

# Korean Belle Data Grid and Analysis of $B \rightarrow \phi\pi$ decays in Belle.

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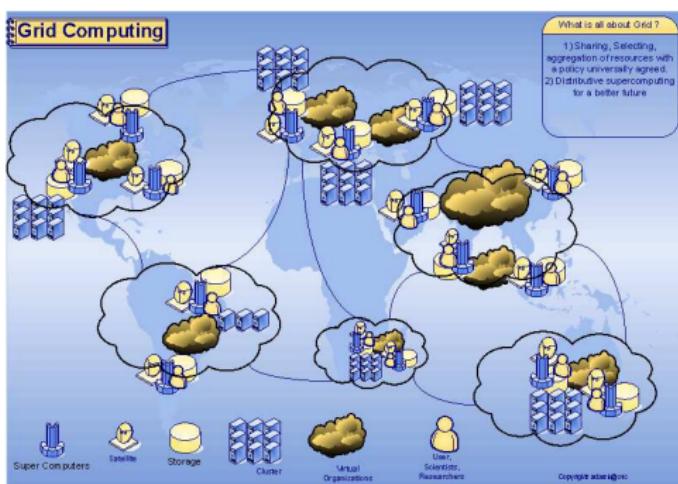
Invitation in KISTI, 2008.11.21

# Outline

- 1 Motivation
- 2 Belle experiments
- 3 Belle analysis
- 4 Korea Belle Data Grid
- 5 Study of  $B \rightarrow \phi\pi$  decays

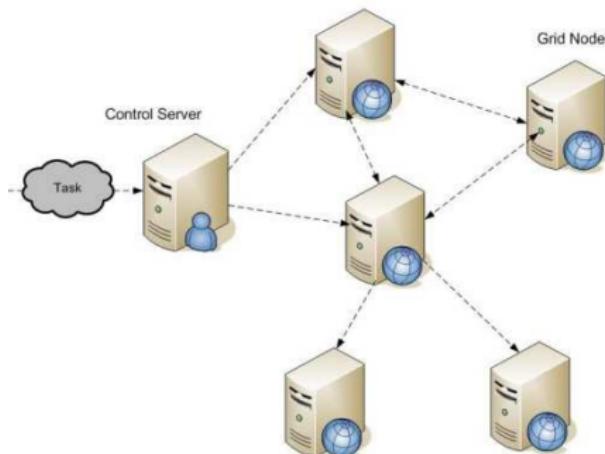
## The problems

- Why We need to use the supercomputing in many fields?
  - The semiconductor Technology has the limitation.  
→ We can't overcome the Relativity effect in semiconductor material.
  - The OS development is so slow.  
→ From 32bit to 64bit, it take over 10 years. From 64bit to 128bit How long time..?? Can you confirm..??



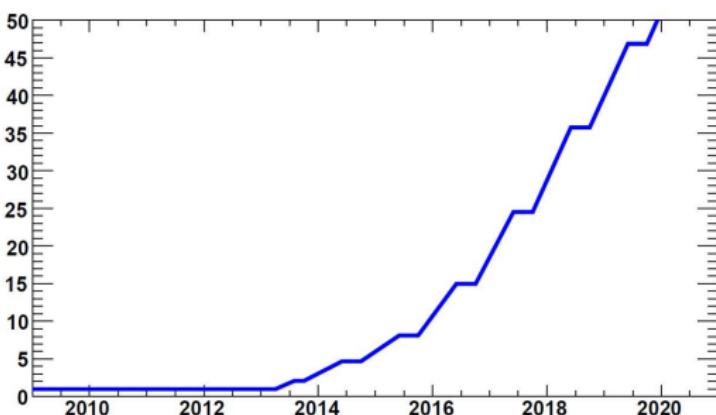
## The problems

- Why We need to use the supercomputing in HEP?
  - The High Energy Physicists want to explore the beyond Standard Model(SM).
  - To explore the SM, The resources are not so bad.  
→ The measurements of branching fraction is larger than  $10^{-6}$
  - To explore the beyond SM, How order is it needed ?  
→ The measurements of branching fraction is less than  $10^{-7}$



## The current status in Belle experiment.

- We have  $656.725 \pm 8.940 \times 10^6$  events,  $605\text{fb}^{-1}$ , to use for the  $B$  physics in Belle experiment.  
→ What is the mean?
  - The data are stored in 144.72 Gbytes per  $1\text{fb}^{-1}$ .
  - At least, we need 95.04Tbytes for the analysis of  $B$  physics.
- Is this all ?
- Super Belle is  $\times 50$  than now!!!!

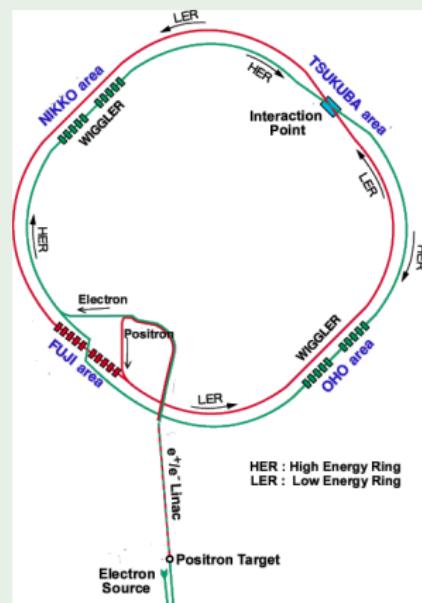


- The integral luminosity of Super Belle experiment.

# Accelerator

- Beam:  $e^+$  (3.5 GeV),  $e^-$  (8.0 GeV)
- The center of mass is 10.58 GeV.
- Ring Circumference: 3016.26m
- Detector location : TSUKUBA area.

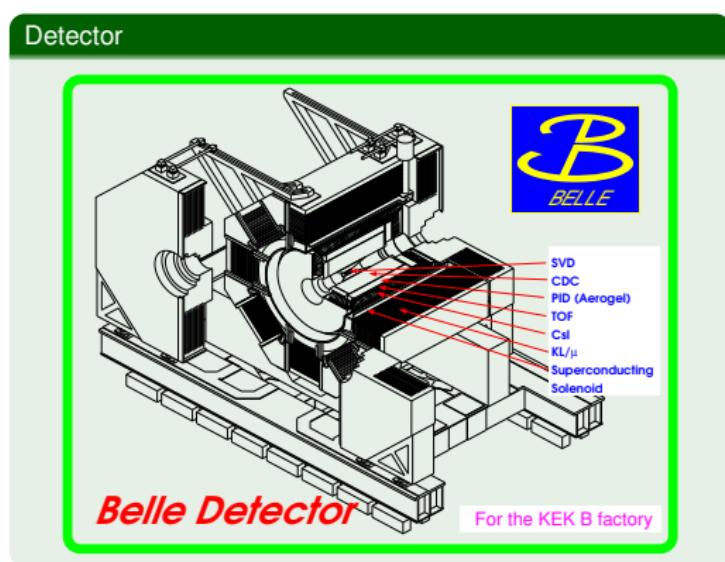
Accelerator



Arrangement of two rings

# Detector

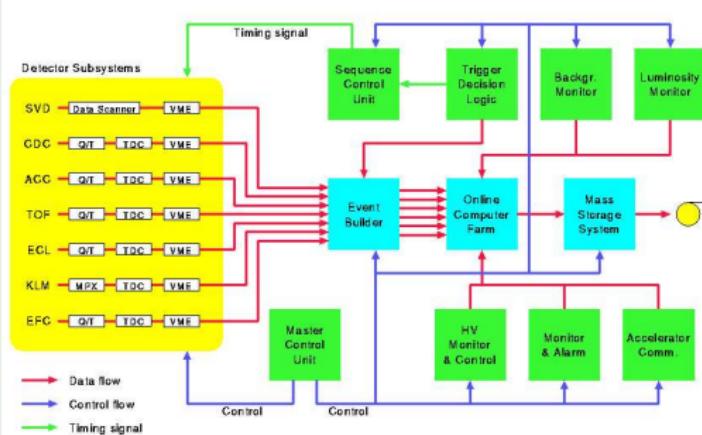
- SVD:  
vertex point
- CDC:  
momentum and  $dE/dx$  of charged particle
- ACC(PID):  
kaon and pion  
seperation( $1.2 \sim 3.5 GeV/c$ )
- TOF:  
kaon and pion  
seperation( $0.6 \sim 1.2 GeV/c$ )
- ECL:  
energy measurement
- KLM:  
measurement the direction of  $K_L$   
and to identify muon



## Belle DAQ system

- From detector, We get the informations of the final state particle
- The useful data is made from DAQ system for analysis.

Belle DAQ system



# Belle Data

- What kind of the data set do you want to get ?
- Find the data at here.

