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한국과학기술정보연구원
Korea Institute of Science and Technology Information
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e-Science paradigm for Flavor Physics in the LHC era

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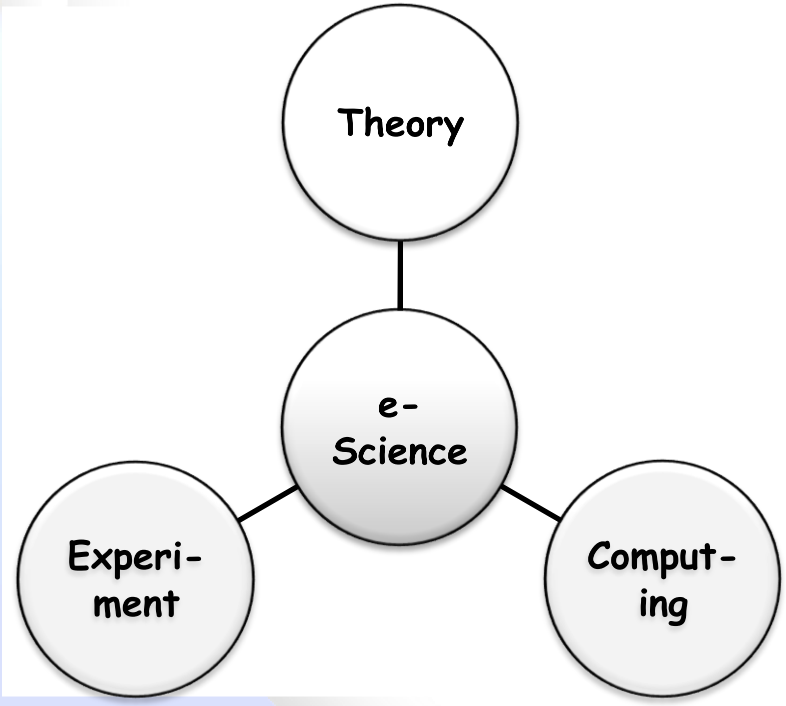
Abstract

- We introduce the e-Science paradigm of experiment-computing-theory. We apply this concept to flavor physics in the LHC era. There are a few interesting results from flavor physics experiments of lepton and/or hadron colliders indicating hints of something unknown. It may provides us with a clue of beyond Standard Model.

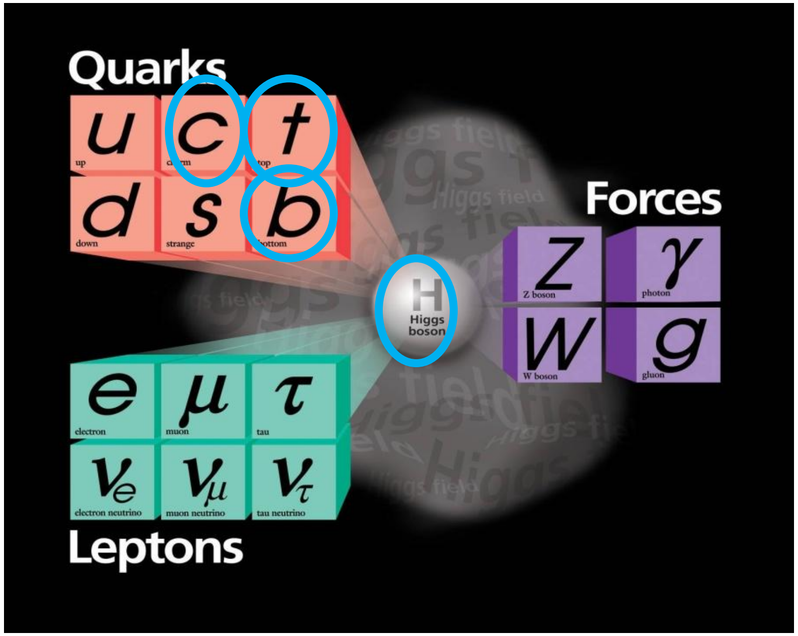
e-Science paradigm of experiment-theory-computing



CDF
Belle/Belle II

cf. LHCb

To probe the Standard Model and search for New Physics



K.Cho and H.W.Kim, JKPS (2009)

Kihyeon Cho

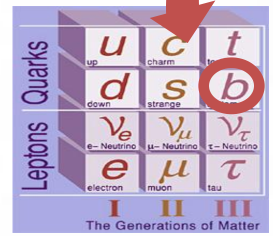
Contents

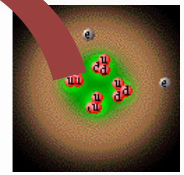
To study Flavor physics both in experiments (Belle & CDF) and theories

