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Construction and Commissioning of X-ray Shielding Box & Magnetic Field Mapping for Varian v-4004 Electromagnet

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General Outline

Purpose:

(1) To summarize the design, construction, and radiation testing of the new Large Lead Box (LLB) for up to 1.2-meter detector prototypes.

(2) To discuss preliminary results concerning the magnetic field strength mapping of the Varian v-4004 electromagnet.

Outline:

- LLB Design and Features
- LLB Radiation Testing Results
- Electromagnet Setup and Configuration
- Electromagnet Field Mapping Results

New Workspace!

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Construction and Commissioning of X-ray Shielding Box

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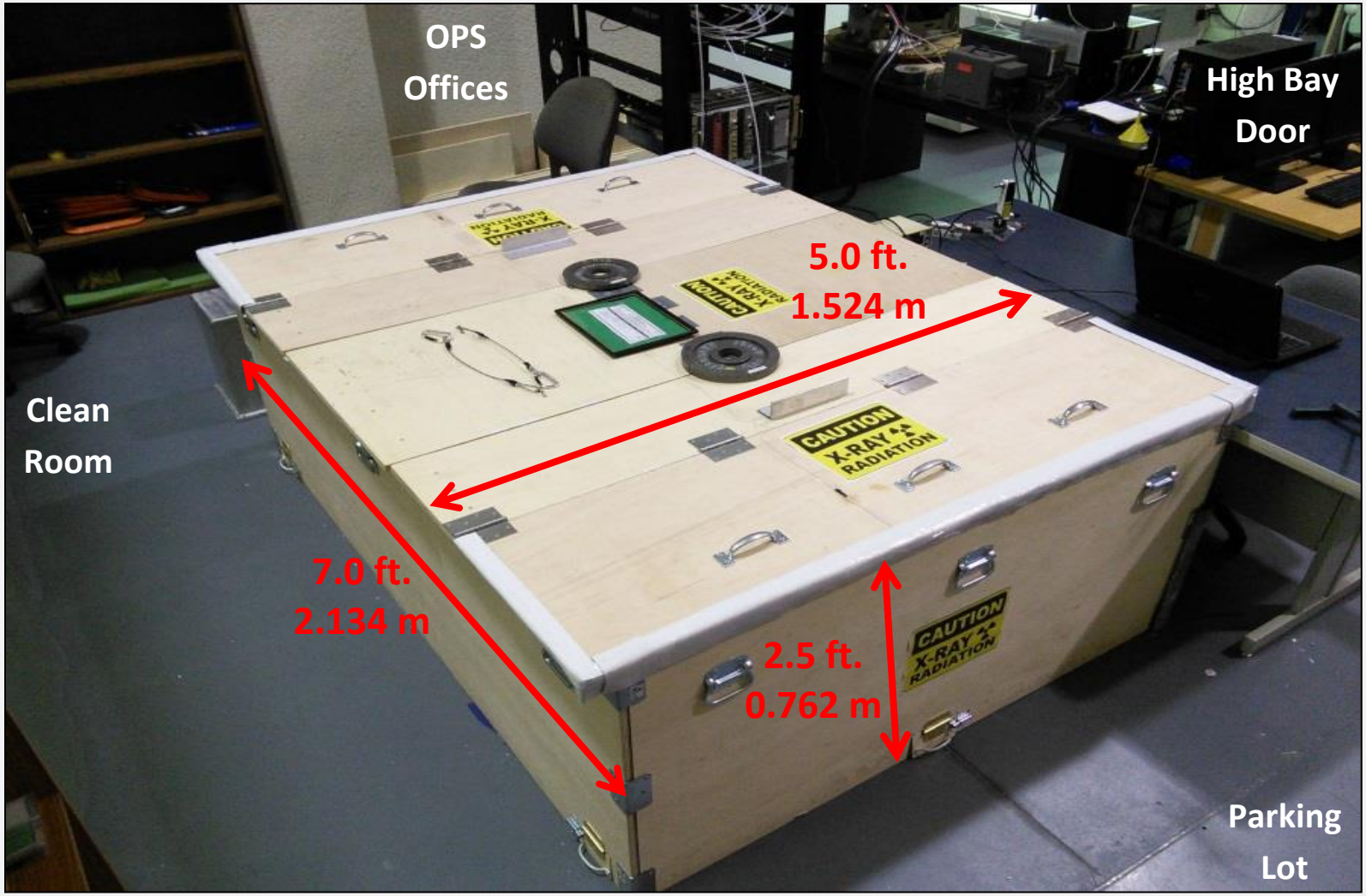
LLB Design and Features

Overview:



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LLB Design and Features

Box Dimensions:

	Height	Width	Length	Volume	Weight
Imperial	2.5 ft.	5 ft.	7 ft.	87.5 ft^3	~600 lbs.
Metric	0.762 m	1.524 m	2.134 m	2.478 m^3	~270 kg

Specifications:

- 4 corners triple-bracketed for support
- 3 aluminum support bars to prevent lid from bowing
- Lead sheets (1/16") covering all interior panels
  - Overlapped and attached with Velcro
  - Detector side has one continuous sheet
- Interior seals: beneath lid and framed around access ports
- Exterior seals: on and under lid
- X-ray source interlock
- Grounding wire

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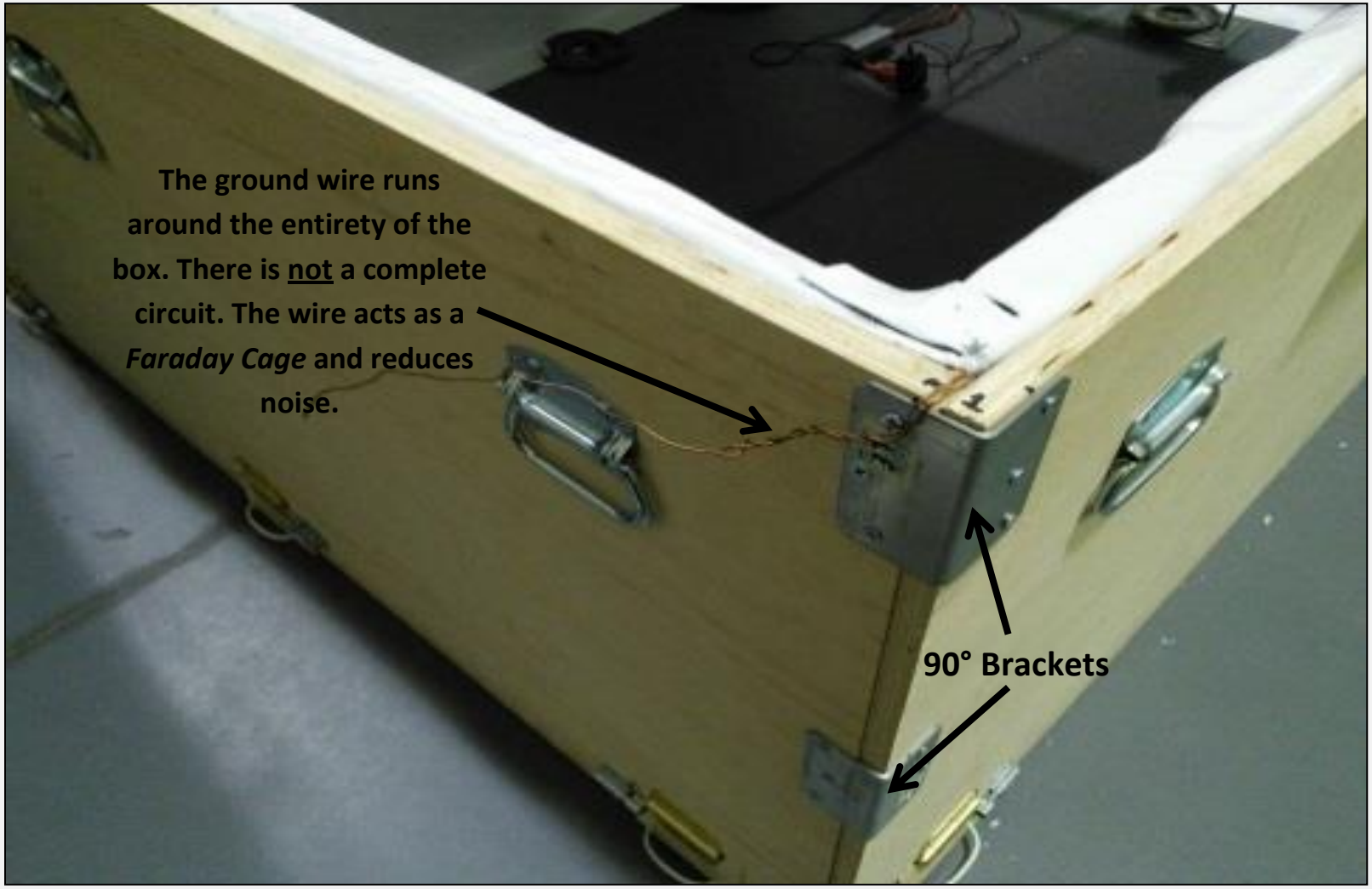
LLB Design and Features

Corners and Grounding Wire:



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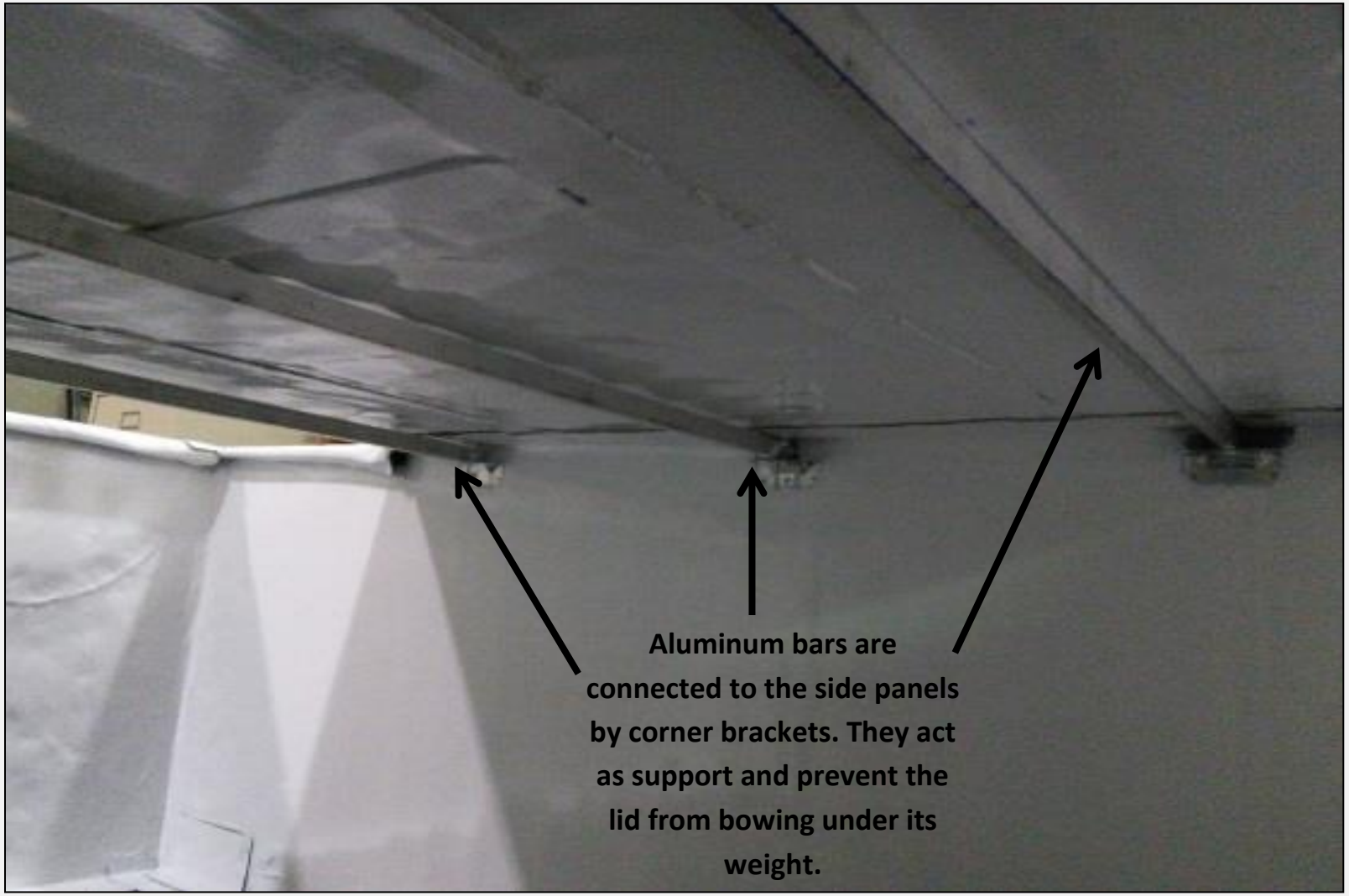
LLB Design and Features

Aluminum Supports:



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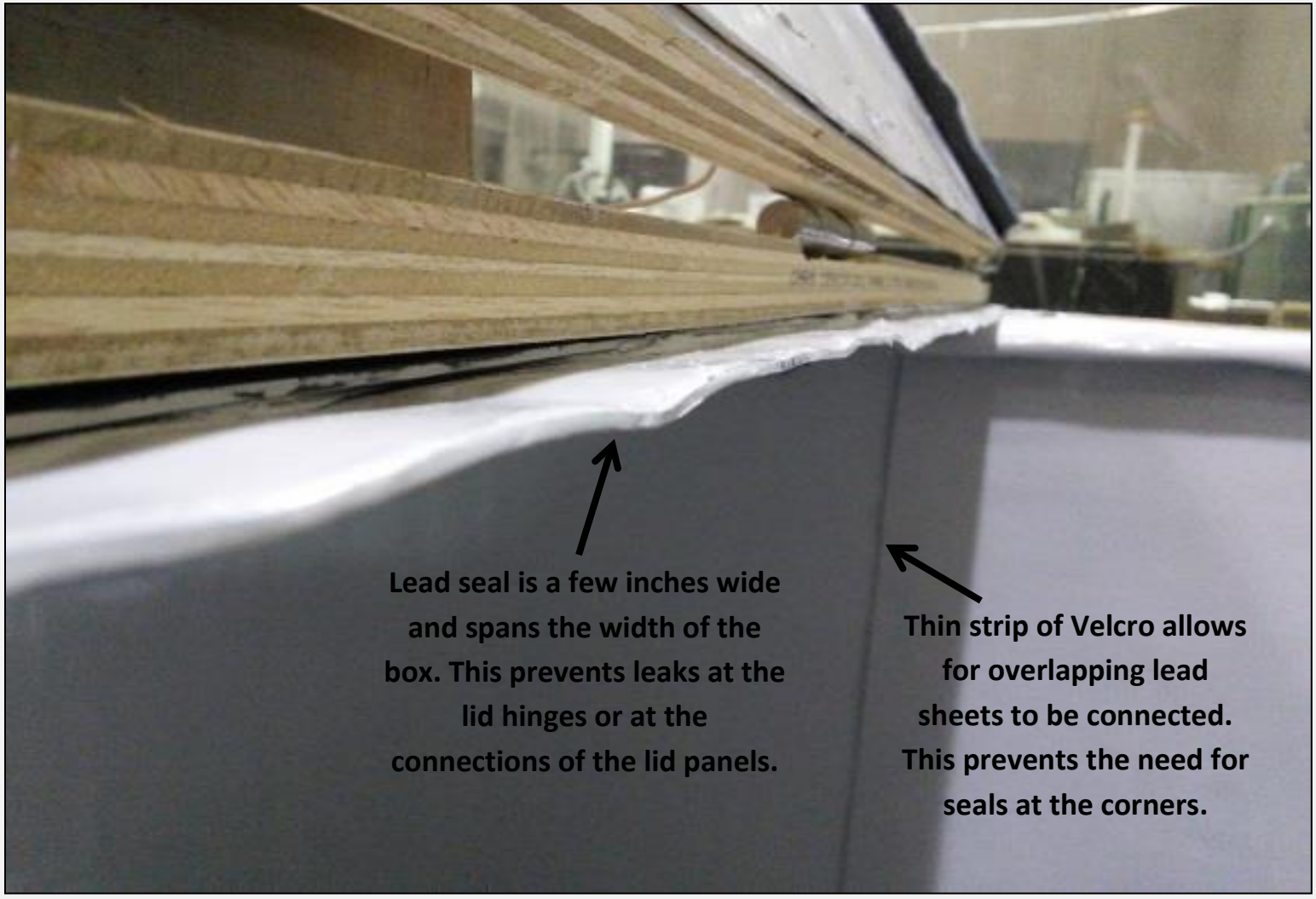
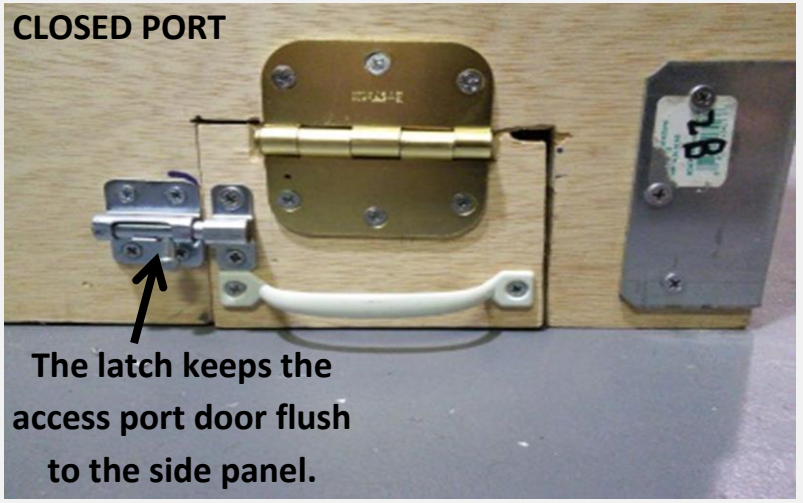
LLB Design and Features

