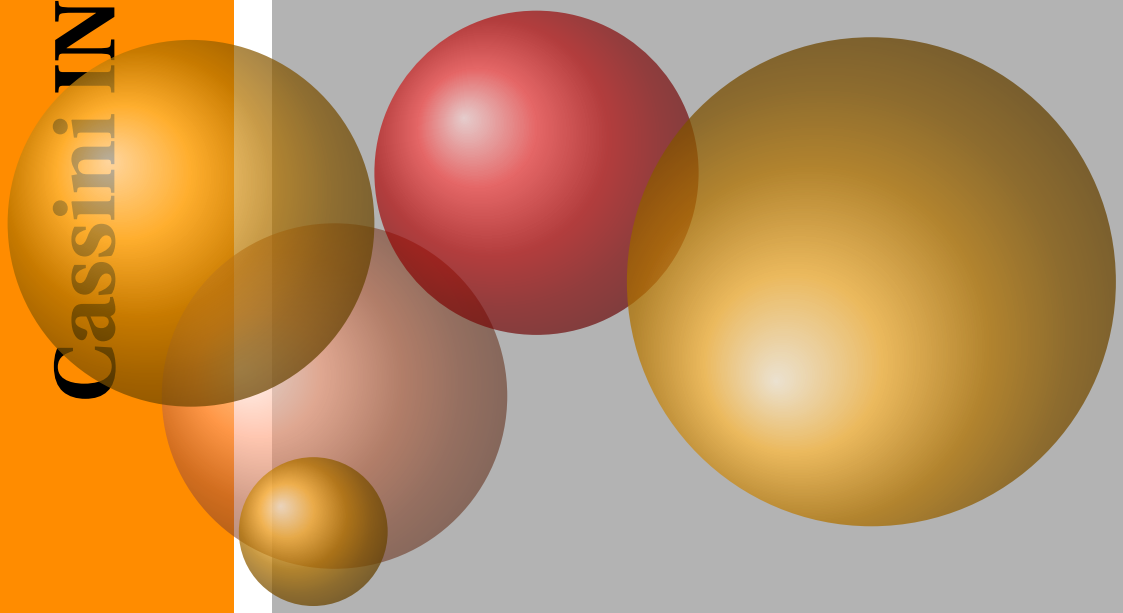
Cassini INMS simulations V 1.0

Enceladus E21 Encounter



GPM

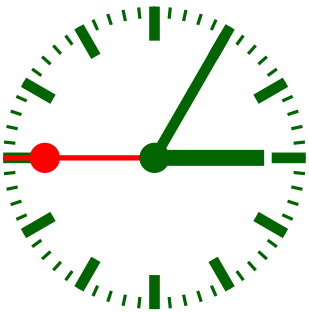
Tuesday 23rd February, 2016

gmiller@swri.edu

Cassini INMS simulations

Enceladus E21 Encounter

GPM



[INMS Tuesday 23rd February, 2016 11:49]

☞ Using **SIMION® Ver 8.1** Simulation program .

Contents

SECTION 1

Ray Trace Model

1.1 SIMION® Model Setup

The SIMION® model used was constructed using the available dimensions. The exact details of the two filament assemblies,their location and their focusing elements could not be obtained for the simulation model.The most probable location of the ionization region was determined by use of several photographs and a poorly rendered CAD cross-section view. The open source deflector, transfer optics, quadrupole switching lens and entrance lens dimensions were obtained from a RCA-Sarnoff Lab report detailing their analysis of the Cassini INMS using their proprietary BEAM3D charged particle simulation code.

