2019 SSI Projects

7 Teams on 7 Different Projects…

14:45 → 17:45 **Projects: Presentations** — 51-1-102 - Kavli Auditorium

Convener: Thomas Rizzo (SLAC)

14:45 **Team 9: b->sll BSM sensitivity** — 15m
Speaker: Felipe Garcia (LLR)
ProjectReport_b2sll-...

15:05 **Team 13: 65 GeV top quark ?** — 15m
Speaker: Emma Oxford (Carnegie Mellon University)
65_GeV_Top_Quark....

15:25 **Team 14: Leptonic g-2** — 15m
Speaker: Felix Kress (Imperial College (GB))

15:45 **Team 15: Measuring tau g-2** — 15m
Speaker: Jannicke Pearkes (SLAC)
Measuring_g_2.pdf

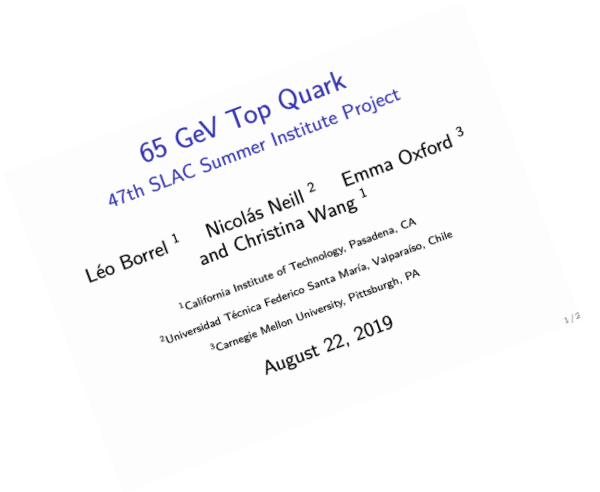
16:05 **Afternoon break** — 20m

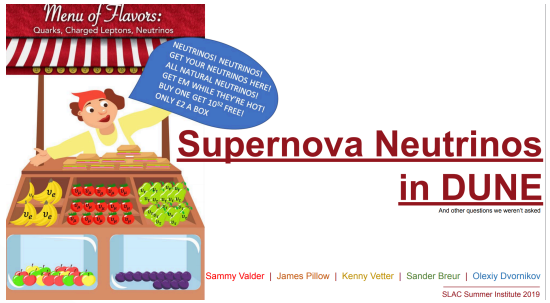
16:25 **Team 16: VHE neutrinos from active galaxies** — 15m
Speaker: Guillaume Pietrzyk (EPFL)
VHE_neutrinos_fro...

16:45 **Team 17: Supernovae neutrinos at DUNE** — 15m
Speaker: Sander Breur (SLAC)
Flat Earth Supernov...

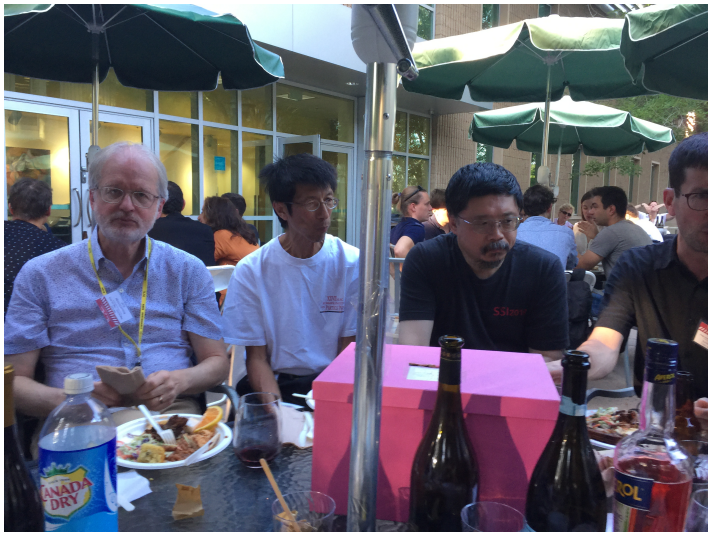
17:05 **Team 19: nu_e vs nu_mu particle ID with Machine Learning** — 15m
Speakers: Martina Ferrillo (University of Zurich), Jonas Eschle

