Some thoughts on error estimation

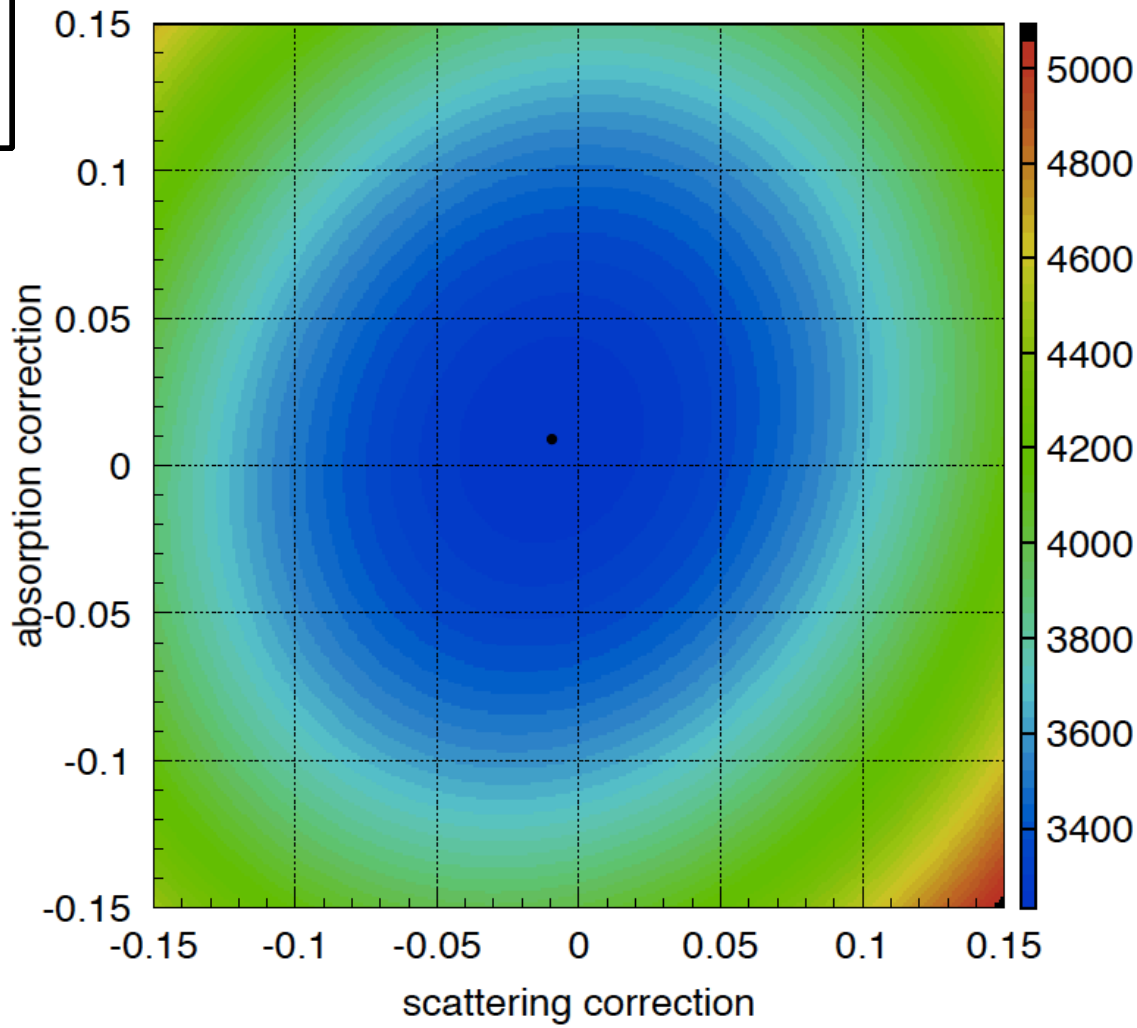
In SPICE paper variations for specific error sources were propagated to the final ice table.

The increase in llh was estimated and applied to absorption vs. scattering plot to get a 1-sigma contour.

Statistical uncertainty estimated by re-simulating all flashers multiple times, leading to the statistical spread of the llh value (1 sigma). This then translated to various uncertainties on parameters.

