Things of note from ECFA in Paris

Artur Apresyan

USFCC meeting
15 October 2024

Introduction

- The 3rd and last of the series of workshops on future e^+e^- machines before the start ESPP
  - https://indico.in2p3.fr/event/32629/timetable/#20241009.detailed
- Lots of interesting presentations, huge amount of work, I invite everyone to browse the agenda and look into details
- Main focus of the workshop was on FCC-ee machine, but many of the studies apply to other machines too
  - Presentations on ***CEPC, C3, ILC*** and an ***Asymmetric Linear Higgs Factory***
- *Main goals of the workshop from Paris Sphicas:*
  - *Review where we stand, and what is mature and ready to go into the Report.*
  - *Define first draft of skeleton/items that will be included in the final Report*
  - *Estimate what else can be completed in the next few weeks so it can be included in the Summary Report.*

ESPP

- This time, we must, i.e., we absolutely must, converge on a crystal-clear, unambiguous choice for the next collider at CERN – with the widest possible consensus

- There is no room for disagreements after we converge.
- The fastest way to getting no new collider is non-convergence of the community on one choice that we will all back.

- There is no room for delaying the choice either. The timescales involved are such that we must start now.
  - Because it takes a minimum of ~20 years to get a new machine
  - And because our junior colleagues need a vision

https://indico.in2p3.fr/event/32629/contributions/140456/attachments/87413/131946/2024-10-09-HET-Wkshp-Intro.pdf

ECFA guidelines for national inputs to the ESPP

- **Suggest: two national community (“town-hall” or similar) meetings.**
  - Clearly, each country/region remains at liberty to decide on the number.
  - The meeting(s) could/should be co-organised by the RECFA delegate and the country’s representative on the ESG (for some countries this is the same person).
  - Suggested timing of town-hall meetings (beyond any meetings prior to March 2025):
    - After contributions are in (end March 25) and before Open Symposium
    - After release of Briefing Book (end Sep 25)
  - National inputs to the ESPP update can be sent at different points in time:
    - Prior to the deadline of 31 March 2025 for the submission of input to the ESPP;
    - After March 2025 deadline and by 26 May, in time for Open Symposium;
    - After Briefing Book, by 14 Nov 2025, in time for ESPP Drafting Session.
- **To be of greatest use in informing the ESPP, the information collected must be as coherent and as uniform as possible, especially when addressing the key issues.**

  → **ECFA has drawn a list of “standard questions” to be addressed by the national communities**

National Input on “next collider at CERN” (I)

Central element of the next ESPP: the choice of next collider at CERN.

ESG remit: “The Strategy update should include the preferred option for the next collider at CERN and prioritised alternative options to be pursued if the chosen preferred plan turns out not to be feasible or competitive”.

→ It is imperative that the European HEP community should provide explicit feedback on both the preferred and alternative options for this “next collider at CERN”, which will be the Laboratory's next flagship project, and an explanation of any specific prioritisation.

a) **Which is the preferred next major/flagship collider project for CERN?**

b) **What are the most important elements in the response to (a)?**
   i) **Physics potential**
   ii) **Long-term perspective**
   iii) **Financial and human resources: requirements and effect on other projects**
   iv) **Timing**
   v) **Careers and training**
   vi) **Sustainability**

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National Input on "next collider at CERN" (II)

c) Should CERN/Europe proceed with the preferred option set out in (a) or should alternative options be considered:

- i) if Japan proceeds with the ILC in a timely way?
- ii) if China proceeds with the CEPC on the announced timescale?
- iii) if the US proceeds with a muon collider?
- iv) if there are major new (unexpected) results from the HL-LHC or other HEP experiments?

d) Beyond the preferred option in (a), what other accelerator R&D topics (e.g. high-field magnets, RF technology, alternative accelerators/colliders) should be pursued in parallel?

e) What is the prioritised list of alternative options if the preferred option is not feasible (due to cost, timing, international developments, or for other reasons)?

f) What are the most important elements in the response to (e)? (The set of considerations in (b) should be used).

