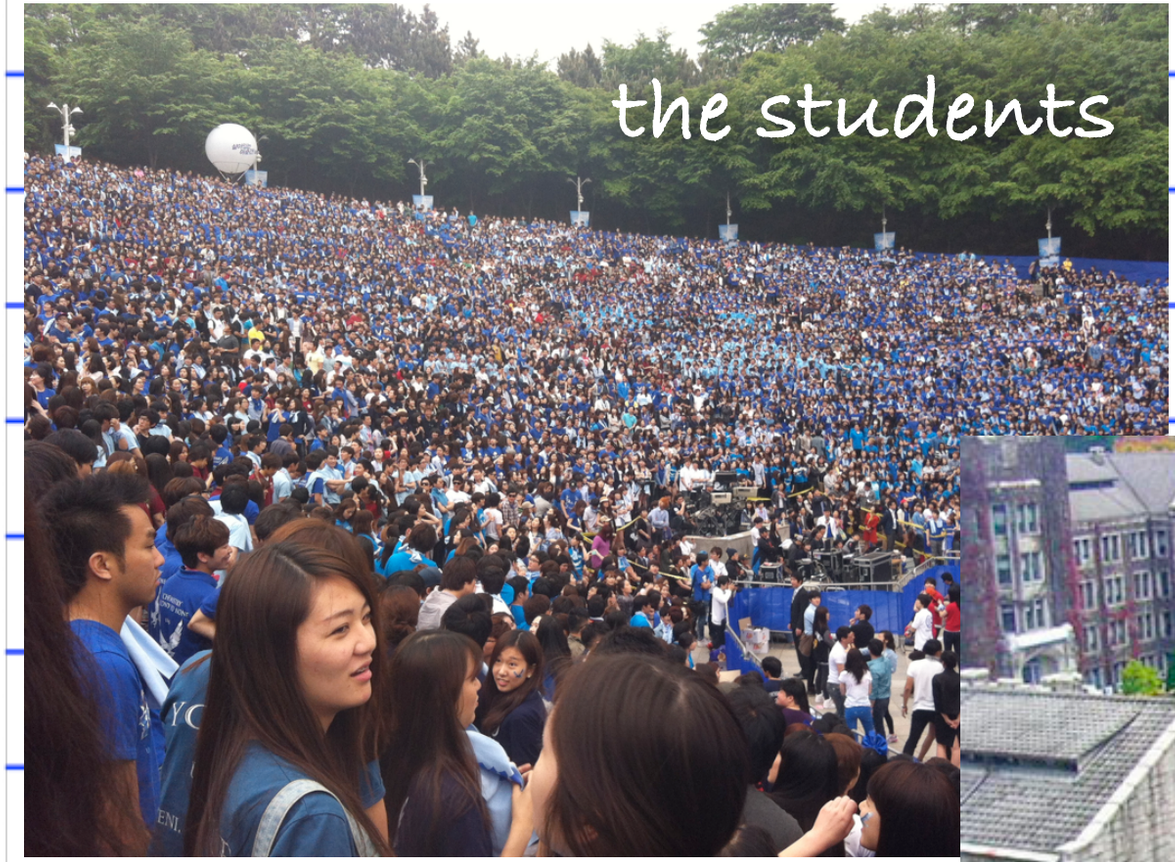
Welcome to Yonsei HEP & LDU

Youngjoon Kwon
Yonsei University

YuCHE, 2019/2/25-27



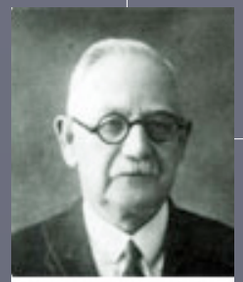
YONSEI UNIVERSITY
연세대학교
YONSEI UNIVERSITY

Physics at Yonsei

- "You will know the truth, and the truth will set you free (John 8:32)"
  - Motto of Yonsei U.
  - Truth and Freedom, the two keywords in Yonsei Science
- The First, and the Best
  - Founded in 1915 (oldest Physics Department in Korea)
  - Producing numerous frontiers & leaders in modern science in Korea
- Yonsei Physics today
  - strong research programs: VMRC (SRC), LDU (BRL)
  - 26 regular faculties & ~170 graduate students, ~140 undergraduates

History of Yonsei
≃ History of Yonsei Physics

Severance Medical School



Math/Physics

Asahi Medical School closed

Centennial

1885 1904 1942 1957 1999 2015

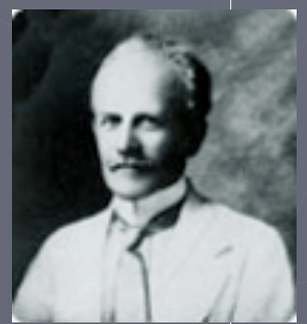
1915 1943 2006

1946

BK21

Yonsei U.

Je-Joong-Won



Yonhui College

"Gwang-Hye-Won"
or
"Je-Joong-Won"

The fountainhead of Yonsei U.

PHYSICAL REVIEW VOLUME 132, NUMBER 1 1 OCTOBER 1963

Study of the Ni(n,p)Co Reaction*†

L. D. SINGLETARY
Lockheed Missiles and Space Company, Palo Alto, California
E. N. STRAIT
Northwestern University, Evanston, Illinois
AND
S. H. AHN
Yonsei University, Seoul, Korea
(Received 15 May 1963)

The total cross section and energy spectrum for the (n,p) reaction on nickel has been measured for 15-MeV neutrons using a modified broad-range magnetic spectrograph and nuclear emulsions. Proton spectra were measured at scattering angles of 0° and 138°. A nuclear temperature of 1 MeV was determined from the 138° spectrum. If isotropy of the compound nucleus reaction products is assumed, the cross section for the compound nucleus part of the (n,p) reaction can be estimated as 650±150 mb. The additional contribution from direct interaction is estimated as 160±80 mb.

INTRODUCTION

THIS experiment is an attempt to add some significant information to the body of data on nuclear reactions produced by high-energy particles (10 to 20 MeV). The most generally studied reactions in this energy region are inelastic scattering of neutrons

DISCUSSION OF EXPERIMENT

In the experiment reported here, measurements were made which differentiate among protons, deuterons, and alpha particles. Total and differential cross sections were determined for the proton component. A broad-range charged particle spectrograph was adapted for

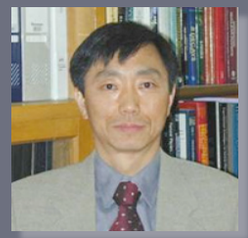
The first ever Physical Review with an affiliation to a Korean institution

Yonsei Physics Faculty

Particle / Nuclear







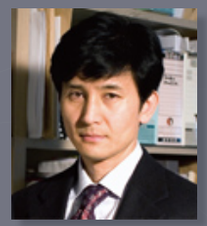

Condensed Matter






Optics / Semiconductor





Surface




Nano-Bio




Particle/Nuclear at Yonsei

- Prof. Ju Hwan Kang
- Nuclear Expt. (ALICE / PHENIX)

- Prof. Choong Sun Kim
- Particle Theory (Flavor)

- Prof. Youngil Kwon
- Nuclear Expt. (ALICE / PHENIX)

- Prof. Su Houng Lee
- Nuclear Theory (Hadrons)

- Prof. Youngjoon Kwon
- Particle Expt. (Belle / Belle II)

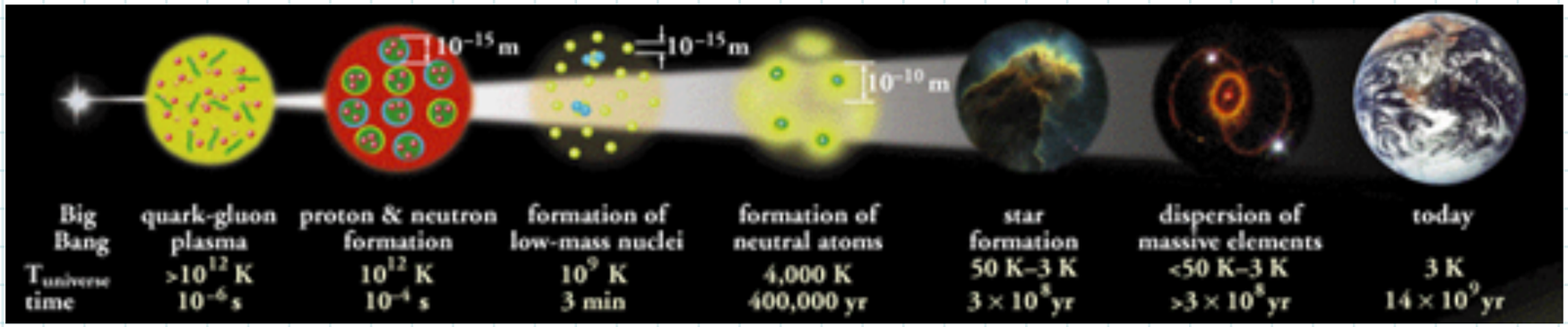
- Prof. Seung joon Hyun
- Superstring Theory

- Prof. Hwidong Yoo
- Particle Expt. (CMS)

- Prof. Seongchan Park
- Particle Theory & Cosmology

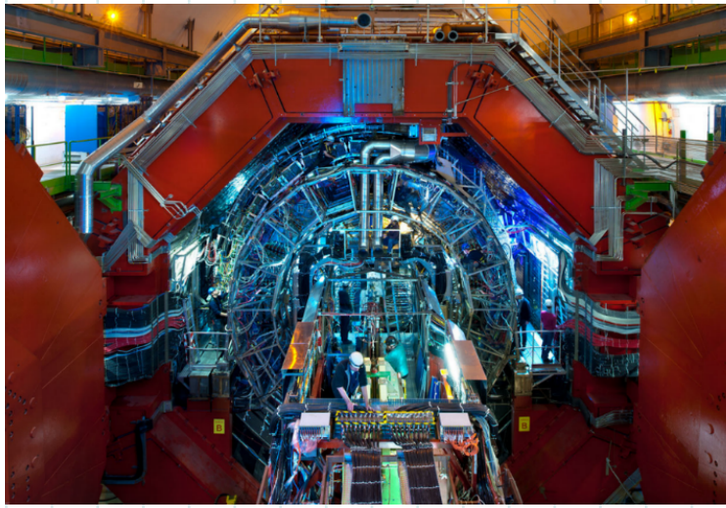
- **Prof. Ju Hwan Kang**
- **Nuclear Expt. (ALICE / PHENIX)**

- **Prof. Youngil Kwon**
- **Nuclear Expt. (ALICE / PHENIX)**



Quark-Gluon Plasma (QGP): State of matter at extremely high temperature, density after a few μs after big bang.

