The time structure in RPCs and Scintillators with GEANT4

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Outline

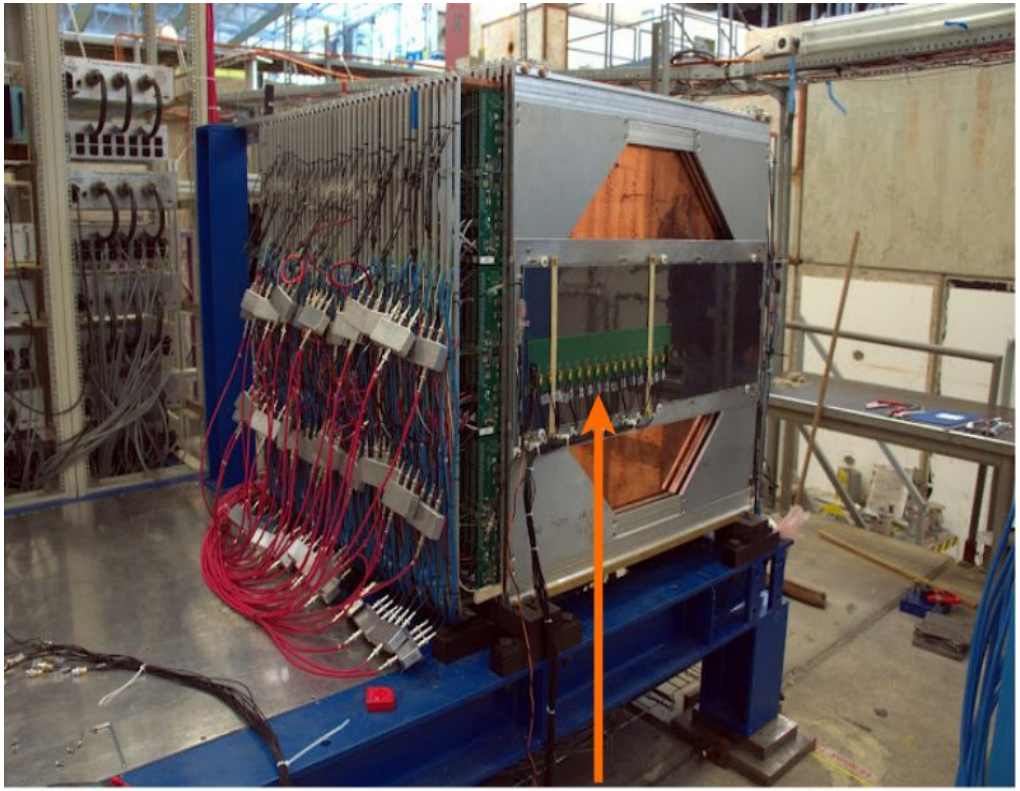
- FastRPC (Resistive Plate Chamber)
- FastRPC Simulation
- Results:
  - GEANT4 Physics list comparison
  - Range cut influence
  - Amplitude MIP cut influence
  - Influence of Gaussian smearing
  - Comparison to measured data

Motivation

- FastRPC took data in 2012
- Study timing in hadronic showers
- How precise can we simulate the time structure in RPCs
- Check if slow neutron processes have late time contribution

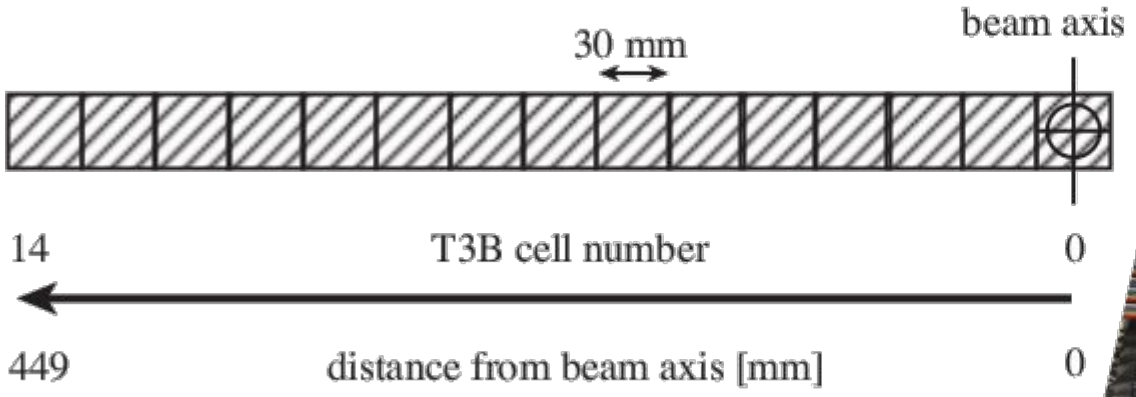
FastRPC

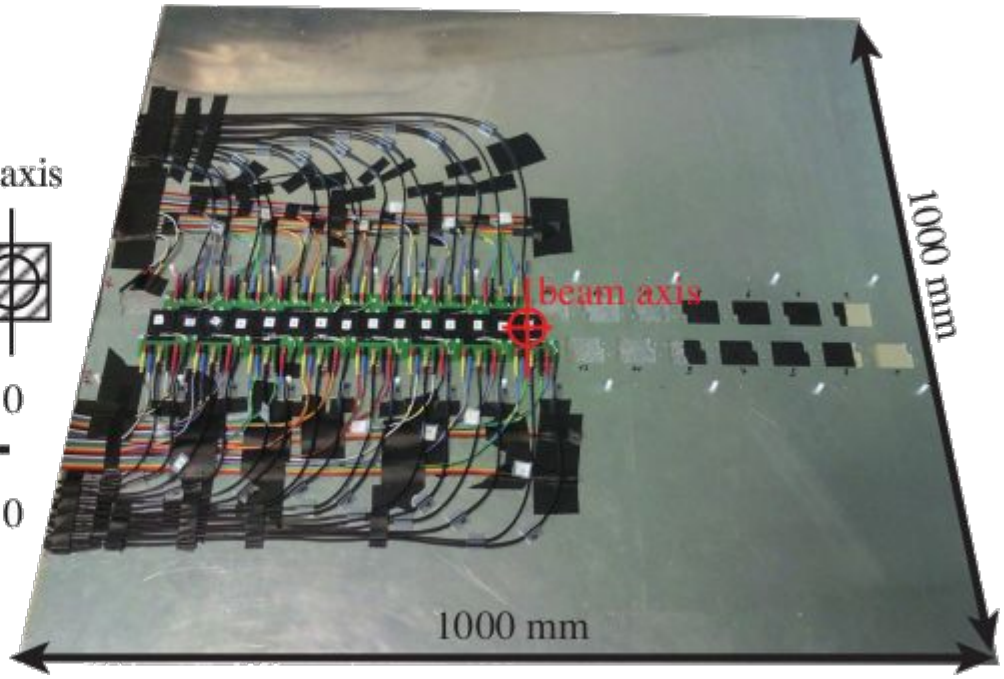
- Experimantal setup in place at CERN PS and SPS facility in 2012
- Resistive Plate Chamber (RPC) sampling calorimeter
  - Tungsten absorbers
- Mirror T3B with different technology / active material
  - 39 layer sampling calorimeter
- FastRPC
  - 15 output channel (Cells)
- Using GlassRPC from the Argonne Group