**Belle Search Engine ver 3.20**

Belle File Search Engine Ver.3.20 - Microsoft Internet Explorer

Exp. No.: 55 [ ]  
Run Range: 1 to 9999  
Ski Type: Any [ ]  
Data Type: Any [ ]  
Belle Level: b200801107\_1418 [ ]  
Device Type: closest [ ]  
Submit [Submit] [Reset]

What's New

MonteCarlo data generated with Belle libraries of b20080701\_1600, b20040727\_1143, and b20050311\_0738 are in the database.  
If you have any suggestion on this page, please post to [datall@postech.ac.kr](mailto:datall@postech.ac.kr) / [acprod.all@postech.ac.kr](mailto:acprod.all@postech.ac.kr).

All old `mc.C` files dropped out of the search engine.  
Please use the `avtgen` files.

\*\* Recent updates to the database \*\*  
08 05/02 MEST exp25 0409 skies  
08 05/02 MEST exp25 0409 available up to b10100  
08 05/11 MEST exp21 1205 skies  
08 05/11 MEST exp23 1205 skies  
08 05/16 MonteCar23 exp25 1205 ses2,3,4,5  
08 07/01 MEST exp27 0528 up to run 899  
08 07/01 MEST exp27 0528 available  
08 08/21 MEST exp25 1205 available  
08 08/25 MEST exp31 01available  
08 07/08 remove exp31 bad runs  
08 07/10 MEST exp37 available up to R1399  
08 07/10 MEST exp37 available up to R1399  
08 04/01 MEST exp41 available up to R1399  
08 04/16 MEST exp41 available up to R1399  
08 04/19 MEST exp41 available for all runs  
08 06/13 MEST exp41 available up to R2899  
08 07/05 MEST exp43 available up to R899  
08 07/05 MEST exp43 available for all runs  
08 04/14 All `aq` files unavailable  
08 04/24 MEST exp45 available for all runs  
08 05/10 MEST exp47 available for all runs  
08 05/15 MEST exp47 available for all runs  
08 05/15 MEST exp53 available for all runs  
08 04/03 MEST exp51 available for all runs  
08 04/03 New MEST (event duplicate events solved) exp45 available for all runs  
08 05/30 MEST exp55 1S runs available  
08 11/25 MEST exp55 1S runs available

## Belle Data type for the analysis

Data for  $B$  physics.

data	size
on-resonance	$605fb^{-1}$ (95.04TB)
off-resonance	$68.2fb^{-1}$ (5.5TB)
skim data	$605fb^{-1} \times 30$

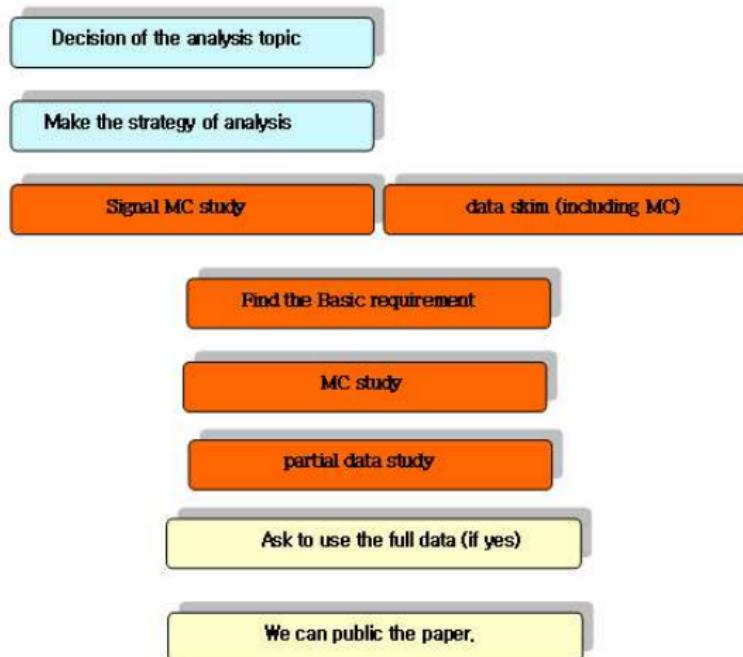
MC for  $B$  physics.

MC	size
uds of on-resonance	$605fb^{-1} \times 10/4(396TB)$
charm of on-resonance	$605fb^{-1} \times 10/4(396TB)$
mixed of on-resonance	$605fb^{-1} \times 10/4(132TB)$
charged of on-resonance	$605fb^{-1} \times 10/4(132TB)$
uds of off-resonance	$68.2fb^{-1} \times 10/4(41.3TB)$
charm of off-resonance	$68.2fb^{-1} \times 10/4(41.3TB)$
rare $B$ MC	$25000fb^{-1}$

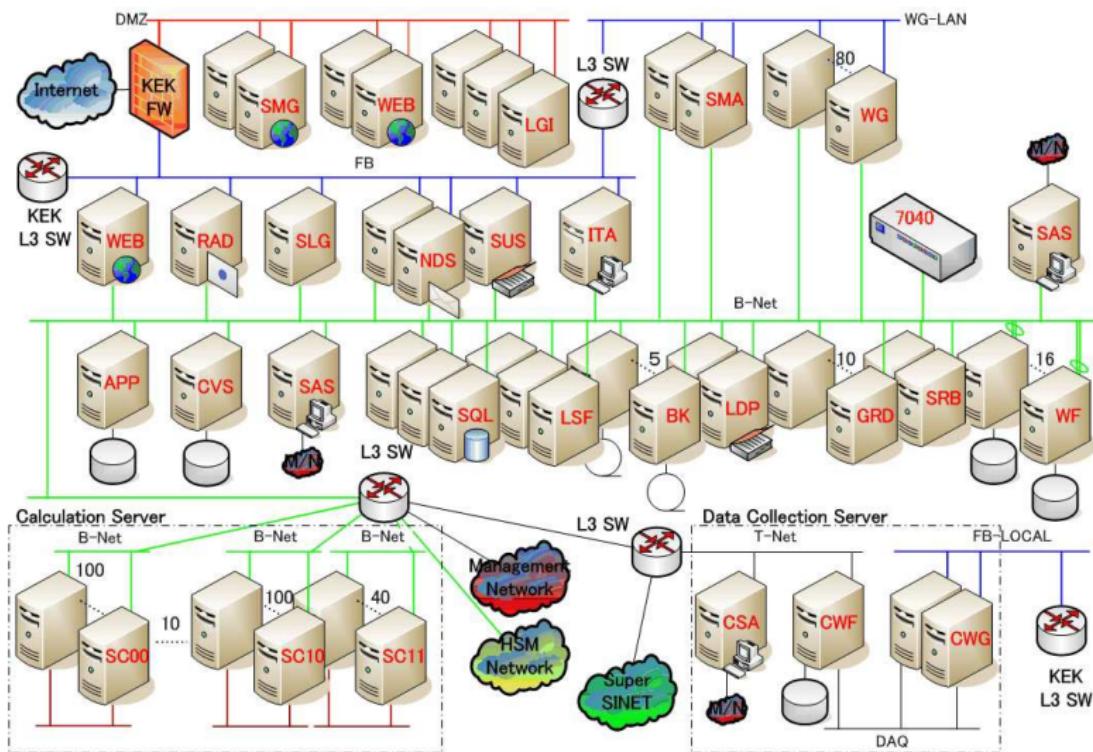
- Although the rare  $B$  MC and each topic skim data are small size, the others are not.
- At least, we need  $(1151.8 + \alpha)T$ bytes storage for  $B$  physics in Belle.

## Analysis for $B$ physics

- A user is assigned 300Gbytes storage for analysis.
- Do you have the sufficient storage ?  $\rightarrow$  Not so bad.
- We need the computing power.

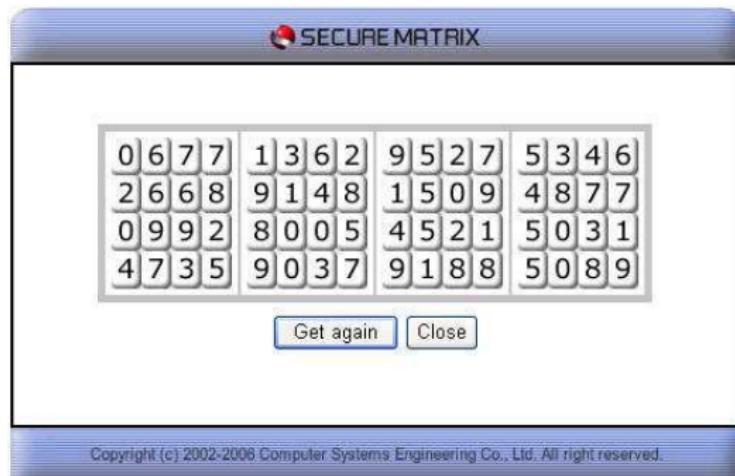


# Computing power in Belle experiment



## Computing power in Belle experiment

- How to use the B computer.
- We can get a account for analysis.
  - LGI: These are used when you login to the B-Factory computer system from Internet.
  - WG: These are used when you do interactive processing, like edit programs, compile programs, submit jobs.
  - SC:These are used for running batch jobs.



## Computing power in Belle experiment

- For analysis and MC production →  
We should use the SC nodes, which are composed on 1140 node.
- batch job system : LSF
- A user is assigned with maximum 20 node.
- Almost people complain to be assigned with the limitation.
- All node was offered by DELL.

system configuration.

