LHC: what if ... ?

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LARGE HADRON COLLIDER - THE LEGAL DEFENSE FUND SITE

The Legal Intervention Donation Site

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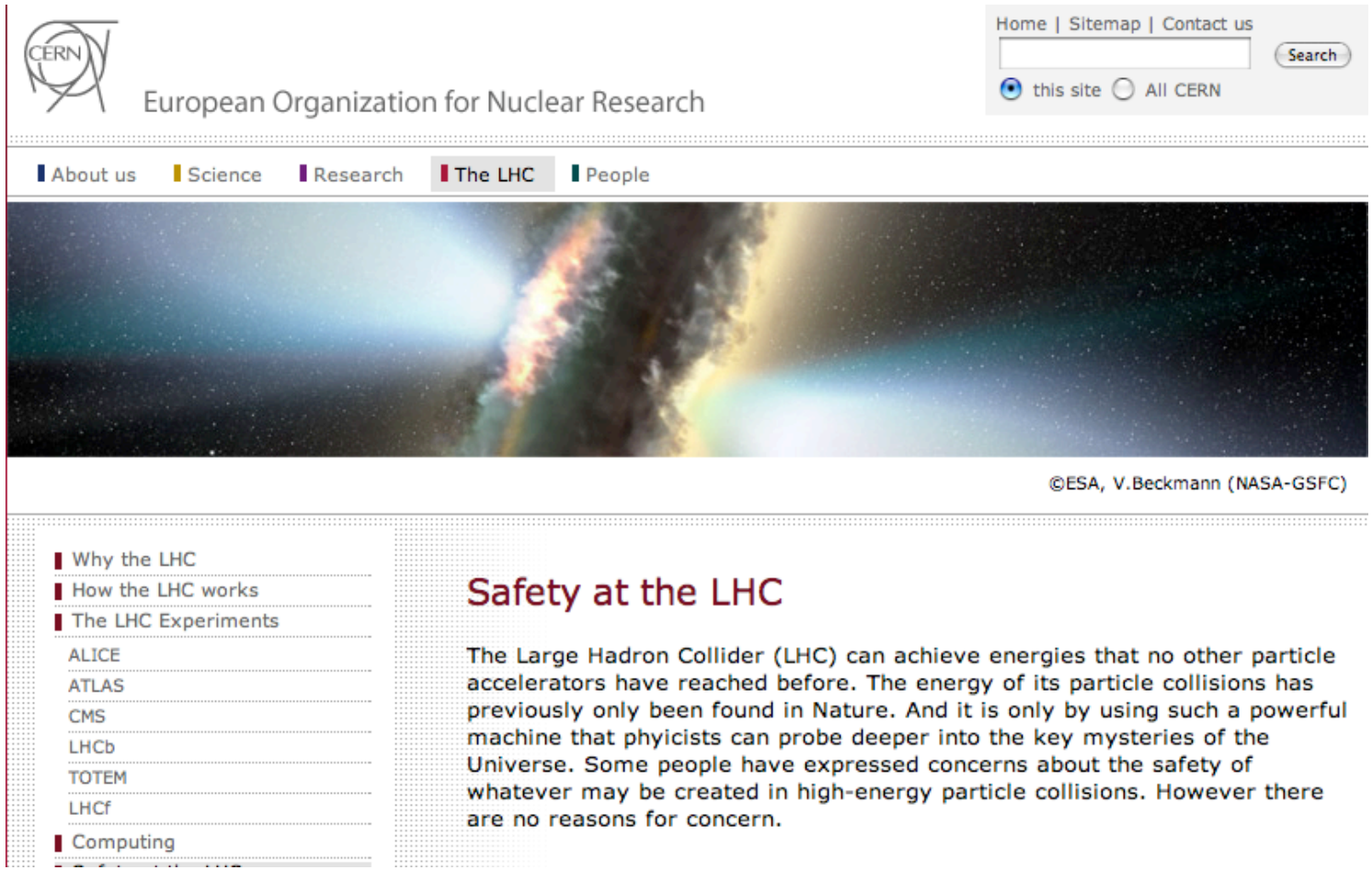
Home Page

