Status of SAND Simulations

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DUNE ITALIA

08/11/23 - Lecce

Content

- Status of Simulated Geometry
  - STT tracker
  - Drift Chamber
- Digitization
- Reconstruction
  - Track fit
  - Kalman Filter
- Future Prospects

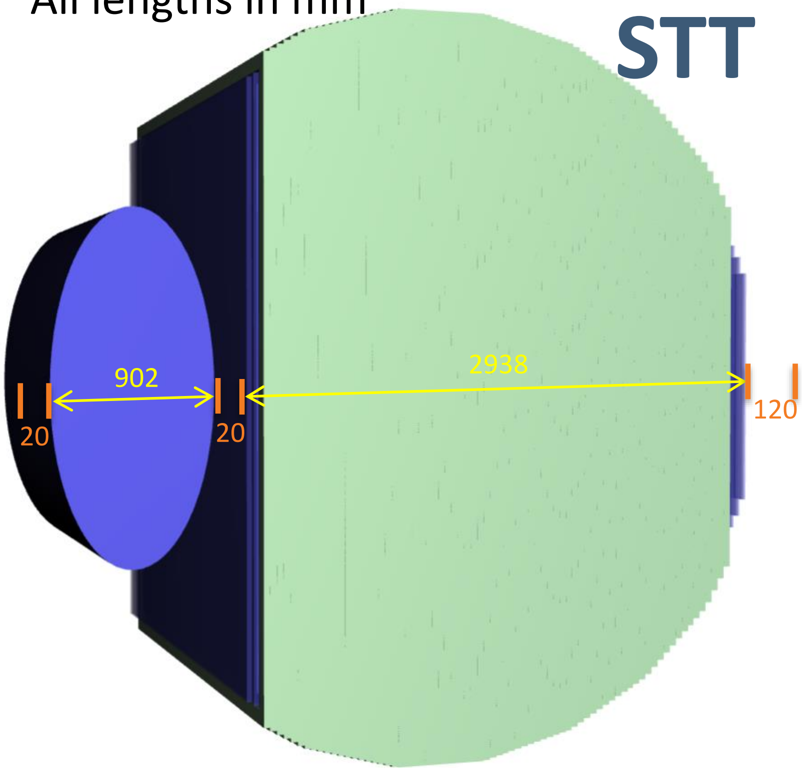
Updates on SAND Geometry

- **GRAIN dimensions** have been updated following the foreseen prototype
- Latest simulation accounts for engineering requirements about **clearances** between GRAIN, STT and ECAL
- Basic STT design left untouched, with fewer modules
- Additional SAND geometry based on **drift chamber**
- Repo : https://github.com/DUNE/dunendggd.git
- Generate: ./build_hall.sh sand_opt3_STT1

