Super Flavor Experiments
Belle-II & LHCb Upgrade

P5 meeting at Brookhaven National Laboratory
December 17, 2013

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University of Maryland

Organization of the talk

- What do we hope to learn on New Physics (NP) from the next generation of Heavy Flavor experiments?
  - For TeV scale NP: Can they reveal info on structure of NP?
  - If noTeV scale NP is found: Can they further constrain the scale of NP?

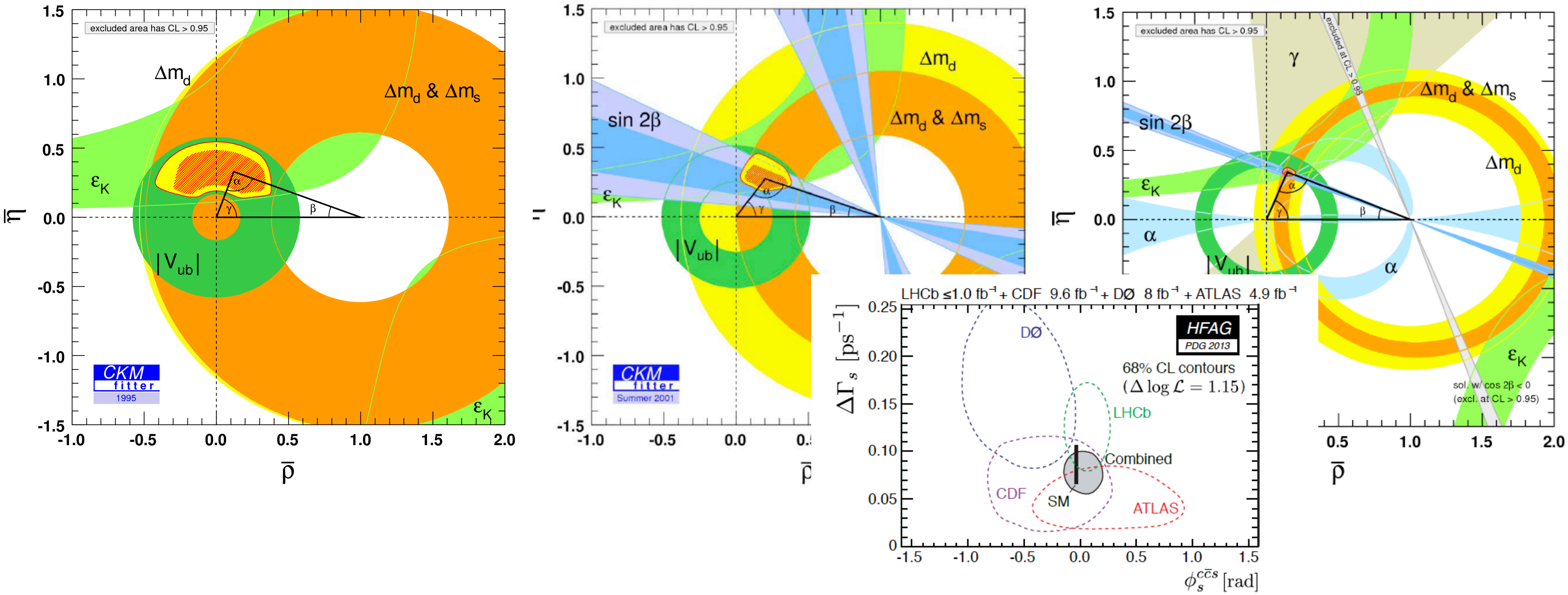
- Belle-II experiment at SuperKEKB:
  - Upgrade of Belle @ KEKB experiment: asymmetric energy e^+e^- collider at $\Upsilon(4S)$, with peak $\mathcal{L}=8x10^{35}\ cm^{-2}s^{-1}$; (σ(bb) ~1 nb)

- Upgrade of LHCb experiment at CERN:
  - Upgrade of the LHCb experiment, forward spectrometer at LHC, to operate at $\mathcal{L}=2x10^{33}\ cm^{-2}s^{-1}$; ($\sigma$(bb)~500 μb)

The past two decades brought tremendous clarity to the CKM picture

Thanks to B factories, Tevatron , LHCb, LQCD & theory insights

1995 | 2001 | 2013



➢The CKM picture of CPV in SM seems to be correct (Nobel 2008)

➢Flavor remains the only source of observed CP & T-violations

➢Flavor Changing Interactions are now amongst the most precisely determined parts of SM:

→ Severe constraints on possible scenarios of New Physics

How much NP can be accommodated in flavor measurements?

Charles, Descotes-Genon, Ligeti et al.

- Example: NP constraints from Meson Mixing

➢Fit the CKM parameters allowing modification of mixing Matrix element:

$$M_{12} = M_{12}^{\mathrm{SM}} \times \left(1 + h\, e^{2i\sigma}\right)$$

Determine NP parameter h & σ for B^0_d and B^0_s systems

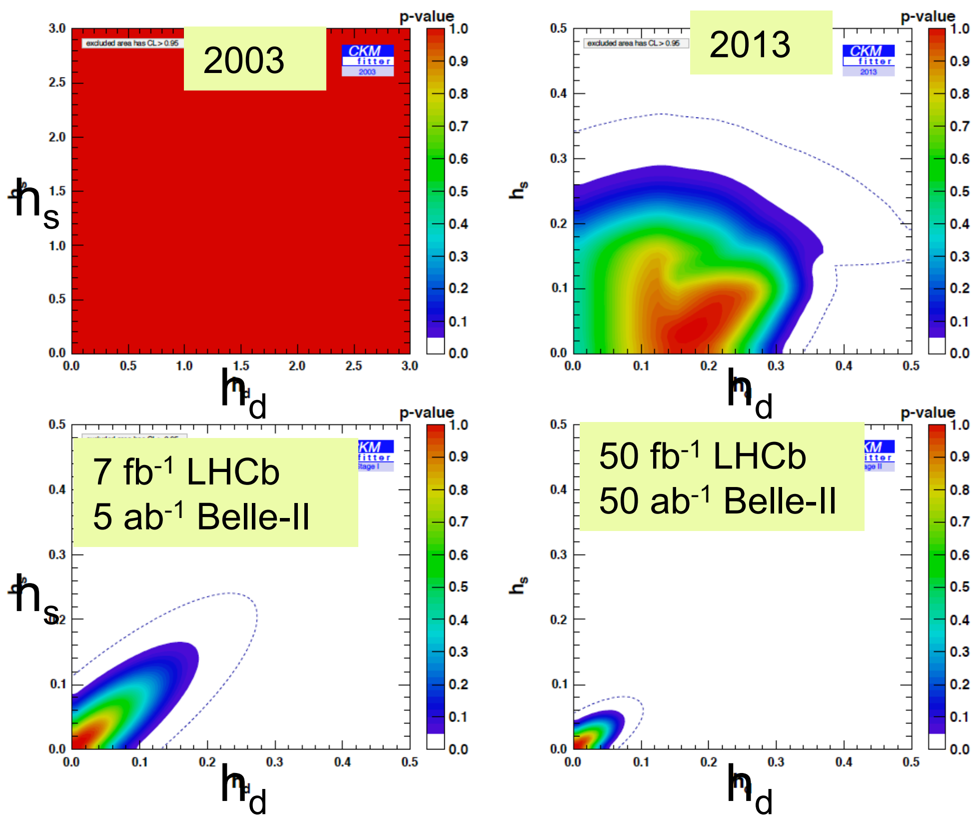
➢Current data:

◆B_s is now on equal ground as B_d system (Thanks to LHCb results).