This is the interim web-site for the Large Hadron Collider [LHC] legal defense fund. This fund has been established by Walter L. Wagner, a nuclear physicist, to initiate legal action to require that CERN and the Large Hadron Collider engage in a full safety analysis for all potential theoretical hazards inadequately addressed to-date. Such hazards include theoretical miniature black holes, theoretical strangelets, deSitter Space transitions, etc. The existing "cosmic ray argument" has been proven falacious for a variety of reasons [see risk-evaluation forum], and no existing proof of safety is currently available. The LHC propaganda machine that 'everything is safe' is well funded by your tax dollars, paying large salaries to thousands of people who have much to lose financially should the LHC be unable to prove its safety. As most of them perceive the risk to be small, they are willing to take that 'small risk' at our expense. The actual risk cannot presently be calculated.

http://www.lhcdefense.org/

http://www.lhcconcerns.com/

http://public.web.cern.ch/Public/en/LHC/Safety-en.html



RHIC Report, Busza et al (1999):
http://doc.cern.ch//archive/electronic/hep-ph/9910/9910333.pdf

CERN Report, Iliopoulos et al (2003):
http://doc.cern.ch/yellowrep/2003/2003-001/p1.pdf

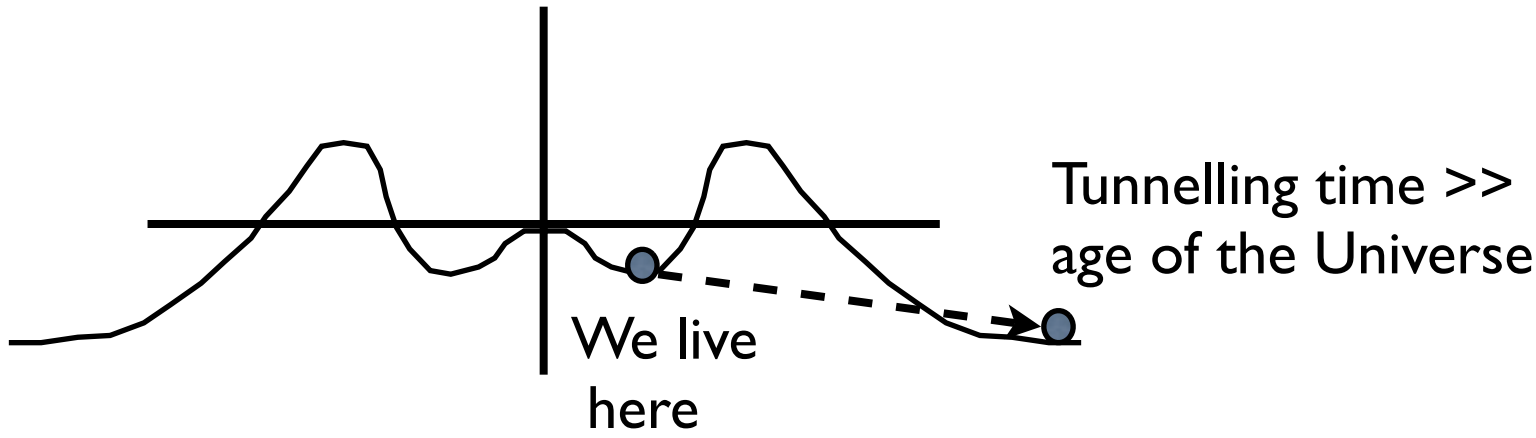
Objects of the concerns

- Magnetic monopoles
- Destabilization of the vacuum
- Strangelets
- Black Holes

Magnetic monopoles

- Predicted by Grand Unified Theories
- Could catalyze proton decay

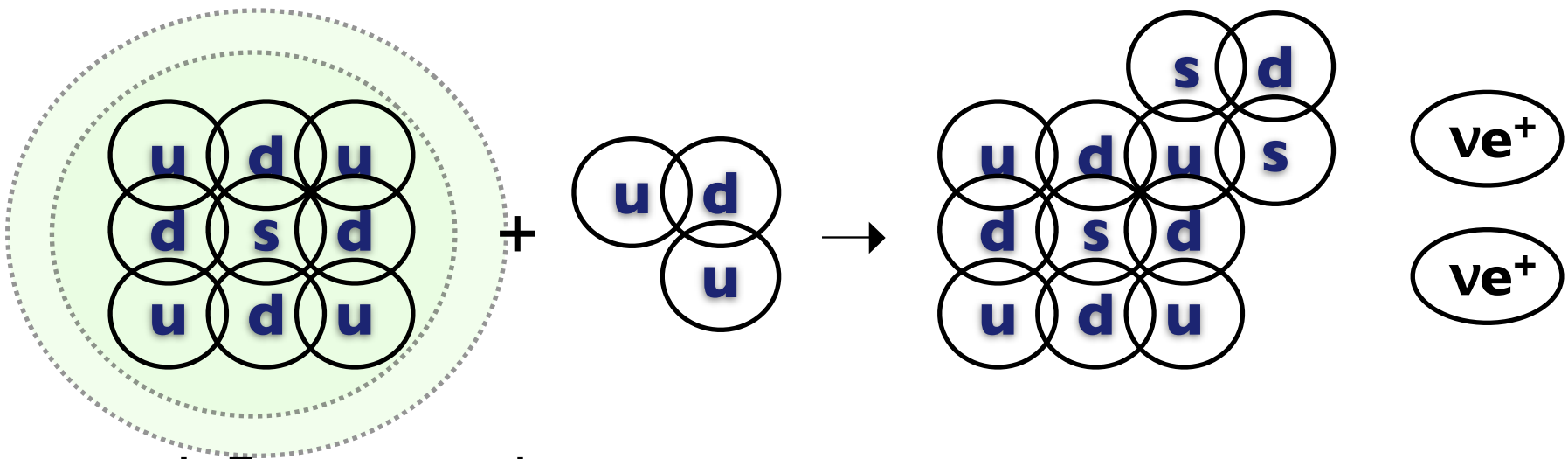
Vacuum instability



- We could be living in a metastable, long-lifetime vacuum
- Creating high energy density could increase the probability of tunnelling into the new vacuum

Strangelets

- Composites of many strange quarks, capable of converting u quarks into s quarks, thus growing by accretion when in contact with normal matter



