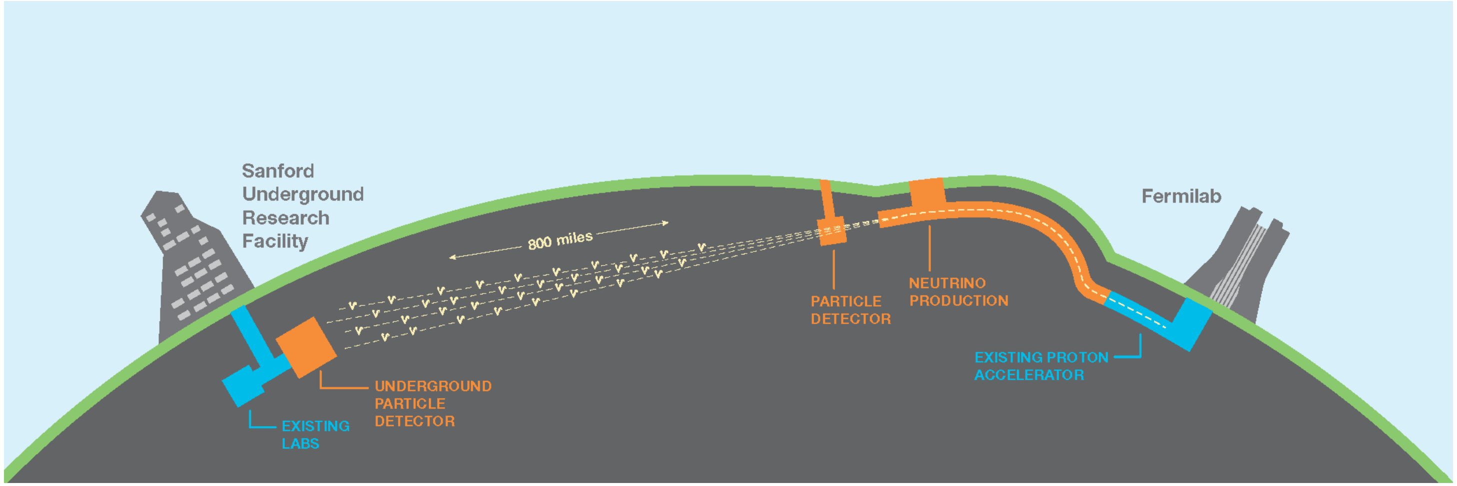


Near Detector Status Report

Alfons Weber
University of Oxford & STFC/RAL

LBNC Meeting

CERN, 22-June-2017

Near Detector Concept Study

- Charge
  - Develop a proposal for a DUNE collaboration near detector concept by the end of 2017.
- Study should
  - Ensure that the proposed near detector concept meets the requirements of the primary scientific goals of DUNE.
  - Assume a single near detector hall of a similar to the CD-1-R design, located at a distance of between 360 m and 575 m from the target.
  - Present a plausible funding model for the proposed concept, based on the interests and likely contributions to the detector construction from the international collaboration.
  - Focus solely on the design of the Near Detector; the scope of the study does not extend to the design of the LBNF near site facility

Organizational Updates

- Near Detector Coordination
  - Appointed in April: Alfons Weber

- Additional workshops to support discussions and progress
  - 6-7 Nov at CERN

Major Milestones

Q1/2017: 1st ND design workshop at FNAL ☑

Q2/2017: 2nd ND workshop at FNAL ☑

Q3/2017: narrow down ND options (on track)

Q4/2017: 3rd ND workshop at CERN (on track)

Q4/2017: Concept for ND agreed (Q1/2018)

Including plausible funding model

Q4/2018: ND CDR (on track)

Q1/2020: ND TDR available for review in August (on track)

Q4/2026: ND ready for beam (on track)

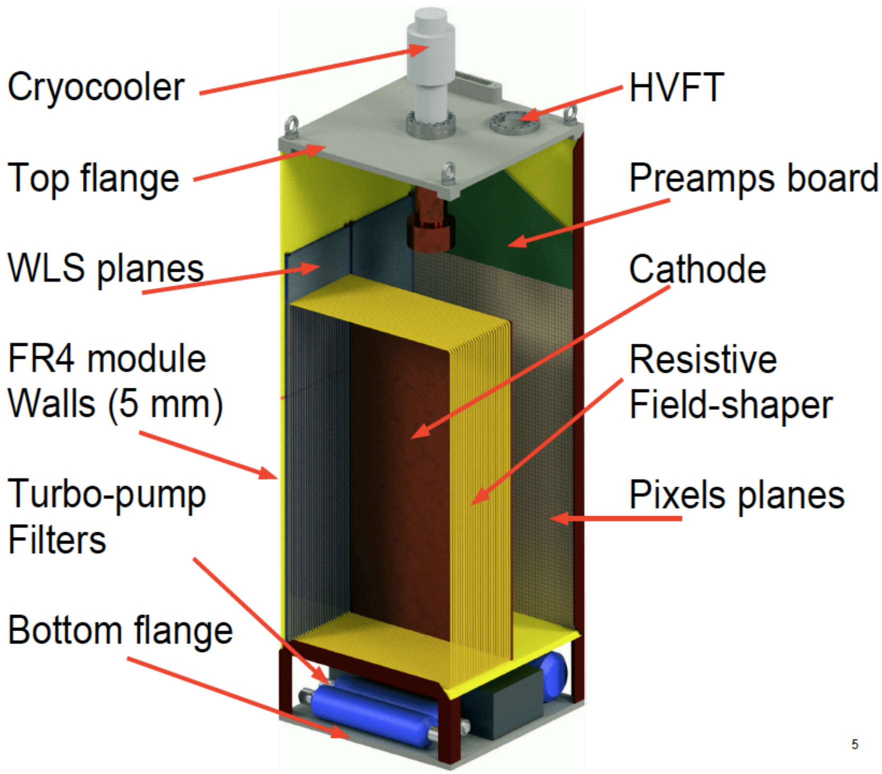
Risks

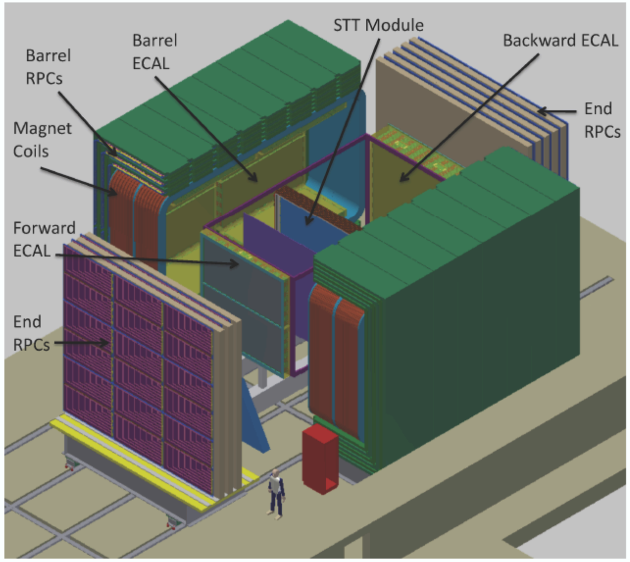
Initial thoughts

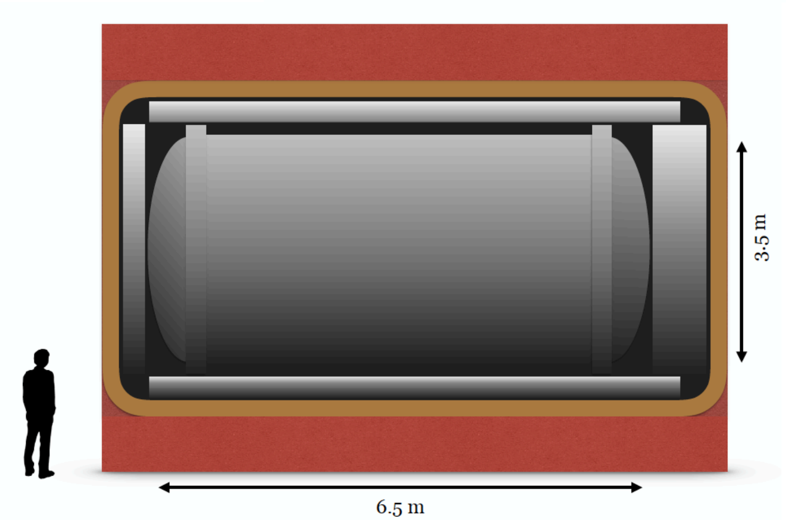
- Can’t agree concept
- Can’t fund agreed concepts
- Decision schedule is too aggressive
- Agreed/needed ND concept requires major/expensive changes to ND facilities
- Fundable/buildable ND will not be able to do physics

