Disk Rings and Assembly

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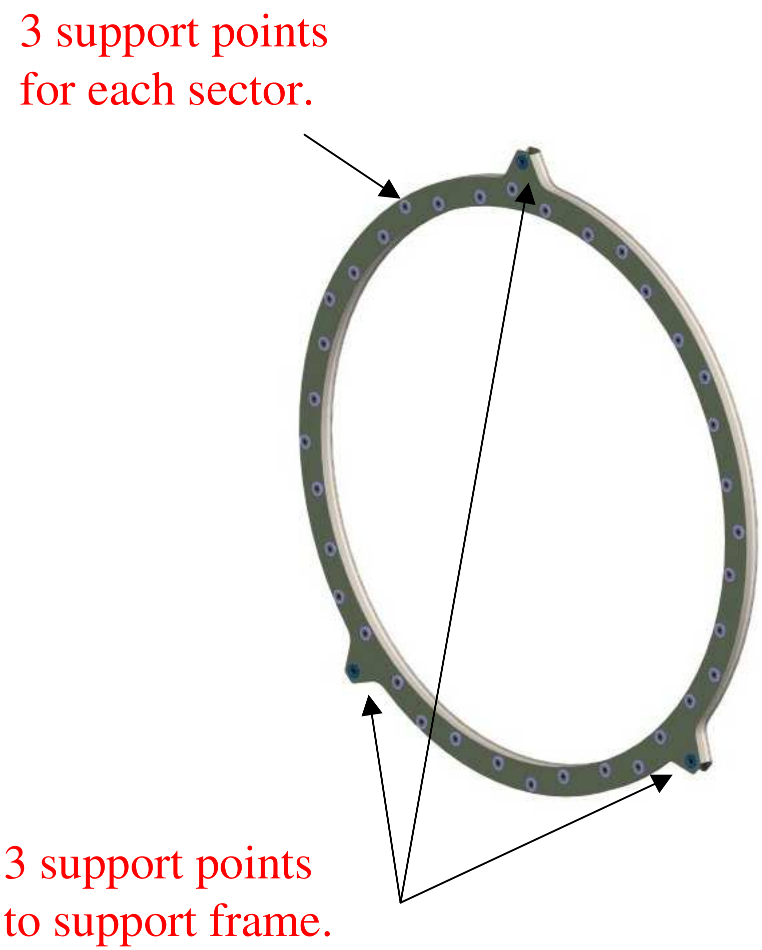
Disk Ring

- Quantities
  - Preproduction: minimum one
  - Production : 6 rings for 11 sector disks and 4 rings for 10 sector disks
- Important requirements
  - Locate sectors(placement accuracy) within window of +/- 50 microns(actual locations for each sector will be surveyed after assembly to accuracy <5 microns rms relative to ring mount definitions using optical CMM).
  - Provide stability of sectors under operating conditions of
    - < 10 microns rms in plane
    - < 50 microns rms out-of-plane
  - Meeting interface requirements(space) for services
- Minimize material/cost consistent with meeting above.



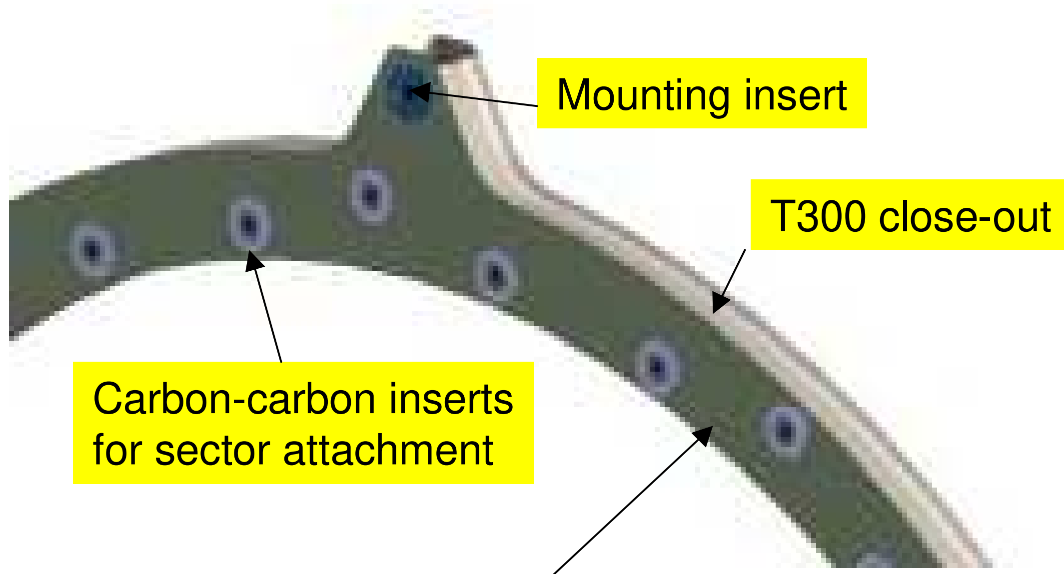
History and Status Summary

- Design is responsibility of Hytec, Inc.
- First prototype design complete, first prototype fabricated and tested with full complement of sectors(but not current baseline design - ESLI sectors). This has been supported by DoE SBIR program. See report also in your notebook.
- Second prototype designed, under fabrication. Will also have full complement of sectors(Hytec design). Also supported by DoE SBIR program. Will have final test results by July.
- Testing shared between Hytec and LBNL.
- First prototype did not meet placement accuracy requirements but appears to meet stability and other requirements.
- Design of second prototype modified to meet placement tolerances, to improve stiffness/stability and better assembly.
- Dimensions of both prototypes not the same as current 11 or 9 sector baseline(layout evolved) but very close(to 11 sector).
- Current plan is to proceed from second prototype directly to preproduction for 11 sector disk ring. Will make at least one additional ring beyond number required for experiment, equip with baseline sectors and repeat stability test program before launching full construction(although materials will be ordered). This will provide spare ring(s).

