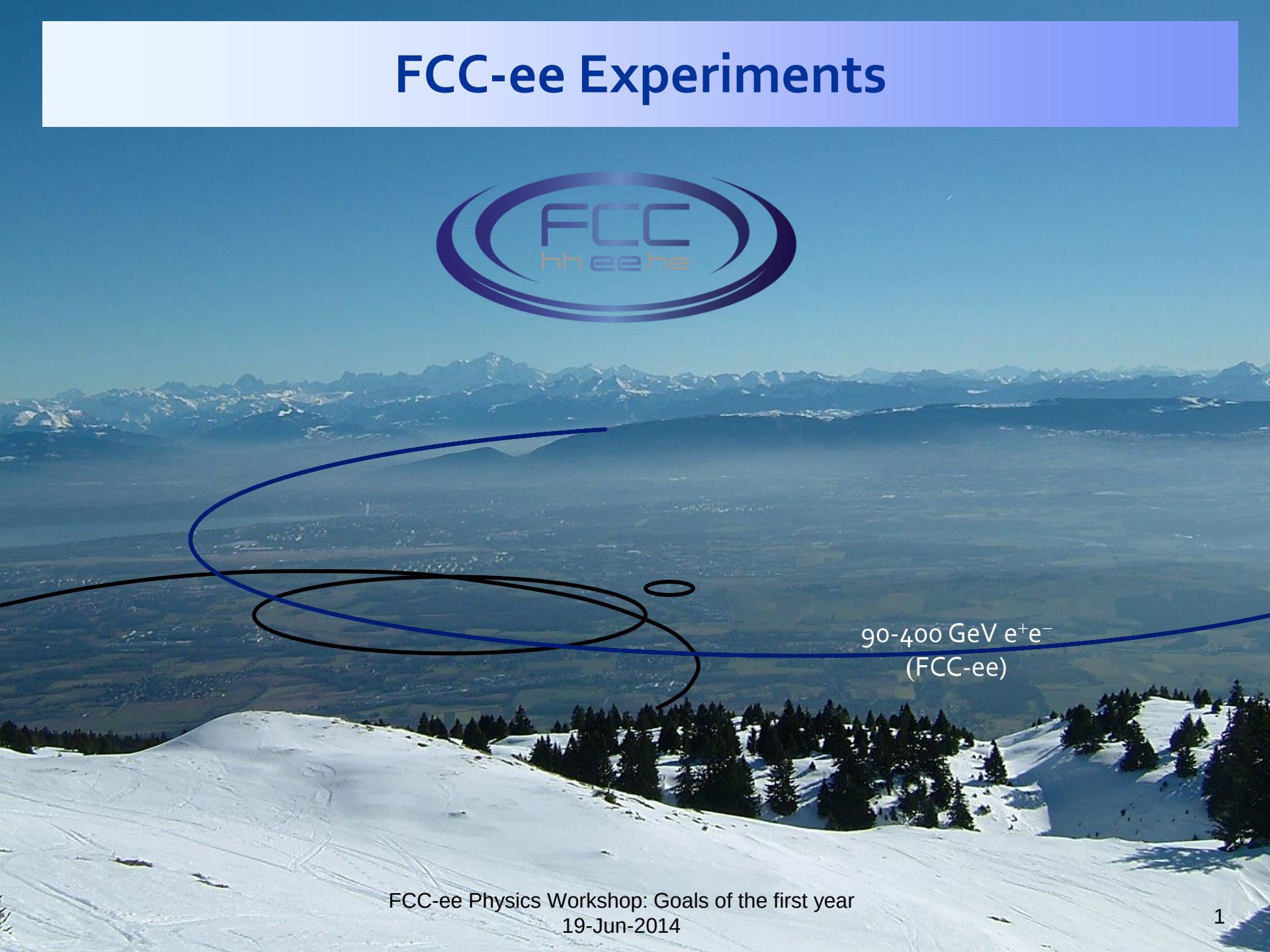
FCC-ee Experiments



FCC-ee Experiments : A four-year study (1)

