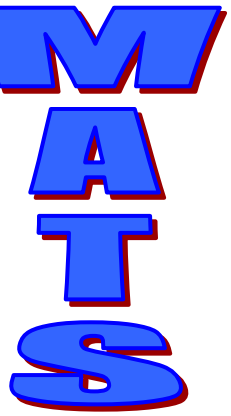
Summary of Cost Estimates for MATS

(within the NUSTAR Collaboration)



Precision **M**easurements of
Very Short-Lived Nuclei using an
Advanced **T**rapping **S**ystem
for Highly-Charged Ions

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With MATS (Precision Measurements of very short-lived nuclei using an Advanced Trapping System for highly-charged ions) at FAIR we aim for applying two different techniques to very short-lived radionuclides exploiting Penning traps: High-precision mass measurements and in-trap conversion electron and alpha spectroscopy. The experimental setup of MATS being installed at the low-energy branch of the Super-Fragment Separator (S-FRS) is a unique combination of an electron beam ion trap for charge breeding, ion traps for beam preparation, and a high-precision Penning trap system for mass measurements and decay studies. A physics case and details of the setup were presented previously in the MATS "Letter of intent" and the corresponding "Technical Proposal".

Here, we summarize the cost estimates for the construction and operation of the MATS device. For orientation, Figure 1 shows a schematic of the proposed setup, Figure 2 shows a more detailed drawing including vacuum system and beamlines. It is divided into the following sub-projects:

(1) General beamlines to connect the different sub-projects.
(2) An off-line ion source (not shown in Fig. 1) for individual tests of all components and for the calibration of the magnetic field magnitude.
(3) An radiofrequency quadrupole (RFQ) for stopping, bunching, and cooling of ions delivered from the gas stopper including a switchyard for distributing the beam to different experimental setups, e.g. MATS and LaSpec.
(4) A charge breeding electron beam ion trap (EBIT) to create high charge states in a very short time.
(5) A *q*/*A*-separation stage to select the desired charge-to-mass ratio for injection into the Penning trap system.
(6) A preparation Penning trap based on a resistive and/or electron cooling technique to provide the precision Penning trap and others with a cooled beam of highly-charged ions.
(7) A measurement precision Penning trap for high-precision mass spectrometry and trap-assisted decay spectroscopy on highly-charged ions
(8) Several detector systems for (i) destructive (time-of-flight technique) and (ii) non-destructive (Fourier-transform ion-cyclotron resonance technique) ion detection techniques for mass spectrometry, and for (iii) in-trap and trap-assisted decay spectroscopy.

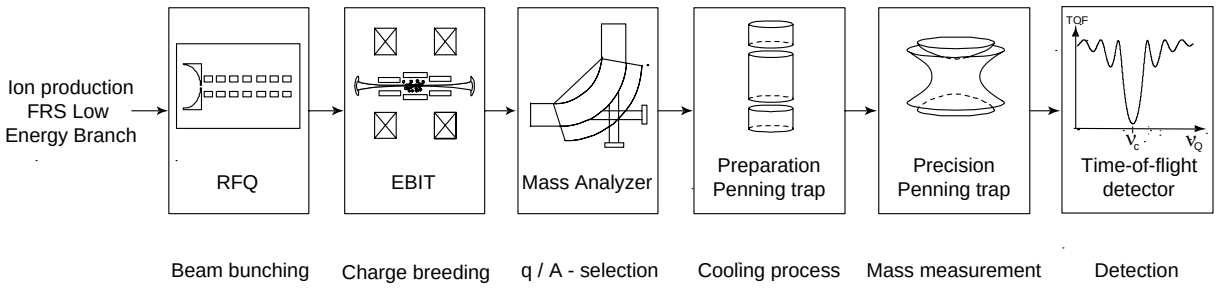

Figure 1: Schematic layout of the electron beam ion trap (EBIT) and Penning trap system. The RFQ is a combination of an ion beam cooler and buncher and a switchyard to provide the beam to different experiments, e.g. MATS and LaSpec. For the detection only one out of three possible schemes is shown (see also MATS Technical Proposal).