ALICE @ CERN/LHC
with 42 countries, 174 institutes,
1800 members



- **Prof. Ju Hwan Kang**
- **Nuclear Expt. (ALICE / PHENIX)**

PHYSICAL REVIEW LETTERS

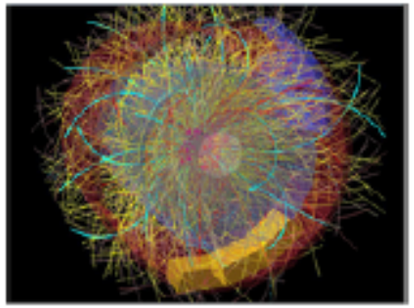
moving physics forward

APS physics

Letter from PRL for highlighted PRL paper prepared by Mr. M. Song as one of the main authors

Dear Sir or Madam,

We are pleased to inform you that the Letter



Correlated event-by-event fluctuations of flow harmonics in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV

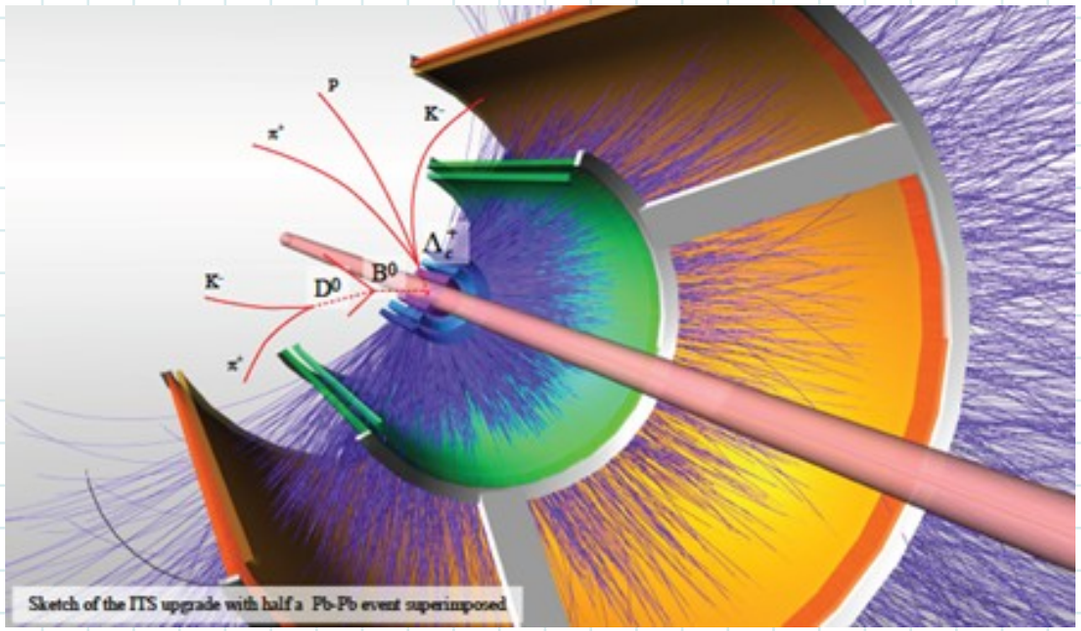
J. Adam *et al.* (ALICE Collaboration)
Phys. Rev. Lett. **117**, 182301 (2016)

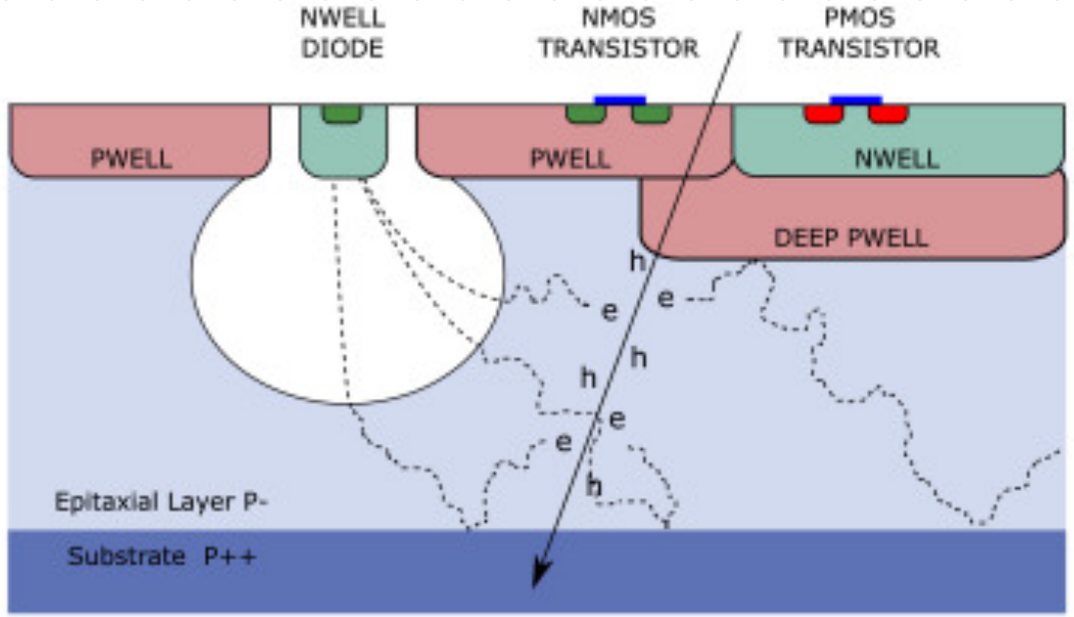
Published 28 October 2016

has been highlighted by the editors as an Editors' Suggestion. Publication of a Letter is already a considerable achievement, as *Physical Review Letters* accepts fewer than 1/4 of submissions, and is ranked first among physics and mathematics journals by the Google Scholar five-year h-index. A highlighted Letter has additional significance, because only about one Letter in six is highlighted as a Suggestion due to its particular importance, innovation, and broad appeal. Suggestions are downloaded twice as often as the average Letter, and are covered in the press substantially more often. If Suggestions were a separate publication, they would have an Impact Factor of 13. More information about our journal and its history can be found on our webpage prl.aps.org.

- **Prof. Youngil Kwon**
- **Nuclear Expt. (ALICE / PHENIX)**

Heavy flavor production & ITS upgrade





Inner Tracking System Upgrade:
Assembled ALPIDE barrel
ALPIDE:
Monolithic Active Pixel Sensors
based CMOS image sensor technology

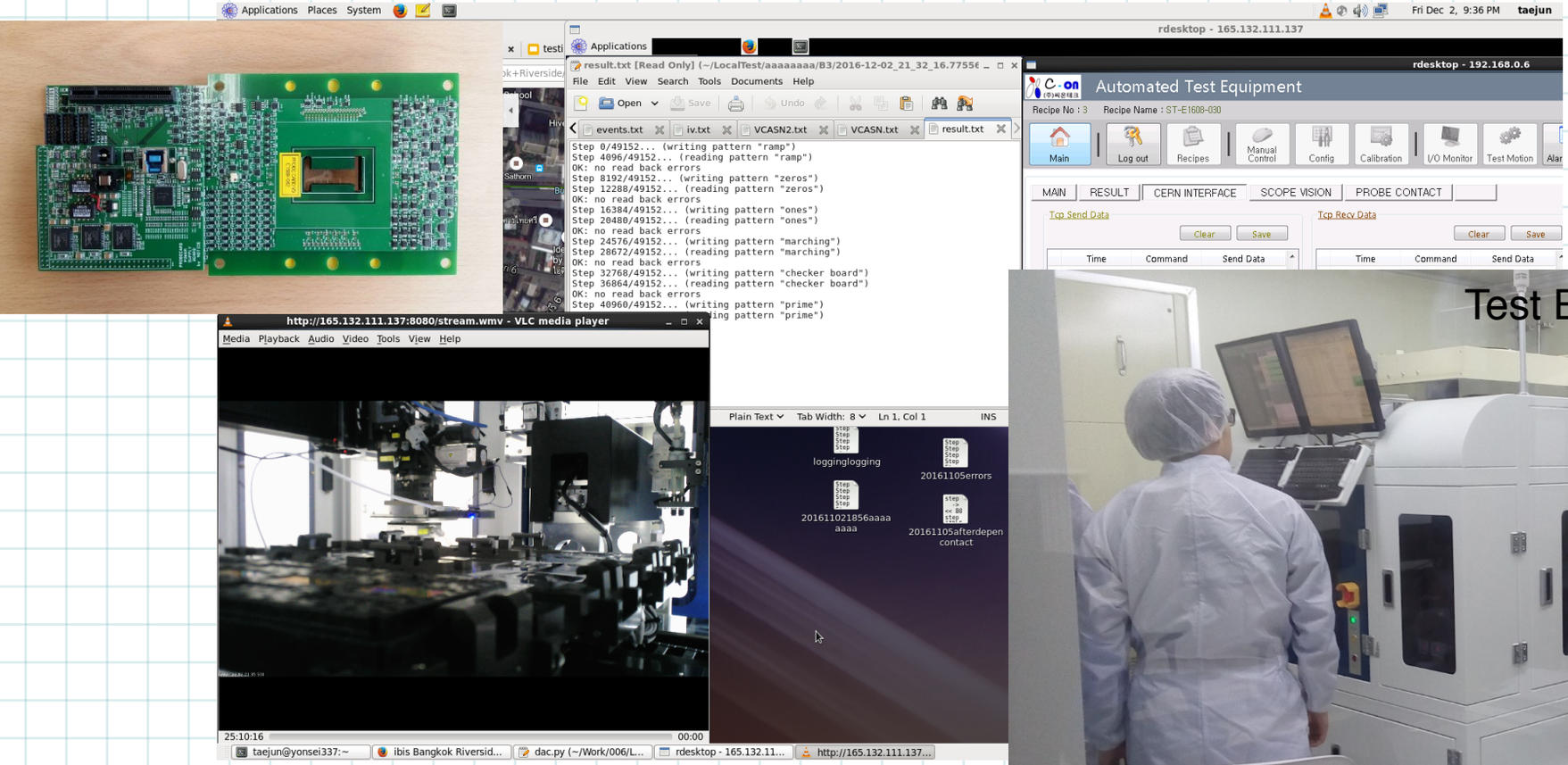
Charge collection:
Diffusion & Drift
50 μ or 100 μ thick Si, Area of 3 (cm) x 1.5 (cm)
0.5 M pixels of size 25μ x 25μ
In-pixel digitization, buffering, priority-encoder,
1.2 Gbps readout
Power consumption: < 100 mA/cm^2

- **Prof. Youngil Kwon**
- **Nuclear Expt. (ALICE / PHENIX)**

Heavy flavor production & ITS upgrade

Mass Production Test

Development of Probe-card & Automatic Test Equipment



Test Environment and Operation

- **Prof. Su Houng Lee**
- **Nuclear Theory (Hadrons)**

Research activities at a glance

	Members	Research Highlights
1990's	S. Cho, S. Kim (Phd)	Vector meson in medium
2000's	T. S. Song, Y.Park (Phd) Y.Oh, H.Kim, K. Morita, K. Ohnishi (Researcher)	Charmonium at finite temperatures
2010's	K. Kim, W. Park, K. Jeong (Phd) S. Ozaki, K. Hattori, Y. Kwon, S. Cho (Researcher)	Exotics and Heavy Ion collision

PHYSICAL REVIEW D **93,** 054035 (2016)

Mass of heavy-light mesons in a constituent quark picture with partially restored chiral symmetry

Aaron Park,[1,*] Philipp Gubler,[2,†] Masayasu Harada,[3,‡] Su Houng Lee,[1,§] Chiho Nonaka,[4,3,‖] and Woosung Park[1,¶]

[1]*Department of Physics and Institute of Physics and Applied Physics, Yonsei University, Seoul 120-749, Korea*

[2]*ECT*, Villa Tambosi, 38123 Villazzano (Trento), Italy*

[3]*Department of Physics, Nagoya University, Nagoya 464-8602, Japan*

[4]*Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University, Nagoya 464-8602, Japan*

(Received 13 January 2016; published 24 March 2016)

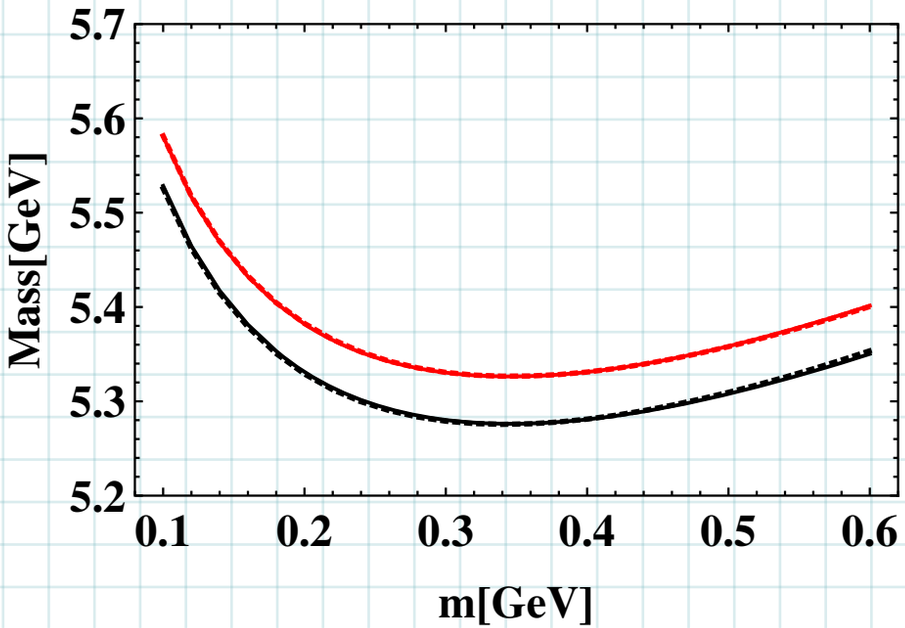


FIG. 3. m_q dependence of B meson (lower curves) and B^* meson (upper curves) masses in the constituent quark model. The dashed lines are the results with $\beta = 0$.

