GAS DISTRIBUTION SHCEMES FOR THE MICROMEGAS DETECTORS OF THE NSW OF ATLAS

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Outline

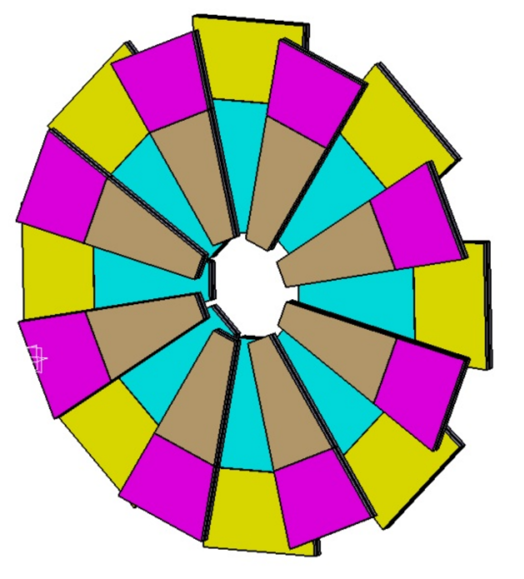
- The features of the gas distribution system
- Possible piping configurations
- Preliminary calculations
- Summary of the results
- Conclusions and Prospects

What is available for the gas ?

- Total gas volume is 6 m^3 (Ar:CO2 93:7 at atm. pressure)
- Flow rate (renewals): ≤ 10 volume changes a day (flow rate ~2500 l/h)
- Existing CSC gas racks (Ar:CO2 80:20 at atm. pressure) with 16 channels/rack can be reused (1 rack/wheel)
- Existing MDT gas racks (Ar:CO2 93:7 at 3 bar) with 17 channels/rack can be easily adapted to atm. pressure (1 rack/wheel)

For each wheel:
16 sectors x 2 typeMM/sector x 8 planes/typeMM = 256 planes
(MM types: LM1&2 or SM1&2)

If we could use all the available channels → 1 gas channel will serve 8 planes



Features of the gas distribution system

Main requirements

- Use of an open gas system with exhaust to the atmospheric air
- Circulation gas mixture Ar:CO_2 (93:7) at ΔP~10 mbar with respect to atmosphere
- In each MM plane & type: 2 upflow inlets and 2 outlets

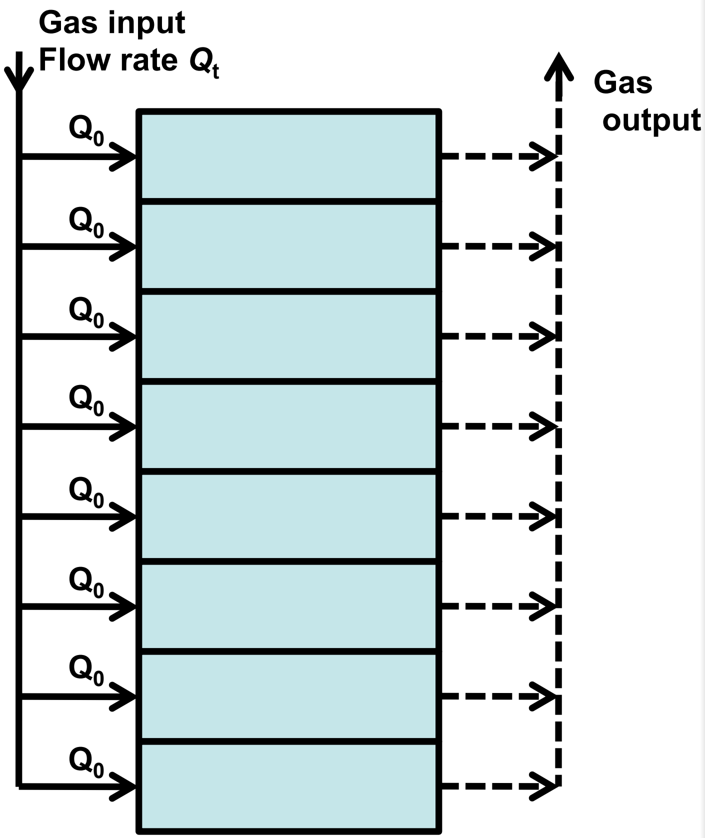
Particular-proposed options

- Gas supply to the MM detectors in parallel connection (8 MMs per channel)
- Flow meter sensors in each channel (input and output)
- Different volume changes among the inner and outer MMs due to different beam induced current (it has to be studied in more detail)?
- Precaution for isolating/disconnecting the MM's in case of catastrophic leakages (e.g. using on-off valves)?

How to share out the gas mixture ?

