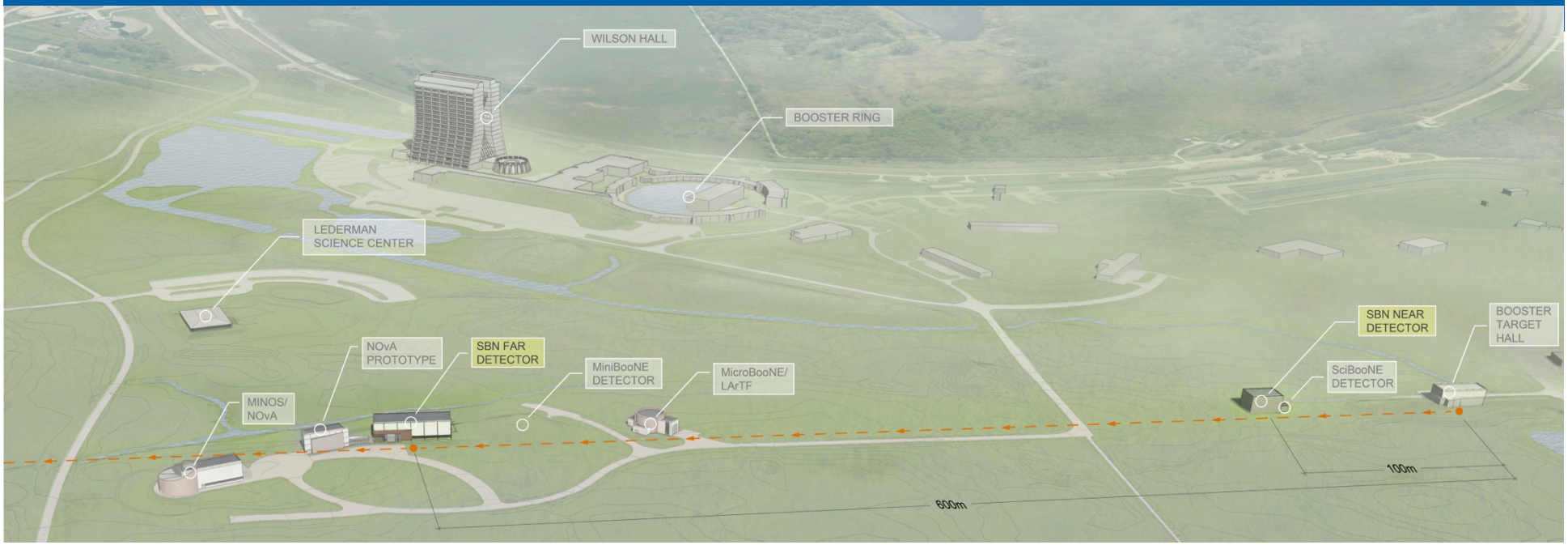


SBND TPC Status

Kostas Mavrokoridis -TPC Manager *(k.mavrokoridis@liverpool.ac.uk)*

Directors' Progress Review of SBN

15-17 Dec 2015, Fermilab

Outline -Key TPC Components

- APA
  - APA frames
  - Geometry boards, mounting platforms
  - Wire mesh, wire support, E-diverter
  - APA assembly procedure and tooling
  - Interface to electronics; faraday cage
  - APA winding
- CPA
  - CPA frames & panels
  - HV Cup
  - CPA suspension features
- Field Cage
  - Field cage panels
  - Roll-formed metallic profiles
  - Resistor divider board
  - Supporting beams
- HV Feedthrough
- TPC Integration
  - APA Interconnect and alignment
  - TPC suspension features
  - TPC assembly procedure and tooling

Preliminary Design Report (docdb ID 613) **Review was held Sept 2015**

http://sbn-docdb.fnal.gov:8080/cgi-bin/RetrieveFile?docid=613&filename=sbnd-tpc-PDR-review.pdf&version=1

The SBND TPC Working Group

Collaboration between UK and USA Institutions, funded by NSF and STFC

Deliverables	Institution
Four APA Frames (2UK&2US)	University of Sheffield
Winding two APAs	University of Manchester
Winding two APAs	Chicago, Syracuse and Yale
CPAs	University of Liverpool
HV Feedthrough	UCL and Yale
Field Cage	BNL and Yale
QA/APA cold tests	Lancaster University
Integration, Assembly, and Installation	Chicago, BNL and Fermilab

The SBND TPC Working Group

The WBS Managers

40SBN/2	SBND Construction	WBS Managers	WBS deputies
40SBN/2.3	TPC Construction	Kostas Mavrokoridis	-
40SBN/2.3.1	TPC Preliminary Design	Bo Yu	-
40SBN/2.3.2	TPC Final Design	Bo Yu&Peter Sutcliffe	-
40SBN/2.3.3	APA Frame Construction - (UK)	Trevor Gamble & Nicola McConkey	-
40SBN/2.3.4	APA Geometry Boards Production - (US)	Bo Yu	Serhan Tufanli
40SBN/2.3.5	APA Construction - (UK)	Stefan Soldner-Rembold	Jarek Nowak
40SBN/2.3.6	APA Construction - (US)	Mitch Soderberg	-
40SBN/2.3.7	CPA Construction - (UK)	Peter Sutcliffe & David Payne	-
40SBN/2.3.8	HV Supply and Feed Through Construction - (US-UK)	Anna Holin & Bonnie Fleming	Serhan Tufanli
40SBN/2.3.9	Field Cage Construction - (US)	Bo Yu	Serhan Tufanli
40SBN/2.3.10	TPC Connection Frame Construction - (US)	Rich Northrop &Dave Schmitz &Bo Yu	-
40SBN/2.3.11	TPC Assembly Preparations - (US)	Rich Northrop &Dave Schmitz &Bo Yu	-

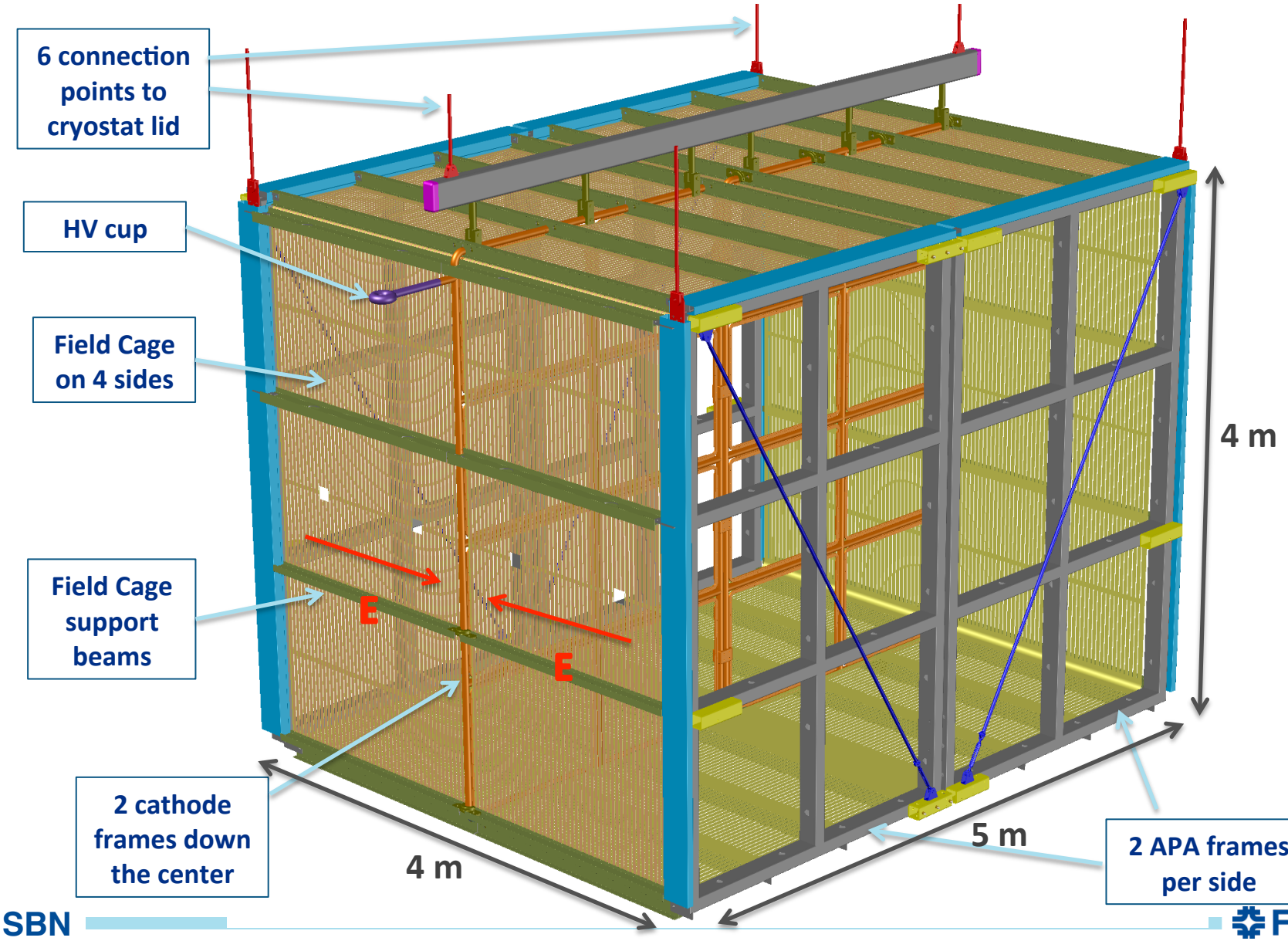
TPC Requirements

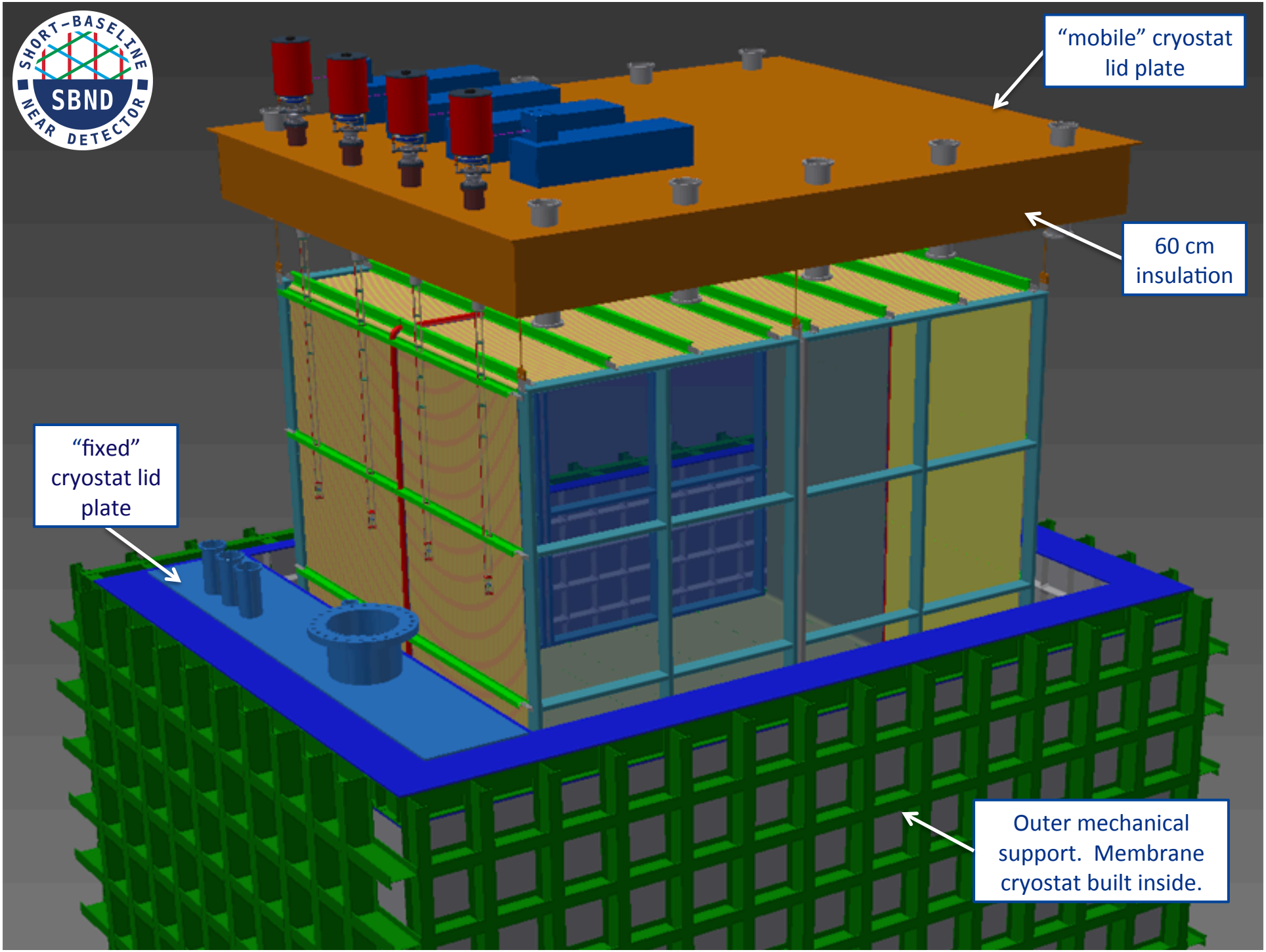
- The TPC volume is large enough to achieve the physics goals of the experiment.
- The 3 mm wire pitch is chosen, as in the MicroBooNE and ICARUS detectors, to enable electron/photon separation to be achieved with identical efficiency.
- Limit variation in the wire sag to < 0.5 mm such that it does not significantly impact the position and energy resolution of the detector.
- The APAs are constructed in a manner that guarantees no wires will break during the operational life of the experiment.
- The electric field must not exceed 30 kV/cm inside the liquid, and not exceed 5 kV/cm in the argon gas to prevent HV breakdown.
- Minimize dead space in the active volume: place the cathode in the center of the TPC.
- The wire plane and HV cathode designs must be compatible with the photon detection system designs being considered for the experiment.
- Use only materials that are compatible with high-purity liquid argon.