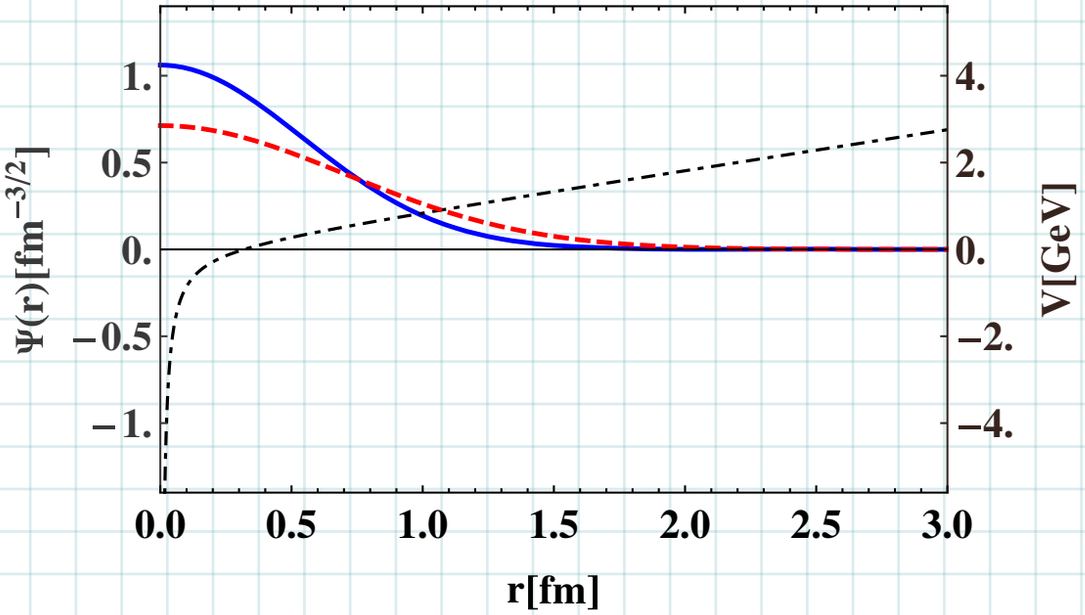


FIG. 4. r dependence of the D meson radial wave function with $m_q = 324$ MeV (blue solid line) and with $m_q = 160$ MeV (red dashed line). The black dot-dashed line represents the sum of the Coulomb and confining potential.

- **Prof. Choong Sun Kim**
- **Particle Theory (Flavor)**

Recent publications

1) Prompt atmospheric neutrino fluxes: perturbative QCD models and nuclear effects, JHEP 1611 (2016) 167
2) Rare decays of B mesons via on-shell sterile neutrinos, PRD 94 (2016) 053001
3) Distinguishing Dirac/Majorana Sterile Neutrinos at the LHC, PRD 94 (2016) 013005
4) Constraints on a Z′ boson within minimal flavor violation, PRD 93 (2016) 095009
5) A Model for Pseudo-Dirac Neutrinos: Leptogenesis and Ultra-High Energy Neutrinos, JHEP 1610 (2016) 092
6) Constraints on the U(1)L gauge boson in a wide mass range, IJMP A31 (2016) 1650059
7) Decay of $B^{\pm} \to \tau^{\pm} +$ "missing momentum" and direct measurement of mixing parameter $U_{\tau N}$, PRD 93 (2016) 013003
8) A facility to Search for Hidden Particles at the CERN SPS: the SHiP physics case, Rept. Prog. Phys. 79 (2016) 124201
9) Light Dark Matter and Dark Radiation, JKPS 68 (2016) 715-721

- Deciphering the Majorana nature of neutrino via 'effective' Dalitz plot method, arXiv: 1612.00607
- Model independent signatures of new physics in $B \to D \ell^+ \ell^-$ decays, arXiv:1610.04343
- Remarks on the Standard Model predictions for R(D) and R(D*), arXiv:1610.04190

- Prof. Choong Sun Kim
- Particle Theory (Flavor)

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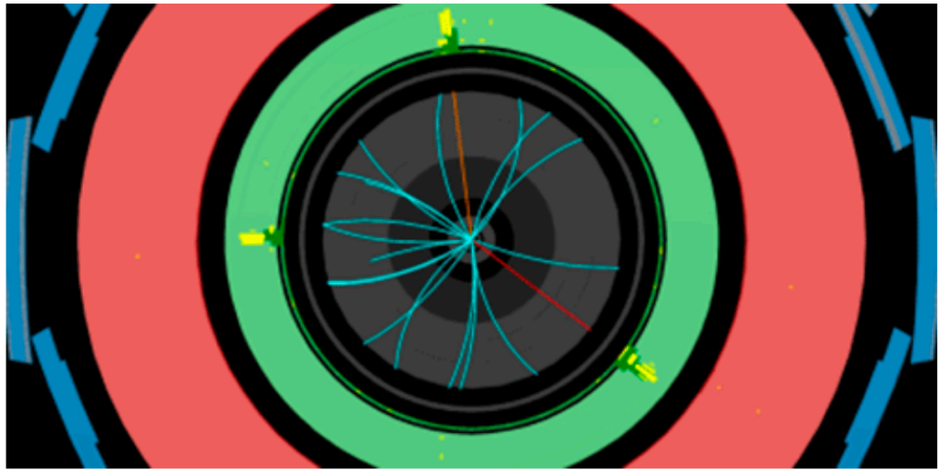
Synopsis: LHC Data Might Reveal Nature of Neutrinos

November 18, 2015

A long-standing question over whether the neutrino is its own antiparticle might be answered by looking at decays of *W* bosons.



CERN

Print

Discovering sterile neutrinos lighter than M_W at the LHC

Claudio O. Dib and C.S. Kim

Phys. Rev. D 92, 093009 (2015)

Published November 18, 2015

Features

Highlights of the Year

Physics looks back at its favorite stories from 2016.

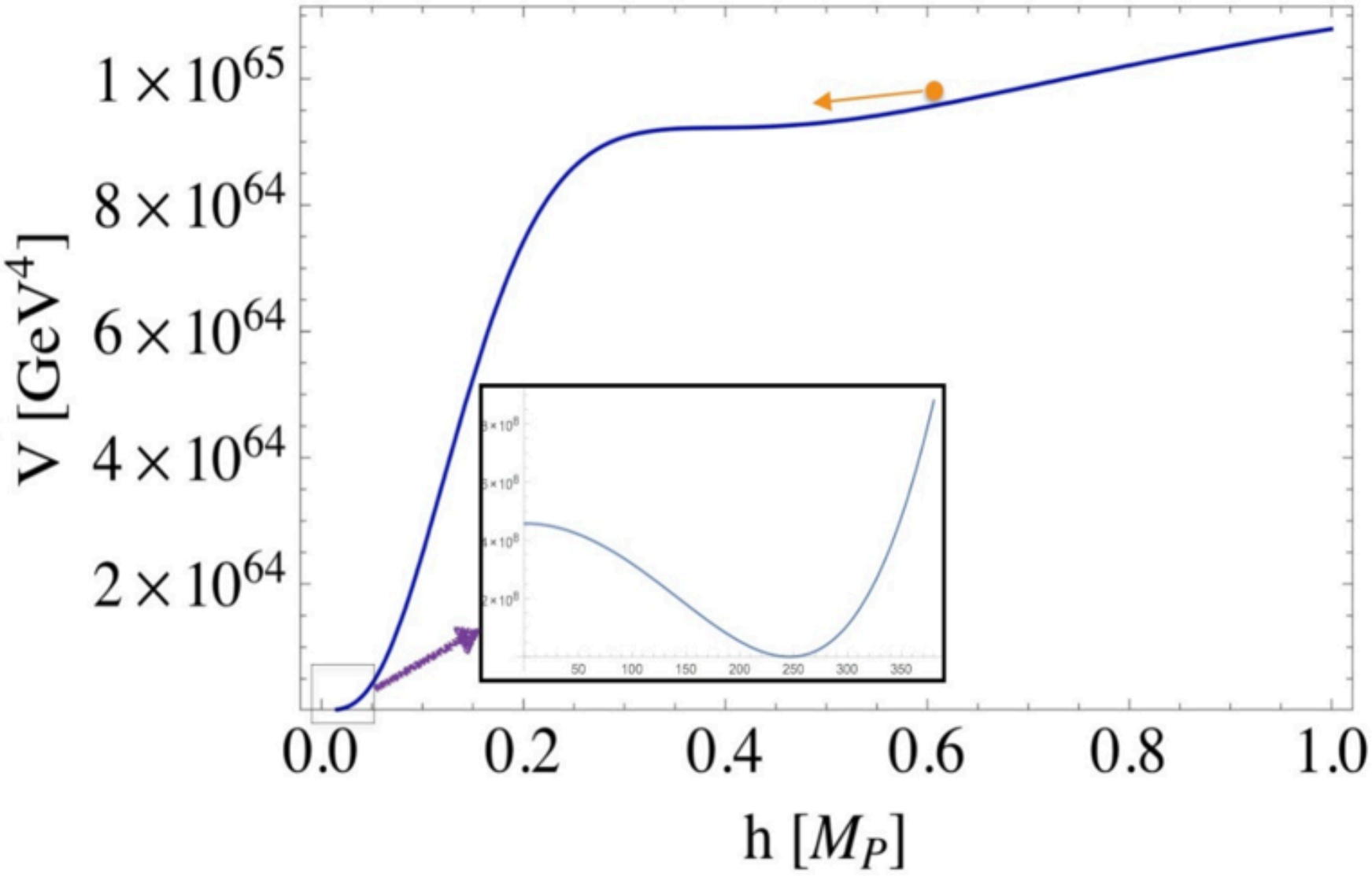
Arts & Culture: Hearing Earth's Creaks

An immersive planetarium show lets audiences experience the sights and sounds of earthquakes as if from deep inside Earth.

Arts & Culture: Science and Filmmaking in

- **Prof. Seongchan Park**
- **Particle Theory & Cosmology**

http://web.yonsei.ac.kr/yonseihepcosmo/



Yuta Hamada, Hikaru Kawai, Kin-ya Oda, and Seong Chan Park,
Phys. Rev. Lett. 112, 241301

- **Prof. Seongchan Park**
- **Particle Theory & Cosmology**

Recent publications

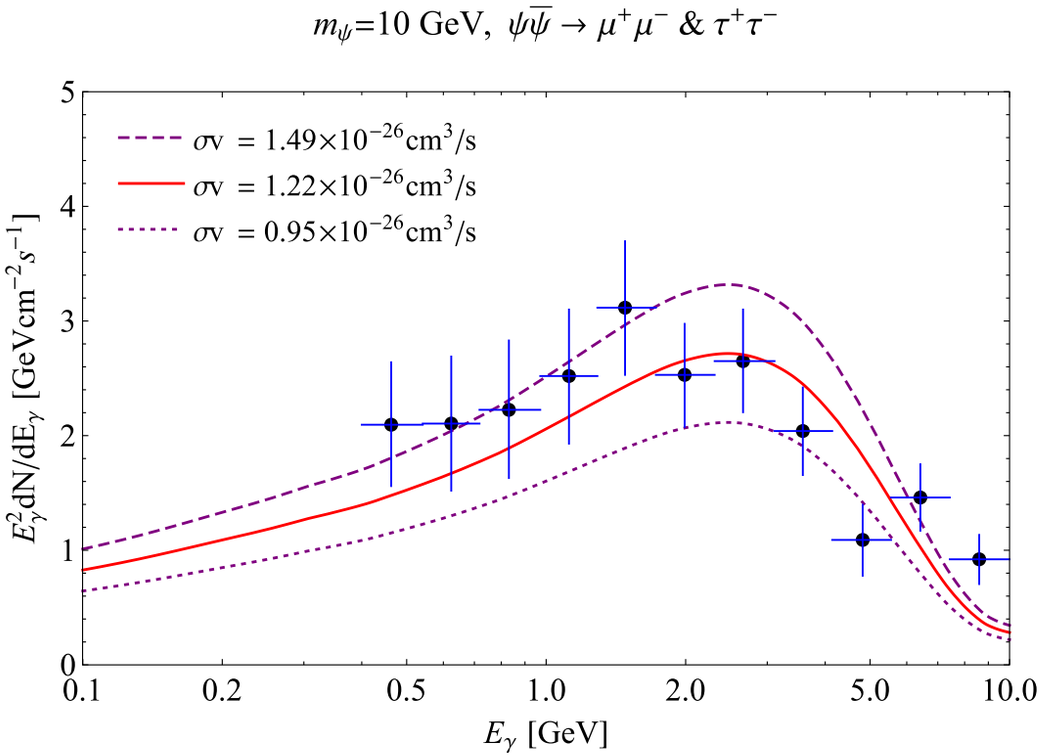
1) Investigating the jet activity accompanying the production at the LHC of a massive scalar particle decaying into photons, Phys.Lett. B761 (2016) 344-349.
2) LHC 750 GeV Diphoton excess in a radiative seesaw model, PTEP 2016 (2016) 123B04.
3) Indirect signature of dark matter with the diphoton resonance at 750 GeV, Phys. Dark Univ. 14 (2016) 4-10.
4) Galactic center GeV gamma-ray excess from dark matter with gauged lepton numbers, PL B752 (2016) 59-65.
5) Diboson Excesses Demystified in Effective Field Theory Approach, JHEP 1511 (2015) 150.
6) Model-Independent Production of a Top-Philic Resonance at the LHC, JHEP 1504 (2015) 029.
7) Higgs inflation from Standard Model criticality, PR D91 (2015) 053008.
8) Superheavy dark matter and IceCube neutrino signals: Bounds on decaying dark matter, PR D92 (2015) 023529.
9) A Review on Non-Minimal Universal Extra Dimensions. MPL, A30 (2015) 1530003.

