Kimberlite Pipes from Impacts of Dark Matter and Degeneracy of Vacua Telling Mass of Bound State of 6 Top + 6 Anti Top Consistent with the 750 GeV

H.B. Nielsen(Copenhagen) mainly with Colin D. Froggatt, and New Particle with Larisa V. Laperashvili

Skeykampen , 2nd to 7th of January , 2016

Kimberlite Pipes, Many Vacua with ≈ 0 Energy Density, and The New Boson $\longrightarrow \gamma\gamma$

Two only weakly related subjects; but they are *related*:

- A. If the new boson $\longrightarrow$ two photons and having mass 750 GeV is our speculated 6 top + 6 anti top bound state, then there could be several (~ 3) very closely degenerate vacuum-phases. "Multiple point principle" (MPP) - meaning degenerate vacua - predicts the mass close to 750 GeV for the bound state!
- B. A speical type of volcanoes - kimberlite pipes - requires just about the right amount of energy so as to possibly be a result of dark matter impacts on earth, if it is split up into pieces of mass ~ 0.5 million tons per piece, then impacting about once in hundred years. Geologists have already seen (the effects of)impacts of dark matter!

The Relation of: Vulcanoes(Kimberlite pipes) $\leftrightarrow$ New 750 GeV Boson

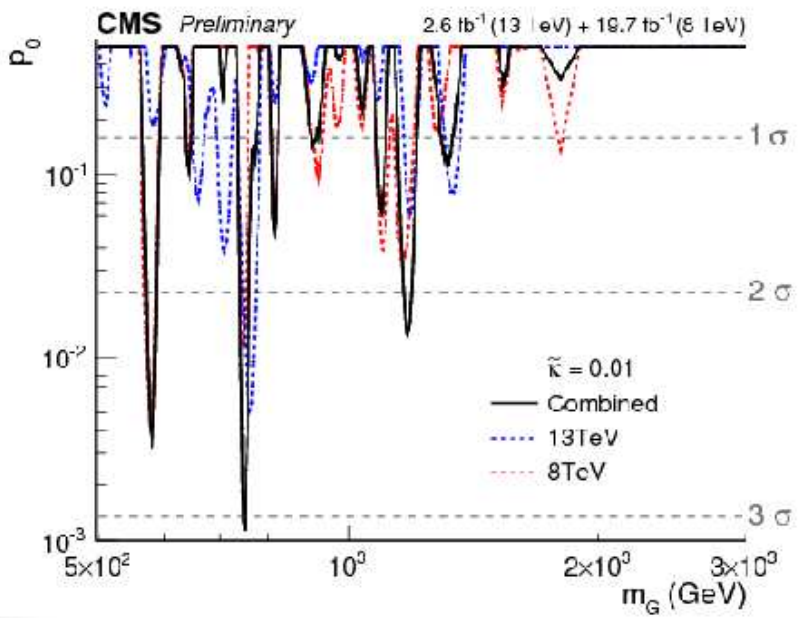
A Boson condensate of the 750 GeV mass Boson is by a speculated fine tuning (MPP) organized to have very closely zero energy density. The same fine tuning for vacuum with a Higgs field of the order of $10^{18} GeV$ is also assumed, so that it has also ~ 0 energy density. For just a mass of the order of 750 GeV a correction makes the vacua be degenerate just for the observed Higgs mass 125 GeV. Balls of pearl-size containing ordinary matter on a background of the Bose-condensate of the 750 GeV bosons, surrounded by a very tensious skin, and weighting about half a million tons make up the dark matter and impact on earth about one pearl every century. There is a condensate of new 750 GeV bosons inside the enormously heavy pearl sized balls causing the Kimberlite pipes

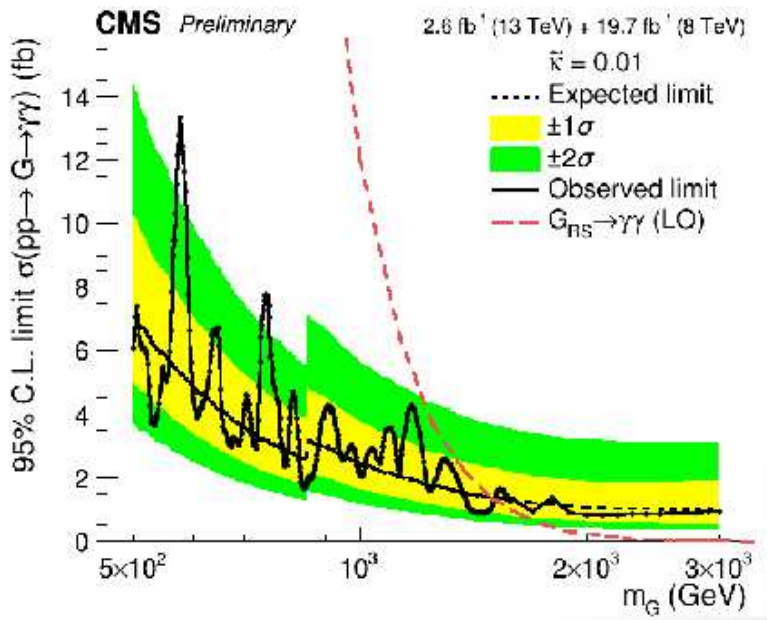
Plan for "The New 750 GeV boson and Kimberlite Pipes"

- Introduction.
- The New 750 GeV Boson.
- Our 6 top + 6 anti top bound state
  - A correction to the effective self coupling λ at "low" energy.
  - Estimating the radius - a parameter b - for the bound state.
  - Prediction of the mass from MPP.
- Kimberlite Pipes.
  - A condensate of our bound states.
  - Mietelsky et al. explaining Kimberlite Pipes.
  - Estimating energy, if kimberlite pipes are due to dark matter.
- Conclusion.