Goal

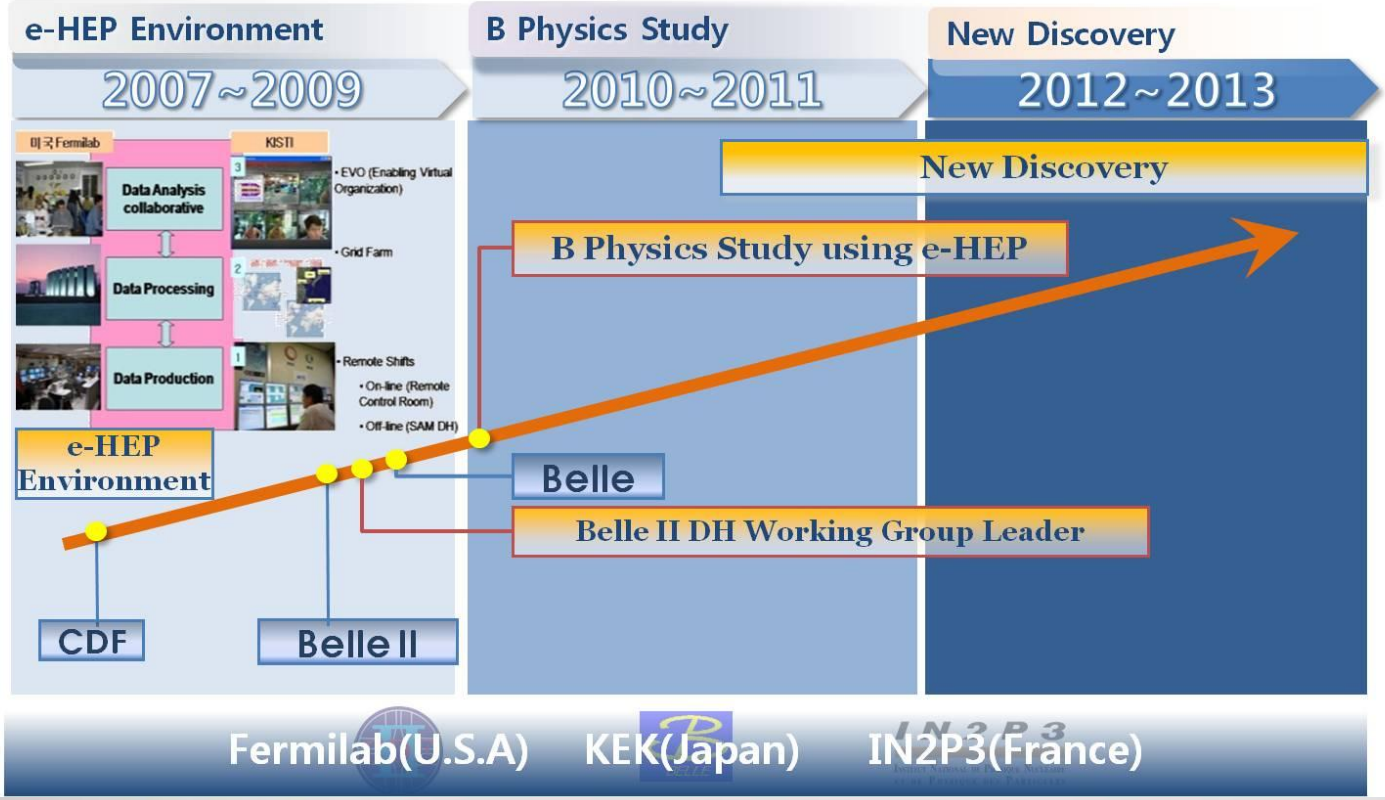
To probe the Standard Model and search for New Physics

⇒ New Discovery





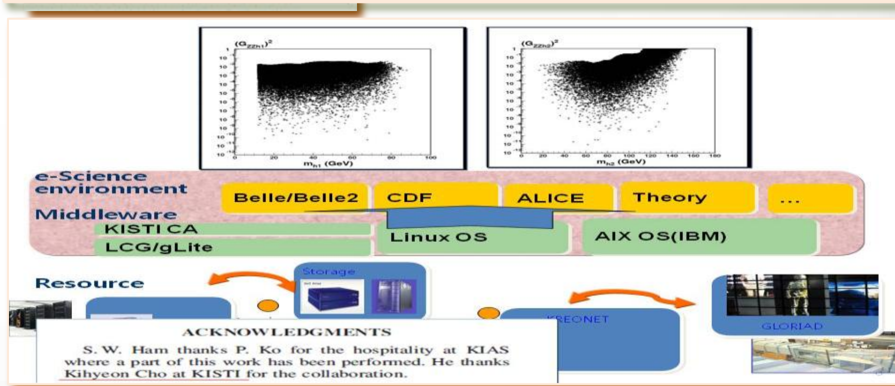
The Standard Model



e-Science for HEP (High Energy Physics)

To study high energy physics anytime anywhere even if we are not on-site (accelerator laboratory)

1. Data production
   - CDF Remote Control Room @KISTI
2. Data processing
   - Pacific CAF(CDF Analysis Farm) ⇒ North America CAF @KISTI
3. Data Analysis Collaboration
   - EVO servers @KISTI
4. Belle II Data Handling System
   - Working Group Chair (K. Cho)



Ex) A study of Higgs model using cyberinfrastructure @KISTI

Table I. Some interesting observables. In the "present status" column, upper bounds are 90% CL.

