

# Float Reduction Estimation for Patterned Geometry

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Prairiefire  
CONSULTING, INC.

# Abstract

Prairiefire has developed a pre-processing tool that simulates the actual float allowed in an over-constrained fastener pattern, allowing accurate representation of the system within the exact constraint requirement of CETOL.

On the design side, the tool also aids in optimizing tolerances for a required amount of float and fit-up yield.

The tool will be available for download after our overview.

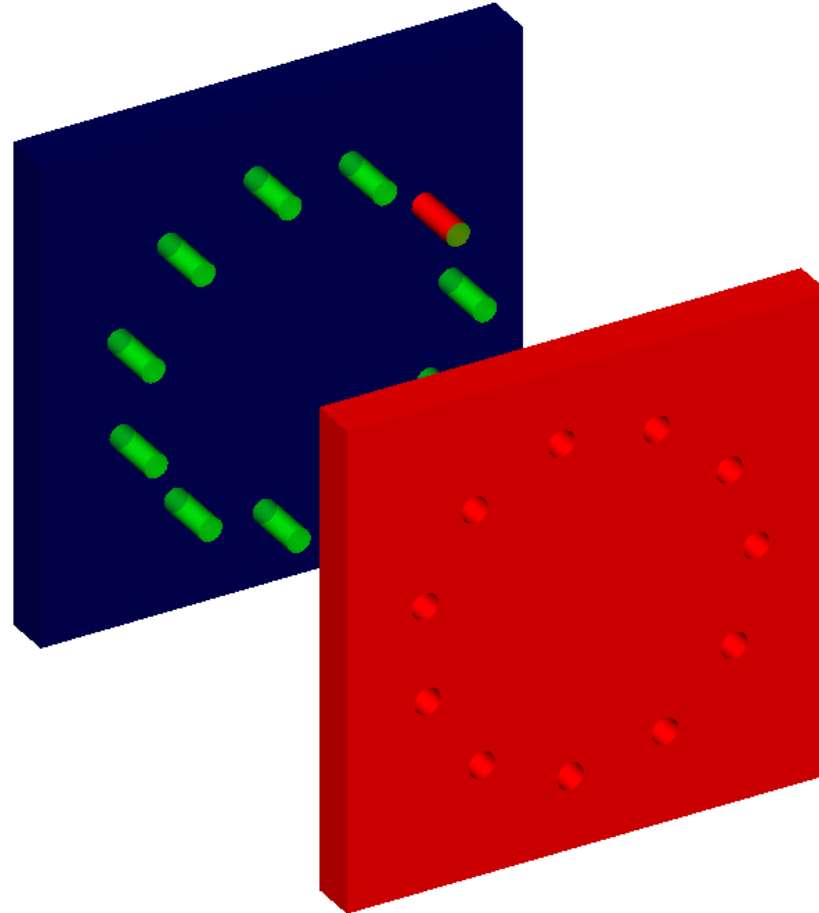
Author: Drew Coverdill

Presenter: Michael Lopez

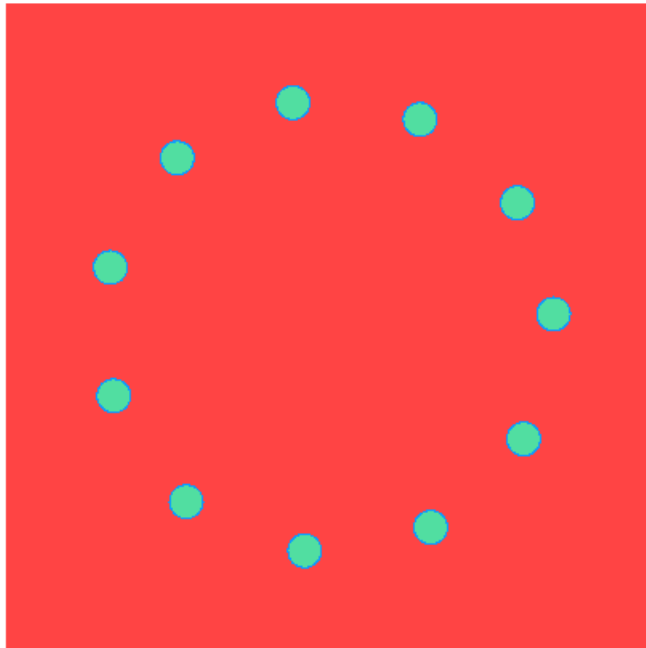
Original work: Eric Gertner, Coverdill, Lopez



