Cornell ERL Vacuum System as a Model for ILC Damping Vacuum System Conceptual Design

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6" of Snow on 4/23 Ithaca

Outline – Why talking about Cornell ERL?

- There are similarities between the proposed Cornell ERL vacuum system and the ILC DR's
- Significant conceptual design work were done in the Cornell ERL vacuum system, such as basic building blocks and chamber, pumping and gauging, etc.
- A extensive cost estimate was recently commissioned by Research Instrument (an German consulting company, April 2010), based on solicited vendor quotes, using Cornell designs
- Designs from other institutes are also employed here

Cornell Energy Recovery Linac

Project Definition Design Report

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research instruments

Report/ Bericht

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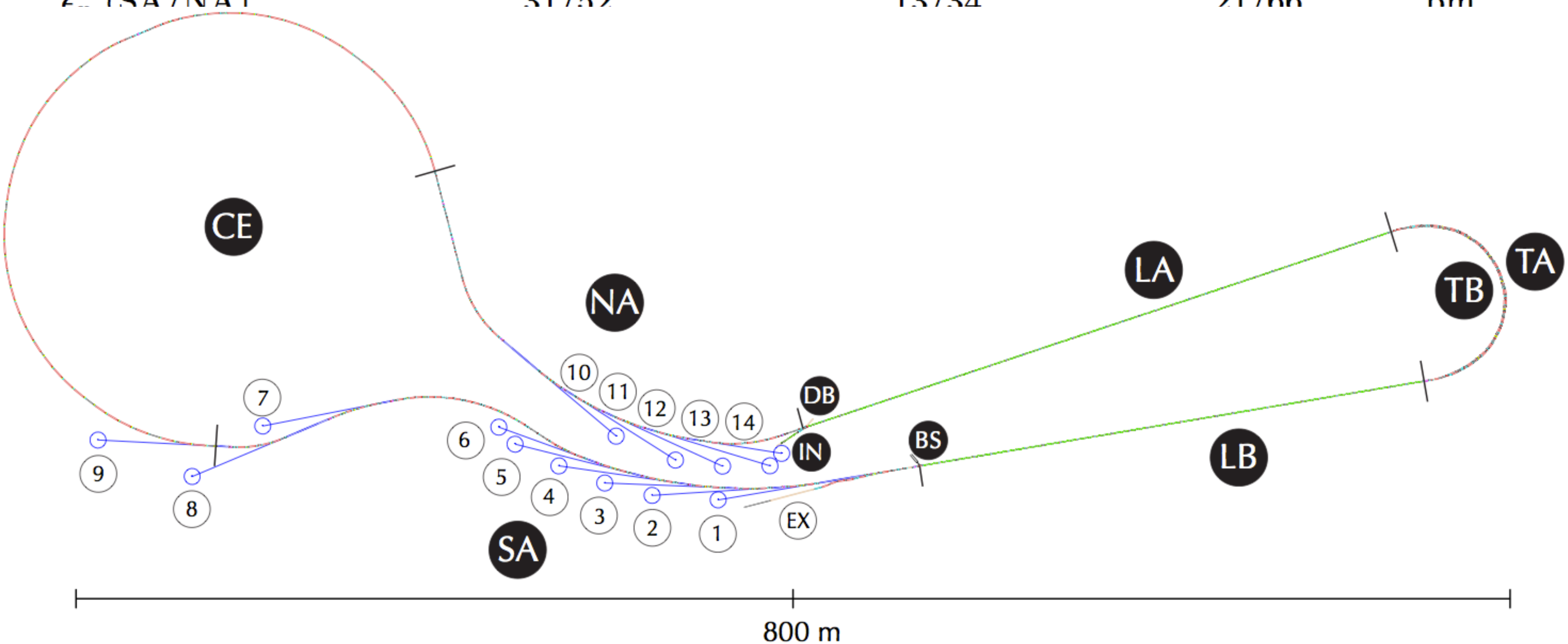
Cornell ERL Layout and Basic Specification

Operating Modes	A *High Flux*	B *High Coherence*	C *Short Bunch*	Unit
Energy	5	5	5	GeV
Current	100	25	25	mA
Bunch Charge	77	19	19	pC
Repetition Rate	1.3	1.3	1.3	GHz
ϵ_x (SA/NA)	31/52	13/34	21/66	pm