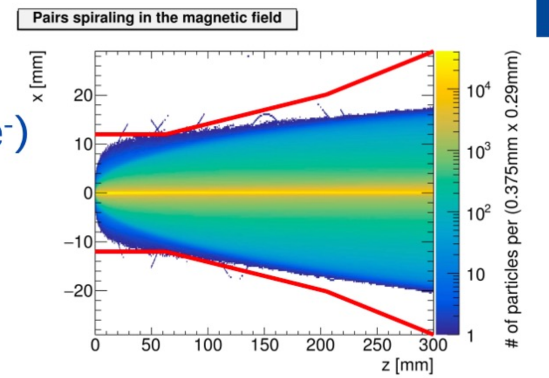
ECFA HET factory studies

- The primary motivation for the ECFA HET study group was to bring together all the people who were interested, active, working on HET studies
  - It has been largely successful.
  - Despite lack of people, huge pressures from ongoing experiments, and the rest of life.
- We are about to start the last lap towards March 2025.
- With the submission of the ECFA Report and a potential short addendum in time for the Symposium in June 2025, the job will be done.
  - Recall: the ESPP drafting session is scheduled to take place on Dec 1-5, 2025.
    - And Council is expected (?)/ supposed (?) to approve the new strategy in Jun 2026.
    - That will be the time that we take stock of how ECFA should contribute in the post-strategy era
- Of course, the work of the other ECFA panels, particularly the Detector Panel, will continue throughout, hand-in-hand with the DRDs.

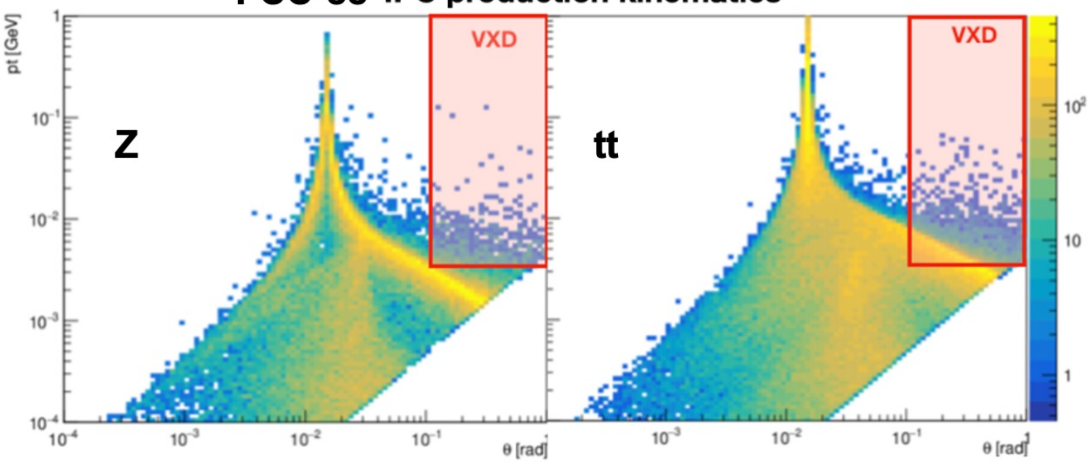
Trackers

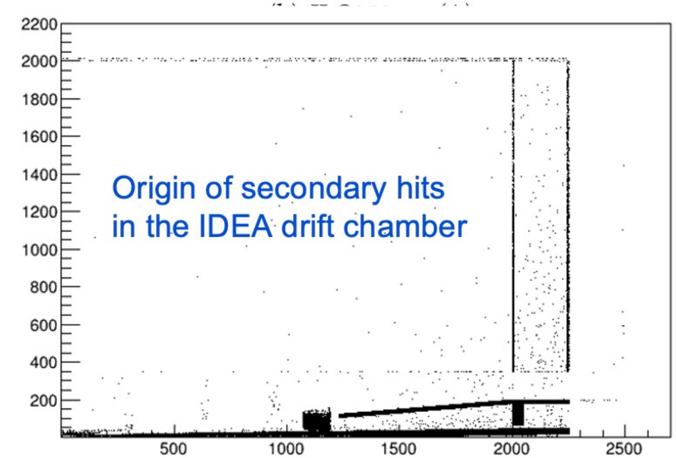
Machine backgrounds

- **Beam-strahlung**
  - Incoherent pair creation (real or virtual photon scattering $e^+ e^-$)
    - Lot of low p_T (few MeV) particles hitting the vertex and the trackers either directly or backscattering off other (mainly accelerator) structures
    - May end up to count rates of O(200 MHz/cm^2)



