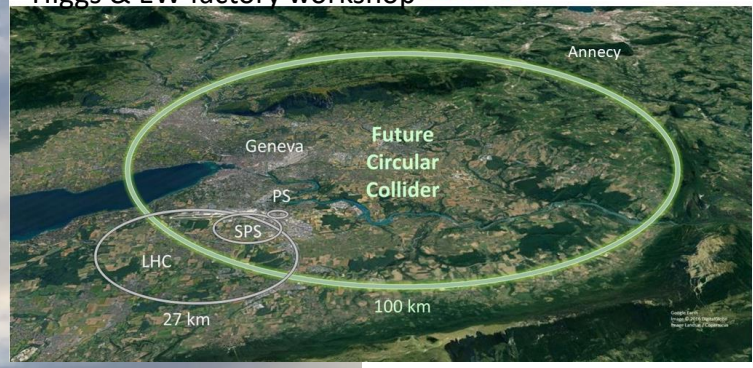
3 Days in Annecy, First Impressions, Next Steps, Next Workshops

FUTURE CIRCULAR COLLIDER
Expanding our Horizons

cnrs IN2P3

cea

Higgs & EW factory workshop



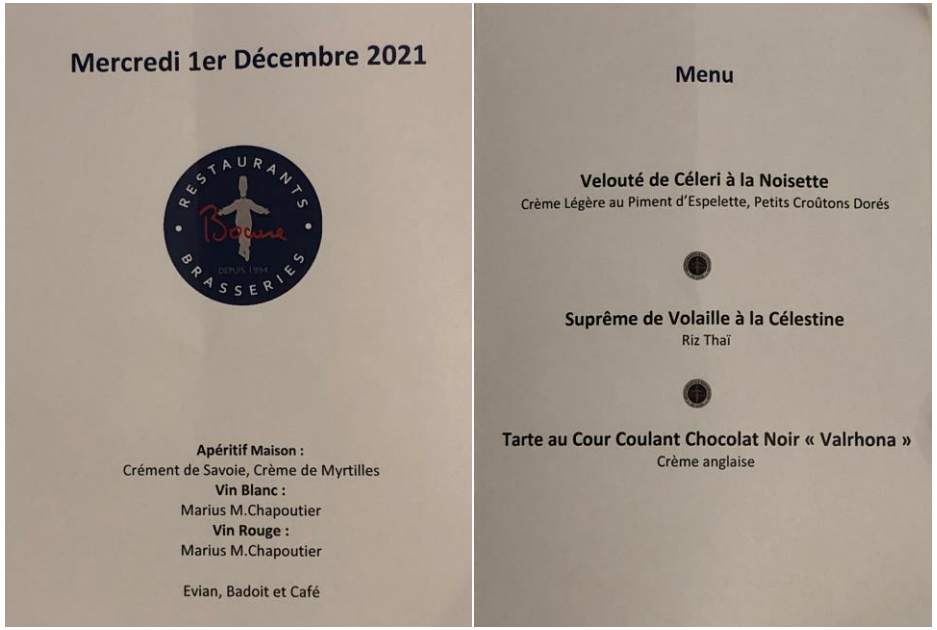
GB's view from LAPP Annecy on 1/12

G. Bernardi
2/12/2021

- Overview of the program
- Next steps, next workshops
- Thanks

Welcome (and temporary goodbye ?) to the Hybrid world !

- 155 registered participants (90 where Zoom-only participants, and 90% of them connected to at least one session)
- Of the 65 planning to come to LAPP/Annecy, 58 made it : 2/3 from France, 1/3 from CERN/Danemark/Italy/Germany
- ~40 made it to the banquet, less on the last day photo ;)



Mercredi 1er Décembre 2021

RESTAURANTS Bocuse BRASSERIES DEPUIS 1994

Apéritif Maison :
Crément de Savoie, Crème de Myrtilles
Vin Blanc :
Marius M.Chapoutier
Vin Rouge :
Marius M.Chapoutier

Evian, Badoit et Café

Menu

Velouté de Céleri à la Noisette
Crème Légère au Piment d'Espelette, Petits Croûtons Dorés

