SAND TPC simulation - SAND software meeting

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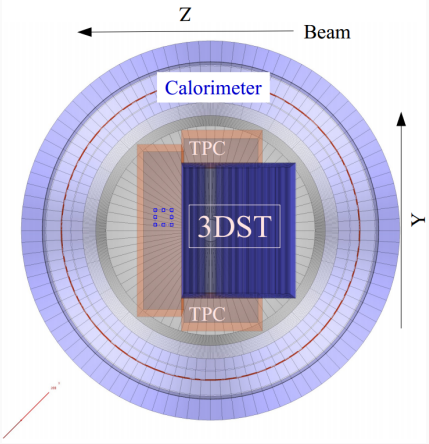
Irfu - CEA Saclay

The TPCs in SAND

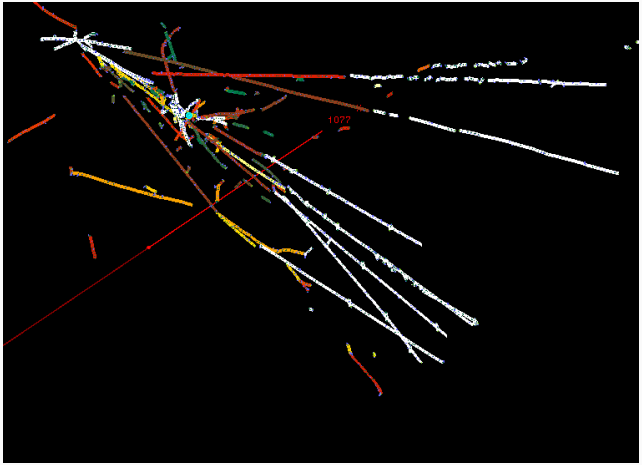


- 3 TPCs :
  - DOWNSTREAM : (x,y,z)
    $3.3\,\mathrm{m} \times 3\,\mathrm{m} \times 0.77\,\mathrm{m}$
  - BOTTOM and TOP : (x,y,z)
    $3.3\,\mathrm{m} \times 0.57\,\mathrm{m} \times 1.41\,\mathrm{m}$
- Cathode in the middle of the TPCs (x direction)
- 2 readout planes for each tpc
- Based on resistive micromegas

Simulation

1. Energy deposition spread uniformly along each track segment
   - Individual ionization electrons are generated and tracked
   - Electrons are drifted towards the pads with a velocity of $78\,\mathrm{mm}\,\mu\mathrm{s}^{-1}$
   - Longitudinal diffusion of $0.29\,\mathrm{mm}/\sqrt{\mathrm{cm}}$ - Transversal diffusion is neglected
2. Charge spreading in pads simulated as gaussian spread
   - Time spreading not yet simulated
   - Possible implementation of more accurate charge spreading to come
3. Simplified pad response with current passed directly to digitization
4. Electronics and DAQ simulated with DAQMulti class
   - 100 ns integration window
   - Signal is integrated while above given threshold
   - Hit time taken as the average current arrival time for each pad
5. Output is a collection of hits with position of the pad, charge and arrival time of the charge.

TPC + 3DST reconstruction example (Preliminary - See Clark's presentation)



DIS event reconstruction. White tracks on the right side are in the TPC.

Summary

TPC model

- A simplified TPC model is available for use.
- Current main simplifications are :
  - Charge spreading model (with no timing involved)
  - Pad response
- Current model should be enough for now.

Availability

- TPC model available in ERepSim : `https://github.com/DUNE-ND-SAND/erep-sim`. See Clark's presentation for full ERepSim description.
- TPC files : `ERepSimDetectorTPC.[c|h]xx` and `ERepSimResponseTPC.[c|h]xx`

Backup slides

Charge spreading

Currently charge spreading is only taken into account as a gaussian.

Formula for charge dispersion of 2D continuous RC network :

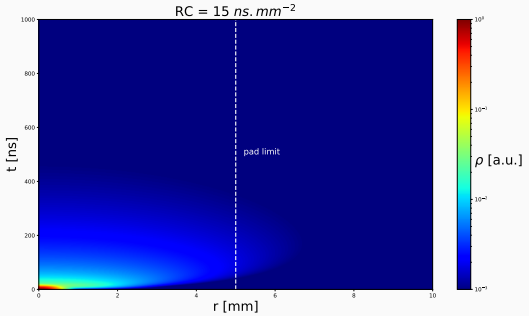
$$\frac{\partial \rho}{\partial t} = \frac{1}{RC}\left(\frac{\partial^2 \rho}{\partial x^2} + \frac{\partial^2 \rho}{\partial y^2}\right)$$

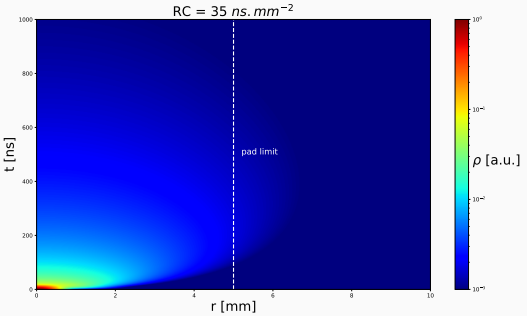
Solution for infinite size and initial gaussian distribution :

$$\rho(x, y, t) = \frac{Nq_e}{2\pi(2ht + w^2)} \exp\left[-(x^2 + y^2)/(2(2ht + w^2))\right]$$

$h = \frac{1}{RC}$, w is the initial gaussian width and Nq_e the initial quantity of charged deposited. Ongoing implementation in erep-sim.