Individual flow rate in each channel

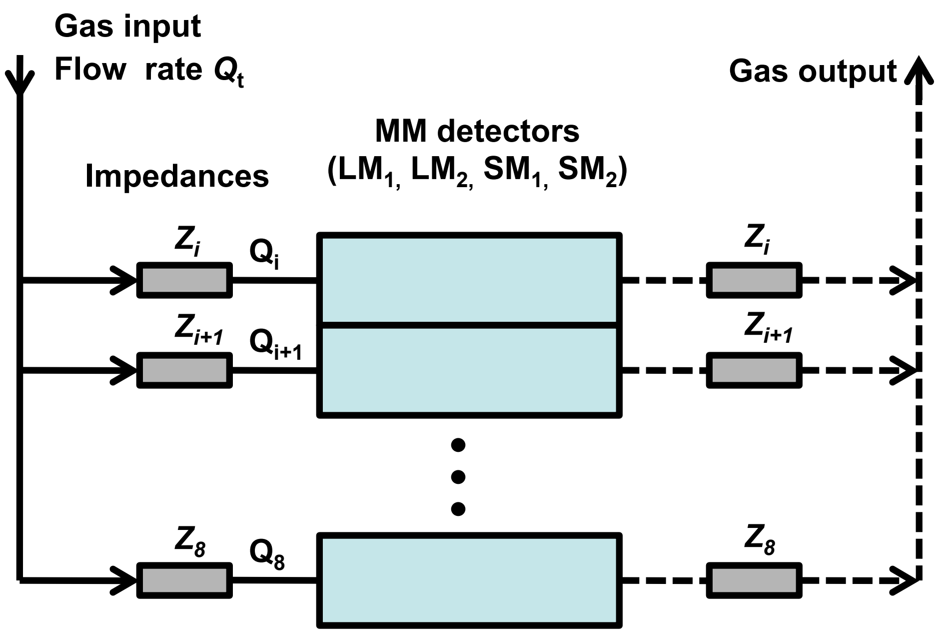
Difficult to equalize the flow rates



$$Q_t = 8Q_0$$

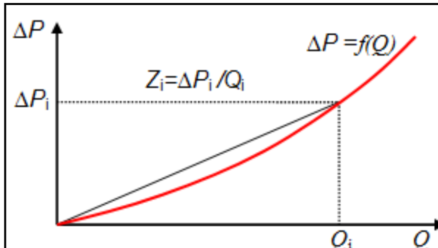
Individual flow rate in each type of MM

Feasible to manipulate the flow rates in a controllable way



$$Q_t = \sum_{i=1}^{8} Q_i$$

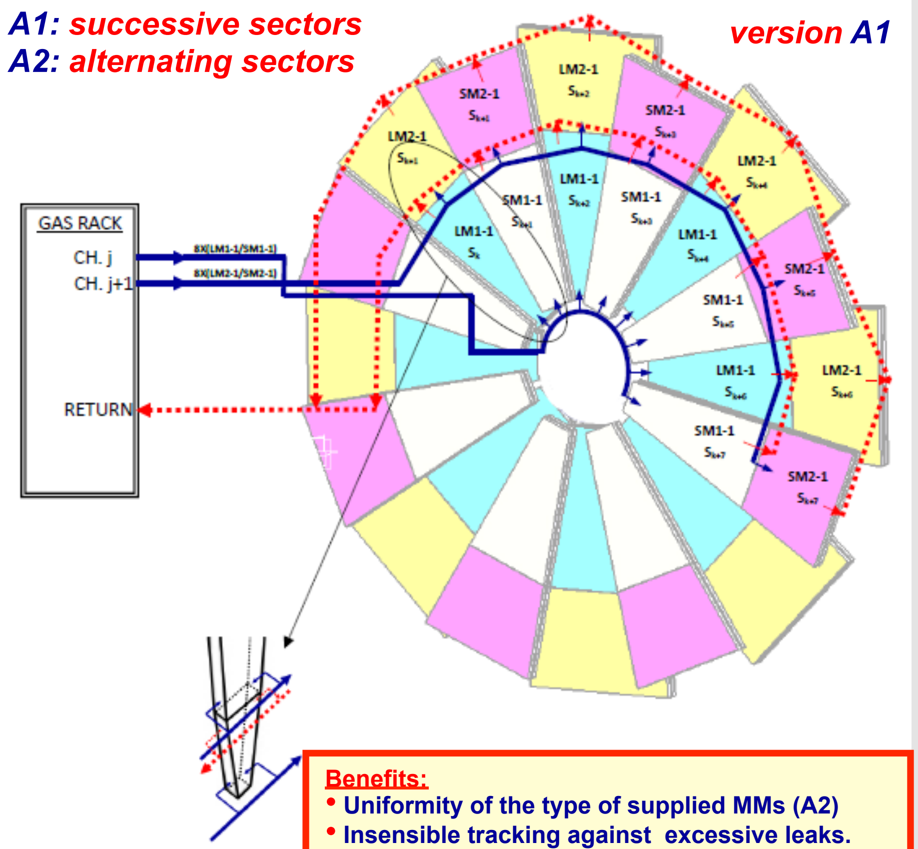
In principle, the ΔP-Q relation is non-linear due to turbulent flow.



Piping configuration

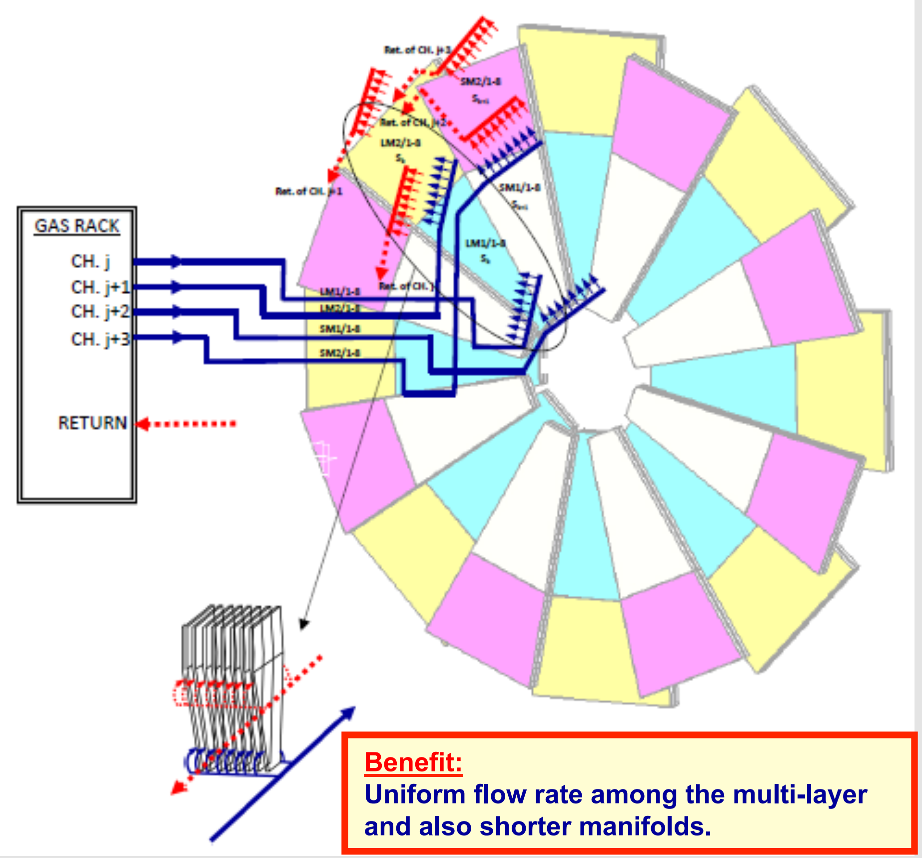
Two alternative configurations of the system could be used

Configuration "A" (chainlike)



Benefits:
- Uniformity of the type of supplied MMs (A2)
- Insensible tracking against excessive leaks.

Configuration "B" (daisylike)



Benefit:
Uniform flow rate among the multi-layer and also shorter manifolds.

The main variables used

Useful formulas

Flow rate of each MM with renewals *r (which is our main goal):* $Q_0 = \frac{rV_0}{24}$ (in l/h)

Flow rate of each channel supplying 8 MMs*:* $Q_t = \frac{rV_t}{24}$ (in l/h)

Interposed impedance for each MM with pressure drop ΔP_0 : $Z_0 = \frac{\Delta P_0}{Q_0}$ (in mbar.h/l)

