

The 7th FCC-ee Physics Workshop

A 100 km Tunnel for Luminosity, Energy and Precision

19 - 21 June 2014

TH Auditorium (CERN)

Register at
indico.cern.ch/event/313708/

Organizing committee
Alain Blondel - U. Geneva
John Ellis - U. College London
Christophe Grojean - ICREA
Patrick Janot - CERN

Designer:
Cristina Martin Perez



100 km
high-luminosity
high-precision
e⁺e⁻ circular collider

Tera Z
Oku W
Mega top
Mega Higgs

27th - 29th
October 2014

LPNHE
Paris

8th Physics Workshop

FCC-ee

- Workshop website -
<http://indico.cern.ch/e/fccee8>

- Local organizing committee -
Roy Aleksan (CEA) | Sandrine Laplace (LPNHE) | Laurence Marquet (LPNHE) | Lydia Roos (LPNHE) | Pietro Slavich (LPTHE) | Dimitris Varouchas (LPNHE)
- Scientific programme committee -
Alain Blondel (Univ. Geneva) | John Ellis (Univ. College London) | Christophe Grojean (ICREA) | Patrick Janot (CERN)



27.10.2014

From Geneva to Paris in a 100 km tunnel? (^-!)



Much has happened since our last physics workshop in June!

- ICHEP and FCC-ee talks
-+- various other conferences**
- CERN SPSC review of future projects**
- HF2014 ICFA sponsored beam dynamics workshop (here + Zimmermann)**
- FCC collaboration progress (see Zimmermann's presentation)
MOU signing and IB chair nomination.**
- FCC design progress (see Ph. Lebrun's presentation)**
- FCC-ee accelerator progress (see J. Wenninger's talk)**
- FCC-ee physics study progress (P. Janot, C. Grojean and all the others!)**



ICHEP'14:
 "ICFA supports studies of
 energy frontier circular
 colliders and encourages global
 coordination"

International Organizing Committee (IOC)

- Michael Benedikt (CERN)
- Marica Biagini (INFN-LNF)
- Alain Blodet (U. of Geneva)
- Alex Chao (SLAC)
- Swapan Chattopadhyay (Cockcroft Inst.)
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- Stuart Henderson (Fermilab)
- Andrew Hutton (JLab)
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- Katsunobu Oide (KEK)
- Qing Qin (IHEP, Co-Chair)
- Dave Rice (Cornell U.)
- John Seeman (SLAC)
- Chuanxiang Tang (Tsinghua U.)
- Jorg Wenninger (CERN)
- Frank Zimmermann (CERN)

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- Huiping Geng (IHEP)
- Yinghua Jia (IHEP)
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- Shan Zeng (IHEP)
- Ning Zhao (IHEP)

HF2014



**55th ICFA Advanced Beam Dynamics Workshop
 on High Luminosity Circular e^+e^- Colliders
 – Higgs Factory**



Topics

- Parameters
- Optics
- Interaction region and machine-detector interface
- Synchrotron radiation and shielding
- Superconducting RF
- Injectors and injection
- Orbit stability and beam instability
- Polarization
- Instrumentation and control
- "Green" Higgs factory

*October 9-12, 2014
 Hotel Wanda Realm
 Beijing, China*



[Http://hf2014.ihep.ac.cn](http://hf2014.ihep.ac.cn)

Email: hf2014@ihep.ac.cn

Registration Deadline: August 31, 2014



ON THE MAP!

Future high-energy circular colliders

China: 50-70 km $e^+e^- \sqrt{s}=240 \text{ GeV}$ (CepC) followed by 50-90 TeV pp collider (SppC) in same tunnel

50 km e^+e^- machine + 2 experiments:

- pre-CDR: end 2014
- construction: 2021-2027
- data-taking: 2028-2035
- cost (material): ~3 B\$

