

# From E8 Root Vector Geometry to the LHC

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## Abstract

This paper is intended to be a only rough semi-popular overview of how the 240 Root Vectors of E8 can be used to construct a useful Lagrangian describing Gravity and Dark Energy plus the Standard Model. For details and references, see viXra/1602.0319.

The 240 Root Vectors of E8 represent the physical forces, particles, and spacetime that make up the construction of a realistic Lagrangian describing the Octonionic Inflation Era followed by a Quaternionic M4 x CP2 Kaluza-Klein Era in which the Higgs emerges by the Mayer mechanism and 2nd and 3rd Generation Fermions appear. By generalizations of the Nambu-Jona-Lasinio models, the Higgs is seen to be a Truth Quark-AntiQuark Condensate giving 3 Mass States of the Higgs and 3 Mass States of the Truth Quark. My analysis of Fermilab and LHC observation data indicates that Fermilab has observed the 3 Truth Quark Mass States and LHC has observed the 3 Higgs Mass States.

The Lagrangian, which is fundamentally classical, is constructed from E8 only and E8 lives in  $Cl(16) = Cl(8) \times Cl(8)$  which corresponds to two copies of an E8 Lattice. A separate paper discusses using a third copy of an E8 Lattice in connection with construction of a realistic Algebraic Quantum Field Theory related to the Leech Lattice.

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The **240 root vectors of E8** are of equal length in 8 dimensions  
as they form the 240-vertex Witting-Gossett polytope

so

you can in 8 dimensions visualize how they group together

If you look at the 240 vertices as points on an 8-dim sphere  
then

you can pick one point as the North Pole

and

see where the other points fall at their angle of latitude:

**1 is at North Pole**

**56 nearest neighbors of the North Pole  
are at North Temperate Latitude**

**126 2nd nearest neighbors of the North Pole  
are at the Equator**

**56 3rd nearest neighbors of the North Pole  
are at South Temperate Latitude**

**1 4th nearest neighbor of the North Pole  
is Anitpodal at the South Pole**

Therefore you see that the 240 break down into  $1 + 56 + 126 + 56 + 1$   
but  
what you need to see next is which root vector corresponds to which physics thing.

## Geometry of the E8 Lie Group gives you some ideas:

$56 + 56 = 112$  Temperate North and South is the  $D8 = \text{Spin}(16)$  subgroup of  $E8$  and they correspond to Gravity + Dark Energy and the Standard Model gauge groups and to 8-dimensional Spacetime position and momentum.

Each 56 breaks down into  $24 + 32$ .

North Temperate  $24 = D4$  Lie Algebra =  $\text{Spin}(2,6)$  which contains Conformal  $\text{Spin}(2,4)$  which gives Gravity plus Conformal Dark Energy as well as Ghosts of Standard Model Gauge Bosons

South Temperate  $24 = D4$  Lie Algebra =  $\text{Spin}(8)$  which contains  $SU(4)$  which gives  $SU(3)$  of the Color Force which is the Global Group of Kaluza-Klein Internal Symmetry Space  $CP^2$  and  $CP^2 = SU(3) / SU(2) \times U(1)$  contains groups of Weak and Electromagnetic Forces as well as Ghosts of Gravity and Dark Energy

Symmetric space  $D8 / D4(\text{gravity}) \times D4(\text{standard model})$  is  $112 - 28 - 28 = 64$ -dim and it corresponds to  $64 = 8$ -dim position  $\times$   $8$ -dim momentum of  $8$ -dim Spacetime which  
 $8$ -dim Spacetime reduces to  $4+4$  dim  $M4 \times CP^2$  Kaluza-Klein spacetime

Symmetric space  $E8 / D8$  is  $128$ -dim Rosenfeld OctoOctonionic Projective Plane which is  
 $1 + 126 + 1$  of the North Pole, Equator, and South Pole

The 128 are the 8 Spacetime components of Fermions: 8 Particles and 8 AntiParticles for  $8 \times 8 = 64$  Particle components +  $8 \times 8 = 64$  AntiParticle components.

1 at North Pole = time component of Neutrino

1 at South Pole = time component of AntiNeutrino

126 at Equator = other components of Leptons and Quarks = root vectors of  $E7$

Symmetric space  $E7 / D6 \times SU(2) = 64$ -dim Rosenfeld QuaterOctonionic Projective Plane corresponds to 8 components of (electron + rgb up quarks) =  $8 \times 4 = 32$

plus 8 components of (positron + rgb up antiquarks) =  $8 \times 4 = 32$

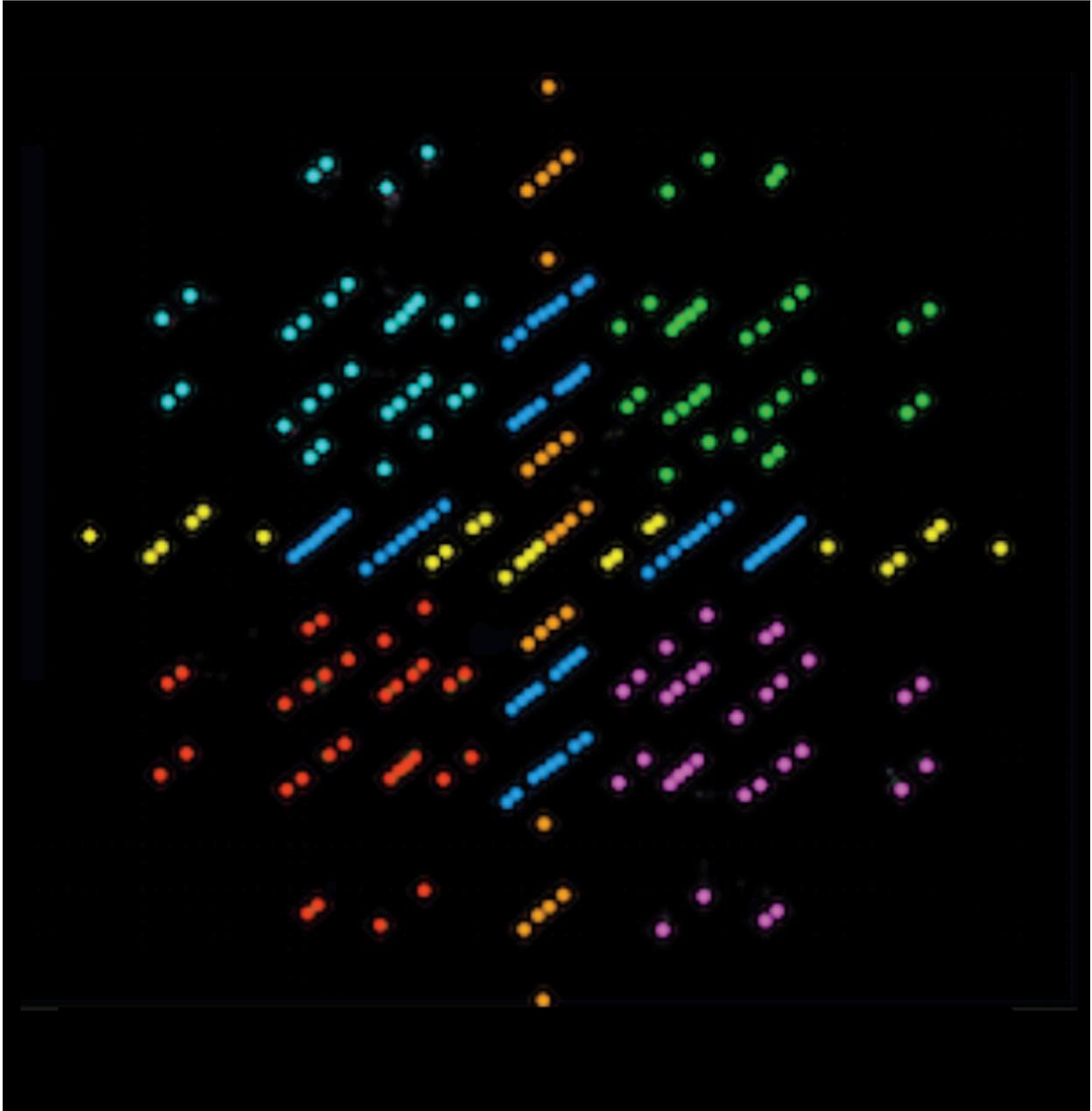
$D6 \times SU(2)$  has  $60+2 = 62$  root vectors so if you add  $1+1$  North and South Poles

you get 64 corresponding to 8 components of (neutrino + rgb down quarks) =  $8 \times 4 = 32$