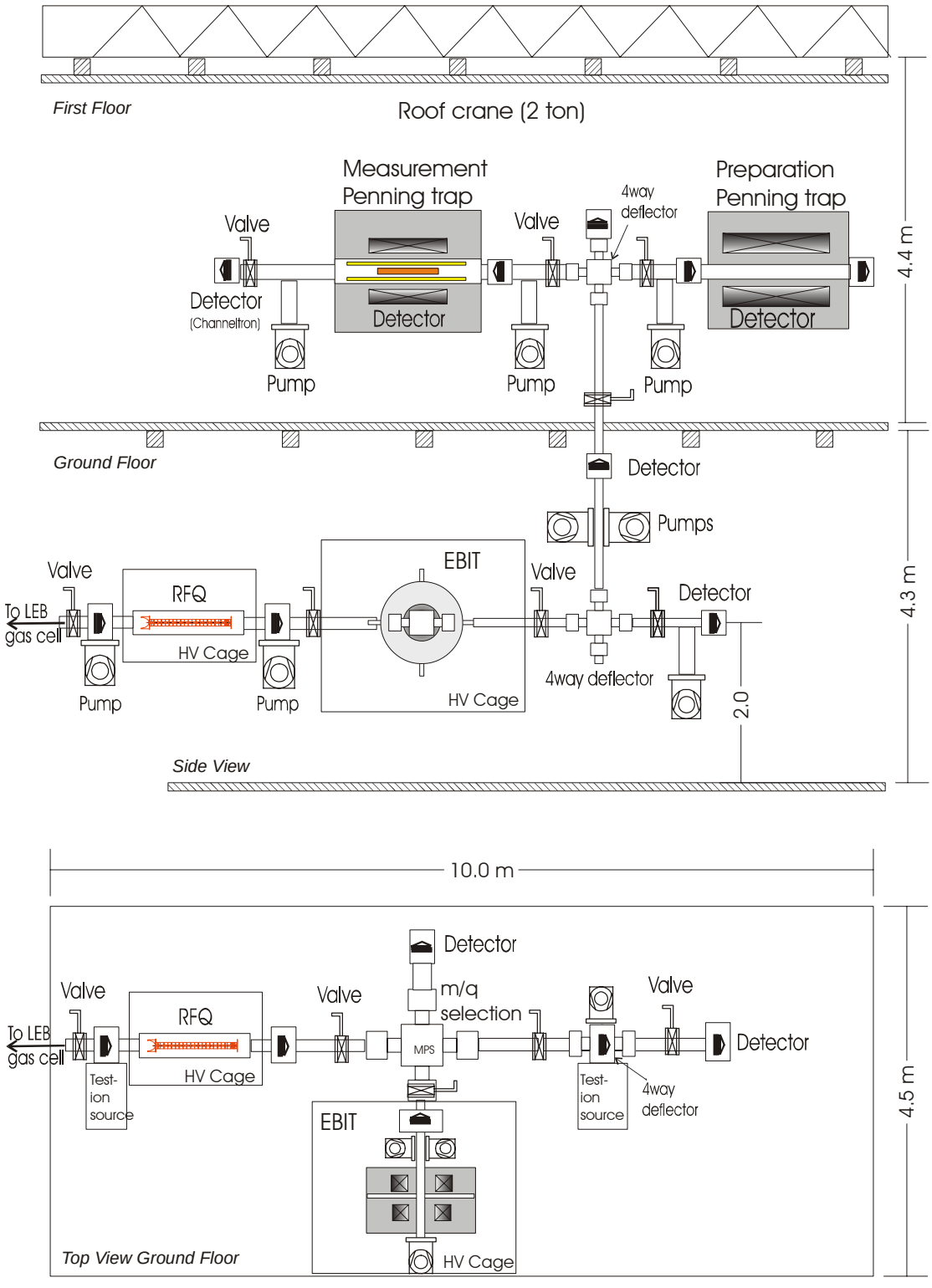

Figure 2: Detailed (but not complete) drawing of the proposed Penning trap mass spectrometer and in-trap conversion electron spectroscopy setup including connecting beamlines. For charge breeding an electron beam ion trap (EBIT) will be used.

At present the MATS Collaboration has 52 members from 16 Institutes. The responsibilities and obligations are as follows (main responsible institutes are marked with a red cross):

	Institutes															
Contribution	UPS	UT	UGW	UEN	GSI	UMZ	UG	UJ	LLNL	LMU	HD	ULB	MSU	SU	CERN	VECC
(1) Beamlines	X		X				X									
(2) Off-Line Ion Source	X				X	X									X	
(3) RFQ + Switchyard	X	X					X	X								
(4) EBIT		X							X		X			X		
(5) Q/A Separation	X				X					X				X		
(6) Preparation Trap					X	X							X	X		
(7a) Measurement Trap		X			X	X							X	X		
(7b) Electronics			X			X										
(8a) Beamline Detectors			X													
(8b) TOF Detector			X			X		X					X			
(8c) FT-ICR Detector			X			X										
(8d) In-Trap EC Detector								X		X						
(9) Control System	X				X											
(10) Vacuum+Safety System	X															
PhD / years	3		6	3	3	8	0.5	2		4			0.5			
PostDoc / years	2		1		3	4	0.5			2	2		1.5			
Engineer / years	1		2			2				1	1					

Abbreviations: UPS – Université de Paris Sud (CSN - CSNSM/IN2P3-Orsay), UT – University of Tübingen, UGW – University of Greifswald, UEN – University of Erlangen-Nürnberg, GSI – Gesellschaft für Schwerionenforschung Darmstadt, UMZ – University of Mainz, UG – University of Gießen, UJ – University of Jyväskylä, LLNL – Lawrence Livermore National Laboratory, LMU – Ludwig Maximilians University Munich, HD – Max Planck Institute for Nuclear Physics, Heidelberg, ULB – Universite Libre des Bruxelles, MSU – Michigan State University, SU – Stockholm University, CERN – European Organisation for Nuclear Rsesearch, VECC - Variable Energy Cyclotron Centre, Kolkata

General Remarks

The cost estimates for the MATS setup are based on similar systems which we (members of the MATS collaboration) are presently developing at the different institutes involved or which are already in operation, as *e.g.*, the radiofrequency ion beam cooler and buncher in Orsay (France), the Electron Beam Ion Trap EBIT at Heidelberg (Germany), and the Penning trap mass spectrometers ISOLTRAP (ISOLDE/CERN), SHIPTRAP (GSI Darmstadt), JYFLTRAP (Jyväskylä, Finland), and LEBIT (MSU, USA). For many of the low cost items offers from companies exist. The price for the superconducting magnets for the precision and preparation Penning traps are estimates based on an offer for a similar system. A final price offer for the magnets can only be provided after the simulation studies are done and the required specifications are fixed. The costs for the beamline strongly depend on the final layout of the experimental hall and the location where MATS will be placed, especially whether MATS will be installed over two floors or not. The costs for the beamline can be scaled accordingly to its length. The radiofrequency ion beam cooler and buncher will also be used by the LaSpec experiment, but the costs are only included in the cost estimates for MATS.

