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Numerical model of the Li evaporator for NSTX[1]

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The work was motivated by and done in close collaboration
with Henry Kugel's LITER development group

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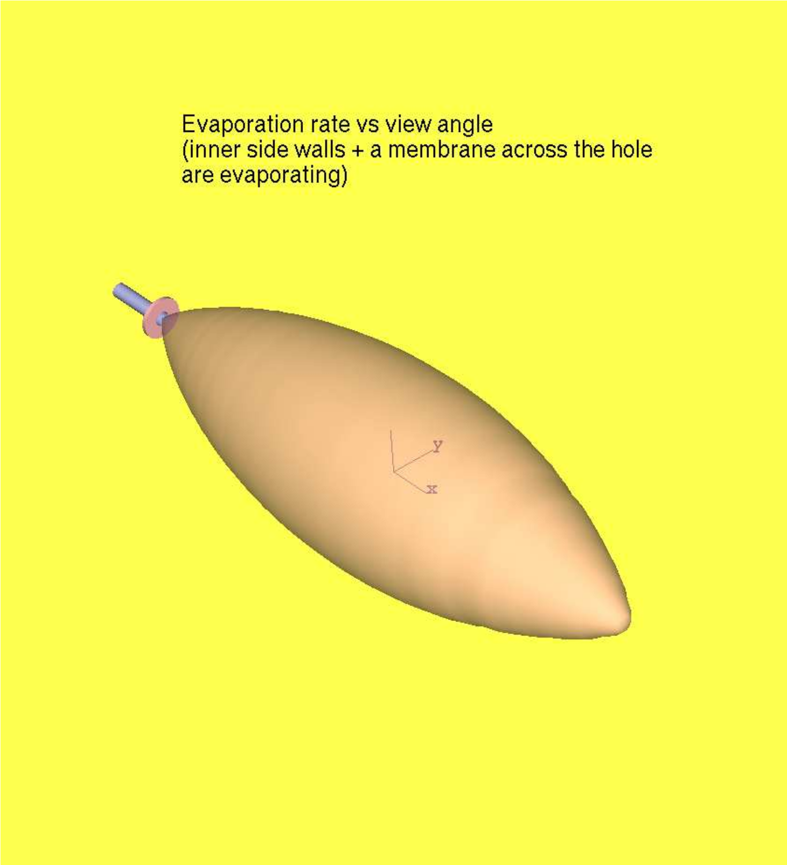
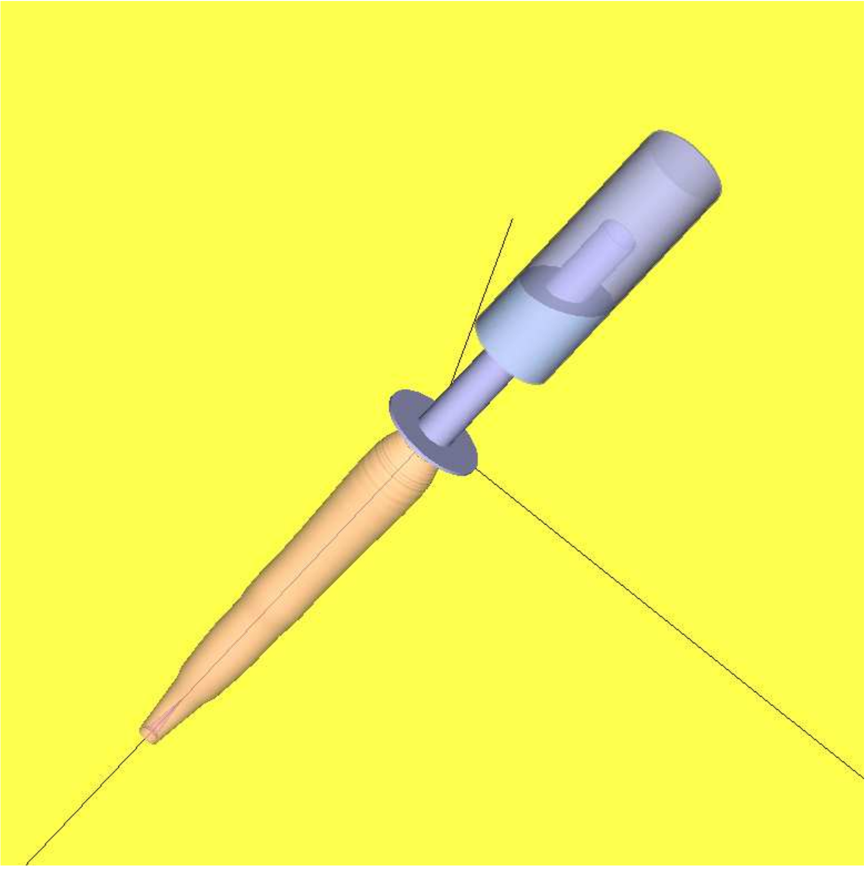
Contents