Type of Server	CPU	Num of CPUs	Amount of Memory	Type of Network	Num.
LGI	Xeon3.6GHz	2	1GB	GigabitEthernet	3
WG	Xeon3.6GHz	2	1GB	GigabitEthernet	80
SC	Xeon3.6GHz	2	1GB	GigabitEthernet	1140

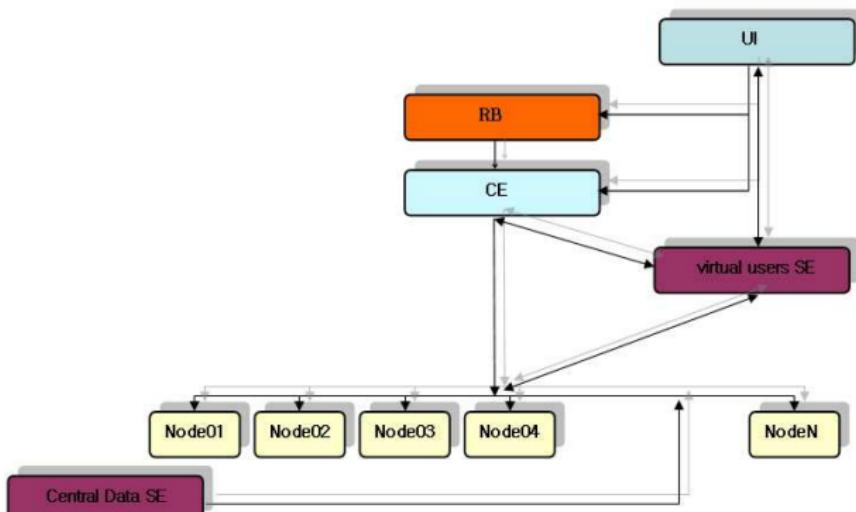
## Computing power in Belle experiment

### Data control for analysis

data type	size	Num. of events	time/events	Time	Result
Data skim	95.04TB	$658 \times 10^6$	2min/10K	8.19 days	skim files
MC skim	1056.0TB	$6580 \times 10^6$	2min/10K	91.00 days	skim files
Signal MC production	4.2GB		8hours/30K	3.3 days	mdst data
analysis run	58.08TB	$658 \times 10^6$	2min/10K	5.01days	ntuple or root

- How much do the resources need to work in Super Belle ?  
→ Super Belle data will be  $\times 50$  for all !!

## The scheme of Korea Belle Data Grid



Schemer: JungHyun Kim(SKKU)

# The work of Korea Belle Data Grid

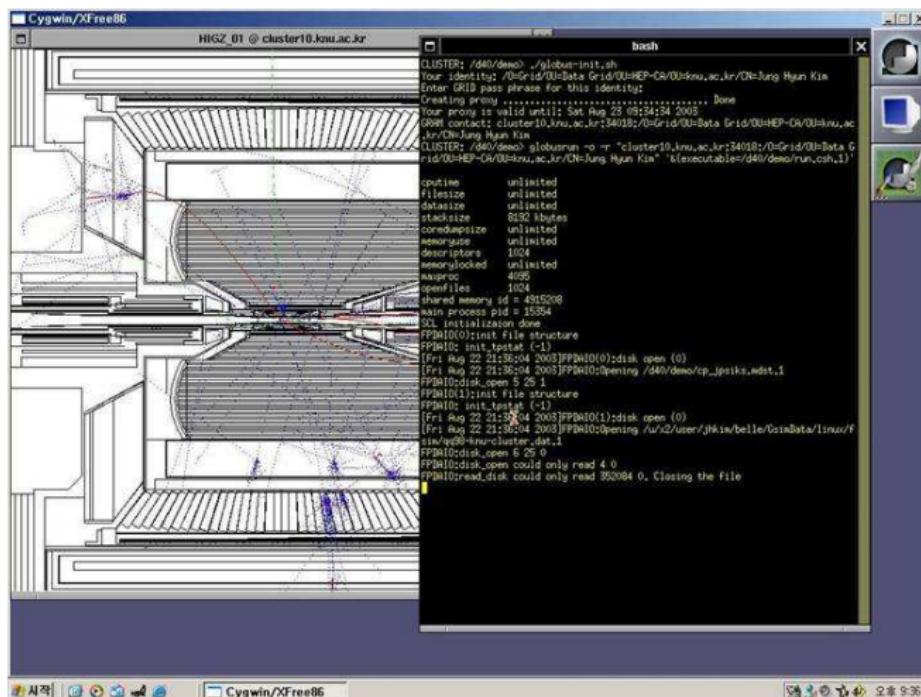
component	purpose	site	development	CPU	OS	middleware	date(year.month)
UI	user interface	hepgrid.skku.ac.kr	O	intel 2.4GHz	linux	globus 2.4	2003.11
VU	virtual user	cluster76.knu.ac.kr	O	AMD 2.0GHz	linux	globus 2.4	2003. 8
CE	computing element	cluster76.knu.ac.kr	O	intel 2.4GHz	linux	globus 2.4	2002. 12
RB	resource broker		X			globus 2.4	
SE	storage element	hep.skku.ac.kr	X	intel 2.4GHz	linux		
Node	computing node	local IP(4)	O	intel 2.0(SMP)	linux		2002. 12
UI on website	portal and GUI	hepgrid.skku.ac.kr	O	intel 2.0(SMP)	linux	globus 2.4	2004. 1
CA on website	CA	hepgrid.skku.ac.kr	O	intel 2.4	linux	globus 2.4	2004. 1

- Development:

- UI,VI,CE,Nodes(JungHyun Kim)
- CA(gridca-1.1.1)(KISTI),modify(JungHyun Kim, SunMin Kim)
- UI on website (JungHyun Kim, SunMin Kim)

# The work of Korea Belle Data Grid

- Connection with Belle library and Globus tool kit.



- UI: hepgrid.skku.ac.kr
- CE: cluster10.knu.ac.kr
- Node: local IP
- SE: hep.skku.ac.kr
- OS : linux
- globus: globus-2.4
- belle lib: b20020424\_1007
- development :JungHyun Kim

# The work of Korea Belle Data Grid

- Website of Korea Belle Data Grid



- UI: hepgrid.skku.ac.kr

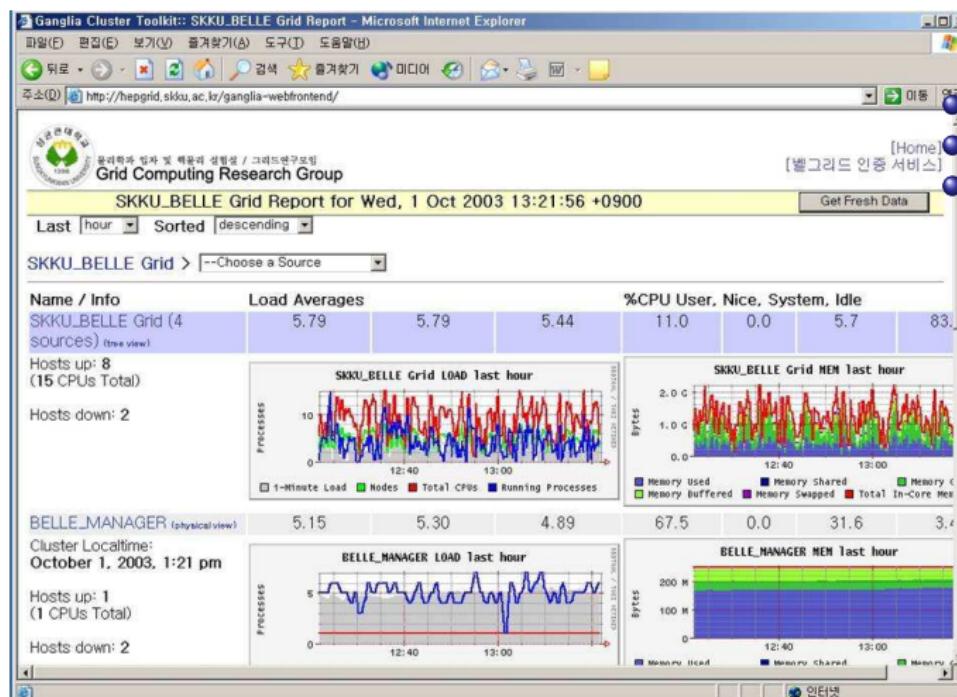
- OS : linux

- globus: globus-2.4 item Design  
:JungHyun Kim

- development :JungHyun Kim, SunMin  
Kim

# The work of Korea Belle Data Grid

- The monitor system of Korea Belle Data Grid



UI: hepgrid.skku.ac.kr

OS : linux item Design :JungHyun Kim

development :JungHyun Kim, SunMin Kim

# The work of Korea Belle Data Grid

## Certification Authority

GridCARegister - Microsoft Internet Explorer

http://hepgrid.skku.ac.kr/GridCA/register.php

**Grid Computing Research Group**

**Register**

Login ID: \_\_\_\_\_ (1-20 characters, no space, no special characters)

Password: \_\_\_\_\_ (6-10 characters)

Repeat password: \_\_\_\_\_ (repeat the above)

Name: \_\_\_\_\_ (real name)

Organization: \_\_\_\_\_

Email: \_\_\_\_\_

**Register**

[[Return to HOME]]

2004-05-27 18:08:00  
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성균관대학교 물리학과, 경기도 수원시 장안구 천천동 300 자연과학부 31107호  
(Tel)82-31-290-7057,(Fax)82-31-290-7055

## User Interface based on the Web.

GridCAGRID 작업설정에 접속하신 key2025님 반갑습니다! - Microsoft Internet Explorer

http://hepgrid.skku.ac.kr/GridCA/jobprepare.php

**Grid Computing Research Group**

GRID 작업설정에 접속하신 key2025님 반갑습니다!