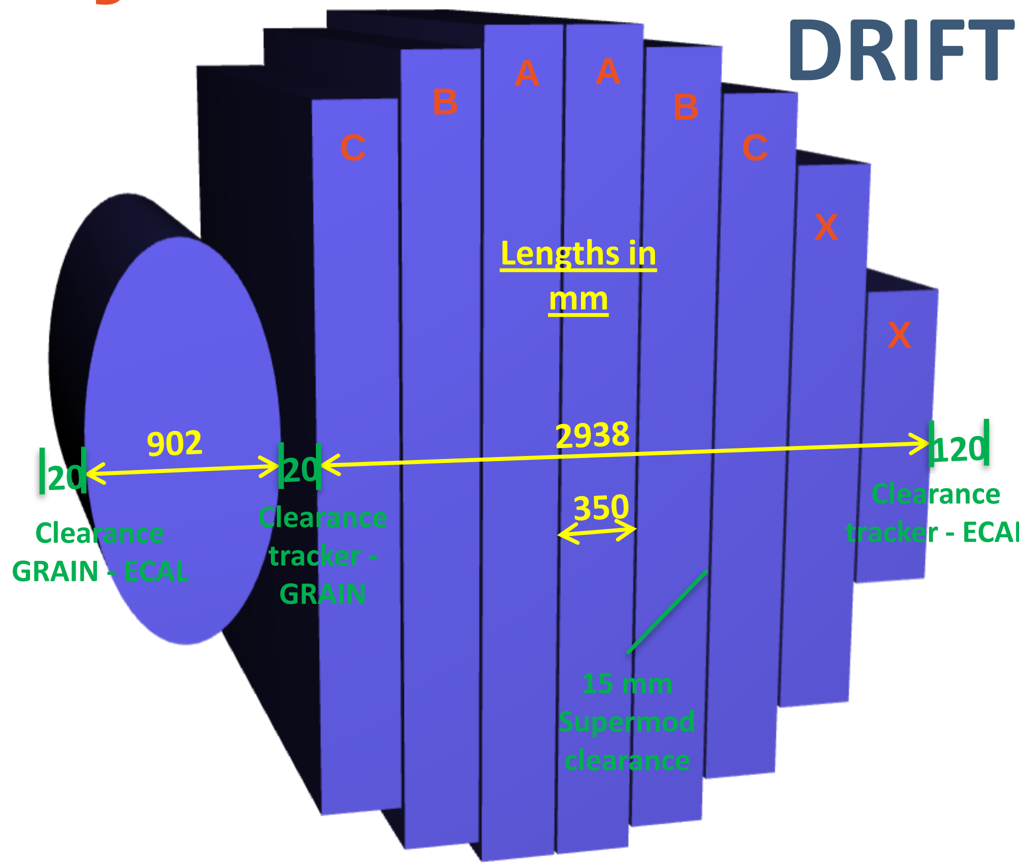
SAND Geometry

All lengths in mm

STT



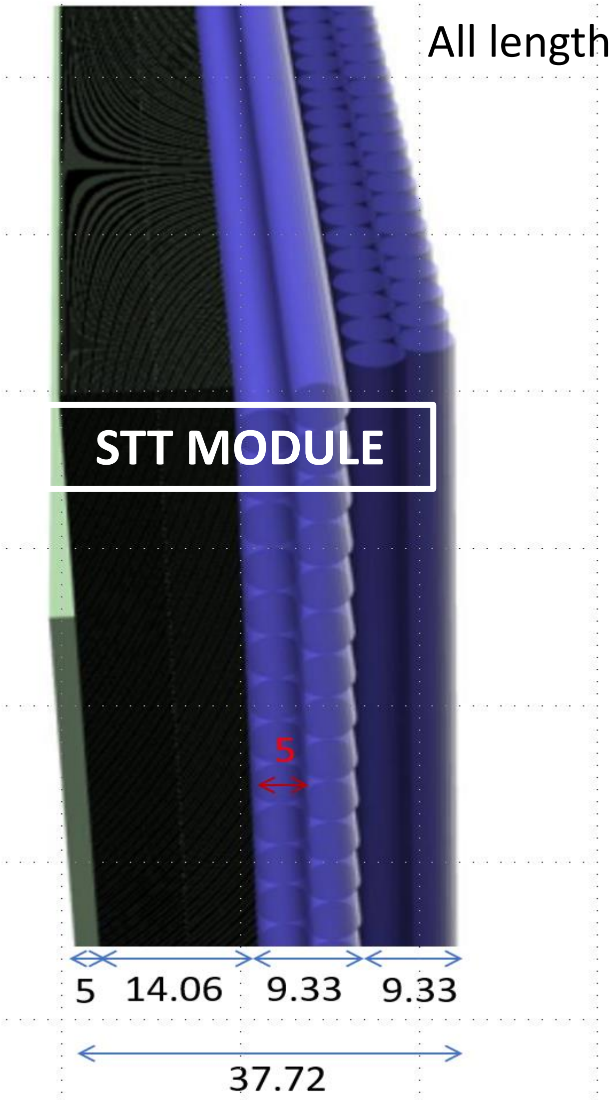
DRIFT

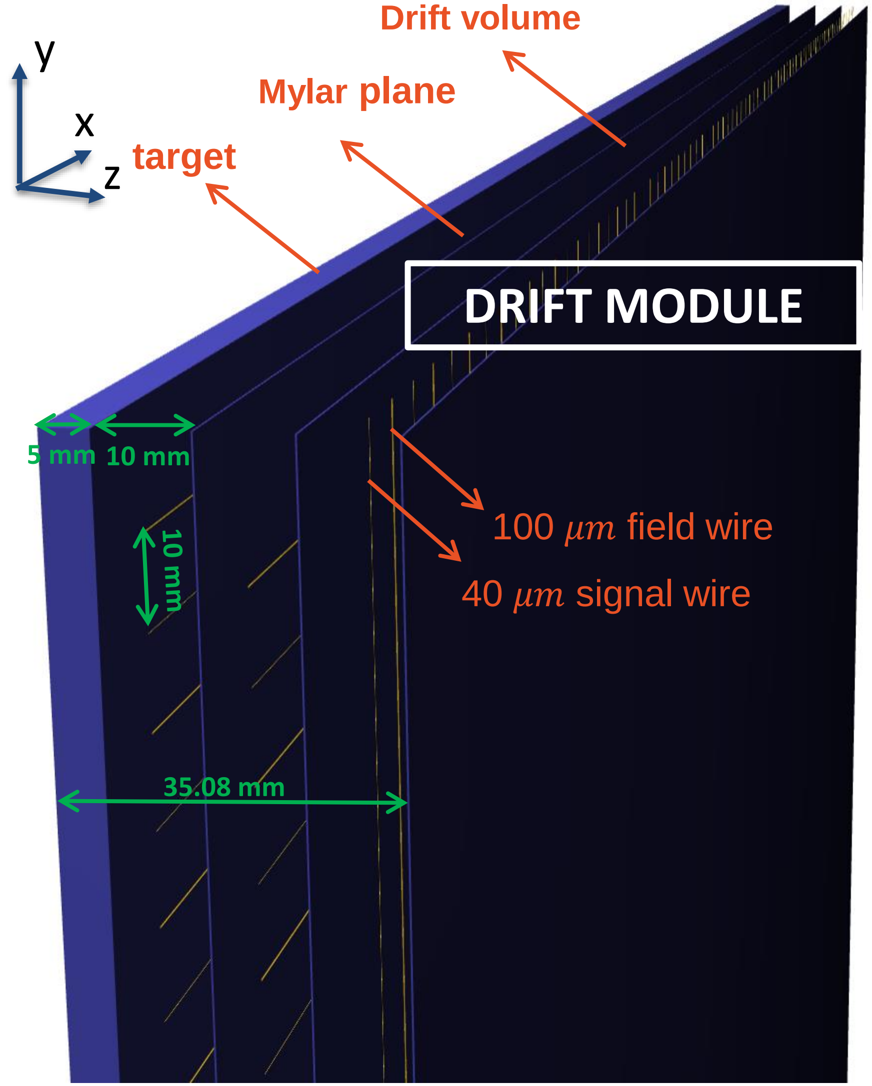


	# C3H6	# C	Mass C3H6	Mass C	Mass Radiator	Mass Mylar	gas	density $[g/cm^2]$	L0 [m]
STT *	65	8	3.1 t	0.7 t	1.3 t	-	0.1 t	0.17	2.7
