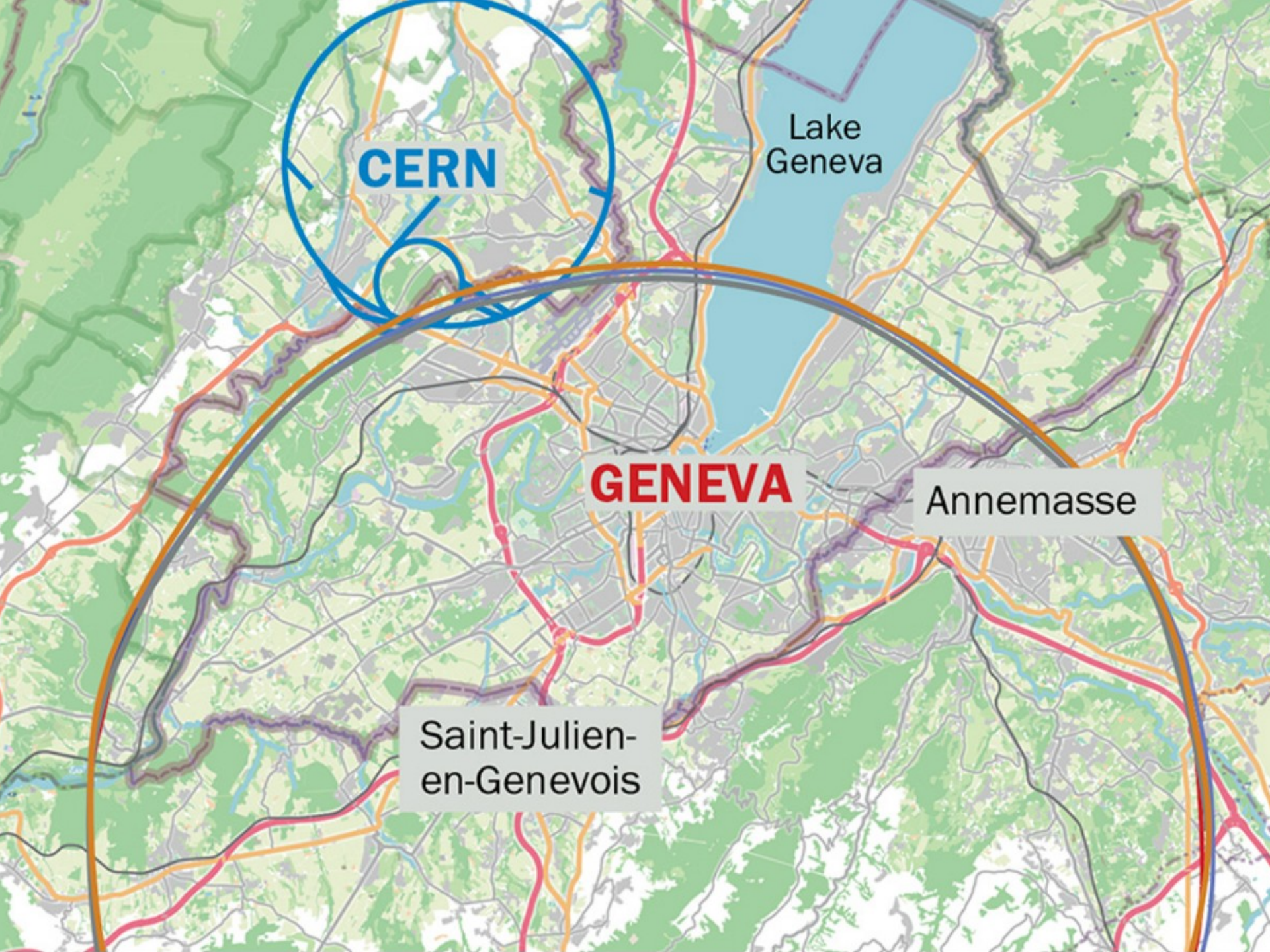


FCC-ee Electroweak Precision Kick-Off Meeting

Ayres Freitas,
Christoph Paus,
Graham Wilson

May 18, 2022





CERN

Lake Geneva

GENEVA

Annemasse

Saint-Julien-
en-Genevois

Ayres Freitas, U. of Pittsburgh

PhD

- University of Hamburg, 2002
- slepton production at e+e- colliders

Interests

- SM electroweak precision physics
- Phenomenology of BSM searches using different probes (colliders, low-energy precision exp, astro/cosmo)



Other interests

- Environmental sustainability, human rights, music, hiking, card/board games

Graham Wilson, U. of Kansas

PhD

- 1989 Lancaster University, UK

Profile

- Experimentalist (CERN fixed-target, OPAL, D0, CMS)
- LEP experience on radiative neutrino counting, di-photons, WW cross-section and di-lepton+MET searches.
- Future e+e- collider focus mostly ILC using ILD detector concept
- Including work on center-of-mass energy determination for enabling W and Z EW program at ILC
- Interested in working on areas that advance our understanding of the realistic physics potential of high energy e+e- colliders.?