TPC Parameters

Parameter	Value
TPC active volume	5m (L) x 4m (H) x 4m (W), 112 metric ton active LAr mass
Number of TPC cells	2 drift volumes, 2m drift length in each
Anode Plane Assembly (APA)	2.5m x 4m active area, with cold electronics mounted on 2 sides.
Wire properties	150μm diameter, CuBe
Wire planes	3 planes on either side of an APA U & V at ±60º to vertical, Y vertical
Cathode bias	-100 kV @ 500V/cm drift field
Number of Wires	2816 channels/APA. 11264 wires total in TPC.
Wire tension	0.5 kg at room temperature

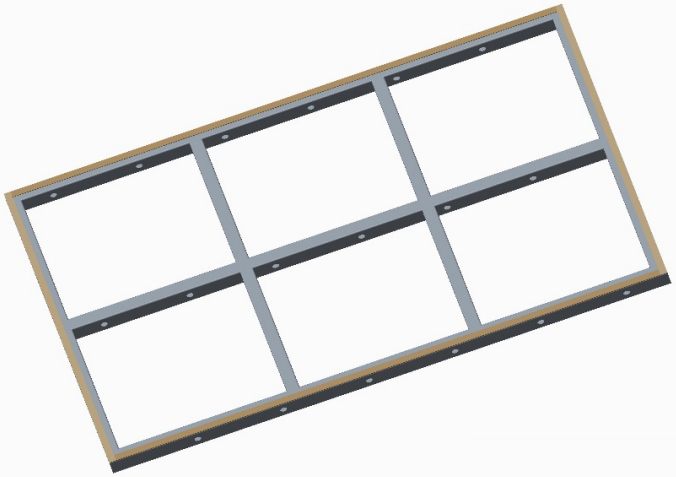
SBND TPC Layout




SHORT-BASELINE
SBND
NEAR DETECTOR
“mobile” cryostat lid plate
60 cm insulation
“fixed” cryostat lid plate
Outer mechanical support. Membrane cryostat built inside.

APA Frame

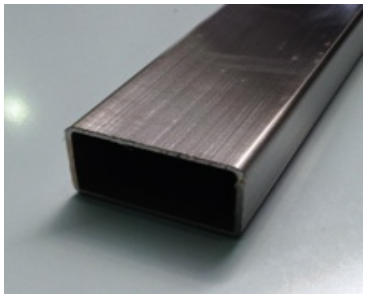
University of Sheffield & Chicago



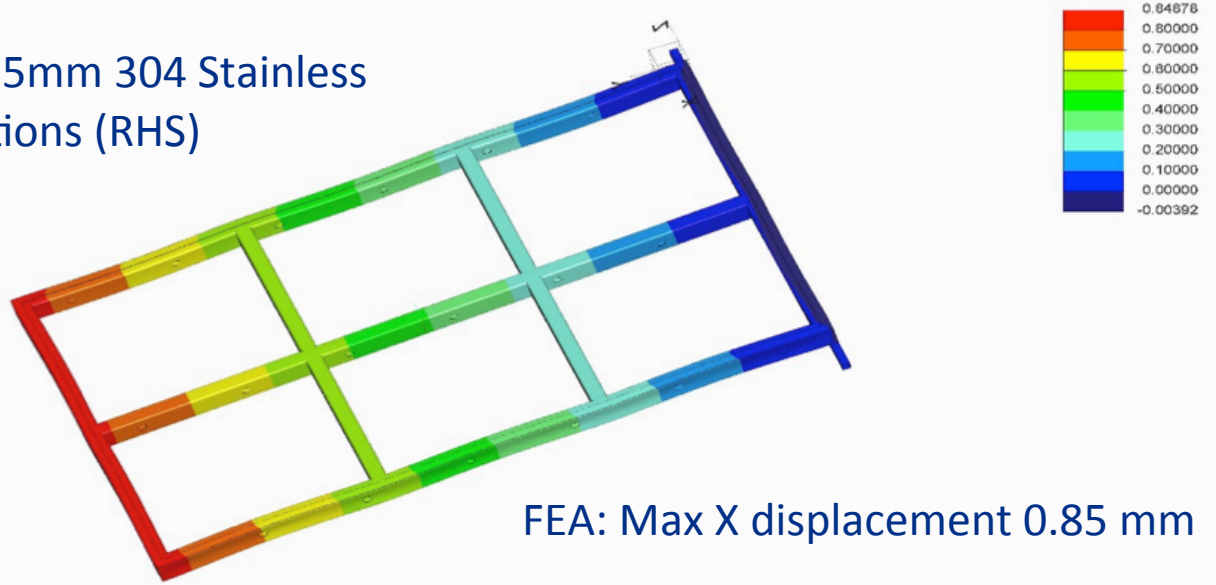
Leveling plate

- For 3 mm wire plane separation need better than ± 2 mm flatness, plate adjustable to ± 0.5 mm

- Fabricated from 150 x 100 x 5mm 304 Stainless Steel rectangular hollow sections (RHS)



