FCC-contacts – May 27

- News
- Debriefing FCC France workshop
- Dialog / Tour de Table
- AOB

Software news

- **Good news! Clément Helsens to work with for one more year**
  - In his role of FCC Software co-coordinator (with Gerardo Ganis)
    - "To put the software project in the right state to be used for TDR work"
- **Highest priority item (from Software Coordinator's mandate)**

Summer/Fall 2019: Have a first prototype of software stack usable for FCC-ee physics simulation, with (for example) the beam pipe, a vertex detector, and tracking/vertexing algorithms.

  - Add also b/c tagging algorithm(s) with tracks
    - Based on vertex position, track impact parameters, vertex mass, …
      - ➔ This item will be developed on tracks obtained with Fast Simulation

        Ongoing integration of latest DELPHES will make it possible
      - ➔ And ultimately need the full simulation of a tracker
  - Clément & Gerardo are developing a plan to get it done ASAP
    - Including a plan to get people working on the project

- **MC Generator integration ongoing: please contact Clément and Gerardo**

FCC Software Meeting

Friday 22 May 2020, 09:30 → 10:55 Europe/Zurich

09:30 → 09:40 **News**

Speakers: Clement Helsens (CERN), Gerardo Ganis (CERN)

FCCSW-22May2020...

09:40 → 10:00 **Investigations on ttbar generation at FCCee**

Speaker: Jeremy Andrea (Centre National de la Recherche Scientifique (FR))

FCCee_ttbar_genera...

10:00 → 10:20 **News on Delphes and EvtGen**

Speaker: Valentin Volkl (University of Innsbruck (AT))

2020-05-21-FCCSW-...

Jeremy Andrea (IPHC, Strasbourg)

- (My) first investigations of the production of $t\bar{t}$ events at FCCee.
- What we might want :
  - **Accurate** : Precise generator, NLO accuracy in QCD and EWK, a good description of the threshold scan (NLO+NLL),
  - **PS/Hadronization** : Can be interfaced to more than one PS algorithm for systematic studies (tuning ?),
  - Account for ISR, Beam Spectra and Beamstrahlung,
  - Can estimate systematics properly and "easily".
- A few generators/configurations have been looked at :
  - Madgraph5 LO, aMC@NLO, whizard for cross section calculations,
  - On shell top pairs production $e^+e^- \to t\bar{t}$ or $e^+e^- \to W^+W^-b\bar{b}$ at NLO with MG+Herwig for PS and hadronization,
  - Not exhaustive at all !
- In this talk : some discussions about the needs and context, and some examples of generations. **Very preliminary !!**

Case Studies

- A number of case studies have been proposed last year
  - To define detector requirements and benchmarks for detector R&D
    - See https://docs.google.com/document/d/1obwT_QMM0S1LfmRR698fnwoIR_nBwyiVzxN8bjBDb4E
  - Summary of basic needs and name of contact persons are still missing for a number of case studies
    - See https://docs.google.com/spreadsheets/d/1ja0UQC-20NHzYq3FktoIpYuNfLM-oGffA0D4PrVJh9E
  - Everybody is welcome / encouraged to
    - Consult the list
    - Manifest their interest
    - Propose new items
- Obvious synergies with software effort
- Possible synergies with Snowmass 2020-2021
  - Once an entry has a contact person, Letters of Interest (LoI's) can be written
    - After consulting with Snowmass contact persons

The Snowmass process

Long-term planning exercise for the particle-physics community.

- "Develop community long-term physics aspirations."
- "Communicate opportunities for discovery in particle-physics to broader community and to the (US) government."

(Young-Kee Kim, DPF Chair, Town-Hall Meeting, 2020 April APS meeting)

Physics-driven effort.

- Covers all areas of particle physics and facilitates cross-cutting.
- Develop overarching physics studies.

Global effort.

- Input from non-US community is essential.
- Input from recent international studies, for example HL-LHC, European Strategy Particle Physics Update (ESPPU), future colliders etc.

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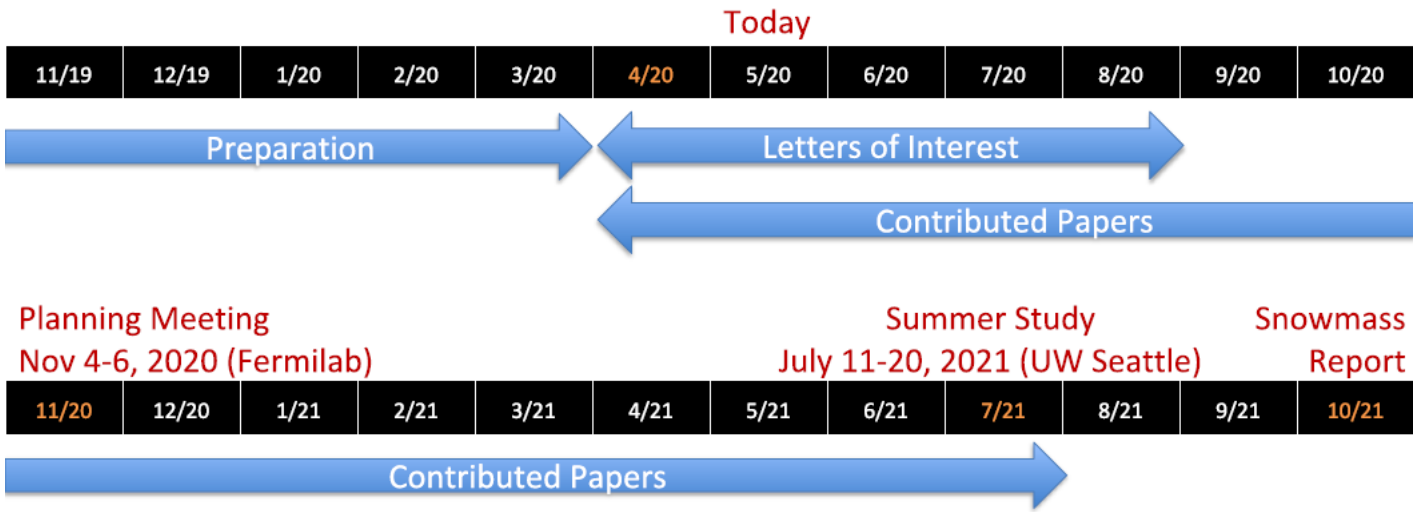


Snowmass Contacts

- **Memorandum sent to Snowmass by FCC Physics Coordination**
  - **See following link**

ttps://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF-RF-TF-IF-CompF-TOPIC0-003.pdf

  - **Snowmass contacts**
    - Overall contact: Markus Klute, plus Alain Blondel, Patrick Janot and Michelangelo Mangano
    - Energy Frontier: Patrizia Azzi and Gregorio Bernardi (FCC-ee), Michele Selvaggi (FCC-hh), Christophe Grojean (Phenomenology)
    - Frontiers in Rare Processes and Precision Measurements: Stéphane Monteil (b and c physics) and Mogens Dam (τ physics)
    - Theory Frontier: Matthew McCullough
    - Instrumentation Frontier: Mogens Dam and Franco Bedeschi
    - Computational Frontier: Luc Poggioli

    Software support can be obtained from the FCC software group (see C. Helsens and G. Ganis in [14]) who will be happy to integrate software contributions.

