SPLINE MODELLING ELECTRON CUTOUT FACTORS USING ROUTINE MEASUREMENTS

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- John Kenny

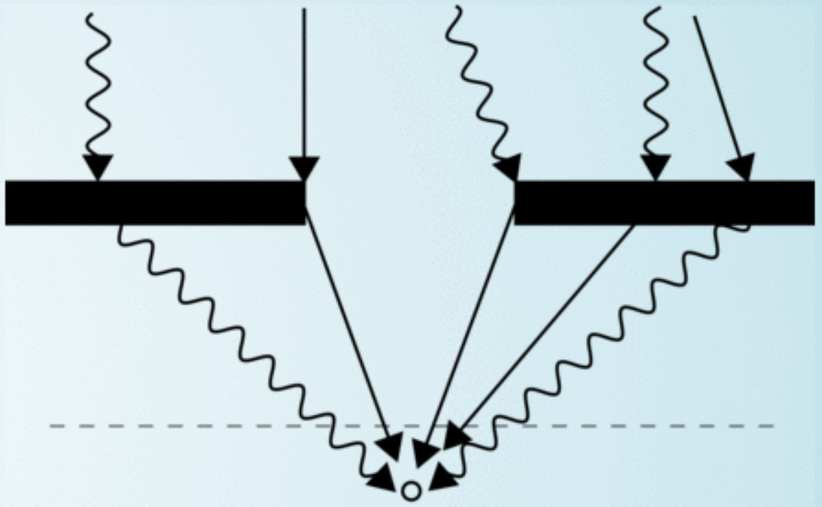
OVERVIEW

- Interpolate between electron factors of irregular shapes
- Interpolation between data many clinics already have
- To an uncertainty that approaches measurement
- With just eight measurements can predict to 0.5% uncertainty
- Many centres directly measure this factor*

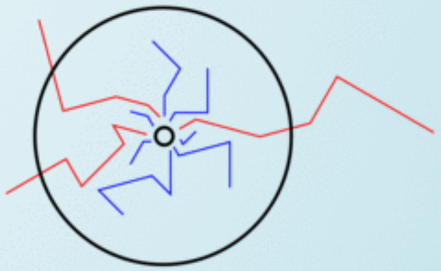
*AAPM TG 71

CONTRIBUTIONS TO THE CUTOUT FACTOR

- Lateral scatter to d_{max} [width]
- Shielding leakage (1-2%)* [1/area]
- Internal surface scatter (1-2%)* [perimeter]



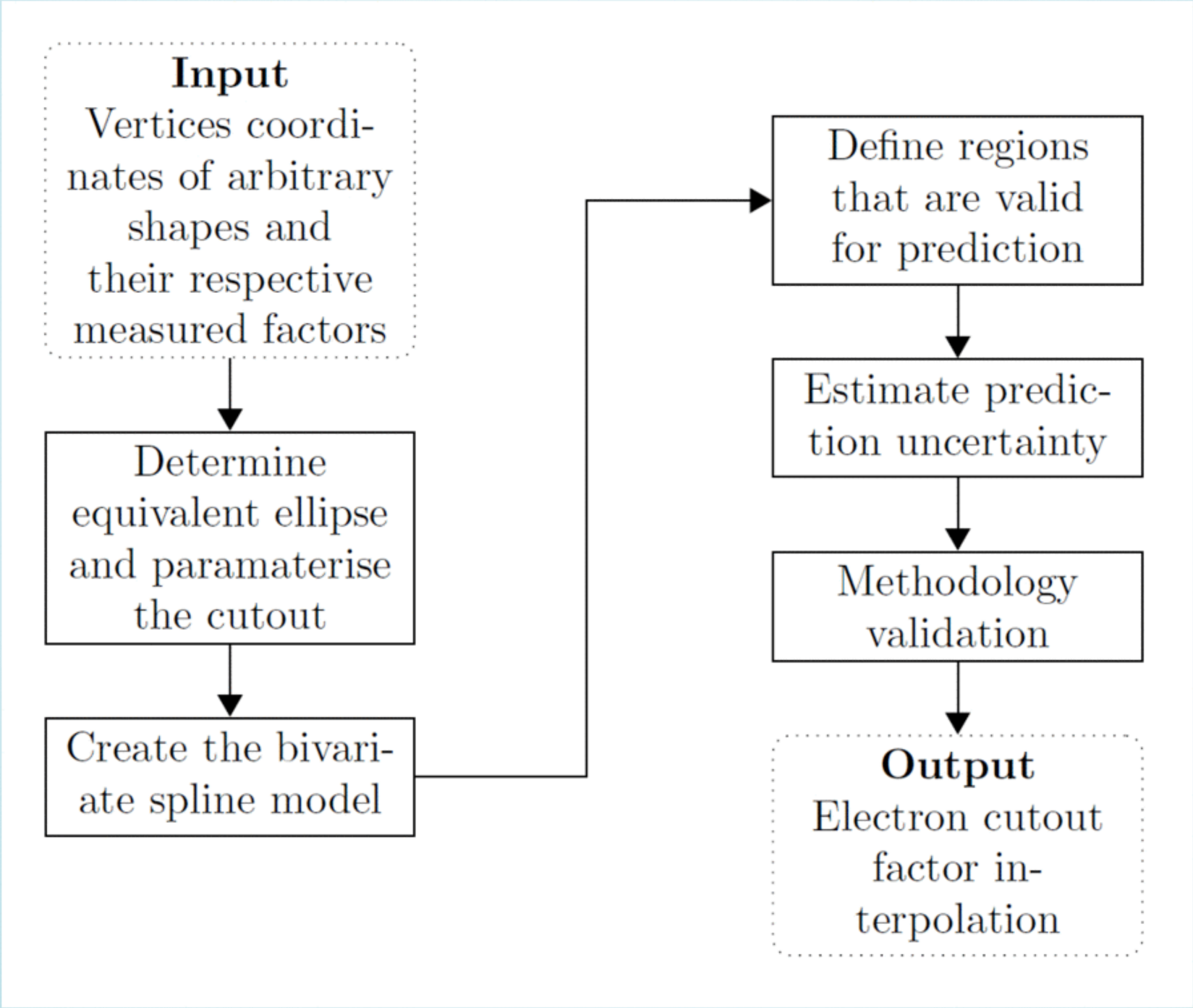
Shielding and internal surface effects



Beam eye view – lateral scatter

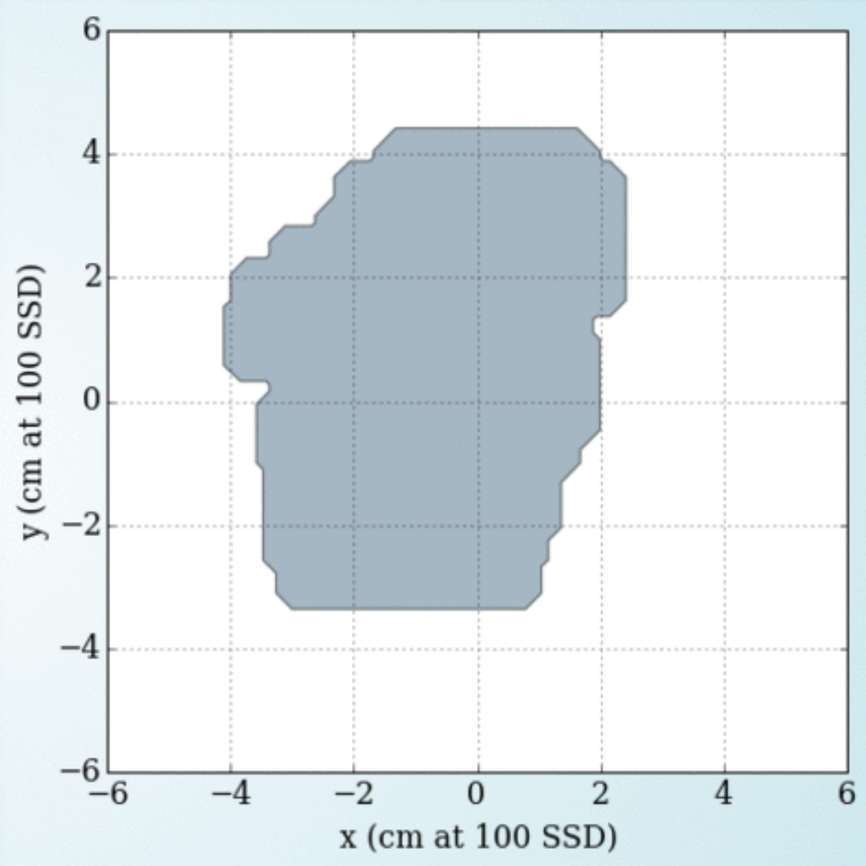
*Faddegon, Villarreal-Barajas. Med Phys 2005.

METHOD OVERVIEW



A SERIES OF MEASURED INSERTS

Simon #104 cutout
Simon #106 cutout
Simon #109 cutout
Simon #112 cutout
Simon #14 cutout
Simon #16 cutout
Simon #18 cutout
Simon #19 cutout
Simon #20 cutout
Simon #22 cutout
Simon #3 cutout
Simon #32 cutout
Simon #33 cutout
Simon #34 cutout
Simon #38 cutout
Simon #41 cutout



Cutout factor = 0.9934

A SERIES OF MEASURED INSERTS

Simon #104 cutout
Simon #106 cutout
Simon #109 cutout
Simon #112 cutout
Simon #14 cutout
Simon #16 cutout
Simon #18 cutout
Simon #19 cutout
Simon #20 cutout
Simon #22 cutout
Simon #3 cutout
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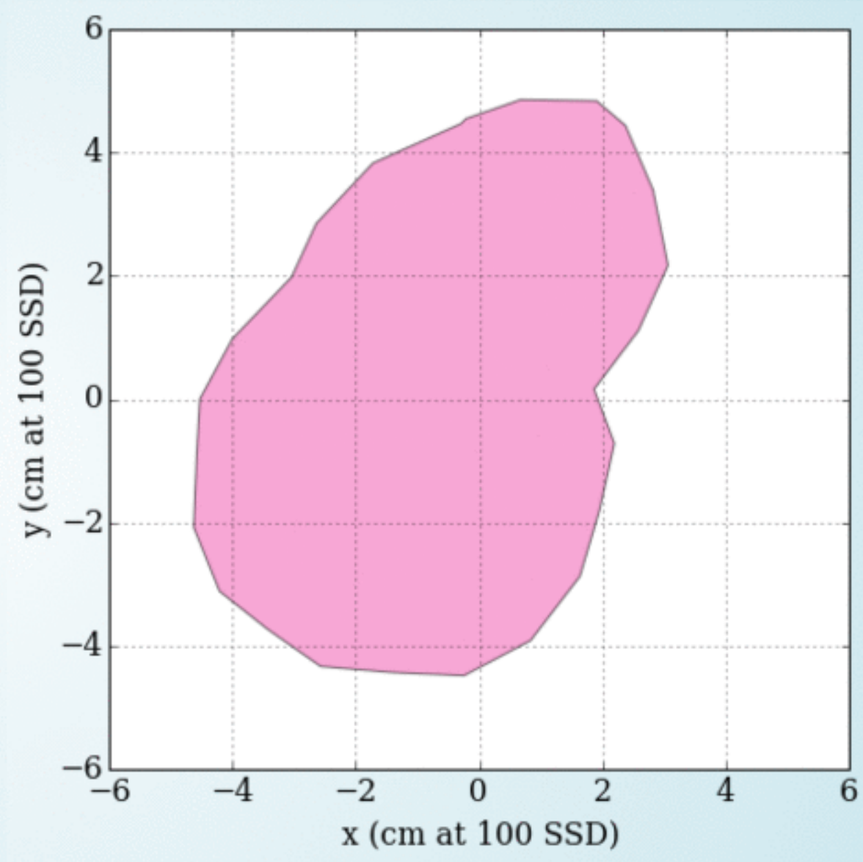
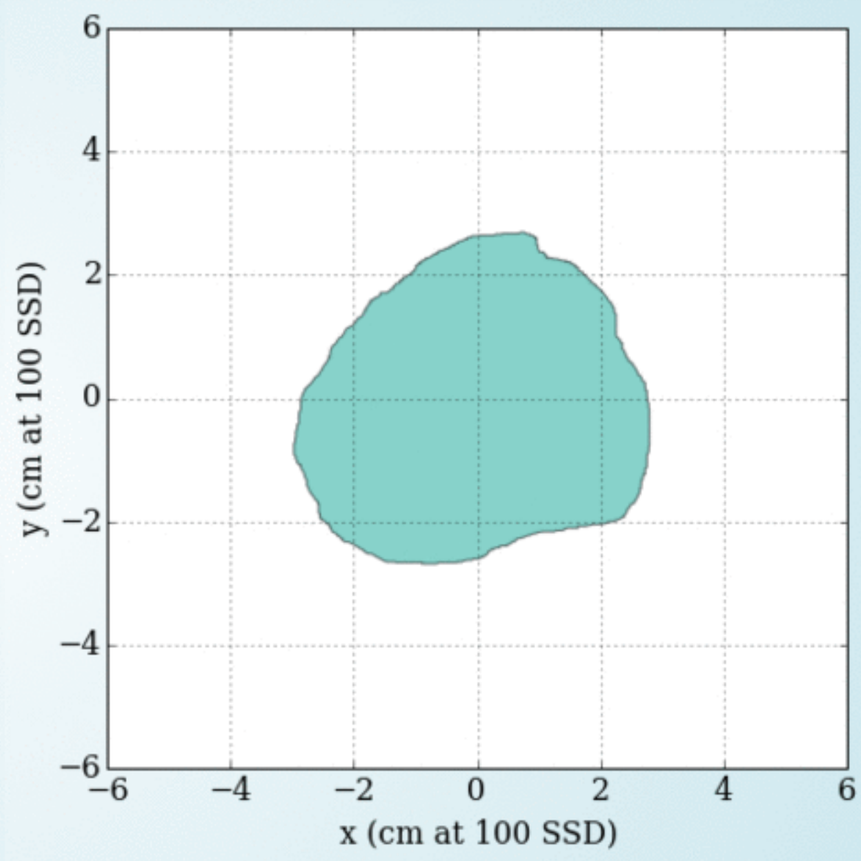
Simon #34 cutout
Simon #38 cutout
Simon #41 cutout



Cutout factor = 0.9991

A SERIES OF MEASURED INSERTS

Simon #3 cutout
Simon #32 cutout
Simon #33 cutout
Simon #34 cutout
Simon #38 cutout
Simon #41 cutout
Simon #43 cutout
Simon #57 cutout
Simon #58 cutout
Simon #6 cutout
Simon #70 cutout
Simon #73 cutout
Simon #82 cutout
Simon #83 cutout
Simon 3cm circle
Simon 3x13cm oval



Cutout factor = 0.9735

A SERIES OF MEASURED INSERTS

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Simon #34 cutout
Simon #38 cutout
Simon #41 cutout
Simon #43 cutout
Simon #57 cutout
Simon #58 cutout
Simon #6 cutout
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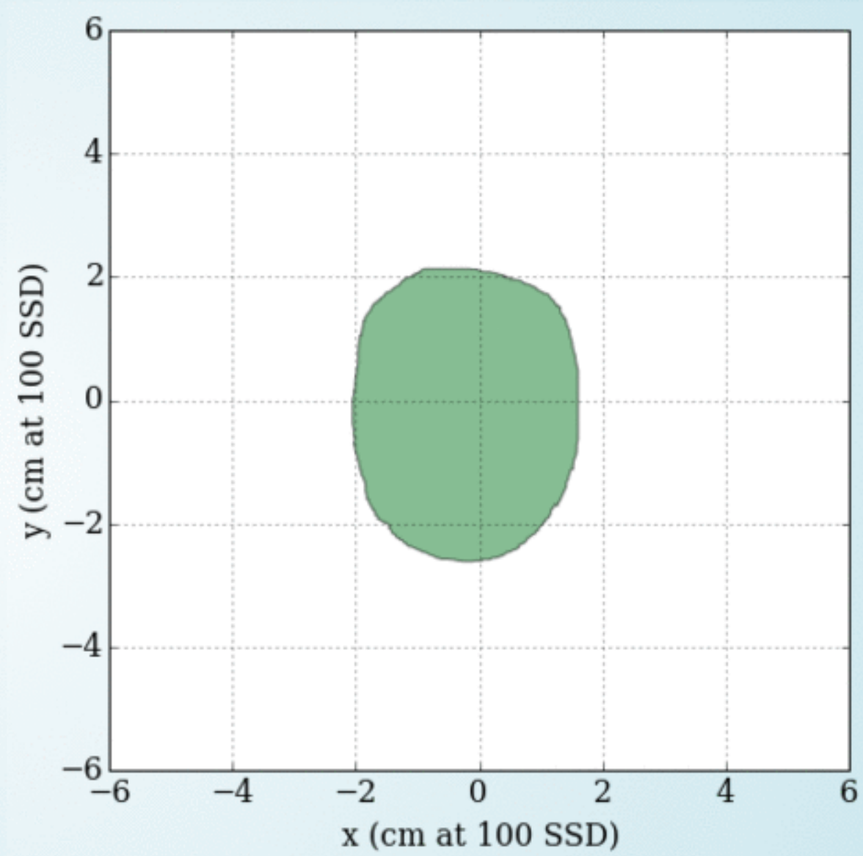
Simon #83 cutout
Simon 3cm circle
Simon 3x13cm oval



