Survey of transfer rates using Zaragoza (Xe – TMA) and Krakow (Ar – CO_2) measurements

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ZAROGOZA measurements in Xe – TMA mixtures

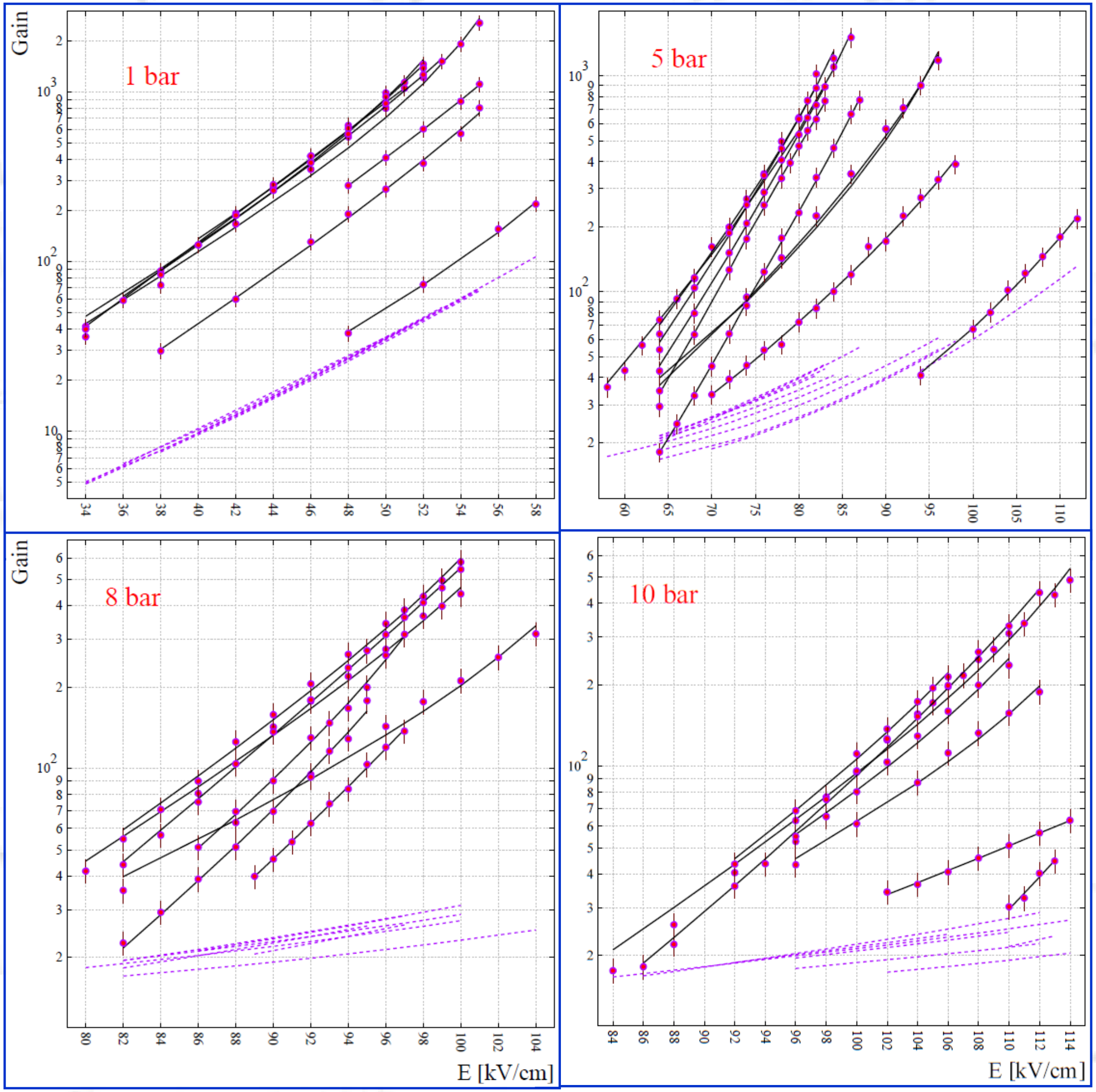
- ❖ 50 μm MMs
- ❖ at 1, 5, 8, 10 bar

Detailed plots given in RD51 Mini Week on January **!**

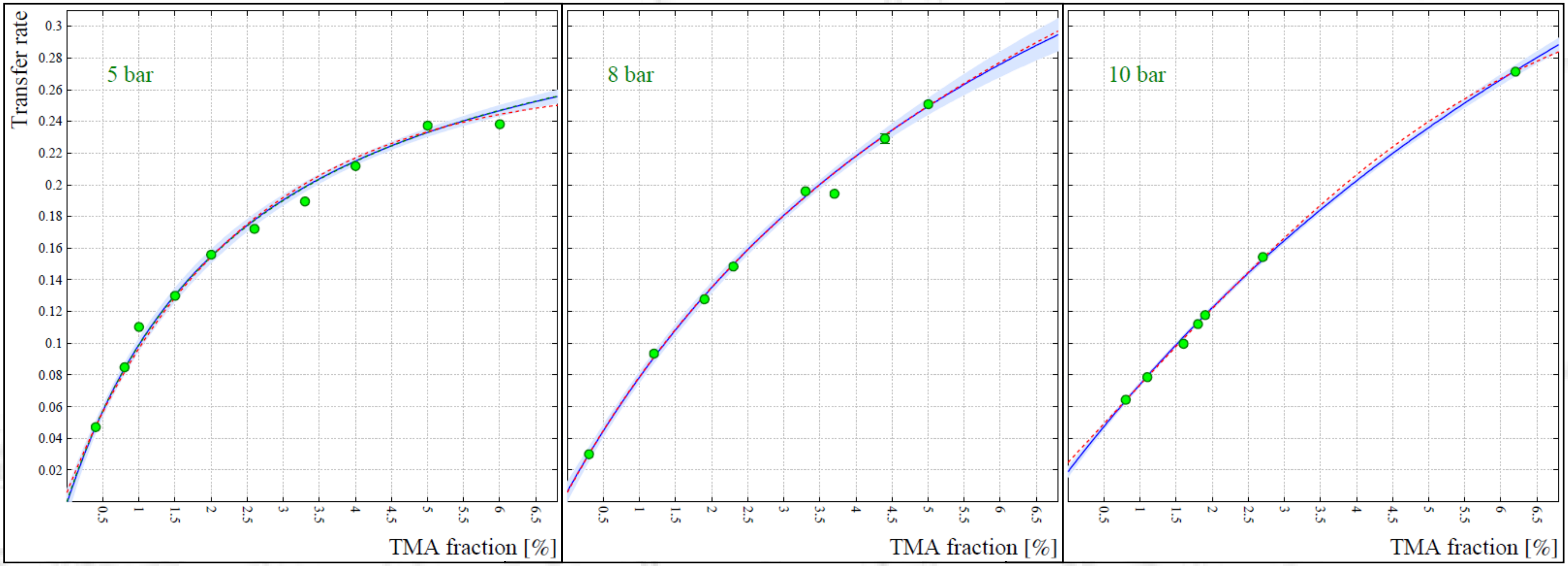
Micromegas-TPC operation at high pressure in xenon-trimethylamine mixtures

S Cebrián et al 2013 JINST 8 P01012

doi:10.1088/1748-0221/8/01/P01012



Transfer rates (reminding)



$$r = \frac{pc\frac{f_{B+}}{\tau_{A*B}} + p(1-c)\frac{f_{A+}}{\tau_{A*A}} + \frac{f_{rad}}{\tau_{A*}}}{pc\frac{f_{B+}+f_{\bar{B}}}{\tau_{A*B}} + p(1-c)\frac{f_{A+}+f_{\bar{A}}}{\tau_{A*A}} + \frac{1}{\tau_{A*}}}$$