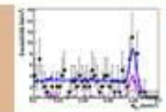
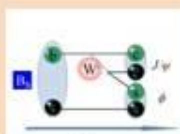
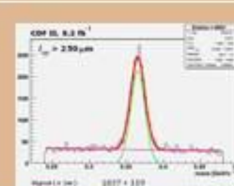
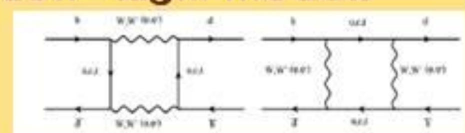
Why Flavor Physics?

Observable	Approximate SM prediction	Present status	Uncertainty / number of events Super-B ($50\,\mathrm{ab}^{-1}$)	LHCb ($10\,\mathrm{fb}^{-1}$)
$S_{\psi K}$	input	0.671 ± 0.024	0.005	0.01
$S_{\phi K}$	$S_{\psi K}$	0.44 ± 0.18	0.03	0.1
$S_{\eta' K}$	$S_{\psi K}$	0.59 ± 0.07	0.02	not studied
$\alpha(\pi\pi, \rho\rho, \rho\pi)$	α	$(89 \pm 4)^\circ$	2°	4°
$\gamma(DK)$	γ	$(70^{+27}_{-30})^\circ$	2°	3°
$S_{K^*\gamma}$	few $\times$ 0.01	-0.16 ± 0.22	0.03	—
$S_{B_s \to \phi\gamma}$	few $\times$ 0.01	—	—	0.05
$\beta_s(B_s \to \psi\phi)$	1°	$(22^{+10}_{-8})^\circ$	—	0.3°
$\beta_s(B_s \to \phi\phi)$	1°	—	—	1.5°
A^d_{SL}	-5×10^{-4}	$-(5.8 \pm 3.4) \times 10^{-3}$	10^{-3}	10^{-3}
A^s_{SL}	2×10^{-5}	$(1.6 \pm 8.5) \times 10^{-3}$	$\Upsilon(5S)$ run?	10^{-3}
$A_{CP}(b \to s\gamma)$	< 0.01	-0.012 ± 0.028	0.005	—
$\lvert V_{cb}\rvert$	input	$(41.2 \pm 1.1) \times 10^{-3}$	1%	—
$\lvert V_{ub}\rvert$	input	$(3.93 \pm 0.36) \times 10^{-3}$	4%	—
$B \to X_s\gamma$	3.2×10^{-4}	$(3.52 \pm 0.25) \times 10^{-4}$	4%	—
$B \to \tau\nu$	1×10^{-4}	$(1.73 \pm 0.35) \times 10^{-4}$	5%	—
$B \to X_s\nu\bar{\nu}$	3×10^{-5}	$< 6.4 \times 10^{-4}$	only $K\nu\bar{\nu}$?	—
$B \to X_s\ell^+\ell^-$	6×10^{-6}	$(4.5 \pm 1.0) \times 10^{-6}$	6%	not studied
$B_s \to \tau^+\tau^-$	1×10^{-6}	$<$ few %	$\Upsilon(5S)$ run?	—
$B \to X_s\tau^+\tau^-$	5×10^{-7}	$<$ few %	not studied	—
$B \to \mu\nu$	4×10^{-7}	$< 1.3 \times 10^{-6}$	6%	—
$B \to \tau^+\tau^-$	5×10^{-8}	$< 4.1 \times 10^{-3}$	$\mathcal{O}(10^{-4})$	—
$B_s \to \mu^+\mu^-$	3×10^{-9}	$< 5 \times 10^{-8}$	—	$> 5\sigma$ in SM
$B \to \mu^+\mu^-$	1×10^{-10}	$< 1.5 \times 10^{-8}$	$< 7 \times 10^{-9}$	not studied
$B \to K^*\ell^+\ell^-$	1×10^{-6}	$(1 \pm 0.1) \times 10^{-6}$	15k	36k
$B \to K\nu\bar{\nu}$	4×10^{-6}	$< 1.4 \times 10^{-5}$	20%	—

Not so near future!!

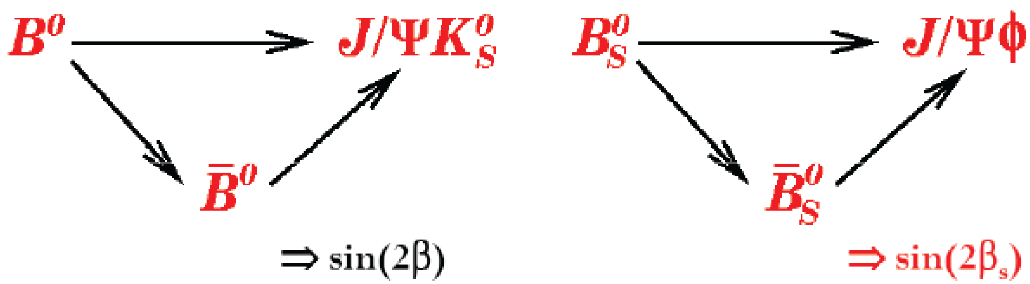
Grossman, Ligeti, Nir (May 2009)

