THIN FILMS FOR CLIC ELEMENTS

Outline

- Motivation
- The role of MME-CCS
- DB and MB transfer lines
- Main beam
- Main beam quadrupoles
- Other issues
- conclusions

Motivation

Changes in the vacuum requirements for CLIC:

In 2006: "*dynamic vacuum should be* ***$1x10^{-8}$ mbar****, static vacuum* ***$1\text{-}5x10^{-9}$ mbar*** *"*

https://clic-meeting.web.cern.ch/clic-meeting/2006

In 2007: *"*whispers" of about **$1x10^{-10}$ mbar** for the main beam (MB) near the intersection point and for the transfer lines (MB and DB).

For the MB: *high luminosity => high electrical field => ionization of the residual gas by tunnel effect => ion induced desorption (IID) => instabilities.*

For the transfer lines: *high current => ionization of the residual gas by collision => ion induced desorption => instabilities.*

Not yet fully studied. Need confirmation from simulations.
Anyway, *"always better than 10^{-8} for the main beam..."*

The role of MME-CCS

CCS has expertise in surface analysis, surface treatments and thin film coatings for UHV applications.

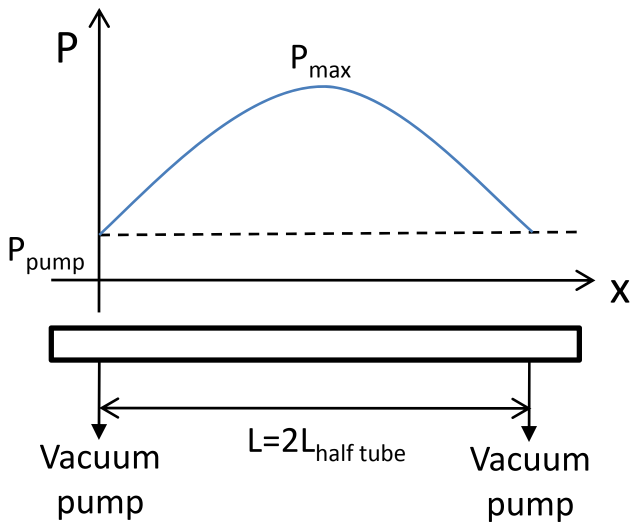
induced desorption, (by photons, electrons, ions), is a surface phenomena.

This expertise can be (and has already being) used to find solutions for surface's related problems.

DB and MB transfer line

Total length: 2x 21km
2% filled with 1m long magnets: 2x 420 magnets
Diameter of the beam pipe ϕ=40mm
Limit pressure to avoid ion stimulated desorption: 10^{-10} Torr ("large" molecules)

Pressure profile in a tube with uniform distributed outgassing



$$P_{max} = q \cdot 2\pi \cdot R\left(\frac{L_{halftube}}{S} + \frac{L_{halftube}}{2C_{halftube}}\right)$$

q -> outgassing rate
R -> radius of the tube
$L_{half\ tube}$ -> length of half tube
S -> pumping speed
C -> conductance of half tube

DB and MB transfer line

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Static vacuum

		q [Torr.l.s^{-1}.cm^{-2}]	S [l.s^{-1}]	L [m]	L [m]	
~~No bakeout: main gas~~	~~H_2O~~	~~$1.4.10^{-12}$~~	~~40~~	~~1.7~~	~~2.3~~	
With bakeout: main gas	H_2	5.10^{-13}	46	5.0	6.8	Possible solution…
With bakeout:	CO	5.10^{-14}	36	9.6	14	
With NEG: not pumped	CH_4	10^{-17}	28	814	1220	Better solution
With NEG: not pumped	Kr	2.10^{-18}	6	1202	1802	

DB and MB transfer line

Total length: 2x 21km
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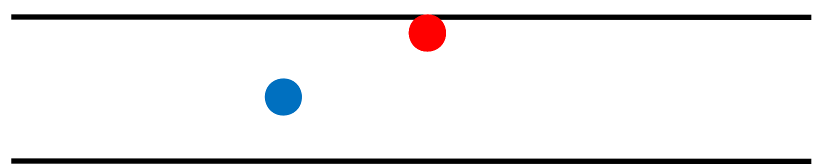
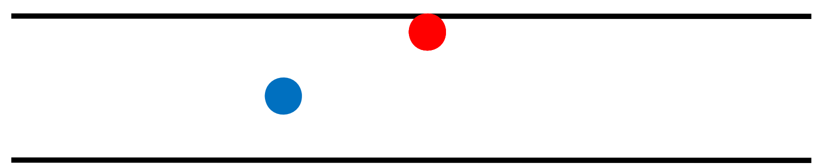
Why NEG coating solution better than bakeout?

