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TARGET FABRICATION TECHNOLOGIES & NONCONTACT DELIVERY SYSTEMS TO DEVELOP A FREE-STANDING TARGET FACTORY OPERATING IN THE REPETITION MODE AT THE IFE RELEVANT LEVEL

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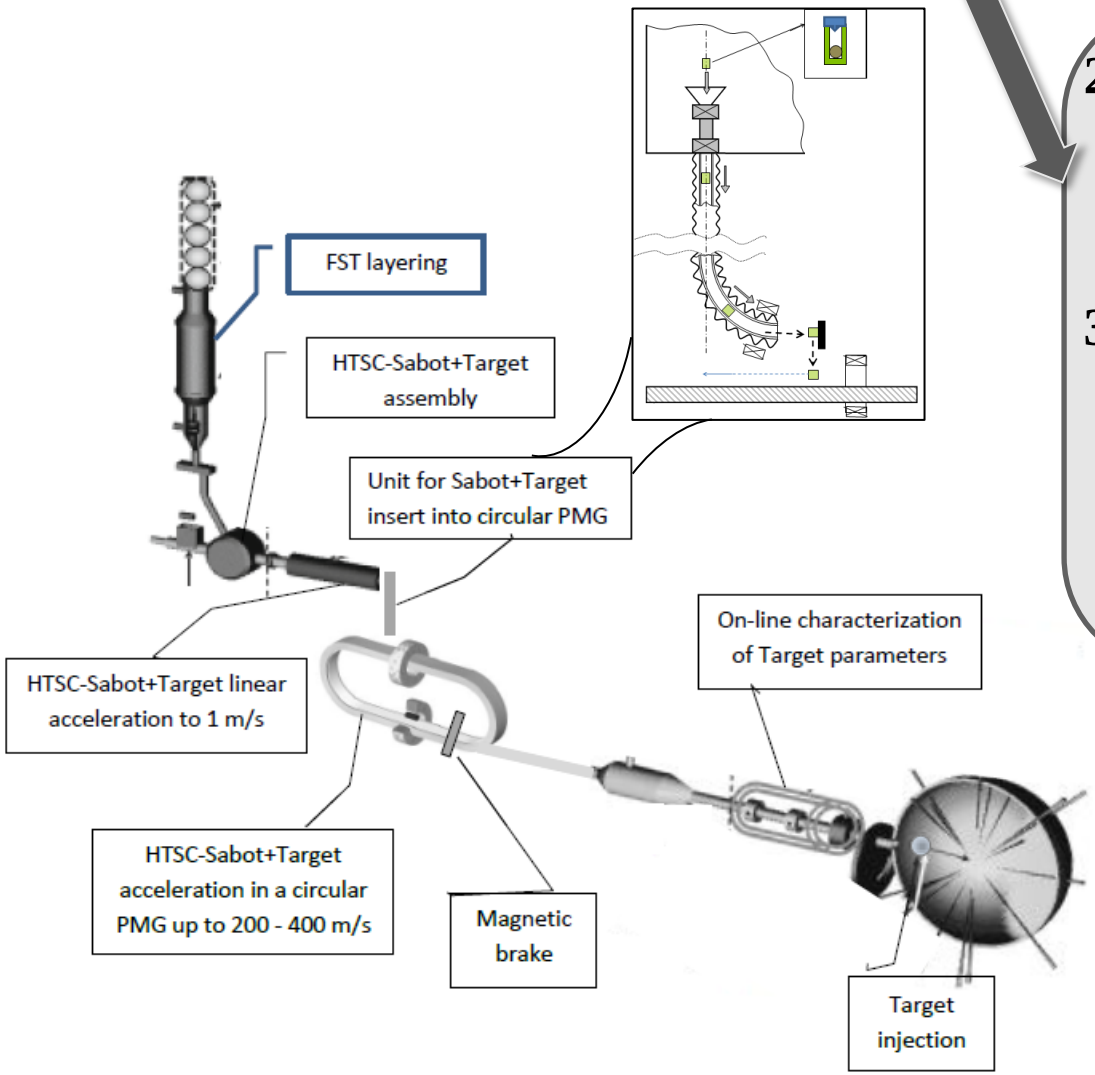
The LPI has proposed a general schematic of the FST-FACTORY.

