Global Strategy in Particle Physics

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European Strategy Says

- Exploitation of the LHC till ~2030 the highest priority
- Accelerator R&D and design studies for high energy frontier machines as the post LHC project in Europe to be chosen by the 14 TeV LHC data
- Participate in ILC if Japanese government moves forward with the project

Why priority and strategy?

- There is not enough resources to do everything we would like to do. Projects are getting expensive and big science is no longer monopoly of particle physics
- There is not enough scientific evidence to guide the way
- Construction time for facilities and detectors is becoming very long, ≳10 years.
- New projects often need intensive R&D effort before realisation, or even before decision.

But there are difficulties

- Longstanding dilemma of balancing: deciding facilities, experiments, R&D and even on theoretical work.
  - large project vs. small initiative
  - global vs. local effort
  - focused effort vs. blue-sky research
  - sensational subjects vs. solid bread and butter work
- Science first but…
  - individual tastes are different, different people have different visions
  - there are always economical, sociological and political constraints

In fact, if we can make strategy purely scientifically, we do not really need strategy.

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  - Obvious evolutional path but will end up with a dinosaur?
  - People have to be ready to give up their own toys. Still room for initiative at smaller scale for surprises?
  - Can be done only with bottom-up effort?

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- In the horizontal space dimension, i.e. avoid duplication to make more diversity:

  Can happen "passively"; two B factories but only one super B factory (direct consequence of resource limitation),

  or may need "active" coordination; neutrino in the US and LHC + upgrade at CERN?

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  For the "active" coordination

  - Community have to agree on their shares
  - Still
    cost of single project ≃ resource of one big country/region

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  - A choice has to be made: bottom-up, top-down, in between, weighting factor between physics and other issues, etc. etc.?
  - Generate a period of no data between the projects.
    - thanks to Tevatron, B factories, BES, DAFNE,…
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Why globalisation?

- Combining space-time dimension allows to realise

  cost of single project > resource of one big country/region

  by global agreement on a single project at a given time and stagger projects in time
  - Can Ω_{cost}(single project) >> $\Omega_{resource}$(~10 years), like a cathedral?
  - May generate worldwide no data period.
  - This is a formidable task dealing with worldwide communities and government! May need to combine with "other quantum number" (see next)

Why globalisation?

- Other quantum number is the “field”, i.e. globalisation in the field: happened in a small scale within particle physics, TRISTAN→KEKB→JPARC→SuperKEKB

  Resource for possible large projects in any field worldwide is VERY large:

  – Could we ever come to an agreement to share this?

Existing machines

- There has been no global machines:
- LEP was $< \Omega_{\text{resource}}$ (CERN, $<O(10)$ years)
  European machine with international detectors
- LHC was $\approx \Omega_{\text{resource}}$ (CERN, $\sim O(10)$ years)
  With international contribution to both machine but with still CERN machine run by CERN
  (NB: HERA was German machine with international contribution)
- Flavour facilities are regional/national
  CERN, CH, CN, IT, JP, RU, US
- Accelerator based neutrino facilities are national
  US, JP
  and will remain so for a while (although international contribution will be for sure welcome)

Current situation and relevant facilities

- Higgs joined as a (unique) tool for precision test of the Standard Model (along with electroweak, quark flavour, charged lepton flavour physics):
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- Neutrinos remain to be mysterious
  - m_ν Majorana vs Dirac (or both?): radioactive source
  - anomalies in reactor neutrino and short baseline experiments: rectors, accelerator
  - m_ν mass and mixing parameters (precision measurements on θ_{12}, θ_{23}, and θ_{23}, and δ_{CP}, mass hierarchy, m_e): sun and universe, radioactive source, reactor, accelerator
  - heavy neutral leptons: cosmic x-ray, accelerator

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- Direct search of new physics: nothing found so far at LHC 7/8 TeV: LHC + upgrade, ILC, FCC, CEPC + SppC,

High energy machines

- LHC 13-14 TeV run ~300 fb^{-1} by 2022
  - Consolidation upgrade for the machine through "classical" path
  - Phase-1 detector upgrade
- LHC 14 TeV run ~3 ab^{-1} by 2035
  - Major machine upgrade through "**classical**" or global path
  - Phase-2 detector upgrade: major upgrade may require some restriction on the cost…?

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- ILC still below 10 BCHF
  might happen as the first global project
- FCC well be well above 10 BCHF (what about CLIC?)
  could happen only as a VERY global project
- CEPC-SppC
  Chinese project with international participation a la LHC?

