Covariances for ^{181}Ta

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Kalman filter

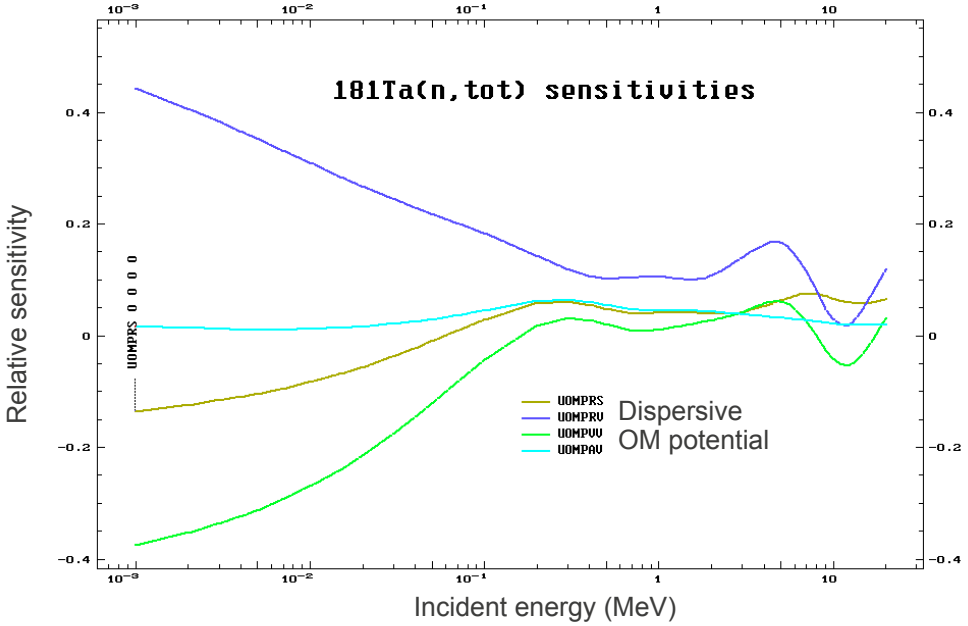
- Typically used for controlling a moving object
- Original formulation: time sequential Bayesian updates => EMPIRE: updates by series of experiments (‘time’ eliminated!)
- Kinematic equations => reaction model calculations => surrogate surface of sensitivities (2n+1 model calculations for n parameters)
- Kalman filter estimates model parameters & their covariances
- Adjusted parameters used in EMPIRE to produce final evaluation
- Parameter covariances propagated to produce cross section covariances

Kalman inputs in Ta181 evaluation

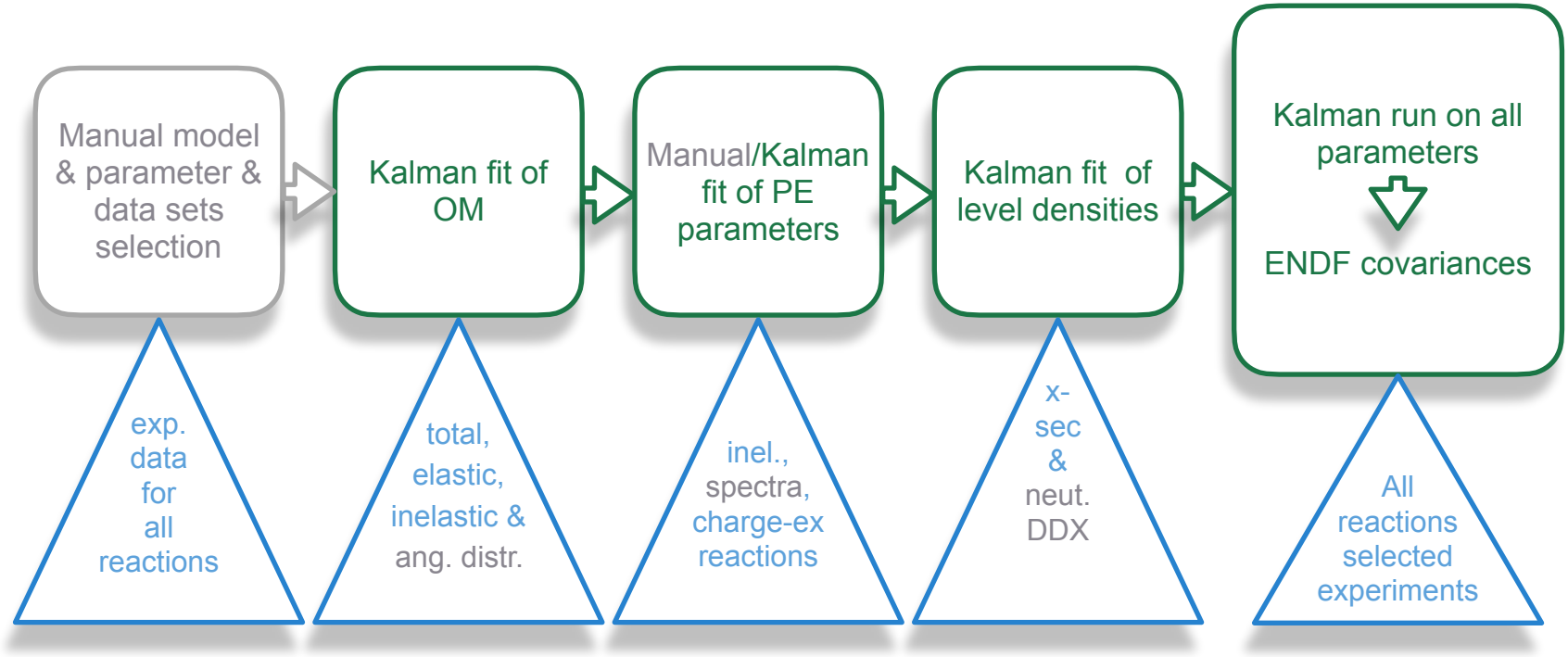
- Uncorrelated prior parameters for selected reaction models
- Calculated x-sec with prior parameters
- Calculated sensitivities of x-sec to model parameters
- **Curated** set of experimental data

The priors are **NOT** default calculations!

