The STT tracker system for SAND

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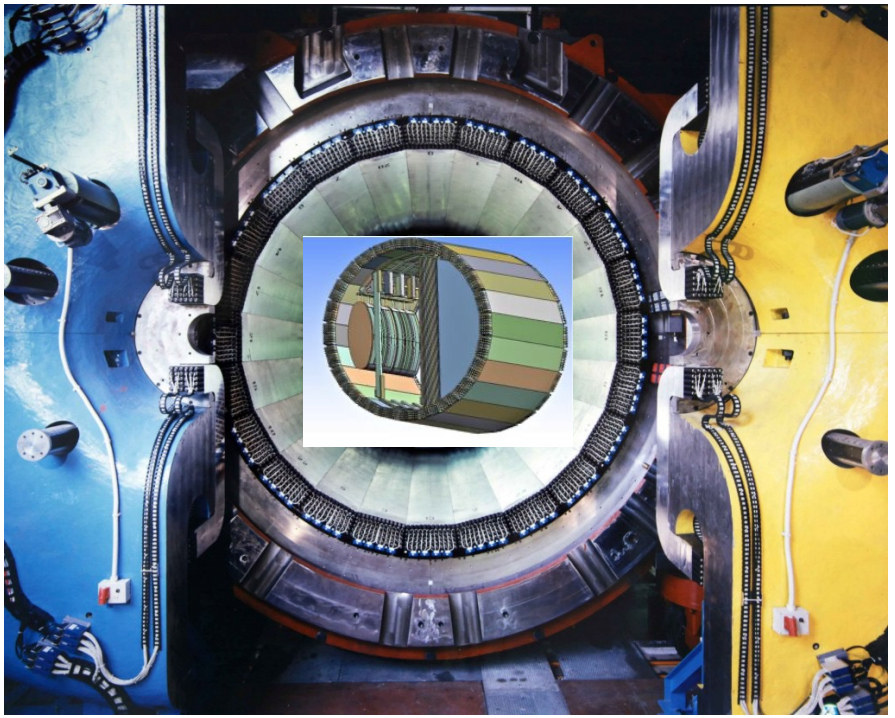
Why SAND needs a tracker system inside the magnet?

- Separation of neutrino and anti-neutrino fluxes (charge ID),
- event-by-event reconstruction,
- neutron identification,
- subtraction analysis to isolate free proton interactions.



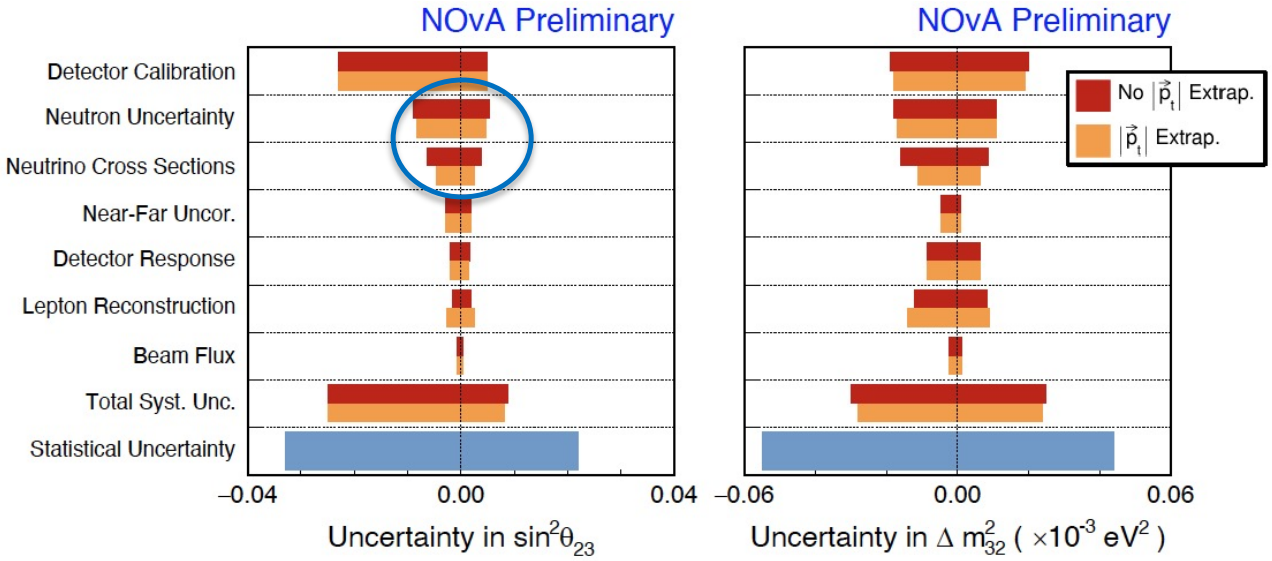
The STT concept *(credits: Roberto Petti, South Carolina)*

