Continued discussion on configuration options.

Milind Diwan with input from many

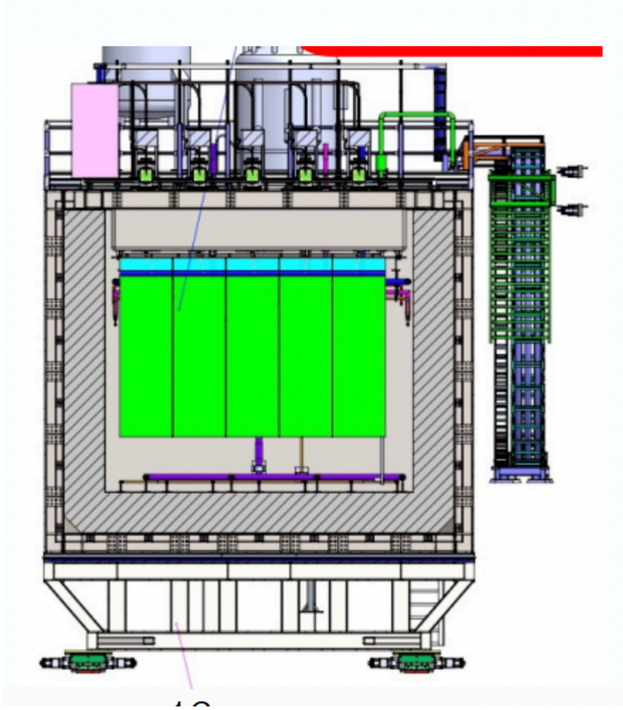
May 12, 2022

Basic detector requirements for FLARE

Item	Choice	Comments
Liquid fill	LAr or LKr or LAr/LXe mix	LKr allows compact events and EM showers, but radioactivity may limit utility.
Cryostat and TPC dimensions	Keep the total to active volume ratio small. Need to fit into FPF space.	Cryostat, field cage, HV design must be integrated.
Cathode/anode and gap size	Central cathode with two anode planes. (makes two drift volumes). Gap < 0.5 m	more channels, better for HV safety and space charge. cathode must be transparent to light
Photon readout	SiPM's. Cannot use PMTs to keep the unused volume small.	Will need large number of channels.
Wavelength shifter for scintillation light	LAr: 128 nm, LKr: 150 nm, LXe: 170nm	DUNE development of ARAPUCA.
SiPM density, timing resolution and trigger	This requires detailed simulations and R&D. **A minimum density is needed for recognizing contained events versus muons for trigger.** Timing resolution is needed to associate with LHC bunch.	
Anode electrode design	Pixels versus wires	Simple wire geometry may not be possible because of straight thru muons. Need Simulation input.
Anode readout pitch	2 to 5 mm	Depends on kinematic resolution needed and also signal to noise.
Electronics	Cold electronics for low noise; how do we optimize for best drift resolution	Need < 1 mm resolution in drift dimension

Cryostat options

Very important for space considerations.



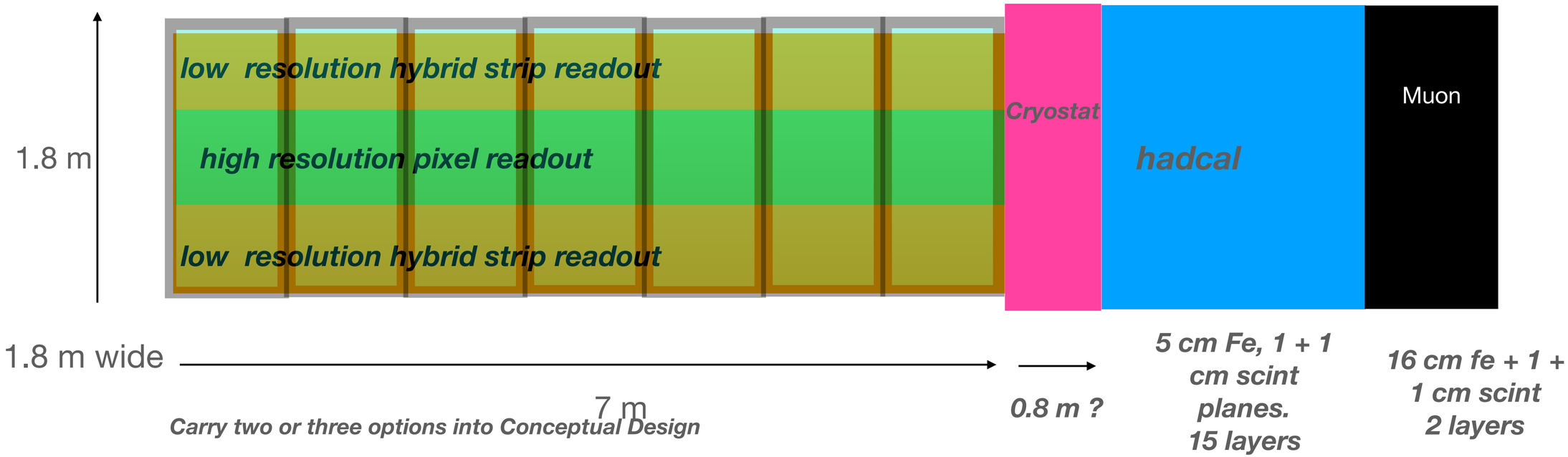
	Cryostat Inner Dimensions	Insulation Type	Insulation Thickness	Insulation density	Heat leak	Cold shield
MicroBooNE	3.8m dia x 12 m	Polyurethane Foam	**400mm**	32 kg/m^3	**~13 W/m^2**	No
ICARUS-GS	3.9m x 3.6m x 19.6m	Nomex honeycomb+perforated Al	**665 mm+ (combined)**	25-35 kg/m^3	**7-22 W/m^2**	Yes
ICARUS-SBN	3.9m x 3.6m x 19.6m	Al extrusion+GTT foam	**665 mm+ (combined)**	25-35 kg/m^3	**10-15 W/m^2**	Yes
ProtoDUNE	7.9m x 8.55m x 8.55 m	GTT membranc	**800mm**	90 kg/m^3	**~8 W/m^2**	No
ND-LAr	3m x 5m x7m	GTT membrance	800mm	90 kg/m^3	**~8 W/m^2**	No
FLArE	~(1m x 1m x 7m)					No?

