Short-Baseline Neutrino Detector (SBND)

Portobello-RMF Visit

January 14, 2016

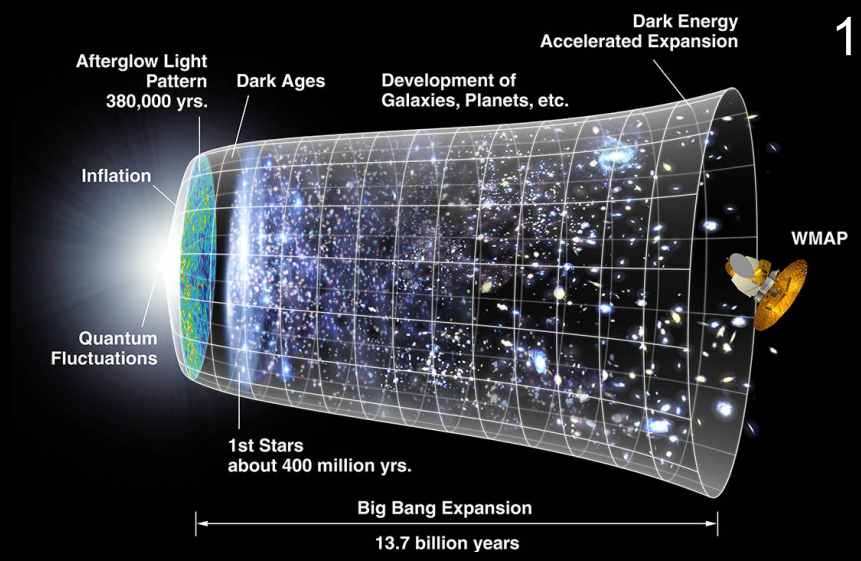
Neutrinos

Our experiments study neutrinos

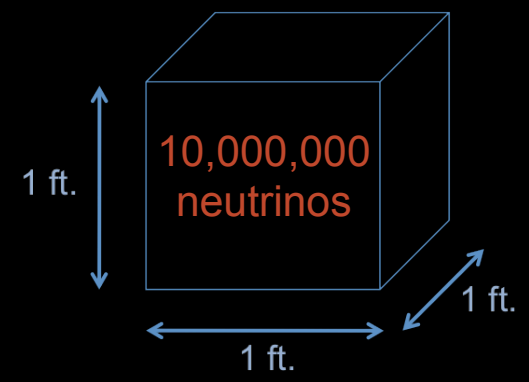
Neutrinos are electrically neutral, nearly massless sub-atomic particles that are EVERYWHERE in the Universe

For every proton, neutron, and electron in the Universe, there are **a BILLION neutrinos**

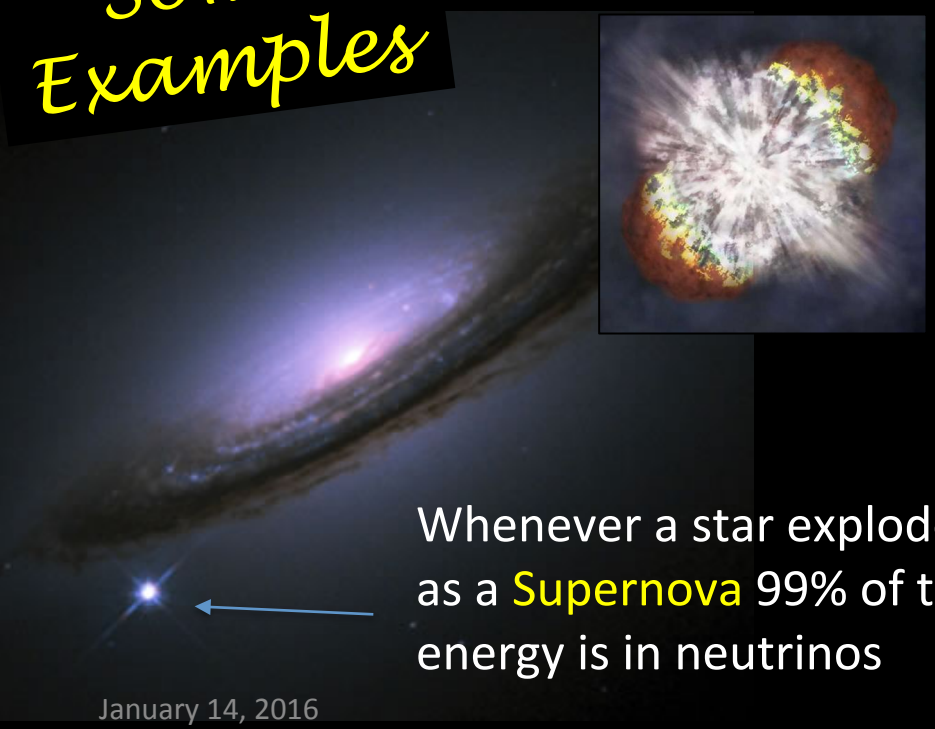
(they're just invisible to the eye, unless you're this guy)



13.7 billion year old neutrinos from the Big Bang are still whizzing around

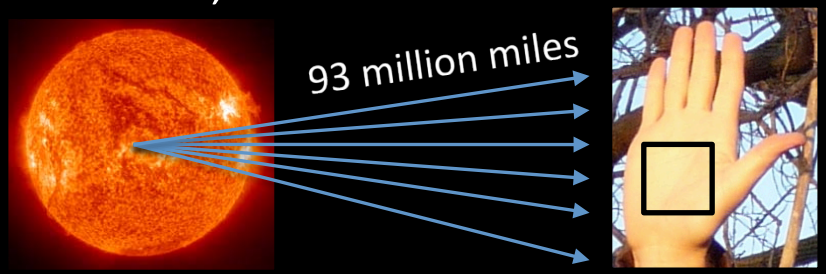


Some Examples



Whenever a star explodes as a Supernova 99% of the energy is in neutrinos

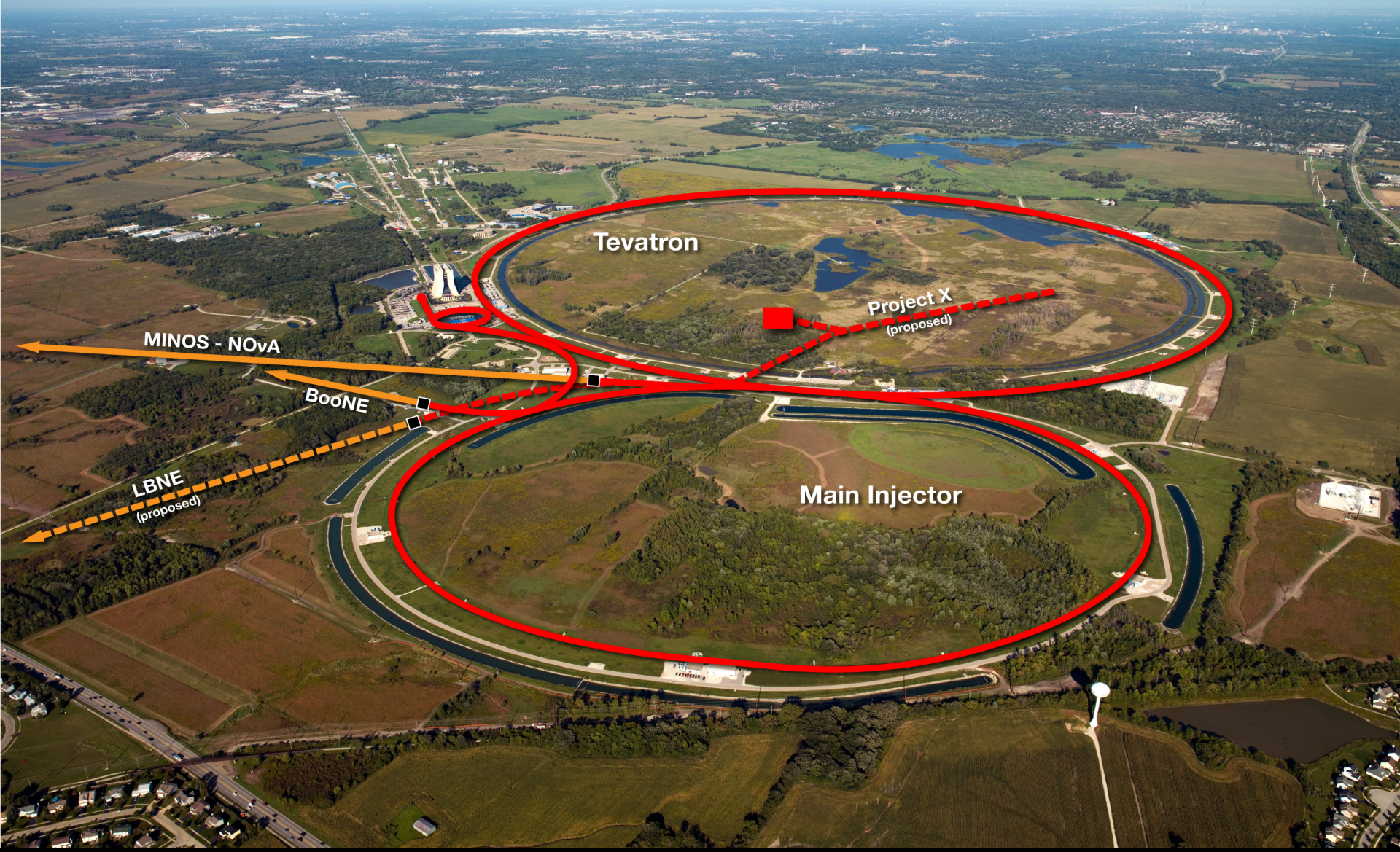
All stars, like our Sun



17,000,000,000,000 from the Sun pass through your hand every 10 seconds !!

A Banana emits about a million neutrinos per day

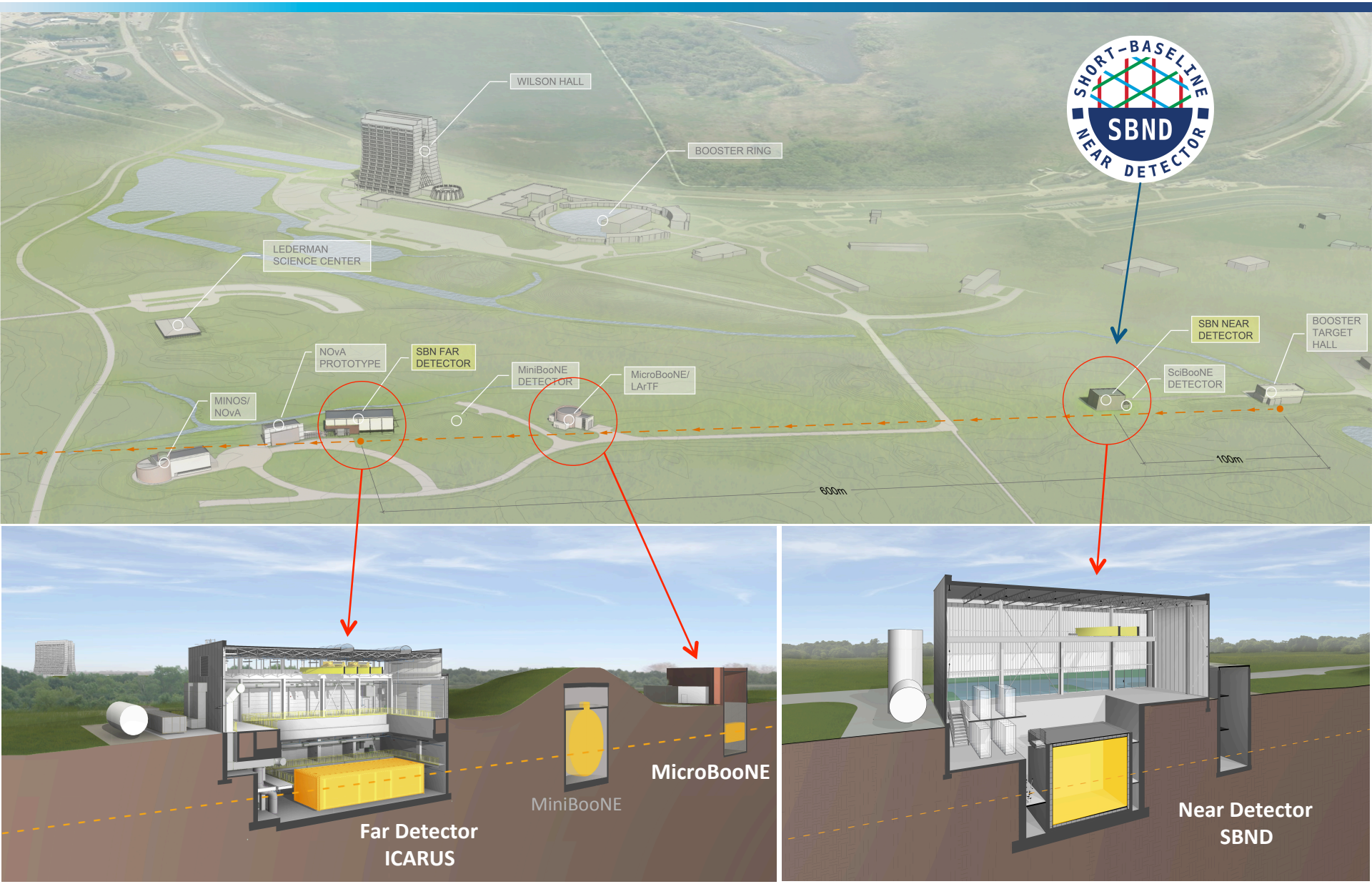
We can even build our own neutrino sources



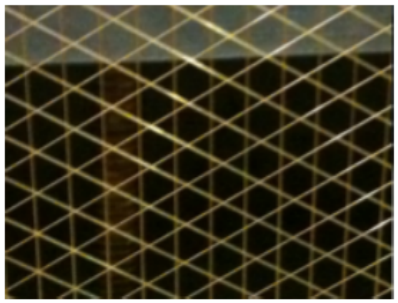
Fermilab Particle Accelerator Laboratory in Illinois, US
where our experiment is being done

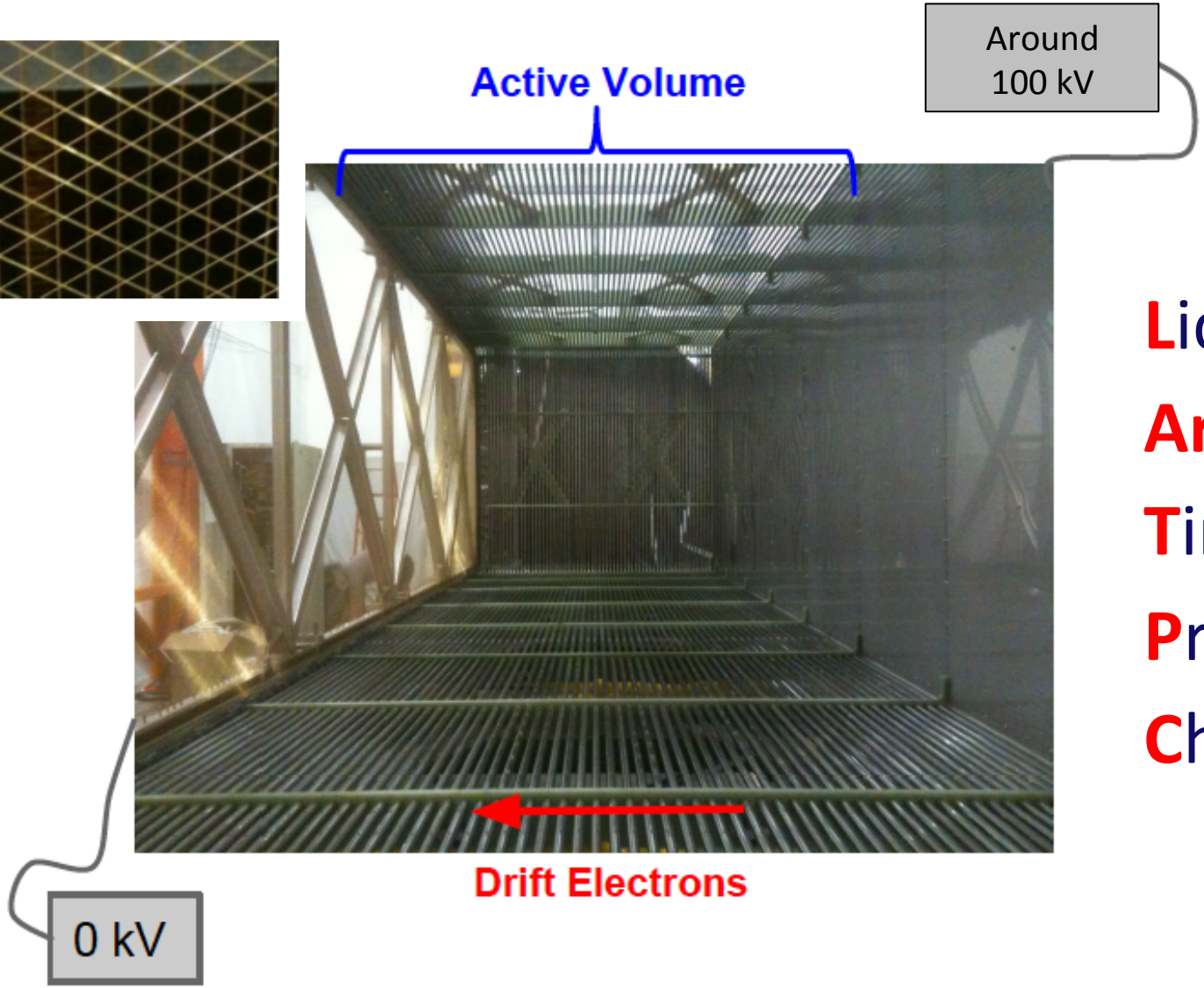
DUSEL Underground Lab
South Dakota
Minnesota
MINOS Neutrino Detector
Nebraska
800 miles
450 miles
Wisconsin
Iowa
Milwaukee
Fermilab
Chicago
Missouri
Image © 2008 TerraMetrics
© 2008 Europa Technologies
Image NASA
© 2008 Tele Atlas
Google
43°14'04.36" N 92°07'15.58" W
Eye alt 678.31 km

