A brief summary of link

Mogens Dam
Niels Bohr Institute

1st FCC-ee mini-workshop on Detector Requirements

chaired by Christos Leonidopoulos (University of Edinburgh (GB)), Mogens Dam (University of Copenhagen (DK)), Gigi Rolandi (CERN)

from Wednesday, 17 June 2015 at **13:00** to Thursday, 18 June 2015 at **13:30** (Europe/Zurich)

The goal of this mini-workshop is to make progress with possible FCC-ee detector designs. Emphasis will be given on the implementation of detector geometries, impact of designs on physics reach, evaluation of background rates, development of software tools.

Four sessions:

1. Detector designs in software (4 talks)
2. Lessons from other experiments (5 talks)
3. Machine Detector Interface (4 talks)
4. FCC software (2 talks)

Total of

- 15 talks
- 34 registered participants

In summary, a very successful first Detector Requirements workshop

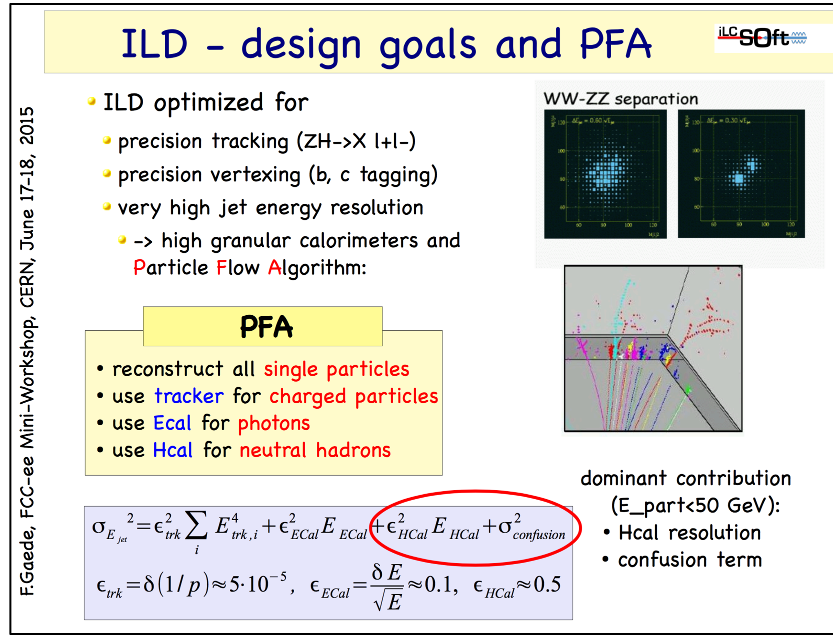
Session: Detector Design in software

Presentations based on ILC/CLIC detector designs

- All designs centered on the exploitation of **particle flow algorithms**
- Very high resolution, highly granular calorimeters
- Extremely good momentum resolution ($2\text{x}10^{-5}$) trackers:
    - ILC: all silicon (SiD) or silicon + TPC (ILD)
    - new CLIC detector: TPC -> Silicon only (6 lays) [backgrounds considerations]
- Power consumption/cooling needs reduced through **power pulsing**

Thoughts for FCC-ee:

- Is TPC possible?
    - CLIC has background problems (@ 3 TeV) integrating over train of 312 BXs. At FCC-ee (Z), TPC will be integrating over ~10,000 BXs.
- Power consumption/cooling
    - Interesting work using CO_2 cooling (calos)



Calorimeter:

- **ECal – options:**
    - SiW: 0.5cm*0.5cm cells
    - SciW: 0.5cm*4.5cm tiles
- **HCal – options**
    - analogue: FeSci: 3cm*3cm tiles
    - semi-digital: Fe-RPC: 1cm*1cm cells

Imad Laktineh
Institut de Physique Nucléaire de Lyon, France

Technical issues related to power consumption and consequently heating and cooling problems are being addressed. Demonstrators are to be built soon.

Collaboration on $e^+ e^-$ is always welcome.