Cutout factor = 0.9437

A SERIES OF MEASURED INSERTS

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Simon #34 cutout
Simon #38 cutout
Simon #41 cutout
Simon #43 cutout
Simon #57 cutout
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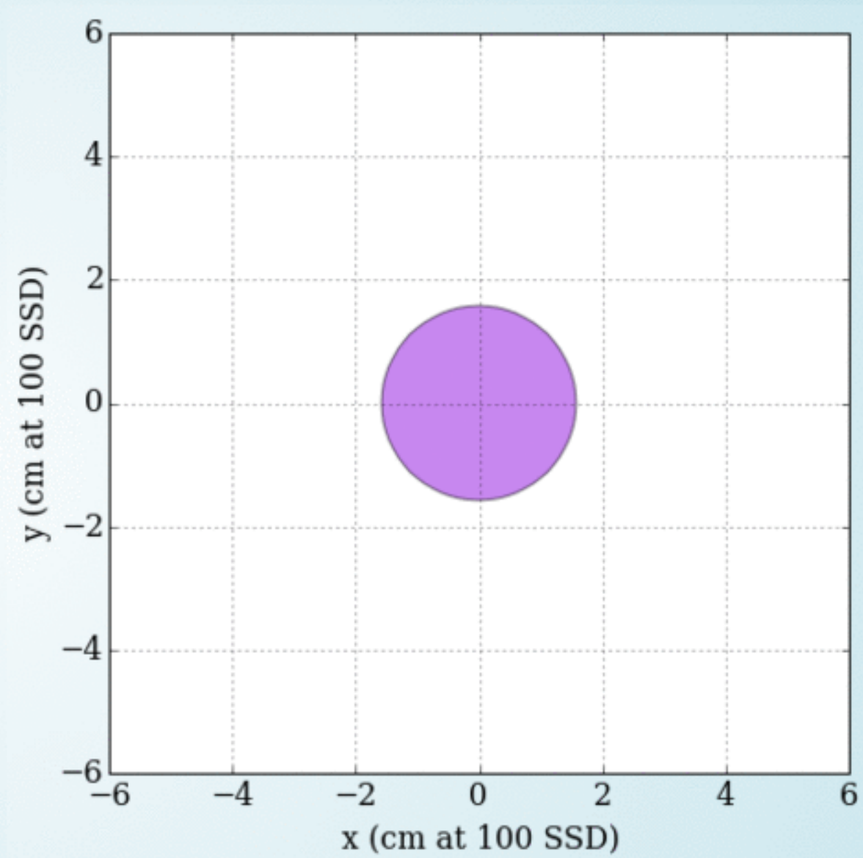
Simon #73 cutout
Simon #82 cutout
Simon #83 cutout
Simon 3cm circle
Simon 3x13cm oval



Cutout factor = 0.9296

A SERIES OF MEASURED INSERTS

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Simon #41 cutout
Simon #43 cutout
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Simon #73 cutout
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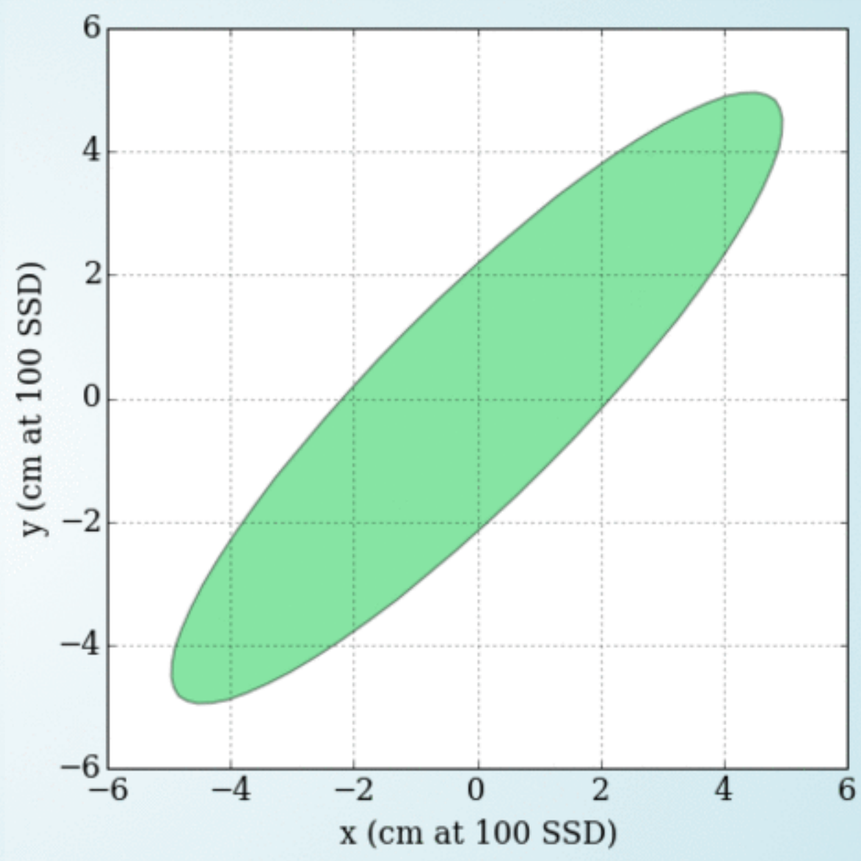
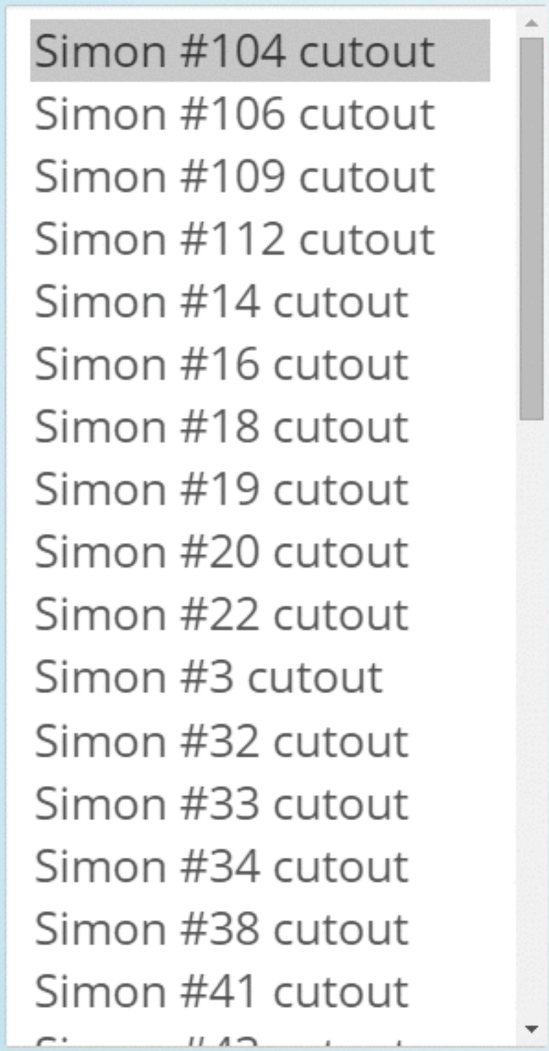
Simon #83 cutout
Simon 3cm circle
Simon 3x13cm oval

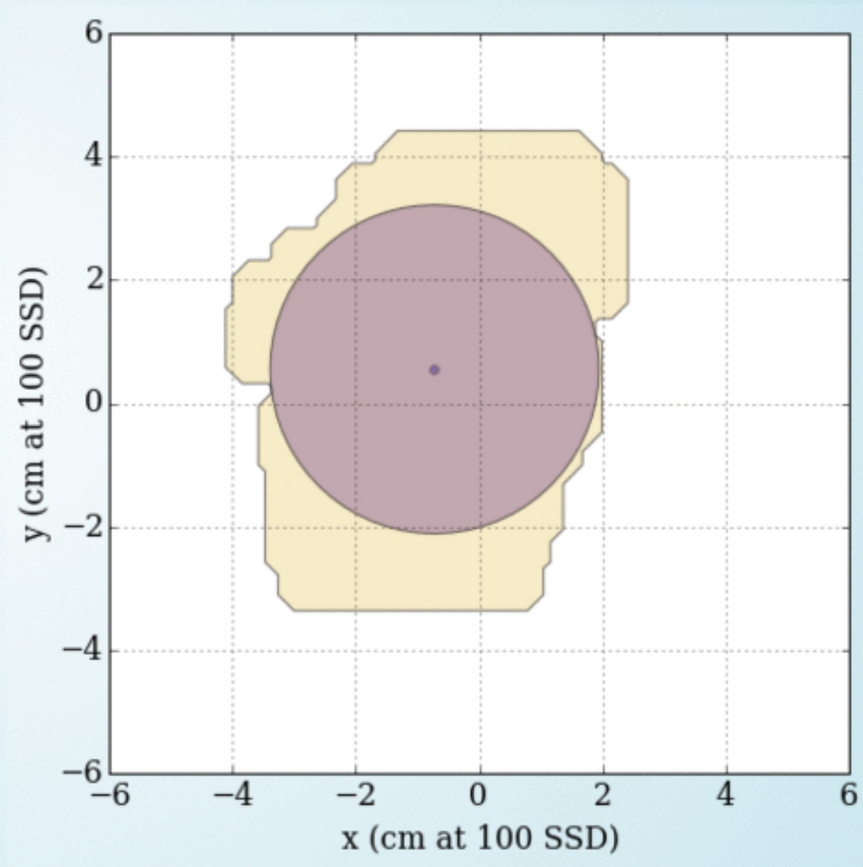


Cutout factor = 0.953

CALCULATING WIDTH

- Diameter of largest circle encompassed by cutout

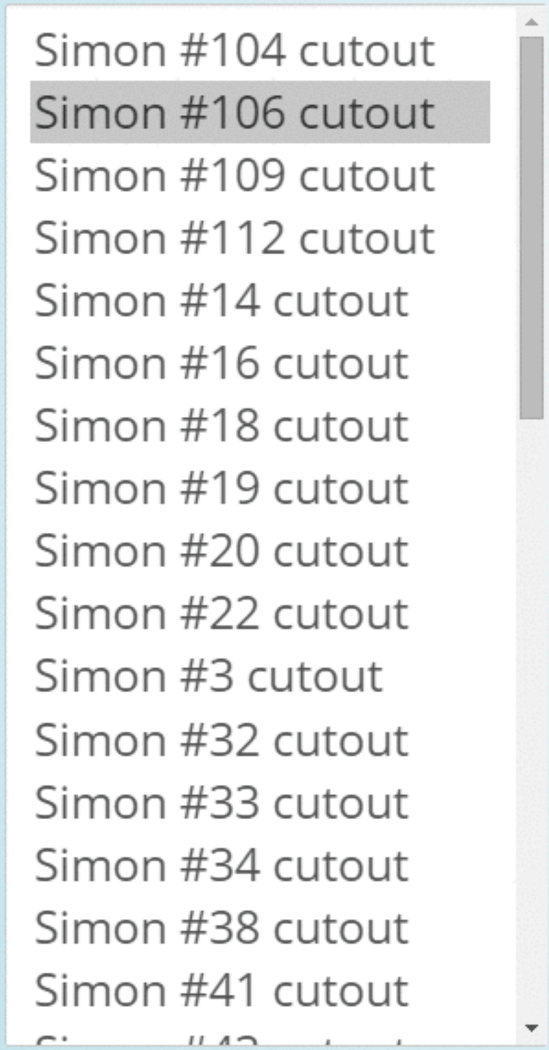


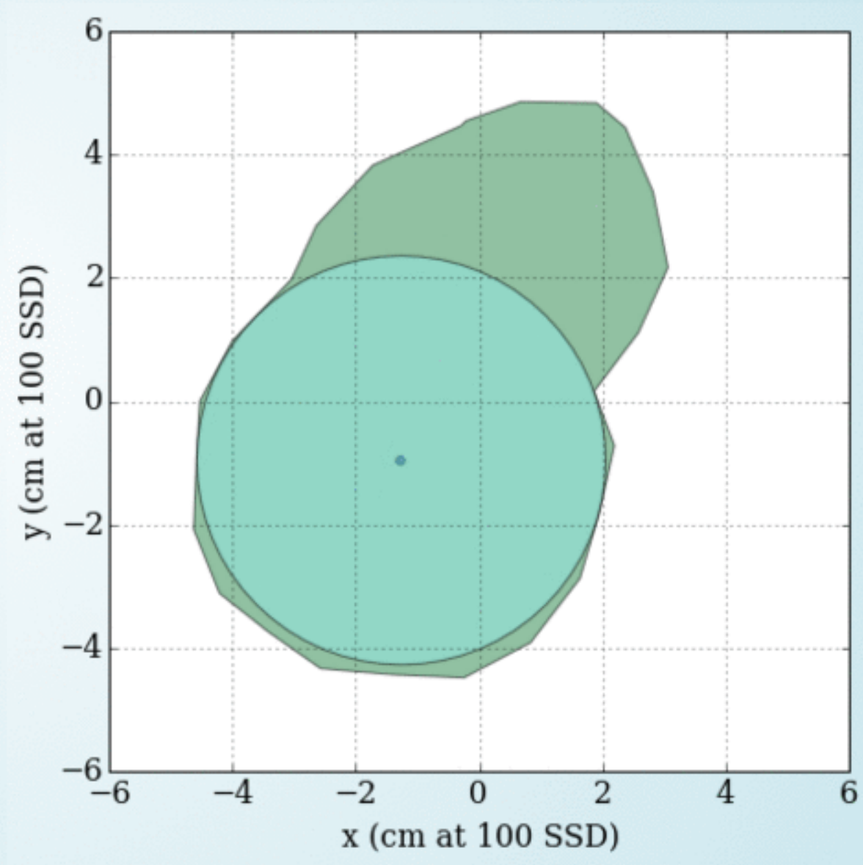


Width = 5.3 cm at 100 SSD

CALCULATING WIDTH

- Diameter of largest circle encompassed by cutout

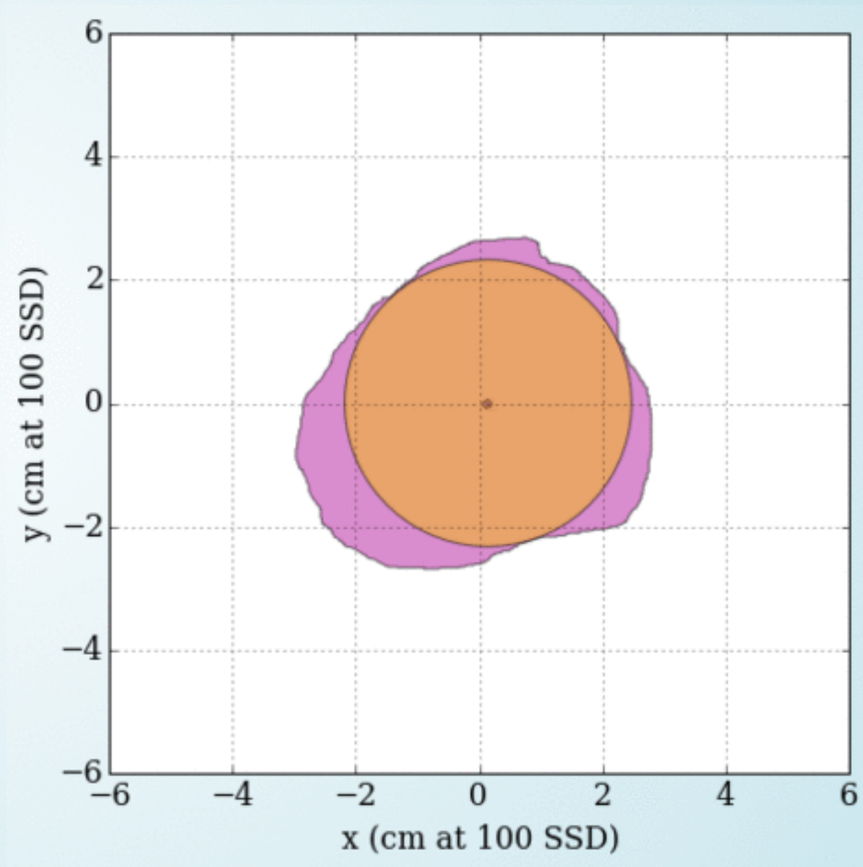




Width = 6.6 cm at 100 SSD

CALCULATING WIDTH

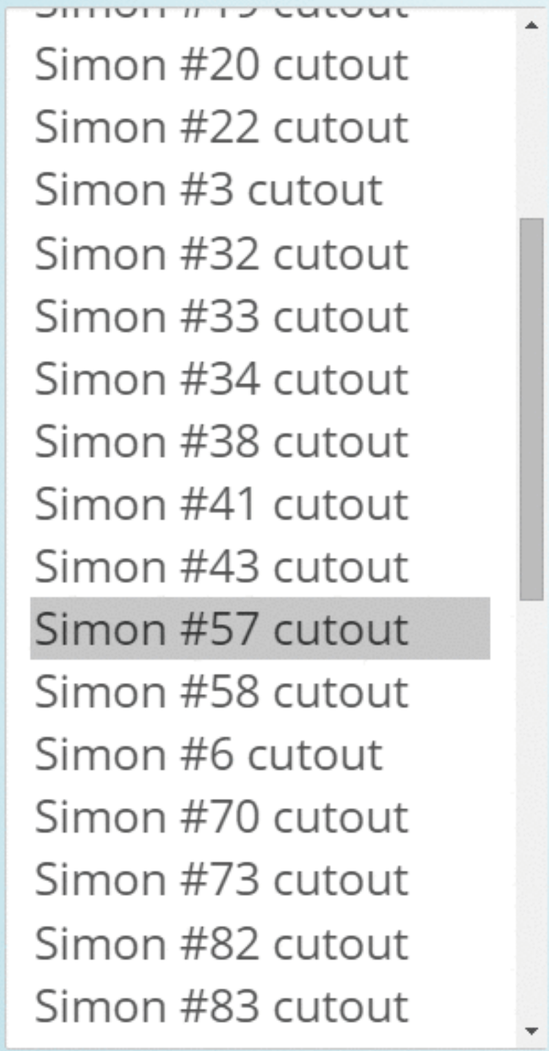
- Diameter of largest circle encompassed by cutout

