WG4 summary

overview of activities

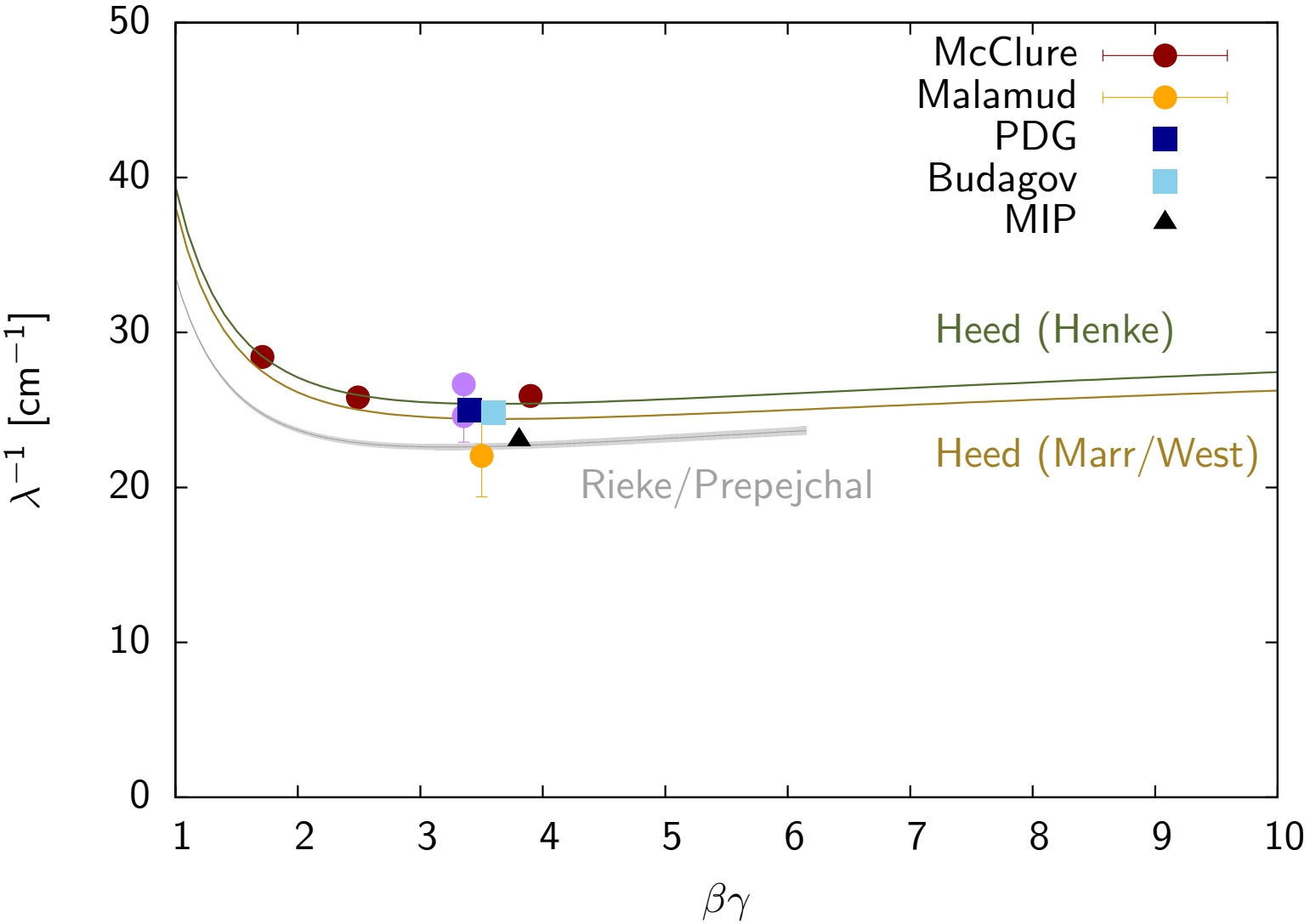
Overview

- WG4 activities concern the following areas:
  - ionisation processes;
  - field calculations;
  - electron and ion transport;
  - avalanche processes;
  - signal calculation.

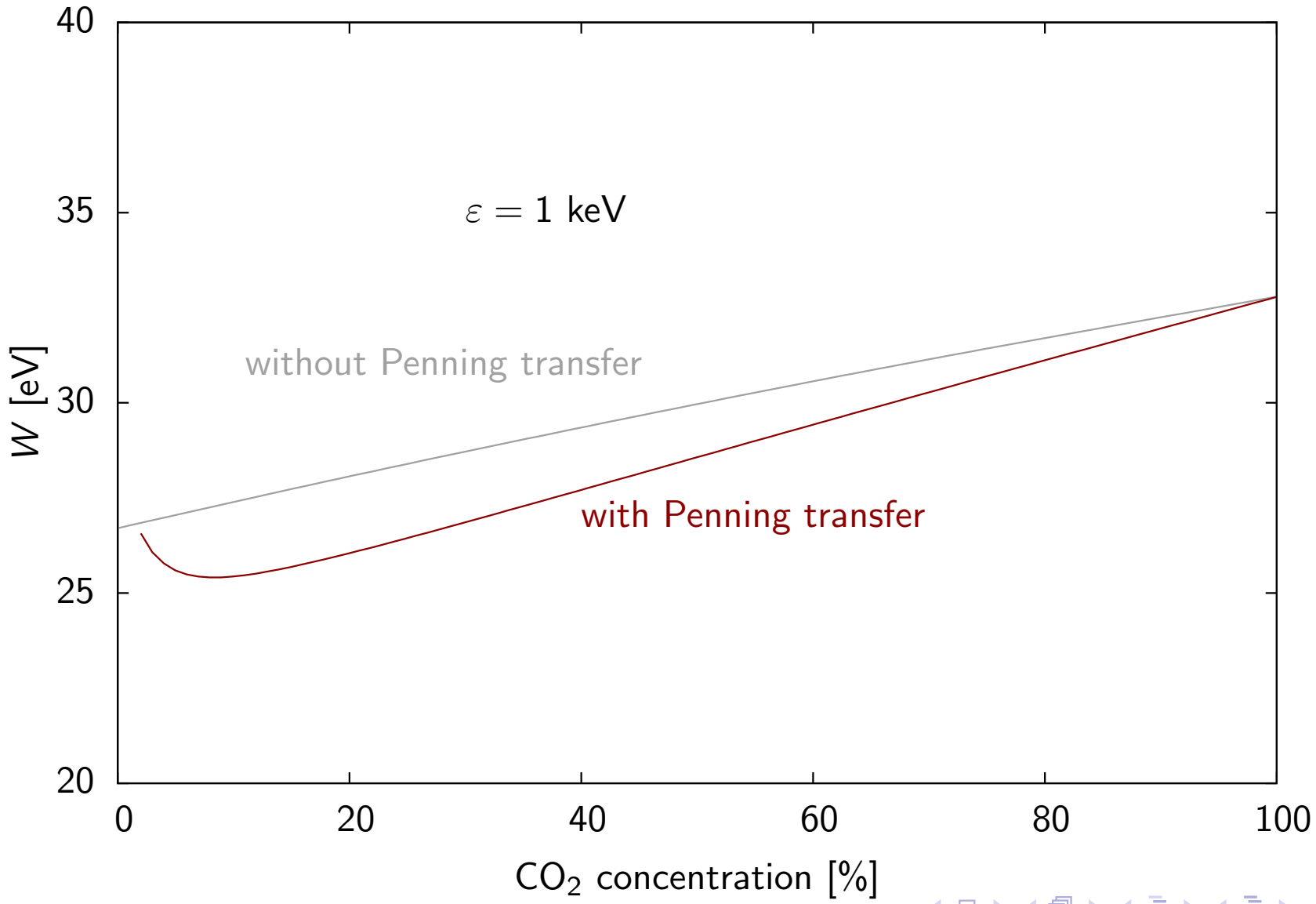
Ionisation

- The workhorse for ionisation by high-energy charged particles remains Igor Smirnov's Heed program.
- This is now complemented by Steve Biagi's MIP program which works out the cluster size distribution, electron range and Fano factors.
- Mary Tsagri is working on the detection of neutron interactions in gases & on interfacing Geant 4 and Garfield++.

Cluster Density - Argon



Delta Electron Transport - Ar/CO_2



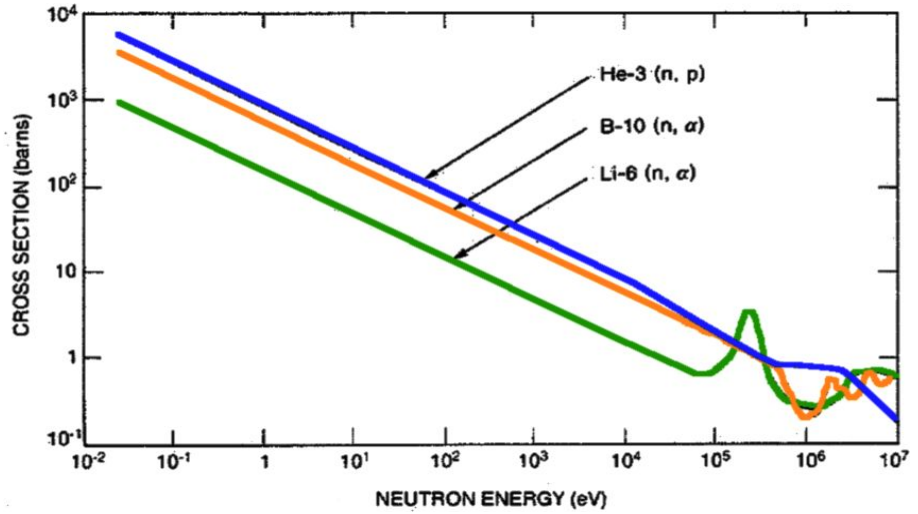
Interactions of neutrons

- $\epsilon < 0.1$ MeV: (n,p), (n,α), capture, fission in suitable materials; unlike p, no Coulomb barrier;
- $\epsilon \sim 1$ GeV: elastic scattering, in suitable materials recoils and charged particle-production;
- $\epsilon > 1$ GeV: mainly nuclear interactions.