Session: Detector Design in software

DD4hep

Markus Frank / CERN

Detector Description Toolkit

Motivation and Goal

- Develop a detector description
  - For the full experiment life cycle
    - detector concept development, optimization
    - detector construction and operation
    - 'Anticipate the unforeseen'
  - Consistent description, single source of information, which supports
    - simulation, reconstruction, analysis
  - Full description, including
    - Geometry, readout, alignment, calibration etc.
- Driven by lazyness of users
  - Get most out of it with minimal efforts

New "standard", it seems:

ILD:

- currently in transition to use DD4hep (DDG4/DDRec) for simulation and reconstruction

newCLIC:

Developing **simulation** and **reconstruction** software based on **DD4hep** in collaboration with ILD

FCC:

Adapt software developments from ILC/CLIC

– DD4Hep for detector description

Invitation to collaboration:

Gaede

- many tools (DD4hep, MarlinTrk, aidaTT, PandoraPFA,...) are fairly generic and could be adopted for FCC-ee detectors and physics studies w/o major effort
- we are happy to collaborate with FCC-ee in this direction to exploit synergies between future lepton colliders

Session: Machine Detector Interface

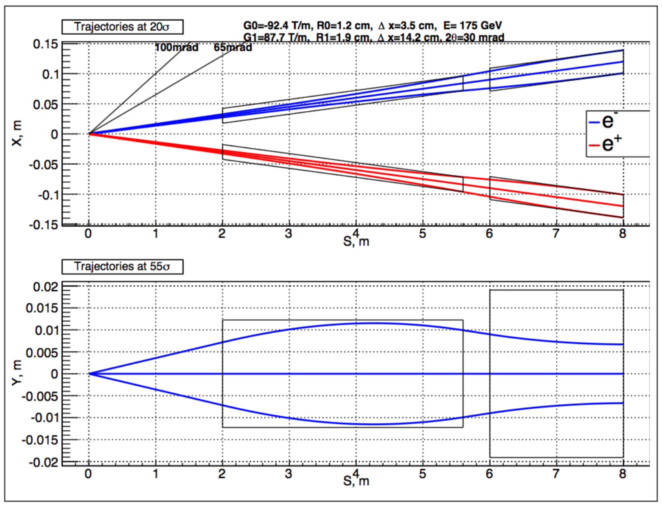
Machine design & final focus

Anton

There are two variants of interaction region. The first one is developed by BINP. The second one belongs to K.Oide and appeared a month ago. Both variants need feedback from the detector for further optimization. The presentation is about BINP design.

Anton/BINP

Final Focus layout



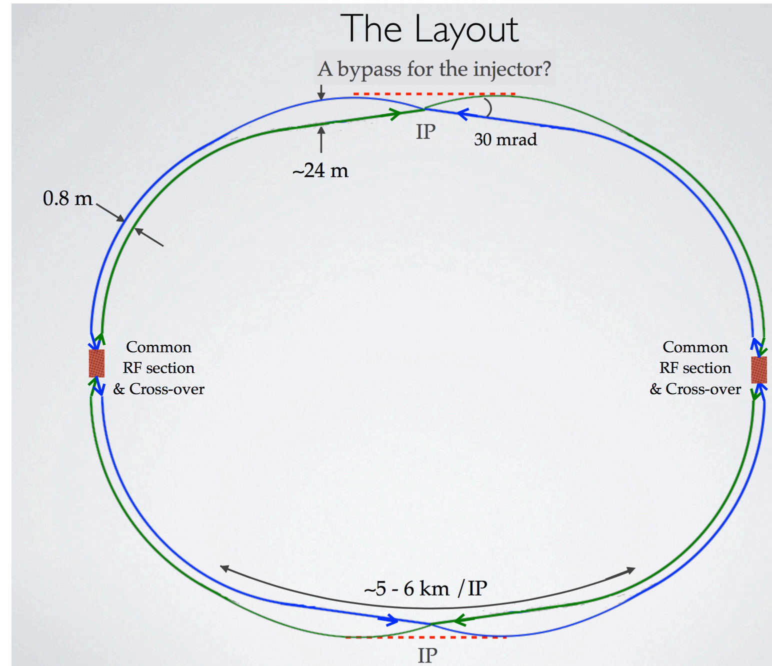
Rectangles are bare apertures.

