sDHCAL Analysis in Clermont

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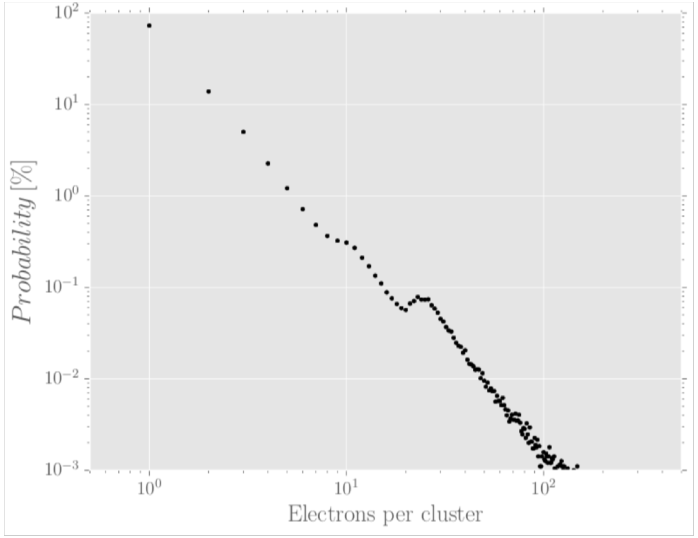
Modeling of RPC response

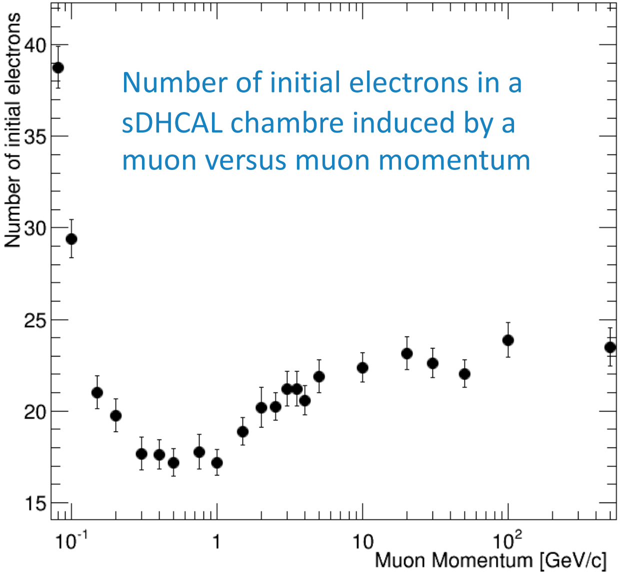
- Monte Carlo simulation of the **ionization**: electron clusters (number, charge, position)
- Electron **multiplication** (drift, multiplication, absorbtion, longitudinal diffusion)
- **Space charge effect**: electric field changes with number of electrons leads to saturations
- **Signal induction**

Method documented in JINST 11 (2016) no.05, C05023

Modeling of RPC response

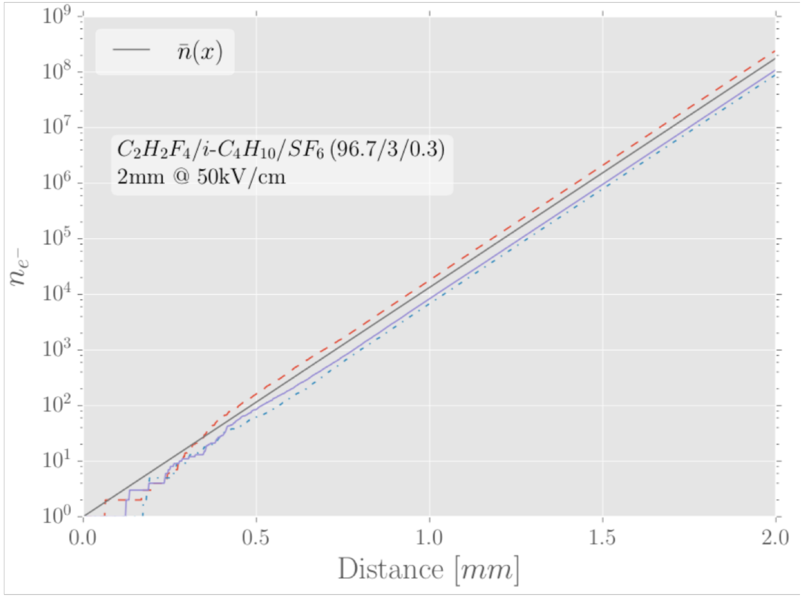
- Monte Carlo simulation of the **ionization**: electron clusters (number, charge, position)
  - Modelled with Garfield and Heed
  - Depends on gaz type, temperature, pressure, particle type and energy