Flavor Physics @ KISTI

Physics	Experiments	Theories
Kaon Semi-leptonic Form factor 	Belle	LGT using Staggered Fermion T. Bae, Work in progress
Rare B^0 decays 	Belle  J.H.Kim, et. al. Belle (2011)	Left-Right models S.-h Nam, Work in progress
Mixing and CPV on $Bs \rightarrow J/\psi\ \Phi$  	CDF  Y.J.Kim, K.Cho et.al. CDF (2011)	Left-Right models  S.-h Nam. et.al, PRD 66, 055008 (2002)
Top Forward-backward asymmetry 	CDF 	Model independent Analysis S.-h Nam. et.al, PLB 691, 238 (2010)
CP violating dimuon charge asymmetry due to B mixing	D0 	Left-Right models S.-h Nam, Work in progress

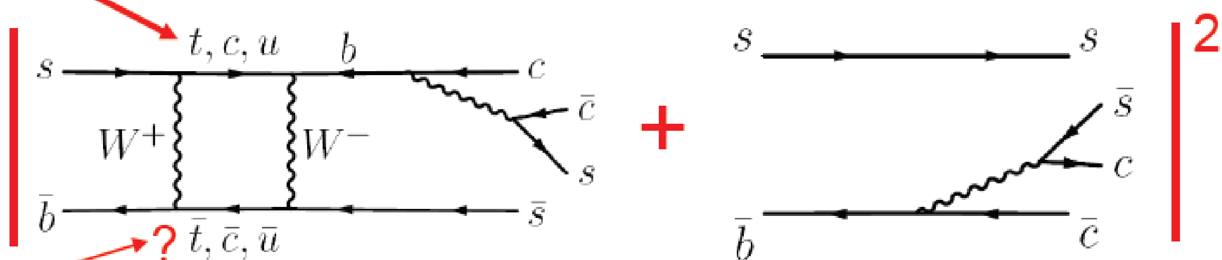
CP violation on Bs −> J/$\psi\,\Phi$

Analogous to the neutral B^0 system, *CP* violation in B_s system is accessible through interference of decays with and without mixing:



dominant contribution from top quark

Decay rate ~



New Physics?

$$\beta_s^{SM} = \arg(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*) \approx 0.02$$

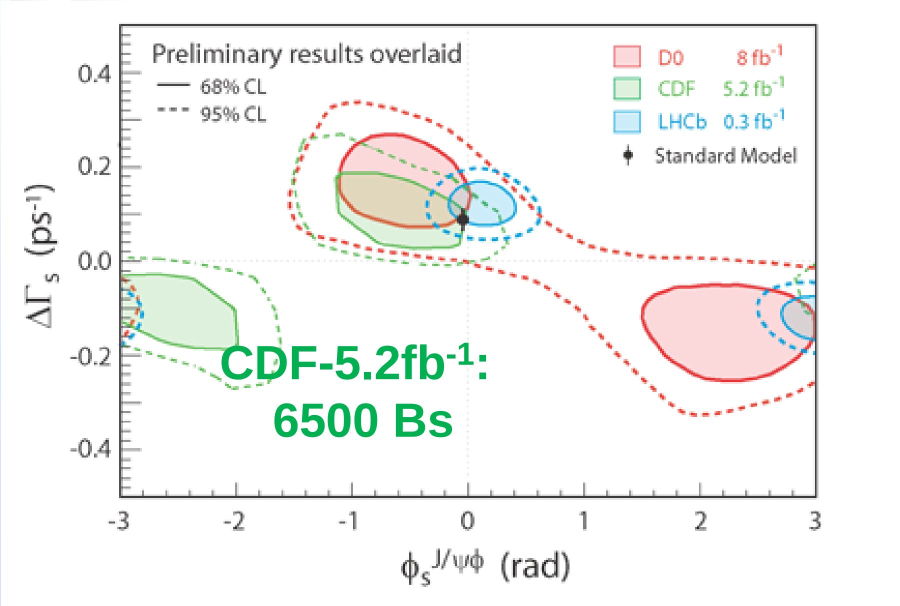
$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

- ***CP* violation phase β_s in SM is predicted to be very small, *O*($\sin^2\theta_c$)**
- **New physics particles running in the mixing diagram may enhance β_s**

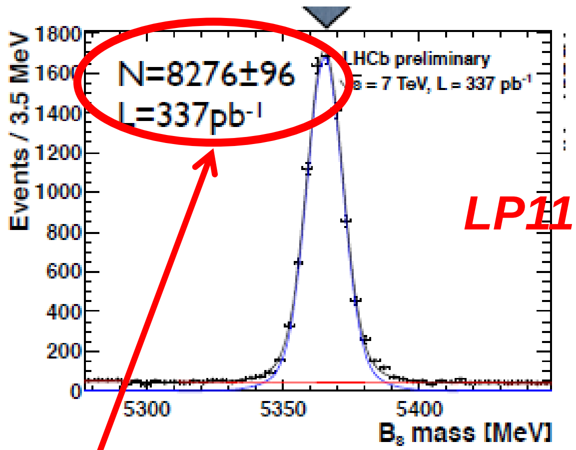
Analysis of TTT data

- The TTT data brings addition (65–70%) to the dimuon sample.