- Bare frame weight = 480 kg
- ± 2 mm flat welded frame

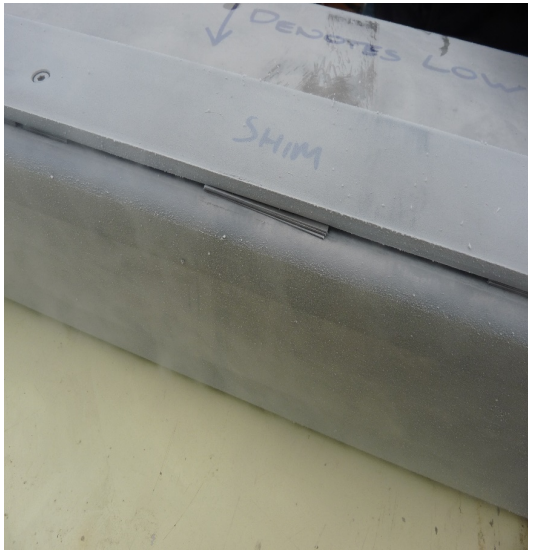


FEA: Max X displacement 0.85 mm

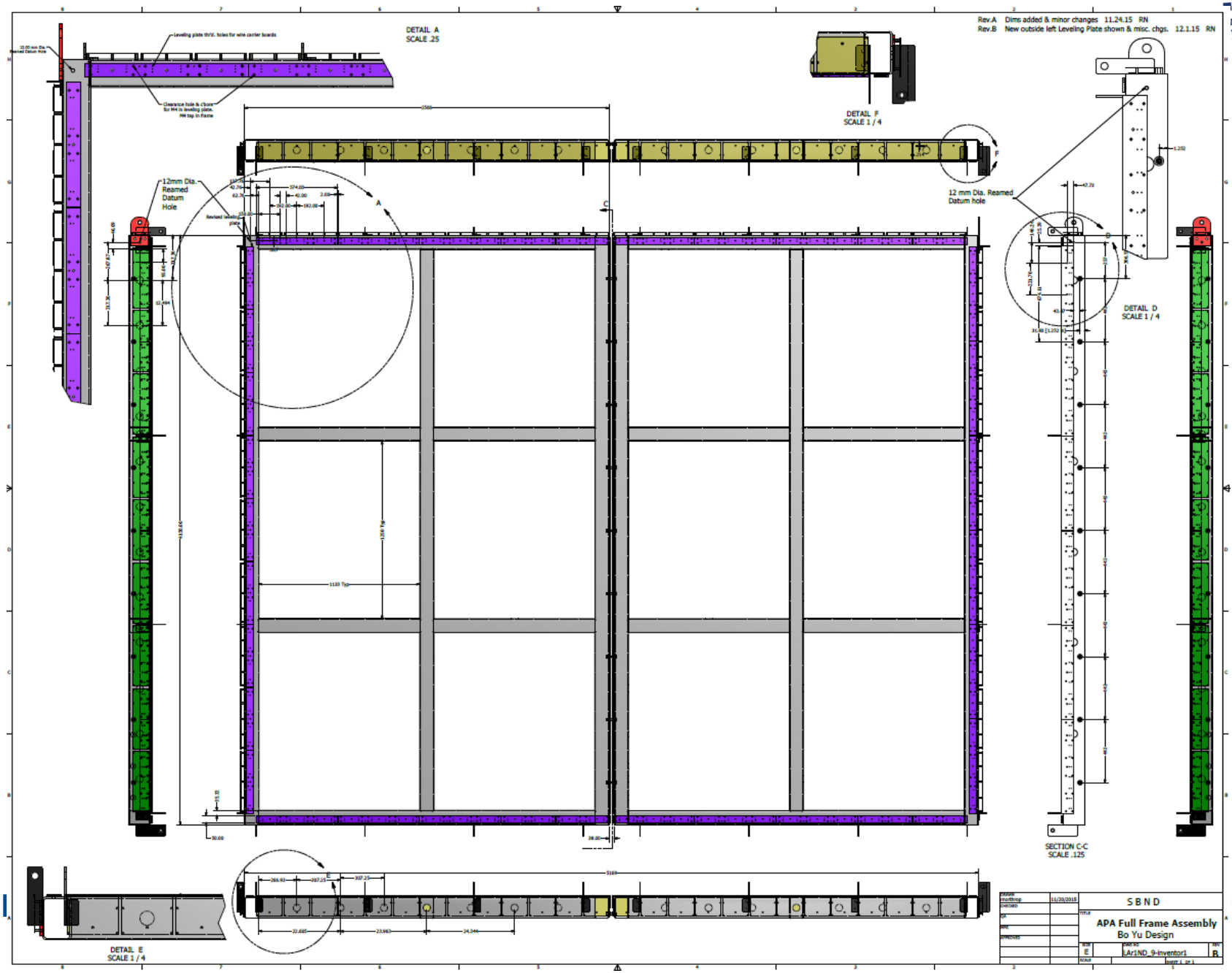
APA Frame

Prototyping levelling plates -deformation check at Sheffield

Shims



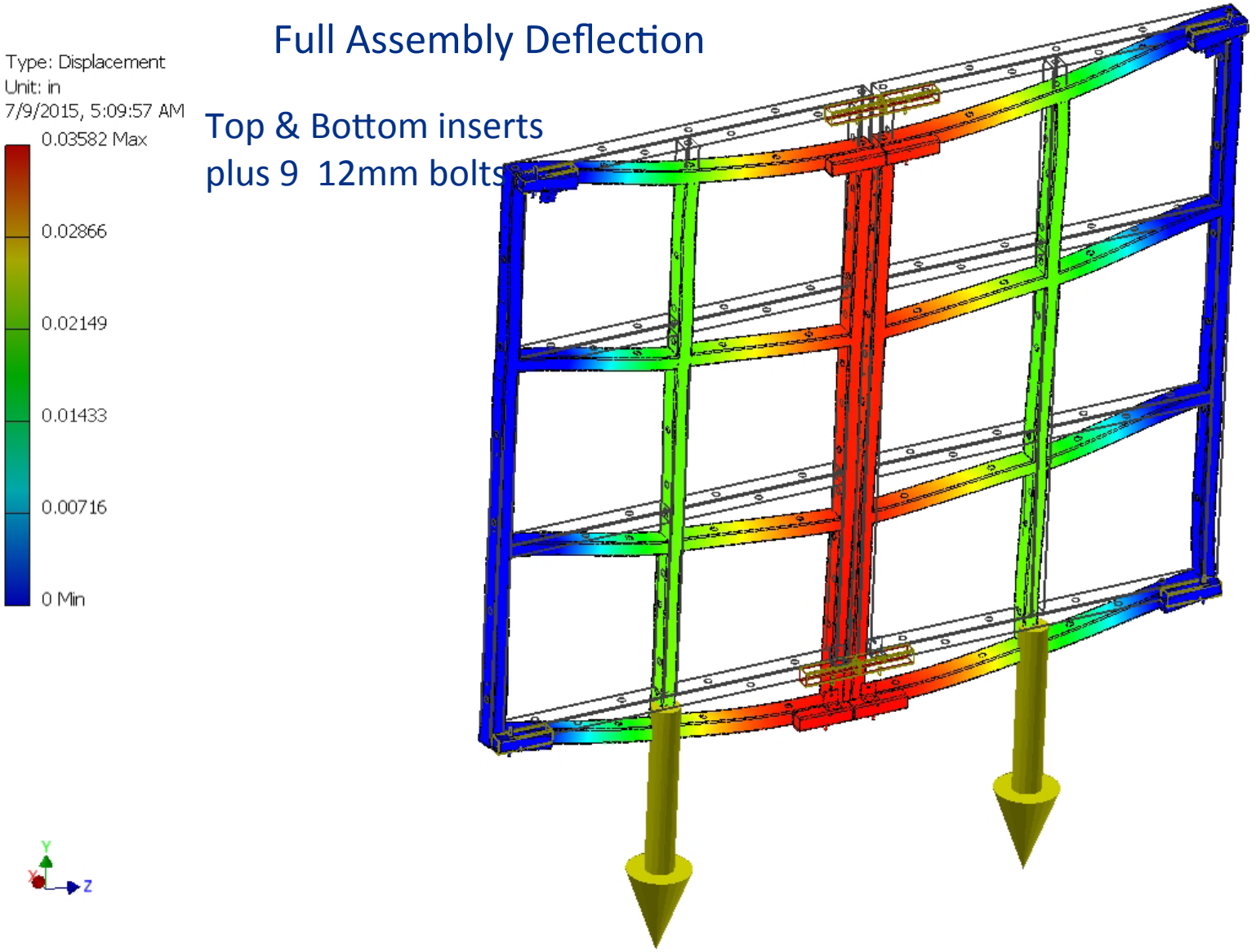
APA Frame


Rev.A Dims added & minor changes 11.24.15 RN
Rev.B New outside left Leveling Plate shown & misc. chgs. 12.1.15 RN
DETAIL A
SCALE .25
DETAIL F
SCALE 1 / 4
12mm Dia. Reamed Datum Hole
12 mm Dia. Reamed Datum hole
DETAIL D
SCALE 1 / 4
SECTION C-C
SCALE .125
DETAIL E
SCALE 1 / 4
SBND
APA Full Frame Assembly
Bo Yu Design
ArtND_9-Inventor1

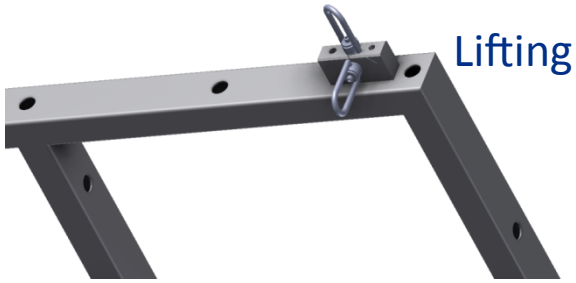
APA Frame

Full Assembly Deflection

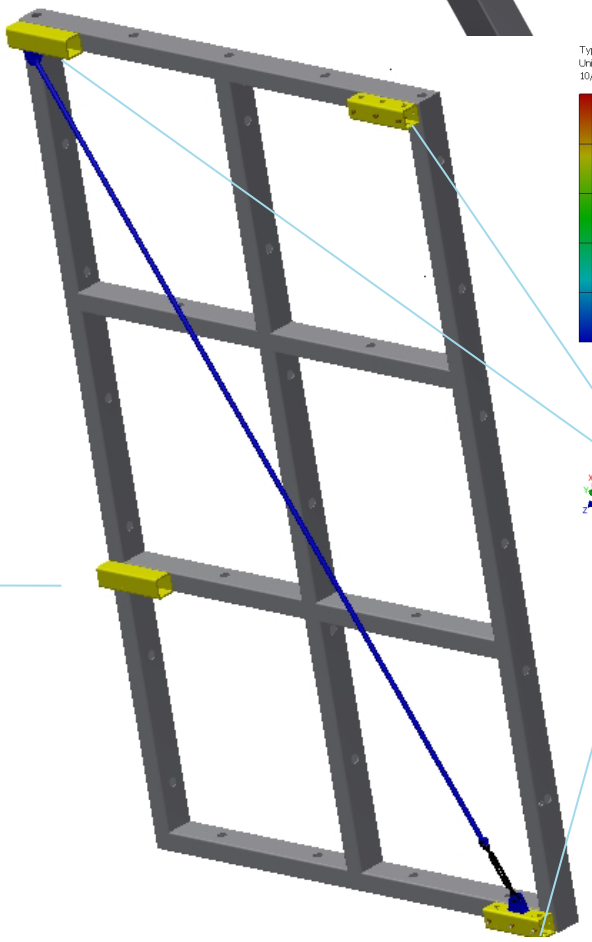
Top & Bottom inserts
plus 9 12mm bolts

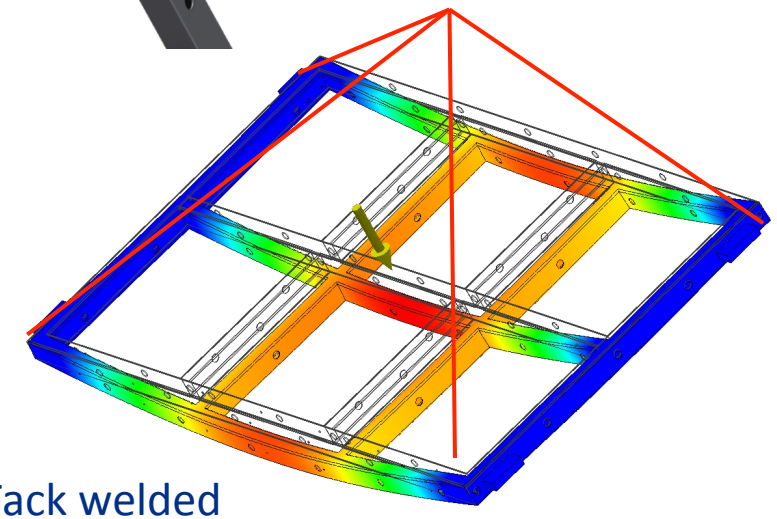


APA Frame



Lifting fixture





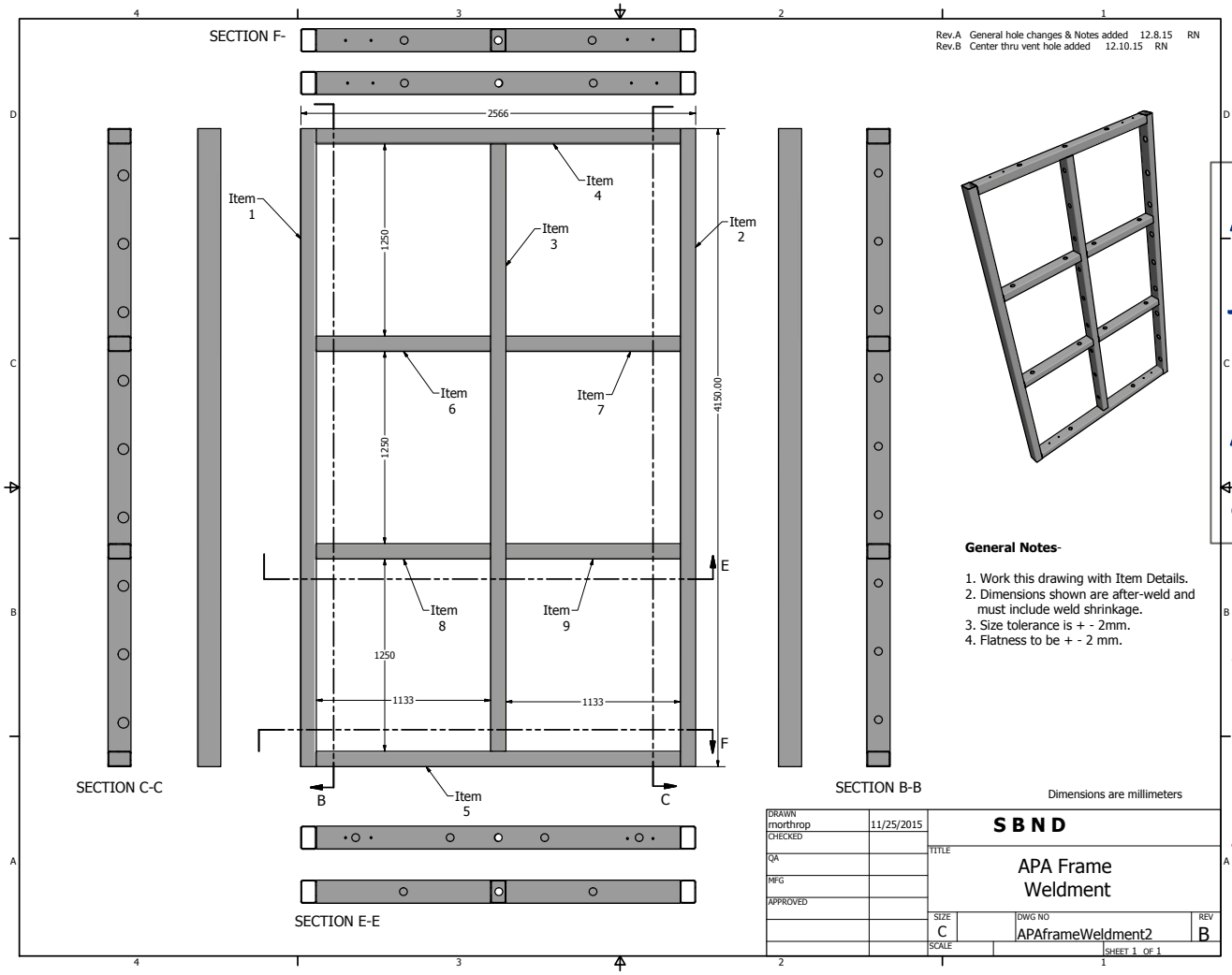
Screw mounted attachment - 8 M6 screws

Tack welded Tube attachments

Deformation while lifting at horizontal position 0.7 mm

APA Frame

Final bare frame design



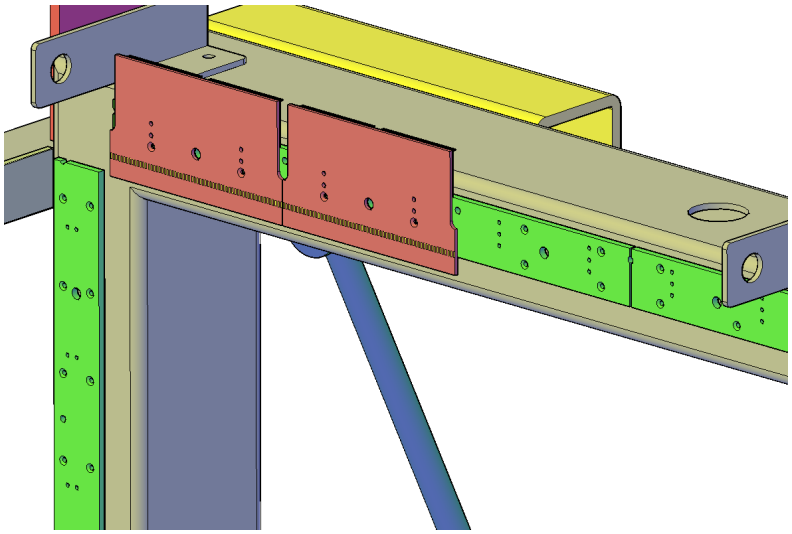
APA bare frame and jig review on Dec 17th