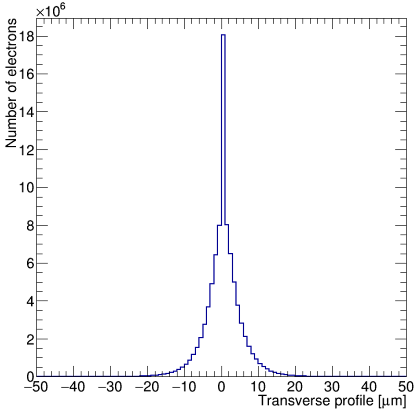


Modeling of RPC response

- Electron **multiplication** (drift, multiplication, absorbtion, longitudinal diffusion)
  - Multiplication and attachment probabilities function of the drift and electric field
  - Drift function of the electric field
  - Longitudinal diffusion changes electron positions (increases the path)
  - Transverse diffusion implemented but swiched *off*

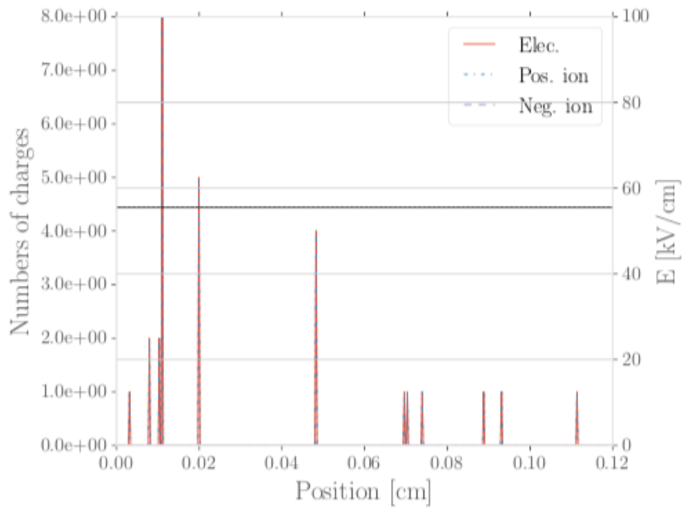


Minor impact but gives an estimate of the avalanche width → small!

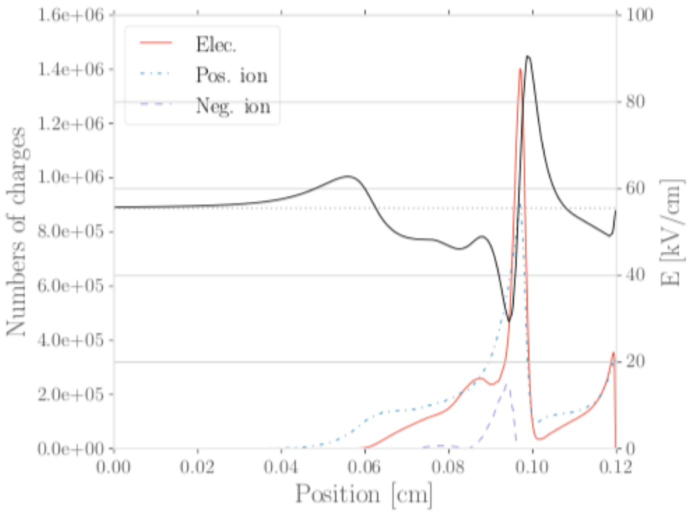


Modeling of RPC response

- **Space charge effect**: electric field changes with number of electrons leads to saturations
  - Fully modelised by computing the field of all the charges in gas gap
  - To be done at each step of the electron multiplication and drift