=> CDF is still competitive with the LHCb latest results for this year (HCP).



http://public.web.cern.ch/public
August 30th 2011
Lepton-photon conf. 2011: LHC data shedding new light



- To apply a similar analysis to the dimuon data

  => to produce results for both data streams

- To expect O(15K) Bs (or may be even more) combining both dimuon and TTT data.

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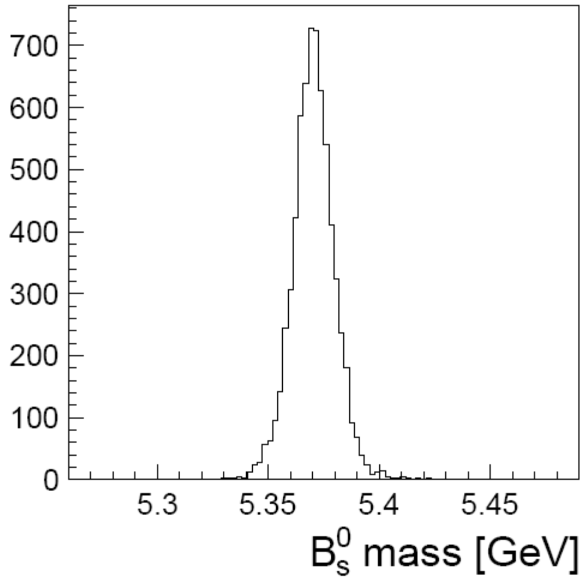
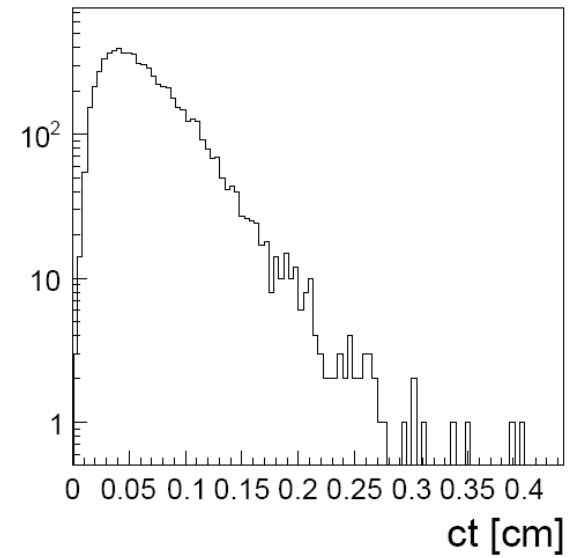
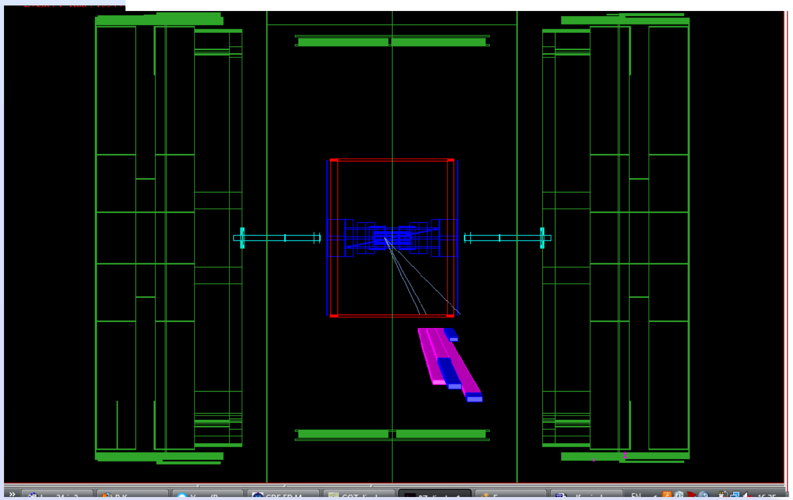
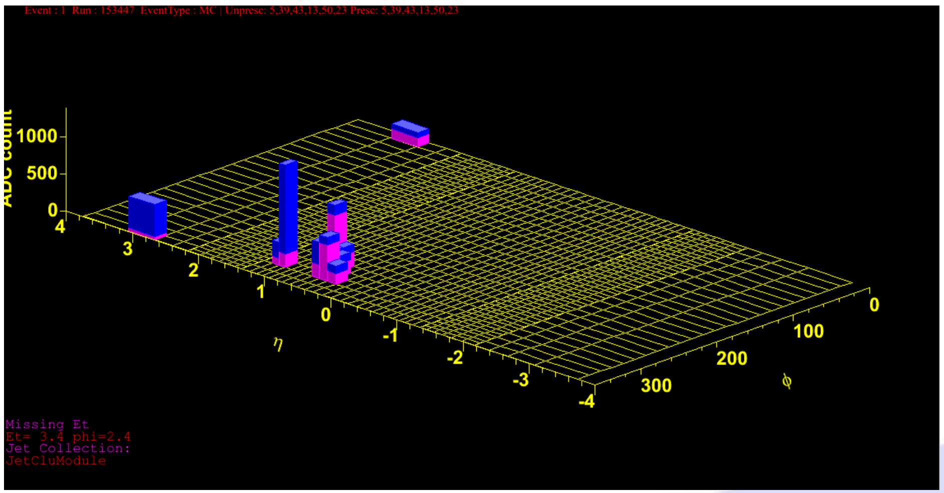
Ref. Aurore (France-Korea Particle Physics Laboratory)

