Beam-gas backgrounds with MDIsim-Geant

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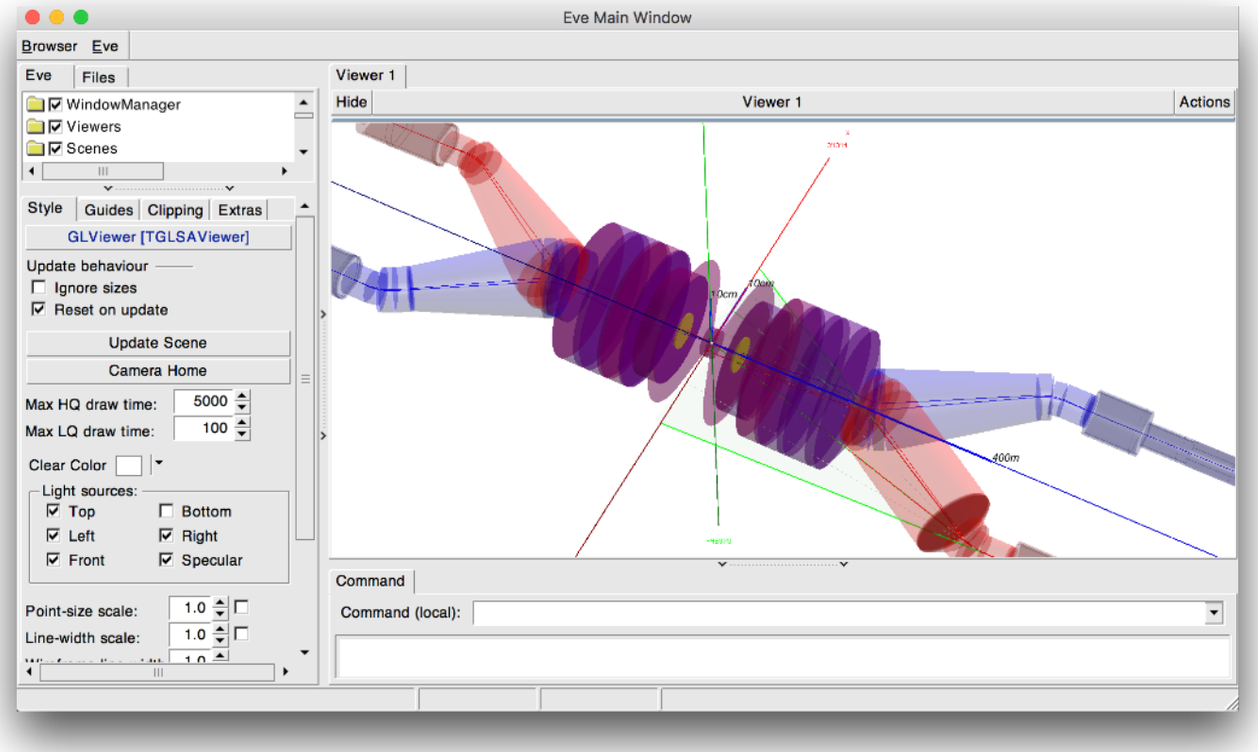
MDISim TOOL

