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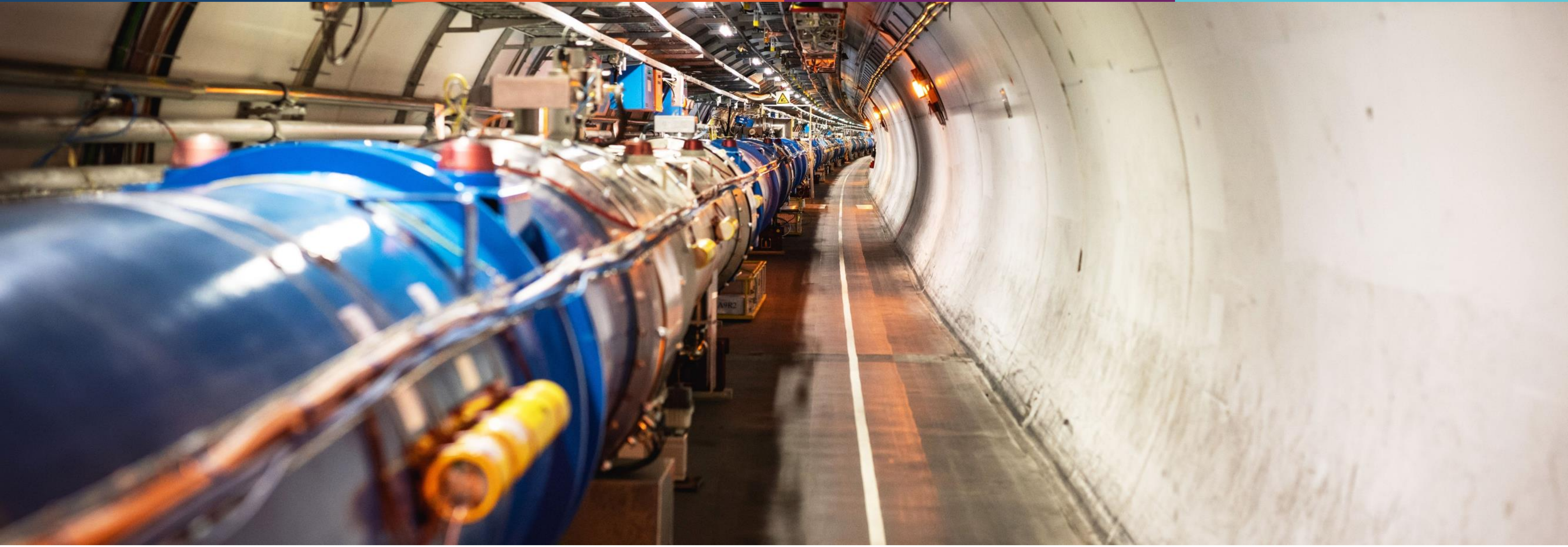

When and how do scientists start to plan for their next scientific experiments?

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There are many unanswered questions in fundamental physics

What is mass? Gravity? Charge?

Why is there something rather than nothing?

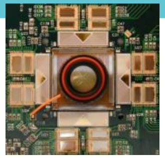
How many dimensions?

When?

- Generally speaking
  - When the main physics goals of current experiments have been reached
  - When current physics discovery potential starts to show signs of reducing
    - Incremental (efficiency) gains witnessed (e.g. energy, luminosity)
  - When new, better ideas start clustering together (bottom up)
    - New theories, new methods
  - When new measurement technologies start becoming within reach (R&D)
  - When the opportunity is right (will and time to pool resources together)

When?

How?