◆Data allows NP at 20-30% SM

➢Future:

If consistency with SM persists- LHCb and Belle-II measurements- combined with improved LQCD errors- will constrain the magnitude of NP contribution to ~5% of SM

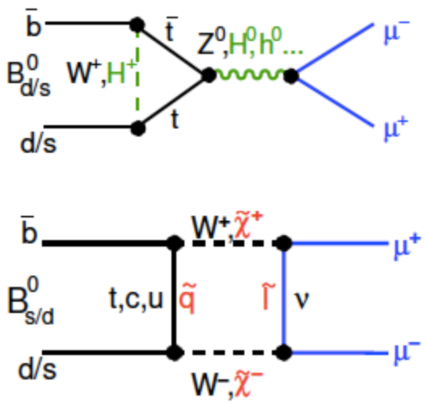


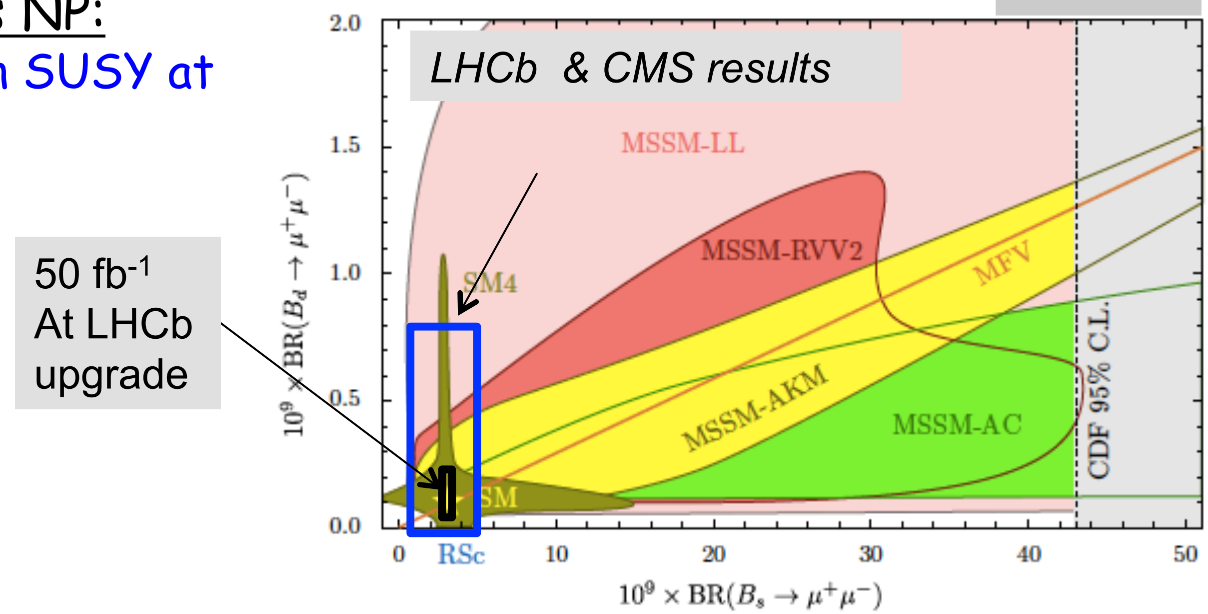
Direct encounter with NP scenarios & parameter space:

D. Straub

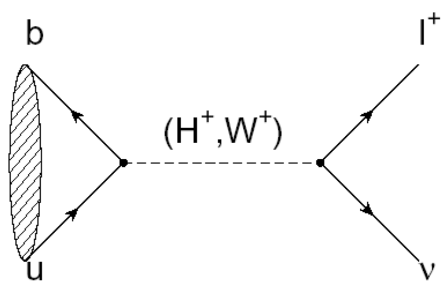
Example of $B^0_s \to \mu^+\mu^-$ vs NP:

sensitive to new scalars in SUSY at large $\tan\beta$

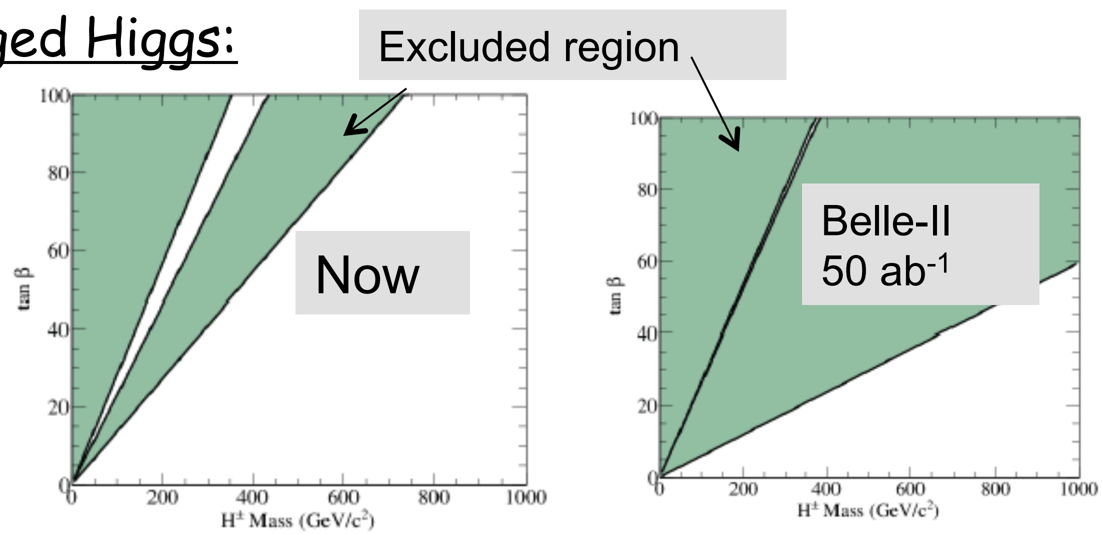




Example of $B^- \to \tau^-\nu$ vs charged Higgs:



$$\mathrm{BR}(B \to \tau\nu) = \mathrm{BR}_{SM}(B \to \tau\nu)\left(1 - \frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$



Implication of not seeing NP in Flavor (yet)

What do we learn on possible scale of NP?

- NP sensitivity is largely owed to FCNC processes: Forbidden at tree level in SM & Highly suppressed at loop level (GIM & CKM)

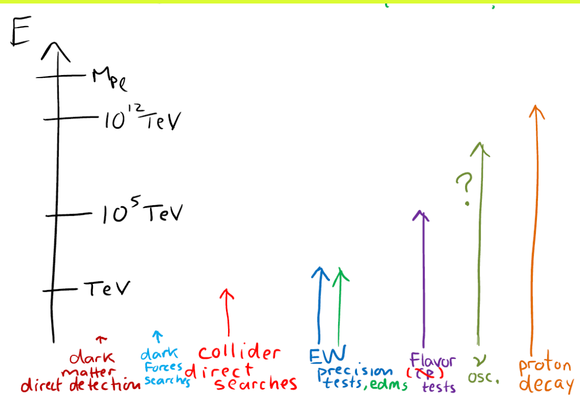
NP contribution at very high scale (Λ) can be comparable to SM amplitude

$$\mathcal{L}_{eff} = \mathcal{L}_{SM}\left(\frac{f(V_{ij}V_{ik}^{*})}{M_W^2}\right) + \sum_{i}^{NP} \frac{c_{ij}}{\Lambda_{NP}^2} O'_{ij}$$

Isidori, Nir, Perez

Operator	Bounds on Λ [TeV] ($C=1$) Re	Bounds on Λ [TeV] ($C=1$) Im	Bounds on C ($\Lambda = 1\,$TeV) Re	Bounds on C ($\Lambda = 1\,$TeV) Im	Observables
$(\bar{s}_L\gamma^\mu d_L)^2$	9.8×10^2	1.6×10^4	9.0×10^{-7}	3.4×10^{-9}	Δm_K; ϵ_K
$(\bar{s}_R\,d_L)(\bar{s}_L d_R)$	1.8×10^4	3.2×10^5	6.9×10^{-9}	2.6×10^{-11}	Δm_K; ϵ_K
$(\bar{c}_L\gamma^\mu u_L)^2$	1.2×10^3	2.9×10^3	5.6×10^{-7}	1.0×10^{-7}	Δm_D; $\lvert q/p\rvert, \phi_D$
$(\bar{c}_R\,u_L)(\bar{c}_L u_R)$	6.2×10^3	1.5×10^4	5.7×10^{-8}	1.1×10^{-8}	Δm_D; $\lvert q/p\rvert, \phi_D$
$(\bar{b}_L\gamma^\mu d_L)^2$	6.6×10^2	9.3×10^2	2.3×10^{-6}	1.1×10^{-6}	Δm_{B_d}; $S_{\psi K_S}$
$(\bar{b}_R\,d_L)(\bar{b}_L d_R)$	2.5×10^3	3.6×10^3	3.9×10^{-7}	1.9×10^{-7}	Δm_{B_d}; $S_{\psi K_S}$
$(\bar{b}_L\gamma^\mu s_L)^2$	1.4×10^2	2.5×10^2	5.0×10^{-5}	1.7×10^{-5}	Δm_{B_s}; $S_{\psi\phi}$
$(\bar{b}_R\,s_L)(\bar{b}_L s_R)$	4.8×10^2	8.3×10^2	8.8×10^{-6}	2.9×10^{-6}	Δm_{B_s}; $S_{\psi\phi}$

<u>Relative to other probes</u>
From R. Sundrum at CKM workshop 2012



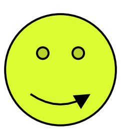
Next phase of Heavy Flavor Physics Program

- The Strength of Flavor Physics program rests with its access to a broad set of observables, and their correlated sensitivity to NP models:
- In practice:
  - Matching improvements in LQCD & other theory inputs also required.
  - Precise measurements ofCKM parameters and "engineering" channels also needed for data driven control of systematics and validation of theory inputs.
  - Belle-II and LHCb coverages, while largely complementary, provide necessary-and healthy- overlap in some areas.