	L [m]
Q0	3.6
Q1	2

	R [m]
Q0	0.012
Q1	0.019

	B [T]
Q0	1.1
Q1	1.7

Oide



Symmetric around IP. Bend of both in- and outgoing beams

- Large SR power through IR
- Relatively strong bends: high E_{crit} of up to 4 MeV (neutrons)

Asymmetric: Only bend of outgoing beam

- Lower SR through IR
- Weak bends: lower E_{crit} of 100 keV
- Separated beams: two tunnels over 5-6 km

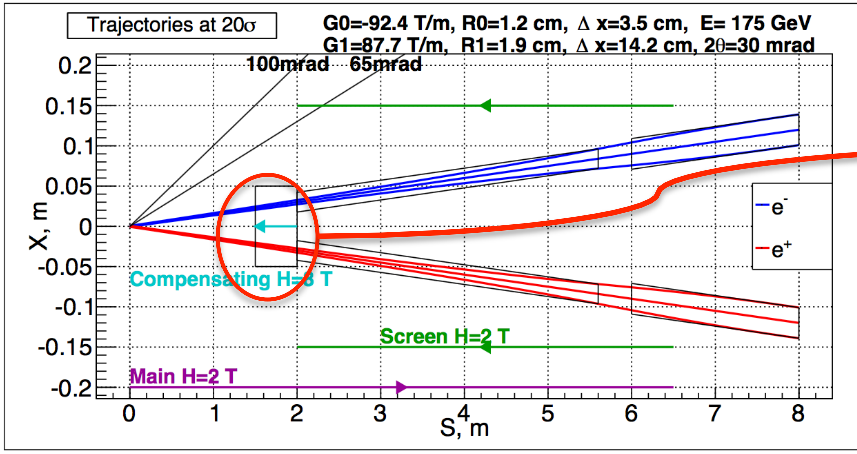
Questions

1. From what dipoles synchrotron radiation is dangerous?
2. What critical energy of synchrotron radiation photons should be?

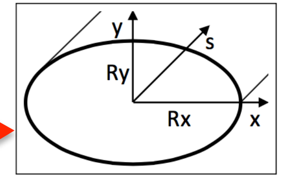
Session: Machine Detector Interface

Compensation of detector solenoid

Coupling compensation: variant 1



Elliptical solenoid: field expansion



$$\begin{cases} B_x = -x\dfrac{B_0' R_y^2}{R_x^2+R_y^2}\,, & B_0' \approx \dfrac{B_0}{L}\,, \\ B_y = -y\dfrac{B_0' R_x^2}{R_x^2+R_y^2}\,, & L \approx 2R_x\,, \\ B_s = B_0 + sB_0'\,, & x = \theta s\,. \end{cases}$$

$$\varepsilon_y = C_q \gamma^2 \frac{I5_y}{I2}\,, \quad I5_y = \left(\frac{B_x L}{B\rho}\right)^5 \frac{1}{60L^2}\left(-15L\alpha_y + 20\beta_y + 3L^2\gamma_y\right),$$

$C_q = 3.84\cdot 10^{-13}$ m, $I2 = 1.68\cdot 10^{-4}$ m^{-1}, $B\rho(\mathrm{Tm}) = E(eV)/c(m/c)$,
$\alpha_y = s/\beta_{0,y}$, $\beta_y = \beta_{0,y} + s^2/\beta_{0,y}$, $\gamma_y = 1/\beta_{0,y}$.

Elliptical solenoid=> weaker horizontal fringe fields => lower vertical emittance => high lumi

Summary of two variants coupling compensation

Version	1	1	2
Energy [GeV]	45	45	45
Solenoid	round	elliptical	round
Vertical emittance, pm	60	1	3.6
Luminosity	$\frac{\mathcal{L}_{design}}{\sqrt{60}}$	$\mathcal{L}_{design}$	$\frac{\mathcal{L}_{design}}{\sqrt{3.6}}$

Compensation behind quads

3. Anti solenoid with 8 T is challenging. Could we make it 1m long instead of 0.5 m?
4. Details about luminosity monitor?!

This is serious business:

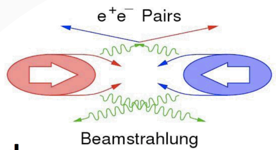
- The most important magnetic force acting on the first coil is an axial force F_z of 7.0x10^{6}N, pushing it away from the interaction point and the main solenoid.