No substantial R&D is required for most parts of the *MATS* setup. All techniques are already employed at ISOL facilities and well working set-ups are operated by members of the collaboration. Moreover, improvements of these techniques are going on in other projects, *e.g.*, the installation of an RFQ for beam cooling and bunching at ISOLDE/CERN, the development of new trapping techniques and cryogenic Penning trap set-ups at LEBIT and in Mainz. Some R&D will be necessary for cooling of highly-charged ions in a Penning trap, for the design of an advanced four-fold Penning trap system, and for trap-assisted decay spectroscopy. Cooling of highly-charged ions is also a major issue in the HITRAP project and presently under investigation. Design studies for a four-trap set-up are in preparation at the University of Mainz. Beside these R&D projects, mainly technical planning is necessary in the R&D phase.

In the following, we list estimated costs for the individual subprojects. All prices are given **exclusive** of VAT (value added tax). We also provide a list with cost estimates for the control system, general safety equipment, and spare parts. Costs that refer to a specific manufacturer and model are based on catalog prices or company quotes. Those given without a company name are estimates based on experience in purchasing such devices. For parts which are build in the workshop of a participating institute we quote estimated material costs and minor machine costs. The costs given here deviate slightly from what was given in the Technical Proposal. A summary and comparison including manpower estimates is provided at the end of this document.

(1) Beamline:

pos	quant	device	company	model	unit price/€	total price / €
1	10	1m Beamline for HCI + pumps + valves (est.)	Pink, VAT, Varian	CF-100 based	25 000	250 000
2	2	Faraday-Detector, feedthrough, chamber	VACOOM, HOSITRAD	CF16, CF100	4 000	8 000
3	1	Digital Picoamperemeter	ELCAL	Keithley 483	3 500	3 500
4	6	Matched pair MCP detectors + feedthrough	HOSITRAD, TOPAG	MCPMA34	2 257	13 542
5	6	UHV chambers + SHV feedthroughs	VACOOM, HOSITRAD	CF100 double cross	2 700	16 200
6	1	Power supply Channeltron/MCP, 4 channels	CAEN	N470	4 740	4 740
7	10	1m beam transport electronics, PS etc. (est.)	CAEN		10 000	100 000
8	10	1m support frame	Homemade, Al	---	1 500	15 000
9	1	Transport + Installation (inlcuding alignment)			10 000	10 000
					SUM	**421 000**

The price of 25000€ for one meter beam line is estimated but is in good agreement to the costs at SMILETRAP/Stockholm where also the transportation of highly-charged ions for precision mass spectrometry is required.

Engineering – design, construction, commissioning: Beam transport calculations for highly-charged ions are presently performed at GSI. 5000€ for a PC and special simulation programs are required. Construction costs and effort will be mainly covered by the Universities of Greifswald, Mainz, Gießen, and Orsay.

Number of spares: Included in the “spare part list” (see below).

(2) Off-line ion source:

pos	quant	device	company	model	unit price/€	total price / €
1	1	Current power supply	XANTREX	XFR 12-100	3 500	3 500
2	1	UHV setup			6 550	6 550
		CF100 double cross with SHV feedthroughs	VACOOM, HOSITRAD		3 000	
		Water or air cooling system	Homemade	---	500	
		Isolator flanch (teflon)			1 550	
		HV cables			1 500	
3	1	Electron Impact Ion Source, QMF, Bender			13 000	13 000
		Electron Impact Ion Source with Bender	ABB EXTREL	#812425	12 000	
		Quadrupole Mass Filter	Homemade, Mb	---	1 000	
4	1	Function Generator, PS, Electronics			12 750	12 750
		Function Generator	Scientific Instruments	DS345	2 050	
		*5*2 Power Supplies, 3.5 kV*	NSE Electronics	Typ: 590-232	5 500	
		HV switch	BEHLKE	HTS650	5 200	
5	1	Gas inlet system, needle valve, pressure control			6 100	6 100
		Regulation needle valve	Pfeiffer	EVR116	1 200	
		Control system	Pfeiffer	RVC300	1 480	
		Cable	Pfeiffer	RVC-ECR conn.	120	
		Pressure reducer stainless steel	Linde	FMD 522-18	1 800	
		Gas feeding line + connectors	Swatchlok	SS-4-VCR	1 500	
6	1	Vaccum pump and controller			12 130	12 130
		Prepump	Alcatel		1 400	
		Ion getter Pumps	Varian	Starcell300	10 000	
		Pirani Gauge	VakMüller	APGX-M KF16	220	
		Penning Gauge	VakMüller	AIM-X KF25	510	
7	1	WAGO-Module for Profi-Bus	WAGO		4 000	4 000
8	1	Support frame	Homemade, Al	---	1 000	1 000
9	1	High-voltage cage - safety interlock	ITEM		1 000	1 000
10	1	Transport + Installation (inlcuding alignment)			1 500	1 500
					SUM	**61 500**

This price list is based on a design which is presently build at ISOLTRAP / ISOLDE-CERN.