(a) timestep 0 ($t = 0\,\mathrm{ns}$)

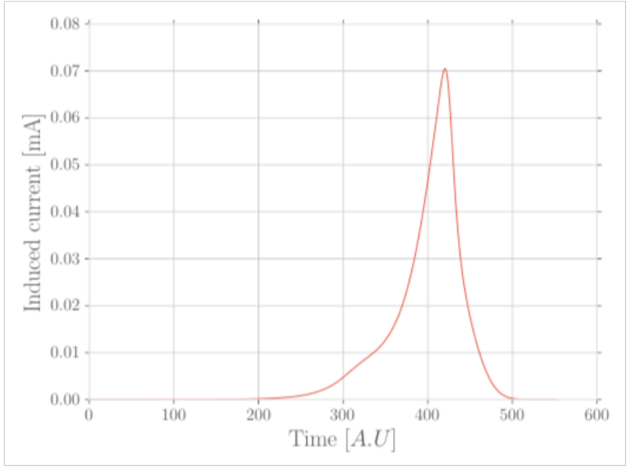


(c) timestep 449 ($t = 1.09\,\mathrm{ns}$)

Modeling of RPC response

- **Signal induction**
  - Output signal is only due to the movement of electrons in the electric field
  - Ions do not contribute due their small velocity Use of Ramo's theorem to compute induced signal
  - Segmentation in pads ignored (*cf.* Lyon studies for size of induced signal)

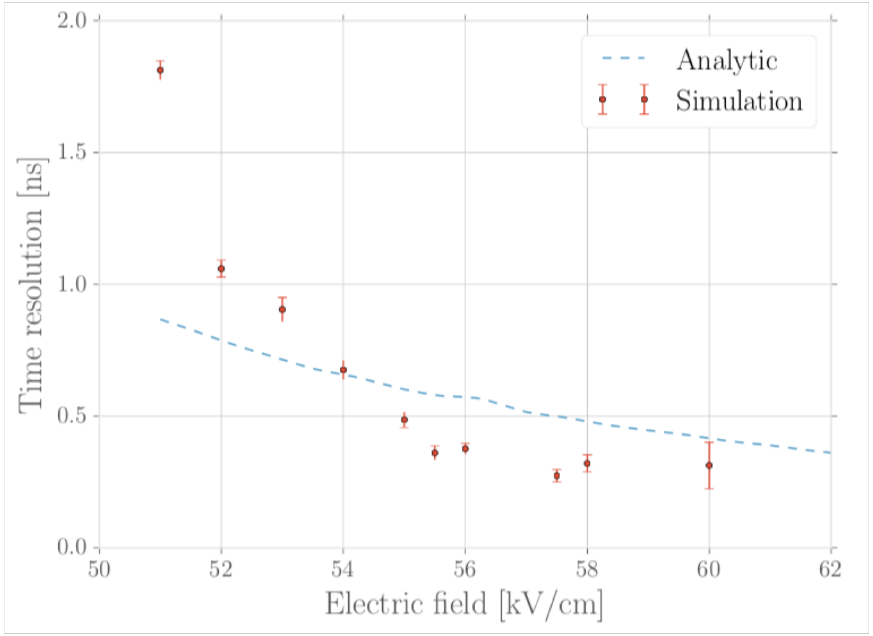
  - Results quantified in efficiency (probability to pass 1st threshold), induced charge, time resolution



Simulation of the response (vs time)

