



A FAMILY OF HIGH-STABILITY GRANITE STAGES FOR SYNCHROTRON APPLICATIONS

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AN OLD MATERIAL (300M YEARS)... And a new use (relatively) in synchrotron world

- Veliciprobe design: stable, "coarse" positioning
- Design intent was to eliminate the compliance from alignment/coarse positioning degrees of freedom
- With success, the question is: how to improve?

"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail."

--Abraham Maslow, 1966



Rev. Sci. Instrum. 90, 083701 (2019); https://doi.org/10.1063/1.5103173



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 (Less space per axis, rotational DOF, scanning)

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BASIC PRINCIPALS OF OPERATION

- Granite mobilized with thin (~6 to 12 μm) air film (orifice balanced)
- In-plane motion common practice
- Vertical motion (wedge) novel
- US Patent 10,393,242
- Used in fly-move-land operation
- As stable as solid granite when vented
- Practical travel ranges:
 - In-plane: 10-100s of mm
 - Vertical: 6-25 mm





USING GRANITE TO MOVE GRANITE

Haytor Granite Tramway, Dartmoor, County Devon, England Built in 1820 to move stone from quarry to canal barge





STATIC STABILITY





- $F_T = F_N^* \cos \alpha = mg^* \sin \alpha^* \cos \alpha$ Where:
- F_w is the weight force
- F_N is the normal force
- ${\it F}_{\rm S}$ is the force along the slope
- F_{T} is the thrust force
- F_F is the friction force





Angle (deg.)



4500

ANGULAR PERFORMANCE (VELOCIPROBE)



- Three sigma angular error for:
 - Pitch 7.5 μrad
 - Roll 12.9 µrad
 - Yaw 9.3 μrad
- Exceeds typical mechanical bearing stage performance
- Influenced by:
 - Granite flatness
 - Geometry
 - Choice of air bearing configuration



VIBRATION STABILITY (VELOCIPROBE)



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WEDGE-JACK SUPPORTED BASE



- First mode: 83 Hz
- Six Airloc 515-KSKC jacks

U.S. DEPARTMENT OF ENERGY Argonne National Laboratory is a U.S. Department of Energy laborator managed by Uchicago Argonne, LLC

- Supported mass = 5400 kg (11,800 lb)
- Load per jack : 8829 N + 44545 N = 53374 N (11,969 lb)





SIBLINGS AND RELATIVES...

Concept and design aspects have been applied in three facilities

Number	Application	Principal engineer	Institution /location	Beamline if known	Number of Stag	es Country	Date
1	Velociprobo	Proisspor Curt					2017
1	Casting system Figure interference and	Preissner, curt	AF3	Z	1	USA	2017
2	Coating system Fizeue interferometer support	Bean, Sunii	APS	coating lab	1	USA	2018
3	IXM Sample Stage	Bean, Sunil	APS	32	1	USA	2018
4	SNOM table	Bean, Sunil	APS	7	1	USA	2019
5	Slit mover-support	Bean, Sunil	APS	2	1	USA	2019
6	Velociprobe II	Preissner, Curt	APS	2	1	USA	2019
7	S34 HDCM	Erdmann, Mark	APS	34	1	USA	2018
8	TXM-II Sample Stage	Tan, Joanna	APS	32	1	USA	2021
9	Fast scanning DCM	Geraldes, Renan Ramalho	LNLS/SIRIUS		1	Brazil	2020
10	Mirror support	Geraldes, Renan Ramalho	LNLS/SIRIUS		24	Brazil	2020
11	CSSI support	Anton, Jayson	APS-U	9	1	USA	to be installed
12	ISN Table	Kearney, Steven	APS-U	19	1	USA	to be installed
13	HEXM Optics Table	Benda, Erika	APS-U	20	1	USA	to be installed
14	HEXM Sample Manipulation Systems	Bean, Sunil	APS-U	20	2	USA	to be installed
15	PtychoProbe support	Preissner, Curt	APS-U	33	1	USA	to be installed
16	NPI	Bean, Sunil	APS-U	26	1	USA	to be installed
17	BNP-II	Bean, Sunil	APS-U	2	1	USA	to be installed
18	Microprobe	Preissner, Curt	APS-U	2	1	USA	to be installed
19	ATOMIC Zoom Optics Support	Preissner, Curt	APS-U	34	1	USA	to be installed
20	Nano CT	Bean, Sunil	APS-U	32	1	USA	to be installed
21	Dual Beam Microscope	Bean, Sunil	APS-U	32	1	USA	to be installed
22	BDA Support	Bean, Sunil	APS-U	32	1	USA	to be installed
23	GRID High-heat-load BPM	Erdmann, Mark	APS-U		19	USA	to be installed
24	GRID Canted Undulator BPM	Erdmann, Mark	APS-U		16	USA	to be installed
25	ALS-U Ultra High Stability Optic Support	Bergeret, Maxime	ALS-U	various	11	USA	to be installed
26	ALS-U Mirror support	Nasiatka, James	ALS-U	COSMIC	1	USA	to be installed
				Total Devices:	93		







COMBINED MOTIONS SAVE SPACE







APS-U nCT INSTRUMENT

Combined X and Y motions









APS-U GRID (GRAZING INCIDENCE) BPM

Providing stable platforms for main beam diagnostic









MATERNAL COUSINS...

ALS-U dual- and single-mirror positioners (Maxime Bergeret)

- Granite stage system to provide stable platform for ALS-U mirrors
- Microradian-level pitch errors ensured by air bearing guides for horizontal motion
- Has been evaluated to be seismically safe







BERKELEY LA

MATERNAL COUSINS... ALS COSMIC M101 (Jamie Nasiatka)

- Granite stage system to provide stable platform for COSMIC instrument mirror
- Designed to improve existing mirror
- New mirror ~200 Hz FNF vs. 33 Hz FNF for current design
- Has been evaluated to be seismically safe







PATERNAL COUSINS LSNL/Sirius devices

Courtesy of and the Sirus Beamline Design Group





High-Dynamics DCM and mirror supports

http://jacow.org/medsi2018/papers/weoama01.pdf





TARUMÃ instrument



THE NEXT GENERATION

More degrees of freedom (up to six), less space

- By rotating wedges, out of plane rotations can be achieved
- Coupled kinematics
- Ranges of a few degrees are reasonably achievable
- Patent applied for (disclosure IN-20-066)







CONSIDERATIONS

A granite stage system may be a good fit for an application if:

- Vibrational stability is important,
- Vertical travel is a maximum of 15-20 mm or so,
- The required motions are not "fast"
- Thermal stability is important
- Large rotations are not needed

We are happy to collaborate/help

When you are faced with a nail, use a hammer...(?)