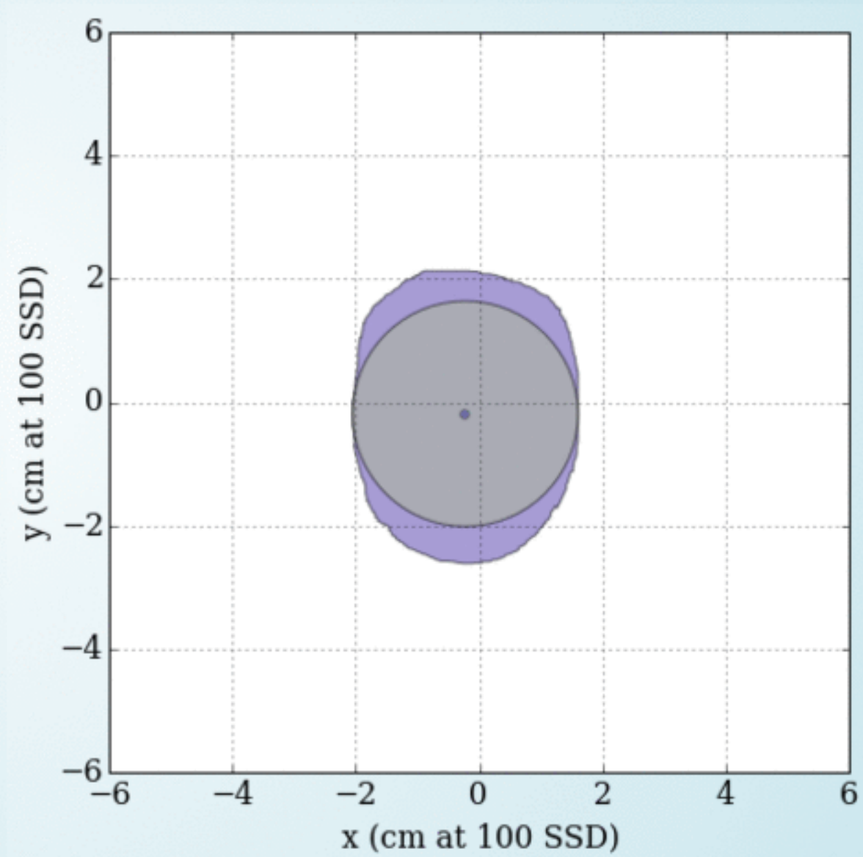


Width = 4.7 cm at 100 SSD

CALCULATING WIDTH

- Diameter of largest circle encompassed by cutout

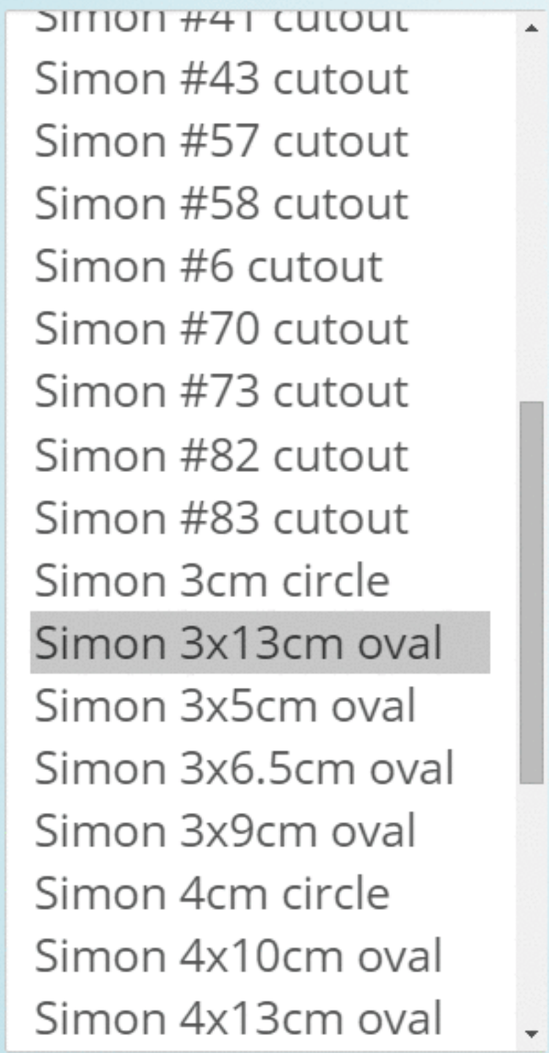


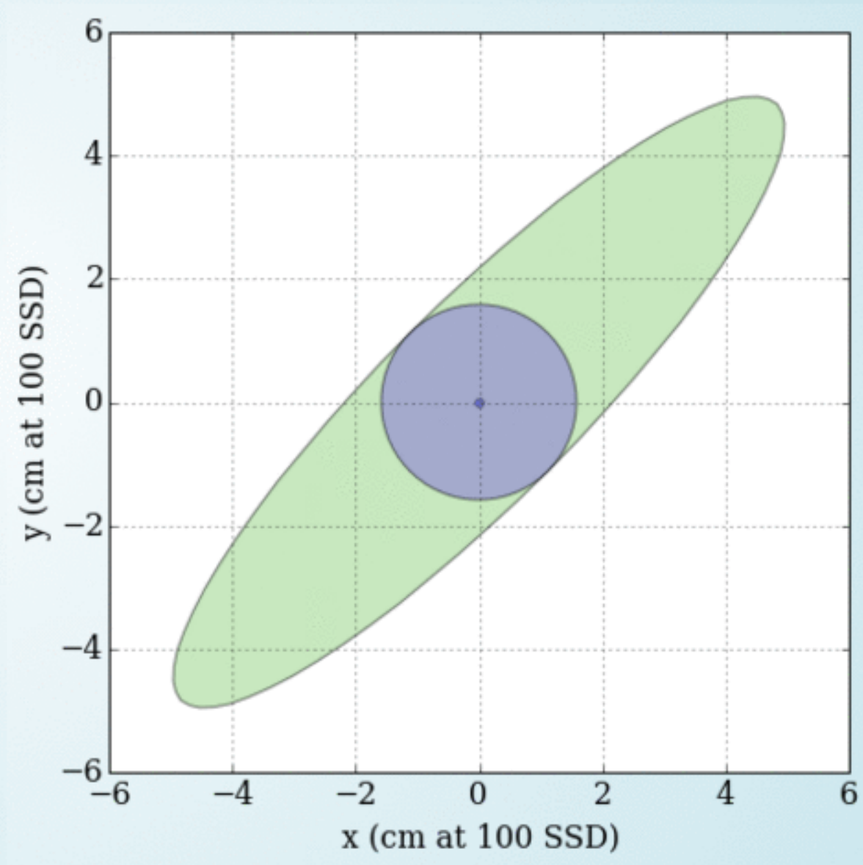


Width = 3.7 cm at 100 SSD

CALCULATING WIDTH

- Diameter of largest circle encompassed by cutout

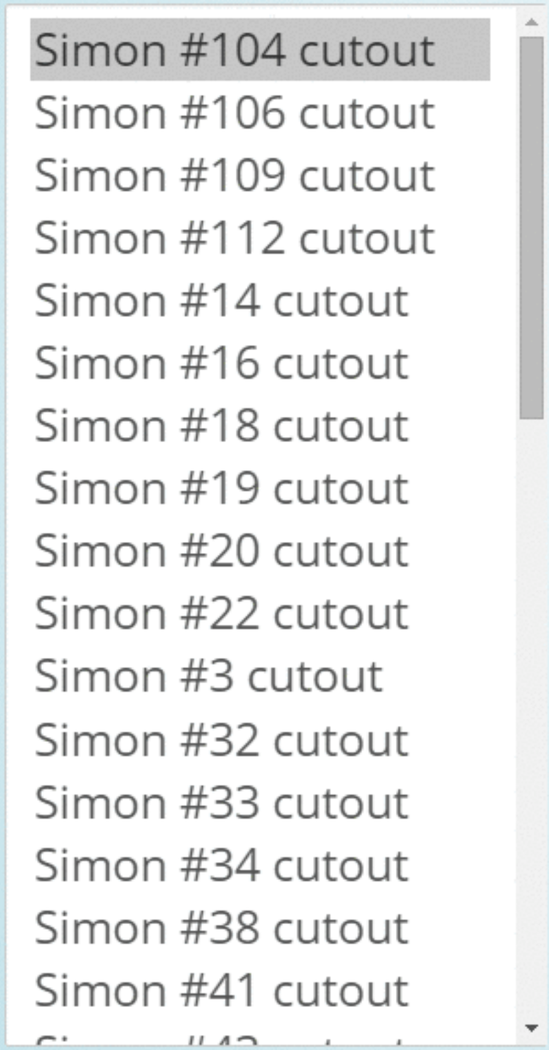


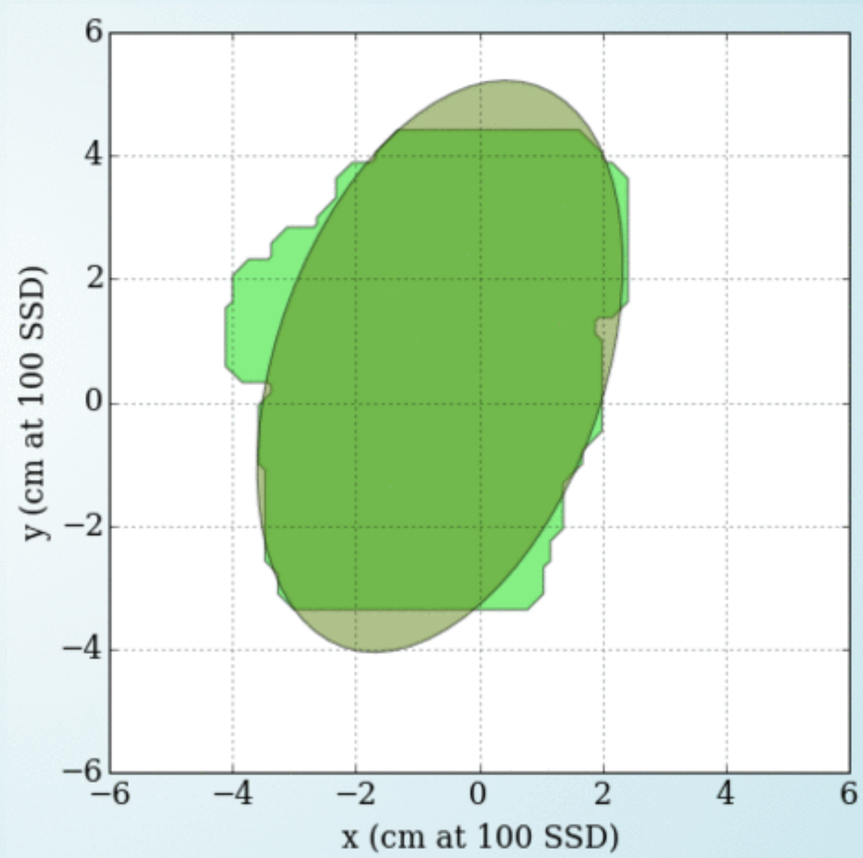


Width = 3.2 cm at 100 SSD

CALCULATING LENGTH

- Length such that ellipse has equal area to cutout

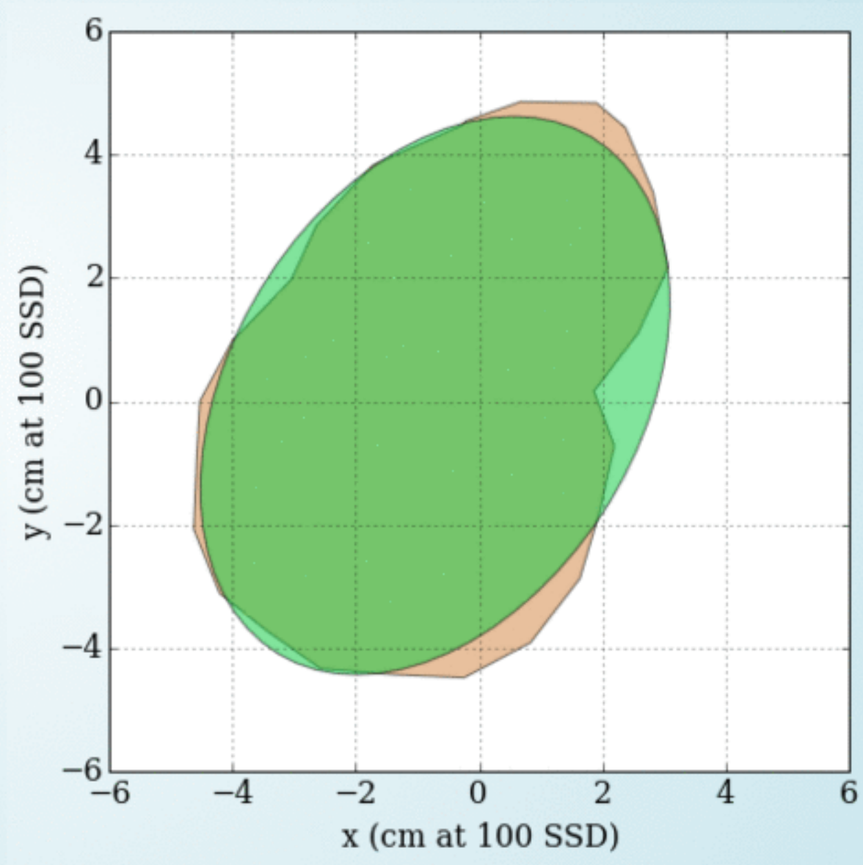




Length = 9.6 cm at 100 SSD

CALCULATING LENGTH

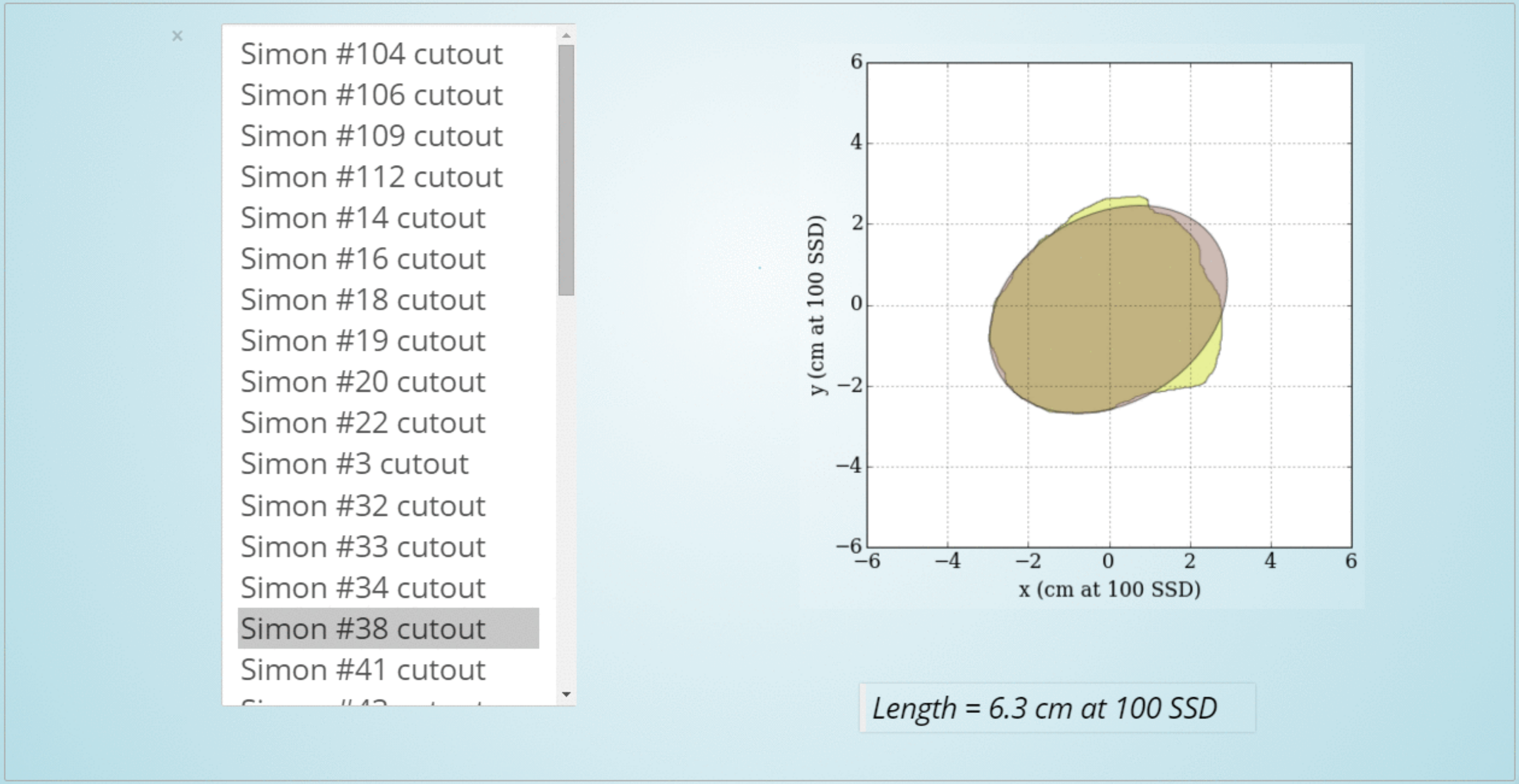
- Length such that ellipse has equal area to cutout



