Pressure distribution calculations for the PETS system and the accelerating structure

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2- The calculation method

3- Preliminary results

4- Conclusions...and... next?

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Recent investigations of TS-MME for the CLIC project, ~~10~~ of June 2005

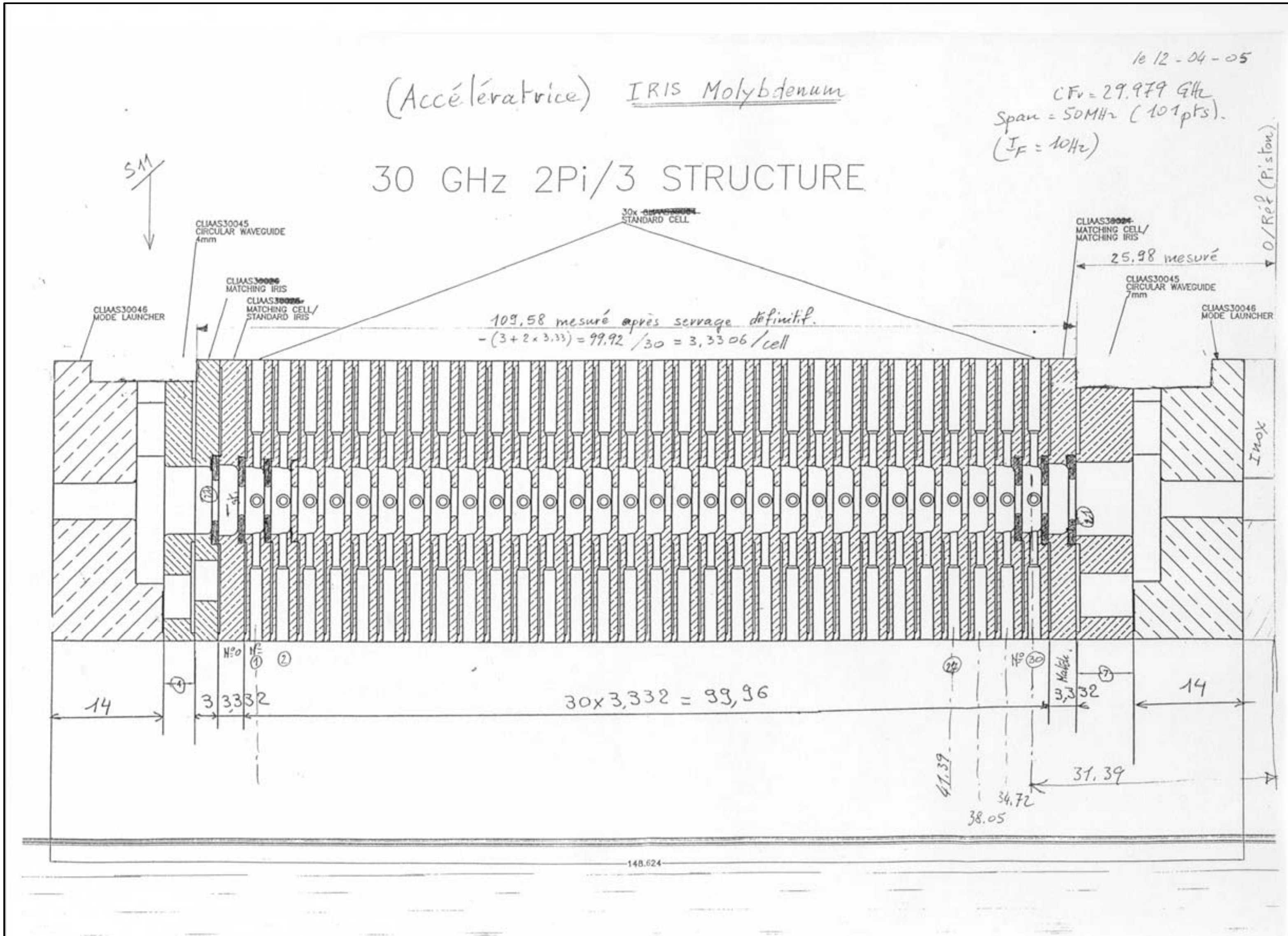
Problem:

RF breakdown in CTF3.

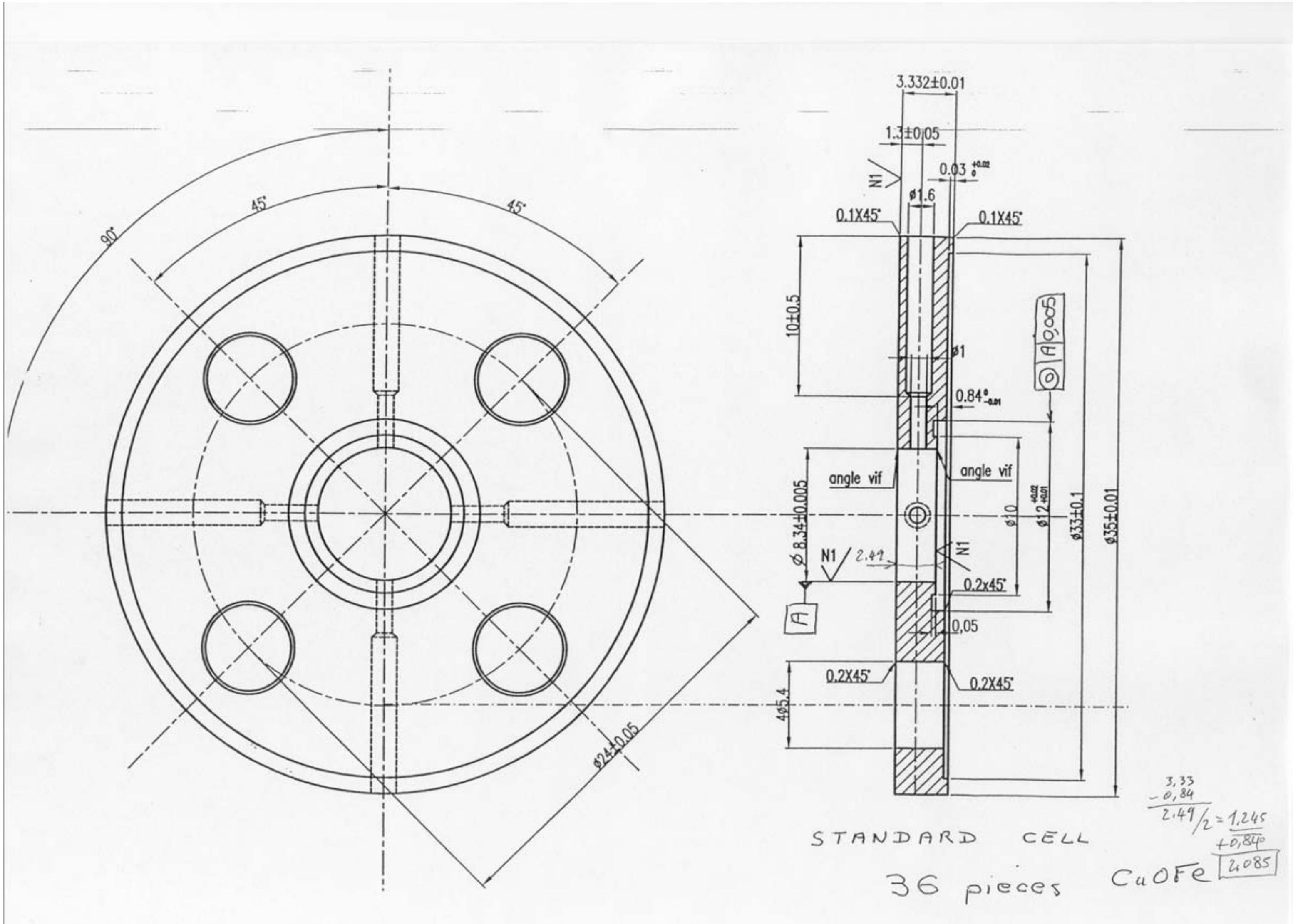
Possible causes: gas discharges?… Electron bombardment due to field emission?…

