Faster than light neutrinos?

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Disclaimer:
While I'm reasonably confident about the contents of this talk, there is the very distinct possibility that I've got things wrong. See the list of references/sources at the end for places where you can get more information

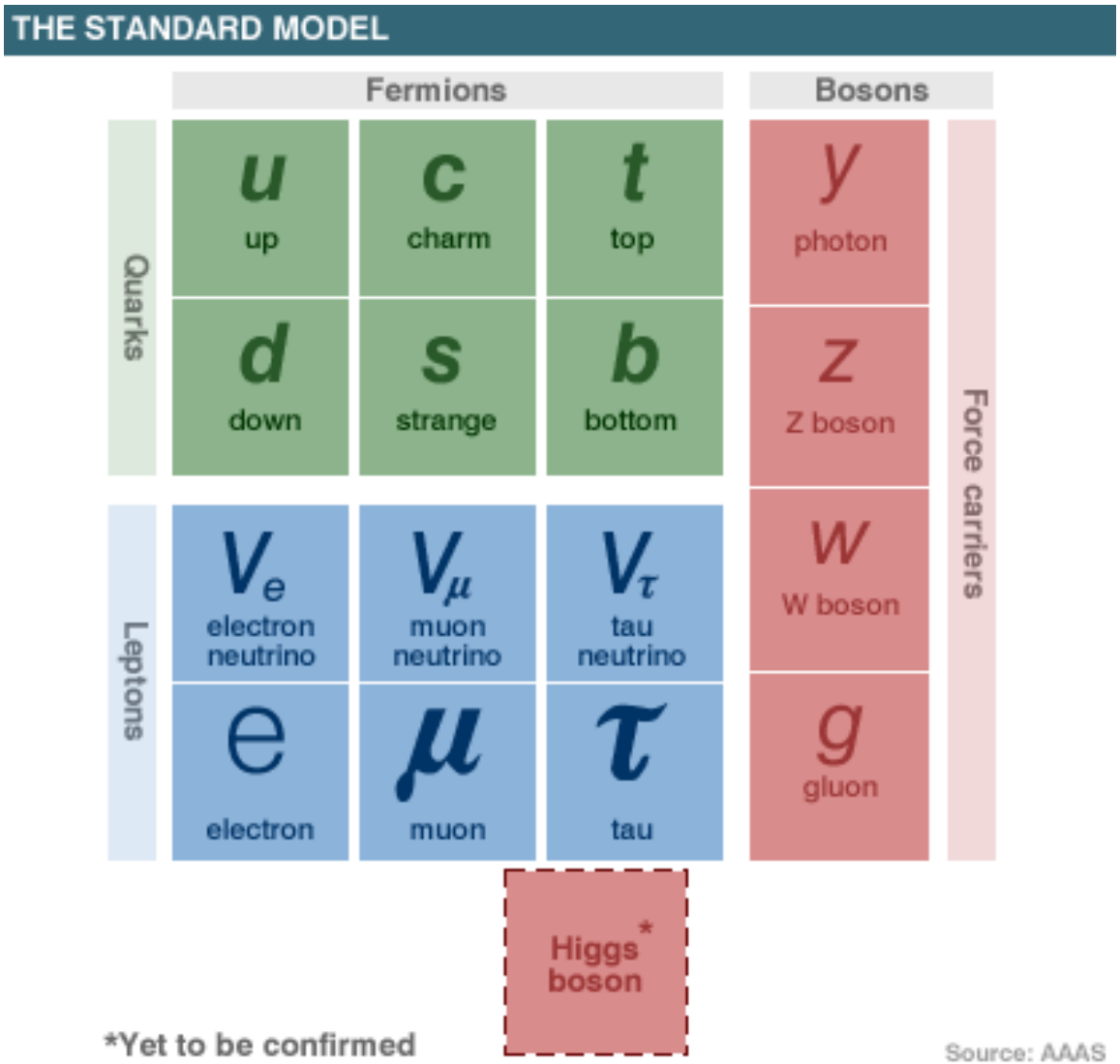

Figure: Standard Model of Physics

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- On average, $10^{16}\mathrm{m}^{-2}\mathrm{s}^{-1}$ at the Earth's surface

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- But only 3 neutrinos will interact with your body over your lifetime, on average
- $\longrightarrow$ Neutrino experiments tend to be difficult!
- To add to that, neutrinos 'oscillate' from one type to another over time, so what you end up with is not necessarily what you started with

- Collaboration of physicists from across the world
- Neutrinos fired at Gran Sasso by CERN
- Detector at Gran Sasso
- Sensitive timing equipment at each end

