Perspective on the European Strategy from Asia

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CoEPP and University of Melbourne,
AUSTRALIA
Yes, from Asia!

... but with input from other Asians ...

Usual Caveat:
Comments are my own, not an official position.
Any good ideas are probably those of others. etc...
But first, some observations from this meeting…

- If we are planning for decades into the future, we must get the opinions and involvement of the younger members of our community (Peter Jenni)

- Experts are telling us that high field magnets take decades to develop. “Are we going to spend the next 3 or 4 decades waiting for 16T magnets…” anon.
  - **100km tunnels may be the easy part of the next generation high energy frontier (with circular machines, at least)**

- For new physics **14TeV μ+μ- ⇐ 100TeV pp** (Vladimir SHILTSEV)
  - **need to pursue muon collider vigorously**

- When will plasma acceleration be central to planning?
How can Asian projects/facilities impact upon Europe’s particle physics future?

Desire
Resources
People
Technology
Outline

• Existing Facilities
• Experience in Asian Collaboration
• Future Facilities of Key Impact to EPPSU2019
  • *In particular: ILC, CepC*
  • *Status*
• Benefits of Asia Hosting Major Facilities
• A Suggestion for Consideration
• Very little technical information will be presented.
• Much has been presented in this Symposium.
• Detailed documents have been submitted and referred to.
• Will concentrate on non-technical Asian perspective
Existing Facilities

• **Japan:**
  - SuperKEKB/Belle II - high intensity B-factory
  - SuperKamiokande (T2K) (→ HyperK and Upgraded J-parc)
  - J-parc high intensity, low energy physics - COMET
  - Kamioka U/G Observatory - XMASS-I Direct Dark Matter Search
  - …

• **China:**
  - Daya Bay (→ JUNO) - Reactor Neutrino Physics
  - BEPC (Proposal: tau/charm factory)
  - LHAASO - Very high energy cosmic ray observatory
  - Jinpin - U/G laboratory - PANDA-X and CDEX Direct Dark Matter Searches
  - …

• **Korea:**
  - RENO - Reactor neutrino physics
Participation in HEP

- Japan
- China
- India
- Korea
- Taiwan
- Hong Kong
- Australia
- Thailand, Vietnam, Indonesia …

Considerable contributions to European and US programs
Asia and the European Strategy

• Strategy concentrates on Future Facilities
  • Present Future Asian Facilities and their impact on European Planning for Future Facilities:
    • HyperK (Japan), JUNO (China) are future facilities, briefly shown here.
    • Underground facilities especially Jinpin and Kamioka Underground Observatory, are of a scale that does not impact strongly on European planning.
  • Will concentrate on:
    • ILC (Japan)
    • CEPC (China)
    (And leave SppC for a future Strategy Planning meeting!)
Postcards from China

Yifang Wang
IAS-HKUST, Jan. 24, 2019

Geoffrey Taylor “Perspective on the European Strategy from Asia”, EPPSU2019, Granada
Postcards from China

Yifang Wang
IAS-HKUST, Jan. 24, 2019
China HEP Hosting Experience

Geoffrey Taylor “Perspective on the European Strategy from Asia”, EPPSU2019, Granada
Postcards from China

JUNO

Overburden ~ 700 m

Kaiping, Jiang Men city, Guangdong Province

Yifang Wang
IAS-HKUST, Jan. 24, 2019


by 2020: 26.6 GW
China HEP Hosting Experience

Europe (28)
- Italy (8): INFN-Catania, INFN-Frascati, INFN-Ferrara, INFN-Milano, INFN-Mi-Bicocca, INFN-Padova, INFN-Perugia, INFN-Roma 3
- Russia (3): INR Moscow, JINR, MSU
- Slovakia (1): FMPICU
- Austria (1): INFN-Vienna

America (6)
- US (2): UMD, UMD-Geo
- Chile (2): PCUC, UFSM
- Brazil (2): PUC-Rio, UEL

Asia (38)
- Thailand (3): SUT, PPRLCU, NARIT
- Pakistan (1): PINSTECH
Postcards from Japan

SuperKEKB to set new Luminosity Record

SuperKEKB

40 times higher luminosity

KEKB

PEP-II

Peak Luminosity Trends (e+e− collider)

10^36

10^35

10^34

10^33

10^32

10^31

10^30

1970

1980

1990

2000

2010

2020

Year

Luminosity

SuperKEKB

COEPP

ABC Centre of Excellence for Particle Physics of the Teraelectronvolt
Belle II Collaboration

- Over 800 International Collaborators
- Commencing operation
- Expected to run through 2026+
**Belle II**
Higher sensitivity to decays with photons and neutrinos (e.g. $B \rightarrow K\nu\nu$, $B \rightarrow \mu\nu\nu$), inclusive decays, time dependent CPV in $B_d, \tau$ physics.