Engineering – design, construction, commissioning: No special engineering work needed since the device will be duplicated from a design presently build at ISOLTRAP / ISOLDE-CERN. Construction costs and effort will be mainly covered by the Universities of Mainz and Orsay and by GSI Darmstadt.

Number of spares: No special spares except some graphite furnaces (10€/piece) are needed

Safety: High-Voltage cage surrounding the off-line ion source (already included in the list above).

(3) RFQ including switchyard:

pos	quant	device	company	model	unit price/€	total price / €
1	1	Vacuum chamber and system			71 200	71 200
		Central chamber plus sealing plus heating	Homemade	---	10 000	
		*2*Bellows and adapter*	VACOOM	KF150-CF100	3 200	
		1000 l/s turbo pump + forepump + gauge	Pfeiffer		25 000	
		*3*insulation flanges*	VACOOM	6 kV	3 000	
		*2*500 l/s turbo pump + forepump + gauge*	Pfeiffer		30 000	
2	1	Buncher parts			12 800	12 800
		RF feedthrough mouning	Hositrad	30 pin	2 500	
		segmented quadrupole rod assembly	Homemade	---	5 000	
		inner chamber for quadrupole	Homemade	---	2 500	
		*2*High-voltage feedthrough mounting*	Hositrad	6 pin	2 800	
3	1	Beam optics and beam detectors			5 000	5 000
		ISOLDE standard scanner/faraday cup	Homemade	---	2 000	
		*6*deceleration/acceleration lenses*	Homemade	---	3 000	
4	1	Electronics			56 550	56 550
		RF frequency generator	Scientific Instruments	DS345	2 050	
		RF Power amplifier	ENI	ENI L240	15 000	
		Isolation transformer (RF)			5 000	
		Isolation transformer (mains)			3 000	
		High-voltage power supply	FUG	10 kV	20 000	
		*10*Lens and RFQ segments 3.5 kV PS*	NSE Electronic	Typ: 590-232	5 500	
		*15*Lens and RFQ segments 1.5 kV PS*	NSE Electronic	Typ: 590-231	6 000	
5	1	Gas inlet system, needle valve, pressure control			12 100	12 100
		Regulation needle valve	Pfeiffer	EVR116	1 200	
		Control system	Pfeiffer	RVC300	1 480	
		Cable	Pfeiffer	RVC-ECR conn.	120	
		Pressure reducre stainless steel	Linde	FMD 522-18	1 800	
		Gas feeding line	Swatchlok	SS-4-VCR	1 500	
		Gad purification system	SAES		3 000	
		Insulator			3 000	
6	1	Control system			4 500	4 500
		Fiber optic coupler (transmitter/receiver)	Beckhoff		1 500	
		*6*ADC to control HT supplies*	Beckhoff		3 000	
7	1	High-voltage cage - safety interlock	ITEM		2 500	2 500
8	1	Switchyard to MATS / LASPEC			66 900	66 900
		Vacuum chamber and system	VACOOM, Pfeiffer		25 000	
		Mechanical support	Homemade	---	6 000	
		*3*Valve*	VAT	DIN-100 KF	9 600	
		*2*Scanner/FC/MCP system*			6 000	
		400 l/s turbo pump + forepump + gauge	Pfeiffer		12 000	
		*2*Bender electronics + power supplies*			4 000	
		Kicker electrode	Homemade	---	500	
		Feedthroughs, 4-plug	CABURN		600	
		*8*HV Power Supplies 1.5 kV*	NSE Electronic	Typ: 590-231	3 200	
9	1	Support frame, Al	Homemade	---	1 500	1 500
10	1	Transport + Installation (inlcuding alignment)			1 500	1 500
					SUM	**234 600**

This list is based on a design which is presently installed at MISTRAL / ISOLDE-CERN.

Engineering – design, construction, commissioning: No special engineering work needed since it will be based on existing systems. Construction costs and effort will be mainly covered by the Universities of Orsay, Tübingen, Gießen, and Jyväskylä.

Safety: High-Voltage surrounding the RFQ (already included in the list above).

(4) EBIT:

pos	quant	device	company	model	unit price/€	total price / €
1	1	Superconducting magnet 6T, cryogen free + PS	Cryogenic Ltd.		160 000	160 000
2	1	Vacuum chamber manufacturing	Pink, VACOOM		20 000	20 000
3	4	Turbo pumps	Varian	300 l/s	4 000	16 000
4	4	Turbo pumps	Varian	70 l/s	2 500	10 000
5	5	UHV full range vacuum gauges	Pink, VACOOM		1 000	5 000
6	1	Vacuum parts, forevacuum accessories	Pfeiffer		7 000	7 000
7	2	UHV valves (1*CF150, 1*CF100)	VAT	DIN-150 KF	4 500	9 000
8	3	Diaphragm pumps			1 500	4 500
9	20	SHV vacuum feedthroughs	HOSIRAD		100	2 000
10	1	Collector HV power supply, 2 kV, 5 A	CAEN		16 000	16 000
11	1	Drift tube HV power supplies, 12 ch., 2 kV	CAEN		7 000	7 000
12	2	Low-voltage magnet power supplies, 20 V, 70 A	CAEN		2 000	4 000
13	10	Low-Voltage power supplies, 30V, 5 A	NSE Electronic		400	4 000
14	1	Insulating transformer			5 000	5 000
15	1	Insulating cage, HV safety interlocking			10 000	10 000
16	1	Electronic and electromechanical supplies			4 000	4 000
17	1	Cooling system, air-to-water/oil heat exchanger			3 000	3 000
18	1	Specialized material for drift tube etc., OHFC, Ti			5 000	5 000
19	6	Ceramic vacuum insulators. 60 kV, CF 150			1 000	6 000
20	2	Ceramic vacuum insulators, 20 kV, CF63			500	1 000
21	1	Electron gun UHV XYZ manip., 300 mm, CF100			11 000	11 000
22	2	Linear feedthrough manipulator, 50 mm, CF 35			1 500	3 000
23	1	Sapphire parts			2 000	2 000
24	1	Support frame, Al	Homemade	---	4 000	4 000
25	1	Auxiliary raw materials, aluminium plate			5 000	5 000
26	1	Transport + Installation + Align. (including SuMa)			6 000	6 000
					SUM	**329 500**

The price list is based on recently designed and constructed EBITs which are operated at the MPI-K in Heidelberg.

Engineering – design, construction, commissioning: No special engineering work needed since the device is based on a design presently in operation at the MPI-K Heidelberg. Construction costs and efforts will be mainly covered by the MPI-K Heidelberg and by the Universities of Stockholm and Tübingen.

Number of spares: General vacuum spare parts are needed. They are included in the list “spare parts” (see below).

Safety: High-Voltage cage surrounding the off-line ion source (already included in the list above).

(5) *q*/*A* selection:

pos	quant	device	company	model	unit price/€	total price / €
1	1	Magnet including power supply			47 000	47 000
		Magnet (round pole face)	OXFORD		22 000	
		Magnet power supply	Heinzinger	200A / 60 V	25 000	
2	1	Vacuum components and lenses			16 000	16 000
		Magnet vacuum chamber	VACOOM		8 000	
		4 vacuum chambers including el. stat. lenses	VACOOM		8 000	
3	2	4 Channel HV power supplies for lenses	CAEN	N470	4 740	9 480
4	2	Vacuum pumping and control system	Pfeiffer		12 130	24 260
		Prepump	Alcatel		1 400	
		Turbopump + Ion getter pumps	Varian	Starcell300	10 000	
		Pirani Gauge	VakMüller	APGX-M KF16	220	
		Penning Gauge	VakMüller	AIM-X KF25	510	
5	1	Support frame, Al	Homemade	---	2 000	2 000
6	1	Transport + Installation (inlcuding alignment)			1 000	1 000
					SUM	**99 700**

Engineering – design, construction, commissioning: Only minor engineering and design work needed. Construction costs and efforts will be covered by the Universities of Frankfurt, Orsay, and Munich.

Number of spares: General vacuum spare parts are needed. They are included in the list “spare parts” (see below).

(6) Preparation Penning trap:

pos	quant	device	company	model	unit price/€	total price / €
1	1	7T Superconducting Magnet (cryogen free)	OXFORD		265 000	265 000
2	1	Trap setup (OFHC electrodes …)	Homemade	---	10 000	10 000
3	2	HV Switch Powersupplies	GSI		3 500	7 000
4	1	HV Main Frame	CAEN	SY2527	9 050	9 050
5	1	HV Powersupply 12 channels 3/4 kV, 3/2 mA	CAEN	1733P/N	3 040	3 040
6	3	Function Generator	Stanford Research	DS345	2 050	6 150
7	3	Fan In/Fan Out	ORTEC		1 800	5 400
8	3	Attenuator	EMCO		200	600
9	1	Pattern Generator	National Instruments		1 800	1 800
10	2	Ion Getter Pumps	Varian	Starcell300	5 000	10 000
11	2	Turbomolecular pump station 300 l/s			17 000	34 000
12	2	CF100 full metal gate valve	VAT		10 000	20 000
13	2	CF35 full metal gate valve	VAT		2 900	5 800
14	2	100CF 6 way cross	VACOOM		3 000	6 000
15	2	Bayard Alpert gauge/ IoniVac			1 750	3 500
16	8	UHV - SHV Feedthroughs (4 on a CF 40 Flange)	VACOOM, HOSITRAD		890	7 120
17	32	HV cable for UHV conditions			300	9 600
18	1	MCP matched pair (not segmented)	TOPAG	MCPMA34	1 287	1 287
19	1	Preamplifier	AMETEK	Preamp. VT120C	465	465
20	1	Fast digitizer	National Instruments		2 000	2 000
21	2	Frequency Generator	Agilent	AG33250A	3 100	6 200
22	2	180 Deg. Phase Shifter			1 000	2 000
23	2	Power amplifier, fast gating, 0.5-100MHz, 100W	Amplifier Research	KAA2020-HG	14 980	29 960
24	2	Preamplifier	Baechli Instruments	VT120C	560	1 120
25	1	Transient recorder, 8MS, 12bit, 2 Ch, 200MHz	Fast ComTec	FI3025 TR	6 795	6 795
26	1	Support frame (for both detectors), Al	Homemade	---	1 000	1 000
27	1	Transport + Installation + Align. (including SuMa)			6 000	6 000
					SUM	**460 900**

The price list is based on recently designed and constructed systems at Michigan State University, at GSI Darmstadt, and Mainz University. The price for the superconducting magnet is estimated since it depends on the final requirements and specifications.