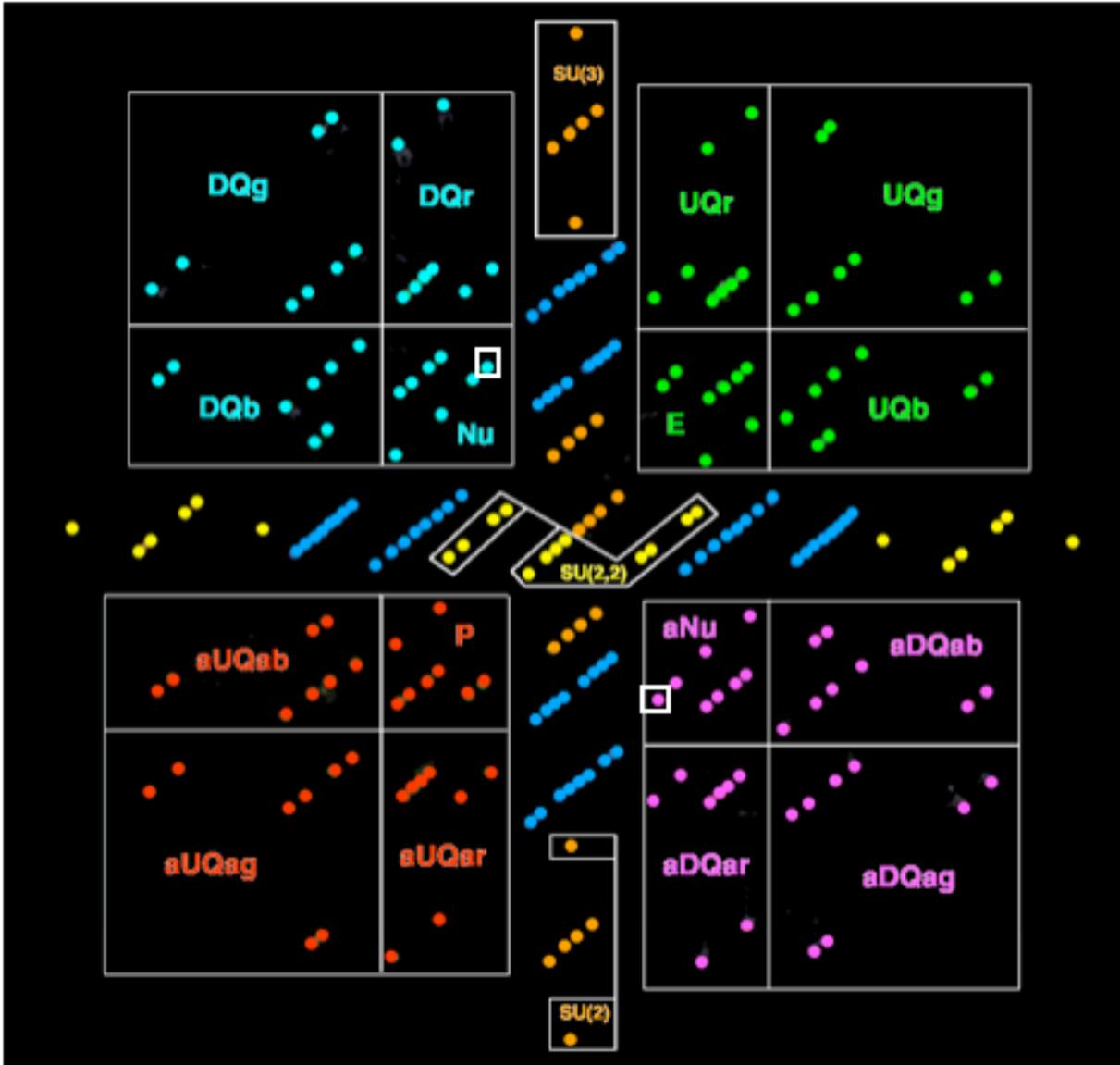
plus 8 components of (antineutrino + rgb down antiquarks) =  $8 \times 4 = 32$

**2-dim projection of 240 E8 Root Vectors  
gives useful visualization of  
which root vector corresponds to which physics thing**

In 2-dim Projection the Root Vectors no longer have the same distance from origin



but in this particular 2-dim projection the physical interpretations of each Root Vector becomes clear:



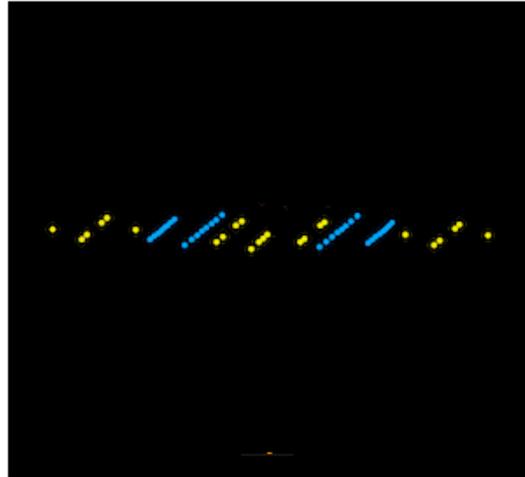
E = electron, UQr = red up quark, UQg = green up quark, UQb = blue up quark  
 Nu = neutrino, DQr = red down quark, DQg = green down quark, DQb = blue down quark  
 P = positron, aUQar = anti-red up antiquark,  
 aUQag = anti-green up antiquark, aUQab = anti-blue up antiquark  
 aNu = antineutrino, aDQar = anti-red down antiquark  
 white boxes enclose time components of neutrino and antineutrino  
 aDQag = anti-green down antiquark, aDQab = anti-blue down antiquark  
 Each Lepton and Quark has 8 components with respect to 4+4 dim Kaluza-Klein  
 6 orange SU(3) and 2 orange SU(2) represent Standard Model root vectors  
 24-6-2 = 16 orange represent U(2,2) Conformal Gravity Ghosts  
 12 yellow SU(2,2) represent Conformal Gravity SU(2,2) root vectors  
 24-12 = 12 yellow represent Standard Model Ghosts  
 32+32 = 64 blue represent 4+4 dim Kaluza-Klein spacetime position and momentum

Here is how the 2-dim physical interpretations correspond  
 to the 8-dim Sphere Latitude decomposition:

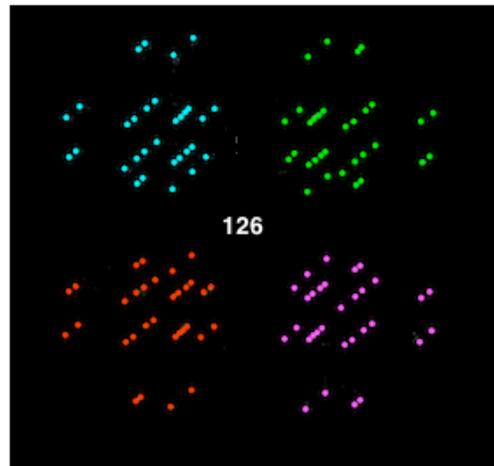
1 is at North Pole



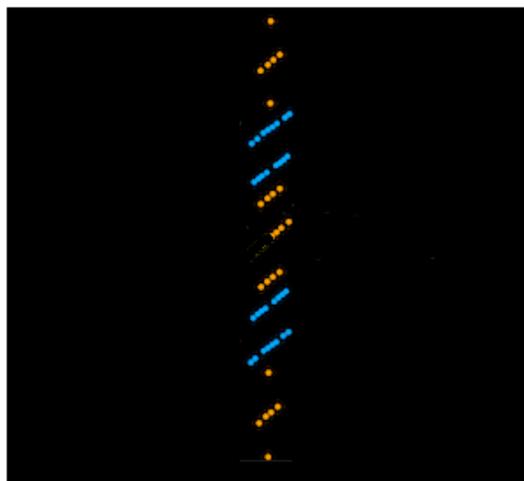
56 nearest neighbors of the North Pole  
are at North Temperate Latitude



126 2nd nearest neighbors of the North Pole  
are at the Equator



56 3rd nearest neighbors of the North Pole  
are at South Temperate Latitude



1 4th nearest neighbor of the North Pole  
is Antipodal at the South Pole



## Recipe for constructing Lagrangian from E8 Root Vectors

My favorite Fundamental Structure of Physics is the Lagrangian.  
In his Dirac Lecture, Steven Weinberg says "... Lagrangian density ...  
you can think of it as the density of energy.  
Energy is the quantity that ... tells us how the system evolves. ...".

The Lagrangian Density contains Boson terms and Fermion terms.  
To get the full Lagrangian, you integrate those terms over Spacetime.

