

Future Circular Collider (FCC) Study - Status



Michael Benedikt

CERN, 26th May 2014

- **FCC study scope and parameters**
- **Kick-off meeting summary**
- **Study timeline and organization**
- **Summary**

Summary: European Strategy Update 2013

Design studies and R&D at the energy frontier

....“to propose an ambitious **post-LHC accelerator project at CERN** by the time of the next Strategy update”:

d) CERN should undertake design studies for accelerator projects in a global context,

- *with emphasis on proton-proton and electron-positron high-energy frontier machines.*
- *These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures,*
- ***in collaboration with national institutes, laboratories and universities worldwide.***
- **<http://cds.cern.ch/record/1567258/files/esc-e-106.pdf>**

Future Circular Collider Study - SCOPE

CDR and cost review for the next ESU (2018)

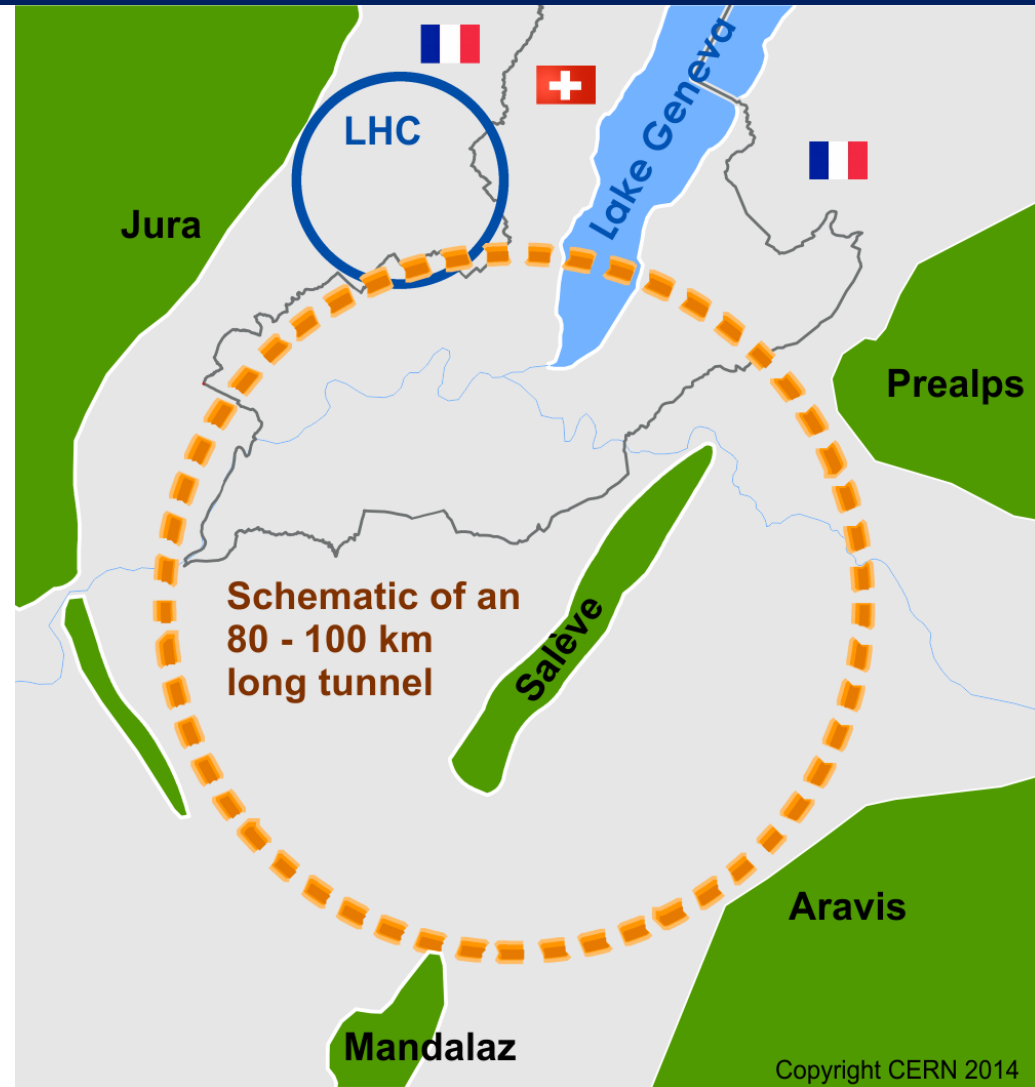
Forming an international collaboration to study:

- **pp -collider (*FCC-hh*)**
→ defining infrastructure requirements

~16 T \Rightarrow 100 TeV pp in 100 km

~20 T \Rightarrow 100 TeV pp in 80 km

- **e^+e^- collider (*FCC-ee*)** as potential intermediate step
- **p - e (*FCC-he*) option**
- **80-100 km infrastructure** in Geneva area





Hadron collider FCC-hh parameters

PRELIMINARY

- **Energy** **100 TeV c.m.**
- **Dipole field** **~ 16 T (design limit) [20 T option]**
- **Circumference** **~ 100 km**
- **#IPs** 2 main (tune shift) + 2
- **Beam-beam tune shift** 0.01 (total)
- **Bunch spacing** **25 ns [5 ns option]**
- **Bunch population (25 ns)** 1×10^{11} p
- **#bunches** 10500
- **Stored beam energy** **8.2 GJ/beam**
- **Emittance normalised** 2.15×10^{-6} m, normalised
- **Luminosity** **$5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$**
- **β^*** 1.1 m [2 m conservative option]
- **Synchrotron radiation arc** **26 W/m/aperture (filling fact. 78% in arc)**
- **Longit. emit damping time** **0.5 h**



Lepton collider FCC-ee parameters

- **Design choice: max. synchrotron radiation power set to 50 MW/beam**
 - Defines the max. beam current at each energy.
 - 4 Physics working points
 - Optimization at each energy (bunch number & current, emittance, etc).

Parameter	Z	WW	H	$t\bar{t}_{\text{bar}}$	LEP2
E/beam (GeV)	45	80	120	175	104
I (mA)	1450	152	30	6.6	3
Bunches/beam	16700	4490	170	160	4
Bunch popul. [10^{11}]	1.8	0.7	3.7	0.86	4.2
L ($10^{34} \text{ cm}^{-2}\text{s}^{-1}$)	28.0	12.0	4.5	1.2	0.012

- For H and $t\bar{t}_{\text{bar}}$ working points the beam lifetime of ~few minutes is dominated by Beamstrahlung (momentum acceptance of 2%).

