

# E8 Physics Fermions: 3 Conformal Generations

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The E8 Lie Algebra of the E8 Physics Model contains two D4 Lie subalgebras:

248-dim E8 = 120-dim D8 + 128-dim half-spinor of D8

120-dim D8 = 28-dim D4 + 28-dim D4 + 64-dim D8 / D4xD4

**One of the D4** contains an A2 = SU(3) Lie subalgebra that represents the Color Force of the Standard Model.

The Weak and Electromagnetic Forces are produced by a Batakis mechanism

(see Class. Quantum Grav. 3 (1986) L99-L105 by N. A. Batakis) in which spacetime is 8-dimensional Kaluza-Klein M4 x CP2.

Color Force SU(3) acts globally on CP2 = SU(3) / SU(2)xU(1) and,

due to Kaluza-Klein structure, acts as local gauge group on M4 Minkowski spacetime.

Local gauge group action of Weak SU(2) and Electromagnetic U(1) Forces comes from their being local isotropy groups of the symmetric space CP2.

Casimir Operators describe some physical properties of the Standard Model Forces:

A0 Lie algebra U(1) has trivial Weyl Group 1

and trivial Casimir of degree 1

so that the Photon carries no charge.

A1 Lie algebra SU(2) has Weyl Group S2 of order 2! = 2

and quadratic Casimir of degree 2 representing isospin

so that SU(2) Weak Bosons can carry Electromagnetic Charge.

A2 Lie algebra SU(3) has Weyl Group S3 of order 3! = 6

and two Casimir Operators of degrees 2 and 3:

a quadratic Casimir representing 2 { + , - } isospin charge states and

a cubic Casimir representing 3 { red, green, blue } colors

so that SU(3) Gluons can carry Electromagnetic Charge and Color Charge.

**The other D4** contains an A3 = D3 Conformal Lie subalgebra that represents

Gravity by a generalized MacDowell-Mansouri mechanism (see section 14.6 of Rabintra Mohapatra's book "Unification and Supersymmetry", 2nd edition, Springer-Verlag 1992).

The Conformal Group in the form SU(2,2) = Spin(2,4) is described by

Robert Gilmore in his books "Lie Groups, Lie Algebras, and Some of Their Applications", Wiley 1974, and "Lie Groups, Physics, and Geometry", Cambridge 2008.

The Conformal Group has a Weyl Group of  $2^2 \times 3! = 24$  elements

and has 3 Casimir Operators of degrees 2 and 4 and  $6/2 = 3$ .

**The Conformal degree 3 Casimir represents the 3 Generations of Fermions**

(instead of the 3 colors as in the case of the Standard Model D4 of E8).

In its D3 Spin(2,4) form the Conformal Lie algebra can be represented as a 6x6 antisymmetric real matrix:

$$\begin{matrix}
 0 & J1 & J2 & M1 & A1 & G1 \\
 -J1 & 0 & J3 & M2 & A2 & G2 \\
 -J2 & -J3 & 0 & M3 & A3 & G3 \\
 -M1 & -M2 & -M3 & 0 & A4 & G4 \\
 -A1 & -A2 & -A3 & -A4 & 0 & G5 \\
 -G1 & -G2 & -G3 & -G4 & -G5 & 0
 \end{matrix}$$

{J1,J2,J3} form a Spin(0,3) subalgebra of Spin(2,4) and produce a quadratic Casimir Operator that represents an Angular Momentum Operator.

Adding {M1,M2,M3} forms a Spin(1,3) subalgebra of Spin(2,4) and produces a second quadratic Casimir Operator that represents a Laplace-Runge-Lenz Operator.

Adding {A1,A2,A3} and {A4} forms a Spin(2,3) AntiDeSitter subalgebra of Spin(2,4) with a quartic Casimir Operator that is a combination of {M1,M2,M3} and {A1,A2,A3}. {A1,A2,A3} represent Momentum and {A4} represents Energy/Mass of Poincare Gravity and its Dark Matter Primordial Black Holes.

Adding {G1,G2,G3} and {G4} and {G5} forms the full Spin(2,4) and produces a cubic Casimir Operator for representation of 3 Generations of Fermions. The {G1,G2,G3} represent 3 Higgs components giving mass to 3 Weak Bosons. and {G4} represents massive Higgs Scalar as Fermion Condensate. As Special Conformal and Scale degrees of freedom they also represent the Momentum of Expansion of the Universe and its Dark Energy.

