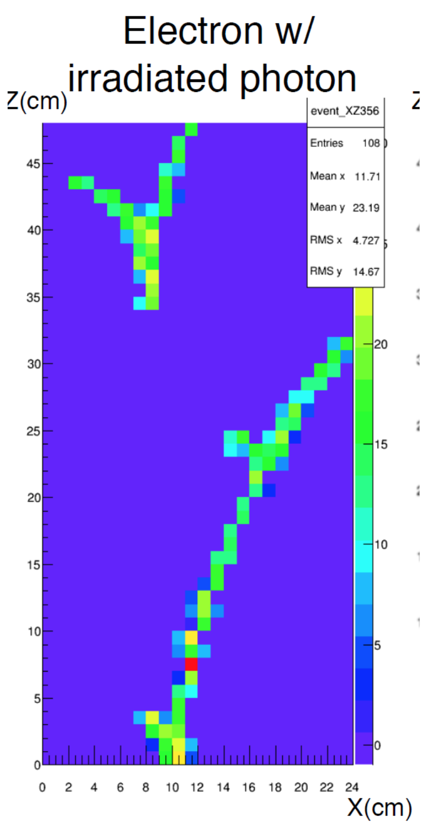
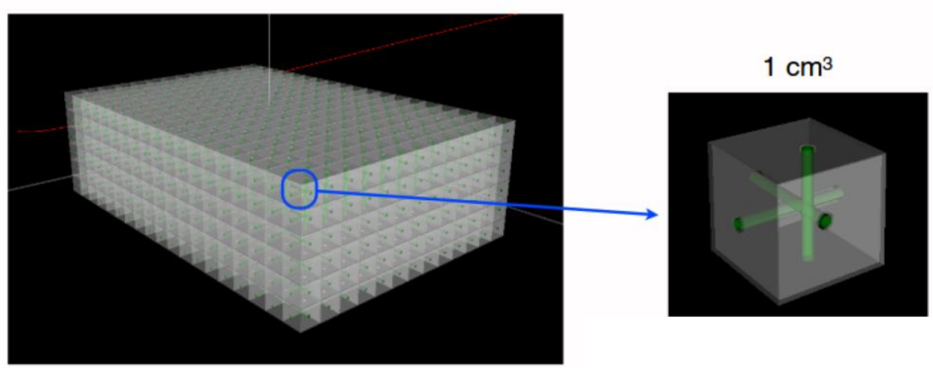
3DST-S in DUNE near detector concept

