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Comparison of Modeling of K-shell Al and Mg from the Implosions of Planar and Cylindrical Wire Arrays produced on the 1MA Zebra Generator at UNR.

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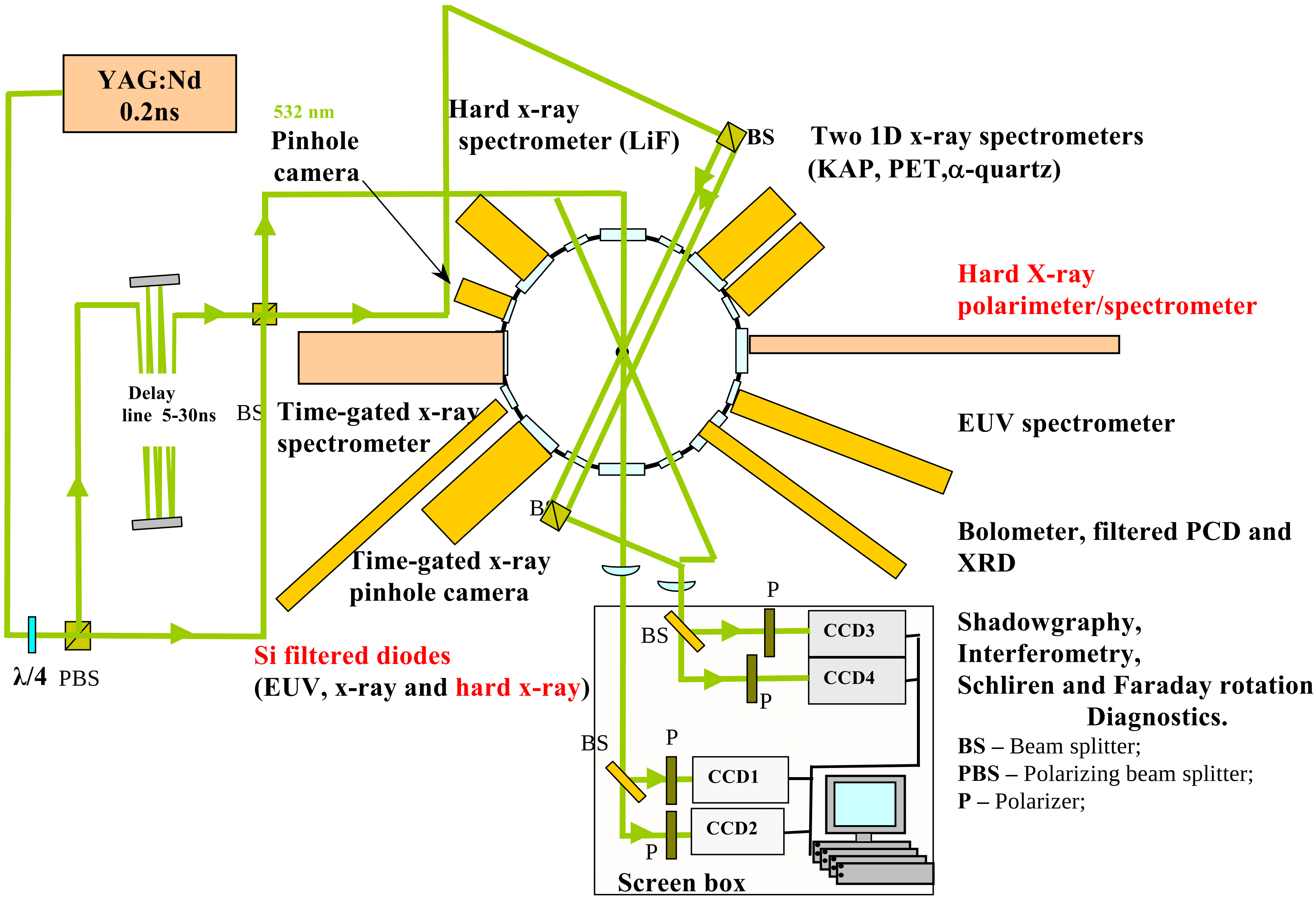
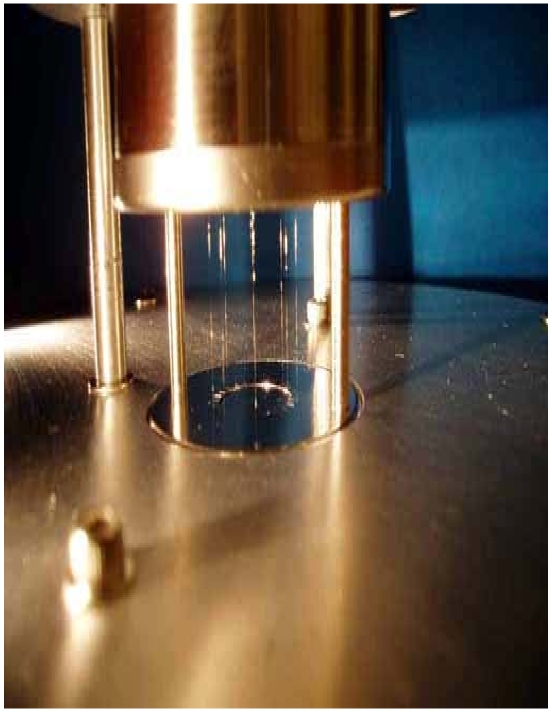
Abstract

K-shell radiation of Al and Mg from implosions of various radius cylindrical and single planar wire arrays on the 1MA NTF-Zebra generator was studied. Specifically, radiation from implosions of 12 mm radius cylindrical arrays with eight Al-5056 (95% of Al and 5% of Mg) wires were analyzed. In addition, smaller radius 3 mm compact cylindrical arrays with twenty-four alloyed Al-5052 (97.5% of Al and 2.5% of Mg) wires were considered. Also, single planar arrays with the ten alloyed Al-5056 and fifteen Al-5052 wires were also studied. The utilization of the alloyed Al wires with different small concentrations of Mg allowed to study opacity of Al lines and to use the opacity-free Mg lines in K-shell plasma diagnostics. Previously developed non-LTE model has been applied to model spatially resolved time integrated as well as time-gated spatially integrated spectra from alloyed Al plasmas. As a result, spatially resolved electron temperatures and densities for all considered experiments as well as time resolved parameters for some of the shots were computed and compared for different wire compositions and types of the loads. The time-gated spectra were recorded at the start of the main x-ray burst and hence their modeling provided the initial electron temperatures and densities at the stagnation. The temporal evolution of these parameters was also compared with the same parameters but derived from the time-gated spectra recorded after the main x-ray burst . In addition, the cases of the most strong opacity in Al lines were identified and discussed along with the future development of the models.

X-RAY, EUV and Laser Probing Diagnostics in Zebra
(for experimental details, see, for example, [1, 5])