A*- B ***A*- A*** ***A*- γ***

$A^* + B \rightarrow A + B^+ + e^-$: collisional ionisation,

$A^* + A \rightarrow A_2^+ + e^-$: homonuclear associative ionisation,

$A^* \rightarrow A + \gamma$: radiative decay

$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

$$r(c) = \frac{a_1 c + a_3}{c + a_2 + a_4(1-c)^2}$$

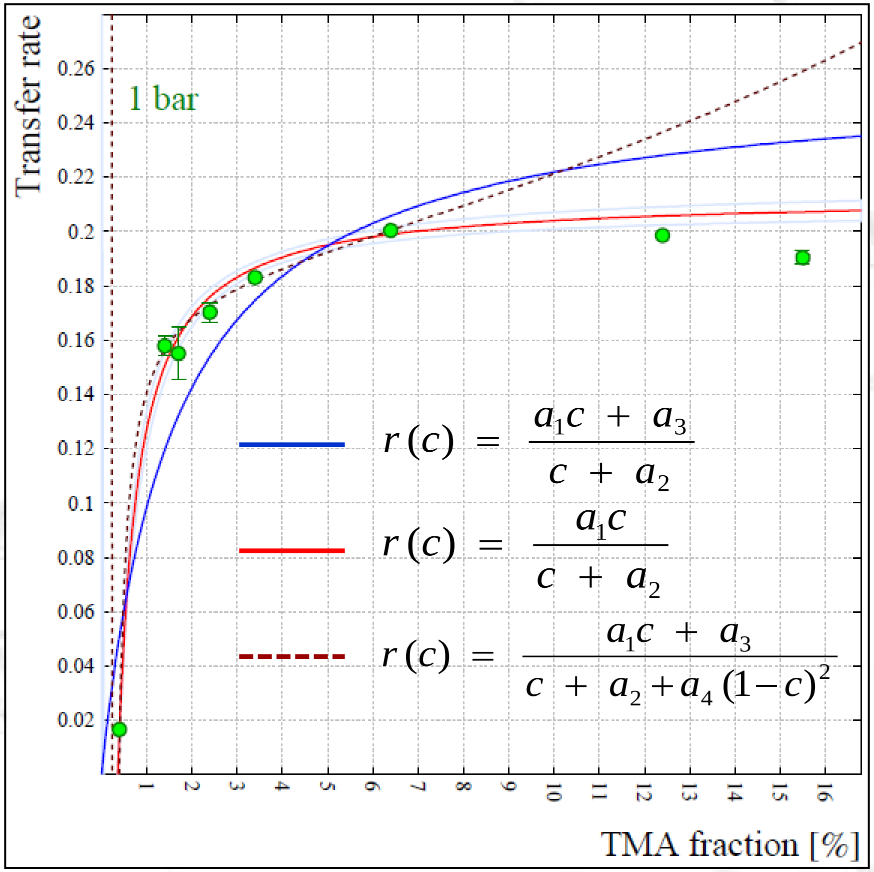
excimer parameter

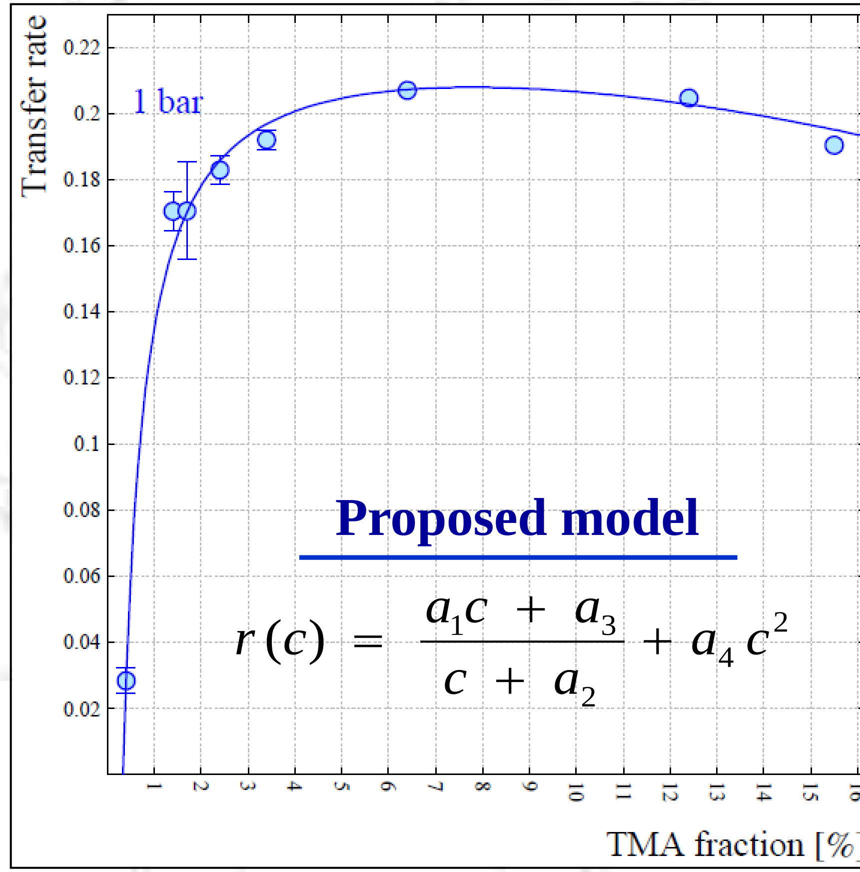
p: dimensionless pressure, $p_{gas} = p \times 1$ atm

c: concentration of the quencher gas

Unphysical results with excimers **!!!**

Update on transfer model





❖ Models do not describe the drop on transfer rates at high TMA concentrations !

❖Also seen Paco's data (see next slides)

a_1, a_2, a_3 : positive values

a_4 : negative (represents the drop on transfer)

c^2 dependence of **a_4**

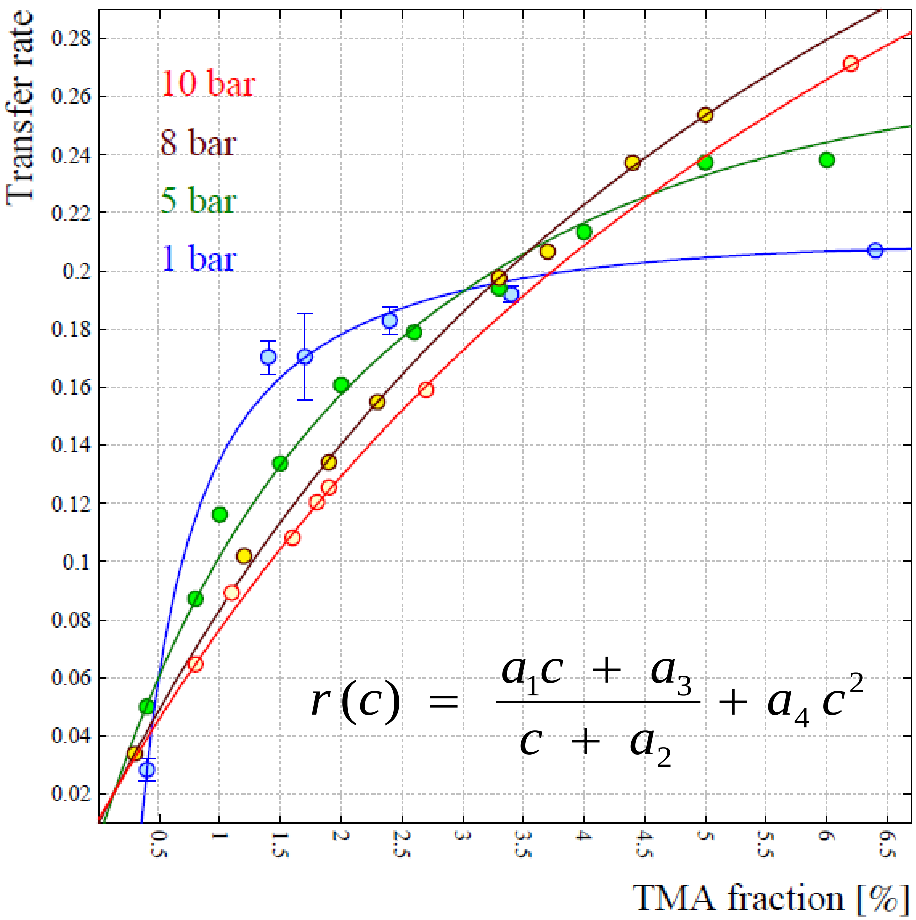
Three-body interactions !??!