Scaling ice coefficients

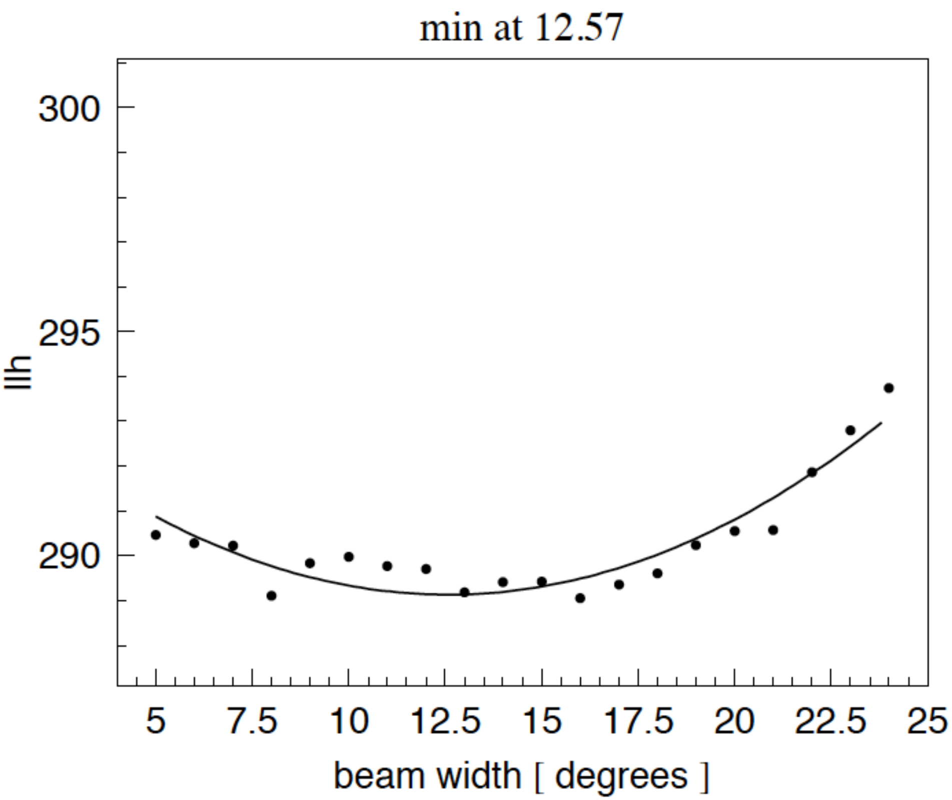
% change from default shown on both axes



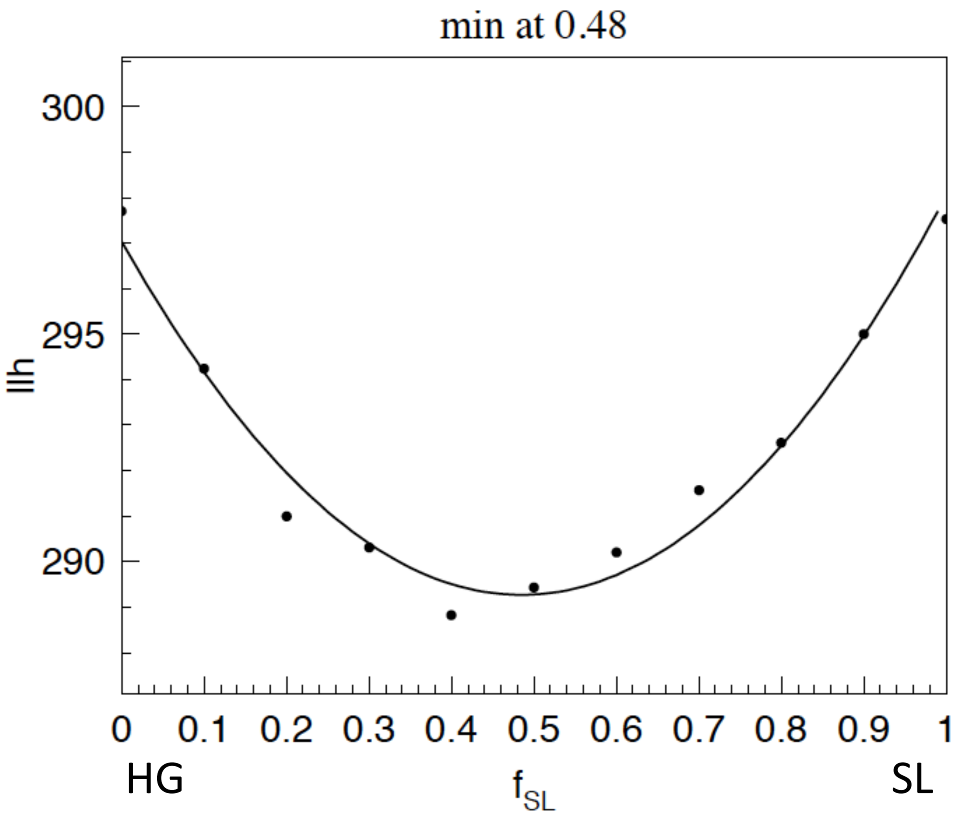
Ice coefficients scaled by shown fractional amount

