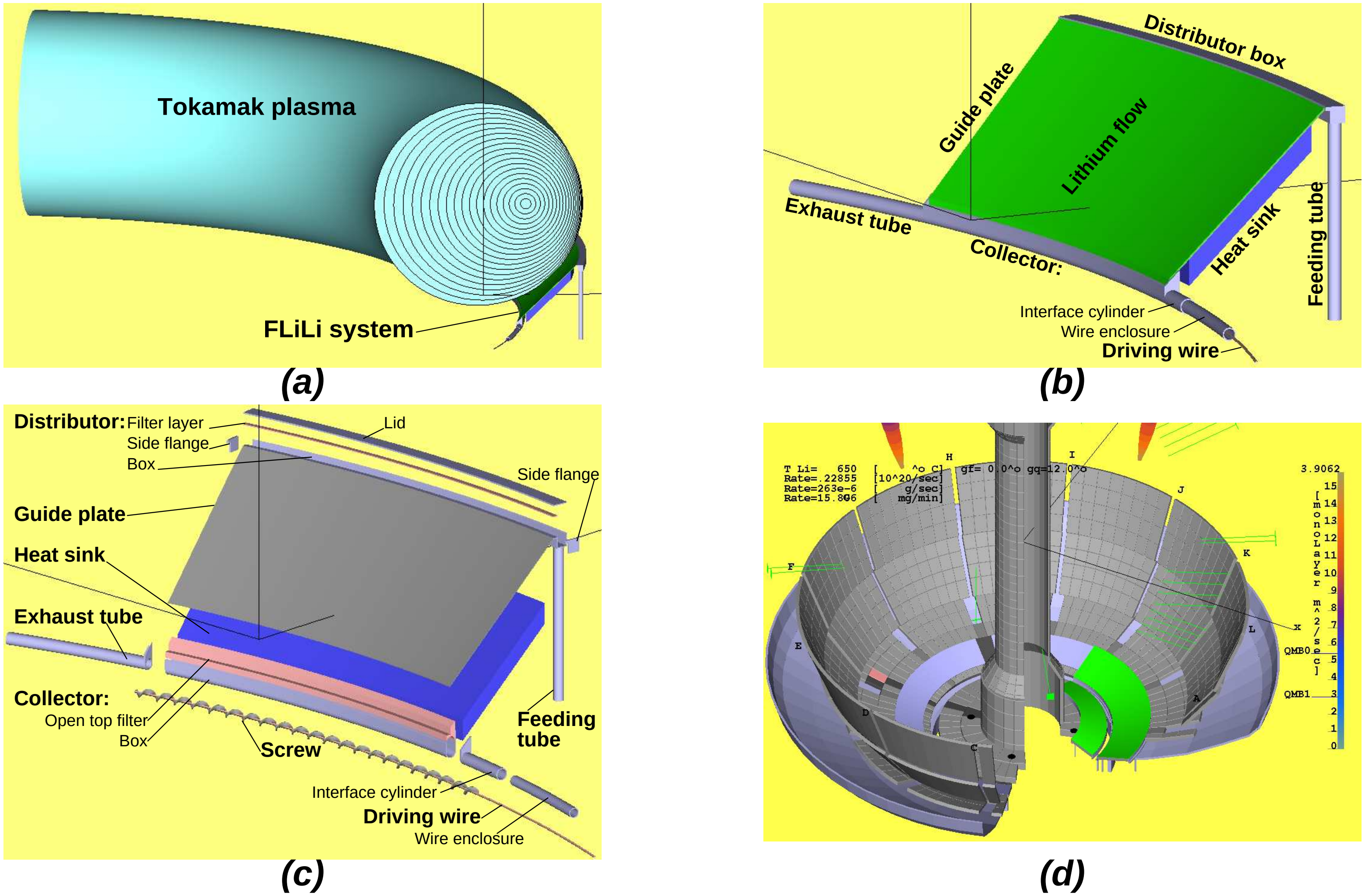
Leonid Zakharov, Charles Gentile, Richard Majeski, Henry Kugel, Dennis Mansfield, Abraham Sternlib

