DUNE-PRISM Installation Planning

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for the DUNE-PRISM Group
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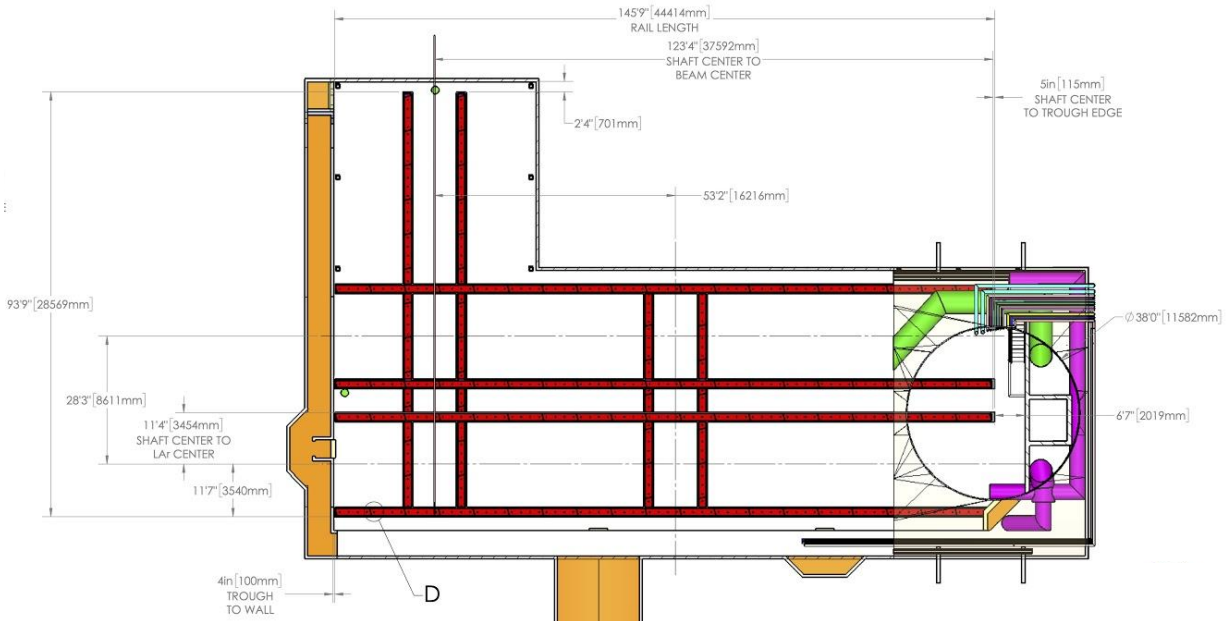
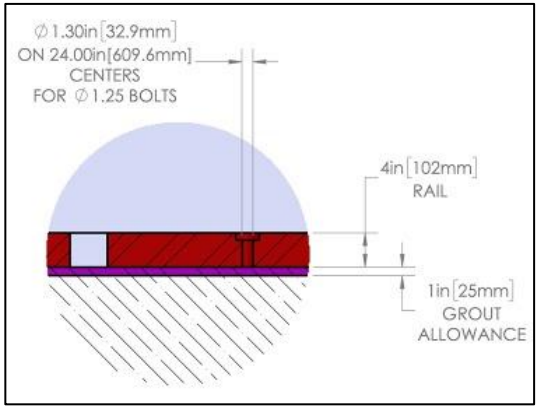
Systems Overview

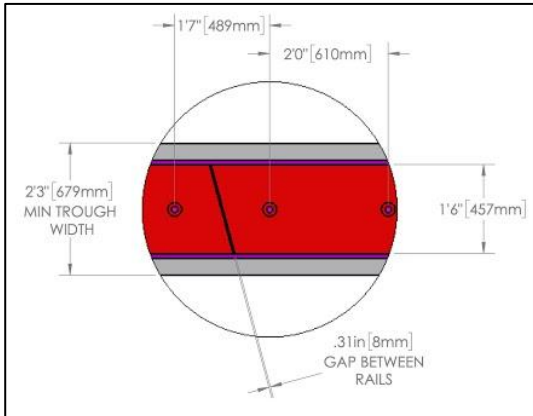
- Transport system
  - Steel rails (8’ segments, floor bolts, epoxy grout)
  - Hilman rollers (8 per detector)
  - Control system (cabinet + cabling)
- Energy chains (3: ND-LAr cryogenics, ND-LAr power/data, TMS power/data)
  - IGUS energy chain segments
  - Wall-mounted (or egress-roof-mounted) track & platform
  - Conveyor system (smoothly rolls and unrolls energy chains during movement)
  - Detector attachment (e.g. anchor boom)
- Safety systems
  - Still being developed (e.g. proposal for a “laser curtain” surrounding the detector that triggers a stop)
  - We may not need this for moving detectors during installation
    - Hope to be able to use crane movement safety protocols (to be confirmed with safety group)
- Monitoring systems (position, velocity, vibration, etc.)
  - Not installation critical (can be installed anytime with minimal disruption to other systems)

Rail Installation

- NDCF provides troughs and bolt anchors for rail installation
- Installation sequence:
  1. Align & install bolt anchors in trenches
  2. Rails installed via floor bolts
  3. Rail alignment / leveling
  4. Grout is inserted below the rails to freeze them in place (support the detector weight)
- ~122 Rails to be installed
  - 4 x 20 segments for mobile detectors
  - 2 x 13 segments for SAND on-axis
  - 2 x 8 segments for midpoint cross rails