Necessary to calculate the pressure distribution inside the PETS and accelerating cavities and correlate it with pressures read by the gauges.

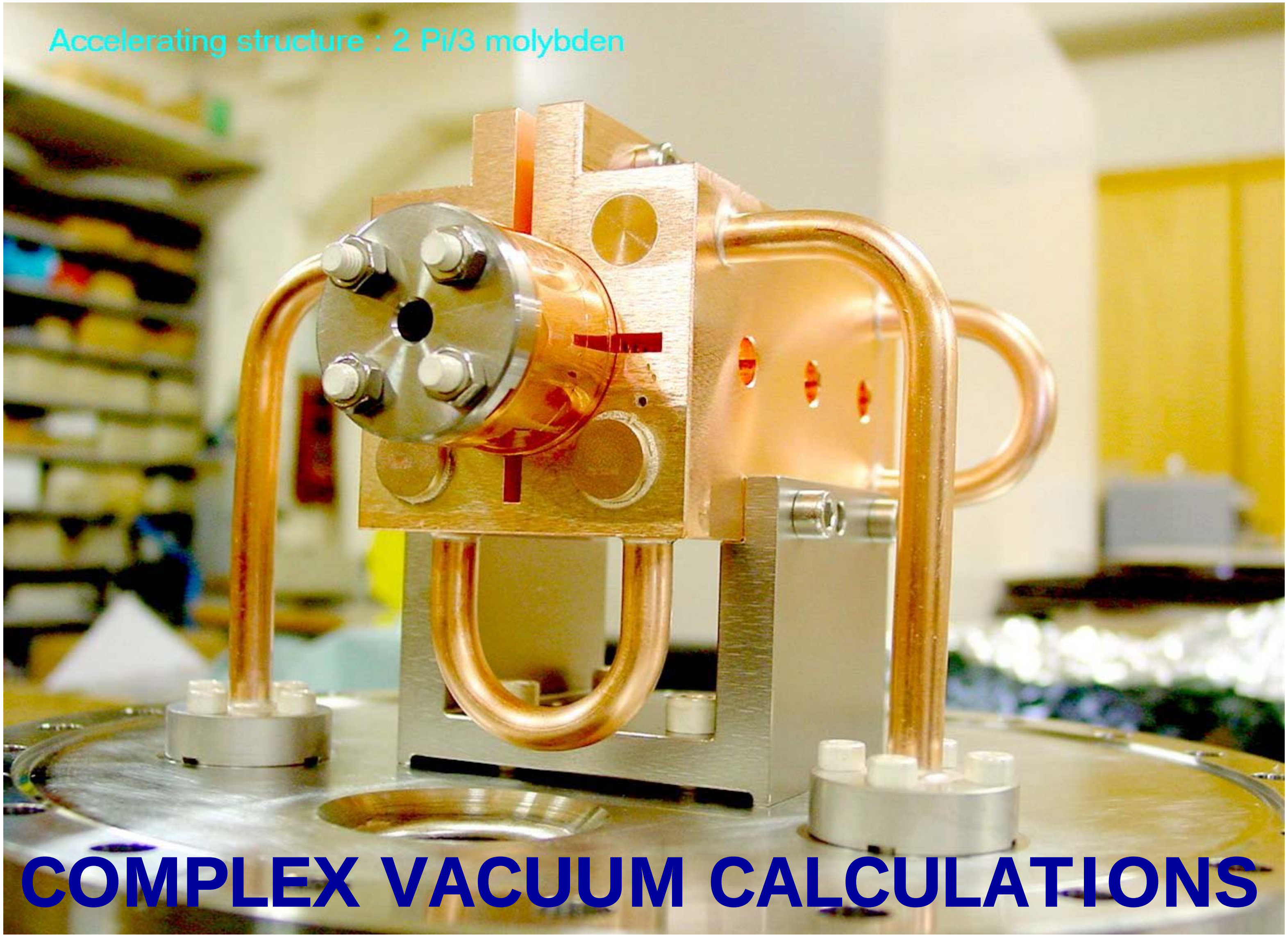
The accelerating cavity



The accelerating cavity



The accelerating cavity



The calculation method

- ~~Analytical solution:~~ too many differential equations!
- ~~Monte Carlo simulation:~~ promising, but long to implement
- Electrical network analogy: The same differential equations as for the analytical solution... but solved numerically by dedicated software! (PSpice)

Fast implementation, user friendly, easy to upgrade

The electrical analogy

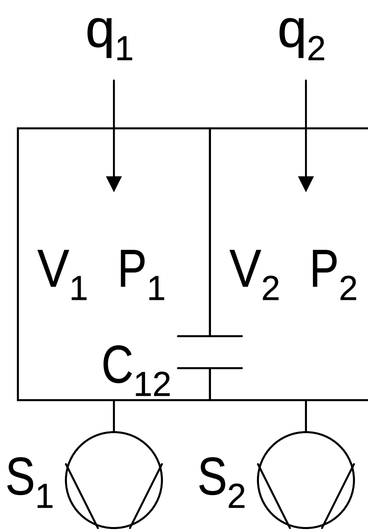
Flow of gas molecules ⇔ Flow of electrons

vacuum	*electric*
$\frac{dQ_{molecules}}{dt} = q = C.p$	$\frac{dQ_{electrons}}{dt} = I = G.V$
$q = V.\frac{dp}{dt}$	$I = C.\frac{dV}{dt}$
Pressure p [Torr]	*Potential V* [V]
Volume V [l]	*Capacitance C* [F]
Conductance C [l s^{-1}]	*Conductivity G* [Ω^{-1}]
Gas flow q [Torr l s^{-1}]	*Current I* [A]

