2020 Physics Week Talk

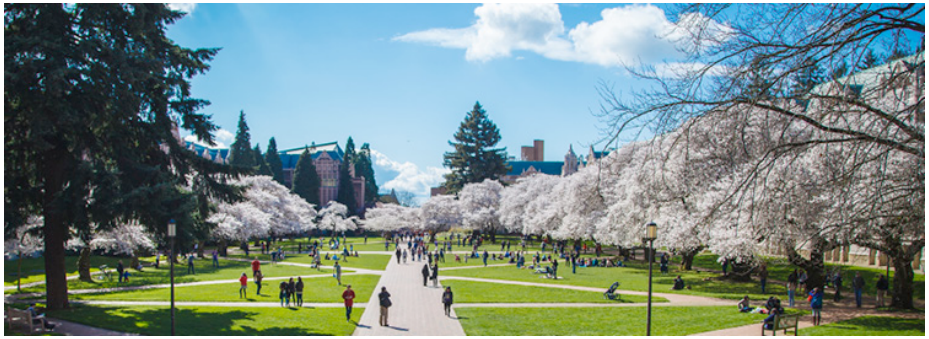
Belle II/SuperKEKB Snowmass White Papers

Tom Browder, University of Hawai'i

Goal: Bring the Belle II/ SuperKEKB program to the attention of the HEP community and make sure that is recognized as one of the highest priority efforts in the search for new physics.

Jargon check: "One Snowmass Year" = 10^7 seconds, typical operation time of an accelerator facility.

Snowmass Village, Colorado



University of Washington, Seattle

https://indico.fnal.gov/event/22303/

Preparing for Snowmass 2021 (International Physics Rodeo)

Scenes from the actual Snowmass Rodeo in Colorado

N.B. Snowmass 2021 to be held in Seattle, Washington in summer of 2021 and the last one was held in Minneapolis, Minnesota in 2013. It is unlikely that there will ever be another month-long planning meeting in Snowmass, CO.

Historical note: Young(ish) Scientist Pier Oddone (originally from Peru/Italy) introduced the concept and first proposal for an asymmetric energy B-factory to the *broad HEP community* at *a* Snowmass in 1988.

Details about Snowmass 2021 can be found on the official page: https://snowmass21.org/

The European Strategy Group (ESG) process has completed. The next major decadal strategy effort is the US Snowmass process, which will be followed by P5 panel recommendations, which in turn will guide funding and resource decisions.

The first milestone for the Snowmass process was the submission of short 2-page LOI's (Belle II already submitted 9 LOIs). Longer "White-Paper" documents are due before the end of summer next year (2021). These White-Papers may update or go beyond the content of the Belle II Physics Book https://arxiv.org/abs/1808.10567 and/or may also discuss technical aspects of SuperKEKB accelerator and Belle II detector upgrades.

Detailed scientific discussions will take place during the next year and a large close-out meeting is planned in Seattle, WA in July 2021. Participation of all international Belle II colleagues and especially junior colleagues is needed in this high energy physics community planning process. Contributions from theoretical colleagues are also welcomed.

Update on the Snowmass process

- 9 Belle II/SuperKEKB LOIs were submitted by the Aug 31st deadline. These 2-page LOIs are now linked from the Belle II home page

https://confluence.desy.de/display/BI/Snowmass+2021

- Phase II: "Let a thousand flowers bloom", collaborate, make plans, find innovations and synergies, write White Papers and post to the Arxiv
- Phase III: Summer 2021 in Seattle, WA: Snowmass closeout workshop

This will be followed by the P5 Panel will decide on priorities in the field of high energy physics. Their recommendations guide long term decisions of the US DOE on funding and resource allocations.

Some general procedures about Snowmass White Papers (a.k.a "Contributed Papers")

White Papers should be posted on the ArXiv
and to https://snowmass21.org/submissions/start before July 31, 2021.

The White Papers should refer to the appropriate Belle II LOI(s) (if it exists) and frontier, the Belle II/SuperKEKB facility, and where appropriate, to the Belle II Physics Book. The White Papers may have short author lists and include theorists (strongly encouraged) and members of other experiments or technical experts.

Physics White Papers should be refereed inside Belle II (we suggest that two reviewers be picked by the relevant physics convener. US Belle II members will help out here and will supply many reviewers.)

More comments:

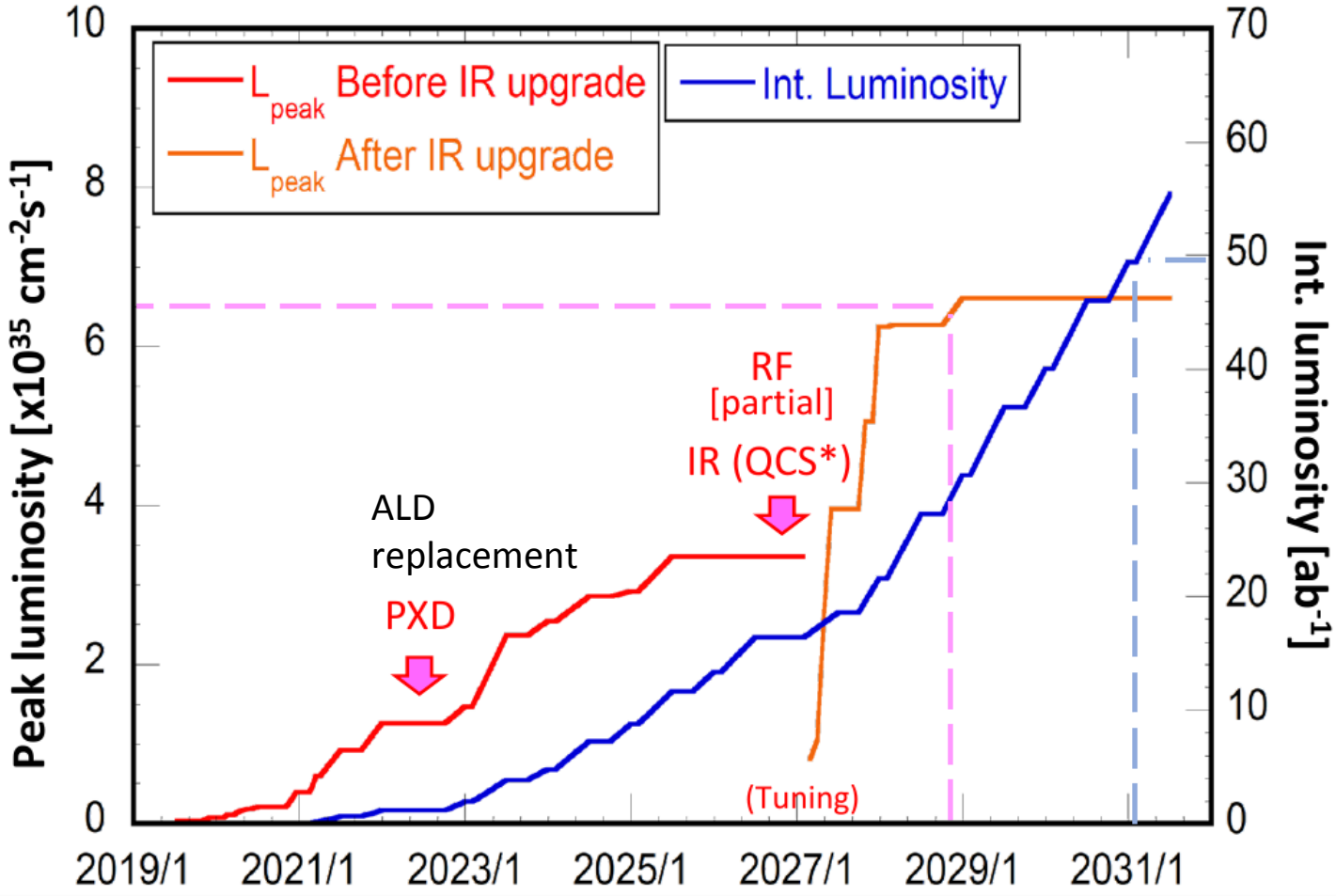
1) Many studies in the Belle II Physics Book did not have a state-of-the-art MC or reconstruction or beam background. These could be out of date or not realistic. Doing MC studies may be required for physics papers on the large Belle II dataset taken before the PXD shutdown (*so you may be doing the work for Snowmass Papers at the same time*).

