Belle NPC activities

- Introduction (Motivation)
- Physics subjects and analysis
- Contribution for Belle II project
- RCNP Computing (Belle Local Center)
- Summary

M. Uchida

Tokyo Tech.

New Hadron Committee, Aug. 4th , 2011 @ Nagoya Univ.

NPC = Nuclear Physics Consortium

NPC is one of the groups in the Belle and Belle II Collaboration.

21 people (10 institutes) from hadron physics community have made the consortium with interests to analyze Belle data from Mar. 2009.

- RCNP, Osaka Univ. : ***T. Nakano, S. Ajimura, T. Hotta, Y. Morino, N. Muramatsu.*** *M. Yosoi*
- Tokyo Institute of Technology : ***M. Uchida, T. Shibata, N. Kobayashi***
- Kyoto Univ. : ***M. Niiyama, H. Fujioka***
- Tohoku Univ. : ***H. Kanda,*** *K. Miwa*
- Univ. of Miyazaki : ***T. Matsuda, T. Motoda***
- Gifu Univ. : ***K. Nakazawa, M. Sumihama***
- Yamagata Univ. : ***Y. Miyachi***
- Showa Pharmaceutical Univ. : ***M. Takizawa***
- Seoul Univ. : *K. Tanida*
- KEK : *K. Ozawa*

Bold = NPC & NPC-II

♣ Participating from LEPS, JPARC, COMPASS, HERMES, … , and also from a theory side.

♣ Subjects are widely overlapped with A01.

Why Belle data is interesting for us?

- High statistics Exotic & low production rate particles, high precision measurements of hadron properties, and new approach for hadron physics.
- Large acceptance detector w/ excellent momentum resolution and PID ability
- High energy

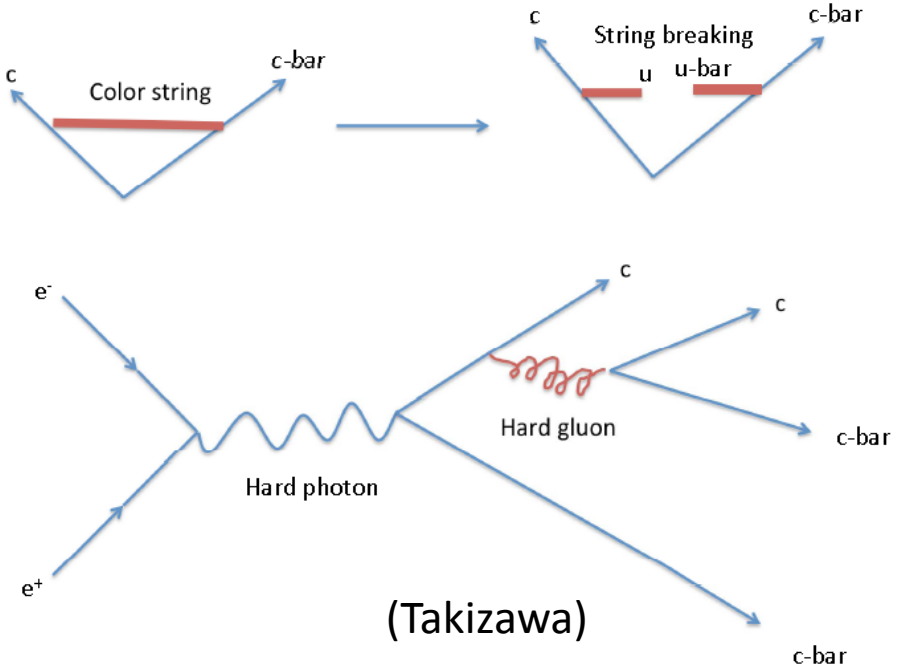
(1) heavy quark hadrons

Produced by Υ productions,

b→c decays, and

hard gluon exchanges.

Kinetic energy term is small.



(2) Also rich production of light quark hadrons

Produced by heavy hadron decays

and color string breaking in hadronization.

Dynamical structure inside hadron becomes more important.

Close to interests of lower energy experiments.

Physics Subjects

Investigating exotic hadrons, controversial hadrons, hadron-hadron interactions, fragmentations

- Light quark hadrons

  scalar & axial vector mesons : Matsuda, Motoda

  Production rate for light flavored hadrons : Uchida

  Excited Ξ* search and so on… : Sumihama

  meson-meson interaction : Niiyama

- Fragmentation functions for light quark hadrons

  Interference FF : Kobayashi

- Heavy quark hadrons

  X(3872) : Muramatsu

  H-dibaryon in Charm sector : Takizawa

Now various analyses are under way.