Status

Options studied by ND TF





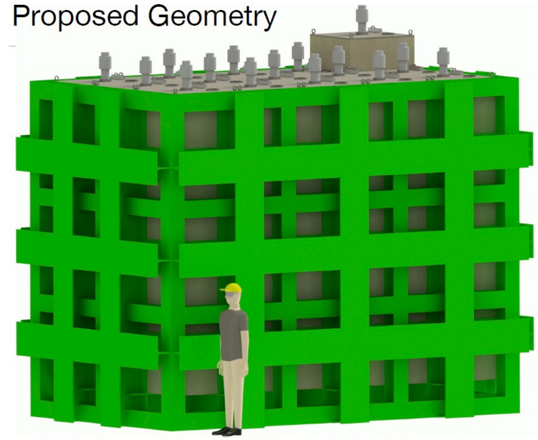


ND Group is following charge

- Several productive workshops
  - (Gas TPC NDs, Nov 2016, CERN)
  - 1st ND workshop, Mar 2017, FNAL
  - 2nd ND Workshop, Jun 2017, FNAL
  - 3rd ND Workshop, Nov 2017, CERN

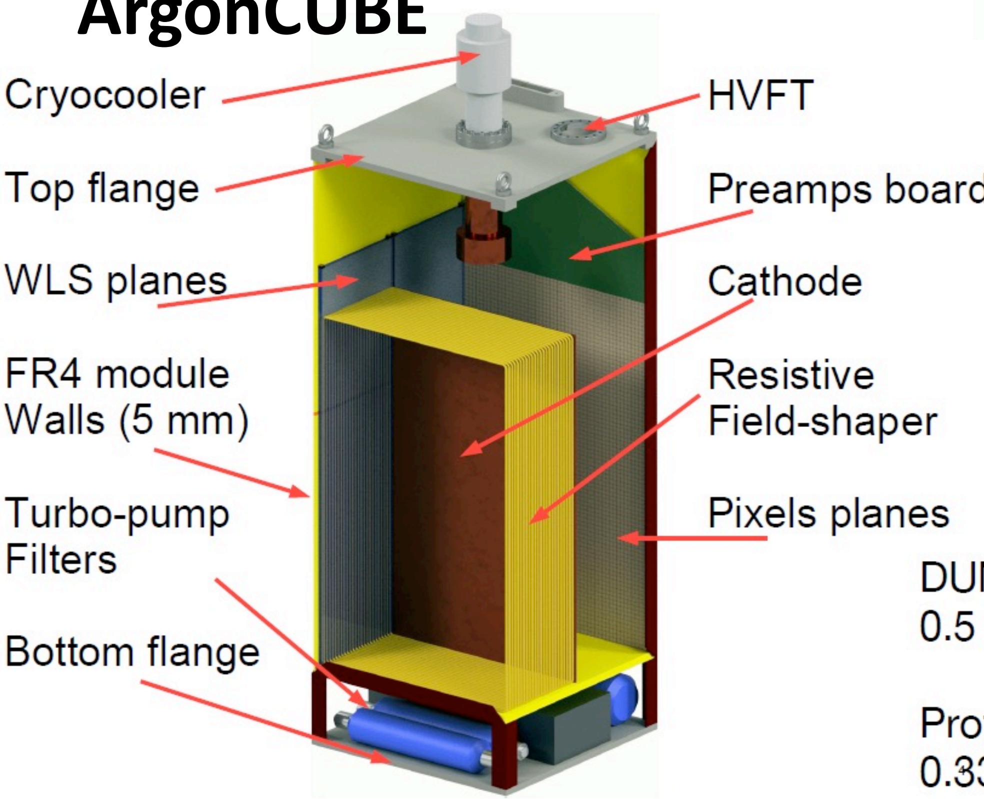
- Aim
  - Fulfil charge and suggest buildable concept to collaboration

