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New ILD strategy and consequences on ILD tracking

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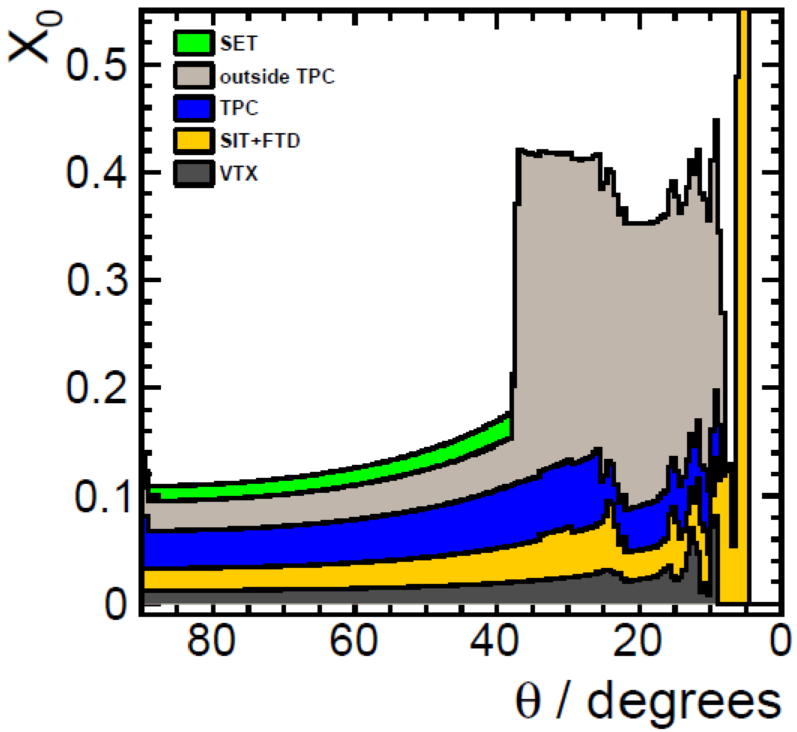
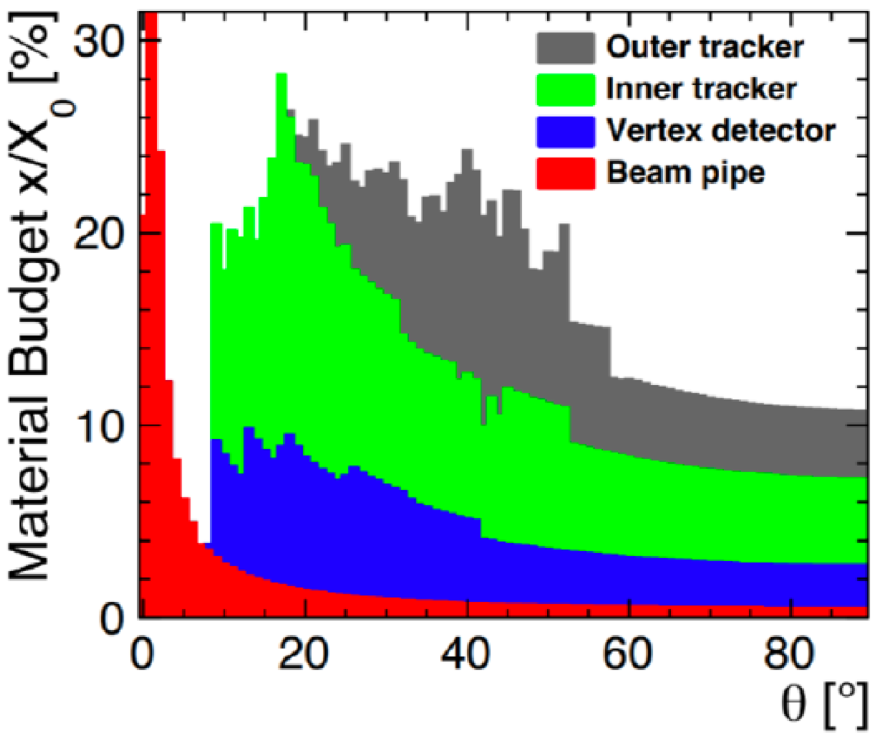
Introduction

- The ILD design includes a pixel vertex detector, followed by a silicon tracker, and a TPC.
- The main motivation for the TPC is to allow a dE/dx measurement on individual tracks, for particle ID purposes
- It also allows to have up to ~200 points on each track, which gives good V0 and kink reconstuction
- The TPC must also provide, together with the silicon tracker, a momentum resolution which allows the Higgs recoil peak against Z->μμ to be seen : $\delta p/p^2 = 2.10^{-5}$ GeV^{-1} . This requires a tracker with 200 μm point resolution and systematics on the sagitta < 20 μm

Material budget (ILD, CLD)





Introduction

In 2022, the ILD collaboration discussed a new strategy adapted to the possibility of ILC not being the first constructed collider. In this event, ILD should adapt to a circular collider, FCC or CEPC.

