Machine Learning & Quantum Computing for Future Colliders

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MLQC4FC

29 May 2026 - Quantum Technologies for Fundamental Physics

Context & Motivations

A driving principle

The second theme that **George Green**'s work exemplifies is the historical fact that **scientific revolutions are more often driven by new tools than by new concepts**.

Thomas Kuhn in his famous book, **"The Structure of Scientific Revolutions"**, talked almost exclusively about concepts and hardly at all about tools. His idea of a scientific revolution is based on a single example, the revolution in theoretical physics that occurred in the 1920s with the advent of quantum mechanics. This was a prime example of a concept-driven revolution. Kuhn's book was so brilliantly written that it became an instant classic. **It misled a whole generation of students and historians of science into believing that all scientific revolutions are concept driven.** The concept-driven revolutions are the ones that attract the most attention and have the greatest impact on public awareness of science, but in fact they are comparatively rare.

In the last 500 years we have had 6 major concept driven revolutions, associated with the names of Copernicus, Newton, Darwin, Maxwell, Einstein and Freud, besides the quantum-mechanical revolution that Kuhn took as his model. **During the same period there have been about 20 tool-driven revolutions,** not so impressive to the general public but of equal importance to the progress of science. I will not attempt to make a complete list of tool-driven revolutions. Two prime examples are the Galilean revolution resulting from the use of the telescope in astronomy, and the Crick-Watson revolution resulting from the use of X-ray diffraction to determine the structure of big molecules in biology.

The effect of a concept-driven revolution is to explain old things in new ways. The effect of a tool-driven revolution is to discover new things that have to be explained. In physics there has been a preponderance of tool-driven revolutions. We have been more successful in discovering new things than in explaining old ones.

George Green's great discovery, **the Green's function, is a mathematical tool rather than a physical concept.** It did not give the world a new theory of electricity and magnetism or a new picture of physical reality. **It gave the world a new bag of mathematical tricks**, useful for exploring the consequences of theories and for predicting the existence of new phenomena that experimenters could search for. The Green's function was **a tool of discovery, like the telescope and the microscope,** but aimed at mathematical models and theories instead of being aimed at the sky and the microbe.

Freeman J. Dyson, Birds and frogs, Selected Papers 1990-2014

Why MLQC4FC?

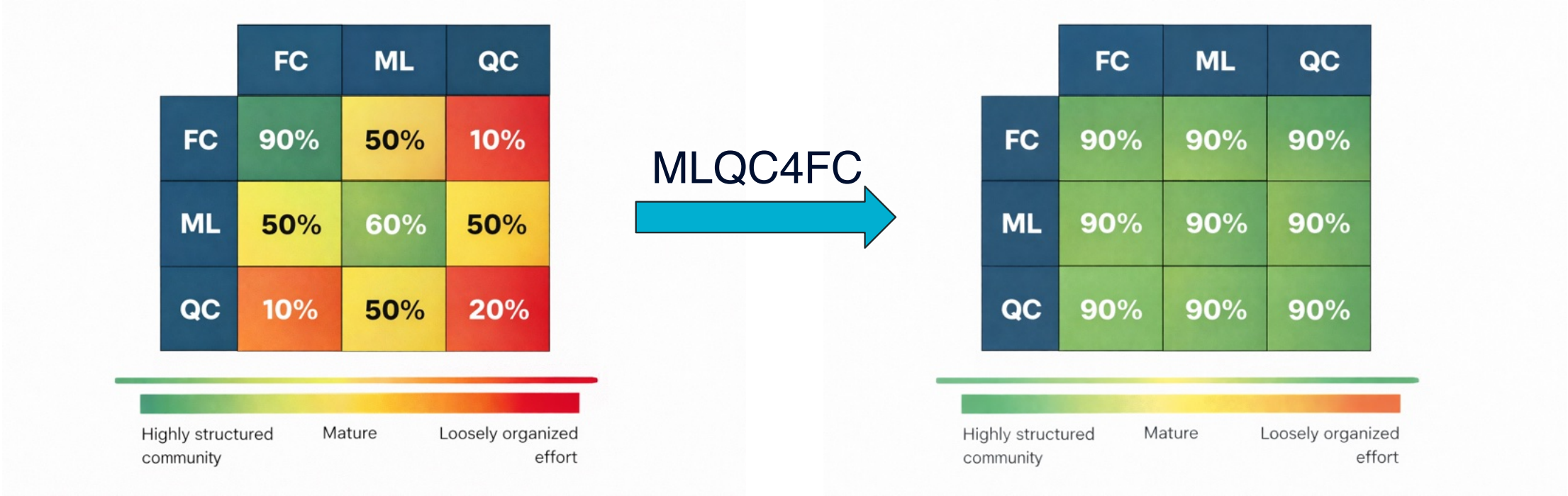
To answer the following question:

What is the impact of emerging computing technologies, such as ML/AI & QC on the design, study, construction, operation and interpretation of results at Future Colliders?

