

Entrance to LINAC



Docent Awareness

- Crossing an area of traffic
- Can be slippery here
- Temperature differences between Wilson Hall, outside and the LINAC building
- Snow may not be plowed
- The Docent has the necessary training to enter.
- Can be a hazard to anyone with a medical device on or in their body, don't get too close to electrical devices.

Visitor Awareness

- Temperature differences between Wilson Hall, outside and the LINAC building Can be slippery here
- Fresh air!
- Where are we headed?
- Radiation sign on door, do I need to be trained, is it safe in here?
-

Facts

- The shape of Wilson Hall resembles that of a cathedral in Beauvais France
- The design of Wilson Hall is timeless.
- Wilson insisted on this design, it was contemporary and would stimulate interest investors.
- Actually two separate but joined buildings.

Start of LINAC



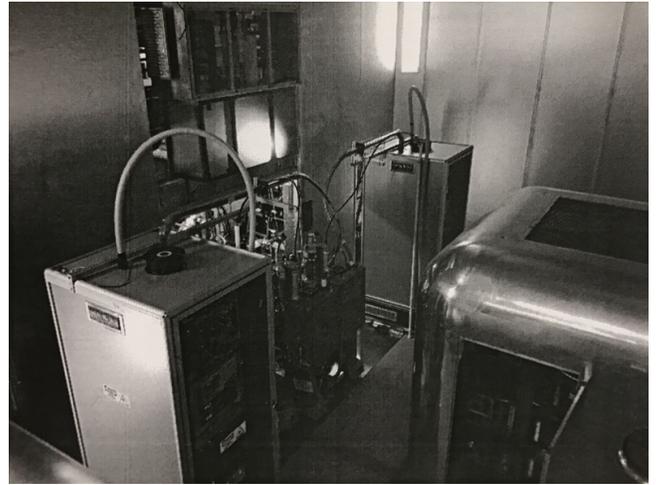
Visitor Awareness

- This is a workplace with a lot of stuff, old stuff too.
- Liquid Nitrogen tanks tanks, are we safe?
- This place is noisy, hot and looks like a factory.

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Physics Tour



Visitor Awareness

- Most of the old CW not removed, the "Cube" and the "Voltage Multiplying Ladder" are still in the pit
- What is the brown cage to the left.
- Why is that light changing colors.
- What is to the left that is hidden from me.
- What are the electronic cabinets on each side of the brown cages.
- The equipment looks old.
- Why accelerate $-H$ ions?

Facts

- We had 2 Cockcroft Walton Pre-Accelerators with Ion Sources. We now have 2 Ion Sources, and one Radio Frequency Quadrupole (RFQ)
- The brown cages are Faraday Cages, to prevent sparks.
- Two ion sources to always have one available if one breaks down.
- To the left of the Faraday Cages is the RFQ.
- One H_2 bottle will supply hydrogen for 4 to 6 months.

RFQ Overlook - Stairs



Docent Awareness

- Very narrow space
- Liquid Nitrogen tanks on left

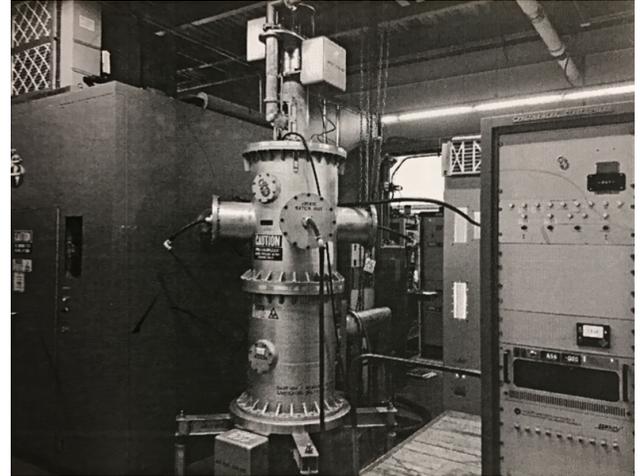
Visitor Awareness

- A lot of equipment around and in the way.
- Is this place safe?
- Where are we going next?
- What is that big bronze colored thing?
- Looks like old equipment.