At such a collider, the luminosity at the Z peak is ~200 10^{34} $cm^{-2}s^{-1}$ per IP.

This corresponds to 65 kHz of hadronic Zs, with an average 20 charged tracks and O(0.2 fC/cm^3) charge density in a typical TPC gas with 0.5 m/s ion velocity. This leads to 300 µm distortions of the tracks, from primary ionization alone.

Gating is not possible at circular colliders, given the continuous beams

Is it possible to correct for such distortions? What is the momentum resolution needed at the Z peak ?

Manqi Ruan at ILD meeting October 2

In-situ calibration of distortion?

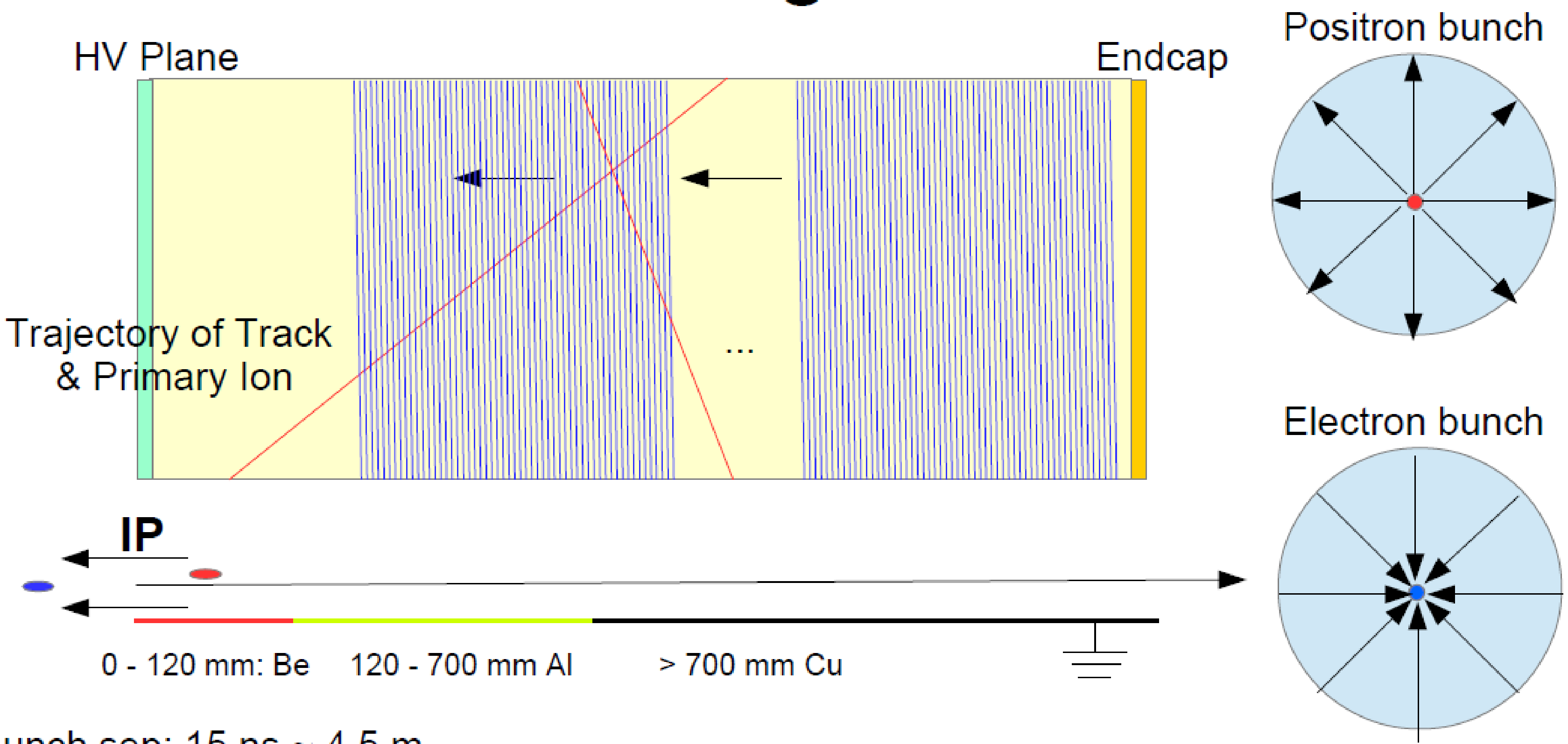
- Tracks corresponding to positive/negative charge, will be biased towards different direction:
  - Increase of Pt for one charge and decrease for another.
- Larger biases at higher Pt.

