Accelerator Science and Technology Centre

Key Parameters for BDS Vacuum System

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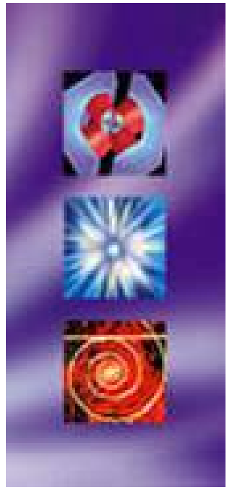


Work fields for Daresbury Laboratory, ASTeC and CI

- Theoretical calculation for variety of pumping layout and vacuum chamber proceedings
  - Calculate the average pressure and pressure profiles in the BDS and the extraction lines
  - Decide on the choice of material for the BDS vacuum systems
  - Recommend the BDS pumping philosophy (coatings, pumping, sectorisation, gauges, etc.)
- Reference mechanical design of BSD vacuum chamber
  - Collecting the necessary information and production of technical designs for first vacuum chamber components, based on preliminary specifications
  - Key components design
  - Reference mechanical design
  - Iterations and revisions as necessary

What is needed as an input for vacuum modelling:

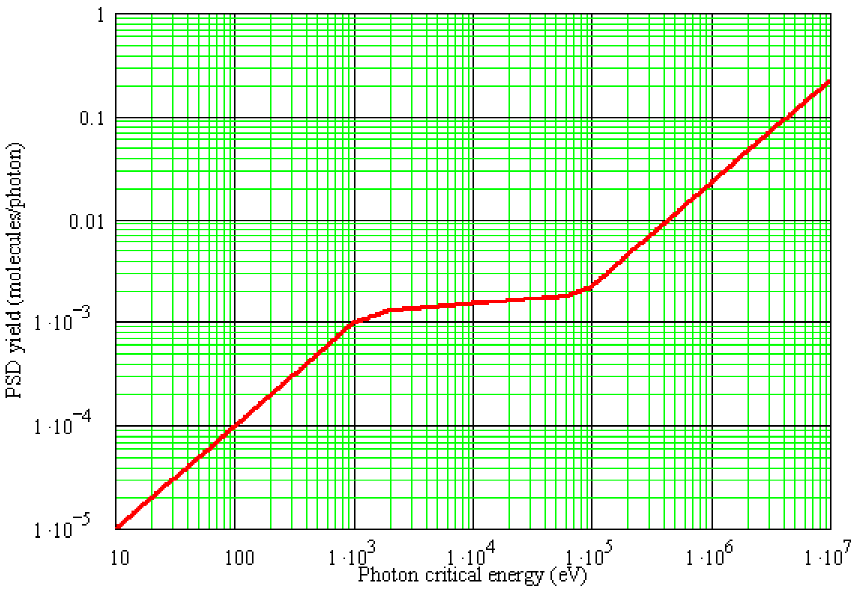
- Required vacuum along BDS parts
  - 1 nTorr near IP (~500m), far 50 nTorr
- Corresponding beam conditioning (A*hrs) –
  - 100 Ahr ?
- Apertures, collimators, spoilers, tapers, SR absorbers
- Material for vacuum chamber (SS, Al, Cu, …)
  - Impedance, other considerations
- Coatings (Cu, Au, TiZrV)
  - Impedance
- Compatibility to bakeout (180°-250°C)
- SR flux [photons/m] and ε_c [MeV]
- Lost e^+ or e^- per metre of vacuum chamber length

Vacuum modelling - unknowns:

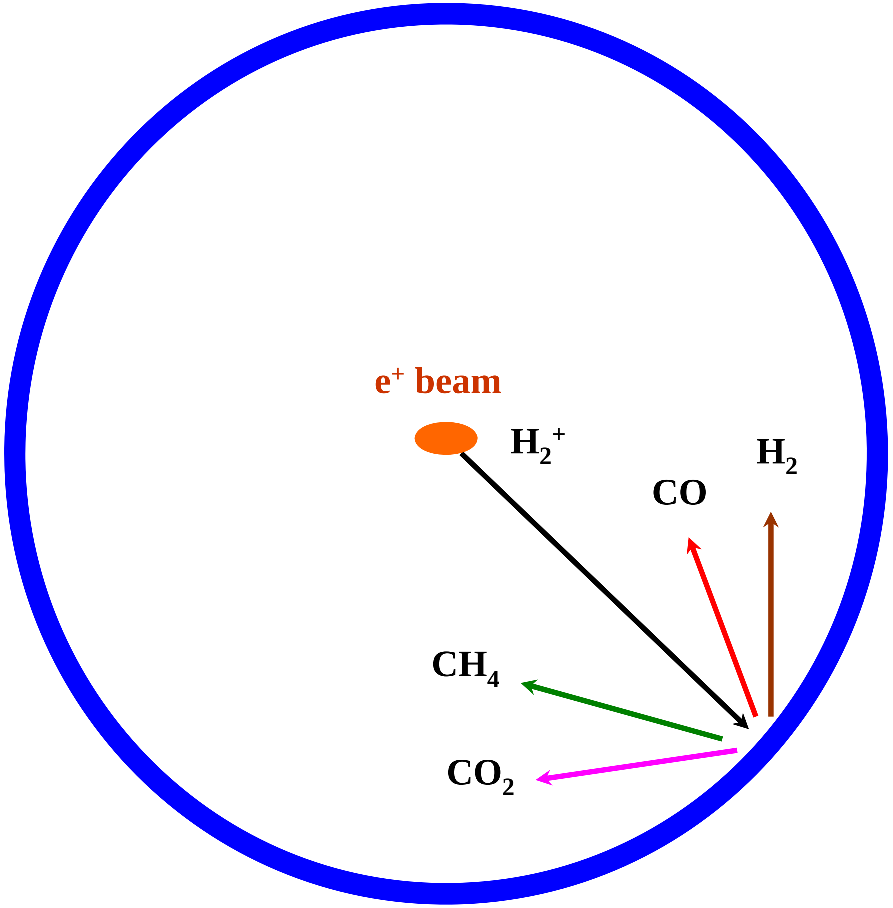
The critical energy of photon spectrum from dipoles at BDS ε_c ~1 MeV

PSD yield at ε_c ~1 MeV is not well studied (LEP data only)

- Beam conditioning studied at DCI at ε_c =~20 keV
- LEP data over lifetime (Al and SS)
- Different materials for vacuum chamber ?
- Coatings (Cu, Au, TiZrV)?



Ion induced pressure instability in BDS



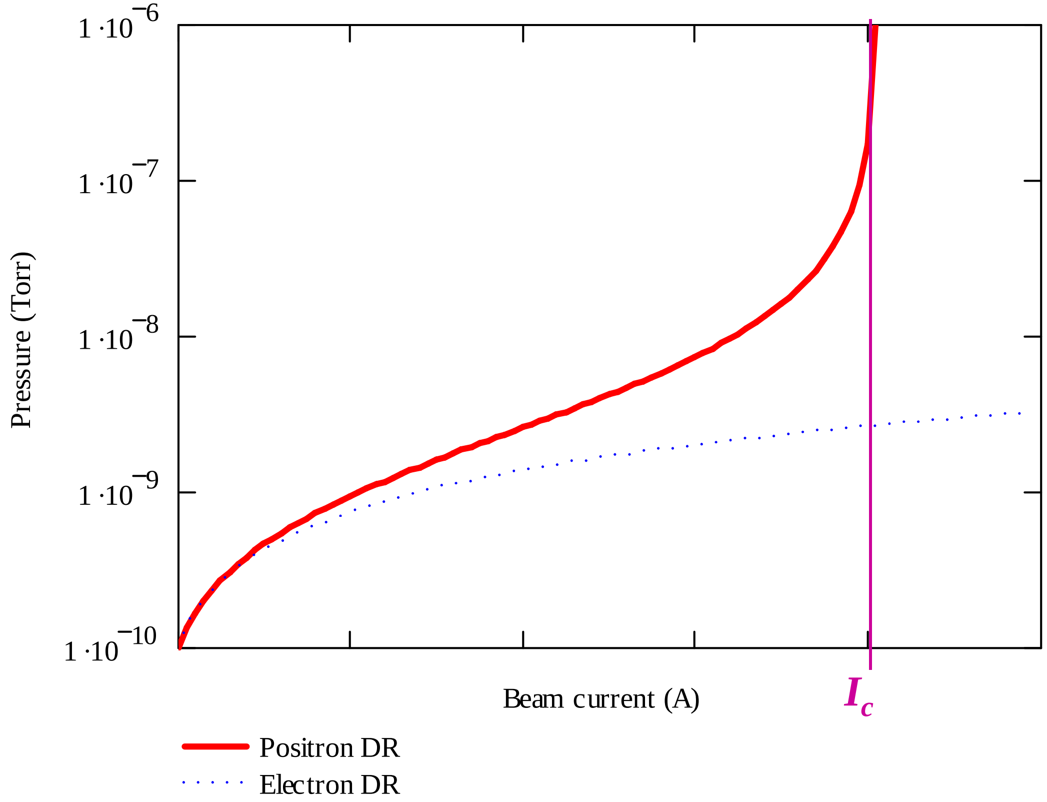
$$n = \frac{Q}{S_{eff} - \chi \frac{\sigma I}{e}}$$