Example of a possible NP-driven program
(W. Altmannshofer, A.J. Buras, S. Gori, P. Paradisi D.M. Straub- "DNA of flavor physics effects") ≈

★★★ large effects
★★ visible but small effects
★ unobservable effects

	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	★★★	★★★	★★	★	★★★	★	★★★
$(g-2)_\mu$	★★★	★★★	★★	★★★	★★★	★	?



NP signature & its structure may be revealed in the pattern of deviations from SM

Physics sensitivity in Key Channels

From Snowmass report. More Detailed tables in backup slides

Belle-II

Will dominate inclusive channels, e.g. b->s γ… unique access to $B \to K\nu\nu$, $B \to \tau\nu$, modes with many π^0 or γ, LFV in $\tau^+ \to \mu^+\gamma$,…Also access to Charm CPV.

Observable	SM theory	Current measurement (early 2013)	Belle II ($50\,\mathrm{ab}^{-1}$)
$S(B \to \phi K^0)$	0.68	0.56 ± 0.17	± 0.03
$S(B \to \eta' K^0)$	0.68	0.59 ± 0.07	± 0.02
α from $B \to \pi\pi$, $\rho\rho$		$\pm 5.4^\circ$	$\pm 1.5^\circ$
γ from $B \to DK$		$\pm 11^\circ$	$\pm 1.5^\circ$
$S(B \to K_S \pi^0 \gamma)$	< 0.05	-0.15 ± 0.20	± 0.03
$S(B \to \rho\gamma)$	< 0.05	-0.83 ± 0.65	± 0.15
$A_{\mathrm{CP}}(B \to X_{s+d}\,\gamma)$	< 0.005	0.06 ± 0.06	± 0.02
A^d_{SL}	-5×10^{-4}	-0.0049 ± 0.0038	± 0.001
$\mathcal{B}(B \to \tau\nu)$	1.1×10^{-4}	$(1.64 \pm 0.34) \times 10^{-4}$	$\pm 0.05 \times 10^{-4}$
$\mathcal{B}(B \to \mu\nu)$	4.7×10^{-7}	$< 1.0 \times 10^{-6}$	$\pm 0.2 \times 10^{-7}$
$\mathcal{B}(B \to X_s\gamma)$	3.15×10^{-4}	$(3.55 \pm 0.26) \times 10^{-4}$	$\pm 0.13 \times 10^{-4}$
$\mathcal{B}(B \to K\nu\overline{\nu})$	3.6×10^{-6}	$< 1.3 \times 10^{-5}$	$\pm 1.0 \times 10^{-6}$
$\mathcal{B}(B \to X_s \ell^+\ell^-)$ $(1 < q^2 < 6\,\mathrm{GeV}^2)$	1.6×10^{-6}	$(4.5 \pm 1.0) \times 10^{-6}$	$\pm 0.10 \times 10^{-6}$
$A_{\mathrm{FB}}(B^0 \to K^{*0}\ell^+\ell^-)$ 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%

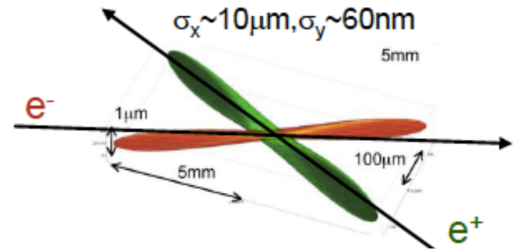
LHCb

Will dominate the B^0_s sector, and exclusive decays with charged particles, e.g B->Kμ+μ−… Unique access to B_c & B-baryons & rare charmed decays, LFV in $\tau^+ \to \mu^+\mu^+\mu^-$

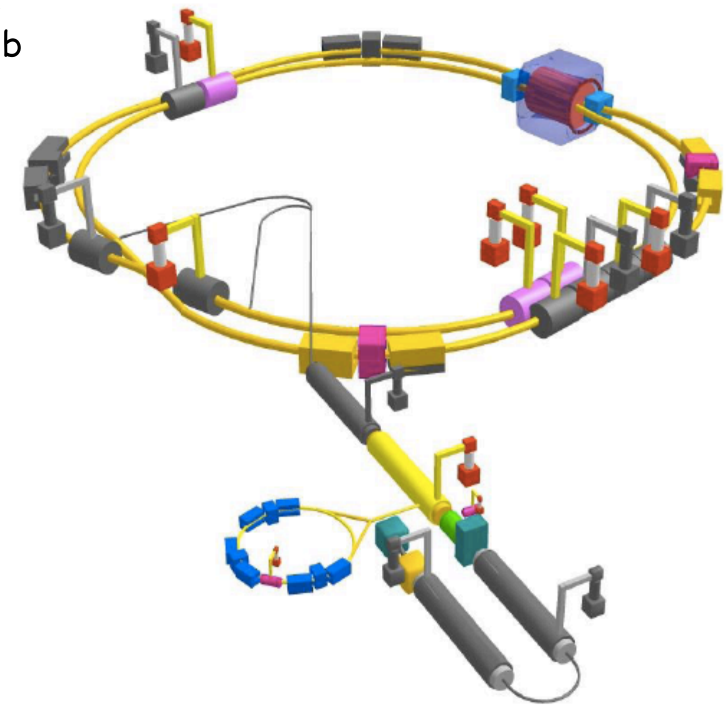
Observable	Current SM theory uncertainty	Precision as of 2013	LHCb (6.5 fb^{-1})	LHCb Upgrade (50 fb^{-1})
$2\beta_s(B_s \to J/\psi\phi)$	~ 0.003	0.09	0.025	0.008
$\gamma(B \to D^{(*)}K^{(*)})$	$< 1^\circ$	8°	4°	0.9°
$\gamma(B_s \to D_s K)$	$< 1^\circ$	—	$\sim 11^\circ$	2°
$\beta(B^0 \to J/\psi K^0_S)$	small	0.8°	0.6°	0.2°
$2\beta_s^{\mathrm{eff}}(B_s \to \phi\phi)$	0.02	1.6	0.17	0.03
$2\beta_s^{\mathrm{eff}}(B_s \to K^{*0}\bar{K}^{*0})$	< 0.02	—	0.13	0.02
$2\beta_s^{\mathrm{eff}}(B_s \to \phi\gamma)$	0.2%	—	0.09	0.02
$2\beta^{\mathrm{eff}}(B^0 \to \phi K^0_S)$	0.02	0.17	0.30	0.05
A^s_{SL}	0.03×10^{-3}	6×10^{-3}	1×10^{-3}	0.25×10^{-3}
$\mathcal{B}(B_s \to \mu^+\mu^-)$	8%	36%	15%	5%
$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s \to \mu^+\mu^-)$	5%	—	~100%	~35%
$A_{\mathrm{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$ zero crossing	7%	18%	6%	2%

Belle-II at SuperKEKB

Asymmetric Energy e+e- collider at goal peak Luminosity 8×10^{35} /cm^2/s aiming for 50 ab^{-1}



Design based on Nano-beam scheme proposed by P. Raimondi (Frascati), tight focusing, larger crossing angle & higher I_b



