FCC France Workshop,
Paris, Nov 26-28, 2025

Recent activities on TPC

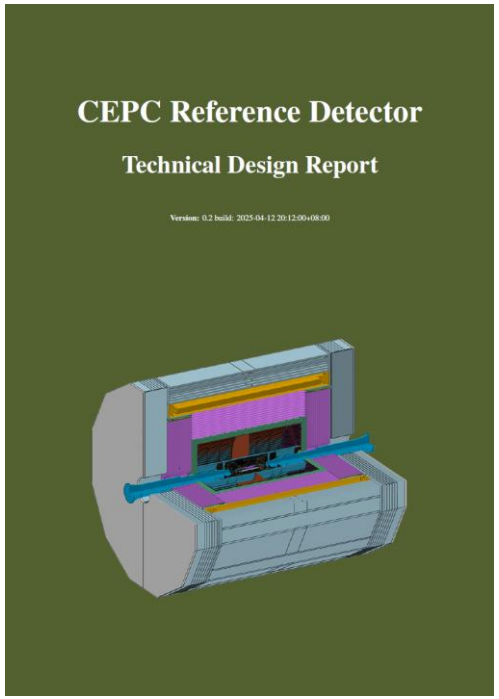
P. Colas

Thanks to Shinya Narita, Daniel Jeans, Kanako Watanabe, Ritsuya Hosokawa, Kohei Oikawa, Ryuki Sugawara, Jurina Nakajiùa, Huirong Qi, Mingyi Dong, and many more

- Recent activity on the TPC were carried out in China (for the CEPC reference detector TDR) and at CERN and KEK (for the beam-induced background studies).
- The main limitation for a TPC is distortions from space charge :
  - Ionization from different sources builds up a space charge
  - As the TPC volume is limited, this gives rise to a transverse E field
  - ExB effect generates a Lorentz force distorting the electron drift trajectories, which ends up in track distortions

TPC for CEPC

- In the last 2 years, a large part of the work was carried out in China, in the preparation of the Technical Design Report for the CEPC Reference Detector, published on October 16, 2025.
- A task force was built for writing the TDR (Chinese from IHEP, Tsinghua and other institutes), and an international committee (the IDRC) was charged to review iterations of the report.
- Central tracking is done by a Micromegas or digital TPC, with substancial differences from ILD TPC :
  - Inner radius increased from 60 cm to 110 cm to lower machine BG
  - Mechanical structure lighter including carbon fibre and aluminum
  - Readout by 500 µm x 500 µm pixels (TEPIX chip)
  - Tentative beam test at DESY finally not followed (CAS decision not to recommend CEPC for the 15th 5-year plan might have played a role).



More details

- Magnetic field 2T or 3T?
  - It was believed so far that a 3T field would ruin the luminosity achievable at circular colliders, but a new scheme with compensation coils further appart was shown to allow going to 3T. This is a big improvement on beam BG reduction.
- Gas choice can lower ionization
  - Ar mixture is good for resolution, but the high ionization (~100 e-/cm) makes it produce more ionization, so more space charge in the TPC, compared to He (30 e-/cm) or neon.
- Also work on ion velocity might allow a faster flushing or the ions.

Progress at KEK, DESY and Iwate University

- The idea is to review ILD@ILC calculations (Kanako Watanabe from Iwate), and possibly to adapt to FCC conditions . Main unknown so far : the beam-related backgrounds.
  - At the Z pole at high luminosity space charge is dominated by Z to hadrons : a TPC is likely not to be operable : the occupancy from synchrotron radiation close to 100% (to be confirmed), the space charge distortions are 2 orders of magnitude larger than expected resolution.
  - For both circular and linear colliders, at the HZ energy the charge produced is dominated by backgrounds : converted synchrotron X-rays and low-energy e+e- pairs, incoherent pair production from Beamstrahlung, neutron collisions in the gas.
- Daniel Jeans (KEK) carried out simulations of Beamstrahlung leading to pair creation.
- The PhD student Alexander Schwan works on MDI at DESY and presently spends a month at KEK with the EAJADE RISE.
- Serguei Ganjour and Shinya Narita try to make an ion filter with graphene to suppress the ion backflow.

