Xe – TMA Calculations

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Experimental data

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

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- 50 µm MMs
- at 1, 5, 8, 10 bar pressures

Measured gain curves

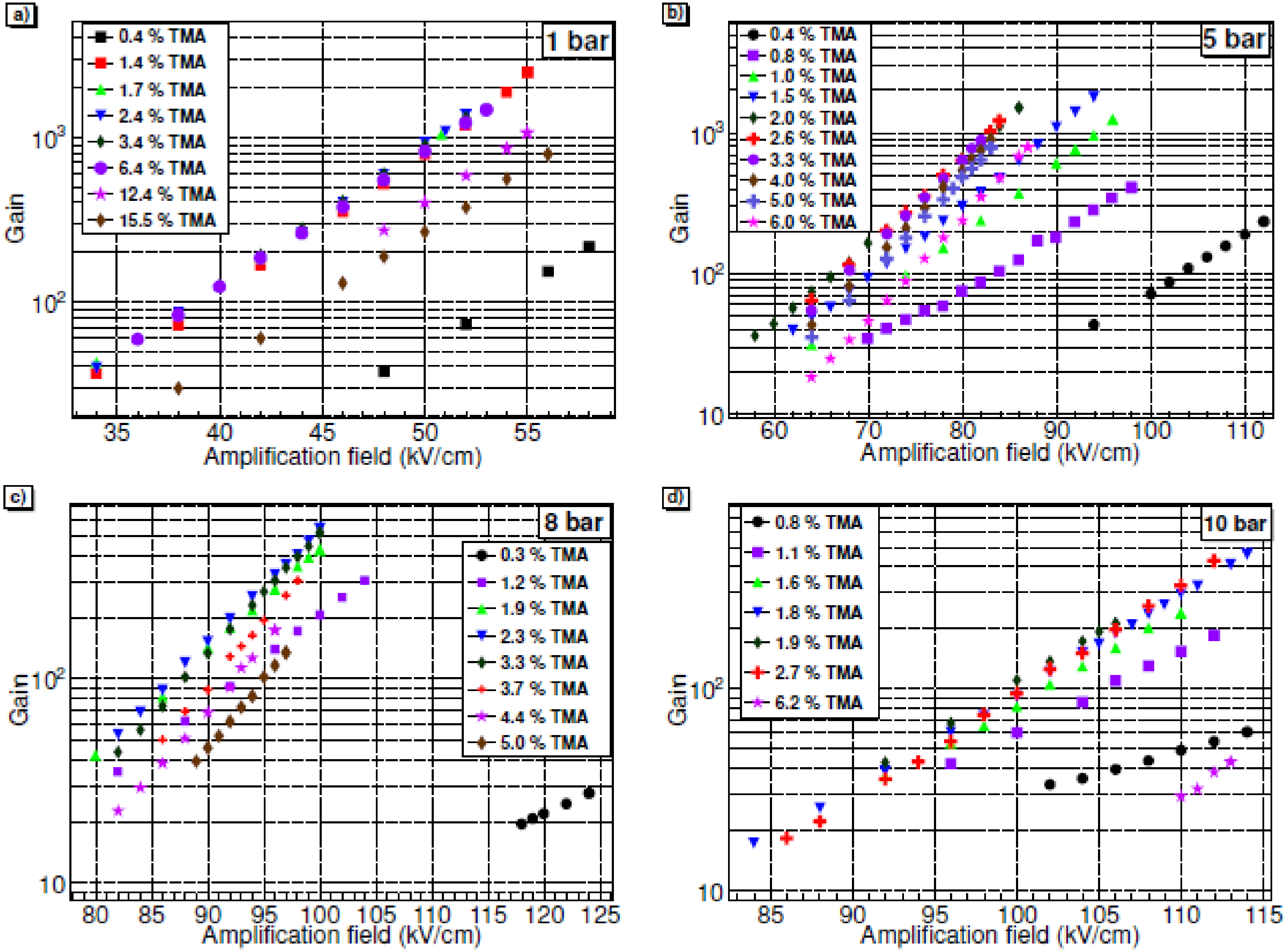


Figure 5. Dependency of gas gain with amplification field for different TMA concentrations at 1 (a), 5 (b), 8 (c), 10 (d) bar. In each graph the TMA concentration is indicated.

Energy transfers

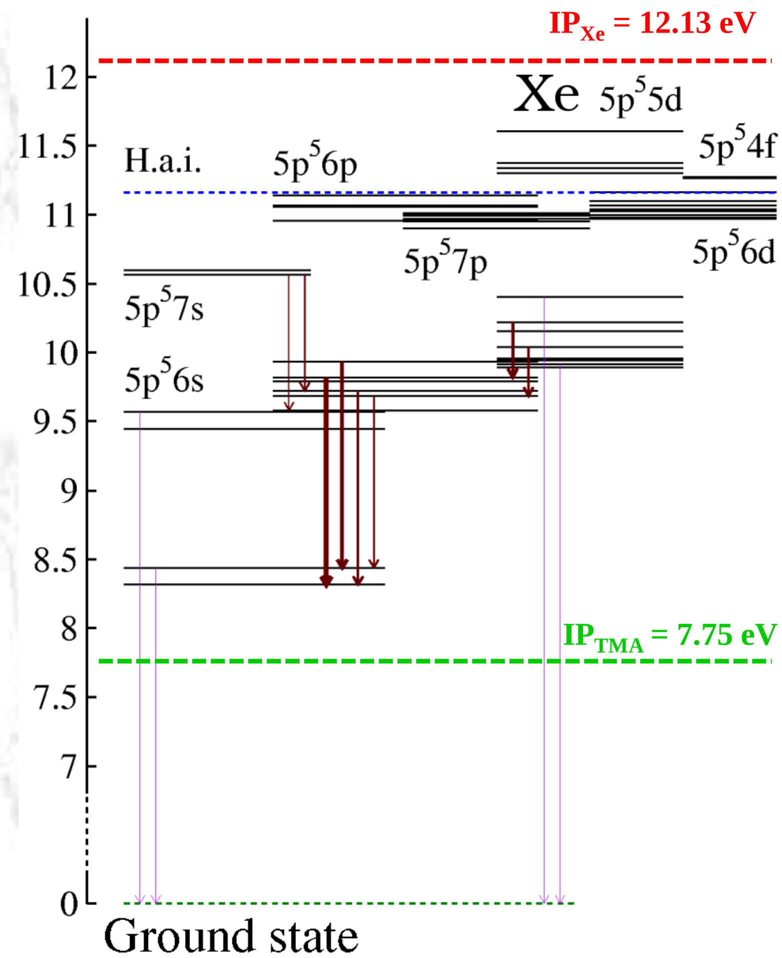
- $Xe^* + TMA \rightarrow Xe + TMA^+ + e^-$

  Penning mixture !