Almost ready to place an order

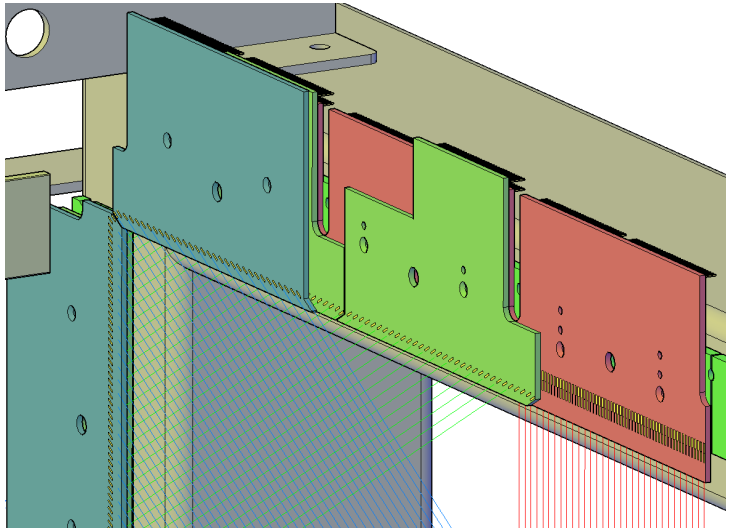
Quote from Portobello: 4 APAs and Jig 129k GBP

Levelling bars and laser surveys 43k GBP

APA Construction

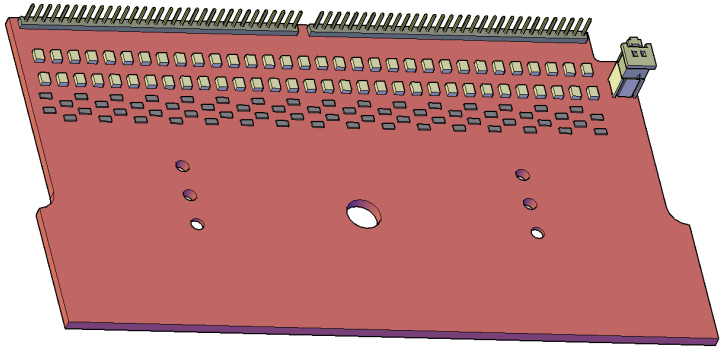


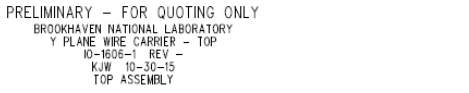
APA leveling plates to achieve flat surface for the geometry boards (± 0.5 mm adjustment)

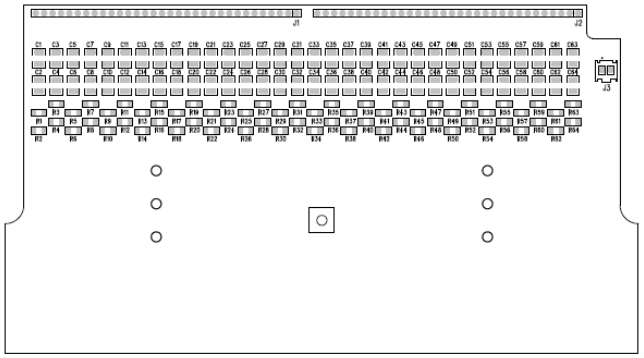


Three layers of the Geometry Boards

- All geometry boards are modeled in 3D
- Layout of the Y_top Geometry Board Complete

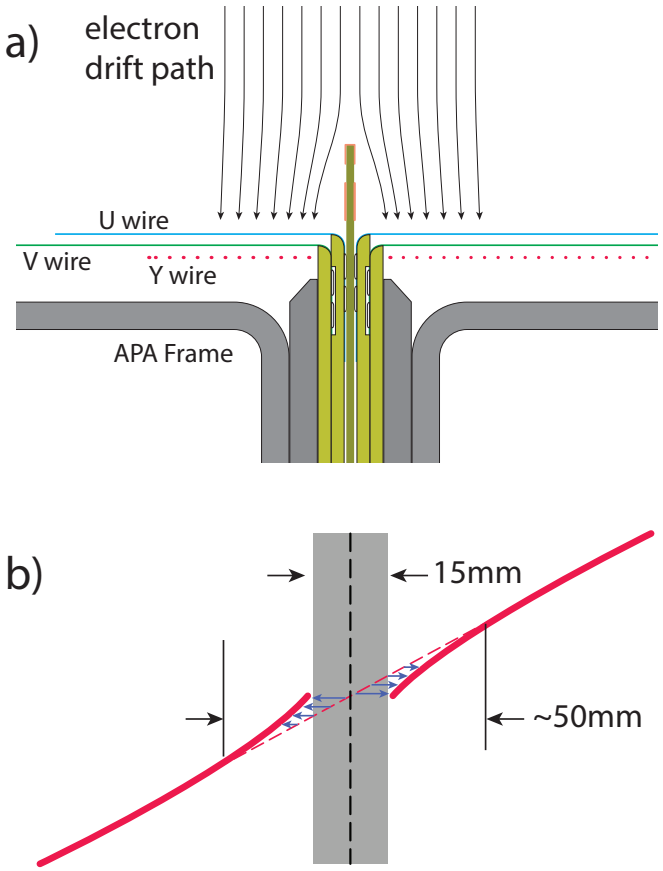






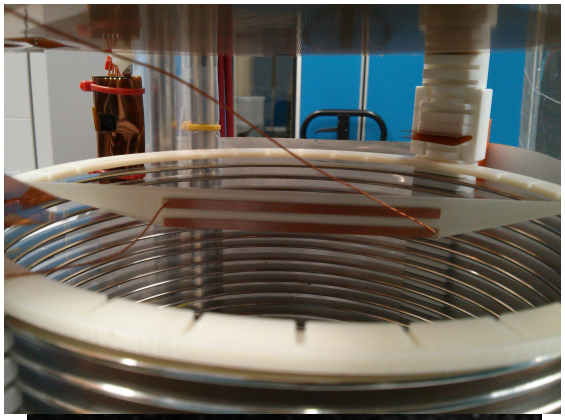
Total Estimate for all boards: ~80k$

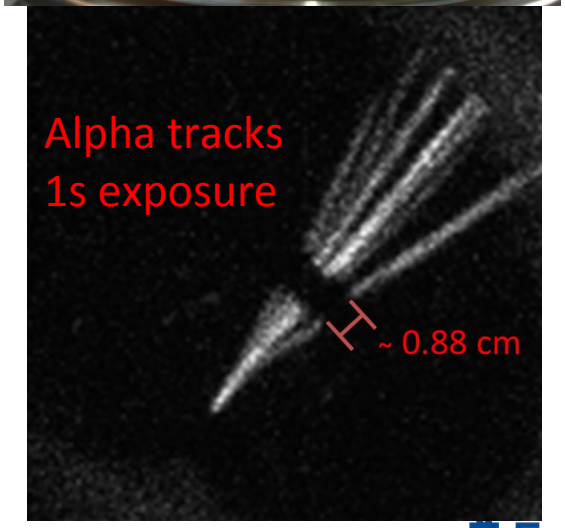
APA Construction –Electron Deflector



Electron deflector to recover the "dead" region (15mm) between the two interconnected APAs

- To be tested in 35t
- Preliminary studies with the Liverpool camera readout TPC in gas

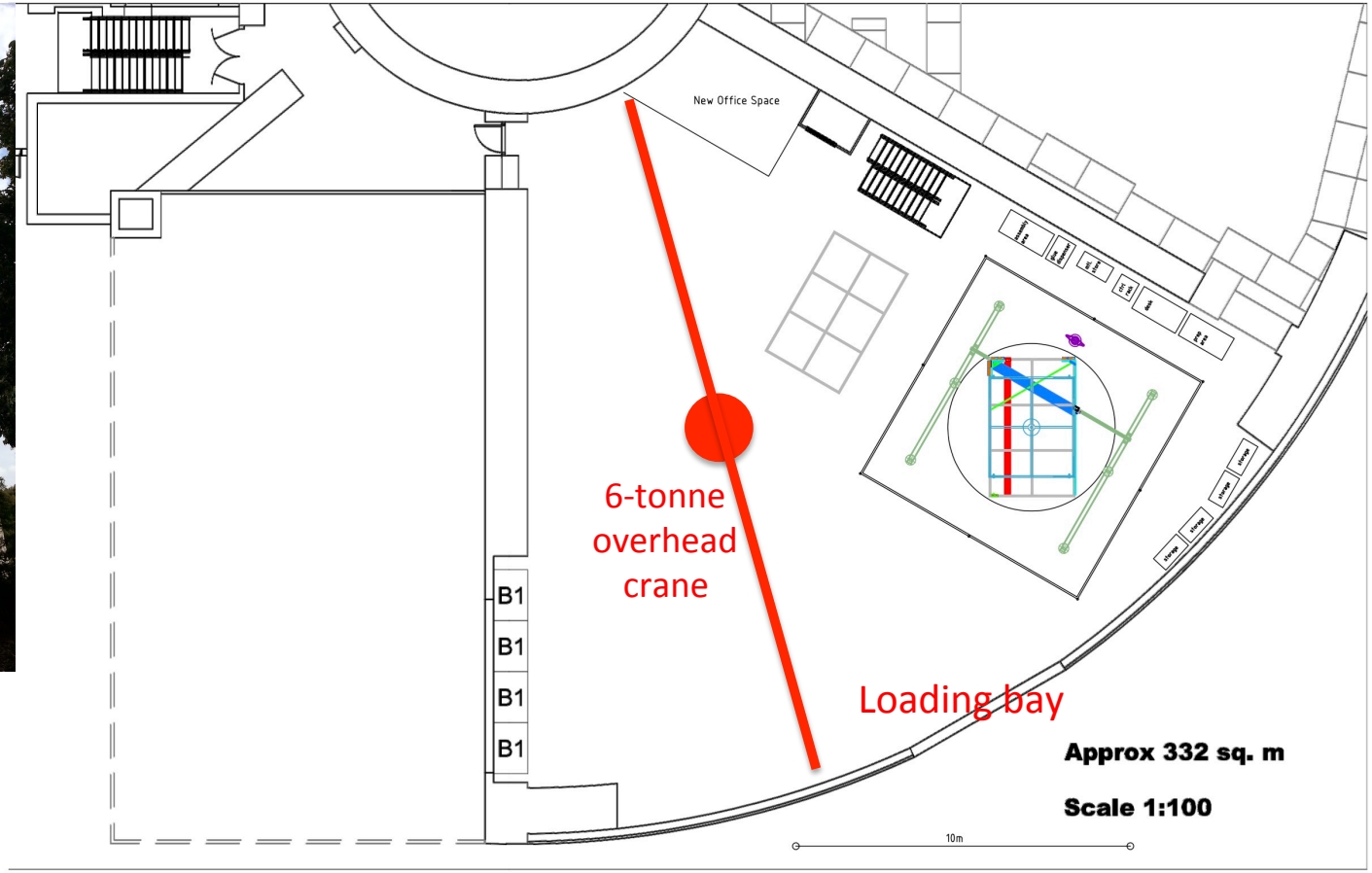




APA Winding

Two winding Facilities
- Daresbury, UK (Manchester group)
- Yale, USA (Syracuse group)

