Joint constraints for SciFi modules alignment

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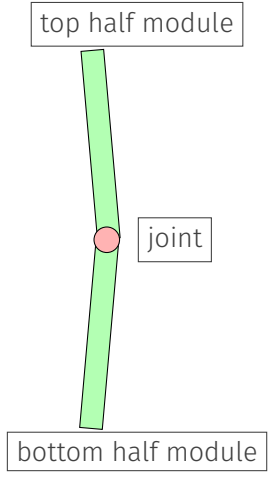
Concept for joint constraint

- Long SciFi modules: slight ”banana shape”
- Half modules + joints reproduce the real shape
- Joints are implemented in the alignment by using a survey constraint (MR!368)
- It constrains parameters of two alignables A and B to each other with a *chi*^{2}: $\chi^2 = (p_A - p_B)^T V^{-1} (p_A - p_B)$
- p_A, p_B: set of parameters for the half modules
- Use common frame (local half module frame)
- Errors taken from diagonal covariance matrix →how realistic? →tuning needed
- No survey available for joints, tuning needed to contol their χ^2



Tuning procedure

- Instead of one χ^2 for whole cov. matrix →look at the χ^2 for joint parameters (Tx,Ty,Tz,Rx,Ry,Rz)
- AlignChisqConstraintTool.cpp was modified to calculate the six chi^2 values to the software (MR coming soon)
- Tune uncertainties by running an alignment for each change to the respective parameter uncertainty until roughly χ^2/dof = 1

- Procedure evaluated with 2023 data (run 269045, warm SciFi) and master from conditions database
- Using the Alignment master branch

```
elements = Alignables()
elements.FTHalfModules("TxRz")

surveyconstraints = SurveyConstraints()
surveyconstraints.FT(addHalfModuleJoints=True)

constraints = []
constraints.append("BackFramesFixed : FT/T3/X2/HL.*/M. : Tx Rz")
```

Tuning of uncertainty : Tx

Initial errors:

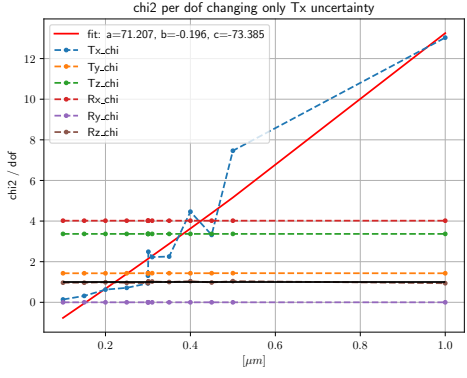
Tx,Ty,Tz [μm]: 1 1 1

Rx,Ry,Rz [mrad]: 0.2 0.2 0.2

- Vary Tx error (starting at 1 μm) →run alignment →calculate χ^2/dof, keep every other parameter at nominal!

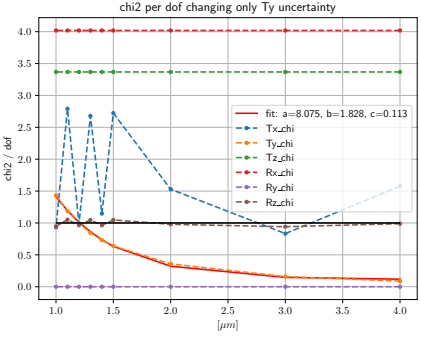
→ Tx=1 μm has χ^2 ≈13, perform a scan in a range of uncertainties to find the intersection with χ^2 = 1 (black line)

intersection (fit): 0.22 μm (0.3 μm from scanning)

