation





CP violation in D^0 mixing

Physics at Belle II

Observable	Belle 2006	SuperKEKB		†LHCb	
	(~0.5 ab^{-1})	(5 ab^{-1})	(50 ab^{-1})	(2 fb^{-1})	(10 fb^{-1})
Hadronic $b \to s$ transitions					
$\Delta\mathcal{S}_{\phi K^0}$	0.22	0.073	0.029		0.14
$\Delta\mathcal{S}_{\eta' K^0}$	0.11	0.038	0.020		
$\Delta\mathcal{S}_{K^0_S K^0_S K^0_S}$	0.33	0.105	0.037	-	-
$\Delta\mathcal{A}_{\pi^0 K^0_S}$	0.15	0.072	0.042	-	-
$\mathcal{A}_{\phi\phi K^+}$	0.17	0.05	0.014		
$\phi_1^{eff}(\phi K_S)$ Dalitz		3.3°	1.5°		
Radiative/electroweak $b \to s$ transitions					
$\mathcal{S}_{K^0_S \pi^0 \gamma}$	0.32	0.10	0.03	-	-
$\mathcal{B}(B \to X_s \gamma)$	13%	7%	6%	-	-
$A_{CP}(B \to X_s \gamma)$	0.058	0.01	0.005	-	-
C_9 from $\overline{A}_{\rm FB}(B \to K^* \ell^+ \ell^-)$	-	11%	4%		
C_{10} from $\overline{A}_{\rm FB}(B \to K^* \ell^+ \ell^-)$	-	13%	4%		
C_7/C_9 from $\overline{A}_{\rm FB}(B \to K^* \ell^+ \ell^-)$	-		5%		7%
R_K		0.07	0.02		0.043
$\mathcal{B}(B^+ \to K^+ \nu\nu)$	†† $< 3\ \mathcal{B}_{\rm SM}$		30%	-	-
$\mathcal{B}(B^0 \to K^{*0} \nu\bar{\nu})$	†† $< 40\ \mathcal{B}_{\rm SM}$		35%	-	-
Radiative/electroweak $b \to d$ transitions					
$\mathcal{S}_{\rho\gamma}$	-	0.3	0.15		
$\mathcal{B}(B \to X_d \gamma)$	-	24% (syst.)		-	-

Observable	Belle 2006 (~0.5 ab^{-1})	SuperKEKB (5 ab^{-1})	SuperKEKB (50 ab^{-1})	†LHCb (2 fb^{-1})	†LHCb (10 fb^{-1})
Leptonic/semileptonic B decays					
$\mathcal{B}(B^+ \to \tau^+\nu)$	3.5σ	10%	3%	-	-
$\mathcal{B}(B^+ \to \mu^+\nu)$	†† $< 2.4\mathcal{B}_{SM}$	4.3 ab^{-1} for 5σ discovery		-	-
$\mathcal{B}(B^+ \to D\tau\nu)$	-	8%	3%	-	-
$\mathcal{B}(B^0 \to D\tau\nu)$	-	30%	10%	-	-
LFV in τ decays (U.L. at 90% C.L.)					
$\mathcal{B}(\tau \to \mu\gamma)$ [10^{-9}]	45	10	5	-	-
$\mathcal{B}(\tau \to \mu\eta)$ [10^{-9}]	65	5	2	-	-
$\mathcal{B}(\tau \to \mu\mu\mu)$ [10^{-9}]	21	3	1	-	-
Unitarity triangle parameters					
$\sin 2\phi_1$	0.026	0.016	0.012	~0.02	~0.01
ϕ_2 ($\pi\pi$)	11°	10°	3°	-	-
ϕ_2 ($\rho\pi$)	$68° < \phi_2 < 95°$	3°	1.5°	10°	4.5°
ϕ_2 ($\rho\rho$)	$62° < \phi_2 < 107°$	3°	1.5°	-	-
ϕ_2 (combined)		2°	$\lesssim 1°$	10°	4.5°
ϕ_3 ($D^{(*)}K^{(*)}$) (Dalitz mod. ind.)	20°	7°	2°	8°	
ϕ_3 ($DK^{(*)}$) (ADS+GLW)	-	16°	5°	5-15°	
ϕ_3 ($D^{(*)}\pi$)	-	18°	6°		
ϕ_3 (combined)		6°	1.5°	4.2°	2.4°
$\lvert V_{ub}\rvert$ (inclusive)	6%	5%	3%	-	-
$\lvert V_{ub}\rvert$ (exclusive)	15%	12% (LQCD)	5% (LQCD)	-	-
††† $\bar{\rho}$	20.0%		3.4%		
††† $\bar{\eta}$	15.7%		1.7%		

