gSPEC at GSI/FAIR

J. Gerl

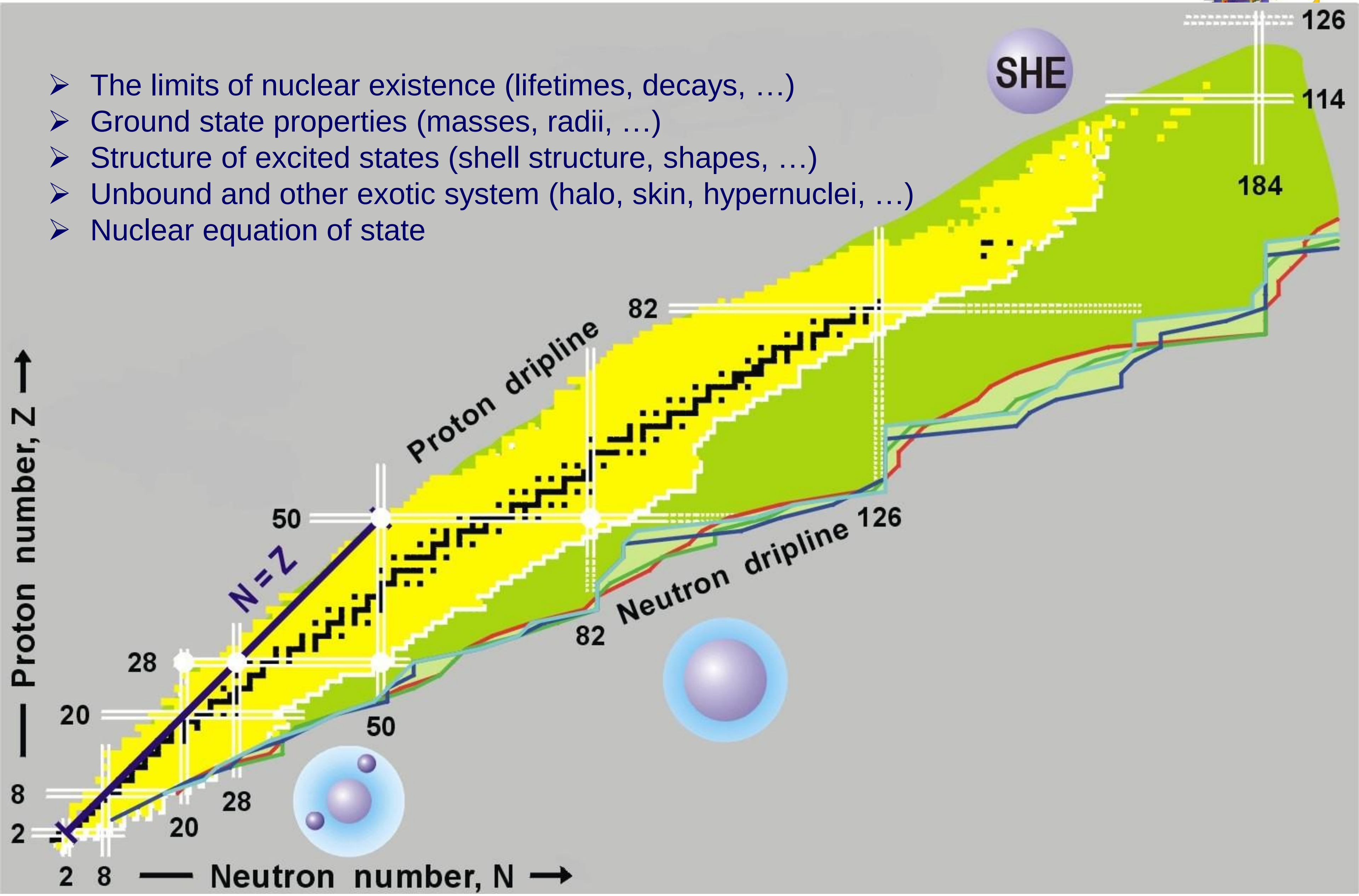
gSPEC Workshop

27. September 2018

Milano, Italy

NUclear STructure Astrophysics and Reactions

- The limits of nuclear existence (lifetimes, decays, …)
- Ground state properties (masses, radii, …)
- Structure of excited states (shell structure, shapes, …)
- Unbound and other exotic system (halo, skin, hypernuclei, …)
- Nuclear equation of state



NUSTAR - The Project

PSP code	Super-FRS	RIB production, separation, and identification
1.2.2	**HISPEC/ DESPEC**	In-beam γ-spectroscopy at low and intermediate energy, n-decay, high-resolution γ-, β-, α-, p-, spectroscopy
1.2.3	**MATS**	In-trap mass measurements and decay studies
1.2.4	**LaSpec**	Laser spectroscopy
1.2.5	**R^3B**	Kinematical complete reactions with relativistic radioactive beams
1.2.6	**ILIMA**	Large-scale scans of mass and lifetimes of nuclei in ground and isomeric states
1.2.10	**Super-FRS**	High-resolution spectrometer experiments
1.2.11	**SHE**	Synthesis and study of super-heavy elements
1.2.8	**ELISe(*)**	Elastic, inelastic, and quasi-free e^--A scattering
1.2.9	**EXL(*)**	Light-ion scattering reactions in inverse kinematics

(*) NESR required – alternative/intermediate “operation” within FAIR MSV under consideration.

NUSTAR Progresses very well

	NUSTAR sub-system	TDR	Cost [k€ 2005]	Funding	Construction	Date completion	Test/ Commissioning
Day 1	LEB infrastr.		1,606			06/2023	
	HISPEC/DESPEC		10,949			03/2024	
	MATS		1,173			08/2024	
	LaSpec		253			05/2021	
	R3B		17,313			03/2023	
	ILIMA		1,099			12/2023	
		80% *value weighted*	32,393	92% *secured*	54% *value weighted*		
	interface items		2,000				
			34,393	87% *secured*	51% *value weighted*		