Building Blocks for DR Vacuum System

- Majority of vacuum chambers (drift beampipes, dipole and multi-pole vacuum chambers) are to be constructed from aluminum extrusions.
- Ante-chamber is to be incorporated in the extrusions, to minimize primary SR photons in the beam apertures
- Distributed pumping with NEG strips is the primary vacuum pumping, with sufficient discrete sputtering-ion pumps for start-up and for handling NEG activations

Chamber Design Examples – I

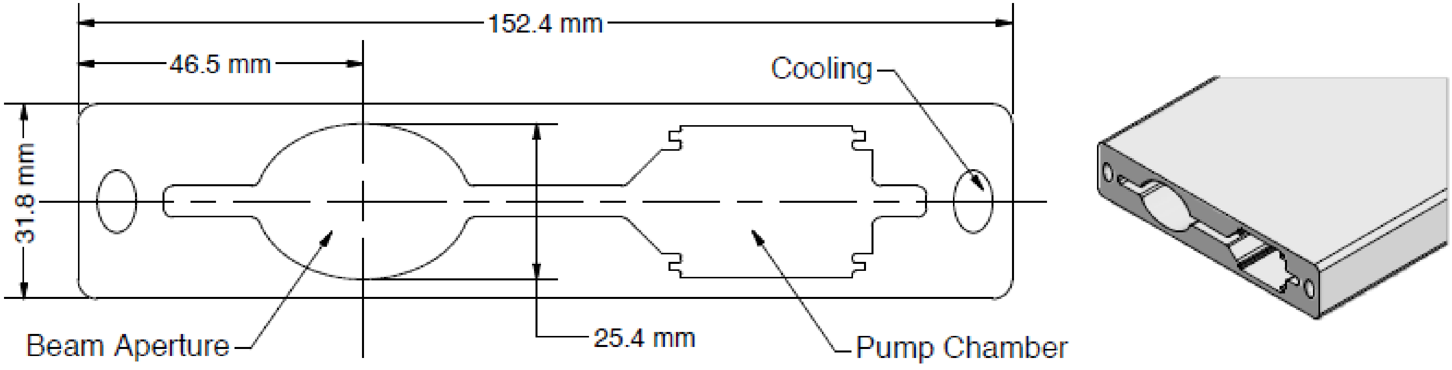


Figure 0.1.1: Extruded aluminum chambers comprise the beam aperture and the ante chamber for pumping and cooling channels.

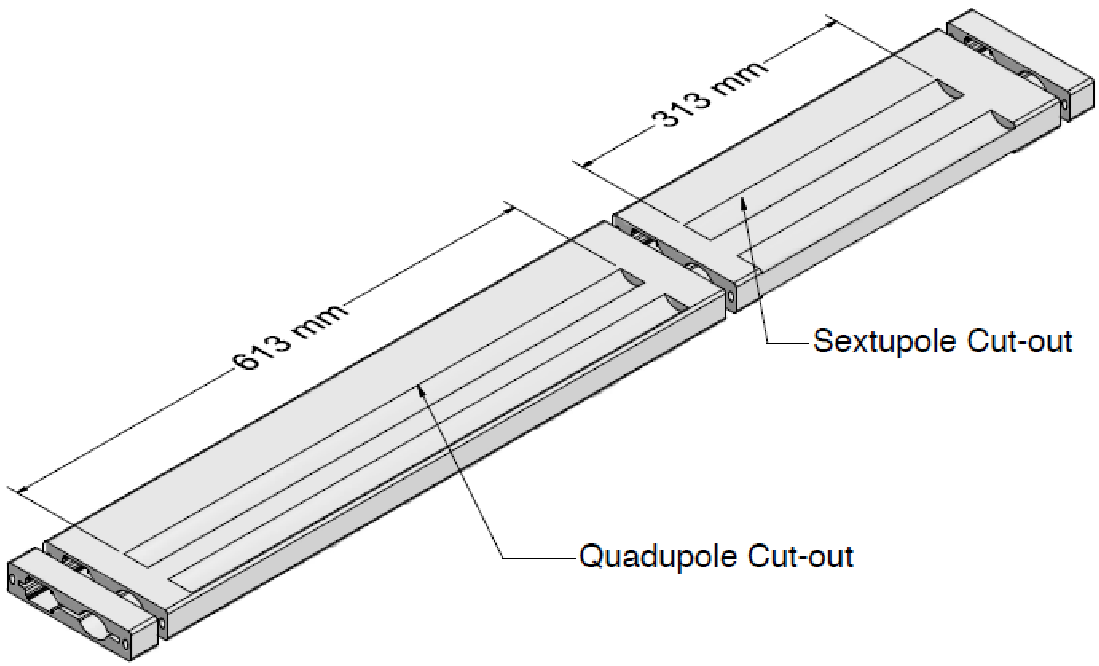


Figure 0.1.2: The extrusion with pole-tip grooves for both quadrupole and sextupole magnets