- Townsend coefficient adjustment

$$G = \exp(\alpha_{Penning}\ d)$$

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



- *d* gap distance
- r_i transfer probabilities: assuming α proportional to the sum of ν_{ion},
- α, ν_i : gas properties (pressure, temperature …)
- calculated by Magboltz (version 9.0.1) [S.F. Biagi, *NIM A* **421** (1999) 234–240.]

Photon feedback

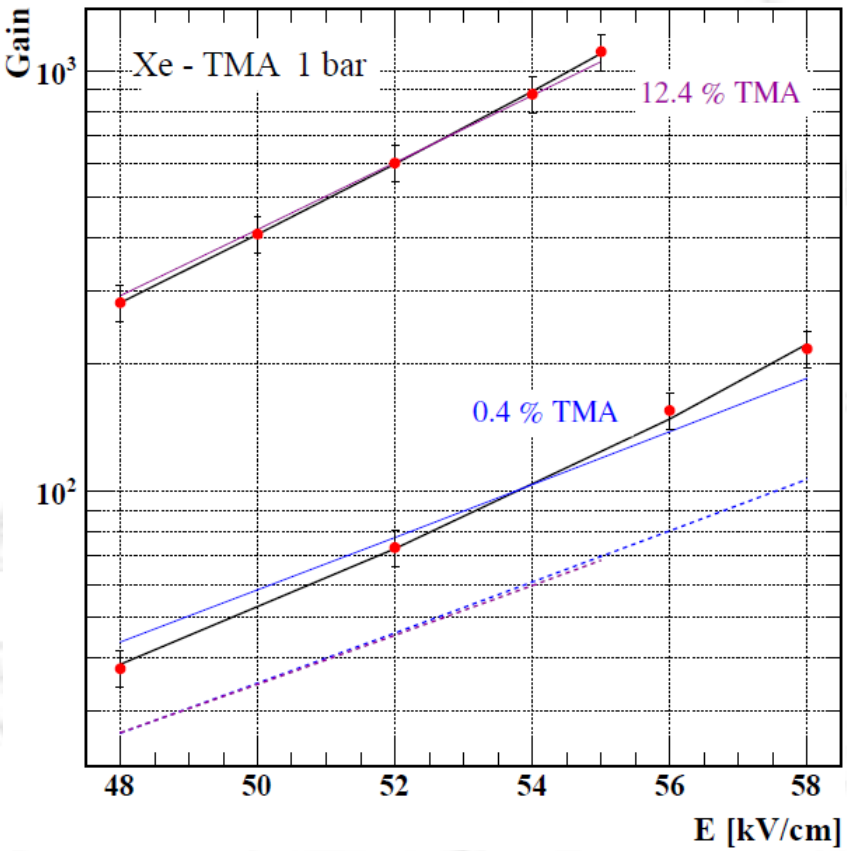
- Excited states (A^*) ⇒ radiative decay ($A^* \rightarrow A + \gamma$),
- Photons ⇒ photo-electrons (from cathode and in gas itself),
- Secondary, delayed avalanches ⇒ over exponential increases at high gains:
  - G ⇒ average avalanche size without feedback,
  - β ⇒ number of secondary avalanches started by one avalanche electron,
    - electrons: 1th step ⇒ βG, 2nd step ⇒ βG^2, 3th step ⇒ βG^3, …
    - Summing over each step:

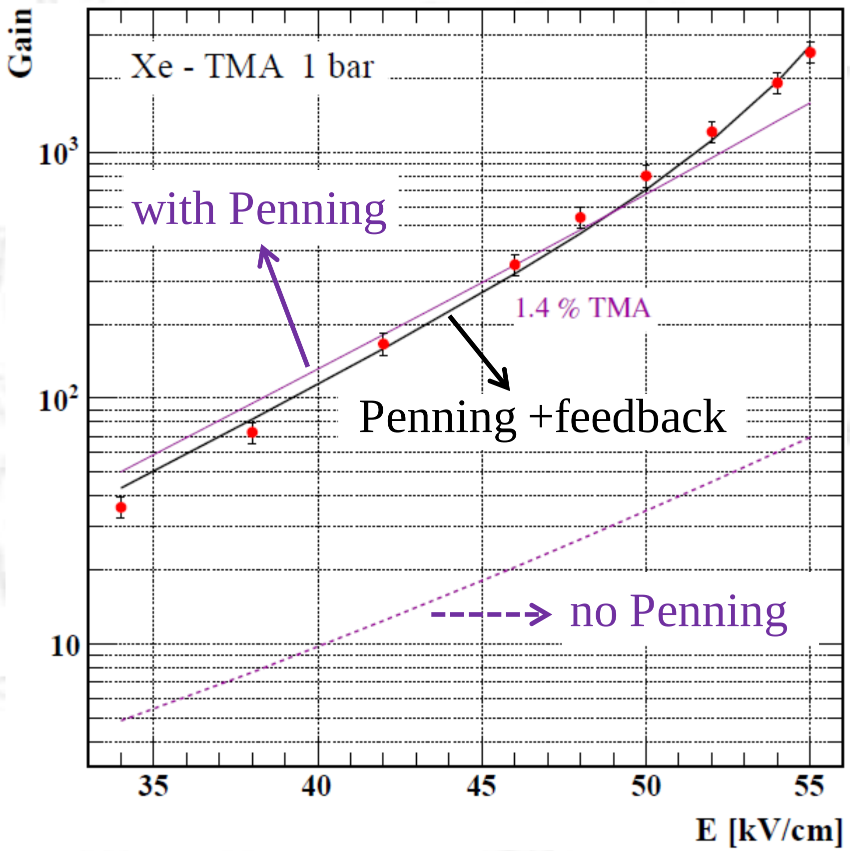
$$G' = G + \beta G^2 + \beta^2 G^3 + \ldots = G/(1-\beta G)$$

    - G` ⇒ average avalanche size with feedback.