1.1.1 Mass analyzer hyperbolic rods

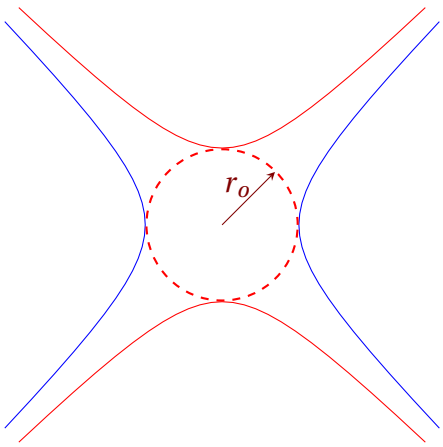


Figure 1: Hyperbolic rod set

The critical analyzer hyperbolic rod spacing dimension r_o used on INMS could not be verified. The rod spacing value in Waite *et al.* is listed as [$\mathbf{0.5}cm$], while a report from Goddard and RCA list them as [$\mathbf{0.51}cm$] and [$\mathbf{0.58}cm$] respectively. One Goddard report found lists the rod spacing to very high precision, [$\mathbf{0.2000000}in$], which would be expected for this critical parameter. This precise value converts to [$\mathbf{0.508}cm$] suggesting that the RCA report may have a misprint. The hyperbolic analyzer rod spacing used in this simulation was chosen to be [$\mathbf{0.508}cm$] with the analyzer rod length of [$\mathbf{10}cm$]. The figure on the left illustrates the definition of the geometric parameter used for the simulation.

1.1.2 Cassini INMS Mass analyzer

The INMS sensor cross-section shown in the figure below list the major components put into the charged particle trajectory simulation code. The entry angle definitions and cylindrical coordinate system are shown as they were modeled. Note that the coordinate system employed is independent of the flight INMS sensor and the spacecraft coordinate system reference frame.

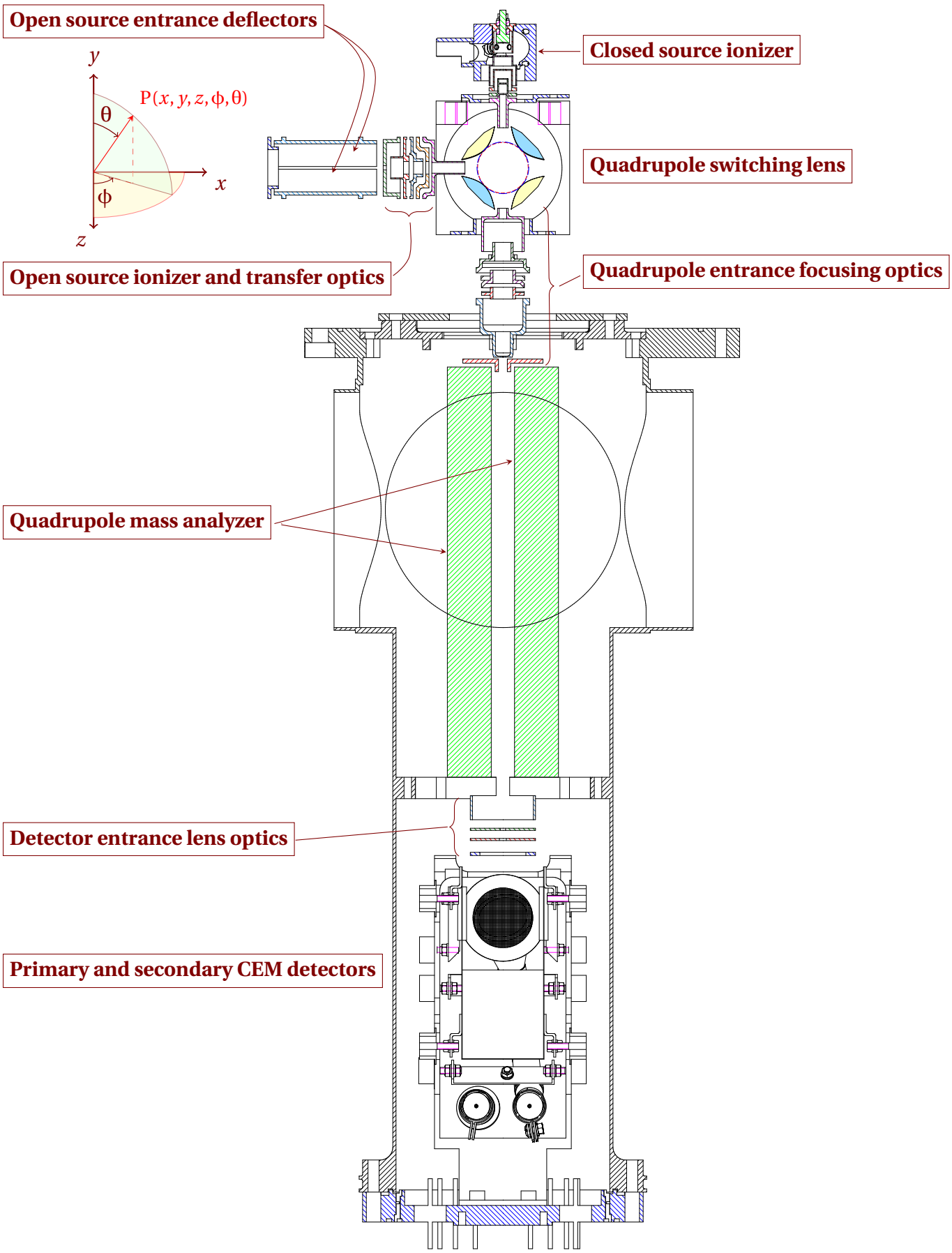
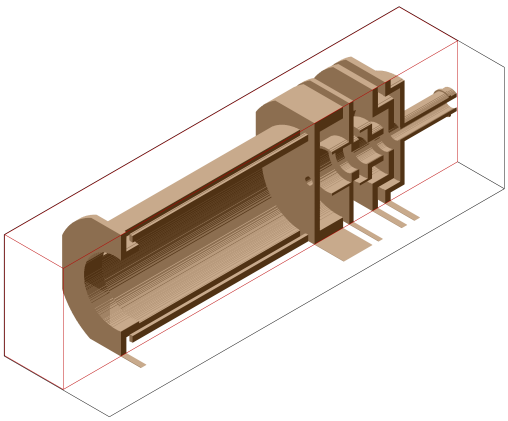