Adding {G5} represents Higgs/Fermion mass of Ordinary Matter.

The Higgs as a Fermionic Condensate gives mass to Fermions. The fundamental Fermion Particles are those of the First Generation:

{neutrino, red down quark, green down quark, blue down quark;  
electron, red up quark, green up quark, blue up quark}

They can be represented as basis elements {1,i,j,k,E,I,J,K} of Octonions O.

Each of {A4} and {G4} and {G5} can represent the mass of Fundamental Fermions.

The {A4} Conformal substructure

$$\begin{array}{cc} 0 & A4 \\ -A4 & 0 \end{array}$$

represents First Generation Fermion Particles as Octonion basis elements O.

The {A4} plus {G5} Conformal substructure

$$\begin{array}{ccc} 0 & A4 & \\ -A4 & 0 & G5 \\ & -G5 & 0 \end{array}$$

represents Second Generation Fermion Particles as Octonion Pairs OxO.

The {A4} and {G5} plus {G4} Conformal substructure

$$\begin{array}{ccc} 0 & A4 & G4 \\ -A4 & 0 & G5 \\ -G4 & -G5 & 0 \end{array}$$

represents Third Generation Fermion Particles as Octonion Triples OxOxO.

Fermion AntiParticles are represented in a similar way.

Combinatorics of O and OxO and OxOxO produce realistic Fermion masses, as calculated in detail in viXra 1108.0027

The Third Generation Truth Quark (Tquark) is by far the most massive Fermion so the Higgs as a Fermionic Condensate is effectively a Tquark Condensate.

Note:

E8 has 8 Casimir Operators of degrees 2, 8, 12, 14, 18, 20, 24, 30

The Conformal quadratic 2 is in E8, the Conformal quartic 4 is in the 8 of E8, and the Conformal cubic  $6/2 = 3$  is in the 12 of E8.

D8 has 8 Casimir Operators of degrees 2, 4, 6, 8, 10, 12, 14, 8

The Conformal quadratic 2 and quartic 4 are in D8 and the Conformal cubic  $6/2 = 3$  is in the 6 of D8.

D4 has 4 Casimir Operators of degrees 2, 4, 6, 4

The Conformal quadratic 2 and quartic 4 are in D4 and the Conformal cubic  $6/2 = 3$  is in the 6 of D4.

SUMMARY:

The Conformal Group in the form  $SU(2,2) = Spin(2,4)$  is described by Robert Gilmore in his book "Lie Groups, Physics, and Geometry", Cambridge 2008: "... 8x8 matrices acting on the four coordinates and the four momenta ... satisfy an antisymmetric ... symplectic metric ... preserve[d by the] ... group ...  $Sp(8;\mathbb{R})$  ... [and a]... symmetric metric ... with signature (+4,-4) ... preserve[d by the] ... group ...  $SO(4,4)$  ...

$$Sp(8; \mathbb{R}) \cap SO(4, 4) = SU(2, 2) \simeq SO(4, 2)$$

... The fifteen-dimensional Lie algebra for the Dirac equation is ... summarized by the 6x6 matrix

$$\begin{bmatrix} 0 & J_3 & -J_2 & M_1 & A_1 & \Gamma_1 & + \\ -J_3 & 0 & J_1 & M_2 & A_2 & \Gamma_2 & + \\ J_2 & -J_1 & 0 & M_3 & A_3 & \Gamma_3 & + \\ -M_1 & -M_2 & -M_3 & 0 & A_4 & \Gamma_4 & + \\ \hline A_1 & A_2 & A_3 & A_4 & 0 & \Gamma_5 & - \\ \Gamma_1 & \Gamma_2 & \Gamma_3 & \Gamma_4 & -\Gamma_5 & 0 & - \end{bmatrix}$$

... three ... operators  $A_4$ ,  $G_4$ ,  $G_5$  close under commutation and span ...  $so(2,1)$  ... The Casimir operator for this [sub]algebra is  $C^2 = G_5^2 - G_4^2 - A_4^2$  ... [ It can be ]... used to determine eigenstates and energy eigenvalues ...".