Observable	Belle	Belle/SuperKEKB		LHCb[†]	
				(2 fb^{-1})	(10 fb^{-1})
B_s physics	(25 fb^{-1})	(5 ab^{-1})			
$\mathcal{B}(B_s \to \gamma\gamma)$	$< 8.7 \times 10^{-6}$	0.25×10^{-6}		-	-
$\Delta\Gamma_s^{CP}/\Gamma_s$ ($Br(B_s \to D_s^{(*)} D_s^{(*)})$)	3%	1% (model dependency)		-	-
$\Delta\Gamma_s/\Gamma_s$ ($B_s \to f_{CP}$ t-dependent)	-	1.2%		-	-
ϕ_s (with $B_s \to J/\psi\phi$ etc.)	-	-	-	0.02	0.01
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-			6 fb^{-1} for 5σ discovery	
ϕ_3 ($B_s \to KK$)	-			7-10°	
ϕ_3 ($B_s \to D_s K$)	-			13°	
Υ decays	(3 fb^{-1})	(500 fb^{-1})			
$\mathcal{B}(\Upsilon(1S) \to$ invisible)	$< 2.5 \times 10^{-3}$	$< 2 \times 10^{-4}$			
	($\sim$0.5 ab^{-1})[‡]	(5 ab^{-1})	(50 ab^{-1})		
Charm physics					
D mixing parameters					
x	0.25%	0.12%	0.09%		0.25%[††]
y	0.16%	0.10%	0.05%		0.05%[††]
$\delta_{K\pi}$	10°	6°	4°		
$\lvert q/p \rvert$	0.16	0.1	0.05		
ϕ	0.13 rad	0.08 rad	0.05 rad		
A_D	2.4%	1%	0.3%		
New particles[ℵ]					
$\gamma\gamma \to Z(3930) \to D\bar{D}^*$		$> 3\sigma$			
$B \to KX(3872)(\to D^0\bar{D}^{*0})$		400 events			
$B \to KX(3872)(\to J/\psi\pi^+\pi^-)$		1250 events			
$B \to KZ^+(4430)(\to \psi'\pi^+)$		1000 events			
$e^+e^- \to \gamma_{\mathrm{ISR}} Y(4260)(\to J/\psi\pi^+\pi^-)$		3000 events			
Electroweak parameters		($\sim$10 ab^{-1})			
$\sin^2\Theta_W$	-	3×10^{-4}			

Comparison Belle II / LHCb

e^+e^- has advantages in…	LHCb has advantages in…
CPV in $B \to \phi K_S$, $\eta' K_S$, …	CPV in $B \to J/\psi K_S$
CPV in $B \to K_S \pi^0 \gamma$	Most of B decays not including ν or γ
$B \to K\nu\nu$, $\tau\nu$, $D^{(*)}\tau\nu$	Time dependent measurements of B_S
Inclusive $b \to s\mu\mu$, *see*	$B_{(s,d)} \to \mu\mu$
$\tau \to \mu\gamma$ and other LFV	B_c and bottomed baryons
$D^0 \overline{D^0}$ mixing	