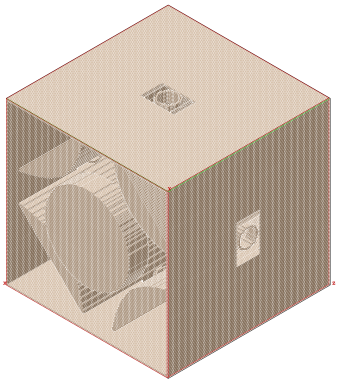
Figure 2: INMS Cross-section showing major functional elements

1.1.3 Constructive solid geometry model

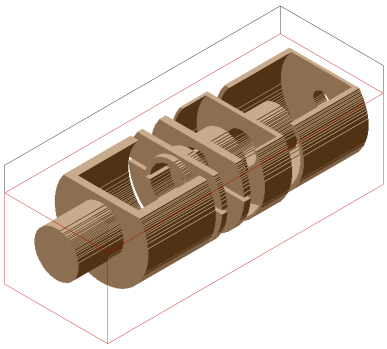
A full 3D-SIMION® geometry using the constructive solid geometry language was built using four independent models (instances) and assembled by carefully matching the boundary conditions at the interfaces. The first model treats the open ion/neutral source, ionization region and transfer optics just in front of the quadrupole switching lens used to multiplex the two ion sources. The second model consists of the quadrupole switching lens and its housing. The third model is a construction of the exit transfer optics including the split plates and exit nozzle. The fourth instance consists of the BS lens, hyperbolic rod set and detector plane. A separate detector model including the detector entrance lens exist but was not used for these simulations since its position at the end of the analyzer quadrupole could not be verified. Verification of the geometry accuracy was made by the comparison of several critical dimensions used on the SIMION® model and overlaying a small portion of the constructive solid geometry model on top of the CAD drawing for those elements.