A. Gaz: Need to use a consistent model of detector performance: (2 PXD layers, use software release-05, BKG campaign 19c overlaid)

B. Propose two luminosity benchmarks: 10 ab^{-1}, 50 ab^{-1}

C. Should request large MC samples (signal and generic) from the data production group soon.

Updated plan for SuperKEKB and Belle II



Four steps: *Intermediate luminosity* (1-2 x 10^{35} /cm^2/sec, 5-10 ab^{-1});

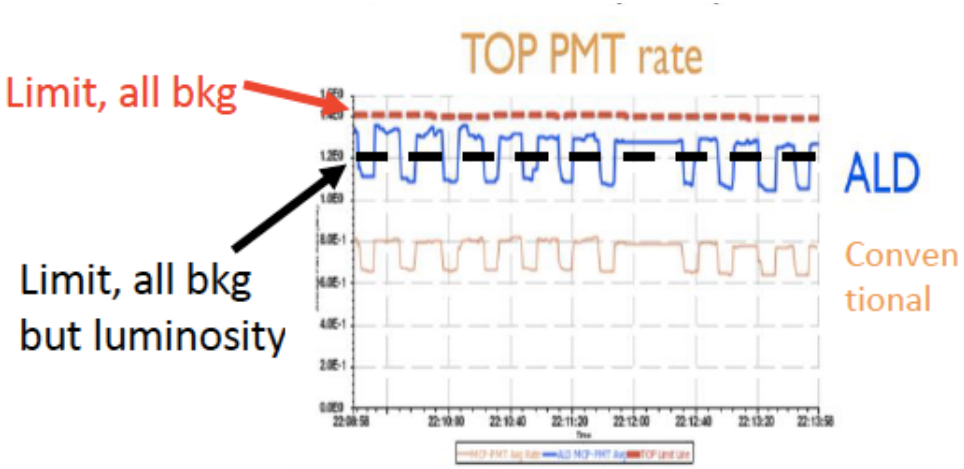
High Luminosity (6.5 x 10^{35}/cm^2/sec, 50 ab^{-1}) with a detector upgrade

Polarization Upgrade, Advanced R&D

Ultra high luminosity (4 x 10^{36}/cm^2/sec, 250 ab^{-1}), R&D Project

A Snowmass White Paper is planned on the Belle II backgrounds for future SuperKEKB machine configurations.

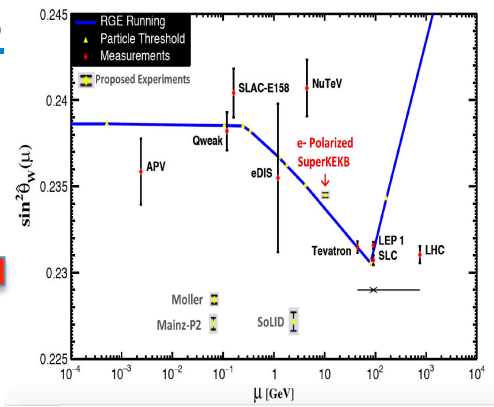
The optics and background calculations for the final SuperKEKB configuration are now obsolete for a variety of reasons (e.g. crab waist, improvements in bkg simulation, new collimators, inj. bkgs, vacuum scrubbing scenarios). It is clear that we need new estimates and a new realistic long-term plan.



Andrii Natochi, Hiro Nakayama, Sven Vahsen et al will write a Snowmass White Paper for the accelerator frontier.

Upgrading SuperKEKB with Polarized e- Beams

Physics case: precision $\sin^2\theta_W$ measurements from b, c, e, μ & τ, probing its running and universality (*White Paper in Preparation by M. Roney*).

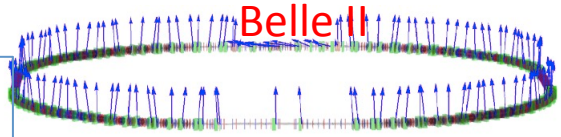


Planning 70% polarization with 80% polarized source.

NEW HARDWARE FOR POLARIZATION UPGRADE:

- **Low emittance polarized Source:** electron helicity can be flipped bunch-to-bunch by controlling circular polarization of source laser illuminating a GaAs photocathode (à la SLC). Inject vertically polarized electrons into the 7 GeV e-Ring, needs low enough emittance source to be able to inject.
- **Spin rotators:** Rotate spin to longitudinal before Interaction Point (IP) in Belle II, and then back to vertical after IP using solenoidal and dipole fields
- **Compton polarimeter:** monitors longitudinal polarization with <1% absolute precision, higher for relative measurements (arXiv:1009.6178) - provides real time polarimetry. → Use tau decays from $e^+e^- \rightarrow \tau^+\tau^-$ measured in Belle II to provide high precision absolute average polarization at IP.

Planning for implementation ~2026 in mid-decade upgrade window for new final focus; This upgrade proposal to be included in KEK Roadmap for MEXT to be submitted 2021



e- spin vector around ring

Known short and medium term Belle II detector upgrades
(from the Belle II LOI on the Instrumentation Frontier)

Subdector	Function	2022 upgrade	2026 upgrades proposed to date
PXD	Vertex Detector	2 layer upgrade	1) New DEPFET 2) SOI 3) CMOS monolithic sensors
SVD	Vertex Detector	—	1) Thin, double-sided strips, w/ new frontend 2) Merge PXD and SVD, CMOS monolithic sensors
CDC	Tracking	Upgrade FE if ready	1) Keep current detector, upgrade FE electronics 2) Replace with TPC w/ MPGD readout
TOP	PID, barrel	Repl. conv. MCP-PMTs	1) Replace not-life-extended ALD MCP-PMTs 2) Partial "STOPGAP" (see below)
ARICH	PID, forward	—	1) Replace HAPPD with Silicon PhotoMultipliers 2) Replace HAPPD with Large Area Picosecond Photodetectors
ECL	γ, e ID	—	1) Add pre-shower detector in front of ECL 2) Replace ECL PiN diodes with APDs
KLM	K_L, μ ID	—	1) Replace 13 barrel layers of legacy RPCs with scintillators 2) On-detector upgraded scintillator readout 3) Timing upgrade for K-long momentum measurement
Trigger		Firmware improvements	Not defined yet, depend on detector upgrades
DAQ		1) 2021: PCIe40 readout upgrade 2) Add 1300 cores to HLT	Add 1900 cores to HLT

Table 1: Known short and medium-term Belle II subdetector upgrade plans, starting from the radially innermost. The current Belle II subdetectors are the Silicon Pixel Detector (PXD), Silicon Strip Detector (SVD), Central Drift Chamber (CDC), Time of Propagation Counter (TOP), Aerogel Rich Counter (ARICH), EM Calorimeter (ECL), Barrel and Endcap K-Long Muon Systems (BKLM, EKLM), Trigger and Data aquistion (DAQ). DAQ includes the high level trigger (HLT).

New vertex detector and improved PID are possible.

