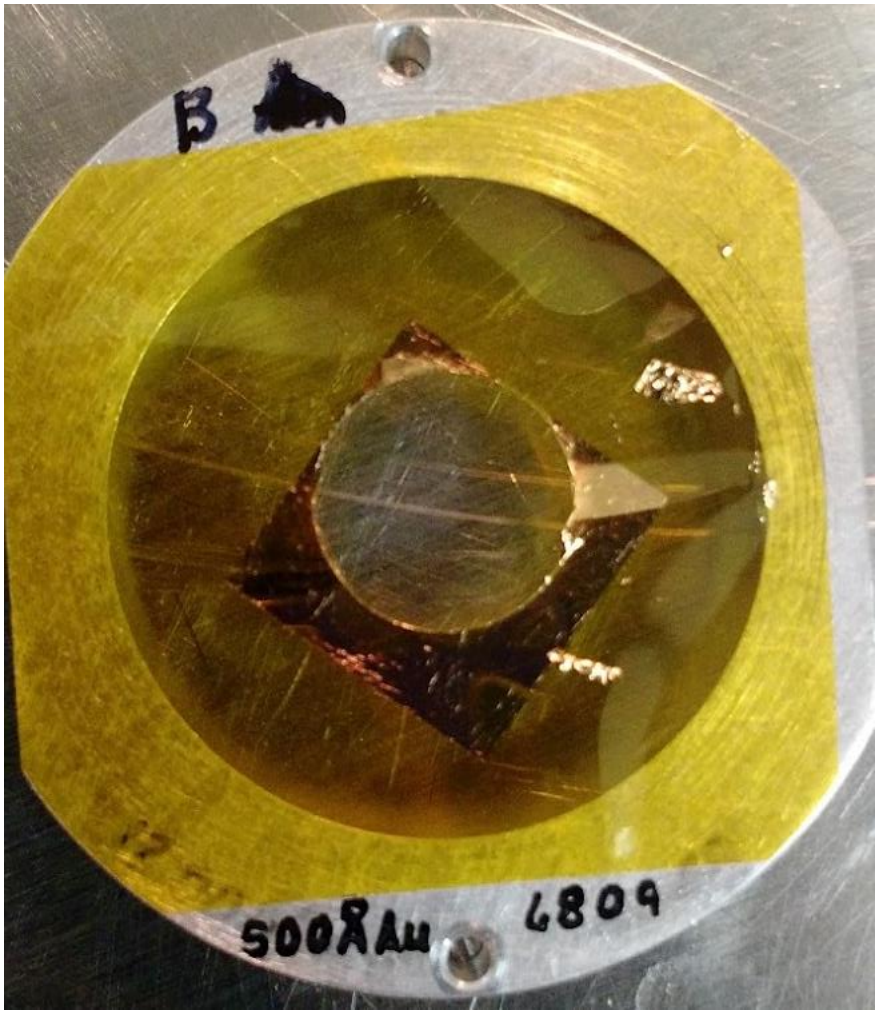
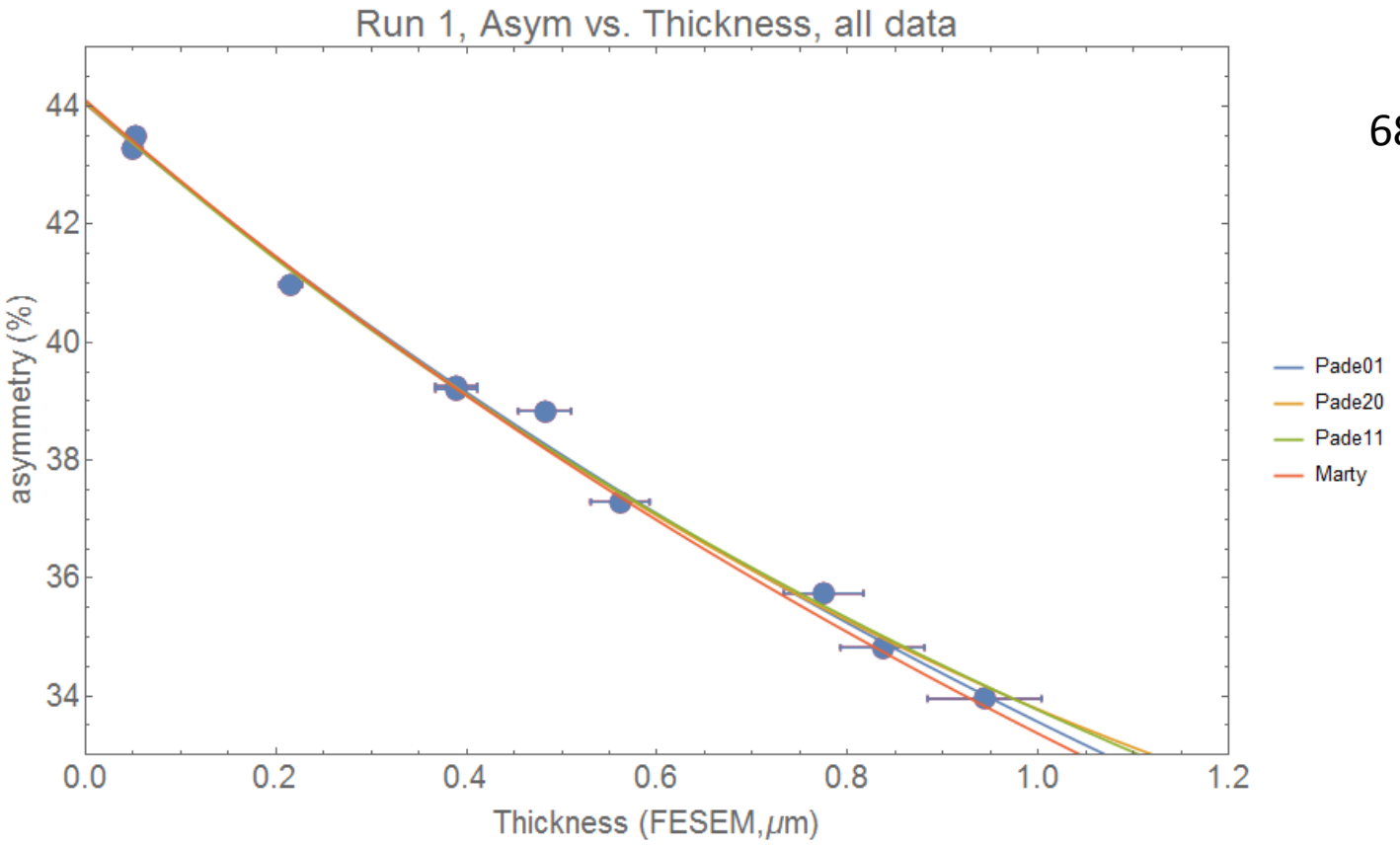
Extrapolation update

24 February 2017

Thinnest foil Questions?

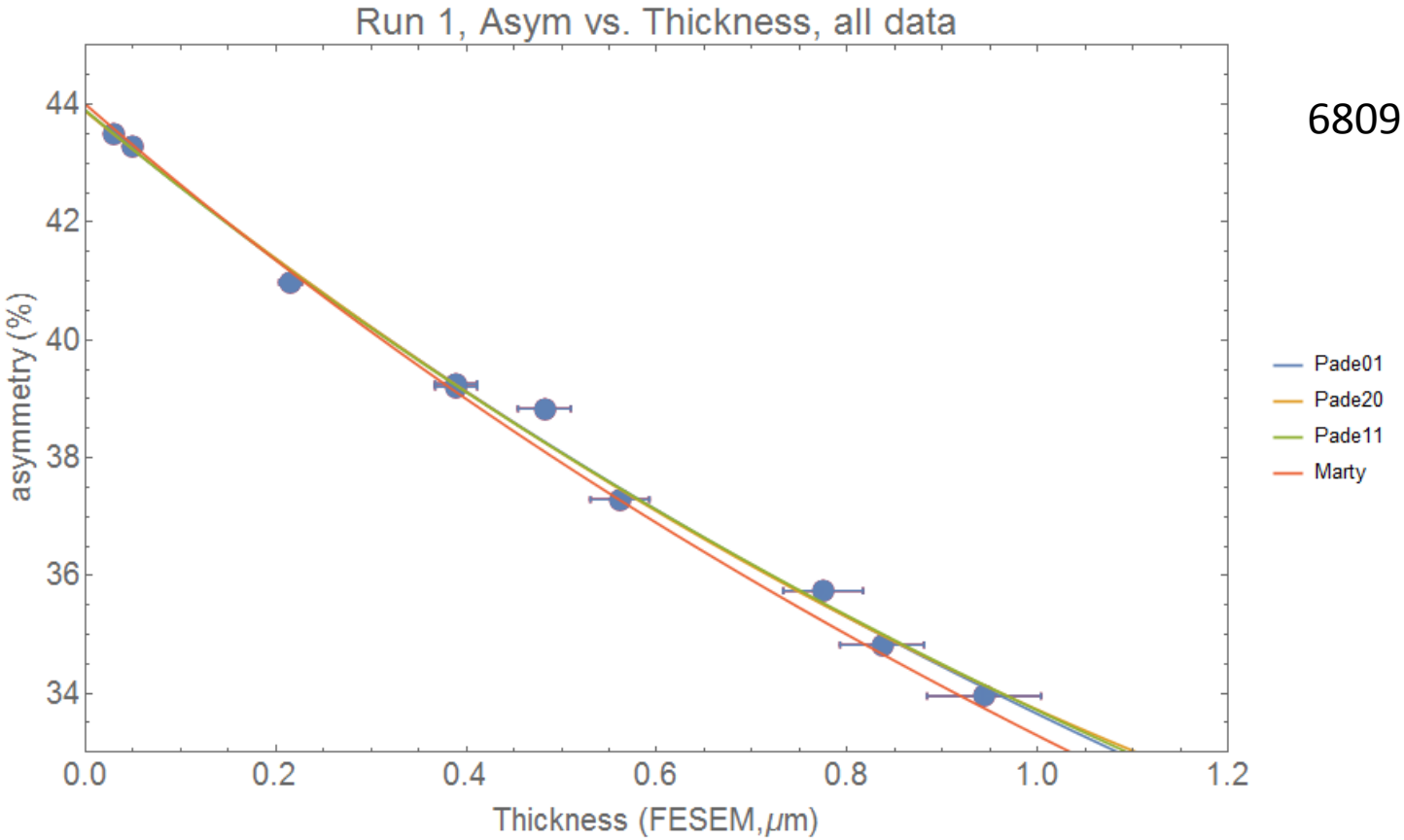
- Wrote to Lebow to verify plastic backing material
- Their records indicate 6809 is 30 nm gold on 300 nm Parylene N backing?!
  - Kapton sheet with hole
  - Inside hole, gold supported by Parylene-N
  - **There is plastic in the center area of this foil according to LEBOW**
- This was measured at 52 nm FESEM
  - Parylene might affect this?
- Other 50 nm foil, unsupported (and no sibling for FESEM)