Combined limits and p-values

- Combined limit improves single analyses sensitivity by 20-30%.
  - Largest excess: M_G=750GeV, local significance 3σ
  - global significance < 1.7σ





(Only) Bad Excuses for Not Seeing the Bound State Also in Other Channels

Untill now only the following bad excuse for the other channels looked being suppressed:

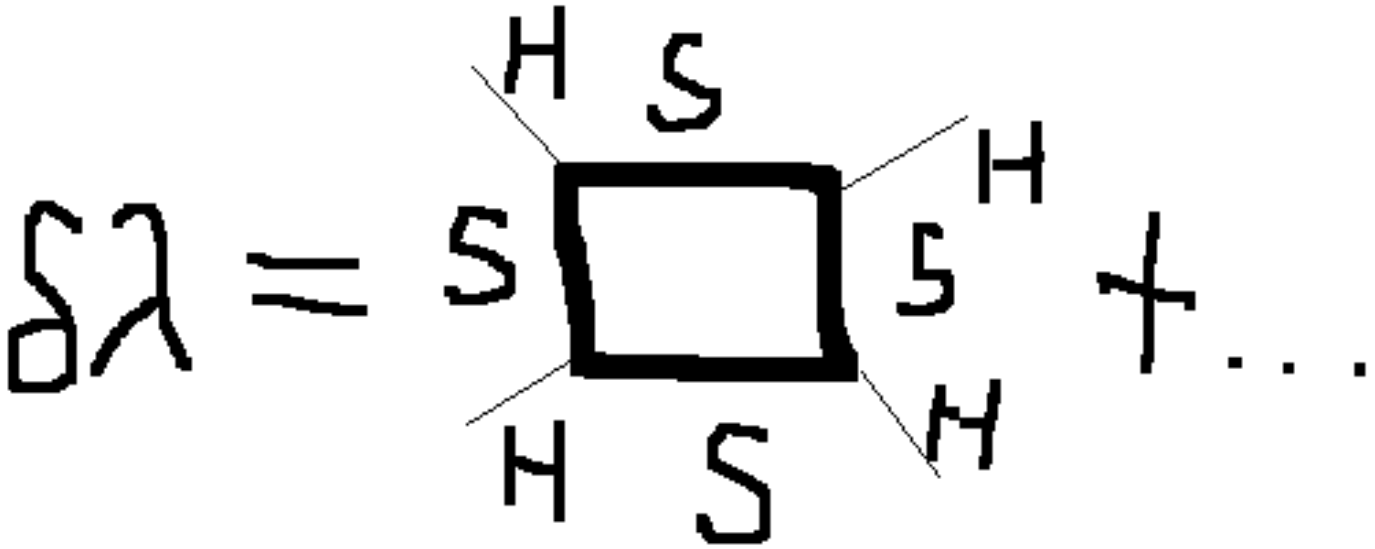
The thinkable decay products, such as gluons, Z, W, and even Higgs, have gauge charges - conserved quatities - that must be compensated for, if one of these particles are emitted. For instance they could be propagated along to another similar particle which is also emitted. It is anyway need to emit for instance two W's say. **But now our bound state consists of many constituents** $(12 >> 1)$ **and emmision of several particles - like W's or gluons - having to compensate each others gauge charges imply that some transport of the charge between the constituents at which the compensating decay products are emitted.**

final state f	σ at $\sqrt{s} = 8\,\text{TeV}$ observed	expected	ref.	implied bound on $\Gamma(S \to f)/\Gamma(S \to \gamma\gamma)_{\text{obs}}$
$\gamma\gamma$	< 1.5 fb	< 1.1 fb	[6,7]	$< 0.8\ (r/5)$
$e^+e^- + \mu^+\mu^-$	< 1.2 fb	< 1.2 fb	[8]	$< 0.6\ (r/5)$
$\tau^+\tau^-$	< 12 fb	15 fb	[9]	$< 6\ (r/5)$
$Z\gamma$	< 4.0 fb	< 3.4 fb	[10]	$< 2\ (r/5)$
ZZ	< 12 fb	< 20 fb	[11]	$< 6\ (r/5)$
Zh	< 19 fb	< 28 fb	[12]	$< 10\ (r/5)$
hh	< 39 fb	< 42 fb	[13]	$< 20\ (r/5)$
W^+W^-	< 40 fb	< 70 fb	[14,15]	$< 20\ (r/5)$
$t\bar{t}$	< 550 fb	-	[16]	$< 300\ (r/5)$
invisible	< 0.8 pb	-	[17]	$< 400\ (r/5)$
$b\bar{b}$	$\lesssim 1$ pb	$\lesssim 1$ pb	[18]	$< 500\ (r/5)$
jj	$\lesssim 2.5$ pb	-	[5]	$< 1300\ (r/5)$

Table 1: *Upper bounds at 95% confidence level on pp cross sections at* $\sqrt{s} = 8\,\text{TeV}$ *for va final states produced through a resonance with* $M = 750\,\text{GeV}$ *and* $\Gamma/M \approx 0.06$. *Assumin that the production cross section grows as* $r = \sigma_{13\,\text{TeV}}/\sigma_{8\,\text{TeV}} \approx 5$, *and that* $S \to \gamma\gamma$ *fi central value of the* $\gamma\gamma$ *anomaly, in the latter column we show the upper bounds on the p*

Main Point: Need the Mass Value Crudely 750 Gev

Our main point is that having a bound state of the 6 top + 6 antitop with a mass much like the 760 GeV we obtain in our picture a correction to that Higgs mass, which just gives *barely* stability of our vacuum, just to make it the 125 GeV.
That is to say an appropriate mass of the bound state S means, that the correction to (critical) Higgs mass to be measured due to loops of the bound state is so, that the instability of our vacuum, seemingly resulting from the experimental Higgs mass, is not really there, but that rather we can have just two degenerate vacua, and thus just barely stability.
Within our uncertainties this mass of the bound state that would give this *just barely stability* could be the 750 GeV of the newly found to two photon decaying boson.


δλ =
H
S
S
H
S
H
H
S
+ . . .