The Code or Recipe just says:

put  
the Gravity + Dark Energy Gauge Bosons and Standard Model Ghosts  
and  
the Standard Model Gauge Bosons and Gravity-Dark Energy Ghosts  
into the Lagrangian Density Boson terms in accord with the standard way of  
constructing physics boson terms

and

put  
the Fermion Particles and AntiParticles  
into the Lagrangian Density Fermion terms in accord with the standard way of  
constructing physics fermion terms

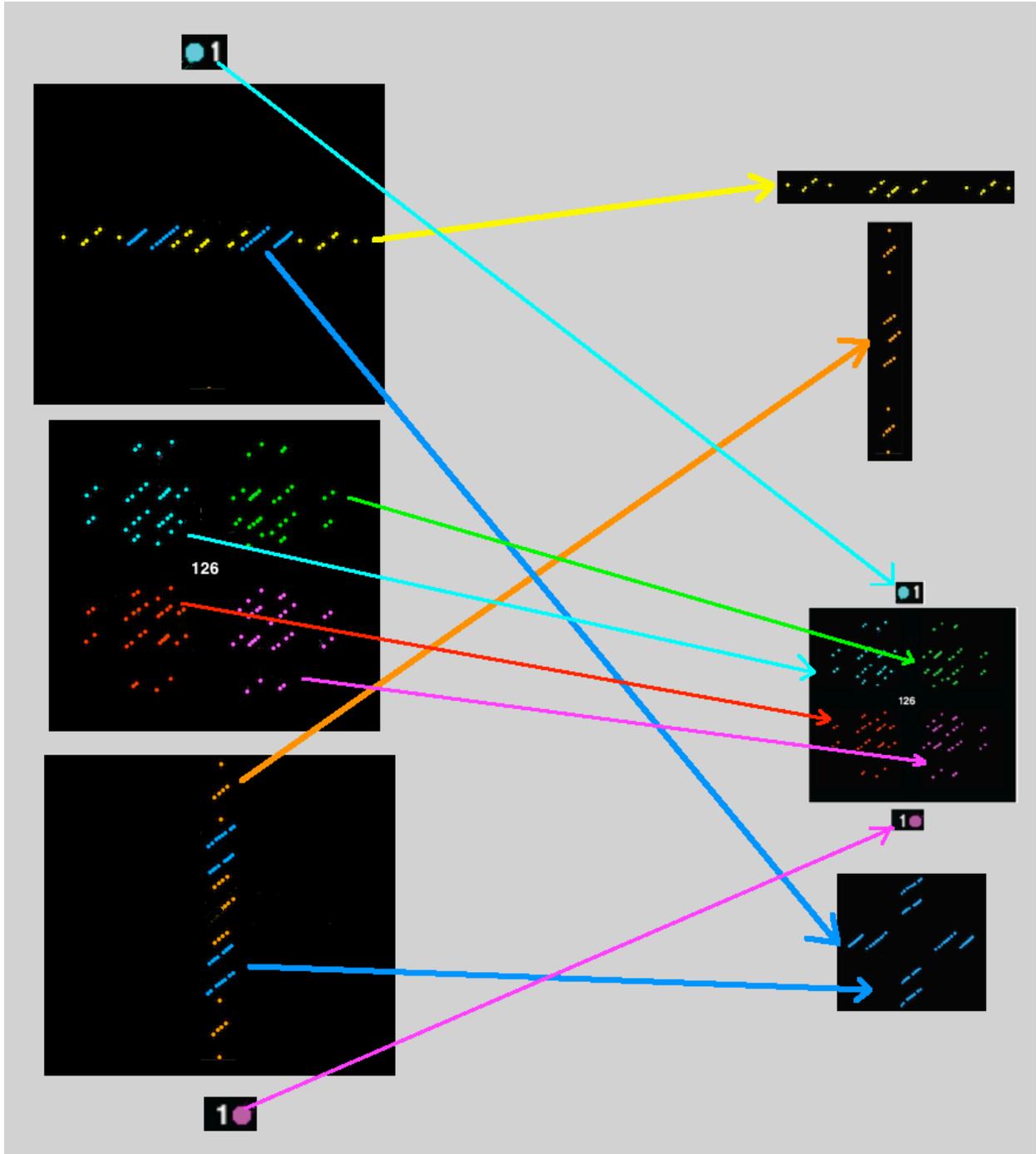
and

put the Spacetime Root Vectors  
into the Spacetime Base Manifold over which the Lagrangian Density is integrated.

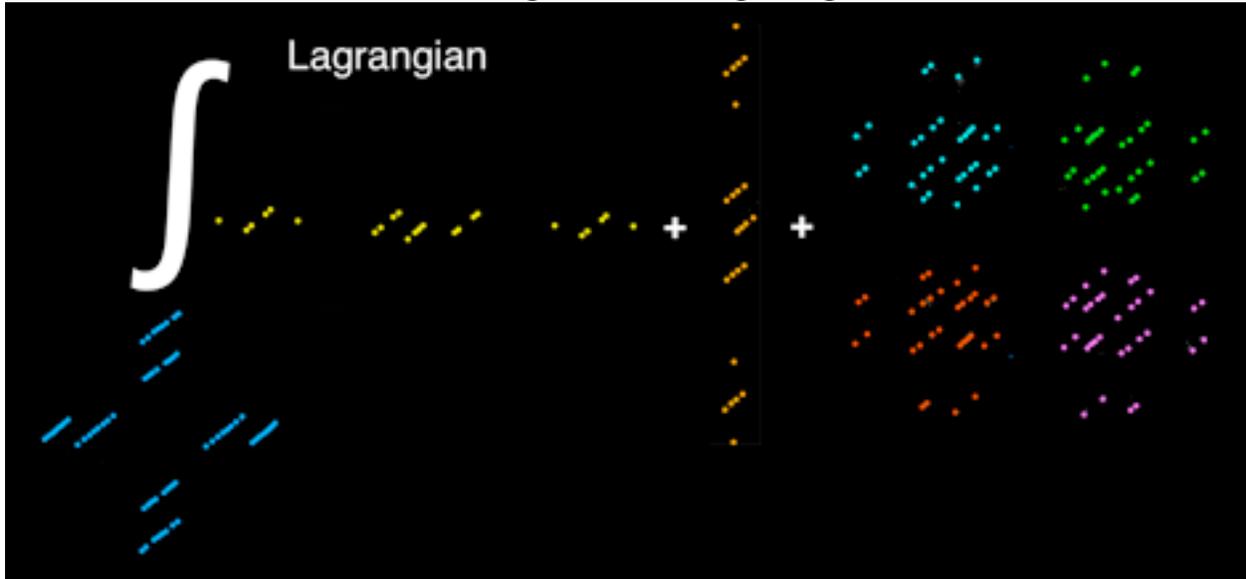
In terms of the preceding pictures of physics of E8 Root Vectors  
the Code or Recipe gives a Lagrangian that is a realistic physics model.

Of course, to completely carry out the Code or Recipe you need to write out  
the Lagrangian terms in the math language of conventional physics  
and that is described in some of the long papers I have written  
(see my web site and my viXra papers).

Here I am just trying to show the basic underlying structure of E8 Geometry  
so I am not writing down the extensive details in this paper.

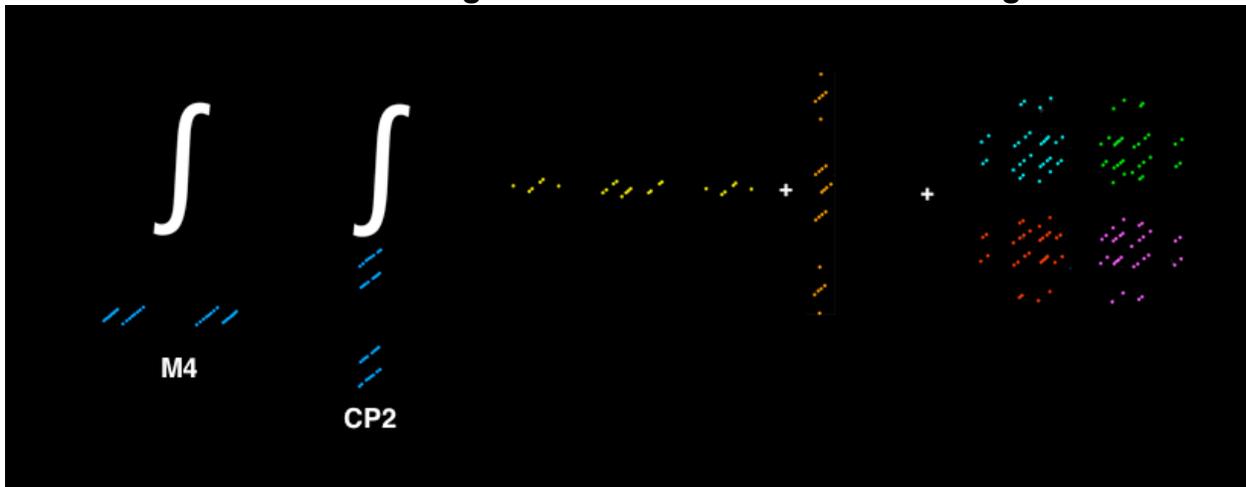


The fundamental Lagrangian formed by this structure is an Octonionic structure over 8-dim Spacetime and is effective during the Initial Big Bang and Inflation.



Since Octonionic Quantum Field Theory is NOT Unitary, Particle / AntiParticle Creation occurs during Inflation.

Inflation Ends when a preferred Quaternionic Subspacetime freezes out, converting 8 dim Spacetime into 4+4 dim M4 x CP2 Spacetime where M4 = Physical Minkowski Spacetime and CP2 = SU(3) / U(2) Internal Symmetry Space and the Octonionic Integral becomes two Quaternionic Integrals



Here is how the Witting 240-Polytope splits into two 600-Cells:

240 Vertex Witting Polytope

Neutrino Time Component

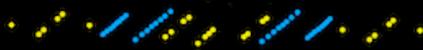


1

North Pole

Conformal Gravity  
Gauge Bosons  
Standard Model  
Ghosts

$$56 = 24 + 32$$



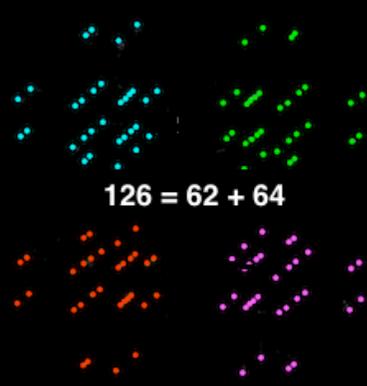
$$56 = 24 + 32$$

North Temperate Zone

M4 Physical Spacetime

Fermion Particles

$$126 = 62 + 64$$



$$126 = 62 + 64$$

Equator

AntiParticles

CP2 Standard Model  
Internal Symmetry Space

56

=

24

+

32



$$56 = 24 + 32$$

South Temperate Zone

Standard Model  
Gauge Bosons  
Conformal Gravity  
Ghosts

AntiNeutrino Time Component



1

South Pole

In more detail, start with the North Pole.