UK Daresbury Space

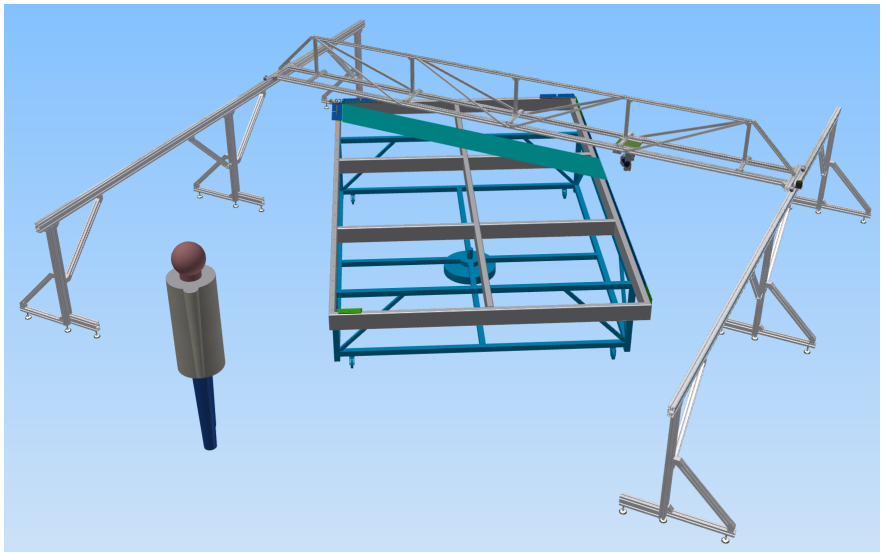


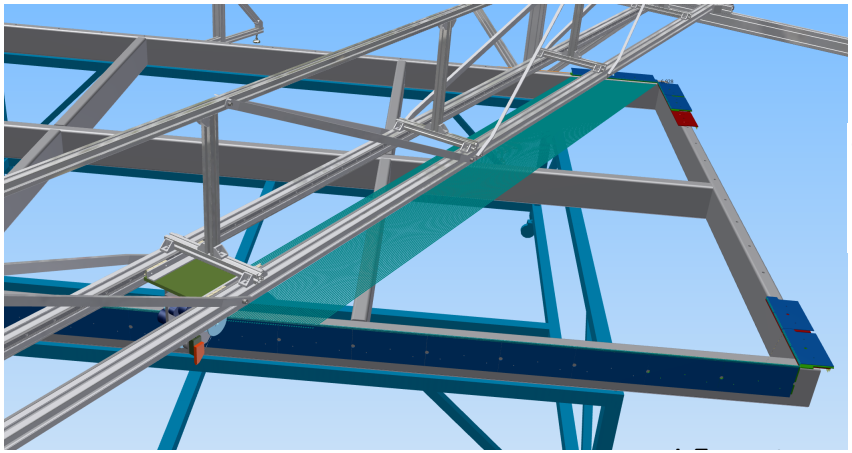
APA Winding

UK Daresbury space ready to be used

APA Winding

Winding Procedure UK: Semi automated



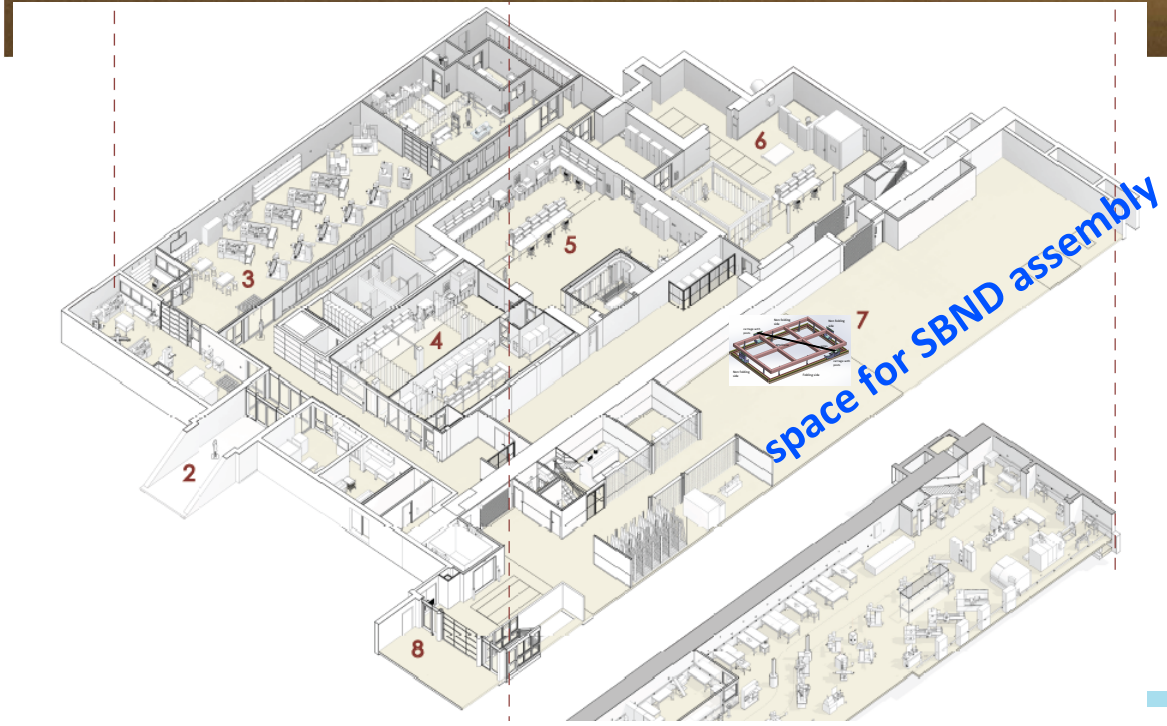


- Frame is supported on a turntable which rotates to three working angles.
  - Working space ~6x6 m^2
  - Full access for operator(s)
- Wiring head traverses on cross beam, which itself travels on fixed side rails.
- Wires are strung one at a time:
  - Ease of design/development
  - Quality control is wire by wire
  - Minimal working area
  - Scalable to any size frame
- Procedure:
  1. Solder wire at one side.
  2. Draw wire over guides to other side.
  3. Tension.
  4. Solder on other side.
  5. Cut wire.
- Finishing:
  - Glue over soldered joints and board edges to fix against possible creep
- Automated option:
  - Computer-controlled stepper motors ensure precise positioning. (otherwise manually)

Turntable framework and bridge design is complete

APA Winding

Yale The New Wright Laboratory



Facilities

85,200 sf of lab and office space include

- PI laboratories
- Specialized laboratories
- Prototyping, teaching, fabrication shops

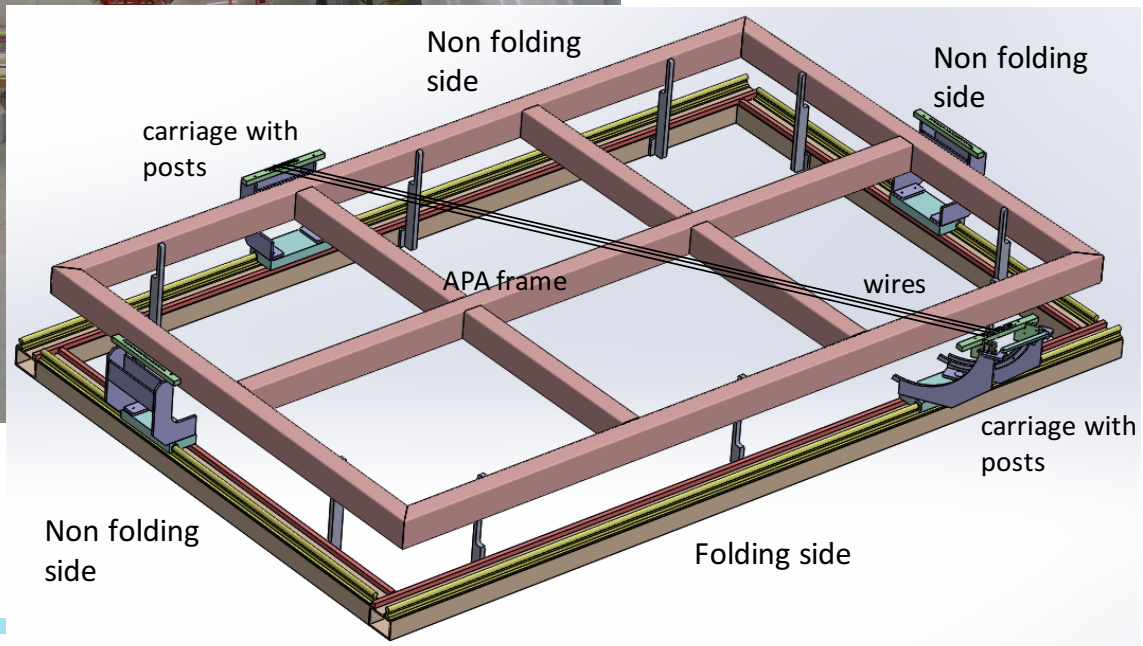
Fermilab

APA Winding

The New Wright Laboratory

Detector assembly and staging areas.
Currently undergoing renovations.
Available in summer 2016

Winding Procedure US: Manual



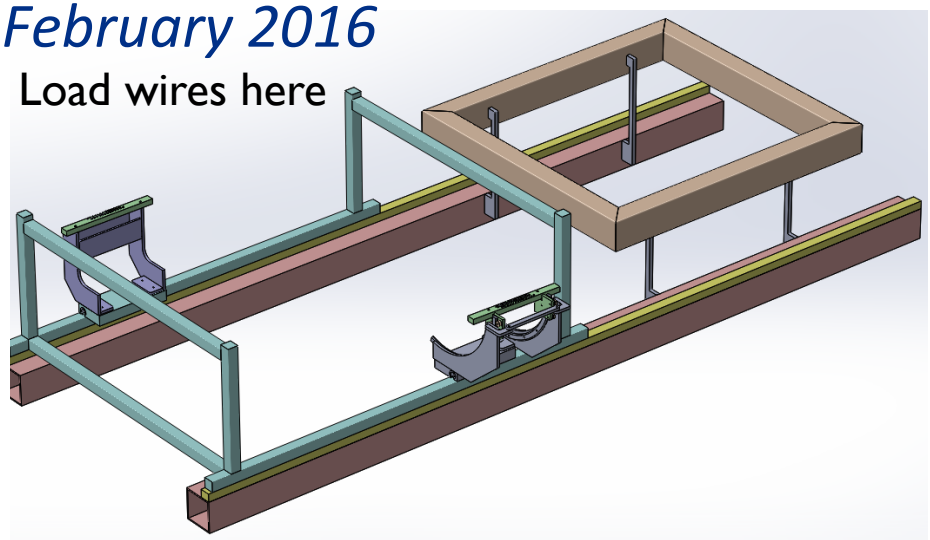
Syracuse group works with PSL

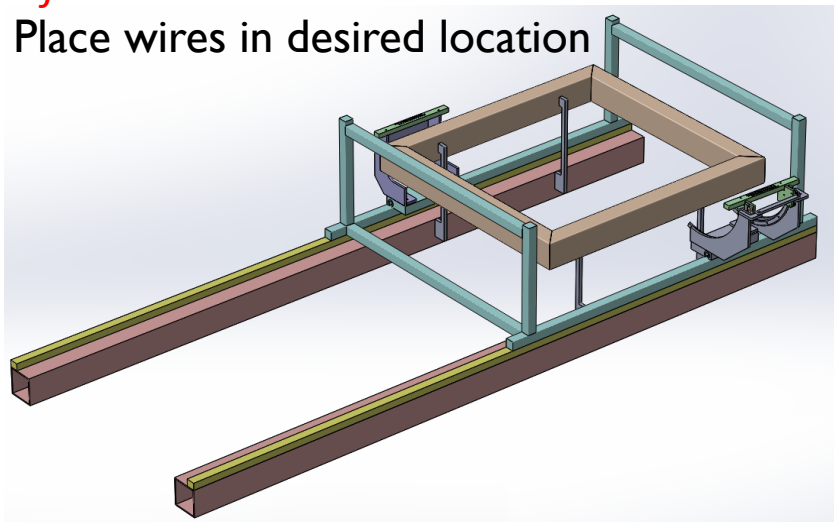
APA Winding

Winding Procedure US: Manual

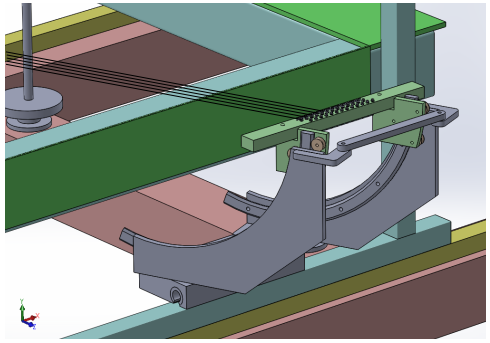
Prototype expected delivery February 2016