**작업입력방법 선택:** 파일Upload 작업입력

Run Script: #!/bin/tcsh -i  
cd /opt/BelleUsers/bkdbs000/blay-ground/demo/  
#setenv DISPLAY 203.252.47.0:0  
setenv BHOME "/belle"

file name: \_\_\_\_\_

etc file: \*.tar.gz \_\_\_\_\_ ex) **run**

2004-05-27 23:02:44  
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(Tel)82-31-290-7057,(Fax)82-31-290-7055

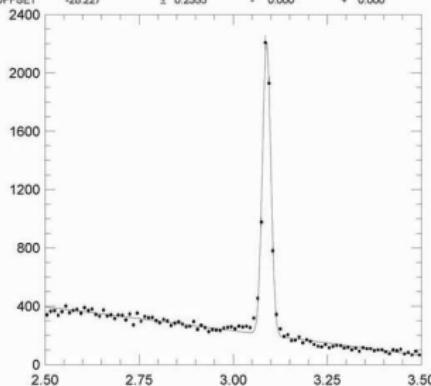
- UI: hepgrid.skku.ac.kr
- OS : linux item Design :JungHyun Kim
- development :JungHyun Kim, SunMin Kim, KISTI(gridca-1.1.1)

# The work of Korea Belle Data Grid

Likelihood = 253.1  
 $\chi^2 = 256.1$  for 100 - 7 d.o.f., Parabolic C.L.=0.356E-14%  
 Errors Minos

Function 1: Gaussian (sigma)  
 AREA= 5494.4 ± 83.98 - 0.000 + 0.000  
 MEAN = 3.0799 ± 1.8352E-04 - 0.000 + 0.000  
 SIGMA = 1.09176E-02 ± 1.7338E-04 - 0.000 + 0.000

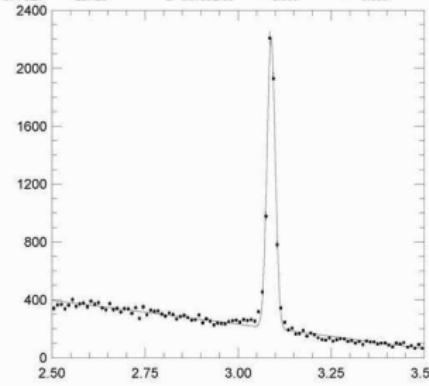
Function 2: Polynomial of Order 2  
 NORM = -1.47391E+05 ± 6965. - 0.000 + 0.000  
 POLY01 = 44296. ± 294.6 - 0.000 + 0.000  
 POLY02 = -1243.6 ± 8.628 - 0.000 + 0.000  
 OFFSET = -28.227 ± 0.2395 - 0.000 + 0.000



Likelihood = 253.6  
 $\chi^2 = 256.7$  for 100 - 7 d.o.f., Parabolic C.L.=0.297E-14%  
 Errors Minos

Function 1: Gaussian (sigma)  
 AREA= 5495.6 ± 83.22 - 0.000 + 0.000  
 MEAN = 3.0887 ± 1.8255E-04 - 0.000 + 0.000  
 SIGMA = 1.09204E-02 ± 1.7341E-04 - 0.000 + 0.000

Function 2: Polynomial of Order 2  
 NORM = -48397. ± 122.3 - 0.000 + 0.000  
 POLY01 = 37817. ± 3.760 - 0.000 + 0.000  
 POLY02 = -1097.9 ± 0.1152 - 0.000 + 0.000  
 OFFSET = -29.425 ± 3.6439E-03 - 0.000 + 0.000



- The difference of the result is less than 1 event.
- The difference of CPU time is shown as the Table.

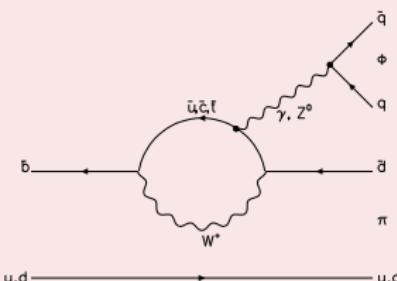
By SunMin Kim  
M.S thesis.

	KISTI nodes(30 nodes)	Belle nodes(20 nodes)
relative CPU time	18 hours 21min 6 sec	53hours 46 min 47 sec

# Introduction

- The measurements of  $B \rightarrow \phi\pi$  decay rates is important... contribution beyond the Standard Model(SM)
- Strongly suppressed in the SM.
- The measurement of BABAR(2007) is  $\lesssim 10^{-7}$
- The  $B^0 \rightarrow \phi\pi^0$  decay is associated with measurements of time dependent  $CP$  asymmetry in  $B^0 \rightarrow \phi K^0$ .

Feynman Diagram



## The Dataset and Skim Criteria

- The Dataset

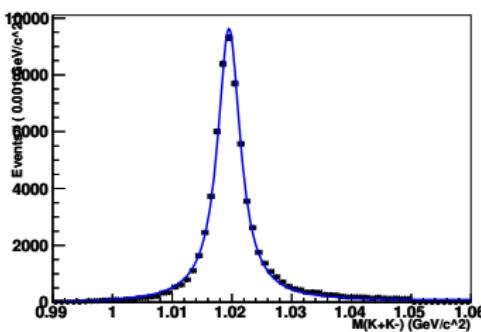
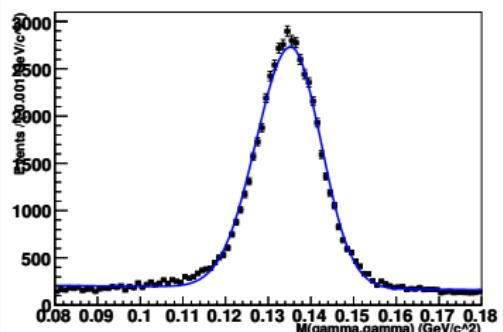
type	Luminosity
each decays signal MC	300K number of events based on exp51(420MB/30Kevent)
qq MC	$2480fb^{-1}(649.31TB)$
$b \rightarrow c$ MC	$3501fb^{-1}(305.54TB)$
$b \rightarrow u, d, s$ MC	$24850fb^{-1}(unknown)$
data	$605fb^{-1}(95.04TB)$

- Skim Criteria

Source	Requirement
Charged K Tracks	$atc\_pidKpi(3, 1, 5, 3, 2) > 0.1$
Charged $\pi$ Tracks	$atc\_pidKpi(3, 1, 5, 3, 2) < 0.0$ (not applied)
$\pi^0$ invariant mass	$0.08GeV < M_{\gamma\gamma} < 0.18GeV$
$\phi$ invariant mass	$1.8GeV > M_{(K+K^-)}$
$\Delta E$ and $M_{bc}$	$ \Delta E  < 0.42GeV$ and $M_{bc} > 5.19GeV$

# Reconstruction

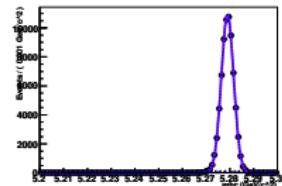
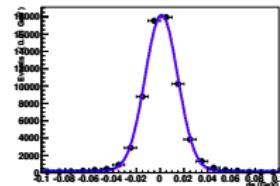
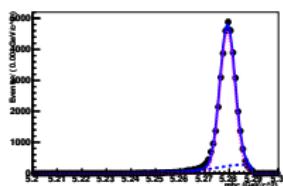
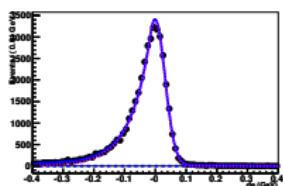
$M_{\gamma\gamma}$  and  $M_{K+K-}$  mass distribution for neutral mode.



type	PDF	$\mu(\text{GeV}/c^2)$	width( $\text{GeV}/c^2$ )	selection range( $\text{GeV}/c^2$ )
$\pi^0$	bifurcated gauss + Cheby 1 <sup>st</sup>	0.1353	-0.0081 +0.0071	$0.1153 < M_{\gamma\gamma} < 0.1528$
$\phi$	Breit-Wigner + Cheby 1 <sup>st</sup>	1.020	0.005	$1.008 < M_{K+K-} < 1.031$
Photon				$> 0.2\text{GeV}$