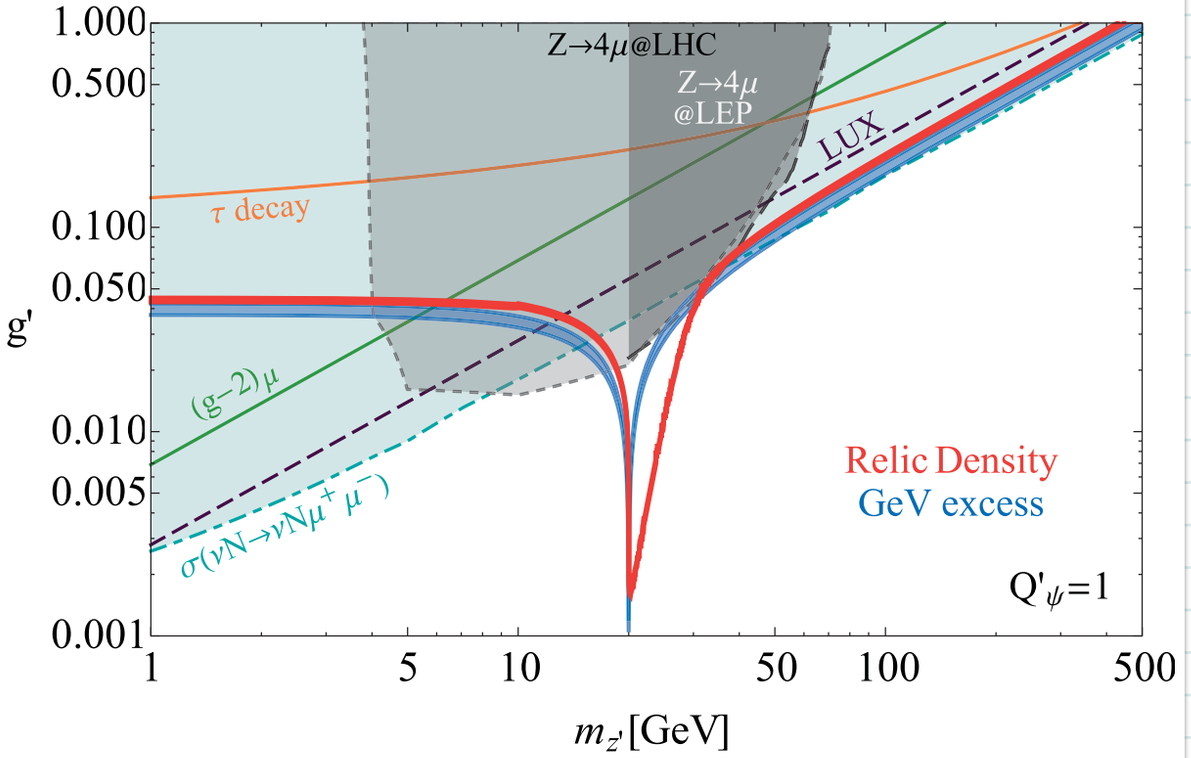
- **Prof. Seongchan Park**
- **Particle Theory & Cosmology**

Galactic center GeV gamma-ray excess, from dark matter with gauged lepton numbers

Jong-Chul Park [a,b], Jongkuk Kim [a], Seong Chan Park [c,d,*]

Physics Letters B 752 (2016) 59–65

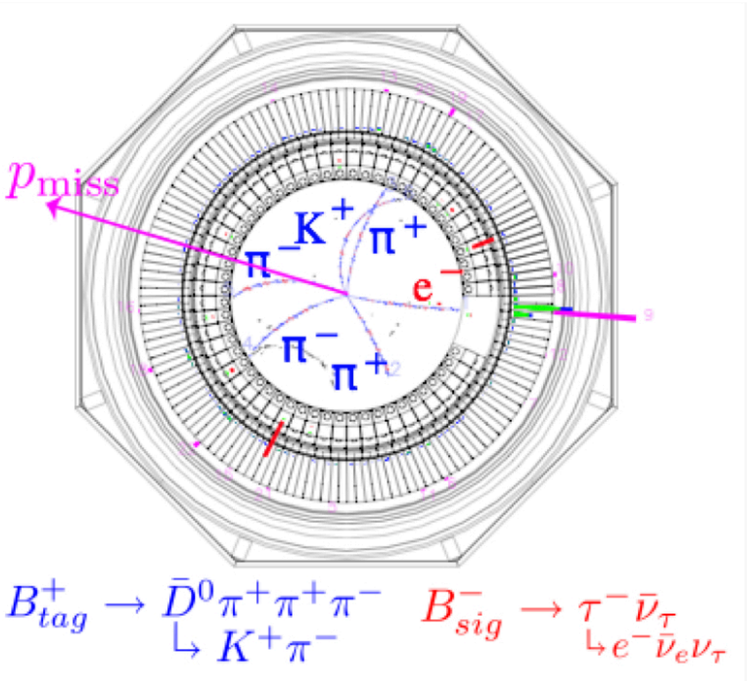


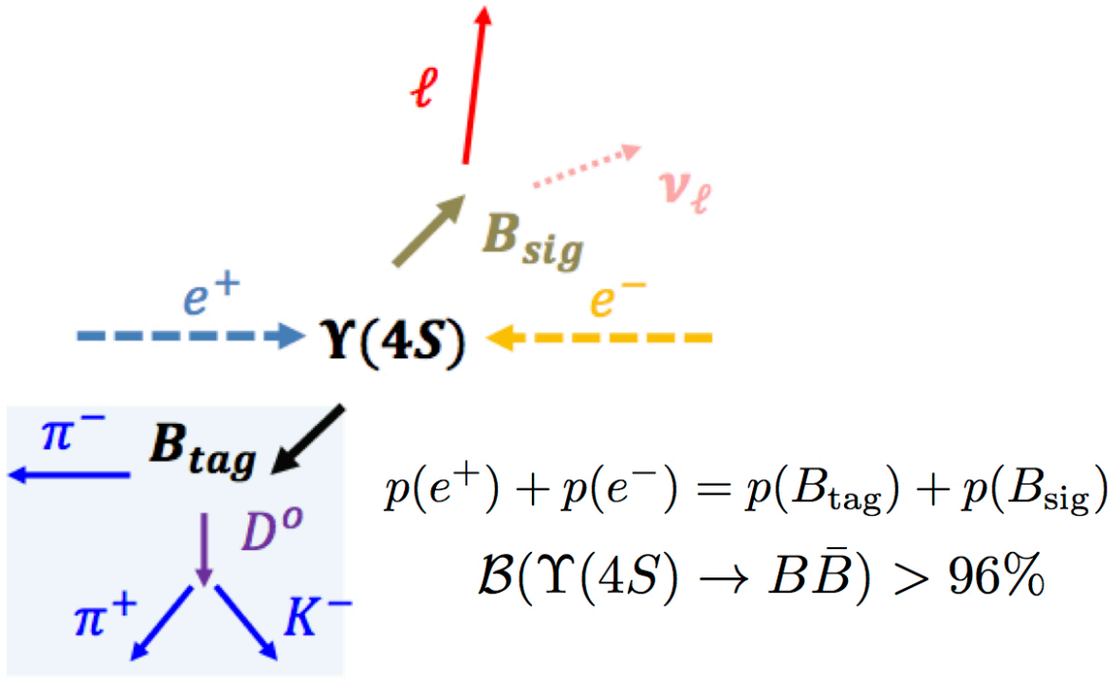


- Prof. Youngjoon Kwon
- Particle Expt. (Belle / Belle II)