…more details by Alex

DESPEC: Decay Spectroscopy

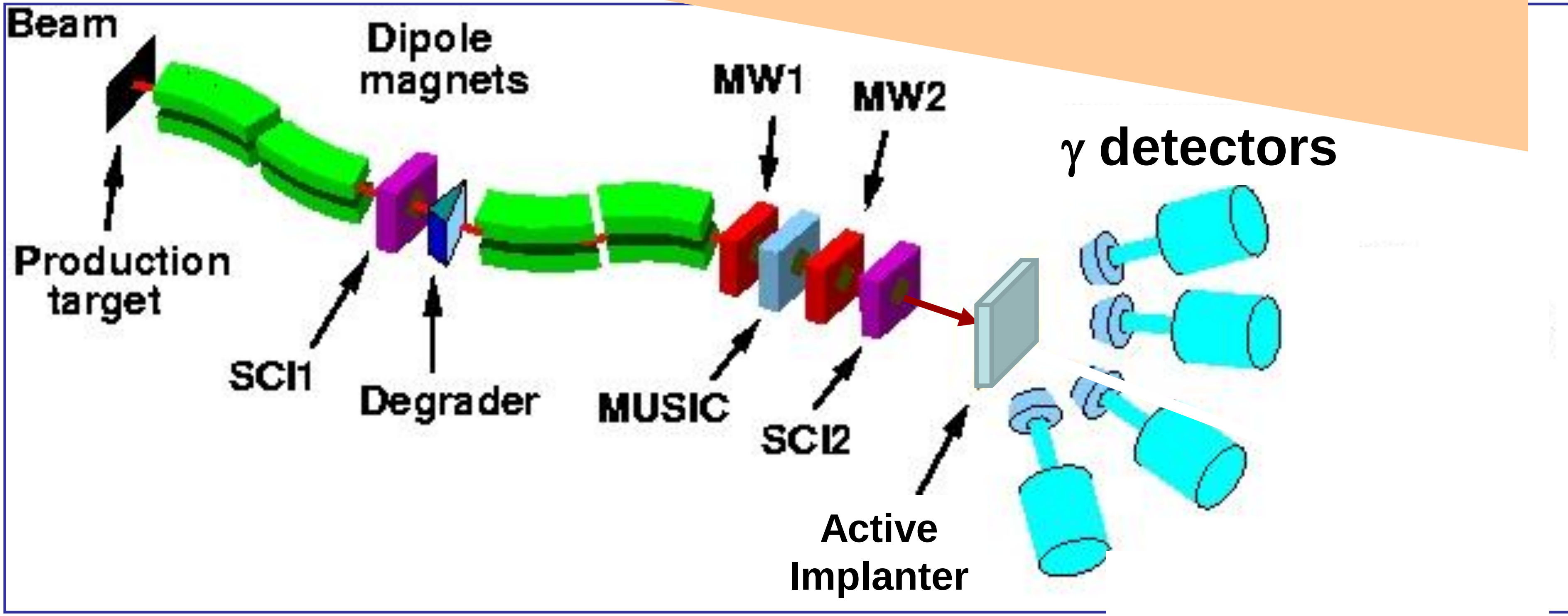
production

selection

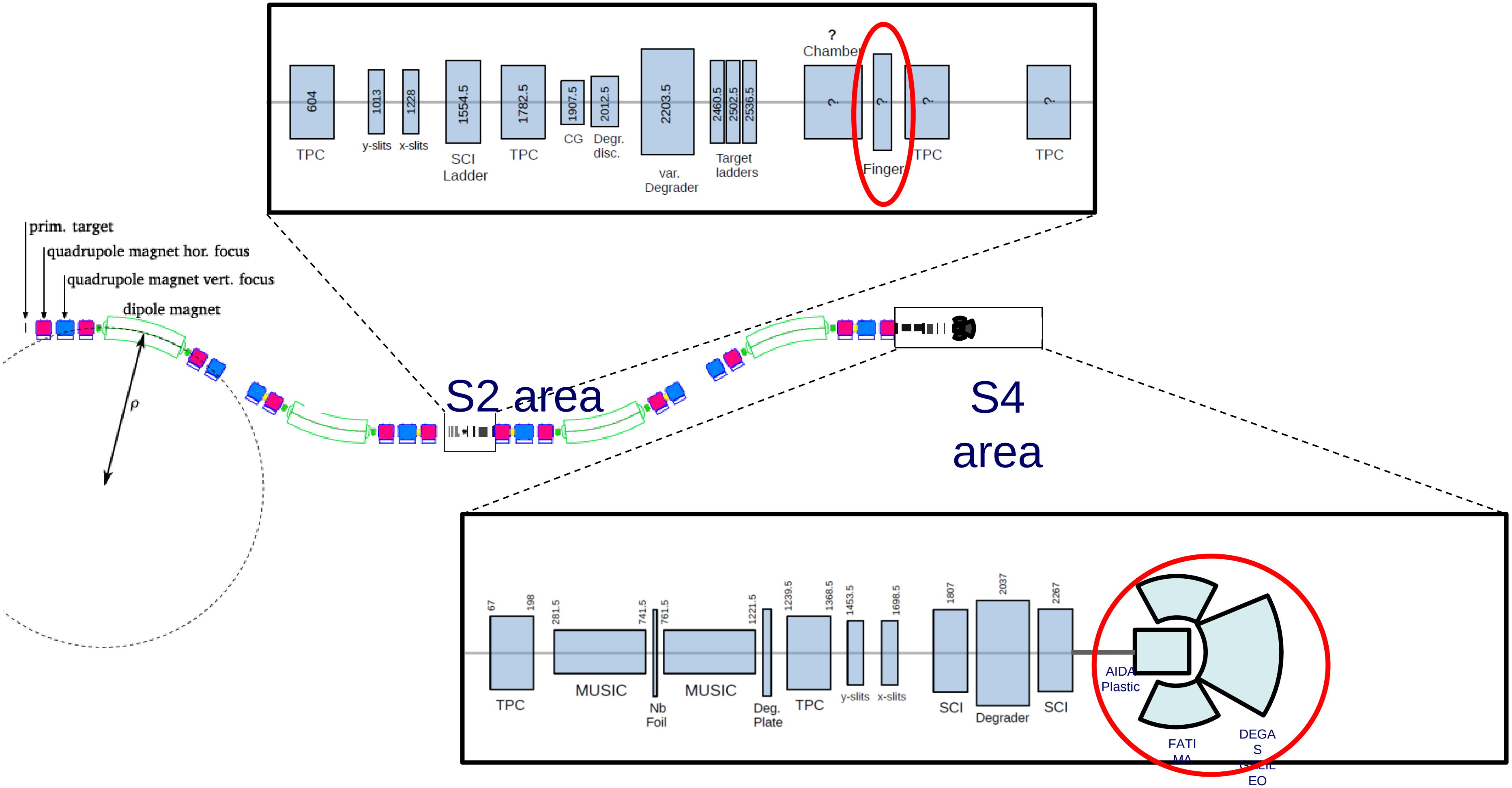
identification

implantation

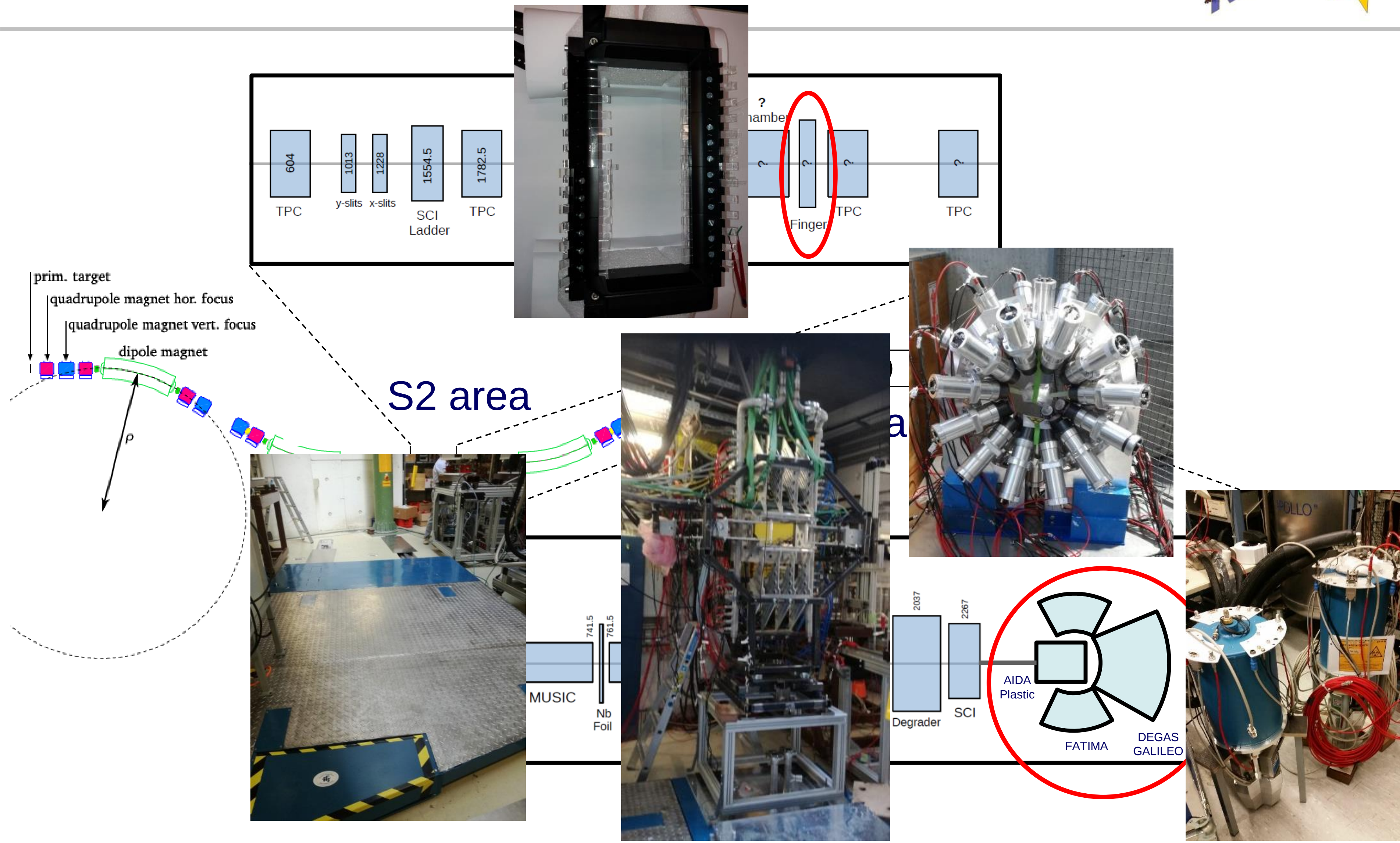
spectroscopy



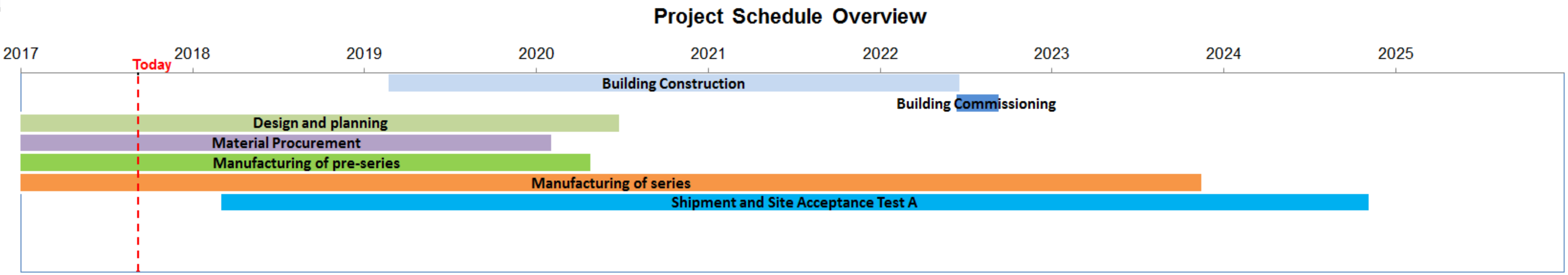
DESPEC Layout 2018

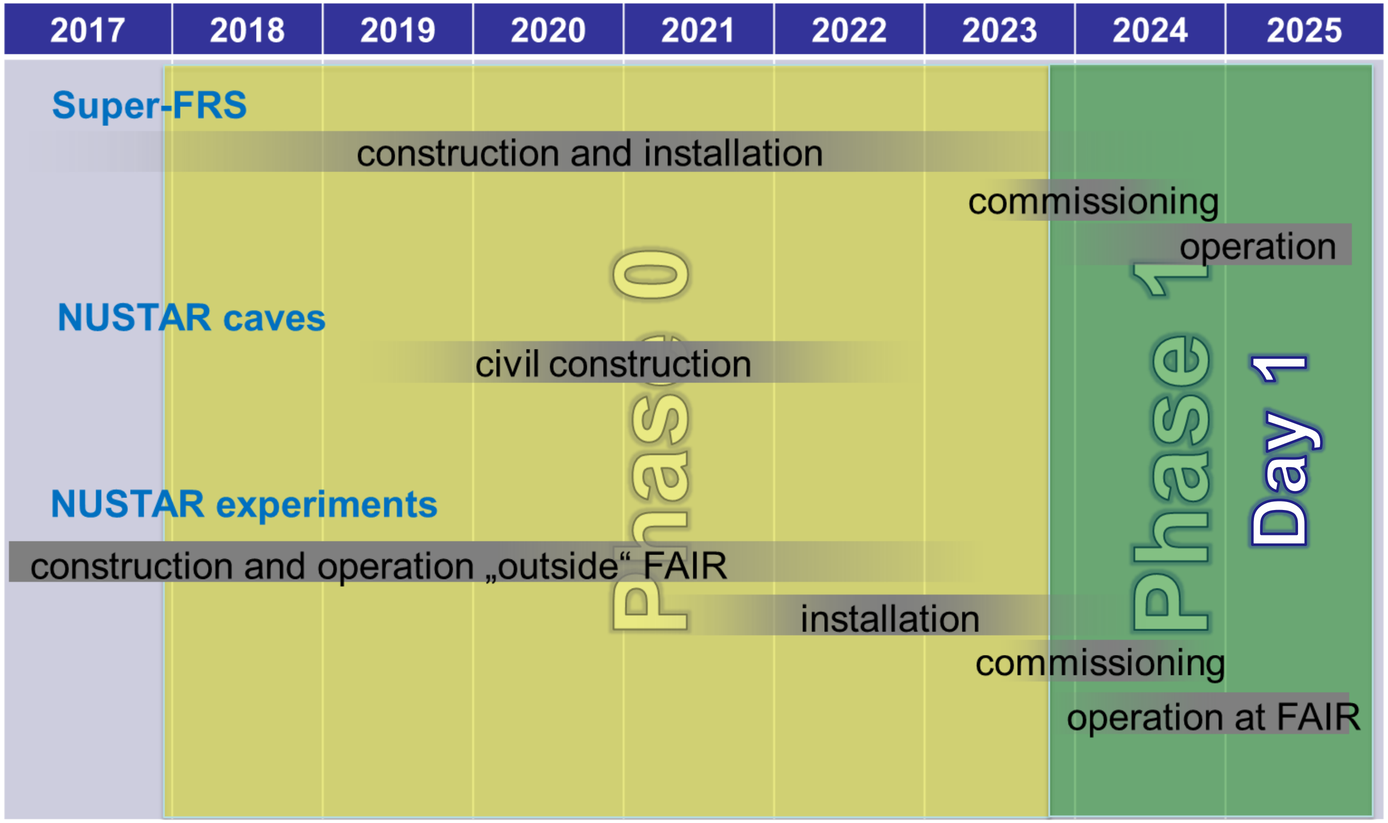


DESPEC Layout 2018



NUSTAR Overall Schedule





NUSTAR Phase 0 and Day 1

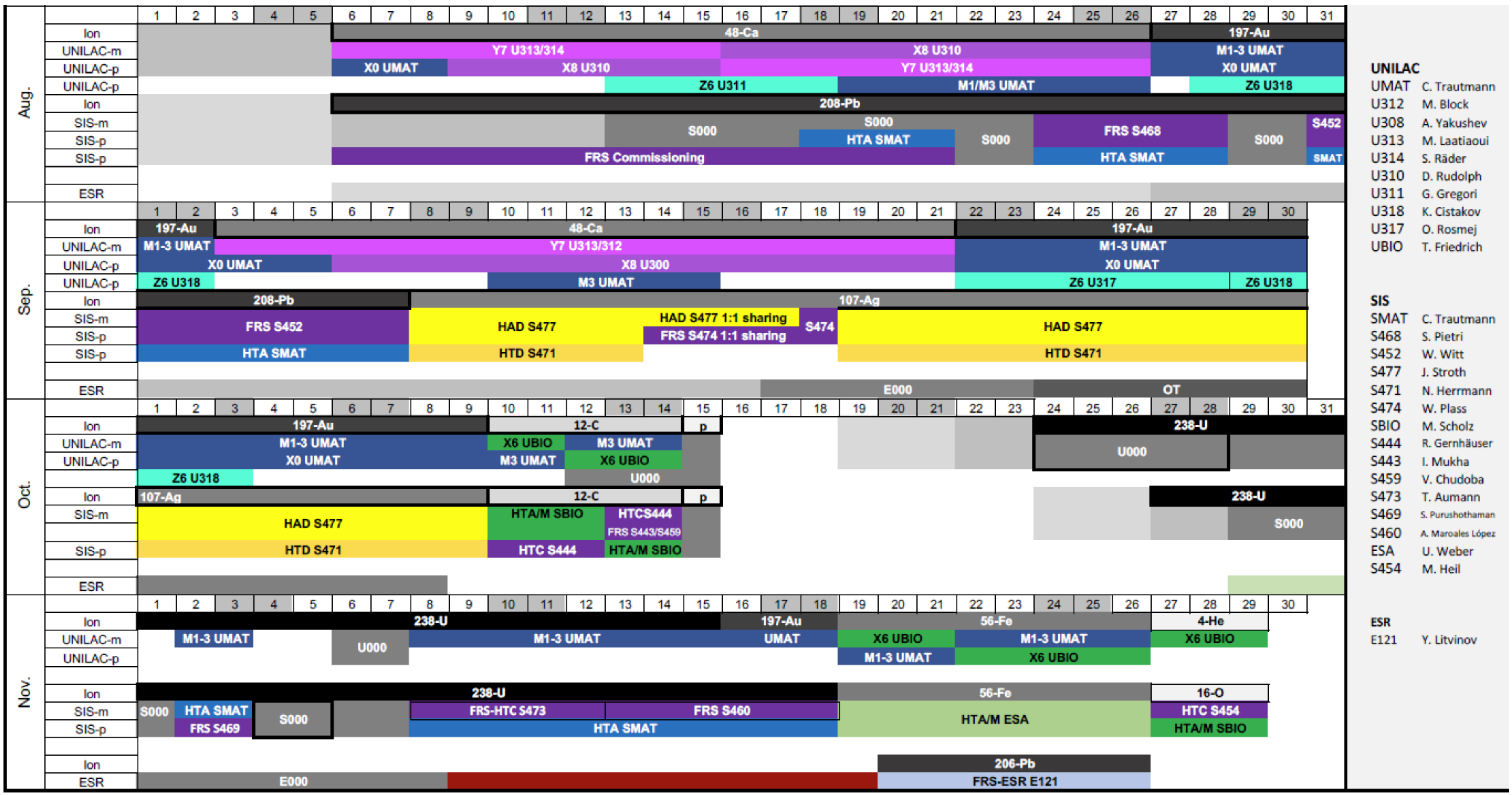
Granted beam time at FAIR/GSI Phase-0

FRS and detector commissioning/development w. parasitic beam

E121	Measurement of the bound-state beta decay of bare ^{205}Tl ions
E127	Measurements of proton-induced reaction rates on radioactive isotopes for the astrophysical p process
S465	Dipole response of the drip-line nuclei ^{6}He and ^{22,24}O
S442	Study of multi-neutron configurations in atomic nuclei towards the drip line
S467	Single-particle structure of neutron-rich Ca isotopes: shell evolution along Z=20