- $\{J_1, J_2, J_3\}$  represent Angular Momentum.  $\{M_1, M_2, M_3\}$  represent LaPlace-Runge-Lenz.
- $\{A_1, A_2, A_3\}$  represent Momentum.
- $\{G_1, G_2, G_3\}$  represent Higgs for W-Bosons and Momentum of Universe Expansion.
- $\{A_4\}$  and  $\{G_4\}$  and  $\{G_5\}$  represent Energy/Mass including Higgs mass for Fermions.

The  $\{A_4\}$  Conformal substructure

$$\begin{bmatrix} 0 & A_4 \\ -A_4 & 0 \end{bmatrix}$$

represents First Generation Fermion Particles as Octonion basis elements O.

The  $\{A_4\}$  plus  $\{G_5\}$  Conformal substructure

$$\begin{bmatrix} 0 & A_4 & \\ -A_4 & 0 & G_5 \\ & -G_5 & 0 \end{bmatrix}$$

represents Second Generation Fermion Particles as Octonion Pairs  $OxO$ .

The  $\{A_4\}$  plus  $\{G_5\}$  plus  $\{G_4\}$  Conformal substructure

$$\begin{bmatrix} 0 & A_4 & G_4 \\ -A_4 & 0 & G_5 \\ -G_4 & -G_5 & 0 \end{bmatrix}$$

represents Third Generation Fermion Particles as Octonion Triples  $OxOxO$ .

## Dark Energy - Dark Matter - Ordinary Matter:

The Lorentz Group is represented by 6 generators

$$\begin{array}{cccc}
 0 & J1 & J2 & M1 \\
 -J1 & 0 & J3 & M2 \\
 -J2 & -J3 & 0 & M3 \\
 -M1 & -M2 & -M3 & 0
 \end{array}$$

There are two ways to extend the Lorentz Group  
(see arXiv gr-qc/9809061 by Aldrovandi and Peireira):

To the **Poincare Group with No Cosmological Constant** by adding 4 generators

$$\begin{array}{ccccc}
 0 & J1 & J2 & M1 & A1 \\
 -J1 & 0 & J3 & M2 & A2 \\
 -J2 & -J3 & 0 & M3 & A3 \\
 -M1 & -M2 & -M3 & 0 & A4 \\
 -A1 & -A2 & -A3 & -A4 & 0
 \end{array}$$

{A1,A2,A3} represent Momentum and {A4} represents Energy/Mass of Poincare Gravity and its Dark Matter Primordial Black Holes.

and to the semidirect product of Lorentz and 4 Special Conformal generators  
to get a **Non-Zero Cosmological Constant for Universe Expansion**

$$\begin{array}{cccccc}
 0 & J1 & J2 & M1 & & G1 \\
 -J1 & 0 & J3 & M2 & & G2 \\
 -J2 & -J3 & 0 & M3 & & G3 \\
 -M1 & -M2 & -M3 & 0 & & G4 \\
 \\ 
 -G1 & -G2 & -G3 & -G4 & & 0
 \end{array}$$

so that {G1,G2,G3} represent 3 Higgs components giving mass to 3 Weak Bosons and {G4} represents massive Higgs Scalar as Fermion Condensate.  
As Special Conformal and Scale Conformal degrees of freedom they also represent the Momentum of Expansion of the Universe and its Dark Energy.

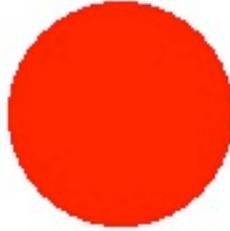
One additional generator {G5} represents Higgs/Fermion mass of Ordinary Matter.

All 15 generators combine to make the full Conformal Lie Algebra  $SU(2,2) = Spin(2,4)$

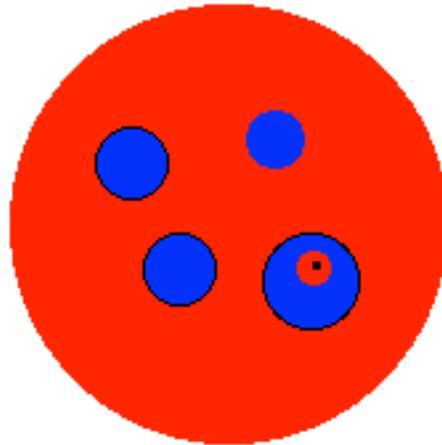
$$\begin{array}{cccccc}
 0 & J1 & J2 & M1 & A1 & G1 \\
 -J1 & 0 & J3 & M2 & A2 & G2 \\
 -J2 & -J3 & 0 & M3 & A3 & G3 \\
 -M1 & -M2 & -M3 & 0 & A4 & G4 \\
 -A1 & -A2 & -A3 & -A4 & 0 & G5 \\
 -G1 & -G2 & -G3 & -G4 & -G5 & 0
 \end{array}$$