Then the North Pole has 56 nearest neighbors that live on a North Temperate Zone which is a fixed Latitude Angle from the North Pole and is a 6-dim sphere Latitude subset of the 7-dim sphere.

The 56 are of two kinds:

32 describing half of 8-dim Spacetime

for 4-dim Minkowski Physical Spacetime and

24 describing Gauge Bosons and Ghosts for Gravity and the Standard Model.

The 32 Spacetime-type vertices live on the Equator of the 6-dim sphere and are distributed on that 5-dim sphere as one half of the 64 vertices of a hypercube in 6-dim space.

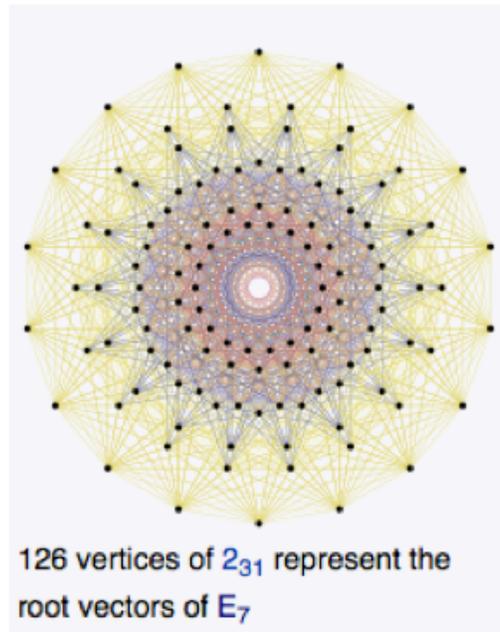
12 of the 24 live on a North Temperate Latitude of the 6-dim sphere

The other 12 of the 24 live on a South Temperate Latitude of the 6-dim sphere.

Then there are 126 next-nearest neighbors to the North Pole.

They live on the Equator of the 7-dim sphere

and are distributed on that 6-dim sphere as the Root Vectors of the  $E_7$  Lie Algebra



They correspond to 126 of the 128 components of 8+8 Fermion Particles+AntiParticles.

Then are the 56 nearest neighbors of the South Pole that of a South Temperate Zone which is a fixed Latitude Angle from the South Pole and is a 6-dim sphere Latitude subset of the 7-dim sphere.

The 56 are of two kinds:

32 describing half of 8-dim Spacetime

for 4-dim  $CP^2$  Standard Model Internal Symmetry Space and

24 describing Gauge Bosons and Ghosts for the Standard Model and Gravity.

The 32 Spacetime-type vertices live on the Equator of the 6-dim sphere and are distributed on that 5-dim sphere as the other half of the 64 vertices of a hypercube in 6-dim space.

12 of the 24 live on a North Temperate Latitude of the 6-dim sphere

The other 12 of the 24 live on a South Temperate Latitude of the 6-dim sphere.

Then there is finally the South Pole. The 240-Polytope decomposes into two 120-vertex 600-Cells

## The 240-Polytope splits into two 120-vertex 600-Cells:

Sadoc and Mosseri in their book “Geometrical Frustration” (Cambridge 1999, 2006), say: “...

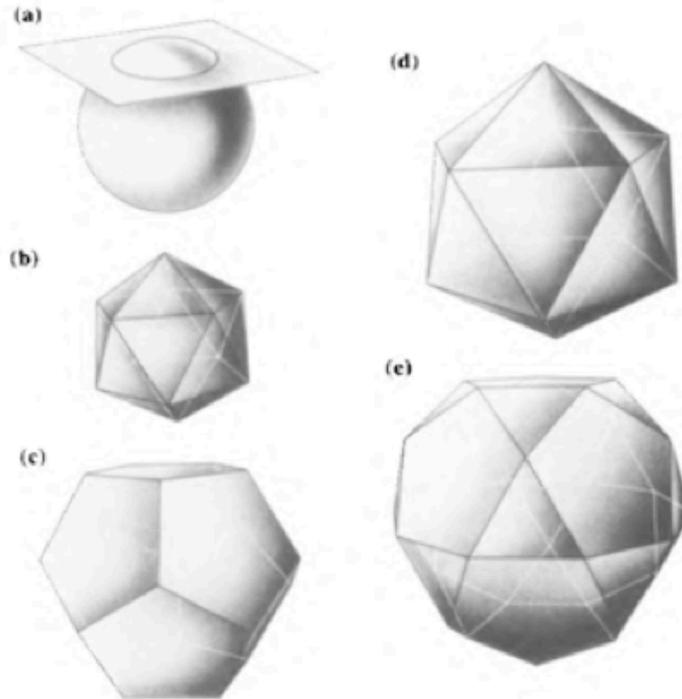


Fig. A5.1. The  $\{3, 3, 5\}$  polytope. Different flat sections in  $S^3$  (with one site on top) give the following successive shells; (a) an icosahedral shell formed by the first 12 neighbours, (b) a dodecahedral shell, (c) a second and larger icosahedral shell, (d) an icosidodecahedral shell on the equatorial sphere. Then other shells are symmetrically disposed in the second ‘south’ hemi-hypersphere, relative to the equatorial sphere (e).

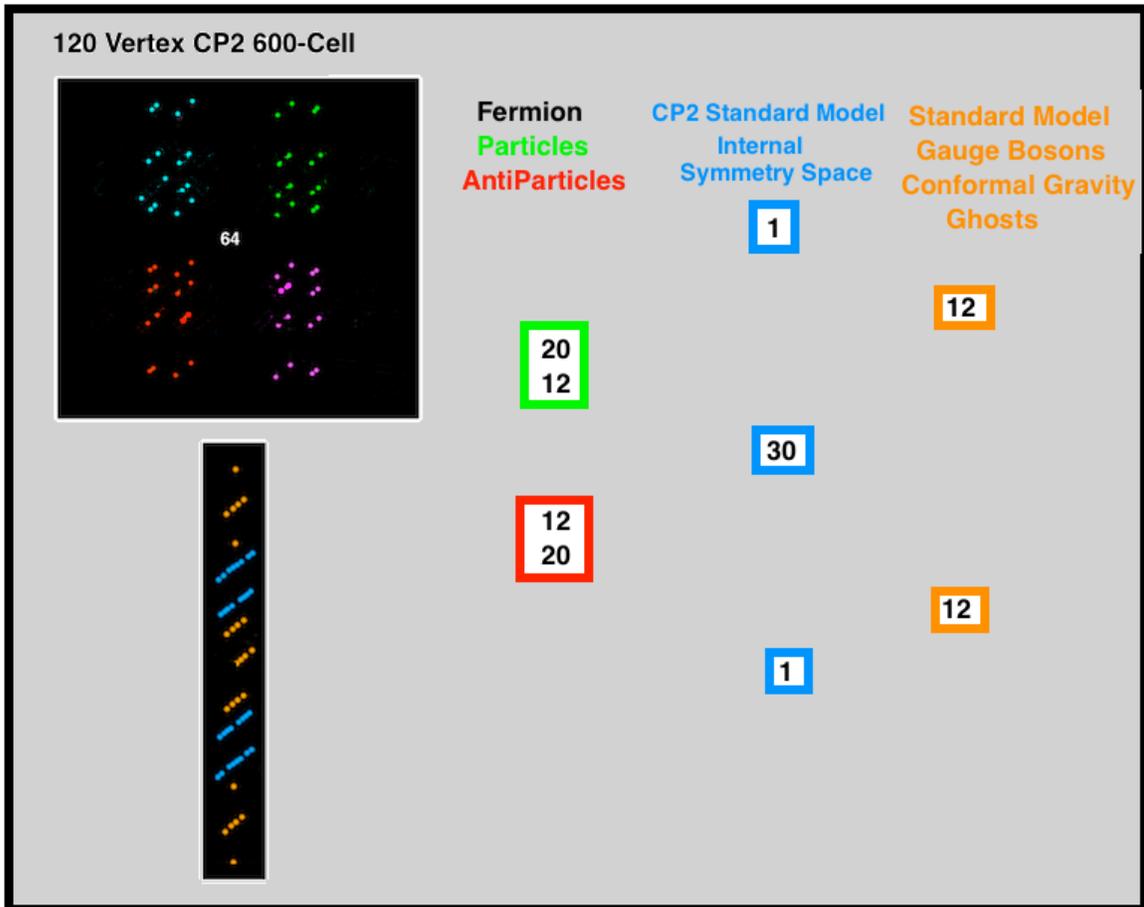
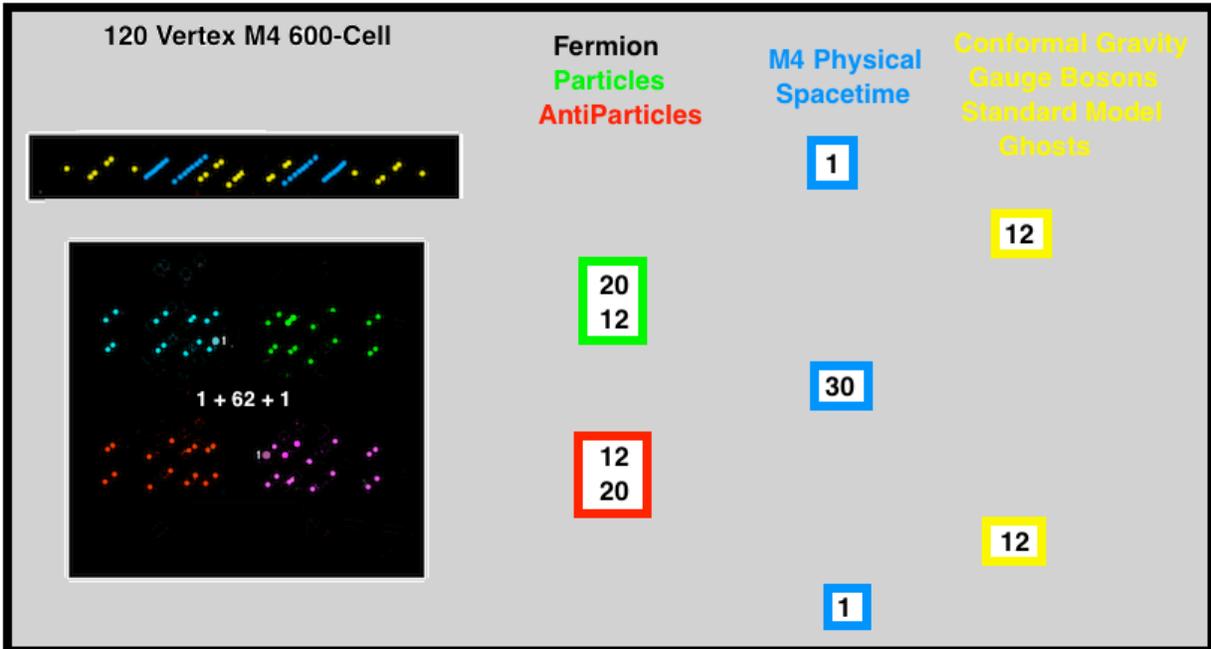
Table A5.1. Sections of the  $\{3, 3, 5\}$  polytope (with an edge length equal to  $2\tau^{-1}$ ) beginning with a vertex