# Test System

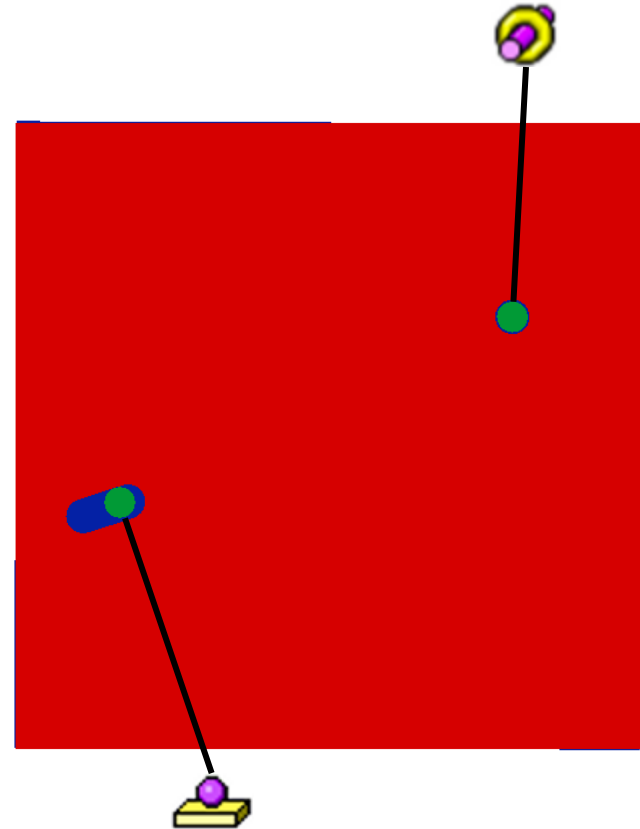


# Standard modeling practice



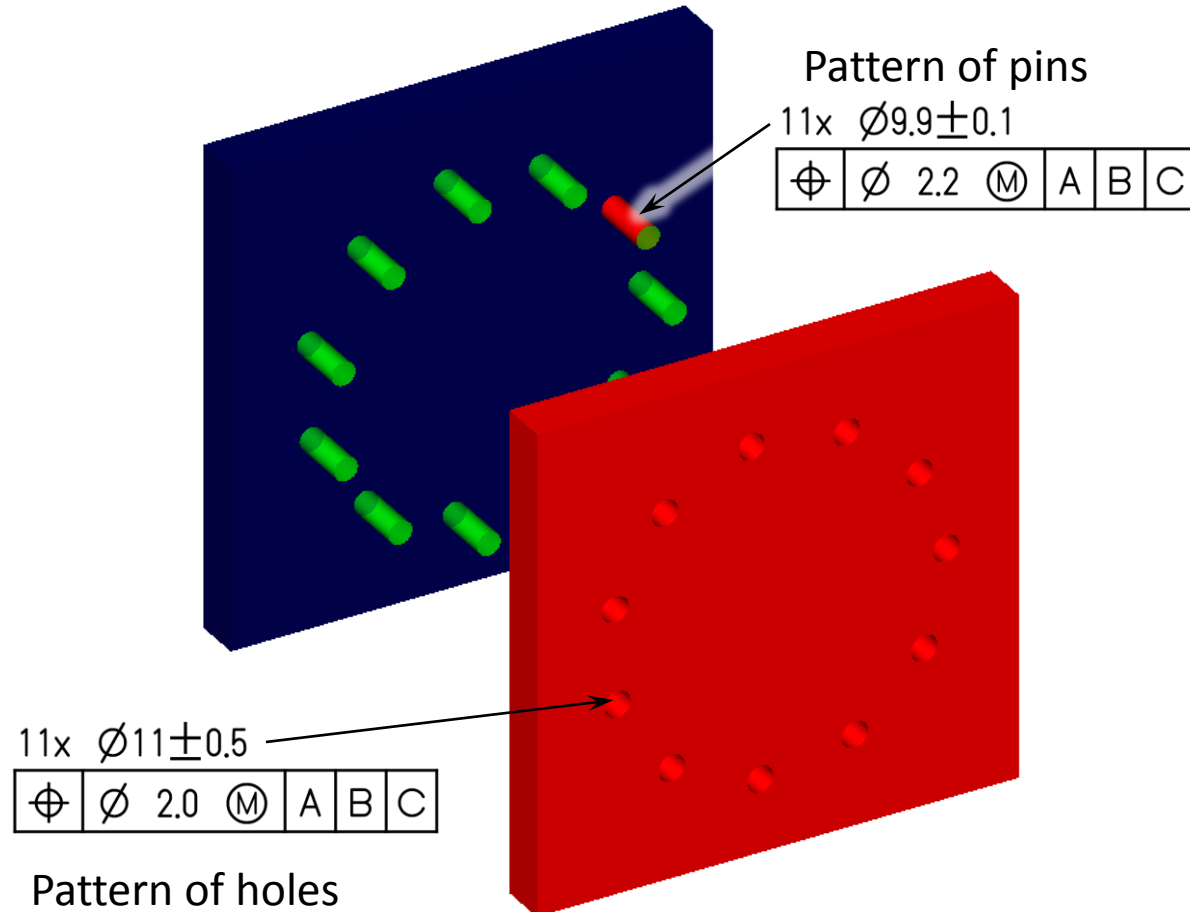
Pattern of holes & fasteners

=

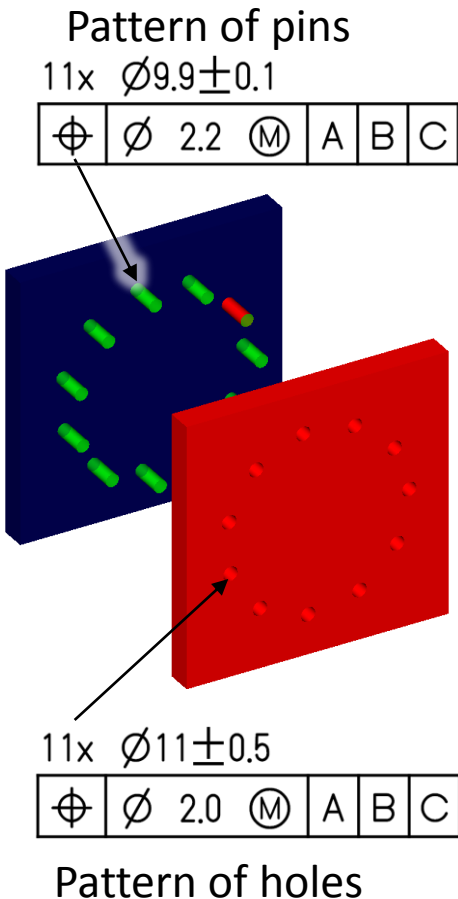


One hole, one slot

# Will all the fasteners fit through the holes?



# Will all the fasteners fit through the holes?



*Worst Case Method  
From ASME 14.5 Fixed  
Fastener appendix*

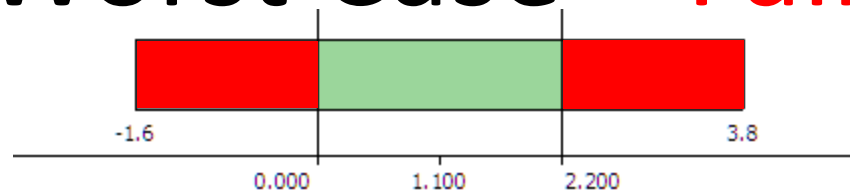
$$Hole_{MMC} \geq Fastener_{MMC} + Tol_{Holes} + Tol_{Fastener}$$

$$10.5 \geq 10 + \sum Tol$$

$$\therefore \sum Tol \leq 0.5$$

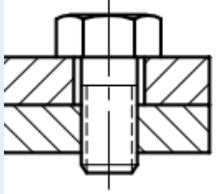
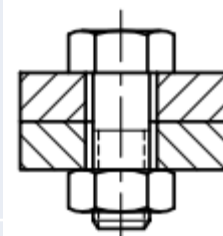
$$Tol_{Holes} + Tol_{Fastener} = 2.0 + 2.2 = 4.2$$