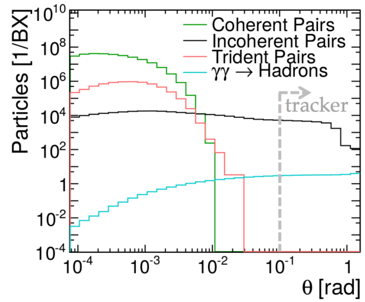
"Anti-solenoid design for CLIC/SiD" Michele Modena, TE-MSC

Background issues

Beam-Induced Backgrounds

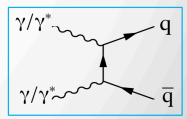
CLIC





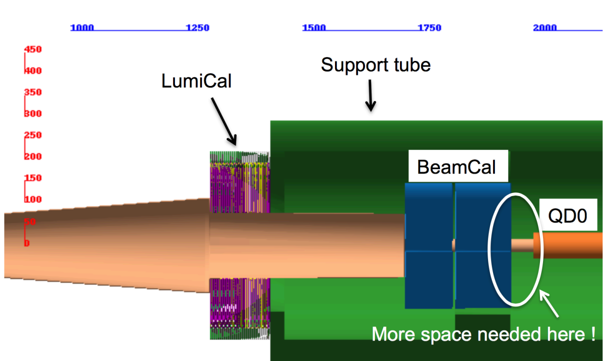
Beamstrahlung:

- **Pair-background**
  - Coherent e^+e^- pairs: 7×10^8/BX
    - Very forward
  - **Incoherent e^+e^- pairs**: 3×10^5/BX
    - Rather forward
    - High occupancies influence detector design
- **γγ to hadrons** (3.2 events/BX @ 3 TeV)
  - Energy deposits (19 TeV/train @ 3 TeV)
  - Main background in calorimeters and trackers



N. Nikiforou, 17 June 2015 • 5

Forward region in Mokka for L* = 2 m, based on ILD_o1_v05



In (y, z) plane

Removed LHcal. For Lumical and Beamcal : kept dimensions of the ILD design.

Moved FTD disks (not shown) closer to the IP.

From Mogen's talk:

z_{front} [mm]	r_{min} [mm]	r_{max} [mm]	θ_{min} [mrad]	θ_{max} [mrad]
1000	80	115	80	115
1300	89	157	68	121
1500	95	185	63	123

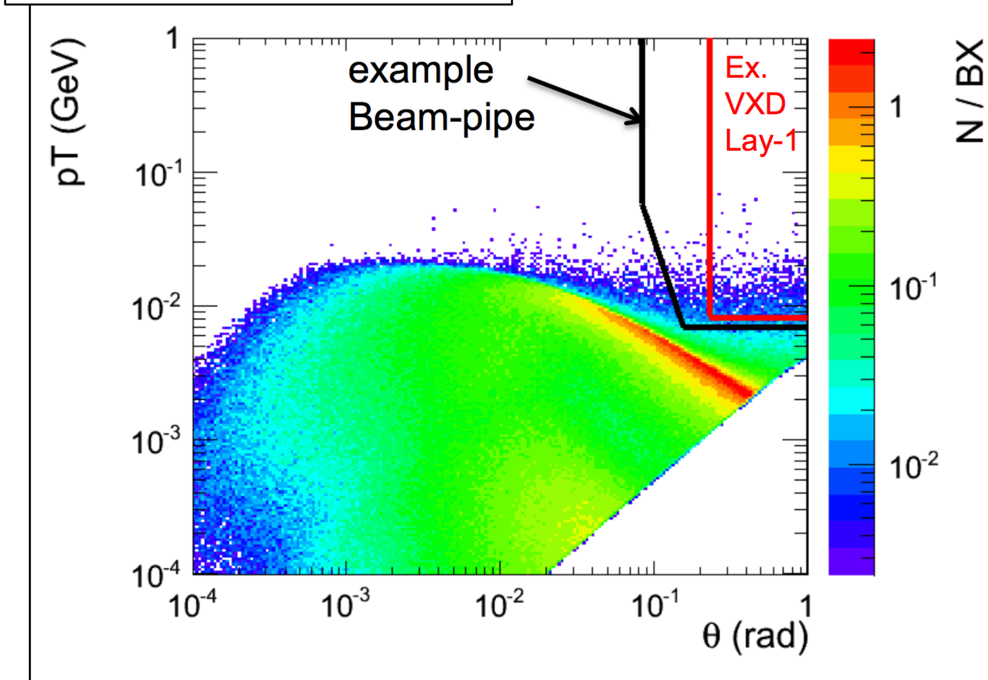
QD0 at z = 2m
LumiCal starts at 1.3 m
(80 < R < 195 mm as in ILD)
BeamCal system a 1.72 m

E.Perez

Pair-production background and event sizes at FCC-ee (Z)

E. Perez (CERN)

Pair-production background



Conclusions

Used the hit multiplicity in VXD and in the TPC to assess the potential increase of the pair-production background when the LumiCal and BeamCal are brought closer to the IP, with QD0 at z = 2m.
No large bckgd is observed in the example considered.