- Z -> mumu events happens at a rate of 2k Hz (1/20 of Hadronic Z), while the momentum shall be measured to a relative precision of 0.1% at each track.
- I guess the full energy lepton tracks, especially muon ones, can provide a solid reference for the correction...

- **But certainly needs more quantification!**

Manqi Ruan at ILD meeting October 2

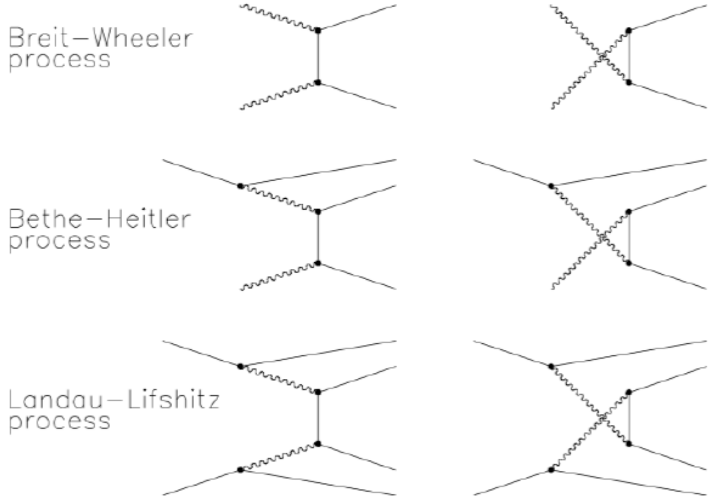
Bunch Charge effect?



- Bunch sep: 15 ns ~ 4.5 m
- Bunch charge: 20 nC (~ ion charge in gaseous volume), highly relativistic
- Is it necessary to shield the radial Electric field induced by bunch? The corresponding material budget?

2/10/2022 ECFA&ILD @ DESY 19

Background at ILC



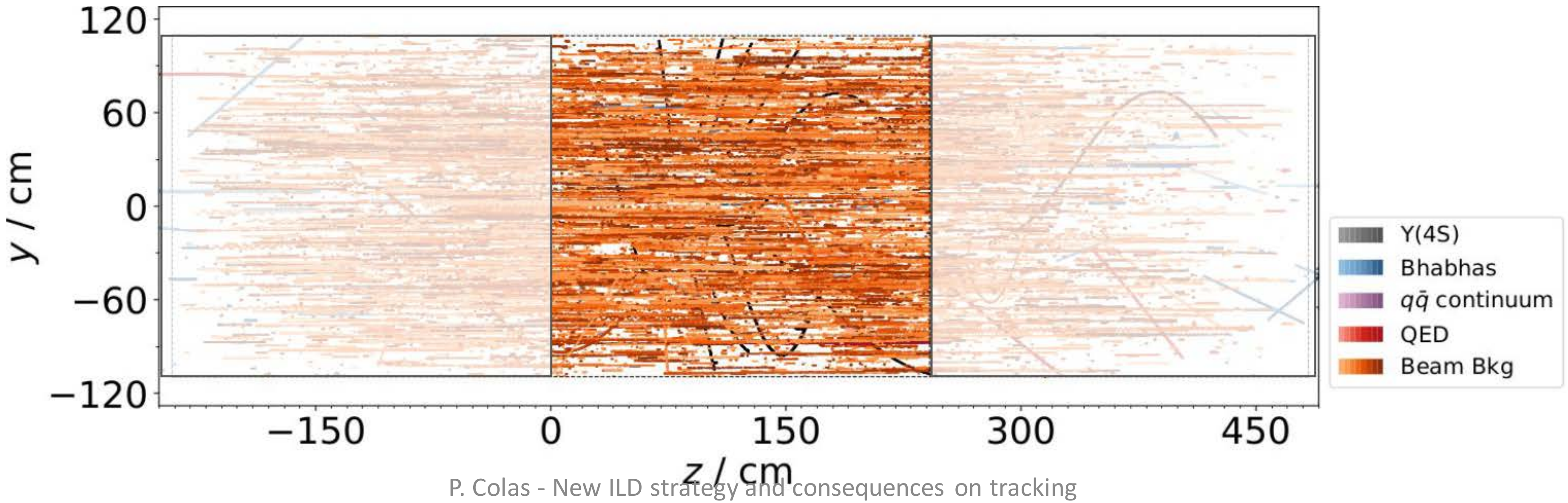
- Beamstrahlung-induced : Incoherent pair production
- Beamline muons (horizontal mips)
- Neutron backgrounds from the beam dump (gas of neutrons, bouncing nuclei in the gas, especially H
- UVs and soft X rays : they ionize the gas and produce ‘snow’ (randomly localized hits)
- Beamstahlung radiation : X-rays MeV to tens of MeV: they produce e+e- pairs curling in the detector magnetic field

