CERN

Vacuum Layout Integration LSS2 including TDIS for LS2

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On behalf of TE-VSC-BVO

Content:

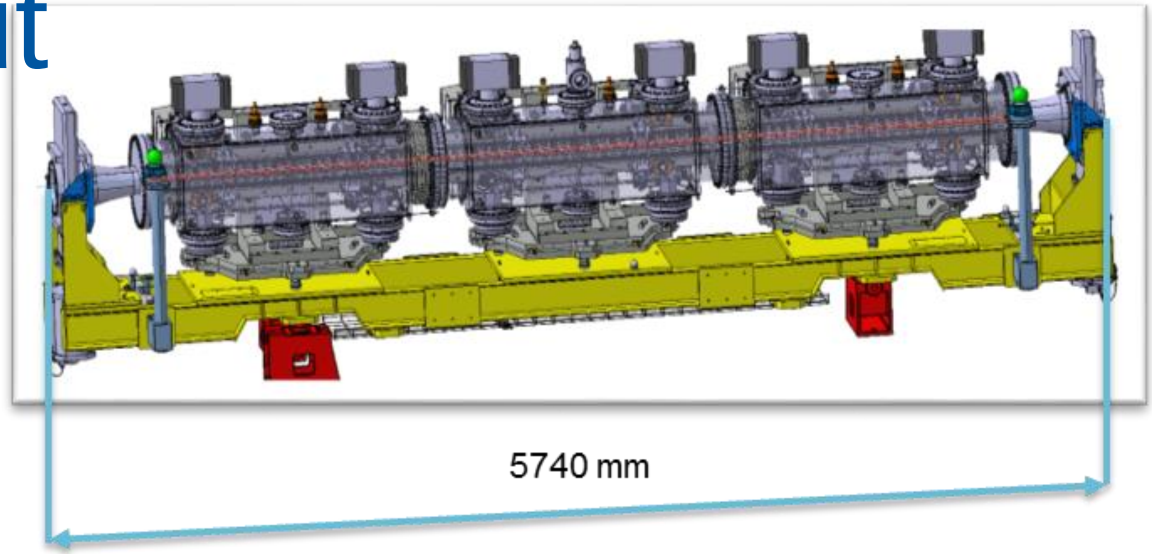
- TDIS Layout
- TDIS Electron Cloud Simulation

  (Galina Skripka, Giovanni Iadarola)
- TDIS Vacuum Simulation
- Conclusion and suggestions for optimal operation
- Vacuum Layout Integration LSS2

TDIS Layout

TDIS Layout

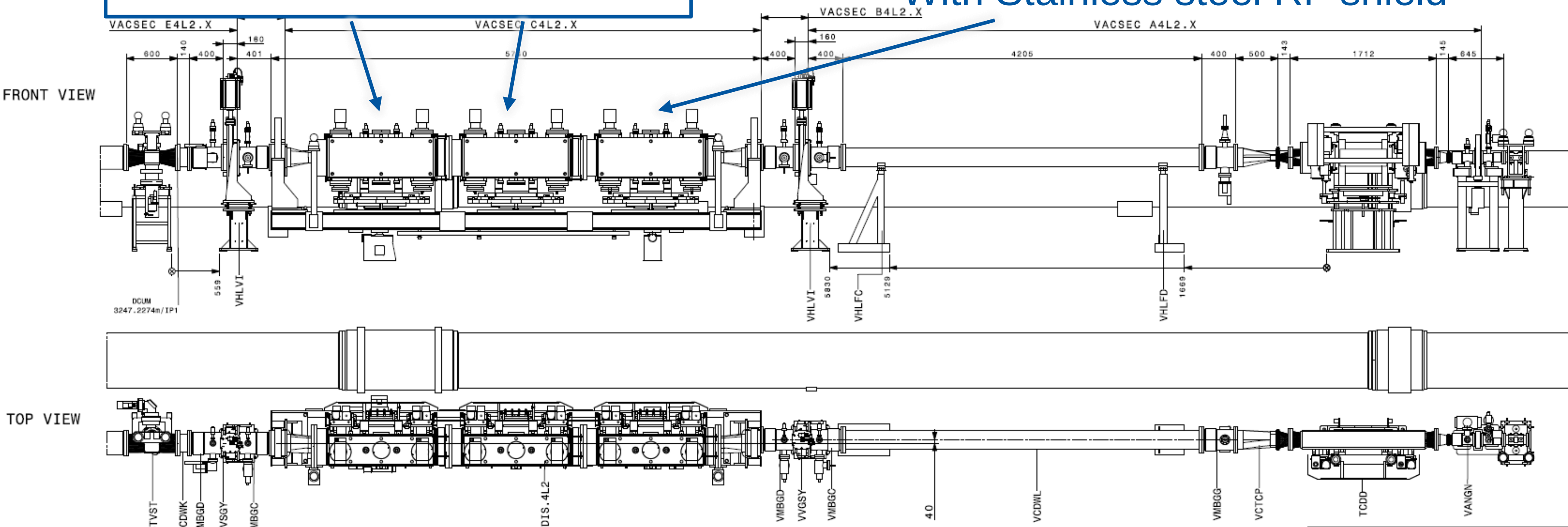
TDIS: ST0724267_01



Courtesy of L. Gentini

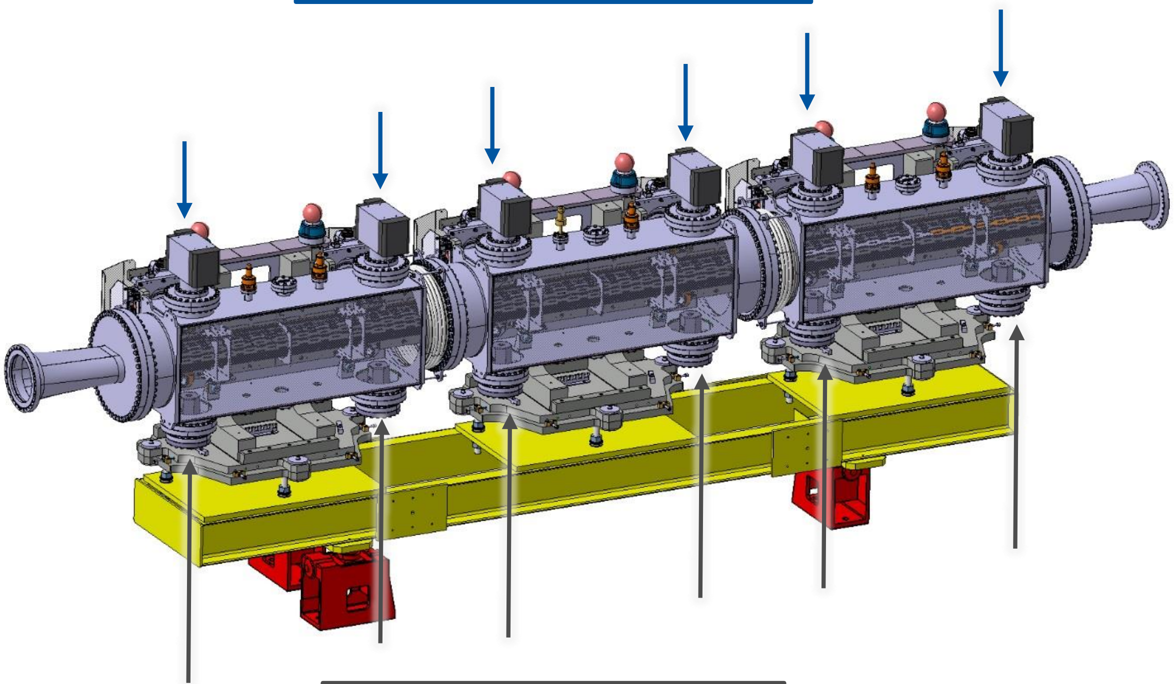
Uncoated graphite jaw
With Stainless steel RF shield

A block of Ti6Al4V 965mm and CuCrZr 600mm
With Stainless steel RF shield



Pumping wise:

Agilent ion pump 75l/s



CapaciTorr HV2100

For each TDIS tank x2 ion pumps

Agilent Ion Pump 75l/s*	[l/s]
H2	75
CH4	60
CO	65
CO2	65

For each TDIS tank x2 HV2100

CapaciTorr HV2100	[l/s]
H2	2100
CH4	0
CO	625
CO2	880

For each TDIS tank

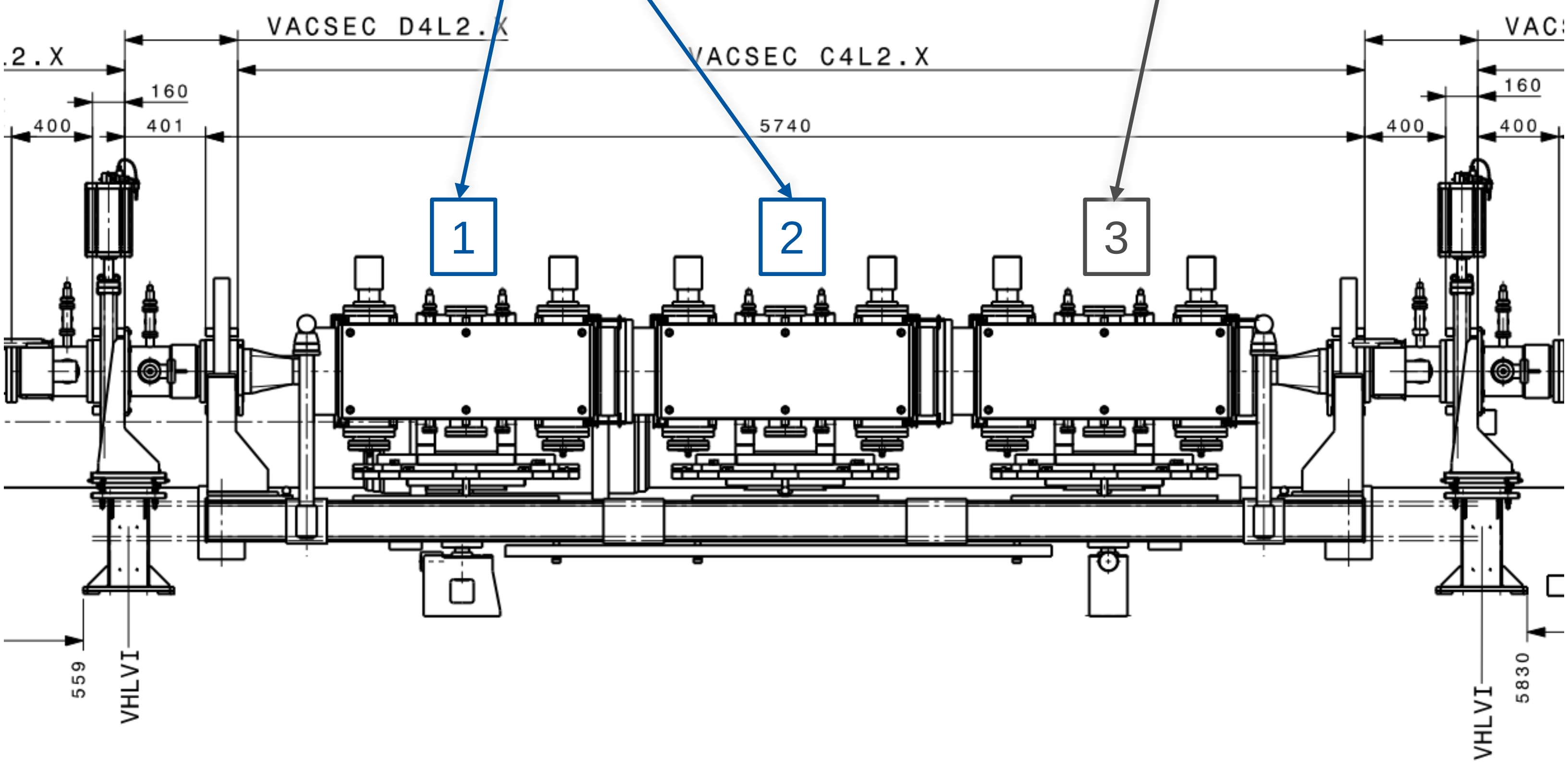
Total Pumping speed*	[l/s]
H2	4350
CH4	120
CO	1380
CO2	1890

