

NUSTAR collaboration news

Zsolt Podolyák

NUSTAR Annual meeting, GSI, 25 February 2026



Finland



France



Germany



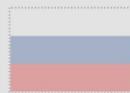
India



Poland



Romania



Russia



Slovenia



Sweden



UK



Czech Republic



NUSTAR week in Prague (Czech Republic) 29 Sept.- 2 Oct. 2025
Low –energy branch physics workshop 1 Oct. 2025 (hybrid)

Joint Scientific Council 23-24 October 2025

JSC in 2024 focussed on future, in 2025 on the past

Meeting with FAIR management Oct. 2025.

=> NUSTAR to make ~~a plan~~ plans for 2028 (Early Science)

ECE/ECSG 5 Nov 2025

Fire at GSI 5 Feb. 2026

Comments on NUSTAR:

-JSC acknowledges... and **looks forward to further details on the publications from FAIR Phase-0 experiments done at GSI**.

-JSC acknowledges the potential scientific impact of the proposed new WASA setup. However, it requests a more elaborated document to be assessed by the JSC at its next meeting.

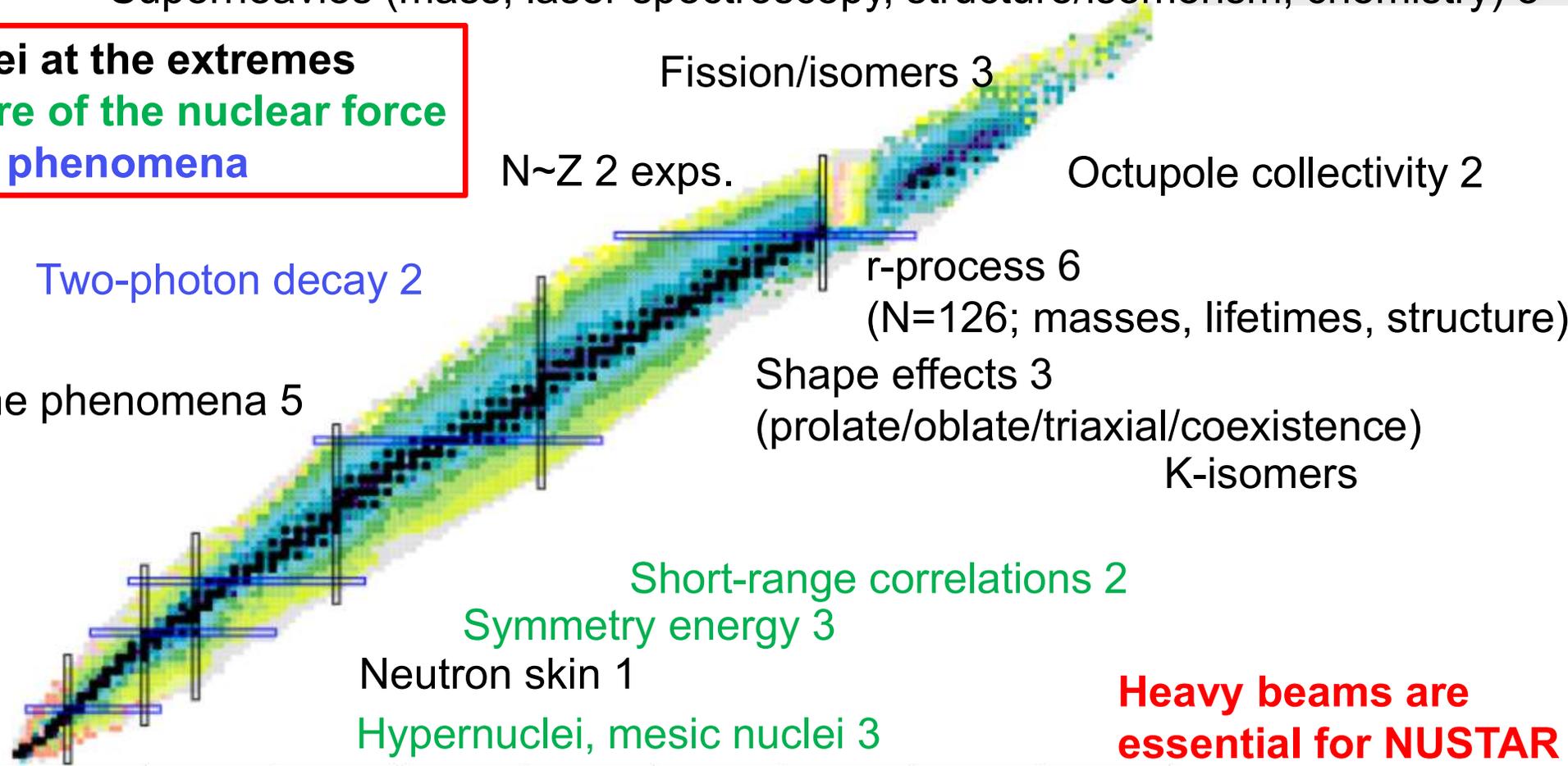
- JSC requests the collaboration and NUSTAR to prepare a plan how to implement the program into the operation of the FRS.

2021-2022	FAIR-0 experiments (27 NUSTAR exps.+tests)
2023	No experiments (but there were tests)
2024-2025	FAIR-0 experiments (27 NUSTAR exps.+tests)
2026-2027	FAIR-0 experiments (G-PAC in 2025) hmmtttt ☹
End 2027 ->	Early Science (with SuperFRS)
End 2028 ->	First Science (with SuperFRS and SIS100)

2021-25: 54 FAIR-0 exps.+tests

Superheavies (mass, laser spectroscopy, structure/isomerism, chemistry) 8

Nuclei at the extremes
Nature of the nuclear force
Rare phenomena



Publications 2021-2025

		Nature family; PRL	PLB	PRC/PRA	NIM	Other	PhD diss.	Total
R3B	2021-25	6	3	11	4	24	16	64
HISPEC/DESPEC	2021-25	3	9	7	7	19	6	51
SuperFRS-EC	2021-25	3	3	6	17	23	2	54
ILIMA	2021-25	5	0	4	1	12	0	22
SHE	2021-24	11	5	20	12	65	6	119
LASPEC/MATS	2021-25	4	0	1	1	3	0	9
NUSTAR	2025	8	2	13	5	33	11	72
	2024	7	5	3	5	30	13	63
	2023	6	5	5	14	35	4	69
	2022	6	4	16	10	31	0	67
	2021	5	4	12	8	17	2	48
NUSTAR	2021-25	32	20	49	42	146	30	319

NUSTAR database
 (based on GSI repository:
<https://repository.gsi.de/>)