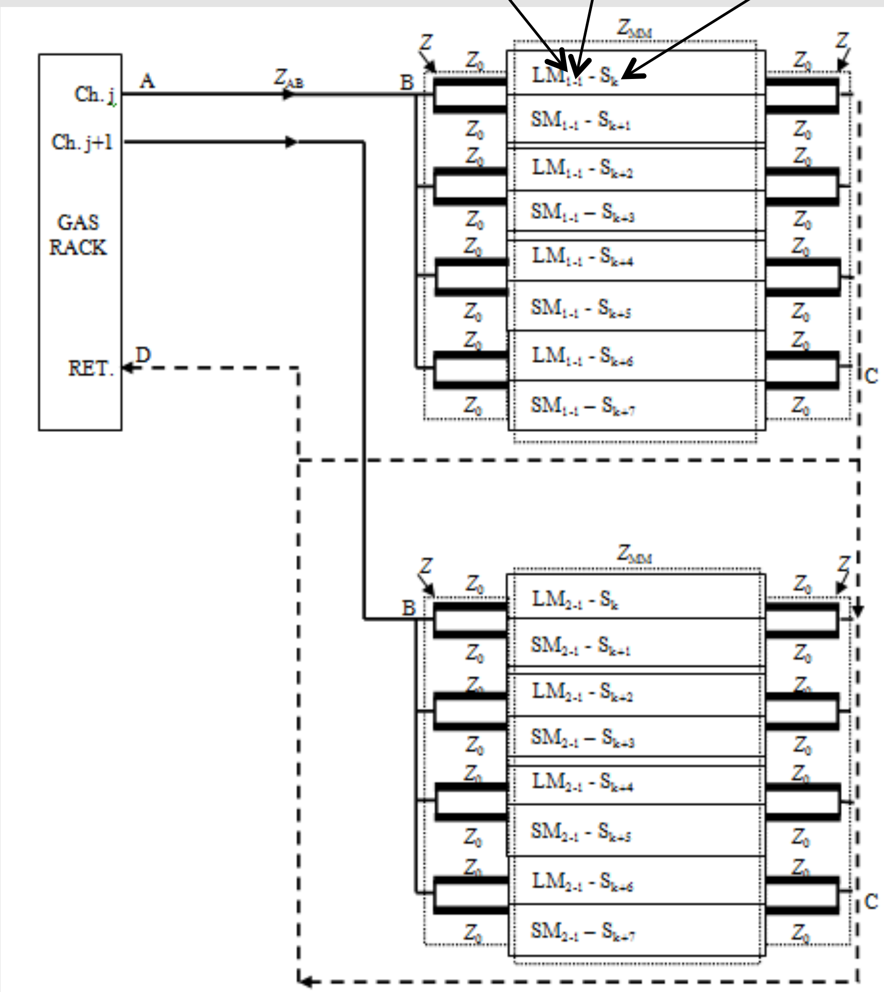
Assumption

In first approximation we consider that among the channels the impedances of supply and return lines are the same.

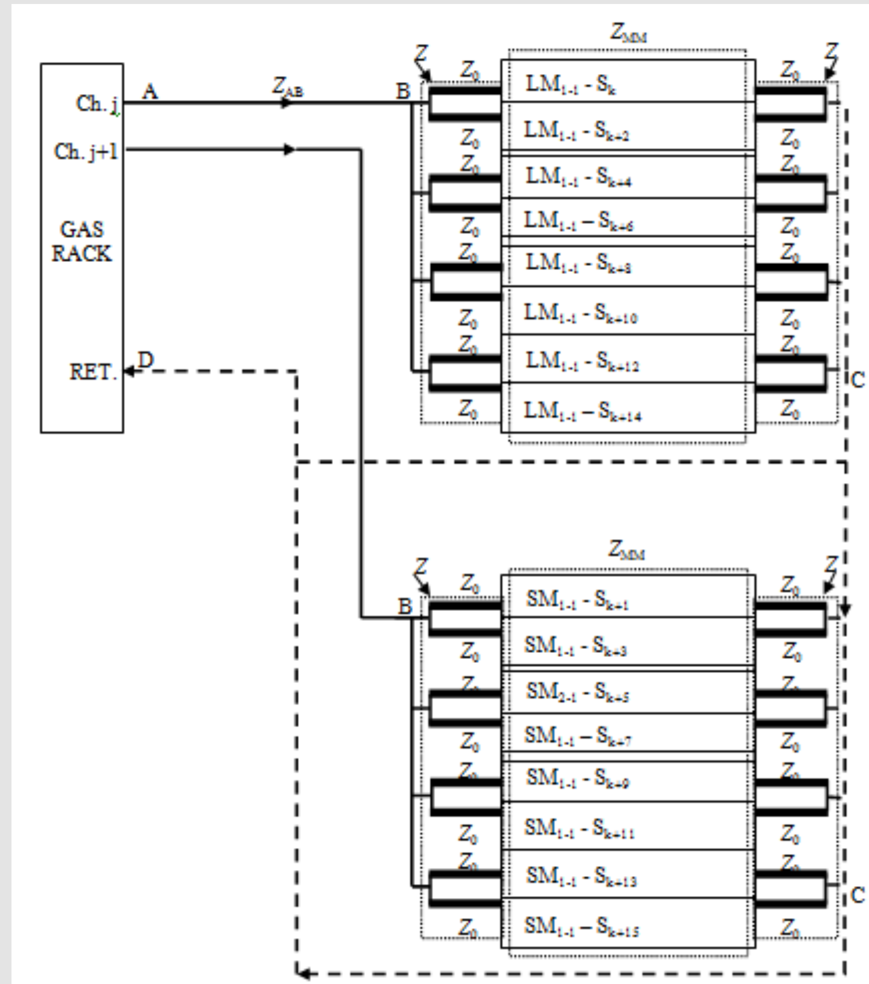
Gas channel piping

Configuration "A"