* at 10^{-7} mbar

Material wise:

Uncoated graphite jaw
With Stainless steel RF shield

A block of Ti6Al4V 965mm and CuCrZr 600mm
With Stainless steel RF shield



Galina Skripka, Giovanni Iadarola

TDIS Electron Cloud Simulations

TDIS Electron Cloud Simulation

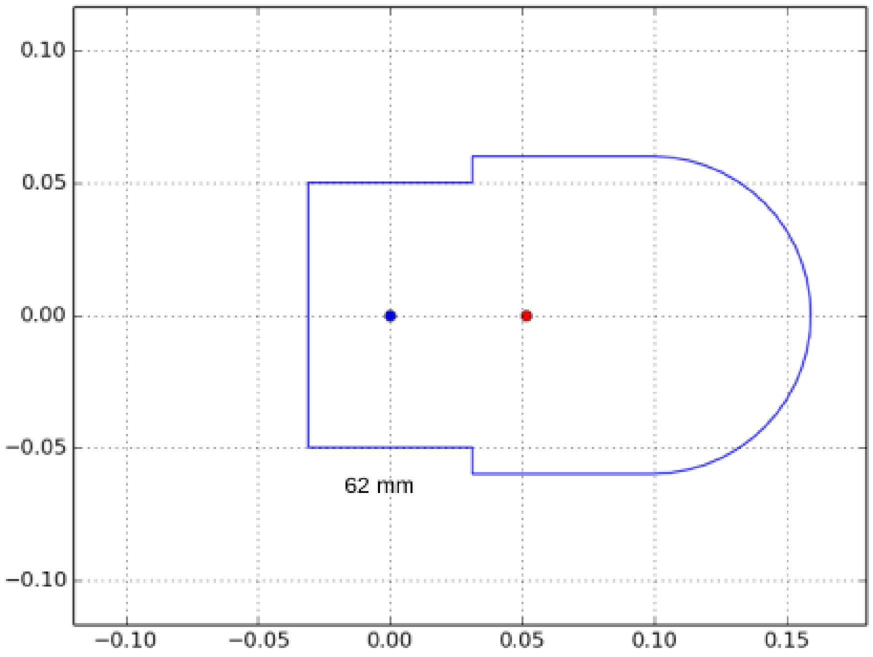
e-cloud simulations in TDIS

We performed a first series of simulations to identify possible critical points:

- Assumed uniform SEY for the whole profile
- SEY=1.4-1.5 (Cu-like) can be considered as a worst case scenario
- We assume that no high SEY surfaces (e.g. aluminum) are exposed to the beam

Main simulation parameters

- Beam parameters: 450GeV, 25 ns spacing, 2.2e11 p/bunch, 1.2 ns bunch
- Two counter-rotating beams (simulated different transverse slices of the device)
- Half-gap scan: 1 - 50 mm
- SEY scan: 1.0 - 1.6



Galina Skripka
Giovanni Iadarola

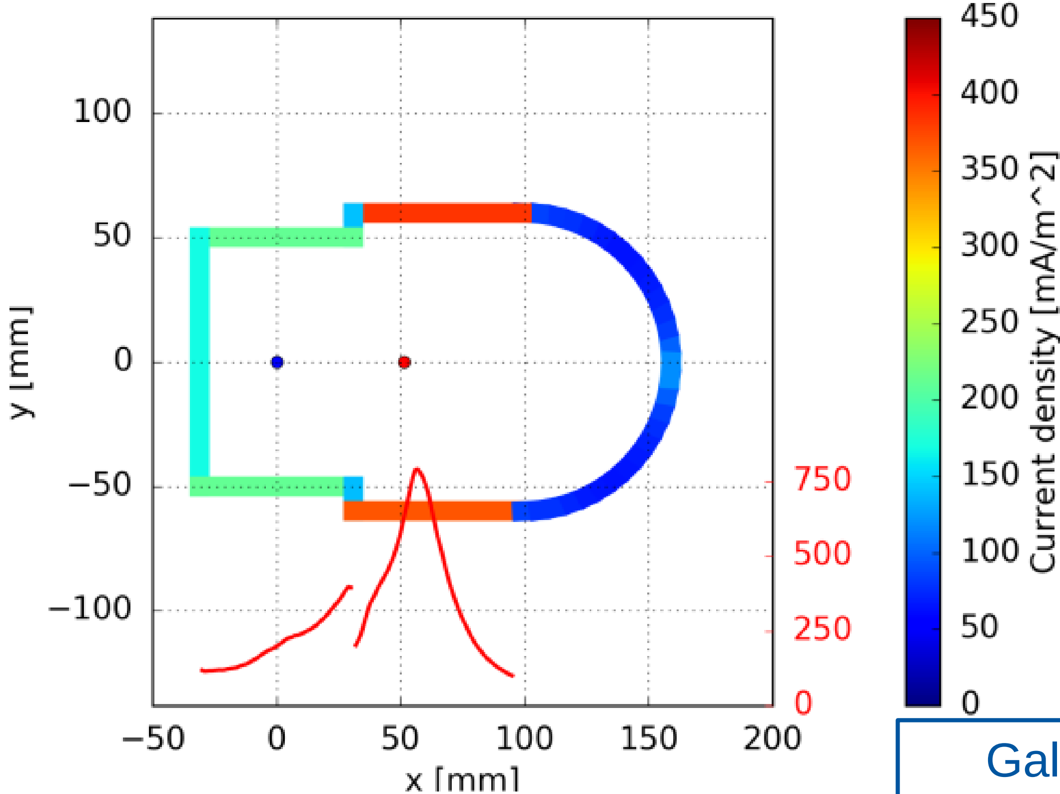
TDIS Electron Cloud Simulation

Electron flux on the different surfaces

SEY=1.4

Section in between two long range encounters

- e-cloud starts to buildup on the surface of the jaws and on the flat parts of the beam screen



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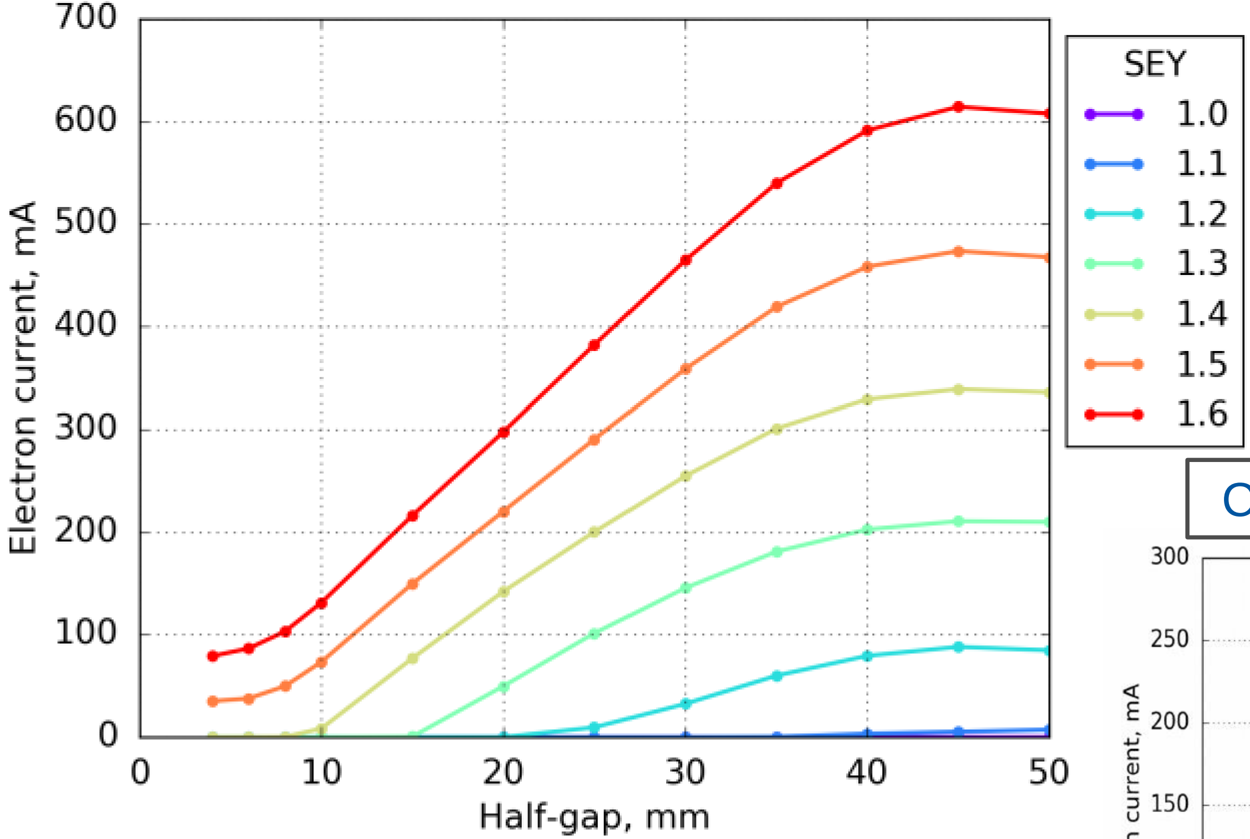
Giovanni Iadarola