- **The FCC-ee physics case is published**

First look at the physics case of TLEP

The TLEP Design Study Working Group

M. Bicer,[a] H. Duran Yildiz,[b] I. Yildiz,[c] G. Coignet,[d] M. Delmastro,[d] T. Alexopoulos,[e]
C. Grojean,[f] S. Antusch,[g] T. Sen,[h] H.-J. He,[i] K. Potamianos,[j] S. Haug,[k]
A. Moreno,[l] A. Heister,[m] V. Sanz,[n] G. Gomez-Ceballos,[o] M. Klute,[o] M. Zanetti,[o]
L.-T. Wang,[p] M. Dam,[q] C. Boehm,[r] N. Glover,[r] F. Krauss,[r] A. Lenz,[r] M. Syph
C. Leonidopoulos,[t] V. Ciulli,[u] P. Lenzi,[u] G. Sguazzoni,[u] M. Antonelli,[v] M.
U. Dosselli,[v] O. Frasciello,[v] C. Milardi,[v] G. Venanzoni,[v] M. Zobov
M. de Gruttola,[x] D.-W. Kim,[y] M. Bachtis,[z] A. Butterworth
F. Carminati,[z] A. David,[z] L. Deniau,[z] D. d'Enterria,[z]
G. Giudice,[z] P. Janot,[z] J. M. Jowett,[z] C. Lour
F. Moortgat,[z] P. Musella,[z] J. A. Osborn
A. de Roeck,[z] J. Rojo,[z] G. Roy,[z]
J. Wenninger,[z] H. Woehri
P. Mermod,[aa] Y. O
D. Porsuk,[af]
Y. Bai,[a
C. Gracio
S. Wang,[a
P. Azzi,[av] O.
W. da Silva,[a
M. Ciuchini,[bd]
E. Locci,[bf] P. S
M. Kikuchi,[bh] H.
M. Gouzevitch[bk] an

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Abstract: Th
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with mass
Standard-Model
a beyond the Standard
uture Higgs factories. A new
, TLEP, is among the most attractive
erimental environment, produces high lumi-
and Z studies, accommodates multiple detectors,
tt threshold and beyond. It will enable measurements of
s and of Electroweak Symmetry-Breaking (EWSB) parameters
ecision, offering exploration of physics beyond the Standard Model in
v range. Moreover, being the natural precursor of the VHE-LHC, a 100 TeV
machine in the same tunnel, it builds up a long-term vision for particle physics.
Altogether, the combination of TLEP and the VHE-LHC offers, for a great cost effective-
ness, the best precision and the best search reach of all options presently on the market.
This paper presents a first appraisal of the salient features of the TLEP physics potential,
to serve as a baseline for a more extensive design study.

The combination of the FCC-ee and the FCC-hh offers, for a great cost effectiveness, the best precision and the best search reach of all options on the market

- **So why would we bother in the next 4 years, and even next year?**

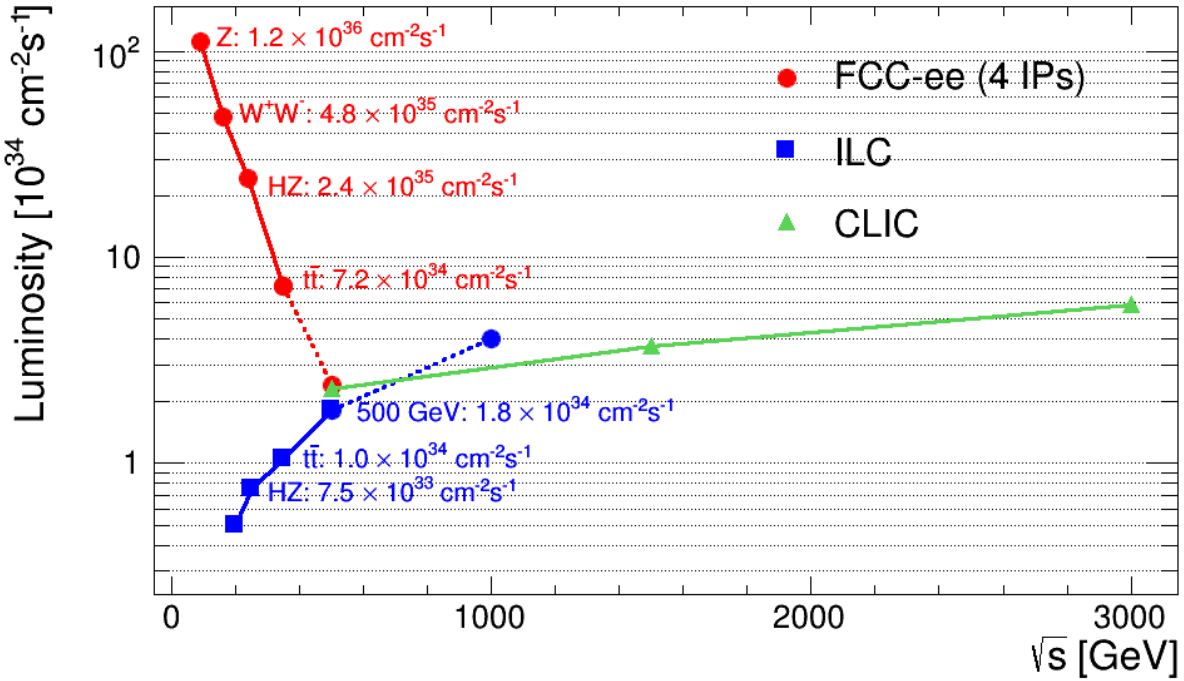
FCC-ee Experiments : A four-year study (2)

