Summary WG4: Calculations

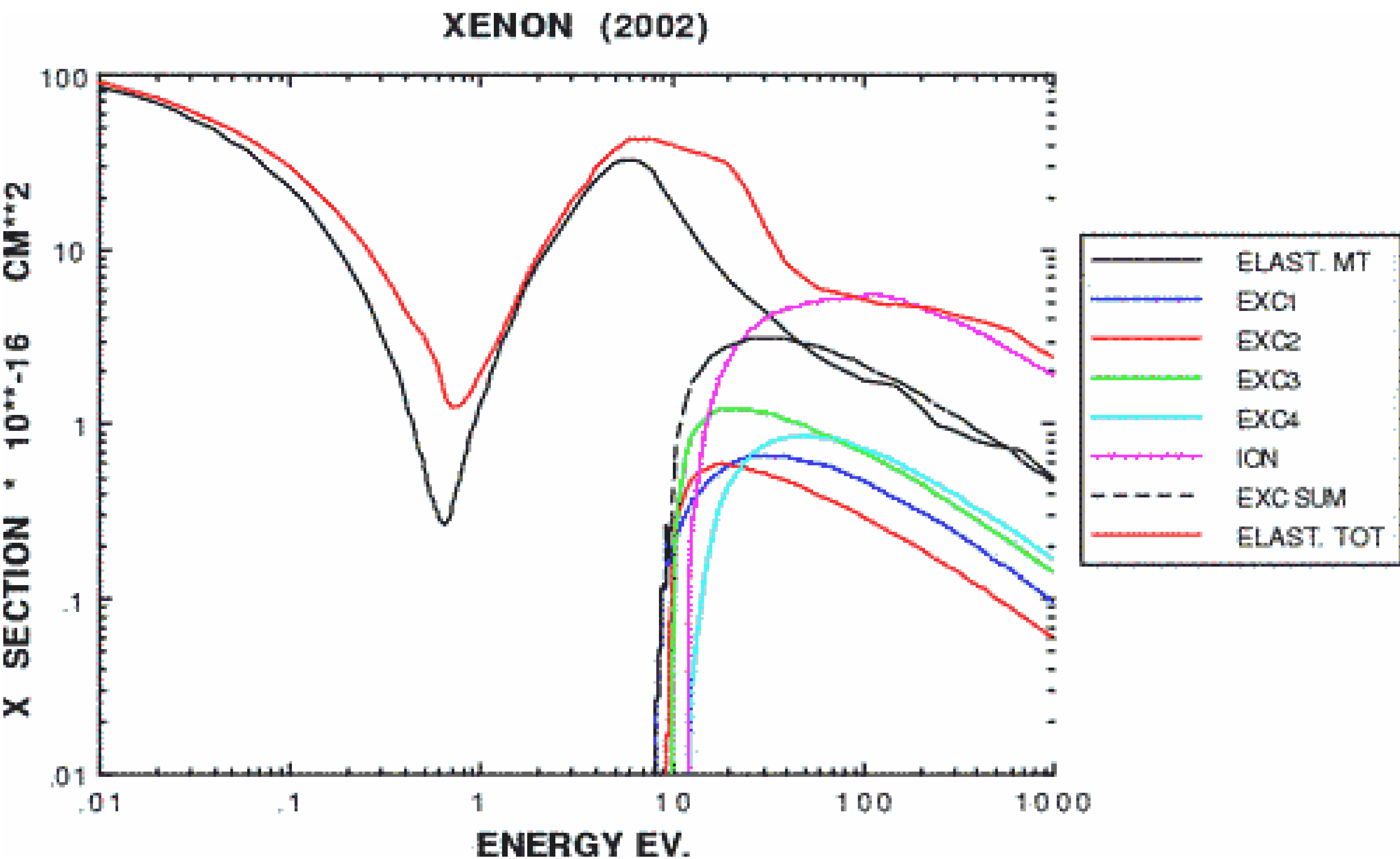
- Presentations:
  - Steve Biagi
  - Carlos Bastos de Oliveira
  - Özkan Şahin
  - Ilhan Tapan
  - Wilco Koppert
  - Heinrich Schindler
  - Kostas Nikolopoulos

Magboltz

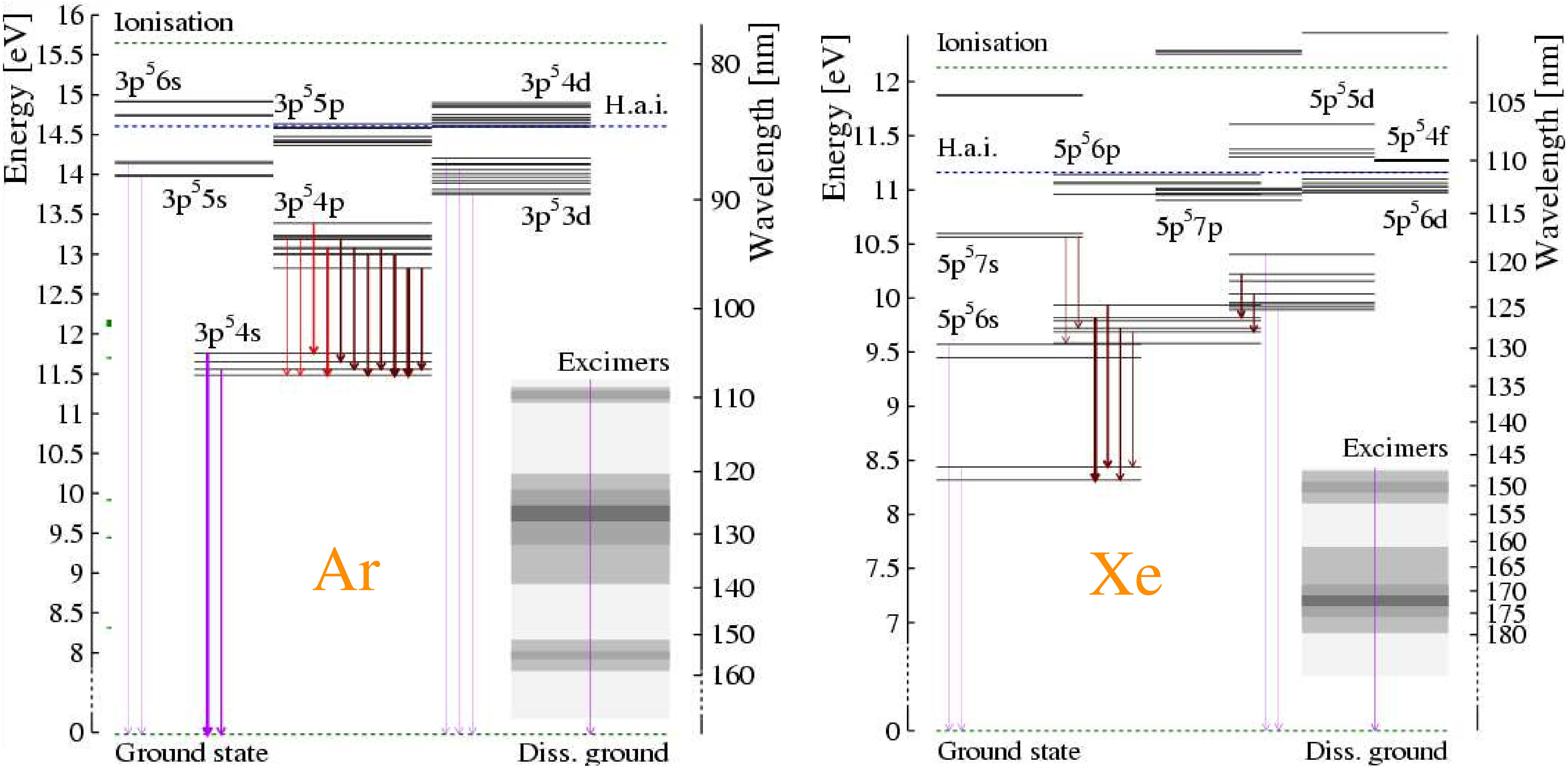
- Magboltz updates:
  - Cross section upgrade:
    - anisotropic cross sections for many gases,
    - enormous refinement of the excitation levels.

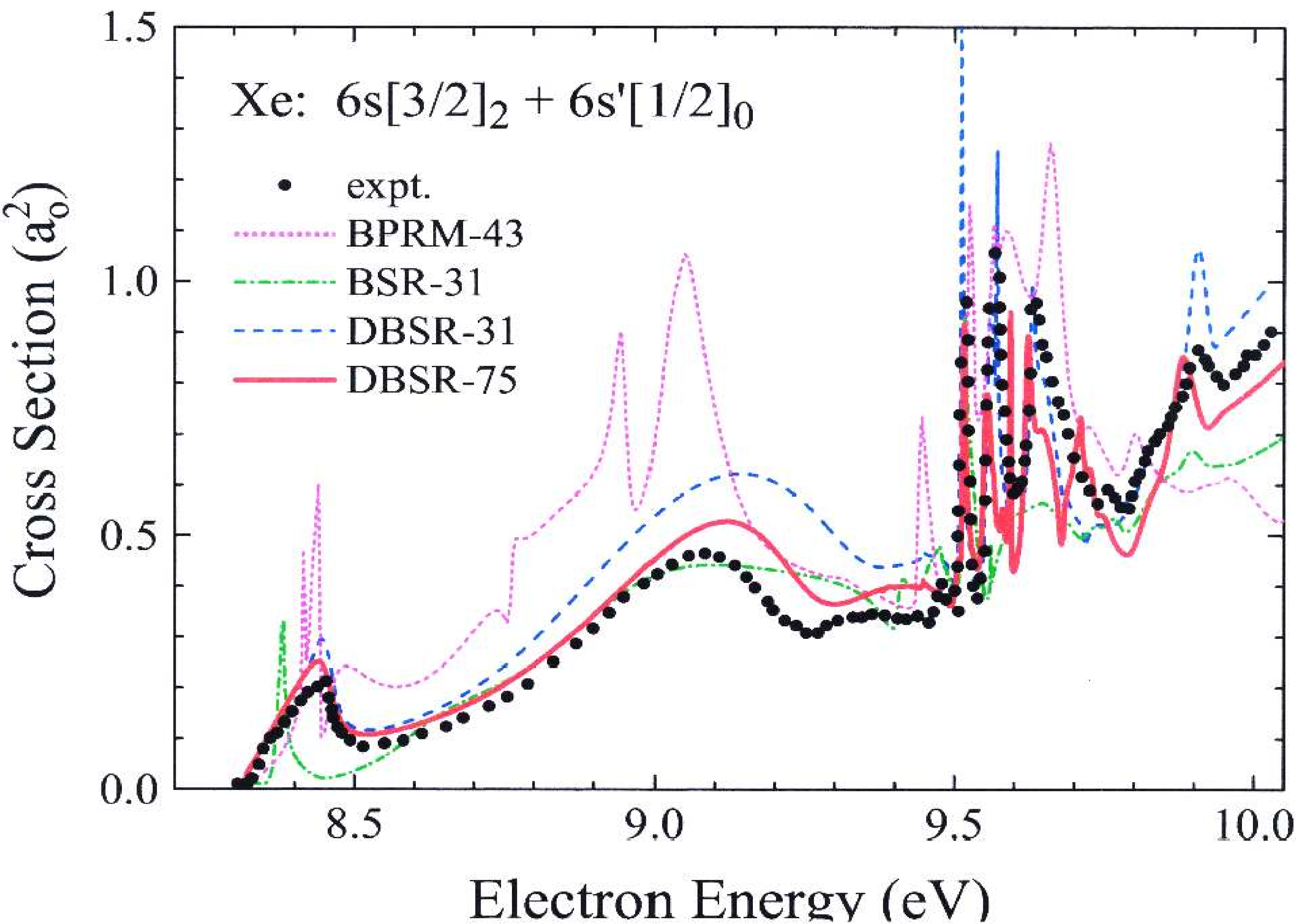
  - Light emission (excimers);

  - Mip program:
    - cluster size,
    - Fano factors,
    - size of x-ray cloud.