- Studies more often consist of applying/extrapolating present analyses/studies, which may result in too conservative conclusions
- We may lose some paths just because we are too "pessimistic" (e.g. triggers/pile-up issues)

Why a COST Action?

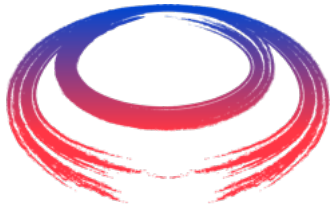
To organise the community and structure the effort:
a challenging networking endeavour



Many communities involved:

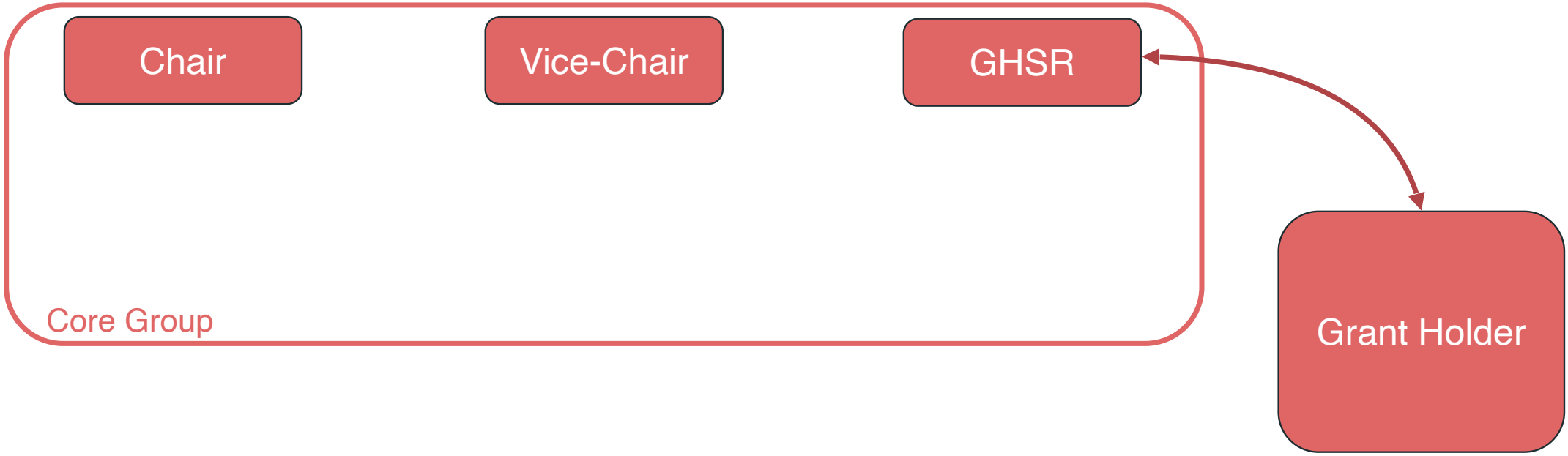
hep-ex, hep-ph, hep-th, hep-lat, physics.acc-ph, physics.data-an, quantum-ph, cs.AI, stat.AP, stat.ML, …