BELLE Belle II

- Studying rare & exotic B meson decays, mainly via full-recon. tagging method

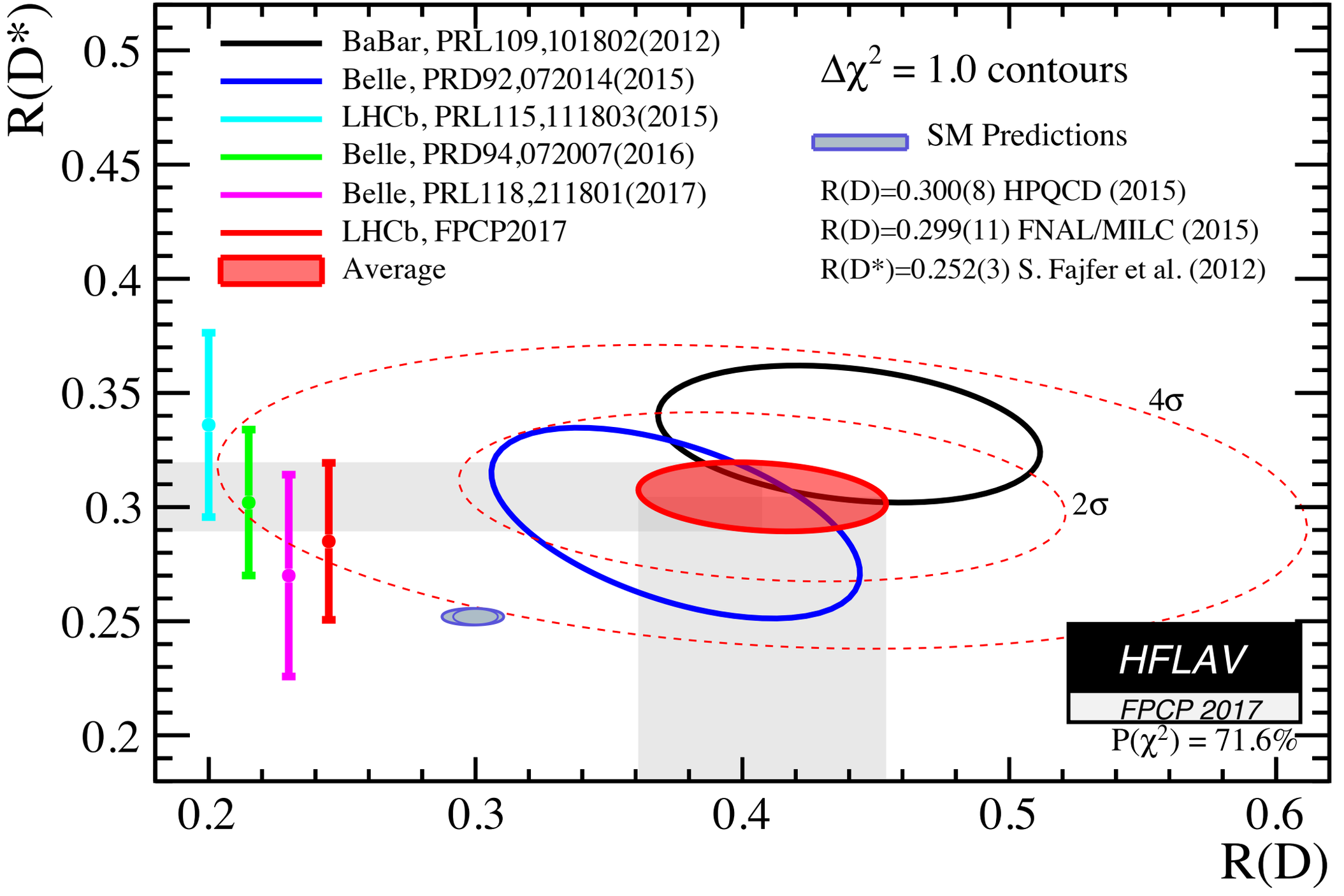




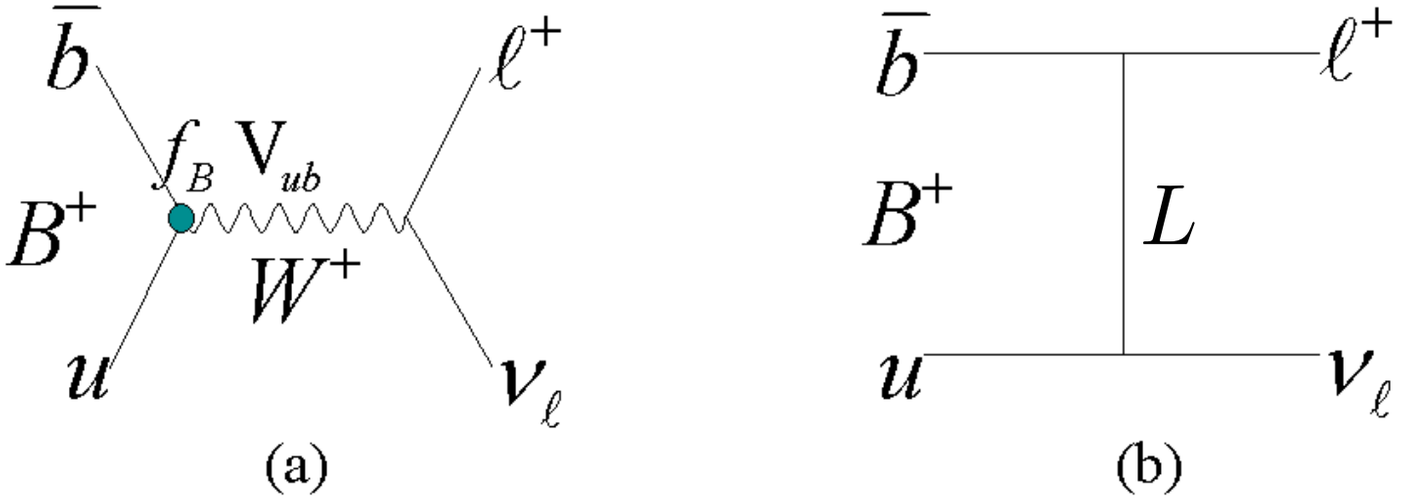
$$p(e^+) + p(e^-) = p(B_{\rm tag}) + p(B_{\rm sig})$$

$$\mathcal{B}(\Upsilon(4S) \to B\bar{B}) > 96\%$$

- DAQ R&D for Belle II


R(D*)
R(D)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.2
0.3
0.4
0.5
0.6
BaBar, PRL109,101802(2012)
Belle, PRD92,072014(2015)
LHCb, PRL115,111803(2015)
Belle, PRD94,072007(2016)
Belle, PRL118,211801(2017)
LHCb, FPCP2017
Average
Δχ² = 1.0 contours
SM Predictions
R(D)=0.300(8) HPQCD (2015)
R(D)=0.299(11) FNAL/MILC (2015)
R(D*)=0.252(3) S. Fajfer et al. (2012)
4σ
2σ
HFLAV
FPCP 2017
P(χ²) = 71.6%

For a clean test of ℓ-universality



$$\Gamma(B^+ \to \ell^+\nu) = \frac{G_F^2 m_B m_\ell^2}{8\pi}\left(1 - \frac{m_\ell^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2$$

$$\frac{\Gamma(B^+ \to \ell^+\nu)}{\Gamma(B^+ \to \tau^+\nu)} = f(m_\ell^2, m_\tau^2)$$ *and all other parameters cancel!*

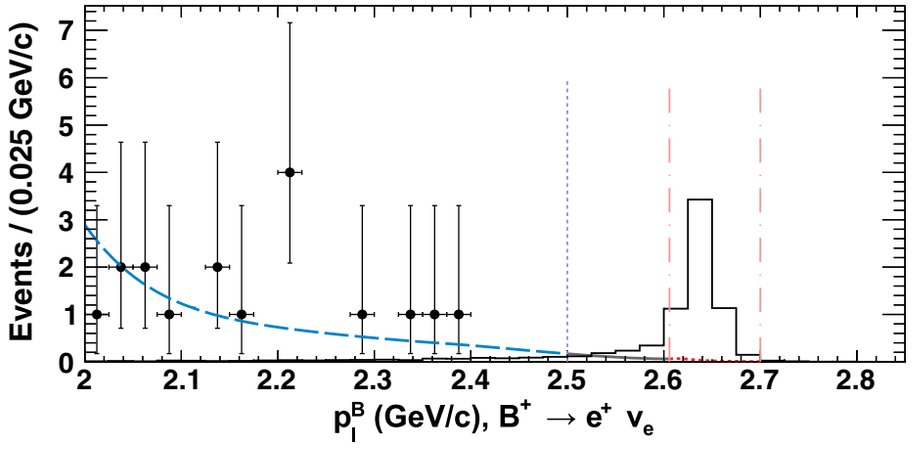
- **Prof. Youngjoon Kwon**
- **Particle Expt. (Belle / Belle II)**

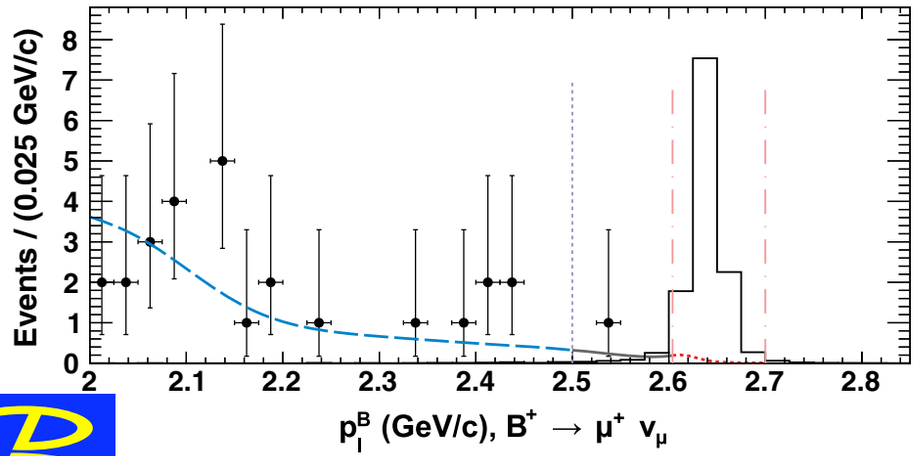
$B^+ \to \ell^+ \nu_\ell$

PHYSICAL REVIEW D **91,** 052016 (2015)

Search for $B^+ \to e^+\nu_e$ and $B^+ \to \mu^+\nu_\mu$ decays using hadronic tagging

Y. Yook,[70] Y.-J. Kwon,[70] A. Abdesselam,[58] I. Adachi,[12] S. Al Said,[58,27] K. Arinstein,[4] D. M. Asner,[49] V. Aulchenko,[4]
T. Aushev,[22] R. Ayad,[58] S. Bahinipati,[15] A. M. Bakich,[57] A. Bala,[50] V. Bansal,[49] V. Bhardwaj,[41] B. Bhuyan,[16] A. Bondar,[4]





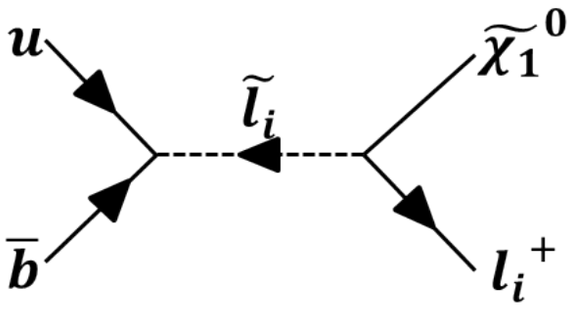
Mode	ϵ_s [%]	N_{obs}	N_{exp}^{bkg}
$B^+ \to e^+\nu_e$	0.086 ± 0.007	0	0.10 ± 0.04
$B^+ \to \mu^+\nu_\mu$	0.102 ± 0.008	0	$0.26^{+0.09}_{-0.08}$

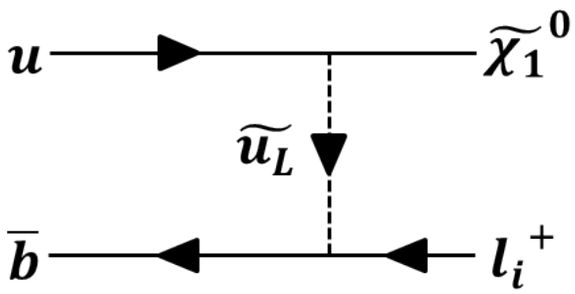
collected by the Belle experiment. We find no evidence of $B^+ \to e^+\nu_e$ and $B^+ \to \mu^+\nu_\mu$ processes. We set the upper limits of the branching fraction at $\mathcal{B}(B^+ \to e^+\nu_e) < 3.5 \times 10^{-6}$ and $\mathcal{B}(B^+ \to \mu^+\nu_\mu) < 2.7 \times 10^{-6}$ at 90% C.L., which are by far the most stringent limits obtained with the hadronic tagging method. Given the low background level demonstrated in this search, we expect more stringent constraints on the new physics models to be set by Belle II [27], the next generation B factory experiment.

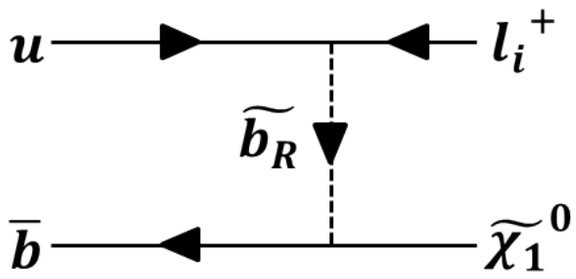
BELLE

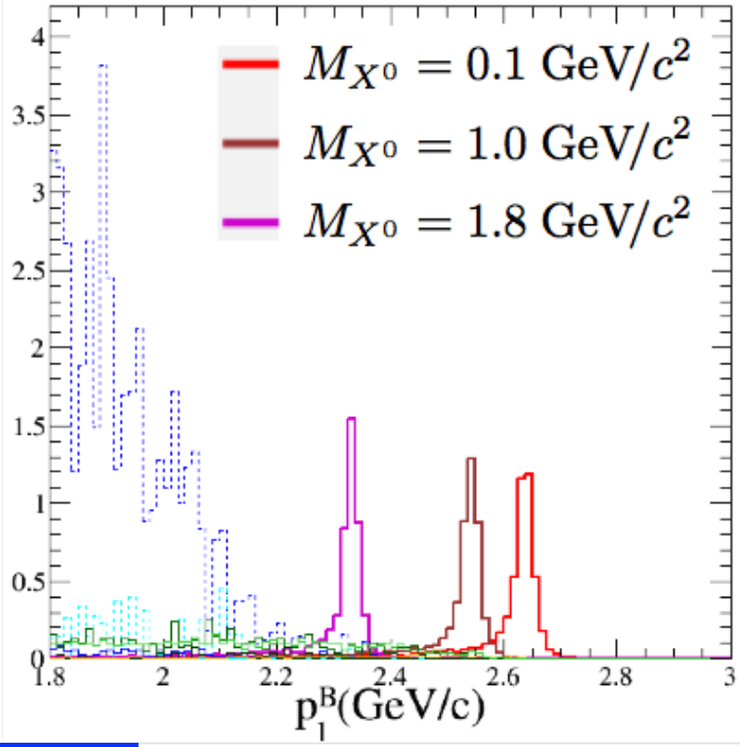
- Prof. Youngjoon Kwon
- Particle Expt. (Belle / Belle II)