- **The published physics case is a very first look indeed**
  - **Higgs physics case : only study with full simulation**
    - The CMS detector was used (!)
    - Only the HZ production process at √s = 240 GeV
    - A number of decay channels were not ex
    - Systematic and theory uncertainti
    - A number of extrapolation
  - **Electroweak physics ca**
    - Solely based
  - **Top quar**
    - from LC studies
    - **D, new physics**
    - **ntioned, at best (e.g., α_s)**
  - **imental environment**
    - Inferred to be very clean (negligible beamstrahlung or synchrotron rad.)
  - **Detector designs and software : none**

Going beyond the "first look" already reveals a much richer physics than expected

FCC-ee Experiments : A four-year study (3)

- **Most of the work lies ahead of us**
  - **Four years are not too many to make an exhaustive and robust review of the physics capabilities, from detector designs to theoretical interpretation**
    - **With √s from 90 GeV to ~400 GeV**
    - **With a luminosity 10 to 1000 times larger than at LCs**



➔ **Synergy with LC is instrumental, but there will be much more to do.**

FCC-ee Experiments : A four-year study (4)

- **Eleven working groups have been set up to this end**
  - **WG1: Electroweak physics at the Z pole (R. Tenchini)**
  - **WG2: Di-boson production and W mass measurement (R. Tenchini)**
  - **WG3: H(126) properties (M. Klute, K. Peters)**
  - **WG4: Top quark physics (P. Azzi)**
  - **WG5: QCD and $\gamma\gamma$ physics (D. d'Enterria, P. Skands)**
  - **WG6: Flavour physics (S. Monteil, J. Kamenik)**
  - **WG7: Experimental signatures of new physics (M. Pierini, C. Rogan)**
  - **WG8: Experimental environment (N. Bacchetta)**
  - **WG9: Offline software and computing (F. Gianotti, P. Janot)**
  - **WG10: Online software (C. Leonidopoulos)**
  - **WG11: Detector designs (A. Cattai, G. Rolandi)**

- **The groups are not closed entities / boxes**

  ➔ **Each group is expected to work closely with all the others**

  Keeping strong links with the relevant machine and theory groups

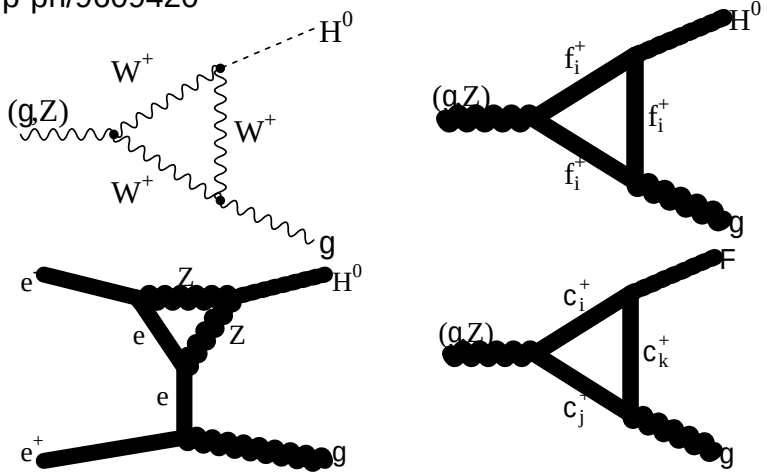
Goals for the first year (1)