**LHCb**
Higher production rates for ultra rare $B, D, \& K$ decays, access to all b-hadron flavours (e.g. $\Lambda_b$), high boost for fast $B$, oscillations.

**Overlap in various key areas to verify discoveries.**

**Upgrades**
Most key channels will be stats. limited (not theory or syst.). LHCb scheduled major upgrades during LS3 and LS4. Belle II formulating a 250 $ab^{-1}$ upgrade program post 2028.

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### Belle II - LHCb Comparison

<table>
<thead>
<tr>
<th>Observable</th>
<th>Current Belle/ Babar</th>
<th>Current LHCb</th>
<th>Belle II (50 $ab^{-1}$)</th>
<th>LHCb (23 $fb^{-1}$)</th>
<th>Belle II Upgrade (250 $ab^{-1}$)</th>
<th>LHCb upgrade II (300 $fb^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CKM precision, new physics in CP Violation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sin 2\beta/\phi_1 (B \rightarrow J/\psi Ks)$</td>
<td>0.03</td>
<td>0.04</td>
<td>0.005</td>
<td>0.011</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>$\gamma/\phi_3$</td>
<td>13°</td>
<td>5.4°</td>
<td>1.5°</td>
<td>1.5°</td>
<td>0.4°</td>
<td>0.4°</td>
</tr>
<tr>
<td>$\alpha/\phi_2$</td>
<td>4°</td>
<td>–</td>
<td>0.6°</td>
<td>–</td>
<td>0.3°</td>
<td>–</td>
</tr>
<tr>
<td>$</td>
<td>V_{ub}</td>
<td>/(</td>
<td>V_{ub}</td>
<td>/</td>
<td>V_{cb}</td>
<td>)$ (LHCb)</td>
</tr>
<tr>
<td>$\phi_8$</td>
<td>–</td>
<td>49 mrad</td>
<td>–</td>
<td>14 mrad</td>
<td>–</td>
<td>4 mrad</td>
</tr>
<tr>
<td>$\Delta c(B \rightarrow \eta^-' Ks, gluonic penguin)$</td>
<td>0.08</td>
<td>–</td>
<td>0.015</td>
<td>–</td>
<td>0.007</td>
<td>–</td>
</tr>
<tr>
<td>$A_{CP}(B \rightarrow K_\pi^0)$</td>
<td>0.15</td>
<td>–</td>
<td>0.04</td>
<td>–</td>
<td>0.02</td>
<td>–</td>
</tr>
<tr>
<td><strong>New physics in radiative $&amp;$ EW Penguins, LFUV</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta c(B_d \rightarrow K^+ \gamma)$</td>
<td>0.32</td>
<td>–</td>
<td>0.035</td>
<td>–</td>
<td>0.015</td>
<td>–</td>
</tr>
<tr>
<td>$R(B \rightarrow K_\tau^{+}\tau^{-}) (1 &lt; q^2 &lt; 6 \text{ GeV}^2/c^2)$</td>
<td>0.24</td>
<td>0.1</td>
<td>0.03</td>
<td>0.03</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>$R(B \rightarrow D^+\tau\nu)$</td>
<td>6.4%</td>
<td>–</td>
<td>10%</td>
<td>1.5%</td>
<td>3%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>$Br(B \rightarrow \tau \nu), Br(B \rightarrow K^+\tau\nu)$</td>
<td>24%, –</td>
<td>–</td>
<td>4%, 9%</td>
<td>–</td>
<td>1.7%, 4%</td>
<td>–</td>
</tr>
<tr>
<td>$Br(B_d \rightarrow \mu \nu)$</td>
<td>–</td>
<td>90%</td>
<td>–</td>
<td>34%</td>
<td>–</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Charm and $\tau$</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta c(B \rightarrow \pi\nu)$</td>
<td>–</td>
<td>$8.4 \times 10^{-4}$</td>
<td>$5.4 \times 10^{-4}$</td>
<td>$1.7 \times 10^{-4}$</td>
<td>$2 \times 10^{-4}$</td>
<td>$3 \times 10^{-4}$</td>
</tr>
<tr>
<td>$A_{CP}(D \rightarrow \pi^+\tau^0)$</td>
<td>1.2%</td>
<td>–</td>
<td>0.2%</td>
<td>–</td>
<td>0.1%</td>
<td>–</td>
</tr>
<tr>
<td>$Br(\tau \rightarrow e \gamma)$</td>
<td>&lt;120 $\times 10^{-9}$</td>
<td>–</td>
<td>&lt;120 $\times 10^{-9}$</td>
<td>–</td>
<td>&lt;5 $\times 10^{-9}$</td>
<td>–</td>
</tr>
<tr>
<td>$Br(\tau \rightarrow \mu \nu)$</td>
<td>&lt;21 $\times 10^{-9}$</td>
<td>&lt;46 $\times 10^{-9}$</td>
<td>&lt;3 $\times 10^{-9}$</td>
<td>&lt;16 $\times 10^{-9}$</td>
<td>&lt;0.3 $\times 10^{-9}$</td>
<td>&lt;5 $\times 10^{-9}$</td>
</tr>
</tbody>
</table>