On "As if Fundamental Diagrams" Due to Bound states

Supposing that our bound state of 6 top + 6 anti top quarks are very strongly bound (and the mass small compared to that of 12 free top-quarks together) we calculate diagrams as if the bound state were a new fundamental particle with its own propagator -denoted as a thick line-, but though with formfactors included and suppressing the diagrams exponentially.

The vertices with two thick line meaning the bound state and one thin meaning the Higgs boson has its coupling denoted G_{HSS} and is estimated - thinking first of a non-relativistic situation of the S (=bound state) being at rest emmiting a Higgs boson:

$$G_{HSS} = 12 g_t / \sqrt{2} * 2 m_S \tag{1}$$

For each of these vertices we include an exponential formfactor cutting the loop integral down of the form

$$\mathfrak{F}_0(q^2) = \exp(\frac{1}{6} < \vec{r}^2 > q^2), \tag{2}$$

Evaluation of Diagram:

$$\lambda_S \approx \frac{G_{HSS}^4}{(2\pi)^4}\int d^4q \frac{(\exp(\frac{1}{2}r_0^2 q^2))^4}{(q^2-m_S^2)^4}$$

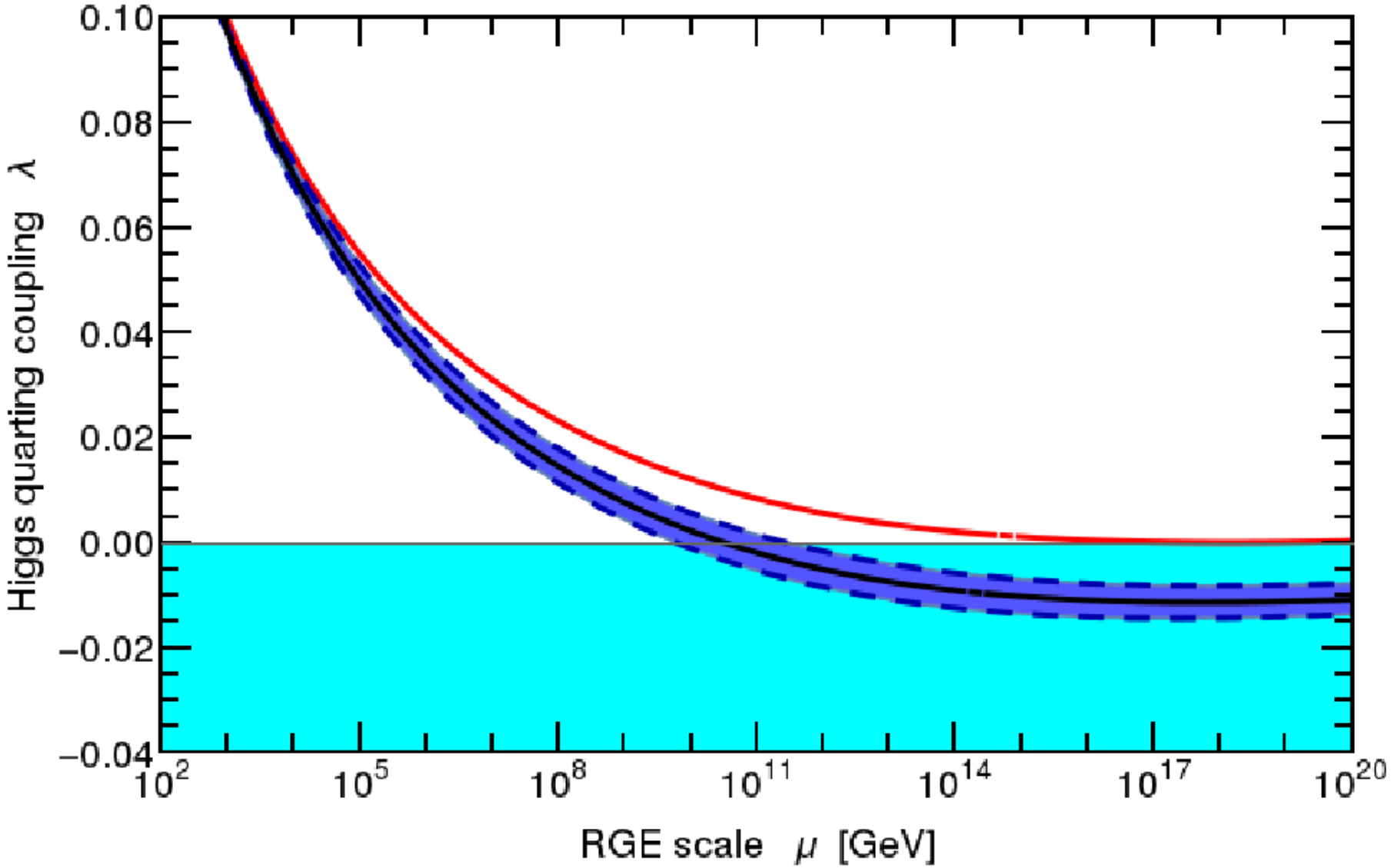
$$= \frac{G_{HSS}^4}{(2\pi)^4}\int d^4q_E \frac{\exp(-2r_0^2 q_E^2)}{(q_E^2+m_S^2)^4}$$

$$= \frac{G_{HSS}^4}{16\pi^2}\int_0^\infty q_E^2 dq_E^2 \frac{\exp(-2r_0^2 q_E^2)}{(q_E^2+m_S^2)^4}$$

