LMU Munich (P.G. Thirolf et al.)

Scientific goal:

exploit the unique properties of ultra-dense laser-driven ion beams for nuclear astrophysics (generation of extremely neutron-rich isotopes near N=126)

Laser-driven ion acceleration:

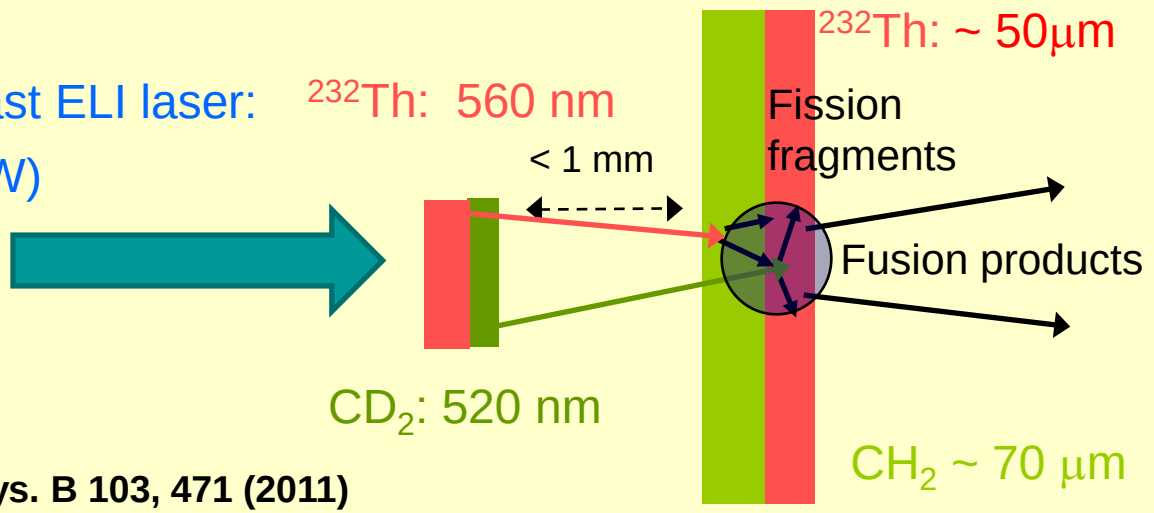
- Radiation Pressure Acceleration (RPA) generates ion bunches with solid-state density

→ ~ 10^{14} x density of conventionally accelerated ion beams

Allows for novel nuclear reaction mechanism: ‚Fission-Fusion'

high-power, high-contrast ELI laser:

- 300 J, ~30 fs (10 PW)
- ~·10^{23} W/cm^2



D. Habs, PGT et al., Appl. Phys. B 103, 471 (2011)

“Fission-Fusion” reaction mechanism

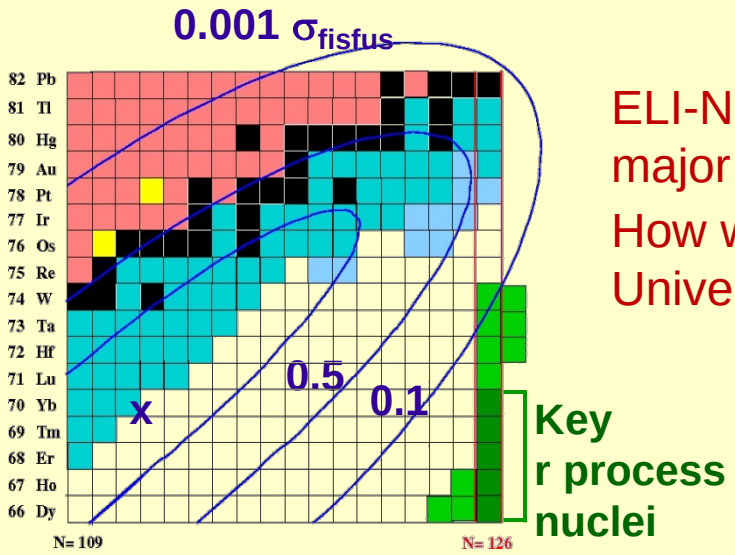
Accelerated ions collide with target species: → fission of (fissile) beam and target nuclei
Conventional radioactive ion beam facilities: (low-density) ion beam + stable target
‚Fission-Fusion‘: light fission fragments of beam + light fission fragments of target

Impact on nuclear astrophysics:

- nucleosynthesis of heavy elements beyond Fe via rapid neutron capture (r process)
- r-process path for heavy elements: runs deep in ‘terra incognita’ of nuclear landscape
- known isotopes ~15 neutrons away from r-process path (Z≈ 70)
- decisive: Waiting Point at N=126 → exp. data needed on masses, lifetimes
- Fission-Fusion’ mechanism leads close to the region of N=126 Waiting Point

→ beyond the range accessible with conventional acceleration schemes

Expected access to very exotic species via Fission-Fusion:



ELI-NP can contribute to one of the major questions in physics:

How were the heavy elements in the Universe made ?