Scaling scattering and absorption in all layers simultaneously

Selected model parameters

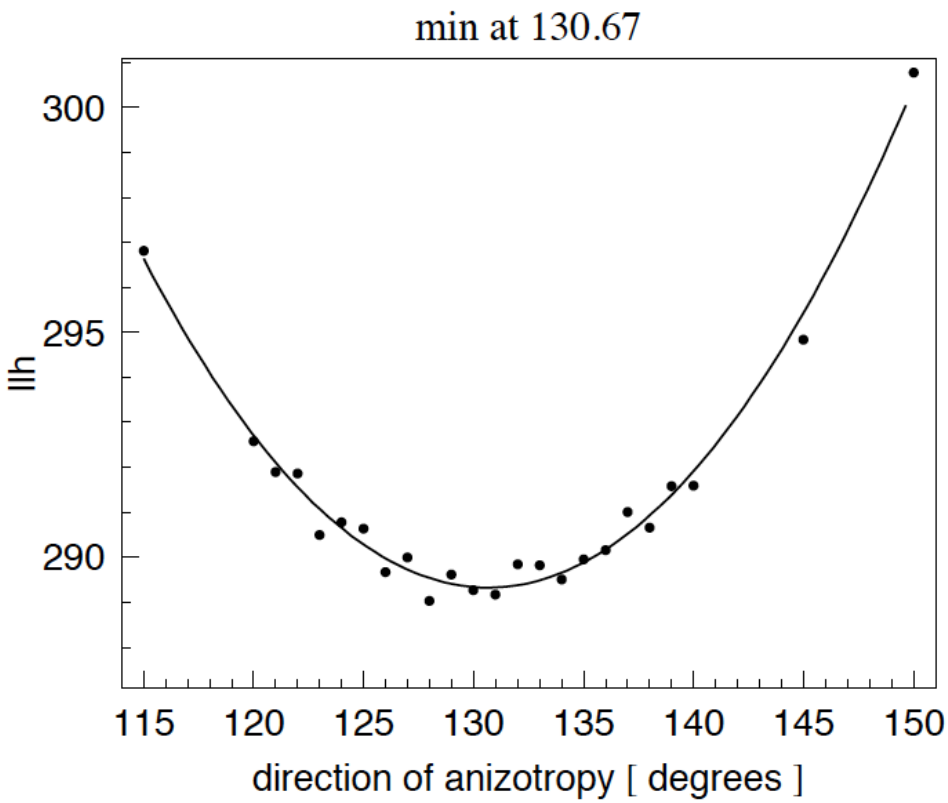


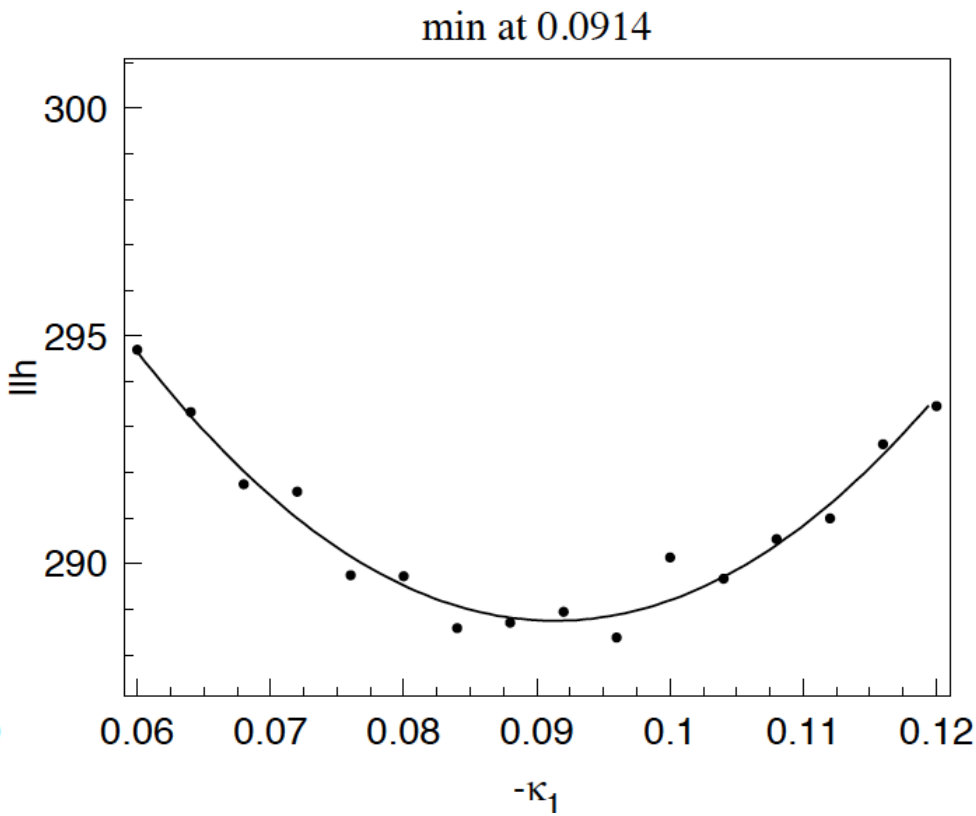
Nominal value = 9.7 degrees



SPICE Mie: 0.45
SPICE Lea: 0.41

Selected model parameters

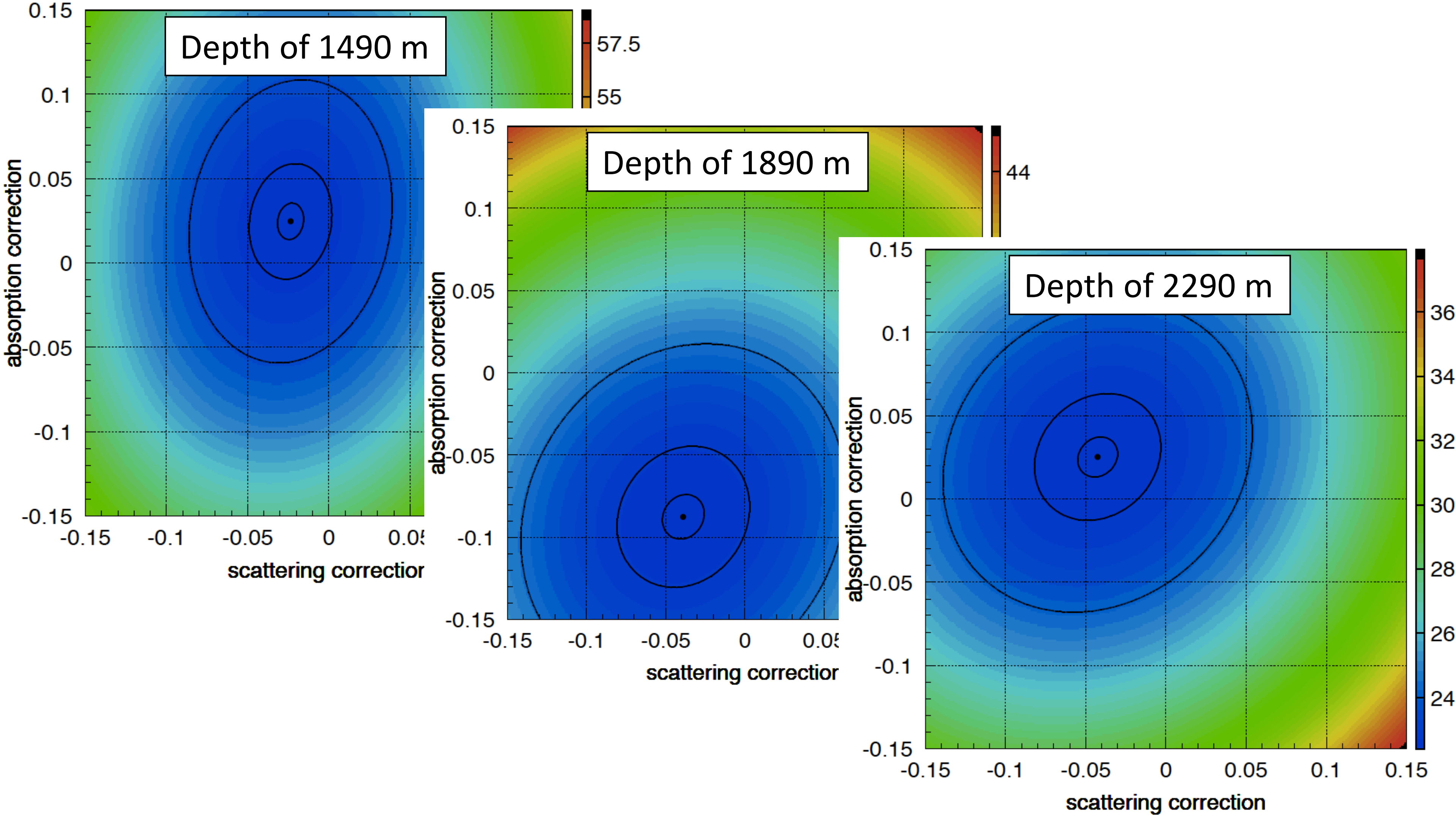




SPICE Lea: 126 degrees

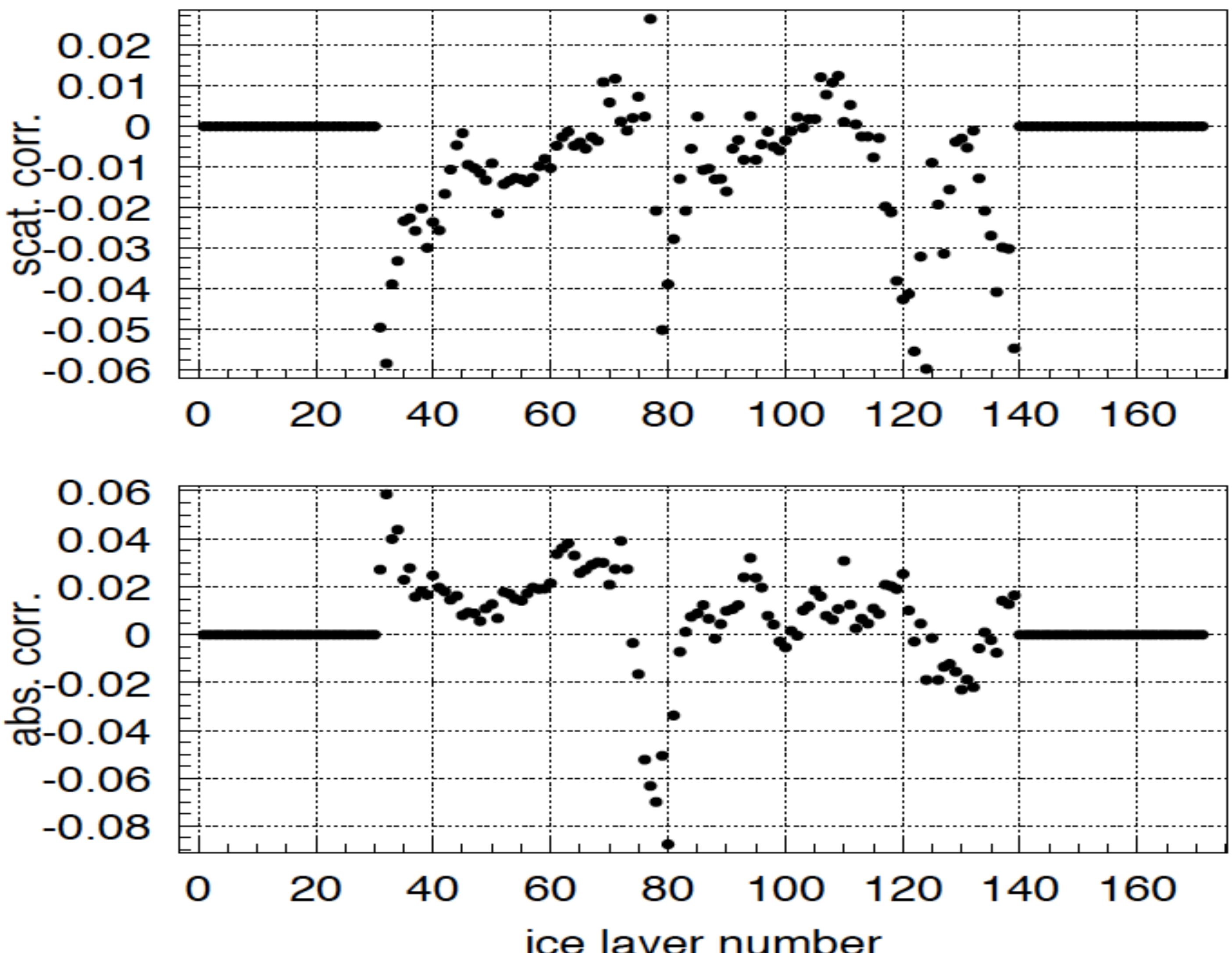
SPICE Lea: 0.08

Scaling ice coefficients layer by layer



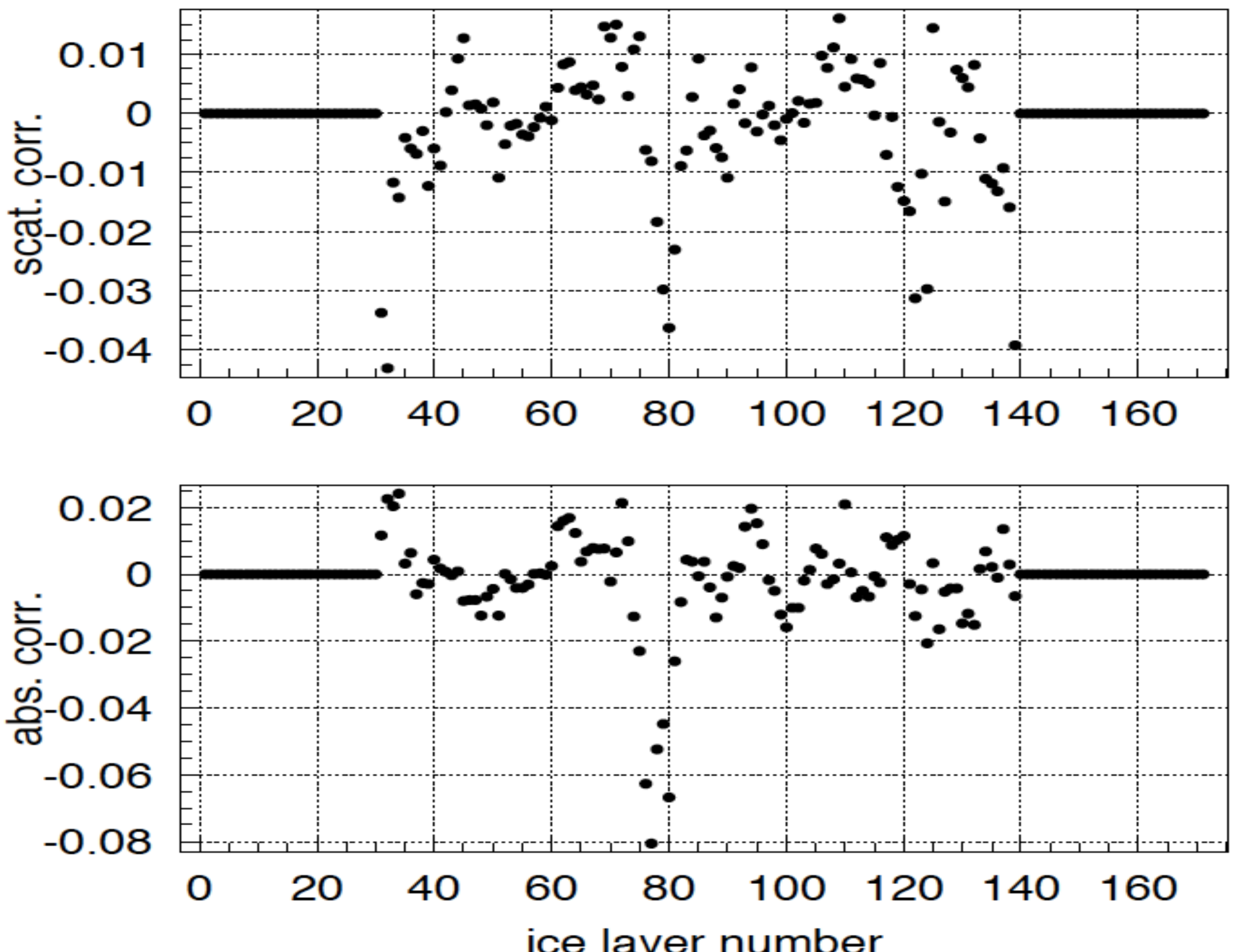
Likelihood evaluated only for flashers in given ice layer