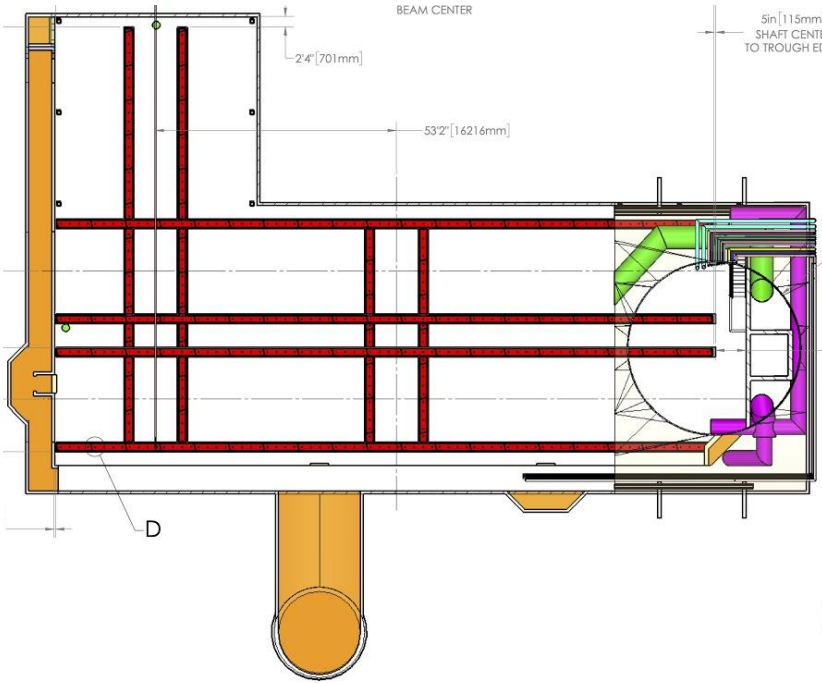






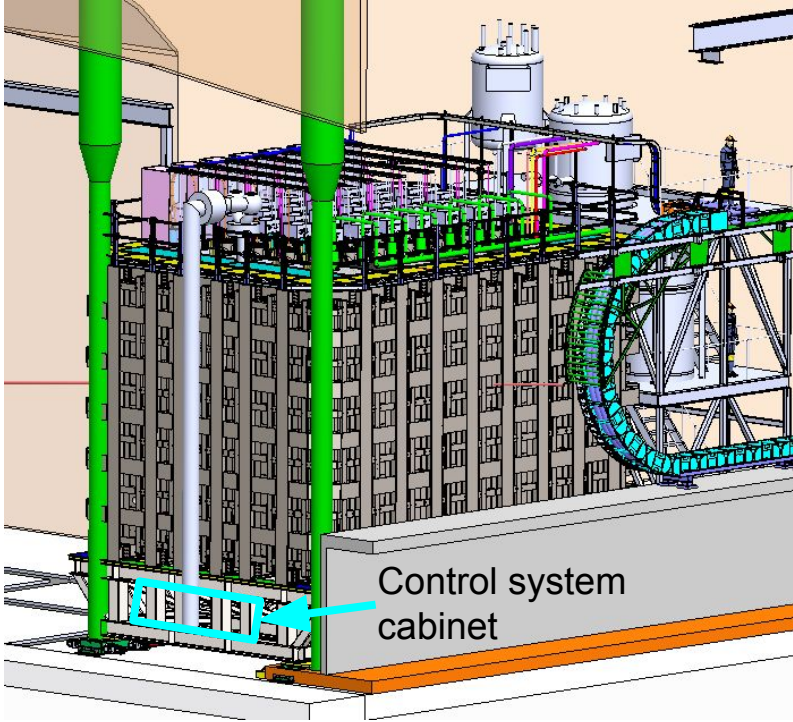
Rail Installation Comments

- We have been in discussions to install the rail system prior to detector beneficial occupancy
  - In conjunction with the last stages of NDCF cavern preparation
- Shaft access needed to lower rail bundles
  - ~10 rails per bundle, ~15 bundles total
  - ~300 buckets of grout needed for final phase
- Installation will take 2 - 3 months
  - Staging: 1 week
    - Prepare materials, set up in-hall alignment system, etc.
  - Align & install bolt anchors in trenches: 1 week
  - Install rails: 1 month
    - Install 4-5 rails per day, 2 crews of 3, forklift
  - Align rails: 1 week
  - Grouting: 1 week



Movement Control System

- Cabinet installation (1 per detector)
  - We currently expect the cabinets to be located on the detector frames, opposite the utilities platform
    - 48”H x 158”W x 18”D
  - About 2 weeks needed for installation and cabling to rollers & detector power/data hub
- The timing for installation of controls system (and energy chains) depends on detector needs
  - Do the detectors need to be able to move during installation?
  - By when is the first movement required?
- If movement is needed during installation, it is possible to use a manual control system
  - Movement is controlled by a handheld device, similar to a crane
    - Movement protocols should also be similar to that of crane operation
  - Hilman uses this solution for many of its clients

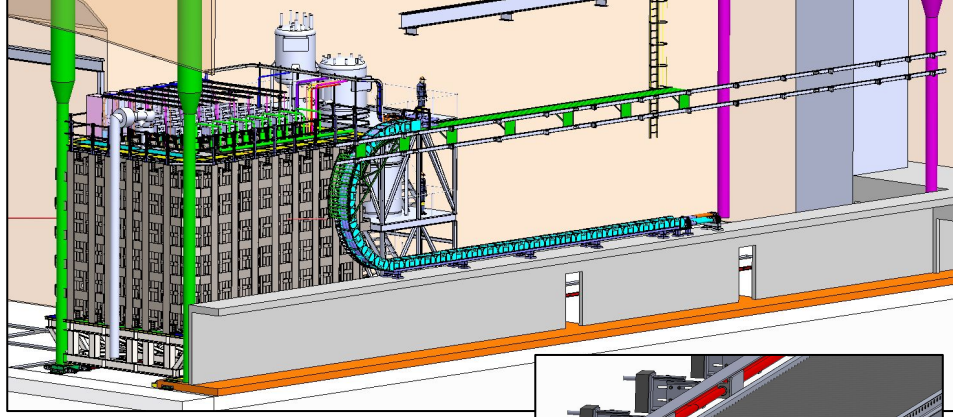


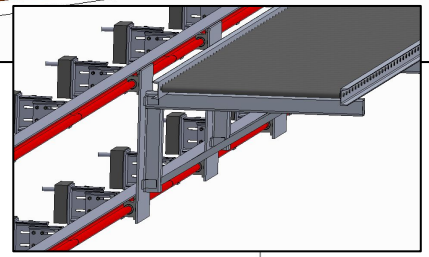
Manual control system

Installation of Energy Chain(s)

Prior to beneficial occupancy?