Suprême de Volaille à la Célestine
Riz Thaï

Tarte au Cour Coulant Chocolat Noir « Valrhona »
Crème anglaise

- THANKS to the LAPP for inviting us at this excellent banquet, at Irma Bocuse !
…and also for the Cocktail/Raclette on the first day

Overall, it was very successful !! good balance between presentations/questions from the room and from video, and good discussions during coffee breaks and lunches/dinners

The Intro Session

Overall R&D Effort @ IN2P3

Accelerators *(A&T portfolio)*:

- 2 main scientific programs related to FCC/Higgs+EW factory:
  - *SCPL: SuperConducting RF cavities & high-power Proton Linac*
  - *LPAC: Laser-Plasma Acceleration & high-energy Colliders*
  - 10 master-projects

Technologies *(A&T portfolio)*:

- *ITIN: Innovative Technologies & Instrumentation for NP & PP*
- 7 master-projects linked with FCC/Higgs Factory

Detector R&D *(P&H portfolio)*:

- *INDE: INnovative DEtectors*

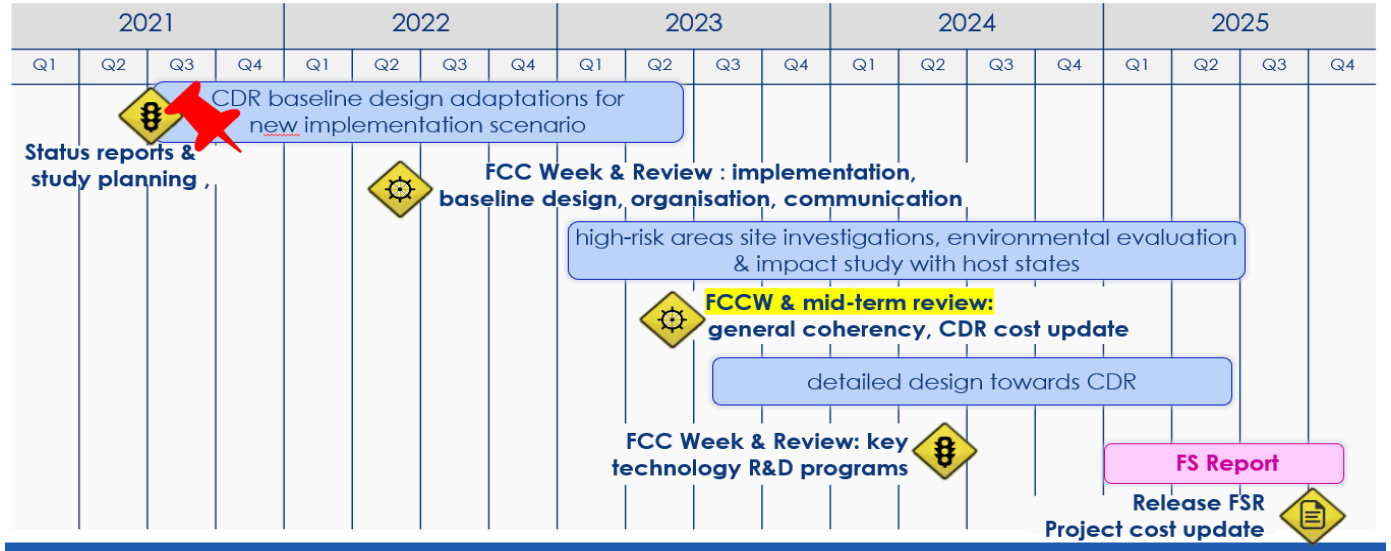
Rough estimate of IN2P3 effort on FCC/Higgs+EW factory in 2021:

- **100 FTE**
- **1.2M€ investment + extra sources**
- **4.5M€ manpower**

Prospective physics, simulation, detector optim *(P&H portfolio)*:

- *FCC-Phys MasterProject*

FUTURE CIRCULAR COLLIDER — Feasibility Study Timeline



13:35 — **e+e- collider efforts in France** ¶
Orateur: Laurent Vacavant (IN2P3)

13:45 — **Potential role of Annecy in FCC**
Orateur: Giovanni LAMANNA (LAPP - IN2P3/CNRS)
GLamanna_FCCAnn...