1 Angle evaporation diagram of LITER

Two models for "wet" and "dry" inner walls regime are implemented into Cbebm code for calculating evaporation diagram



Wetted snout inner walls. Unit (predictably) failed in L245 vessel



"Dry" model for LITER. Pipe attenuates the Li flux by 10 times

2 Physics model and relevant Li vapor parameters

The Knudsen gas model was adopted for the "dry" case

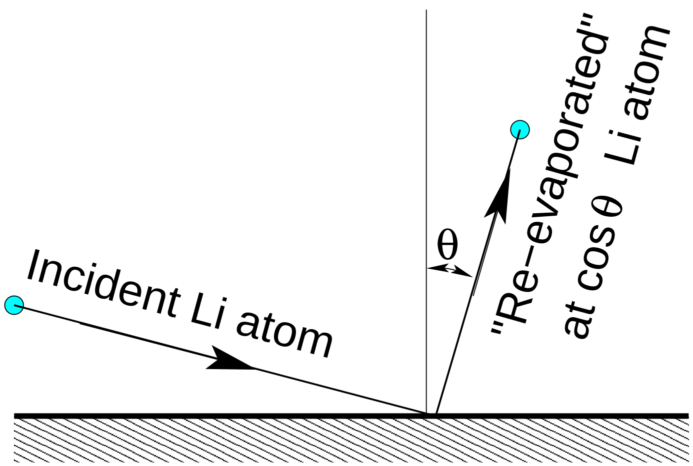
Vapor density as a function of Li surface temperature:

$$n_{20}^{vapor} = 10^{9.6-7.8\frac{1000}{T_K}}. \qquad (2.1)$$

Mean free path of Li vapor atoms

$$\lambda = \frac{1}{\sqrt{2}\pi d^2 n} = \frac{1.34}{n_{20}} \cdot \frac{4.1^2}{d^2\ [\text{A}^2]}\ [\text{cm}],$$

$$d_{Li} \simeq 4.1\ [\text{A}]. \qquad (2.2)$$



sticking-re-evaporation as Li-LITER wall interaction

The Knudsen model is valid when

$$\lambda > L, \qquad (2.3)$$

where L represents the characteristic distances inside evaporator.

At $T > 600^o\ C$ the model is not longer applicable inside the canister

The method of integral equations was used for simulating vapor kinetics

Same approach, including interactions of plasma with neutrals was proposed earlier by P.M.Valanju "NUT: A fast 3-Dimensional neutral Transport Code", J.Comp.Phys. v.88,p 114 (1990)

The balance between incoming flux of the vapor to the wall and "re-evaporated" flux $\Gamma(\mathbf{r})$ can be written in the form

$$\Gamma_{incoming}(\mathbf{r}_{wall}) = \Gamma_{outcoming}(\mathbf{r}_{wall}),$$
$$\Gamma_{inlet}(\mathbf{r}) + \int_{wall} \Gamma(\mathbf{r}') \frac{-(\mathbf{t}\cdot\mathbf{n}_w)(\mathbf{t}\cdot\mathbf{n}_e)}{L^2} dS_{wall} = \Gamma(\mathbf{r}), \tag{3.1}$$