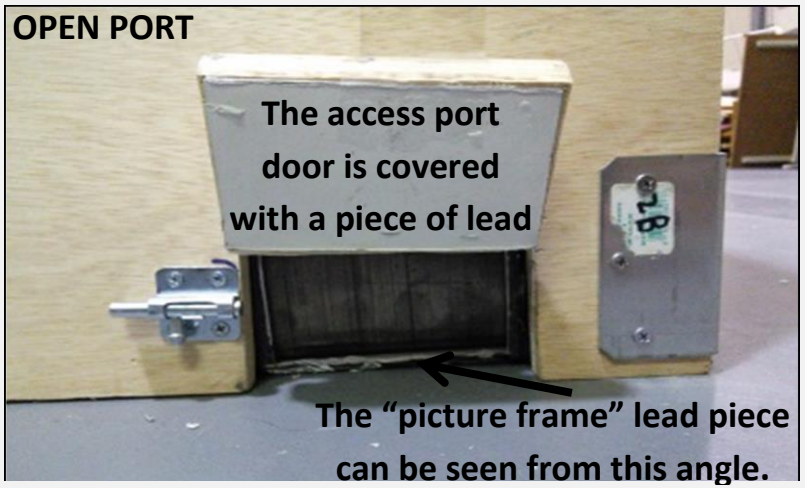
Interior Seals:



LLB Design and Features

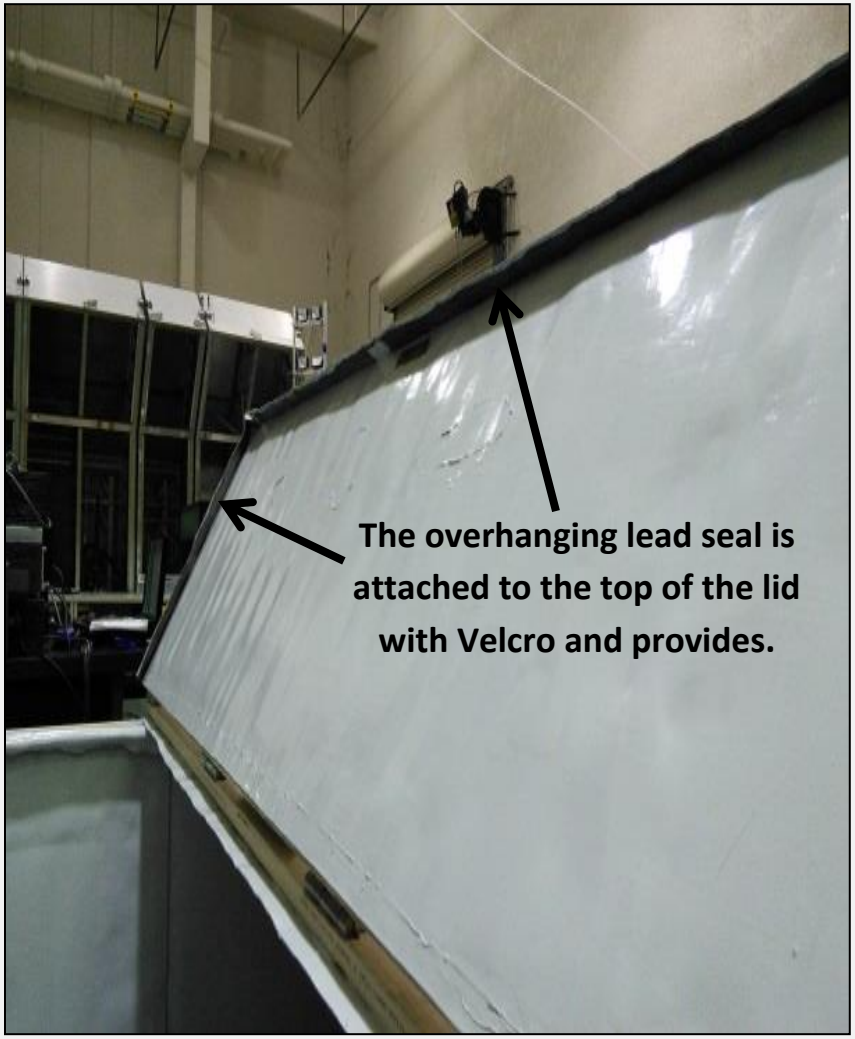
Access Ports:

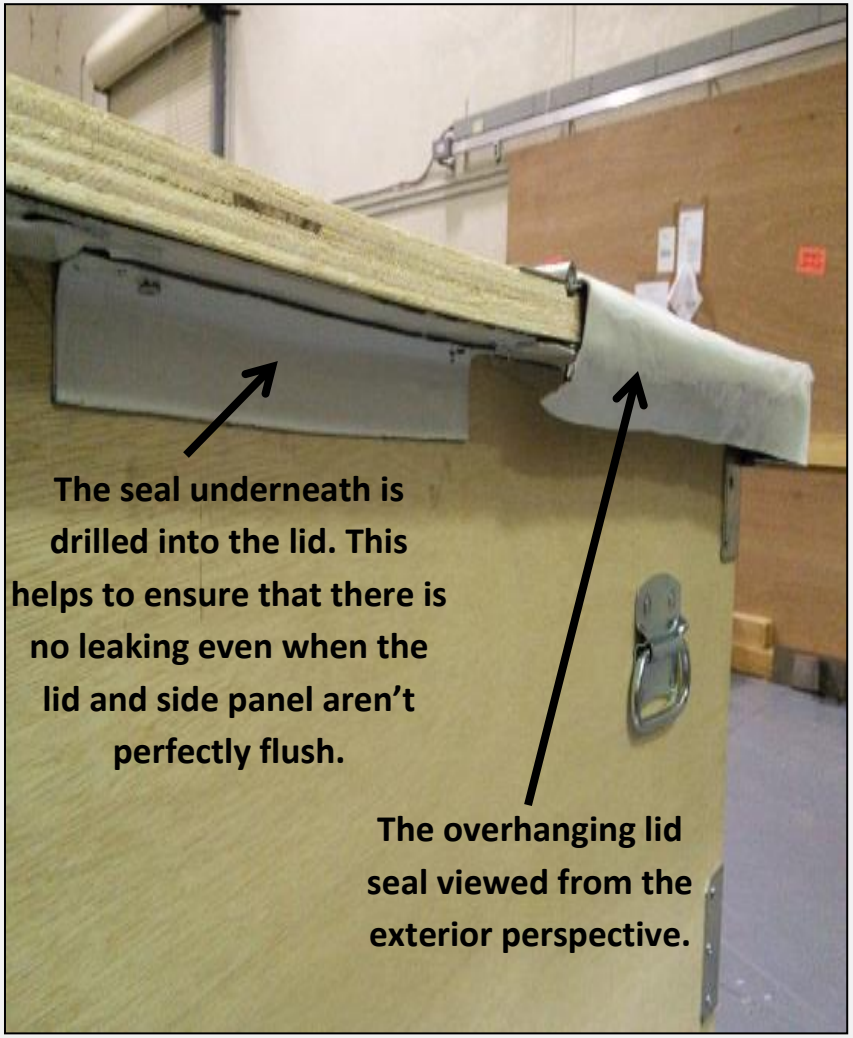




LLB Design and Features

Exterior Seals:





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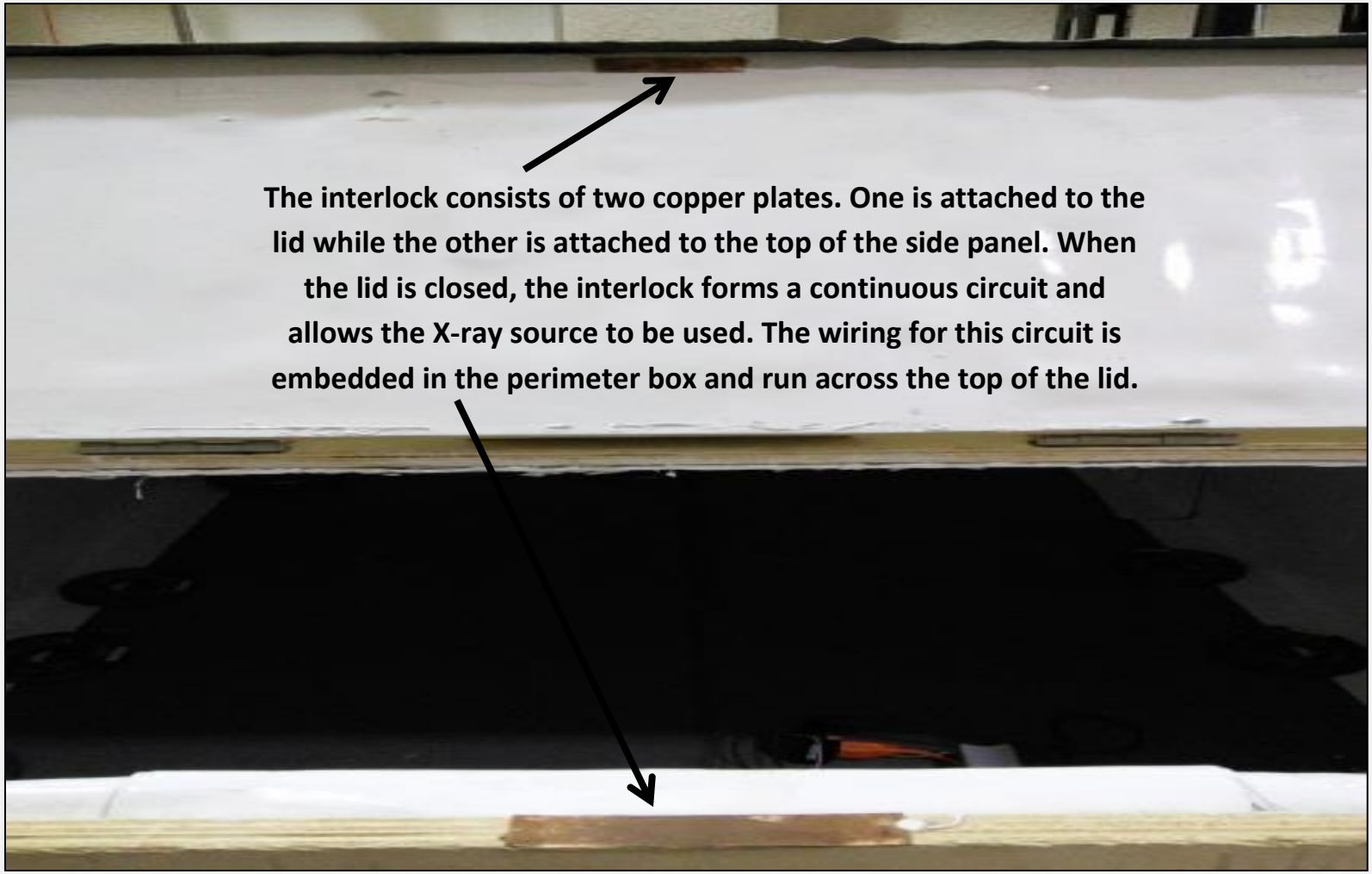
LLB Design and Features

Interlock:



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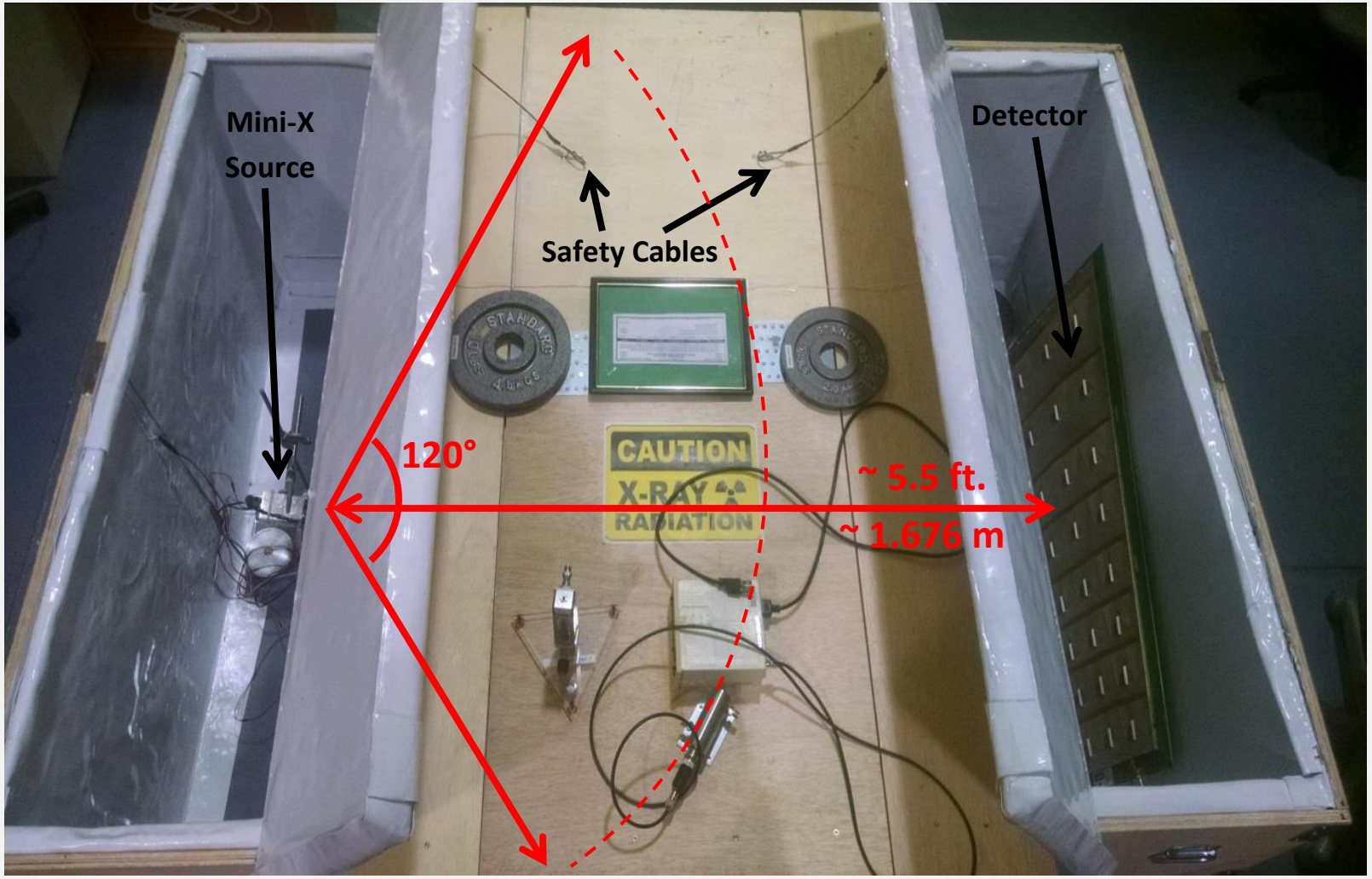
LLB Design and Features

Testing Configuration:



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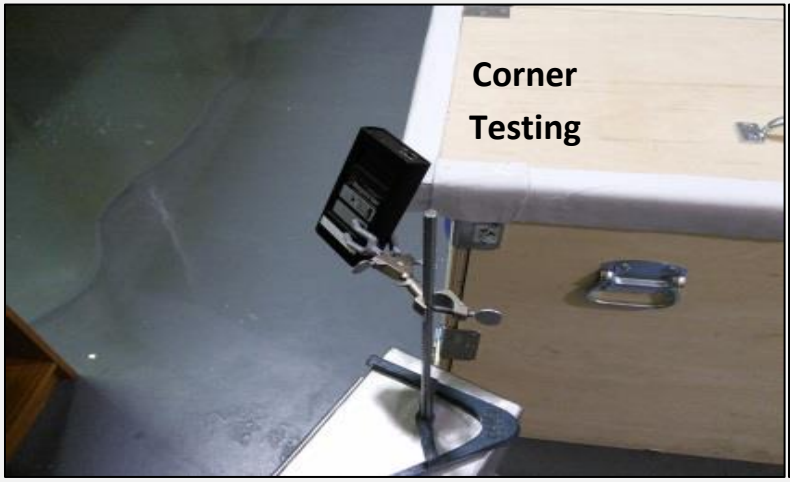
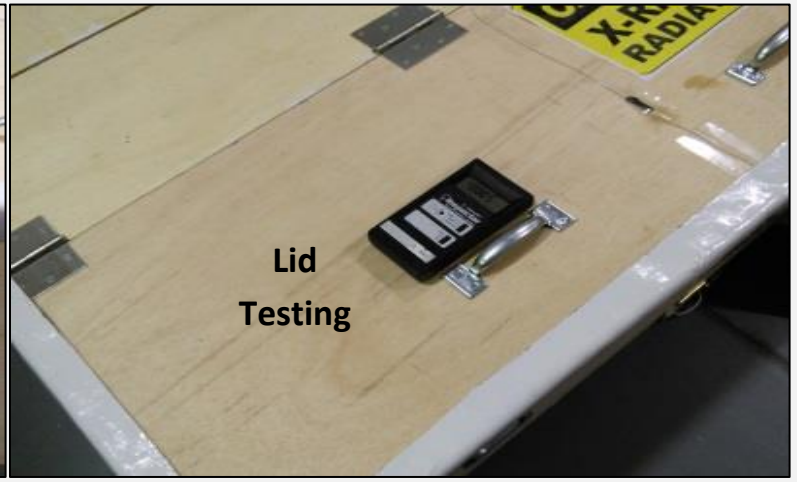
LLB Radiation Testing Results

Detection with Geiger counter:





LLB Radiation Testing Results

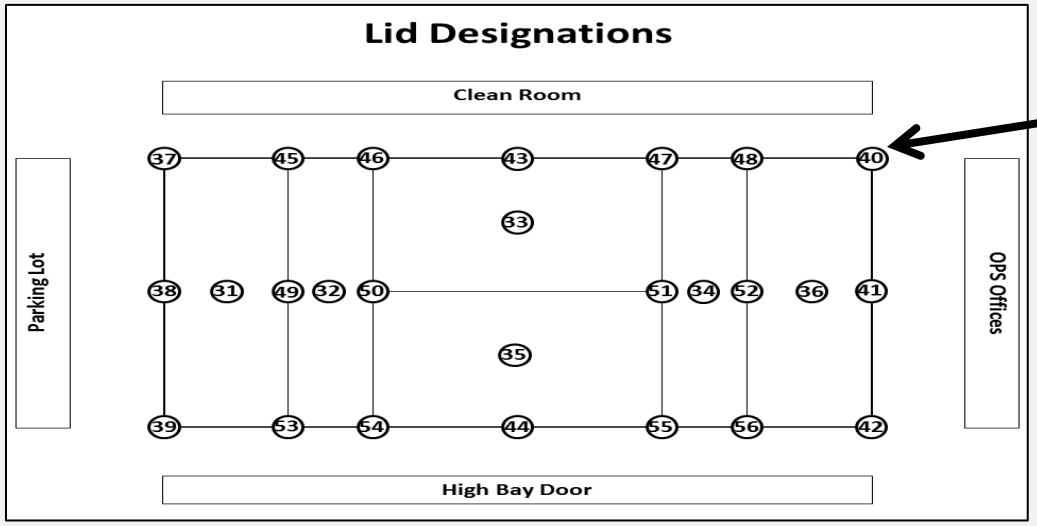
- Mini-X source (120° cone / 50 keV x-rays): measured counts per 5 minutes

Testing Configurations:

- Normal Operation: source position used during regular detector testing
- Point Blank: source is roughly 1 foot (~0.3 m) from Geiger counter position

Designations:

- All charts are at the end of the presentation for future reference (ex. below)



Location numbers correspond to the point number in the radiation testing plots. There were 56 spots tested.

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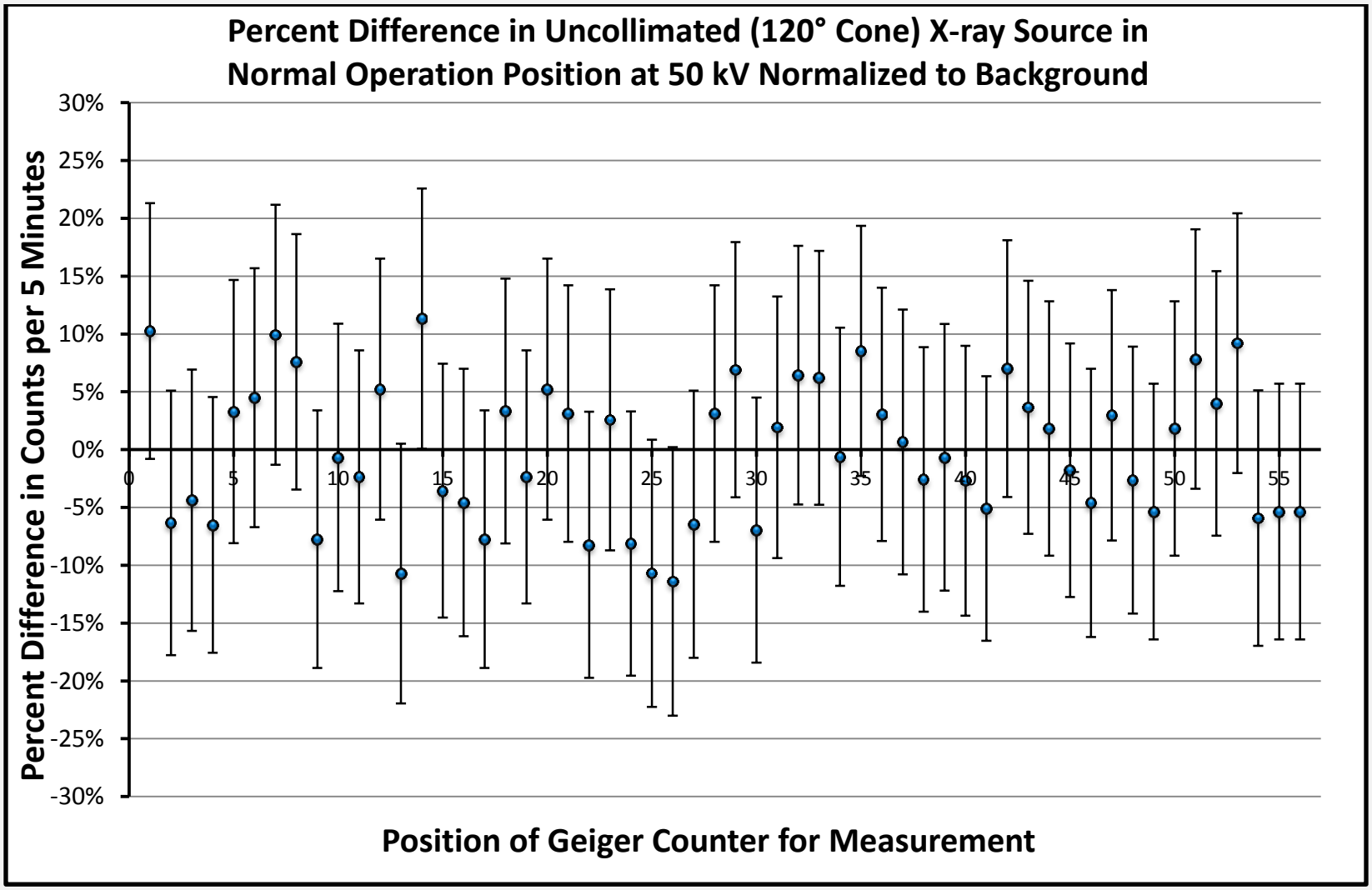
LLB Radiation Testing Results

Normal Operation:



LLB Radiation Testing Results

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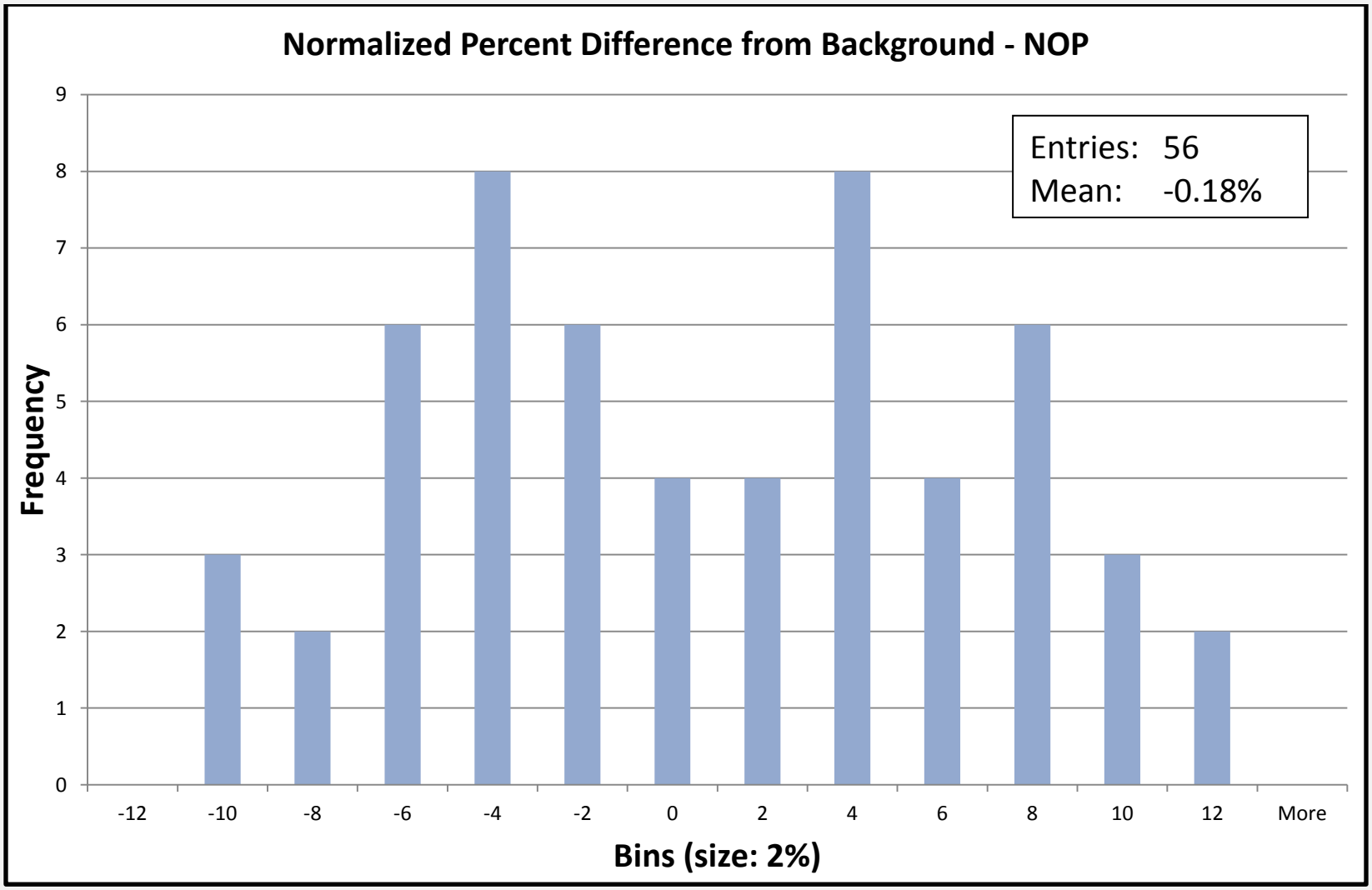

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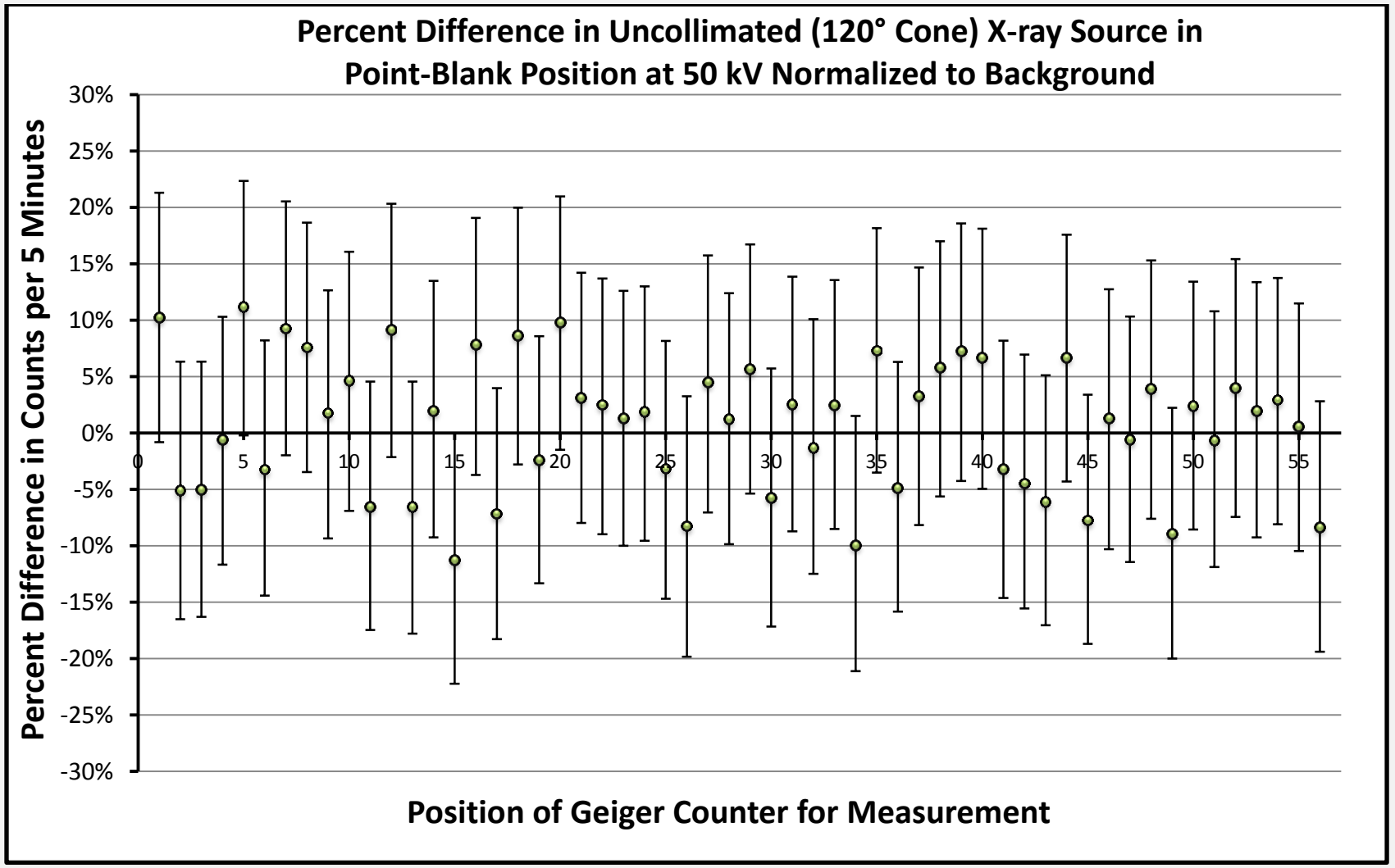
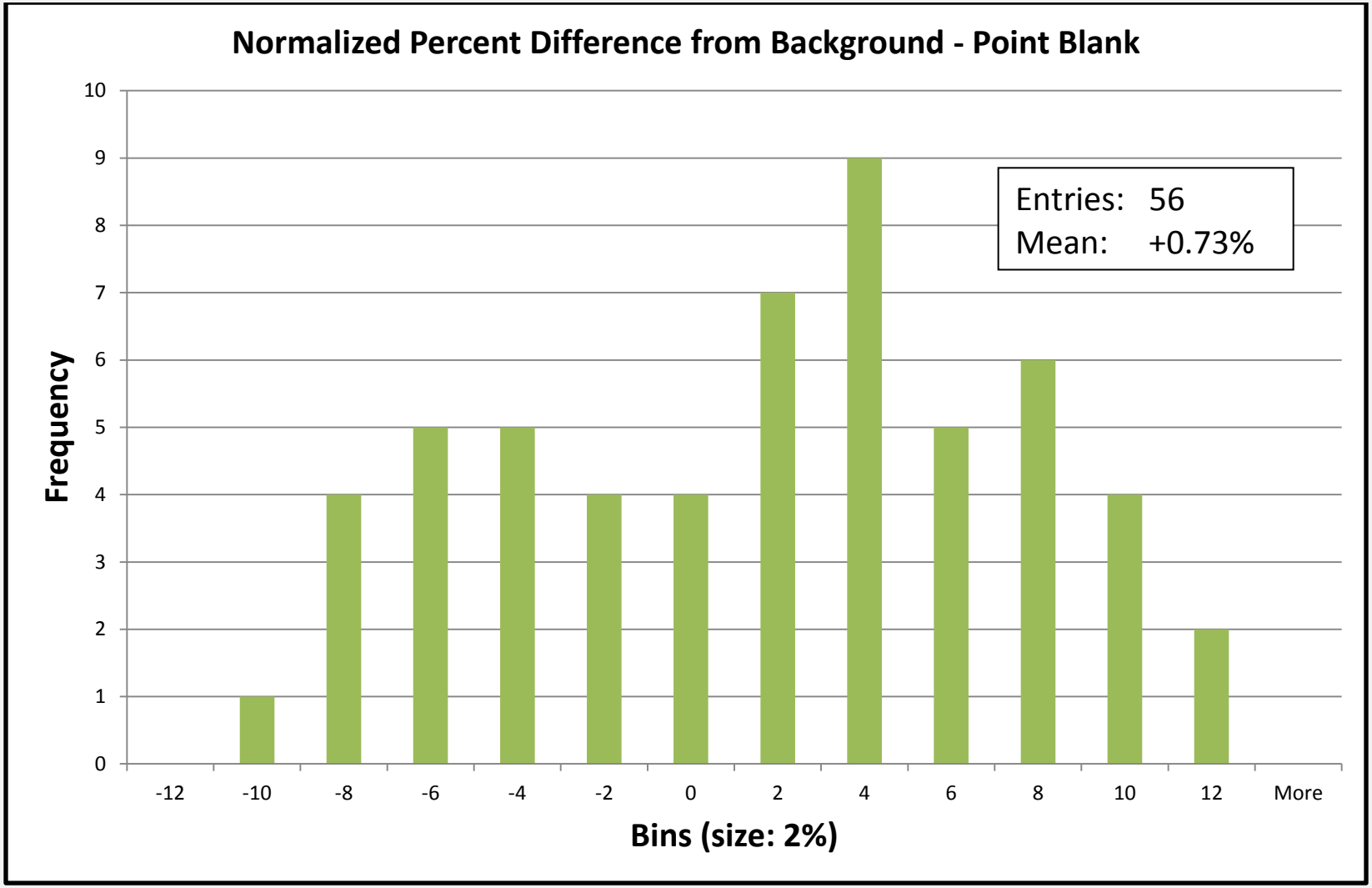
LLB Radiation Testing Results