Best beach & cleanest air
Summer capital of China

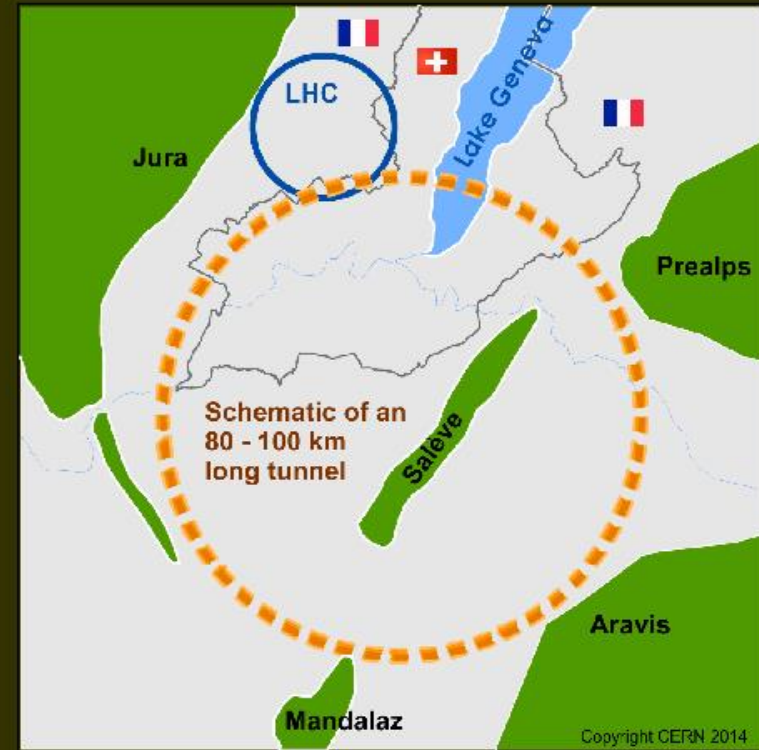
Possible site:
Qinghungdao



<http://cern.ch/fcc> and
<http://cern.ch/fcc-ee>

CERN FCC: international design study for Future Circular Colliders in 80-100 km ring:

- 100 TeV pp: ultimate goal (FCC-hh)
 - 90-350 GeV e^+e^- : possible ^{first} intermediate step (FCC-ee)
 - $\sqrt{s} = 3.5-6 \text{ TeV}$ ep: option (FCC-eh)
- Goal of the study: CDR in ~2018.





Conferences, workshops and seminars

FCC-ee 4 parallel session talks and 2 posters at ICHEP2014

title	session	speaker
Higgs Physics at the FCC-ee ,	Higgs Physics	Manqi Ruan (CERN/IHEP BEijing)
Precision Electroweak measurements at FCC-ee,	EW and top physics	Roberto Tenchini (Pisa)
Search for rare phenomena at FCC-ee	BSM Searches	Maurizio Pierini (CERN)
Heavy neutrino hunting in Higgs- and Z decays	Neutrino	
Strong coupling constant measurements at the FCC-ee	QCD → Future colliders	
FCC-ee accelerator performance and limitations	Future colliders Koratzinos	Poster

DO WRITE PROCEEDINGS!
Post on FCC-ee web site
and on FCC study site →

and some more at various conferences

Please help us by signaling conferences where FCC-ee could contribute

We have good stories to tell!

→ Mike Koratzinos

CDS Cheat Sheet

PROPOSAL by FCC coordination group



Prepare

1. **Obtain approval for publication in your organisational unit** (institute, department, group)
2. Select **document type** from list below
3. Choose **technical domain** from list on page 2
4. **Use FCC template** to prepare document or front page



Help!

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 You need to be member of an „fcc-“ e-group. Subscribe at <http://cern.ch/egroups>
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Submit via e-mail to **FCC-CDS@CERN.CH**

- **Document** as MS Word/Latex **and** PDF attachment
- Document **type**
- Technical **domain**

Allow 5 working days for initial feedback



MS Word & Latex templates

<http://cern.ch/fcc/collaboration/Templates>

Technical domains:

<http://cern.ch/fcc/collaboration/Help/CDS.aspx>

Document Types:

Type		Template	Description
Note	Reviewed	A	Internal scientific or technical note
Conference		B	Proceedings contribution
Preprint, Periodical		B	Scientific journal article
Thesis		n/a	Master or doctoral thesis work
Report	Approved	B	Technical, scientific or managerial report
Slides, posters		n/a	Support material for public presentations
Press, news, brochure		n/a	Outreach & publicity