Facts

- The brown cabinet on the right is generating radio waves for the RFQ
- The copper pipe carries the radio waves to the black box on the wall
- The black box is used to adjust the wavelength of the radio waves
- The rectangular aluminum box is the RFQ
- Look through the hole in the panel and view the RFQ and the “Buncher”
- The buncher forms the bunches of $-H$ ions that go into the LINAC

LINAC "Radio Station" - Tank 2



Docent Awareness

- Area of staff movement, be ready to make room.
- There is a lot of electrical equipment in this hall, keep the tour individuals away from it.
- "Do Not Touch" zone
- The pictures on the wall show the inside of the LINAC.

Visitor Awareness

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- Is this place safe?
- Where are we going next?
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Facts

- The inside of the LINAC pictures shows the Drift Tubes and the accelerating gap between.
- Drift Tubes have quadrupole magnets inside to keep the beams focused.
- There is a "standing" radio wave vibrating in the gaps.
- The wave vibrates 201 million times a second (201 MHz)
- In the center of the LINAC the electric field in the radio wave alternates directions as the wave vibrates, half of the wave will accelerate the ions, the other half will decelerate the ions.
- The Drift Tubes protect the ion bunches from the decelerating half.
- The large "triode" is a vacuum tube that amplifies the radio waves to a pulse of 5 million watts. (WGN radio broadcasts at 50,000 watts.)
- One pulse every 1.3 seconds.
- The large copper pipe coming out the back is a "wave guide" to carry the radio waves to a "trombone" that adjusts the wave length.
- 5 "radio stations" one for each of the 5 LINAC "tanks".
- The LINAC is an Alvarez LINAC, and is 300 feet long. It delivers beam to the High Energy LINAC.

Neutron Therapy



Docent Awareness

- Don't block the hallway, employees are moving about.
- Their backs will be to the electrical equipment, keep the away from it.
- It is loud, make sure everyone can hear.

Visitor Awareness

- The area is noisy
- Only old electrical equipment and a few pictures.

Facts

- Fermilab used to have a cancer treatment center using neutron radiation
- Neutrons (and protons) are good for tumors that are localized in one area.
- Neutrons cannot be focused into a narrow beam, protons can be focused
- Neutrons will break up DNA to kill the cell
- Protons can also breakup DNA, but work mostly through "free radicals" to damage DNA
- Fermilab developed the first small accelerator to accelerate protons for cancer treatment, and had it installed at the Loma Lynda medical center.
- Neutrons and Protons work best in soft tissue tumors such as salivary and prostate.

LINAC - Klystrons - Crossover hallway



Docent Awareness

- Do not block the halls, traffic from 3 directions.
- Keep the group together, and can hear.

Visitor Awareness

- Some may be needing a bathroom about this time
- A lot of different equipment and models at this

Facts

- The LINAC was built with 1950's technology, used equipment worked fine and saved a lot of money.
- The challenge is to keep it running for 5 more years until PIP II is ready.
- New technology is added to keep everything running, ie Marx Modulators
- High energy LINAC area looks and sounds different, newer technology.
- High Energy LINAC is 200 feet long and uses microwaves (806.1 MHz) instead of radio waves (201 MHz). More "kicks" per meter length.
- Klystrons tubes produce the microwaves. Big brother of magnetron tubes in your microwave ovens.
- Microwave ovens can be up to 1200 watts at 2.45 Ghz, this Klystron Tube operates at 12,000,000 watts at 806 MHz, pulsed once every 1.3 seconds
- The new Marx Modulator to your right, pulsed the electricity to pulse the microwaves.
- The model of the Main Injector would be a standard electromagnet, carrying so much electric current, it must have cooling low conductivity water pumped through a 5 gallons an minute.
- The large stainless steel pipes carry the cooling water.
- The copper "pipes are "wires" that carry the current to the magnets, and. They have cooling water passing through them.
- Above is the "Recycler", although it does not recycle. It used to store antiprotons, now it stores protons to be used in experiments.
- The recycle uses high tech permanent magnets, instead of electromagnet.
- There was doubt that it would ever work.