# Reconstruction

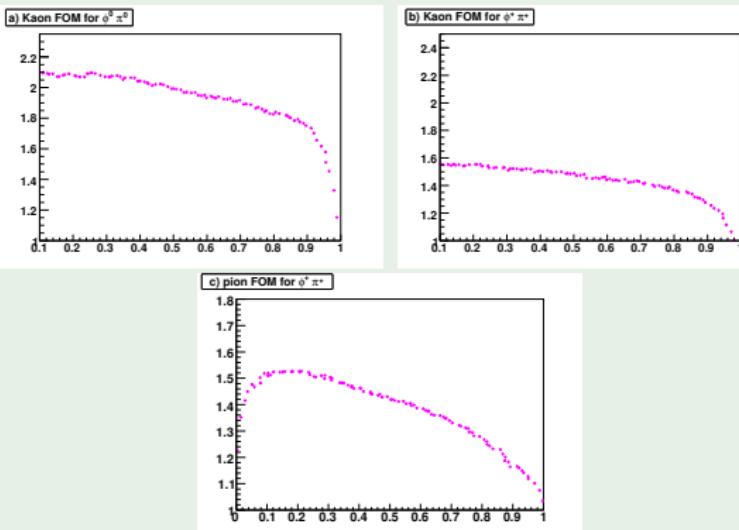
$M_{bc}$  and  $\Delta E$  distribution in  $B \rightarrow \phi\pi$  decays(left side:neutral, right side: charged)



	$B^0 \rightarrow \phi\pi^0$	$B^+ \rightarrow \phi\pi^+$
$\Delta E$ PDF	Crystal Ball	Double Gaussian
$M_{bc}$ PDF	Gaussian	Gaussian
$\Delta E$ window	$-0.4\text{GeV} < \Delta E < 0.4\text{GeV}$	$-0.1\text{GeV} < \Delta E < 0.1\text{GeV}$
$M_{bc}$ window	$5.2\text{GeV}/c^2 < M_{bc} < 5.3\text{GeV}/c^2$	$5.2\text{GeV}/c^2 < M_{bc} < 5.3\text{GeV}/c^2$
$\Delta E$ Slice range	$-0.16\text{GeV}(5.0\sigma) < \Delta E < 0.10\text{GeV}(3.0\sigma)$	$-0.04\text{GeV}(3.0\sigma) < \Delta E < 0.040\text{GeV}(3.0\sigma)$
$M_{bc}$ Slice range	$5.27\text{GeV}/c^2 < M_{bc} < 5.29\text{GeV}/c^2$	$5.27\text{GeV}/c^2 < M_{bc} < 5.29\text{GeV}/c^2$

# Particle Identification(PID)

## The F.O.Ms of $B \rightarrow \phi\pi$ decays



- Signal :  $B \rightarrow \phi\pi$  decay
- Noise :  $qq$  and  $b \rightarrow u, d, s$  background
- Corr. factor : discrepancy of MC versus data for the continuum candidates
- Iteration with continuum suppression

### ● The results

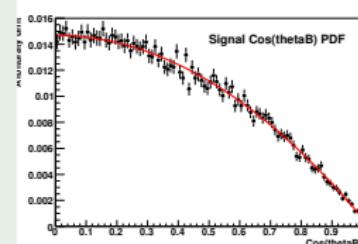
decay	Kaon ID	$\pi$ ID
$B^0 \rightarrow \phi\pi^0$	$> 0.3$	
$B^+ \rightarrow \phi\pi^+$	$> 0.3$	$< 0.2$

## $\text{Cos}(\theta_B^*)$ and $\text{Cos}(\theta_{\text{Helicity}})$

- $\text{Cos}(\theta_B^*)$

- $\theta_B^*$  is defined as the angle of the  $B$  meson flight direction with respect to the beam axis.
- The angular momentum conservation
- Signal: spherical
- Continuum: jet-like(flat)
- $\text{cos}\theta_{B^*} = P_0 - P_1 \text{cos}^2\theta_{B^*}$

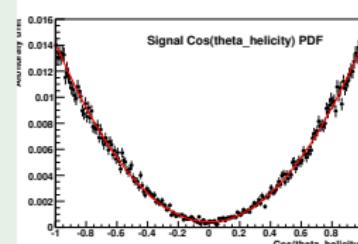
$\text{cos}\theta_{B^*}$  distribution of  $B^0 \rightarrow \phi\pi^0$  decay



- $\text{Cos}(\theta_{\text{Helicity}})$

- $\theta_H$  is defined as the angle between  $K^+$  direction and the  $B$  meson direction in the  $\phi$  mass rest frame.
- $\text{cos}\theta_H = P_0 - P_1 \text{cos}^2\theta_H$

$\text{Cos}(\theta_{\text{Helicity}})$  distribution of  $B \rightarrow \phi\pi^0$  decay



$\Delta Z$ 

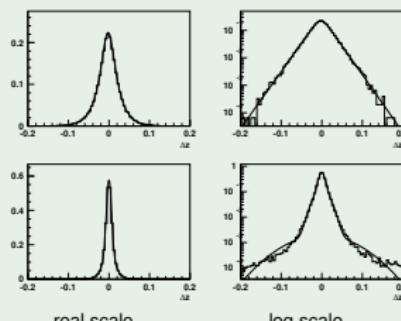
- assymmetric life-time convolute with the gaussian in signal events

$$LF \otimes R = \exp(-|x|/\tau) \otimes R = \int_{-\infty}^{-\infty} \exp(-|x - \mu|/\tau) * \exp[-0.5 * (\frac{x - M_{mean}}{\sigma})^2] d\mu \quad (1)$$

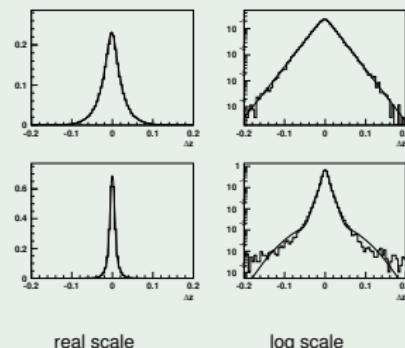
- $\delta$  function convolute with the gaussian in continuum events.

$$\delta \otimes R = R_1 + R_2 + R_3 \quad (2)$$

- $\Delta Z$  PDF of  $B^0 \rightarrow \phi\pi^0$

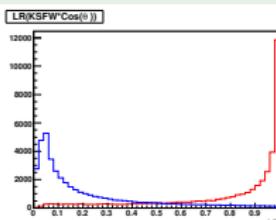
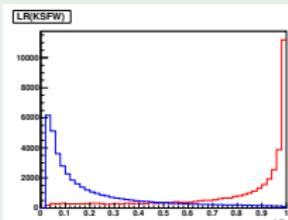


- $\Delta Z$  PDF of  $B^+ \rightarrow \phi\pi^+$

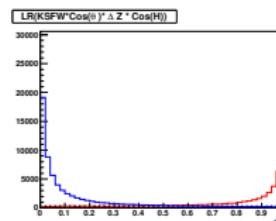
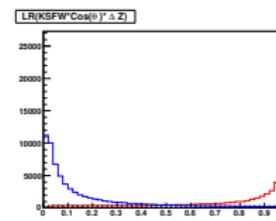
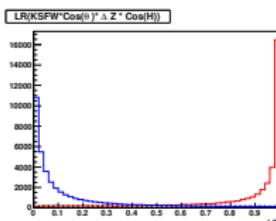
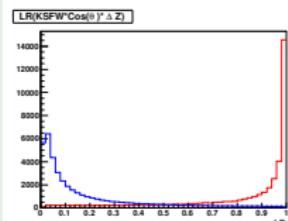
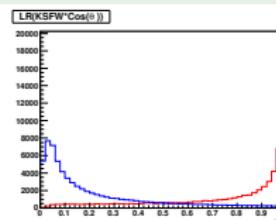
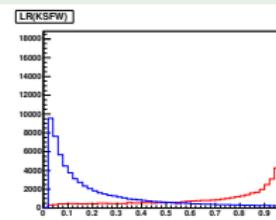


# Likelihood Ratio(KSFW, $\text{Cos}(\theta_B^*)$ , $\Delta Z$ , $\text{Cos}(\theta_H)$ )

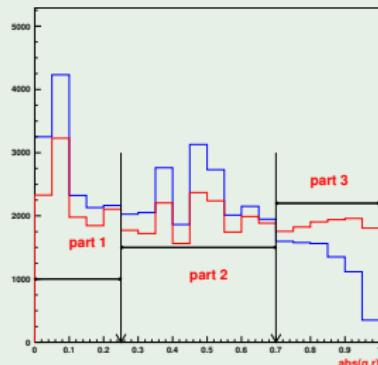
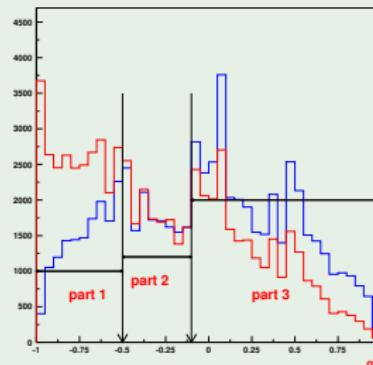
LR of  $B^0 \rightarrow \phi \pi^0$



