Forward Physics Facilty
LArTPC – physics motivations

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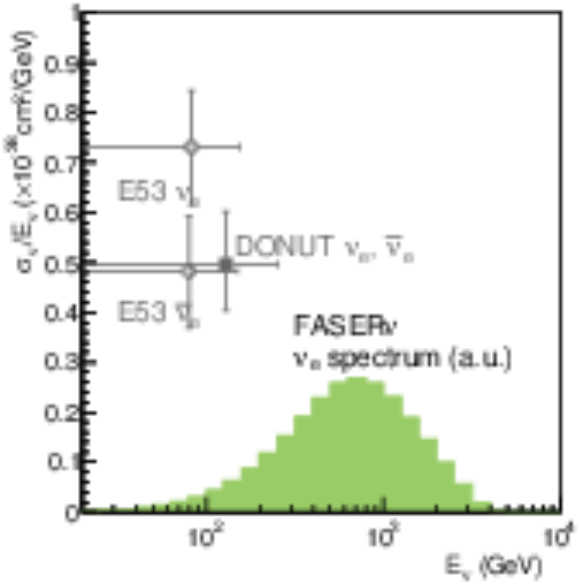
Slides on civil engineering studies here:
https://indico.cern.ch/event/1010002/contributions/4238346/attachments/2191972/3704924/2021 02 17 FPF Progress Meeting Rev0.pdf

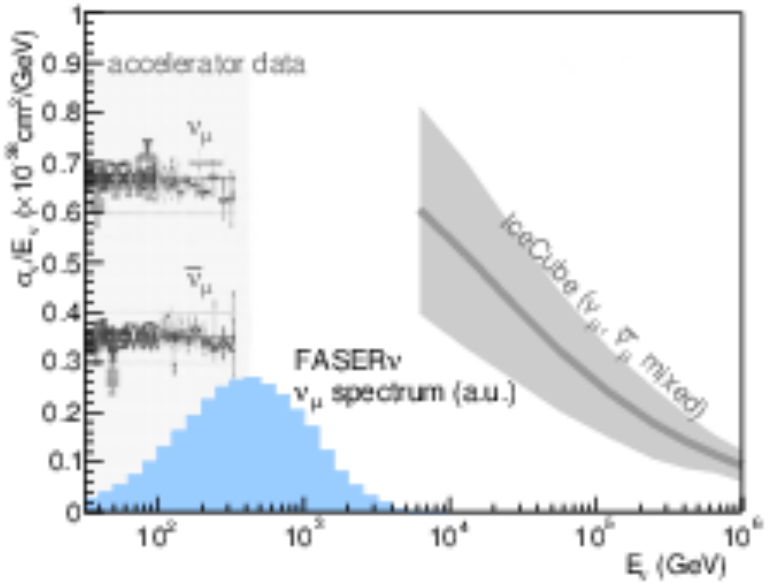
FPF introduction

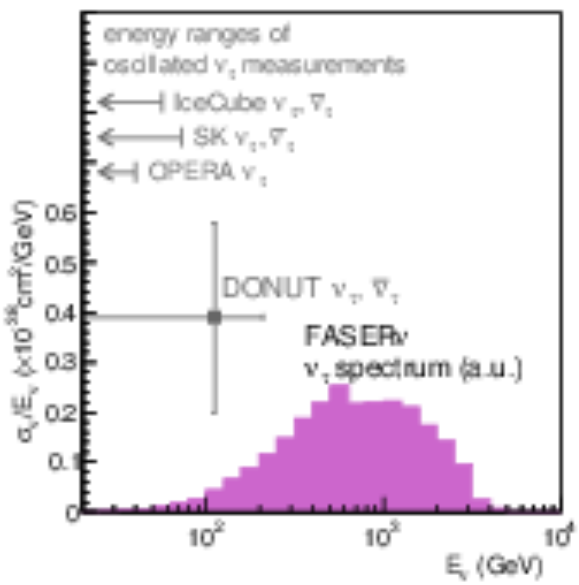
- FASER detector (r=10cm) currently being installed on the ATLAS collision axis line-of-sight (LOS) – 480m from the IP
  - Good sensitivity to new, light and weakly coupled new particles produced in light meson decay – e.g. dark photons produced in pi0 decay
- A bigger detector (r=~1m) (FASER2) would have good sensitivity to new particles also produced in heavy meson decay (e.g. dark-Higgs from B-decays)
- FASER also includes a 1ton tungsten/emulsion detector (FASERnu) to measure high energy neutrino cross section
  - First detection of neutrinos produced at a collider
  - Expect ~20k, 1k, ~10 mu/e/tau neutrino interactions in LHC Run3 (150/fb)
  - FASERnu2 (10tonne detector for HL-LHC) would have 200x statistics (10x target mass, 20x luminosity)
- In order to house FASER2 / FASERnu2 would require significant civil engineering
  - Benfit from this by thinking of other possible detectors which can benefit from the physics on the LOS – milicharge particle experiment, LAr TPC etc…
  - Such a facility is being looked at by the PBC study group, called Forward Physics Facility (FPF)