Neutron detection – MeV range

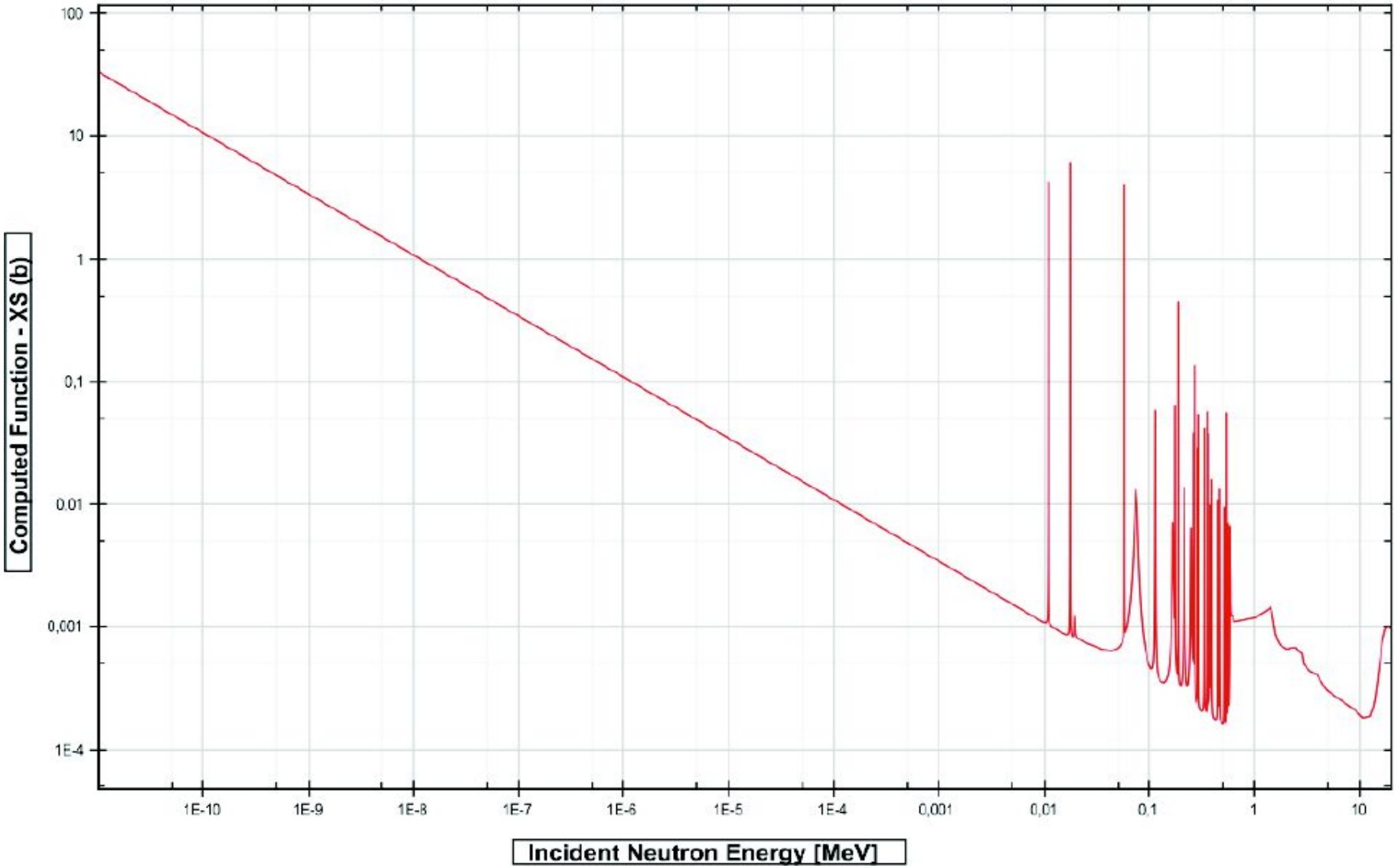
- Neutrons are neutral – only nuclear interactions.
- Penetrate deep into materials, excellent for diagnostics.
- Source of background at LHC if producing charge.

- Typical reactions up to the MeV energy range include:
  - detection of recoil protons
    - n $^{3}He \rightarrow {}^{3}H\ p + 765$ keV
  - nuclear reaction
    - n $^{10}B \rightarrow {}^{7}Li^{*}\ {}^{4}He + 2310$ keV,
    - $^{7}Li^{*} \rightarrow {}^{7}Li + 480$ keV

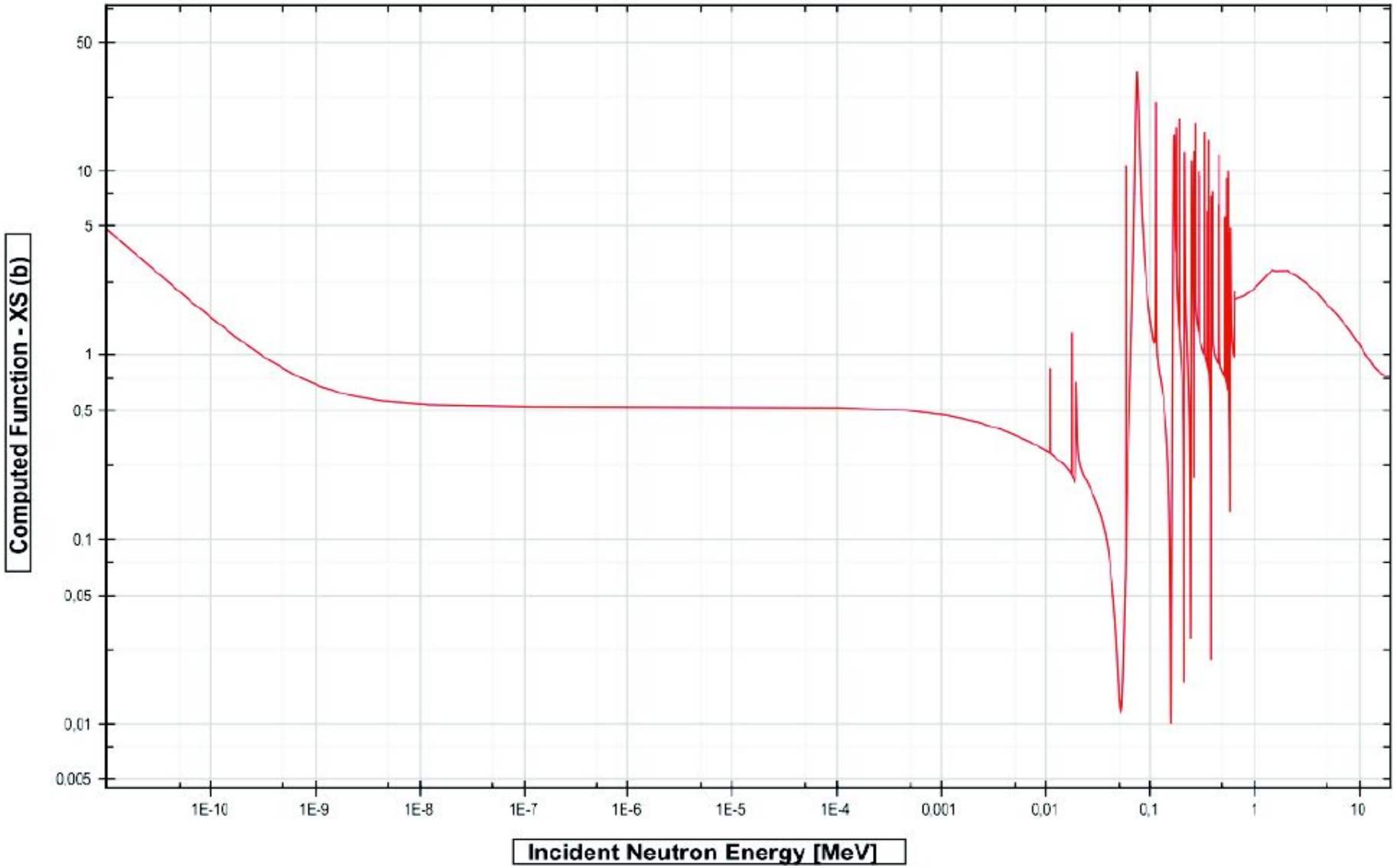


[Adapted from TW Crane and MP Baker, Neutron detectors]

Radiative capture in Ar

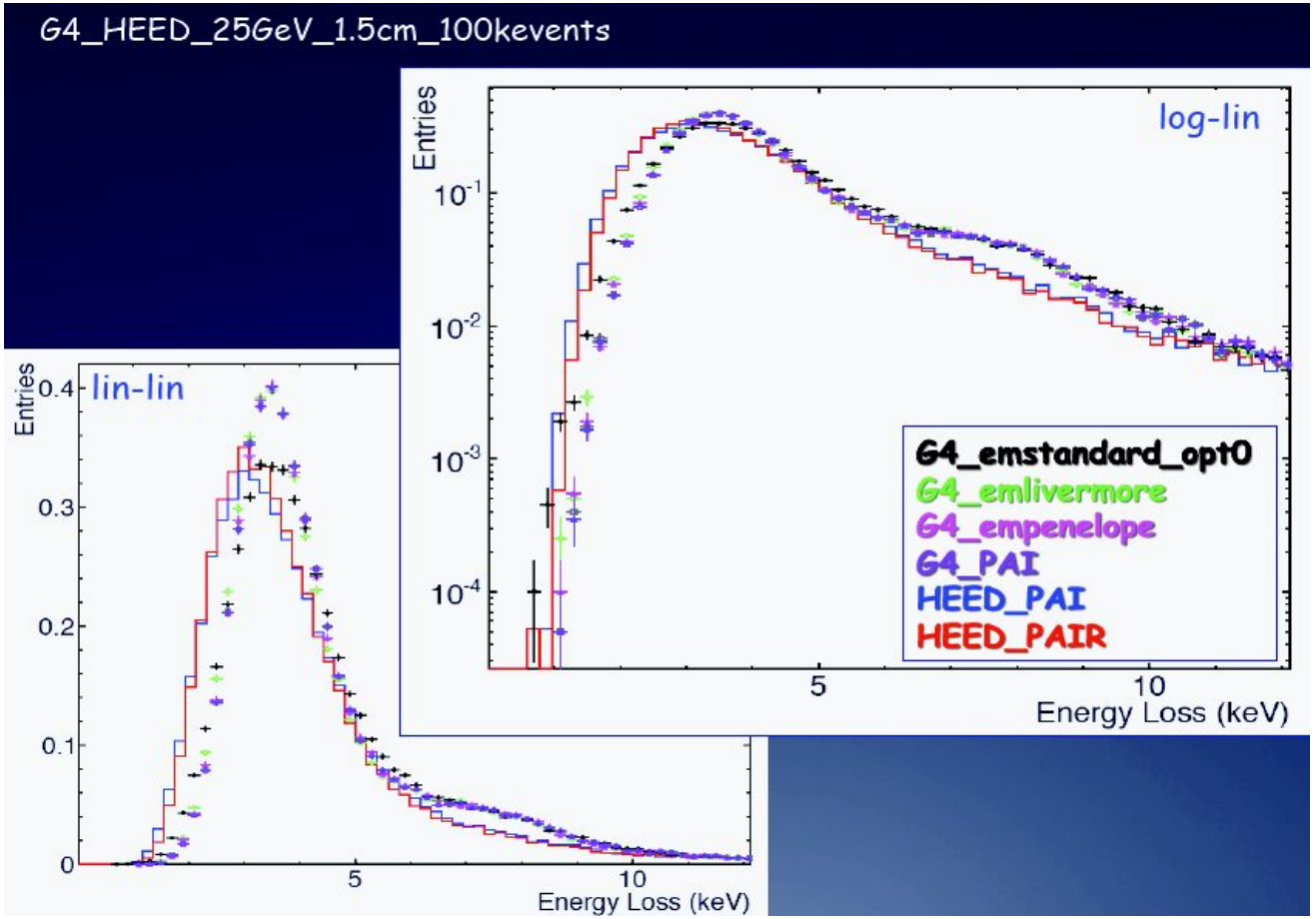


Elastic neutron scattering in Ar



Geant-Garfield++

- Current activity, comparing Heed and Geant4.
- Example: 25 GeV electrons in argon 80 % CO_2 20 %.