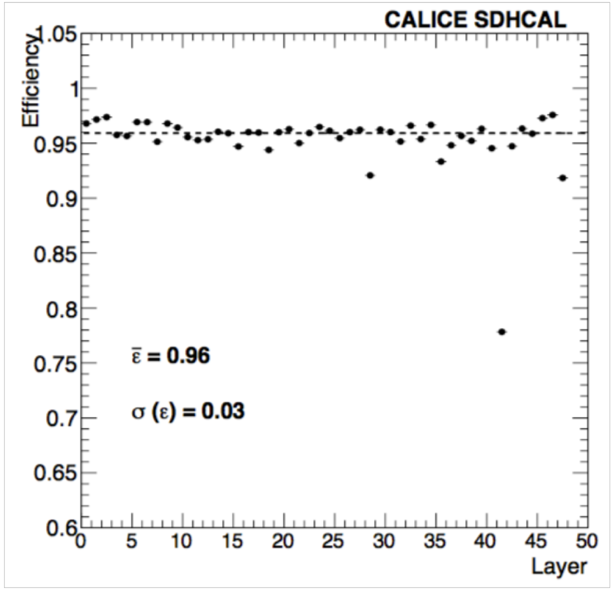
- Simulation of the signal shape and evolution allows to estimate the time resolution

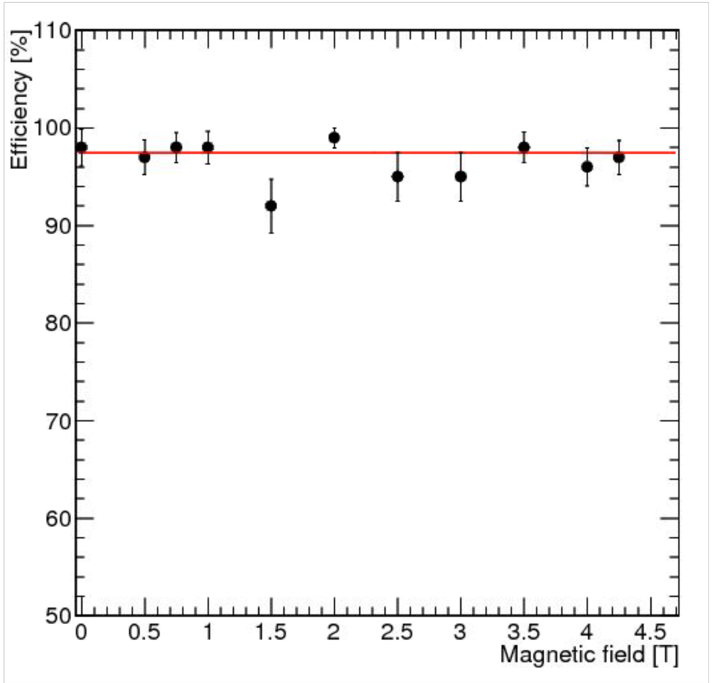
- About 300 *ps* for a single gap



Simulation of the response (vs B field)

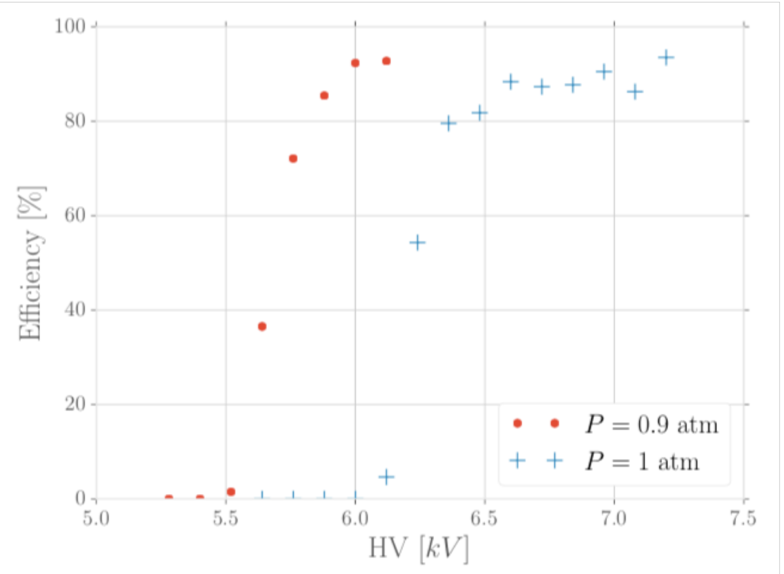
- sDHCAL efficiency per RPC in response to 100 GeV muons
- Stable w.r.t a magnetic field (0 to 4.25 T)
- Efficiency coherent with testbeam measurements





