FRA Request for Information – MAGIS-100 Quantum Sensor

Issue Date: 5 October 2022
Site Visit Details: 1 November 2022
Last Day to Contact FRA re: Interest in Site Visit: 21 October 2022
Questions Regarding this RFI during the open period should be directed to:
Grace Gomez: ggomez@fnal.gov
Questions Deadline: 4:00-PM 8 November 2022
Due Date and Time: Noon, 18 November 2022

Sources Sought and RFI

Request for Information (RFI) for the 100-meter-long Matter-wave Atomic Gradiometer Interferometric Sensor, also known as MAGIS-100, at Fermilab in Batavia, IL. Installation of both the detector along its support structures and utilities will be open for bidding at a future time. In anticipation of a solicitation for the services described below, Fermi Research Alliance, LLC. (FRA) is conducting this RFI to gather supplier input regarding the capability, availability, and feasibility of performing this work. Please review the preliminary specifications and scope of work provided in this RFI. FRA is requesting suppliers provide feedback on the project description below, including responses to the questions listed at the end of this RFI.

Summary

MAGIS-100 is a quantum sensor under construction at Fermilab that aims to explore fundamental physics with 300+ foot-long atom interferometer. The experiment will be installed vertically in the 313-foot section of the vertical MINOS shaft at Fermilab.

The Installation will be broken into two components: civil construction and experiment installation. The main civil construction tasks are (in order of operation):

- Move an existing 26-inch diameter airduct that runs the entire length of the shaft.
- Install utilities:
    - Installing two (2) 12-inch cable open ladder style trays that will run vertically 300+ feet down the shaft wall.
    - Installing eight (8) 1-inch conduits with various junction boxes at specified points down the shaft wall.

    - Pulling between three (3) and ten (10) wires (10-AWG or higher) down each conduit.
    - Install three water chiller & supports
    - Install compressed air plumbing
- Attaching 34 experimental module supports to the shaft wall.
- Attaching the “rough vacuum station” support to the shaft wall.
- Attaching three “atom source” supports to the shaft wall.
- Attaching the “retro-mirror box” support to the shaft wall.

Experimental Installation Tasks are broken down as follows:

- Lowering each of 17 modules down the shaft and into their respective module support structures.
- Installing the rough vacuum station at the bottom of the shaft.
- Lowering each of the three atom sources onto their respective stands.
- Installing the 15-foot telescope atop the highest module.

FRA will then:

- Complete the interfaces between each module.
- Complete the interfaces between the atom sources and the interferometer.
- Complete the interface between the rough vacuum station and retro-mirror box with the interferometer.
- FRA Alignment & Metrology department will independently verify positions of the hangers and experimental apparatus.

Anticipated Time Frame

Jan-March 2023 - relocate air duct, install compressed air and electrical power
March-May 2023 - install cable trays
May 2023 - install cooling water
June-July 2023 - install cables
July 2023-Oct 2023 - install wall supports
Oct 2023-Dec 2023 - install experiment

Requirement Description

The vendor will complete both the installation of experimental infrastructure – module supports, cable trays, wire conduits, etc. – and the experimental modules and atom sources, and other components as noted.

The MAGIS-100 experiment will be installed in the existing MINOS experimental access shaft. The shaft is approximately 360-feet deep from the surface to the lowest point. It has a semi-circular shape with a radius of 11-feet; this section of shaft is roughly 313 feet deep from the surface. The experiment will be mounted in the north side of the shaft where the arced wall meets the flat wall of the semi-circle (see figure #1 or picture #2).

Air Duct Move:
As depicted below, a ventilation duct in the shaft will require relocation by about 8-feet to provide space for experiment installation and maintenance. This work shall be part of the bid. The 26-inch diameter duct supplies air to the enclosure about 320 feet underground. The shaft needs to be moved at the surface about eight feet before it goes down the 300 foot shaft. Because the duct is part of the life/health/safety infrastructure for the underground enclosure a temporary measure will need to be employed while the shaft is in the process of being relocated. The duct is supported by wall mounted Unistrut.

Module Mounting Fixture Installation:
FRA will design and fabricate mounting fixtures that will be hung from the wall approximately every 8-feet down the 313-foot long vertical shaft. The vendor will install these fixtures need to within +/- 1-inch of nominal position and +/- 2^{o} of nominal orientation.

Atom Source Support Installation:
The experiment will use three “atom sources” set near the top, middle and bottom of the shaft. The atom sources weigh roughly 1000 pounds and are 32”x15”x78”. FRA designed and fabricated atom source supports will be set in place by the vendor within the same requirements as the module mounting fixtures above.

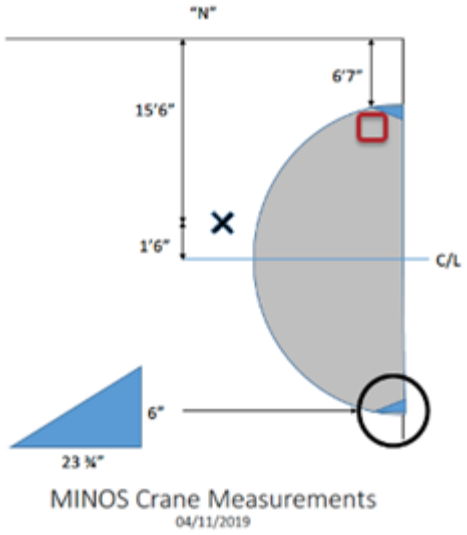
Retro Mirror Box Support:
A “Retro Mirror Box” will be installed at the bottom of the experiment (bottom of the shaft). The vendor will install the supports for this component with the same requirements as the module mounting fixtures noted above. The support weighs 900 lbs and is 51” x 27” x 30”.

Cooling Chiller Station Supports:
Specifications not yet complete. There will be three water chiller station supports approximately 500 lbs in weight.

