The Next Great Supercollider - Beyond the LHC

TECHNICAL NOTE

Environmental Safety Assessment

THE LARGE HADRON COLLIDER: 14 TeV COLLISION LEVELS & A LEGACY OF SAFETY REVIEW

The Large Hadron Collider (LHC) at The European Organisation for Nuclear Research (CERN) is now a familiar engineering triumph to almost anyone interested in science, physics or engineering. It has allowed scientists to push the boundary of our understanding on 'inner space', not least the finding of proof and measurement of the Higgs field and Higgs boson, enhancing our understanding of why the Standard Model is the way it works, and resolving many long-standing puzzles of particle physics.

Its p-p collisions peak at 14 TeV, for which an extensive safety review was conducted by CERN's LHC Safety Assessment Group (LSAG) prior to its operation, culminating most notably in the often cited 'Astrophysical implications of hypothetical stable TeV-scale black holes' (Giddings, Mangano, '08) [1].

That seminal paper has been regularly challenged in outsider debate since [2-17], but rarely faulted in its scientific conclusions, or the astrophysical analogies on which that safety assurance is based.

However, faults were indeed found. A cornerstone astrophysical safety assurance (relating to black hole production on white dwarfs, magnetic screening, and stopping distances) had relied on data which had just 99% confidence at the time LHC collisions commenced [25]. A subsequent revisitation by the LSAG of the derivation, based on more recent astrophysical data, proved more reassuring [8].

It is with this in mind, one should not become complacent about safety in review of future colliders.

THE NEXT SUPERCOLLIDER: 100 TeV COLLISION LEVELS

Engineering is progressive. The industry has plans to build a far greater and more powerful collider to follow from the achievements to date at CERN with the LHC. That new super-collider is planned for construction, nominally in China, to have an eventual capability of 100 TeV p-p collisions [18-23].

The proposal for the new Supercollider in China is focused on electron-positron at 240 GeV in a first phase, the 'Circular Electron Positron Collider', CEPC, followed by a 100 TeV p-p collisions in a second phase of development, the 'Super Proton Proton Collider', SPPC. That latter phase is not expected to become reality until at least 20 years time [23], as a further plan, requiring additional infrastructure.

However, feasibility studies for both the CEPC and SPPC are both at a highly advanced stage, with a conceptual design report for both published in 2015, a follow-on progress report published in 2017, and ongoing workshop events. The CEPC-SPPC Preliminary Conceptual Design Report [24] includes consideration of various environmental concerns, including 'ionizing radiation (to which a dedicated and somewhat detailed section is devoted), electrical safety, non-ionizing radiation, fire safety, construction activities, cryogenic and oxygen deficiency hazards, seismic safety issues, hazardous material issues, environmental, waste, noise, confined space, pressure, ozone, material handling, and experimental operation'. Surprisingly, however, it does not include any consideration for safety with regard to the potential of metastable MBH production, as was done for the LHC safety analysis.

ASTROPHYSICAL ASSURANCES AGAINST METASTABLE MBH AT 100 TeV COLLISION LEVELS

As the theory of Hawking Radiation still remains unverified, and the hypothetical existence of micro black holes are still a feasibility (based on the unrelated hypothesis that gravity may operate in additional 'dimensions' at the quantum level), we turn to analogies in nature for safety assurances.

The CERN safety analysis [1] prior to 14 TeV LHC collisions looked at the impact of cosmic rays (CR) on astronomical bodies - specifically the high-density bodies of white dwarf stars and neutron stars, which are sufficiently massive and dense to capture the products of CR collisions, assuring normality.

However, that CERN safety analysis considered collisions at energy levels no greater than 14 Tev. A brief look at the white dwarf analysis shows it does not necessarily hold up at higher energy levels:

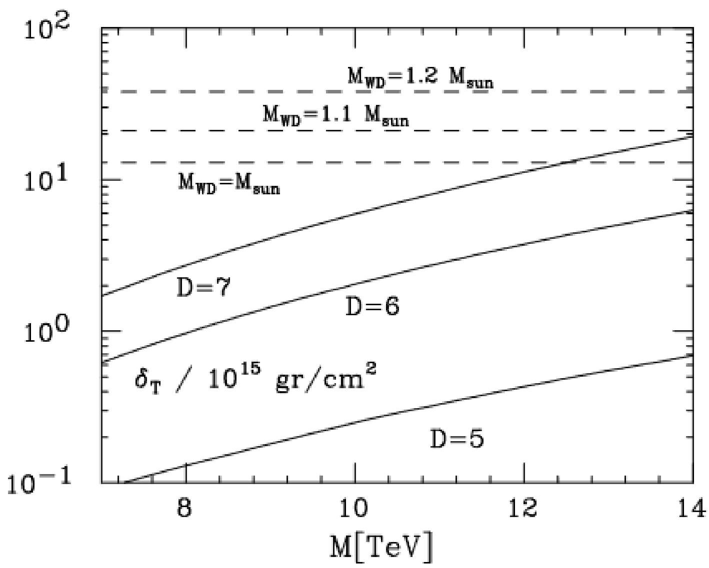

Figure 2: *Column densities required to stop black holes of different masses in different space-time dimensions D (solid lines) and integral column densities for white dwarfs of mass $M_{WD} = (1,\ 1.1,\ 1.2)$ solar masses.*

Figure reproduced from 'Astrophysical implications of hypothetical stable TeV-scale black hole'. Giddings, Mangano. 2008, with kind appreciation.

In the figure above, from the 2008 analysis by *Giddings & Mangano*, column densities required to stop micro black holes (MBH) of varying space-time dimensions (D) are plotted against their mass M[TeV]. Those column densities which correspond to white dwarf (WD) stars of mass M_{WD}=M_{SUN}, M_{WD} = 1.1 M_{SUN}, and M_{WD} = 1.2 M_{SUN}, the largest observed WD, are also indicated. It was shown that MBH of 14 TeV MBH and lower, with dimensions no greater than D=7, can be stopped by the most massive WD.

Analysis to 100 TeV is beyond the scope of this technical note, but if one follows the curvature of these same plots, and extrapolates to 100 TeV, it appears 100 TeV MBH of similar dimensions D=7, D=6 and D=5 are highly unlikely to be stopped at the M_{WD} = 1.2 M_{SUN} limit, nullifying any assurance of safety which could be drawn from WD analysis for 100 TeV MBH.

It remains an open question as to whether the neutron star (NS) safety assurance, required in safety assurance for MBH of dimensions > 8 for 14 TeV MBH, is sufficient as a solitary assurance at 100 TeV. An exploratory analysis I undertook on the NS assurance [5] raised some specific concerns, and more detailed analysis on NS assurances is required, if to be relied on as a solitary astrophysical assurance.

ARGUMENTS IN FAVOUR OF SAFETY

This technical note is primarily one of due diligence, not alarm. There are many reasons to consider the matters raised here to be null and void. MBH are a theoretical construct, never observed. Even if MBH were created, Hawking Radiation (HR) is expected to result in their immediate decay.

While gravity may occupy any further dimensions that exist (with super string theory expecting 10 dimensions, M-theory 11 dimensions, in some models more), no evidence of extra dimensions exist.

The LHC experiments at CERN in recent years at 14 TeV, have not only failed to detect MBH, but give us new insights into how gravity interacts at the quantum level [27], none of which currently suggest that gravity operates in the additional dimensions required in order for MBH to manifest.

Indeed, in ongoing astrophysical research of gravitational waves, specific contraction and expansion patterns known as ‘breathing’, expected if such extra dimensions exist [26], have yet to be observed.

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