CDS Cheat Sheet



Technical Domains

See also: <https://espace2013.cern.ch/fcc/collaboration/Help/technical%20domain.aspx>

PHYSICS (checked by hh: M. Mangano, ee: A. Blondel, he: M. Klein):

Hadron experiments, lepton experiments, ep experiments, hadron theoretical physics, lepton theoretical physics, ep theoretical physics

ACCELERATORS (checked by F. Zimmermann, J. Wenninger):

Hadron collider, lepton collider, ep collider, hadron injectors, lepton injectors

TECHNOLOGIES (checked by JM. Jimenez, V. Mertens):

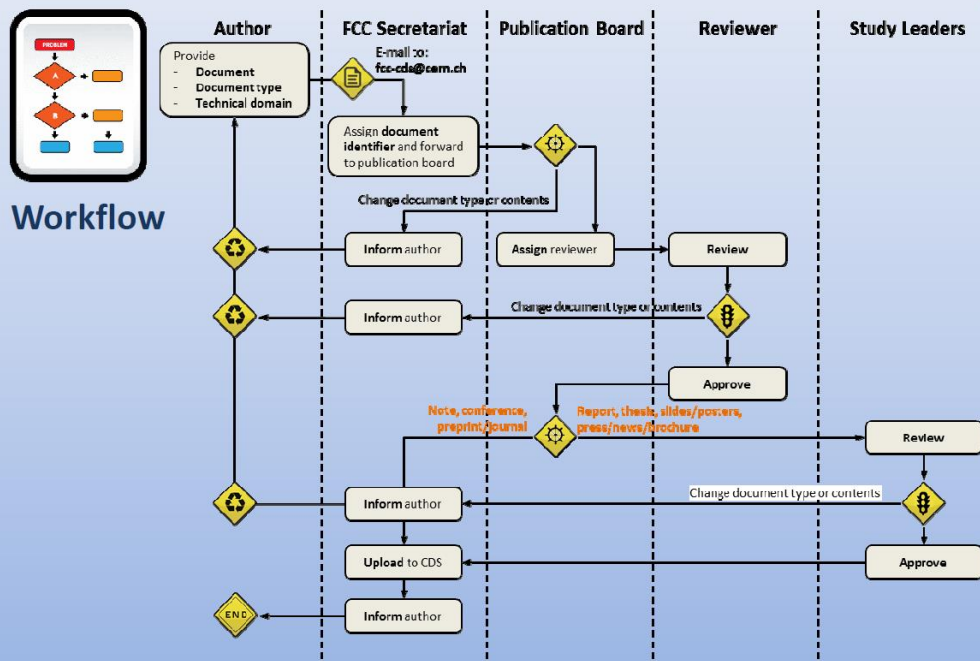
Beam diagnostics, Beam transfer, Collimation, Accelerator controls, Detector controls, Dumps and stoppers, Equipment and machine protection, Normal conducting magnets, Super conducting magnets, Power converters, Stored energy management, Radio frequency, Vacuum, Particle sources, Cryogenics, Detectors, Trigger, Data acquisition, Electronics, Software, Computing and IT, Safety monitoring and alarming systems

ENGINEERING (checked by P. Lebrun):

Civil engineering, Technical infrastructures, Electrical engineering, Chemical engineering, Transport and handling, Installation and integration, Radiation effects (equipment and material), Mechanical engineering, Mechatronics, Element support and alignment, Energy management and efficiency, Reliability and availability, Maintenance and repair, Systems engineering, Project implementation, Manufacturing techniques and processes, Information management and administration

HEALTH, SAFETY AND ENVIRONMENT (checked by R. Trant):

Safety concepts, Technical risk assessment, Environmental impacts, Radiation protection, Conventional waste management, Radioactive waste management, Occupational health and safety, Community health and safety





CERN Scientific Policy meeting 15 September

- Status of HL-LHC project (Bordry)
- Status of ILC project (Harrison)
- Status of CLIC project (Stapnes)
- Status of CEPC-SppC (Wang)
- Status of FCC(hh and ee) (Benedikt)
- Physics of high energy colliders (Mangano)

my own selection of highlights of the discussion:

-- to question whether CEPC could not be slightly upgraded to reach top threshold
Y. Wang: «We do not want to make everybody unhappy!»