Chamber Design Examples – II

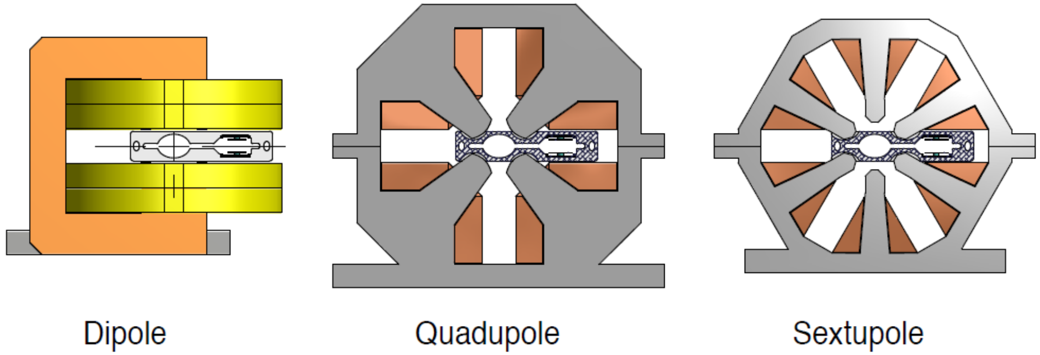


Figure 0.1.3: Cross sections of the beampipe extrusions and magnets at dipole, quadrupole and sextupole magnets.

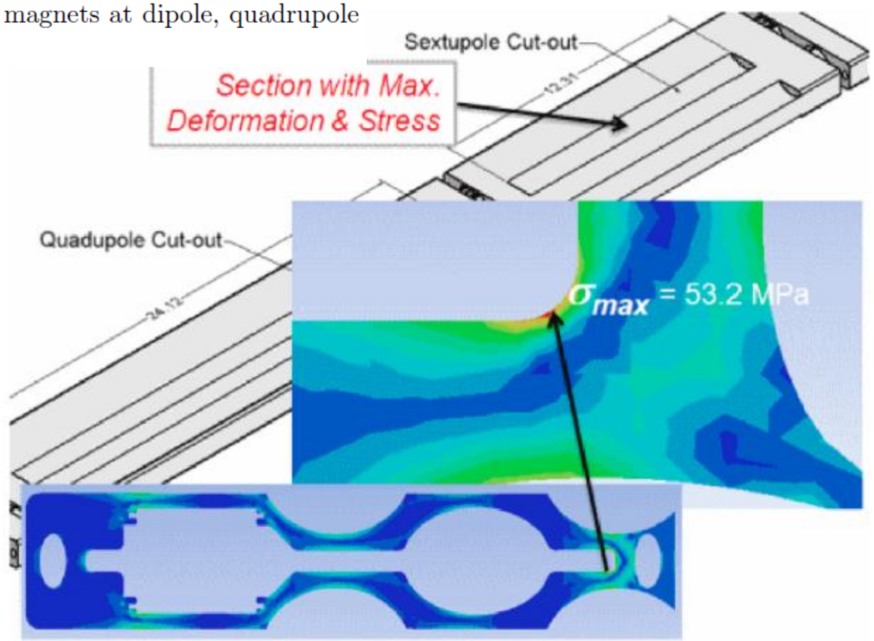


Figure 0.1.4: Calculated deformation of the chamber extrusion after pole-tip grooving. Maximum deformation is ≈ 0.1 mm in the middle of a sextupole magnet, and maximum stress at the corner is ≈ 53.2 MPa, well below material yield stress of 240 MPa for 6063-T6 aluminum alloy