The Short-Baseline Detectors at Fermilab



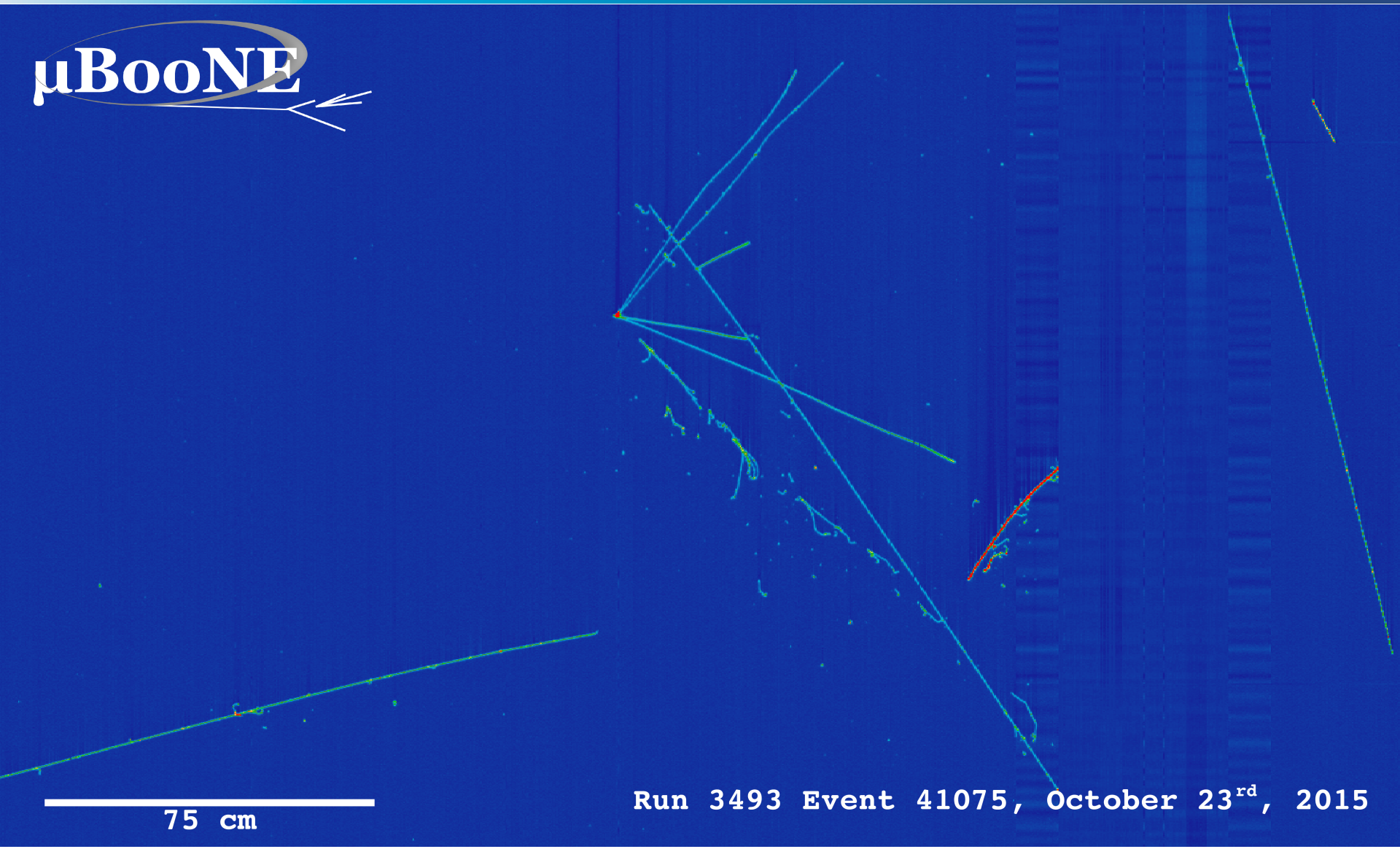
Need Specialized Neutrino Detectors



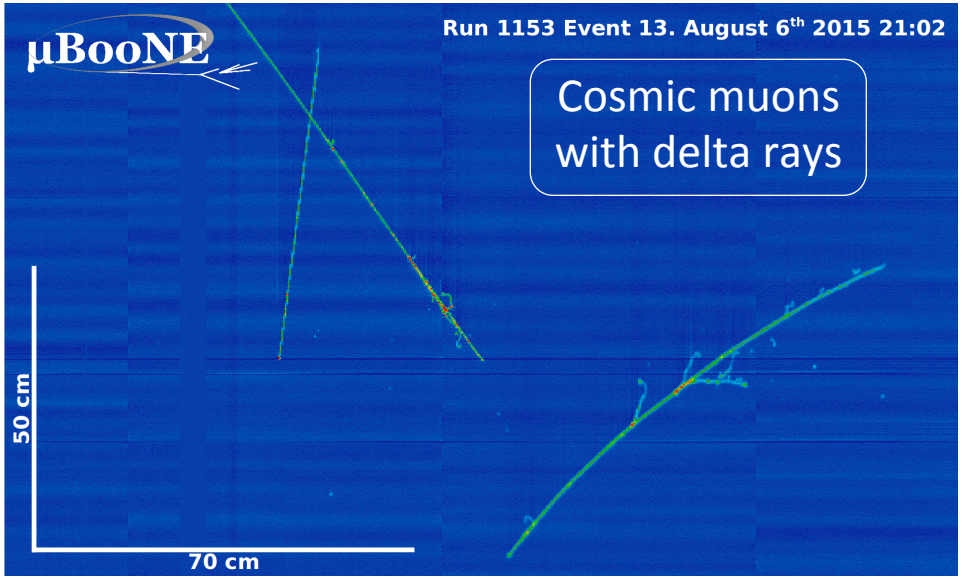


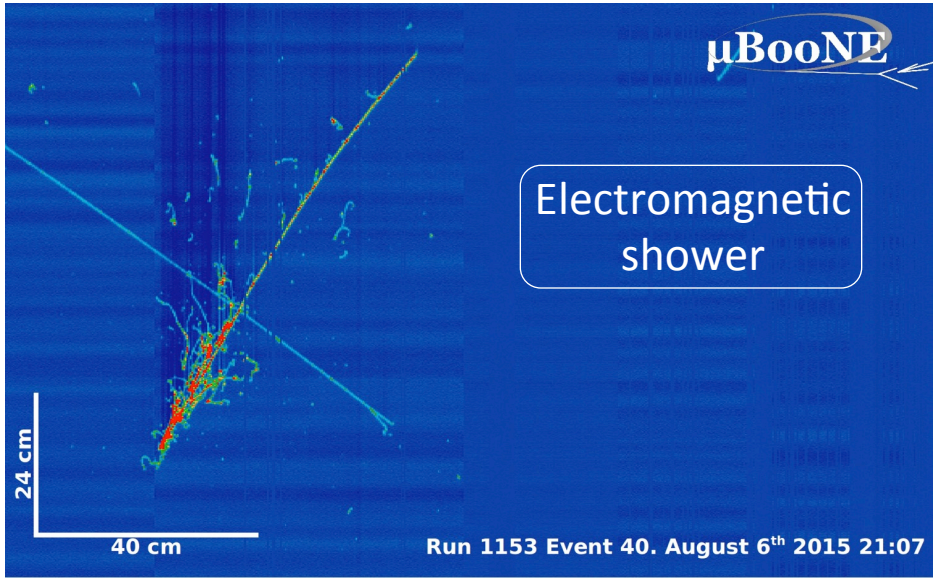
Liquid
Argon
Time
Projection
Chamber

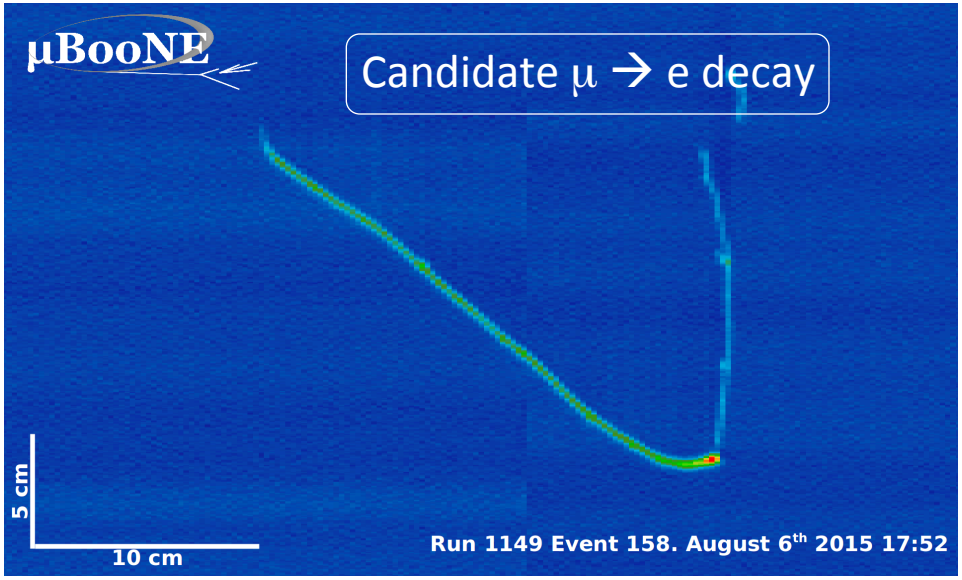
Image of a Neutrino Interaction

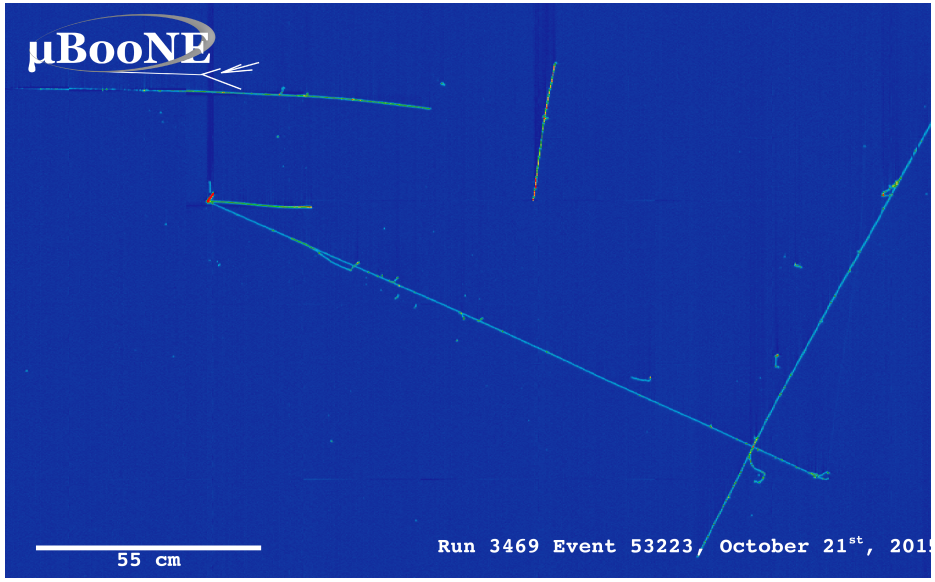


More Images from a LAr TPC

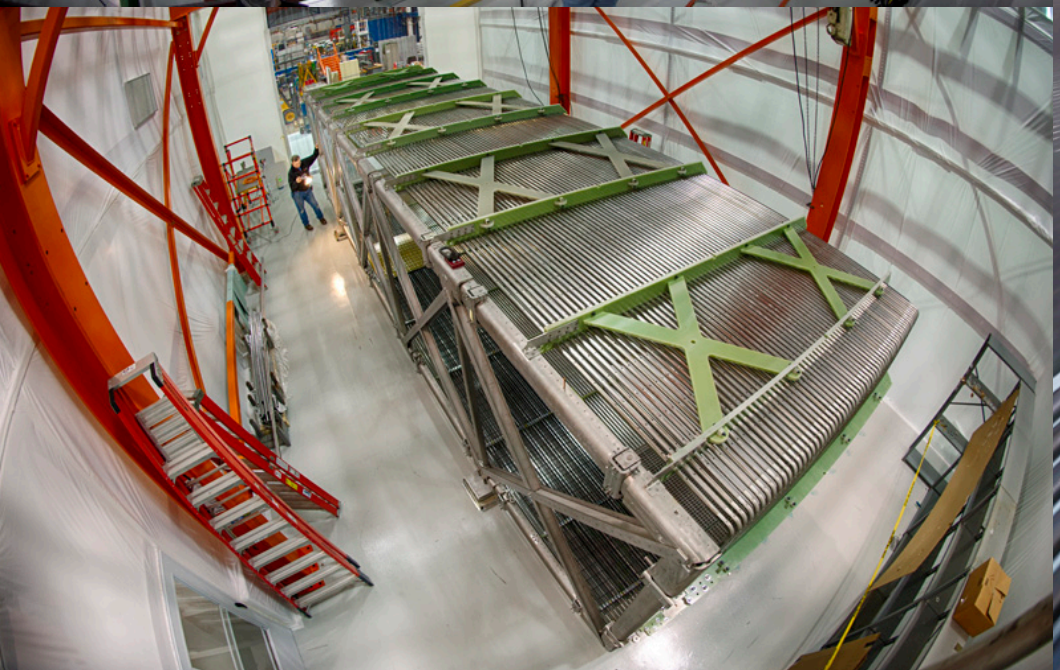




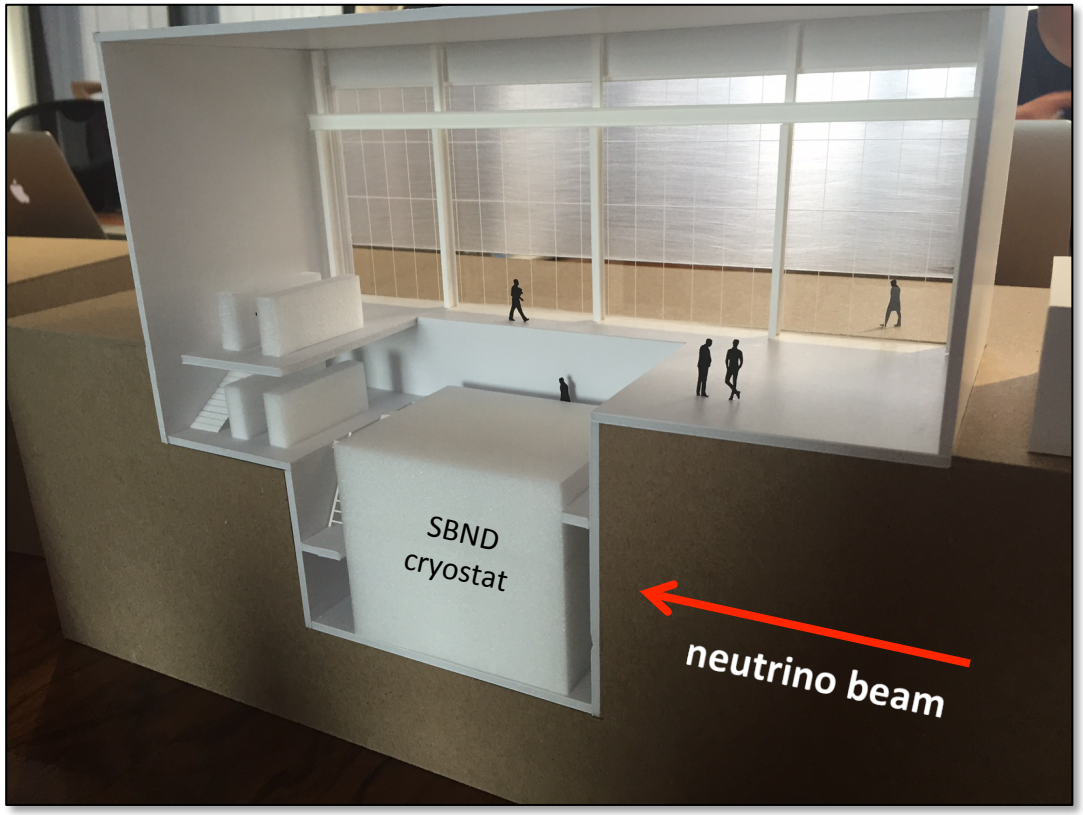


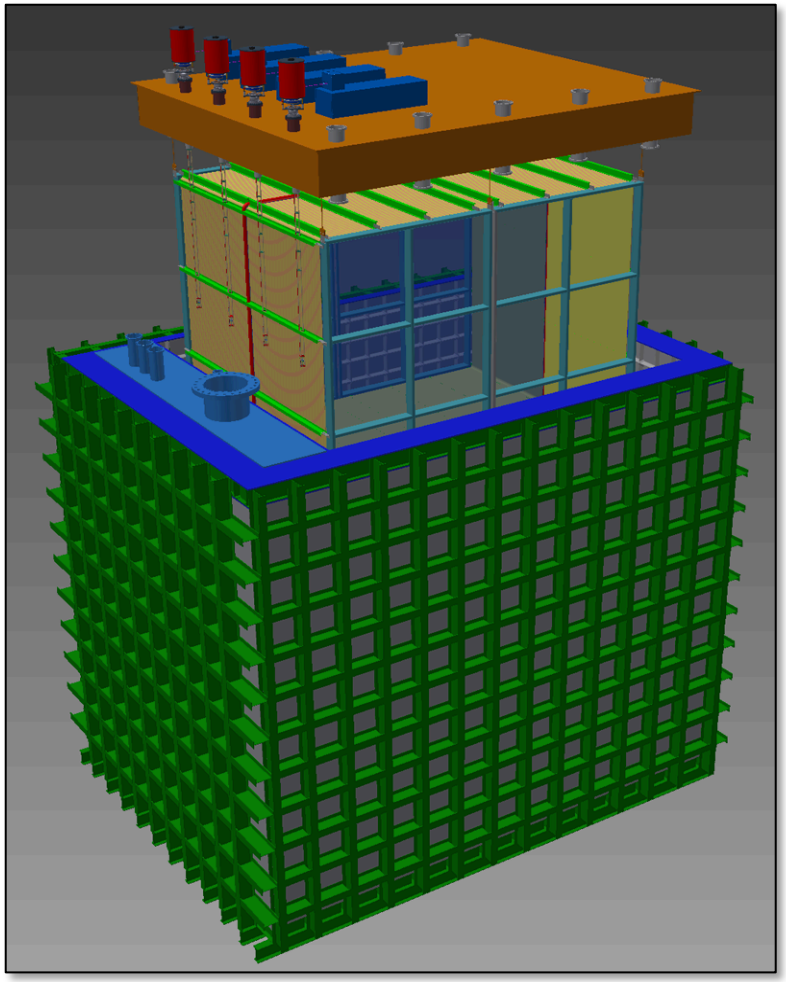


The First Detector in the Program (2015)



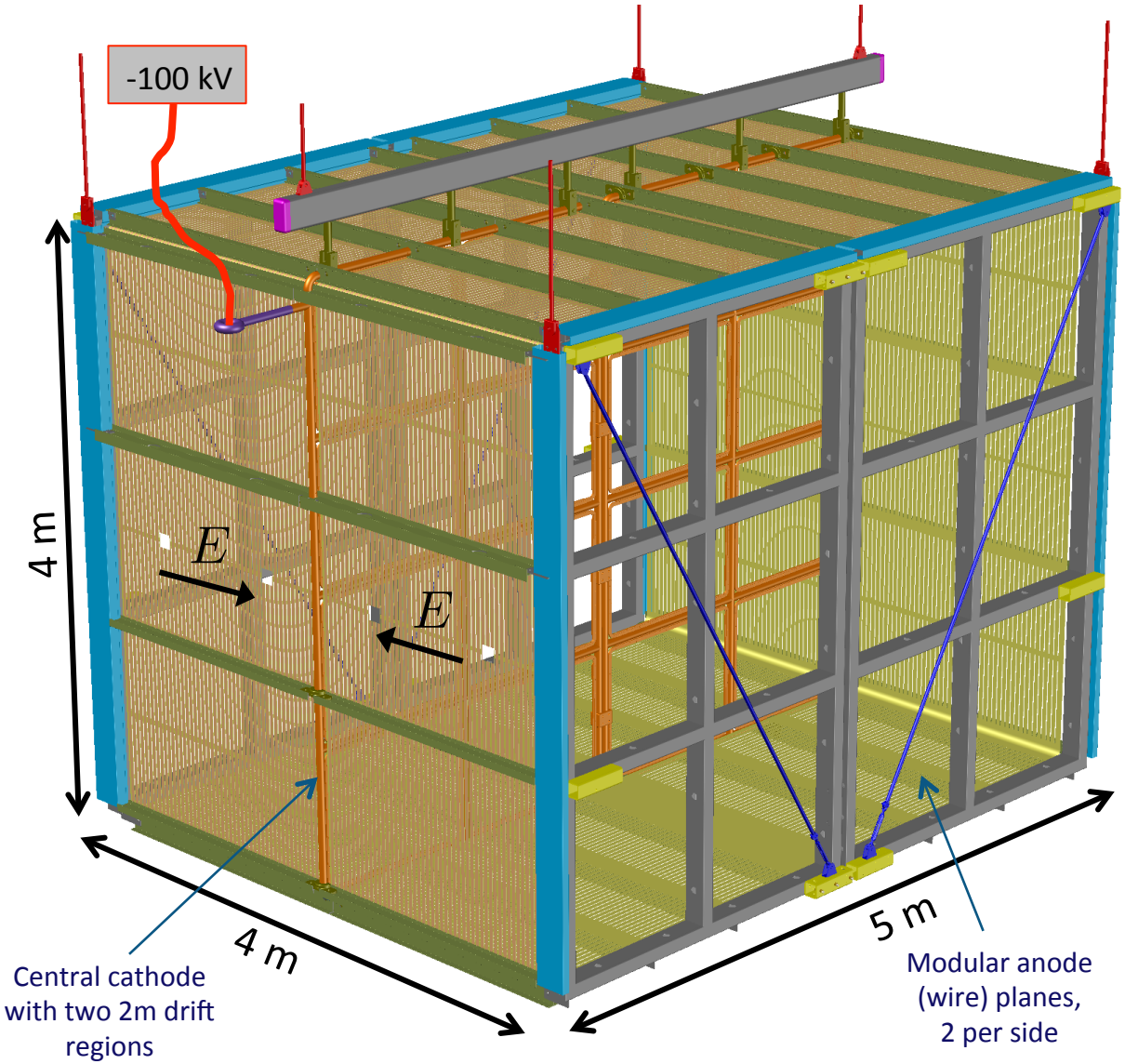
The Short-Baseline Near Detector





SBND TPC is 4m (W) x 4m (H) x 5m (L)
and will contain 112 tons of liquid Argon

The SBND TPC



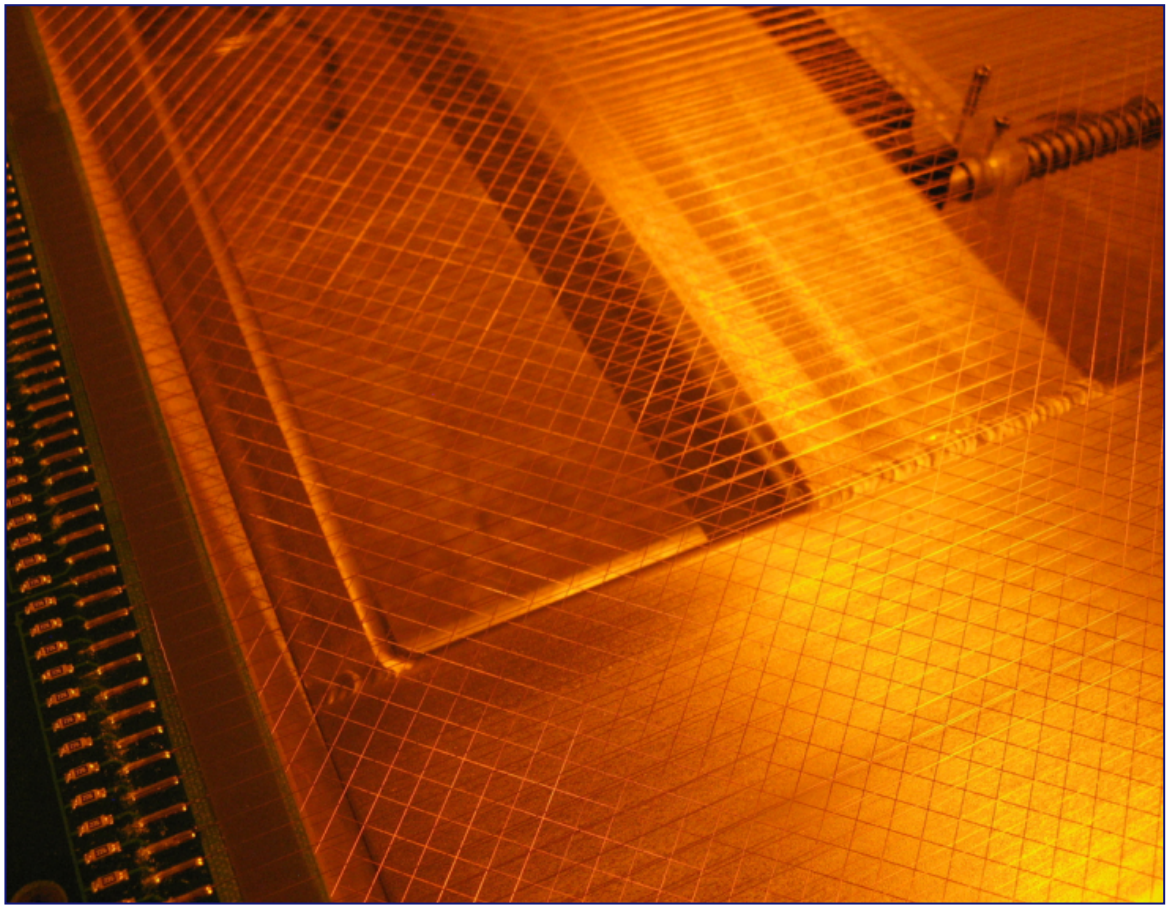