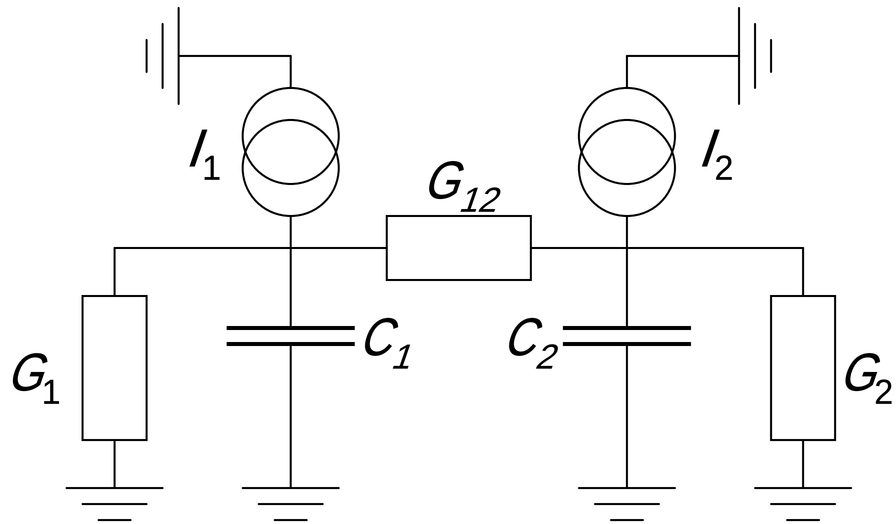
The calculation method

Flow of gas molecules ⇔ Flow of electrons

vacuum



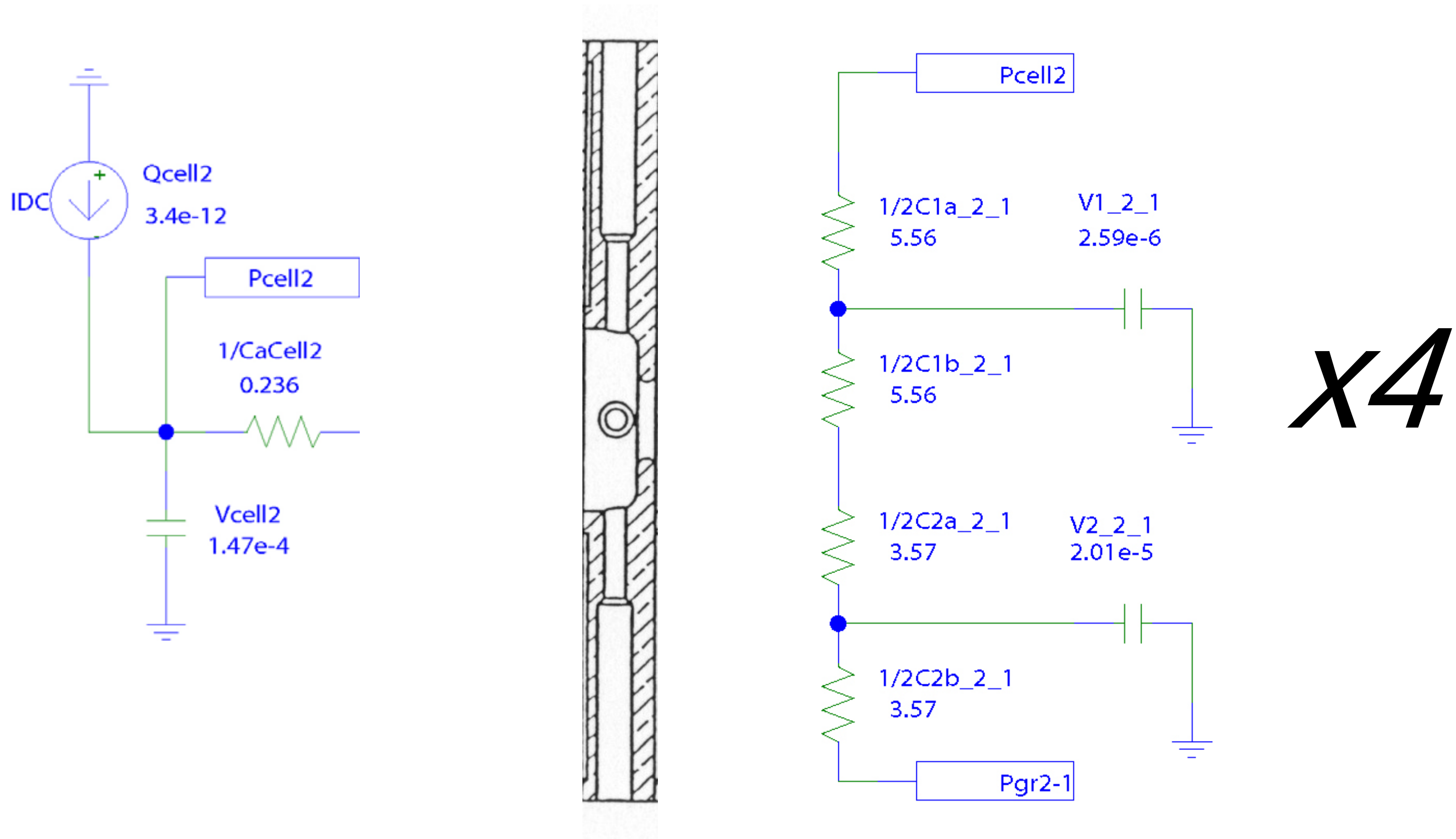
electric



Pressure p [Torr]	*Potential V* [V]
Volume [l]	*Capacitance* [F]
Conductance [l s^{-1}]	*Conductivity* [Ω^{-1}]
Gas flow [Torr l s^{-1}]	*Current* [A]

