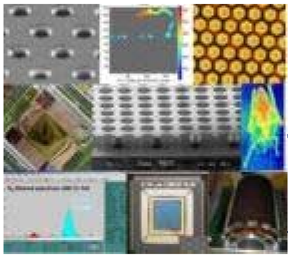
Report of WG4

Alain Bellerive



5th RD51 Collaboration Meeting

24-27 May 2010 *Freiburg, Germany*
Europe/Zurich timezone

WG4: Simulations and Software Tools

Place: *Freiburg, Germany Gustav-Mie-Haus*
Room: Seminar Room (GMH)

Dates: Wednesday 26 May 2010 09:00

Conveners: Rob
Bellerive, Alain
Bellerive, Alain

Contribution List   Time Table

Wednesday, 26 May 201

09:00

[68] Electroluminescence in noble
by Carlos Alberto BASTOS DE OLIVE
(Seminar Room (GMH): 09:00 - 09:

[9] Feedback mechanisms
by Ozkan SAHIN (Uludag Universit
(Seminar Room (GMH): 09:30 - 10:

10:00

[10] Avalanche statistics
by Heinrich SCHINDLER (Technische Univer:
(Seminar Room (GMH): 10:00 - 10:

Coffee Break
(10:30 - 11:00)

11:00

[5] Gas flow
by Stefano COLAFRANCESCHI
(Seminar Room (GMH): 11:00 - 11:

[46] Status C++ and worksh
by Alain BELLERIVE
(Seminar Room (GMH): 11:30 - 12:

http://indico.cern.ch/event/89325
Last modified: 26 May 2010 16:41

Remarks

- Use of GEANT4 to characterize response of MPGD with neutron [Gabriele Croci – CERN]
- Calculation of streamer development in MPGDs with COMSOL [Paolo Fonte - LIP]
- Relevant for future workshop…

Electroluminescence in noble gases using Garfield and Magboltz 7.1

C. A. B. Oliveira[1] A. L. Ferreira[1] S. Biagi[2] R. Veenhof[3] J. M. F. dos Santos[4] C. M. B. Monteiro[4] J. F. C. A. Veloso[1]

[1] I3N, Physics Department, University of Aveiro, Aveiro, Portugal

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26/05/2010 - 5th RD51 Collaboration Meeting

universidade de aveiro

CERN

RD51
Micro Pattern Gaseous Detectors R&D

- Excimer formation (3 body collision)

$$R^* + 2R \rightarrow R_2^{**} + R$$

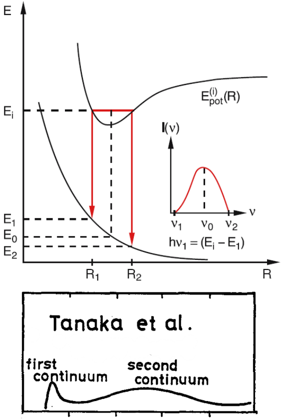
- Direct radiative decay ($p < 400 mbar$)

$$R_2^{**} \rightarrow 2R + h\nu$$

- Vibrational & radiative decays ($p > 400 mbar$)

$$R_2^{**} + R \rightarrow R_2^* + R$$

$$R_2^* \rightarrow 2R + h\nu$$

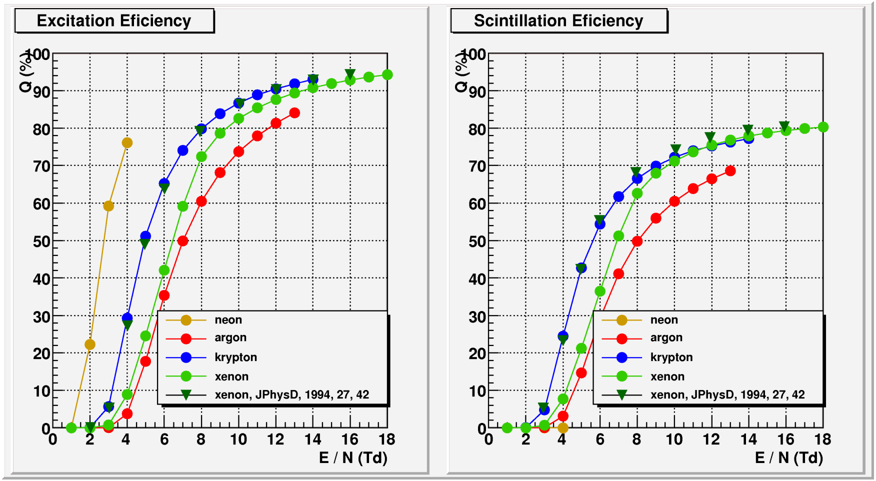


Simulation model / interface

- Microscopic technique of Garfield 9
- Vacuum trajectory between collisions for e_s^-
- $\lambda(\varepsilon) = \frac{e^{-x/l(\varepsilon)}}{l(\varepsilon)}$ - Null-collision technique [H.R. Skullerud 1968]
- C++ Wrapper around Fortran version of Garfield (with Magboltz 7.1)

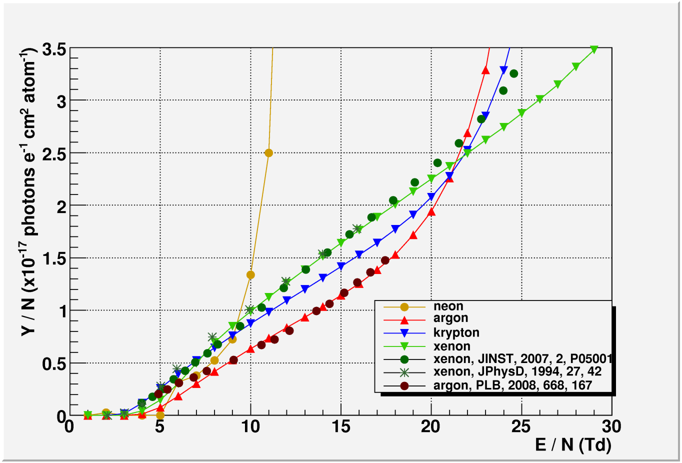
Uniform field geometry

Results - Q_{exc} & Q_{sci}



Uniform field geometry

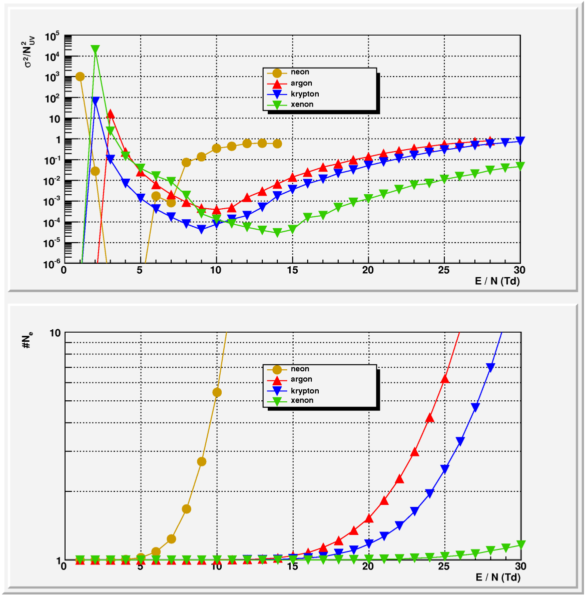
Results - Y



- Good agreement with former simulation work and experimental data (Ar & Xe)
- Experimental measurements for Ne & Kr are in progress

Uniform field geometry

Results - Light fluctuations



- $\frac{\sigma^2_{N_{UV}}}{\bar{N}^2_{UV}}$ decreases until ionisations begin
- E_{res} is a critical information for detector design

Conclusions

- A simulation tool based (C++ wrapper) in Magboltz / Garfield was developed to follow produced excited states in noble gases
- Strong agreement with experimental data and with other independent Monte Carlo simulation results
- Reliable method for electroluminescence simulations
- Other applications were shown namely electroluminescence produced in a cylindrical geometry with thick wire

Current and future work

- New C++ version of Microscopic Technique available interfacing Magboltz 8.3

  (studies are being repeated)
- X-sections files were updated recently by Stephen Biagi
- Systematic studies for cylindrical geometry as a function of wire and tube diameter, gas type and pressure
- Compare fluctuations with uniform field geometry
- Complete multiwire detector simulation

  $\left(\frac{E}{N}\right)$ bellow ionisation threshold
- Study of light emission spatial distribution and light signal

Feedback mechanisms

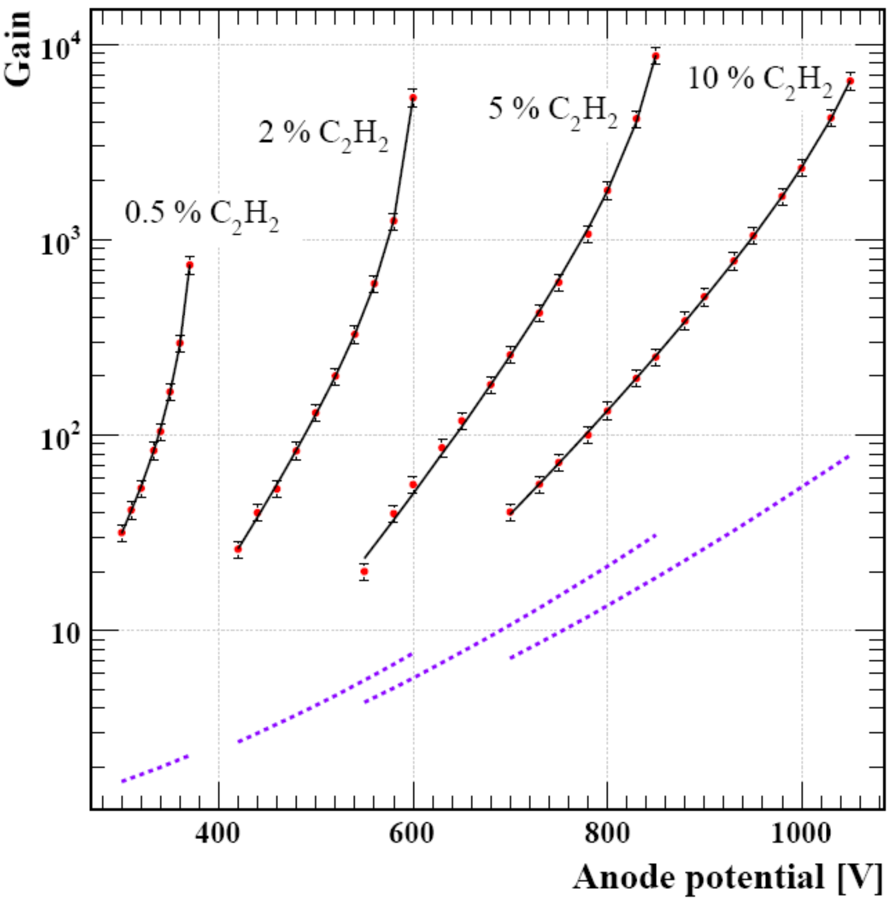
Ö. Sahin et al., JINST **5** P05002:

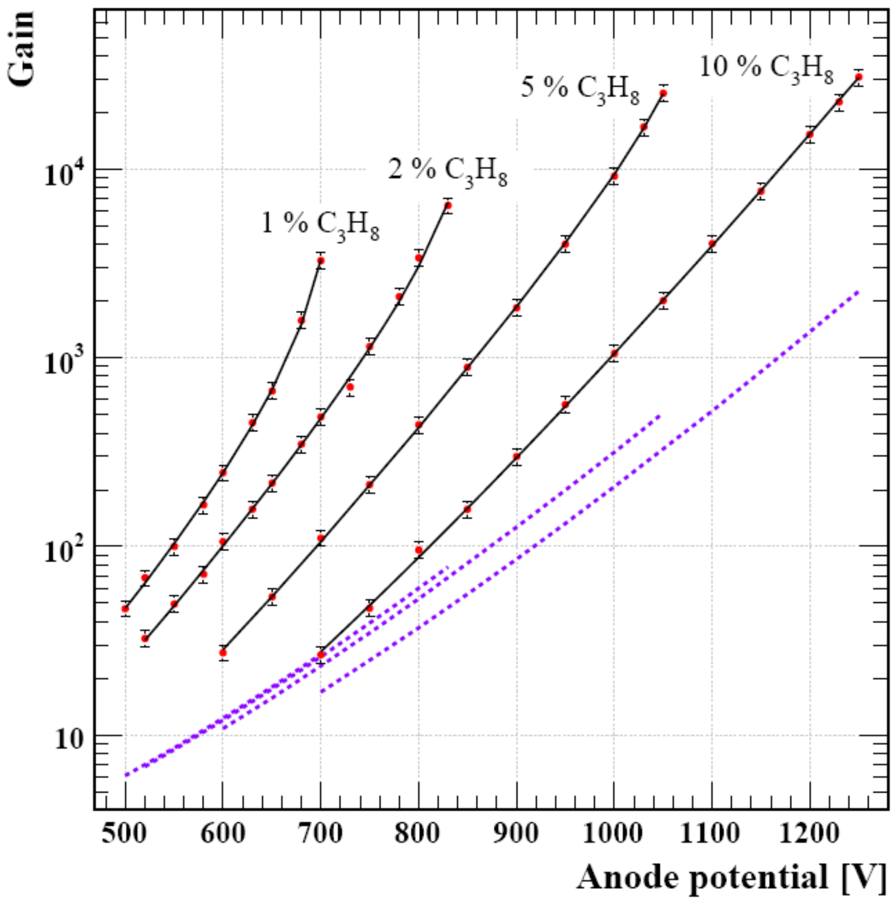
Özkan ŞAHİN
Uludağ University Physics Department
Bursa -TURKEY

Examples

Penning transfers, a group of processes by which excitation energy is used to ionise the gas, increase the gas gain in some detectors

Ar + quencher





Exp. data: P.C. Agrawal et al., *Study of argon-based Penning gas mixtures for use in proportional counters, Nucl. Instrum. Meth.* **A 277** (1989) 557.

Plots: Ö. Şahin, İ. Tapan, E. N. Özmutlu and R. Veenhof, *Penning transfer in argon-based gas mixtures*, 2010 *JINST* **5** P05002.

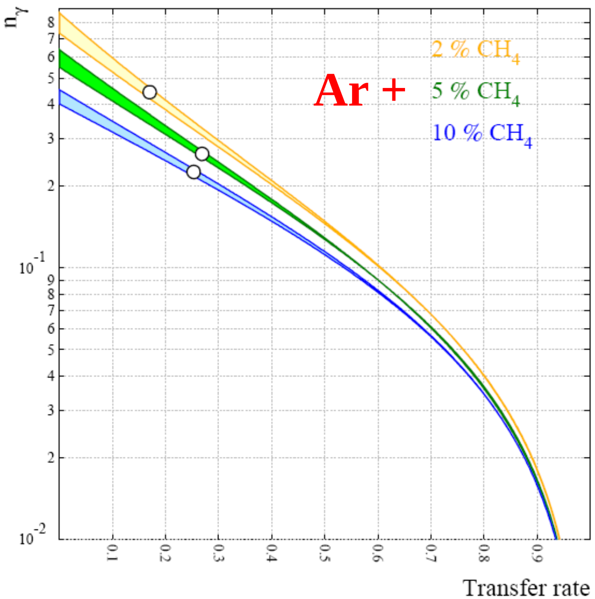
A simple model of β

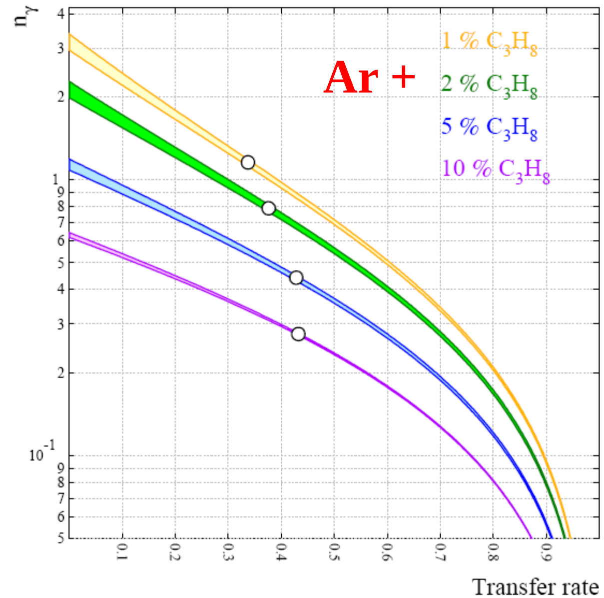
$$G := G/(1 - \beta G)$$

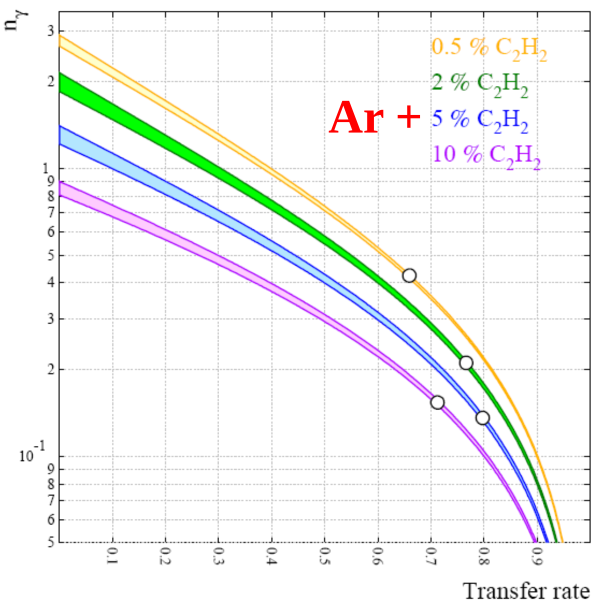
$$\beta = n_\gamma \exp(-d/\lambda)$$

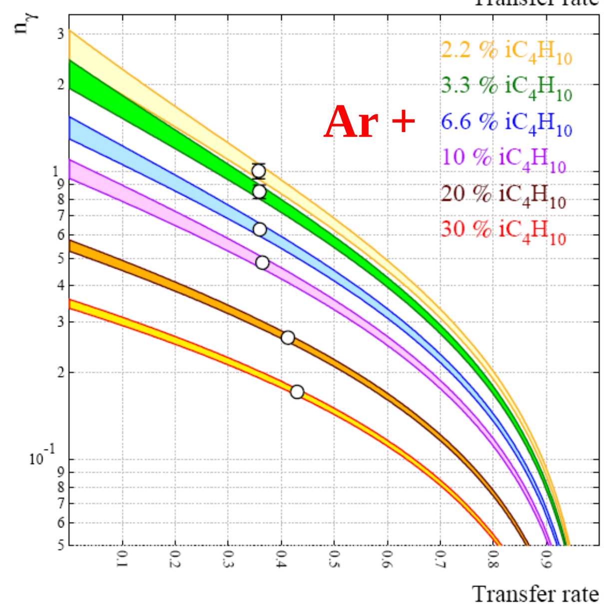
- n_γ : number of photons emitted per avalanche electron,
  - Penning transfer probabilities,
  - Rates of excited states (Magboltz)
- d : avalanche sizes,
  - Townsend coeefficients (Magboltz)
- λ : mean free path of photons
  - Absorption cross sections (literature)

Number of photons (n_γ)