  - **Task of Snowmass contacts**
    - **Understand what happens at SNOWMASS21 in your track, and inform regularly the FCC physics coordination group.**
    - **Inform and sensitize the Snowmass working groups of the pertinent elements concerning FCC, get FCC members invited to the Snowmass working groups, welcome individual Snowmass group members to work with us.**
    - **As opportunities or questions arise, call for FCC community action.**

ITN Spiral-Net did not pass

(Study of performance of Innovative Reconstruction Algorithms at Lepton Colliders)

Criterion 1 - Excellence

Score: **3.20** (Threshold: 0/5.00 , Weight: 50.00%)

Quality, innovative aspects and credibility of the research programme (including inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality and innovative aspects of the training programme (including transferable skills, inter/multidisciplinary, intersectoral and, where appropriate, gender aspects)
Quality of the supervision (including mandatory joint supervision for EID and EJD projects)
Quality of the proposed interaction between the participating organisations

Strengths:
- The research objectives are clearly defined.
- There are some innovative aspects in the algorithms to be developed.
- The multidisciplinary perspective of the research programme is evident.
- The training programme addresses several disciplines, like event generators, detector developments, scientific computing, data analysis, and offers possibilities to develop soft skills. This is all valued positively.
- The quality of the supervisors' qualifications and experience is very high, and the proposal illustrates very well their records in supervision. Moreover, the proposal convincingly demonstrates that the supervisors are committed to provide the best possible support to ESRs.
- The contribution of the academic partners to the network activities is evident, being based on the achievements they accumulated over years of active developments in the field of experimental high-energy physics.
- The synergies between the participating organisations are clear and comprehensively presented.
- All participants will make a relevant and valuable contribution to the training programme.

Weaknesses:
- The scientific need behind the stated objectives is not sufficiently demonstrated. In particular, the proposal fails to describe why the reconstruction of the algorithms should differ from the ones currently used for hadron colliders.
- The proposal does not sufficiently address the target performance required in the algorithms.
- The intersectoral elements are limited to the secondments, and are not sufficiently justified.
- The contribution of some non-academic partners to the training of the ESRs is not sufficiently demonstrated in the proposal.
- The amount of time the ESRs will dedicate to scientific and technical training, compared to training in soft skills is not sufficiently described in the proposal.
- Co-supervision, whenever envisaged, is not sufficiently justified in the proposal.
- The quality of the interaction between academic and industrial partners is not sufficiently demonstrated in the proposal.

Criterion 2 - Impact

Score: **4.20** (Threshold: 0/5.00 , Weight: 30.00%)

Criterion 3 - Quality and Efficiency of the Implementation

Score: **3.80** (Threshold: 0/5.00 , Weight: 20.00%)

Debriefing of the 1st international FCC-France Workshop

Program of the workshop

Some talks teasers

General Messages from this Workshop

Next Steps for FCC(-France)

Program of the Workshop (I)

Excellent quality of the talks, thanks to all speakers from France and from abroad !

- 6 sessions, focused on the detector constraints implied by Physics, mainly at FCC(ee)
- 32 talks, inputs also from the ILC community
- 1 round table

Introduction/ Status/Goals Session

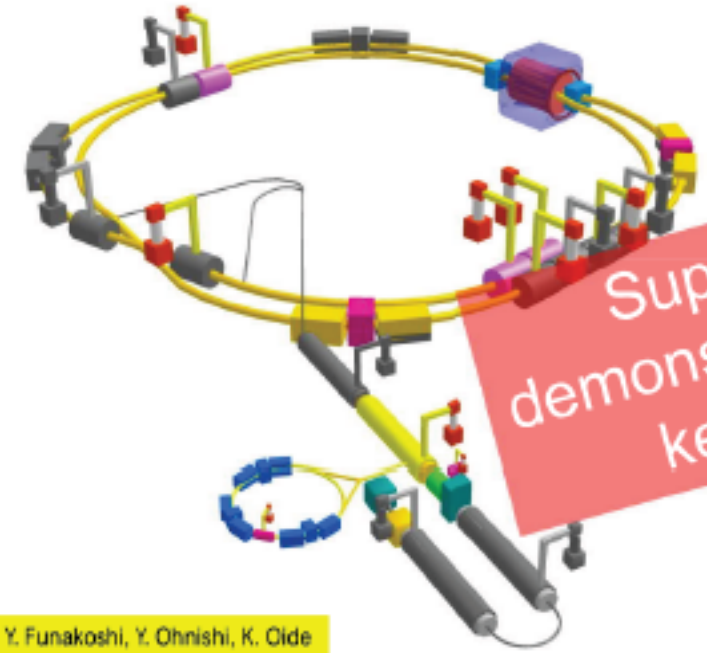
Welcome from the organizers / Last infos	
LPNHE-Paris / En Video	10:20 - 10:
Introduction and Goals (15'+5')	*Laurent Vacavant*
LPNHE-Paris / En Video	10:30 - 10:
Status and plans of the FCC project (20'+5')	*Michael Benedikt*
LPNHE-Paris / En Video	10:50 - 11:
ECFA Objectives for the future colliders detectors and physics studies (20'+5')	*Jorgen D'Hondt*
LPNHE-Paris / En Video	11:15 - 11:
Global discussion on the first 3 presentations (15')	
LPNHE-Paris / En Video	11:40 - 11:
Status of CEPC (20+5)	*Prof. Manqi RUAN*
LPNHE-Paris / En Video	11:55 - 12:
Brief Summary of FCC-Phys activities in the French Labs (20+5)	*FCC-France contacts*
LPNHE-Paris / En Video	12:20 - 12:

News from Japan

Michael Benedikt
@FCC France

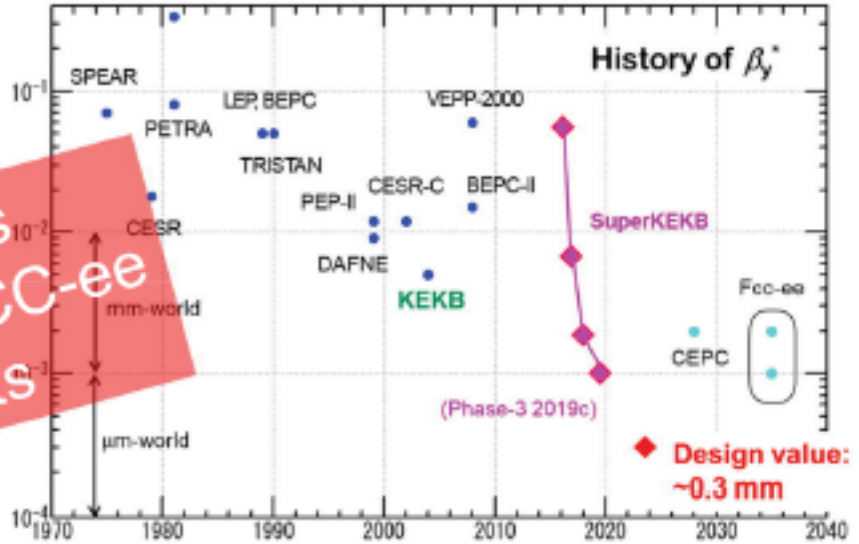
SuperKEKB – pushing luminosity and β^*

Design: double ring e^+e^- collider as *B*-factory at 7(e^-) & 4(e^+) GeV; design luminosity ~8 x 10^{35} $cm^{-2}s^{-1}$; β_y^* ~ 0.3 mm; nano-beam – large crossing angle collision scheme (crab waist w/o sextupoles); beam lifetime ~5 minutes; top-up injection; e^+ rate up to ~ 2.5 10^{12} /s ; under commissioning



Y. Funakoshi, Y. Ohnishi, K. Oide

SuperKEKB is demonstrating FCC-ee key concepts



β_y^* =1 mm achieved in both rings - world record
crab-waist collisions implemented recently

→ IPAC'20 Talk by K. Shibata

FCC studies continue

Michael Benedikt
@FCC France

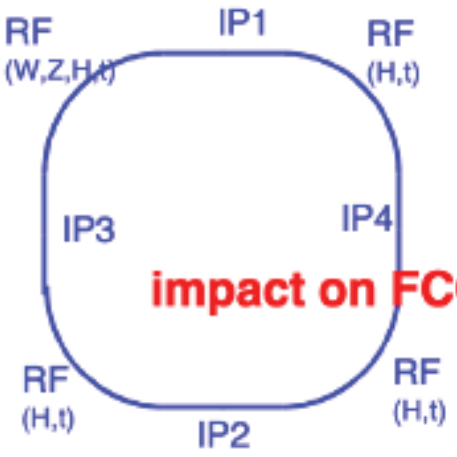
FCC-ee 2 vs. 4 IPs studies

- Potentially up to 1.7x higher total luminosity
- Major impact on layout,RF sections, additional caverns, infrastructure, etc.

baseline w 2 IPs

works fine

periodic alternative with 4 IPs



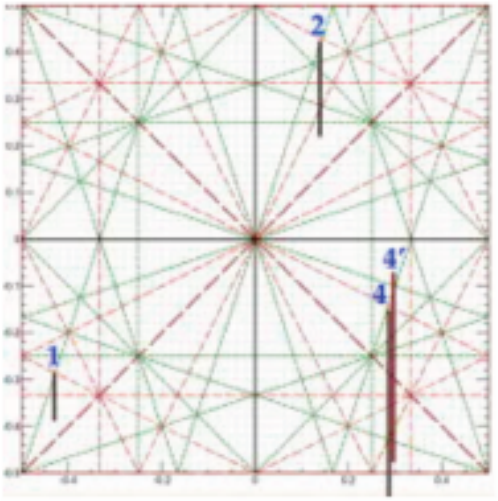
so far OK for lattice and beam-beam

less symmetric alternative with 4 IPs

not yet studied, but considered challenging

impact on FCC-hh layout!

beam-beam footprint Z



"1":perfect periodicity for 2 or 4 IP
"2":2 IP with imperfections
"4":4 IP with imperfections
"4' ":an alternative vertical tune to avoid ν_y = half integer

K. Oide,
D. Shatilov

Recent Progresses

- Physics studies
- New beam parameters
- Accelerator technologies
  - SRF
  - Klystron
- High Temperature Super Conductor
- Link to the industrial

- *Reference to Prof. Foster and Prof. Gao's summary talks at the CEPC Oxford Workshop as well as Prof. Chi's slides at HK IAS meeting*

Summary of FCC-Phys activities in the French Labs

R. Aleksan, J. Andrea, G. Bernardi, A. Besson, V. Boudry S. Gascon, T. Guillemin,
F. Malek, S. Monteil, N. Morange, S. Muanza, L. Poggioli, R. Salerno, J. Stark

IRFU	Saclay
CPPM	Marseille
IJCLab	Orsay
IPHC	Strasbourg
IP2I	Lyon
LAPP	Annecy
LPC	Clermont
LLR	Palaiseau
LPNHE	Paris
LPSC	Grenoble
L2IT	Toulouse

People involved

Activities, Goals

Physics interest

Algorithms interest,
subdetector interest

Future R& D ?

Previous Lab involvement
in Future Collider R&D

Summary of FCC-Phys activities in the French Labs Conclusions

Physicists involved :

- About 30 permanent physicists involved on FCC (including those by the end of 2020)
- Potential for ~15 more, soon after (2021)
- Large technical teams in all the labs.
- Numbers are significant, % of involvement has to grow, taking into account HL-LHC.

  (Reminder: Accelerator R&D/personpower not covered in this talk)

Wide Physics interest :

- Higgs, Electroweak, Top, Heavy Flavour, QCD, BSM

Algorithms interest,

- b-tagging, particle-ID, Tracking and Calorimeter reconstruction, Particle Flow

Subdetector interest

- Microvertex, P-ID, Tracker, Calorimeter

Future R&D ?