Section	$x_0$	$(x_1, x_2, x_3)^{\dagger}$	Vertex number	Shape
0	2	(0, 0, 0)	1	point
1	$\tau$	(1, 0, $\tau^{-1}$ )	12	icosahedron
2	1	(1, 1, 1)	20	dodecahedron
		( $\tau, \tau^{-1}, 0$ )		
3	$\tau^{-1}$	( $\tau, 0, 1$ )	12	icosahedron
4	0	(2, 0, 0)	30	icosidodecahedron
		( $\tau, 1, \tau^{-1}$ )		
5	$-\tau^{-1}$	( $\tau, 0, 1$ )	12	icosahedron
6	-1	(1, 1, 1)	20	dodecahedron
		( $\tau, \tau^{-1}, 0$ )		
7	$-\tau$	(1, 0, $\tau^{-1}$ )	12	icosahedron
8	-2	(0, 0, 0)	1	point

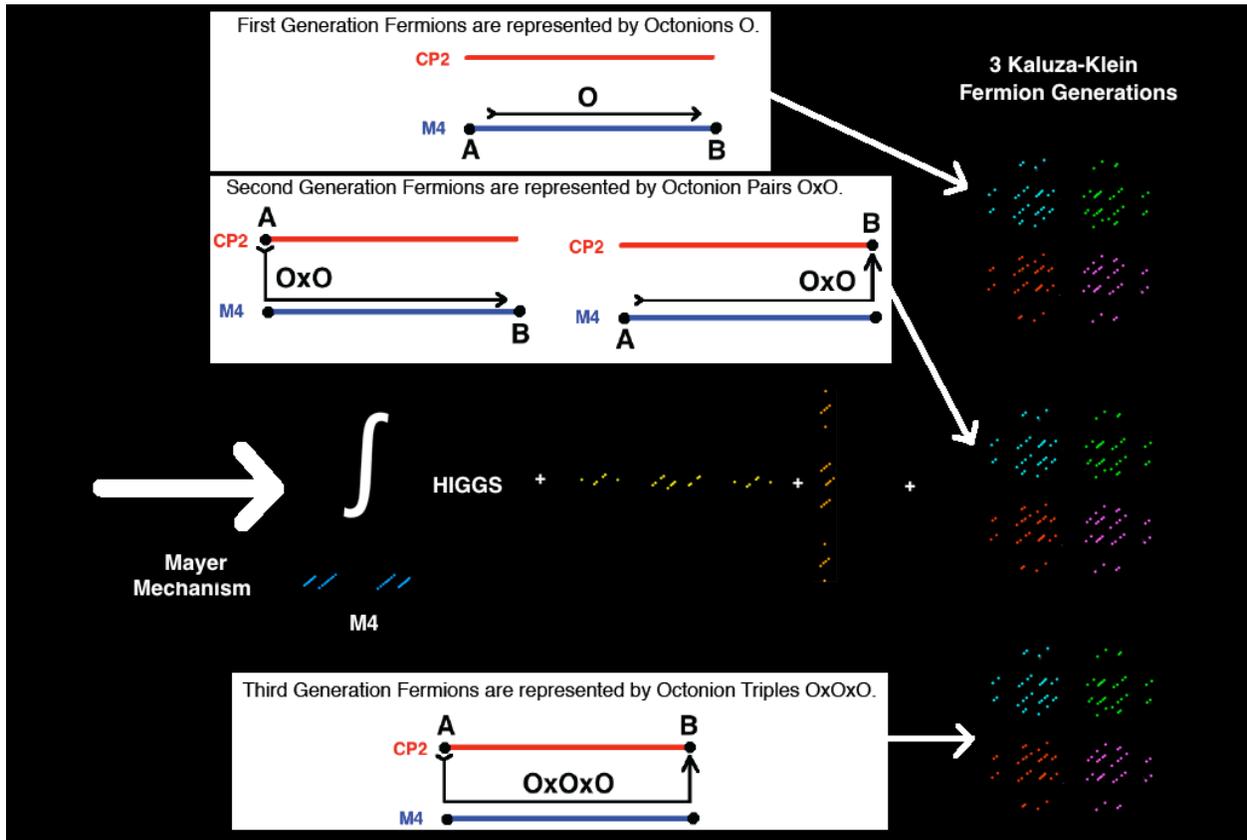
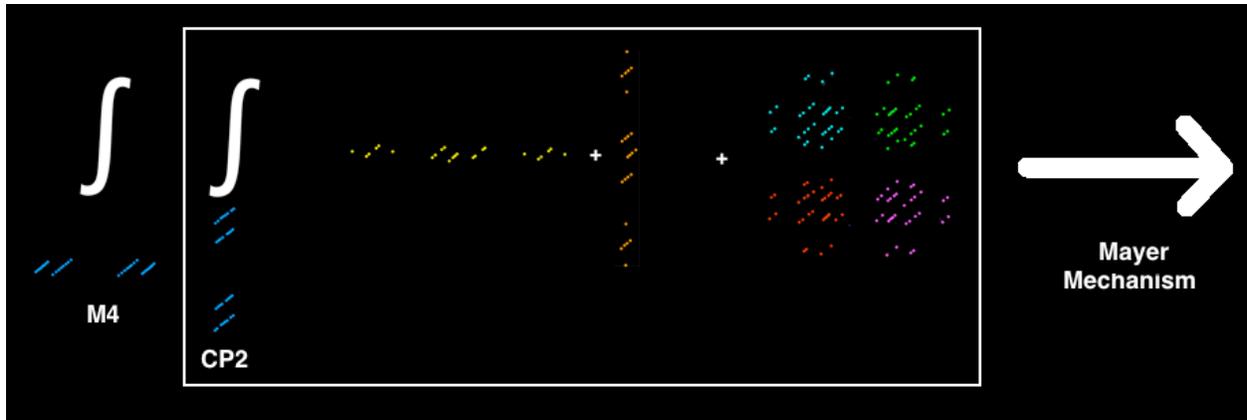
<sup>†</sup>Cyclic permutation with all possible changes of signs.  $\tau = (1 + \sqrt{5})/2$ .

...”