- **β** almost uncorrelated with **r**, use as a free parameter

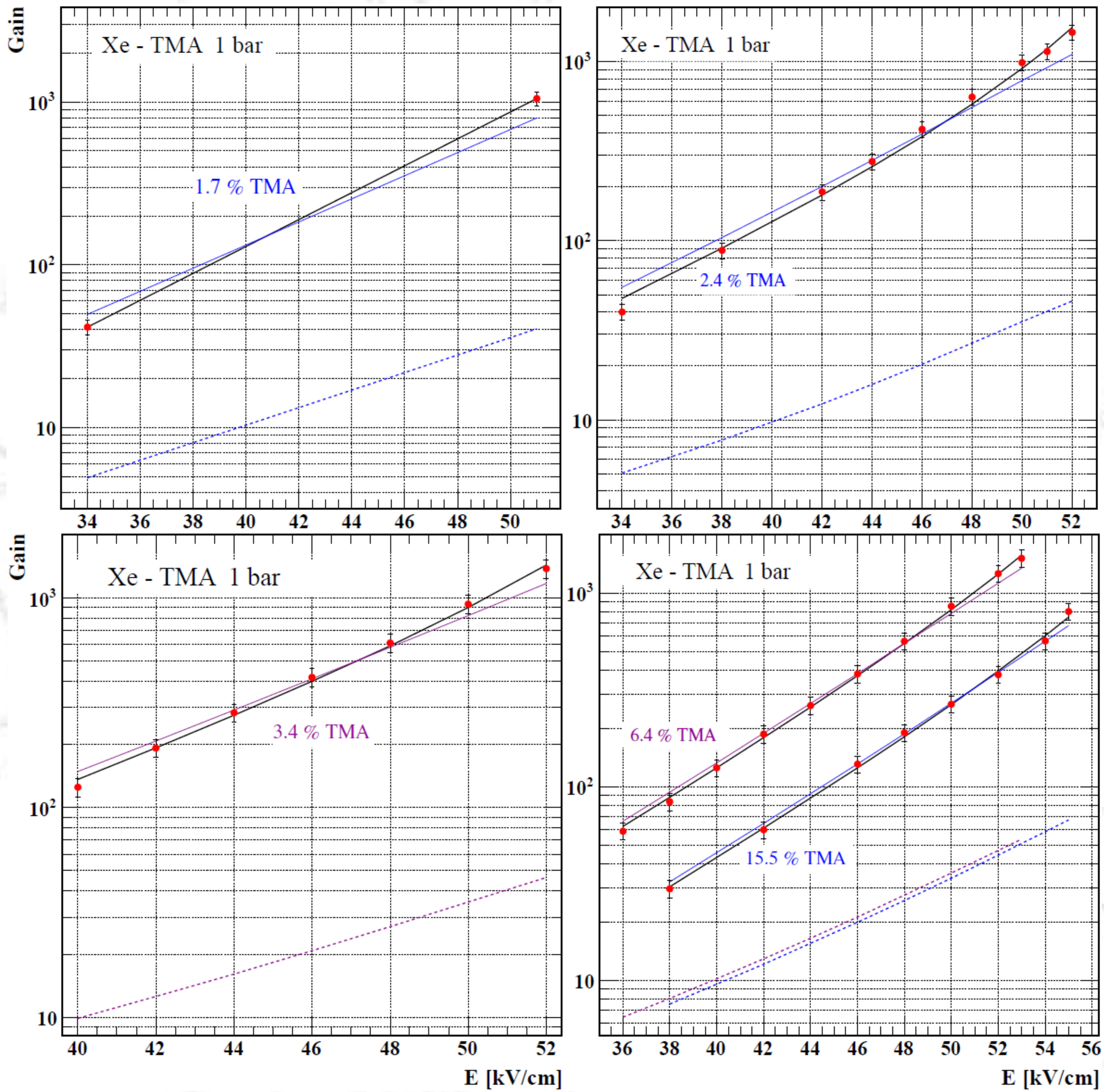
Gain fits at 1 bar



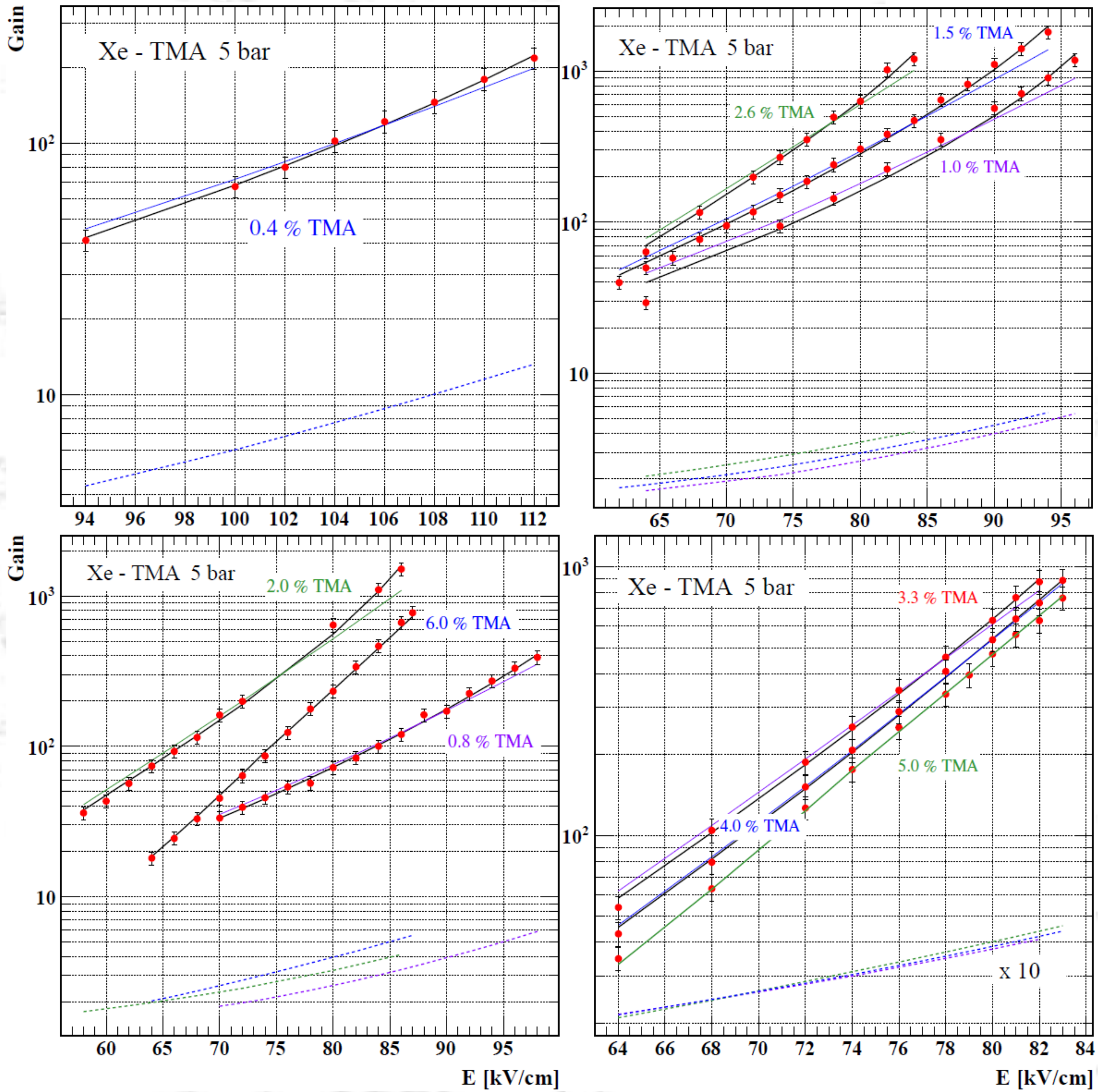


- ❖ Dashed lines: calculation without Penning transfers
- ❖ Colored thin straight lines: fits with Penning transfers ($\mathbf{r_p}$)
- ❖ Black straight lines: fits including Penning transfers and photon feedback ($\boldsymbol{\beta}$)
- ❖ Red circles: experimental data points

1 bar continue ...

