Status report on HIE-ISOLDE experiment IS581 "Determination of the fission barrier height in fission of heavy radioactive beams induced by the (d,p)-transfer"

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Motivation for experiment IS581 (brief recap): Experimentally measured fission barriers heights of exotic nuclei are needed !

Most of the known (directly measured) fission barriers heights were obtained more than 30 years ago, using reactions with light beams such as (d,pf), for nuclei close to beta-stability line. **Fission barrier heights of exotic nuclei are unknown** !

Values of **fission barrier heights extracted from compound nucleus reactions using statistical model are model-dependent and inconclusive**. Especially the observed drop of fission barriers compared to theoretical calculations needs verification !

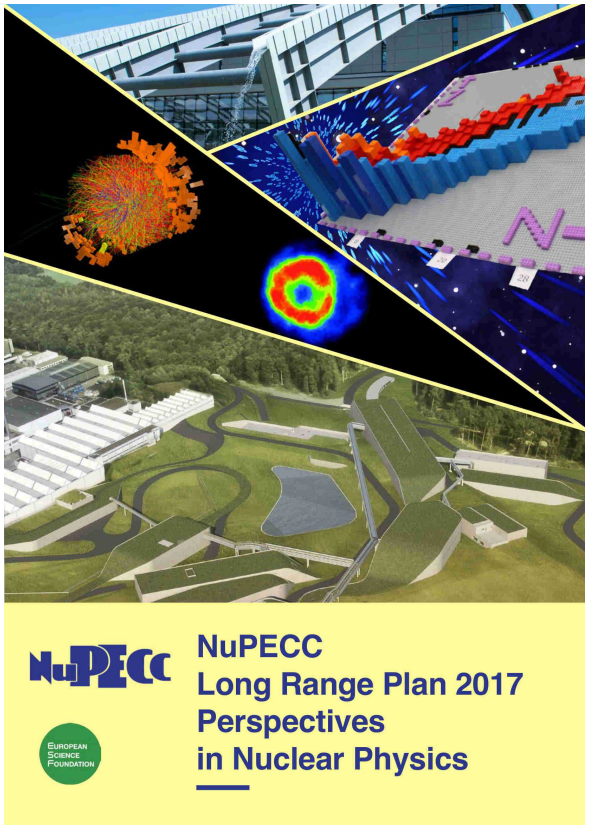
Values of **fission barrier heights** of several even-even nuclei, **extracted from observed beta-delayed fission** (including experiments at ISOLDE) are **inconclusive due to unknown strength of pairing in the saddle point**.

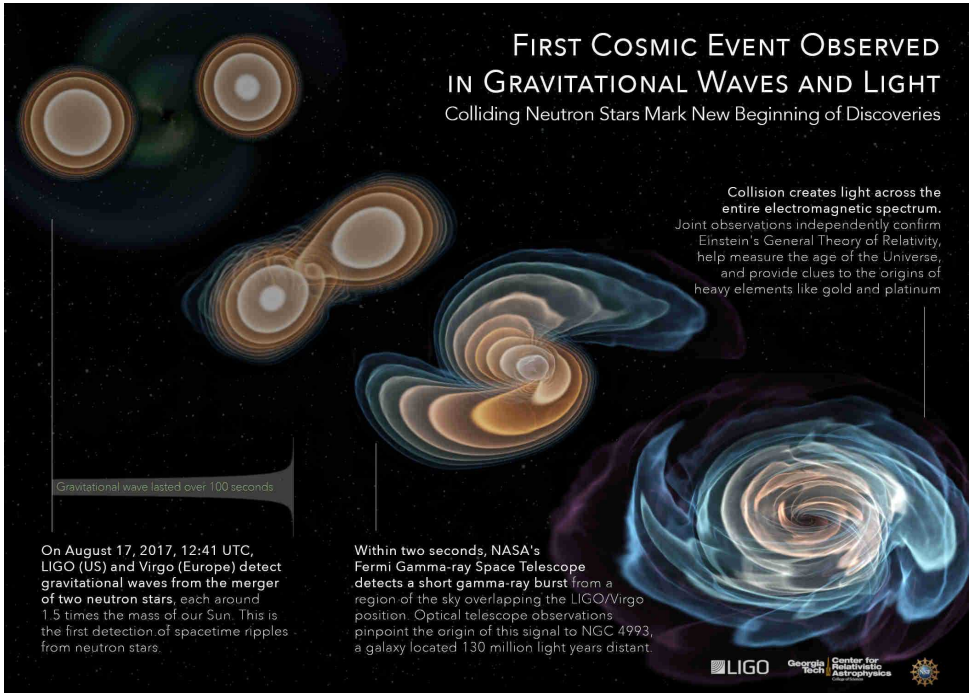
Solution: **Direct measurement for exotic nuclei** is needed. Experiment IS581 plans to measure fission barriers using (d,pf) **in inverse kinematics using the ACTAR TPC**.