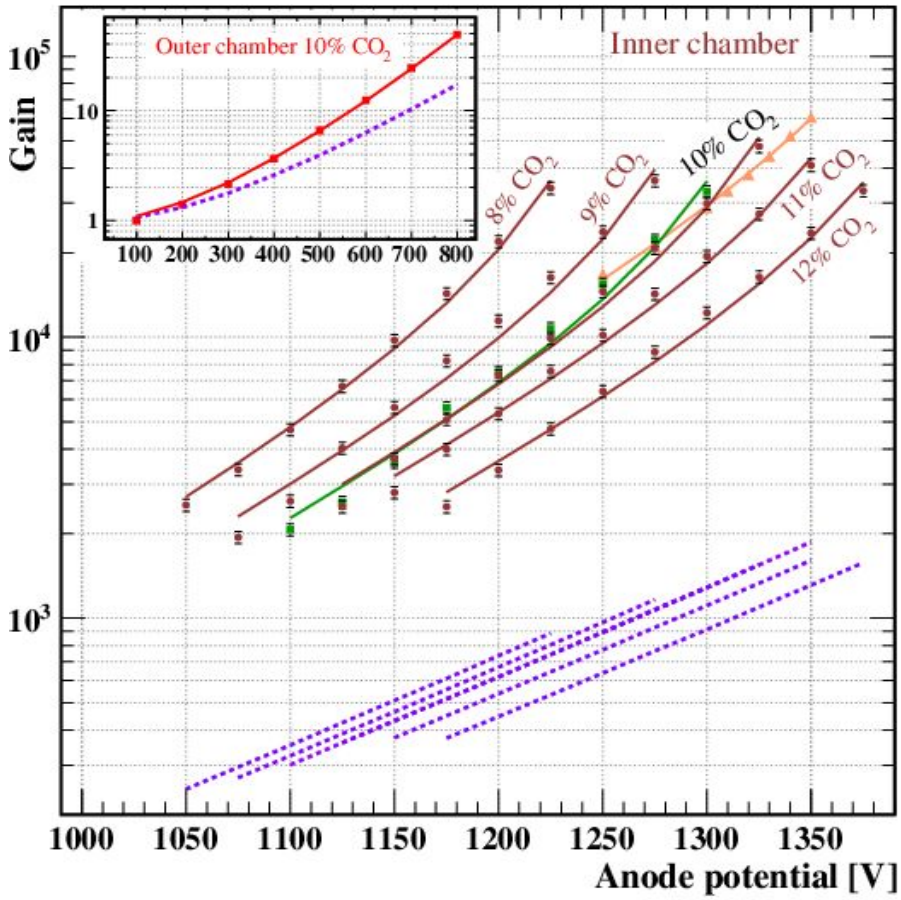


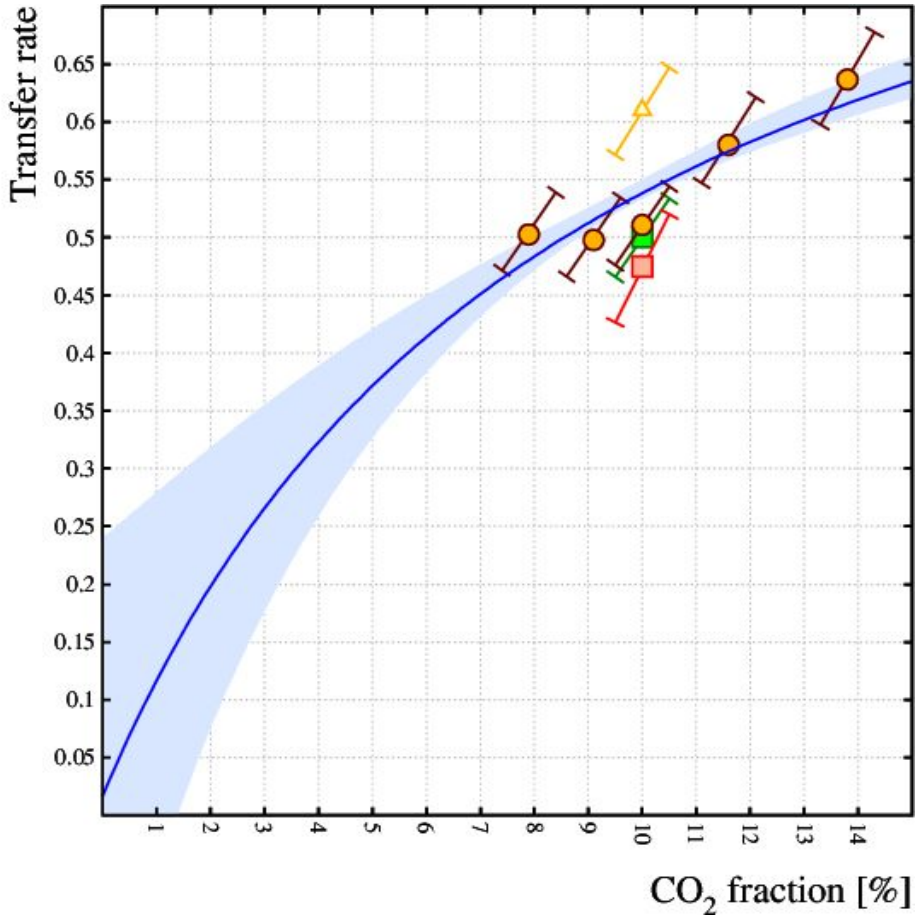
Magboltz

- Magboltz was considerably extended in 2009/2010:
  - version 8.6 (Oct 2009) Ar, 44 excitation levels
  - version 8.7: Xe, 50 levels
  - version 8.8: (Jan 2010) He, 49 levels
  - version 8.9: (Mar 2010) Ne, 45 levels
    - 3s and 3p region described by Zatsarinny & Bartschat calculations, in agreement with new measurements of J Phys B 42(2009)044009;
    - good agreement for 2 of the 3s and 1 of the 3p excitation rates;
    - Townsend coefficient lower: Penning transfer of ppm contaminations.
  - version 8.9.1: (Oct 2010) GeH_4, SiH_4, $C_2H_2F_4$
  - next: hydrogen

Neon update

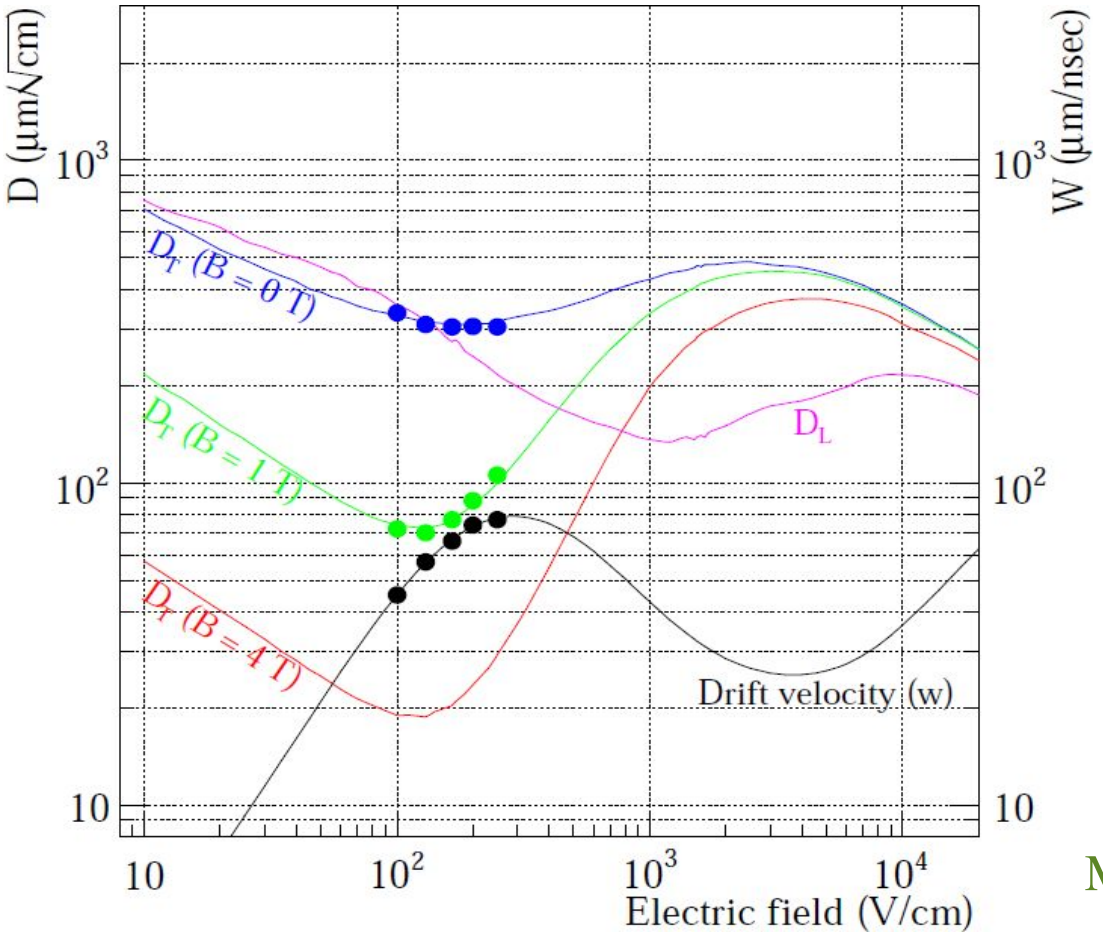
- The Ne update is for instance visible in the Penning rates for Ne-CO_2 mixtures, earlier held to be 45 %:





Diffusion check: ILC TPC

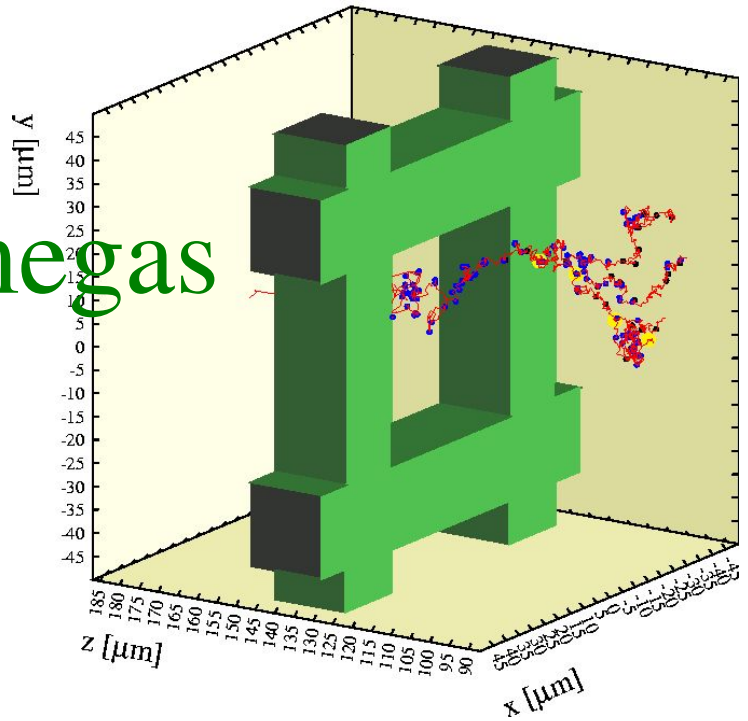
- Ar – CF_4(3%) – isobutane (2%) with B field:

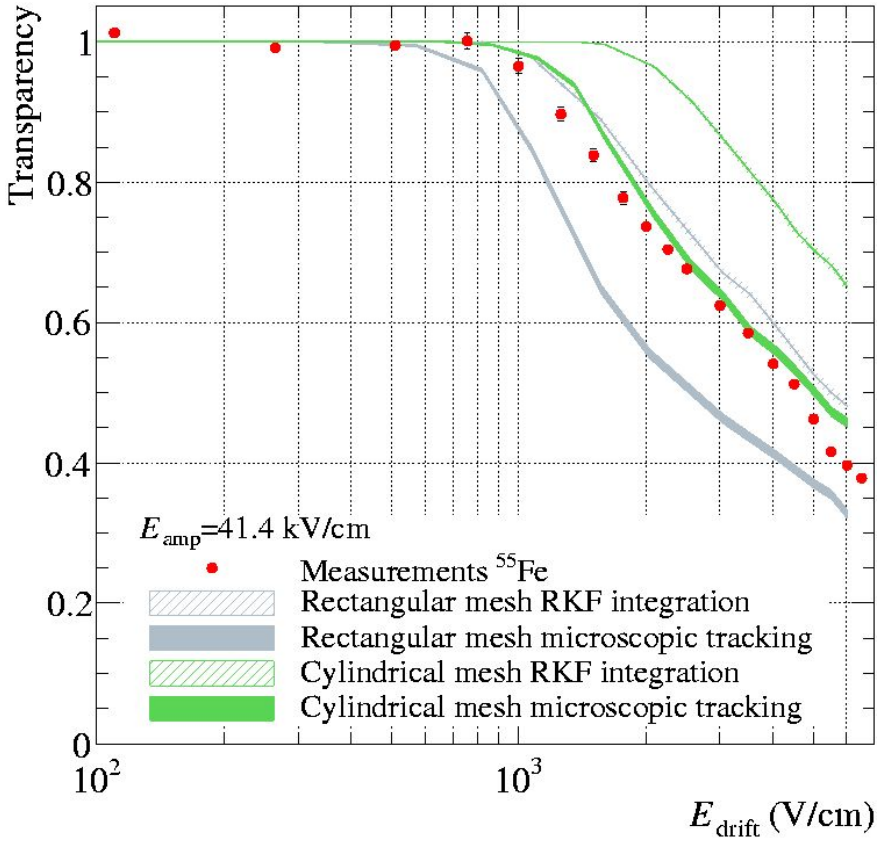


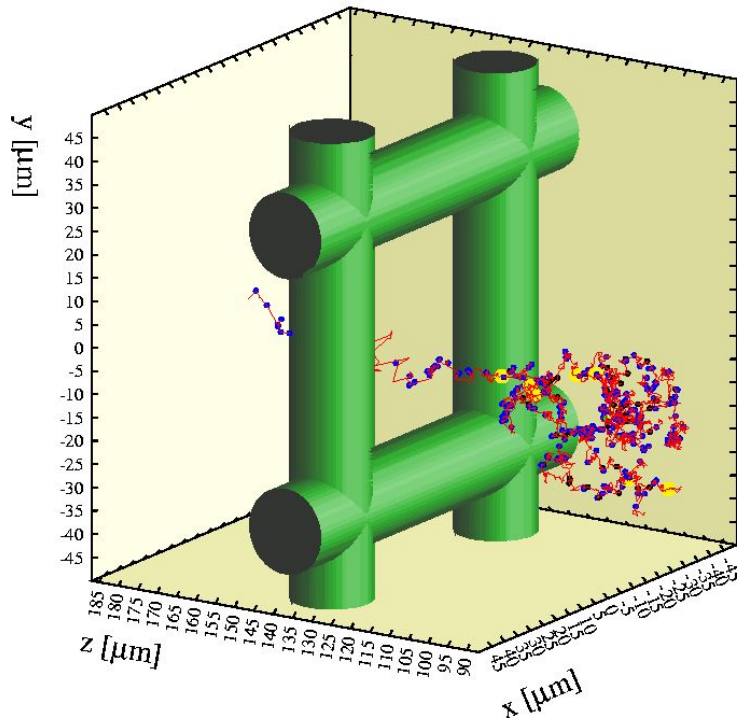
M. Kobayashi et al. arxiv 1008.5068

Diffusion check: Micromegas

- Kostas Nikolopoulos' paper in principle ready for submission, a calculation for a double Micromegas is likely to be added.

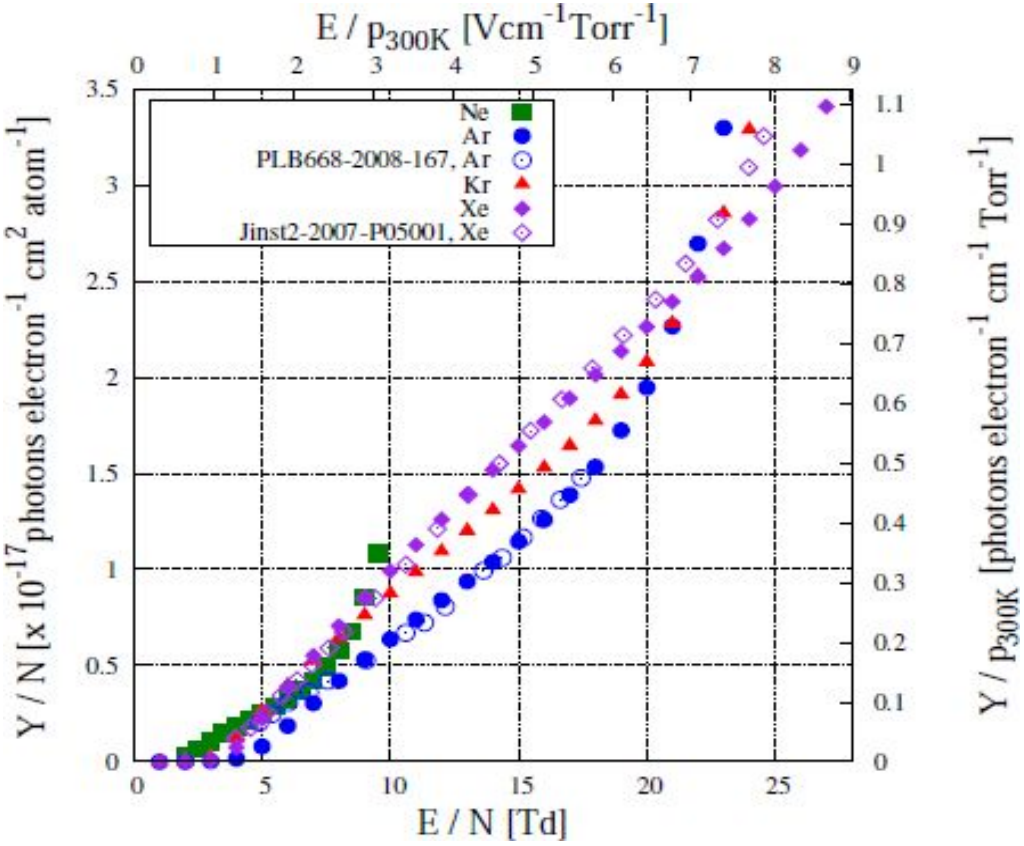






Excitations

- The Aveiro group studies light emitted by excited states and by the decay of excimers formed in (pure) noble gases.
- Plan to move to newer releases of Magboltz.