A distributed target mass with low density ≤ 0.18 g/cm^3

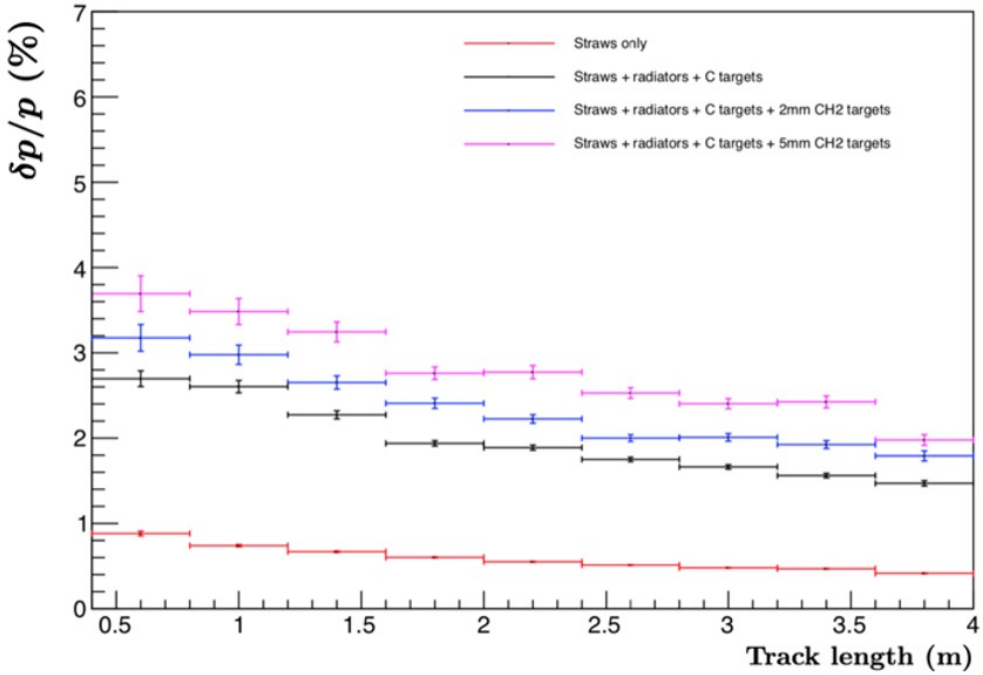
Why targets are needed?

1) Get neutrino interactions in the tracker
2) Get free proton (H) interactions

1) physics beyond LBL osc.
2) Systematics uncert.