**Worst Case = Failed**



# Will all the fasteners fit through the holes?

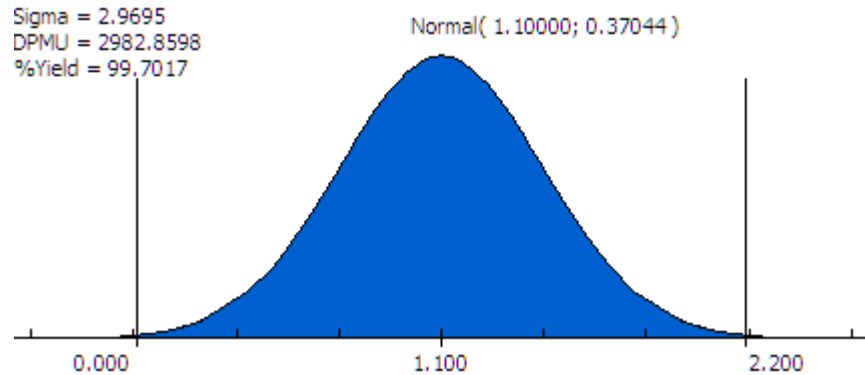
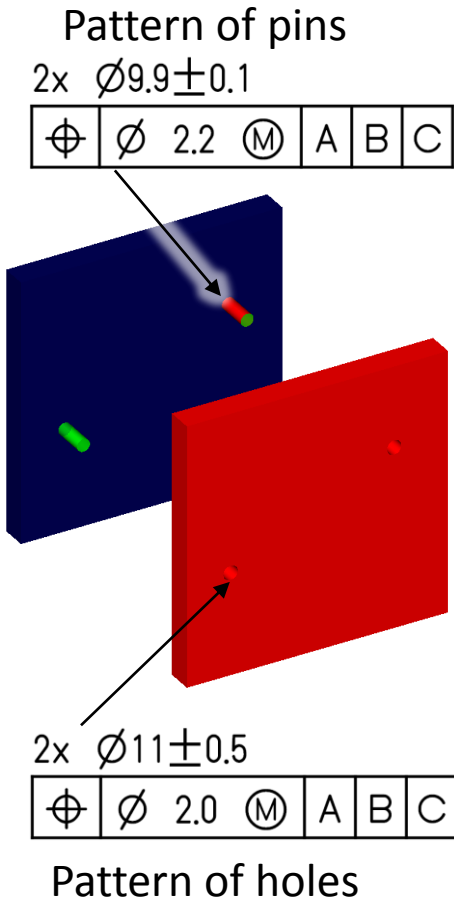
## *Statistical Methods*

		Pattern Tol for each Component	
		One Side Threaded	Both Sides Floating
Nom Thread Size	Nom Standard Clearance		
M8	9	0.8	1.2
M10	11	0.8	1.2
M12	14	1.5	2.5



