SAND Physics/Software WG

M. Tenti - Bologna

INFN
Istituto Nazionale di Fisica Nucleare

The Contributors

Paolo Gauzzi	Sapienza/Roma1	Valerio Pia	Bologna
Grigory Vorobyev	JINR	Giulia Lupi	Bologna
Artem Chukanov	JINR	Gianfranco Ingratta	Bologna
Paolo Bernardini	Lecce	Valentina Cicero	Bologna
Antonio Surdo	Lecce	M. Tenti	Bologna
Francesca Alemanno	Lecce	F. Battisti	Bologna
Denise Casazza	Ferrara	A. Ruggeri	Bologna
Riccardo D'amico	Ferrara	Matteo Sorbara	Roma2
Lea Di Noto	Genova	Antonio Gioiosa	Roma2

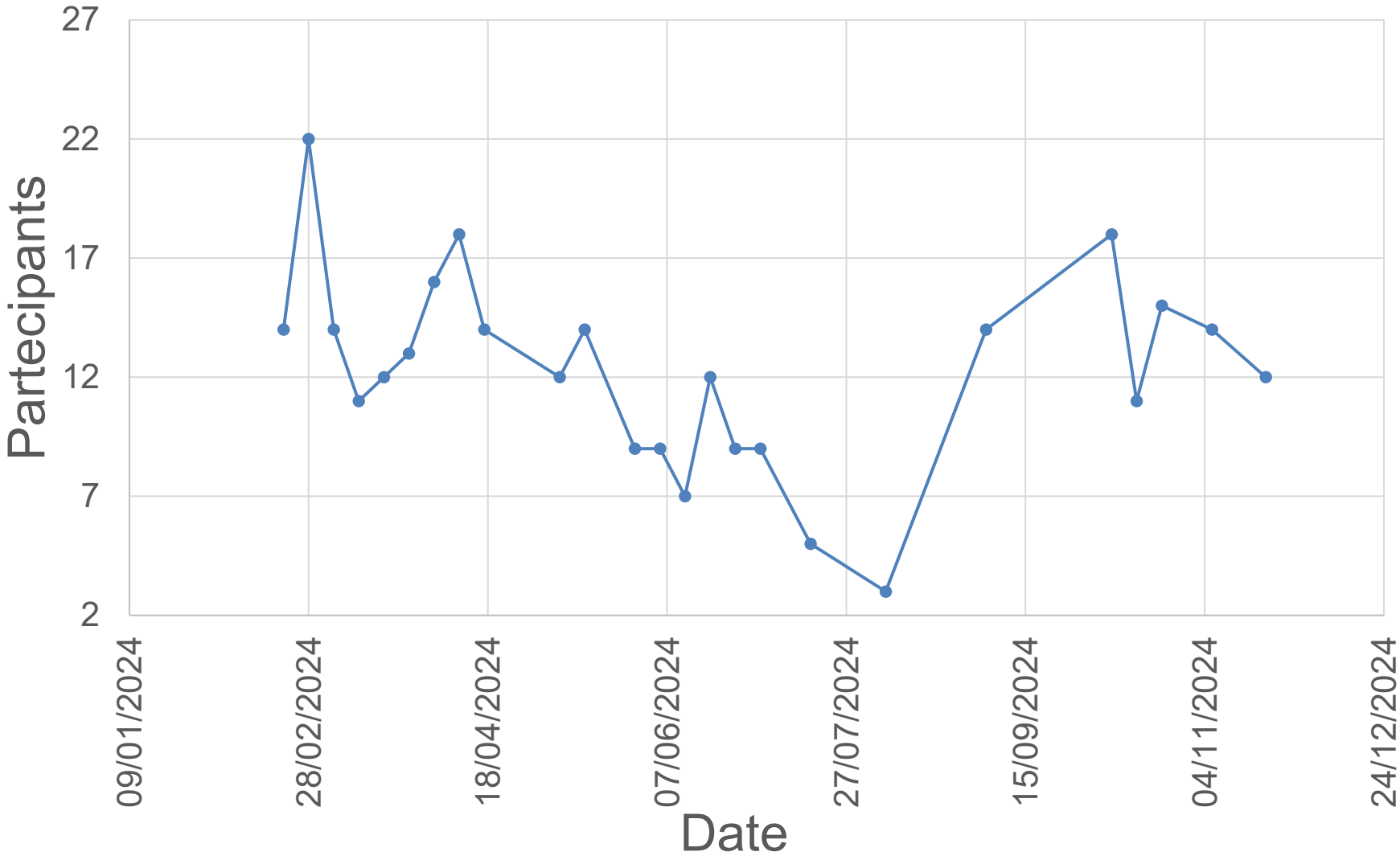
18 people in total

ECAL clustering + PID w/ ECAL	Kalman Filter	Kalman Filter w/ GENFIT	H sample w/ fast reco	Straw -VS drift- based tracker	Event reconstruction	CAF	Integration
D. Casazza R. D'amico P. Gauzzi	V. Pia G. Lupi F. Battisti	A. Chukanov G. Vorobyev	G. Ingratta	M. Sorbara A. Gioiosa A. Ruggeri	P. Bernardini A. Surdo F. Alemanno	L. Di Noto	M. Tenti