Chamber Design Examples – III

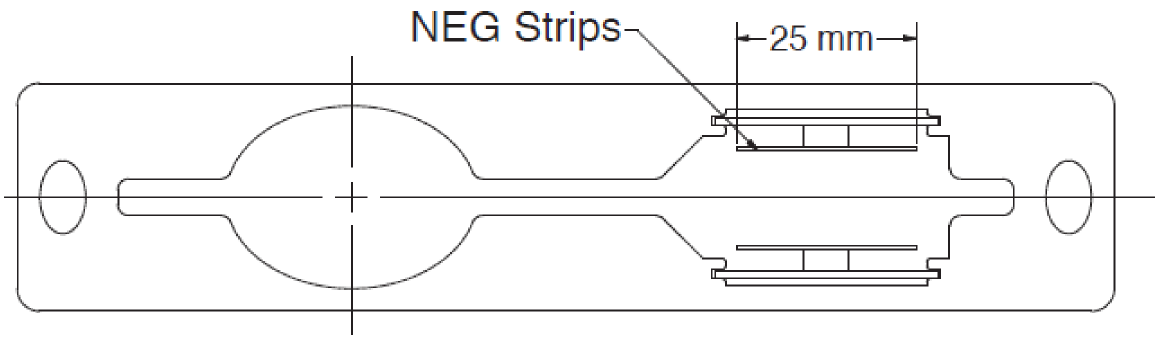
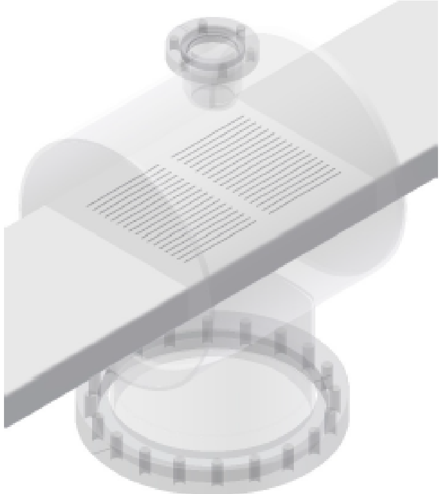


Figure 0.1.5: NEG strips are mounted in the ante-chamber, located on the radial outside of a bending magnet, close to the SR-induced gas load.

(a)