Since 2013, when IS581 was approved, the **knowledge of fission barrier heights of exotic nuclei became even more important** !

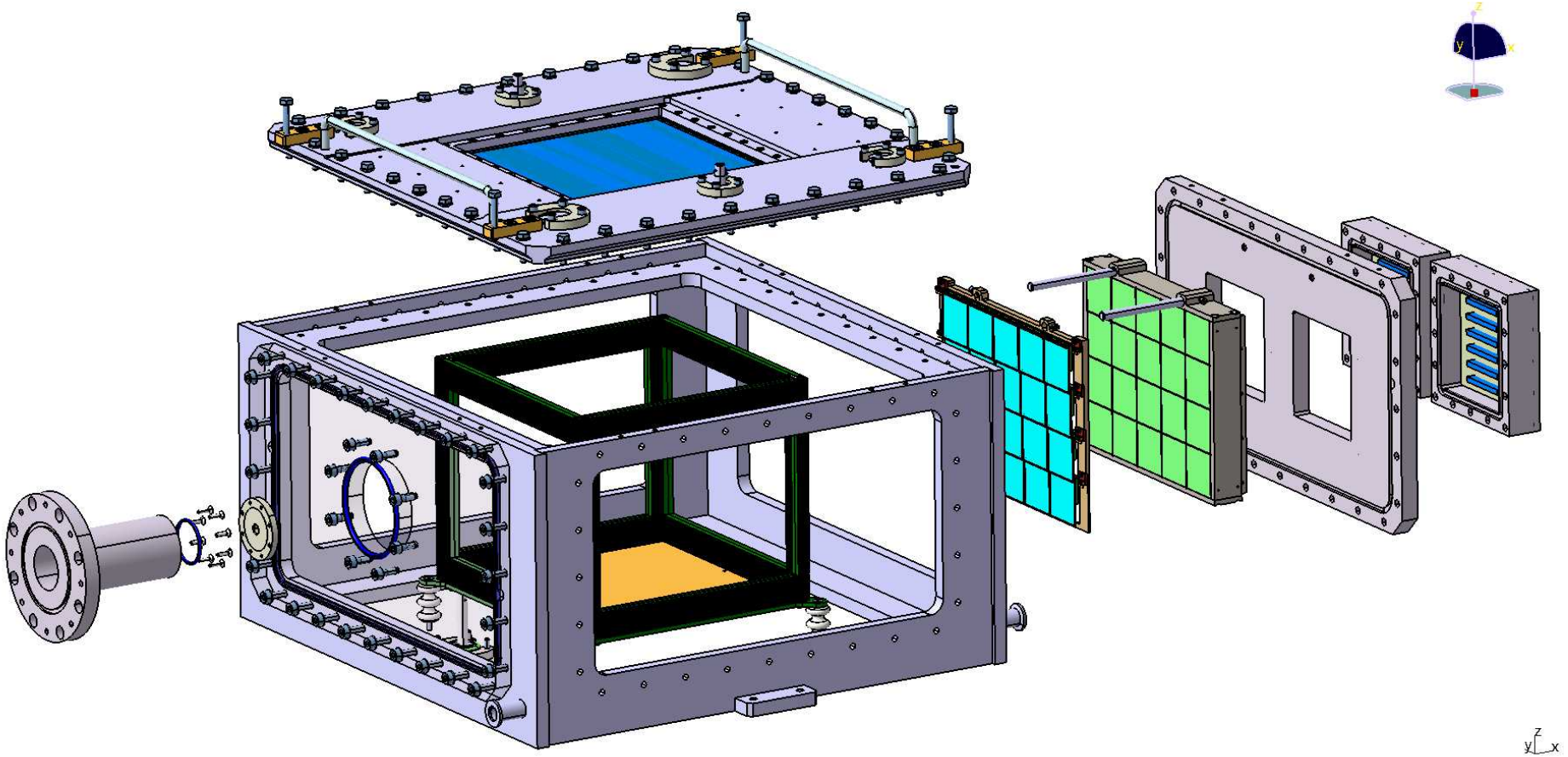
The **NUPPECC Long range plan** in several instances formulates need for knowledge of “fission rates” (fission barrier heights) for solution of the problem of nucleosynthesis of heaviest elements in Universe.