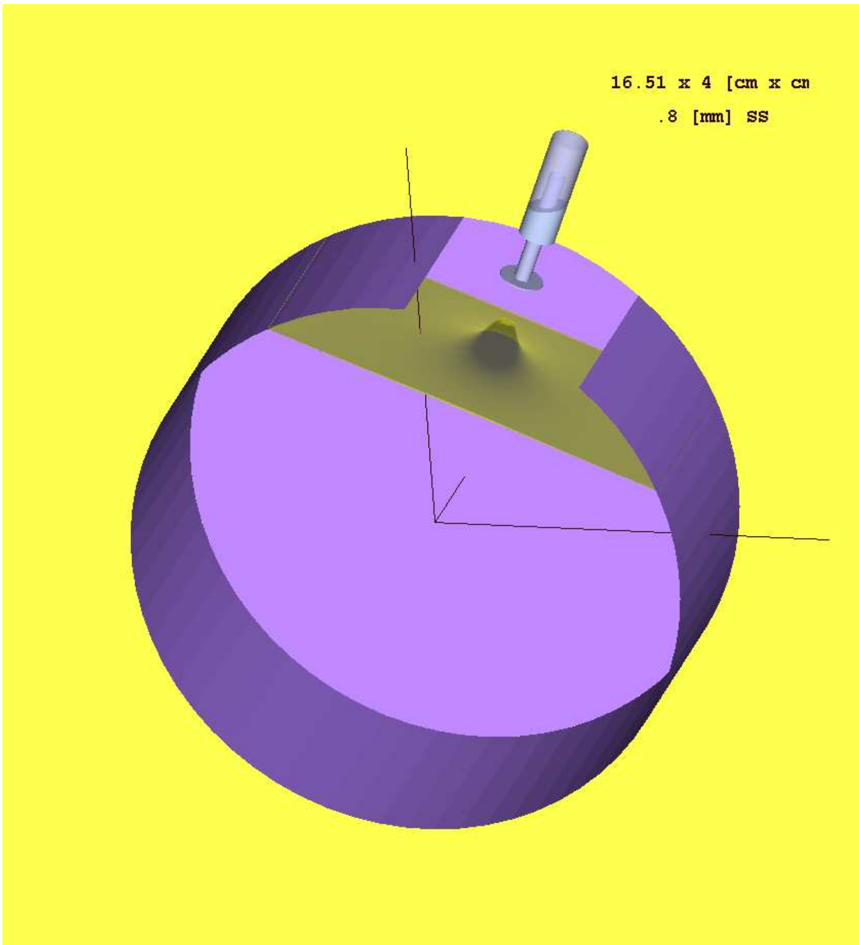
where Γ_{inlet} represents evaporation rate from the free surface of Li.

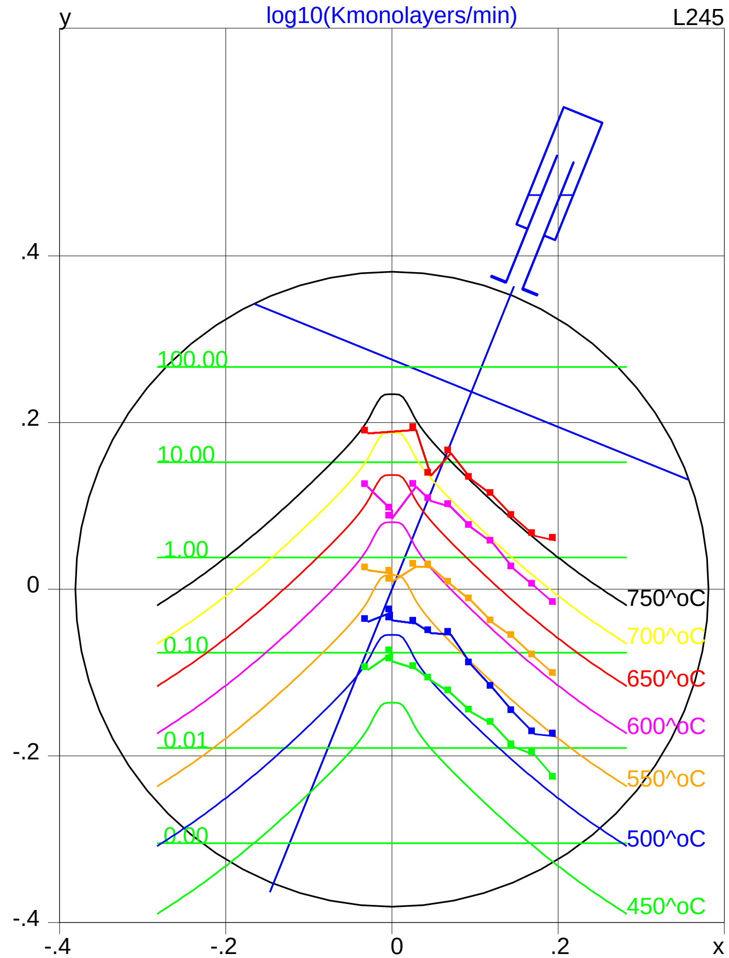
Specifics of the matrix in Eq(3.1) was understood and properly taken into account