Without NEG, desorbed molecules will follow random walk movement until being pumped by localized pumps (extremities of the beam pipe)



With NEG, the pumping power is right there! pressure recovering time is much shorter.



DB and MB transfer lines seams feasible with actual technology.

THIN FILMS FOR CLIC ELEMENTS

Main Beam

Bakeout excluded: tight mechanical tolerances.

Pumping speed in the accelerating structures is limited

If 10^{-10} torr are necessary… this is a feasibility issue for CLIC!

Dynamics of the H_2O pumping in limited conductance systems must be better understood

- An experimental set-up is being implemented to study H_20 pumping dynamics

Best possible dynamic vacuum must be simulated

- Pumping speed and geometry
- Thermal desorption/adsorption rates
- Surface coverage *vs* time
- Ion desorption yields
- Ionization efficiency per train
- Ion bombardment of the walls
- Breakdown rate
- Gas released per breakdown
- ……………………………………

We propose monte carlo and electrical network analogy approach

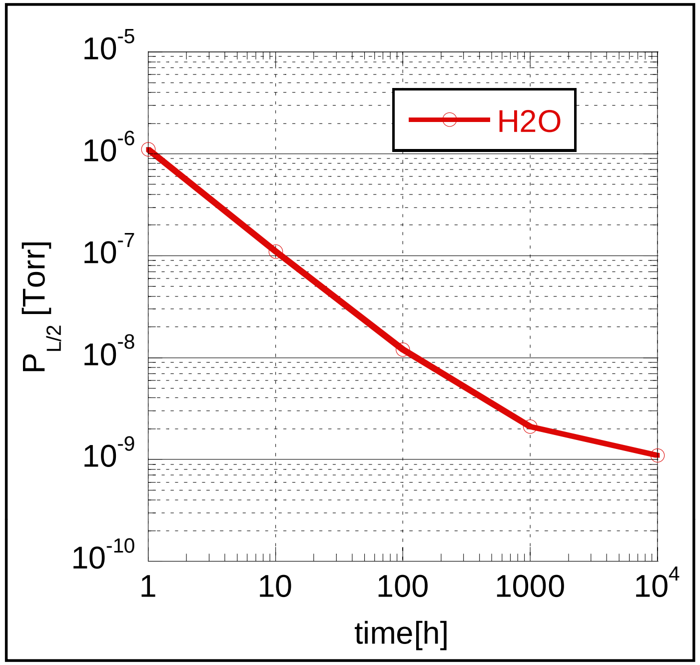
Main Beam quadrupoles

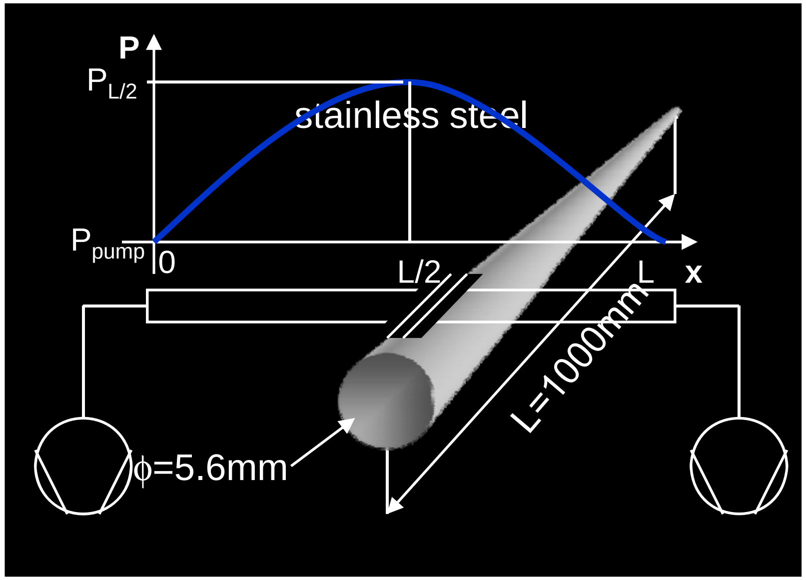
length: ~1-2m
Diameter of the beam pipe ~5-6mm
Limit pressure to avoid ion stimulated desorption: 10^{-10} Torr ("large" molecules)

Bakeout excluded: temperature of the magnets < 80°C

$$q(h) = q_{limit} + q_{1h} \cdot t^{-1}$$

Non baked stainless steel: $q_{1h}=10^{-9}$ Torr.l/s/cm^2





What about q_{limit}?