XENON (2002)
X SECTION * 10**-16 CM**2
ENERGY EV.
100
10
1
.1
.01
.01
.1
1
10
100
1000
ELAST. MT
EXC1
EXC2
EXC3
EXC4
ION
EXC SUM
ELAST. TOT

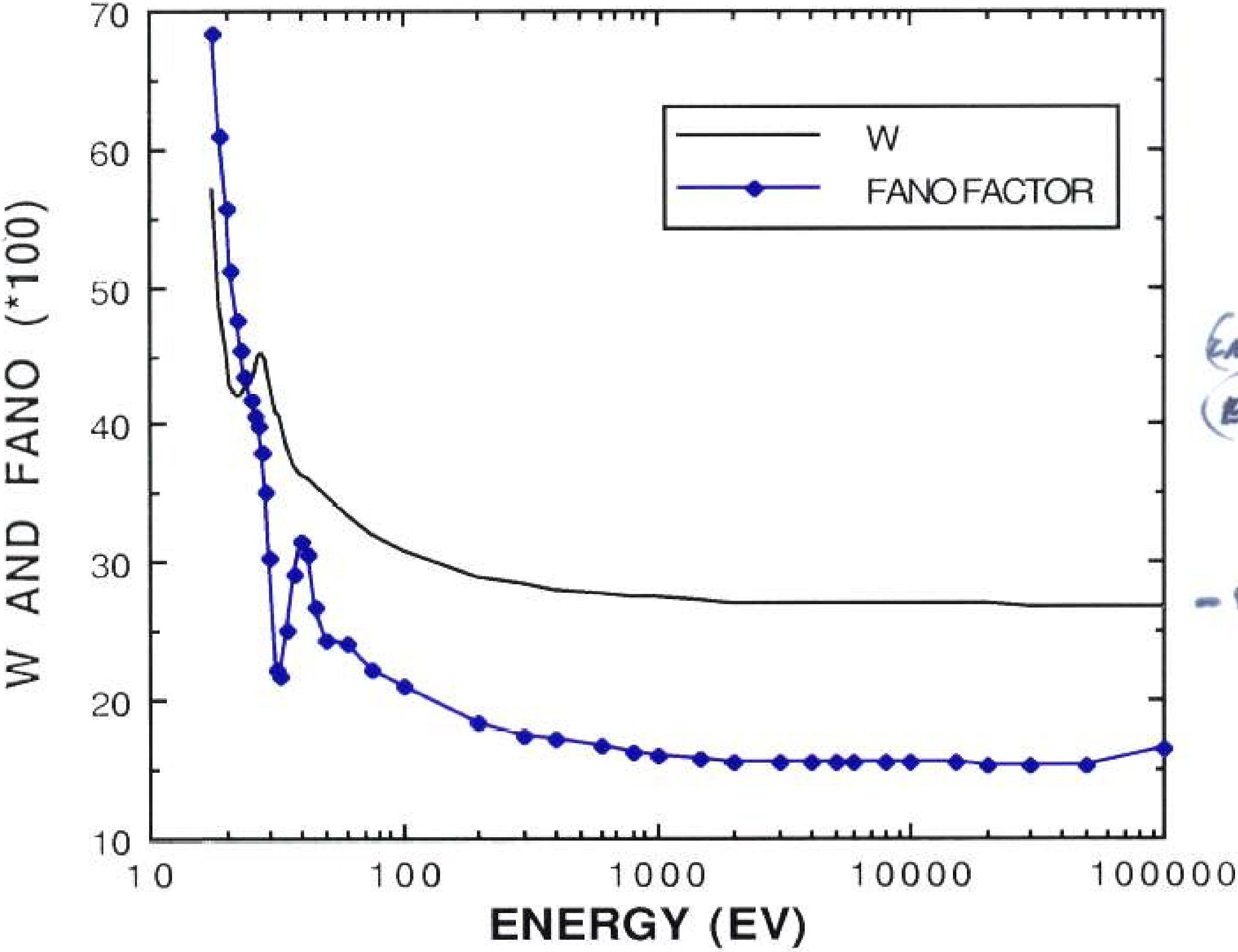
Excitation and Ionisation levels





Xe: $6s[3/2]_2 + 6s'[1/2]_0$
expt.
BPRM-43
BSR-31
DBSR-31
DBSR-75
Cross Section (a_o^2)
Electron Energy (eV)
0.0
0.5
1.0
1.5
8.5
9.0
9.5
10.0

FANO FACTOR AND EV/ION PAIR IN ARGON



(CALC) F_B = 0.17
(EXP) F_1 = 0.18(1)

– W = 26.8 eV = F_0

W_{exp} = 26.4 eV.

$AR^* + AR \rightarrow AR_2^+ + e^-$

~1–2%
AT
760 TORR

A request ...

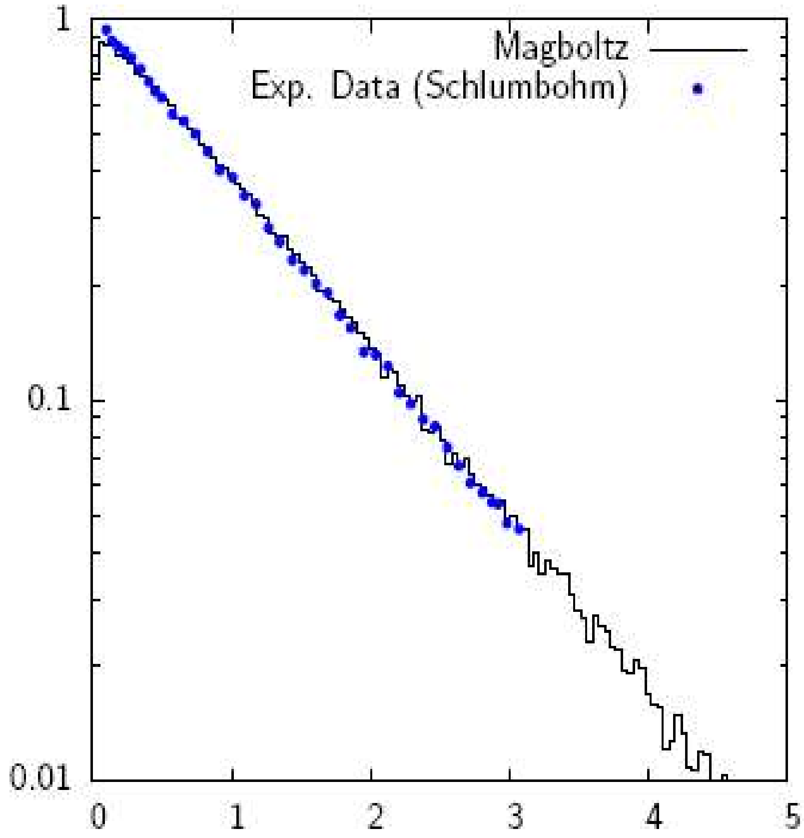
- Would someone repeat the measurement of F. Rieke and W. Prepejchal with modern electronics, please !
  [Phys. Rev. A **6** (1972) 1507-1519]

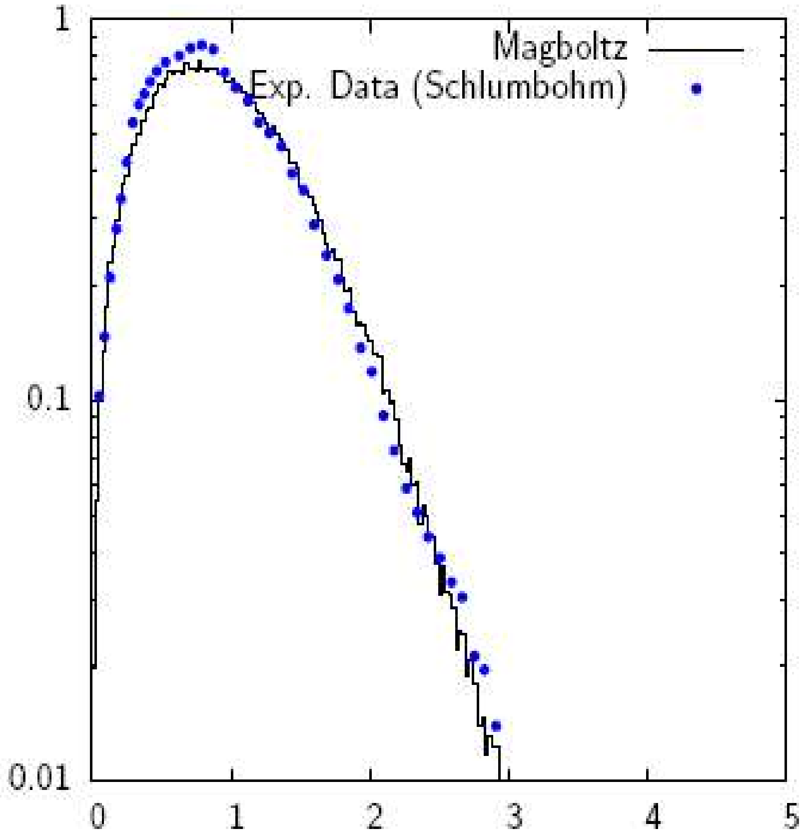
- This is one of the most important papers in atomic physics as well as having great importance for understanding chamber performance.

Calculation of ionisation with Garfield

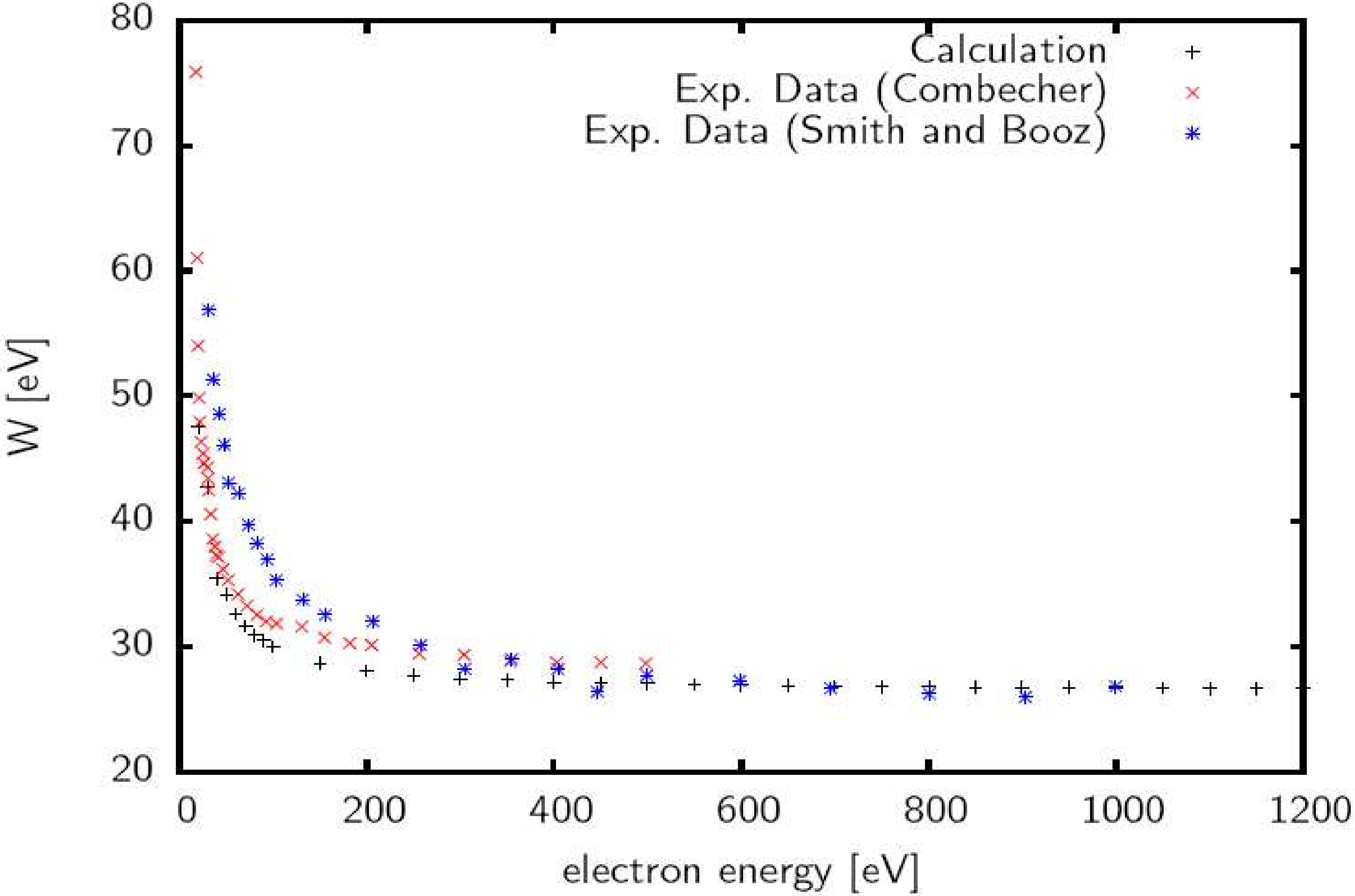
- Energy loss by primary charged particle
  - PAI model (e.g. Heed)
  - SRIM/TRIM
  - MIP
- Emission of δ-electron and atomic relaxation
- Transport of δ electron(s)
  - Heed algorithm (phenomenological)
  - Microscopic tracking
- Amplification of ionisation
  - Townsend coefficient $\alpha(E)$
  - Microscopic tracking