Background at FCC

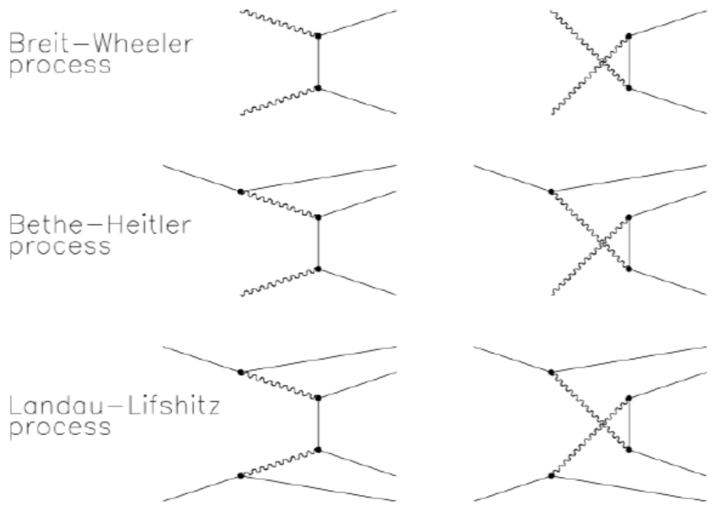
- Beamstrahlung-induced : Incoherent pair production : Increasing with energy
- Less beamline muons and neutrons than at ILC
- Synchrotron radiation : UVs and X-rays

Background studies at BELLE II

- Real accelerator SuperKEKB, goal lumi of 80.10^{34} $cm^{-2}s^{-1}$
- Initial background at start (2018) was 1 to 3 orders of magnitude higher than expectations.
- Main backgrouds were Touschek electrons (expected to decrease as E^3)and beam gas.
- Synchrotron radiation (keV to 100 keV) in the final focusing is also huge
- At the Υ(4S), the ionization from physics if probably overwhelming for a TPC, however under discussion in BELLE II (A. Löschke-Centeno, P. Lewis).



