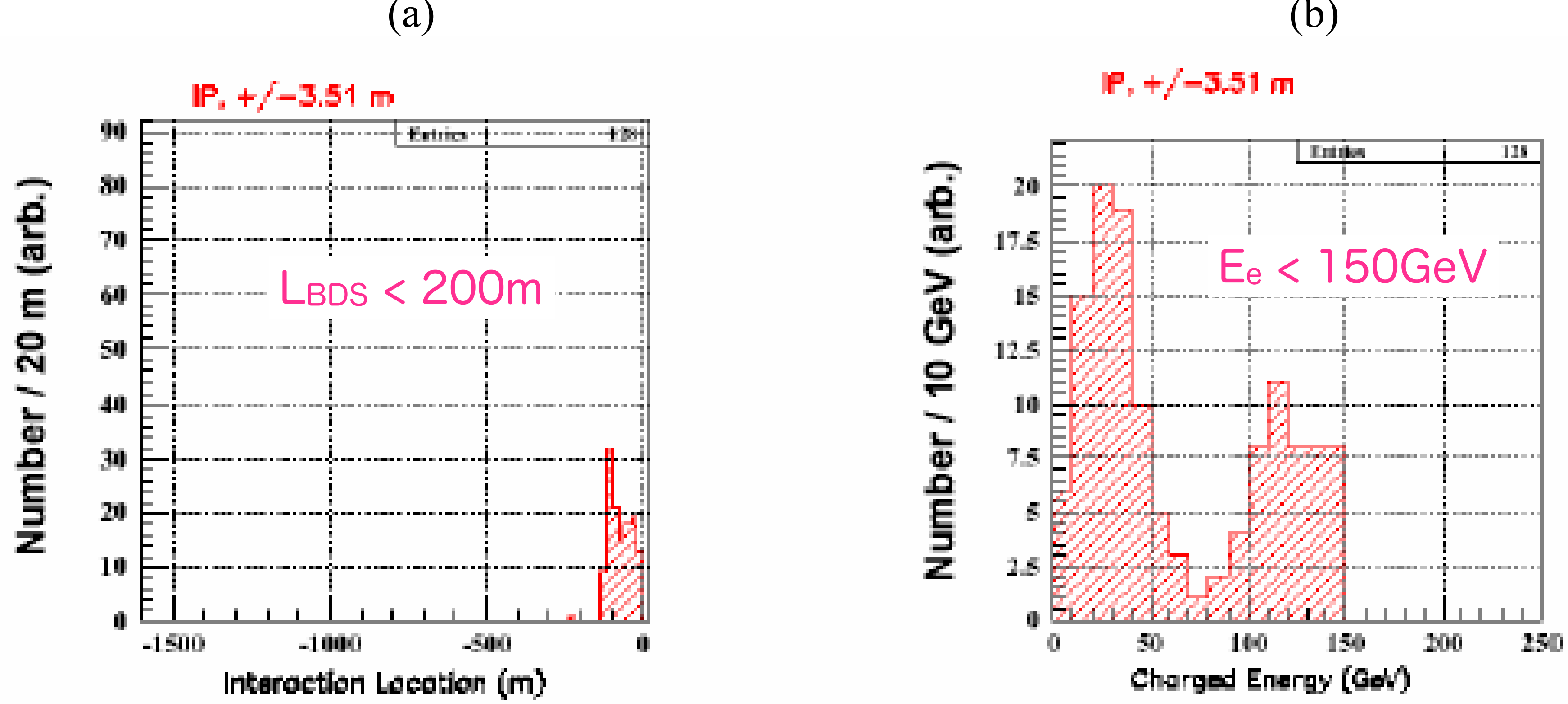
Vacuum pressure in ILD-IR

preliminary consideration

T. Tauchi, KEK, LCWS2014, Belgrade, Serbia,
6-10 October, 2014



L/Keller, T.Maruyama, and T.Markiewicz
ILC-Note-2007-016

E_b = 250GeV

Figure 5. Points of origin (a) and energies (b) of bremsstrahlung interactions for those which hit within the drift section +/-3.51 m of the IP.

Summary of Hits/bunch and Hits/160 bunches (TPC) – both beams, 10 nTorr

Hits/bunch — Hits/160 bunches (TPC)

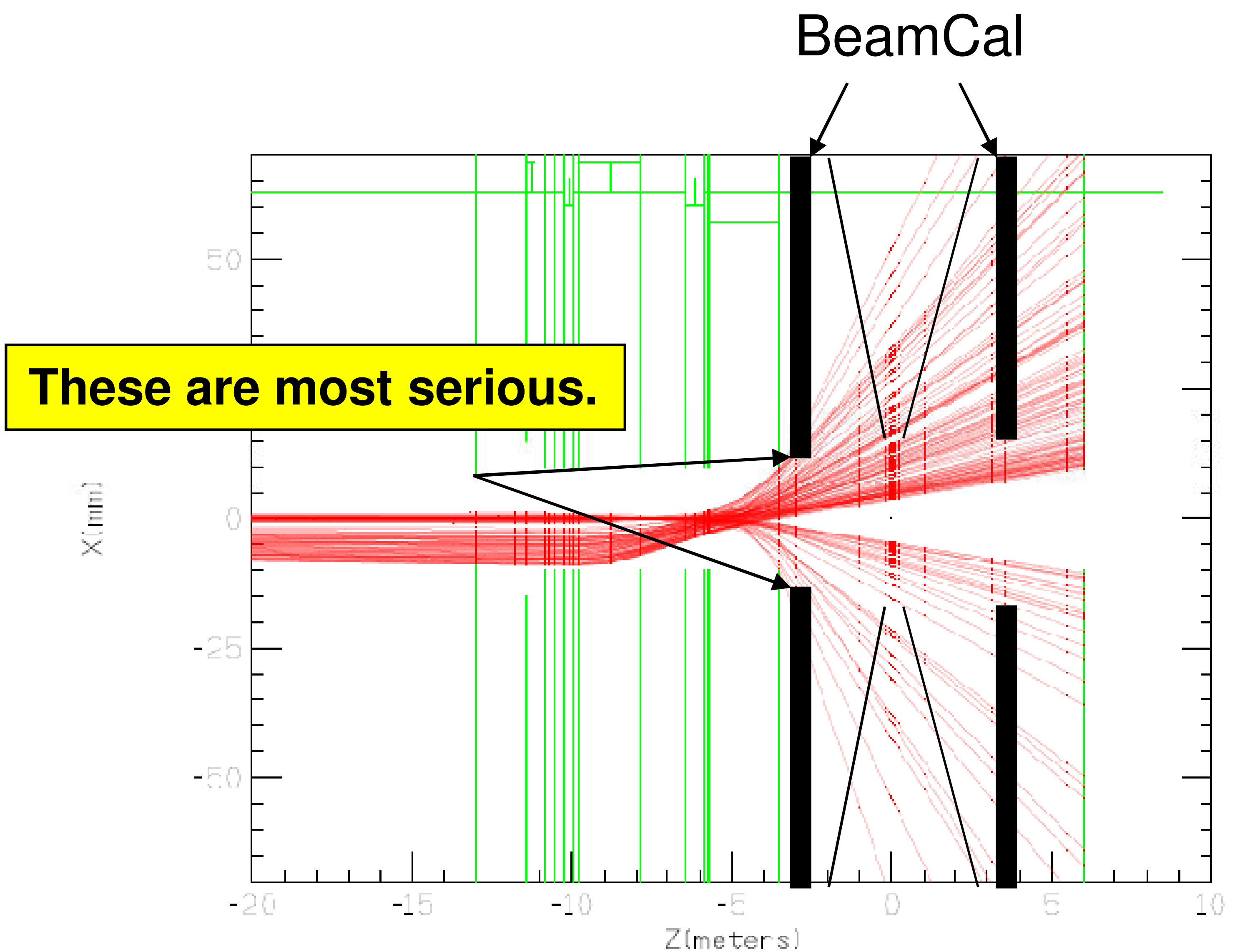
Hit Location	GEANT3 Beam-gas brem (charged) Hits	TURTLE Beam-gas brem (charged) Hits	TURTLE Beam-gas brem (charged) <E>	TURTLE Beam-gas brem (photons) Hits	TURTLE Beam-gas brem (photons) <E>	TURTLE Coulomb (charged) Hits	TURTLE Coulomb (charged) <E>
FD Prot. Coll. |x| > 0.74 cm |y| > 0.45 cm	0.22 35	0.17 27	235 GeV	0.056 9.0	~50 GeV	0.009 1.4	250 GeV
Inside F.D. (QF1 to QD0)	0.014 2.2	0.006 1.0	~100 GeV	0	-	0	-
IP region (± 3.5 m) (R > 1 cm at Z = 3.5 m)	0.04 6.4	0.02 3.2	~100 GeV	0	-	0	-