Point Blank:



LLB Radiation Testing Results

Point Blank:



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Magnetic Field Mapping for Varian v-4004 Electromagnet

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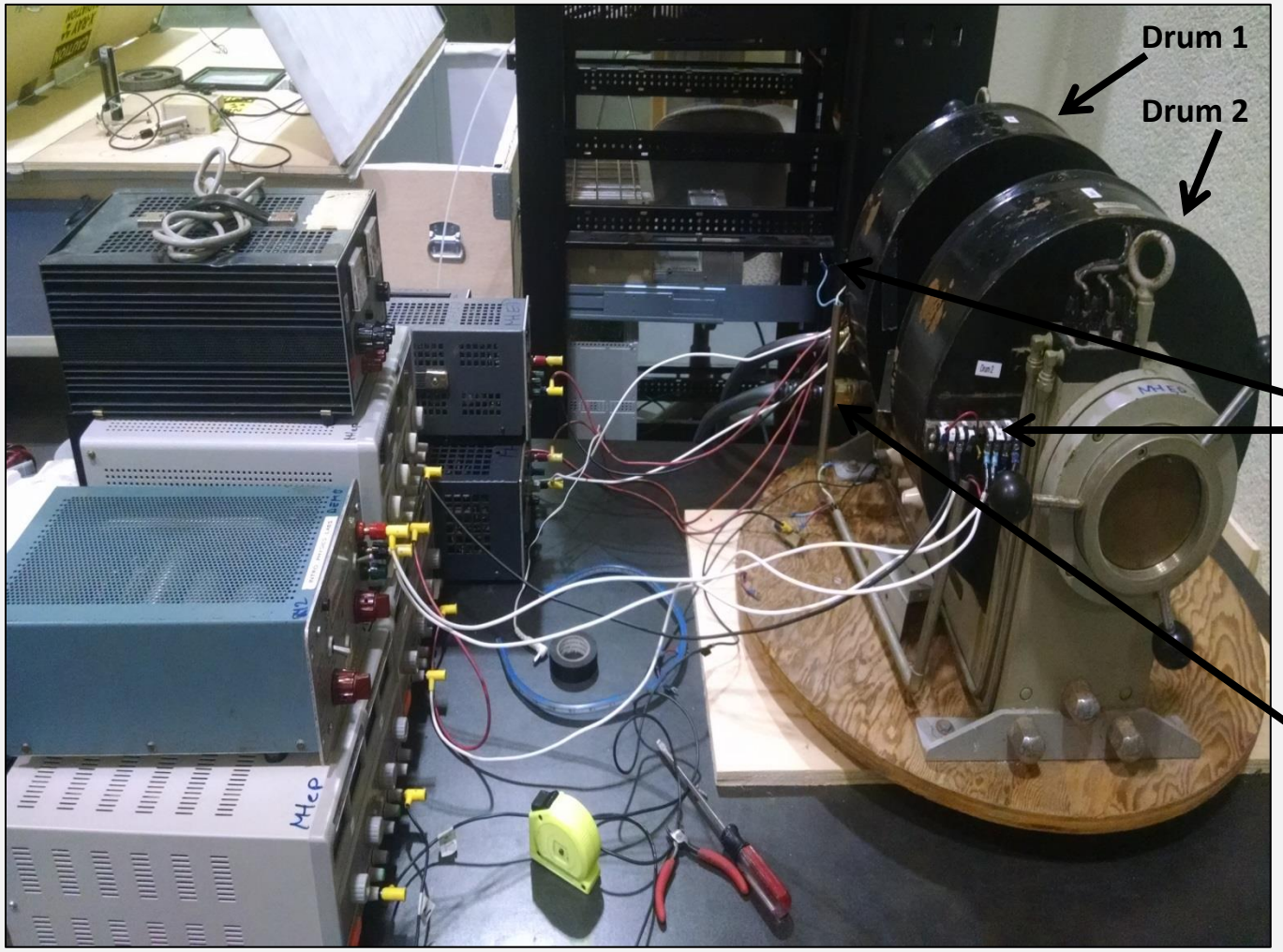
Electromagnet Setup and Configuration

Current Setup:



Magnet consists of 2 drums. Each drum contains 4 coils of 2,000 turns.

Terminals can be wired in any configuration to power the individual coils.

Water cooling prevents the coils from overheating and melting.

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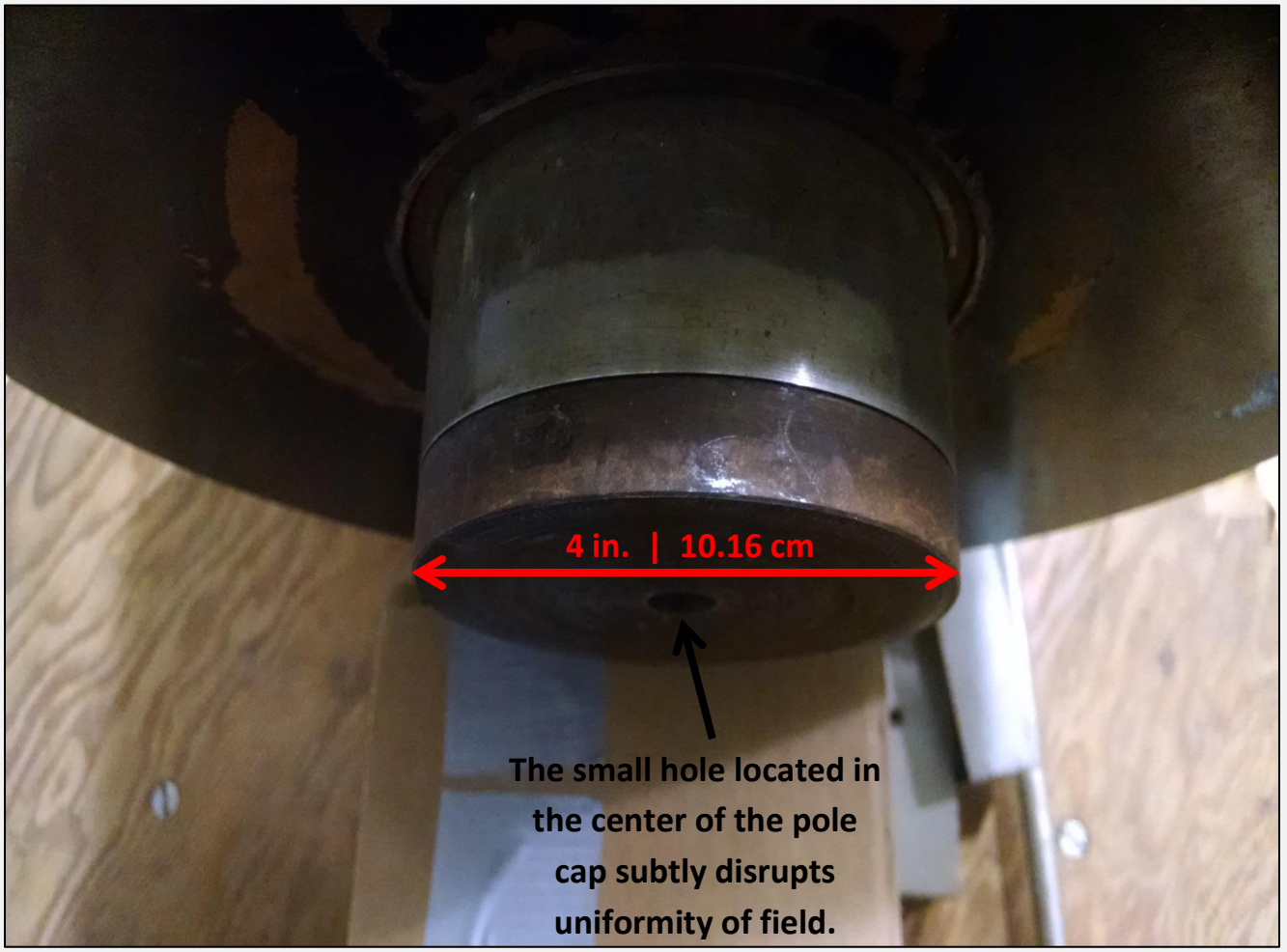
Electromagnet Setup and Configuration

Pole Cap:



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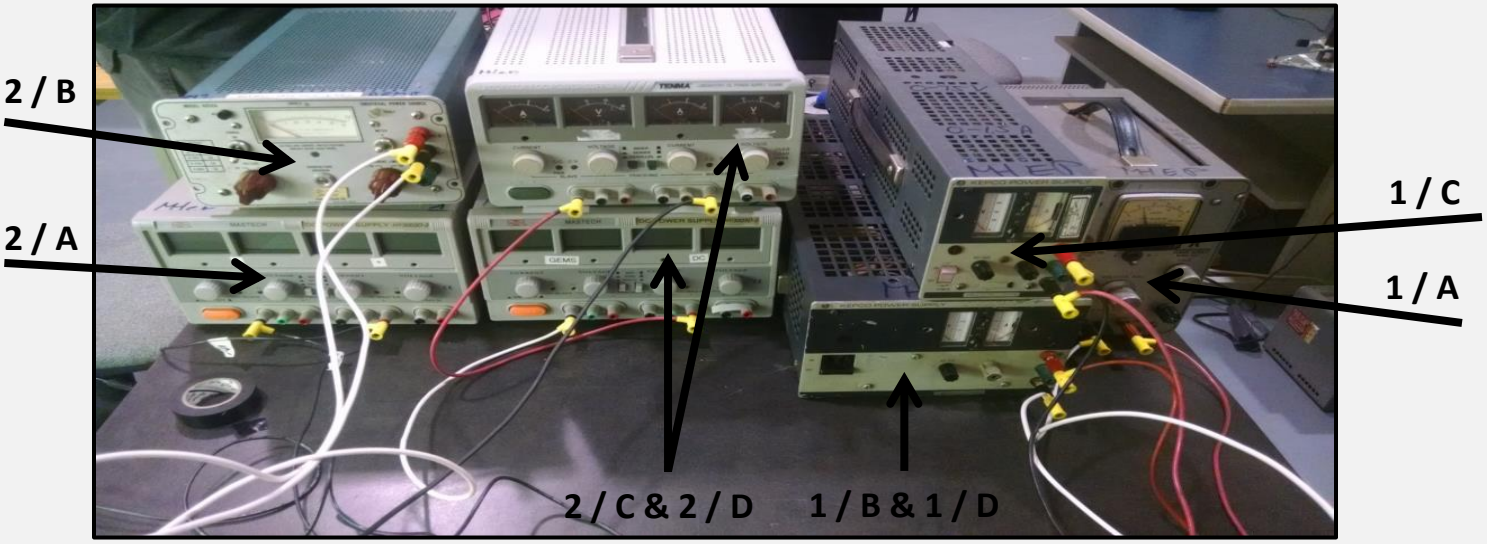
Electromagnet Setup and Configuration

Configuration:

Element (Drum/Coil)	Resistance (Ω)	Voltage (V)	Current (A)
1/A	25.0	50.0	2.00 (max)
1/C	42.0	65.0	1.55
1/B & 1/D	81.0	115.0	1.42
2/A	25.0	50.0	2.00 (max)
2/B	32.0	0.0*	0.0*
2/C & 2/D	91.0	123.5	1.36



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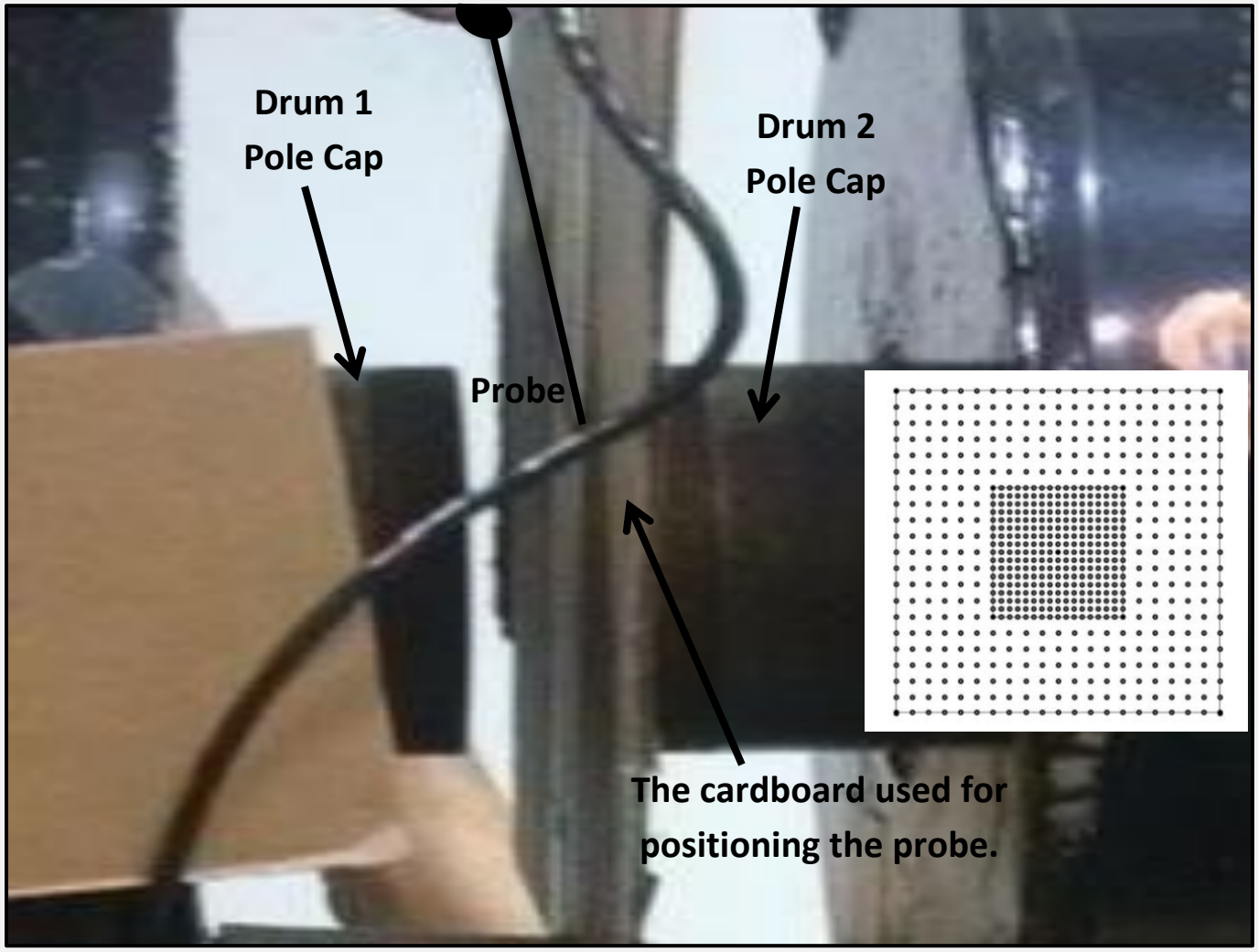
Electromagnet Setup and Configuration

Probing Technique:



This pattern was printed on the cardboard. The outer region has 1-cm spacing while the central region has 0.5-cm spacing.