Accelerator Upgrade

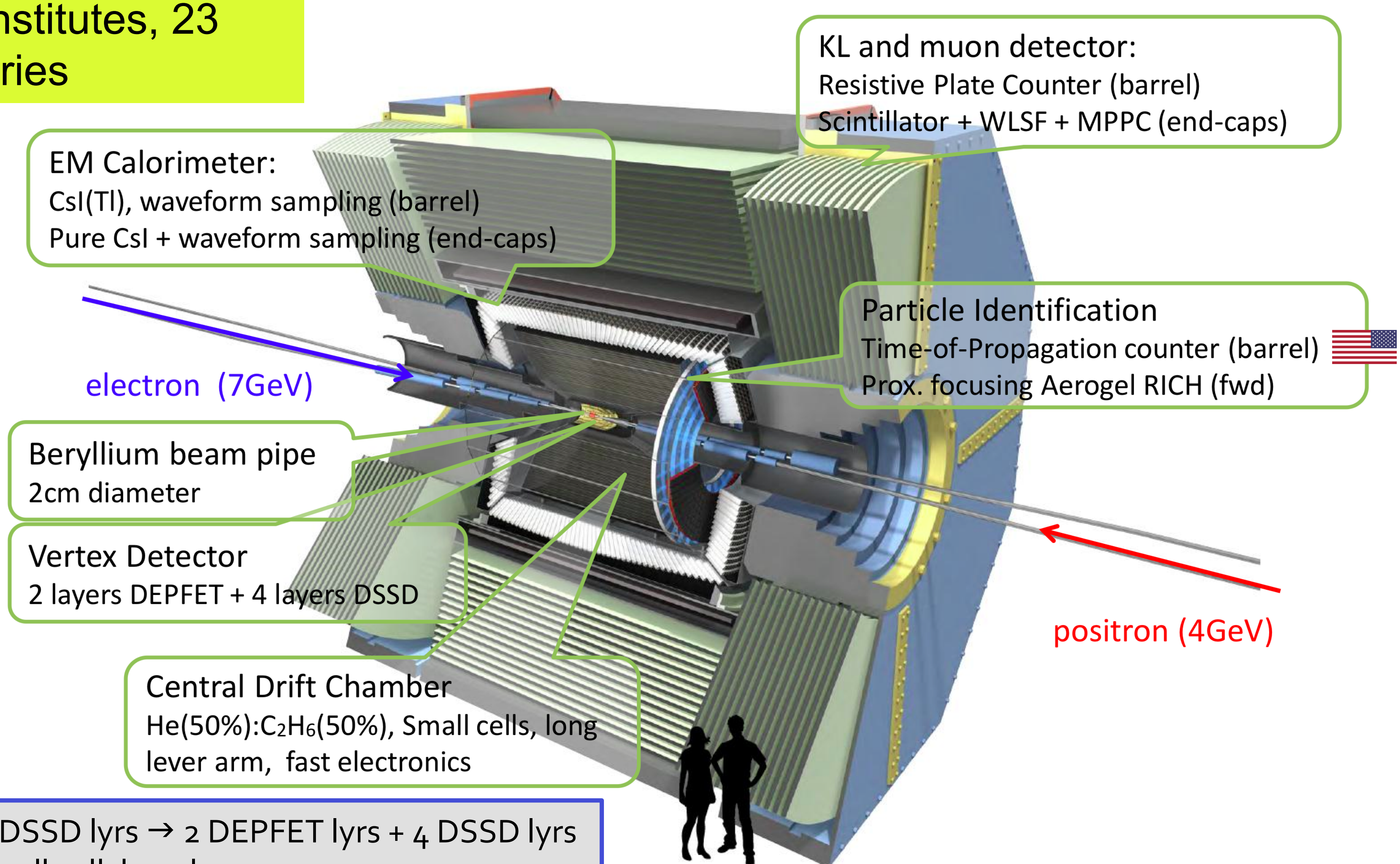
- low emittance electron injector
- New positron damping ring
- New vacuum chambers
- New HER and LER lattice and long dipoles for low emittance
- New IR for low β^*
- Modified and additional RF for higher currents

- Cost ~$400M (+ $50 M detector)

Detail Schedule in backup slides

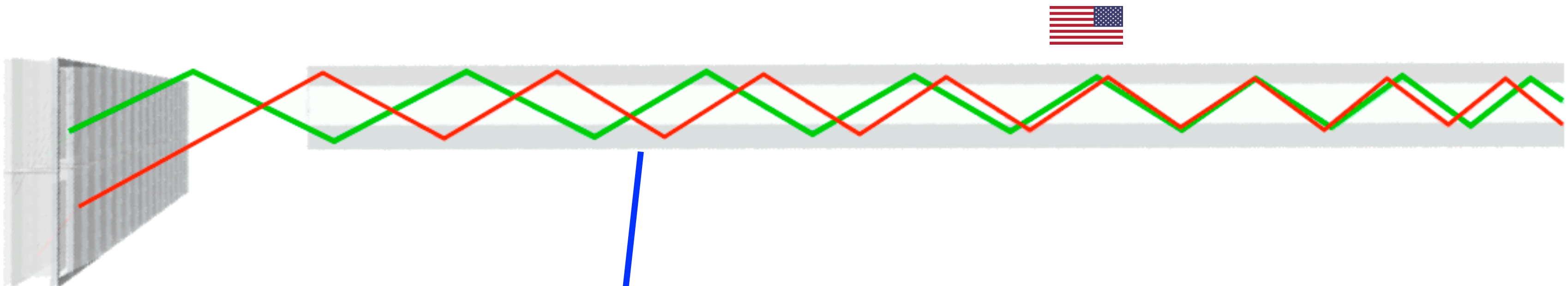
Belle II Detector

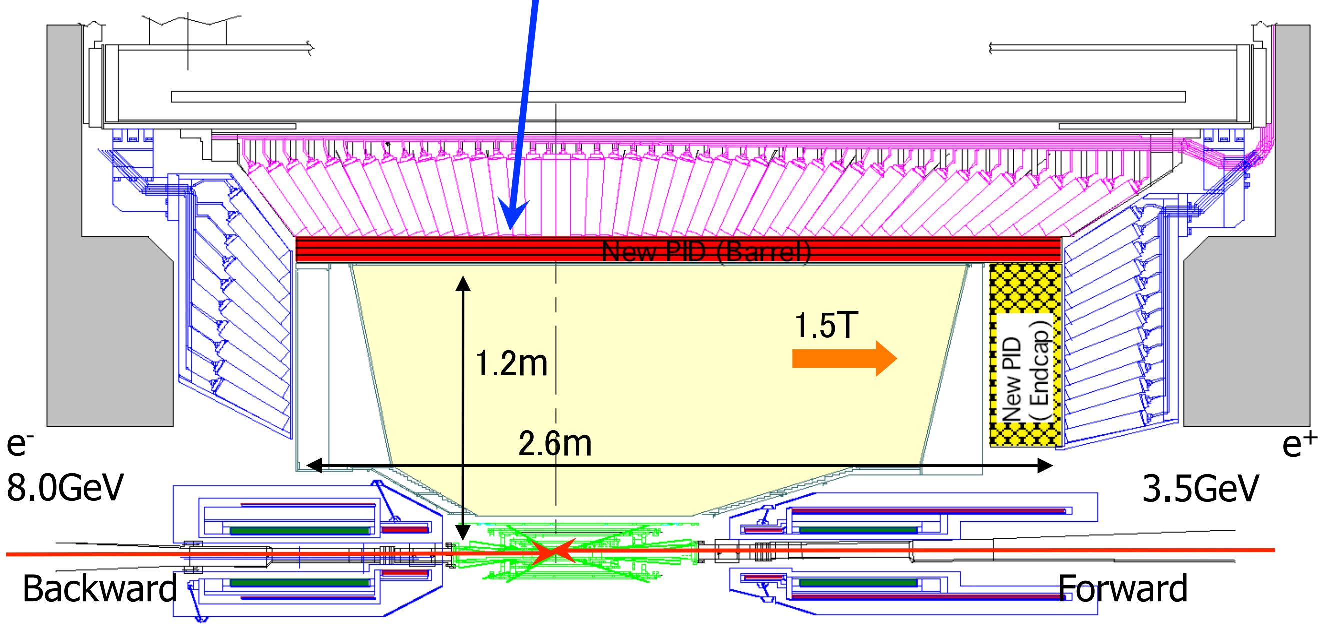
~600 collaborators
100 institutes, 23 countries



SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

iTOP : An imaging time-of-propagation detector





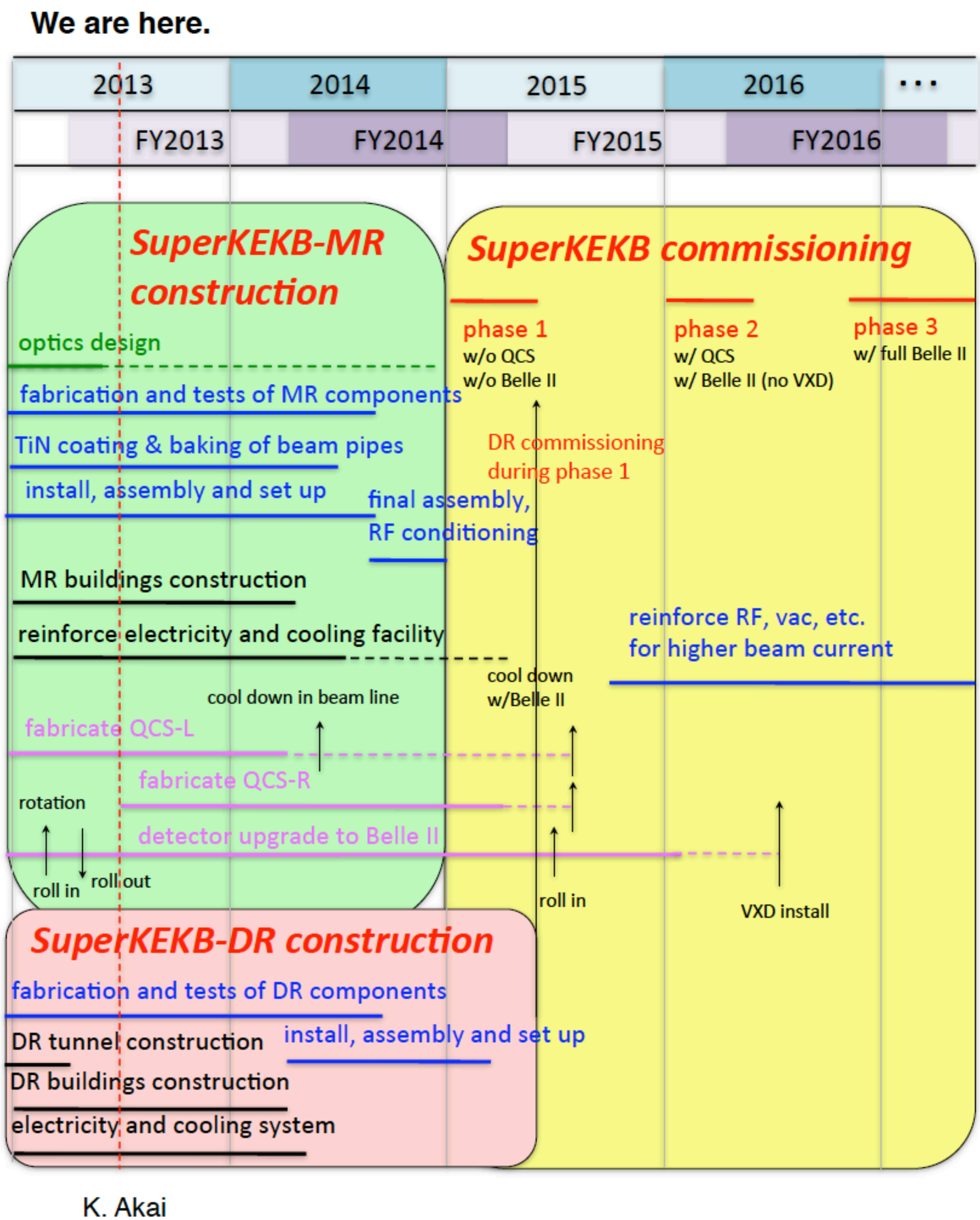
US Contributions to Belle II

US Belle-II is 43 PhD's from 13 institutions (PNNL, CMU, Cincinnati, Hawaii, Indiana, Kennesaw State, Luther College, Mississippi, Pittsburgh, S. Carolina, S. Alabama, Virginia Tech, Wayne State)

Funding: DOE (2/3) NSF Seeking-funding

- US contributions to particle identification systems
  - iTOP system (barrel PID) (Providing quartz optical elements)
  - KLM (muon system upgrade, endcap and barrel)
    - Providing replacement of inner layers of BKLM (done)
  - ASICs and front-end electronics
- To provide beamstrrahlung monitors for accelerator
- Proposing to lead commissioning detector effort
- US (PNNL) hosting "tier 1" computing facility for Belle II

- The program has received CD0 & CD1 & preparing for CD 2 &3
- Total cost at 15M$ + 15M$ computing (15% of Belle-II computing)



<u>Phase I:</u>

w/o QCS and Belle II

Jan-May, 2015

<u>Phase II:</u>

with QCS and Belle II w/o inner detector

Feb-June, 2016

<u>Phase III:</u>

Physics Run with full Belle II with partial TOP *Starts Oct, 2016*

The LHCb Experiment

A Single Arm Spectrometer at LHC

Acceptance: $2 < \eta < 5$

σ_{inel}~70-80 mb

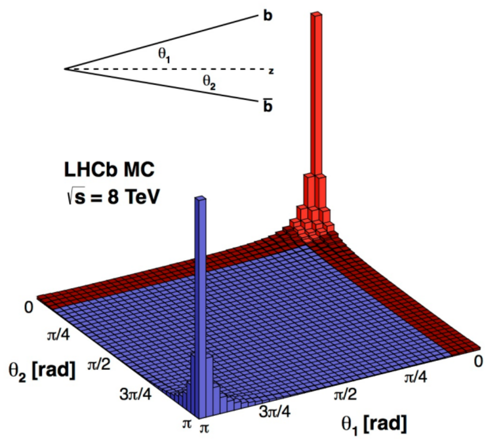
σ_{cc}~6 mb (7 TeV)

σ_{τ}~80 μb (7 TeV)

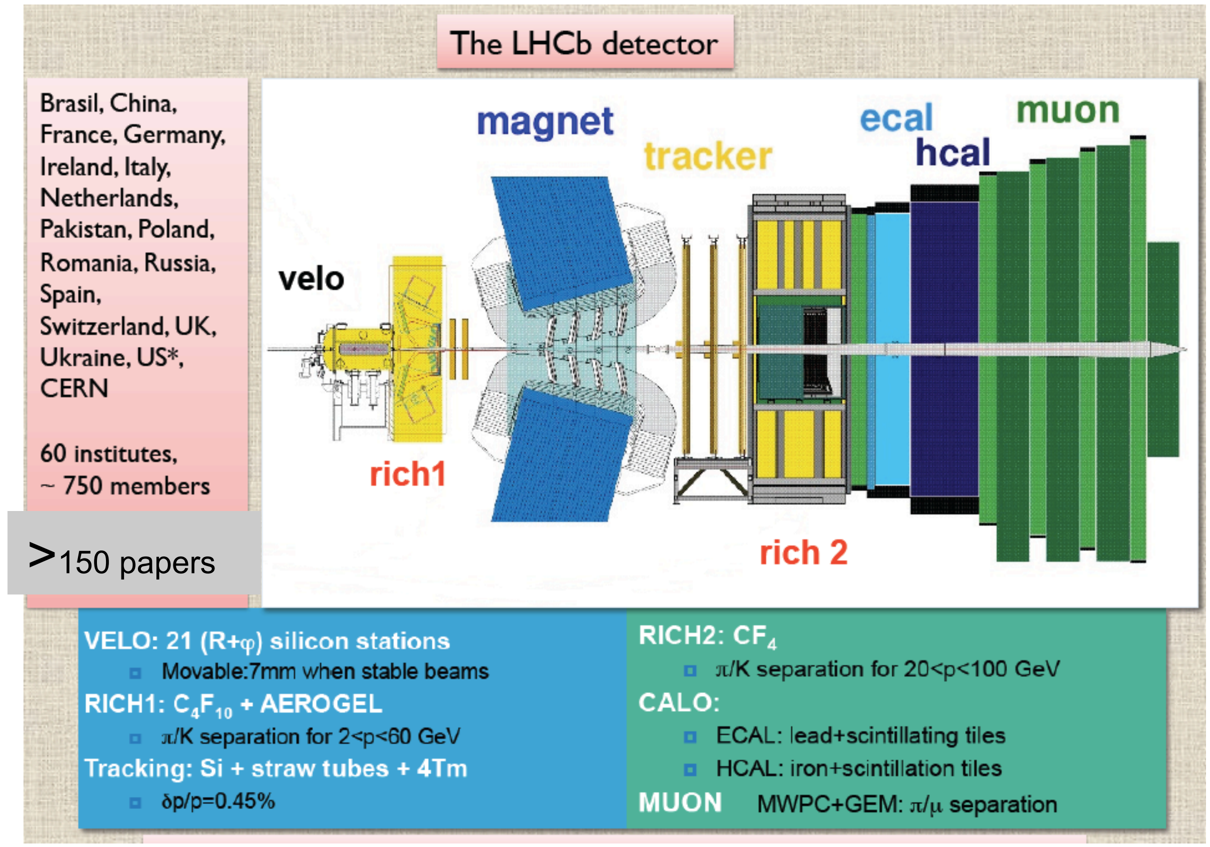
Σ_{bb}~300 μb (7 TeV)