LR of  $B^+ \rightarrow \phi \pi^+$



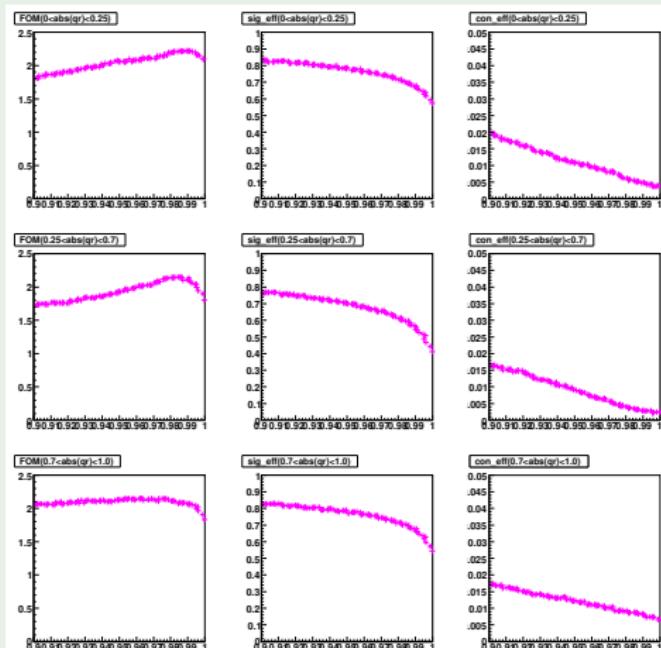
- The likelihood ratio is improved from gradually using the discriminants.

$q \bullet r$  $q \bullet r$  of  $B^0 \rightarrow \phi\pi^0$  $q \bullet r$  of  $B^+ \rightarrow \phi\pi^+$ 

- $q(+1 = B^0, -1 = \overline{B^0})$
- $r (= 1-2w)(0 \rightarrow 1: \text{better tagging quality})$
- part1: signal < continuum, part2:signal ~ continuum, part3: signal > continuum

# Figure of Merit(KSFW, $\text{Cos}(\theta_B^*)$ , $\Delta Z$ , $\text{Cos}(\theta_H)$ ) dependent on $q \bullet r$

LR and FOM of  $B^0 \rightarrow \phi\pi^0$  with  $q \bullet r$

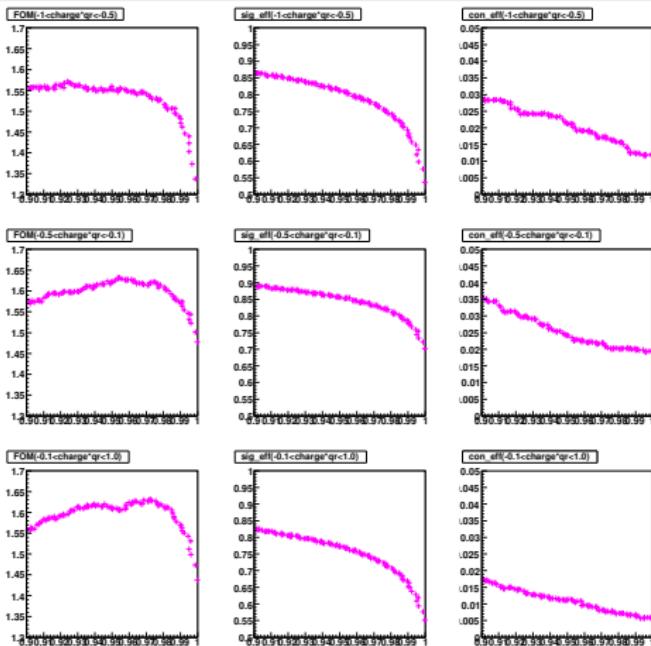


the requirement of the FOM with q.r

- correction factor = 2.37 by  $M_{bc} < 5.27 \text{GeV}/c^2$  of side band data
- if  $0 < |q \bullet r| < 0.25$  ,  $LR = 0.99$
- if  $0.25 < |q \bullet r| < 0.7$  ,  $LR = 0.98$
- if  $0.7 < |q \bullet r| < 1.0$  ,  $LR = 0.96$

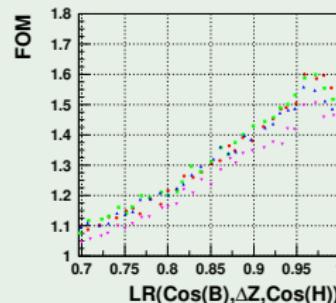
## Figure of Merit(KSFW, $\text{Cos}(\theta_B^*)$ , $\Delta Z$ , $\text{Cos}(\theta_H)$ , $q \bullet r$ ) dependent on $q \bullet r$

### LR and FOM of $B^+ \rightarrow \phi\pi^+$ with $q \bullet r$



the requirement of the FOM with q.r

- correction factor = 1.35 by  $M_{bc} < 5.27 \text{ GeV}/c^2$  of side band data
- if  $-1.0 < q \bullet r < -0.5$  ,  $LR = 0.93$
- if  $-0.5 < q \bullet r < -0.1$  ,  $LR = 0.96$
- if  $-0.1 < q \bullet r < 1.0$  ,  $LR = 0.97$

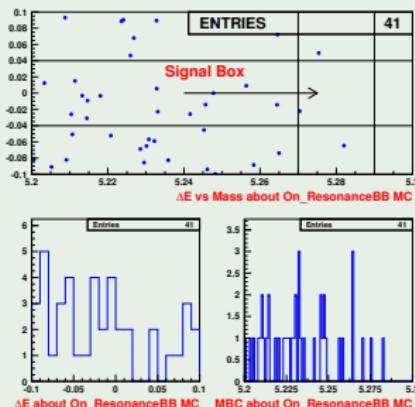
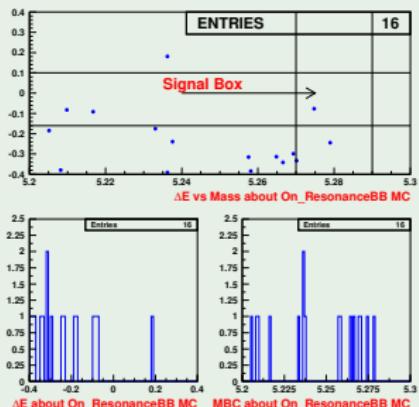


●  $-2.5\Gamma < M_{K^+K^-} < 2.5\Gamma$

# $b \rightarrow c$ background

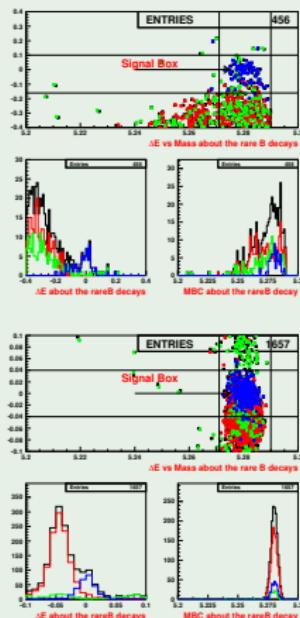
	$B^0 \rightarrow \phi\pi^0$	$B^+ \rightarrow \phi\pi^+$
remained evt	16	41
Expectation( $605fb^{-1}$ )	2.76	7.08

$\Delta E, M_{bc}$  distribution for  $b \rightarrow c$  background(left:neutral, right:charged)



# $b \rightarrow u, d, s$ background

## $\Delta E, M_{bc}$ distribution for $b \rightarrow u, d, s$



## • $b \rightarrow u, d, s$ background

Decay Mode	$\text{Br}(10^{-6})$	remained evt	Expectation( $605\text{fb}^{-1}$ )
$B^0 \rightarrow \phi \omega$	< 1.2	5	0.12
$B^0 \rightarrow \phi K_S$	= 8.6	202	4.91
$B^\pm \rightarrow \phi \rho^\pm$	= 0.45	27	0.66
$B^0 \rightarrow K^+ K^- \pi^0$	< 19	28	0.68
$B^0 \rightarrow a_0^0 \pi^0$		14	0.34
$B^0 \rightarrow f_0 \pi^0$		22	0.54
other decays		158	3.84
<hr/>			
$B^\pm \rightarrow \phi K^\pm$	= 8.3	1205	29.32
$B^\pm \rightarrow K^+ K^- \pi^\pm$	< 6.3	7	0.17
$B^\pm \rightarrow a_0^0 \pi^\pm$	< 5.8	273	6.64
$B^\pm \rightarrow f_0 \pi^\pm$		4	0.10
other decays		168	4.08

## PDF component

- The PDF components of  $B^0 \rightarrow \phi\pi^0$  decay

Component	$\Delta E$	$M_{bc}$
signal	Crystall Ball	Gaussian
continuum	Chebyshev polynomial 1 <sup>st</sup>	ARGUS background
$b \rightarrow c$	histogram to PDF	histogram to PDF
$b \rightarrow u, d, s$	histogram to PDF	histogram to PDF