*SBND TPC design and construction is a joint **US-NSF** and **UK-STFC** project*

TPC Component	Institutions
Anode frames	Chicago, Sheffield
Anode wiring	Manchester, Syracuse
Cathode plane	Liverpool
Field cage	BNL, Yale
High voltage feed-through	UCL, Yale
APA testing	Lancaster
Integration, assembly, and installation	Chicago, BNL, Fermilab

*The APA Steel Frames are the **first step** in the TPC construction process*

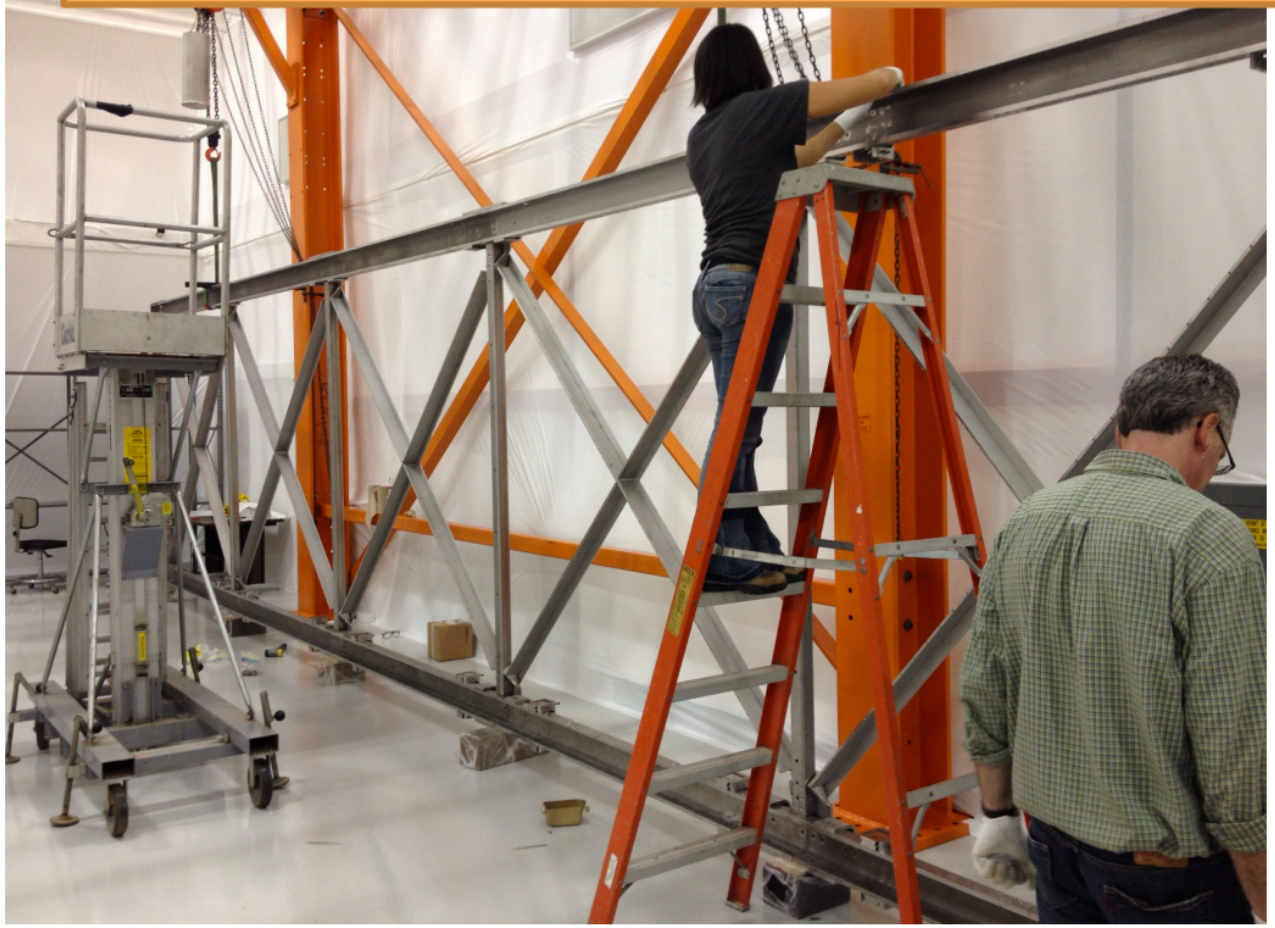
The Wires

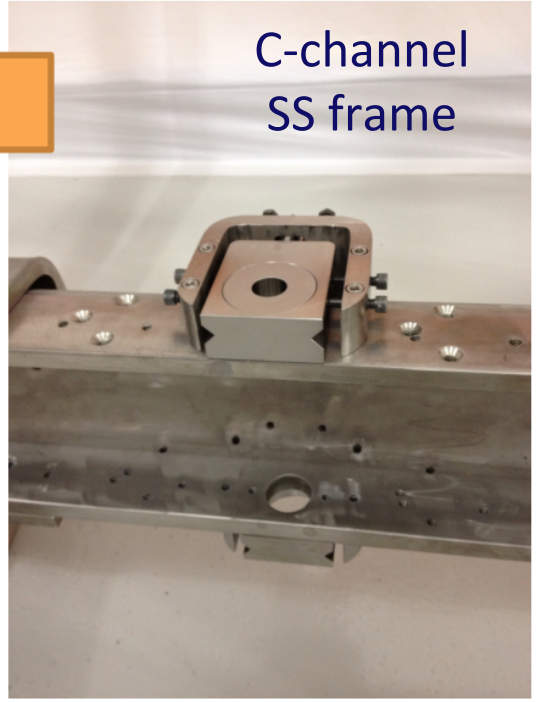
- 150 μm diameter CuBe wire
- 0.5 kg nominal tension per wire
- About 3000 wires per frame
- Each frames will support 3 layers of wires (vertical, +60 deg, -60 deg)
- Wire spacing is 3 mm
- Wire planes are separated by 3 mm
- Wire spacing and separation must be <u>very uniform</u> across the surface of the APA frame
- Wires can NEVER touch