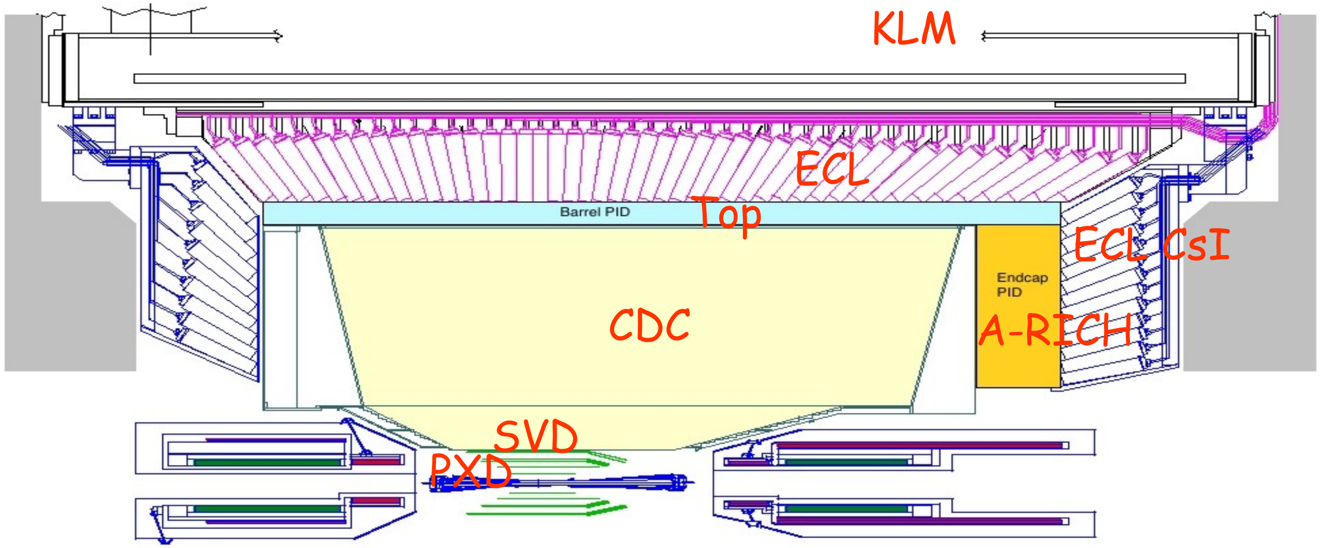
Expected performance

Table 1.3: Expected performance of components of the Belle II spectrometer.

Component	Type	Configuration	Readout	Performance
Beam pipe	Beryllium double-wall	Cylindrical, inner radius 10 mm, 10 μm Au, 0.6 mm Be, 1 mm coolant (paraffin), 0.4 mm Be		impact parameter resolution $\sigma_{z_0} \sim 20\ \mu$m (PXD and SVD)
PXD	Silicon pixel (DEPFET)	Sensor size: 15×100 (120) mm^2 pixel size: 50×50 (75) μm^2 2 layers: 8 (12) sensors	10 M	
SVD	Double sided Silicon strip	Sensors: rectangular and trapezoidal Strip pitch: 50(p)/160(n) - 75(p)/240(n) μm 4 layers: 16/30/56/85 sensors	245 k	
CDC	Small cell drift chamber	56 layers, 32 axial, 24 stereo r = 16 - 112 cm - 83 $\leq z \leq$ 159 cm	14 k	$\sigma_{r\phi} = 100\ \mu$m, $\sigma_z = 2$ mm $\sigma_{p_t}/p_t = \sqrt{(0.2\% p_t)^2 + (0.3\%/\beta)^2}$ $\sigma_{p_t}/p_t = \sqrt{(0.1\% p_t)^2 + (0.3\%/\beta)^2}$ (with SVD) $\sigma_{dE/dx} = 5\%$
TOP	RICH with quartz radiator	16 segments in ϕ at $r \sim 120$ cm 275 cm long, 2 cm thick quartz bars with 4x4 channel MCP PMTs	8 k	$N_{p.e.} \sim 20$, $\sigma_t = 40$ ps K/π separation : efficiency > 99% at < 0.5% pion fake prob. for $B \to \rho\gamma$ decays
ARICH	RICH with aerogel radiator	4 cm thick focusing radiator and HAPD photodetectors for the forward end-cap	78 k	$N_{p.e.} \sim 13$ K/π separation at 4 GeV/c: efficiency 96% at 1% pion fake prob.
ECL	CsI(Tl) (Towered structure)	Barrel: $r = 125$ - 162 cm End-cap: $z =$ -102 cm and +196 cm	6624 1152 (F) 960 (B)	$\frac{\sigma E}{E} = \frac{0.2\%}{E} \oplus \frac{1.6\%}{\sqrt[4]{E}} \oplus 1.2\%$ $\sigma_{pos} = 0.5\ \mathrm{cm}/\sqrt{E}$ (E in GeV)
KLM	barrel: RPCs	14 layers (5 cm Fe + 4 cm gap) 2 RPCs in each gap	θ: 16 k, ϕ: 16 k	$\Delta\phi = \Delta\theta = 20$ mradian for K_L ~ 1 % hadron fake for muons
	end-caps: scintillator strips	14 layers of $(7-10) \times 40$ mm^2 strips read out with WLS and G-APDs	17 k	$\Delta\phi = \Delta\theta = 10$ mradian for K_L $\sigma_p/p = 18\%$ for 1 GeV/c K_L