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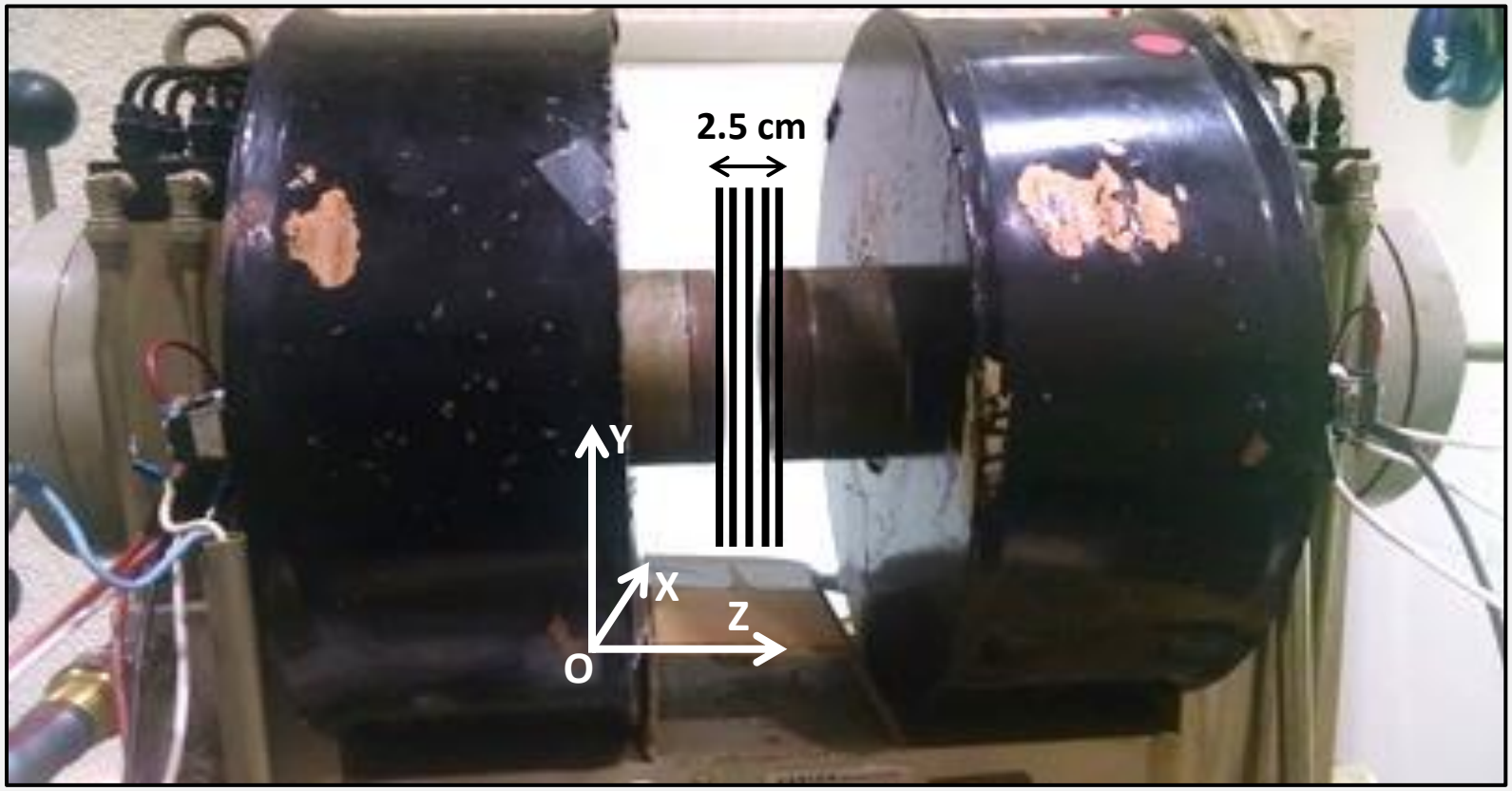
Electromagnet Setup and Configuration

Geometry:



- A few plots from each planar orientation are included in the following slides

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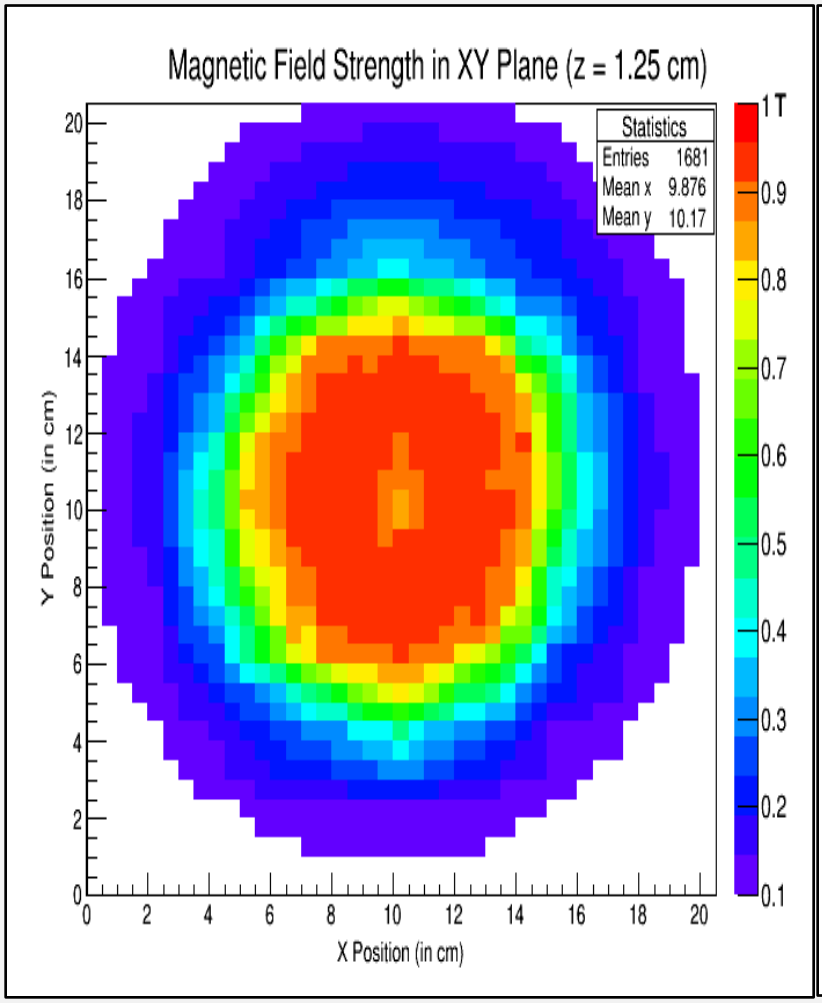
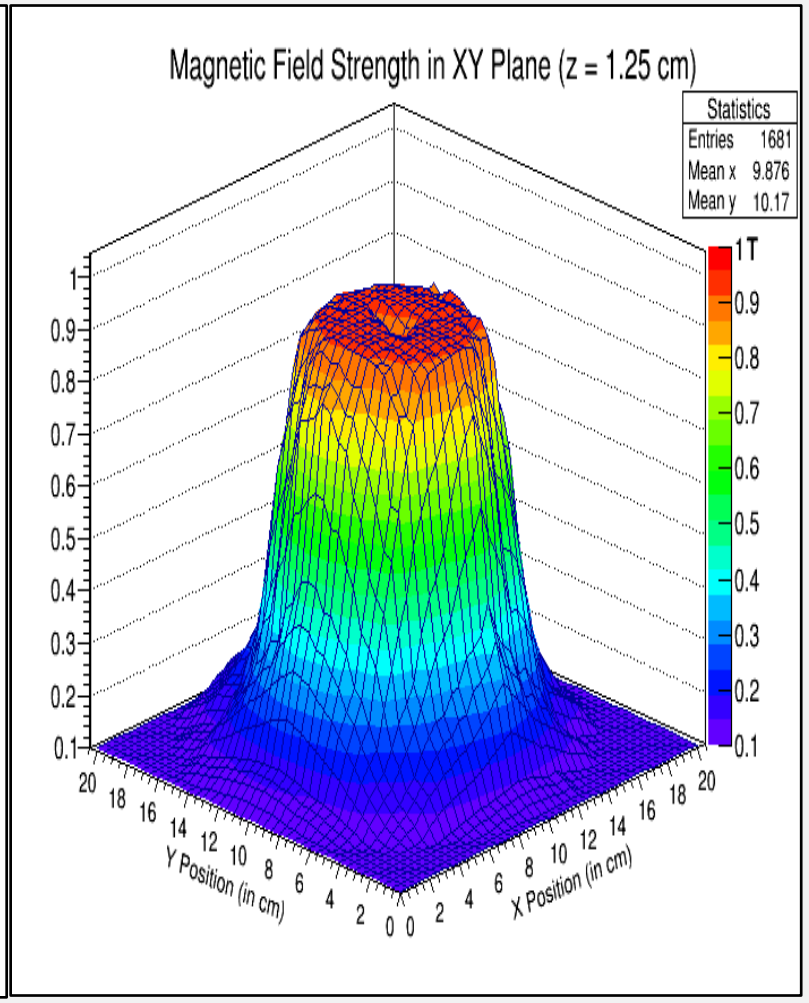
Electromagnet Field Mapping Results

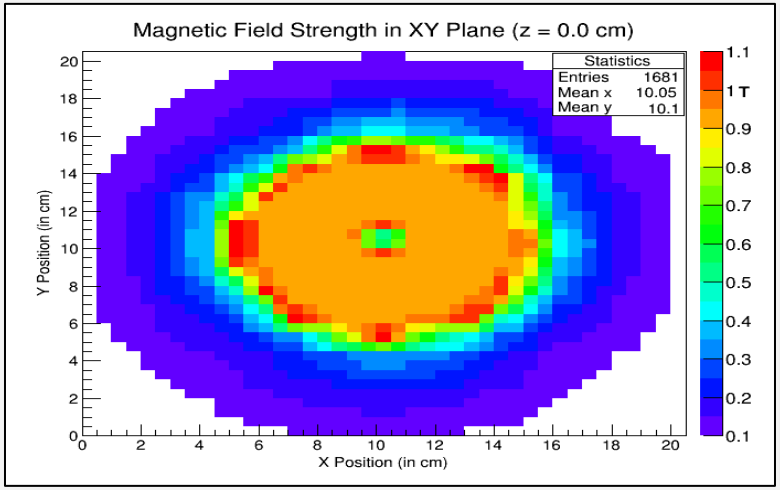
XY-Plane (Center):

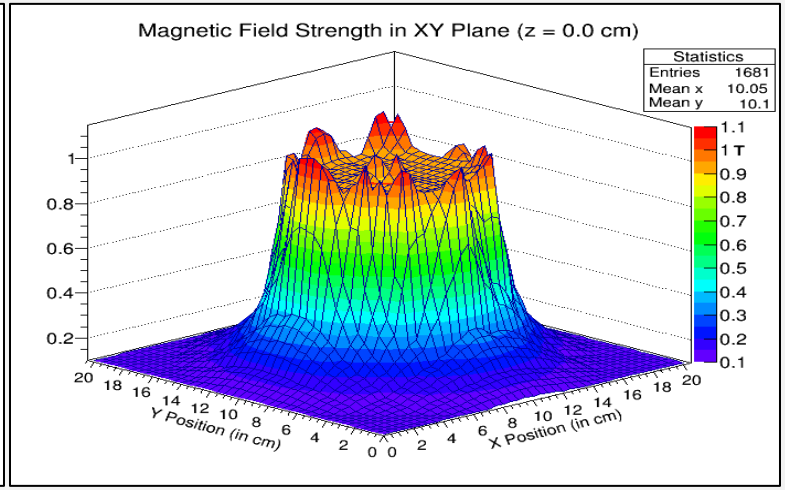


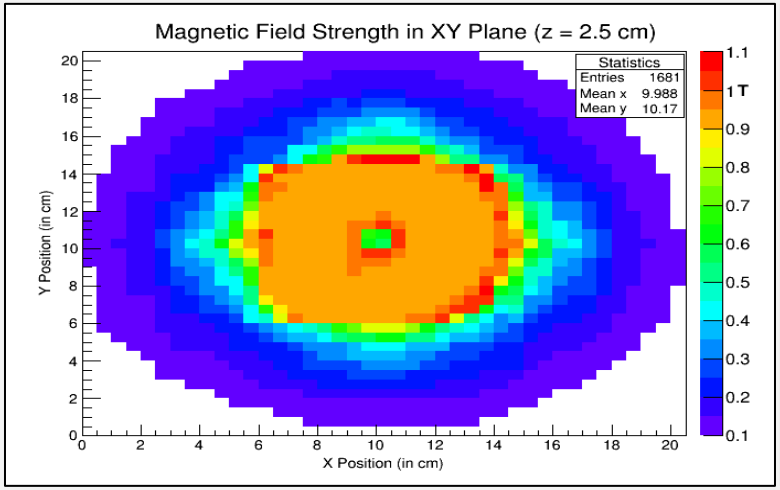


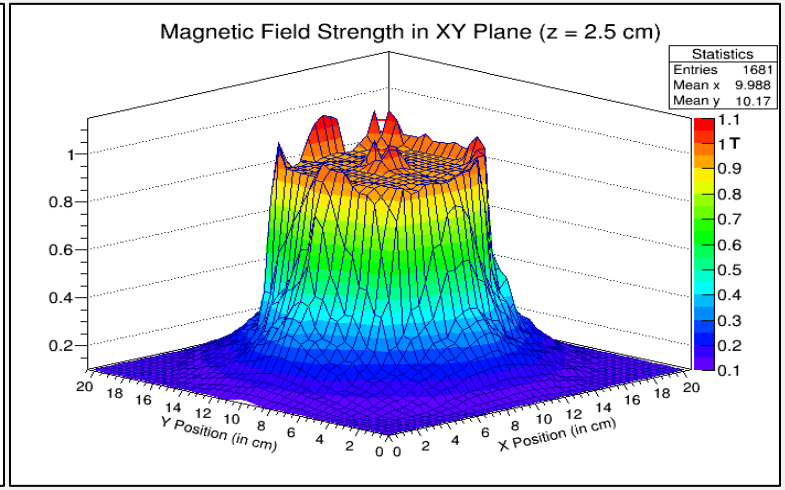
Electromagnet Field Mapping Results

XY-Plane (Pole Caps):