13:55 — **The FCC Feasibility and Innovative Studies**
Orateur: Michael Benedikt (CERN)
211130_FCC-Feasib...

14:25 — **FCC Innovative Study socio-economic impact**
Orateur: Leslie Alix
FCCIS Socio-econo...

14:45 — **FCCIS: Engagement and Communication Strategy**
Orateur: Claire Adam (LAPP)
ClaireAdam-WP5rep...

15:05 — **FCC as a global collaboration**
Orateur: Emmanuel Tsesmelis (CERN)
Tsesmelis FGC.pptx

15:20 — **FCC-ee Physics potential and the PED organization**
Orateur: Patrick Janot (CERN)

Thanks Angeles, Pierre, Giacomo, Benjamin

Accelerator session

Président de session: Angeles Faus-Golfe (IJClab)

16:10 **Introduction to the accelerator sessions**
Orateur: Angeles Faus-Golfe (IJClab)
FCC _France_2021_...

16:15 **High Field Magnets R&D status update:**
Orateur: Etienne Rochepault (CEA Paris-Saclay)
FCCWorkshop21_M... FCCWorkshop21_M...

16:33 **Stability and positioning for FCCee**
Orateur: Eva Montbarbon
2021-11-30_Stabilit...

16:50 **SRF R&D for FCCee**
Orateur: Mohammed Fouaidy (IPNO)
Meeting-FCC-Franc...

17:07 **Optimization of e+ sources for FCCee**
Orateur: Salim Ogur (IJCLab)
FCC-France_Positro...

Theory @ FCC(ee) and (hh)

Président de session: Giacomo Cacciapaglia (IP2I Lyon)

09:00 **Introduction to the theory session** ¶
Orateur: Giacomo Cacciapaglia (IP2I Lyon)
FCCTHIntro.pdf

09:10 **MadGraph5_aMC@NLO for ee colliders**
Orateur: Olivier Mattelaer (FNRS - CP3)
21_11_30_eecolider...

09:30 **Determination of Dark Matter Properties at e+e- colliders**
Orateur: Alexander Belyaev (Southampton University)
Belyaev-FCC-2021-...

09:50 **A Z-portal to the dark sector at FCC-ee**
Orateur: Ennio Salvioni (CERN)
Talk_FCC_France_u...

10:10 **Neutrino physics in high-energy proton-proton collisions**
Orateur: Richard Ruiz (Institute of Nuclear Physics (IFJ) PAN)
rruiz_FCCfrance_Nu...

10:30 **Testing new-physics models with global comparisons to collider measurements**
Orateur: Mohammad Mahdi AlTakach
FCC-France-1-12-21...

10:50 **Testing charge-radius coupling of the composite Higgs boson at hadron colliders**
Orateur: Antoine LESAUVAGE

First presentation of the plans of the detector concepts working group

- Develop, study and evaluate DCs: Make sure DCs are capable of delivering the detector requirements
  - Main tool: Detailed simulation studies
- Optimize compatibility of DCs with operation at FCC-ee:
  - MDI layout; timing and background conditions
- Identify and encourage necessary R&D in the direction of the requirements for FCC-ee
- Gather and engage a wide community around the DC effort; foster collaboration towards the common goal of developing FCC-ee DCs
- Function as a forum, where progress, ideas and results from individual R&D efforts and test-beam activities are presented, discussed and reviewed in view of FCC-ee detector requirements and physics.
  - Follow technological developments that could lead to new physics opportunities

Detectors Concepts and Software

Président de session: Mogens Dam

17:35 **The Detector Concepts working group plans**
Orateur: Mogens Dam (Niels Bohr Institute, Copenhagen U
20211130-FCCFran...

17:55 **The ECFA R&D roadmap**
Orateur: Felix Sefkow (DESY)
ECFA-RM4FCC.pdf

15:40 **Examples of detector concept for FCC-ee: CLD & IDEA**
Orateur: Paolo Giacomelli (INFN Bologna)
Detector-concepts-...

18:15 **Software for detector concepts development**
Orateur: Valentin Volkl (CERN)
2021-11-30-FCCAnn...