Experiments in 2021 and 2022

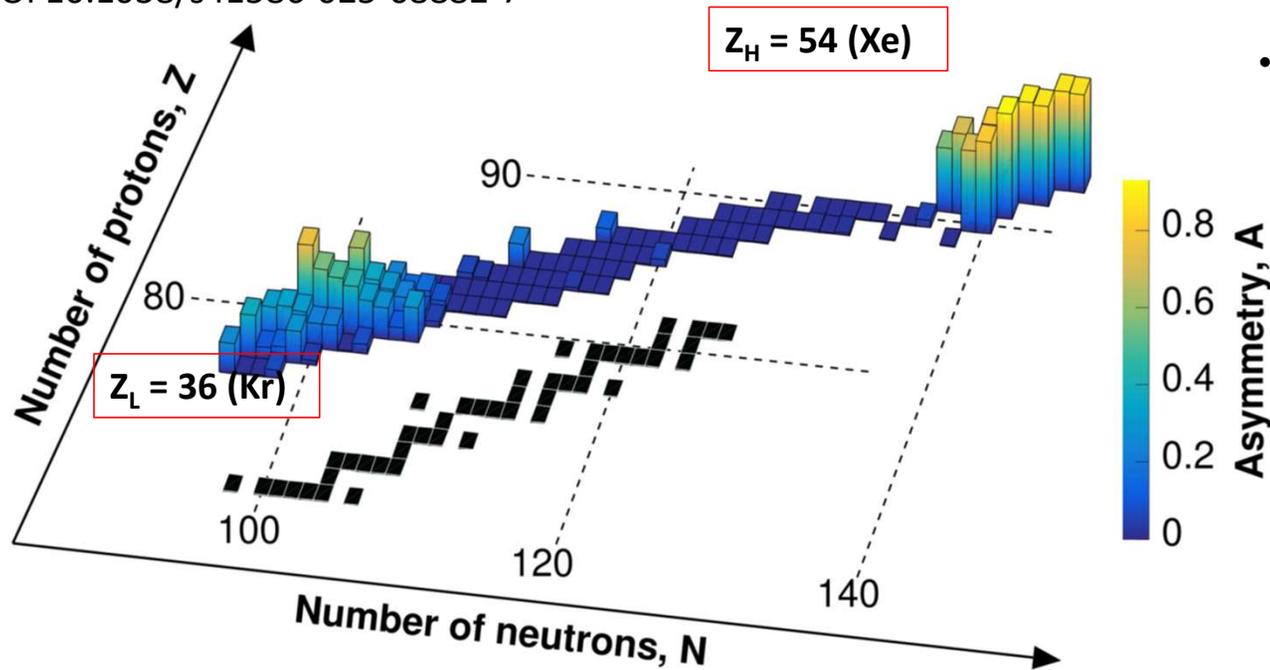
		publications from repository.gsi.de	PhD thesis	conf. proc
G-PAC44 2020		ON 17-23 FEB 2026		
Proposal-ID	Title	Execution Year		
S455	S455: Fission investigated with relativistic-radioactive beams and the advanced SOFIA@R3B setup	2021	Nature 2025; NPA2025	3yes
S509	Study of drip-line phenomena in neutron-rich nuclei	2022		1
S515	Constraining energy-density functionals and the density-dependence of the symmetry energy by measurements of accurate cross sections with large acceptance at R3B	2021		2yes
S522	First characterization of Short-Range Correlations in exotic nuclei at R3B	2022	NIM 2023	3
S450	Study of N=126 nuclei: isomeric and beta decays in 202Os and 203lr	2022		1yes
S460	Investigation of 220<A<230 Po-Fr nuclei lying in the south-east frontier of the A~225 island of octupole deformation	2021		1yes
S496	Core-breaking in the most neutron-deficient Tin isotopes	2021	PLB 2025; NIM 2022	yes
S505	Investigation of the beta-strength crossing N=126 and the formation of the 3rd r-process abundance peak	2022	JofInst 2026	yes
S452	The Prolate-Oblate Shape Transition around A~190	2021	PLB 2024	1yes
S447	Studies of the $d+\pi^-$ signal and lifetime of the $^3_{\Lambda}H$ and $^4_{\Lambda}H$ hypernuclei by new spectroscopy techniques with FRS (S447)		NPA 2025; CPC 2025; NIM 2026; NIM 20222024; NIM 2023	2yes
S490	Search for η -mesic nuclei in $^{12}C(p,d)$ reaction	2022	NIM 2026; NIM 2024; NIM 2022	yes
S526	Direct mass measurements of heavy N=Z and N=Z-1 nuclides	2021	nothing	
S530	Fission isomer studies with the FRS	2021	NPA 2025; NIM 2024	yes
S533	Measurements of nuclear and atomic interactions needed for ion-beam therapy with positron emitters of carbon		Sci.Rep 2023; NIM 2023; PhysMedBio 20212023; FronOnc2021	
U323	Study of the multinucleon transfer process in the reactions $^{136}Xe+^{192}Os$ and $^{136}Xe+^{197}Au$	2022	nothing	
U327	Chemical studies of the superheavy element Z=115	2021, 2022	NIM 2025; FrontChem 2024	
U328	Final beam commissioning and first scientific experiments with an Adsorption-based Nuclear Spectroscopy Without Evaporation Residue Signal (ANSWERS) setup at TASCA	2021	PRL 2025	
U319	Discovery and Spectroscopy of Neutron-Deficient Pu Isotopes and their Alpha-Decay Daughters	2022	nothing	
U321	Laser spectroscopy of fermium, nobelium and lawrencium around N=152	2021, 2022	NIM 2025; PRR 2024; Nature 2024; NIM 2023; Atoms 2025X2	1
U324	High-precision direct mass measurements of ground states and low-lying isomers in heavy and superheavy isotopes with SHIPTRAP.	2021	nothing	
E143	Search for the nuclear two-photon decay in swift fully-stripped heavy ions	2021	PRL 2024	

A New Island of Asymmetric Fission

S455 accepted 2020, run in 2021

P. Morfouace *et al.* Nature 641, 339 (2025)

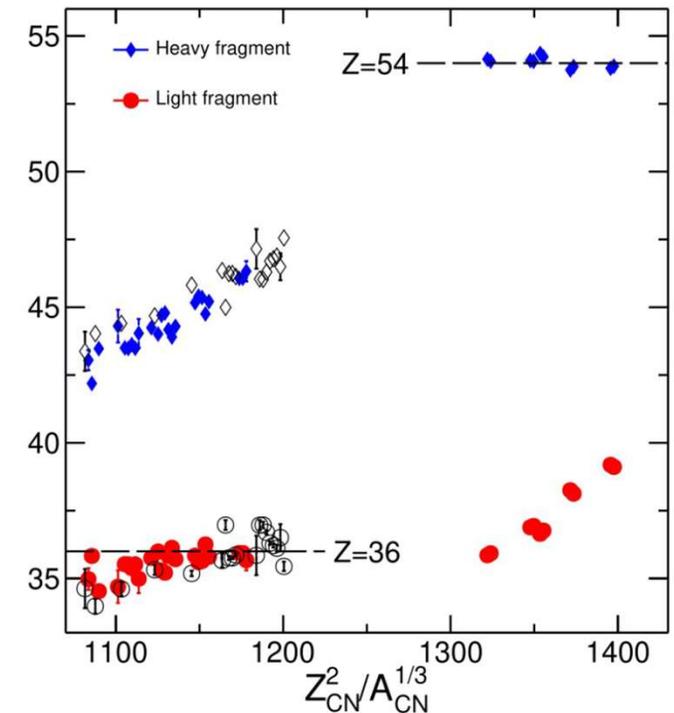
DOI 10.1038/s41586-025-08882-7



Results

- First set of charge distribution across a wide range of exotic fissioning systems.
- Experimental evidence of strong proton-shell stabilization at $Z=36$

Unlike the actinides, the asymmetric fission in the neutron deficient sub-lead region is driven by shell effect in the light fragment.



