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Vacuum Requirements in the Detector Region from Beam Gas and other Considerations

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Beam-gas Interactions in the Beam Delivery System

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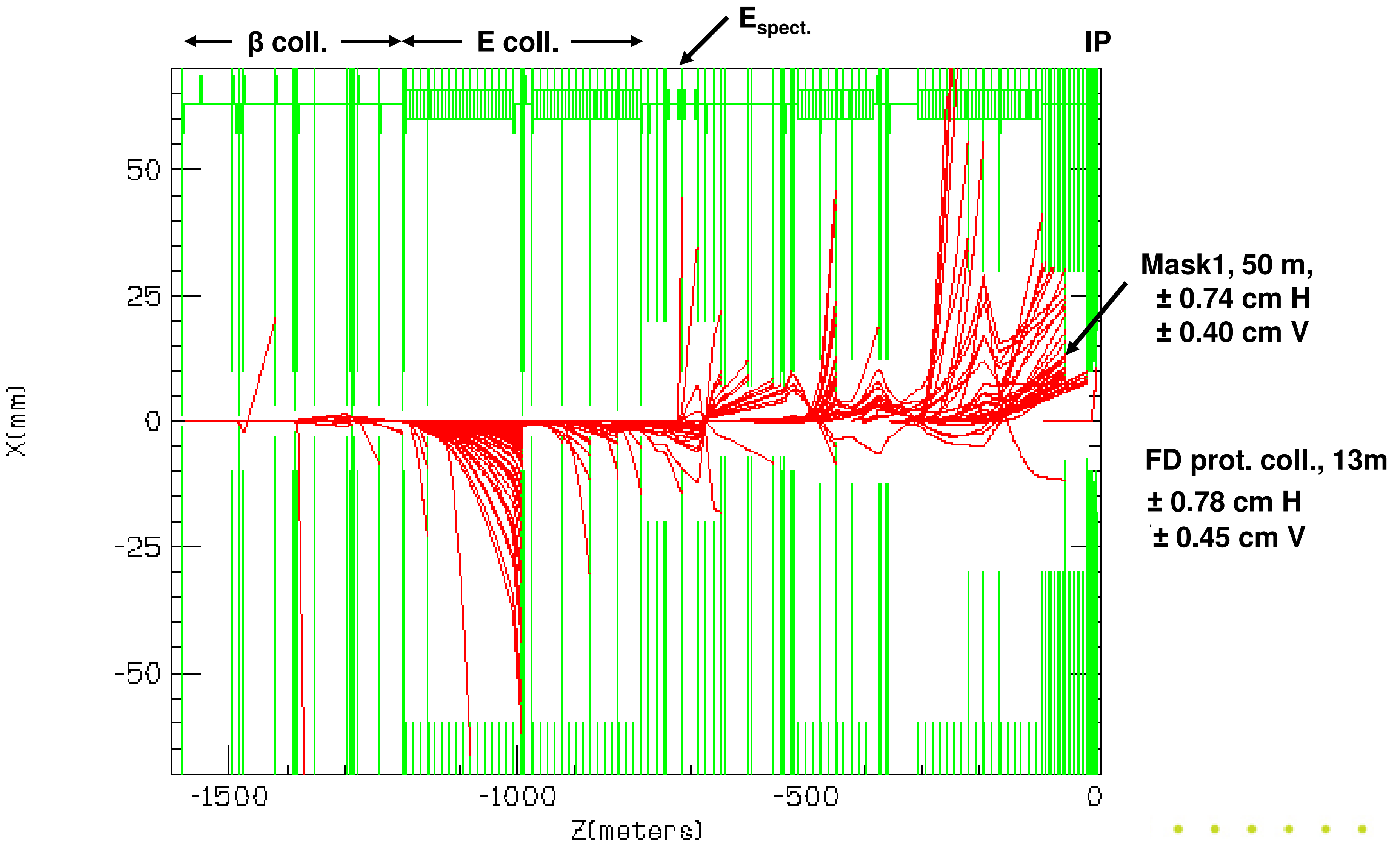
- Beam-gas interactions are simulated in the ILC Beam Delivery System.
  - BDS length 1500 m
  - "SLC" gas: 62% H_2, 22% CO, 16% CO_2
    - $\rho = 6.5\times10^{-4}$ g/cm^3@1 atm room temp.,
    - $X_0 = 5\times10^{13}$ m @10 nTorr
- Scattering rates at 10 nTorr (both beams):
  - Bremsstrahlung 2.9/bunch
  - Coulomb 2.3/bunch
  - Moller (atomic electrons) 0.3/bunch
- Find the point of origin of charged particles which hit the FD protection collimator and reach the IP.