Implementation

Equivalent circuit for a standard cell$_i$



Implementation

Circuit for the accelerator structure and half of the wave guide to PETS

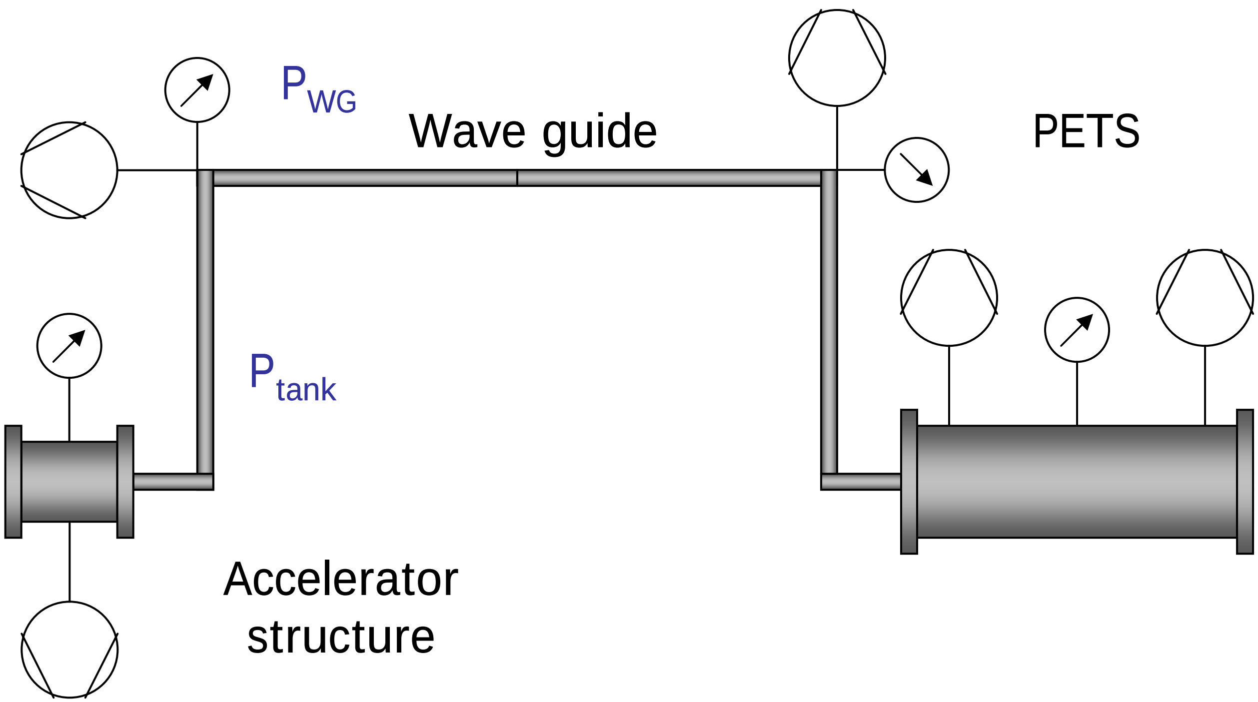
Watch me

Preliminary results

Steady state (bias point analysis)

Assumptions: ~~Well baked~~ system with outgassing rate of 2×10^{-12} Torr.l.s^{-1}.cm^{-2}

Gas loads are distributed (current sources)



	Simulation [Torr]	Experimental [Torr]
P_{tank}	1.7×10^{-10}	3.8×10^{-9}
P_{WG}	3.5×10^{-10}	9.0×10^{-9}
	0.49	0.42

OK!

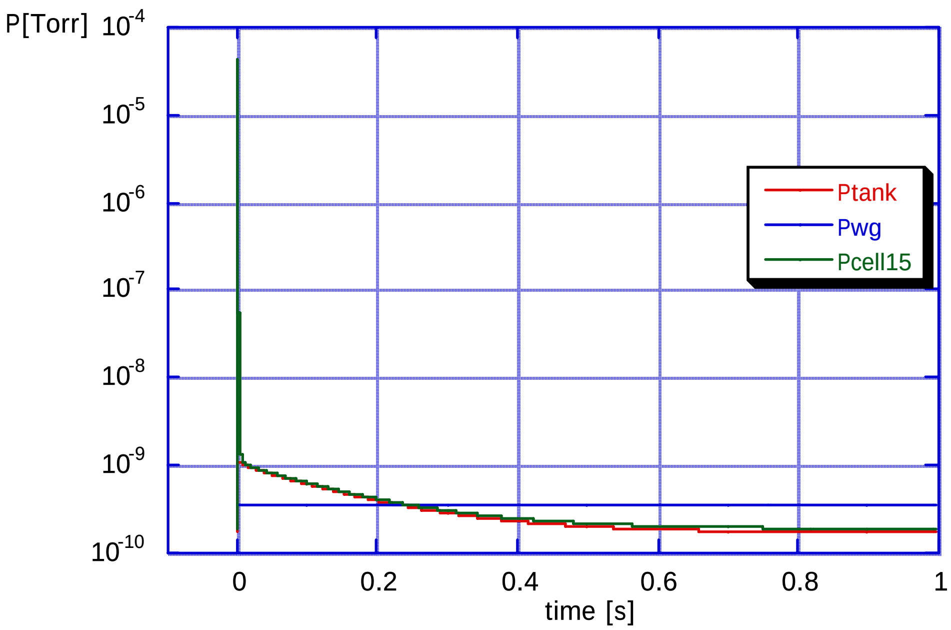
Preliminary results

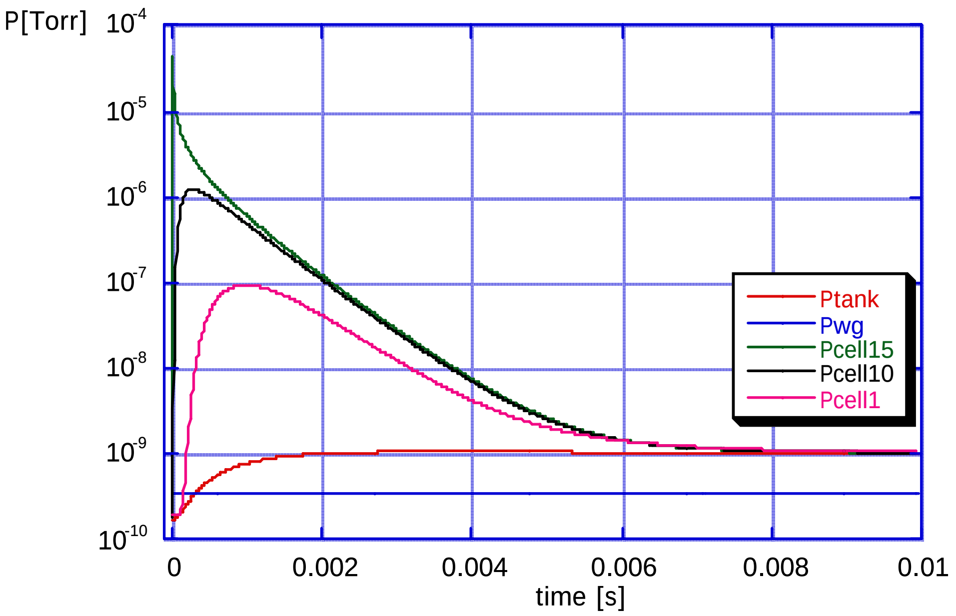
Transient analysis: Simulation of a pressure burst caused by a spark.