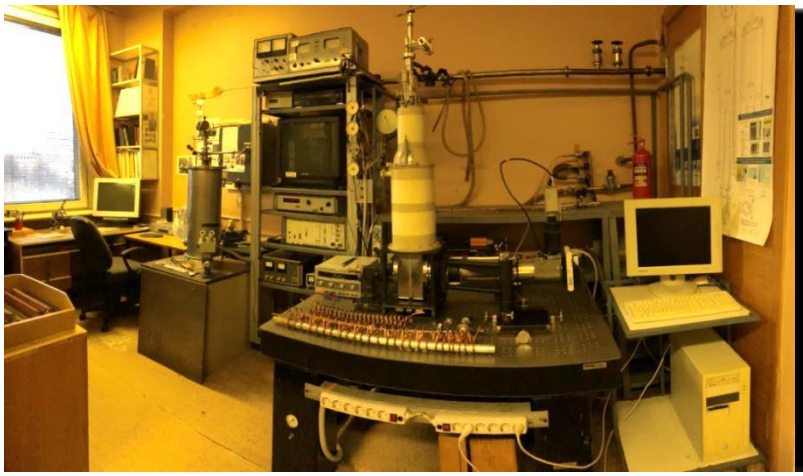
FINE FEATURES OF THE FST-FACTORY ARE AS FOLLOWS:

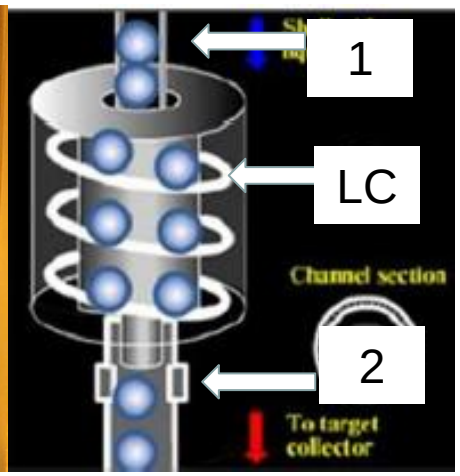
To be considered in the current report

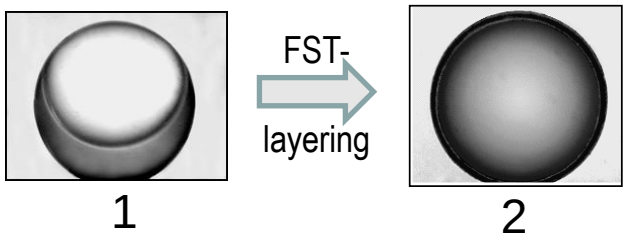


1. **Diffusion filling of a shell batch**
2. **FST-layering method** for in-line target fabrication with a stable isotropic fuel layer
3. **Using of HTSC-Sabot & permanent magnet guideway (PMG) systems in coil accelerator** for noncontact Target delivery.
4. **Fourier holography** for flying Target tracking

FST-layering method developed at LPI uses the free-standing and line-moving targets that are a scientific and technological base for high repetition rate target supply at the laser focus.







FST-layering result

CH shell: ∅ 1.23 mm; Layer: 41 μm,
D_2+20% Ne; Nu < 2%, δ < 0.5 μm
Layering time: t < 8 s

Facility for the FST-layering ⇒ FST-layering module (LM) & 100–projection visual-light tomograph for precise characterization of the layering results (1μm resolution for λ=490 μm)