σ_{bb}~500 μb (14 TeV)

$b\bar{b}$ peaked forward or backward with ~25% in detector acceptance

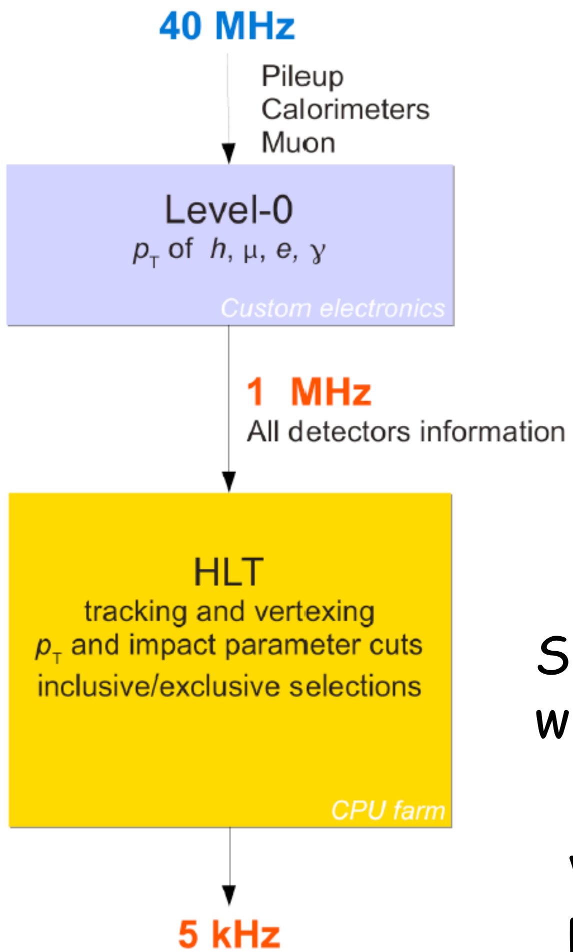


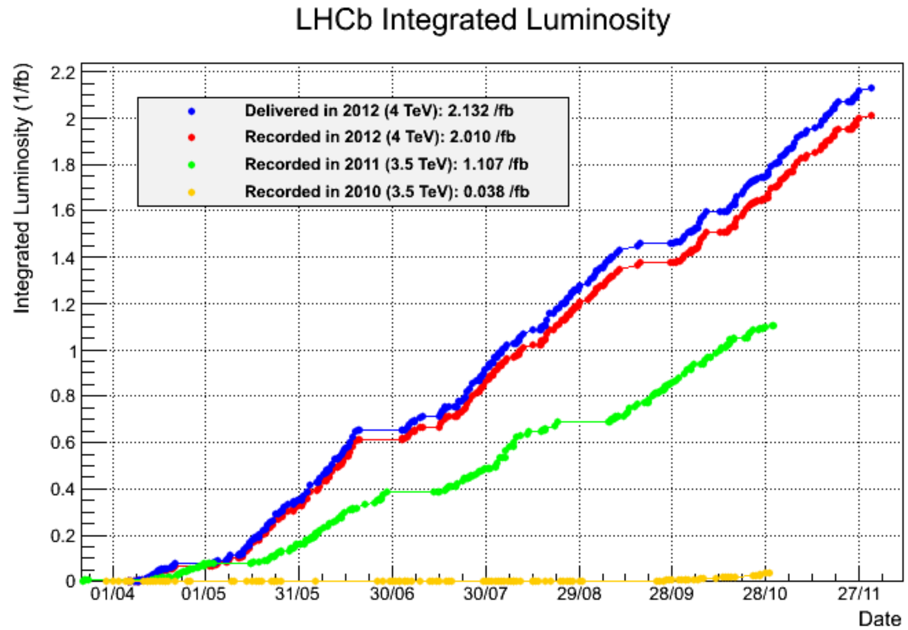
Access to all species of B hadrons



US Participation: Syracuse(since:2005); Cincinnati, Maryland & MIT (since 2012)

Current data & Plan





Since end of 2011, run with L~**4×10^{32} cm^{-2} s^{-1}** with 50 ns bunch spacing.

Will restart in 2015 at 13 TeV, with 25 ns bunch spacing (nominal). Expect to reach a total of ~8 fb^{-1} by 2018

The LHCb upgrade

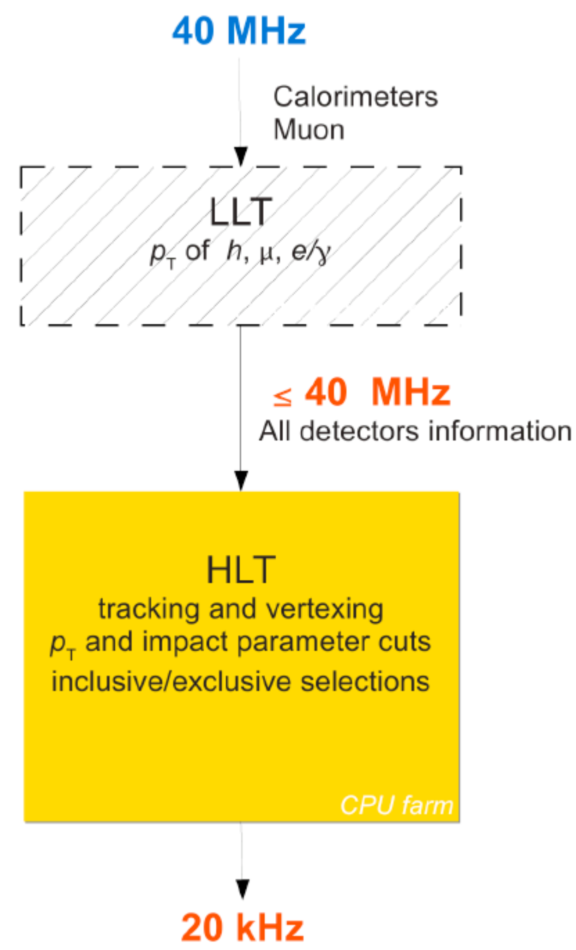
The upgrade is designed to run at luminosity of $(1\text{-}2)\times10^{33}$ $cm^{-2}s^{-1}$; Aiming for $50\ fb^{-1}$

- Requires new approach to the LHCb trigger scheme to overcome L0 (1MHz) limitation.