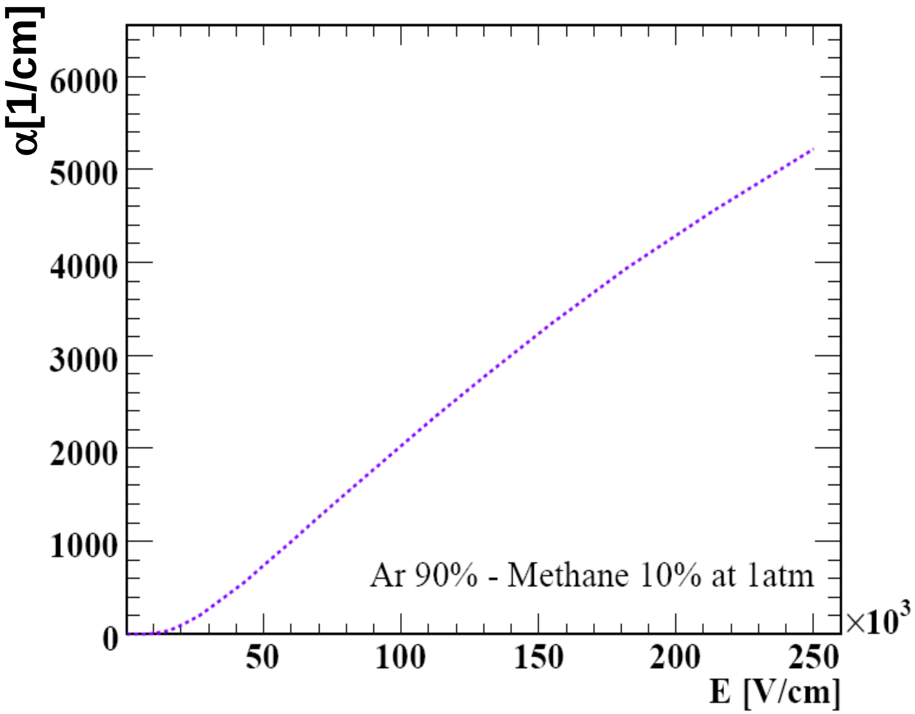








Avalanche sizes (*d*)



Example

r_{wire}=0.00125 cm r_{tube}=0.539 cm

Ar 98% - CH4 2%

===================

Alpha = 20/cm E = 10.5 kV/cm

V_{max} = 1300 V d_{min} = 100 μm (min. avalanche size)

V_{min} = 750 V d_{max} = 200 μm (max. avalanche size)

Ar 95% - CH4 5%

===================

Alpha = 20/cm E = 11 kV/cm

V_{max} = 1400 V d_{min} =120 μm (min. avalanche size)

V_{min} = 800 V d_{max} = 210 μm (max. avalanche size)

Ar 90% - CH4 10%

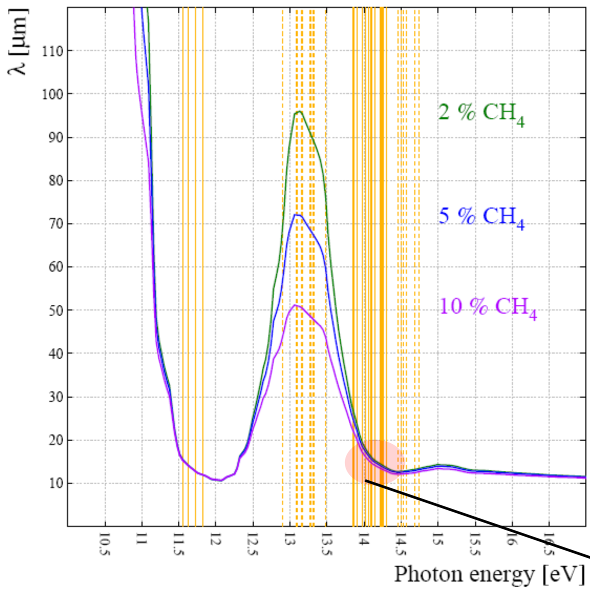
===================

Alpha = 20/cm E = 12 kV/cm

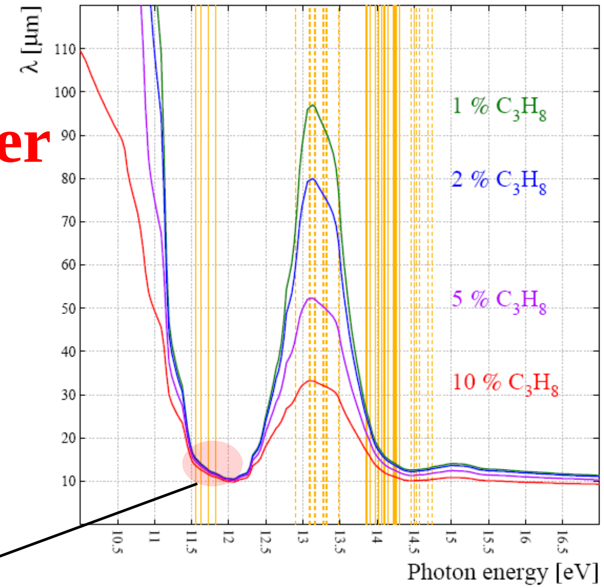
V_{max} = 1475 V d_{min} = 110 μm (min. avalanche size)

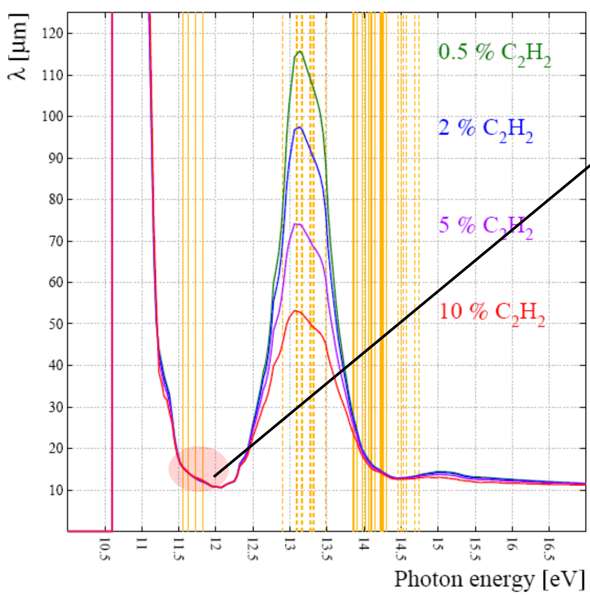
V_{min} = 800 V d_{max} = 200 μm (max. avalanche size)

Mean free path of photons (λ)