Simulation of the response (vs pressure)

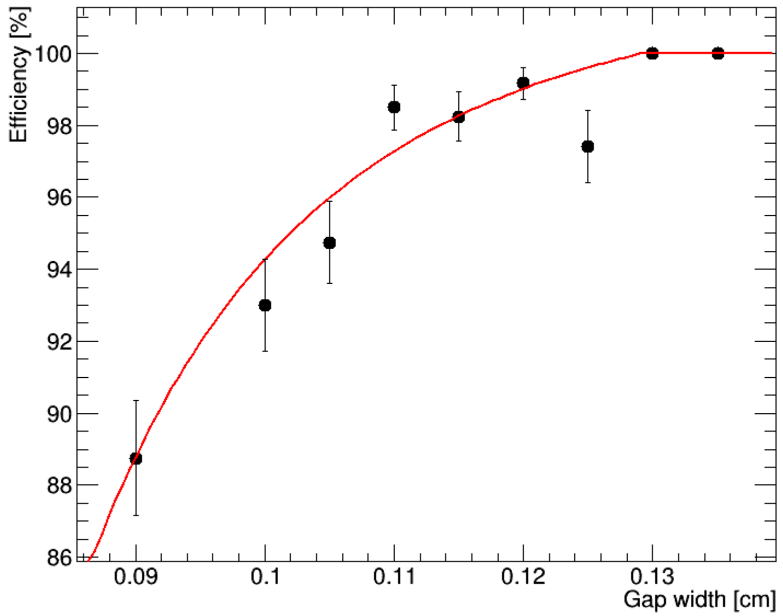
- Estimate of the impact of the environment
- Impact of pressure (extreme case with 10% variation)



- Cathode 0.11 cm, Anode 0.07 cm, Gap 0.12 cm, HV 57.5 kV/cm
- Glass @ $10^{12}\ \Omega cm$

Simulation of the response (vs thickness)

- Non-linear dependence due to saturation effects
- A deformity of ±100 μm leads to +1.5%/-3% variation in the efficiency



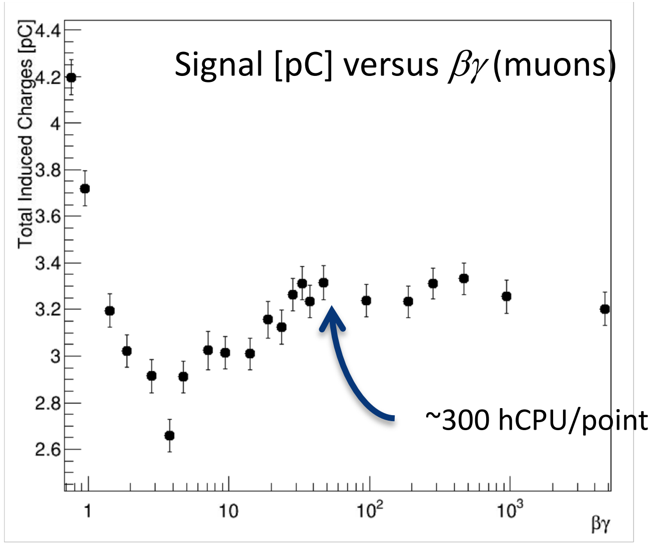
Simulation of the response (vs particle)

- MIPs are usually considered as a reference for calibration
- The simulation tells us that there is a dependence between induced signal and particle $\beta\gamma$ and type
- Digitization in the current simulation considers all ionizations as identical and calibrated with 100 GeV muons

→ Since sDHCAL is not analog, this is ~OK (only migrations hit1→hit2 matters)

→ Still the impact on the efficiency should be sizable

→ Use the avalanche simulation to dump a model of efficiency correction $f\,(\beta\gamma$, particle type)