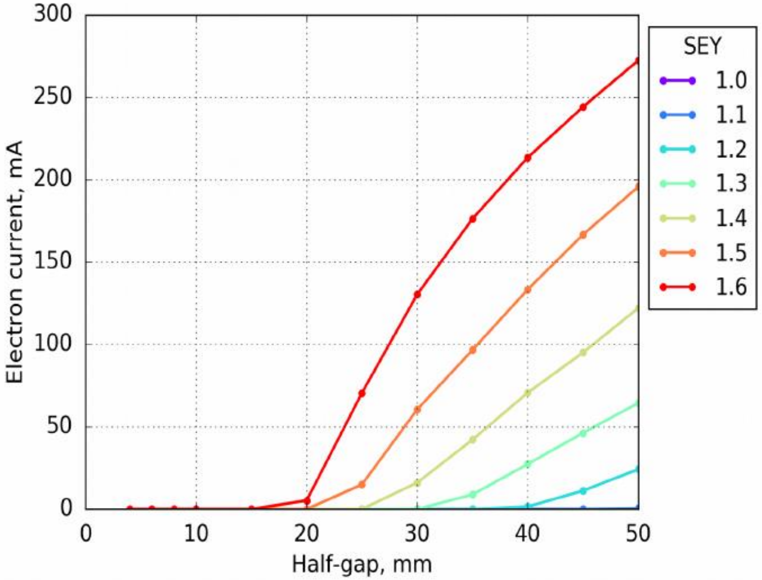
TDIS Electron Cloud Simulation

Total Electron Flux as function of SEY and half-gap distance



With new TDIS, at least twice higher electron flux is expected according to simulation.

Compare to the current TDI



Galina Skripka
Giovanni Iadarola

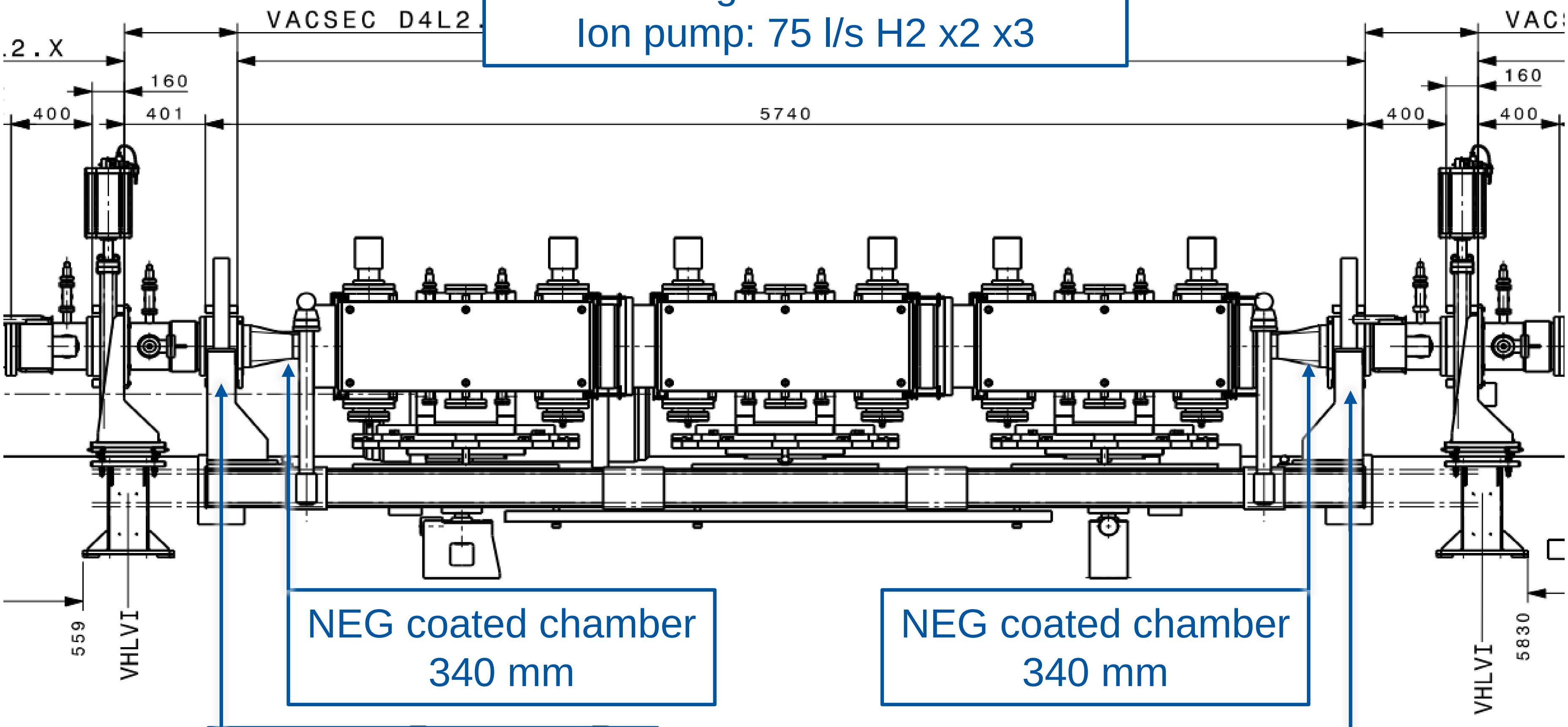
TDIS Vacuum Simulation

Vacuum simulation

Sector valve
Ion pump 30 l/s H2

TDIS: 5060 mm
NEG cartridge: 2100 l/s H2 x2 x 3
Ion pump: 75 l/s H2 x2 x3

Sector valve
Ion pump 30 l/s H2



NEG coated chamber
340 mm

NEG coated chamber
340 mm

Additional Sector valve
VVGY 160 mm

Additional Sector valve
VVGY 160 mm

Vacuum simulation (1) -simulation input

Total pumping speed inside TDI*

H_2	CH_4	CO	CO_2
4350	0	0	0
0	120	0	0
0	0	1380	0
0	0	0	1890

Electron stimulated desorption for unbaked copper [Molecules/e-]

	ESD at SEY = 2.0	ESD at SEY = 1.6	ESD scrubbed Cu SEY = 1.0
H_2	0.22	4.00E-02	1.00E-03
CH_4	0.012	1.00E-03	2.00E-05
CO	0.028	3.00E-03	1.00E-04
CO_2	0.075	3.00E-03	1.00E-04

- ESD at SEY = 2.0: Un-scrubbed
- ESD at SEY = 1.6: Initial state — Needed dose: 4×10^{16} e-/cm^2
- ESD scrubbed Cu SEY = 1.0: Complete scrubbed — Needed dose: 1×10^{19} e-/cm^2

Thermal Degassing [mbarl/s/cm^2]

New sector valve	
H_2	9.45e-12
CH_4	1.18e-15
CO	5.90e-15
CO_2	5.90e-15

TDIS	
H_2	1.03e-11
CH_4	2.44e-14
CO	1.44e-13
CO_2	3.31e-14

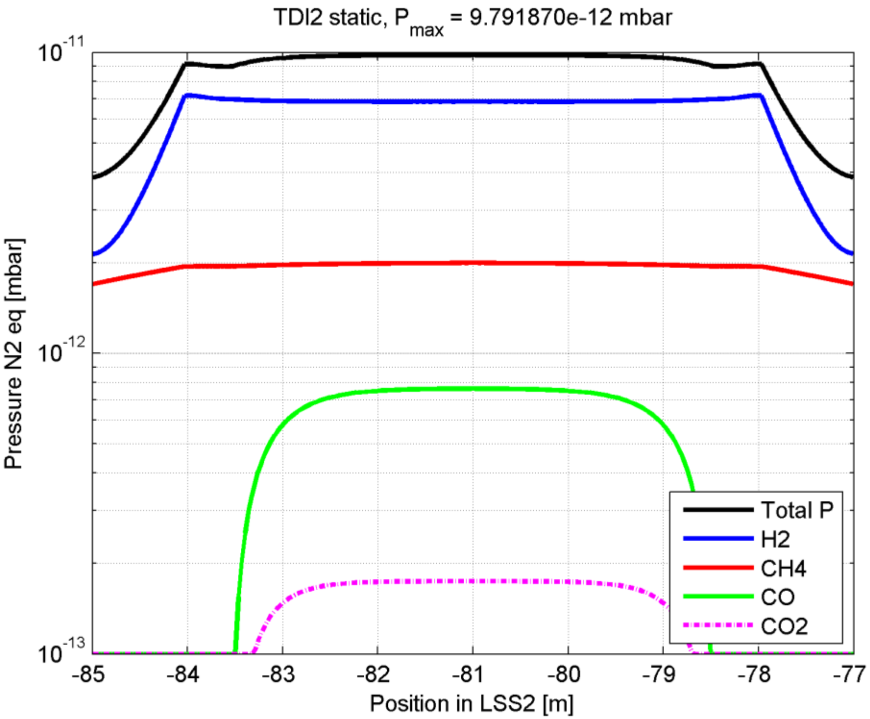
* at 10^{-7} mbar

Vacuum simulation (2) -static pressure

Total pumping speed inside TDI*

H2	CH4	CO	CO2
4350	0	0	0
0	120	0	0
0	0	1380	0
0	0	0	1890

- P_{max} = 9.8x10^{-12} mbar.
- Static Pressure dominated by H2.