- Adequate reaction models are selected
- Initial adjustment of parameters is manual but hierarchical



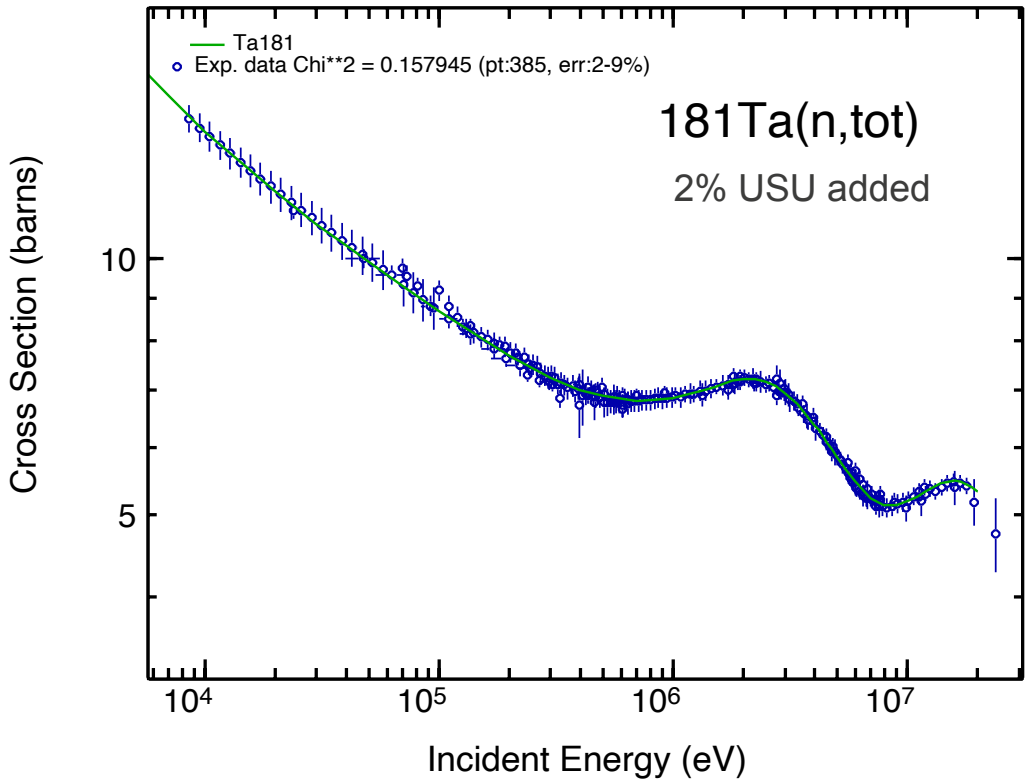
Hierarchical use of Kalman in Ta181 evaluation



181Ta(n, tot) evaluation

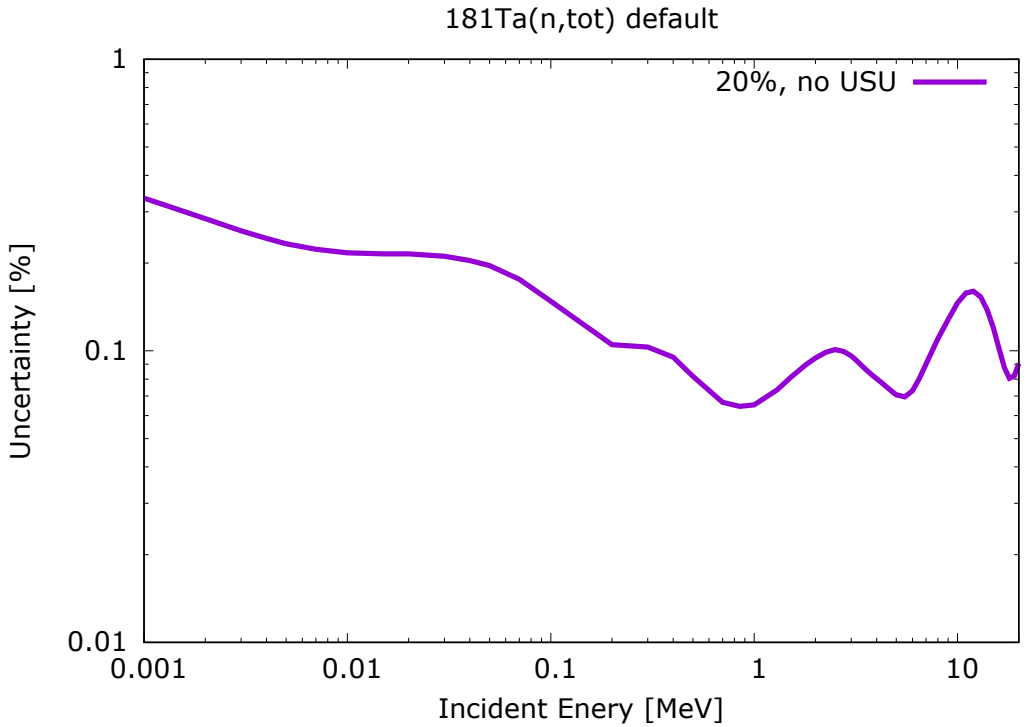
- Selected experimental data
- Excellent fit with dispersive CC potential using Kalman