Scaling corrections by layer



GOF goes down from 3237.36 to 3217.38 (statistical fluctuations on order +- 1.)

Trying this again



GOF does not(!) go down: from 3213.49 to 3218.54 (statistical fluctuations on order +- 1.)

Other approaches

Tried various scaling of the found corrections:

1	3218.54
0.5	3215.01
0.35	3213.91
0.25	3210.94
0.15	3215.39
0.10	3214.1

→ 0.25 yields an improvement, but it becomes worse again at even smaller scaling fractions

Finally the method described in the following slide improved the GOF to 3209.79 (it extrapolated the 2 iterations in a way that brings the 2 results closer together)

Overall improvement from SPICE 3.1:
With 10 simulated evens per flasher: 3237.36 → 3209.79
With 100 simulated events per flasher: 5749.79 → 5599.8

1. Effects of scattering and absorption are roughly cumulative with overburden
2. Nearby layers are anticorrelated: too much scattering in one layer can be offset by lowering it in adjacent layers by same total amount as excess in given layer

Posit the following form of correction to the scattering vector (absorption is similar):

$$S_{start} + \begin{vmatrix} 1+\alpha+\beta & -\alpha & 0 & \dots \\ -\beta & 1+\alpha+\beta & -\alpha & \dots \\ 0 & -\beta & 1+\alpha+\beta & \dots \\ \dots & \dots & \dots & \dots \end{vmatrix} \cdot \begin{vmatrix} \delta S_1 \\ \delta S_2 \\ \dots \\ \dots \end{vmatrix}$$

Then if there are 2 iterations the answer should be similar:

$$S_1 + (\dots)\,\delta S_1 = S_2 + (\dots)\,\delta S_2 \quad \rightarrow \quad S_1 - S_2 = (\dots)\,(\delta S_2 - \delta S_1)$$

