# FCC-France prospects

- **How are we getting organized for the next steps (post strategy)**

- Originally there were these last years several efforts on-going in France

Some around ILC
- R&D Calice (including current spokesperson)
- R&D CMOS microvertex detectors
- Machine aspects
- study of the physics potential

Some around FCC
- mainly on machine aspects (magnets…), in which both IN2P3 and IRFU are involved + individual contributions to the study of the physics potential

- **Let's see what happened this last year, triggered by the ESPP**

# 2019/2020 update of the European Strategy

**13-16 Mai 2019 :** symposium ouvert à Grenade

- 13/7/2019 EPS-conférence Gand : session commune EPS/ECFA sur la stratégie européenne

**Septembre 2019 :** publication du « Briefing Book »

- 14-16/10/2019: JENAS conférence (ECFA, APPEC, NUPPEC) à Orsay

**November-January : FCC-France days and IN2P3/IRFU preparation for the prospectives**

**20-25 Janvier 2020 :** « Drafting Session » à Bad Honnef

**19-20 Mars 2020 :** session du Conseil pour la discussion du document pour la stratégie

~~**25 Mai 2020 :** session extraordinaire du Conseil à Budapest en vue d'approuver la stratégie~~

# FCC-France days / Future Colliders Scenarios

14-15 Nov. 2019 : FCC-France Days

https://indico.in2p3.fr/event/19693/

| | |
|---|---|
| **Bienvenue** | *Marco Zito* |
| *Amphi Charpak, LPNHE, Paris* | 10:45 - 10:50 |
| **Objectifs de la réunion** | *Laurent Vacavant* |
| *Amphi Charpak, LPNHE, Paris* | 10:50 - 11:00 |
| **FCC, physique et expériences** | *Patrick Janot* |
| *Amphi Charpak, LPNHE, Paris* | 11:00 - 11:30 |
| **FCC, les défis des accélérateurs** | *Frank Zimmermann* |
| *Amphi Charpak, LPNHE, Paris* | 11:30 - 12:00 |
| **Le projet FCC, et l'importance de la France** | *Michael Benedikt* |

13 Jan. 2020 : Discussion "Scénarios de futurs collisionneurs & Questions ouvertes"

14:00 **Le processus de révision de la stratégie européenne EPPSU2020**
Speaker: Ursula BASSLER (IN2P3 - Présidente du Conseil du CERN)

https://indico.in2p3.fr/event/20221/timetable/

14:20 **Contribution IN2P3: processus et status**
Speaker: Laurent VACAVANT (IN2P3)
EPPSU2020_IN2P3_...

14:40 **Contribution CEA: processus et status**
Speaker: Gautier HAMEL DE MONCHENAULT (CEA-Saclay/IRFU-SPP)
EPPSU_CEA-IRFU.pdf

15:00 **L'ESG et la préparation de Bad Honnef: scénarios de machines considérés, proposition de position française, questions ouvertes**
Speaker: Reynald PAIN (IN2P3)
2020.01.13 ESPP.pp... NoteESG

0 **Discussion**
Conveners: Anne-Isabelle ETIENVRE (CEA-Irfu), Reynald PAIN (IN2P3), Achille STOCCHI (IJCLab)

# ESPP : CONTRIBUTION FROM THE FRENCH COMMUNITY -

## 2 highest priorities

- High precision study of Higgs boson and EW sector. New physics through precision
  - FCC-ee physics potential most appealing than CLIC, allowing for Higgs, W, Z, top quark sectors studies, and flavour physics
  - Several detectors will enhance the overall scientific involvement and feedback

- High energy frontier, exploration for new physics
  - Ultimate goal – CERN leadership
  - FCC-hh (eh) is the most ambitious and promising machine
  - Requires a strong, immediate R&D effort on high field magnets

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- If an **e+e- machine is decided in Asia**, this could allow having $e^+e^-$ and pp machines running at the same time (in parallel). A clear strategy for Europe could then be to **express now a priority for FCC-hh, which can be rediscussed in case Asia is not moving forward on with $e^+e^-$ (scenario 4) or express now a priority for FCC-ee and jump** or not **directly to FCC-hh if Asia moves forward with e+e+ (scenario 3)**

- **FCC-all option should be immediately explored in depth**
  - *technical feasibility (tunnel, machine)*
  - *financial aspects (what can be expected from non member states, from other partners,…)*
  - *(social) acceptability*

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# FCC-France since February 2020)

**FCC is the long term priority of the HEP French community, and the scientific structure has thus been adapted:**

- Responsable IN2P3 (Master projet FCC-Phys) : Gregorio Bernardi **NEW**
- Responsable IN2P3 (Master projet FCC-Acc) : Jean-Luc Biarotte
- Responsable IRFU : Roy Aleksan **NEW**