Engineering – design, construction, commissioning: Design and construction work is needed for the trap itself as well as for the cooling scheme of highly-charged ions. Design studies are presently ongoing at GSI Darmstadt, University of Mainz, and Stockholm University. Some R&D money (about 15000€) is needed for preliminary machining tests, simulation studies etc.. Construction costs and efforts will be mainly covered by the Michigan State University, University of Mainz, and Stockholm University.

Number of spares: General vacuum spare parts are needed. They are included in the list “spare parts” (see below).

Safety: An oxygen alarm system has to be installed in order to make sure that the oxygen in the air stays above a certain level.

(7) Precision Penning trap:

pos	quant	device	company	model	unit price/€	total price / €
1	1	7T Superconduct. Magnet (large bore, cryo free)	OXFORD		320 000	320 000
2	1	Trap setup (OFHC electrodes …)	Homemade	---	10 000	10 000
3	2	HV Switch Powersupplies	GSI		3 500	7 000
4	1	HV Main Frame	CAEN	SY2527	9 050	9 050
5	1	HV Powersupply 12 channels 3/4 kV, 3/2 mA	CAEN	1733P/N	3 040	3 040
6	3	Function Generator	Stanford Research	DS345	2 050	6 150
7	3	Fan In/Fan Out	ORTEC		1 800	5 400
8	3	Attenuator	EMCO		200	600
9	1	Pattern Generator	National Instruments		1 800	1 800
10	2	Ion Getter Pumps	Varian	Starcell300	5 000	10 000
11	2	Turbomolecular pump station 300 l/s			17 000	34 000
12	2	CF100 full metal gate valve	VAT		10 000	20 000
13	2	CF35 full metal gate valve	VAT		2 900	5 800
14	2	100CF 6 way cross	VACOOM		3 000	6 000
15	2	Bayard Alpert gauge/ IoniVac			1 750	3 500
16	8	UHV - SHV Feedthroughs (4 on a CF 40 Flange)	VACOOM, HOSITRAD		890	7 120
17	32	HV cable for UHV conditions			300	9 600
18	1	Pattern Generator	National Instruments		1 800	1 800
19	2	Frequency Generator	Agilent	AG33250A	3 100	6 200
20	1	Rubidium Frequency Standard	Scientific Instruments	FS725	7 000	7 000
21	1	Temperature / Pressure stabilization system	MKS / Homemade		10 000	10 000
22	1	Support frame (for both detectors), Al	Homemade	---	1 000	1 000
23	1	Transport + Installation + Align. (including SuMa)			6 000	6 000
					SUM	**491 100**

The price list is based on recently designed and constructed systems at the Michigan State University, at GSI Darmstadt, and Mainz University. The price for the superconducting magnet is estimated since it depends on the final requirements and specifications.

Engineering – design, construction, commissioning: Design and construction work is needed for the trap itself as well as for the cooling scheme of the highly charged ions. Design studies are presently ongoing at GSI Darmstadt, University of Mainz, and Stockholm University. Some R&D money (about 15000€) is needed for preliminary machining tests, simulation studies etc.. Construction costs and efforts will be mainly covered by the Michigan State University, and the Universities of Mainz, Tübingen, and Stockholm.

Number of spares: General vacuum spare parts are needed. They are included in the list “spare parts” (see below).

Safety: An oxygen alarm system has to be installed in order to make sure that the oxygen in the air stays above a certain level.

(8) Detectors:

pos	quant	device	company	model	unit price/€	total price / €
Cost estimate for MCP/Channeltron						
1	2	Channeltron	DeTech	402A-H	785	1 570
2	2	Power supply Channeltron/MCP	CAEN	N470	4 740	9 480
3	2	segmented MCP on linear feedthrough			2 257	4 514
		linear feedthrough	CABURN		*970*	
		MCP matched pair (not segmented)	TOPAG	MCPMA34	*1 287*	
4	2	UHV setup (CF150 double cross) + SHV feedthr.	VACOOM, HOSITRAD		3 200	6 400
5	1	General equipment (NIM modules)			1 265	1 265
		Discriminator			*500*	
		Amplifier	AMETEK	Preamp. VT120C	*465*	
		Switch			*300*	
6	1	Multichannel analyzer	Stanford Research	SR430	11 000	11 000
7	2	NIM Crate	Wiener	300W, 6,12,24V	3 000	6 000
8	1	General material (racks, cables, ...)	Homemade, Conrad	Lemo/BNC/SHV	2 200	2 200
9	1	Vaccum pump and controller			12 130	12 130
		Prepump	Alcatel		1 400	
		Turbopump + Ion getter pumps	Varian	Starcell300	10 000	
		Pirani Gauge	VakMüller	APGX-M KF16	220	
		Penning Gauge	VakMüller	AIM-X KF25	510	
Cost estimate for narrow and broad FT-ICR						
1	2	Frequency generator	Agilent	33250A, 80MHz	3 950	7 900
2	2	180deg Phaseshifter			1 000	2 000
3	2	Power amplifier, fast gating, 0.5-100MHz, 100W	Amplifier Research	KAA2020-HG	14 980	29 960
4	2	pre-amplifier	Baechli Instruments	VT120C	560	1 120
5	1	Transient recorder, 8MS, 12bit, 2 Ch, 200MHz	Fast ComTec	FI3025 TR	6 795	6 795
6	1	TDC			10 000	10 000
7	1	Support frame (for both detectors), Al	Homemade	---	1 000	1 000
8	1	Transport + Installation (including allignment)			2 000	2 000
					SUM	**115 300**