Three White Papers are planned so far on the instrumentation frontier

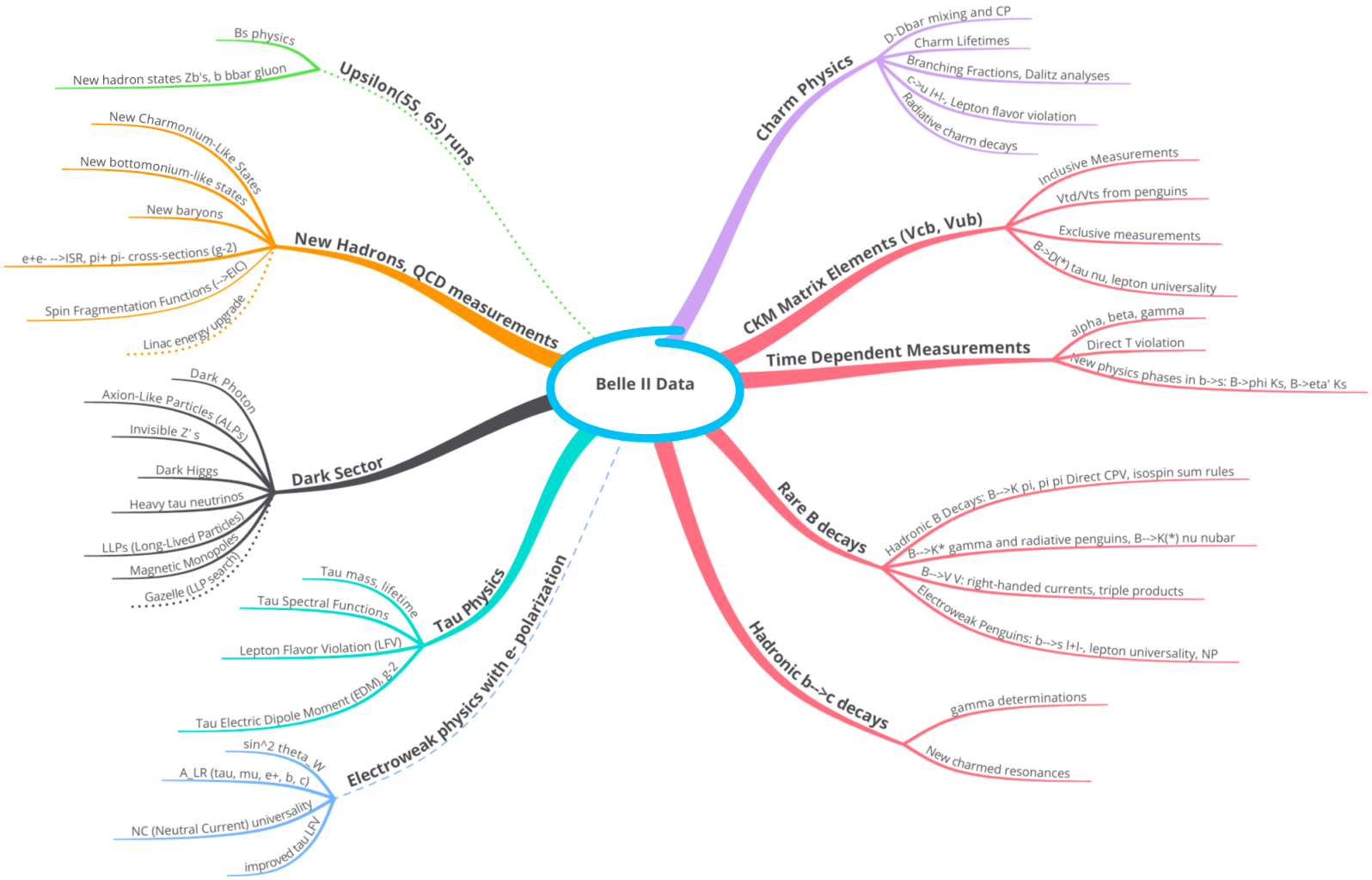
1. TPC replacement for the CDC, Peter Lewis et al.

2. VXD upgrades, Carlos Marinas et al.

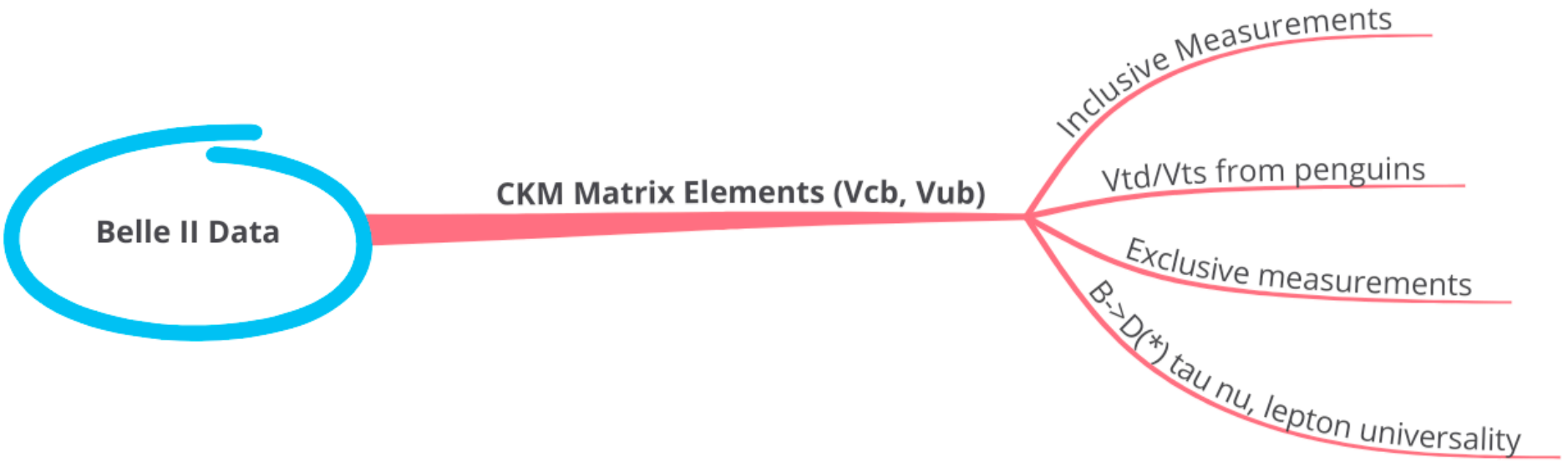
3. STOPGAP fast timing detector, Oskar Hartbrich, Umberto Tamponi et al. (may also contribute to a general fast-timing detector White Paper).

Belle II Physics "Mind Map" for Snowmass 2021

Wealth of new physics possibilities in different domains of HEP (weak, strong, electroweak interactions). Many opportunities for *initiatives* by young scientists.



Dashed lines indicate extensions to SuperKEKB/Belle II that can enhance the physics reach of the facility. LOIs: https://confluence.desy.de/display/BI/Snowmass+2021

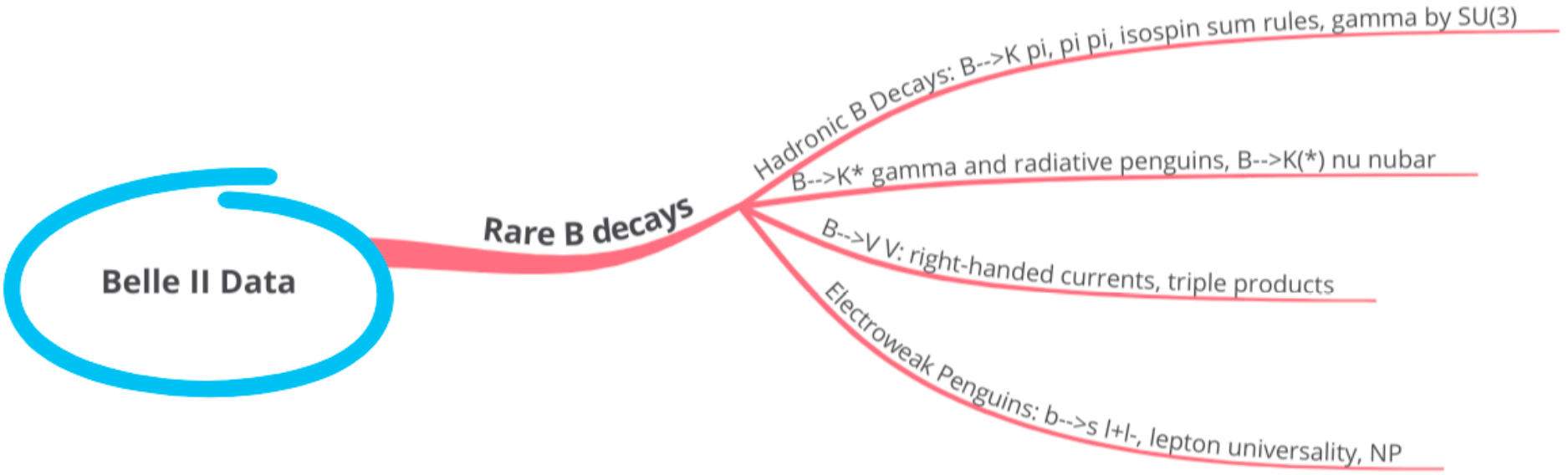


Racha Cheaib et al will write a Belle II White Paper on prospects for missing energy semileptonic decays.