# Will all the fasteners fit through the holes?

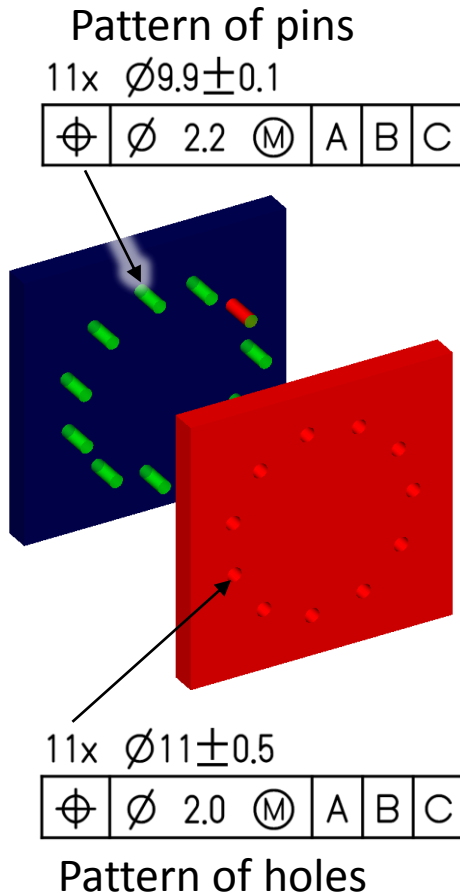
*Statistical calculation for 2 holes*



Statistically = Passed

# Will all the fasteners fit through the holes?

*FRAC calculation for 11 holes*



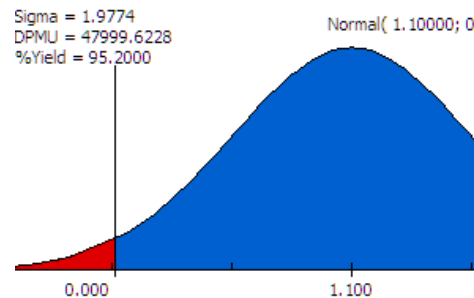
```
Geometry
Pattern size: 11x
Holes:      dia 11.0 ± 0.5
            IP ± 1.0
Bolts:      dia 9.9 ± 0.1
            IP ± 1.1

.. running simulation
.. post processing
.. calculating statistics

Results
Fail count: 48 out of 1000
Pattern yield: 95.2%

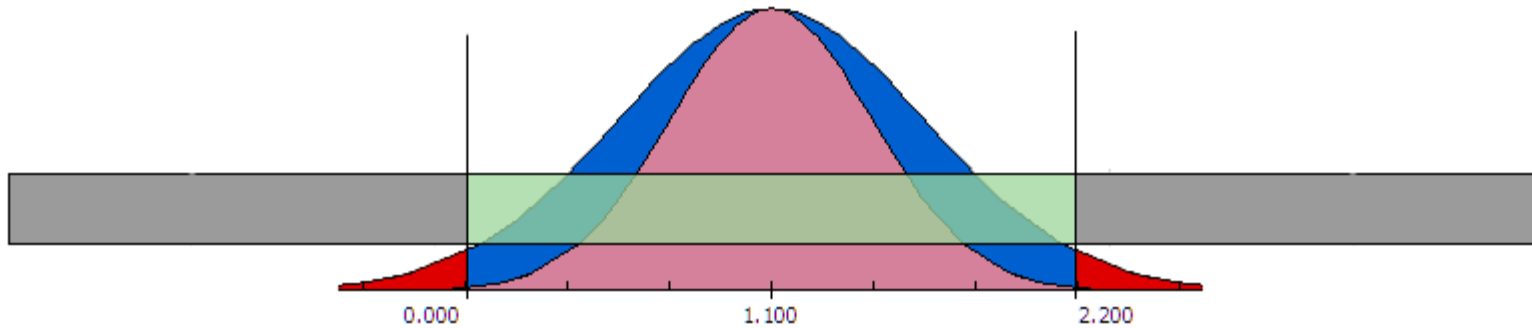
Stdev: 0.15
Kurt: 2.45

Nominal float: ±0.55
±3σ float: ±0.46
```



**Failed?**

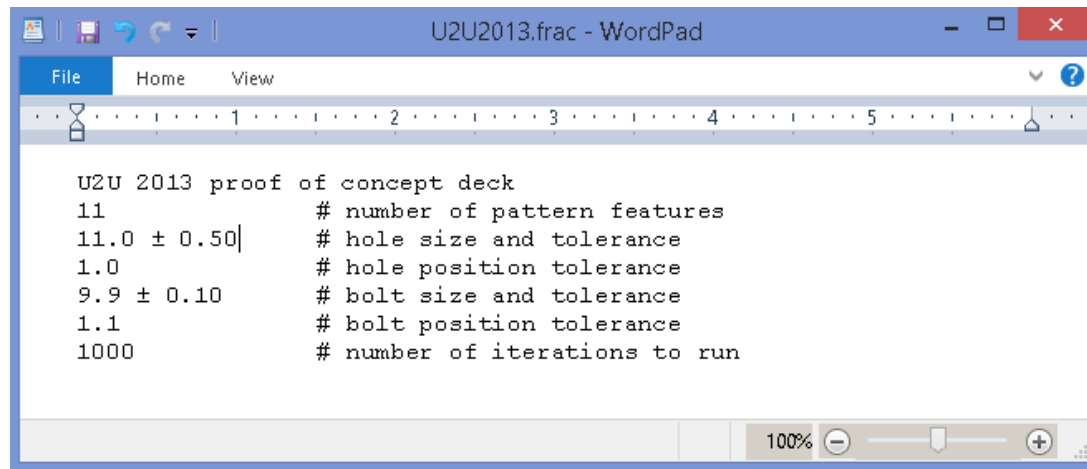
# Will all the fasteners fit through the holes?



