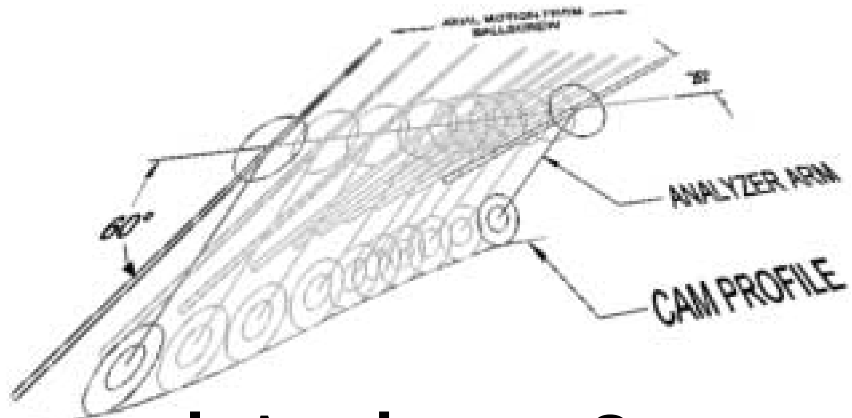

MACS

Double Crystal Analyzer System

phase A study

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Phase A Study: MACS Double Crystal Analyzer System

System Description:

An arrangement of highly oriented pyrolytic graphite crystals with fixed vertical focusing capabilities. Each analyzer contains nine graphite crystals. The system must be able to focus within a specified incident beam angle range. In order to achieve proper focusing, the analyzers must have two degrees of freedom. One degree of freedom is rotation about the center of gravity of each analyzer and the other is translation parallel to the beam. The analyzers rotate about a common center (see Figure 1). Each system is to be duplicated 21 times since there is one double crystal analyzer system per detector channel.

System Requirements:

1. Incident beam angle range is $20^o \leq \theta \leq 60^o$.

2. Crystal size is 60mm x 20mm x 4mm. Each analyzer consists of nine crystals.

3. Fixed vertical focus radius is 500mm.

4. Analyzer height is 180mm.

5. Analyzer rotation offset due to center of gravity is 2.7mm.

6. Actual orientation of each crystal must be within 0.15^o of the theoretical orientation.

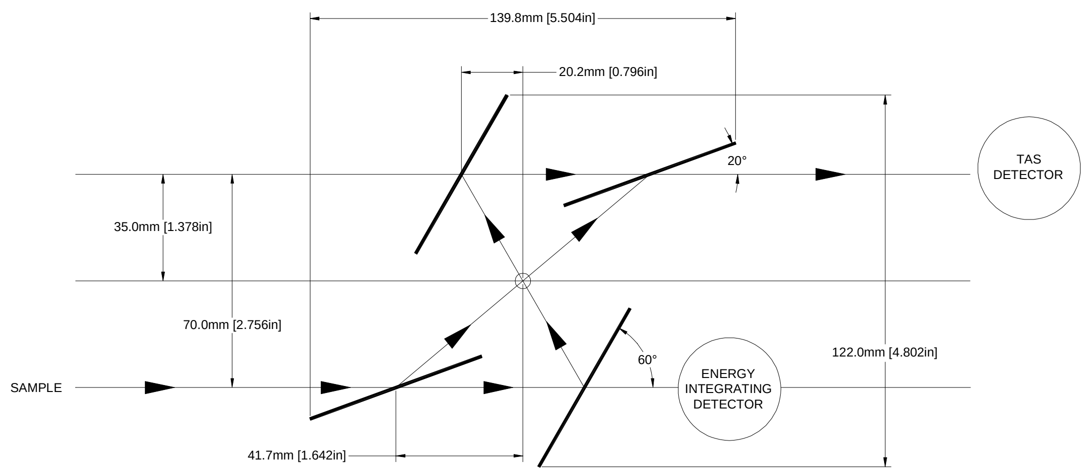


Figure 1: Bird eye's representation of the double crystal analyzer system.
The thick lines are the analyzers and the arrows show the path of the beam.
The diagram shows the two extreme positions of the system.