Avalanche size distribution



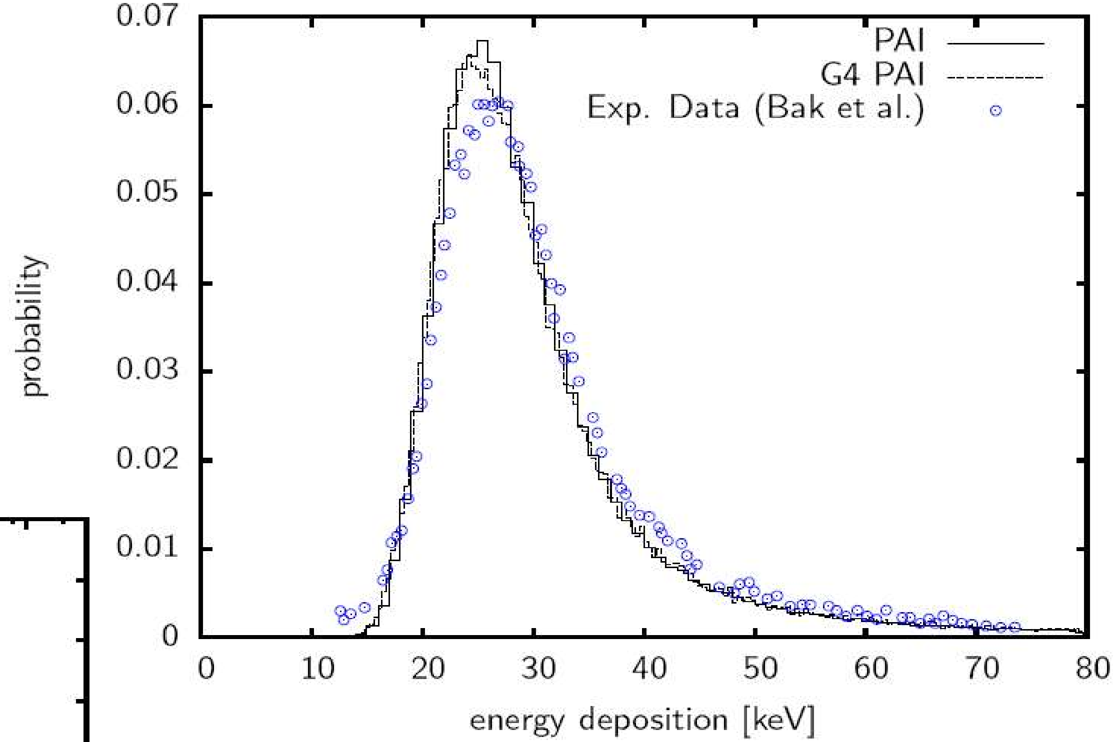


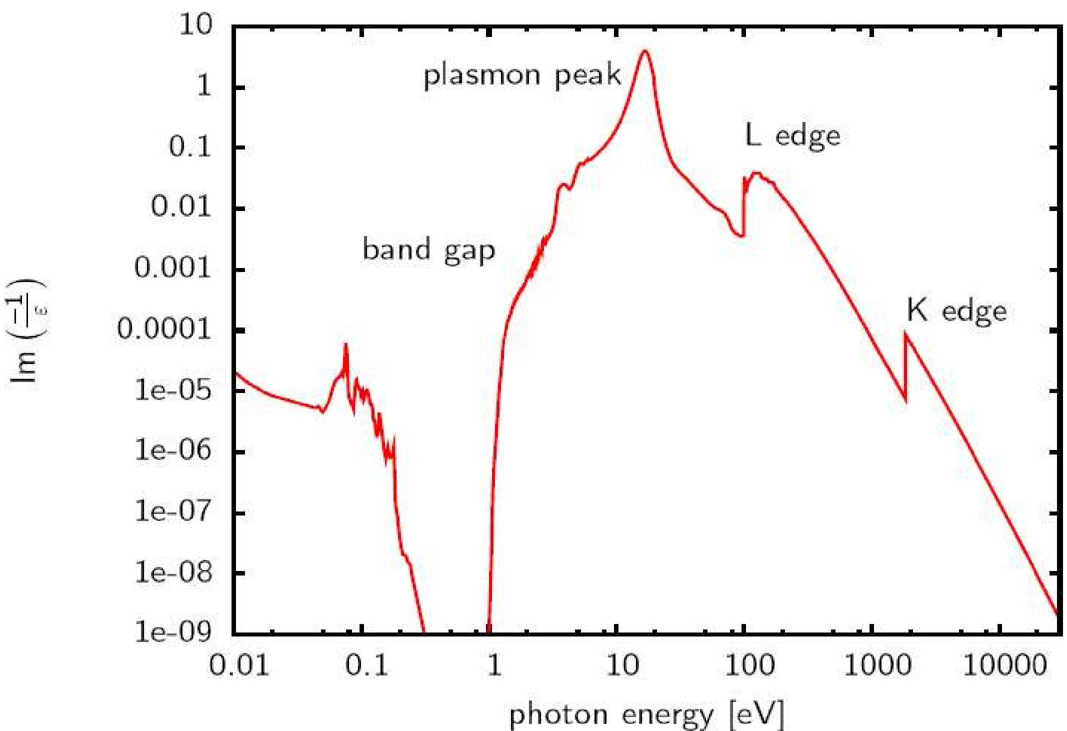
W value for argon



PAI model for silicon !

- 100 μm, 2 GeV π





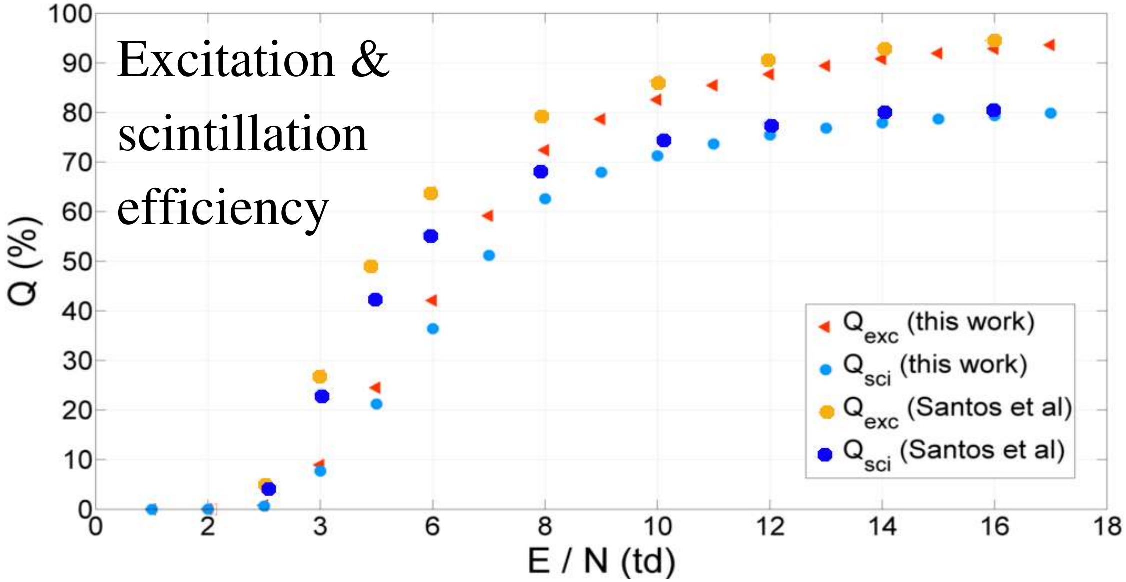
Xe electroluminescence

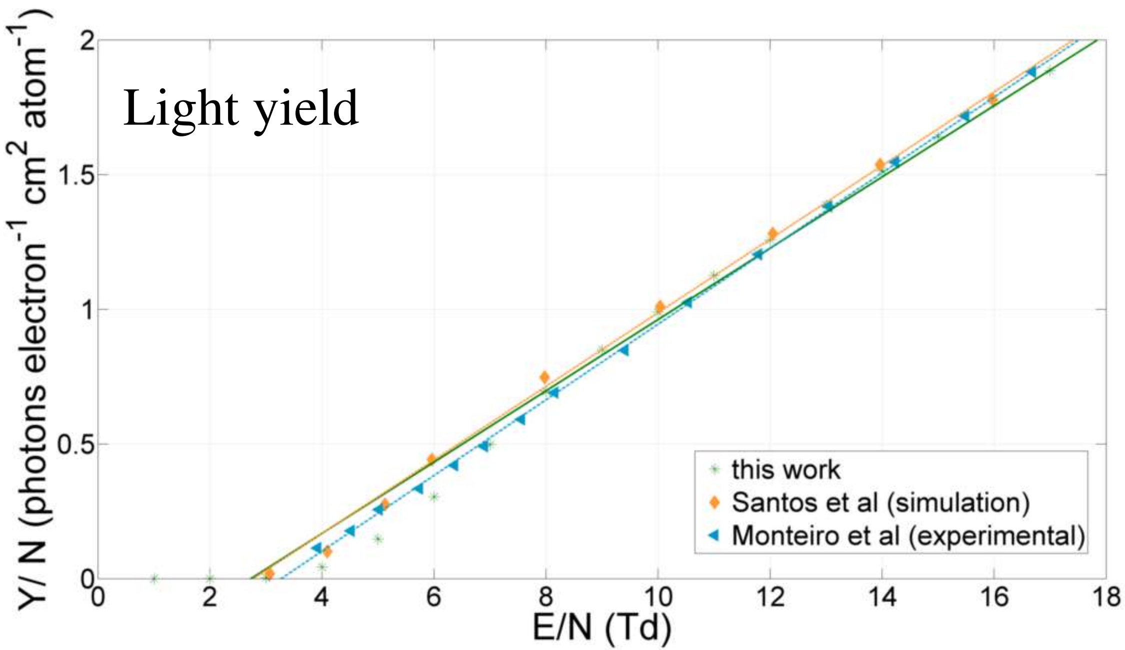
- Study of light emission in avalanches in pure xenon.

- Two principal light sources:
  - low pressure: atomic decays (3*s* states: 130 & 147 nm),
  - high pressure: excimers (1st continuum at low pressure, 2nd continuum at high pressure: 147 & 172 nm).

- Taking advantage of both electrons and photons.