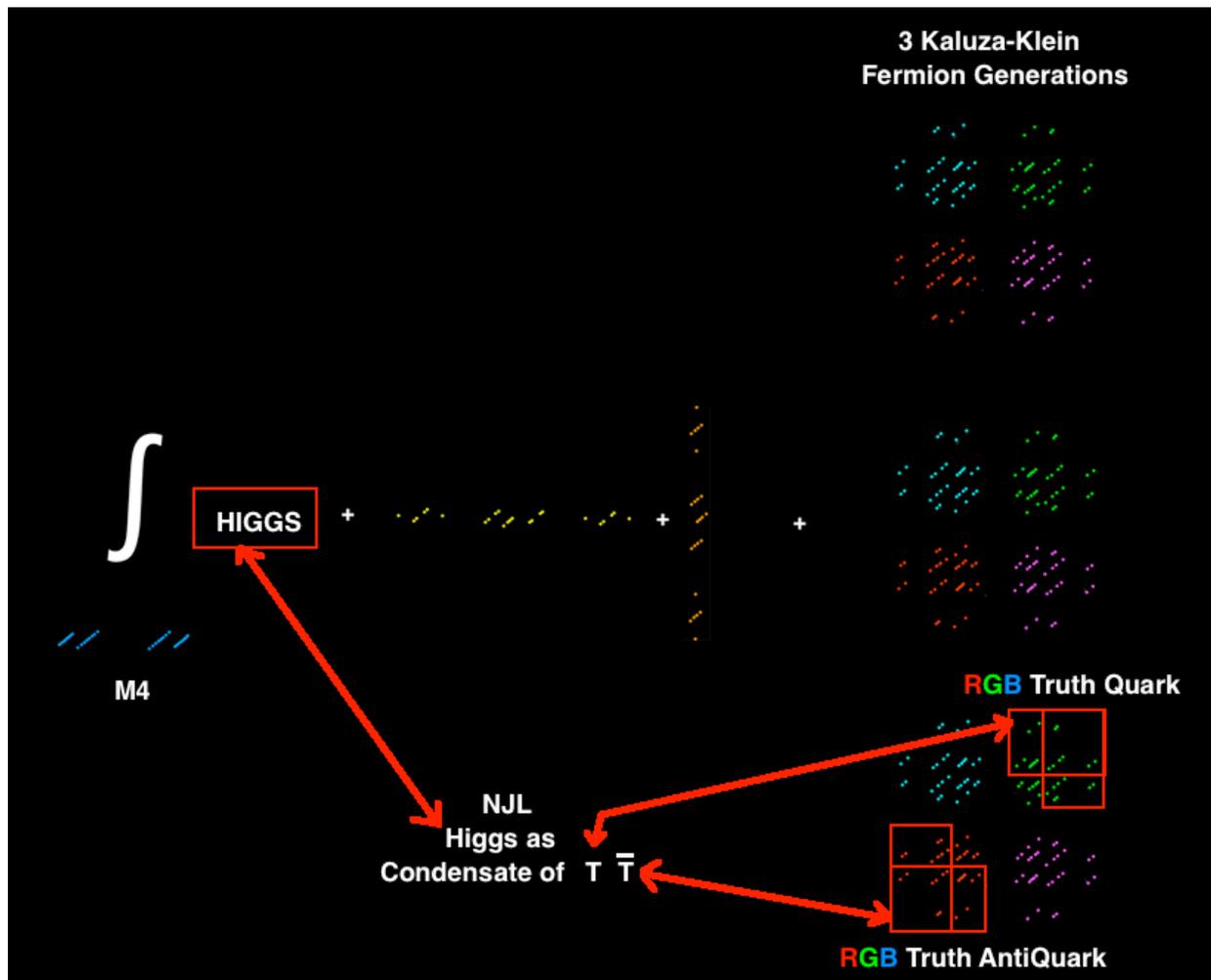
One 600-Cell represents M4 and the other 600-Cell represents CP2:



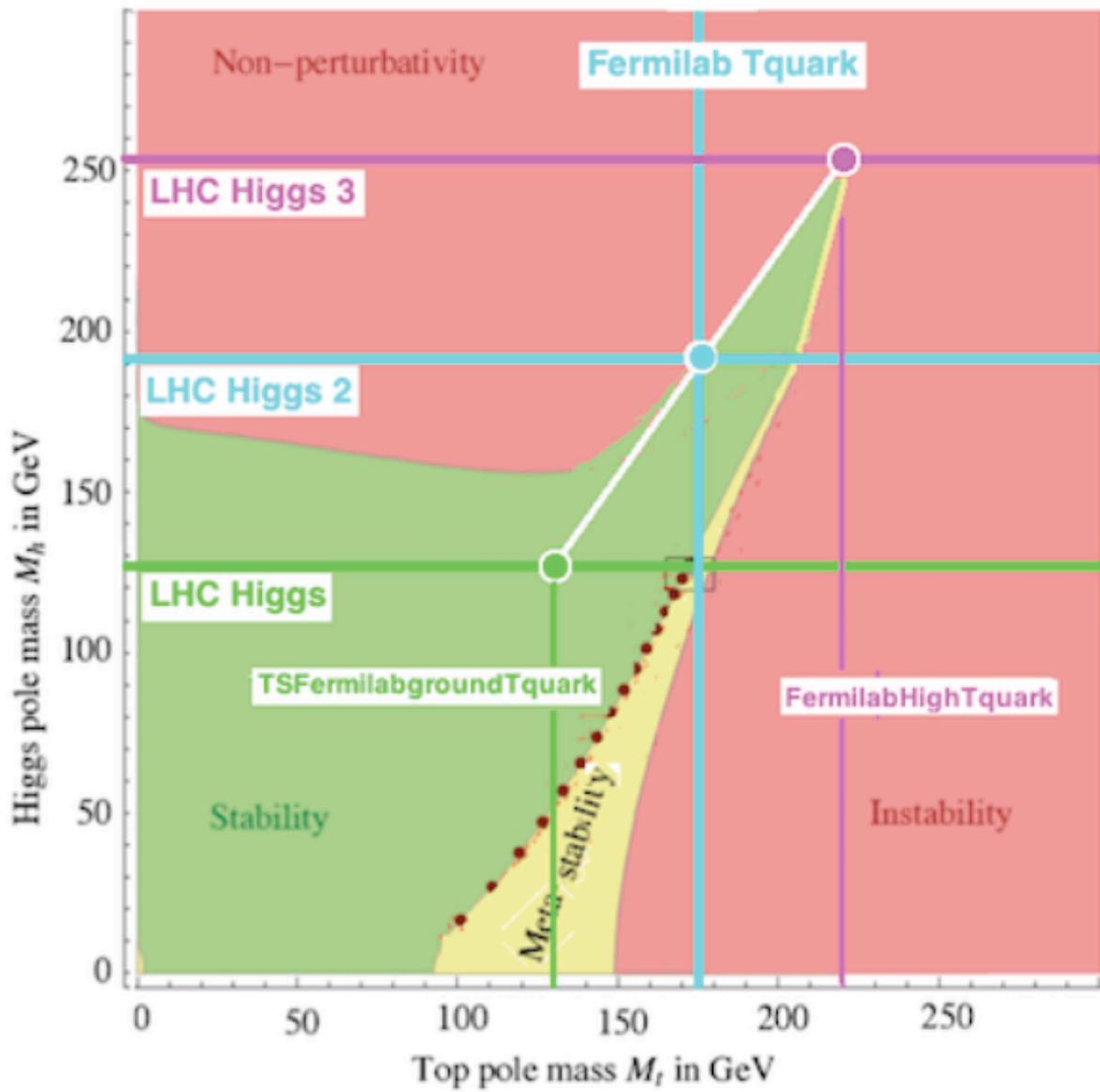
Splitting Octonionic Spacetime into Quaternionic  $M4 \times CP2$  Kaluza-Klein over  $CP2$  produces  
Higgs by the Mayer Mechanism and  
Second and Third Generation Fermions



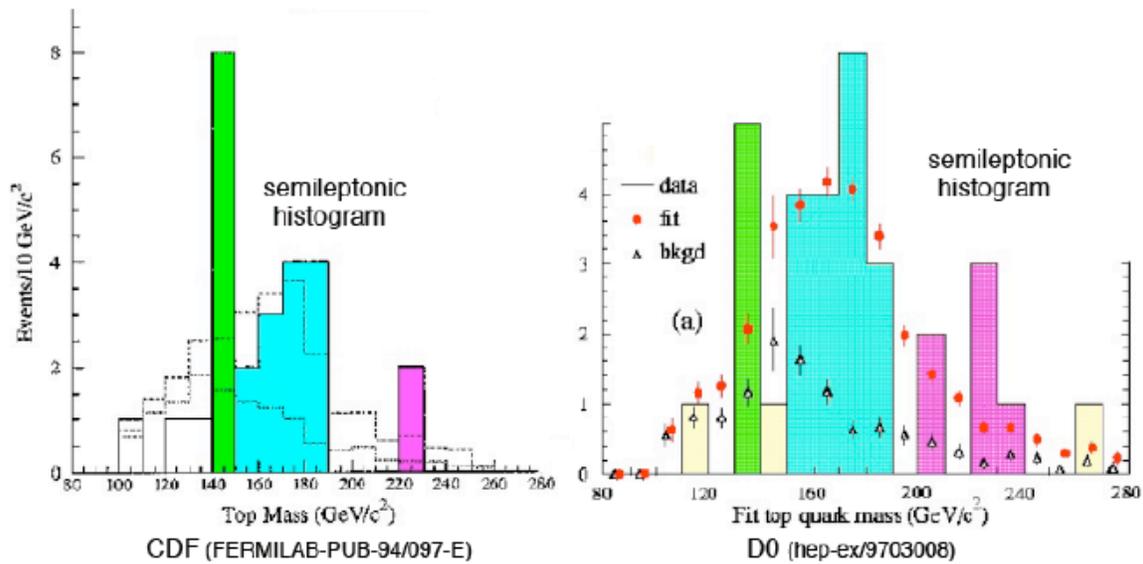
By generalizations of the Nambu-Jona-Lasinio mechanism  
Higgs is a Fermion Particle-AntiParticle Condensate  
which, since the Truth Quark is by far the most massive Fermion,  
effectively means that Higgs is a Truth Quark - Truth AntiQuark Condensate.