Experimental R&D Phases

- **Develop RPA-based laser ion acceleration of heavy elements:**
  - laser-ion acceleration of heavy species: energies, charge states …
  - optimized target development (multi-layer, repetition rate capability)
  - control of ion energy

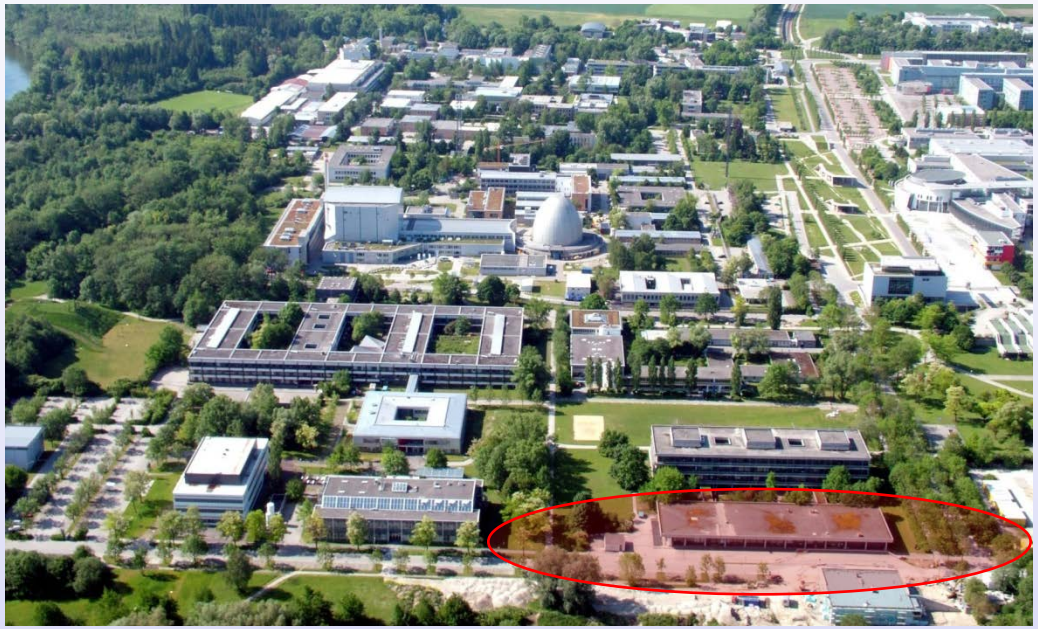
- **Theoretical consolidation required:**
  - 2D/3D simulations for RPA of heavy species
  - robust reaction yield estimates

- **Proof-of-Principle experiments:**
  - test concept of collective effects on ion beam stopping range
  - perform proof-of-principle experiment for ‘fission-fusion’ mechanism
  - optimize reaction yields: fission stage, fusion stage

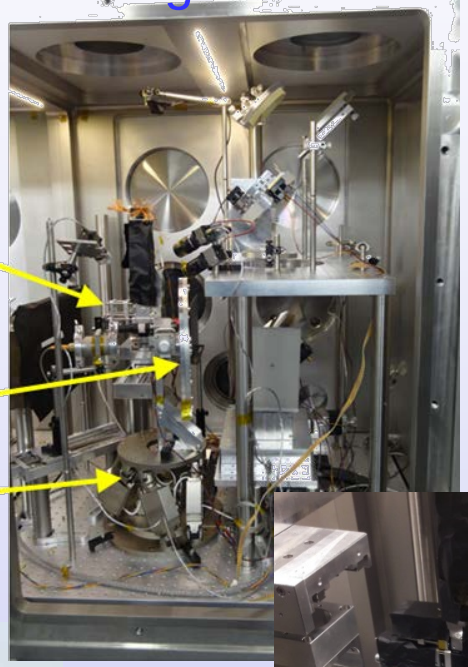
- **Physics program:**
  - identification of reaction products: decay spectroscopy
  - separation of species of interest: recoil separator
  - measurement of fusion product properties: masses, lifetimes, …

Exploratory Studies: CALA (Garching)