FastRPC

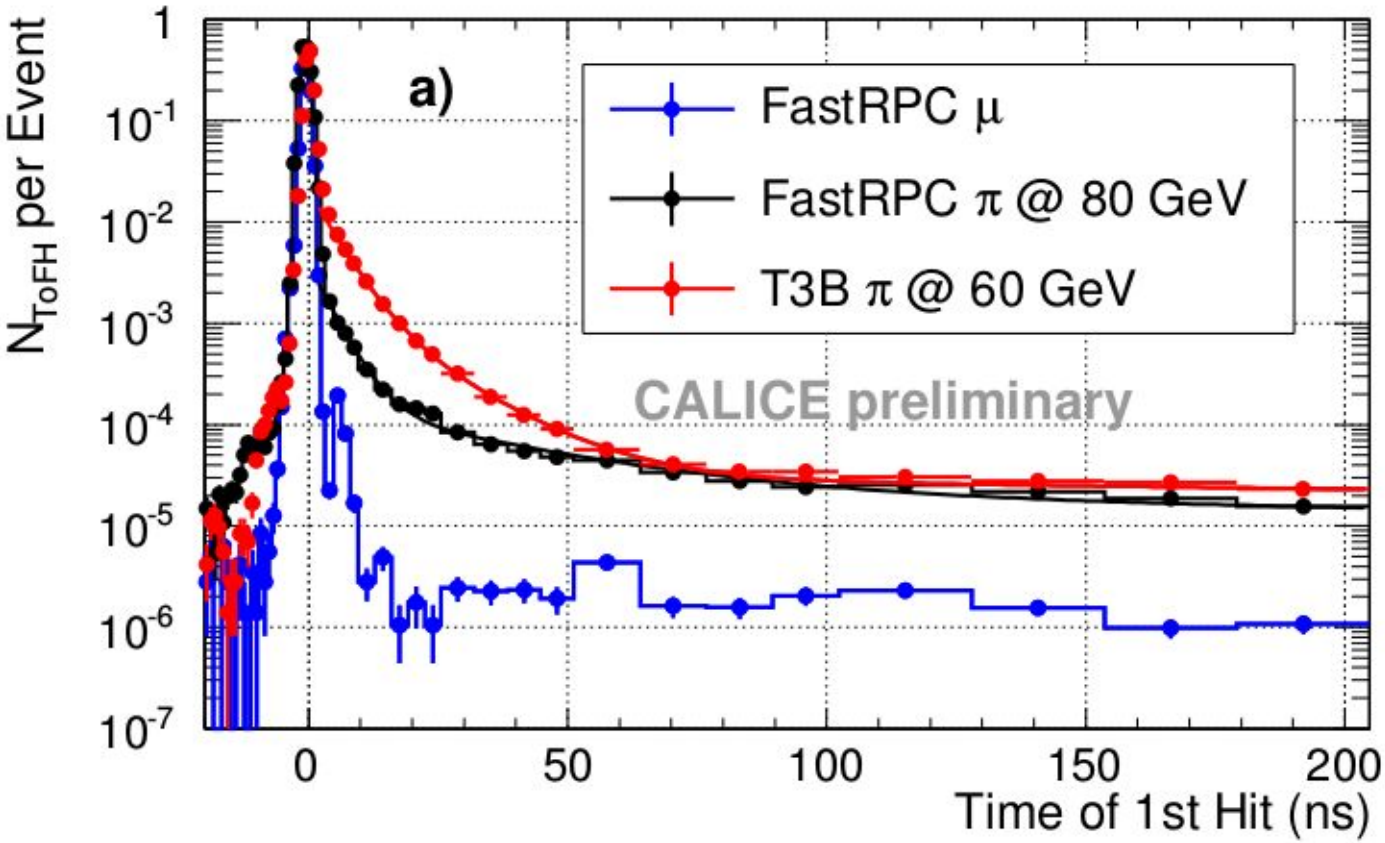
- FastRPC/T3B has 15 3*3cm cells
- Cell 0 is in the beam center





Measurement

- Muon calibration
- Peak mostly EM shower, relativistic hadrons (~ 1 ns)
- Current interpretation:
  - Neutron elastic scattering (~ 10 ns) suppressed with gas detector readout
  - Capture of slow neutrons (> 100 ns)

