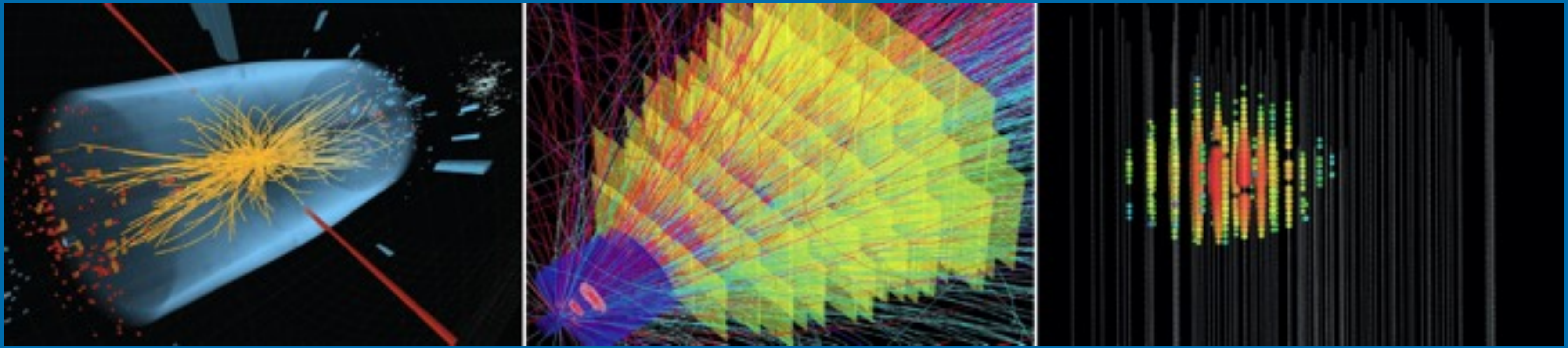
Belle (II)

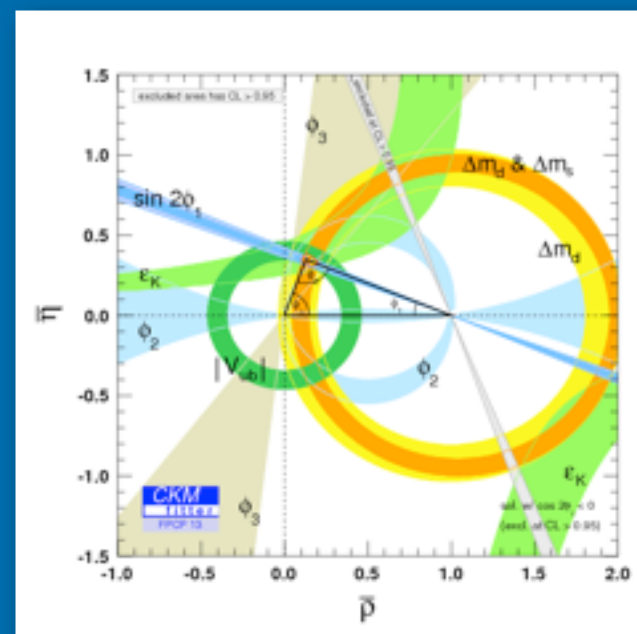


Carsten Niebuhr – DESY

HELMHOLTZ ASSOCIATION

Motivation

Search for Origin of CP Violation and New Physics

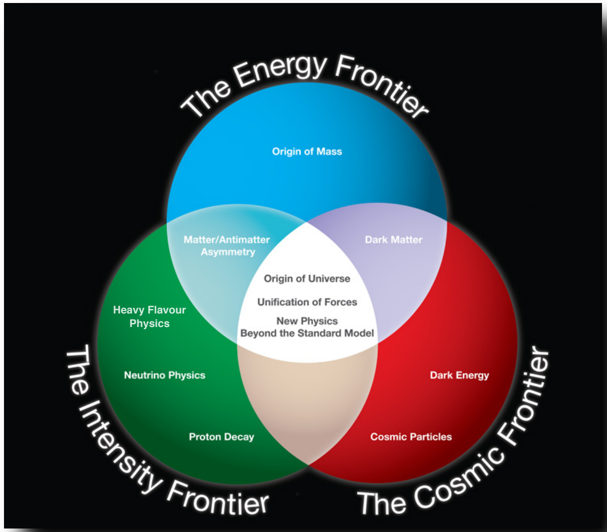


Alternative Search Strategies for New Physics

Complementary approaches to study shortcomings of the SM

Energy frontier

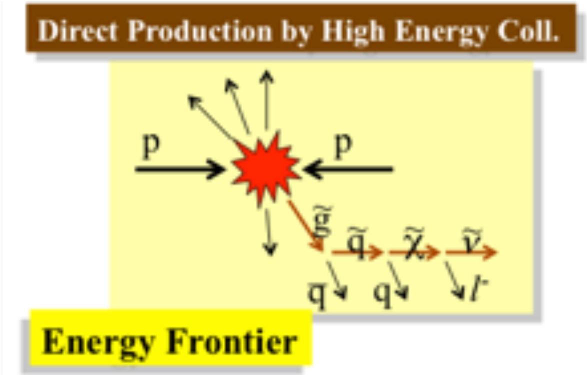
- direct search for production of new particles at the highest energies
  - pp collider LHC
  - to be complemented by future high energy e^+e^- collider: ILC / CLIC

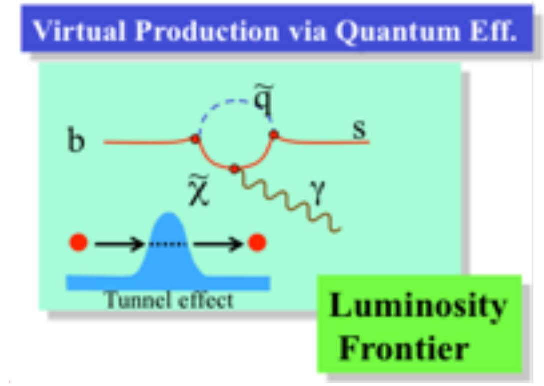


Intensity frontier

- search in very rare processes for deviations between theory predictions and experiments with ultimate precision
- see effects of „virtual“ new particles in loops
  - (Super-)Flavour Factories, high intensity proton accelerators

The Role of Flavour Physics





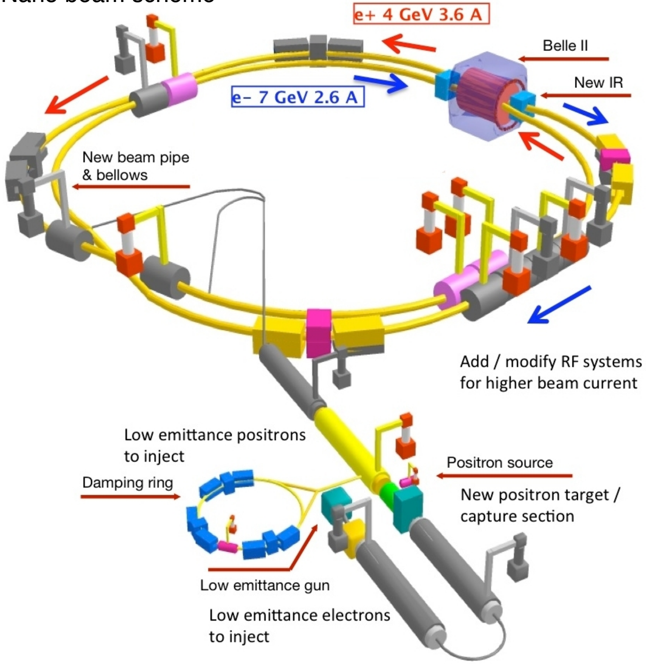
LHC and Belle II/SuperKEKB yield complementary information

Possible future scenarios:

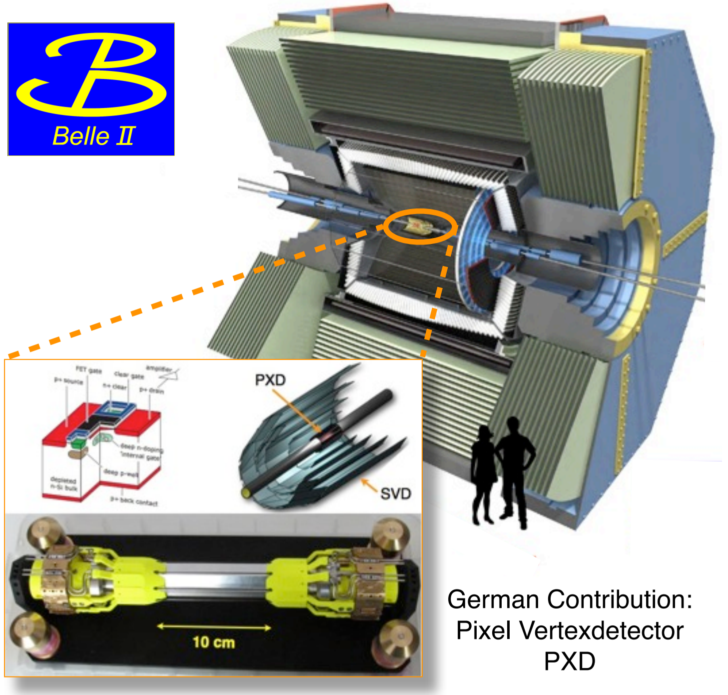
- LHC discovers new high-mass states
  - then have to distinguish between alternative models
  - this will inevitably require tighter constraints also from the flavour sector
- LHC does not find any new physics
  - ability of high precision flavour experiments to probe mass scales far above the LHC reach through virtual effects is very important to establish scale of new physics Λ_{NP}

Belle II and SuperKEKB in Japan

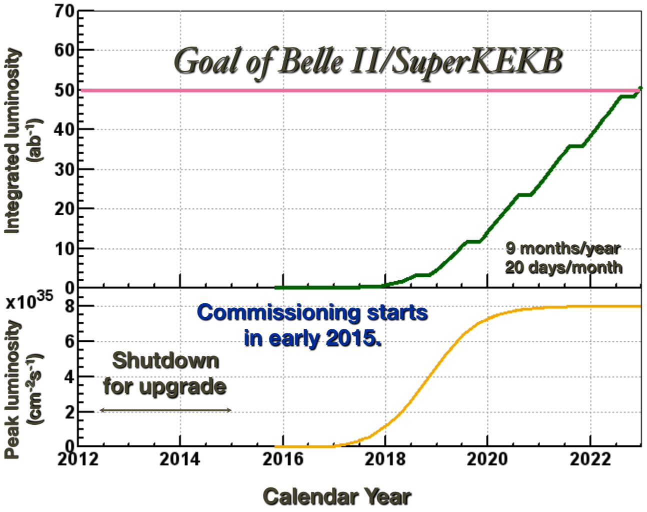
SuperKEKB and Belle II



DESY joined Belle II in November 2011

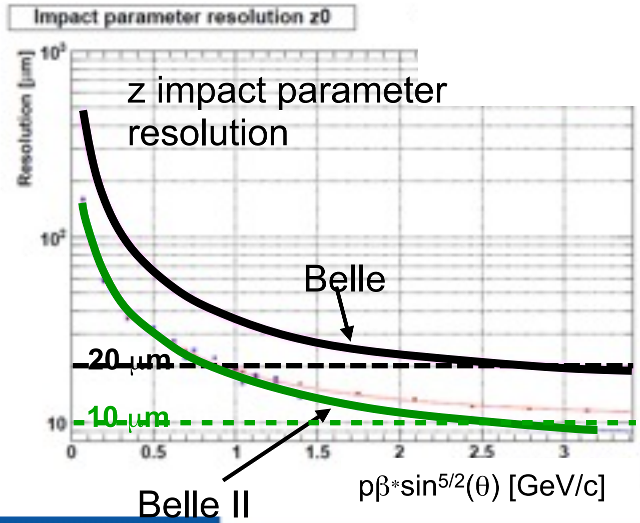


German Contribution:
Pixel Vertexdetector
PXD



Goal:

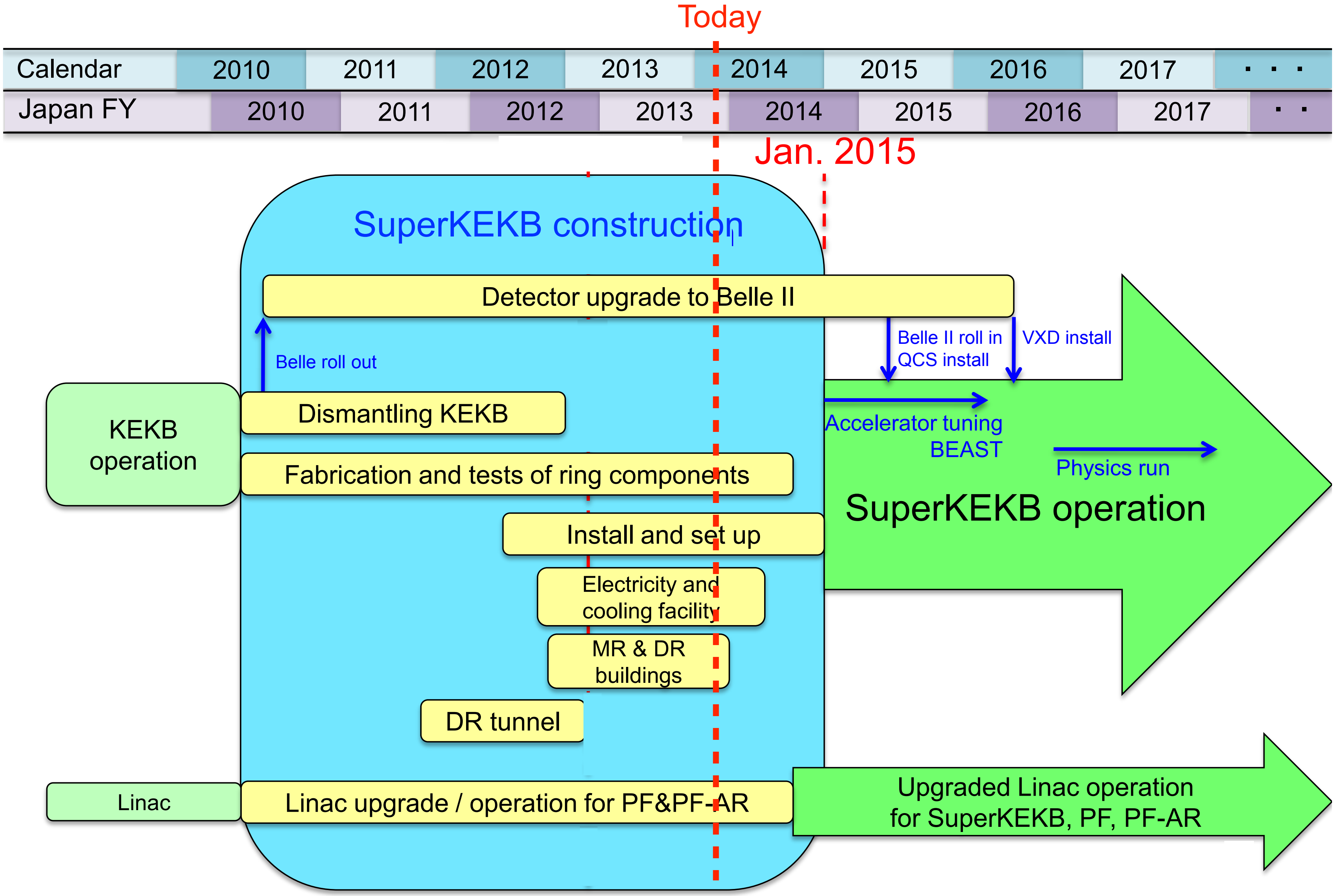
$$\int \mathcal{L}_{\mathrm{KEKB}} \cdot \mathbf{50}$$