# Put tolerance data into the FRAC deck

A test deck

11	# number of pattern features
11 ± 0.5	# hole size and tolerance
1.0	# hole position tolerance
9.9 ± 0.1	# bolt size and tolerance
1.1	# bolt position tolerance
1000	# number of iterations to run



```
U2U 2013 proof of concept deck
11          # number of pattern features
11.0 ± 0.50| # hole size and tolerance
1.0         # hole position tolerance
9.9 ± 0.10  # bolt size and tolerance
1.1        # bolt position tolerance
1000       # number of iterations to run
```

# Run Frac

```
C:\Windows\System32\cmd.exe

#####
# Welcome to F.R.A.C BETA v0.1.3 - Float Reduction Analysis Calculator #
# Contact info@pfcae.com for support and check pfcae.com for updates #
# "Your friendly Neighborhood pattern float calculator." #
#####

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> Enter deck name: U2U2013
```

```
C:\Windows\System32\cmd.exe

Deck
-----
File: U2U2013.frac
Desc: U2U 2013 proof of concept deck
Iterations: 1000

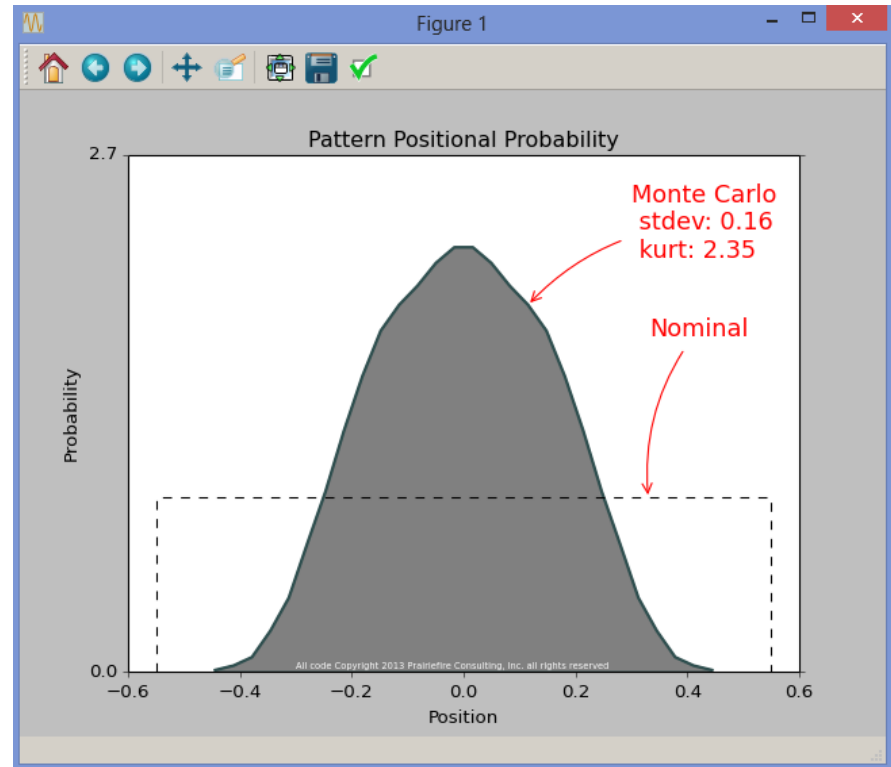
Geometry
-----
Pattern size: 11x
Holes:      dia 11.0 ± 0.5
            TP ± 1.0
Bolts:     dia 9.9 ± 0.1
            TP ± 1.1

... running simulation
... post processing
... calculating statistics

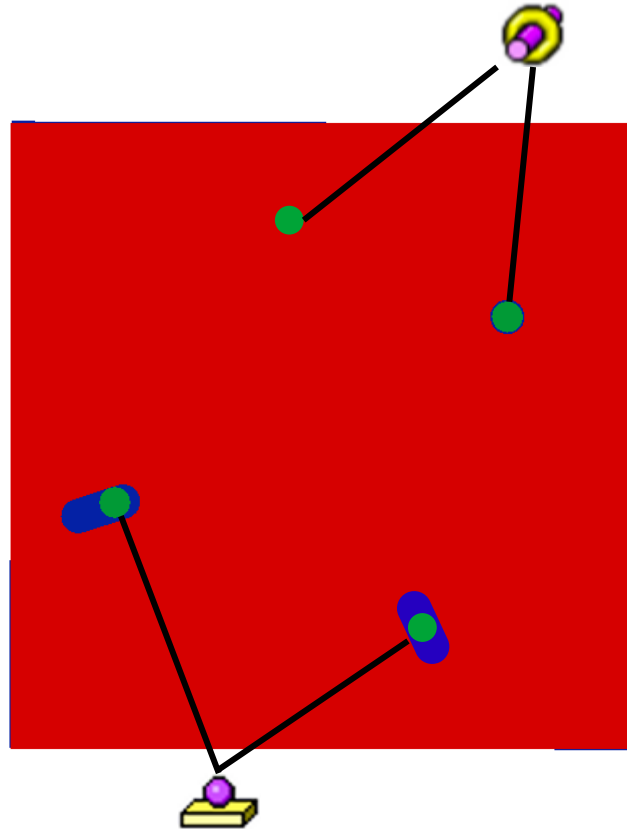
Results
-----
Fail count: 48 out of 1000
Pattern yield: 95.2%

Stdev:      0.16
Kurt:       2.35

Nominal float: ±0.55
±3σ float:  ±0.48
```