First Prototype Disk Ring

- BOND TOGETHER AND THEN MACHINE BONDED ASSEMBLY TO FINISHED DIMENSIONS
- RING O.D.420mm
- RING I.D. 380mm
- DEPTH 11mm
- **MATERIAL**
- FACESHEETS:K321 CARBON-CARBON .7mm THK
- C CHANNEL:T300 GRAPHITE LAMINATE, 4 PLY (0/20/-20/0) 60% VOLUME FIBER AND CYANATE ESTER RESIN
- BUSHINGS/WASHERS:CARBON-CARBON BRAKE MATERIAL
- RING MOUNTS:6061-T6 ALUM, BLACK ANODIZE
- **CONSTUCTION**
- FACESHEETS: EACH FACESHEET COMPOSED OF 4 PARTS BONDED TOGETHER
- C CHANNELS: SHAPE OF CHANNELS CONFORM TO FACESHEET PROFILE
- **PROBLEMS:**
- TWIST INGRAINED IN C CHANNELS DUE TO LAYUP PATTERN
- DRILL BIT WANDERED WHILE MACHINING SECTOR MOUNTING PATTERN

- **FINAL WEIGHT:** 124gms



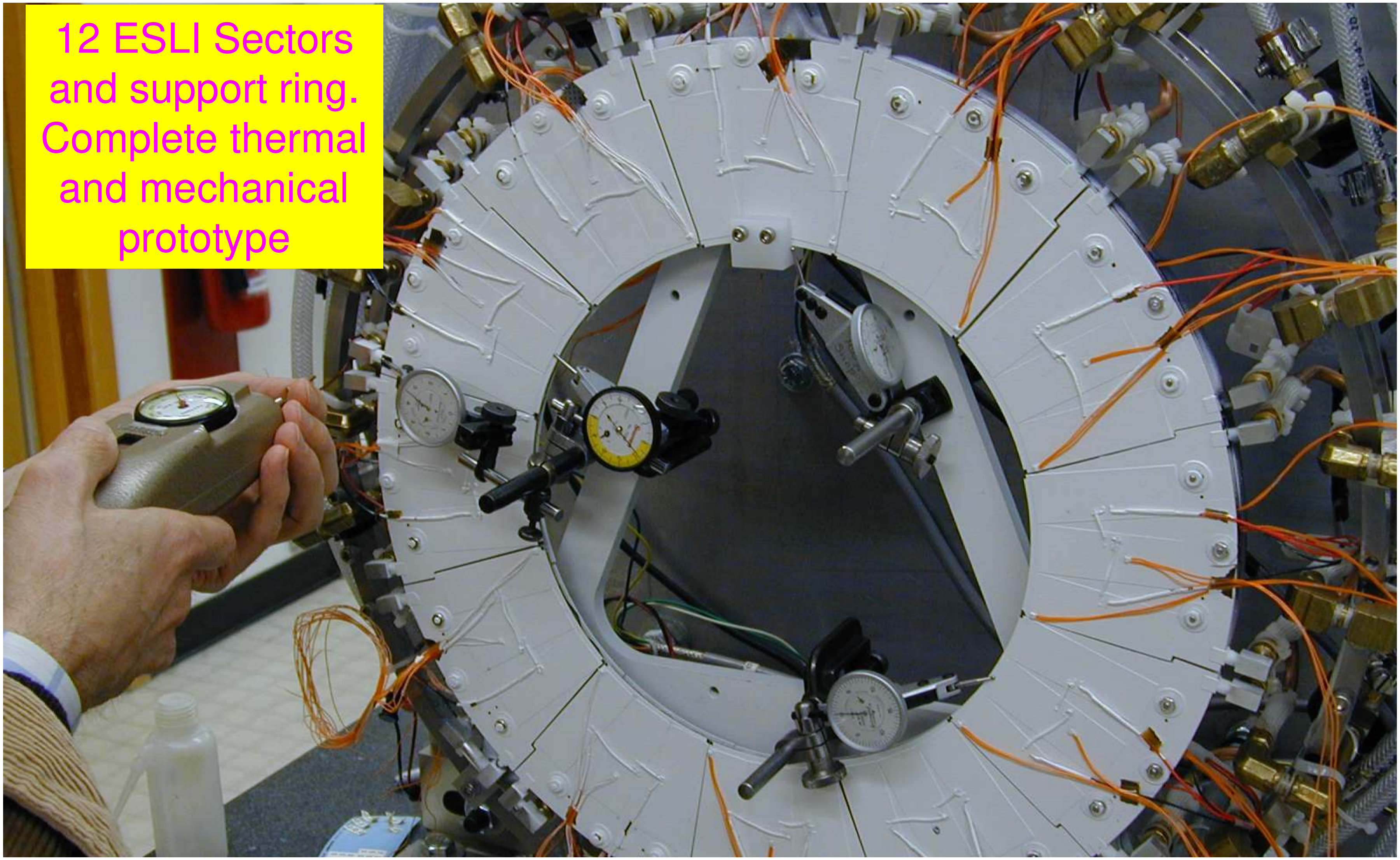
First Prototype Ring Photos

Second Prototype Ring

- BOND PREMACHINED PARTS TOGETHER USING PRECISE GRAPHITE BOND JIG. C-CHANNELS WILL BE FABRICATED USING AN AUTOCLAVE PROCESS TO ACHIEVE DESIRED FIBER FRACTION AND A BETTER FINISHED PRODUCT. BOND JIG WOULD BE INVAR IN PRODUCTION.
- RING O.D. 423.34mm
- RING I.D. 374.65mm
- DEPTH 16.04mm
- SECTOR MOUNT PATTERN B.C. DIAMTERS: SAME AS FIRST PROTOTYPE RING
- RING MOUNT PATTERN B.C.: SAME AS FIRST PROTOTYPE RING
- **MATERIAL:**
- FACESHEETS:HEAT TREATED P30 CARBON-CARBON UNITAPE .4mm THK 8 LAYER 0/45/-45/90/-S)