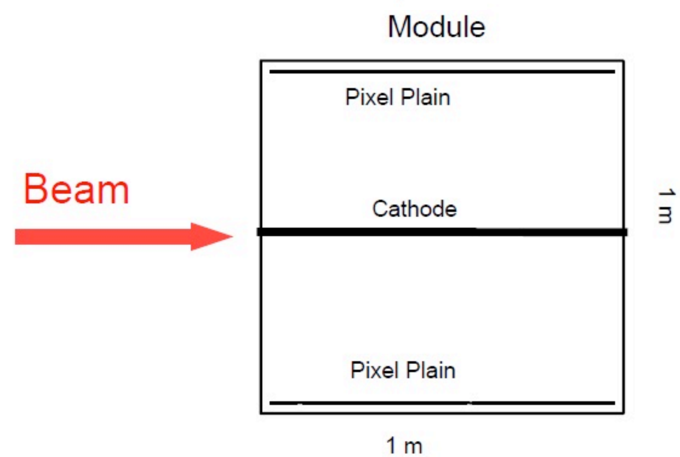
Agreed: LAr TPC



CAD of the modular LarTPC for the DUNE ND complex

ArgonCUBE

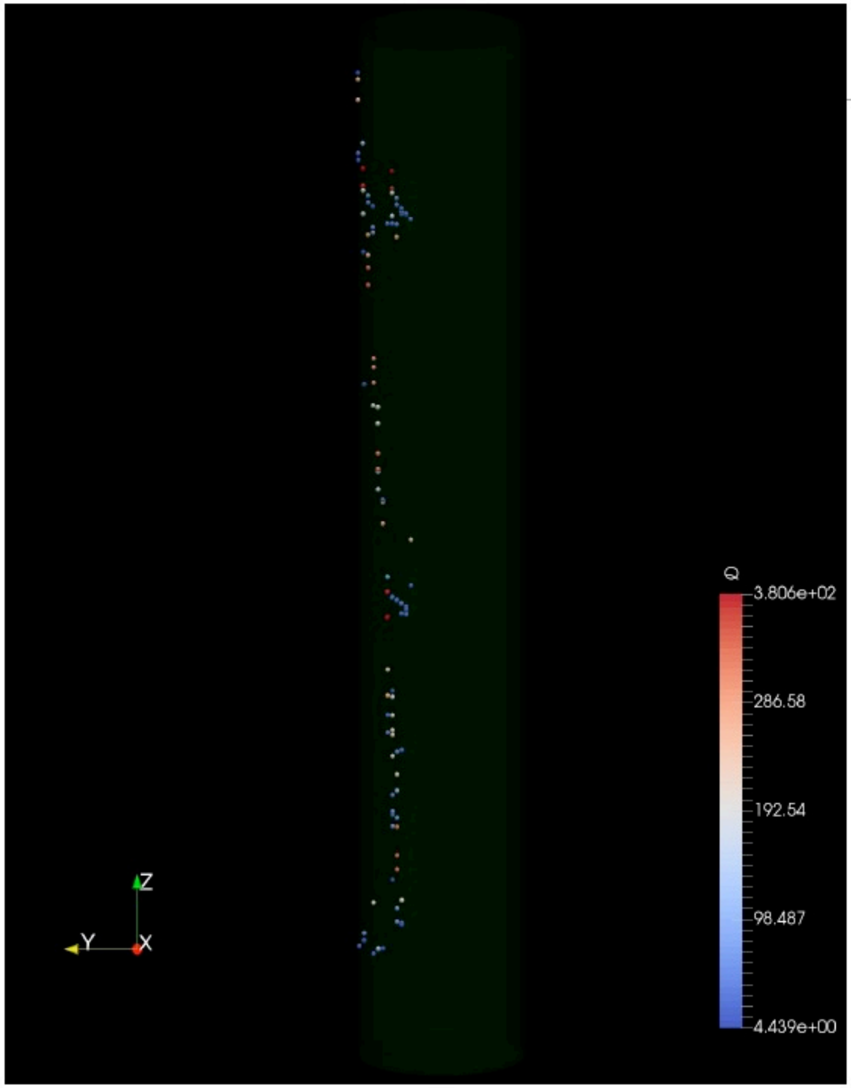


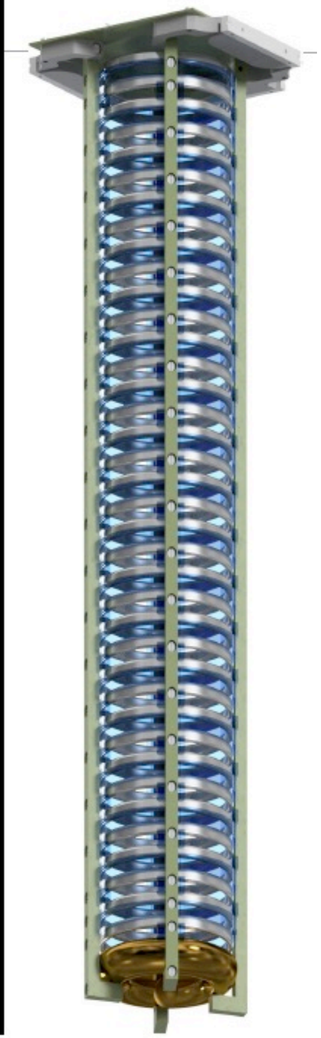


DUNE ND modules: 1.0 x 1.0 x 2.0 m^3.
0.5 m drift length

Prototype modules 0.67 x 0.67 x 1.8 m^3.
0.33 m drift

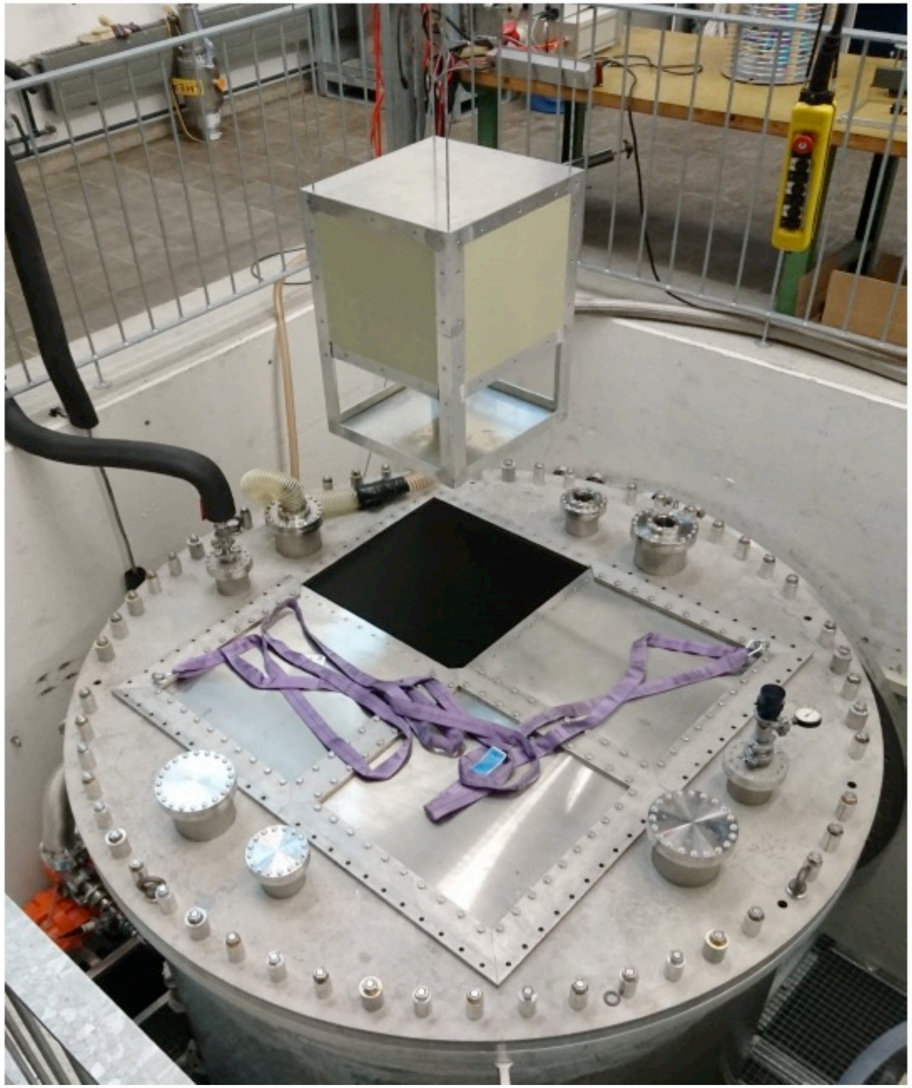
Pixel Readout Events



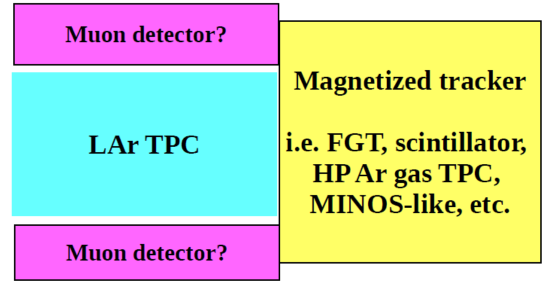


Status and Outlook

- Cryostat and module material test successfully completed (Oct 2016)
- Lightweight simulation framework summer 2017
- First TPC deployment summer 2017, pending updates to the cryogenic infrastructure.
- Pixel scalability, Light readout & field shaping studies summer 2017.
- LArPix tests spring 2018.
- Fully instrumented module deployment 2018