➔ New Trigger Apporach:

- Remove L0 (hardware) trigger
- Readout the detector at the 40 MHz LHC clock rate
- Move to a fully flexible software trigger

=>>Major upgrade of LHCb detector required : to cope with increase occupancy, data rate and radiation dose, & to preserve efficiency and low ghost rate: Replace all readout electronics, entire tracking system (Vertex locator, upstream & downstream tracking detectors) & upgrade Particle ID system



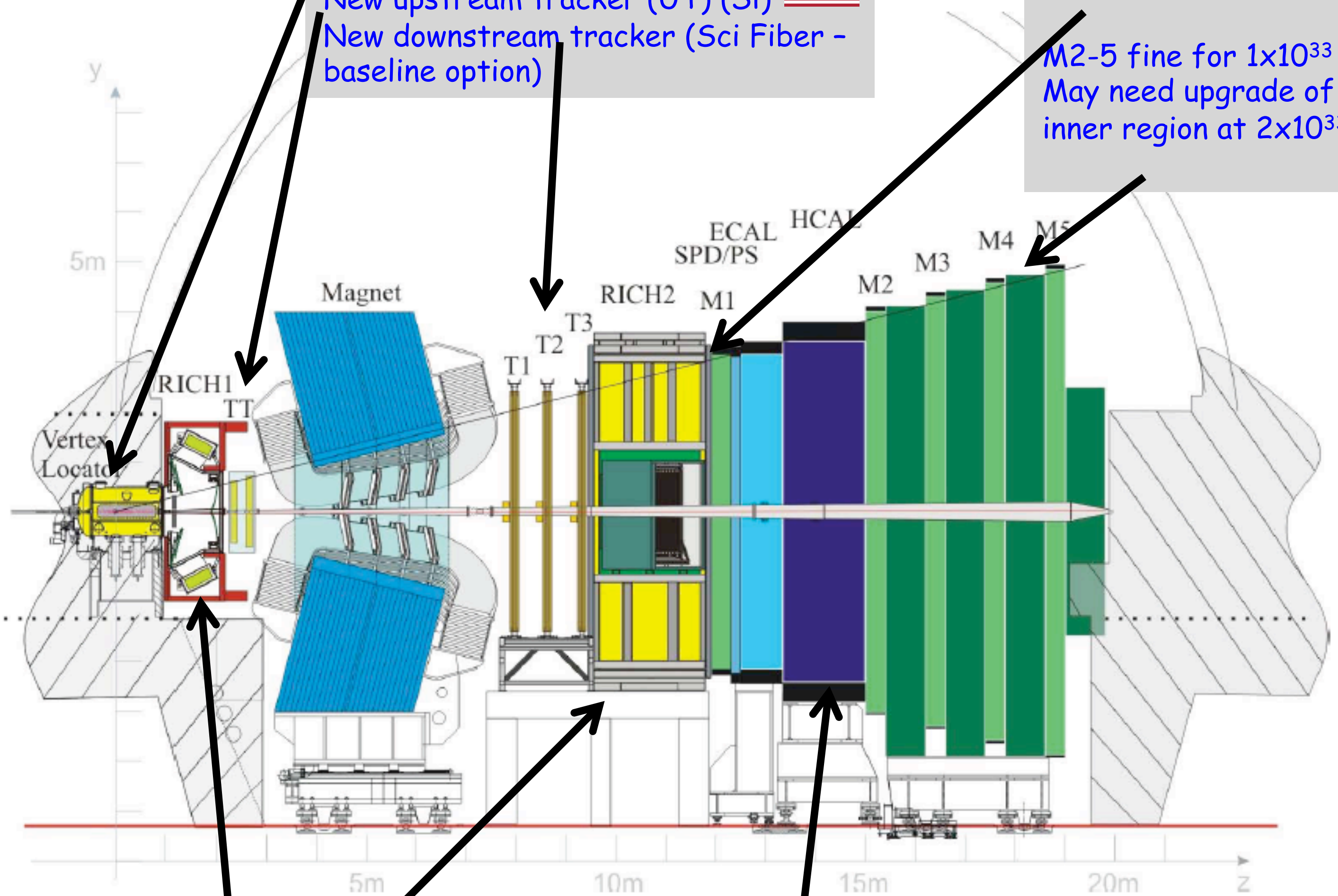
Upgrade plan

<u>Tracking system</u>:
New VELO (Si strip → Pixel)
New upstream tracker (UT) (Si)
New downstream tracker (Sci Fiber – baseline option)

<u>Muon System</u>:

Remove M1

M2-5 fine for $1x10^{33}$
May need upgrade of inner region at $2x10^{33}$



<u>RICH 1 & RICH 2</u>
HPD→ MaPMT
New 40 MHz R/O
RICH1: new optics
remove aerogel

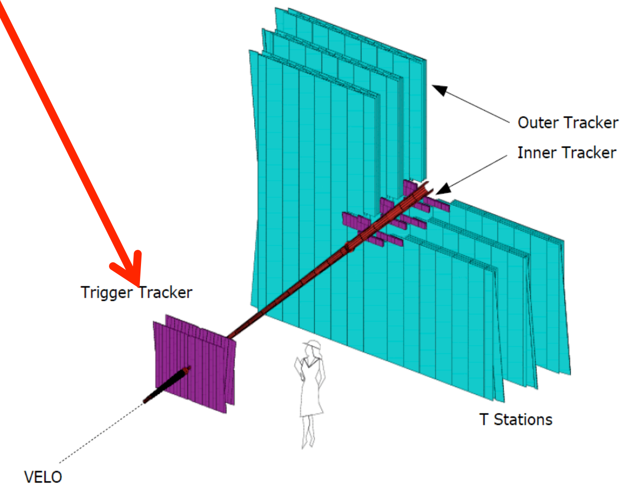
<u>Calorimeter:</u>
New 40 MHz R/O
Lower PMT gain to reduce anode current
Remove SPD & PS

US Contribution to LHCb Upgrade

Construction of new Upstream Tracker (UT)

4 planes of single sided silicon sensors with segmentation optimized for the expected occupancy increase of LHCb upgrade, improved coverage & reduced material budget & new FE and readout electronics to cope with high data rate at 40 MHz readout.

• UT has a key role in High Level Trigger by reducing ghost rate & providing fast momentum measurement



- US collaboration: 4 institutions (Cincinnati, Maryland, Syracuse, MIT) (18 Ph.D.'s) all supported by NSF

- Upgrade proposal being prepared for submission to NSF
  - NSF Cost at ~$6 M , plus funds from Zurich and Milano (~1.5 MSF)
  - Schedule: 2014(R&D and design)- 2015(start of production &QA) , 2018-2019(installation)

- US collaboration will continue participation in LHCb operation (2015-2017) and data analysis

LHCb timeline

P.Campana

2011 - LoI submitted: encouraged by the LHCC to proceed to TDRs

2012 - “Framework TDR” with costing (~57 MSF envelope) and technical options submitted. Endorsed (LHCC) & approved (RB: *“LHCb upgrade approved to be part of the long-term exploitation of the LHC”*)
Submission of Addendum to MoU for Common Projects

2012/13 - R&D towards technical choices

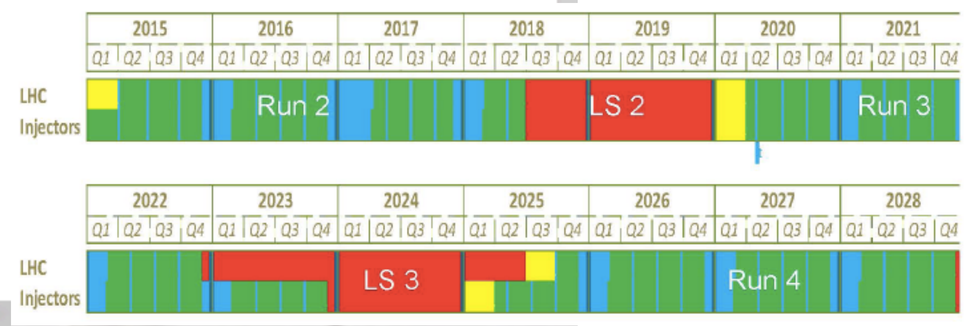
2013/14 - Technical Design Reports & MoUs of sub-systems (updated costs still within the envelope of the FTDR)

2014 - Prototype validation & Engineering Design Reviews

2014/16 - Tendering & serial production

2016/17 - Quality control & acceptance tests

2018/19 -18 months installation during LS2



Summary

- ✓ Heavy Flavor Physics has had tremendous progress in the past two decades and remains as one of the most powerful probes of Physics Beyond the Standard Model.

- ✓ The future of the field will be defined by the Super Flavor experiments, Belle-II & LHCb upgrade, planned for realization by the end of this decade.

- ✓ US has had a long history of leadership in this field and the participation of US physicists in these off-shore experiments is important to the health of US high energy physics program, as they have significant potential to discover or describe the structure of the physics beyond the Standard Model.

