Neutrino Factory Vacuum Parameters

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Outline

- Front End
  - Induction Linac
  - Cooling
  - Others
- Acceleration
- Muon Storage Ring

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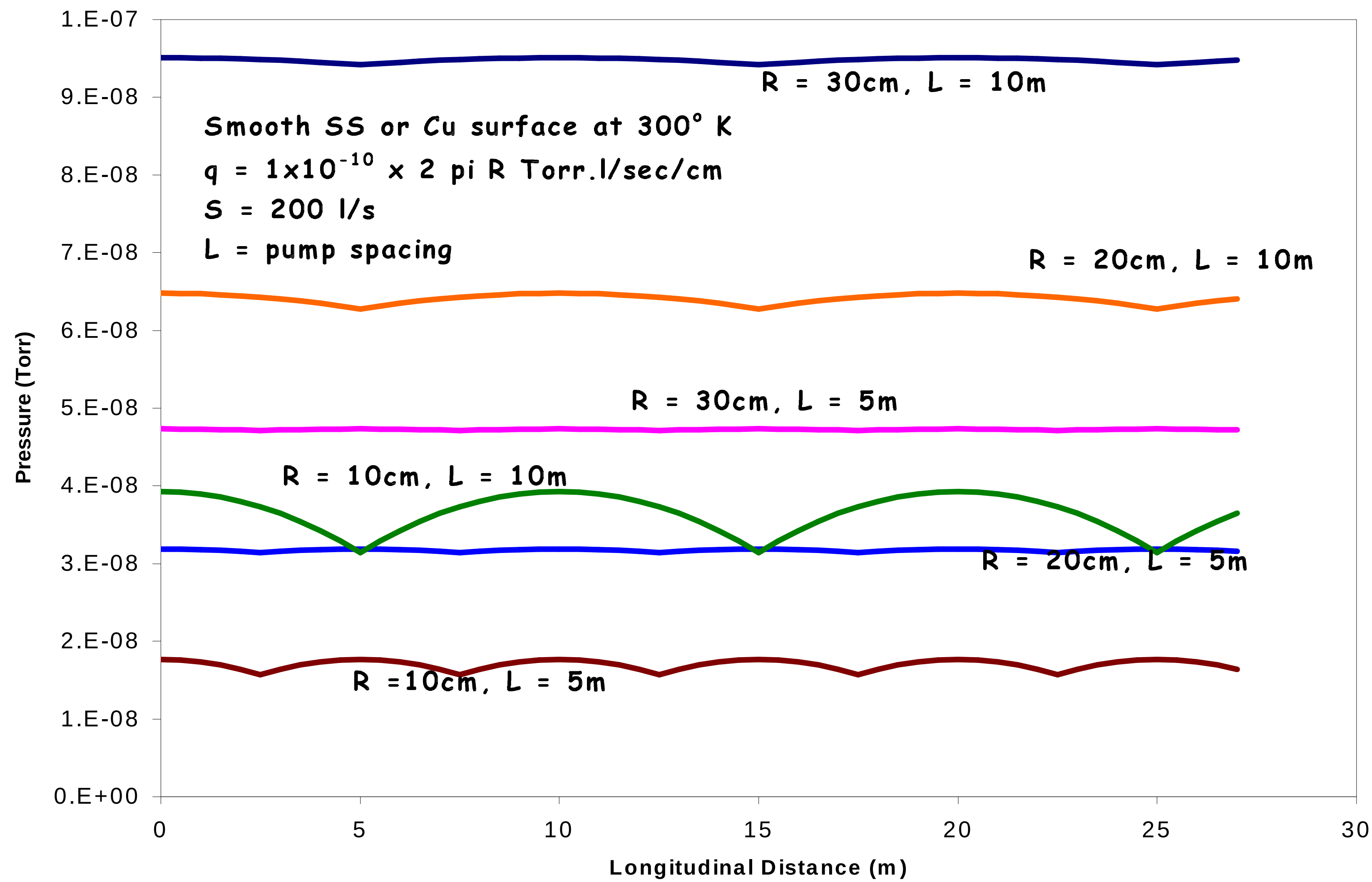
Front End Vacuum Parameters

- Distinct (complicated?) vacuum systems – 2 k, 4 k, 16 k, 300 k
  - Need to define vacuum requirement for each sections
    - Assume no significant beam induced vacuum phenomena
      - straight single path therefore - no desorption…
- Cold sections: UHV (<< 10^{-9} Torr) achievable due to low (zero?) outgassing and large cryopumping
  - If no H_2 & He leaks into beam and insulating vacuums
- Warm sections: HV of 10^{-8} to 10^{-6} Torr
  - Most sections have sufficient linear conductance *C'*
    - $C' ; R^3$ so the pumps can be spaced
  - Assume non-bakeable, smooth all metal chambers and components
  - No high outgassing components in vacuum

Front End Vacuum Parameters (contd.)