How to Achieve Uniform, Stable Wire Planes

Attaching adusting assemblies for wire tensioning

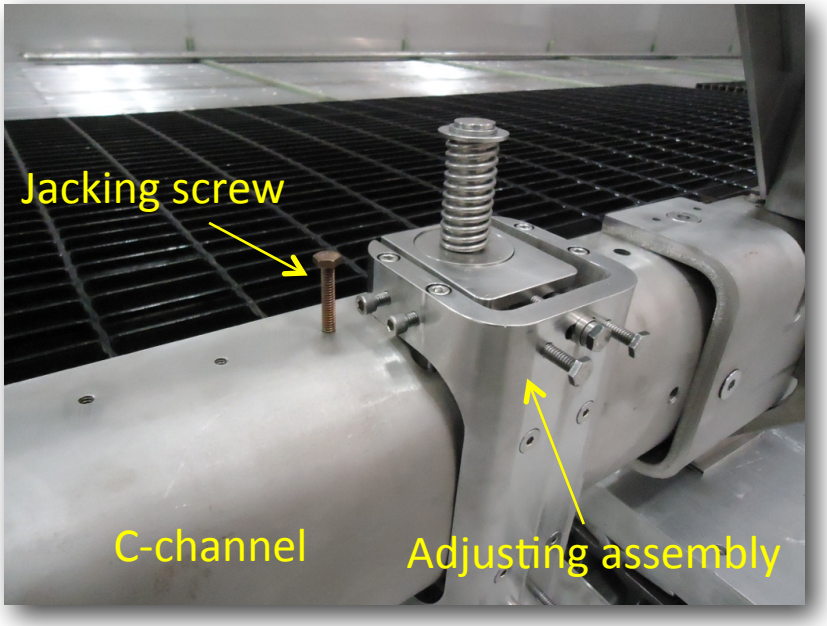


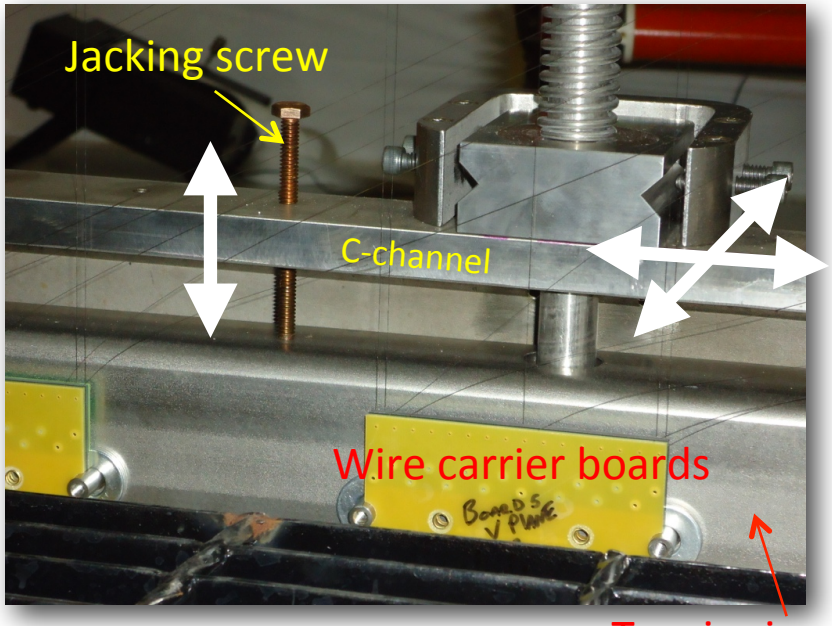


This is the **last detector** we built

How to Achieve Uniform, Stable Wire Planes

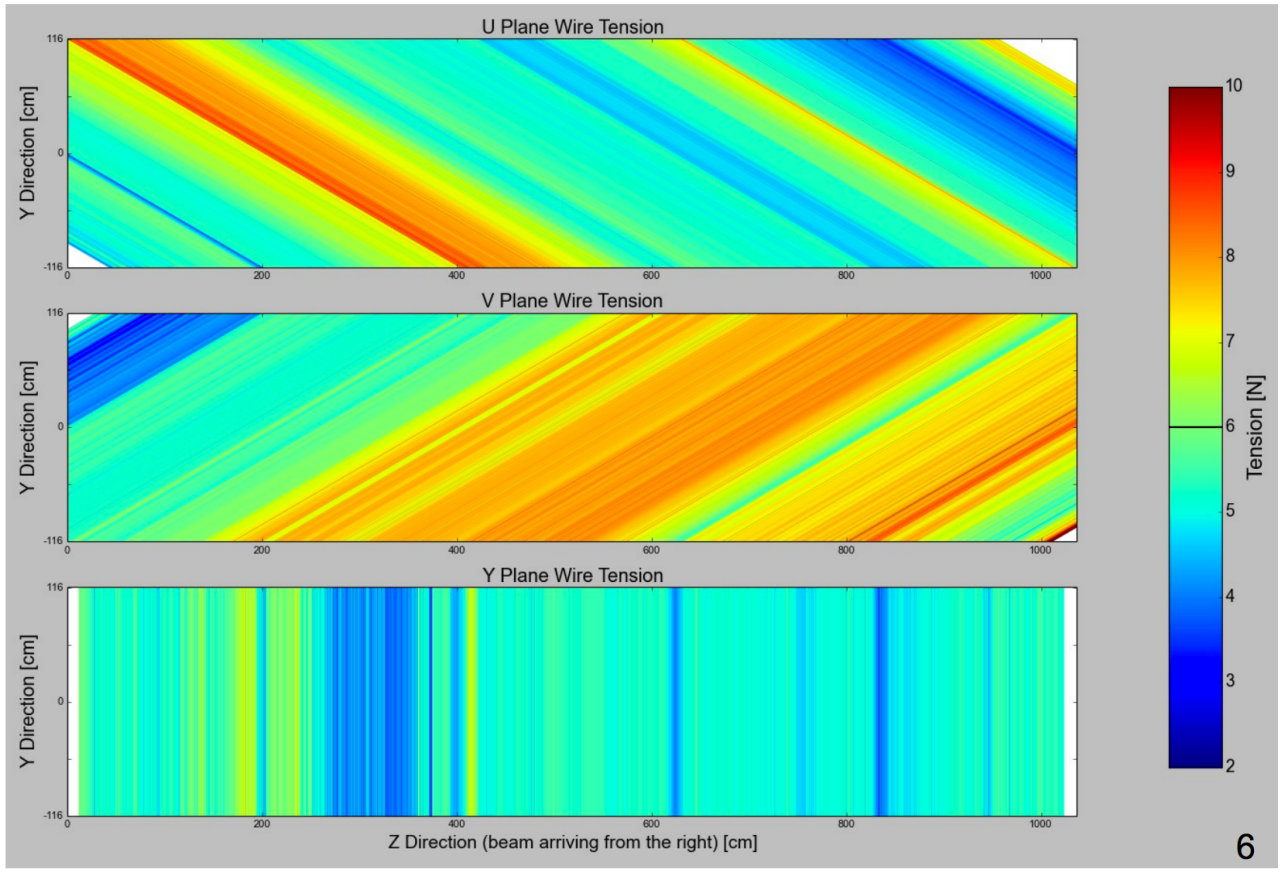
- Wire carrier boards are attached to tensioning bar, wires loose
- Adjusting assemblies allow for minor adjustment of tensioning bar location
- Jacking screws push down on tensioning bars to provide wire tension
- Go around the frame adjusting jacking screws, trying to create uniform tension and wire plane spacing across a 10.5m x 2.5m area.





How to Achieve Uniform, Stable Wire Planes

- Fermilab Metrology team spent 4 days helping to adjust tensioning bars to locations consistent with a flat plane
  - *Not so easy. Mechanical interferences limit allowed range of adjustments.*



Tension Map

Factor three variation in tension.

Can cause noise issues in electronic signals from the detector.

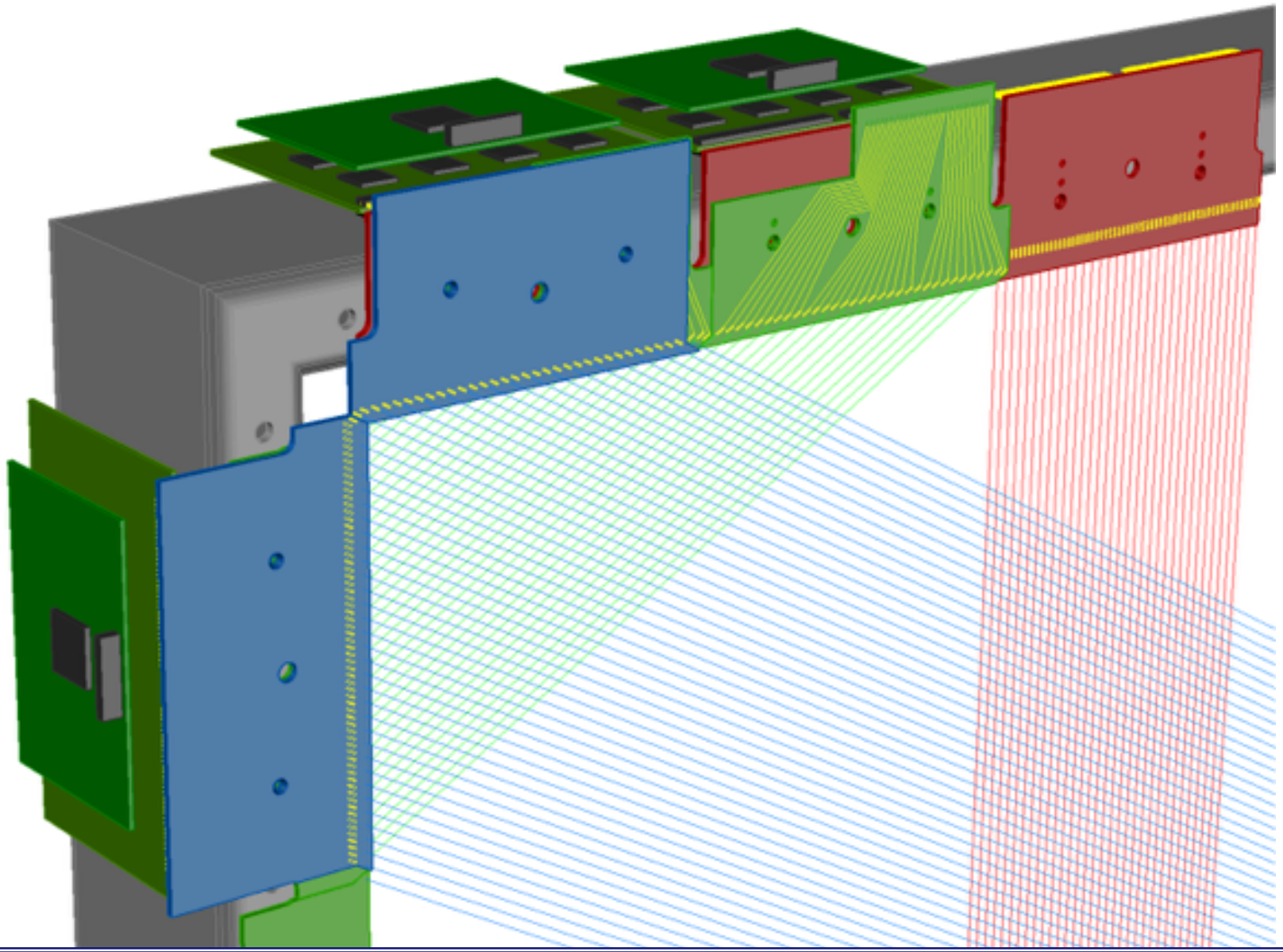
The SBND Approach

- Instead of adjusting the wire positions and tensions once they are on the frame, build a uniform surface to attach the wires to and a very rigid frame that will not deform under the tension. Attach each wire, one at a time, at its nominal tension.

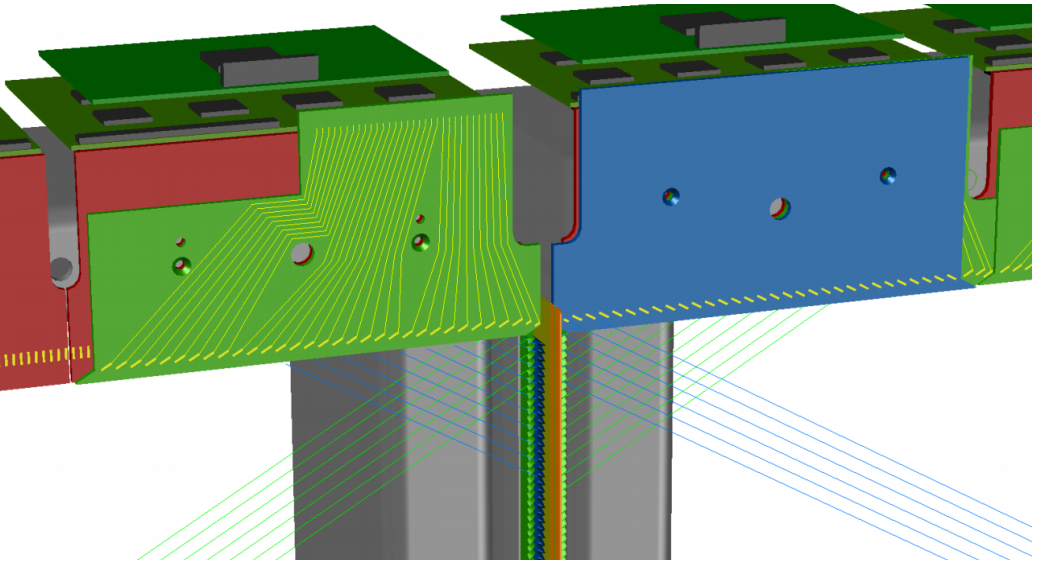
- In our design, the opportunity to ensure this uniform surface is in the addition of intermediate wire carrier board mounting plates or “leveling plates”

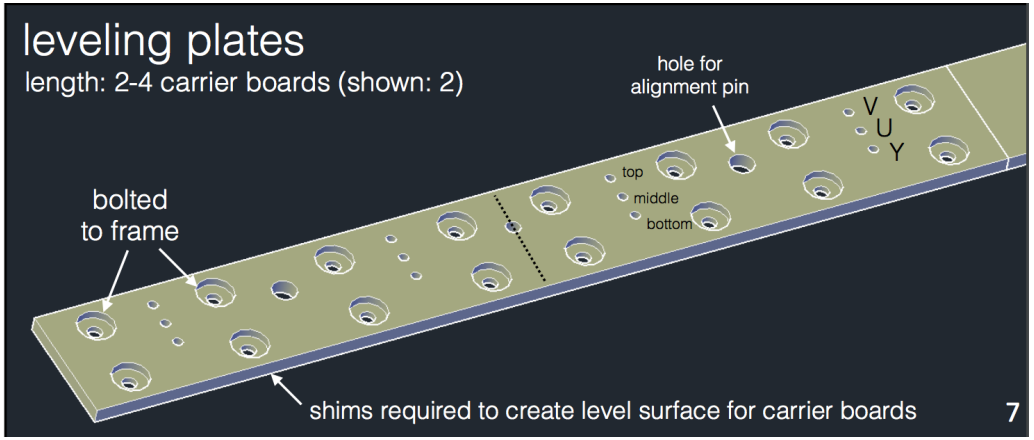
- There is no adjustment mechanism later, once the wires are attached.