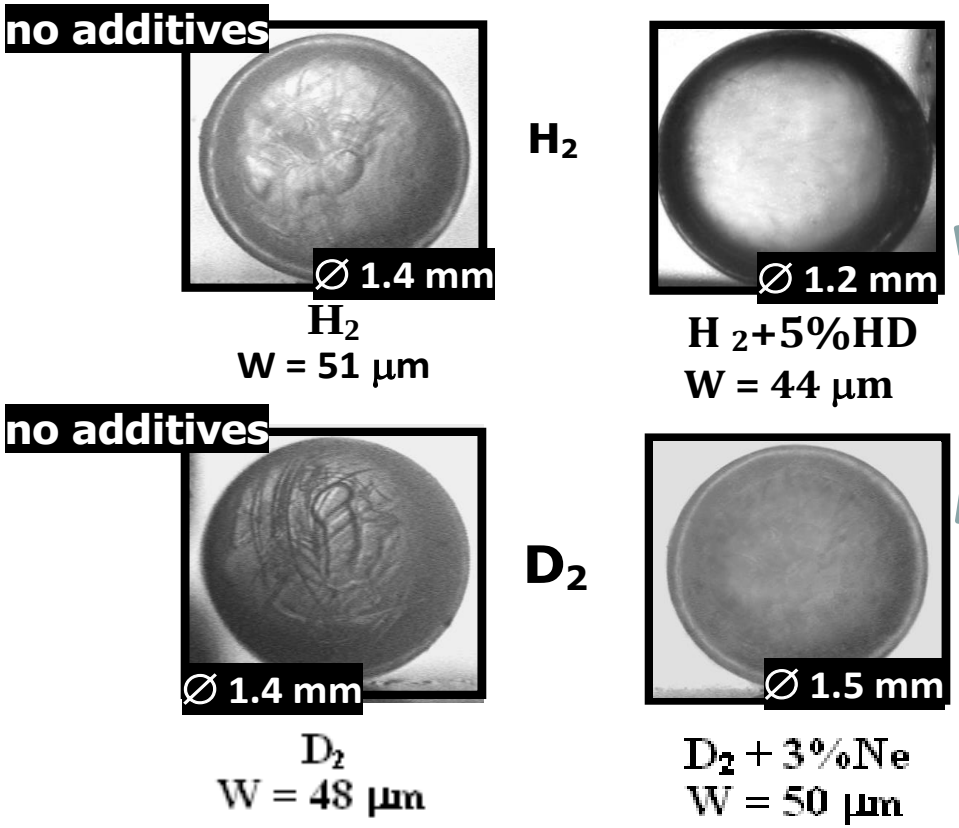
FST-layering method ⇒ How it works:

– Liquid layer symmetrization due to target rotation when it is rolling down under gravity along the LC;

– Liquid layer freezing due to heat transport outside the target through a small contact area between the shell wall & the wall of the LC;

– High cooling rates (q = 1−50 K/s) combined with fuel doping are used to form a stable isotropic solid fuel layer within free-rolling target

Isotropic fuel structure is necessary to reach the fusion conditions.
Our approach to form stable isotropic fuel layer are as follows ⇒
high cooling rate (1−50 K/s) + application of doping