Berkeley Picture - Network and Computer Rooms

Docent Awareness

- An area of personnel traffic. be aware.
- Office is next door, keep noise down.
- Good place to wait if another group is ahead of you.
- Picture shows Lawrence's scientific team.
- The windows show both the network room and the computer room.

Visitor Awareness

- Why stop at a picture of old men?
-

Facts

- The picture has 2 Nobel Prize winners, Ernest Lawrence and Luis Alvarez.
- A young Robert Wilson is in the middle, he was a post Doc at the Lawrence Lab.
- In the top row, middle is Robert Oppenheimer, the picture is taken a couple of years before the Manhattan Project.
- The Network Room collects data from some 250,000 sensors on the accelerators and sends the data to the computer room to the left.
- The computer room, parallel processing "super computer" then processes the data to be displayed in the Main Control Room.
- They had to use a new technology, parallel processing to do this. The current technology of the time was the Cray computer with one very fast processor core, that had liquid cooling. It was not powerful enough to do the job. Our smart phones are more powerful than the Cray.

Physics Tour

MCR -



Docent Awareness

- Will look at through the windows at the main control room, and notice the sign “Do not feed the operators”.
- They will also look at the pictures behind them
- A operator may come out and talk to you,

Visitor Awareness

- Neat pictures
- What are they doing in this room?
- Do they feed the operators?
- Why is there all the beeping?

Facts

- All the accelerators needed to study neutrinos and Muons are controlled in this room, 24 hours a day, every day of the year. Even when shut down.
- To be hired you must have a bachelors' degree in physics, Fermilab will train you once you get hired. Usually takes two years or more.
- They monitor the weather because of lightning and flooding threats.
- The operators are the first line of defense, they can make changes in the MCR, or go to where the problem is check in out. They may have to call in a specialist, or as a last resort, shut down the beam.
- No one goes out on a repair alone, there must be at least two operators. They both must have access keys, and a restart cannot occur unless all keys have been returned.
- The small monitor above the window shows the current status of the complex.
- The beep you hear is the ID badge being read for access to the MCR.
- There is a beeping every 1.3 seconds in the control room as an audible reminder that all is well. This data comes from the Main Injector.
- 5 days a week there are three eight hour shifts. On weekends there are two 12 hour shifts.

MCR maps and Magnet Models



Docent Awareness

- May not have time to stop here if an operator talks to the group or Duane comes out.
- Good place to talk about Dipole and Quadrupole magnets
- The tack for the South Korean facility is actually in North Korea.
- Students may be looking at the map for areas they know.
- The map is an old one, things have changed.

Visitor Awareness

- What is shown on the map?
- Are any near me?
- Why isn't anything in Africa?
- What is at the far end of the hall?

Facts

- there are 2 quadrupole conventional magnets, 1 hybrid magnet, 2 superconducting magnets (dipole and quadrupole).
- There is a pressure relief valve and sensors.

Machine Shop



Docent Awareness

- Materials are all safely stored.
- This is one of several machine shops
- This is for hand made parts.