Cylindrical Wire Arrays



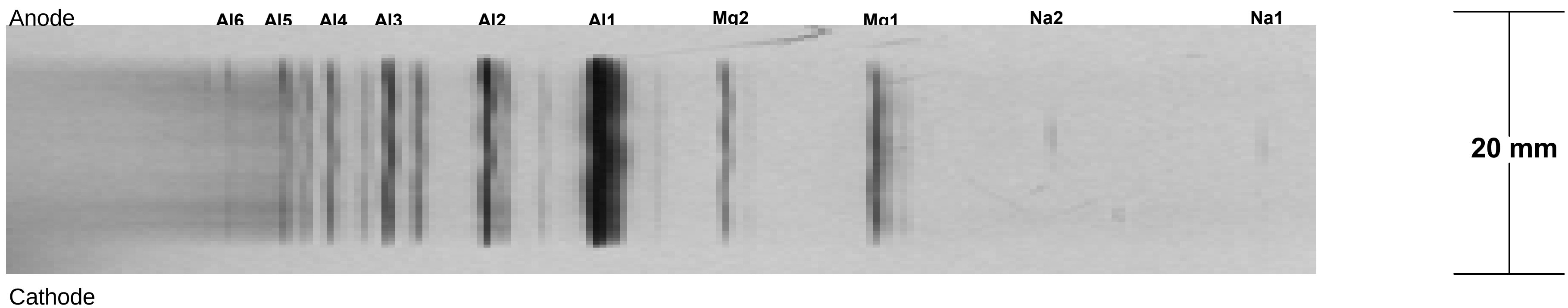
Compact Cylindrical Wire Arrays

Planar Wire Arrays

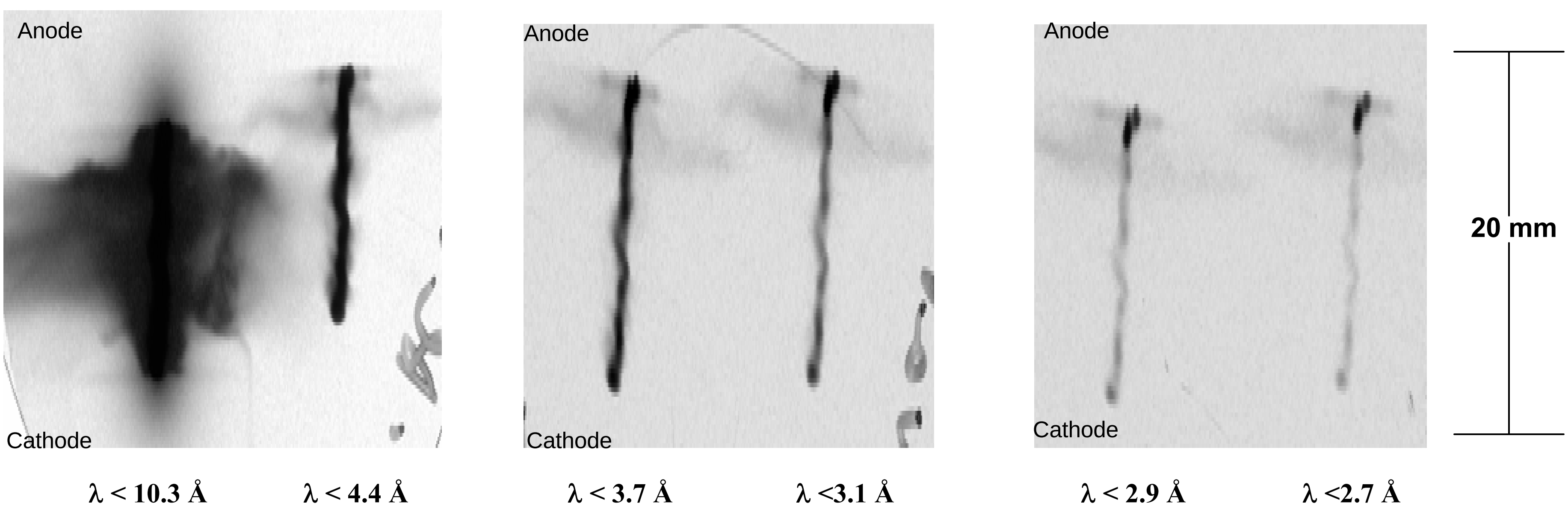
Load Information

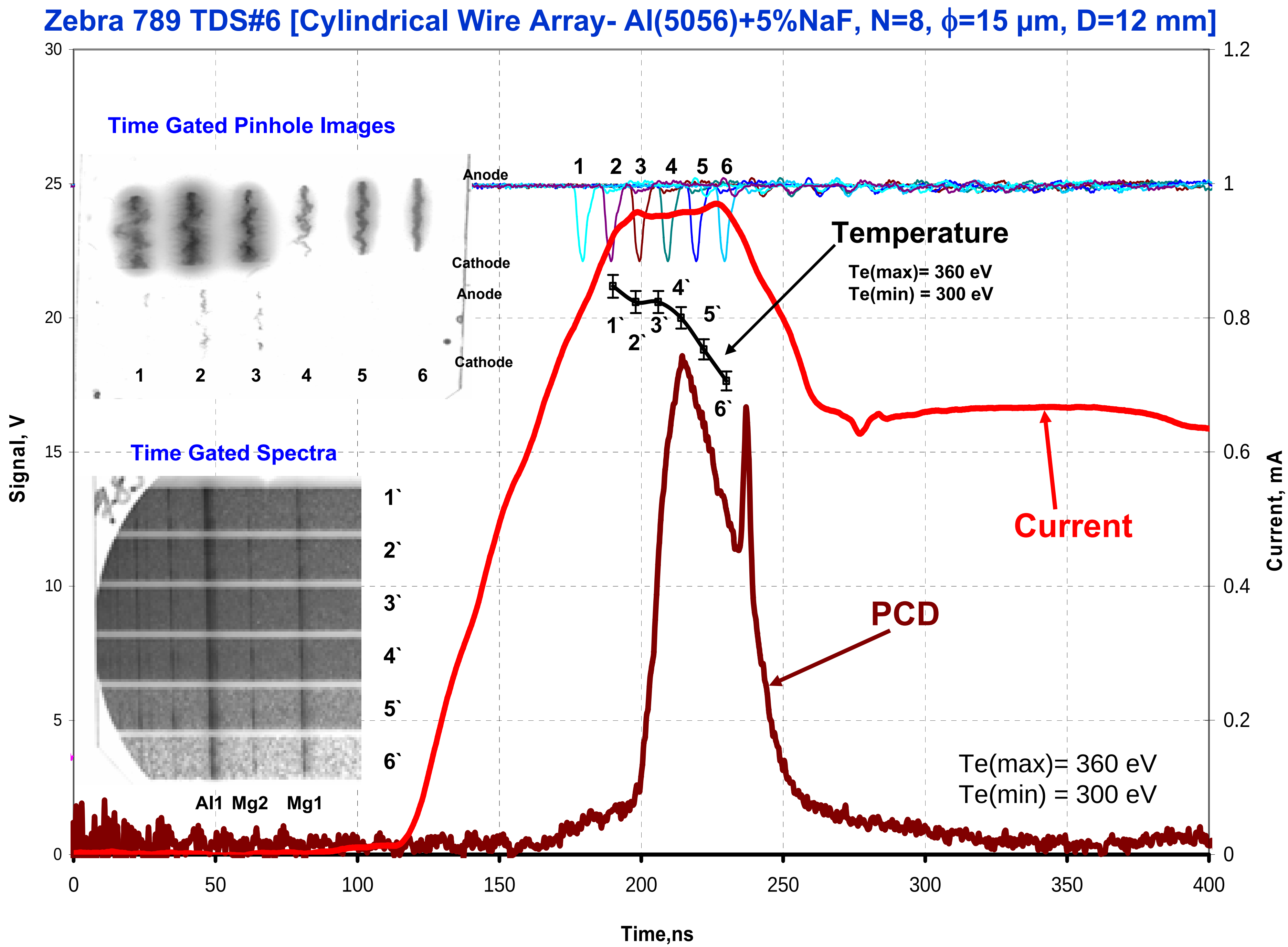
Shot No	Configuration	Wire Material	Number of Wires	Wire Dia.(μm)	Load Dia.(mm)	IWG (mm)	Mass (μg)
789	Cylindrical Wire Array	Al(5056) + 5%NaF	8	15	12	-	76
1254	Compact Cylindrical Wire Array	Al(5052)	24	15	3	-	115
797	Single Planar Wire Array	Al(5052)	15	15		1	143
799	Single Planar Wire Array	Al(5056)	10	Distributed:15,198.8,22.6,19.8,15,15,19.8,22.6,19.8,15	-	1	148

Axially resolved Al K-Shell spectra from the Al-5056+5%NaF Cylindrical Wire Array (N=8,ϕ=15 μm, D=12 mm) recorded by a KAP crystal (Zebra Shot 789-08/10/06)



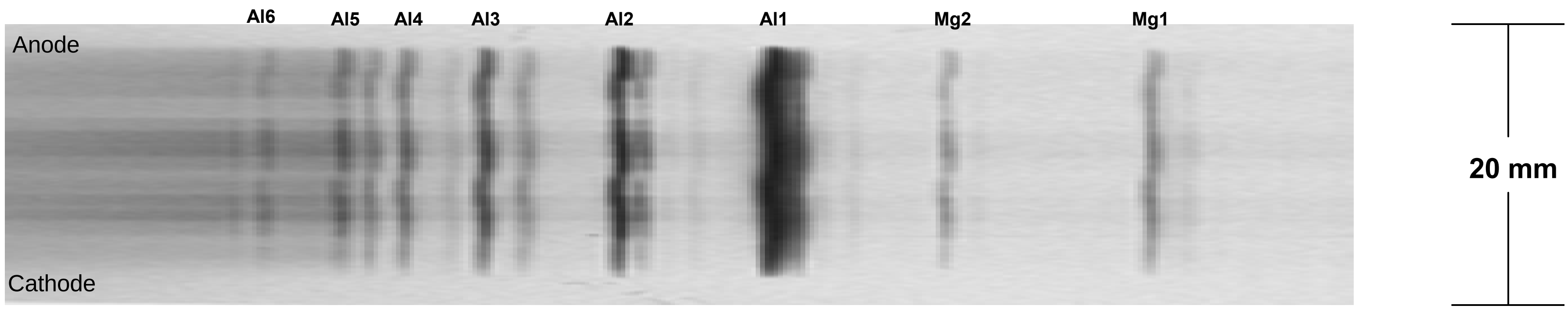
Time Integrated Pinhole Images from Al Cylindrical Wire Array Implosion (Zebra Shot 789)