Quasi-real-time range monitoring in hadron therapy using positron emitters of carbon and oxygen

S533 accepted 2020, run 2021

Best candidate?

^{16}O beam \rightarrow ^{15}O 43 mb 122 s
 ^{14}O 1.2 mb 71s

^{12}C beam \rightarrow ^{11}C 47 mb 1221 s
 ^{10}C 4.3 mb 19 s

Sivaji Purushothaman et al., Sci Rep 13, 18788 (2023)

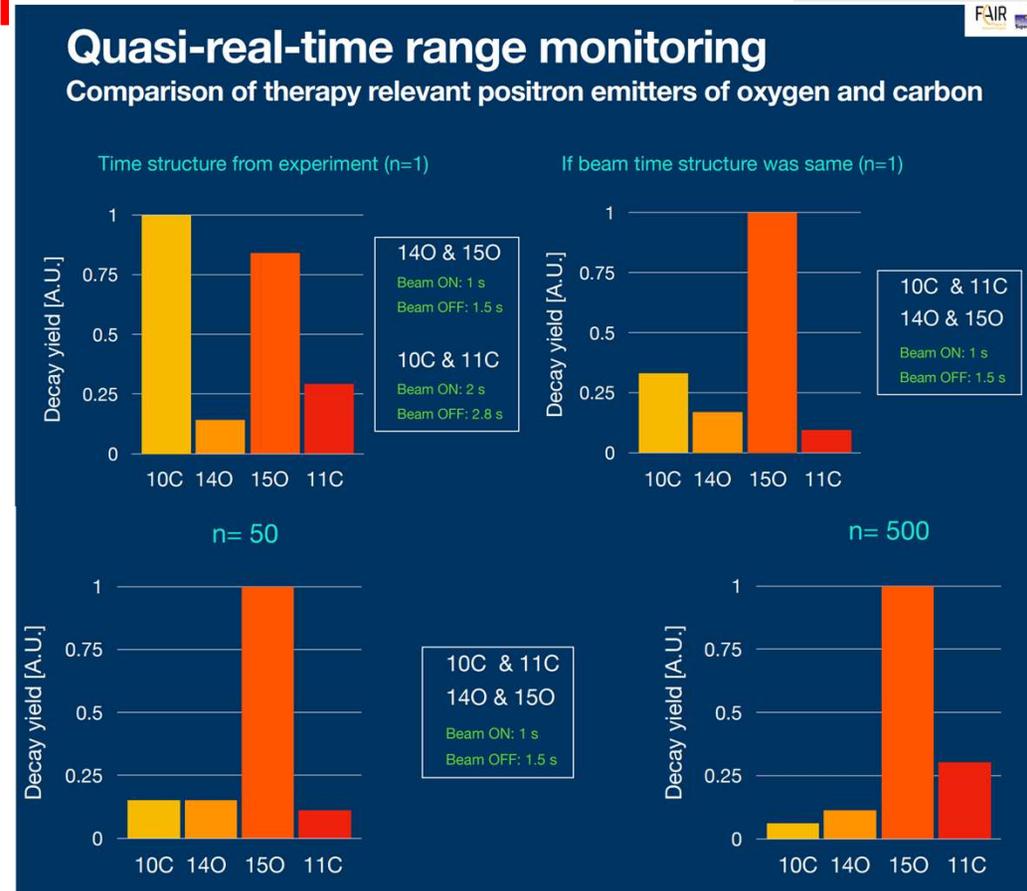
Quasi-real-time range monitoring by in-beam PET:

a case for ^{15}O

BIOMAT

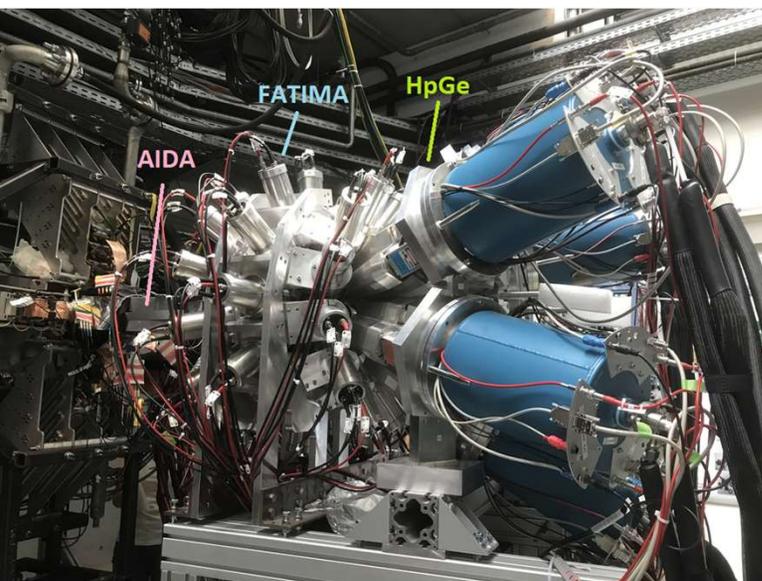
also hadron therapy with ^{11}C on mouse **in Feb. 2024;**

Boscolo et al., Nature 21, 1648 (2025)

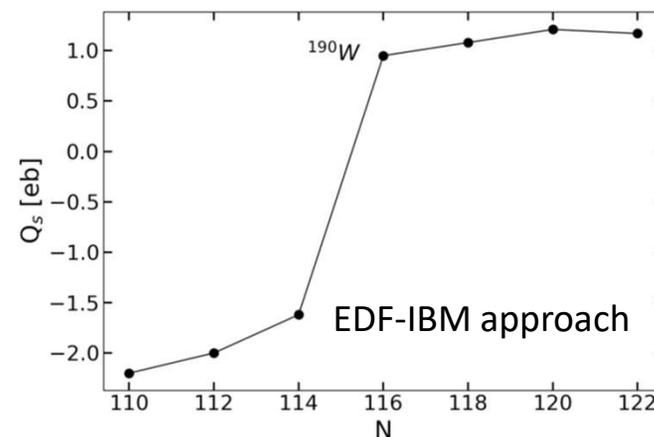
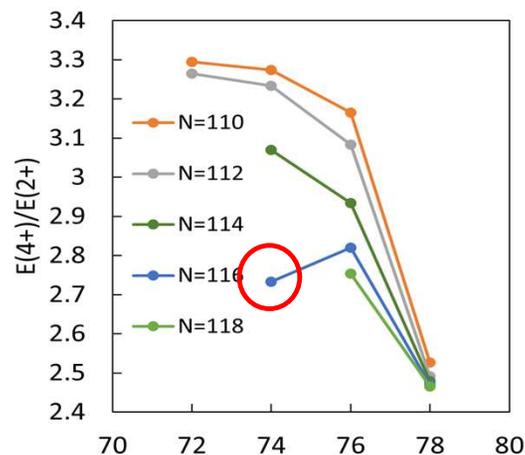
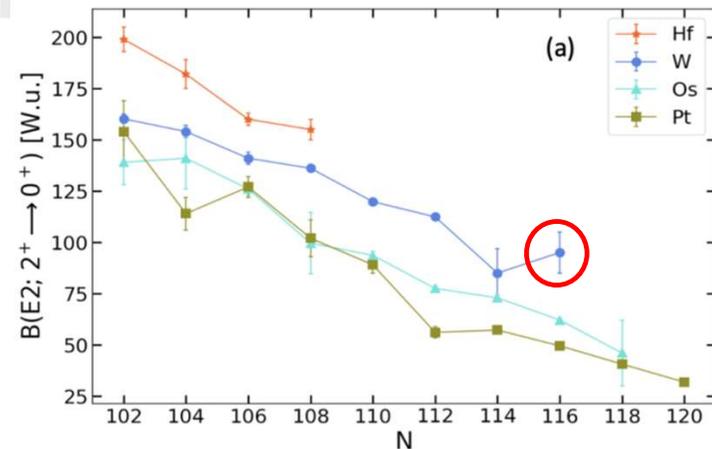
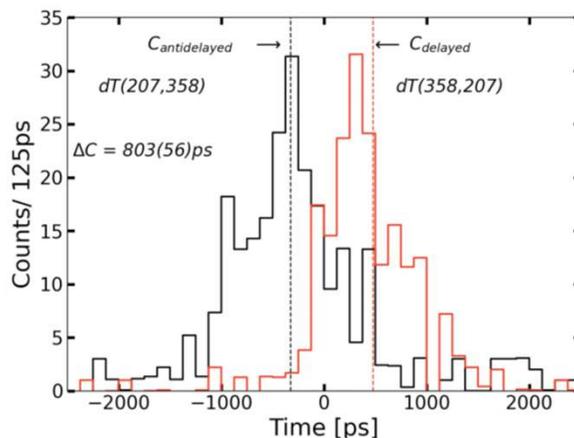