u-quark Fermi sea above $m_{strange}$ → u-s conversion is energetically favourite

Conditions for strangelets to be dangerous

- Strange matter should be negatively charged (else will repel normal nuclei and accretion stops). Difficult, since N(s)<N(d),N(u)
- Should produce a metastable "seed". Ordinary strange particles decay quickly. Need to directly produce an object with enough quarks to populate Fermi sea, and allow stable strange quarks to aggregate.

Microscopic Black Holes

If extra dimensions for $r<R_D$ (possibly as large as 10-100μm):

$$F_G \sim \frac{G m_1 m_2}{r^2} \left(\frac{R_D}{r}\right)^{D-4} \quad , \quad \text{when } r<R_D$$

at $r \sim 1/\sqrt{s} \sim 1/\text{TeV}$, D=6, we get gravitational forces of the same order of the EW ones

⇨ space-time metric ~ Schwarzschild

⇨ event horizon , black holes at M≥TeV

Expected not to cause any problem, since they are predicted (Hawking) to decay with a lifetime of $1/M \sim 10^{-27}$ sec

Recent concerns stimulated by statements in the literature that perhaps Hawking decay does not take place

Formal issues

- Criticism of Hawking decay is not based on proofs that BHs are stable, but on the need for more solid proof.
- QM requires BHs formed at the LHC to decay:
  - from CPT, if q q' → BH, then BH→q q'

➡BH's stability violates quantum mechanics

Notice

- Contrary to statements in the literature of LHC-disaster web sites, BHs are not something that WILL be produced at the LHC.
- These are not standard Einstein BHs (for which there is not enough energy).
- These BHs only exist in some speculative BSM scenarios, that have no a-priori direct or indirect support from data or from logic elaboration of new frameworks such as string theory (meaning: they are not NEEDED by any theory).
- They are discussed because they appeal to some, and because they can't be ruled out experimentally as yet.