- Exploit current expertise on MicroVertex, Tracking (TPC), and Calorimetry (Calice) ?
  ➔ See round table at 6PM:

  Can FCC(-France) benefit from the ILC(-France) expertise ?

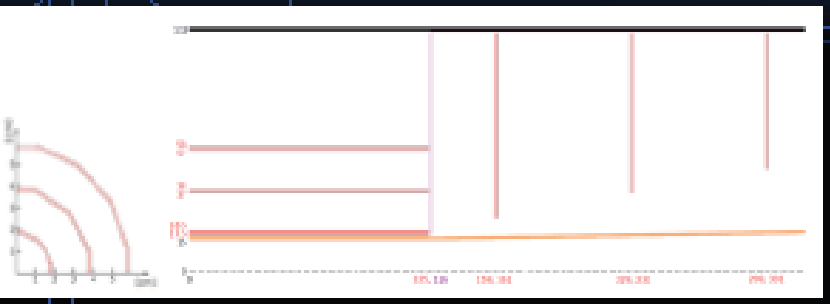
Program of the Workshop (II)

Detectors and Software

Global concepts for an FCC detector, the IDEA & CLD examples (15'+5')	*Franco Grancagnolo*
LPNHE-Paris / En Video	14:00 - 14:
Calorimetry for FCC-ee (15'+5')	*Vincent Boudry*
LPNHE-Paris / En Video	14:20 - 14:
Insights for FCC-ee tracking and vertexing, based on ILC/CLIC experience (15'+5')	*Maxim Titov*
LPNHE-Paris / En Video	14:40 - 15:
Particle-ID for FCC-ee (15'+5')	*Guy Wilkinson*
LPNHE-Paris / En Video	15:00 - 15:
Status of the FCC Software (15'+5')	*Gerardo Ganis*
LPNHE-Paris / En Video	15:20 - 15:

CLD vs. IDEA / detailed comparison

CLD Vertex detector IDEA

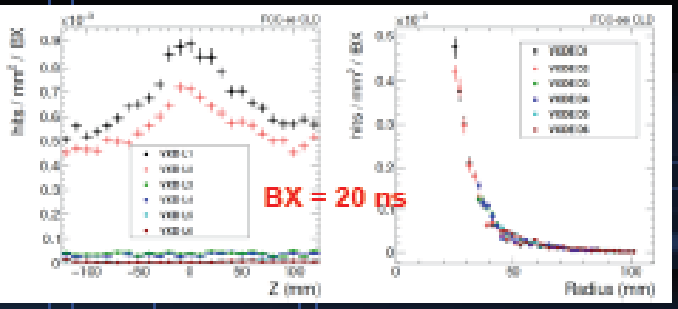


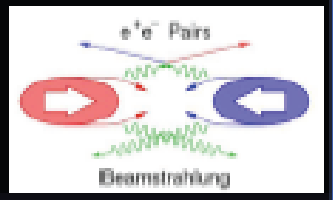
0.5 m²
≈ 10⁹ ch.

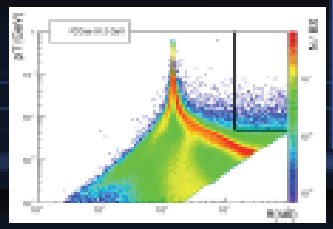
- Silicon pixels (25 x 25 μm²), 3 μm single point resolution
- 3 double layers in barred R = 17, 27, 57 mm
- 3 double layers in end-cap disks Z = 160, 230, 300 mm
- Material budget: 0.6%/0.7% X0 per double layer in barrel/e-c

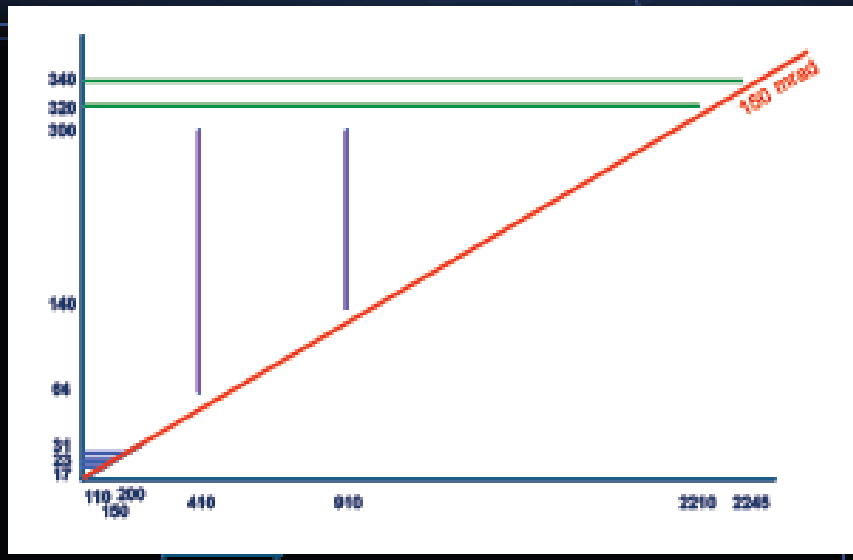
Full MC simulation

Occupancy at Z pole < 1-2×10-3 hits/pixel









Inspired by ALICE ITS based on MAPS technology

- inner layers 20×20 μm² pixel 0.3% X_0 per layer
  expected point resolution 3μm
- outer layers 0.05×1 mm² strips 1% X_0 per layer
- disks 50×50 μm² pixel 0.3% X_0 per layer

to be optimized …

2 m², ≈ 1.2×10⁹ ch. (+ 20 m², ≈ 0.4×10⁹ ch.)