Comment on roadmap exercise

- Some regions/countries are working for roadmap
- Europe, CERN Council, European Strategy for Particle Physics, we know it by heart (or already forgot it)
- Japan, Japanese Association for High Energy Physicists
- US HEPAP with P5 subpanel

Roadmap Japan

- Association of Japanese High Energy Physicists (community organisation) regards that ILC and Hyper-K are the two priority projects in Japan
  - Hyper-K:
    through international cooperation
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    hosting ILC as a global project
- Science Council of Japan, an advisory body to the government consists of the scientists from all the discipline selected 27 large projects for Japanese Roadmap (out of 192): two selected for particle physics
  - Upgrade of JPARC experimental facility: μ(g−2), μ2e, hadron areas, …
  - Hyper-K, detector construction, operation + JPARC operation

Roadmap Japan

- A separate assessment by the Science Council of Japan was made for ILC on request by the Japanese government
  - Importance of Higgs physics acknowledged
  - Technological maturity of ICL acknowledged
  - Outstanding issues to be resolved before deciding on whether to host ILC: two big ones are…
    - Consolidation of physics, taking into account the LHC upgrades and prospect for direct observation of new physics
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- Academia-industrial support
  - Advanced Accelerator Association: industries and academic institutions
- Political support
  - Nonpartisan federation of Japanese Diet members for promotion of ILC

Roadmap the US

- P5 identify five since "drivers" and now working hard to prioritise the projects (slide from S. Ritz, P5 Chair)

P5 Identified Scientific Drivers for the Field

"Driver" = a compelling line of inquiry that shows great promise for major progress over the next 10-20 years. Each has the potential to be transformative. Expect surprises.

- Use the Higgs as a new tool for discovery.
- Explore the physics associated with neutrino mass.
- Identify the new physics of Dark Matter.
- Test the nature of Dark Energy in detail, and probe the physics of the highest energy scales that governed the very early Universe.
- Search for new particles and interactions; new physical principles.

These drivers are intertwined, possibly even more deeply than we currently understand. A selected set of different experimental approaches, which reinforce each other, is required. This effort also opens important discovery space beyond the drivers.

March 2014 8

Anticipation in 2018

- In 2018, with results from the 14 TeV LHC data we may
  - find new particles: If $m \lesssim 1$ TeV, CLIC becomes a very interesting option. (Would there be a way to increase the LHC energy with the existing tunnel with below "global Ω" threshold?)
  - find no new particles but a sign of deviation from the Standard Model in Higgs properties: ILC becomes a very interesting machine, since technically it will be ready to go
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  - there is one more possibility, which you know too well
    Continue precision physics. Can we argue for FCC?
- How far are we ready for a global project? For FCC, we really need to make it as a global project…

Note that …

- The first European strategy for particle physics was adopted in June 2006: Colliders at the moment were:
  - HERA @ DESY — ep — DE
  - DAFNE @ LNF — e^+e^- — I
  - LHC @ CERN under construction — pp — CH
  - CESR-C @ Cornell — e^+e^- — US
  - Tevatron @ FNAL — pp — US
  - RICH @ BNL — $(p,d,Cu,Au,U)^2$ — US
  - PEP II @ SLAC — e^+e^- — US
  - KEKB @ KEK — e^+e^- — JP
  - BEPC-II @ IHEP under construction — e^+e^- — CN
  - VEPP4M @ BINP — e^+e^- — RU
  - VEPP2000 @ BINP under construction — e^+e^- — RU

And now

- The last European strategy for particle physics was adopted in May 2013: Existing colliders were:
  - DAFNE @ LNF e^+e^- I
  - LHC @ CERN pp CH
  - RICH @ BNL $(p,d,Cu,Au,U)^2$ US
  - SuperKEKB @ KEK under construction e^+e^- JP
  - BEPC-II @ IHEP e^+e^- CN
  - VEPP4M @ BINP e^+e^- RU
  - VEPP2000 @ BINP e^+e^- RU

Five closed down and **only one has been approved**…

Finally

What do **you** think about the future facilities of high energy physics facility?

To decide on the future of particle physics, globalisation, strategy, roadmap, etc etc are just tools to help looking for a solution, but not the solution nor objectives. What we really need is passion for science, healthy practical common sense and some, or even better many, luck.

and

- I am sorry for full of my personal prejudice in this talk!