LAr TPC motivation - neutrinos

Neutrinos in unexplored energy regime ~TeV energies







Differences between the generators checked with the same propagation model (RIVET-module)

	DPMJET	SIBYLL	Pythia8
ν_e , $\bar{\nu}_e$	3390 , 1024	800 , 452	826 , 477
ν_μ , $\bar{\nu}_\mu$	8270, 2391	6571 , 1653	7120 , 2178
ν_τ , $\bar{\nu}_\tau$	111 , 43	16 , 6	22 , 11

Large uncertainties in expected neutrino rates but could expect ~2-3k interacting tau neutrinos in a 10ton detector installed for the HL-LHC.

Question – can a LArTPC see tau neutrino with O(1TeV) energy?

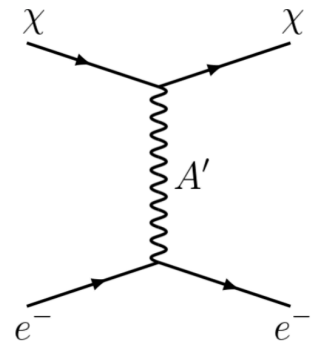
Some potentially interesting tau neutrino physics questions:

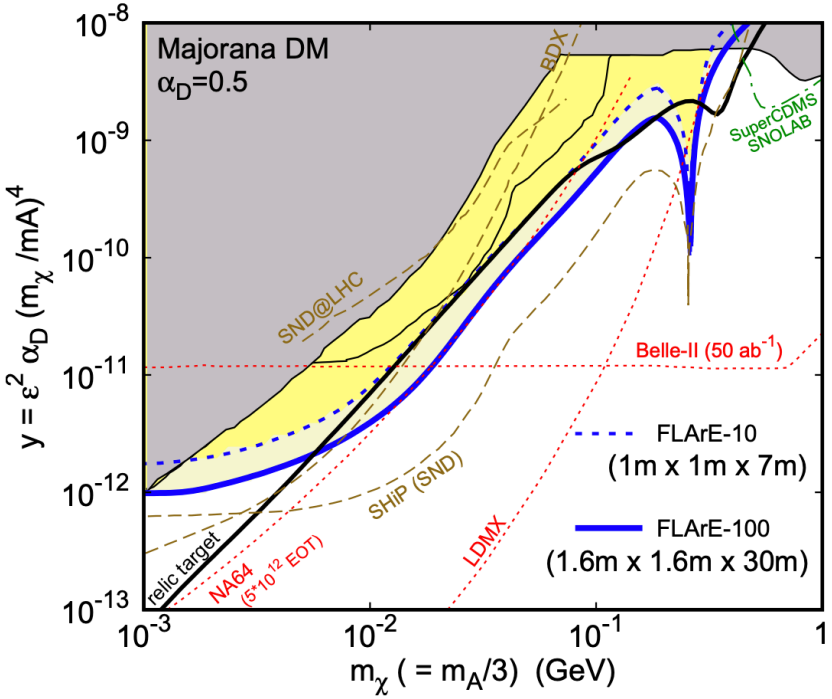
- Measure anti-tau neutrino for first time (need magnet to ID muon charge)
- Constrain tau neutrino electric dipole
- Measure tau-neutrino + heavy-flavour (related to LHCb flavour physics anomolies)