- Installation procedure (per detector):
  - Install wall mounts and/or egress hallway roof mounts
  - Install the track (top) and platform (bottom) to the mounts
  - Assemble and install conveyor system on the track
  - Attach chain links to construct full chain
  - Insert services into the chain
  - Detector attachment
  - ~1.5 months per new chain
    - ~3 weeks for 2nd ND-LAr chain (cryo hoses)
- Energy chains exist outside of large crane coverage
  - Plan to use forklift, and possibly a lower capacity temporary crane
- Some interference with detector installation will occur if installed simultaneously
  - We believe it's possible to install the energy chains in the curled position to minimize interference, but unrolled (flat) position is likely preferred



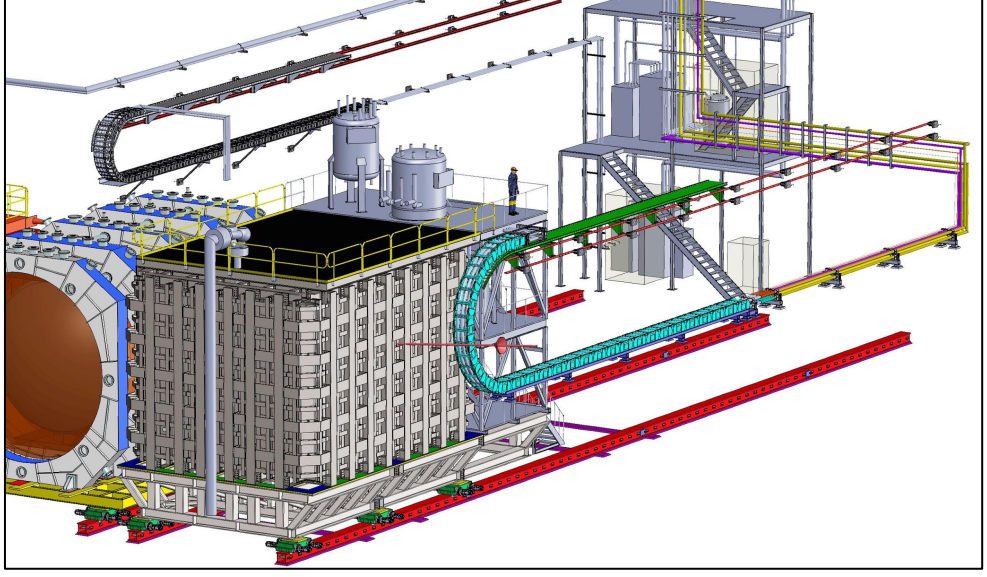


Action Items

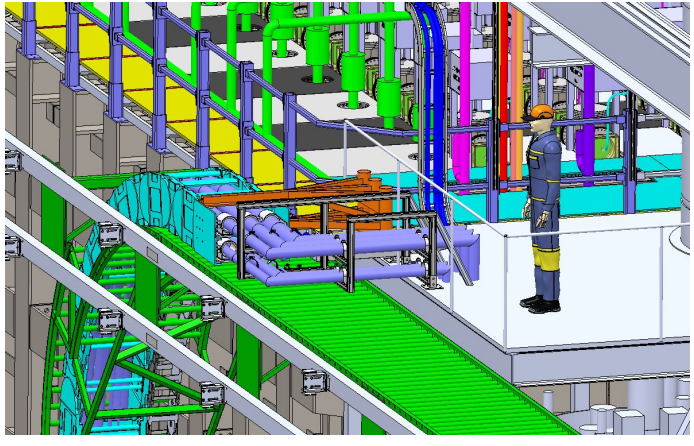
- Coordinate rail installation (and energy chain wall mounts / tracks) with NDCF
  - Ahead of detector beneficial occupancy
- Determine need for moving each detector during installation
  - Which detector should be connected first?
  - Is it necessary to double the installation teams to install power/data to both detectors simultaneously?