Meetings

- Starting from 21/02 we have regular weekly meetings
- A shared google docs is used to take notes [here the folder]
- Meetings are recorded [here the folder]
- A list of action items is produced and checked during the meeting
- Notes, video and action items can be found in the corresponding indico agenda

Participants



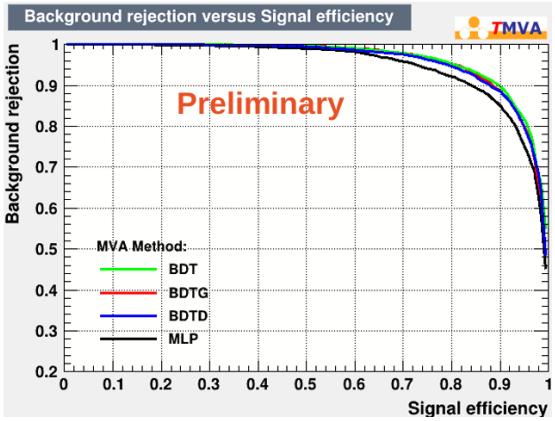
ECAL Clustering

D. Casazza and R. D'Amco

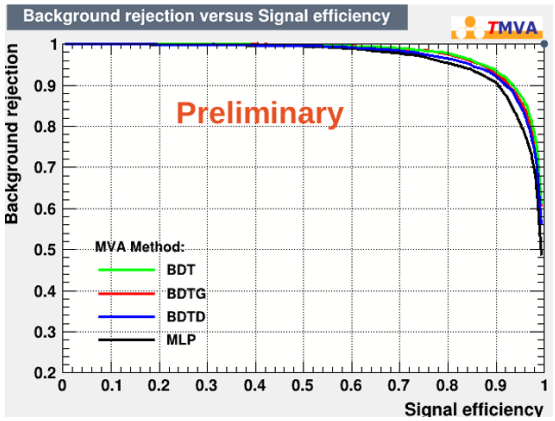
- Clusters generated by e^- (sig) and π (bkg) from 30k ν_e events in STT
- 17 variables to characterize the clusters and train four algorithm: MLP, BDT(G,D)
- BDT seems better than MLP
- BDT performance improves requiring..

Clustering integration in *sandreco* on GitHub: done

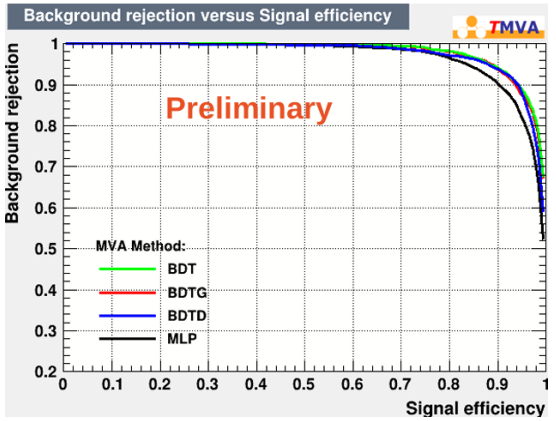
Debug, test and validation activites on clustering and analysis



