Transfer rate updates

$(Ne – CO_2)$

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Ne – CO_2 measurements and calculations

Admixture concentration

3 months ago	**Now**
1) 2% CO_2	1) 1% CO_2
2) 5.1% CO_2	2) 3.6% CO_2
3) 7.3% CO_2	3) 30.1% CO_2
4) 10.1% CO_2	4) 50% CO_2
5) 15% CO_2	5) 74.1% CO_2
6) 20.2% CO_2	**6) Pure CO_2**

Penning correction

- ❖ $Ne^* + CO_2 \rightarrow Ne + CO_2^+ + e^-$
- ❖ All of the excited Ne atoms can ionise CO_2

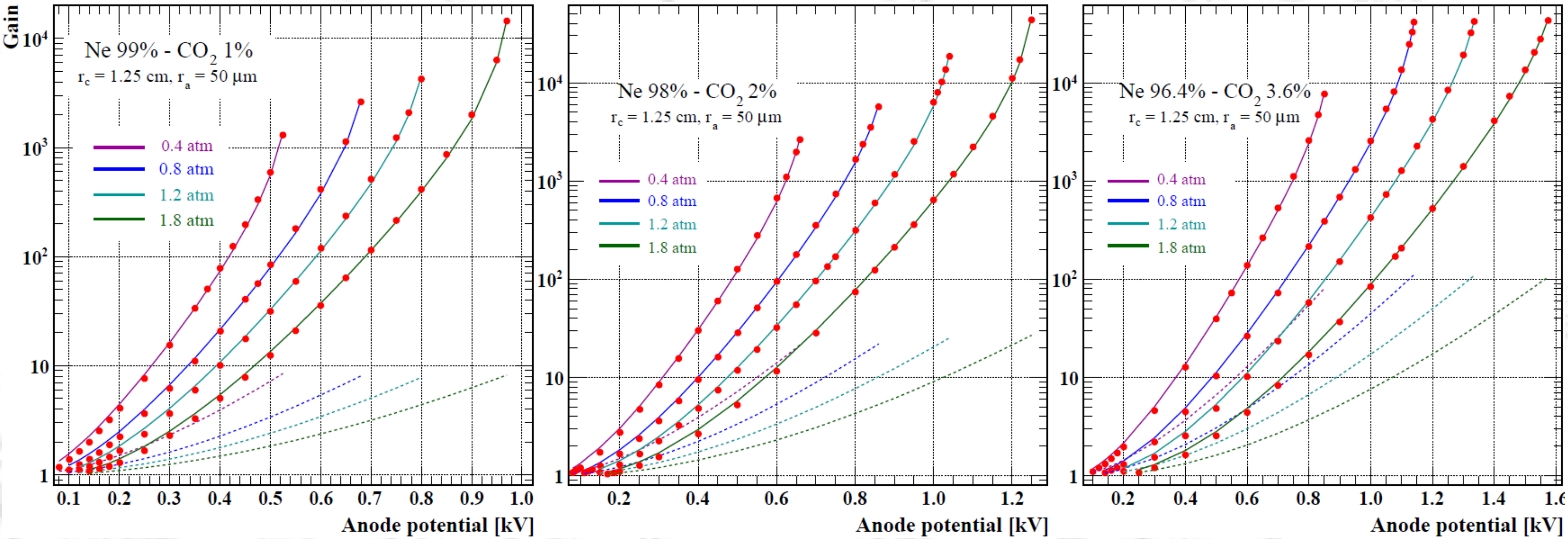
$$\alpha_{Penning} = \alpha \frac{\sum \nu_i^{ion} + \sum r_i \ \nu_i^{exc}}{\sum \nu_i^{ion}}$$

Photon feedback $G' = G/(1-\beta G)$

!!! No gain scaling needed in the fits !!!

- ❖ High precision gain measurements in Krakow (Tadeusz KOWALSKI)
- ❖ Single wire proportional counter: $r_c = 1.25$ cm, $r_a = 24$ µm or $r_a = 50$ µm
- ❖ Wide gain regime: ionisation to higher than 10^5; less than 5% error on gas gain,
- ❖ Pressure range: 0.4 – 1.8 atm; in addition 0.25 atm for a few mixtures.

Gain measurements and fits (r_a = 50 µm)



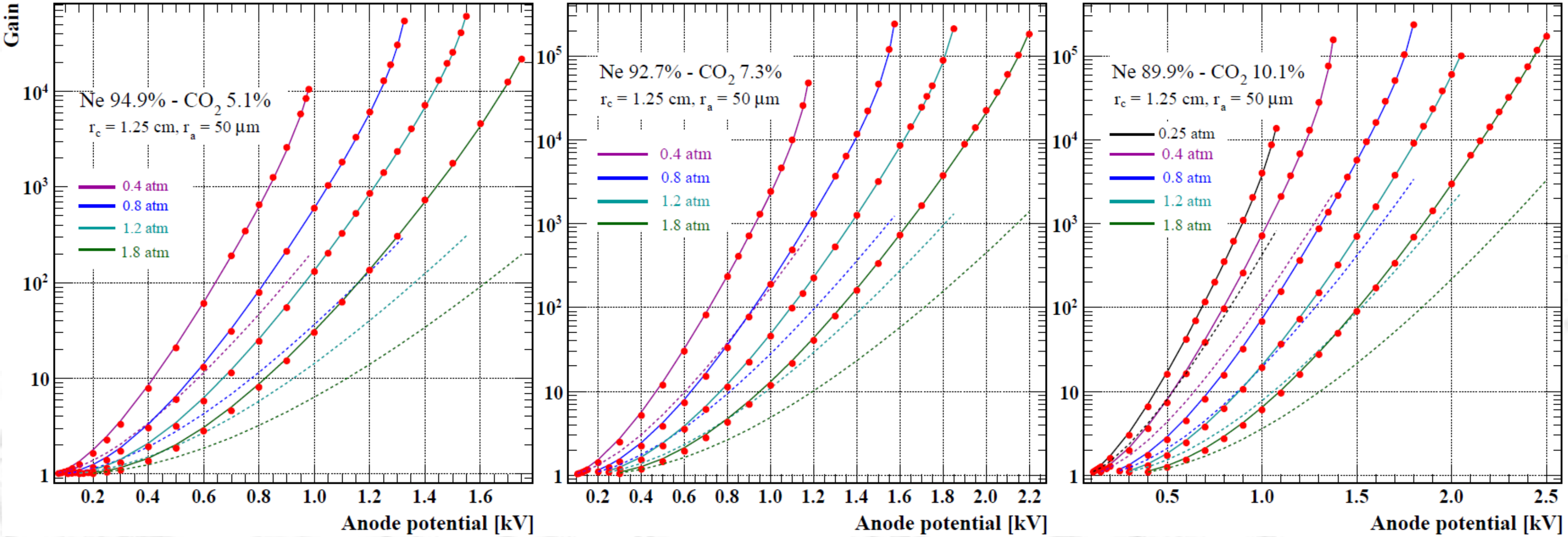
- ❖ **Better** agreement with experimental data after the gain of 10,
  - ❖ departs before gain of 10 decrease at high pressures .