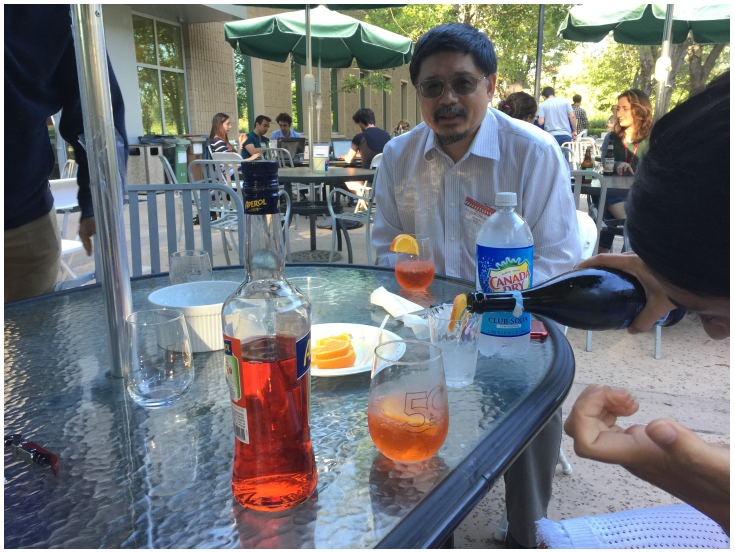
Much Work Was Done & Interesting Ideas Were Presented…





A Panel of Distinguished Experts Called into Service…





The Winners !

47th SLAC SUMMER INSTITUTE

The leptonic g-2 puzzle

Team 14

Arushi Bodas[a], Rupert Coy[b], Elisabeth Maria Niel[c], Felix Kress[d], Peilong Wang[e], Jennifer Rittenhouse West[f]

(a) University of Maryland, College Park, USA
(b) CNRS Laboratoire Charles Coulomb, Montpellier, France
(c) CNRS, Laboratoire de l'Accélérateur Linéaire, Orsay, France
(d) Imperial College London, London, UK
(e) Southern Methodist University, USA
(f) SLAC National Accelerator Laboratory, USA

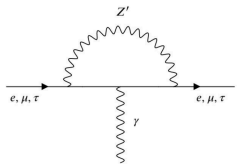
The LFUV Z' model

- Diagram gives for the electrons

$$\Delta a_e = \frac{g'^2(\lambda_{Le}^2 - \lambda_{Le} - 1)m_e^2}{12\pi^2 m_{Z'}^2}$$

which is negative for

$$\frac{1}{2}\left(1-\sqrt{5}\right) < \lambda_{Le} < \frac{1}{2}\left(1+\sqrt{5}\right)$$



- And for muons, we found

$$\Delta a_\mu = \frac{g'^2 m_\mu^2}{8\pi^2}\int_0^1 dx\,dy\,dz\,\delta(x+y+z-1)\frac{z\left[1+z-2\lambda_{L\mu}(z-1)+2\lambda_{L\mu}^2(z-1)\right]}{(1-z)^2 m_\mu^2 - xym_{Z'}^2}$$

Charges of the lepton flavours are related by

$$\lambda_{L\mu,\tau} = \frac{-24+10\lambda_{Le}-\lambda_{Le}^2 \pm \sqrt{47568-7736\lambda_{Le}-92\lambda_{Le}^2+4\lambda_{Le}^3+\lambda_{Le}^4}}{2\lambda_{Le}-12}$$