Cable Tray & Electrical Conduit Installation:
In addition to installing the various mounting fixtures the vendor will also install eight (either ¾ or 1-inch) conduits and two cable trays (8’” and 12”, respectively) down the wall along the experimental apparatus. They will also pull AC power wires down the conduits. Wire quantity and size will vary from three to ten wires per conduit all 10-AWG or higher. The conduits will run the entire 300 feet of the experiment with multiple breakout boxes for making connections to the experiment at different points down the shaft. Some wires will run the full length, others will be shorter based on destination down the experiment.

Crane Considerations:

The MINOS building has a 15-ton overhead crane that can be used to support a personnel basket and to move general loads to the underground tunnel system serviced by the shaft. However, the crane does not directly service the area occupied by the equipment to be installed because of limitations in its hook coverage. Please see **pictures #4-6** for existing crane arrangement. A secondary bridge crane has been conceptually designed to fit below the main crane and above the top of the experiment; this may be considered as a possible method for installation as well as other methods, and the preferred method should be indicated in the proposal. Please see Proposed Bridge Crane section below for additional details.



Drawing #1: Diagram showing MINOS shaft dimensions and existing crane range. The location of MAGIS installation (red square) is indicated at the north wall of shaft.

MAGIS-100 Experiment Modules:
The bulk of the MAGIS-100 experiment apparatus is comprised of 17 individual modules. Each module is 17-feet long and has a constant cross-section of 33" x 21". The modules weigh 2000 pounds and will be lowered vertically into place and set in the aforementioned supports. The modules are composed of a 80/20 Aluminum "strongback" frame. Inside that frame will be a 6" round stainless steel tube that will be wrapped in various layers of magnetic shielding. The modules are fragile and will not withstand uncontrolled impacts with the stands or wall.

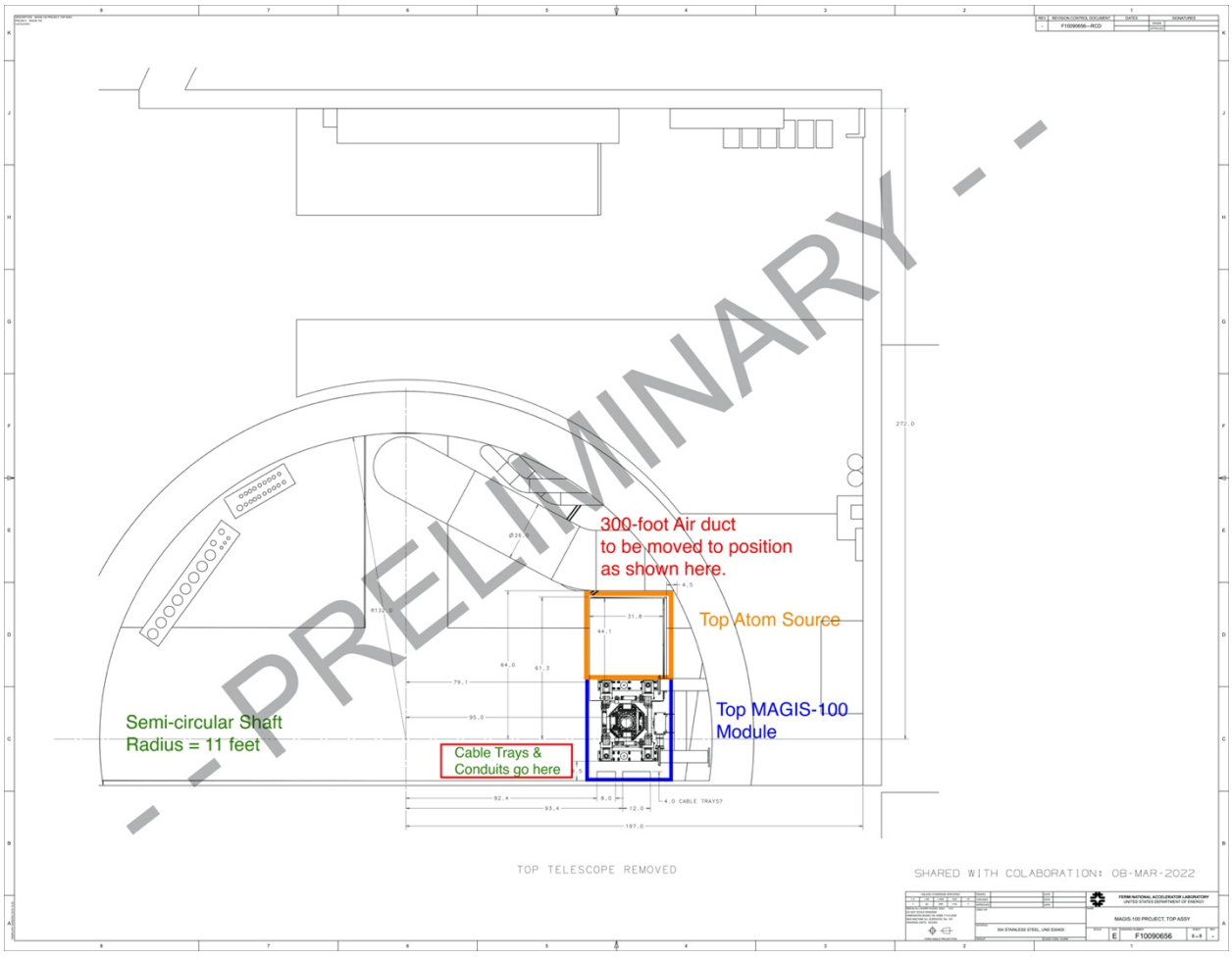
The vendor will set each of the modules into place. Once all vendor installation activities are complete FRA personnel will make the interconnections between the modules and the atom sources.