$X(3872) \to J/\psi\pi^0\pi^0$ in B decays (N. Muramatsu)

Discussion of C-parity

C=+1 : $\Gamma(X(3872) \to J/\psi\pi^0\pi^0)/\Gamma(X(3872) \to J/\psi\pi^+\pi^-)=0$ [I=1 through $J/\psi\rho$]

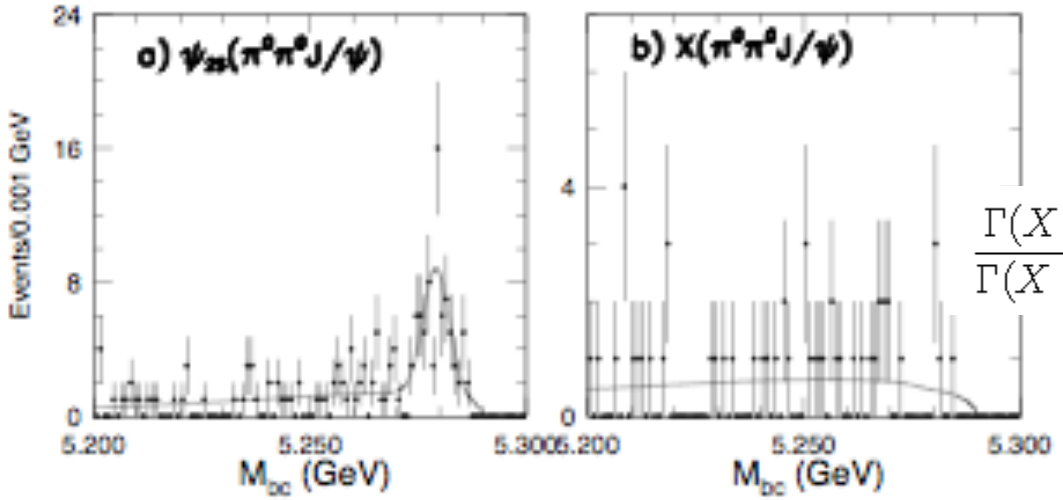
C=-1 : 1/2 [I=0, ex. ψ']

If X(3872) is 1^{++} DD^* molecule, this decay mode cannot be seen.

$\Upsilon(4S) \to B^+B^-$ [51.6%] ; $B^{+-} \to K^{+-}X(3872)$; $X(3872) \to J/\psi\pi^0\pi^0$

$\Upsilon(4S) \to B^0B^0$ [48.4%] ; $B^0 \to K^0 X(3872)$; $K_S \to \pi^+\pi^-$ [50% x 69.20%] ; $X(3872) \to J/\psi\pi^0\pi^0$

Previous measurement at Belle : hep-ex0408116 using 253 fb^{-1}



$$\frac{\Gamma(X \to \pi^0\pi^0 J/\psi)}{\Gamma(X \to \pi^+\pi^- J/\psi)} < 1.3 \frac{\Gamma(\psi' \to \pi^0\pi^0 J/\psi)}{\Gamma(\psi' \to \pi^+\pi^- J/\psi)}.$$

vs. Currently increased up to 711 fb^{-1}

Before examining X(3872),

$\psi' \to J/\psi\pi^0\pi^0$ [16.84%]

must be checked as

a control sample.

$\Rightarrow$ Now optimizing

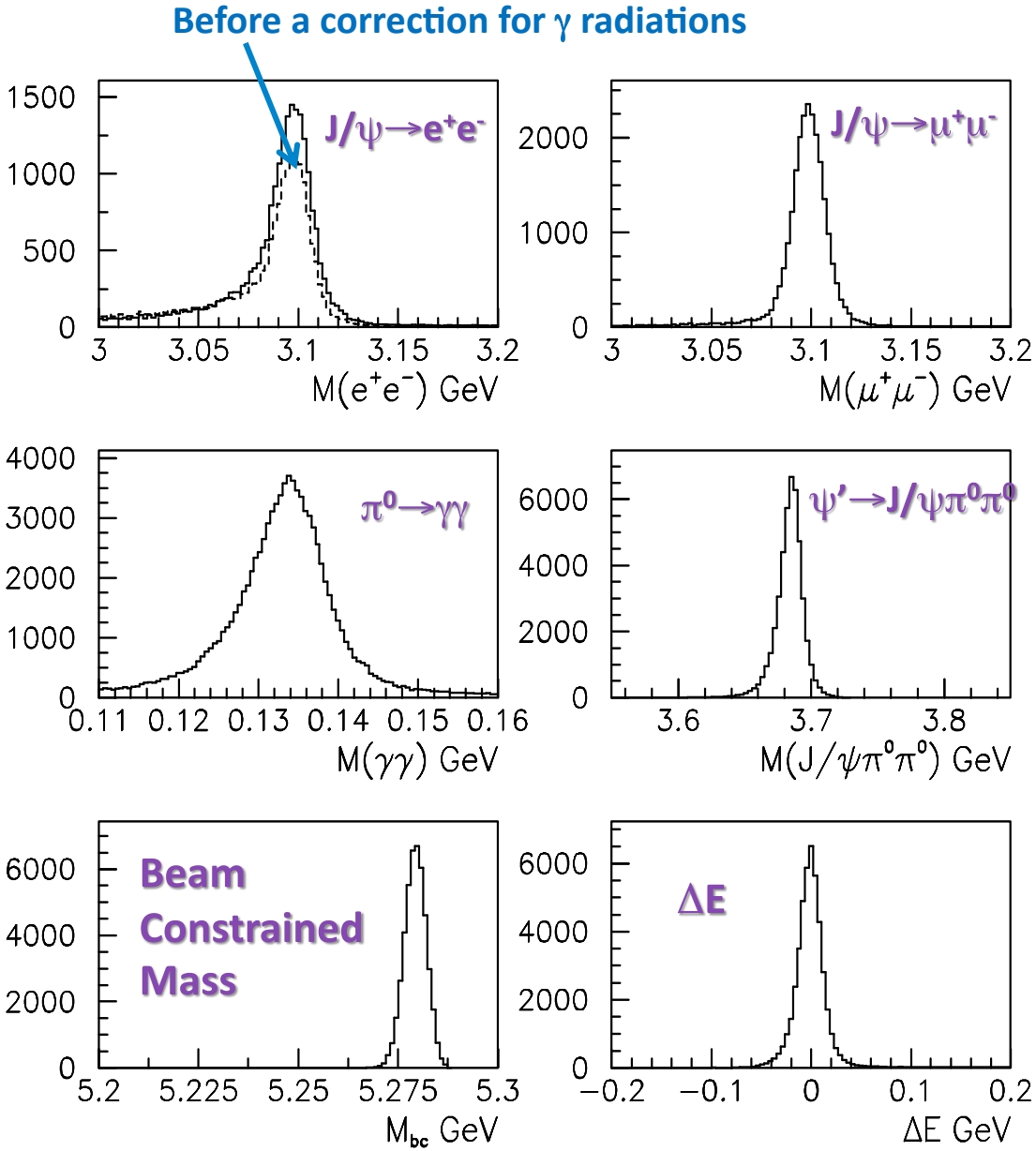
selection criteria.