❖ Energy transfers have more impact on gain (Penning effect) with increasing pressure and CO_2 concentration,

- ❖ Shorter collision time with excited Ne atoms !

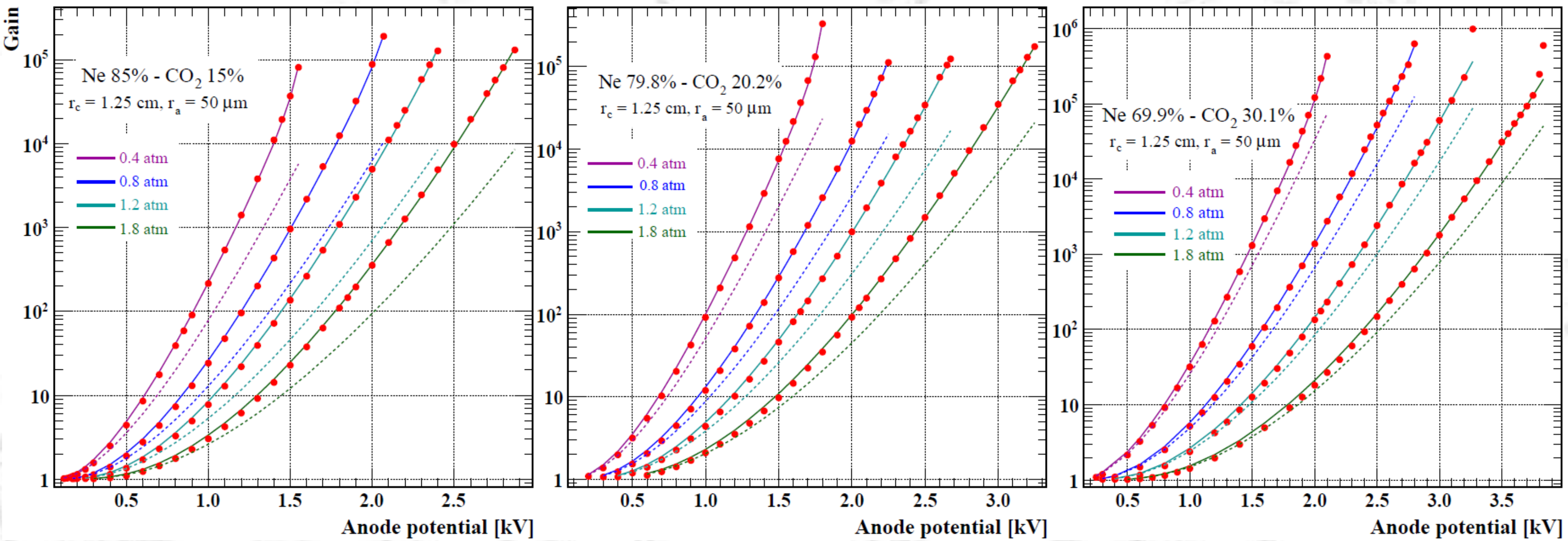
❖ The strongest over-exponential increases.

Gain measurements and fits (r_a = 50 μm)



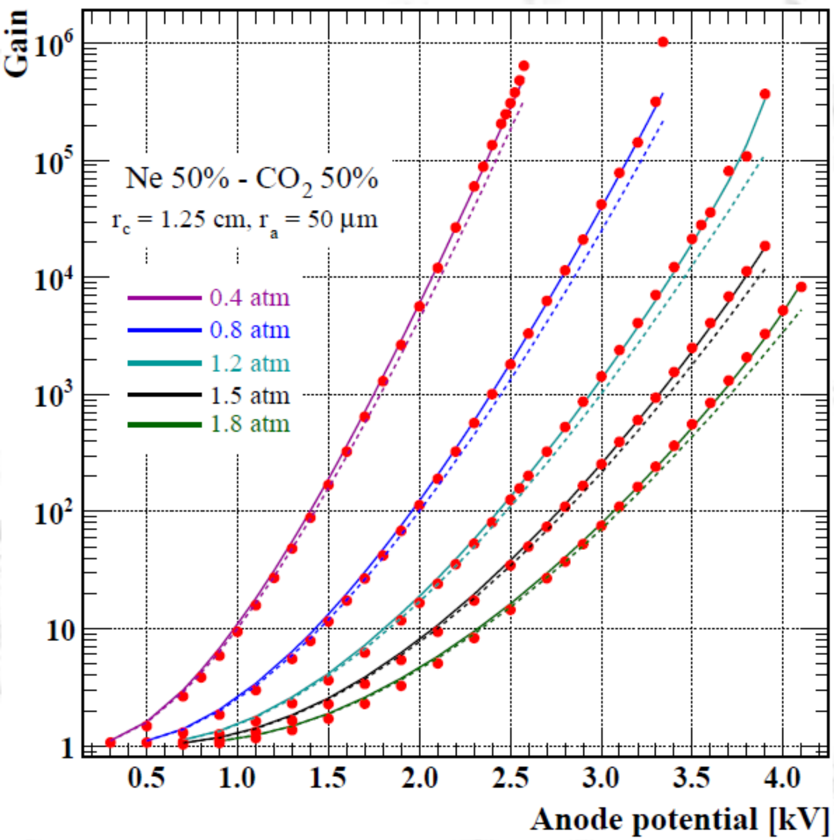
- ❖ Almost perfect fits even at very low gains,
- ❖ Additional data at 0.25 atm for 10.1% CO_2 mixture,
- ❖ Visible decrease on photon feedback at high pressures.