MAGIS-100 Atom Sources:
The experiment employs three atom sources that will be set on the aforementioned supports near the top, middle and bottom of the shaft. The atom sources weigh 1000 pounds and are 44" wide x 31.5" deep x 72" tall. Like the modules, atom sources are very delicate and must be lowered and set into place with great precision. Once vendor installation is complete FRA personnel will connect the atom sources to the experimental modules.

Retro Mirror Box:
The retro mirror box weighs 300lbs and is 20” x 20” x 11” and will be situated at the bottom of the shaft and will be connected to the lowest module. FRA will make this final connections.

Rough Vacuum Station:
A “rough vacuum station” will be installed at the bottom of the experiment (bottom of the shaft). This includes a tube which connects the lowest module to the retro-mirror box. The vendor will install the FRA-designed and fabricated supports for this component with the same requirements as the module mounting fixtures noted above.

Plan View of Experiment Installation



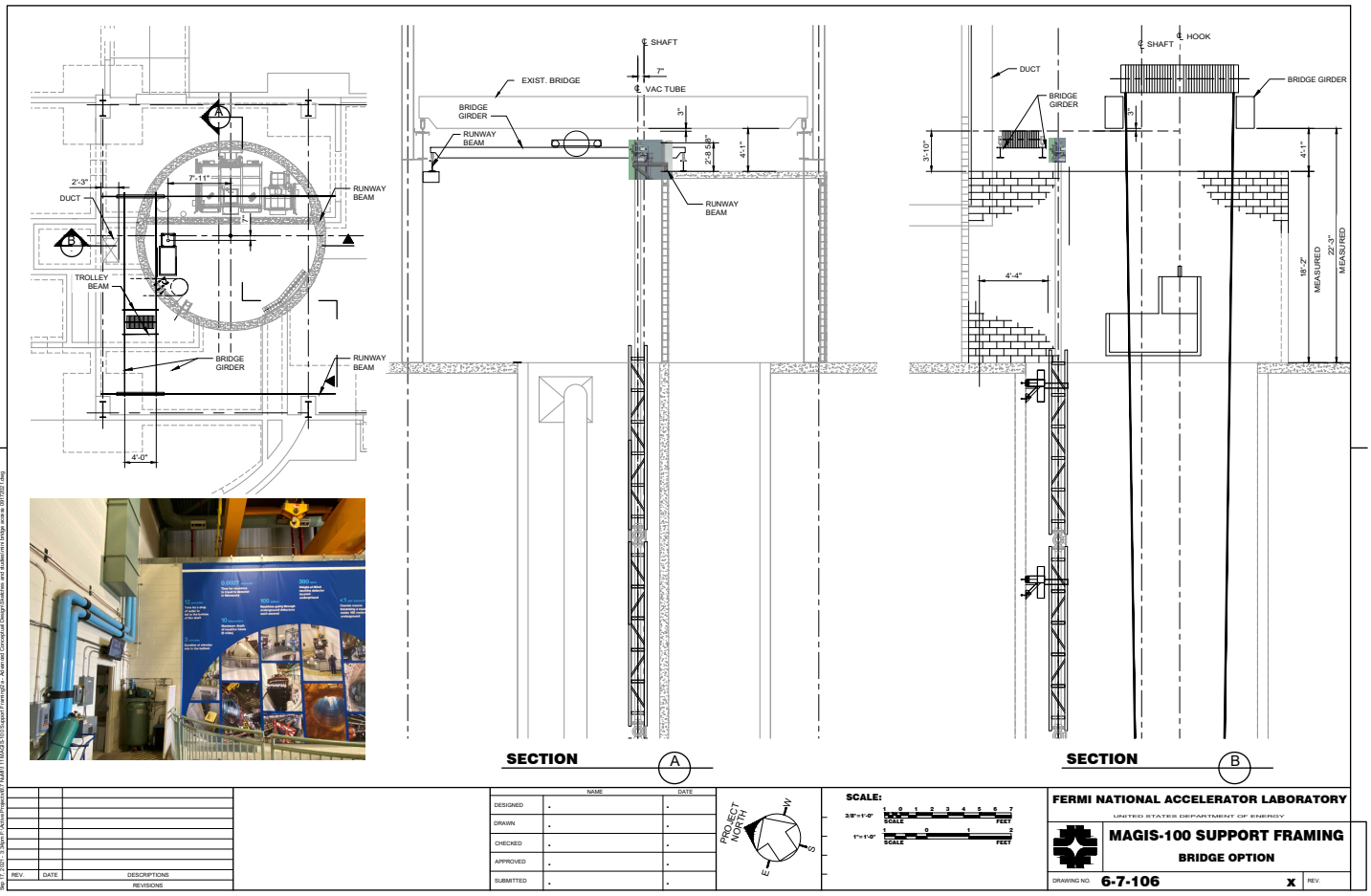
Drawing #2: *Plan view of the experiment looking down the shaft from the above the surface.*

The plan view show above shows the final location of the air ventilation shaft, the location of the top-atom source, the location of the top module and the approximate

location of the cable trays and conduits that will run vertically down the wall into the shaft.

