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Devising grassroots mechanisms for stimulating and supporting international collaboration

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What collaboration styles exist in astro(particle), particle and nuclear physics?

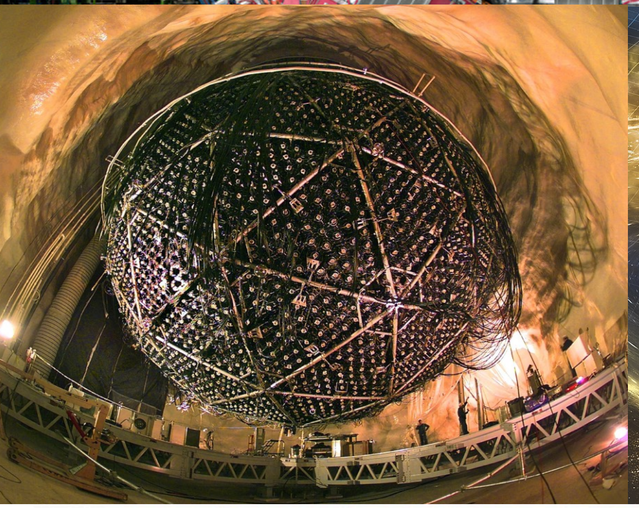
- **Centralised facility hosting major user-based infrastructure**
  - Various scaling of support to these infrastructures:
    - Global - CERN,
    - Regional - ESS, XFEL, FAIR
    - National - FNAL, JPARC, SNOLAB
- **Distributed networks of researchers using multipurpose remote infrastructure & observatories:**
  - Space, Telescopes, Computing
  - e.g. SKA, CTA, Grid
- **Large scale project-orientated collaborations**
  - IceCube, Auger, Advanced-LIGO
- **Grassroots development starts from bottom-up**

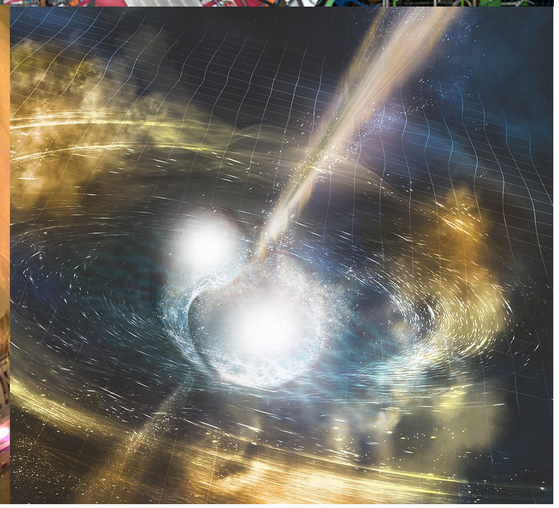
How do international collaborations develop from grassroots and up?

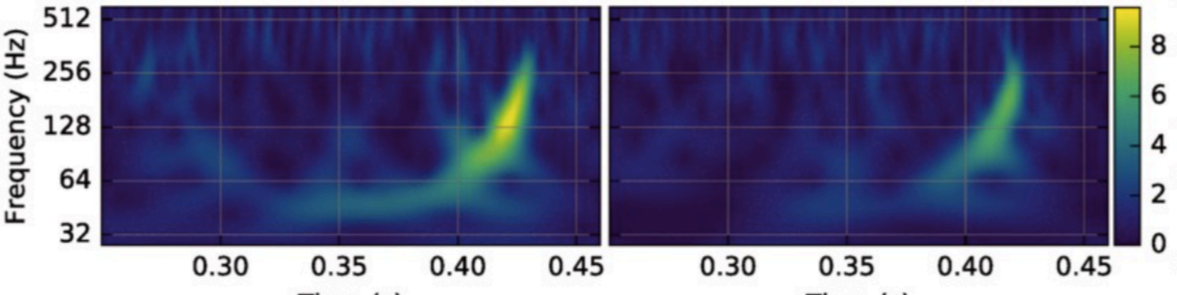
- **Slowly!**
  - Need to develop consensus for requirement within large scientific (and funding) community
  - Long timescales for many projects - decadal
- **Focused on the physics problem and required project to solve the question**
  - Where do cosmic rays come from? Does the neutrino have mass? Do gravity waves exist?
  - Precision measurements follow discovery
- **Development of project concept is multi-pronged**
  - Technology R&D essential to push boundaries
  - Progenitors required to demonstrate capability
  - Down-select based on physics potential
  - Eventually you've got to build something...

What challenges exist in developing international collaborations? How do you overcome?

- **Challenge: Balance between R&D and project delivery**
  - R&D essential to attack new problems, requires long timescales and flexibility, but…
  - Resource specification requires well defined project
- **Challenge: Scale of required resources**
  - Require appropriate scale of collaboration
  - Need to persuade multiple agencies across national boundaries (and any internal boundaries)
- **Challenge: Variations in research ecosystems**
  - Funding, oversight, commitment timescales
- **Solutions: Road-mapping exercises**
  - Charge-based: e.g. US NSAC and P5, ESFRI, …
  - Grassroots regional-based: e.g. EU Astroparticle
  - Grassroots theme-based: e.g. facility strategy, national strategy for field (Snowmass)
- **Solutions: Community consensus development**
  - IUPAP Commissions and Working Groups
    - e.g. Neutrino Panel for Hyper-K/DUNE support
- **Solutions: Personal connections**
  - Primary grass-roots development still through personal connections at conferences, talks/ seminars, workshops and conferences (e.g. Aspen/PI) - e.g. next-gen dark matter







What does success look like? What supports are needed?

- **Amazing successes in this model**
  - ATLAS/CMS: Discovery of the Higgs boson
  - Homestake/Super-K/SNO: Neutrino has mass, neutrino oscillations occur
  - Advanced-LIGO: Gravitational waves exist, neutron star mergers
  - IceCube: Extra-Galatic neutrinos created in blazars
- **Requires established, long-term structures across national boundaries**
  - Major science objective, and consensus on need
  - Funding for R&D, M&O and HQP
  - Strong governance, management, operations
  - Engagement and access across borders
    - especially for specialised location infrastructures