- C CHANNEL:YSH50 WOVEN CLOTH, 4 PLY $[0/90/45/-45]_s$ 60% VOL FIBER AND YLA RS-12 CYANATE ESTER RESIN
- BUSHINGS/WASHERS:PEEK MATERIAL
- RING MOUNTS: 6061-T6 ALUM, BLACK ANODIZE
- **CONSTRUCTION:**
- FACESHEETS: FACESHEETS CONSTRUCTED FROM ONE PIECE
- C CHANNELS: 180°PROFILE CONFORMS TO OUTER AND INNER DIA OF FACE SHEET
- MOUNTING CORNERS: CARBON-CARBON CORNERBLOCK INSERT REPLACES C CHANNEL PROFILE
- FINAL BOND ADHESIVE: HYSOL 9396 WITH .003” GLASS BEAD FILLER
- **PROBLEMS:** TBD
- **FINAL WEIGHT:** TBD

First Prototype Disk

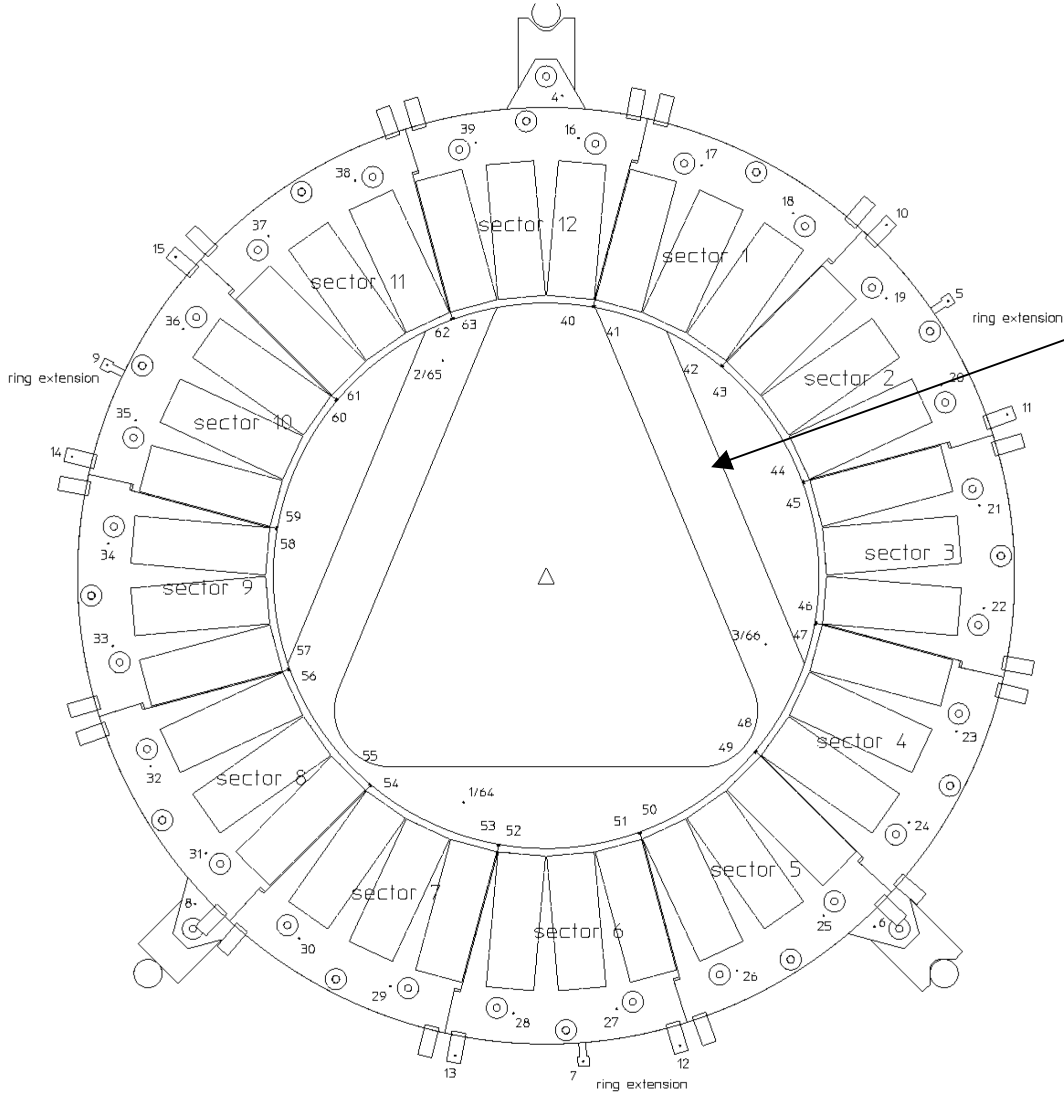
12 ESLI Sectors and support ring. Complete thermal and mechanical prototype



First Prototype Disk

- Purpose
  - Gain assembly experience
  - Test stability under operating conditions
- Scope
  - First prototype disk support ring
  - 12 sectors from ESLI(of which 2 were damaged during shipment/assembly and leak)
  - Dummy heaters on each sector to simulate heat load(up to 60 Watts/sector).
  - Multiple optical targets on each sector, on ring and other locations.
  - Temperature and pressure readout via computer
  - Coolant connections using standard components(not low mass) and coolant is water/alcohol mix.
- Measurement program
  - Use optical CMM to measure targets under variety of operating conditions
  - See video tape of measurement process.