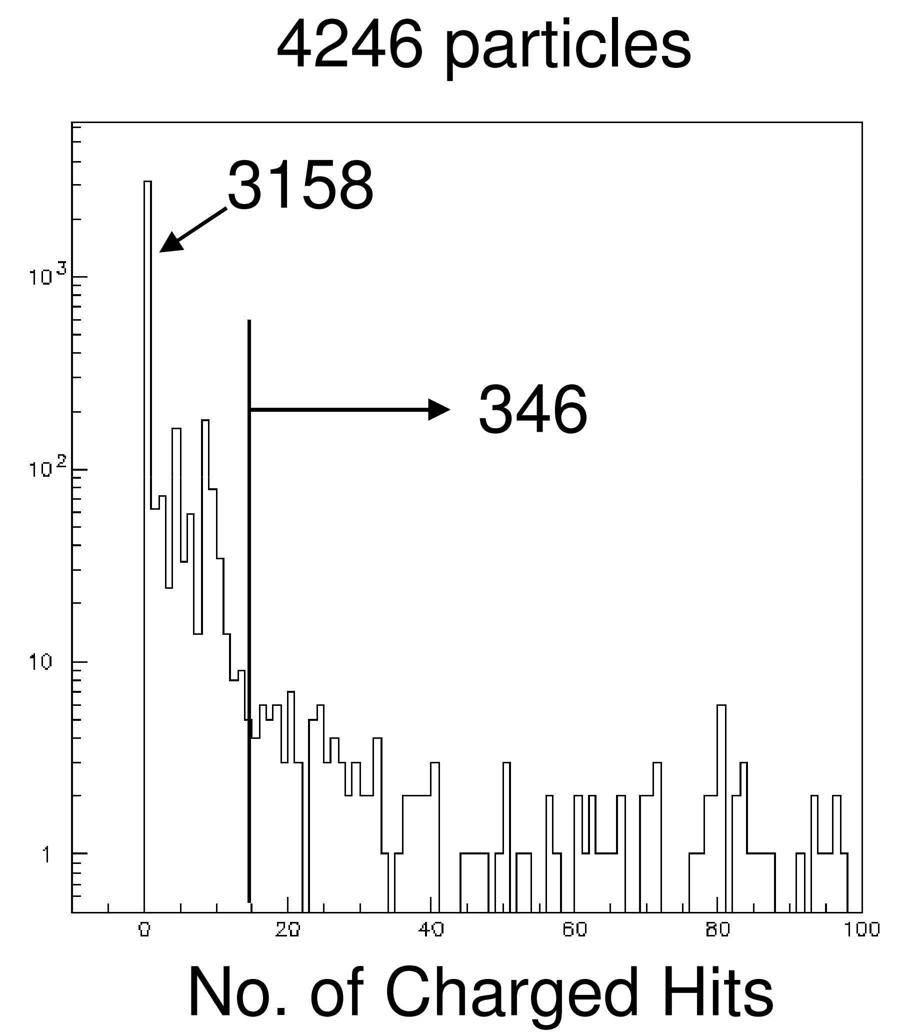
Assuming ,
P_{BDS} = 10nTorr (10^{6}Pa)

Table 1. Summary of GEANT3 and TURTLE simulations of BGB and coulomb single-scatters resulting in hits on apertures in the IP region for both beams and 10 nTorr. The upper (blue) entries are Hits/bunch; the lower (red) entries have been multiplied by 160.

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%

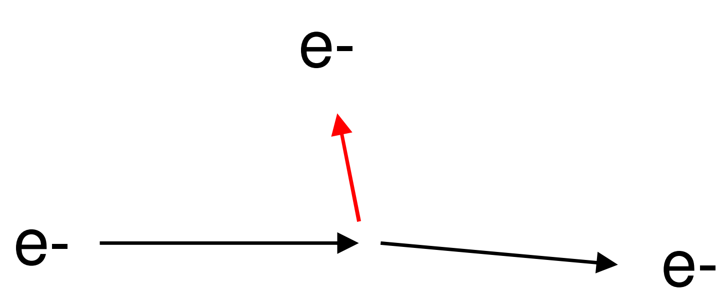
Only 10% of particles would generate significant number of hits.

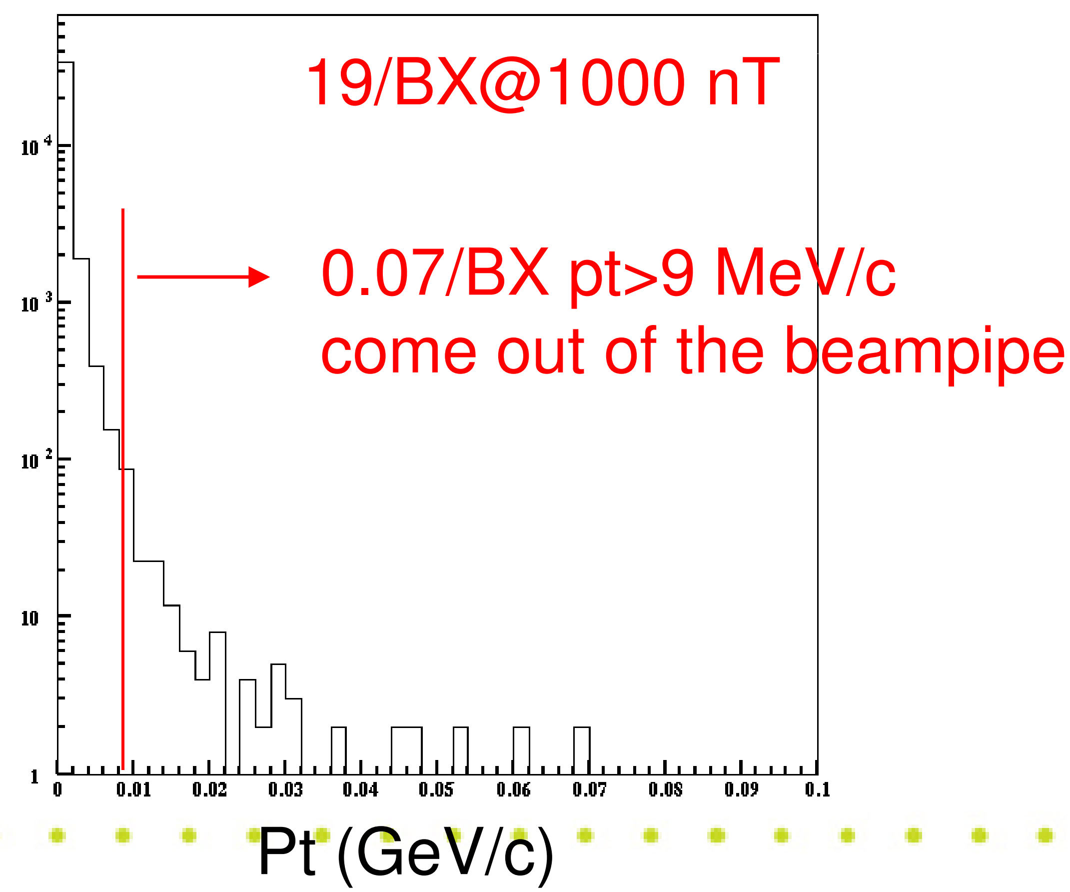
→ 10 nTorr is acceptable.