Monkeying ↑With g-2

Representations

NEW

Field	$SU(3)_c$	$SU(2)_L$	$U(1)_Y$	$U(1)'$	$SU(4)$
H	**1**	**2**	1/2	1	**1**
l_{Le}	**1**	**2**	-1/2	λ_{Le}	**1**
$l_{L\mu}$	**1**	**2**	-1/2	$\lambda_{L\mu}$	**1**
$l_{L\tau}$	**1**	**2**	-1/2	$4-\lambda_{Le}-\lambda_{L\mu}$	**1**
$e_{R\alpha}$	**1**	**1**	-1	$\lambda_{L\alpha}-1$	**1**
q_L	**3**	**2**	1/6	4/3	**1**
u_R	**3**	**1**	2/3	1/3	**1**
d_R	**3**	**1**	-1/3	1/3	**1**
ψ_L	**3**	**1**	0	-1/2	**4**
ψ_R	**3**	**1**	0	0	**4**
ψ'_L	**1**	**1**	0	3/2	**4**
ψ'_R	**1**	**1**	0	0	**4**
χ_L	**1**	**2**	0	-4	**4**
χ_R	**1**	**2**	0	0	**4**
χ'_L	**1**	**2**	0	8	**4**
χ'_R	**1**	**2**	0	0	**4**
f_L	**1**	**1**	0	13	**1**
f_R	**1**	**1**	0	0	**1**

…write this up…

The Question

"A discovery in the area of the Physics of Flavor could lead to the first clear signal of BSM physics. What will it be (all present anomalies excluded!!) and how will it impact future developments in HEP?"

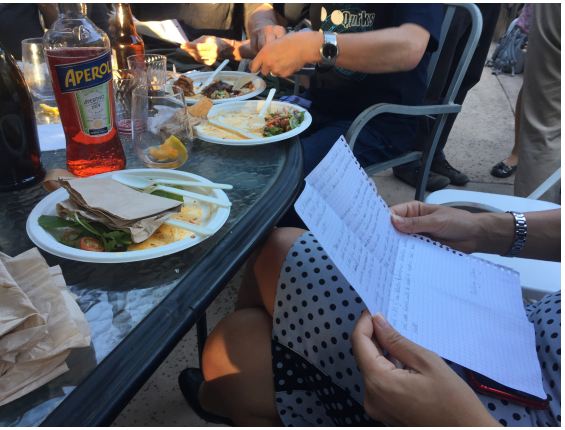
Many interesting entries…
some from non-attendees..

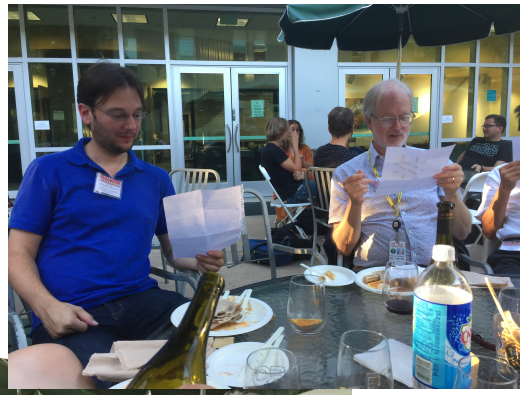
“A Flavor-full Brexit will pave the way for great new discoveries in particle physics. However, I am particularly interested in the physics of Dark Matter & the Dark Sector.”

Who knew ???

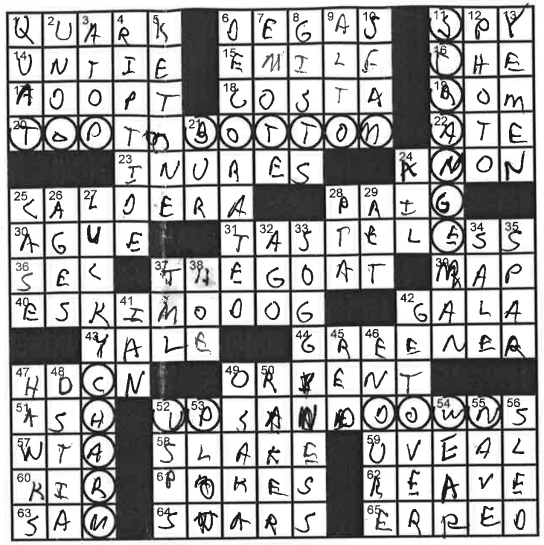
“..flavor good.. Dark Sector bad”