The importance of known fission barrier heights further increased since observation of the **binary neutron star merger GW170817** via gravitational and other signals. Binary neutron star merger is most probable candidate for the site of nucleosynthesis of heaviest nuclei and fission barrier heights are missing part of the puzzle !





ACTAR TPC

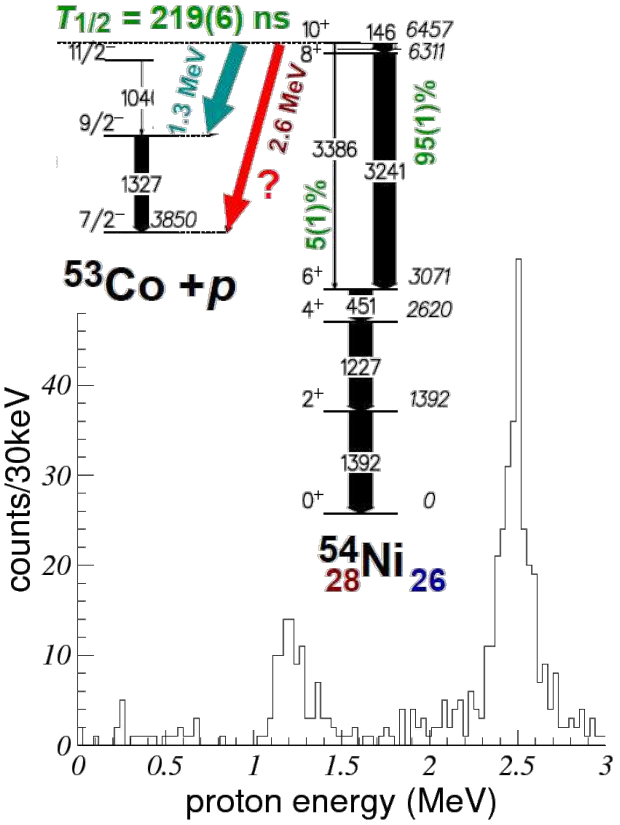


Active target allowing to measure fission excitation function

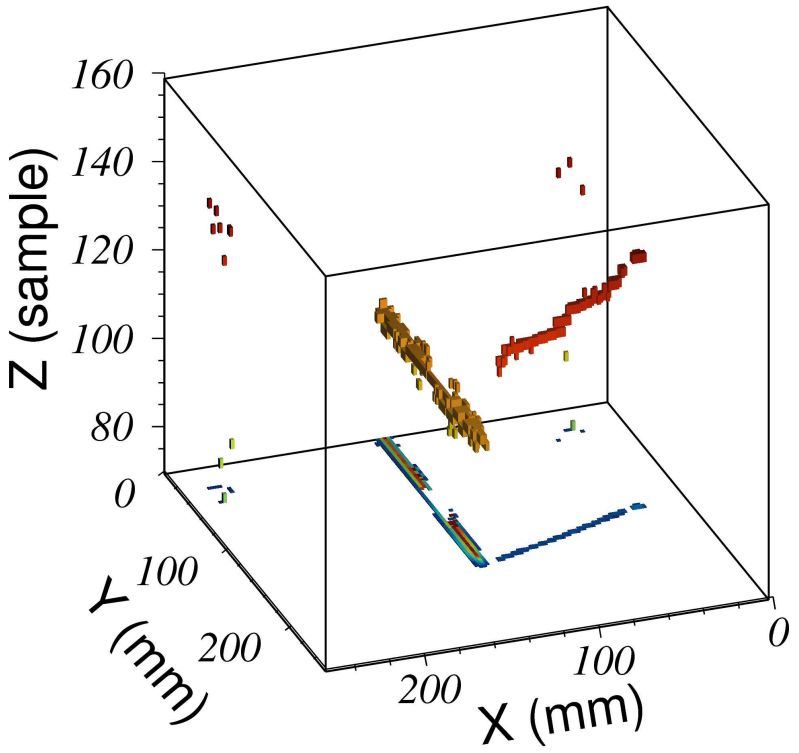
ACTAR TPC : Achievements