Cost estimate for in-trap decay spectroscopy						
pos	**quant**	**device**	**company**	**model**	**unit price/€**	**total price / €**
1	1	Electron detectors			44 000	44 000
		2*24-fold annular segmented Si(Li) detectors	EURISYS	IPS-A28-500-N24DF	34 000	
		2*Peltier cooling element for Si(Li) detectors	EURISYS	IPS-A28-500-N24DF	10 000	
2	1	Charged particle detectors			7 000	7 000
		2*40x40 Double-Sided Silicon Strip Detectors	MICRON	BB1-1000	7 000	
3	1	Electronics: Electron Detector			27 400	27 400
		Preamplifier, 48 channels	EURISYS	PR-16SF	14 400	
		Shaper	MESYTEC	STM-16 (16 ch.)	8 000	
		ADC	CAEN	V785 (32 ch.)	5 000	
4	1	Electronics: DSSSD Detector			80 000	80 000
		Preamplifier, 16 channels, 10 Modules	MESYTEC	MPR-16 (16 ch.)	15 000	
		Shaper, 10 Modules	MESYTEC	STM-16 (16 ch.)	40 000	
		ADC, 5 Modules	CAEN	V785 (32 ch.)	25 000	
5	1	HV power, logic modules			10 000	10 000
6	1	Cable sets, feedthroughs			5 000	5 000
7	4	NIM Crate	Wiener	300W, 6,12,24V	3 000	12 000
8	1	Vacuum components (partly TOF detector)	VACOOM, HOSITRAD		5 000	5 000
9	1	Support frame (for both detectors), Al	Homemade	---	1 000	1 000
10	1	Transport + Installation (including allignment)			2 000	2 000
					SUM	**193 400**

The FT-ICR detector and the trap-assisted decay spectroscopy detector are new developments and the prices are based on company offers.

Engineering – design, construction, commissioning: 10000€ for a R&D work is needed. Construction costs and efforts will be mainly covered by the Universities of Greifswald, Munich, Jyväskylä, and Mainz.

(9) Control system:

pos	quant	device	company	model	unit price/€	total price / €
1	4	Control and user PCs, Flat Screen 19''	Dell		1 500	6 000
2	1	PXI-Bus 14slots + Controller	PXIT / NI	PX2000-514 / MXI-3	4 000	4 000
3	50	1m GPIB Cable	WIR Electronic		80	4 000
4	2	GPIB repeater	WIR Electronic		1 000	2 000
5	1	LabView Control System Program	National Instruments		10 000	10 000
6	1	Timing-Generator Card	C&H	MA202 / F202	4 000	4 000
7	1	Einsteck-Scope	National Instruments	NI5512	2 500	2 500
8	3	Combi-GPIB&Ethernet-Card	National Instruments	NI8212	1 500	4 500
9	2	National Instruments, Multi I/O Karte	National Instruments		1 150	2 300
10	1	4-fach RS-485 Card	National Instruments	NI8421/4	2 000	2 000
11	1	Scaler	National Instruments	NI6602	3 500	3 500
12	1	Beckhoff - PC Interface Karte	Beckhoff		1 000	1 000
13	50	Beckhoff - Power Supply Control Units	Beckhoff		150	7 500
14	1	Transport + Installation			1 000	1 000
					SUM	**54 300**

The data acquisition and controls will be very similar to systems used in presently operated trap experiments and detector setups. The data rates are low and the main technical challenge is in the real-time handling of a large number of different parameters. With today's technology the control and data acquisition requirements for MATS can be satisfied with 4 standard PCs and standard interfaces like GPIB, ProfiBus and cards connected to the PCI slots of one of the PCs.
Costs and efforts will be mainly covered by the University of Mainz, GSI Darmstadt, and Michigan State University.

(10) General vacuum, control, and safety equipment

pos	quant	device	company	model	unit price/€	total price / €
1	4	Oscilloscope, GPIB*Rackmount	DataTec	TDS2014	2 710	10 840
2	1	Oxygen Safety System	MIKA	GMC 8022	1 700	1 700
3	1	Vacuum Safety System	National Instruments		4 000	4 000
4	11	Rack Fire Detection Safety System	CERN		250	2 750
5	1	Pressurized Air System	Festo		5 000	5 000
6	1	Picoamperemeter	ELCAL	Keithley 483	3 500	3 500
7	1	Hall-Probe			6 000	6 000
8	30	Prevacuum tubes	Pfeiffer		100	3 000
9	200	Cupper Cealings	Pfeiffer		10	2 000
10	200	Viton Cealing Systems	Pfeiffer		30	6 000
11	1	LN2 filling tank	Messer Griesheim		5 000	5 000
12	1	Vacuum baking equipment CF100-CF150	VACOOM		6 000	6 000
13	5	Vacuum blind flanges CF100	VACOOM		300	1 500
14	5	Vacuum blind flanges CF150	VACOOM		450	2 250
15	1	Doublecross CF150 with SHV Feedthroughs	VACOOM		3 200	3 200
16	1	Doublecross CD100 with SHV Feedthroughs	VACOOM		2 600	2 600
17	1	FeCo Tools for strong magnetic fields	OXFORD		500	500
18	1	Several hundreds of stainless steel screws	FATCHER		10 000	10 000
					SUM	**75 800**