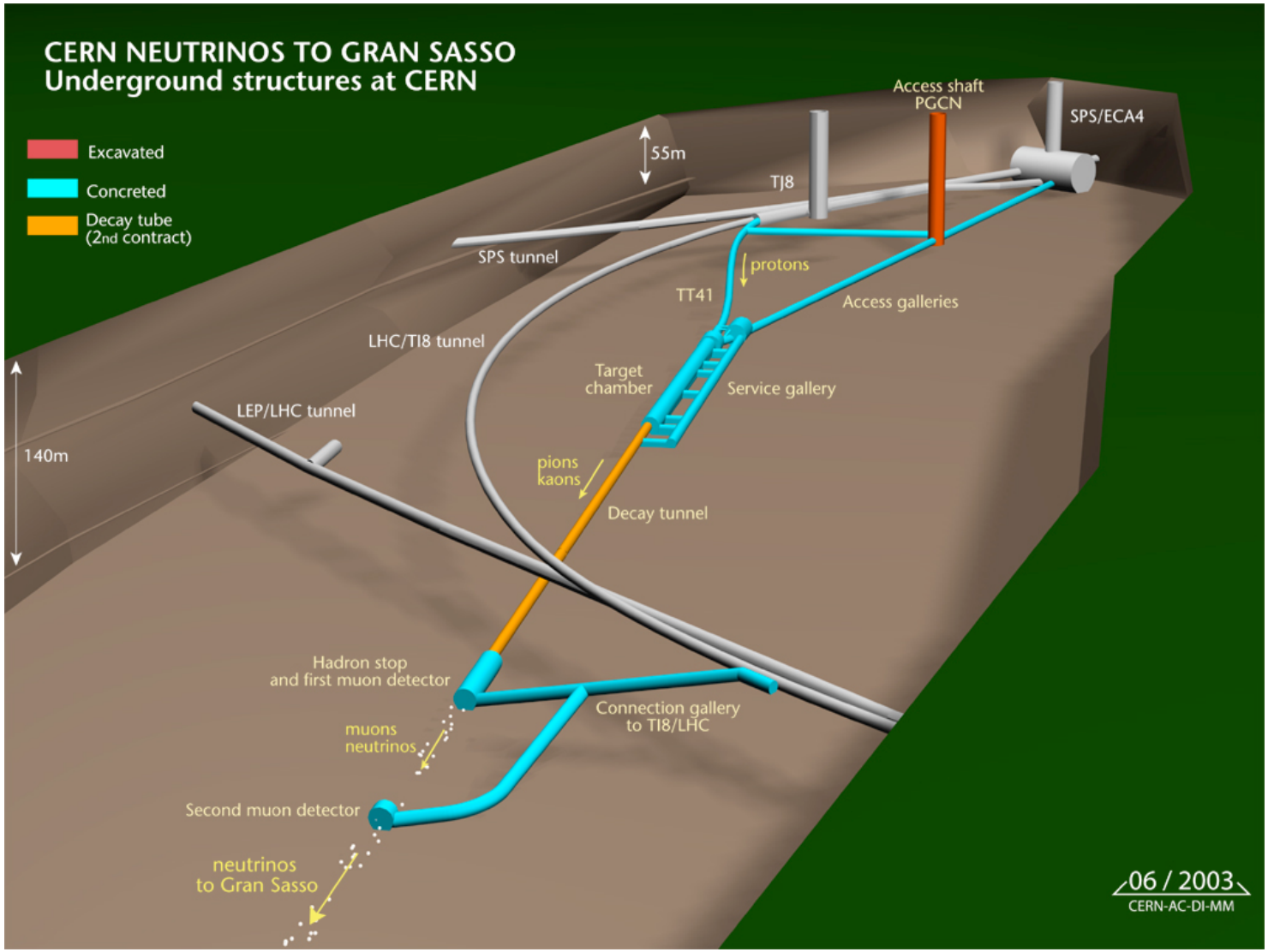

Figure: The "Particle Cannon", aimed at Gran Sasso

- The main aim is to observe tau-neutrinos from the oscillation of muon-neutrinos
- One of the other possible experiments is to measure the time of flight between CERN and Gran Sasso

- Based on measurements over 3 years (2009,2010,2011), the distance was measured to be $730\mathrm{km}$
- Each packet of neutrinos sent from CERN was recorded, and the profiles matched to the corresponding bunches detected at Gran Sasso
- The result issued in September indicated that neutrinos were arriving sooner than they would if they travelled at c
- The 'anomaly' was calculated as $60.7 \pm 6.9(stat.) \pm 7.4(sys.)$ ns
  (Statistical and Systematic errors respectively)

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Possibilities:

- Clocks weren't synced right
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- Difference between expected and actual neutrino production
- And so on

Timing system:

- The master clocks were synced to each other, then transported to the experiment sites.
- Calibrated by Swiss Metrology Institute (METAS) and verified by the German Metrology Institute PTB

The error analysis saw a lot of attention when the paper was published - seems to be fine

The best explanation I've found suggests that OPERA may not have allowed for the motion of the GPS satellites.
This would add an error of $\sim$ 64ns, which would make the results consistent with known physics.

Any Questions?

- OPERA Collaboration http://operaweb.lngs.infn.it/
- CNGS http://proj-cngs.web.cern.ch/proj-cngs/
- The OPERA preprint http://arxiv.org/abs/1109.4897
- (A) Possible solution http://arxiv.org/abs/1110.2685