DRIFT	72	8	3.4 t	0.7 t	-	0.1 t	0.1 t	0.15	3.0

SAND Geometry – single module

All lengths in mm





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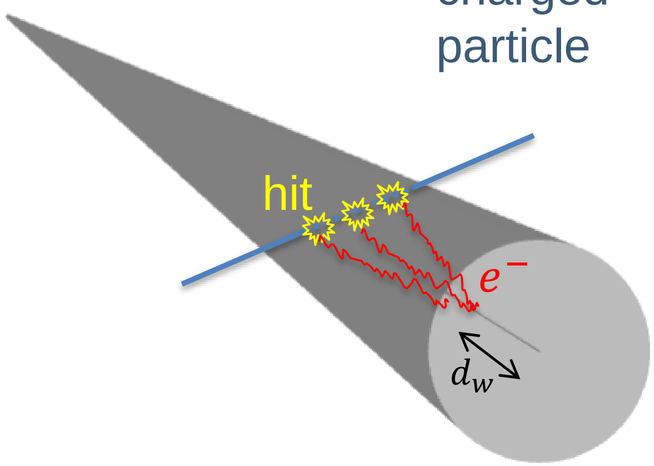
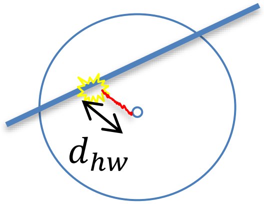
Digitization – Straw Tube