Validation in a uniform field

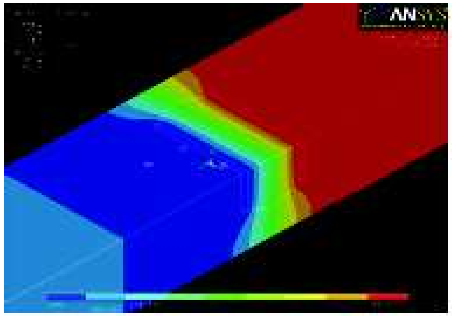


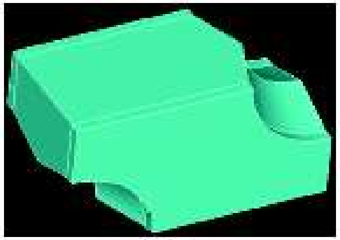


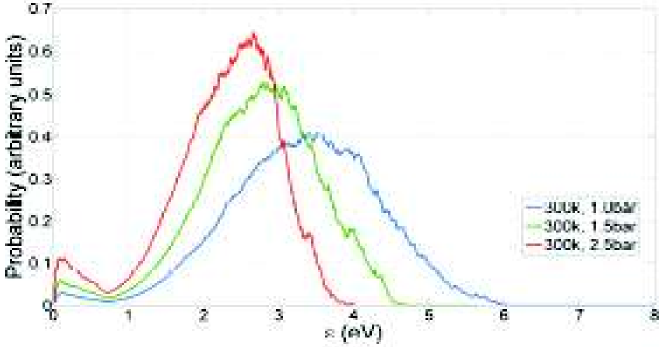
F P Santos et al.
J. Phys. D 27 (1994) 42-48
10.1088/0022-3727/27/1/007

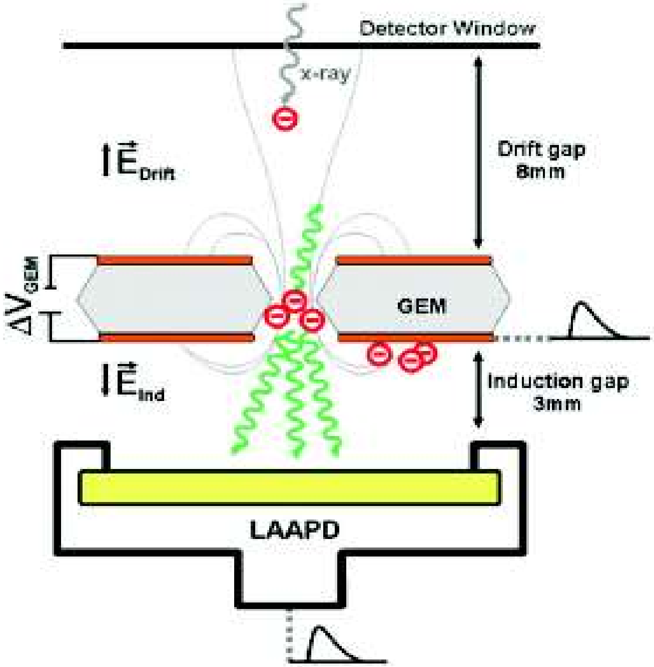
C.M.B. Monteiro et al.
2007 JINST 2 P05001

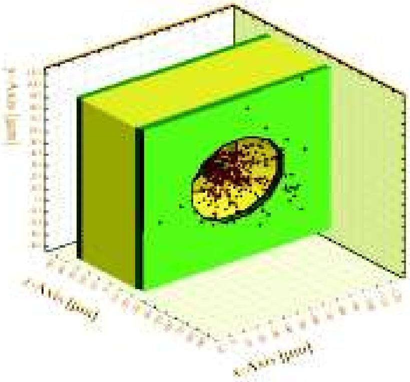
Applied to a GEM









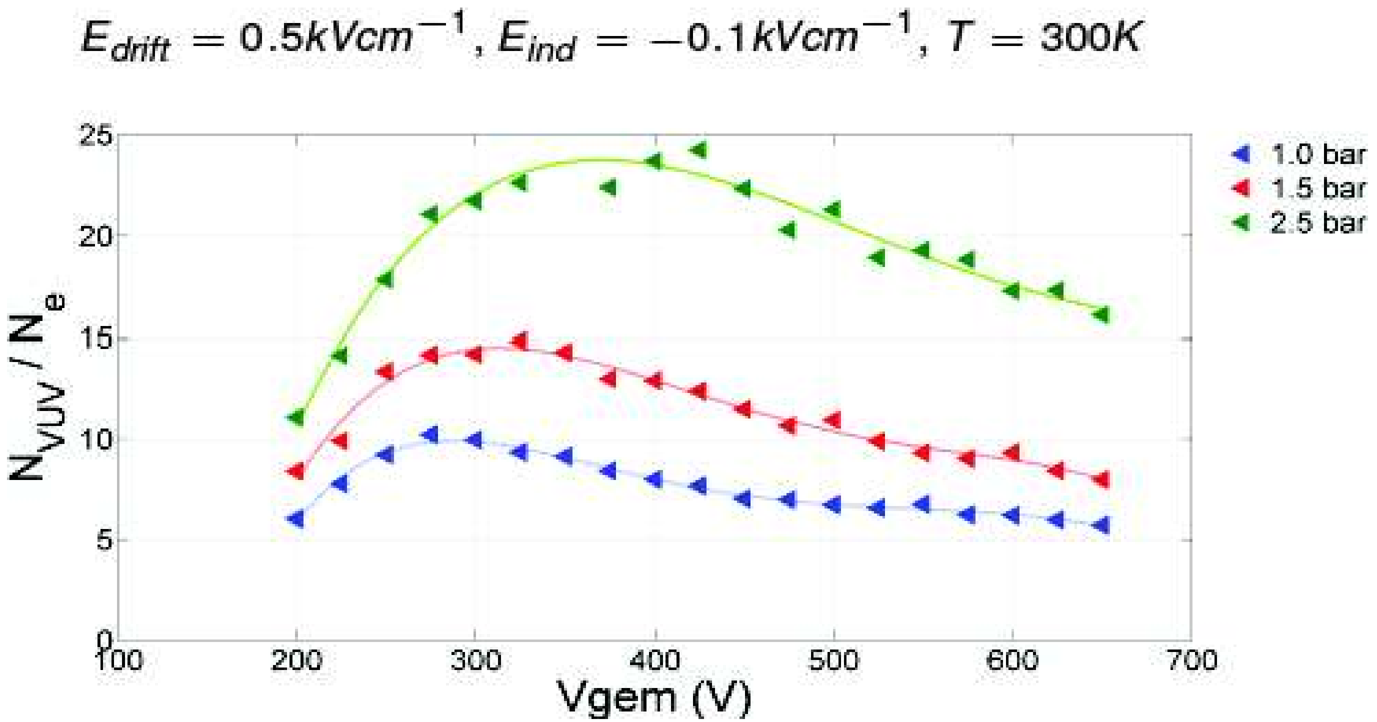


Monteiro et al, PLB677 (2009) 133

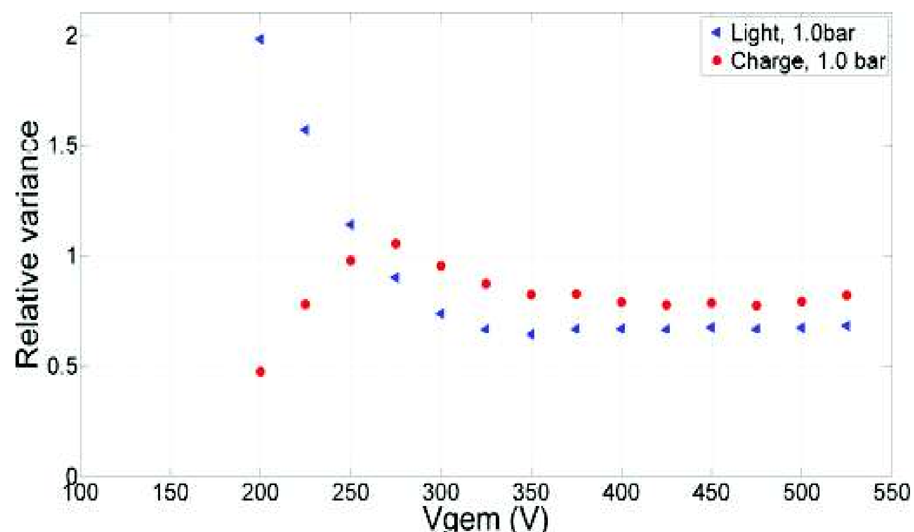
- Ansys 11 field maps
- $z_{start} = 250\mu m$
- random (x, y)
- random ε_{start} (Magboltz)

Electrons and Photons

- Photons far outnumber electrons.



- At normal gain, fluctuations comparable.



Penning transfer mechanisms

- Usually, it is the noble gas A^* which is excited and the admixture B which is ionised via one of several processes:
  - dipole-dipole coupling: $A^* \to A\,\gamma,\quad \gamma\,B \to B^+\,\mathrm{e}^-$
  - e^- exchange (“Auger”): $A^*\,B \to A^{*-}\,B^+,\quad A^{*-} \to A\,\mathrm{e}^-$
  - associative ionisation: $A^*\,A \to A^+_2\,\mathrm{e}^-$
  - excimers in some gases
- A^* can undergo natural decay. In case of radiative decay, the photon sometimes ionises.
- Each process has its characteristic time dependence (decay time, collision frequency) which translates into a partial pressure dependence.

Approach

- From gain curves, determine the Penning transfer rate r:

$$G = e^{\int \alpha \left(1 + r \frac{\sum \nu_{\text{exc}}}{\sum \nu_{\text{ion}}}\right)}$$

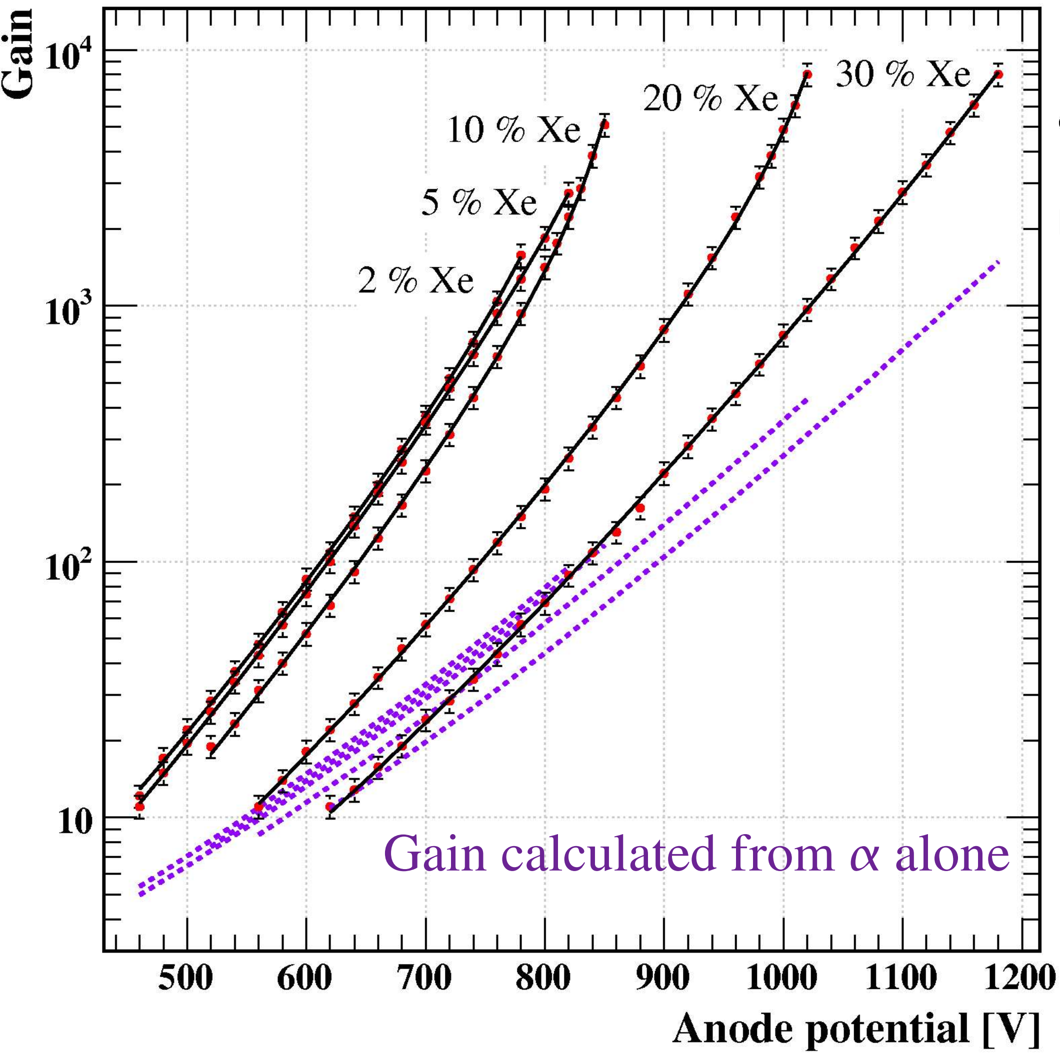
- From the transfer rates r as function of pressure p and concentration c, work out which mechanisms are at play:

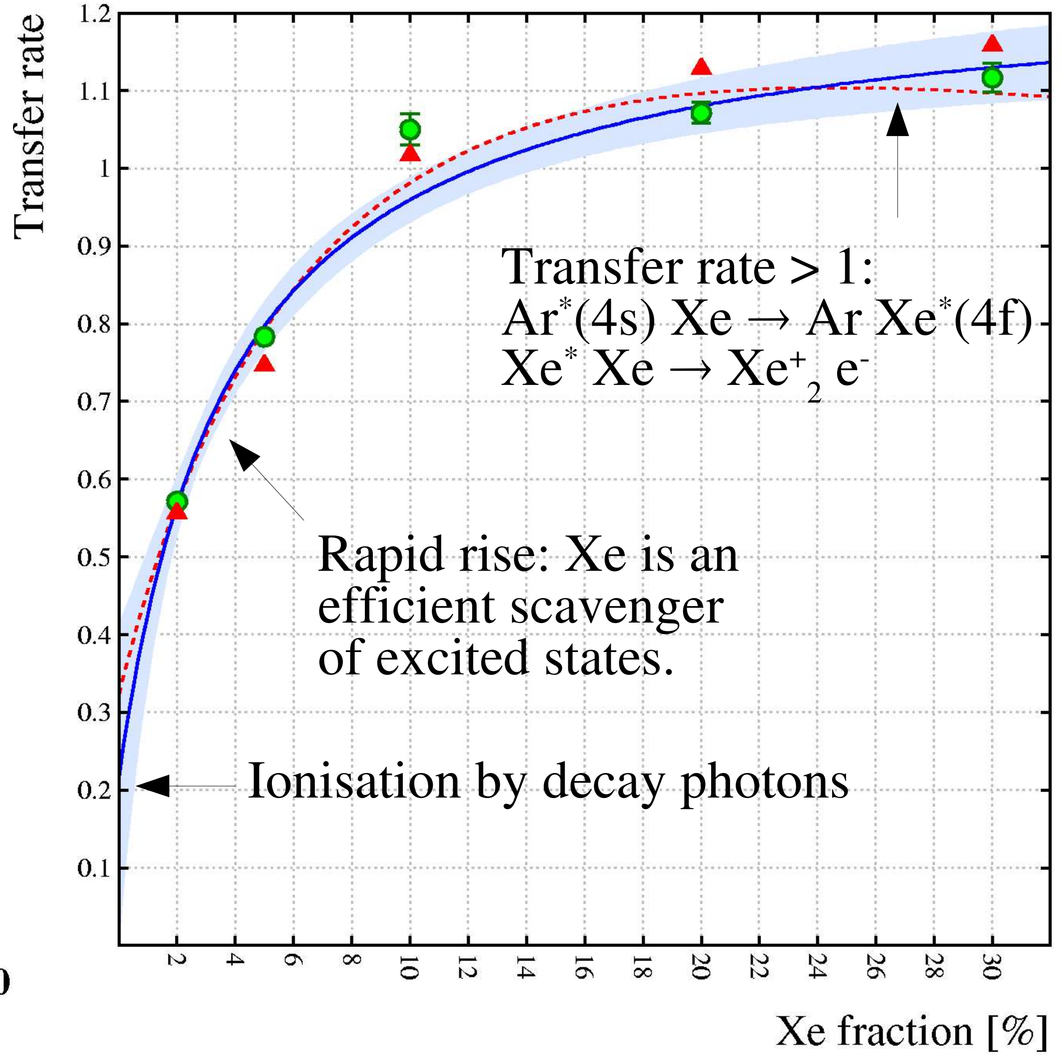
$$r = \frac{p\, c\, f_{B^+}/\tau_{AB} + p(1-c) f_{A^+}/\tau_{AA} + f_{\text{rad}}/\tau_{A^*}}{p\, c(f_{B^+} + f_{\bar{B}})/\tau_{AB} + p(1-c)(f_{A^+} + f_{\bar{A}})/\tau_{AA} + 1/\tau_{A^*}}$$

$$A^* \to B^+ \qquad A^* \to A^+ \qquad A^* \to A\,\gamma$$

Ar-Xe

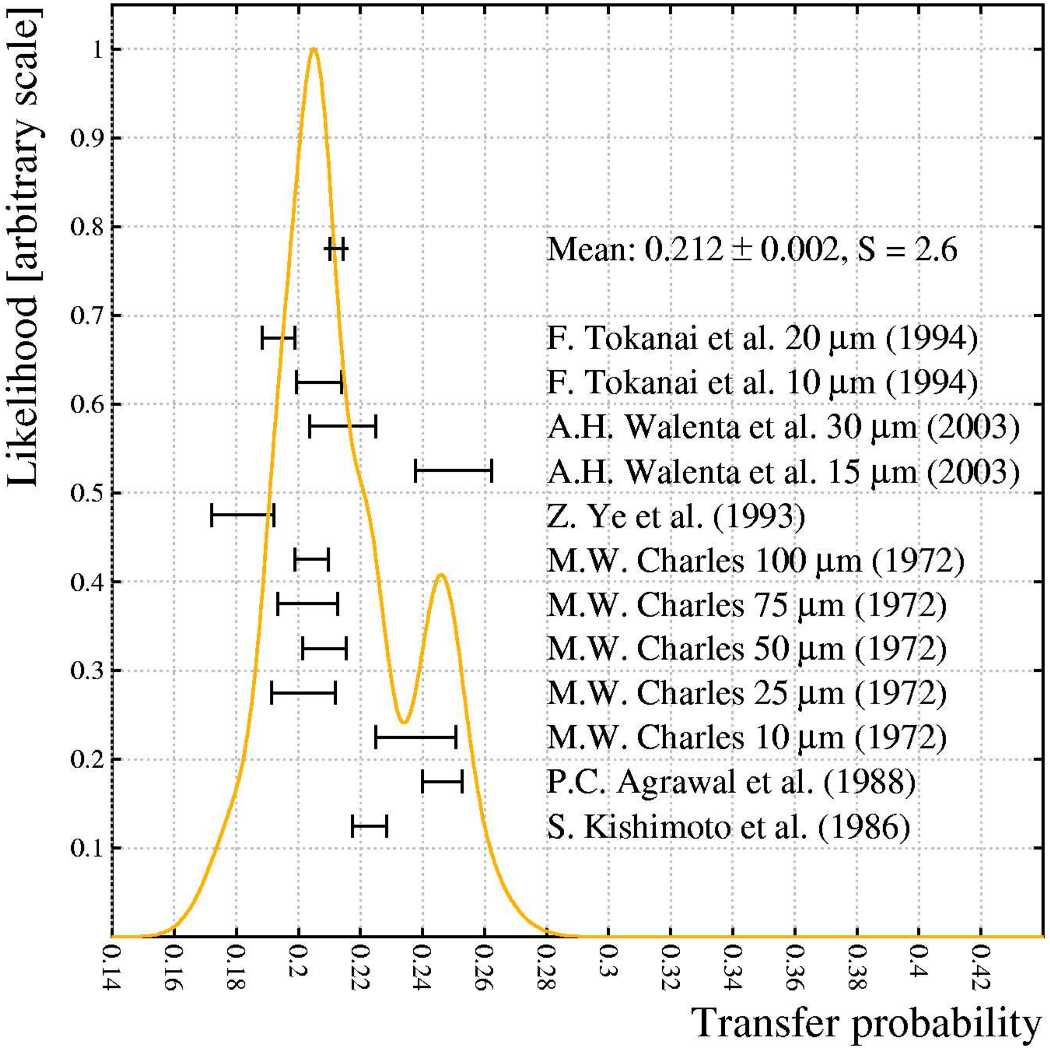
- Ar 4*p*, 3*d* and higher above the Xe ionisation threshold.