FCC-ee IPC production kinematics

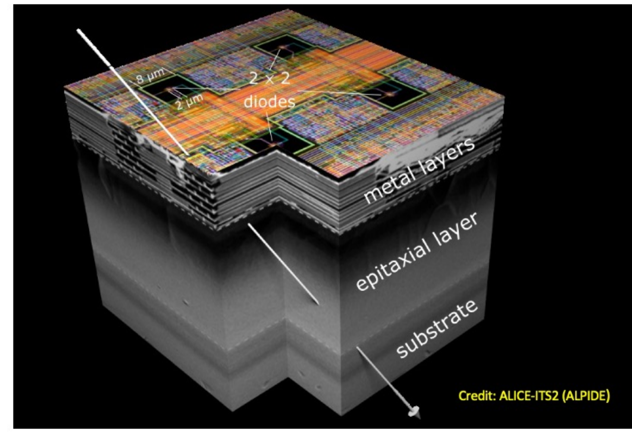




Trackers

Technologies for vertex detectors

- Monolithic Active Pixel Silicon Detectors (MAPS)
  - CMOS sensors and electronics fully integrated
  - Can reach 30 μm thickness (0.032% X_0)
  - Very low power (<50 mW/cm^2)
  - Sensors stitching up to 12” or ‘abuttable’
- Several CMOS sensors in use or development
  - Dependence on CMOS process (foundry) characteristics
    - 3 prominent ones: LFoundry, TJsc, TPSCo
    - ECFA-DRD3 WG1 addresses the R&D
- New trends and opportunities
  - 3D integration: possibility to have a more complex readout (and Silicon Photonics) tier bonded to a sensor one
- Optimisation
  - Spatial resolution vs timing vs power vs radiation tolerance



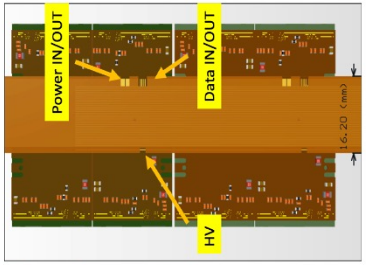
Technologies for Outer tracker

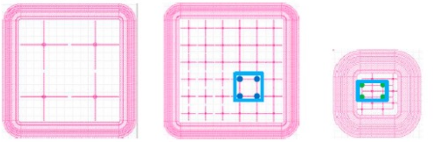
- Drift Chambers
  - Low mass (He 90%: - C_4H_{10} 10%), 1.6% X0 in the barrel, ~ 5% X0 in the endcap,
  - Feedthrough-less design, Challenging mechanics
  - Full length 10 layers prototype Drift Chamber be build in 2025 in INFN
- TPC
  - 5% X0 in the barrel and 25% X0 in endcap
  - Use MPGD readout,
- Straw tubes
  - Lighter than drift tubes, Simpler (but still complex) mechanics
  - Reduced drift time, good $r\text{–}\phi$ resolution but difficult to achieve good z-resolutions,
  - R&D ongoing to build small prototype

Silicon Wrapper

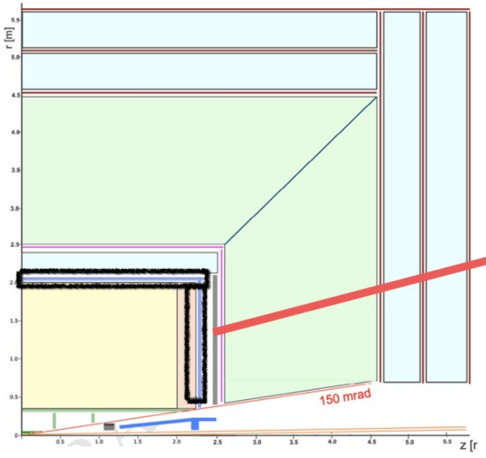
Silicon wrapper

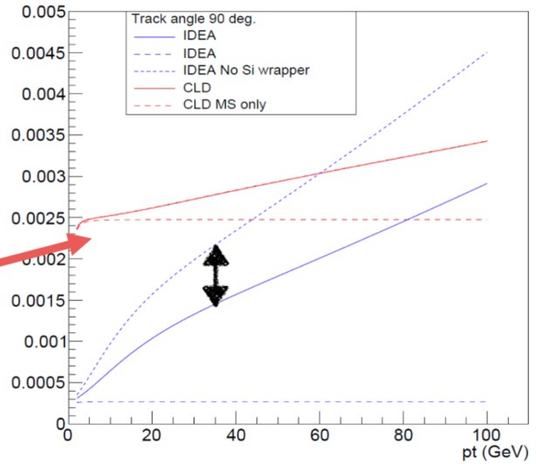
- Adding a precise double layer at large radius
  - Improves momentum and angular resolution
    - Pixels of 50μm pitch can define angular acceptance with10 μrad precision
    - ATLASPix3
  - Can be used for TOF
    - Resistive Silicon Detectors
      - 30-40 ps / 10 μm