Mechanism Description:

The design goals for this system are simplicity, precision and repeatability. Simplicity is achieved by the development of a system that completes all required motion with only one drive. Precision will be accomplished through proper analysis of the desired motion and allowing the system to have fine tuning capabilities during calibration such that the correct orientation of the crystals can be achieved. Repeatability will be addressed by choosing the most appropriate off-the-shelf parts and obtaining the best suited manufacturing techniques for various components of the system. In order to simplify the description of the proposed mechanism, it is best to break up the design into two sub-groups: Translation and Rotation.

Translation:

The translation of this system requires that each analyzer travel along a path parallel to the beam in opposing directions. Since the analyzers will always move together along parallel paths, the analyzers will share the same guideway and ballscrew. The guideway will provide precise and accurate motion along one axis. The ballscrew will have two sets of threads: one right-handed and one left-handed. This allows one motor to drive the ballscrew such that the analyzers always move in opposing directions (see Figure 2).

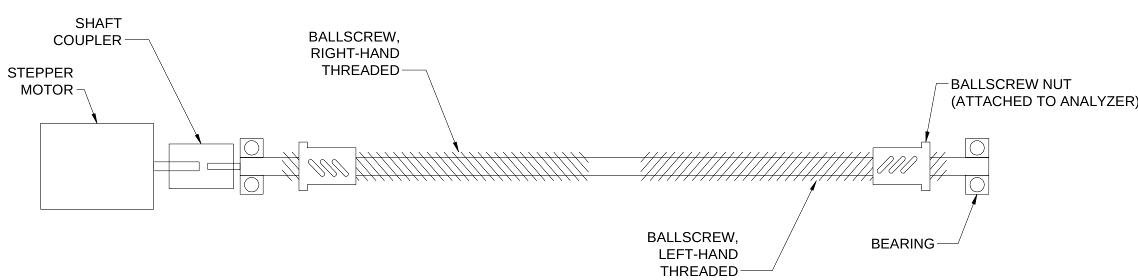


Figure 2: Opposing translation of the analyzers will be achieved with a ballscrew that has two sets of threads: one right-handed and one left-handed.

Rotation:

To obtain rotation without the addition of another drive system, the axial motion of the analyzers will be used to achieve the appropriate angular position. Each analyzer will have its rotational degree of freedom controlled by an attached arm that will be referenced to a surface. This surface will have a calculated profile (a cam) that moves the arm, and therefore rotates the analyzer, to the appropriate orientation. The arm will be spring-loaded such that it will always remain in contact with the cam (see Figure 3).

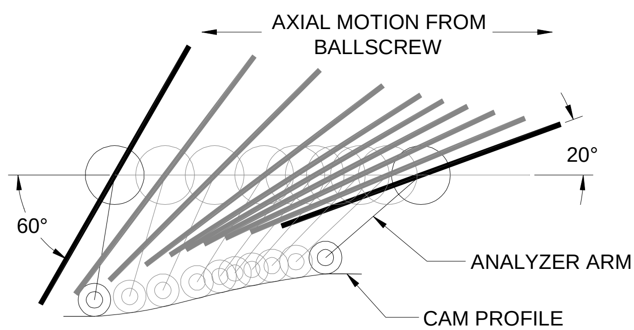


Figure 3: The rotation of the analyzer will be achieved by using the axial motion from the ballscrew and an arm referenced to a cam.

Other important features of this system will be closed-loop positional control through the use of an LVDT (linear variable displacement transducer) on one of the linear slides. For calibration, RVDT's (rotary variable displacement transducer) will be placed on each analyzer to report its angular position. Limit switches will be incorporated to protect the system from reaching harmful and unnecessary orientations.

Software will be required to control the motor and read positioning information from RVDT's, LVDT's and limits switches. The software will also need to do error checking, provided a user interface as well as an online mode that receives commands from a top-level computer.

Since this document is only a Phase A Study, there are several designs issues that will become paramount upon commencement of this project. One such issue is the acquisition of the cam profile. It is not obvious as to how accurate and precise this profile needs to be in order to obtain sufficient orientation of the analyzers.