Assumptions: A 40 ns spark in cell 15 induces gas desorption from a region of 100μm diameter & 1μm deep.

gas from 1 monolayer: $q_m = 6.1 \times 10^{-2}$ Torr l s^{-1}

gas from 5ppm of O in Cu: $q_O = 1 \times 10^{-1}$ Torr l s^{-1}





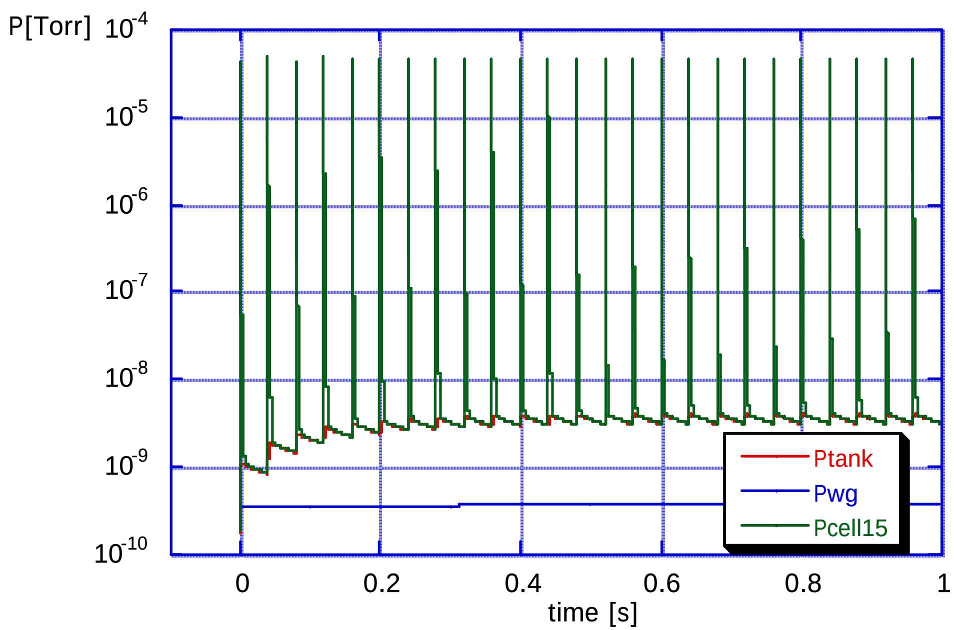
Preliminary results

Transient analysis: Simulation of successive pressure bursts induced by 40ns sparks at 25Hz repetition rate.

Assumptions: Each 40 ns spark in cell 15 induces gas desorption from a region of 100μm diameter & 1μm deep.

gas from 1 monolayer: q_m=6.1x10^{-2} Torr l s^{-1}

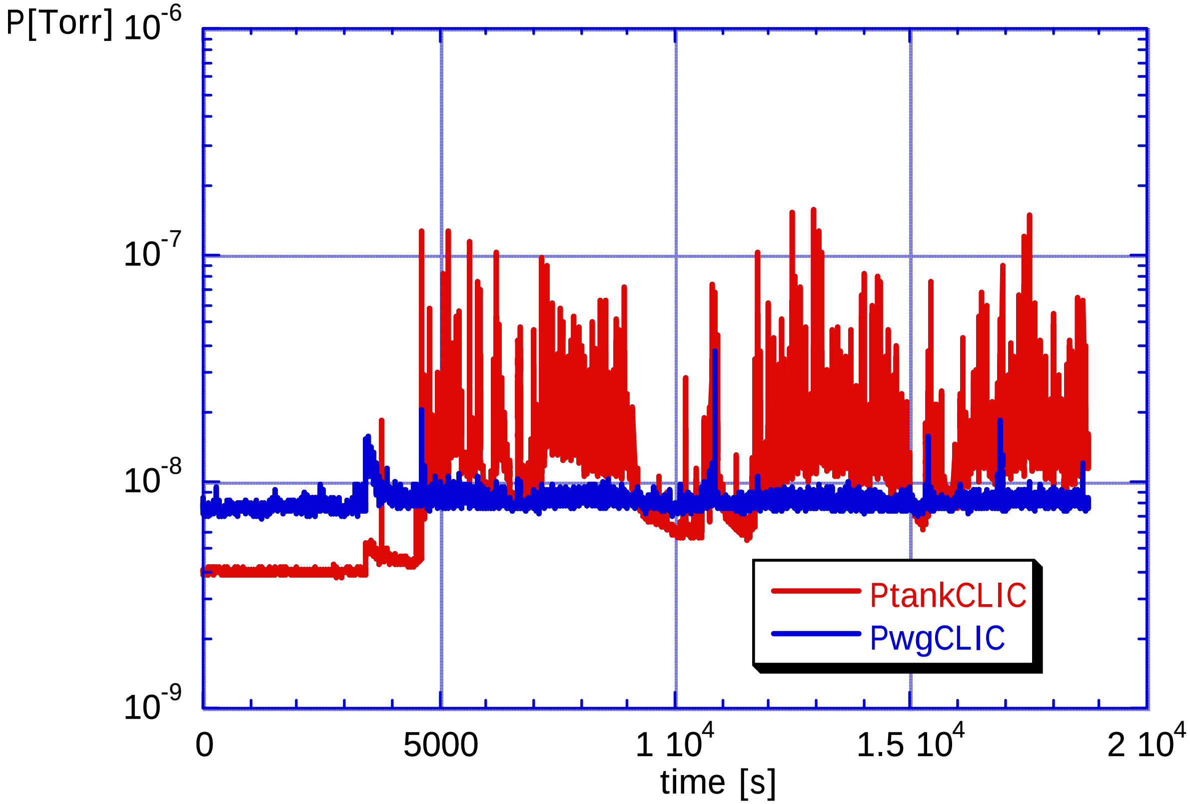
gas from 5ppm of O in Cu: q_O=1x10^{-1} Torr l s^{-1}



Preliminary results

Transient analysis: Comparison with experimental data.

conditions: Pressure measured by penning gauges and recorded every second.