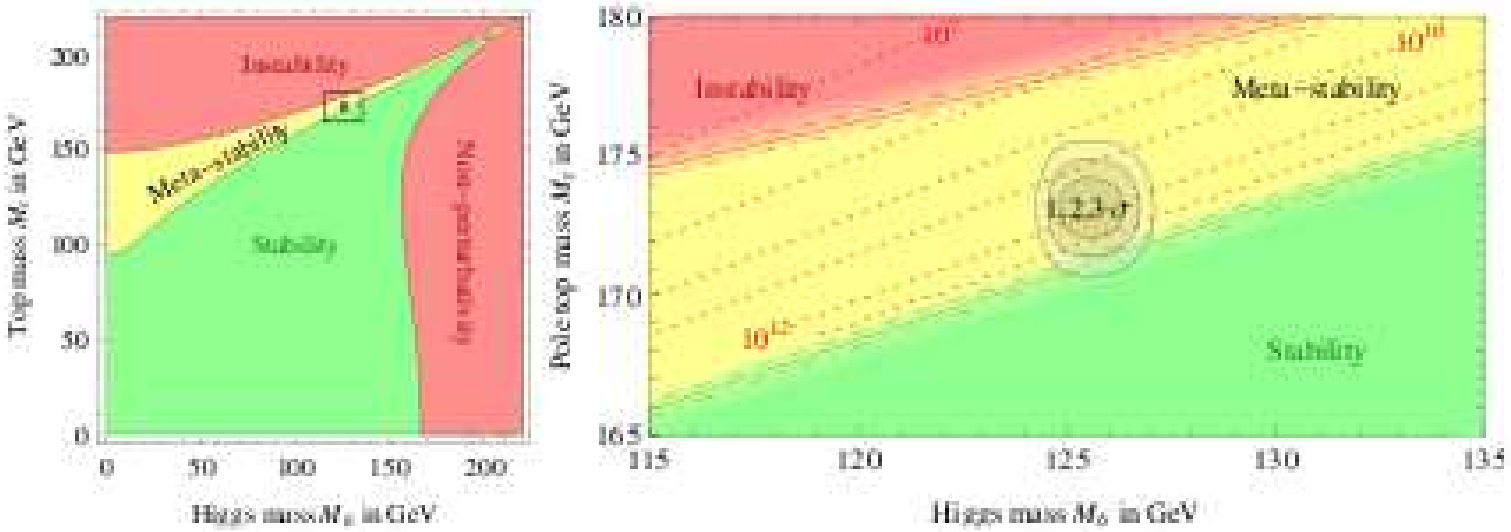
$$= \frac{G_{HSS}^4}{16\pi^2 m_S^8}\int_0^\infty q_E^2 dq_E^2 \frac{\exp(-2r_0^2 q_E^2)}{(q_E^2/m_S^2+1)^4}$$

$$= \left(\frac{G_{HSS}}{2m_S}\right)^4 \frac{1}{\pi^2}\int_0^\infty y dy \frac{\exp(-(2r_0^2 m_S^2)y)}{(y+1)^4}$$

$$\approx \frac{1}{4\pi^2}\left(\frac{G_{HSS}}{r_0 m_S^2}\right)^4 = \frac{1}{\pi^2}\left(\frac{6g_t}{b}\cdot\frac{m_t}{m_S}\right)^4, \qquad (3)$$


0.10
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
Higgs quarting coupling λ
10^2
10^5
10^8
10^11
10^14
10^17
10^20
RGE scale μ [GeV]

A Higgs mass of ~ 125 GeV is a very special value



G.Degrassi, S. Di Vita, J.EM, J. Espinosa, G.F. Giudice, G. Isidori, A. Strumia. [hep-ph/1205.6497]

If any S-resonance (with $m_S \approx 300$ GeV or 750 GeV) gives

$$\lambda_S \simeq 0.01, \tag{4}$$

then this contribution transforms the metastable curve into stable curve, and we have exact vacuum stability and exact MPP.
Now

$$\lambda_S \simeq \frac{1}{\pi^2}\left(\frac{6g_t\xi}{b}\right)^4, \tag{5}$$

where

$$\xi = \frac{m_t}{m_S}.$$

We see that $\xi_1 \approx 173/750 \approx 0.231$ for the resonance with the mass $m_1 \approx 750$ GeV and $\xi_1 \approx 173/300 \approx 0.577$ for $m_2 \approx 300$ GeV. Respectively:

$$b_1 \simeq \frac{0.231}{0.095} \approx 2.43, \tag{6}$$

and

$$b_2 \simeq \frac{0.577}{0.095} \approx 6.07. \tag{7}$$

If both resonances give their contribution to λ_S, then we have:

$$(\frac{\xi_1}{b_1})^4 + (\frac{\xi_2}{b_2})^4 \simeq 0.01 \frac{\pi^2}{(6g_t)^4} \approx 0.00008. \quad (8)$$

Theoretically we obtained $b_1 \simeq 2.34$ and for the experimental values $g_t \approx 0.935$ and $m_S \simeq 750$ GeV, we have:

$$\lambda_S \simeq 0.009, \tag{9}$$

what transforms the metastable curve of the Fig into the stable curve. Of course, the uncertainty coming from the contributions of diagrams shown in Fig. can reach 25%, and then we have:

$$\lambda_S \simeq 0.009 \pm 0.002. \tag{10}$$

If $b_2 >> b_1$, then the resonance with mass 300 Gev gives a negligible contribution.
It is very important to investigate experimentally the radii of the discovered resonances.

Conclusion on the Part about Stability and the Bound State of 6 top + 6 antitop Identified with the two Photon Resonance:

- The identification of our since long speculated bound state of 6 top + 6 anti top quarks with the newly seen peak in the two photon spectrum is not so good from the point of view, that the bound state is expected to have stronger decays into other channels - though less easy to see because background but...-.
- But it is very successfully fitting in to bring a correction to the stability of the vacuum, so that with our identification of the 750 GeV particle with our bound state we can get the Higgs effective potential to *just touch zero energy density in stead of going under to destabilize the vacuum*!