Thermal Degassing [mbar·l/s/cm^2]

New sector valve	
H2	9.45e-12
CH4	1.18e-15
CO	5.90e-15
CO2	5.90e-15

TDIS	
H2	1.03e-11
CH4	2.44e-14
CO	1.44e-13
CO2	3.31e-14

* at 10^{-7} mbar

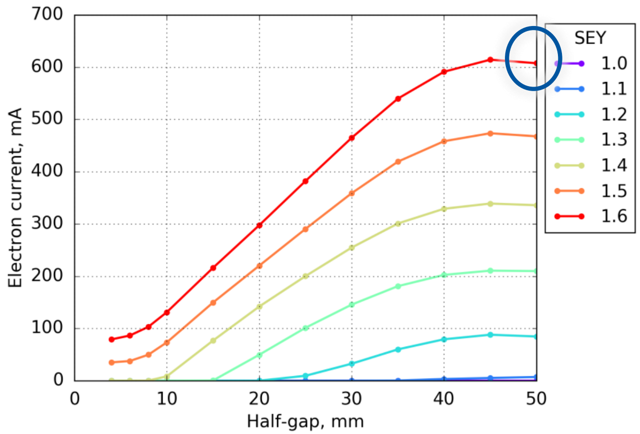
Vacuum simulation (3) -dynamic pressure

Assume the following: the worst scenario

- ESD max for unbaked Cu
  (To be noted: SEY = 2.2)

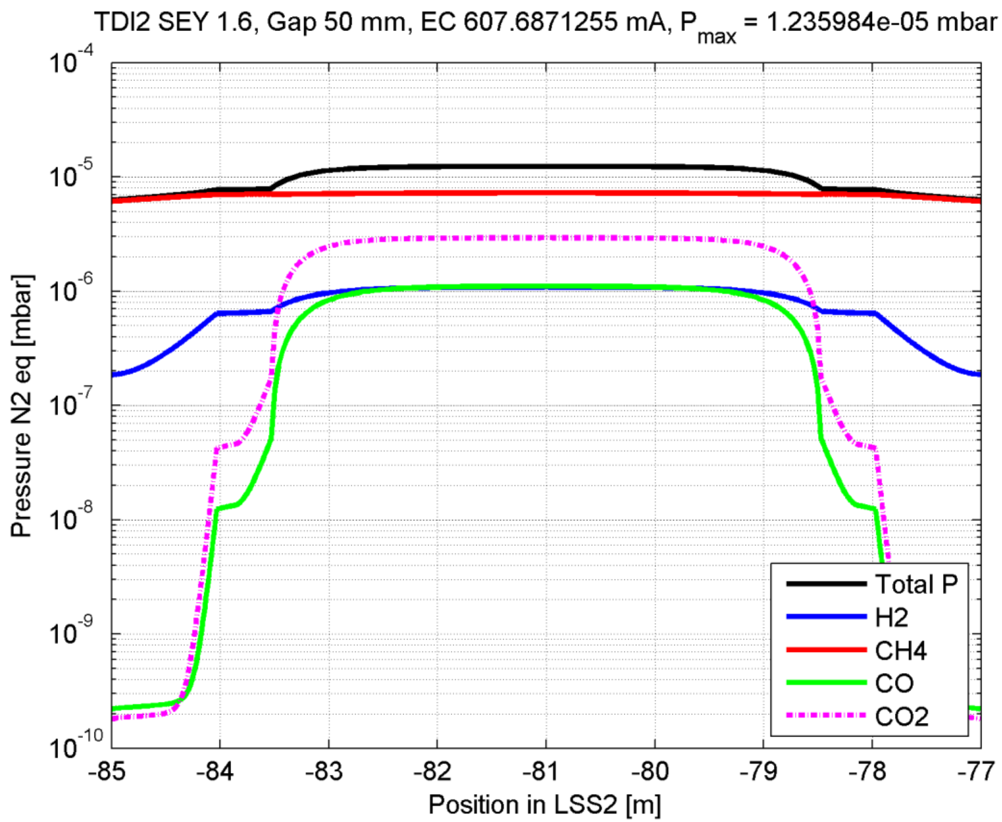
H_2	0.22
CH_4	0.012
CO	0.028
CO_2	0.075

- Largest half-gap opening = 50mm
- Electron flux = 607.7mA



- 3 TDIS have the same homogenous electron current.

- $P_{max} = 1.24 \times 10^{-5}$ mbar.
- Dynamic Pressure dominated by CH_4.



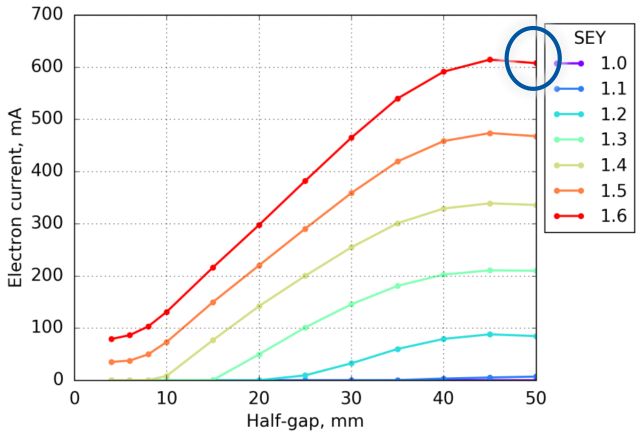
Vacuum simulation (4) -dynamic pressure

Assume the following: SEY = 1.6

- ESD for unbaked Cu at SEY = 1.6

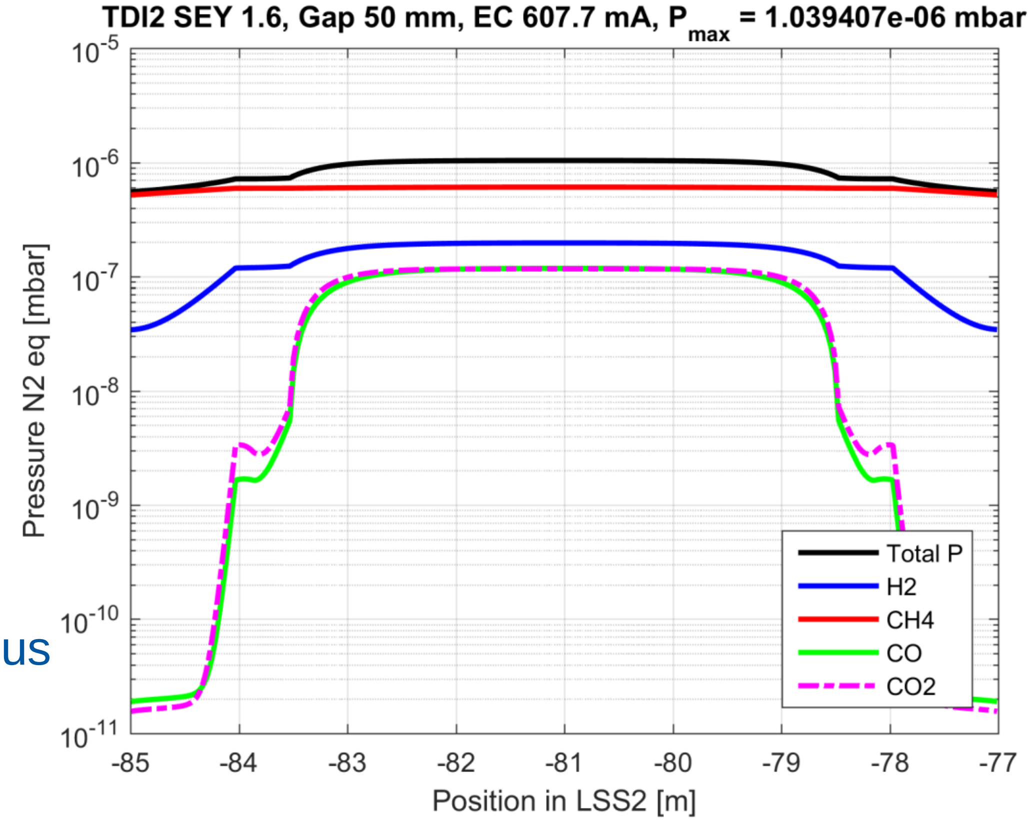
H_2	4.00E-02
CH_4	1.00E-03
CO	3.00E-03
CO_2	3.00E-03

- Largest half-gap opening = 50mn
- Electron flux = 607.7mA



- 3 TDIS have the same homogenous electron current and SEY = 1.6.

- $P_{max} = 1.04 \times 10^{-6}$ mbar.
- Dynamic Pressure dominated by CH_4.
- To reach SEY of 1.6, 4×10^{16} e/cm2 is needed => ~ **5 mins scrubbing** at 250mA/m2.



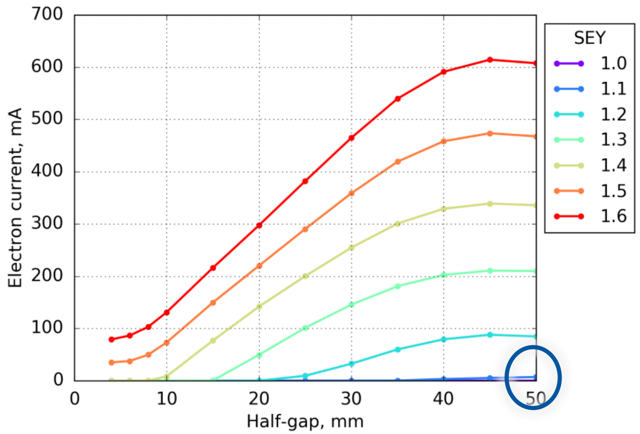
Vacuum simulation (5) -dynamic pressure

Assume the following: SEY = 1.0

- ESD for unbaked Cu at SEY = 1.0

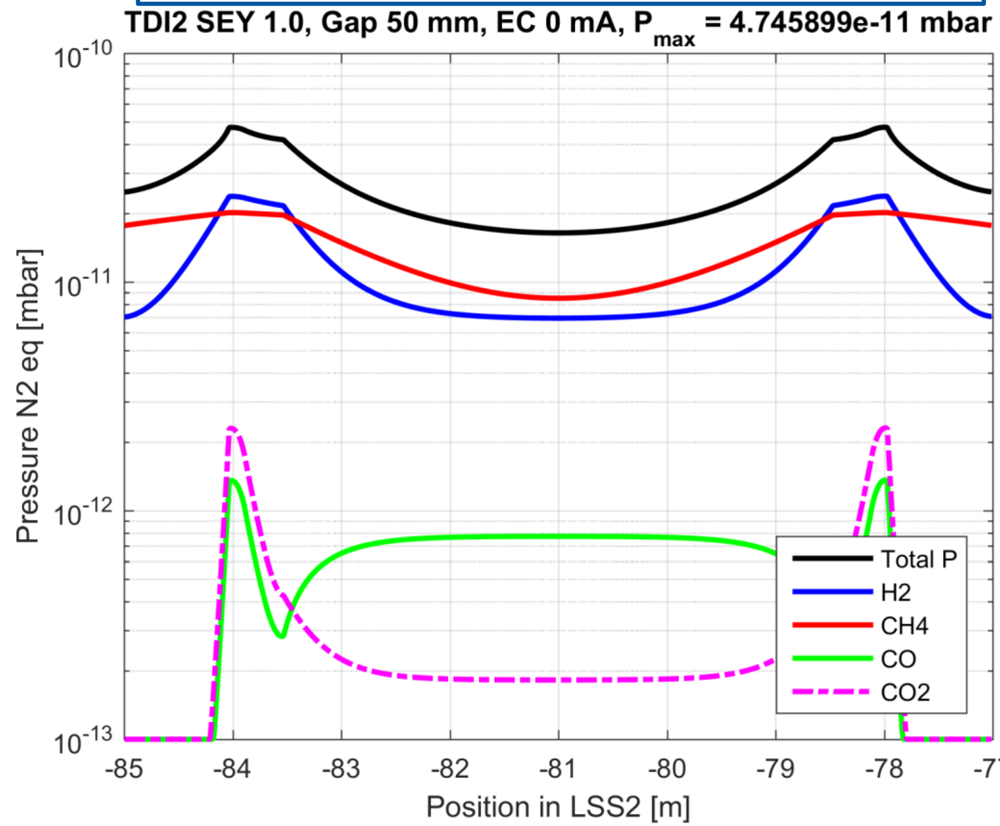
	ESD scrubbed Cu SEY = 1.0
H2	1.00E-03
CH4	2.00E-05
CO	1.00E-04
CO2	1.00E-04

- Largest half-gap opening = 50mm
- Electron flux ~ 0mA



- 3 TDIS have the same homogenous electron current and SEY = 1.0.