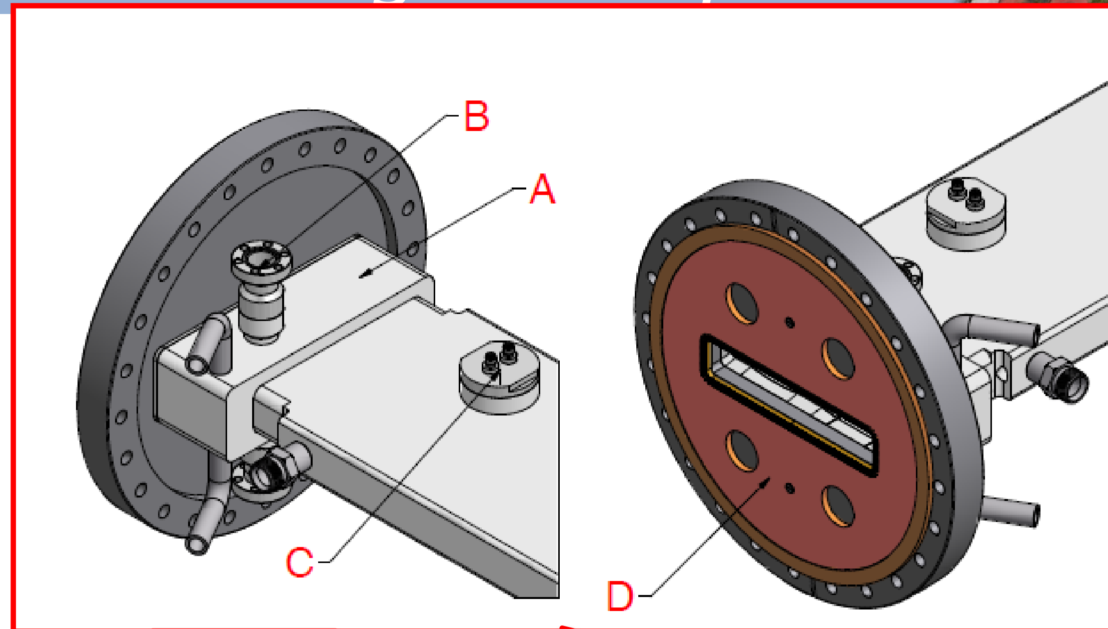


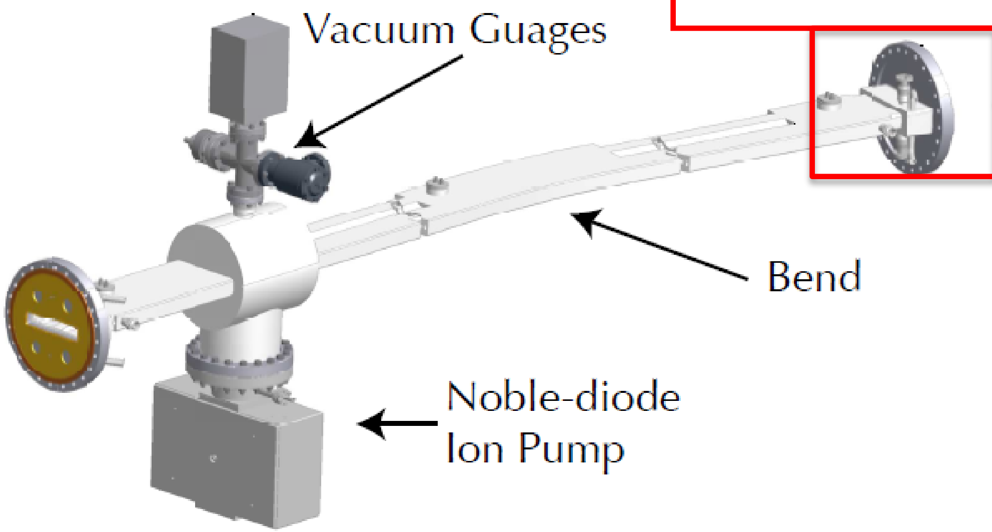
(b)

Figure 0.1.6: Lumped pumps are installed at pump ports comprising a shroud (Fig. 0.1.6a) welded around the extrusion