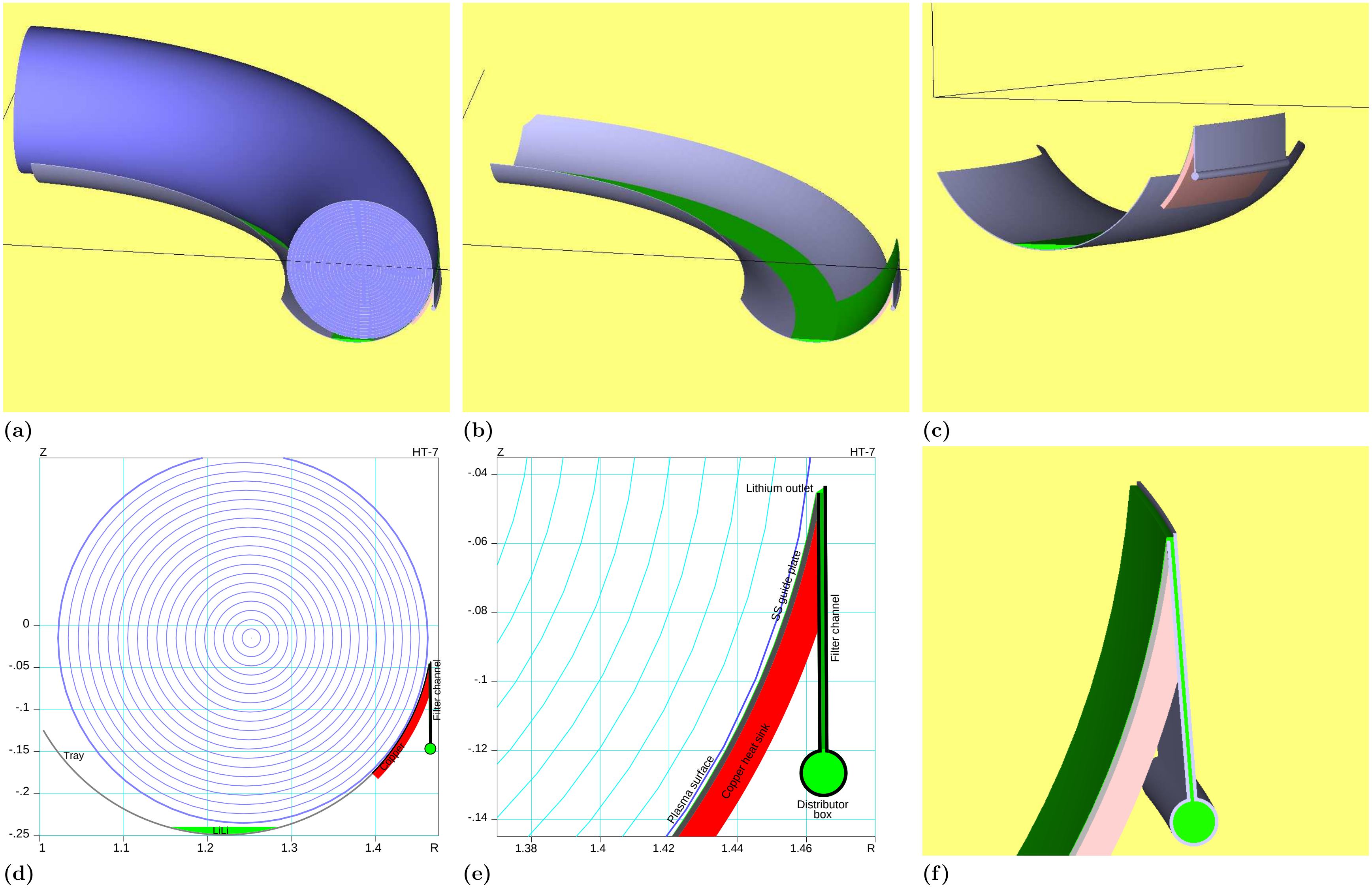





**Conceptual design of the FLiLi system. (a) Example of FLiLi system as a limiter for a tokamak with a circular cross section (e.g., HT-7). (b) Assembly of distributor, feeding pipe, guide plate with LiLi flow (green), heat sink, collector and exhaust mechanism. (c) Separate parts of FLiLi system. (d) Two FLiLi systems for NSTX-U**

# Toroidal tray and FLiLi on HT-7 (August 2012)





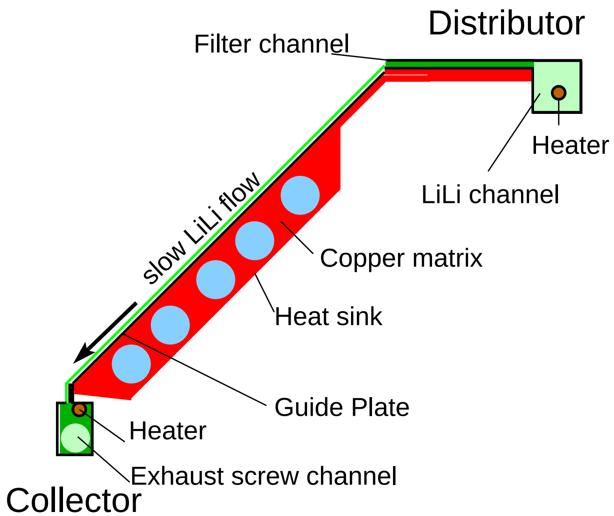

**(a) HT-7 plasma over a toroidal tray with a pool of LiLi. FLiLi is located at the low field side of the tray. (b) HT-7 toroidal tray with a pool of LiLi and the FLiLi system with poloidal flow of LiLi (green color). (c) Backside view on FLiLi. (d) FLiLi as a limiter for shifted HT-7 plasma, (e) Poloidal cross-section of FLiLi (f) 3-D elements of FLiLi.**