## Dark Energy - Dark Matter - Ordinary Matter:

In E8 Physics, our 4-dimensional Physical SpaceTime **Universe** begins as a relatively small spatial volume in which all 15 generators of Conformal  $SU(2,2) = Spin(2,4)$  including all 4 Special Conformal and Scale Conformal generators are fully effective.



Rabindra Mohapatra (in section 14.6 of "Unification and Supersymmetry," 2nd edition, Springer-Verlag 1992) said: "... we start with a Lagrangian invariant under full local conformal symmetry and fix its conformal and scale gauge to obtain the usual action for gravity ... the conformal d'Alembertian contains ... curvature ...  $R$ , which for constant ... scalar field ...  $\Phi$ , leads to gravity. We may call  $\Phi$  the auxiliary field ...". I view  $\Phi$  as corresponding to the Higgs 3 Special Conformal generators  $\{G1, G2, G3\}$  that are frozen fixed during expansion in some regions of our **Universe** to become **Gravitationally Bound Domains** (such as **Galaxies**) like icebergs in an ocean of water.



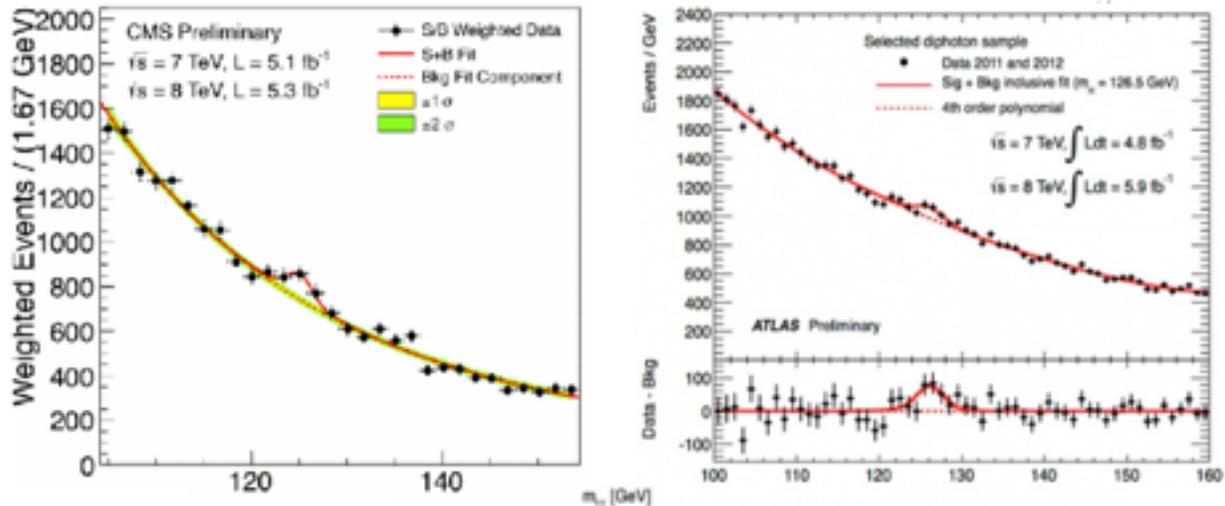
Since the **Gravitationally Bound Domains** (such as our Inner Solar System) have no Expansion Momentum we only see there the Poincare Part of Conformal Gravity plus the Higgs effects of  $\{G4\}$  and  $\{G5\}$  and the ElectroWeak Broken Symmetry caused by freezing-out fixing  $\{G1, G2, G3\}$ :