S455	Fission investigated with relativistic-radioactive beams and the advanced SOFIA@R3B setup
S447	Studies of the d+p signal and lifetime of the $^{3}_{\Lambda}$H and $^{4}_{\Lambda}$H hypernuclei by new spectroscopy techniques with FRS
S474	Detector tests with the prototype of the CSC for the Super-FRS and direct mass measurements of neutron-deficient nuclides below ^{100}Sn
S468	Search for new neutron-rich isotopes and exploratory studies in the element range from terbium to rhenium
S452	The Oblate-Prolate Shape Transition around A~190
S460	Investigation of 220-A-230 Po-Fr nuclei lying in the south-east frontier of the A~225 island of octupole deformation
S450	Study of N=126 nuclei: isomeric and beta decays in ^{202}Os and ^{203}Ir

DESPEC Super-FRS R3B EXL ILIMA

Planned NUSTAR Experiments in 2018



NUSTAR UNILAC

NUSTAR SIS/FRS

Desaster of the year…

During accelerator commissioning in Summer it turned out that the RFQ can run only up to 6 V RF amplitude instead of 10 V!
-> No intense heavy beams!

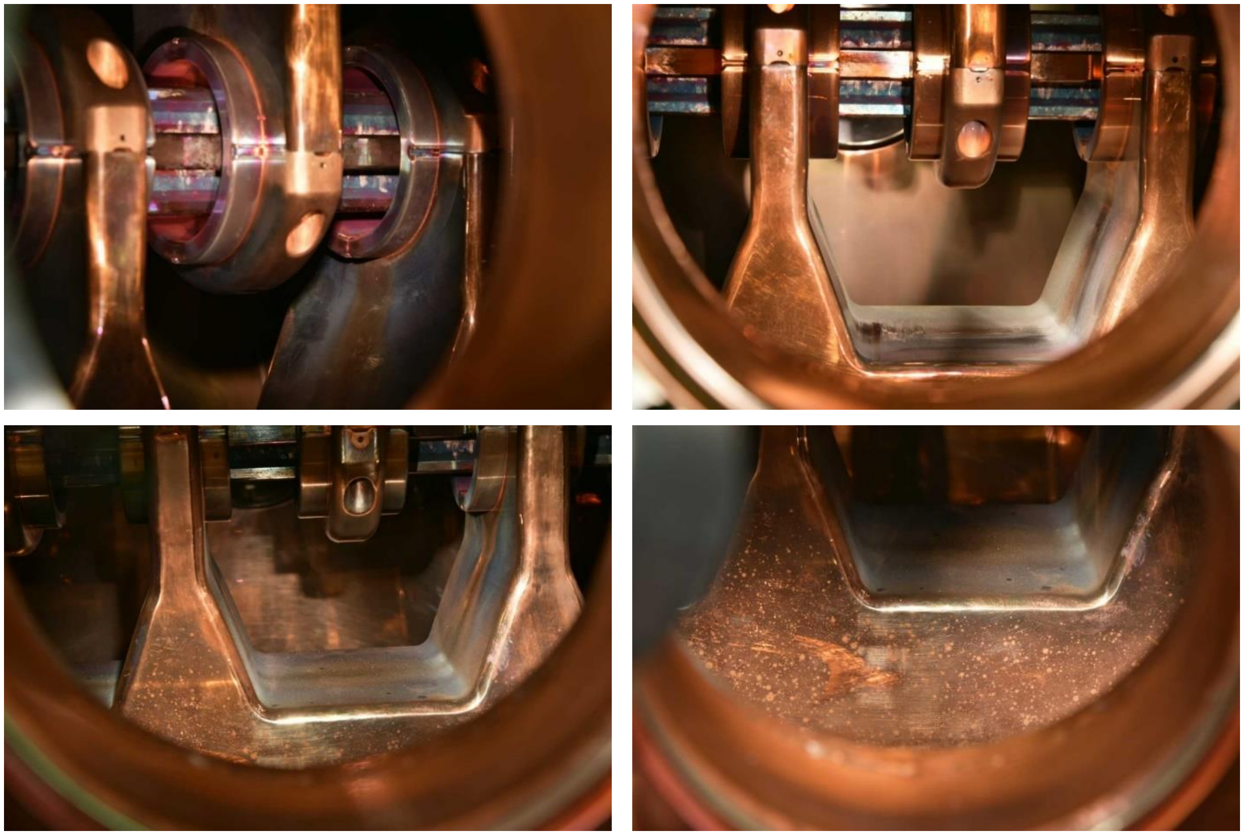
In August a fire of a power transformer in the UNILAC RF gallery caused a major disruptio of the accelerator start-up.
After decontamination of the polluted area it was discovered that aluminum particles causing a massive shortcut were the reason for the fire.
Before operation can resume all electrical devices in the area need to be thoroghly cleaned **-> No user beams this year!**

Available beam intensities in 2018 with defect RFQ

(Announced by Accelerator Section on 9.7.18)

ion	mass	q_min	q_best	I_TK(q_best) [eμA]	I(q_min) / I(q_best) (LEBT)	I_TK(q_min) [eμA]	q(SIS18)	N(Spill) [10^7]	dN/dt(mean) [10^7/sec]	comment		dN/dt(anticipated)	Reduction
				summary			TK-stripped	no cooler				[10^7/sec]	
Pb	208	5	4	400	0,01	4	67	1,0	0,3		m = 12	50	**152**
Au	197	5	4	300	1,00	300	65	76,0	25,3		T = 2.2 μs	150	6
Ag	107	3	2	440	0,50	220	43	84,3	28,1			100	**4**