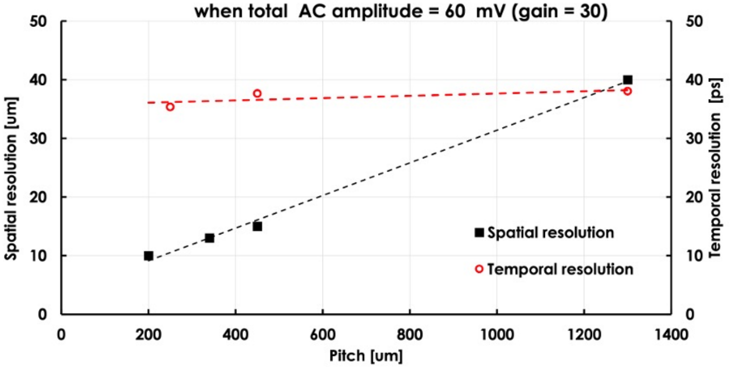




1.3 × 1.3 mm² 450 × 450 µm² 200 × 340 µm²
Cross-shaped electrodes







Fabrizio Palla - INFN Pisa and CERN

3rd ECFA workshop on e+e- Higgs, ElectroWeak & Top Factories - 11 Oct 2024

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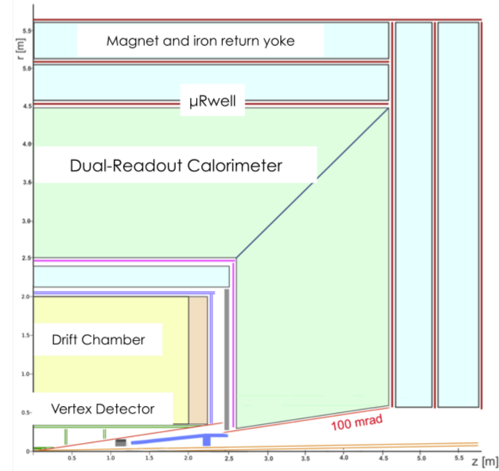
Calorimeters

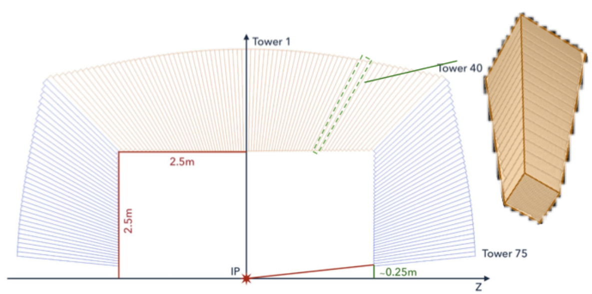
IDEA and IDEA calorimeter

- Silicon VTX detector plus ultra-low material drift chamber
- Thin solenoid in front of the calorimeter

Single, dual-readout calorimeter for EM and HAD calorimetry

- Option with dedicated crystal ECAL in front
- O(100M) fibres embedded in steel tubes, read by SiPM
- Signals from 8 SiPMs grouped to reduce the number of channels to be read out
- No longitudinal segmentation out of the box
- High transverse granularity, excellent angular resolution
- Full simulation available, integration with DD4hep ongoing





Calorimeter

ALLEGRO detector concept and its calorimeters

- **A L**epton co**L**lider **E**xperiment with **G**ranular **R**ead-**O**ut
- Highly-granular noble liquid ECal
  - Pb/W+LAr (or denser W+LKr)
  - Light coil (0.76 X_0) inside same low-material cryostat (< 0.1X_0) as ECal
- TileCal-like or CALICE-like HCal
  - TileCal: WS fibres+SiPMs at outer radius
  - Calice: SiPMs directly on scintillators
- Detector design optimisation not finalized
  - Current focus on implementing all calorimeters in the full simulation
  - Advanced reconstruction techniques needed (e.g. particle flow)
  - Will present preliminary results