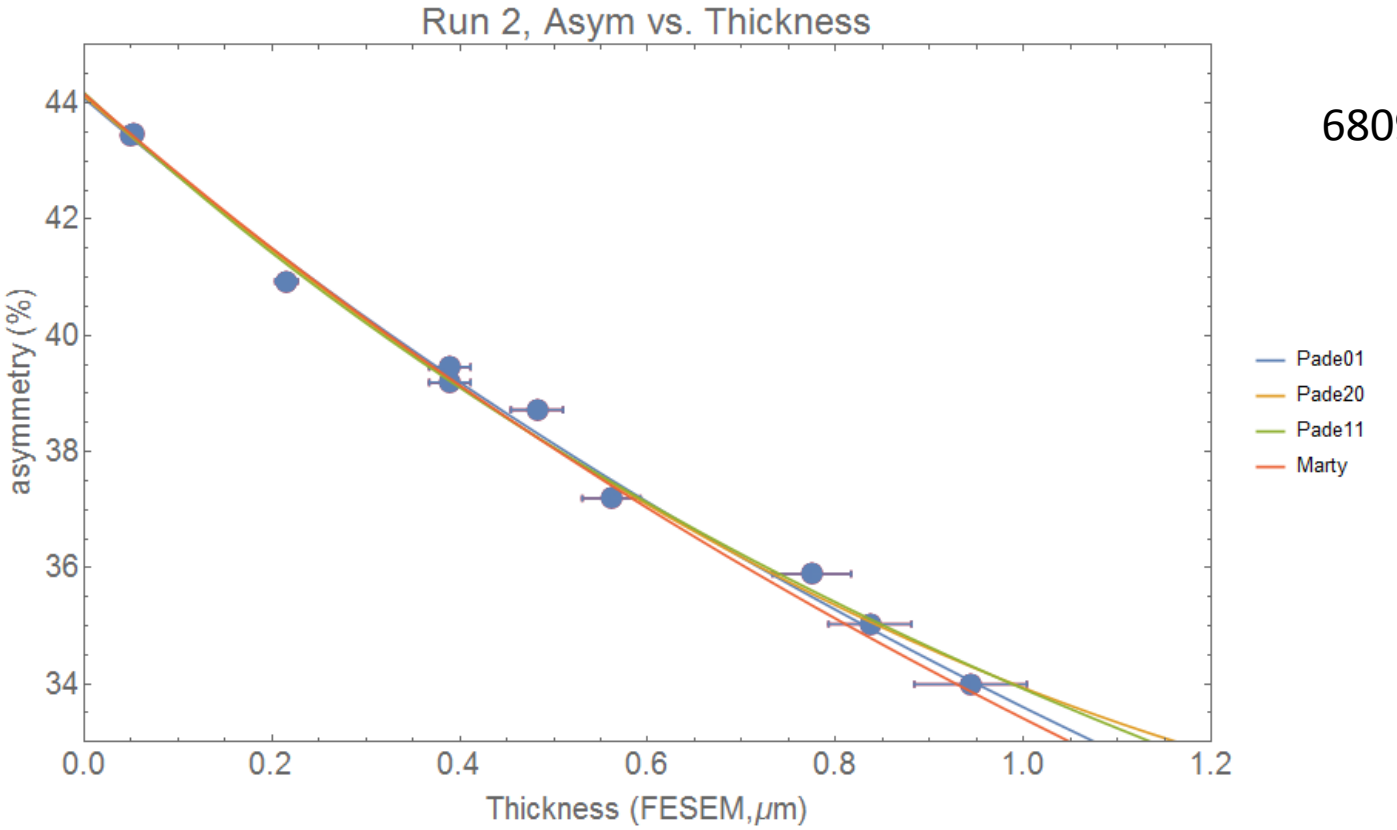
6809 = 52 nm

Pade01	$\frac{44.0395}{1+0.312289\,x}$	Reduced $\chi 2$	1.15953
Pade20	$44.0492 - 13.7301\,x + 3.45486\,x^2$	Reduced $\chi 2$	1.36746
Pade11	$\frac{44.0928+3.36456\,x}{1+0.405728\,x}$	Reduced $\chi 2$	1.27408
Marty	$-\frac{85.9731\,(-0.101574+0.000682\,x)}{0.198+0.062\,x}$	Reduced $\chi 2$	1.18032
Marty Intercept	44.1042		



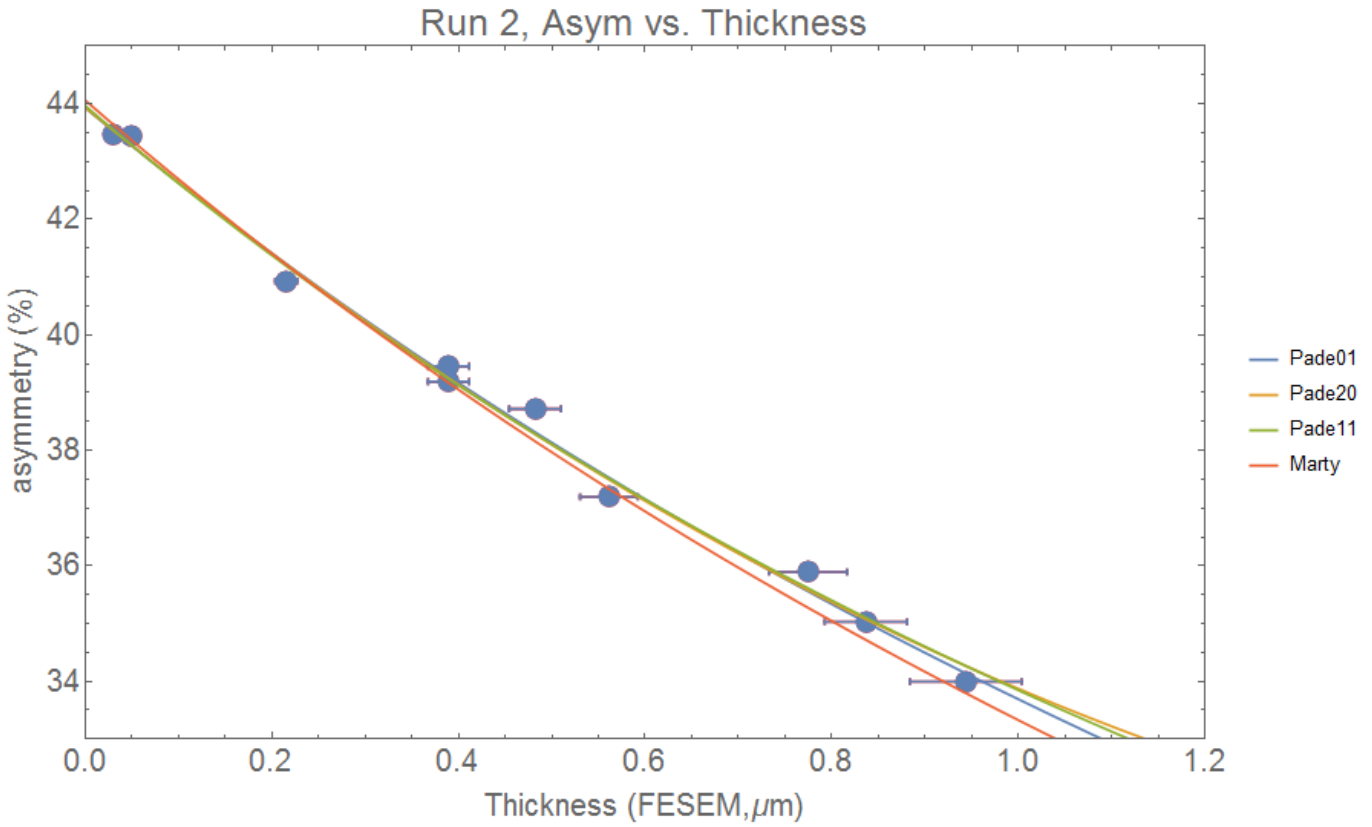
6809 = 30 nm

Pade01	$\frac{43.8885}{1+0.304301\,x}$	Reduced $\chi 2$	0.821235
Pade20	$43.8776 - 13.0527\,x + 2.89727\,x^2$	Reduced $\chi 2$	0.991149
Pade11	$\frac{43.9001+0.91529\,x}{1+0.329545\,x}$	Reduced $\chi 2$	0.940989
Marty	$-\frac{85.7681\,(-0.101574+0.000682\,x)}{0.198+0.062\,x}$	Reduced $\chi 2$	1.19832
Marty Intercept	43.999		



6809= 52nm

Pade01	$\frac{44.0809}{1+0.312034\,x}$	Reduced $\chi 2$	1.14571
Pade20	$44.1172 - 14.0333\,x + 3.84757\,x^2$	Reduced $\chi 2$	1.29458
Pade11	$\frac{44.1759+5.64007\,x}{1+0.468957\,x}$	Reduced $\chi 2$	1.17529
Marty	$-\frac{86.0788\,(-0.101574+0.000682\,x)}{0.198+0.062\,x}$	Reduced $\chi 2$	1.20308
Marty Intercept	44.1584		