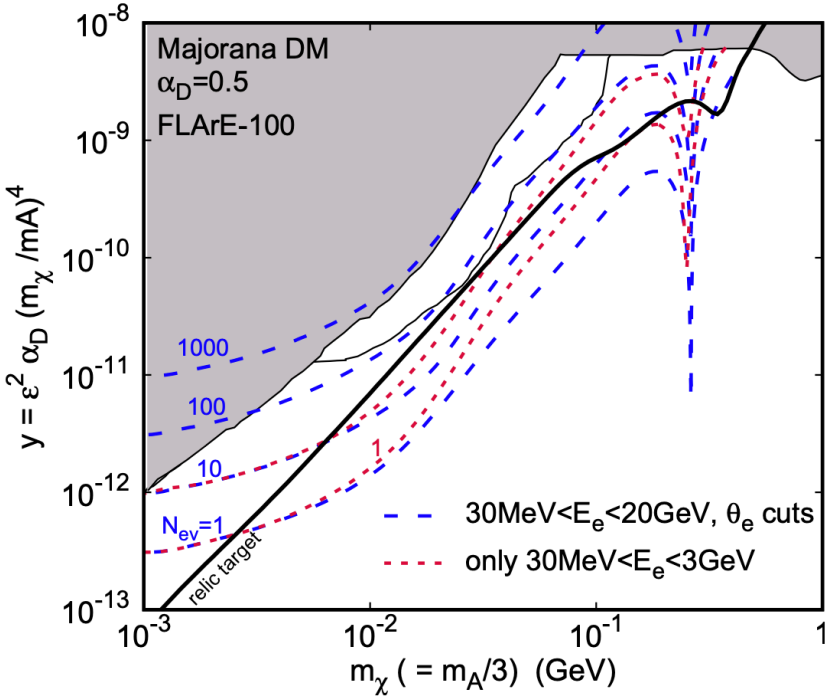
https://arxiv.org/pdf/2101.10338.pdf

LAr TPC motivation – dark matter

- Recent paper by theorists on search for DM at FPF with LArTPC or emulsion detector
  - Consider a simple dark photon mediated DM model
  - Only consider DM electron scattering (should be extended to nucleus scattering)
  - Consider backgrounds from muon, and neutrinos (but at 'theorist' level)







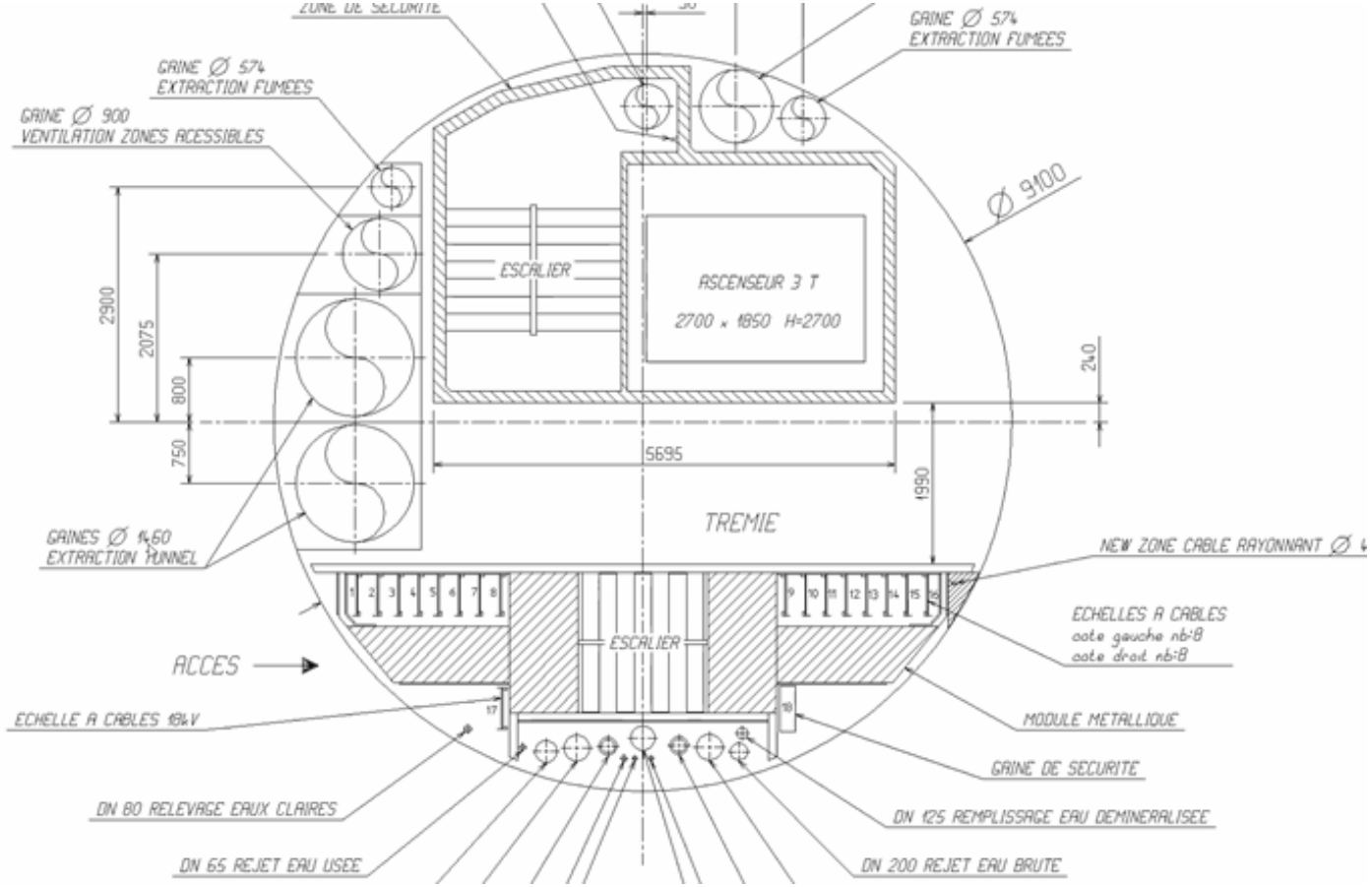
Results look quite strong – have sensitivity to most of parameter space compatible with the measured thermal relic density.