Here are some snap shots

of event reconstruction

w/ ψ'-signal MC (only

$B^+ \to K^+\psi'$) as an example.



Study of Light quark mesons from B decays

T. Matsuda,T. Motoda (Univ. of Miyazaki) with Prof. J. MacNaughton

Motivation:

- Nature of scalar and axial vector mesons are still discussed.

  σ, κ, $f_0(980)$, $a_0(980)$, a_1, K_1, ...

  $\Rightarrow$ molecule states, tetraquarks, glueballs or others?

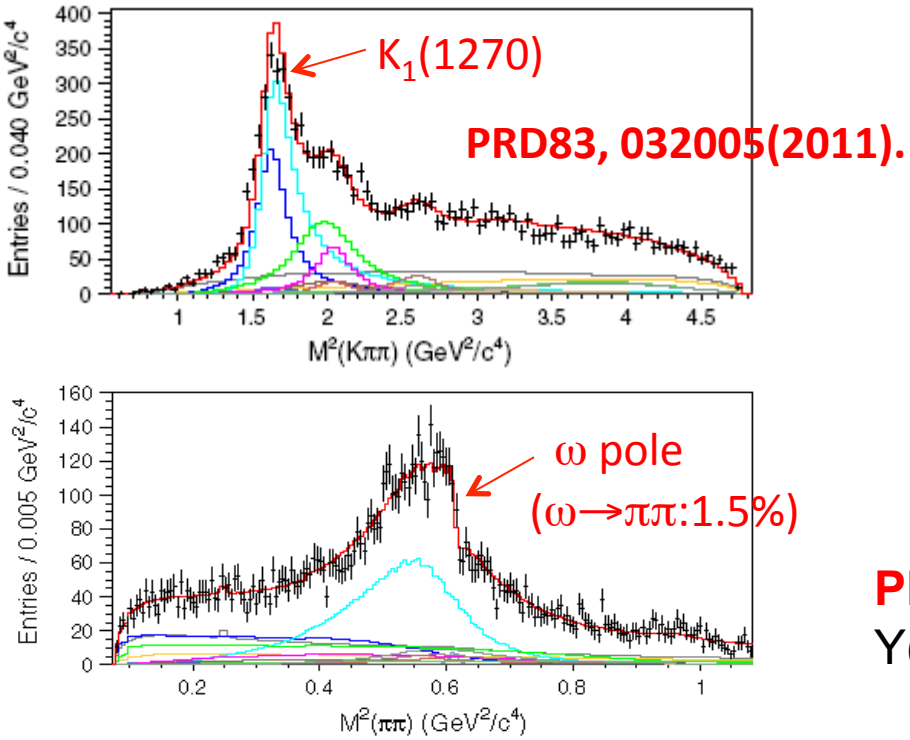
Strategy and Method:

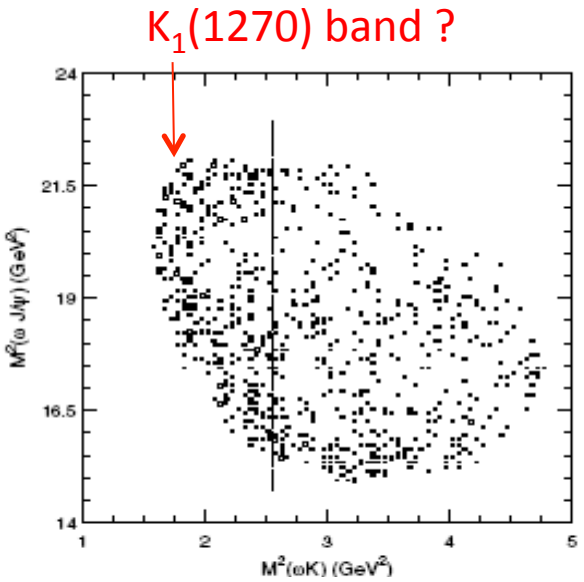
- Construct and carry out **Partial Wave Analyses**.
- Study properties of axial vector, scalar mesons: mass, width, mass line shape, branching ratio, mixing angles, and even existence.
- Currently two reactions are being analyzed.