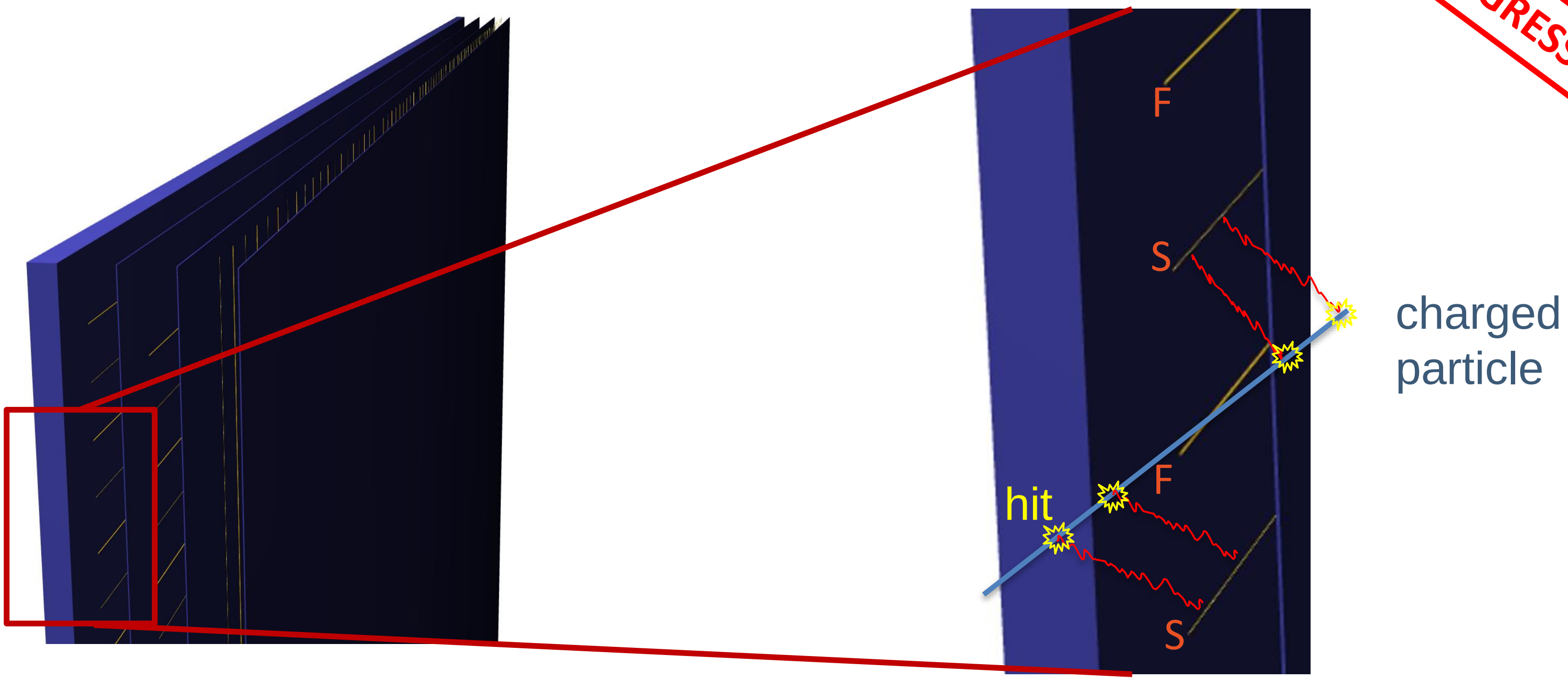
- ADC = $\sum_{hits} E_{hit}$ ← Hit energy deposit (MC truth)
- TDC = $t_{hit} + d_{hw}/v_{drift} + d_w/v_{signal} + Gauss(1\ ns)$

Hit time (MC truth) — e^- drift velocity — Signal propagation velocity along the wire



Digitization – Drift Module

WORK IN PROGRESS



- ADC = $\sum_{hits} E_{hit}$

Hit energy deposit (MC truth)