Depends on H_2O desorption-adsorption dynamics

Effects of beam conditioning?...

THIN FILMS FOR CLIC ELEMENTS

Main Beam quadrupoles

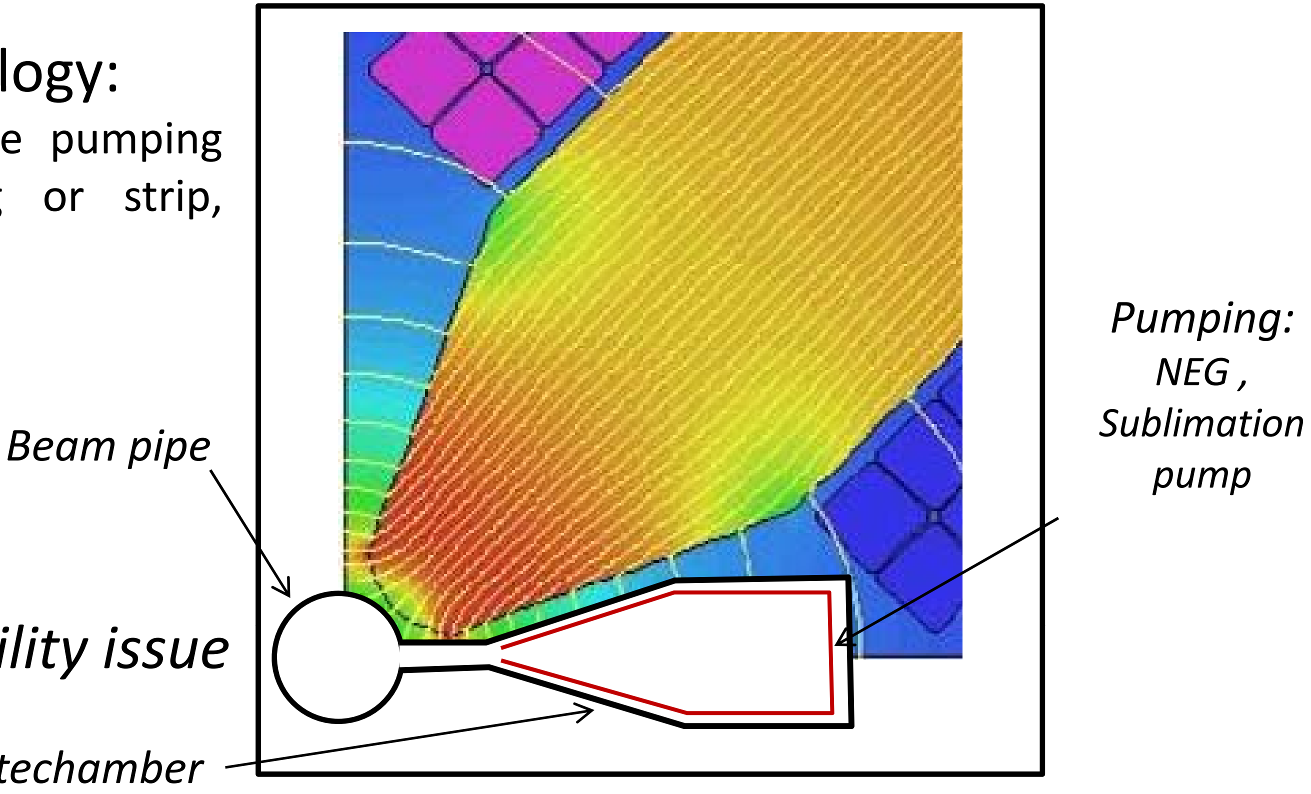
length: ~1-2m
Diameter of the beam pipe ~5-6mm
Limit pressure to avoid ion stimulated desorption: 10^{-10} Torr ("large" molecules)

Distributed pumping is required

With actual technology:

Antechamber with active pumping elements (NEG coating or strip, sublimation pump)