Ar + quencher

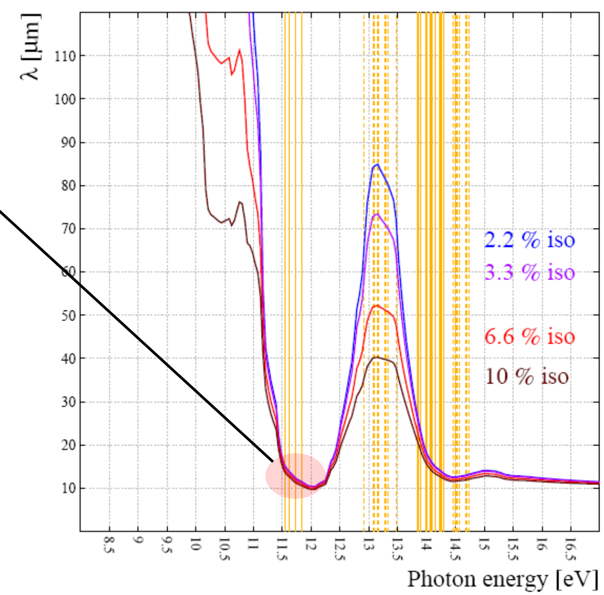




$\lambda \approx 12\ \mu m$

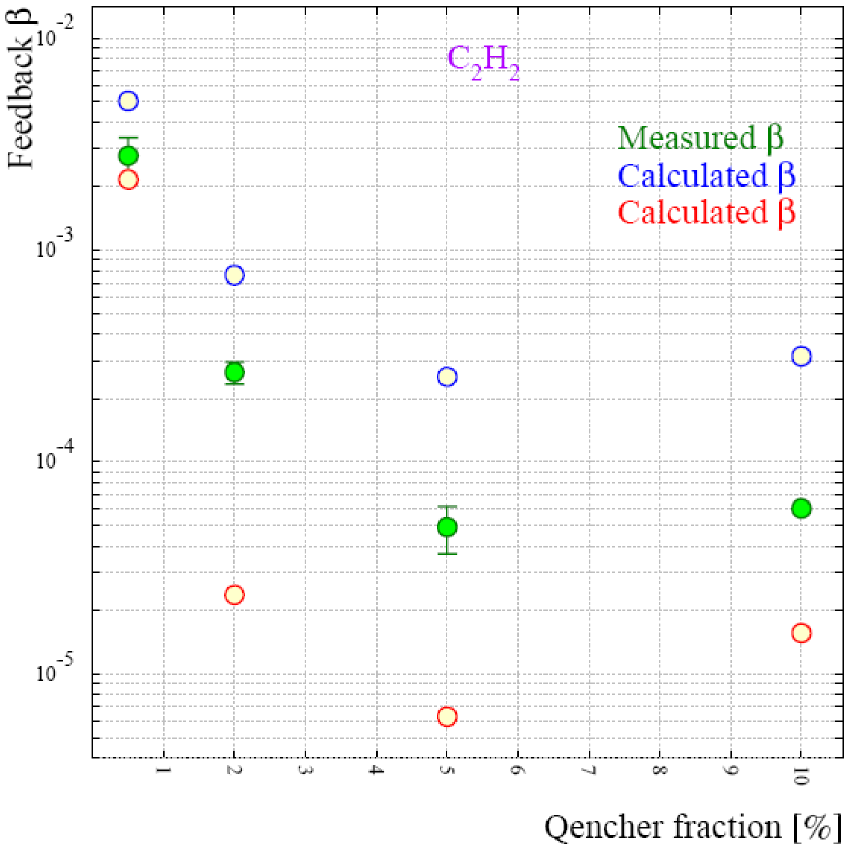
$\exp(-d/\lambda)$

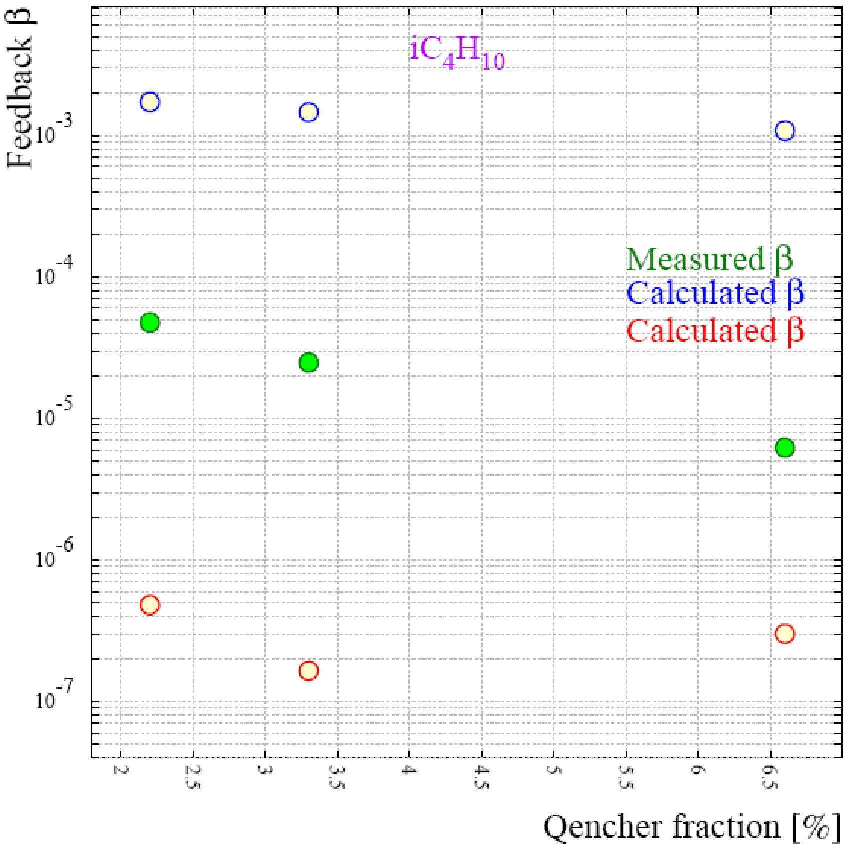
Photons will be outside the avalanche



Estimated feedback probabilities

Ar + quencher





Summary

- We can learn about the feedback mechanisms considering;
  - Mean free paths,
  - Avalanche sizes,
  - Number of photons produced per avalanche electron,
    - Penning transfer probability from the gain fits.

- A microscopic model is needed to understand the mechanisms in detail.

Update on Calculation of Gain Fluctuations

Heinrich Schindler

CERN

May 26, 2010

Penning Transfer

- transfer probability r_i: probability for excited state i to produce an ionization electron
- Ö. Sahin et al., JINST **5** P05002: determination of "overall" transfer probability r (for energetically eligible excitations) from gain curve fits for a number of Ar based mixtures
- can be implemented in a straightforward way in MC simulation

Penning Transfer

Conceptually, the effect of Penning transfer on the gain spectrum can be understood in terms of a simple model:

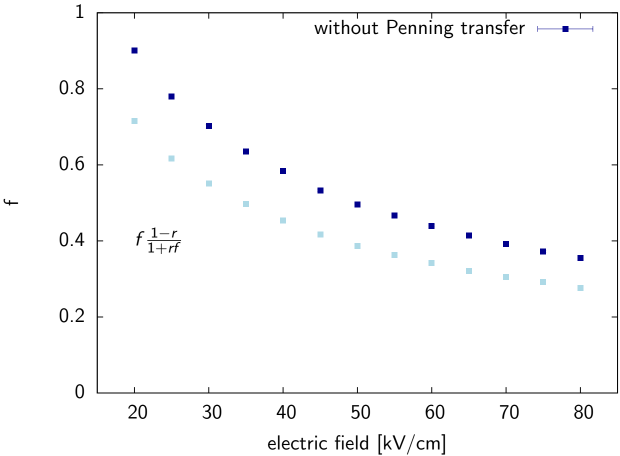
- imagine the multiplication to occur in discrete, equally-sized steps
- after each step an electron either
  - ionizes (with probability p) or
  - suffers an inelastic collision (with probability $1 - p$).
- relative width

$$f = \frac{\sigma^2}{\overline{n}^2} = \frac{1-p}{1+p}$$

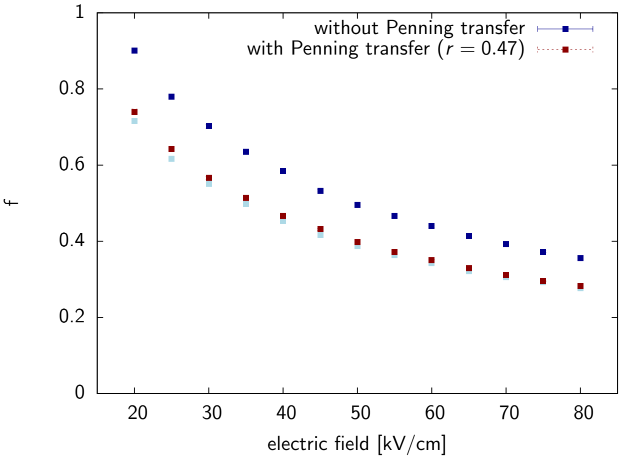
- Penning transfer enhances the effective ionization probability: $p \rightarrow p' = p + r\,(1-p)$
- relative width with Penning transfer

$$f' = f\,\frac{1-r}{1+fr}$$

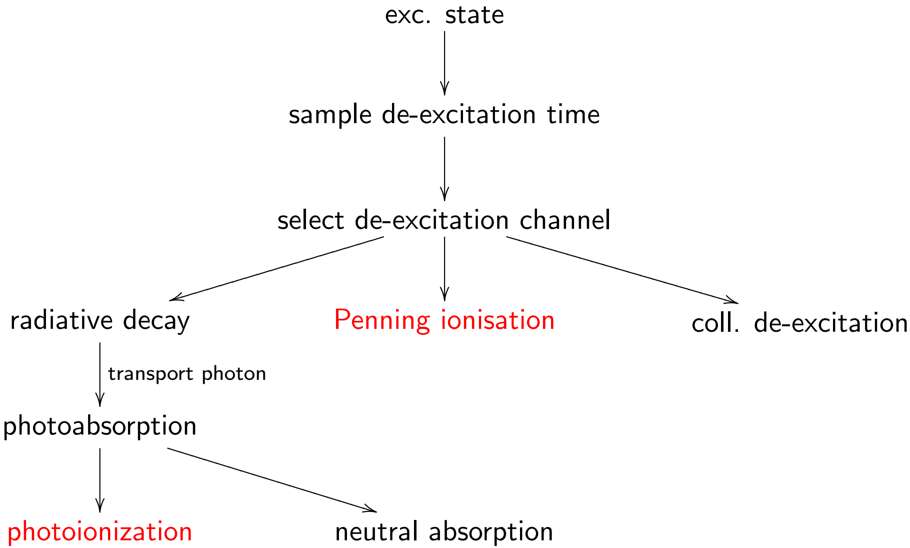
Example: Ar - CO_2



Example: Ar - CO_2

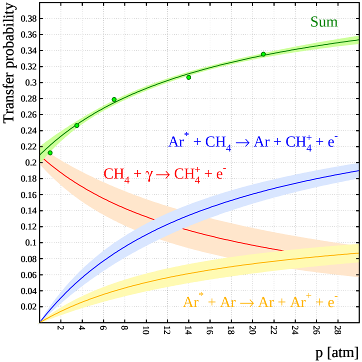


Microscopic Model



Example: P10

Ö. Sahin et al., JINST **5** P05002: Transfer probability r as function of pressure



The main processes, other than direct ionisation, responsible for the gas gain are found to be photo-ionisation and energy transfer in collisions between excited argon atoms and admixture molecules.

Transfer probability at $p = 1$ atm can approximately be reproduced in the simulation using only radiative decay.

Summary

- Penning transfer can be included in "microscopic tracking" algorithm by means of
  - (average) transfer probability $r \to$ straightforward implementation, but limited approach
  - detailed modelling of de-excitation processes and photon transport $\to$ promising, needs careful tuning (to be done) relative B.R.
- Penning transfers reduce the relative width of gain spectra due to enhanced ionisation "branching ratio"