The Panel of Distinguished Experts Called Back into Service…





Menu of Flavors: Crossword Edition



Across

1. Particle whose six flavors appear in this puzzle's circled letters

6. Remove the air from

11. 2015 Melissa McCarthy comedy

14. Loosen, as shoelaces

15. "J'Accuse...!" author Zola

16. Not just any

17. Get a pet, for example

18. ____ Rica

19. CD-____

20. Thorough

22. Had dinner

23. Accustoms (to)

24. Author who Virginia Woolf famously speculated was a woman

25. Large volcanic crater

28. Prude

30. Fever and chills

31. Lacking flavor

36. Dry, as champagne

37. Nanny on a farm

39. Traveler's aid

40. Arctic companion

42. Apple that, in 2018, replaced Red Delicious as the most popular variety in the United States

43. Elis' school

44. More lush

47. Cyanic acid, to a chemist

49. Put on course

51. Bat wood

52. Features that make an experience comparable to a roller coaster

57. Org. for the Williams sisters

58. Satisfy, as thirst

59. Relating to a particular part of the eye

60. Cassis aperitif

61. Prods

62. Raid and plunder

63. Fictional Winchester brother

64. Partner of stripes

65. Replied to all, probably

Down

1. Suffix with kum- or lo-

2. Button you might find yourself looking for after a faux pas

3. At the summit of

4. Dangerous current

5. Many a sugar, chemically

6. Iced, as a cake

7. Ham it up

8. Main ideas

9. Type of saxophone

10. Tailor's line

11. Someone you might avoid on the street

12. Instagram upload

13. Country Chandler accidentally moves to in an episode of "Friends"

21. Prickly plant part

24. Feel unwell

25. Job for a detective

26. Eons

27. Rabbit's foot, perhaps

28. Sch. group

29. Part of AARP, briefly

32. In days gone by

33. Quality to avoid in a pie crust

34. Fire ____

35. Prepare for a fight

37. T-shirt sizes, for short

38. Garden tool

41. Bilbo or Gandalf portrayer in *The Lord of the Rings* trilogy

42. Recover from

45. Word after see or before Sea

46. Put up with

47. Birds of prey

48. ____ Antica (archaeological site that was once an ancient Roman city)