Loss pts. of 150 random beam-gas brem. trajectories in the BDS

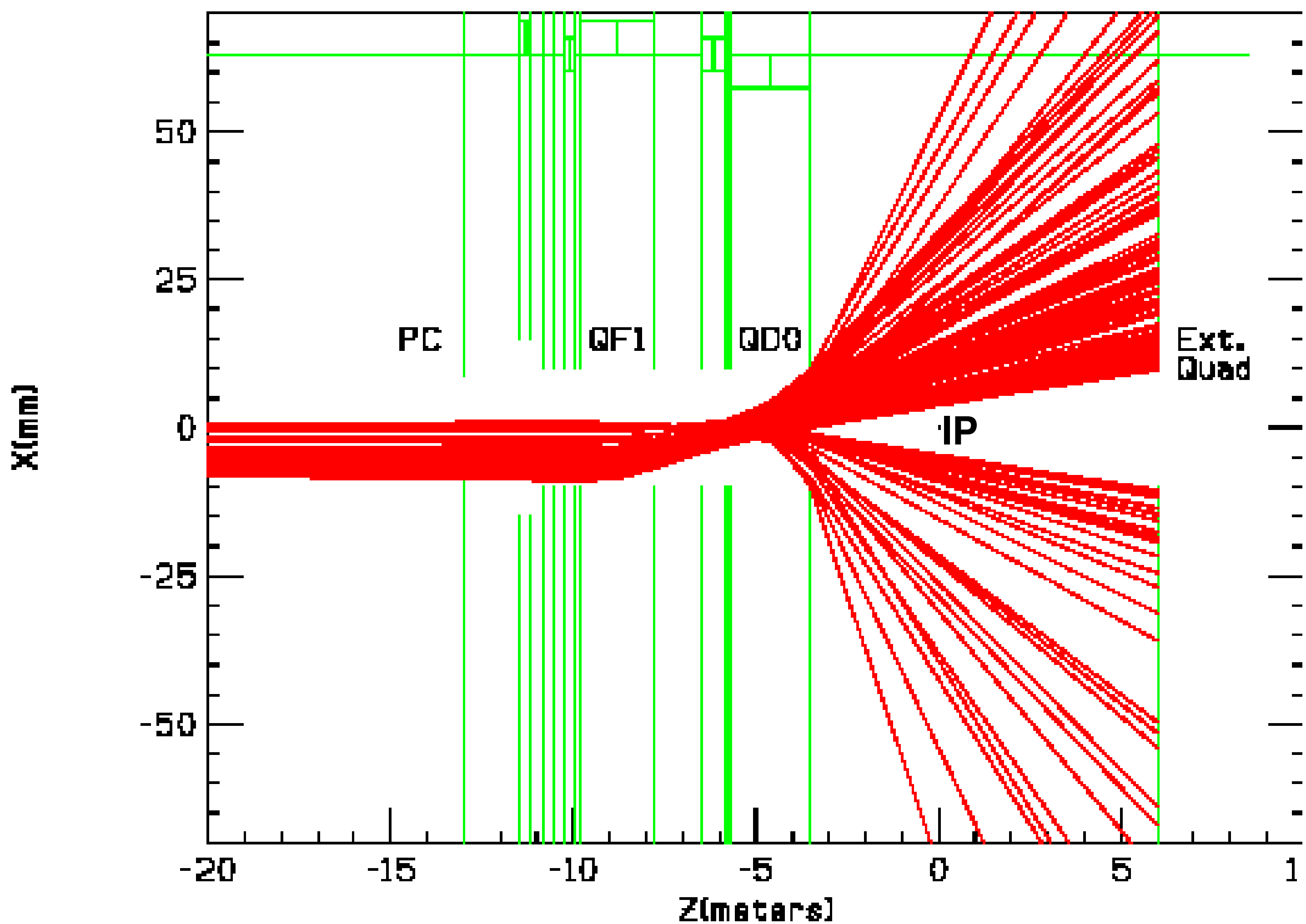


Beam-Gas Bremsstrahlung Electrons Hitting Beyond the Final Doublet

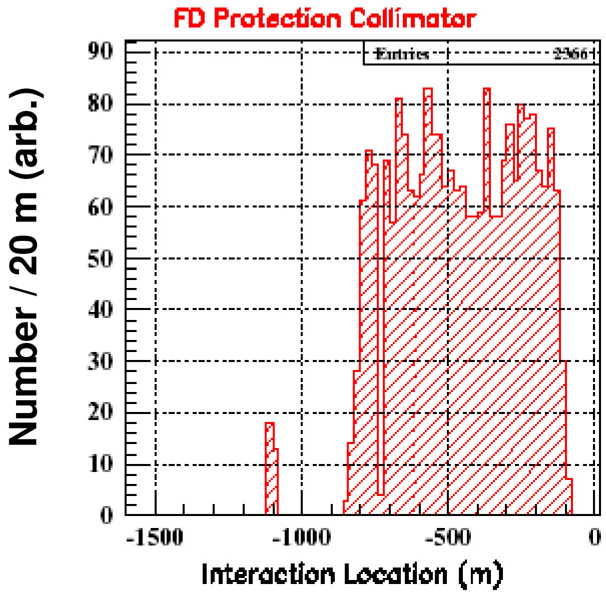
Cut: Outside 10 mm at entrance to 1st extraction line quad