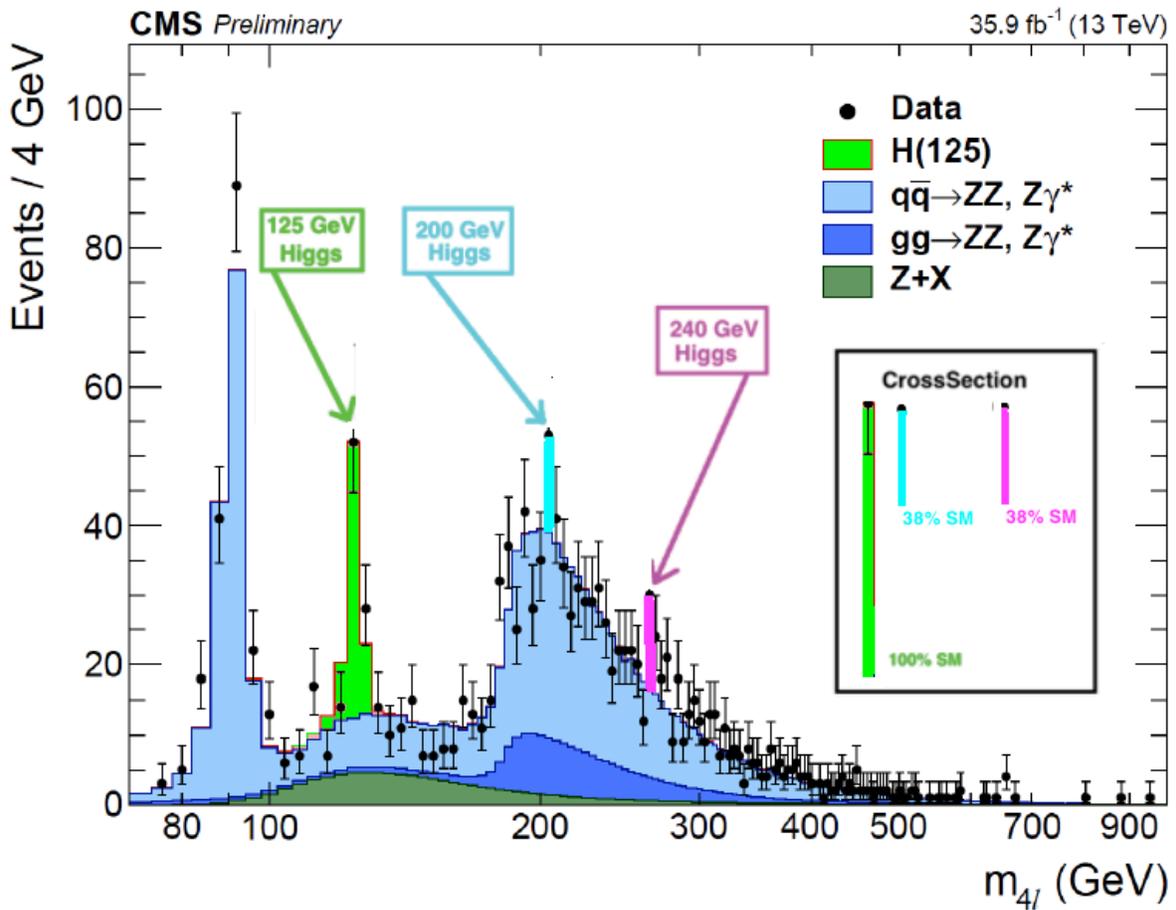
Higgs - Truth Quark System has 3 mass states for Higgs and for Truth Quark that have (in my opinion) been seen by Fermilab and LHC experiments

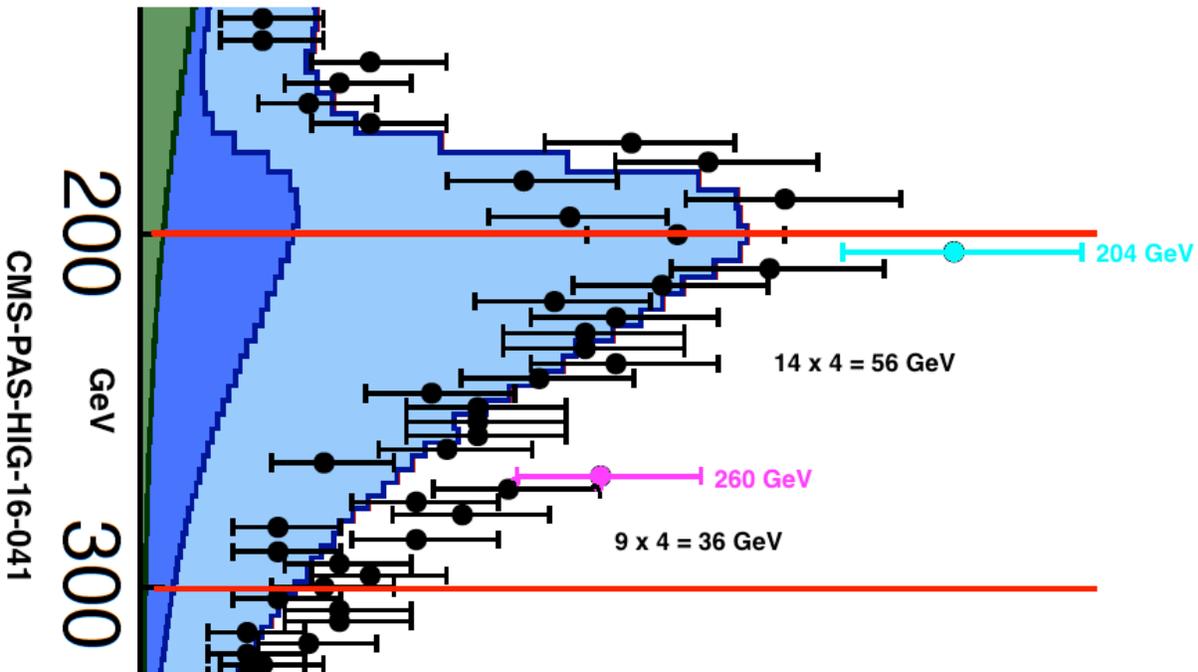


### Semileptonic histograms of CDF and D0 show 3 Truth Quark Mass States



### Higgs -> ZZ -> 4l channel histogram of CMS shows 3 Higgs Mass States





The histogram, from CMS-PAS-HIG-16-041 discussed at Moriond March 2017, has bins of 4 GeV width, so that CMS analysis shows two higher Higgs mass states:  
middle-mass Higgs state (cyan) with mass 204 GeV  
high-mass Higgs state (magenta) with mass 260 GeV

The CMS observation of 260 GeV for the high-mass Higgs state is somewhat higher than the theoretical value given by Koichi Yamawaki in hep-ph/9603293 where he says: "... the four-fermion theory in the presence of gauge interactions (... gauged Nambu-Jona-Lasinio (NJL) ... model ) can become renormalizable and nontrivial ... The Higgs boson was predicted as a  $t\bar{t}$  bound state ... Its mass was ... calculated by BHL ... [ Bardeen-Hill-Lindner ] ... through the full RG equation ... the result being ...  $MH = m_t \times 1.1$  at  $10^{19}$  GeV ...[which gives]...  $MH = 239 \pm 3$  GeV ...".

The CMS observation of 204 GeV for the middle-mass Higgs state is also somewhat higher than the theoretical value given by Hashimoto, Tanabashi, and Yamawaki in hep-ph/0311165 where they say: "... We perform the most attractive channel (MAC) analysis in the top mode standard model with TeV-scale extra dimensions for ...[ Kaluza-Klein type ]... dimension...  $D=8$  ...  $m_t = 172-175$  GeV and  $m_H=176-188$  GeV ...".

In both cases  
the CMS observed mass is about 20 GeV higher than the theoretical mass  
which is close enough to show that the theory is fundamentally realistic  
but indicates that further experimental data and study of data analysis  
and consideration of refinements of the theoretical models would be useful.

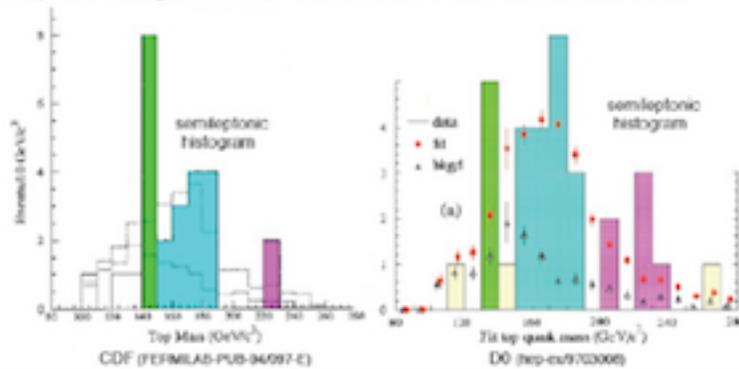
**Consensus 1-state Higgs and Tquark give Metastable Universe  
but E8 3-state Higgs and Tquark gives Stable Universe at Low Energy  
and 8-dim Kaluza-Klein Compositeness at Medium Energy  
and Full Electroweak Symmetry at High Energy**

The Consensus View of experimental results of the LHC and Fermilab is that there is only one Higgs state and it is the 125 GeV state and everything else seen by the LHC is statistical fluctuation and that there is only one Tquark state and it is the 174 GeV state and everything else seen by Fermilab or the LHC is statistical fluctuation.