49. Japanese seaport

50. Leaf gatherer

52. Org. that can't be stopped by snow or rain or heat or gloom of night

53. Scheme

54. Have on

55. Part of a church

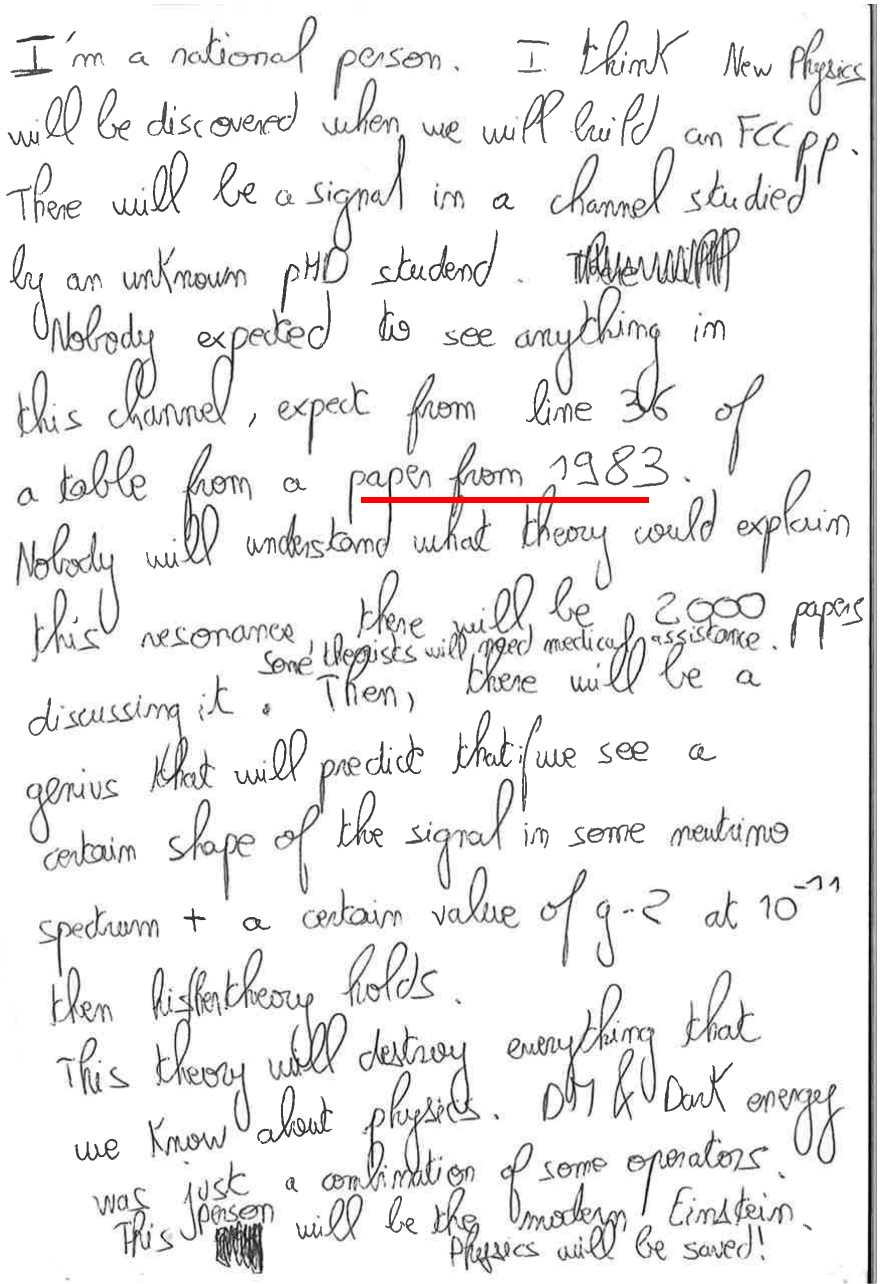
56. Rosebud, famously

Email ero122102@gmail.com if you want a digital copy or the solution :)

Fortunately, we were given a crossword puzzle to relieve the stress of our heavy labors…

Honorable Mention:

New physics at FCC-pp



I'm a national person. I think New Physics will be discovered when we will build an FCC pp. There will be a signal in a channel studied by an unknown PhD student. Nobody expected to see anything in this channel, expect from line 36 of a table from a paper from 1983. Nobody will understand what theory could explain this resonance, there will be 2000 papers discussing it. Some theorists will need medical assistance. Then, there will be a genius that will predict that if we see a certain shape of the signal in some neutrino spectrum + a certain value of g-2 at 10^{-11} then his/her theory holds. This theory will destroy everything that we know about physics. DM & Dark energy was just a combination of some operators. This person will be the modern Einstein. Physics will be saved!

Honorable Mention:

New physics at FCC-pp

PHYSICAL REVIEW D VOLUME 27, NUMBER 1 1 JANUARY 1983

Analysis of preon models with a small number of flavors

Thomas G. Rizzo
Ames Laboratory and Department of Physics, Iowa State University, Ames, Iowa 50011
(Received 9 August 1982)

We analyze a large number of four- and five-preon models along with several six-preon models. By imposing constraints such as cancellation of anomalies and reproduction of the usual quarks and leptons as composites we are able to eliminate many of these from further consideration. If we try to embed the electroweak interactions into the flavor group G_{PF}, we are left with a single, five-preon model. The remaining model is inconsistent with grand unification and asymptotic freedom. We conclude that the simplest preon model must have at least six flavors and contain a single 3_C and three 1_C's.

I. INTRODUCTION

The idea that ordinary quarks and leptons may be composite objects[1] has now been accepted as a theoretical possibility although direct experimental evidence is lacking. Although the similarities between quarks and leptons in terms of their electroweak interactions may be explainable within the context of grand unified theories[2] (GUT's) the explanation for the apparent multifamily structure appears to be lacking. Horizontal symmetries[3] do not usually limit the number of families or explain why only (?) three exist and are only useful for calculating Cabibbo-type mixing angles.[4] The large number of "basic" fermionic states (six color-triplet quarks and six color-singlet leptons) cries out for an explanation. Although we are not (yet) in the situation of the early 1960's (when the quark model was proposed), in terms of the large number of states observed it seems unlikely that all these fermions are elementary. Theoretical prejudice is also swayed by observing that the Higgs bosons of the standard electroweak model,[5] which can be thought of as elementary fields as well, may also, in fact, be composites—condensates of fermion-antifermion pairs via hypercolor[6] and that electroweak symmetry breaking is dynamical.[6]