Probably not a feasibility issue



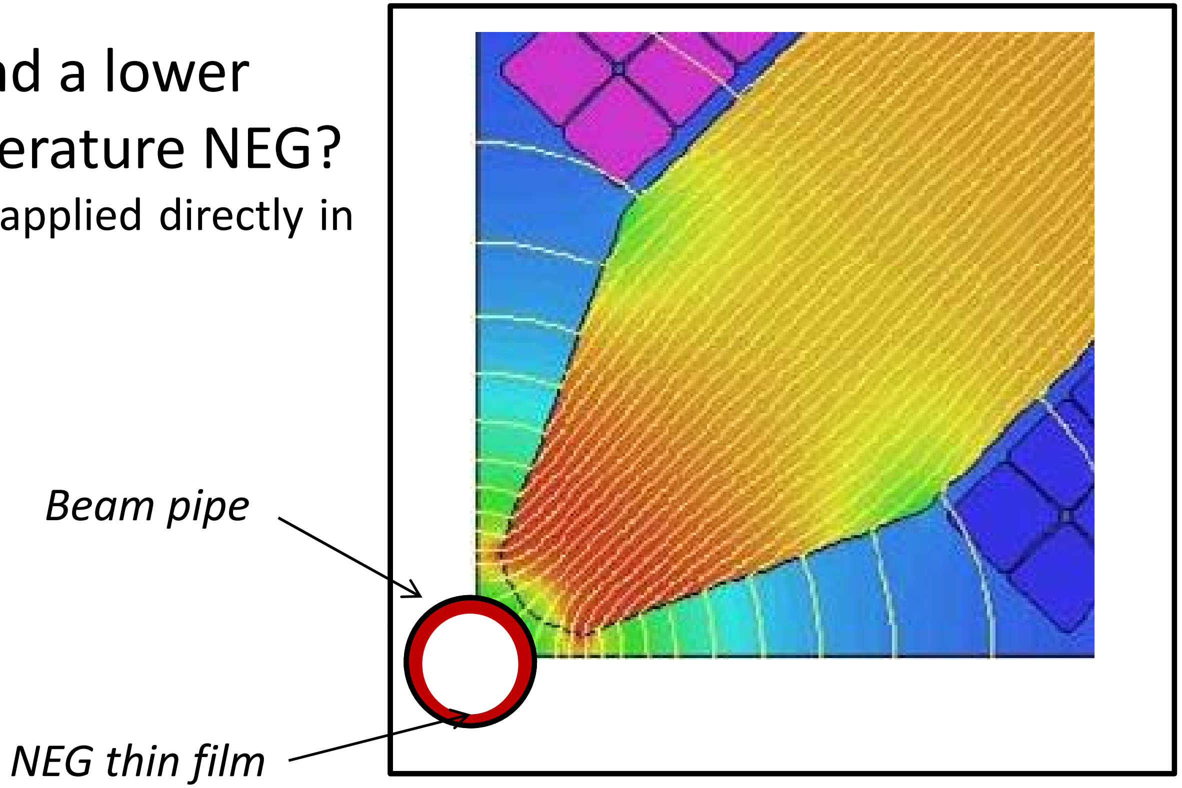
Main Beam quadrupoles

length: ~1-2m
Diameter of the beam pipe ~5-6mm
Limit pressure to avoid ion stimulated desorption: 10^{-10} Torr ("large" molecules)

Distributed pumping is required

And If we find a lower activation temperature NEG?

The NEG film will be applied directly in the beam pipe.



Other issues

Combining rings

- High levels of synchrotron radiation => high photon induced desorption
- Requires high distributed pumping speed
- NEG coatings are widely used in electron storage rings for synchrotron light sources. (ESRF, Elettra…)
- More details are necessary to evaluate situation.

not a feasibility issue

injection lines

- VERY low secondary electron yield (SEY) required (0.9... maybe…)
- CCS is launching a program to develop new materials with low SEY. Nitrides, carbides and borides of transition metals, C:N and other carbon based materials will be studied.

feasibility issue

Conclusions

•MB and DB transfer lines: 10^{-10}torr feasible with bakout or NEG. (NEG better for dynamic vacuum). ***Not a feasibility issue***.

•Main beam: 10^{-10}torr not possible without heating the structures. Best possible dynamic vacuum must be simulated. H_2O behavior must be studied. ***feasibility issue***.

•Main beam quadrupoles: distributed pumping required. ***Probably not a feasibility issue***.