Gas flow simulations for GEM

RD51 week

24-27 May - Friburg

Stefano Colafranceschi

Motivations

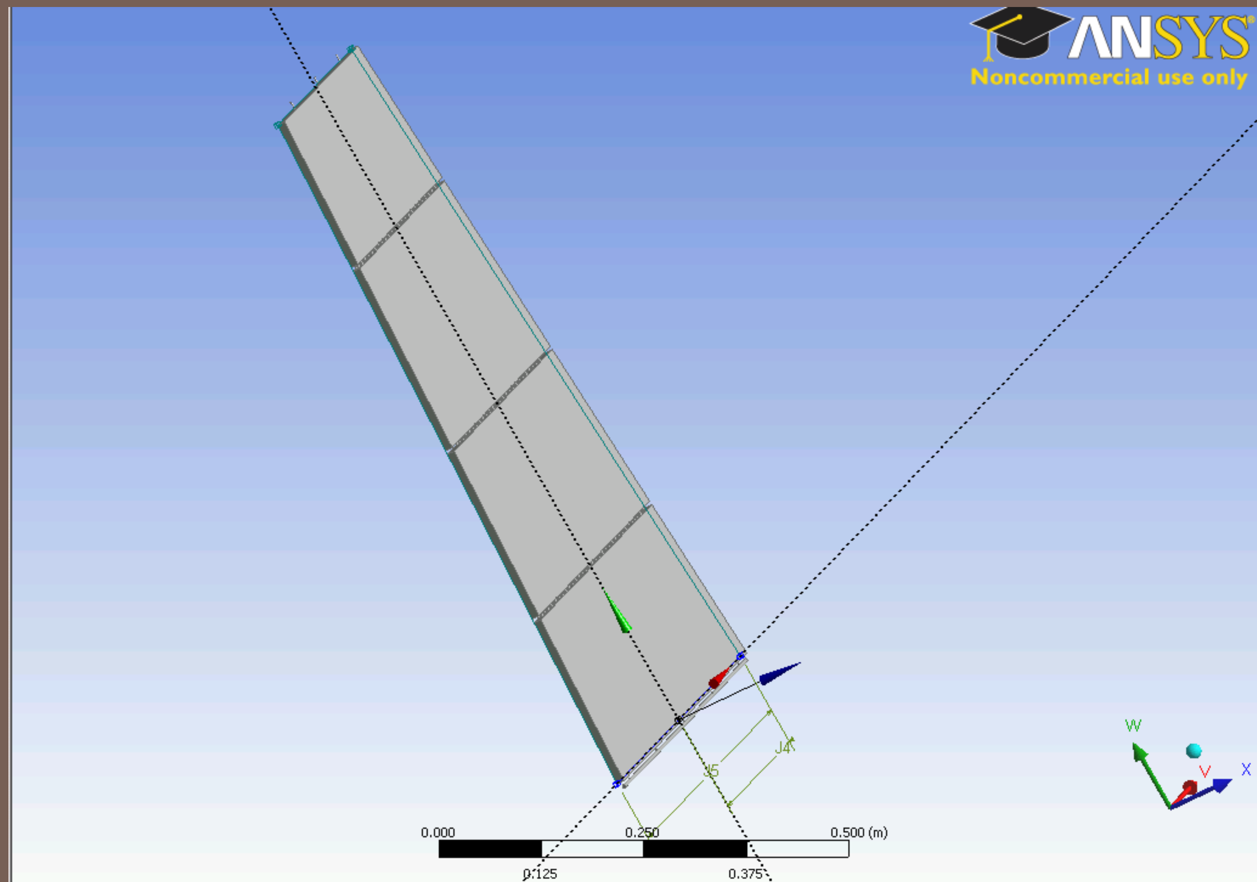
1. The goal of this work is to simulate the gas flow inside a realistic GE1/1 prototype.
2. Once the model is set, playing with parameters in order to obtain the best gas layout configuration.

RPC@CMS gas background..

1. RPC detector is very sensible to the gas mixture which is a freon based mix. When the chamber is in operation many radicals/contaminants pollute the gas mixture.
2. Hence a good gas flow is crucial to avoid dangerous contaminant accumulation .

Detector Mechanical Layout:

- The geometry is fixed and based on the RE1/1 dimensions.



Gas Layout:

- One common inlet
  One common outlet
  (5mm diameter)

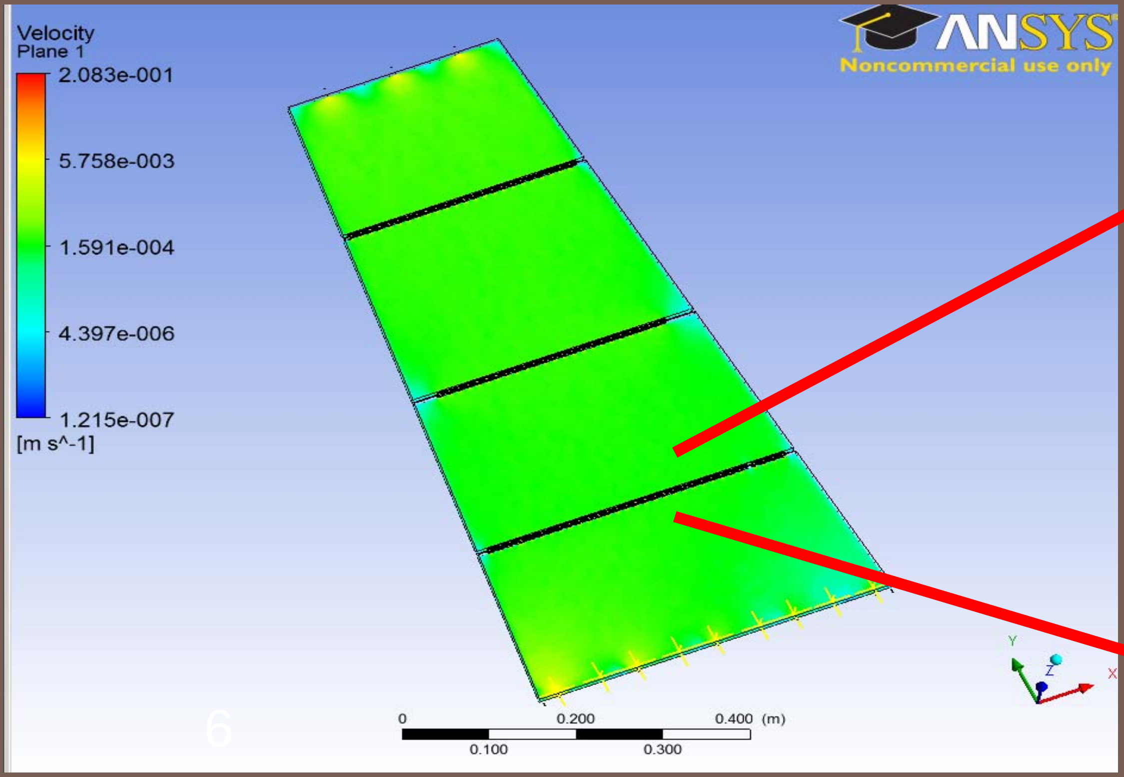
- 5 inlets and 3 outlets
  (1mm diameter)

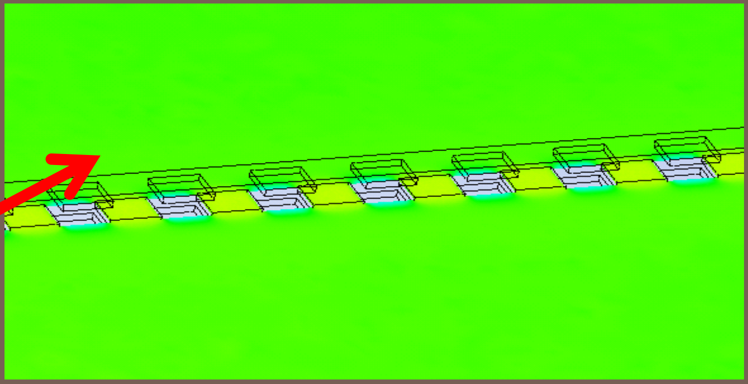
- Openings between
  chamber sectors

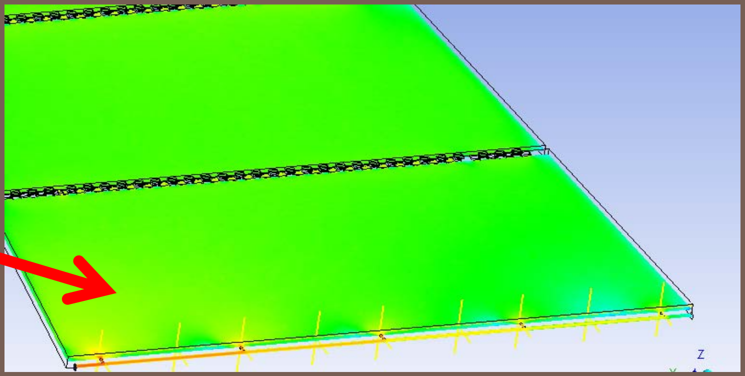
EXAMPLE CASE STUDY:

Parameters:

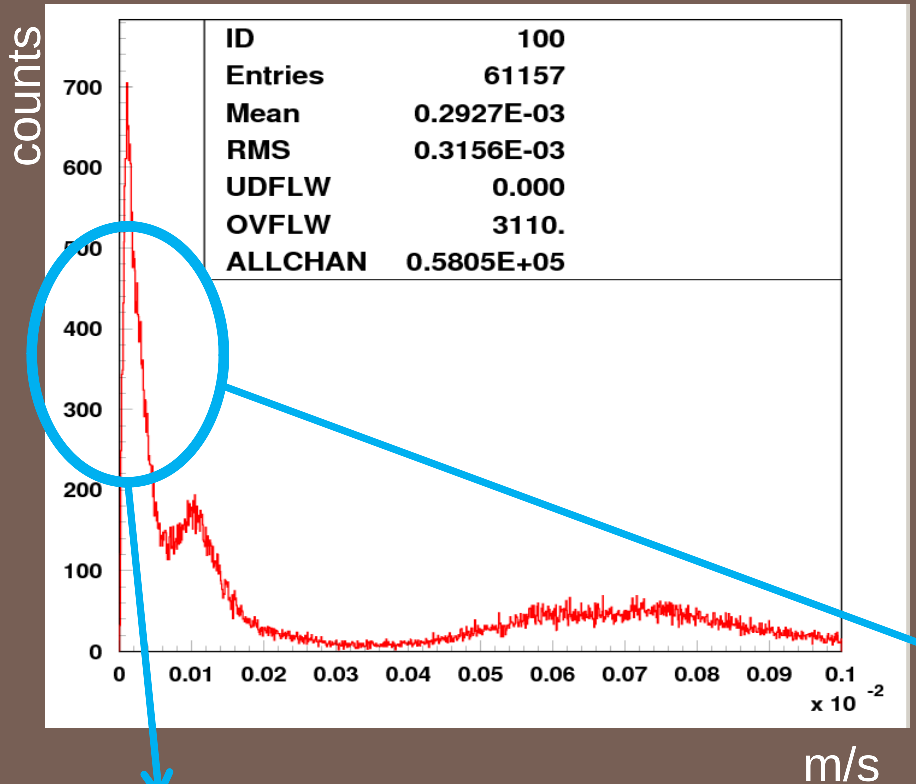
- Input gas flow 3 volume / day
- Gas mixture: Ar / Co2 (70:30) fixed
- Lateral Input