On the experimental side, present-day experiments using accelerators show no apparent quark or lepton substructure[7] strongly indicating that the binding rons within quantum chromodynamics (QCD).[10]

In QCD we have several flavors of fundamental massless fermions (in the limit we turn off the electroweak interactions) which bind into bound states whose masses are of order Λ_c, the scale at which QCD becomes strong (i.e., $\alpha_s \sim 1$). This is due to flavor-chiral-symmetry breakdown giving masses to the baryons and vector mesons. The pseudoscalar mesons, on the other hand, would be massless Goldstone bosons except for the "small" quark masses produced via the electroweak interactions.

If quarks and leptons (which are essentially massless at a scale of order 100—1000 TeV) are preonic bound states then the preon dynamics must be such that preflavor chiral symmetry remains unbroken otherwise quark and lepton masses would be of order Λ_{PC}. These chiral symmetries would then only be broken, very weakly, by the electroweak interactions and yield the light composite masses. These preflavor chiral symmetries thus protect the composites from getting masses on the scale of Λ_{PC}. How do we ensure that chiral symmetry remains unbroken such that this miracle can occur?[7]

't Hooft[11] has proposed a set of conditions that would require massless composite bound states to occur in preon theories so long as these chiral symmetries remain unbroken. The first condition is that the massless composites as well as the preons must produce the same contribution to the Adler-Bell-Jackiw[12] (ABJ) anomalies in the currents of the un-

??

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Honorable Mention :

CP Violation in Charm at Belle II Saves HEP !!!

..hopefully we can all hold out until 2027..

This is the way the Standard Model ends
This is the way the Standard Model ends
This is the way the Standard Model ends
Not with a bang but a whimper

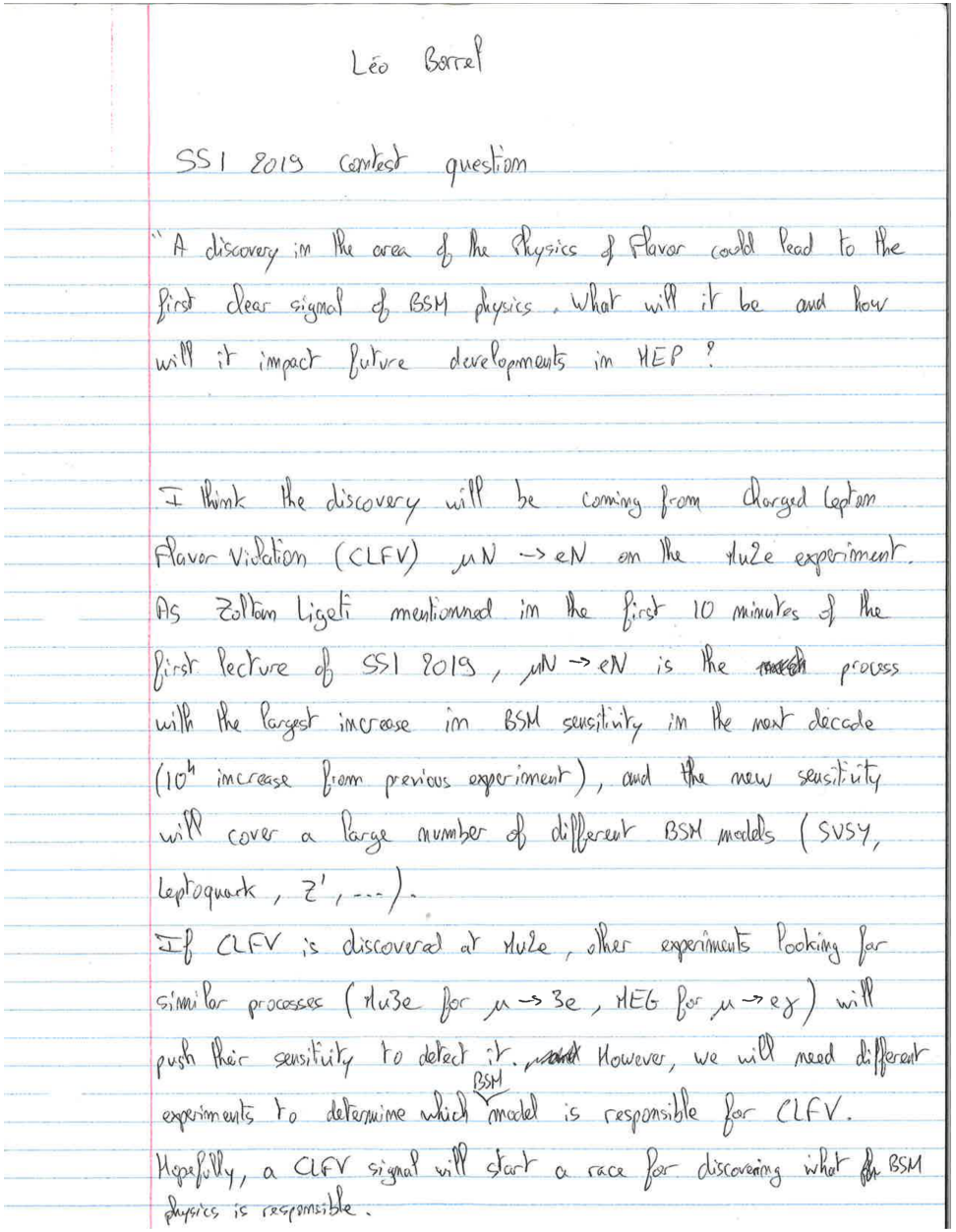
– T.S. Eliot
(close enough)