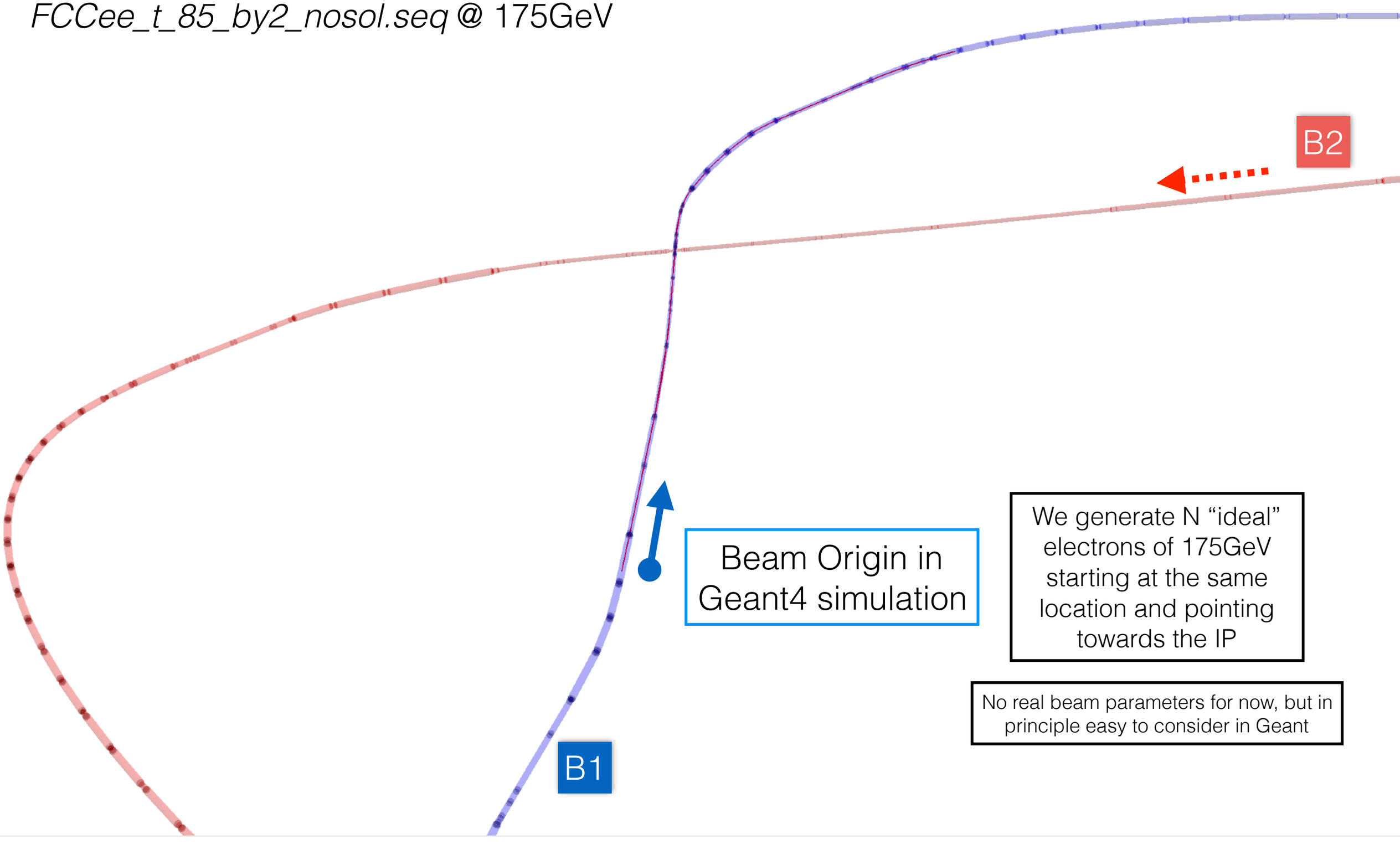
- Developed by *Helmut Burkhardt* (CERN), is a set of C++/Root classes that allow to:
  - Run Madx on the desired lattice of the FCC
  - Read Madx output, plot the lattice
  - Calculate Synchrotron Radiation (Power Radiated, Critical Energy..) and plot it over the geometry using Root's TEve
- Import geometry and SR in Geant to perform full simulation