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)

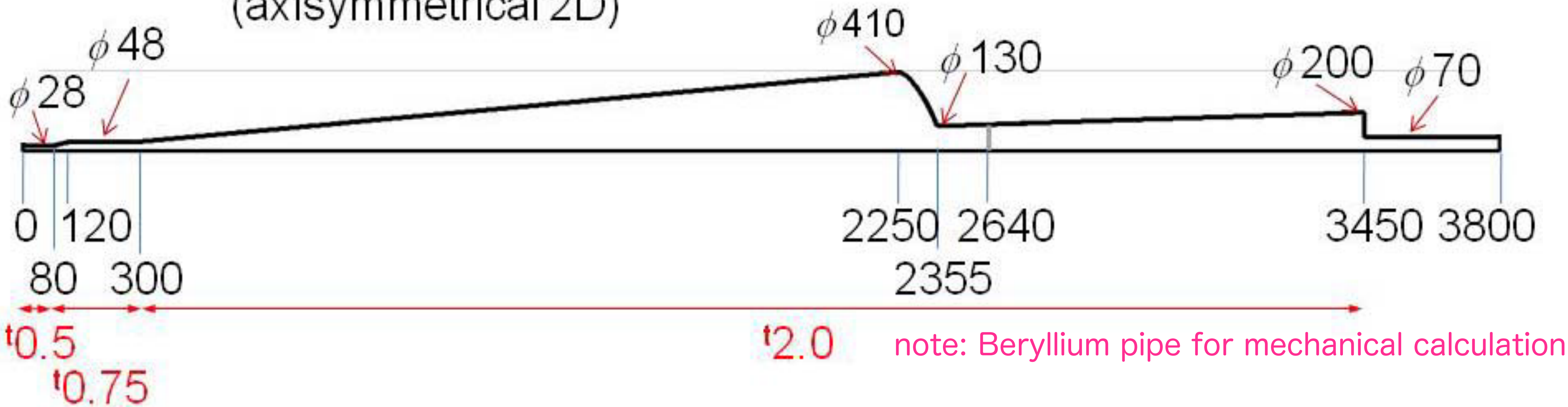
- Among the three beam gas scattering processes considered in the BDS, only Moller scattering off atomic electrons is significant.