with pumping slots and (Fig. 0.1.6b) cutting through both top and bottom.

Chamber Design Examples – IV

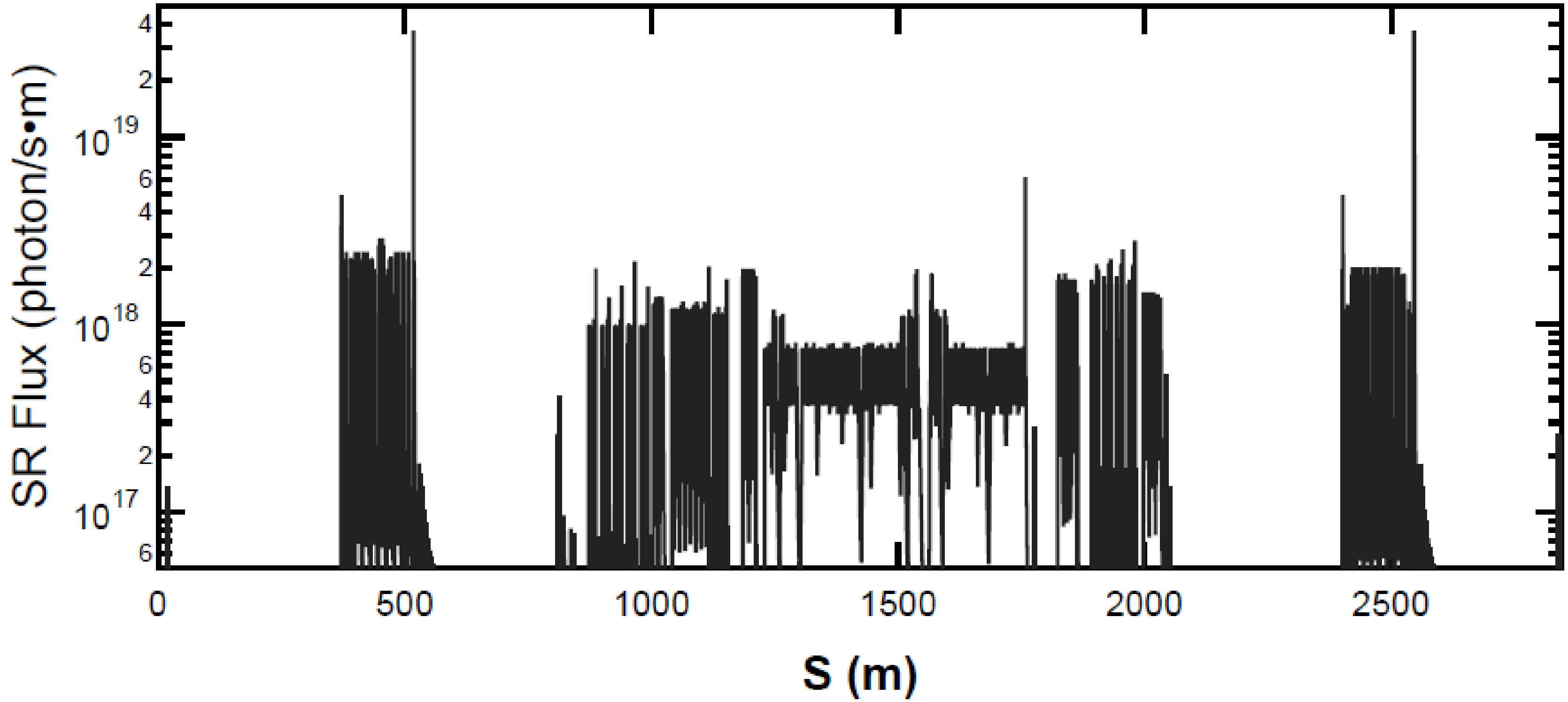
A: Alum/SST Transitions
B: NEG Port
C: BPMs
D: RF Gap Ring