Prolate-oblate shape transition at $^{190}\text{W}_{116}$

S452 accepted in 2020, run in 2021



Hybrid array for fast-timing measurements

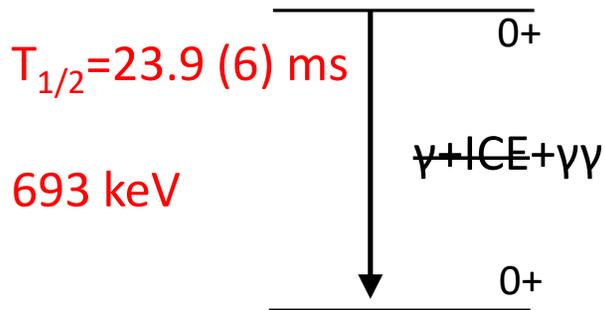


E. Sahin et al., Phys. Lett. B 857, 138976 (2024)

E143 approved 2020, run 2021

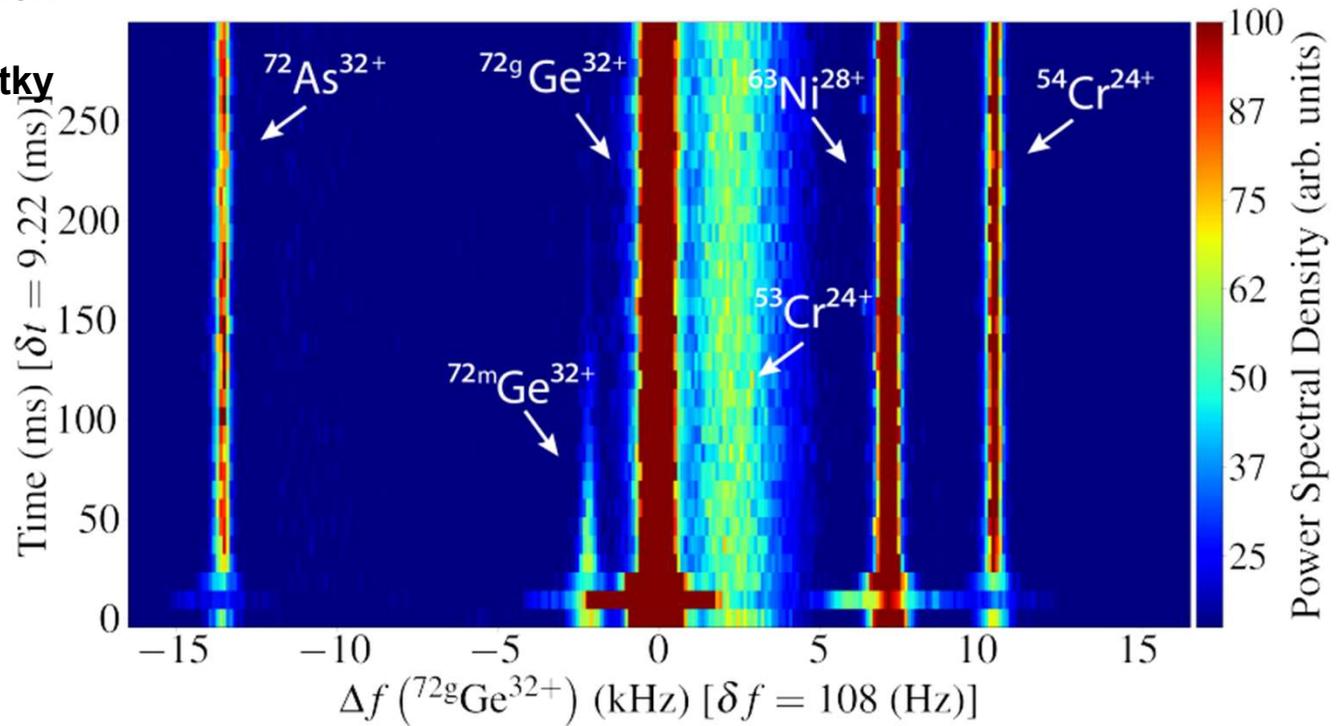
- High precision isochronous condition
 - Mass resolution $\sim 10^{-6}$
- Single-ion sensitivity of new Schottky

Rare processes



excitation energies down to $\sim 100 \text{ keV}$
and half-lives as short as $\sim 10 \text{ ms}$.