Yichen Li

- *Space in FPF hall currently is limited to 3.5 m X 3.5 m X 9.6 m for FLARE.*
- *80 cm GTT membrane occupies 1.6 m out of 3.5 m. More space might be needed for corrugations.*
- *But despite the installation for th GTT membrane would be much easier.*
- *The DUNE ND-LAR design has installation from top. This would also simplify things.*
- *Further engineering might be needed, but we can settle on this option for now.*

Simulations have confirmed that these dimensions allow reasonable containment of neutrino events in LAr and total energy measurement.

They also fit within the cryostat allowed transverse space.



Carry two or three options into Conceptual Design

Field perpendicular to the beam direction
either 2 X 7 vertical modules with 0.45 m gap
or 3 x 7 vertical modules or with 0.3 m gap

Field along beam direction
7 vertical modules with 0.5 meter gap.

None of this is optimized

Nominal configuration

To be detailed in a spread sheet and developed into a detail for a conceptual design parameters. (This is for the option with field perpendicular to the beam)

Cryostat outer	**3.5 m X 3.5 m X 9.6 m**	**Membrane**
Insulation thickness	0.8 m	including corrugations
Detector dimension	1.8 m X 1.8m x 7 m	good for >90 % containment
Fiducial volume	1 m x 1m x 7 m (10 tons)	Length may be adjusted later
TPC Modules	2 X 7 or 3 X 7	Keep two options
Module opt1 dimensions	0.9 m (W) X 1.8 m (H) X 1 m (L)	Central cathode: gap: 0.45 m
Module opt2 dimensions	0.6 m (W) X 1.8 m (H) X 1 m (L)	gap: 0.3 m
Anode design fiducial region	5 mm x 5 mm for 1 m x 1 m	80000 chan/mod
Anode design containment region	10 mm x 10 mm for 0.8 m x 1 m	16000 chan/mod
photon sensor	Bare SiPM or X-ARAPUCA	~50 chan/mod
Downstream cryo wall	80 cm	Can it be thinned down
HADCAL	2 m x 2 m x (5 cm Fe + 1+1 cm scint, 15 layers) x (1.05 m)	Optimize for resolution
Murange	•2 m x 2 m x (16 cm Fe + 1 + 1 cm scint, 2 layers) x (0.36 m)	Increase to 1 m to get clean muID

Field along beam direction.

Cryostat outer	**3.5 m X 3.5 m X 9.6 m**	**Membrane**
Insulation thickness	0.8 m	including corrugations
Detector dimension	1.8 m X 1.8m x 7 m	good for >90 % containment
Fiducial volume	1 m x 1m x 7 m (10 tons)	Length may be adjusted later
TPC Modules	2 X 7 or 3 X 7	Keep two options
Module dimensions	1.8 m (W) X 1.8 m (H) X 1 m (L)	Central cathode: gap: 0.5 m
~~**Module opt2 dimensions**~~	~~0.6 m (W) X 1.8 m (H) X 1 m (L)~~	~~gap: 0.3 m~~
Anode design fiducial region	5 mm x 5 mm for 1 m x 1 m (pixels could be smaller)	80000 chan/mod
Anode design containment region	10 mm x 10 mm for surrounding the central 1x 1 meter	? chan/mod
photon sensor	Bare SiPM or X-ARAPUCA	~50 chan/mod
Downstream cryo wall	80 cm	Can it be thinned down
HADCAL	2 m x 2 m x (5 cm Fe + 1+1 cm scint, 15 layers) x (1.05 m)	Optimize for resolution
Murange	•2 m x 2 m x (16 cm Fe + 1 + 1 cm scint, 2 layers) x (0.36 m)	Increase to 1 m to get clean muID

This option would work best with the Q-PIX style readout. Aleksey B.: If the drift if along the beam direction then we must worry about charge recombination since the ionization at the vertex will be ~10 MIPs.

What is Q-PIX ?