Target Locations First Prototype Disk



BACK of disk was mounted facing away from invar,
(toward viewer), sector numbers are clock positions as viewed.

Coordinate system is defined by targets on Invar support triangle. These are remeasured after measuring other targets to gauge stability of measurement.

Targets on ring, on inlet and outlet(in/out) tubes, at inner radius of sectors and outer radius of sectors(at mounts).

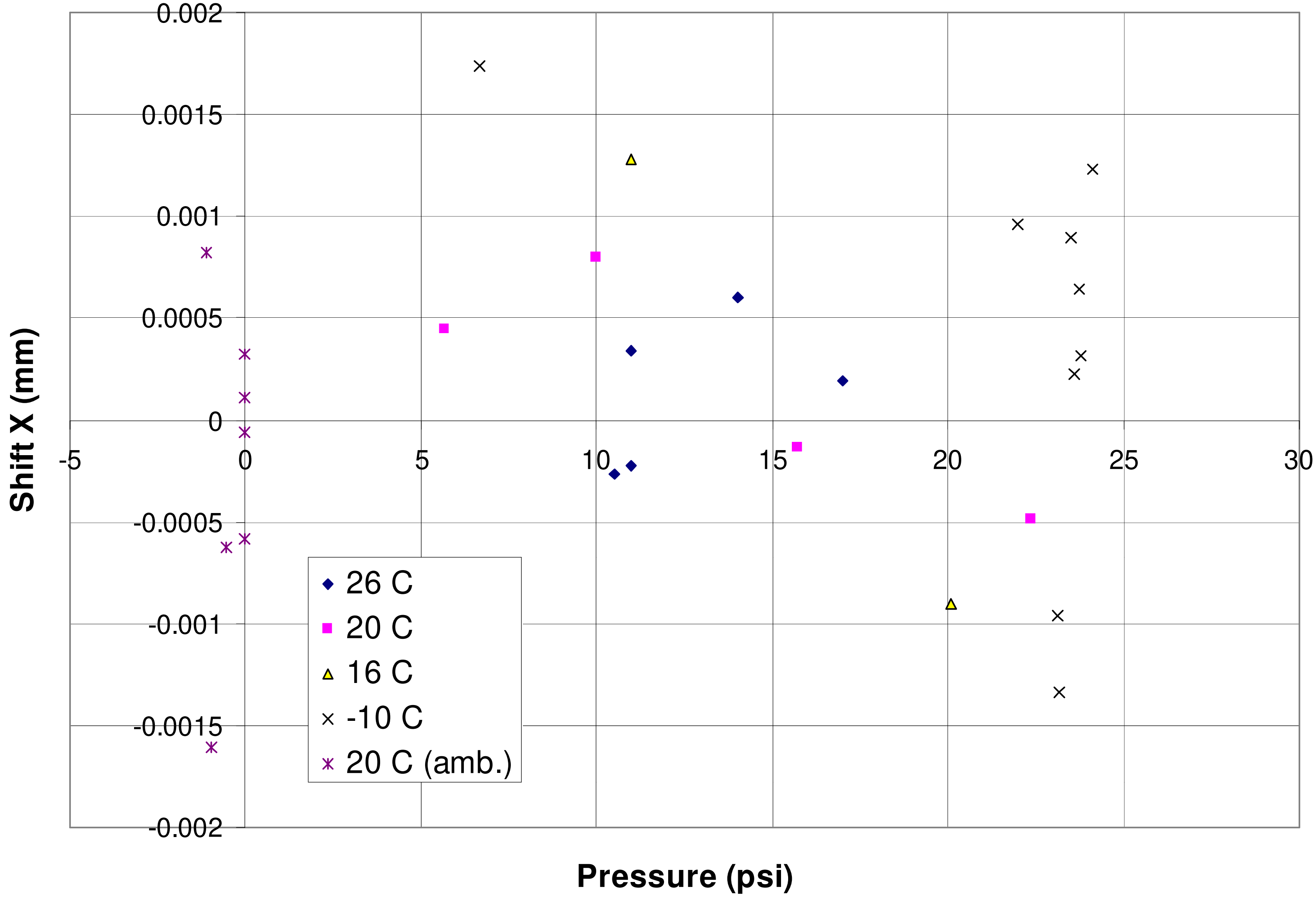
Stability Measurements

- Preliminary analysis is complete. We have spent most of time understanding reliability of measurements.See note in book and some plots next pages.
- Present here example of motion seen by comparing room temperature(average) base state with -10^{o}C, 60 Watts state.
- Results indicate that stability requirements can be met.
- Intrinsic resolution of device is about 1 - 1.5 microns rms in X and Y and about 3-5 microns in Z.

AVE is average motion between the two states. SPREAD is the largest-smallest motion(including sign). RMS is standard deviation. Units are mm.