$\circ$ Possible in similar channels, lower precision
$-$ Not competitive.

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*arXiv: 1808.08865 (Physics case for LHCb upgrade II), 1808.10567 (Belle II Physics Book)*

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Geoffrey Taylor “Perspective on the European Strategy from Asia”, EPPSU2019, Granada
New water Cherenkov detector, Hyper-Kamiokande with 190 kiloton fiducial mass and double-sensitivity PMTs

J-PARC neutrino beam upgrade to 1.3MW with new and upgraded near detectors

Broad science program

- Precise measurements of neutrino oscillations and CP asymmetry in lepton sector
  $\delta_{CP}$ accuracy $22^\circ (\delta = \pm 90^\circ)$
- Proton decay reach to 1035 years ($p \rightarrow e^+\pi^0$)
- Rich neutrino astronomy objects: Sun, nearby supernova, diffuse SN neutrinos, GW coincidence $\nu$, etc
European participation in Japan-based neutrino program

Super-Kamiokande (as of Jan. 2019)
- France
- Italy
- Poland
- Spain
- UK

T2K (as of Jan 2019)
- France: 39
- Germany: 4
- Italy: 22
- Poland: 32
- Russia: 24
- Spain: 14
- Switzerland: 29
- CERN joined T2K in March 2019

Hyper-Kamiokande (as of Dec. 2018)
- Europe (130 people)
  - Armenia
  - France
  - Germany
  - Italy
  - Poland
  - Russia
  - Spain
  - Switzerland
  - UK
- Asia (105 people)
  - Armenia
  - Korea
  - India
  - Japan
- Americas (62 people)
  - Brazil
  - Canada
  - USA

~300 members from 17 countries

~500 members from 12 countries

25-50% of collaborators are from Europe!
Complementarity of DUNE/LBNF and T2HK

- Different v-energy
- Different Baseline (1300 vs. 295km)

Complementary sensitivity to Lepton-CP Violation and v Mass Hierarchy
Hyper-K project status

- Priority project of host labs, ICRR/UTokyo and KEK
  - *International review committee under directors*
- Listed among seven priority projects in the MEXT Roadmap 2017
  - *Its importance and urgency are recognized by the Japanese government*
- Seed funding for FY2019 has been allocated by MEXT
- Preparing for start of construction in 2020
- Expect to begin operation in ~2027
Direct Impact on CERN Planning

- ILC ←→ CLIC
- CEPC ←→ FCC(ee)
- Nature of Impact of these parallels on planning

(And potentially impact of SppC on FCC(hh), but will not be considered further here.)
ILC or CLIC

- Status well documented
  - https://clic.cern/european-strategy
  - https://ilchome.web.cern.ch/content/ilc-european-strategy-document

- See S. Steinar Stapnes talk (Monday)
- See D. Schulte talk (Monday)

  - No feasibility issue is known for any of the proposed higgs factories CLIC, ILC, FCC-ee and CEPC
ILC or CLIC?

- “We need a linear collider!”
- Both are capable of providing the essential “Higgs Factory”:
  - \textbf{240-250\text{GeV} e+e- Collider}
  - \textbf{Extending to high energy}:
    - CLIC initial capability already at 380\text{GeV} - top quark threshold
    - ILC up to \textasciitilde800 -1000\text{GeV} - Future upgrade, more $
    - CLIC to multi-\text{TeV} - Future upgrade, more CHF
    - both at significant additional cost

See S. Stapnes talk this Symposium
Apparently significant difference at the overlap region (~250GeV) quite a range of luminosities.