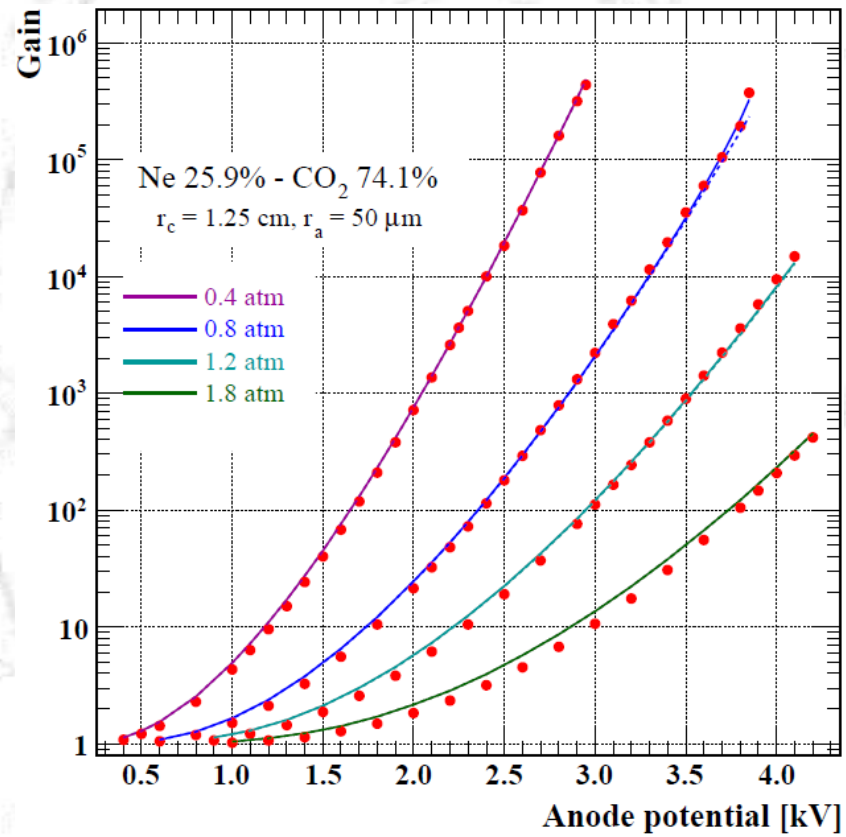
Gain measurements and fits (r_a = 50 µm)



- ❖ Lesser impact of the transfers on gas gain at high CO_2 concentrations,
- ❖ 20.2% CO_2: no visible over – exponential increases higher than 0.4 atm but still feedback parameters are needed to get better agreement
- ❖ 30.1% CO_2 mixture: no fit of the latest gain data at 1.2 atm and 1.8 atm,
  - ❖ Given photon feedback is valid if we still working in proportional region,
  - ❖ Proportionality of the gain curves destroys (breakdown points?).

Gain measurements and fits (r_a = 50 μm)





❖ the biggest admixture concentration in which Penning effect on gain is clearly seen,

❖ Still we have feedback but the uncertainty is large (see later),

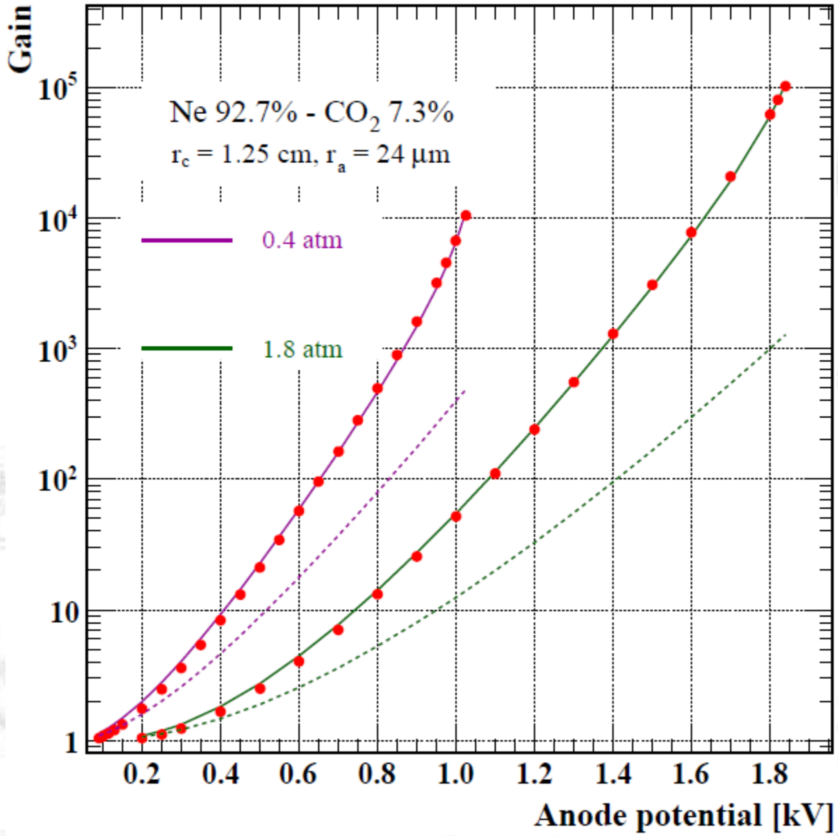
❖ the fits with feedback parameter at 0.4 and 0.8 atm are not shown on the plot.