Based on the history of Fermilab analyses since the 1990s and on the fact at Moriond 2017 for the channel  $H \rightarrow ZZ^* \rightarrow 4l$  Oda's slide 14 about ATLAS analysis covered only Higgs masses 80 to 170 GeV and Mei's slide 2 about CMS analysis covered only Higgs masses 70 to 170 GeV it seems likely that all Higgs mass analysis of 2017 data will be only for the region 70 to 170 GeV so that the two higher-mass Higgs states of E8 physics will forever be ignored.

A similar thing happened with analyses of Tquark mass states at Fermilab in the 1990s.

Semileptonic histograms of CDF and D0 show 3 Truth Quark Mass States



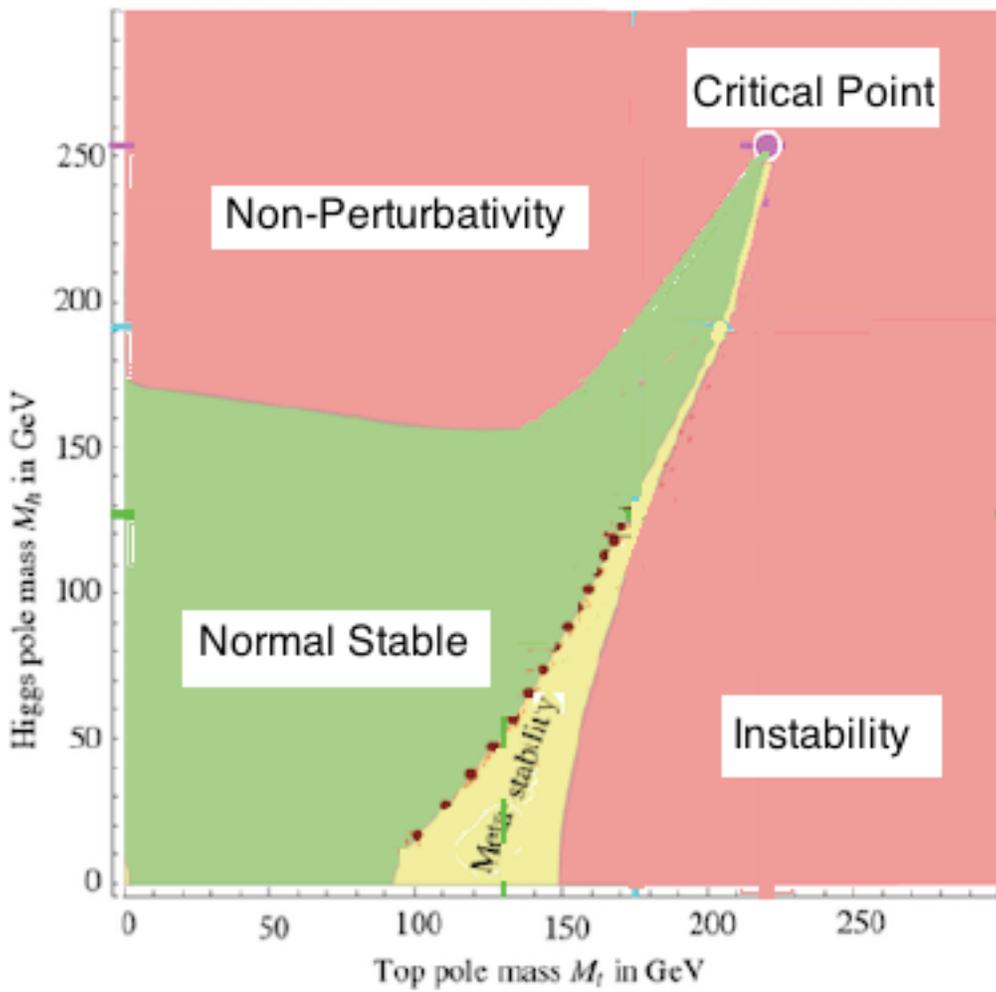
Then the Fermilab Consensus decided: that there is only one Tquark mass state; that it is the 174 GeV central (cyan) peak; and that the green and magenta peaks predicted by E8 physics are only statistical fluctuations. Therefore later Fermilab analyses experiments ignored the green and magenta peaks.

**What does this mean for physics ?**

It means that every physics student has been since the 1990s and will be from now on taught that the Standard Model has only one Higgs mass state (125 GeV) and one Tquark mass state (174 GeV).

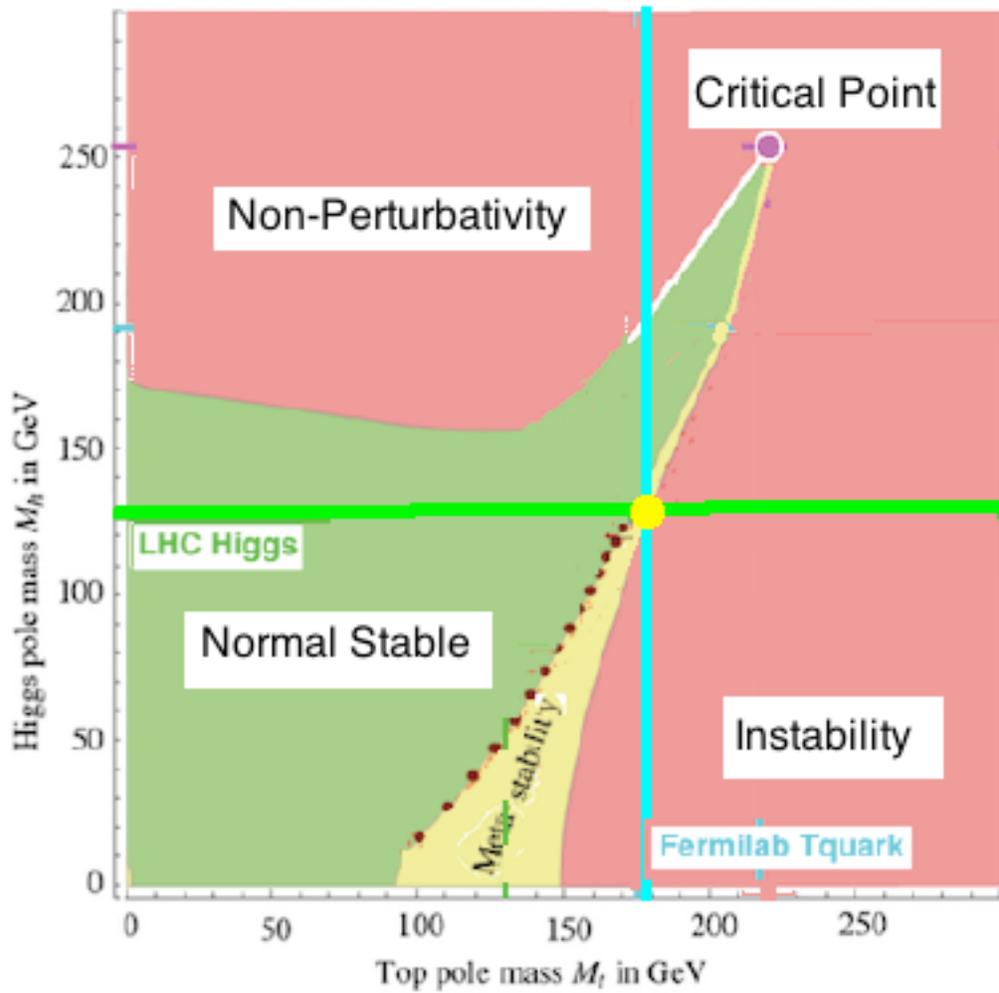
**WHAT IS WRONG WITH THAT ?  
WHAT REAL DIFFERENCE WOULD IT MAKE TO FOLLOW THE CONSENSUS ?**

If you use the Standard Model to plot Higgs mass against Tquark mass you get this phase diagram:



**Where is the Consensus View on the Phase Diagram ?**

The Consensus View of one Higgs at 125 GeV and one Tquark at 174 GeV gives a METASTABLE UNIVERSE that might destroy itself at any moment:



How about the E8 physics model with 3-state Higgs and 3-state Tquark ?

In the E8 physics 3-state model there are 3 intersections:

- low mass H with low mass Tq
- medium mass H with medium mass Tq
- high mass H with high mass Tq

Those 3 intersections are, respectively:

in the Normal Stable region - with STABLE Universe

on the boundary line of non-perturbativity - at which Higgs compositeness and 8-dim Kaluza-Klein spacetime structure become manifest ( see hep-ph/0311165 by Hashimoto, Tanabashi, and Yamawaki )

at the critical point - beyond which Electroweak Symmetry is NOT broken and W and Z bosons stay massless