Version A1

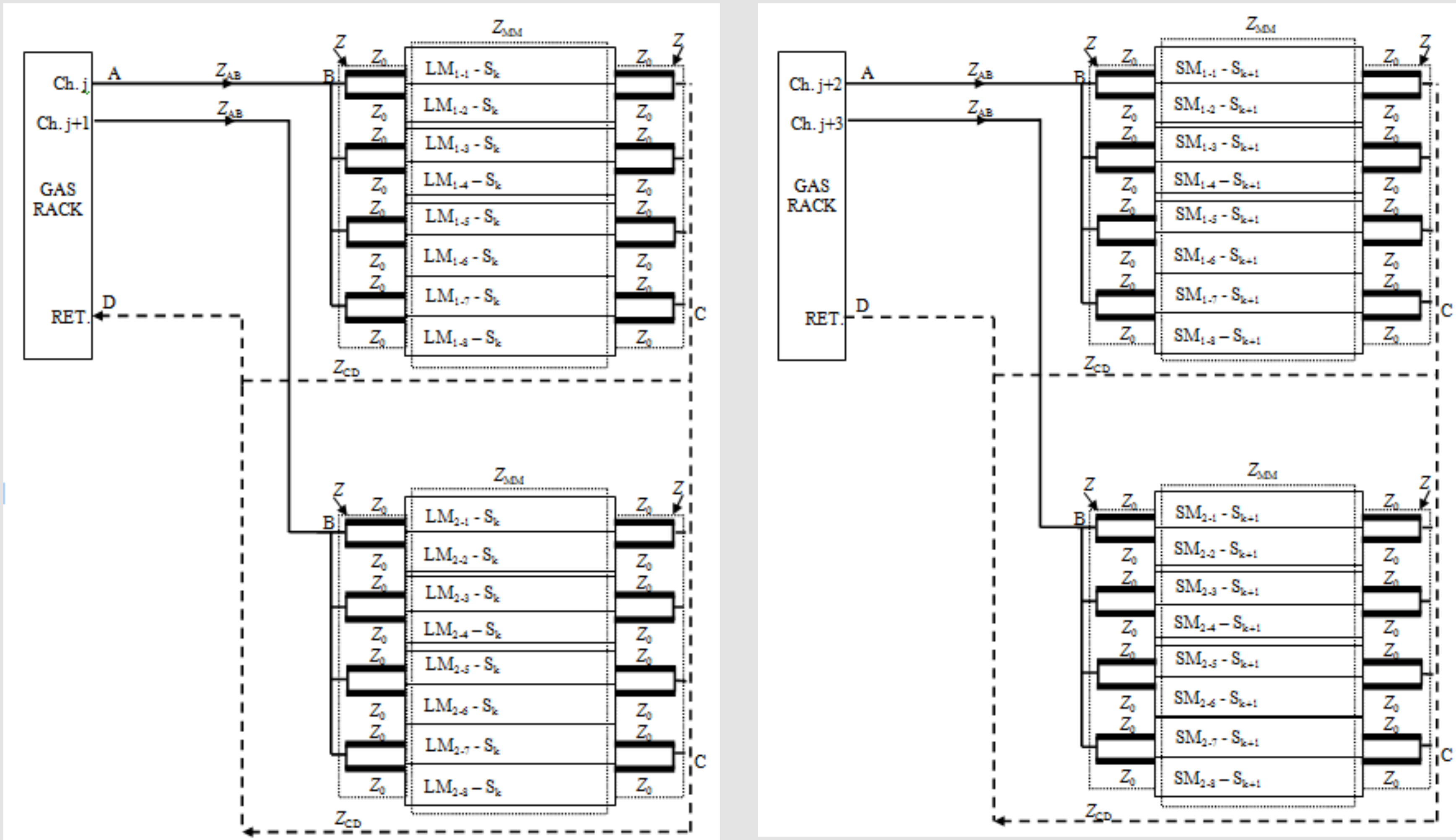


Version A2



Gas channel piping

Configuration "B"



Calculation of the impedances

Equivalent impedance of the group of 8 MMs in a channel: $\frac{2Z_0 + Z_{\mathrm{MM_i}}}{8} = \frac{Z_0}{4} + \frac{Z_{\mathrm{MM_i}}}{8}$

We can consider an equivalent impedance 2*Z*: $2Z \equiv \frac{Z_0}{4} + \frac{Z_{\mathrm{MM_i}}}{8} \Rightarrow Z = \frac{Z_0}{8} + \frac{Z_{\mathrm{MM_i}}}{16}$

Assuming $Z_{MMi} << 2Z_0$ we obtain: $Z = \frac{Z_0}{8} + \frac{Z_{MM_i}}{16} \cong \frac{Z_0}{8}$

Let also be: $Z_{\mathrm{MM}} \equiv \frac{Z_{\mathrm{MM_i}}}{8}$

Total impedance along a gas channel: $Z_{\mathrm{t}} = \frac{\Delta P(Q_t)}{Q_t} = Z_{\mathrm{AB}} + 2Z + Z_{\mathrm{MM}} + Z_{\mathrm{CD}}$

In the case that we would like to accomplish individual flow rates among the MMs, according to their renewal rates, we have to solve analytically the piping network using an appropriate software, e.g. "Pipe Flow".

Some early results

The particular volumes of the MMs are: $V_{LM_1} = 15.9\ \text{l},\ V_{LM_2} = 15.4\ \text{l},\ V_{SM_1} = 9.7\ \text{l},\ V_{SM_2} = 10.8\ \text{l}$

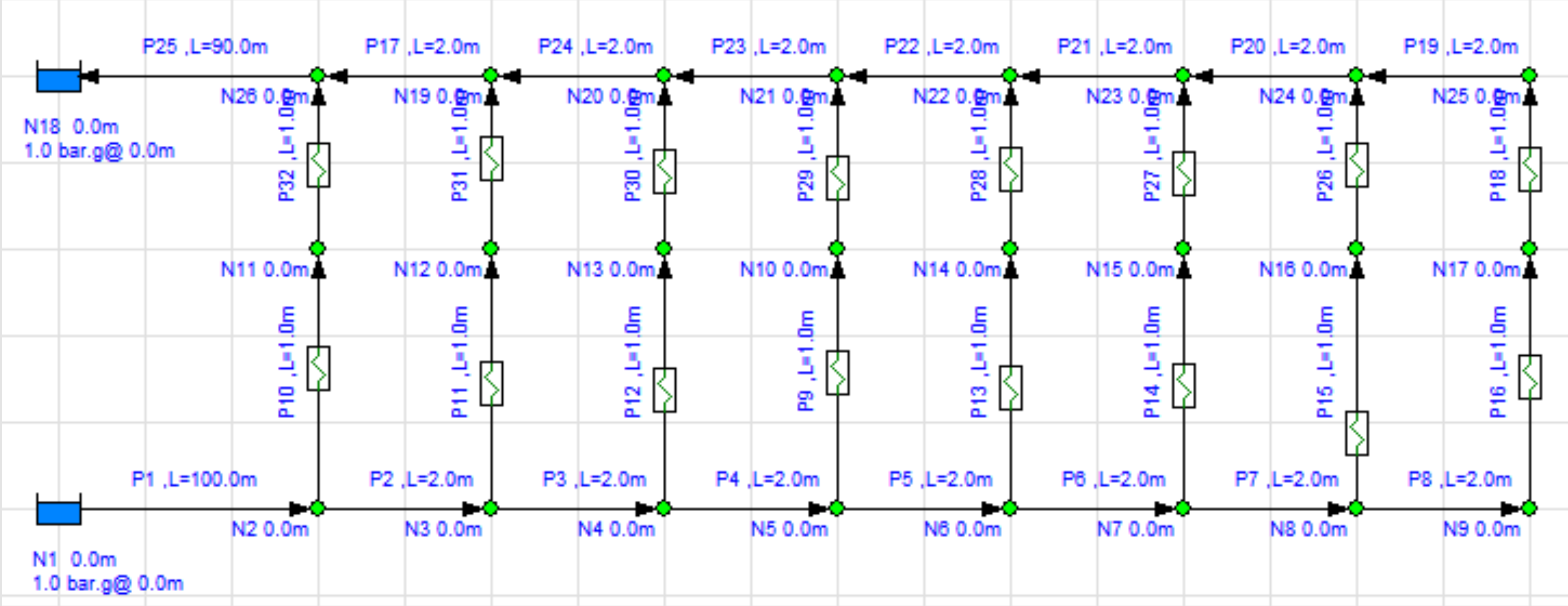
We also used indicative (order of magnitude) impedance values obtained experimentally at the modified RPC gas distribution system: Z_{AB} =0.085 mbar.h/l , Z_{CD}=0.025 mbar.h/l and Z_{MM}=Z_{MMi}/8=0.02/8=0.0025 mbar.h/l

Then, *Z* is calculated from: $$Z = \frac{Z_t - Z_{AB} - Z_{CD} - Z_{MM}}{2} = \frac{Z_t - 0.1125}{2} \text{ (in mbar.h/l)}$$