Length = 9.8 cm at 100 SSD

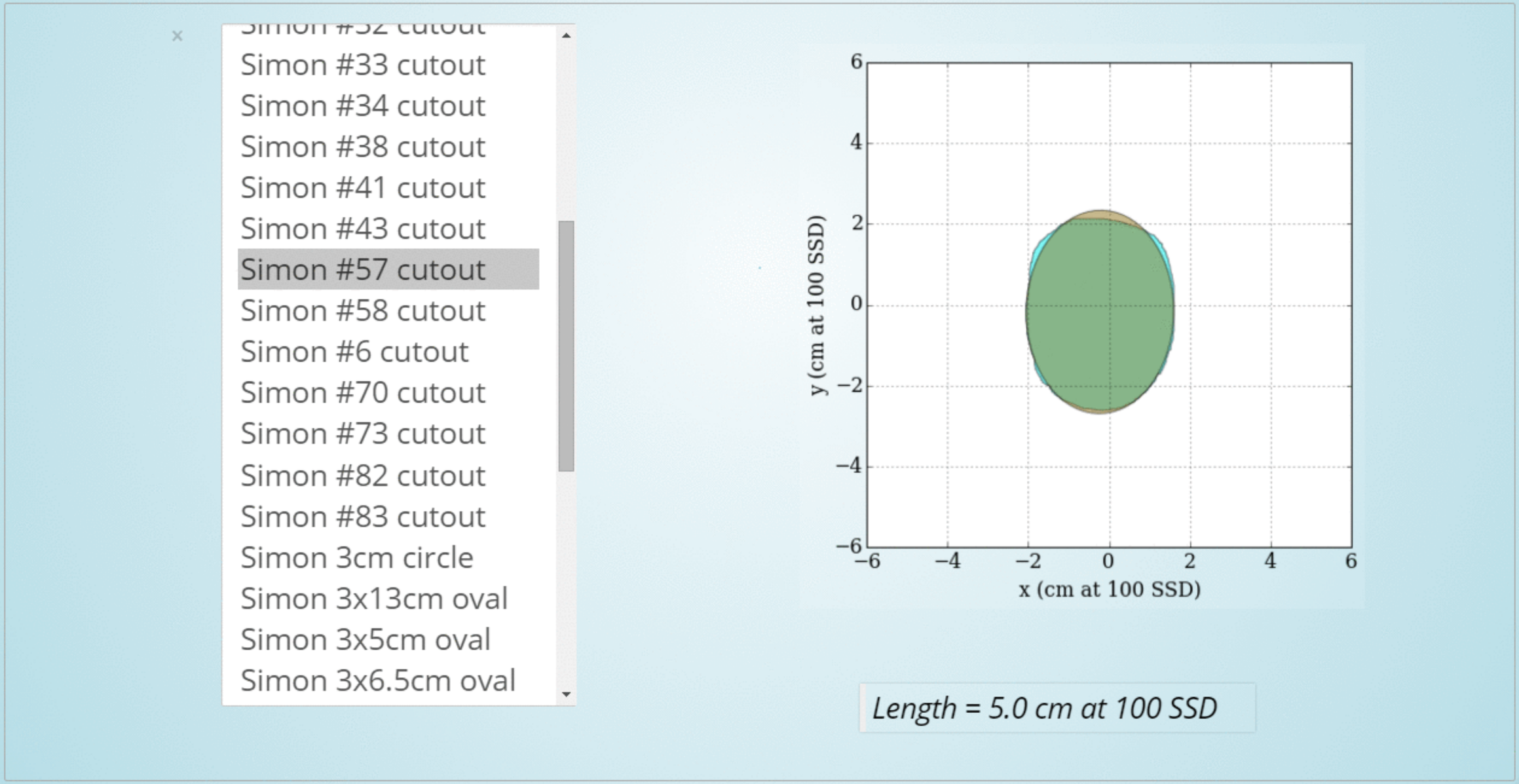
CALCULATING LENGTH

- Length such that ellipse has equal area to cutout

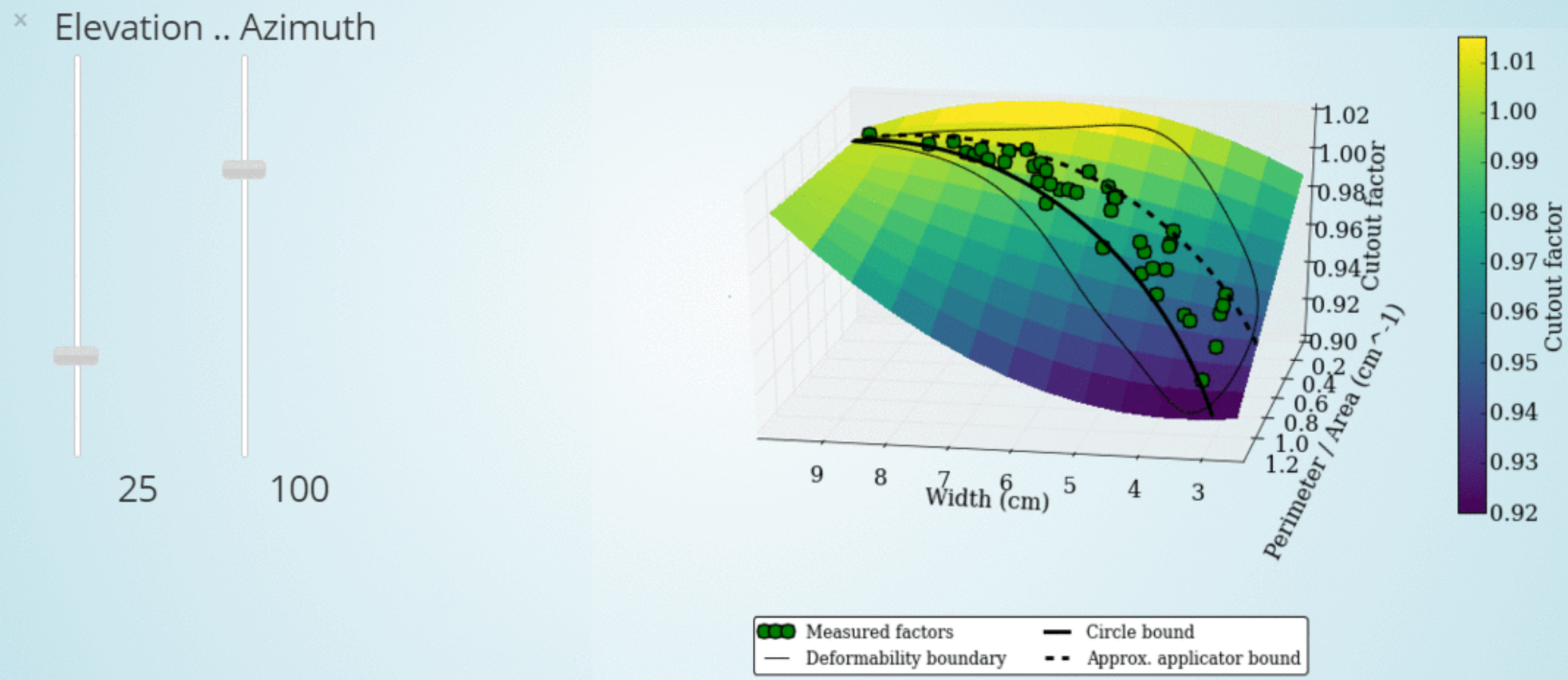


CALCULATING LENGTH

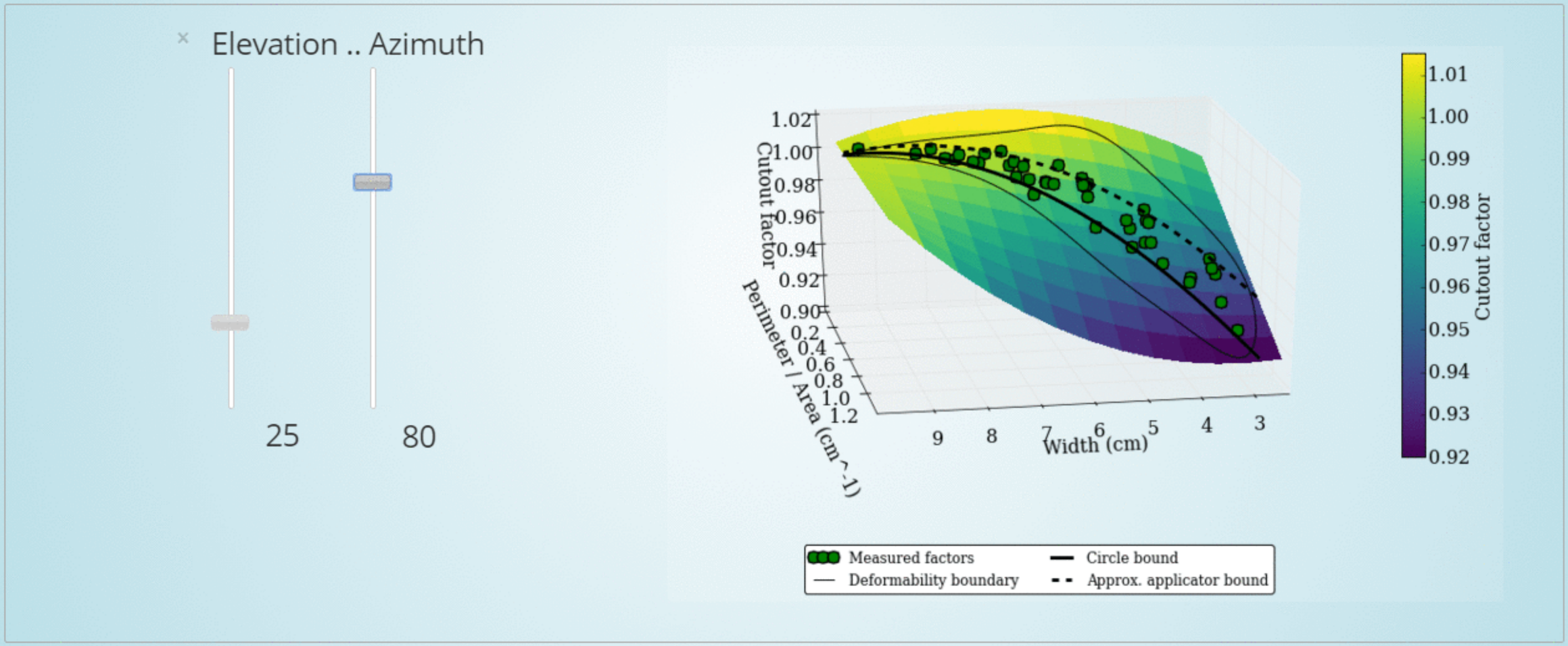
- Length such that ellipse has equal area to cutout