0	J1	J2	M1	A1	-
-J1	0	J3	M2	A2	-
-J2	-J3	0	M3	A3	-
-M1	-M2	-M3	0	A4	G4
-A1	-A2	-A3	-A4	0	G5
-	-	-	-G4	-G5	0

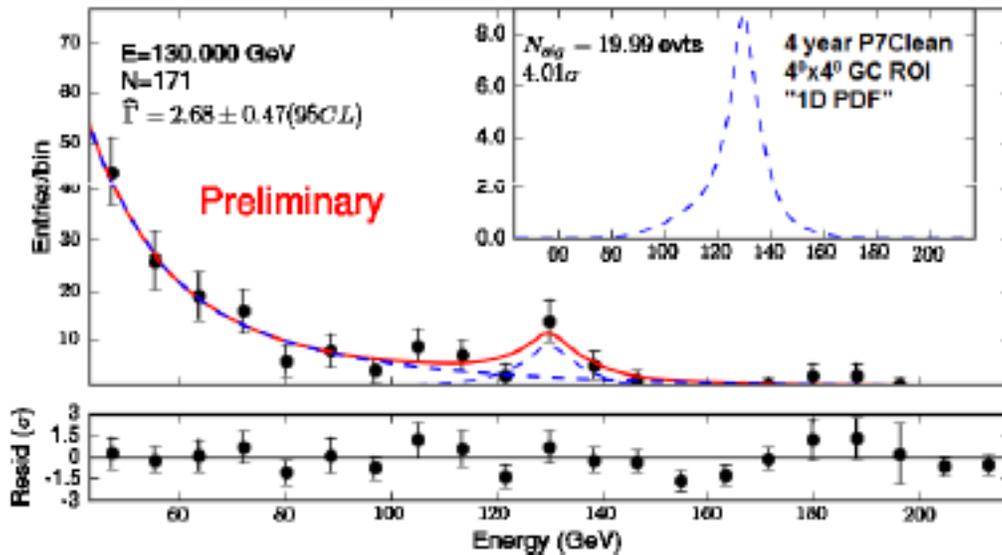
Sgr A\* and Higgs = Tquark-Tantiquark Condensate:

Sagittarius A\* (Sgr A\*) is a very massive black hole in the center of our Galaxy into which large amounts of Hydrogen fall. As the Hydrogen approaches Sgr A\* it increases in energy, ionizing into protons and electrons, and eventually producing a fairly dense cloud of infalling energetic protons whose collisions with ambient protons are at energies similar to the proton-proton collisions at the LHC.

LHC diphoton histograms for ATLAS and CMS as of mid-2012 clearly show a peak that probably is evidence of a Higgs boson with mass around 125 GeV.



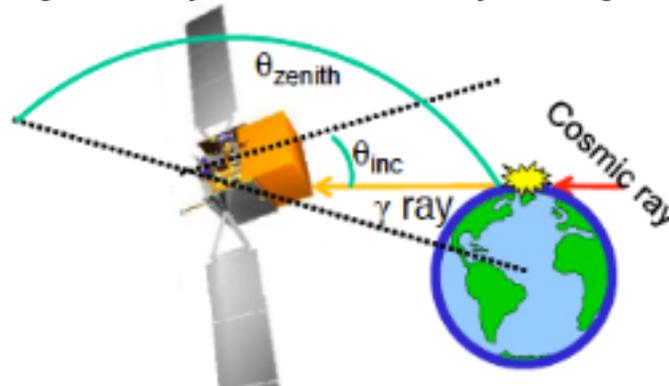
Andrea Albert at The Fermi Symposium 11/2/2012 said: "... gamma rays detectable by the Fermi Large Area Telescope [ FLAT ] ...



... Line-like Feature near 135 GeV ... localized in the galactic center ...".