Valadity of the proposed transfer model

❖ All the fits using the proposed model

❖ It describes transfer curves sufficiently well

❖ **BUT**; $\mathbf{a_2}$ and $\mathbf{a_3}$ negative at higher pressures than 5 bar



$$r(c) = \frac{a_1 c + a_3}{c + a_2} + a_4 c^2$$

❖ 3 – body interactions only happen for large TMA fractions at low pressures **???**

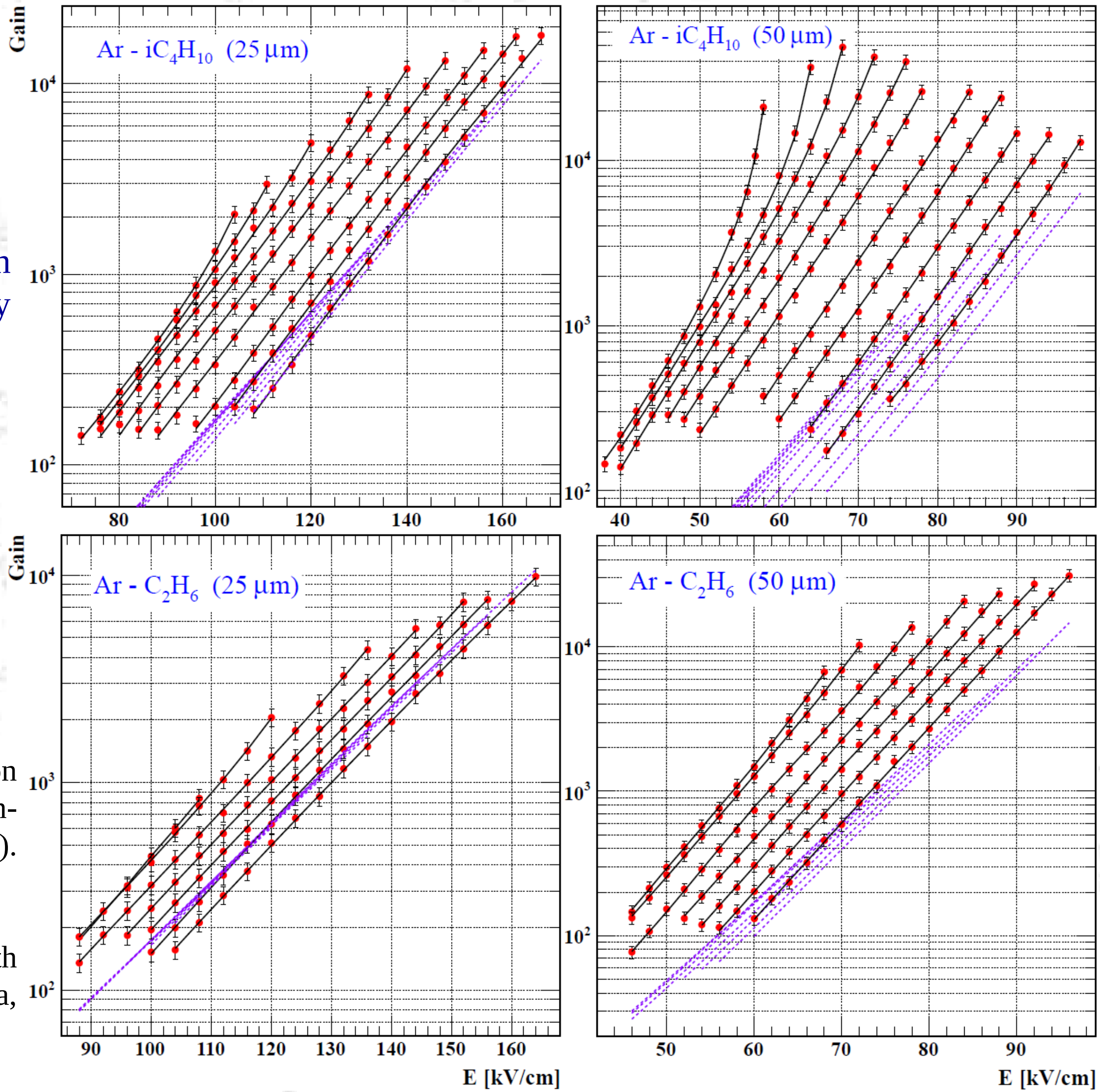
❖ Should be checked, with gain measurements at large TMA concentrations at high pressures

❖ What is the physical meaning of $\mathbf{a_4}$ parameter, which mechanism(s) leads to drop on transfer curve; in progress.

PACO's measurements (reminding earlier calculations)

- p_{gas} = 1 atm
- calculation details given

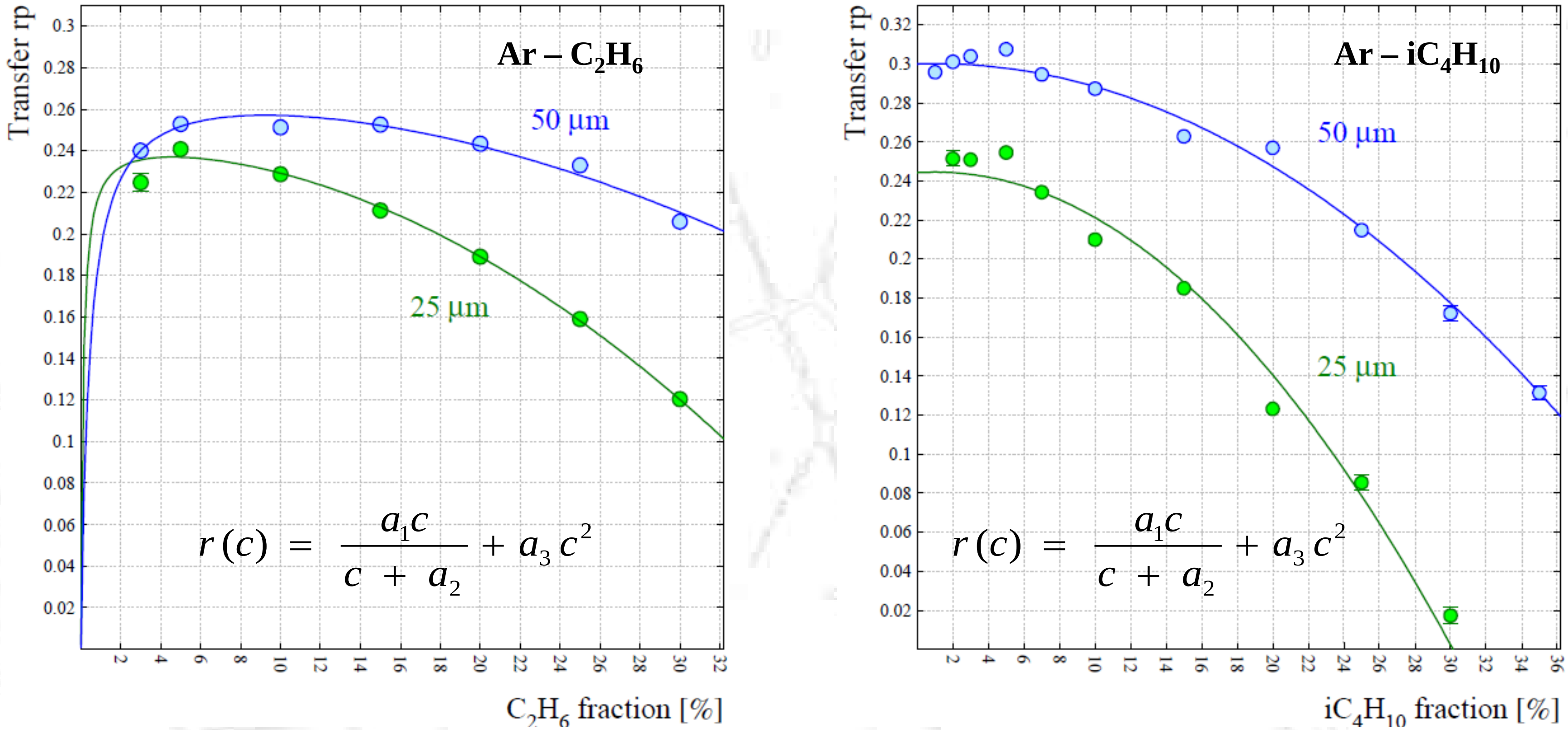
9th RD51 Collaboration Meeting, 20-22 February 2012, CERN



F. J. Iguaz et al., Characterization of microbulk detectors in argon- and neon-based mixtures (2012). http://arxiv.org/abs/1201.3012v1

Also private communication with F. J. Iguaz for unpublished data, 12 Feb 2012

Fits of the transfer rates extracted from Paco's data



- ❖ Drops at large quencer fractions (beyond ≈%5), seen also in Xe – TMA mixtures at 1 bar,
- ❖ $r(c) = \dfrac{a_1 c + a_3}{c + a_2} + a_4 c^2$ does not give physical results; negative values for fit parameters,
- ❖ Fits at low quencher percentages are poor, no experimental gain data below %2,
- ❖ What is the reason of lower transfer rates for smaller gap distance **???**