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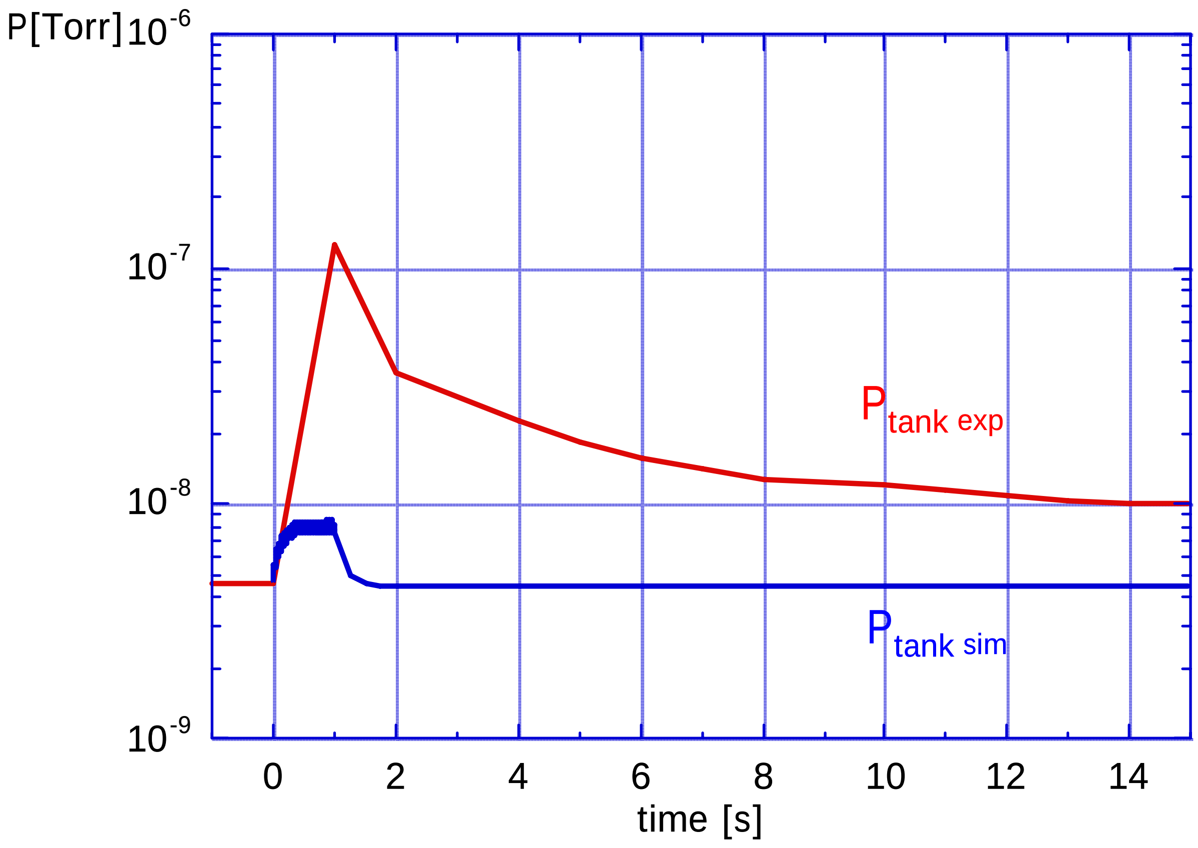

Preliminary results

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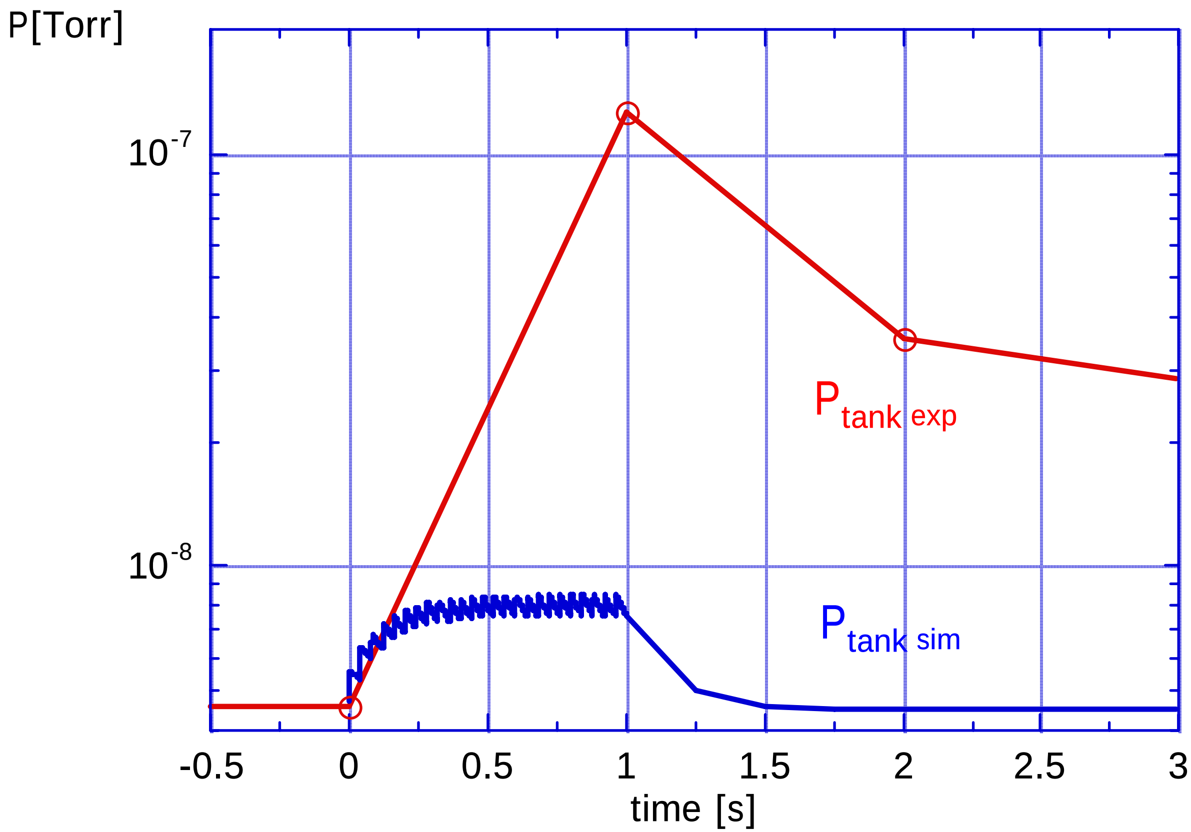


Conclusions

PSpice is a useful tool to perform transient vacuum calculations using the electrical network analogy.

The simulation of the accelerator structure and half of the wave guide give coherent results.

And next?...

Complete the simulation (PETS side, HDS)

Improve knowledge about the gas released: composition, quantity and time dependence. (increase acquisition rate; install RGA, measure real pumping speed in the tank, calibrated gauges).

Analyze experimental data and find gas loads matching the pressure profiles.

Thanks:

C. Achard

For the drawings and the photos of accelerator structure.