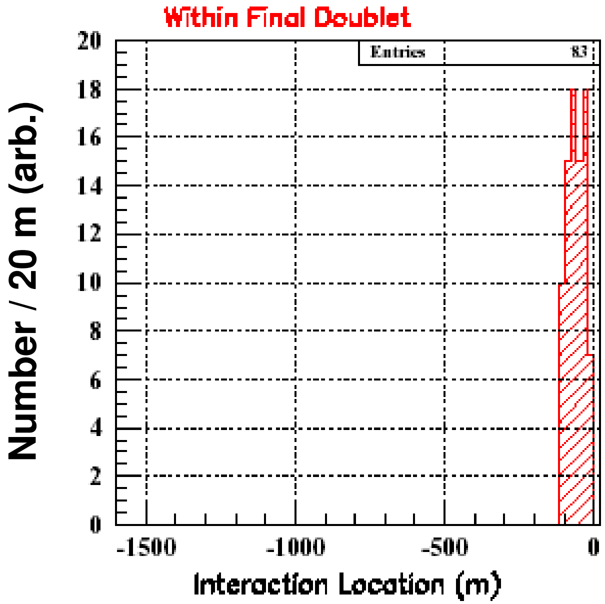
Average Energy = 100 GeV

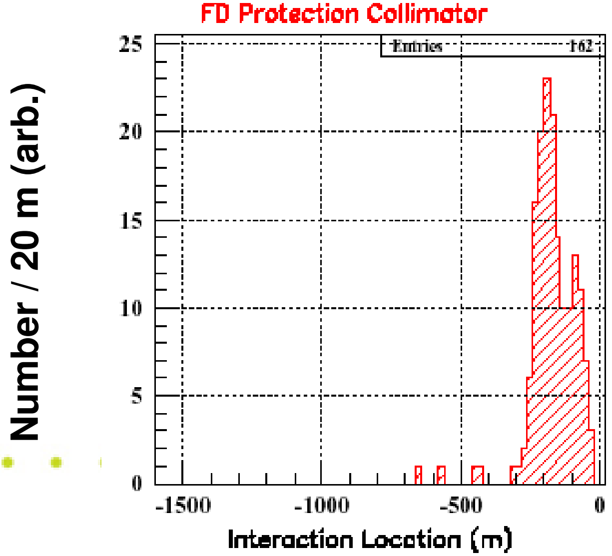
Origin is inside 200 m from the IP



Origin of Charged Beam-gas Bremsstrahlung for Hits Near FD







Coulomb electrons
(all beam energy)