Where we sit in the ecosystem



Structure & Governance

Overall Action Structure



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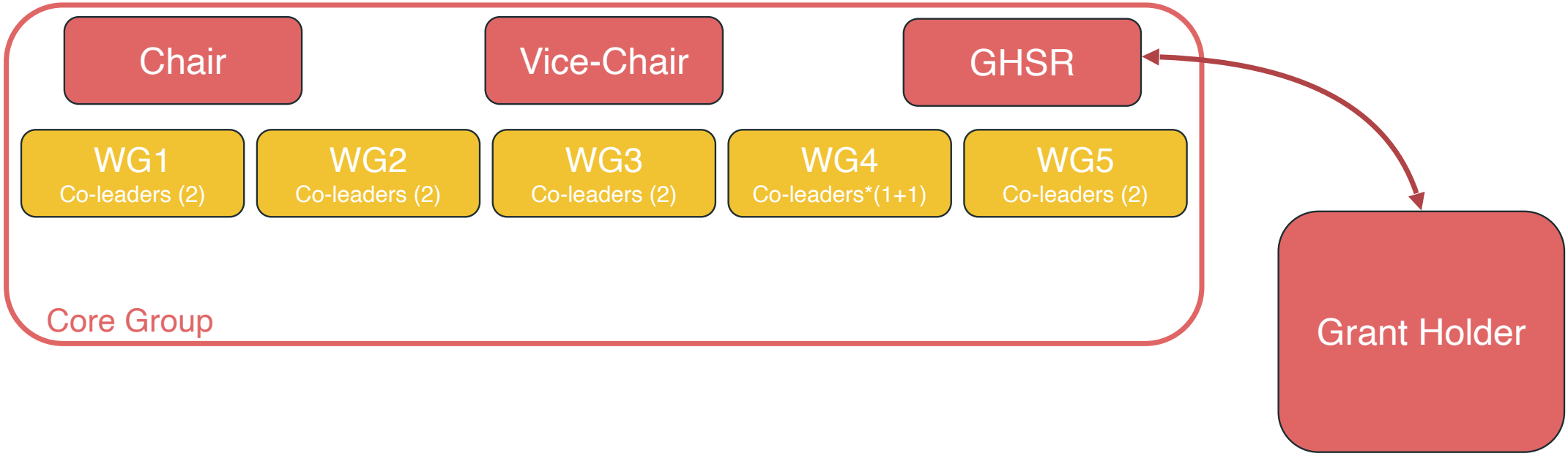

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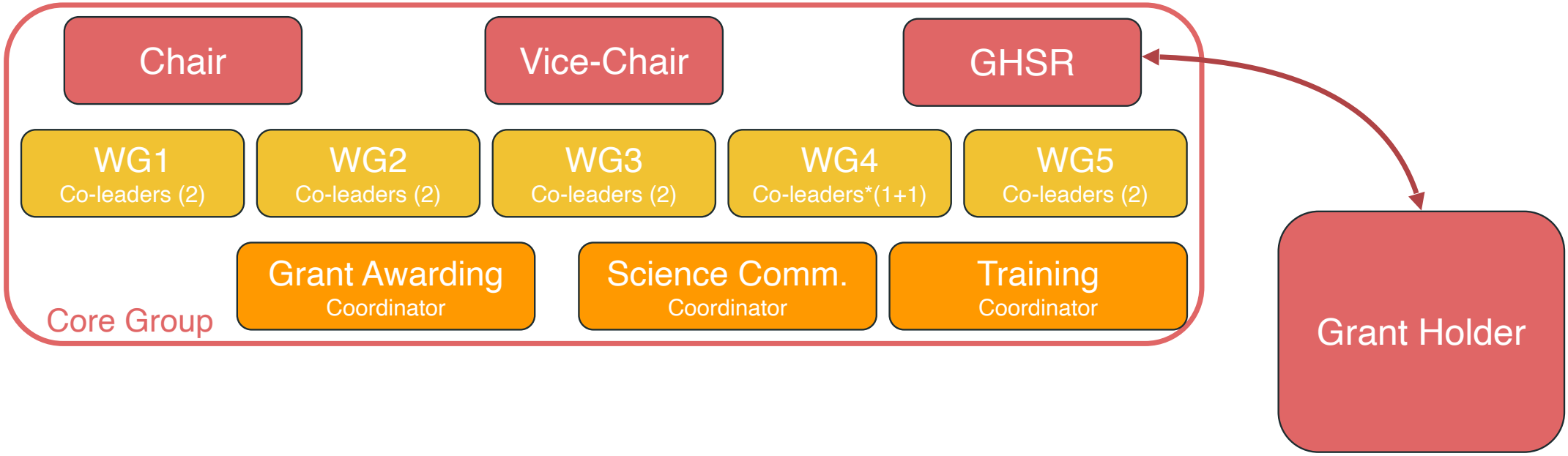

