Super-FRS Experiment Collaboration: Day-1 configuration

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On behalf of the Super-FRS Experiment Collaboration

ECE & ECSG meetings
5 November 2019

Super-FRS Experiment Collaboration

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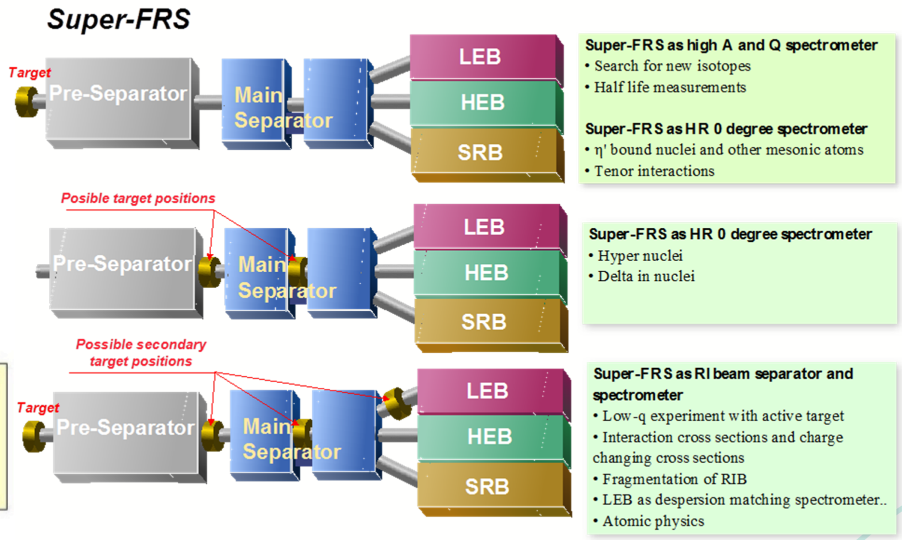
H. Weick (ex officio)
M. Winkler (ex officio)

External technical advice

- Int'l. Expert Meeting
- Int'l experts
- FAIR MAC
- ...



Mandate

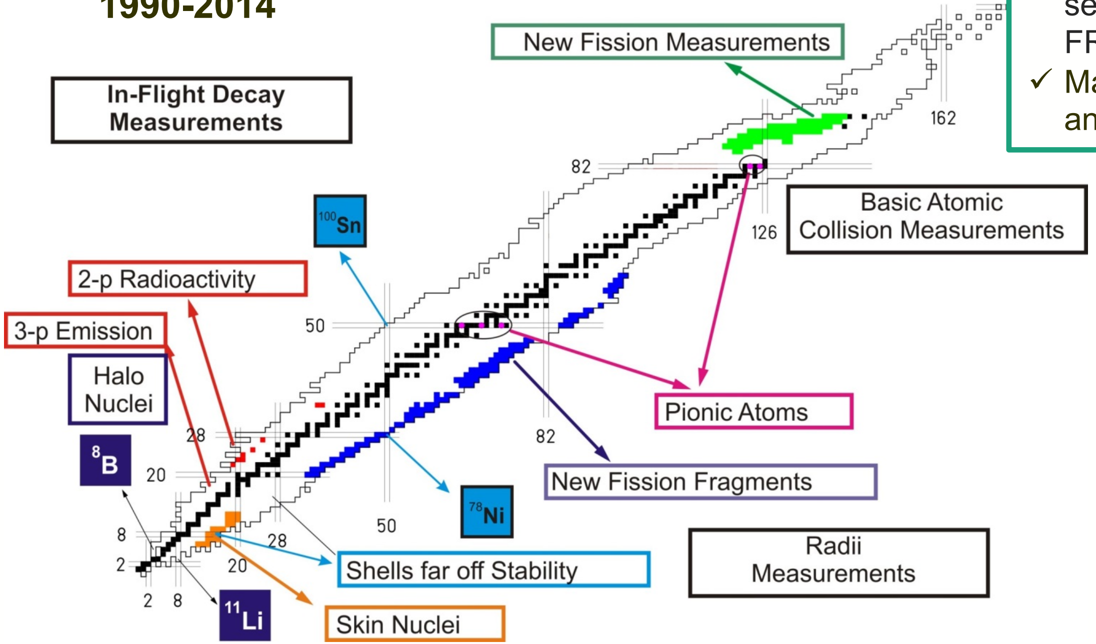
1. Exploitation of Super-FRS in separator-spectrometer experiments
2. Support development and construction of Super-FRS and its sub-systems