Summary for 10 nTorr:

1. Within the IP region there are 0.02 - 0.04 hits/bunch
   at an average energy of about 100 GeV/hit originating 0–200 m from the IP.
   Therefore 1 nTorr from 0–200 m is conservative.

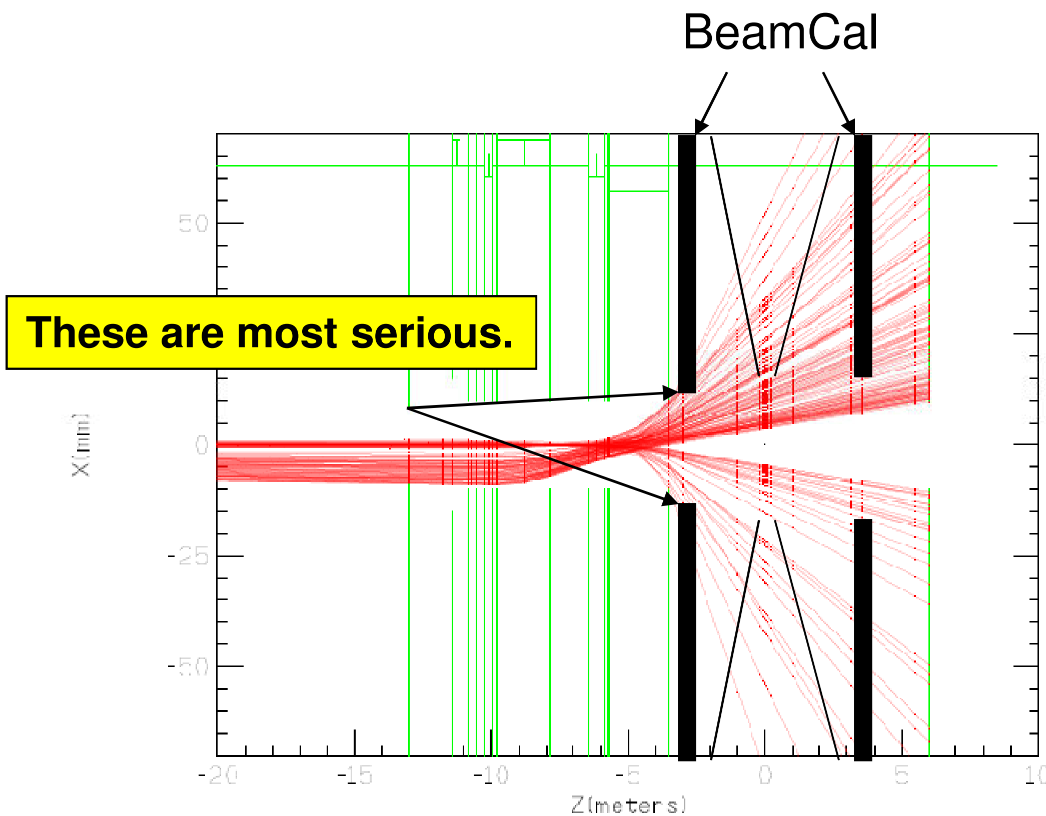
   Pressure in the IP Region can be much higher.

