Beam - related vacuum requirements for PXIE

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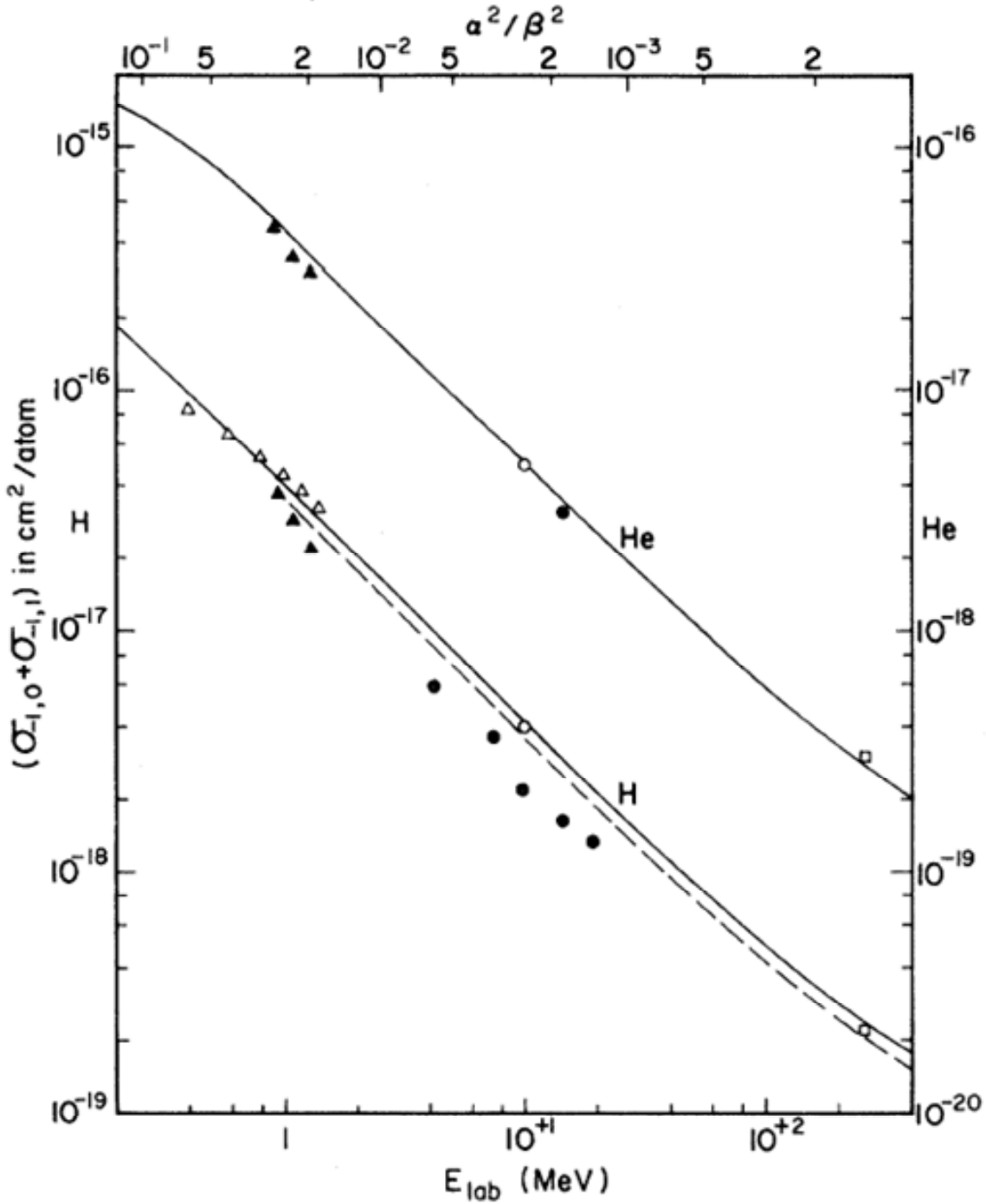
Beam Intensity, Gas Load, Pumping Speed and Vacuum