  1. $B^0 \rightarrow D^{*+/-}$ $a_1^{-/+}$
  2. $B^+ \rightarrow J/\psi\ K_1(1270)$; $\mathbf{K_1(1270) \rightarrow \omega K}$

2. $B^+ \to J/\psi\ K_1(1270);\ K_1(1270) \to K\omega \to K\pi\pi\pi$ (T. Motoda)

- Recently Belle renewed the mass and width of $K_1(1270)$ in **$B \to J/\psi K\pi\pi$ channel**. This must be also checked by $K\pi\pi\pi$ mode.
- BR($K_1 \to K\omega$) may be larger than PDG (11%) because of strong $\rho\omega$ interference.
- Skim programs for $B^+ \to J/\psi K^+\omega$ are under construction by using signal MC.





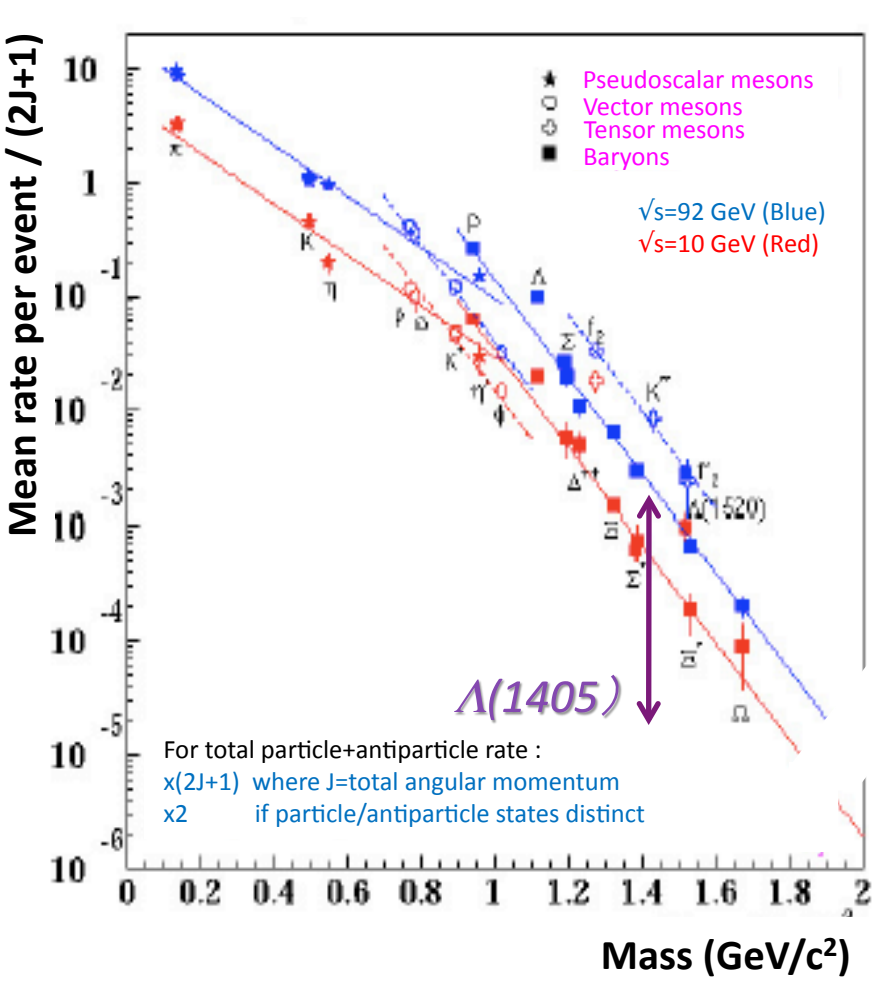
PRL94, 182002(2005):
Y(3940) production in $B^+ \to J/\psi K^+\omega$ reaction

Production Rate for Light Hadrons (M. Uchida)

- Production rate of light hadrons ($q\bar{q}$/qqq) tend to be proportional to their masses. (LEP, BaBar)
- Statistical formalism
  [Y.-J. Pei, *Z. Phys.* **C** 72, p39 (1996)]

$$< N >= C \cdot \frac{2J+1}{C_B} \cdot (\gamma_s)^{N_s} e^{-\frac{E_{bind}}{T}}$$

- Discrepancy from the global trend indicates the different production mechanism and/ or internal structure from the 2 or 3 constituent quarks.
  ⇒ ***Λ(1405) and some exotic candidate hadrons*** will be examined.

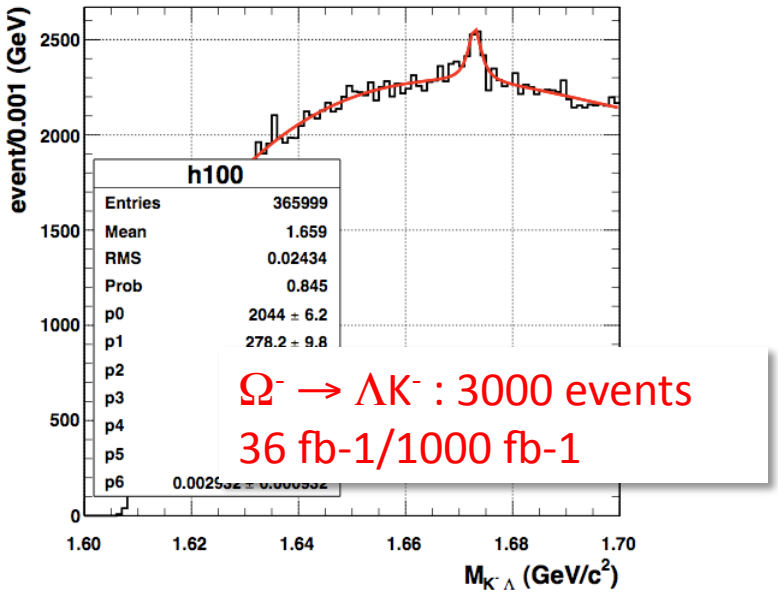


Λ(1405): Hard -> Soft process -> coalescence ?