$B^+ \to \ell^+ X^0$









- Search for massive neutral invisible fermion "X^0"

  It can be a heavy neutrino, or an LSP in RPV models, or whatever
- Experimentally, very similar signature to $B^+ \to \ell^+ \nu_\ell$
- But, p_ℓ^B gives a handle on M_X

BELLE

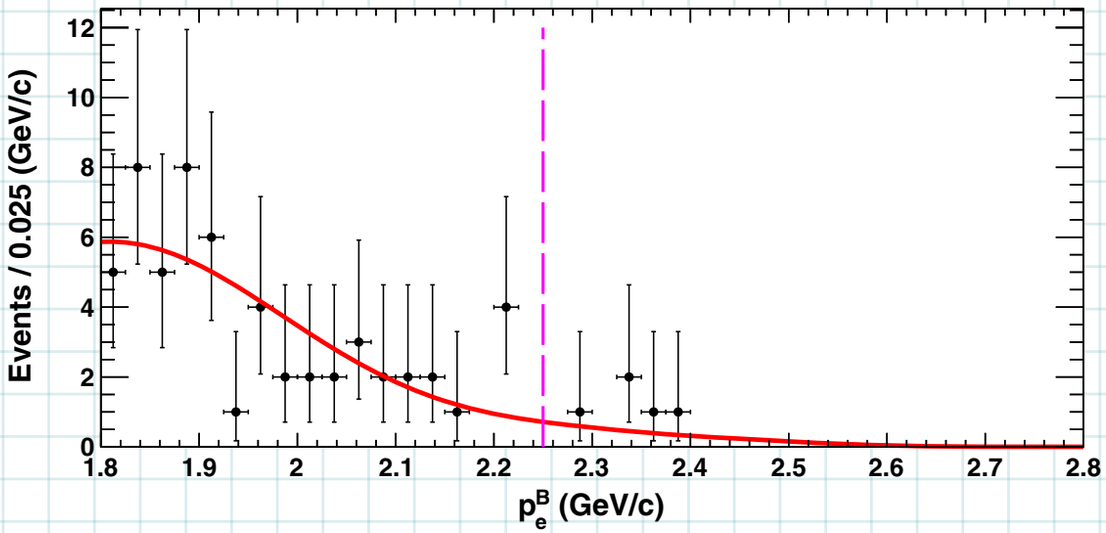
- **Prof. Youngjoon Kwon**
- **Particle Expt. (Belle / Belle II)**

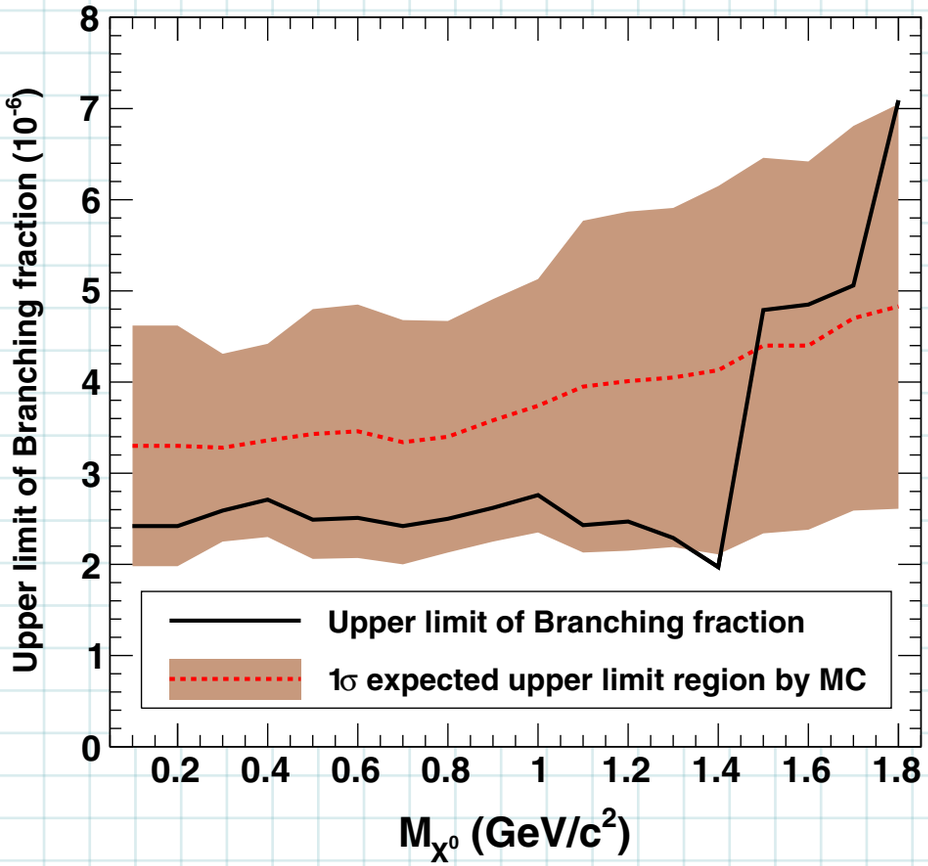
$$B^+ \to \ell^+ X^0$$

PHYSICAL REVIEW D **94,** 012003 (2016)

Search for a massive invisible particle X^0 in $B^+ \to e^+ X^0$ and $B^+ \to \mu^+ X^0$ decays

C.-S. Park,[69] Y.-J. Kwon,[69] I. Adachi,[12,9] H. Aihara,[61] D. M. Asner,[47] T. Aushev,[35] V. Babu,[55] I. Badhrees,[54,24] A. M. Bakich,[53] E. Barberio,[33] P. Behera,[16] V. Bhardwaj,[51] J. Biswal,[21] G. Bonvicini,[67] A. Bozek,[42] M. Bračko,[31,21] T. E. Browder,[11] D. Červenkov,[5] V. Chekelian,[32] A. Chen,[39] B. G. Cheon,[10] K. Chilikin,[34] R. Chistov,[34] K. Cho,[25]



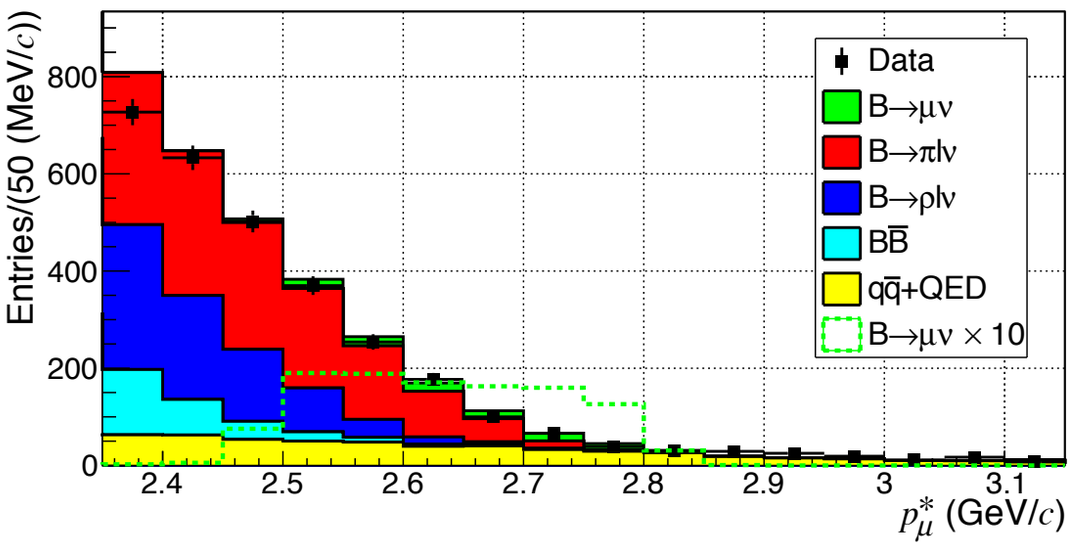


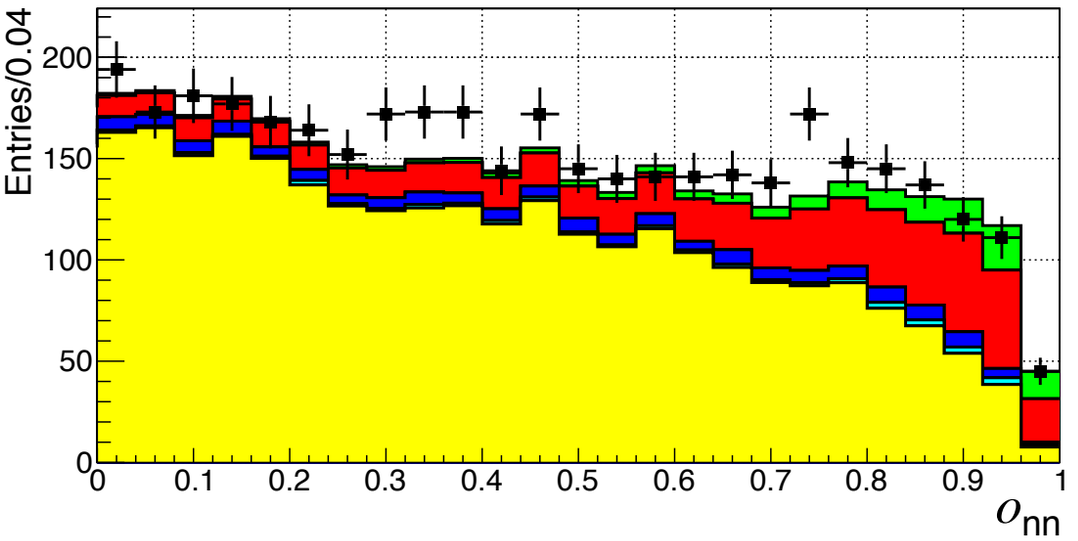
new *untagged* $B^+ \to \mu^+\nu$ from Belle

- all particles except for the μ^+ are to come from the other B, but its decay chain is not explicitly reconstructed (hence, *untagged*)
  - require $-3 < \Delta E < +2$ and $5.1 < M_{bc}$
- In the B rest frame, $p_\mu = 2.64$ GeV (*sharp!*), but
  - in the CM frame, $2.45 < p^*_\mu < 2.85$ GeV
- Use p^*_μ and neural net (NN) for signal extraction (2D fit)

BELLE

new *untagged* $B^+ \to \mu^+\nu$ from Belle





- $B \to \pi\ell\nu$, $\rho\ell\nu$, studied in detail by FF variation
- measure $R \equiv N_{B\to\mu\nu}/N_{B\to\pi\ell\nu}$ for (partial) cancellation of syst. error
- most significant (2.4σ), and consistent with SM

$$\mathcal{B}(B^+ \to \mu^+\nu) = (6.46 \pm 2.22 \pm 1.60) \times 10^{-7}$$
$$\in [2.9, 10.7] \times 10^{-7} \text{ @ 90\% C.L.}$$

BELLE

$B^+ \to \ell^+ \nu\gamma$

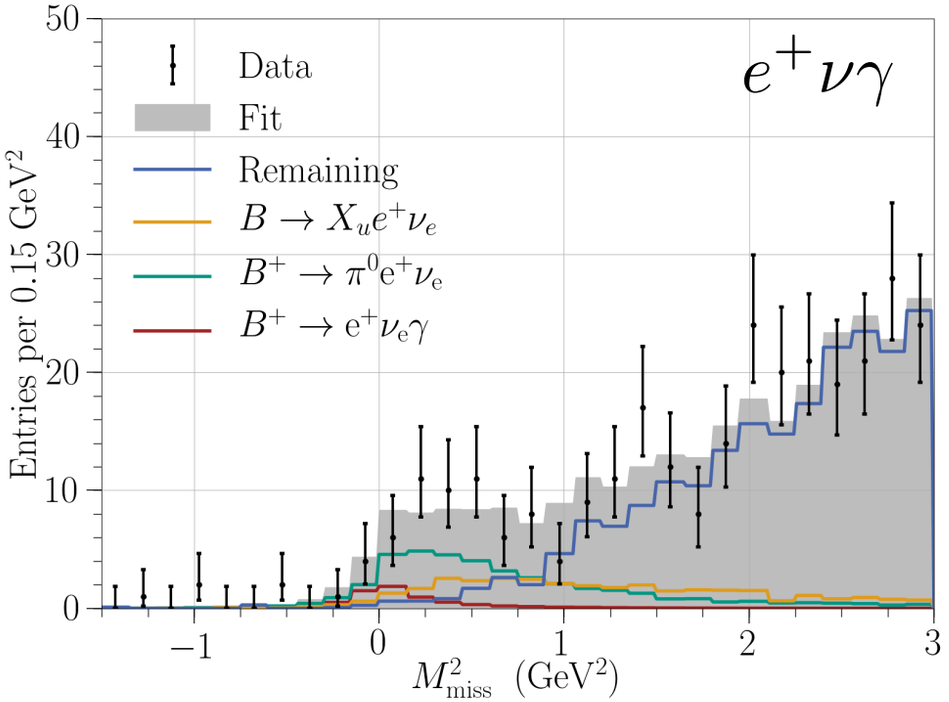
- Helicity suppression (of $B^+ \to \ell^+\nu$) is avoided by γ.