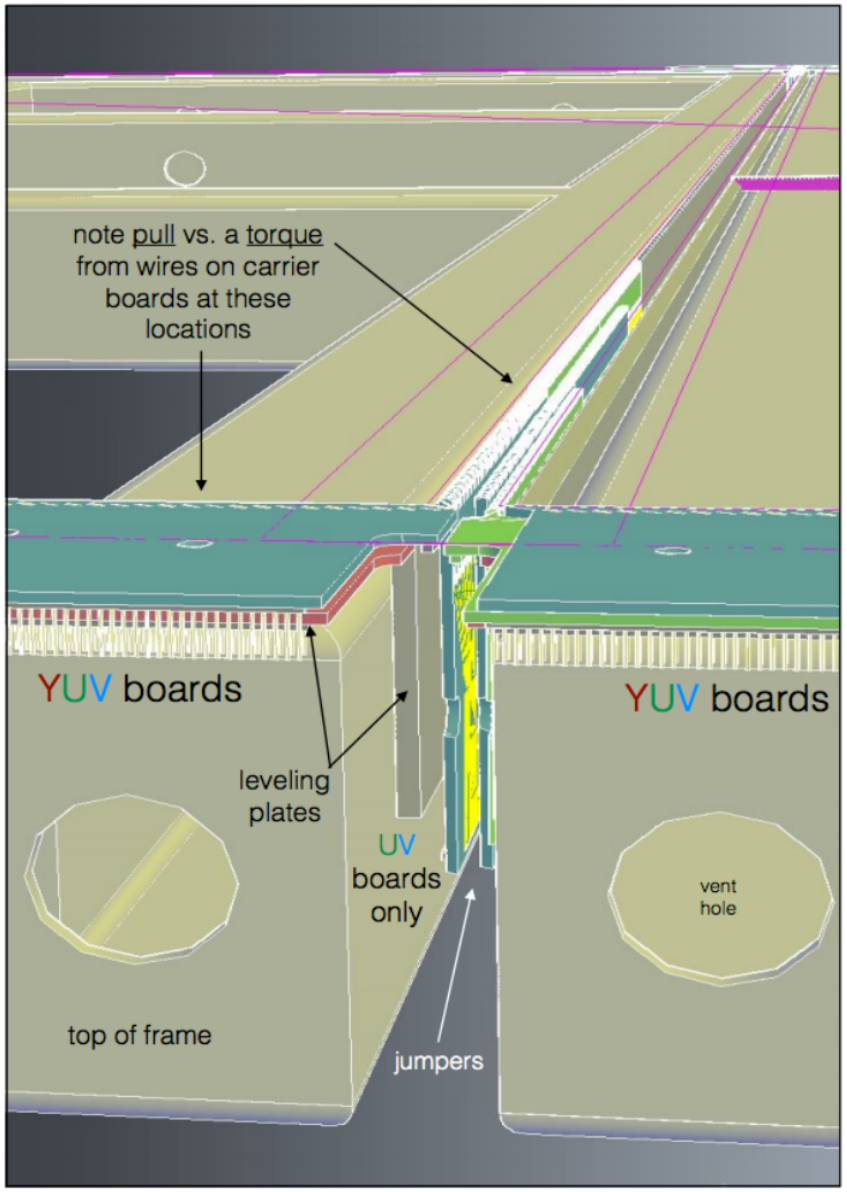
The Wire Mounting “Stack”



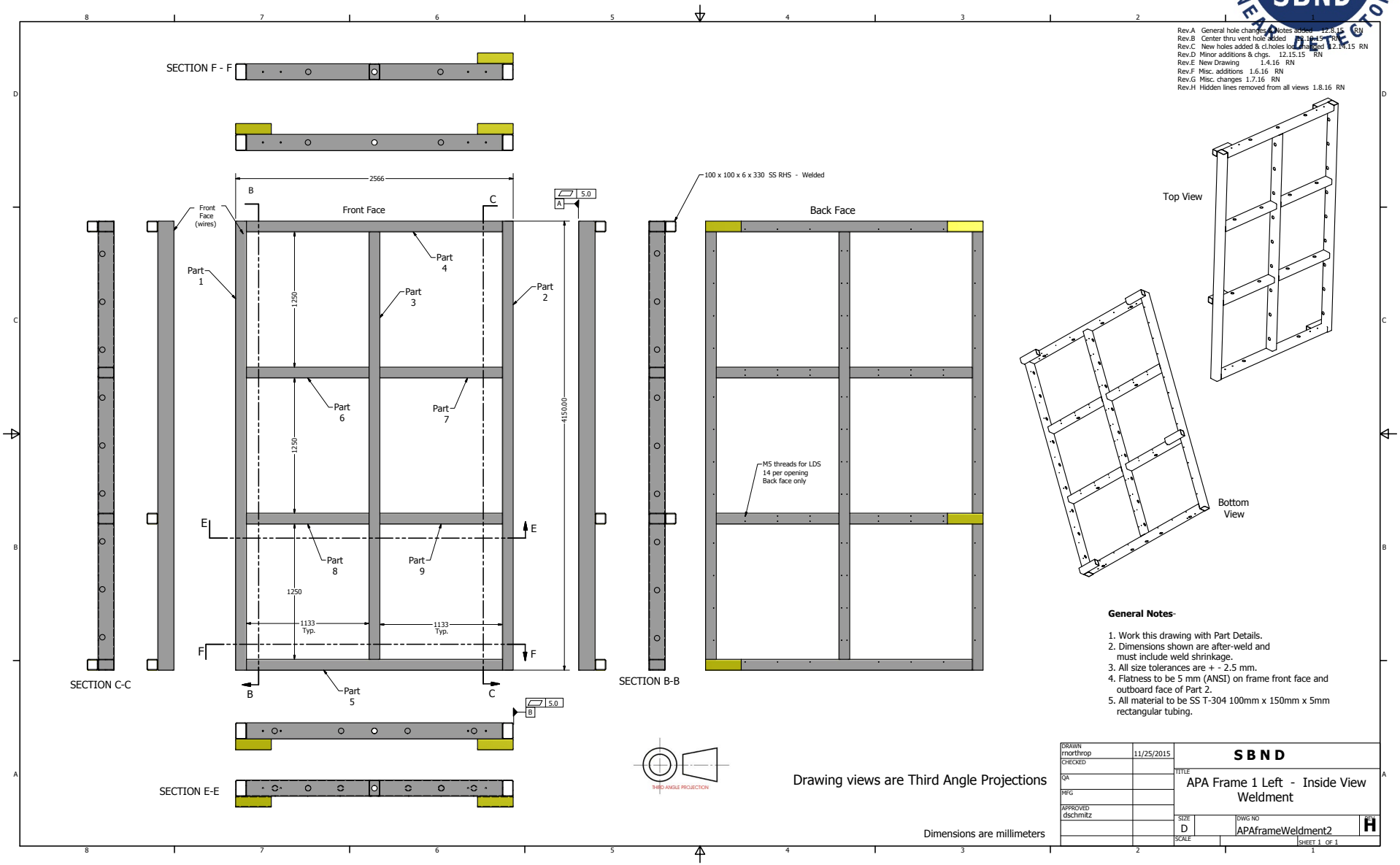
The Wire Mounting "Stack"







The “Bare” Frame and “pre-weld” Holes

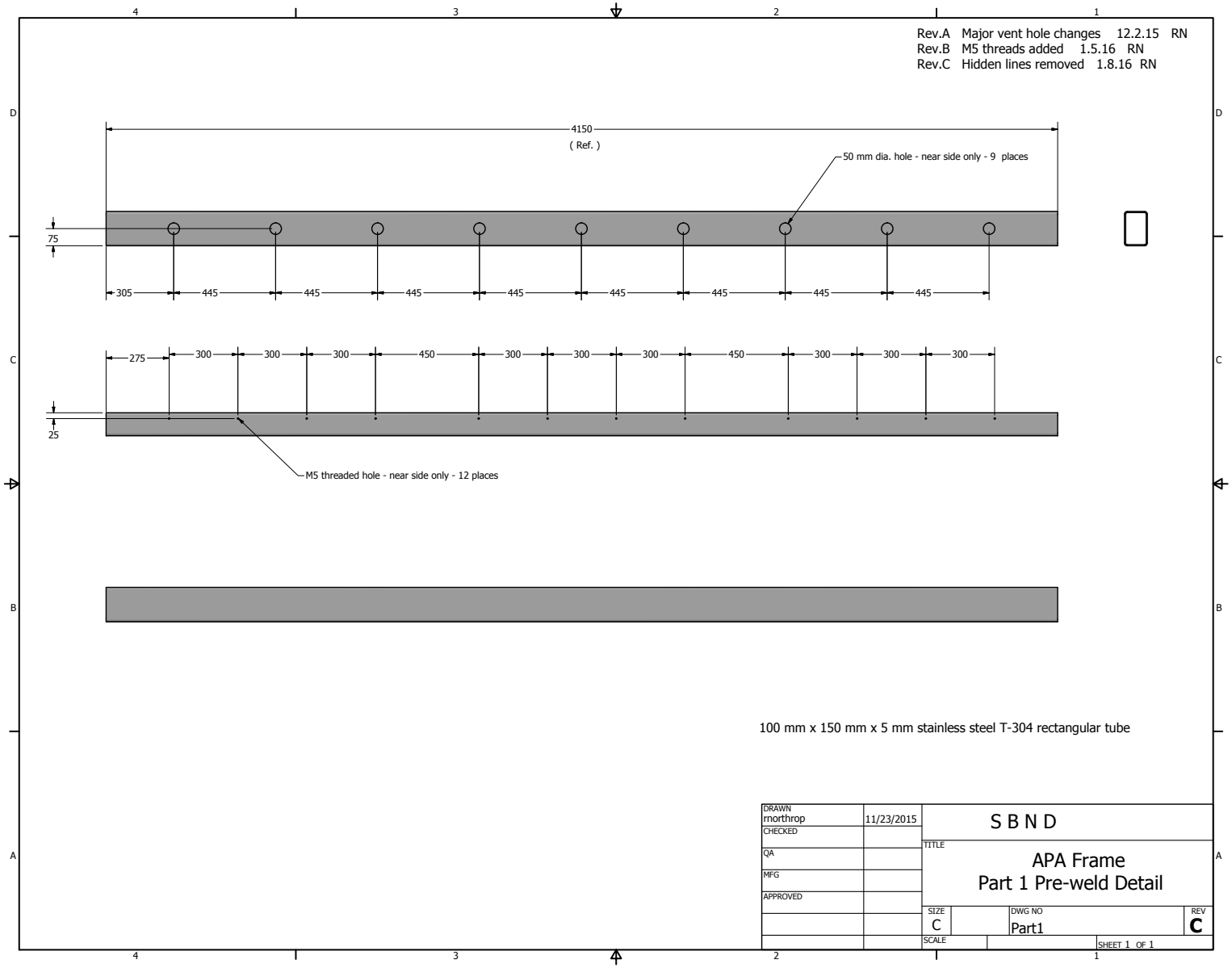


The “Bare” Frame and “pre-weld” Holes

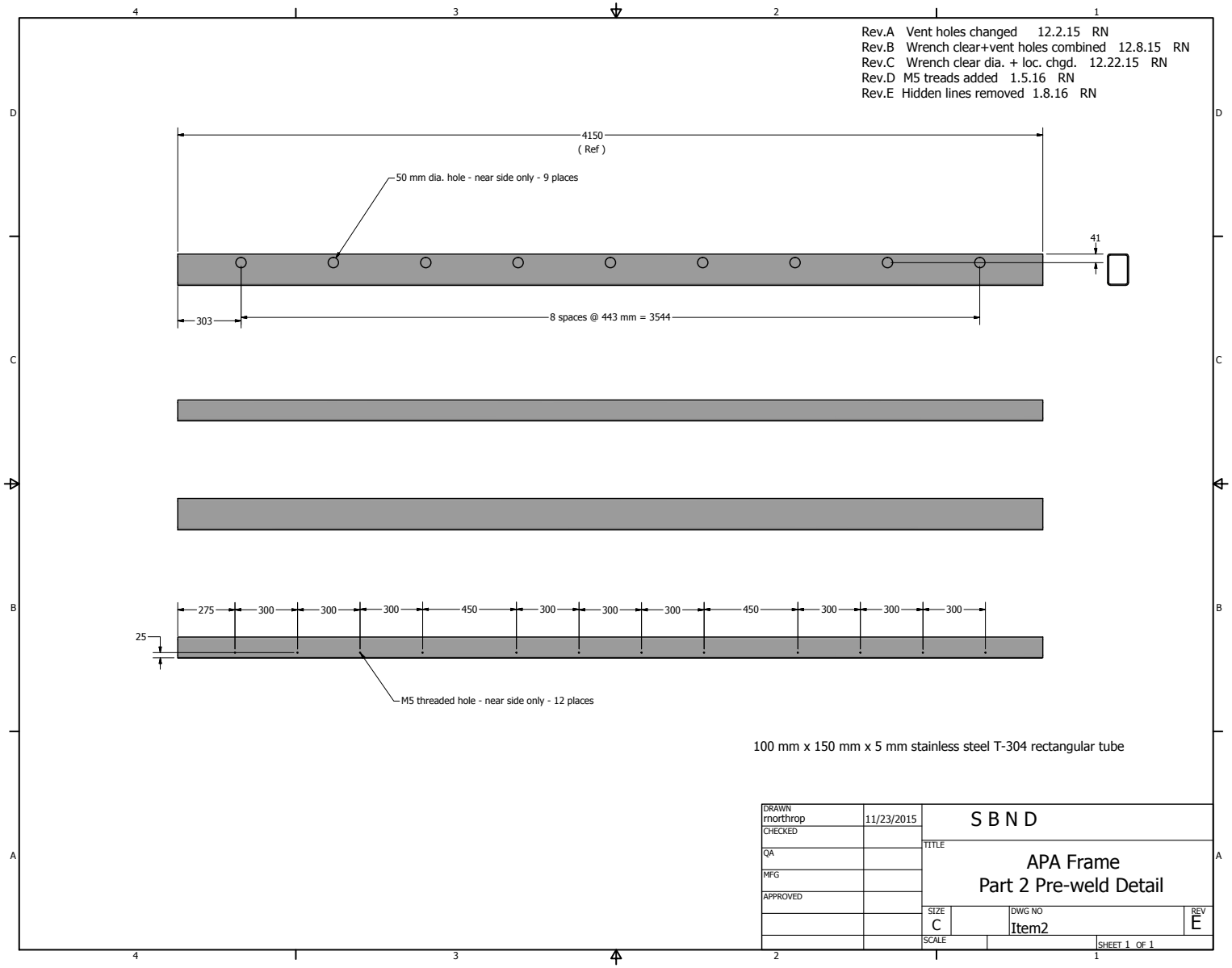
Table 1: Description of bare frame pre-weld holes. See Figure 3.