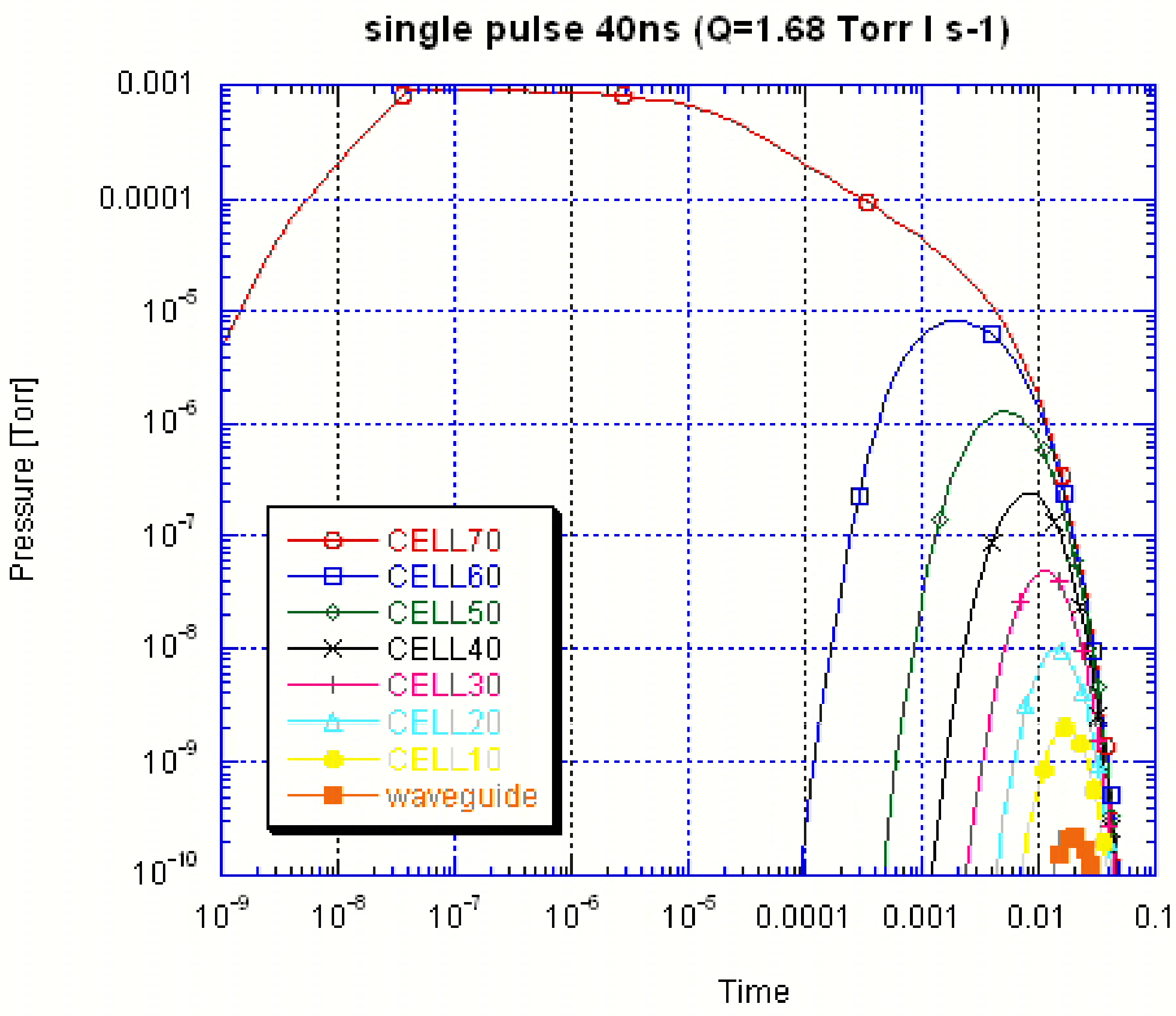
•Combining rings: classical NEG solution. Input is necessary to correctly evaluate the situation. ***Not a feasibility issue***.

•injection lines: maybe a SEY of 0.9 is required. ***feasibility issue***.