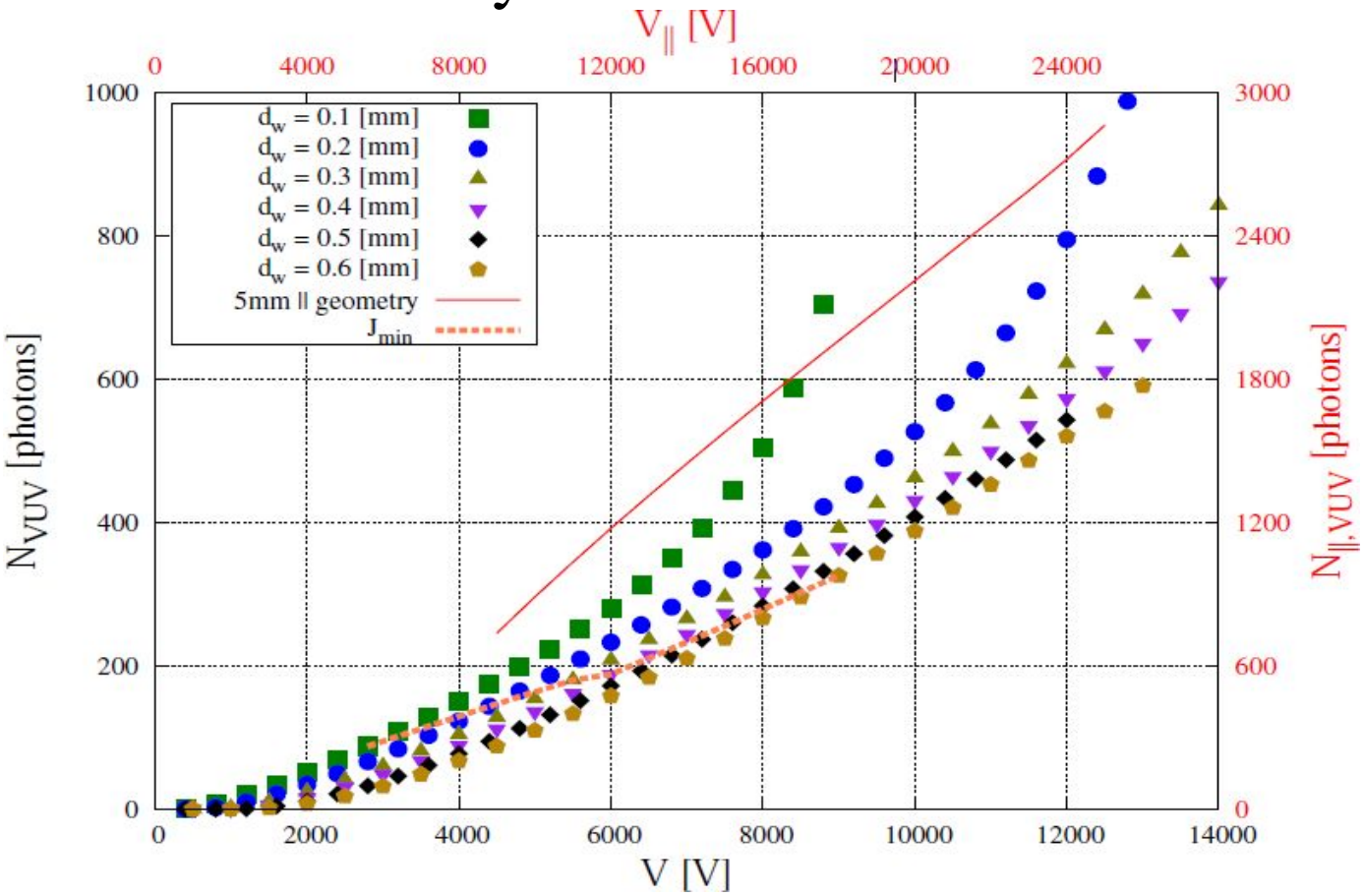


Open symbols: data

Closed symbols: calculations

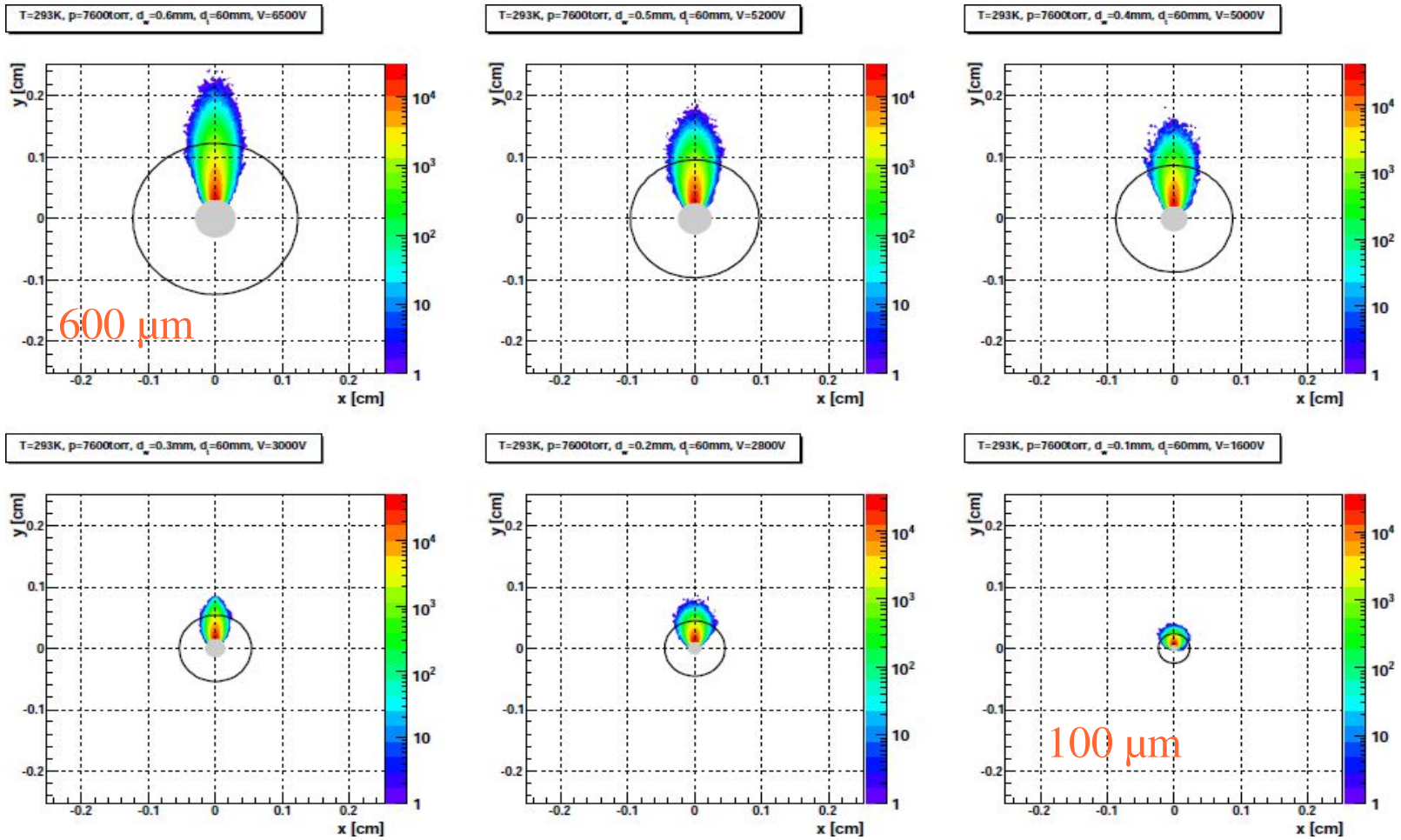
Cylindric geometry

- Comparing light yield of parallel and cylindric structures.
- Mechanically more stable.



Cylindric geometry

- 10 bar Xe TPC, neutrino less double beta decay: the importance of the wire diameter



Avalanches

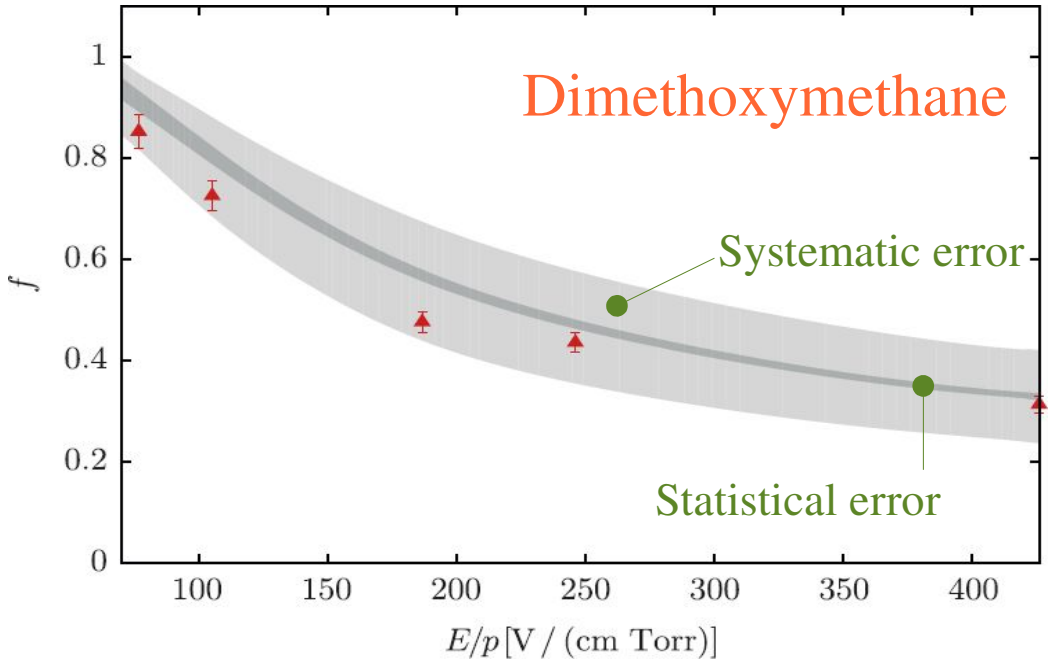
- Heinrich's paper on avalanche statistics has been accepted for publication.
  - Verification that a microscopic model based on Magboltz reproduces historic data;
  - Toy model offering insight;
  - Comparison of mixtures for various noble gases.