- **Note: The first year ends in March-April 2015**
  - The activities will be reviewed in a general FCC workshop by then
    - Deliver a written report (one section per group?) with
      - ➔ A summary of the achievements
      - ➔ A plan for the second year
- **Absolute (ongoing) priority: the FCC software environment (WG9)**
  - Chosen to be common to FCC-ee, FCC-hh, and FCC-eh (synergy)
    - Small group (~five active people so far) – had already 7 meetings
      - ➔ Overseen by Fabiola Gianotti and myself for the time being
  - The FCC-ee would gain a lot in being more active (only one person so far)
    - Large number of small projects ideal for young graduate students
      - ➔ Unique training: Spans over a large spectrum; project is just starting
    - Opportunity for convenership
      - ➔ Oversees most aspects of the FCC physics and experiments
  - All FCC-ee groups are expected to contribute in a way or another
- **See presentation from Benedikt Hegner for the software framework**

Goals for the first year (2)

- **Create a library of event generators**
  - For the working groups 1 to 7 (EW, Higgs, Top, QCD, Flavours, New Physics)
    - Infer the interesting signal processes to be studied with FCC-ee
      - ➔ Down to a cross section of ~1 ab
    - Review the existing "signal" generators (synergy with LC)
      - ➔ Understand their physics content and their limitations for FCC-ee
      - ➔ Evaluate and proceed with the necessary improvements
    - Make a list of the missing signal generators (to be developed)
      - ➔ Example: $e^+e^- \rightarrow H\gamma$

hep-ph/9609420



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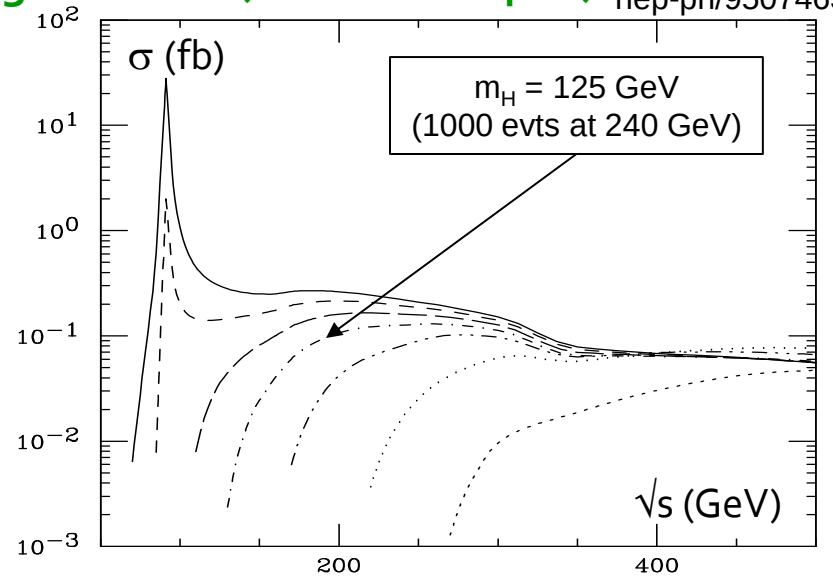
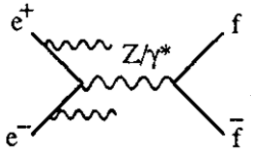


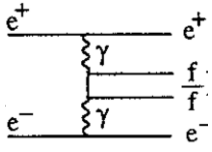
Goals for the first year (3)

- **Create a library of event generators (cont'd)**
  - **For the working groups 1 to 7 (EW, Higgs, Top, QCD, Flavours, New Physics)**
    - **Review the existing "background" generators**
      - ➔ **Typically for √s = 240 GeV**



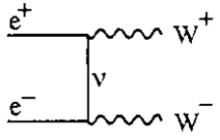
$e^+e^- \to q\bar{q}$, l^+l^-

60 pb



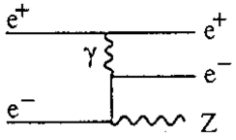
$\gamma\gamma \to qq$, l^+l^-
$m > 30$ GeV

30 pb



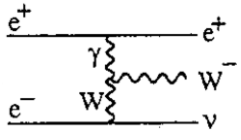
$e^+e^- \to W^+W^-$

16 pb



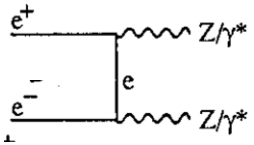
$e^+e^- \to Ze^+e^-$

3.8 pb



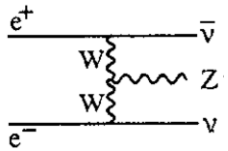
$e^+e^- \to We\nu$

1.4 pb



$e^+e^- \to ZZ$

1.3 pb



$e^+e^- \to Z\nu\bar{\nu}$

32 fb

- **Understand physics content and limitations for FCC-ee**
  - ➔ **Is PYTHIA sufficient ?**