U	238	5	4	800	0,10	80	73	18,1	6,0	RFQ at 80% voltage, scaling = 0,2(source)*0,5(RFQ)		200	**33**
Fe	56	2	3	44,7	1,00	44,7	25	29,5	9,8		Tcycl = 1 sec		
Bi	209	5	4	800,0	0,28	224	68	54,3	18,1	no experience w.r.t. stability	Text = 2 sec		
Ta	181	5	4	988,5	0,15	148,275	61	40,1	13,4	no experience w.r.t. stability			
Xe	132	3	3	161,4	0,80	129,12	48	44,3	14,8	RFQ at 95% voltage, scaling = 0,8(RFQ)*...(source)		200	**14**
Sn	112	3	5	6,0	1,00	6	45	2,2	0,7				
Kr	86	2	2	2500,0	1,00	2500	33	1248,3	416,1				
Kr	84	2	2	125,0	1,00	125	34	60,6	20,2				
Ni	58	2	2	1200,0	1,00	1200	26	760,5	253,5				
Ti	50	2	2	30,0	1,00	30	22	22,5	7,5			20	3
Xe	124	3	3	700	1,00	700	48	240,3	80,1	enriched material from ion source			
Xe	136	4	3	500	0,35	175	48	60,1	20,0	enriched material from ion source			
Mo	92	2	2	200,0	0,80	160	42	62,8	20,9	RFQ at 95% voltage, scaling = 0,8(RFQ)*...(source)			

Machine meeting 28.08.18 - UNILAC



Replacement needed. Components need 8 months to be delivered and installed.