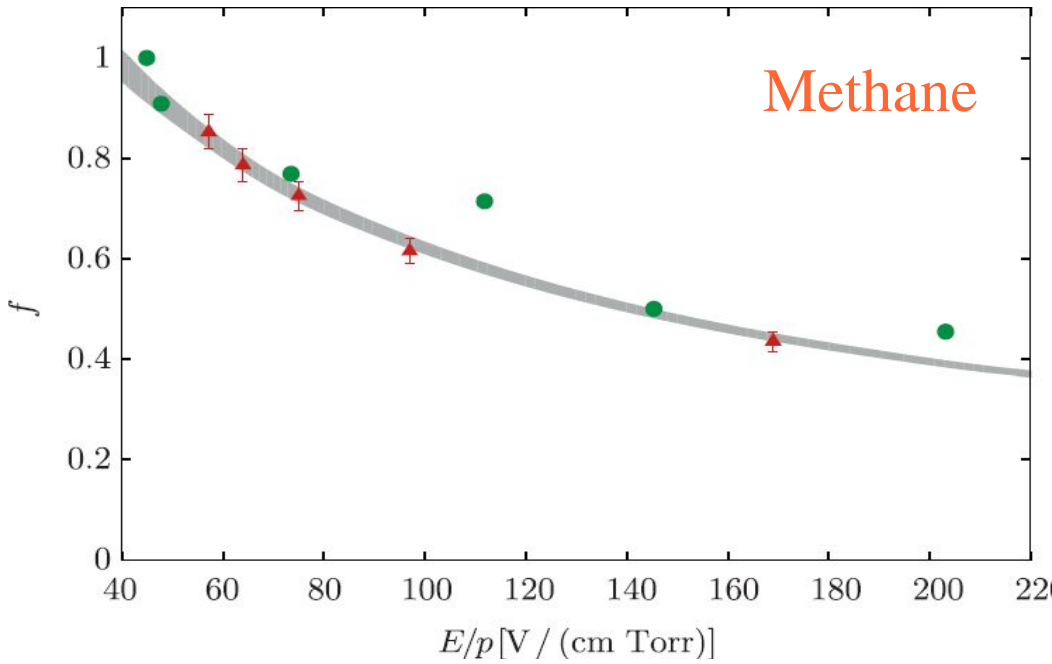
- DOI: `10.1016/j.nima.2010.09.072`

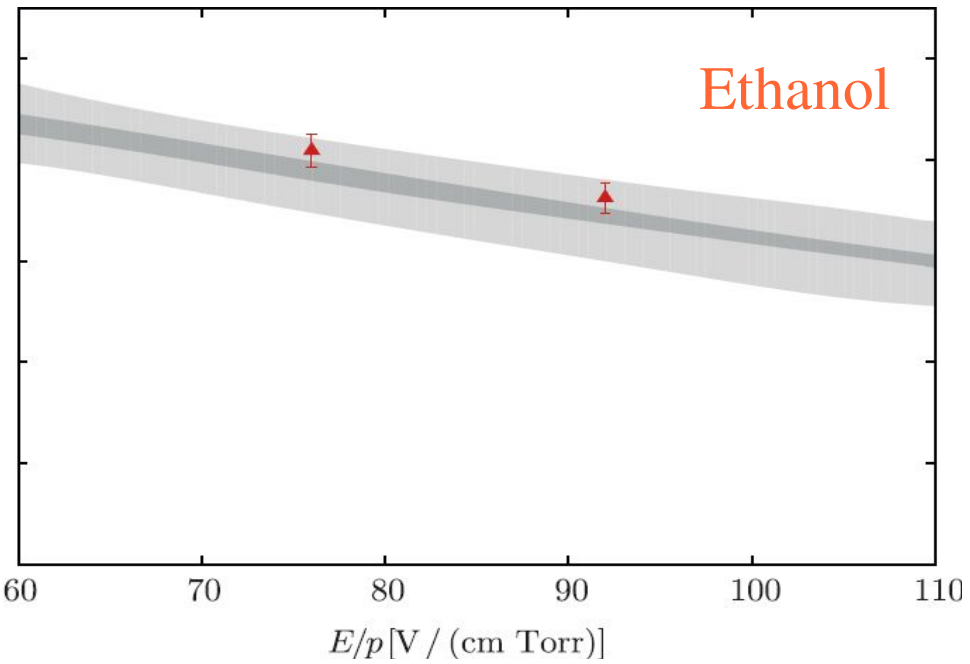
Verification

$f = \sigma^2/\bar{n}^2$ relative variance

$f = 1$ exponential

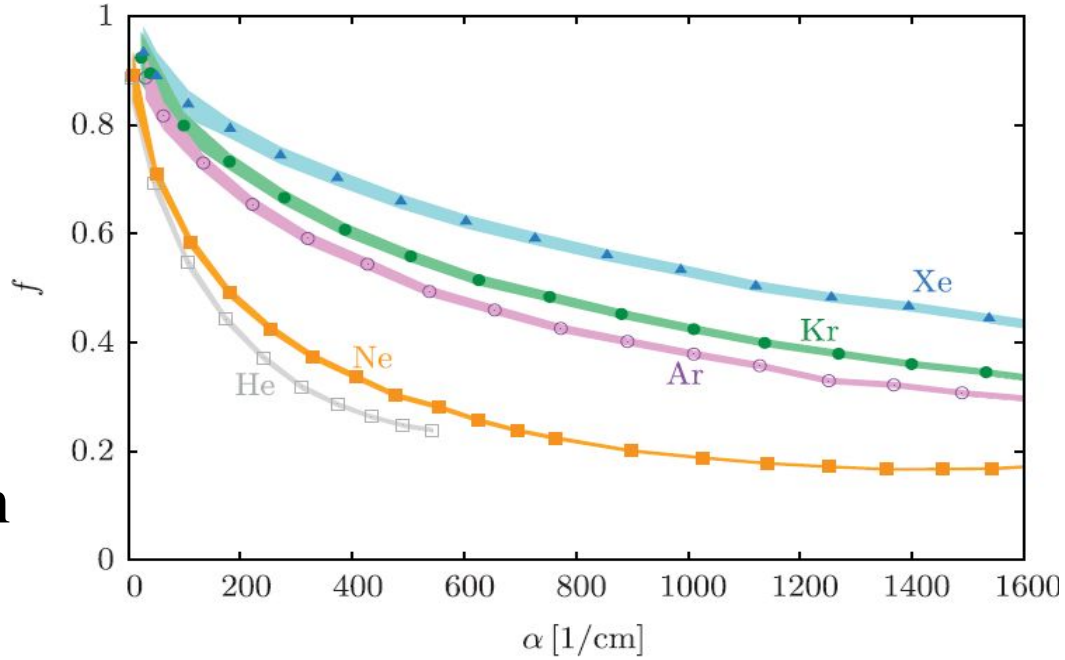


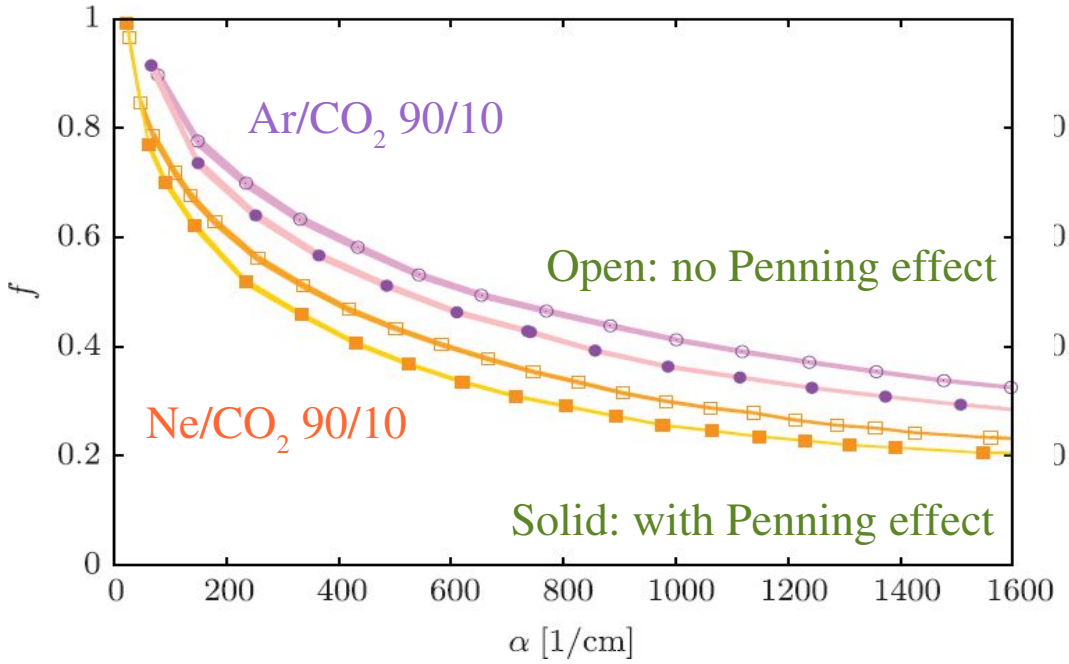


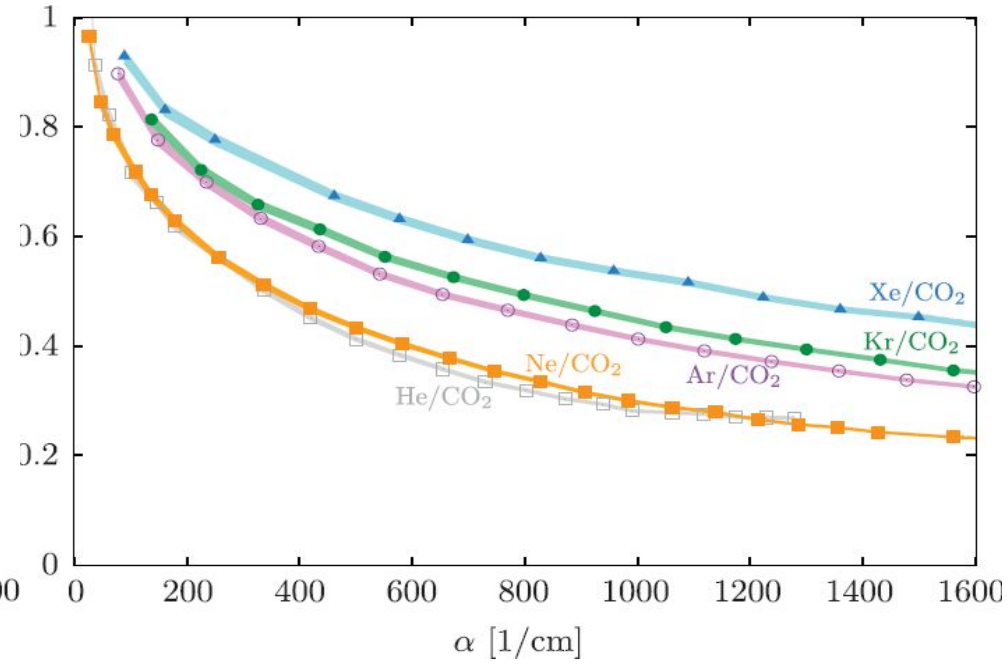


The noble gases

- Quenchers: more inelastic & less ionisation → larger f ;
- Penning transforms excitation into ionisation → smaller f.