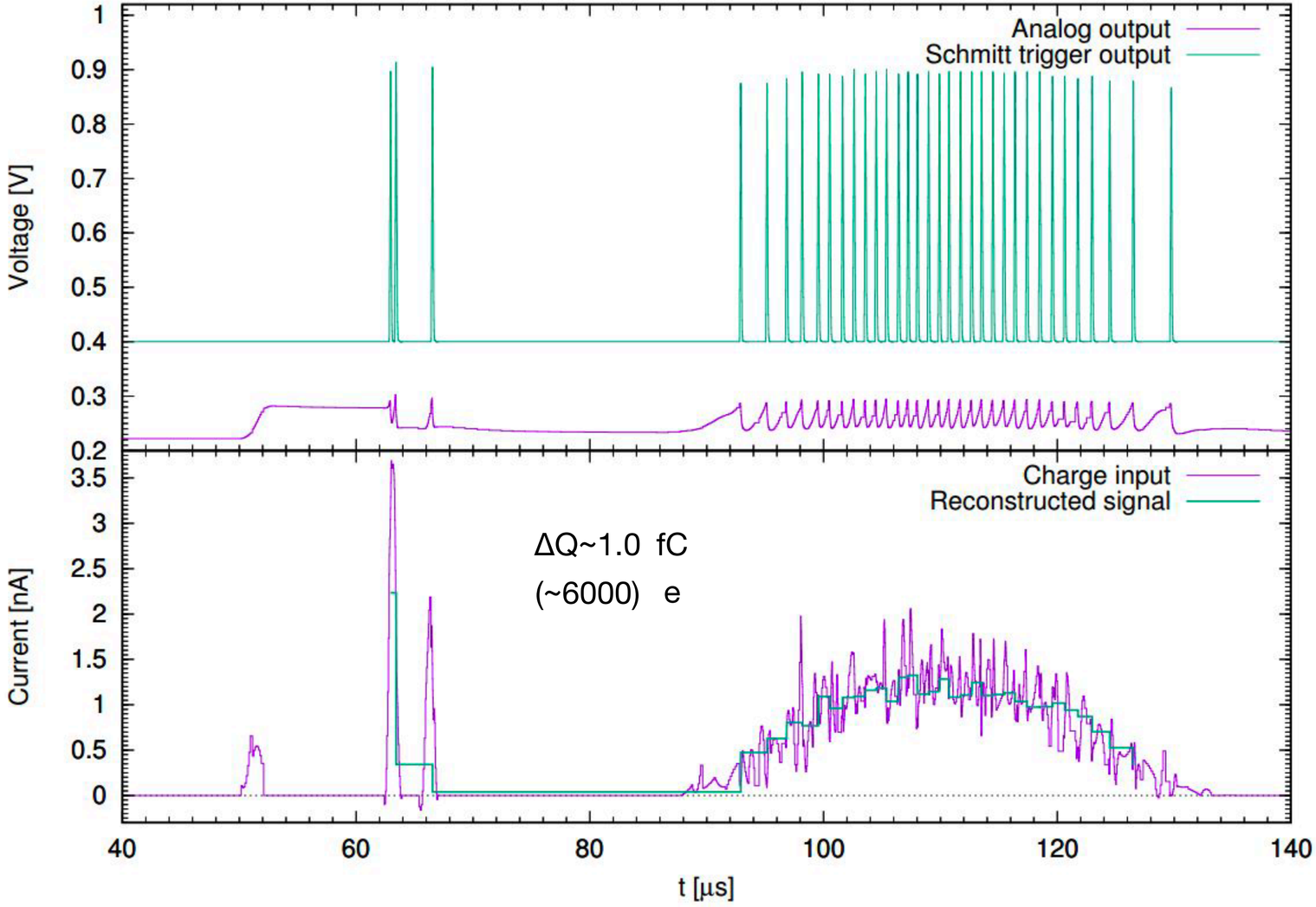
The idea is to capture a waveform in time with minimum data load.

Q-Pix: Pixel-scale Signal Capture for Kiloton Liquid Argon TPC Detectors: Time-to-Charge Waveform Capture, Local Clocks, Dynamic Networks

D.Nygren, Yuan Mei, https://arxiv.org/abs/1809.10213

Also see Asaadi's talk

https://indico.fnal.gov/event/22038/contributions/65902/attachments/41450/50153/QPix_FNALSeminar_Asaadi.pdf



Some organizational updates

Switch this current meeting to monthly starting with today.

Add another meeting for technical discussion on detector.

Provide more support for CERN experimentalist's monthly meeting run by Jamie Boyd.

The FPF short paper now has a citation

https://www.sciencedirect.com/science/article/pii/S0370157322001235

The Forward Physics Facility: Sites, experiments, and physics potential

Physics Reports, Vol 968, 19 July 2022.

What are we doing at SNOWMASS ? This is in Seattle (Washington State near the University of Washington) July 17 -July 26

MVD will be there the entire time. I can organize couple of 1/2 day workshops.
workshop 1 dedicated to phenomenology and workshop 2 to detector options and simulations

MVD will coordinate with Jamie to see who might be coming to Seattle to see if we can have such a workshop.