Proposed New Bridge Crane:

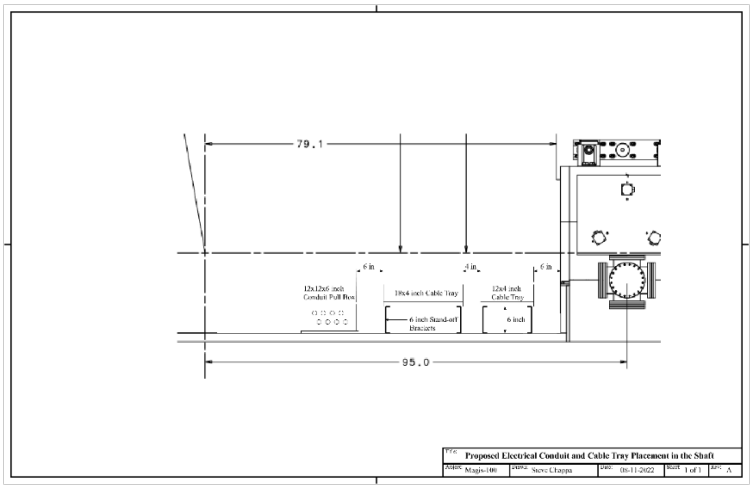
As noted above the existing 15 Ton bridge crane lacks the needed hook coverage for lowering the various modules into position on their supports. One proposal is to build a second, smaller bridge crane over the north end of the shaft. A conceptual design of such a crane has been completed, but details remain unresolved. Below is the conceptual design drawing.



Drawing #3: Proposed bridge crane installation shown with existing bridge crane.

FRA welcomes vendor input on using a new bridge crane or an alternative method using existing the shaft crane.

Proposed Plan View of Electrical Infrastructure Shaft Installation:



Drawing #4: This diagram shows the plan view of the placement of electronics cable trays and conduit with respect to the location of the experimental modules. The conduits and trays will be mounted vertically down the flat shaft wall and will run the length of the shaft.

Existing Infrastructure:

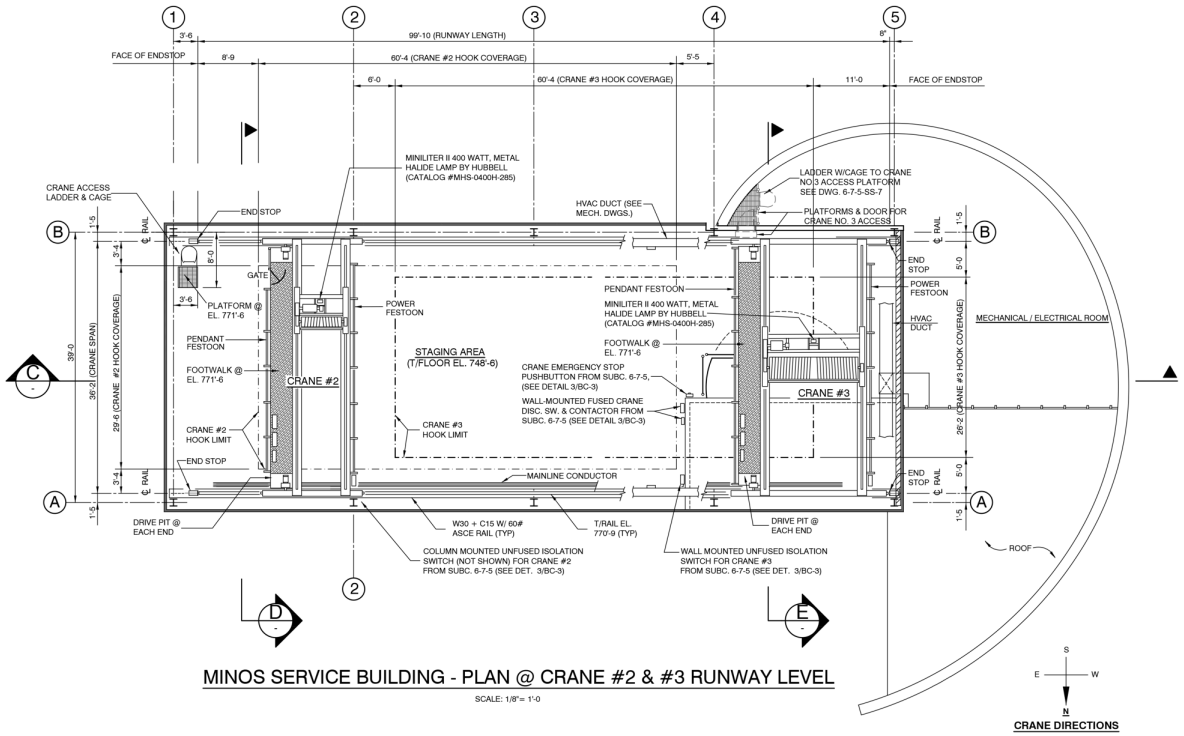
The MINOS building that houses the shaft where MAGIS will be installed has a regularly inspected and certified 30-Ton bridge crane. The existing bridge crane does not provide enough coverage to the north to allow for its use in the lowering of individual MAGIS modules or atom sources, though it may be used to lower a personnel basket during vacuum assembly when modules are coupled together.

A 26-inch diameter air duct from that runs from the surface to the cavern underground will need to be moved in order to effectively fit the MAGIS-100 modules and atom sources. As part of the installation the vendor will re-route the duct from its current location and down the wall 300+ feet to the cavern below.

The MAGIS-100 experiment has been exploring installation of a secondary bridge crane or a mobile crane for module and atom source installation. The vendor may wish to comment on their preference for this purpose.