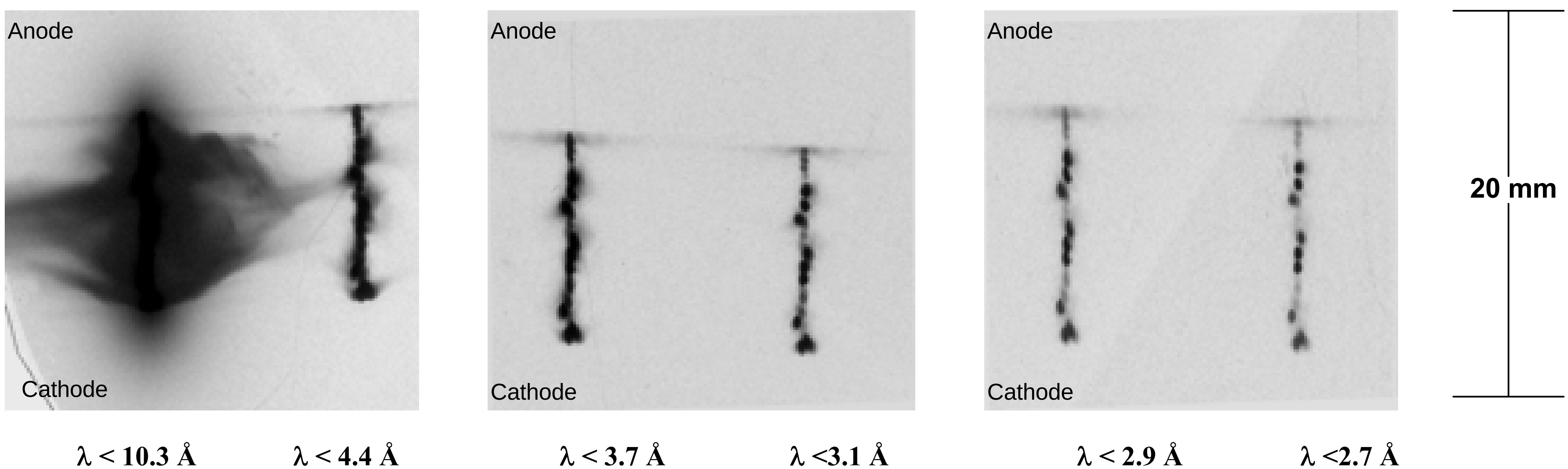


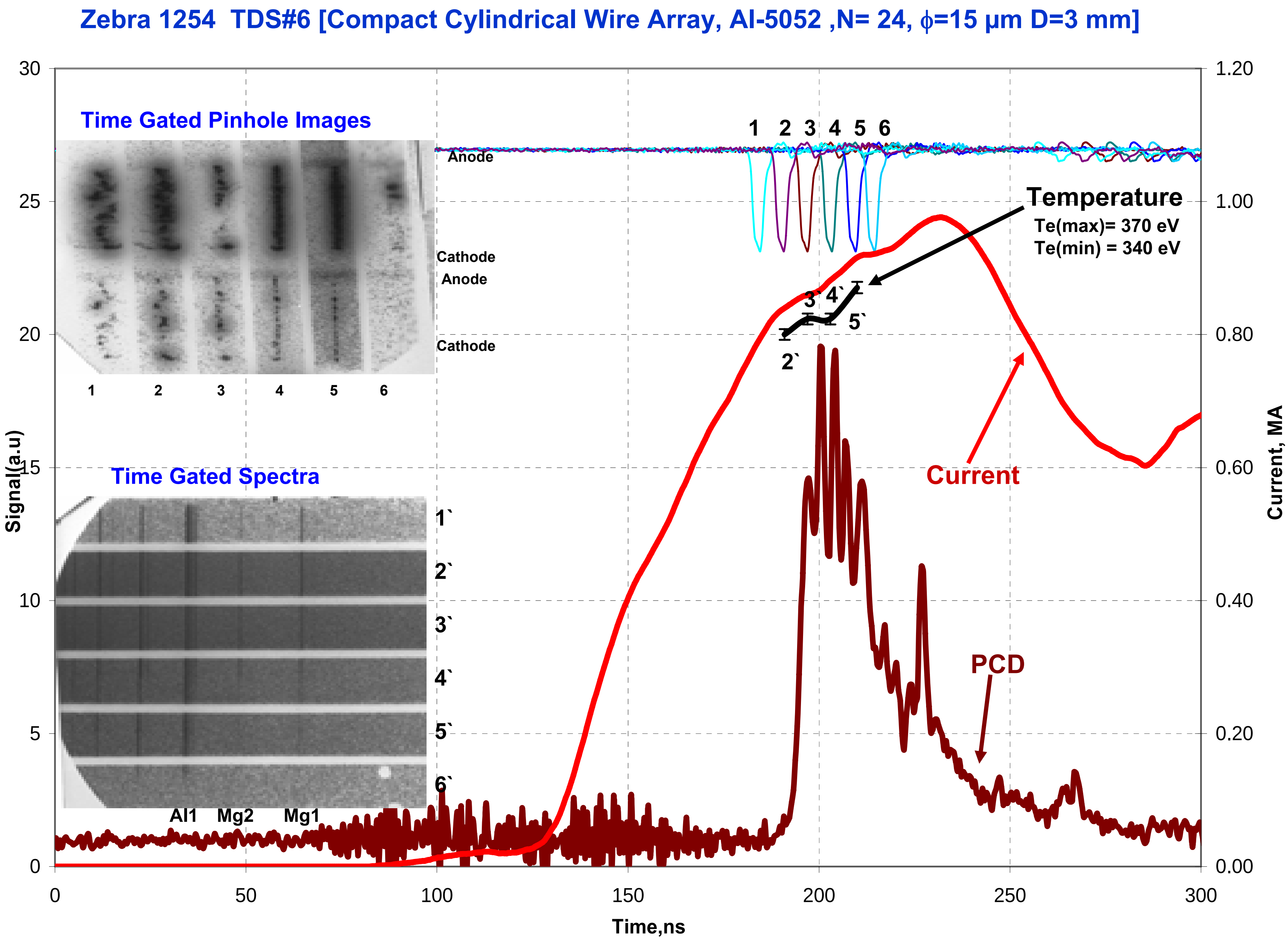
Zebra 789 TDS#6 [Cylindrical Wire Array- Al(5056)+5%NaF, N=8, ϕ=15 μm, D=12 mm]
Time Gated Pinhole Images
Anode
Cathode
Anode
Cathode
1 2 3 4 5 6
Time Gated Spectra
1` 2` 3` 4` 5` 6`
Al1 Mg2 Mg1
Temperature
Te(max)= 360 eV
Te(min) = 300 eV
Current
PCD
Te(max)= 360 eV
Te(min) = 300 eV
Signal, V
Current, mA
Time,ns

Axially resolved Al K-Shell spectra from the Al-5052 Compact Cylindrical Wire Array ($N=24, \phi=15\ \mu m$, $D=3$ mm) recorded by a KAP crystal (Zebra Shot 1254)

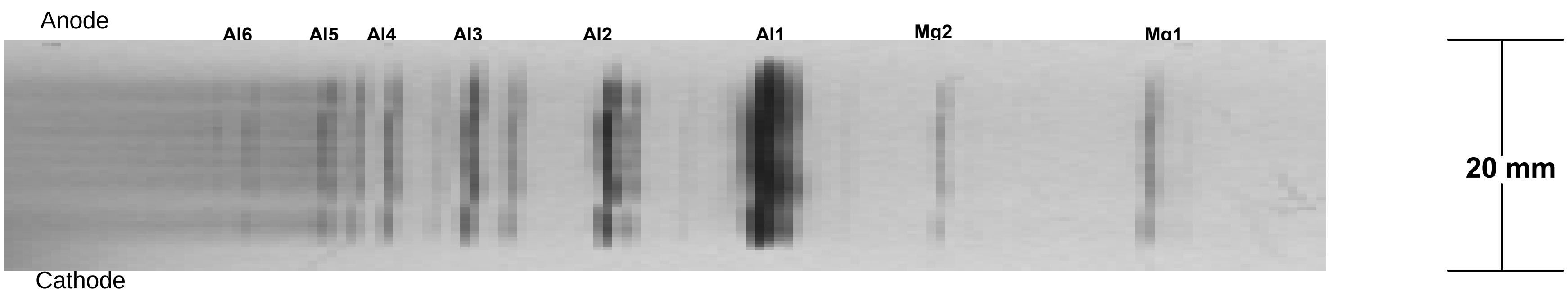


Time Integrated Pinhole Images from Al Compact Cylindrical Wire Array Implosion (Zebra Shot 789)

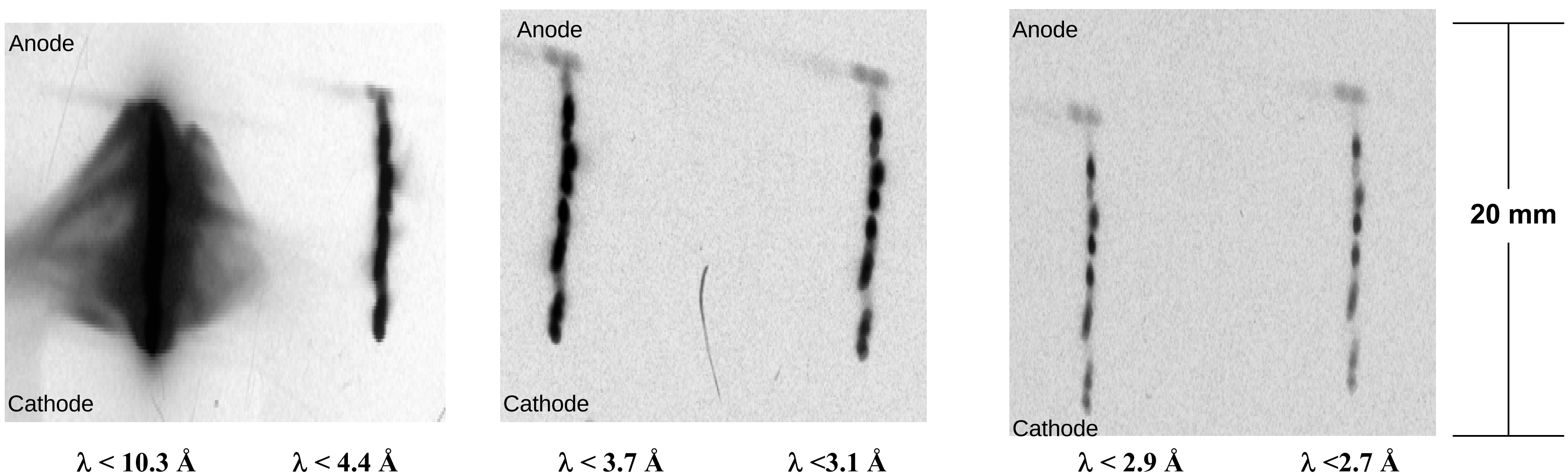



Zebra 1254 TDS#6 [Compact Cylindrical Wire Array, Al-5052 ,N= 24, ϕ=15 μm D=3 mm]
Time Gated Pinhole Images
1 2 3 4 5 6
Anode
Cathode
Anode
Cathode
Temperature
Te(max)= 370 eV
Te(min) = 340 eV
2` 3` 4` 5`
Current
Time Gated Spectra
1` 2` 3` 4` 5` 6`
Al1 Mg2 Mg1
PCD
Signal(a.u)
Current, MA
Time,ns
0 50 100 150 200 250 300
0 5 10 15 20 25 30
0.00 0.20 0.40 0.60 0.80 1.00 1.20

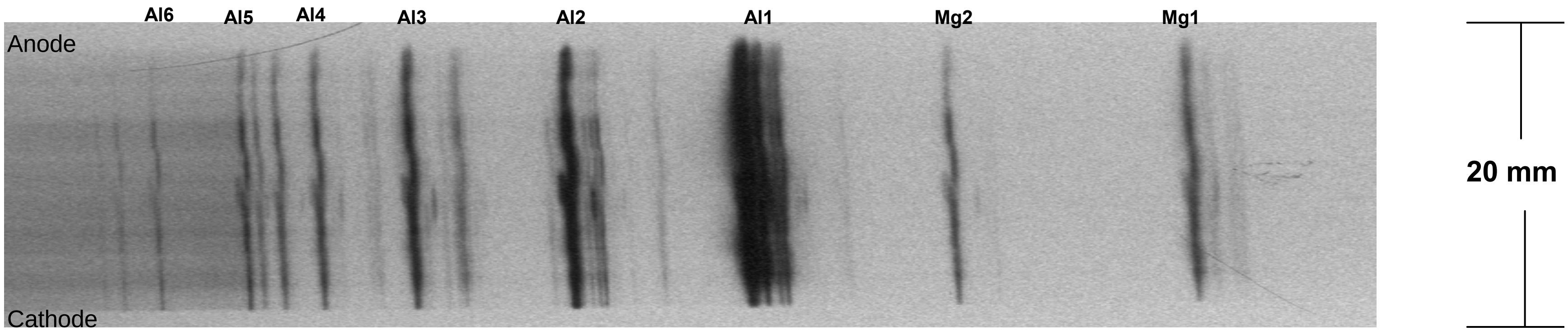
Axially resolved Al K-Shell spectra from the Al-5056 Planar Wire Array (N=15,ϕ=15 μm, ΔR=1.0 μm) recorded by a KAP crystal (Zebra Shot 797-08/15/06)