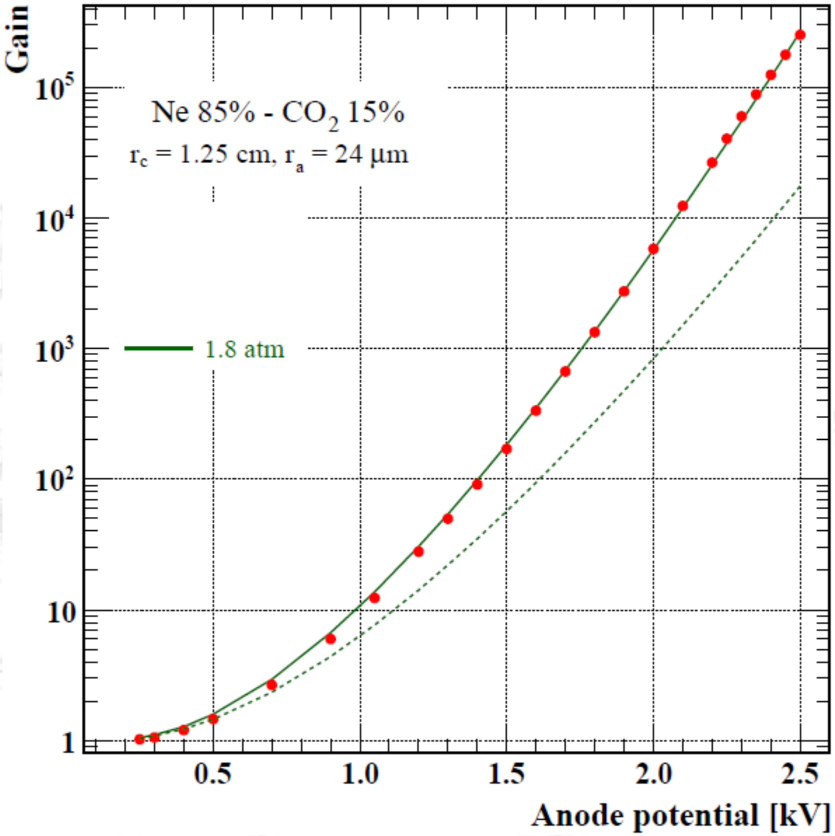
❖ 0.04 transfer rates at 0.8 atm;

❖ 0.4, 1.2 and 1.8 atm data are fitted without Townsend adjustment

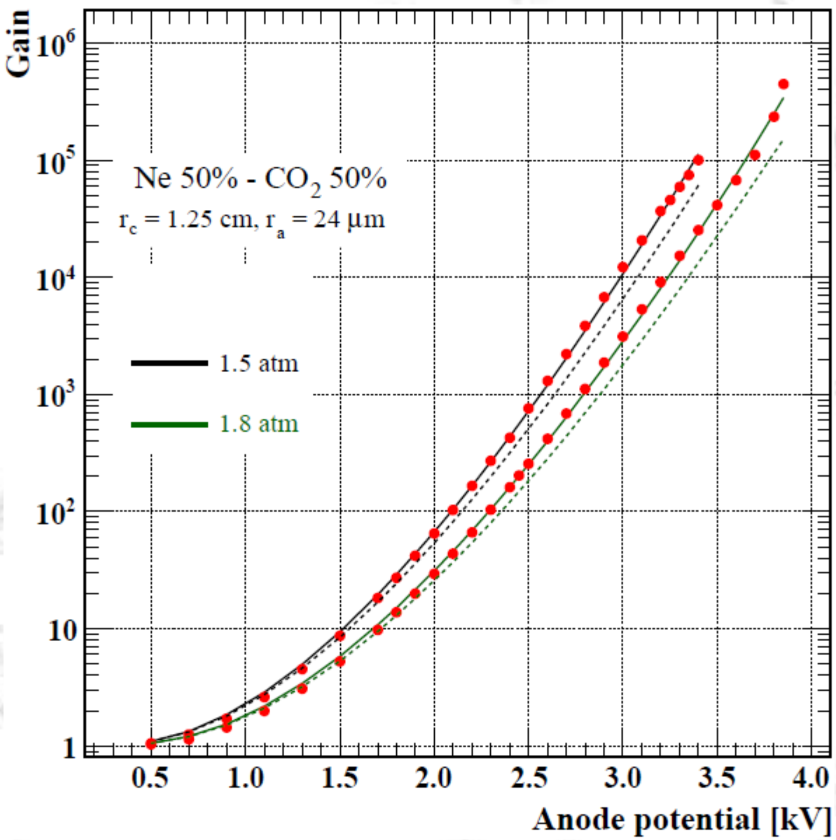
❖ 1.8 atm: agreement at very beginning and high gains