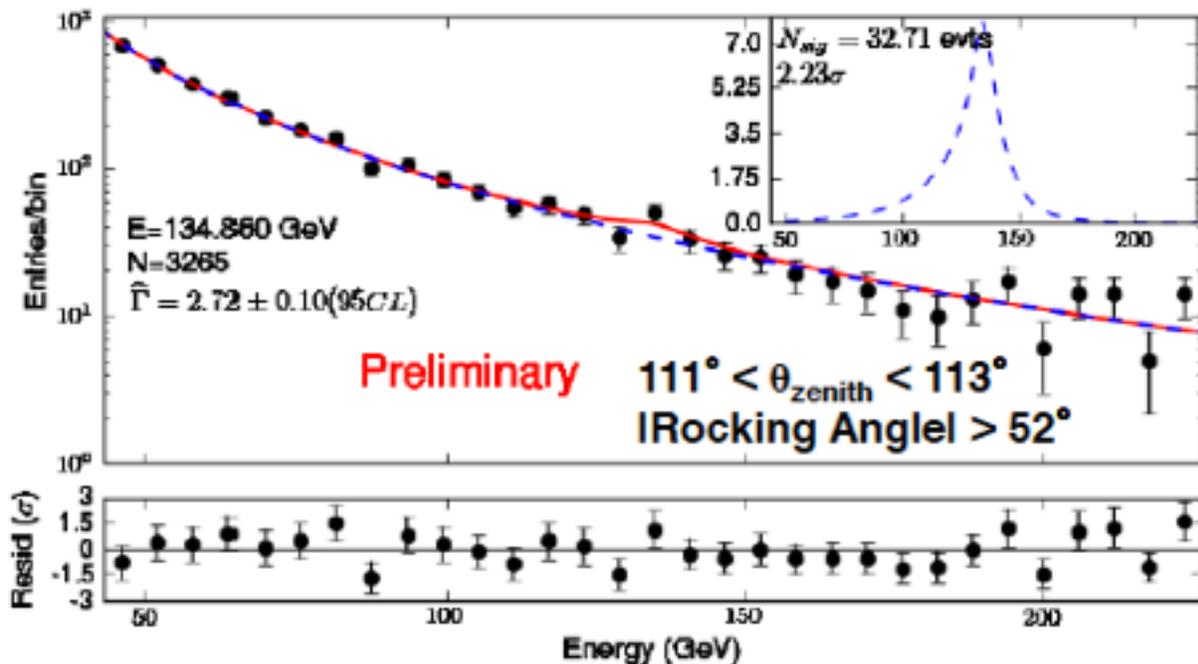
Sgr A\* and Higgs = Tquark-Tantiquark Condensate:

In addition to the Galactic Center observations,  
**Fermi LAT looked at gamma rays from Cosmic Rays hitting Earth's atmosphere**



by looking at the Earth Limb.

Andrea Albert at The Fermi Symposium 11/2/2012 also said: "... Earth Limb is a bright gamma-ray source ... From cosmic-ray interactions in the atmosphere ...



... Line-like feature ... at 135 GeV .. Appears when LAT is pointing at the Limb ...".

Since 90% of high-energy Cosmic Rays are Protons and since their collisions with Protons and other nuclei in Earth's atmosphere produce gamma rays, the 135 GeV Earth Limb Line seen by Fermi LAT is also likely to be the Higgs produced by collisions analogous to those at the LHC.

## Sgr A\* and Higgs = Tquark-Tantiquark Condensate:

Olivier K. in a comment in Jester's blog on 10 November 2012 said:

"... Could the 135GeV bump be related ... to current Higgs ... properties ? ...

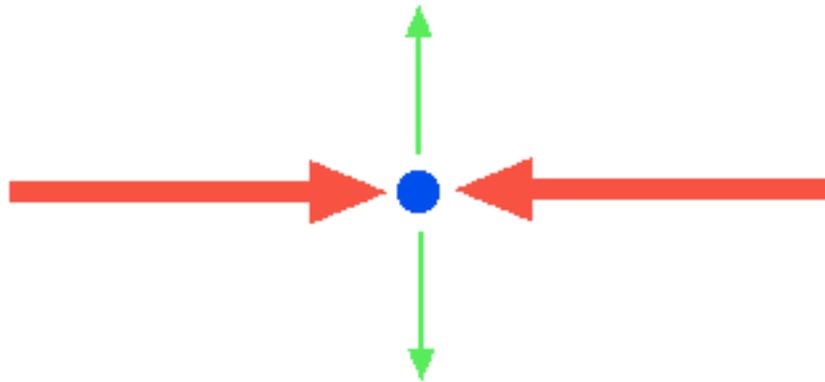
**The coincidence between GeV figures ...[ for LHC ] Higgs mass and this [ Fermi LAT ] bump is thrilling for an amateur like me..."**

Jester in his resonances blog on 17 April 2012 said, about Fermi LAT:

"... the plot shows the energy of \*single\* photons as measured by Fermi, not the invariant mass of photon pairs ...".