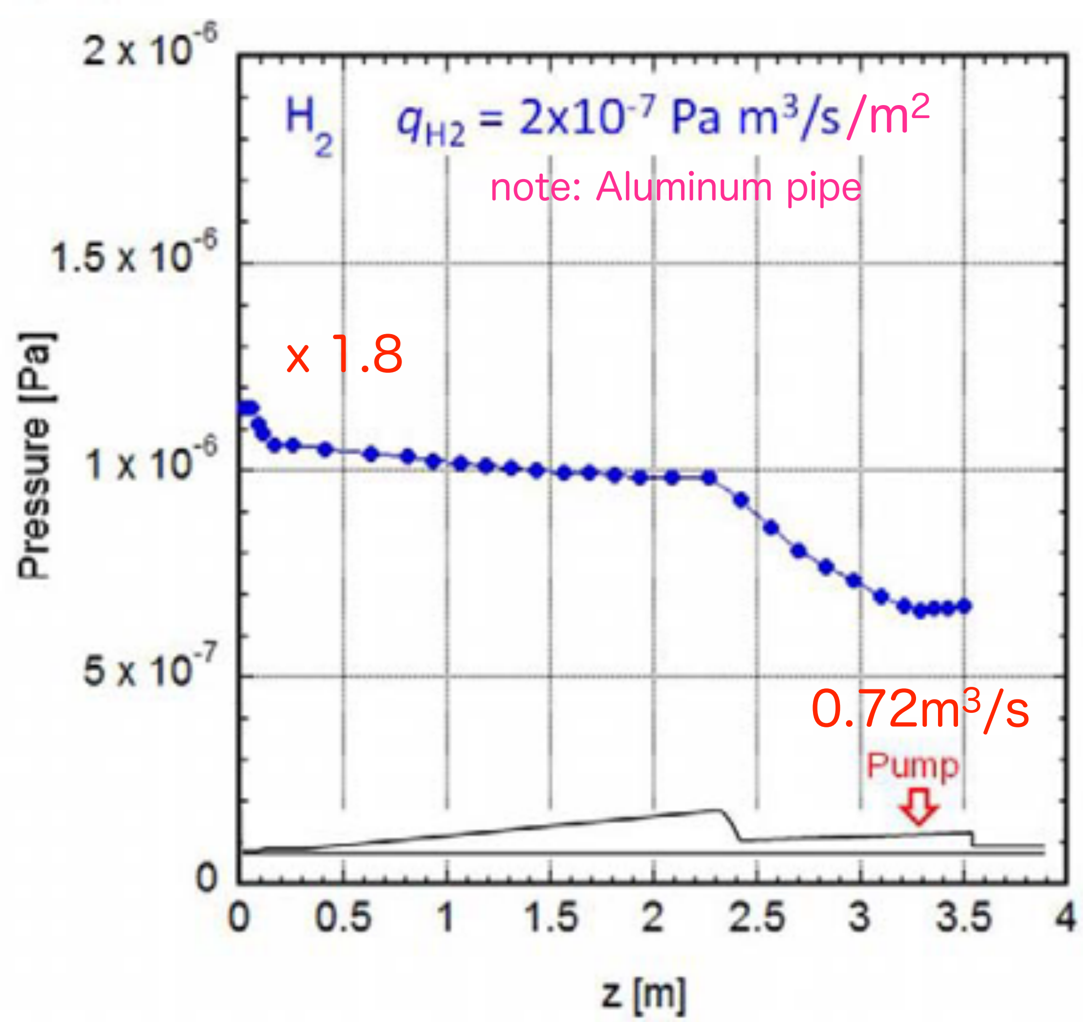


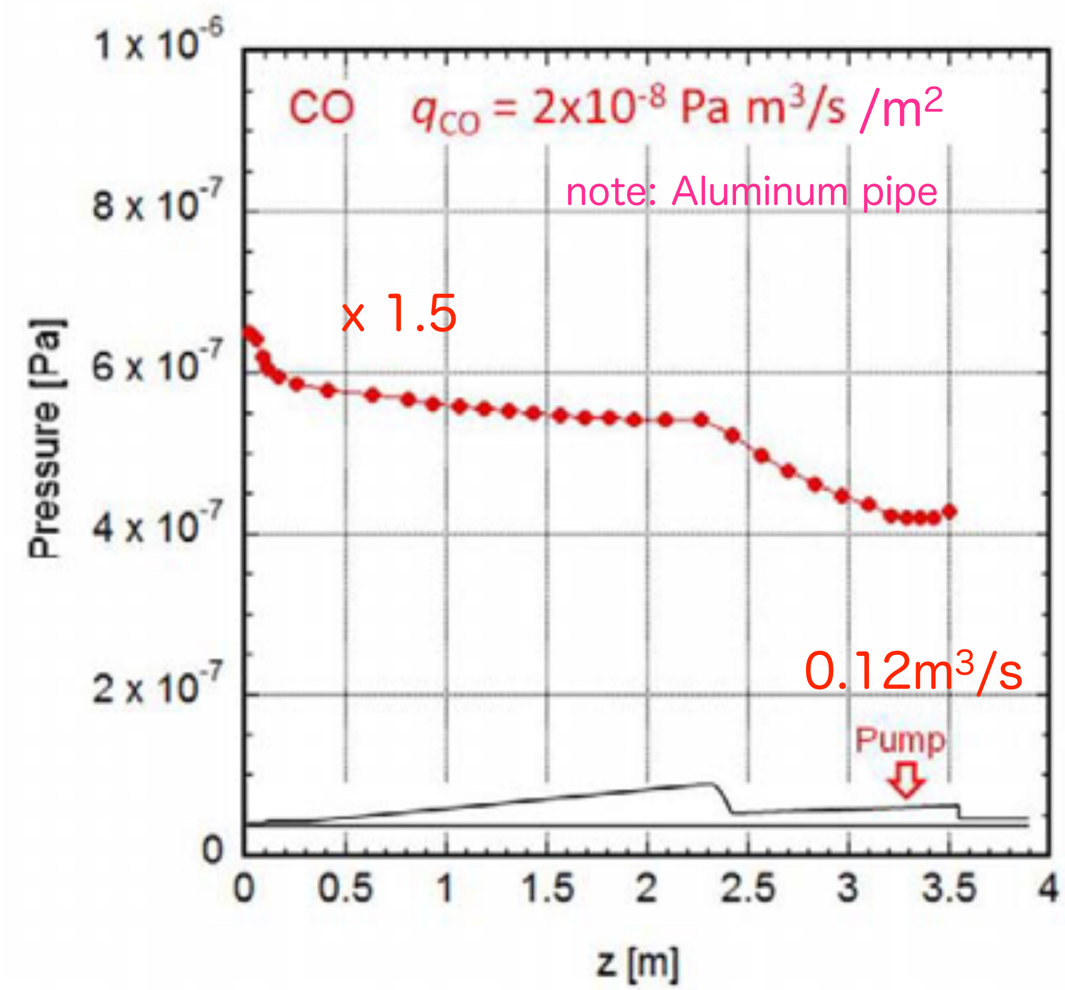


Calculation Model

(axisymmetrical 2D)