Beam-related backgrounds

1) Beamstrahlung
2) Synchrotron radiation
3) Beam-gas effects
4) Halo muons
5) Low-energy neutrons
6) Operational particle losses
7) Touschek effect
8) Thermal photon compton scattering

Beam-related backgrounds

1) Beamstrahlung
2) Synchrotron radiation
3) Beam-gas effects
4) Halo muons (produces horizontal lines)
5) Low-energy neutrons
6) Operational particle losses
7) Touschek effect (negligible at high energy)
8) Thermal photon compton scattering (not yet studied)

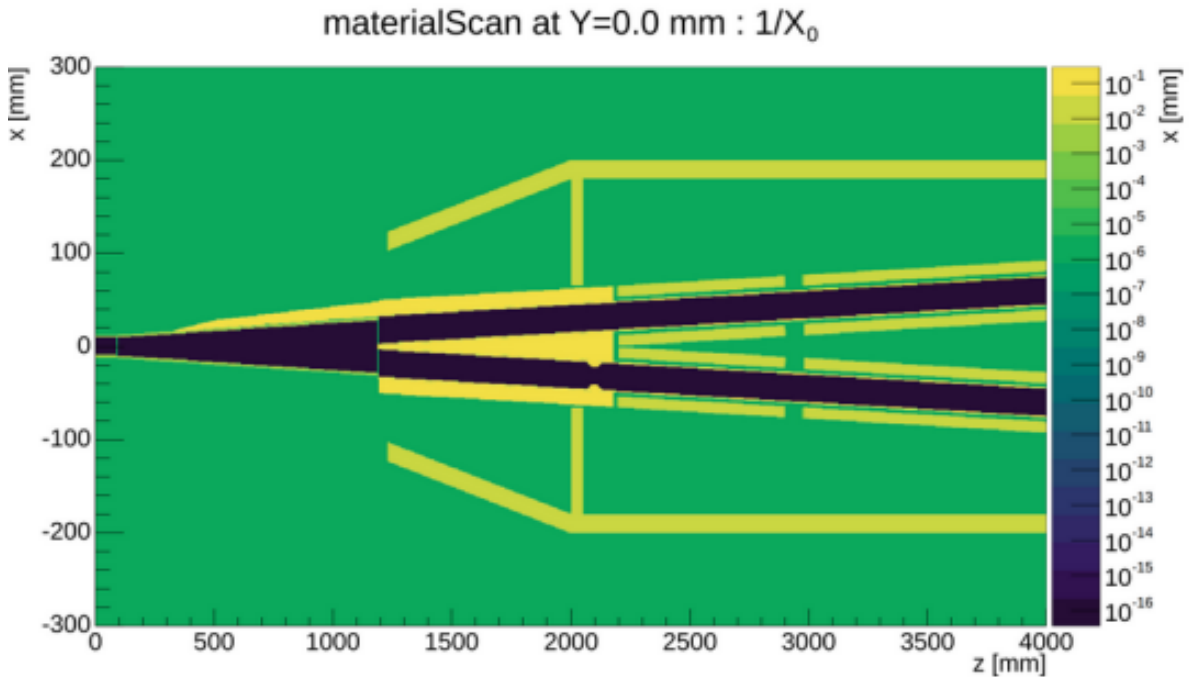
Machine-Detector-Interface Models

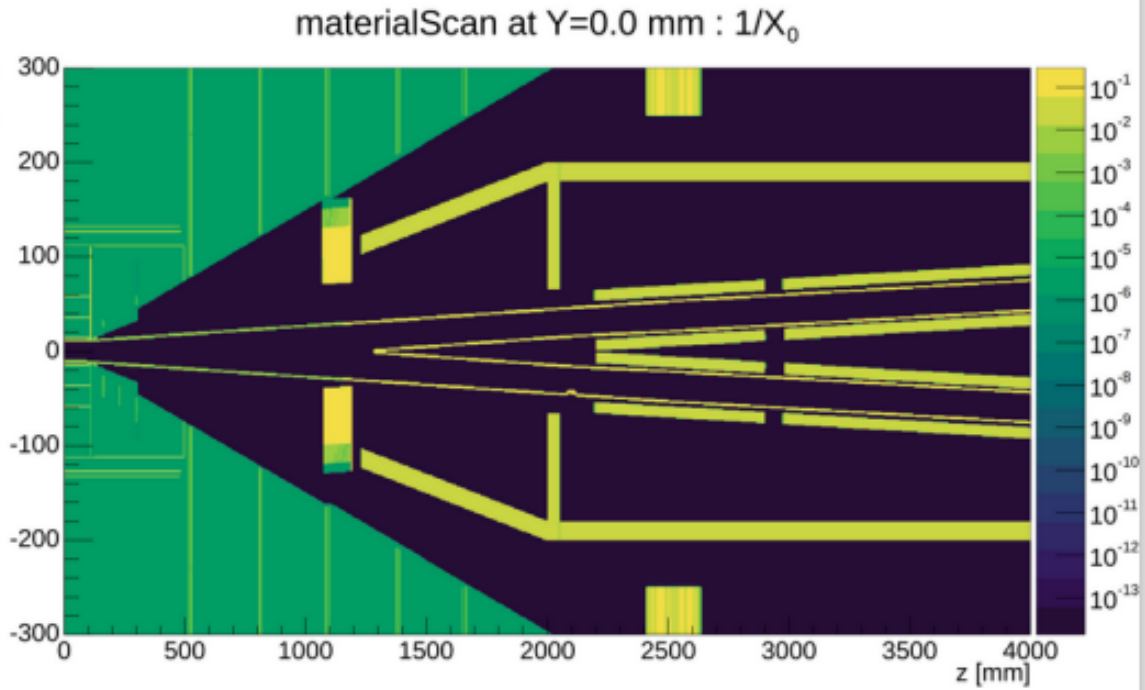
Prior Shape-Based MDI model

- Native DD4hep
- By CLD people

Newer CAD-Based model