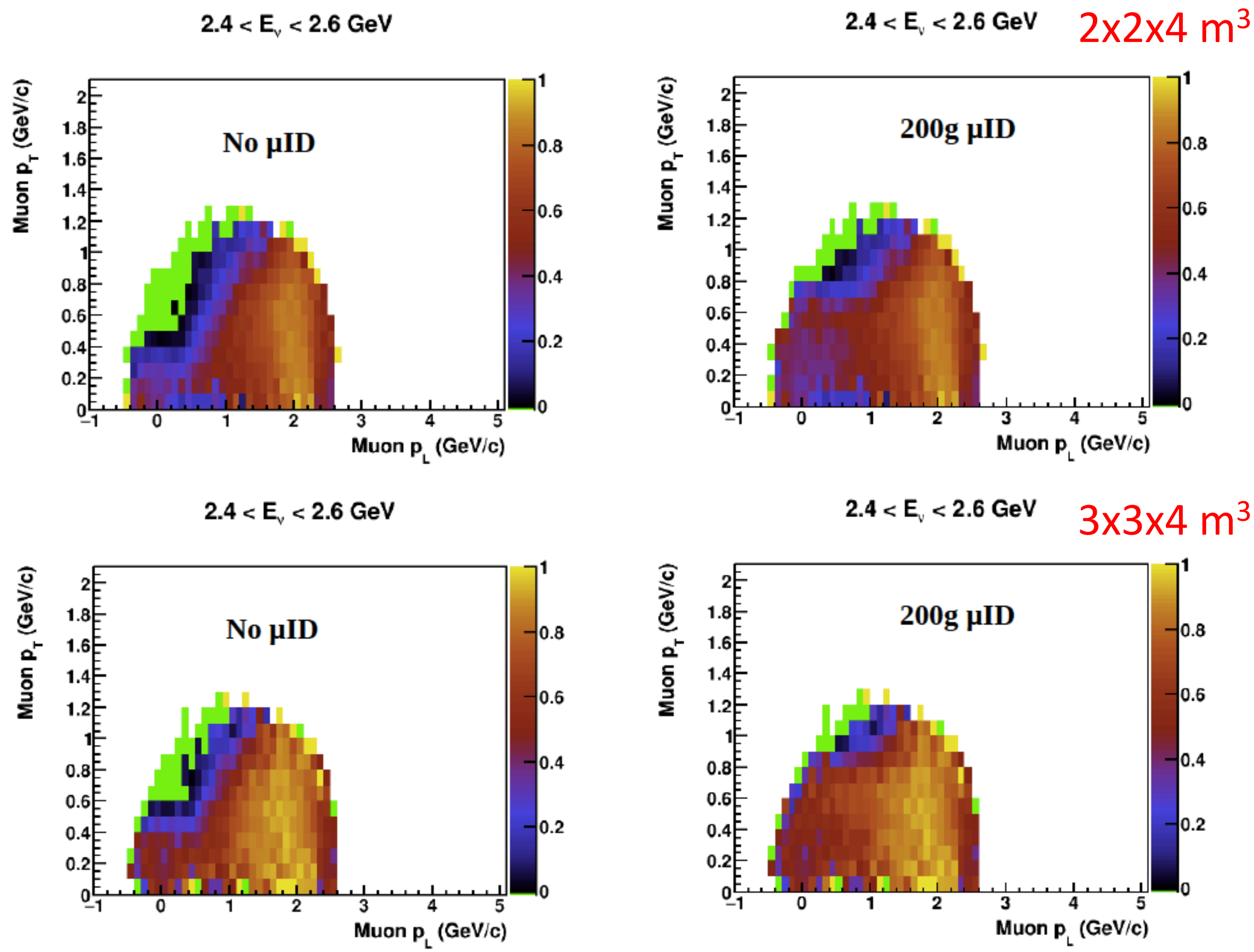


LAr Detector



Needs to be combined with downstream and side muon detectors

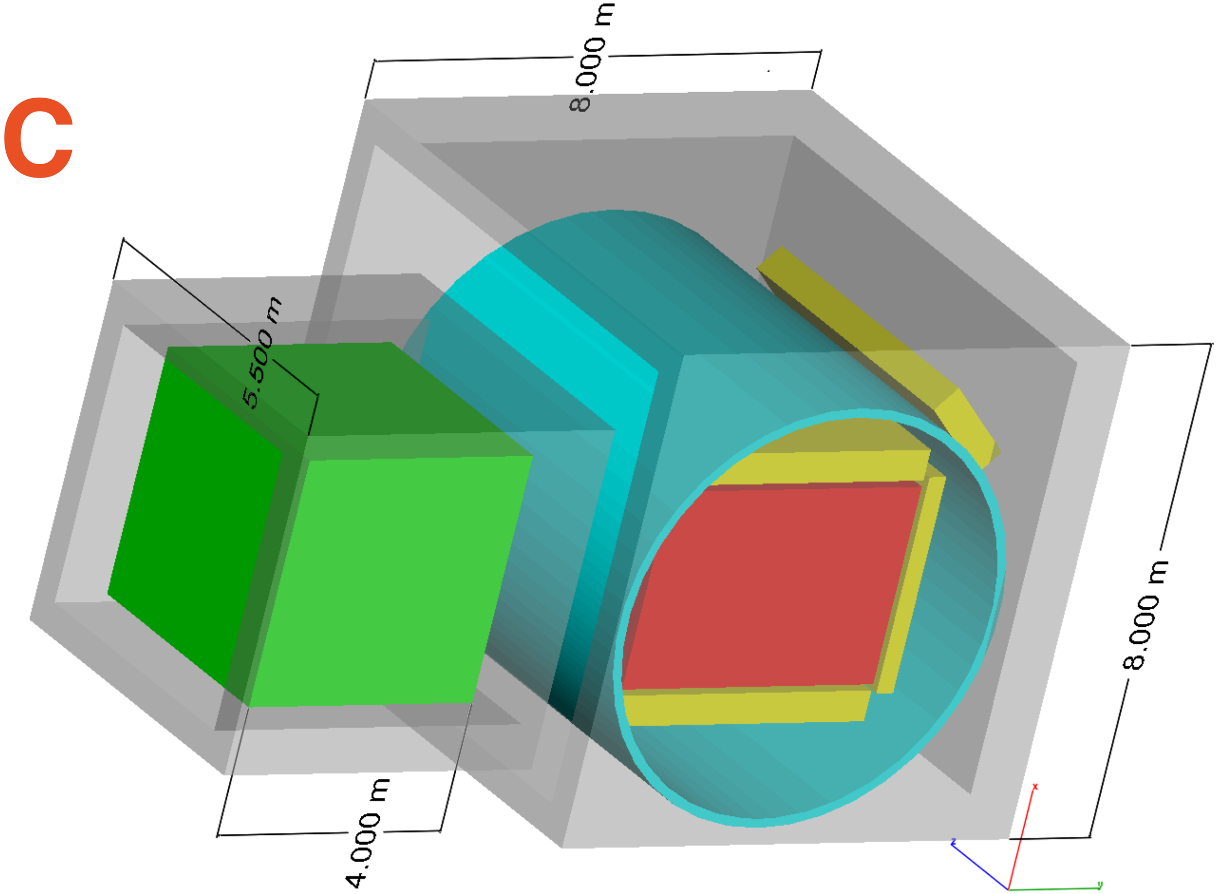
Bigger detector increases acceptance, but not phase space coverage



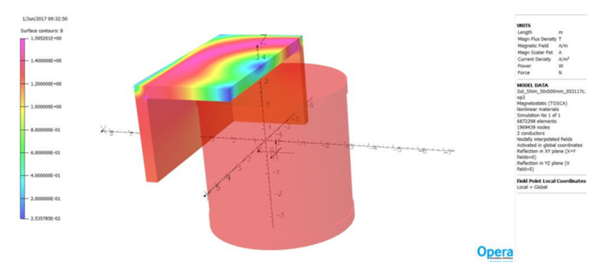
HP GAr TPC

- Magnet (0.5T)
- LAr
- TPC_{hpg}
- EM Cal ($20X_o$)
- Steel ($4\lambda_o$)

LAr:
with 2 X 2 m FV
~ 7 X_o annulus
~ 1.25 λ_o annulus



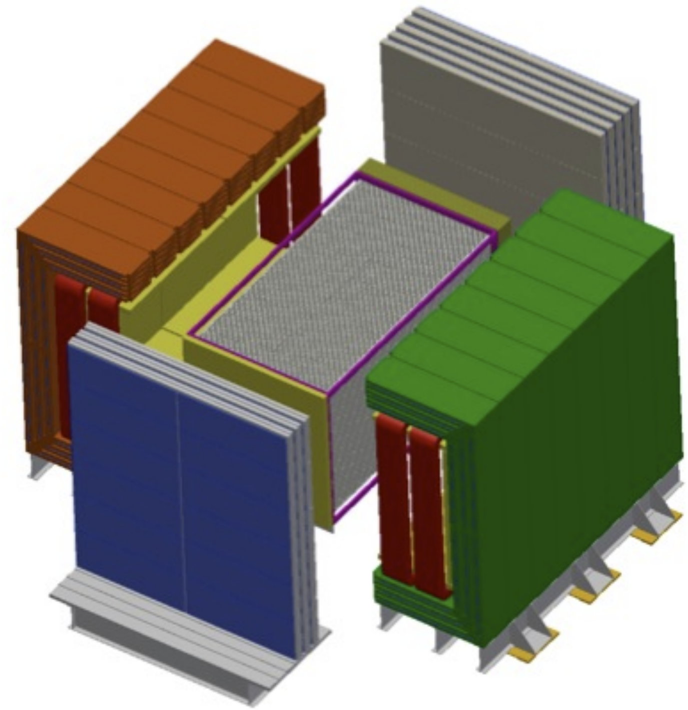
Magnet is this model is 6.5m diameter and 7 m long
Maximize acceptance for μ from LAr



Coil could become pressure vessel

Straw Tube Tracker

- Function
  - Use as spectrometer for LAr
  - LAr provides in-situ check of STT prediction
  - Independent neutrino electron measurement

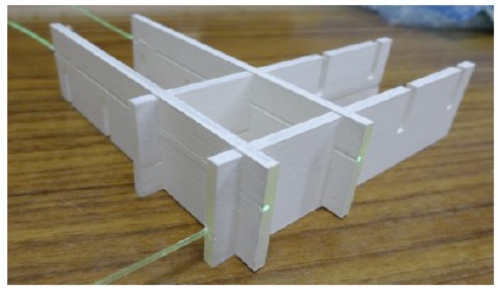


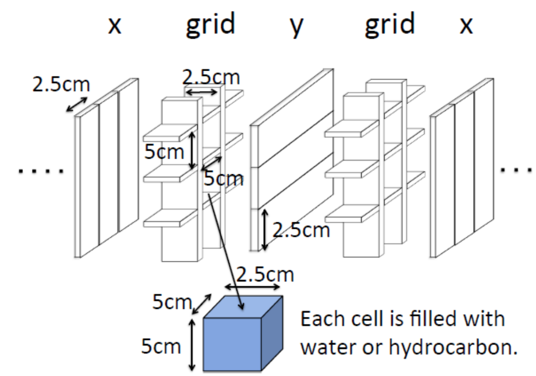
- Statements
  - 3.5 x 3.5 m^2 is absolute minimal transverse dimension
  - 4.5 m is minimum length

3D Scintillator Tracker

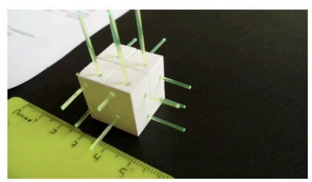
- Several options studied for T2K/ND280 upgrade

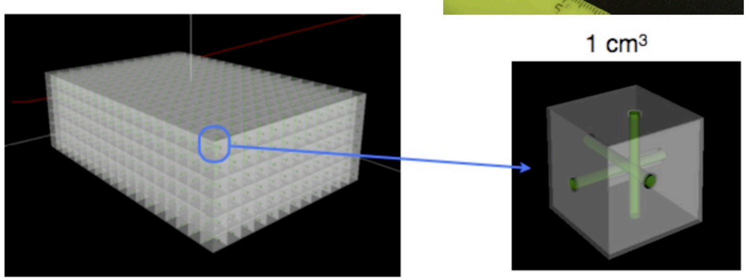
3mm thin scintillator bar
made @ Fermi-lab is used.