Future Circular Collider Study Kick-off Meeting

12-15 February 2014,
University of Geneva,
Switzerland

LOCAL ORGANIZING COMMITTEE

University of Geneva

C. Blanchard, A. Blondel,
C. Doglioni, G. Iacobucci,
M. Koratzinos

CERN

M. Benedikt, E. Delucinge,
J. Gutleber, D. Hudson,
C. Potter, F. Zimmermann

SCIENTIFIC ORGANIZING COMMITTEE

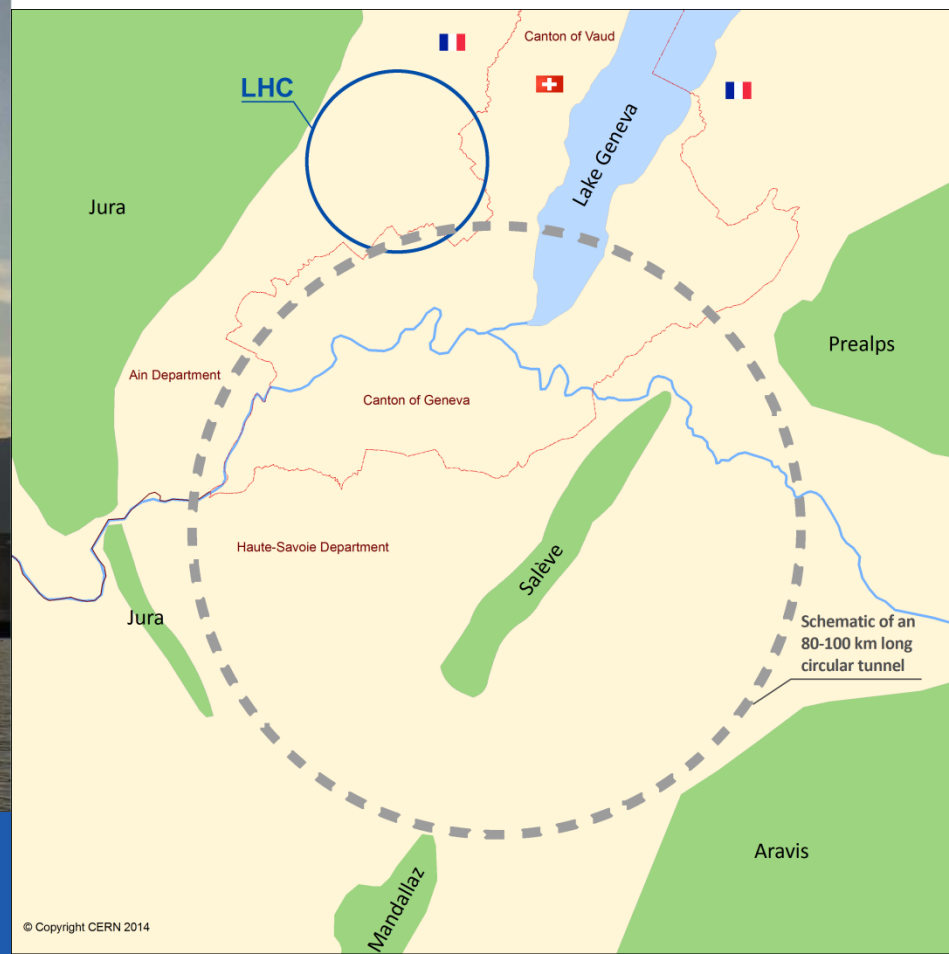
FCC Coordination Group

A. Ball, M. Benedikt, A. Blondel,
F. Bordry, L. Bottura, O. Brüning,
P. Collier, J. Ellis, F. Gianotti,
B. Goddard, P. Janot, E. Jensen,
J. M. Jimenez, M. Klein, P. Lebrun,
M. Mangano, D. Schulte,
F. Sonnemann, L. Tavian,
J. Wenninger, F. Zimmermann



FCC Kick-off Meeting Geneva

<http://indico.cern.ch/e/fcc-kickoff>



Schematic of an
80-100 km long
circular tunnel

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UNIVERSITÉ
DE GENÈVE



[http://indico.cern.ch/
e/fcc-kickoff](http://indico.cern.ch/e/fcc-kickoff)



Future Circular Collider Study
Michael Benedikt
CERN, 26th May 2014



FCC Kick-off Meeting



Kick-off Meeting of the Future Circular Colliders Design Study
12 - 15 February 2014, University of Geneva / Switzerland
341 registered participants

photo by Michael.Hoch@cern.ch



Future Circular Collider Study
Michael Benedikt
CERN, 26th May 2014



FCC Kick-off participants

341 registered participants - geographical distribution

Americas (37)

Canada: 1

Mexico: 2

US: 34

Asia (19)

China: 9

Japan: 9

Republic of Korea: 1

Africa (1)

South Africa: 1

Europe (284)

Austria: 1

CERN: 140

Czech Republic: 2

Denmark: 1

France: 30

Germany: 14

Greece: 1

Hungary: 2

Italy: 20

Poland: 6

Portugal: 2

Russia: 8

Serbia: 1

Spain: 11

Sweden: 1

Switzerland: 19

(w/o CERN)