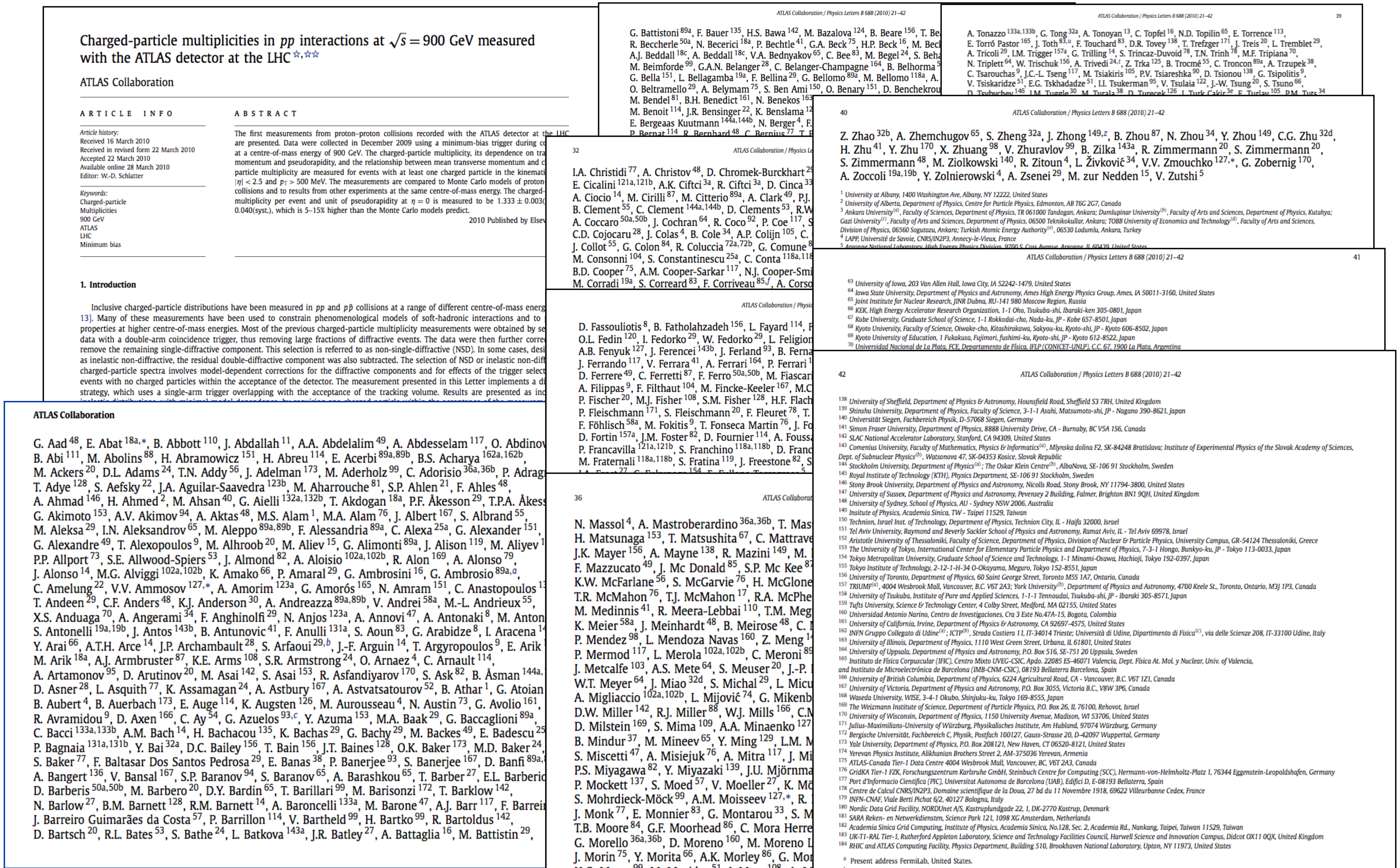


- Shaping the shared purpose (“dreams”)
  - Articulating the measurable goals and the timeline
    - Physics goals/questions (on several layers)
    - Avoiding too narrow challenges; leaving room also for serendipity
- Agreeing on a (light) bottom-up project structure (collaboration)
  - Memorandum of Understanding (MoU)
    - Principles for contributions (“deliverables”), pooling of resources, recognizing (individual) contributions, reporting use of resources etc.
  - Host Lab involvement and support (infra, admin, reporting etc.)
- Agreeing on procedures how to solve challenges (technical, admin)
  - Guiding principle of consensus-seeking (avoiding voting, if possible)
  - Principle of transparency (“we are all in the same boat”)

Simple Micro «Rules»

- Allow people to dream (5% makes already a difference)
- Tolerate diversity
- Let the physics decide, not the hierarchy. Elect leaders based on technical competence, credibility and trust
- Collaborate and compete
- Question and justify – Respect the Dukes of Doubt rather than Kings of Truth

Generous sharing of success

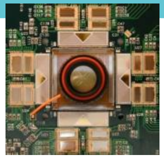


Progress is being closely monitored also outside…

Memorandum of Understanding (MoU)

- The Project Charter is the Memorandum of Understanding (MoU)
- Legally non-binding agreement based on best effort
- Drafted between **CERN** (Host Lab) and **Funding Agencies**, the MoU describes the sharing of detector hardware construction responsibilities and costs
- Relationship between the Host Lab and Experiment (e.g. ATLAS) broadly defined
- Fundamental principle of *deliverables* (in-kind contributions)
    - Potluck party
    - Deliverables grouped around **sub-projects**
    - Items not pledged for are pooled centrally, funds collected as “tax”
- The construction cost envelope in 1995 Swiss Francs was 475 MCHF
    - Direct costs, excluding manpower, R&D, institute infrastructure, prototyping, VAT
    - Major exchange rates fixed (e.g. $/CHF=1.1; GBP/CHF =1.8)
    - No centralized budget contingency
    - CERN provides technical infrastructure support, but is also a participating scientific institute
- Project personnel (management, project leaders, coordinators) are elected by the **community**
- Participating institutes have equal voting rights

Timeline of the LHC Experiments



- Initial (conceptual) project planning started by informal, ad-hoc group(s) of interested scientists in mid 1980’s
- Timeline
  - Late 1980’s: Further R&D was needed to prove feasibility of proposed technical concepts. CERN initiated formal, generic detector R&D projects
  - Early 1990’s: Bottom-up detector proposals; merging into Letters of Intent (LoI, 1992)
  - Mid 1990’s: Technical Proposals (TP,1995); sub-detector prototyping; sub-system Technical Design Reviews (TDRs)
  - Late 1990/Early 2000’s: Approval of Cost Book; signing of MoU; start of detector modules manufacturing (always following a Production Readiness Review PRR and respective TDRs); start of installation at CERN (cavern handed over in 2003)
  - Mid 2000’s: Installation, commissioning of Detectors in the cavern; completed in 2008 for initial runs
- Initial project coordination was implicit and handled by the contact persons for the early proposals. After LoI in 1992, the project coordination was carried out by elected mgmt teams
  - Later on, reporting interactions got defined and set up in the MoU (signed in 1998)
- LHC and the experiments started producing physics (results) as of 2009

Any lessons for the future? My personal reflections

- Well, it can be done …
  - … but ultimately depends on the quality of new ideas, available technologies and resources available (and geopolitical situation)
  - … but perhaps not best model for more incremental projects?
- What could be improved next time around?
  - Handling of effects of economic uncertainty (contingency)
  - Better mechanisms to ensure delivery of agreed contributions (deliverables)
- Can the LHC model be replicated? Where?
  - Next generation physics experiments (and not only HEP)…
  - In open science/innovation models
  - In complex, large-scale undertakings where risks/benefits are high, where (thus) a collaborative approach is required, where not all steps can be determined ex ante (fuzzy processes).

More background info here: doi.org/10.1093/acprof:oso/9780199567928.001.0001

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