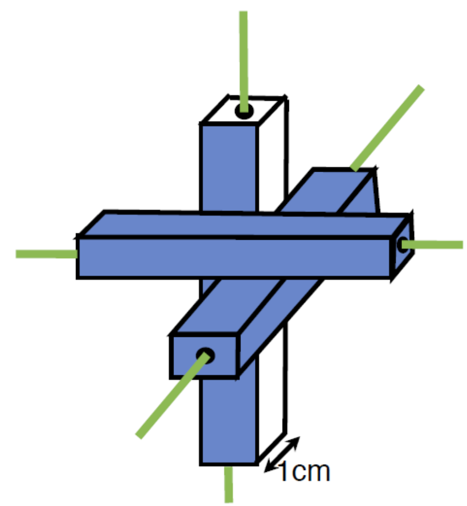




Super FGD

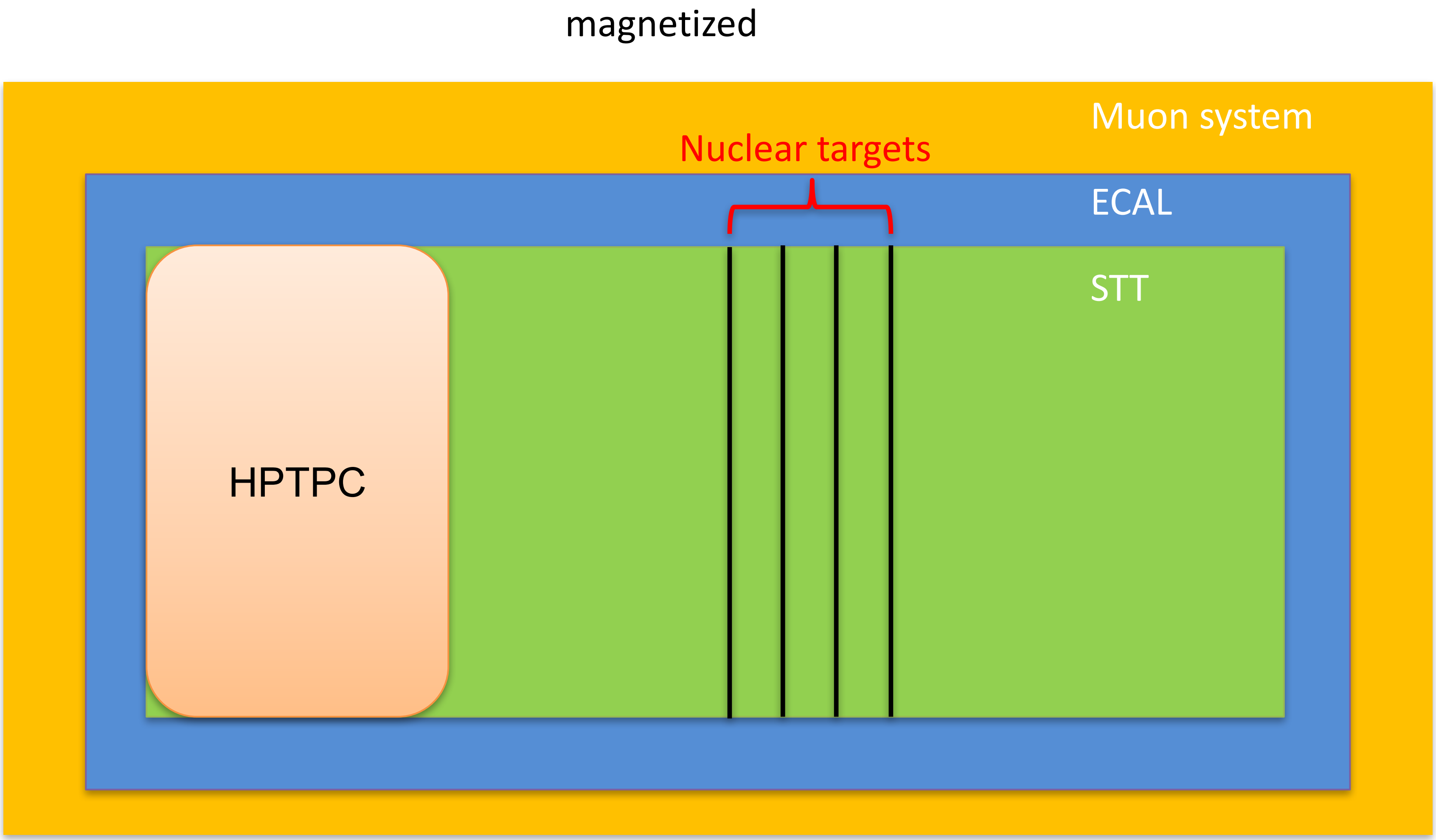




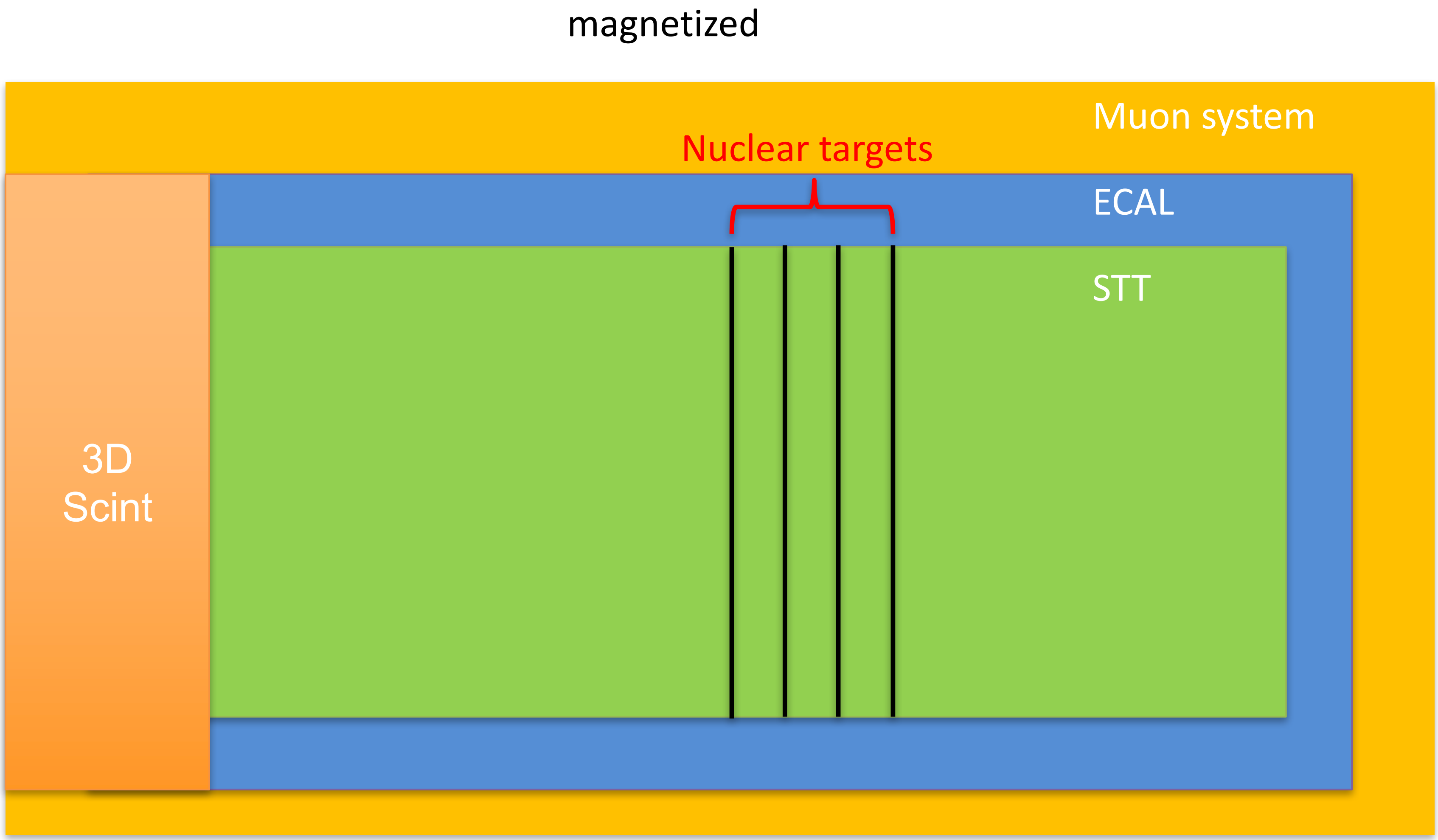


https://indico.cern.ch/event/633840/timetable/
Please check the section "Super-FGD"

Other Hybrids (I)