	X	Y	Z
RMS (ring)	0.0038	0.0055	0.0073
RMS (in/out)	0.0088	0.0052	0.0111
RMS (sector@mount)	0.0023	0.0041	0.0083
RMS (sector@inner R)	0.0028	0.0033	0.0091
SPREAD (ring)	0.0105	0.0134	0.0180
SPREAD (in/out)	0.0206	0.0133	0.0323
SPREAD (sector@mount)	0.0079	0.0141	0.0320
SPREAD (sector@inner R)	0.0107	0.0134	0.0378
SPREAD (invar, final)	0.0041	0.0018	0.0014
AVE (ring)	-0.0027	-0.0005	0.0014
AVE (in/out)	-0.0005	0.0014	0.0013
AVE (sector@mount)	-0.0013	0.0002	0.0014
AVE (sector@inner R)	-0.0010	-0.0012	0.0135
AVE (invar, final)	-0.0008	-0.0005	-0.0016

SHIFT X avg, inner targets, vs inlet pressure



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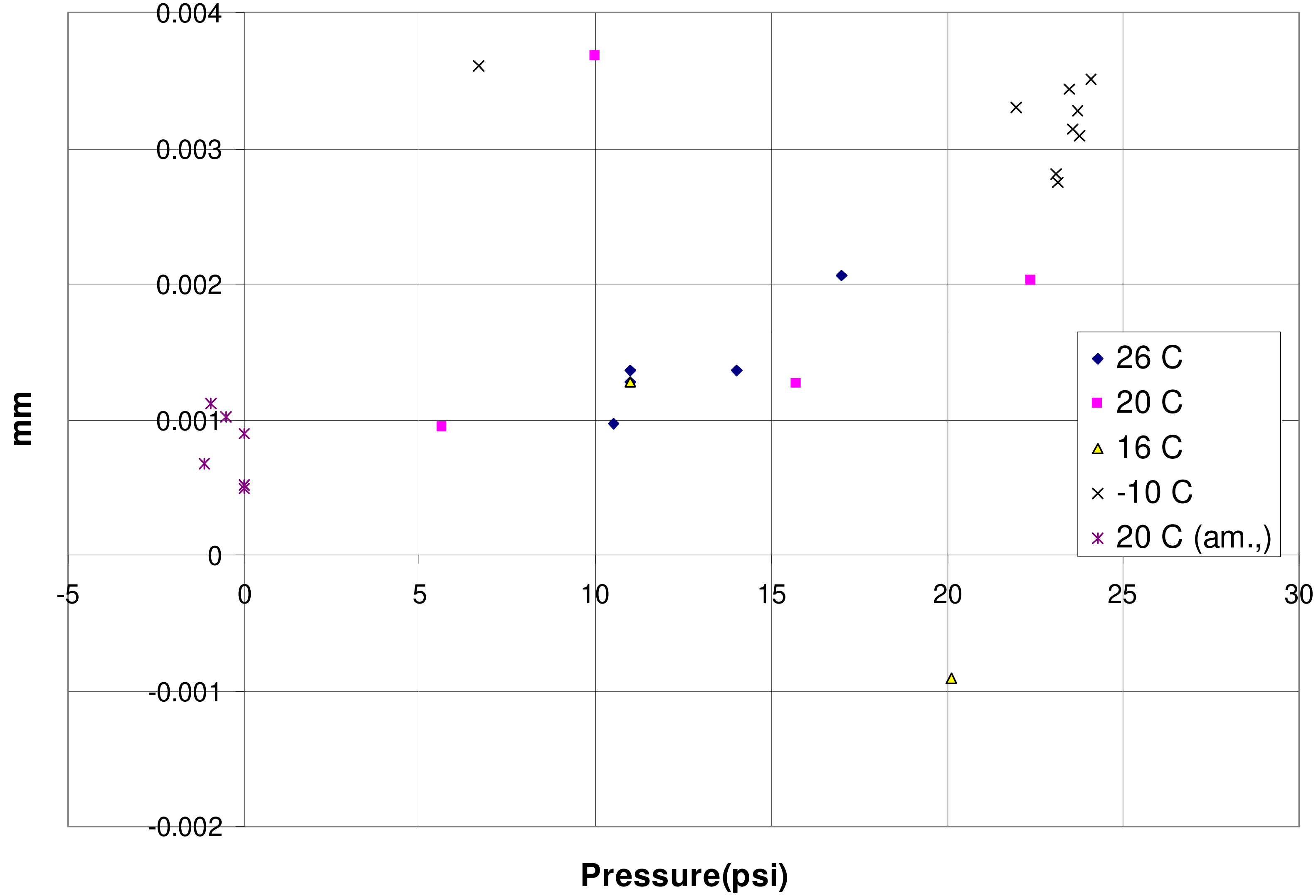
X RMS, inner targets, vs inlet pres.