UK: 25

Well-balanced world-wide attendance





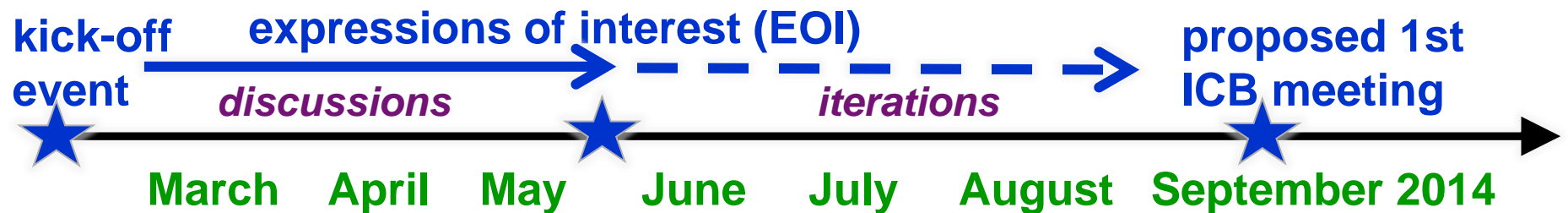
Workshop Goals

Rolf Heuer
Opening talk

- Discussion of all FCC aspects
- Refine scope of the study
- Define schedule, WBS, milestones of the study
- Establish the path towards international collaboration: Expressions of Interest, formation of collaboration, accepting new partners throughout the duration of the study
- Open process

Next steps

- **Establish an international collaboration:**
- Following very positive reactions and the enthusiasm during the Kick-off meeting:
 - **Invitations to institutes to join collaboration**
 - Aiming at **expressions of interest by end May 2014** to form nucleus of collaboration by September 2014
 - Enlargement of the study preparation team
 - **First international collaboration board meeting 9-10 September at CERN**



Collaboration based on general MoU and specific addenda:

Draft 23 May 2014 11:30

Memorandum of Understanding for the Future Circular Collider (FCC) Study hosted by CERN

THE INSTITUTES, LABORATORIES, UNIVERSITIES AND THEIR FUNDING AGENCIES AND OTHER SIGNATORIES OF THIS MEMORANDUM OF UNDERSTANDING AND CERN AS THE HOST LABORATORY (“the Participants”)

Whereas

At a dedicated session of the CERN Council held on 30 May 2013, the Council adopted the Update of the European Strategy for Particle Physics which included *inter alia* the following statement:

“...Europe needs to be in a position to propose an ambitious post-LHC accelerator project at CERN by the time of the next Strategy update, when physics results from the LHC running at 14TeV will be available. CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme, including high-field magnets and high-gradient accelerating structures, in collaboration with national institutes, laboratories and universities worldwide.”

The conceptual design study (the “FCC Study”) must be available in time for the next update of the European Strategy for Particle Physics for the Council to take

DOCUMENT ID / Doc. Mgmt. Sys. ID VERSION DATE

ADDENDUM {IDENTIFIER}

{Name of Participant} (“Participant”)	
This Addendum defines a contribution by one or more Participants under Article 6 of the Memorandum of Understanding for the FCC Study {MoU Identifier and date}	
SCOPE OF WORK	
{General description of scope of work}	
PROJECT CONTACTS	
The following contacts may, on behalf of the Participant and of CERN as the Host Organization, update the contents of this Addendum by issuing a revised Addendum that will cancel and replace all previous versions.	
Participant Project Contact:	{FIRST NAME} {LAST NAME} {e-mail} {phone}
CERN Project Contact:	{FIRST NAME} {LAST NAME} {e-mail} {phone}

DETAILED WORK DESCRIPTION

Note: The following table is repeated for each individual Work Unit constituting the Scope of Work (i.e. each deliverable, identifier, title, description and planned delivery date). The identifier should have the form {3-letter institute letter code}-{work unit code}-{deliverable code}.