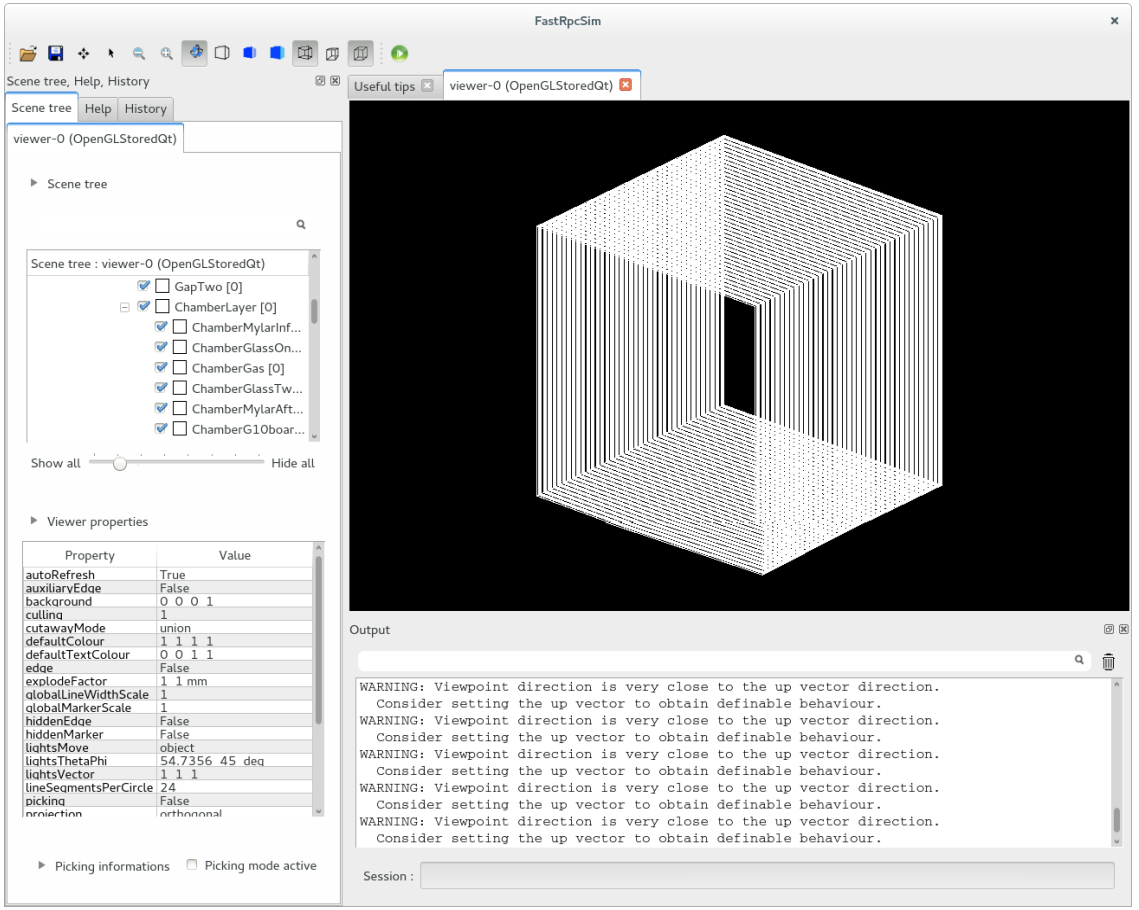


Simulation Geometry

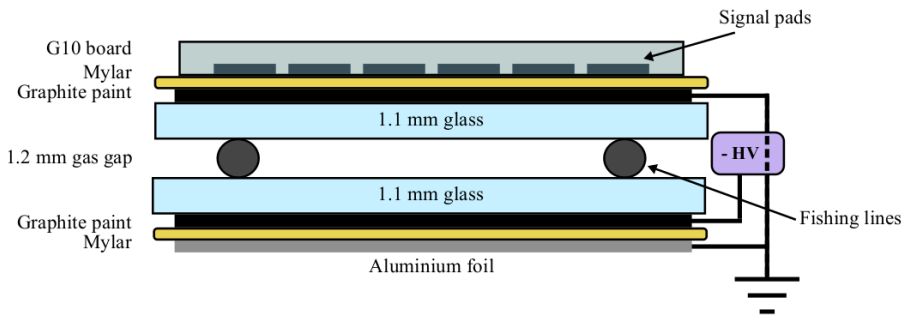
- Simulate all 39 Layers of the sampling Calorimeter DHCAL
- The 15 FastRPC

  Cells are in the

  last layer



Simulated Active Layer



RPC Gas simulated:

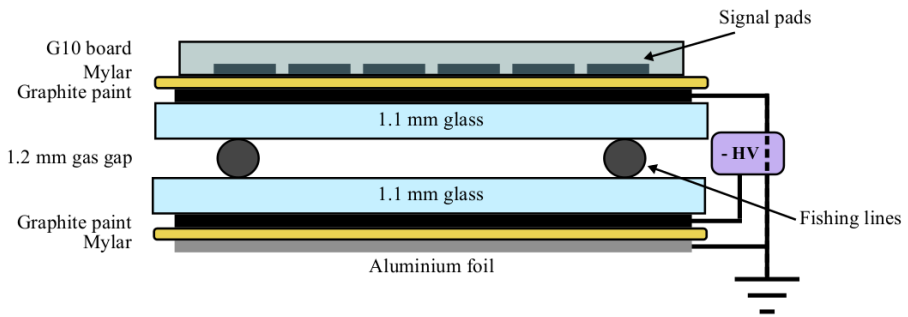
94.5 % PVDF (C2H2F2)

5 % Isobutane (C4H10)

0.5 % SF6

- Each Layer has:
  - two Absorber
    - 0.5 mm steel
    - 10 mm Tungsten
  - 2.15 mm air gap
  - 2 mm steel absorber
  - 0.5 mm air gap
  - 0.05 mm mylar
  - 1.15 mm glass
  - 1.15 mm of RPCGas
  - 0.85 mm glass
  - 0.05 mm mylar
  - 3.35 mm of NemaG10
  - 1.5 mm of air gap

Simulated Active Layer



RPC Gas simulated:

94.5 % PVDF (C2H2F2)

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0.5 % SF6

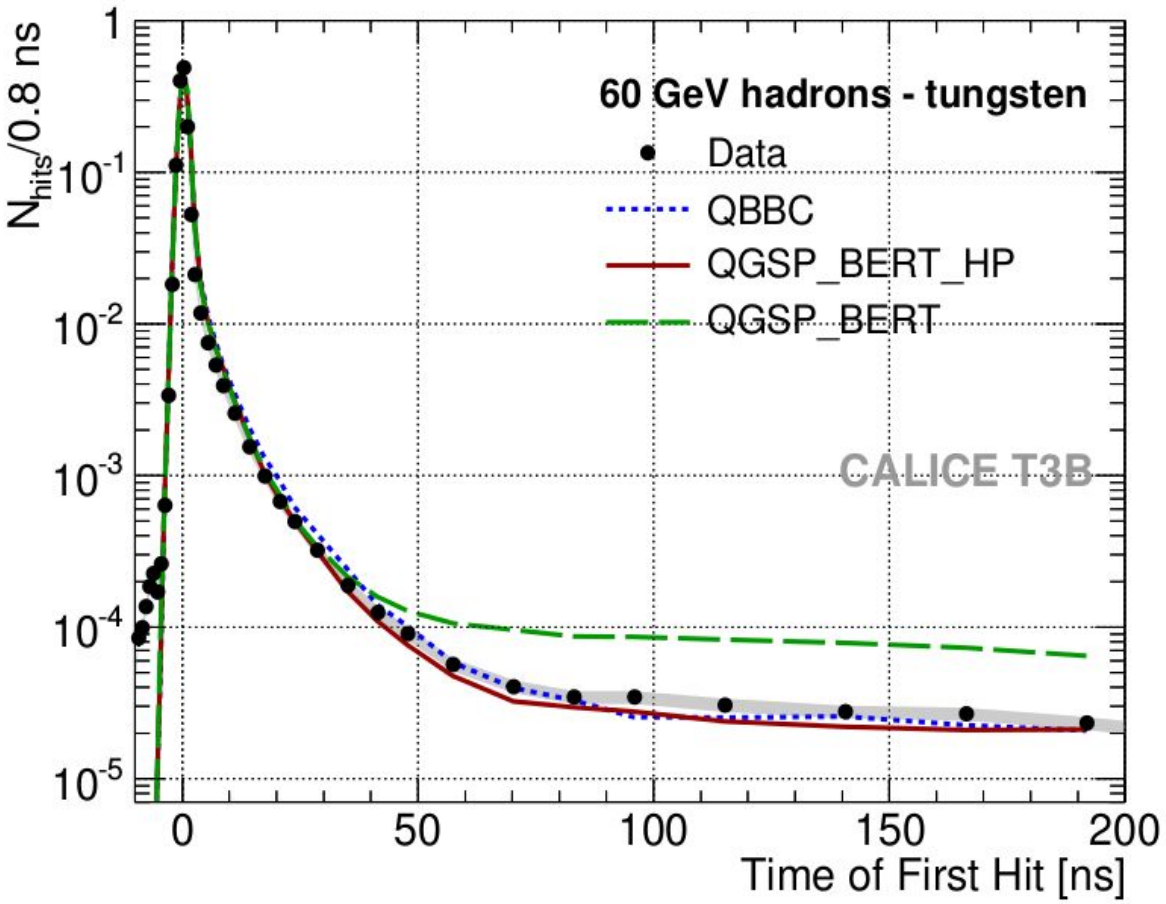
Scintillator simultation for comparison by replacing Gas with Scintillator