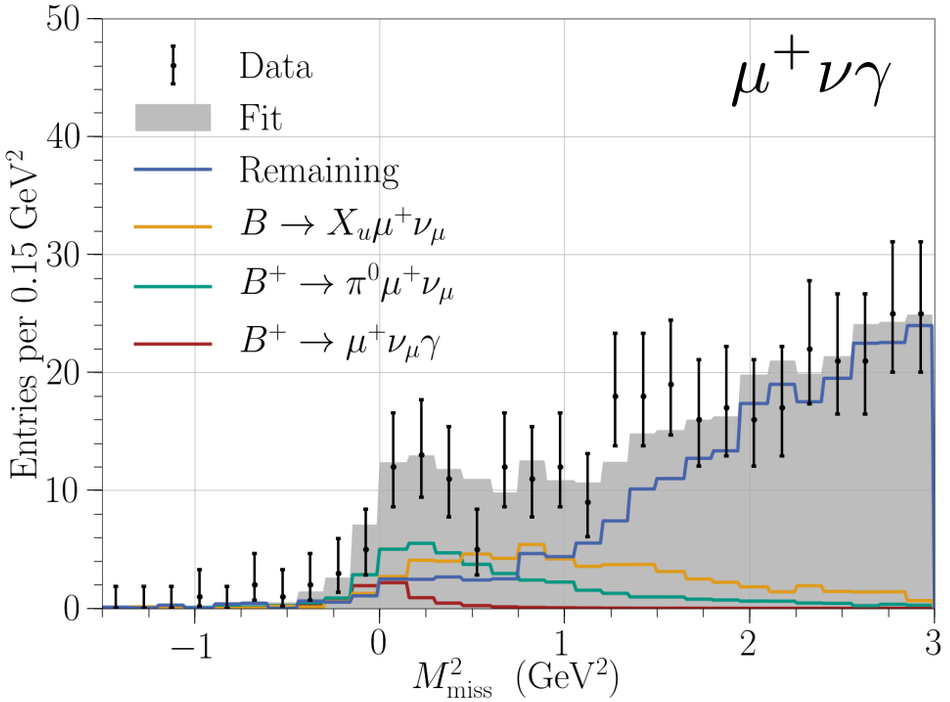
$$\frac{d\Gamma(B^+ \to \ell^+\nu\gamma)}{dE_\gamma} = \frac{\alpha_{\rm em} G_{\rm F}^2 |V_{ub}|^2}{6\pi^2} m_B E_\gamma^3 \left(1 - \frac{2E_\gamma}{m_B}\right) \left(\left|F_{\rm V}\right|^2 + \left|F_{\rm A} + \frac{e_\ell f_B}{E_\gamma}\right|^2 \right)$$

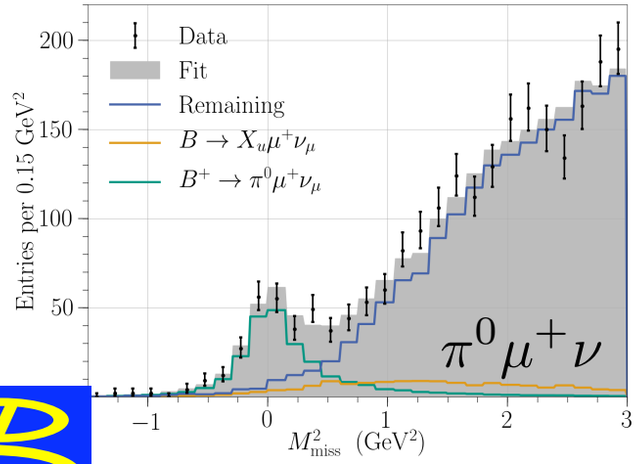
$$F_{\rm V}(E_\gamma),\ F_{\rm V}(E_\gamma) \sim \frac{e_u f_B m_B}{2E_\gamma \lambda_B} + \cdots$$

- λ_B is needed for QCDF to calculate, e.g., charmless hadronic B decays
- SM expectation: $\mathcal{B}(B^+ \to \ell^+\nu\gamma) \sim \mathcal{O}(10^{-6})$
  - Calculation is reliable only for $E_\gamma > 1$ GeV
- Previous Belle (2015): $\Delta\mathcal{B}(B^+ \to \ell^+\nu\gamma) < 3.5 \times 10^{-6}$
- Updated results from Belle (2018) with 'FEI' algorithm
  - a new B-tagging algorithm developed for Belle II

$B^+ \to \ell^+ \nu\gamma$ Belle (2018) results



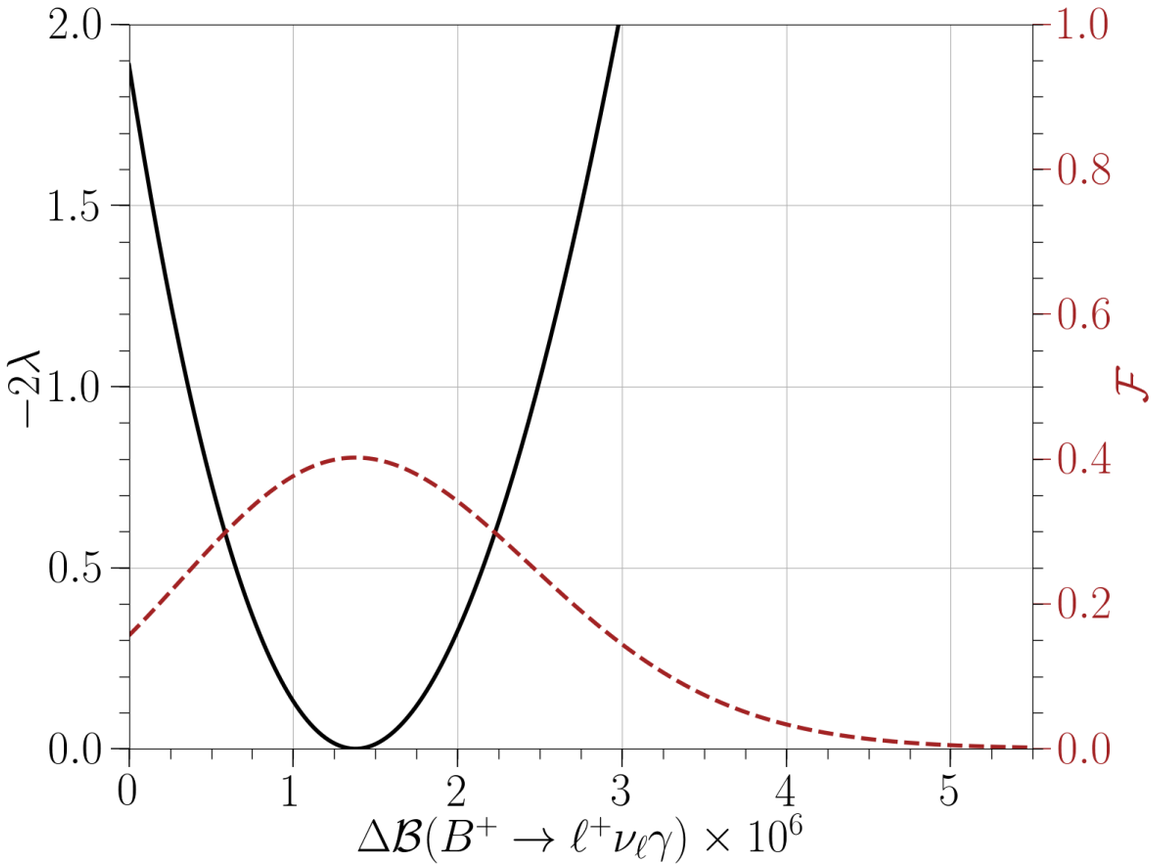




ℓ	$\mathcal{B}(B^+ \to \pi^0 \ell^+ \nu_\ell)$ (10^{-5})	σ	$\Delta\mathcal{B}(B^+ \to \ell^+ \nu_\ell \gamma)$ (10^{-6})	σ
e	$8.3^{+0.9}_{-0.8} \pm 0.9$	8.0	$1.7^{+1.6}_{-1.4} \pm 0.7$	1.1
μ	$7.5^{+0.8}_{-0.8} \pm 0.6$	9.6	$1.0^{+1.4}_{-1.0} \pm 0.4$	0.8
e, μ	$7.9^{+0.6}_{-0.6} \pm 0.6$	12.6	$1.4^{+1.0}_{-1.0} \pm 0.4$	1.4

BELLE

$B^+ \to \ell^+ \nu\gamma$ Belle (2018) upper limits



Bayesian limit

$$0.9 = \frac{\int_0^{\mathrm{UL}} \mathcal{F}(\Delta\mathcal{B}) d\Delta\mathcal{B}}{\int_0^{\infty} \mathcal{F}(\Delta\mathcal{B}) d\Delta\mathcal{B}}$$

ℓ	BaBar	Belle (2015)	Belle (2018)
e	-	< 6.1	< 4.3
μ	-	< 3.4	< 3.4
e, μ	< 14	< 3.5	< 3.0

BELLE

$B^+ \to \ell^+ \nu\gamma$ Belle (2018) for λ_B

$$R_\pi^{\rm meas} = (1.7 \pm 1.4) \times 10^{-2}$$

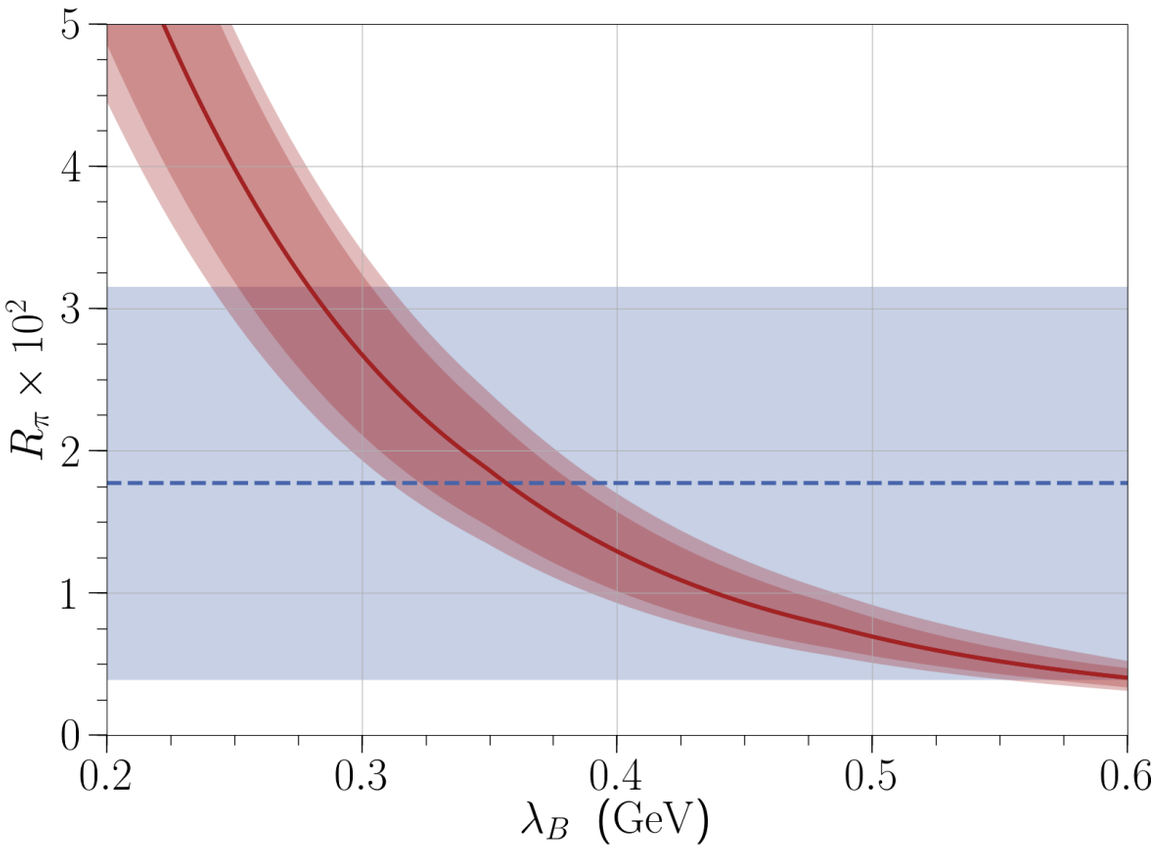
$$R_\pi = \frac{\Delta\Gamma(\lambda_B)}{\Gamma(B^+ \to \pi^0 \ell^+ \nu)}$$