See D Schulte’s talk: differences should not be taken too seriously at this stage!
ILC Update

“Why is it taking so long to get a decision from Japan?”

**ILC IS STILL VIABLE**

We are hopeful of a positive response from the Japan
Recent Developments of ILC in Japan

- KEK & Japanese HEP: Post-2012 Higgs ->
  - ILC 250GeV Higgs factory in Japan, upgradable in energy.

- November 2017:
  - LCB strong support
  - Timely decision sought from Japanese Government

- July 2018:
  - ILC Advisory panel of MEXT recommended the ILC proposal be reviewed by the SCJ.

- December 2018:
  - SCJ released its report - some issues need addressing

- March 2019:
  - MEXT presented its view to the LCB meeting in Tokyo
  - ILC Federation of Diet Members message of support
    - MEXT and KEK released their action plans.
  - ICFA made clear that other options being considered at EPPSU2019

MEXT= Ministry of Education, Culture, Sports, Science & Technology in Japan
Science Council of Japan (SCJ), Master Plan

• SCJ represents all sciences but
  • *Not policy making nor budgetary authority*

• Large-scale project proposals sought every three years.
  • *recommends “priority programs” to MEXT*
  • *2017 round: 20 selected from 200 proposals*

• MEXT Minister: ILC be evaluated in this process to provide evidence of support by the broader academic community in Japan
  • *ILC proposal submitted with recommendation letter from Barry Barish*
  • *Results of this evaluation will be publicist February 2020 (informally late 2019?)*

• Active political work continues
International WG initiated by KEK, MEXT

- Members: 2 (Europe), 2 (North America), 2 (Asia incl. Japan)

- Update ILC-PIP to describe:
  - *International share of the remaining technical development*
  - *Organization and governance of the ILC Laboratory*
  - *Model of international cost-sharing for construction and operation*

- Will report to MEXT and other government agencies as a recommendation from the international ILC community ~ September 2019

- Draft report will be presented at the LCB meeting in August 2019
But can CERN/Europe Rely on Asia?

ILC:

- It has taken a long time to get this far
  - (SLC), NLC, GLC, JLC …
- But finally ILC - International Linear Collider
  - ILC250 as first phase
  - Japan as Host, with strong participation by all regions
- So why so hard?
  - 4.8-5.3BILCU pricetag with about half from Japan
    - Very big additional national investment in HEP
  - “Zero Sum Gamers” (non-HEP scientists) in Japan (... but remember the SSC)
  - Process, cultural differences: perhaps our expectation of the process unrealistic
- Are we there yet?
  - No! but Very Positive Signals
  - Still hoping for international negotiations to start soon, construction from 2023-24
CepC or FCC(ee)

- Similar and becoming more so!
- Still have different constraints applied in design details

See M. Benedikt talk this Symposium

Also, CEPC Conceptual Design Report
Volume 1 - Accelerator
IHEP-CEPC-DR-2018-01

Geoffrey Taylor “Perspective on the European Strategy from Asia”, EPPSU2019, Granada
e+e- Lumi Comparison

- Complementary nature:
  - **Circular colliders** have very high luminosity at low energy
  - **Linear colliders** have high energy development path

- Original Plot, F. Bedeschi, CEPC Workshop, Rome, May 2018
- Updates Private communication, Keisuke Fujii, IPNS, KEK
CepC Path to Funding

• “Chinese Initiated International Large Scientific Plan and Large Scientific Project”:
  
  • **By 2020 3-5 Projects will be selected for further development with some funding**
  
  • **Following a small number of years (?), 1~2 projects selected for construction**
  
  • **Should be complementary to other large national or multinational scientific projects.**
  
  • **Be seen to be important to international scientific organizations’ and laboratory scientific projects and activities.**
  
  • **Process has commenced**

Yifang Wang, Jie Gao
Asian Perspective

• CepC represents additional resources to our field.
  • ~$6B additional resource is very significant.
• Possible to have CepC operational by early to mid-2030?
  • Considerably ahead of FCC(ee)
• China wishes to achieve international status with large scientific projects
  • We should try very hard to gain from this strategy.
• Circular and Linear Solution to (initial) higgs factory have different development strengths
  • Complementary solutions
But can CERN/Europe Rely on Asia?

- **CepC**
  - *Approval process will be internal but needs International (moral) support*
    - ICFA support for potential international facility
- **But clear advantages**
  - *Considerable hosting cost moved to China*
  - *Additional staff and students for the field*
- **China will depend upon international involvement**
  - *IAC for CepC/SppC has been operating for several years*
Western attitude to China?