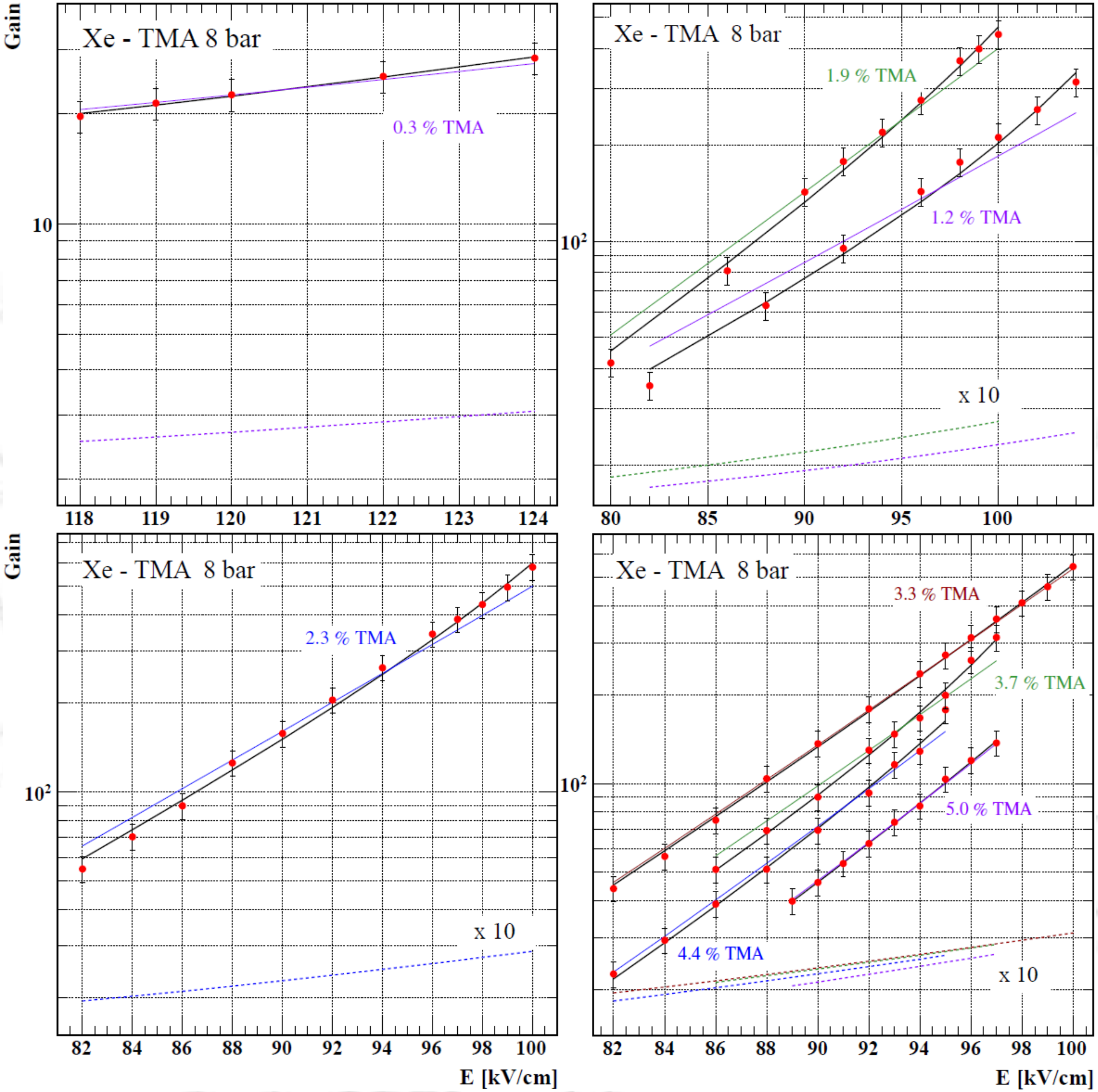


5 bar



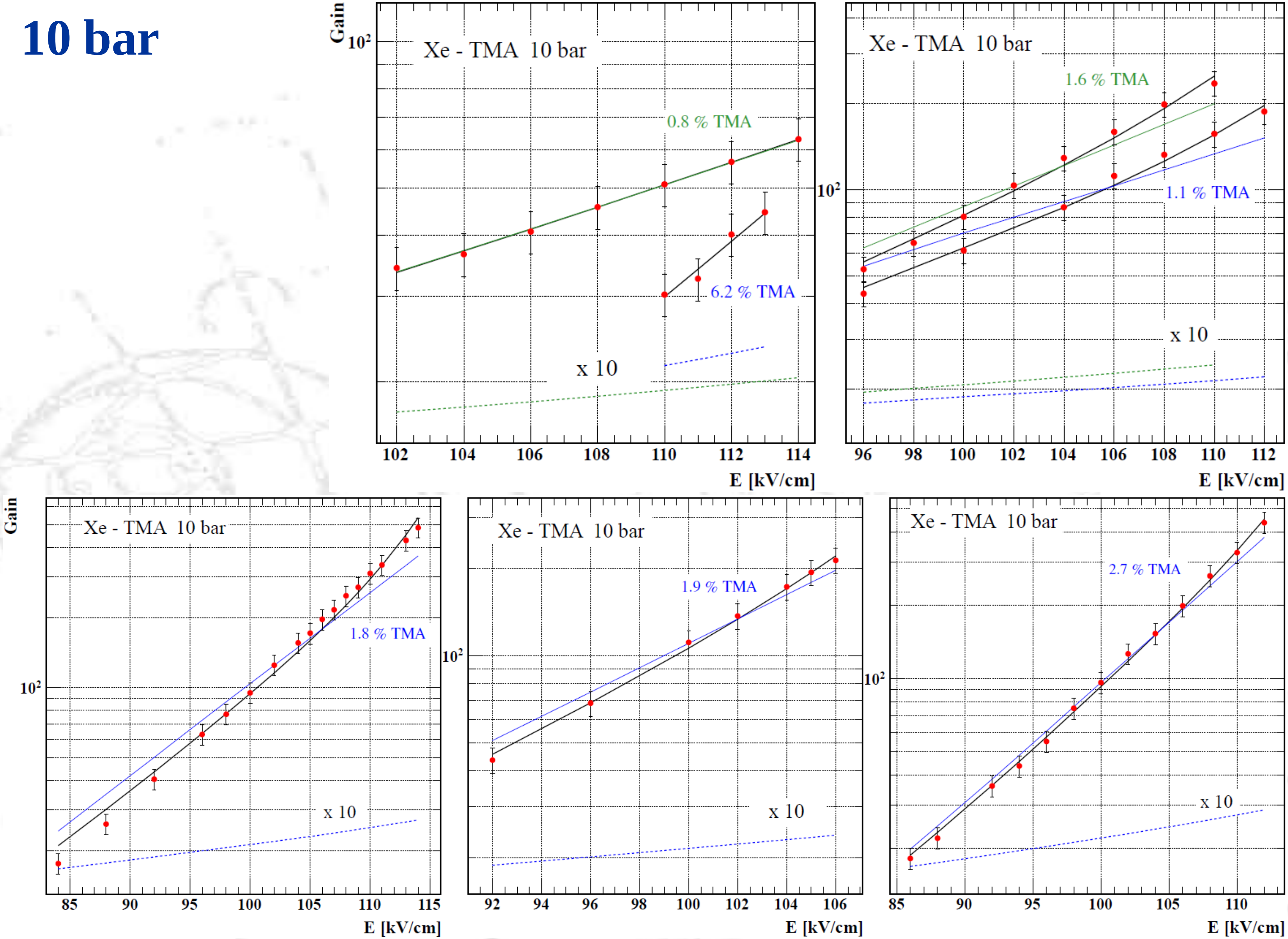
Gain
Xe - TMA 5 bar
0.4 % TMA
1.5 % TMA
2.6 % TMA
1.0 % TMA
2.0 % TMA
6.0 % TMA
0.8 % TMA
3.3 % TMA
4.0 % TMA
5.0 % TMA
x 10
E [kV/cm]