Some possible questions

- Service requirements for 10tonne or bigger active volume LAr detector either in separate cavern, or in alcove of existing UJ12 cavern
  - What would drive cost?
  - What would need to be taken into account from start of design of facility?
- Safety aspects for both scenarios
  - What would drive cost?
  - What would need to be taken into account from start of design of facility?
- Physics questions:
  - Can LArTPC see tau neutrino interaction with p>~1TeV?
  - Can LArTPC handle background muon rate of ~3Hz/cm^2? (from physics and operational point of view) (maybe able to be substantially reduced with a sweeper magnet installed ~300m downstream)
  - What radiation level is OK for LArTPC?
  - Can LArTPC be interfaced to a magnet to measure outgoing muon momentum?

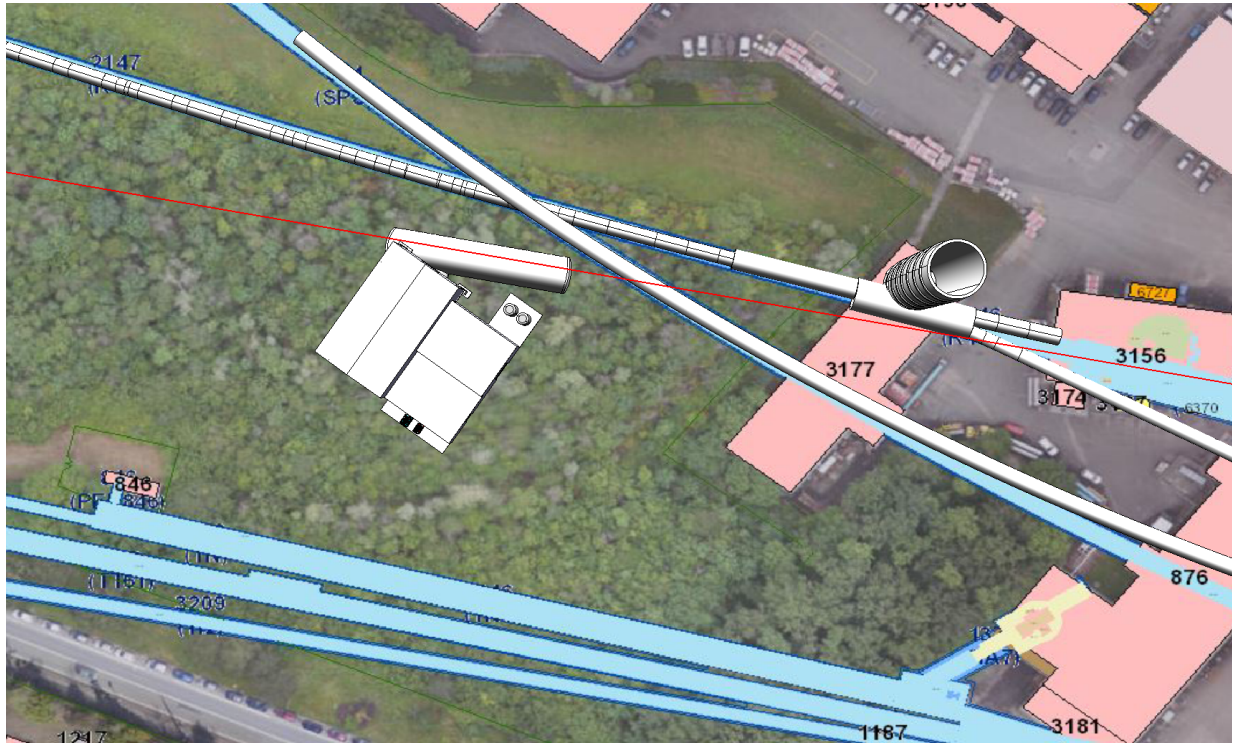
Shaft size?