In all cases,

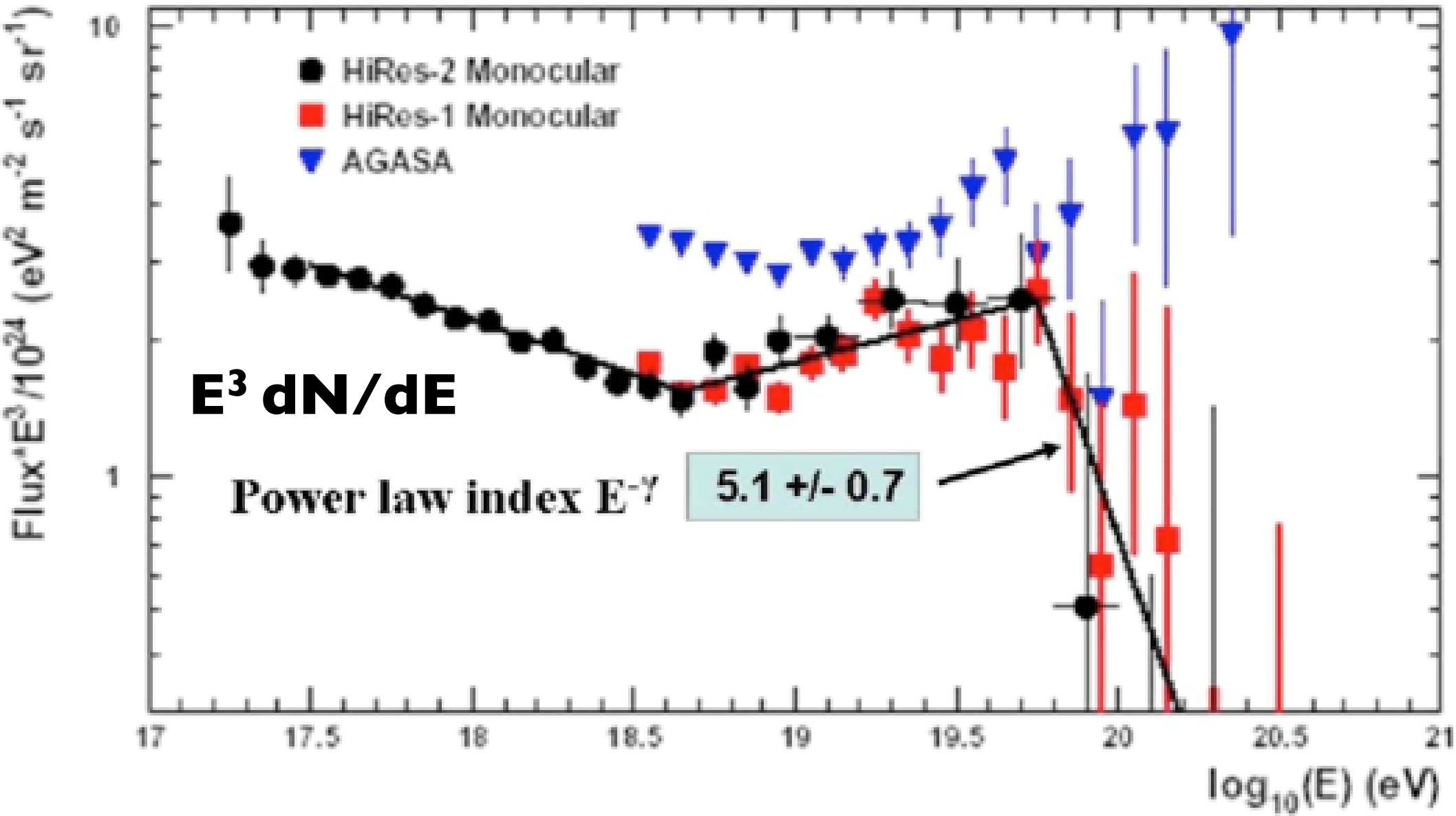
How do we rule out the possibility that these objects can cause major environmental disasters?

- Rely on solid, unimpeachable theoretical arguments (conservation laws, properties of well-known interactions – EM, EW – etc)

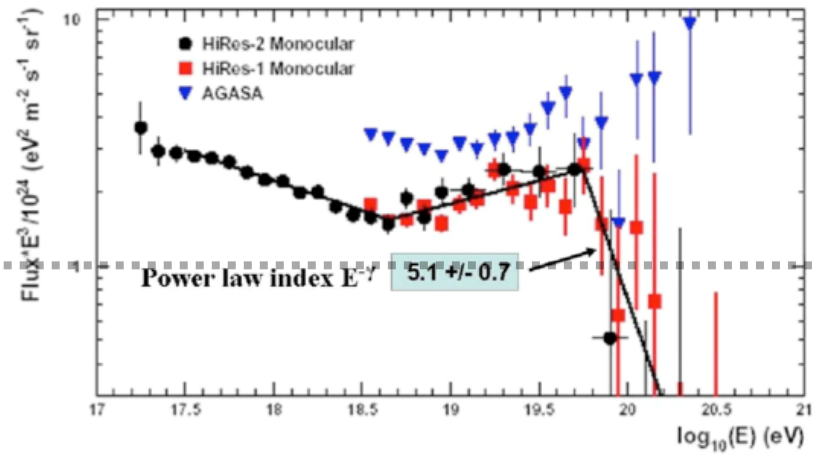
- Rely on empirical evidence: analyze the effect of such phenomena in other contexts (other HEP experiments, astrophysics, cosmology, virtual effects, etc), and exclude their possible occurrence at the LHC