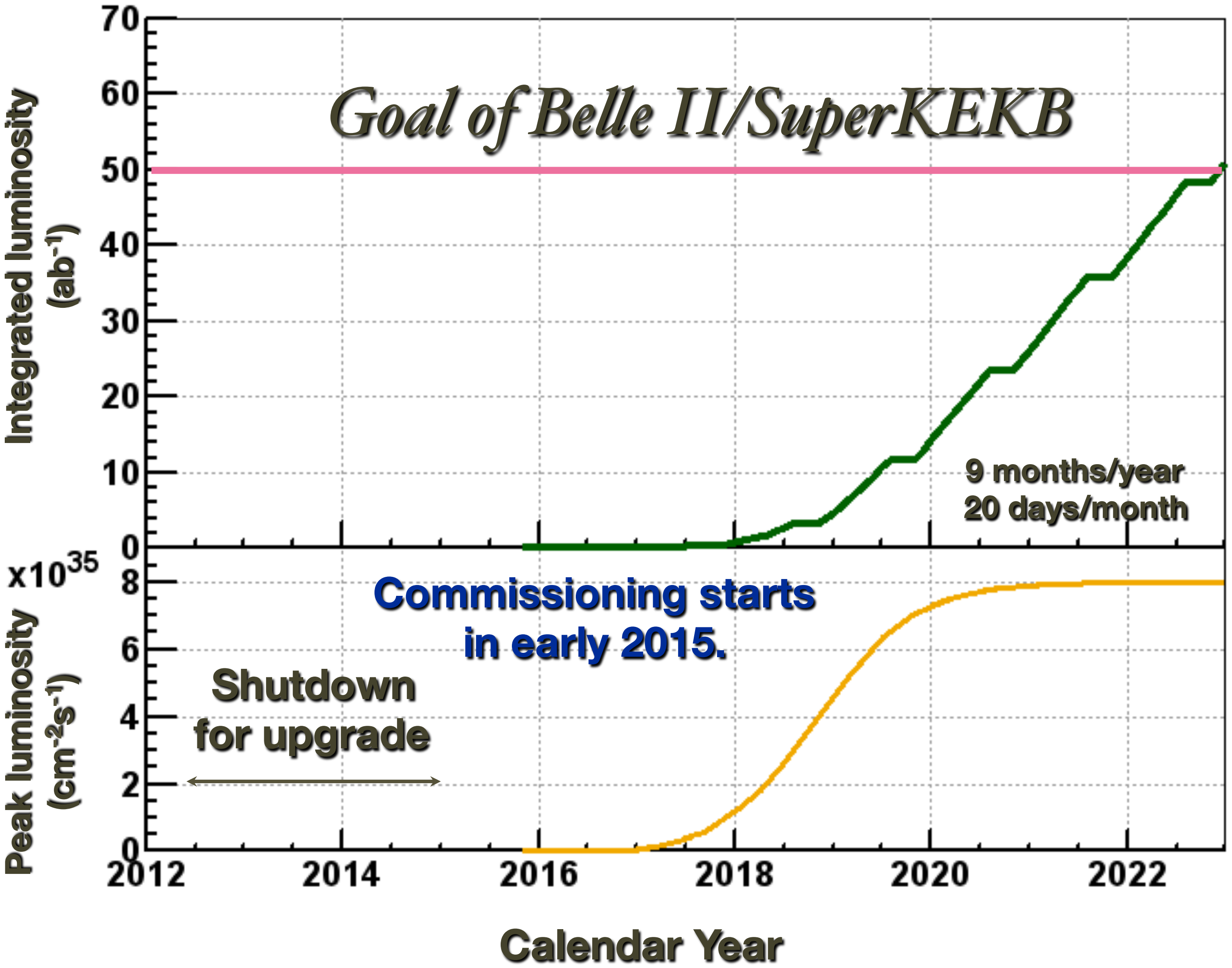
Goal:

$$\frac{\sigma_z(\mathrm{Belle})}{\mathbf{2}}$$

SuperKEKB Schedule

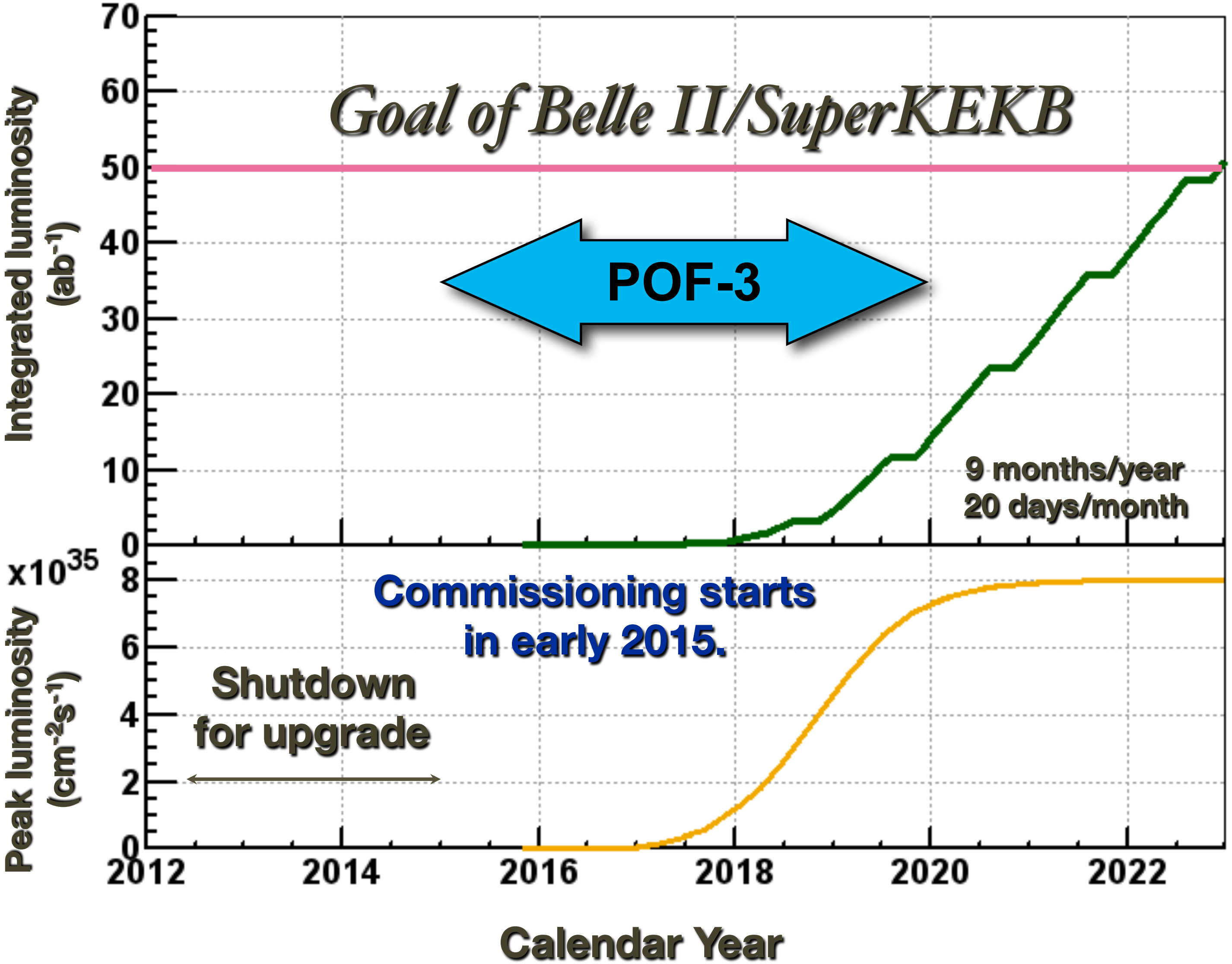


Challenging Luminosity Goal of Belle II/SuperKEKB



$$8 \cdot 10^{35} \mathrm{cm}^{-2}\mathrm{s}^{-1} = 40 \times \mathcal{L}_{KEK}$$

Challenging Luminosity Goal of Belle II/SuperKEKB

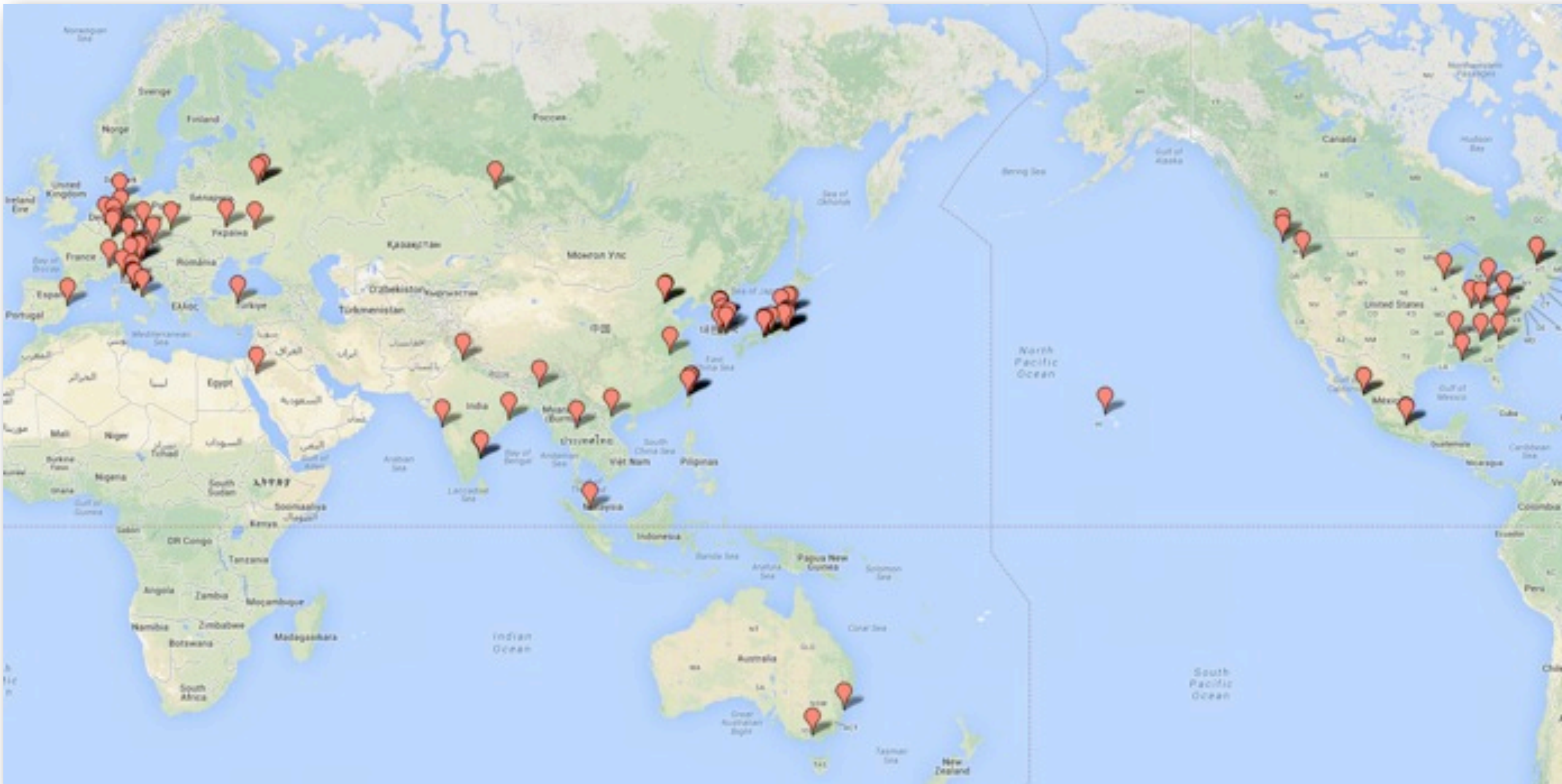


$$8 \cdot 10^{35} \mathrm{cm}^{-2}\mathrm{s}^{-1} = 40 \times \mathcal{L}_{KEK}$$

Growing Belle II Collaboration

- Recently significant influx from former SuperB members

- 595 members from 95 institutions
- 23 countries



Growing Belle II Collaboration

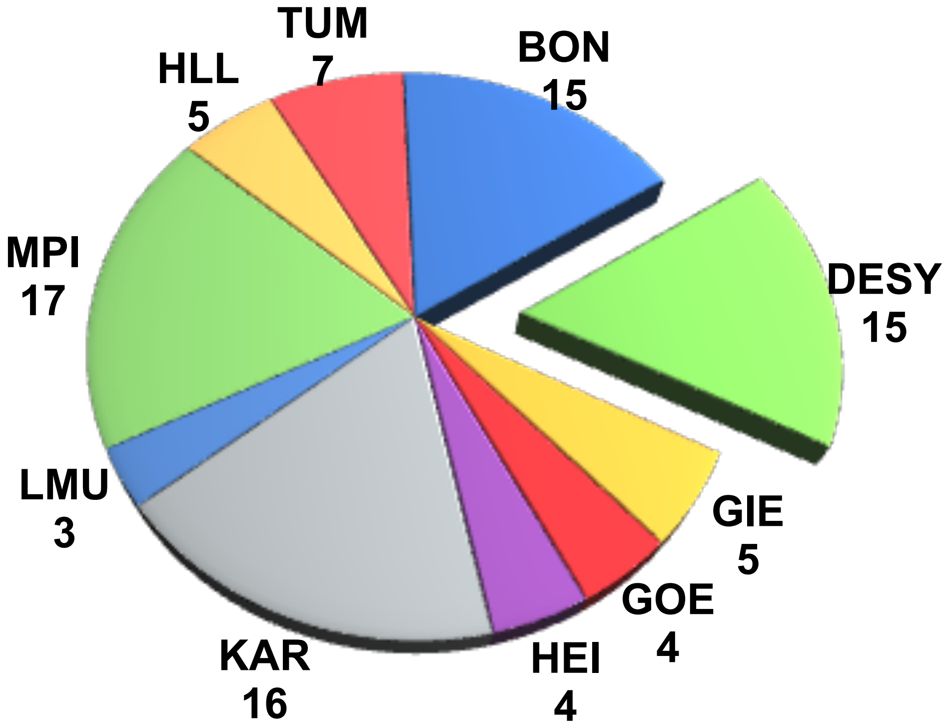
- Recently significant influx from former SuperB members

- 595 members from 95 institutions
- 23 countries

German Participation in Belle II

Germany 2nd largest country after Japan

- Belle II 3rd largest particle physics project in Germany after ATLAS and CMS
- DESY among 4 largest German groups
- University of Hamburg intends to join in the near future (Caren Hagner et al.)