Backup

Procurement / Storage



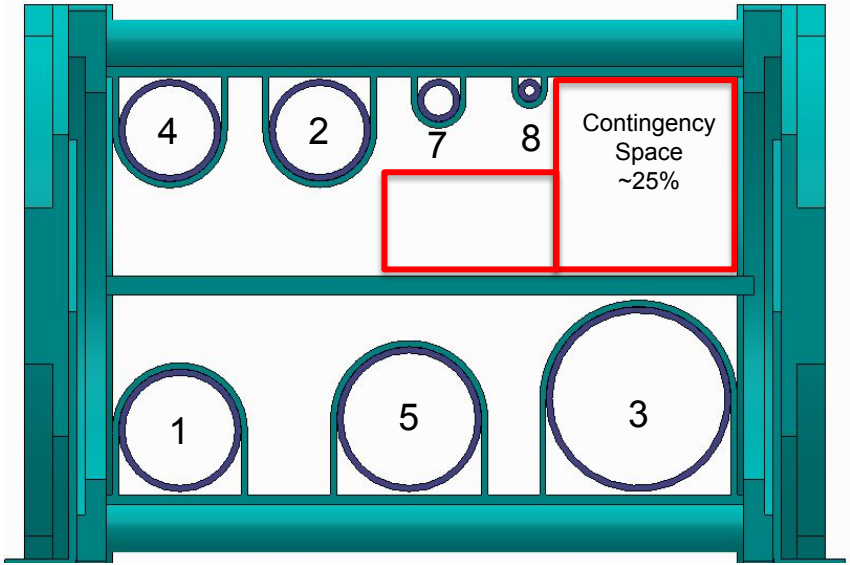
- Transport system
  - Rollers (16): 8 per detector, 2 detectors
    - Non-powered rollers?
  - Rails (150’, 4” thick plates?)
  - Rail bolts (200): M36 bolts, 20 cm long each
  - Epoxy grout (300 55-lb buckets): 1” thick layer over 500 sq. ft. & 6 sq. ft. per bucket
  - Control system (two 60” x 158” x 18” cabinets)
  - Power and data cabling (not insignificant?)
  - Rail-cleaning brushes?
- Energy chain
  - IGUS energy chains (3): ND-LAr cryo, ND-LAr power & data, TMS power & data
  - Conveyors (4?): 2 linear, 2 circular (1 each for each detector)
  - Conveyor tracks (top & bottom)
  - Wall mounting hardware (“floor” mounting for on top of egress hallway)
  - Conveyor frame components: frame assembly pieces to be assembled/welded
  - Anchoring hardware for ND-LAr and TMS (“anchor boom”)
- Monitoring systems are unlikely to take up much space, and installation is not time critical
- Safety systems not needed immediately



Schedule and Detector Requirements

- We are still investigating installing the rails / bolts / grout prior to ND beneficial occupancy
  - Some coordination with NDCF needed? Does this remove the installation of these items from our BOE?
- TMS has expressed a need for moving the detectors during installation
  - Not enough real estate for ND-LAr, TMS, and SAND installation simultaneously?
- If so, we would need to aim for early installation of energy chains
  - Perhaps cryogenics energy chain could wait, but conveyor system must be installed for power/data energy chain anyway
- Energy chains are installed outside of the planned crane coverage
  - Temporary crane needed for installation; Maximum load required?
- Initially, we may be aiming for crude movements (i.e. controlled by a crane-style remote control); will be replaced by more sophisticated software movement system after installation

Pipe Sizing and Placement



Model: IGUS E4-350-500
Internal Width: 350mm
Internal Height: 500mm
Weight: 65.7 kg/m

Name	Function	Flexible Line External Diameter	Manufacturer /Model	Mass per unit length	Max Pressure	Max Manuf. Length	Comment
1	LAr line - 2" – 10 barg (flexible VJP)	Ø 98.2 mm (DN80/40)	Nexans HIGHFLEX	7,0 kg/m	20 barg	25m	
2	LN2 line - 2" – 10 barg (flexible VJP)	Ø 81.4 mm (DN65/32)		5,3 kg/m	10 barg		
3	GN2 exhaust 2 ½" – 1barg (flexible VJP)	Ø 148.2 mm (DN125/65)		9,0 kg/m	10 barg		
4	GAr supply – 2" – 10barg	Ø 82 mm	Witzenmann HYDRA RS330	1.67 kg/m	30 barg	100 m	
5	GAr exhaust – 4" – 1 barg	Ø 116 mm		2.5 kg/m	10 barg	20 m	
~~6~~	~~Cryostat Relief Exhaust - 12" - 0.3 barg~~	~~Ø 340 mm~~	~~Witzenmann HYDRA RS430~~	~~33 kg/m~~	~~4 barg~~	~~3 m~~	Removed.
7	Instrument Air – 1" – 10 barg	Ø 34 mm	Witzenmann HYDRA RS330	0.79 kg/m	65 barg	100 m	
8	GN2 – ½" – 10 barg	Ø 18 mm		0.25 kg/m	75 barg	100 m	Supply of insulation purge gas
9	Cryogenics LV, UPS and Network by I&I	n/a	Configuration and installation by I&I				

Table 1. Energy chain piping list, preliminary design rough order of magnitude dimensions.
(20% spare required at preliminary design stage)
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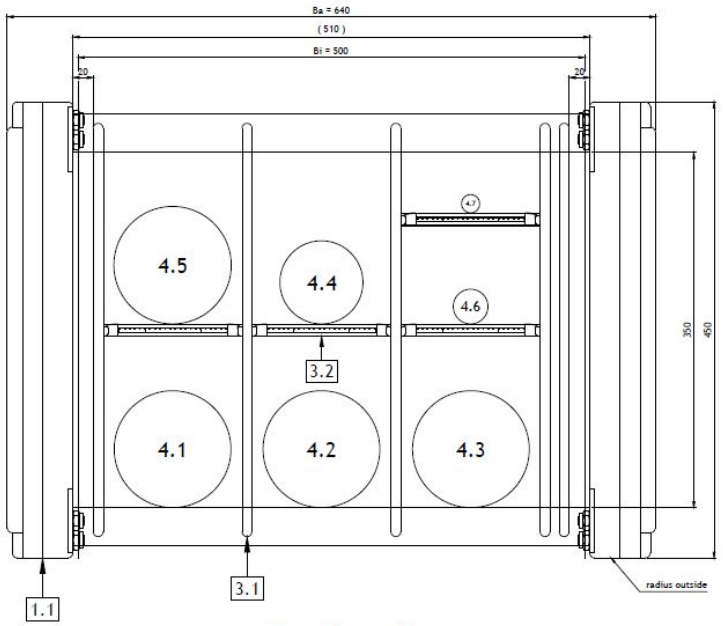
*Final sizing and layout of lines TBD