-- to question by CERN council chair Zalewska why FCC report talks of e+e- machine while it was decided to concentrate on the hadron machine for design study
R. Heuer: « CERN would be crazy not to study the e+e- option!»

- my own comments:*
1. Chinese proposal certainly has a strong impact on people's minds!
 2. Mangano had way too little time to make future sound exciting but made point very clear that one cannot promise next discovery!
 3. conclusion of chairman of SPC: CERN is implementing the strategy....

1. CEPC people in full proposal-writing swing

- 54 km ring, optimized for 240 GeV ECM
- single ring, head-on collisions, 100 MW SR
- $L = 210^{34} / \text{cm}^2/\text{s}$ @ ZH, $5 \cdot 10^{34}$ @ Z-pole
- emphatically: no top, start date 2028
- run 7 years, then install proton machine
- exist: optics, detector simulations (from ILD)
some MDI
- do not exist or issues:
 - injector and booster
 - energy calibrations, polarization etc...

see talk by W. Chou



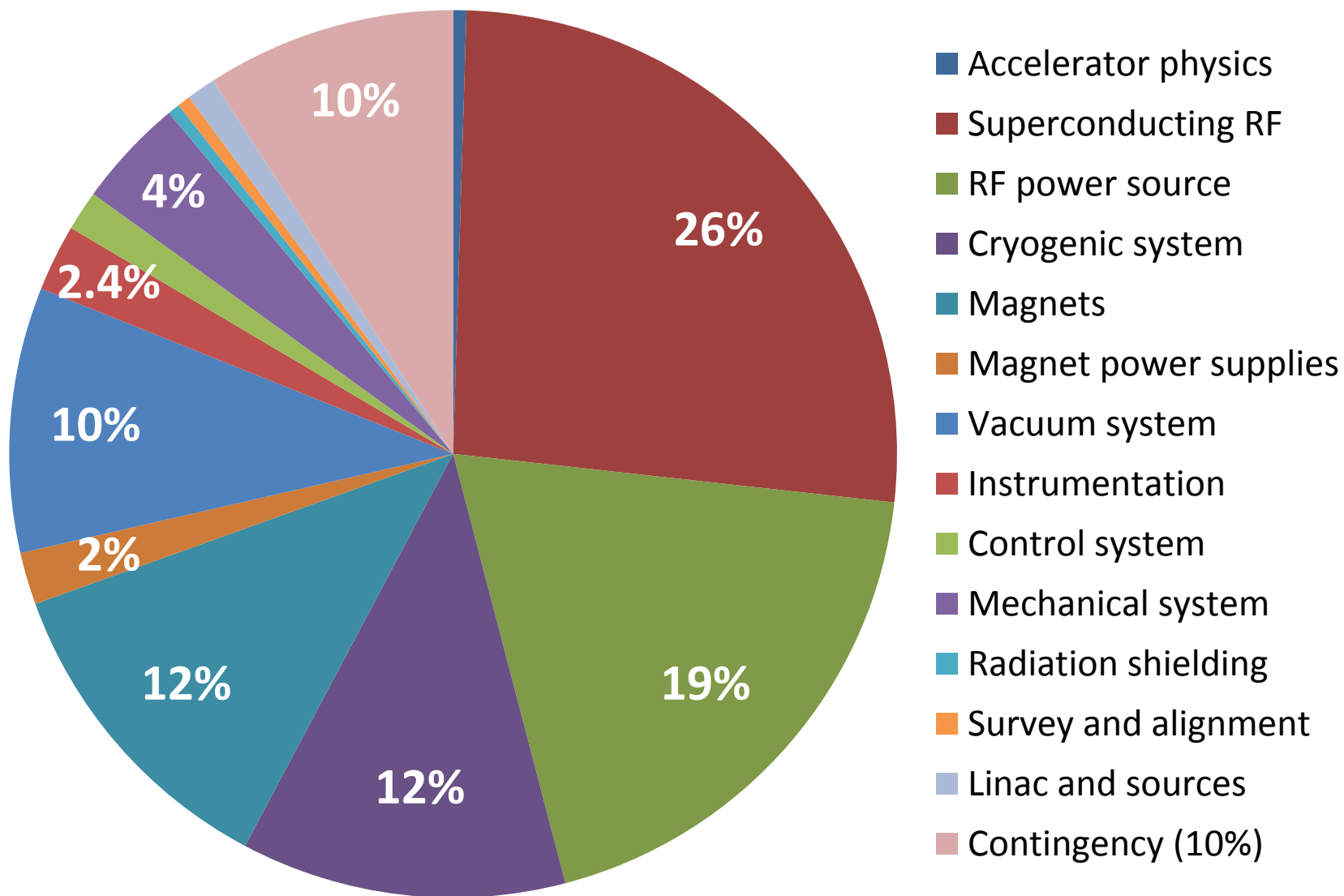
Work Breakdown Structure (WBS)