- P_{max} = 4.75x10^{-11} mbar.
- Dynamic Pressure dominated by CH4.
- Highest dynamic pressure rise is at the extremities where the sector valves are located.



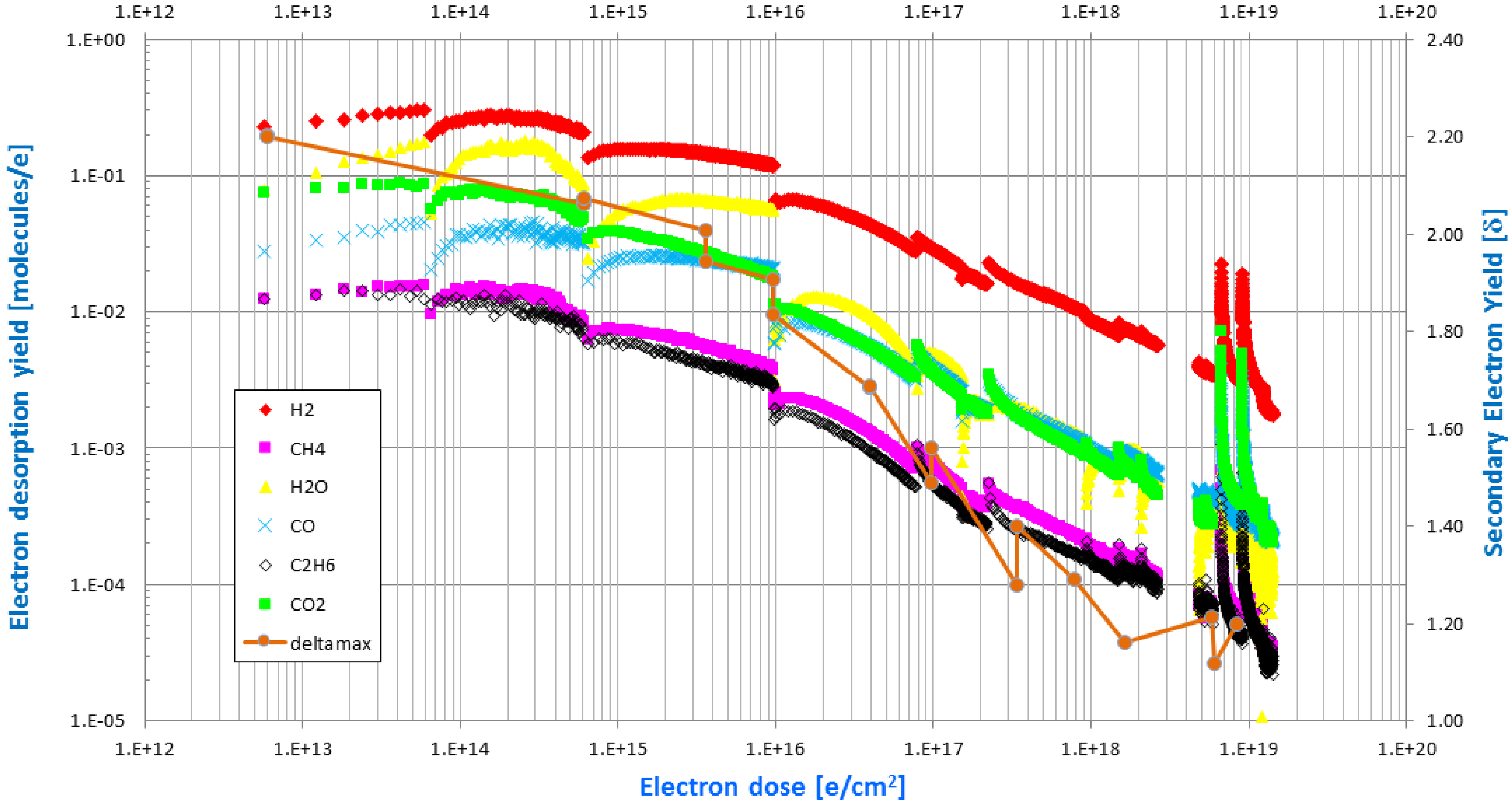
Dynamic pressure rise

- Dynamic pressure rise strongly depends on the ESD (Electron stimulated desorption yield) of the material.
  - Will need to measure different surfaces in the lab.
- Optimal operation distances and scrubbing are needed if the TDIS runs as it is.

TDIS
Vacuum Simulation Summary

ESD for Cu as function of SEY

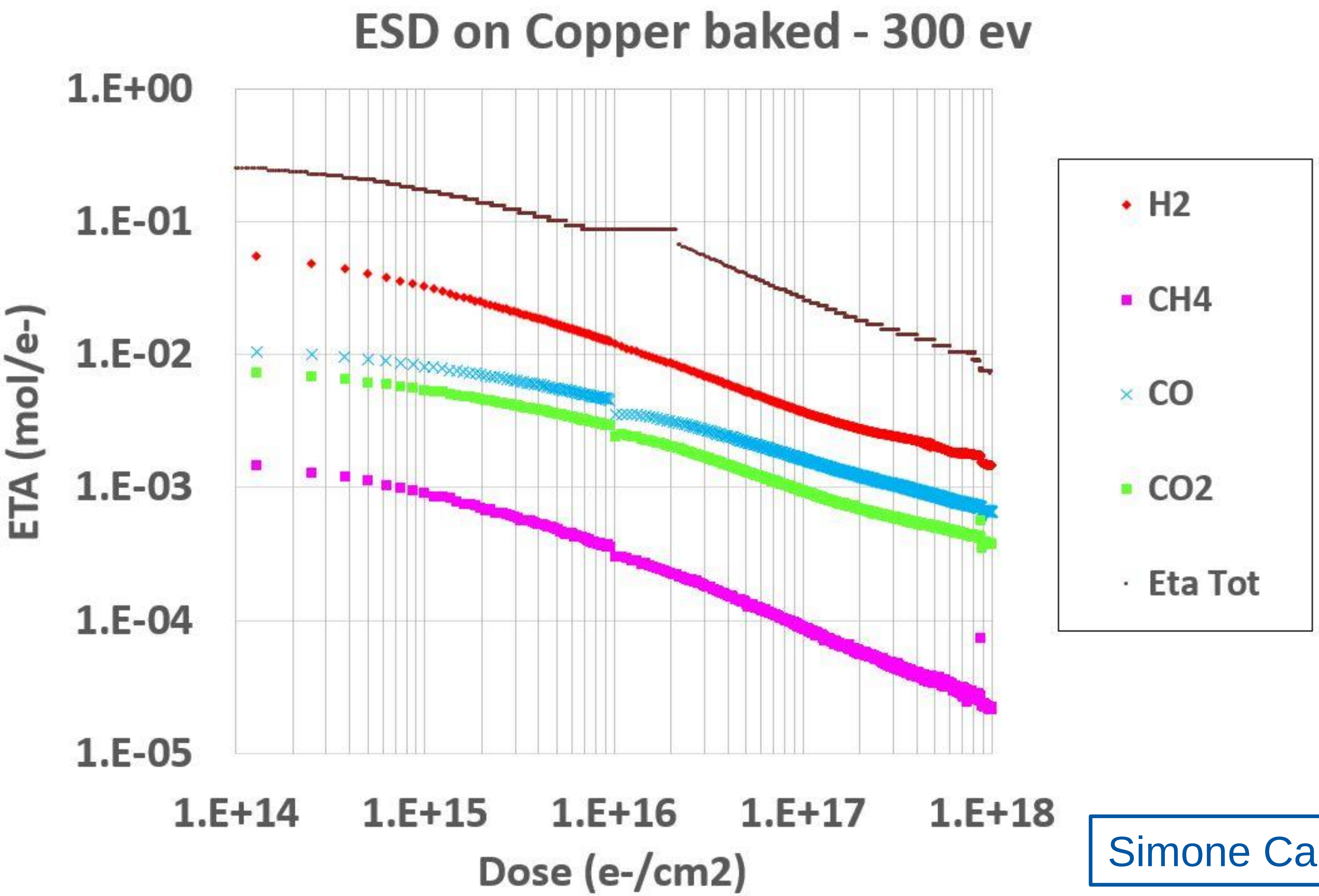
- Consider the ESD dependence on SEY in the simulations.



Unbaked copper - 300 eV
(G. Vorlaufer, B. Henrist)

ESD for Cu as function of SEY

- ESD on Baked copper measured in the ESD lab @ 300 eV
- A factor of 5 less than the un-baked Cu in H2.