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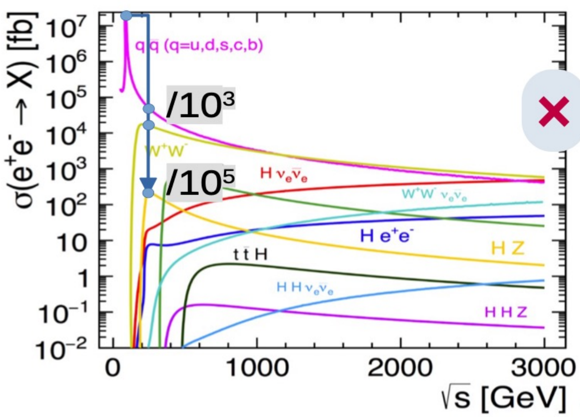
Fermilab

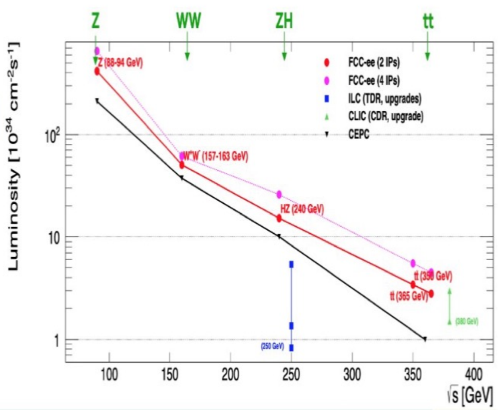
Calorimeters

Revisiting the HG calorimeters for circular colliders

Large panel of running conditions

- 90GeV × 10^7 fb × $5{\cdot}10^{36}$ cm^{-2} s^{-1} (qq × 20,000 ILC @ 250)
- 150 GeV (WW) + 250 GeV (ZH) + 280 GeV (tt)
  ~10^4 fb × $5{\cdot}10^{35}$ cm^{-2} s^{-1} (qq × 5–10 ILC @ 250)





Are the current hypothesis viable ?

- Occupancy, DAQ, Cooling
- 1 detector fit-all ?
  - What are the limits :
    - Power vs Granularity → Active Cooling ?
- New electronics (DRD6):
  - TSMC 130 nm vs AMS 130 nm (or 65nm)
    - Down to 1mW / ch ? Timing ?
  - Running mode (continuous, trigger-less)
    - Trigger for other detectors ?

Need rough numbers $\mathcal{O}$(±50%) for Occupancy, Data, Power, Dynamic Range (E, t) for all calorimeter's regions

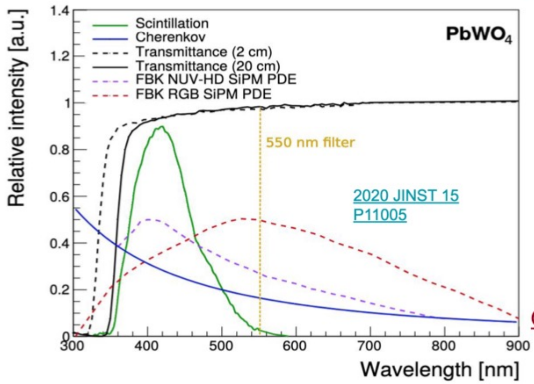
Electronics/ASICs

Higgs Factory Applications

- Reconfigurability of eFPGAs enables generic ML methodologies: applicable to wide variety of datasets & subsystems
  - **Dual readout calorimetry**: ML to extract Cherenkov C and scintillation S photon yields from single waveform
  - **High granularity calorimetry**: ML for pattern recognition of hits → showers & energy regression
  - **Liquid argon**: ML to extract energy and timing from time-domain waveform

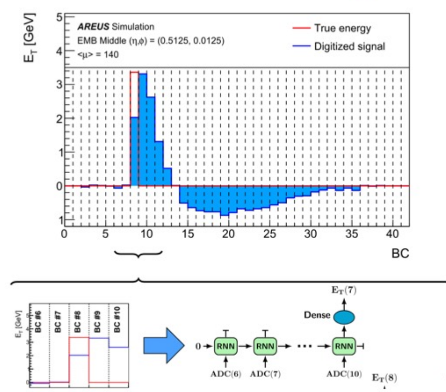
➡Get in touch if interested!

Dual Readout Waveform Analysis



G. Cummings

LAr Waveform Analysis



LARG-PROC-2021-001