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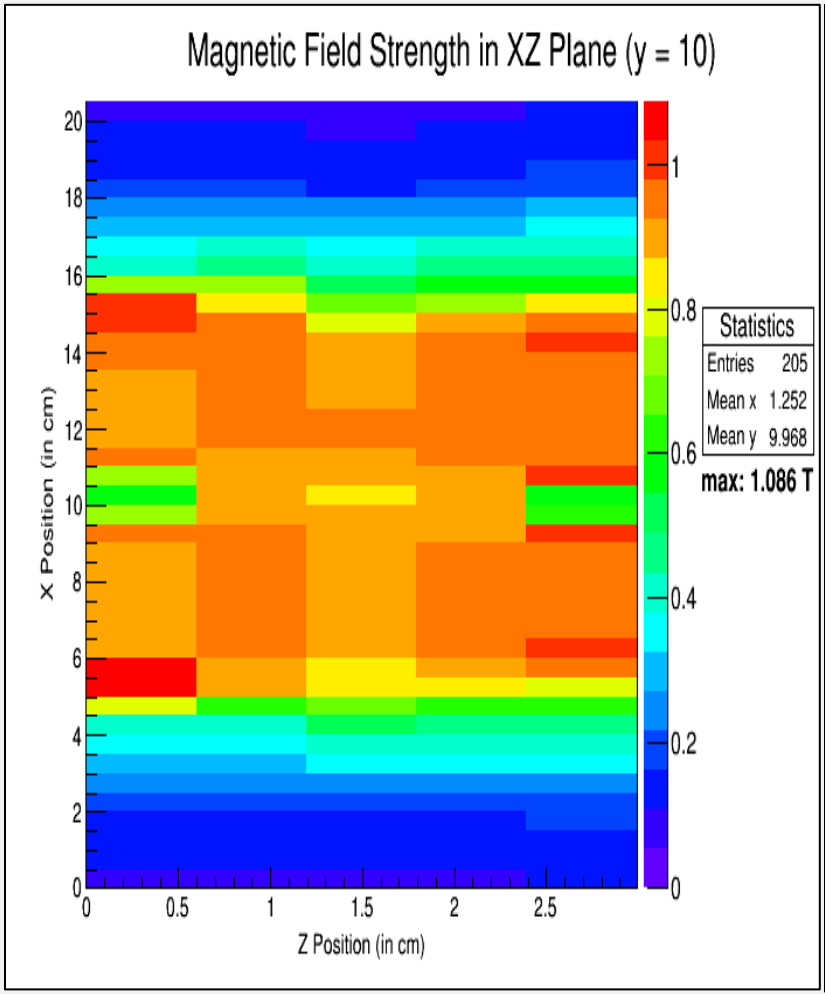
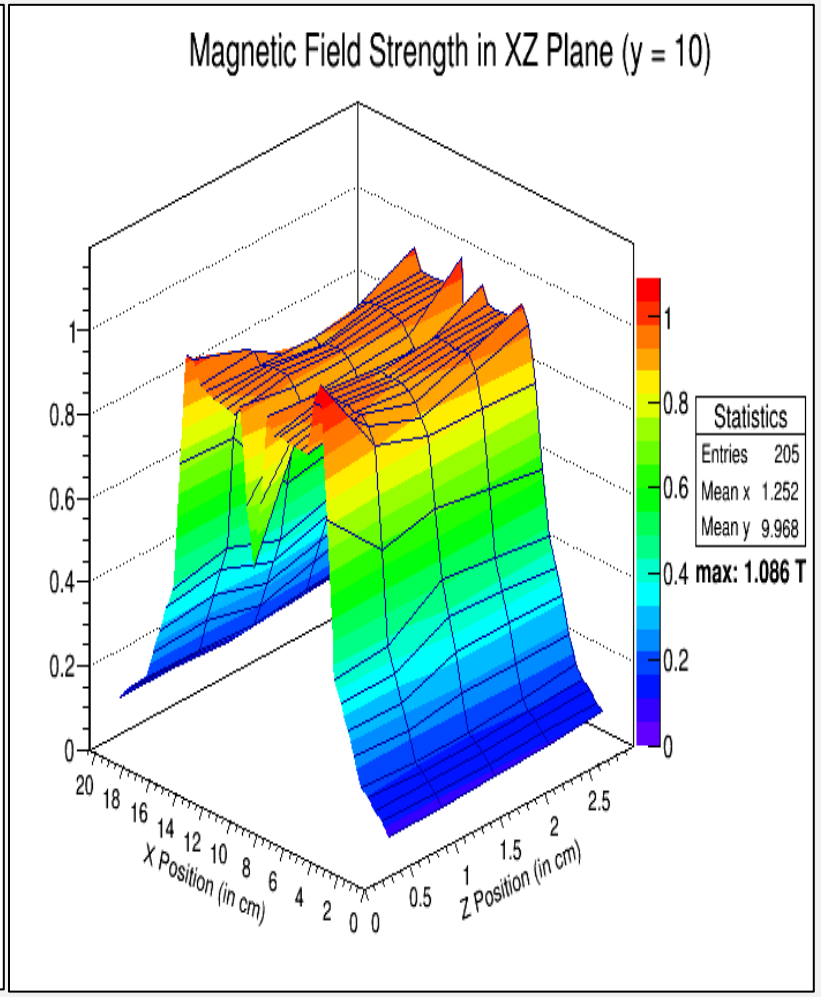
Electromagnet Field Mapping Results

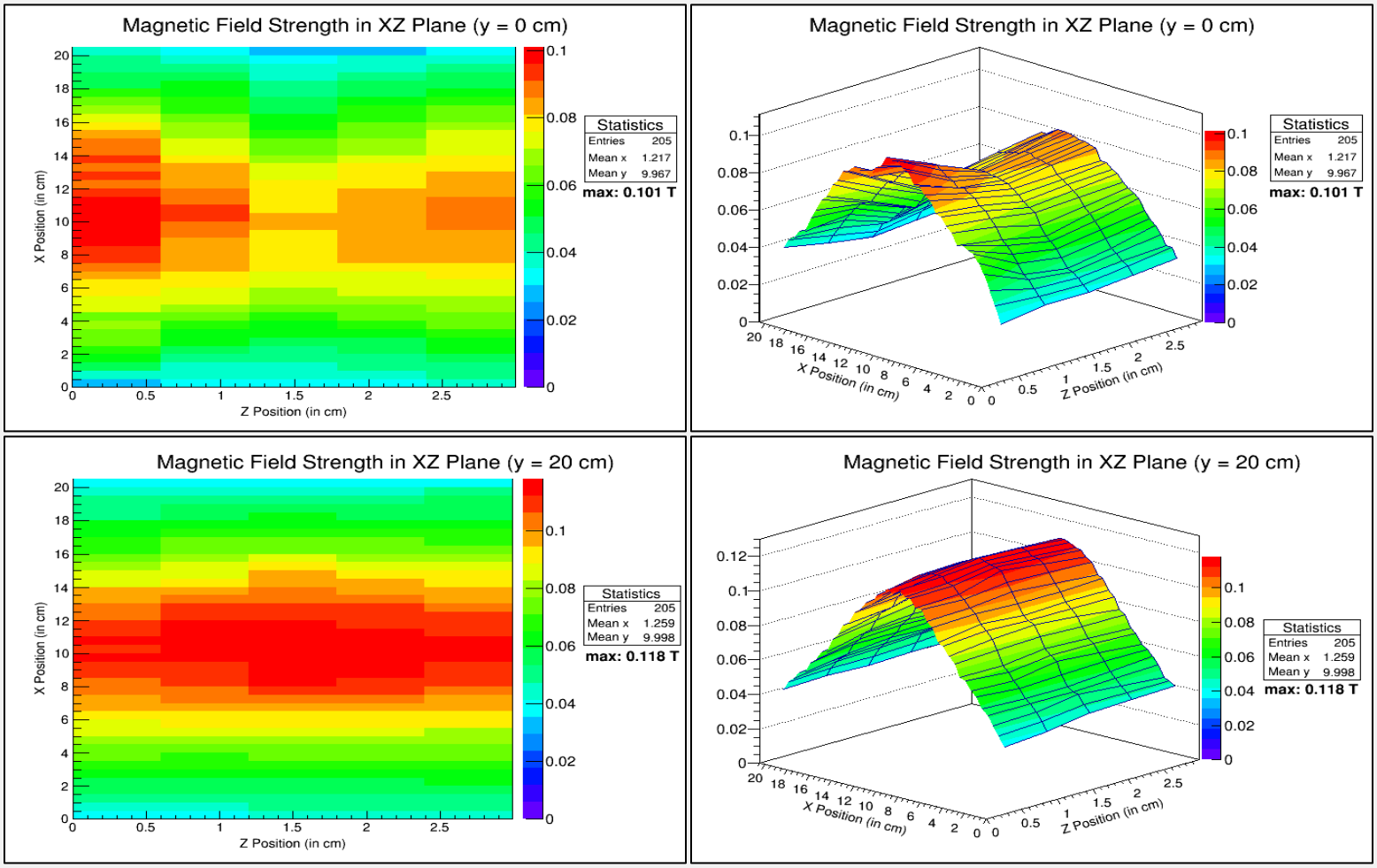
XZ-Plane (Center):





Electromagnet Field Mapping Results

XZ-Plane (Pole Caps):



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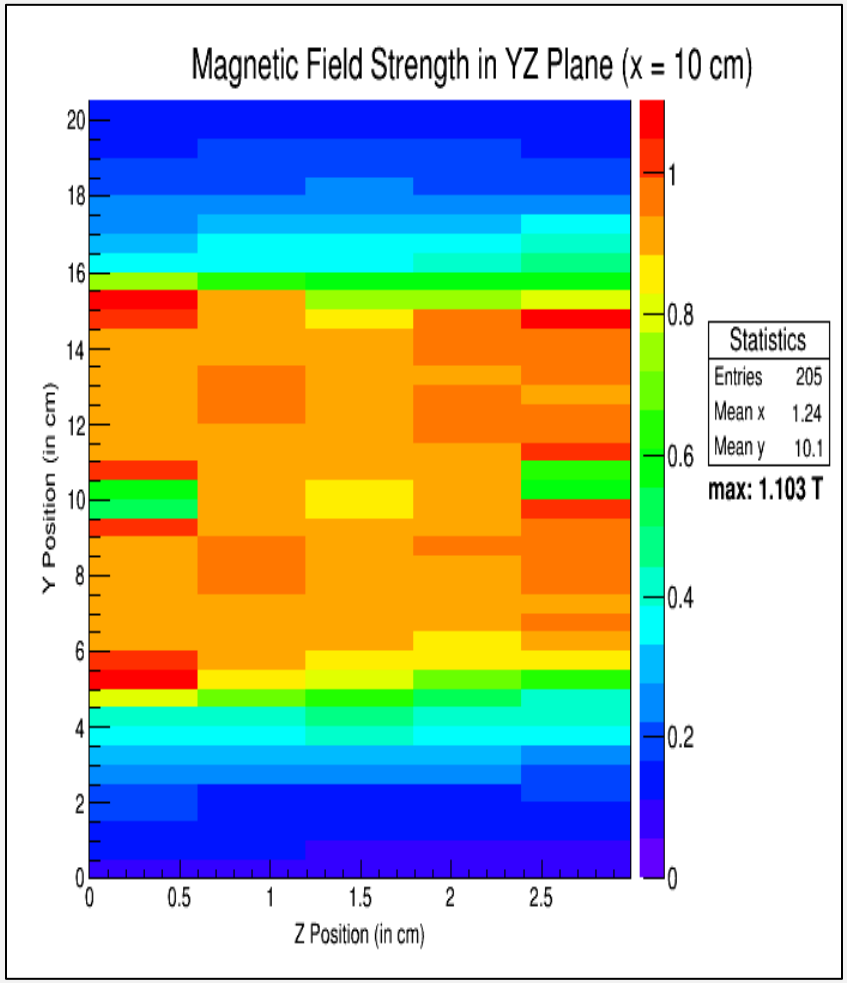
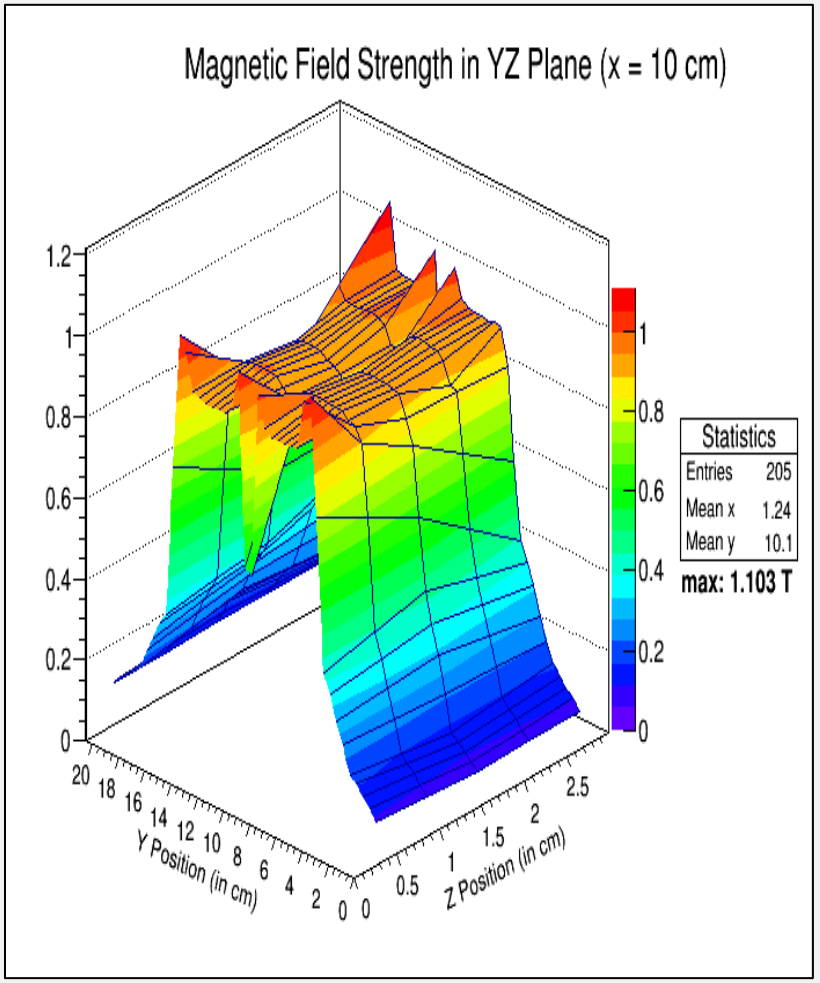
Electromagnet Field Mapping Results

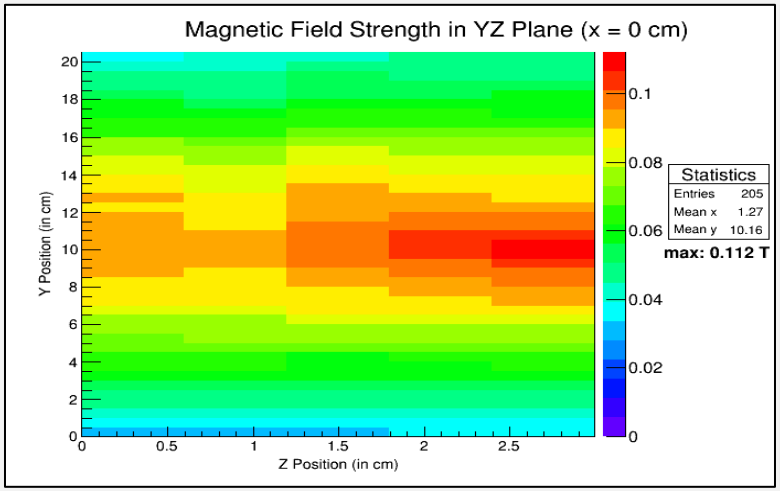
YZ-Plane (Center):