Continuation of Conclusion on the Bound State Part

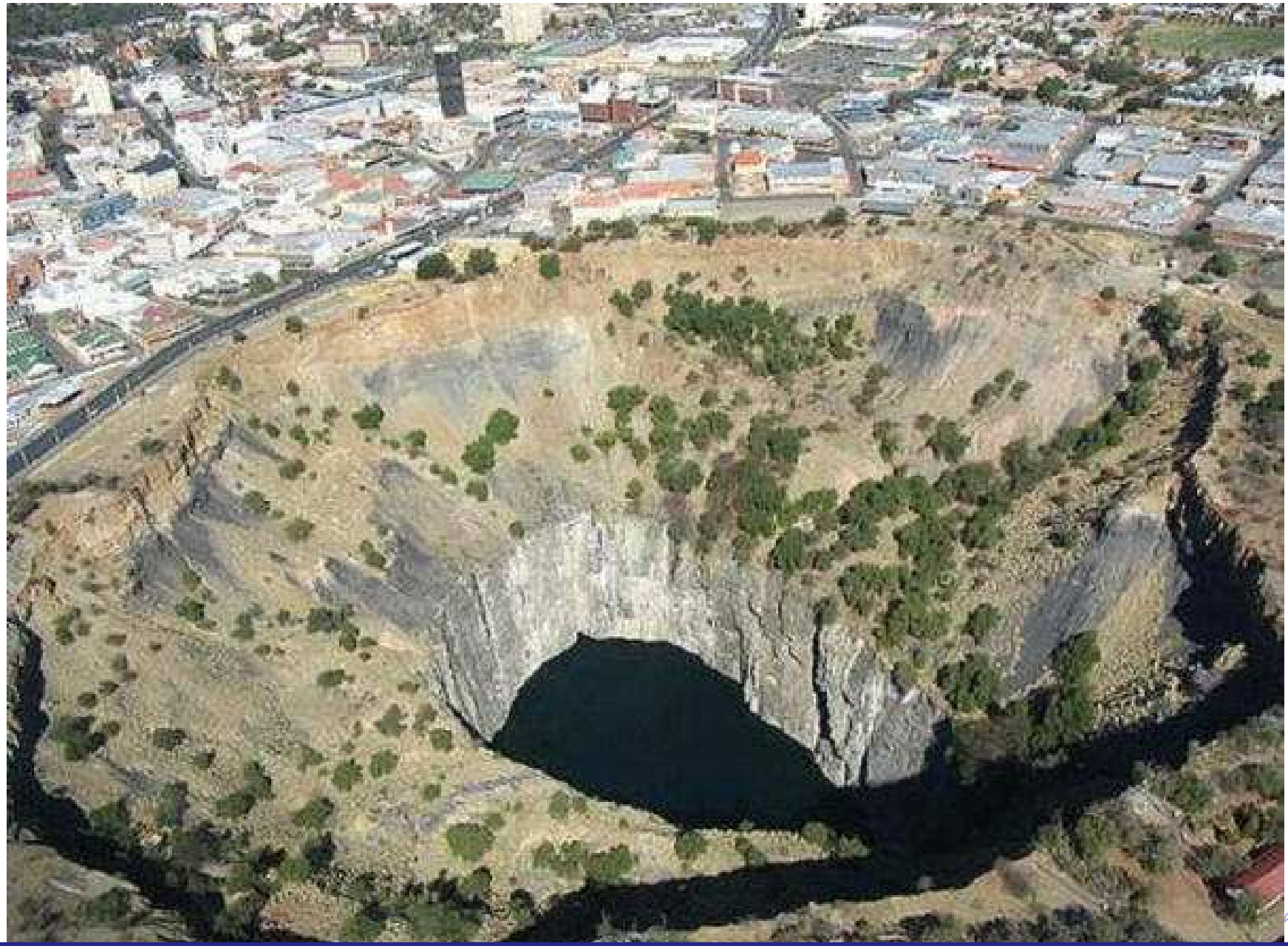
- If one takes seriously the success of bringing the effective Higgs potential to *just touch zero*, it is strong support for our "multiple point principle" that as new law of nature coupling are adjusted to just make several vacua(phases) have very small energy densities!
- Also then to sufficient accuracy the Standard Model alone is a good approximation for obtaining the true effective potential for the Higgs field. so Standard Model is almost everything in spite of its difficulties.