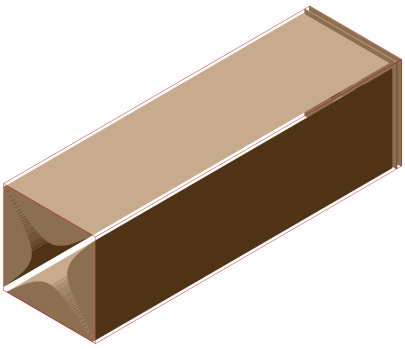
(a) Open ion/neutral source



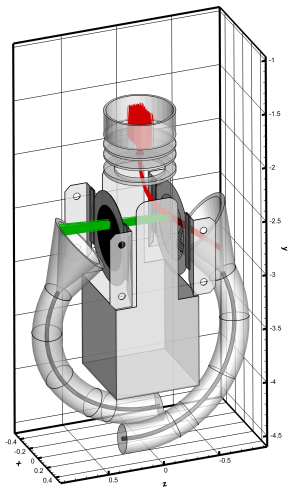
(b) Quad switching lens



(c) Analyzer quad entrance lens



(d) Analyzer rod set



(e) Exit lens and detector

Figure 3: SIMION® subsytems

1.1.4 Electrode potential control

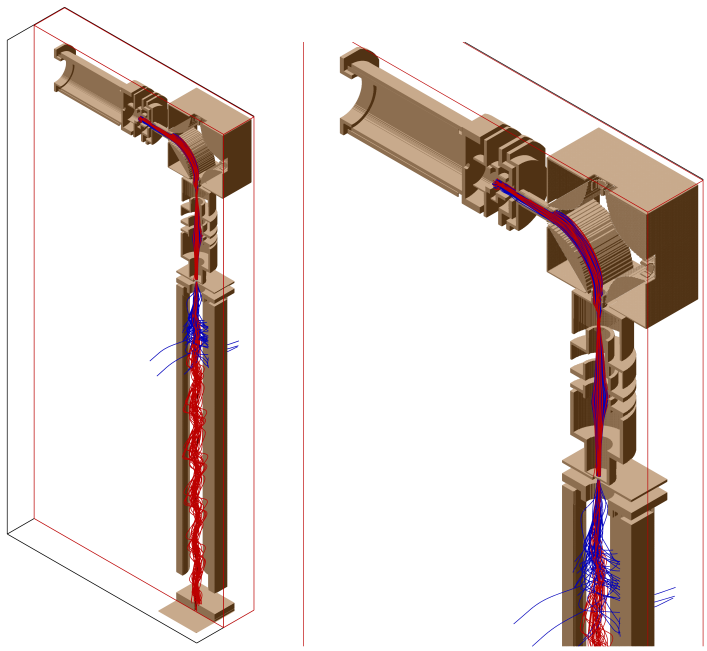
Adjustable electrode potentials were defined and values adjusted via an external written program using the SIMION® command line interface. The dynamic control of the quadupole analyzer, RF frequency, RF and DC voltage amplitude, phase and quadrupole DC offset was done via a Lua code. Mass selection is performed by the varying the RF potential U_{rf} to satisfy the relation,

$$\boxed{m/z[u] \approx 0.55 \frac{U_{rf}[V]}{\nu^2[MHz]}.}$$

Where, U_{rf} is the peak-to-peak amplitude of the RF in volts and ν is the frequency of the Rf in MHz. The mass analyzer quadrupole rod set on Cassini operates at two distinct RF frequencies, (**3.57** MHz for $1-8u$) and (**1.64** MHz for $12-99u$). These two RF frequencies were confirmed with a scope on the laboratory engineering unit but the INMS paper has these two frequencies reversed.

1.1.5 Example OSNB INMS simulation

The following figures show an example simulation of INMS operation in OSNB mode. Two ion populations are simulated, $^+H_2$ shown in red and ^+H shown in blue. The mass analyzer RF/DC was set to transmit $m/z = 2$ simulating $^+H_2$ ions. It can be seen that $m/z = 1$ is quickly filtered out near the front of the quadrupole rod set while transmitting $^+H_2$ ions to the detector.