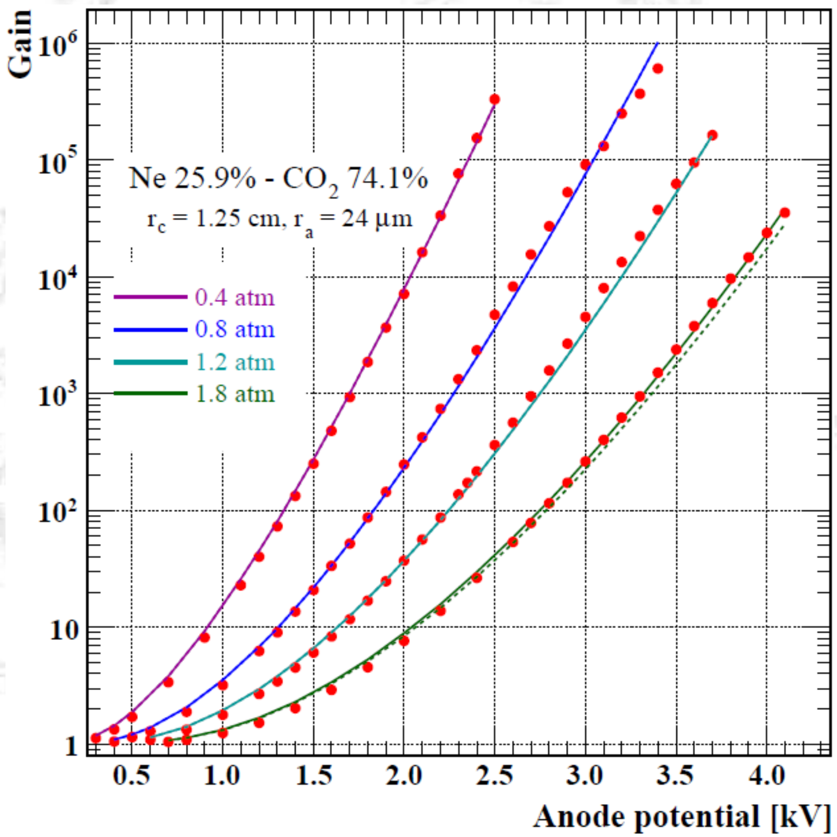
Gain measurements and fits (r_a = 24 μm)





Gain measurements and fits (r_a = 24 μm)





❖ 1.8 atm: departure from the proportionality for the last data point,

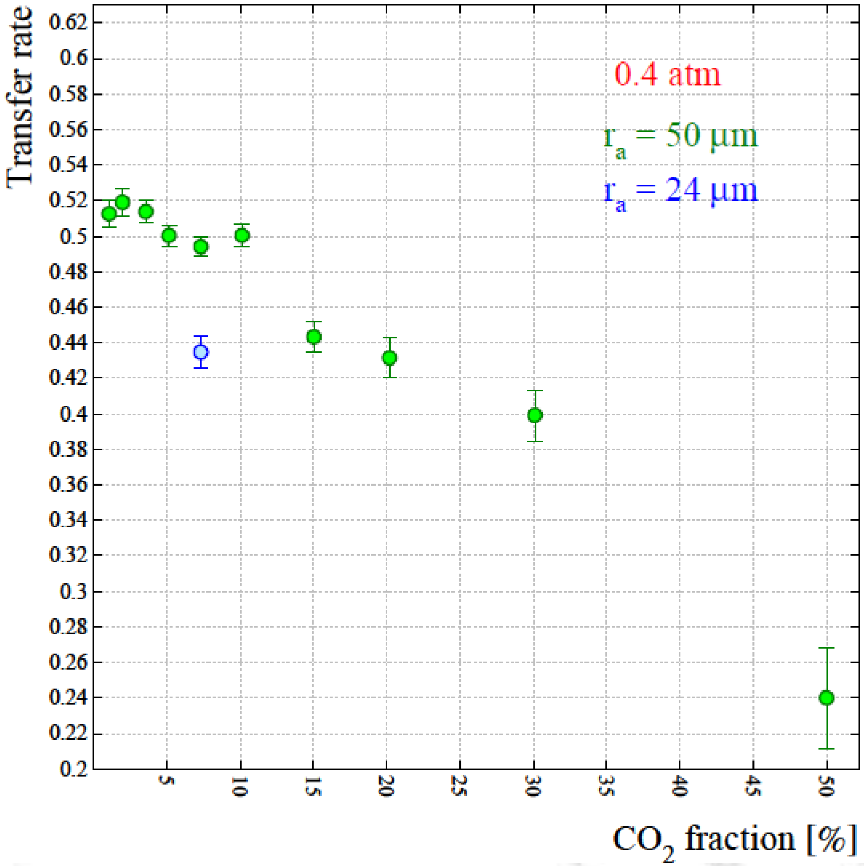
❖ seen the same for at 1.2 atm for the counter with r_a = 50 μm and also for 30.1 admixture concentration at 1.2 and 1.8 atm.