List of Hadrons under considerations

Analysis : inclusive analysis
e+e- → vpho → B/M + X
B:baryon, M: Meson

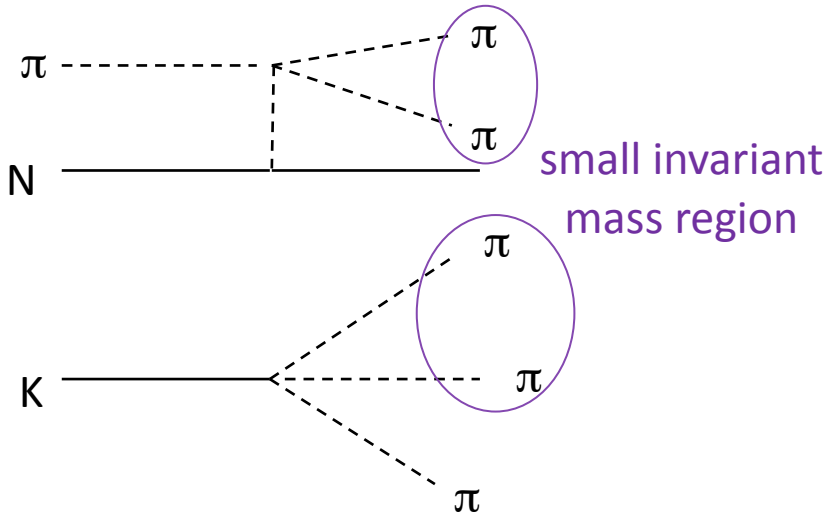
Mesons	Decay	Status
π		Cuts optimized
η	$\gamma\gamma$	Cuts optimized
η'	$\pi^+\pi^-\eta$	Cuts optimized
K		Cuts optimized
$K^*(892)$	$K\pi$	Cuts optimized
ρ	$\pi\pi$	Cuts optimized
ω	$\pi^+\pi^-\pi^0$	Cuts optimized
ϕ	K^+K^-	Cuts optimized
a^0	$\pi^0\eta$	Future plan
f^0	$\pi\pi$	Future plan

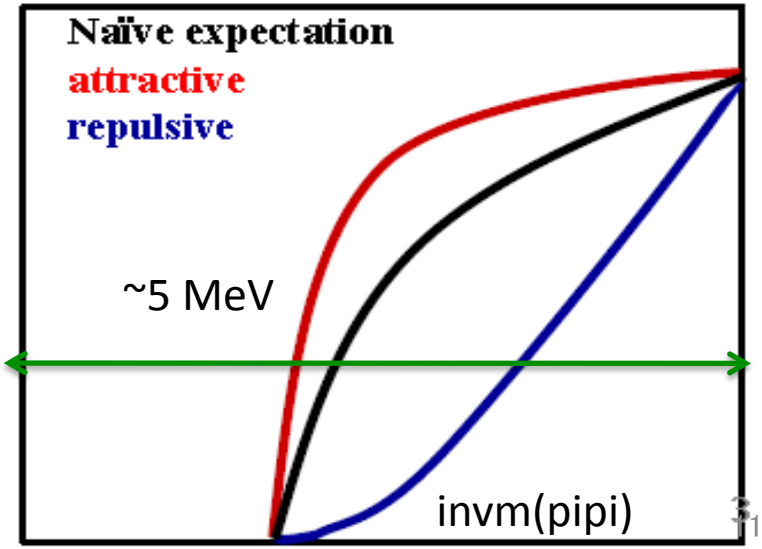


Baryons	Decay	Status
P		Cuts optimized
Δ	$N\pi$	In progress
Λ	$p\pi$	Cuts optimized
Σ	$\Lambda\gamma$	Cuts optimized
$\Sigma(1385)$	$\Lambda\pi$	In progress
$\Lambda(1405)$	$\Sigma\pi$	In progress
$\Lambda(1520)$	pK^-	Cuts optimized
$\Lambda(1520)$	$\Sigma\pi$	in progress
Ξ	$\Lambda\pi$	Cuts optimized
Ω	ΛK^-	Cuts optimized
N(1535)	$p\eta$	Future plan