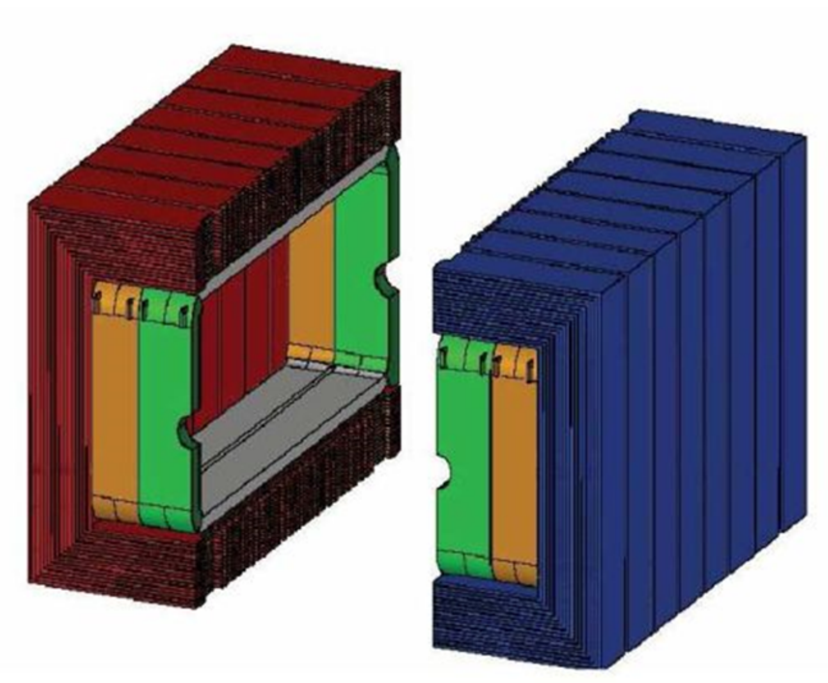


Other Hybrids (II)



Magnets (I)

- Dipole ala UA1/NOMAD/ND280

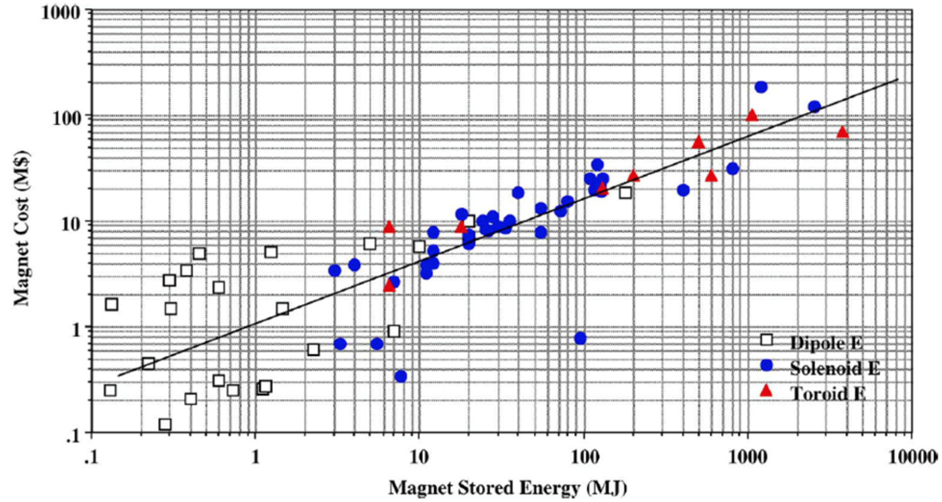


$ Million	Your Base Cost	This review
Design	$ 1.44	$ 3.24
Procurement and Fabrication	$ 6.54	$ 10.78
Assembly and Installation	$ 0.62	$ 0.94
Total	$ 8.60	$ 14.96
Materials		
Yoke Steel	$ 2.04	$ 1.64
Coil Aluminum	$ 0.35	$ 0.38
Fabrication		
Yoke Steel	$ 2.00	$ 1.56
Coil	$ 0.70	$ 0.52
Controls		
Power Supply	$ 0.65	
Cooling System	$ 0.30	

Magnets (II)

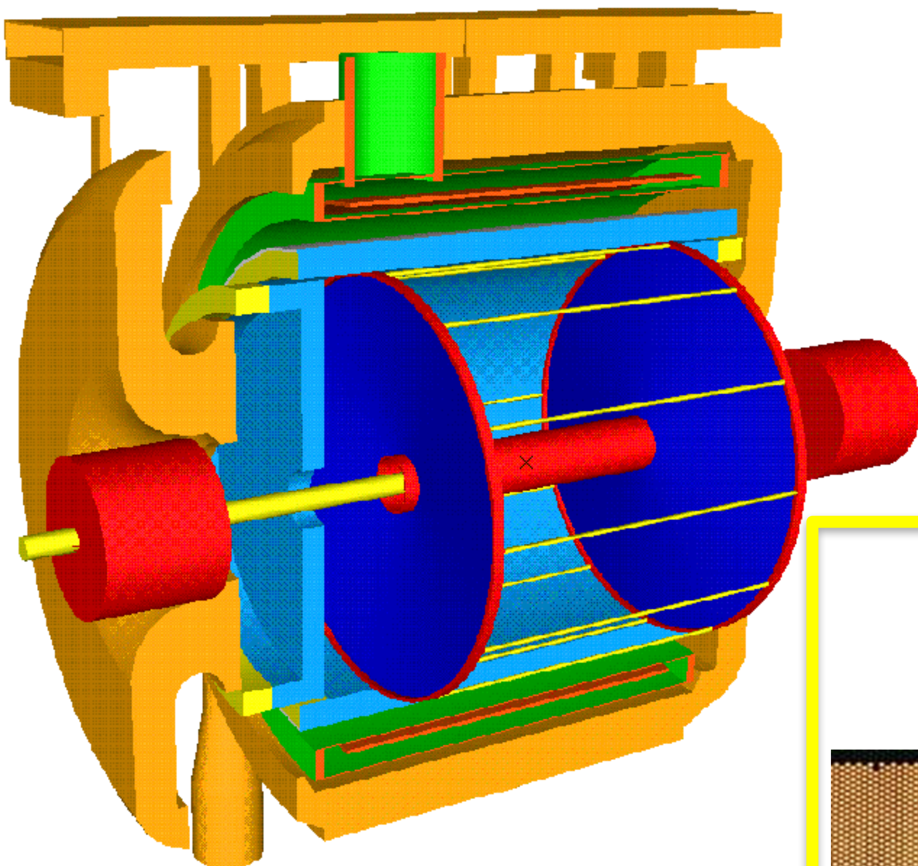
Solenoid Costs

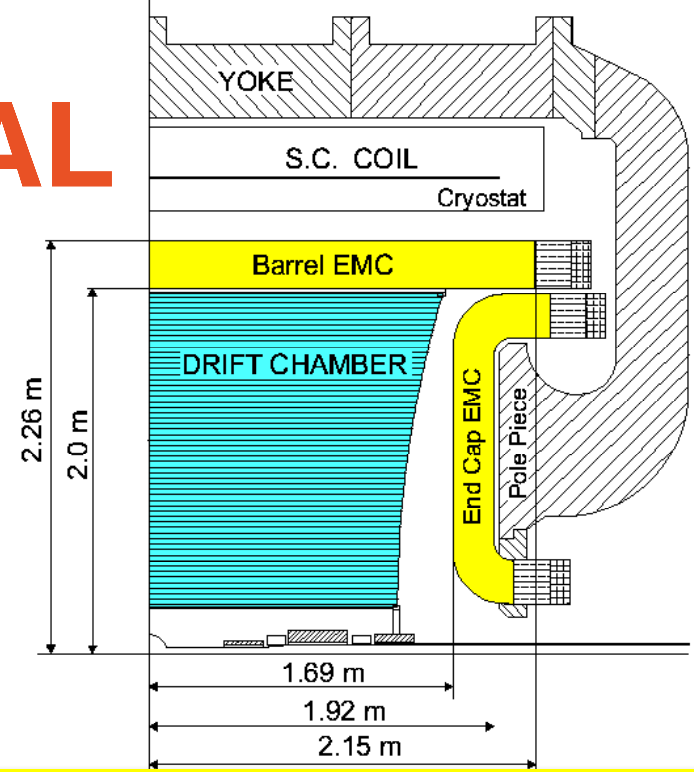
- B=0.5T, inner diameter= 6.5 m, L=7m
- Updated Herve Model
- P($) = P_0 + P_E [Cost for mechanics (B=0) + Cost for B]
- P(M$) = $0.33S^{0.8} + 0.17E^{0.7}$
  - S(m^2) surface area of cryostat: ~ 143 m^2
  - E(MJ) is the stored energy ~ 23MJ
- P ~ 19M$
- Alternative model
  - ~ 10M$ (E); 15M$ (BV)
- Average of two models: $17M
  - Similar in cost to the UA1-like magnet



			ALEPH	CMS	GEM
Mean radius of winding	R	m	2.65	3.2	9
Length of vacuum tank	L	m	7	14.5	27
Mean surface of vacuum tank	S	m^2	128.2	320.7	1526
Mean magnetized volume	V	m^3	154.4	466.5	6870
Central induction	B	T	1.5	4	0.8
Energy	E	MJ	138	2969	1749
P_0		MCHF	16.0	33.4	116
P		MCHF	21.4	79.2	147
P_0		M$	10.7	22.2	77.3
P		M$	14.3	52.8	98