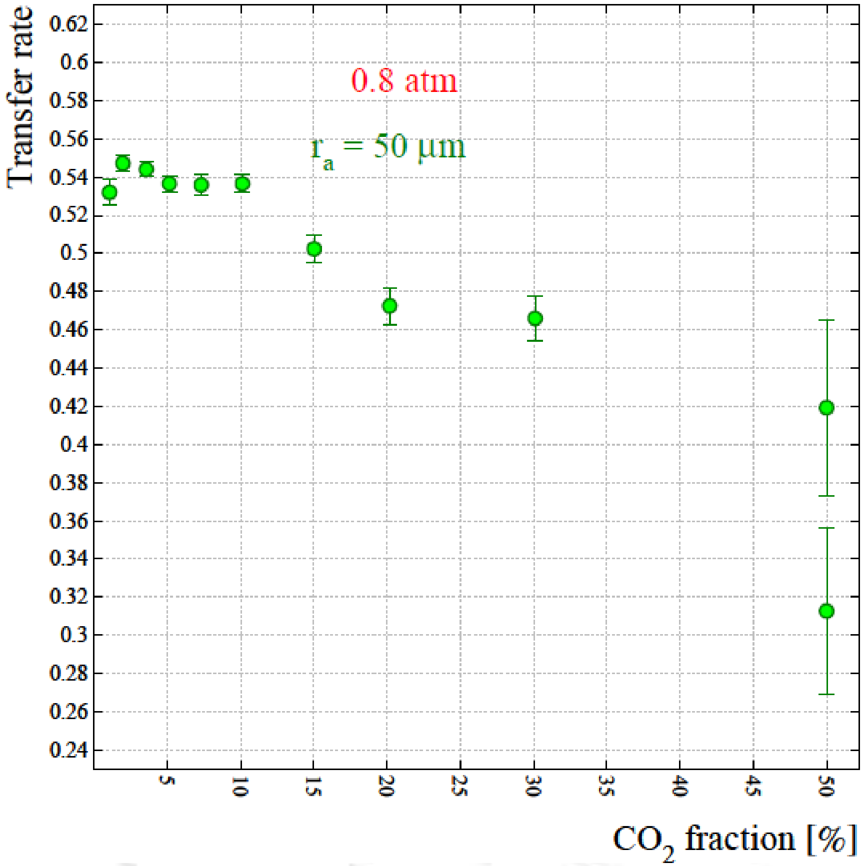
❖ Penning adjustment needed only for the highest pressure but **seems improbable to have 0.7 transfer rate ???**

❖ last 2 gain points at 0.8 atm: calcuted gains are bigger than the measured ones,