	Factor
T.Y.Byoun (73)	0.96
I.Tsubone, et.al. (84)	1
W.P.Poenitz, et.al. (81)	1
A.B.Smith, et.al. (68)	1
R.Hannaske, (13)	0
M.J.Rapp, et.al. (19)	1
W.P.Poenitz, et.al. (83)	1
D.G.Foster Jr, et.al. (71)	1.015
A.D.Carlson, et.al. (67)	1
R.W.Finlay, et.al. (93)	0



181Ta(n, tot) - “default” uncertainty 0.1%

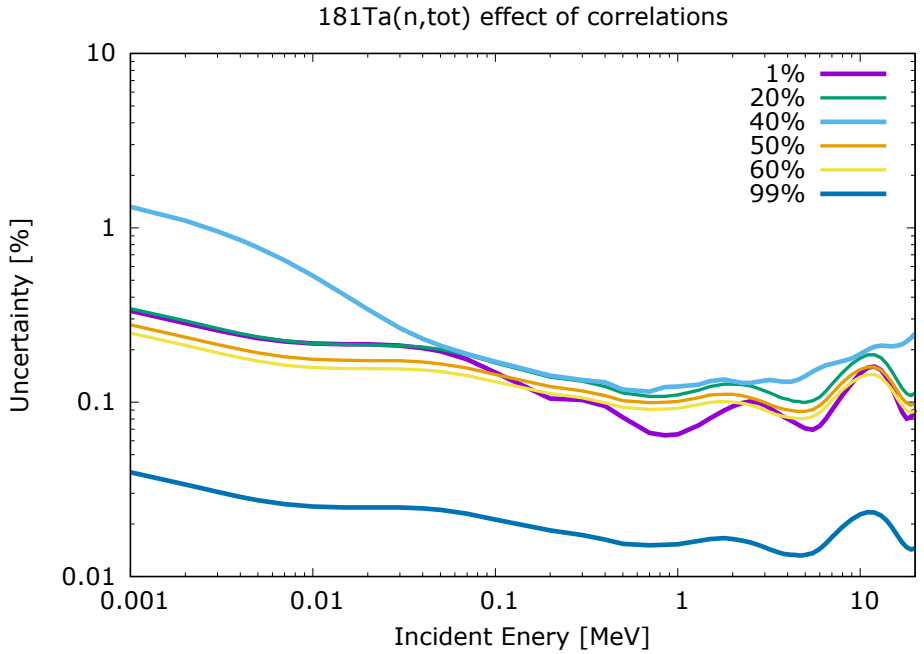
Uncertainties of the best experiments for Ta181 total are ~0.5%. Kalman’s 0.1% result is not that surprising but not very realistic.



Correlation of experimental points

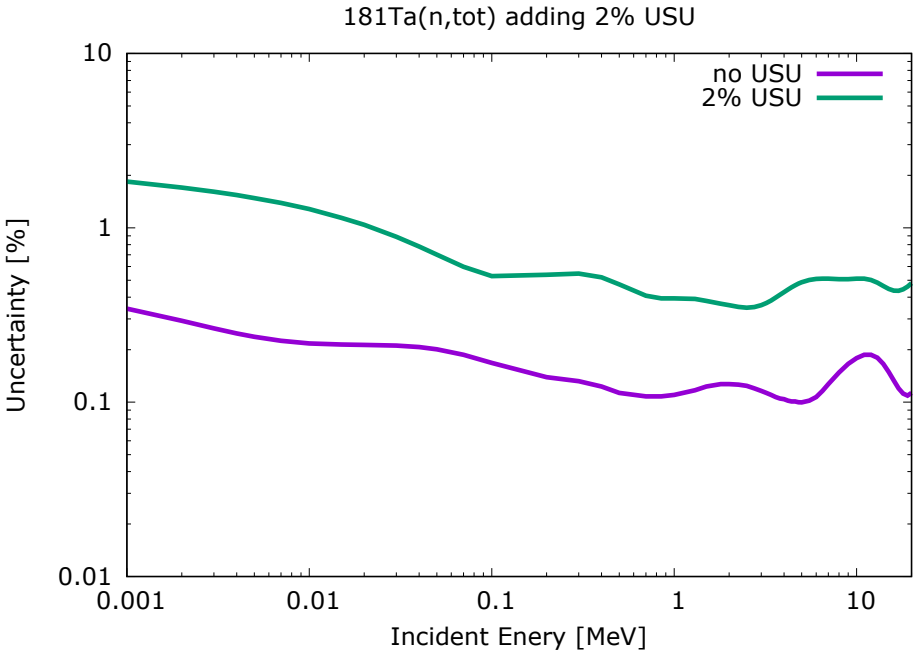
Common sense - increase of correlations among data points in an experimental data set to 1 should result in overall uncertainty approaching the systematic uncertainty (effectively removing # of points).