8 bar



Gain
Xe - TMA 8 bar
0.3 % TMA
10
118
119
120
121
122
123
124
Xe - TMA 8 bar
1.9 % TMA
1.2 % TMA
10^2
x 10
80
85
90
95
100
Gain
Xe - TMA 8 bar
2.3 % TMA
10^2
x 10
82
84
86
88
90
92
94
96
98
100
E [kV/cm]
Xe - TMA 8 bar
3.3 % TMA
3.7 % TMA
5.0 % TMA
4.4 % TMA
10^2
x 10
82
84
86
88
90
92
94
96
98
100
E [kV/cm]

10 bar


Gain
Xe - TMA 10 bar
0.8 % TMA
6.2 % TMA
x 10
E [kV/cm]
Xe - TMA 10 bar
1.6 % TMA
1.1 % TMA
x 10
E [kV/cm]
Gain
Xe - TMA 10 bar
1.8 % TMA
x 10
E [kV/cm]
Xe - TMA 10 bar
1.9 % TMA
x 10
E [kV/cm]
Xe - TMA 10 bar
2.7 % TMA
x 10
E [kV/cm]

Fitting transfer rates

$e^- + A \rightarrow A^+ + 2e^-$: ionisation

$e^- + A \rightarrow A^*$: excitation

- The following can happen for an excited atom (A^*):
  - $A^* + B \rightarrow A + B^+ + e^-$: collisional ionisation,
  - $A^* + A \rightarrow A_2^+ + e^-$: homonuclear associative ionisation,
  - $A^* \rightarrow A + \gamma$: radiative decay

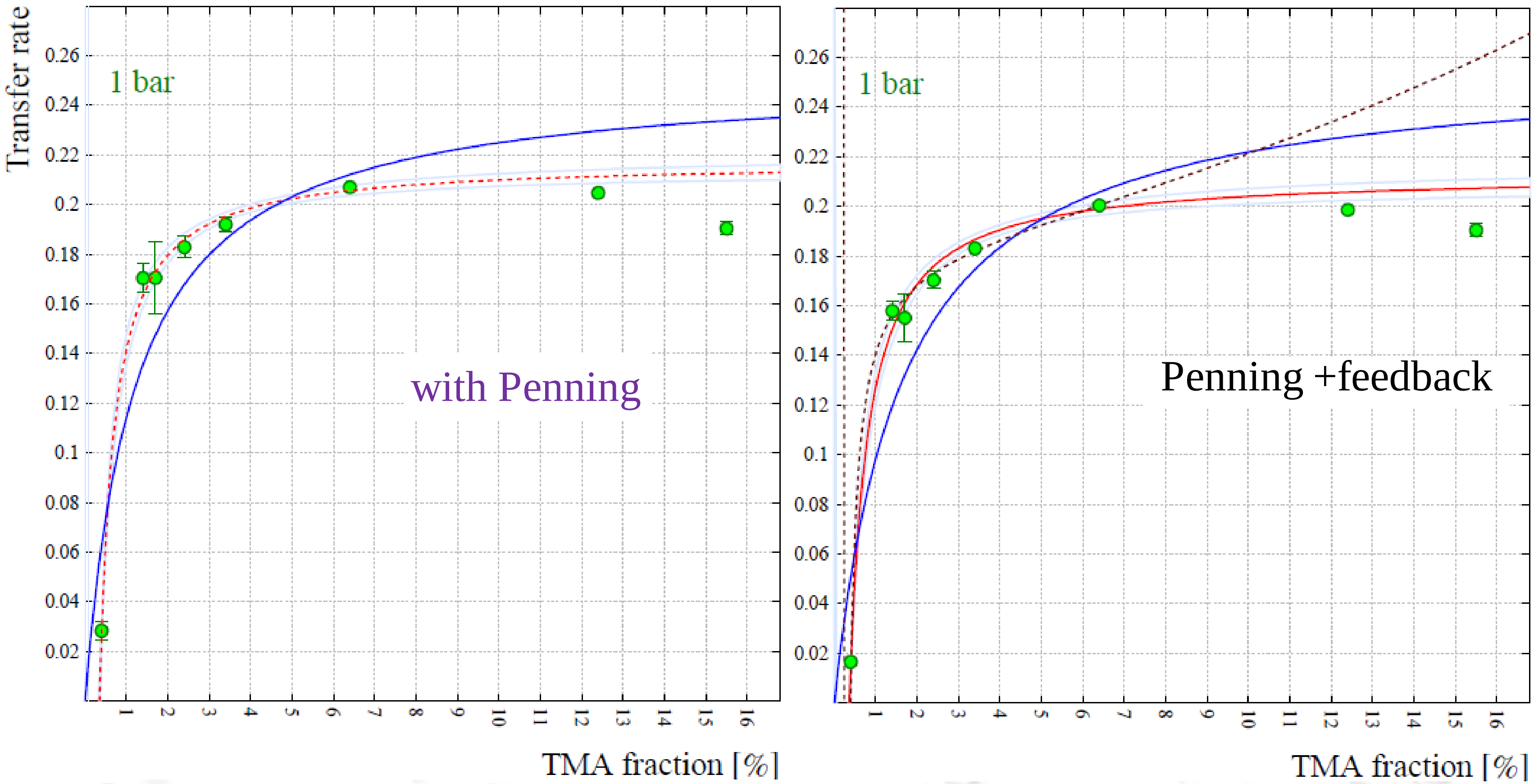
$$r = \frac{pc\frac{f_{B^+}}{\tau_{A^*B}} + p(1-c)\frac{f_{A^+}}{\tau_{A^*A}} + \frac{f_{rad}}{\tau_{A^*}}}{pc\frac{f_{B^+}+f_{\bar{B}}}{\tau_{A^*B}} + p(1-c)\frac{f_{A^+}+f_{\bar{A}}}{\tau_{A^*A}} + \frac{1}{\tau_{A^*}}}$$