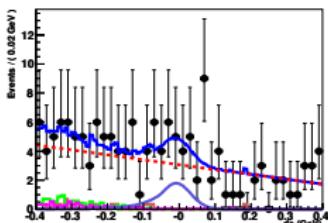
- The PDF components of  $B^+ \rightarrow \phi\pi^+$  decay

Component	$\Delta E$	$M_{bc}$
signal	double Gaussian	Gaussian
continuum	Chebyshev polynomial 1 <sup>st</sup>	ARGUS background
$b \rightarrow c$	histogram to PDF	histogram to PDF
$b \rightarrow u, d, s$ (dominant)	double Gaussian	Gaussian
$b \rightarrow u, d, s$ (the rest of background)	histogram to PDF	histogram to PDF

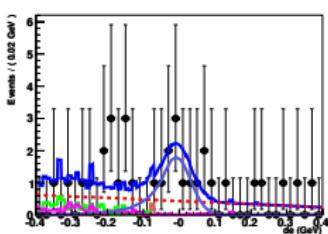
# MC Fit of $B^0 \rightarrow \phi\pi^0$ decay

MC fit based on  $605fb^{-1}$

● Entire Region



● Slice Region



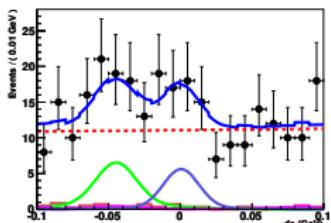
the fit result

	expected(input)	fit result
ArgPar		$-20.0 \pm 11$
dElin		$-0.38 \pm 0.15$
$q\bar{q}$	75.08	$70.5 \pm 8.7$
$b \rightarrow c$	2.76	fixed
dominant B	5.69	fixed
the rest B	3.84	fixed
nSig	8.45	$11.1 \pm 4.1$

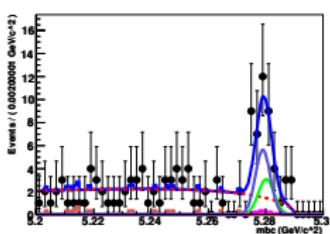
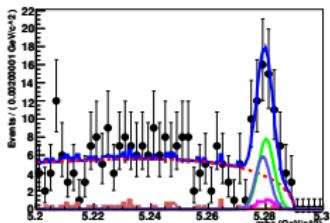
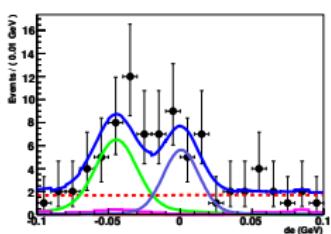
# MC Fit of $B^- \rightarrow \phi\pi^-$ decay

MC fit based on  $605fb^{-1}$

● Entire Region



● Slice Region

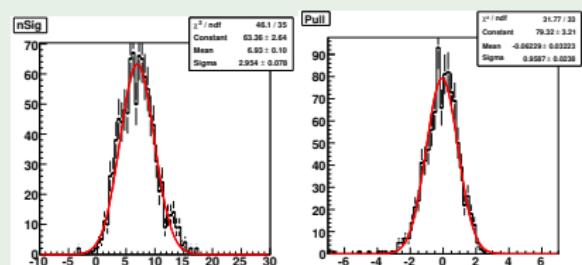


the fit result

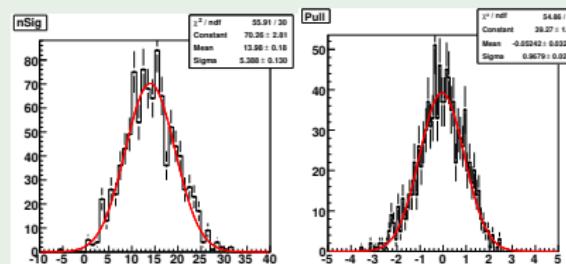
parameters	expectation	fit result
ArgPar		$-24.54 \pm 8.3$
dElin		$0.02 \pm 0.12$
$q\bar{q}$	216.22	$222 \pm 16$
$b \rightarrow c$	7.08	fixed
dominant B	29.32	$26.9 \pm 6.7$
the rest B	4.06	fixed
nSig	14.34	$18.8 \pm 5.6$

# Toy MC

$B^0 \rightarrow \phi \pi^0$ : 1K samples, 94 candidates



$B^+ \rightarrow \phi \pi^+$ : 1K samples, 271 candidates



- The result of  $B^0 \rightarrow \phi \pi^0$

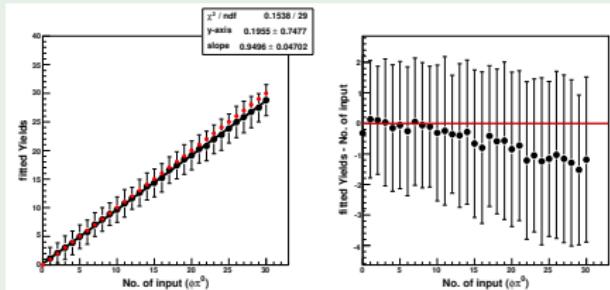
parameter	mean( $\mu$ )	sigma( $\sigma$ )
nSig	$6.93 \pm 0.10$	$2.954 \pm 0.078$
pull	$-0.06229 \pm 0.03223$	$0.9587 \pm 0.0238$

- The result of  $B^+ \rightarrow \phi \pi^+$

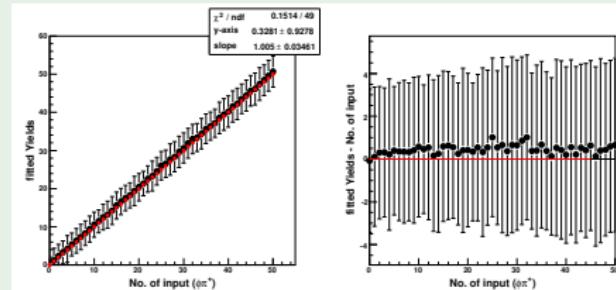
parameter	mean( $\mu$ )	sigma( $\sigma$ )
nSig	$13.988 \pm 0.18$	$5.388 \pm 0.130$
pull	$-0.05242 \pm 0.03297$	$0.9679 \pm 0.0265$

## GSIM linearity test

$B^0 \rightarrow \phi\pi^0$



$B^+ \rightarrow \phi\pi^+$



- 100 samples for each signal number of events
- $Y_{\phi\pi^0} = 0.950(Y'_{\phi\pi^0}) + 0.196$
- data point : mean, error : standard deviation

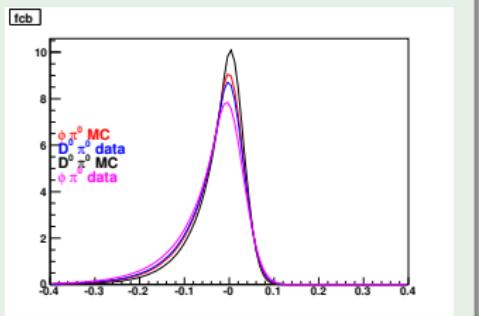
- 100 samples for each signal number of events
- $Y_{\phi\pi^+} = 1.005(Y'_{\phi\pi^+}) + 0.328$
- data point : mean, error : standard deviation

# Calibration for $B^0 \rightarrow \phi\pi^0$

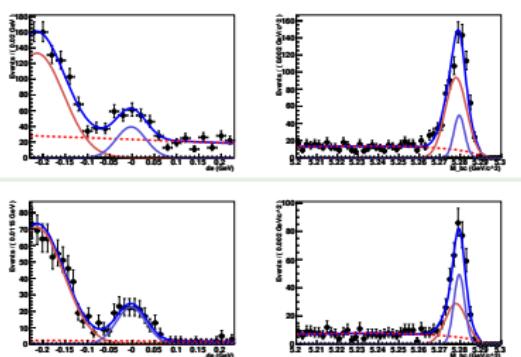
	$B^0 \rightarrow \phi\pi^0$ MC	$B^0 \rightarrow \overline{D}^0\pi^0$ MC	$B^0 \rightarrow \overline{D}^0\pi^0$ data	$B^0 \rightarrow \phi\pi^0$ data
$\mu$	-0.001096	0.002881	-0.00218	-0.006157
$\sigma$	0.03215	0.02896	0.0335	0.03719

- control sample :  $B^0 \rightarrow \overline{D}^0\pi^0$
- $\mu_{\phi\pi^0}^{data} = \mu_{\phi\pi^0}^{MC} + (\mu_{D\pi^0}^{data} - \mu_{D\pi^0}^{MC})$
- $\sigma_{\phi\pi^0}^{data} = \sigma_{\phi\pi^0}^{MC} \times (\sigma_{D\pi^0}^{data} / \sigma_{D\pi^0}^{MC})$

## CB shape



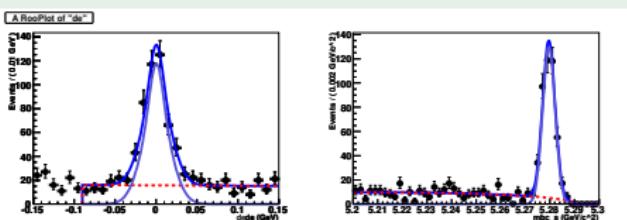
## $B^0 \rightarrow \overline{D}^0\pi^0$ data fit