^{98}Mo and ^{98}Zr in May 2024

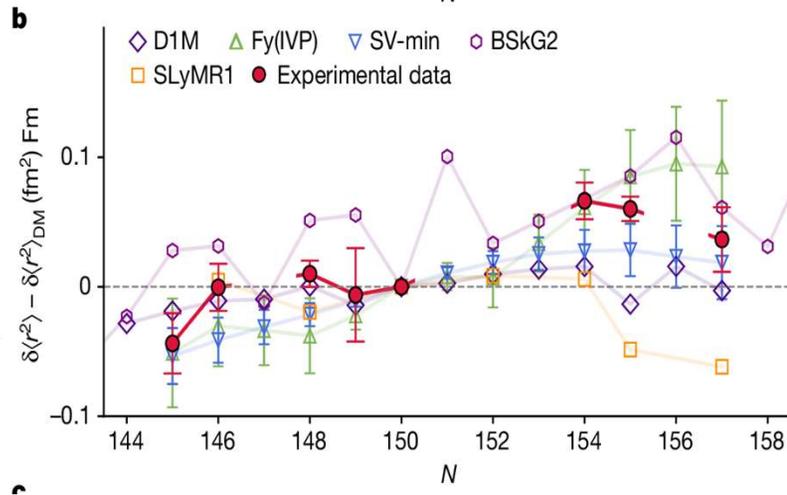
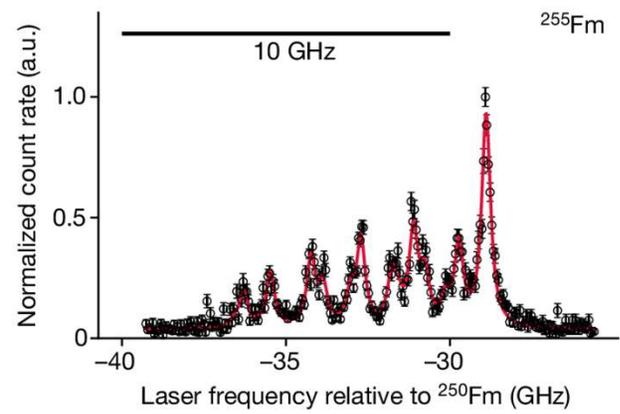
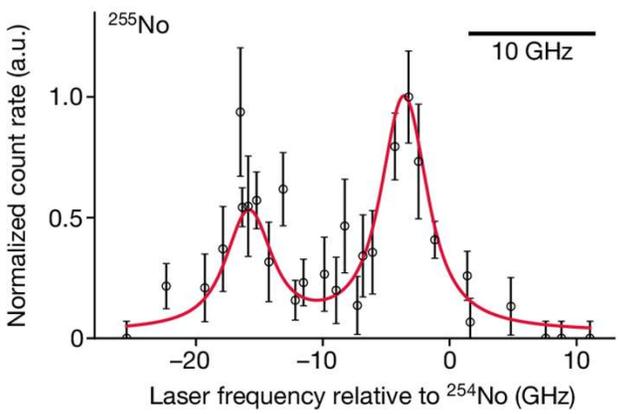
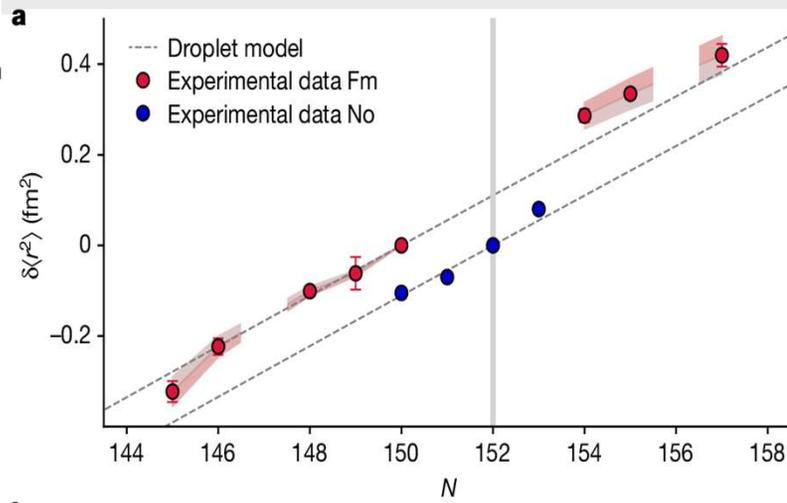
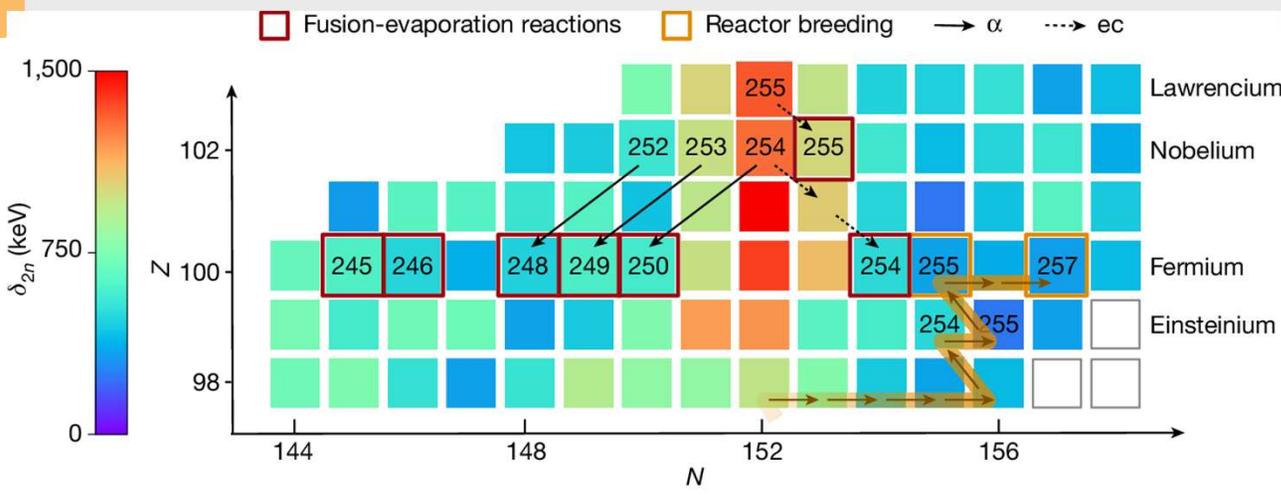


D. Freire-Fernandez et al., Phys. Rev. Lett. 133, 022502 (2024)

New lifetime record: 1 ms in April 2025, bridge to decay spectroscopy

Smooth trends in fermium charge radii and the impact of shell

U321 accepted 2020, run 2021-22



J. Warbinek et al., Nature 634, 1075 (2024)



G-PAC outcome: experiments in “2026-2027”



	outcome	A shifts	A- shifts
ILIMA	1 A; 3 A-; 3 B	15	27
HISPEC/DESPEC	3 A (1 resubmitted); 1 A-; 2 B	36	14
SuperFRS-EC	4 A; 0 A-; 3B; 4C; (one A for applications proposal)	48	0
R3B	2 A (1 resubmitted); 1 A- ;3 B	48	9
SHE	4 A ;2 A-	216	81
NUSTAR:	TOTAL:	363	131
	granted experiments has also been made public: https://gate.gsi.de/cgi-bin/prop-overview?ranking=a		

Postponed! To be run at FAIR?



NUSTAR tests and commissioning “2026-2027”



The NUSTAR collaboration manages the relevant tests and commissioning
(in the past G-PAC or management decided)

We were asked to develop a realistic scenario on NUSTAR’s detectors tests in those two years and how we intend to make best use of this beamtime (**email 25 April 2025**)

The collaboration will take responsibility:

- + Increased cohesion within NUSTAR
- + Flexibility
- oversubscribed => need to prioritise

Principle for priorities: prepare for the Early Science (with SuperFRS from end of 2027) and First Science (with SIS-100+SuperFRS from end of 2028)



NUSTAR tests and commissioning “2026-2027”



Outcome: 1 Oct. 2025

Proposal	Title	Facility	main (ic)	sec (ic)	paras	Ion species	
G-24-00256/UR	R3B - 2027 COMMISSIONING CALIFA, TRT, PAS, ACTAF & Tracking Working Groups	cave C	6		10	100X, 238U	A*
G-24-00302/UR	Test of the DESPEC Implantation Stack Detectors	1.1-S HFS			6	Parasitic mode, preferen	A*
G-24-00214/UR	Detector tests for the (Super-)FRS Ion Catcher	1.1-S HFS			18	238U preferred (Z>74)	A*
G-24-00252/UR	Test of the DESPEC FIMP' implanter	1.1-S HFS			12	A>100, fragments	A
G-24-00285/UR	FRS and detector developments for NUSTAR and joint NUSTAR-APPA experiments	1.1-S HFS	12			light (Ne...Ni), medium-h	9 shifts A ,3 A-
G-24-00264/UR	In-beam test of the MONSTER detector modules and associated digital DAQ	1.1-S HFS		15		180	it should be combined with G-24-00302/UR or G-24-00252/UR (EDAQ part only); 0 days
G-24-00262/UR	Commissioning of the HISPEC Plunger and investigation of the atomic background in experiments at relativistic energies	1.1-S HFS		3		74-Ge (or alternatively 5	B
			15	0	46		

$$=15+0.1*46= \sim 20 \text{ shifts} + \text{protons for R3B}$$

Additional beamtime for SuperFRS detectors! **Postponed! To be run at FAIR?**

Commissioning (first results) experiment follows directly Super-FRS commissioning

Need to be published fast (preparation; flexibility in primary beam selection)

Low risk (follows directly from SuperFRS commissioning)

-use new capabilities (transmission, beam energy, etc.)