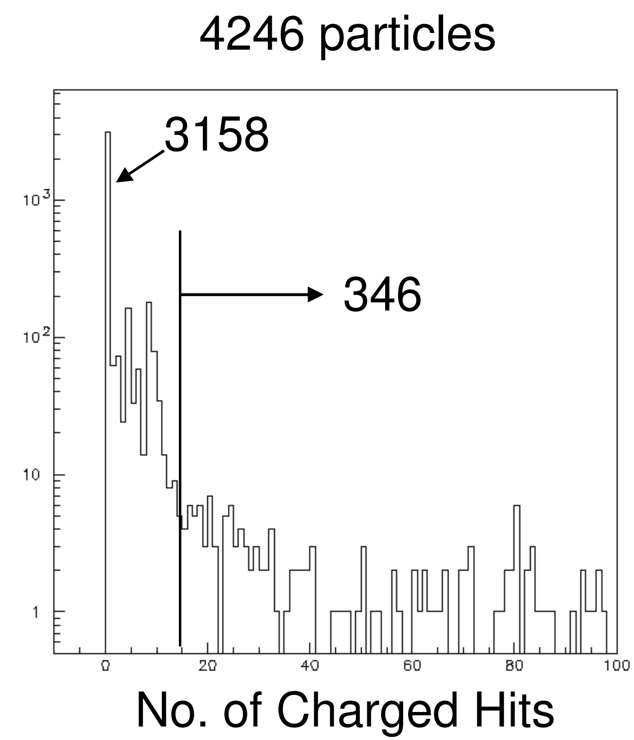
2. On the FD protection collimator there are 0.20 charged hits/bunch
   at an average energy of about 240 GeV/hit and 0.06 photon hits/bunch
   at an average energy of about 50 GeV/hit originating 0–800 m from the IP.
   Therefore 10 nTorr from 200–800 m.

3. Beyond 800 m from the IP the pressure could conceivably be at least
   an order of magnitude higher than 10 nTorr.

Update on Conclusion 1

Track those 0.02-0.04 particles/BX in the SiD detector.





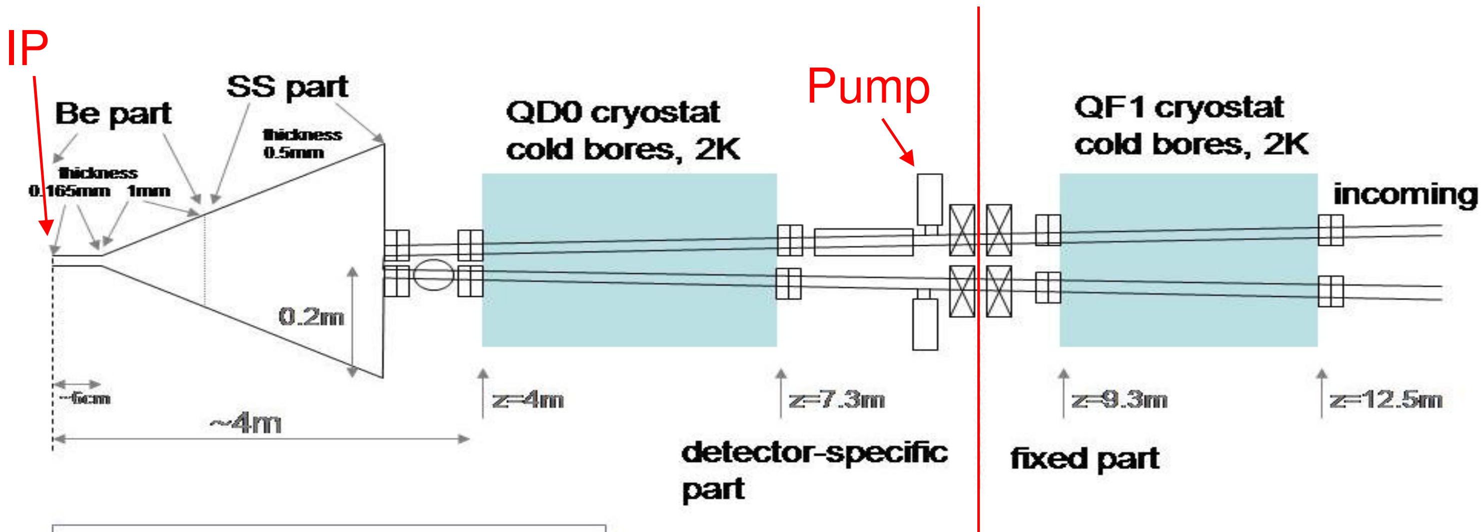
- NH = 0: 3158/4246 = 74%
- NH ≤ 15: 742/4246 = 17%
- NH > 15: 346/4246 = 8%