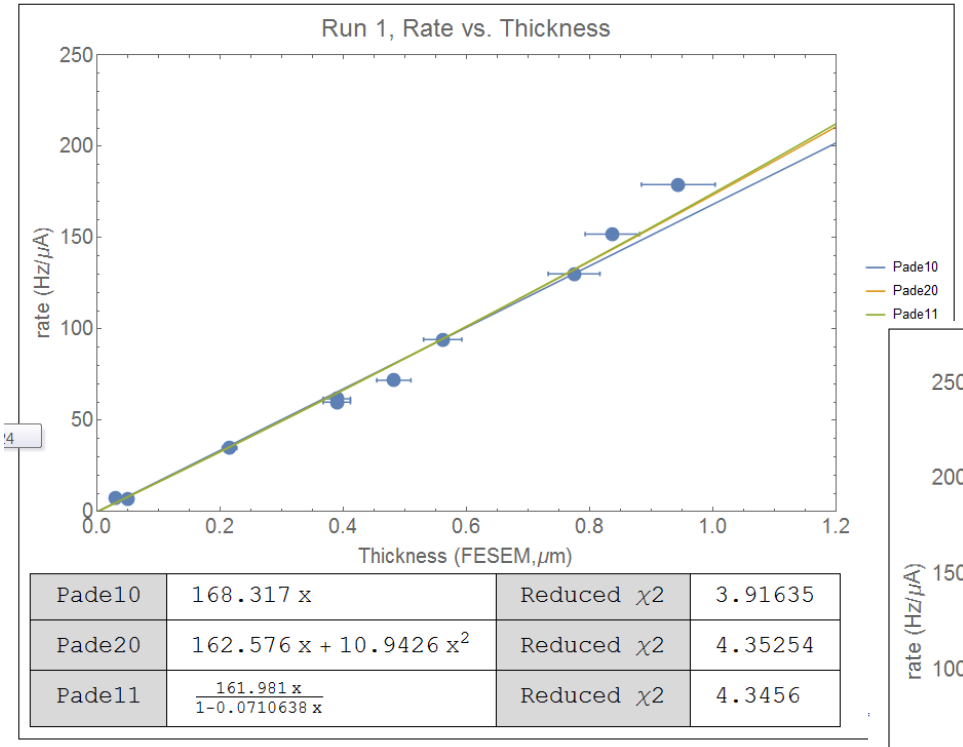


6809= 30nm

79]=

Pade01	$\frac{43.9273}{1+0.303892\,x}$	Reduced $\chi 2$	1.13216
Pade20	$43.9341 - 13.2908\,x + 3.22797\,x^2$	Reduced $\chi 2$	1.33175
Pade11	$\frac{43.9628+2.59445\,x}{1+0.37559\,x}$	Reduced $\chi 2$	1.27109
Marty	$-\frac{85.8845\,(-0.101574+0.000682\,x)}{0.198+0.062\,x}$	Reduced $\chi 2$	1.49072
Marty Intercept	44.0587		

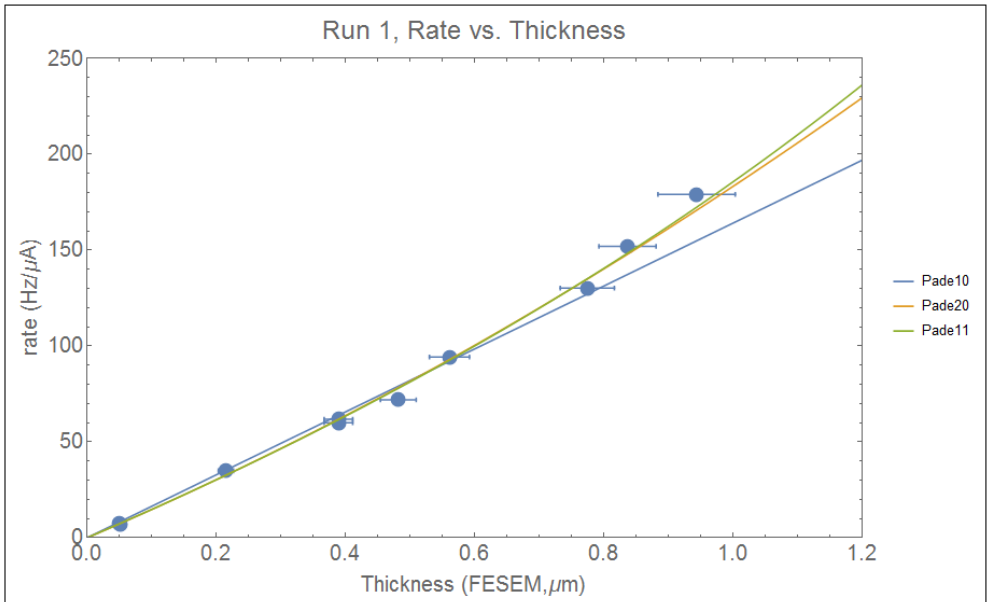
Rate vs. Thickness Run 1



Pade10	$168.317\,x$	Reduced $\chi 2$	3.91635
Pade20	$162.576\,x + 10.9426\,x^2$	Reduced $\chi 2$	4.35254
Pade11	$\frac{161.981\,x}{1-0.0710638\,x}$	Reduced $\chi 2$	4.3456

30 nm

52 nm



Pade10	$164.154\,x$	Reduced $\chi 2$	1.88589
Pade20	$143.325\,x + 39.9559\,x^2$	Reduced $\chi 2$	0.527209
Pade11	$\frac{144.568\,x}{1-0.221354\,x}$	Reduced $\chi 2$	0.490346

Is 6809 30 or 52 nm?

- Lebow statement

  Dear Dr. Stutzman,
  I apologize for the incorrect label on that foil.
  The Au foils are:
  6809 made in December 1998: 30nm Au supported on 300nm of Parylene N.
  There is little or no chance that the foil is 50nm thick. Remember, there is 300nm of Parylene N under the Au. This may affect your results. The yellow plastic around the foil is Kapton.
  I hope this is helpful. We welcome any further questions you may have.
  Sincerely,
  Edward Graper
  ed@lebowcompany.com

- Rate data looks like foil is 52 nm – affected by parylene backing?
- Ao drops with 30 nm, better fit (Run 1), no better fit (Run 2)

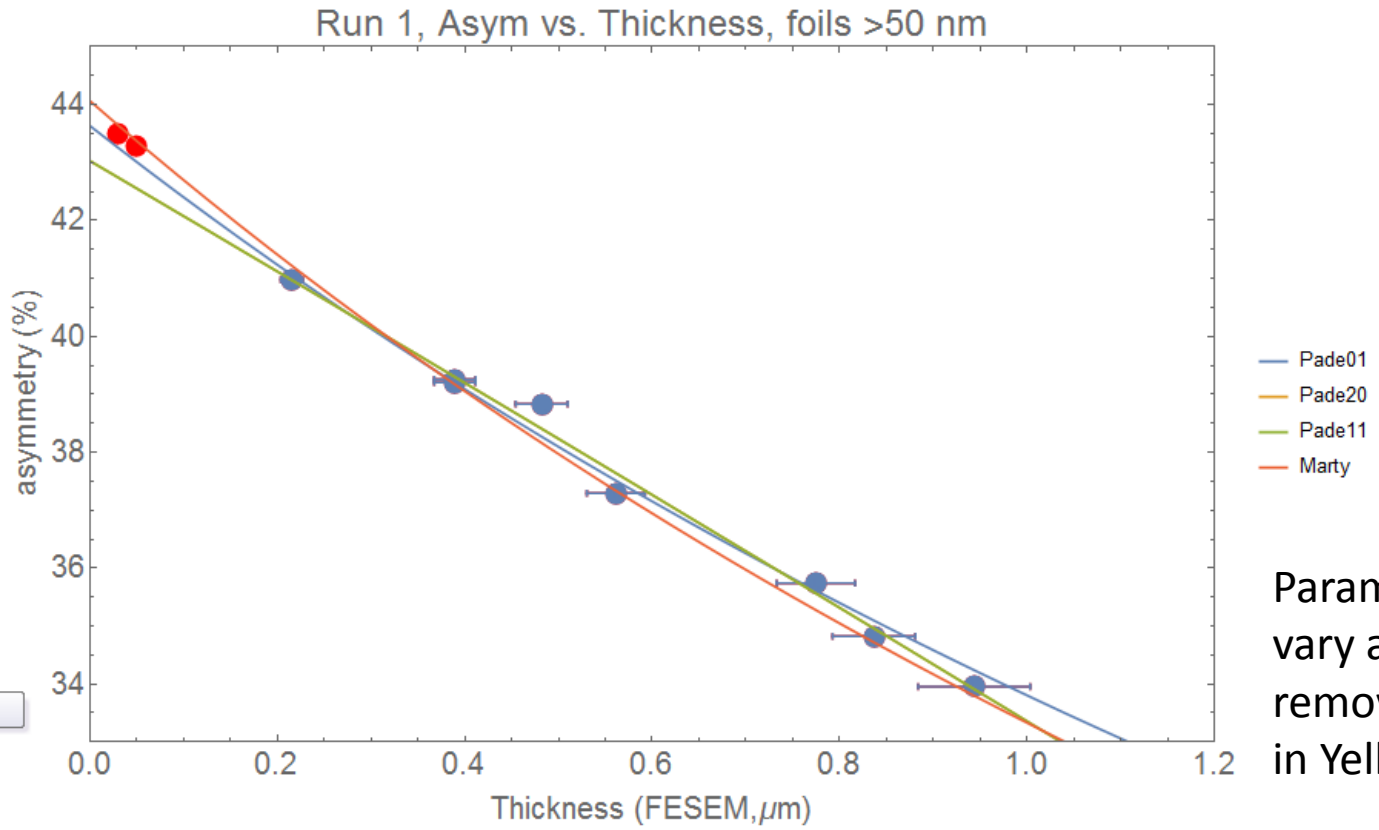
- Safest: drop data from 6809??
- Can be considered: use 6809 at 52 nm or at 30 nm