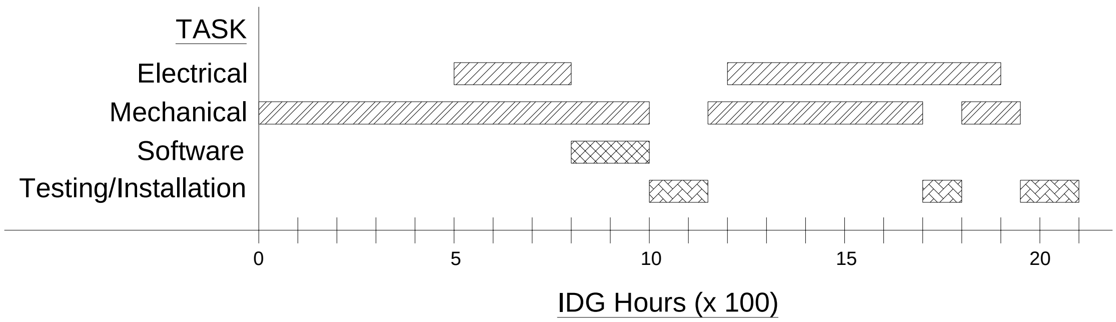
Determining these factors will take several iterations of analysis and manufacturing. Another important design issue pertains to the alignment of the mechanism. It will be possible for certain components to have only one precise location, other components to use neighboring parts as references to establish their position and then a third group that requires the ability of fine adjustments to attain alignment. Finally, detailed assembly and calibration procedures will accompany the design to ensure proper installation.

There are some tasks that have been omitted from this Phase A and this is reflected in the statement of work. These tasks include detector installation and management and pyrolytic graphite crystal machining and installation. However, test crystals for optical calibration and proof of functionality are included in the prescribed cost.

In the appendix, there are rendered drawings of a conceptual design of the double crystal analyzer system. For the sake of time, fasteners and other specifics have been left out of the images. Also, a mounting plate for the entire mechanism has been omitted since there are still some unknowns about the entire detector system.

Task	Description	Qty or [Hrs]	Unit Cost	Total
Phase A				
	Labor	[65]	$51	$3,315
Electrical				
	Labor	[1000]	$51	$51,000
	Stepper Motor	23	$300	$6,900
	Indexer	23	$500	$11,500
	Cables/Connectors	23	$250	$5,750
	LVDT	23	$600	$13,800
	RVDT	46	$600	$27,600
	Electronics Box	1	$5,000	$5,000
	Misc Components	1	$2,000	$2,000
SUBTOTAL				**$123,550**
Mechanical				
	Labor	[1700]	$51	$86,700
	Ballscrew	22	$350	$7,700
	Bearings	23	$150	$3,450
	Guideways	22	$470	$10,340
	Fasteners	23	$25	$575
	Misc Components	23	$50	$1,150
SUBTOTAL				**$109,915**
Software				
	Labor	[500]	$51	$25,500
Machining				
	Cam Development	[100]	$50	$5,000
	Cam	22	$300	$6,600
	Ballscrew Hardware	22	$900	$19,800
	Analyzer Hardware	22	$2,000	$44,000
	Mounting Hardware	40	$50	$2,000
SUBTOTAL				**$77,400**
Testing/Installation				
	Labor	[400]	$51	$20,400
	1 Set of Test Crystals	1	$550	$550
SUBTOTAL				**$20,950**
Administration				
	Labor	[350]	$51	$17,850
IDG SUBTOTAL				**$378,480**
NIST				
	PG	1	$225,000	$225,000
	He-3 Detector, L=4.5 in	21	$1,000	$21,000
	He-3 Detector, L=7.125 in	21	$1,125	$23,625
	Charge Amp for Detectors	42	$925	$38,850
SUBTOTAL				**$308,475**
GRAND TOTAL				**$686,955**

Timeline:



List of Deliverables:

1 complete off-line unit for testing/software development
21 complete & calibrated units (includes all necessary cabling)
Spare parts of certain components will be supplied
Installation at NIST

APPENDIX:

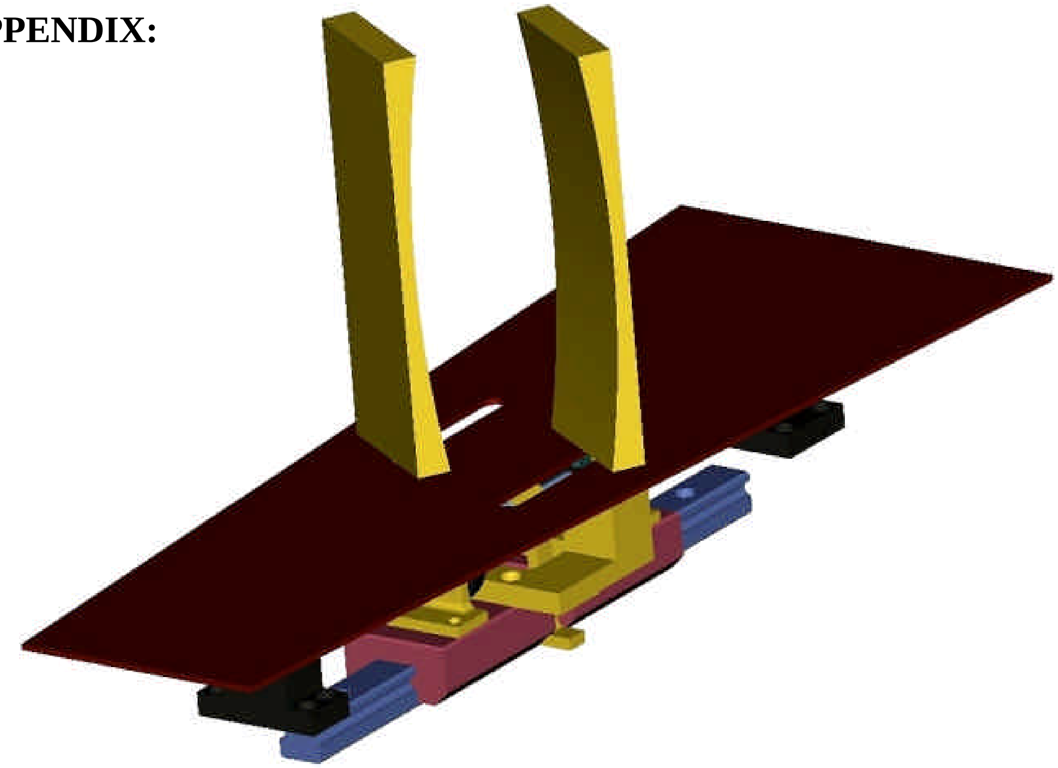


Figure A1: Full assembly with cadmium shielding. Note that the PG crystals are not shown. The assembly is in the 60^o incident beam angle orientation.

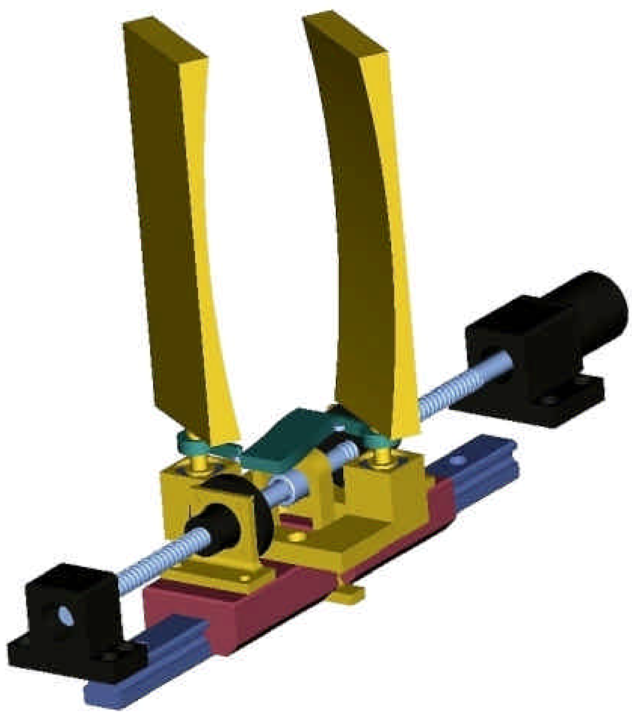


Figure A2: Full assembly with the cadmium shielding suppressed.