Question: Will E_{ECL} still work well at high luminosity and backgrounds ?

Question: Is FEI always required or can more efficient ROE analyses work ?

Need Updated sensitivity estimates



To check for new physics from electroweak penguins in the B→Kπ system in a model-independent manner using the isospin sum rule, need to measure all *four final states* and their CP asymmetries. Need to measure modes with π^0's and Kshort's.

https://arxiv.org/abs/hep-ph/0508047

$$A_{CP}(K^+\pi^-) + A_{CP}(K^0\pi^+)\frac{\mathcal{B}(K^0\pi^+)}{\mathcal{B}(K^+\pi^-)}\frac{\tau_0}{\tau_+} = A_{CP}(K^+\pi^0)\frac{2\mathcal{B}(K^+\pi^0)}{\mathcal{B}(K^+\pi^-)}\frac{\tau_0}{\tau_+} + A_{CP}(K^0\pi^0)\frac{2\mathcal{B}(K^0\pi^0)}{\mathcal{B}(K^+\pi^-)}$$

This one is especially relevant to the 2020 Physics Week

Slide from D. Tonelli

Belle II charmless for Snowmass

Hadronic (tree) $b \to u$ and (loop) $b \to s,d$ transitions — a traditional B physics workhorse making up for 15% of scientific output: CKM angle α/ϕ_2, plenty of CPV in decay amplitudes, ingenious rate combinations for stringent SM tests, etc.

Can we do something new? Tom@B2GM: *`may update or go beyond the content of the Belle II Physics Book'*. We want to update *and* go beyond.

Updating is easy: refresh B2TiP projections with updated pheno/expt knowledge.

Going beyond is more exciting: loop-based γ/ϕ_3 from charmless 3-body. Combine amplitude-analyses from $B^+ \to K^+\pi^+\pi^-$, $B^0 \to K^+\pi^-\pi^0$, $B^0 \to K^0_S K^0_S K^0_S$, $B^0 \to K^0_S\pi^+\pi^-$, *and* $B^0 \to K^0_S K^+K^-$ in a SU(3)-based fit that overconstrains dynamics to determine γ/ϕ_3.

SU(3) violations (assumed common to all amplitudes) get `averaged' over the Dalitz plot.

O(1°) uncertainties on loop-based γ/ϕ_3 with full Belle II statistics. Amplitude analysis on hadronic decays with final-state π^0/K^0_S make it challenging for LHCb.

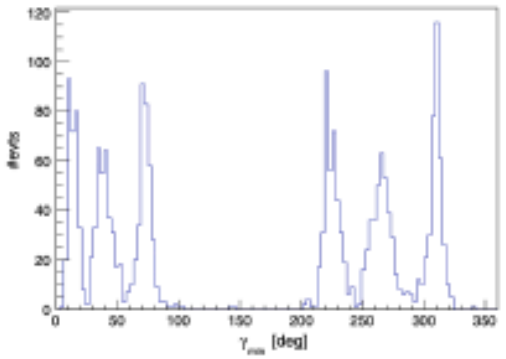


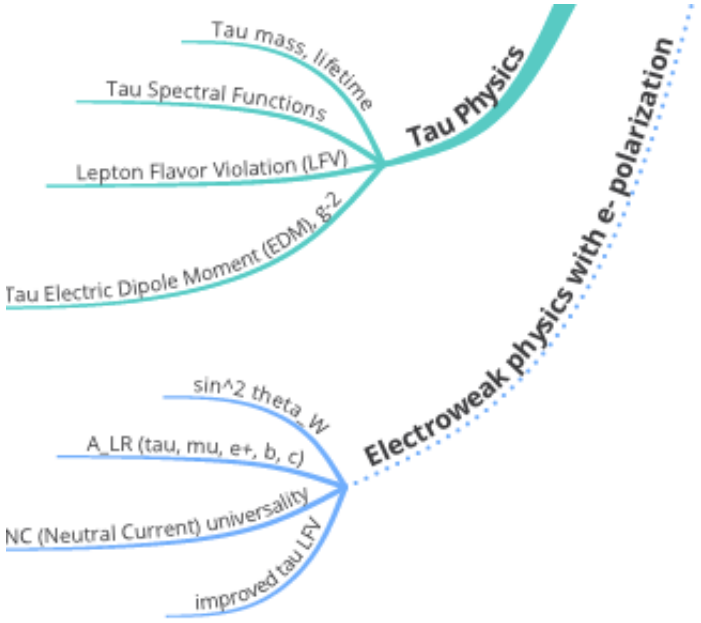
FIG. 4. The minima found with five decay modes, with $\alpha_{SU(3)}$ free to vary in the fit. For each of the 401 sets of random combinations of three points in the Dalitz plot, a χ^2 scan for γ is performed and the minima γ_{min} are found. The histogram shows the accumulation of the minima across all 401 scans.

References: method in PRD 85 016010 (2012) and references therein. Babar results in PRD 99 114011 (2019)
Contributor list (in progress): B. Battacharya, E. Bertholet, P. Goldenzweig, D. London, S. Raiz, B. Wach, D. Tonelli

Gianluca Inuglia et al. (White Paper on the Interleptons Project)

Innovative studies of lepton flavor universality breakdown in a variety of Belle II physics domains (Z' searches, tau physics, Upsilon decays) making full use of machine learning techniques.

Swagato Bannerjee et al (White Paper on Belle II Tau Physics).



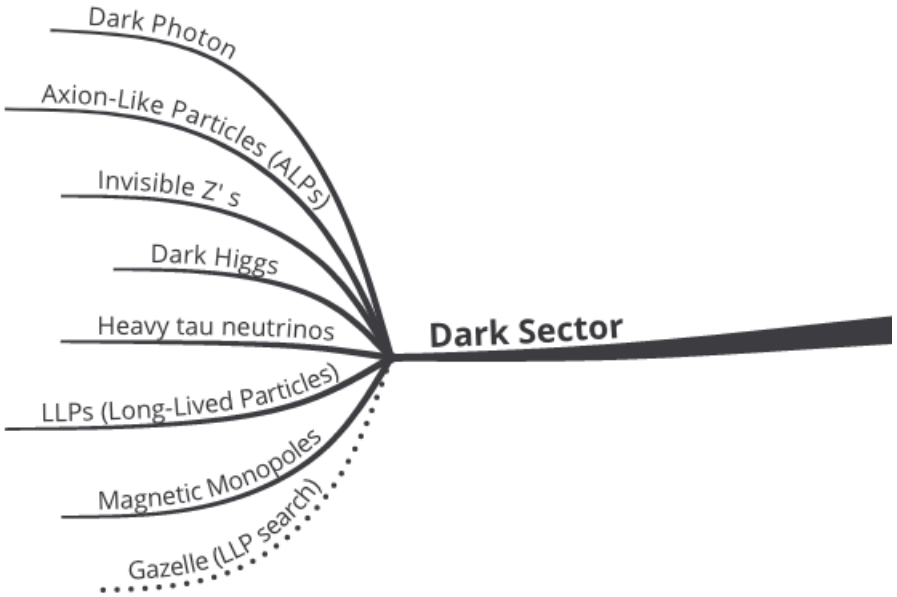
A recent hot issue: What is our sensitivity for g-2 (tau lepton) ?

https://arxiv.org/abs/1803.00501

How does this compare to CMS Pb-Pb collisions (gamma gamma production) ?