In contrast to Monte-Carlo particle simulations, typically used for the Knudsen gas simulations (as well as in the DEGAS code), solving an integral equation gives an instantaneous answer.

4 Comparison with deposition in the L245 test vessel

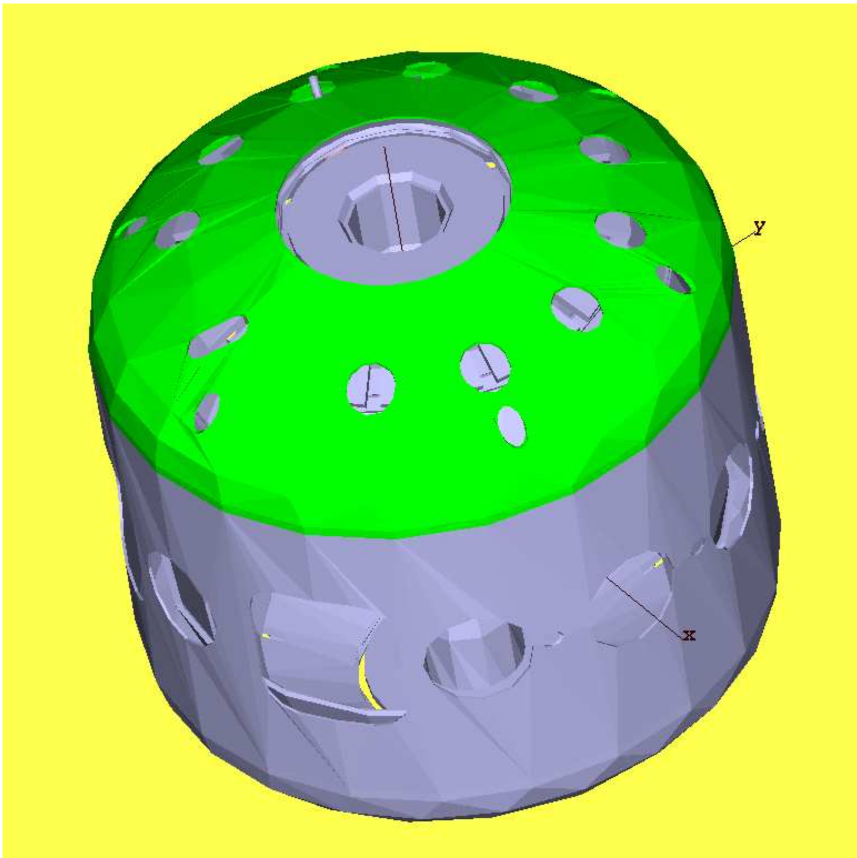
Numerical model shown an excellent reproduction of deposition profile in L245 test vessel