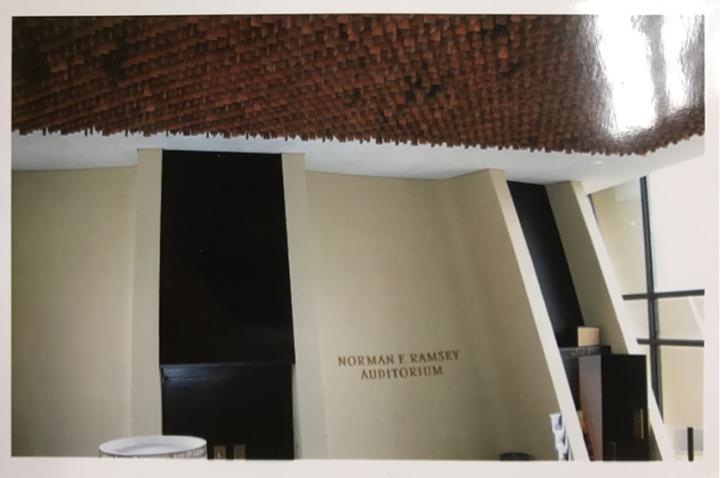
Visitor Awareness

- They do not think about prototypes or replacement parts that may be needed.
- you don't need a college degree, but you do need specialized training and skills.
- It has been hard to find qualified workers, and are now trying to set up an apprenticeships.
- Not a boring place to work.
- Safety records are on the wall.

Facts

- there are 2 quadrupole conventional magnets, 1 hybrid magnet, 2 superconducting magnets (dipole and quadrupole).
- There is a pressure relief valve and sensors.

Auditorium Lobby



Docent Awareness

- Who is coming and going through the area
- Are we nearing lunch time?
- Is there anyone in the Auditorium that we might be disturbing?

Visitor Awareness

- What is with the the ceiling?
- Can we go in the Auditorium?
- Can I take any of the flyers or pamphlets?

Facts

- Banners show the public events.
- There is a wide variety of lectures, cultural events and concerts.
- There is a cost for the events, look for them on the website register.
- Ceiling is made of black walnut, from trees that were illegally cut down and recovered.
- Flyers and pamphlets are free to take

The Auditorium



Docent Awareness

- Do I need to turn on the lights?
- Where **is** the light switch?
- Is the Auditorium in use, should I wait or come back.
- Can be used to introduce the LINAC part of the tour.

Visitor Awareness

- Interesting design, trimmed with recovered Black Walnut.
- What is the seating capacity?

Facts

- One of the few circular auditoriums with good acoustics.
- The black walnut was cut down illegally, and recovered, and dried and milled to be used for trim.
- The auditorium is used for major announcements by experiments, and the director, and the cultural activities listed outside.
- Docents may use this area for a time of questions
- Flyers and pamphlets are free to take

Wilson Hall entry and Atrium



Docent Awareness

- Is a Lunch count needed?
- Divide into the your groups?
- Remind students that their voice will echo throughout the building.
- Which docent is going where?
- Introduction to Fermilab, and ask what they know?
- Your chance to evaluate what the group knows, and what you need to cover.

Visitor Awareness

- Why all the plants, and why all the space?
- Do I really want to be here? Will I enjoy this?
- Will I understand anything that goes on here?
- What else can be done at Fermilab.
- This is different than I expected.

Facts

- Explain the 50th anniversary banners.
- Explain the rules and expectations for the trip.
- This is the only “single purpose” national lab, High Energy Physics. (Not atomic energy)
- Tell the story of the labs architecture.
- Fermilab studies the physics of matter and energy at the time of the Big Bang.
- The flags represent the different countries that have scientist at Fermilab.

ROC East (Remote Operation Center - East)



Docent Awareness

- What does the group know about CERN?
- Does the group know what is being monitored?
- During lunch, the group's attention may wander.
- Keep the group standing, and keep the way past the group open.
- Many distractions to overcome

Visitor Awareness

- The room is dark with many monitors
- Some people look to be working, others are watching the monitors.
- One monitor shows another control room somewhere.
- What is shown on the screens.

Facts

- Fermilab and CERN are partners and competitors, we cooperate.
- This room monitors what is going on in the CMS Detector at CERN. One of 4 experimental detectors on the LHC.
- The LHC at CERN is currently the largest, most powerful accelerator in the world.
- CERN is near Geneva Switzerland, and partly in France.
- CERN receives funding from many member countries.
- Fermilab does not take a shift monitoring the detector, but all the data comes to Fermilab to be shared with other countries

ROC West (Remote Operation Center - West)



Docent Awareness

- Time to explain Neutrinos and Muons, and the experiments that are monitored here.
- Need to maintain quiet in this area, people are working in hear.
- NOVA, MINERvA, and the new neutrino and muon experiments will be monitored here.
- DUNE will be monitored here when it begins.
- Can use the small monitor to show pictures to the group.