**2020: https://indico.in2p3.fr/event/20792/ FCC-France 1st workshop 14-15 May 2020**

- FCC-contacts in the 10 IN2P3 participating labs an in the 2 related R&D master-projets (MP) :

| | |
|---|---|
| Jeremy Andrea | (IPHC-Strasbourg) |
| Suzanne Gascon | (IP2I Lyon) |
| Thibault Guillemin | (LAPP-Annecy) |
| Fairouz Malek | (LPSC Grenoble) |
| Stephane Monteil | (LPC Clermont) |
| Nicolas Morange | (IJC-Lab Orsay) |
| Steve Muanza | (CPPM Marseille) |
| Luc Poggioli | (LPNHE Paris) |
| Roberto Salerno | (LLR Palaiseau) |
| Jan Stark | (L2IT, Toulouse) |

Groups are growing in each lab, since IN2P3 and IRFU encourage a participation in FCC in parallel to HL-LHC, with priority to FCC-ee vs. hh
Heavy Flavor community strongly supports FCC-ee.

Long term goal is to merge all the exisiting e+e- expertise (physics and detectors in particular)

| | |
|---|---|
| Auguste Besson | (MP microvertex pour collisionneurs linéaires) |
| Vincent Boudry | (MP Calice) |

# Next FCC- France workshops

**1) FCC-France devoted to physics & detectors on 14-15 May, (1.5 day)**

**2) FCC- physics-detectors-accelerator in December in Annecy (2.5 days).**

Sessions for the May workshop :

Introduction, General, Machine

Detectors/Software : CLD, IDEA, Software, ILC-detectors

Higgs : Physics and detector contraints

EW Physics @ Z / WW & QCD: Physics and detector contraints

Heavy Flavour & Taus @ Z : Physics and detector contraints

ttbar : Physics and detector contraints

hh-100 TeV : Physics

about 30 talks have been assigned.

# Agenda du 14 Mai

## Status & Goals

**Président de session**: Gregorio Bernardi (LPNHE Paris)

10:30 **Introduction and Goals (15'+5')**
**Orateur**: Laurent Vacavant (CPPM)

10:50 **Status and plans of the FCC project (20'+5')**
**Orateur**: Michael Benedikt (CERN)

11:15 **ECFA Objectives for the future colliders detectors and physics studies (20'+5')**
**Orateur**: Jorgen D'Hondt (Vrije Universiteit Brussel)

11:40 **Global discussion on the first 3 presentations (20')**

12:00 **Stauts of CEPC (20+5)**
**Orateur**: Prof. Manqi RUAN (Chinese Academy of Sciences (CN))

12:25 **Brief Summary of FCC-Phys activities in the French Labs (15+5)**

Lunch break

## Detectors & Software

**Président de session**: Roy Aleksan (CEA-Saclay)

14:00 **Global concepts for an FCC detector, the IDEA & CLD examples (15'+5')**
**Orateur**: Franco Grancagnolo

14:20 **Calorimetry for FCC-ee (15'+5')**
**Orateur**: Vincent Boudry (LLR - CNRS, École polytechnique/IPP Paris)

14:40 **Vertexing and tracking for FCC-ee (15'+5')**
**Orateur**: Maxim Titov (CEA Saclay, IRFU/SPP)

15:00 **Particle-ID for FCC-ee (15'+5')**
**Orateur**: Guy Wilkinson (Oxford)

15:20 **Status of the FCC Software (15'+5')**
**Orateur**: Gerardo Ganis (CERN)

## Electroweak Physics and QCD @ Z pole and at WW : Physics and Detector Contraints

**Président de session**: Alain Blondel (LPNHE Paris-Sorbonne)

16:00 **EW Precision Observables measurement and impact on SM constraints at FCC(ee)(15'**
**Orateur**: Giacomo Cacciapaglia (IPNL - Univ. Lyon 1)

16:20 **Luminosity measurement / Precise measurement of the centre of mass energy at FCC(**
**Orateur**: Emmanuel PEREZ (CERN)

16:40 **Systematics on EWPO measurements / line-shape + AFB leptonic/Sin2.theta.W (15'+5')**
**Orateur**: lucia di ciaccio (lapp)

17:00 **Systematic uncertainties on Rb and Rc measurements at an e+e- collider**
**Orateur**: Zhijun Liang (IHEP Beijing)

17:20 **W mass and Gamma(W) measurements (15'+5')**
**Orateur**: Elizabeth Locci (CEA-IRFU)