Part No. (Fig. 3)	Hole Purpose	Hole Description	Count	Face Description
1	venting	50 mm, plain	9	inboard face
1	photon detector mounting	M5, tapped	12	back-face
2	venting + bolt access	50 mm, plain	9	inboard face
2	photon detector mounting	M5, tapped	12	back-face
3	venting	50 mm, plain	9	through both faces
3	photon detector mounting	M5, tapped	24	back-face
4	venting	50 mm, plain	7	inboard(4)/outboard(2)/through(1)
4	lifting attachments	13 mm, clearance	4	through both faces
4	photon detector mounting	M5, tapped	6	back-face
5	venting	50 mm, plain	7	inboard(2)/outboard(4)/through(1)
5	lifting attachments	13 mm, clearance	4	through both faces
5	photon detector mounting	M5, tapped	6	back-face
6	venting	50 mm, plain	3	inboard face
6	photon detector mounting	M5, tapped	6	back-face
7	venting	50 mm, plain	3	inboard face
7	photon detector mounting	M5, tapped	6	back-face
8	venting	50 mm, plain	3	inboard face
8	photon detector mounting	M5, tapped	6	back-face
9	venting	50 mm, plain	3	inboard face
9	photon detector mounting	M5, tapped	6	back-face
TOTAL			145	

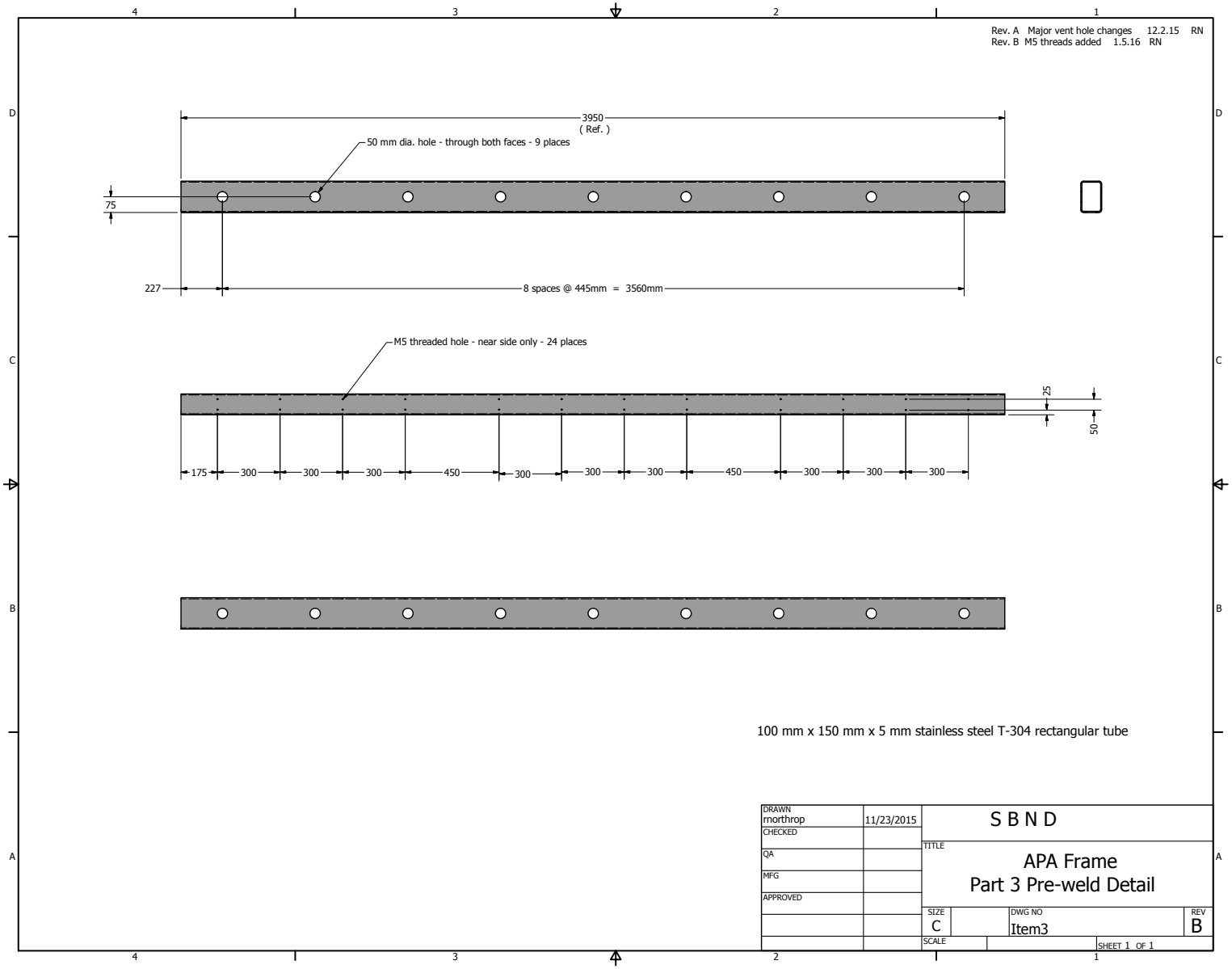
Bare Frame Part 1



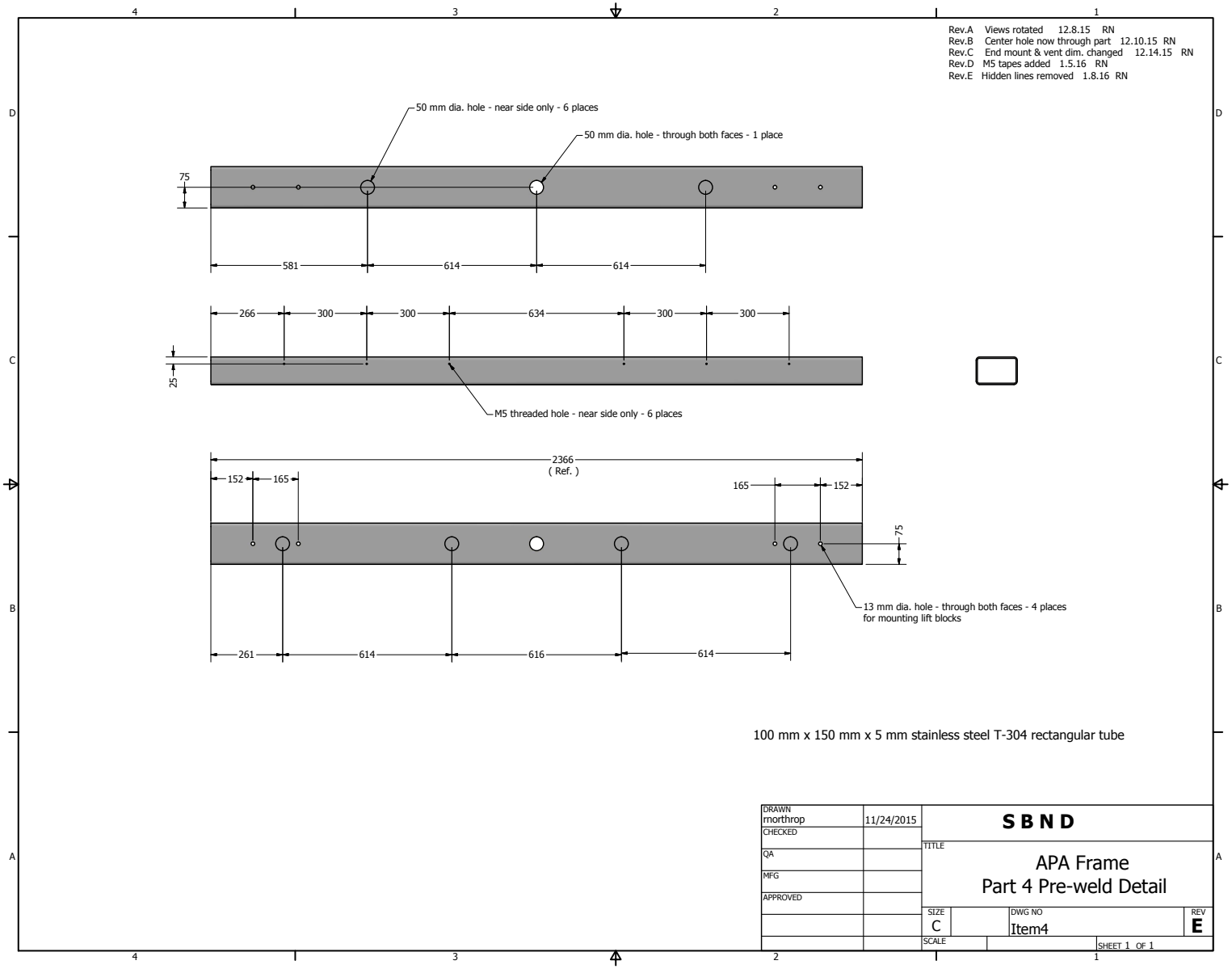
Bare Frame Part 2



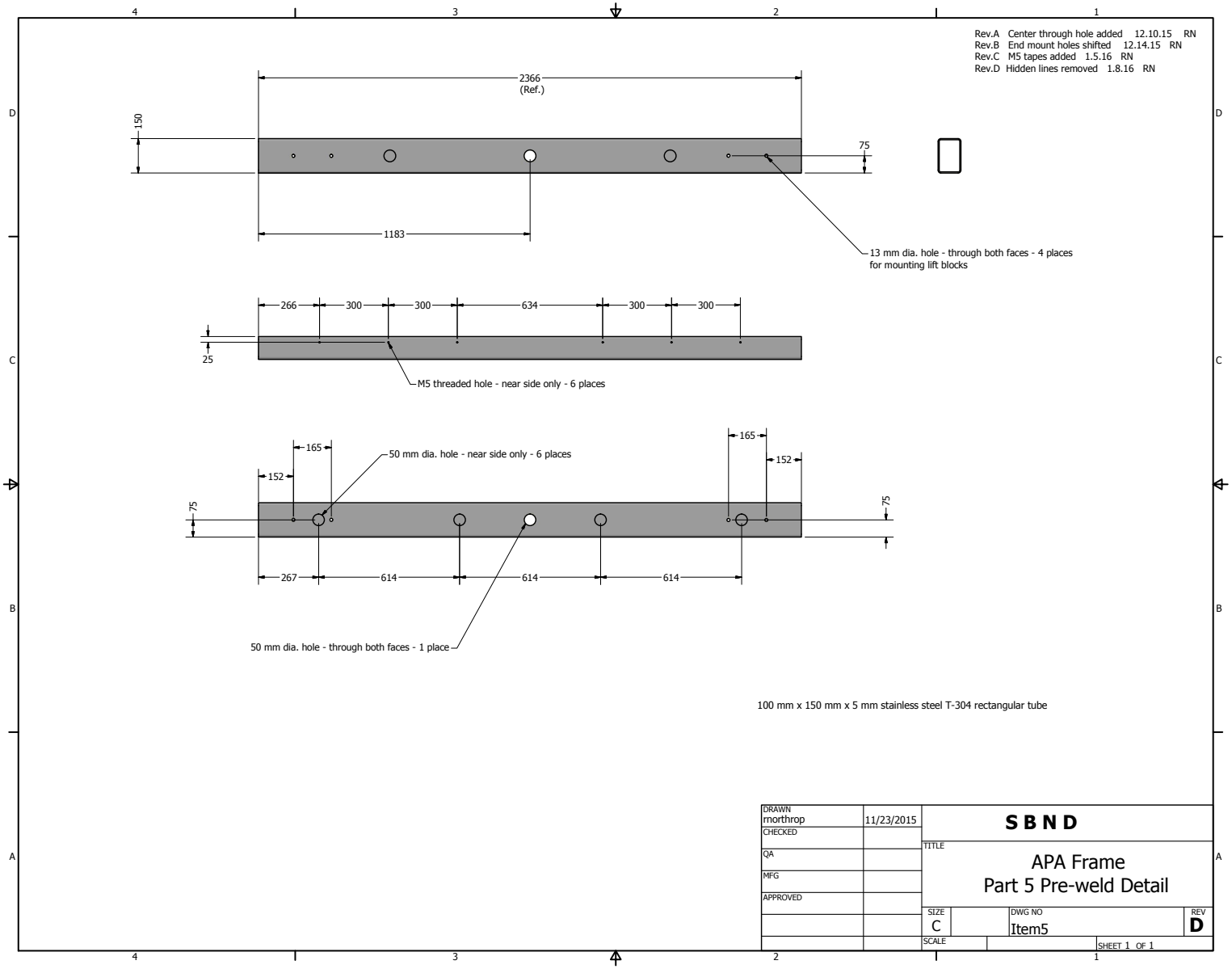
Bare Frame Part 3



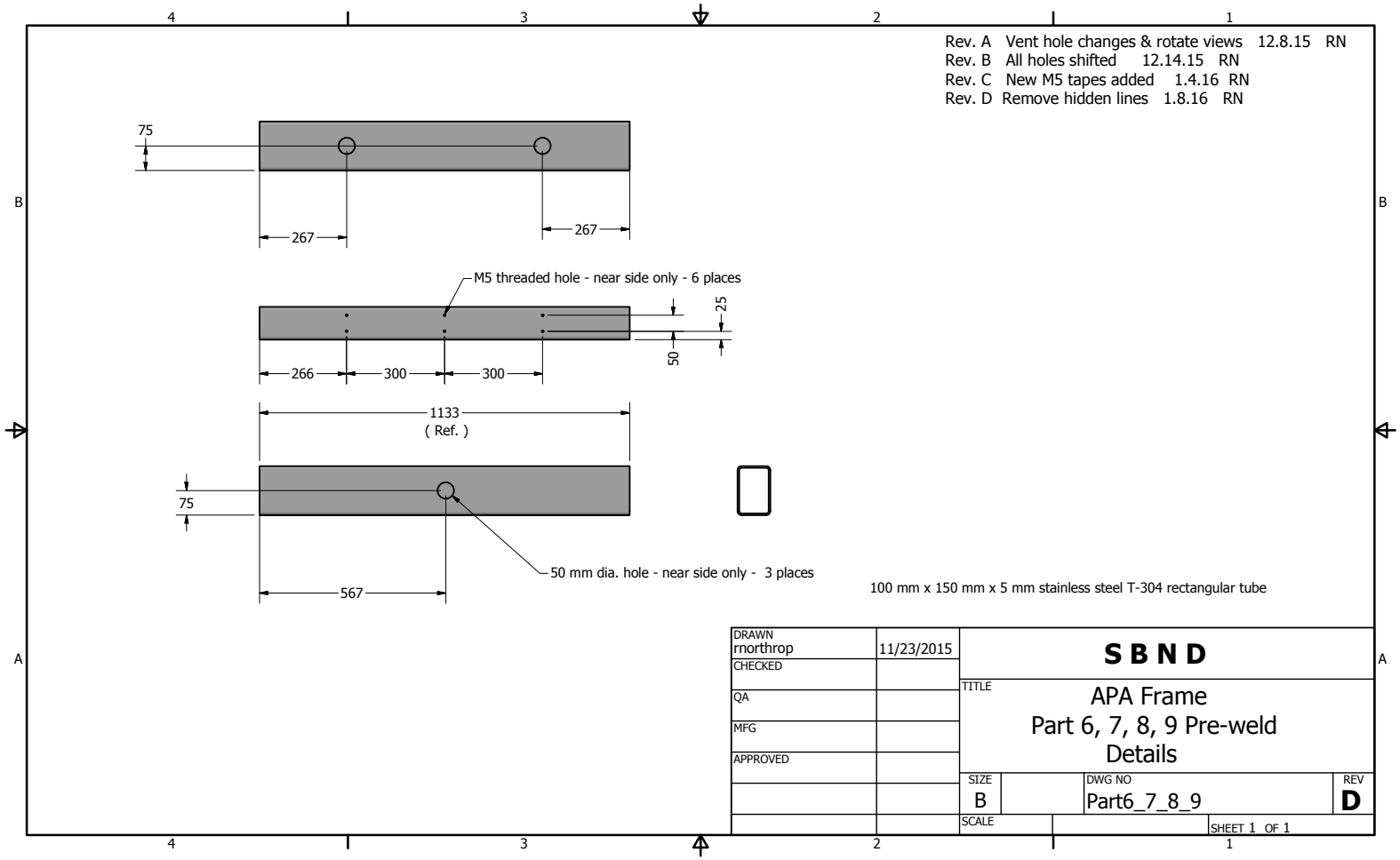
Bare Frame Part 4



Bare Frame Part 5



Bare Frame Part 6-9



Discussion – Bare Frame Welding

1. Does manufacturer require any weld specifications/symbols on the assembly drawing?

2. Does manufacturer require weld preparation specification on individual Part drawings?

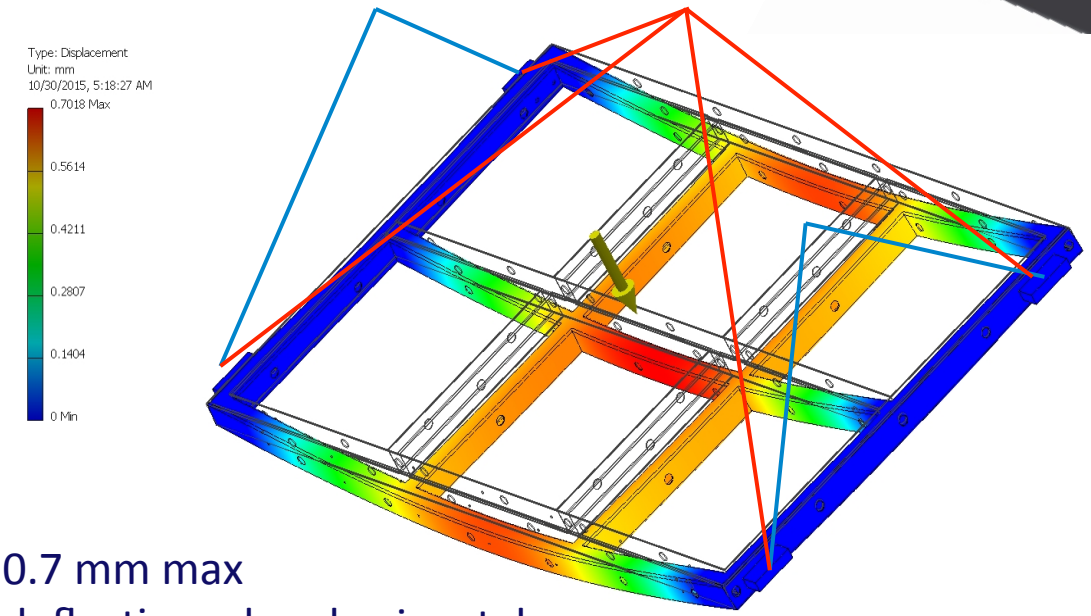
3. With regard to items 1,2, SBND happy to leave to expertise of manufacturer to determine weld specs and prep. Current drawings do not specify.