- **Kinematic analysis** requires integrated & hermetic detector including both STT and ECAL
- Reconstruction critically depends on **total material** in **magnetic volume** inside ECAL: angular & momentum resolution (multiple scattering), energy resolution of e±, γ etc.
- Average **track length L** over entire volume determines maximal affordable target mass : increase in multiple scattering from target(s) balanced by long L to achieve excellent resolutions



All ν_μ CC FHC interactions (STT fiducial volume: 20cm from edges)

STT configuration	Average $\delta p/p$ (%)
Straws only (no targets)	0.69
Straws + CH_2 radiators + 4mm C targets	1.98
Straws + CH_2 radiators + 4mm C targets + 2mm CH_2 targets	2.32
Straws + CH_2 radiators + 4mm C targets + 5mm CH_2 targets	2.80

STT performances *(docDB-13262)*

on top of the performances from “proton interactions” …
(done with kinematic separation, i.e. with likelihood evaluation)

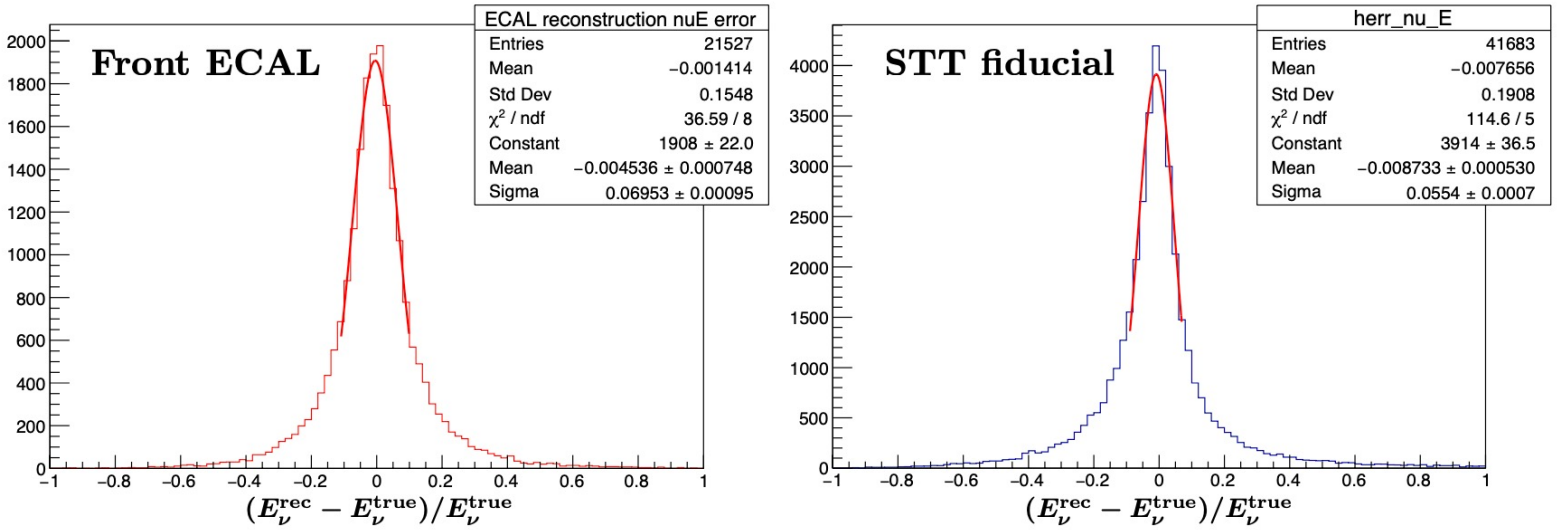


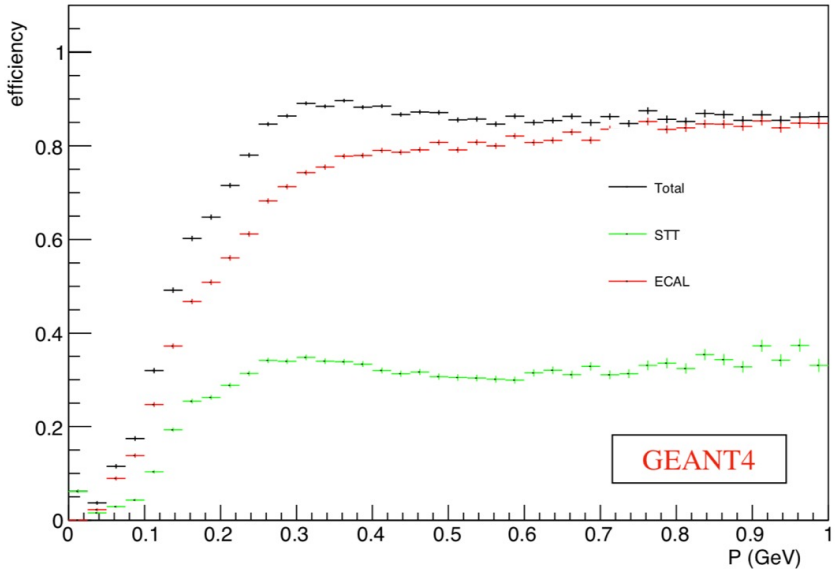
Figure 171: Left plot: resolution of the reconstructed neutrino energy in ν_μ CC interactions originated in the front barrel ECAL after all corrections. Right plot: same as previous but for ν_μ CC interactions originated in the STT fiducial volume.

Neutron detection

The combined STT+ECAL system offers a high detection efficiency for neutrons originated in (anti)neutrino interactions.
The efficiency below is averaged over all neutrons from $\overline{\nu}_{\mu}$ CC RHC interactions uniformly distributed within the standard STT fiducial volume (20cm from edges) with energy thresholds of

- 250 eV in STT and
- 1.1 p.e. in ECAL.

For QE on H the fraction of neutrons detected in STT is 30.6% and 49.9% in ECAL.



STT only	QE	RES	DIS	Total
Carbon	25.3 %	29.7 %	32.9 %	29.1 %
Hydrogen	30.6 %	34.5 %	38.2 %	32.5 %

Target	QE	RES	DIS	Total
Carbon	64.8 %	76.5 %	80.1 %	73.6 %
Hydrogen	80.5 %	85.0 %	87.4 %	82.3 %