Use theory to determine interval for λ_B

- Beneke, Braun, Ji, Wei, JHEP 1807, 154 (2018)
- HFLAV, EPJC 77, 895 (2017)

Two one-sided limits

$\lambda_B > 0.24$ GeV and $\lambda_B < 0.68$ GeV



Belle Publication Status

Year	PRL	PRD	PRD RC	PLB	Other	Total
2001-02	23	4	4	12	—	**43**
2003	14	4	4	2	—	**24**
2004	18	6	4	3	1	**32**
2005	21	5	8	10	—	**44**
2006	18	6	7	5	—	**36**
2007	19	11	9	5	2	**46**
2008	15	8	13	9	1 (Nature)	**46**
2009	4	6	10	4	—	**24**
2010	8	8	11	3	—	**30**
2011	7	3	7	2	—	**19**
2012	10	6	9	—	—	**25**
2013	6	8	11	2	3 (JHEP/PTEP)	**30**
2014	5	9	4	—	3 (“/“/EPJC)	**21**
2015	5	12	5	—	1 (JHEP)	**23**
2016	4	15	3	1	1 (PTEP)	**24**
2017	5	12	0	0	0	**17**
2018	5	15	4	0	4 (EPJC/PTEP)	**28**
All	**182**	**123**	**109**	**58**	**12**	**512**

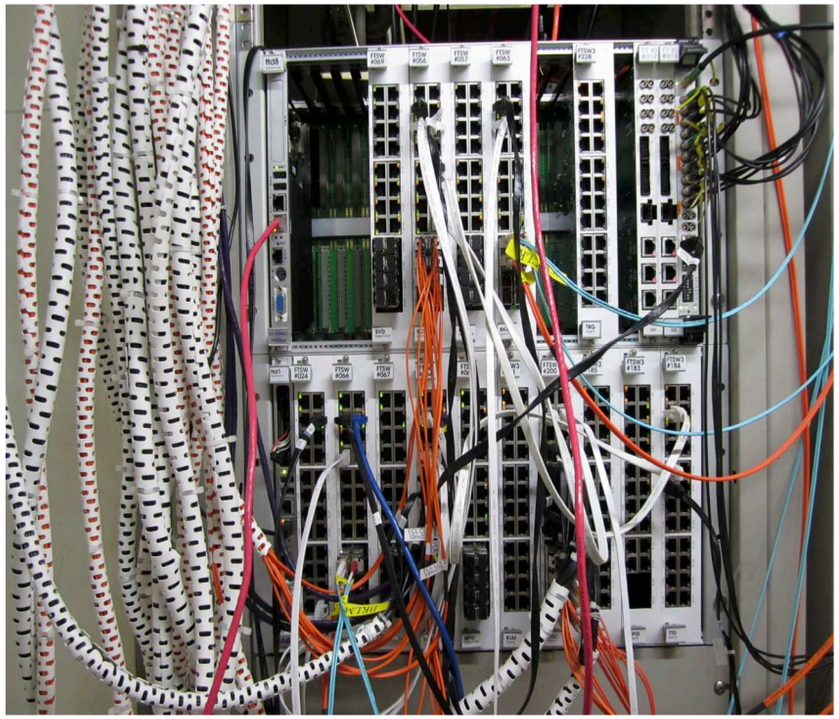
+4 published in 2019 +5 accepted +1 submitted

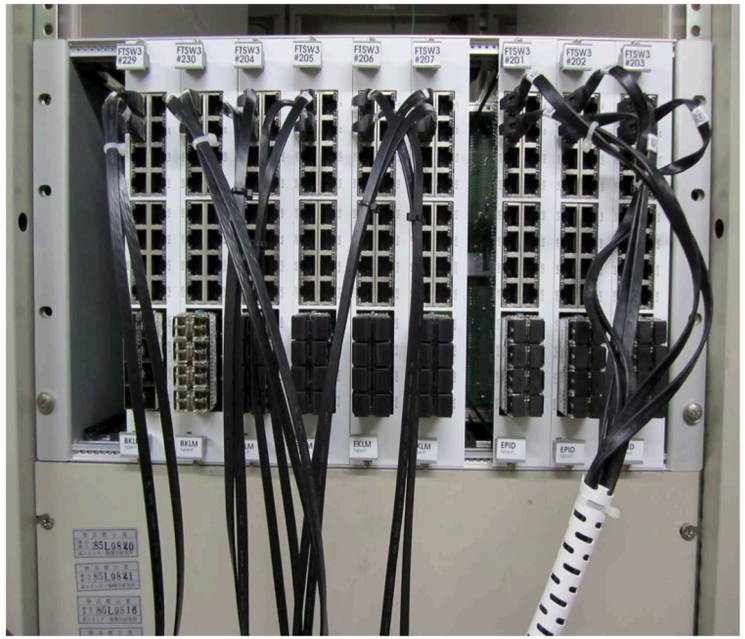
BELLE

- **Prof. Youngjoon Kwon**
- **Particle Expt. (Belle / Belle II)**

R&D for Belle II DAQ

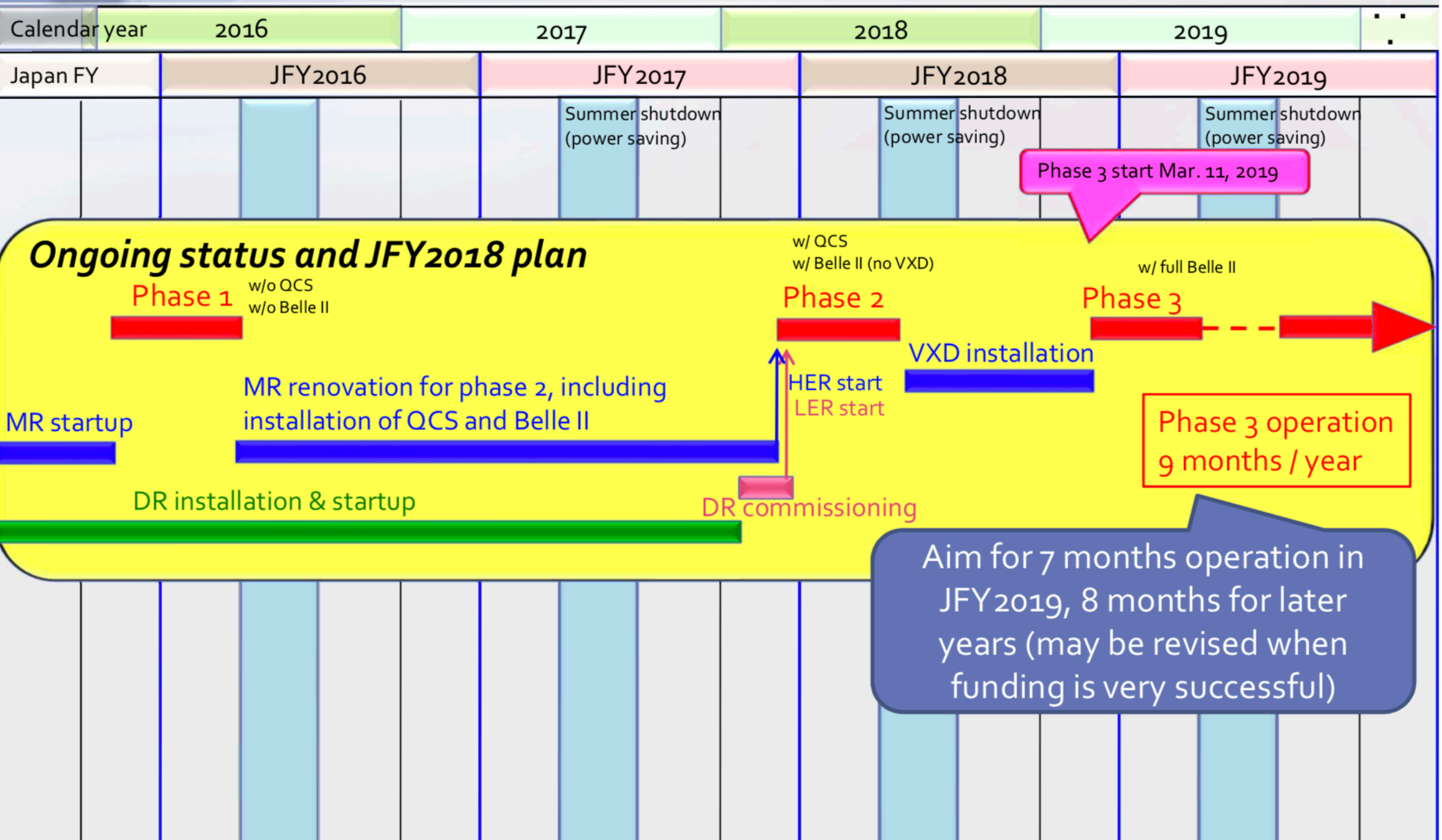
- DAQ firmware test and improvement
  - e.g. fixing bug in high-f transmission
- FTSW board test and installation (picture below)
- jtagft S/W development for FTSW firmware remote control





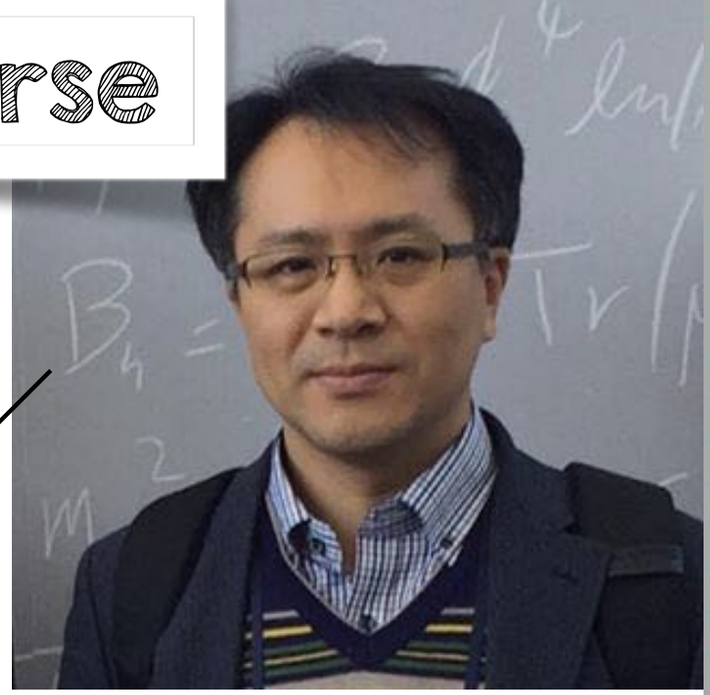
Global Schedule

as of Oct. 2018



Lab. for Dark Universe

3 papers
(평균인용수 37)



5 papers
(평균인용수 10.6)

2 papers
(평균인용수 228)

9 papers
(평균인용수 40.6)

Now, the Workshop is launched.

Enjoy the workshop, the physics, the campus, and the town!