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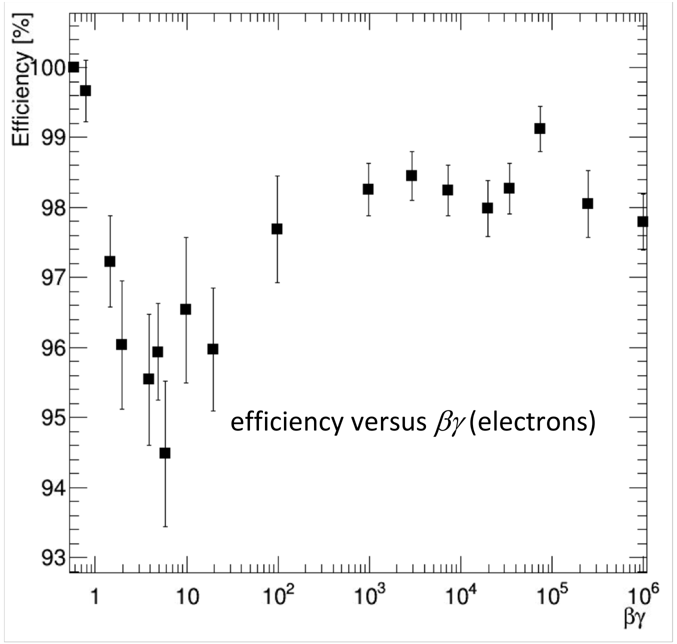


Impact on digitization

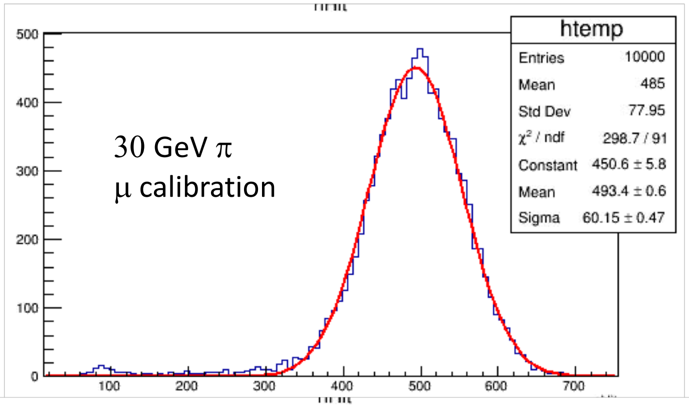
- Already implemented with help of Guillaume using Lyon digitization

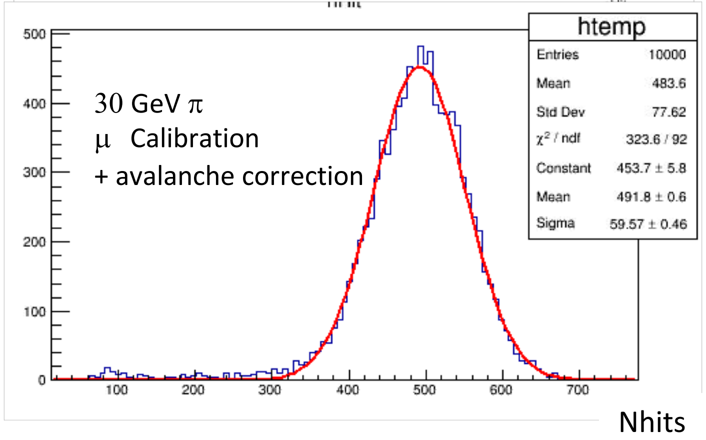
- Full simulation and digitization using muon calibration + avalanche simulation corrections

  option added in a private version of the digitizer

- First results under study and check

- need to use a full set of electron and pion simulations to compare with data





Outlook

- Studies being documented in a note. Other variations were tested (eg., gaz composition, HV, ...)
- Digitization part must be harmonized with potential other updates from Lyon
- Contribute to another data analysis : priorities needed for next months