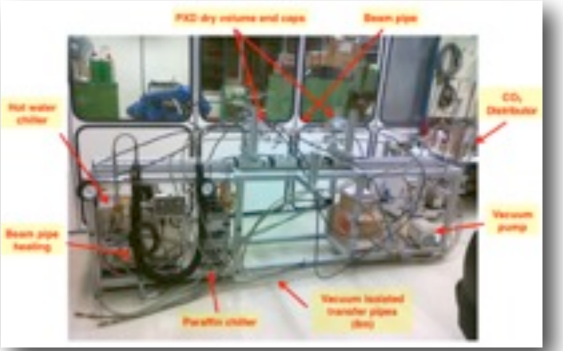


DESY Contributions

DESY Activities around Belle II VXD

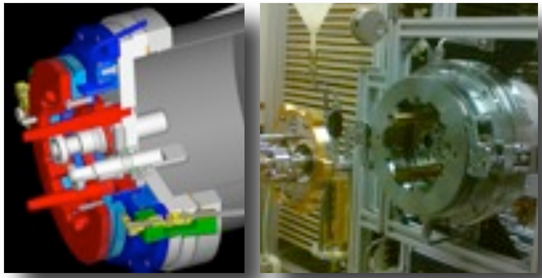
Support German Belle II groups by exploiting specific expertise available at DESY

Thermal Mock-up & CO_2 Cooling



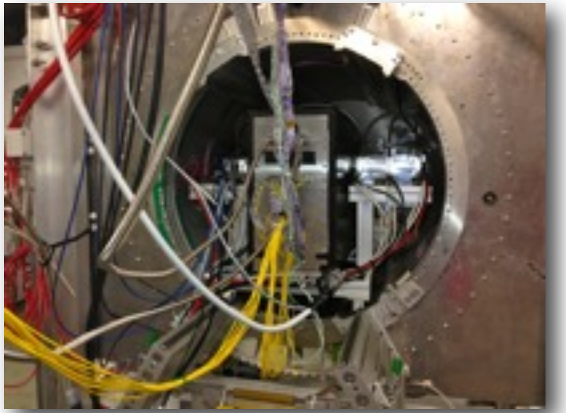
VXD Support Structure

Remote Vacuum Connection

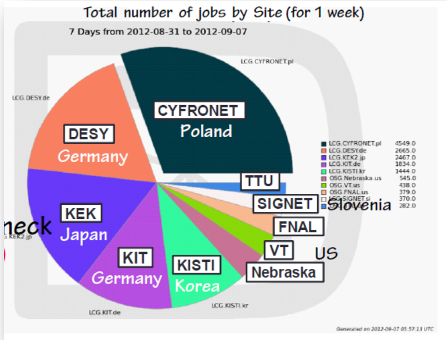


Slow Control & DAQ

DESY Testbeam

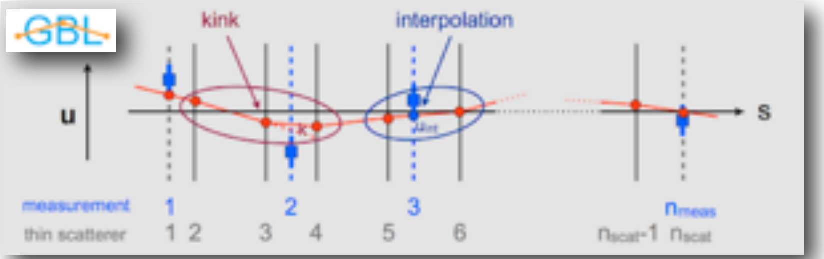


Grid/NAF/Data Preservation



SynRad Background MC

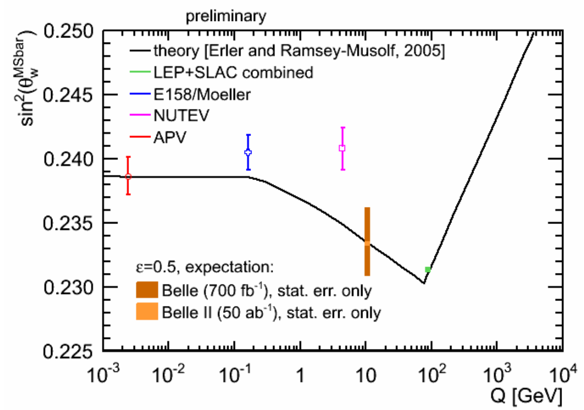
Tracking, Alignment and Calibration



Ongoing Analyses of Belle Data @ DESY

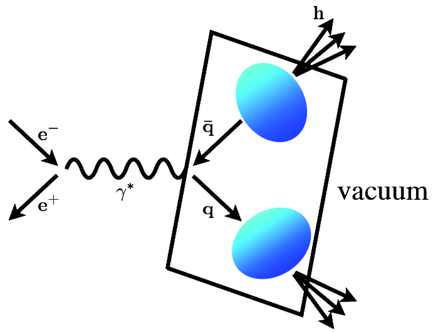
Measurement of forward-backward asymmetry A_{FB} of muon pairs

- huge statistics of $O(10^9)$ muon pairs yields sensitivity to weak mixing angle $\sin^2\theta_W$



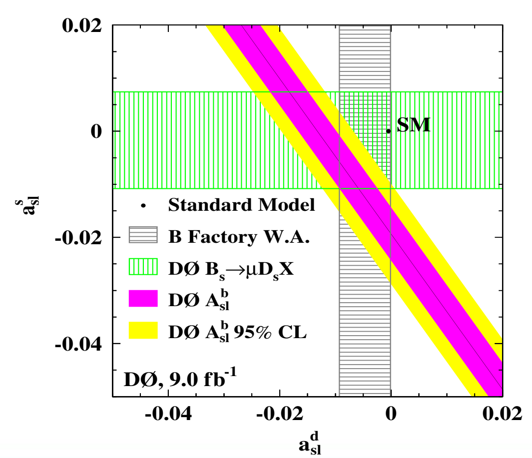
Probing the QCD vacuum structure

- measure 2-hadron final states
- longitudinal jet handedness & correlation



Search for rare process $B \to K^{(*)}\tau\tau$

- present upper limit (BaBar) $\mathcal{B}(B \to K\tau\tau) < 10^{-3}$
- may help to understand anomalously large CPV in semileptonic neutral B-decays (like-sign dimuon charge asymmetry D0: 3.9σ from SM)



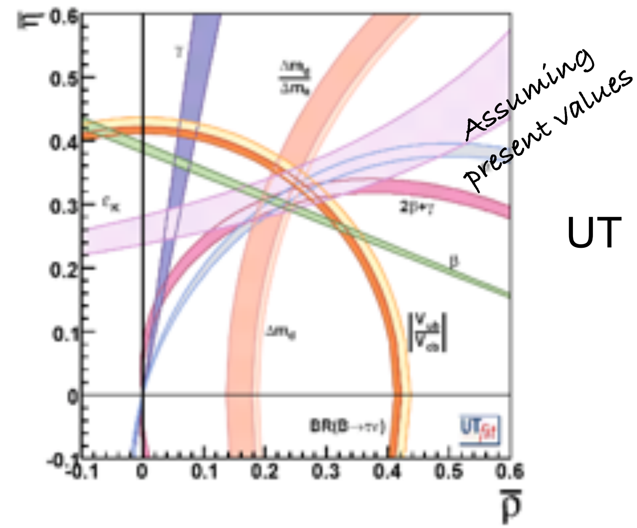
Conclusions

Belle II offers very rich Physics Program

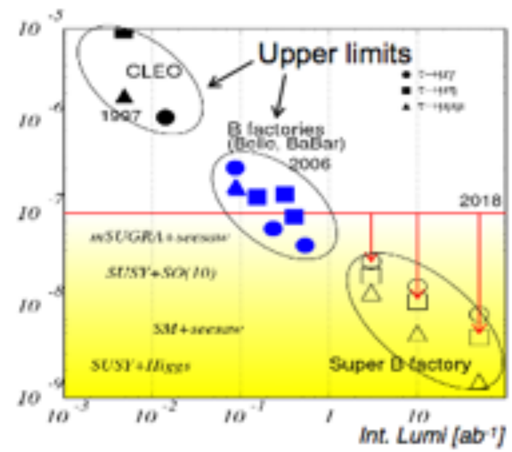
Search for New Physics

- Detailed studies of CP violation to improve understanding of the origin of matter – anti-mater dominance in the universe
- Explore large variety of physics channels
- Study flavour structure with unprecedented precision using few times 10^{10} $B\overline{B}$ pairs
- Measurements are complementary to direct searches performed at LHC
  - Enhanced sensitivity through study of strongly suppressed higher-order processes
- Search for rare or forbidden decays

Expected Sensitivity for L~O(50 ab^{-1})



UT



LFV

Challenges and Milestones

High luminosity operation at SuperKEKB requires much improved detector

- German groups provide novel DEPFET pixel vertex detector PXD for Belle II

DESY contributes crucially to VXD project

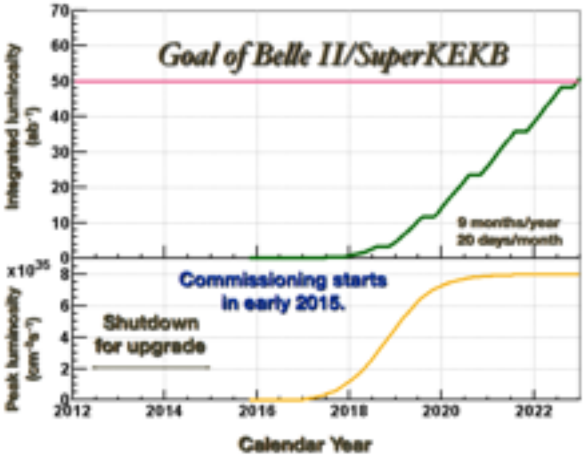
- Infrastructure (cooling, installation)
- Testbeam & background simulation
- Tracking, alignment & calibration
- Computing & software & data storage

Physics analysis of Belle I data

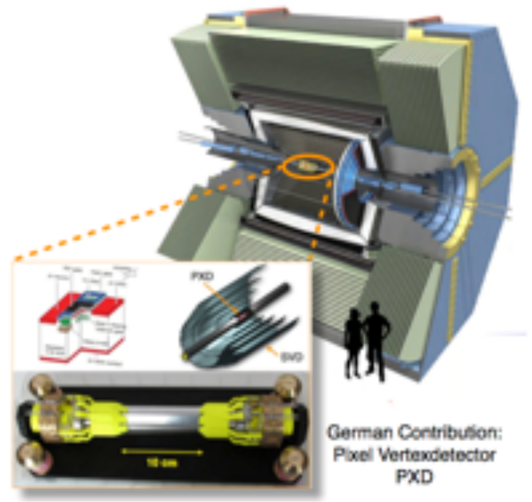
POF-3 Milestones

- Install & commission VXD in 2016
- Align detector & start physics programme
- Ramp up SuperKEKB and accumulate ~ $10ab^{-1}$