NB: not full T3B simulation

- Each Layer has:
  - two Absorber
    - 0.5 mm steel
    - 10 mm Tungsten
  - 2.15 mm air gap
  - 2 mm steel absorber
  - 0.5 mm air gap
  - 0.05 mm mylar
  - 1.15 mm glass
  - 1.15 mm of RPCGas
  - 0.85 mm glass
  - 0.05 mm mylar
  - 3.35 mm of NemaG10
  - 1.5 mm of air gap

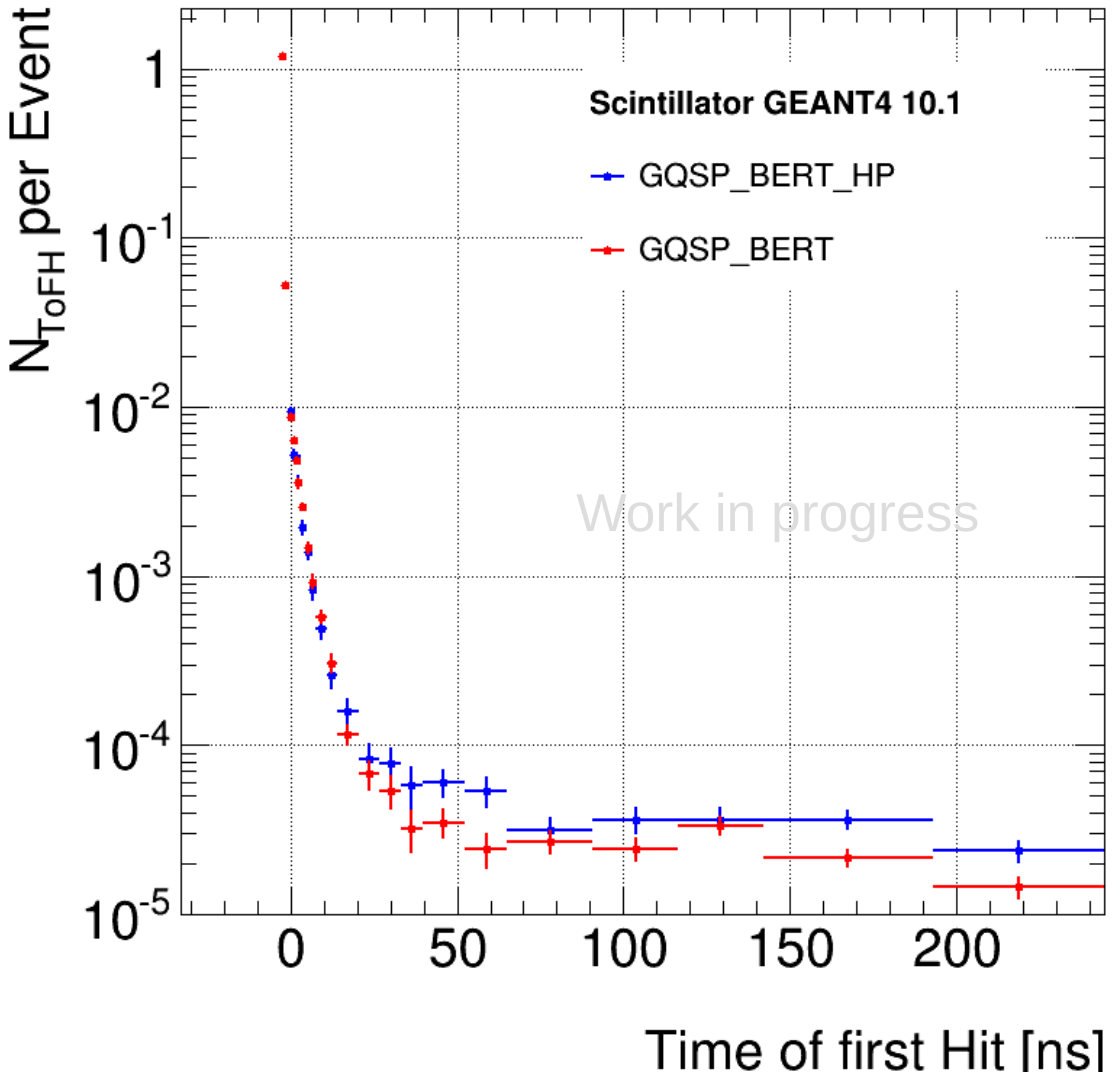
Physics list comparison

- T3B simulations with G4 9.4.p03
- Quark-Gluon-String (QGS)
- Bertini cascade with data driven NeutronHP
- QGSP_BERT above QGSP_BERT_HP for t > 50 ns



Physics list comparison

- Scintillator Simulation with G4 10.1.p02
- Quark-Gluon-String (QGS) model has been improved significantly
- Bertini cascade with data driven NeutronHP