Most of the energy from e^- or π



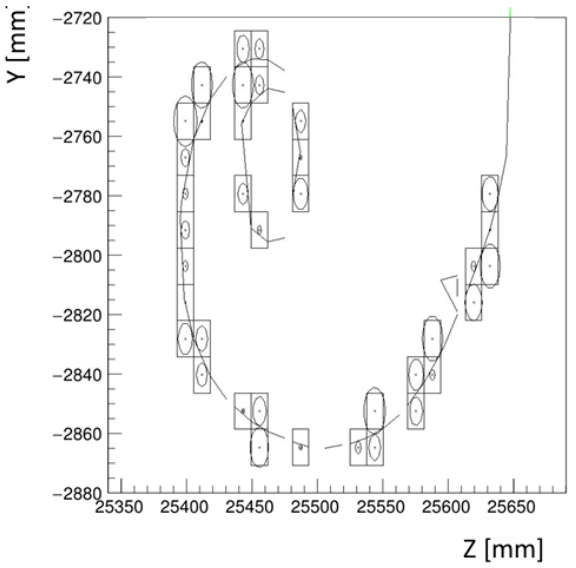
Energy from e^- or π > 80%



Energy from e^- or π = 100%

Tracking

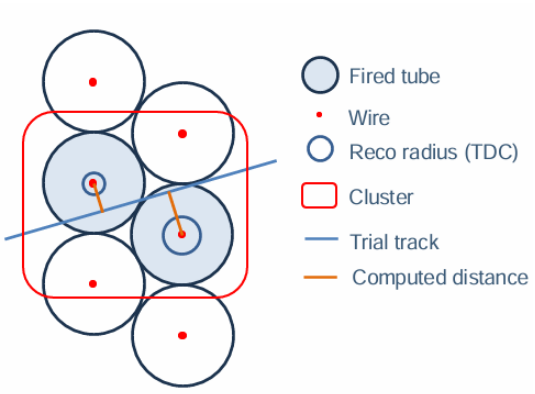
V. Pia…other will join



- A wire signal produces ADC and TDC
- These are used to reconstruct the cylinder around the wire independetly from geometry
- All triplets of hit wired are used to reconstruct tracklet (position, angle) minimizing:

$$D = \sum_i (d_i - r_i)^2$$

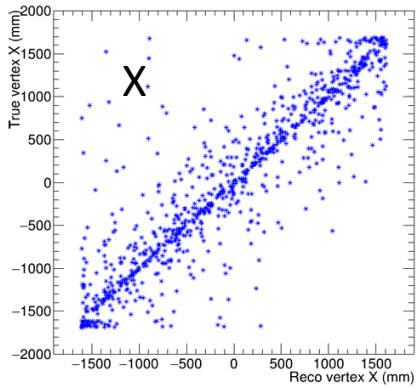
- d_i is the distance between the i-th fired wire and the trial track
- r_i is the radius (from the TDC) of the i-th fired wire