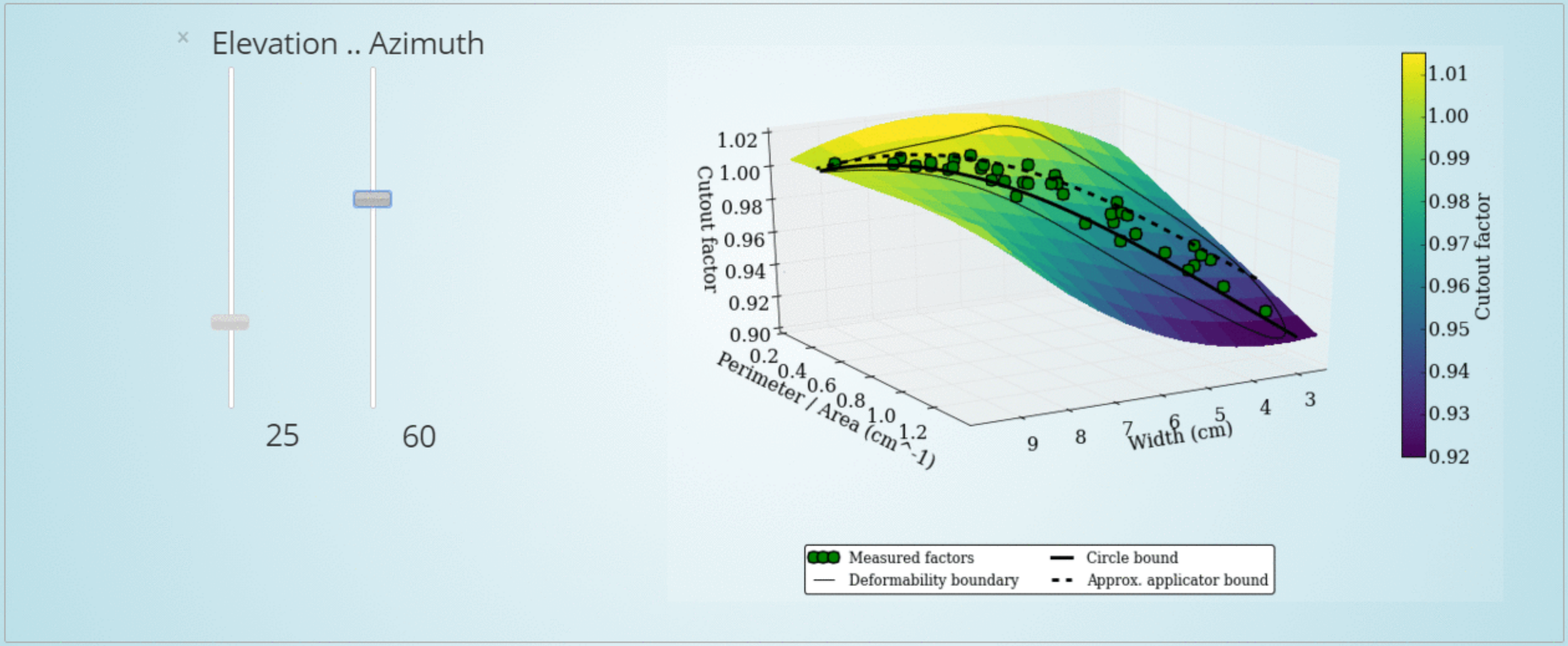
SMOOTHING BIVARIATE SPLINE



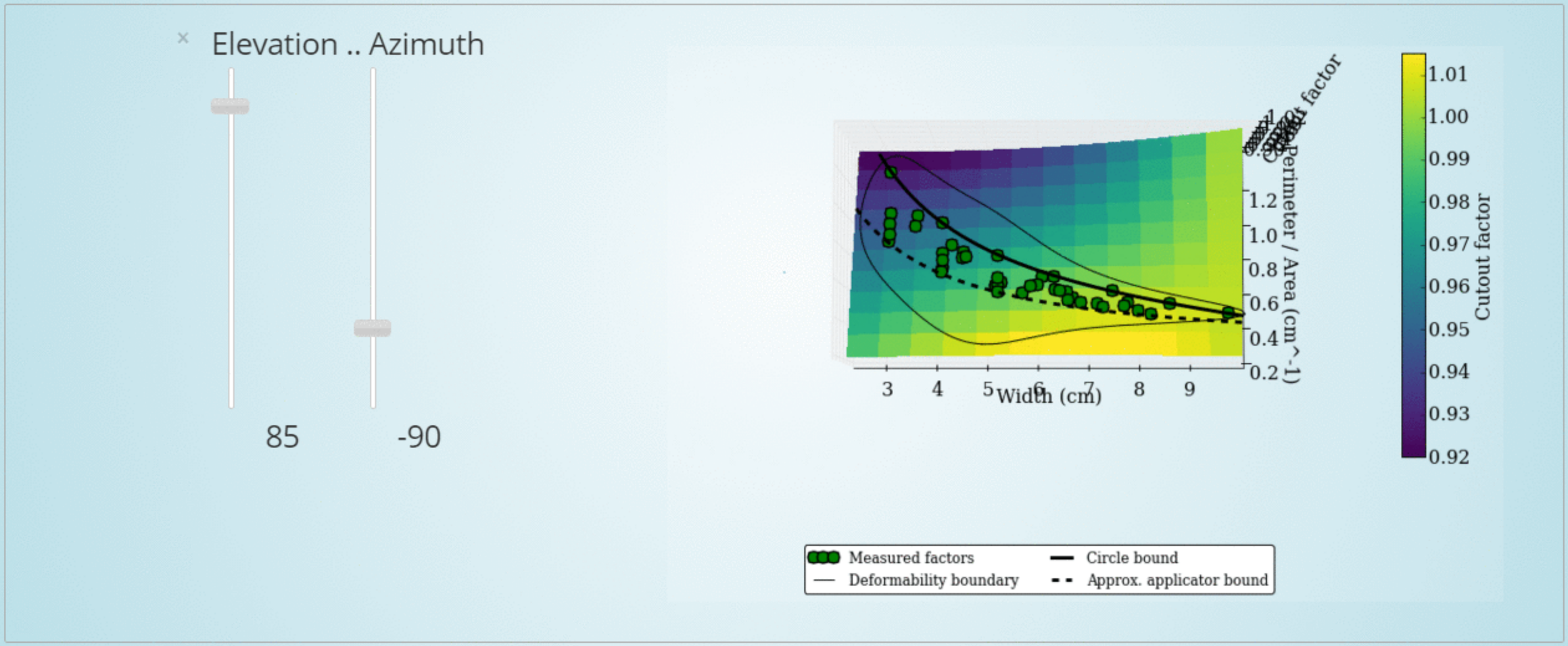
SMOOTHING BIVARIATE SPLINE



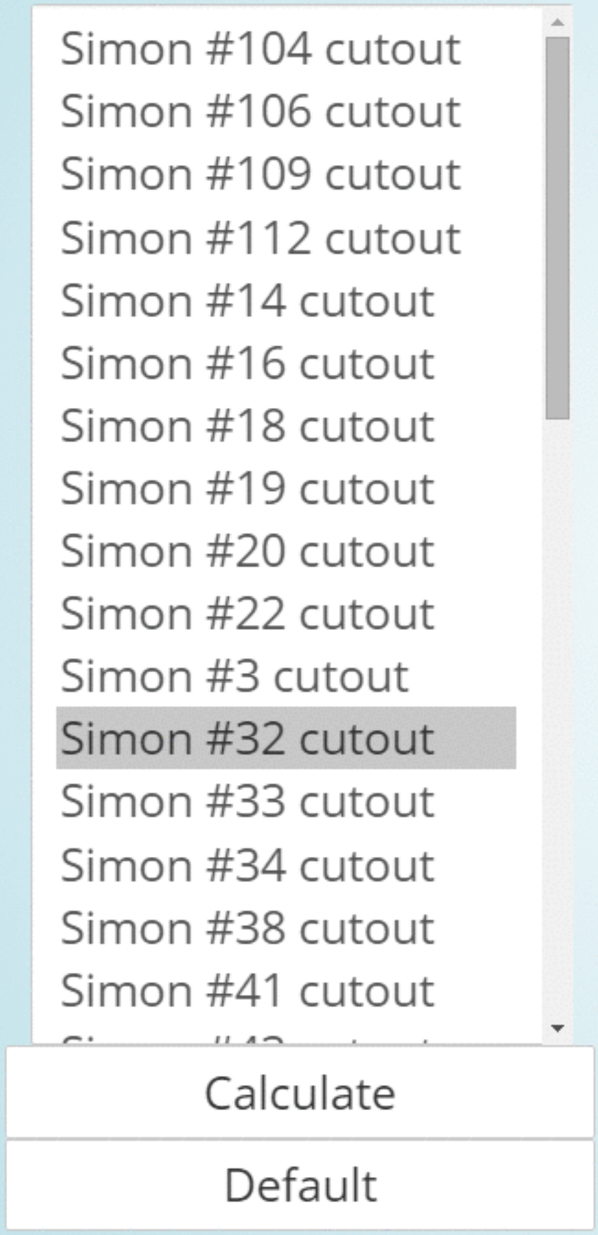
SMOOTHING BIVARIATE SPLINE

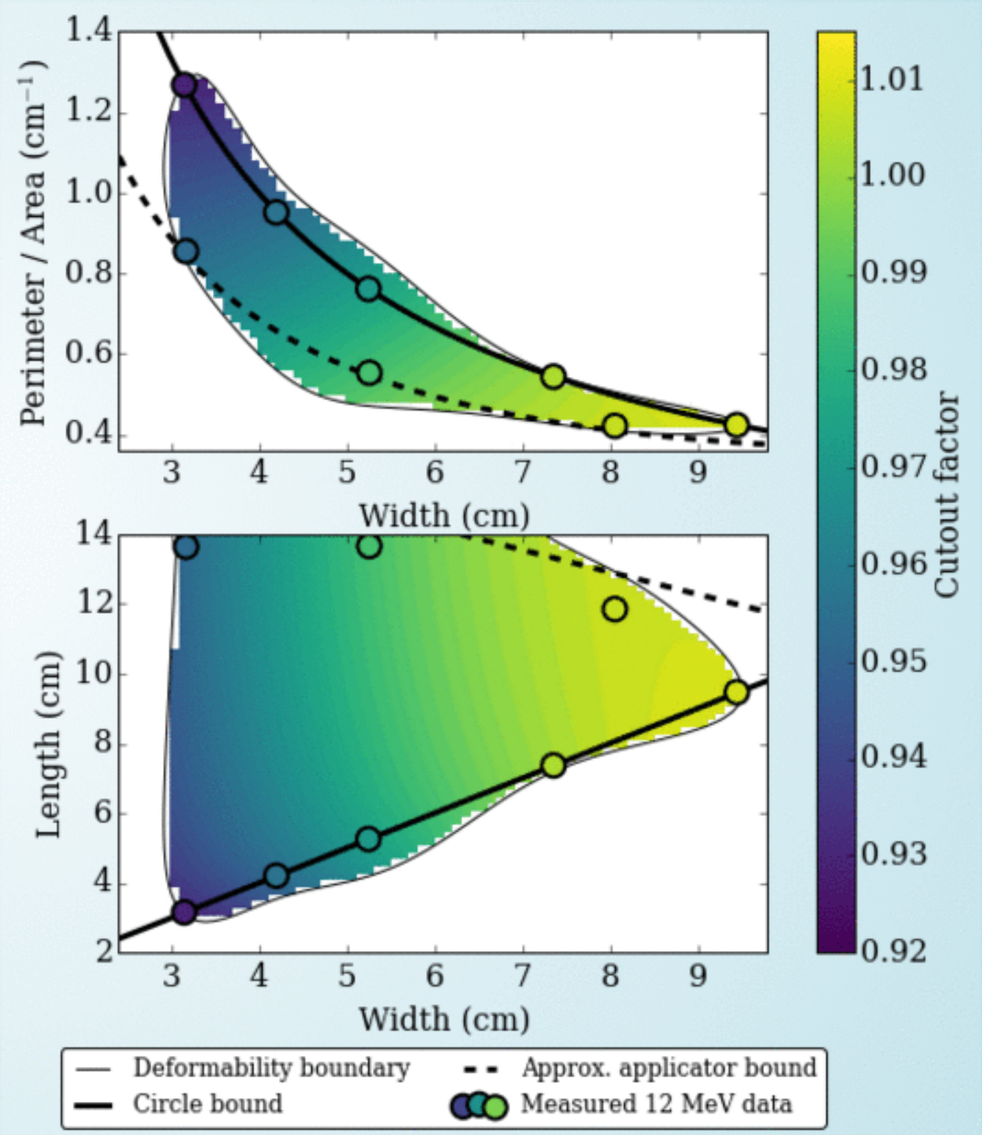


SMOOTHING BIVARIATE SPLINE



PRODUCING THE SPLINE





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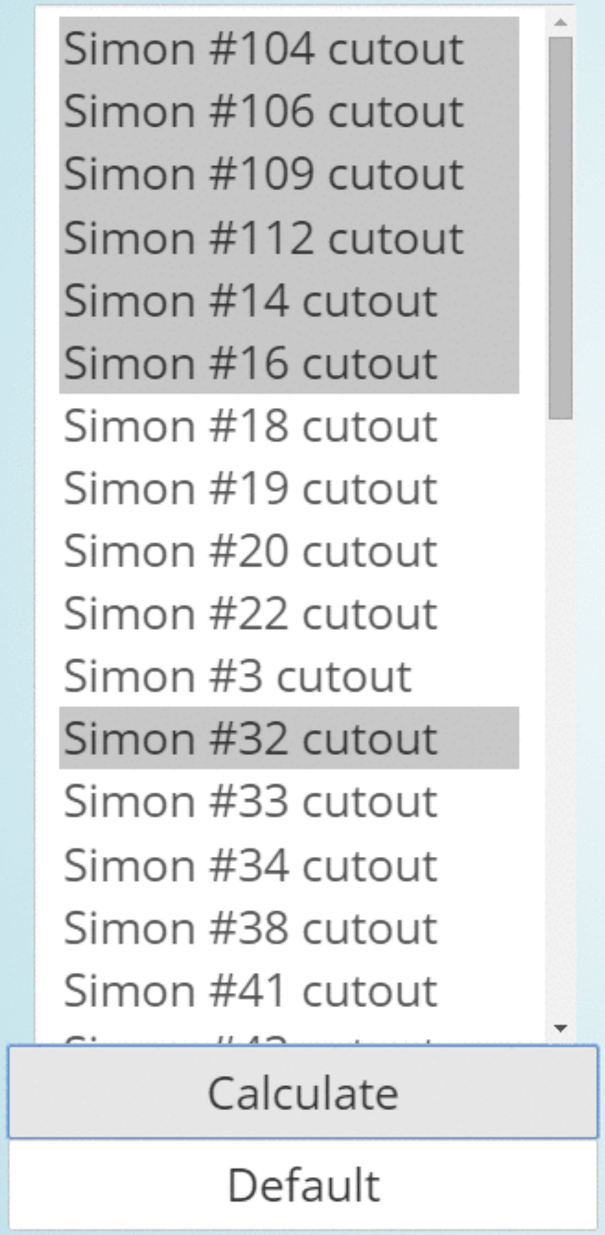

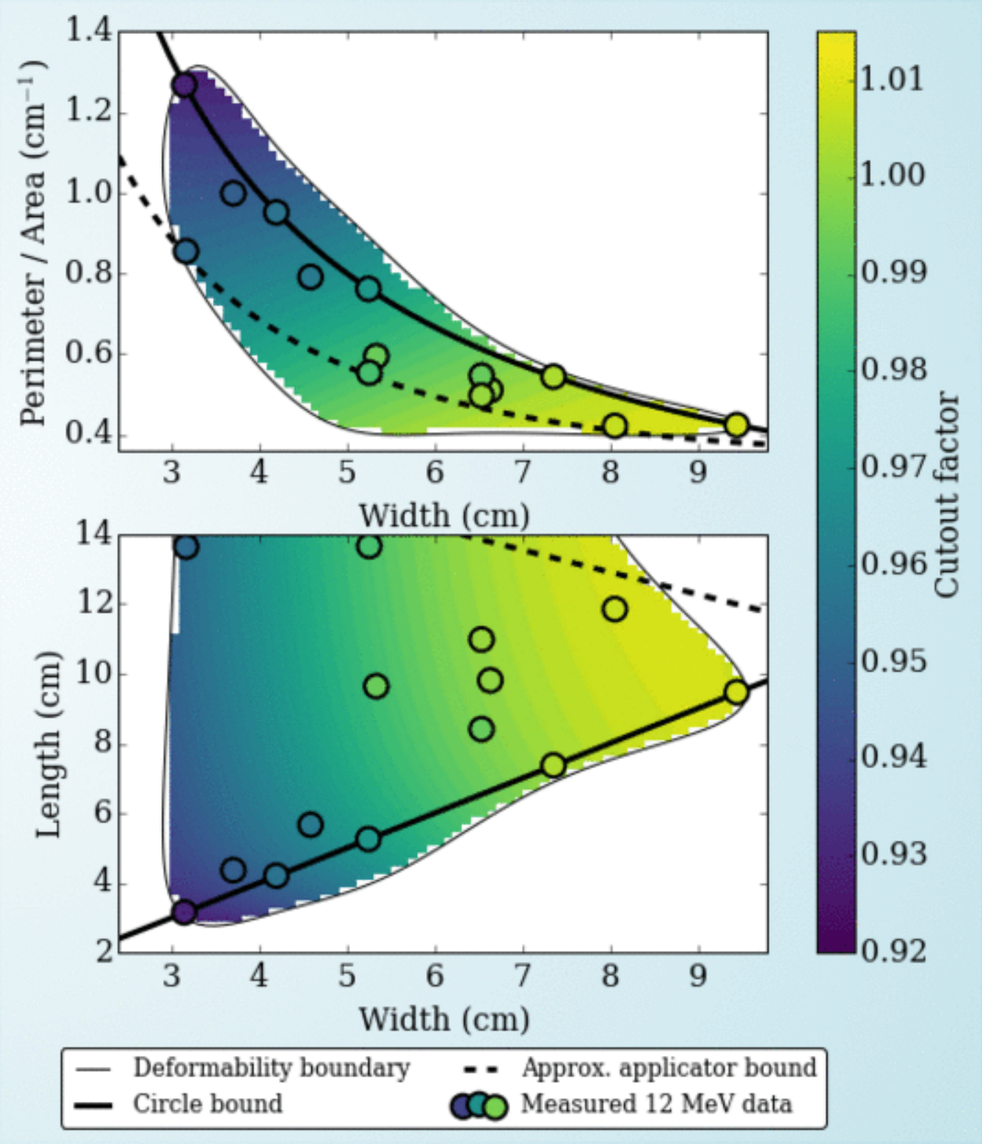

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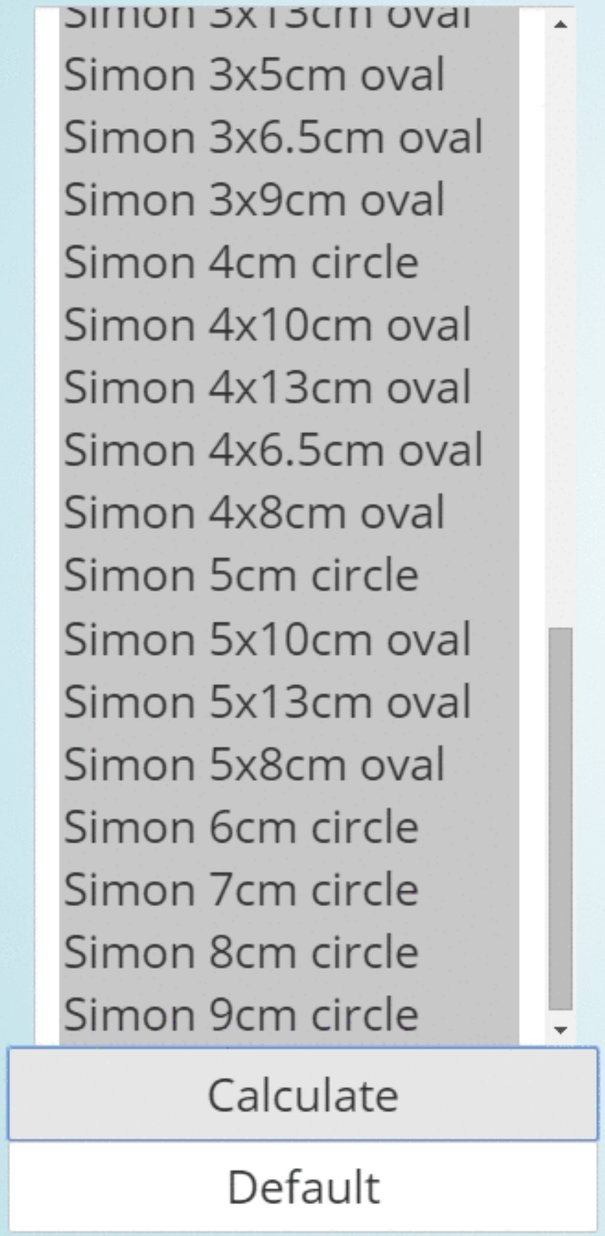

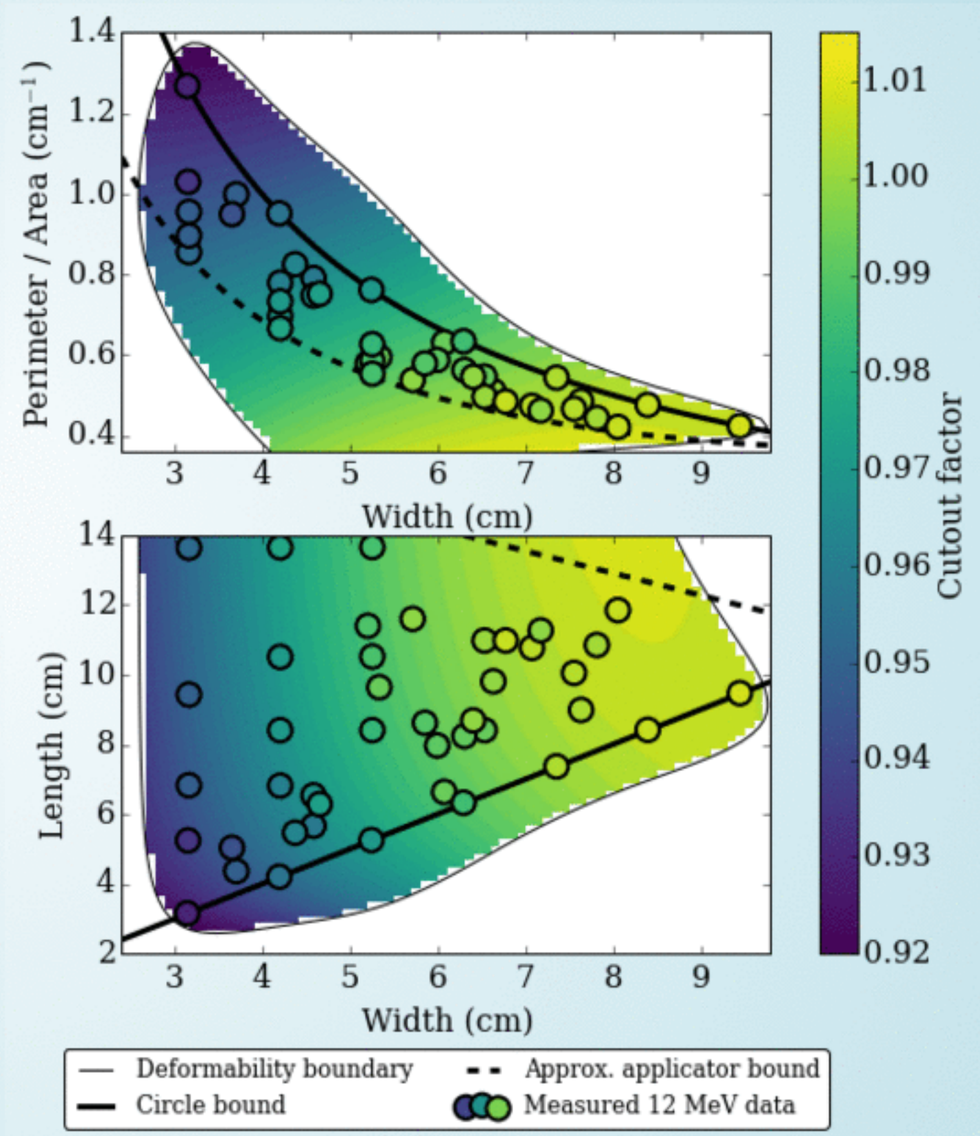

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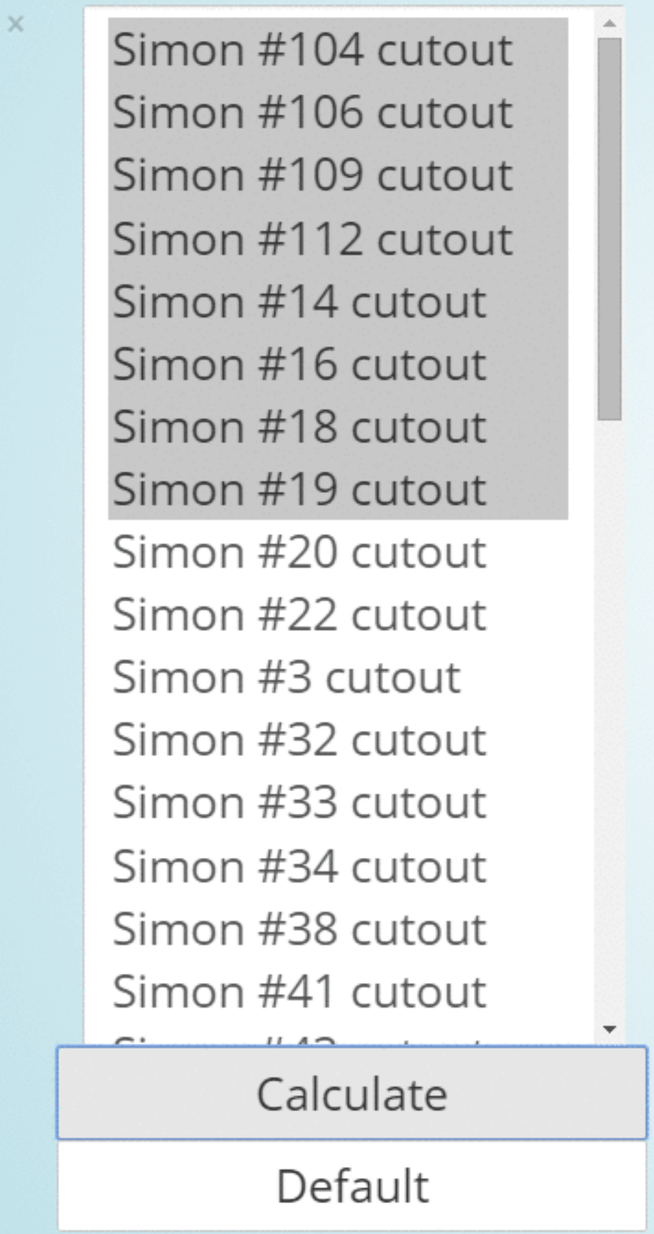