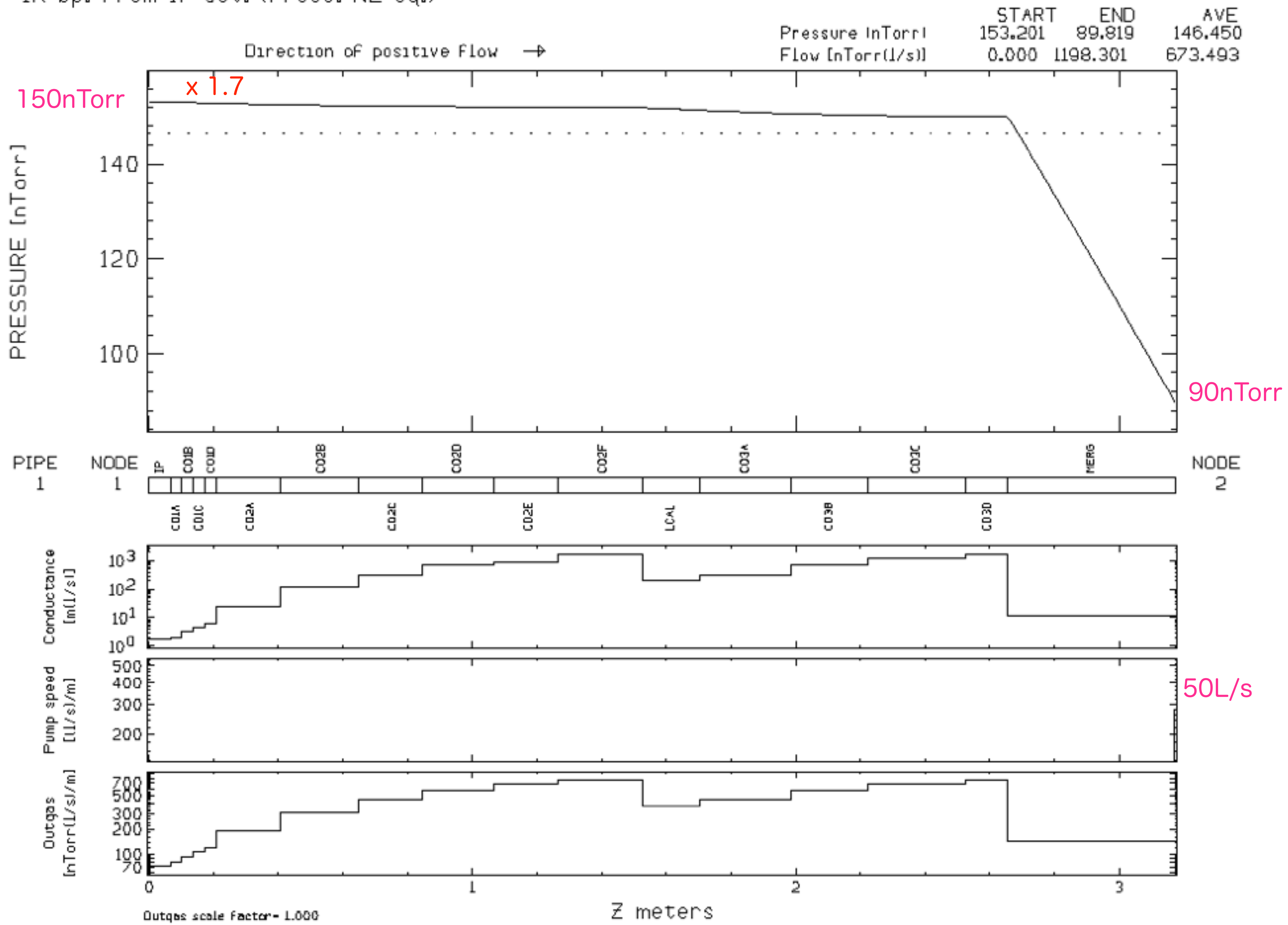


Also, see “Vacuum update”, M. Sullivan, MDI meeting, Jan. 26, 2012

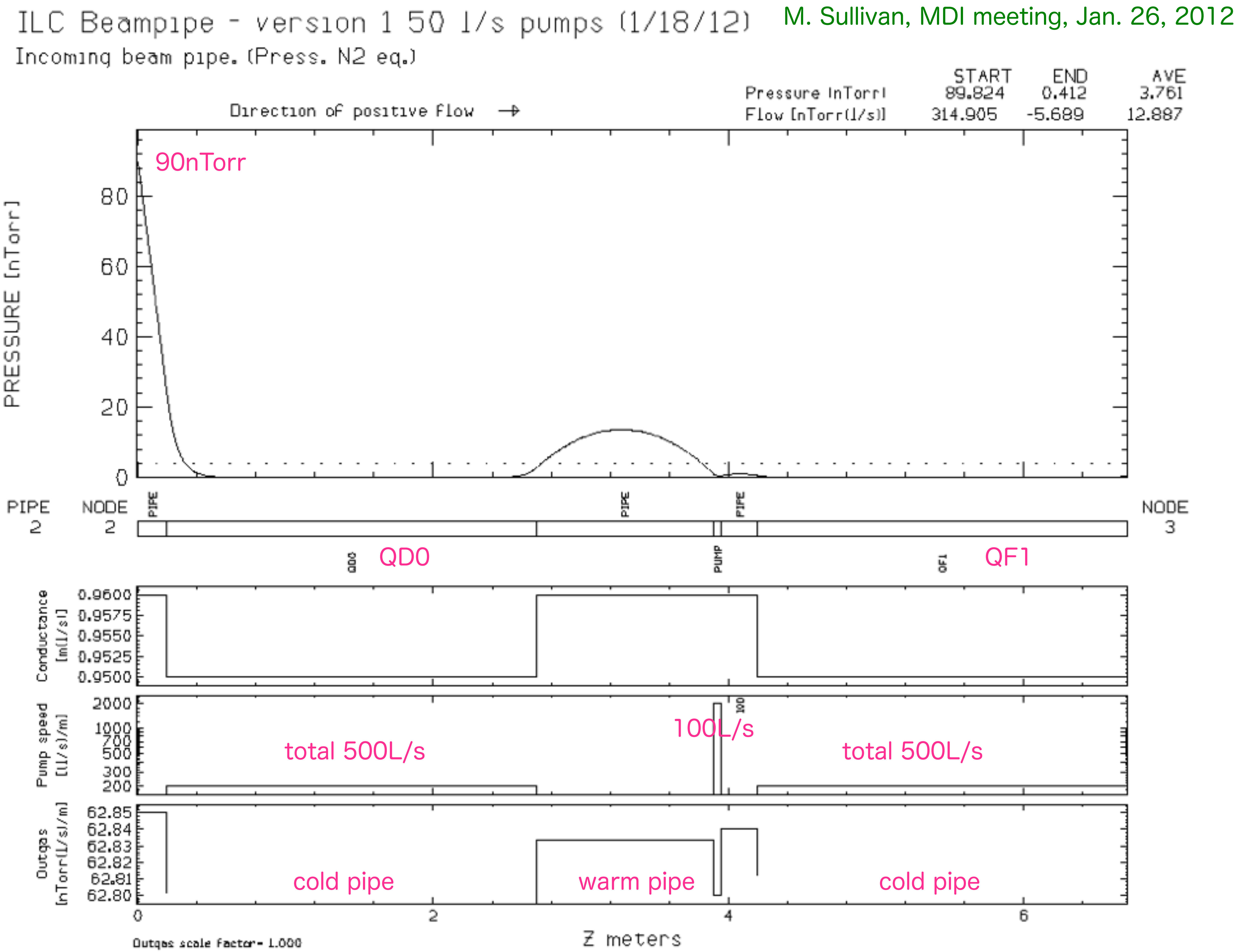
ILC Beampipe - version 1 50 l/s pumps (1/18/12)

M. Sullivan, MDI meeting, Jan. 26, 2012

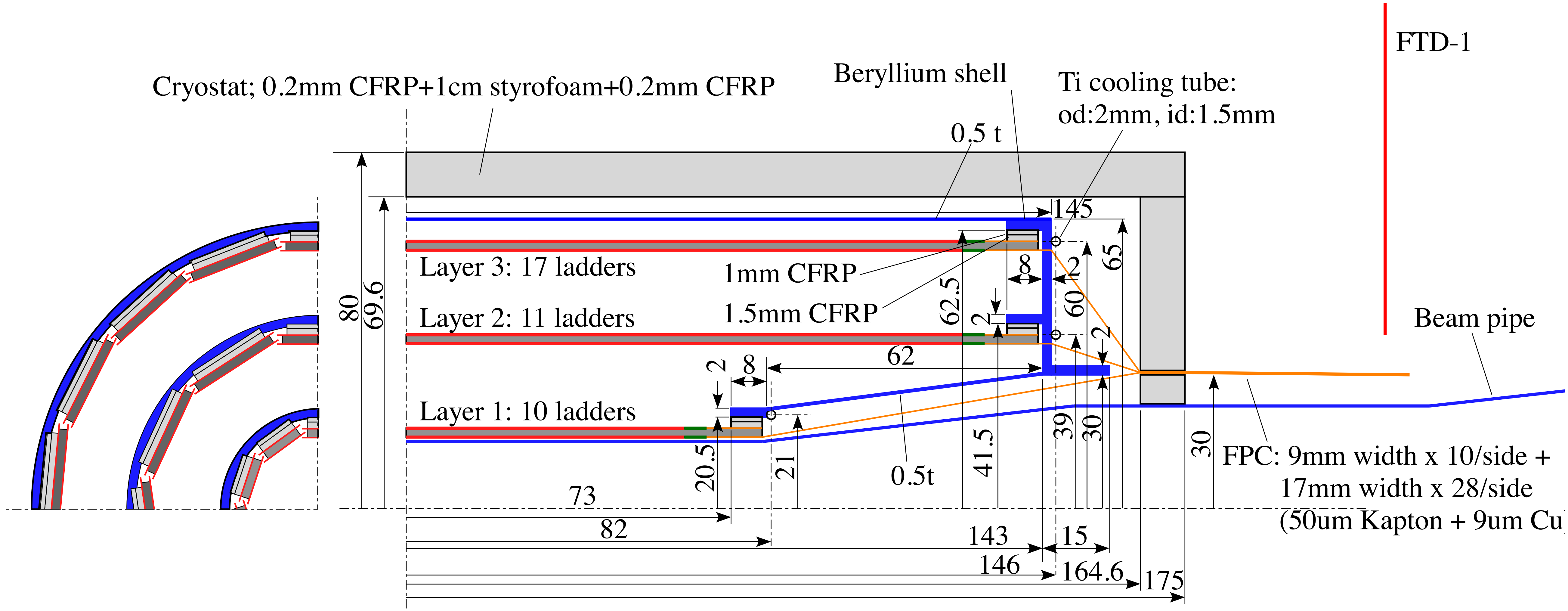
IR bp. From IP out. (Press. N2 eq.)



M. Sullivan, MDI meeting, Jan. 26, 2012



Vertex detector



0.5x2mm Be , 0.05x6mm Si, 0.2x2mm CFRP + 1cm styrofoam

Table III-2.1
Vertex detector parameters. The spatial resolution and readout times are for the CMOS option described in section 2.1.2.1.