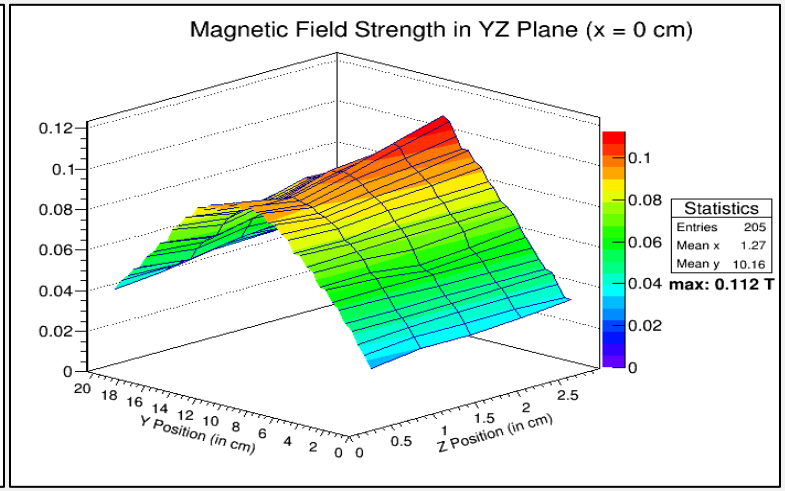


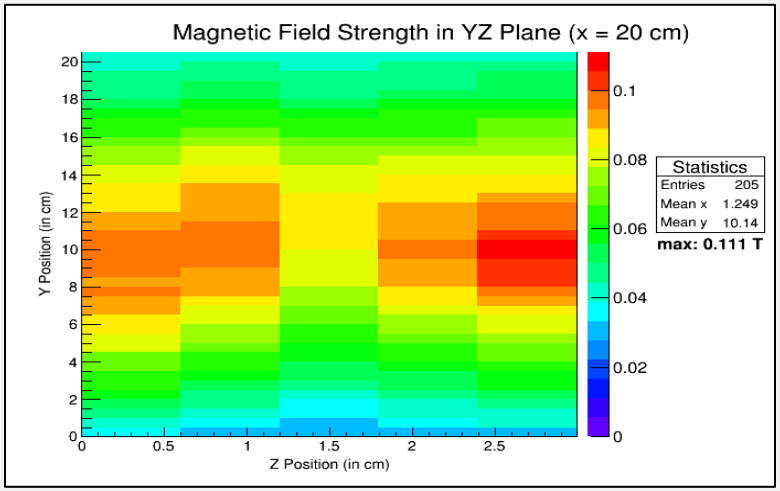


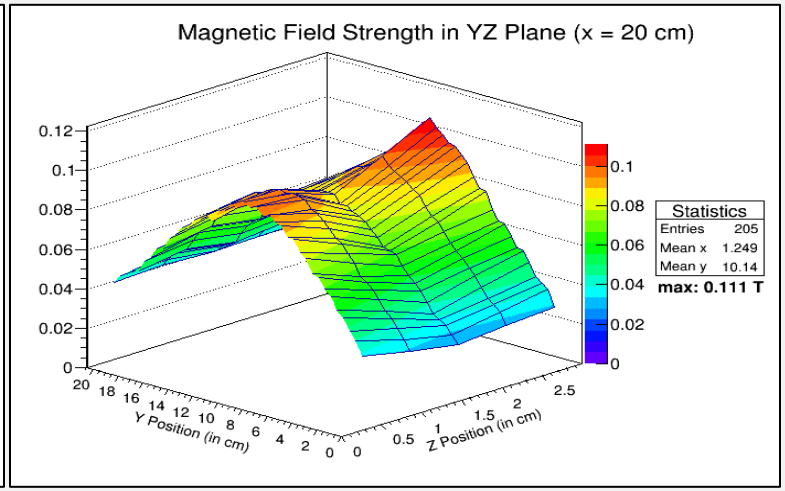
Electromagnet Field Mapping Results

YZ-Plane (Pole Caps):









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Electromagnet Field Mapping Results

Summary of Plots:

(1) The magnetic field strength can reach about **1 T**

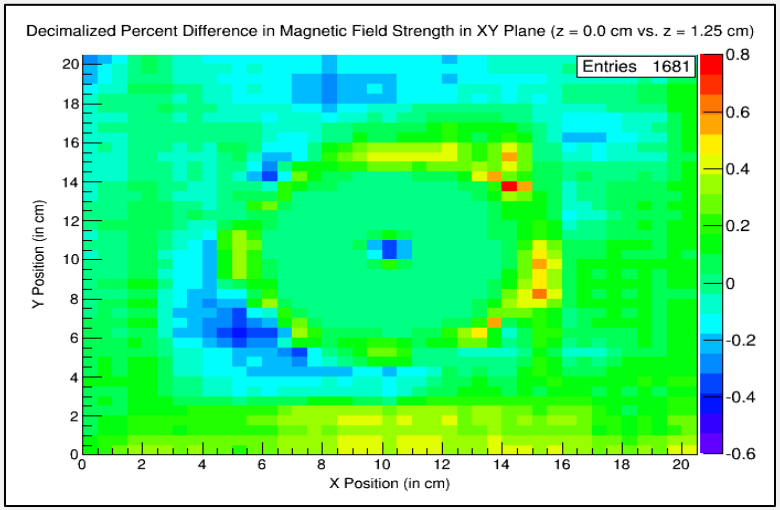
(2) The volume of the region: 20 cm x 20 cm x 2.5 cm = **1000 cm^3**

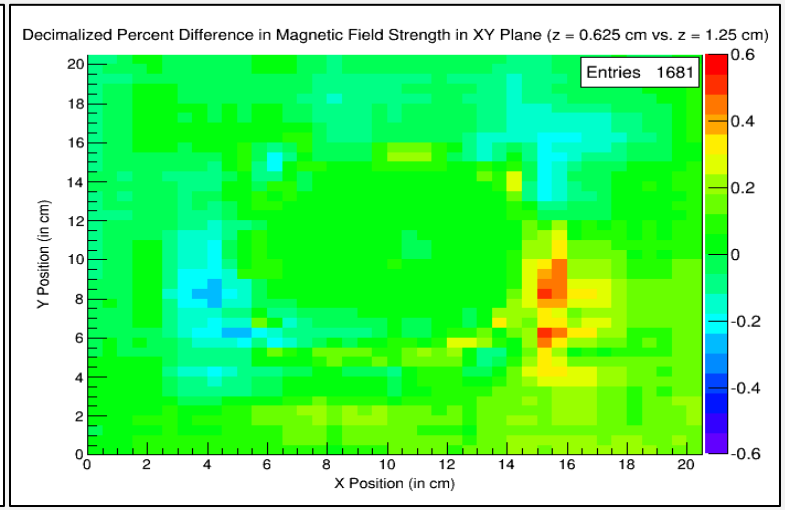
Interesting Features:

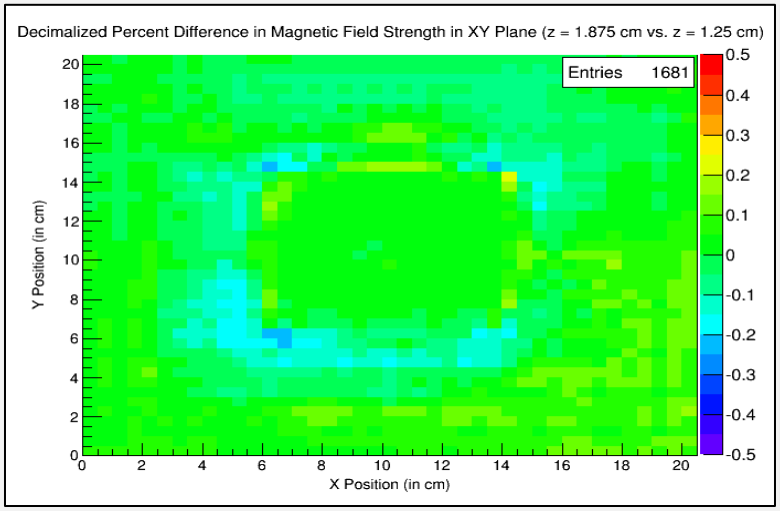
- Appearance of spikes in the field strength around the edges of the pole caps
  - Most likely due to fringing: higher density of field lines
- Decrease in field strength directly along center axis of pole caps
- Region of uniformity present in central part of the pole caps

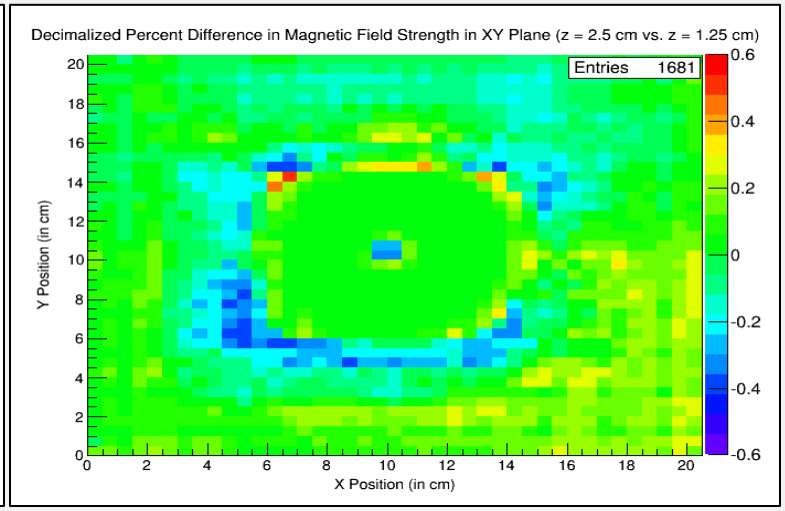
Electromagnet Field Mapping Results

Uniformity (XY-Plane):









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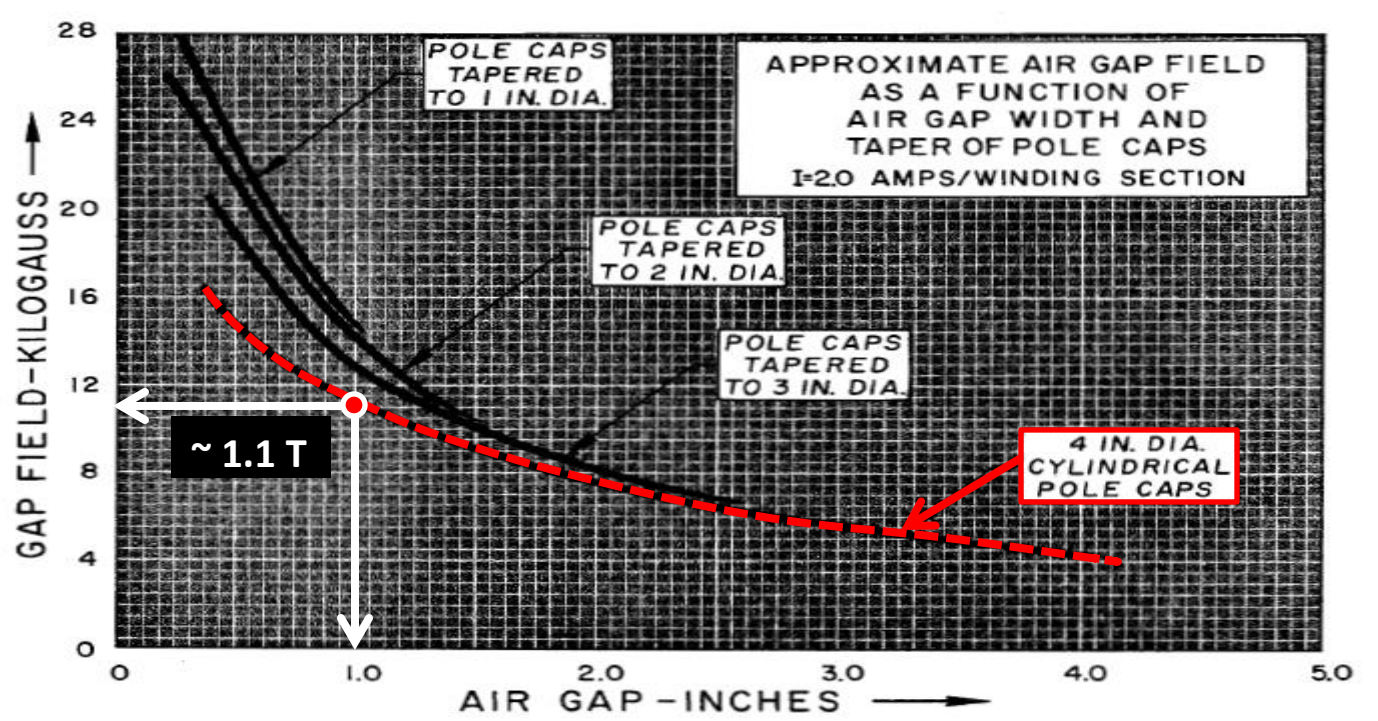
Electromagnet Field Mapping Results

Summary of Uniform Region:

(1) The magnetic field strength ranges from **0.90 – 0.95 T**

(2) The volume is approximately: 8 cm x 8 cm x 2.0 cm = **128 cm^3**

Maximizing the Field:



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Conclusions and Future Work

Conclusions for the LLB:

- The LLB has been successfully tested and investigated for its safety in shielding x-ray radiation. Under the maximum power settings of the Mini-X source, there is no significant difference between the measured counts as compared to background radiation.
- The LLB should be reassessed at locations which change from the current setup (i.e. access ports which are opened for gas lines or wiring).

Conclusions for the Electromagnet:

- The electromagnet has been mapped successfully and it has provided a nice visualization of the shape and strength of the magnetic field in the air gap.
- There is a distinctly uniform region at the central $1/10^{th}$ of the volume measured which is nearing 1 T.
- Mapping for electromagnet will need to be done again in the future after more power supplies are added and all coils are maximized.

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Conclusions and Future Work

Future of the LLB:

- The next step is to commission a detector. There are currently two prototypes present in our clean room. One needs to be placed in the box and tested for signal before performing standard experimentation. The other needs to be assembled and then moved through the same process.

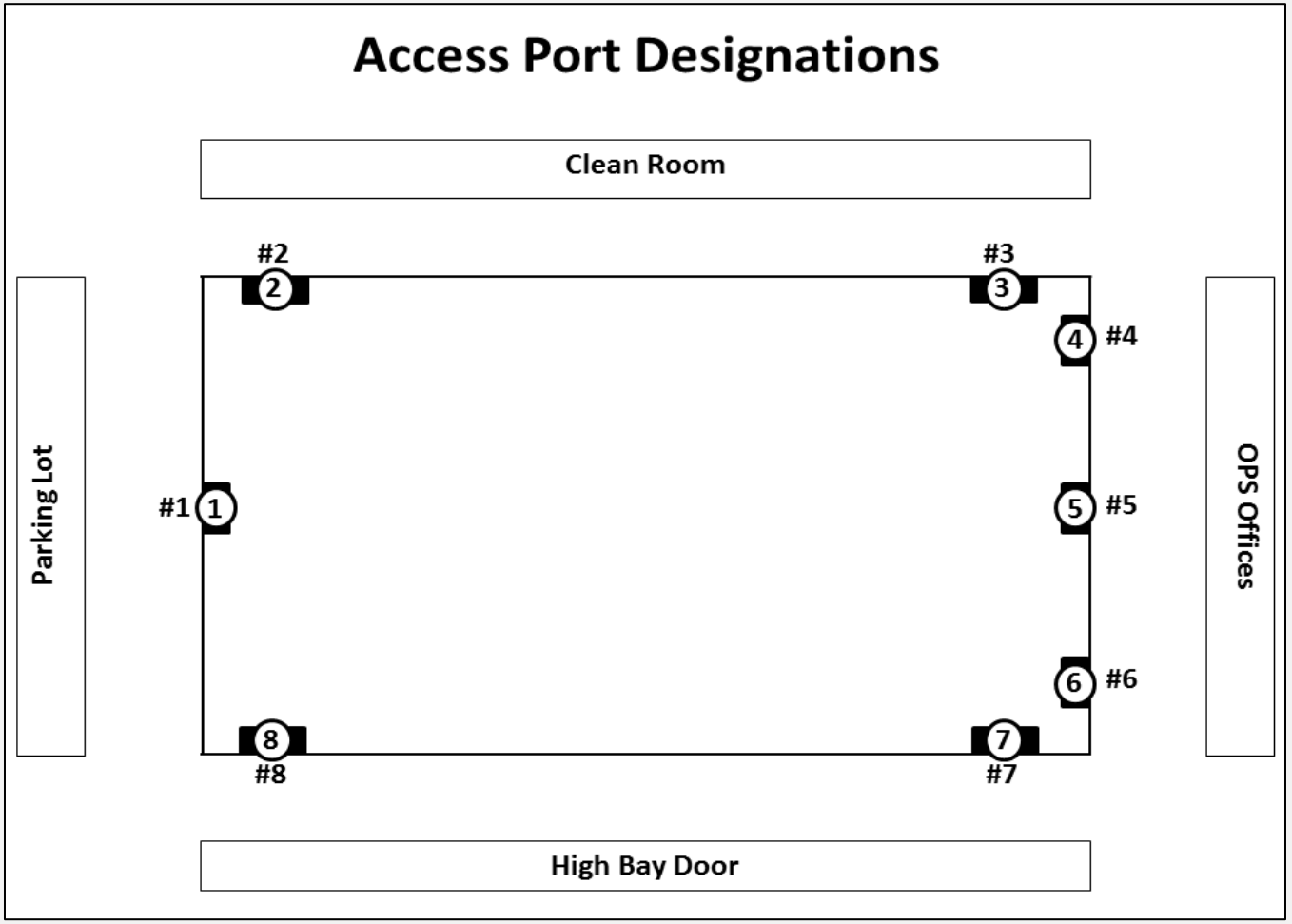
Future of the Electromagnet:

- The electromagnet has been an interesting side project. More power supplies are needed to maximize all the coils. After achieving this, a new map will need to be made to update all the values for the plots. The ultimate goal is to finish the hardware aspects of the magnet to allow for a 10x10 GEM detector to be placed into the field and studied with a small open source.