A^*- B **A^*- A** **A^*- γ**

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

c: concentration of the quencher gas

Fits at 1 bar



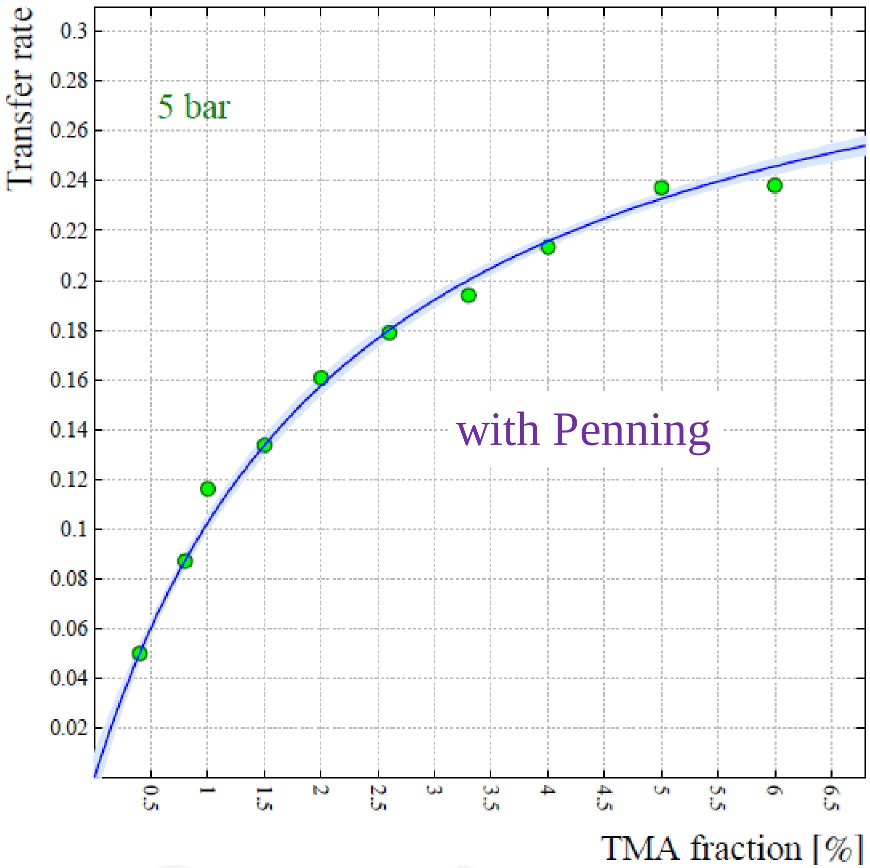
$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

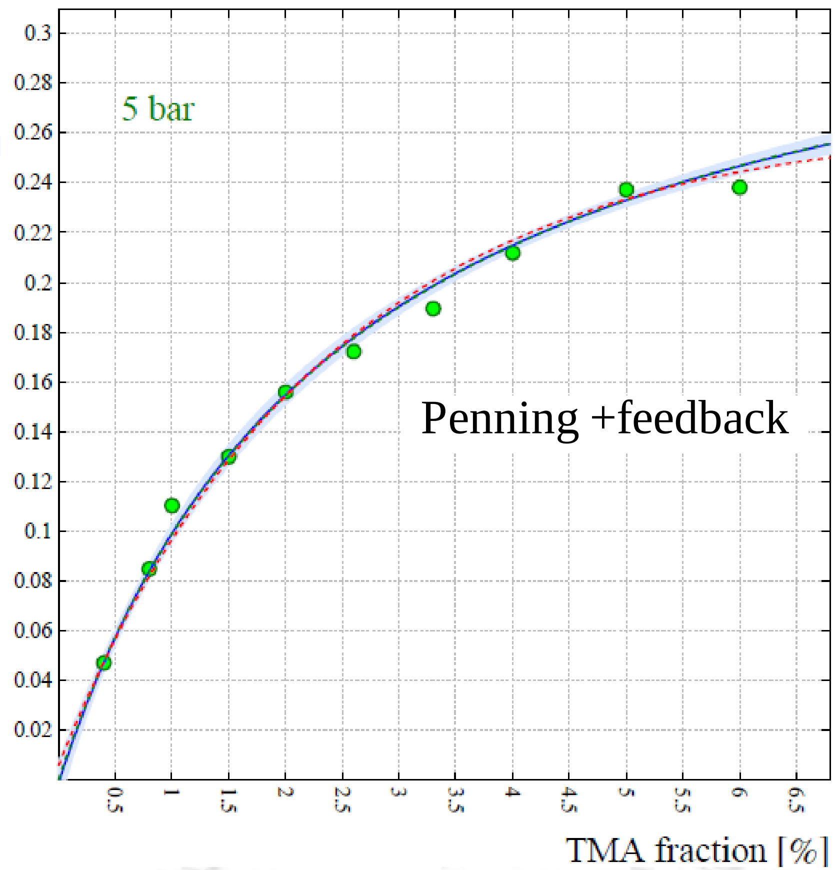
$$r(c) = \frac{a_1 c}{c + a_2}$$

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

excimer parameter

Fits at 5 bar





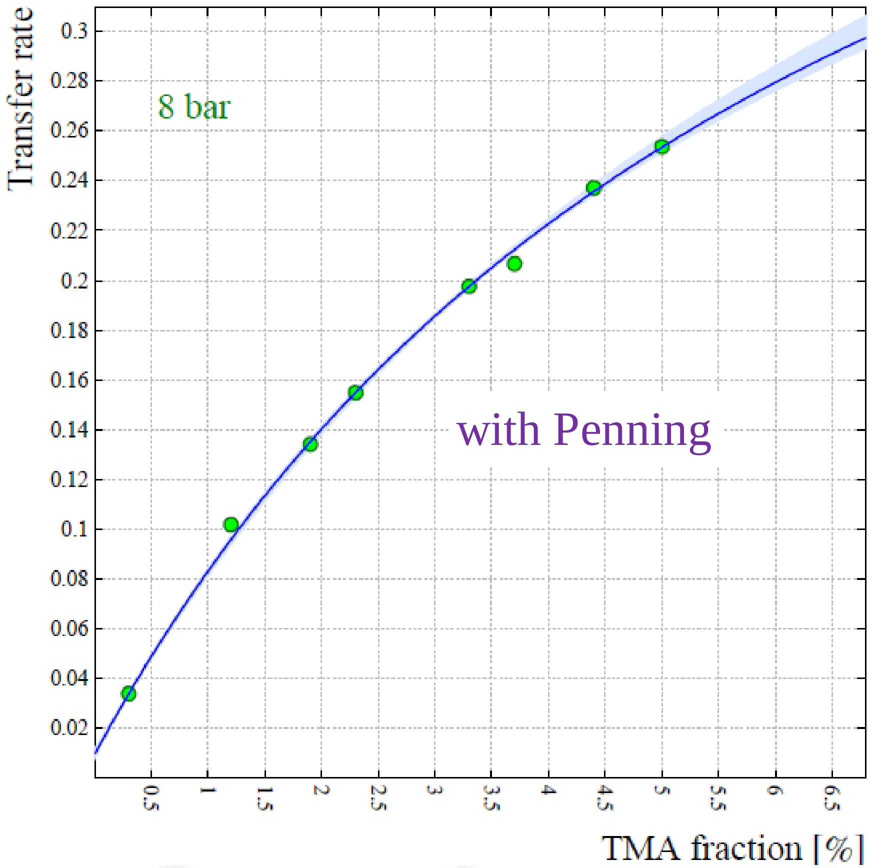
$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