17:40 **Alpha-s (MZ and MW) / other QCD measurements (15'+5')**
**Orateur**: David d'Enterria (CERN)

## Round Table

18:00 **Round Table**

How can FCC benefits from the ILC expertise

# Agenda du 15 Mai

## Higgs @ FCC(ee): Physics and Detector Constraints

**Président de session**: Patrick Janot (CERN)

09:00 **Model independent Higgs boson coupling determination (15'+5')**
**Orateur**: Giovanni Marchiori (LPNHE Paris)

09:20 **Higgs boson self-coupling measurements and extended Higgs boson sector (15'+5')**
**Orateur**: Roberto Salerno (LLR)

09:40 **EW theory needs for Higgs physics at FCC (15'+5')**
**Orateur**: Sven Heinemeyer (IFCA (CSIC-UC, Santander))

10:00 **Jets measurements requirements for Higgs boson physics at FCC (ee) (15'+5')**
**Orateur**: Gérald Grenier (IPN Lyon/Université Lyon 1)

10:20 **Vertex requirements for Higgs boson physics at an e+e- Collider (15'+5')**
**Orateur**: Marc Winter

coffee break

## Heavy Flavor and Taus @ Z Pole: Physics and detector constaints

**Président de session**: Marie-Hélène Schune (LAL)

11:00 **Overview on Heavy Flavour physics and related BSM (15'+5')**
**Orateur**: Damir BECIREVIC (IJCLab - Pôle Théorie)

11:20 **b,c and light quark-flavour tagging for Vcb and Vcs at WW. Vertexing performance (**
**Orateur**: Stephane Monteil (Laboratoire de Physique de Clermont - UCA/IN2P3)

11:40 **Exclusive reconstruction of b- and c-hadron decays (15'+5')**
**Orateur**: Karim Trabelsi (LAL)

12:00 **Overview on tau physics and contrainst on tracking from taus (15'+5')**
**Orateur**: Mogens Dam

12:20 **Tau reconstruction at CEPC (15'+5')**
**Orateur**: DAN YU

## Physics and detector constraints near the ttbar threshold

**Président de session**: Patrizia Azzi (INFN)

14:00 **Top physics at FCC-ee (15'+5')**
**Orateur**: Benjamin Fuks (LPTHE Paris)

14:20 **Precise theoretical predictions for top physics at FCC-ee (15'+5')**
**Orateur**: Gauthier Durieux (Technion)

14:40 **Detector constraints from Top physics (15'+5)**
**Orateur**: jeremy andrea (IPHC)

## Physics @ FCC(hh)

**Président de session**: Christophe grojean (CERN)

15:00 **Higgs self coupling and Higgs rare decays (15'+5')**
**Orateur**: Elisabeth Petit (CPPM-IN2P3)

15:20 **BSM physics at FCC-hh / SUSY (15'+5')**
**Orateur**: Monica D'Onofrio (University of Liverpool)

15:40 **BSM physics at FCC-hh / Exotica (15'+5')**
**Orateur**: Marie-Helene Genest (LPSC-Grenoble, CNRS/UGA (FR))

## Next Steps

16:00 **Next Steps**

# FCC-Phys Goals

- Focus on the  Physics and Detector studies in 2020 – 2022
  - Start from statistical precision as reference
  - Identify places where detector design/construction will be the limiting factor
  - Identify places where further input requires full simulation results
  - Leave aside theory systematics for the time beign

- Start new R&D developments in 2022-2024 based on the first results of these studies

- Write TDR in 2024-2025 for the Physics / Detector aspects, to allow next strategy to come to a decision to officially start FCC the digging of  the tunnel