Other interests

- Hiking and golf

Christoph Paus, MIT

PhD

- 1996 RWTH Aachen, Germany
- Experimentalist (L3)
- Z boson mass and electroweak parameters

Interests

- Electroweak (L3, CMS, FCC-ee)
- Higgs Boson Physics (CMS, FCC-ee)
- Dark Matter searches (CMS)
- B Physics (CDF, CMS)



Other interests

- Stars, machine learning, hockey (on Ice), family

EW Precision Goals

Electroweak precision measurements

- Constrain the phase space of the electroweak theory by performing more precise tests and providing more precise predictions
- Main goal is to find inconsistencies in the Standard Model and claim new physics

Best way to make precision measurements

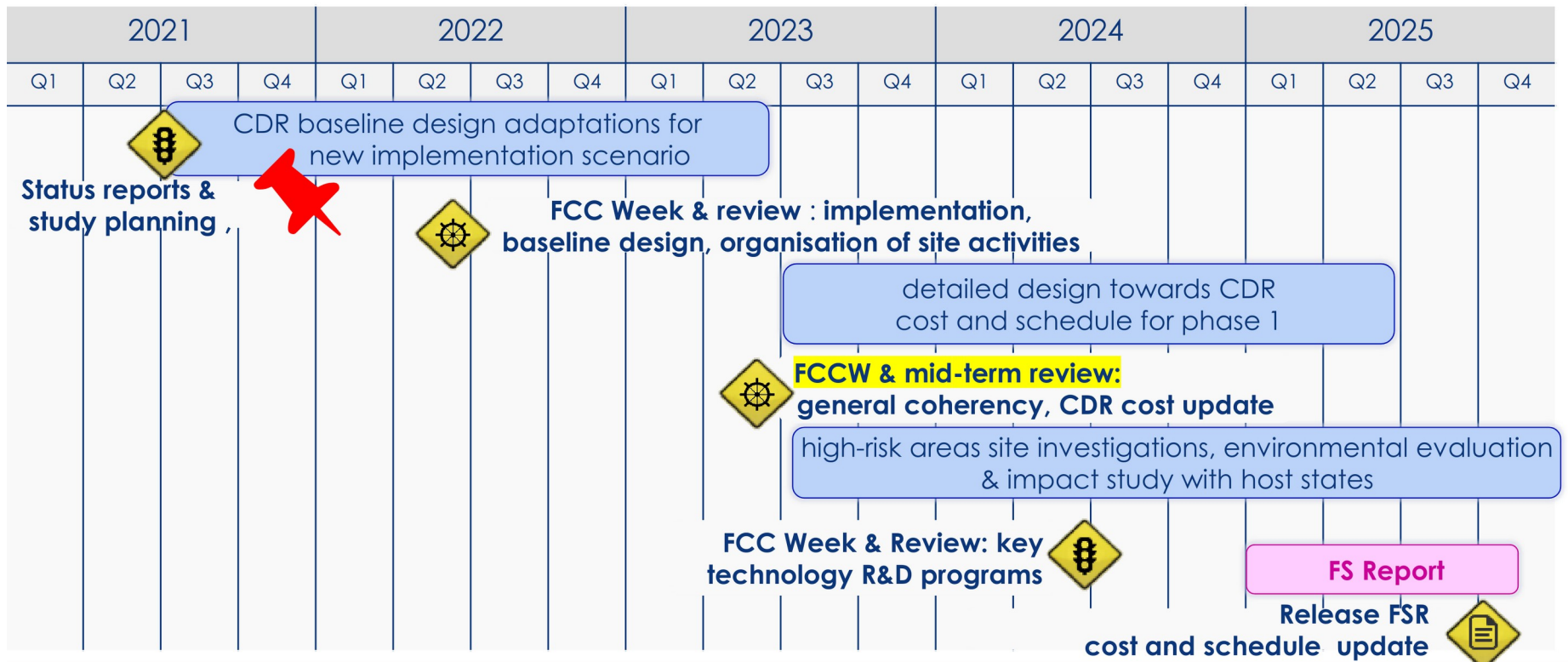
- Create cleanest possible environment
 - Precise theory predictions (avoid QCD & non-elementary particles)
 - Clean particle collisions: control initial state
 - Highest luminosity to reduce statistical uncertainties
- Lepton colliders
 - Electrons easy and abundant (muons difficult, later?; taus – no)
 - Last time we did this was at LEP 1 and 2 with e^+e^- collisions