- Approaching full correlation decreases uncertainties!
- Experimental correlations ~40% maximize uncertainties
- Correlating all experiments - no significant difference



Increasing experimental uncertainties

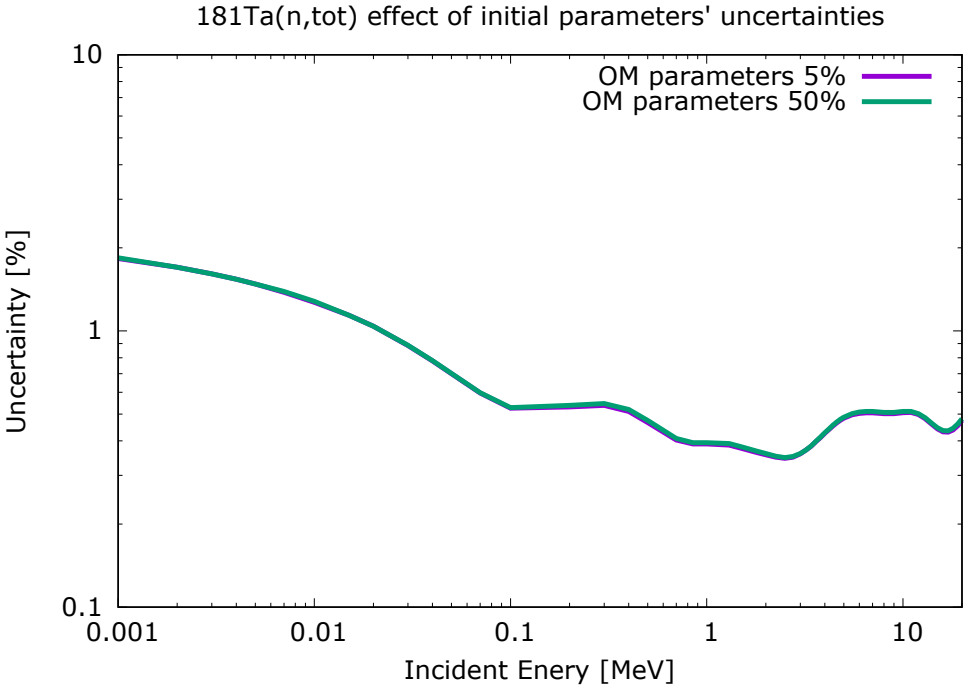
- Adding 2% USU (~1.7% of systematic uncertainty was missing) brings uncertainties up to ~0.4% (still rather low).
- Adding of 20-30% (2 barns) uncertainty to all experiments for total increases uncertainties to the level of 8-5%. 5% uncertainty on the model parameters capped the increase.



Common sense works but is not enough.

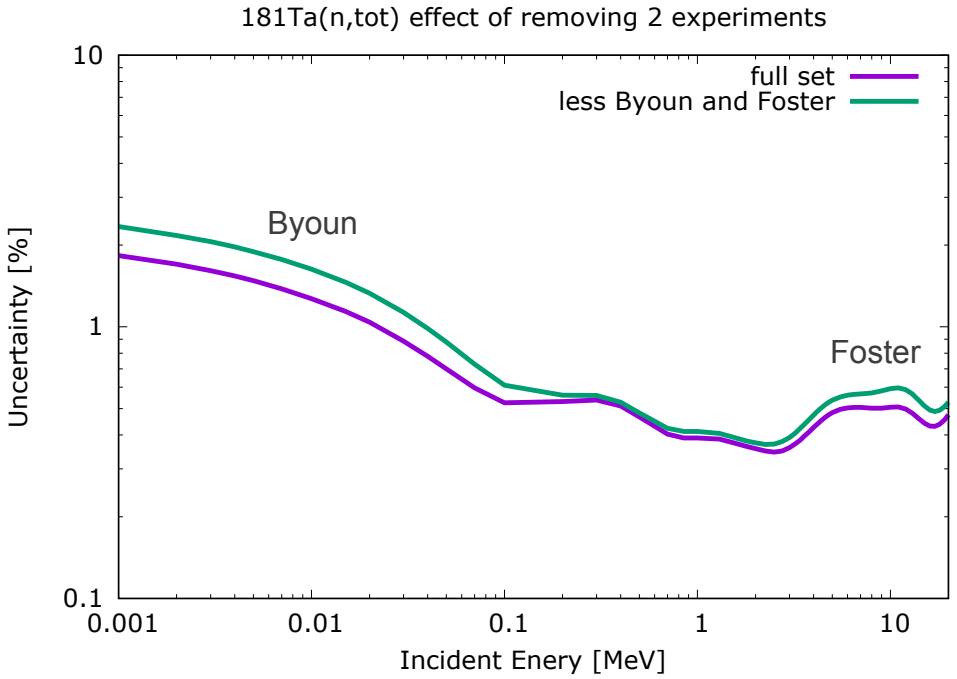
Opening model parameter uncertainties

- Well constrained total **is not sensitive** to opening initial parameter uncertainties. At 50% fit is essentially unchanged and uncertainties are on the level of 0.4%
- Opening parameter uncertainties boosts only uncertainties in the energy regions where there are no experimental data.