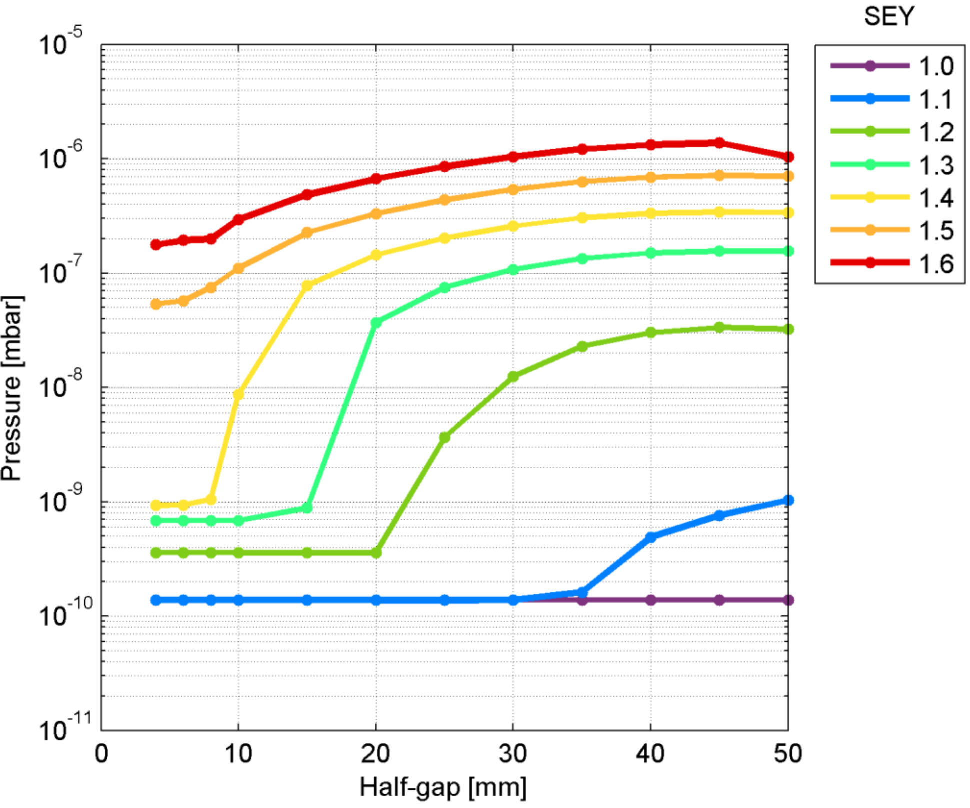
Simone Callegari

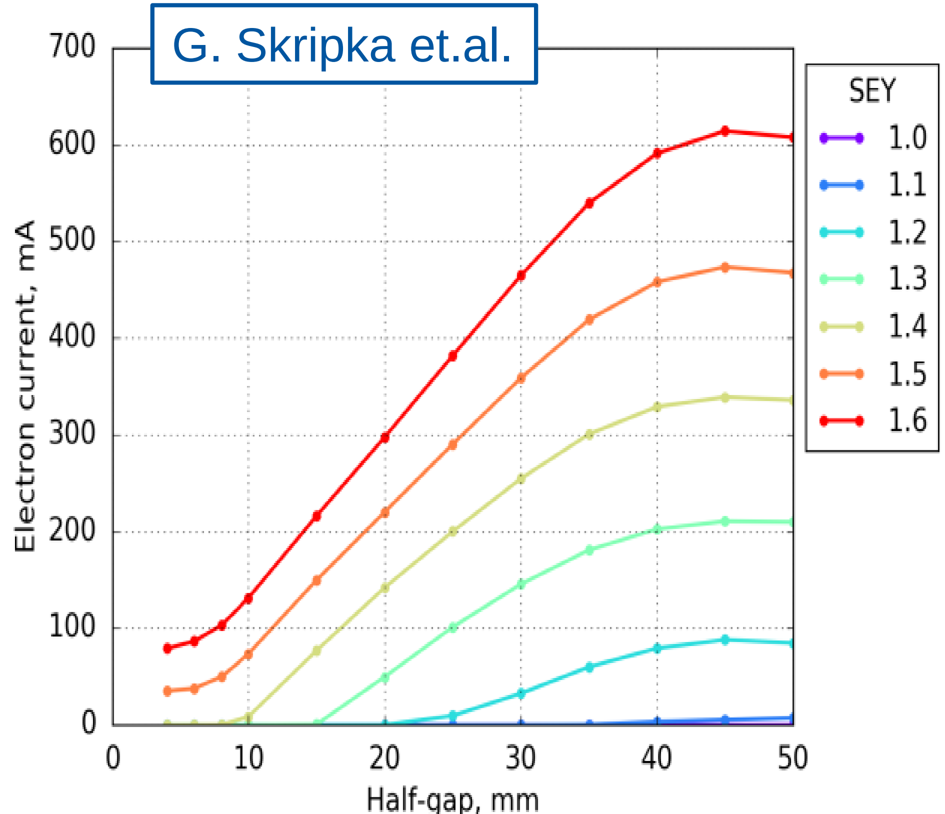
Vacuum v.s total electron flux

Max Dynamic pressure in TDIS as a function of half-gap, SEY

input

Total electron flux in TDIS as a function of half-gap, SEY

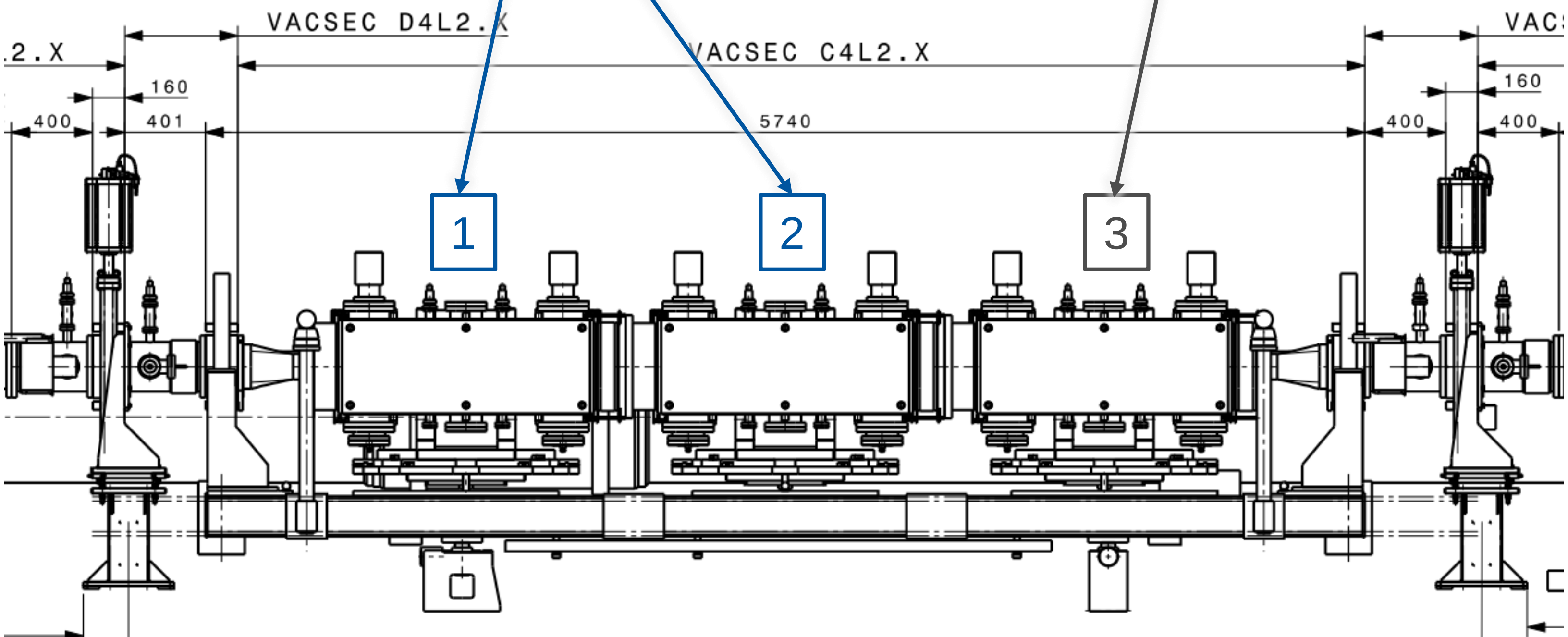




Real case vacuum profile simulation

Uncoated graphite jaw
With Stainless steel RF shield

A block of Ti6Al4V 965mm and CuCrZr 600mm
With Stainless steel RF shield



Assume:

- δ_{max} for graphite = 1.1
- δ_{max} for StSt ~ 1.6
- δ_{max} for Cu/Ti/Al = 1.6

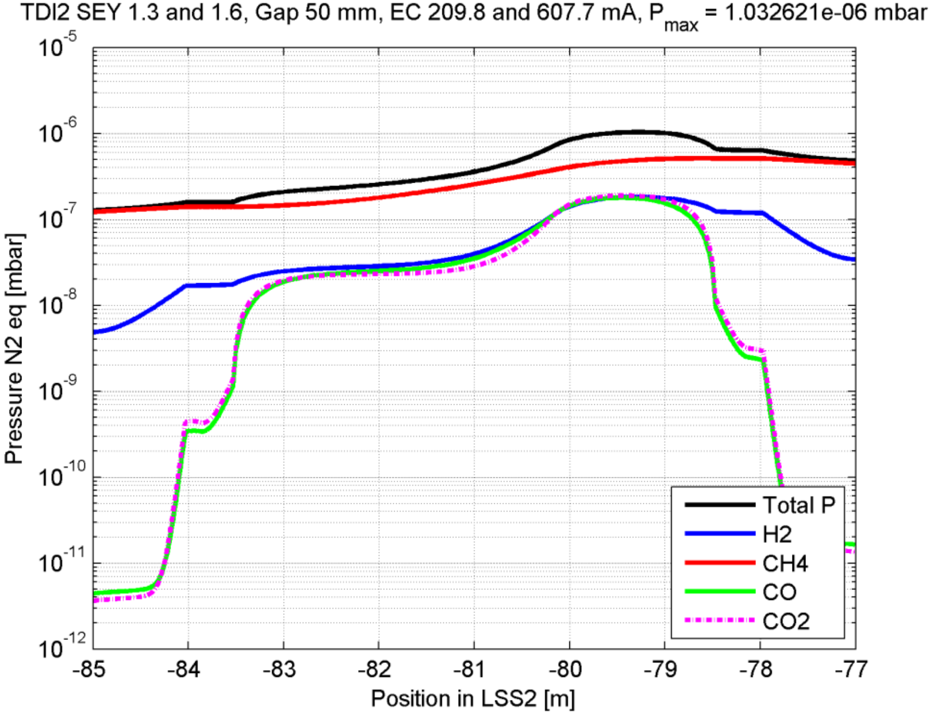
Assume:

- $Average\ \delta_{max}$ for Tank1 and Tank2 = 1.3
- $Average\ \delta_{max}$ for Tank3 ~ 1.6

Vacuum simulation (6) –reality case study

- Tank 1 and 2: uncoated graphite jaw with Stainless steel RF shield.
- Tank 3: A block of Ti6Al4V 965mm and CuCrZr 600mm with Stainless steel RF shield.

- Consider Half-gap = **50 mm**
- SEY = 1.3 for Tank 1 and 2.
- SEY = 1.6 for Tank 3.
- P_{max} = 1.03x10^{-6} mbar.