Super-FRS Experiment Collaboration news

- ✓ Collaboration meeting was held in Walldorf on 17-19 June 2019
- ✓ Collaboration Agreement (CA) was circulated earlier among the participating universities/institutes
- ✓ So far 40 institutes have signed the agreement (82%) and therefore it is in force
- ✓ CA defines organisation structure, membership and best practises within the Collaboration

Landmarks from FRS Experiments

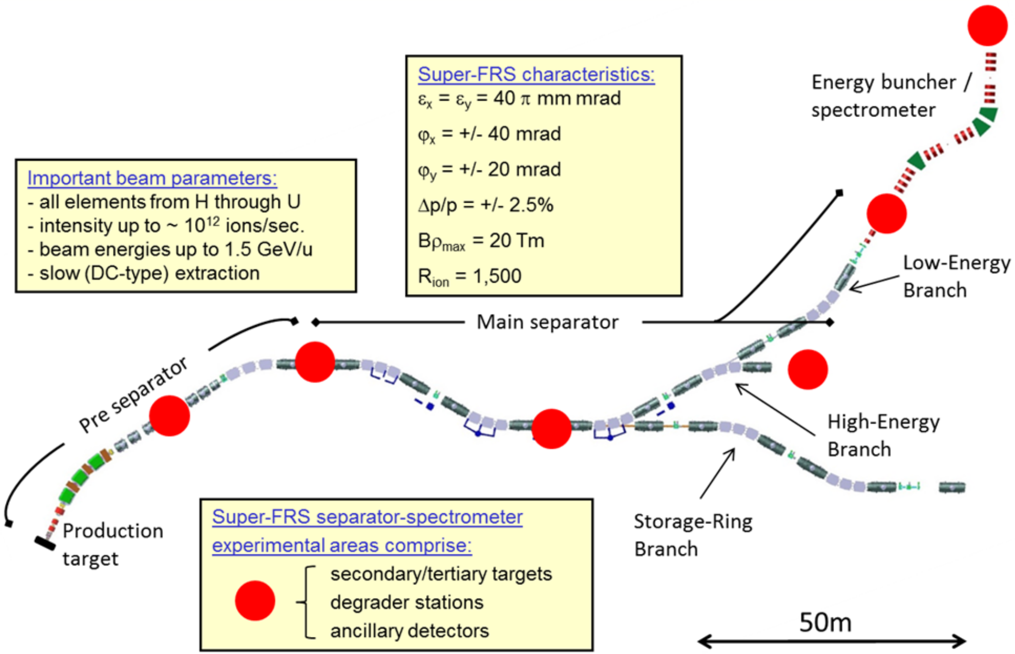
1990-2014



Super-FRS Experiment Collaboration

- ✓ Experimental programme emerges from the (pilot) separator-spectrometer experiments performed at FRS
- ✓ Mandate is to support the *realisation of Super-FRS* and pursue its *experimental programme*

I. Tanihata et al., GSI Report 2014-4
doi:10.15120/GR-2014-4



Super-FRS separator-spectrometer

- ✓ High-energy primary beams of FAIR, high momentum-resolution multiple-stage spectrometer with large acceptance and flexible ion-optical settings ⇒ rendering *unique science programme*
- ✓ Versatile, multiple-stage spectrometer experiments by different combinations of separator sections
- ✓ Large part of the physics programme can be carried out *by using the standard Super-FRS detectors*
- ✓ Appealing addition to the NUSTAR experiment portfolio