FCC-ee is an obvious candidate!

Milestones

Timeline of the FCC-ee feasibility study [1]

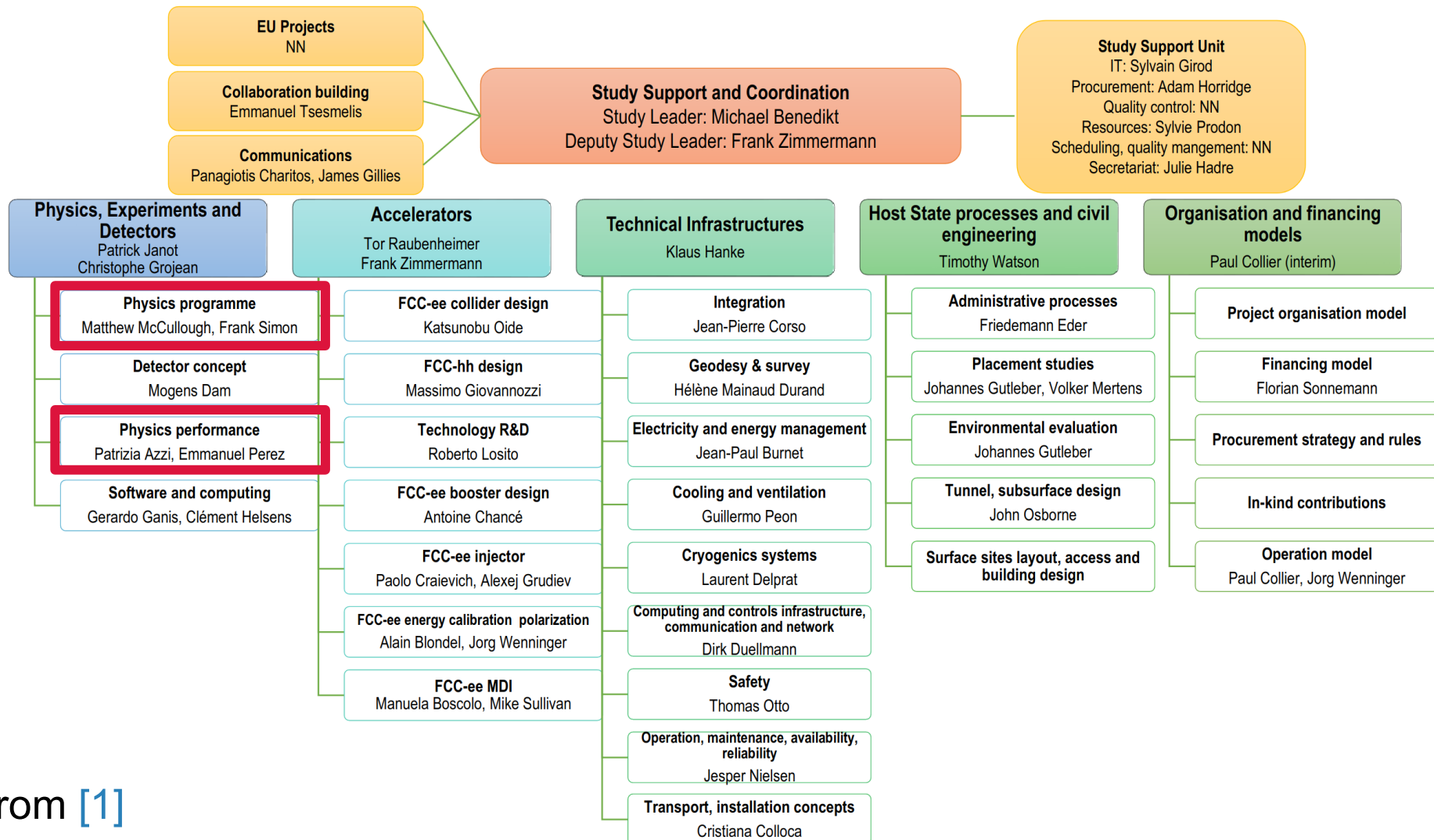
- Deliver report by mid 2025
- Intermediate reports in summer 2023 and summer 2024



