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Why is an isolated neutron unstable?

Both protons and neutrons are hadrons consisting of quarks, which are held by gluons. Then how is an isolated proton stable while an isolated neutron isn't?

A free neutron, composed of two down quarks and one up quark, can decay into a proton (two ups and a down), an antineutrino, and an electron through the W- boson, since a down quark is more massive than the resulting up quark.

However, when a neutron is bound in a stable nucleus, the proton that's left behind by this decay finds itself in an *extremely* positively charged environment, and is *not happy* to be there. At all. In fact, the extreme energy cost of swapping a proton in for a neutron in the extreme positive charge environment of a nucleus costs more energy than the neutron releases by converting a down quark into an up quark.

Then why aren't all nuclei composed exclusively of neutrons? Well, let's think about a nucleus with two neutrons and no protons. One of the neutrons can freely decay into a proton without seeing *any* positive charge. It thinks of itself as a free neutron, and decays straight away into a proton, creating deuterium.

Okay, so clearly we can't have *just* neutrons. We need to have some protons around to keep the other neutrons from wanting to be protons. What if we have one proton and three neutrons?

These cases, some neutrons and some protons, are more complicated because of the energy shell structure of the nucleus and the Pauli exclusion principle forcing protons and neutrons into high energy states, but suffice to say that a neutron in this scenario prefers to decay to a proton, not remain a neutron, thus creating helium-4. The repulsion of a single extra proton is not sufficient to counteract the neutron's natural inclination to decay, combined with the Pauli exclusion principle forcing the third neutron into a higher energy state, whereas a second proton could sit in the lowest energy state.

I hope I've convinced you that it's a non-trivial question whether it's "better" for a neutron in a given nucleus to decay to a proton or not. We need enough protons around to "convince" the neutrons that it's better not to decay.

So why can't a free proton decay? Well, there are no baryons lighter than the proton, so the proton, if it decays, must do so in a way that converts two quarks to an antilepton and antiquark or something equally bizarre (notice the potential for an attractive matter/antimatter asymmetry explanation). No interactions that can accomplish this are known to exist.

A proton in a nucleus *can* decay, because the huge electromagnetic repulsion can make it more favorable for a proton to convert to a neutron than to endure the enormous repulsion. In this case, we just run the above diagram in reverse, swapping the W- for a W+, the electron for a positron, and the antineutrino for a neutrino.

Because in case of a neutron there exists a lower-energy state (it is the state consisting a proton, an electron, and an antineutrino), into which it can decay without violation of any conservation laws. In case of a proton no such state exists - proton is the lightest barion, so any decay into lighter particles would have to violate the barion number conservation.

Strictly speaking we are not sure that the barion number is conserved in all processes, and therefore we are not sure, that proton is completely stable. We know however, that it if decays, its lifetime must be very long (well over 1030 years), therefore the eventual barion number violating interactions must be very weak at the energies we are observing.

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Overview of jet energy calibration at the LHC

The purpose of the jet energy calibration is twofold. First, the energy scale of reconstructed jets does not correspond to the truth-particle jetenergy scale (JES),defined as the energy of jets built from all stable Monte Carlo particles from the hard interaction only, including the underlying event (UE) activity. A dedicated jet energy calibration is then needed to calibrate, on average, the reconstructed jet energy to that of the corresponding truth-particle jet. The energy scale calibration needs to also correct for the e ect of pileup. Second, the jet energy calibration has to bring the energy scale of jets in data and simulation to the same footing.