Science topics

✓ **Super-FRS for high mass and charge resolution (early stage)**

1. Rare isotope yields and limits of existence
2. Atomic collision studies at relativistic energies

✓ **Super-FRS as high-energy and high-resolution spectrometer**

3. Spectroscopy of meson-nucleus bound system (mesonic atoms)
4. Exotic hypernuclei and their properties
5. Effect of tensor forces in nuclear structure at high momentum transfer
6. Delta resonances probing nuclear structure

✓ **Super-FRS as a multi-stage separator and spectrometer**

7. Nuclear radii, skins and state-selective momentum distributions
8. In-flight radioactive decays and continuum spectroscopy by particle emission (EXPERT)
9. Low-*q* experiments with an active target
10. Reaction studies and synthesis of isotopes with low-energy RIBs

Readiness for Day-1

PSP code	Description	Responsible person	TDR editor	phase	TDR via ECE	sub-mitted	TDR date	TDR number
1.2.10	**Super-FRS Experiments**	Isao Tanihata						
1.2.10.1	Infrastructure, DAQ, ancillary systems	Stephane Pietri (GSI, Germany)	Stephane Pietri	Day one	Yes	2019	May 2019	2_39
1.2.10.2	Cylindrical Detector System (CDS)*	Kenta Itahashi (RIKEN, Japan)	Take Saito	Phase 1	Yes	2024	Jul 24	2_42
1.2.10.3	Pion detection system*	Take Saito (GSI, Germany)		Phase 0				
1.2.10.4	Liquid hydrogen target	Alexandre Obertelli (TU Darmstadt, Germany)	Alexandre Obertelli	Phase1	Yes	2021	Jul 21	2_40
1.2.10.5	Tensor force detection system and chamber	Hooi Jin Ong & Takahiro Kawabata (Osaka)	Hooi Jin Ong & Takahiro Kawabata	Day one	Yes	2021	Jul 21	2_41
1.2.10.6	Ice target	Takahiro Kawabata & Hooi Jin Ong (Osaka)		Day one				
1.2.10.7	EXPERT	Ivan Mukha (GSI, Germany)	Ivan Mukha	Phase 1	yes	2016	Sep 16	2_38
1.2.10.8 ***	CSC adaptation/application for physics Topic 10c of Super-FRS Experiment Collaboration**	Wolfgang Plaß (GSI/Giessen)	Wolfgang Plaß	Day one	yes	2018	Aug 18	2_02

WASA, Phase 0: For information only
Not to be scrutinized.

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✓ **Super-FRS as high-energy and high-resolution spectrometer**

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5. **Effect of tensor forces in nuclear structure at high momentum transfer**
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✓ **Super-FRS as a multi-stage separator and spectrometer**

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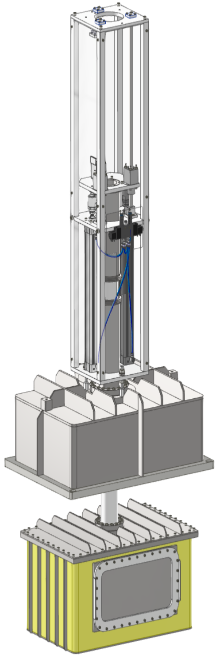
Standard Super-FRS detectors/equipment

Large part of the equipment needed in the Super-FRS Experiment Collaboration Day-1 experiments are standard Super-FRS equipment:

- Targets
- Degraders
- Beam profile/intensity monitors
- Detectors for particle identification

These are items in the ACC-CB and *already funded* by FAIR.

Additional equipment are and will be funded outside the FAIR budget.



Submitted TDRs vs. experiments/science topics

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Infrastructure TDR

Describes the equipment needed in the most of the experiments.