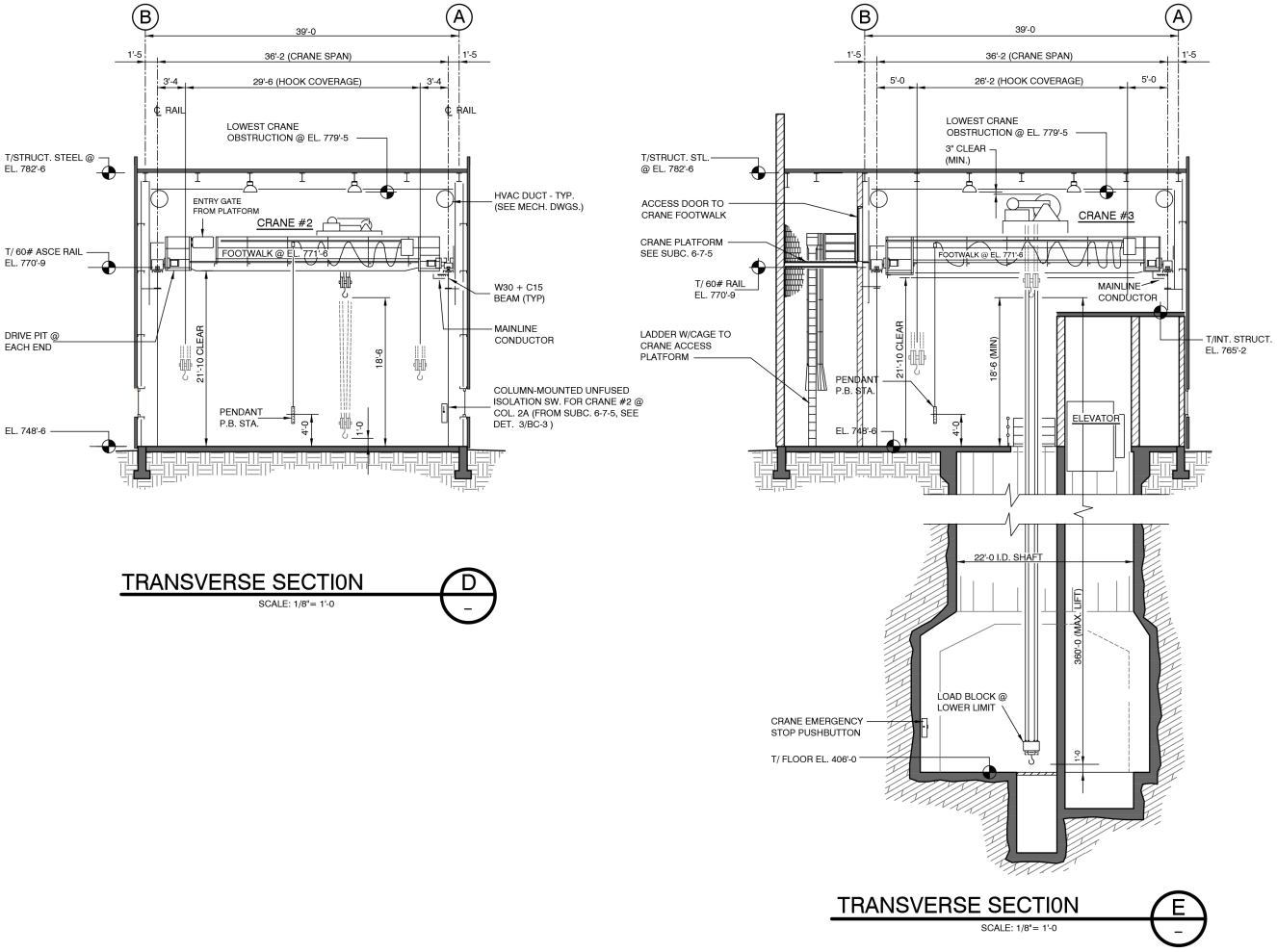
The MINOS shaft is part of the on-going scientific complex at Fermilab. It is used to lower large items to underground work areas. During MAGIS-100 installation periods the installation will be the top priority; we expect the subcontractor will have full access to the shaft and crane(s). That said, there may be requests from other FRA users to access the shaft and if possible we wish to maintain the flexibility to accommodate such requests if sufficient notice is given.

Existing MINOS Service Building & Crane Layout: Plan View



Drawing #5: Crane #3 is the existing shaft crane. The aforementioned proposed bridge crane would be installed under this crane and further to the right side of the shaft (as seen in the picture).

Existing MINOS Building Cranes: Transverse View



***Drawing 6**:* Transverse view of two existing building cranes. Crane #3 is the shaft crane. Both are bridge cranes and have a 15T load capacity.

