



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

CERN-IPU Science for Peace School, December 5, 2022

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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)







- 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

	ATLAS Collabora	tion / Physics Letters B 688 (2010) 21-42	ATLAS Callaboration / Physics Letters ii 6588 (2010) 21–42 39
Charged-particle multiplicities in <i>pp</i> interactions at $\sqrt{s} = 900$ GeV measured with the ATLAS detector at the LHC $\stackrel{*}{\leftrightarrow}, \stackrel{\pm}{\sim}$	G. Battistoni ^{89a} , F. Bauer ¹³⁵ , H.S. Bawa ¹⁴² , M. R. Beccherle ^{50a} , N. Becerici ^{18a} , P. Bechtle ⁴¹ , C A.J. Beddall ^{18c} , A. Beddall ^{18c} , V.A. Bednyakov M. Beimforde ⁵⁹ , G.A.N. Belanger ²⁸ , C. Belang G. Bella ¹⁵¹ , L. Bellagamba ^{15a} , F. Bellina ²⁹ , G.	C.A. Beck ⁷⁵ , H.P. Beck ¹⁶ , M. Becl ⁶⁵ , C. Bee ⁸³ , M. Begel ²⁴ , S. Beh er-Champagne ¹⁶⁴ , B. Belhorma ⁵ Bellomo ^{89a} , M. Bellomo ^{118a} , A.	A. Tonazzo ^{133,1339} , G. Tong ³²² , A. Tonoyan ¹³ , C. Topfel ¹⁶ , N.D. Toplin ⁶⁵ , E. Torrence ¹¹³ , E. Torró Pastor ¹⁶⁵ , J. Toth ^{53,47} , F. Touchard ⁵³ , D.R. Torey ¹³⁸ , T. Tretzger ¹⁷¹ , J. Treis ²⁰ , L. Tremblet ²⁹ , A. Tricoli ²⁹ , I.M. Tigger ¹³⁷ , G. Tilling ¹⁴ , S. Trinczz-Duvol ²⁷ , J.N. Tinh ⁷⁵ , M.F. Triphan ⁷⁰ , N. Triplett ⁶⁴ , W. Trischuk ¹⁵⁶ , A. Trivedl ²⁴⁴ , Z. Tika ¹²⁵ , B. Trocme ⁵⁵ , C. Toncon ⁵⁸ , A. Trzupel ³⁸ , C. Tsarouchas ⁹ , J.CL. Tseng ¹¹⁷ , M. Tsiakiris ¹⁵⁰ , P.V. Tsiareshka ³⁰ , D. Tsionou ¹³⁸ , G. Tsipolitis ⁹ , V. Tsiskartudg ²⁷ , E.G. Tsikhadga ²⁷ , I.I. Tsiwerman ⁷⁰ , Y. Tsiareshka ³⁰ , J. Tsionou ¹³⁸ , G. Tsipolitis ⁹ ,
ARTICLE INFO ABSTRACT	O. Beltramello ²⁹ , A. Belymam ⁷⁵ , S. Ben Ami ¹ M. Bendel ⁸¹ , B.H. Benedict ¹⁶¹ , N. Benekos ¹⁶³ M. Benoit ¹¹⁴ , J.R. Bensinger ²² , K. Benslama ¹²	⁵⁰ , O. Benary ¹⁵¹ , D. Benchekrou	v. Isiskai Juce 6 (v. 1 Saudaduze , h. Isiska: Julian , v. Fsudata , J. Fw, Isung , S. Isuno , D. Teoduchev 46 [M] Tunel 30 M. Turels 36 Threese 226 [Turk Galer 28] E. Turk Galer 28 E. Turksv 105 PM. Tute 34 ATLAS Collaboration / Physics Letters B 688 (2010) 21–42
	E. Bergeaas Kuutmann ^{144a, 144b} , N. Berger ⁴ , F. P. Bernat ¹¹⁴ R. Bernbard ⁴⁸ C. Bernius ⁷⁷ T. F.		
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Introduction Inclusive charged-particle distributions have been measured in <i>pp</i> and <i>pp</i> collisions at a range of different centre-of-mass energy 13]. Many of these measurements have been used to constrain phenomenological models of soft-hadronic interactions and to properties at higher centre-of-mass energies. Most of the previous charged-particle multiplicity measurements were obtained by se data with a double-arm coincidence trigger, thus removing large fractions of diffractive events. The data were then further corre remove the remaining single-diffractive component. This selection is referred to as non-single-diffractive (NSD). In some cases, des as inelastic non-diffractive, the residual double-diffractive components and for effects of the trigger select events with no charged particles within the acceptance of the detector. The measurement presented in this Letter implements a d strategy, which uses a single-arm trigger overlapping with the acceptance of the tracking volume. Results are presented as in	 M. Consonni ¹⁰⁴, S. Constantinescu^{25a}, C. Conta ^{118,116} B.D. Cooper⁷⁵, A.M. Cooper-Sarkar¹¹⁷, N.J. Cooper-Smi M. Corradi ^{19a}, S. Correard⁸³, F. Corriveau^{85,7}, A. Corso ArLAS Collaboration / Physic D. Fassouliotis⁸, B. Fatholahzadeh ¹⁵⁶, L. Fayard ¹¹⁴, F O.L. Fedin ¹²⁰, J. Fedorko²⁹, W. Fedorko²⁹, L. Feligion 	⁶⁴ Iowa State University, Departmen ⁶⁵ Joint Institute for Nuclear Researc ⁶⁶ KEK, High Energy Accelerator Res ⁶⁷ Kobe University, Graduate School ⁶⁸ Kyoto University, Faculty of Scient ⁶⁹ Kyoto University of Education, 11	Hall, Iowa City, IA 52242-1479, United States for QF Physics and Astronomy, Ames High Energy Physics Group, Ames, IA 500011-3160, United States h. JRN Duhma, XU-14 1980 Moscow Mcgion, Russia earch Organization, I-1 Ohn, Tsukuba-shi, Ibaraik-ean 305-6801, Japan of Science, 1-1 Rokado-tshi, Nata-ka-ka, Pocho EG-78-501, Japan roc, Owake-cha, Kitashirakawa, Salyoun-ku, Kyoto-shi, JP - Nyoto Gio-Stoz, Japan Wakasan, Ajilumo, Thahimi-ku, Kyoto-shi, P- Nyoto Gio-Stoz, Japan
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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 Lol 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).