Calorimetry / Tracking talks from ILC experts

Requirements from Physics

Basis: sep of H → WW/ZZ → 4j

- σ_E/E (jets) < ~4%
- Sign ~ S/√B ~ (resol)$^{-1/2}$
  60%/√E → 30%/√E ⇔ + ~40% in $\mathscr{L}$

Large acceptance

Large Tracker

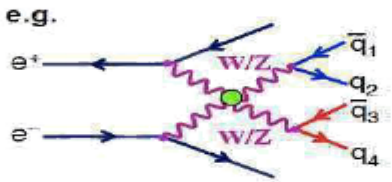
- Precision and low X_0 budget
- Pattern recognition

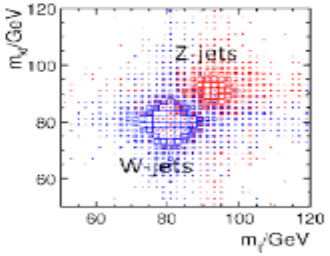
High precision on Si trackers

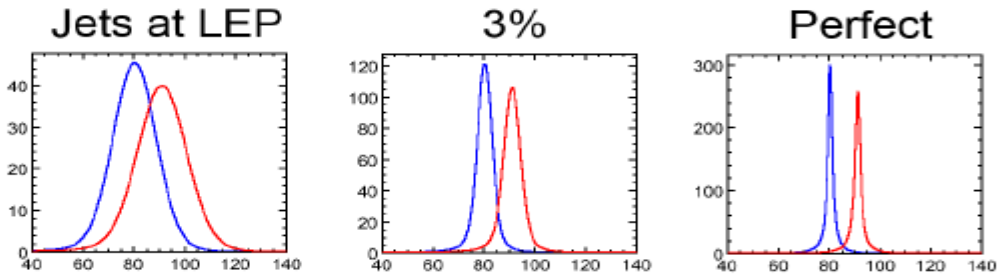
- Tagging of beauty and charm

Fwd Calorimetry:

- lumi, veto, beam monitoring

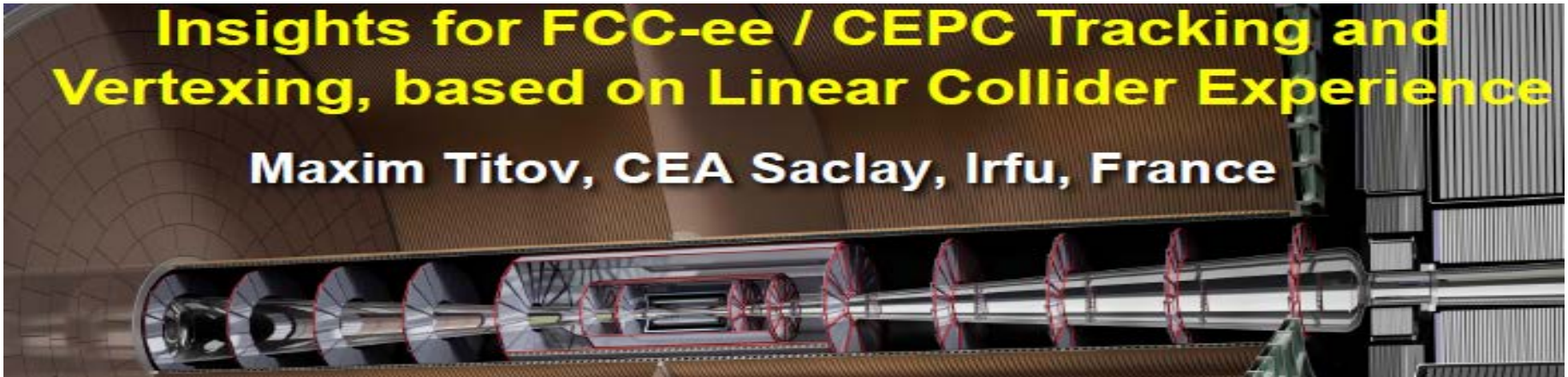






σ_E/E (γ) ≤ 10 %/√E

Tau Physics (γ vs π_0) → Photons in jets ?



Systematics on EWPO measurements: Z line-shape + $A_{FB}^{0\ell}$ ($\sin^2\vartheta_W$)

Theoretical uncertainties

- Common across the experiments
- Theory uncertainties related to the knowledge of :
  - QED radiative effects
    (@LEP: ± 0.3 MeV on m_Z, ± 0.3 MeV on Γ_Z, 0.02% on σ^0_Z)
  - parametrization of line shape and A_{FB} in term of the pseudo observables

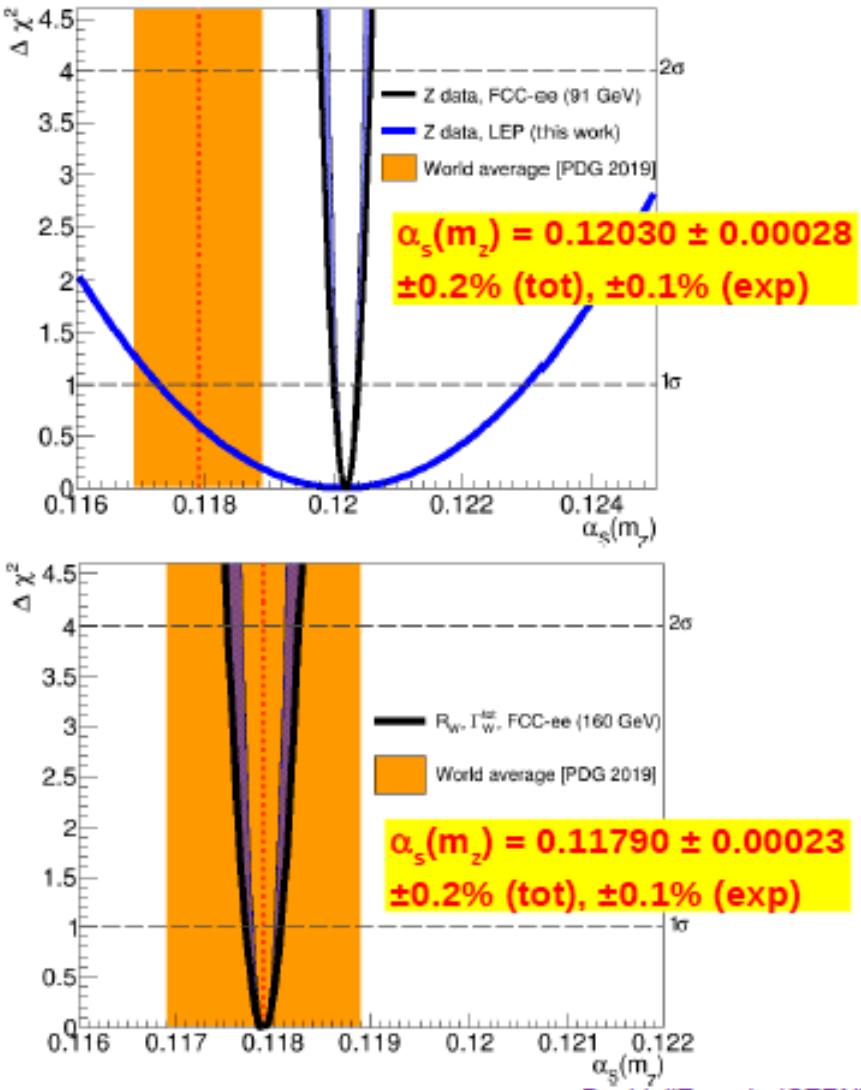
Δm_Z [GeV]	$\Delta\Gamma_Z$ [GeV]	$\Delta\sigma^0_{had}$ [nb]	ΔR^0_ℓ	$\Delta A^{0,\ell}_{FB}$
0.0001	0.0001	0.001	0.004	0.0001