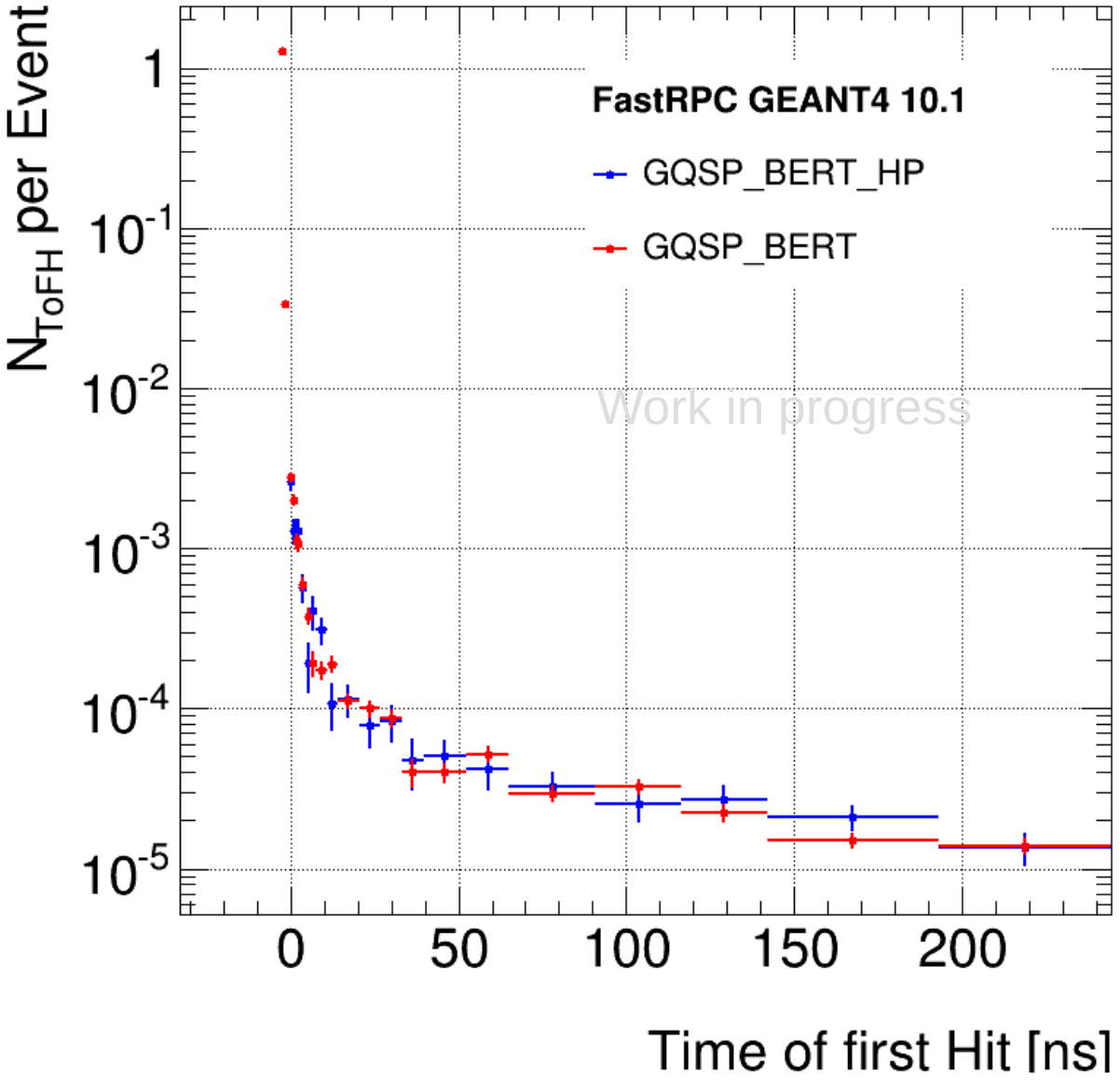


Physics list comparison

- RPC Simulation

  with G4 10.1.p02

- Less hydrogen
  - → less sensitive to Neutrons
  - → less important

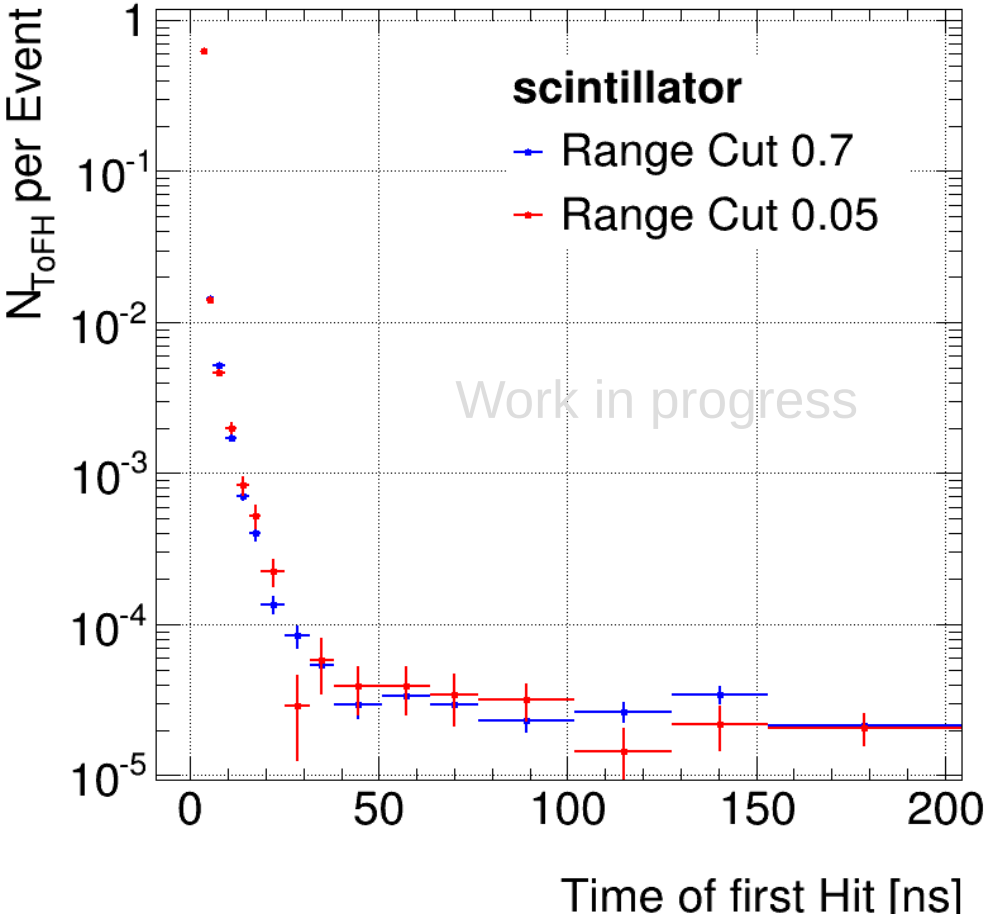


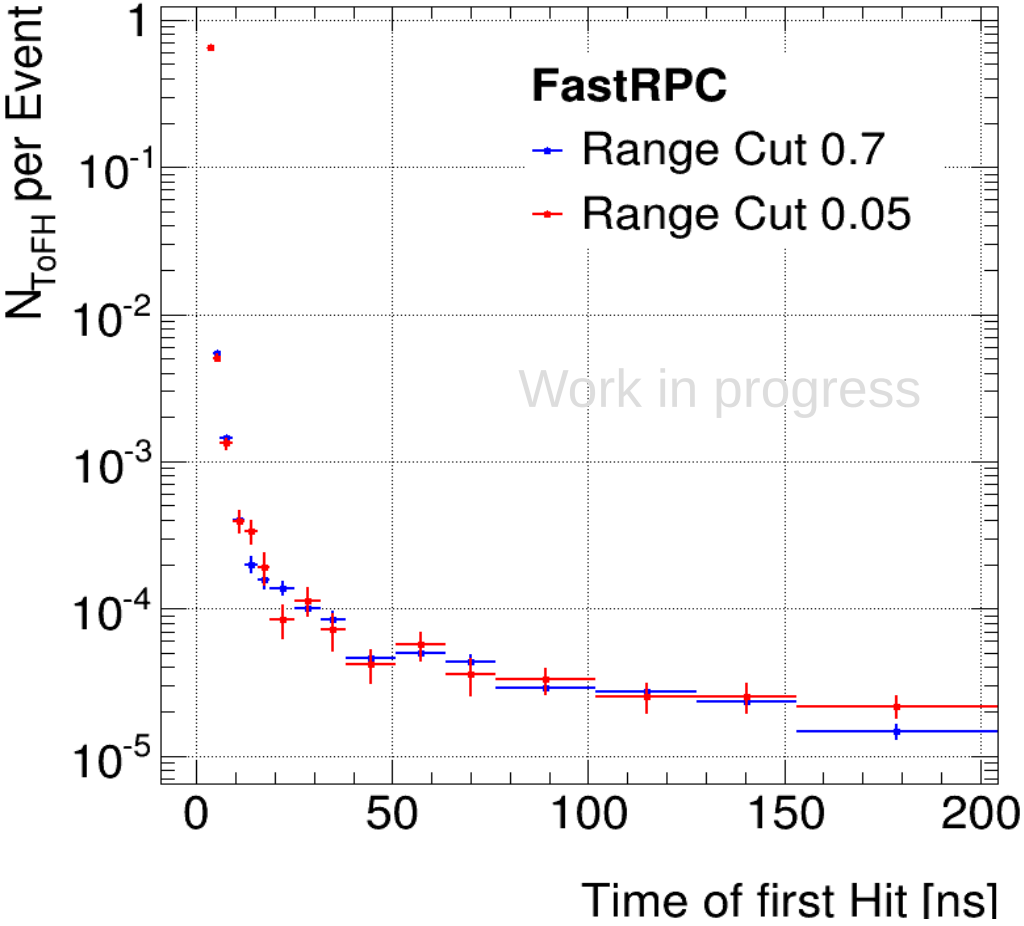
Simulation pipeline

- No digitisation implemented yet
- Use the Steps of Geant4
- Each Step we read out Edep + Time