The year is 2027. Belle II has completed its run. The LHC is operating at unprecedented luminosities. Against all odds, the world has not yet crumbled to dust, but the field of particle physics seems headed dangerously in that direction. Frantic experimentalists struggle in the face of an increasingly hostile and impatient landscape to find something, ANYTHING, that will put particle physics back on the map.

And then, finally, buried in a rare charm decay, there it is: CP violation that cannot be explained by the SM. Evidence of NP! OMG! The community is energized like it hasn't been since 2012. There is more out there, and we can find it. We haven't been searching in vain all these years.

Honorable Mention :

LFV in μ → e !



Léo Borrel

SSI 2019 contest question

"A discovery in the area of the Physics of Flavor could lead to the first clear signal of BSM physics. What will it be and how will it impact future developments in HEP ?

I think the discovery will be coming from charged lepton flavor violation (CLFV) $\mu N \rightarrow eN$ on the Mu2e experiment. As Zoltan Ligeti mentionned in the first 10 minutes of the first lecture of SSI 2019, $\mu N \rightarrow eN$ is the process with the largest increase in BSM sensitivity in the next decade (10^4 increase from previous experiment), and the new sensitivity will cover a large number of different BSM models (SUSY, Leptoquark, Z', ...).

If CLFV is discovered at Mu2e, other experiments looking for similar processes (Mu3e for $\mu \rightarrow 3e$, MEG for $\mu \rightarrow e\gamma$) will push their sensitivity to detect it. However, we will need different experiments to determine which BSM model is responsible for CLFV.

Hopefully, a CLFV signal will start a race for discovering what BSM physics is responsible.

The Winner !

Majorana rises from the grave thanks to $\beta\beta_{0\nu}$ discovery !

(That's REALLY BSM !!)

!!→

A discovery in the area of Flavor physics → BSM signal.
What will it be + how will it impact future developments in HEP?

I believe that the next big discovery will be a detection of neutrinoless β-β decay ⇒ confirmation of the Majorana nature of neutrino mass.

It seems very strange that, if there are two mass generation methods possible for neutral particles, that we would have no particle which follows the Majorana method.

The impact of this would lead to exploration of precise neutrino measurements in light of a more specific modelling regime. eg) what do Majorana phases do? Plus more Majorana mass model building with intersections in other areas of flavor physics.

Also, I would like to think that Majorana himself will come out of hibernation to accept the Nobel Prize.