D7.2 Report on simulations and experiments on extraction and beam transport

ARES Time Schedule

	Quarter	Month - Name	Month #	MS	Deliverable	Periodic Reports		Status of 07.11.2014	
		Nov 12	27	MS81					
		Dez 12	28						
	Q2	Jan 13	29						
year #3		Feb 13	30	MS82a					
		Mrz 13	31						
	Q3	Apr 13	32						
		Mai 13	33						
		Jun 13	34						
	Q4	Jul 13	35						
		Aug 13	36	MS84 postponed to March 2014		P2			
		Sep 13	37						
	Q1	Okt 13	38						
		Nov 13	39						
		Dez 13	40						
	Q2	Jan 14	41						
year #4		Feb 14	42	MS83	D7.3				
		Mrz 14	43	MS82b + MS84					
	Q3	Apr 14	44						
		Mai 14	45						
		Jun 14	46						
	Q4	Jul 14	47					Status of 07.11.2014	
		Aug 14	48						
extended		Sep 14	49						achieved
to		Okt 14	50						due
December		Nov 14	51						upcoming
2014		Dez 14	52		D7.1, D7.2	P3			due later

ARES Commitments

MS81	Correlation of X-rays emission measurements and electron heating study
MS82	3D-simulations of ion-beam extraction and transport
MS83	Experimental beam analysis
MS84	Ionization efficiency measurements with with different mixing gas parameters

D7.1	Report on experimental results of microwave to plasma coupling: Report on experimental results of microwave to plasma coupling and description of the ion-source improvements obtained in the frame of the JRA
D7.2	Report on simulations and experiments on extraction and beam transport
D7.3	Report on experimental results for metal ion beam

P1	Reporting period from month 1 to month 18
P2	Reporting period from month 19 to month 36
P3	Reporting period from month 37 to month 48

	achieved
	due
	upcoming

In addition:

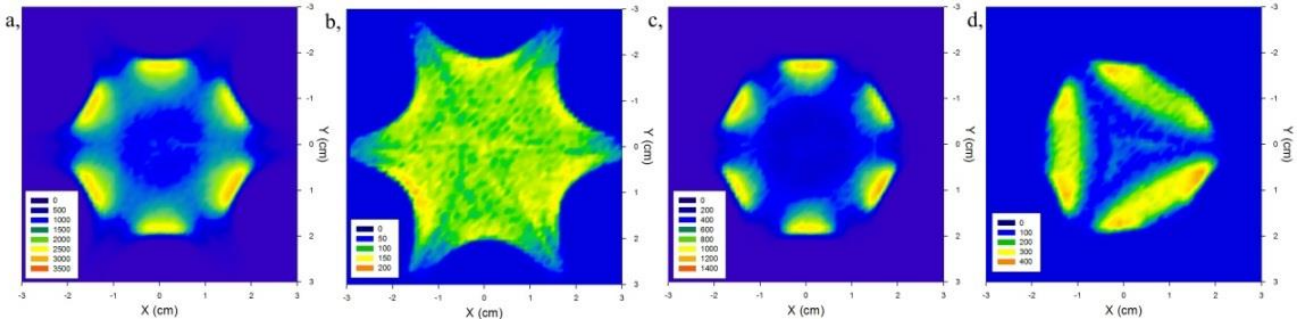
Preparation of the conclusive report to submit to ENSAR in January-February 2015.

JRA01-ARES/ENSAR Task 2: GSI, INFN-LNS, KVI, JYFL, ATOMKI, IFIN-HH, IKF

Task 2 - Ion beam formation and transport

Milestone **MS82 -** 3D-simulations of ion-beam extraction and transport: achieved, final work in progress

- Simulations of spatial distribution of electrons in an ECRIS plasma in 3D using upgraded TrapCAD code. (ATOMKI)
- KOBRA3D trajectory simulations: Trajectories starting inside the plasma are strongly bound to the magnetic field lines without noticeable influence of collisions (input obtained from TOSCA code for magnetic flux density distribution and from TrapCAD code for initial current density distribution). (GSI)
- Extraction and transport of ion beam from the KVI AECR ion source and LEBT: comparison of simulation with experiment. The COSY INFINITY code has been used to calculate transfer maps for the 110°-spectrometer-dipole. (KVI)
- Design of new extraction for the JYFL 14 GHz ECRIS with IBSimu code. (JYFL)



Axial projection of all the non-lost (a), of the cold (b), of the warm (c) and of the energy and spatially filtered coordinates (d) electrons in the GSI CAPRICE source (output from TrapCAD).