RFQ structures are affected by beam sputtering and surface degradation.
Reasons not yet fully understood.

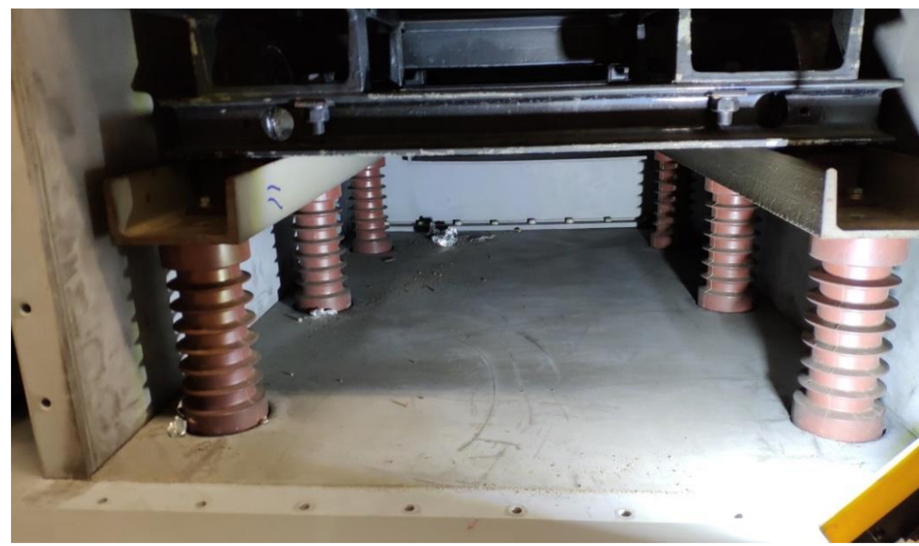
ER1 fire and RF ventilation contamination

- Fire in the ER1 transformer
- Power-off in the entire rf gallery

- Separation of the ER1 system
  - No single gap resonators

- Cleaning of all amplifiers AND all transformers
  - No rf operation until mid. Oct.

→ No more physics beam time 2018



Accelerator Goals and Boundary conditions

Foil by Mei Bai

- Engineering run: Nov. 2018 – Dec. 2018
  - Goal: to establish basic operation conditions that are required for the Physics program in 2019
  - boundary conditions:
    - limited capabilities of new FAIR controls
      - Not yet comprehensive tools including up to date lattice layouts for beamline tuning
      - no storage mode capabilities available for comprehensive ESR commissioning
- Physics run: March 2019 – April 2019
  - Goal: to provide reliable operation for the scheduled Physics programs
  - boundary conditions
    - limited choice of heavy ions due to HSI RFQ technical limitation
    - No single gap resonators at the end of post striper
    - No parallel operation in planning to ensure reliability
- Engineering run: Nov. 2019 – Dec. 2019
  - Goal: 1) to establish ESR storage mode 2) to establish deceleration in ESR 3) to complete the comissioning of CRYRING with ESR beam
  - newly introduced FAIR controls for ESR must allow storage mode
    - Expect to be available for commissioning no earlier than Sept. 2019