# Brief Summary of Physics Studies in FCC-France

IRFU-Saclay : **Electroweak, Heavy Flavour,** Higgs

IPHC-Strasbourg : **Top,** Heavy Flavour

IP2I Lyon : Higgs, Electroweak

LAPP-Annecy : **Higgs**

LPSC Grenoble : Electroweak, New Phenomena

LPC Clermont : **Heavy Flavour**

IJC-Lab Orsay : Higgs, Heavy Flavour

CPPM Marseille : **New Phenomena**

LPNHE Paris : **Higgs, QCD,** Heavy Flavour

LLR Palaiseau : **Higgs**

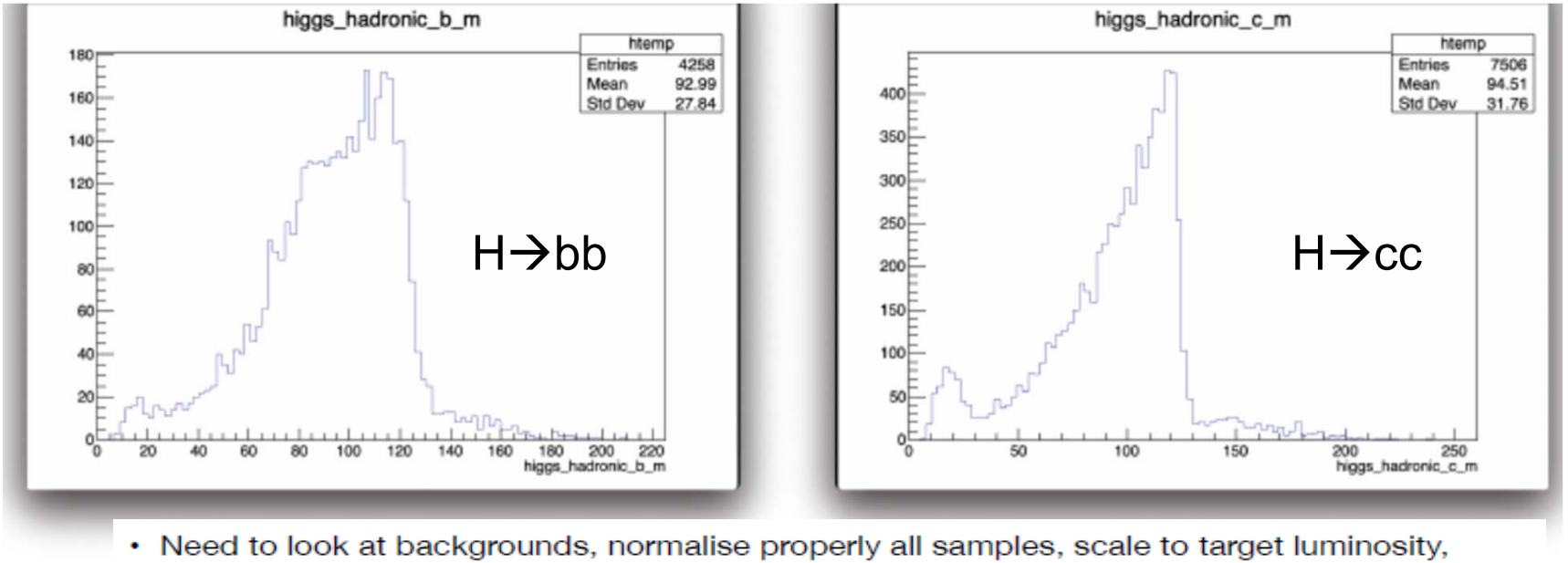
L2IT, Toulouse : Higgs

Legend : **Activity started,** activity foreseen

# H—>bb/cc/gg at FCC-ee

G. Marchiori

- Physics process under study: ZH, Z->leptons (e, mu), H->bb/cc(/gg)
  - Select muons and electrons with pT>10 GeV, isolated
  - Select jets with pT>10 GeV, not within R=0.2 of previously selected muons or electrons
  - Apply b-tagging and c-tagging on selected jets
  - Build Z boson candidates from pairs of electrons or muons (use analysis class "ResonanceBuilder")
  - Build Higgs boson candidates from pairs of both b-tagged, both c-tagged, or neither b- or c-tagged jets (use analysis class "JetResonanceBuilder")




- Need to look at backgrounds, normalise properly all samples, scale to target luminosity, define strategy to extract in single fit the bb/cc/gg rates
- Would like to better understand dijet mass resolution, though probably not critical for leptonic Z case since we can look at recoil mass rather than directly looking at dijet mass.. but can be relevant later when looking at other Z channels (invisible, hadronic) where we don't have the recoil mass available

# Challenges !

Getting more people to work, especially in this period !

Find Software experts to help the FCC software effort.

Hire Ph.D. students on FCC, or on FCC+LHC

Convince HL-LHC people that a small  but real contribution to FCC will bring them large benefits and will help a lot the community

Get closer to the world FCC community

Get the French Linear Collider community to fully endorse the FCC project

Get a full consensus of the European community on the FCC project, without strongly arguing ee vs hh now.

# Conclusions

In this last year, the French HEP community and funding agencies has clarified its position in full support of the FCC project at CERN.

The possibility that a Japan-based or Chinese-based machine see the light is seen as positive emulation and justify the support to the CERN project. A contribution to one of these projects would probably be done if approved, but nothing comparable to the potential contribution to the FCC project.

It remains a big challenge to convince the French government to invest now large amounts of money for the tunnel. We definitely need an even stronger consensus on this project and the newly introduced FCC-physics project will contribute to this French and European goal if we want this project to exist for real.