Charge spreading

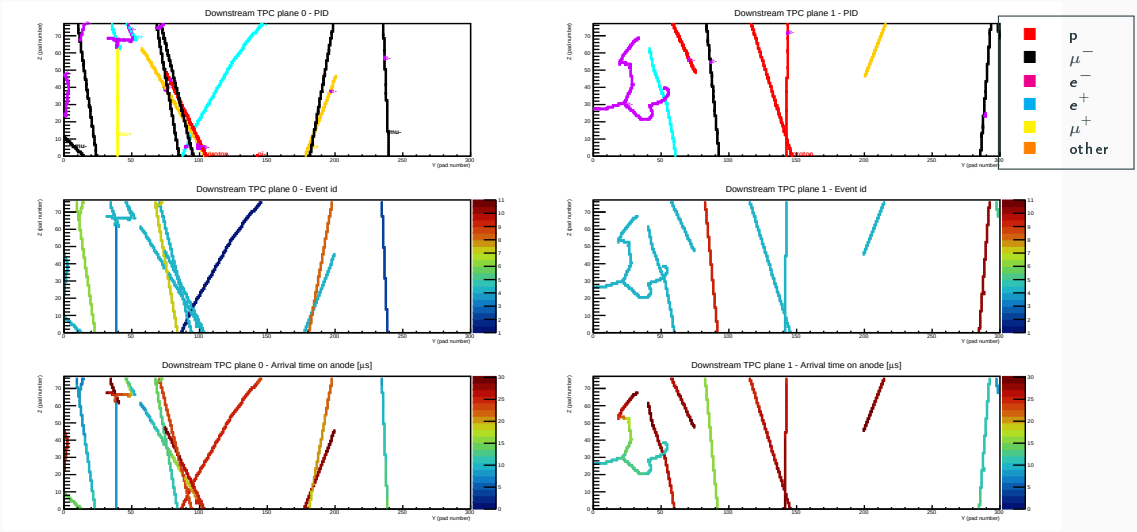




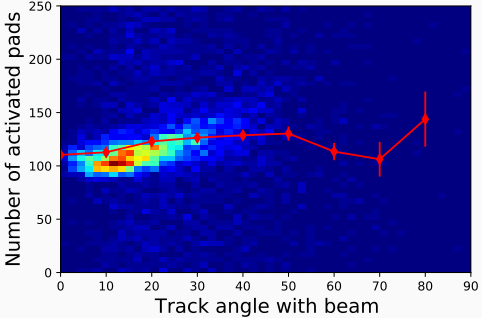
The charge spreading radius does not depend on the RC value. RC only impacts the speed of the charge spreading.

Ongoing implementation in erep-sim.

Full spill example in TPC (fig. from previous implementation)



δP_t resolution - inputs



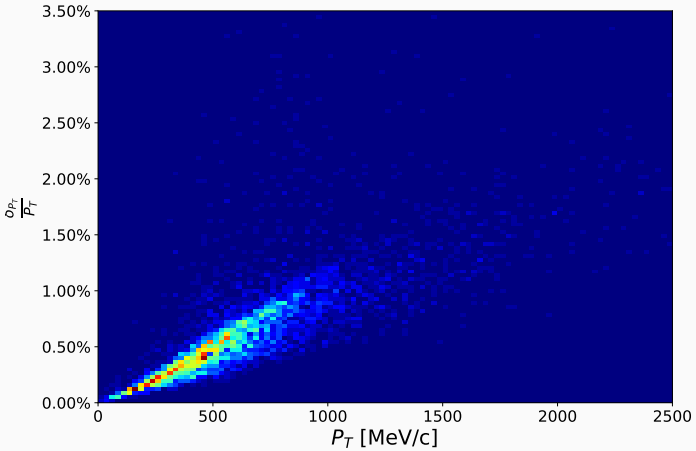
Number of tracks as function of the angle in simulation.

DESY resolution data ($\sigma_{r,\phi}$) as function of angle are used.

Resolution is computed with :

$$\frac{\sigma_{p_T}}{p_T} = \frac{p_T}{0.3BL^2}\sqrt{\frac{720}{N+4}}.\sigma_{r\phi}$$

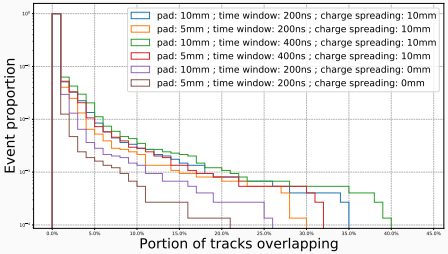
δP_t resolution

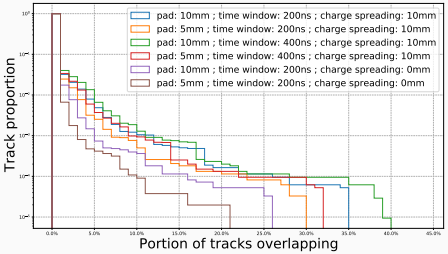


Estimated resolution from simulation (10mm pads).

Inverse cumulative distribution of overlaps - DOWNSTREAM

Inverse cumulative distributions





In all the tested configurations, less than 1 % of the events contain tracks with more than 10 % of overlapping pads (0.1 % of events for 20 % of overlapping pads).