  - t-channel and s-t interference contribution to the e^+e^- cross section
  - small angle Bhabha cross section for the luminosity (@LEP ~ 0.061%)
- Need to match experimental uncertainties: dedicated workshop, 2018 → @FCC
  need:
  * New approach for the extraction of the observables
  * Three loop calculations (EW, QCD, mixed)
  * Dedicated generators
- Need close collaboration theorists-experimentalists

Summary: α_s at FCC-ee

- World-average QCD coupling at N^{2,3}LO today:
  - *Determined from 7 observables with combined 0.85% uncertainty (least well-known gauge coupling).*
  - *Impacts all LHC QCD x-sections & decays.*
  - *Role beyond SM: GUT, EWK vacuum stability, New colored sectors?*
- e^+e^- extractions:
  - Hadronic tau decays: ±1% TH
  - Event shapes, jet rates: ±1% TH
  - Z&W pseudo-observ.: ±0.1% TH
- State-of-the-art extractions:
  - Z boson: New fit with high-order EW corrections + updated LEP data: ~2.3% (exp.) uncertainty today.
  - W boson: New N^{3}LO fit to Γ_W, R_W ~27% (exp.) uncertainty today.

- Permil uncertainty only possible with a machine like FCC-e^+e^-



The 2 ways to perform λ_{HHH} measurement

below the double Higgs boson production threshold

1. an exclusive analysis of single Higgs processes at higher order, considering only deformation of the Higgs cubic coupling ➔ a one-dimensional EFT fit

2. a global analysis of single Higgs processes at higher order, considering also all possible deformations of the single Higgs couplings ➔ a multi-parameter EFT fit

↳ Robust bounds can be obtained

In the SMEFT$_{EWPO}$ mostly used in the following, the perfect EW constraints(*) are assumed and 12+1 parameters are fitted:

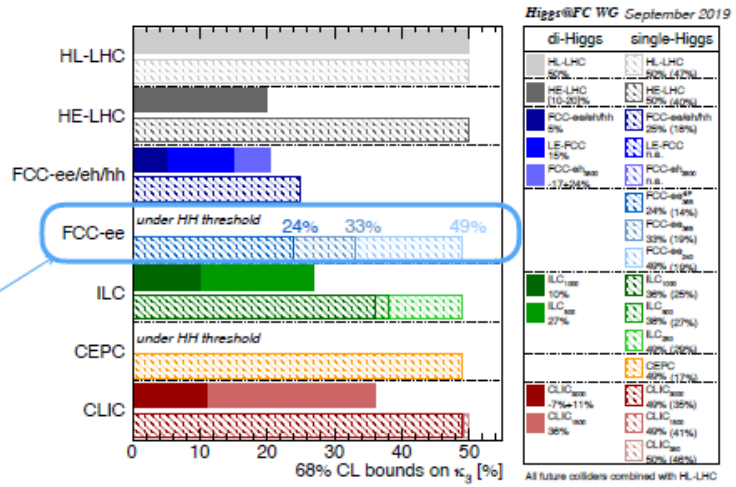
- (6) corrections to the Higgs boson couplings to the gauge bosons
- (5) corrections to the Yukawa couplings
- (1) correction to trilinear gauge couplings
- (1) correction to the trilinear Higgs boson self-coupling

(*) any new physics contributions to the EW precision observables are bounded to be exactly zero, after running at FCC-ee(Z), this assumption is "almost" verified

arXiv:1905.03764

Main results

collider	(1) di-H excl.	(2.a) di-H glob.	(3) single-H excl. with HL-LHC	(3) single-H excl. w/o HL-LHC	(4) single-H glob.
HL-LHC	$^{+60}_{-50}$% (50%)	52%	47%	125%	50%
HE-LHC	10-20% (n.a.)	n.a.	40%	90%	50%
ILC$_{250}$	–	–	29%	126%	49%
ILC$_{350}$	–	–	28%	37%	46%
ILC$_{500}$	27% (27%)	27%	27%	32%	38%
ILC$_{1000}$	10% (n.a.)	10%	25%	n.a.	36%
CLIC$_{380}$	–	–	46%	120%	50%
CLIC$_{1500}$	36% (36%)	36%	41%	80%	49%
CLIC$_{3000}$	$^{+11}_{-7}$% (n.a.)	n.a.	35%	65%	49%
FCC-ee$_{240}$	–	–	19%	21%	49%
FCC-ee$_{365}$	–	–	19%	21%	33%
FCC-ee$^{4IP}_{365}$	–	–	14%	n.a.	24%
FCC-eh	17-24% (n.a.)	n.a.	n.a.	n.a.	n.a.
FCC-ee/eh/hh	5% (5%)	6%	18%	19%	25%
LE-FCC	15% (n.a)	n.a	n.a.	n.a.	n.a.
CEPC	–	–	17%	n.a.	49%



Uncertainties on Higgs measurements

Intrinsic uncertainties for decay widths: [arXiv:1905.03764]

"ILC/CEPC/FCC-ee" = expected precision on g^2_{Hxx} (incl. HL-LHC meas.)