# Float in standard modeling practice



Hole-slot approximation overestimates pattern float

Animated

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# Use FRAC

```
> Enter deck name: U2U

Deck
-----
File: U2U.frak
Desc: 11 Pin Test Pattern
Iterations: 50000

Geometry
-----
Pattern size: 11x
Holes:       dia 11.0 ± 0.1
              TP ± 0.5
Bolts:       dia 9.9 ± 0.1
              TP ± 0.2

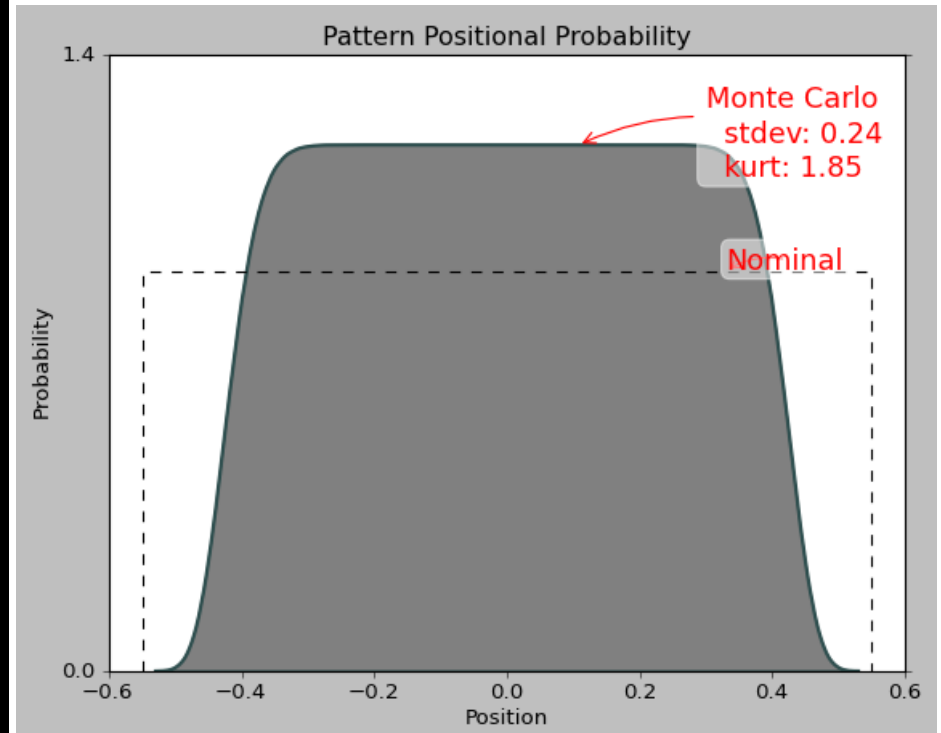
... running simulation
... post processing
... calculating statistics

Results
-----
Fail count: 0 out of 50000
Pattern yield: 100.0%

Stdev: 0.24
Kurt: 1.85

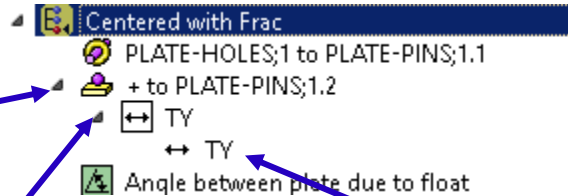
Nominal float: ±0.55
±3σ float: ±0.73

... Close plot window to continue.
```



# Where to click to enter the FRAC data

Step 1, Joint direction orientation!