Electric field correction in MMs

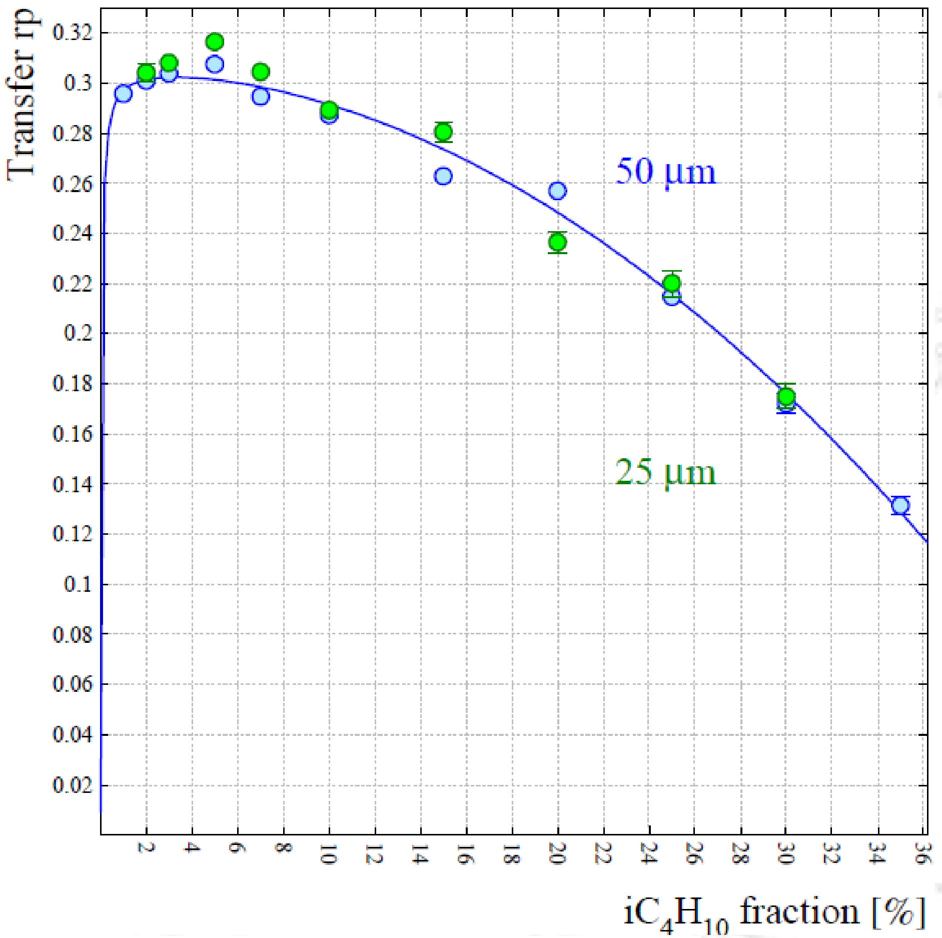
❖ *"... the field in a Micromegas is actually smaller than the voltage difference divided by the gap. The difference is larger in the 25 micron than in the 50 micron chamber ..."* (Disscussion with Rob Veenhof, 8 Mar 2013)

❖ A simple example to see: decrease given electric field data by 0.95 of 25 μm chamber,

❖ Fitted experimental data again to find transfer rates,

❖ Overlapping of transfer rates for both two different gap distances,

❖ But, still missing e–field of 50 μm chamber



❖ **Real calculations with ANSYS in progress ...**

KRAKOW measurements

❖ **RECENT UNPUBLISHED DATA**

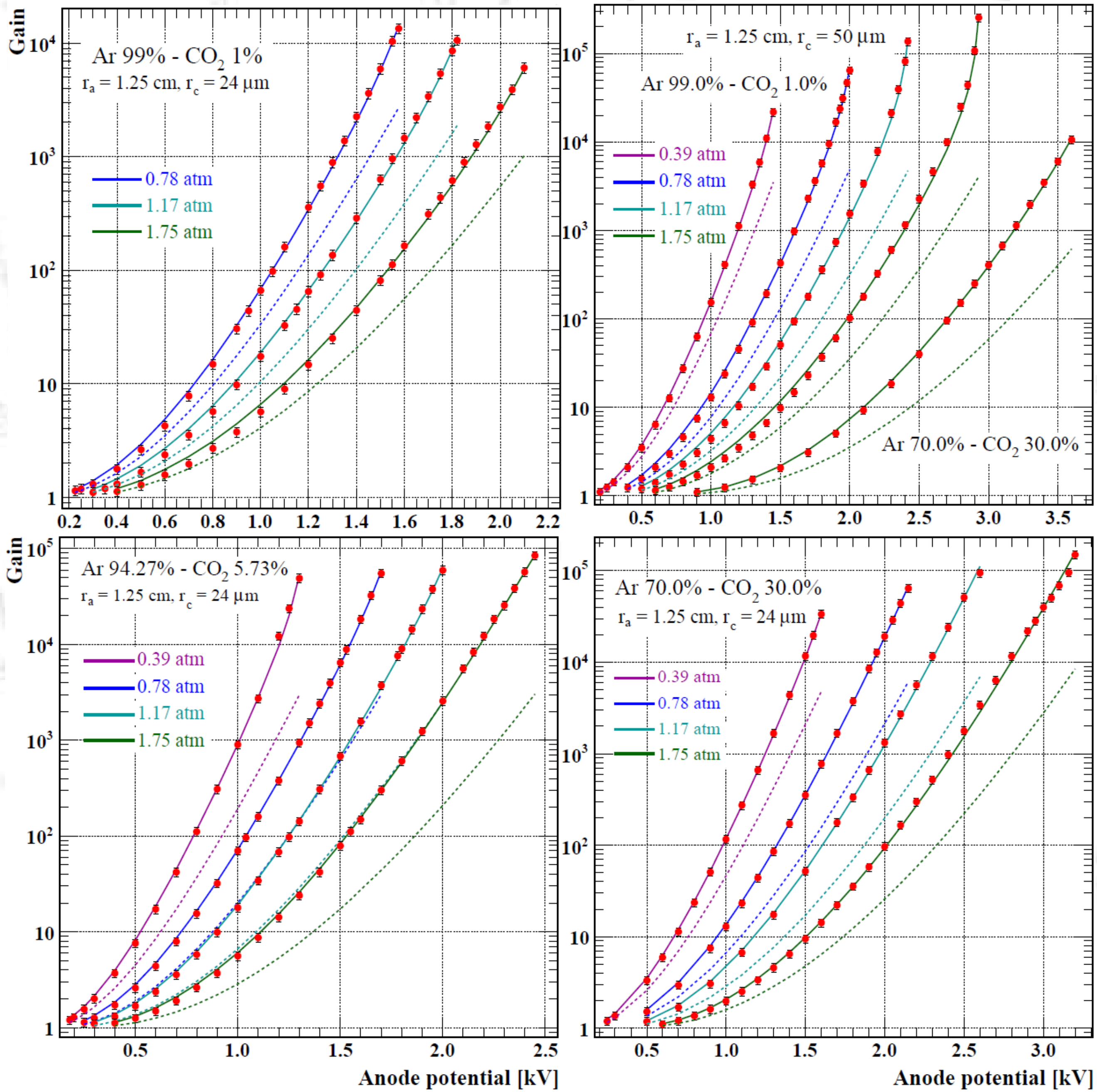
❖ No need to use gain scaling factor, shows very carefully calibrated equipment,

❖ Photon feedback term used as a free parameter,

❖ Measurements begin from very low gains

❖ Fills a big gap of earlier calculations (see next slides),

❖ With the permission of Tadeusz Z. Kowalski (19 April 2013)