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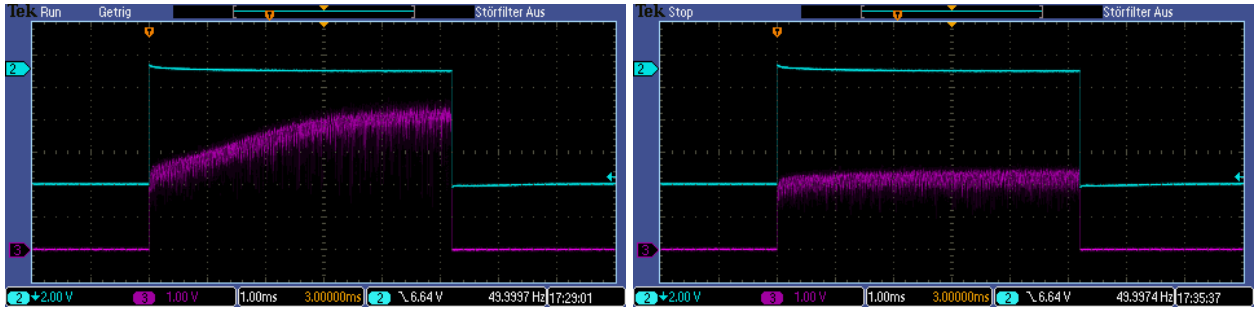
Task 2 - Ion beam formation and transport

Milestone **MS83 -** Experimental beam analysis: achieved

- Influence on the space charge compensation: deterioration by a positively biased grid and improved compensation by neutral gas injection. (JYFL)
- Investigations on the evolution of space charge compensation using a fast electrostatic beam chopper unit. (GSI).
- TWTA – frequency sweep between 12.5 and 16.5 GHz: considerable influence on intensity and transmission through the LEBT. (GSI)
- Investigation of ion beam instabilities of the analyzed ion beam by measuring the ion current with a fast Faraday cup detection. (JYFL)
- The typical internal structures of ion beam profiles have been verified by different experimental methods. (GSI)