Cosmic ray spectrum

N.B.: $S = 2Em_p \Rightarrow E = [14\ \text{TeV}]^2/2m_p \sim 10^{17}$ eV



Collisions on Earth's atmosphere



$$\frac{d\Phi}{dE} \gtrsim 10^6 (E/\mathrm{GeV})^{-3}\ \mathrm{m}^{-2}\,\mathrm{s}^{-1}\,\mathrm{sr}^{-1}\,\mathrm{GeV}^{-1}$$

$$N(\sqrt{S} > E_{LHC}) = A \int_{E>E_{min}(A)} \frac{d\Phi}{dE}\, dE \sim \frac{1.6 \times 10^3}{A}\ \mathrm{yr}^{-1}\,\mathrm{km}^{-2}\,\mathrm{sr}^{-1}$$

A=CR atomic number (p=1, Fe=56)

⇨ 10^{22} / A collisions above √S=14 TeV since 5 Byrs

cfr LHC: 100mb x 10^{34} $cm^{-2}s^{-1}$ x 10 yrs ~ 10^{17}

Notice

- 10^{22} / 10^{17} is not a large number, but consider that the argument can be applied also to the Sun, to all other stars in the galaxy.
- Since $R_{sun} \sim 100 R_{earth}$, with 10^{10} sun-like stars in the galaxy, we get an additional factor of 10^{14}
- .....Then count galaxies causually connected with our slice of the universe ...

Implications

- Rule out false-vacuum decay (the bubble of new vacuum expands at the speed of light)
- Rule out magnetic-monopoles (would get trapped on Earth, and start decaying protons)

Problems with using "cosmic rays hitting the Earth" to rule out strangelets

- CR-produced strangelets have large velocity, and could get broken apart at their first interaction with a nucleous

- ... on the other hand, at the LHC some fraction will be produced slow enough that they wont break, and will be free to grow

Solutions

- Consider head-on collisions of cosmic rays, producing slow stranglets, trapped by the galactic B-field. They will end up in gas clouds, and eventually inside stars. Rates of NS-like explosions rules this out (Dar, De Rujula, Heinz,http://arxiv.org/abs/hep-ph/9910471)
- Verify with data (SpS, RHIC) that the rate for producing complex quark aggregates behaves as predicted, and that this production becomes less and less likely as the energy density (i.e. T) grows, thus further suppressing the probability at the LHC (For details see Iliopoulos and RHIC reports)

Problems with using "cosmic rays hitting the Earth" to rule out Black Holes

- CR-produced BHs have large velocity

  $\gamma \sim M/m_p \gtrsim 1000$

- At production BHs have small cross section

  $\sigma \sim R^2 \sim 1/\mathrm{TeV}^2$

➡ they fly through the Earth like a neutrino (unless it is charged!!)

➡ no limit can be set

- At the LHC, some of them will have v<10 km/s, will be gravitationally trapped, and could start growing

Cures (MLM, S.Giddings: work in progress)

- Study their accretion evolution on Earth, assuming the most pessimistic (i.e. fastest growth) scenario.
  - Establish that $T_{Earth} > 10^{11}$ years (for D>7)
  - Weaker limits for D≦7, thus resort to the following:
- Prove that CR-produced BHs are trapped by neutron stars
  - Establish that assuming the most pessimistic (i.e. slowest growth) scenario, accretion will destroy the NS in less than ~ 1Byrs (which is the known age of several NS seen in the sky)

Difficult study, but can rely on robust, generic physical arguments (energy conservation, continuity equation, radiative and chemical equilibrium, basic solid-state physics, etc)

Bottom line (still preliminary):
T_{NS} [BH accretion] ~ 100 Myrs , which is less than the known lifetimes of several observed NS

The details will be documented in a forthcoming paper.

- A report, updating the previous Iliopoulos et al document, will be released before LHC start-up by the LHC Safety Assessment Group

- This will include the discussion of the stable BH cases, a review of the implications of RHIC data, etc.

- We expect that the report will be submitted for refereeing to a panel of experts, outside CERN and not engaged in the LHC programme

Other issues

- Often web sites (even BBC) quote the risk in terms of probabilities. Notice that nowhere do we have probabilities here, we only have, if anything, **upper limits** to probabilities.
- What if we are requested to foresee the unknown unkowns? What if all we know breaks down at the LHC energy?

If going through the literature of LHC-distaster web pages you find questions that you would not know how to address, feel free to send mail to the LHC safety assessment group before April 6

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