18:35 **Software for e+e- analysis**
Orateur: Thomas Madlener (DESY)
edm4hep_analysis_...

18:55 **Overview of the Software for FCC**
Orateur: Clement helsens (CERN)

+ detailed report of the ECFA R&D roadmap + overview of unified SW for the Higgs Factories

R&D Overview

Synergies Dominate

Detector Technology	Linear & Circular Colliders common R&D	Differences
All	test infrastructure prototype electronics software for reconstruction and optimisation	readout rates power and cooling requirements
Silicon Vertex and Track Detectors	highest granularity and resolution, timing ultra-thin sensors and interconnects simulation and design tools low-mass support structures cooling micro-structures	emphasis on timing (background) and position resolution
Gaseous Trackers and Muon Chambers	ultra-light structures for large volumes industrialisation for large area instrumentation eco-friendly gases	DC and TPC presently considered only at some colliders
Calorimeters and Particle ID	highly compact structures and interfaces advanced photo-sensors and optical materials ps timing sensors and electronics	emphasis on granularity and stability DR and LAr pesresently only considered for circular

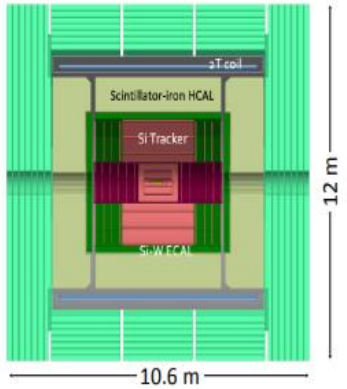
R&D session

On going R&D will lead to additional Detector concepts.
R&D Developments in Tracking and Calorimetry, many of these Projects having been encouraged by Linear Colliders, which can now also be adapted for Circular ones.

CDR: 2 Detector concepts

"Proof of principle concepts"
• Not necessarily matching (all) detector requirements, which are still being spelled out

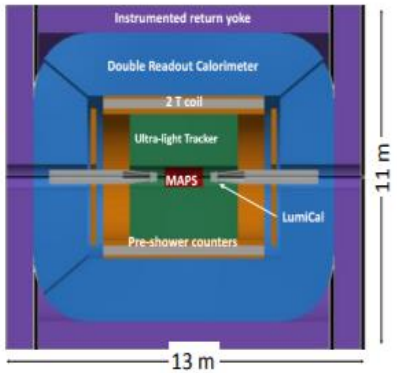
CLD



- Based on CLICdet detector design; profits from technology developments carried out for LCs
  - All silicon vertex detector and tracker
  - 3D-imaging highly-granular calorimeter system
  - Coil *outside* calorimeter system
  - Muon system made of RPC layers embedded in the iron yoke

https://arxiv.org/abs/1911.12230, https://arxiv.org/abs/1905.02520

IDEA



- New, innovative, possibly more cost-effective concept
  - Silicon vertex detector
  - Short-drift, ultra-light wire chamber
  - Dual-readout calorimeter
  - Thin and light solenoid coil *inside* calorimeter system
  - Muon system made of 3 layers of µRWell detectors in the return yoke

https://pos.sissa.it/390/

R&D projects

Président de session: Jessica Leveque (LAPP)

14:00 **CMOS status**
Orateur: auguste besson (Institut Pluridisciplinaire Hubert Curien)
FCC_2021_12_Anne...

14:20 **DICE status**
Orateur: Marlon Barbero (CPPM)
20211201_FCC_DIC...

14:40 **Update of R&D on fast detector for ToF using Micromegas**
Orateur: Thomas Papaevangelou (CEA Saclay)
PICOSECMM_FCC-F...

15:00 **Calice for FCC**
Orateur: Vincent Boudry (LLR - CNRS, École polytechnique/IPP Paris)
2021-12-01_CALICE...

15:20 **Powder-O Calorimetry**
Orateur: Jacques Lefrançois (IJCLab)
Annecy_5.pptx

11:40 **LAr Calorimeter for FCC-ee**
Orateur: Nicolas Morange ({CNRS}UMR9012)
LAr-FCC-Workshop....