- Induction Linacs
  - Need 10^{-8} Torr to prevent multipacting and voltage breakdown
  - One pumping port of ~ 6" ϕ every 5 m
  - No magnet core or ferrite in vacuum
- Cooling Sections
  - Need 10^{-8} Torr to prevent multipacting and voltage breakdown
  - Cryopumping by SC RF cavities and LH_2 absorbers
  - Adequate access ports for pumping and monitoring?
  - Integrity of LH_2 windows and Be windows, H_2 leaks, safety…
- Drift sections - 10^{-7}, 10^{-6} Torr
- Matching, Mini-cooling & Bunching sections - ???
- Differential pumping between sections of diff. vacuum requirements!
- Isolation and protection of sections by gate valves or windows

Pressure Distribution versus the Vacuum Chamber Radius and Pump S



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Accelerator Vacuum Parameters

- Vacuum of < 10^{-11} Torr in accelerator sections
  - due to cryopumping by 2°KSC RF (if no He leaks)
  - Clean room technology for cavity fabrication
  - Isolation and pumping of modules after initial conditioning
    - Need warm space for gate valves, pumps and gauges
    - Monitoring and interlock of RF windows at power couplers!
  - Insulating vacuum for SC RF!
- Vacuum of 10^{-8} Torr in the warm arcs
  - Pumped by ion pumps every 5-10m (depending on cross section *A*)
    - or pump from both ends if *A* is significant (**$C' \propto R^3$**)
    - or with Distributed Ion Pumps (DIPs)
      - ***complicated chambers, feedthroughs, holding pumps…***
- Differential pumping bet'n SC RF & Warm to minimize contamination
- Isolation and protection of sections by gate valves
  - Large (> 8") all-metal gate valves not commercially available!

Mu SR Vacuum Requirement

- Nuclear scattering - $\sigma_\mu (CO) \sim 1\times10^{-25}$ cm^2
  - $P \sim 5\times10^{-4}$ Torr if $dI/I \sim 1\times10^{-4}$ over 2msec
  - Heat load to chamber wall due to lost muons
    - ~ 5 watts per Arc at $dI/I \sim 1\times10^{-4}$ (assume 100%)
    - E-M shower from lost μ and the resulted desorption?
    - Not an issue if $P < 10^{-6}$ Torr
- Multiple Coulomb scattering and emittance growth
  - even less an issue
  - $d\varepsilon/\varepsilon \sim 1\times10^{-5}$ at $P \sim 5\times10^{-4}$ Torr
- Need 10^{-7} Torr for ion pump lifetime, beam diagnostics…
  - but not for μ

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Mu SR Outgassing and Desorption

- $Q_{thermal}$ ~ 1×10^{-4} Torr.l/sec per 53m Arc
- SR from muons (1000 turn of 3×10^{13} u x 2.5 Hz)
  - ~ 2×10^{19} photons/sec/Arc of E_c of 0.12 eV
  - ~ 0.1 watts per Arc
  - No desorption (need > 5 eV to generate photoelectrons)
- SR from electrons (1 turn of 3×10^{13} e x 2.5 Hz)
  - 7×10^{15} photons/sec/Arc with $E_c(h\nu)$ of 45 keV
  - ~ 16 watts per Arc
  - ~ 2×10^{-5} Torr.l/sec/Arc if η ~ 1×10^{-1} (< $Q_{thermal}$)
- Desorption due to electron loss (3×10^{13} e x 2.5 Hz x 7 GeVx10%)
  - < 10 kW per Arc
  - E-M shower and electron stimulated desorption?
  - Thermal desorption from collimators/shields (with water cooling!)?

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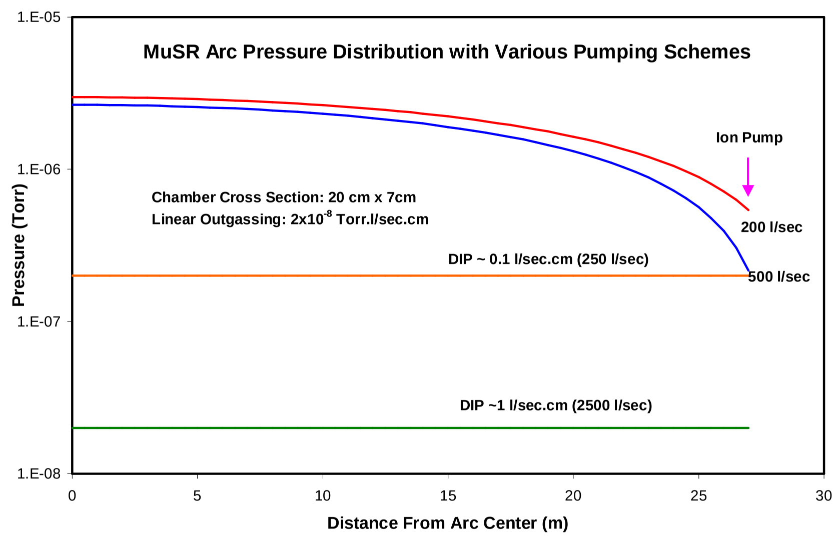
Pressure in Mu SR

Straight sections: one 200 l/sec ion pumps / 10 m P_{avg} ~ 10^{-8} Torr

Arcs: (1) DIPs < 10^{-7} Torr (engineering, service, access, feedthroughts…)

or (2) Lumped ion pumps at both ends: P_{center} > 10^{-6} Torr



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Other Vacuum Related Issues

- Insulating vacuum for SC RF or Solenoids:
  - Vacuum of < 10^{-5} Torr; Most difficult due to potential He Leaks
  - Common volume w/o vacuum barriers (RHIC experience!)
  - Reduce # of warm-cold transitions (reliability, $$$ and heat load)
- Simple design ⇒ cost and reliability, especially SC elements
- Vacuum requirements for beam diagnostics (IPM, Harp…)
- Insulating vacuum vessel wall as beam tubes in MuSR arcs?
  - Or 80° K heat shield as beam tubes
    - ***Logistics, desorption, outgassing, heat removal….***
- Vacuum monitoring inside the warm Arcs (Accel. & MuSR)
- Pumping and monitoring inside the cooling and SRF sections
- Need more information for "Vacuum Implementation"
  - Scope: pumps, gauges…. or vacuum chambers….or insulating vacuum, impedance, technical writeup…& cost estimate?

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