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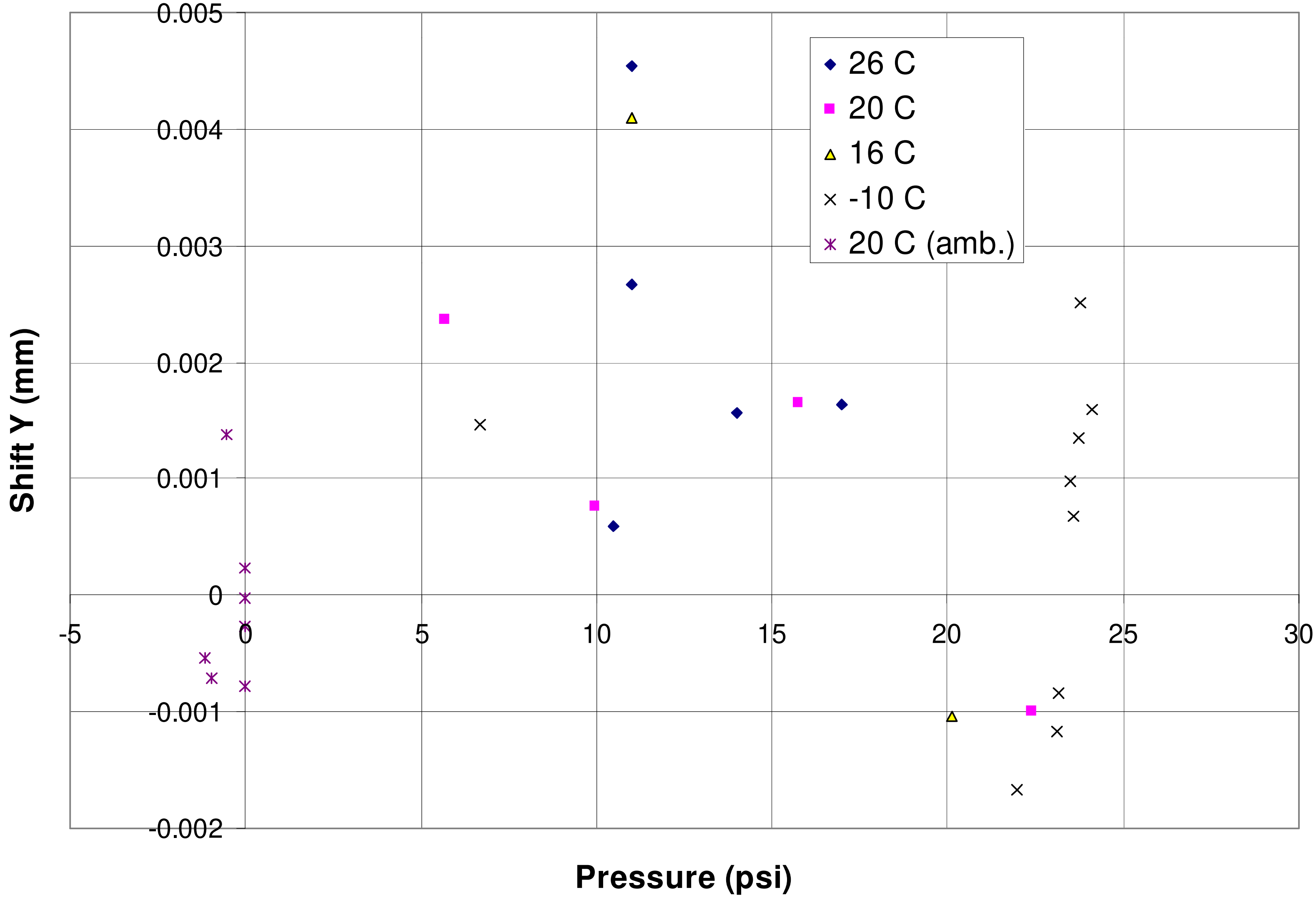
shift Y avg. inner targets vs inlet pressure



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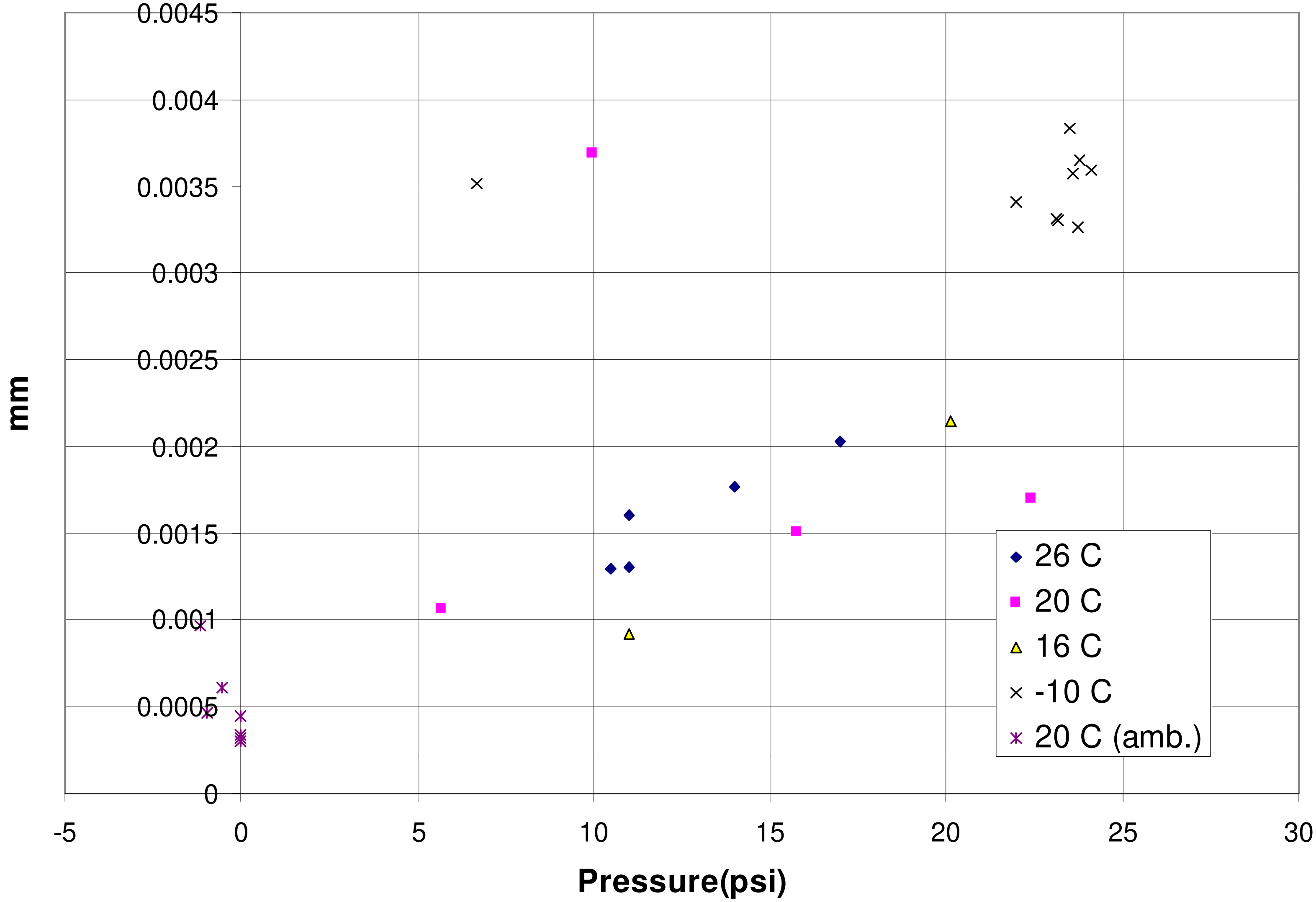
RMS Y, inner targets, vs inlet pressure