Data acquisition (NUSTAR DAQ):

- Some additional equipment needed (increased performance, closer location)
- In total 134 k€, Day-1 configuration 44 k€ (fully funded)

Other: vacuum components 6 k€, plastic scintillator 40 k€ (also funded)

Element	Number	Cost per unit	Cost total
Pendulum valve	3	40 000 €	120 000 €
Windows and pump	3	2 000 €	6 000 €
60ℓ dewar	2	15 000 €	30 000 €
LN2 piping	20 m	300 €/m	6 000 €
Total			162 000 €

	Super-FRS exp. collab.	
SEPs	D2, E2, H2	
	Units	Cost [kEUR]
VME		
VME crate	3	18
SLM VULOM-X	12	48
Opt. trans. x12	76	7.6
Timing		
BuTiS rec.	0	0
BuTiS ref. gen.	0	0
WR rec.	3	3
WR sw.	3	7.5
Network		
Switch (48+4)	4	8
Optical trans. 40-4x10	1	5
Optical trans. 10	4	6
Computing		
File server	.5	7.5
Netw. card+cable	2	1.5
Racks		
Racks	15	22.5
Sums		134.6

One focal plane i.e. 1/3 of this

Infrastructure TDR

The funded part for the Day-1 configuration makes it possible to run experiments for the following topics:

- Topic 1: New isotope search, cross section, reaction mechanism
- Topic 2: Atomic collisions

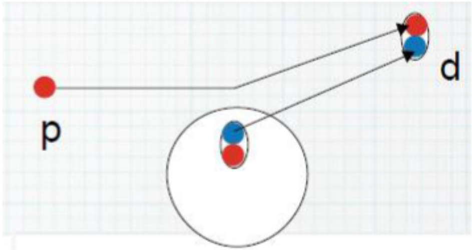
And if using the existing GSI MUSIC detectors, also

- Topic 7: Radii and momentum distributions

Tensor force detection system and chamber & ice target TDRs

To be submitted in 2021. Addresses the equipment required for Topic 5: Effect of tensor forces in nuclear structure at high momentum transfer.

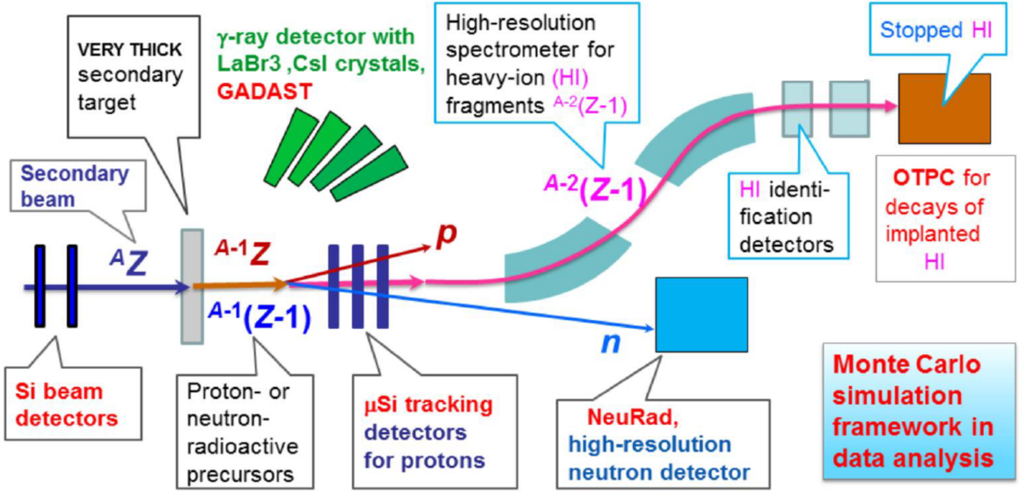
The Japanese and Chinese institutions have already equipment largely available. These existing detectors can be used for Day-1 experiments. New devices can be constructed when more funding becomes available.



EXPERT TDR

Was submitted in 2016 and subsequently approved by ECE.

Part of the equipment exists already and therefore the EXPERT set up is ready for Day-1 experiments