(a) OSNB operation (b) OSNB zoom

Figure **4**: SIMION® OSNB simulation showing transmission of $^+H_2$ red and ^+H shown in blue

SECTION 2

SIMION® Open Source Neutral Beam Simulations

To simulate ionization of particles beaming into the INMS open ion source (Open Source Neutral Beaming) OSNB, a flat particle distribution (charge state 0) in energy and angle that exceeds the angular, energy and area acceptance of the entrance apertures was employed. The transmitted distribution of neutrals after passing through the outer and inner aperture (top lens aperture) was collected at the presumed ionization region of the open ion source. This neutral distribution of particles represents the minimum and maximum angular acceptance through the apertures beaming into the ionization region. The simulation code then changes the distribution of neutral particles to ions by switching the charge state to +1. This new ion distribution is then traced through the rest of the INMS optics using the OSNB parameters from the E21 OP. To realistically model the quadupole mass analyzer transmission, the simulation scrambles the ion time-of-birth between (0 and $1/\nu$) where ν is the frequency of the RF. This ensures that the ions do not all arrive at the same phase of the Rf during the simulation. In neutral mode operation, Open lens 1 and 2 (**OL1**,**OL2**) are programmed to discriminate gas particles that have thermally accommodated to the ion source walls from the direct beaming components at spacecraft energies. When gas particles are ionized at spacecraft thermal energies, the potential barrier set up between **OL1** and **OL2** lens elements reject transmission and focusing of these ions into the analyzer. In the simulation, these values are set to the same potential as the flight unit and one can observe a sharp particle energy cut-off for energies below this threshold.

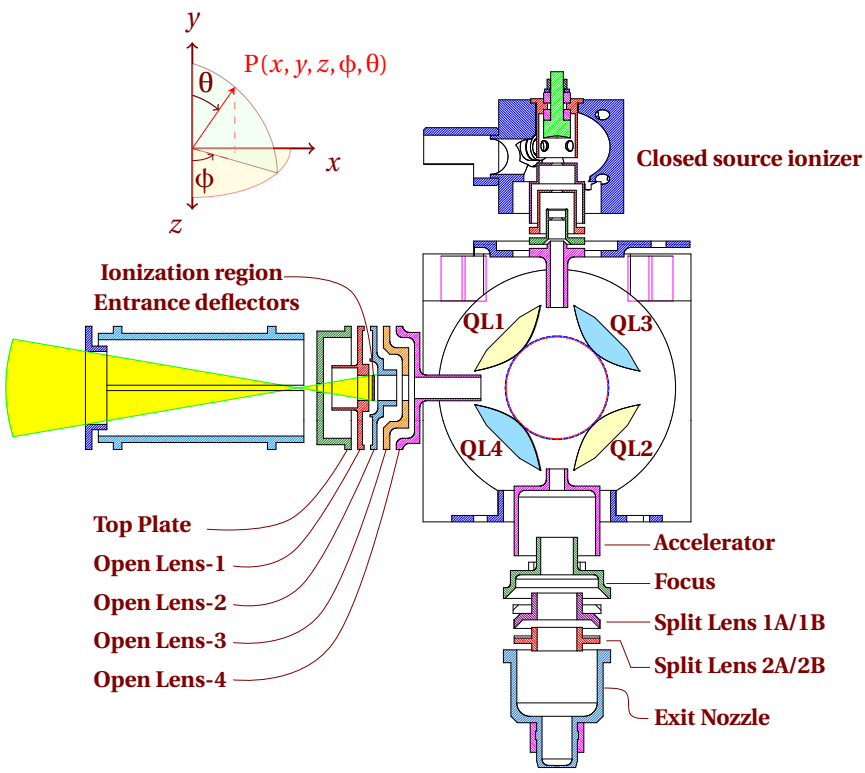
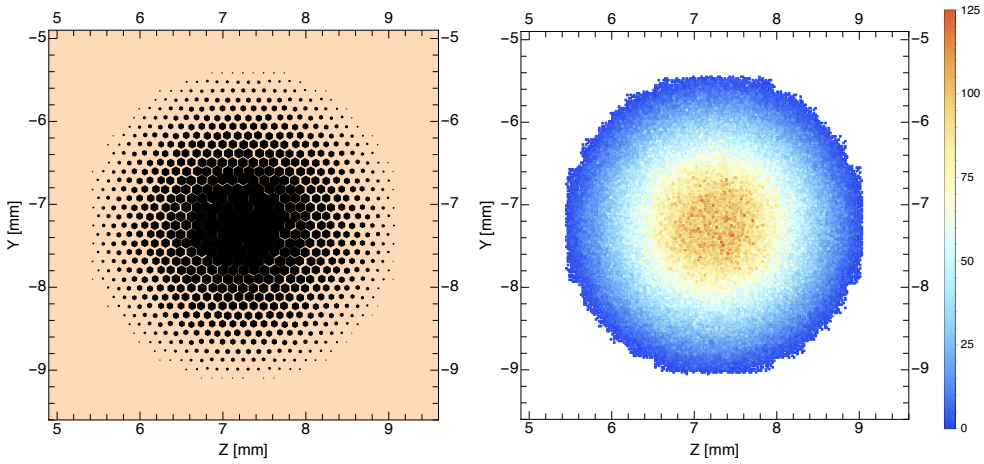