Igus Shelving and Proposed Pipe Layout



Fixed End

E-Chain Data

E-Chain Part Number (**ITEM 1.1**):	**E4.350.500.2000.0**		
Lowered Mounting Height:	No		
LMH DWG:	-	Links to Flip:	-
Moving End Bracket (**ITEM 2.1**):	**E4.350100.1**		
Fixed End Bracket (**ITEM 2.2**):	**E4.350100.2**		
Tiewrap (**ITEM 2.3**):	-	QTY (PCS):	-
Bracket Configuration:	-		
E-Chain Length without MB:	25850 mm		
Quantity of Regular Links:	55	pitch:	0 mm
Interior Separation in Every:	2nd	Link	
Starting on the:	1st	Link	

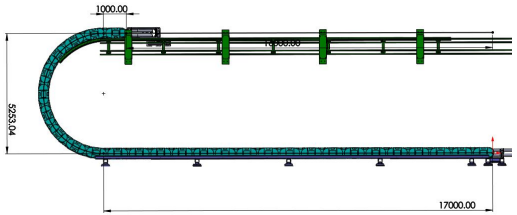
Item	Part Number	QTY/Link	Total
3.1	E4.351.1F	4	108
3.2	450.13	4	108

Project Technical Data

Travel Length:	31.60 m
Speed:	0.05 m/s
Acceleration:	0.10 m/s²
Deceleration:	0.10 m/s²
Application Type:	-
Operational Area / Environment	-
Country / Place:	-
Temperature: (-°C ... +°C):	- -
Humidity (%):	-
Wind Speed:	
In Operation:	-
Out of Operation:	-
Cycles Per Year:	N/A

Cryogenic Energy Chain Load Values

Length of energy chain: 26.25 meters
-16 m for necessary travel
-8.25 m in energy chain bend
-1 m relief at both ends



Line	Volume (m3)	Material Density kg/m	Material Mass kg	Pipe Weight kg	Total Weight kg
L. Argon	0.05321	1430	76.08685	105	181.1
L. Nitrogen	0.05321	804	42.77890	105	147.8
G. Nitrogen	0.08314	1.2	0.09976	105	105.1
G. Argon supply	0.05321	17.8	0.94709	43.8375	44.8
G. Argon exhaust	0.21283	1.65	0.35117	65.625	66.0
Instrument Air	0.01330	1.23	0.01636	20.7375	20.8
G. Nitrogen (purge gas)	0.00333	12.4	0.04124	6.5625	6.6
Total					572.1

Weight of Energy Chain

Cryogenic Piping(filled): 572.1 kg

Igus Chain(65.7kg/m): 1,724.6 kg

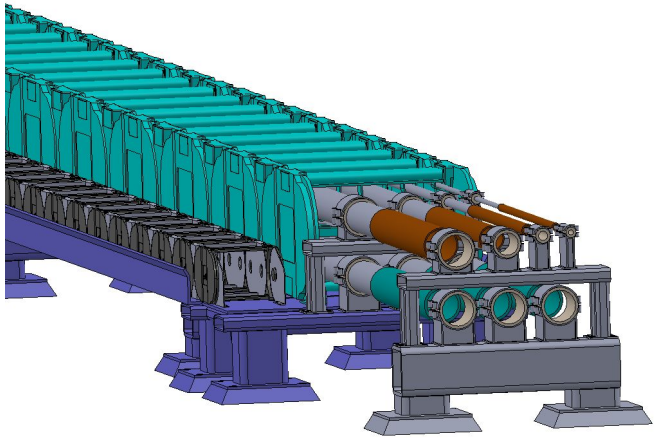
Total Weight: 2,296.7 kg

Power Supply Energy Chain

IGUS chain model for power and data

- Inner Height: 162mm
- Inner Width: 200mm

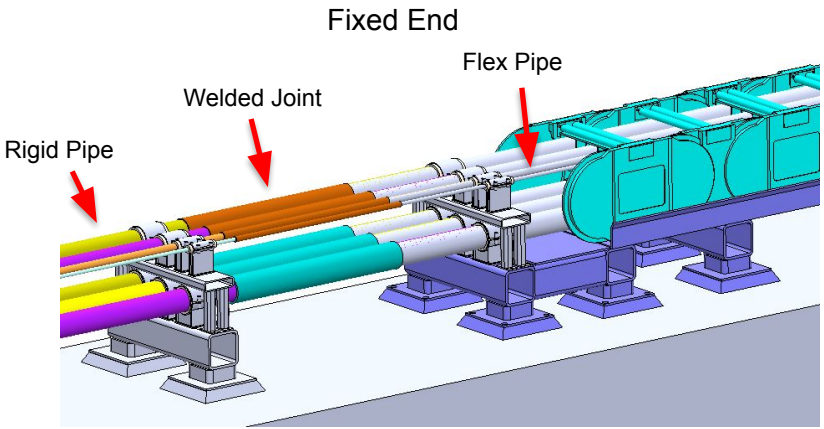
*chain selection to chain per volume requirements