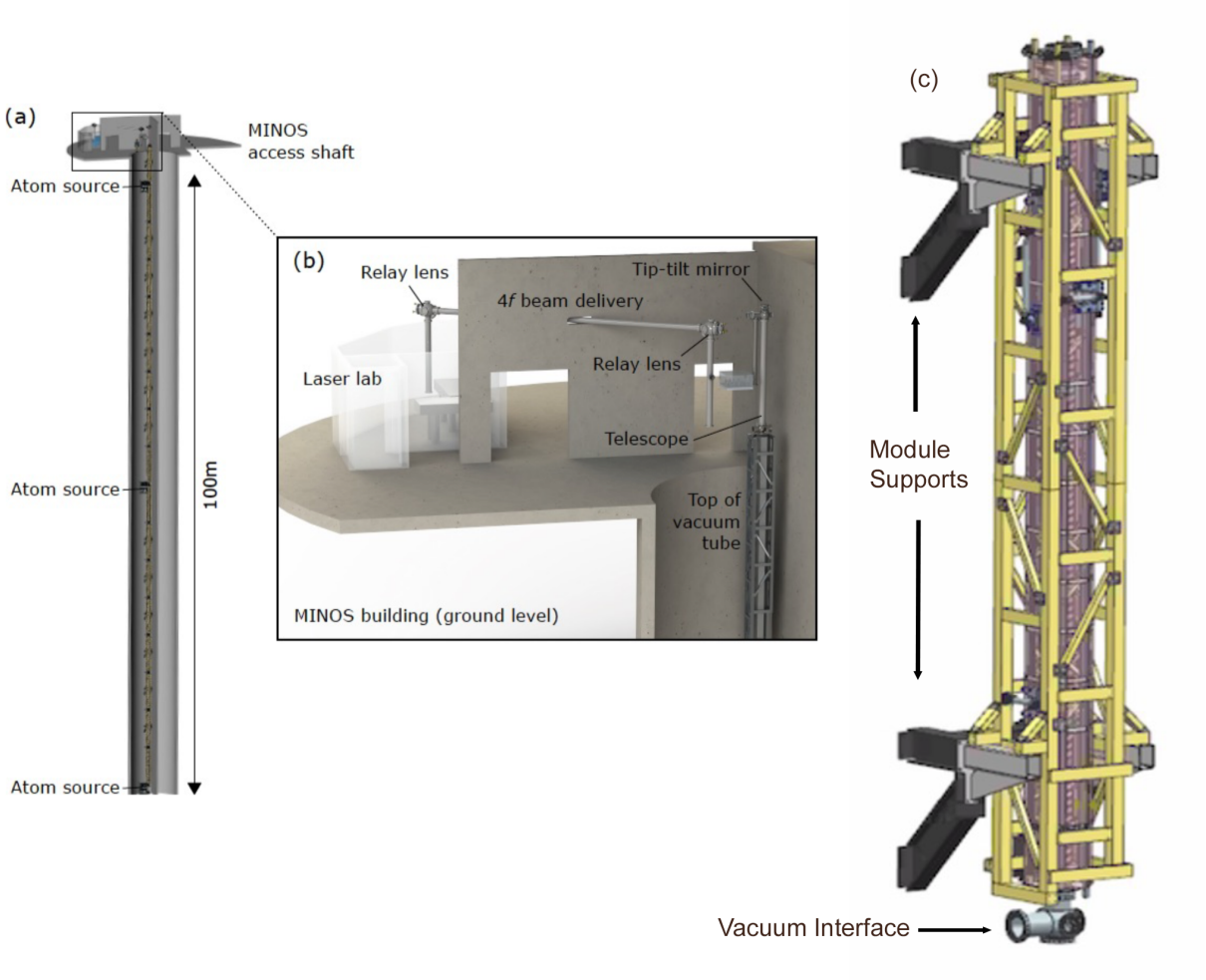
New Infrastructure to be installed:

2 cable trays (12 and 18 inches)
8 conduits ¾ to 1-inch in diameter for AC power distribution. Wires will be pulled too.
34 Module hangers
3 atom source support structures
1 retro mirror support structure
3 closed loop water chillers & supports
1 "rough" vacuum pumping station & support
1 5-meter telescope section

Table of Useful Information

Item	**Quantity**	**Dimensions**	**Approx. Weight** (lbs)
Modules	17	204" x 33" x 0021"	2000
Module hangers	34	40" x 48" x 40"	450
Atom Sources	3	15" x 32" x 78"	1000
Atom Source Stand	3	42" x 34" x 36"	800
Retro Mirror	1	20" x 20" x 11"	300
Retro Mirror Stand	1	51" x 27" x 30"	900
5-meter Telescope Assembly	1	TBD	TBD
Rough vacuum station supports	1	TBD	TBD
Rough Vacuum Pump	1	TBD	TBD
Turbo Vacuum Station	1	50" x 33" x 28.5"	400
Conduits	8	1" diameter x 300 feet	
Cable Trays	2	18-in wide x 300 feet	
AC power cables/wires	12	50' to 350'	
Shaft Diameter at surface		11 feet	
Shaft Depth with 11-ft radius		313 feet	
Shaft depth to lowest point (bottom of sump pit)		360 feet	
Shaft depth to underground floor		340 feet	

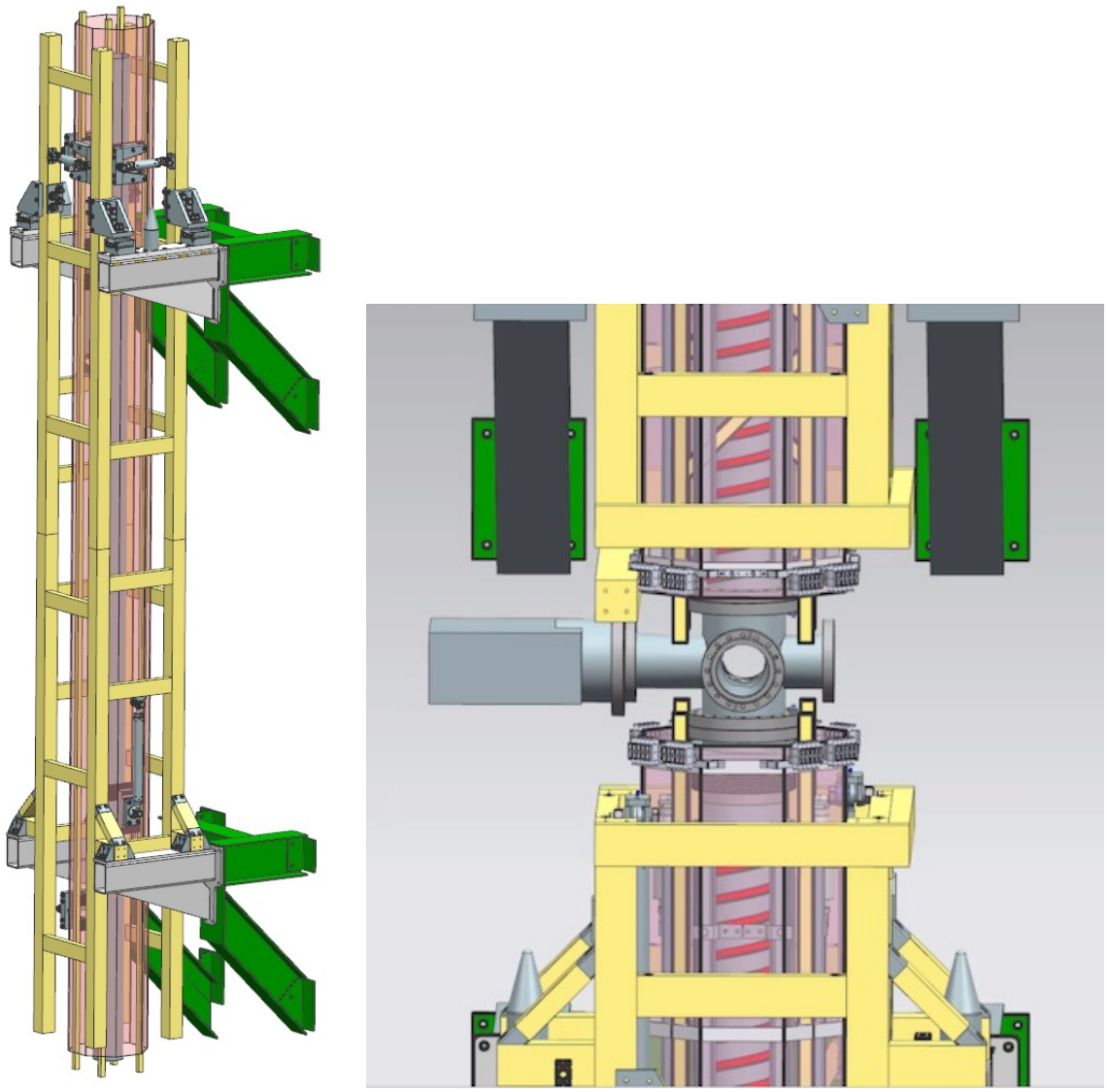
System Overview:



Drawing #7: *Modular assembly& system overview. (a) 100-meter deep shaft, (b) surface view, (c) single module with supports & vacuum interface.*

Modular assembly concept uses 17 sections, each one 17-feet long and ~2000 lbs in weight. In addition to the 17 modules there will be three atom sources installed in the system. Atom sources are 15” x 32” x 78” and weigh 1000 lbs. Atom source details will follow in this document.

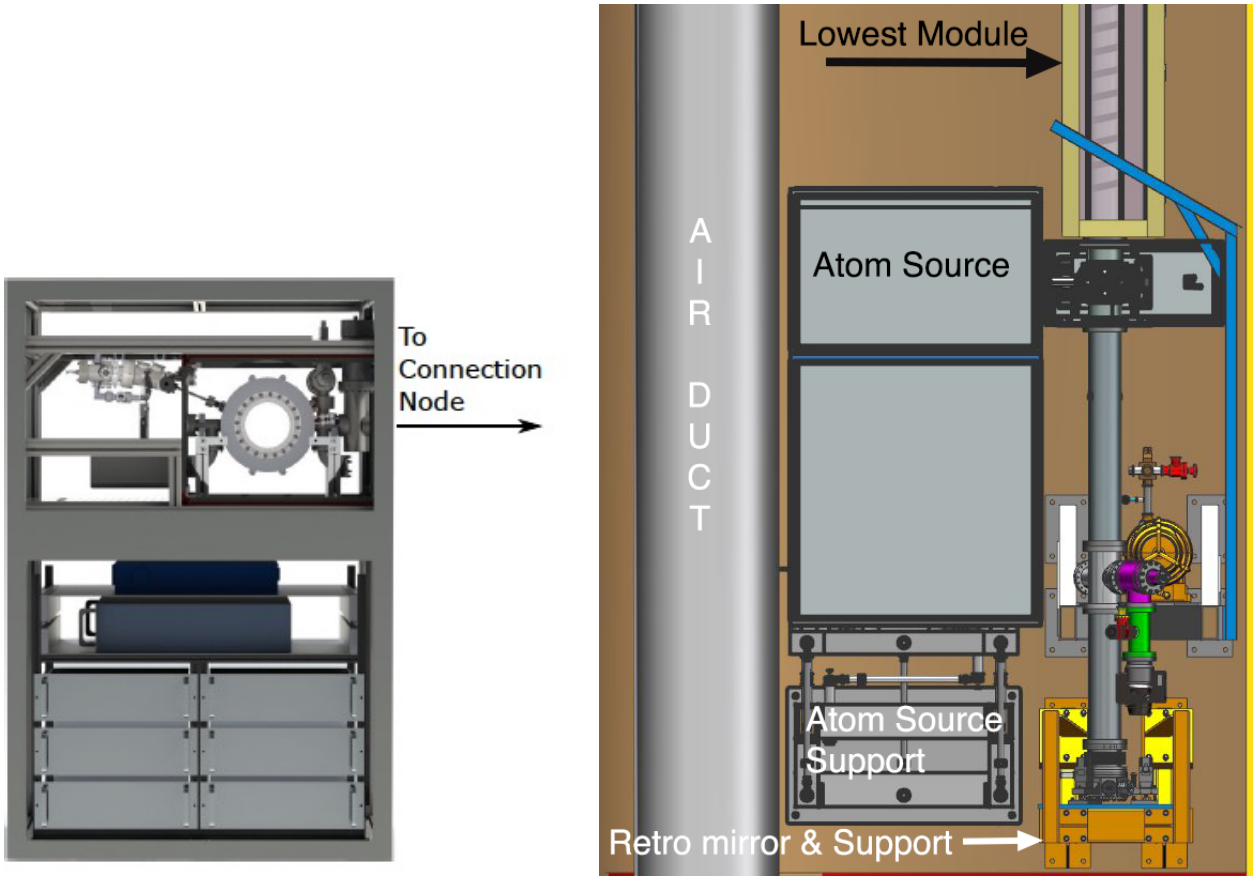
Module Supports, Modules & Module Vacuum Interfaces



Drawing #8
Left: 3D model showing a module (yellow frame box) set in place upon the support structures (in green & gray). Right: Connection interface between modules. The connection interface will accommodate vacuum pump stations. FRA will perform the vacuum pump installation and connect vacuum interfaces.