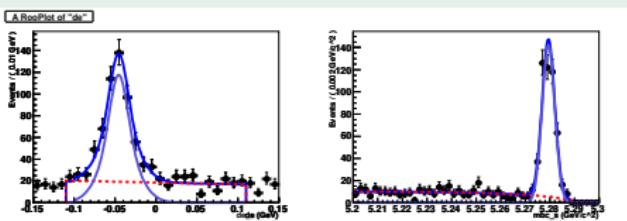
# Calibrations for $B^+ \rightarrow \phi\pi^+$ , $B^+ \rightarrow \phi K^+$ Background

$B^+ \rightarrow \phi K^+$  for data:  $\text{prob}(K/\pi) > 0.6$

●  $B^+ \rightarrow \phi\pi^+$  calibration



●  $B^+ \rightarrow \phi K^+$  Background calibration



●  $B^+ \rightarrow \phi\pi^+$  calibration

prob( $K/\pi$ )	0.6
$\sigma_1$	0.0173
$\sigma_2$	0.0076
$\mu$	0.00049
frac	0.81

●  $B^+ \rightarrow \phi K^+$  Background calibration

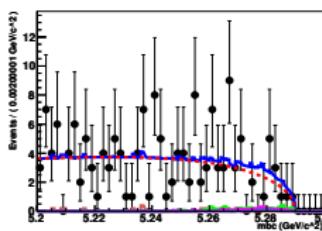
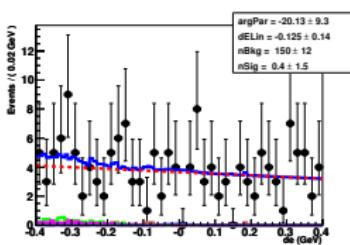
prob( $K/\pi$ )	0.6
$\sigma_1$	0.0102
$\sigma_2$	0.0209
$\mu$	-0.04454
frac	0.37
nSig	268

● expectation :  $19.77(357 \text{ fb}^{-1})$

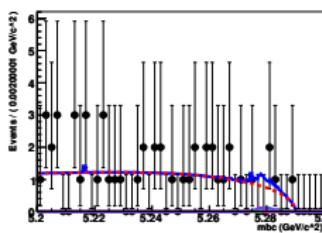
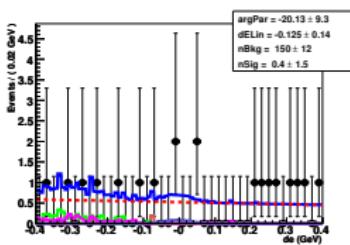
# Data Fit of $B^0 \rightarrow \phi\pi^0$ decay: with $a^{00}\pi^0$ component

357 $fb^{-1}$  data

Entire Region



Slice Region



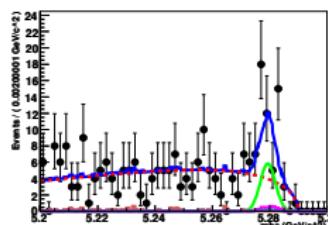
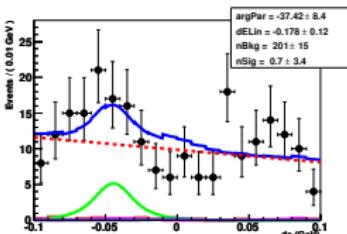
the fit result

	expected(input)	fit result
ArgPar		$-20.13 \pm 9.3$
dElin		$-0.125 \pm 0.14$
$q\bar{q}$	44.37	$150 \pm 12$
$b \rightarrow c$	1.63	fixed
dominant B	3.36	fixed
peaking	0.44	fixed
the rest B	2.27	fixed
nSig	4.20	$0.4 \pm 1.5$

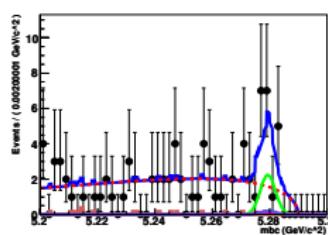
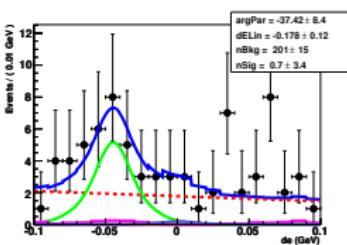
# Data Fit of $B^+ \rightarrow \phi\pi^+$ decay : with $K^+K^-\pi^+$ component

357 $fb^{-1}$  data

Entire Region



Slice Region



the fit result

parameters	expectation	fit result
ArgPar		$-37.42 \pm 8.4$
dElin		$-0.178 \pm 0.12$
$q\bar{q}$	127.78	$201 \pm 15$
$b \rightarrow c$	4.18	fixed
dominant B	19.77	fixed
the rest B	2.40	fixed
peaking	3.21	fixed
nSig	8.42	$0.7 \pm 3.4$

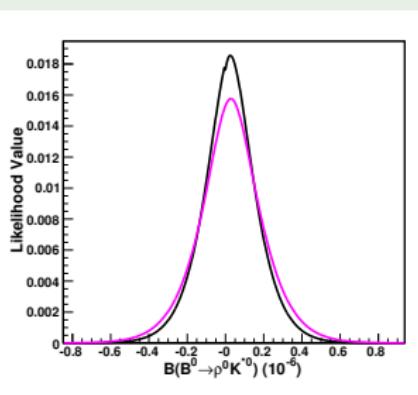
# systematics of $B \rightarrow \phi\pi$ decays for $357fb^{-1}$

Type		$B^0 \rightarrow \phi\pi^0$		$B^+ \rightarrow \phi\pi^+$	
		$+\sigma$	$-\sigma$	$+\sigma$	$-\sigma$
$M_{bc}$	$\sigma_A$	0.07	-0.08	0.08	-0.07
$\Delta E$	$\sigma_A$	0.13	-0.15	0.49	-0.67
$\Delta E$ range	$\sigma_A$	0.07	-0.0	-	-
$b \rightarrow qq$	$\sigma_A$	0.26	-0.26	0.89	-0.89
$b \rightarrow c, b \rightarrow u, d, s$ background	$\sigma_A$	0.02	-0.04	0.77	-0.89
The non resonance	$\sigma_A$	+0.21	-0.34	0.9	-2.88
The fitting bias	$\sigma_A$	0.20	-	0.33	-
MC acceptance	$\sigma_M$	+0.9%	-0.9%	+0.6%	-0.6%
PID	$\sigma_M$	+1.3%	-1.3%	+2.0%	-2.0%
Tracking	$\sigma_M$	+2.0%	-2.0%	+3.1%	-3.1%
$\pi^0$ detection efficiency	$\sigma_M$	+3.0%	-3.0%	-	-
MDLR efficiency	$\sigma_M$	+11.1%	-11.1%	+7.1%	-7.1%
$N_{B\bar{B}}$	$\sigma_M$	+1.2%	-1.2%	+1.2%	-1.2%

# Upper Limit: $357 fb^{-1}$ data

$B^0 \rightarrow \phi\pi^0$

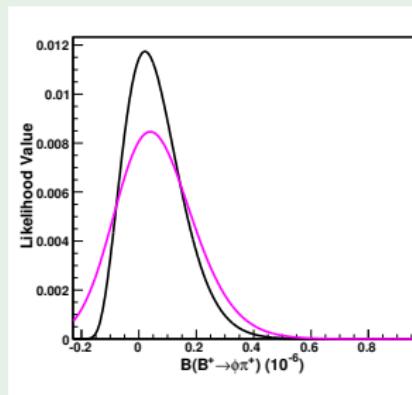
- Central mode :  $B^0 \rightarrow a_0^0\pi^0$



- Upper Limit :  $0.30 \times 10^{-6}$
- $BF(B^0 \rightarrow \phi\pi^0) :$   
 $(0.02^{+0.11}_{-0.07}(stat)^{+0.04}_{-0.03}(syst)) \times 10^{-6}$

$B^+ \rightarrow \phi\pi^+$

- Central mode :  $B^+ \rightarrow K^+ K^- \pi^+$



- Upper Limit :  $0.27 \times 10^{-6}$
- $BF(B^+ \rightarrow \phi\pi^+) :$   
 $(0.02^{+0.11}_{-0.09}(stat)^{+0.06}_{-0.09}(syst)) \times 10^{-6}$

## Plan

- $357fb^{-1} \rightarrow$  Graduation thesis.
- $605fb^{-1} \rightarrow$  Will be submitted to PRD.
- We find the interesting something.  $B^+ \rightarrow K^+K^-\pi^+$  final stat has a peak in the side band in the viewpoint of  $M(K^+K^-)$ .  
→ The peak has high probability of  $B^+ \rightarrow a_0^0\pi^+$ .
- We have the similar modes , $B \rightarrow \phi\rho$ .  
→ Nobody study the modes.