

Proton antimatter is even more one-sided than we thought

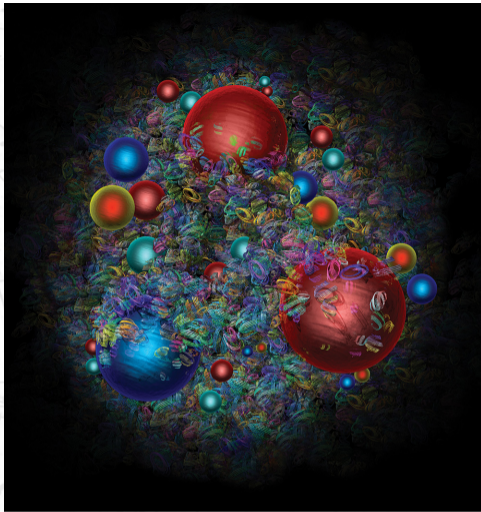
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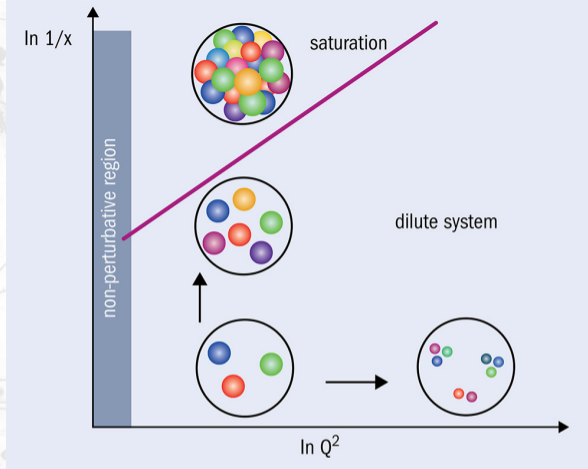
arXiv: 2103.04024

NICA



Protons are disordered internally. Composed of three main quarks (shown as large spheres), the particles also contain an ever-changing set of transition quarks and antiquarks (smaller spheres) and gluons (squiggles) that bind the quarks together.

DANIEL DOMINGUEZ/CERN




Structure of a proton depending on the scale Q^2 and the momentum fraction x . The number of partons increases with Q^2 , but they have less momentum. The number of partons also increases as x decreases to the point where the population becomes so dense that gluon recombination can lead to saturation. At low Q^2 , the strong coupling α_s is so strong that reliable perturbative calculations are impossible.

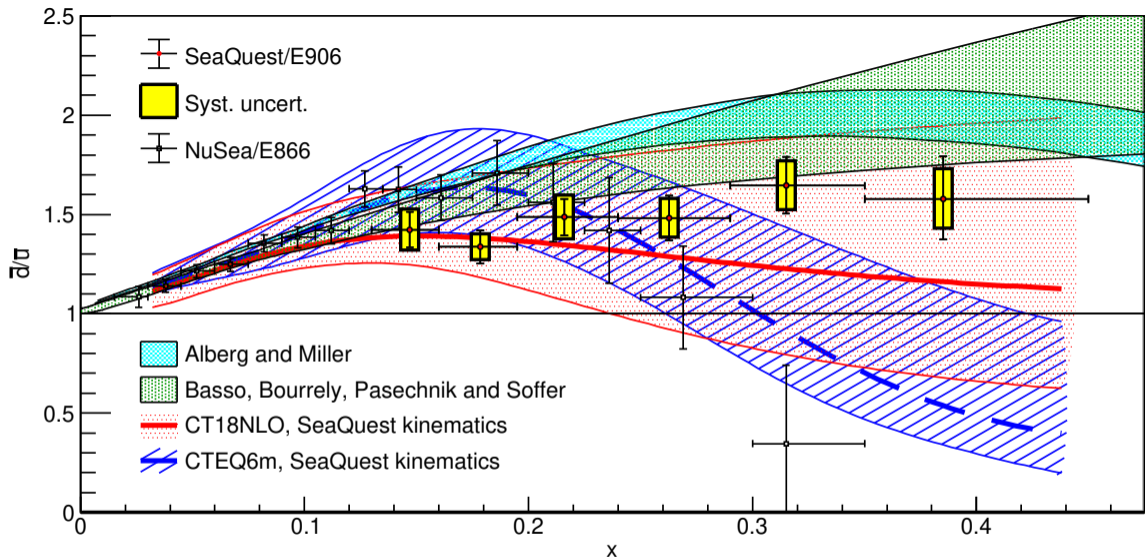
■ Very interesting note:

 *The proton laid bare, Amanda Cooper-Sarkar, (8 May, 2019)*
<https://cerncourier.com/a/the-proton-laid-bare/>

■ SeaQuest experiment at Fermilab:

 *The asymmetry of antimatter in the proton, J. Dove et. al,*
*Nature, **590**, 561–565 (2021)*

- Protons are made up of three quarks - two "up" quarks and one "down" quark. But they also contain a seething sea of fleeting quarks and antiquarks that oscillate before rapidly annihilating each other.
- Within that sea, down antiquarks outnumber up antiquarks, measurements revealed in the 1990s.
- Typically, each antiquark carries only a tiny slice of a proton's total momentum. But sometimes a single antiquark can make up a large fraction of the momentum.
- Earlier measurements suggested that up and down antiquarks with a sizable chunk of momentum might be found in similar numbers. But the new tests, made by slamming protons into targets made of hydrogen and deuterium (hydrogen with an extra neutron in its nucleus), contradict that idea.
- SeaQuest researchers found that down antiquarks were about 50 percent more prevalent than up antiquarks — even when a single antiquark carried nearly half the proton's total momentum.



The red solid and blue dashed curves show the calculated ratios of $\bar{d}(x)$ to $\bar{u}(x)$.