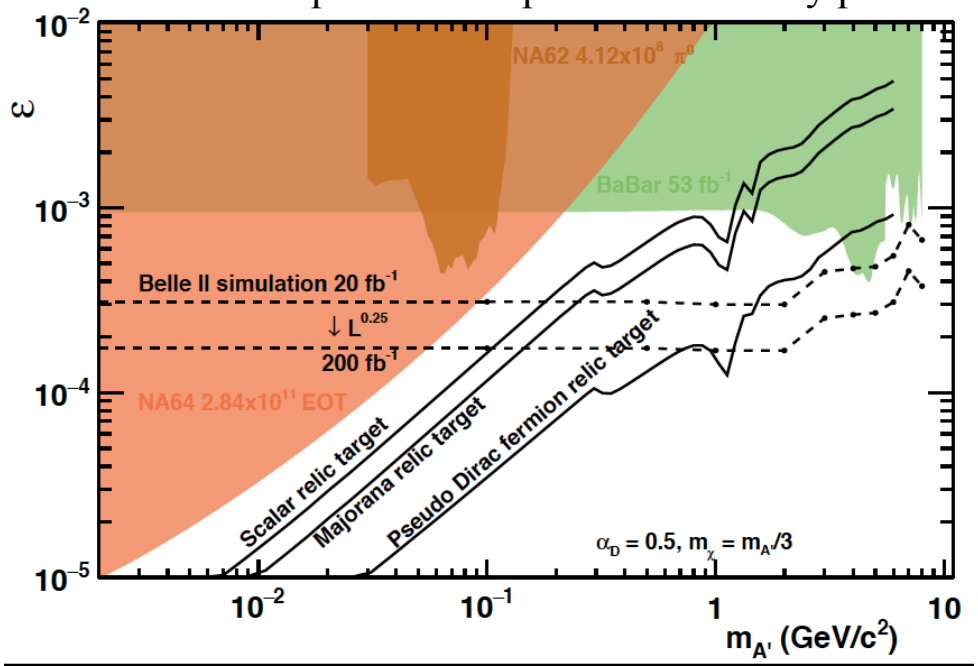
https://arxiv.org/pdf/1908.05180.pdf

Zoom in on the Dark Sector



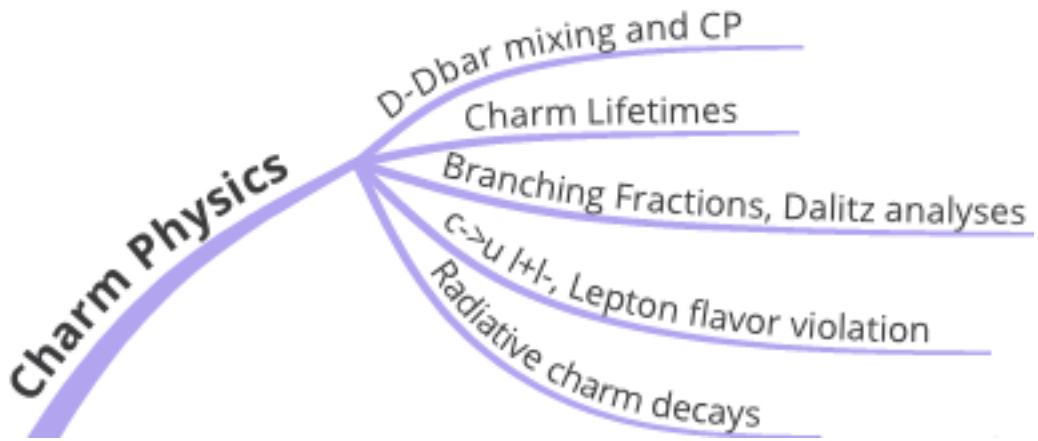
LLP White Paper (including the Gazelle proposal): Torben Ferber, Suzanne Westhof et al

Updated dark photon sensitivity plot



Dark Sector Capabilities of Belle II White Paper, Chris Hearty, Kevin Flood et al.

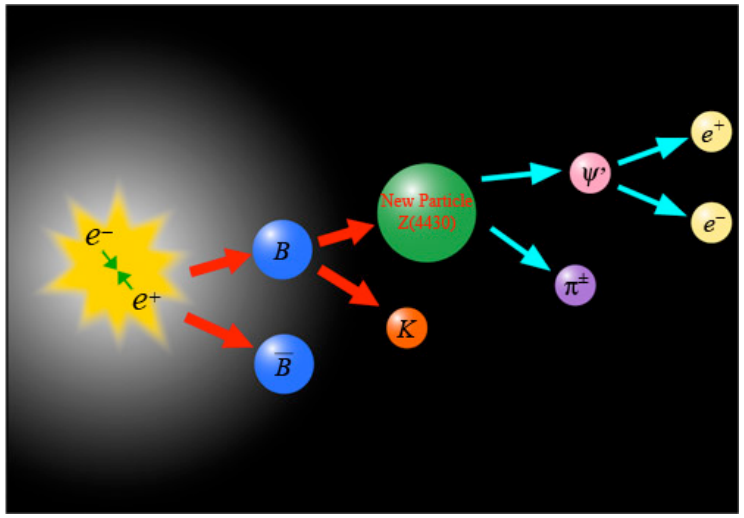
Zoom in to the Charm Physics Branch



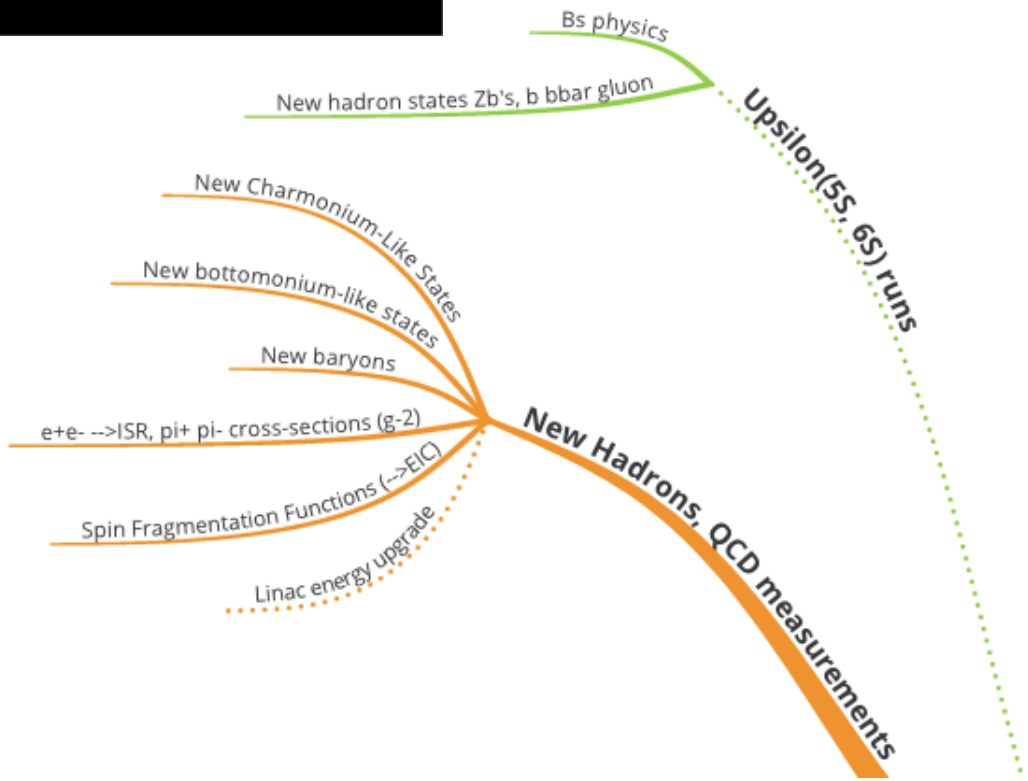
Belle II Charm Physics Capabilities White Paper being organized by Alan Schwartz et al.

Will include updated sensitivities for D-Dbar mixing, Charm direct CP violation and T violation channels.

Look at the QCD and New Hadrons Branches



Bryan Fulsom et al, together with LHCb, theorists is writing a White Paper on hadron spectroscopy prospects.