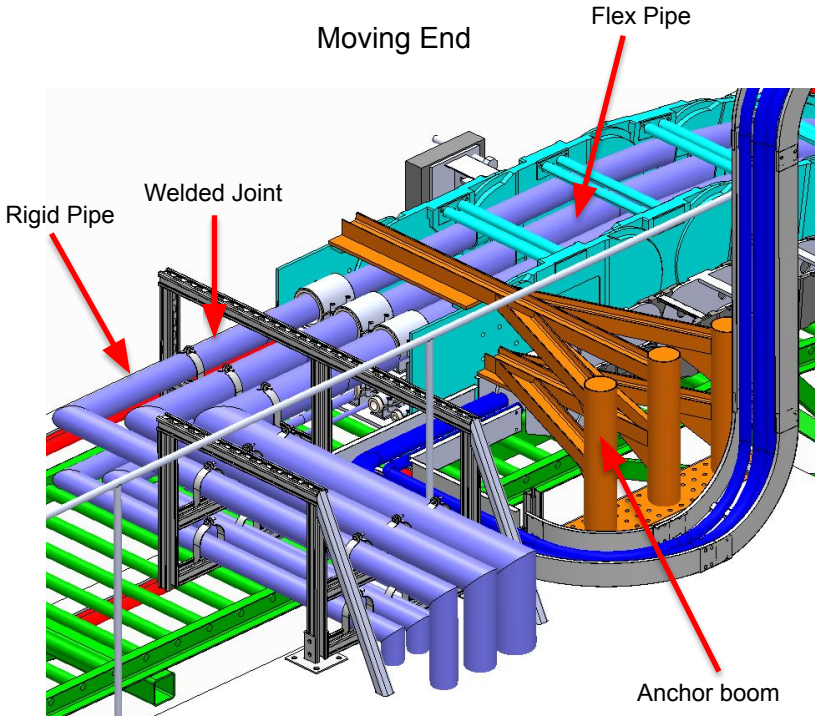


End Connections

Rigid piping from cyroplant and surface transfer lines will connect via welded connections

90 degree turn at end of chain to mate with LAr cryogenic mezzanine



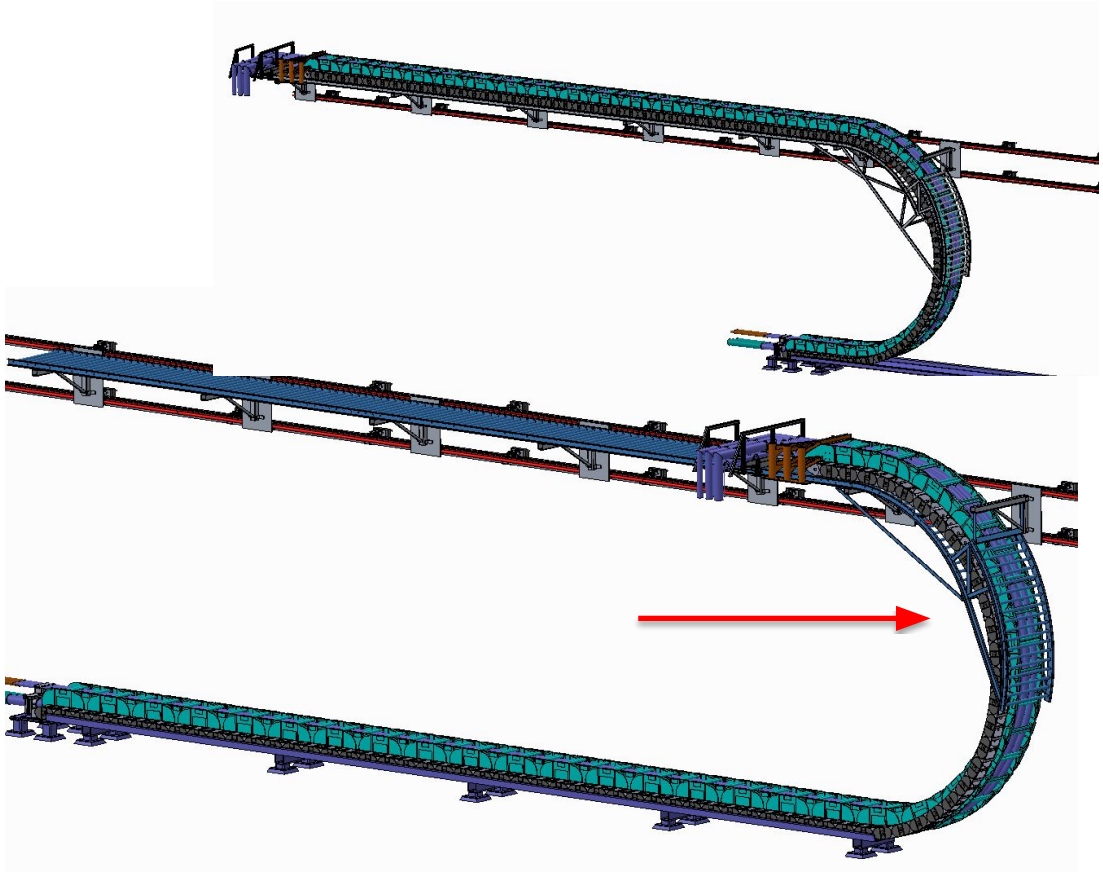


Conveyor Shelf

Energy chain traveling support needs to return with energy chain

Can this be accomplished without another powered motion system?

Added a concentric conveyor to guide travel support back to starting position



Commercially Available Conveyor

Model RS19U/G-31-6, 10’

Rollers Max Load: 8,757kg

15m(49.21ft) of straight conveyor results in 99 rollers

99x195lb= 19,305lb (8,757kg) max load

Frame max load:

10ft separated supports: 49.21ft x 120lb/ft = 5,905lb(2,678kg)

5ft separated supports: 49.21ft x 660lb/ft = 32,478lb(14,732kg)

*We will have to fabricate custom transfer module at end

Working with custom conveyor vendor CSE for a custom conveyor with wall-mounted rollers

RS19

GRAVITY ROLLER CONVEYOR
(1.9 in. dia. x 16 ga. rollers)

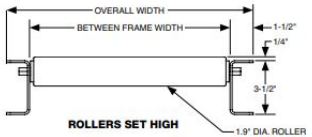
Gravity roller conveyor is ideal for conveying light or medium weight packages. They are useful for assembly, warehousing, or shipping applications.