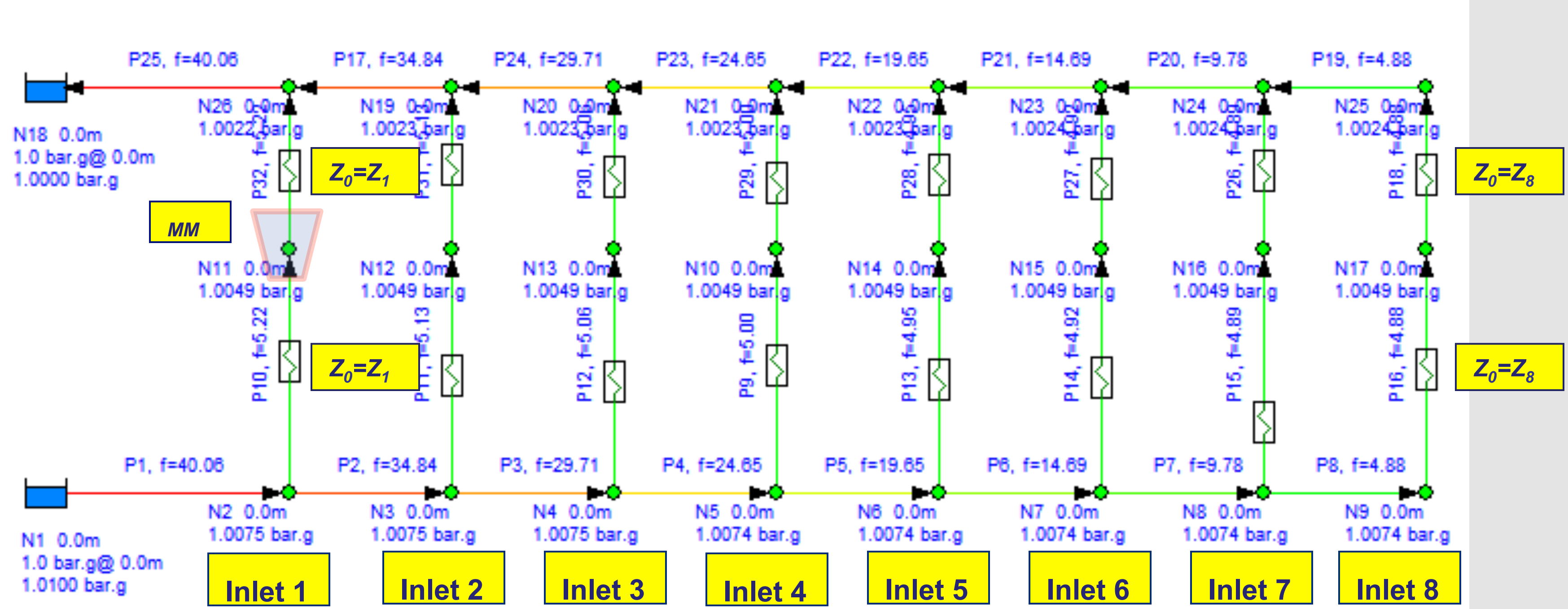
CONFIGURATION	"A" -A1		"B"			
CHANNEL	j	j+1	j	j+1	j+2	j+3
Sectors accessed per gas channel	8	8	1	1	1	1
V_t (l)	102.4	104.8	127.2	123.2	77.6	86.4
Q_t (l/h)	42.7	43.7	53.0	51.3	32.3	36
Z_t (mbar.h/l)	0.234	0.229	0.189	0.195	0.309	0.278
Z (mbar.h/l)	0.061	0.0583	0.038	0.041	0.098	0.083
Z_0=8Z (mbar.h/l)	0.488	0.466	0.305	0.329	0.787	0.661
ΔP_{Z0}	2.60	2.54	2.02	2.11	3.18	2.98

The numerical results for A2 (j & j+1) are equal to "B" (j & j+1) respectively.

Piping simulation – «Pipe Flow»



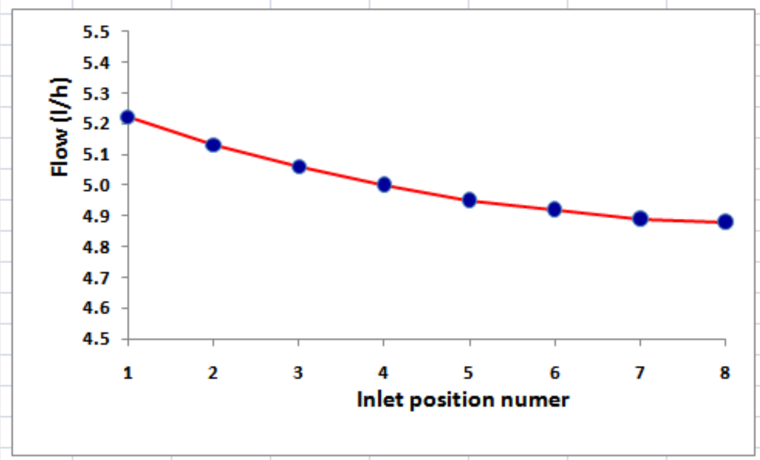
Piping simulation results – «Pipe Flow»



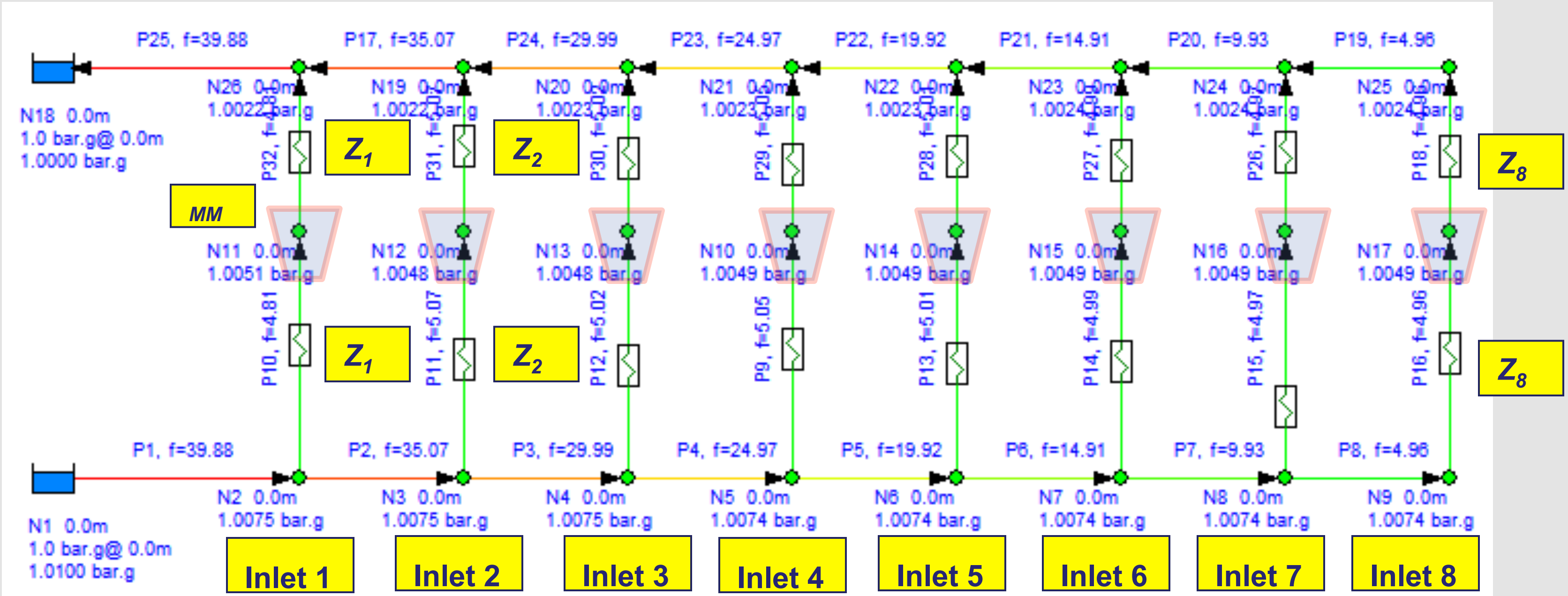
Assumed gas in the simulation: argon

- **Simulation of the gas distribution system for a typical gas channel. The impedance of the MM chamber is considered negligible (not simulated).**