❖ **Space charge ??!!!??**

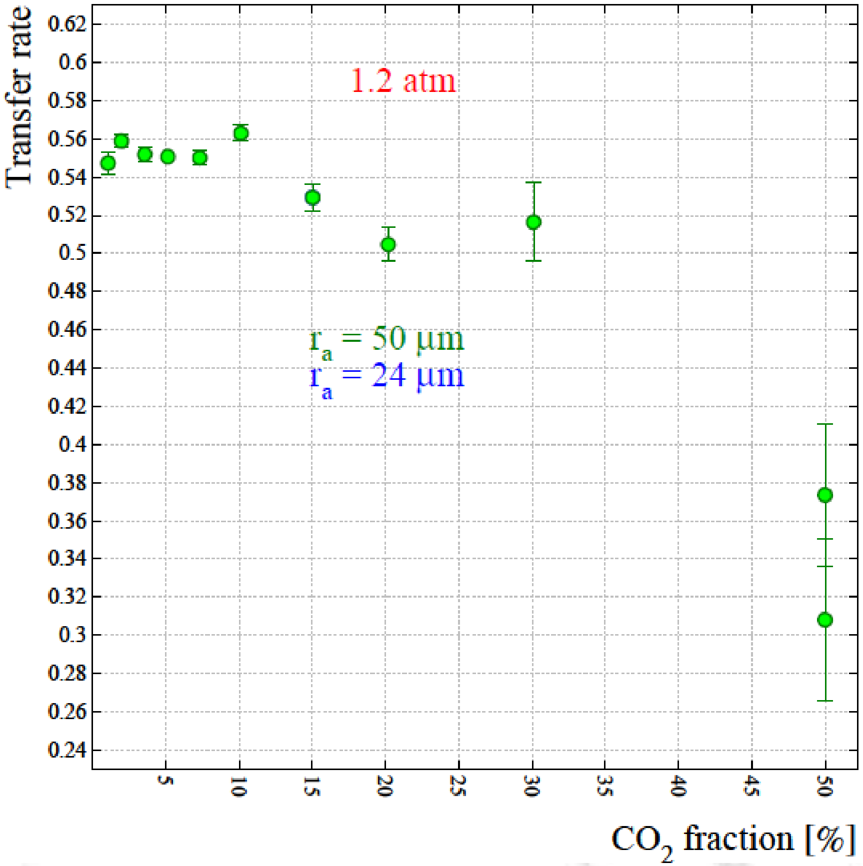
Penning transfer rates

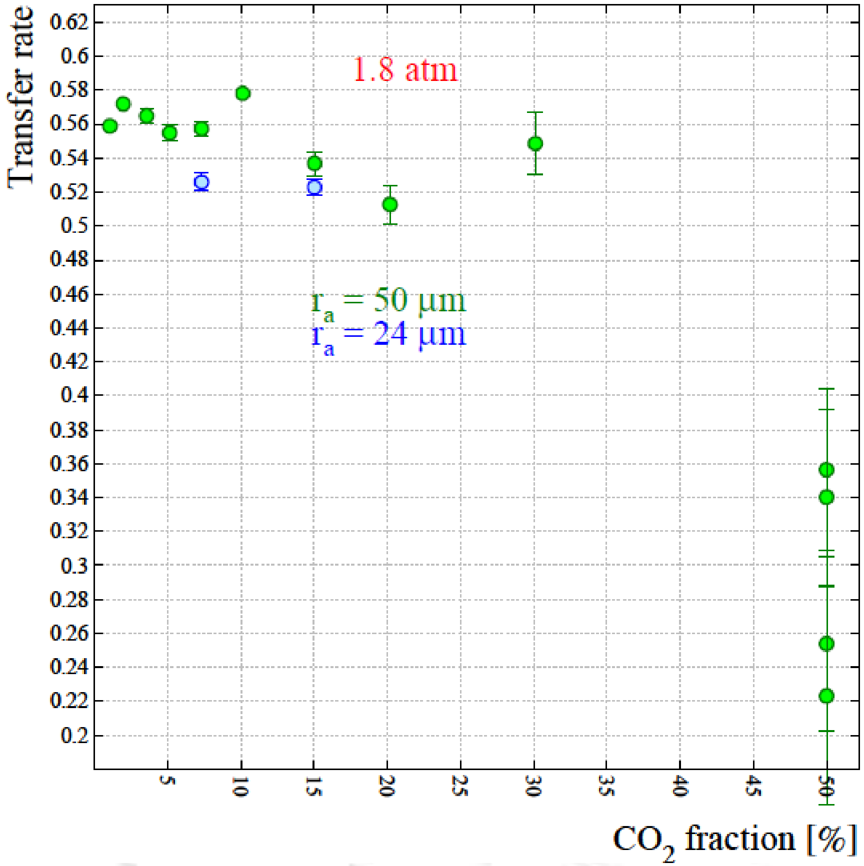




- ❖ The biggest transfer rate for 2% CO_2 (both at 0.4 atm and 0.8 atm),
- ❖ Systematic decrease of the rates with increasing admixture fraction,
- ❖ Larger energy transfer at 0.8 atm than 0.4 atm,
- ❖ 0.8 atm in 50% CO_2: upper rate corresponds to the fit without Penning transfer.

Penning transfer rates



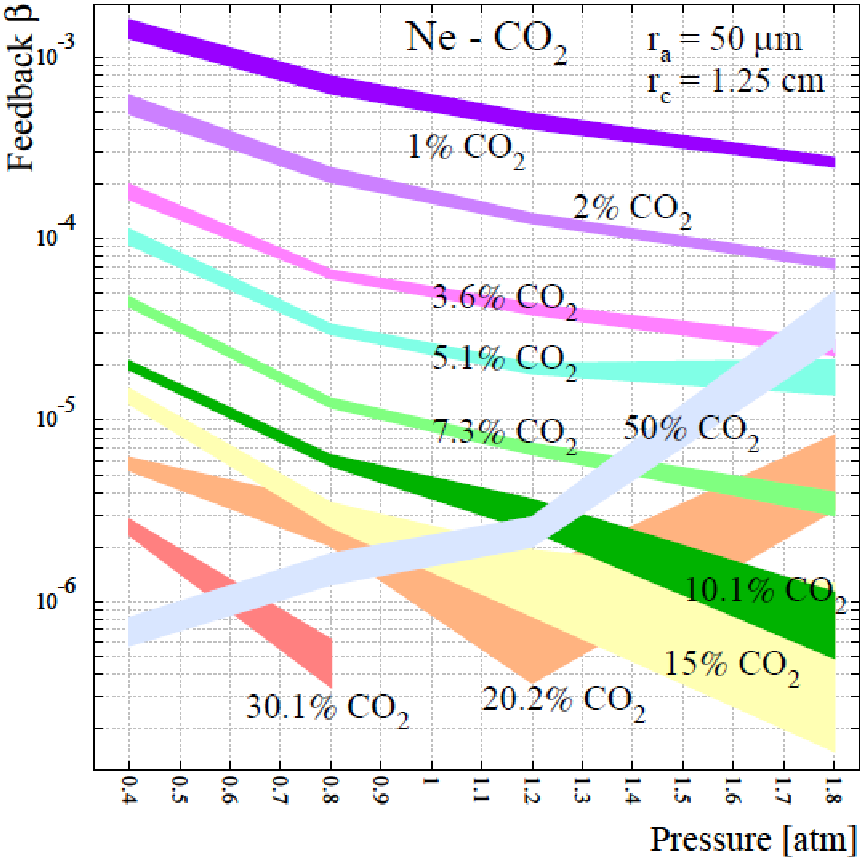


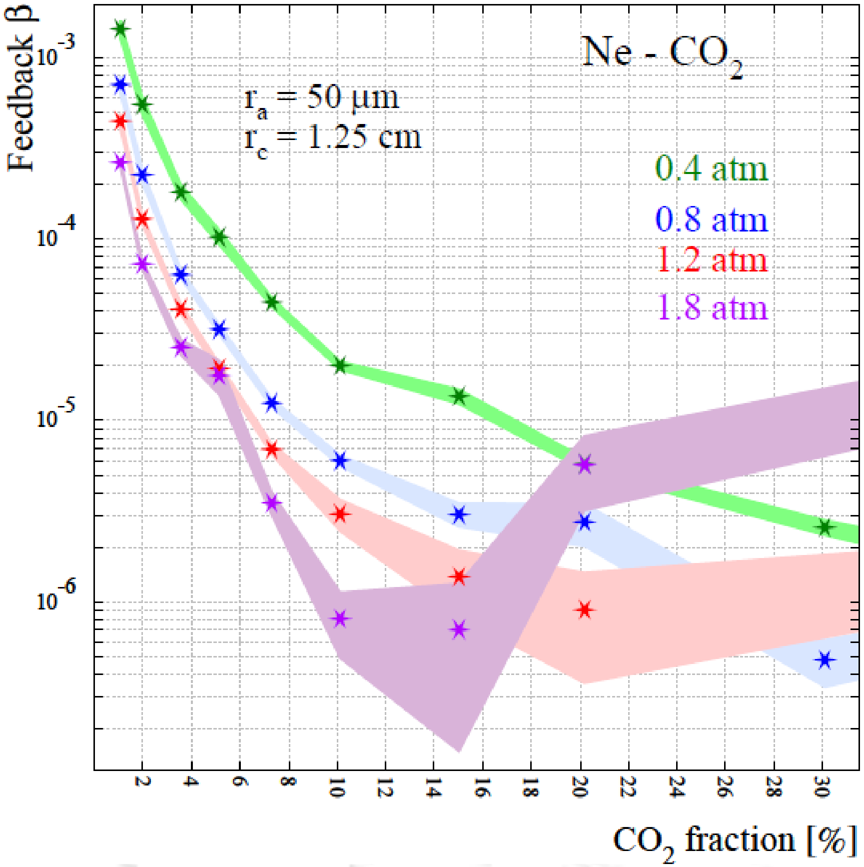
❖ The biggest transfer rate shifts to 10% CO_2 (both at 1.2 atm and 1.8 atm),

❖ Systematic decrease of the rates loses and the rates become flat with increasing pressure till 30% CO_2 admixture fraction,

❖ 1.8 atm: two different data for 50% CO2 mixture indicates the same rates.