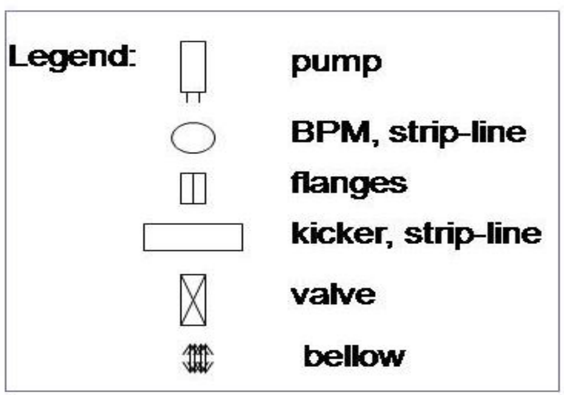
Only 10% of particles would generate significant number of hits.

→ 10 nTorr is acceptable.

IP Vacuum

- 0-th draft of IR region (A. Seryi)





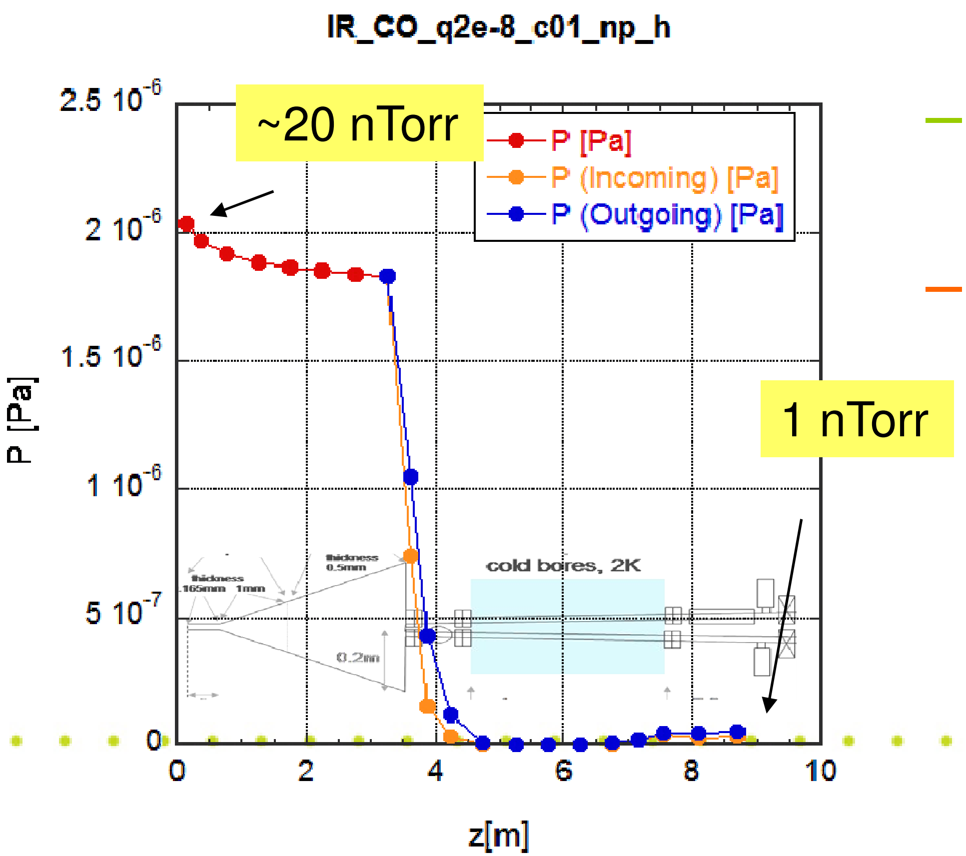
Apertures typically r=1cm in incoming beamline, and r=1.2cm+0.08cm*Z(m) in the outgoing beamline