Transfer rates in Ar – CO_2 mixtures

❖ Now, we have transfer rates from 1% to 30% CO_2 in Ar – CO_2 mixtures

❖ Almost flat at lowest CO_2 fraction

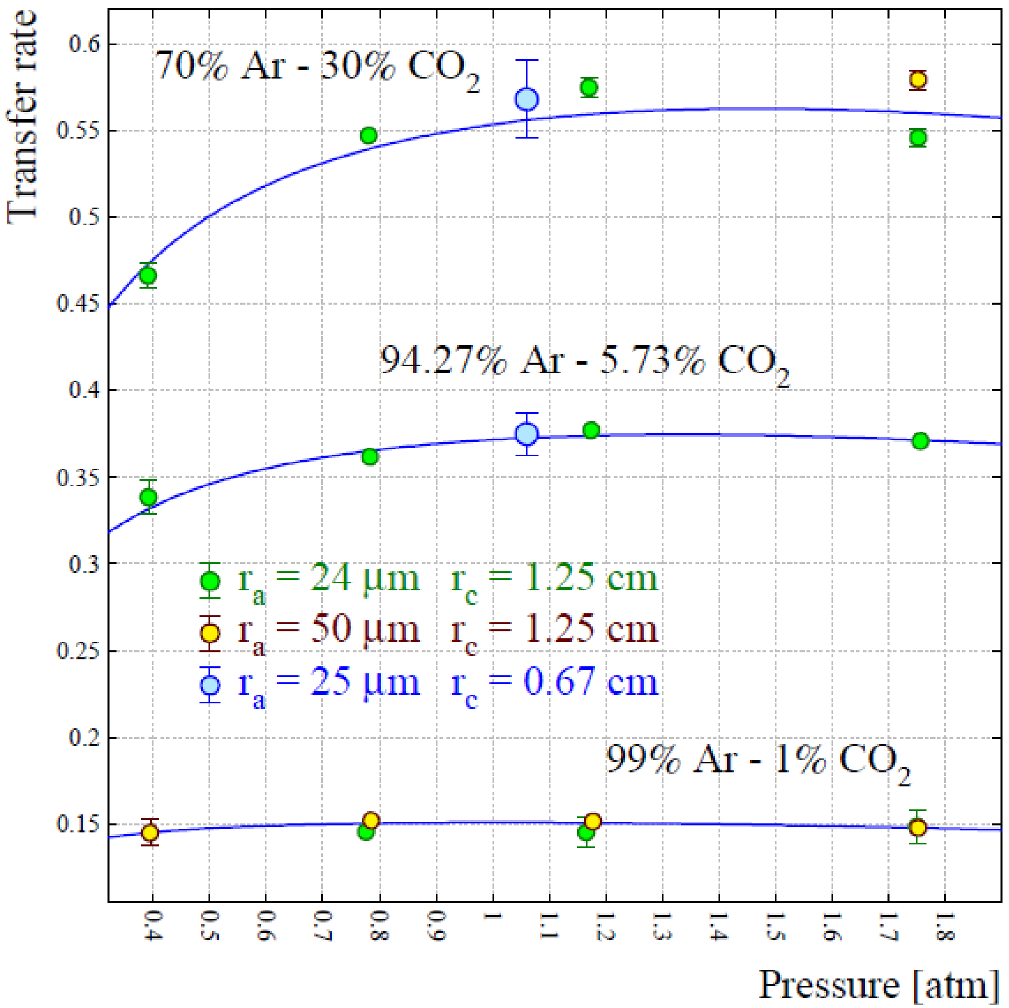
❖ Transfer rates always drop in 30 % CO_2 mixtures at high pressure (1.75 atm)

❖ Only proposed 3 parameter fit function describes the transfer data

❖ Sign of three – body interactions ?

❖ Error bands will be drawn

❖ **Great agreement with earlier extracted transfer rates (blue circles), given in our Penning paper (details in the next slides), using measured data of the same author !!!**



$$r(p) = \frac{a_1 p}{p + a_2} + a_3\, p^2$$

Concentration dependence of transfer rates

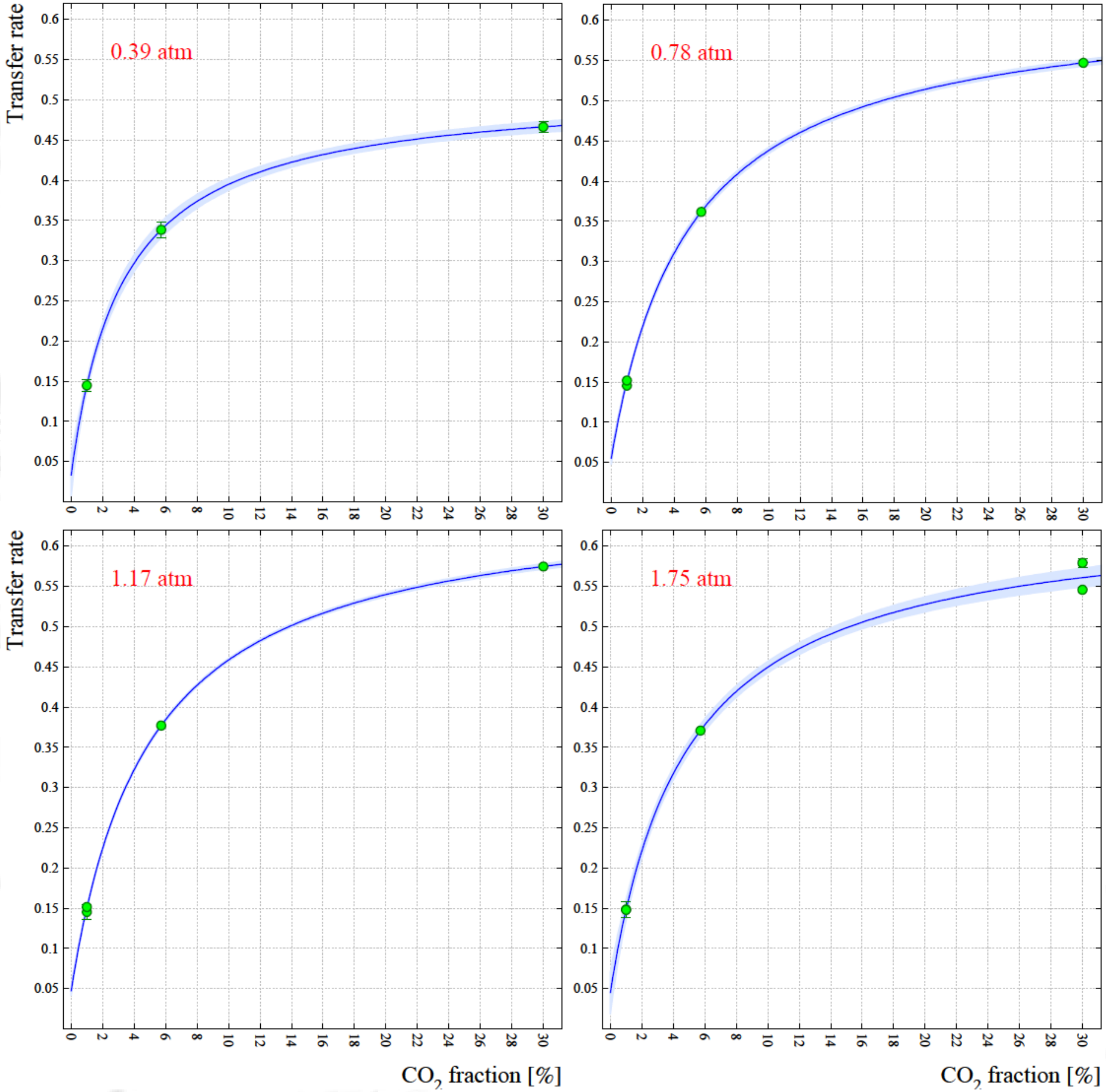
❖ Three parameter fit function describe the rates well