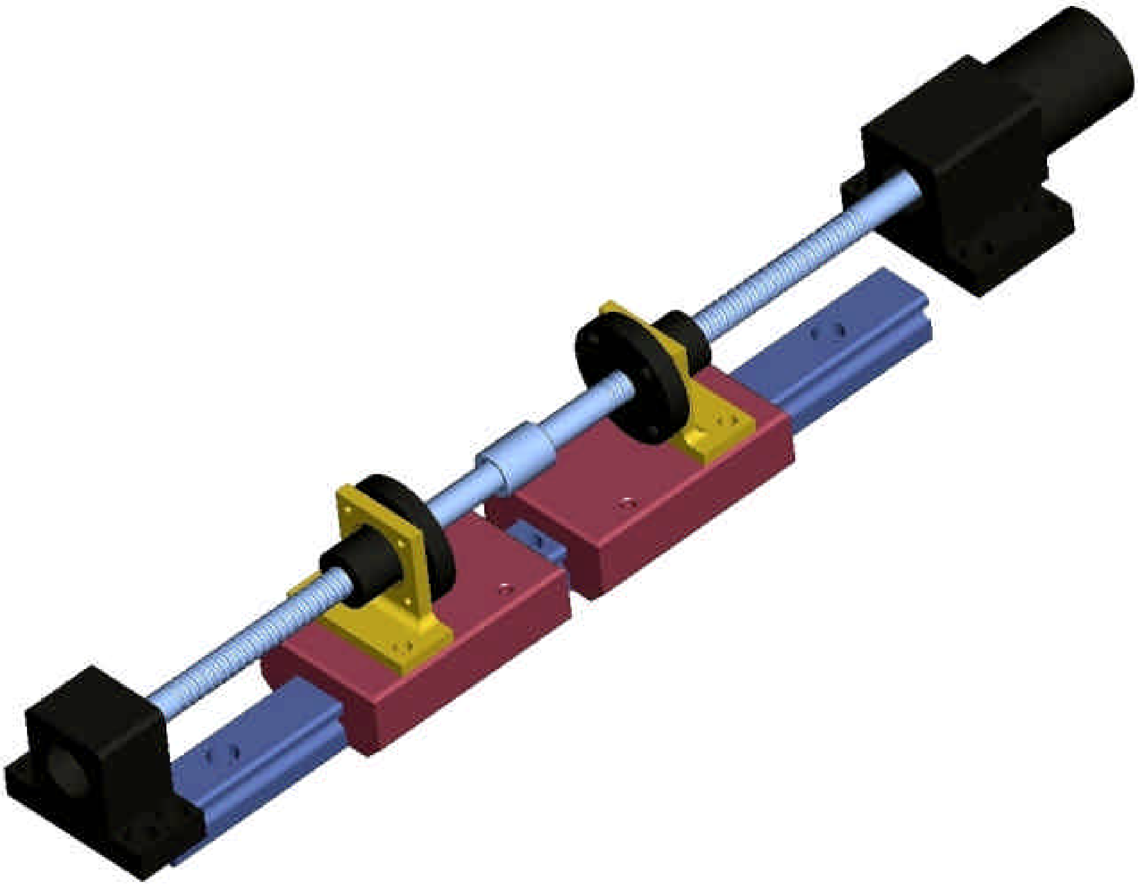


Figure A3: Translation mechanism showing the linear guideway (rail & two carriages) and the ballscrew with opposing threads.