A vacuum chamber with integrated vacuum pumps, gauges, BPMs and features to accommodate dipole, quadrupole and sextupole magnets.

SR-Induced Gas-Load



$$\dot{Q} = \eta_{\mathrm{ph}} \cdot F_{\mathrm{SR}} \quad \eta_{\mathrm{ph}} \propto D^{-\alpha}$$

SR-Induced Gas-Load

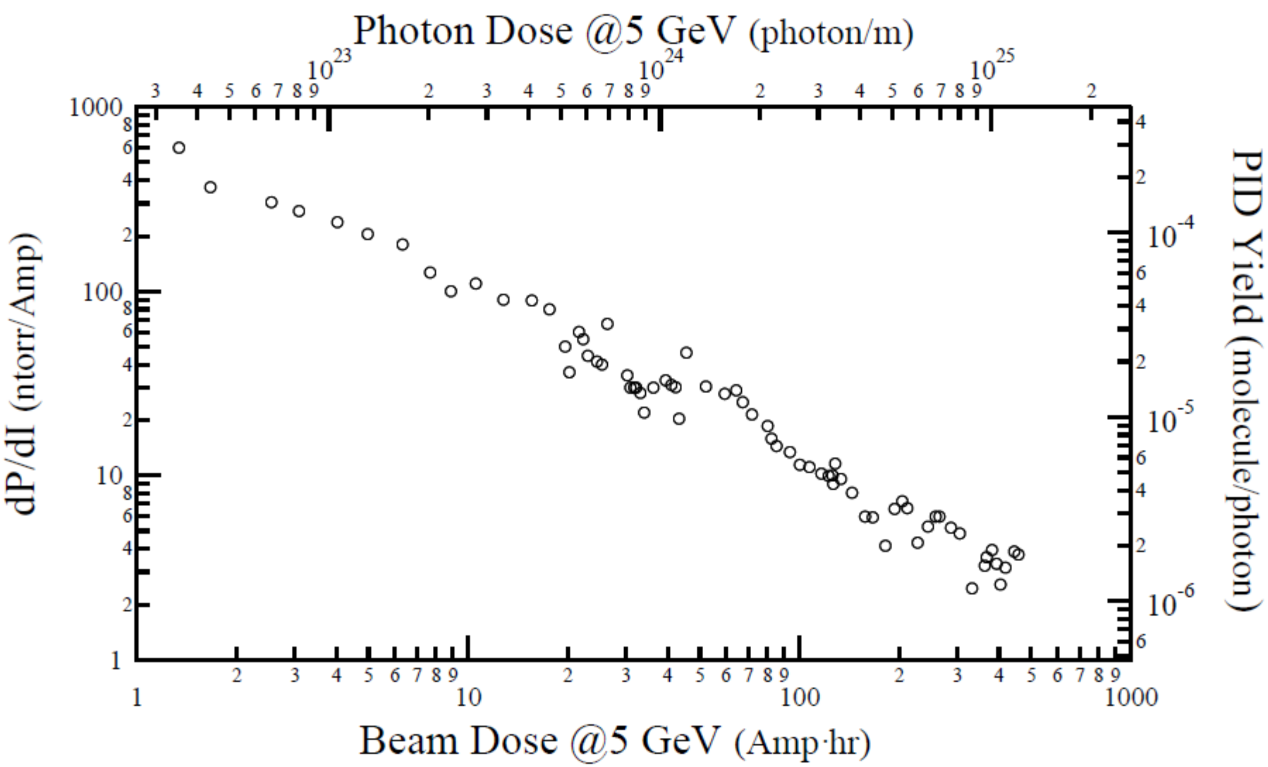
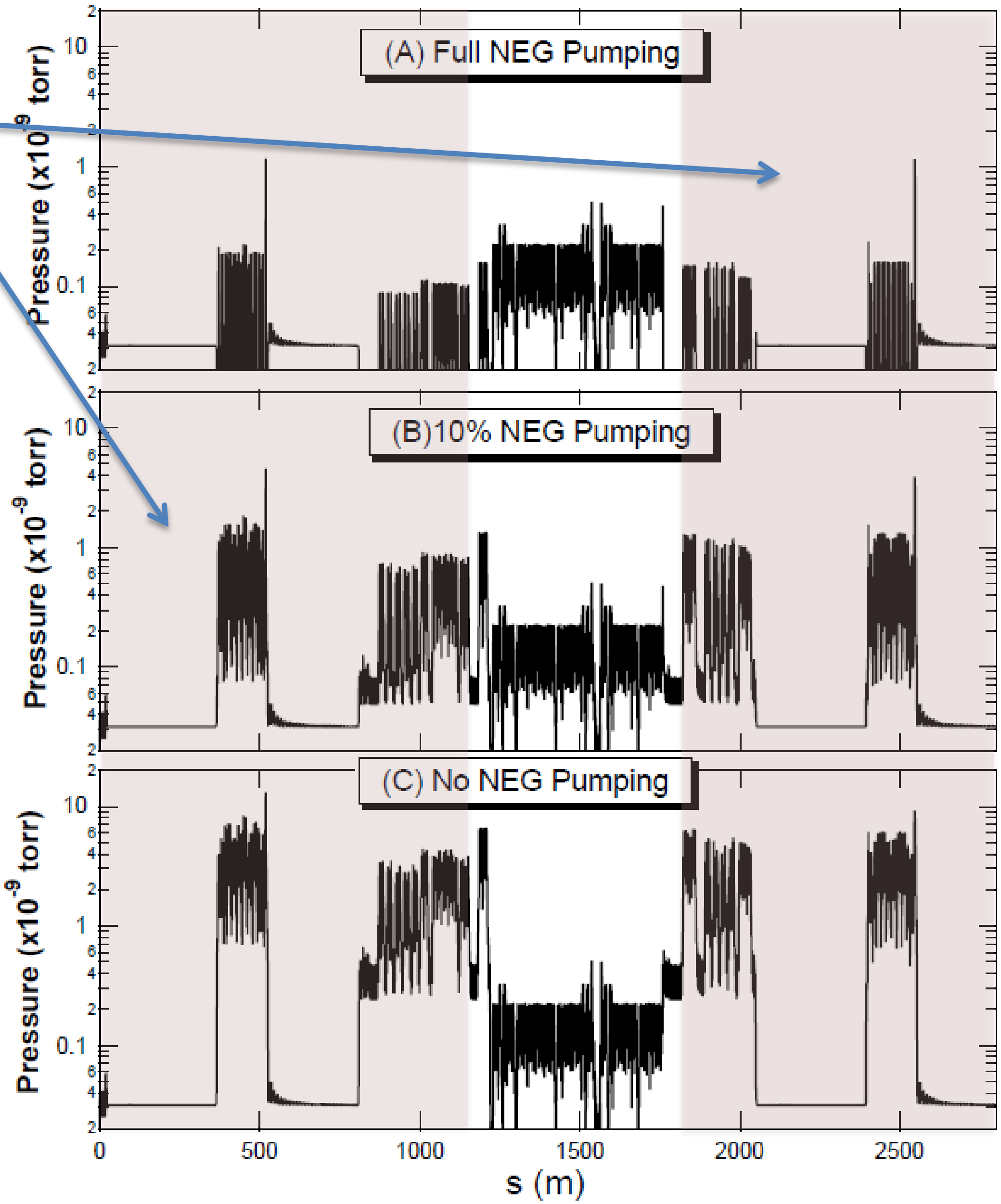


Figure 0.1.13: A typical vacuum-beam conditioning trend of a newly installed aluminum chamber in a CESR dipole magnet.