where
Q = gas desorption,
S_{eff} = effective pumping speed,
χ = ion induced desorption yield
σ = ionisation cross section,
I = beam current.

$$\chi = f\left(E_{ion}, M_{ion}, material, bakeout, \ldots\right)$$

$$E_{ion} = f\left(N_{bunch}, \tau, T, \sigma_x, \sigma_y, \ldots\right)$$

Critical current



Critical current, I_c, is a current when pressure (or gas density) increases dramatically.

Mathematically, if

$$P = \frac{Q}{S_{eff} - \chi \frac{\sigma I}{e}}$$

when $S_{eff} > \chi \frac{\sigma I}{e}$

Hence $I < I_c$,

where $I_c = \frac{S_{eff} e}{\chi \sigma I}$

Ion energy at BDS and Ion induced desorption yields

The energy of ions reached at BDS is:

- From 200 keV to 1.6 MeV for $\mathbf{H_2^+}$ *to be double checked*
- From 50 keV to 1.4 MeV for $\mathbf{CO^+}$

Ion induced desorption yields [molecule/ion]:

for Cu for E=3 keV (CERN):

Columns: ***H2, CH4, CO, CO2***; rows: ***H2+, CH4+, CO+, CO2+***

$$\chi = \begin{pmatrix} 0.8 & 0.045 & 0.28 & 0.09 \\ 2.6 & 0.17 & 1.4 & 0.45 \\ 4.3 & 0.3 & 2.8 & 0.9 \\ 5.2 & 0.39 & 3.9 & 1.26 \end{pmatrix}$$

for E= 100 MeV – 1 GEV (CERN, GSI, TSL):

$100 - 10^4$ molecule/ion

Pressure instability thresholds:

What can be calculated for given beam parameters and vacuum chamber geometry

- I_c – critical current
  - for Cu, Al or SS tube, pump every XX m
  - for NEG coated tube, pump every XX m
- L_c – critical length between pumps
  - for Cu, Al or SS tube
  - for NEG coated tube
- S_c – critical pumping speed
- Hence,
  - For given parameters and large uncertainties, there is a possibility of ion induced pressure instability in BDS, if pumping is insufficient.
  - Further studies are needed

What is needed as an input for mechanical design of BDS vacuum chamber:

- Apertures, collimators, spoilers, tapers
- Special vacuum chambers
  - BPMs (design and locations)
  - …
- Material for vacuum chamber (SS, Al, Cu):
  - Wall thickness – mechanical stability
- Coatings and thickness (Cu, Au, TiZrV)?
- Compatibility to bakeout (180°-250°C)
- Bellows (type, travel, RF fingers, possible locations)
- SR power
  - distributed along vacuum chamber and on
  - SR absorbers and spoilers
- Lost particles power, if large power deposited
- Flanges (gaps, special gaskets)
- Sectorisation and sector valves (location, SR shield and RF smoothness)