Ambitious Luminosity Goal

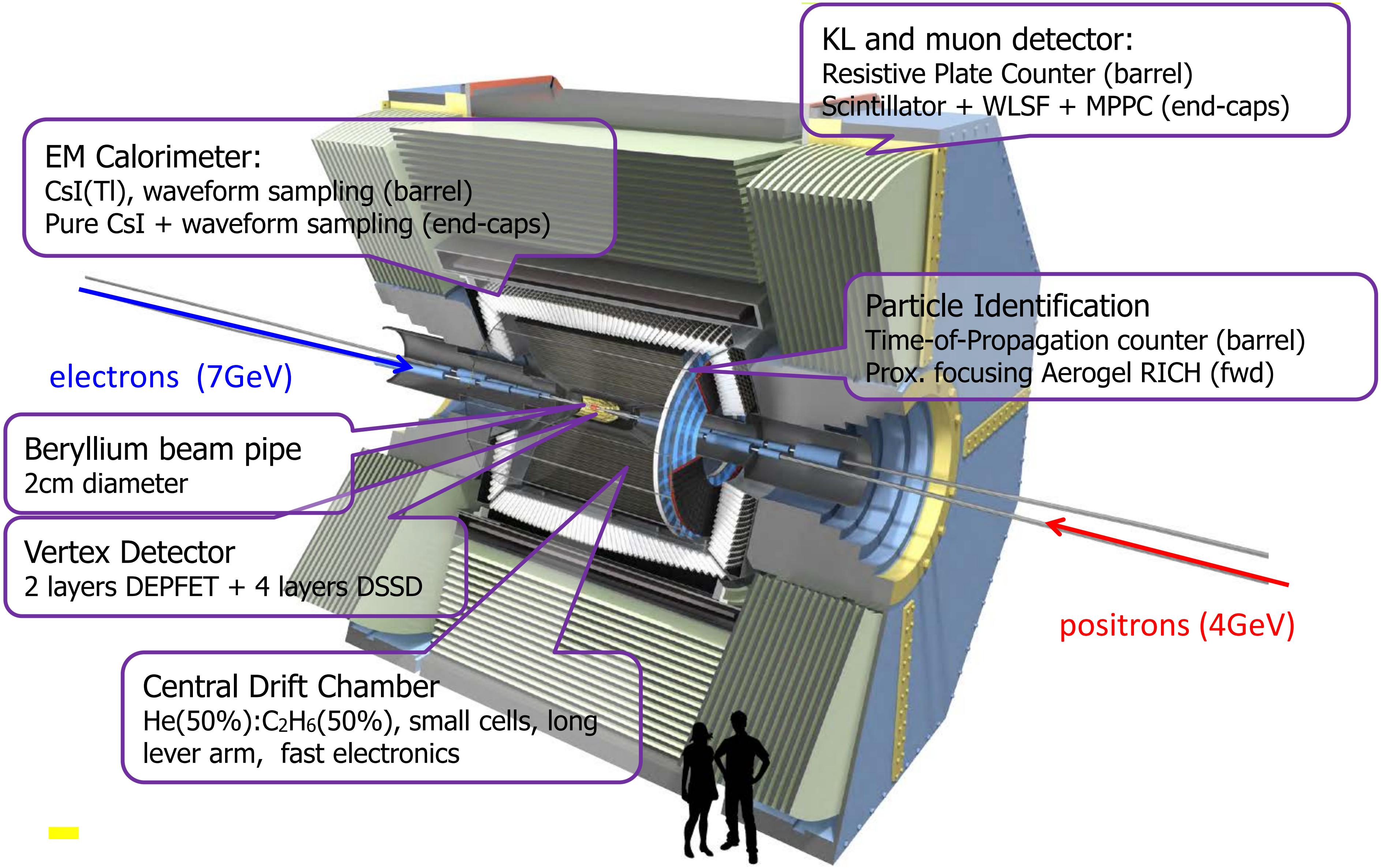


Challenging Detector Upgrade



Additional Material

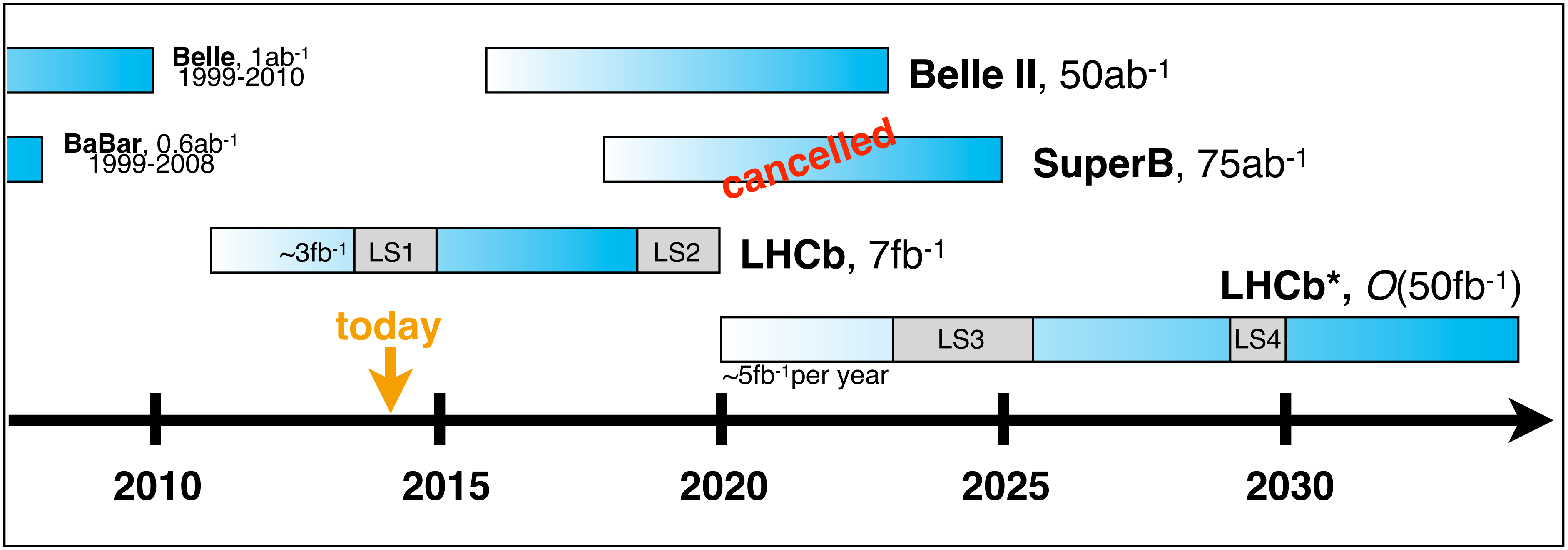
Belle II Detector



DEPFET Collaboration

China	CAS	Institute for High Energy Physics (CAS), Beijing	Zhen'An Liu	
Czech Rep	PRA	Charles-University Prague	Zdenek Dolezal	
Germany	BON	HyperlinkUniversity of Bonn	Norbert Wermes	
	DES	DESY Hamburg	Carsten Niebuhr	
	GIE	University of Gießen	**Sören Lange**	**SP Germany**
	GOE	University of Göttingen	Ariane Frey	
	HEI	University of Heidelberg	Peter Fischer	
	KAR	University of Karlsruhe	Thomas Müller	
	LMU	Ludwig-Maximilans-University Munich	Jochen Schieck	
	MPI	Max-Planck-Institute for Physics, Munich	**Christian Kiesling**	**PL**
	HLL	Semiconductor Laboratory Munich	**Hans-Günther Moser**	**TC**
	TUM	Technical University of Munich	Stephan Paul	
Poland	KRA	Institute of Nuclear Physics, Krakow	Maria Rozanska	
Spain	IFV	Instituto de Fisica Corpuscular (IFIC), Valencia	Carlos Lacasta	
	UBA	University of Barcelona	Angel Dieguez	
	CNM	Centro Nacional de Microelectronica, Barcelona	Enric Cabruja	
	IFB	Inst. de Fisica d'Altes Energies (IFAE), Barcelona	Mokhtar Chmeissani	
	IFC	Inst. de Fisica de Cantabria (IFCA), Santander	Ivan Vila Alvarez	

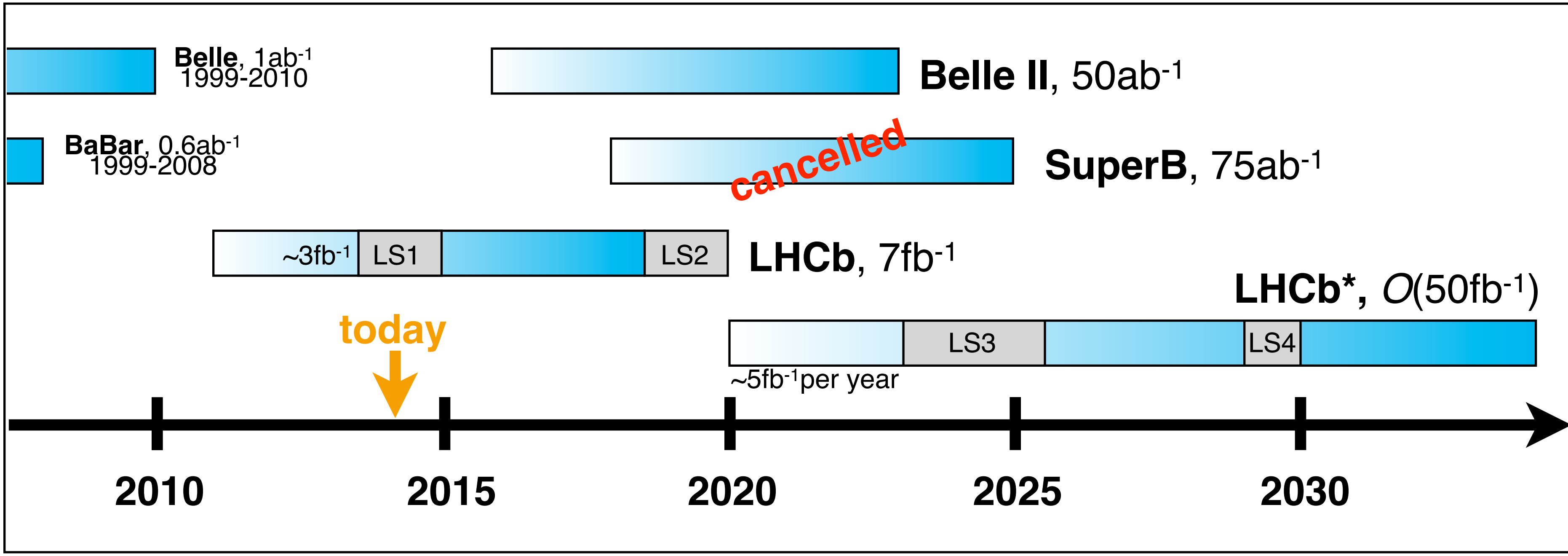
Timeline of Flavour Experiments



Interplay with other important projects at the intensity frontier:

- rare kaon decays (NA62, KLOE2, KOTO,...)
- lepton flavor violation (Mu2e, COMET, MEG, Mu3e, ...)
- light quark factories (BESIII, VEPP-2000,CLEO-c, ...)

Timeline of Flavour Experiments



Decay	LHCb		Belle		Ratio
$B_u \to J/\psi K$	10049	34 pb^{-1}	41315	711 fb^{-1}	5.1
$B_u \to D^0{}_{CP}\pi$	1270	34 pb^{-1}	2163	250 fb^{-1}	4.3
$B_d \to K\pi$	838	35 pb^{-1}	4000	480 fb^{-1}	2.9
$B_u \to K\ell\ell$	35	35 pb^{-1}	161	605 fb^{-1}	2.6
$B_d \to K^*\ell\ell$	144	165 pb^{-1}	230	605 fb^{-1}	2.3
$B_d \to J/\psi K^0_S$	1100	33 pb^{-1}	12681	711 fb^{-1}	1.9
$B_d \to K^*\gamma$	485	88 pb^{-1}	450	78 fb^{-1}	1.0
$B_s \to J/\psi\phi$	1414	95 pb^{-1}	45	24 fb^{-1}	7.9
$B_s \to J/\psi f_0$	111	33 pb^{-1}	63	121 fb^{-1}	6.5
$B_s \to \phi\gamma$	60	88 pb^{-1}	18	24 fb^{-1}	0.9
$D^+ \to \phi\pi$	$90k$	35 pb^{-1}	$237k$	955 fb^{-1}	10

$1fb^{-1}$ at 7TeV at LHCb ≈ (1-5)ab^{-1} at Belle before tagging

The Fate of Anti-Matter

$$\frac{\Delta_{\mathrm{Bar}}}{n_\gamma} \simeq \frac{n_{\mathrm{Bar}}}{n_\gamma} = \eta = (6.19 \pm 0.14) \times 10^{-10}$$

- No evidence for anti-matter annihilation radiation
- So far no evidence for anti-nuclei in cosmic rays
  - eagerly waiting for AMS results ...

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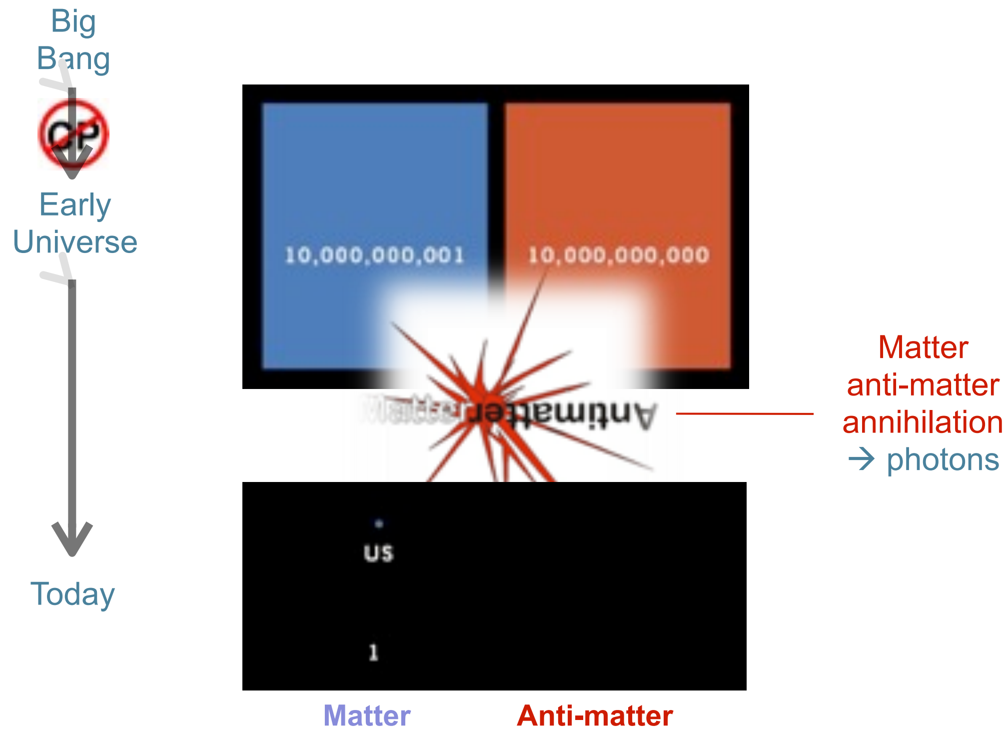

- Sakharov: a matter-dominated universe requires:
  1. baryon number non-conservation
  2. C- and CP-violation
  3. thermal non-equilibrium
- All three conditions are satisfied in the SM, but:
  - SM-Higgs too heavy to drive 1st order phase transition
  - CP-violation in CKM-sector is too small to explain η

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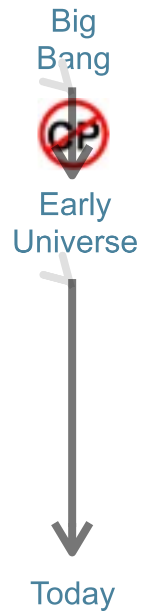
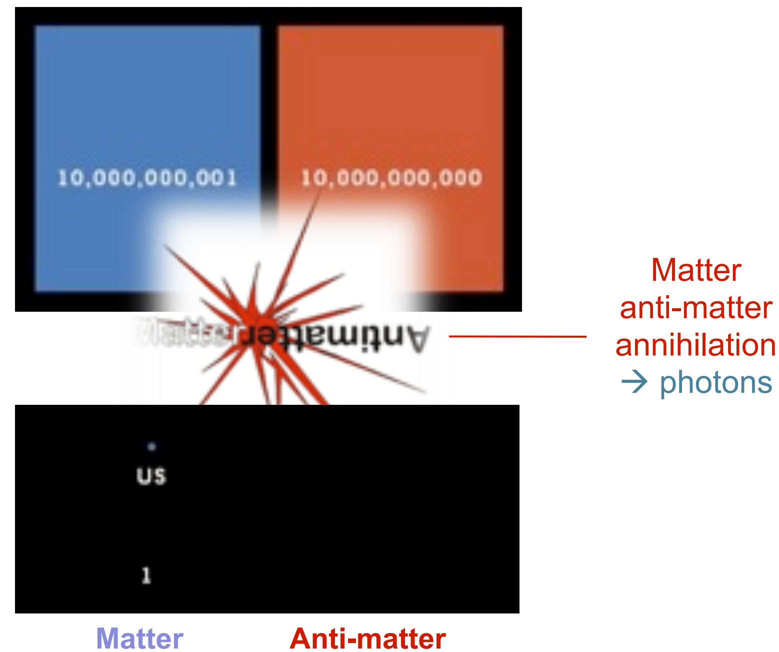




Consequences:

- CPT is not conserved or
- there must be additional sources of CP-violation
  - in the quark-sector (baryogenesis) or
  - in the lepton-sector (transferred to quark sector, leptogenesis)

„Golden Modes“ of SuperB Factories

Areas where SuperB Factories can provide important insight into New Physics complementary to other experiments (LHCb):

E_{miss}:

$\mathcal{B}(B \to \tau\nu)$, $\mathcal{B}(B \to X_c\tau\nu)$, $\mathcal{B}(B \to h\nu\nu)$,...