Cost prototype ~40k USD
Cost for full machine ~50k USD

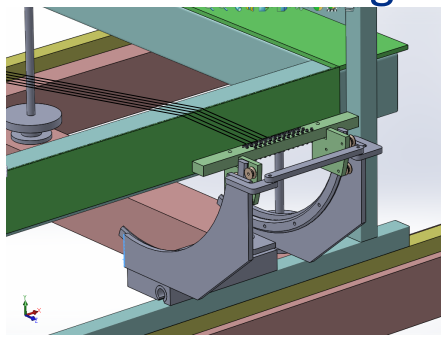




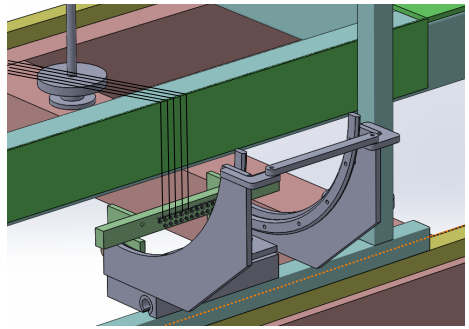
Procedure for wires to be placed over the edge:



1. Starting position



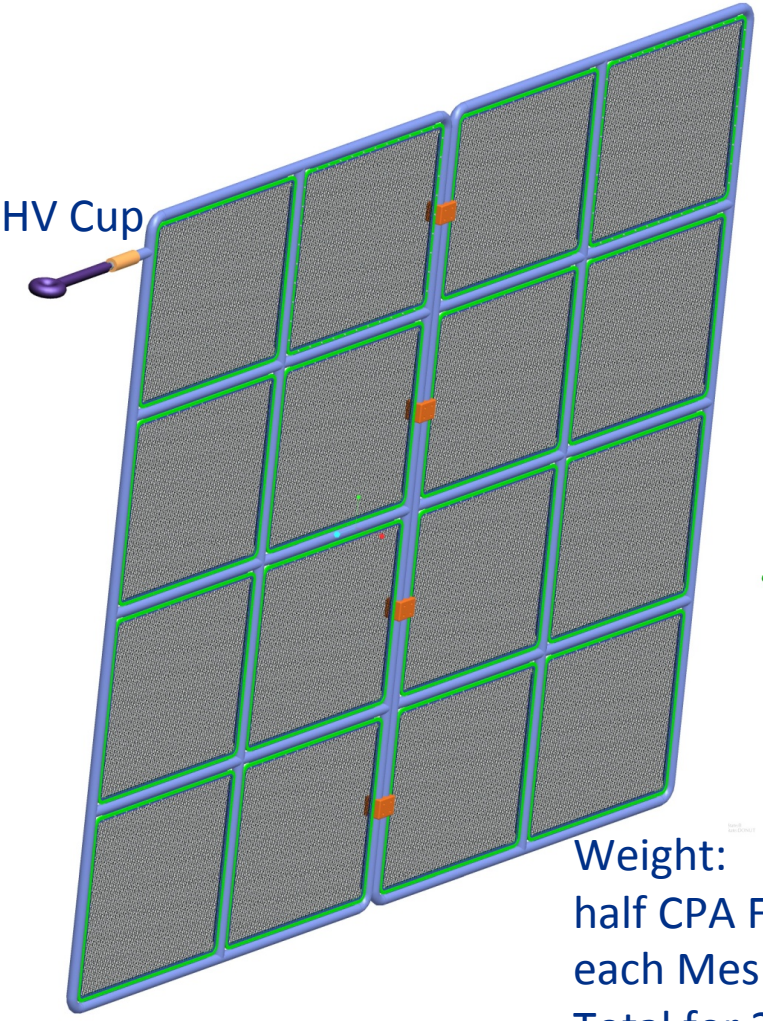
2. The 1st fold brings the wire outside the APA perpendicular to the side

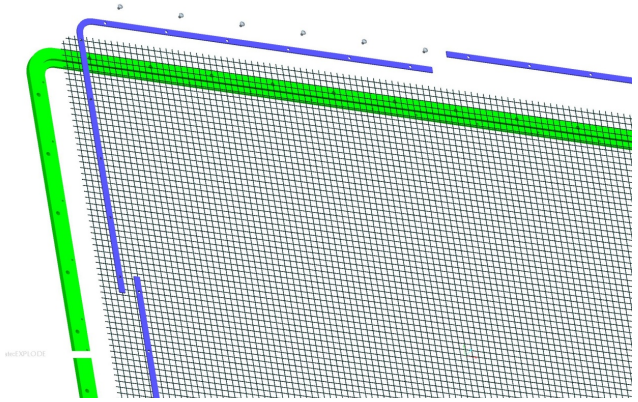


3. The 2nd fold brings the wires down along the edge geometry boards where they are then soldered

CPA

Construction University of Liverpool

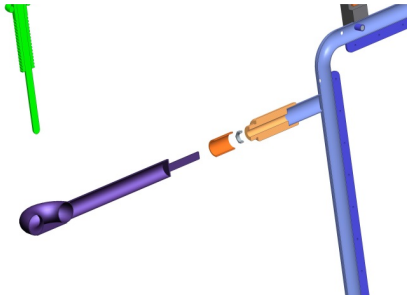




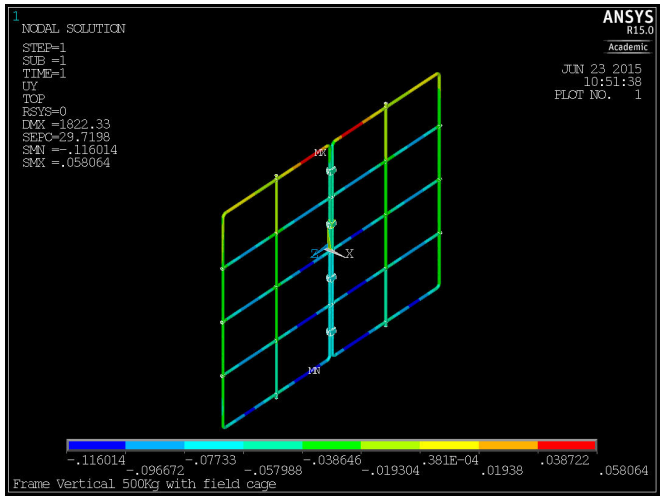
Cost 39k GBP

- 5 mm aperture
- 1 mm wire ID
- 70% transparency

Baseline design transparent mesh



Weight:
half CPA Frame 130Kg
each Mesh Panel 8.5Kg
Total for 2 CPAs around 440Kg



FEA: Deflection 0.116 mm

CPA Made up of a Stainless steel frame and 8 stainless steel wire mesh smaller frames.

HV supply & Feedthrough

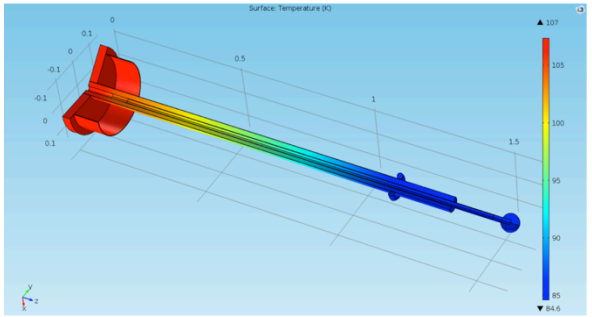
Yale and UCL groups

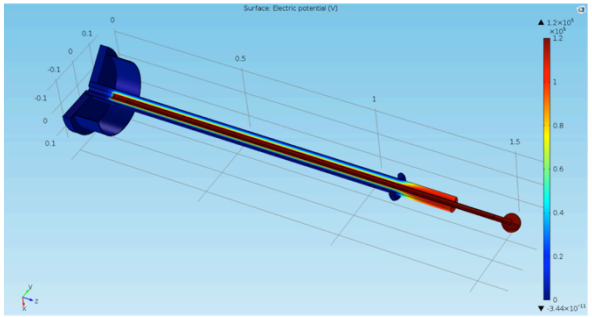
100 kV FT, Spring loaded tip based on 35ton design

Heinzinger PNChp 150000 – 1 neg
High Precision – HighVoltage – Power Supply

Material cost is 67k $

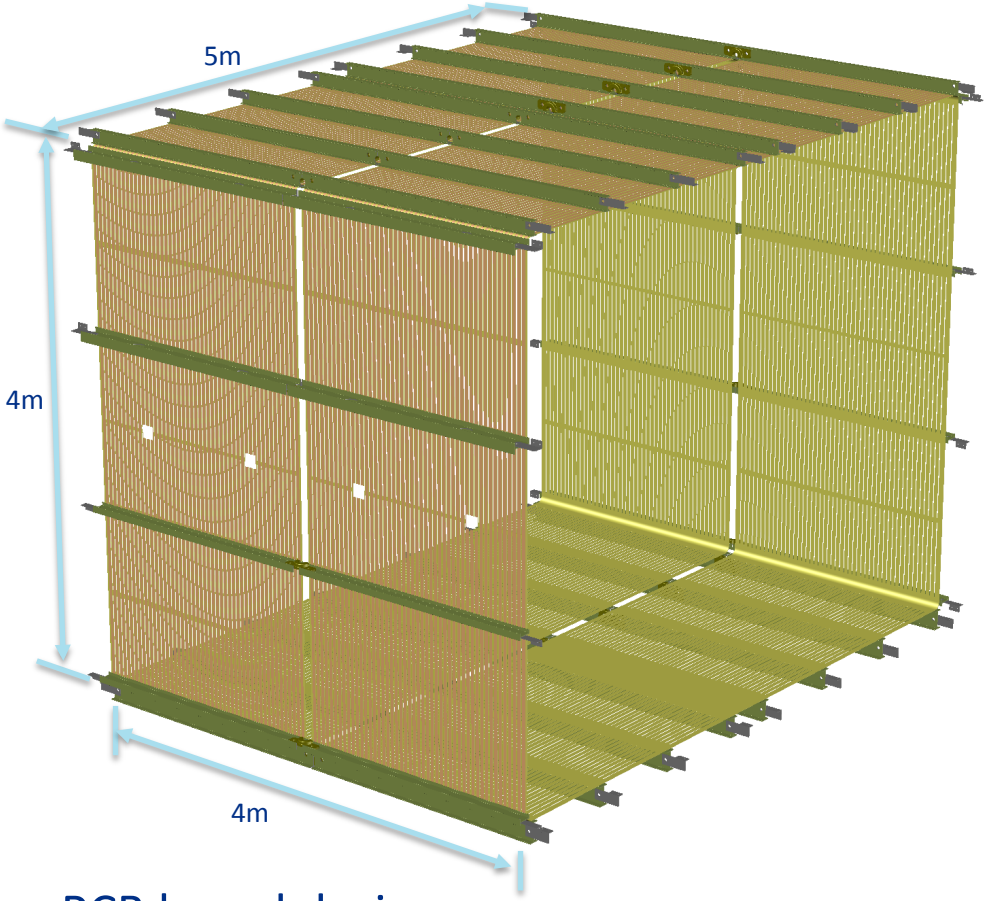
- Simulations:
  - electric field
  - thermal