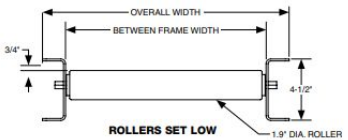
- 12 widths
- 4 roller centers
- Powder coated steel frames

ULTIMATION

BETWEEN FRAME WIDTH	OVERALL WIDTH	MODEL NO. 1.9" X 16 GA. UNPLATED	MODEL NO. 1.9" X 16 GA. GALVANIZED	ROLLER CENTERS	WT. (LBS.) 5'	WT. (LBS.) 10'
31"	34"	RS19U-31-2.25	RS19G-31-2.25	2 1/4"	169	340
		RS19U-31-3	RS19G-31-3	3"	146	278
		RS19U-31-4.5	RS19G-31-4.5	4 1/2"	112	214
		RS19U-31-6	RS19G-31-6	6"	97	179

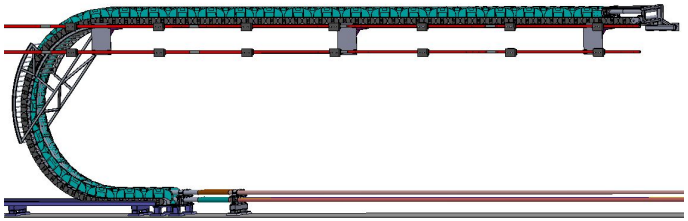
FRAME CAPACITY		ROLLER CAPACITY		
SUPPORT CENTERS	MAX. DISTRIBUTED LIVE LOAD PER FOOT (LBS.)	BETWEEN FRAMES	MAX. STATIC LOAD PER ROLLER (LBS.) 1.9 X 16 GA.	MAX. STATIC LOAD PER ROLLER (LBS.) 1.9 x 9 GA.
5'	660	13"-29"	265	290
10'	120	31"-45"	195	165
		47"-60"	100	80





Wall Mounting of Chain Support Conveyor

Travel support conveyor needs linear motion system to span travel distance of cryostat



Load Breakdown on linear motion system

Energy Chains:
~2,405 kg

Cryogenic Chain w/ VJP's, 24.55m at max travel (16.3m on conveyor, 8.25m in bend): ~2,148 kg

Power Supply Chain: 24.55m at max (10.45kg/m) ~257 kg

Travel Support Conveyor: ~1,085 kg

Conveyor: 987 kg

Support Shelves: 97.12 kg , 12.14 kg per unit

Load on linear bearings(max): ~3,490 kg

Linear Bearing Selection

Introduced Thomson linear bearings into model.

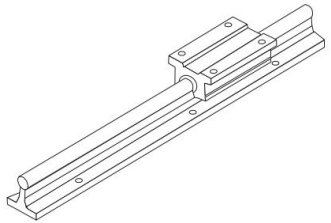
Two preferred options given for layout:

2 or 4 bearing per mounting pad

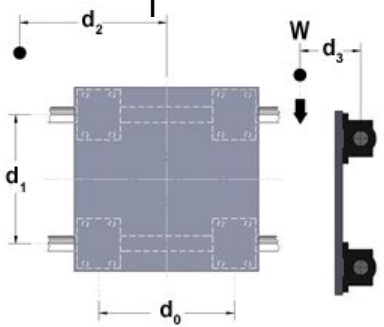
THOMSON
Linear Motion. Optimized.

FluoroNyliner® Linear Guides

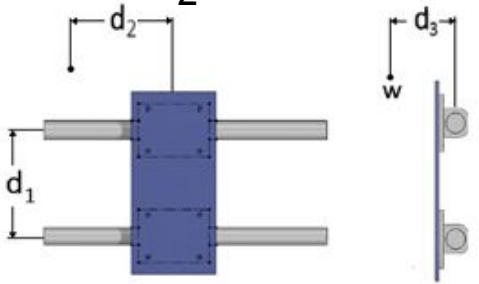
Corrosion resistant, smooth, quiet, industry standard envelope



Option 1



Option 2



Conveyor Support

Specs:

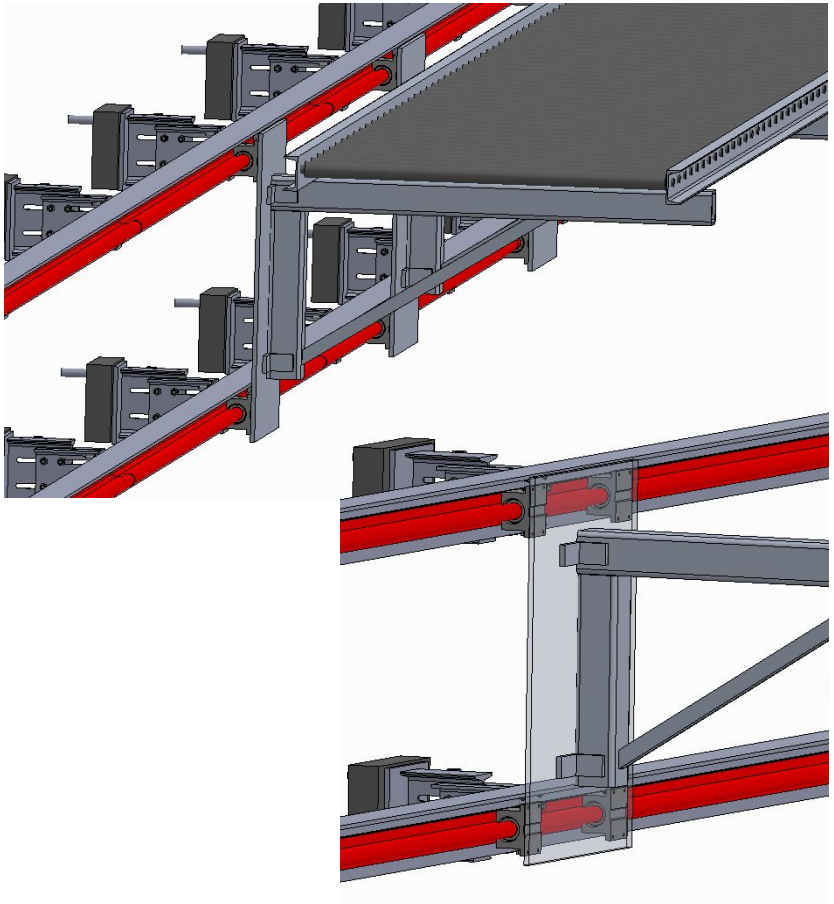
Rail Diameter: 1.5 inch

Bearing Max Load(per): 7000 lbf, or 3175kg

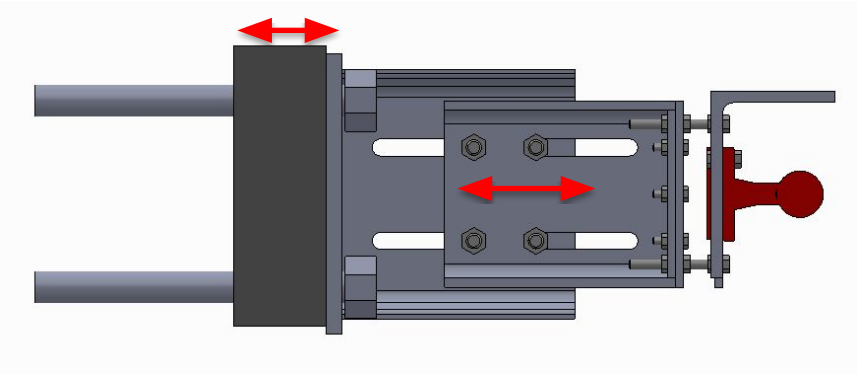
Max Load per support unit: 12,700 kg

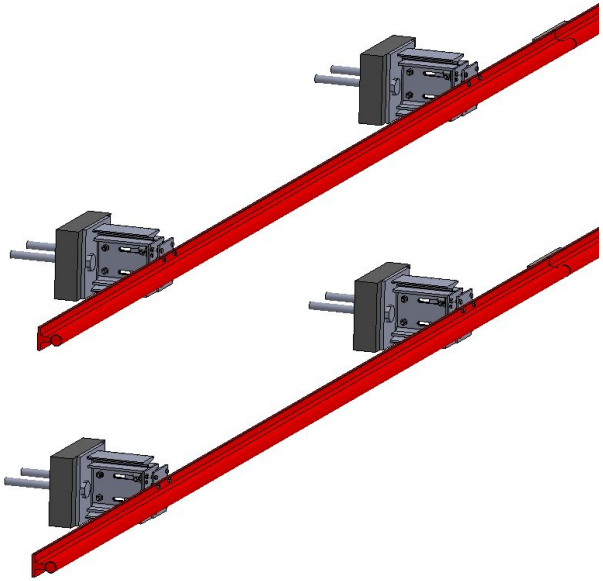
3+ support units mounted along conveyor

Total bearing max load capacity: 38,100 kg



Rail Mounting

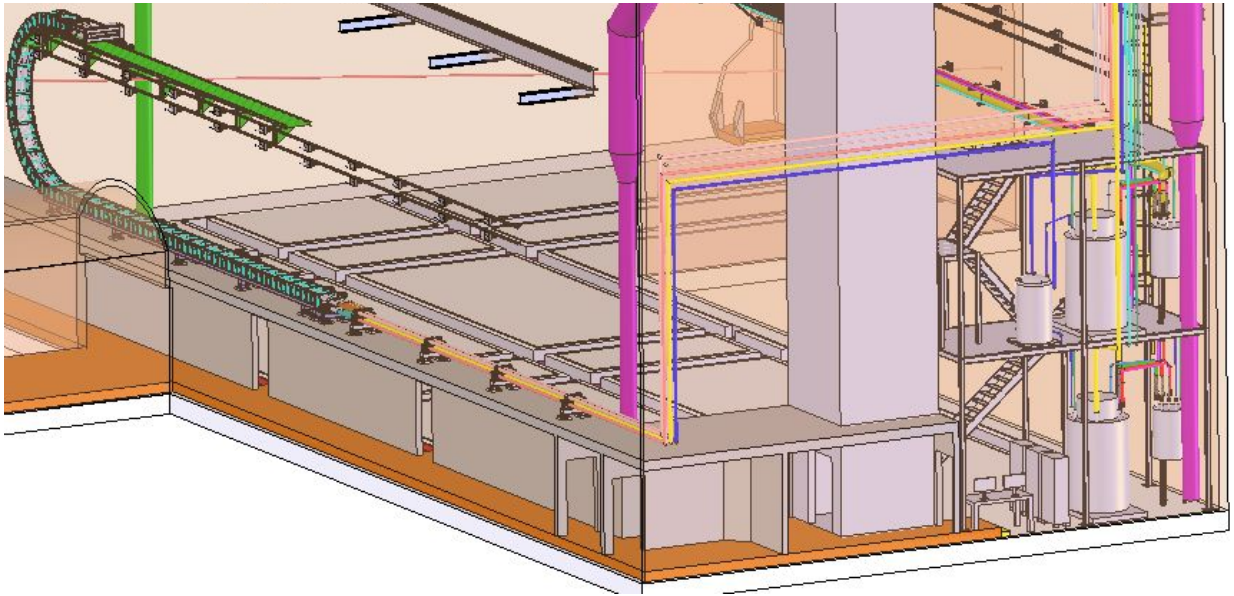




Slotted beam mounted to grout pad/shotcrete surface

3” slot + grout pad thickness (0 to 3+ inches) can overcome 6”+ variability in cavern wall surface.

Cryogen Pipe Routing in Cavern



Preliminary routing along rear wall of cavern and down to egress surface.

Concerns: Equipment placement along desired path, Interference with current ventilation model and power distribution equipment