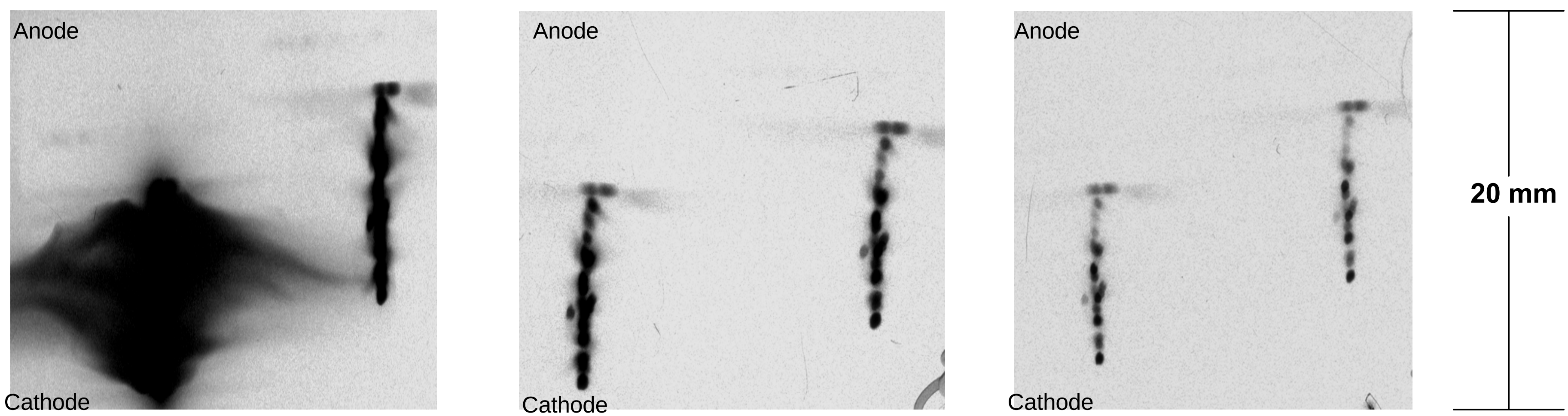
Time Integrated Pinhole Images from Al Planar Wire Array Implosion (Zebra Shot 797)



Axially resolved Al K-Shell spectra from the Al-5052 Planar Wire Array (N=10, ϕ=15,198.8,22.6,19.8,15,15,19.8,22.6,19.8,15 μm, ΔR=1.0 μm) recorded by a KAP crystal (Zebra Shot 799-08/16/06)

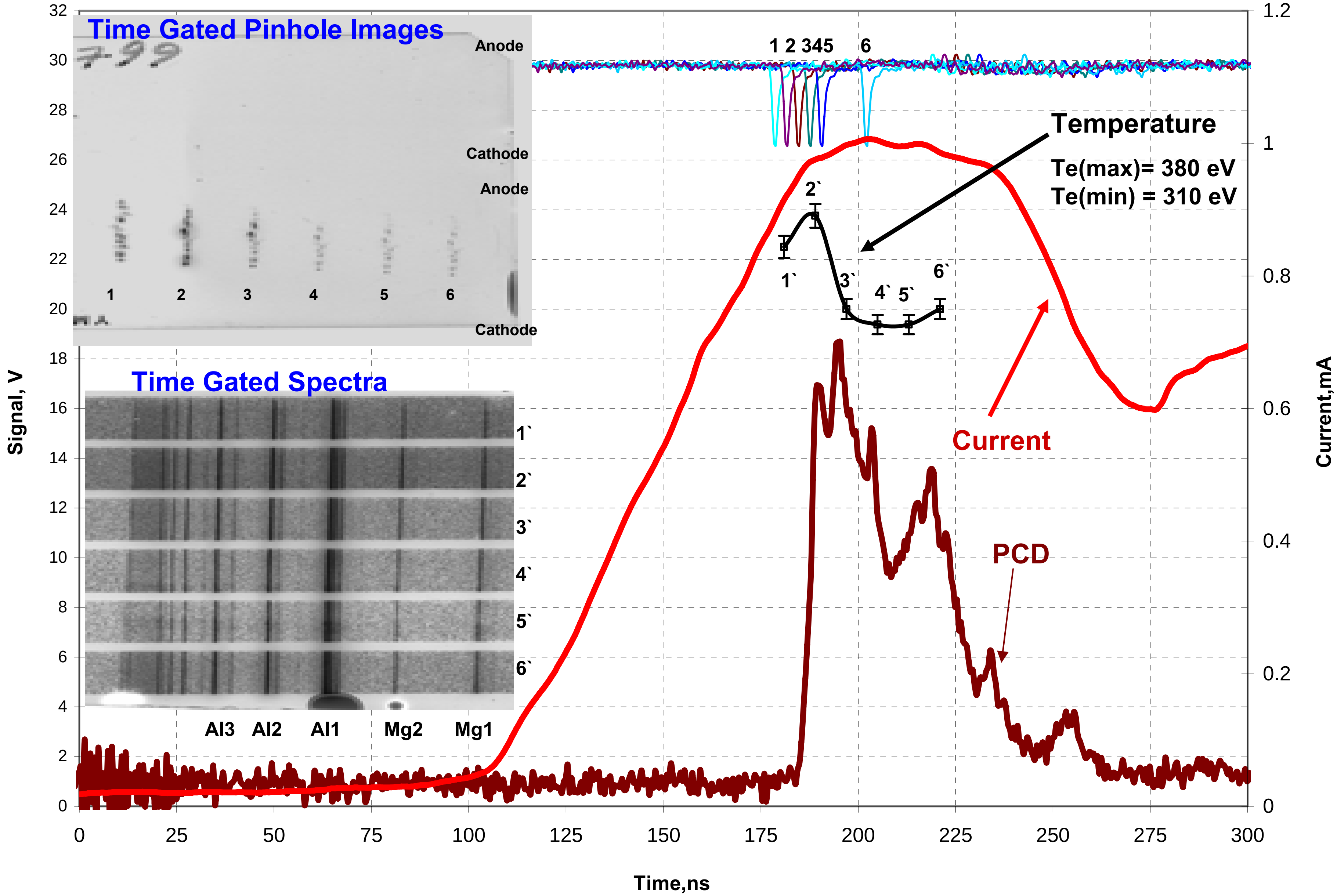


Time Integrated Pinhole Images from Al Planar Wire Array Implosion (Zebra Shot 799)



λ < 10.3 Å λ < 4.4 Å λ < 3.7 Å λ <3.1 Å λ < 2.9 Å λ <2.7 Å

Zebra 799 TDS#6 [Planar Array- Al, N= 10, ϕ=15,198.8,22.6,19.8,15,15,19.8,22.6,19.8,15 15 μm, ΔR=1mm]



Resonance and inter-combination lines of He- and H-like Mg and Al ions

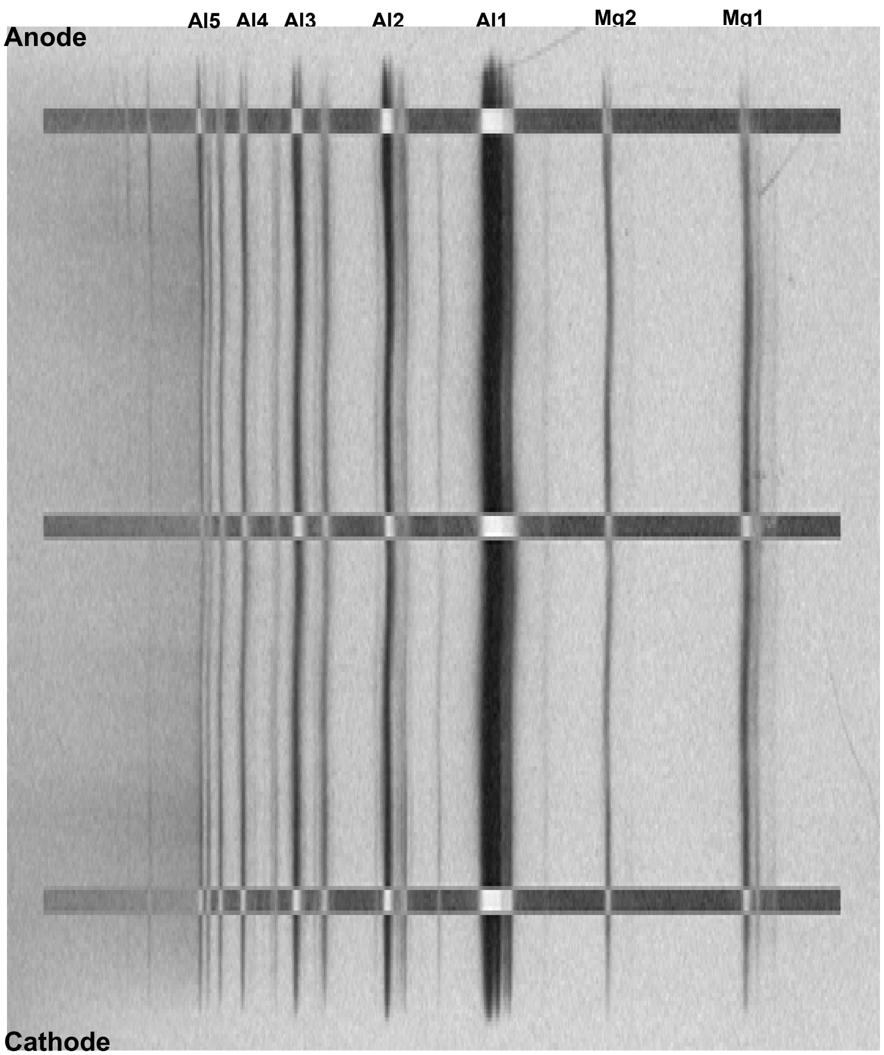
Mg (Z=12)