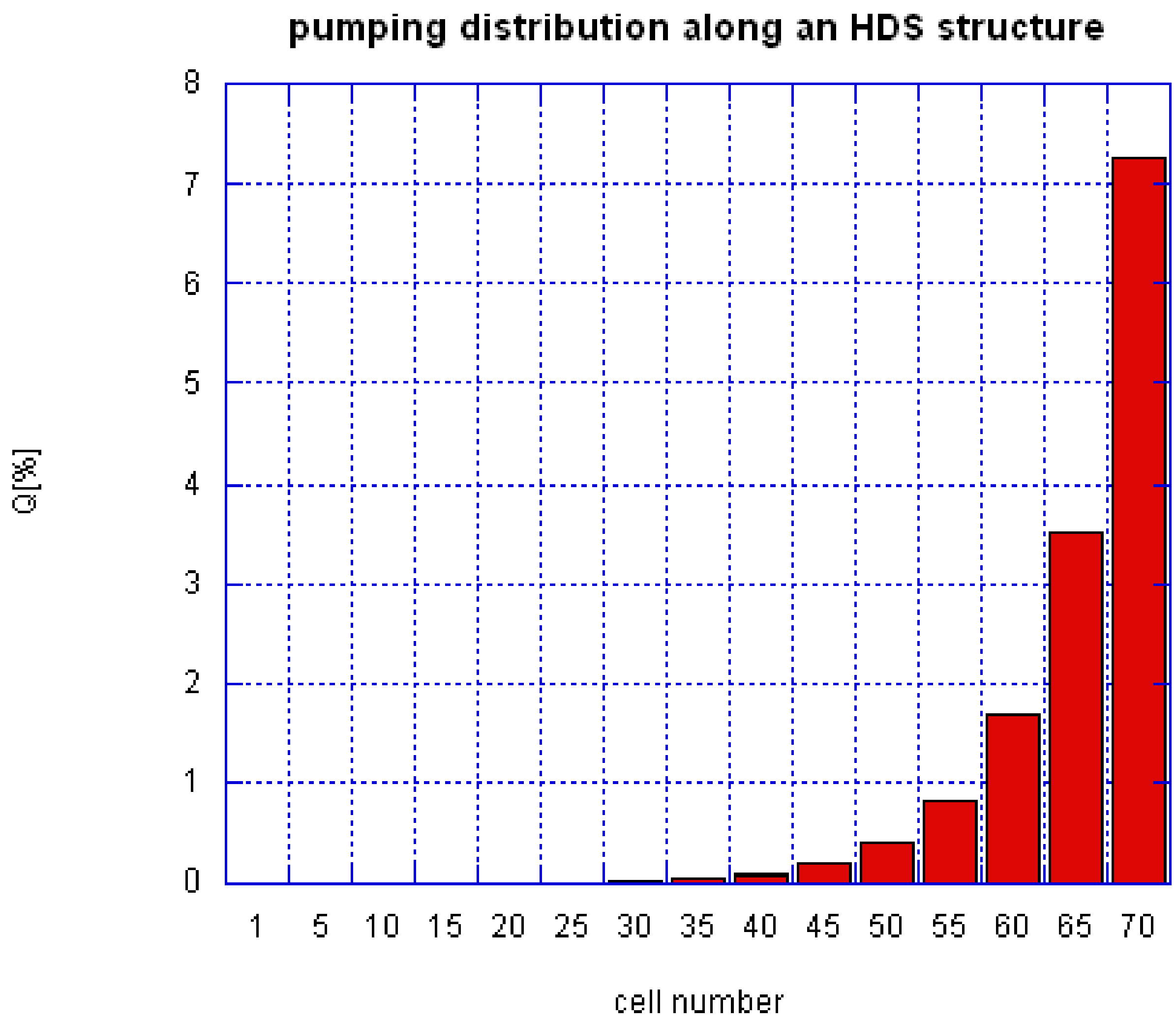
acknowledgments

Bernard Jeanneret and Daniel Schulte.

CO pressure evolution in an 30GHz HDS structure



Pumping distribution in 30GHz HDS structure



Introduction

Brief overview of the outgassing in UHV systems

Thermal outgassing:

Driving force: thermal energy.

Non baked systems: mainly H_2O $$q(t) \approx q_{\lim it} + \frac{10^{-9}}{t[hours]}[Torr \cdot l \cdot s^{-1} \cdot cm^{-2}]$$

baked systems: mainly H_2 $$5 \cdot 10^{-14} < q < 10^{-11}[Torr \cdot l \cdot s^{-1} \cdot cm^{-2}]$$

But also CO, CO_2 , CH_4 … Outgassing rates

Stimulated outgassing:

Introduction

Brief overview of the outgassing in UHV systems

Thermal outgassing: Driving force: thermal energy.