Histogram distribution of the velocity field point by point

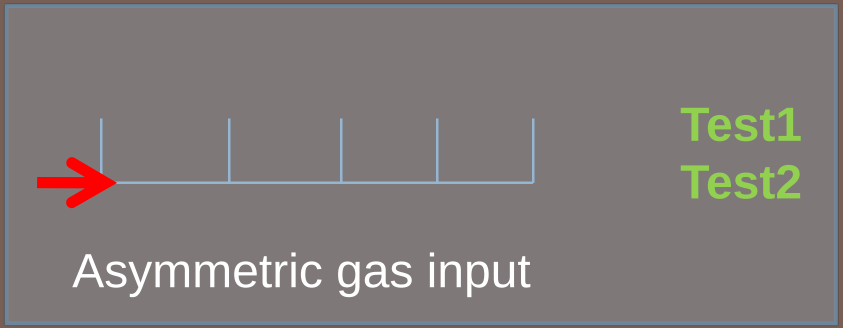


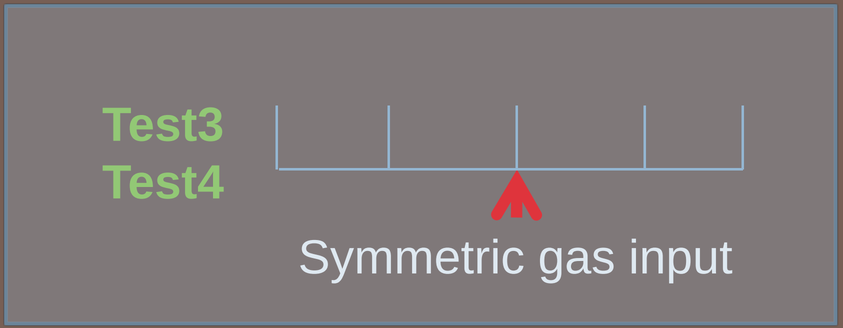
This area is representing points where the velocity field is low!

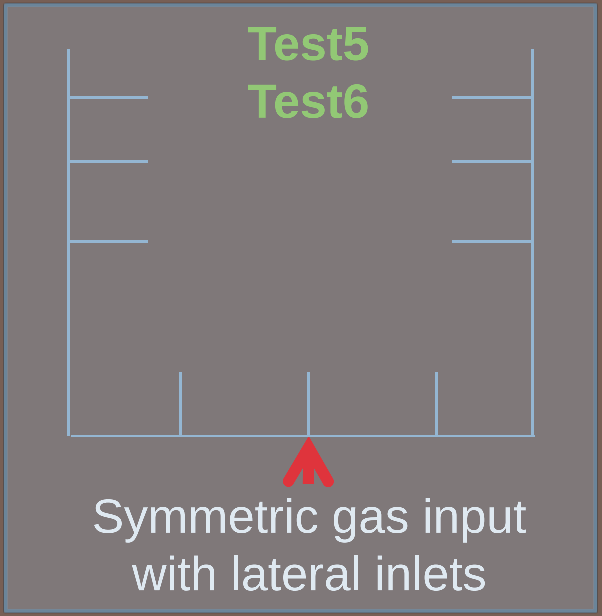
PRELIMINARY CONCLUSIONS FROM THE VELOCITY FIELD

30% chamber has a velocity field 5 times slower with respect to the mean value

Several different configurations have been taken into account changing the inlet/outlet geometry in order to reduce areas with low flux velocity.