Electron measurement

SAND is greatly enhanced in physics capability measuring electrons

If CPT invariance hold the transition probabilities for $\nu_i \rightarrow \nu_j$ and anti-$\nu_j \rightarrow$ anti-ν_ι are equal. Henceforth, no CP{violation can be observed in the disappearance mode (i=j). One needs to observe the transition among avours, for both neutrinos and antineutrinos, to access CP violation:

$$P(\nu_\mu \rightarrow \nu_e) \text{ not.equal } P(\text{anti-}\nu_\mu \rightarrow \text{anti-}\nu_e)$$

The STT system measures electron with the TRD (transition radiation detection), with electron efficiency above 90% and a π rejection factors exceeding 10^3.

Instead of using just ECAL, do we really need it?

What was said

SAND is fully committed to be ready from DAY-1 to contribute to the first data taking and analysis. Moreover, INFN as major stakeholder of SAND is fully committed to have a complete SAND detector including the Inner Tracker for DAY-1 physics program, beyond beam-monitoring.

For the CD1-RR and the CD2 reviews a detailed funding scheme along with the corresponding detector design will (should) be available for the chosen IT option.

What was stated

- The responsibility for the delivery of the STT tracker will lie with INFN who will construct the STT tracker in collaboration with groups from Indian and Georgian universities, as well as Dubna and other Institutions t.b.c.
- We expect the SAND Consortium to develop a project plan which identifies the resources that will be needed to construct the STT.
  The Consortium should appoint a resource coordinator for this task
- We encourage collaborators who would be interested in working on the SAND tracker to reach out to the Consortium leadership team to see how they could contribute.
- We are all convinced that SAND cannot replace ND-LAr in the DUNE Near Detector

(notes from the September 2021 Executive Board)

BACKUP

Software/Analysis Board