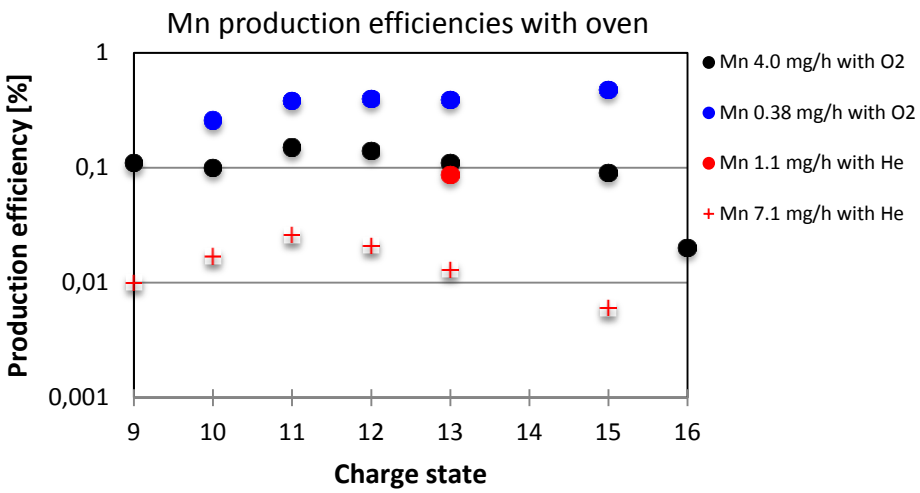


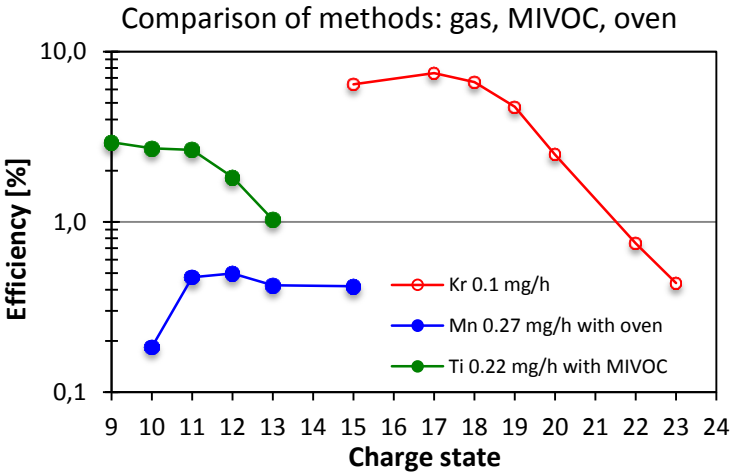
Evolution of space charge compensation – chopped beam of He^+, 5keV, 400µA (200µA), p ≈ 10^{-7} mbar
τ=3.5ms without additional electron generation (left), τ<0.3ms with additional electron generation (right)

JRA01-ARES/ENSAR Task 3: JYFL, GSI, INFN-LNL, GANIL

Task 3 - Production of metal ion beams

Milestone **MS84 -** Ionization efficiency measurements with different mixing gas parameters: achieved





Main findings:

- as a mixing gas oxygen is superior compared to helium (left-hand-side graph)
- MIVOC method is very efficient when compared to oven method (right-hand-side graph)
- oven method has space for further improvements in terms of production efficiency (oven geometry, location, means to guide the evaporated elements into the plasma,…)

Simulations

Simulations of spatial distribution of particles in an ECRIS plasma

- Upgrade of Atomki-TrapCAD code ➔ 3D density distribution of ions.
- Provide data for generating starting conditions of ions for ion trajectory simulation

Ion beam transport

- Ion beam formation in the ECR plasma by PIC-MCC code (developed at KVI) + ion trajectory simulation by GPT code (He^+ beam from KVI-AECR source + LEBT).
- KOBRA3D – trajectories starting inside the plasma for different combinations of coil currents ➔ magnetic flux density configuration obtained from TOSCA
- KOBRA3D – trajectories starting inside the plasma are strongly bound to the magnetic field lines without noticeable influence of collisions.

Combination of TrapCAD and KOBRA3D modelling the CAPRICE ECRIS

- The TrapCAD code has been used to determine the electron spatial distribution in a certain energy window. Then the full 3D electron tracking within the plasma chamber has been combined with the generation of initial ion starting conditions including particle density for ion tracking. The magnetic field has been modeled with OPERA, whereas for solving the electric potential and the particle tracking the computer code KOBRA3-INP has been used.

Experiments

Ion source extraction

- Design of new extraction for the JYFL 14 GHz ECRIS with IBSimu + experimental investigation
- Investigation of the effect of a collar structure on ECRIS performance at the JYFL 14 GHz ECRIS.

Ion beam transport

- EIS test setup @GSI operated with TWTA – frequency sweeps between 12.5 and 16.5 GHz ➔ considerable influence on intensity and transmission through the LEBT.
- Extraction and transport of an ion beam from the KVI ECR ion source: comparison of simulation with experiment. The COSY INFINITY code has been used to calculate transfer maps for the 110°-spectrometer-dipole

Experiments

Space charge compensation

- Influence on the space charge compensation: deterioration by a positively biased grid and improved compensation by neutral gas injection. (JYFL)
- Investigations on the evolution of space charge compensation using an electrostatic chopper unit to generate beam pulses with steep slopes of rise time at GSI

Ion beam properties

- Investigations of ion beam instabilities of the analyzed ion beam by measuring the ion current by means of a Faraday cup at the JYFL 14 GHz ECRIS.
- The typical structures of ion beam profiles, measured with viewing targets have been confirmed by measurements at the EIS test setup @GSI with a multi Faraday Cup Array (FCA) in collaboration with the University of Kiel (Germany).
- Investigations on the beam property emittance in relation to measurements with a pepper pot (KVI, GSI).

Initial Intention

From the work package description:

- Improve our understanding ... of multicharged ion production and intense ion-beam formation and transport.
- Therefore the investigation of the phase space properties with appropriate beam diagnostic tools is essential.
- Experimentally investigate ... Ion correlations induced by the magnetic configuration of an ECR ion source may introduce additional image errors negatively affecting the beam transport.
- To compare several different low energy beam transport lines to improve the existing ion beam injection by taking advantage of the participation of the major European accelerator laboratories. This is unique up to now in the field.