    Data-driven background estimates will often be used
  - ➔ **Do we need a generic four-fermion generator?**

    Or is it enough/preferred to generate each of the poles separately ?
- **Evaluate the needs and the means of common sample production**
  - ➔ **At each centre-of-mass energy**

Goals for the first year (4)

- **Define the basic characteristics of detector designs (WG11)**
  - **Two courses of actions (at least)**
    - **Parameterized approach**
      - **➔ e.g., DELPHES, or home-made emulation of PF reconstruction**
        - **Check b- and c-tagging efficiency and purity as a function of the track IP resolution**
        - **Check jet angular and energy resolutions as a function of the magnetic field and calorimeter granularity**
        - **Optimize performance / cost for a few benchmark channels – to be identified by the physics groups (WG1 to 7)**
    - **Brute-force approach (together with WG9 – offline software)**
      - **➔ Implement the geometries of a few known-to-be-adequate detectors (e.g., ALEPH, SiD, ILD, ALICE inner tracker, Pid detector ?)**
        - **Check their performance for a few benchmark physics channels (WG1 to 7) through fast/full simulation + reconstruction**
    - **Both courses of actions need to be started in parallel**
      - **➔ With probably faster outcome for the first approach**

Goals for the first year (5)

- **Understand and simulate the experimental environment (WG8)**
  - **The experimental environment is expected to be quite gentle, but w need to check this impression, with possible consequences on the dete gns**
    - **Impact of beamstrahlung (priority #1)**
      - **➔ Beam-energy spread, large angle γ and**
        - **Provide a model for beamstra ion (for interacting or not-int**
    - **Evaluate the amount of in the detector (#2)**
      - **➔ Strong focu arc regions, top-off injection**
        - **P hits distribution overlaid to physics events**
        - **adiation-hardness of the detectors**
        - **evance of pile-up interactions (#3)**
        - **ity from γγ interactions, including beamstrahlung**
        - **easurement of integrated luminosity with low-angle Bhabha (#4)**
      - **➔ Impact of machine design (L*, crossing angle) on detector layout**
  - **Keep an eye on the evolution of the machine design and parameters**

Understand the effects of the various backgrounds on online trigger rates and thresholds (WG10)

Goals for the first year (6)

- **Develop the analysis software (WG1 to 7, WG9)**
  - WG9 will provide a light event data model, and a light analysis framework
    - Ongoing development, see talk of Benedikt
  - Analysis tools will have to be added as needed, with WG1-to-7 contributions
    - Jet clustering, with possibility to fix the number of jets
    - b- and c-tagging algorithms
    - etc…
- **Develop the simulation + reconstruction software**
  - Probably use only parameterized simulation during the first year
    - Interface DELPHES with the software framework and the EDM
      - ➔ Useful to develop analysis software, select benchmark channels, and define some of the characteristics of the detector design
  - Develop full simulation and reconstruction software in parallel, for a few detector geometries
    - Keeping the algorithm as generic as possible
      - ➔ Tracking, Particle Flow, lepton and photon Id, …

Goals of the first year (7)

- **Most importantly: attract (young) people to work with us !**
  - General mails to long mailing lists are proven not very useful at this level
    - It is better to propose well-defined and targeted projects to individuals in your network
      - ➔ And ask them to do the same in turn
  - Arguments
    - FCC-ee project in its infancy : there is a lot to learn
      - ➔ Machine, detectors, software, physics
    - FCC-ee is no pp collider
      - ➔ Knowledge/training very complementary to that acquired at LHC
    - FCC-ee is an e^+e^- collider
      - ➔ Deep physics understanding is possible at all levels
    - FCC-ee is arguably the next high-energy collider
      - ➔ Young trainees will be the managers at the time of start-up

Goals of the first year (8)

- **Intense communication is of utmost importance in this first year**
  - **Active web site in intense development: http://cern.ch/fcc-ee/**
    - **Interactive communication, meetings and workshop, news, opportunities for talks, subscription to the study, …**
      - **➔ Check it out and advertize it**
  - **Twiki pages: https://twiki.cern.ch/FCC**
    - **Technical communication, projects, tasks in each of the working groups**
      - **➔ Check it out and choose a project**
  - **Conferences, workshops, panels, committees**
    - **Take every opportunity to give a talk or mention the FCC-ee**
      - **➔ No need to be shy:**

        "The combination of the FCC-ee and the FCC-hh offers, for a great cost effectiveness, the best precision and the best search reach of all options on the market"

- **Let's get started !**