Decay setup: Ge+Si active stopper/passive stopper

“Decay experiments are “the easy ones” to start with”

R3B commissioning

First full experiment R3B (unique)

Experiments in the SuperFRS tunnel and high-energy cave

Which ones?



Early science in 2028; what to do?



Meeting with FAIR management Oct. 2025.

=> **NUSTAR to make a plan-plans for 2028 (Early Science)**

Will there be a PAC/PEC for expts. in 2028?

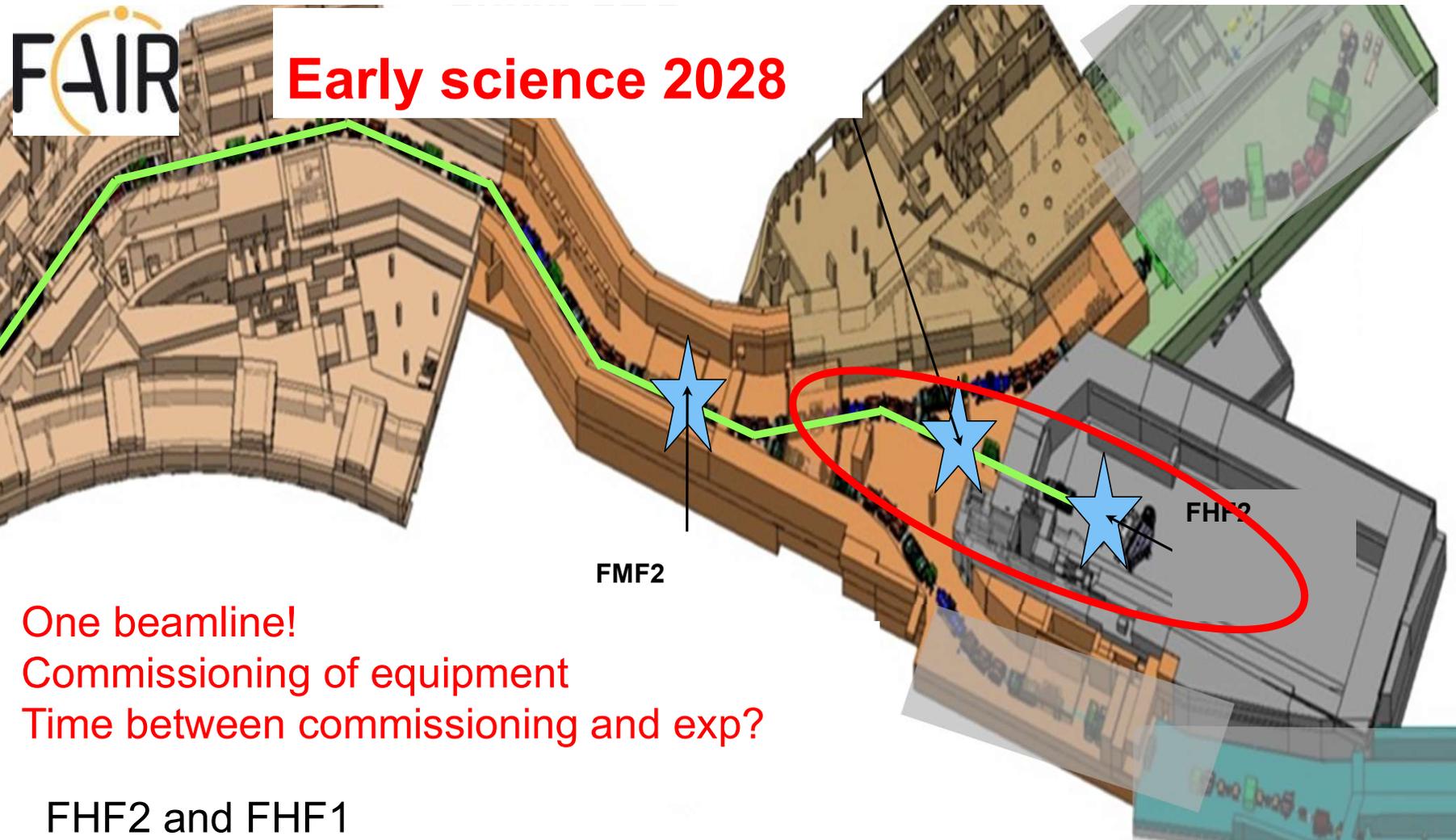
Possibly only for GSI, not for FAIR

(PECs will replace both ECE and PAC)

NUSTAR presented the suggested process on how to develop the programme, and principles, at the ECE/ECSSG 5 Nov 2025

Flexibility needed (one beamline for several setups!)

Lots of technical boundary conditions



FMF2

FHF2

One beamline!
Commissioning of equipment
Time between commissioning and exp?

FHF2 and FHF1
Only R3B, HISPEC/DESPEC, Super-FRS EC

Maximise impact

- low number of setups
 - in high-energy cave
 - SuperFRS tunnel (FHF1 only)
- physics cases are being collected (Lols)
 - R3B (fission, neutron skin, etc),
 - DESPEC (which setup? Ge+Si?)
 - SuperFRS-EC (new cryogenic stopping cell?)

Planning for several scenarios

Discussions started within Board and Collaboration Committee
(Technical Board input!)

Learn from RIBF/RIKEN. And FRIB. And HIAF.