Schedule for early 2019 operation suggested by Accelerator division

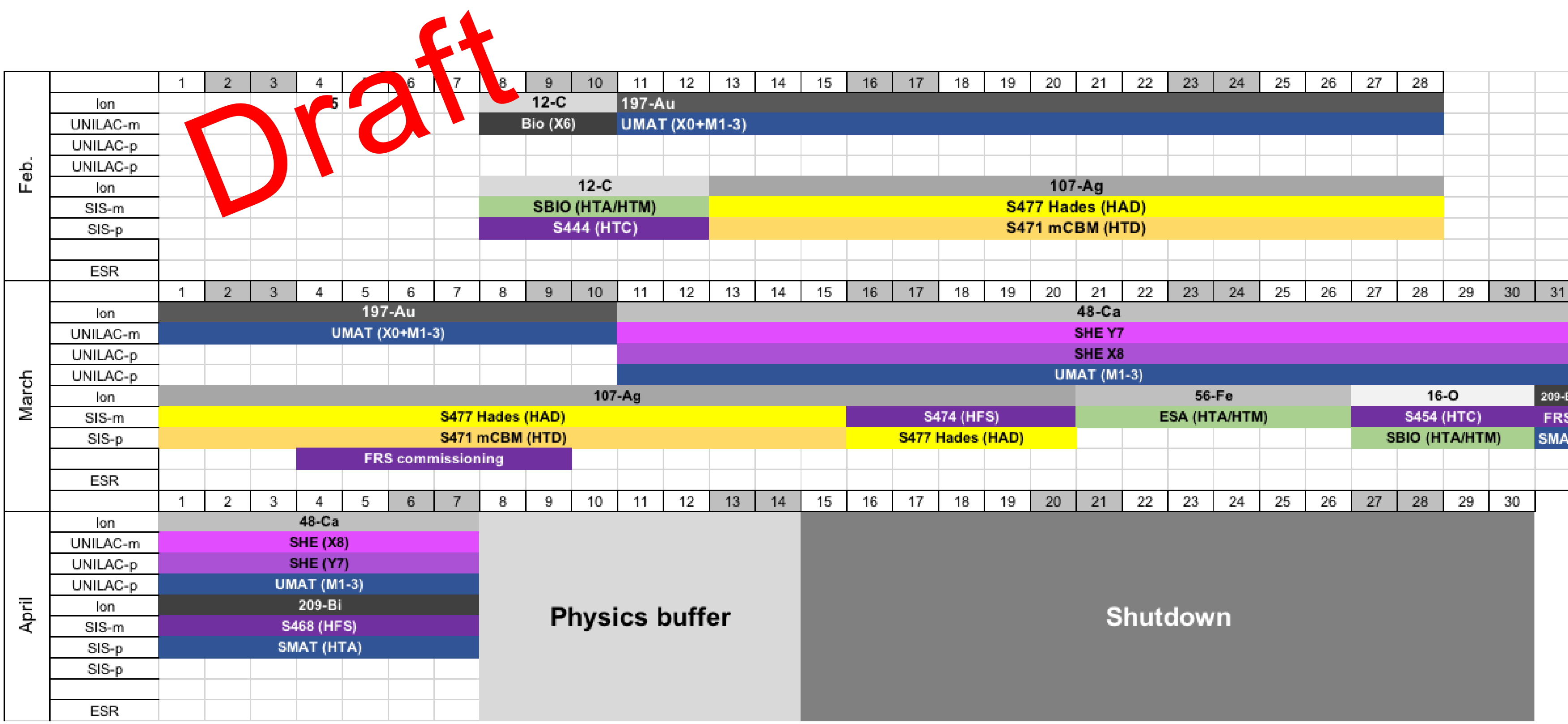
Draft

Feb.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Ion				5							6							7							197-Au			
UNILAC-m																									UMAT (X0+M1-3)			
UNILAC-p																												
UNILAC-p																												
Ion																												
SIS-m																												
SIS-p																												
ESR																												

March	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ion	197-Au																					48-Ca									
UNILAC-m	UMAT (X0+M1-3)																					SHE Y7									
UNILAC-p																						SHE X8									
UNILAC-p																						UMAT (M1-3)									
Ion				107-Ag																				107-Ag							
SIS-m				S477 Hades (HAD)																											
SIS-p																															
ESR																															

April	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ion	48-Ca														Shutdown															
UNILAC-m	SHE (X8)																													
UNILAC-p	SHE (Y7)																													
UNILAC-p	UMAT (M1-3)																													
Ion									56-Fe																					
SIS-m	Nustar or Bio								ESA (HTA/HTM)																					
SIS-p																														
SIS-p																														
ESR																														

Schedule for early 2019 operation wanted by Research division

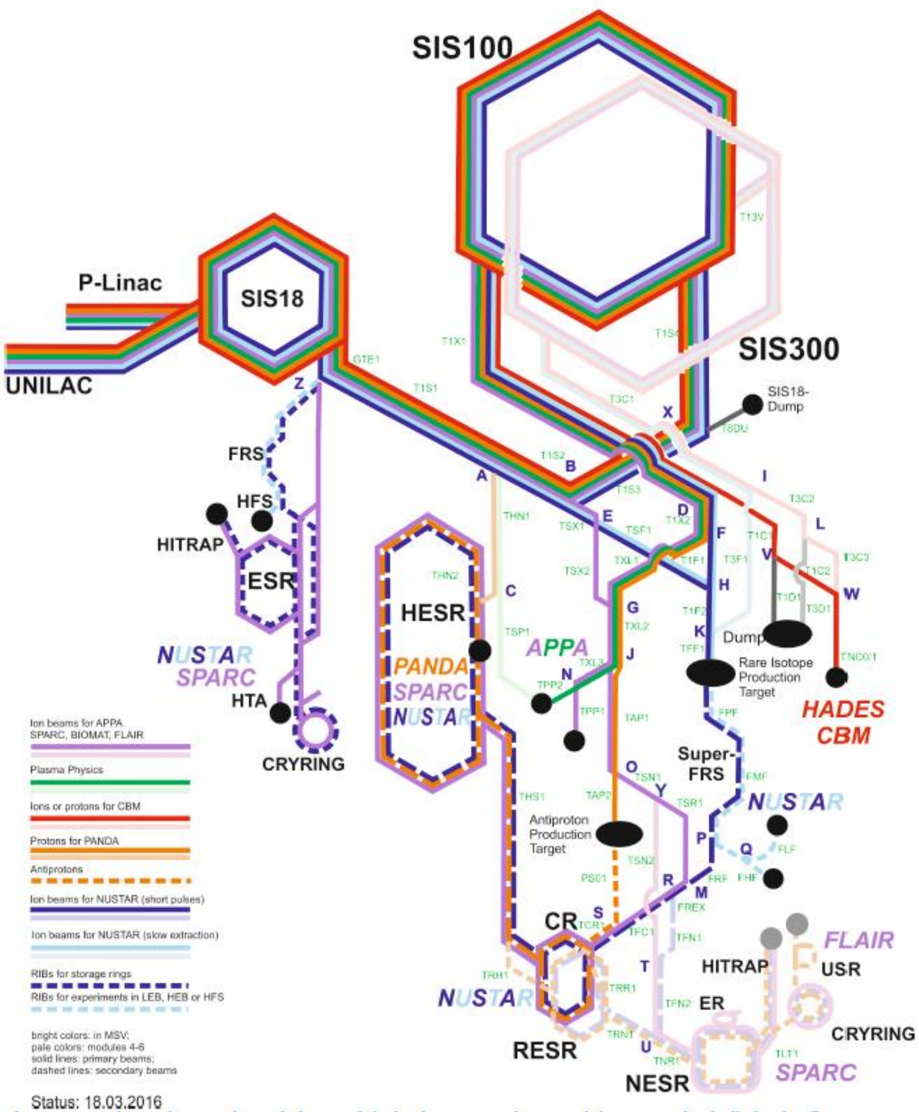


Beam scheduling is curently being revised

<u>Status 24.9.18:</u>

- All experiments need to be re-scheduled in 2019/20.
- Beam is planned to be provided again earliest from February 2019.
- Beam time will start with ^{107}Ag to test the quality for HADES and to start the NUSTAR commissioning.
- When NUSTAR requests, ^{209}Bi will be provided for intensity test and further commissioning.
- In the best case one experiment per sub-collaboration might be possible (NUSTAR Beam Coordination Committee will investigate)
- Operation based on a regular beam schedule may start in January 2020