	R (mm)	$\lvert z \rvert$ (mm)	$\lvert \cos\theta \rvert$	σ (μm)	Readout time (μs)
Layer 1	16	62.5	0.97	2.8	50
Layer 2	18	62.5	0.96	6	10
Layer 3	37	125	0.96	4	100
Layer 4	39	125	0.95	4	100
Layer 5	58	125	0.91	4	100
Layer 6	60	125	0.9	4	100

TPC inner field cage

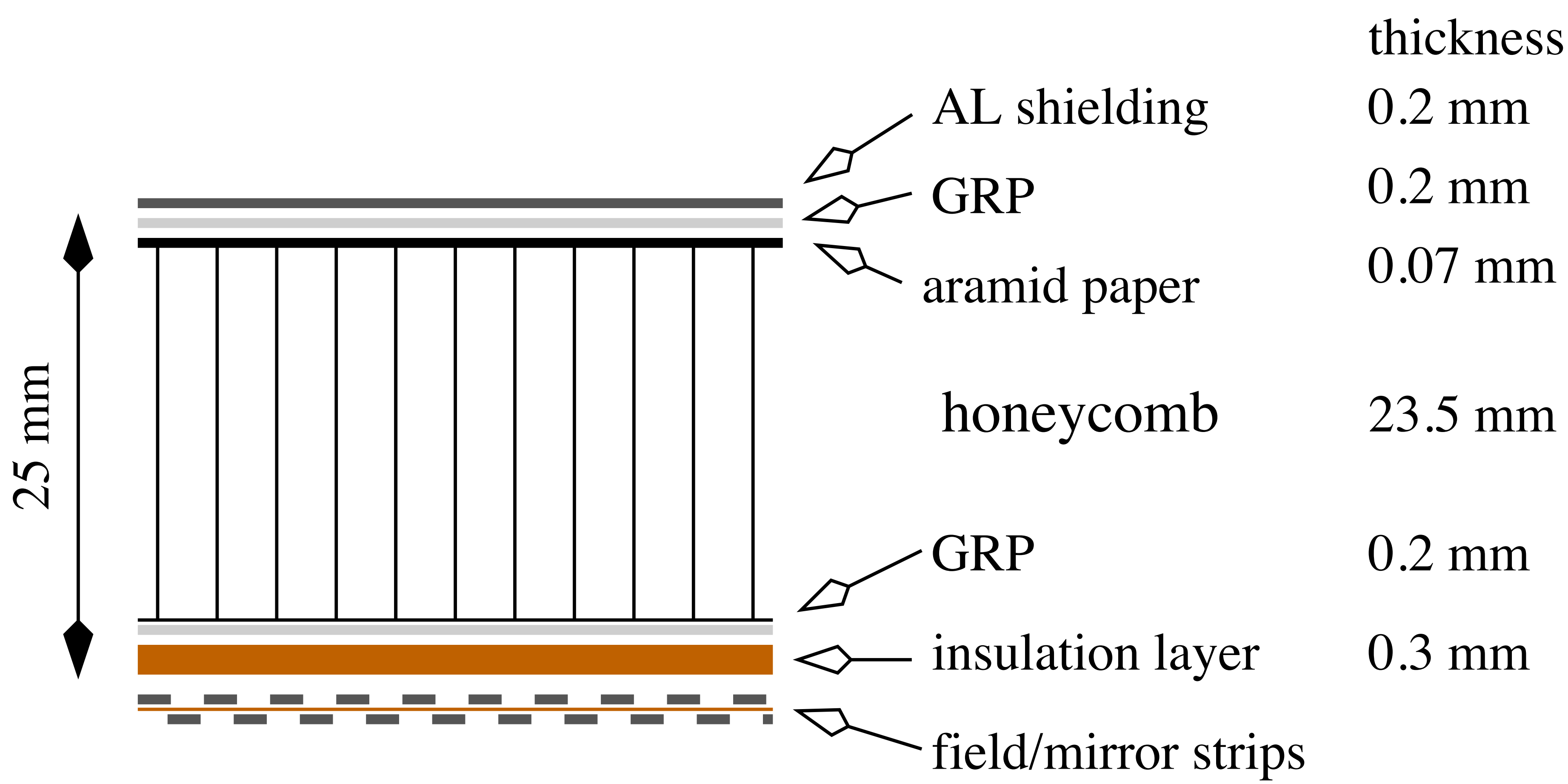


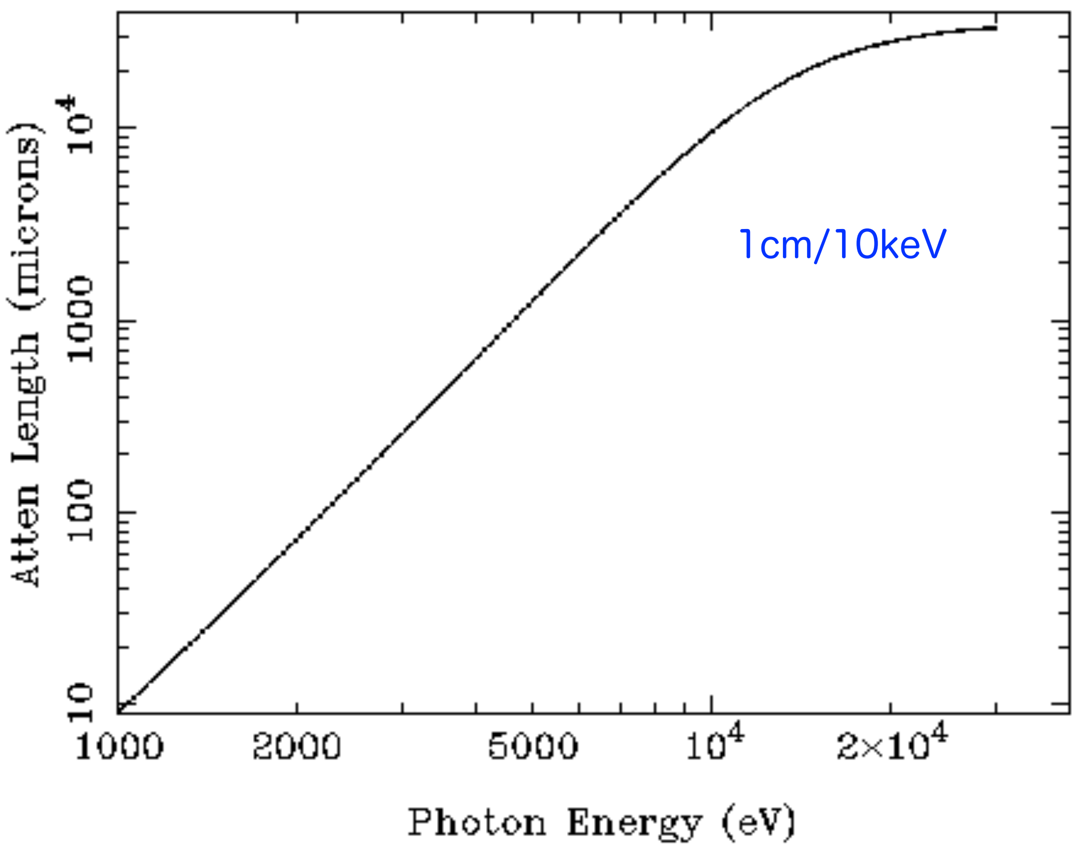
Figure 13: *First draft of the cross section for the wall of the inner field cage of the ILD TPC.*

A Lightweight Field Cage for a Large TPC Prototype for the ILC, T. Behnke et al., June 17, 2010, arXiv:1006.3220