Part 2: Pade analysis

- Pade is an statistical technique. It is descriptive rather than predictive. The reason for doing the Pade analysis was
  - If Marty's Geant4 didn't work out
  - To look statistically at the data and see uncertainty in Ao due to different viable fitting functions
  - To be able to handle data that we don't have models for, such as asym vs rate

Geant4 simulations

- Geant4 simulations strive to be predictive rather than descriptive
  - They use first principles calculations to predict functional form of the data
  - They don’t change shape since the only factor is a scaling factor to get the smallest variation between fit and the data points



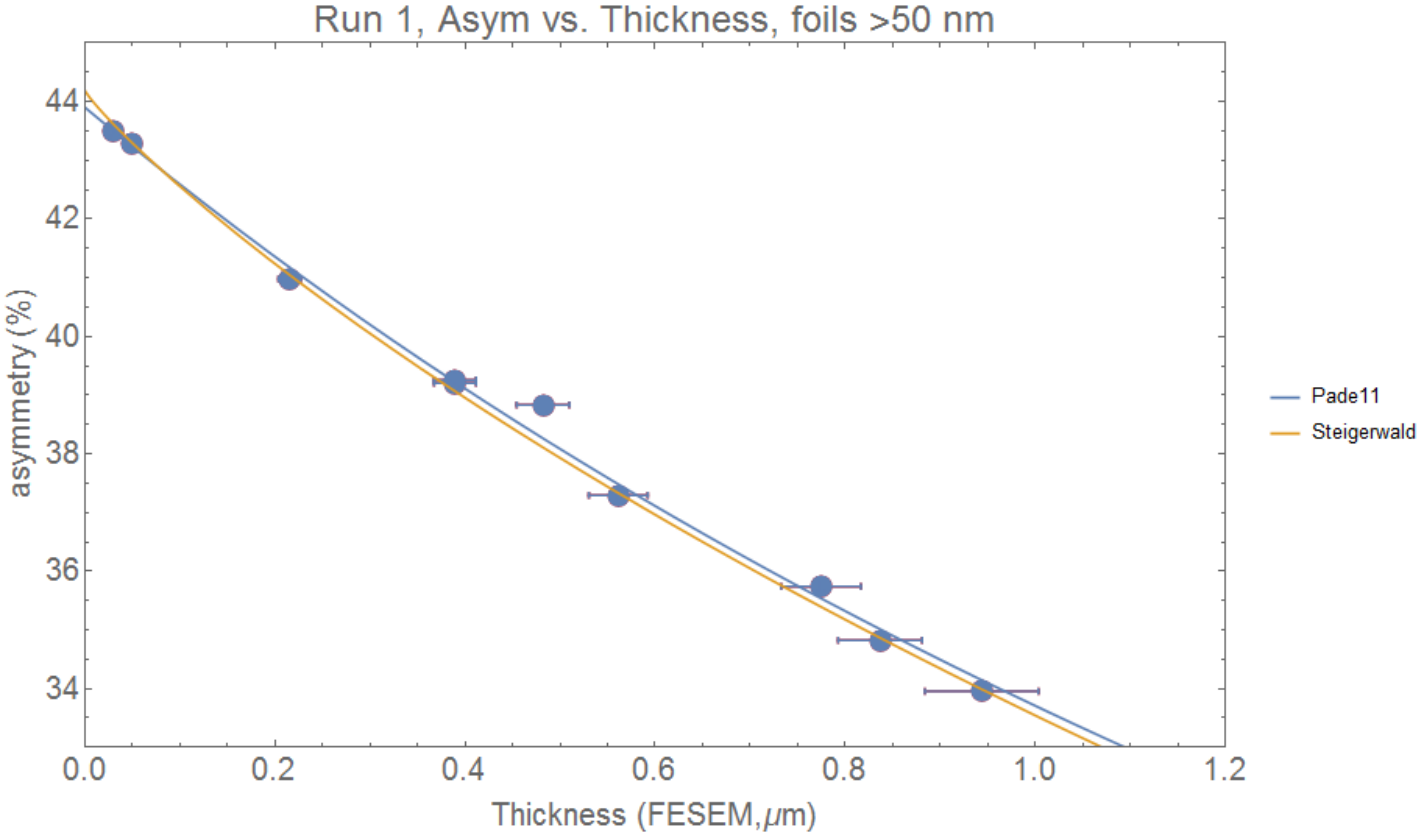
Parameters allowed to vary as two points removed highlighted in Yellow

Pade01	$\frac{43.6333}{1+0.290798\,x}$	Reduced $\chi 2$	0.953795
Pade20	$43.0279 - 9.51265\,x - 0.157844\,x^2$	Reduced $\chi 2$	0.783894
Pade11	$\frac{43.0282-10.2091\,x}{1-0.0161361\,x}$	Reduced $\chi 2$	0.783928
Marty	$-\frac{85.8918\,(-0.101574+0.000682\,x)}{0.198+0.062\,x}$	Reduced $\chi 2$	1.44743
Marty Intercept	44.0625		

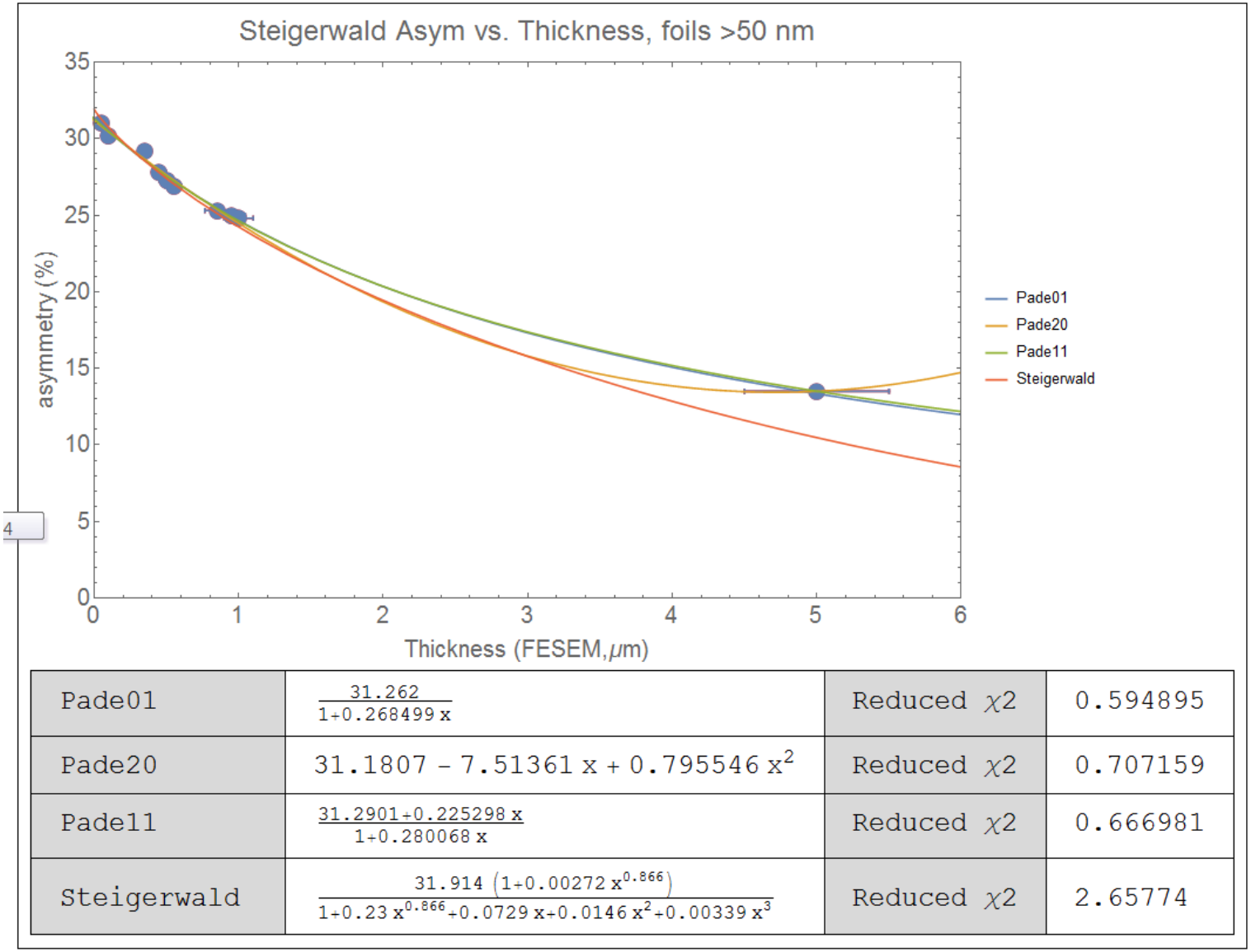
Pade vs. Geant

- The Pade analysis is descriptive.
  - Excellent for determining point within the data range
  - Useful for extrapolating beyond data range for small amounts
  - Pade analysis leads to Geant4 predicted form (+1 more)
  - Required for A vs. Rate – no Geant4 model there
- The Geant4 simulations strive to be predictive
  - They should work for larger data ranges
  - They are much more computationally intensive
  - Marty's fits the data pretty well, is understood

Should we show Steigerwald function with our data?