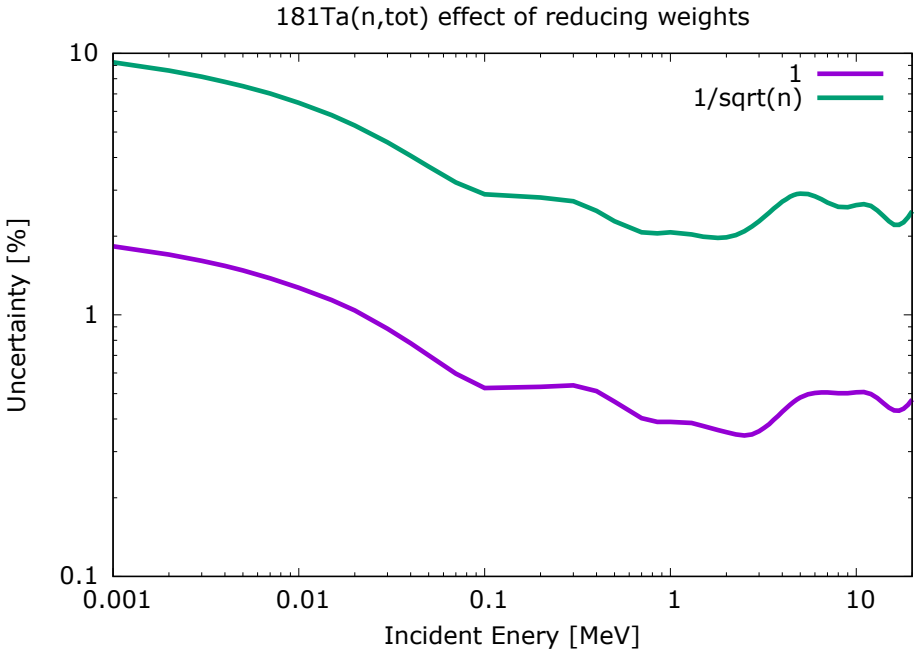
Including more (somewhat discrepant) experiments

- Uncertainties are driven by the most precise experiments.
- Adding experiments with larger uncertainties still decreases final uncertainties.
- Discrepant experiments make a significant damage!



Number of experimental points!

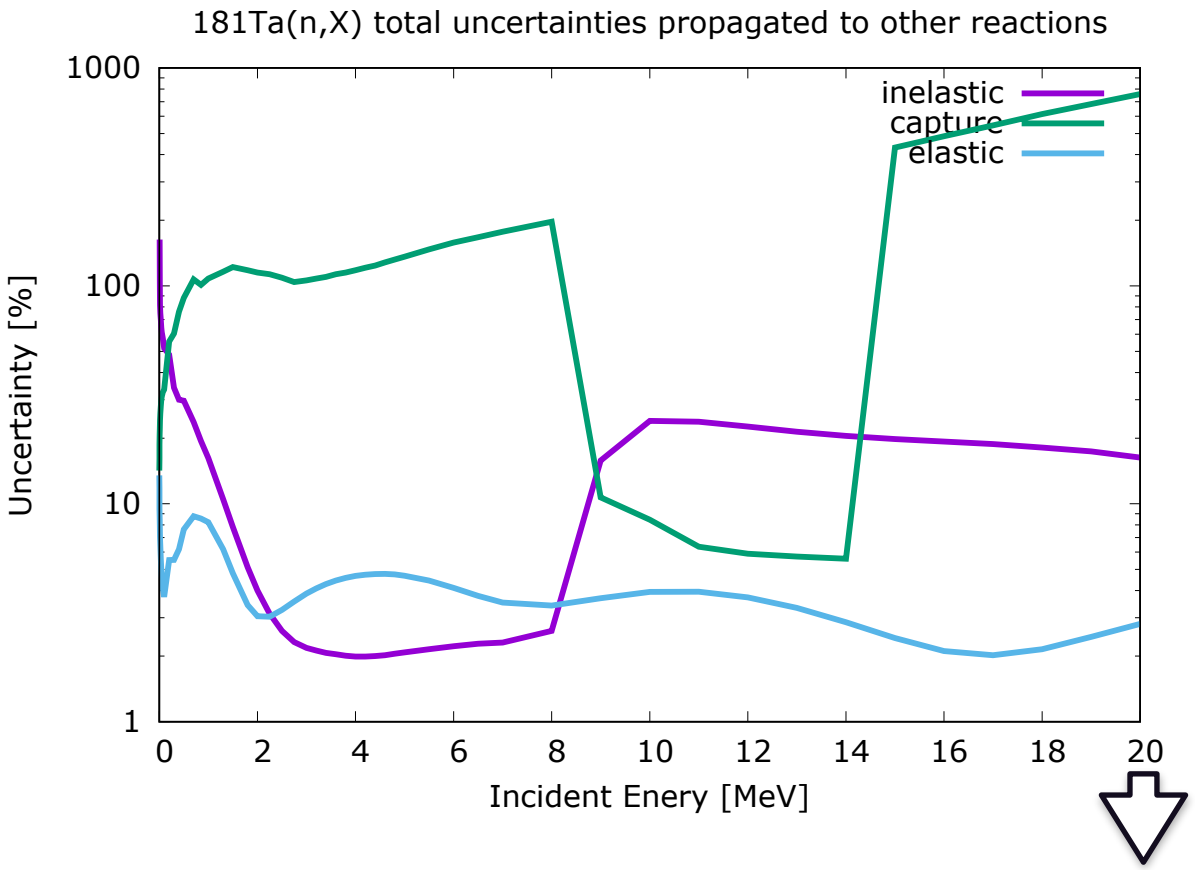
- **Number of experimental points is critical** for posterior uncertainties! Scaling weights by 1/sqrt(n) (n being number of points in a given experiment) makes a substantial difference bringing uncertainties for total from ~0.4% up to ~3%.



Reason for low uncertainties from Kalman is lowering uncertainty with every point added!