Safety: Oxygen safety system, vacuum safety system, rack fire detection safety systems, high-voltage safety systems, doors with restricted access, and interlocks are needed. Some of these devices are already included in the lists for the different sub-projects.

(11) Spare parts

pos	quant	device	company	model	unit price/€	total price / €
1	2	Vaccum pump and controller			13 130	26 260
		Prepump	Alcatel		1 400	
		Turbopump/Ion getter pump	Pfeiffer		11 000	
		Pirani Gauge	VakMüller	APGX-M KF16	220	
		Penning Gauge	VakMüller	AIM-X KF25	510	
2	2	Power supply Channeltron/MCP	CAEN	A503N/SY403	4 040	8 080
3	4	UHV HV Feedthroughs	VACOOM		500	2 000
4	10	BNC/SHV Feedthroughs	VACOOM		80	800
5	2	Preamplifier	AMETEK	VT120C	415	830
6	1	PCI-GPIB Card	National Instruments	NI-488.2	585	585
7	10	Linear ball bearing	SKF	LUCT 25 BH	90	900
					SUM	**39 500**

Here only the most important and time crucial spare parts are listed. Anyhow spare parts exist in larger amounts at the Penning trap facilities already in operation and being collaboration members of MATS.

Manpower estimates (not costed):

Men power estimates (FTE, numbers given in years)						
Part	R&D	Design	Machining	Construction	Comissioning	R&D costs / €
Beamline	1	2	2	1	0.5	5000
Off-line ion source	0	0.2	0.2	0.6	0.2	
RFQ	1	0.5	1	1.5	0.5	
EBIT	1	0.5	1	2	1	
A/q selection	1	0.5	0.5	1	0.5	
preparation Penning trap	3	2	1	2	2	15000
precision Penning trap	3.5	2.5	1	2	2.5	15000
TOF/FT-ICR Detectors	1	0.2	0.4	0.6	0.2	
Decay detectors	2	1	0.5	1.5	0.5	10000
Control System	0.5	2	0	1	0.5	5000
SUM	**14**	**11.4**	**7.6**	**13.2**	**8.4**	**50000**

A detailed list is available in the MATS technical proposal. There we distinguished also between PostDoc and PhD man years. Required manpower for the operation of MATS is 2 PostDocs and 3 PhD students per year.

MATS COST SUMMARY

Cost Summary

Item	Sub-Project	Costs	Cost estimate from TP
1	Beamline	421 000	400 000
2	Off-line ion source	61 500	60 000
3	RFQ + Switchyard	234 600	260 000
4	EBIT	329 500	310 000
5	q/A selection	99 700	100 000
6	Preparation Penning trap	460 900	450 000
7	Precision Penning trap	491 100	530 000
8	Detectors (TOF, FT-ICR, Decay)	308 700	265 000
9	Control system	54 300	-
10	General control + safety equip.	75 800	-
	Sum	**2 537 000**	**2 375 000**

Estimated Maintenance and Operating Costs

Item	Sub-Project	Costs
1	Beamline	20 000
2	Off-line ion source	1 000
3	RFQ + Switchyard	1 000
4	EBIT	10 000
5	q/A selection	1 000
6	Preparation Penning trap	15 000
7	Precision Penning trap	15 000
8	Detectors (TOF, FT-ICR, Decay)	8 000
9	Control system	3 000
10	General control + safety equip.	2 000
	Sum	**76 000**

These costs include expendable items and maintenance (mainly of the vacuum system for 1-8). Annual costs for LN2 and LHe are not included.

Institute manpower (not costed) and R&D costs.

Men power estimates (FTE, numbers given in years)						
Part	R&D	Design	Machining	Construction	Comissioning	R&D costs / €
Beamline	1	2	2	1	0.5	5000
Off-line ion source	0	0.2	0.2	0.6	0.2	
RFQ	1	0.5	1	1.5	0.5	
EBIT	1	0.5	1	2	1	
A/q selection	1	0.5	0.5	1	0.5	
preparation Penning trap	3	2	1	2	2	15000
precision Penning trap	3.5	2.5	1	2	2.5	15000
TOF/FT-ICR Detectors	1	0.2	0.4	0.6	0.2	
Decay detectors	2	1	0.5	1.5	0.5	10000
Control System	0.5	2	0	1	0.5	5000
SUM	**14**	**11.4**	**7.6**	**13.2**	**8.4**	**50000**

Machining is mainly done by technicians; all other work is performed by PhD students and PostDocs (not distinguished here). All values are given in man years.
Required manpower for the operation of MATS is 2 PostDocs and 3 PhD students per year.