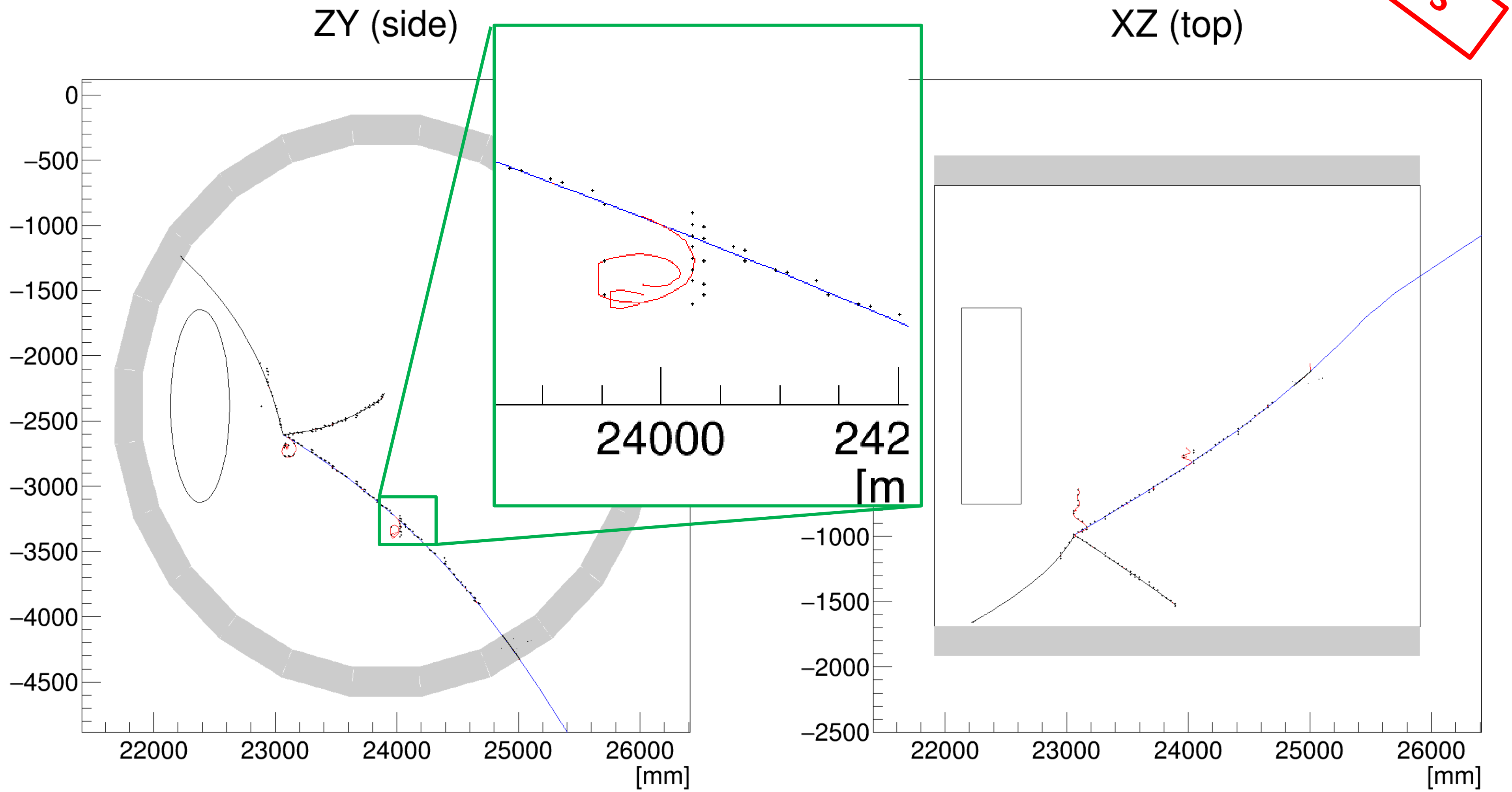
- TDC = $t_{hit} + d_{hw}/v_{drift} + d_w/v_{signal} + Gauss(1\,ns)$