Inclusive:

$\mathcal{B}(B \to s\gamma)$, $A_{CP}(B \to s\gamma)$, $\mathcal{B}(B \to sll)$, ...

Neutrals:

$S(B \to K_S\pi^0\gamma)$, $S(B \to \eta' K_S)$, $S(B \to K_SK_SK_S)$, $\mathcal{B}(\tau \to \mu\gamma)$, $\mathcal{B}(B_s \to \gamma\gamma)$, ...

A.G. Akeroyd et al., arXiv: 1002.5012

Physics at Super B Factory

Belle II

B. O’Leary et al., arXiv: 1008.1541

SuperB

SuperB

Progress Reports

Physics

Physics Reach of Super Flavour Factories vs LHCb

Observable/mode	Current now	LHCb (2017) 5 fb^{-1}	Super*B* (2021) 75 ab^{-1}	Belle2 (2021) 50 ab^{-1}	LHC*b* upgrade (10 years of running) 50 fb^{-1}	theory now
			τ Decays			
$\tau \to \mu\gamma$ ($\times 10^{-9}$)	< 44		< 2.4	< 5.0		
$\tau \to e\gamma$ ($\times 10^{-9}$)	< 33		< 3.0	< 3.7 (est.)		
$\tau \to \ell\ell\ell$ ($\times 10^{-10}$)	$< 150 - 270$	< 244	$< 2.3 - 8.2$	< 10	< 24	
			$B_{u,d}$ Decays			
BR($B \to \tau\nu$) ($\times 10^{-4}$)	1.64 ± 0.34		0.05	0.04		1.1 ± 0.2
BR($B \to \mu\nu$) ($\times 10^{-6}$)	< 1.0		0.02	0.03		0.47 ± 0.08
BR($B \to K^{*+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 80		1.1	2.0		6.8 ± 1.1
BR($B \to K^{+}\nu\overline{\nu}$) ($\times 10^{-6}$)	< 160		0.7	1.6		3.6 ± 0.5
BR($B \to X_s\gamma$) ($\times 10^{-4}$)	3.55 ± 0.26		0.11	0.13	0.23	3.15 ± 0.23
$A_{CP}(B \to X_{(s+d)}\gamma)$	0.060 ± 0.060		0.02	0.02		$\sim 10^{-9}$
$B \to K^*\mu^+\mu^-$ (events)	250	5000	10-15k	7-10k	65,000	-
BR($B \to K^*\mu^+\mu^-$) ($\times 10^{-6}$)	1.15 ± 0.16		0.06	0.07		1.19 ± 0.39
$B \to K^*e^+e^-$ (events)	165	400	10-15k	7-10k	5,000	-
BR($B \to K^*e^+e^-$) ($\times 10^{-6}$)	1.09 ± 0.17		0.05	0.07		1.19 ± 0.39
$A_{FB}(B \to K^*\ell^+\ell^-)$	0.27 ± 0.14		0.040	0.03		-0.089 ± 0.020
$B \to X_s\ell^+\ell^-$ (events)	280		8,600	7,000		-
BR($B \to X_s\ell^+\ell^-$) ($\times 10^{-6}$)	3.66 ± 0.77		0.08	0.10		1.59 ± 0.11
S in $B \to K^0_S\pi^0\gamma$	-0.15 ± 0.20		0.03	0.03		-0.1 to 0.1
S in $B \to \eta' K^0$	0.59 ± 0.07		0.01	0.02		± 0.015
S in $B \to \phi K^0$	0.56 ± 0.17	0.15	0.02	0.03	0.03	± 0.02
			B^0_s Decays			
BR($B^0_s \to \gamma\gamma$) ($\times 10^{-6}$)	< 8.7		0.3	$0.2 - 0.3$		0.4 - 1.0
A^s_{SL} ($\times 10^{-3}$)	-7.87 ± 1.96		4.			0.02 ± 0.01
			D Decays			
x Charm mixing	$(0.63 \pm 0.20\%)$	0.06%	0.02%	0.04%	0.02%	$\sim 10^{-2}$
y	$(0.75 \pm 0.12)\%$	0.03%	0.01%	0.03%	0.01%	$\sim 10^{-2}$ (see above).
y_{CP}	$(1.11 \pm 0.22)\%$	0.05%	0.03%	0.05%	0.01%	$\sim 10^{-2}$ (see above).
$\lvert q/p \rvert$	$(0.91 \pm 0.17)\%$	10%	2.7%	3.0%	3%	$\sim 10^{-3}$ (see above).
arg$\{q/p\}$ (°)	-10.2 ± 9.2	5.6	1.4	1.4	2.0	$\sim 10^{-3}$ (see above).
			Other processes Decays			
$\sin^2\theta_W$ at $\sqrt{s} = 10.58$ GeV$/c^2$			0.0002			clean

cancelled

arXiv:1109.5028v2 [hep-ex] 19 Oct 2011
The impact of SuperB on flavour physics

Projected sensitivities for CKM measurements

Observable/mode	Current now	LHCb (2017)	Super$B$ (2021)	Belle II (2021)	LHCb upgrade (10 years of running)	theory now
		$5\,\mathrm{fb}^{-1}$	$75\,\mathrm{ab}^{-1}$	$50\,\mathrm{ab}^{-1}$	$50\,\mathrm{fb}^{-1}$	
Φ_2 α from $u\bar{u}d$	6.1°	$5^{\circ\,a}$	1°	1°	^{b}	$1-2^\circ$
Φ_1 β from $c\bar{c}s$ (S)	0.8° (0.020)	0.5° (0.008)	0.1° (0.002)	0.3° (0.007)	0.2° (0.003)	clean
S from $B_d \to J/\psi \pi^0$	0.21		0.014	0.021 (est.)		clean
S from $B_s \to J/\psi K_S^0$		?			?	clean
Φ_3 γ from $B \to DK$	11°	$\sim 4^\circ$	1°	1.5°	0.9°	clean
$\|V_{cb}\|$ (inclusive) %	1.7		0.5%	0.6 (est.)		dominant
$\|V_{cb}\|$ (exclusive) %	2.2		1.0%	1.2 (est.)		dominant
$\|V_{ub}\|$ (inclusive) %	4.4		2.0%	3.0		dominant
$\|V_{ub}\|$ (exclusive) %	7.0		3.0%	5.0		dominant

cancelled

arXiv:1109.5028v2 [hep-ex] 19 Oct 2011
The impact of SuperB on flavour physics

Super Flavour Factory Potential

Observable	SM prediction	Theory error	Present result	Future error	Future Facility
$\lvert V_{us}\rvert$ $[K \to \pi \ell \nu]$	input	$0.5\% \to 0.1\%_{\rm Latt}$	0.2246 ± 0.0012	0.1%	K factory
$\lvert V_{cb}\rvert$ $[B \to X_c \ell \nu]$	input	1%	$(41.54 \pm 0.73) \times 10^{-3}$	1%	Super-B
$\lvert V_{ub}\rvert$ $[B \to \pi \ell \nu]$	input	$10\% \to 5\%_{\rm Latt}$	$(3.38 \pm 0.36) \times 10^{-3}$	4%	Super-B
γ $[B \to DK]$	input	$< 1^\circ$	$(70^{+27}_{-30})^\circ$	3°	LHCb
$S_{B_d \to \psi K}$	$\sin(2\beta)$	$\lesssim 0.01$	0.671 ± 0.023	0.01	LHCb
$S_{B_s \to \psi \phi}$	0.036	$\lesssim 0.01$	$0.81^{+0.12}_{-0.32}$	0.01	LHCb
$S_{B_d \to \phi K}$	$\sin(2\beta)$	$\lesssim 0.05$	0.44 ± 0.18	0.1	LHCb
$S_{B_s \to \phi \phi}$	0.036	$\lesssim 0.05$	—	0.05	LHCb
$S_{B_d \to K^* \gamma}$	few $\times$ 0.01	0.01	-0.16 ± 0.22	0.03	Super-B
$S_{B_s \to \phi \gamma}$	few $\times$ 0.01	0.01	—	0.05	LHCb
$A^d_{\rm SL}$	-5×10^{-4}	10^{-4}	$-(5.8 \pm 3.4) \times 10^{-3}$	10^{-3}	LHCb
$A^s_{\rm SL}$	2×10^{-5}	$< 10^{-5}$	$(1.6 \pm 8.5) \times 10^{-3}$	10^{-3}	LHCb
$A_{CP}(b \to s\gamma)$	< 0.01	< 0.01	-0.012 ± 0.028	0.005	Super-B
$\mathcal{B}(B \to \tau\nu)$	1×10^{-4}	$20\% \to 5\%_{\rm Latt}$	$(1.73 \pm 0.35) \times 10^{-4}$	5%	Super-B
$\mathcal{B}(B \to \mu\nu)$	4×10^{-7}	$20\% \to 5\%_{\rm Latt}$	$< 1.3 \times 10^{-6}$	6%	Super-B
$\mathcal{B}(B_s \to \mu^+\mu^-)$	3×10^{-9}	$20\% \to 5\%_{\rm Latt}$	$< 5 \times 10^{-8}$	10%	LHCb
$\mathcal{B}(B_d \to \mu^+\mu^-)$	1×10^{-10}	$20\% \to 5\%_{\rm Latt}$	$< 1.5 \times 10^{-8}$	[?]	LHCb
$A_{\rm FB}(B \to K^*\mu^+\mu^-)_{q_0^2}$	0	0.05	(0.2 ± 0.2)	0.05	LHCb
$B \to K\nu\bar{\nu}$	4×10^{-6}	$20\% \to 10\%_{\rm Latt}$	$< 1.4 \times 10^{-5}$	20%	Super-B
$\lvert q/p\rvert_{D-\rm mixing}$	1	$< 10^{-3}$	$(0.86^{+0.18}_{-0.15})$	0.03	Super-B
ϕ_D	0	$< 10^{-3}$	$(9.6^{+8.3}_{-9.5})^\circ$	2°	Super-B
$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$	8.5×10^{-11}	8%	$(1.73^{+1.15}_{-1.05}) \times 10^{-10}$	10%	K factory
$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu})$	2.6×10^{-11}	10%	$< 2.6 \times 10^{-8}$	[?]	K factory
$R^{(e/\mu)}(K \to \pi\ell\nu)$	2.477×10^{-5}	0.04%	$(2.498 \pm 0.014) \times 10^{-5}$	0.1%	K factory
$\mathcal{B}(t \to c\,Z,\gamma)$	$\mathcal{O}(10^{-13})$	$\mathcal{O}(10^{-13})$	$< 0.6 \times 10^{-2}$	$\mathcal{O}(10^{-5})$	LHC (100 fb^{-1})
$\mathcal{B}(B \to X_s\gamma)$				6%	Super−B
$\mathcal{B}(B \to X_d\gamma)$				20%	Super−B
$S(B \to \rho\gamma)$				0.15	Super−B
$\mathcal{B}(\tau \to \mu\gamma)$				$3 \cdot 10^{-9}$	Super−B
$\mathcal{B}(B^+ \to D\tau\nu)$				3%	Super−B
$\mathcal{B}(B_s \to \gamma\gamma)$				$0.25 \cdot 10^{-6}$	Super−B
$\sin^2\theta_W$ @ $\Upsilon(4S)$				$3 \cdot 10^{-4}$	Super−B

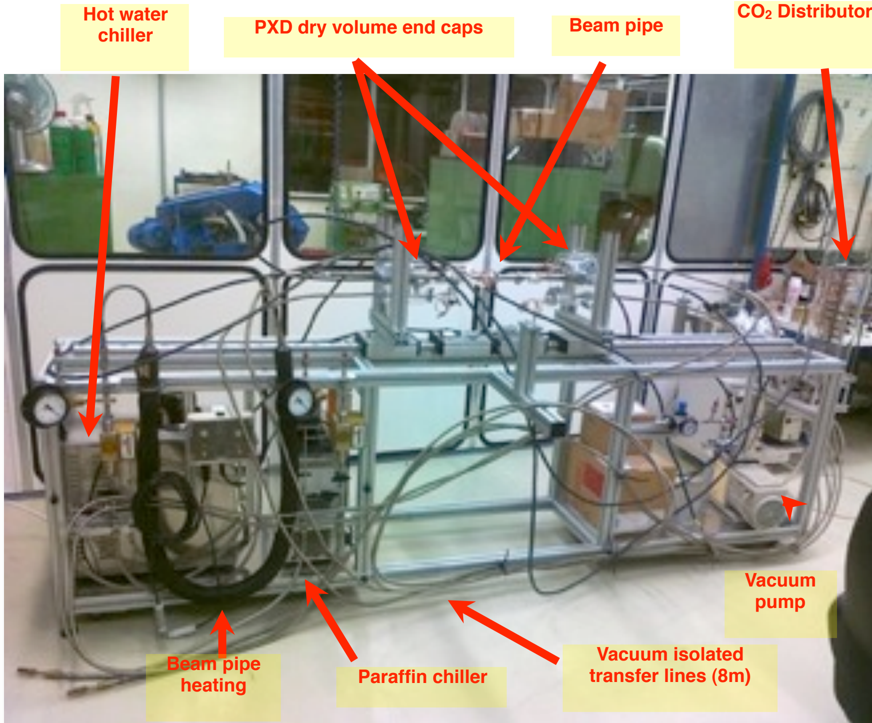
Adopted from G. Isidori et al., Ann.Rev.Nucl.Part.Sci. 60, 355 (2010)