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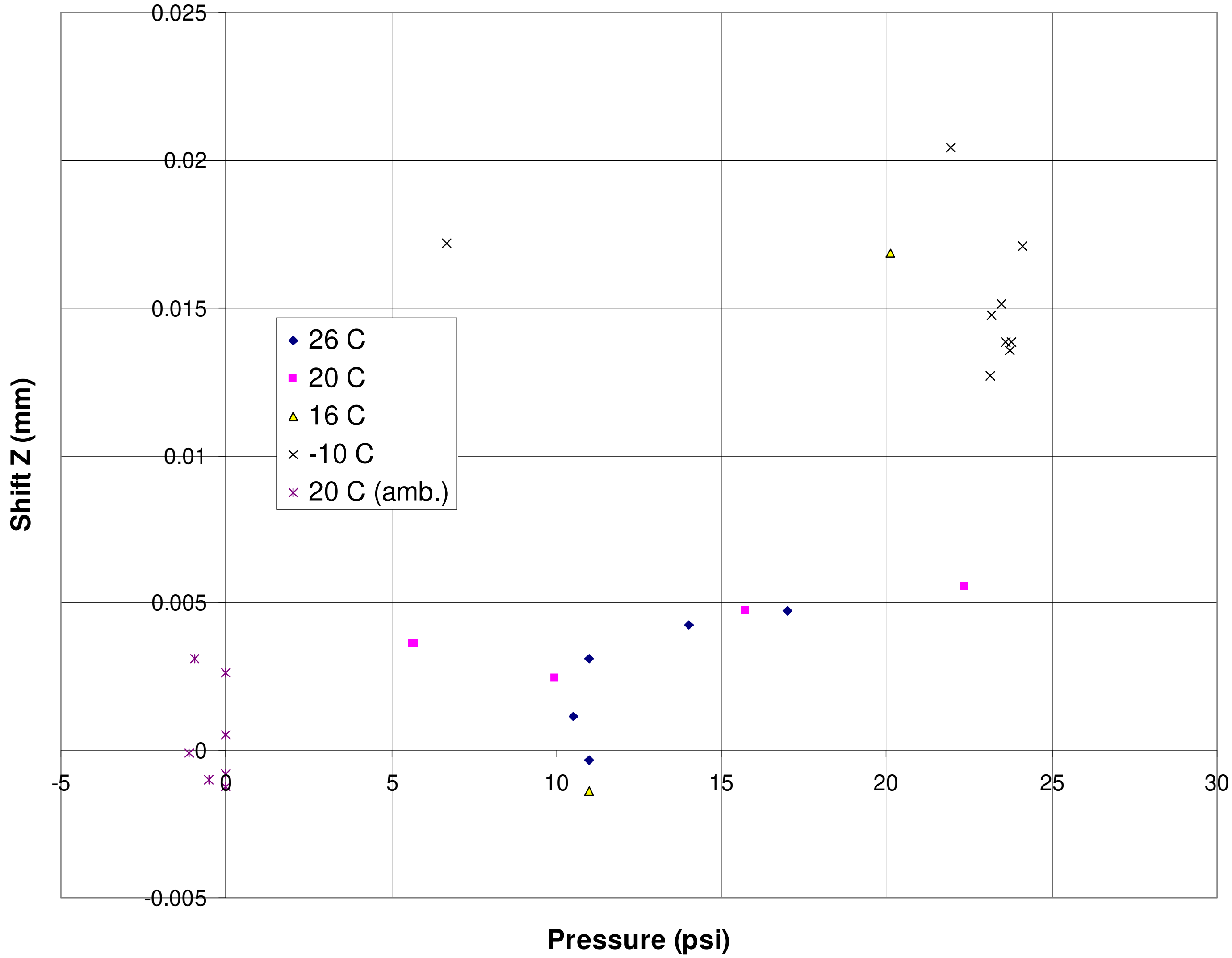
SHIFT Z AVG INNER R VS INLET PRESSURE