Hit time (MC truth) e^- drift velocity Signal propagation velocity

Digitization – Drift

WORK IN PROGRESS

MC tracks VS fired wires position



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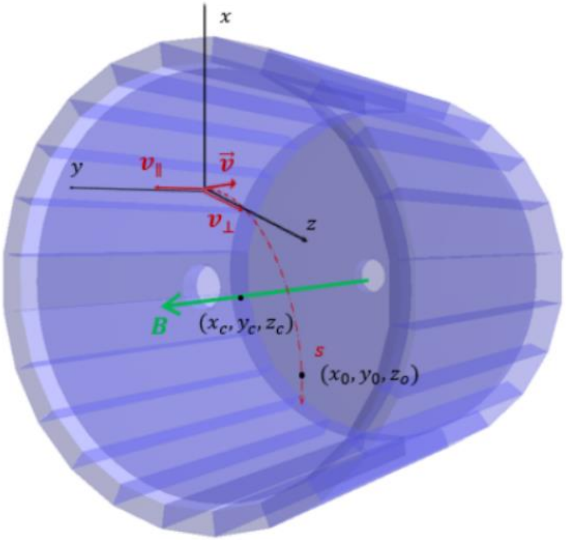
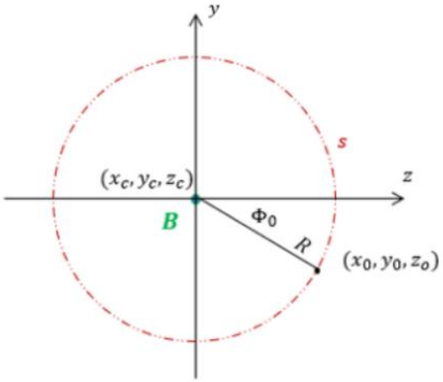
Track Reconstruction

ECAL, GRAIN see dedicated talks





- **Input**: STT hits position
- Assume helicoidal motion
- Circular fit on y-z plane → R curvature
- Linear fit on x-z plane → λ dip angle
- **Output**: reconstructed particle momentum

$$\begin{cases} p_x = p_T \tan\lambda \\ p_y = p_T \sin(\pi/2 - \Phi_0) \\ p_z = p_T \cos(\pi/2 - \Phi_0) \end{cases}$$

$$p_T[MeV/c] = 0.3 \times B[T]R[m]$$

Track Reconstruction

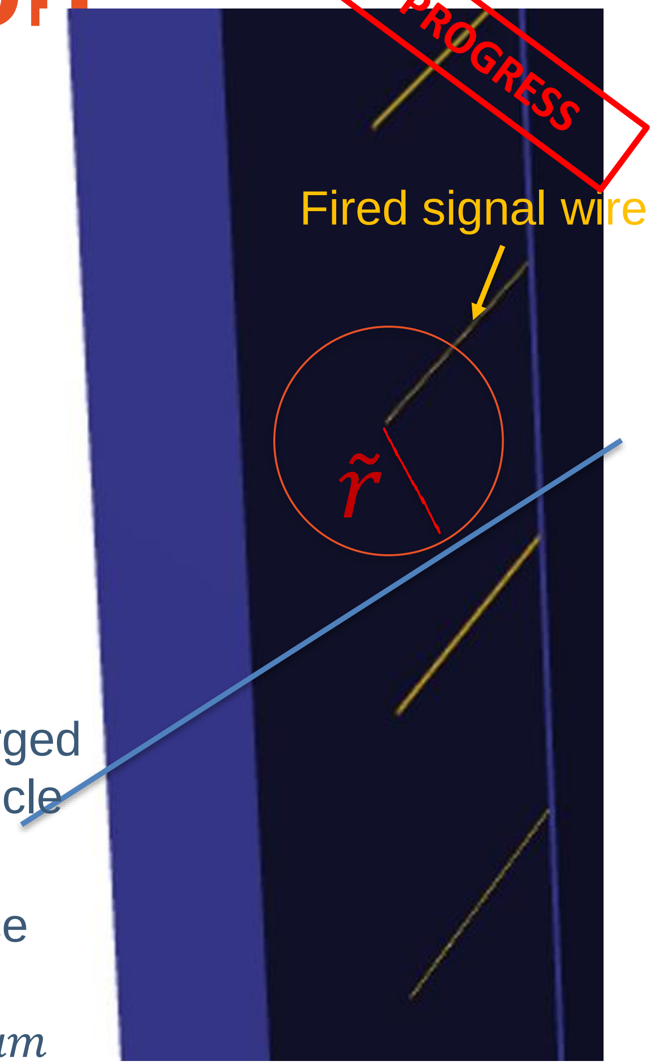
WORK IN PROGRESS

- Assuming charged particles moves along a helix, the **impact parameter** is the minimum distance between the helix and the fired wire
- $\widetilde{r}_i$ expected impact parameter provided by i^{th} wire TDC
- r_i inferred impact parameter from NLL method:

$$NLL = \sum_i \frac{(r_i - \widetilde{r}_i)^2}{\sigma_r^2}$$

I runs over the fired wires

Expected space resolution for single hit $200\ \mu m$

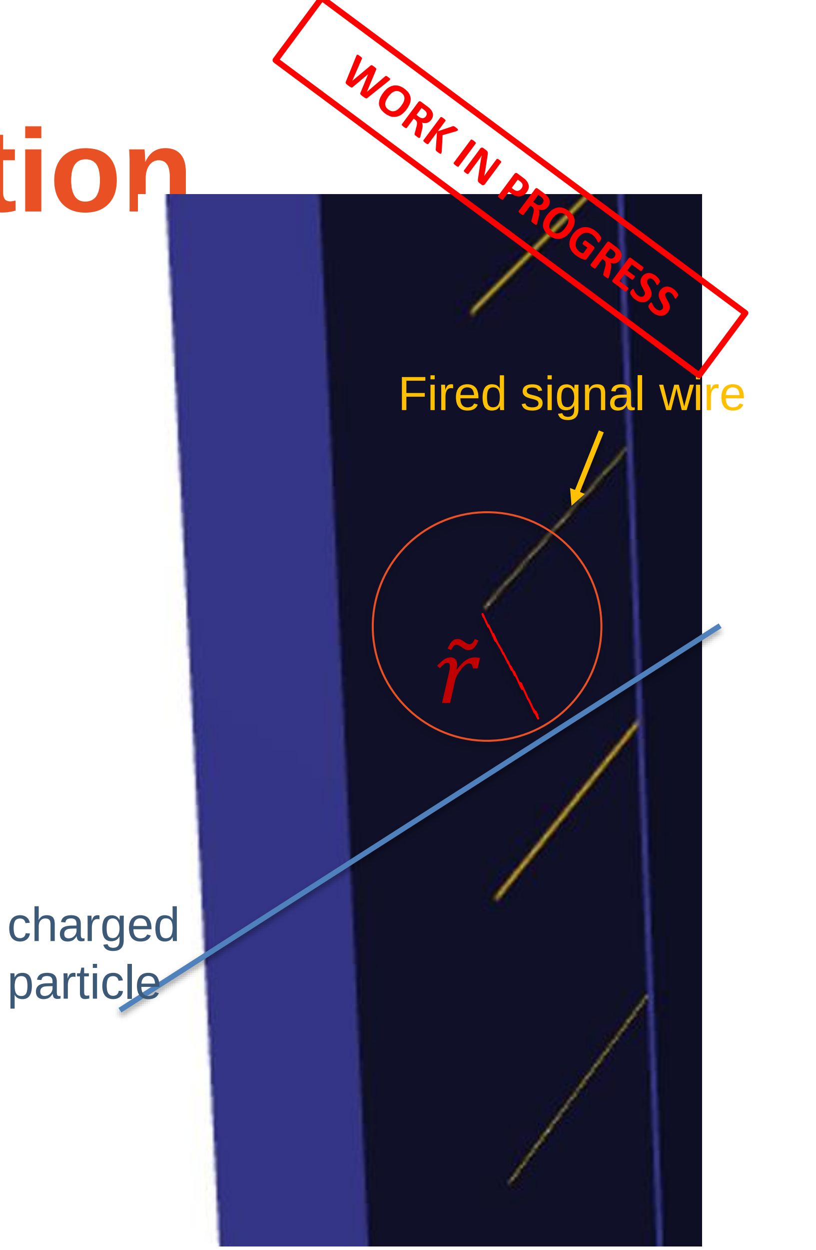


Track Reconstruction

- r_i inferred impact parameter from NLL method:

$$NLL = \sum_i \frac{(r_i - \tilde{r}_i)^2}{\sigma_r^2}$$

- NLL minimization provides the helix parameter estimate
  - Φ_0, x_0 initial angle and position
  - R helix radius
  - λ dip angle
  - h helicity



Kalman Filter - Motivation

VALERIO'S TALK

- The assumption that the particle's trajectory is a helix is not true when accounting for Coulomb scattering (**MCS**) and **energy loss** during propagation

- KF reproduces the particle's trajectory by proceeding **step by step** and considering in each step the energy loss, MCS, measurement noise, etc.

Future Prospects

- We have SAND geometry simulation both for STT tracker and Drift Chamber

- A simulation campaign of **2 millions ν_μ CC** already produced (GENIE + edepsim + digitization) to get physics performances (muon momentum solution, neutron and proton detection efficiency…)

- Working on a charged **tracks reconstruction** to obtain SAND tracking performances and physics capabilities