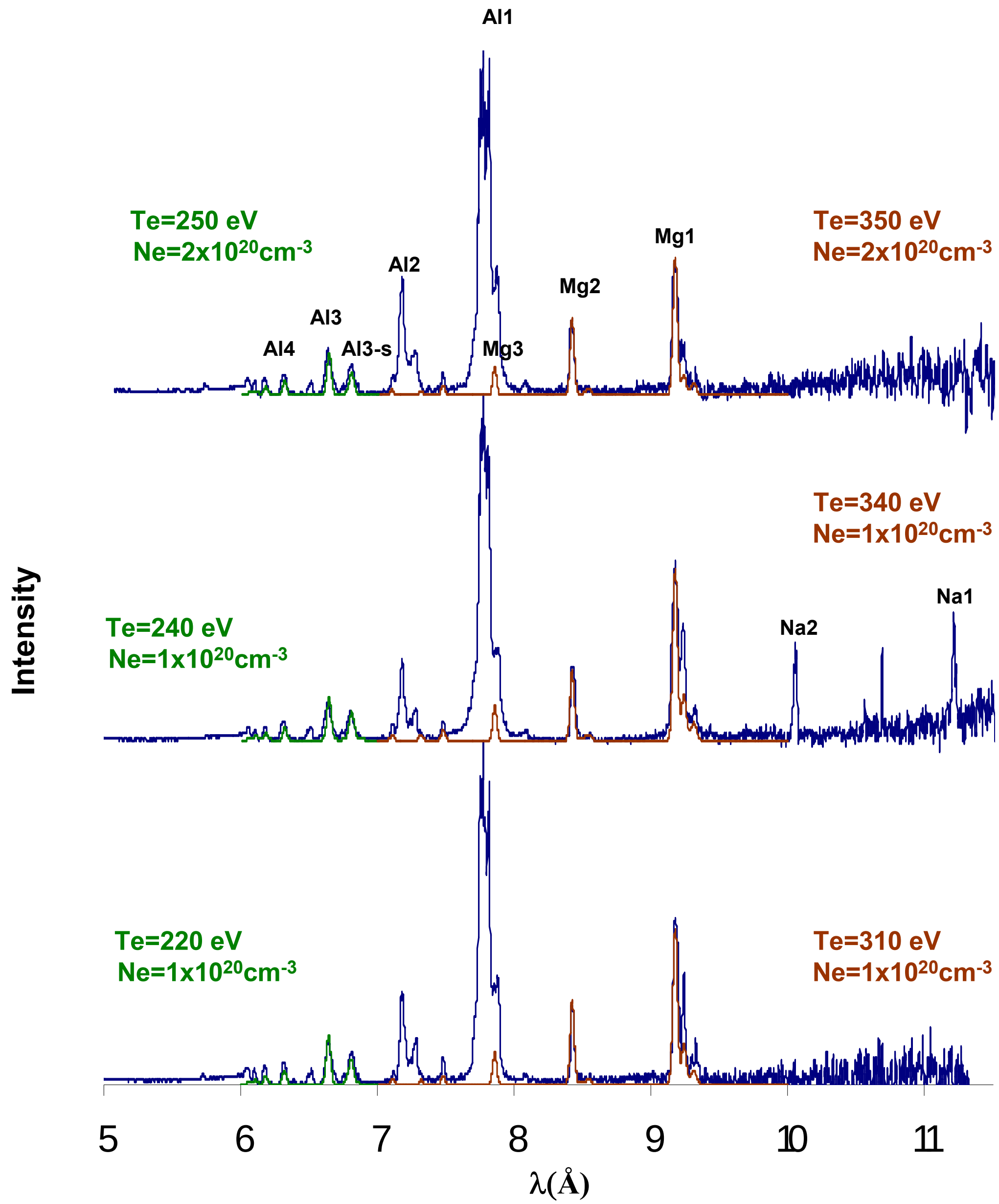
Line	λ (Å)	Ar (s^{-1})
R (Heα)	9.1695	1.97E+13
IC (2-1)	9.2312	3.29E+10
Lyα (3/2-1/2)	8.4192	1.31E+13
Lyα (1/2-1/2)	8.4246	1.31E+13
Heβ (3-1)	7.8507	5.48E+12
IC (3-1)	7.8632	1.05E+10
Heγ (4-1)	7.4733	2.21E+12
IC (4-1)	7.4780	4.24E+09
Lyβ (3/2-1/2)	7.1058	3.49E+12
Lyβ (1/2-1/2)	7.1069	3.49E+12

Al (Z=13)

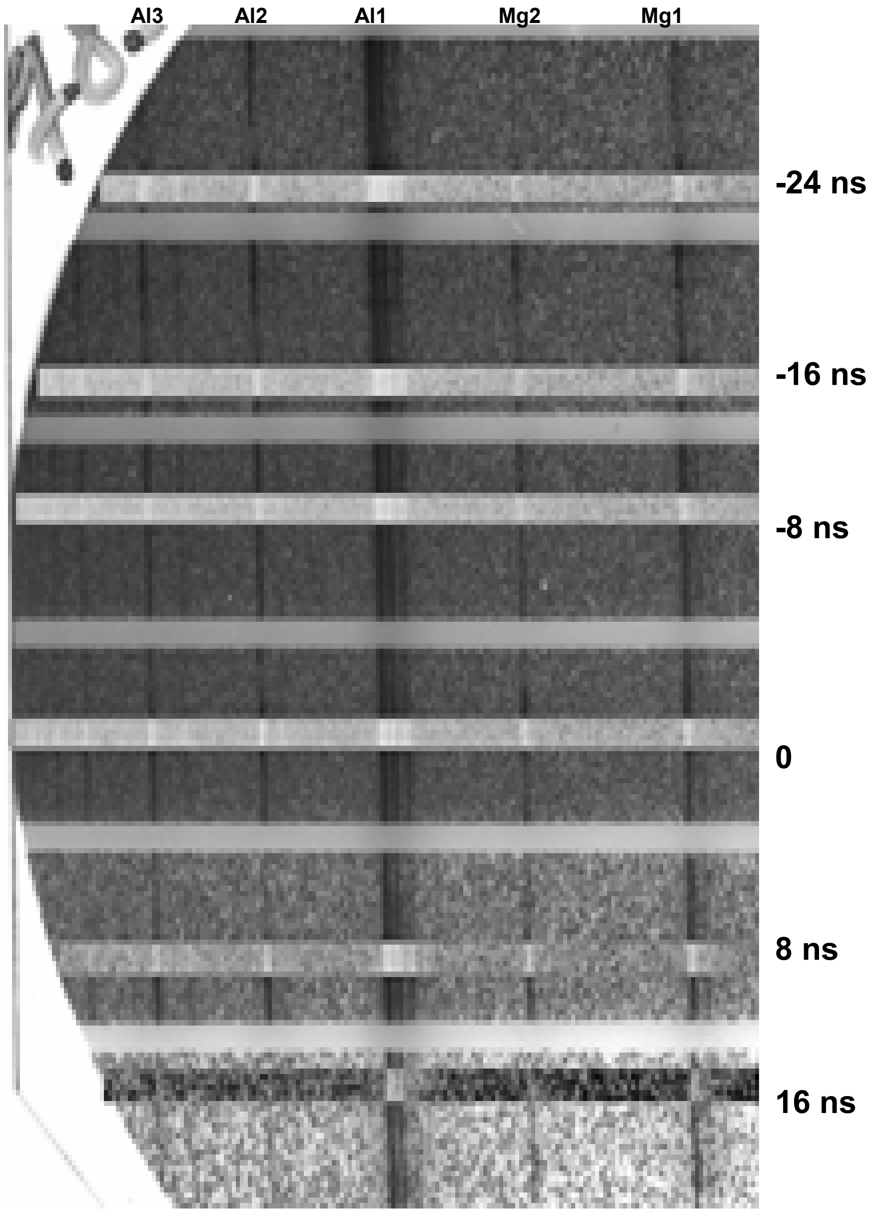
Line	λ (Å)	Ar (s^{-1})
R (Heα)	7.7578	2.78E+13
IC (2-1)	7.8070	7.31E+10
Lyα (3/2-1/2)	7.1709	1.80E+13
Lyα (1/2-1/2)	7.1763	1.80E+13
Heβ (3-1)	6.6349	7.70E+12
IC (3-1)	6.6449	2.33E+10
Heγ (4-1)	6.3140	3.10E+12
IC (4-1)	6.3178	9.45E+09
Lyβ (3/2-1/2)	6.0525	4.81E+12
Lyβ(1/2-1/2)	6.0537	4.81E+12

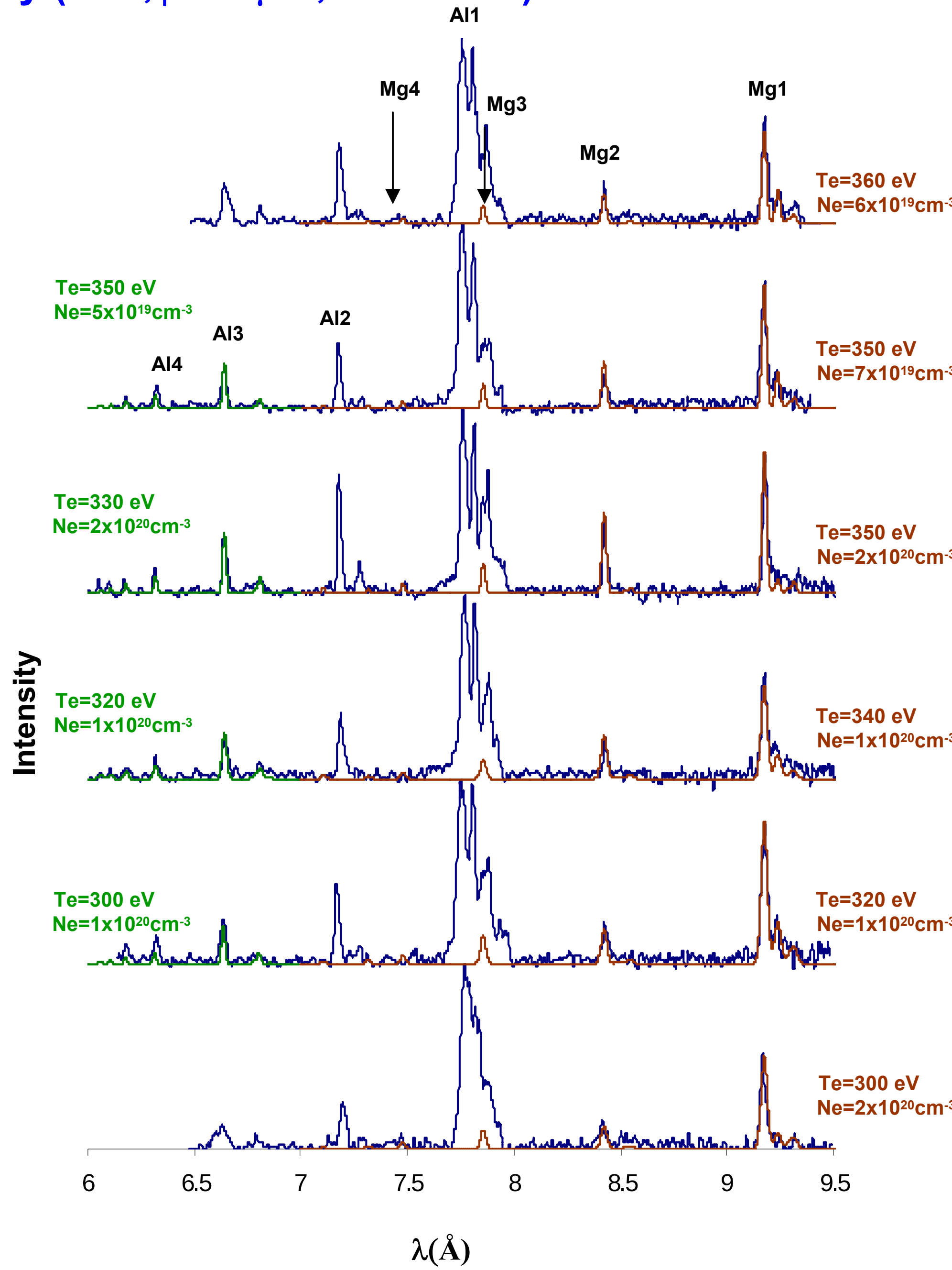
Modeling of NTF-Zebra Shot 789, Al-5056(95.0 % Al+5.0% Mg)+ 5%NaF TIXR Cylindrical Array (N=8,ϕ=15 μm, D=12 mm)