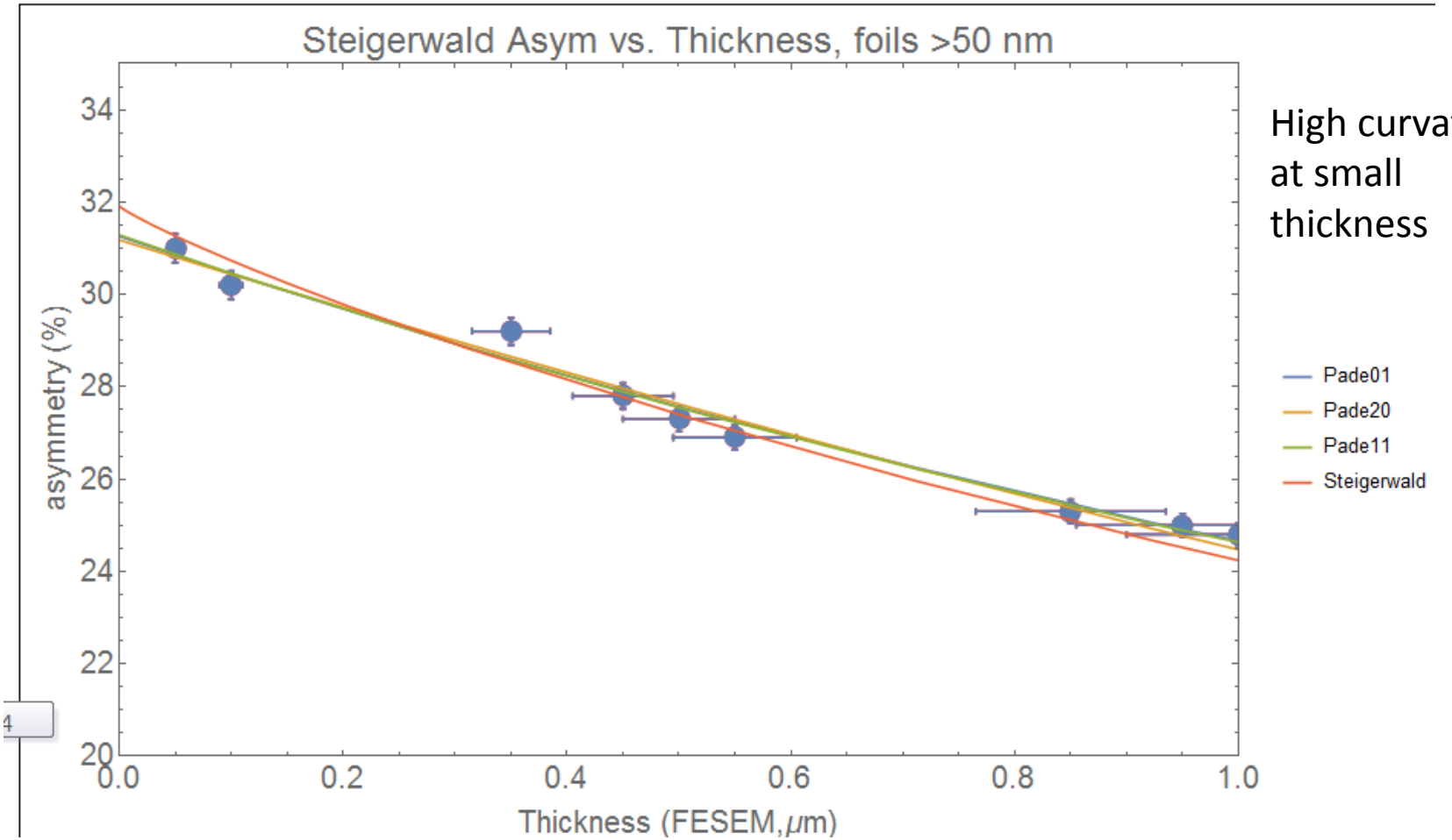
Pade11	$\frac{43.9001+0.91529\,x}{1+0.329545\,x}$	Reduced $\chi 2$	0.940989
Steigerwald	$\frac{44.1862\,(1+0.00272\,x^{0.866})}{1+0.23\,x^{0.866}+0.0729\,x+0.0146\,x^2+0.00339\,x^3}$	Reduced $\chi 2$	1.02463



Pade01	$\frac{31.262}{1+0.268499\,x}$	Reduced $\chi 2$	0.594895
Pade20	$31.1807 - 7.51361\,x + 0.795546\,x^2$	Reduced $\chi 2$	0.707159
Pade11	$\frac{31.2901+0.225298\,x}{1+0.280068\,x}$	Reduced $\chi 2$	0.666981
Steigerwald	$\frac{31.914\,(1+0.00272\,x^{0.866})}{1+0.23\,x^{0.866}+0.0729\,x+0.0146\,x^2+0.00339\,x^3}$	Reduced $\chi 2$	2.65774

Predicts his largest foil poorly

Steigerwald data set zoomed in



High curvature at small thickness

Should we include Steigerwald analysis of our data

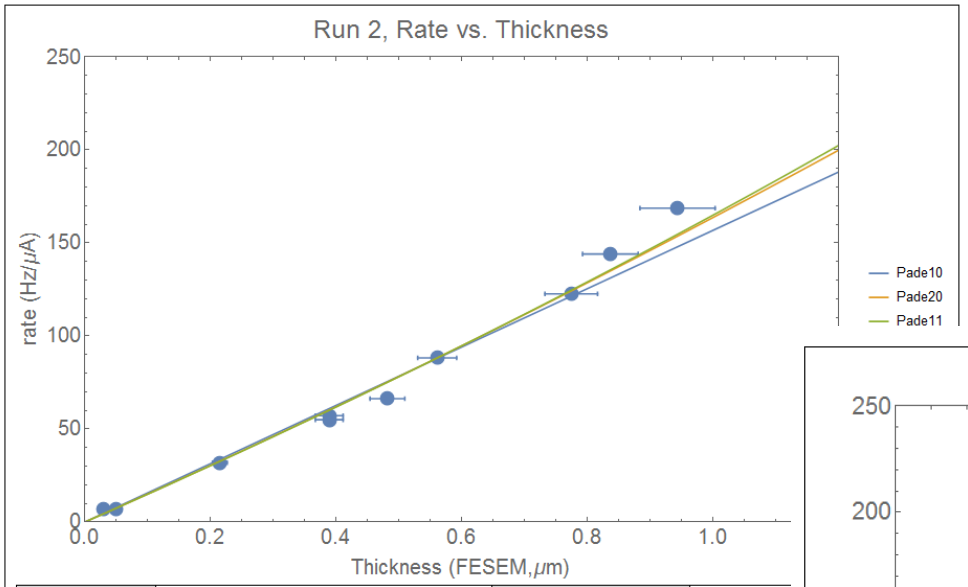
- Determined for 5 MeV, we are not at this energy
- Only if we understand why he has this function with odd exponents and low thickness curvature
- We understand the physics in Marty's Geant – stick with that for this round?
- Michael's has really high order terms, hooks up left of data, which is dangerous

Fitting left to do

- Settle 30 vs. 52 nm fit
- Are we ready for working on graphs in publication form?
- Tech note on Pade analysis is in progress
  - Supplemental material can now be submitted with Phys. Rev. C articles, tech notes can be attached to the paper
  - https://journals.aps.org/authors/supplemental-materials-journals

Extra slides

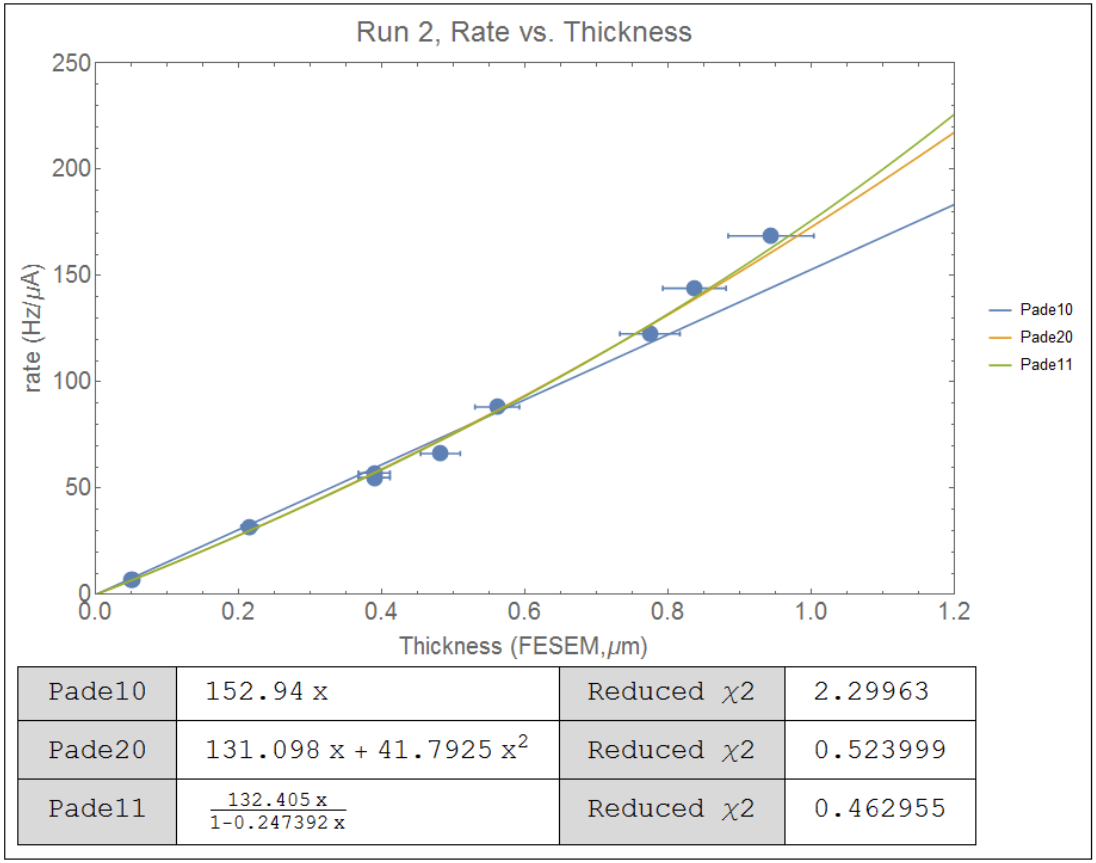
Rate vs. Thickness?