Belle Detector Performance

Performance parameters expected (or achieved) for the Belle detector

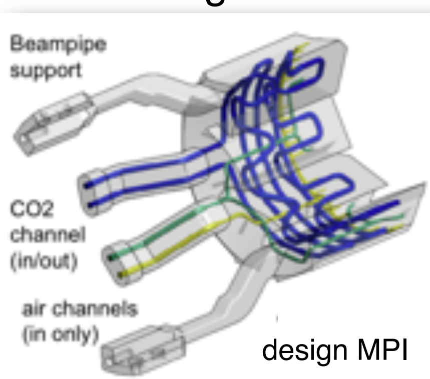
Detector	Type	Configuration	Readout	Performance
Beam pipe	Beryllium double wall	Cylindrical, $r = 20$ mm 0.5/2.5/0.5 (mm) = Be/He/Be		He gas cooled
EFC	BGO	Photodiode readout segmentation: 32 in ϕ; 5 in θ	160×2	RMS energy resolution: 7.3 % at 8 GeV 5.8% at 3.5 GeV
SVD	Double-sided Si strip	Chip size: 57.5×33.5 mm^2 Strip pitch: 25 (p)/50 (n) μm 3 layers: 8/10/14 ladders	ϕ: 40.96k z: 40.96k	$\sigma_{\Delta_z} \sim 80$ μm
CDC	Small cell drift chamber	Anode: 50 layers Cathode: 3 layers $r = 8.3$–86.3 cm $-77 \leqslant z \leqslant 160$ cm	A: 8.4k C: 1.8k	$\sigma_{r\phi} = 130$ μm $\sigma_z = 200$–1400 μm $\sigma_{p_t}/p_t = 0.3\%\sqrt{p_t^2 + 1}$ $\sigma_{\mathrm{d}E/\mathrm{d}x} = 6\%$
ACC	Silica aerogel	960 barrel/228 end-cap FM-PMT readout		$N_{\mathrm{p.e.}} \geqslant 6$ K/π separation: $1.2 < p < 3.5$ GeV/c
TOF	Scintillator	128 ϕ segmentation $r = 120$ cm, 3-m long	128×2	$\sigma_t = 100$ ps K/π separation: up to 1.2 GeV/c
TSC		64 ϕ segmentation	64	
ECL	CsI (towered structure)	Barrel: $r = 125$–162 cm End-cap: $z = -102$ cm and $+196$ cm	6624 1152 (F) 960 (B)	$\sigma_E/E = 1.3\%/\sqrt{E}$ $\sigma_{\mathrm{pos}} = 0.5$ cm$/\sqrt{E}$ (E in GeV)
KLM	Resistive plate counters	14 layers (5 cm Fe + 4 cm gap) 2 RPCs in each gap	θ: 16k ϕ: 16k	$\Delta\phi = \Delta\theta = 30$ mr for K_L $\sim$1% hadron fake
Magnet	Supercon.	Inner radius = 170 cm		$B = 1.5$ T

Thermal VXD Mockup and CO_2 Cooling

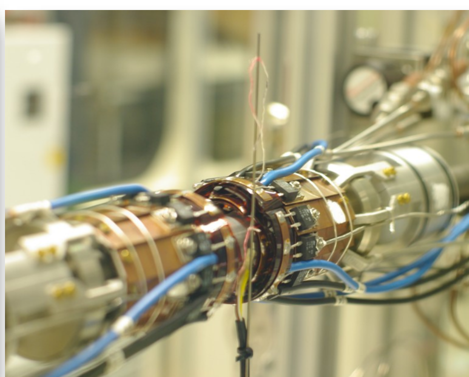


CO_2 System MARCO

Cooling Block



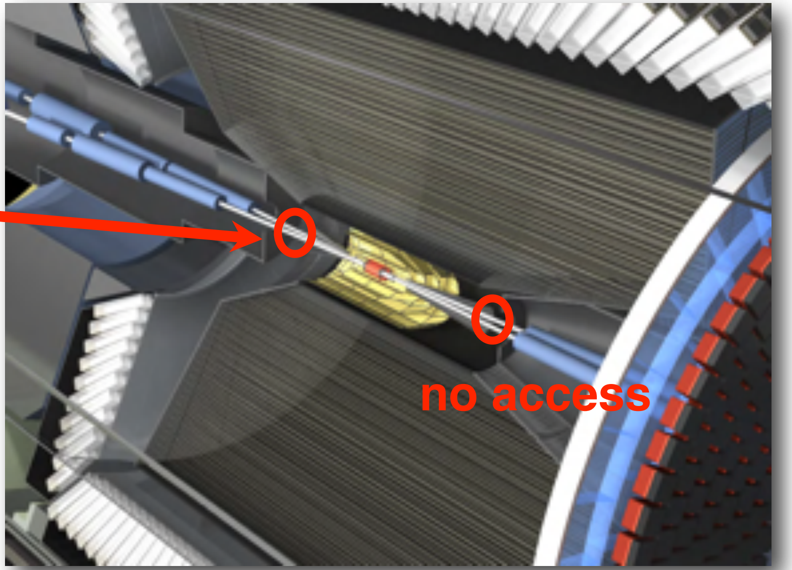
PXD Detail



- VXD cooling based on evaporative 2-phase CO_2 cooling
- Common development with ATLAS
  - CERN, NIKHEF, MPI, (DESY)
  - high level of synergy
- Verify concept of VXD heat management
- Optimise layout of transfer lines, inlet and outlet tube geometry

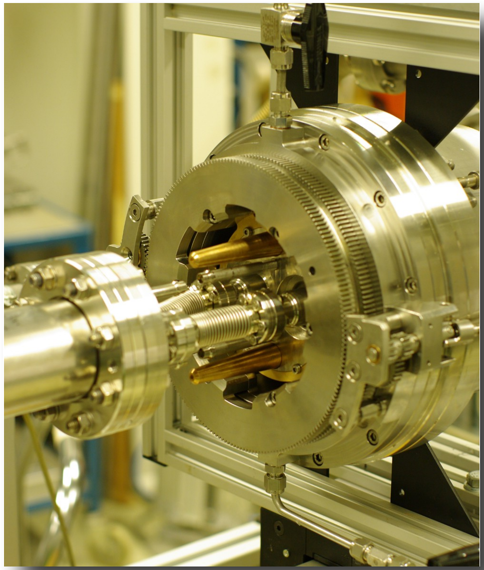
Remote Vacuum Connection & VXD Installation

- Extremely tight space constraints around IP
- Only very limited or even no access possible to vacuum flanges between IR and QCS beam pipes on left side
- Proposal for alternative installation procedure based on novel hydraulic RVC designed by DESY
  - requires close interaction with SuperKEKB machine group (magnet, vacuum)



Installation Mockup @ MPI

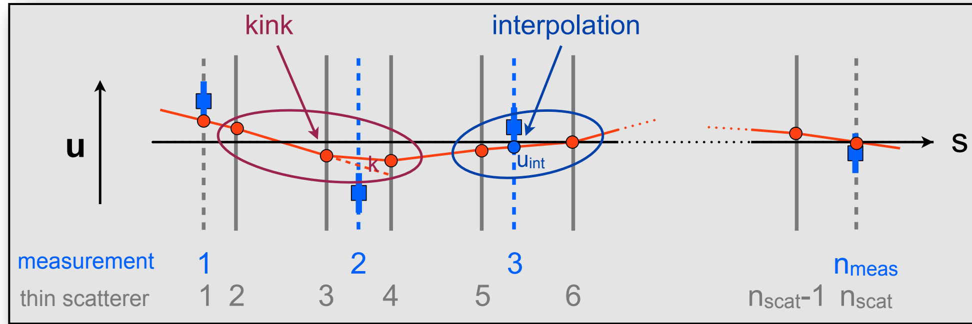
RVC Mockup @ DESY



Tracker Alignment

Alignment and calibration with MillePede using General Broken Lines interfaced via GENFIT

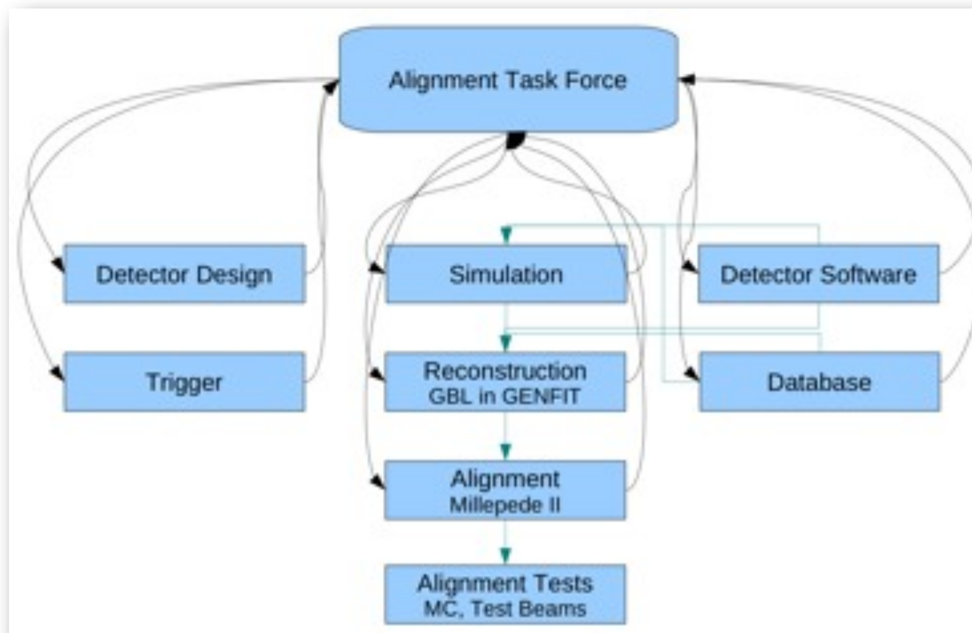
- Linearization of the track model to calculate corrections to initial values of global alignment and calibration parameters
- Fast global track refit taking multiple scattering into account



Alignment and calibration task force lead by DESY

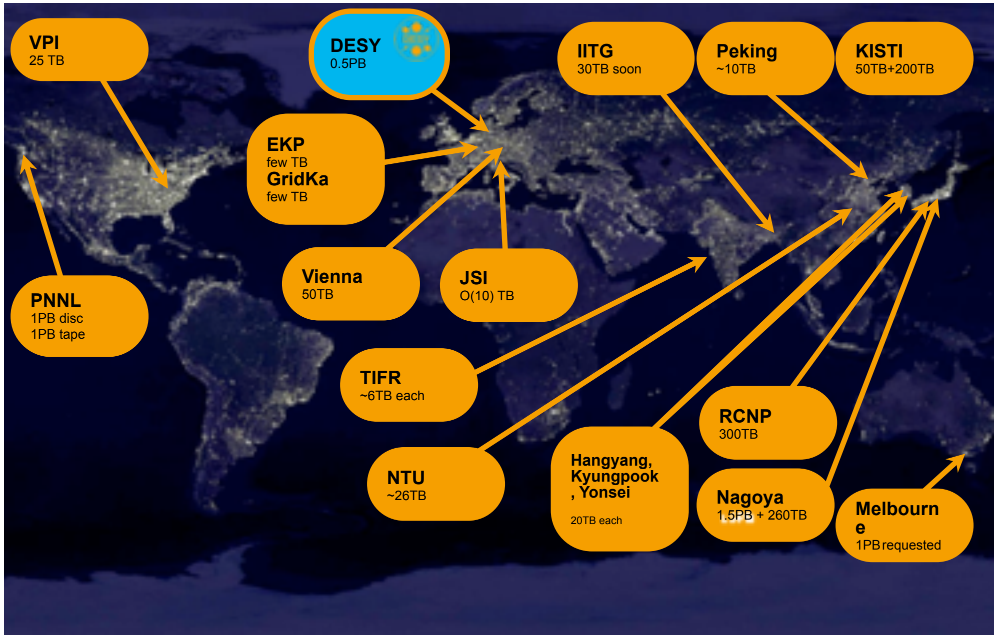
Milestones:

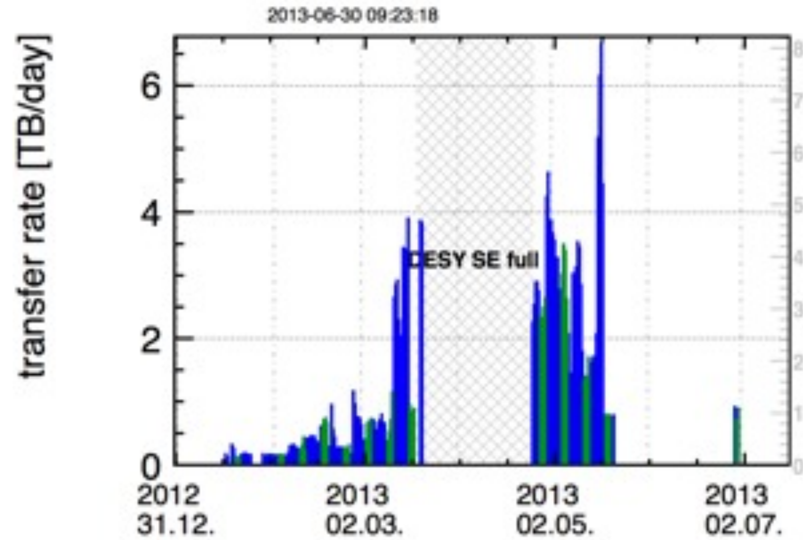
- Test of alignment framework with Jan 2014 testbeam data ongoing
- CDC cosmics alignment: May 2015
- VXD cosmics alignment: Oct 2015



Computing & Data Preservation

Distribution of Belle I physics data skims





- Full Belle mdst data set copied to DESY in 2013
  - contribution to data preservation effort
  - needed for A_{FB} analysis
- DESY contributed very visibly to first large Grid Belle II MC production challenge
- Belle II Computing MoU recently signed
  - GRIDKA as Tier1
  - DESY as Tier2

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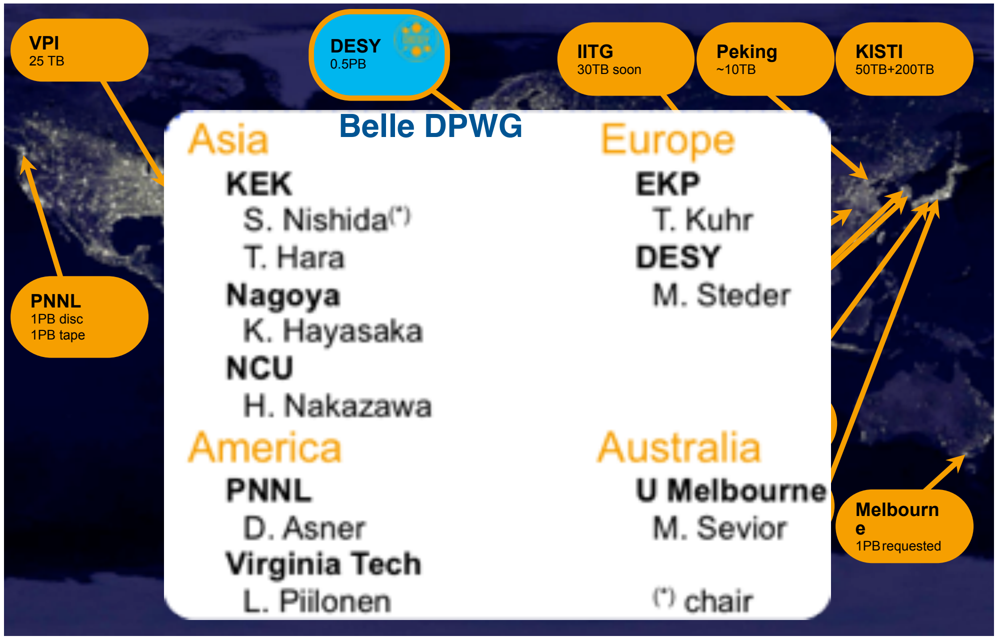