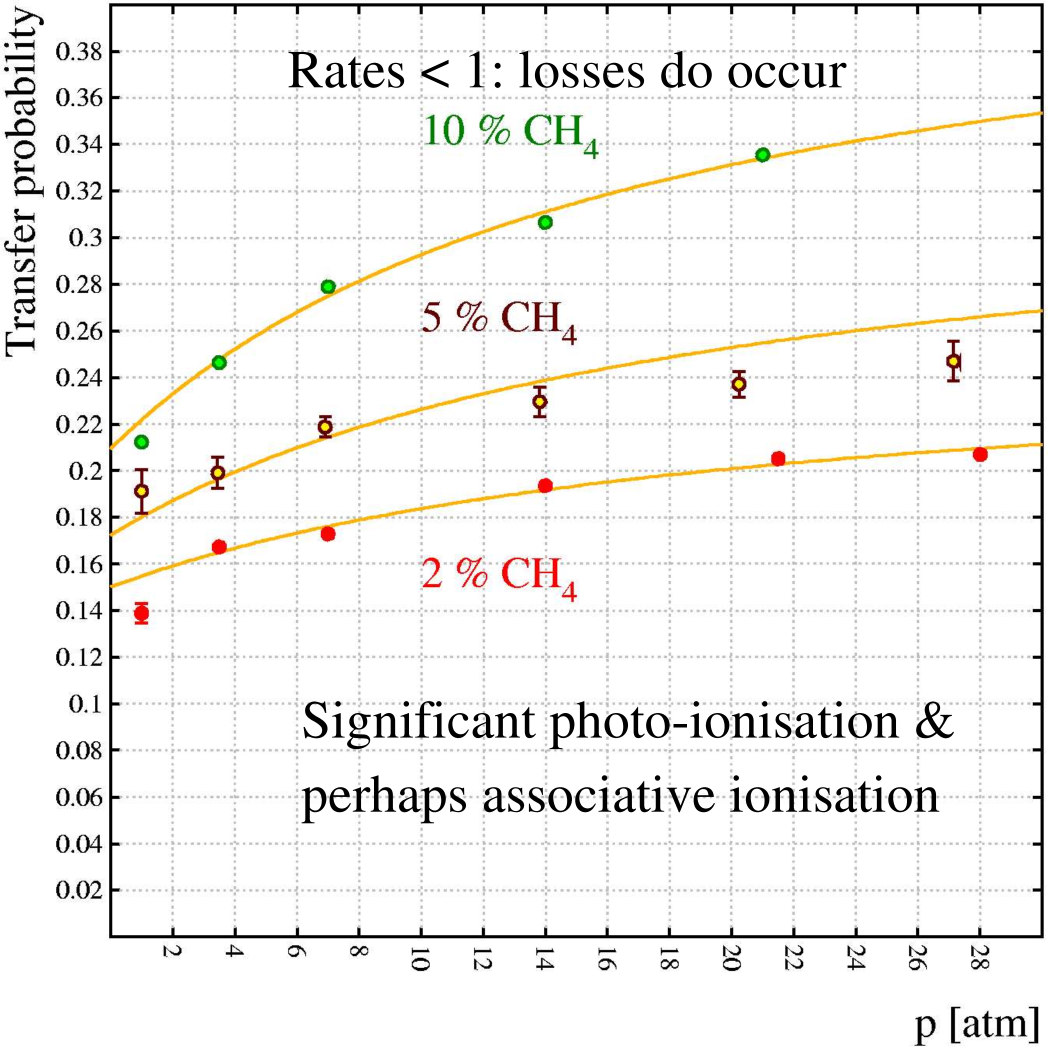




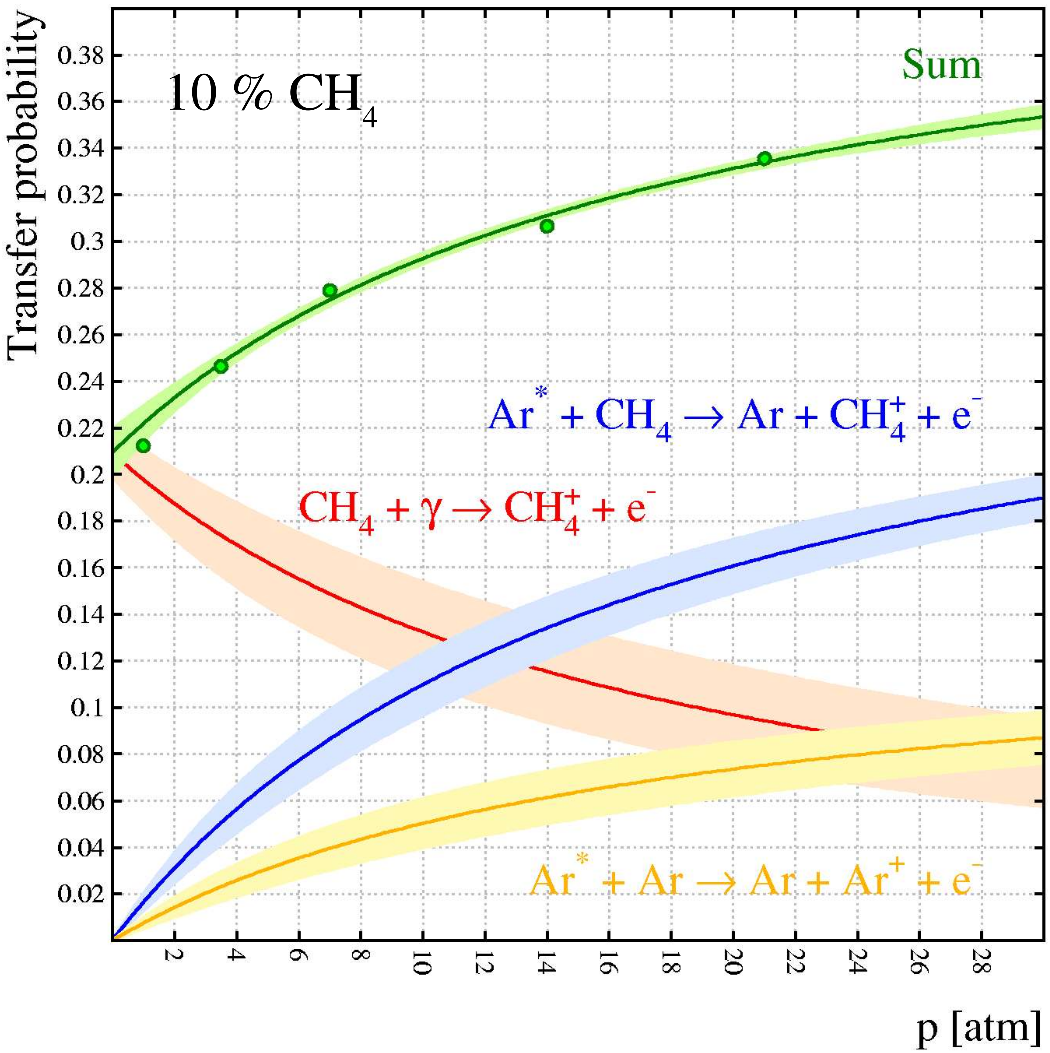
Ar-CH_4

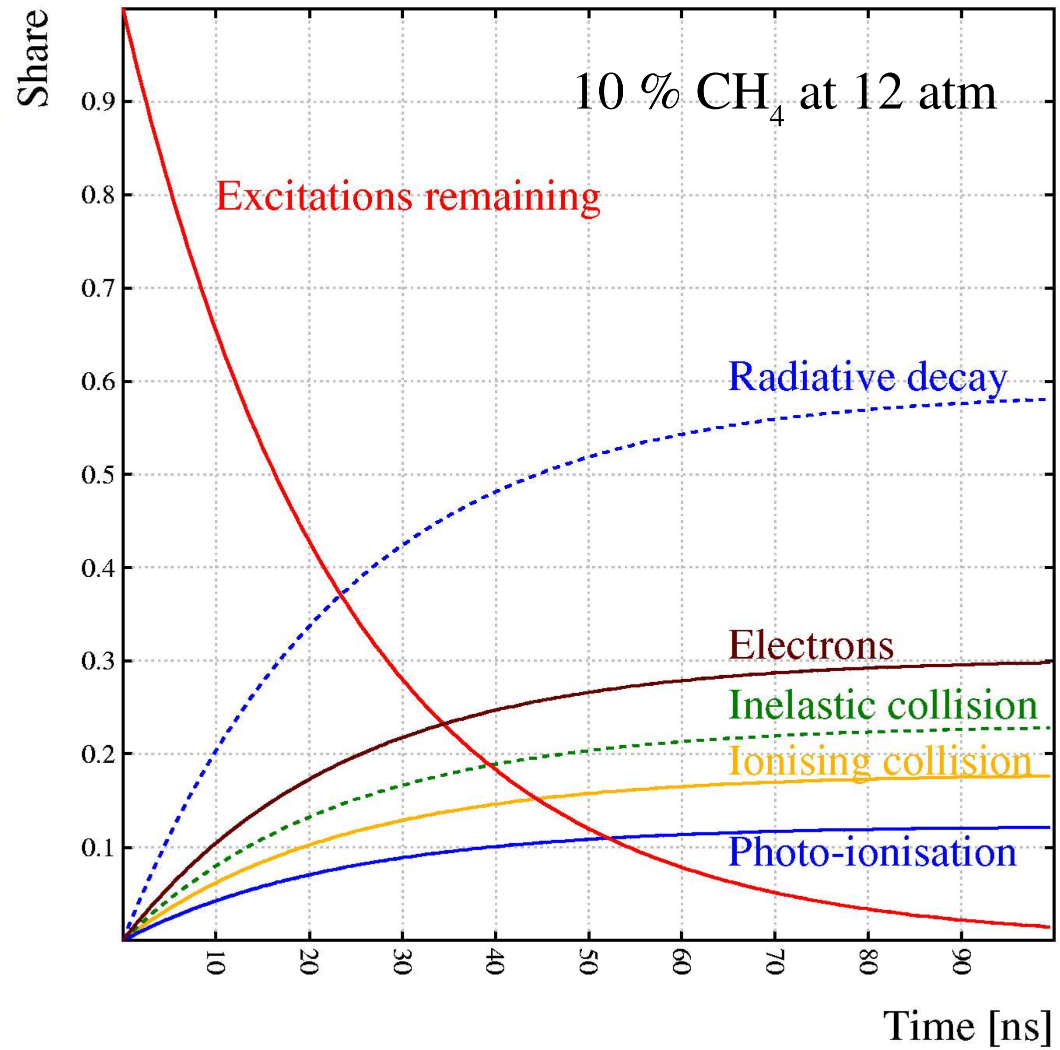
- Large numbers of gain curves available.





Ar-CH_4: processes and timing



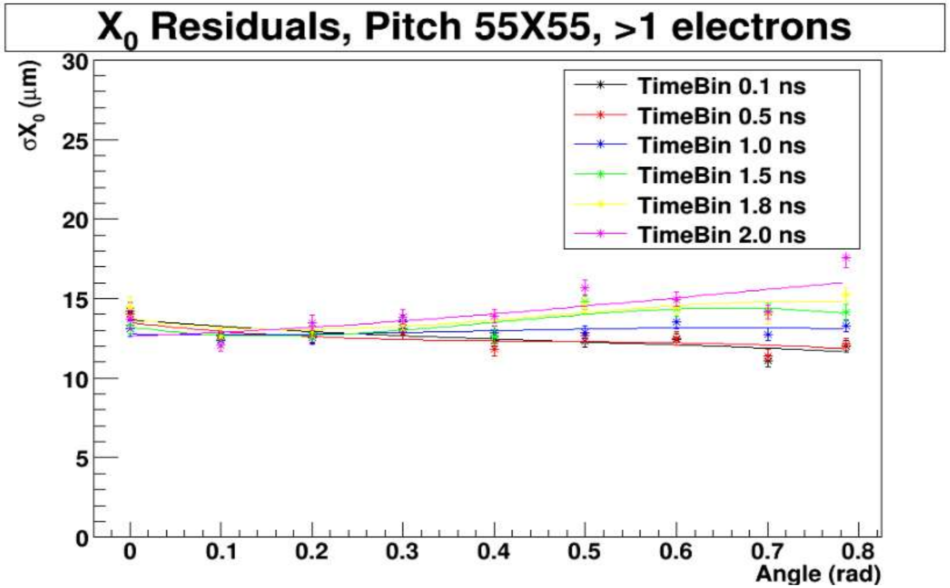


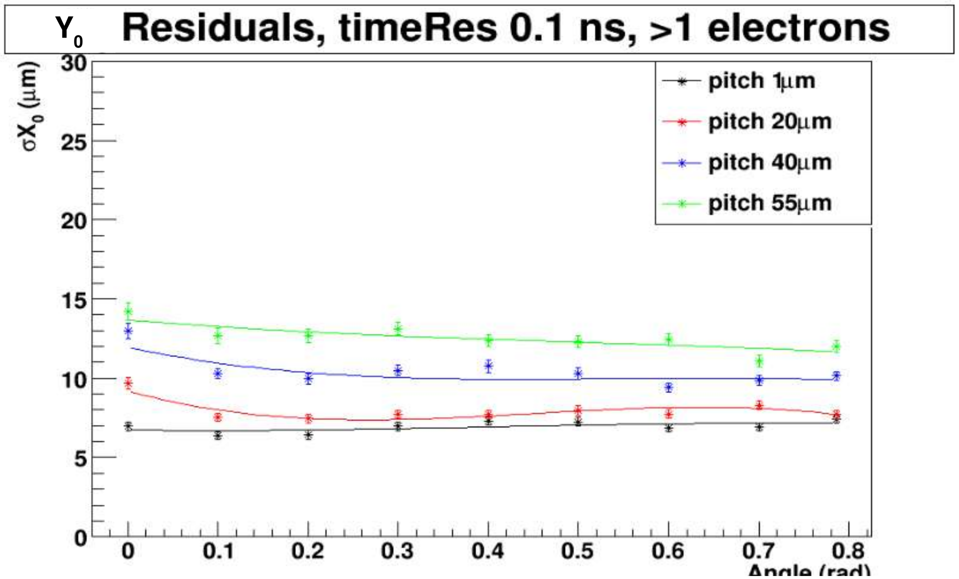
Penning: current status

- An amazing amount can be learned from gain curves. The chemistry of each mixture becomes visible.
- Unfortunately, gain curves for the most relevant gas mixtures for MPGDs are rare – these can and must be measured if an accurate Penning model is desired.
- Penning transfers can be modeled with only a few parameters and we should introduce this model in the microscopic tracking and avalanche procedures.