$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

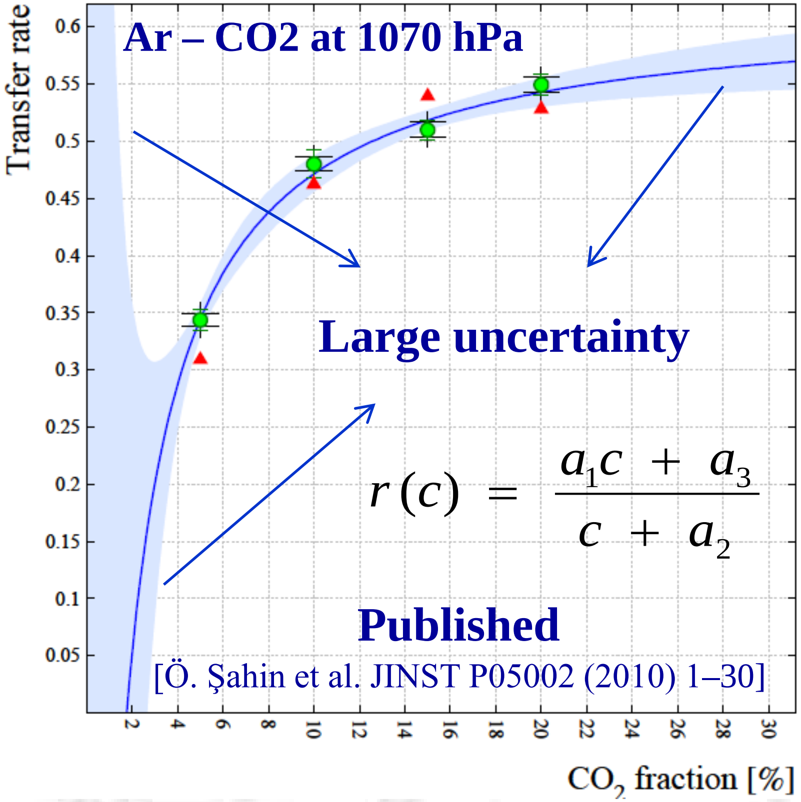
❖ Physically meaningful fit parameters

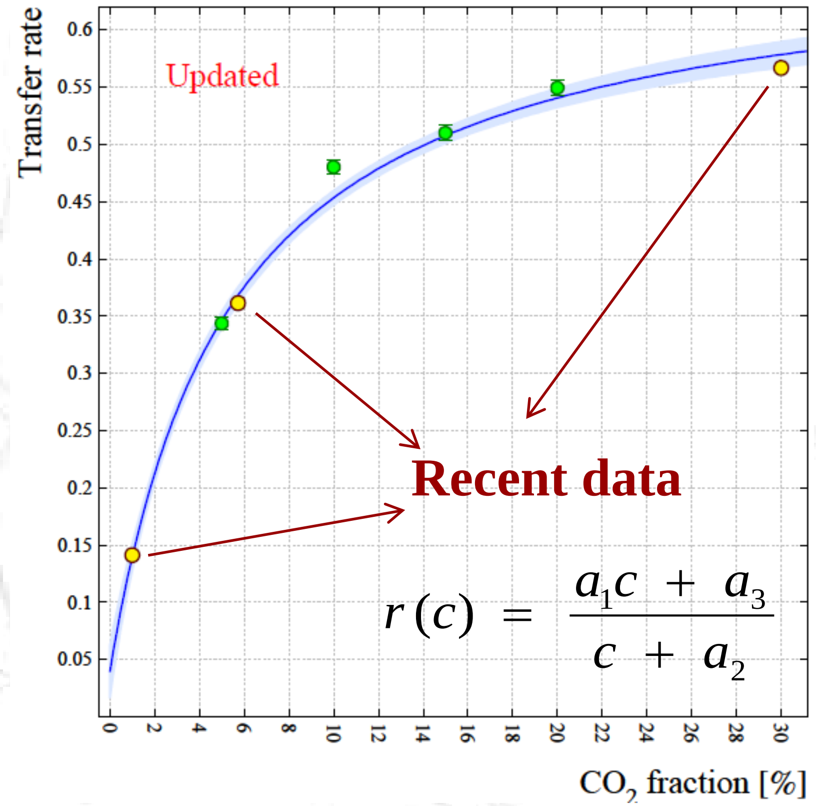
❖ Not taken into account very small differences of the pressures

❖ More detailed analysis coming



Importance of the new measurements





- No photon feedback term used,
- 1.06 gain scaling factor,
- Unphysical fit at low CO_2 concentrations and wide error band at high percentages

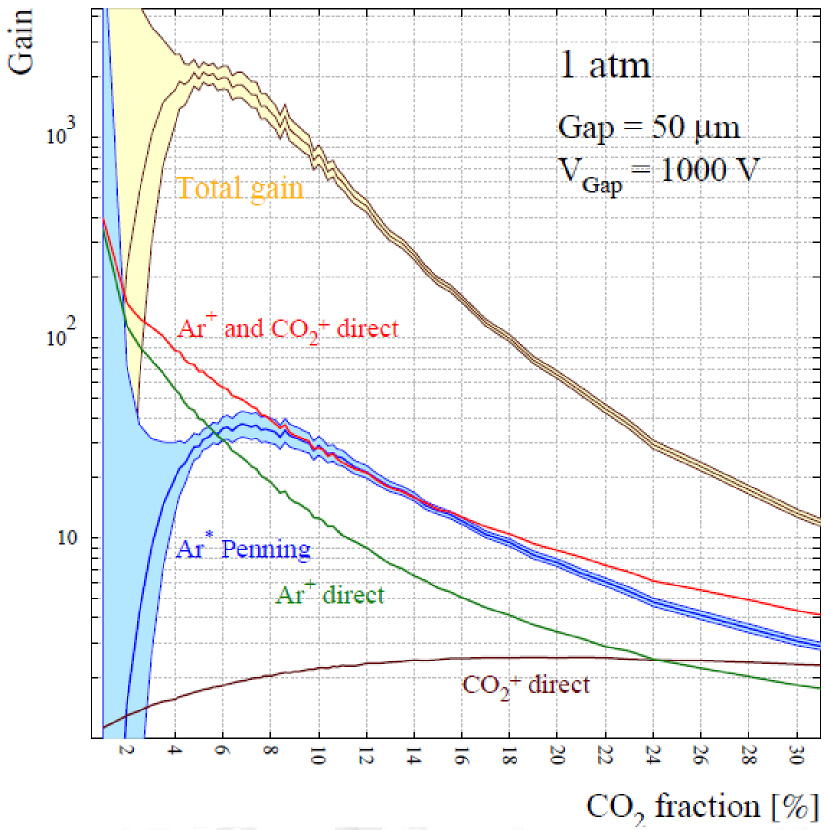
(lack of experimental data at low and high fractions !!!)

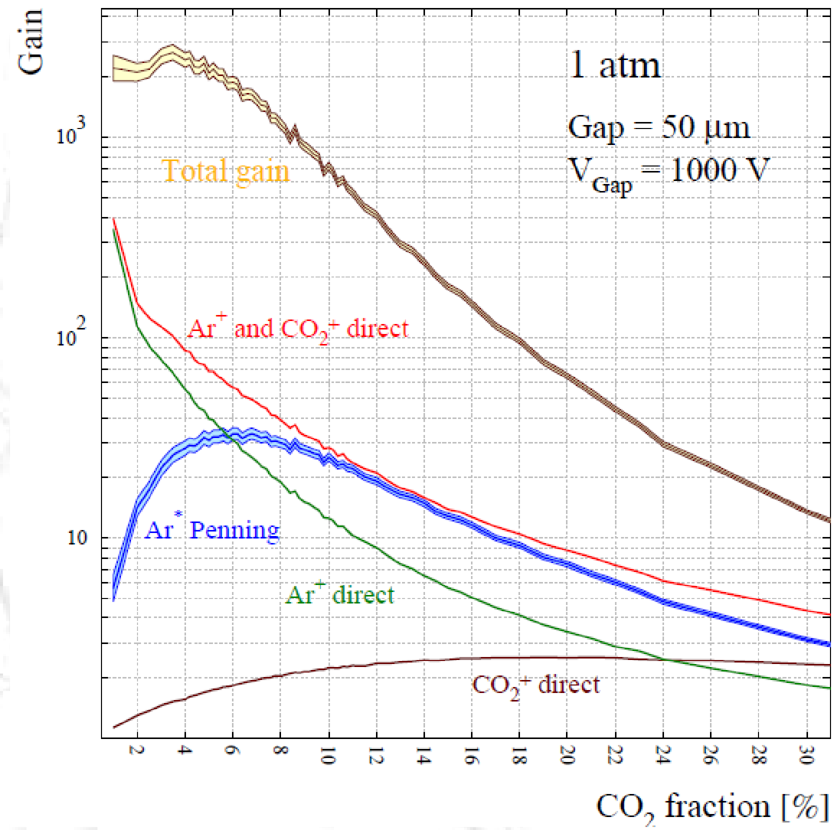
- [T.Z. Kowalski *et al.*NIM *A* **323** (1992) 289–293]

- Pressure scaling for 1.17 atm transfer rates to put them on the plot,
- Narrow error band both at low and high CO_2 percentages,
- **All the fit parameters are physical**, relevant to learn about radiative transfers

(**a_3 / a_2** was negative in earlier fit, plot on the left)