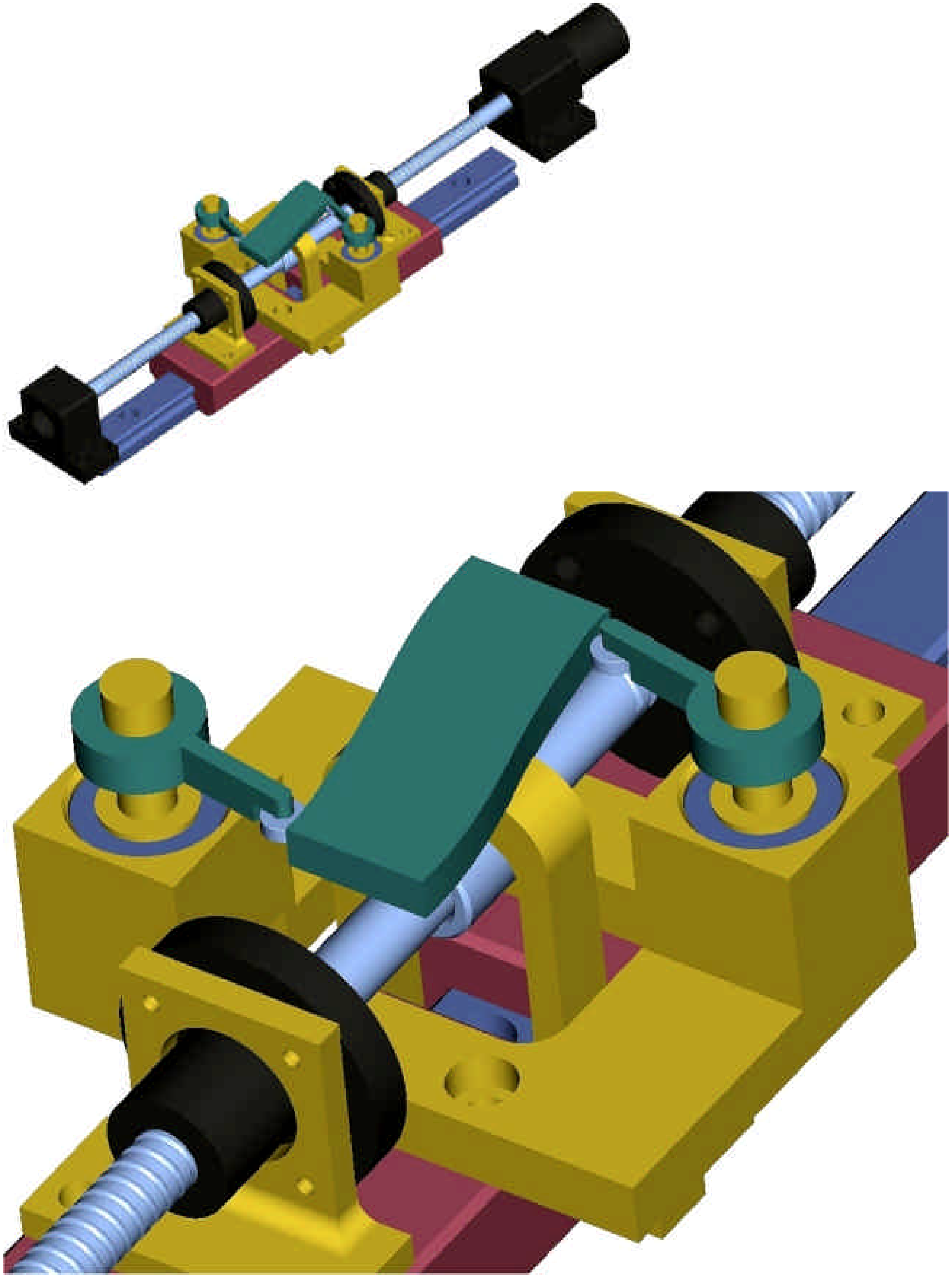


Figure A4: Rotation mechanism shown with a detail of cam and analyzer arms. The analyzers have been removed from the images for clarity. The system is in the 60^{o} incident beam angle orientation.