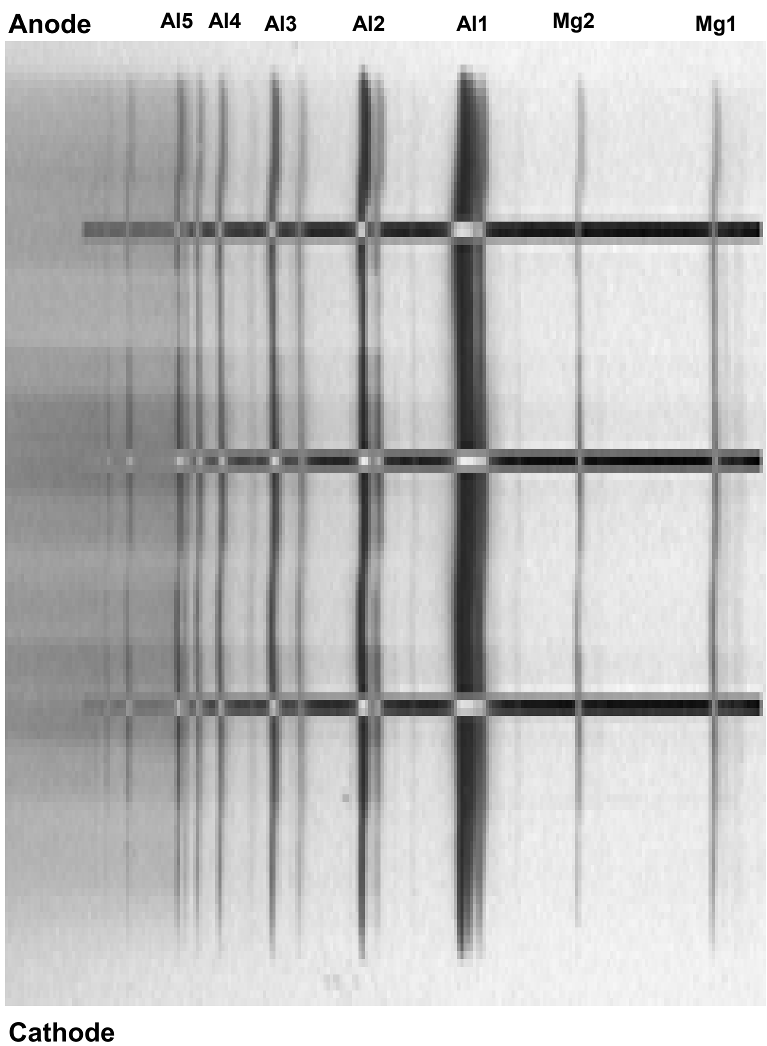


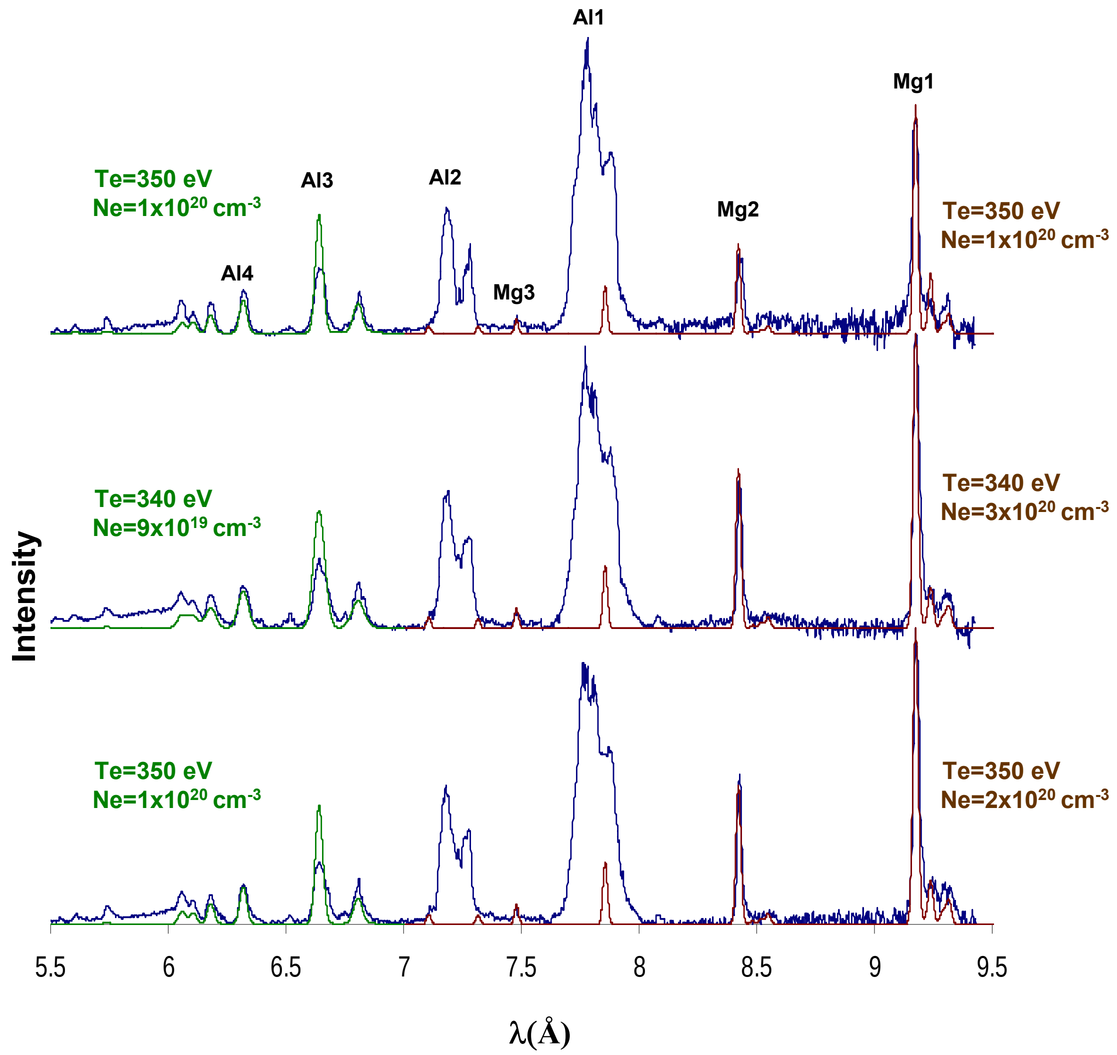
Modeling of NTF-Zebra Shot 789 Al-5056(95.0 % Al+5.0% Mg)+ 5%NaF
TGS Cylindrical Array (N=8,ϕ=15 μm, R=12 mm)



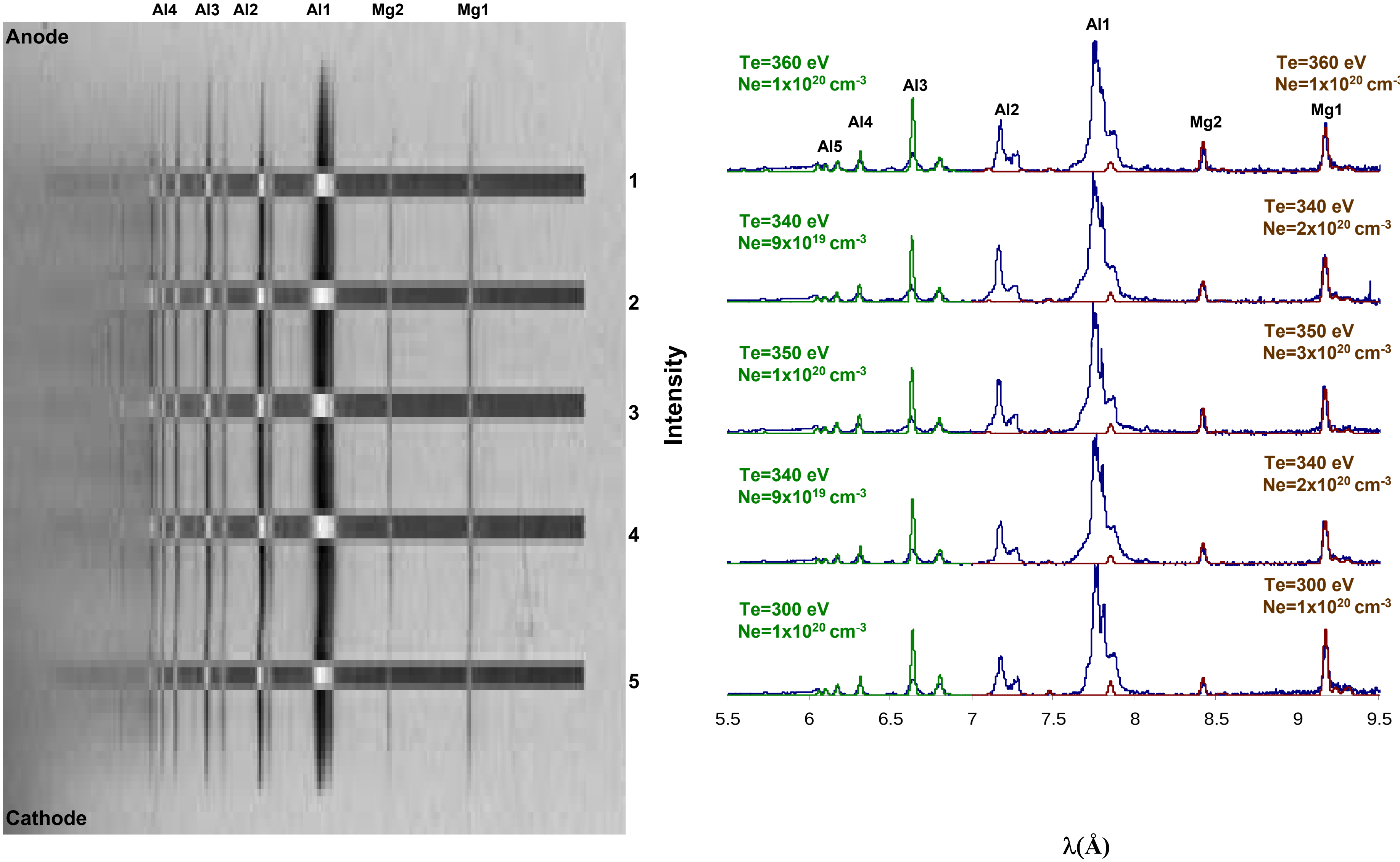


Modeling of NTF-Zebra Shot 1254 Al-5052(97.5 % Al+2.5% Mg)
TIXR Cylindrical Array (N=24,ϕ=15 μm, D=3 mm)