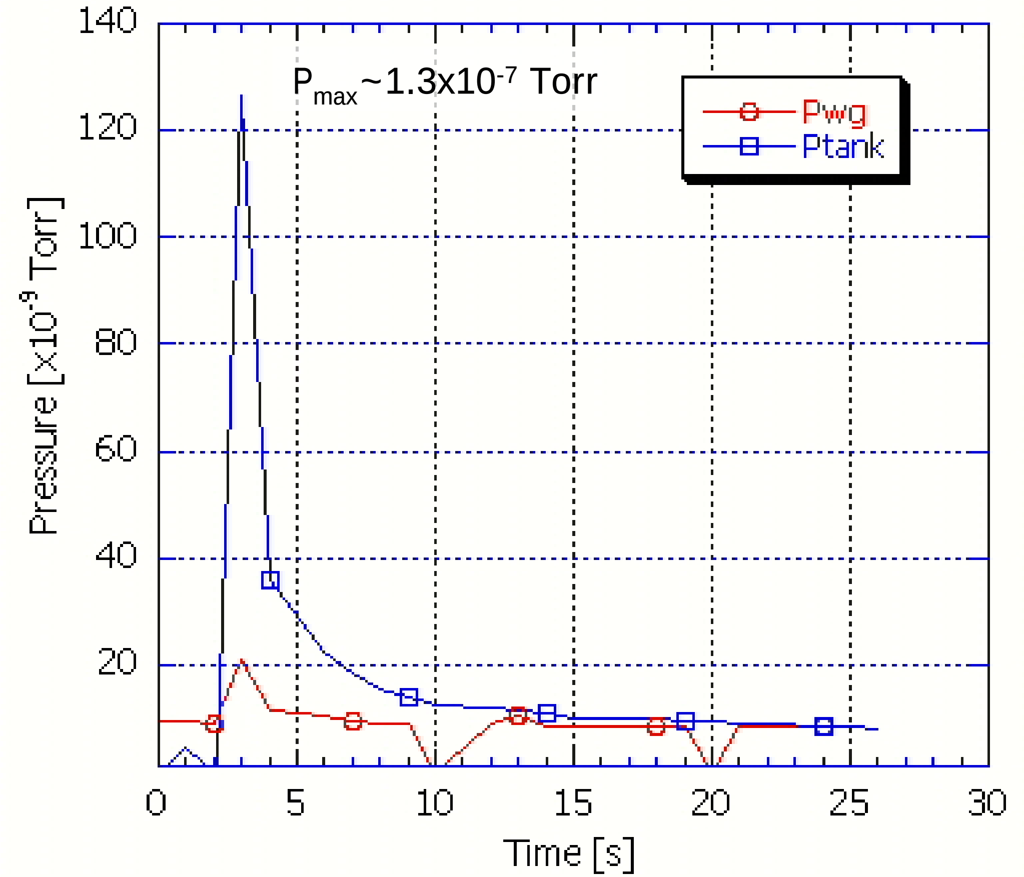
F. Tecker

For the pressure data.