link

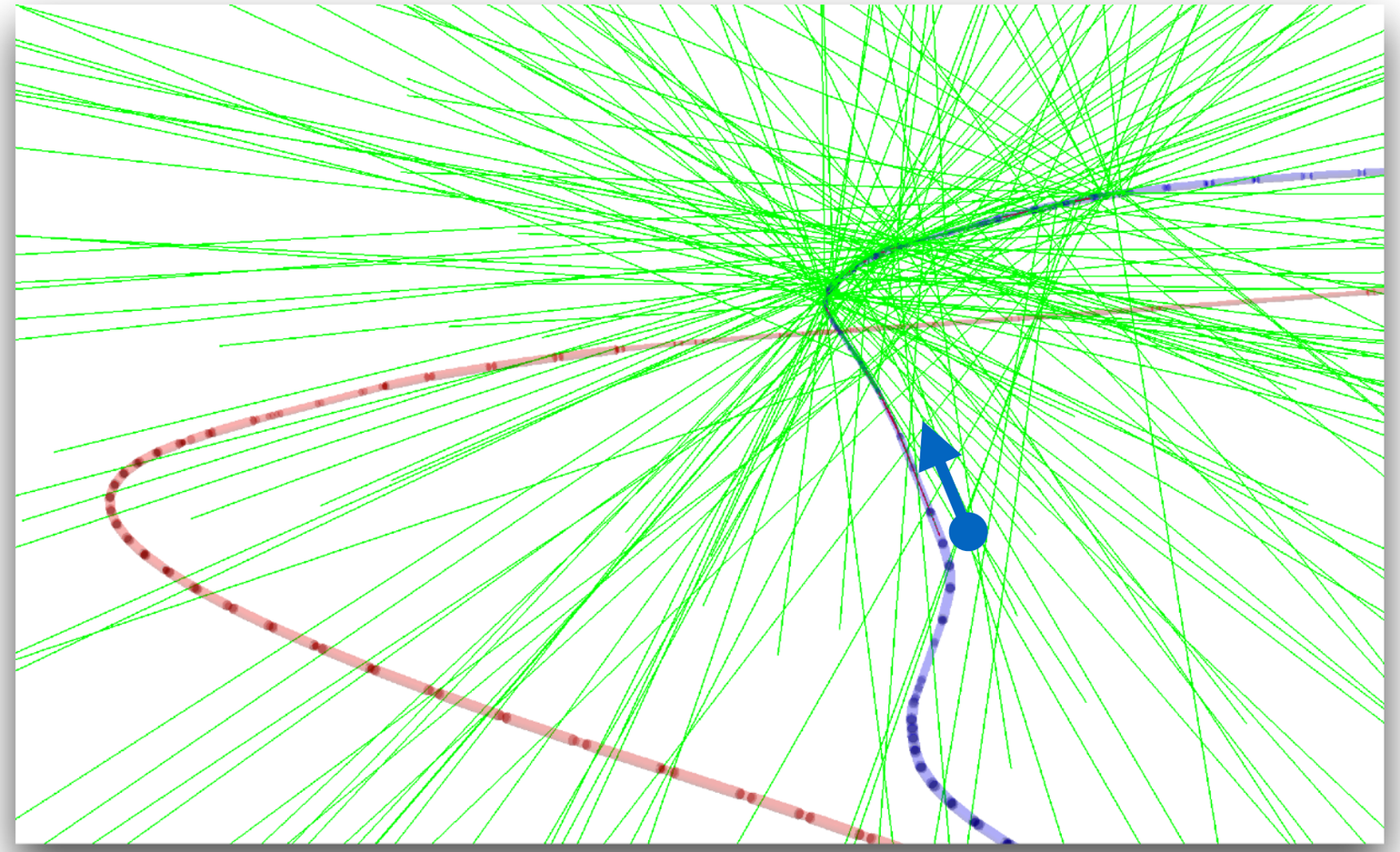


GDML reconstruction of the beam pipe

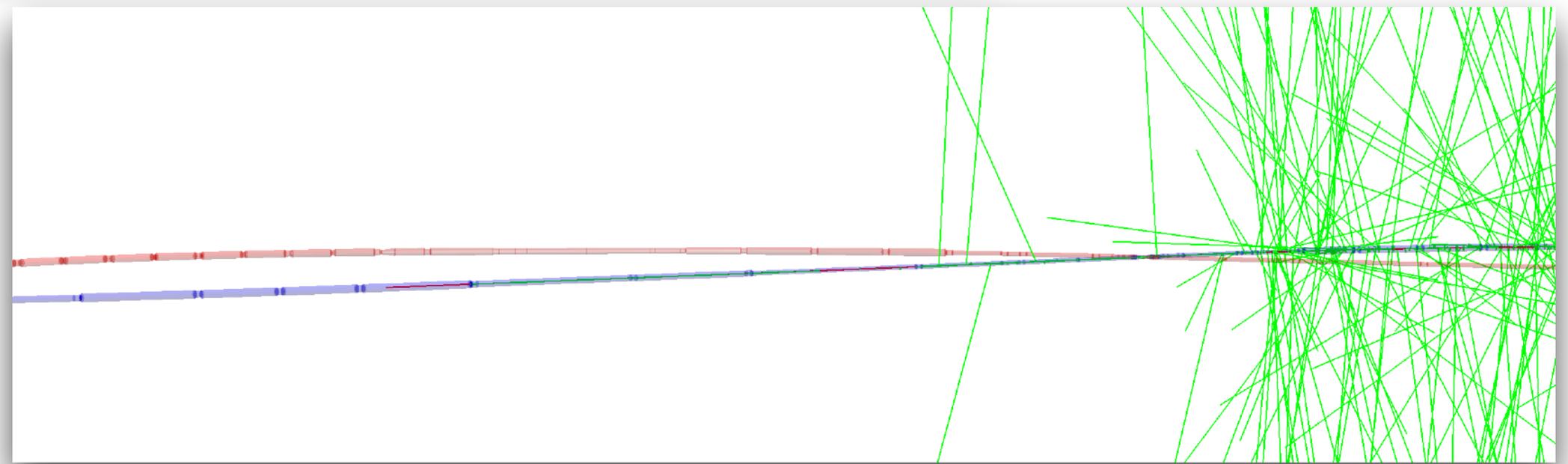
Optics version:
FCCee_t_85_by2_nosol.seq @ 175GeV



Synchrotron Radiation photons emitted



Transverse 50x zoom (needed to gain readability) creates apparent “huge deflections” in photon’s track!



Beam Gas

- The beam scattering with residual gas in the vacuum chamber can be either elastic or inelastic scattering, in both cases the scattered beam particles may get eventually lost

Beam Gas inelastic

- Usually the gas Bremsstrahlung lifetime is estimated from the integrated cross section via the approximated formula:

$$\frac{1}{\tau_{Brems}} = \rho\,\sigma_{inel}^{N}\,c$$

$$\sigma_{inel}^{N} = 4r_e^2\,Z^2\alpha\,\frac{4}{3}\left(\ln\frac{183}{Z^{1/3}}\right)\left(\ln\frac{1}{\varepsilon_{RF}} - \frac{5}{8}\right)$$

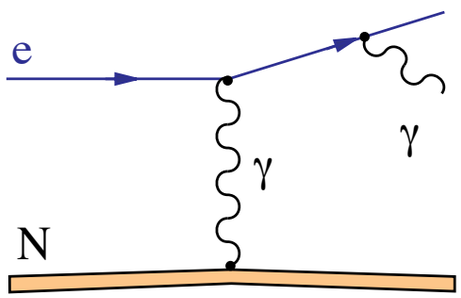
$$\rho\ [m^{-3}] = 3.217\times10^{22} P\ [\text{Torr}].$$

FCCee case:

Z= **7** (CO, N_2)

P=0.1 nTorr

ε_{RF}= 0.03

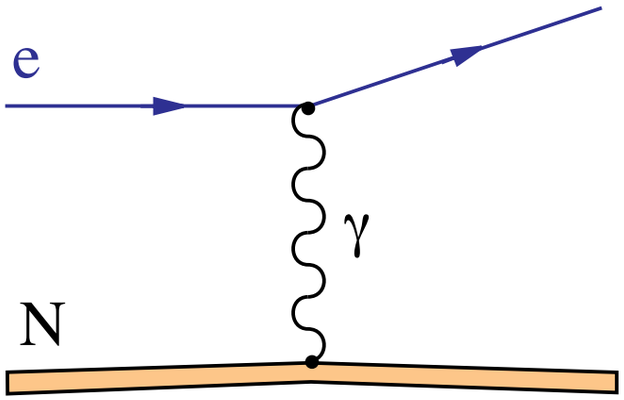


cross section ~ 6 barn

lifetime ~ 400h

At **LEP** off-energy particle background was largely dominated by beam-gas bremsstrahlung along the straight sections
[lifetime = 430 h, P=10^{-10} Torr, NIM A 403 (1998) 205-246]