Feedback parameters

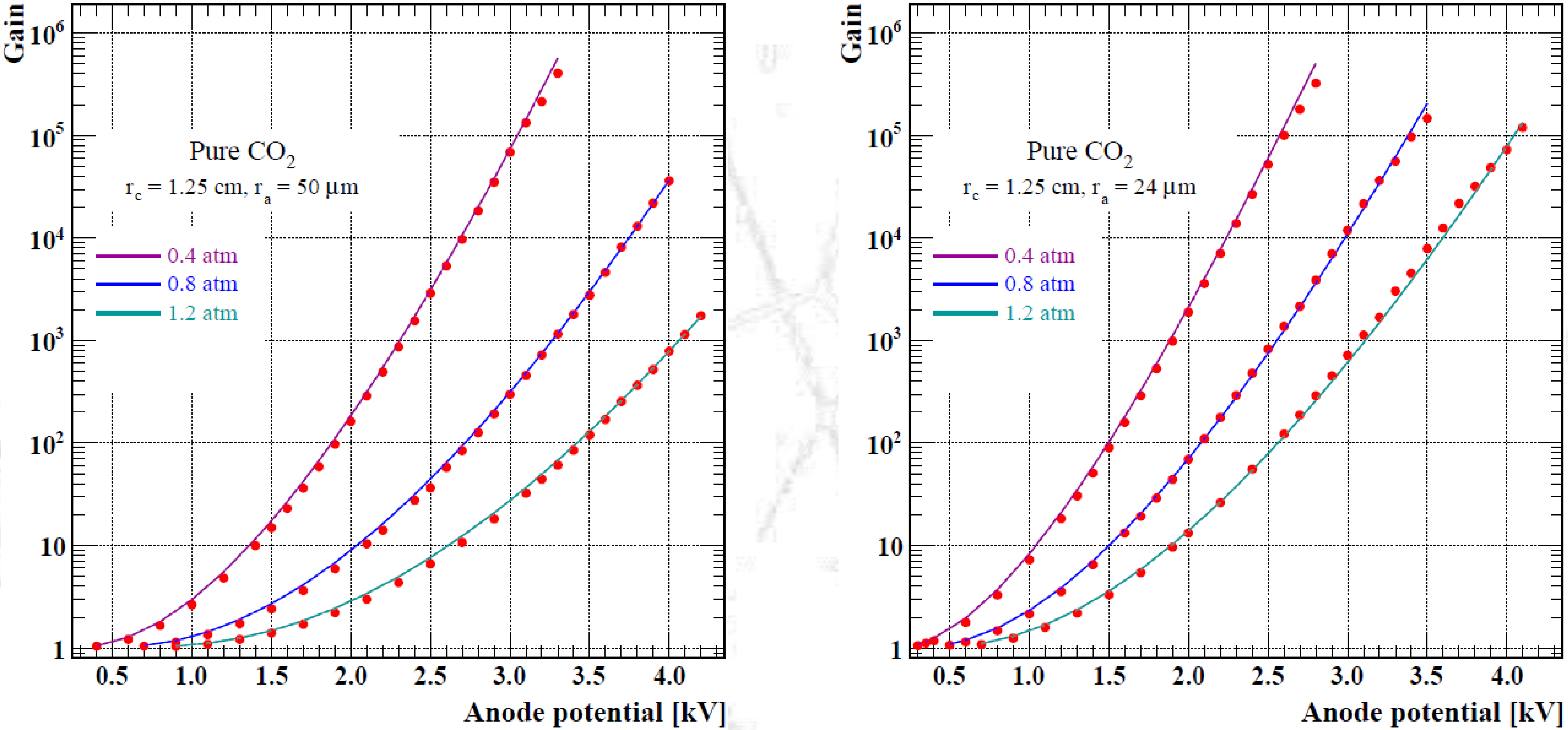




❖ Photon feedback parameters decrease with increasing pressure and admixture fraction till 20.2% CO_2 (related with the mean free path of the photons),

❖ Increase of the feedback with pressure for 20.2% and 50% CO_2 mixtures could be a sign that the model we use is not sufficient in breakdown region **?!?**

Gain measurements and fits for Pure CO_2



❖ Perfectly fine overlaps with all experimental gain curves,

❖ the first time that we ever have such a successful agreement for pure gases without using any scaling or correction factor:

- ❖ confirmation of the high precision measurements (thanks to Tadeusz),
- ❖ correctness of the cross sections used in Magboltz (thanks to Steve),
- ❖ our calculation method is sufficient enough to reproduce the measured gain curves.

Summary

❖ Until 50 % CO2 admixture concentration transfer rates change in a narrow range (0.46 – 0.58) in Ne – CO2 mixtures,

❖ the range in Ar – CO_2 was much bigger (0.15 – 0.56),

❖ Larger than 50% CO_2 admixture fraction kills the energy transfers,

❖ Understanding of the drops on the transfer rate at high CO_2 fractions,

❖ Increase of the photon feedback parameters with pressure in 20% and 50% CO_2 (breakdown regime),

❖ Space charge effect is visible in 74% CO_2 and pure CO_2,

❖ Calculations with pure CO_2 measurements are not only useful for Ne – CO_2 but also very important for Ar – CO_2 mixtures.

Thanks and ???