**Since the LHC 125 GeV peak is for "invariant mass of photon pairs" and the Fermi LAT 135 GeV peak is for ""single" photons" how could both correspond to a Higgs mass state around 130 GeV ?**

**The LHC sees** collisions of high-energy protons (red arrows) forming Higgs (blue dot)

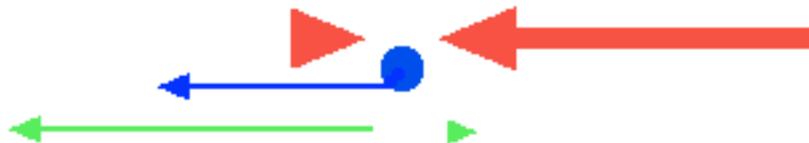


with the Higgs at rest decaying into a photon pair (green arrows)

giving the observed Higgs peak (around 130 GeV) as **invariant mass of photon pairs**.

### **Fermi LAT at Galactic Center and Earth Limb sees**

collisions of one high-energy proton with a low-energy (relatively at rest) proton forming Higgs



with Higgs moving fast from momentum inherited from the high-energy proton decaying

into two photons: one with low energy not observed by Fermi LAT

and the other being observed by Fermi LAT as a high-energy gamma ray carrying almost all of the Higgs decay energy (around 130 GeV) as a **"single" photon**.

Therefore, **the coincidence noted by Olivier K. is probably a realistic phenomenon.**

## Sgr A\* and Higgs = Tquark-Tantiquark Condensate:

Jester, replying to the comment by Olivier K., dismissed the proposal that Fermi LAT may have seen the Higgs, saying on 11 November 2012:

"Afaik,  
there's no model connecting the 130(5)GeV Fermi line to the 125 GeV Higgs."

so

I hereby propose a model:

Protons from Hydrogen infalling into Sgr A\* acquire enough energy and density to produce proton-proton collisions similar to those at the LHC, as could Cosmic Ray Protons hitting the Earth's atmosphere,

and

the 135 GeV Line observed by Fermi LAT is due to proton-proton collisions producing Higgs in the diphoton channel

and

the 125 GeV Higgs-like evidence observed by ATLAS and CMS is also due to proton-proton collisions producing Higgs in the diphoton channel

and

the difference between 135 GeV at Fermi LAT and 125 GeV at LHC can be accounted for by comparing details of experimental setup and analysis-related assumptions.

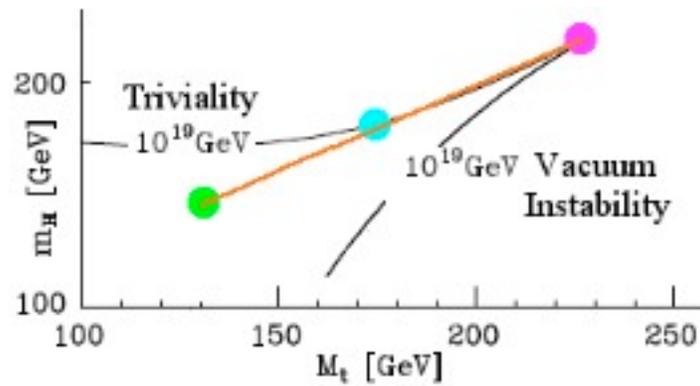
Given that model,

I propose that Olivier K. be given credit for stating the possibility that both Fermi LAT and the LHC have indeed seen the Higgs, which is an interesting example of mutual confirmation of Collider Physics and Astrophysics observations.

The {G4} conformal generator that represents both Dark Energy of Universe Expansion and the Massive Higgs Scalar as Fermionic Condensate (dominated by third-generation Tquark-Tantiquark Condensate) may be involved in the Sgr A\* Galactic Center Process.

## Sgr A\* and Higgs = Tquark-Tantiquark Condensate:

Due to its relationship with the Higgs as Tquark-Tantiquark Condensate,  
the Truth Quark might be related by  $\{G_4\}$  to Dark Energy of Universe Expansion  
as well as  
by a 3-state mass system due to its interaction with the Higgs as Condensate to



a Strong Coupling / Composite-Higgs Regime (known as Triviality)

and

a Vacuum Instability Regime.