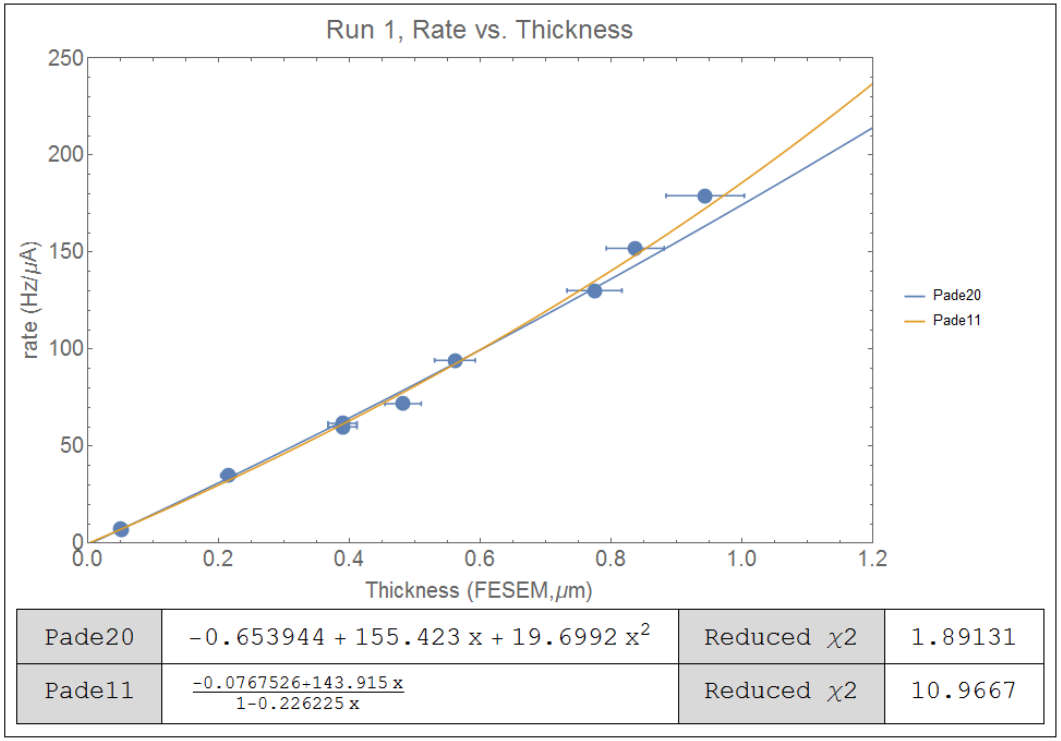
Pade10	156.822 x	Reduced $\chi 2$	4.267
Pade20	149.182 x + 14.5143 x^2	Reduced $\chi 2$	4.631
Pade11	$\frac{148.427\,x}{1-0.100298\,x}$	Reduced $\chi 2$	4.609

30 nm

52 nm

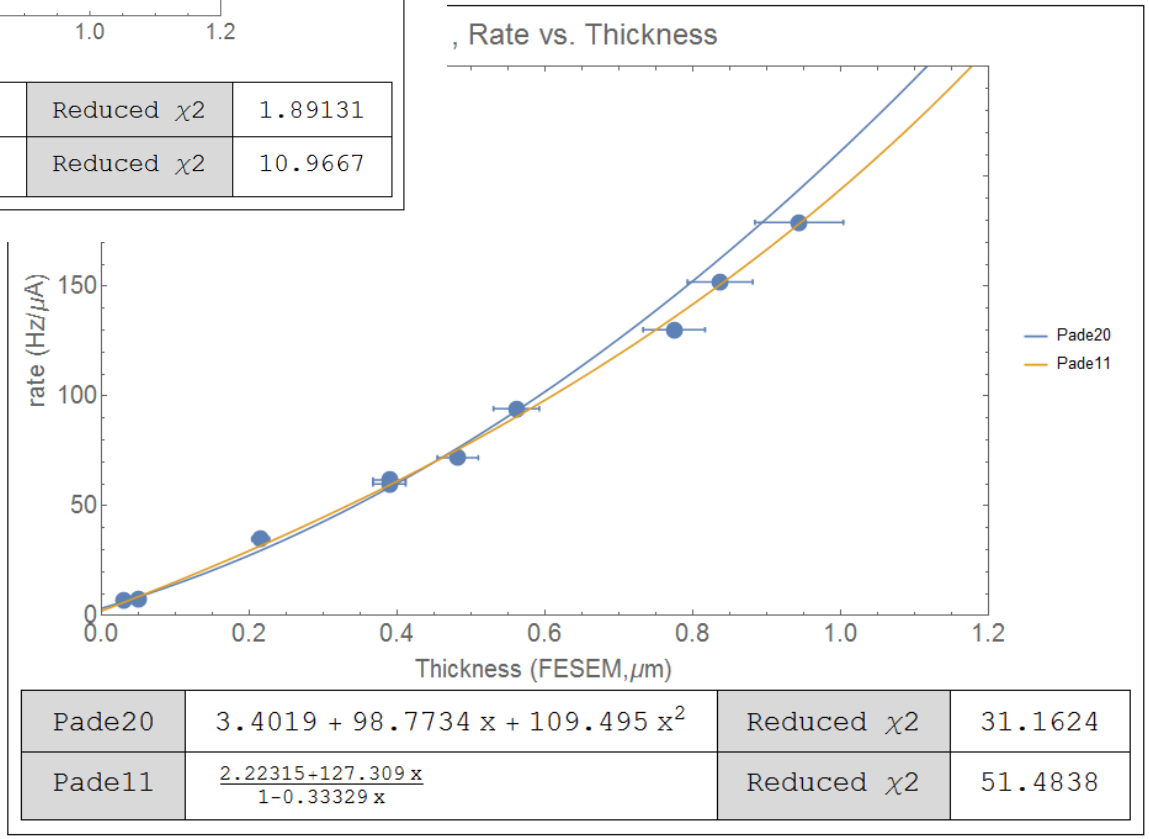


Pade10	152.94 x	Reduced $\chi 2$	2.29963
Pade20	131.098 x + 41.7925 x^2	Reduced $\chi 2$	0.523999
Pade11	$\frac{132.405\,x}{1-0.247392\,x}$	Reduced $\chi 2$	0.462955



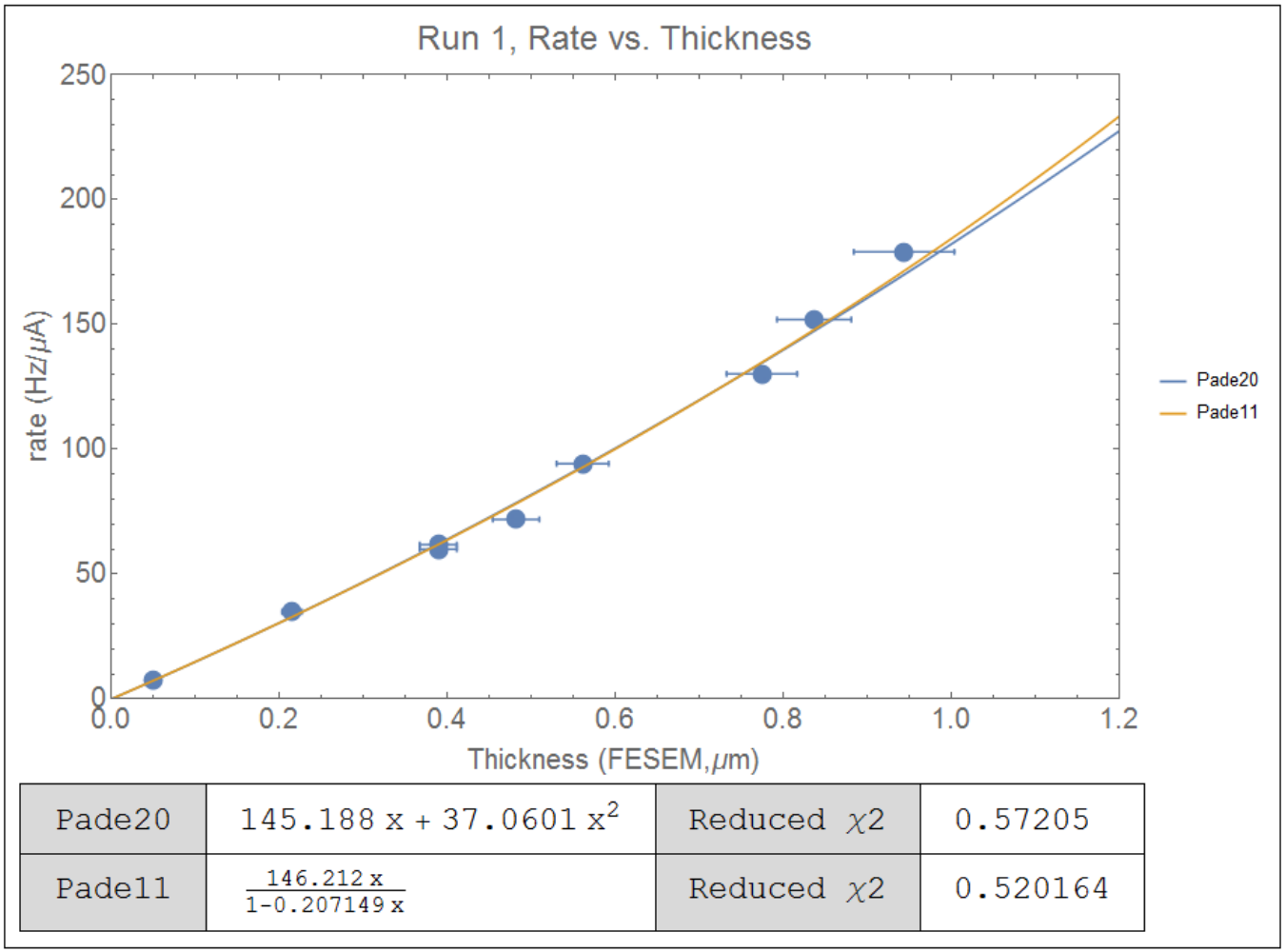
Pade20	$-0.653944 + 155.423\,x + 19.6992\,x^2$	Reduced $\chi 2$	1.89131
Pade11	$\frac{-0.0767526 - 143.915\,x}{1 - 0.226225\,x}$	Reduced $\chi 2$	10.9667