Gossip resolution: simulations

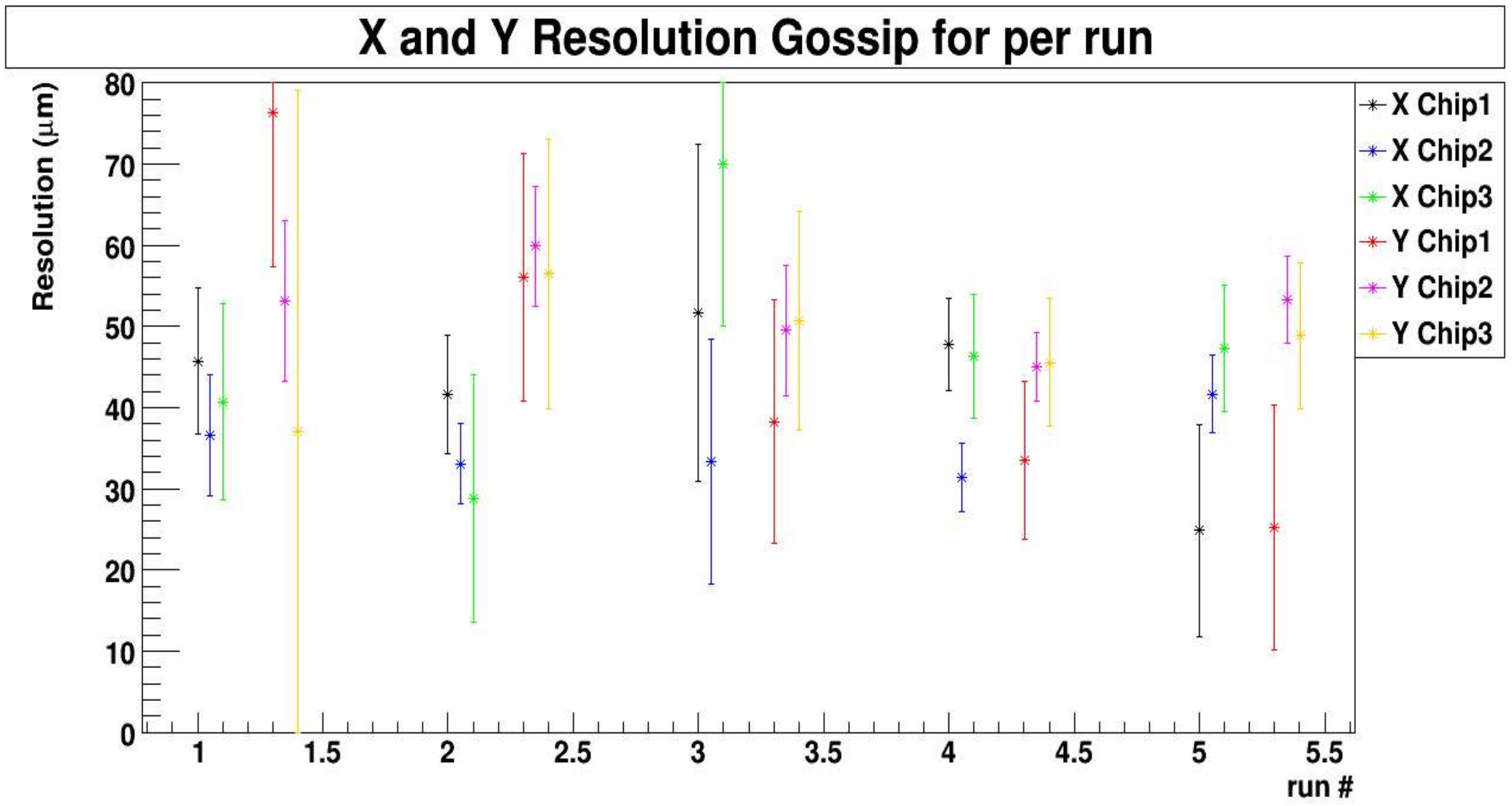
- Simulations for an ideal field, without MC avalanche.
- Calculated using CO_2 50 % DME 50 %.
- Resolutions quoted for plane of lowest σ.
- Current Gossip has a 55 μm pitch.





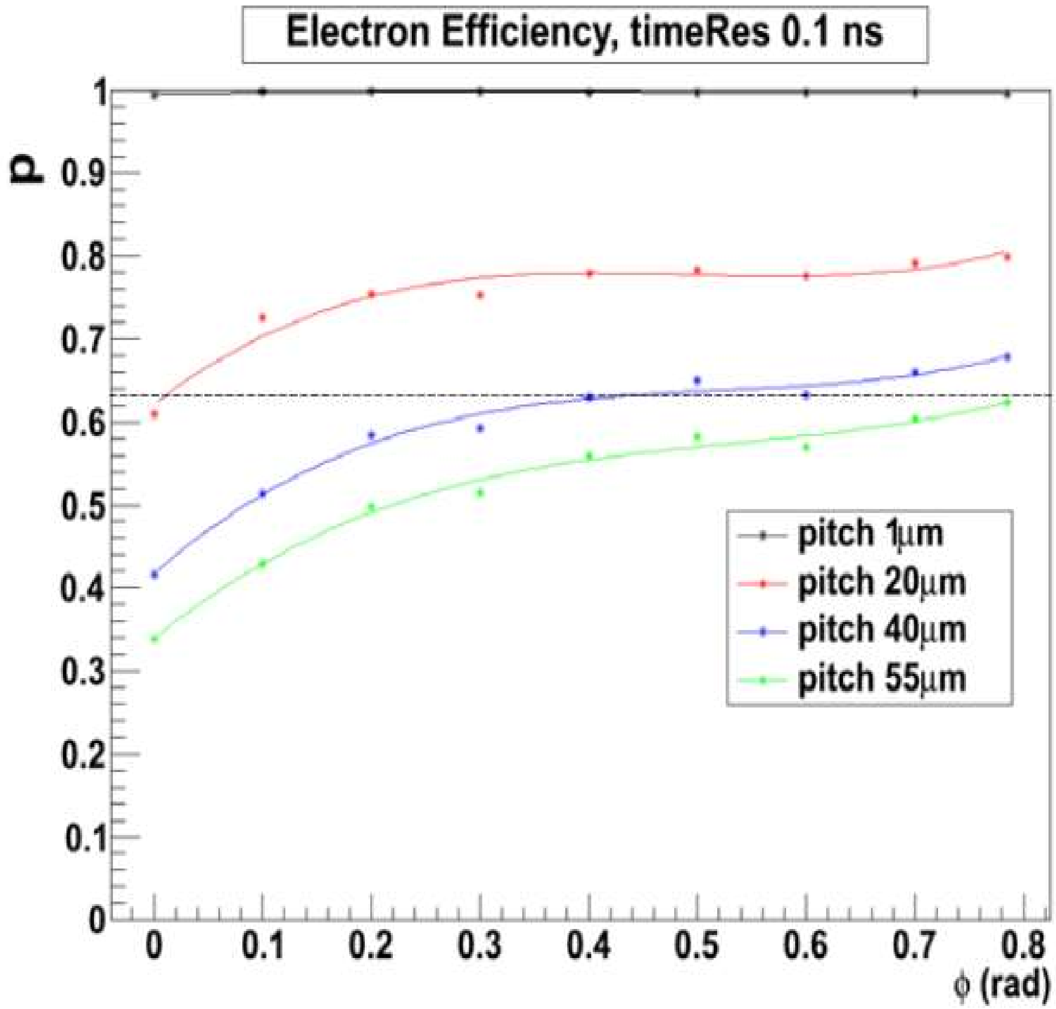
Gossip resolution: measurement

- Measurements with Ar 80 % iC_4H_{10} 20 %, which has 2.3 times larger transverse diffusion.



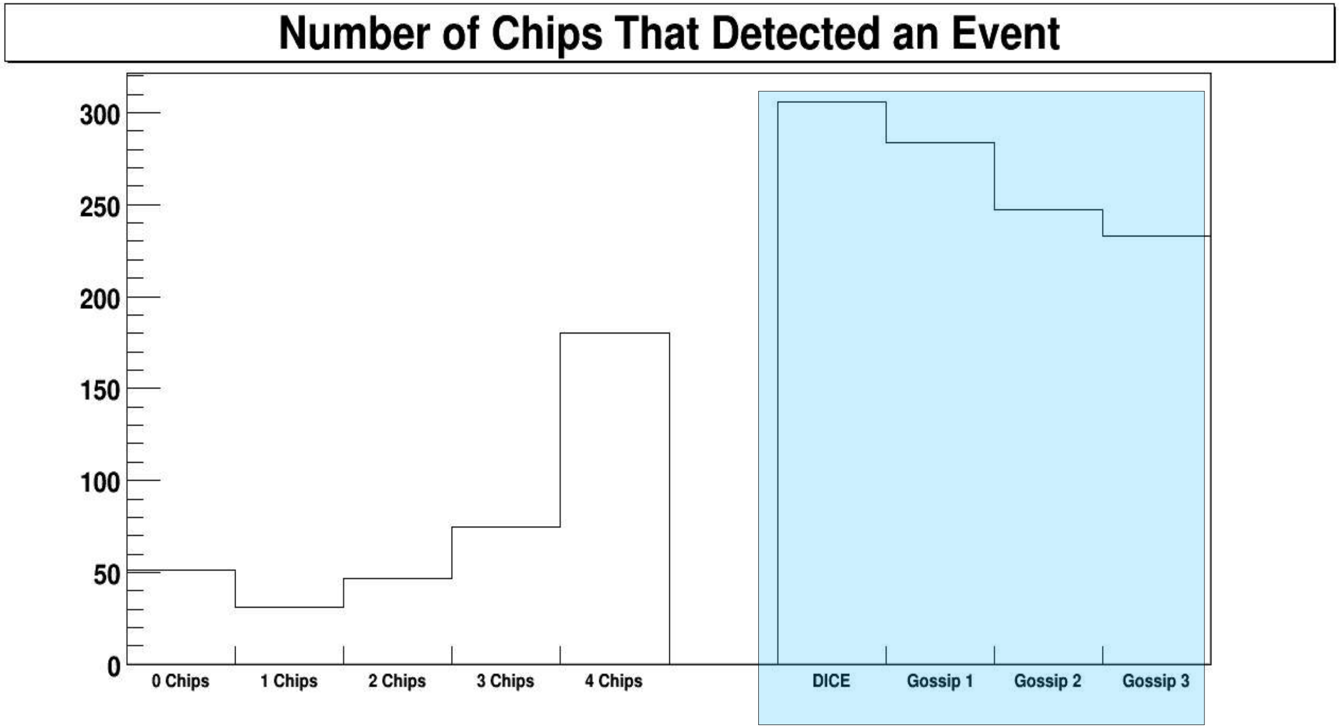
Gossip efficiency: simulation

- The expected amount of electrons per track is ~12.
- The electron efficiency is dominated by the amount of double hits, this effect is larger at larger pitches.
- For perpendicular tracks in the current Gossip (55 μm pitch), the electron efficiency is roughly 35 %.



Gossip efficiency: measurement

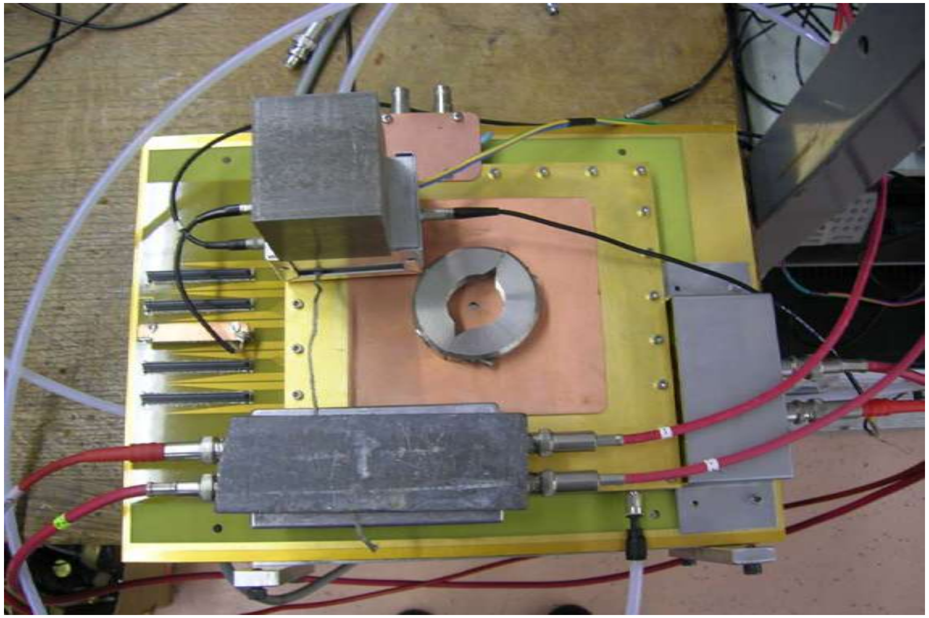
- Efficiency:
  - From 10000 events per run, only ~150 are usable: problems with trigger/data acquisition,
  - Gossip 1 is ~90 % so efficient as DICE