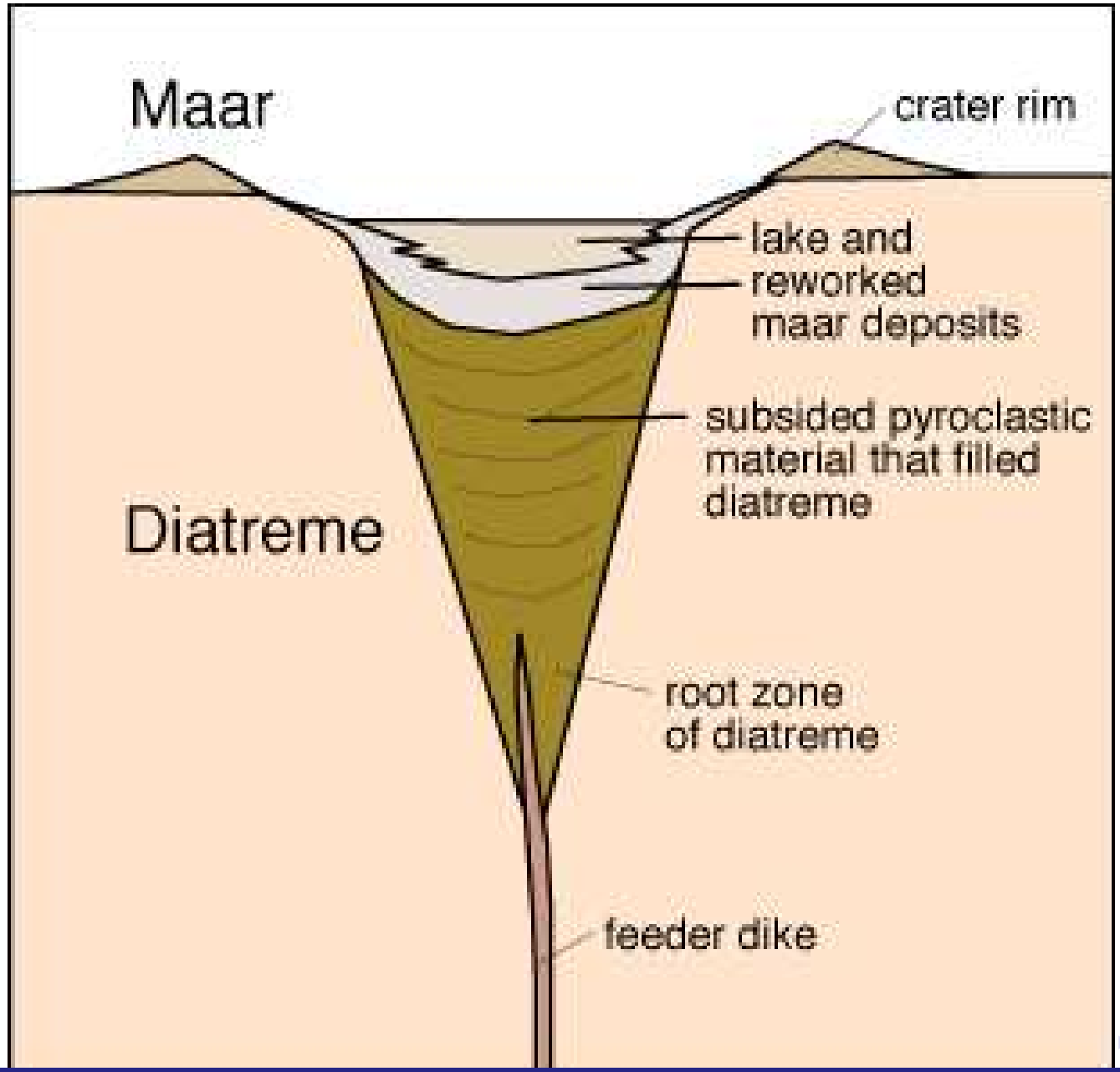
Did Dark Matter Cause the Kimberlite Pipes (a strange type of volcanos)?

I want to be as general as possible by not committing ourselves to too special models, but rather just consider some type of weakly interacting objects of a *general mass*, and then remark that they could cause a slightly mysterious geological phenomenon "kimberlite pipes", a kind of volcanos with a little round lake.

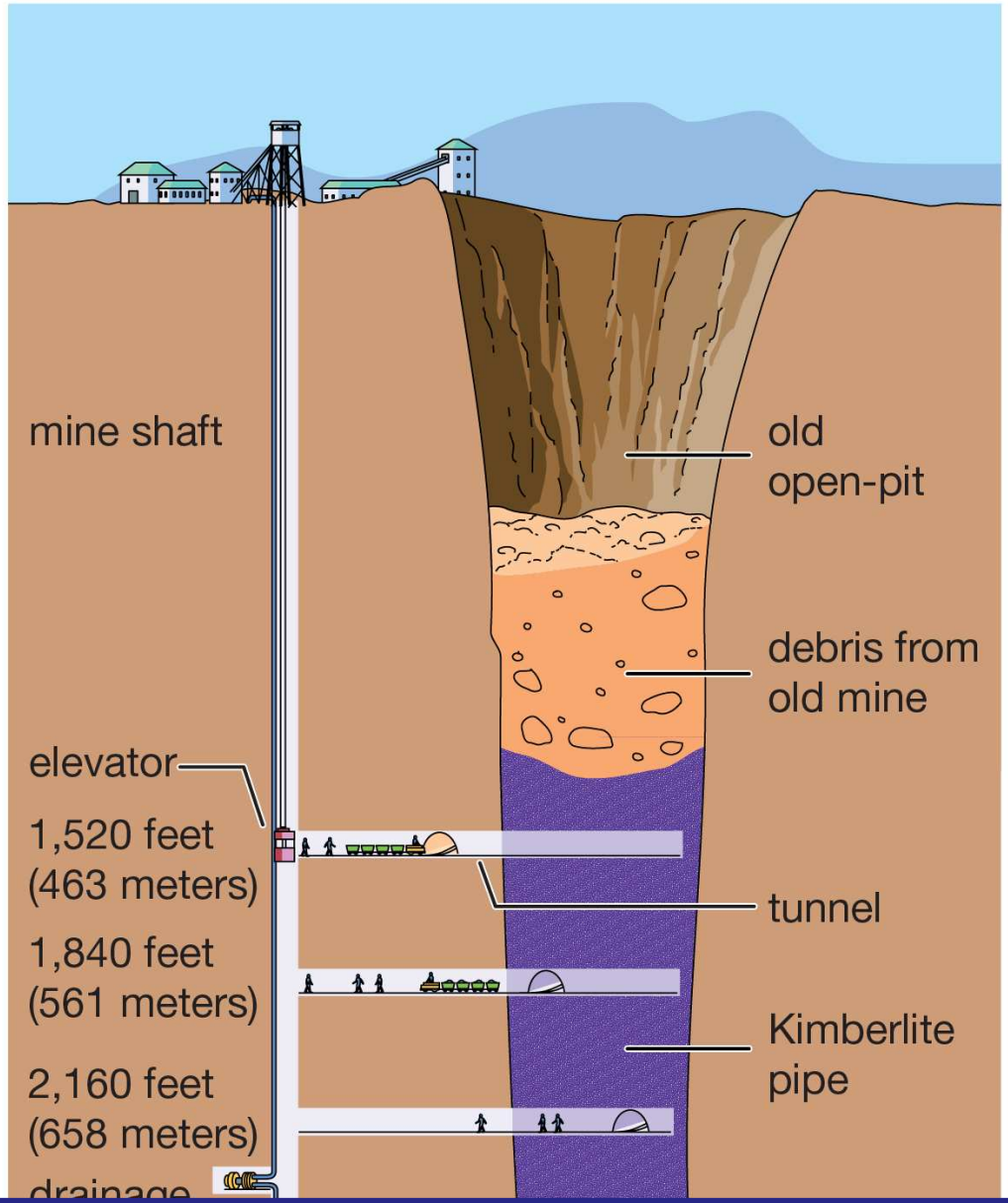
Review of M. Paszkowski, J.W. Mietelski's work on Kimberlite Pipes