Non baked systems: mainly H_2O

baked systems: mainly $H_{2,}$ but also CO, CO_2, CH_4 at lower rates

Stimulated outgassing: Driving force: particles striking the surfaces of the system (photons, electrons, ions)

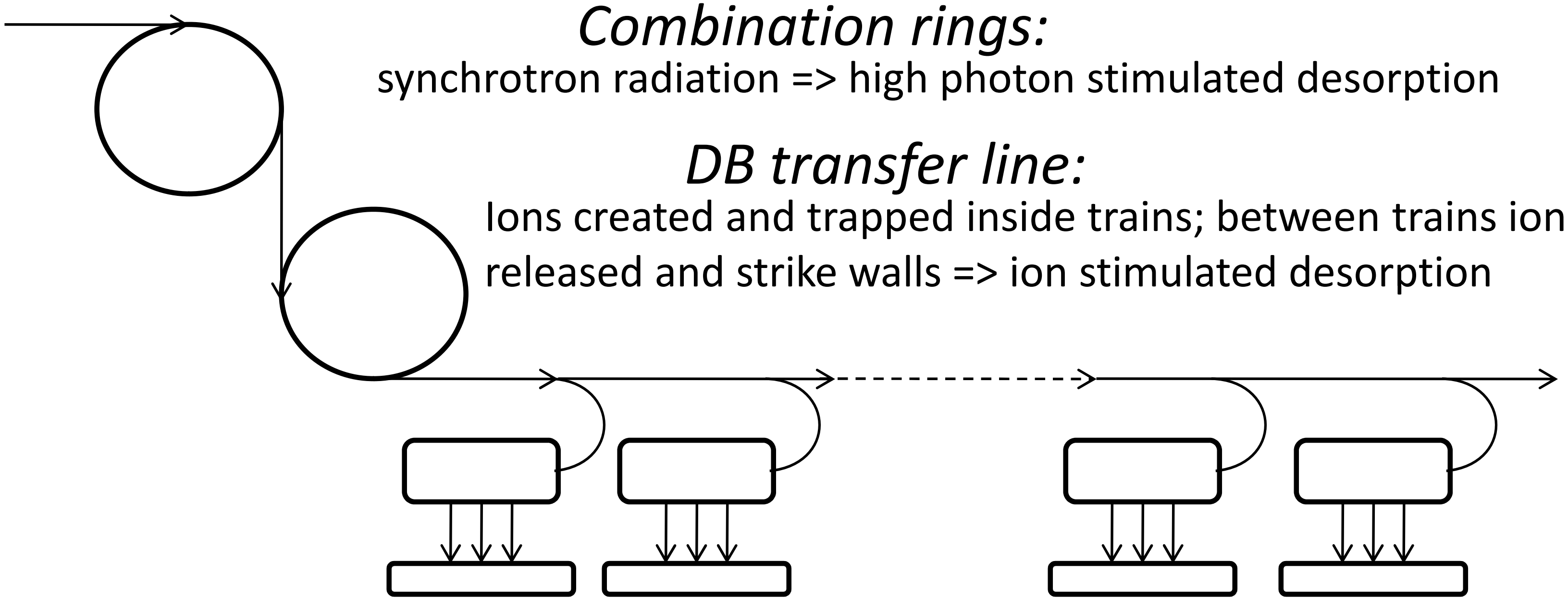
Strongly dependent

baked systems: mainly $H_{2,}$ but also CO, CO_2, CH_4 at lower rates

Introduction

Combination rings:
synchrotron radiation => high photon stimulated desorption

DB transfer line:
Ions created and trapped inside trains; between trains ions are released and strike walls => ion stimulated desorption



MB transfer line: Roughly the same as DB transfer line

Main beam: Near the interaction point beam’s electrical field is enough to ionize residual gas => ion stimulated desorption