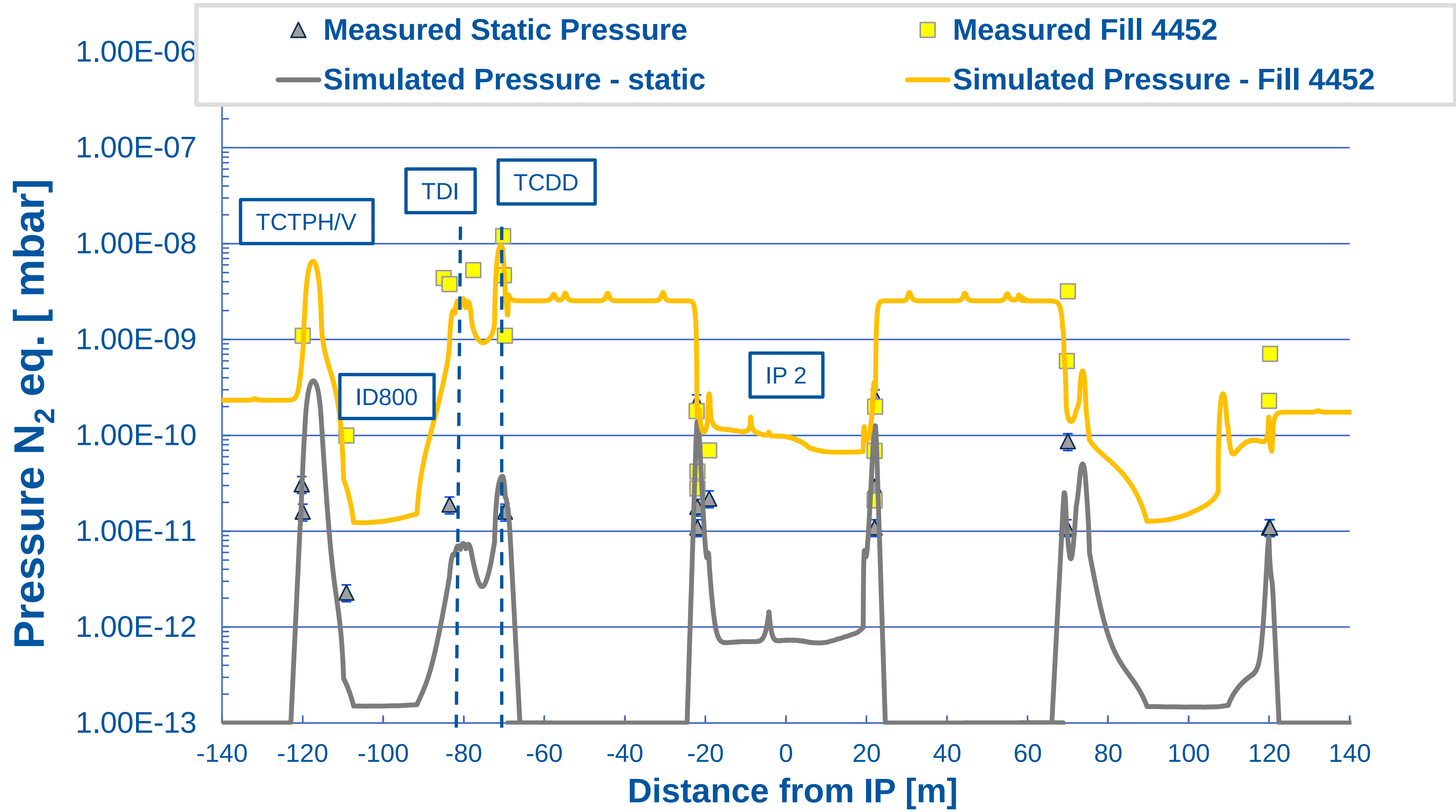
Conclusion TDIS:

- The expected electron cloud flux for the new TDIS is twice of the value as what we have today.
- The dynamic pressure rise in the TDIS is 1.04×10^{-6} mbar by considering SEY=1.6 and Half-gap of 45-50 mm.
- Optimal operation distances and **scrubbing** are needed if the TDIS runs as it is.
- NEG/a-C coating may be an option for the Cu blocks and the RF shields to reduce the initial dynamic pressure rise. More studies are needed.