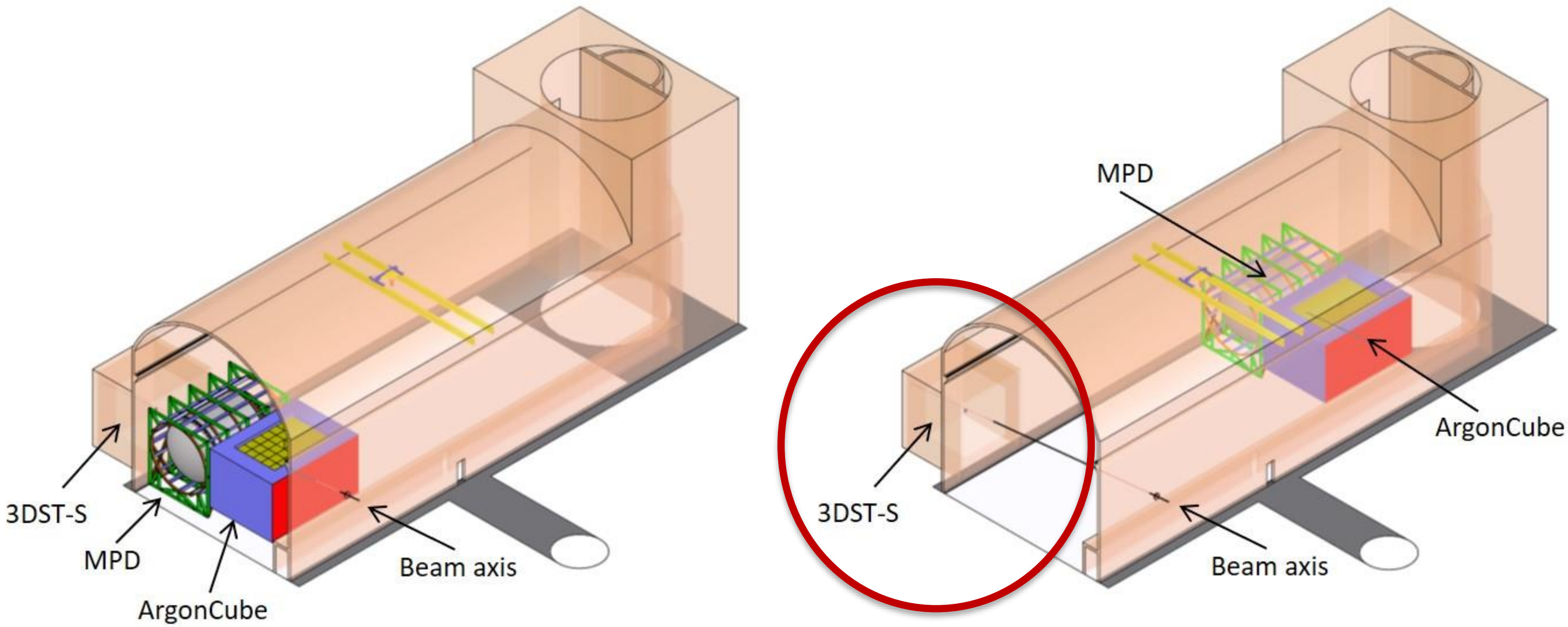


S. Manly
University of Rochester

LBNC Meeting
Fermilab
June 4, 2019

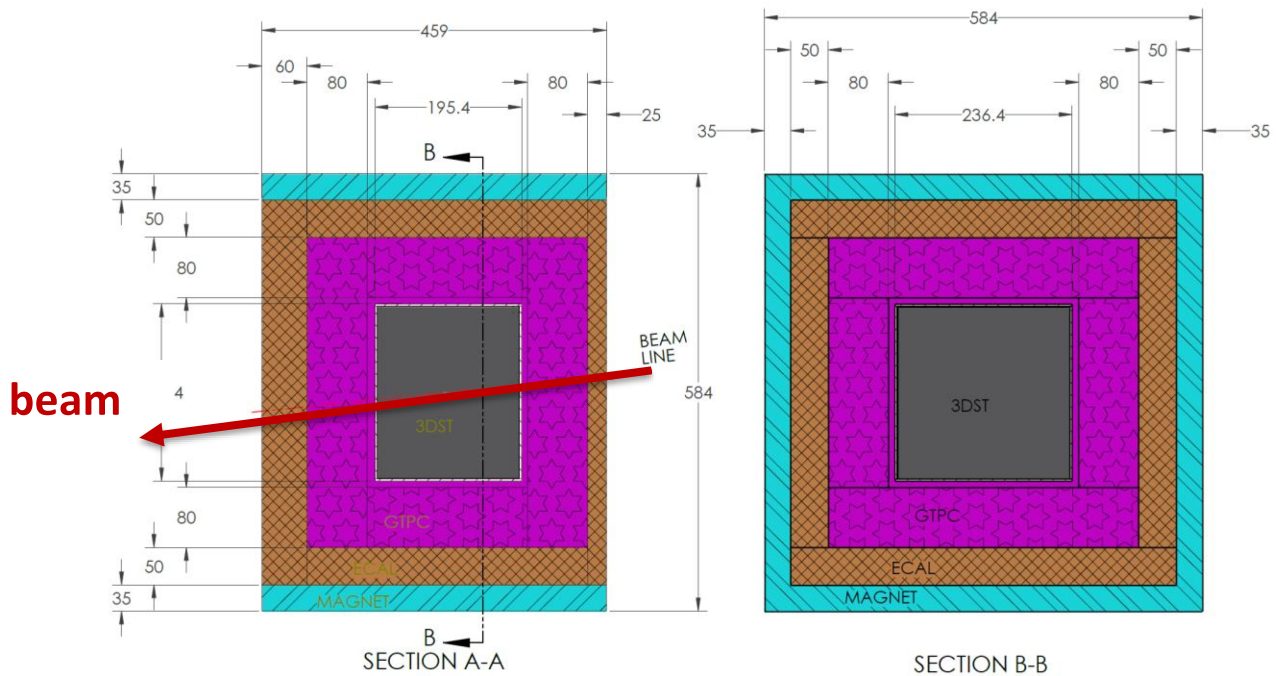


Overview



3DST-S stays on axis

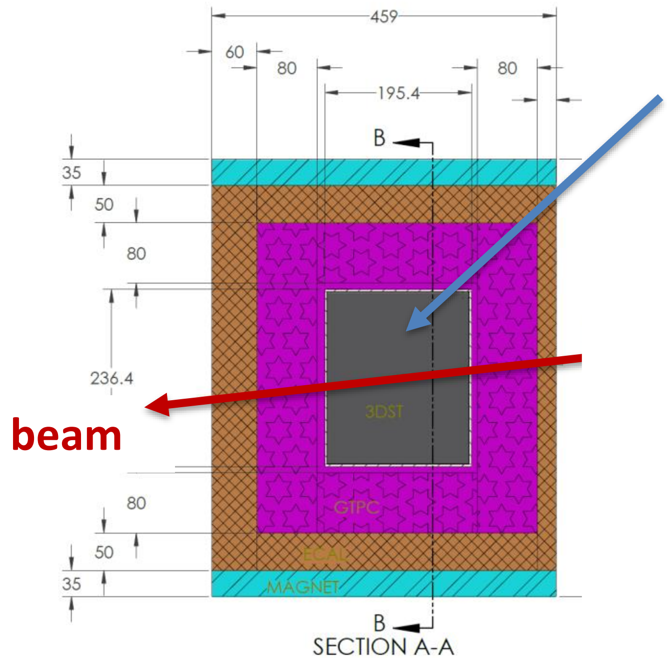
Overview



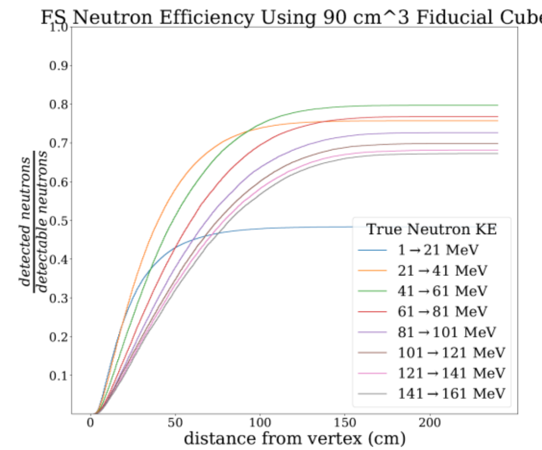
Side view **Beam's eye view**

Overview

Size of 3DST driven by statistics for beam monitoring and efficiency of neutron tagging.

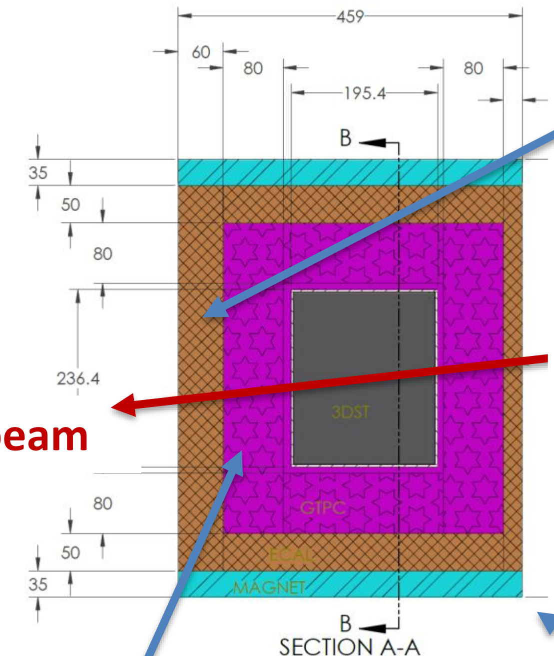


Side view



Channel	ν mode	$\bar{\nu}$ mode
ν_μ CC inclusive	13.6×10^6	5.1×10^6
CCQE	2.9×10^6	1.6×10^6
CC π° inclusive	3.8×10^6	0.97×10^6
NC total	4.9×10^6	2.1×10^6
ν_μ-e$^-$ scattering	1067	1008
ν_μ CC coherent	$1.26\ \times10^5$	$8.6\ \times10^4$
ν_μ CC low-ν (ν <250 MeV)	1.48×10^6	$8.8\ \times10^5$
ν_e CC coherent	2.1×10^3	719
ν_e CC low-ν (ν <250 MeV)	2.1×10^4	$4.7\ \times10^3$
ν_e CC inclusive	2.5×10^5	0.56×10^5