Maximise impact

- low number of setups
 - in high-energy cave
 - SuperFRS tunnel (FHF1 only)
 - physics cases are being collected (Lols)
 - R3B (fission, neutron skin, etc),
 - DESPEC (which setup? Ge+Si?)
 - SuperFRS-EC (new cryogenic stopping cell?)
- + accepted proposals+tests previously planned for 2026-27

Planning for several scenarios

Discussions started within Board and Collaboration Committee

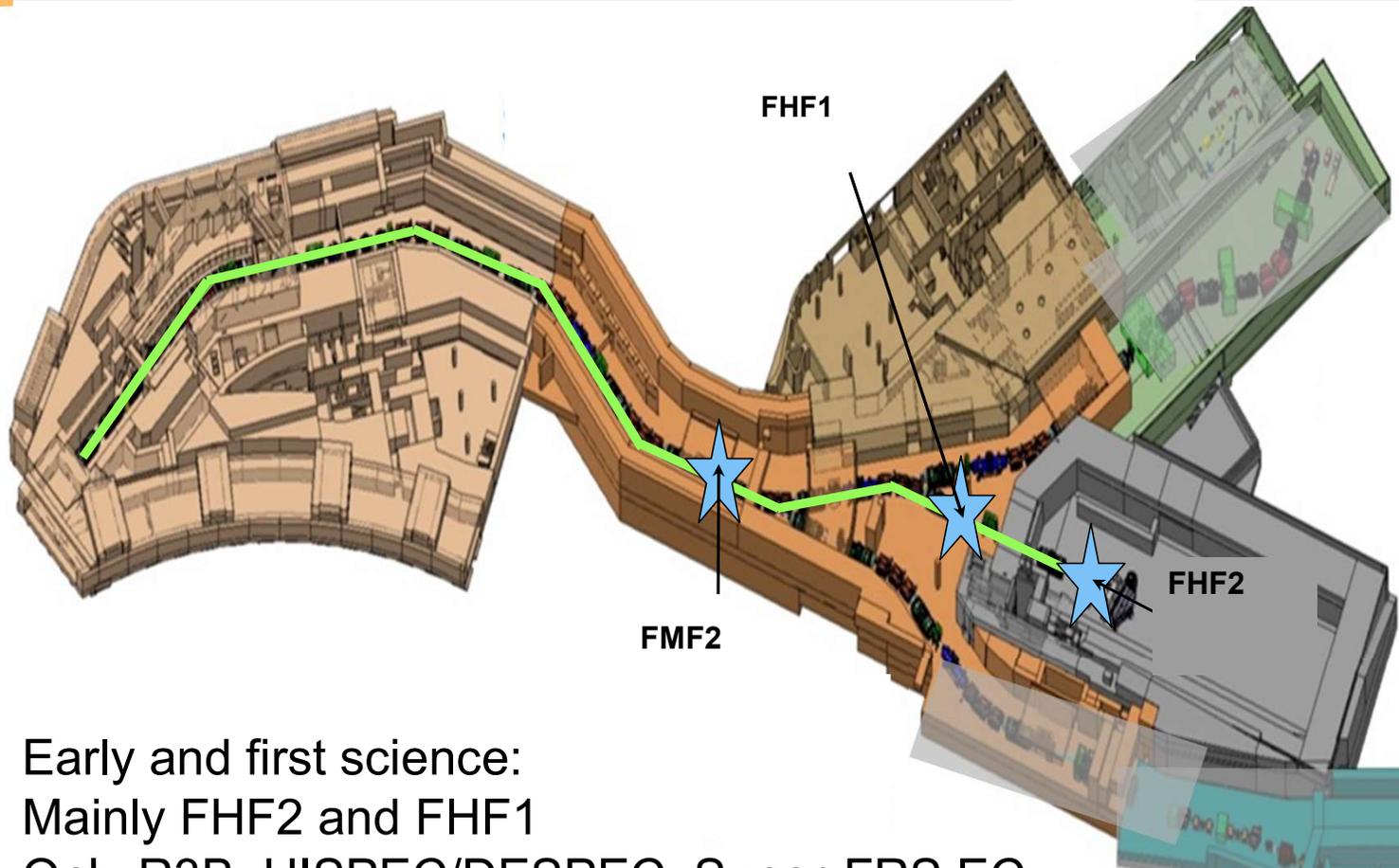
Learn from RIBF/RIKEN. And FRIB. And HIAF.

Why do we need a plan for Early Science?

FAIR site not affected by fire
Installation going to plan

We need to specify primary targets for SuperFRS!
-fewer targets than at FRS; fixed for several years

We need to know which beams we want!
-even more important now when solutions for injector are discussed



Early and first science:
 Mainly FHF2 and FHF1
 Only R3B, HISPEC/DESPEC, Super-FRS EC

FS++
Low-energy branch
 -needs infrastructure
 -serves:
 Super-FRS EC,
 HISPEC/DESPEC,
 MATS,
 LASPEC
-physics workshop:
1 October 2025



Low-energy branch physics workshop



1 October 2025 (Prague ~40 people and online ~45 people= ~85)

LEB technical background: Martin Winkler

SuperFRS-EC: Timo Dickel

HISPEC (AGATA): Kathrin Wimmer

DESPEC: Alejandro Algora

MATS: Tommi Eronen

LASPEC: Kristian Koenig

Discussion

Some physics cases described in published works:
e.g. AGATA (Korten et al., EPJA 56, 137 (2020),
Bentley, Benzoni, Wimmer EPJA 59, 172 (2023)

Parallelised operation

Space and low background (zero degree)

MATS (high precision mass measurement)

LASPEC (laser spectroscopy)

SuperFRS-EC

DESPEC

DTAS (total absorption spectrometer)

MONSTER (neutron spectroscopy)

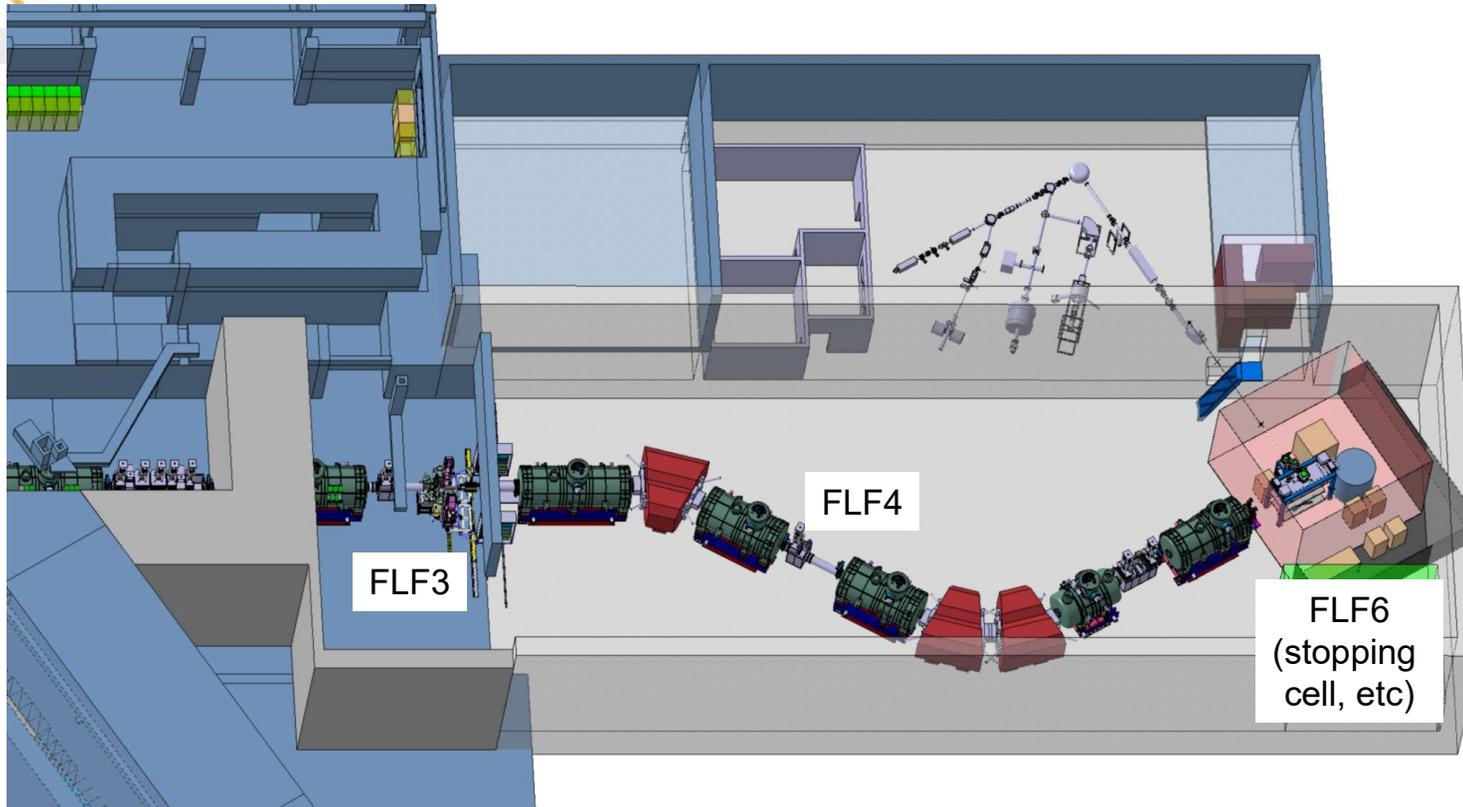
BELEN (neutron counter)