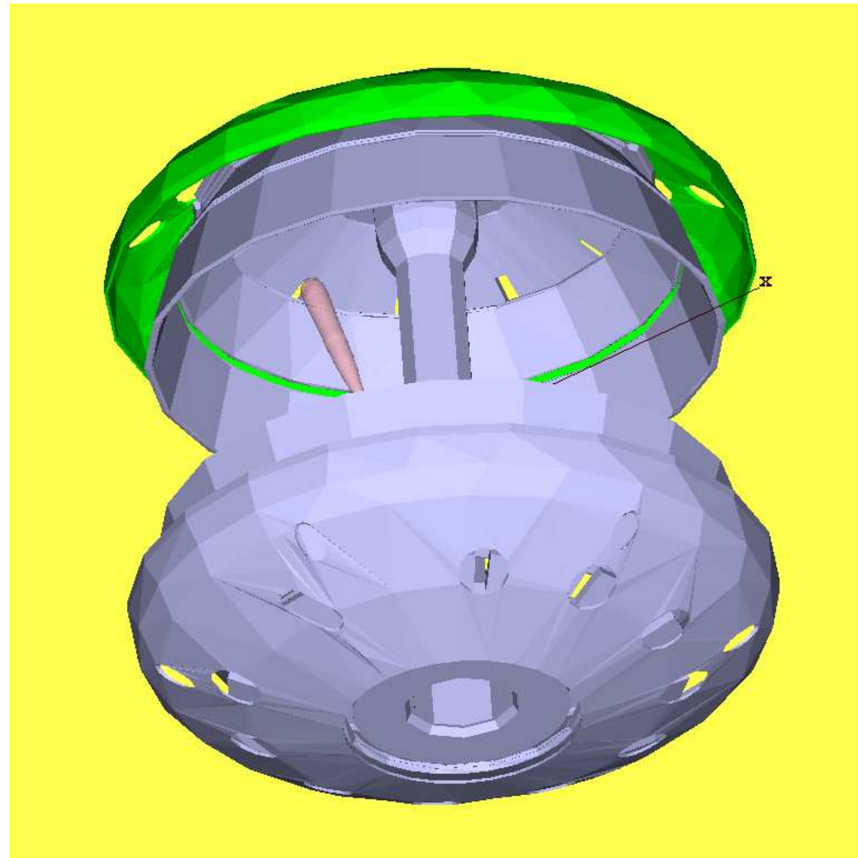




Factor of 3 in amplitude was not yet recovered, but not of concern

The interface with ProEngineer is under development



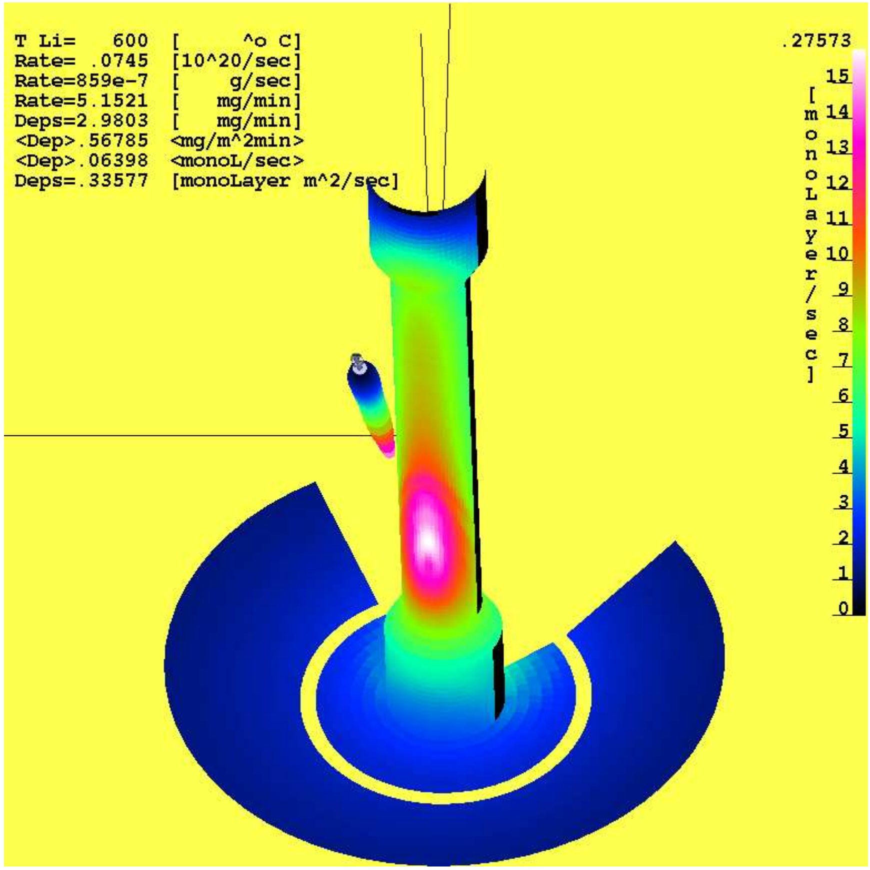


External view on LITER position

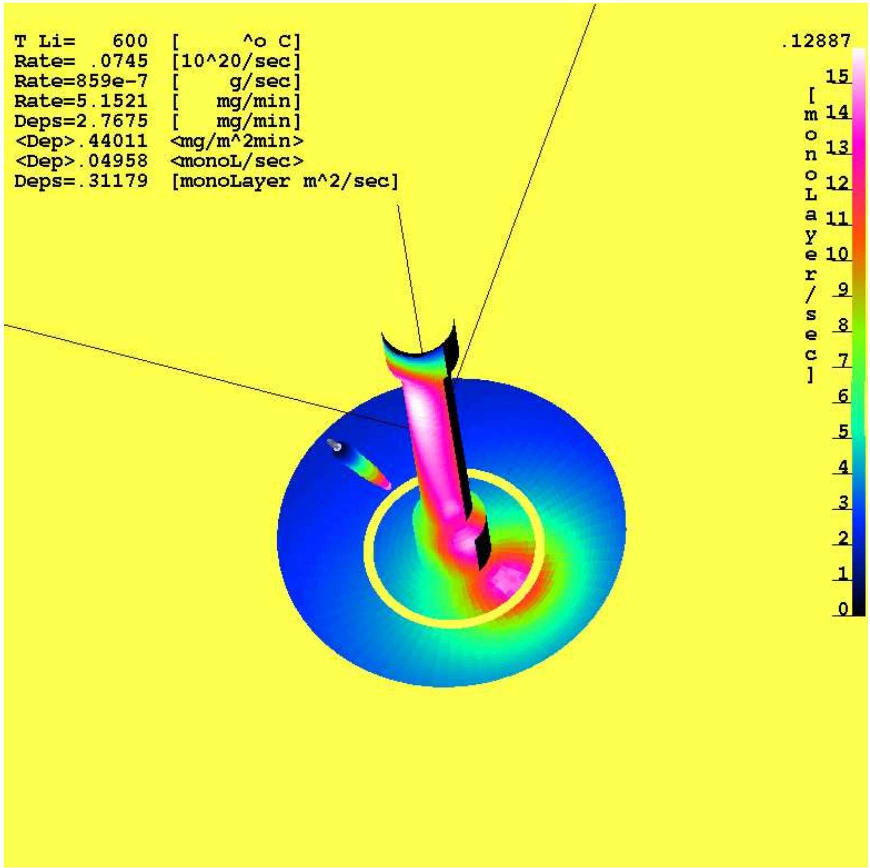
Internal view on LITER position

A progress is made in order to connect C-code with ProE