Figure **5**: INMS Source Region with neutral beam geometric acceptance in Yellow

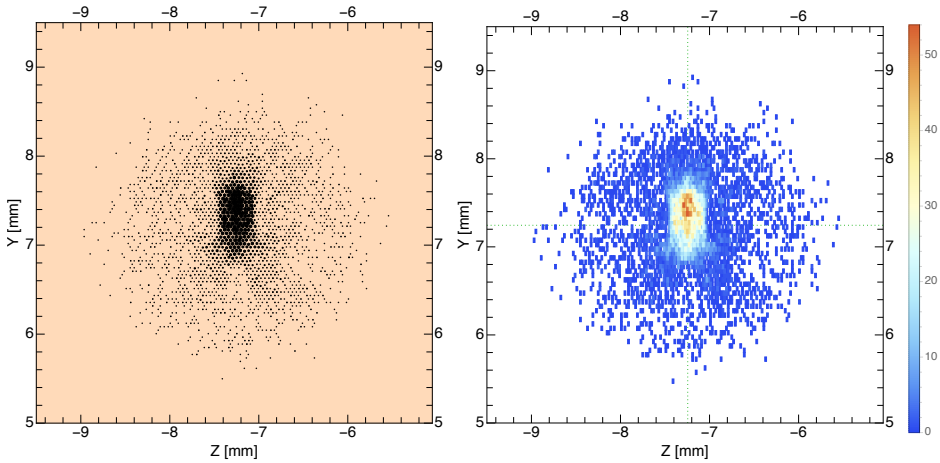
2.0.1 Example of entry distribution and transmitted distribution

The following figures illustrate the initial and final ion distributions for low energy H_2 mapped back to the ionization region of the open ion source shown in the figure above as the ionization region. The transmission favors ions at slightly higher entry positions.



(a) Hexagonal binning (b) Wade binning

Figure **6**: Inital ionization disk distribution.



(a) Hexagonal binning (b) Wade binning

Figure **7**: Transmitted ion distribution mapped back to the open source ionization region. The scale on the left represents counts/bin.

2.1 Instrument Ion Optical Parameters

The following table list the relevant dimensional parameters used in the simulation. The neutral start position places the neutral particle distribution outside the first aperture before the entrance deflectors. The coordinate system is one used for defining the geometry in SIMION®.