Phase-1 start-up scenarios and implications for day-1



NUSTAR start-up scenario

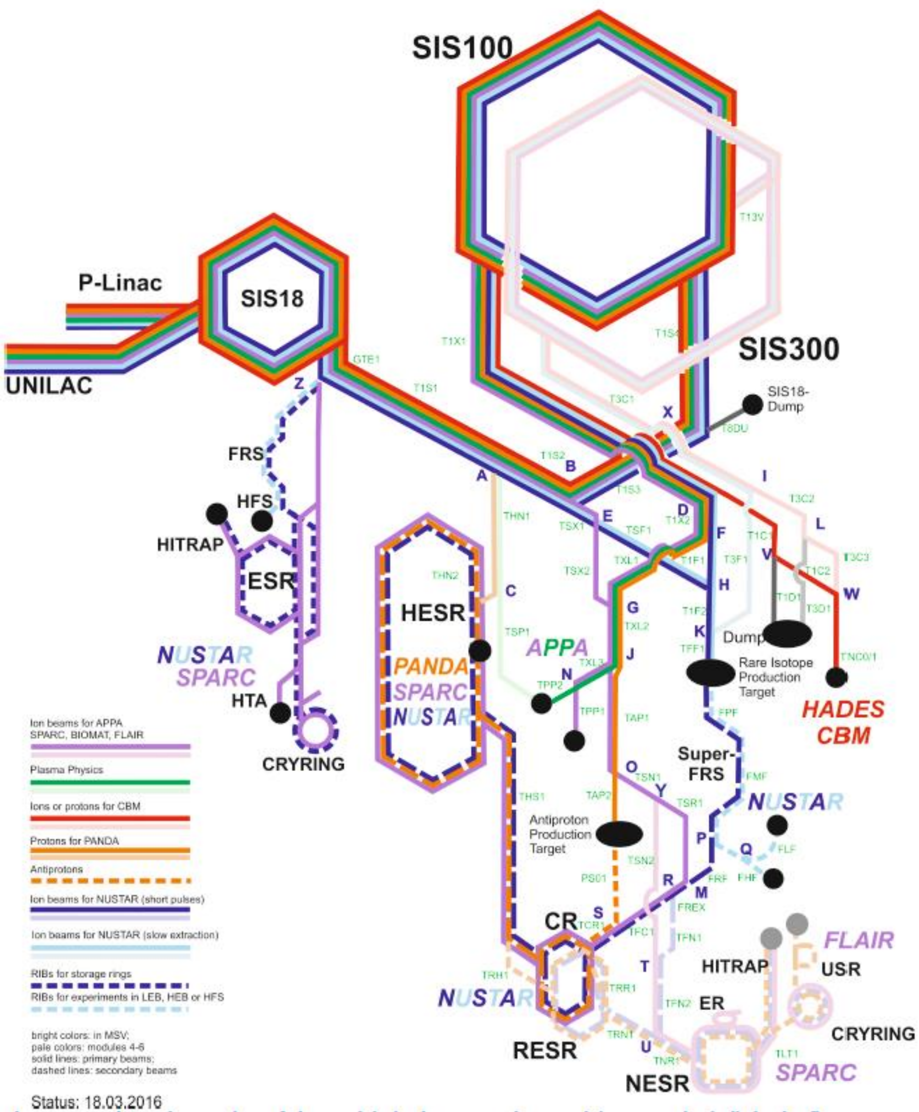
for an advanced start of FAIR Phase-1

<u>1. Step</u>
requires
UNILAC + SIS18 + S-FRS

realisation:
complete installation, followed by stepwise commissioning

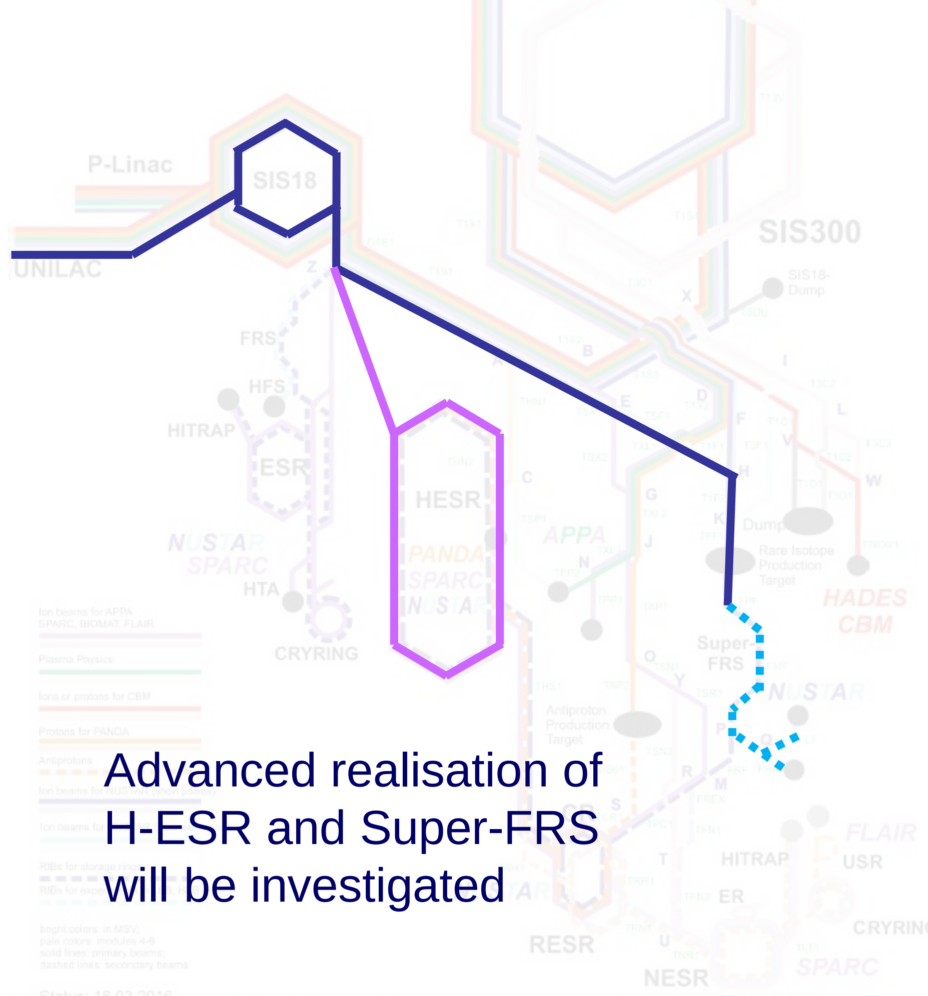
first physics experiments in stages
1. Intermediate S-FRS focal planes
2. HEB
3. LEB
Covers about 70% of Day-1 Physics

Phase-1 start-up scenarios and implications for day-1



FAIR start-up scenarios

for an advanced start of FAIR Phase-1



Advanced realisation of H-ESR and Super-FRS will be investigated

Phase-1 start-up scenarios and implications for day-1

Advantages

- Early start of Phase-1 physics experiments
- Reduced risk by not requiring SIS100 operation
- Reduced risk by better resource balancing
- Reduced risk by staged approach not requiring full NUSTAR facility at once

Disadvantages

- Not serving all experiments from the beginning
- Longer total start-up time

gSPEC with PARIS

PARIS

- Increased efficiency
- Sufficient energy resolution
- Complementing Ge