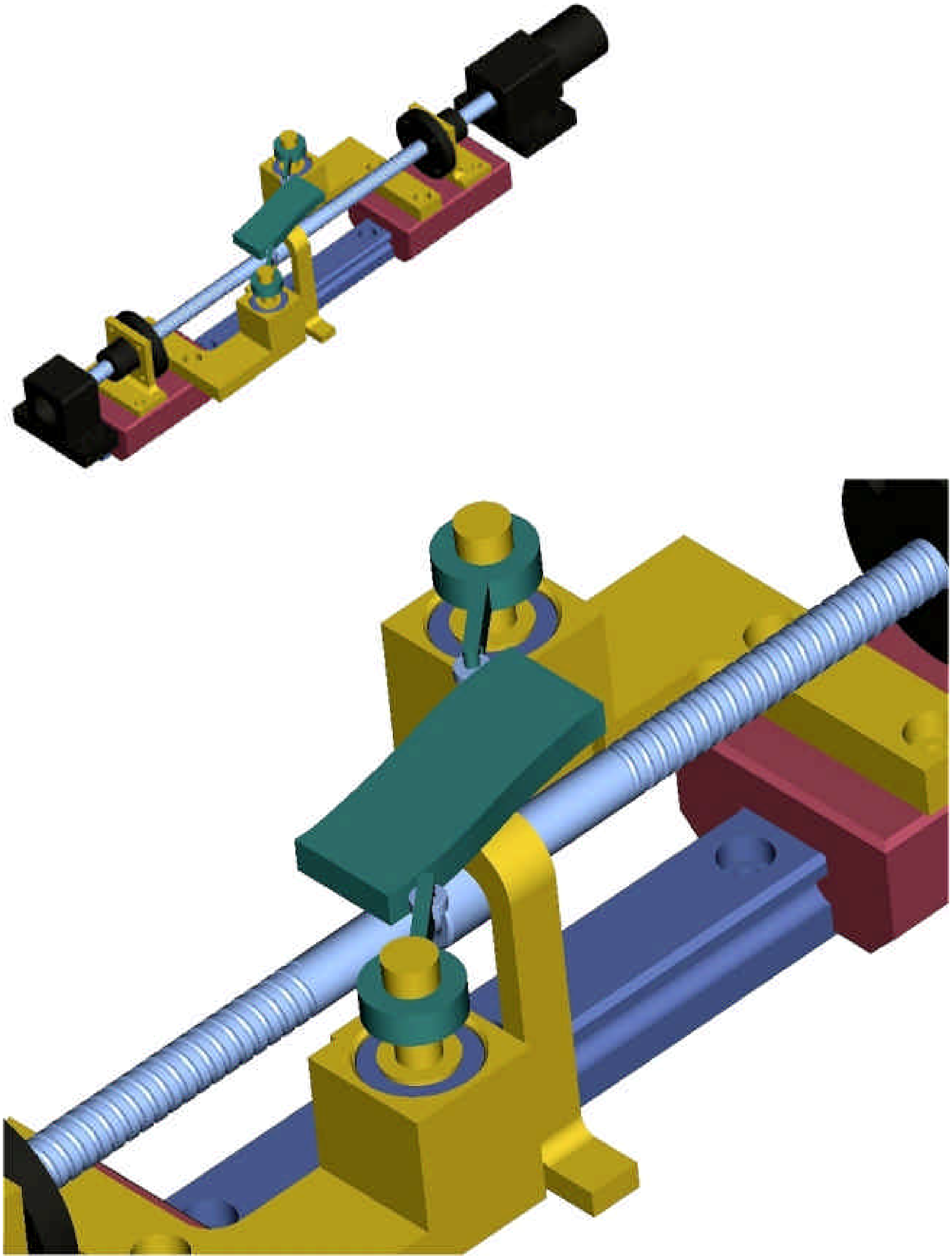


Figure A5: Rotation mechanism shown with a detail of cam and analyzer arms. The analyzers have been removed from the images for clarity. The system is in the 20^{o} incident beam angle orientation.