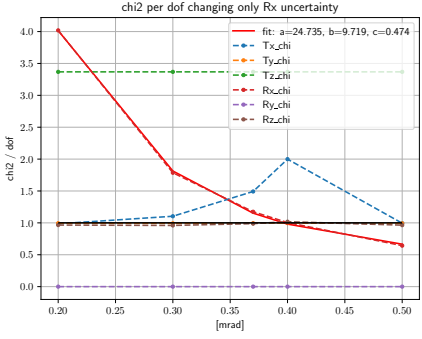


Tuning of uncertainties : Ty Rx

obtained uncertainty of Ty: 1.2 μm

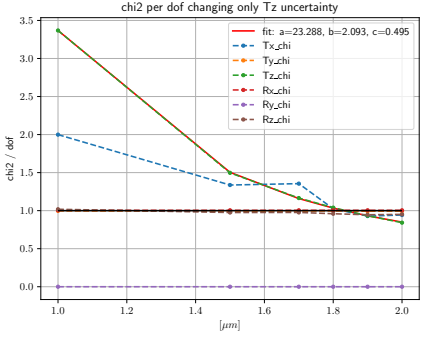


obtained uncertainty of Rx: 0.4 mrad

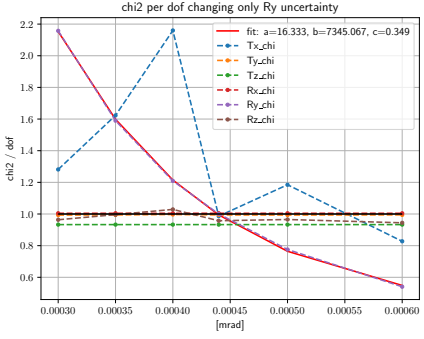


Tuning of uncertainties : Tz Ry

obtained uncertainty of Tz: 1.83 μm

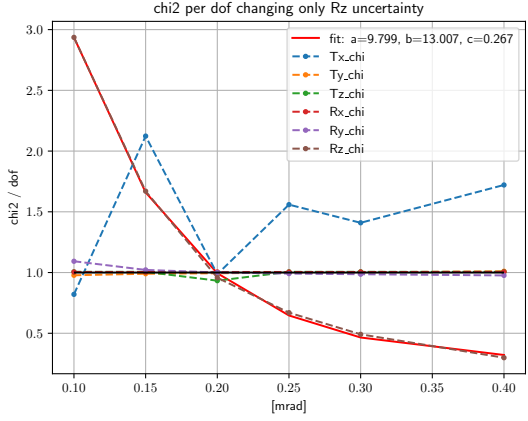


obtained uncertainty of Ry: 0.44 μrad



Tuning of uncertainty : Rz

- In the last step, Rz was tuned
- intersection at 0.2 mrad was already correctly set from nominal
- All parameters show good behaviour at the chosen uncertainty



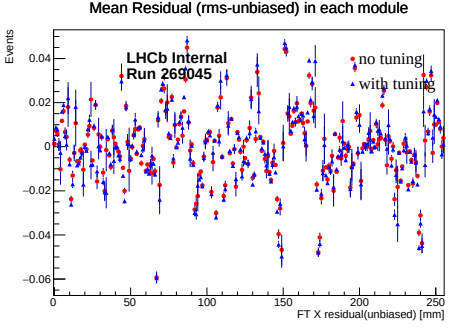
Uncertainty tuning results

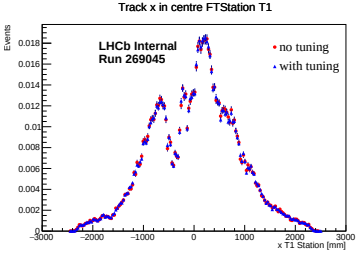
final tuned errors: 0.0003 0.0012 0.00183 0.4 0.00044 0.2

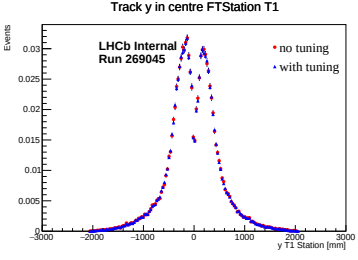
parameter	χ^2/dof (befor)e	χ^2/dof (after)	uncertainty (before)	uncertainty (after)
Tx	13.031	0.986	1 μm	0.3 μm
Ty	1.429	0.994	1 μm	1.2 μm
Tz	3.368	0.933	1 μm	1.83 μm
Rx	4.019	1.005	0.2 mrad	0.4 mrad
Ry	4.8e-6	1.0003	0.2 mrad	0.44 μrad
Rz	0.939	0.957	0.2 mrad	0.2 mrad

First checks of tracking quantities

this does not introduce degradation in performance







Next steps

- Check the effect of different constraints, selections (particles and tracks) on the joints χ^2
- Test tuned parameters with online stack setup
- We make sure to check the alignment constants before deploying this in data-taking