16:05 **Combining dual-readout crystals and fibers in a hybrid calorimeter for the IDE**
Orateur: Marco Toliman Lucchini (INFN & University of Milano-Bicocca)

Heavy Flavour/tau programme makes use of the enormous statistics 10^{12} bb, cc, 2.10^{11} tautau

CKM matrix, CP meas., flavour anomaly studies, Rare decas, LFV, Lepton universality….

QCD

- α_s from *hadronic τ & Z decays*
- α_s from *(ISR) jet production*
- *Jet substructure* opportunities

Some example of tau physics

Tau decays
Search for NP

Tau neutrino mass
High lumi. allows to have a large stat. of tau decays to $5\pi^{\pm}$ (or $7\pi^{\pm}$?)

Tau CC universality , Michel parameters
e vs μ , even at very low energy
Control sample of PID efficiency (easy with Z decays)

Tau as polarimeter
for Z decays to τ τ , polarization and AFB(Pol) , which could be affected by Z' somewhere
BUT ALSO for a very important piece of the program at FCCee : the CP violation in Higgs decays

Heavy Flavour, Taus, and QCD: Physics and Detector Contraints

Président de session: Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3)

11:40 **Introduction to the Heavy Flavour, Tau and QCD session**
Orateur: Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3)
FCC_France_2021_...

11:50 **CP violation and determination of the bs "flat" unitarity triangle**
Orateur: Emmanuel PEREZ (CERN)
2021_12_01_CPV_s...

12:10 **Opportunities to measure semileptonic asymmetries**
Orateur: Dennis Arogancia (MSU-ILIGAN INSTITUTE OF TECHNOLOGY)
AsIsUncertainty_up...

12:30 **Perspectives for high-precision αS(mZ^2) determinations @ FC**
Orateur: Luc Poggioli (LPNHE Paris)
Annecy_Poggioli.pdf

18:05 **Tau Physics at Future e+e- colliders**
Orateur: Jean-Claude brient (LLR)
talk fcc 2021.pdf

Electroweak Physics: Physics and Detector Contraints

Président de session: lucia di ciaccio (Iapp)

17:00 **EW measurements: comparing theory and experiments**
Orateur: Ayres Freitas (Pittsburg)
fccfrance21_freitas....

17:25 **Energy calibration and Polarization : where do we stand ?**
Orateur: Alain Blondel (LPNHE Paris-Sorbonne)
Blondel-EPOL-FCC-F...

17:45 **Angular analysis of e+e- —> W+ W- final states at sqrt(s)=240 GeV**
Orateur: Jean-Loup RAYMOND (LAPP)
Angular analysis ee ...

18:25 **Study of the Z-boson couplings to heavy fermions**
Orateur: Marina Cobal (Udine)
Annecy_cobal-final_...

18:45 **Searches for LLP at FCC-ee**
Orateur: Marcin Chrzaszcz (University of Zurich)
mchrzasz.pdf

Contributions in **Higgs and Top** coming from cases studies performed in both FCC & ILC

In the **EW session**, TeraZ and LLP searches potential were presented

Top Physics and R&D

Président de session: jeremy andrea (IPHC)

10:40 **top-antitop production in ee collisions at threshold**
Orateur: Jürgen Reuter (DESY Hamburg, Germany)
2021_FCCee_Franc...

11:00 **Latest top analyses in FCC framework**
Orateur: Patrizia Azzi (INFN)
TopTools-FCCFranc...

11:20 **Top and (Heavy) quark studies at linear colliders**
Orateur: Roman Poeschl (LAL Orsay)

Higgs: Physics and detector constraints

Président de session: Suzanne GASCON-SHOTKIN (IPN Lyon)

08:30 **The total e+e- → ZH cross section σHZ and mass measurement from the recoil**
Orateur: Ang LI (APC Paris)
2021_12_02_FCC_F...

08:50 **The total e+e- → ZH cross section and the Higgs self-coupling σHZ**
Orateur: Roberto Salerno (LLR)
RobertoSalerno_FC...

09:10 **Higgs boson coupling measurements to charm quarks at FCC-ee**
Orateur: Giovanni Marchiori (APC Paris)

09:30 **A combined fit of the Higgs branching ratio using ILD detector at Higgs Factory**
Orateur: Jonas Kunath (LLR)
fcc_higgs_combine...