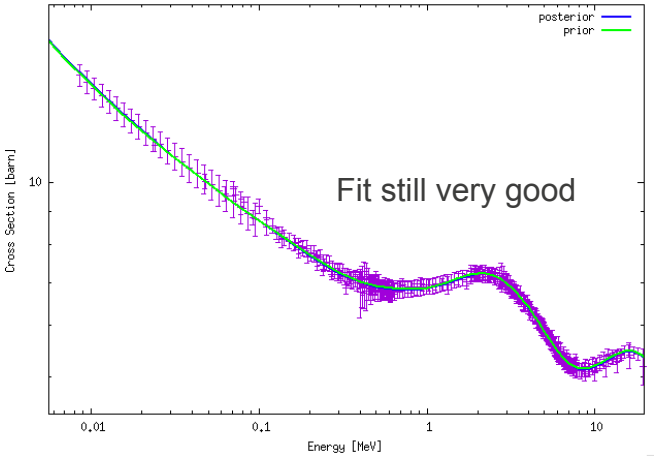
Propagation to other reaction channels

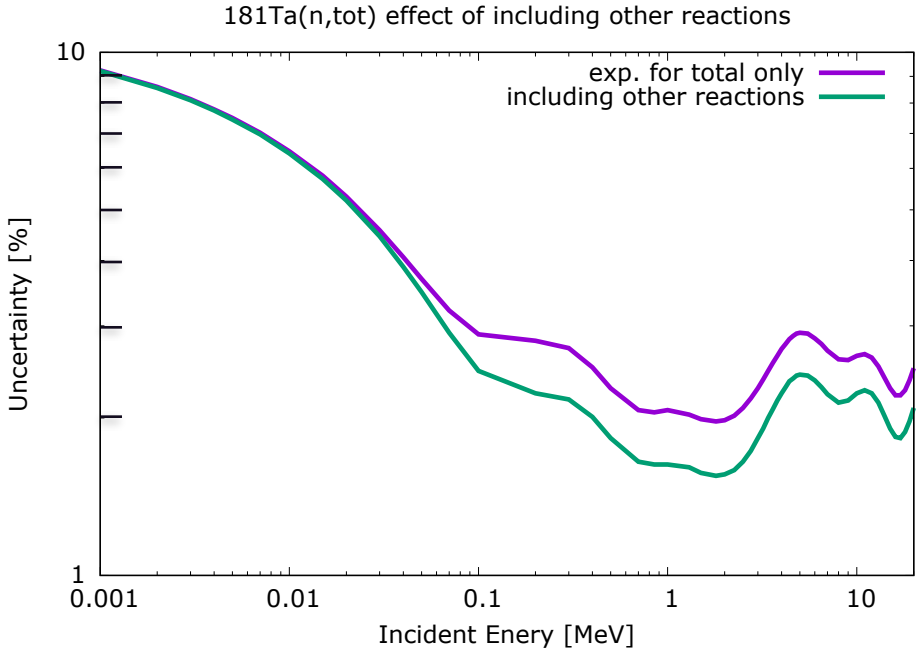
- Total uncertainties propagate to all reactions restricting some of them quite dramatically, e.g., elastic and inelastic.
- Other reactions, if left with enough freedom (e.g., outgoing Tl's) end up with relatively large uncertainties 30-1000%