Vol. 44 (2013) ACTA PHYSICA POLONICA B No 4 p 787:
"ARE KIMBERLITE PIPES A KIND OF MACROSCOPIC NUCLEAR TRACKS FORMED IN COLLISION WITH CUDO?"
Mariusz Paszkowski
Institute of Geological Sciences, Polish Academy of Sciences Senacka 1, 31-002 Krakw, Poland and Jerzy W. Mietelski
The Henryk Niewodniczaski Institute of Nuclear Physics Polish Academy of Sciences Radzikowskiego 152, 31-342 Krakw, Poland
(Received March 8, 2013; revised version received March 26, 2013)
(CUDO=Cosmic Ultra-Dence Objects)




Maar
crater rim
lake and
reworked
maar deposits
subsided pyroclastic
material that filled
diatreme
Diatreme
root zone
of diatreme
feeder dike

A typical diamond mine



There is large hole in the scale of masses, where one tends to forget to look for dark matter particle mass:

between

- **The largest mass producable by LHC, say** $10\,TeV \approx 10^{-20} g = 10^{-23} kg$**, and**
- **the smallest mass visible by gravitational lensing - when passing in th way for the light from behind - of the order of 1/3 moon mass** $\approx 2 * 10^{22} kg$

hopes have been mainly black holes and interest relatively little.

We shall find by Kimberlite pipes a mass $m \approx 3 * 10^{8} kg$!

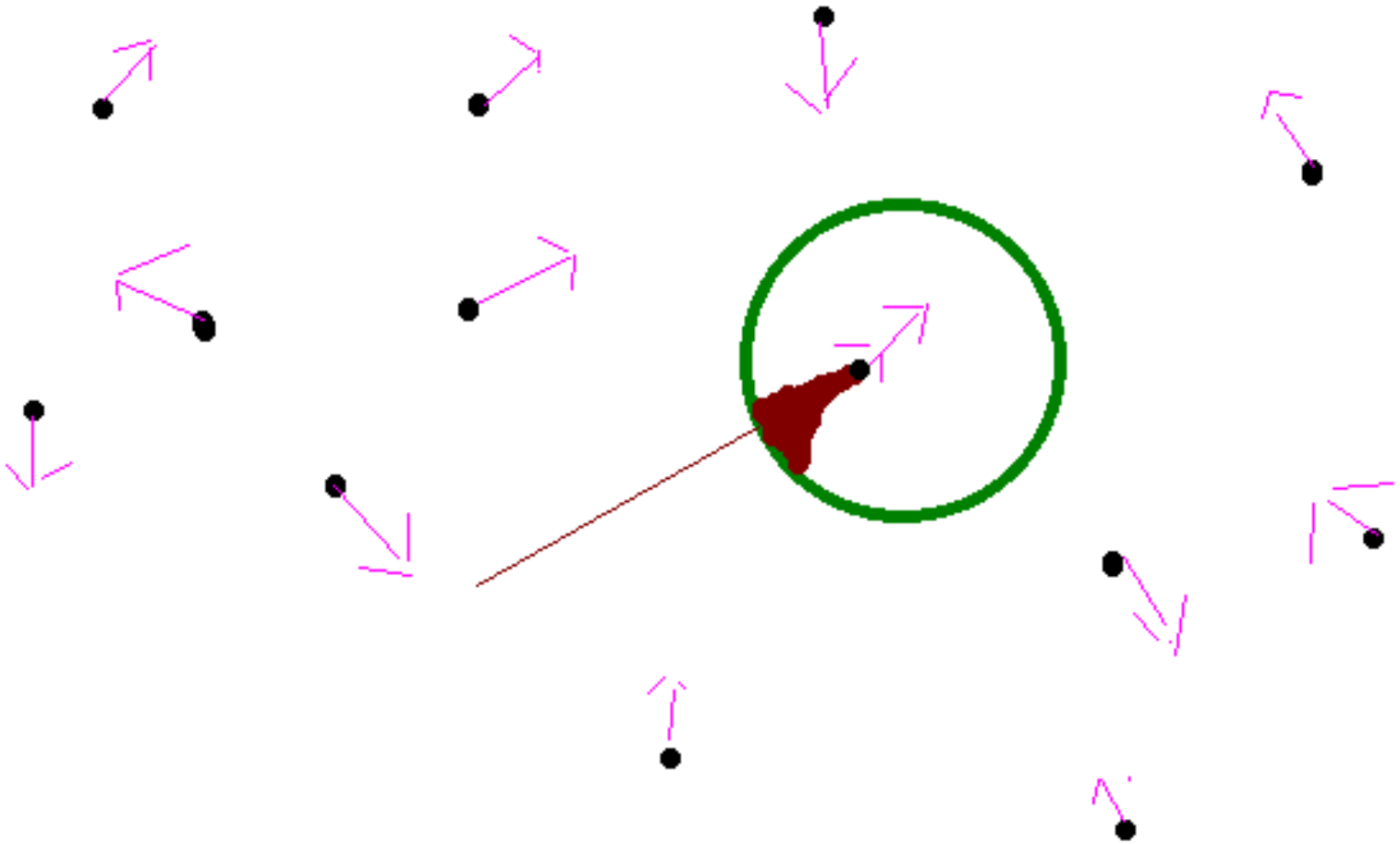
Have in mind that the mass of the single dark matter particle has no influence on the large scale flow behavior and gravitational effects; only the dark matter density matters at the large scales of length where the observation astronomically take place

Estimate, Dark matter Energy Matches that Needed for Kimberlite Pipes

A lower bound for making a kimberlite pipe would seem to be that there should be at least enough energy to lift the material from the mantle/ the deep up to nearer to the earth surface. Some energy delivered must be lost by being conducted as heat out into the rock. But still we may take say 5 times the energy for just lifting the rocks from the deep to an estimate for what it costs in enrgy to produce the kimberlite pipe.