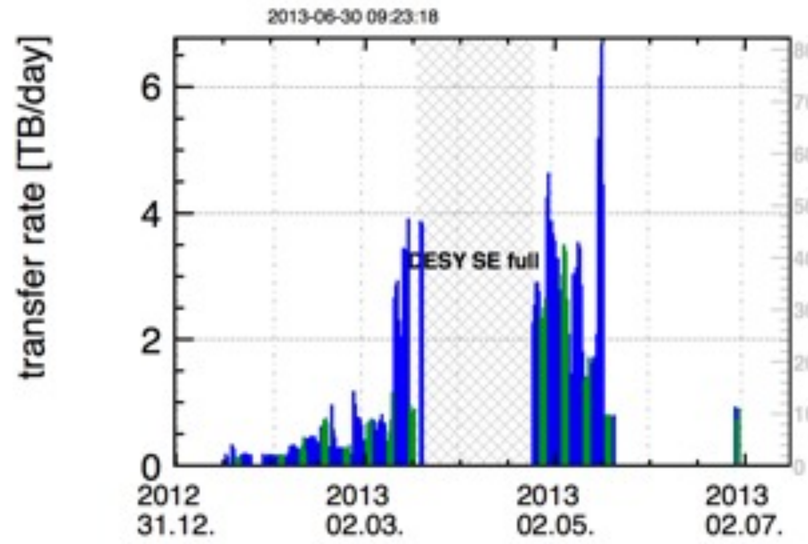

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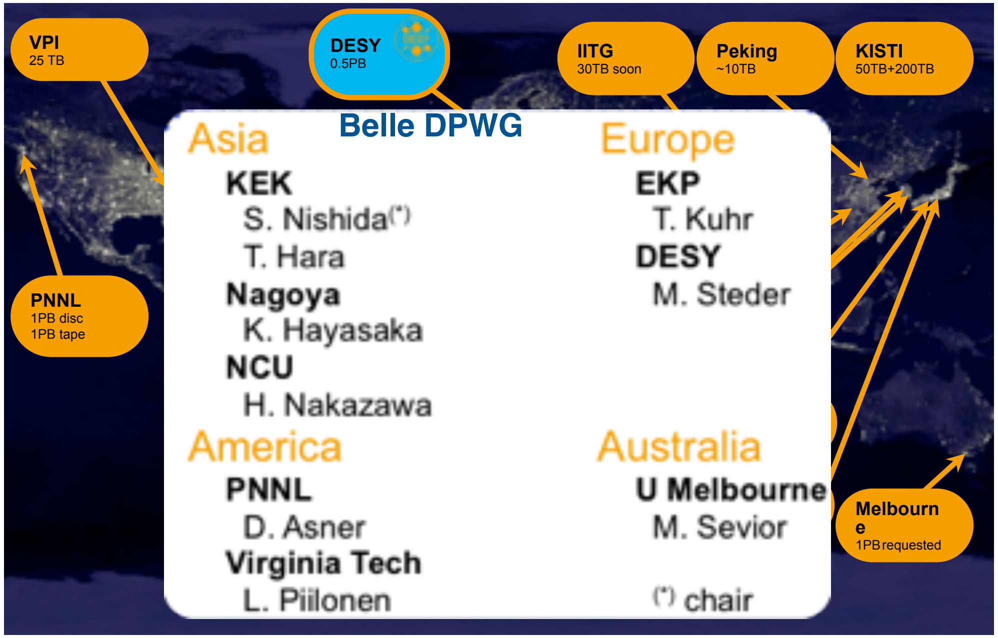

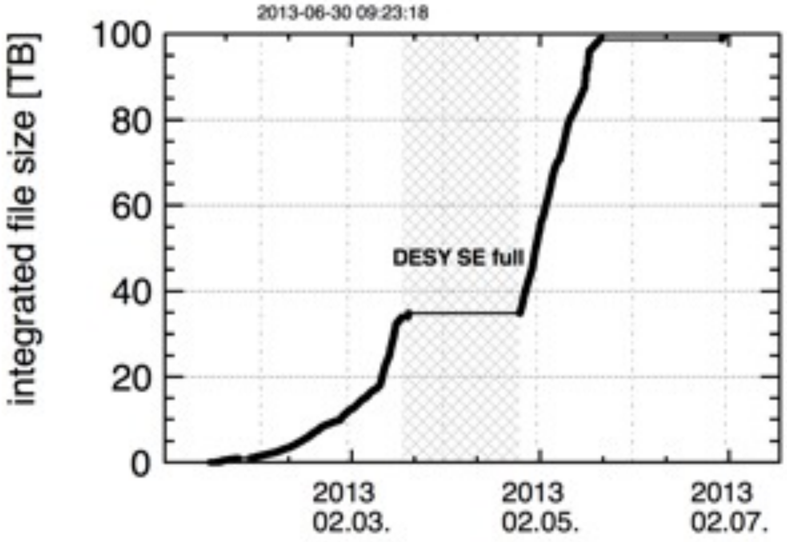

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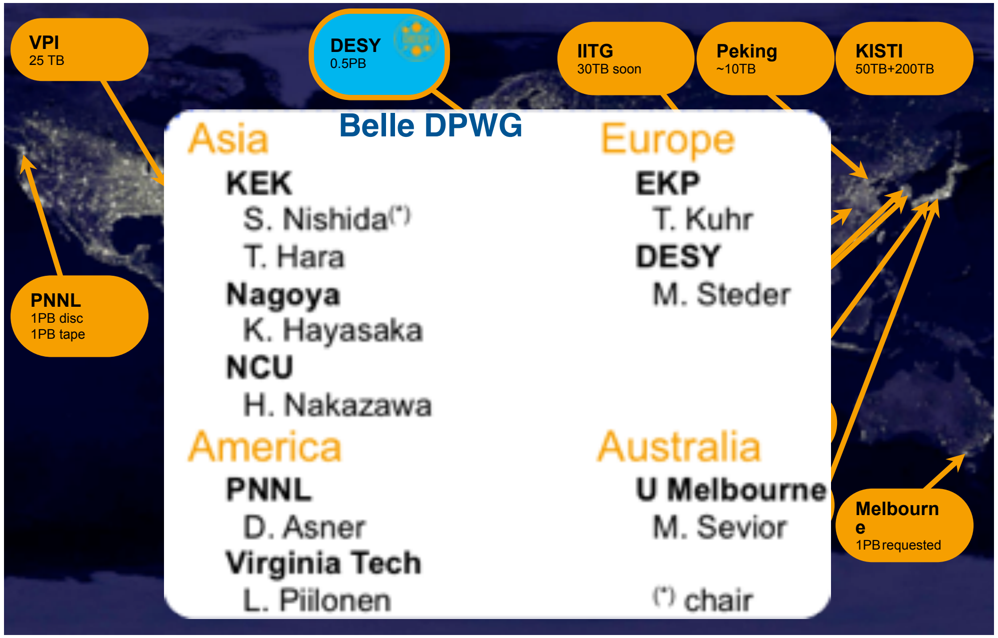

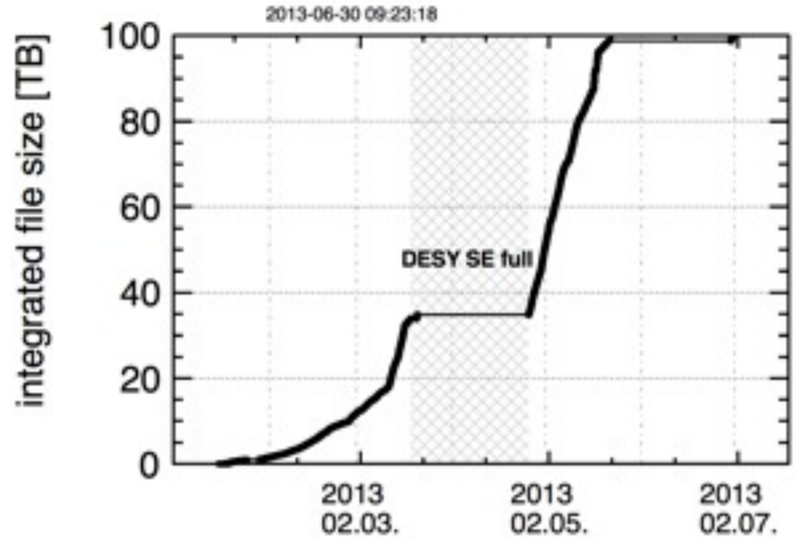

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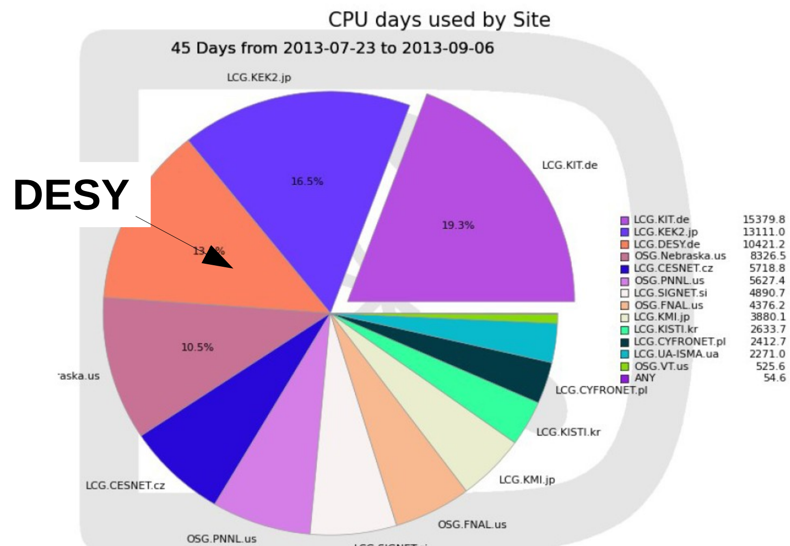
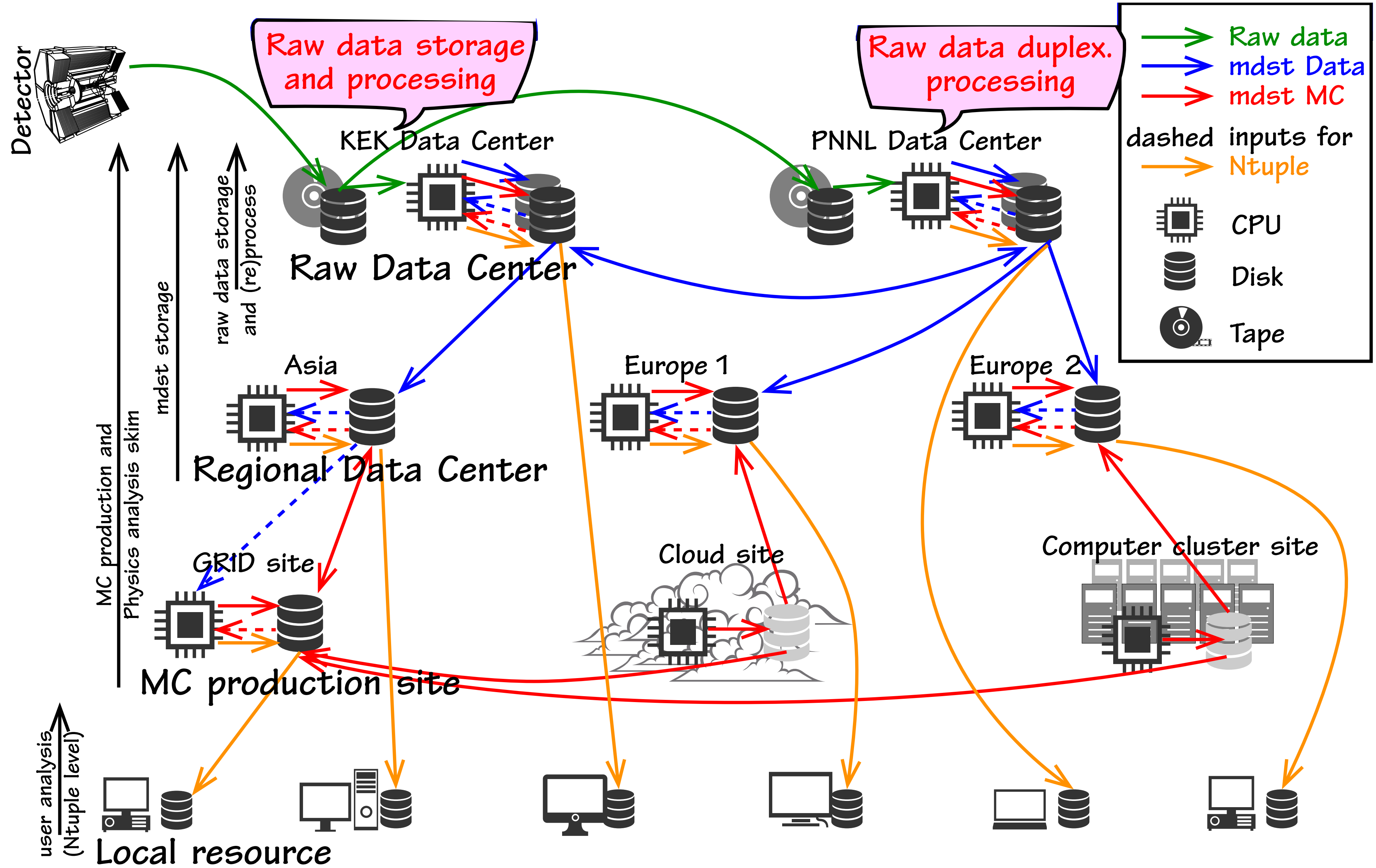


[CHEP 2013]