Visitor Awareness

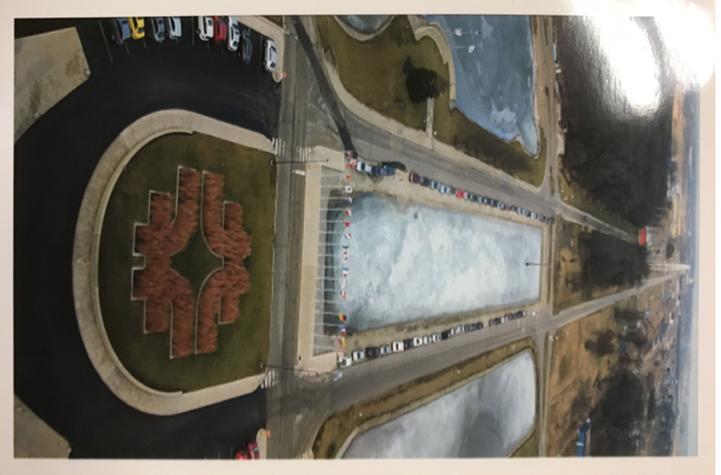
- What is this room?
- What is being done in this room
- Why all the monitor screens on the wall?
- What is shown on the screens.
- What is that junk on the bench where I could sit?

Facts

- This room monitors and controls the experimental detectors of NOvA, MINERVA, the three new short range neutrino experiments, the two new muon experiments an DUNE.
- The experiments are trying to learn about the neutrinos oscillating between the 3 types, and the masses of each.
- There are 3 neutrino waves that interact to make the three flavors of neutrinos.
- The sun sends electron neutrinos to the earth, we can only detect about a third of them, why.
- At least 100 trillion neutrinos pass through each second, but do not interact with the atoms in your body.
- Neutrinos produced at Fermilab travel through the earth to Northern Minnesota to our experiments there.
- Neutrinos may explain why there is more matter than antimatter, Dark Matter and the early universe.

Physics Tour

15th Floor - North window



Docent Awareness

- Where should I stand?
- What “Story” do I tell and how much of it, History and or the Science?
- Which buildings or areas should I talk about?
- Start at the window or the table?
- Should I point out areas in at the window or ask for questions about what they see.
- Do I have time to tell the story of the “Obelisk”

Visitor Awareness

- I do not want to go near the window.
- Can i sit down and listen?
- Why are the building all blue, with some orange or yellow.
- Can I look down into the atrium>
- What can I see that I know out the window.

Facts

- Explain the LOGO which is in the middle of the circle, made from Little Bluestem grass.
- The flags are from countries, users and contributors
- You can see 3 former experimental areas, the power lines coming in, and the different ways we use the land, and different experimental ares.
- 6800 acres, over 10 square miles, including to former town of Weston, Illinois.
- Mostly family farms before Fermilab.
- Fermilab supports the 5 legs of our culture: Scientific excellence. Nature, Aesthetic beauty, Equality of opportunity, Fiscal responsibility.
- Tell the stories of the power poles, the obelisk, and the gradual change of the lab.
- Why was this site chosen for the National Accelerator Lab. Major universities, 2 airports, railways, the national highway system, abundance of electrical power, industry, and Everett Dirkson.

Physics Tour

15th Floor Theater



Docent Awareness

- Where are the other docents on this floor?
- Noise level, this is an office area.
- People will be exiting and entering the elevators.
- The theater may be used for discussions and/or videos.
- Model of the Dark Energy Camera can be used.
- Can talk about Quarknet and Silicon Vertex.

Visitor Awareness

- I see displays and objects around me.
- They will want to set down.
- What else is going on up here.