After each of the 17 modules are installed they will be coupled together via the vacuum pump interfaces or via the three atom sources.

Atom Sources & Retro Mirror Box



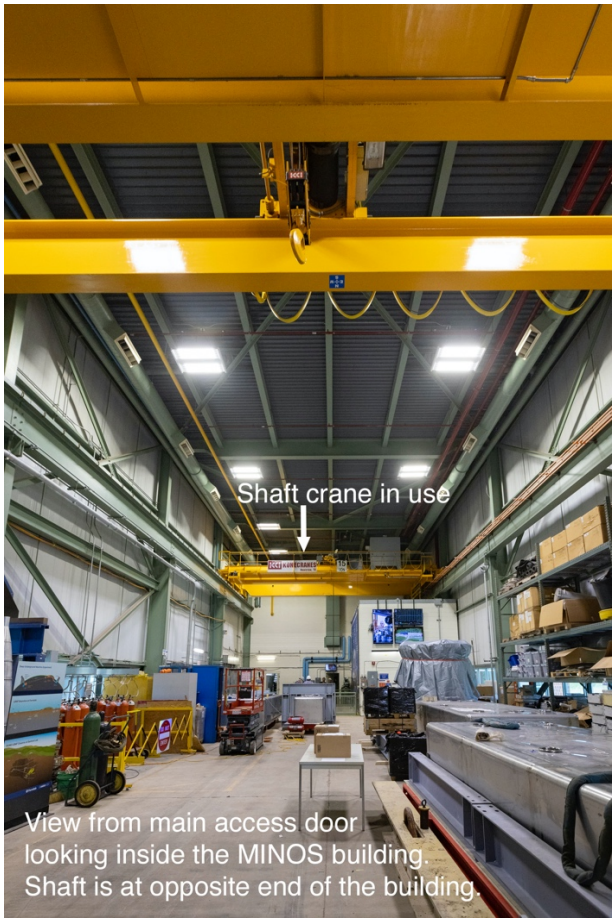
Drawing #9: *Left: Atom source. Right: 3D model of the lowest (bottom) atom source in place (vacuum pump station not shown). The orange support at the bottom is for the retro mirror box.*

MAGIS-100 will employ three atom sources stationed in the top middle and bottom of the shaft. Each source will weigh up to 1000 lbs and are 32”x15”x78”. They will be installed after the 17 modules are in place. It is a very tight fit and they must be handled with extreme care as they cost approximately $1M each.

Vendors shall install the supports for the atom sources and retro mirror box (supports are in orange in *Figure #4*. There are three atom sources and one retro mirror box (installed at the bottom of the shaft). Atom source and retro mirror support installation will happen during the civil construction stage along with experiment module supports, cable trays, conduits, etc.

Pictures & Video

Top: **Picture #1.** View looking down the shaft; experiment will be installed left of the large air duct in its current location. Bottom-Left: **Picture #2.** View down the shaft with approximate location of experiment shown in red. Bottom-Right: **Picture #3.** View at bottom of the shaft.



Top Left: Picture #4, view from inside the MINOS building entrance. **Top right: Picture #5**, view looking across top of shaft and toward the main building entrance. **Bottom: Picture #6**, personnel basket suspended by crane being lowered down the shaft during an inspection.

Video of the Shaft:

Please follow the link below to see a video of the shaft.
https://www.youtube.com/watch?v=OXl4kegSQtI

Fermilab has strict access and environmental health and safety requirements. Please see the attachment "Exhibit A" document for details.

Questions for Vendors:

1. Do you have any experience working in a National Laboratory environment or at Fermilab in particular?

2. Are the tolerance requirements for the project achievable and can your company meet them? Does your company have any experience installing or constructing similar projects involving sensitive equipment and tolerances? If so please list them in your response.

3. Wall supports must be installed first and aligned within one inch and +/-2 degrees vertically. Can you meet these requirements? What risks or challenges do you foresee in this element of installation and how does your firm approach or mitigate such challenges?

4. A second crane *may* be needed for installation. FRA has described in detail the work area including available space and potential approaches for utilization of a second crane. We are seeking feedback regarding the most appropriate crane type (bridge vs. mobile crane) for installation. FRA is open to alternative methods of module and atom source installation utilizing the existing shaft crane and an appropriate lifting fixture.

FRA intends to solicit for these services using the Firm Fixed Price approach. Given the preliminary scope of work, requirements, schedule, and other details provided in the project description, please indicate which elements of price, in your opinion, most subject to fluctuation/volitivity. If possible, please prove an estimate based on the information provided (price ranges, pricing with assumptions listed, etc. are acceptable). FRA will not award a Subcontract as a result of this RFI, and pricing will be used for informational purposes only.

FRA will conduct an on-site visit to allow interested suppliers to see the project area and ask questions. FRA will attempt to compile all questions and answers into a document and attach to this RFI, allowing all interested parties access to information conveyed. Attendance is not a requirement in order to submit a response to this RFI, though it is encouraged.

SITE VISIT REGISTRATION

A site visit is scheduled for **Tuesday November 1, 2022, at 10:00 A.M. Central Time**. Visitors should meet at Wilson Hall ground floor west side of building at the designated time.

Each Offeror is considered a business visitor and is required to fill out an Access Request form no later than **Friday October 21, 2022. Y**ou can register at:

https://fermi.servicenowservices.com/expert_shell.do?sysparm_sys_id=63f9f6a8dbd148104e65ff621f961975

Upon request approval, the business visitor will receive an email with a QR code, which you must present at the security gate. If the individual has not submitted the request, the business visitor will be denied entry. Note that onsite access will be dependent on citizenship status. If you are a Foreign National, access may be delayed or denied.

If you have a current Fermilab badge, you are not required to fill out the Access Request form.