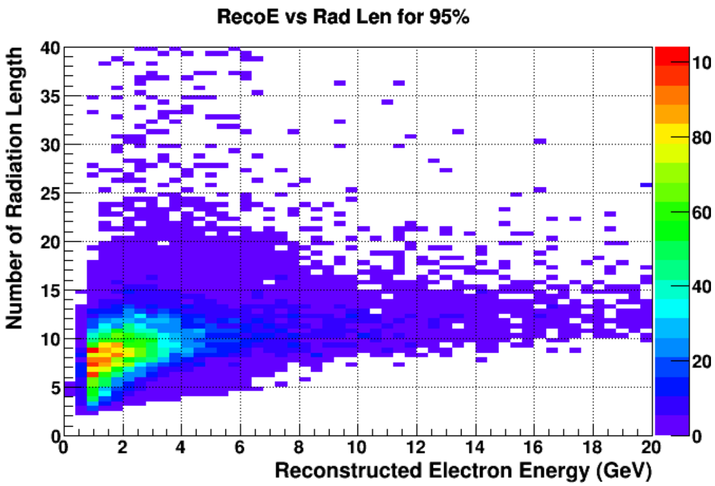
Overview



beam

Side view

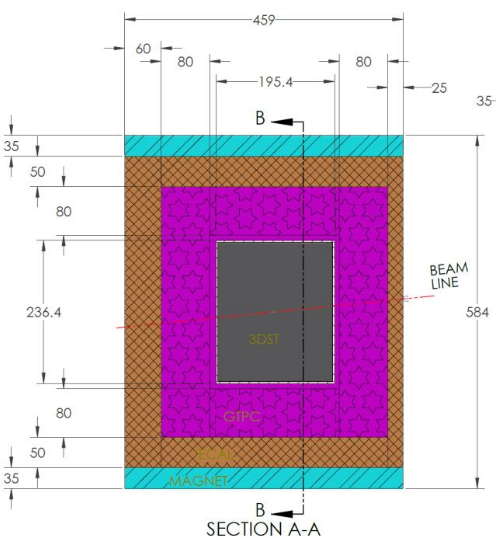
Downstream ECAL approx. 12 radiation lengths to contain electrons in neutrino-electron scattering sample

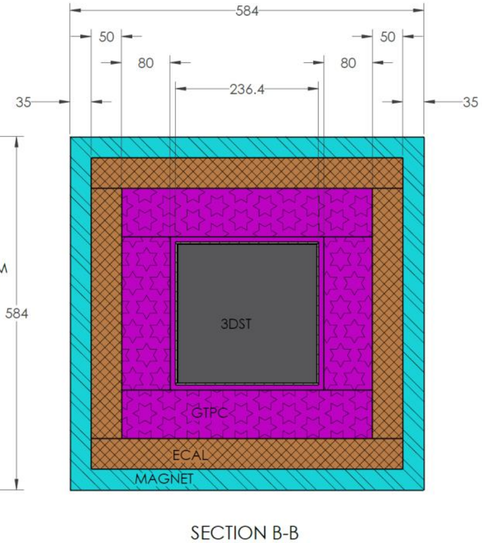


Magnet and downstream TPC for muon analysis for spectral monitoring

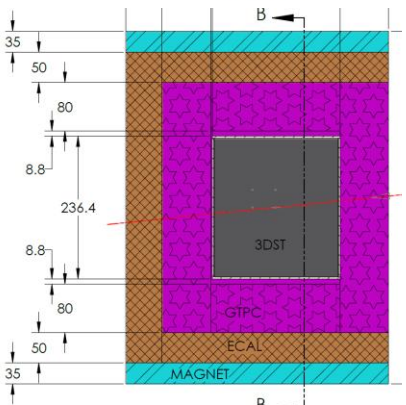
Broad solid angle containment for low-nu flux measurement and event morphology for event-by-event neutron studies