Application of transfer rates



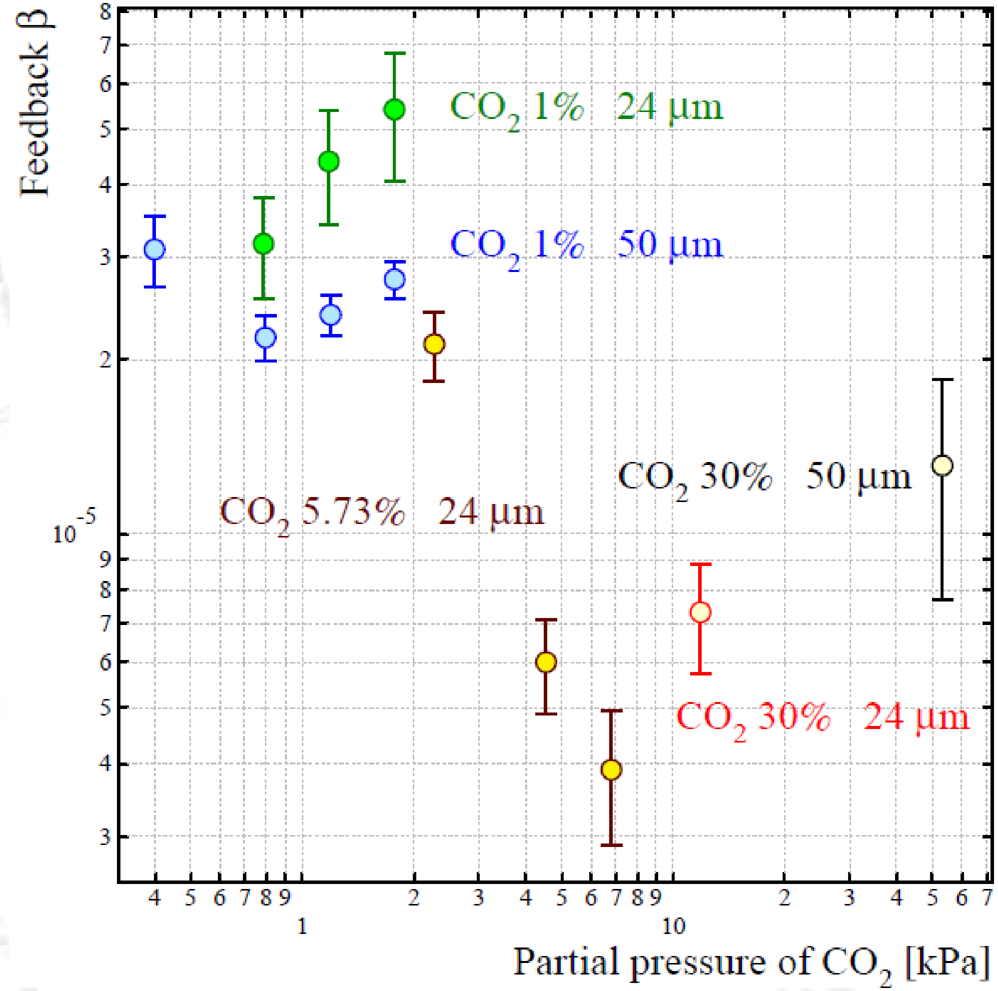


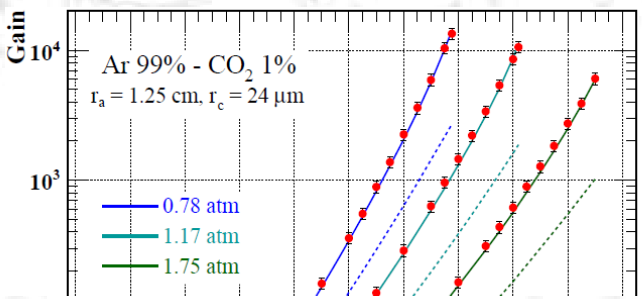
- MMs like simple geometry, 1% to large CO_2 concentrations (Magboltz 9.0.1),
- Possible to separate ionisation mechanisms contributing to total gain,
- High precision at low CO_2 fractions with updated transfer rates (plot on the right) ,
- Highest Penning transfer around 1% CO_2, maximum on total gas gain ≈ 3% CO_2,
- **Should be confirmed**, measurements with MMs in Ar – CO_2 mixtures **???**

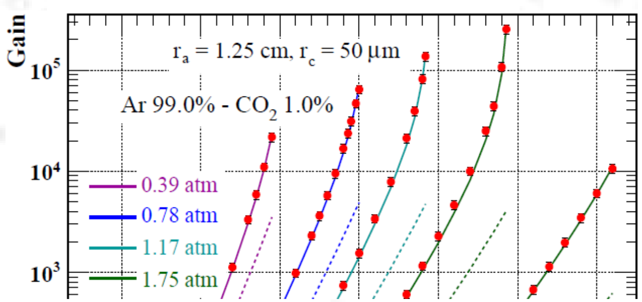
Feedback parameters of recent Krakow measurements

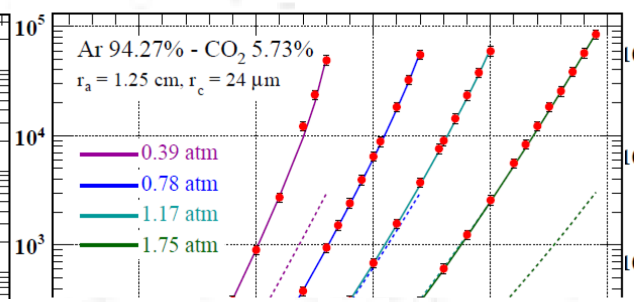
$$G' = G/(1-\beta G)$$

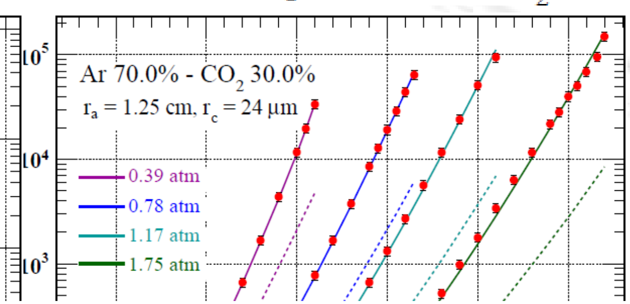
- ❖ Decrease on feedback with partial pressure only in Ar 94.27% - CO_2 %5.73 mixture
- ❖ Largest β at lowest CO_2 concentration, lack of quencher, unabsorbed photons
- ❖ Trends of β with partial pressure not fully understood, **ideas ???**