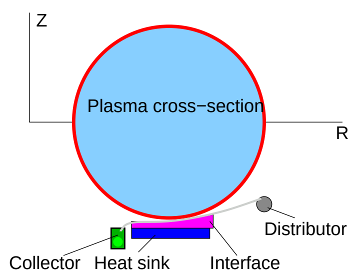
***There are no technical obstacles to adjust a pair of FLiLi systems for NSTX-U as well***

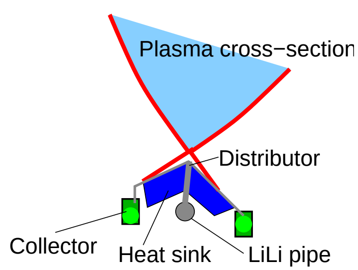
# Flow parameters and key properties

$$V_{cm/s} = 0.2 - 1, \quad Q_{cm^3/s} = 1 - 2, \quad H^{filt}_{mm} = 1, \quad L^{filt}_{cm} = 2 - 10$$

$$\Delta p^{filt}_{Pa} = 1.6 \cdot 10^2 V^{filt}_{cm/s} L_{cm} B^2_T, \quad \Delta p^{dist}_{Pa} = 1.6 \cdot 10^2 V^{dist}_{cm/s} L_{cm} \frac{d}{w} B^2_{\perp}$$




*Design requirement* $\boxed{\Delta p^{filt}_{Pa} > \Delta p^{dist}_{Pa}}$

***Good properties are countless:***

1. *FLiLi solves the problem of the Li surface contamination: open loop during machine operation, close loop overnight*
2. *Flow rate is under external control by pressure in the feeding pipes.*
3. *The system is scalable in both poloidal and toroidal direction, and from a laboratory test chamber to a real tokamak device.*
4. *Minimal in-vessel inventory of LiLi. LiLi is supplied from outside and is exhausted to outside the VV.*
5. *The bulk of LiLi is protected from plasma disruptions by the filter layer.*
6. *No side walls for LiLi flow, no leading edges.*
7. *Simple for maintenance, at the end of the campaign can be flushed out by argon and then by vinegar.*
8. *Is insensitive to yet unknown* $\mathbf{j} \times \mathbf{B}$ *forces.*
9. *Filter channel geometry and orientation is flexible.*

***FLiLi is compatible with any tokamak, including NSTX-U. The plasma regime, it can provide, is beyond the dreams.***

***FLiLi is simply amazing.***

# Flow parameters and key properties



***The most fundamental aspect (and a huge problem) of magnetic fusion is that its physics and technology cannot be presented as a set of independent virtual "bricks".***

***Everything in the tokamak plasma regime (confinement, stability, fueling, power extraction, wall erosion) is interlinked in unbreakable fashion.***

***All plasma physics tendencies in the current non-LiWF are bad.***

***In integrated tokamak plasma physics, the plasma edge and PFC represent the most sensitive element. This understanding should be the guidance for strategy.***

**The Table of consistency of NSTX-U Li suggestions with the tokamak physics and technology.**

| Name | $\tau_E$ | CoreSt | EdgeSt | Disr | $Q \frac{MW}{m^2}$ | Li MHD | $T_{surf}^{LiLi}$ | $h_{mm}$ | $V \frac{cm}{s}$ | $(VS)\frac{cm^3}{s}$ | HT-7 | NSTX-U | NxtStep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLiLi | BP | BP | BP | BP | BP | BP | $< 400^o$C | 0.1 | <1 | 2 | Yes | Yes | Yes |
| Pool | BP | BP | BP | BP | $< 5$ | TBD | $< 400^o$C | 1-3 | $\simeq 1$ | 0 | TBD | Yes | No |
| Trench | BP | BP | BP | BP | $< 5$ | Ignored | $< 400^o$C | 1 | ?? | ?? | TBD | Yes | No |
| CPS | gmbl | gmbl | gmbl | gmbl | TBD | TBD | Any | 1-5 | $\simeq 1$ | TBD | TBD | Yes | No |

| | |
|---|---|
| BP | - the best possible |
| TBD | - to be determined |
| gmbl | - gambling with the problem |

***In fact, except of FLiLi there is no reasonable concept for NSTX-U.***

***The RDM is a substitution of the real problem, intended to drain the research time and taxpayers money.***

***Instead of "bricks", like RDM, the phases of implementation of FLiLi should be adopted***