DB and MB transfer line

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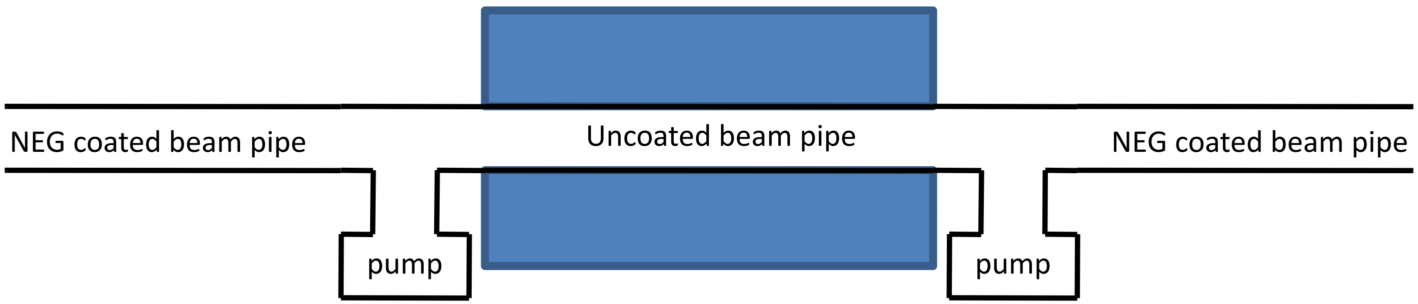
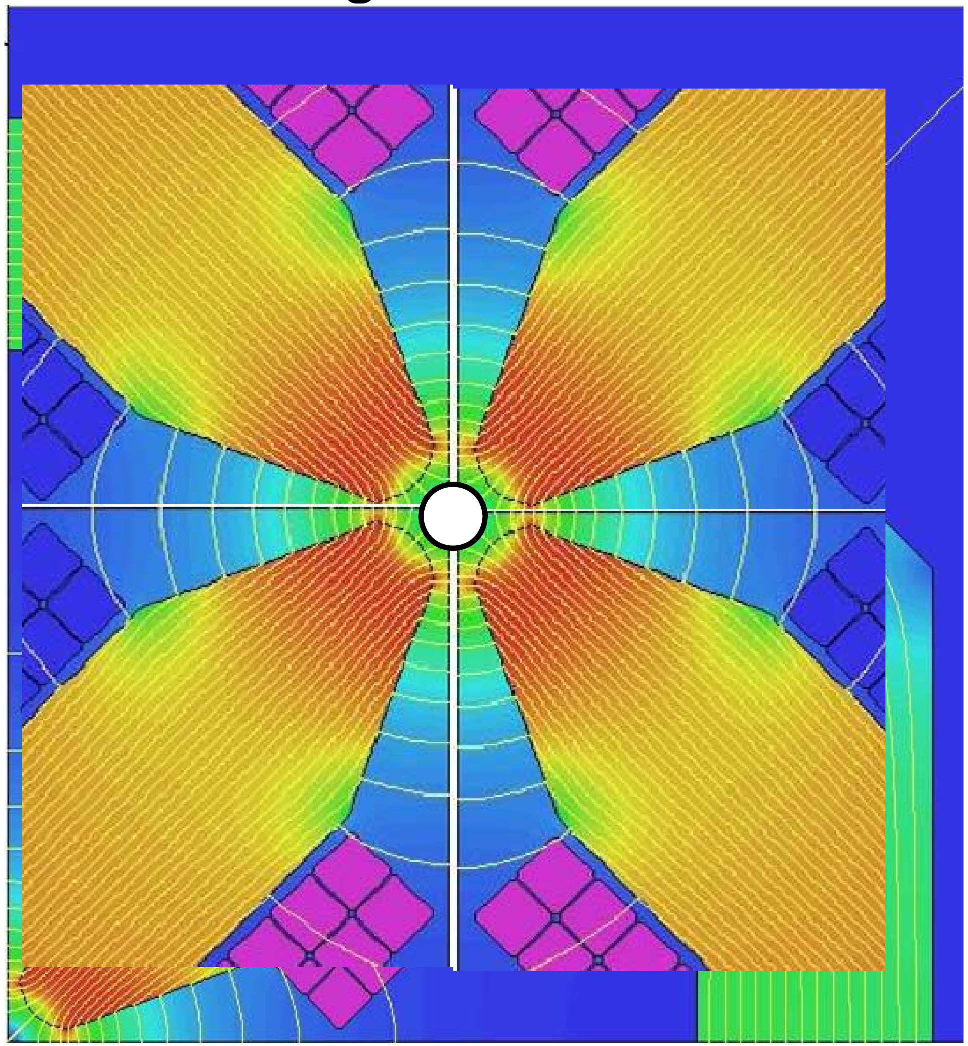
And for the magnets?

- if T_{max}=200C ok for existing NEG
- If not, *hybrid* solution!



Main Beam quadrupoles

Bakeout excluded: tight mechanical tolerances.



Main Beam quadrupoles

length: ~1-2m
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Distributed pumping is required