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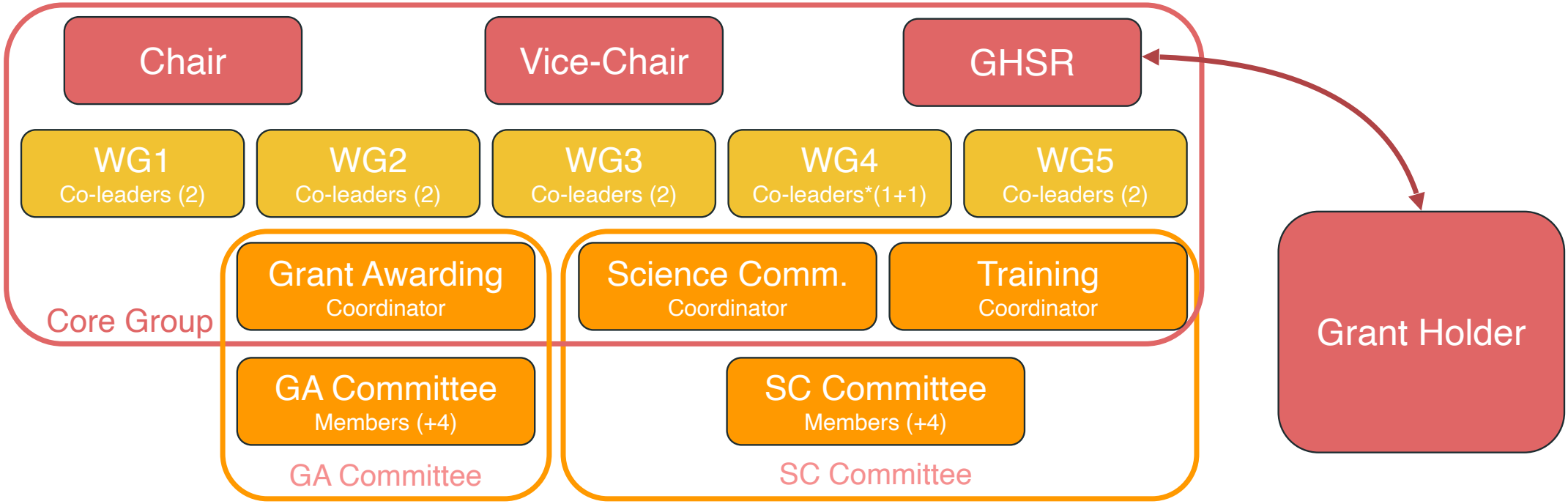

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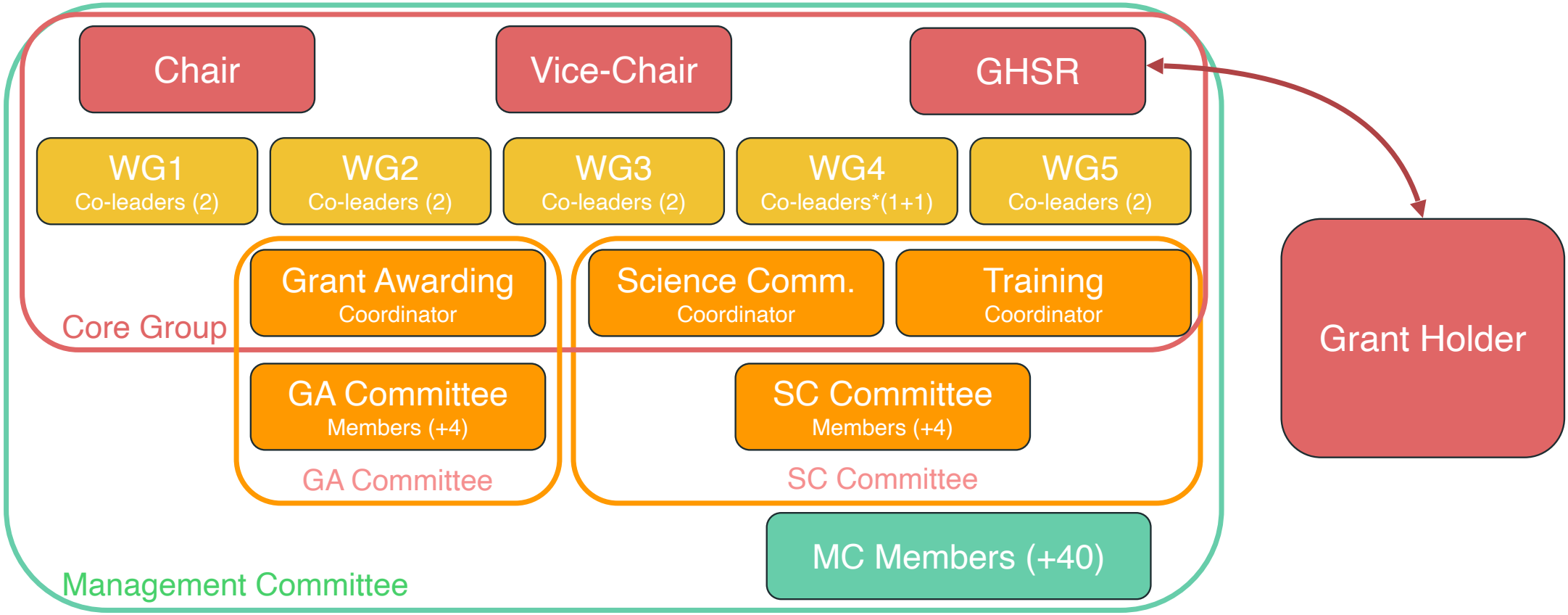