• This and other cultural differences need to be overcome
  • Both Real and Imagined.

• China would be well advised to pursue a CERN-like approach to operation
  • Can our Chinese colleagues achieve this?
  • We need to give support / encouragement for real internationalisation of this major initiative

• Can CERN provide the example and leadership in this goal?
  • Highly regarded at scientific and government level
  • We hope so!!
ILC/CepC Advantage for Europe

• Allows concentration on proton, high energy future
  • CERN essential for the energy frontier.
  • Proton and high-field magnet expertise
  • The ONLY laboratory capable of attempting very difficult projects, thus should be setting a “high bar”

• CERN infrastructure in protons beams outlays the fear of a second 100km tunnel.
  • Possible to see a new proton collider at CERN by mid-2040s (not mid 2060s, but also not 100TeV)
• European Particle Physics Planning is CERN Planning
• CERN Planning is Planning for the whole field.
• Asian capacity, needs and contributions are important.
Achieving an optimum?

• CERN is unique to our field and must be maintained at the leading edge.
• Whilst acknowledging the benefits and power of competition our field is renowned for cooperation.
• Cooperation across regions requires a strong base (CERN) and strong leadership.
• Consider how best to satisfy our field (in fact how best to keep it viable) with all potential resources.
The Needs of Particle Physics

- A $e^+e^-$ collider higgs factory ASAP
  - and, yes, in time, $t\bar{t}$, $ttH$, $HH$, ..
- A new energy frontier facility following HL-LHC
  - even without a specific physics driver, as yet
  - $pp$, ion-ion and ep all possible
- An active field, with multiple activities in parallel:
  - particle physics data taking and analysis
  - accelerator physics, including $\mu\mu$ colliders and plasma acc’n
  - detector development
  - advanced computing techniques
Asian (and personal) View

- Diversity is Critical to thrive in all environments, including HEP.
  - *Big and small facilities/experiments, at various stages of development and operation*
- Push for e⁺e⁻ colliders, both Linear and Circular, as soon as possible.
  - *Linear Collider: ILC*
  - 1 Collision point
  - *Circular Collider: CepC*
  - 2 Collision points
- Push for FCC tunnel to be ready at completion of HL-LHC
  - *Stage the energy frontier with best option magnets available for early 2040’s*
  - ?? Default: ~8T LHC magnets optimised for price
    - Minimum energy: >50TeV
    - Magnet upgrade foreseen.
  - *ep and ion-ion options available*
  - 4 collision points
  - *Upgrade path to higher energy after 20 years operation?*

See A. Yamamoto, L. Rossi, V. Shiltzev talks this symposium
Some comments to this suggestion

• The key point is to embrace Asian resources/desires/competencies in Europe planning.
• Construction and operation time/geography/national spread
• Avoid a serial program going out to end of century
  • We already have an issue of timelines with potential students
Asian (and personal) View

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See A. Yamamoto, S. Rossi, V. Shiltzev talks this symposium
Happy planning!
Acknowledgements

• Thanks Halina Abramovich and Open Symposium Team the this opportunity
• Much input from and discussion with many including:
  • Masa Yamauchi, Sachio Komamiya, Yasuhiro Okada, Hiroaki Aihara, Masashi Yokoyama, Phillip Urquijo, Yifang Wang, Jie Gao, Joachim Mnich, Steinar Stapnes, Max Klein, Lucio Rossi, Karl Jakobs, Peter Jenni, Rolf Heuer, and others
ICFA Statement, Tokyo March, 2019

- **ICFA confirms the international consensus that the highest priority for the next global machine is a “Higgs Factory” capable of precision studies of the Higgs boson.** At this ICFA meeting **options for a Higgs Factory were discussed -- the ILC, as well as other collider technologies**

- **ICFA reaffirms the scientific significance of the ILC and that the ILC is in a sufficient state of technical readiness for approval for construction**

- **... A clear statement of Japan’s position towards hosting the ILC would have had significant impact in the ongoing discussions on the formulation of the European Strategy for Particle Physics Update.**

- **... All options will be considered in the European Strategy for Particle Physics Update and by ICFA**
SCJ concerns, Dec. 2018

• The ILC project is far more expensive than the large number of big research facilities ... examined by SCJ ... the committee considers it is necessary to have broad support ... (Requires) More extensive discussion including not only the elementary particle physics field

• More dialogue with the general public and residents ... is needed to communicate ... potential merits ...of regional development ...

• ... not feasible unless it is based on unprecedentedly strong international cooperation. ... no clear prospect for appropriate international cost-sharing ...