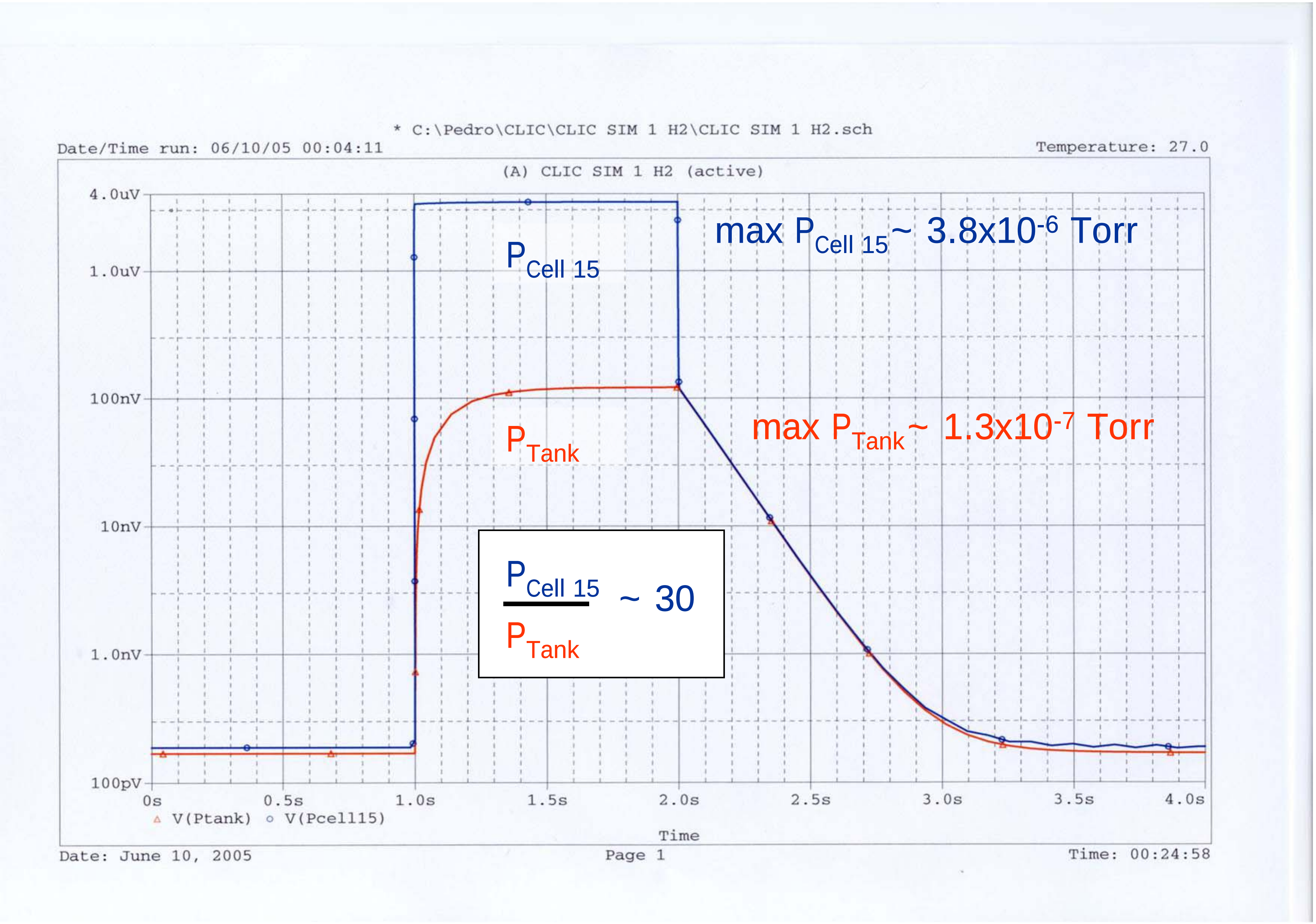
Preliminary results

Transient analysis

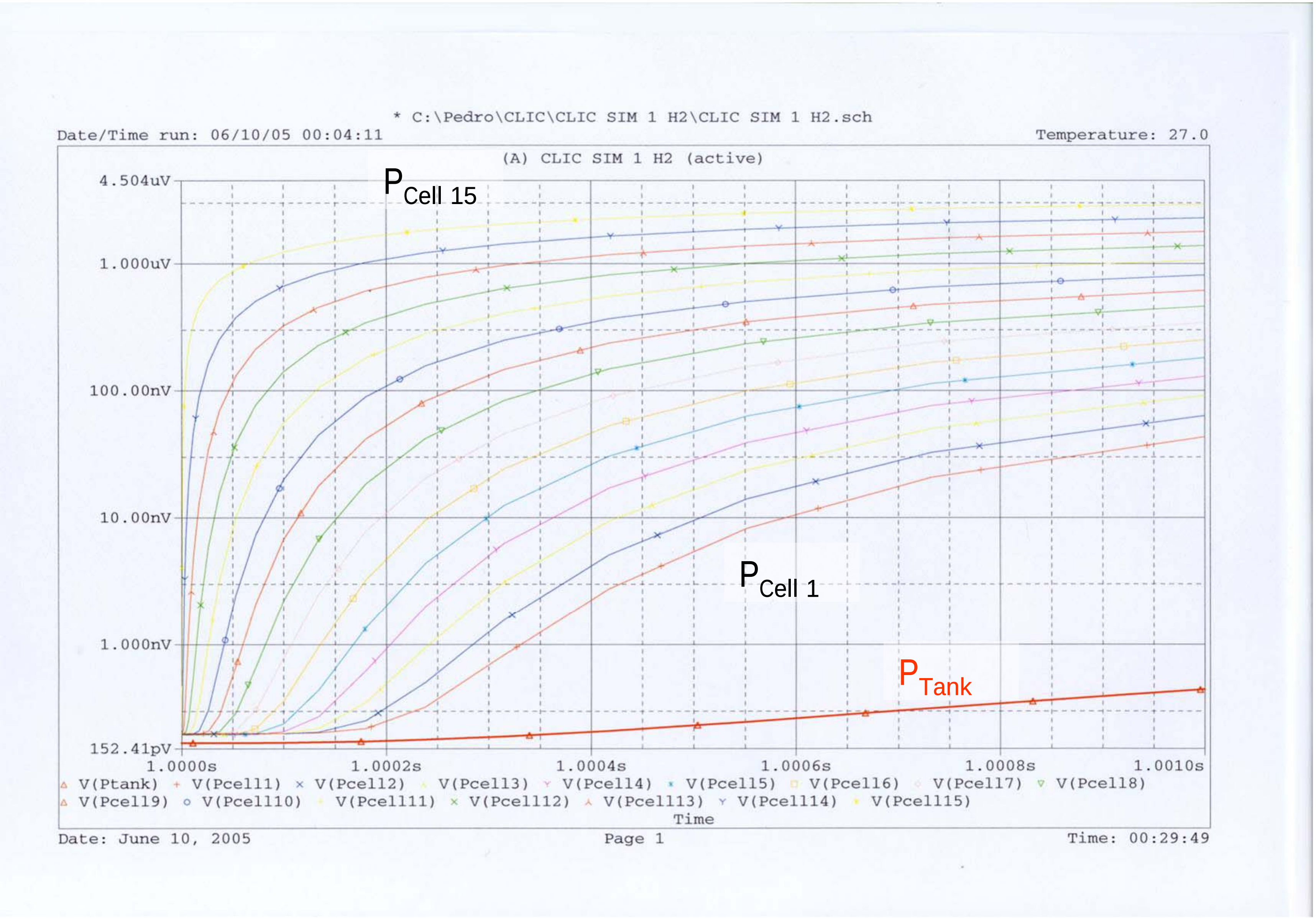
Typical pressure burst on P_{Tank}:

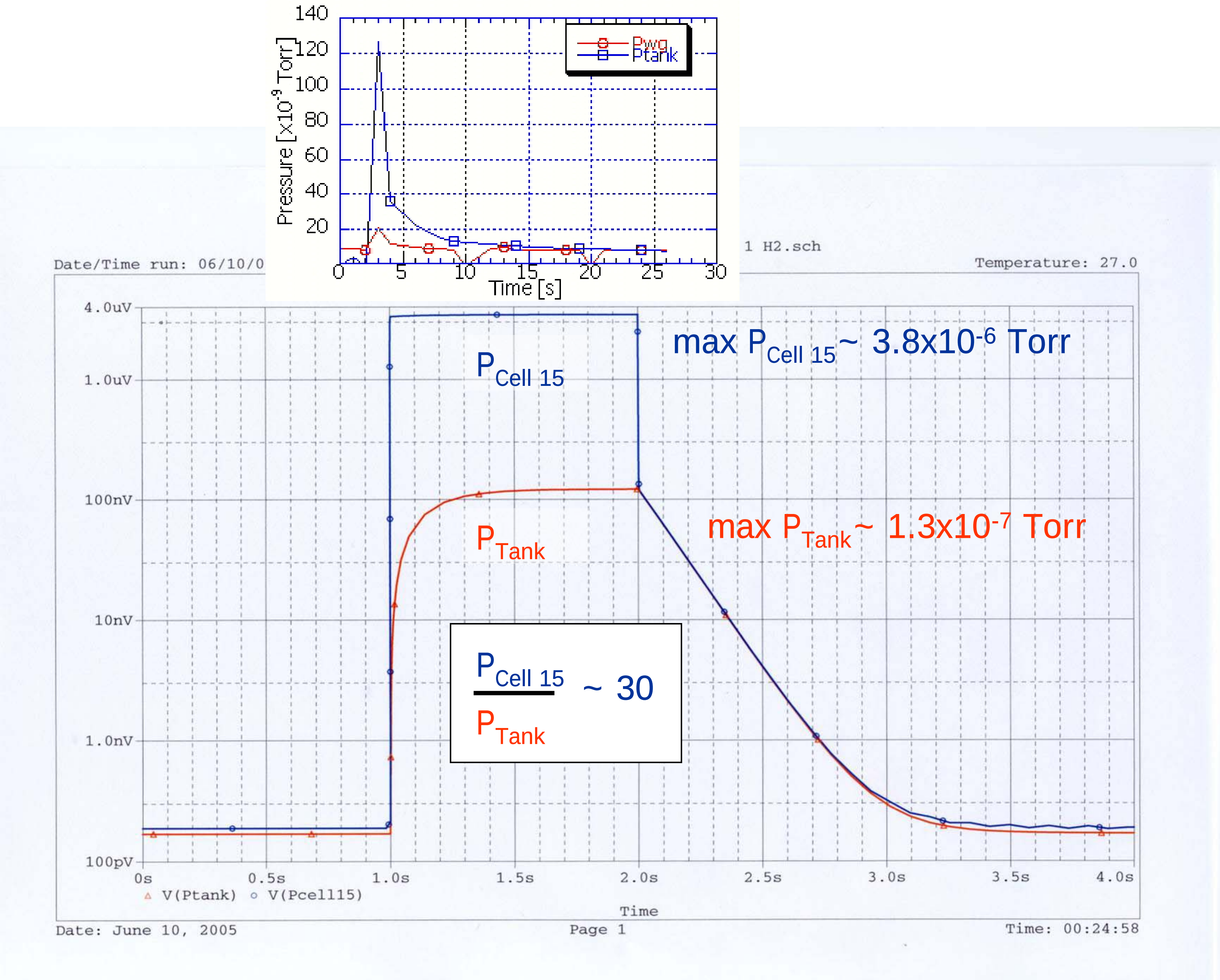


Preliminary results



Preliminary results





Pressure [x10^-9 Torr]
Time [s]
Pwg
Ptank
1 H2.sch
Date/Time run: 06/10/0
Temperature: 27.0
max P_Cell 15 ~ 3.8x10^-6 Torr
P_Cell 15
max P_Tank ~ 1.3x10^-7 Torr
P_Tank
P_Cell 15 / P_Tank ~ 30
V(Ptank)
V(Pcell15)
Time
Date: June 10, 2005
Page 1
Time: 00:24:58