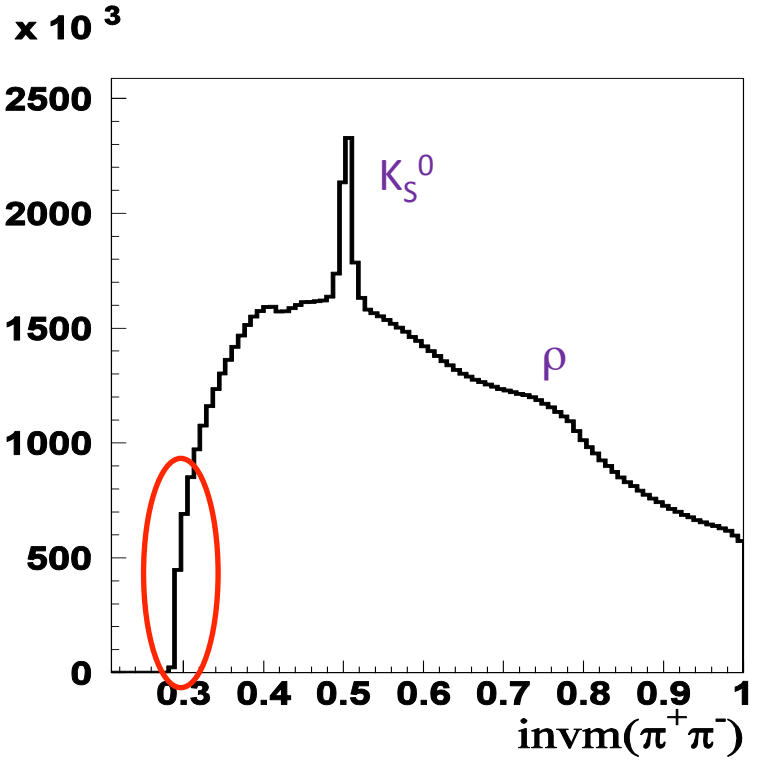
Measurements of Scattering Lengths (M. Niiyama)

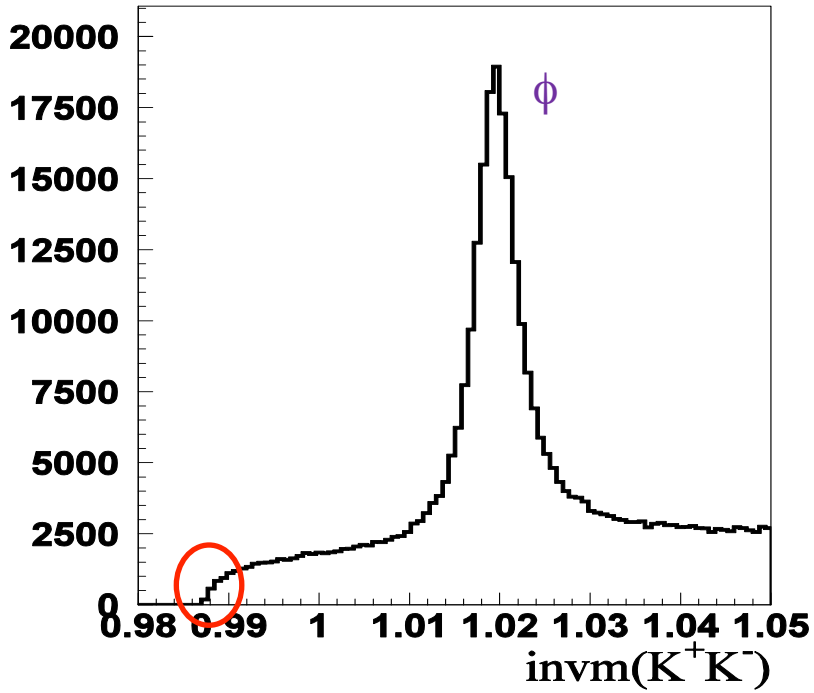
- Meson-meson scattering length is an important fundamental variable in hadron physics. While **ππ channel** has been studied in detail, **KK & Kπ channels** are not studied well.
- Analysis strategy : Using continuum data, the meson-meson invariant mass distributions will be compared with phase space in the kinematical region of relative momentum ~ 0.
- Belle data is suitable for this analysis because of (1) high statistics, (2) variations of meson pairs, and (3) good momentum resolutions [no target material, w/ vertex detector].





$\pi^+\pi^-$ and K^+K^- invariant mass spectrum



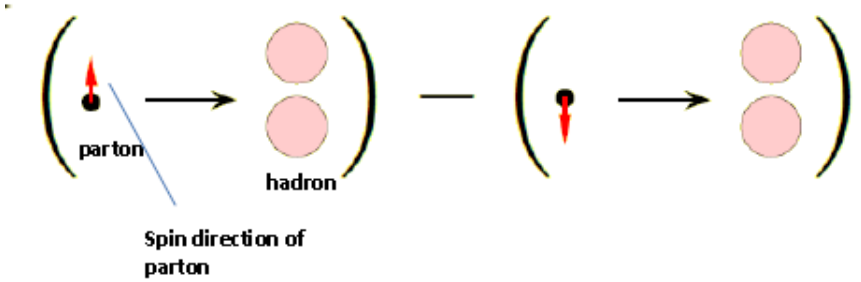


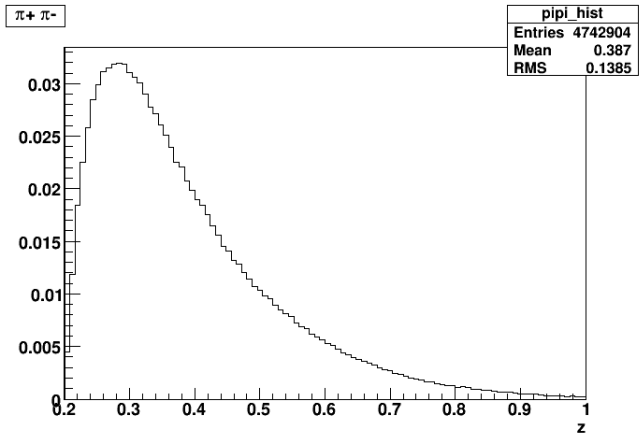
To do:
- Acceptance corrections.
- Understand compositions of invariant mass distributions.
- How to extract scattering lengths is under discussions.
- Systematic study for various meson-meson interactions.