TTT MC Generation









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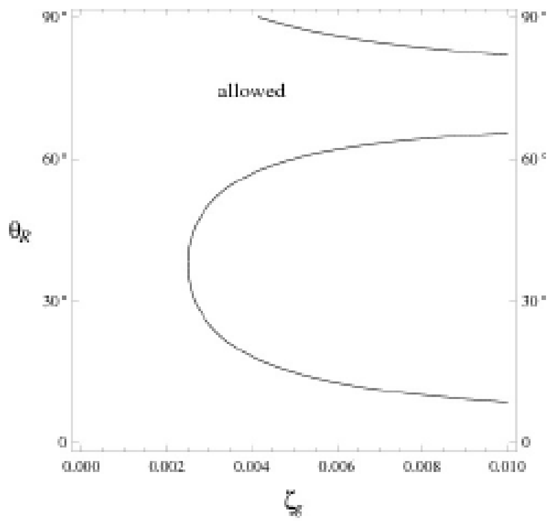
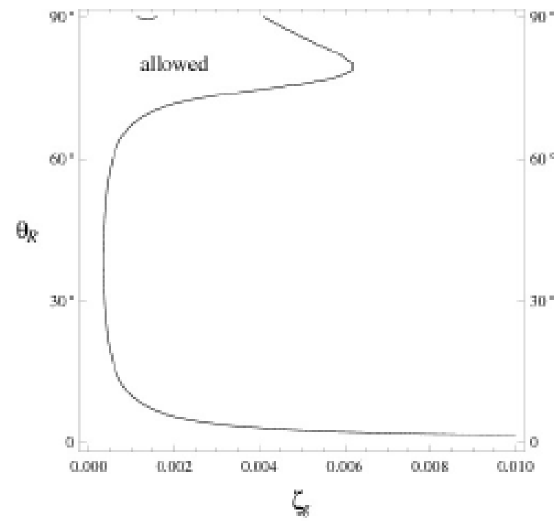
=> See Dr. Youngjin Kim work's presentation

$B\bar{B}$ Mixing @ KISTI

- Contour plot corresponding to $0.7 < |1 + r_{LR}| < 1.3$ for $\zeta_g = 2\xi_g$ and $\alpha_{2,3,4} = 120°$:



$B_s\bar{B}_s\ (V_I^R)$



$B_d\bar{B}_d\ (V_{II}^R)$

- Right-handed currents cannot significantly contribute to ΔM_{B_d} and ΔM_{B_s} simultaneously.