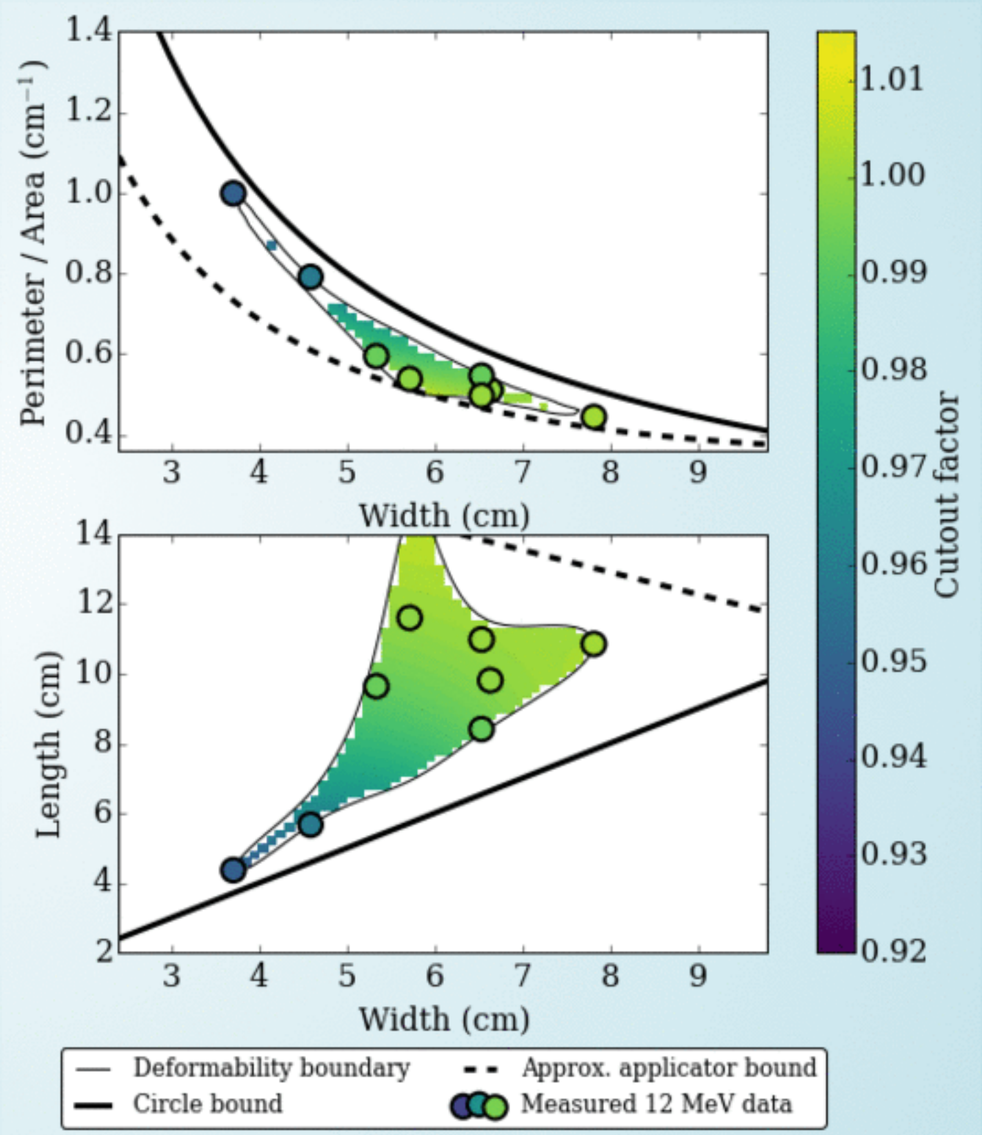

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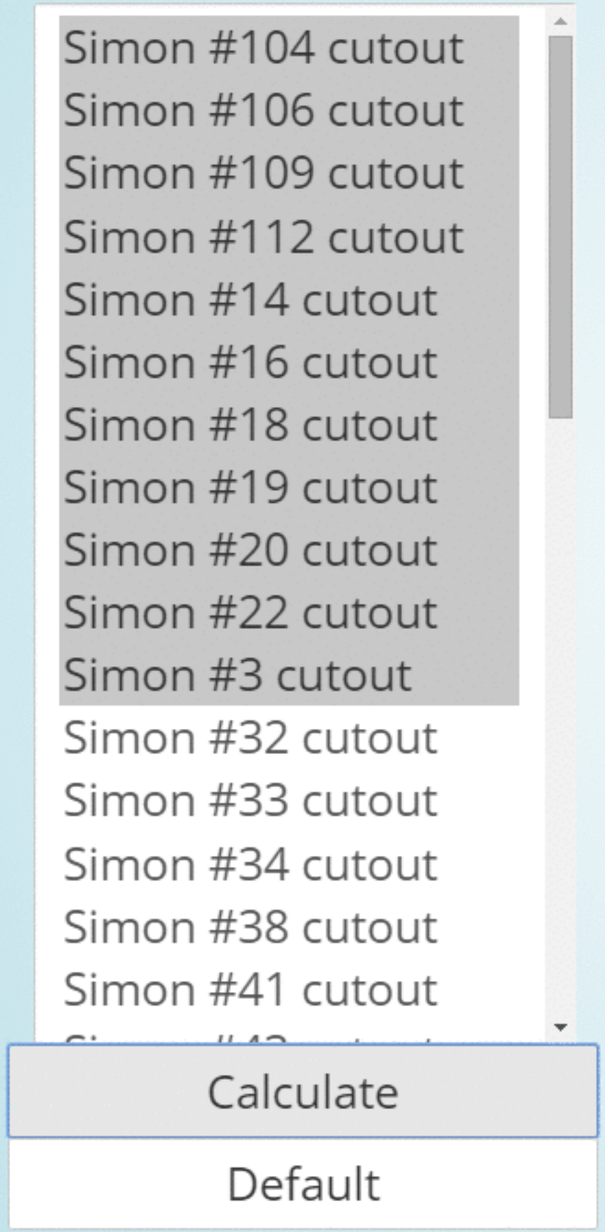

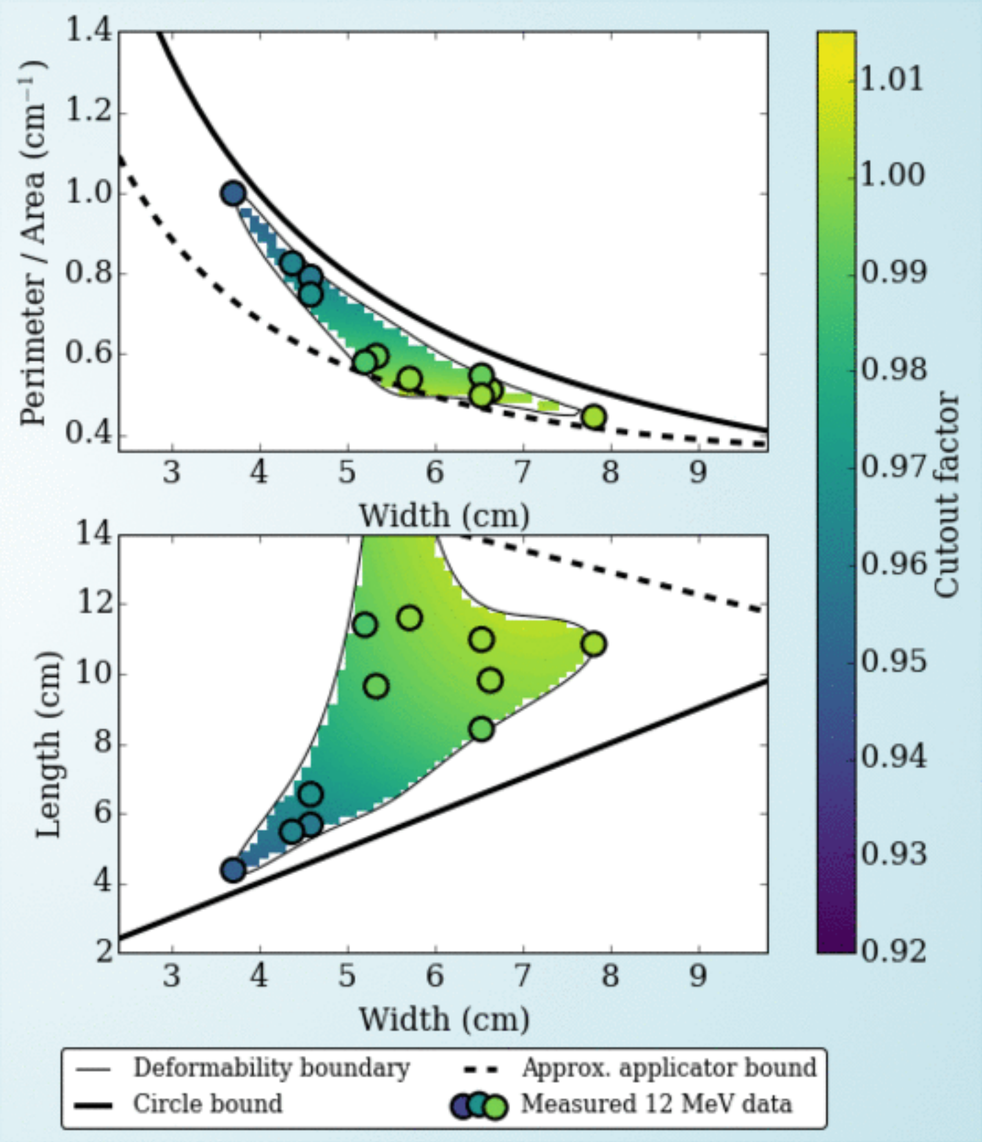

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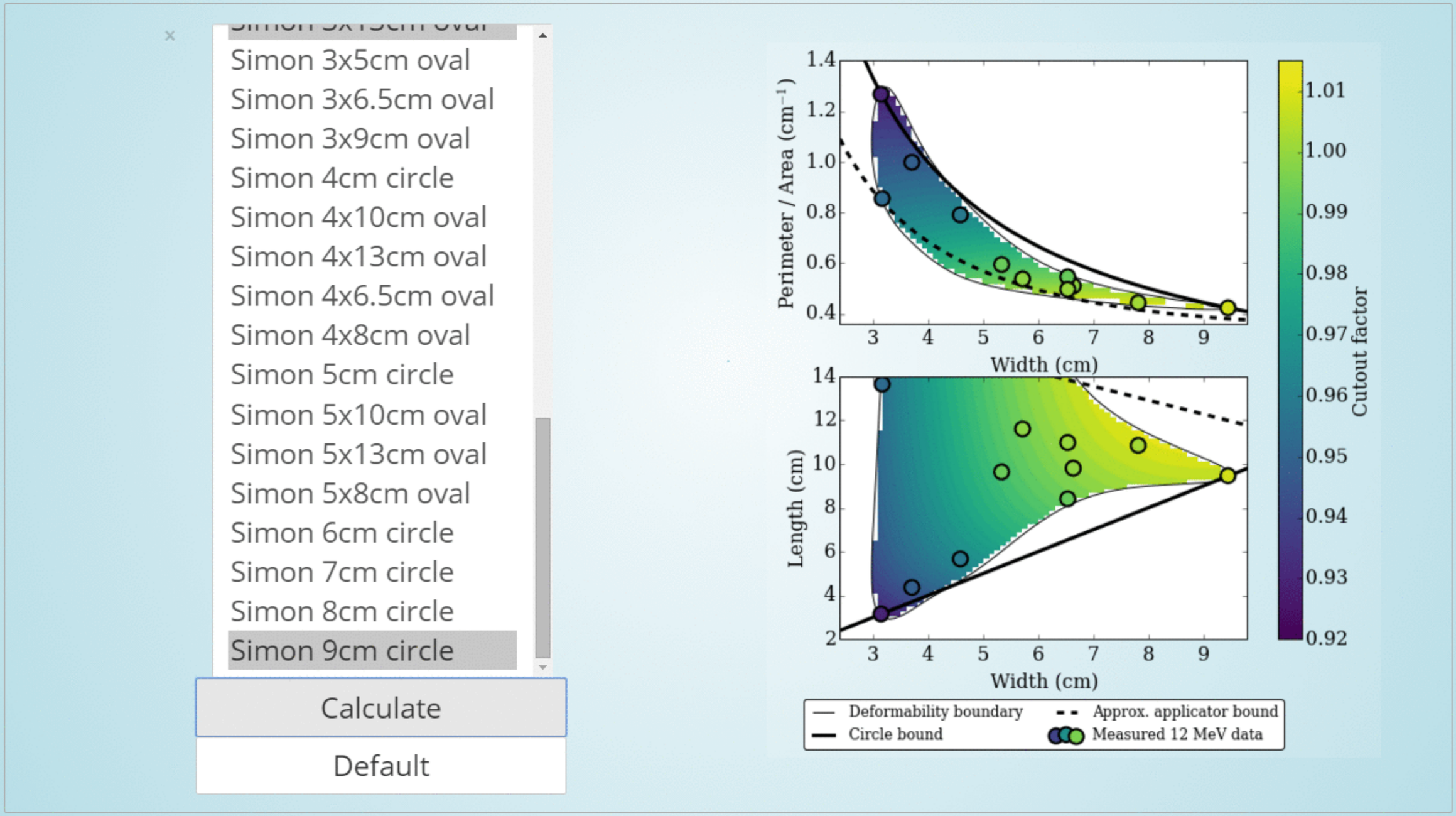

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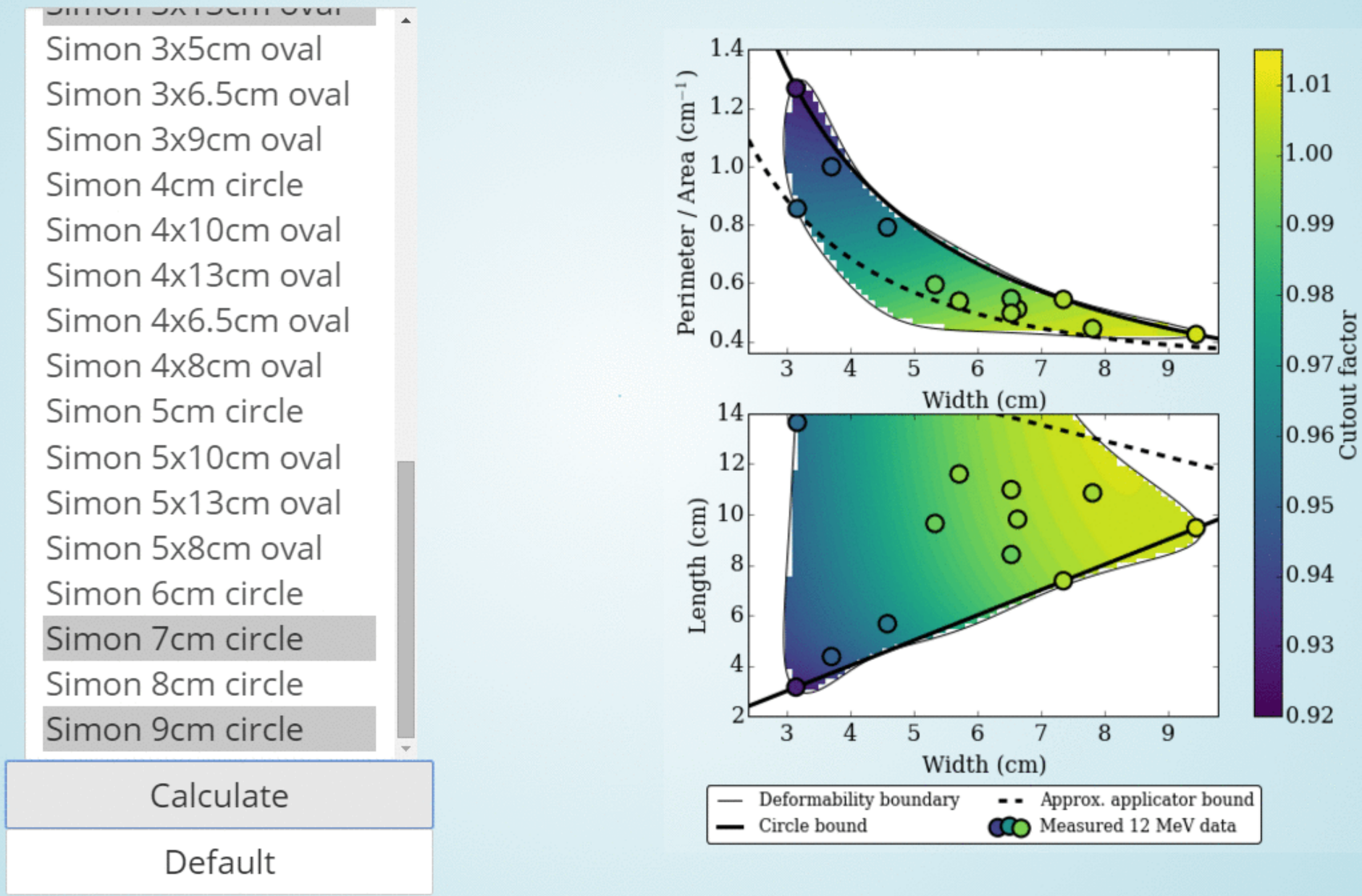
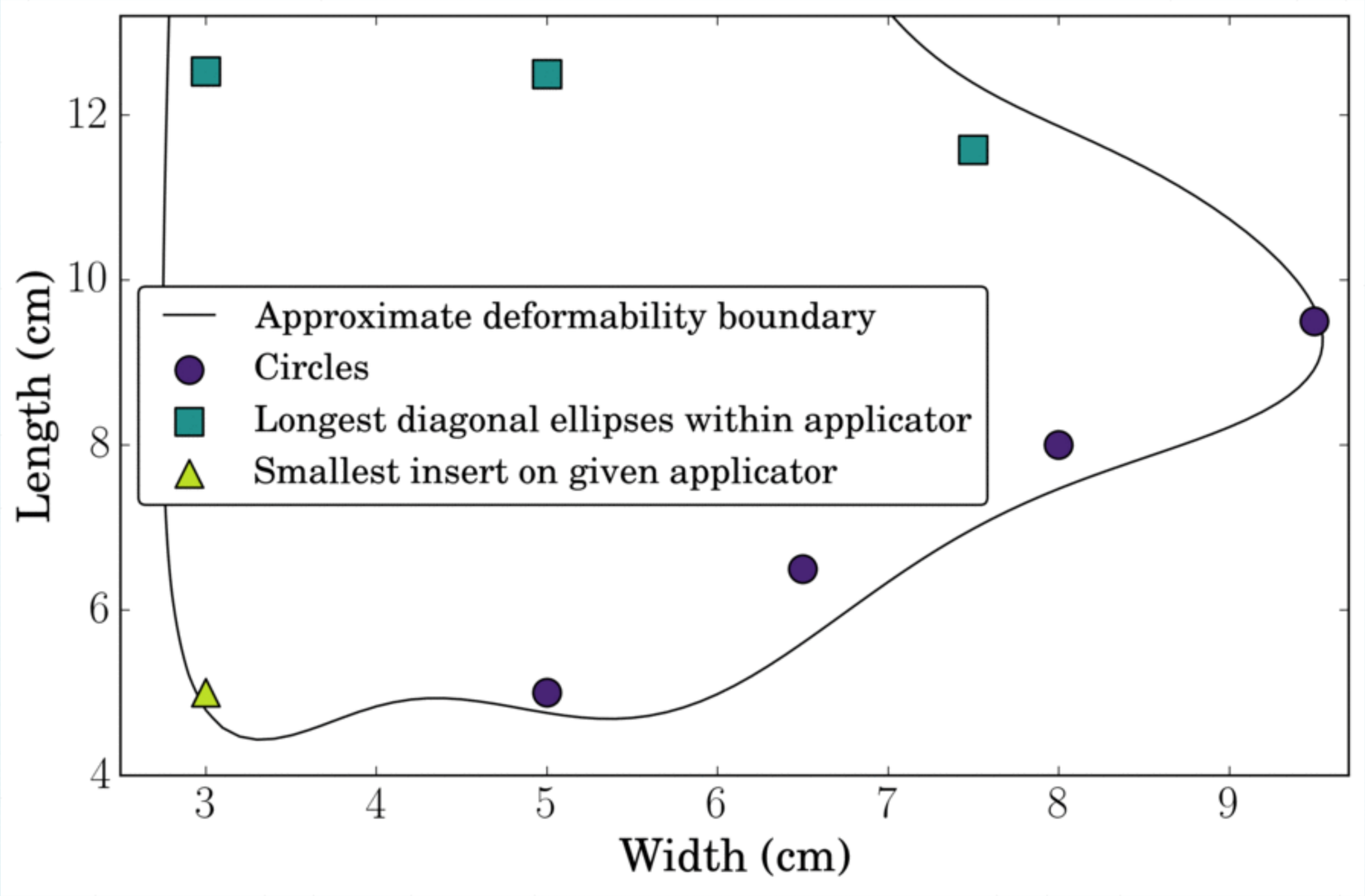
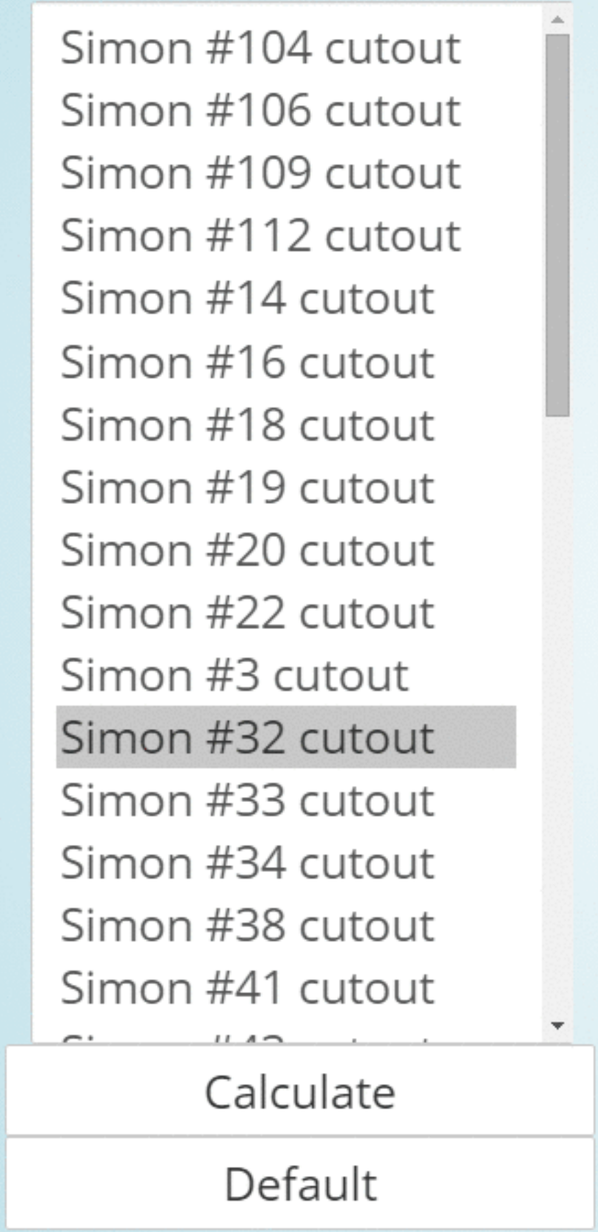
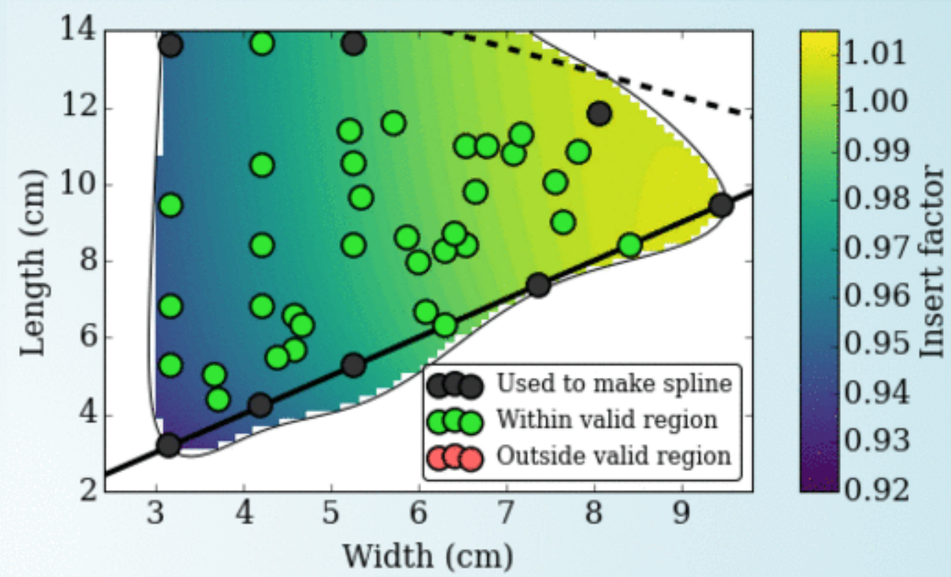