Partial width	QCD	electroweak	total	future	ILC/CEPC/FCC-ee
$H \to WW \to 4f$	$< 0.5\%$	$< 0.3\%$	$\sim 0.5\%$	$\lesssim 0.4\%$	0.6/1.9/0.8%
$H \to ZZ \to 4f$	$< 0.5\%$	$< 0.3\%$	$\sim 0.5\%$	$\lesssim 0.3\%$	0.4/0.4/0.3%
$H \to gg$	$\sim 3\%$	$\sim 1\%$	$\sim 3.2\%$	$\sim 1\%$	1.7/2.2/1.8%
$H \to \gamma\gamma$	$< 0.1\%$	$< 1\%$	$<1\%$	$< 1\%$	2.4/2.4/2.4%
$H \to Z\gamma$	$\lesssim 0.1\%$	$\sim 5\%$	$\sim 5\%$	$\sim 1\%$	22/13/20%
$H \to b\bar{b}$	$\sim 0.2\%$	$< 0.3\%$	$< 0.4\%$	$\sim 0.2\%$	1.2/1.8/1.3%
$H \to c\bar{c}$	$\sim 0.2\%$	$< 0.3\%$	$< 0.4\%$	$\sim 0.2\%$	2.4/4.0/2.6%
$H \to \tau^+\tau^-$	–	$< 0.3\%$	$< 0.3\%$	$< 0.1\%$	1.3/1.9/1.3%
$H \to \mu^+\mu^-$	–	$< 0.3\%$	$< 0.3\%$	$< 0.1\%$	7.8/7.8/7.8%
Γ_{tot}				$\sim 0.3\%$	1.1/1.8/1.2%

$\Rightarrow$ non-negligible for $H \to WW/ZZ \to 4f$

Program of the Workshop (III)

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

EW Precision Observables measurement and impact on SM constraints at FCC(ee)(15'+5')	*Giacomo Cacciapaglia*
LPNHE-Paris / En Video	16:00 - 16
Luminosity measurement / Precise measurement of the centre of mass energy at FCC(ee)(15'+5')	*Emmanuel PEREZ*
Systematics on EWPO measurements / line-shape + AFB leptonic/Sin2.theta.W (15'+5')	*lucia di ciaccio*
LPNHE-Paris / En Video	16:55 - 17:
W mass and Gamma(W) measurements (15'+5')	*Elizabeth Locci*
LPNHE-Paris / En Video	17:15 - 17:
Alpha-s (MZ and MW) / other QCD measurements (15'+5')	*David d'Enterria*
LPNHE-Paris / En Video	17:35 - 17:

Higgs @ FCC(ee): Physics/Detector Constraints

Model independent Higgs boson coupling determination (15'+5')	*Giovanni Marchiori*
LPNHE-Paris / En Video	09:00 - 09:
Higgs boson self-coupling measurements and extended Higgs boson sector (15'+5')	*Roberto Salerno*
LPNHE-Paris / En Video	09:20 - 09:
EW theory needs for Higgs physics at FCC (15'+5')	*Sven Heinemeyer*
LPNHE-Paris / En Video	09:40 - 10:
Jets measurements requirements for Higgs boson physics at FCC (ee) (15'+5')	*Gérald Grenier*
LPNHE-Paris / En Video	10:00 - 10:
Vertex requirements for Higgs boson physics at an e+e- Collider (15'+5')	*Marc Winter*

B-physics and viable NP(LQ) scenarios

Damir Bečirević

Pôle Théorie, IJCLab
CNRS et Université Paris-Saclay

based on works done with
A. Angelescu, P. Arnan, I. Doršner, S. Fajfer, D. Faroughy, N. Košnik,
F. Mescia, O. Sumensari, R. Zukanovich-Funchal

Tau Physics, two talks

Outline

a. τ Polarisation Measurement
b. τ-lepton Properties and Lepton Universality
c. Lepton Flavour Violating τ decays
d. Lepton Flavour Violating Z decays

References:

- FCC CDR Volume 1
- Mogens Dam
  Tau-lepton Physics at the FCC-ee circular e^+e^- Collider
  SciPost Phys.Proc. 1 (2019) 041,
  DOI: 10.21468/SciPostPhysProc.1.041

Top pair production close to threshold (2)

$$\sigma_{t\bar{t}} = \sigma_0 \sum_n \left[\frac{\alpha_s}{v}\right]^n \sum_j \left[\alpha_s \log v\right]^j \left(\mathrm{LL} + \mathrm{NLL}(\alpha_s, v) + \mathrm{N^2LL}(\alpha_s^2, \alpha_s v, v^2) + \dots\right)$$

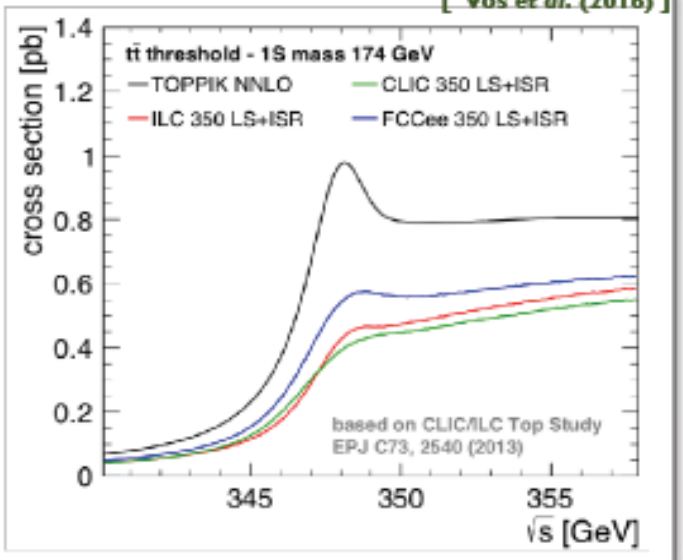
Theory calculations

- Higgs-boson exchange
- Bound state effects large
- N³LO corrections in NRQCD [Beneke *et al.* (PRL'15)]
- N²LL (velocity logs)
  - ★ Threshold: $\alpha_s \approx v \approx 0.1$ [Hoang & Stahlhofen (JHEP'14)]
- Matching with the *WbWb* continuum [Bach *et al.* (JHEP'18)]

More realistic predictions

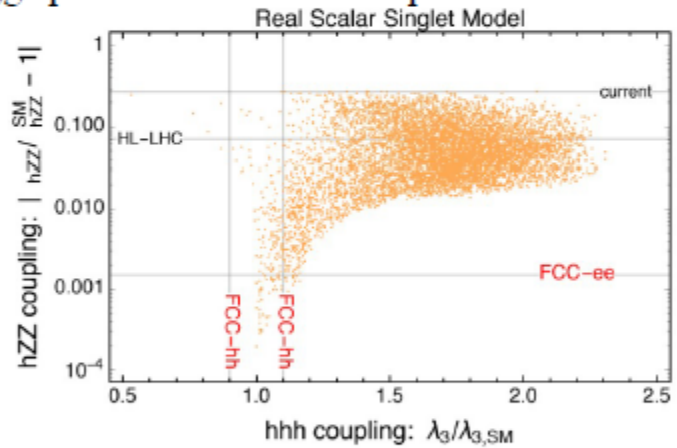
- ISR profile to include
- Broadening of the peak
- Taming of the tail