The crucial question is now:

Does the energy required for making the kimberlite pipes formed during the history of the earth correspond to the amount of energy brought as kinetic energy of dark matter in the corresponding time?



Estimating the Mass of Dark Matter Ball / CUDO in Two ways

We estimate the dark matter ball mass m from the density of dark matter in the solar neighborhood taken to be $\rho_{DM} = 1 GeV/cm^3$ as supposed from astronomy, called $m|_{DMdensity}$,

$$m|_{DMdensity} = \tag{11}$$

$$= \frac{\rho_{DM} l v \frac{1}{4} A}{1/P * c} \tag{12}$$

$$= \frac{1.7 * 10^{-21} kg/m^3 * 10^{17} s * 2 * 10^5 m * 1/4 * 10^{13} m^2 * 2.2 * 10^{-3}}{30} \tag{13}$$

$$= 0.6 * 10^{10} kg = 6 * 10^9 kg = 6 * 10^6 ton \tag{14}$$

Estimate of the Corpuscle Masses m_{pipe}

The kimberlite pipe is seen to broaden out near the top where it passes the earth surface to a diameter of "several hundred meters", so we should use the diameter to be $d \approx 500m$ We should take into account that the broad part of the kimberlite pipe only goes down about 1.5km to 2 km, thus we should take the hight of the block of material lifted by the impact energy to be $h = 1.5km = 1.5 * 10^3 m$, We would get for the mass of the impacting dark matter ball needed to provide the enrgy of a pipe

$$m_{pipe} \approx 3 * 10^8 kg = 3 * 10^5 ton \tag{15}$$

We indeed estimate with hight of the thick part of the pipe $h' \approx 1.5km$, while material is pumped from the defth $h \approx 500km$ and diameter of this thick part being $d \approx 500m$:

$$m_{pipe} \tag{16}$$

$$= \frac{\rho_{stone} * g * h' h * d^2}{\zeta * 1/2 * v^2} \tag{17}$$

$$= \frac{3 * 10^3 kg/m^3 * 10m/s^2 * (1.5 * 10^3 * 5 * 10^5 m) * (500m)^2}{1/5 * 1/2 * (2 * 10^5 m/s)^2} \tag{18}$$

$$\approx 3 * 10^8 kg = 3 * 10^5 ton \tag{19}$$

Estimating the Dark Matter Ball Mass $m_{DMdensity}$ from Astronomically Known Density.

On the whole earth it were claimed that $c_{earth} = 6400$ kimberlite pipes had been found Including a factor $\frac{1}{4}$ for the probability of the area being turned in the right direction for being hit as if perpendicularly the quarter of the surface area is $\frac{1}{4}A_{earth} = \pi R_{earth}^2 = 1.275 * 10^{14} m^2$. If we should only expect that one found these Kimberlite pipes on land, then we replace this number by 29% of it. In that case we would effectively have $\frac{1}{4}A$ replaced by $\frac{1}{4}A_{land} = .29 * 1.28 * 10^{14} m^2 = 3.7 * 10^{13} m^2$ and the mass of the dark matter particle would have to be:

$$m_{DMdensity} \approx 4 * 10^5 ton, \tag{20}$$

$$m_{DMdensity} \approx 4 * 10^5 ton, \tag{21}$$

means that it matches phantastically well with the from the size and defth of Kimberlite pipes estimated $m_{pipe} \approx 3 * 10^5 ton$:

$$m_{pipe} \approx m_{DMdensity}, \tag{22}$$

or it means that we from studies of the Kimberlite pipes in number and requirement energy would have been able to predict the dark matter density to:
$\rho_{DM}|_{\text{from Kimberlite pipes}} \approx 3/4 * 1 GeV/cm^3 \approx .7_5 GeV/cm^3$.
So we really fit well to all dark matter being the material causing the Kimberlite pipes in the earth!

The calculation of the mass of a single dark matter corpuscle mass $m_{DMdensity}$ in order to fit the astronomically needed dark matter density $\rho DM = 1.7 * 10^{-21} kg/m^3$ - and a velocity $v = 200 km/s$ - with the number of kimberlite pipes gives:

$$m|_{DMdensity} = \tag{23}$$

$$= \frac{\rho_{DM} l v \frac{1}{4} A}{1/P * c} \tag{24}$$

$$= \frac{1.7 * 10^{-21} kg/m^3 * 10^{17} s * 2 * 10^5 m/s * 3.7 * 10^{13} m^2 * 2.2 * 10^{-3}}{6400} \tag{25}$$

$$= 4 * 10^8 kg = 4 * 10^5 ton \tag{26}$$

Conclusion Concerning the Posibility of the Kimberlite Pipes found on Earth could be Dark Matter Caused

- **Within our very crude estimates the energy density astronomically found for dark matter fits well with the amount of energy estimated to be needed to produce the kimberlite pipes found geologically on earth**(assuming a typical halo velocity 200 km/s for the speed of the objects).
- The mass of the individuel dark matter particles associated with this fit is $m_{DMdensity} \approx m_{pipe} \approx (3 to 4) * 10^5 ton$.

Conclusion on Kimberlite Pipes Due to Dark Matter (continued)

- The average time interval between impacts of dark matter on land is

$$\Delta t|_{impact} \tag{27}$$

$$= \frac{m}{\rho_{DM} v \frac{1}{4} A_{earth} * .29} \tag{28}$$

$$= \frac{3 * 10^{11} kg}{1.3 * 10^{-17} kg/m^3 * 2 * 10^5 m/s 1.28 * 10^{14} * .29} \tag{29}$$

$$= 3 * 10^9 s = 100 years. \tag{30}$$

(Just the time since the Tunguska event in 1908) (31)