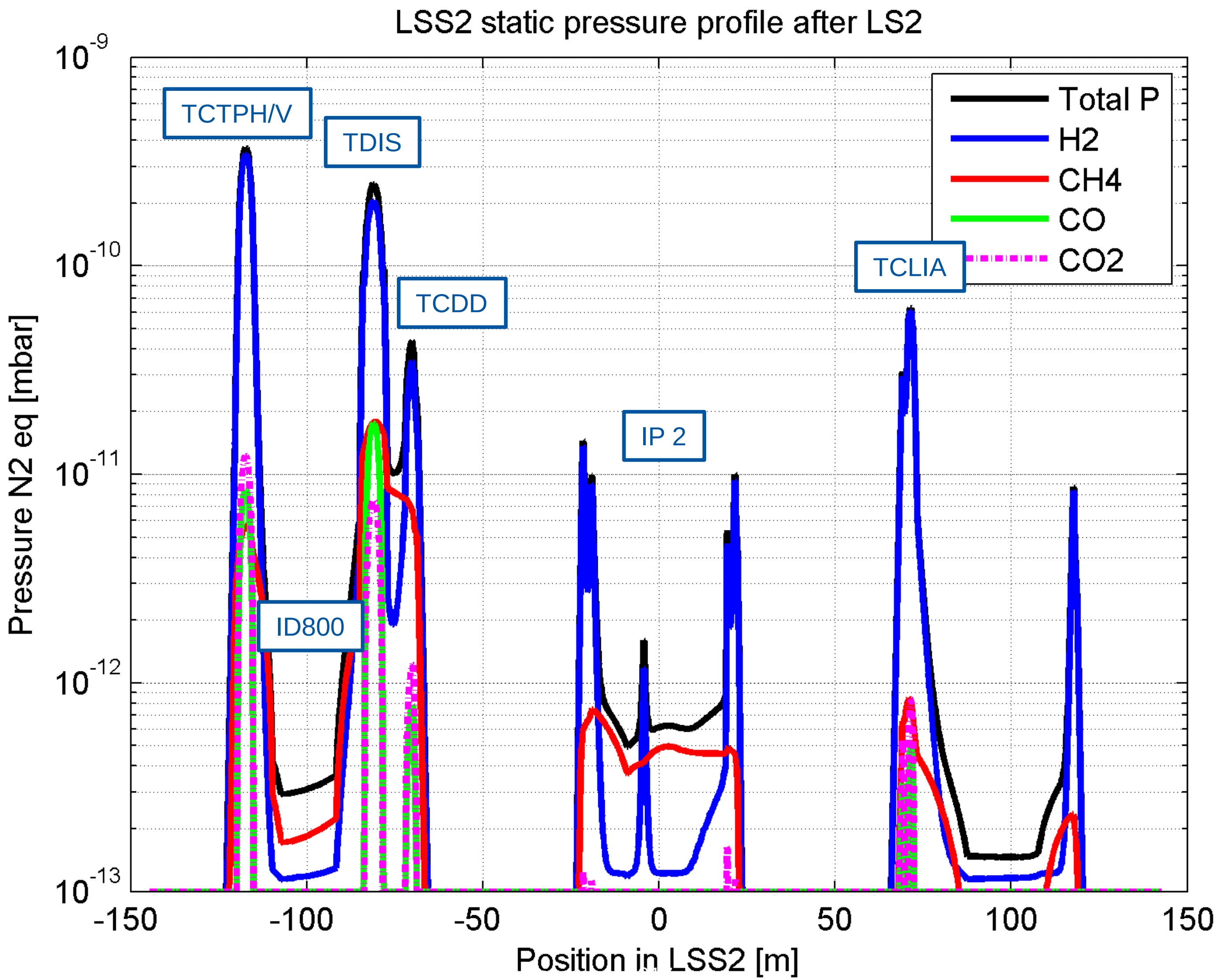
Vacuum Layout Integration LSS2

Static/Dynamic pressure after LS1

Fill 4452: 25ns 1465b in B1 and B2, stable beam 55825s



Static Pressure after LS2



Back-ups

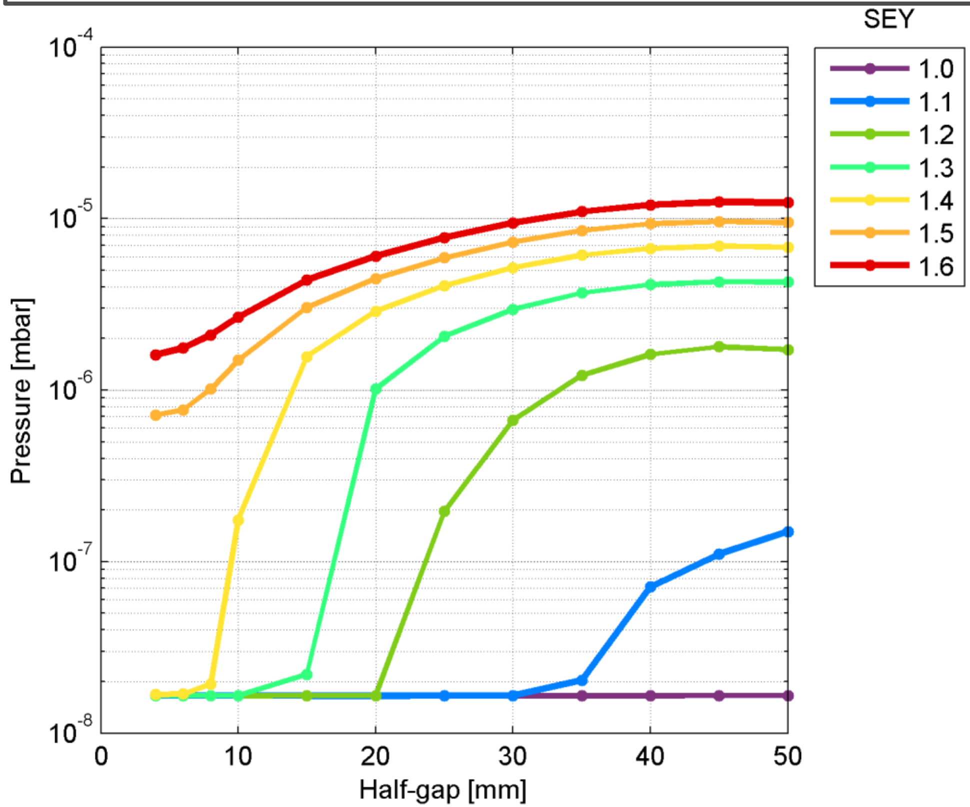
Vacuum v.s total electron flux

Max Dynamic pressure in TDIS as a function of half-gap, SEY

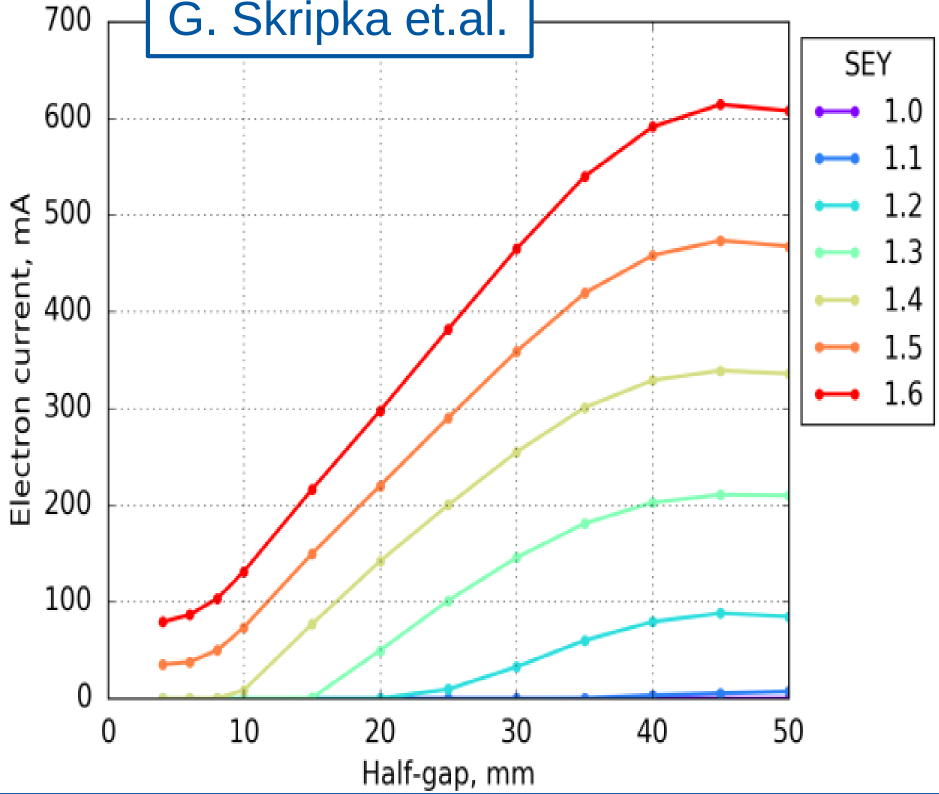
input

Total electron flux in TDIS as a function of half-gap, SEY

Worst scenario by considering the ESD_max

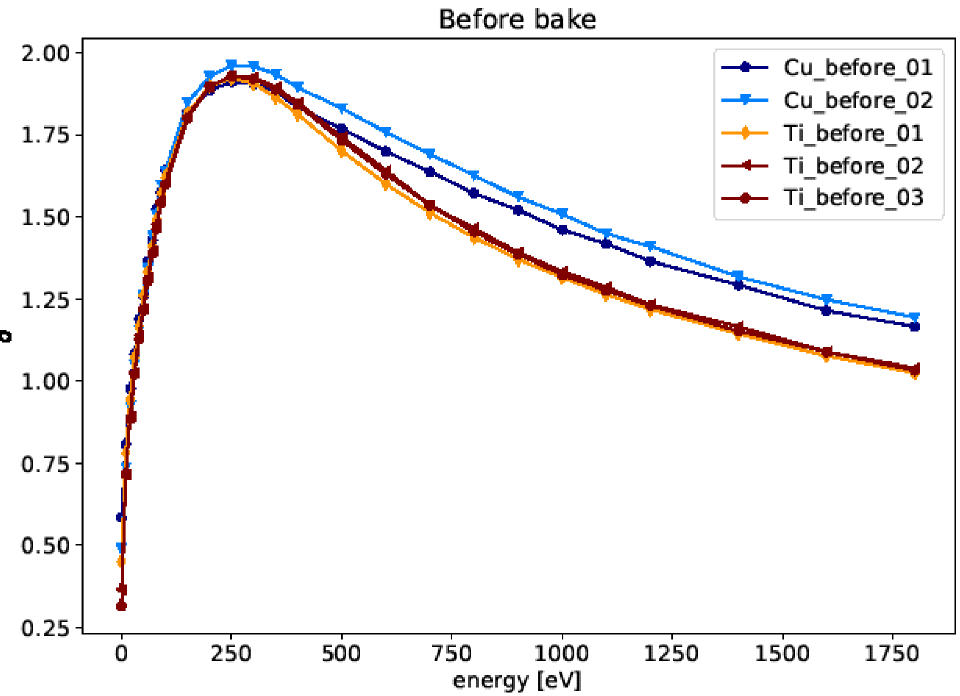


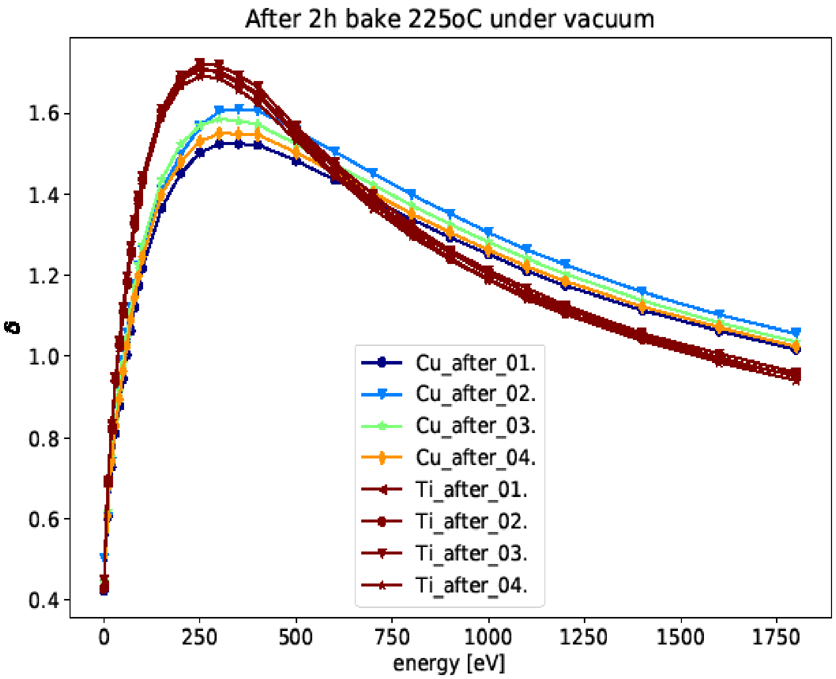
G. Skripka et.al.



SEY measurements

- Before the bake out (2h at 225ºC), Ti and Cu have similar SEY_{max}.
- After the bake out, Ti: SEY_{max} ~ 1.75 while Cu: SEY_{max} ~ 1.6.





Holger Neupert

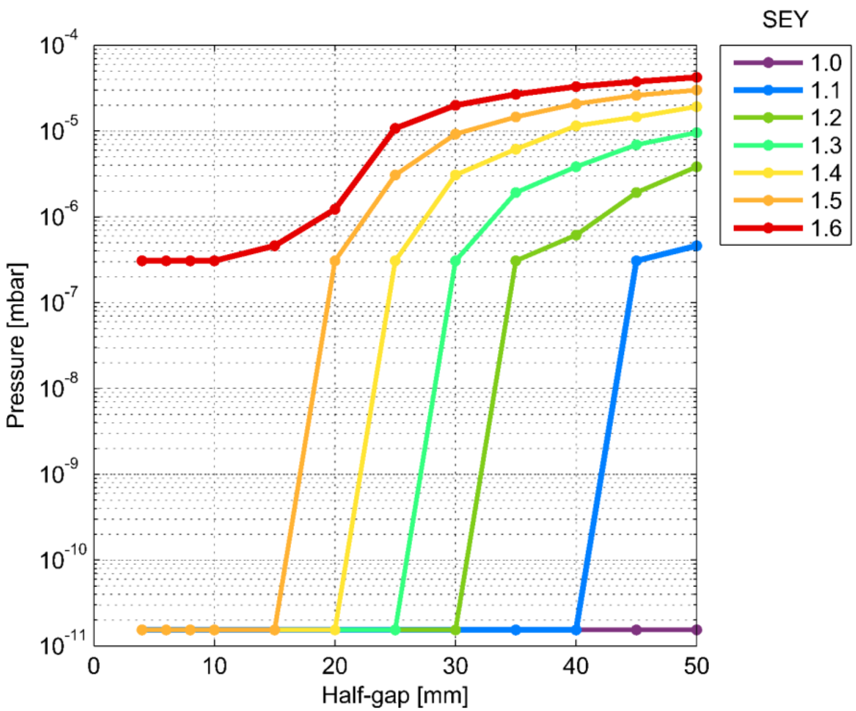
The Current TDI

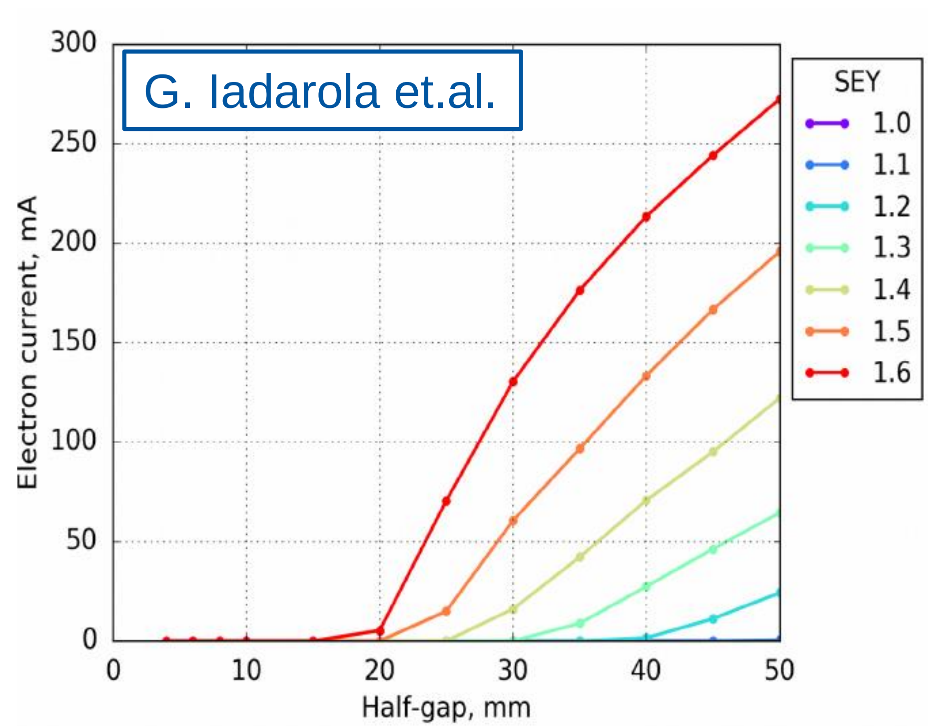
Vacuum v.s total electron flux

Dynamic pressure in TDI as a function of half-gap, SEY

input

Total electron flux in TDI as a function of half-gap, SEY





- To be noted: ESD is considered as ESD_max, not as a function of SEY
- The plot represents the worst scenario in pressure rise.