KLOE Magnet & ECAL





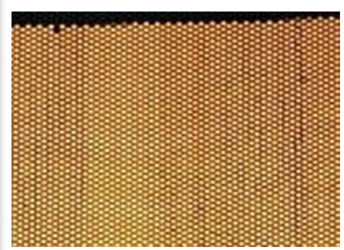
Superconducting coil (5 m bore)

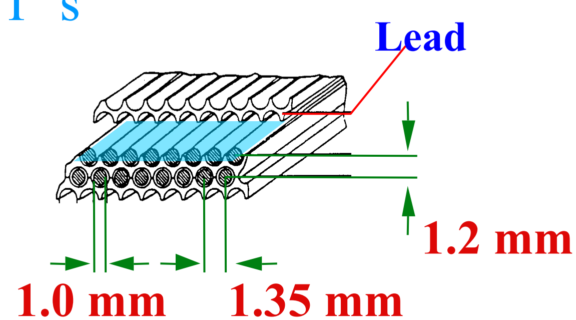
$B = 0.6$ T ($\int B\, dl = 2.2$ T·m)

Electromagnetic calorimeter

Lead/scintillating fibers

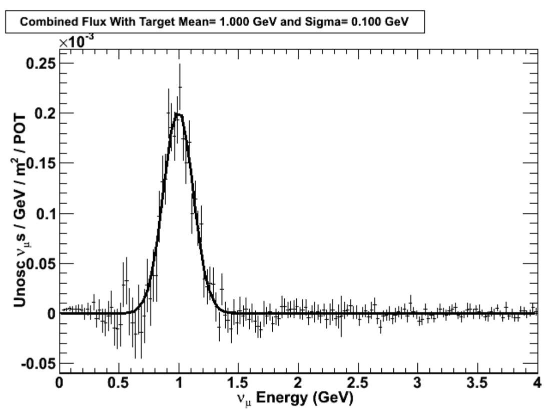
4880 PMT's



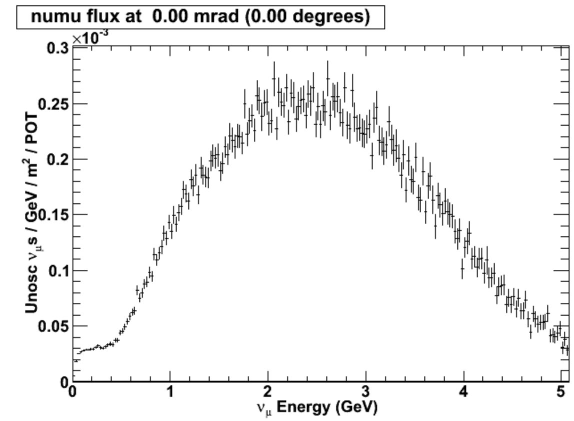


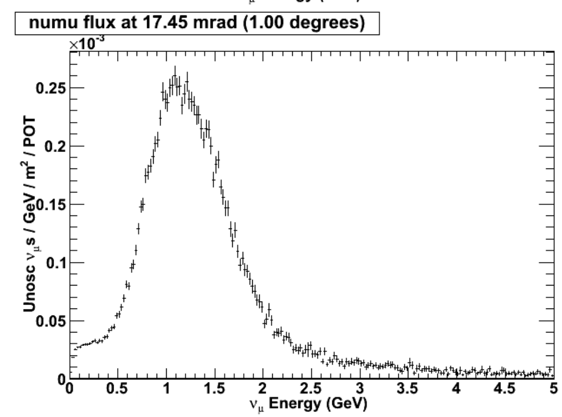
DUNE-PRISM

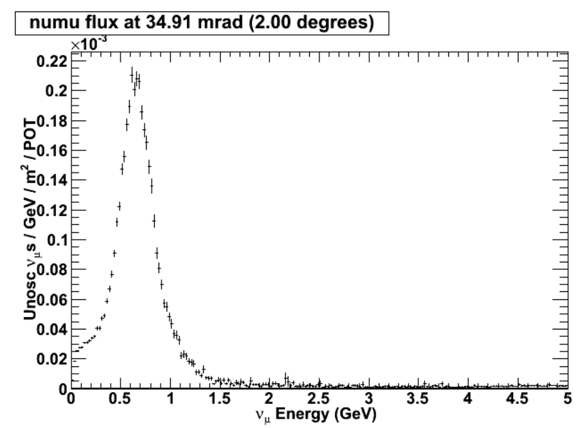
- Energy Spectrum changes with off-axis angle
  - Can be used for direct extrapolation
  - Mono-energetic beams



  - Controlled change of flux
    - Additional handle on cross section and other measurements