- MIP Cut: **fraction** of energy of a Minimum Ionizing Particle
- Smearing to emulate time resolution
- Time of first Hit: deposition of Energy with more than a **fraction** of a MIP in the FastRPC gas layer

Range Cut impact

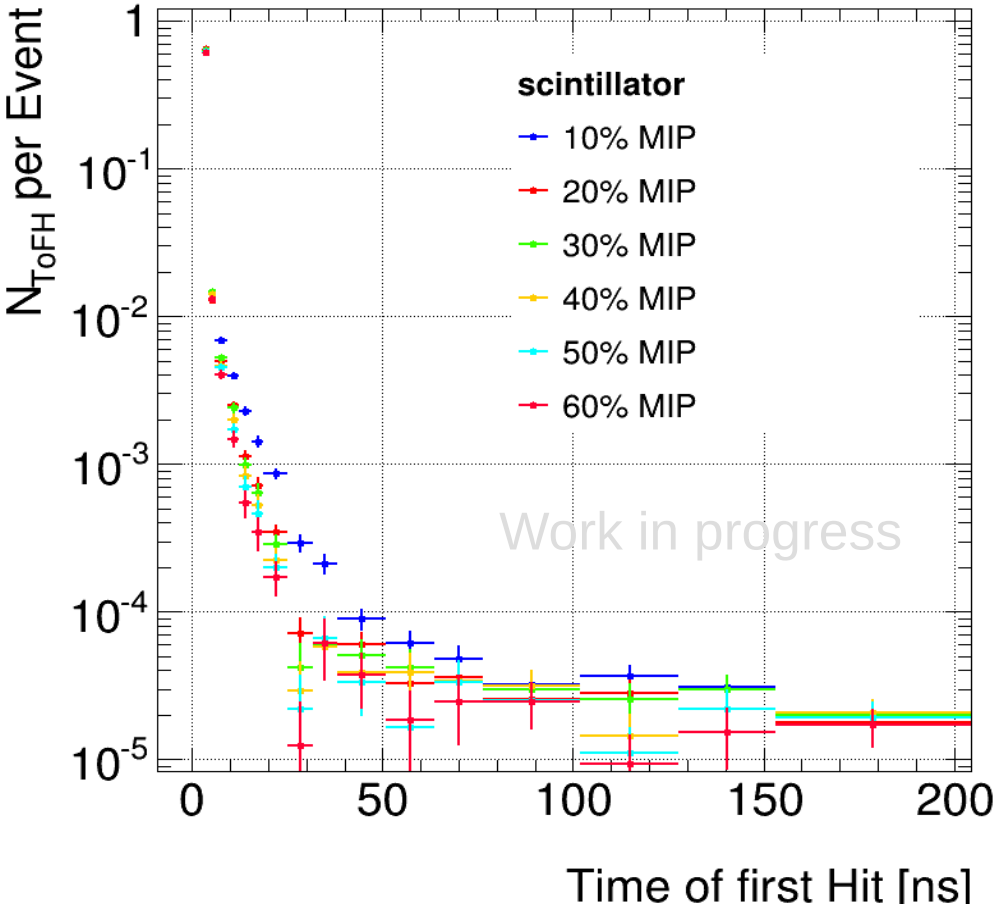
Range cut is needed for simulations and is a threshold (distance) below which no secondary will be generated