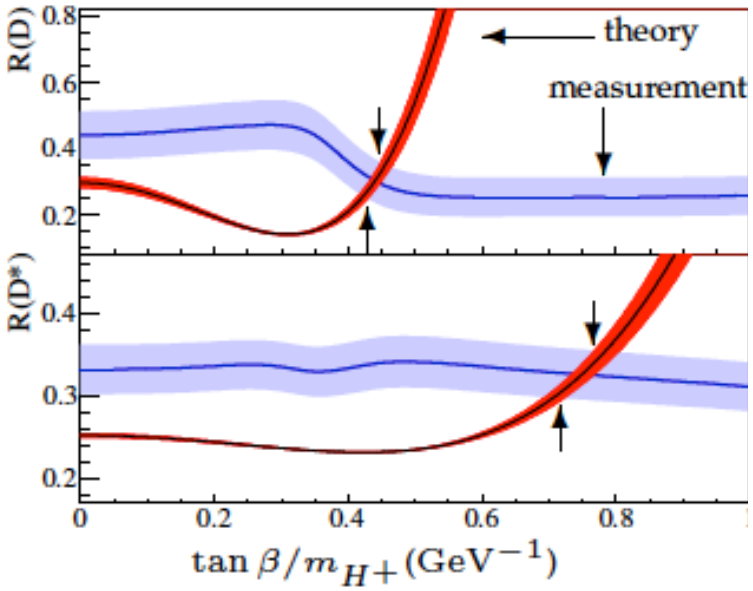
Anselm Vossen et al. is writing a White Paper on QCD measurements.

Here note the synergies with the EIC (Electron Ion Collider) and muon g-2 experiment(s) at FNAL and JPARC.

Example of why we need new physics *MC generators*

N.B. Change in R(D) and R(D*) as a function of NP, due to efficiency, phase space changes.

BaBar



Belle

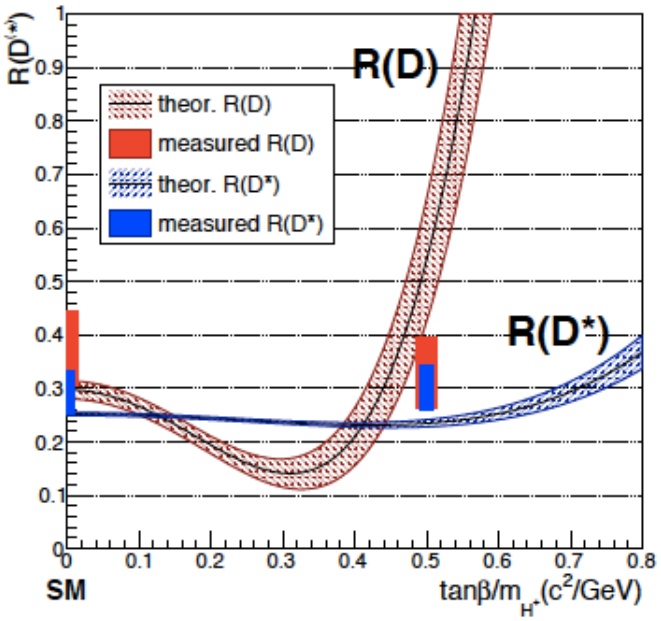


FIG. 7. Theoretical predictions with $1\,\sigma$ error ranges for $R(D)$ (red) and $R(D^*)$ (blue) for different values of $\tan\beta/m_{H^+}$ in the 2HDM of type II. The fit results for $\tan\beta/m_{H^+} = 0.5\,c^2/\text{GeV}$ and SM are shown with their $1\,\sigma$ ranges as red and blue bars with arbitrary width for better visibility.

The world average has fluctuated down from the BaBar result in 2012.
Type II HDM tightly constrained, Leptoquarks are now in fashion……

Also note that q^2 dependence, D* angular dependence not used, just BFs.
Again lack of MC generators is the issue for better analyses.

The problem is more severe for $B \rightarrow K^* l^+ l^-$, $b \rightarrow s l^+ l^-$

Whitepaper on New Physics *MC generators* and Improved Analyses

$B \rightarrow D^{(*)}$ τυ study group:	Alakabha Datta (U Miss) and new graduate students, Bhubanjyoti Bhattacharya (LTU), Alexei Sibidanov and students, and TEB.

First task: implement V+A couplings from NP.

$B \rightarrow K^{*} l^{+} l^{-}$, $b \rightarrow s l^{+} l^{-}$ group:	Rahul Sinha (IMSc) and students, Saurabh Sandilya (Hyderabad), Alexei Sibidanov, K. Flood, S. Vahsen and TEB (Hawaii).

More are welcome, especially experts on EVTGEN or HAMMER packages.

Conclusions

- Now launching Belle II/SuperKEKB Snowmass White Papers
- Please contribute (also new timely initiatives are welcome)
- We need to finish and submit these papers by July 31, 2021
- The White Papers will make the case for the priority and importance of the Belle II/ SuperKEKB and flavor physics program in the field of high energy physics.

* Snowmass Conveners may want bullet points and early sensitivity results from White Papers as early as May.

** I apologize for any omissions and will update the slides with corrections to the author lists etc.

Backup slides

Snowmass, CO

Minneapolis, Minnesota

Chinese [edit]

	describing the scene where all the flowers bloom synchronously; having different varieties, styles or talents		contention of the Hundred Schools of Thought; to let a hundred schools of thought contend
trad. (百花齊放，百家爭鳴)	百花齊放	，	百家爭鳴
simp. (百花齐放，百家争鸣)	百花齐放	，	百家争鸣
Literally: "let one hundred flowers bloom; let one hundred schools of thought contend".			

"Let a thousand flowers bloom"

In English this is taken to mean: Do not interfere with promising developments in their early stages.

Some of the Snowmass talks given so far by Belle II members in 2020 at workshops and “kick-off” meetings.

Talks at meetings/workshops

- May 20, 2020 - EF06 Kick-off meeting: Summary of proposed Belle II activities: Charmonium, Bottomonium, and XYZ states, Bryan Fulsom
- Jun 24, 2020 - EF06 Topical Group Meeting: Belle II Overview (Hadron Spectroscopy), Bryan Fulsom
- Jul 10, 2020 - Preparatory Joint Sessions on Open Questions and New Ideas - Hadron Spectroscopy (includes Belle II), Bryan Fulsom
- Jul 23, 2020 – RF5 Workshop CLFV - Tau Decays and Transitions
  - Tau LFV decays at Belle II, Swagato Banerjee
- Sep 23, 2020 - RF07 Workshop: Bottomonium (Experimental, includes Belle II), Todd Pedlar
- Sep 28-29, 2020 – RF1/5 Workshop Lepton flavor violation and lepton universality violation in meson and baryon decays
  - LFV+LFU in neutral-current b/c decays at Belle II, Karim Trabelsi
  - LFU in charged-current b decays at Belle II, Florian Bernlochner
- Oct 2, 2020 – RF Town Hall meeting
  - Physics prospects of Belle II, Soeren Prell
  - CKM measurements and CPV in b decays at Belle II, Alessandro Gaz
  - Rare b decays at Belle II, Alan Schwartz
  - Charm physics at Belle II, Jake Bennett
  - Hadron Spectroscopy at Belle II, Bryan Fulsom
  - Long-lived particles at Belle II, Susanne Westhoff
  - Dark sector studies at Belle II, Kevin Flood
  - CLFV in tau decays, Swagato Banerjee
- Oct 6, 2020 – AF5 organization with contributors
  - Upgrades of SuperKEKB/Belle II, Tom Browder
  - Precision Electroweak Physics with Polarized Beams at SuperKEKB/Belle II, Michael Roney

Snowmass 2021 Letter of Interest: Belle II/SuperKEKB Upgrades & Overview

on behalf of the U.S. Belle II Collaboration

D. M. Asner[1], Sw. Banerjee[2], J. V. Bennett[3], G. Bonvicini[4], R. A. Briere[5], T. E. Browder[6], D. N. Brown[2], C. Chen[7], D. Cinabro[4], J. Cochran[7], L. M. Cremaldi[3], A. Di Canto[1], K. Flood[6], B. G. Fulsom[8], R. Godang[9], W. W. Jacobs[10], D. E. Jaffe[1], K. Kinoshita[11], R. Kroeger[3], R. Kulasiri[12], P. J. Laycock[1], K. A. Nishimura[6], T. K. Pedlar[13], L. E. Piilonen[14], S. Prell[7], C. Rosenfeld[15], D. A. Sanders[3], V. Savinov[16], A. J. Schwartz[11], J. Strube[8], D. J. Summers[3], S. E. Vahsen[6], G. S. Varner[6], A. Vossen[17], L. Wood[8], and J. Yelton[18]