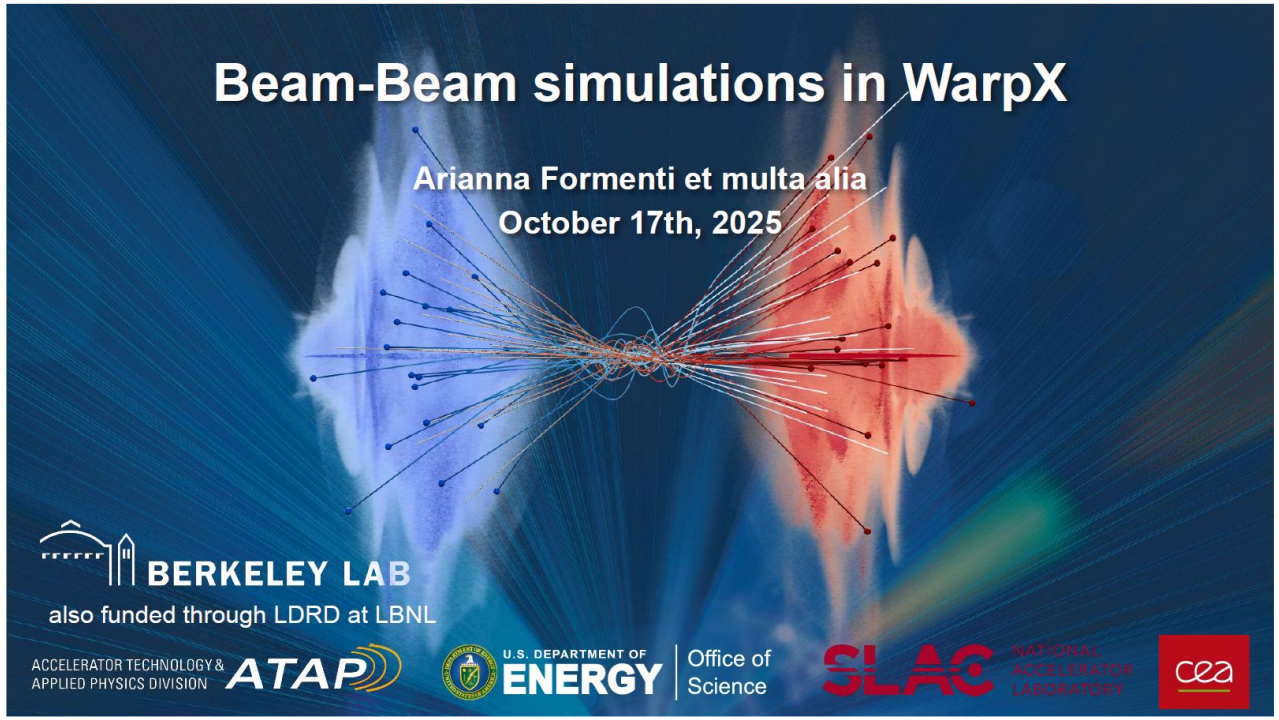
- CAD import
- By FCC's MDI group





WarpX

- Modernize the software (Andrea Ciarma, DESY PhD student Victor Schwan,…)
- To replace the GuineaPig generator which is not maintained anymore.



Conclusions

- Much progress in the mechanics and electronics at CEPC and EIC
- Delay will come from CAS decision not to select CEPC in the 15th five-year plan, but it might be pursued for the next plan.
- TPC R&D is pursued in Europe within the ILD concept. It is planned to adapt the concept to a circular collider a FCC.
- Main progress has to be done in beam-related background studies, and MDI studies are necessary to mitigate these backgrounds.