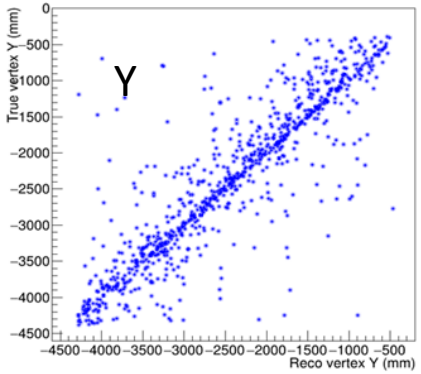


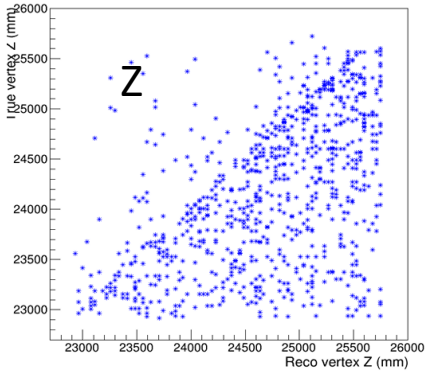
Event Reconstruction

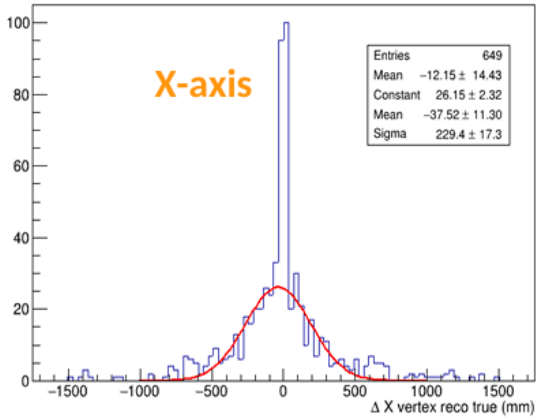
F. Alemanno and A. Surdo

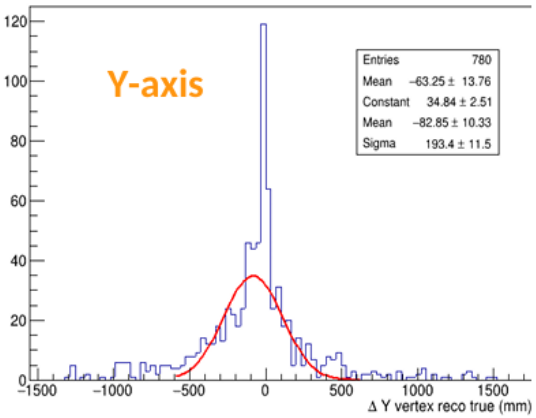
- First look at vertex reconstructed position

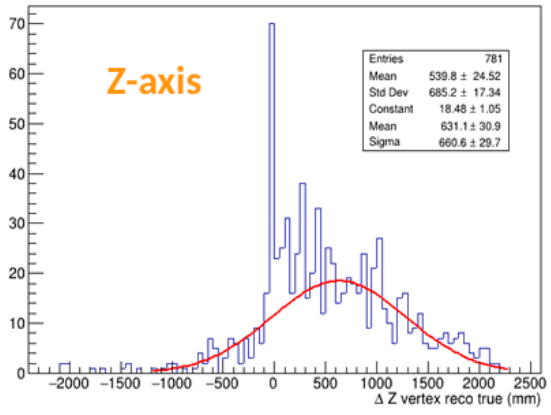








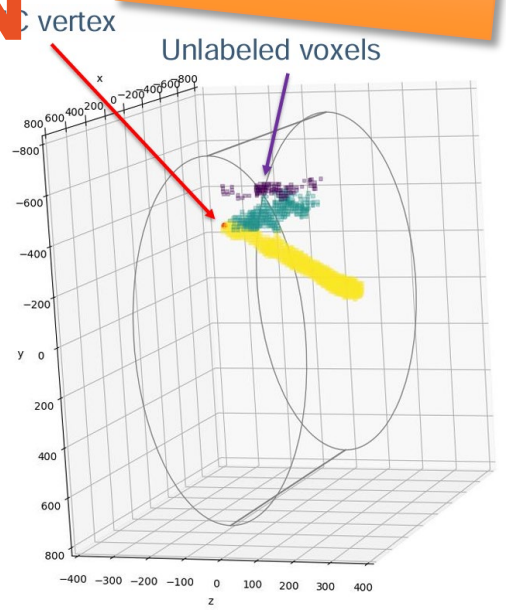




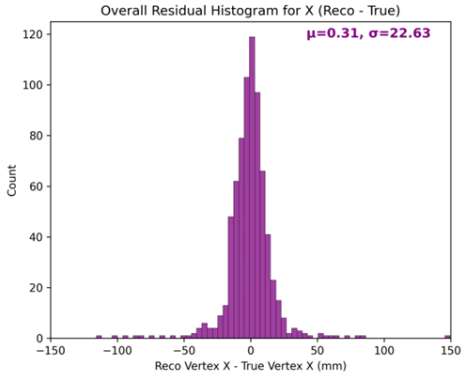
- First naive implementation do not succed in more complex events