Backup slides

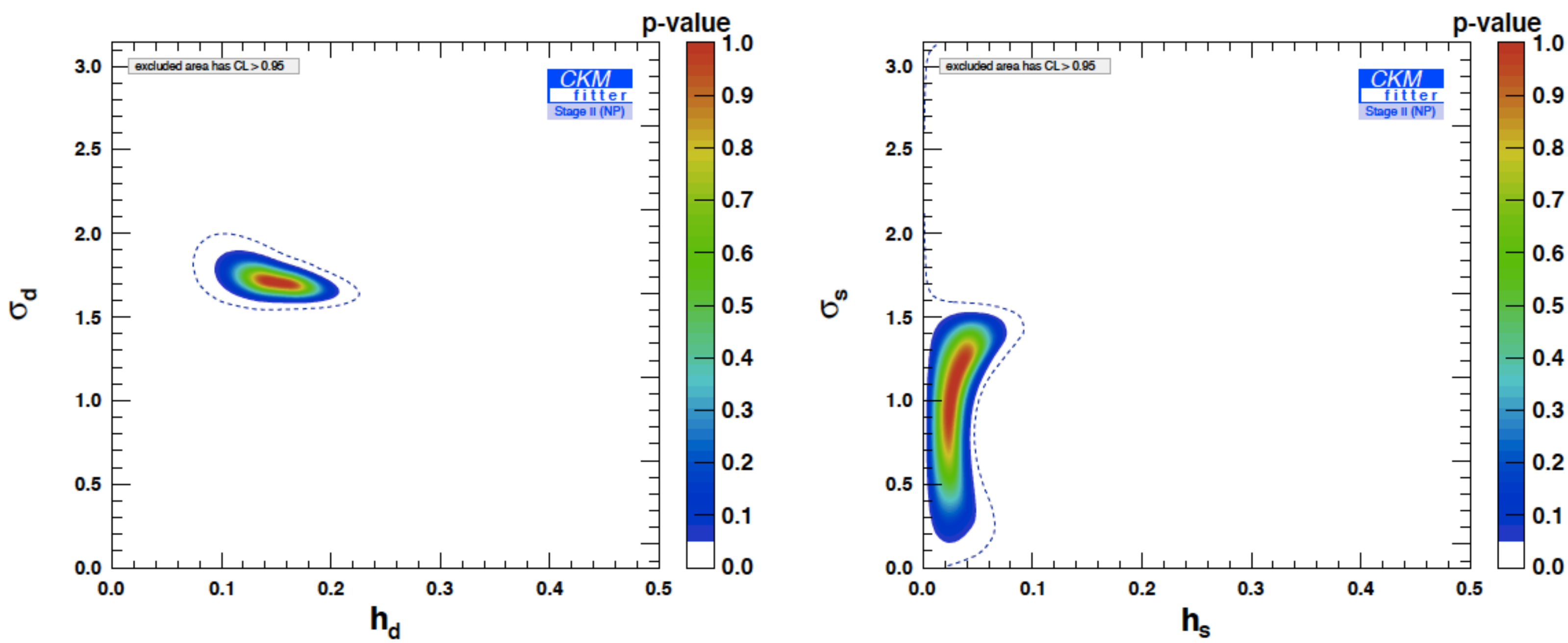


FIG. 10. Hypothetical Stage II fits for NP, assuming that all future experimental results correspond to the current best-fit values of $\bar{\rho}$, $\bar{\eta}$, $h_{d,s}$ and $\sigma_{d,s}$ (with measurement uncertainties as given in Table I, but different central values).

LHCb sensitivity to key flavour channels

Table 1: Statistical sensitivities of the LHCb upgrade to key observables. For each observable the expected sensitivity is given for the integrated luminosity accumulated by the end of LHC Run 1, by 2018 (assuming $5\,\mathrm{fb}^{-1}$ recorded during Run 2) and for the LHCb Upgrade ($50\,\mathrm{fb}^{-1}$). An estimate of the theoretical uncertainty is also given – this and the potential sources of systematic uncertainty are discussed in the text.

Type	Observable	LHC Run 1	LHCb 2018	**LHCb upgrade**	Theory
B^0_s mixing	$\phi_s(B^0_s \to J/\psi\,\phi)$ (rad)	0.05	0.025	**0.009**	~ 0.003
	$\phi_s(B^0_s \to J/\psi\, f_0(980))$ (rad)	0.09	0.05	**0.016**	~ 0.01
	$A_{sl}(B^0_s)$ (10^{-3})	2.8	1.4	**0.5**	0.03
Gluonic penguin	$\phi_s^{\mathrm{eff}}(B^0_s \to \phi\phi)$ (rad)	0.18	0.12	**0.026**	0.02
	$\phi_s^{\mathrm{eff}}(B^0_s \to K^{*0}\bar{K}^{*0})$ (rad)	0.19	0.13	**0.029**	< 0.02
	$2\beta^{\mathrm{eff}}(B^0 \to \phi K^0_S)$ (rad)	0.30	0.20	**0.04**	0.02
Right-handed currents	$\phi_s^{\mathrm{eff}}(B^0_s \to \phi\gamma)$	0.20	0.13	**0.030**	< 0.01
	$\tau^{\mathrm{eff}}(B^0_s \to \phi\gamma)/\tau_{B^0_s}$	5%	3.2%	**0.8%**	0.2 %
Electroweak penguin	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.04	0.020	**0.007**	0.02
	$q_0^2\, A_{FB}(B^0 \to K^{*0}\mu^+\mu^-)$	10%	5%	**1.9%**	$\sim 7\%$
	$A_I(K\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.14	0.07	**0.024**	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	14%	7%	**2.4%**	$\sim 10\%$
Higgs penguin	$\mathcal{B}(B^0_s \to \mu^+\mu^-)$ (10^{-9})	1.0	0.5	**0.19**	0.3
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B^0_s \to \mu^+\mu^-)$	220%	110%	**40%**	$\sim 5\,\%$
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	7°	4°	**1.1°**	negligible
	$\gamma(B^0_s \to D_s^{\mp}K^{\pm})$	17°	11°	**2.4°**	negligible
	$\beta(B^0 \to J/\psi\, K^0_S)$	1.7°	0.8°	**0.31°**	negligible
Charm *CP* violation	$A_\Gamma(D^0 \to K^+K^-)$ (10^{-4})	3.4	2.2	**0.5**	–
	ΔA_{CP} (10^{-3})	0.8	0.5	**0.12**	–

Belle-II sensitivity in key flavour channels

Observable	Belle II sensit. (50 ab^{-1})	SM[1]	comment
Hadronic $b \to s$ transitions			
$S(B \to \phi K_S)$	0.03	0.03 ± 0.02	
$S(B \to \eta' K_S)$	0.02	0 ± 0.015	
$S(B \to f_0 K_S)$	0.03	0 ± 0.015	
Radiative/electroweak $b \to s$ transitions			
$S(B \to K_S \pi^0 \gamma)$	0.03	-0.04 ± 0.1	
$Br(B \to X_s \gamma)$ $(\times 10^{-4})$	0.13	3.2 ± 0.2	inclusive Br
$Br(B \to K \nu \bar{\nu})$ $(\times 10^{-6})$	1.0	3.6 ± 0.5	
$A_{FB}(B \to K^* \ell^+ \ell^-)$	0.03	-0.10 ± 0.02	for $0 \leq q^2 \leq 4.3$ GeV^2
Radiative $b \to d$ transitions			
$S(B \to \rho \gamma)$	0.15	< 0.05	
Leptonic B decays			
$Br(B \to \tau \nu)$ $(\times 10^{-3})$	0.04	1.1 ± 0.2	
LFV in τ decays (U.L. at 90% C.L.)			
$Br(\tau \to \mu \gamma)$ $(\times 10^{-9})$	3	0	
B_s physics			
$Br(B_s \to \gamma \gamma)$ $(\times 10^{-6})$	0.3	0.7 ± 0.3	with 5 ab^{-1} of data
A_{SL} $(\times 10^{-3})$	5	0.23 ± 0.06	at $\Upsilon(5S)$
D meson mixing and CPV			
x $(\times 10^{-4})$	4		SM expectations
y $(\times 10^{-4})$	3		difficult to
$\lvert q/p \rvert$	0.03		estimate due to the
Arg$(\lvert q/p \rvert)$ $(^\circ)$	1.5		LD contributions
$A_{CP}(D^0 \to K^+ K^-)$ $(\times 10^{-4})$	6		

Table 1: Some expected accuracies of *selected* physics observables at Belle II with a 50 ab^{-1} data sample. The second column gives approximate expectations within the SM along with theoretical uncertainties.

SuperKEKB Schedule