Other aspects of the IR, as discussed yesterday, may have an important effect.

Trigger

Triggers @ LEP

Roberto Tenchini

LEP Trigger Strategy

- In the eighties, experiments were prepared having in mind the **high backgrounds of PETRA**, however **LEP turned out to be a fantastically background-free machine**.
- The driving concept was:
  - accept all annihilation events
  - accept two-photon events only if you can (well, in some experiment $\gamma\gamma$ have been considered background until LEP2 ...)

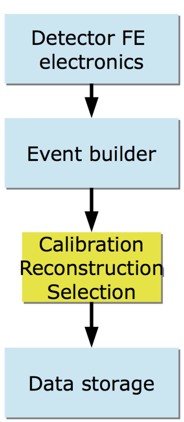
Anything to learn for FCC-ee ?

- LEP precision measurements were not affected by trigger systematic uncertainties because of the **large redundancy of the trigger system** and a very quiet accelerator
  - **preparing for the worst conditions open the possibility to employ redundancy to avoid bias lower systematic uncertainties**
- A **flexible HLT** can always be re-used for other purposes (example from ALEPH Level 3)

Readout system trigger-less "*b* and *c* -factory": full reconstruction and selection in real time

LHCb upgrade (hardware-less) trigger

R. Le Gac
CPPM, CNRS/IN2P3



Farm of CPUs running in real time

Simple/interesting concept:

- Adopted also by newCLIC; readout once per bunch-train (312 BX)
- Appropriate for FCC-ee?
  - Continuous BX (no trains)
  - 5 ns BX separation; physics in every 1000^{th} BX
  - How often would we read detectors: every BX? every 1000 BX?

Software

B. Hegner, CERN

Objectives and Considerations

Provide robust software to allow physics studies for CDR in 2018

Detector Description

FCC joined these efforts of DD4hep

FCC Simulation

FCC choices are

- Delphes (*)
- Fast simulation
- Full simulation with Geant4

Should all be accessible from within the same framework

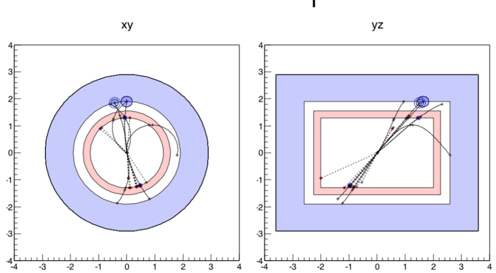
What about iterating on the FCC-ee data cards?

- We have a volunteer who might need some co-worker to speed up the process

Fast Simulation - PAPAS

PAPAS is a PArametrized PArticle Simulation package

Presentation in the next FCC-ee detector workshop



Full and Fast Simulation

Goal is to have a **combined fast and full simulation**

- Decide at the config level where to do what

Analysis

Analysis should be easy and powerful

C++ and Python

Manpower situation

Manpower still very critical

Manpower slowly arriving

Where are we now?

Ideas are getting turned into real code

- Fast/full sim design validated and being turned into real code
- Data model library in 2nd iteration
- Python analysis interface available

Personal Impressions

Very successful workshop with many interesting talks

- Thank you to all speakers!

Personally, I learned a lot.

But, don't forget this was a workshop on **Detector Requirements**

- I think we did not identify many FCC-ee detector requirements this time around

So, now the real work starts!

Some questions to start with:

1. What are the physics processes defining the FCC-ee detector requirements?
   - we go lower in energy than ILC/CLIC, but we have much higher stats
2. Momentum resolution, what do we need?
3. Jet energy resolution, what do we need?
   - Calorimeter depth?
4. Flavour tagging
   - an easy one, we simply need the best!
5. Hermeticity?
   - What do we need at small angles?
   - Seems to be potentially difficult around very crowded IR region
6. Luminosity measurement, how to get what we need?
   - Again, crowded IR region seems to be problematic
7. …

Much interesting work ahead