

# Tracker to Tracker Clearance Reduction Contributors

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1. Tolerances on grid features.
2. Low frequency vibration environment - spacecraft and grid structure.
3. High frequency vibration environment - tracker modes.
4. Launch thermal environment.
5. Survey precision at SLAC (apparent clearance increase or reduction )
6. Sidewall flatness .
7. Angle of parallelepiped to grid plane.
8. Bottom tray to grid features – includes corner fittings, flexures, close outs, and assembly of these items.

In addition, some level of clearance margin is needed for items not identified in 1-8 above.

# Combining Parameters

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- **Normally a worst case approach is desirable ( when possible ) in order to minimize risk.**
- **RSS approach is often implemented to lower the answer and obtain a value more frequently expected .**
- **For tracker clearances, a worst case combination of variables may not be excessively conservative since there are 18 interchangeable trackers with 4 sides each.**
- **Calculations performed have used multiple methods including worst case, RSS, 1.5 \* RSS, sum of two largest variables, and  $k * ( v_1 + v_2 + v_3 + \dots + v_N )$  where K is a function of the number of variables**

# Clearance Allocations at Top of Trackers

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- **Nominal clearance between trackers**
  - at top of trackers = 2.5 mm (at bottom of trackers = 1.0 mm)
- **Computed clearance reductions at top of trackers due to grid features, launch environments, and measurement capability**
  1. Grid features .243 mm X 2 = .486 mm
  2. Low freq dynamics .280 mm X 2 = .280 mm
  3. High freq dynamics .291 mm X 2 = .582 mm
  4. Launch thermal environment .038 mm X 1 = .038 mm
  5. Survey precision at SLAC .200 mm X 1 = .200 mm

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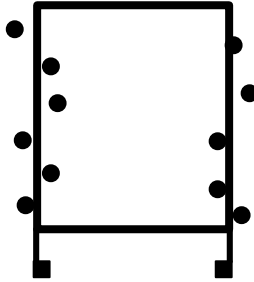
1.586 mm

  6. 7. and 8. Remaining budget for all tracker considerations and all other effects = ( 2.5mm – 1.586mm ) / 2 = .457 mm per tracker

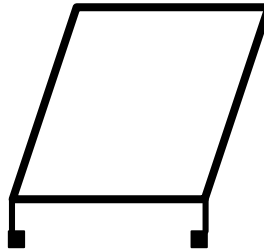
# Tracker Clearance Reductions

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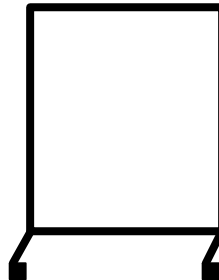
6. Sidewall flatness



7. Parallelepiped



8. Corner fitting  $\perp$



# Tracker Contributions to Clearance Reduction

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## 6. Sidewall flatness

- 0.1 mm based on provided EM measurement data
- 0.3 limit ?

## 7. Angle of parallelepiped to grid plane

- controlled by holes in sidewall and assembly tooling
- small value ?, influenced by vibration ?

## 8. Tracker corner assembly ( with concentric cones rather than eccentric cones )

- single corner assembly
  - .246 mm vector sum of swing from .1 mm  $\perp$  on corner fitting
  - .101 mm from three other factors
  - worst case = .347 mm, RSS = .257 mm
- four corners with additive effects
  - worst case = 1.04 mm, RSS = .45 mm, 1.5 RSS = .68 mm

0.1  $\perp$  tolerance on corner fitting is significant contributor to clearance reduction and has potential to cause interference between adjacent trackers when concentric cones are used

# Options for Consideration

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- 1. Maintain concentric cones at three locations and reduce 0.1  $\perp$  tolerance on corner fittings**
  - Tooling cost and schedule penalty
  - Alignment is set but not adjusted with concentric cones
  - Record keeping for eccentric cone rotations not required
  - Potential to adjust alignment as a back-up plan is possible if adequate measurements are implemented
- 2. Utilize dual eccentric cones at all positions ( 3 locations selected to define reference plane )**
  - No impact on tooling
  - CMM measurement of sidewalls and flexure cones plus analytical determination of eccentric cone rotations required at INFN
  - A valid solution for cone rotations verifies cones have adequate range of eccentricity and that tracker related errors can be either eliminated or centered relative to reference plane
  - Cone rotations at three reference locations would be used to position tracker on grid at SLAC

# Conclusions

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- **Validated CMM measurements are more useful than any fitment of a completed tracker to a “hard tooling cage “**
- **CMM measurements relating sidewall planes, flexure cone centers, bottom tray tooling holes, and top tray tooling balls are needed in any case.**
- **Effort is needed at INFN and at SLAC to correlate CMM measurements of a single tracker at INFN with the SLAC survey of the tracker on the grid**
- **All of the measurement and analysis work for option #2 is needed to implement the back-up plan for option #1**

# Recommendations

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- **Baseline option #2 but evaluate cost and schedule penalty of reducing tolerances on perpendicularity of assembled corner fittings and implement reasonable changes.**
- **Implement CMM measurements relating sidewall planes, flexure cone centers, bottom tray tooling holes, and top tray tooling balls at INFN.**
- **Identify individuals at INFN and at SLAC to correlate CMM measurements of a single tracker at INFN with the SLAC survey of the tracker on the grid. SLAC individual should bridge the gap between SLAC Tracker group, INFN, and SLAC I & T.**
- **Perform Tower A CMM measurements before and after the vibration environment to demonstrate shape stability.**