- ✓ Detector commissioned (2017): 18O(p,p) and 18O(p,α) excitation functions
- ✓ 2 experiments done (2019):

- E690: Proton-decay Branches from the 10+ Isomer in 54Ni (D. Rudolph, B. Blank)
  - → Implantation (550 MeV 54Ni/53Co beams)/Decay (2 MeV protons)
  - → Detection dynamics OK (capacitive couplings manageable)



Courtesy B. Mauss



Electrostatic mask for field screening

→ Tested with 105 Hz of 238U @ 4.2A MeV

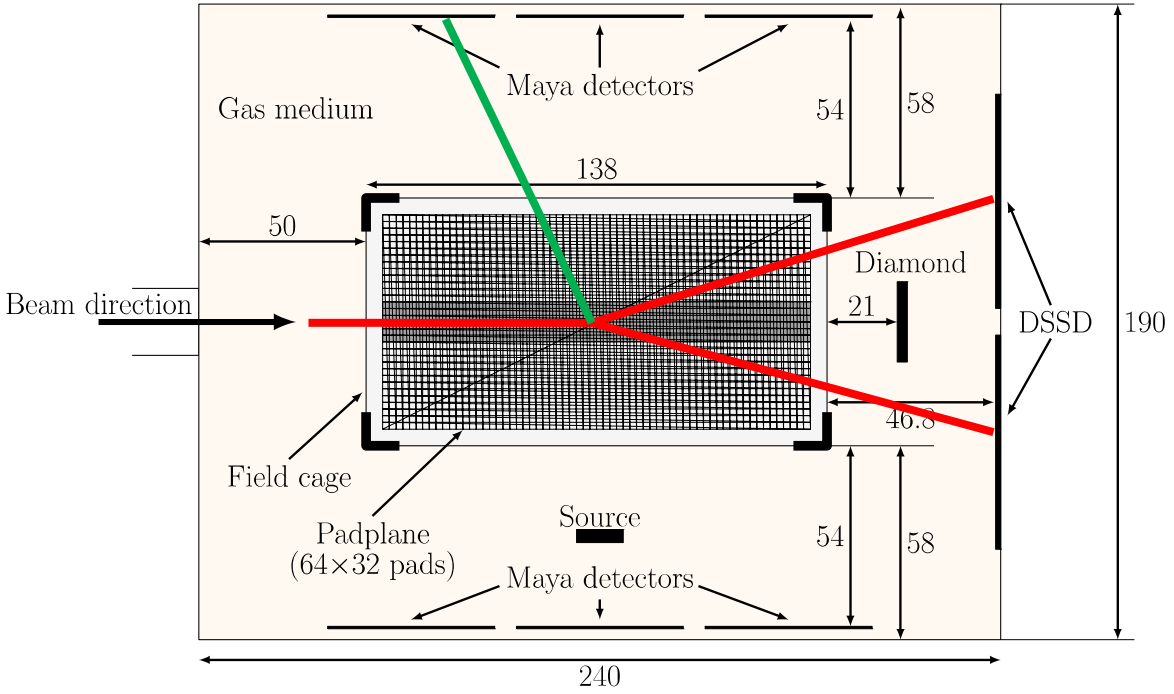
*C. Rodriguez et al., NIM A**768**, 179 (2014)*