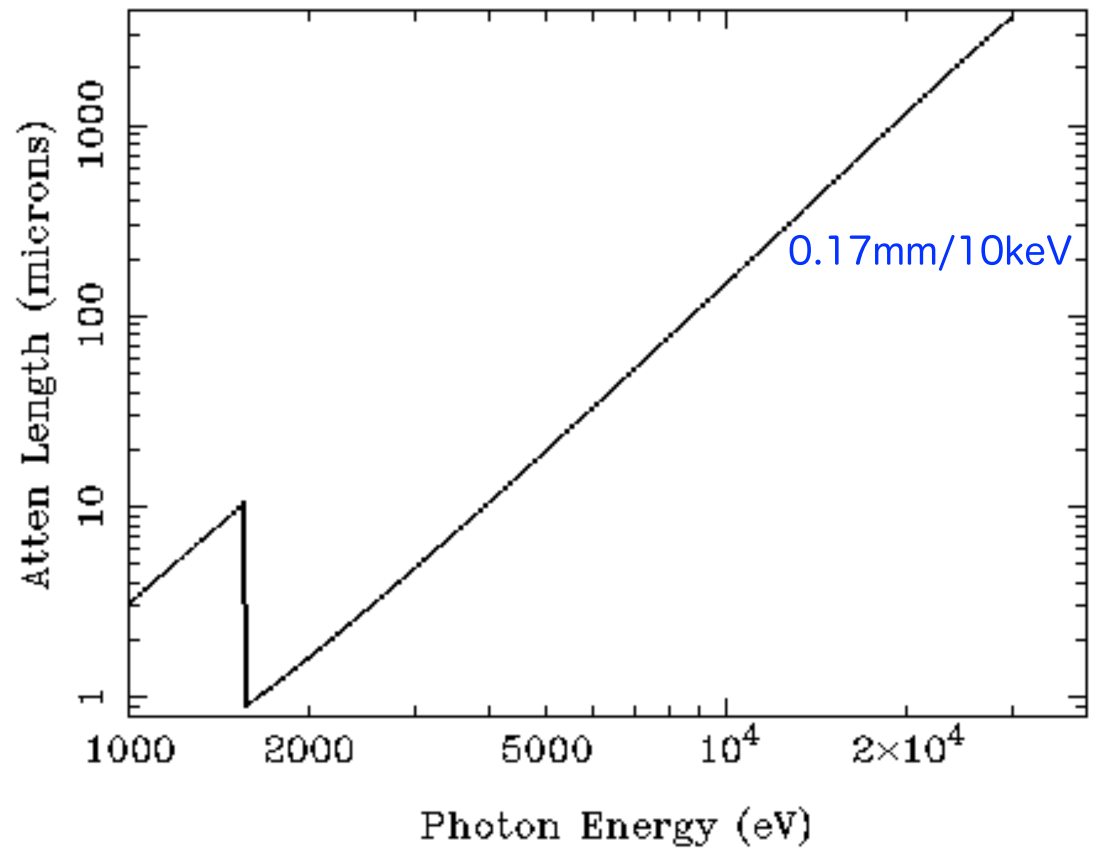
X-Ray Attenuation Length

http://henke.lbl.gov/optical_constants/atten2.html

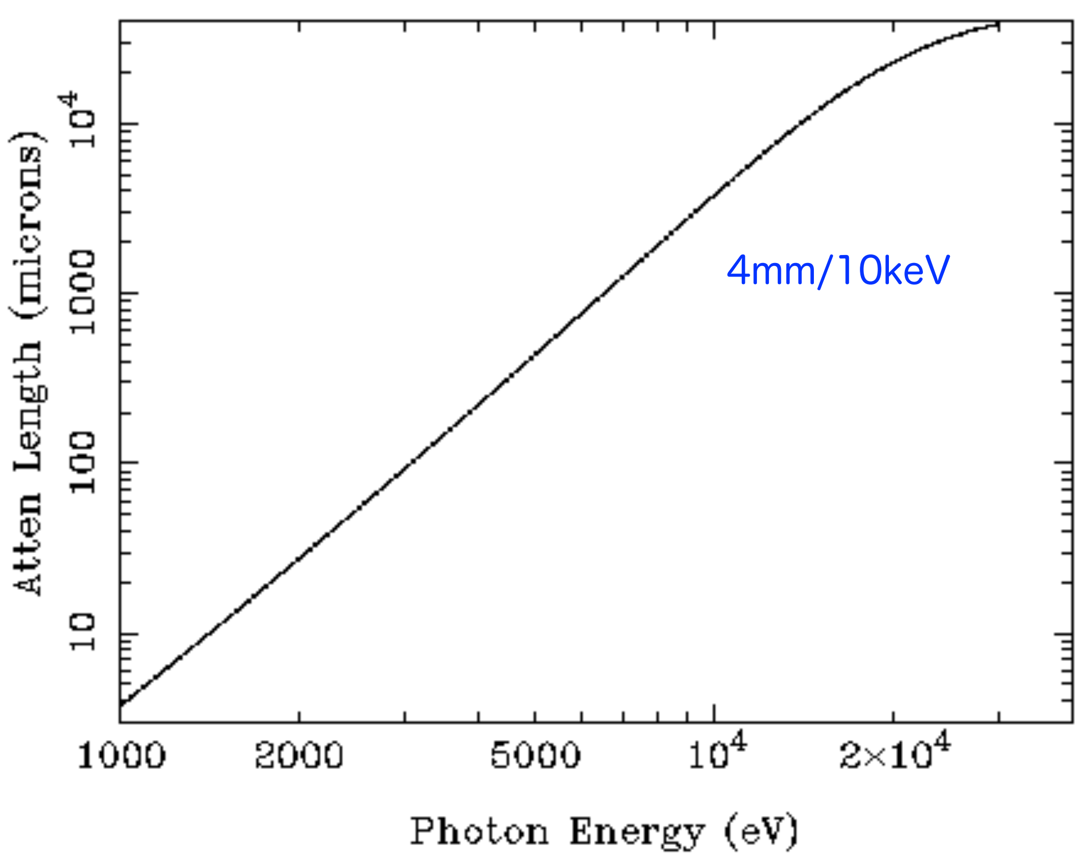
Be Density=1.848, Angle=90.deg



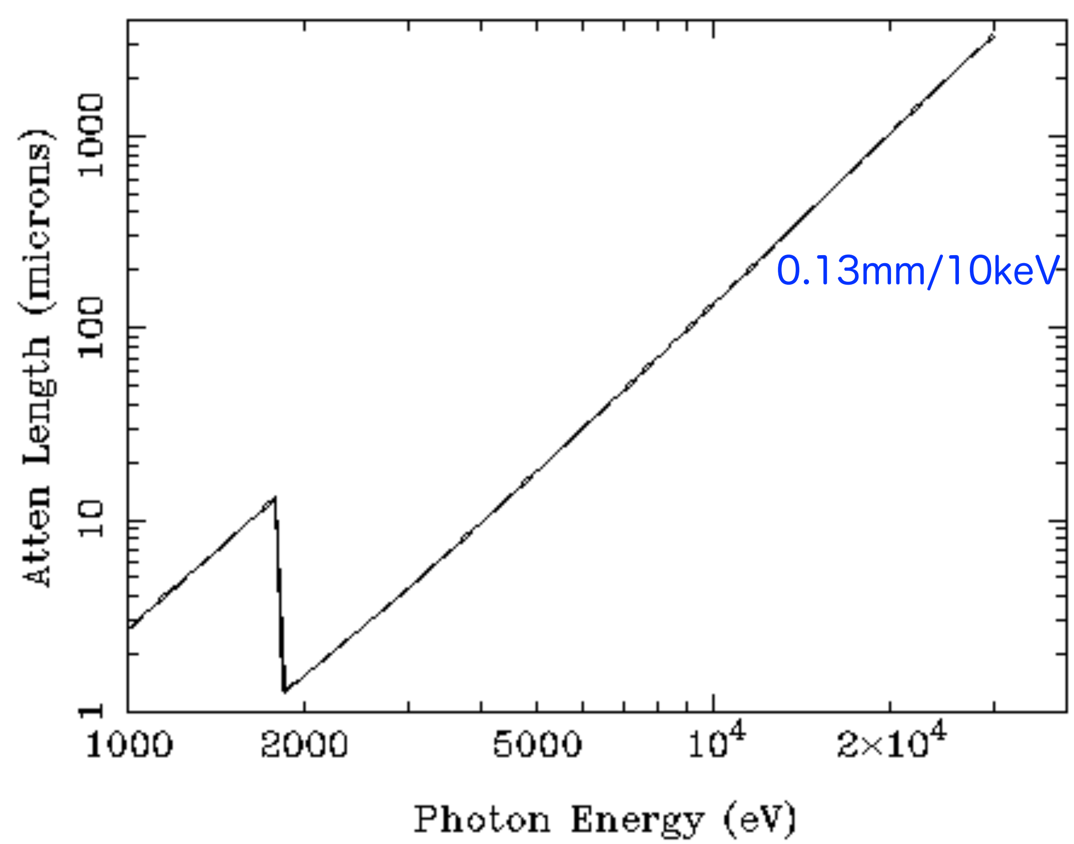
Al Density=2.699, Angle=90.deg



C Density=1.2, Angle=90.deg



Si Density=2.33, Angle=90.deg



Bremsstrahlung in residual gas

$$dN = N_b \rho \cdot 4\alpha Z^2 r_e^2 F(x) \frac{dk}{k} ds$$

s = path length

$$F(x) = (1 + x^2 - \frac{2}{3}x)\ln(183Z^{-1/3}) + \frac{x}{9} \qquad F(y) = (y^2 - \frac{4}{3}y + \frac{4}{3})\ln(183Z^{-1/3}) + \frac{1-y}{9}$$

$$x = \frac{E_e}{E_b}, \quad y = \frac{k}{E_b}, \quad x + y = 1 \qquad E_b = \text{beam energy}, \ E_e = \text{electron energy}, \ k = \text{photon energy}$$

residual gas density: $\rho = \frac{N_A}{22.4 \times 10^3} \frac{P(P_a)}{1.013 \times 10^5} \times 10^6 \qquad \rho = \frac{N_A}{22.4 \times 10^3} \frac{P(torr)}{760} \times 10^6$

$[\mathrm{m}^{-3}]$

fine structure constant: α = 1/137

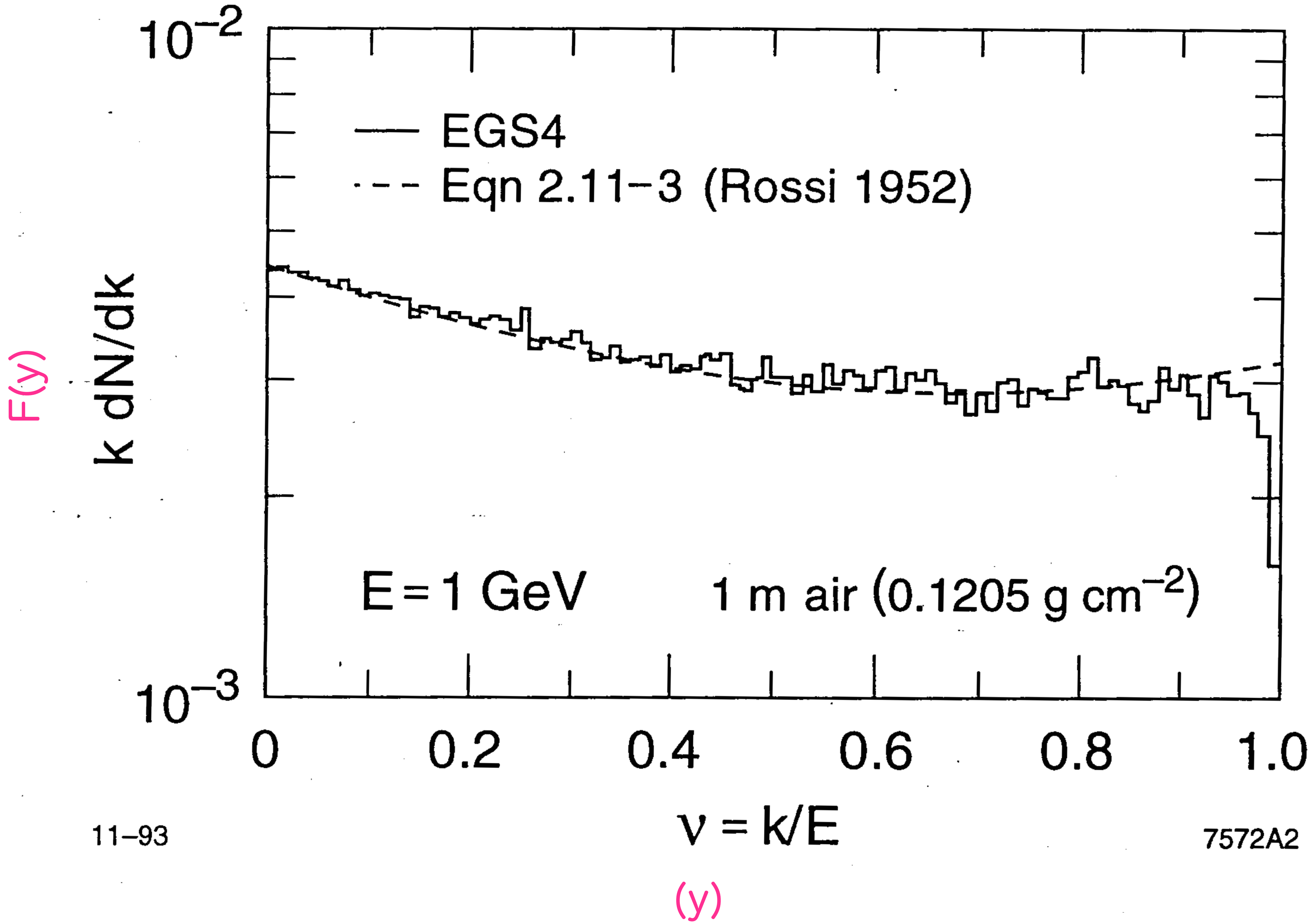
classical electron radius: $r_e = 2.82 \times 10^{-15}\mathrm{m}$

Avogadro constant: $N_A = 6.02 \times 10^{23}$