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Snowmass 2021 Letter of Interest: B Physics at Belle II

on behalf of the U.S. Belle II Collaboration

D. M. Asner[1], Sw. Banerjee[2], J. V. Bennett[3], G. Bonvicini[4], R. A. Briere[5], T. E. Browder[6], D. N. Brown[2], C. Chen[7], D. Cinabro[4], J. Cochran[7], L. M. Cremaldi[3], A. Di Canto[1], K. Flood[6], B. G. Fulsom[8], R. Godang[9], W. W. Jacobs[10], D. E. Jaffe[1], K. Kinoshita[11], R. Kroeger[3], R. Kulasiri[12], P. J. Laycock[1], K. A. Nishimura[6], T. K. Pedlar[13], L. E. Piilonen[14], S. Prell[7], C. Rosenfeld[15], D. A. Sanders[3], V. Savinov[16], A. J. Schwartz[11], J. Strube[8], D. J. Summers[3], S. E. Vahsen[6], G. S. Varner[6], A. Vossen[17], L. Wood[8], and J. Yelton[18]

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Thematic Area(s):

■ (RF01) Weak Decays of b and c Quarks

Snowmass 2021 Letter of Interest: Dark sector studies at Belle II

on behalf of the U.S. Belle II Collaboration

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Thematic Area(s):

■ (RF06) Dark Sector at Low Energies

Snowmass 2021 Letter of Interest: Charm Physics at Belle II

on behalf of the U.S. Belle II Collaboration

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Thematic Area(s):

Rare Processes and Precision Measurement Frontier
- (RF01) Weak Decays of b and c
- (RF04) Baryon & Lepton Number Violation

Snowmass 2021 Letter of Interest: Tau Physics and Precision Electroweak Physics with Polarized Beams at SuperKEKB/Belle II

on behalf of the U.S. Belle II Collaboration

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Snowmass 2021 Letter of Interest: Hadron Spectroscopy at Belle II

on behalf of the U.S. Belle II Collaboration

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Thematic Area(s):

■ (RF07) Hadron Spectroscopy

Snowmass 2021 Letter of Interest: QCD and Hadronization Studies at Belle II

on behalf of the U.S. Belle II Collaboration

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Snowmass 2021 Letter of Interest: Belle II Detector Upgrades

on behalf of the U.S. Belle II Collaboration

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Snowmass 2021 Letter of Interest: Computing, Software, and Data Analysis at Belle II

on behalf of the U.S. Belle II Collaboration

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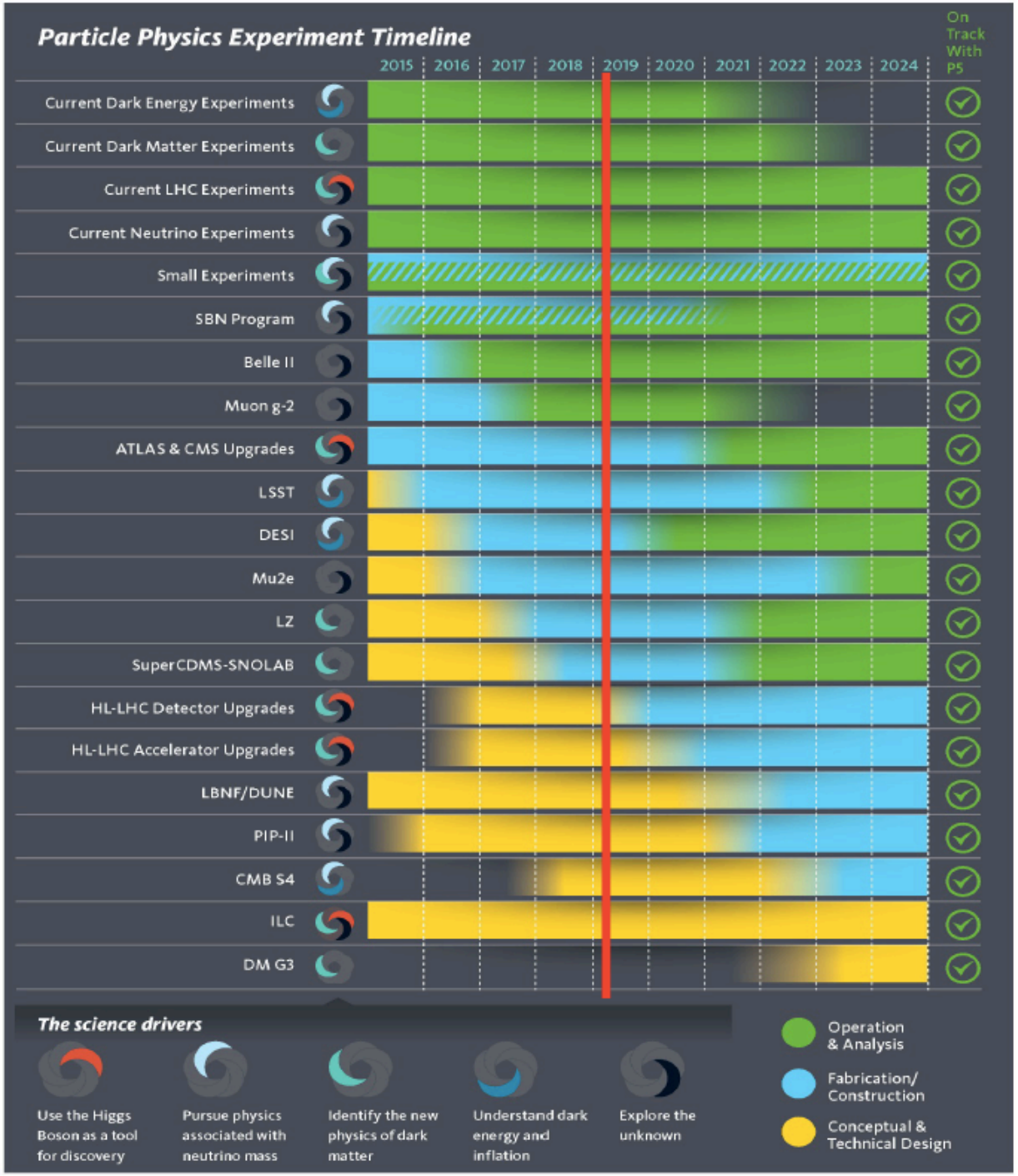


Slide from J. Hewett/ HEPAP DOE

ODDONE: And then there are several interesting things about the

Japan decided to do one also, and they had a remarkably similar situa

extraordinary is that KEKB, the Japanese machine, and the Asymmet

neck and neck the whole way through to the discovery of CP violatio

Former Fermilab director Pier Oddone at his vineyard in California. CREDIT: Barbara Oddone

ODDONE: These are complicated machines. There were lots of things to do that could go wrong. It's so easy to fall out of sequence with some component so that you would be six months behind. But it didn't happen. It was neck and neck the whole five years of building the machine, the detectors, all the way to the discovery paper. So, at the end, they have been very, very productive machines. The Asymmetric B Factory got killed probably prematurely with the budget crisis in 2008. The Japanese went ahead and have built SuperKEKB, the successor to KEKB, which is starting to work now to get even 40 times more luminosity than the Asymmetric B Factory. We'll see how far they get. It's not clear. And, of course, there was very productive B physics with CDF at the Tevatron and now with LHCb at CERN.