Micromegas mesh transparency

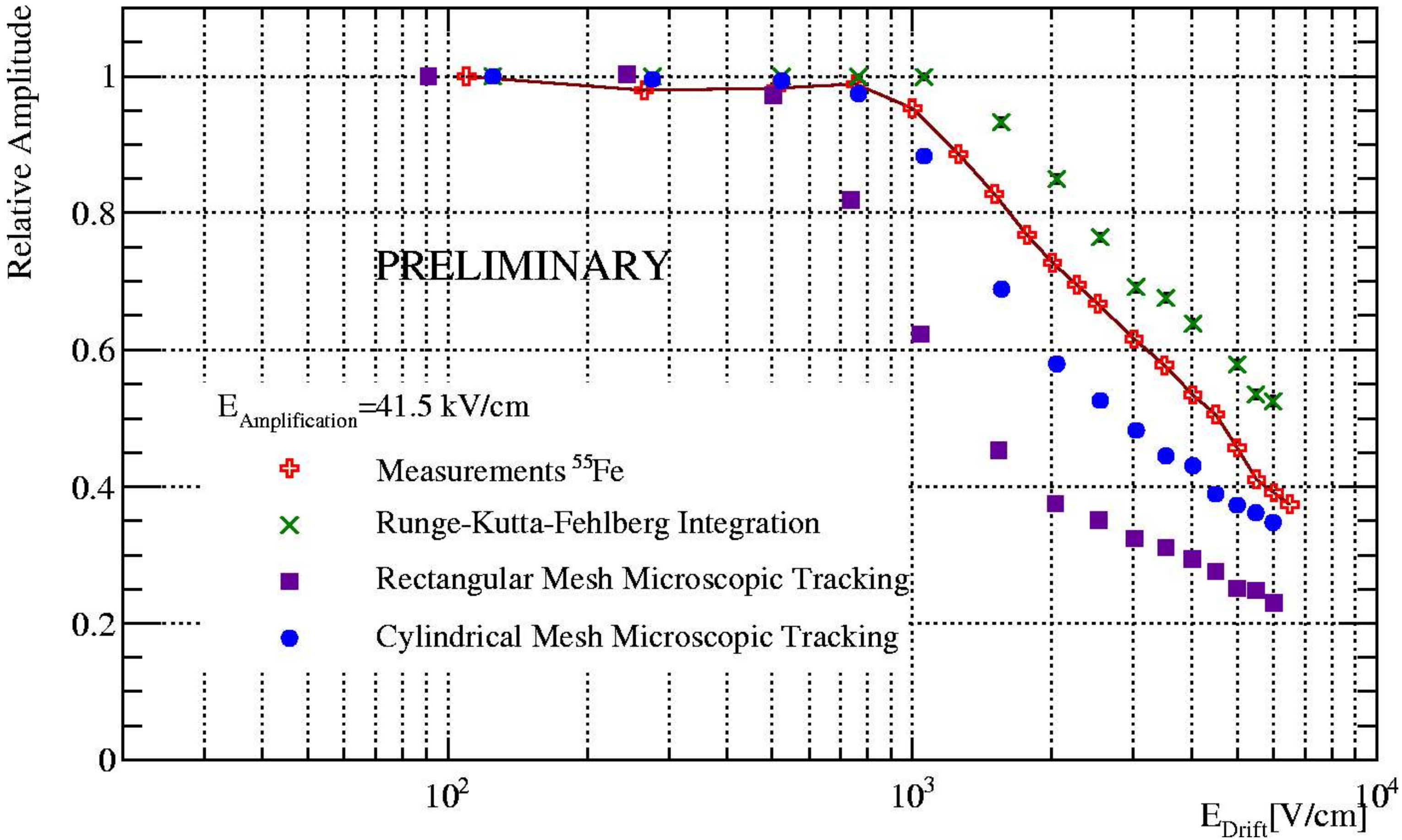
- Ansys models of a
  - square-wire mesh and
  - rounded wire mesh.
- Microscopic tracking compared with RKF (~ flux argument).

- Measurements:
  - ^{55}Fe and ^{241}Am sources,
  - long integration time,
  - strips summed.

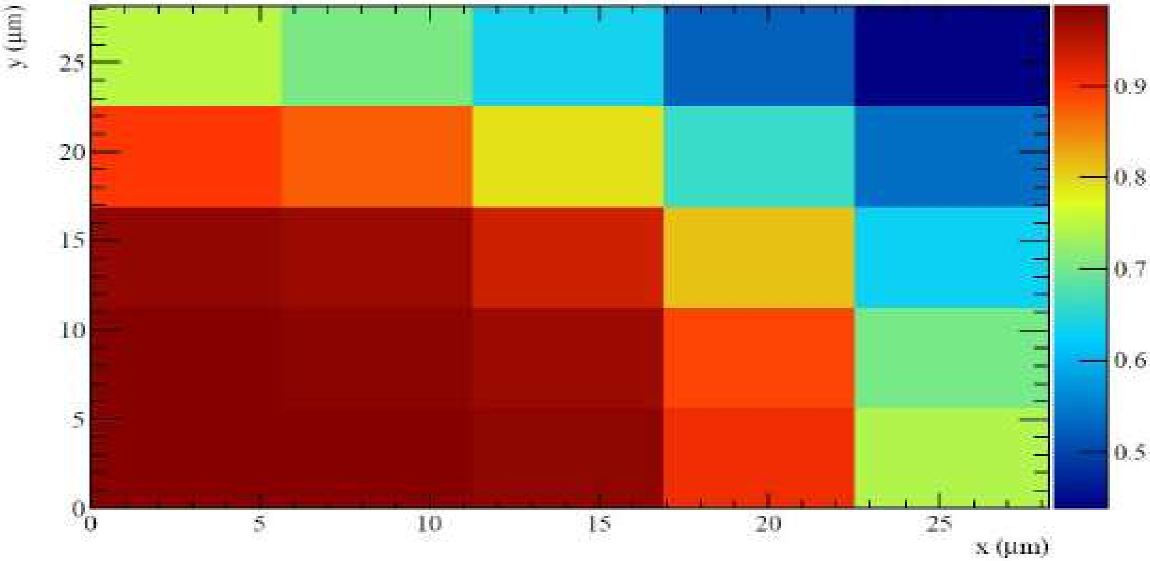


Mesh transparency for ^{55}Fe

- Square wires are a poor approximation.
- Round wires better – but far from perfect ...

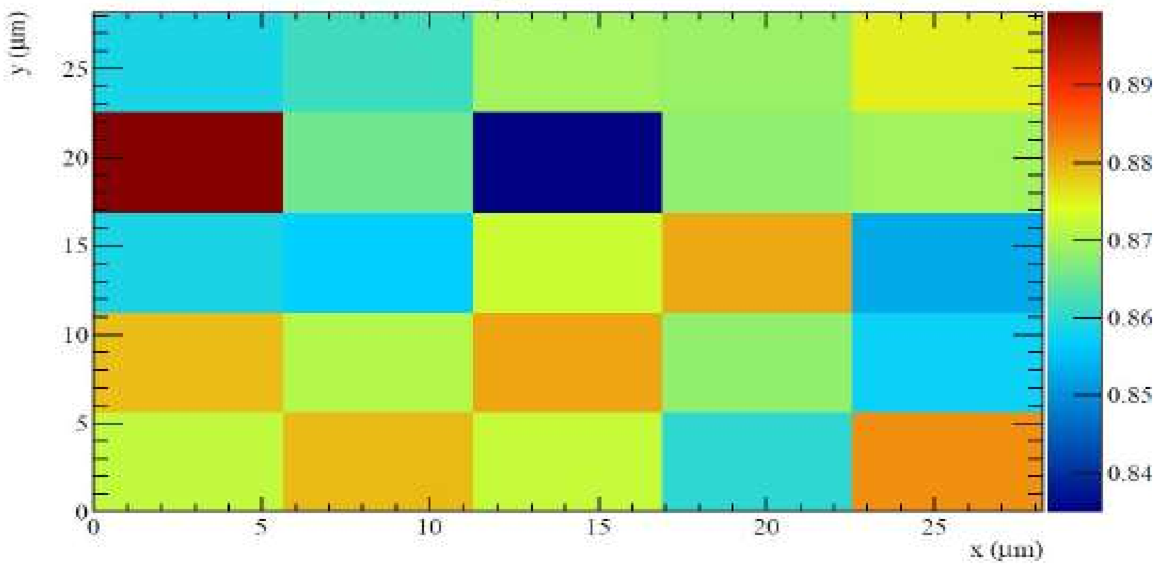


Initial height



Electron released
5µm above the mesh

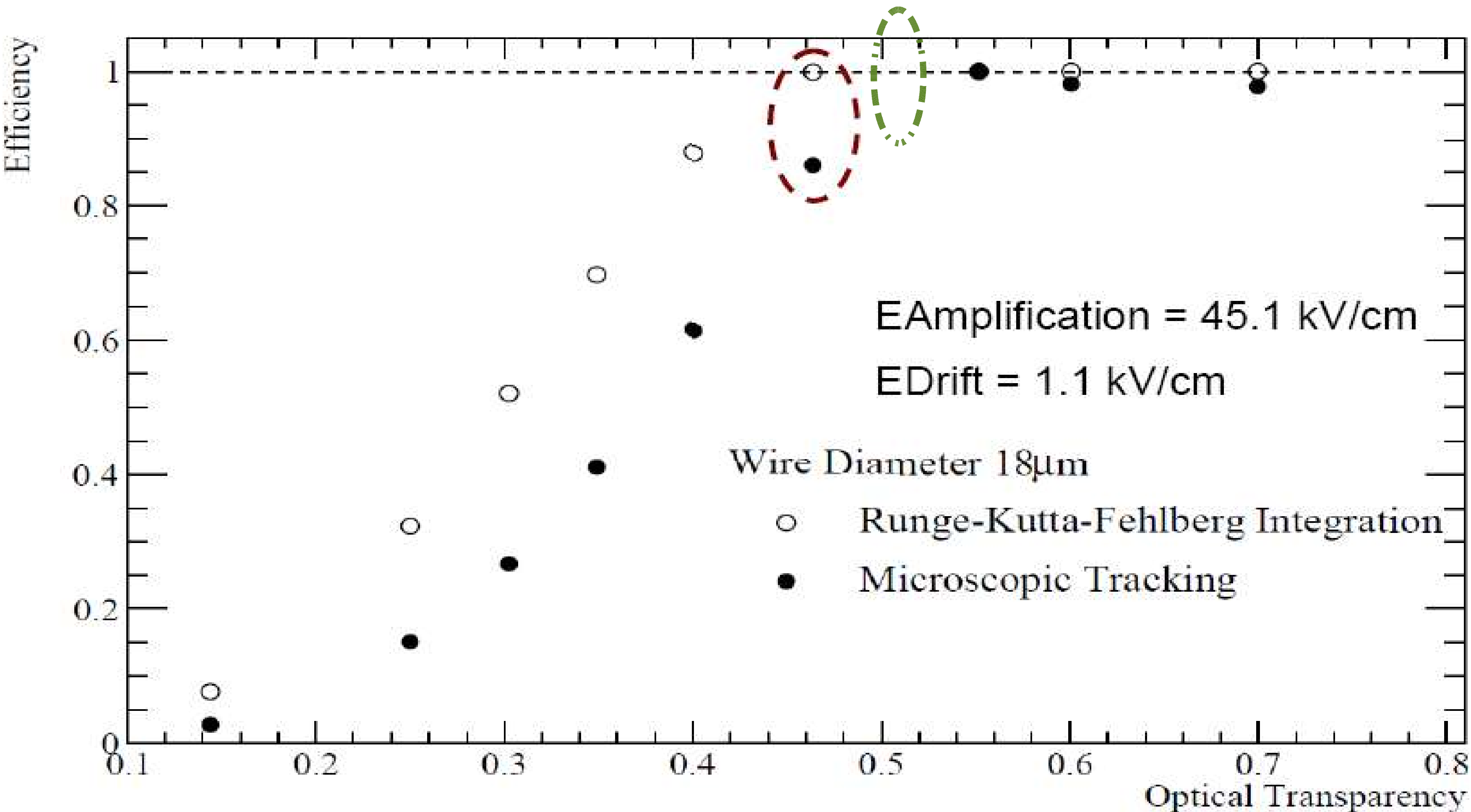
Electron released
100µm above the mesh



100 µm (or even 50 µm) of drift smear any possible correlation between the efficient collection in the amplifcation region and initial position of the electron

Effect of the pitch (constant diameter)

- model hole (38.5 μm) < mesh hole (45 μm) !



Summary

- The current trend is towards closer integration of gas transport and fields.

- Refinement of the gas descriptions and their use is a never-ending activity – results are being obtained, which will undoubtedly lead to refined calculations.