⇒Currently working on Bs mixing

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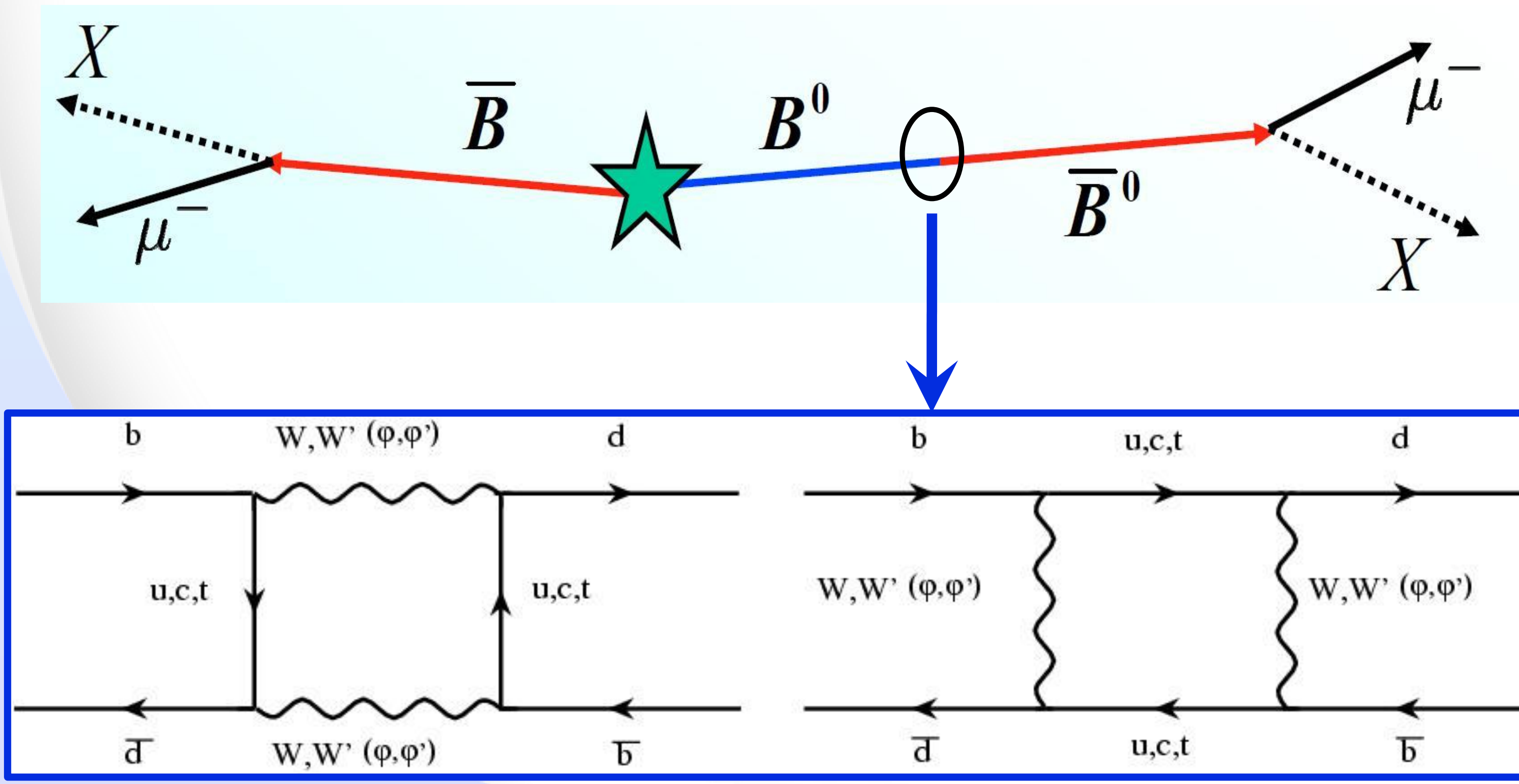
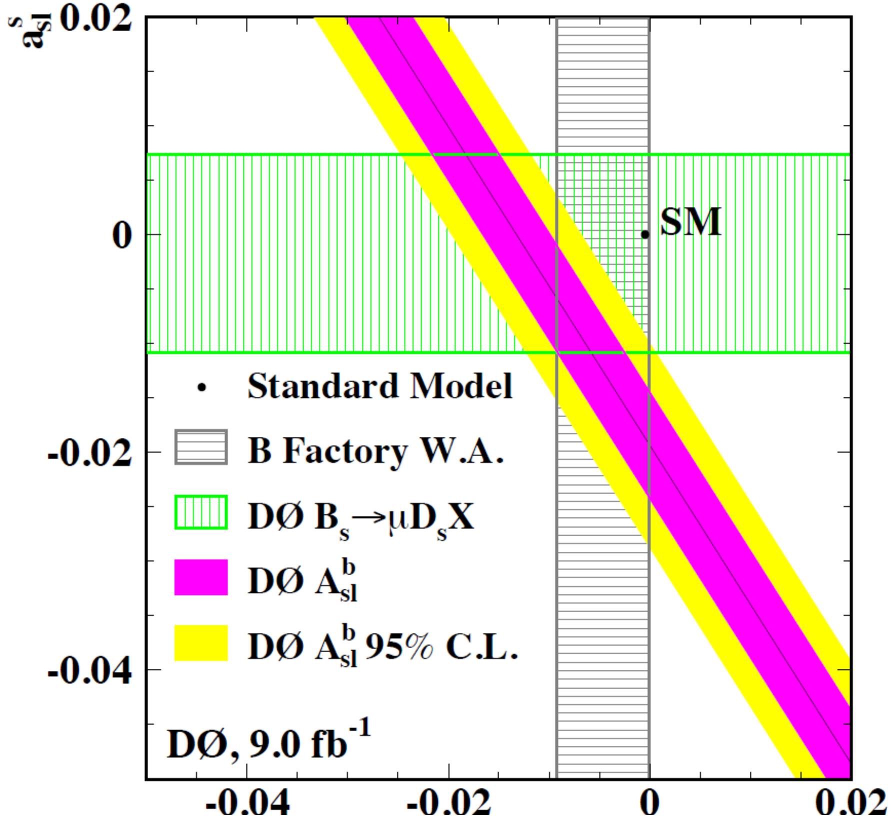
=> See Dr. Soo-hyeon Nam work's presentation

Same sign dileptonic asymmetry

- Another way to probe B0– B0bar mixing
- D0 experiment



Same sign dileptonic asymmetry



- This measurement (2011) with 9.0 fb^{-1}:
  $A^b_{sl} = (-0.787 \pm 0.172\ (\text{stat}) \pm 0.093\ (\text{syst}))\ \%$, 3.9σ from SM.