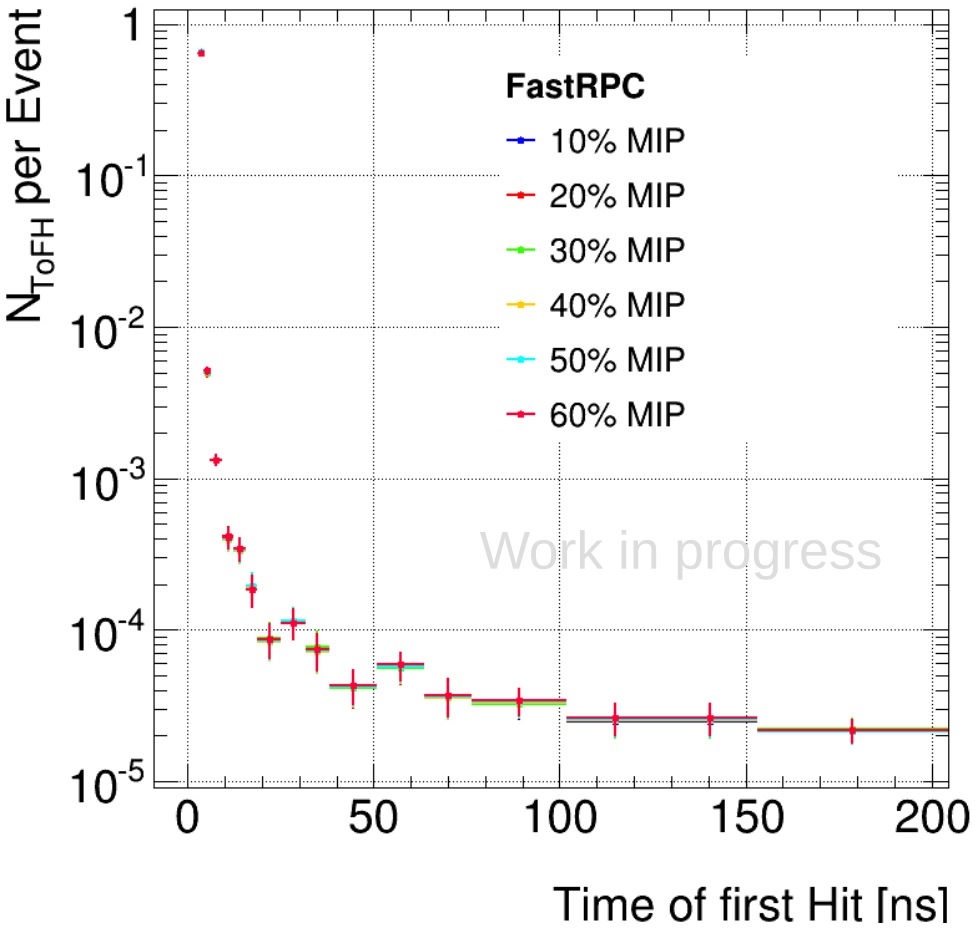




Amplitude MIP Cut

Tested 10%, 20%, 30%, 40%, 50% and 60%
Minimum **I**onizing **P**article





Check influence on the observable

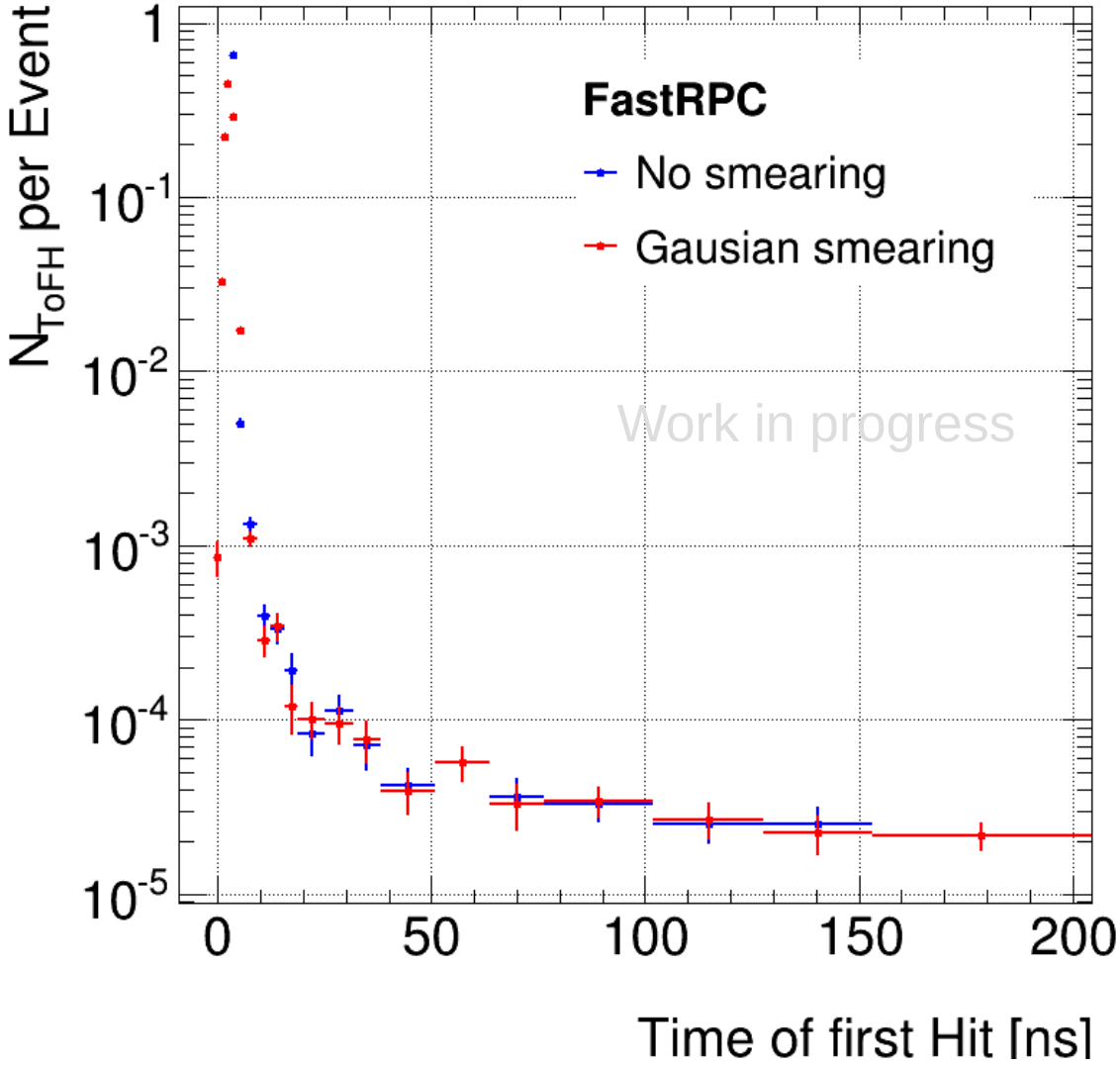
Gaussian Smearing

- Smearing the time of first Hit
- Broaden the peak
- Detector uncertainty
- Take into account detector effects (time resolution and trigger jitter)
- Smearing Simulation with measured Muon data