2.1.1 Table of geometric parameters

\Geometric ion optical parameters known or derived used in the simulation

Parameter	Nominal Value	Min	Max	Notes
Anal.Rod Len.[mm]	100.0	-	-	Single value
Anal.Rod r_o [mm]	5.080	-	-	Single value
Ionization gap [mm]	1.0668	-10	10	Flat
Ionization radius [mm]	1.0668	-10	10	Flat
Neutral start coordinates				
X_N [mm]	41.94	-	-	Flat
Y_N [mm]	7.2456	5.5	9.0	Flat
Z_N [mm]	-7.2456	-9.0	-5.5	Flat
r_N [mm]	0	-7	7	Flat
Ionization coordinates				
x_i [mm]	41.94	-	-	Flat
y_i [mm]	7.2456	-	-	Flat
z_i [mm]	-7.2456	-	-	Flat
Open Source Ent.Aprt[ϕ mm]✠	8.636	-	-	Single value
Top Lens Aperture [ϕ mm]	1.016	-	-	Single value
Nozzel Lens Aperture [ϕ mm]	0.254	-	-	Single value
BS Lens r_BS [mm]	5	-		Unknown dimensions

✠ **This is the Top Plate**

2.1.2 Tables of Lua and ion generation parameters used for H_2 simulations

\Lua program variables used for H_2

Parameter	Nominal Value	Min	Max	Notes
Lua Variables				
RF [MHz]	3.57	-	-	Single value
_percent_tune [%]	97	-	-	Single value
_quad_axis_voltage [V]	-8	-	-	Single value
_amu_mass_per_charge [μs]	2	-	-	Single value
_quad_entrance_voltage [V]	0	-	-	Single value
_quad_exit_voltage [V]	-100	-	-	Single value
_detector_voltage [V]	-1500	-	-	Single value
_phase_angle_deg [°]	0	-	-	Single value
_effective_radius_in_cm [cm]	0.51	-	-	Single value
_pe_update_each_usec [μs]	0.05	-	-	Single value

\Simion Ion Generation Parameters for used for H_2

Parameter	Nominal Value	Min	Max	Notes
TOB [μs]	0	0	0.2801	Flat Dist.
CWF	0	0	0	Single value
Mass [u]	2	-	-	Single value
Charge	1	1	1	Single value
Neutral start coordinates				
X_N [mm]	1.00	-	-	Flat Dist.
Y_N [mm]	7.2456	5.5	9.0	Flat Dist.
Z_N [mm]	-7.2456	-9.0	-5.5	Flat Dist.
Ion start coordinates				
X_i [mm]	41.94	-	-	Flat Dist.
Y_i [mm]	7.2456	5.5	9.0	Flat Dist.
Z_i [mm]	-7.2456	-9.0	-5.5	Flat Dist.
az angle [°]	0	-11	11	Flat Dist.
el angle [°]	0	-11	11	Flat Dist.
KE [eV]	.75	.001	3.0	Flat Dist.
Color	2			Single value