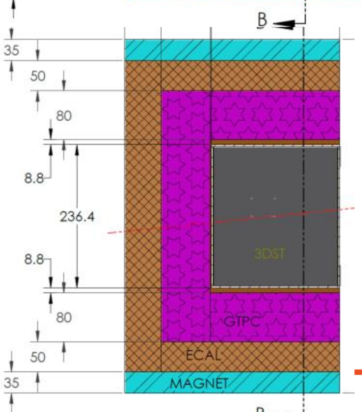
Optimization

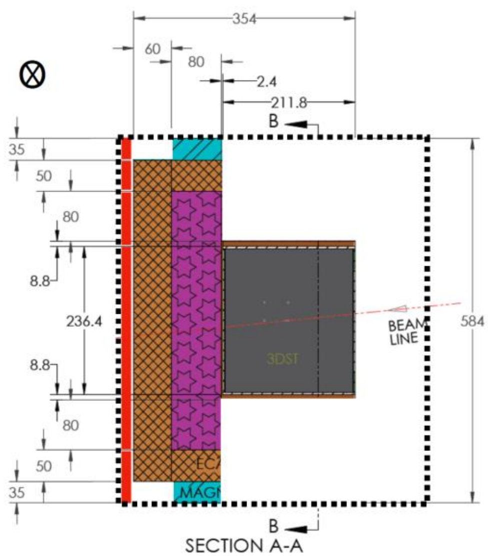


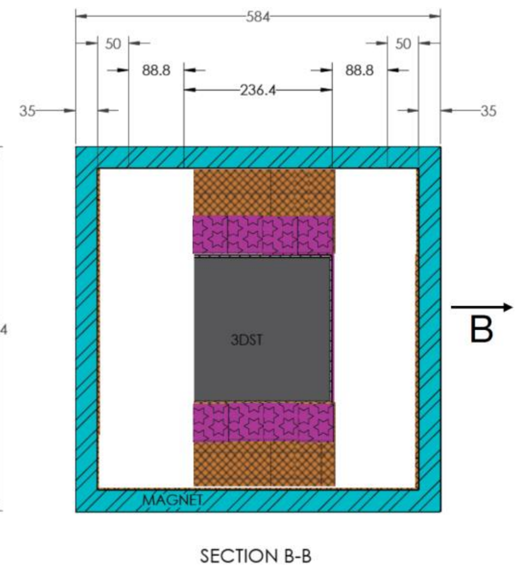


Different configurations under study









Technical status

3DST
CERN prototype
US-Japan prototype progress, box prototype
Electronics status
Upcoming neutron run
Fabrication technique R&D, Russia and Japan
SuperFGD design/construction

TPC design, similar to ND280 upgrade TPCs (proven old versions okay too)

ECAL, study needed, no reason to expect technically challenging or huge number of channels

Magnet design being considered, probably NC, technically achievable

Technical risks

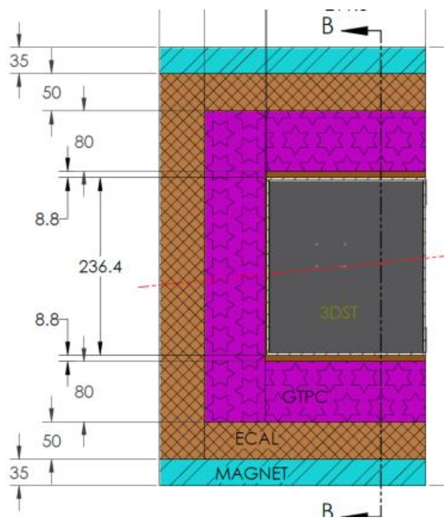
Component technologies proven/prototyped

Construction
superFGD size and construction

Triad of physics deliverables

Intended to play a complementary role to the argon parts of the experiment. Minimal input directly into the CPV analysis.

Beam monitoring



Neutrons

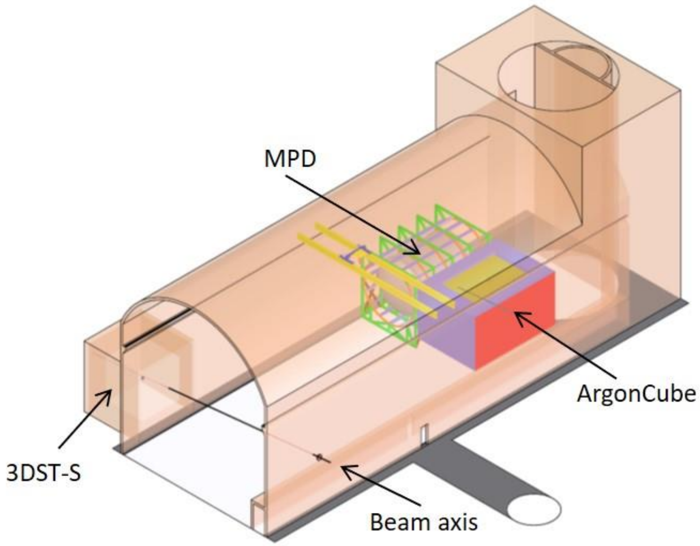
New tool

Model development

Redundancy and risk mitigation

Triad of physics deliverables

Beam
monitoring



- Need at least minimal on-axis dedicated neutrino beam spectrum monitor for core CPV program.
- Off-axis detectors are less sensitive to beam element/spectral changes
- Rate alone is not good enough
- Plan for frequent on-off axis LAr detector movement? Maybe