Measurement of e+e- =>nunuH at future lepton Colliders
Orateur: Guillaume Garillot (IPNL)

Next workshops

Several ECFA Higgs+EW+Top Factory workshops in the coming months (hopefully Hybrid)

+ Big gatherings :

FUTURE CIRCULAR COLLIDER Innovation Study

FCC Physics Workshop 7-11 February 22

Liverpool, UK

number of in-person participants limited to ~160 (first come -- first served)
- registration fee: 300£
- broadcast on zoom

Date	Monday 7.2.22		Tuesday 8.2.22		Wednesday 9.2.22		Thursday 10.2.22		Friday 11.2.22	
Location	*UoL Campus*		*ACC*		*ACC*		*ACC*		*UoL Campus*	
Morning	*Coffee/Tea*		*Coffee/Tea*		*Coffee/Tea*		*Coffee/Tea*		*Coffee/Tea*	
	Plenary	Yoko Ono LT	Parallel	Rm 4A, 4B, 14, 12	Parallel	Rm 4A, 4B, 14, 12	Plenary	Rm 11	Plenary	Yoko Ono LT
	Coffee Break		Coffee Break	Rm 12	Coffee Break	Rm 12	Coffee Break	Rm 11	Coffee Break	
	Plenary	Yoko Ono LT	Parallel	Rm 4A, 4B, 14, 12	Parallel	Rm 4A, 4B, 14, 12	Plenary	Rm 11	Plenary	Yoko Ono LT
	Lunch		**Lunch**	Rm 12	**Lunch**	Rm 12	**Lunch**	Rm 11		
Afternoon	Plenary	Yoko Ono LT	Parallel	Rm 4A, 4B, 14, 12	Excursion	Around Liverpool City Centre	Plenary	Rm 11		
	Coffee Break		Coffee Break	Rm 12			Coffee Break	Rm 11		
	Plenary	Yoko Ono LT	Parallel	Rm 4A, 4B, 14, 12			Plenary	Rm 11		
Evening	Drinks and Posters	Atrium CTL	Outreach Event	Anglican Cathedral	Dinner	Liver Building				

FUTURE CIRCULAR COLLIDER

FCC Week 2022

In Paris 30 May to 3 June 2022

We are looking forward to seeing you there !

What about French community future steps and workshops?

Next Steps, next workshop, for French community

- New paths have been presented in this workshop
- Build on these, strengthen the collaborations, in particular between FCC and ILC → Higgs/EW factory approach, but also possibly with neighbouring countries
- Follow up on detector concepts, using already advanced R&D developed in particular for ILC
- Merge developments in Physics cases, and in Theory progress

➔ Organize in November 2022 another Workshop (funding already requested)

FUTURE CIRCULAR COLLIDER
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3rd FCC-France / Higgs & ElectroWeak Factory Workshop, Annecy (Nov.30-Dec.2/2021)

Intitulé du colloque : 4th FCC-France / Higgs & ElectroWeak Factory Workshop
Dates: les 22-24 novembre 2022
lieu :IP2I Lyon
Entité organisatrice : IP2I lyon
Directrice d'unité : Anne EALET
entité gestionnaire : IP2I Lyon
code division si entité CNRS: 0764

BUDGET PREVISIONNEL

Sur la base de 100 participants (a priori en presentiel)

DEPENSES	H.T

Thanks to everybody who participated in the workshop,

Special thanks to our foreign colleagues who made the effort to come from CERN and beyond:

Patrizia Azzi
Michael Benedikt
Marcin Chrzaszcz
Mogens Dam
David D'Enterria
Paolo Giacomelli
Patrick Janot
Marco Lucchini
Emmanuel Perez
Jürgen Reuter
Roberto Tenchini
Emmanuel Tsesmelis
Valentin Volkl
Haijun Yang

Thanks to the organizing committee,

And very special thanks to Jessica Leveque

and Corinne Feullar

Thanks again to everybody who participated in the workshop,

and

Have a safe trip back home !

it’s good to be able to say such sentence again ;)