- Direct flux of protons from H- beam makes major contribution to the gas load
  - 5 mA = $3.1 \cdot 10^{16}$ atoms/s = $4.4 \cdot 10^{-4}\ l \cdot torr/s$ for H_2
- Spattering
  - For 2.1 MeV has comparatively weak dependence on material
  - Rough estimate for Cu, E=2.1 MeV, θ = 29 mrad
    - W $\approx 6 \cdot 10^{-3}$ atoms/proton dx/dt $\approx$ 1.5 atomic layers/min
    - stop length $\approx$5 μm
      $\Rightarrow$ Penetration $\approx$0.15 μm $\approx$ 600 atomic layers
  - Even if all spattered material would be converted to gas it would make less than 1% contribution to the gas load
  - All atoms absorbed on the surface should be removed within few minutes of full power operation
- For 1000 l/s pumping speed P $\approx 5 \cdot 10^{-7}$ torr of H_2

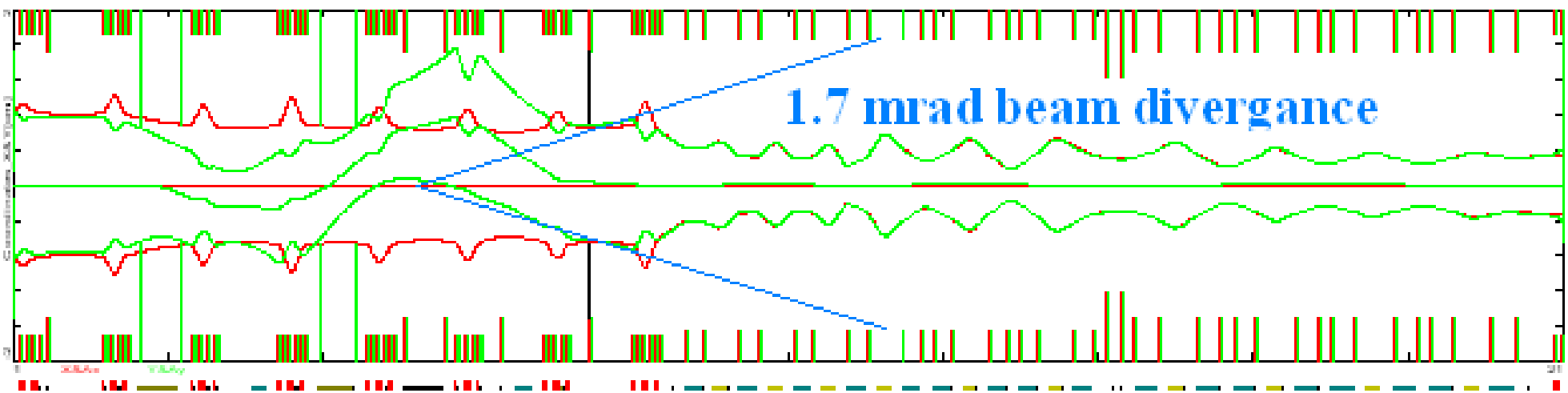
H^- stripping

- Stripping cross-section
  $\sigma \approx 0.4 \cdot 10^{-16}$ cm^{-2}
- Stripping probability
  $W = 1.4 \cdot 10^{-4}$
  for $P \approx 5 \cdot 10^{-7}$ torr of H_2
  and L=2 m
- That corresponds to
  ~ 1.5 W of poorly
  controlled power loss
- It should not create
  overheating problems
  even if this power is lost
  at 2 K



Collimation of lost particles

- Stripped H^- are mainly converted to H^0
- The rms beam divergence: $\theta_x \approx 1.7$ mrad, $\theta_y \approx 3.5$ mrad
  - $\Delta x = 5$ mm, $\Delta y = 10$ mm at 3 m base
- Collimation at the entrance to the HW cryomodule with $2a = 14$ mm allows interception of well above half of this loss at the room temperature
- Assuming symmetric vacuum profile one obtains at minimum another factor of 2 because only 1 mA will propagate beyond the dump
- Misalignments will further improve the collimation



- Thus, the direct power deposition due to vacuum loss will be below ~ 0.1 W and does not present a problem

Gas leakage to SRF cavities and differential pumping

- Problems created by H_2 gas
- Problems created by H^- ions of the beam stuck in the wall
- Very preliminary estimates yield that it is not dangerous
  - Better understanding expected within 1 month

Conclusions

- Total integral of bad vacuum in a dump vicinity should be less than ~10^{-6} torr·m
- Pumping speed of ~1000 l/s is required
- Direct power deposition due to stripped particles does not present a heating problem at both room and 2K temperatures
- Loss of near longitudinal tails is happening in the first two cryomodules and yields about the same power