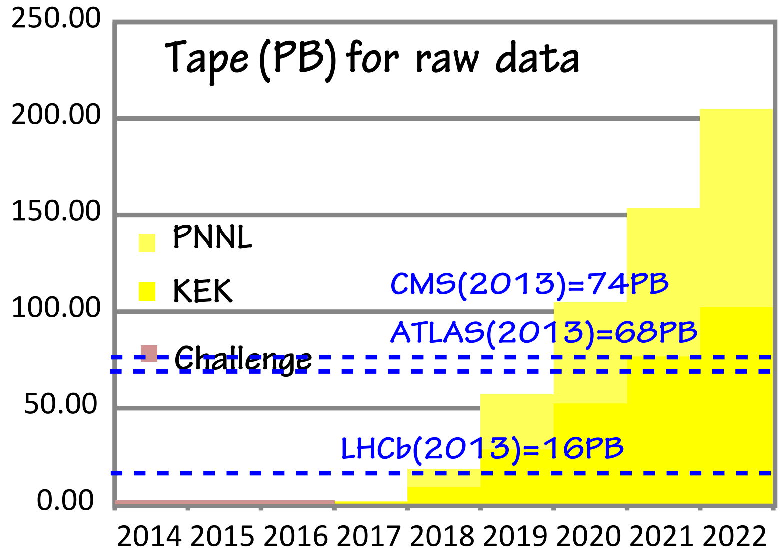
Belle II Computing Model

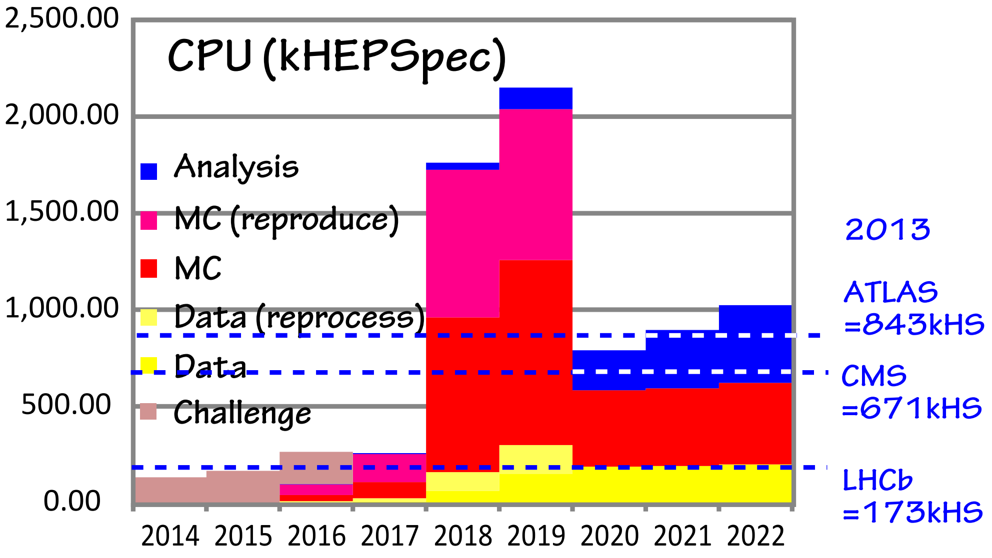


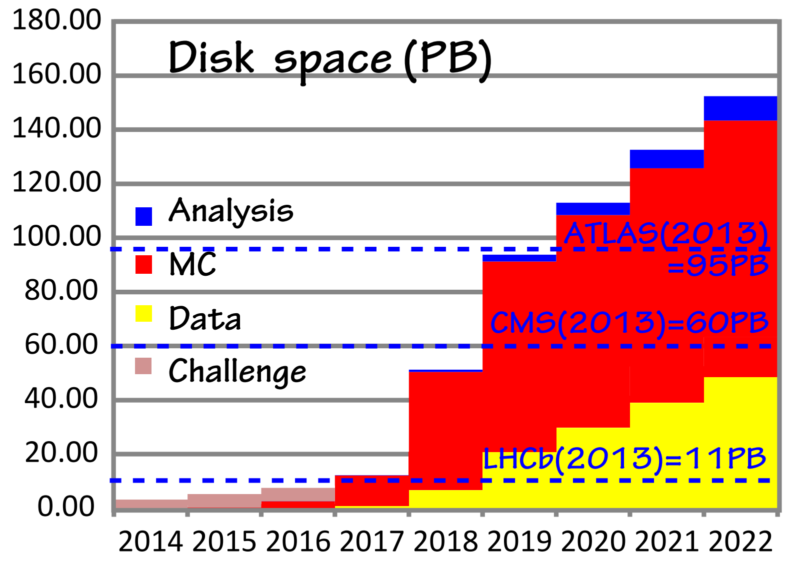
Computing Hardware Resources for Belle II

Preliminary estimates depend on many unknown parameters

- . accelerator performance
- . data reduction
- . performance of simulation/reconstruction
- . analysis requirements, ...







Nano-Beam Scheme for SuperKEKB

Lorentz factor

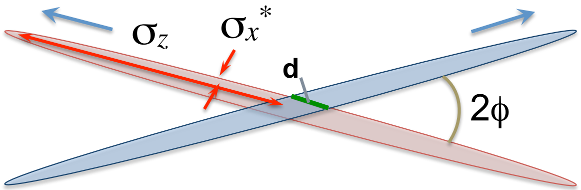
beam current (x 2)

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

Lumi reduction factor
cross angle&tune shift red.
(hourglass effect) 0.8-1

vertical beta function @ IP (x 20)

$$\sigma_{x,y} = \sqrt{\varepsilon_{x,y}\beta_{x,y}}$$



Half crossing angle: ϕ

overlap region (≠ bunch length)

$$d = \frac{\sigma_x^*}{\phi}$$

„Nano-Beam“ scheme (P. Raimondi, DAΦNE):
Squeeze vertical beta function at the IP (β^*_y) by minimizing longitudinal size of overlap region of the two beams at the IP, which generally limits effective minimum value of β_{y*} through hourglass effect.

Parameter	KEKB LER	KEKB HER	SuperKEKB LER	SuperKEKB HER
Beam energy [GeV]	3.5	8	4	7
Half crossing angle [mrad]	11		41.7	
Horizontal emittance [nm]	18	24	3.2	5.0
Emittance ratio [%]	0.88	0.66	0.27	0.25
Horizontal beta function at IP [mm]	1200		32	25
Vertical beta function at IP [mm]	5.9		0.27	0.31
Beam currents [A]	1.64	1.19	3.60	2.60
Beam-beam parameter	0.129	0.090	0.0886	0.0830
Luminosity [10^{34} cm^{-2}s^{-1}]	2.1		80	

Reduced energy asymmetry

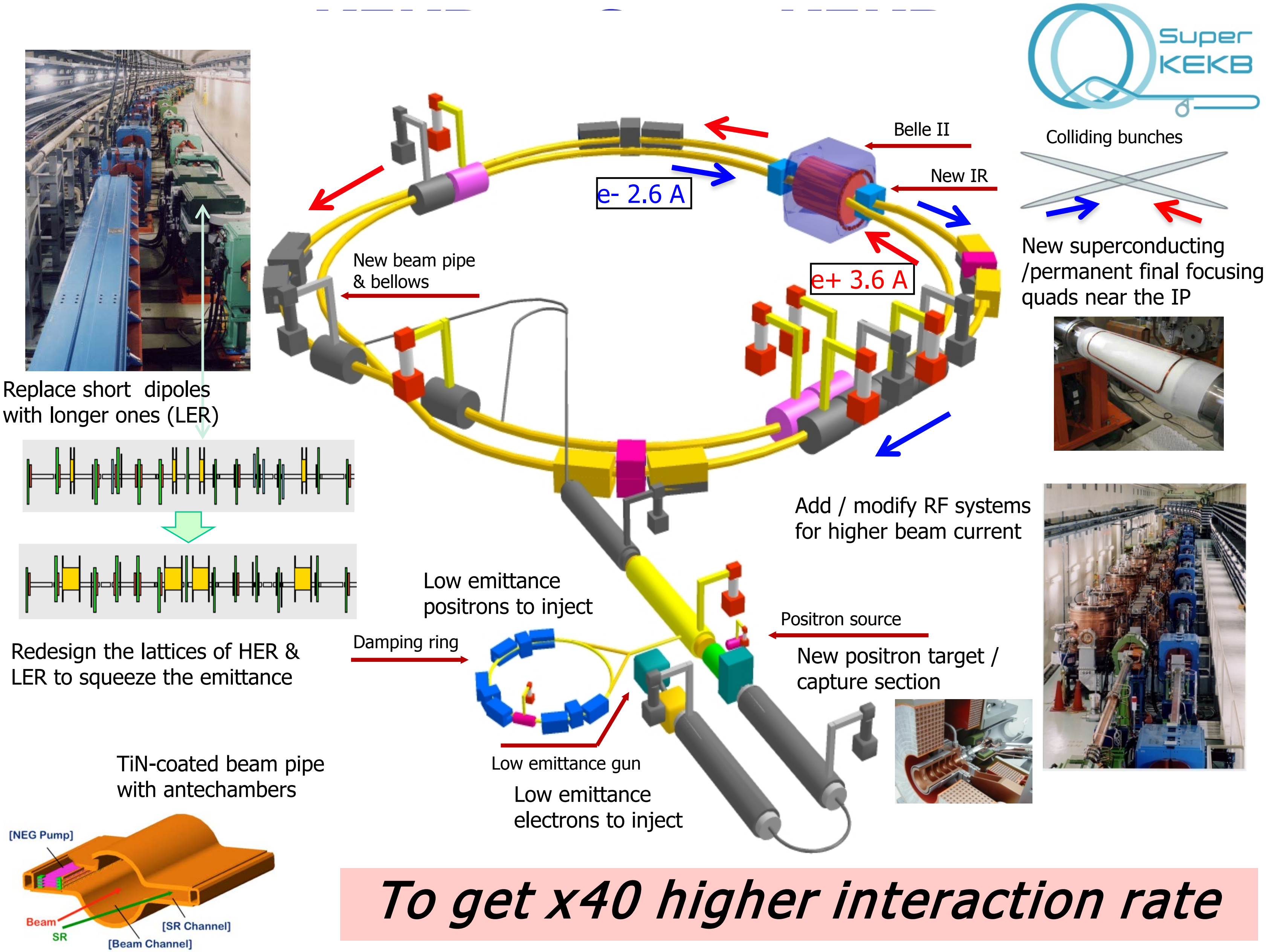
- HER 8 –> 7 GeV:

  reduced synrad, E_c
- LER 3.5 –> 4 GeV:

  better beam lifetime $\tau_{Touschek} \propto \gamma^3$
- smaller Lorentz boost:

  need better vertex resolution
  $\Delta z = \beta\gamma\Delta t$

From KEKB to SuperKEKB



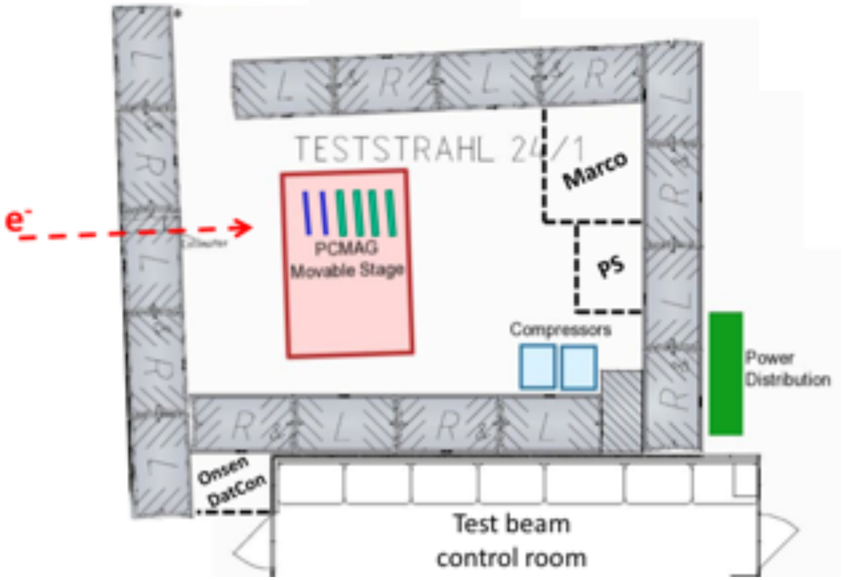
To get x40 higher interaction rate

VXD Slice Test @ DESY Testbeam in Jan 2014

Major Belle II milestone

- operate 2 PXD + 4 SVD sensors in B-field of 1T with final electronics + CO_2 cooling
- perform full system test
- integration of SC system based on EPICS
- establish data-size-reduction scheme using HLT feedback to the PXD-readout (RoI)
- test reconstruction & alignment framework

PCMAG @ TB24/1



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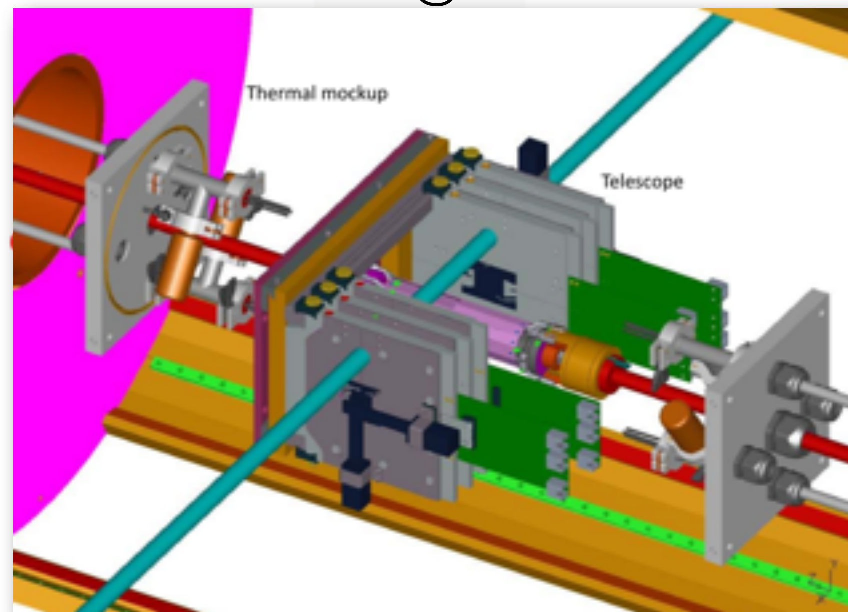

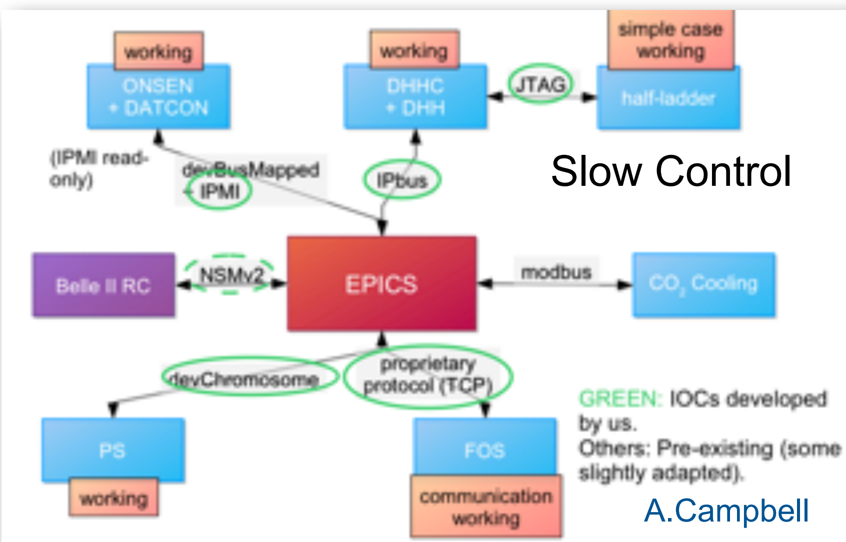

Integration of PXD DAQ into Belle II DAQ