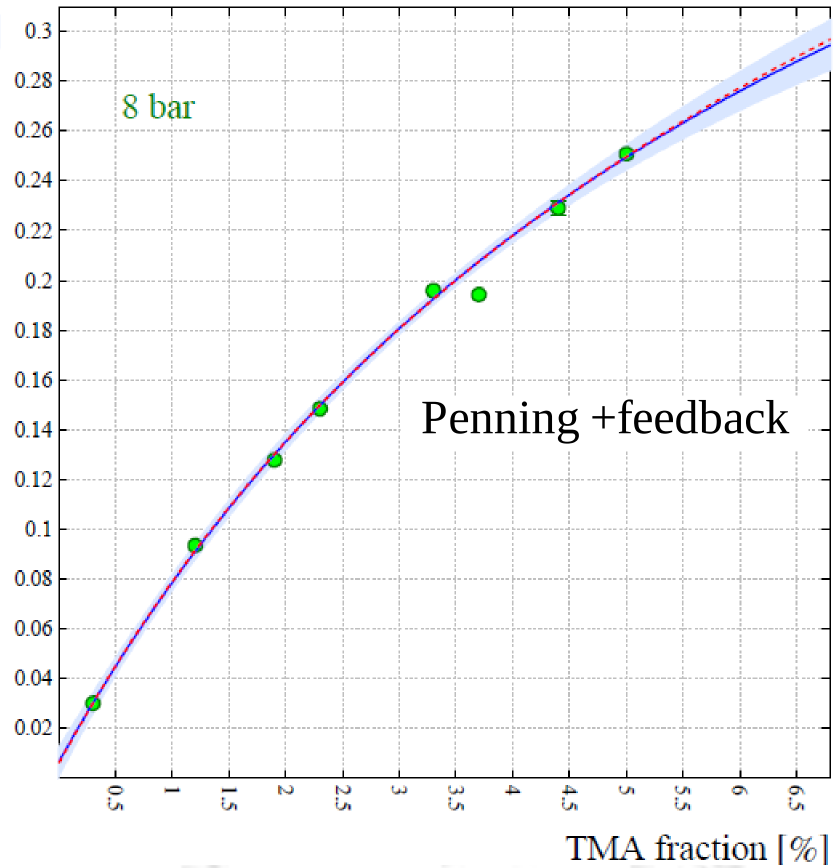
Parameters are physical

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

Non physical results **!!!**

Fits at 8 bar





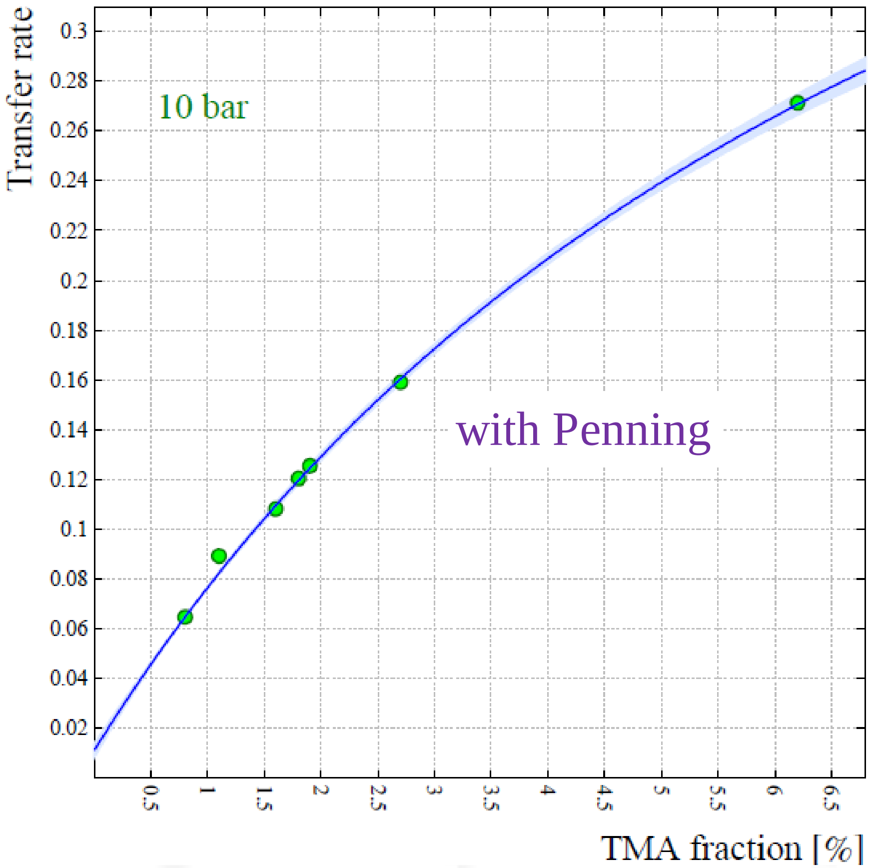
$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