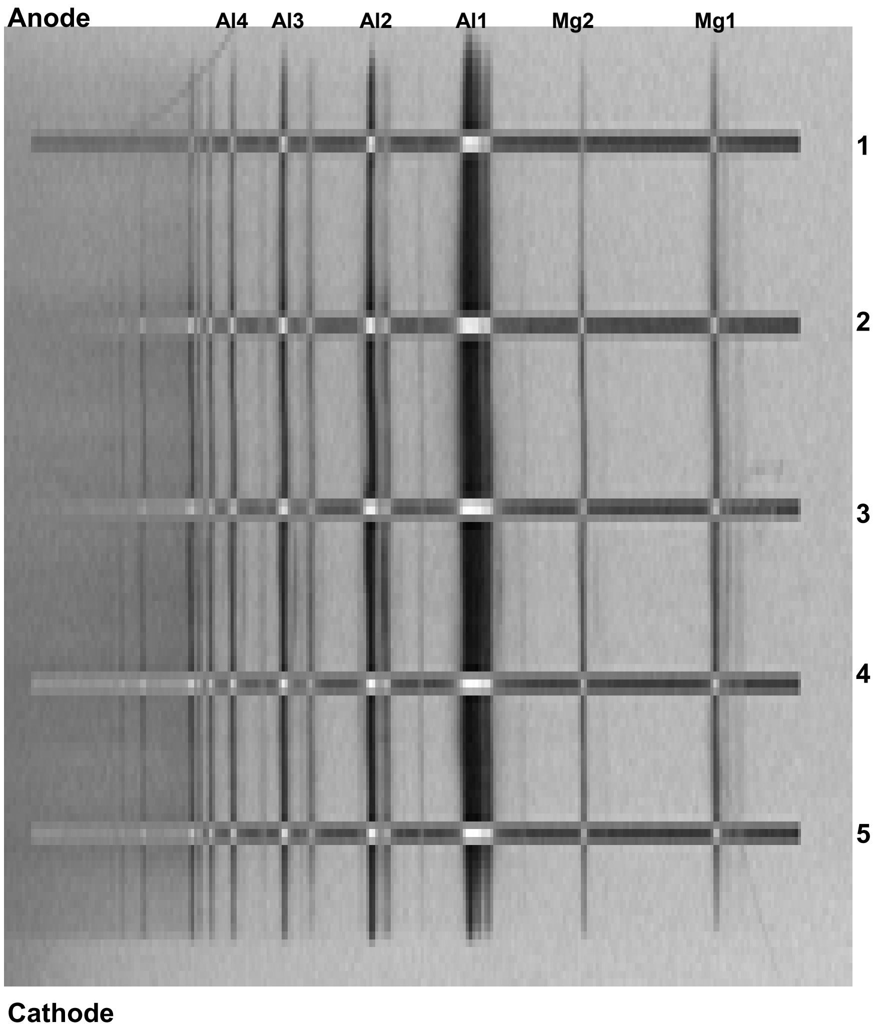


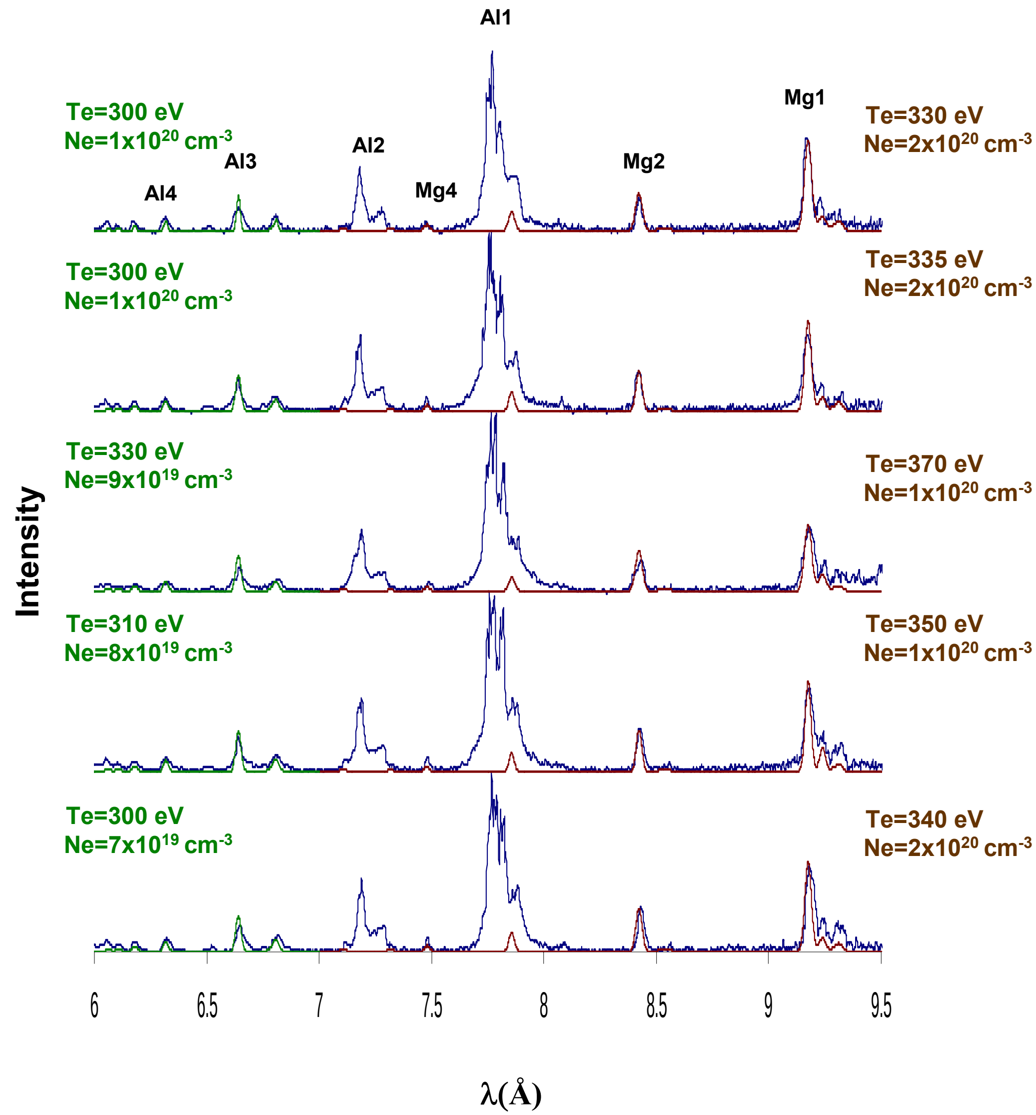


Modeling of NTF-Zebra Shot 797 Al-5056(95.0 % Al+5.0% Mg)
TIXR Planar Array (N=15,ϕ=15 μm, ΔR= 1mm)

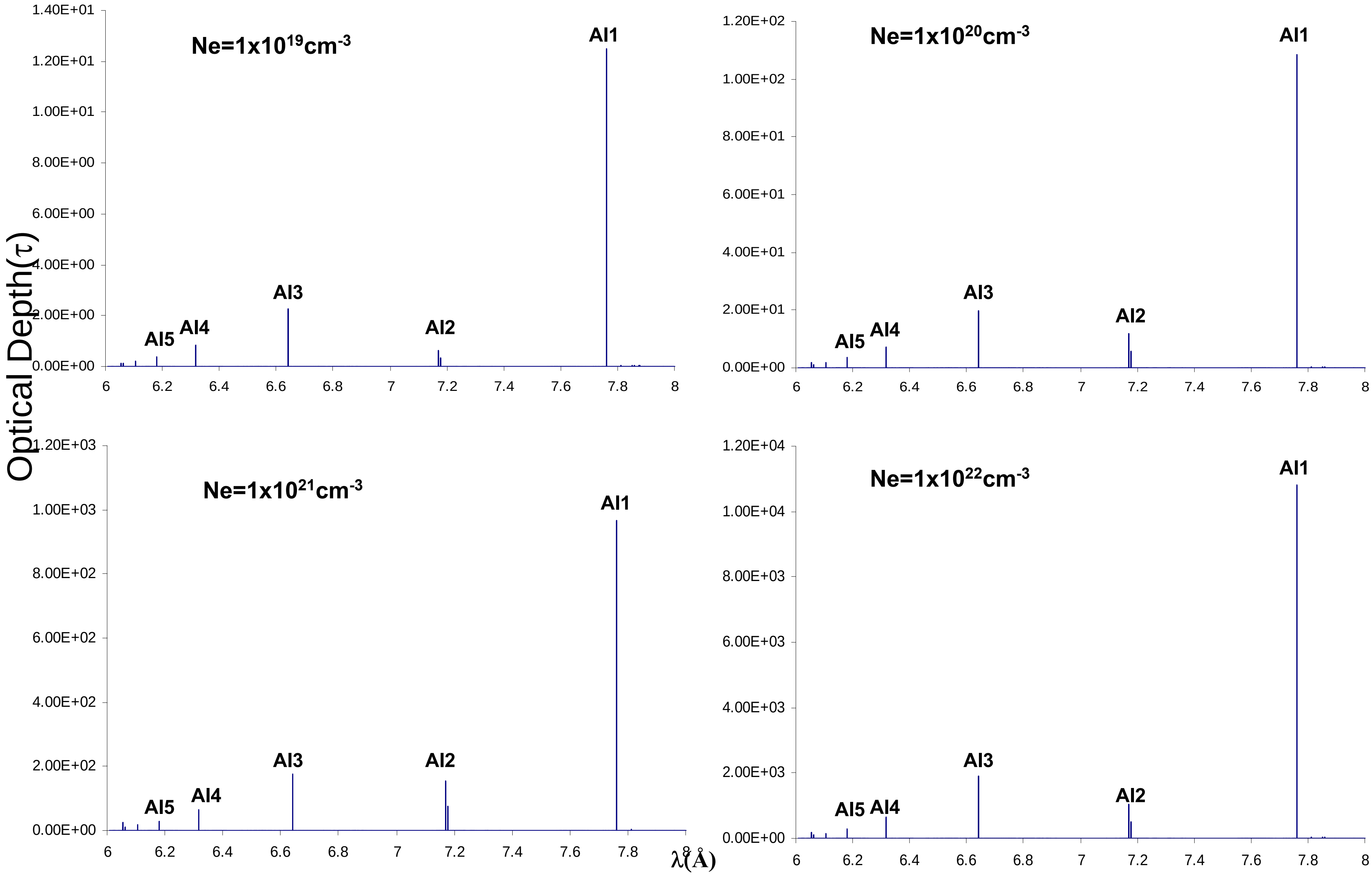


Modeling of NTF-Zebra Shot 799 Al-5056(95 % Al+5% Mg)
TIXR Planar Array (N=10,ϕ=15 μm, ΔR= 1mm)