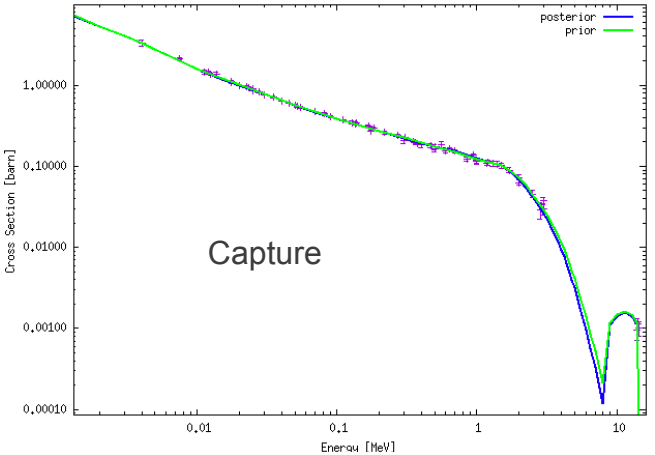
Including other reaction channels

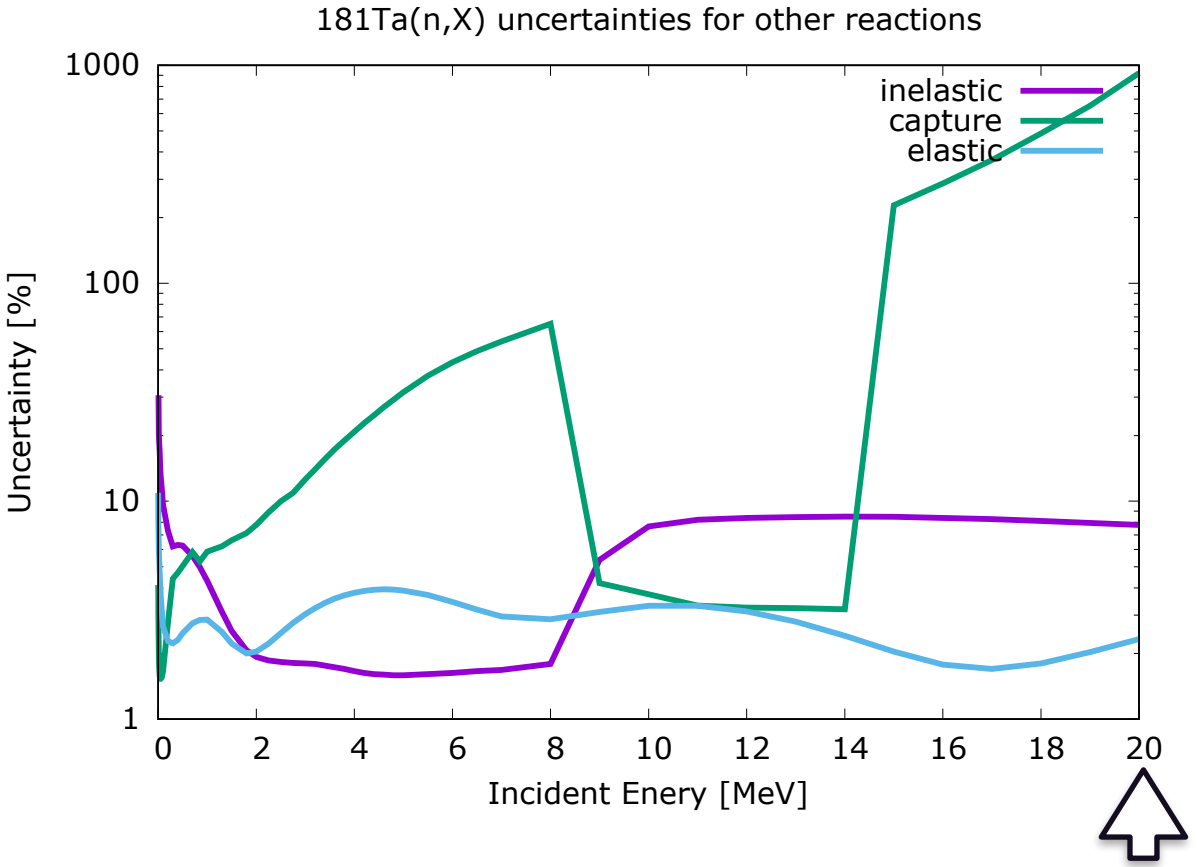
- Including experiments for other reactions lowers total uncertainty from minimum of 1.97 to 1.55% (Every exp. point counts!)



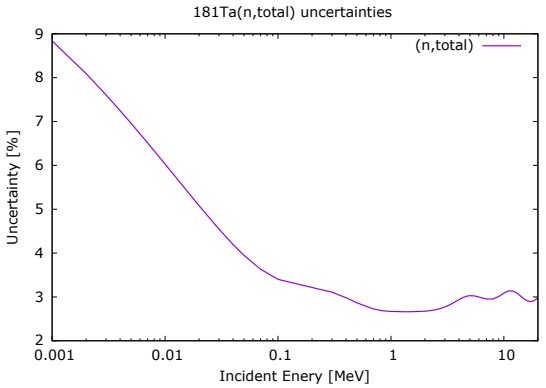


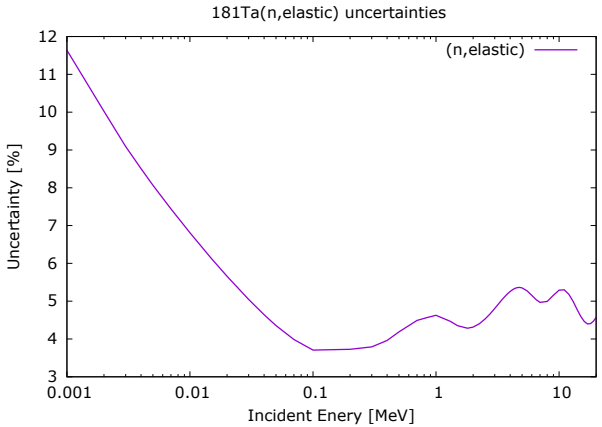
Other reaction channels (with their experimental data)