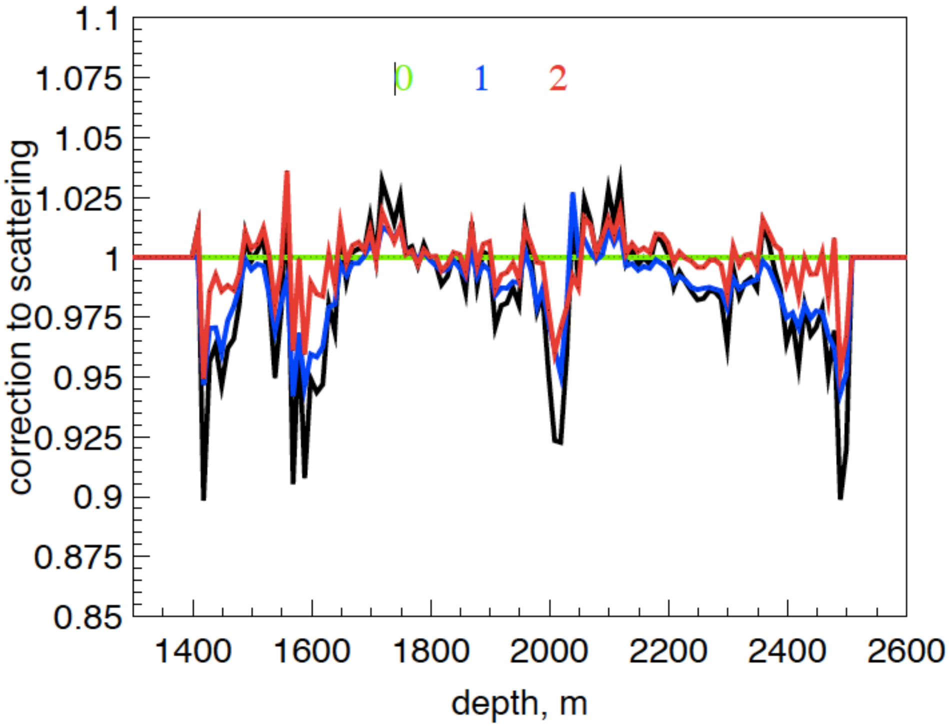
The best values of scattering achieved by the two iterations are

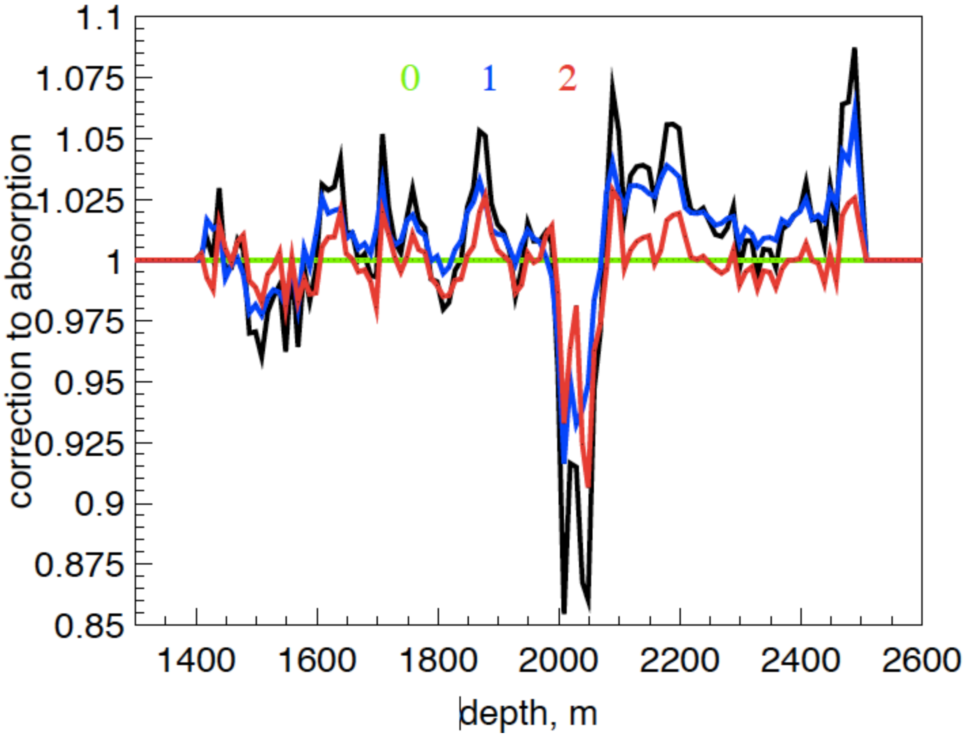
$S_1' = S_1 + \mathbf{1}\,\delta S_1$, $S_2' = S_2 + \mathbf{1}\,\delta S_2$ (**1** is unit matrix)

$$\rightarrow \quad S_1' - S_2' = \left(\alpha \begin{vmatrix} 1 & -1 & 0 & \dots \\ 0 & 1 & -1 & \dots \\ \dots & \dots & \dots & \dots \end{vmatrix} + \beta \begin{vmatrix} 1 & 0 & 0 & \dots \\ -1 & 1 & 0 & \dots \\ \dots & \dots & \dots & \dots \end{vmatrix}\right)(\delta S_2 - \delta S_1)$$