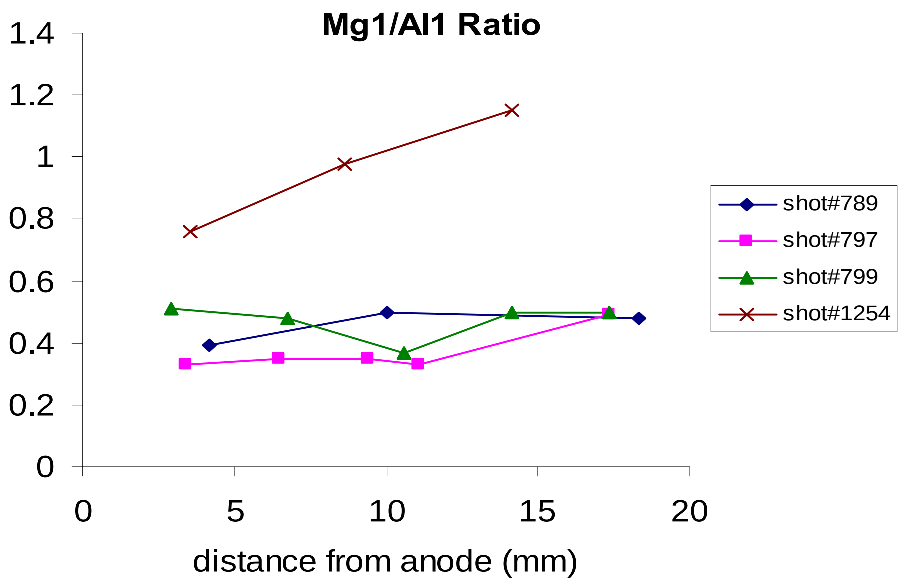
Optical depth dependence of Al for different Densities at 380 eV and 1 mm plasma size

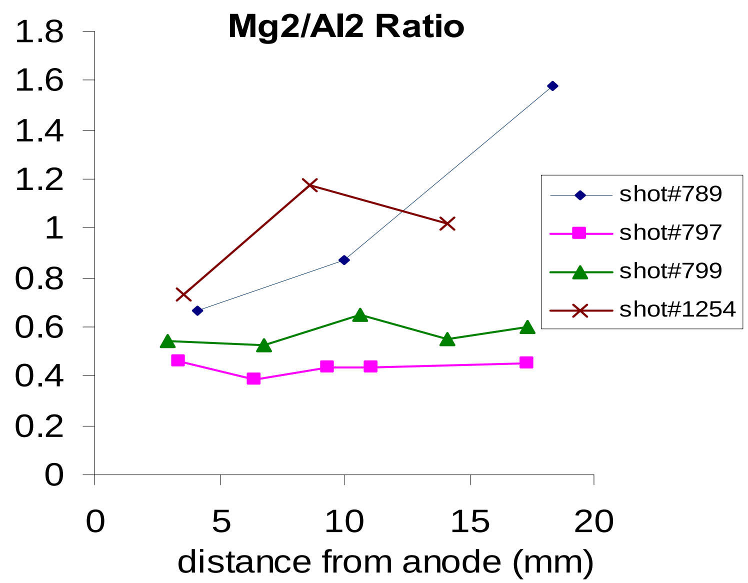


Optical Depth dependence of Al lines for different Densities at the 380 eV and 1mm plasma size

	Optical Depth of the Al Lines				
Density(cm^{-3})	Al5	Al4	Al3	Al2	Al1
$1x10^{19}$	0.39	0.81	2.25	0.64	12.47
$1x10^{20}$	3.42	7.12	19.64	11.68	108.4749
$1x10^{21}$	29.84	62.88	174.52	153.72	965.98
$1x10^{22}$	273.64	647.2923	1907.86	1034.72	10803.53

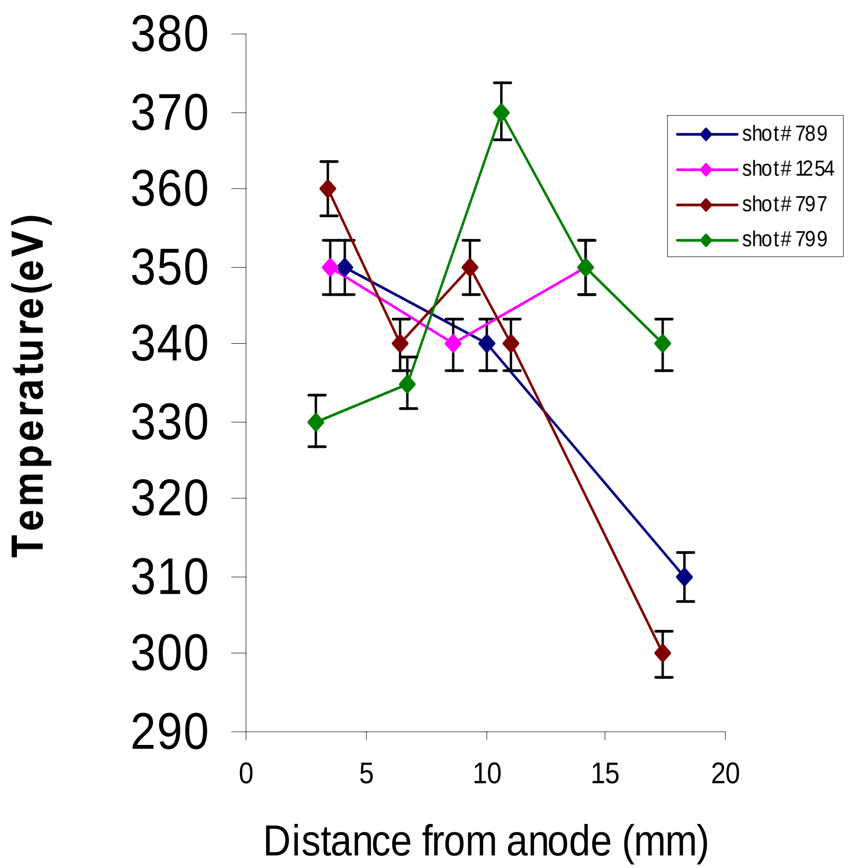
Relative line intensities for the lines important for K-shell plasma diagnostics.



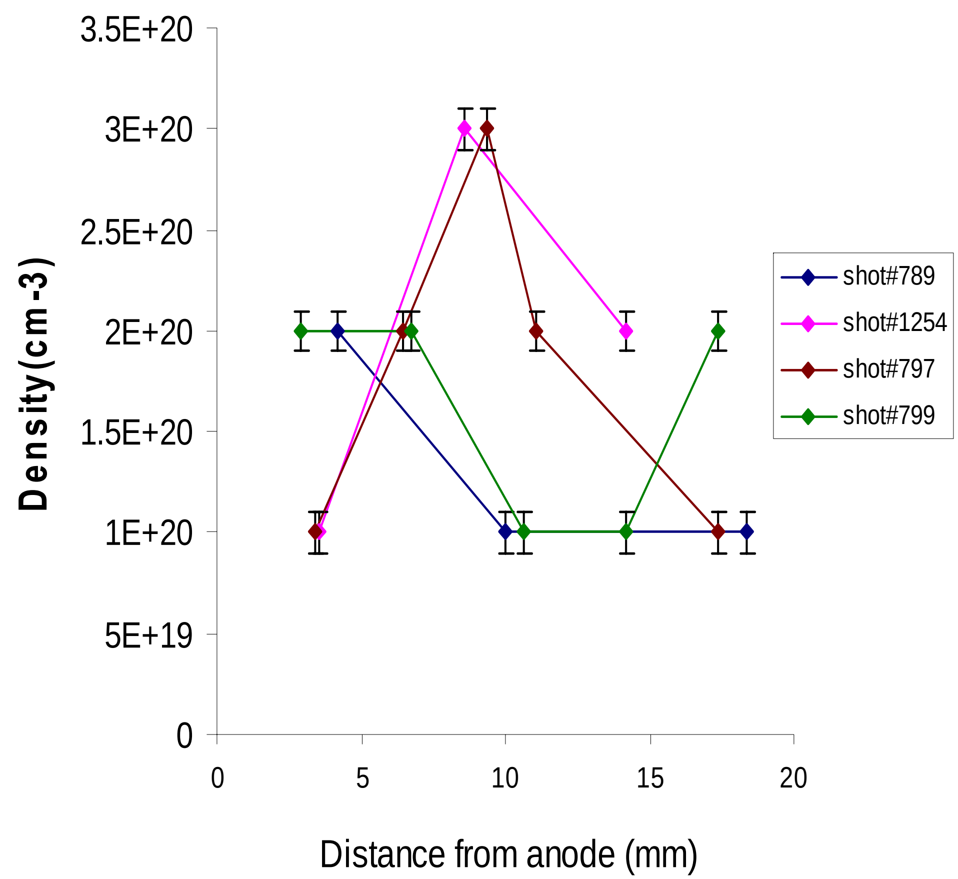


Results of the modeling of spatially resolved spectra

Temperature Dependence



Density Dependence



CONCLUSIONS

- PCD signals show that there is no precursor formations seen for all considered experiments.
- Also PCD signals show that, plasma is hotter before the stagnation for the cylindrical wire arrays (shot 789) and planar wire arrays (shot 799). However, for the compact cylindrical wire arrays plasma is hotter after stagnation.
- Compact cylindrical and planar wire arrays generate hot spots.
- Planar wire arrays with 10 wires of Al(5056) (shot 799) radiate the plasma with the highest temperature for all considered experiments. (T_e=370 eV, n_e=1x10^{20}cm^{-3}).
- Cylindrical wire arrays (shot 1254 and shot 789) show more opacity signatures.

References

1. V.L. Kantsyrev, L.I Rudakov, A. S. Safronova , Dimitry A. Fedin , *et al*., IEEE vol.34, p.2295-2302 (2006)
2. B.Jones, C.Deeney, J.L. McKenney, D.J.Ampleford, C.A.Coverdale *et al,* PRL (in press)

3. V.L. Kantsyrev, A. S. Safronova , Dimitry A. Fedin ,V.Ivanov *et al*., IEEE vol.34, pp.194-212 (2006)

4. F. Yilmaz, A.S. Safronova, V.L. Kantsyrev, K. Williamson, N. Ouart, I.Shresta *et al*, ICOPS, pp.408 2007

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