Beam Gas elastic



total cross section

$$\sigma_{\mathrm{el}} = \frac{4\pi\, Z^2\, r_e^2}{\gamma^2\, \theta_{\mathrm{min}}^2}$$

$$\theta_{\mathrm{min}} = n_\sigma \times \mathrm{BeamDivergence}$$

$$\simeq \sqrt{\frac{\epsilon_y}{\beta_y}}$$

$$n_{\sigma_x} \leq 30$$
$$n_{\sigma_y} \leq 70$$

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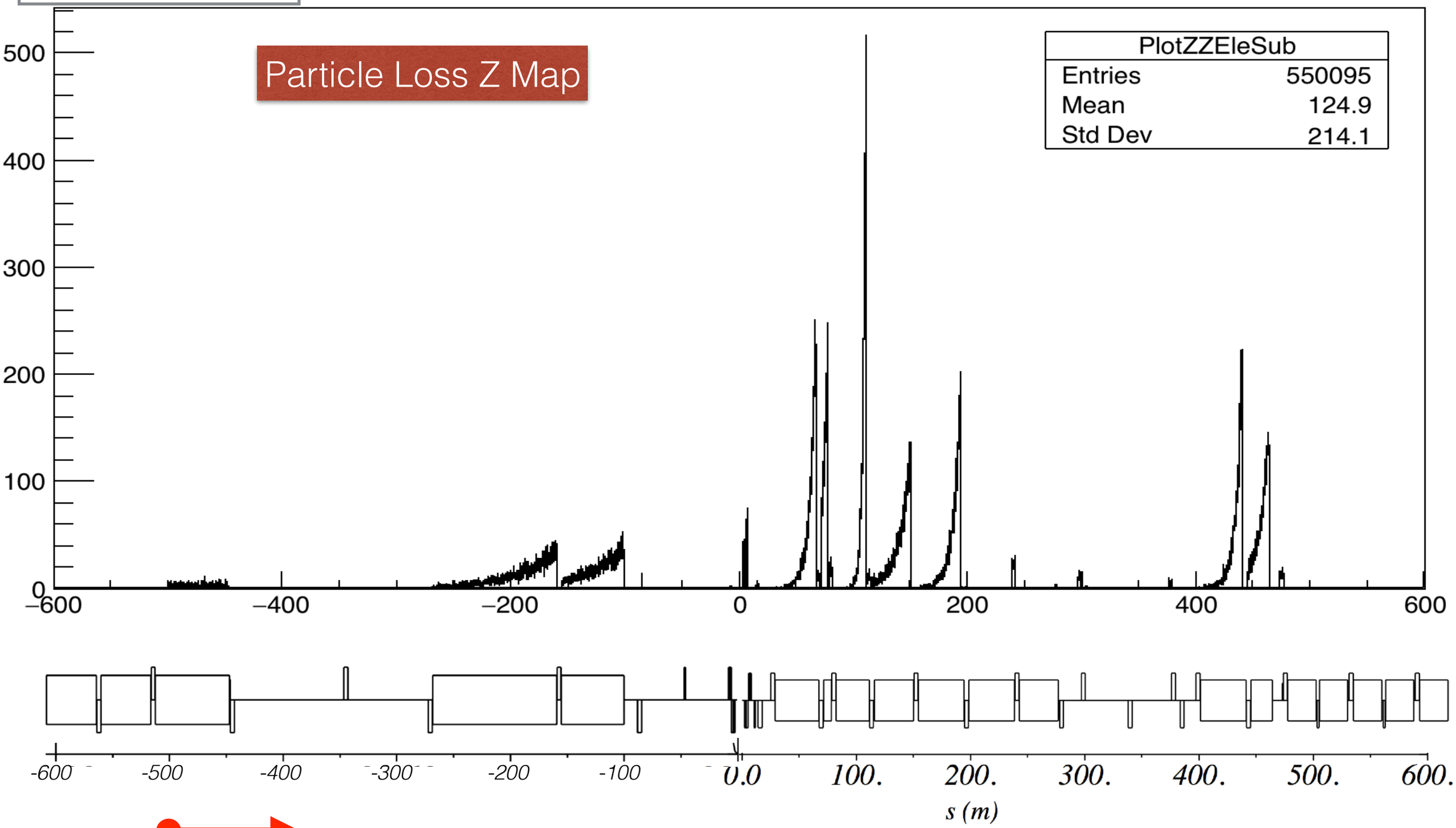
Due to the small ε, elastic can be significant!