- 3DST-S can do this

Traditional blind spots in neutrino physics: low p pi, p, and neutrons
DUNE ND concept aims to let us see in these blind spots
Neutrons on argon, good. We get that and are exploring that.
Neutrons on carbon a new tool:

1) Flux, STV analysis
2) Explore neutrino interaction physics.
   - Well founded skepticism that neutrons on carbon can be "scaled" to directly constrain neutrons on argon.
   - Ability to incorporate neutrons over broad kinematic range is likely to be helpful information for continuing development of interaction models
     - Example: 2p2h/MEC was encountered and explored in neutrino-carbon and will most certainly be a component of the model we use for neutrino-argon interactions. Our current picture for 2p2h is known to be incomplete and requires ad hoc tuning to be useful for oscillations. In 2027, we will do that tuning with the ND argon samples. Still, input to model development has been critical for this and will likely continue to be useful, particularly if we add a new handle like neutrons.
   - May have available slide on SUSA (done with care, because we have skepticism now does not mean we should avoid taking data that may help us eventually develop model)
   - May have some thoughts on ability to deconvolve stages of interaction to help modeling
   - What other things will we encounter?

N

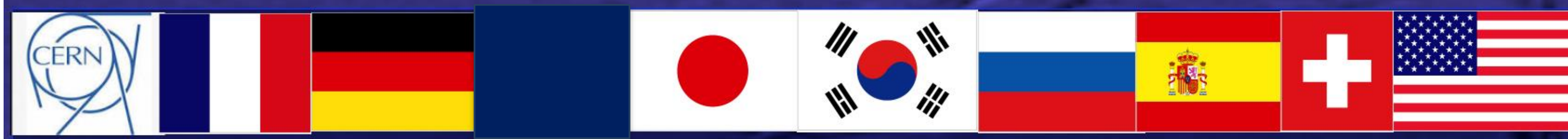
New too

Triad of physics deliverables

- Dedicated on-axis neutrino spectrum
- Neutrino-electron scattering measurement, nucleus agnostic to first order, has low stats relative to LAr, but also different systematics and different sensitivity to backgrounds
- Low-nu, different detector systematics
- Provides additional handle for deconvolution of flux*xsec, done with PRISM (yay), but this may be helpful for evaluating systematics in how well that is done via PRISM, and useful backup if have unexpected technical problems with PRISM
- Able to do sign separated nue, nuebar measurements (HPgArTPC hopefully able to do background free in the end but will take time to high enough statistics)
- Minimal risk in technology
- Very fast detector, robust to unexpected backgrounds
- Transparent connection to past CH data if need to explore new aspects of modeling (that may or may not apply to Ar)

edundancy
nd risk
nitigation

The SuperFGD/3DST Group
(19 institutions, 9 countries + CERN)



CERN

France
CEA Saclay

Germany
MPI Munich

[redacted]

Japan
KEK
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U. Kyoto
U. Tokyo
Yokohama National U.

Korea
Chung-Ang U.

Russia
INR

Spain
IFAE, Barcelona

Switzerland
U. Geneva

USA
BNL
Fermilab
Louisiana S. U.
S. Dakota School of Mining and Technology
Stony Brook U.
U. California, Irvine
U. Colorado
U. Minnesota, Duluth
U. Pennsylvania
U. Pittsburgh
U. Rochester

* Institutions in yellow have expressed specific interests in DUNE ND 3DST-S

* Two students from Madagascar are very actively involved in the 3DST studies.

* Monireh (Minoo) Kabirnezhad, Oxford, just joined the 3DST effort

Summary:
Why 3DST-S rather than minimal beam spectrum monitor?

We need to get from home to job.
A Smart car will do that.

A 4WD Subaru Forester will do that, too.
More expensive, yes. Needs a bigger garage.
But, provides much more functionality and preparedness for the known unknowns like snow and the unknown unknowns like kids and dogs.

A few years down the road, when faced with needing to drive two kids to a hockey tournament in the snow, I'd rather have the Subaru. I could do it with the Smart car, but it would take two trips and each would be more risky.

Backups