→ Solve for α, β using least squares linear regression

Results

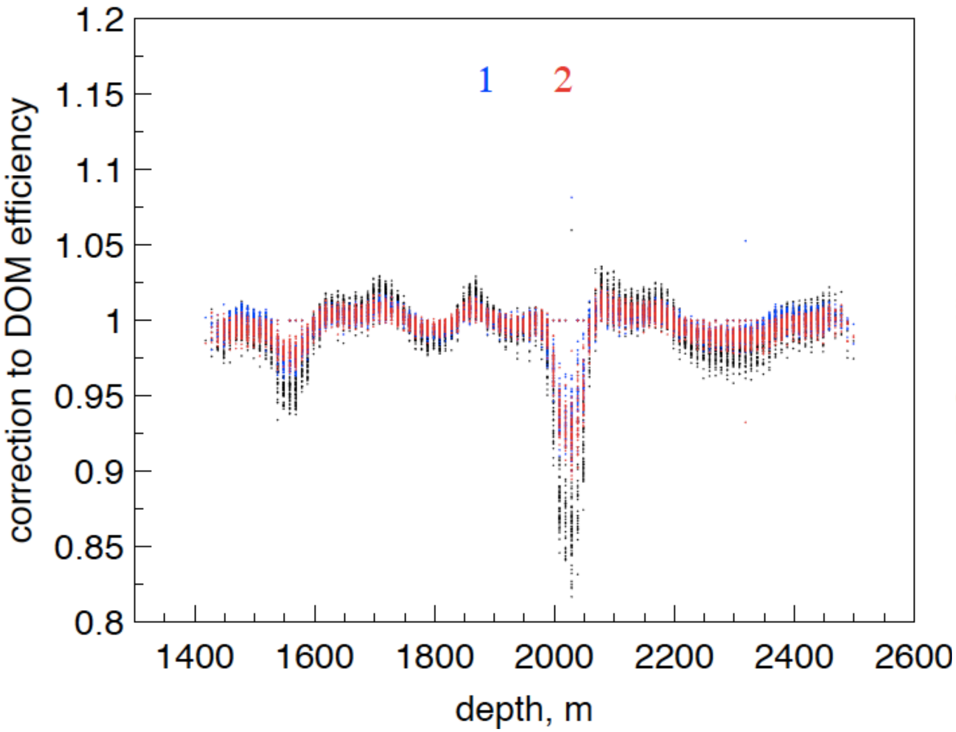


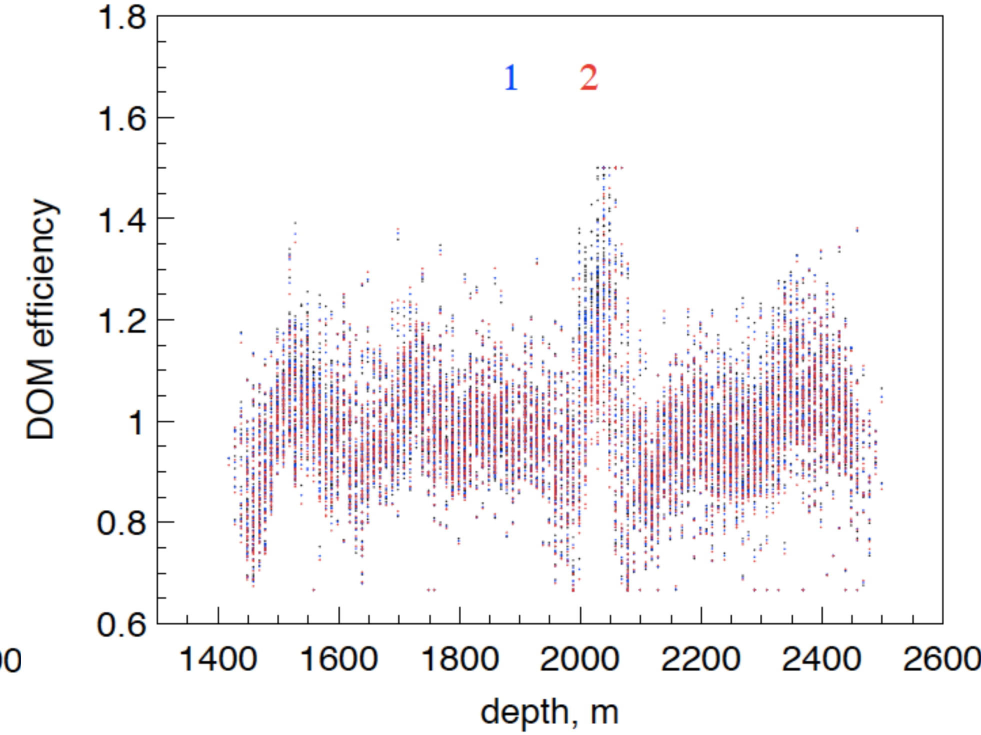


Corrections to SPICE 3.1: after iteration 1 and 2 (with correlation corrections)
Corrections of about 5%, up to 15% (largest in the dust layer)

Derived DOM efficiencies

Shown are nominal DOMs only





Cumulative change shown in black (in plot on the left)
(available as part of ice-models module in resources/models/spice-latest-full/eff-f2k)

Time of 1 full llh evaluation (2017)

With SREP=10 simulation:

440 hours on npx4 cluster (averaged over available nodes)

With good priority this completes in a few hours

Can run several llh variation per day, ~100 per month (assuming no priority penalty)

Need really good proposal distribution of ice parameters for this to be useful.