1	合计
2	加速器 Accelerators
2.1	加速器物理
2.2	高频系统
2.3	低温系统
2.4	磁铁系统
2.5	电源系统
2.6	机械系统
2.7	真空系统
2.8	束测系统
2.9	准直
2.10	控制系统
2.11	辐射防护
2.12	直线加速器
2.13	功率源
2.14	增强器
2.15	超导加速器磁铁 (SPPC) R&D
2.16	不可预见费10%
3	探测器 Detectors
3.1	径迹探测器 (TPC)
3.2	顶点探测器 (VTX)
3.3	量能器 (电磁+强子)
3.4	Muon探测器
3.5	探测器磁铁
3.6	物理模拟与软件组
3.7	计算资源系统
3.8	触发与数据获取系统
3.9	不可预见费10%

4	同步辐射装置 Light Sources
4.1	光束线站
4.2	不可预见费10%
5	土建 Civil Construction
5.1	地下建筑工程(钻爆法、6.5m)
5.2	地面建筑
5.3	独立费用
5.4	其他费用
5.5	不可预见费10%
6	通用设施 Utilities
6.1	供配电系统
6.2	水冷系统
6.3	通风空调系统
6.4	压缩空气
6.5	独立费用
6.6	其他费用
6.7	不可预见费10%