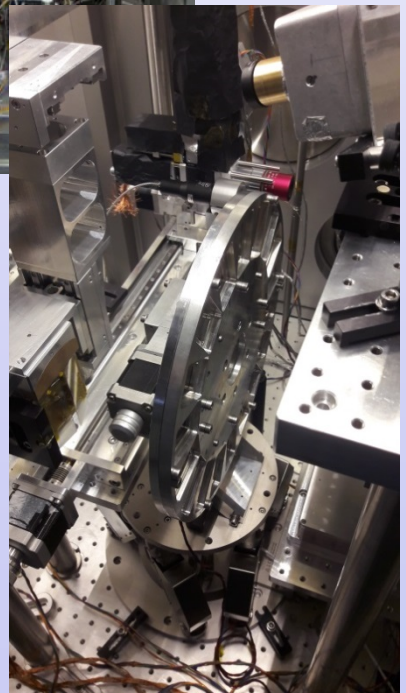
(Center for Advanced Laser Applications)



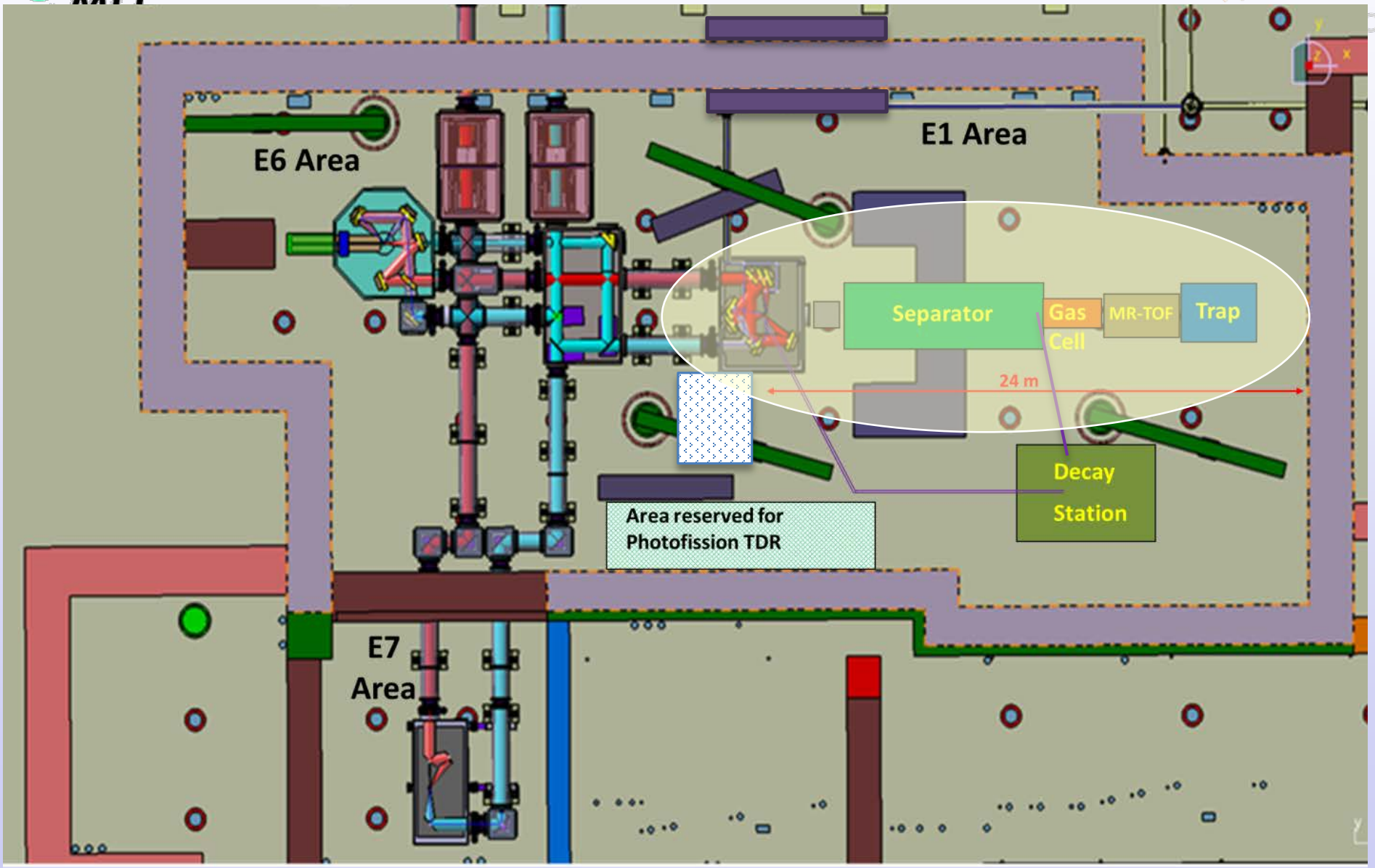
laser target chamber:



target wheel



ELI-NP: ‘E1’ Experimental Area



also: 1 PW laser beam (1 Hz) for preparatory studies