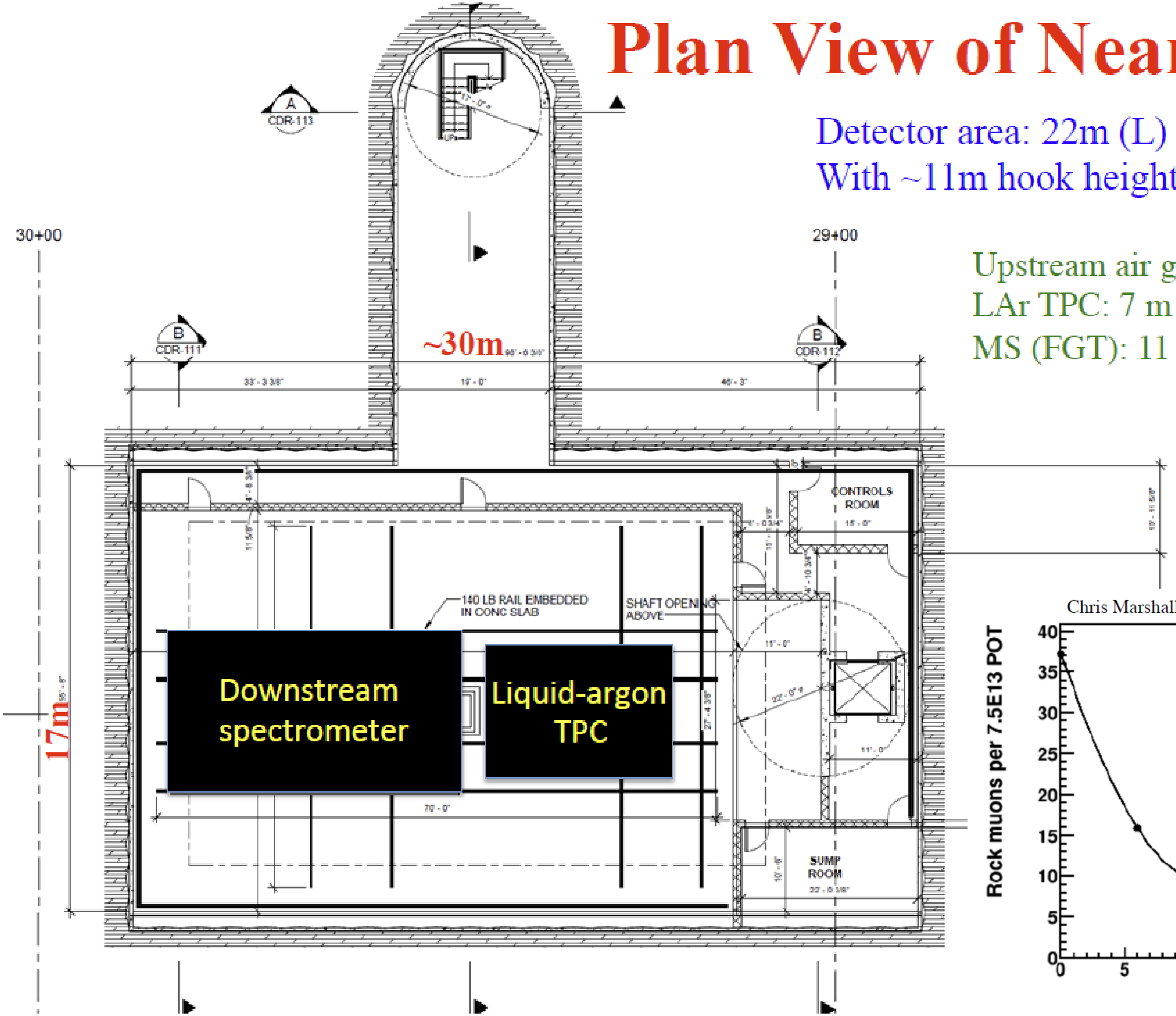




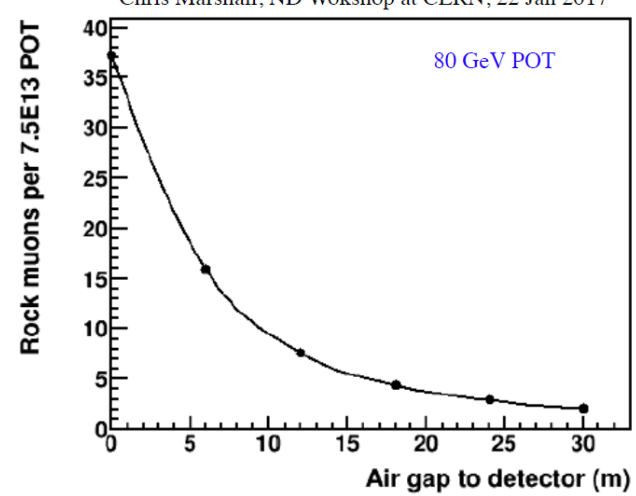
Plan View of Near Hall

Detector area: 22m (L) × 15m (W)
With ~11m hook height

Upstream air gap: 9 m
LAr TPC: 7 m (z) x 5 m (w)
MS (FGT): 11 m x 6 m

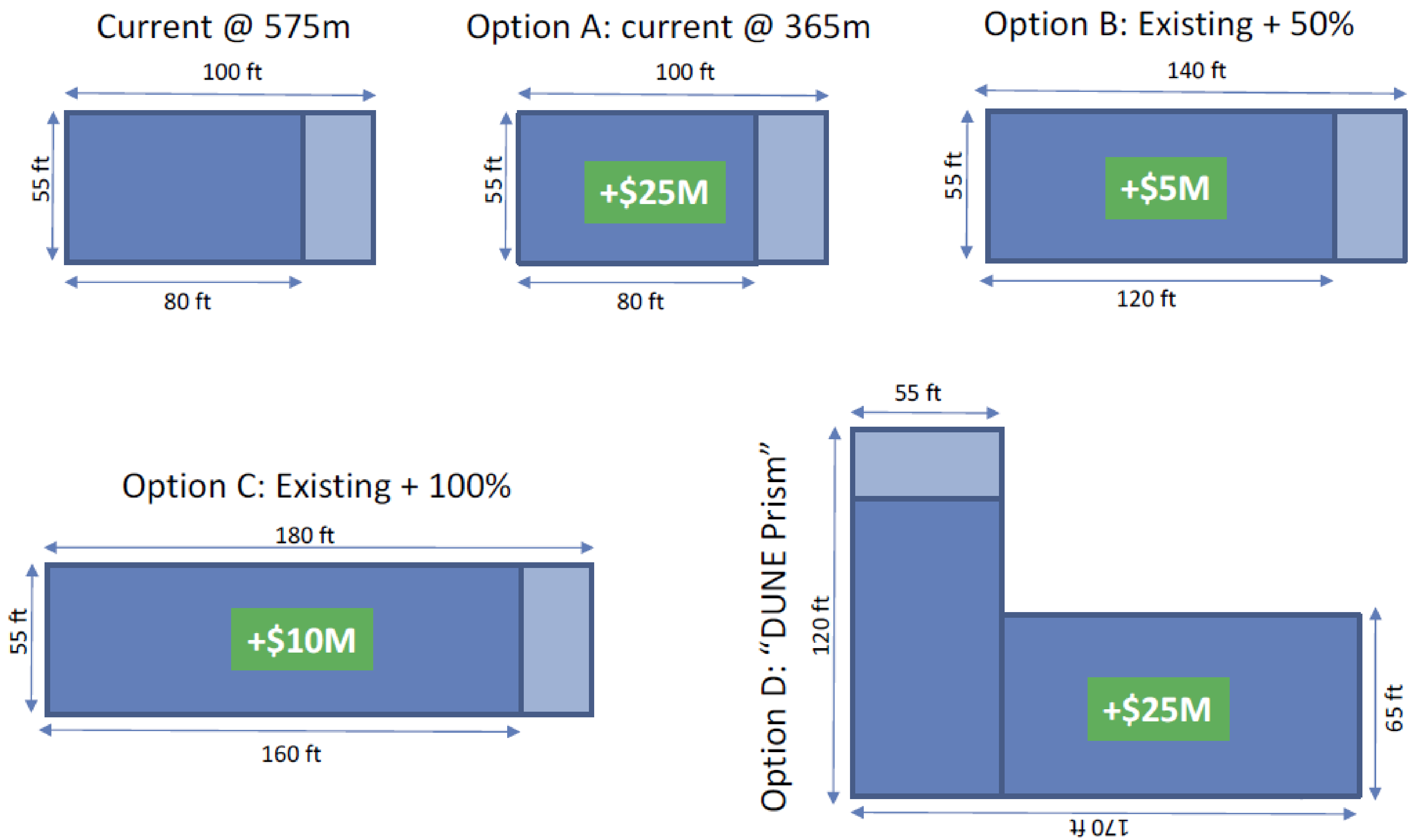


Chris Marshall, ND Wokshop at CERN, 22 Jan 2017



Science & Technology Facilities Council Rutherford Appleton Laboratory · University of Oxford · DUNE

Conventional Facilities

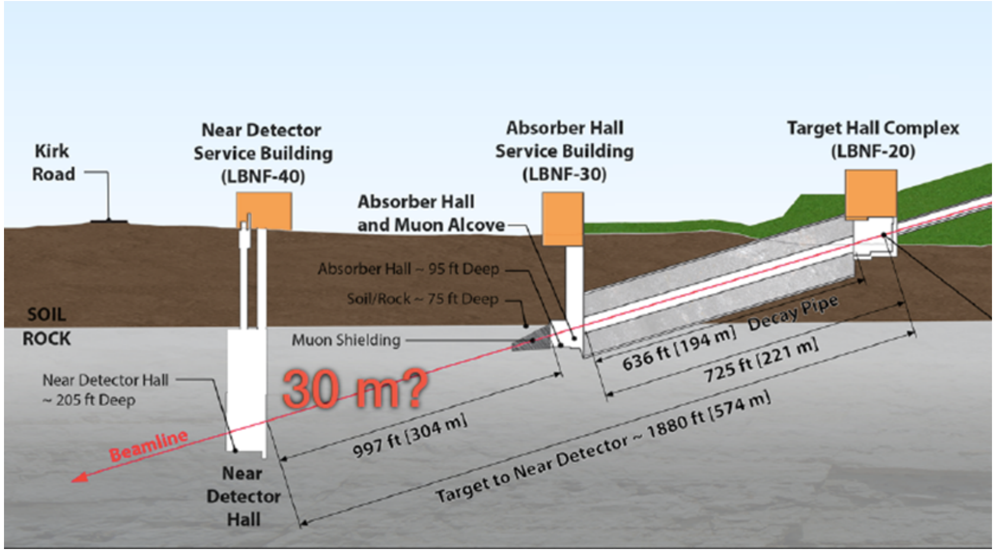


Conclusions

Preliminary Conclusions (I)

- LAr TPC
  - Not magnetized
  - Pixel readout (to reduce effect of pile-up)
  - Size: **3x3x4** m^3 (to be optimised)
  - Functionally coupled to MPT
- MPT ⇔ high resolution detector is needed in addition
  - Magnetized (dipole or solenoid?)
  - STT or HPTPC

Preliminary Conclusion (II)



- Location
  - **Case for 370 m not convincingly made**
  - ~ M$ 25 more expensive
  - Not significantly better physics performance
    - Only high stat neutrino-electron scattering (beam divergence needs to be understood)
  - Near-to-far extrapolation similar to standard location

Stay with default distance.

Preliminary conclusion (III)

- Hall size
  - +50% at least to fit LAr & MPT detectors

- DUNE-PRISM
  - Provides alternative handle on systematics
  - Too premature to make a decision
  - Need to check, if it can be fitted without prohibitive additional cost
  - additional costs for moving detectors

Action Items

- Answer questions
- Executive summary of low level requirements (Convenors)
- Can the STT fit into and work in the KLOE Magnet (FGT)
  - What would be lost?
- Can the HPTPC fit into and work in the KLOE Magnet (HPTPC)
  - What would be lost?
- Study 3D-Scintillator in STT (US)
- Can ArgonCube handle 2.4 MW beam (Antonio)

- Neutrons
  - Can you tag them in LAr (?)
  - Can the ECAL tag/measure them (?)
  - (Rock-neutrons?)

Next Steps

- Convenors to write workshop executive summary
- Need to home in on default option by August
  - Short document summarizing from proponents (<10 pages)
    - Key physics performance
    - R&D needs
    - Realistic Funding model
    - Addressing action items/questions
  - HPTPC, STT (& scintillator target)
- Present option to collaboration
- Next workshop at CERN
  - Probably November 6-7, 2017