52 nm foil, float zero intercept



Pade20	$3.4019 + 98.7734\,x + 109.495\,x^2$	Reduced $\chi 2$	31.1624
Pade11	$\frac{2.22315 - 127.309\,x}{1 - 0.33329\,x}$	Reduced $\chi 2$	51.4838

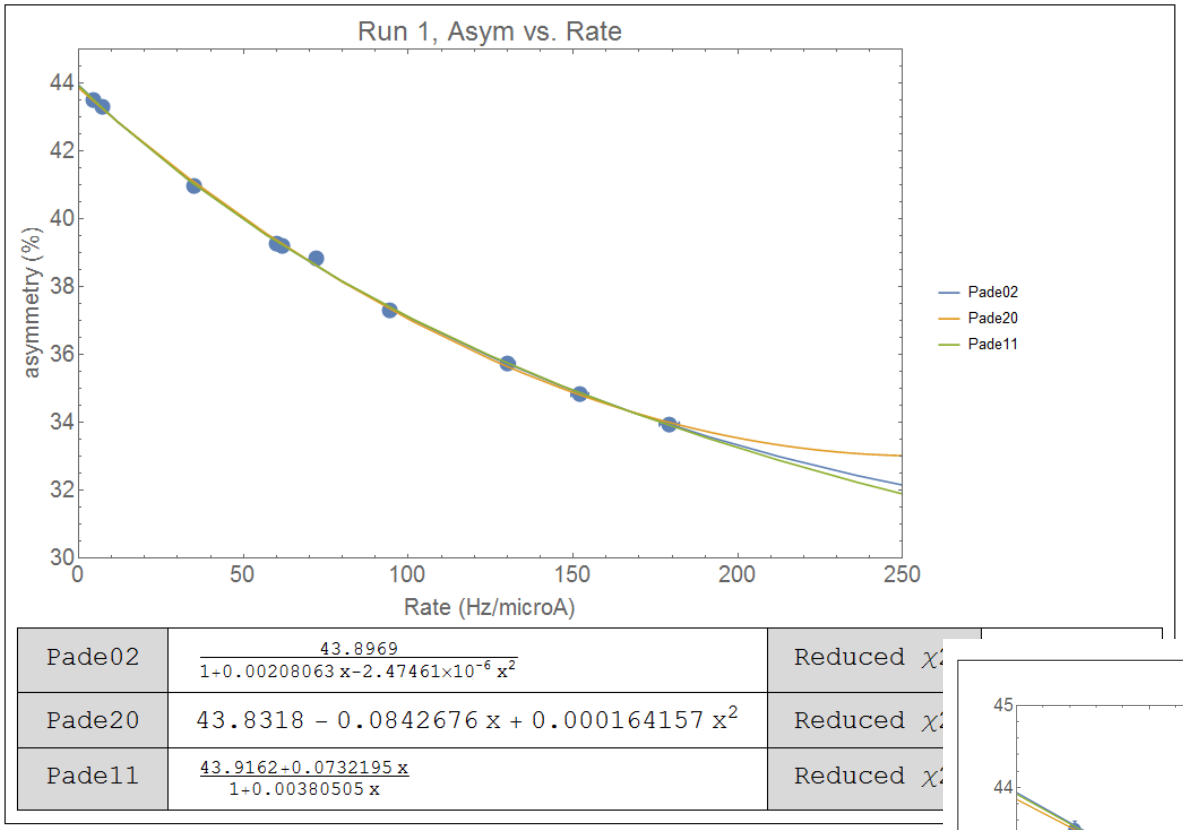
30 nm foil, float zero intercept



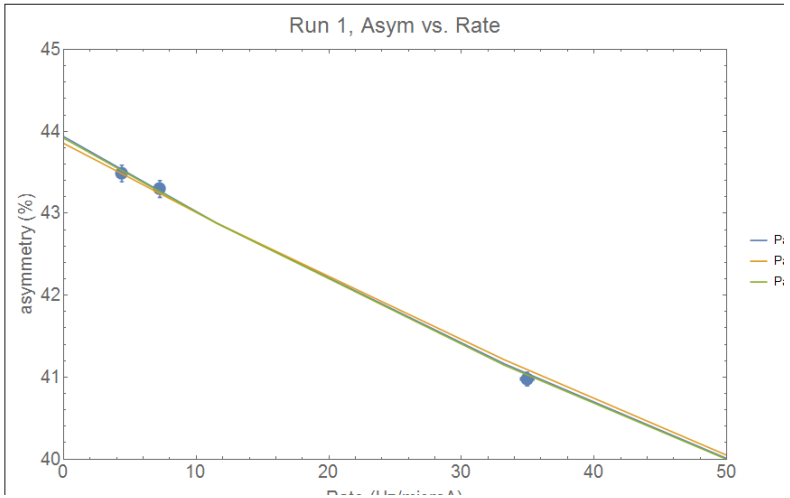
4]=

Pade20	$145.188\,x + 37.0601\,x^2$	Reduced $\chi 2$	0.57205
Pade11	$\frac{146.212\,x}{1-0.207149\,x}$	Reduced $\chi 2$	0.520164

Without questionable foil



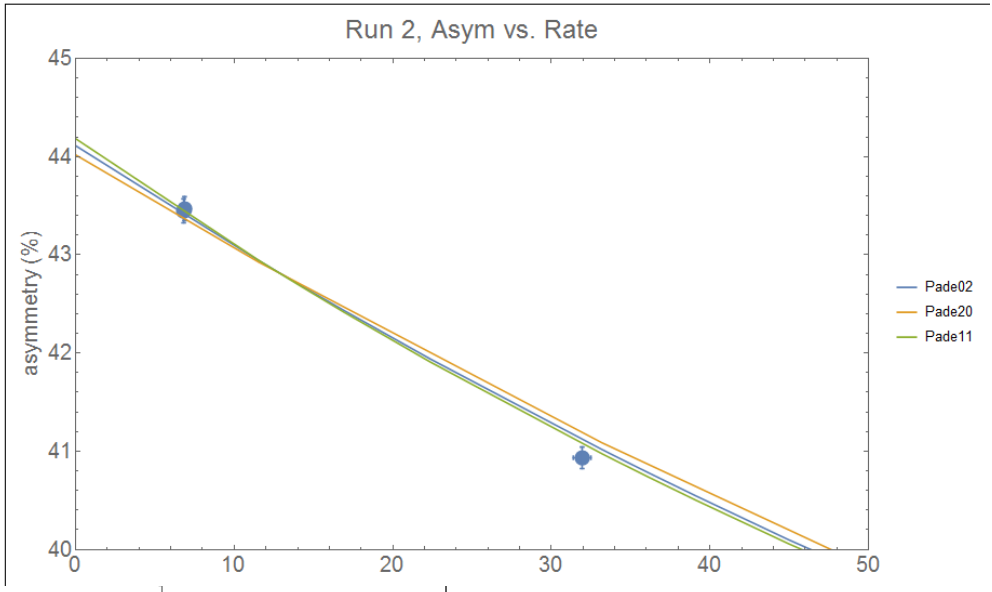
Pade02	$\frac{43.8969}{1+0.00208063\,x-2.47461\times10^{-6}\,x^2}$	Reduced χ^2
Pade20	$43.8318 - 0.0842676\,x + 0.000164157\,x^2$	Reduced χ^2
Pade11	$\frac{43.9162+0.0732195\,x}{1+0.00380505\,x}$	Reduced χ^2