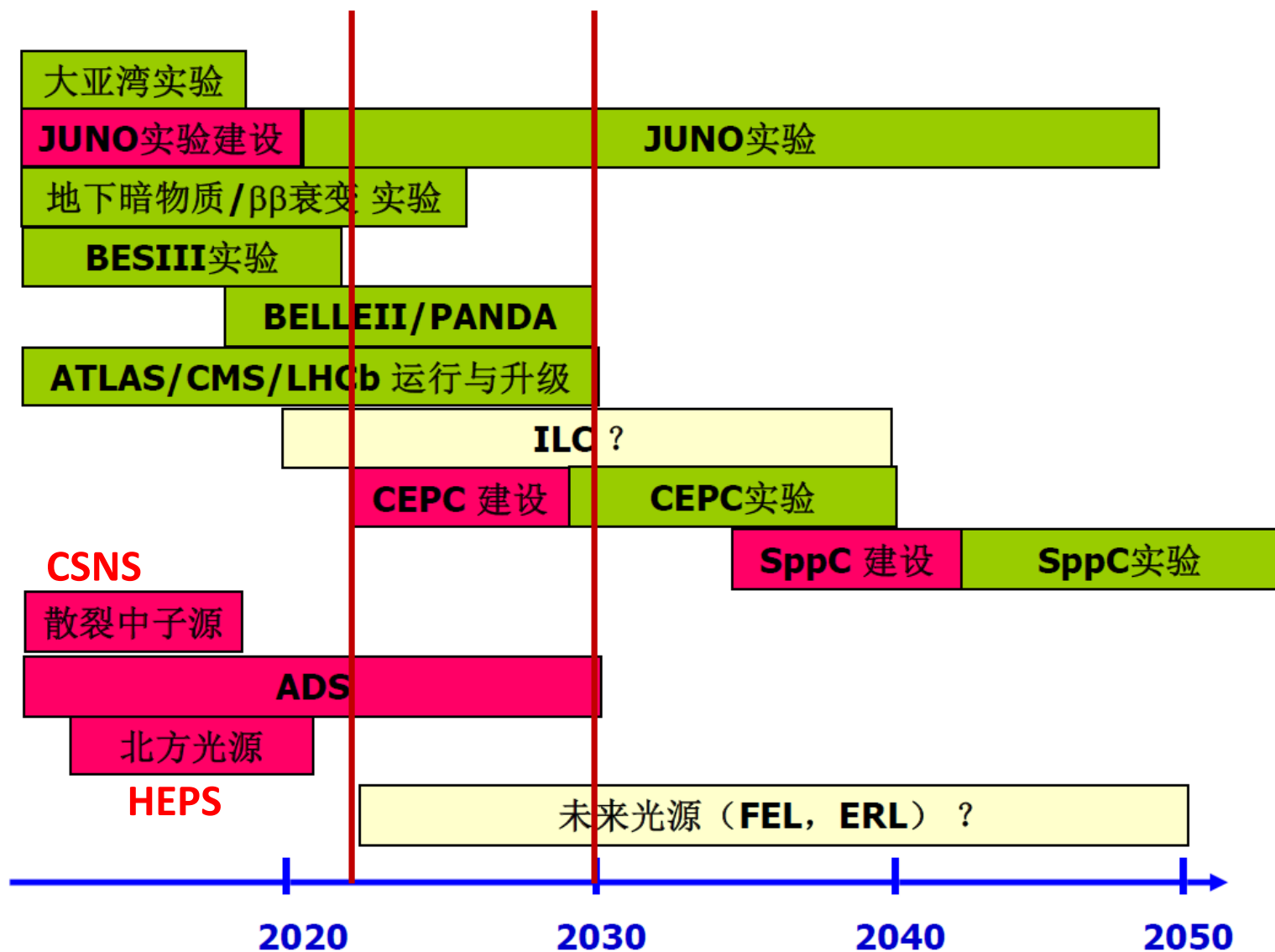


CEPC Relative Cost Estimate





A Window of Opportunity for CEPC-SPPC





Other salient aspects of Workshop

-- (I) NIMA'a talk

- stresses complementarity of Higgs factory (+ precision EW measts) with 100 TeV pp collider
- big points: 'phase transition' 'naturalness' and 'Dark Matter'
- no neutrino/flavour in talk (but tons in write-up -- he says)

in detail

- stresses that triple gauge g_{HHH} coupling anomaly should normally result in $g_{H\gamma\gamma}$ coupling anomaly. (much better measured of course)
- coupling of Higgs to new singlet would appear as invisible width or g_{HZZ}



Other salient aspects of Workshop (II)

Polarization and energy calibration

lots of talks, interesting alternatives/complements to Resonant Depolarization (RD)

-- spin precession of injected horizontally -polarized electrons

-- how do we get polarized positrons to inject?

-- end point of compton scattering (with electrons)

none of these alternatives would convincingly give 10^{-6} precision...

-- some caution that RD might exhibit small biases due to interference effects between main resonance and Q_s side bands.

-- **what physics priority is given to longitudinal polarization?**

-- interesting ideas for spin rotators in double channel machine open interesting possibilities for spin configurations.

-- possibility to polarize beam using a laser and spin dependent γe^\pm cross-sections



Experiments at FCC

FCC-PHYSics-COordination-group

FCC-ee

Alain Blondel

John Ellis

Christophe Grojean

Patrick Janot

FCC-hh

Austin Ball

Fabiola Gianotti

Michelangelo Mangano

FCC-he

Max Klein

Monica d'Onofrio



Aims of the FCC «Physics and Experiments» design study:

- to establish the physics capabilities of the FCC machines (- ee, hh, he) and the complementarity and coverage of the complex.**
- scope the discovery sensitivities to a number of (new) physics scenarios by**
 - direct observation of new particles**
 - precision measurements of Higgs, Electroweak, Flavour etc observables**
 - search for rare or forbidden phenomena**
- understand the experimental environment**
- establish the sensitivity of the physics performance of detectors to basic properties and identify which ones:**
 - are within reach of existing technologies and R&D**
 - would most benefit from a new, dedicated, detector R&D program**
- define suitable layouts and requirements for infrastructure , study staging scenarios**
- identify which issues would require new theoretical calculations or additional external or internal experimental input**



First phase until March 2015:

SCOPING the physics panorama and the main technical issues

Establish collaboration and reach out to interested groups

Document, and get things started.