HISPEC: AGATA + LYCCA (Pygmy giant res., Coulex? $A < 100$ knockout?)

Buncher/spectrometer (need to be optimised?)

HISPEC: AGATA + full ID for high Z

Increased yield for MATS, LASPEC, SuperFRS-EC



Strategy:
follow the CBM
precedent

Aim: request to
the FAIR Council,
second part of
2026 (?)

- Technical building infrastructure
- Complete Low-Energy Branch up to FLF3 >2.5 yr
- Realise full Energy Buncher up to FLF6 ≈5 yr

“around 6 a.m. on February 5 in the area of the high-voltage power supply for the UNILAC linear accelerator at the GSI facility, presumably due to a short circuit.”

“this fire which impairs UNILAC operation severely, the beamtime in 2026/27 cannot run as they were planned.”

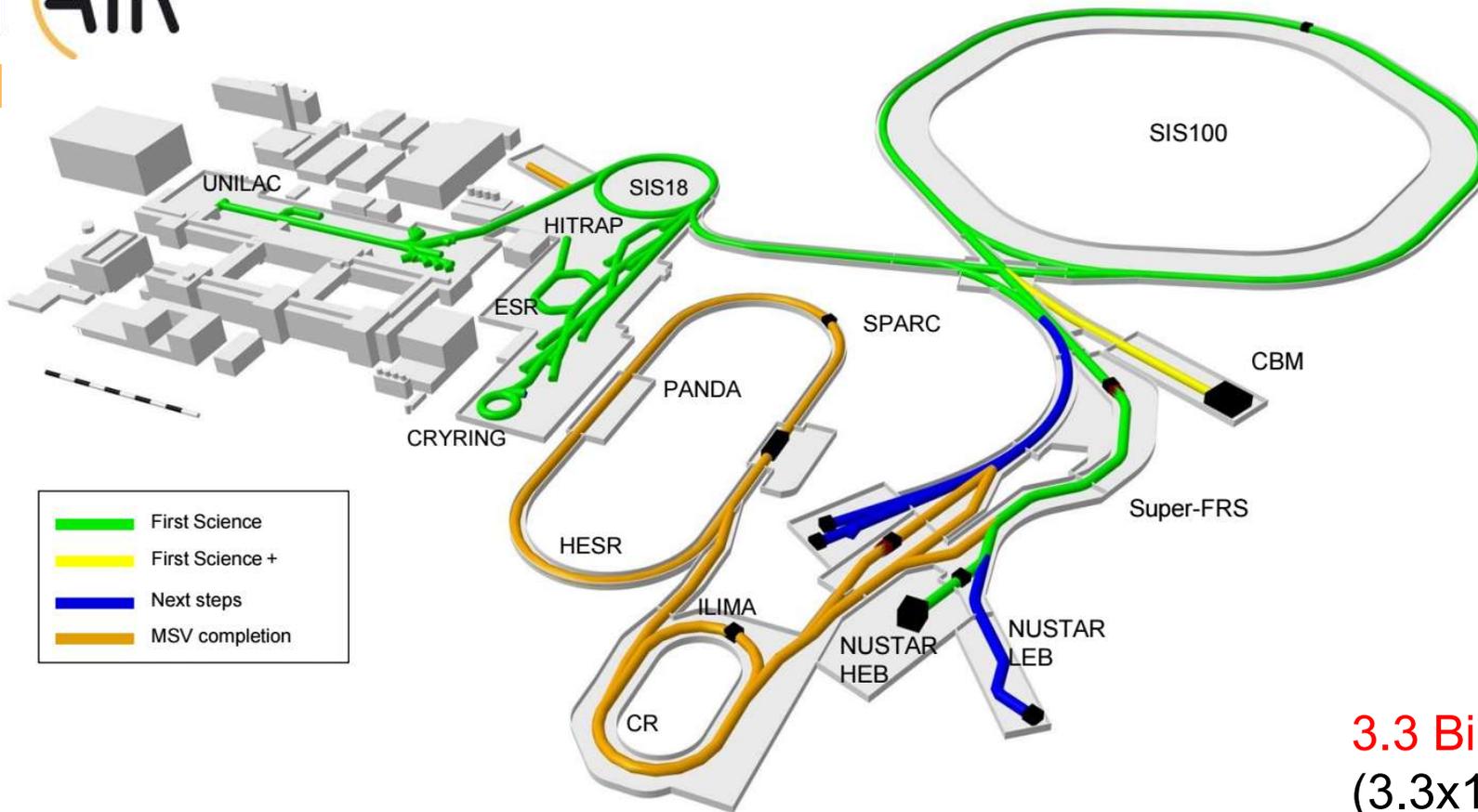
“in 2026 we actually expect no beamtime at the UNILAC-dependent facilities UNILAC, SIS18, FRS, ESR.”

“Technical concepts for partial use of UNILAC and alternative injectors are being developed and evaluated at the moment”

(talk by Ralph Assmann)

Joint task force involving the **Federal Ministry** of Research, Technology, and Space, the **Hessian Ministry** of Science and Research, Arts and Culture, and the **management**
=> funds?

Campus Science Task Force
NUSTAR represented



- First Science
- First Science +
- Next steps
- MSV completion

← until 2028

← after 2028

3.3 Billion Euros
(3.3×10^9)

NUSTAR is the first user of FAIR (SuperFRS); this has not and should not change;
for injector a competitive solution needs to be found

- publish previous results (many of them publicly available in PhD thesis)
- focus on starting FAIR
- injector; FAIR/NUSTAR competes with FRIB and RIBF/RIKEN. And HIAF
=> it needs a solution which allows high intensity heavy beams

FAIR

Now

HUSTAR 



FAIR

A solution

HUSTAR 



The solution



No UNILAC beams for 2026 ...

FAIR Phase-0 is productive and assures readiness for Early and First Science

NUSTAR ES&FS experiments will mark the start of FAIR
Highest priority

Solution for a FAIR injector is needed;
one which allows for competitive NUSTAR experiments

Which experiments for Early Science?

Plan for FS++: road to low-energy branch (science, costs etc.)