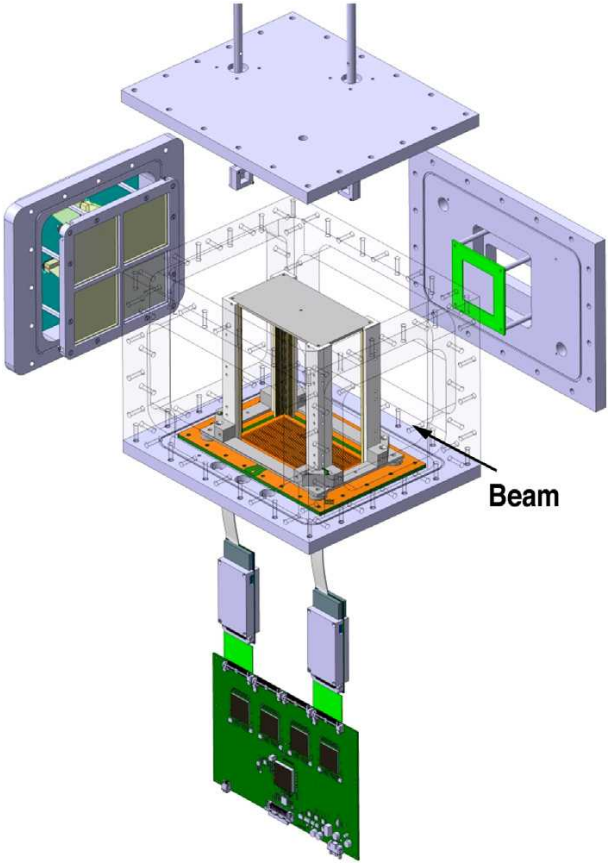
Experiment accepted in LNS Catania: 208Pb

208Pb on deuterons and α's

Transfer: (d,p)209Pb, (α,p)211Bi
new data

Fusion: 210Bi, 212Po (verification)