Interference Fragmentation Function (N. Kobayashi)

- IFF $H_q^<(z,M_h^2)$: Fragmentation of a quark (q) with transverse spin into a pair of unpolarized hadrons.
- Model predictions by Jaffe et al. [PRL 80] & Radici et al. [PRD 65] for ππ (accepted to PRL, arXiv:1104.2425v3), **KK, & Kπ** (will be analyzed by N.K.)

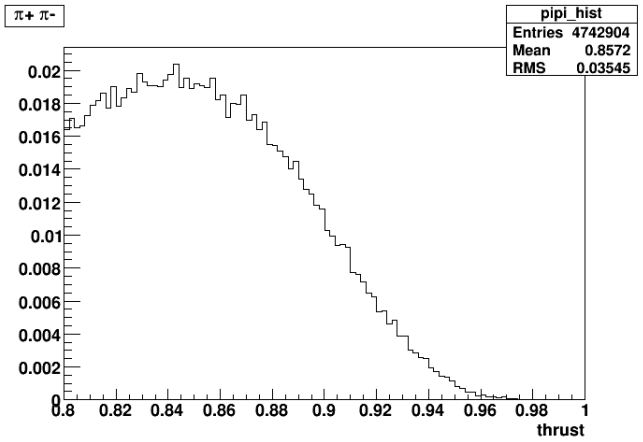
Transverse spins of back-to-back partons must be correlated.





Fractional energy :

$$z = \frac{2E_h}{\sqrt{s}}, \quad \sqrt{s} = 10.52 \text{ GeV}$$



Thrust :

$$T \overset{max}{=} \frac{\sum_h |\mathbf{P}_\mathbf{h}^{\mathrm{CMS}} \cdot \hat{\mathbf{n}}|}{\sum_h |P_h^{\mathrm{CMS}}|}$$

H-bibaryon in charm sector

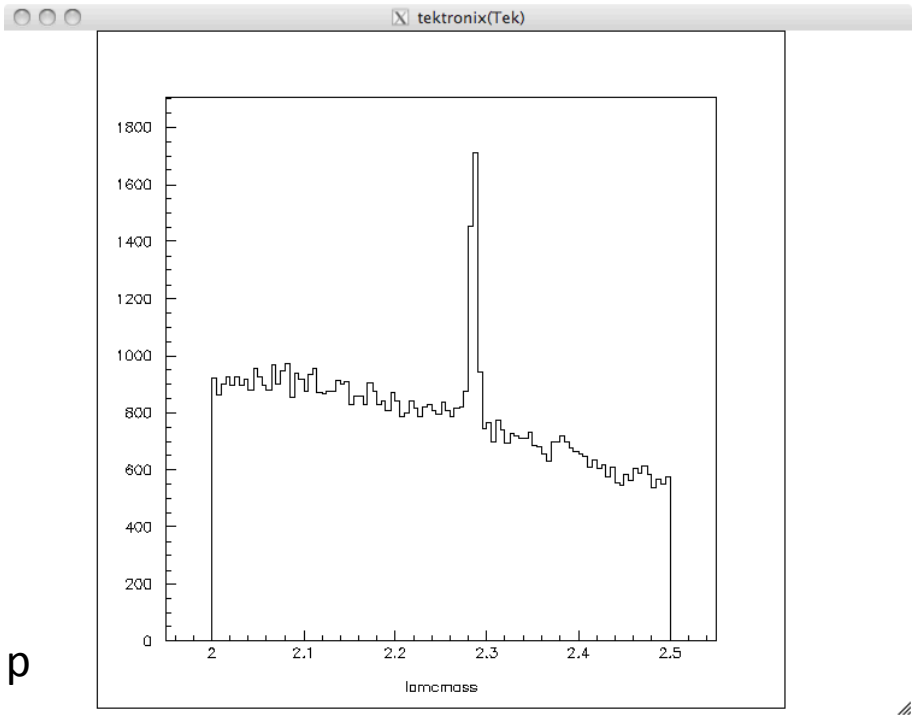
• Jaffe predicted in 1977 that flavor singlet dibaryon state (udsuds) is stable.
• No positive experimental results was reported until now.

Singly charmed dibaryon

• udsudc (lambda_c lambda) singly charmed dibaryon (H_c dibaryon)
• Smaller kinetic energy
• Smaller instanton induced repulsive interacntion
• stable dibaryon state or resonance state?
• How about uud udc (Lamba_c p)?