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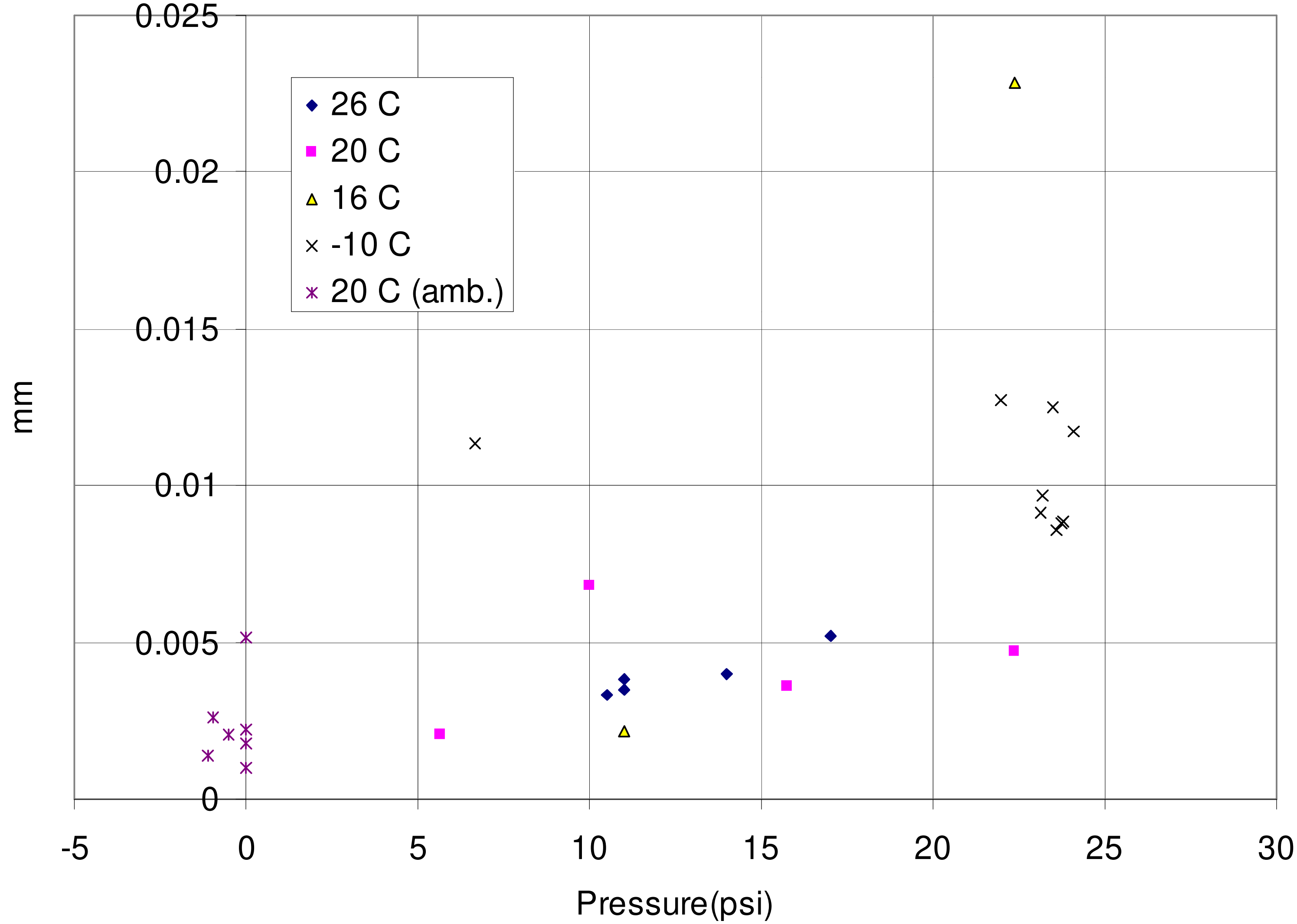
Z RMS inner R vs inlet pressure



Measurement Implications and Plan

- Stability in-plane appears to be adequate - better than 10 microns rms, although full temperature range not explored.
- Out-of-plane stability is within requirement.
- FEA estimates predict(see Hytec note in your book) small motion(max 12 micron displacement for 40 degree temperature change) but do not include pressure effects.
- Measurements will be repeated on 2nd prototype disk
  - Will use TV holography at Hytec, which has order of magnitude better resolution in out-of-plane coordinate.
  - TV holography being adapted to measure in-plane but can also use LBNL optical CMM again if this fails albeit with poorer but still adequate precision.
  - Will increase temperature range, and use simple evaporative system(at Hytec but not LBL) for cooling.
- We also applied known loads to coolant connection points and measured deflections. These deflections during services connection must be controlled monitored during actual assembly => assembly concept devised to take this into account(services support frame and motion monitors during assembly will be implemented).

Interfaces

- Sector mounting
  - Under control and part of prototype program
- Support to frame
  - This is current critical issue - see next page
- Services
  - This is current critical issue - see next page
- Assembly and final assembly
  - Early conceptual design complete(see Eric's talk later).
  - Do we need additional hard points, connections on ring for assembly? Current answer is <u>no</u> - will incorporate into three supports to frame.
  - Must monitor/control deflections from attaching services to sectors when on disk
- Survey
  - Will include optical targets on ring for survey after assembly but expect to use survey targets on sectors since <u>sector</u> location is critical issue.
  - Expect to measure locations of all sectors relative to 3 support points using optical CMM with technique like that used to assess stability.
  - In addition, will have targets mounted at inner radius of sectors for post-assembly survey.

Critical Issues

- Critical Issues
  - Overall stability of disk will be affected by design of ring-to-frame support.
  - Conceptual design started but no prototypes for 4-6 months(aim to have by end September).
  - Will use existing frame prototype parts to mockup support(see Eric's talk later) and assess stability.
  - Services interface and strain relief. Current plan has all of strain relief in sectors and frame and none in ring. But this needs to be verified. Timescale: by June FDR of sectors.