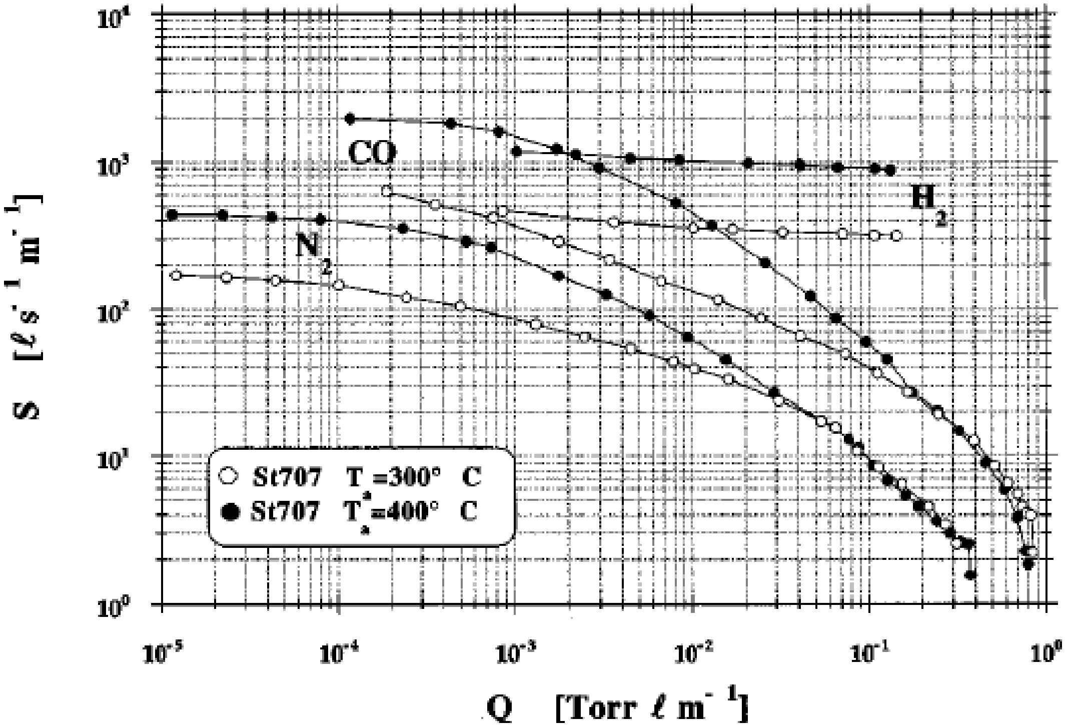
$$\eta_{\rm ph} \propto D^{-\alpha}$$ with α = 0.6 ~ 1.0

Pressure Profile Calculations

Arcs (TA/TB)
& "Drifts' (IDs)



NEG Strip Pumping Capacity



- In the Cornell ERL vacuum system design, sufficient NEG pumping capacity is build in to provide adequate running period between activations
- ILC DR design need to a similar estimation

Table 0.1.2: NEG Duration with continuous 100 mA Operation

Section	Average SR Flux (Photon/s/m)	SR Gas-load (CO-equivalent) (Torr×l/s/m)	Time before losing 50% pumping speed (Days at 100mA)
TA	7.80×10^{16}	2.21×10^{-10}	89
SA	3.42×10^{16}	9.68×10^{-11}	203
NA	3.91×10^{16}	1.11×10^{-10}	178
TB	6.49×10^{16}	1.84×10^{-10}	107

Brief Summary – More to Come

- Used Cornell ERL vacuum system conceptual design as a model for ILC DR vacuum system cost estimation
- Similar vacuum pumping for arcs and drifts is figured in the ILC DR design.
- For locations with very high dynamic gas load (such as the photon absorbers for the wigglers), high capacity TiSPs are used.
- See more from Joe's presentations