Doubly charmed dibaryon

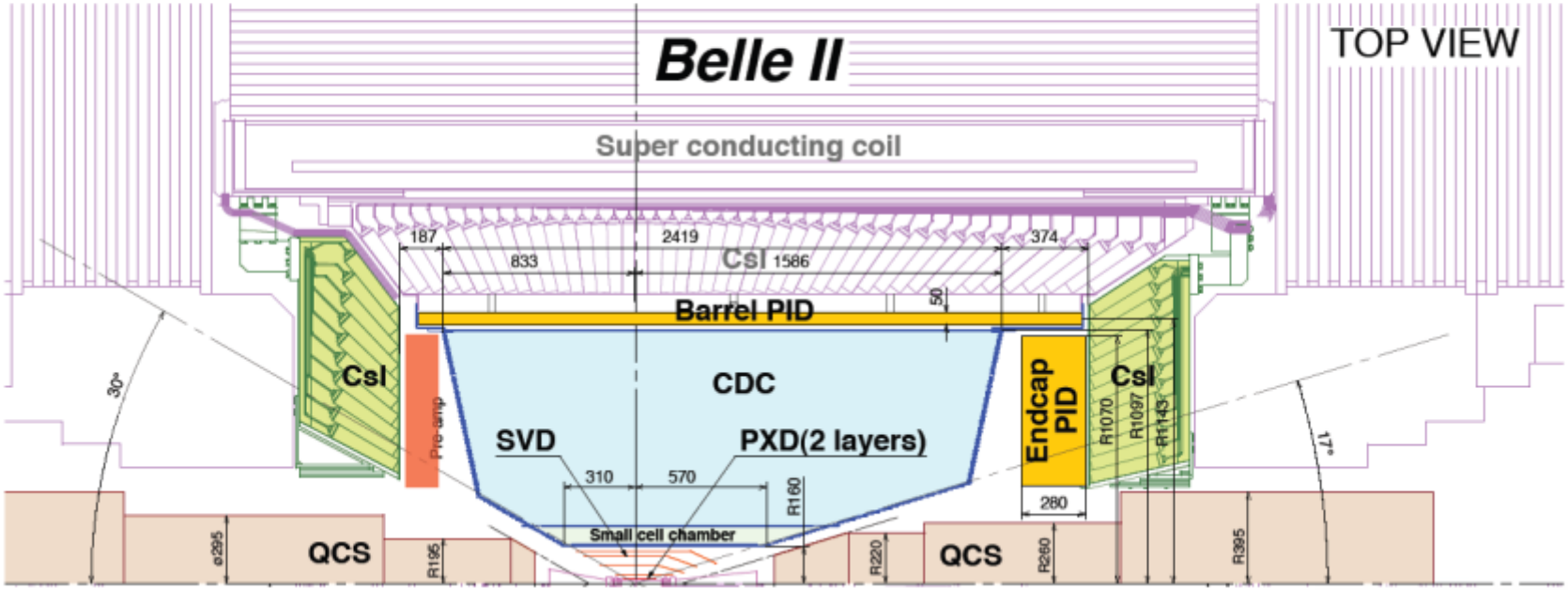
• Much smaller kinetic energy
• No instanton induced repulsive int.



Lambda_c+→K-pi+ p reconstructed.

NPC-II Contribution

- Removal of Belle-CDC cables on 27 & 28 Dec, 2010 (Uchida, Sumihama, Matsuda, Motoda, Kobayashi)
- Qualification assurance for sense/potential wire (next summer)
- Contribution for CDC part of Belle II simulator (Sumihama, M.U)
  (Fine tuning of geometry, digitization, dE/dx, etc …)
- Performance test exp. for CDC prototype chamber @ LEPS/SP8



RCNP computing as a Local Center (Kanda, Niiyama, Kobayashi)

☆Motivation : To increase ***analysis speed and performance*** of NPC members, ,dig up ***analysis man powers*** inside NPC, and prepare for the coming shutdown of B-comp. (March, 2012).

☆Comparisons of computing powers

	B computers	*RCNP computers*
CPU & clock	*Intel Xeon X5460 (3.16 GHz)*	*Intel Xeon X5680 (3.33 GHz)*
#CPU	*2 x 480 node*	*2 x 76 node*
Throughput/CPU	*48*	*128*
Total throughput	***2.37***	***1***
Data storage	*3.5 PB Tape + 1.5 PB HDD*	*3.5 PB*
#User	*600(FY2008)*	*~10 (current active user)*

☆ status

1. *Construction of BASF (Belle Analysis Framework) environment was completed.*
2. *Real Data/ generic MC for exp. 7 – 41 (400fb-1/1000fb-1)*
3. *Signal MC generation : EVTGEN, GSIM and run indep. BG (exp. 07-65)*

Contributions other than analyses

- 18 shifts in 2009 & 6 shifts in 2010
- Efficiency, fake rate & systematic error tables for Belle-PID

  with great helps of Nishida-san

  (KID: Niiyama, eid/muid : Uchida, Sumihama, Muramatsu) → study the fundamental belle analysis framework.
- Internal referees of Belle papers (Muramatsu, Matsuda, Niiyama, Miyachi, Sumihama, Takizawa, Uchida) ⇒ Having physics discussions & Learning Belle analysis procedures.
- Host the 55th Belle General Meeting in May 11,12, 2011 at RCNP.
- A01 and NPC joint meeting (“new hadron meeting”) in every two weeks.

Summary

- NPC peoples have experienced the belle analysis framework.
- Many physics analysis programs are under way (active phase).
- NPC (II) peoples are working on the CDC development
  - software development and prototype test in this year.
- RCNP provide enough computing resource as a Belle Local Center.
- We cooperated with A1 people (and also related Belle people) and boost up physics analysis.