The crystal growth did not observed in the temperature range of

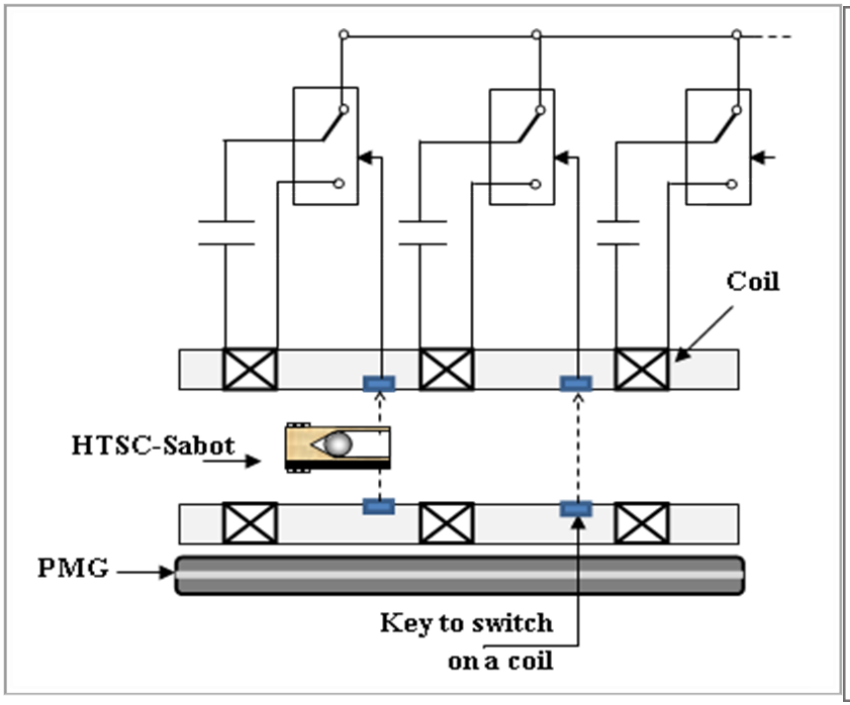
$T = 4.2\ K - T_{tp}$

T_{tp} is the triple point of main component

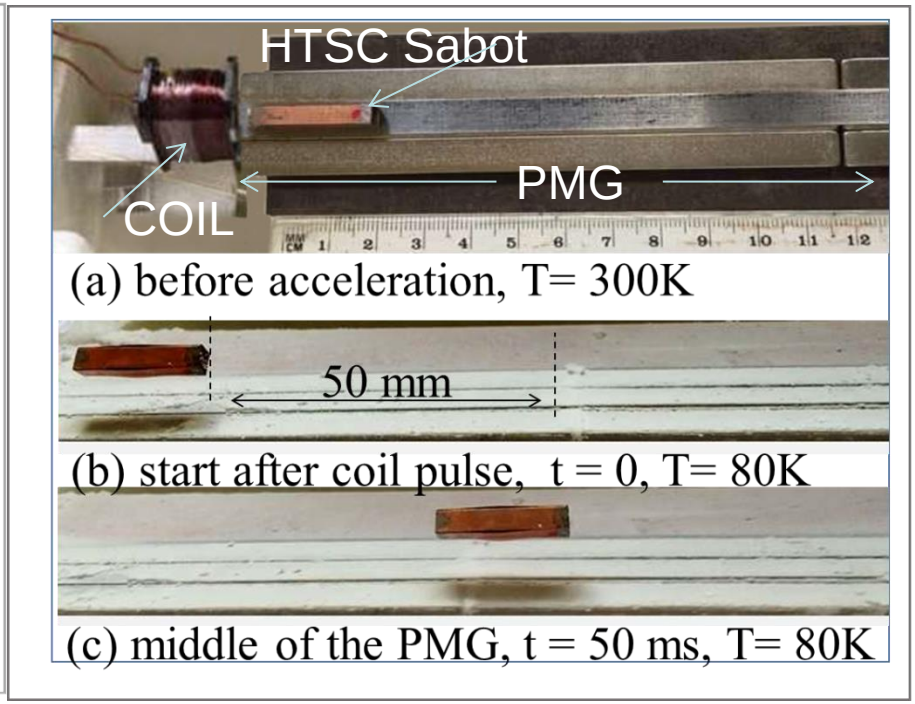
Our experiments have shown that using the FST-layering method combined with fuel doping (3-to-20 % of Ne, Ar or H_2 isotopes) ensures the formation of a stable isotropic cryogenic layer inside spherical polymer & glass shells (∅ < 2 mm, ΔR = 5 -15 μm)

IFE reactor-scaled experiments require developing noncontact delivery systems for safe, stable & friction-free target transport with a rep-rate.

Our approach ⇒ target delivery using a quantum levitation effect of HTSC in the magnetic field of the PMG-system



Schematic of linear coil accelerator of the "HTSC Sabot + Target" levitated over the PMG

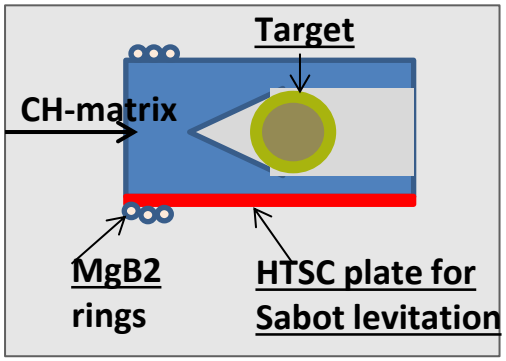


Mock-up results for "HTSC Sabot + Target" linear acceleration up to 1.0 m/s

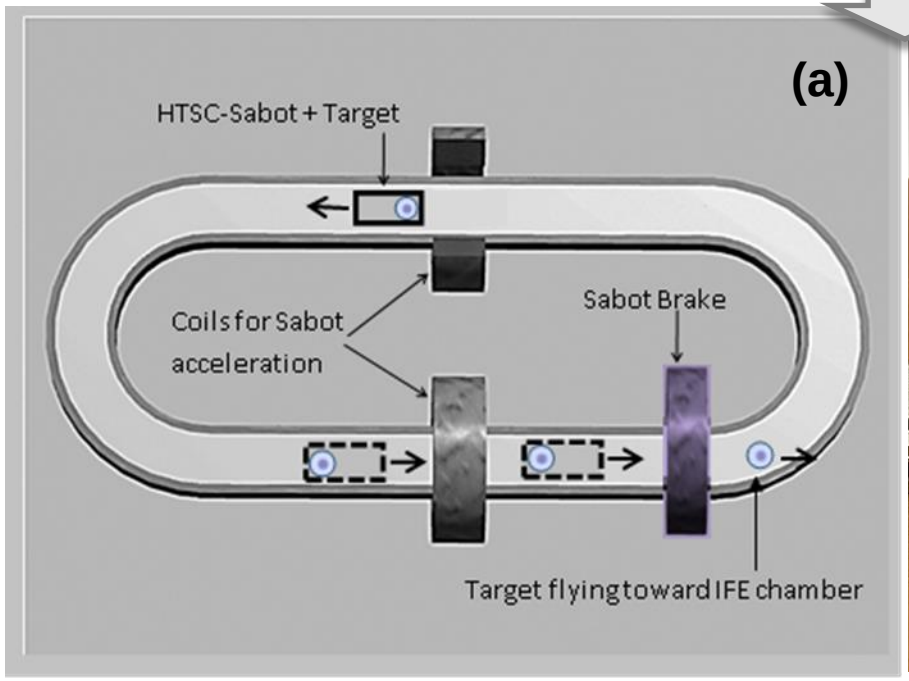
Our experiments have shown that for "HTSC Sabot + Target" transport from the Assembly Unit to Target Injector it is enough to use only one coil