Be-SS connection is permanent

Pump system_5

Suetsugu (IRENG07)

- Pressure distribution after 100 hours evacuation
- Calculated by a Monte Carlo code



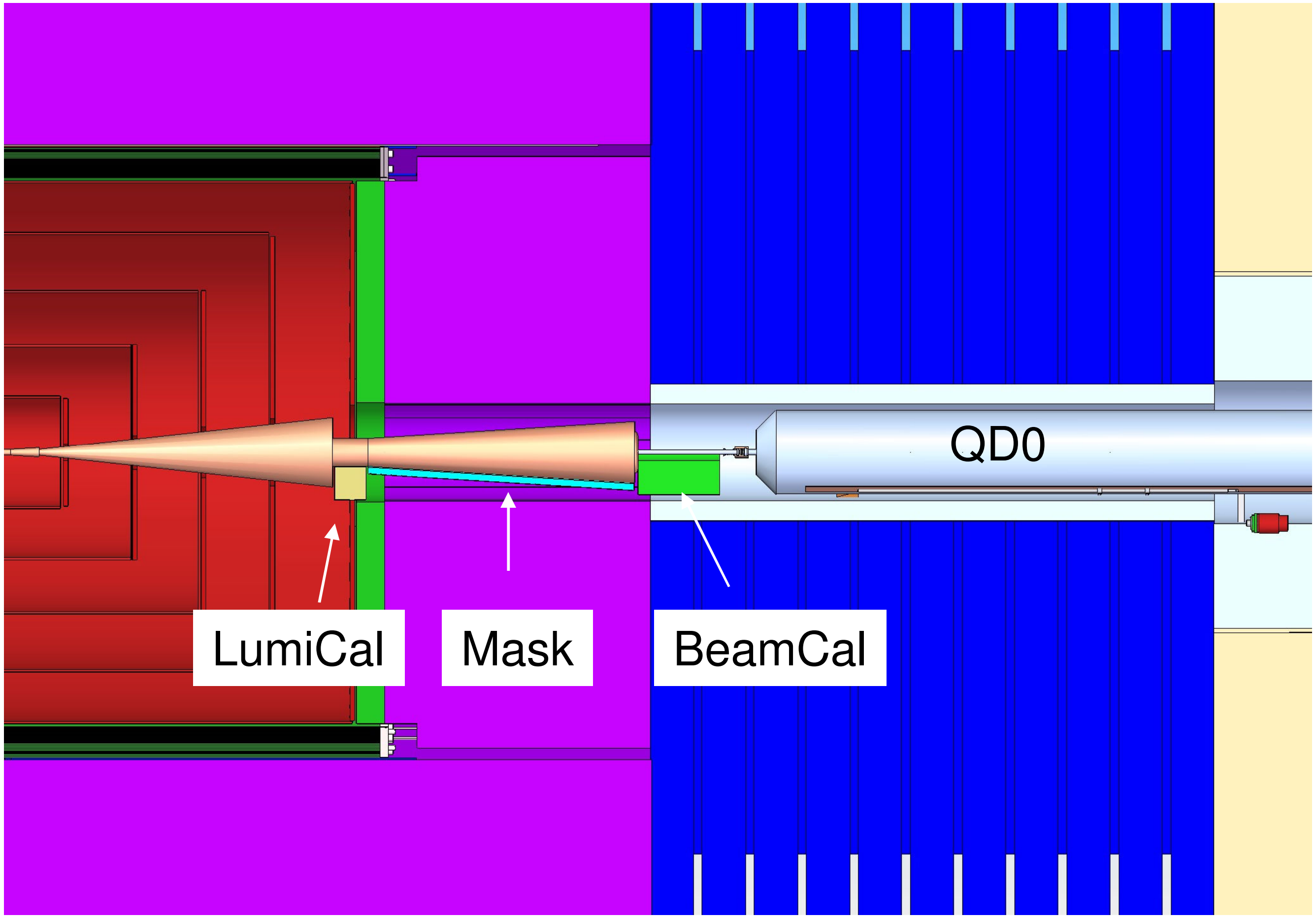
– $Q = 2x10^{-8}$ Pa m^3 /s /m^2 for CO

– P (z < L*) > $1x10^{-6}$ Pa!