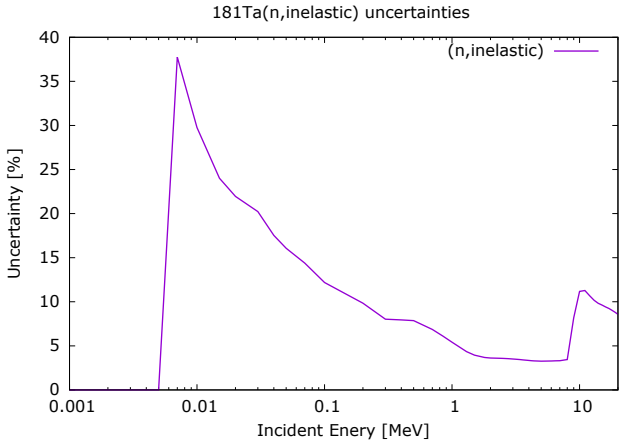


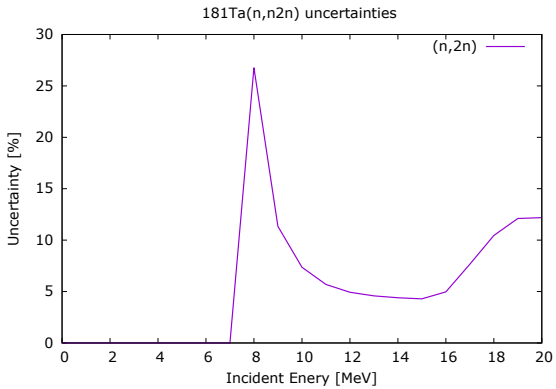


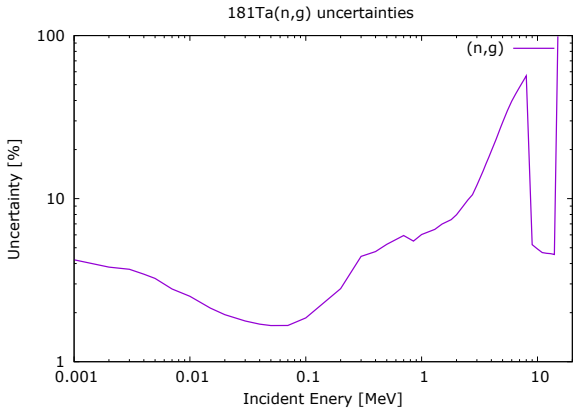
Actual uncertainties for 181Ta

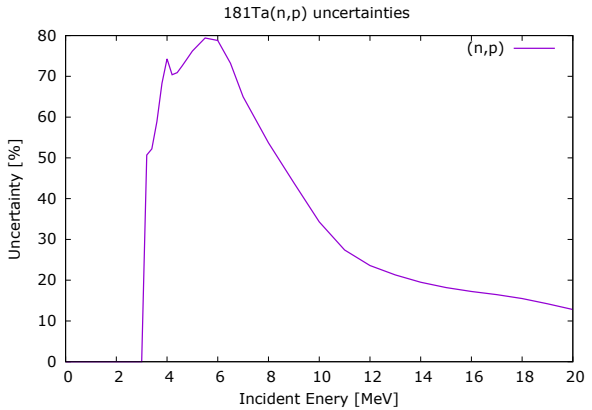






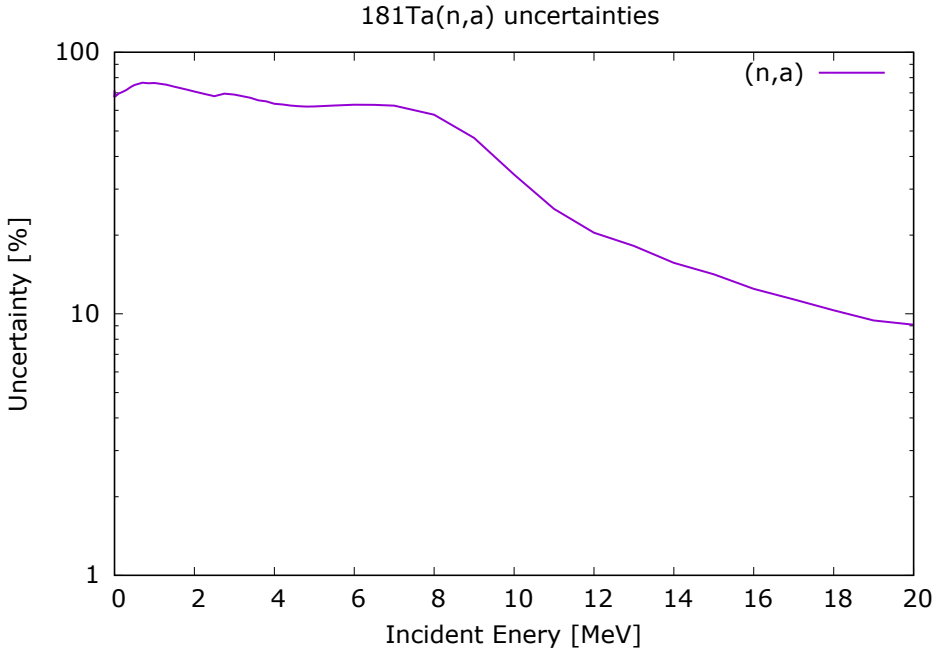


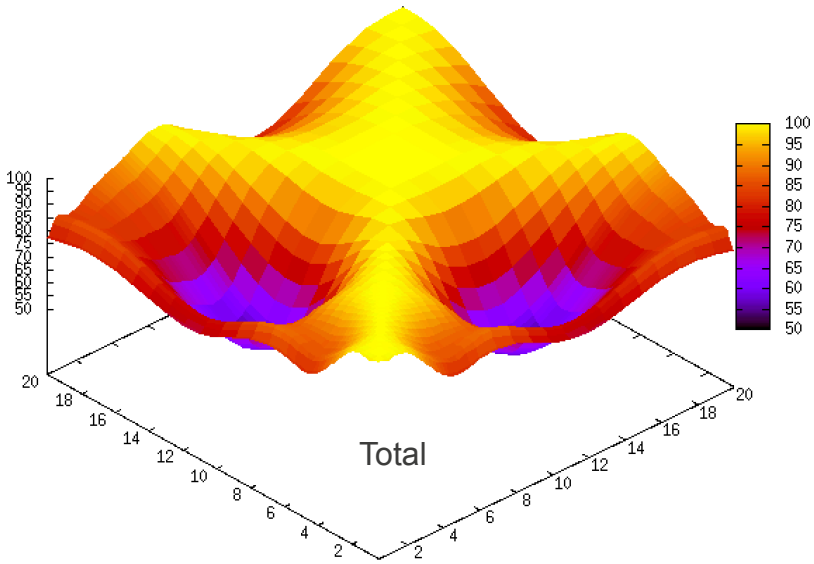




Actual uncertainties (cont.)

- Conservative correlations for experiments - 40% systematic
- No correlations among experiments
- 6 scaling parameters included to increase flexibility of dispersive OM potential (little effect!)





Conclusions

- **Scaling weights** 1/sqrt(n) (n being number of points in a given experiment) is central to solving a problem of too small uncertainties.
- **Model flexibility** is critical, not only for fitting the data, but also for the covariances.
- **Curating experimental data (**reducing their number, removing outliers, scaling, smoothing and thinning) is also important for obtaining sensible uncertainties and consistent correlation matrices including cross-correlations.
- Easier to **deal with a single reaction** at a time, but then cross-correlations are lost and the set of model parameters is reaction dependent.

- Preliminary (diagonal) covariances included in the ENDF file (cross-reaction correlations to be formatted in January).