Complementarity

Proposed physics topics to be used in the study of **synergy/complementarity** among experiments at **FCC-hh/ee/eh**

Subject		ee	hh	he
Higgs Physics	precision studies higher dimension operators composite Higgs rare and exotic decays multiple Higgs production extra Higgs bosons			
Interface with Cosmology	Dark matter baryogenesis right-handed/(almost) sterile neutrinos			
Electroweak Sym. Breaking	WW scattering supersymmetry extra dimensions composite models			
Flavour Changing	rare H,Z,W,top decays lepton flavor violation			
Extensions of the SM	extra vector-like fermions SU(2) _R models leptoquarks			
QCD	Perturbation theory, structure functions Modelling final states			
EW/SM precision issues	precision measts ($m_Z, m_W, m_t, \alpha, \alpha_s(m_Z), \sin^2\theta_W, R_b, \dots$) higher-order EW corrections W,Z triple and quadruple couplings top (anomalous) couplings charm/bottom flavor studies			

Top couplings as a NP discriminator

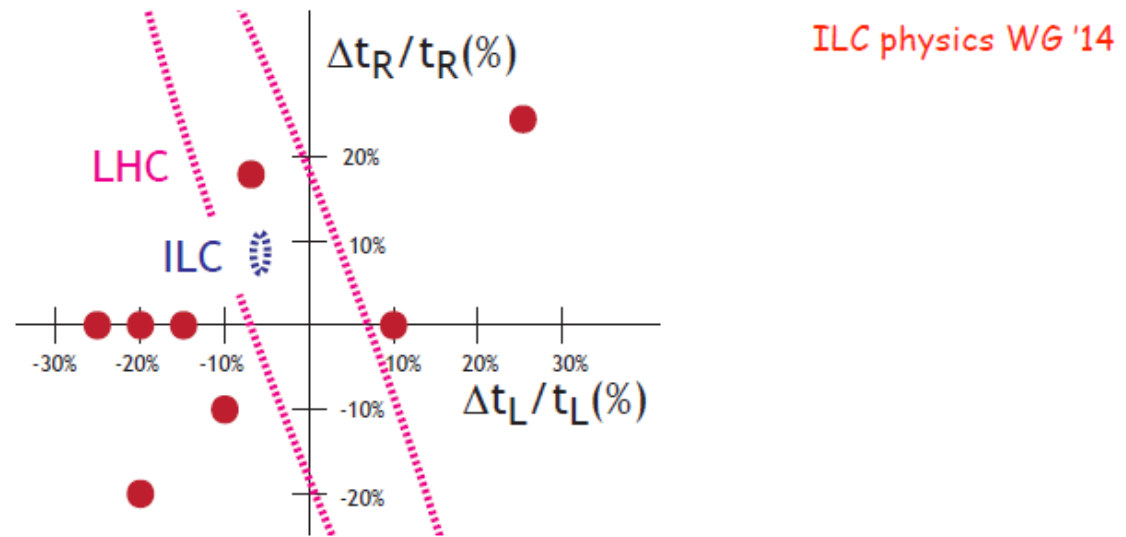


Figure 9: The heavy dots display the shifts in the left- and right-handed top quark couplings to the Z boson predicted in a variety of models with composite Higgs bosons, from Ref. [31]. The ellipses show the 68% confidence regions for these couplings expected from the LHC [26] and the ILC [30].

Need to estimate the sensitivity in the ttZ couplings

@ 350GeV and 500GeV

The polarization of the initial beams is a big asset!

Questions for top group: What energy is really needed? What does Polarization really buys?



CONCLUSIONS

- FCC-ee physics studies are in construction phase for software, event generators, etc..**
- contacts with linear collider groups positive**
- high luminosity FCC-ee offers real opportunities for discovery**
 - precision measurements**
 - rare processes (FCNCs, LFV, heavy neutrinos, etc..)**
- Circular Collider complex (ee, hh, eh) is a fantastic story in the making!**