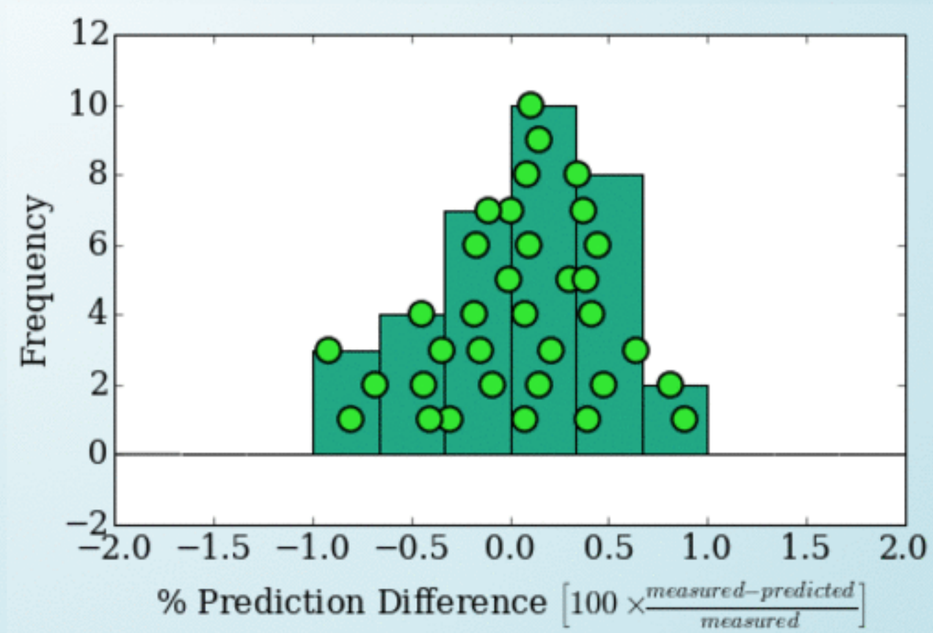
WHERE TO MEASURE FOR OPTIMUM COVERAGE



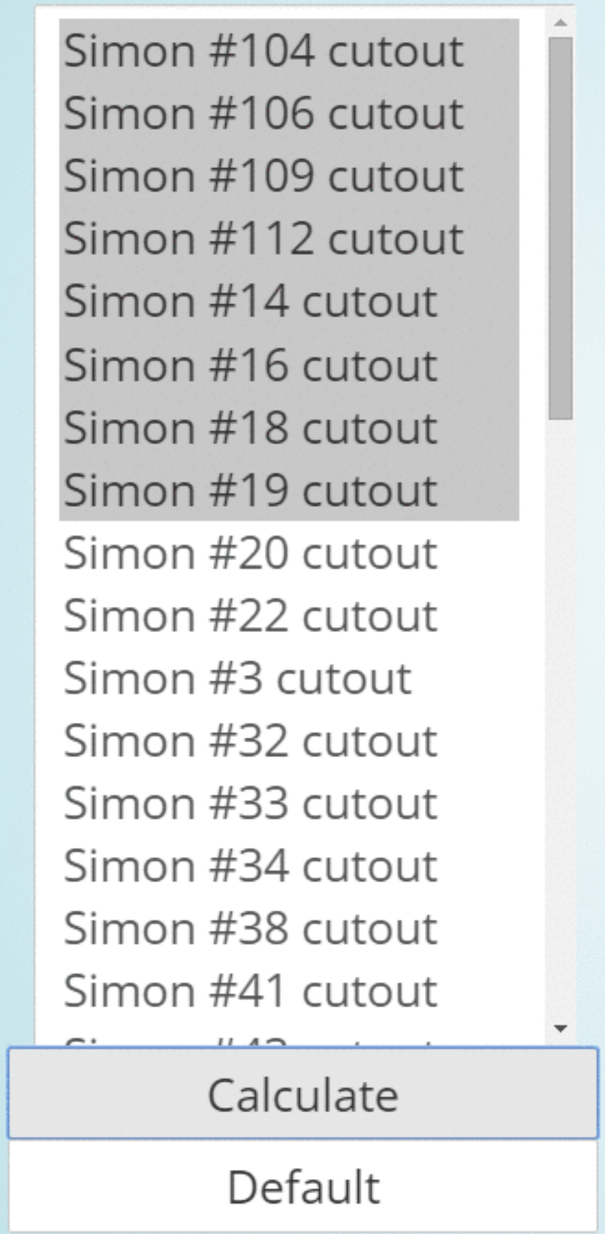
MODEL VALIDATION

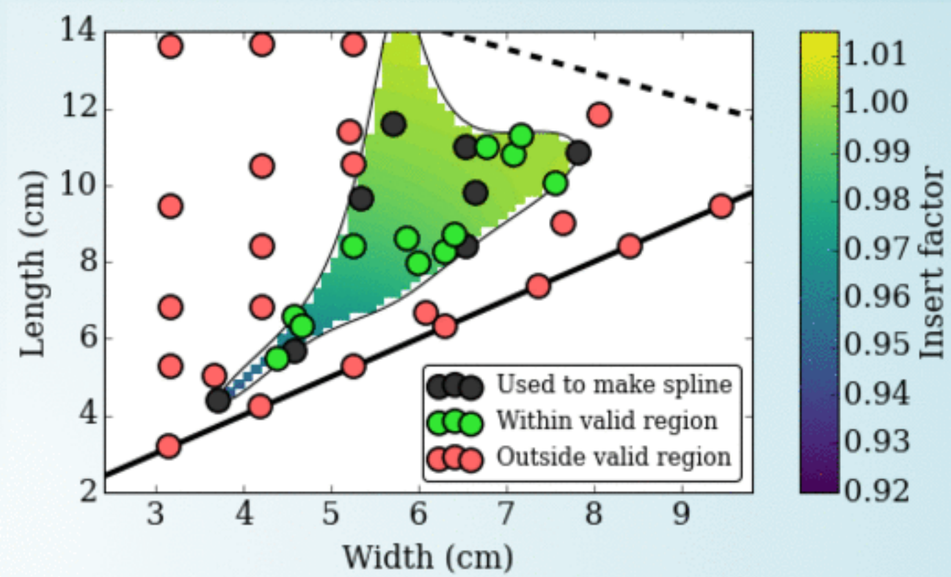


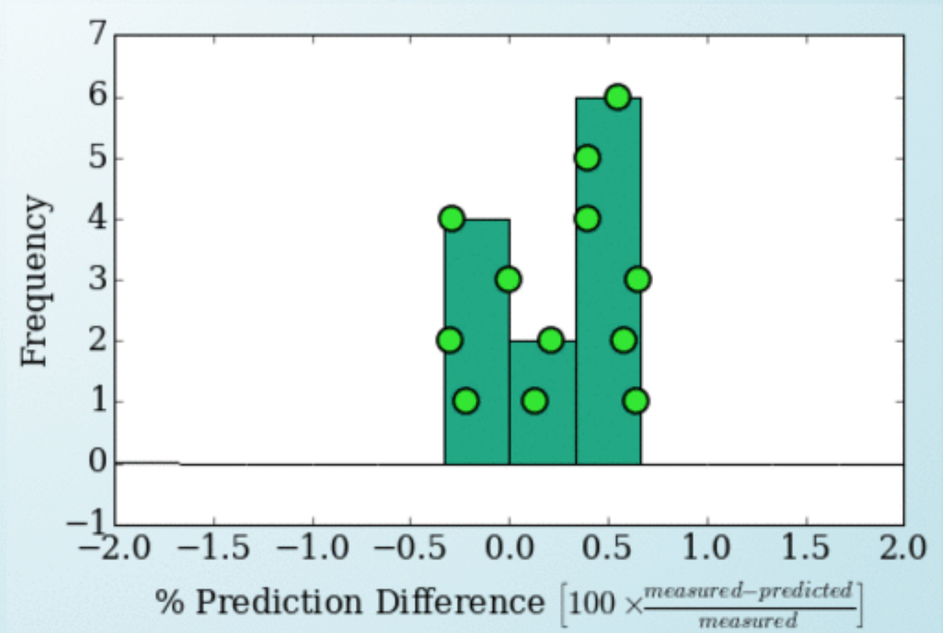




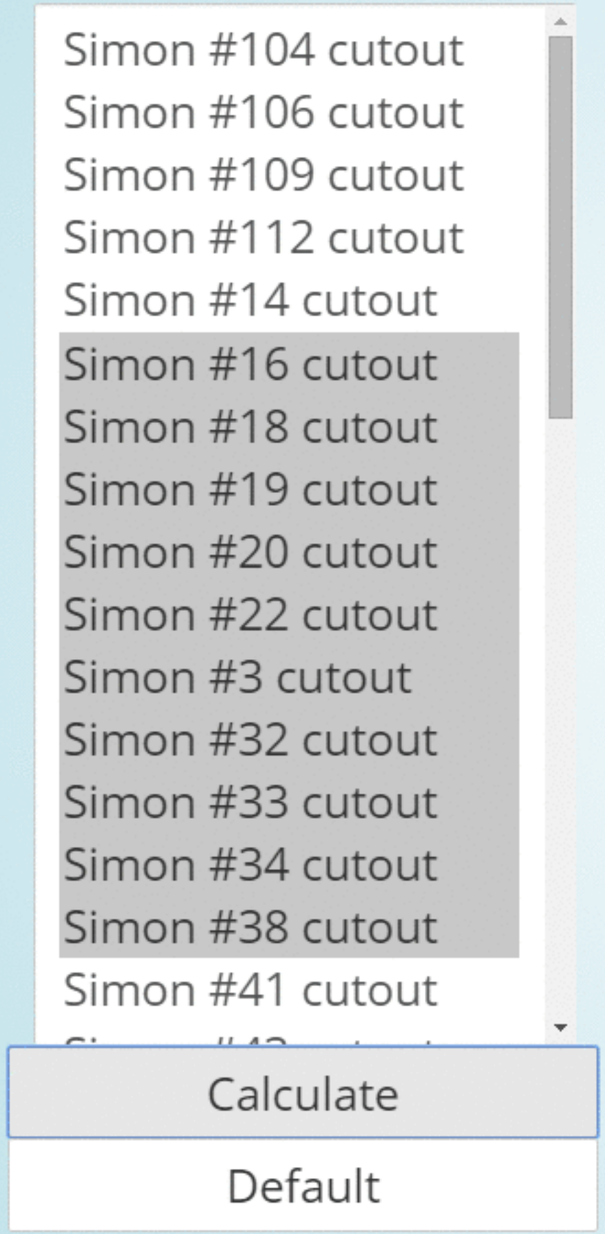
MODEL VALIDATION

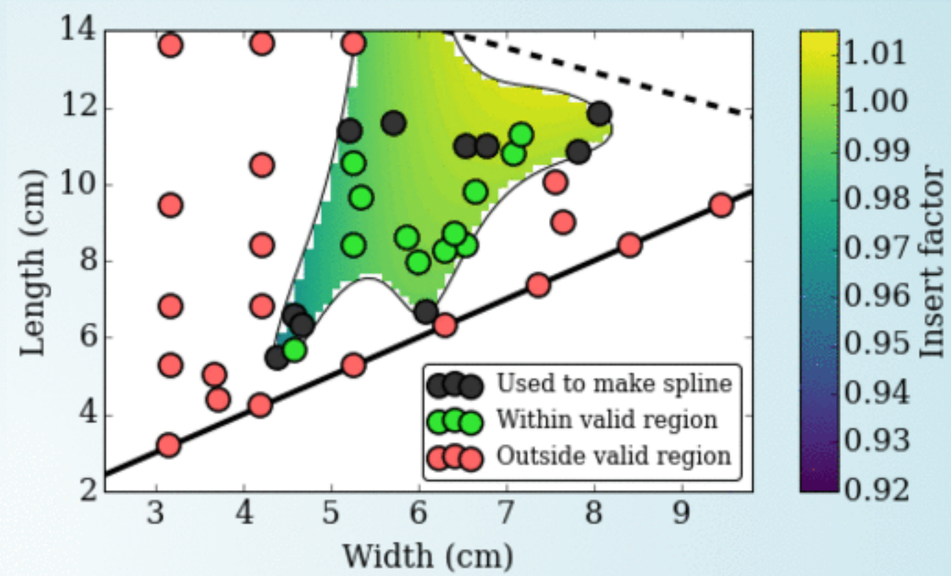


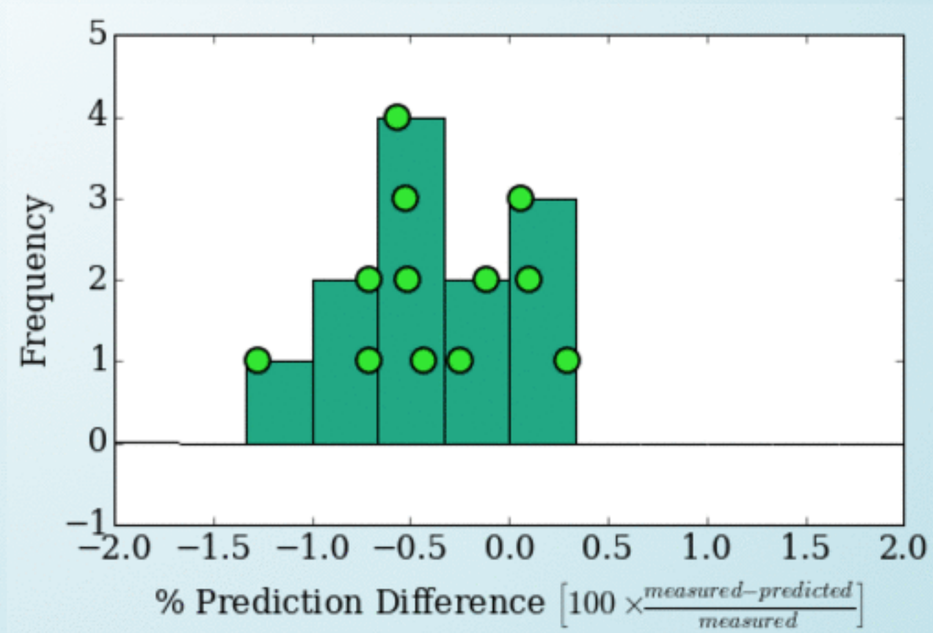




MODEL VALIDATION







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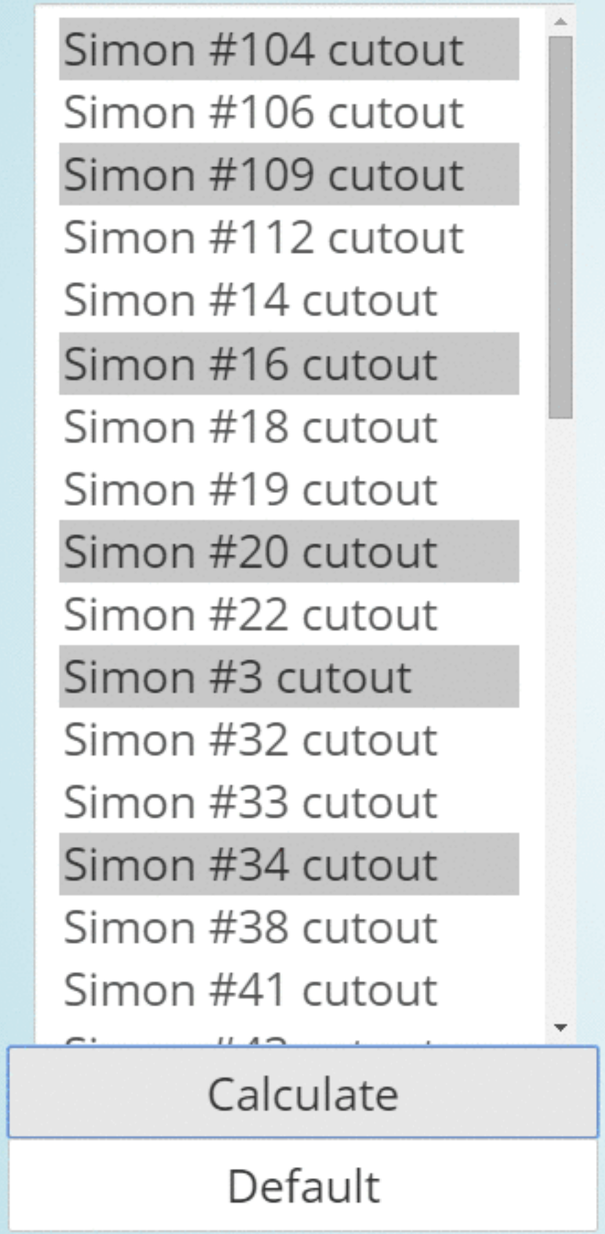

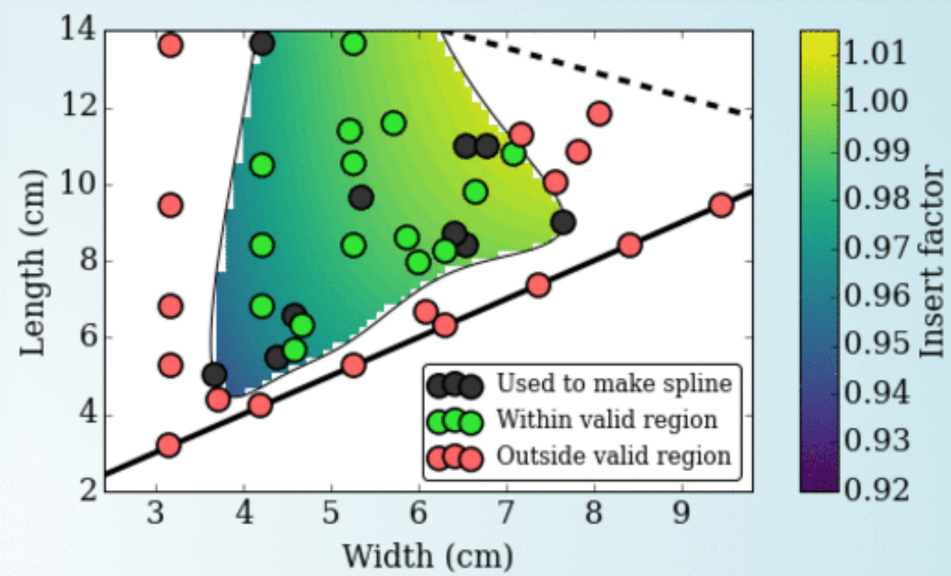

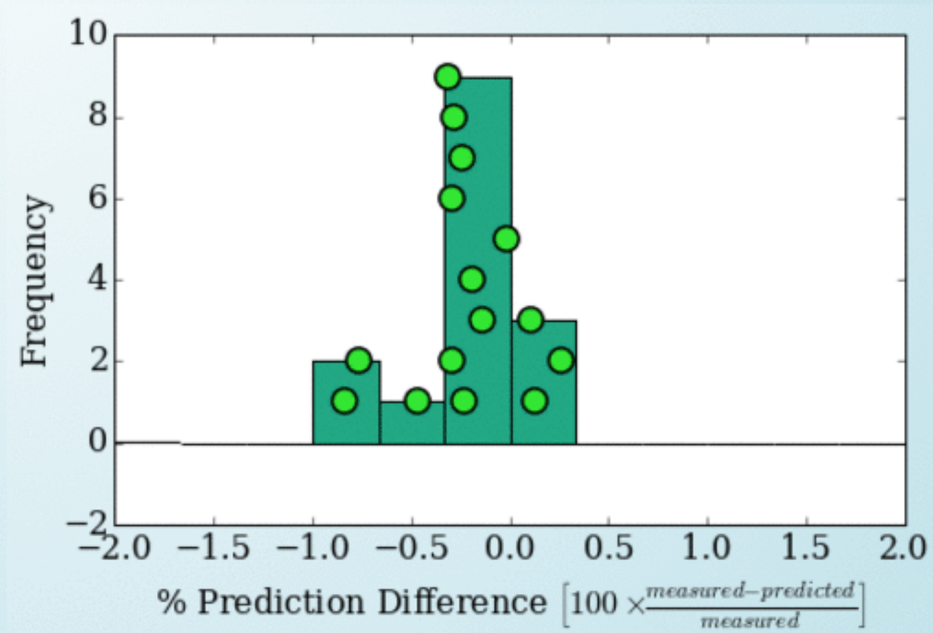

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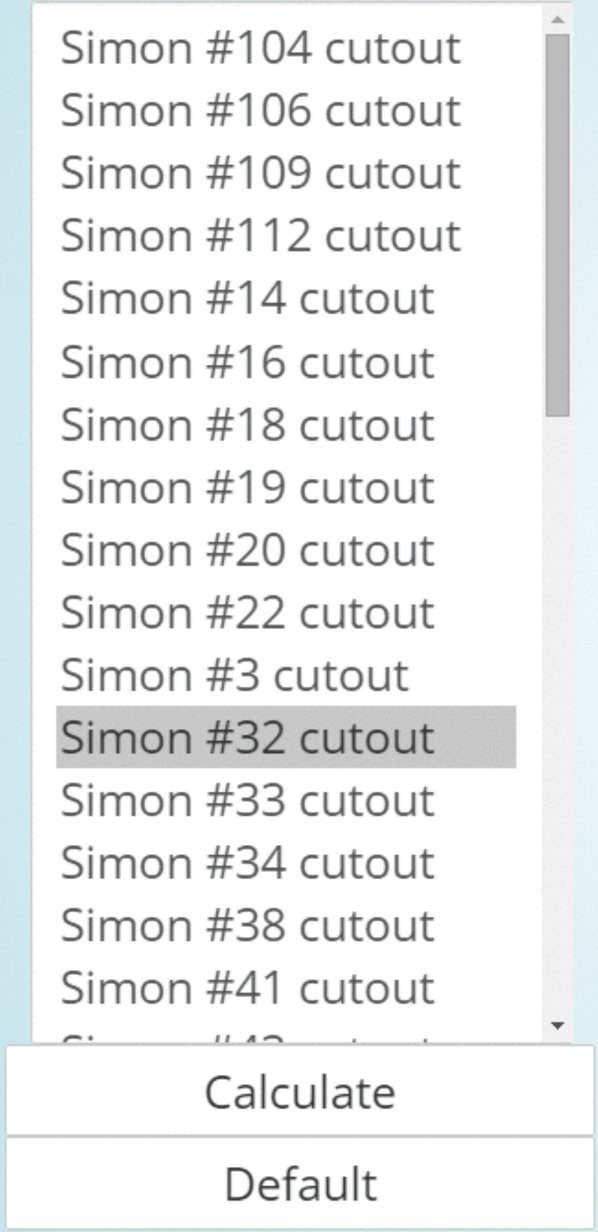
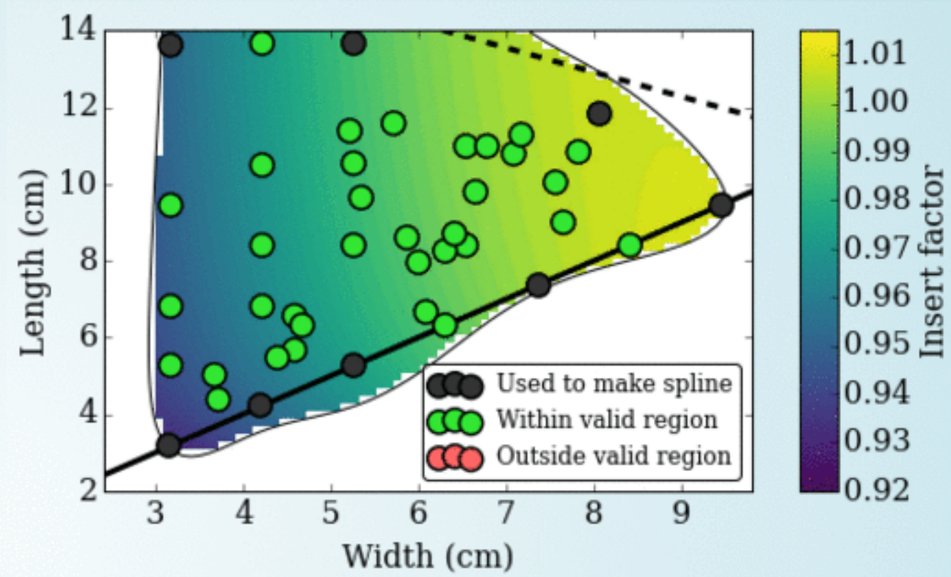
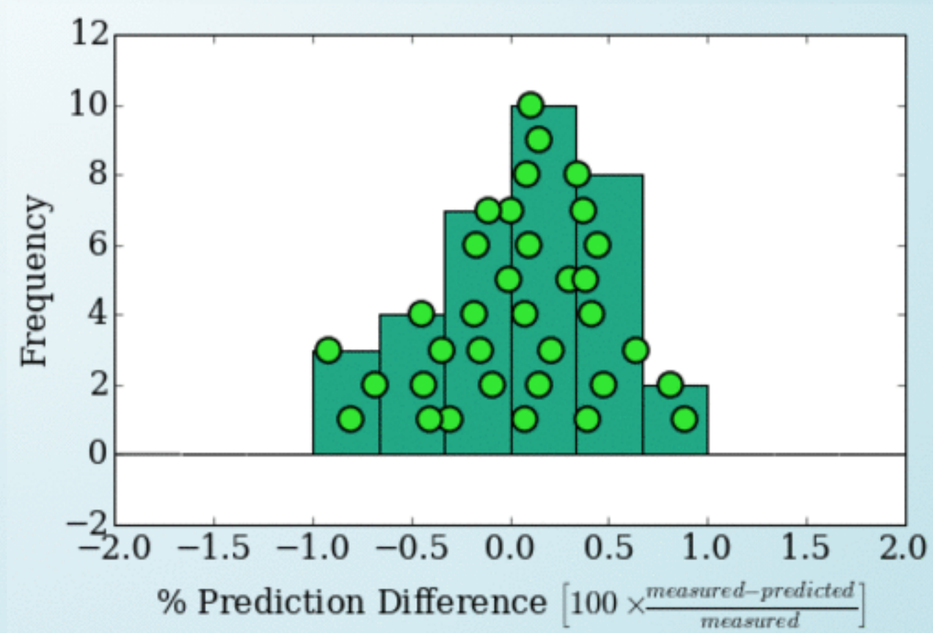
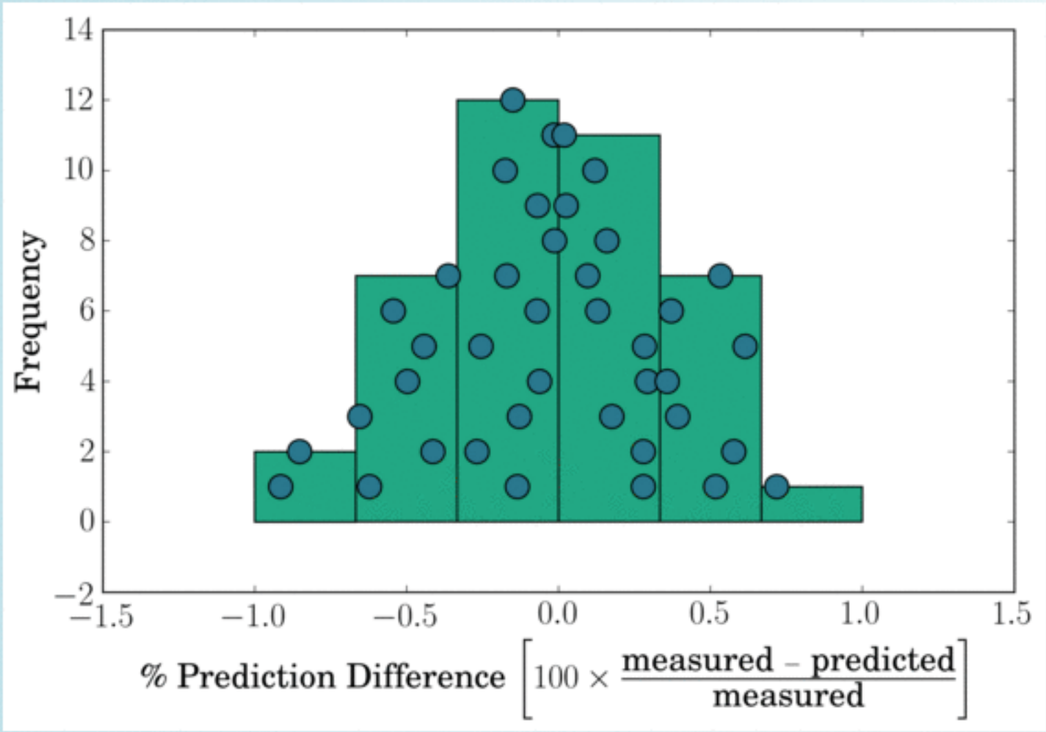
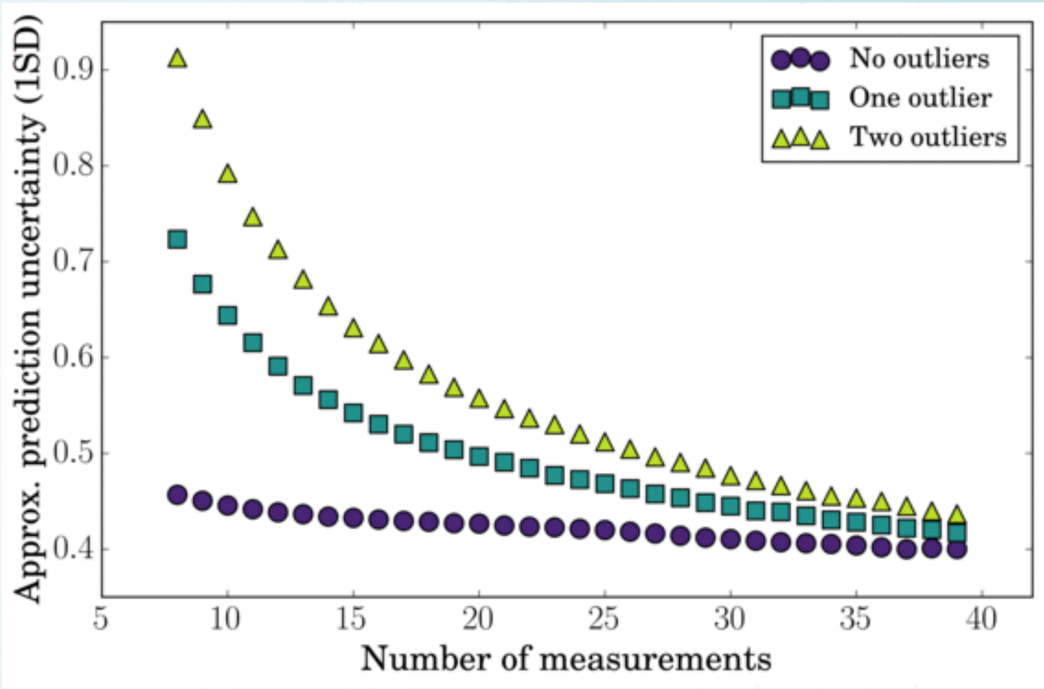






UNCERTAINTY AND OUTLIERS





OVERVIEW OF RESULTS

- 12 MeV validation data had a predicition uncertainty of 0.4%
- For 6, 9, 15, and 18 MeV the maximum recorded deviations were 0.8%, 0.8%, 0.9%, and 1.0%
- One may expect an approximate uncertainty of 0.5% when as little as 8 data points are used
- In 10^6 predictions no random subset of 8 datapoints produced a prediction difference greater than 2%

CONCLUSION

- A method that is easy to impliment
- Uncertainty approaching measurement
- Builds upon the vast amount of data already available
- The level of accuracy combined with the ease with which this model can be generated demonstrates its suitability for clinical use
- DOI of paper: 10.1016/j.ejmp.2015.11.002
- Code available at: github.com/SimonBiggs/electronfactors
- Feel free to contact me: mail@simonbiggs.net