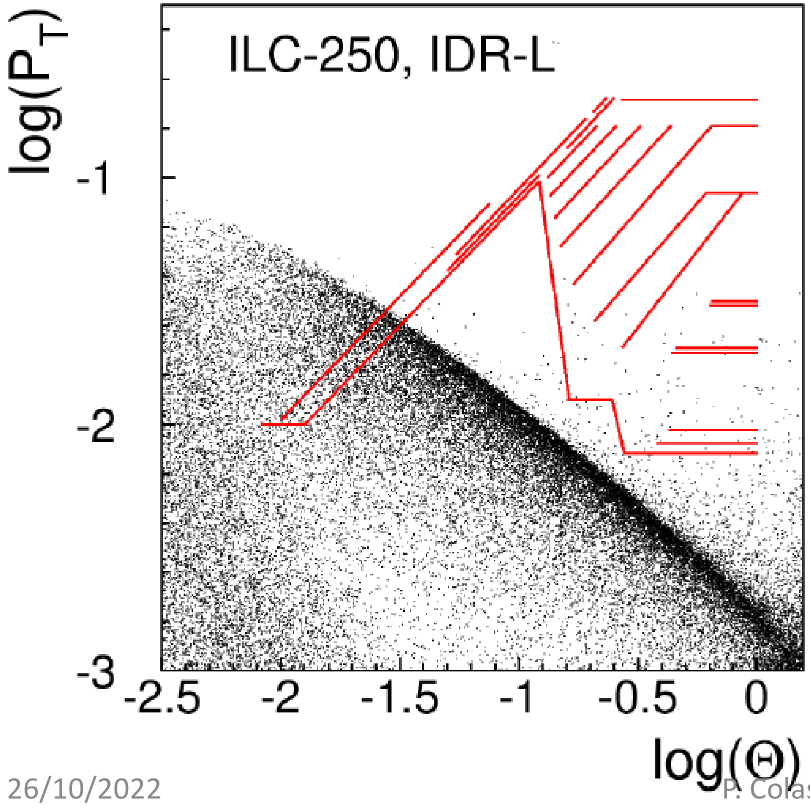
Pair production background



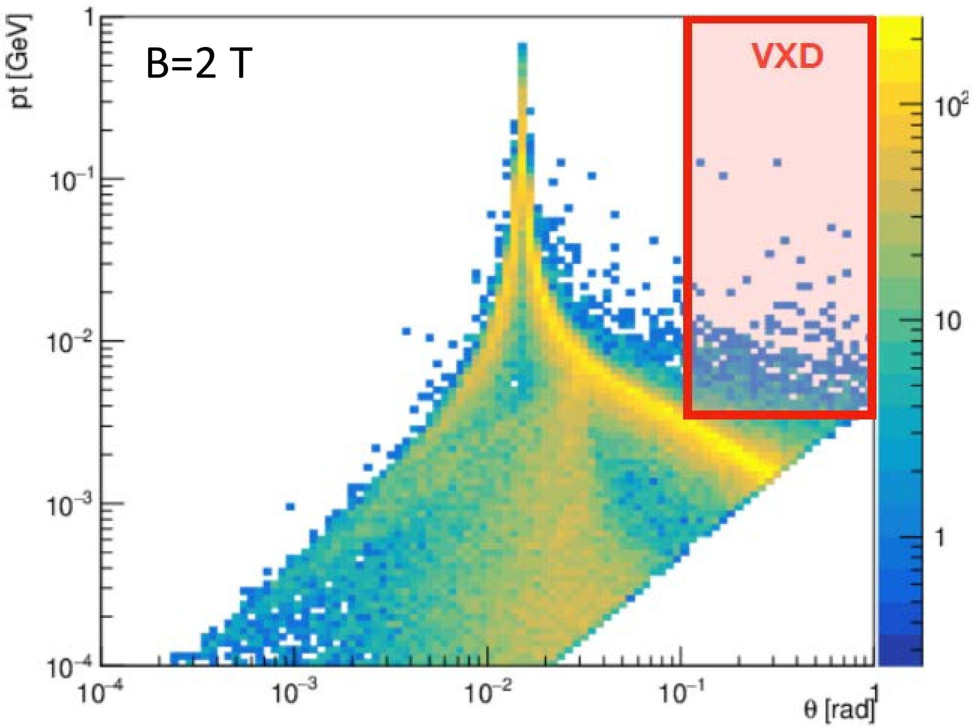
Studied with GUINEA-PIG MC (ILC, D. Schulte 2003, A. Vogel 2007) and GUINEA PIG++ (FCC, E. Perez 2019, A. Ciarma 2022)

ILC 250 GeV

B=3.5 T



FCC 91.2 GeV



- At ILC 250 GeV (Higgs factory) the ionization in the TPC is dominated by the beam background.
- This produces a significant space charge (O(0.06 fC/cm^3) which causes distortions up to 60 µm.
- Gating is necessary to limit the ions flowing back from the amplification region

CONCLUSIONS

- The possibility to use a TPC at the future Higgs factory is appealing (particle ID for free, low material), but requires a large amount of difficult studies to meet physics requirements of Z peak at the highest luminosity of circular colliders.
  - Ion backflow suppression without loss of resolution
  - Possibility to correct for distortions (on average? or event by event?)
  - Especially difficult at the Z peak at the highest luminosity
  - What is our requirement for resolution at the Z peak?
  - Update all beam background estimates at the HZ energy.

- I wish to thank my ILD, CEPC, LCTPC, Saclay and KEK colleagues for enriching discussions. Thanks to the organizers of the workshop for inviting me.