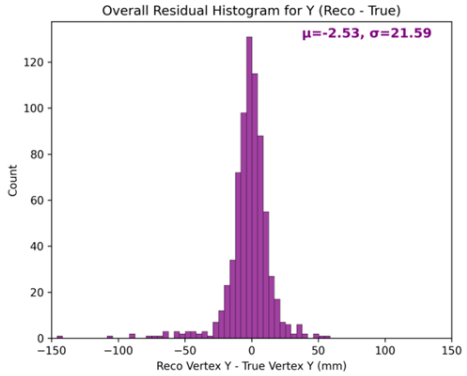
Reconstruction in GRAIN

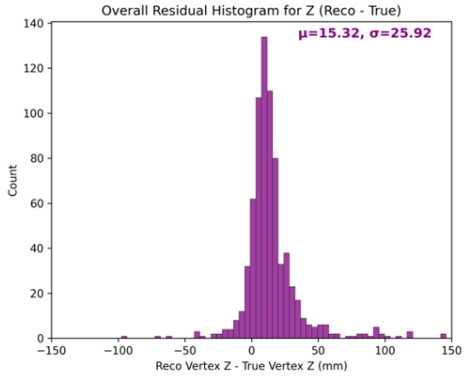
V. Cicero and F. Mei



- 1k ν_μCCQE in internal GRAIN volume
- Reconstructed with Maximum Likelihood Expectation Maximization technique
- Voxels are clusterized into tracks using MC truth
- Vertexing with n == 2 good tracks: matched lengh > 50 mm + deposited energy > 20 MeV
- The vertex position is the median of the distance between the two lines



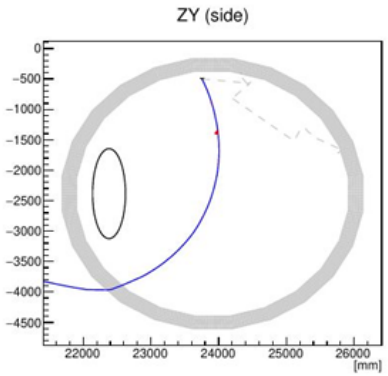


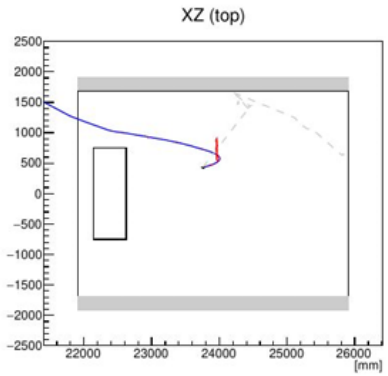


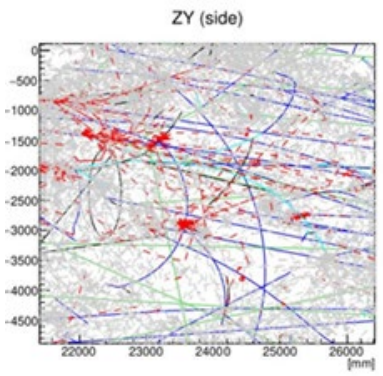
Tracker technologies comp.

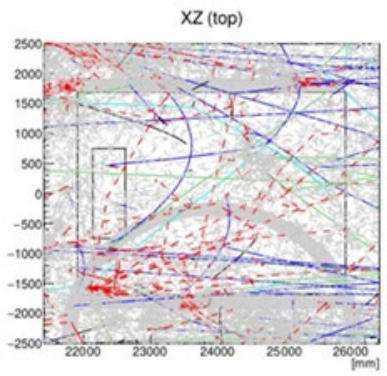
A. Gioiosa and M. Sorbara

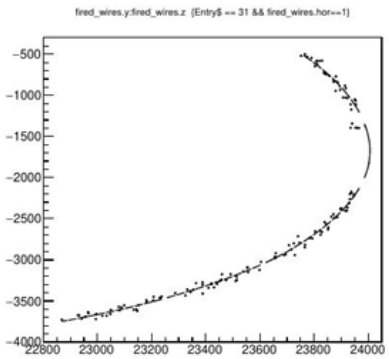
- First look at the drift-chamber digitization with muon tracks look good (both single event and spill)