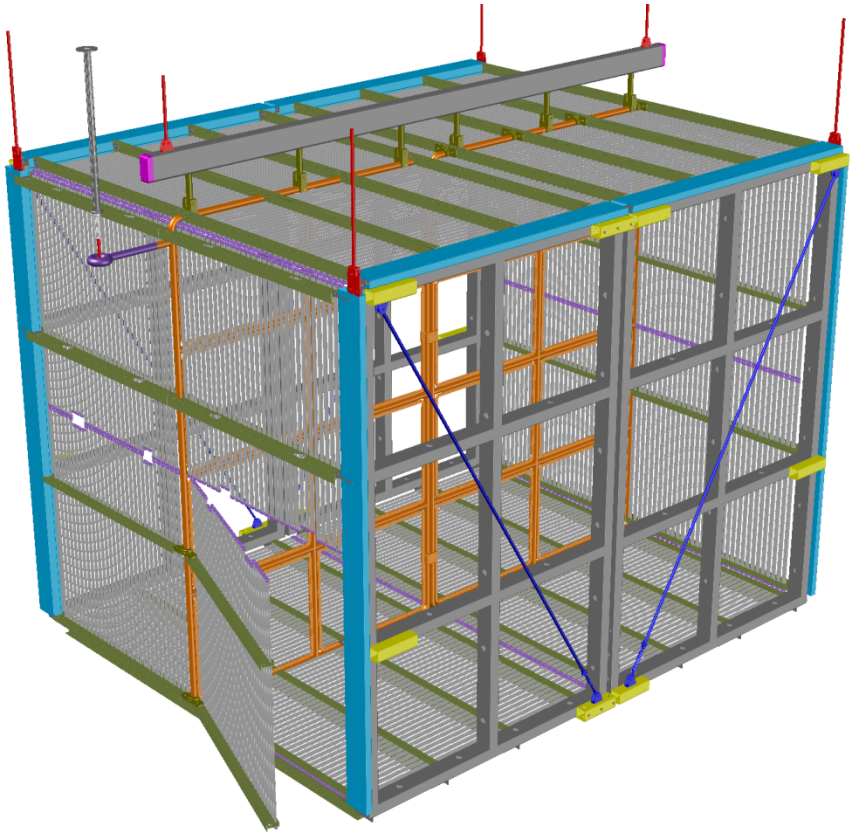
Field Cage

Work led by BNL and Yale



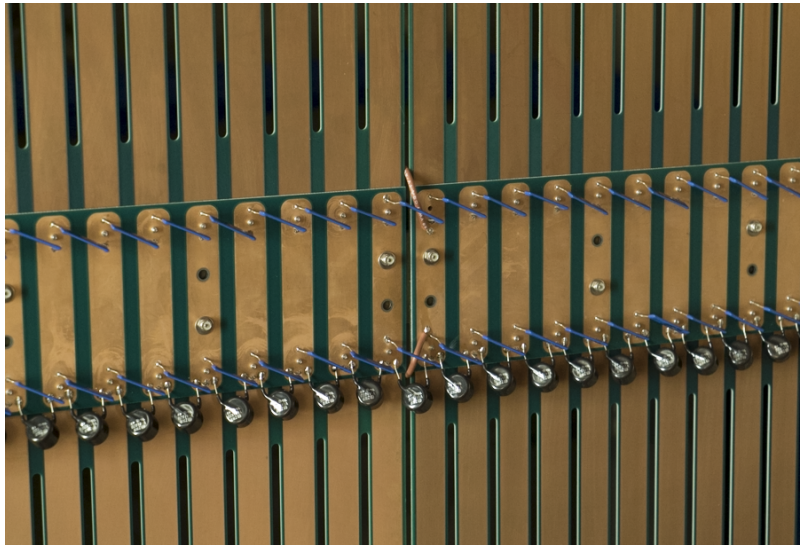
PCB based design

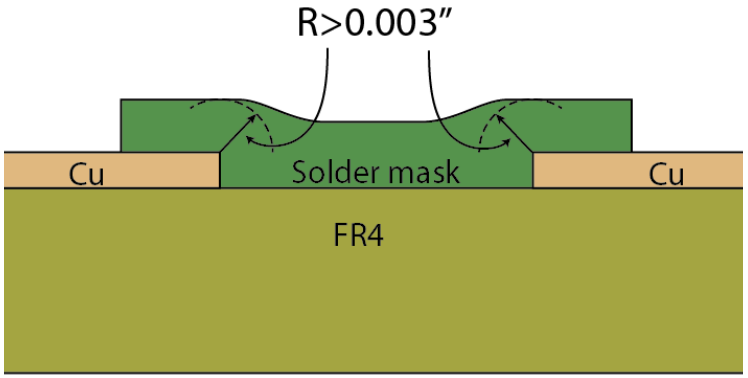
Roll-formed metallic profiles
Field cage Design



Field Cage

PCB design based on 35t

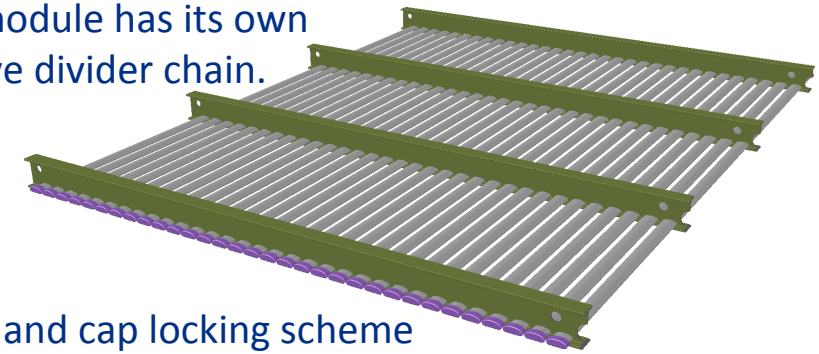




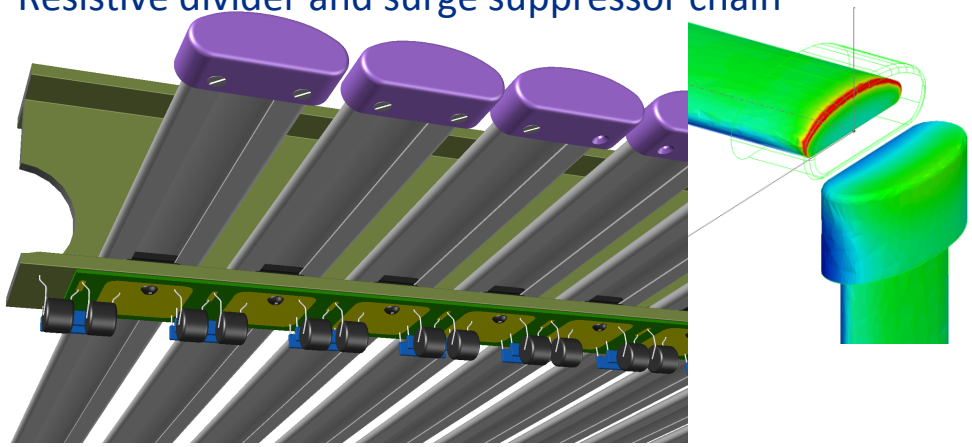
Cost ~250k USD

Roll-formed metallic profiles design

A pre-assembled module:
32 bars @ 6cm pitch to cover 2m drift.
There is no electrical connection between adjacent field cage modules.
Each module has its own resistive divider chain.



Profile and cap locking scheme
Resistive divider and surge suppressor chain



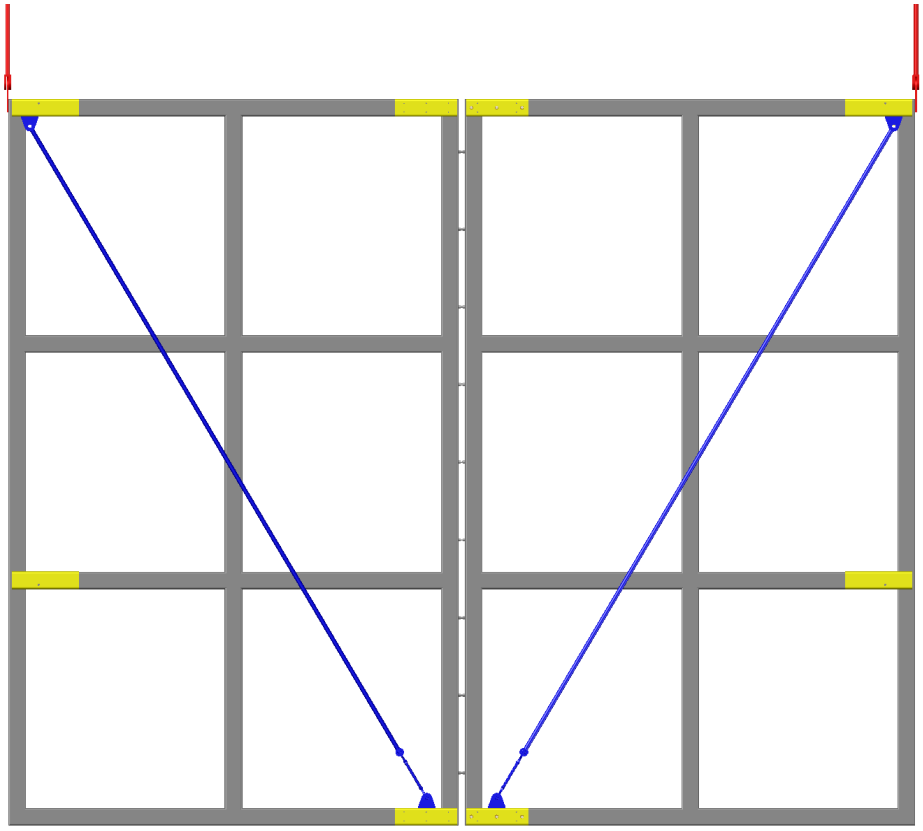
Cost ~67k USD

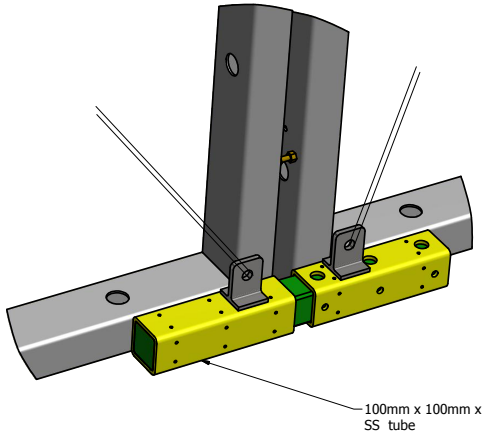
Awaiting performance of 35t and Roll-formed field cage prototype test at CERN

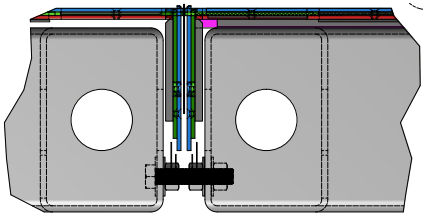
TPC Integration & Installation

Work led by Chicago, BNL and Fermilab

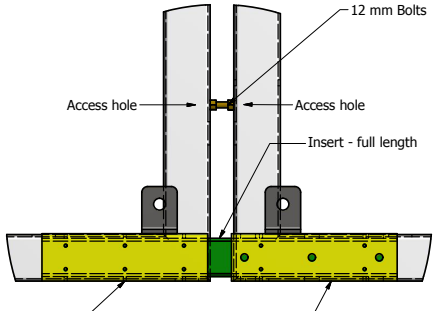
APA sub-assembly scheme







M12 bolt connecting the frames

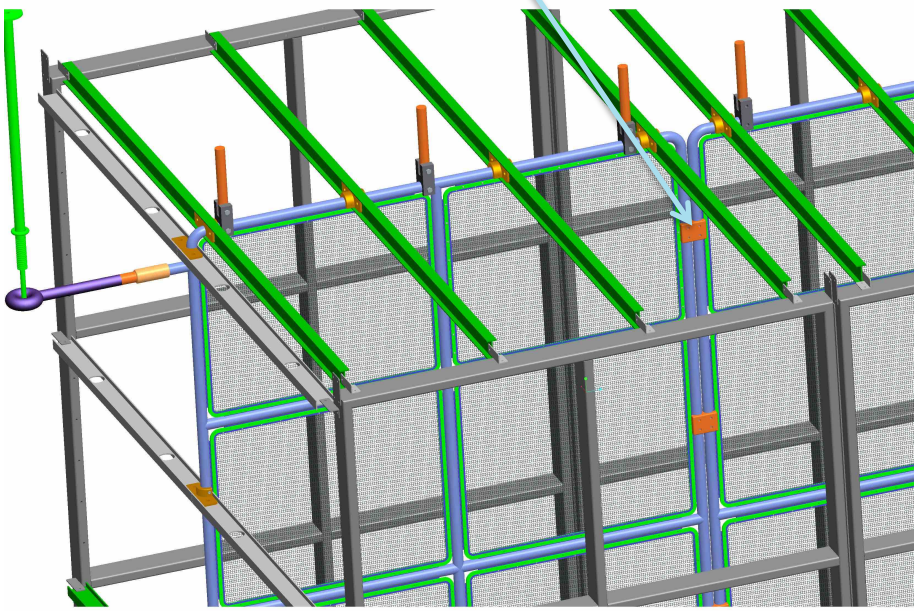


Connected using two custom connection fixtures, allowing uniform gap and ensure alignment of U/V wires across two frames