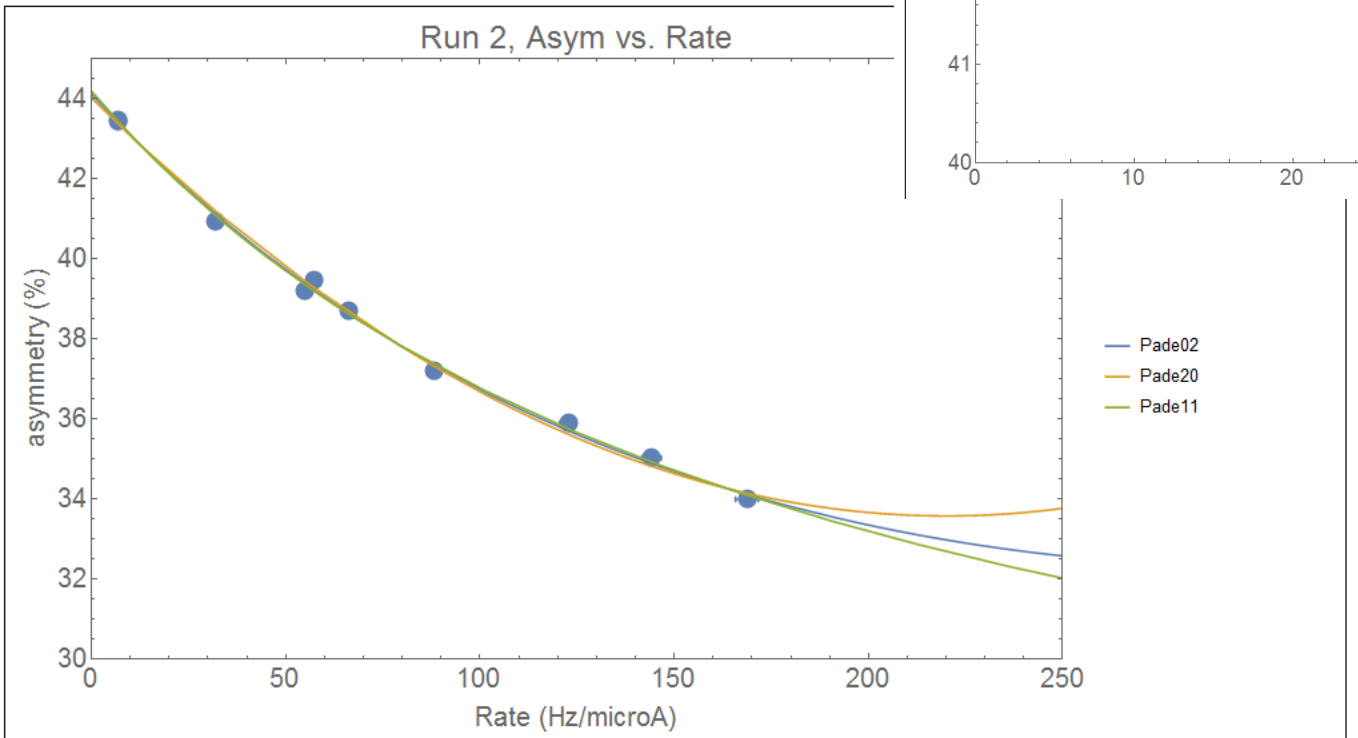


A(R) using R(6809) scaled from R(t) data

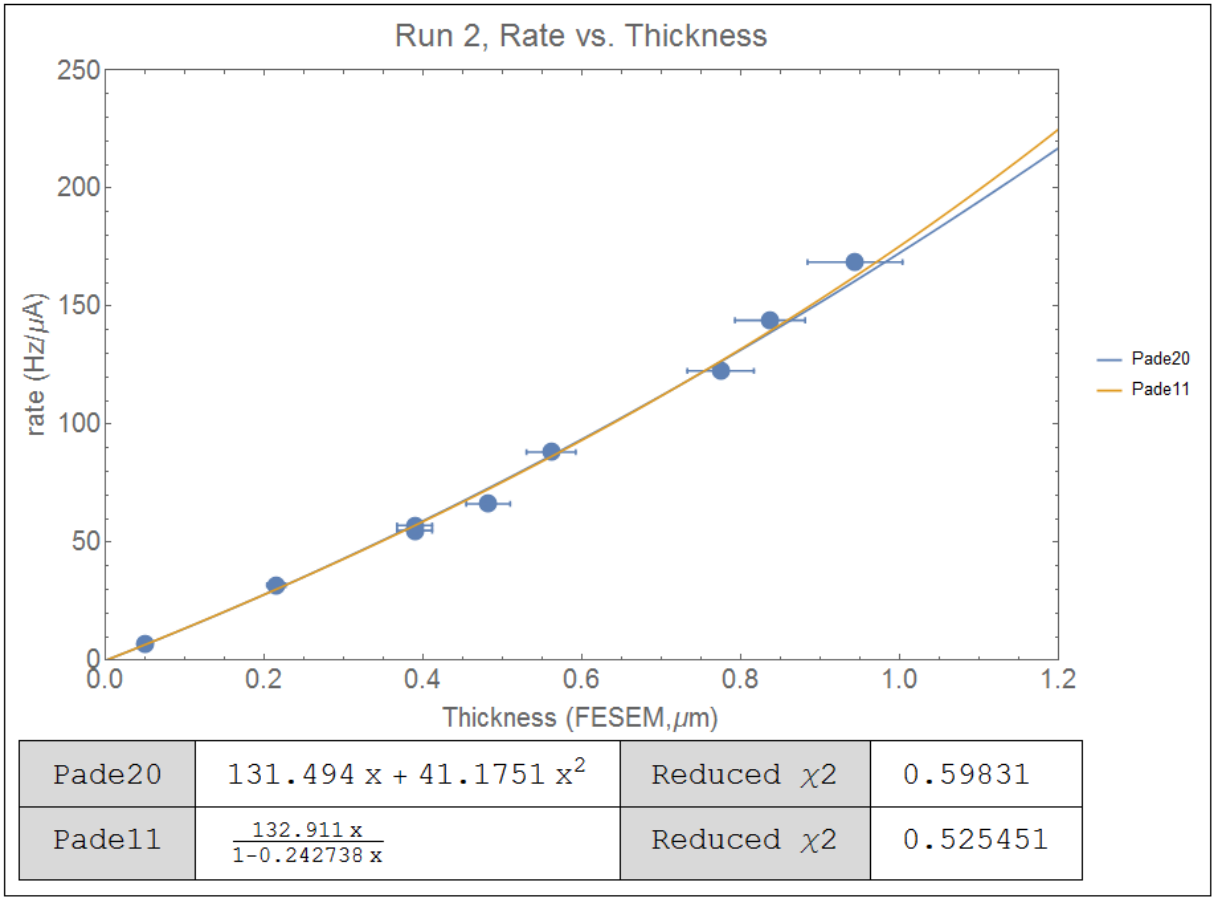
Run 2 data

A(R) using 52 nm





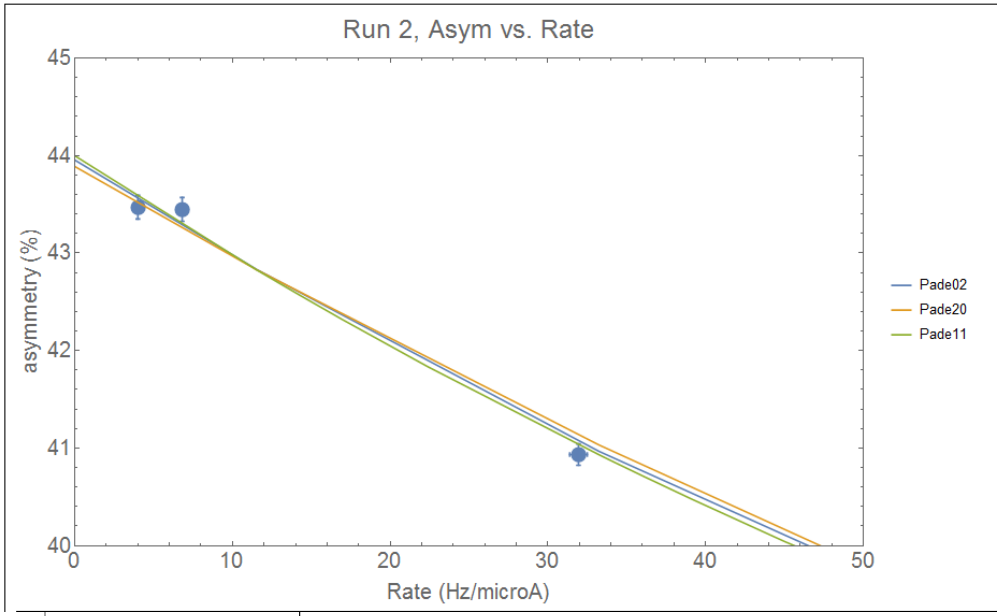
Pade02	$\frac{44.1112}{1+0.00240285\,x-3.94908\times10^{-6}\,x^2}$	Reduced $\chi2$	2.00337
Pade20	$43.9894 - 0.0945947\,x + 0.00021487\,x^2$	Reduced $\chi2$	3.00645
Pade11	$\frac{44.1828+0.122933\,x}{1+0.00535897\,x}$	Reduced $\chi2$	1.71058

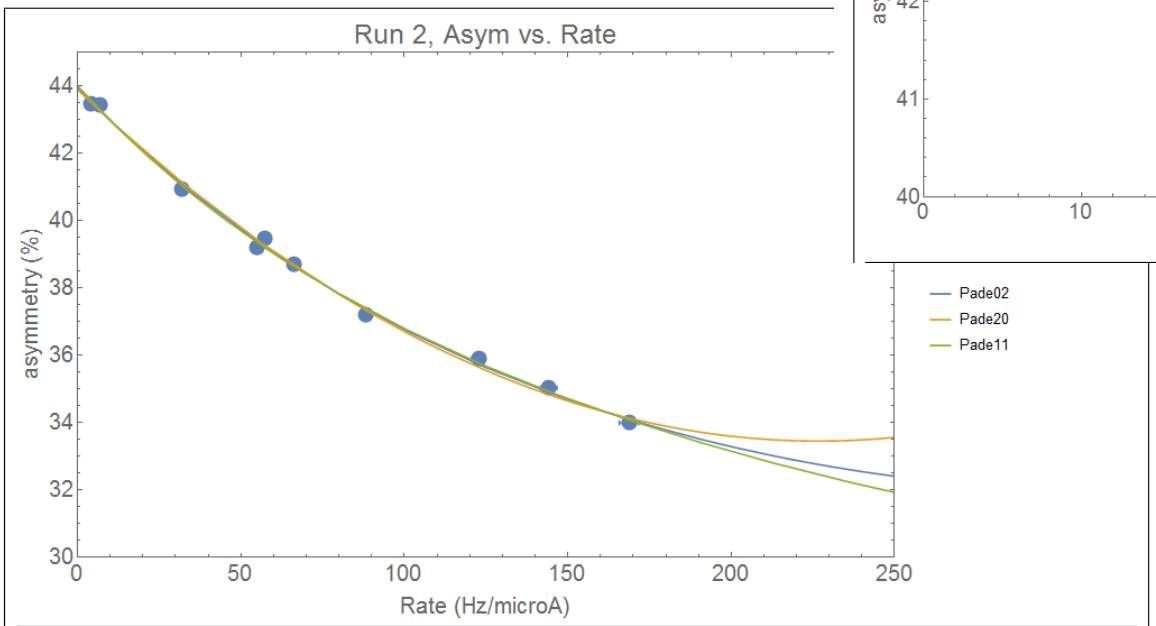


Pade20	$131.494\,x + 41.1751\,x^2$	Reduced $\chi 2$	0.59831
Pade11	$\frac{132.911\,x}{1-0.242738\,x}$	Reduced $\chi 2$	0.525451

Run 2 R(t) without 6809 foil

A(R) using R(6809) from extrapolation





Pade02	$\frac{43.9537}{1+0.00231089\,x-3.54352\times10^{-6}\,x^2}$	Reduced $\chi 2$	2.05766
Pade20	$43.8609 - 0.0918123\,x + 0.000202462\,x^2$	Reduced $\chi 2$	2.76663
Pade11	$\frac{43.9978+0.107248\,x}{1+0.00487312\,x}$	Reduced $\chi 2$	1.91569