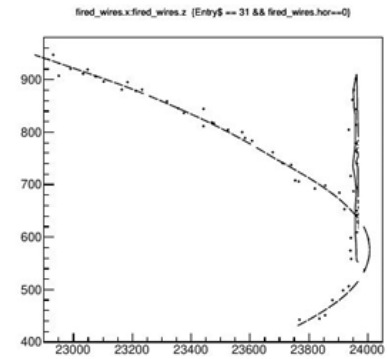


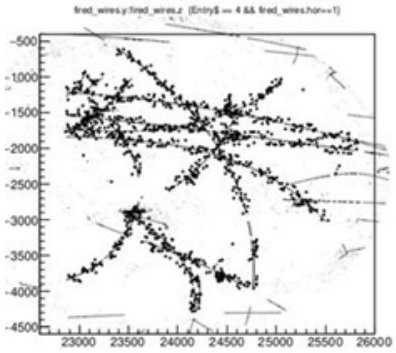


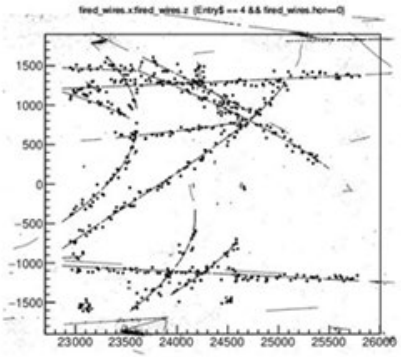








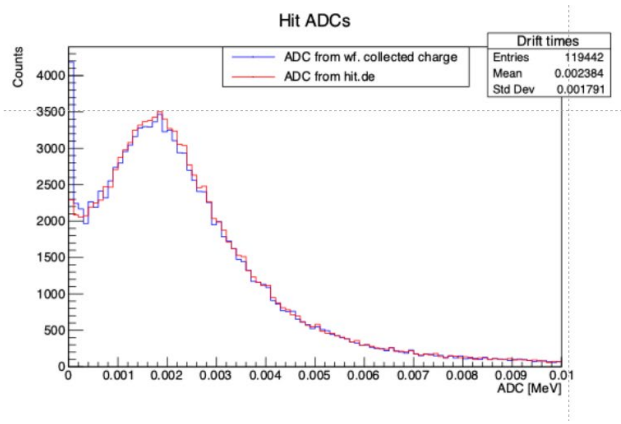


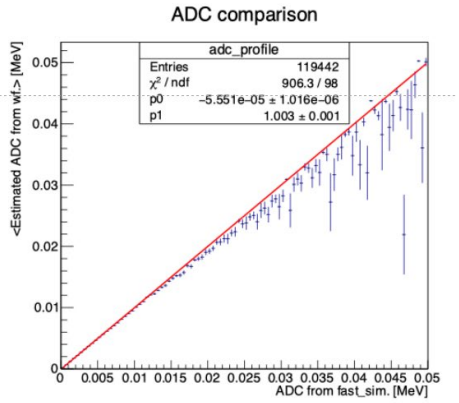


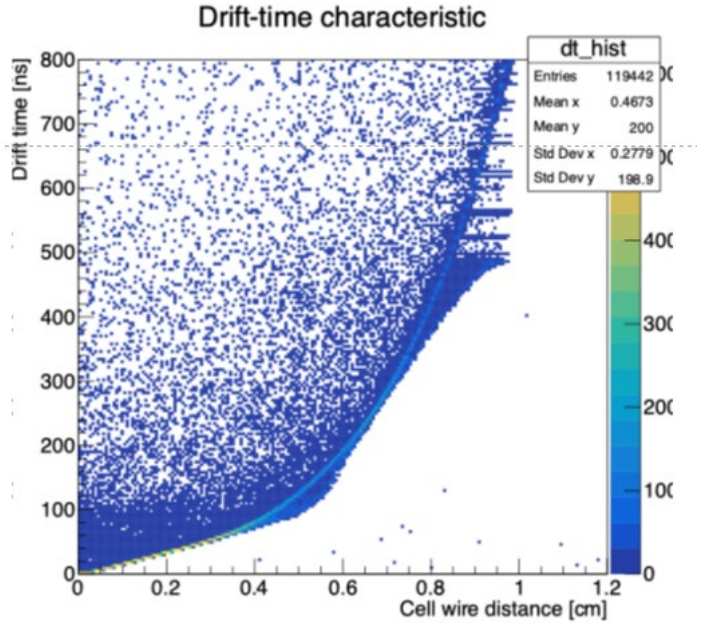
A. Ruggeri

Response simulation of tracker

- Towards a front-end response simulation of the tracker
- Map of electron waveforms for each cell position
- Convert energy release into a number of ion-electron pair
- Add waveform for each electron
- Extract TDC and ADC from the waveform







In addition

- Study of $\bar{\nu}_\mu + H \rightarrow \mu^+ + n$ channel. G. Ingratta is finishing its studies. Some technical aspects have to be better understood

- (Re) kick-off of SAND CAF development. The activities are restarting. Today there was a meeting with Lea, Denise and Linda.

TDR

Link to the TDR status

Software and Computing

Section	Title	Contributor(s)	Status	Deadline	Notes
1	Code	Tenti	in progress	31/07/2024	
1.1	Repositories	Tenti	in progress	31/07/2024	
1.2	Code Formatting	Tenti	in progress	31/07/2024	
1.2	Code Documentation	Tenti	in progress	31/07/2024	
1.4	Continuous Integration	Tenti	in progress	31/07/2024	
2	Simulations	Tenti	in progress	31/07/2024	