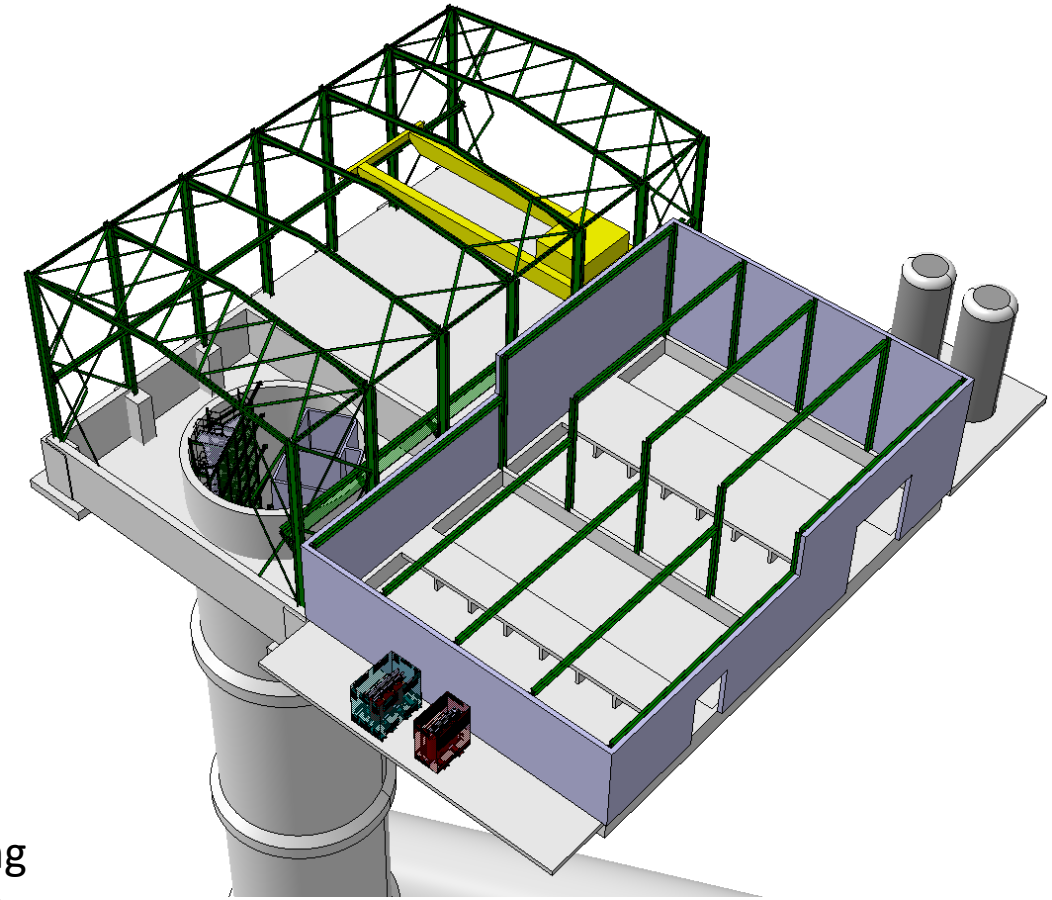
- Size of shaft (part needed for cryo services)?



Current design foresees 9.1m diameter shaft (based on HL-LHC shafts).
If we could reduce diameter to ~8.5m would save significant money.
How much space would be needed for cryo related services (incl. safety).

Surface building infrastructure





What size, constraints, services would be needed for a service building over the shaft. Above picture is first guess used for the current design.