- **Using identical impedances, the decrease of the flow rate from the 1st to the 8th inlet is -6.5 %.**

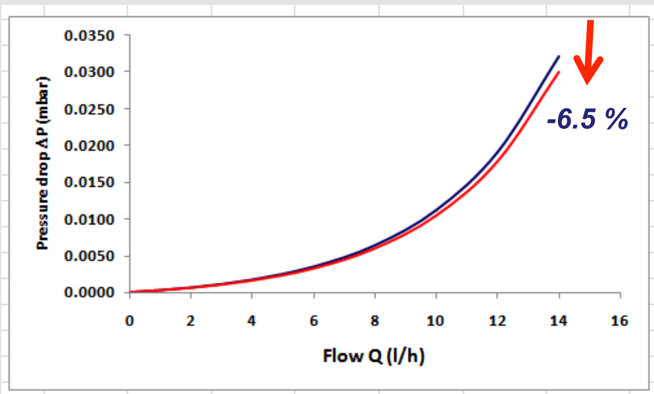


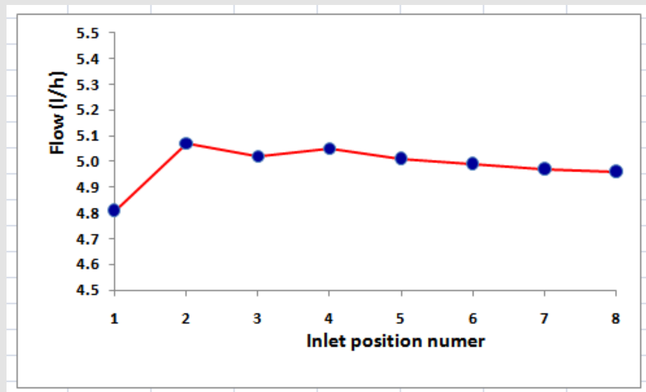
Piping simulation results – «Pipe Flow»

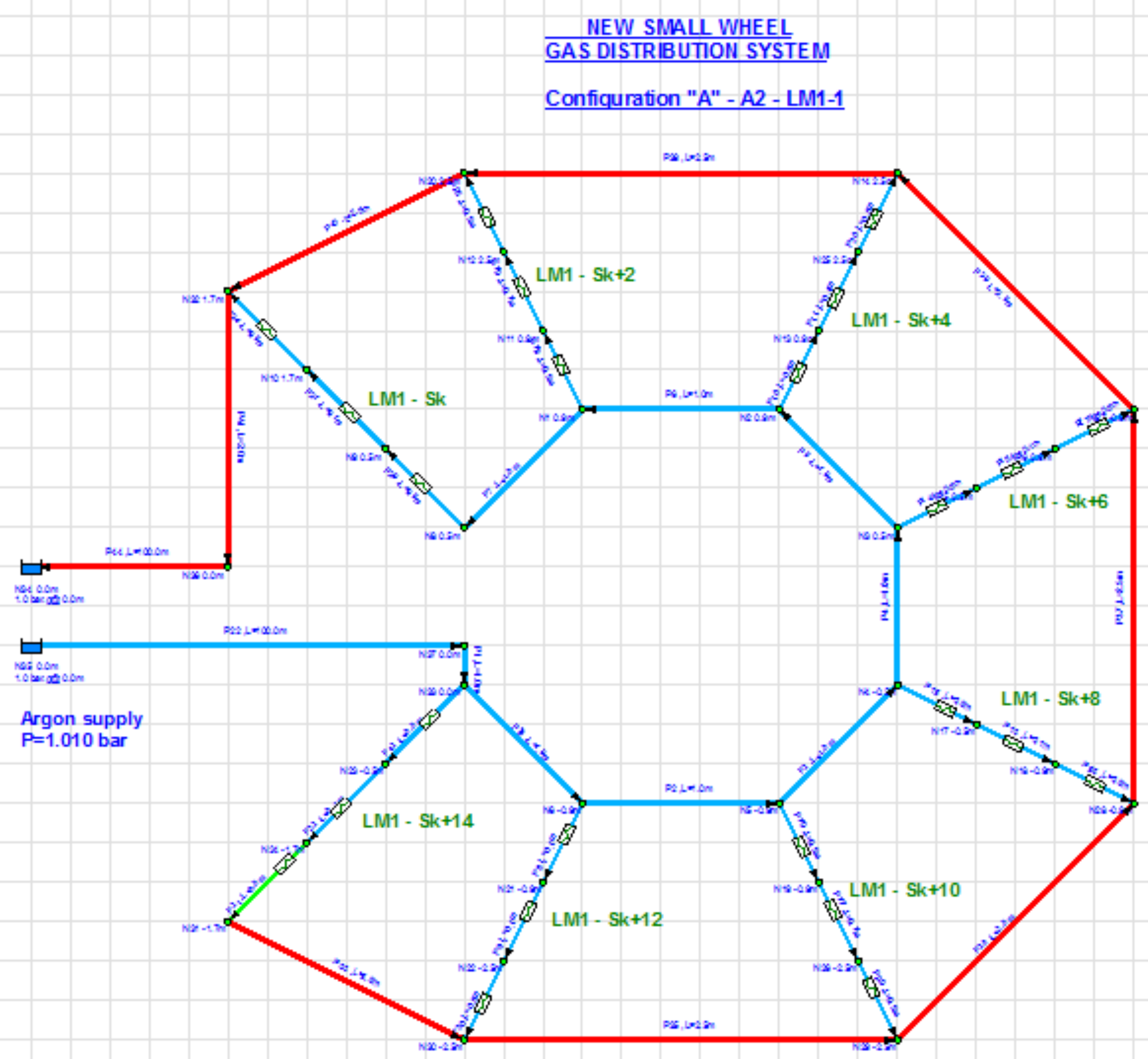


Selected gas in the simulation: argon

Using individual impedances with progressively decreasing values, we can counterbalance the flows. The obtained relative standard deviation by the simulation is 1.6 % .