Facts

- How to make a neutrino beam.
- Dark Matter and Dark energy.
- Discuss prairie life.
- Short videos can explain things instead of you.
- Visitors are now welcome on the 15th floor if they want more time.

Transitions/Logistics

15th floor overview



Pictures 1

- Move groups to different areas of the Atrium to find quieter places.
- Separate the groups in front of the atrium.
- good areas are in front of the information slide show, ROC East, and ROC West.

Picture 2

- You can talk about conventional and superconducting magnets in the mock-up.

Facts

- You can see the savannah in the middle.
- We have volunteer seed collecting in the prairie.
- The circular berm with pipes on the top marks where the Main Ring and Tevetron are.
- Ponds never dried up or froze over while the main ring was operating.
- The prairie in the center is the Robert Betz prairie, Betz started the restoration program.
- The prairie is burned every 3 years, and other areas are burned every three years. This helps maintain the prairie.
- Fermilab is rich in different types of habitats, thus many different kinds of plants, and many different kinds of animals and birds.

Visitor Awareness

- The views can capture their attention.
- Ponds are drying up, why?
- Why is that one area mowed just to the east.

15th Floor Main Ring Mock-up



Docent Awareness

- Other groups may want to pass by going in or out.
- The group may be looking in the mirrors.
- It gets hot in here during the morning, the sun can be bright.
- Good view of the Main Ring program buildings.
- You can mention IARC while in here.

Visitor Awareness

- It is hot in here.
- Does this relate to what I see outside?
- Ponds are drying up, why?
- What can be seen from up here?
- Why is that long narrow area mowed?
- What is this picture showing and why is it here?

Facts

- Both the Main Ring and the Tevatron exhibit Dipole and Quadrupole Magnets.
- The Main Ring needed pipes to carry cooling water, and the wires that carried the current also had cooling water in them.
- There is a sextupole magnet for focusing and dipole magnet to position the beam in the beam pipe.
- The beam pipe is rectangular because the magnet and pipe are straight and the beam is curved.
- The prairie in the center is the Robert Betz prairie, Betz started the restoration program.
- The Savanna is in the middle of the ring prairie.
- The mirrors give you the impression of what it looks like in the main ring.
- D0 (DZero) can be seen straight across the ring.

15th Floor Applications Hallway



Docent Awareness

- Quiet, people are working through the doors.
- Groups may also be in the south balcony
- A lot of movement through this area.

Visitor Awareness

- What do all the pictures tell us.
- What does this mean to me?