Interview May 2020

ESG report

The quest for dark matter and the exploration of flavour and fundamental symmetries are crucial components of the search for new physics. This search can be done in many ways, for example through precision measurements of flavour physics and electric or magnetic dipole moments, and searches for axions, dark sector candidates and feebly interacting particles. There are many options to address such physics topics including energy-frontier colliders, accelerator and non-accelerator experiments. A diverse programme that is complementary to the energy frontier is an essential part of the European particle physics Strategy. ***Experiments in such diverse areas that offer potential high-impact particle physics programmes at laboratories in Europe should be supported, as well as participation in such experiments in other regions of the world.***

The observed pattern of masses and mixings of the fundamental constituents of matter, quarks and leptons, remains a puzzle in spite of the plethora of new experimental results obtained since the last Strategy update. Studying the flavour puzzle may indicate the way to new physics with sensitivity far beyond what is reachable in direct searches, e.g. the evidence for the existence of the top quark that followed from the study of B-meson mixing. In addition, flavour physics and CP violation, which play a vital role in determining the parameters of the Standard Model, are explored by a wide spectrum of experiments all over the world. These include measurements of electric or magnetic dipole moments of charged and neutral particles, atoms and molecules, rare muon decays with high intensity muon beams at PSI, FNAL and KEK, rare kaon decays at CERN and KEK, and a variety of charm and/or beauty particle decays at the LHC, in particular with the LHCb experiment. New results are expected in the near future from the Belle II experiment at KEK in Japan and from LHCb (currently undergoing an upgrade) at CERN.

https://arxiv.org/abs/1808.10567

Outcome of the B2TIP (Belle II Theory Interface) Workshops (2014-2018)
Emphasis is on New Physics (NP) reach.

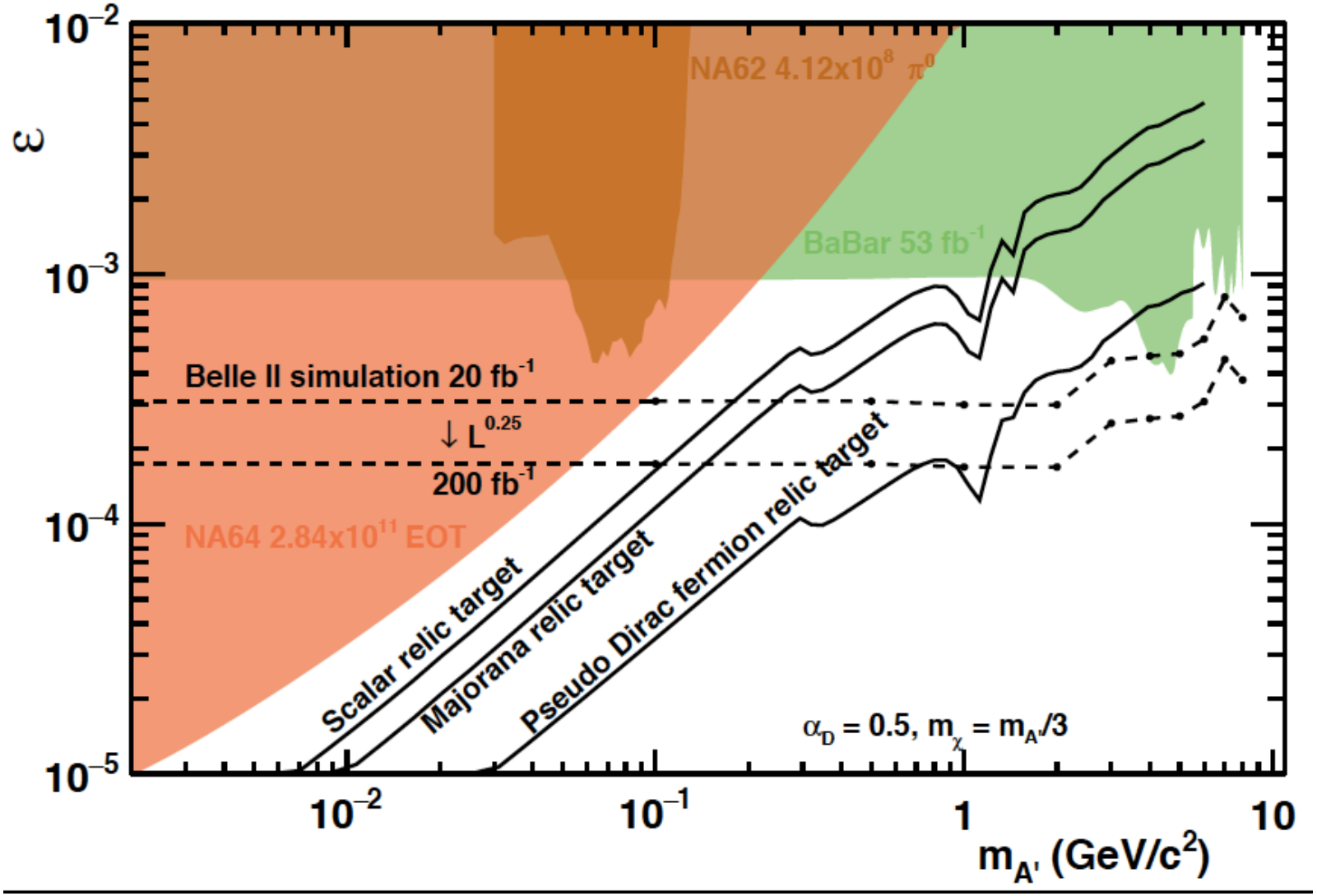
Strong participation from theory community,
lattice QCD community and Belle II experimenters.
689 pages, published by Oxford University Press

First steps toward realizing this program at ICHEP2020

The Belle II Physics Book

E. Kou[74,¶,†], P. Urquijo[143,§,†], W. Altmannshofer[133,¶], F. Beaujean[78,¶], G. Bell[120,¶], M. Beneke[112,¶], I. I. Bigi[146,¶], F. Bishara[148,16,¶], M. Blanke[49,50,¶], C. Bobeth[111,112,¶], M. Bona[150,¶], N. Brambilla[112,¶], V. M. Braun[43,¶], J. Brod[110,133,¶], A. J. Buras[113,¶], H. Y. Cheng[44,¶], C. W. Chiang[91,¶], M. Ciuchini[58,¶], G. Colangelo[126,¶], H. Czyz[154,29,¶], A. Datta[144,¶], F. De Fazio[52,¶], T. Deppisch[50,¶], M. J. Dolan[143,¶], J. Evans[133,¶], S. Fajfer[107,139,¶], T. Feldmann[120,¶], S. Godfrey[7,¶], M. Gronau[61,¶], Y. Grossman[15,¶], F. K. Guo[41,132,¶], U. Haisch[148,11,¶], C. Hanhart[21,¶], S. Hashimoto[30,26,¶], S. Hirose[88,¶], J. Hisano[88,89,¶], L. Hofer[125,¶], M. Hoferichter[166,¶], W. S. Hou[91,¶], T. Huber[120,¶], S. Jaeger[157,¶], S. Jahn[82,¶], M. Jamin[124,¶], J. Jones[102,¶], M. Jung[111,¶], A. L. Kagan[133,¶], F. Kahlhoefer[1,¶], J. F. Kamenik[107,139,¶], T. Kaneko[30,26,¶], Y. Kiyo[63,¶], A. Kokulu[112,138,¶], N. Kosnik[107,139,¶], A. S. Kronfeld[20,¶], Z. Ligeti[19,¶], H. Logan[7,¶], C. D. Lu[41,¶], V. Lubicz[151,¶], F. Mahmoudi[140,¶], K. Maltman[171,¶], S. Mishima[30,¶], M. Misiak[164,¶],

Updated Dark Photon Sensitivity Plot, C. Hearty



Revisionist History and Paradigm Shift

The B factory experiments, Belle and BaBar, discovered large CP violation in the B system in 2001, compatible with the SM and provided a large range of CKM measurements. These provided the experimental foundation for the 2008 Nobel Prize to Kobayashi and Maskawa.

In the meantime, the LHC was constructed in 2008, ATLAS and CMS completely changed the nature of high energy physics. Of particular importance was the landmark discovery in 2012 of the Higgs boson.

This discovery was recognized by the 2013 Physics Nobel Prize to Englert and Higgs.

In addition, the high pT experiments, established tight constraints on direct production of high mass particles (e.g. M(Z'), M(W')>3 TeV, vector-like fermions > 800 GeV) and limits on SUSY. This noble search continues with the high luminosity LHC.

Paradigm shift: inspired by intriguing results from LHCb and the potential of Belle II, the possibility of finding new physics in flavor has emerged as a *complementary* route to the LHC.

Younger theorists: Dark Sector may be another path.


BEGINNER BOOKS
for BEGINNING Beginners
OLD HAT
NEW HAT
by
Stan and Jan Berenstain