2.1	Neutrino Fluxes	Chukanov	empty		
2.2	Geometry	Ingratta/Ruggeri	in progress	31/07/2024	STT geometry is missing
2.3	Event Generator	Ingratta	empty	31/07/2024	
2.4	Overlays	Tenti	empty	31/07/2024	
2.5	Particle Propagation	Pia	complete	31/07/2024	
2.6	Detector Simulation	Tenti	in progress	31/07/2024	STT simulation is missing
2.6.1	Tracker	Ingratta	empty		
2.6.2	GRAIN	Cicero + Pia	empty		
2.6.3	ECAL	Casazza, + D'Amico + Gauzzi	complete	31/07/2024	
3	Reconstruction (algorithm)	Tenti	complete	31/07/2024	
3.1	Tracker	V. Pia	in progress	31/07/2024	Fit of circles is missing
3.2	GRAIN	Cicero + Di Noto + Martina	empty		Already in GRAIN section
3.3	ECAL	Casazza + D'Amico	complete	31/07/2024	
3.4	Global event reconstruction	Surdo	empty	31/07/2024	Already in the Event Rec. section
4	Data Formats	Tenti	complete	31/07/2024	
4.1	edepsim output	Pia	complete	31/07/2024	
4.2	Detector simulation output	Tenti	empty	31/07/2024	
4.3	Reconstruction output	Tenti	empty	31/07/2024	
4.4	Common Analysis Files	Di Noto	empty		
5	Computing resources	Tenti	empty	31/07/2024	
5.1	Data volume	Tenti	empty	31/07/2024	
5.2	Data processing	Tenti	empty	31/07/2024	
6	Visualization	Pia + Chukanov	empty		
7	Integration	Tenti	empty	31/07/2024	