WORK UNIT	
Title:	{Name of the unit of work to be carried out}
Identifier:	{Identifier used in communication between Participant and CERN}
Reference:	{Associated FCC Work Breakdown Structure items}
Objectives:	{Description of objectives}



FCC EU Design Study Proposal



Horizon2020 call – design study,

submission 28.08.2014 (deadline 02.09.2014)

Prepare proposal parallel to FCC collaboration setup

Goals fo EU DS: conceptual design, prototypes, cost estimates, ...

From FP7 HiLumi LHC DS → positive experience:

- **5-6 work packages as sub-set of FCC study → Call limited to 3 MEURO EU**
- **~10 beneficiaries** (signatories of the contract with EC)

Time line



Non-EU partners can join as beneficiary – signatory with or w/o EC contribution (contractual commitment) **or as associated partner – non-signatory** (in-kind contribution with own funding, no contractual commitment)





WP1: Management, Coordination, Implementation & Costing

- Coordination & Outreach
- Realization aspects

WP2: Interaction region design FCC-hh

- IR and final focus design
- MDI
- Shielding and FF quad protection
- Beam parameters
- Collimation requirements
- *Beam-beam*

WP3: Arc design FCC-hh

- Arc lattice design
- Dynamic aperture evaluation
- Impedance calculations and instabilities
- *SR: photo-electrons and e-cloud effect*
- Aperture and field quality specifications

WP4: High-field Accelerator Magnet Design FCC-hh

- Magnet design
- Field quality evaluation and comparison
- Field optimisation for DA maximum

WP5: Beam pipe design FCC-hh



- Vacuum design
- Beam screen optimisation
- Beam screen coating
- Cryogenics integration
- Prototype production
- Performance measurements

WP6: *IR&beam-beam FCC-ee*

italics: optional inclusion in H2020 WP 5

- ESGARD review of FCC EU DS proposal on 10th June

Study timeline

2014				2015				2016				2017				2018			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
 Study plan, scope definition				 Workshop & Review: identification of baseline															
Explore options "weak interaction"																			

Explore options, now – spring 2015:

- Investigate **different options** in all technical areas, **taking a broad view**
- **Deliverables: description and comparison of options with relative merits/cost, Develop schedules, understand relative impact of options on overall schedule (physics operation time, machine installation time, etc.)**
- **FCC workshop to converge to common baseline with small number of options**
- **Proposed WS date 23 – 27 March 2015** (presently no known collisions...)
- Followed by review ~2 months later, begin June 2015

Report
Release CDR





Work and organisation status (i)

Work/meeting structures established based on INDICO, see:

- **FCC Study:** <https://indico.cern.ch/category/5153/>

In particular:

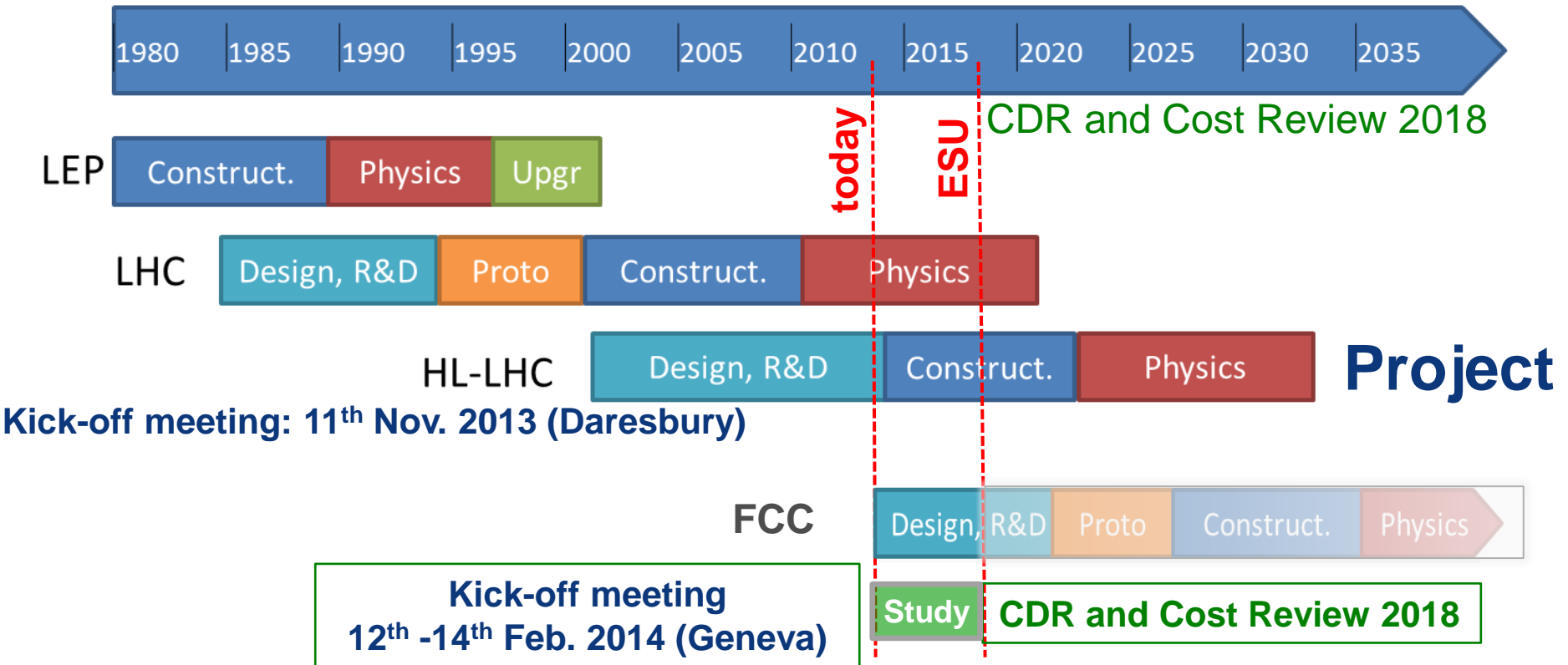
- **FCC-hh Hadron Collider Physics and Experiments VIDYO meetings**
 - <https://indico.cern.ch/category/5258/>
 - **Contacts:** michelangelo.mangano@cern.ch,
fabiola.gianotti@cern.ch, austin.ball@cern.ch
- **FCC-ee Lepton Collider (TLEP) Physics and Experiments VIDYO meetings**
 - <https://indico.cern.ch/category/5259/>
 - **Contacts:** alain.blondel@cern.ch, patrick.janot@cern.ch



Work and organisation status (ii)

- **FCC-hh Hadron Collider VIDYO meetings**
 - <https://indico.cern.ch/category/5263/>
 - **Contacts:** daniel.schulte@cern.ch
- **FCC-hadron injector meetings**
 - <https://indico.cern.ch/category/5262/>
 - **Contacts:** brennan.goddard@cern.ch
- **FCC-ee (TLEP) Lepton Collider VIDYO meetings**
 - <https://indico.cern.ch/category/5264/>
 - **Contacts:** jorg.wenninger@cern.ch,
- **FCC infrastructure meetings**
 - <https://indico.cern.ch/category/5253/>
 - **Contacts:** philippe.lebrun@cern.ch, peter.sollander@cern.ch

CERN and FCC timelines



- LHC and HL-LHC operation until ~2035
- Must start now developing FCC concepts to be ready in time

Summary

- There are strongly rising activities in energy-frontier circular colliders worldwide. CERN is setting-up an international study for the design of Future Circular Colliders (FCC).
- Worldwide collaboration in all areas, i.e. physics, experiments and accelerators will be important for the field of HE physics in general and to reach the demanding goal of a CDR by 2018.
- Work in all areas has started, over the coming months a global collaboration will be formed. First collaboration board meeting 9/10 September 2014.





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