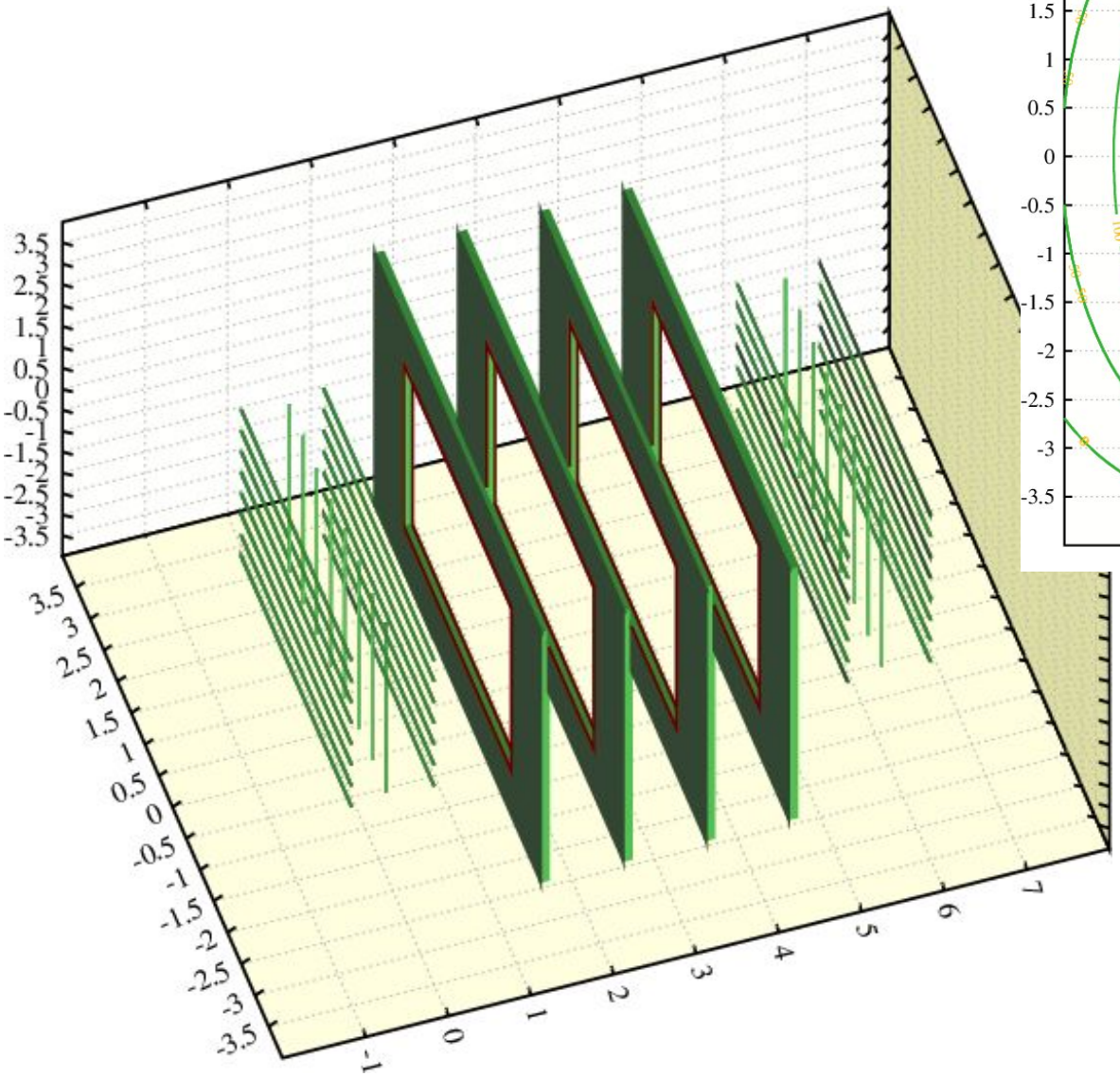


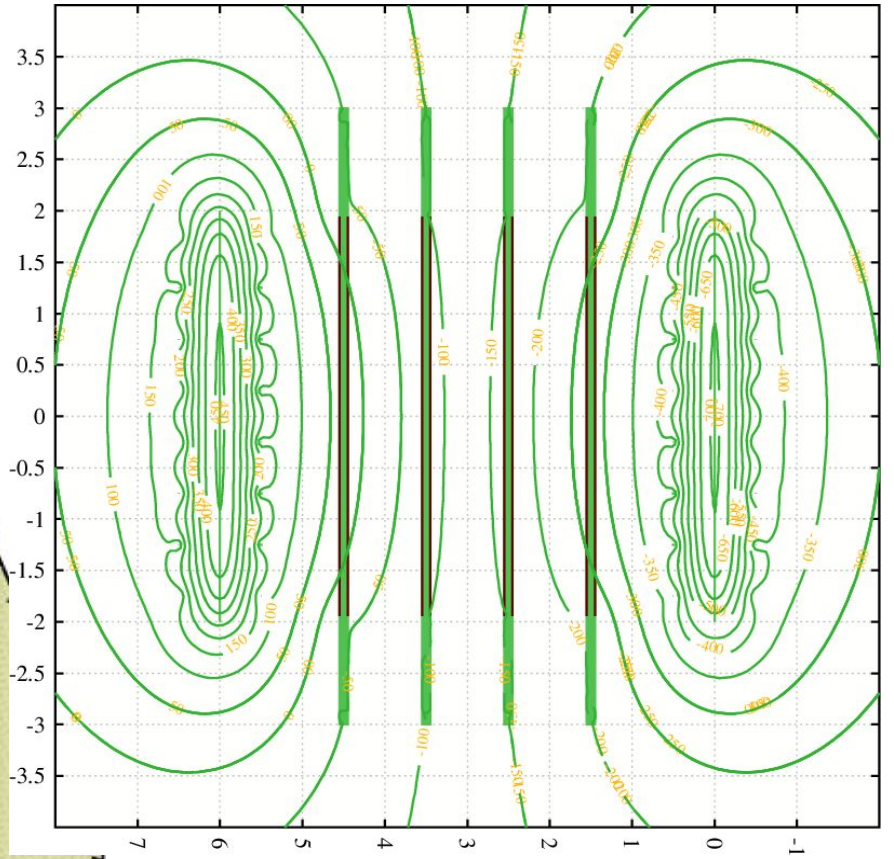


neBEM - Recent Developments

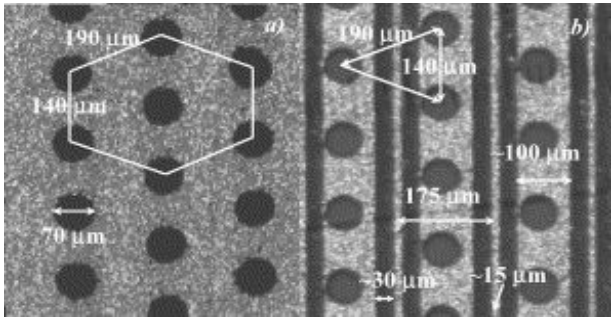
- Repeated structures and Mirror reflections
- Weighting field: signal calculations
- New / reuse model: saves recomputing influence matrix
- Discretization controls: more economic high precision
- Wire primitives: TPC-like devices
- Effect of known point, line and surface charge