Approved beams

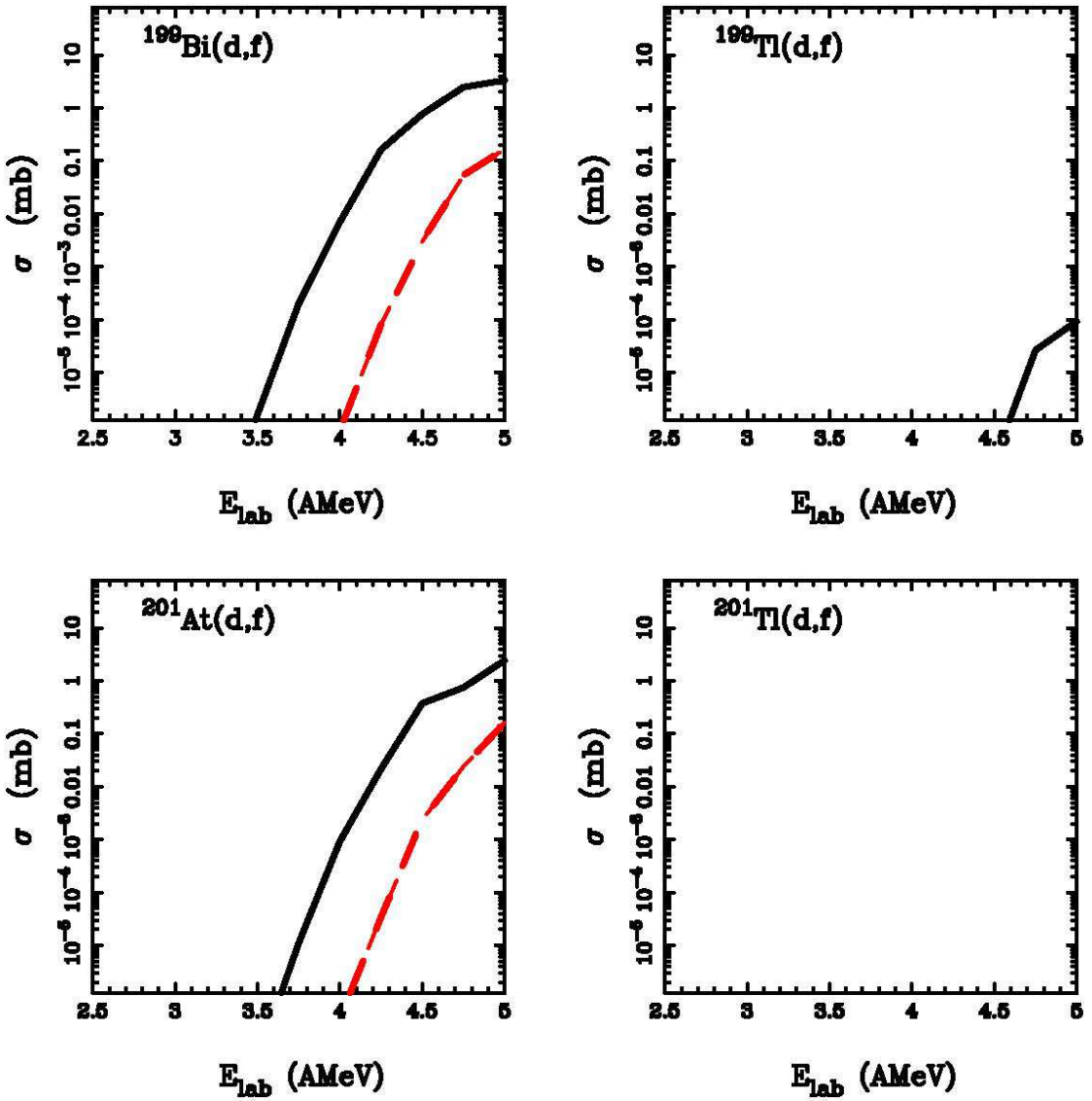
The isotopes of interest for the transfer induced fission studies range from Tl to Fr, specifically **^{193}Tl, ^{199}Bi, ^{201}At and ^{209}Fr, accelerated to 5 AMeV.** The **expected rates of accelerated ions of the requested isotopes around $10^{5\text{-}6}$/s**.

Total: 28 shifts (split into 2 runs over 2 years)

Beamline: 3rd REX beamline

TAC comment: Tl contamination of ^{199}Bi and ^{201}At beams

No problem at all! ^{199}Tl and ^{201}Tl beams won't fission below 5 AMeV !



Summary

Physics case became stronger since 2013, especially post-GW170817

ACTAR TPC is operational and ready for HIE-ISOLDE beamtime

Expected contaminations will be no problem, all the safety procedures will be followed

Added value: IEAP CTU Prague became new institutional member of ISOLDE Collaboration