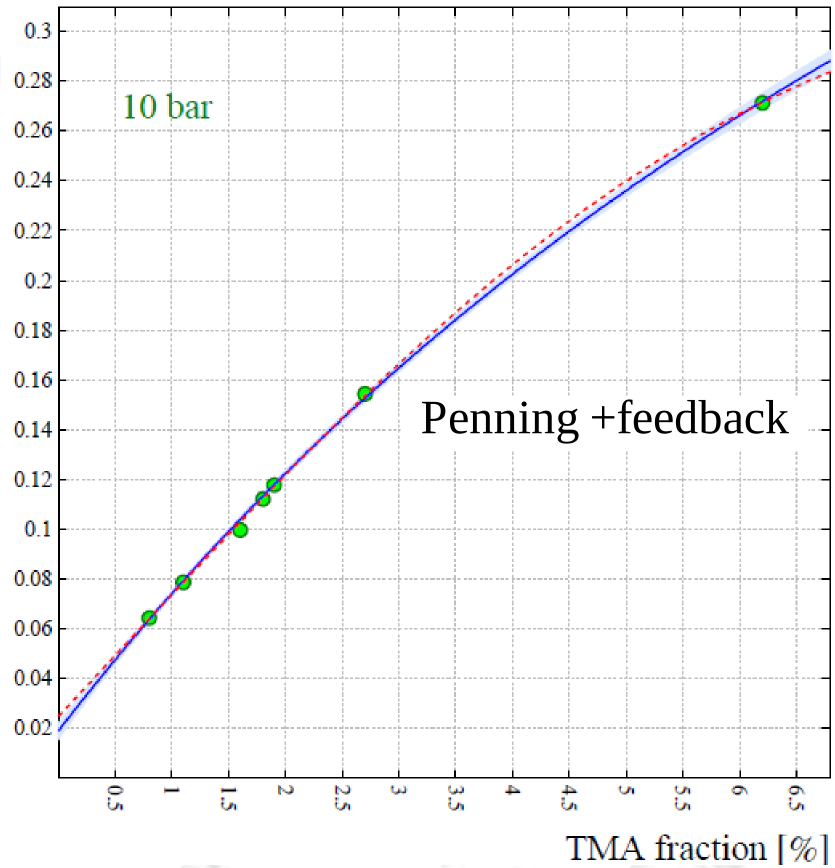
Parameters are physical

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

Non physical results **!!!**

Fits at 10 bar





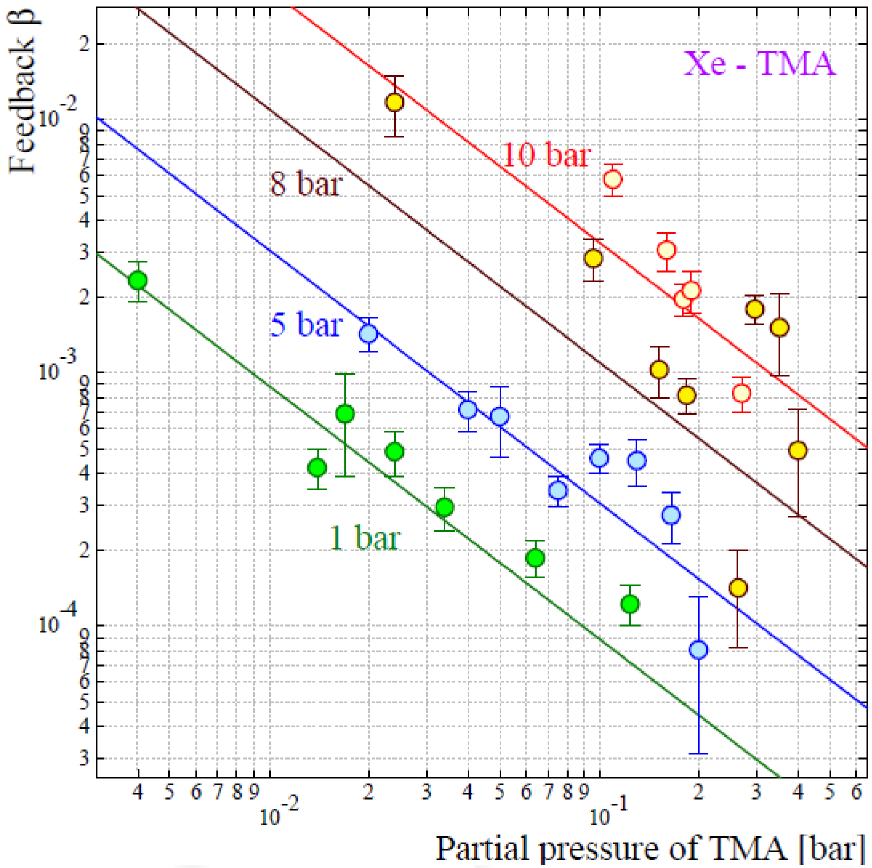
$$r(c) = \frac{a_1 c + a_3}{c + a_2}$$

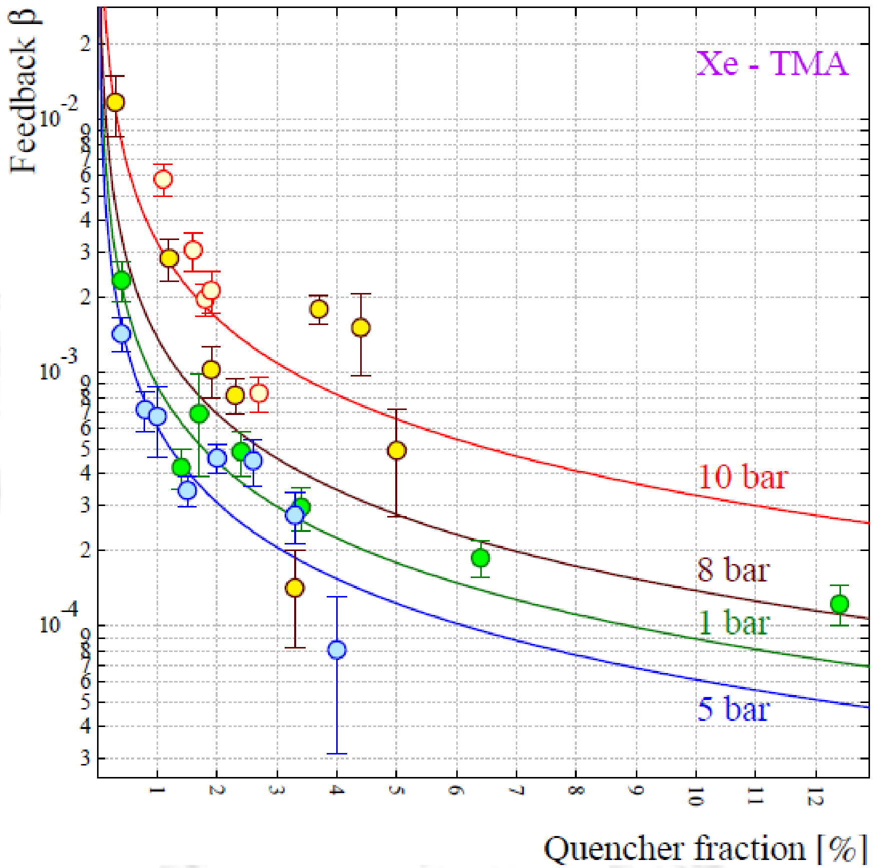
Parameters are physical

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

Non physical results **!!!**

Feed – back parameters





- Fitted by $\boldsymbol{\beta / p_{gas}}$
  - p_{gas}: partial pressure of TMA
- Fitted by $\boldsymbol{\beta / f_q}$
  - f_q: concentration of TMA

NEXT

- ❖ Decrease on transfer rates at 1 bar
- ❖ Interpretations of the transfer fit parameters
- ❖ Feedback due to ions ???
- ❖ Reachable gain maximums
- ❖ Continue to the survey with 25 μm MMs measured gain curves when they are ready

Many thanks to Diego and his group for sharing their recently measured data

Thanks and ??????