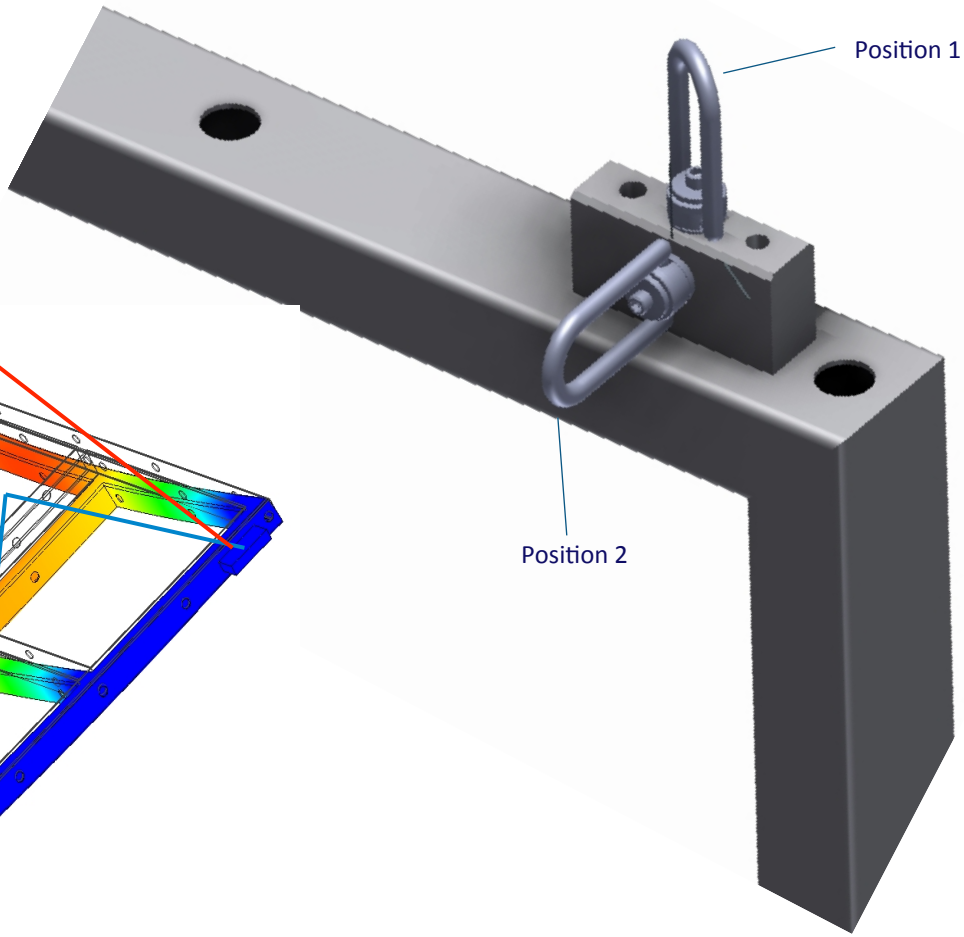
4. Detailed part drawings are for reference only, completed fabrication dimensions having priority (with tolerance of ±2.5 mm). Can manufacturer accommodate weld shrinkage of the RHS as detailed in the individual drawings?

5. SBND requests continuous flushing of weld area during welding with argon gas to provide an inert environment for welding and avoid oxidation in the welds that could contaminate later.

Discussion – Lifting Bare Frame

6. SBND to identify lifting lugs/loads and locations and any additional equipment required for lifting the assembled APA frames.

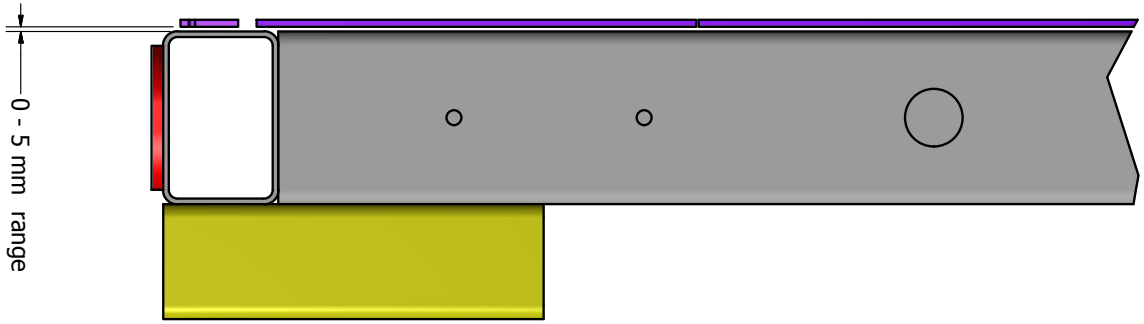


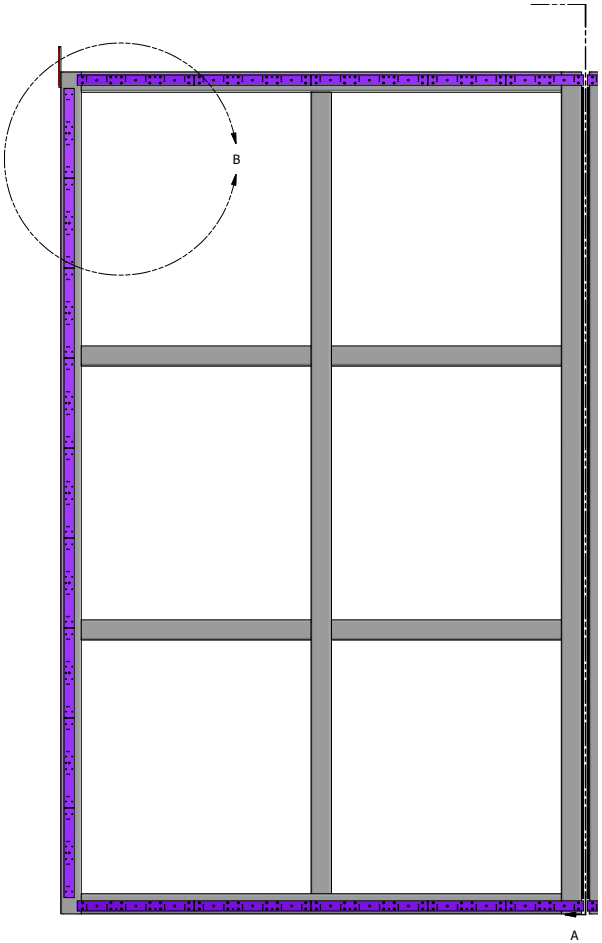


0.7 mm max deflection when horizontal

Discussion – Frame Flatness

7. Geometric tolerance symbols in relation to flatness are depicted on the assembly drawing. The secondary wire carrier plate system has been designed to accommodate a maximum shimming of 5~mm off the RHS surfaces, however flatness achieved beyond that specification may ease the process of plate installation.





Note, not all surfaces subject to tight flatness requirement. Outer perimeter of front-face and out-board face of Part 2 most important.

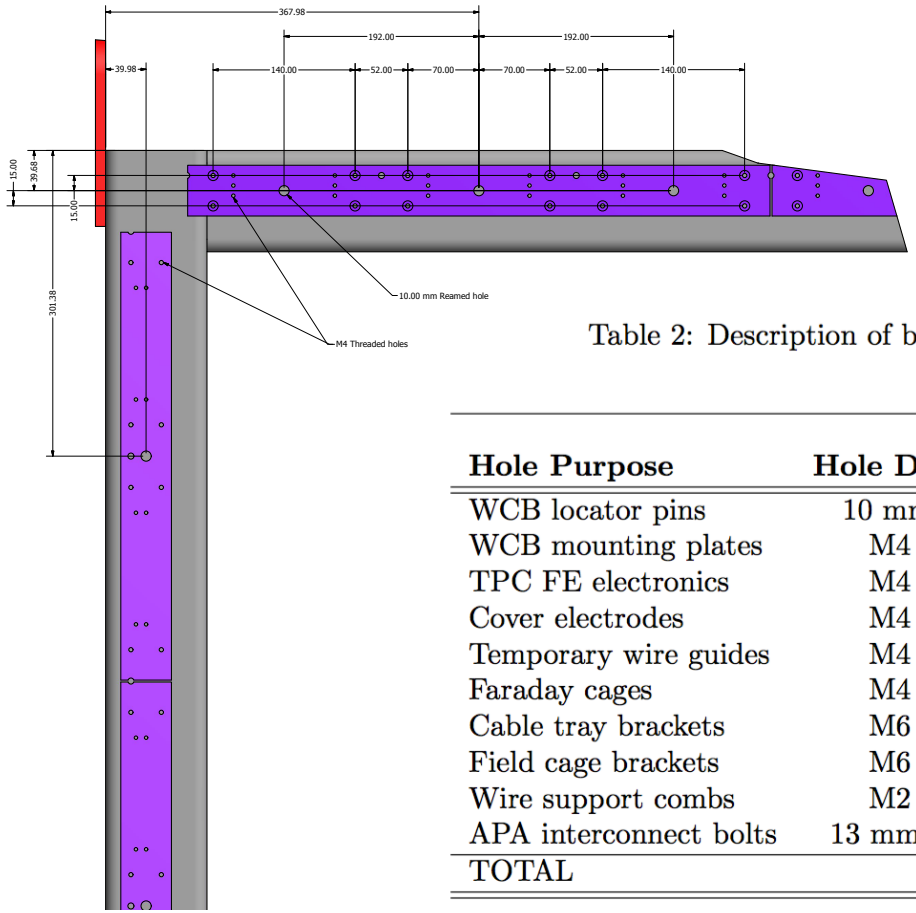
Discussion – Bare Frame

8. After the jig has been assembled and fixed, will the manufacturer batch fabricate all 4 APA's or build a first complete bare frame to assess outcomes?

9. A ``pre-weld'' hole set has been defined which can be machined on individual parts prior to APA assembly. Some of these holes are on the back-face or inboard edges of the frame.

The “post-weld” Hole Design

10. A ``post-weld'' hole set has been separately defined which must be machined onto the completed bare frame in order to achieve needed precision in relative locations. All of these holes are on the front-face or outboard edges of the frame.

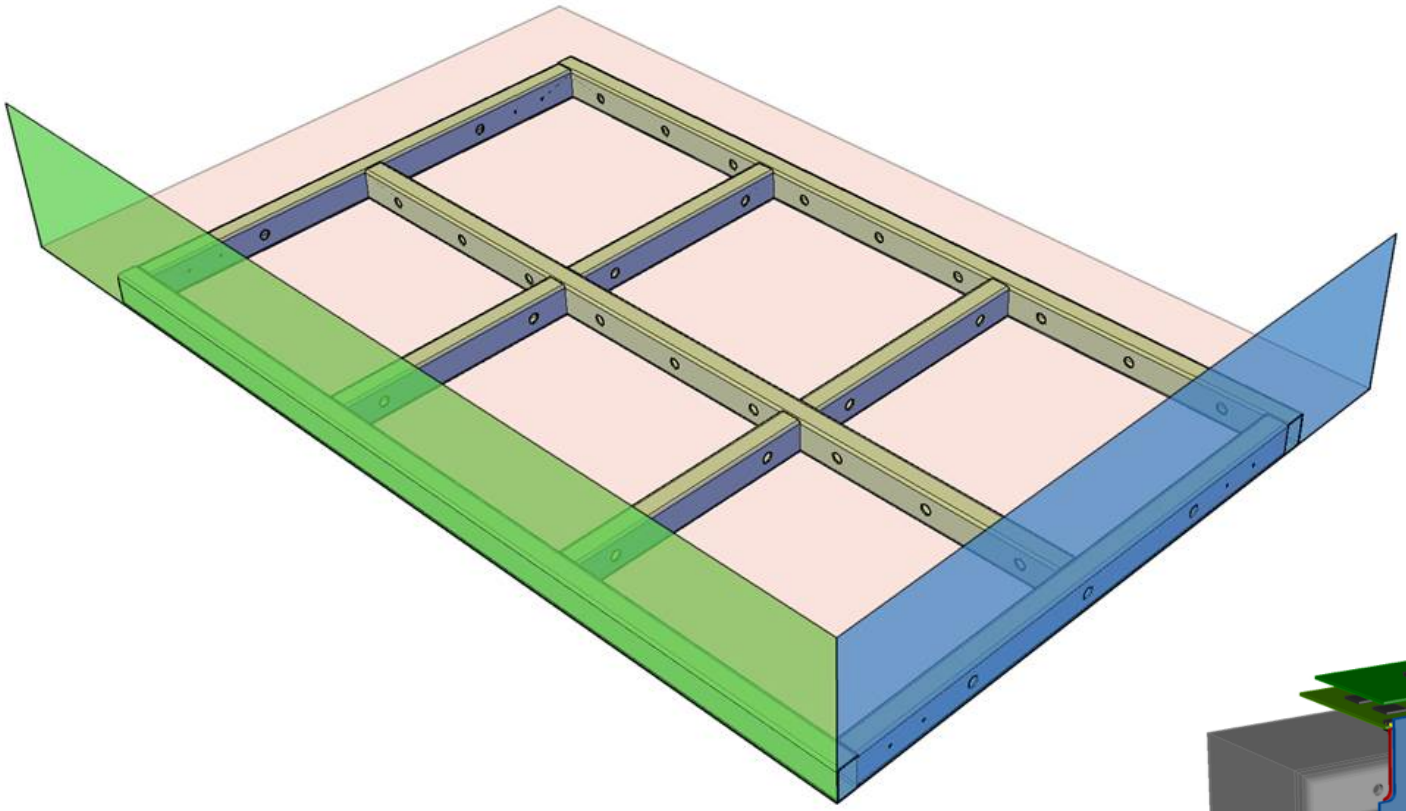


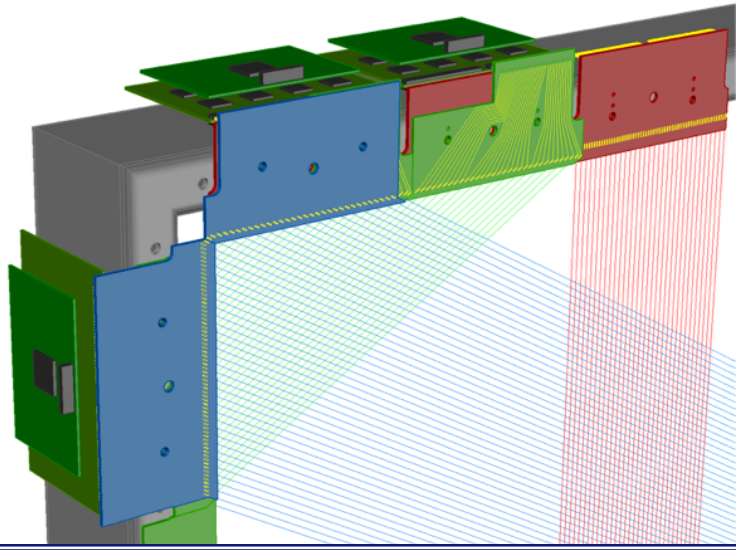
Design involves integration of all detector components. Working on final engineering design now.

Table 2: Description of bare frame post-weld holes. WCB = Wire Carrier Boards.