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Overlap Removal

Overlap removal summarises two aspects of the object selection that are similar in their implementation but are performed for different reasons. One of the aspects is the removal of objects that are overlapping due to a double counting of objects by the reconstruction algorithms. In this case only one of the two objects is an actual object while the other is an artefact of the reconstruction mechanism. This concerns electrons and jets, that are both reconstructed as jets by the jet algorithms. Therefore, any

jet that is found to be closer than DR(e;jet)<0: 2 to an electron after applying the object selection criteria is discarded. It can also happen that an electron is erroneously reconstructed twice. In order to reject the second electron, whenever two electrons are found within DR(e1;e2)<0:1, the electron with the lower energy is discarded

The other aspect is the spatial separation of two objects. Leptons can arise from the semileptonic decay of b or c quarks inside a jet. These leptons should in general be re-

jected by the isolation requirements, but a sizeable contribution of leptons inside jets passing the isolation requirements can be seen. Electrons and muons are thus required to be separated from jets by more than DR(lep;jet) =0:4. Muons and electrons are also seen to overlap in the detector when a muon emits bremsstrahlung and the resulting photon is misidentified as an electron. Both objects are rejected in this case if they overlap within DR(μ;e)<0:1 as both are likely to be badly reconstructed.

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Trigger matching

For plots shown in Figure 2 so called trigger matching was applied. This procedure drops electrons which did not trigger the event, e.g. gammas that were misidentified

as electrons during the reconstruction process. The idea is to match offline electrons to trigger objects with pTover given trigger threshold using minimization of the ΔR distance, defined by Equation 2. Only offline electrons with a trigger object matched in ΔR <0.2 cone were considered.One can see the effect of the trigger matching in Figure 3. After applying trigger matching there is no artifact in the low-pT region that is caused by fake electrons. The efficiency in general is a little bit lower, but comparing the mean plateau efficiencies the efficiencies are the same when taking into account the statistical uncertainity (without trigger matching (0.993 ± 0.005), with trigger matching (0.992 ±0.005)).

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QCD Background

In simple terms QCD as a "background" usually refers to LHC research where hadronic jets create a lot of particles that clutter up the results you're trying to see. I think it has become a slang term and the use is discouraged.

ABCD method is a tool used to separate the particles of interest (signal) from the "other stuff" (background) made by the jets. It is a set of boundaries that relies on the fact that you have two independent distributions to distinguish between signal and background. See section 5.3 here http://dare.uva.nl/document/221955

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CalibrationDataInterface (CDI)

https://twiki.cern.ch/twiki/bin/view/AtlasProtected/BTaggingCalibrationDataInterface#Basic_interface

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he Asimov data set

To estimate median value of -2ln (μ), consider special data set where all statistical fluctuations suppressed and ni,mi are replaced by their expectation values (the Asimov data set):

The name of the Asimov data set is inspired by the short story Franchise, by Isaac Asimov [1]. In it, elections are held by selecting a single voter to represent the entire

electorate.

The "Asimov" Representative Data-set for Estimating Median Sensitivities with the

Profile Likelihood G. Cowan, K. Cranmer, E. Gross , O. Vitells

[1] Isaac Asimov, Franchise, in Isaac Asimov: The Complete Stories, Vol. 1, Broadway Books, 1990.

A useful element of the method involves estimation of the median significance by replacing the ensemble of simulated data sets by a single representative one, referred to here as the Asimov data set.

https://arxiv.org/pdf/1007.1727.pdf

http://e-pepys.livejournal.com/47526.html

22 beam spot

Using charged-particle tracks emerging from pp collisions and measured by the ATLAS Inner Detector we reconstruct vertices on an event-by-event basis within the HLT. The three-dimensional distribution of these vertices reflects that of the luminosity and can be parametrized by a three-dimensional Gaussian whose paramters are sometimes referred to as the luminous ellipsoid, or also as the beam spot . The coordinates of its luminous centroid determine, in the ATLAS coordinate system, the position of the average collision point; the orientation of the luminous ellipsoid in the horizontal (x-z) and vertical (y-z) planes is determined by the angles and relative transverse sizes of the two beams at the IP; and the transverse and longitudinal dimensions of the luminous region, quantified in terms of the luminous sizes , are related to the corresponding IP sizes of the two beams.