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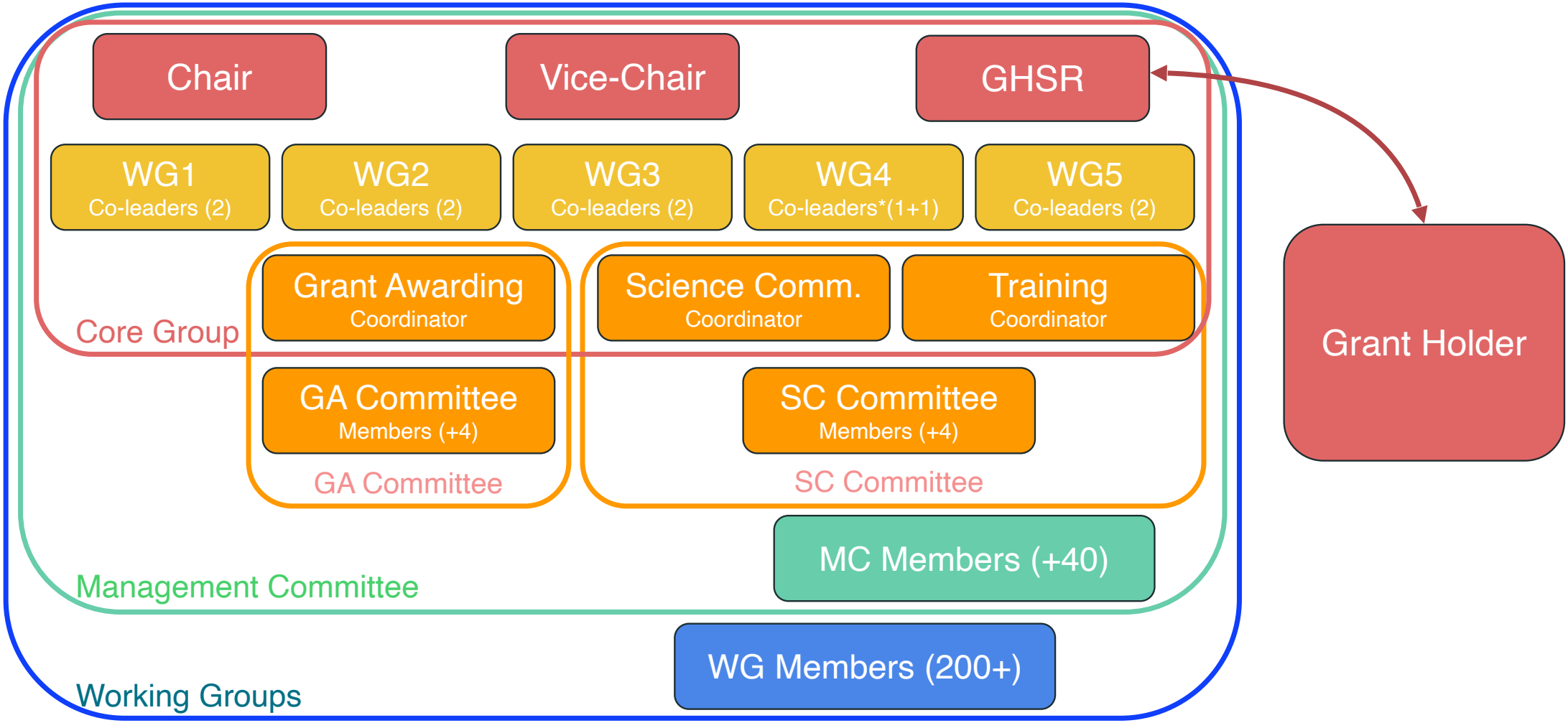

The MLQC4FC webpage

Thank you for your attention!