Step 2

Step 3

Step 4

Properties

+ to PLATE-PINS;1,2

General Features Constraint Notes

Variable	Type	Value	State
↔ Ty	Linear	0	Variant

Apply Automatic Float

Distribution: Uniform

Z-Score: 3.00

Properties

TY

General Tol/Rule Notes

Tolerance Edit

Type: Limits Precision: 2

Upper Limit: 0.65

Lower Limit: -0.65

Apply Rule Edit Rule...  Use Part Rule

- Tolerance Independent
- Distribution Independent

Properties

TY

General Distribution Equivalent Notes

Lambda( 0.0000; 0.2500; 0.00; 1.86 )

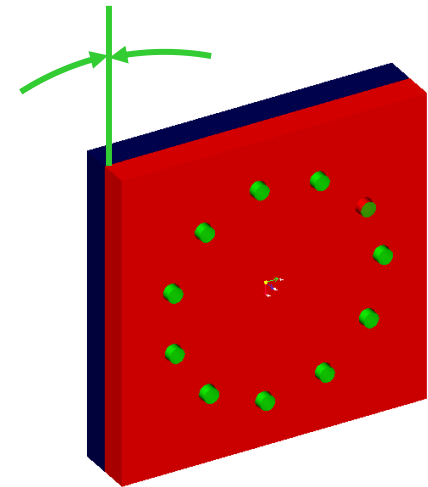
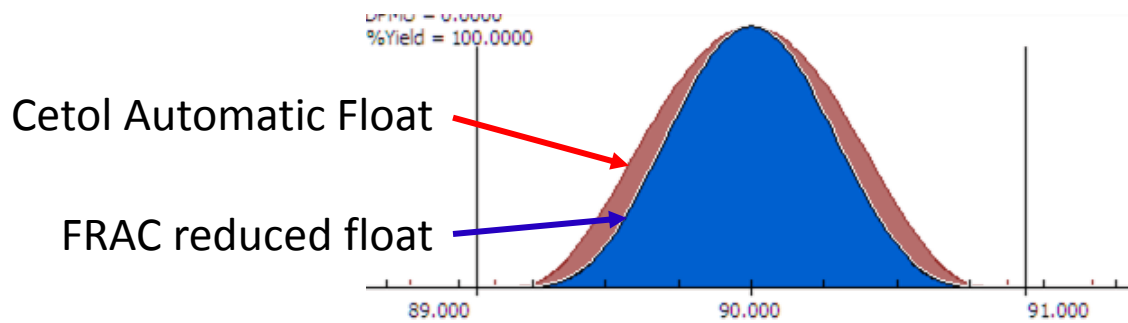
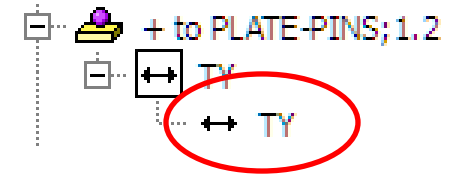
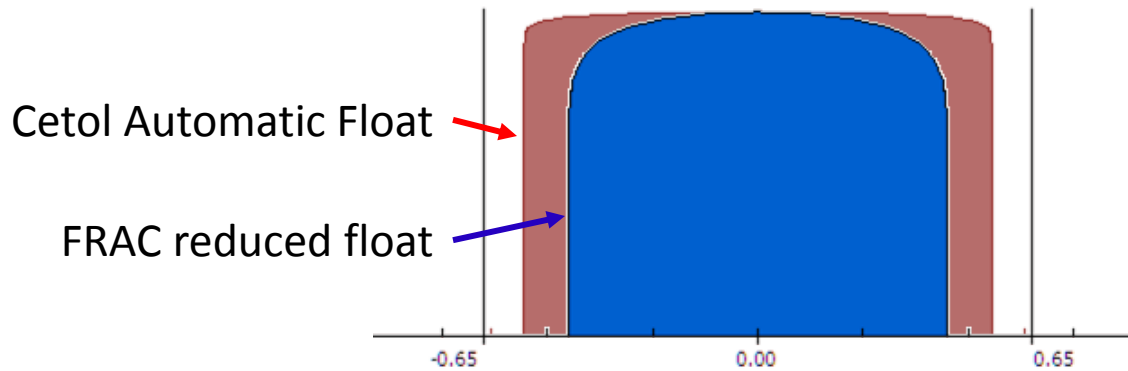
Distribution: Lambda

Mean: 0 Skewness: 0

Std Dev: 0.25 Kurtosis: 1.86



# Compare results



# Discussion

- Observations and applications