Beam Gas

- The detailed study of Beam-Gas interaction can be done in Geant4
- To evaluate this quantity, it is possible to score in Geant the particles that exit the volume of the pipe and enter the surrounding vacuum:
  - Scoring approach:
    - *if (ThisVol==Pipe && NextVol==Vacuum)* …
  - For each particle exiting the pipe we score its position, direction and energy…

Vertical Axis needs to be fully understood

Particle Loss Z Map

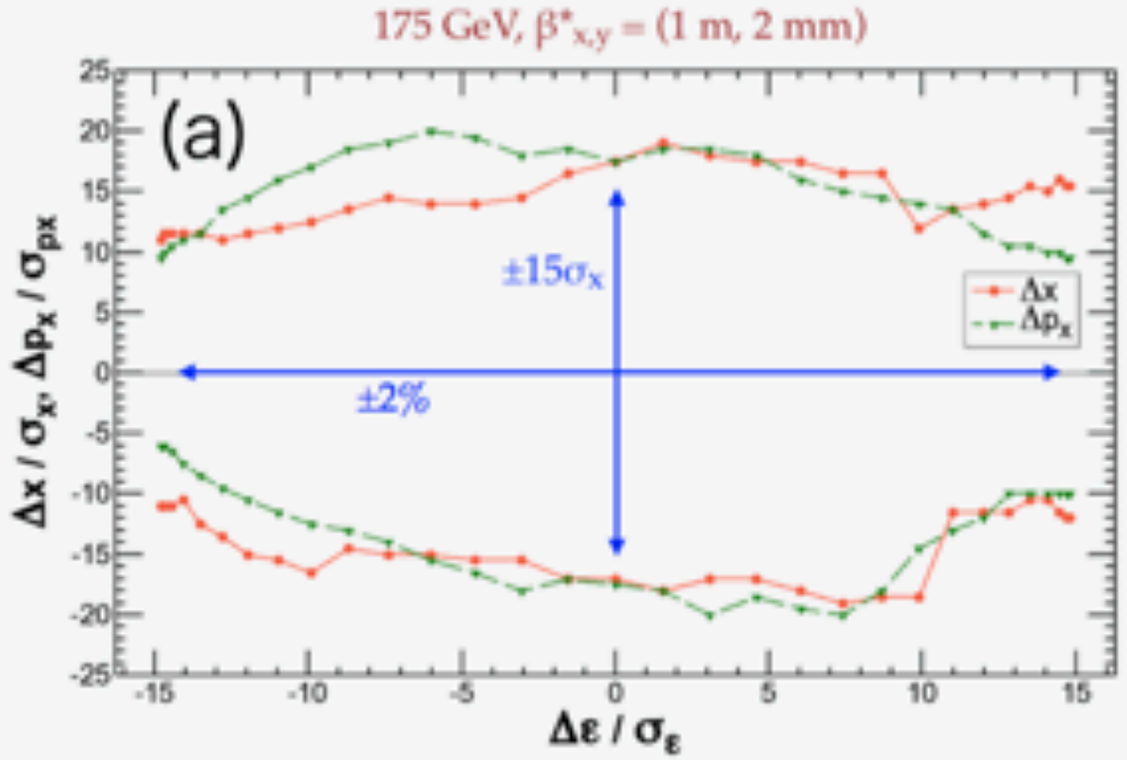


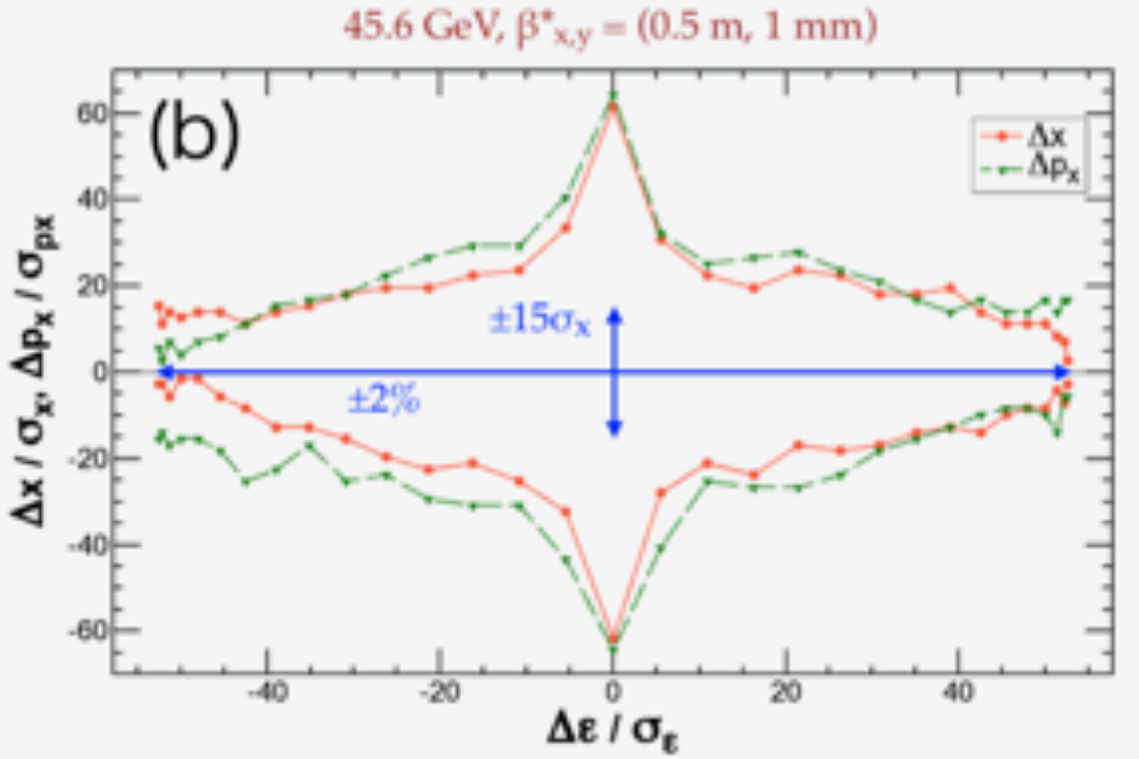
Beam Origin

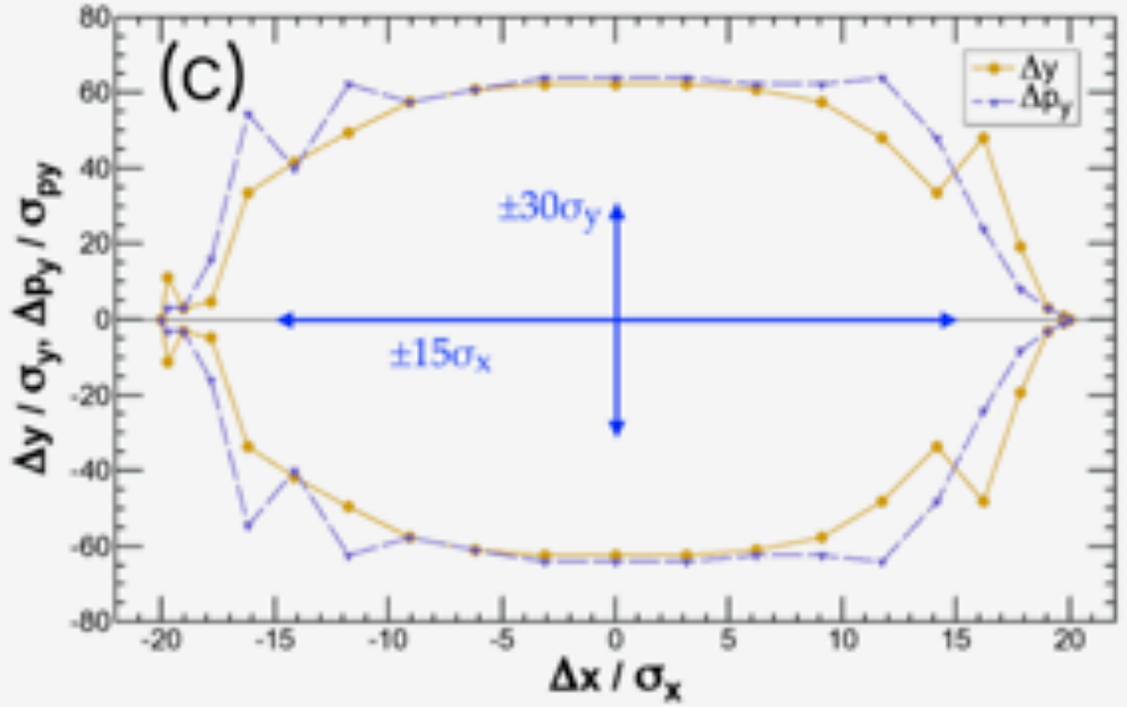
Conclusion and next steps

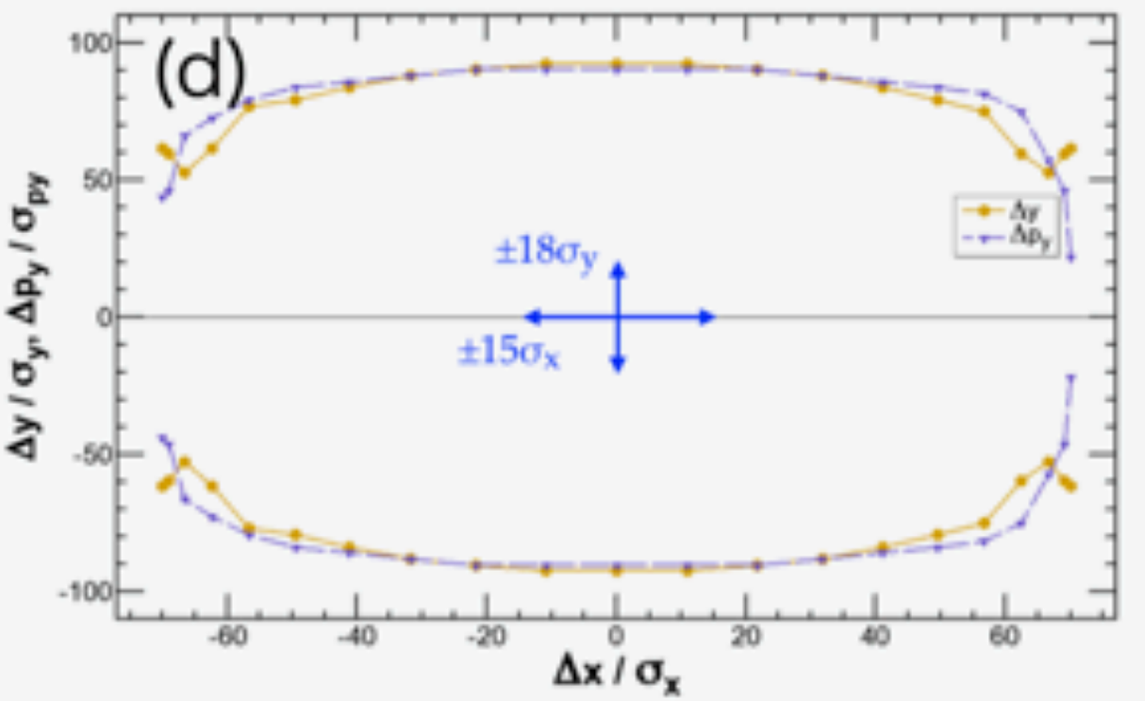
- MDISim provides a way to make a detailed model of Synchrotron Radiation in Geant4
- The same model can be used for Beam-Gas studies
- A goal is to predict flux and distribution of Beam-Gas background into the interaction region

backup









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