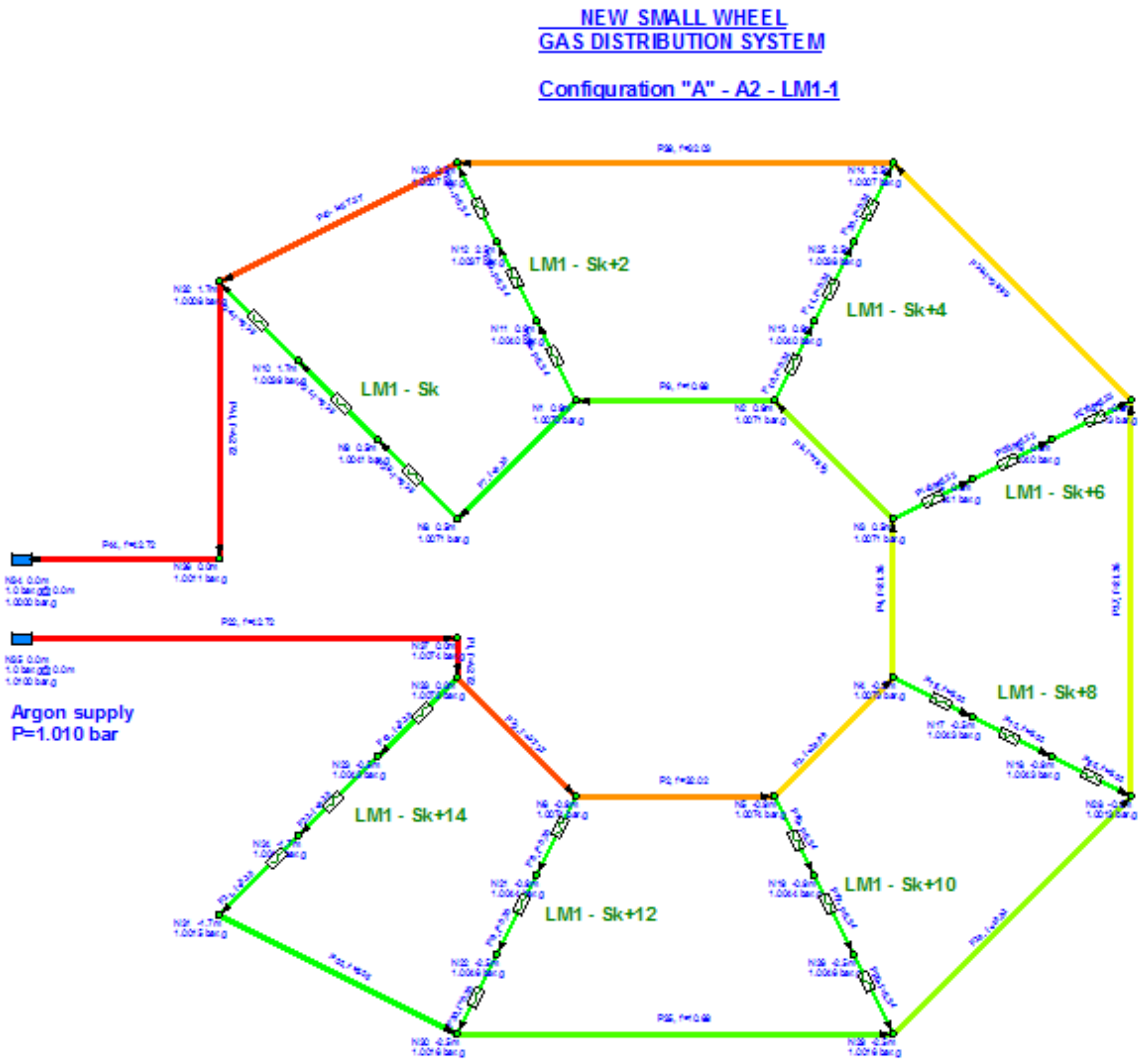


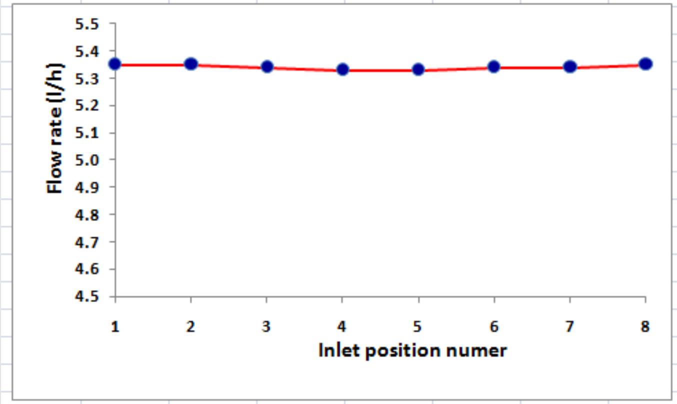




In this simulation we were used the effective impedances of the MMs, height differences and the actual lengths of the pipes is used.

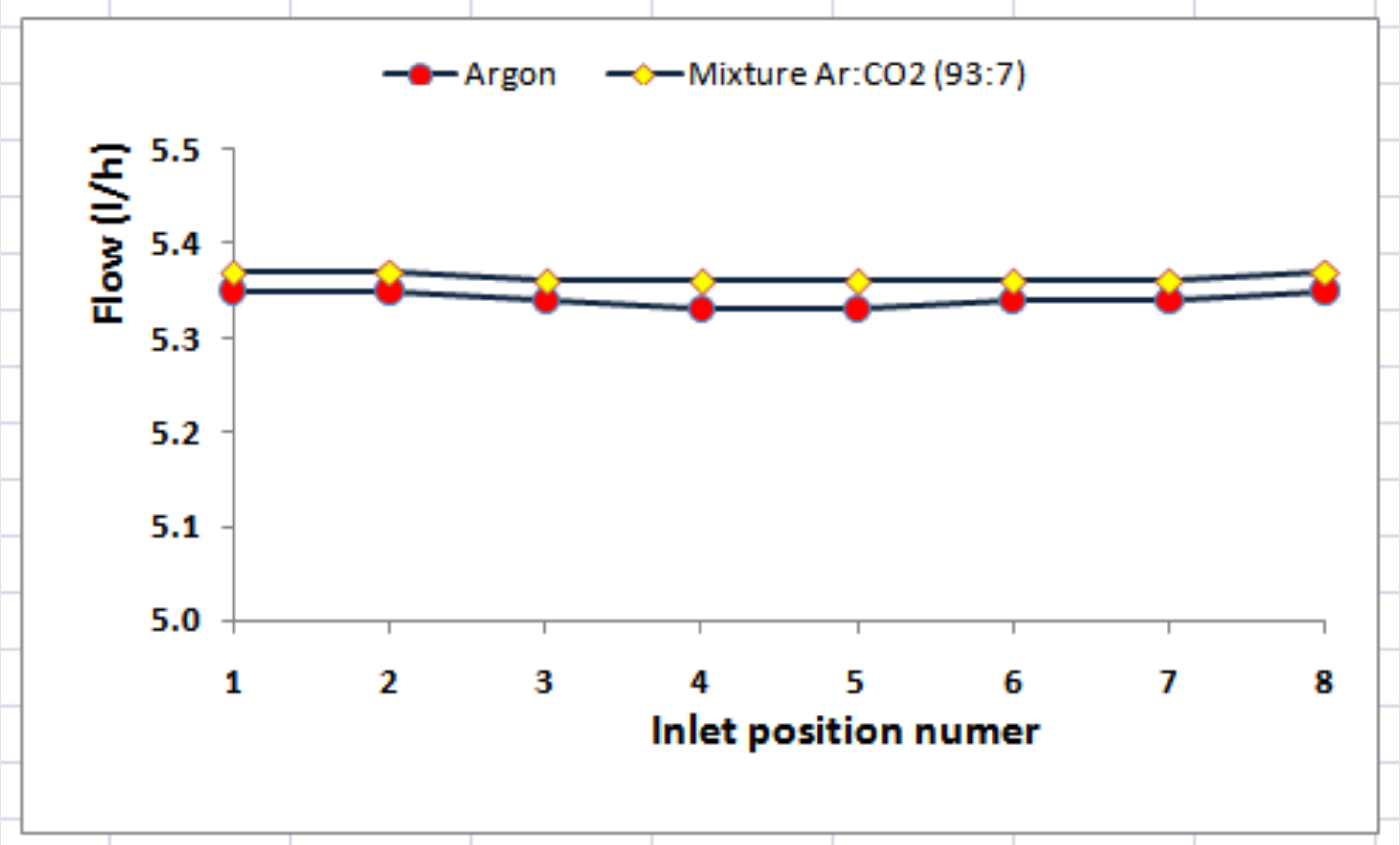
Simulation results – «Pipe Flow»