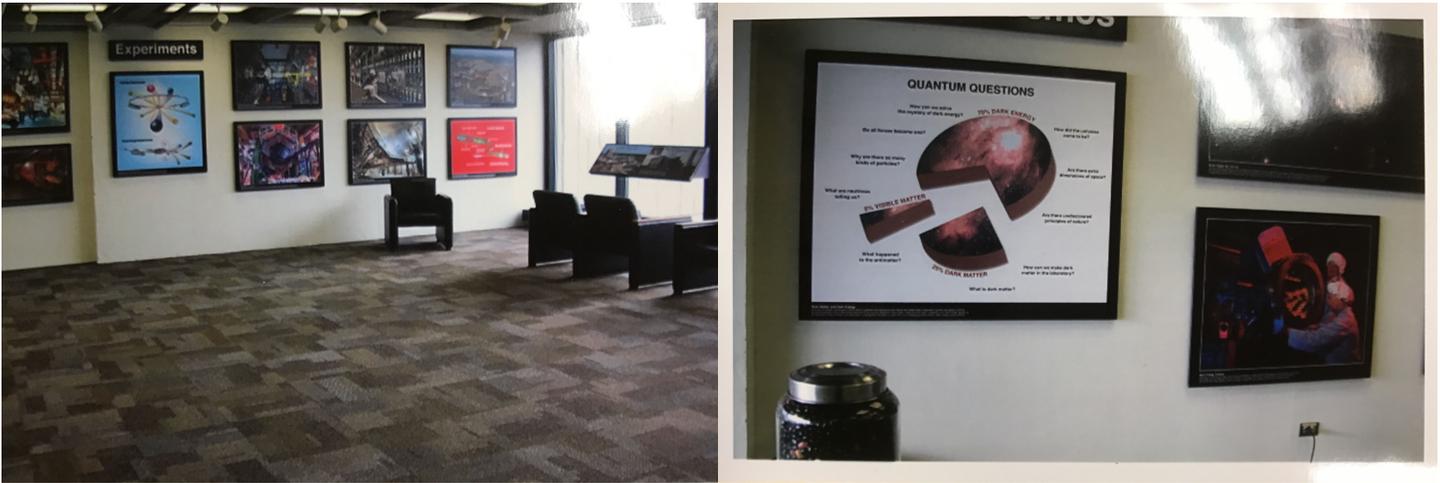
Facts

- We have MRI's because of the superconducting wire technology developed at Fermilab
- PET Scans are possible because of the production of radioactive isotopes and because of the detector technology from High Energy Labs like Fermilab.
- Shrink wrap materials are made possible by electron accelerators.
- Containers can be scanned quickly because of x-rays produced by accelerators.
- Drugs, diapers, can be made better because x-rays can be tuned to study specific structures.
- Detectors developed from accelerators helped locate areas in the great pyramids, and used to get and image of the damaged Japanese nuclear reactors using cosmic muons.
- Artificial body parts can be made stronger by bombardment

- Other groups may want to pass by going in or out.
- The group may be looking in the mirrors.
- It get hot in here during the morning, the sun can be bright.
- Good view of the Main Ring program buildings.
- You can mention IARC while in hear.
- These accelerators and no longer operating.

Visitor Awareness

15th Floor South Crossover



Docent Awareness

- Be aware of other groups behind or in front of you
- Can use to set up the rest of the tour.
- Pictures can be used as an introduction.
- Show where the tour comes out on the way back to Wilson Hall.
- Review what has been seen during the tour.
- May be tired by this time, or the sun may be hot through the windows

Visitor Awareness

- What can we see out the window?
- What are the exhibit by the north windows?
- Why do they have jelly beans in the jar?

Facts

- After 2000 years or more of study, we only know about 4% of the universe. What is Dark Matter and Dark Energy.
- Dark Matter has many forms or evidence, but nothing has be found to account for what it is.
- Dark Energy is causing the universe to expand faster, not slow down.
- Dark energy was discovered by scientists looking for “a standard candle” which could be used for measuring the distance to galaxies.
- There is a Microwave Linear Acceleration tank in the cast. You can see that the Drift Tubes in the middle get longer as you go to the left. Why?
- There is an early version of a RFQ that was developed in Russia.
- There is an imaging disk from the Sloan Digital Survey. The green fibers would carry light from individual galaxies to spectroscopes that would record their light spectrums.
- Walking along the detector pictures with people in them gives a sense of perspective and scale.

15th Floor South Window



Docent Awareness

- This room can get crowded quickly
- Employees on both side of the room
- You could spend too much time in this room
- Dark Matter, Dark Energy, and atomic scale come into play here.

Visitor Awareness

- Is that smoke coming out of that building?
- Why circular accelerators?
- Why all the ponds of water on site?
- What are those new buildings

Facts

- You can talk about Astrophysics in this room, dark matter, dark energy, and cosmic rays, and the Sloan Digital Survey.
- From the south window you can see the booster ring, the main cooling plant, the Muon Accelerator, Muon G-2, Mu2E.
- The Auditorium roof and the Mobius Strip can be seen from here.
- You can see the LINAC building and the main control room building.
- The Main Injector Ring can be seen in the distance.
- You could talk about the production of antiprotons at Fermilab.
- You can see the SBNE behind the forest and MU2E
- The Jelly Beans illustrate the Visible, and Dark Matter plus the Dark Energy
- You can explain the Standard Model using the poster on the wall.