[1] https://indico.cern.ch/event/1066234/contributions/4594213/attachments/2385608/4077362/220207_FCC-FeasibilityStudyStatus.pdf

FCC Organization

FCC Feasibility Study – coordination team and contact persons



from [1]

Some Upcoming Events

Workshops

- 05/30 – 06/03, 2022: FCC week in Paris
- 06/07-17, 2022 CERN workshop “Precision calculations for future e+e-colliders: targets and tools”
 - Week 1: select key physics questions and observables
 - Week 2: status and advancements in multi-loop calculations required to match the precision goals

Talks

- ICHEP 2022, Bologna, July 6-13, <https://www.ichep2022.it/>, "EWK precision measurements at FCC-ee"
- IPA 2022, Vienna, Sept. 5-9. <https://indico.cern.ch/event/837621/>, Talk: The FCC-ee Project, plans & physics potential
- SUSY 2022, Univ. Ioannina (GR), June: <https://indico.cern.ch/event/1083758/>, Potential talk: SUSY at FCC-ee
- Flavour-2022, Quy Nhon, Aug. 2022: <https://indico.in2p3.fr/event/20329/>, Potential talk: Flavour at FCC-ee
- Top-2022, Durham, Sept 2022: <https://conference.ippp.dur.ac.uk/event/925/>, Potential talk: Top physics at FCC-ee
- NuFact meeting, July-Aug. 2022: <https://indico.fnal.gov/event/53004/>, Potential talk: HNL at FCC-ee
- PSI2022, October: <http://www.psi.ch/psi2022>, Potential talks: Precision tau physics, rare Z and/or Higgs decays
- Higgs 2022, Pisa, Nov. 2022, Potential talks: Higgs physics at FCC-ee/FCC-hh

Key Ingredients

Theory calculations for various processes

- LEP precision will improve by over two orders of magnitude
- Theory calculations need to 'keep up'

Center-of-mass energy

- Key ingredient for mass measurements (Z and W)

Luminosity measurement

- Unprecedented precision will need special detector design and maybe new methods

Detector Fiducial Volume

- Coverage
- Precision and reproducibility in Monte Carlo simulations

Background processes

- Theory predictions and signal/background separation
- Two photon production as one difficult example

Bench Mark Processes

Looking at LEP precision measurements [1] for

- Z mass and W mass
- Z width, peak cross section
- $R_{\text{lepton}} = \sigma(Z \rightarrow \text{hadrons}) / \sigma(Z \rightarrow \text{leptons})$,
- $\sin^2\theta_{W,\text{eff}}$
- Couplings: α_{QED} and α_s
- Tau polarization and exclusive branching ratios
- Lepton universality, lepton flavor violation
- Z pole observables with heavy flavor quarks

Those benchmarks will help us develop requirements for various parts of the detector and theory predictions.

[1] Electroweak reference manuals from LEP+:

Z – <https://arxiv.org/abs/hep-ex/0509008>

W – <https://lepewwg.web.cern.ch/LEPEWWG/2/lep2rep.pdf>

Tools we have

Theory programs...

- Need thorough re-evaluation of uncertainties to match up experimental precision

Monte Carlo Simulation

- The majority is Delphes only detector simulation
- Decent number of samples for studies available

Detailed detector description

- Full simulation needs to be developed and become more common in the next 1-2 years
- Delphes studies could help identifying areas where detailed simulations are essential and others where Delphes simulations are enough for now

Existing studies

The entire conceptual design report has plenty of relevant studies: Alain will introduce them to us next...

We would like to collect existing studies and more importantly the people and integrate them here and provide constructive environment to progress towards the feasibility report!

How to proceed?

We need to create a community and therefore we need people

- Experts, analyzers, aficionados and listeners from both sides of the aisle: experimentalists and theorists

We need a forum where we can discuss and get ourselves organized

- Let's meet regularly: *once a week, or once in two weeks, or maybe once a months?*
- Initially we need to collect people, information, ideas and make a plan: *please send your interestes and work done already*
- ... then we need to work :-)

We need to provide a work setup with documentation