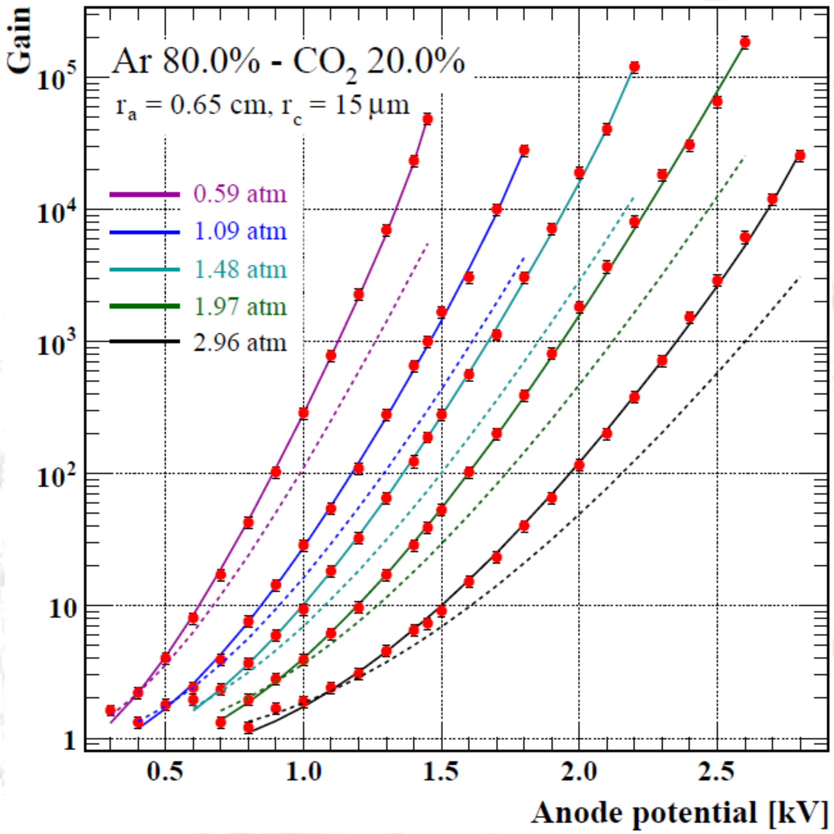


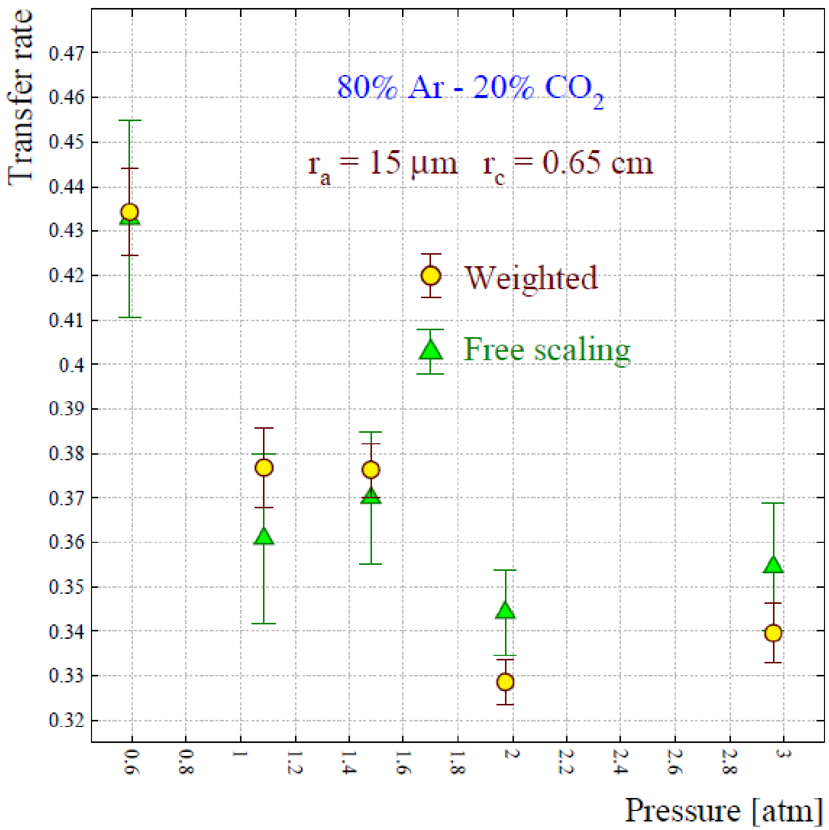






Measurements in Ar 80 % - CO_2 20 % mixtures





- ❖ Feedback term and gain calibration needed while fitting,
- ❖ Common scaling factor ≈ 0.75 (yellow circles on the right plot),
- ❖ Transfer rate found at 1.09 atm does not support earlier calculations,
- ❖ Peculiar trend of the rates, **ideas ???**

Missing calculations and Wishlist (Krakow)

❖ Will be useful to find transfer rates at low CO_2 fractions with more accuracy,

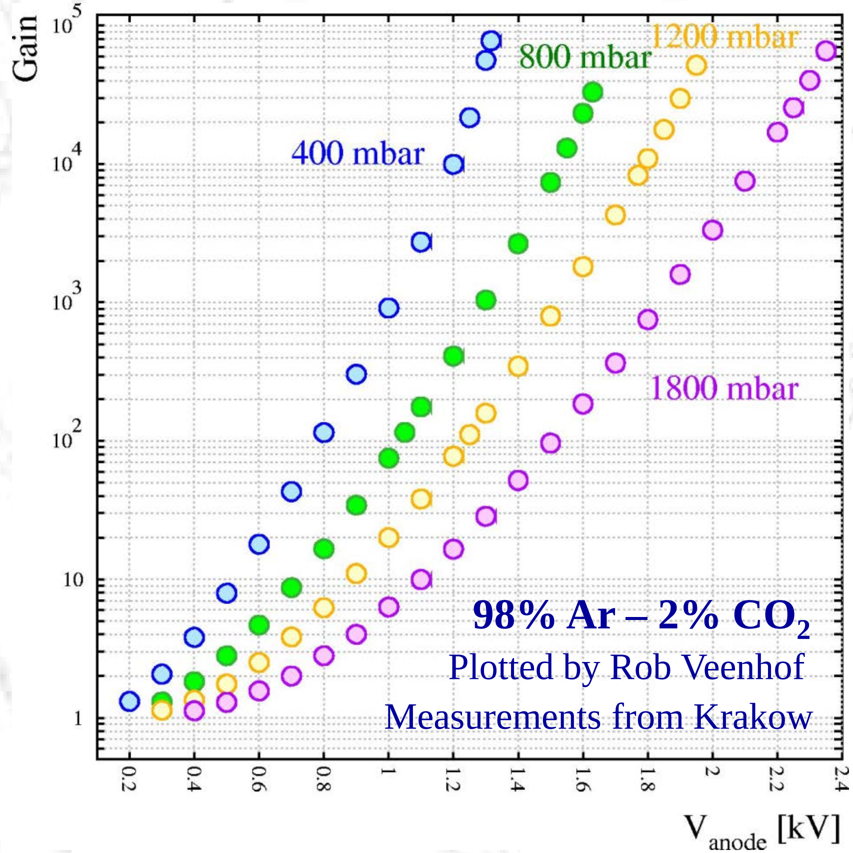
❖ Similarly 4% CO_2 data will also be proper,

❖ Ar + 50 % CO_2 measurements in progress ,
(private communication with Tadeusz Z. Kowalski, 19 Apr)

❖ Hope to find decrease for uncertainties on transfer rates beyond 30% CO_2, also crucial to understand pressure dependence of the transfers

❖ Curious to see existence of 3 – body interactions if really they are at large fraction of CO_2

❖ **Very important mixture for GEMs !!!**



Next:

❖ Survey with Ar – CO_2 – CF_4 mixtures; already have some measured data from Krakow, another important mixtures for GEMs **!!!**

❖ **If possible:**

- ❖ Gain in Xe – TMA mixtures, cross – check would be very nice for **MMs**
- ❖ Gain in Ne – CO_2, Ne – CO2 – N_2 and Ne – CF_4 mixtures for **Alice people**

Missing calculations and Wishlist (Zaragoza)

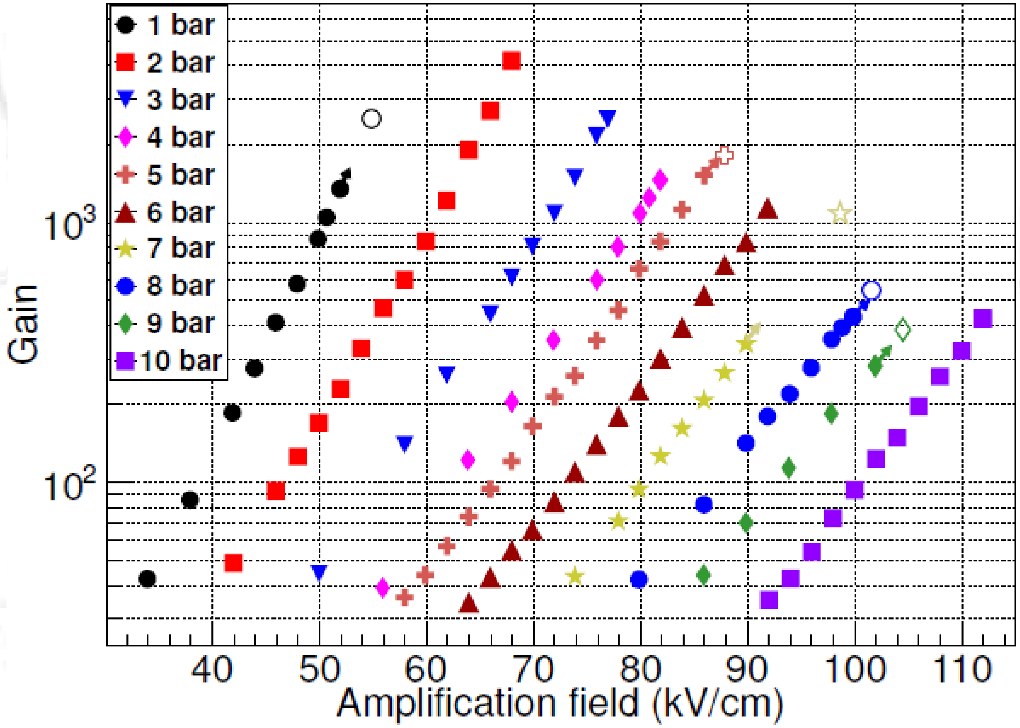
❖ Measurements in Ar + 1.5% - 2.0% TMA mixtures, at 1 – 10 bar pressures

❖ More information at low TMA percentages,

❖ Zaragoza group already made some calculations for transfer rates;
cross – check of the results will be useful

❖ **Important mixture for TPCs people !!!**

http://arxiv.org/pdf/1303.5790.pdf (22 Mar 2013)



Next:

❖ Detailed error bars on gas gain are coming, more price calculations on transfer rates,

❖ Gain measurements higher than 10% TMA at high pressures (e.g. 2 to10 bar) could be nice to be sure about 3 – body ionisation loses,

❖ Mentioned earlier, measurements in Ar – CO_2 would confirm our current knowledge extracted from Krakow data; also would be useful to find gain maximums with simulation

Thanks and ?????