End of Presentation

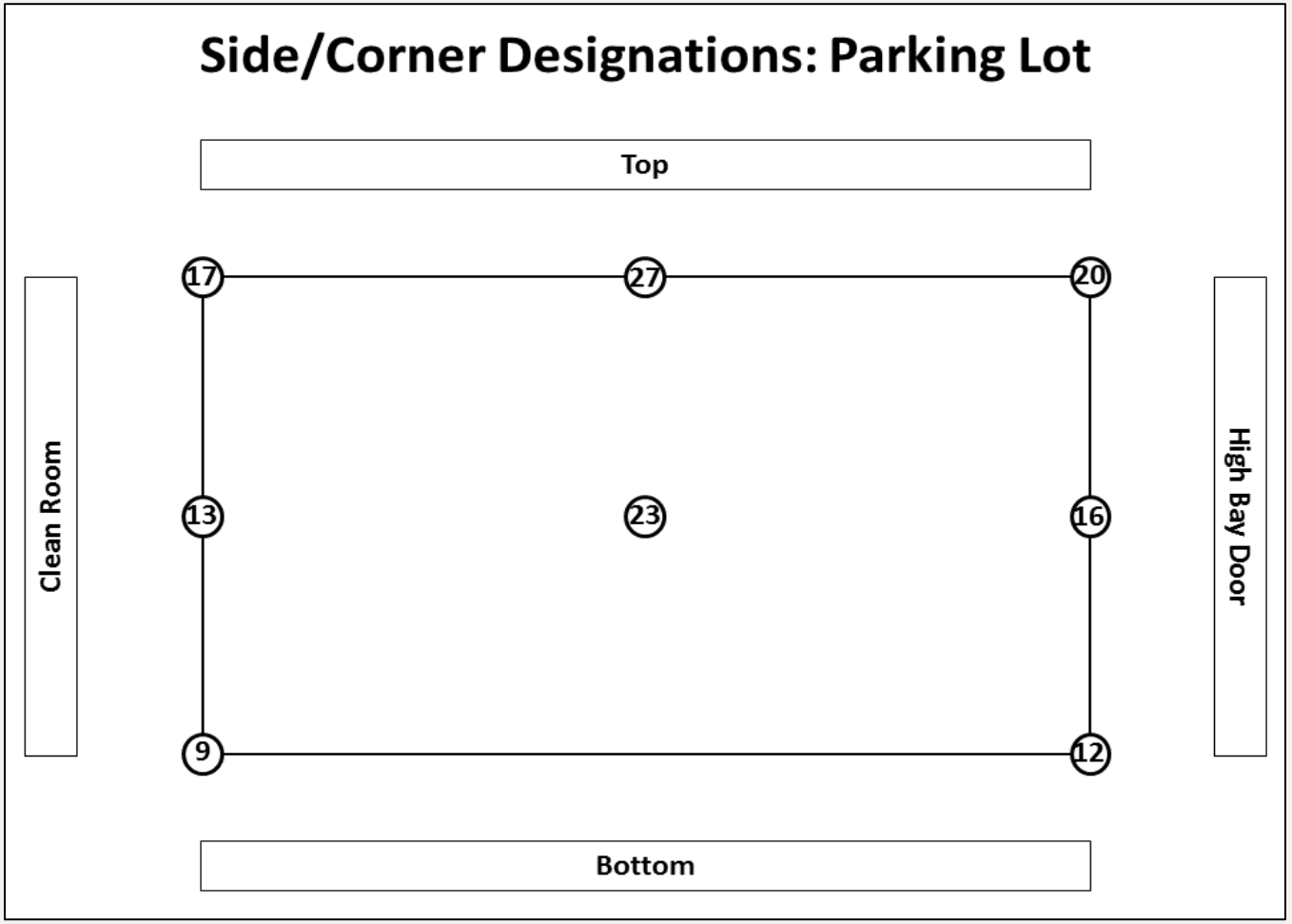
LLB Designation Charts

Access Ports:



LLB Designation Charts

Side Panels:



LLB Designation Charts

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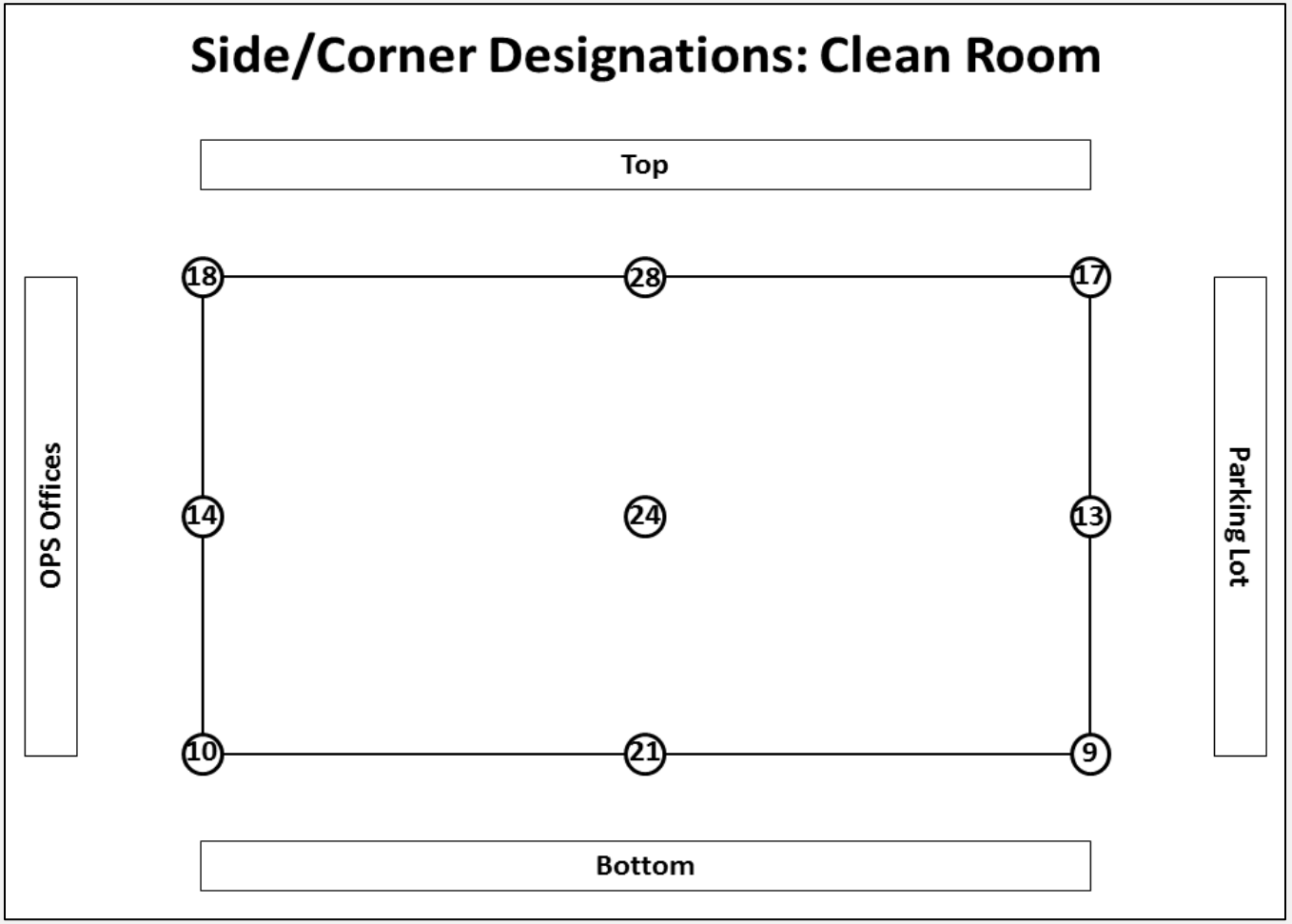

LLB Designation Charts

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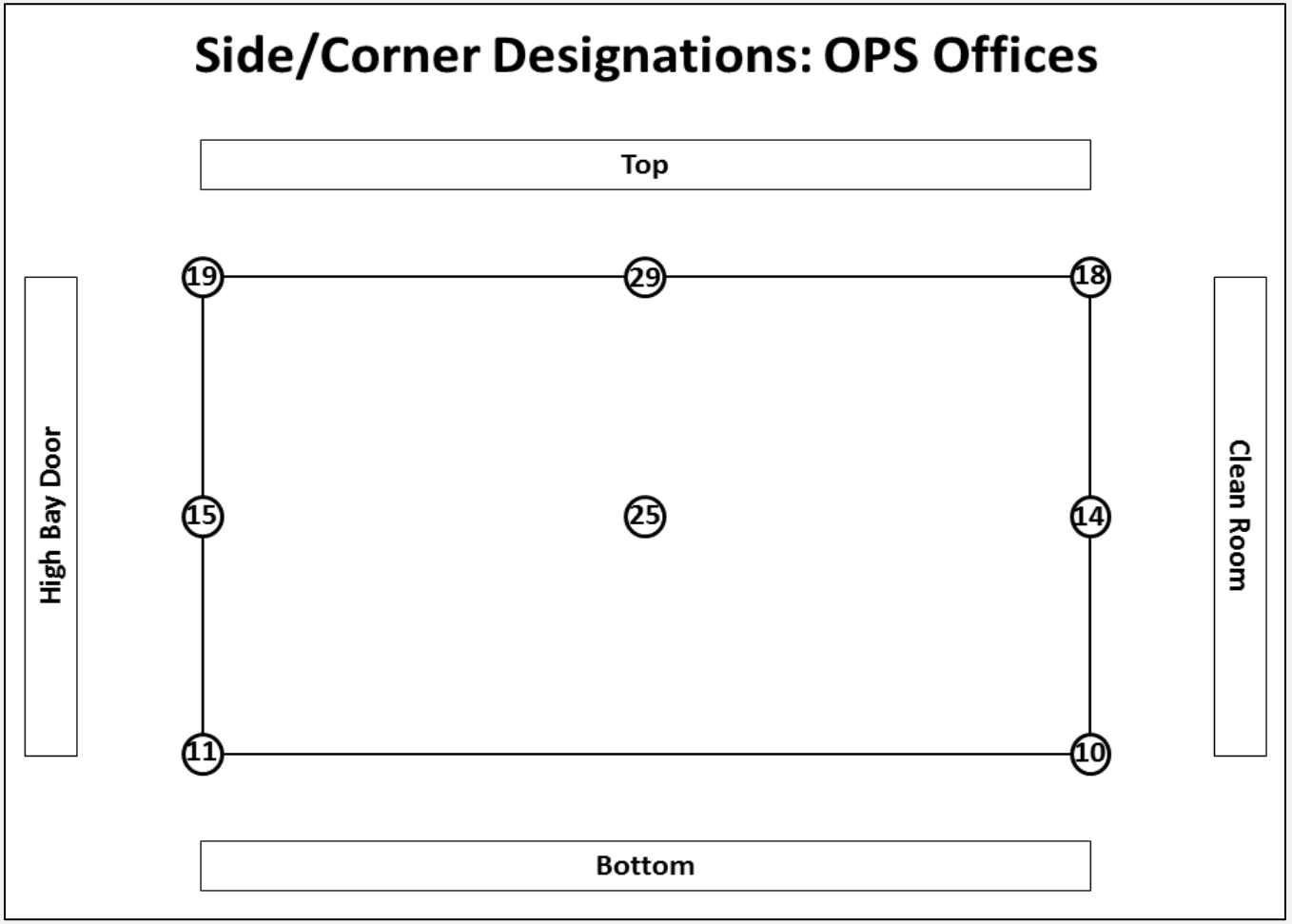

LLB Designation Charts

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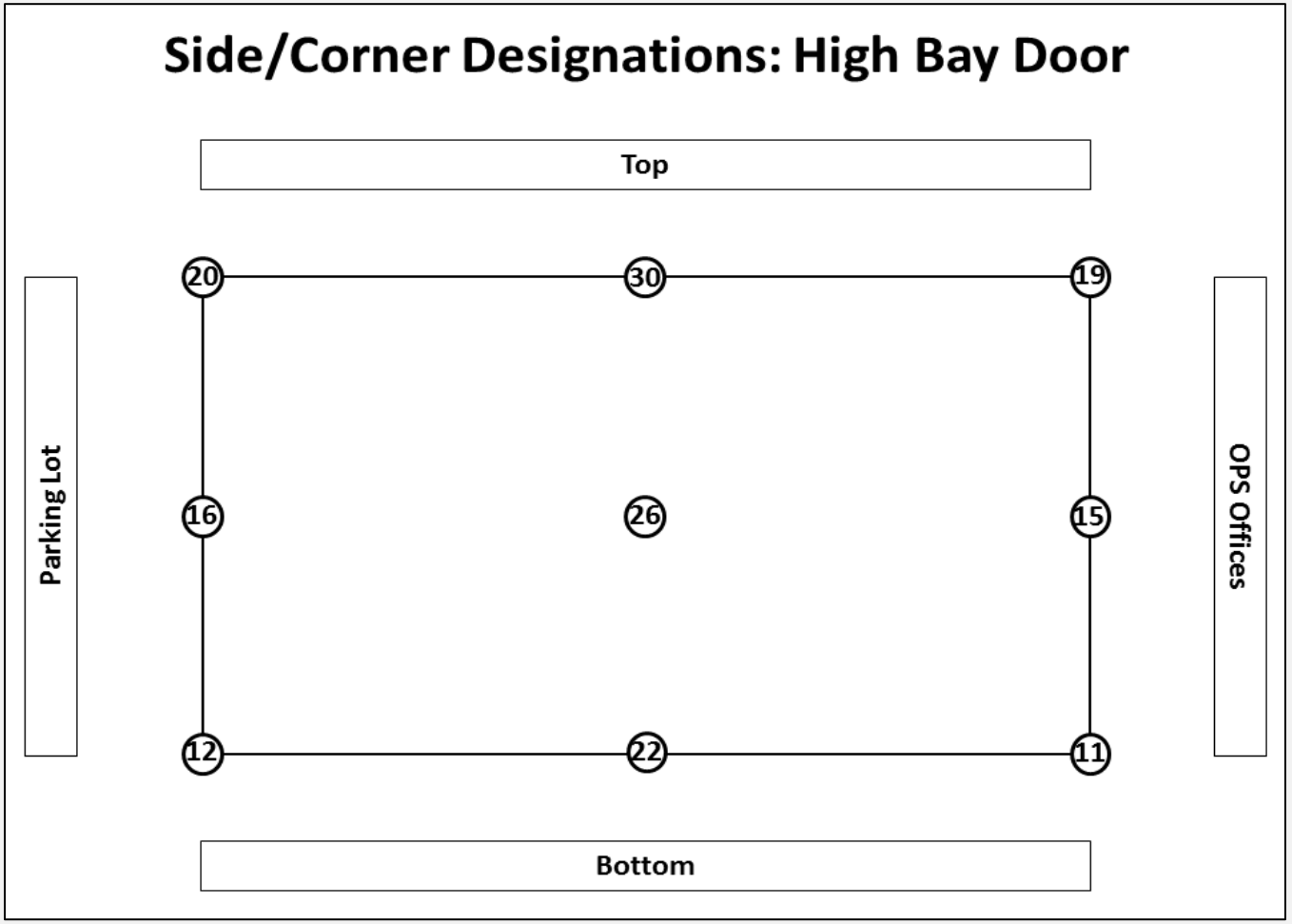

LLB Designation Charts

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