Belle II Detector

Designed for improved performance and to cope with higher event rates and backgrounds



SVD: 2 DEPFET pixels layers
+ 4 DSSD layers
CDC: small cell, long lever arm, wave-form sampl.
TOP +Aerogel Focusing RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: Scintillator +SiPM (end-caps)

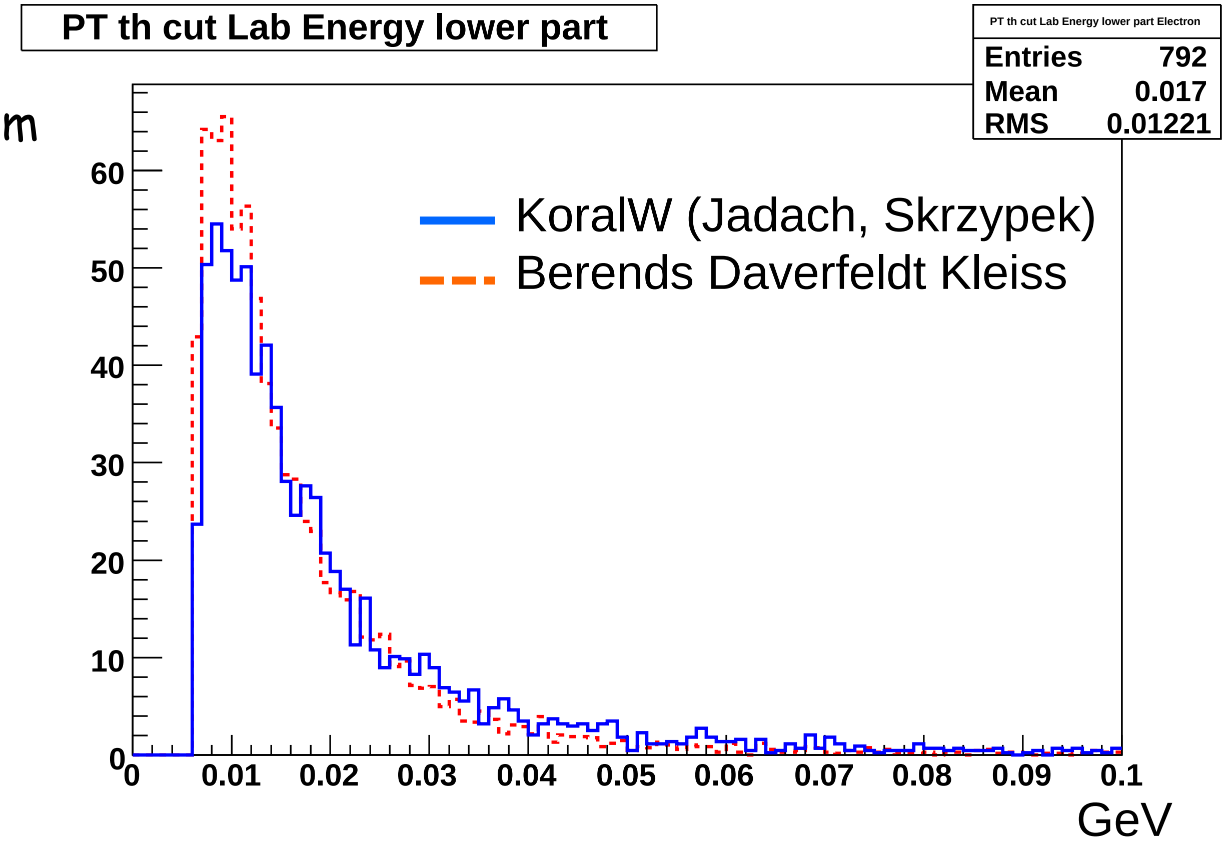
new dead time free readout and high speed DAQ systems

QED background simulation

First PXD layer, spectrum normalized to one event

These (additional) tracks yield an occupancy of 0.1 %

KoralW simulation constants confirmed by the KoralW authors



Such spectra have never been measured yet: → recently background study runs taken at different conditions in Belle

Benefits of virtualisation

- Site perspective
  - Resource flexibility
    (e.g. wrt Linux distributions)
  - Easy resources management

- User perspective
  - Isolation from environment:
    multisystem applications
    identical environment on multiple sites
    identical environment on local machine

Drawbacks:
- performance penalty (depends on virt. method)
  number crunching: negligible,
  I/O varies....