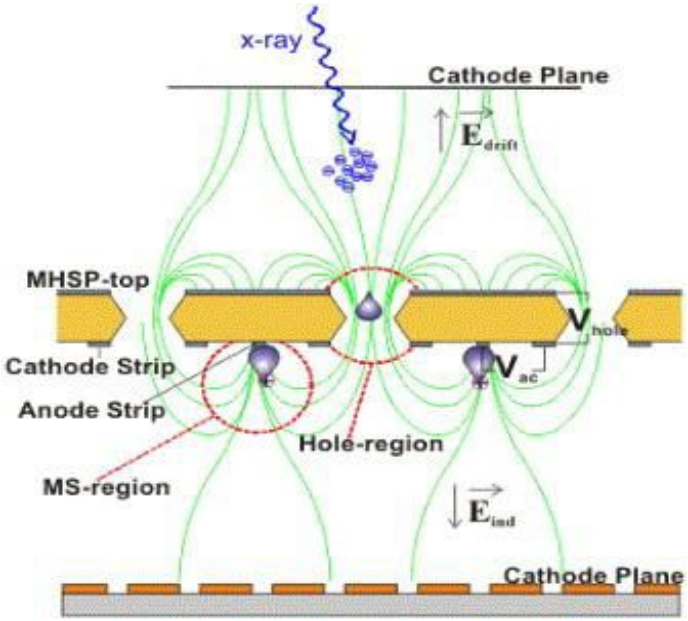
Wire elements

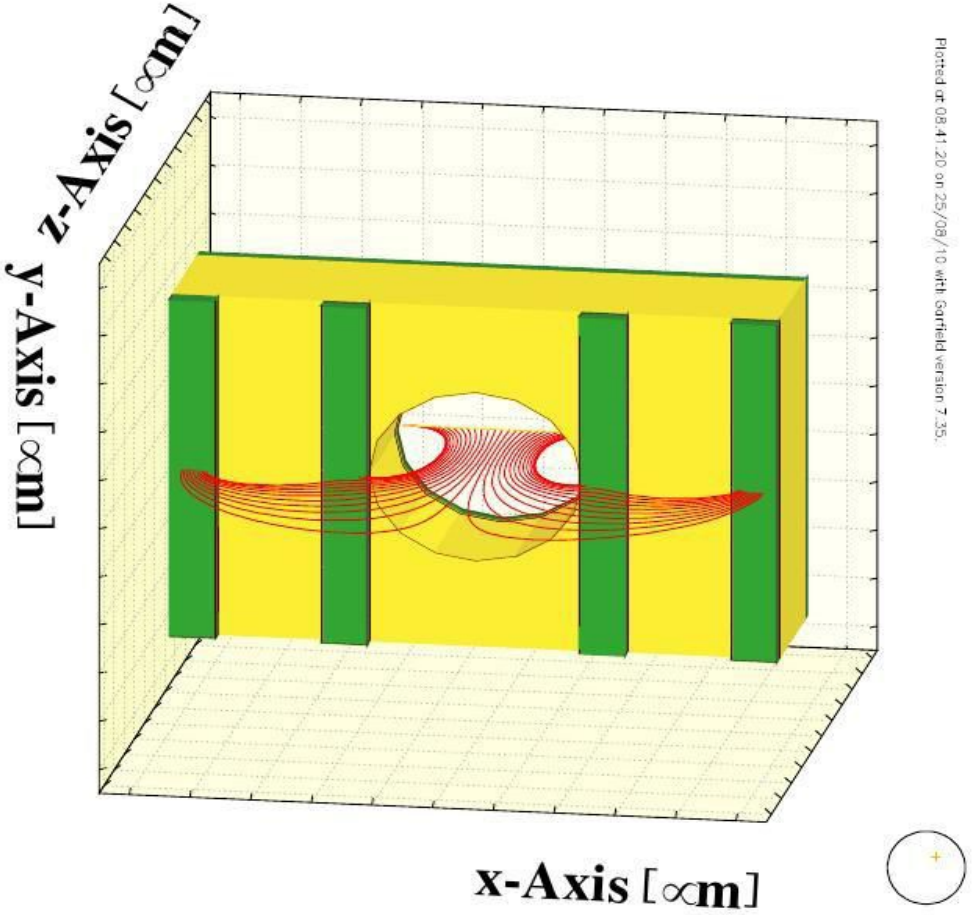




neBEM+Magboltz+Heed: MHSP

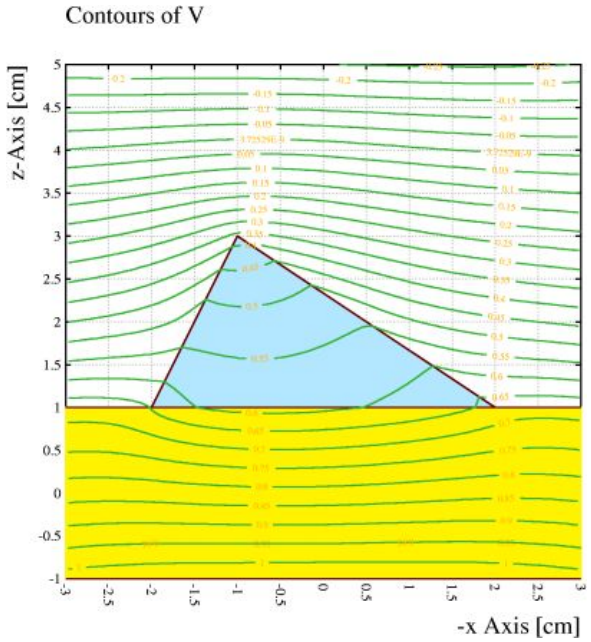




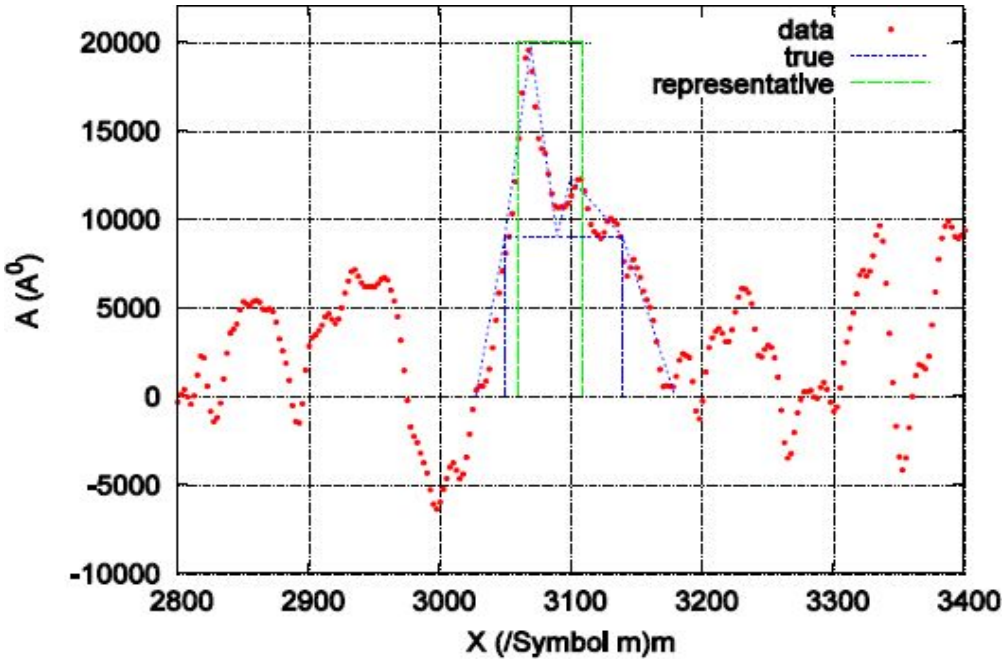


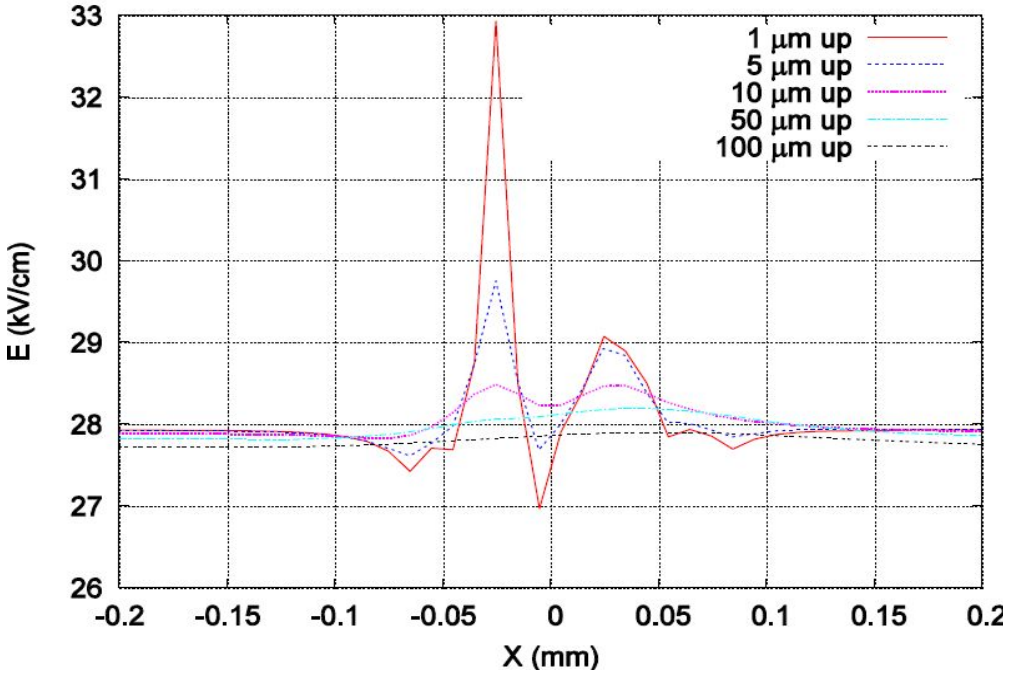
Surface asperities

- RPC surfaces are irregular, which leads to irregularities in the field:



For the “true” model





More general geometries

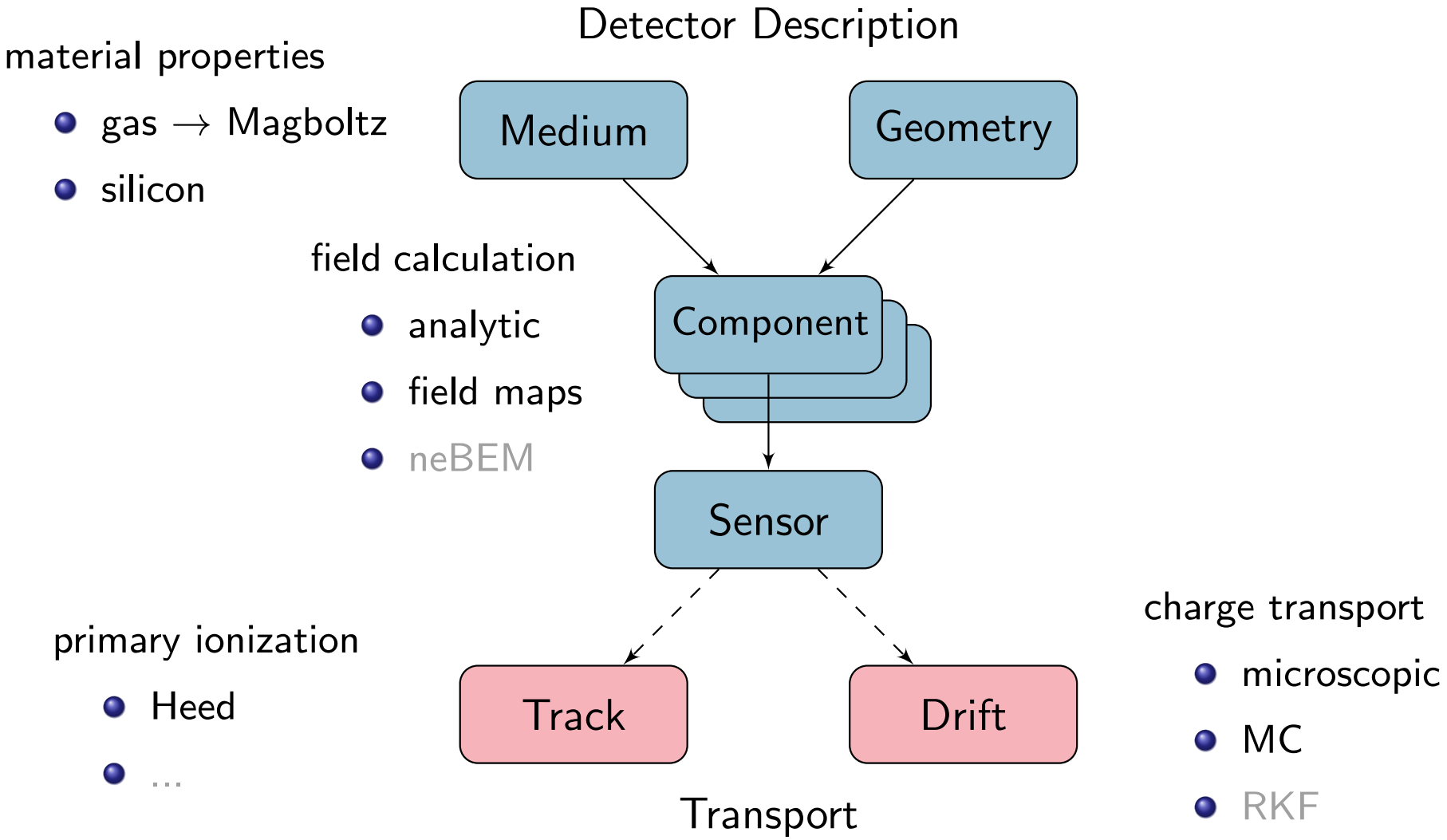
- Meshing (Delaunay) being worked upon using the CGAL library;
- Arbitrary flat polygons have been discretized;
- Complex shapes, such as holes, yet to be tried;
- Needs more work and Interface to be developed.

Gas class

- Nicholi Shiell has meanwhile produced a C++ class which has the functionality of the Fortran &gas section.

- Since drift path integration algorithms and analytic field calculations had already been translated (Heinrich Schindler), the path to TPC-like calculations is now open.

Garfield++


Detector Description
material properties
gas → Magboltz
silicon
Medium
Geometry
field calculation
analytic
field maps
neBEM
Component
Sensor
primary ionization
Heed
...
Track
Drift
Transport
charge transport
microscopic
MC
RKF

Garfield++

Recent Activities

In the last few months (since the Freiburg meeting) we have worked mainly on

- analytic two-dimensional fields (wrapper and rewrite)
- interface to Heed++
- creation and interpolation of gas tables

How to get the code

- `http://svnweb.cern.ch/trac/garfield`
- `http://svnweb.cern.ch/world/wsvn/garfield`

First release within the next weeks or so.
Any feedback is highly appreciated...

Schools in 2011

EDIT

- Februrary 1^{st} to 9^{th}
- introductory lectures of sheer excellence
- excellent demonstrations accompanied by miserable simulations (e. g. ATLAS MDTs)

Schools in 2011

RD 51 Simulation School

- January 20^{th} - 21^{st}
- Idea: "getting your hands dirty doing calculations"
- Contents
  - Introduction to Geant4
  - Introduction to FEM, COMSOL
  - Field calculations
  - Transport of electrons in small-scale devices
  - Calculation of signals and their processing
- Prerequisites: working knowledge of ROOT, basic of C++, some knowledge of the physics of gas detectors
- More detailed announcements and enrolment in November