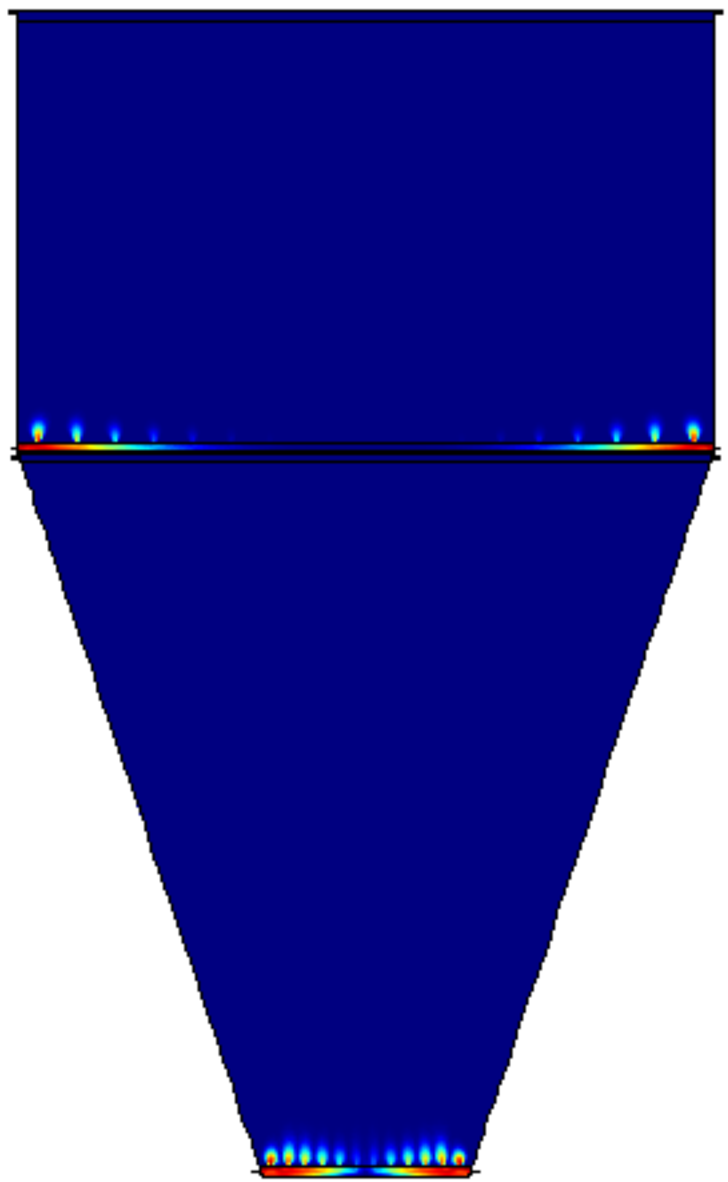
Using identical impedances, the decrease of the flow rate from the 1st to the 8th inlet is -0.4 % .

Results with gas mixture Ar:CO_2 (93:7)

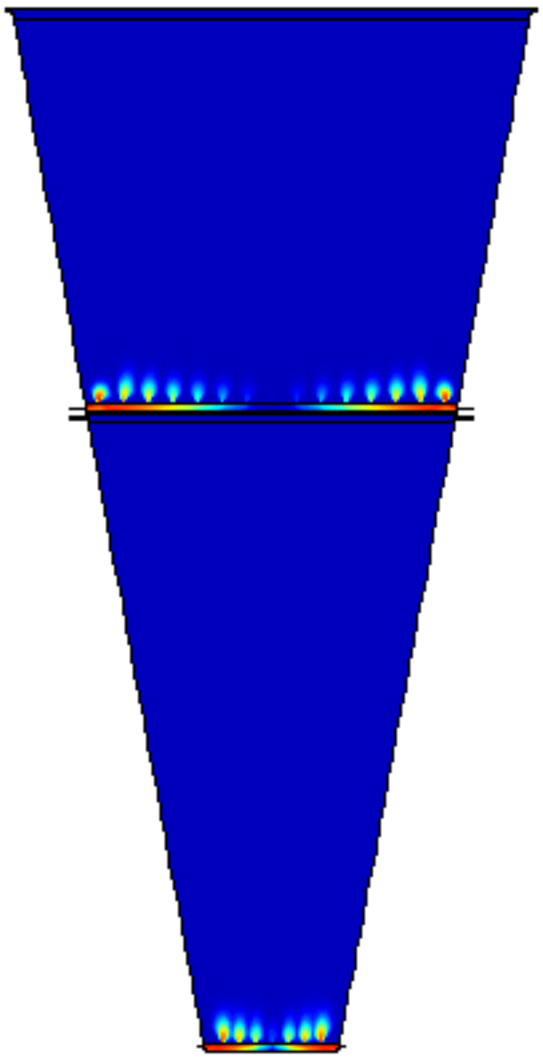


Comparison of the flow distribution between argon and gas mixture Ar:CO_2 (93:7). The relative variation of flow among the inlets is about 0.1 % in both cases. The higher flow levels are due to the lower viscosity of the gas mixture (h_{Ar} =0.0223 cP and $h_{mixture}$ =0.0218 cP).

Gas Flow – «ANSYS or COMSOL»



Gas Flow – «ANSYS or COMSOL»



Conclusions and prospects

- According to the available gas mixture supply system we are investigating the optimal solution for the gas distribution scheme.
- Two candidate configurations, "A” (chainlike) and “B” (daisylike) could be used. The optimal one should be finalized before going to the detail design studies.
- The issue of using individual impedances in each MM detector or a single toggle valve in each gas channel, has to be clarified in the present stage.
- Some preliminary numerical results, under particular assumptions and estimates, have been performed.
- More detailed analysis of the pipe network is performed using “Pipe Flow” software.