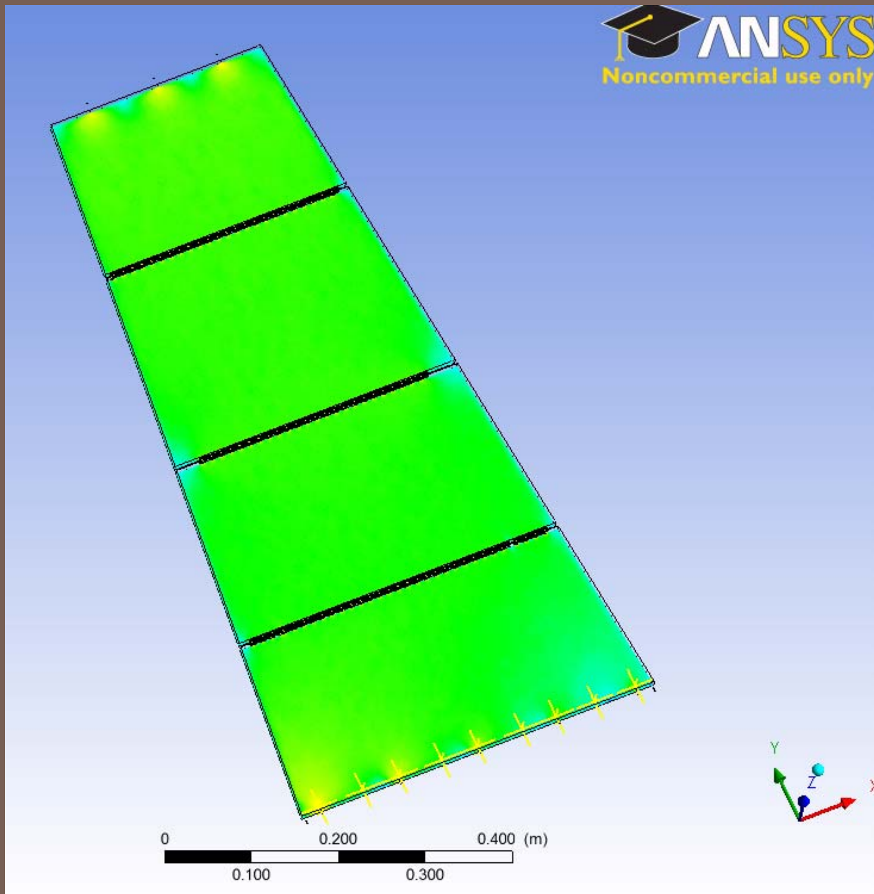




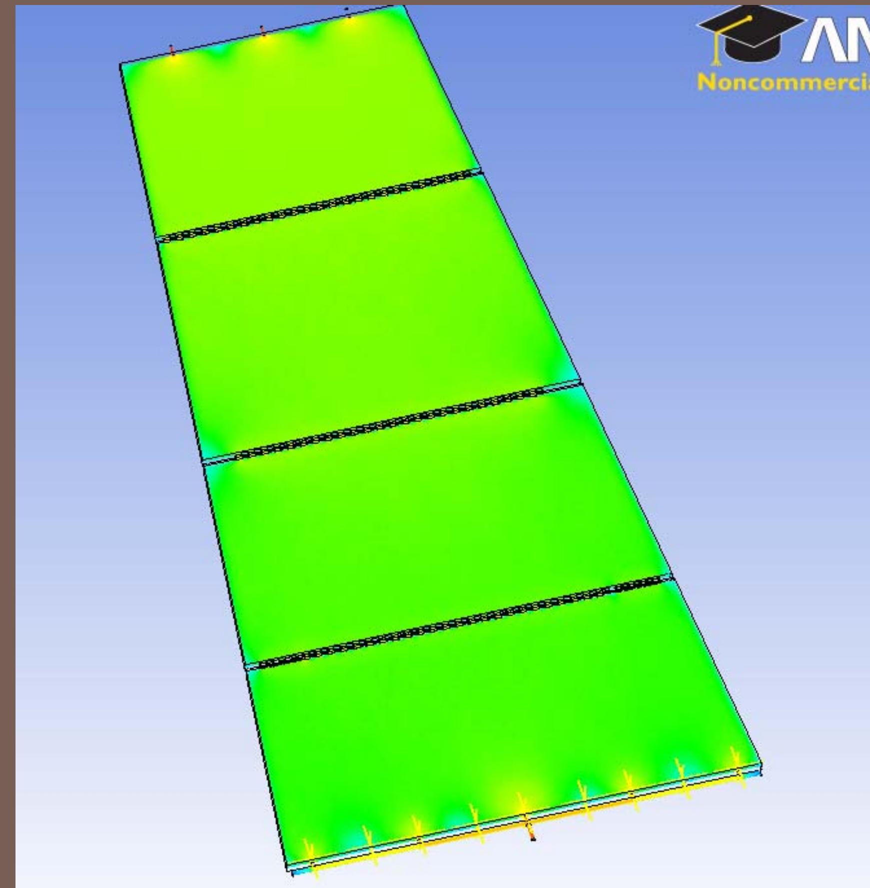


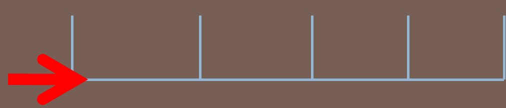
Gas simulations, preliminary studies

Test1, Test2

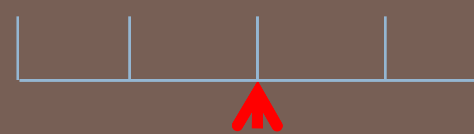


Test3, Test4





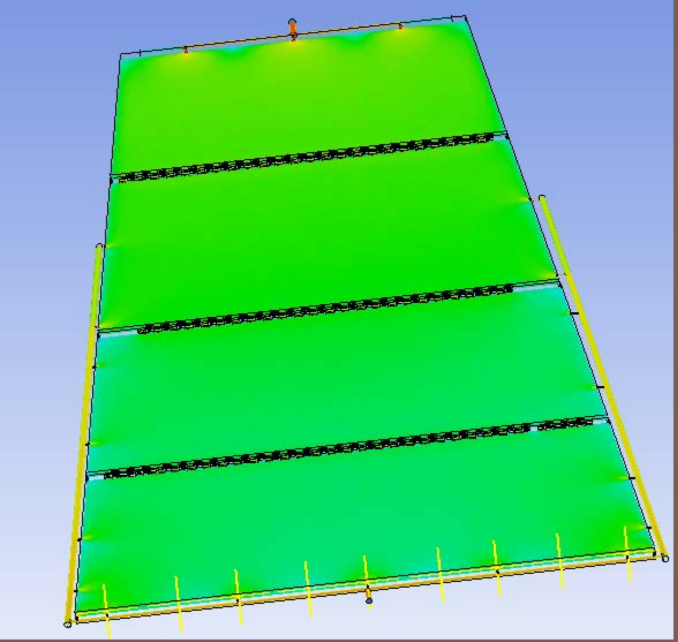
Asymmetric gas input



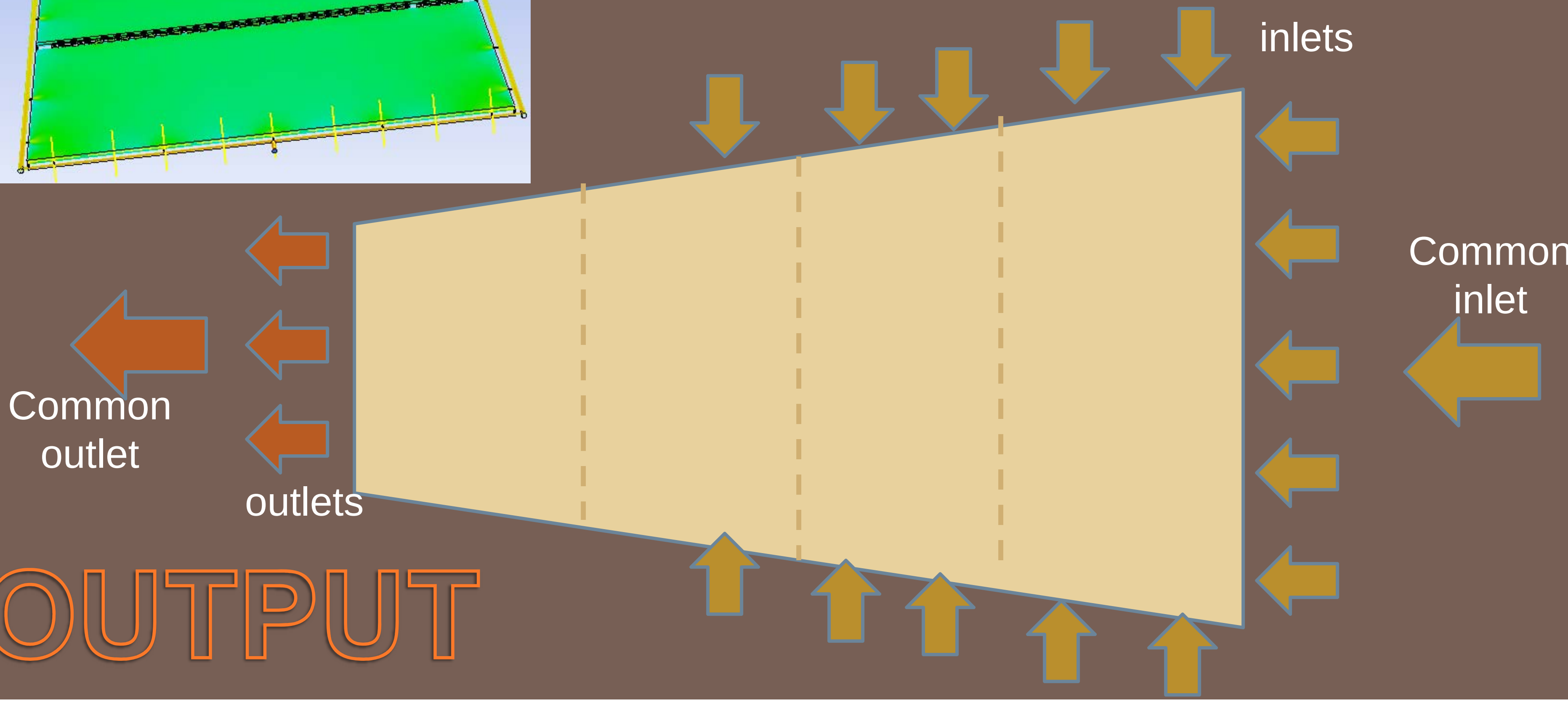
Symmetric gas input

Gas simulations, preliminary studies

Test5

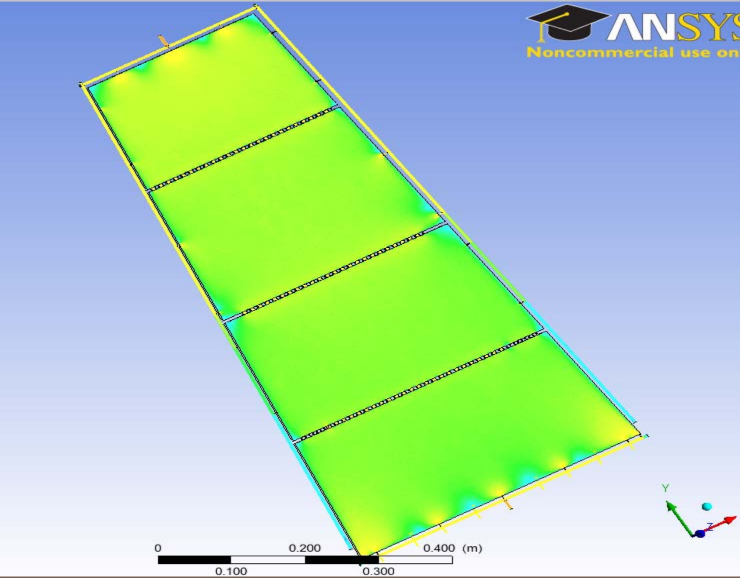


INPUT

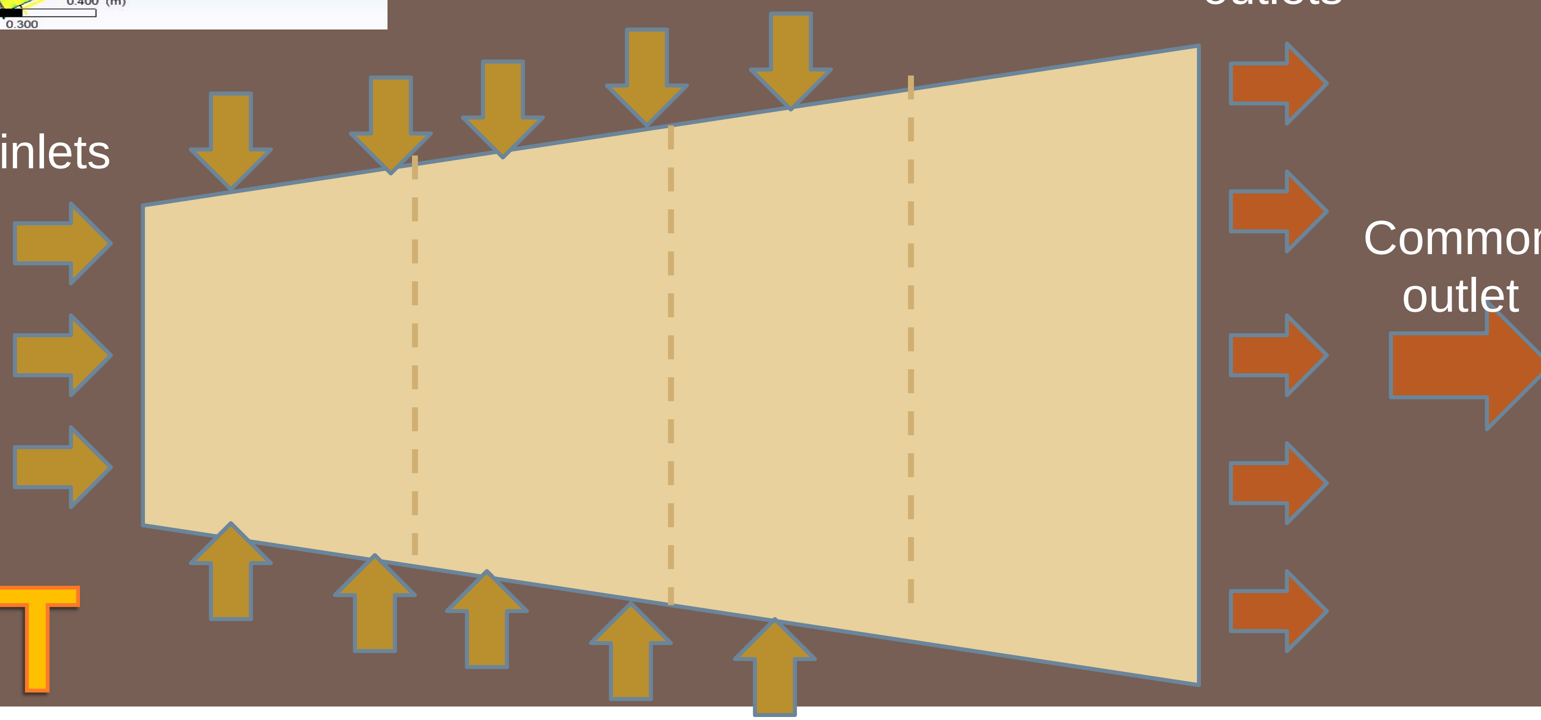


OUTPUT

Test6



OUTPUT



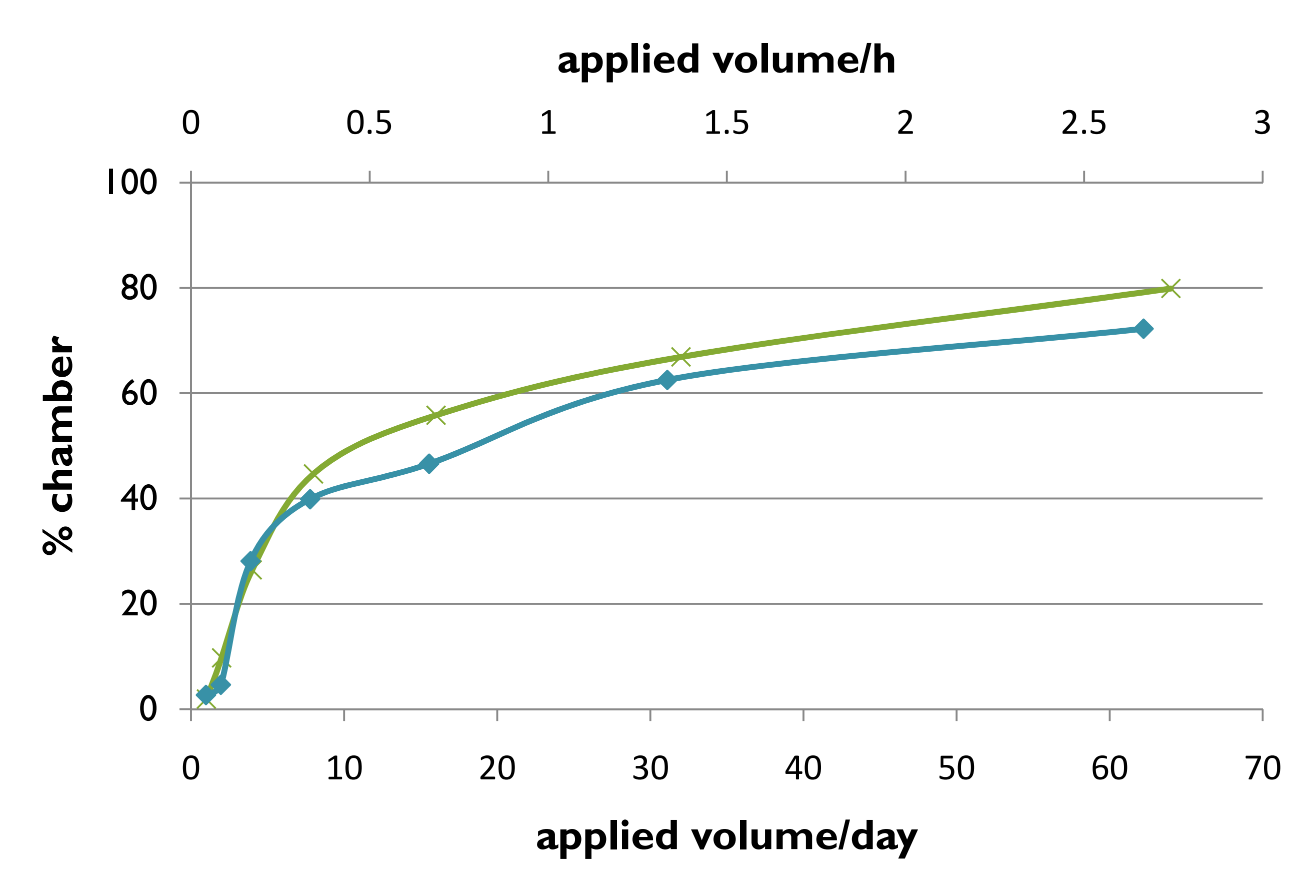
INPUT

Gas simulations, preliminary studies

Comparison lateral/lateral+central

16

ELEMENTS WITH flow >0.1vol/h



Lateral+central
Lateral

Simulations

1. The geometry has been designed with Ansys MODELER and with CFX solver we estimated the velocity field inside the chamber volume.
2. We have tested some configuration for the prototype chamber, changing the gas flow in the inputs and modifying the gas layout adding more inlets.

Data analysis

1. For each dataset we estimated the percentage of the chamber volume where the flow is below a threshold,
2. .. still a lot of work to be done to further improve the results.

Outline

C++ Interface... Interface... Interface...

- C++ GarfieldMainFrame (3rd attempt!!!)
- New Garfield in C++ for MPGD (the future)
- Geant4 Parameterization Framework (example)

- Plan for an RD51 'Software School‘

- Summary

Allow Garfield to propagate primary and daughter particles in gas volume for Geant4 !!!

- Primary Particle
- Detector geometry
- Visualization

- Primary Particle
- Ionized electron Paths
- Trajectory

Need to create Garfield Simulation in Geant4:

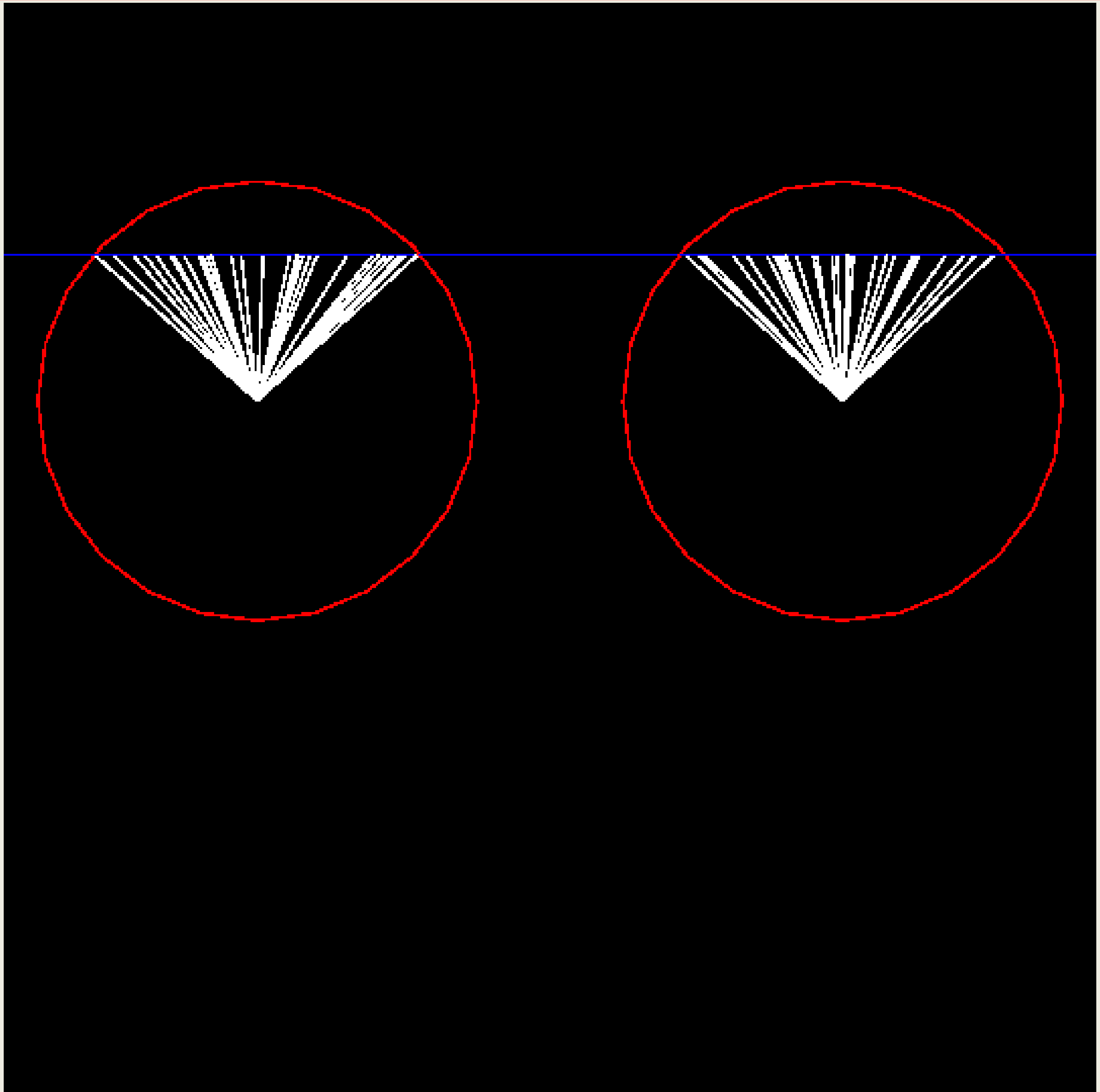
- Cell
- Gas
- DriftLine
- Track

Want to do this using **G4FastSimulationModel**:

- Define constructors
- Define pure virtual functions
  - isApplicable
  - ModelTrigger
  - DoIt

Example: Results

Visualization of Electron Paths in Geant4:



Summary (C++)

Plan of Activities C++ specific

- Consolidate C++ code... Maintain, distribute, tag, etc...

- Interface with Geant4
  - In place: cell with wires and planes with G4FastSimulation
  - Missing: generic field calculator for any geometry
  - Missing: automatic gas definition properties
  - Merge GarfieldMainFrame in C++ platform
  - Be more MPGD specific (!)

- C++ data analysis platform (test beam)

Simulation and SoftwareWorshop

Early 2011 (mini-week)

General gas detector physics

Statistical data analysis

Linux

C++

ROOT

GARFIELD (Heed/Maxwell/Margzbolz)

GEANT4

Field calculation and Boundary Element Method

Discharge / Transport

General

for junior students

Advance

for senior students

Simulation and SoftwareWorshop

Requirements and open questions

- Invited speakers (pedagogical)

- Prepare examples and lectures

- Linux laptop or fast connection to lxplus (or fast connection to remote machine)

-Standard software installed (to be defined)

- Survey the ‘level’ of the workshop (simulation & software)

- Location: at CERN (to be confirmed)

- When : to be defined

Conclusion

- Great progress in electroluminescence simulation
- Penning transfer milestone with paper in JINST
- Now at the stage of implementation (tuning) for the penning transfer
- Gas flow simulation is important and ongoing
- C++ consolidation
- Simulation and Software workshop early 2011