Axisymmetric NSTX vessel model was used for deposition calculations



As it was install in NSTX

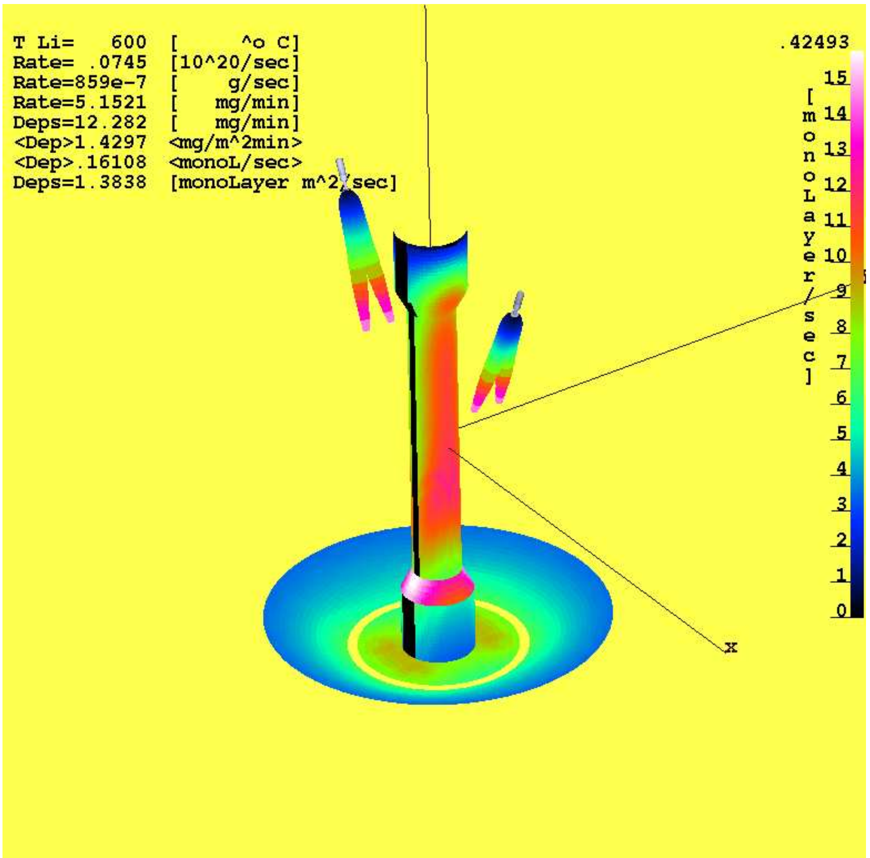


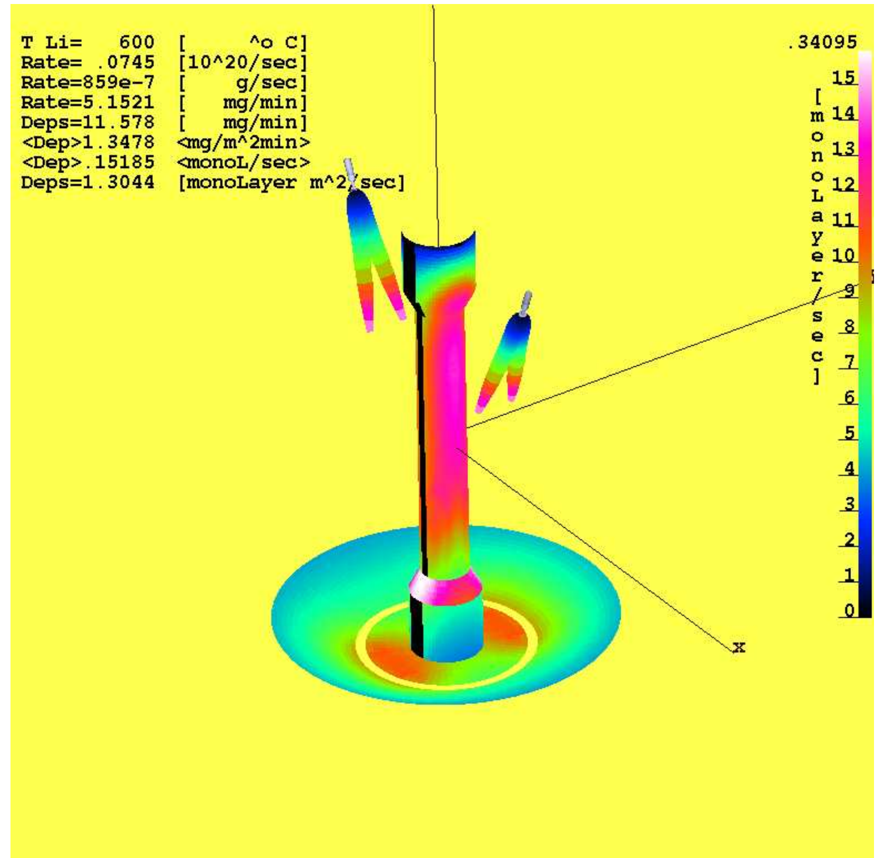
Would be better miss-directed pipe

Cbebm code is quantitatively consistent with C.Skinner deposition monitor

7 Other LITER potential options for NSTX

With modest modifications better coverage can be obtained with the same evaporator





A decisive step would be the redesign of the plasma contact surfaces in the low divertor area.

- **A reasonable numerical model for 3-D geometry of both Li evaporator and deposition surfaces was developed.**
- **The mathematical approach and interfaces with ProE created (or under development) for the Cbebm code are useful for other applications.**