For residual gas, Z=14 of CO

beam intensity: $N_b = 2 \times 10^{10}$

Ref) J.C.Liu, W.R.Nelson and K.R.Kase, SLAC-PUB-6532, June 1994



J.C.Liu, W.R.Nelson an K.R.Kase, SLAC-PUB-6532, June 1994

F(x) is factorized as a constant, F(x)=F(y)=4.5 .

$$dN = 2 \times 10^{10} \cdot 4.55 \times 10^{-29} \cdot 4.5 \cdot \ln(k_{max}/k_{min}) \cdot ds \cdot \mathrm{P(Torr\ or\ Pa)}$$

(1) E_e <150GeV, L_{BDS}=200m, ILC-Note-2007-016, L/Keller, T.Maruyama, and T.Markiewicz

N = 2.9 x10^7 · P(Torr) / bunch = 2.2 x 10^5 · P(P_a) /bunch

N = 0.29 / bunch at 10nTorr → 0.02 (0.04) by GEANT3 (TURTLE)

(2) IR within ± L* =4.5 m for Xray background in TPC ?

If k_{min} = 10keV and k_{max} = 0.26GeV (m_e/k_{max} = R_{ex}/2L* , R_{ex}=1.75cm)

N = 1.5 x10^7 · P(Torr) / bunch = 1.1 x 10^5 · P(P_a) /bunch

N = 0.15 / bunch at 10nTorr

But, X-rays much go through the beam pipe, so they should be irrelevant .

Conclusion

Most of bremsstrahlung background would not come out the beam pipe between the two QD0's. So, the vacuum pressure could be higher than 10nTorr (1×10^{-6}Pa).

For ILD, need a simulation study especially by taking account of X ray background in the VTX and TPC.