TDR

Link to the TDR status

Event Reconstruction

Section	Title	Contributor(s)	Status	Deadline	Notes
1	Single Particle Reconstruction		complete		
2	Track reconstruction in GRAIN		complete		
3	Two-dimensional fitting ("fast-fitting") of lens provided images (results)	Genova (?)	complete		(Matteo V. work/GE)
1.1.2	Stereo reconstruction based on projective geometry (results)	De Matteis	complete		
1.1.3	Voxel approach for direct 3D track reconstruction (results)	Cicero	complete		
1.2	Track reconstruction in the Tracker (STT)		complete		
1.2.1	Kalman Filter	Pia	empty	31/07/2024	Already in SW and Comput. section
1.2.2	Helix 3D fast fit	Ingratta	complete	31/07/2024	
1.3	Muon Momentum and Angular Resolutions (from STT track)		complete		
1.4	Electron Momentum and Angular Resolutions (from STT track)		complete		
1.5	π 0 and γ Reconstruction in STT		complete		
1.6	π 0 Identification and Reconstruction in ECAL		complete		
1.7	Proton Reconstruction		complete		
1.8	Neutron Detection		complete		
1.9	K0 and Λ0 Reconstruction		complete		
2	Particle Identification		complete		
2.1	Electron Identification in STT		complete		
2.1.1	Optimization of the STT Radiators for e± Identification		complete		
2.2	Electron Identification in ECAL ... (criteria/results)	Casazza	complete	31/07/2024	(docdb-13262 + Denise C.)
2.3	Proton Identification		complete		
2.4	Muon Identification		complete		
2.5	Muon/pion separation		complete		
3	Neutrino interaction identification in the spill	Tenti	empty	31/07/2024	Analysis not done !?
3.1	Expected Rates per Spill		empty		
3.2	Event separation inside the spill		empty		
4	Event Reconstruction in GRAIN		empty		
4.1	Vertex reconstruction	Genova (?)	empty		(Matteo V. work/GE)
4.2	Multiple track reconstruction	Genova (?) + De Matteis + Cicero	empty		(Matteo V. work/GE) + Giovanni D.M. + Valentina C.
4.3	Energy deposit reconstruction	Pia	empty	31/07/2024	
4.3.1	Calorimetric approach		empty	31/07/2024	
4.3.2	Track-by-track approach		empty		
5	Tracker and ECAL acceptance for muons, protons, pions	Surdo	empty	31/07/2024	
6	Event Reconstruction in STT		complete		(docdb-13262 + ..)
7	Neutrino Energy Reconstruction in inclusive CC Events		complete		
7.1	Neutrino interaction in STT		complete		
7.2	Neutrino interaction in GRAIN		complete		
7.3	Neutrino interaction in Upstream ECAL		complete		

TDR

[Link](#) to the TDR status

Analysis

Section	Title	Contributor(s)	Status	Deadline	Notes
1	Selection of CC interactions	Surdo	complete		
1.1	Kinematic Tagging of Leading CC Lepton	Surdo	complete		
1.2	Selection of νμ & ν̄μ CC interactions	Surdo	complete		
1.3	Selection of νe & ν̄e CC interactions	Surdo	complete	31/07/2024	
2	Measurements of ν(ν̄)-Hydrogen Interactions	Surdo	complete	31/07/2024	
3	Determination of Relative and Absolute Fluxes	Surdo	complete	31/07/2024	
4	Constraining the Nuclear Smearing in Ar	Surdo	complete	31/07/2024	
5	ν-e Elastic Scattering	Surdo	complete	31/07/2024	
6	Coherent π ± Production	Surdo	complete	31/07/2024	
7	νe/νμ & ν̄e/ν̄μ Flux Ratios	Surdo	complete	31/07/2024	
8	On-Axis Beam Monitoring	Chukanov	complete	31/07/2024	
8.1	Monitoring of the Beam Parameters	Surdo	complete	31/07/2024	
8.2	Monitoring of the Beam Direction	Surdo	complete	31/07/2024	
9	External Backgrounds	Surdo	complete	31/07/2024	
9.1	Expected Rates per Spill	Surdo	complete	31/07/2024	
9.2	Rejection of Random Neutron Background in ν(ν̄)-H Interactions	Surdo	complete	31/07/2024	
9.3	Rejection of Random Neutron Background in Inclusive ν(ν̄) CC	Surdo	complete	31/07/2024	
9.4	Rejection of Rock Muons and Magnet Events in Upstream ECAL	Surdo	complete	31/07/2024	
9.5	Rejection of External Neutrino Interactions in STT	Surdo	complete	31/07/2024	
9.6	Pile-up Background in Upstream barrel ECAL	Surdo	complete	31/07/2024	

Thank you