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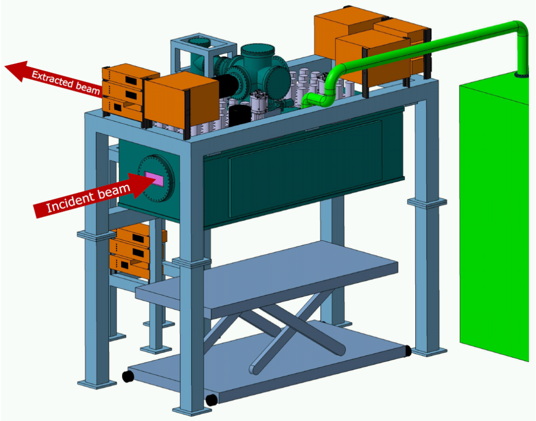
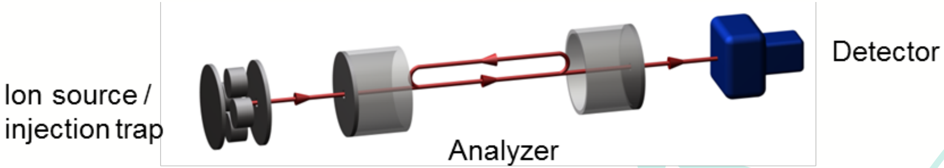
Cryogenic Stopping Cell (CSC) for LEB of Super-FRS (MATS, LaSPEC)

- TDR was submitted in 2018. The prototype exists and is in use for Phase-0.
- Will be used, together with MR-TOF-MS, for mass measurements (Topic 1)
- CSC will be adapted for Topic 10 (MNT reactions, beta-delayed neutron emission)





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Conclusions

- Day-1 (*funded by outside FAIR sources*) configuration is defined by the previous TDRs
- Most important: Super-FRS Experiment Collaboration is in a position to carry out unique experiments at Day 1
- Complementarity and collaboration: Super-FRS Experiment Collaboration aims to complement NUSTAR science portfolio and collaborate with other NUSTAR sub-collaborations
  - ✓ This is already happening with DESPEC and Phase-0 experiments

Thank You.

Existing equipment–EXPERT

Topic 8: In-flight decays	Responsible person:	A. Fomichev	Institute and funding			
Item name	Estimated cost/value (k€)	Status	Responsible person	Institute	Country	Funding source
Additional modules for GADAST	370	ready 50%, expected to be ready completely in 2021	V. Chudoba	Silesian Uni,Opawa	Czech	Silesian Univ.
NeuRAD - mechanical structure and readout electronics	450	prototype tested, expected to be available and ready in 2025	A. Fomichev	Flevov Institute	Russia	JINR Dubna
OTPC	220	old version ready 100%, new version expected to be available and ready in 2025	M. Pfutzner	Warsaw University	Poland	Warsaw Univ.
Si-microstrip DSD	540	ready 100%, new version will be available and ready in 2021	A. Fomichev	Flevov Institute	Russia	JINR Dubna
Si--SSD fast and radiation hard	300	ready 25%, new electronics will be available and ready in 2021	A. Fomichev	Flevov Institute	Russia	JINR Dubna
Chamber and support	60	expected to be available and ready in 2025	A. Fomichev	Flevov Institute	Russia	JINR Dubna
MC simulation framework	50	expected to be available and ready in 2020	L. Grigorenko	Flevov Institute	Russia	JINR Dubna

Existing equipment–Tensor force studies

Topic 5: Tensor force		Responsible person:	H.-J. Ong/S. Terashima	Institute and funding			
Item name	**Source**	**Estimated cost/value (k€)**	**Status**	**Responsible person**	**Institute**	**Country**	**Funding source**
Detectors for protons and neutrons at backward angles (BAND)	Equipment will be used which is already existing at Collaborating Partner Institute or at GSI	40	One of the two detectors exists and has been tested; the other detector is under construction, funding is available	H.-J. Ong	RCNP, Osaka	Japan	RCNP
Cryogenic H2O target	Equipment will be used which is already existing at Collaborating Partner Institute or at GSI	20	The existing device can be used; a new device will be constructed if funding becomes available	T. Kawabata	Department of Physics, Osaka Univ.	Japan	Osaka Univ.
Active proton target	New, TDR will be prepared (2021)	20	Under development, expected to be available in 2025	H.-J. Ong	RCNP, Osaka	Japan	RCNP
Fiber scintillator detectors	New, TDR will be prepared (2021)	210	One of the two detectors exists; the other detector is under construction	S. Terashima	Beihang Univ.	China	Beihang Univ.