Some pumping are required at z < L* !

SiD Forward Region

No Space for Vacuum pump in the SiD Forward region

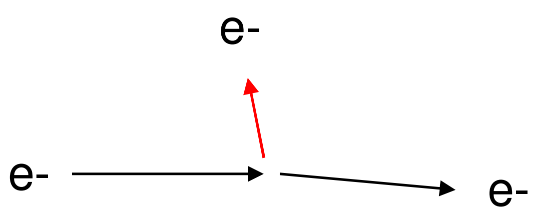


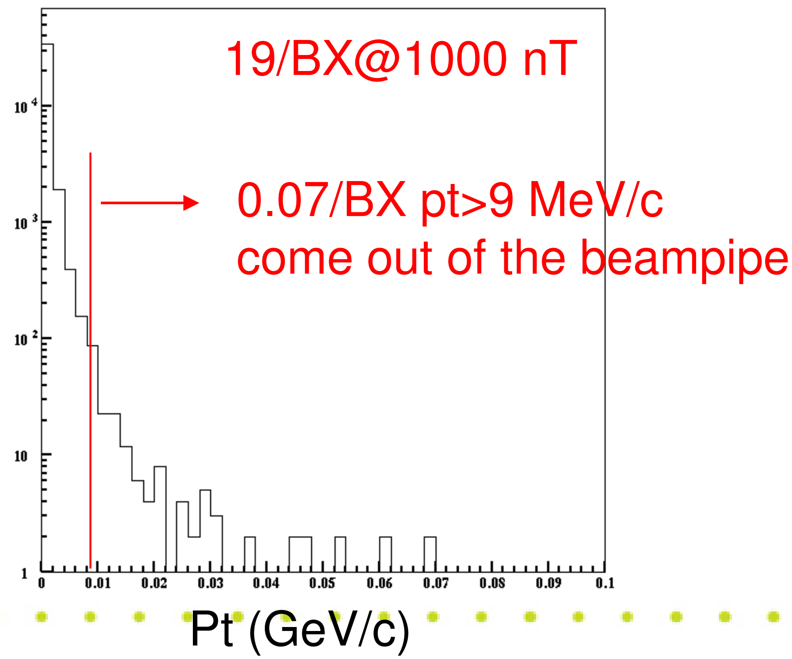
Do we need vacuum pumps inside the detector?

How bad is the beam gas scattering if the IP vacuum is 1000 nT?

250 GeV e- → 2.4-cm ϕ 7-m long gas ($H_2/CO/CO_2$)

- Among the three beam gas scattering processes considered in the BDS, only Moller scattering off atomic electrons is significant.





- Electro-production of hadrons
  - Fixed target data
    - σ_{TOT} ~ 2 mb $\Rightarrow$ 5×10^{-3}/BX
  - FLUKA does not simulate this process.
    - Replace e- with γ : 1.9×10^{-3}/BX@1000nT
  - GEANT4 simulates this process (GHAD package)
    - 3.3×10^{-3}/BX

Luminosity backgrounds (pairs, $\gamma\gamma\rightarrow$hadrons) are much higher.

Other IP Vacuum Issue

- Particle stimulated gas desorption (Malyshev)
  - e+/e- flux from beamstrahlung pairs can reach ~10^9/s.
  - NEG coated vacuum chamber?

Conclusions

- Based on the beam gas scattering, the vacuum requirements are
  - Up to 800 m from IP 10 nT
  - Beyond 800 m >> 10 nT
- Beam gas scattering inside the detector is negligible compared to the luminosity background even at 1000 nT.
  - IP vacuum requirement is not determined by the beam-gas scattering rate.
- Gas desorption needs to be studied for the IP vacuum consideration.