Hole Purpose	Hole Description	3D Pos Tolerance	Count	Part No./Face Description
WCB locator pins	10 mm reamed	0.1 mm	TBD	1,4,5/front-face, 2/outboard
WCB mounting plates	M4 tapped			1,4,5/front-face, 2/outboard
TPC FE electronics	M4 tapped			1,4/outboard
Cover electrodes	M4 tapped			1,4,5/front-face (?)
Temporary wire guides	M4 tapped			5/outboard (?)
Faraday cages	M4 tapped			1,4/outboard (?)
Cable tray brackets	M6 tapped			
Field cage brackets	M6 tapped			1,4/outboard
Wire support combs	M2 tapped			3,6,7,8,9/front-face
APA interconnect bolts	13 mm clearance			2/outboard
TOTAL			≈800	

The “post-weld” Hole Design



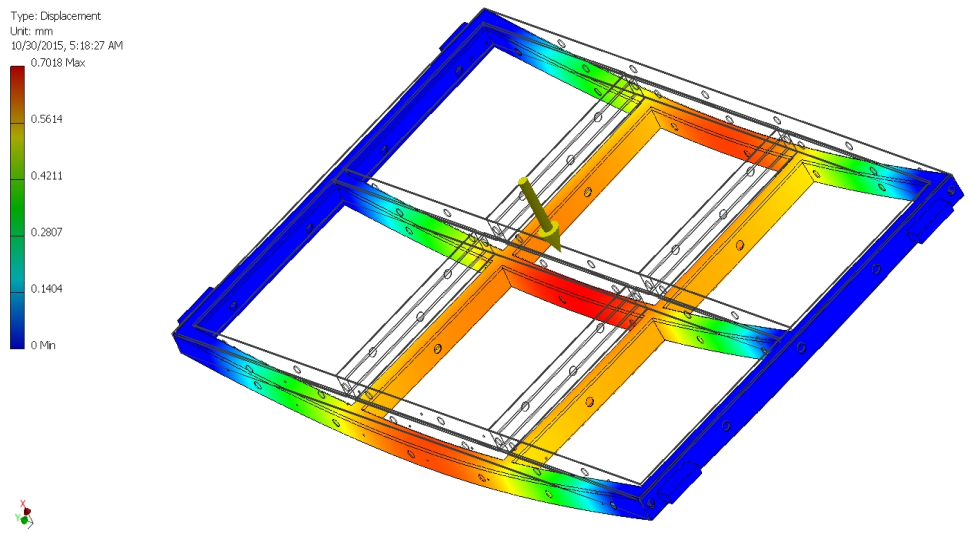


Machining of post-weld holes

Discussion – Leveling Plates

11. Installation of wire carrier plates (i.e. leveling bars) necessitates a survey to determine the shim pattern that will improve wire mounting surface flatness over the as-built bare frames to the required 1~mm (ANSI) level. Frame may need to be in vertical position when surveyed in order to avoid measuring and shimming out a gravity-induced sag while in a horizontal orientation. There may be other ways to remove the sag and create a ``vertical-like'' positioning - requires additional thought and discussion.

12. Are shims and miscellaneous fasteners to be supplied by manufacturer or by SBND?



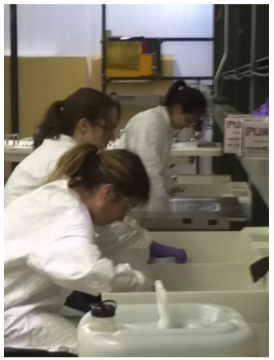
Discussion – Cleaning

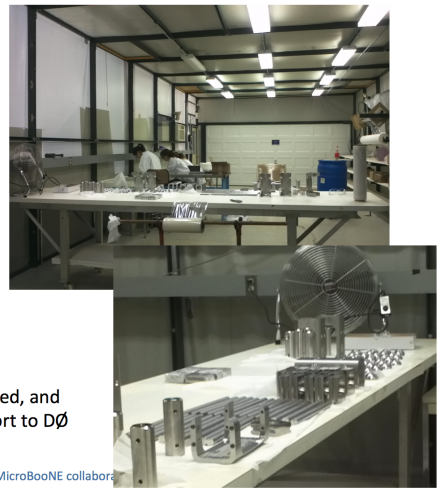
13. Cleaning of the frames inside and out is very important. Shavings from pre-weld holes can be flushed more easily from the individual parts tubes before welding. Shavings from post-weld holes present a bigger challenge as some will become trapped in capped RHS's. The 50~mm vent holes could perhaps be used to inject high pressure air/water or vacuum hoses for flushing out debris. Note that if trapped dirt or metal shavings leave the tube once submerged in liquid argon, it could be very damaging for the detector.

First cleaning of square tubes (part of cathode frame) done by spraying pressurized water and pulling soapy rag through tube wasn't good enough – found many small metal shavings could be shaken out upon drying

Second cleaning with better tool (pipe brush shown above) produced much better results. No more shavings found.

More cleaning (stainless steel)…



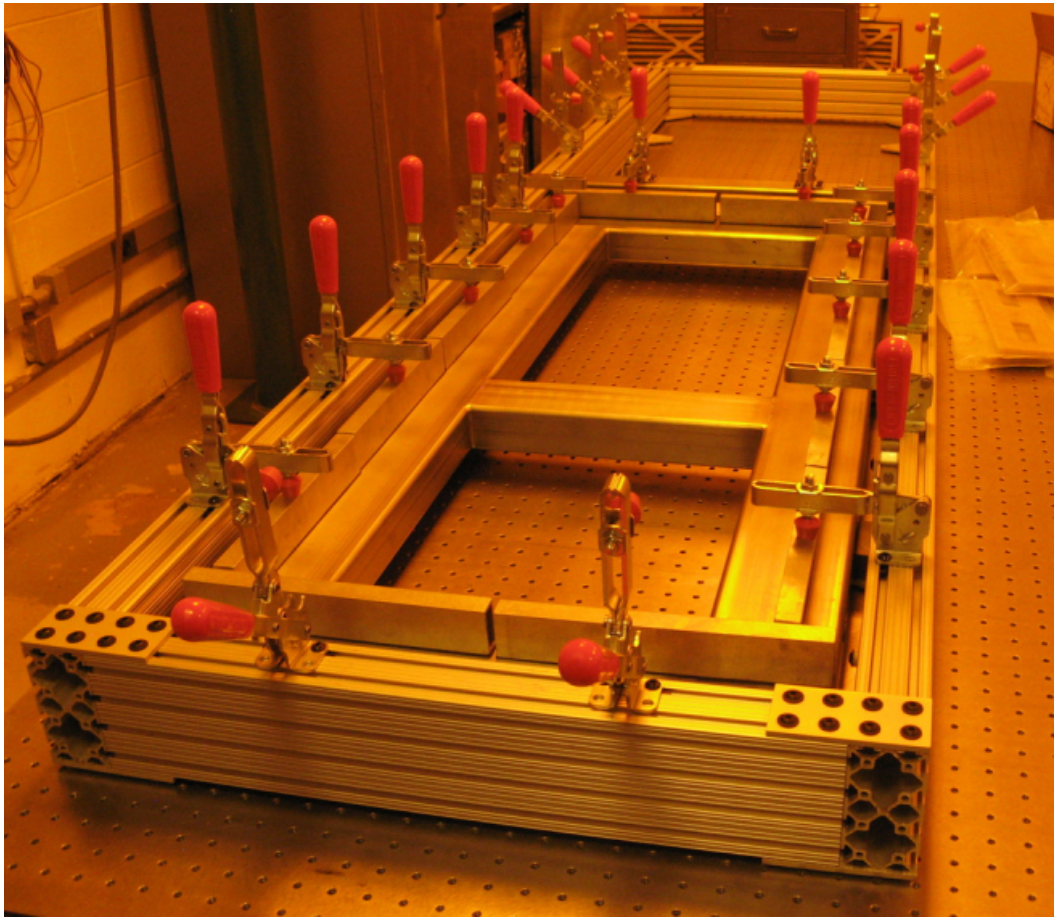


Small parts washed, double-wrapped, and placed in labeled boxes for transport to DØ and storage.

July 19, 2012 MicroBooNE collabora

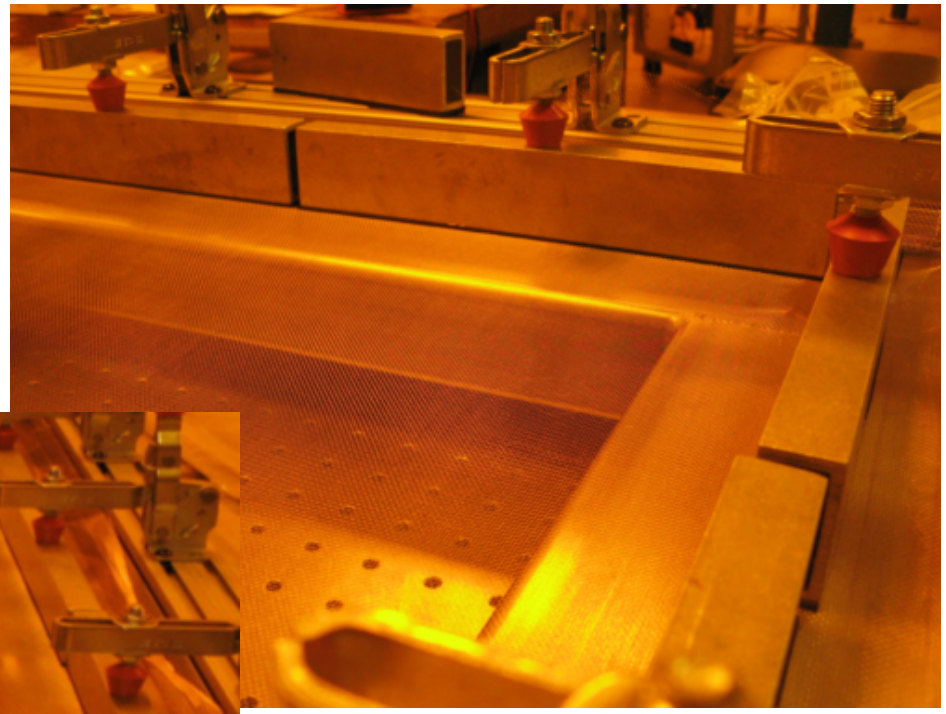
Discussion – Mesh

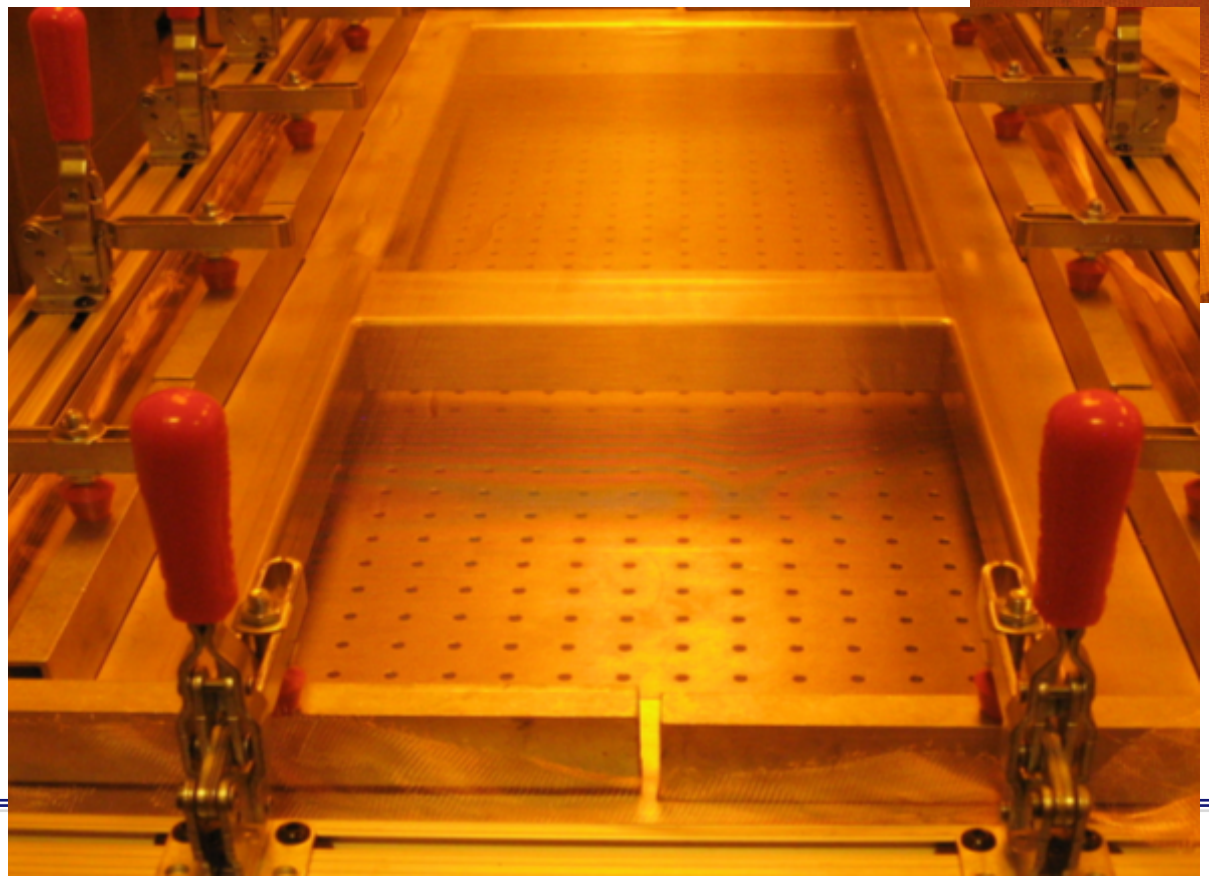
14. Stretching and gluing of mesh on the front-face probably most easily done prior to installation of leveling plates. SBND to supply mesh and adhesive.

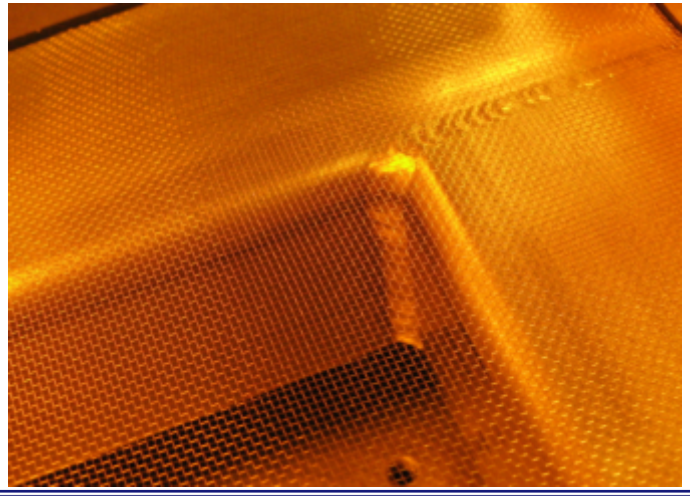


Discussion – Mesh

Installing mesh on prototype frame. Once it was cut and put loosely in place it only took a few minutes to pull it taut.







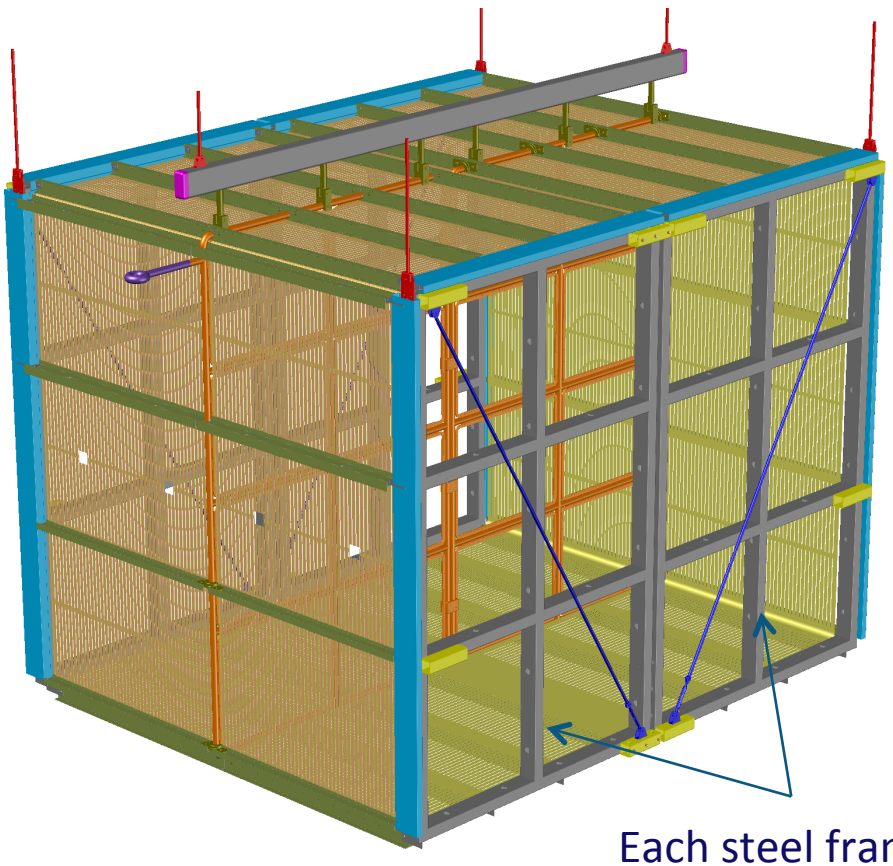
Discussion – Transport

15. SBND to organize transportation and logistics to Daresbury.

Discussion – Load

- Support loads in final detector configuration
  - *6 Hanger supports: 4 at APA corners, 2 at CPA ends*
  - *TPC total weight **~4400 kg***

Entire detector suspended at 6 points from above in final configuration



Each steel frame about 480 kg

Thank you for your time!

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