[Vos *et al.* (2016)]



Conclusion

- Ten billion Higgs bosons will be produced at FCC-hh
  - opening measurements to rare phase-spaces and decays
- The Higgs trilinear self-coupling will be measured with a precision of a few %
  - sensitive to quantum corrections of the Higgs potential and 1st order phase transitions
- First limits on the Higgs quartic self-coupling could be set



- Precise measurements of couplings to 2nd generation of fermions (μ, c) will be achievable
- Measurement of the Higgs invisible decays below the SM expectation → portal to Dark Matter

Program of the Workshop (IV)

Systematic uncertainties on Rb and Rc measurements at an e+e- collider	*Zhijun Liang*
LPNHE-Paris / En Video	11:00 - 11
Overview on Heavy Flavour physics and related BSM (15'+5')	*Damir BECIREVIC*
LPNHE-Paris / En Video	11:20 - 11
b,c and light quark-flavour tagging for Vcb and Vcs at WW. Vertexing performance (15'+5')	*Stephane Monteil*
LPNHE-Paris / En Video	11:40 - 12
Exclusive reconstruction of b- and c-hadron decays (15'+5')	*Karim Trabelsi*
LPNHE-Paris / En Video	12:00 - 12
Overview on tau physics and contrainst on tracking from taus (15'+5')	*Mogens Dam*
LPNHE-Paris / En Video	12:20 - 12
Tau reconstruction at CEPC (15'+5')	*DAN YU*
LPNHE-Paris / En Video	

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

Physics and detector constraints
@ttbar threshold
Physics @ FCC(hh)

Top physics at FCC-ee (15'+5')	*Benjamin Fuks*
LPNHE-Paris / En Video	14:15 - 14
Precise theoretical predictions for top physics at FCC-ee (15'+5')	*Gauthier Durieux*
LPNHE-Paris / En Video	14:35 - 14
Detector constraints from Top physics (15'+5)	*jeremy andrea*
LPNHE-Paris / En Video	14:55 - 15
Higgs self coupling and Higgs rare decays (15'+5')	*Elisabeth Petit*
LPNHE-Paris / En Video	15:15 - 15
BSM physics at FCC-hh / SUSY (15'+5')	*Monica D'Onofrio*
LPNHE-Paris / En Video	15:35 - 15
BSM physics at FCC-hh / Exotica (15'+5')	*Marie-Helene Genest*
LPNHE-Paris / En Video	15:55 - 16
Concluding Remarks	*Gregorio Bernardi*

Some General Messages from this Workshop

The French FCC community is in an «Exploration» phase (2019-2021)

- The IN2P3 and IRFU physicists working or starting to work on FCC are getting numerous. Sharing time with Run3/HL-LHC is a challenge but also an opportunity to increase our knowledge
- Expand the current effort to build strong links with the theoretical community which is motivated and very needed for the physics which can be achieved at FCC-ee
- Further refine the detector requirements, mostly through simulation, fast and detailed.
  ➔ need to get more involved in the FCC software effort
- Work on the conceptual development of detectors, along the CLD & IDEA models but also beyond, in particular since the project would benefit a lot from 4 detectors.

The Round table (which included 2 ILC-France, 3 FCC-France + D. Bortoletto, P. Giacomelli and C. Helsens) **"***Can FCC(-France) benefit from the ILC(-France) expertise* **" was successful and constructive**

- Build on acquired expertise. From ILC R&D, develop a few strong lines of R&D
- Try to develop new ideas and also work on generic R&D at this stage
- Collaborate closely between all the ee projects

The Future may arrive faster than we think !

- The «Focus & Consolidation» phases are around the corner: (~2022)
- We may have to soon focus on only a few options to get a strong French contribution
- The size of the community will shape the French contributions: how many (sub-)detectors ?
- Proto experiments/collaborations are expected by 2025/26

Next Steps for FCC(-France)

- **Snowmass** effort begins in the USA
  - US DOE committment to FCC was a very important input to ESPP.
  - Snowmass is a good opportunity to put forward new efforts for FCC

- **Approval of the FCC-Innovation Study**
  ➔ strong motivation to deepen FCC physics and detector studies right away.

- **FCC-IS kick-off meeting @ CERN 9-13 November 2020**
- **4th FCC Physics workshop @ CERN 9-13 November 2020**
  For FCC-ee emphasis on:
  - precision measurements and calculations.
  - BSM aspects of precision, flavour (τ,b), and direct search program
  - flavour program
  - detector requirements from benchmark studies, and new ideas

- **Next FCC-France workshop @ Annecy**, **December or January 2021**
  will cover Accelerator, Detector and Physics (exp&theory)

- **FCC General Meeting @ Paris, April 2021 (following Brussels in 2019)**

Participation/Thanks/Lessons from an online workshop

- 138 Registered participants, thanks to all participants !
- Good attendance to all six sessions (from 50 to 90, stable during the sessions)
- Questions and Round Table were useful to build a link while we are far away from each other
- Hope to see you all soon in person at the next FCC events, including at the next FCC France workshop in Annecy
- Thank you to all speakers, chair and round table members for their nice presentations, and ideas.
- Thanks to IN2P3/CNRS and IRFU/CEA for their support
- Special thanks to our Foreign colleagues for enriching the workshop

General comments

- More opinions ?
- Next workshop, December or January ?

Dialog (old slide, où en es t-on ?)

- Possibilité de demander des missions pour les collègues engagés ou s'engageant à au moins 10% de FTE d'ici Septembre 2020.
- Mieux vas ne pas demander pour ceux qui promettent pour 2021 (ils iront aux meetings FCC sur le budget de leur équipe principale).
- Possibilité de demander une gratification de stage (3 ou 4 mois = 1800 ou 2400 E) pour stagiaire M1 ou M2
- Pas de demande de poste cette année
- Pas de demande d'argent R&D cette année
- Possibilité de proposer des thèses conjointes LHC-FCC

Tour de Table

IRFU	Saclay
CPPM	Marseille
IJCLab	Orsay
IPHC	Strasbourg
IP2I	Lyon
LAPP	Annecy
LPC	Clermont
LLR	Palaiseau
LPNHE	Paris
LPSC	Grenoble
L2IT	Toulouse