Gaussian Smearing

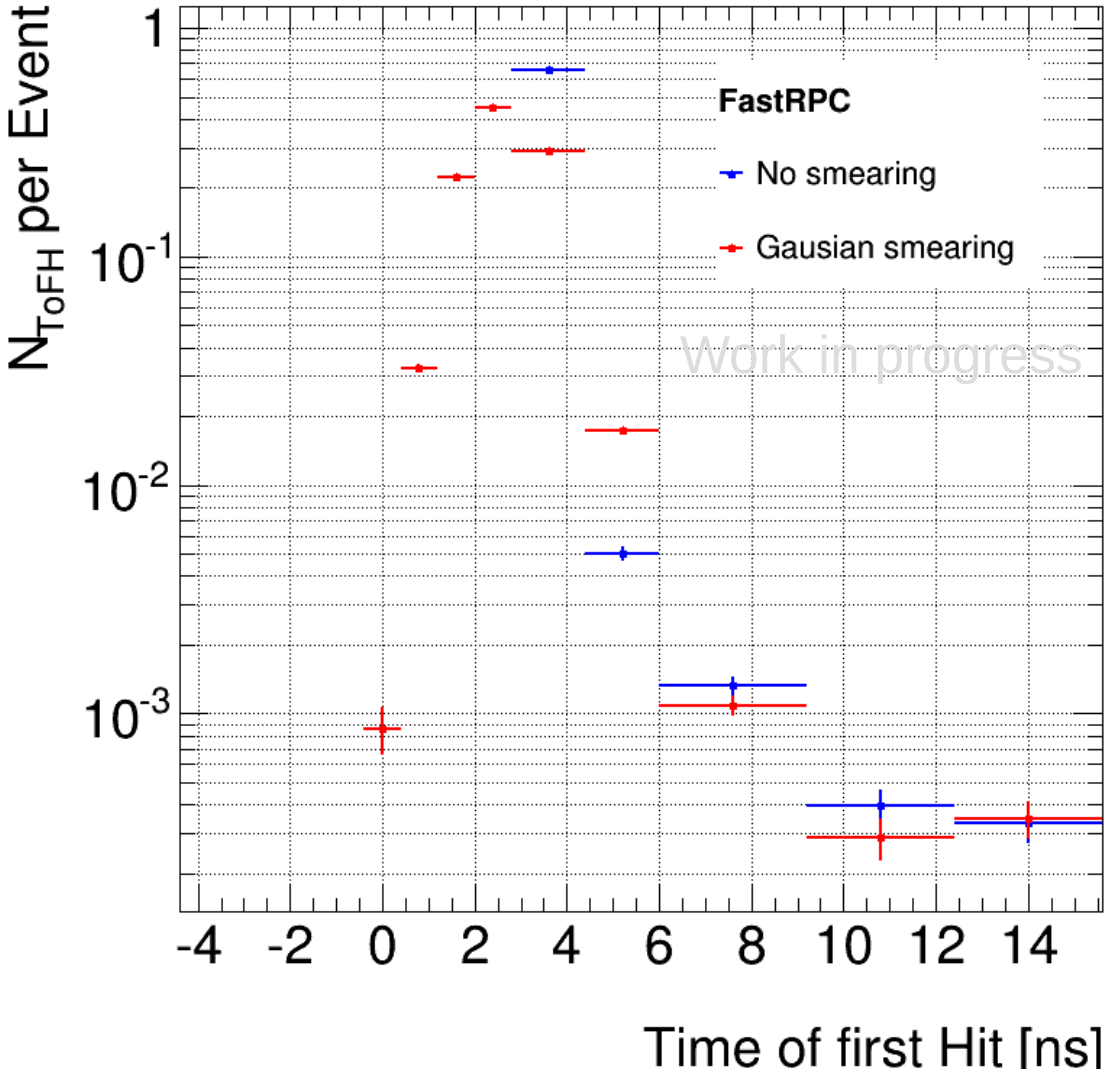
- Smear the time with a Gauß with mean = -0.528120 and Sigma = 0.728050

- Resulting from a fit on muon data



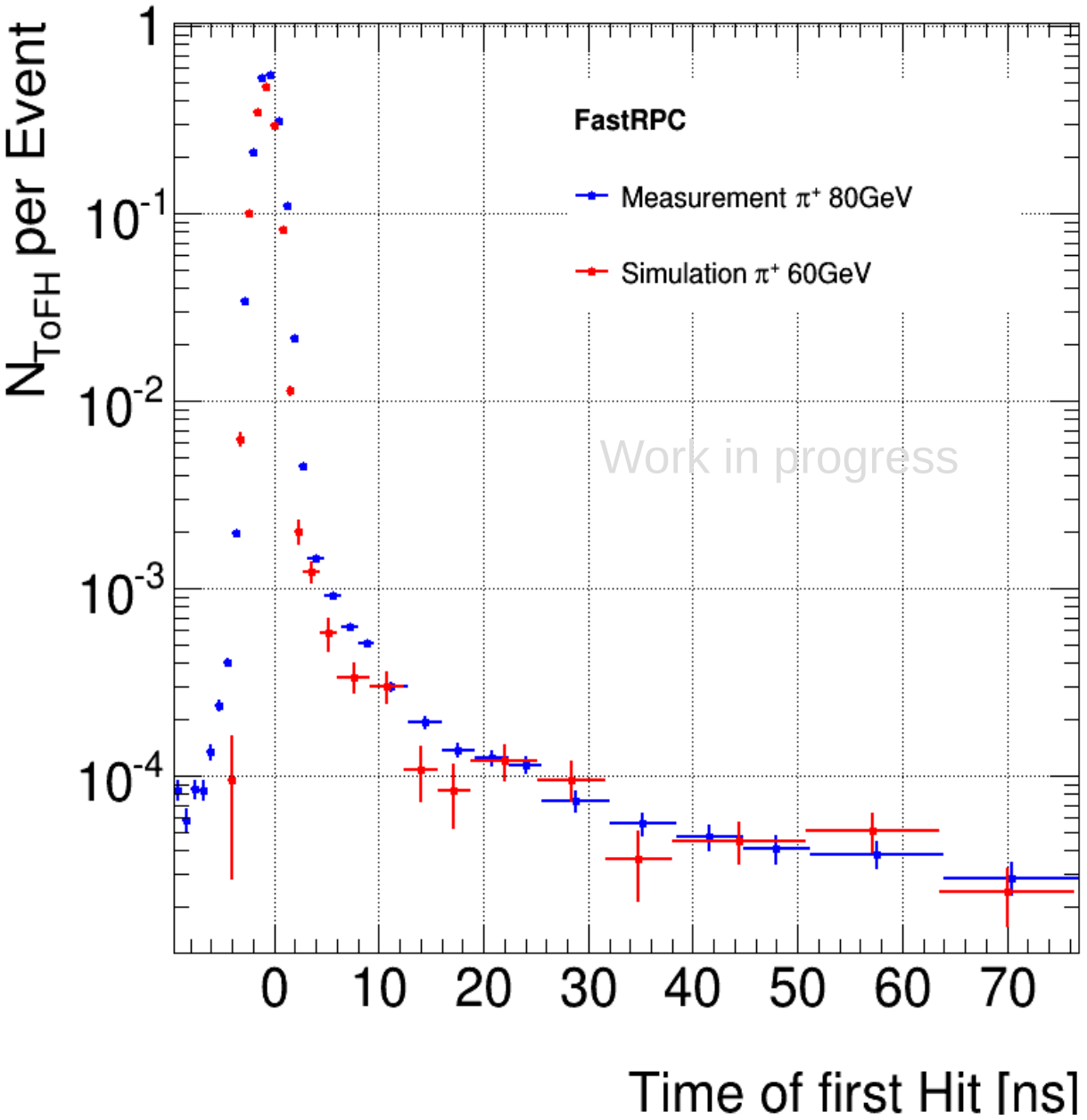
Gaussian Smearing

- Sharp peak gets broadened



Simulation VS Measurement

- Very good agreement observed
- Remaining detector effects hopefully small



Outlook

- Good agreement of simulations for both RPC and Scintillator readout motivate the use of GEANT4 to investigate the difference in response between the two detectors
- Will look into/implement further detector effects like charge spread and its resulting Pad Multiplicity

  (less impact as in DHCAL due to bigger cells [3 x 3 vs 1 x 1])
- want to check which processes contribute in which time region to confirm/improve interpretation of FastRPC/T3B results
  - We collect which processes produce the particles we see in the last layer
  - Also looking into proposed G4ShowerMap by Andrea Dotti
- Work in progress

The End

Thank you!

Backup