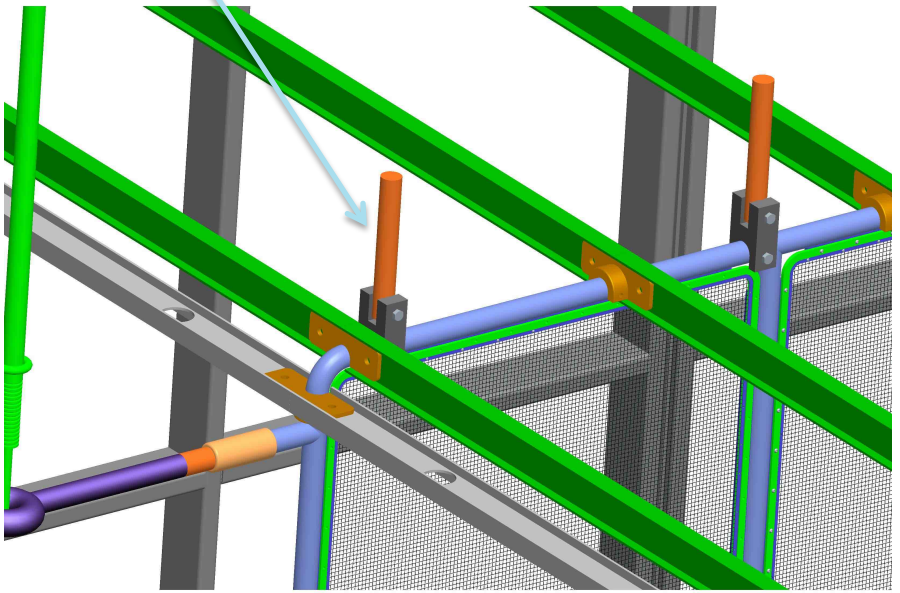
TPC Integration & Installation

CPA Integration

G10 connecting brackets



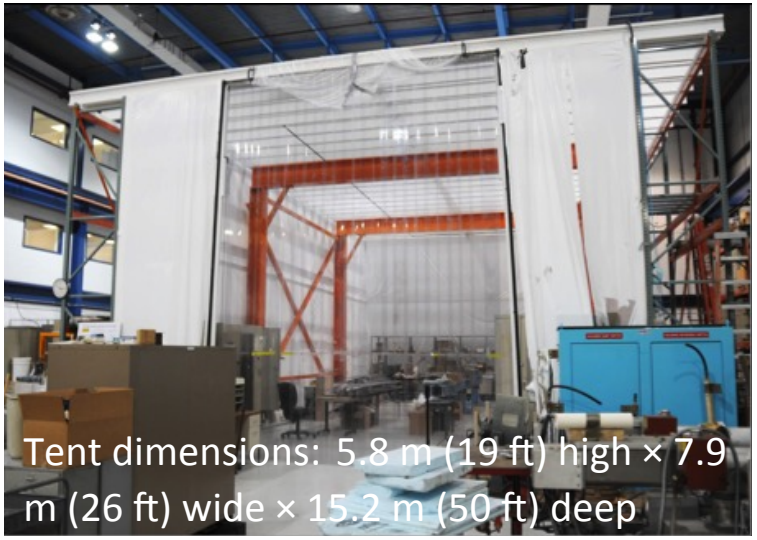
G10 hanging brackets



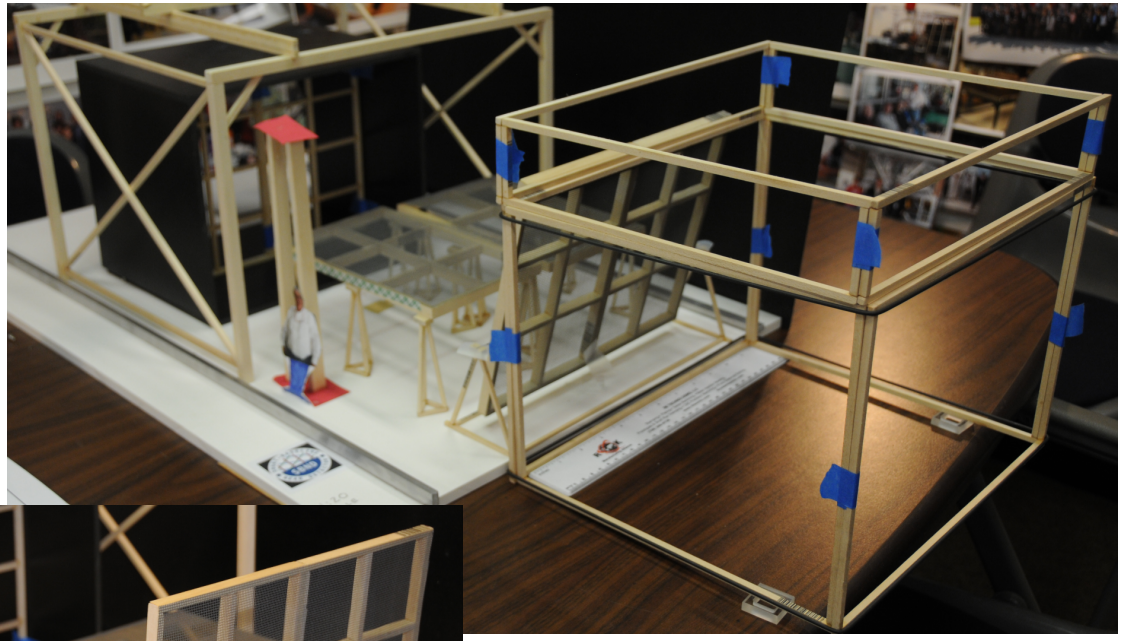
TPC Integration & Installation

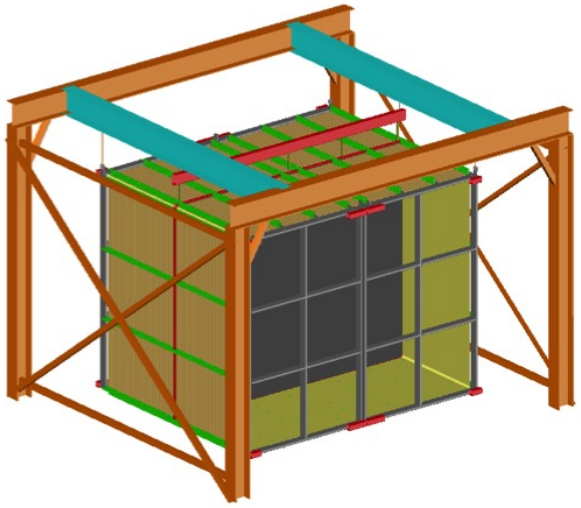
TPC assembly in the DAB tent

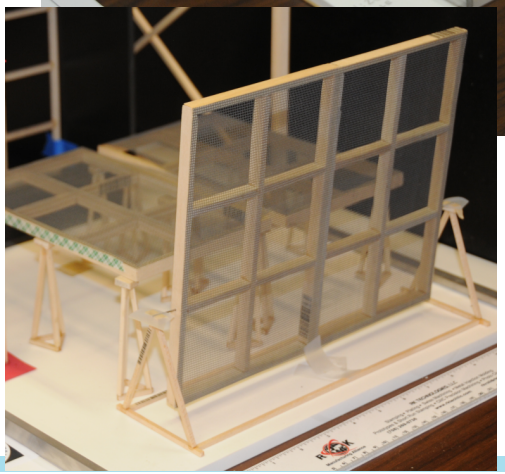
Work led by Chicago, BNL and Fermilab



(See Joe Howell's talk for more details)

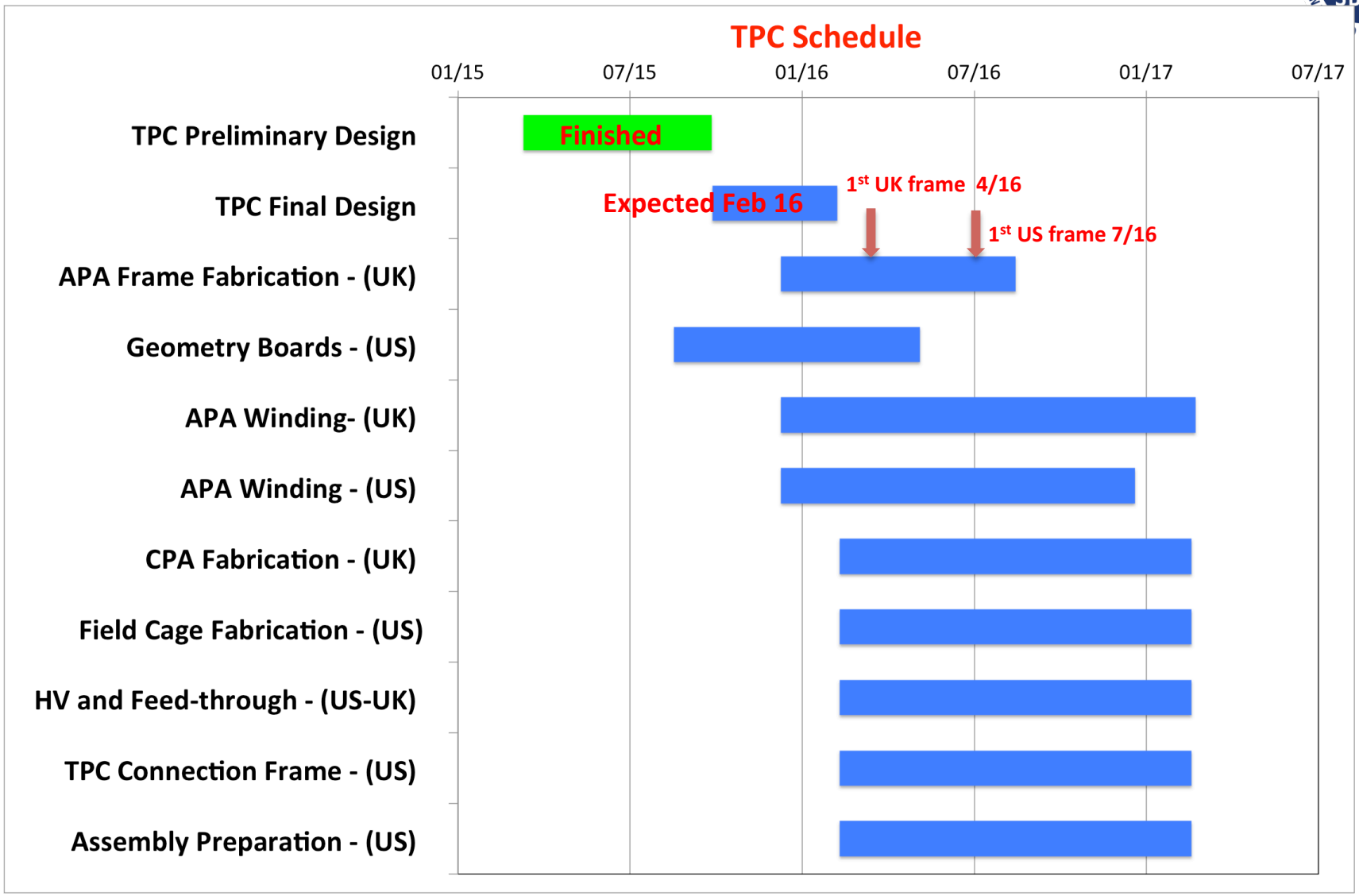






Model of SBND assembly

TPC Schedule



All TPC components to be delivered to Fermilab by March 2017