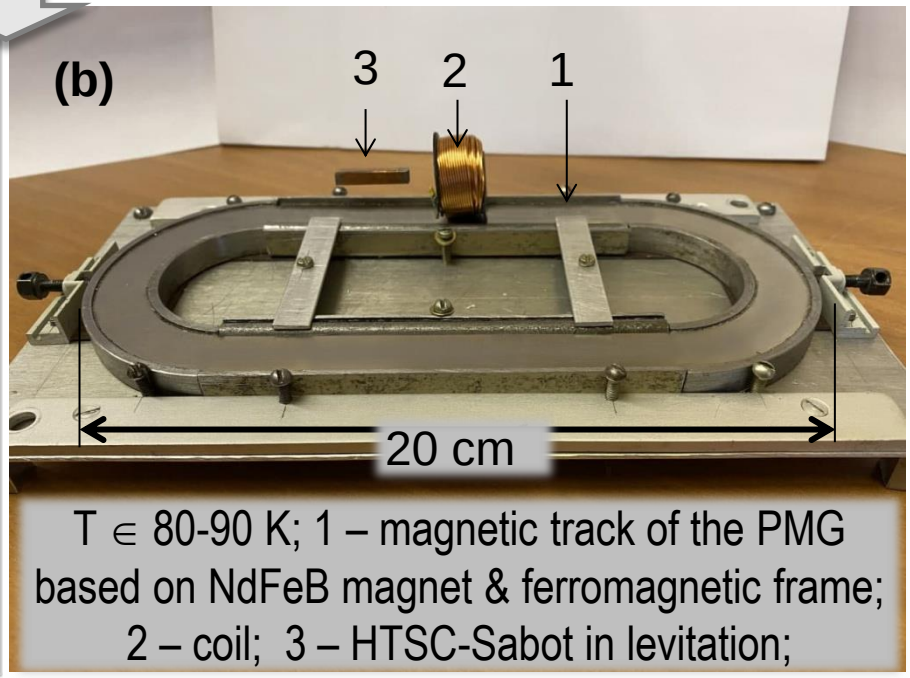
Stage of "HTSC-Sabot + Target" acceleration up to 200−400 m/s

▪ **Calculations for the linear coil accelerator:** Using driving body from MgB_2 super-conducting coils as an HTSC-Sabot component (I_{CR} = 5000 A at B = 0.25 T) allows reaching the **injection velocities of 200 m/s under 400g overload at 5-m-acceleration length (the number of the field coils 200)**



Significant reduction of the accelerator dimensions & the number of the field coils (compare to linear accelerator) **may be reached by using an oval shaped PMG system**





T ∈ 80-90 K; 1 – magnetic track of the PMG based on NdFeB magnet & ferromagnetic frame; 2 – coil; 3 – HTSC-Sabot in levitation;

Oval shaped cyclic accelerator schematic (a) and 1-st version of the mockup (b)

CONCLUSION

1. **A scheme** of the target factory has been proposed at the LPI (FST-Factory).

2. **FST-layering method** for in-line target production with a stable isotropic fuel layer has been proposed & examined. Wherein, precisely moving targets co-operate all production steps in the FST transmission line that is considered as a potential solution of mass-production layering and noncontact target delivery.

3. **A new approach to target delivery** based on HTSC-maglev technologies has been proposed and examined. Our results have shown that it is a successful noncontact schedule compatible with mass target production and operation at high rep-rate conditions:

- Calculations have showed that using the linear accelerator allows reaching the injection velocities of 200 m/s under 400g overload at 5-m-acceleration length (the number of the field coils 200).
- First mockup experiments have shown that significant reduction of the accelerator dimensions & number of the field coils may be reached by using an oval shaped PMG system
- Currently, several PMG-systems is being designed to support the target survivability & demonstrate successful acceleration scenarios.