Using Left–Right model

To be submitted to "CP violating dimuon charge asymmetry in the LR model" by S.–h. Nam

Summary

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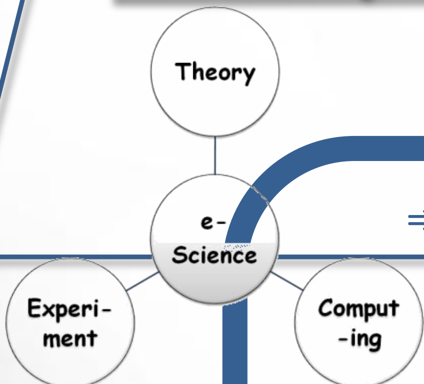
Output

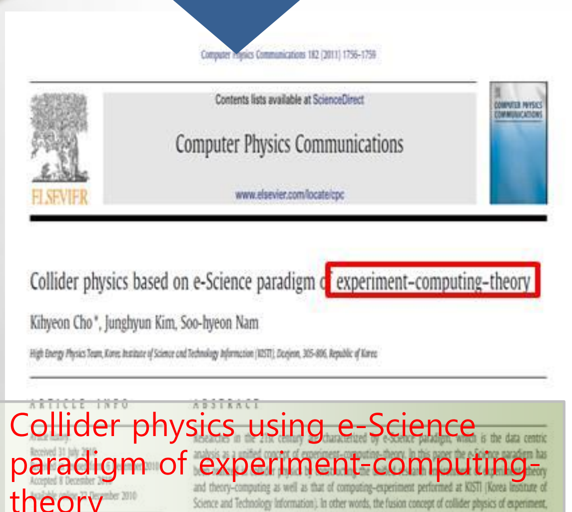
Flavor physics using the concepts of e-Science



- To study high energy physics anytime and anywhere
- Fusion research of experiment-computing–theory

⇒ We are applying both concepts to high energy physics. It is a great success!

Publication


Computer Physics Communications 182 (2011) 1756–1759

Contents lists available at ScienceDirect

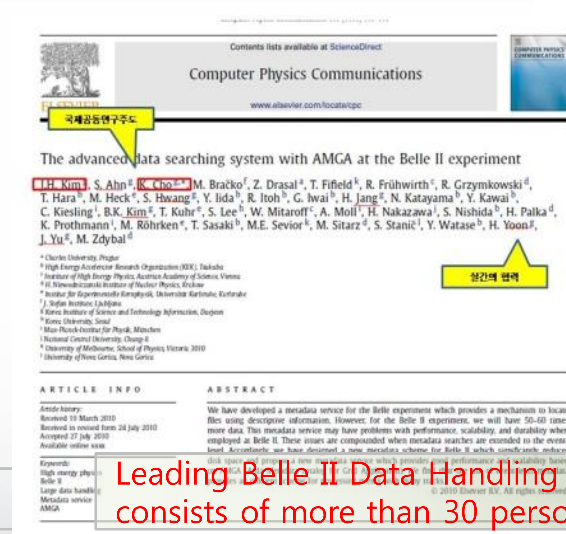
Computer Physics Communications

www.elsevier.com/locate/cpc

Collider physics based on e-Science paradigm of experiment-computing-theory

Kihyeon Cho *, Junghyun Kim, Soo-hyeon Nam

Collider physics using e-Science paradigm of experiment-computing-theory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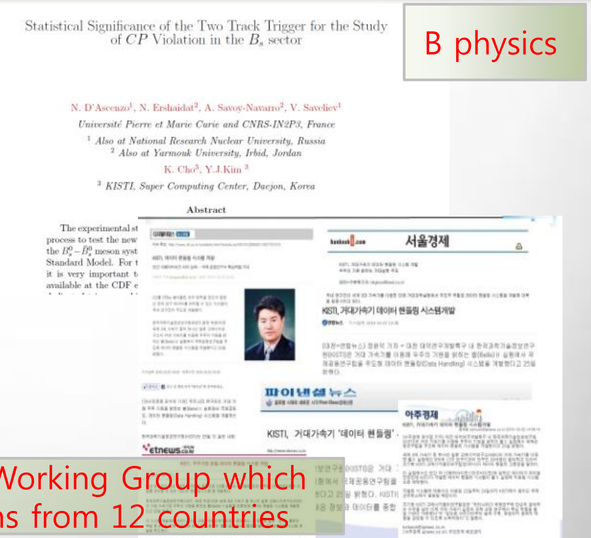
The advanced data searching system with AMGA at the Belle II experiment

Leading Belle II Data Handling Working Group which consists of more than 30 persons from 12 countries


Statistical Significance of the Two Track Trigger for the Study of CP Violation in the B_s sector

B physics

Thank you.