2.2 E21 QL Simulations For H_2

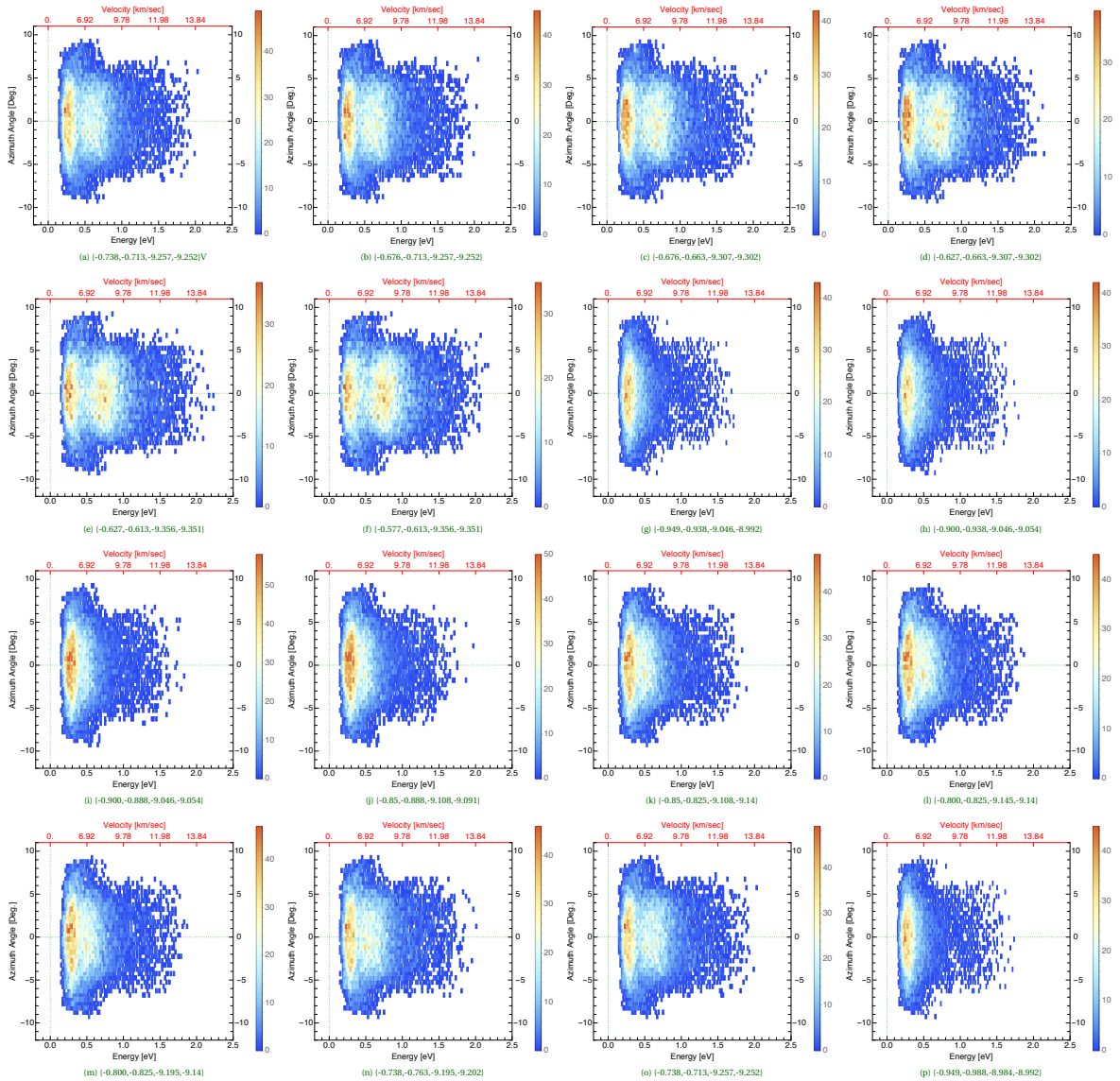
2.2.1 Quadrupole switching lens settings for H_2 at E21 during CA+/-3 seconds

Sixteen simulations were performed using the following list of all the QL combinations used for mass 2 measurements during CA+/-3 seconds. For each of the quad switching lens values, a distribution of particles was traced through the optics to obtain transmission information.

\Quad switching lens voltage values for QL2,QL1,QL4,and QL3

Simulation No.	QL2 [V]	QL1 [V]	QL4 [V]	QL3 [V]
Simulation-1	-0.738	-0.713	-9.257	-9.252
Simulation-2	-0.676	-0.713	-9.257	-9.252
Simulation-3	-0.676	-0.663	-9.307	-9.302
Simulation-4	-0.627	-0.663	-9.307	-9.302
Simulation-5	-0.627	-0.613	-9.356	-9.351
Simulation-6	-0.577	-0.613	-9.356	-9.351
Simulation-7	-0.949	-0.938	-9.046	-8.992
Simulation-8	-0.900	-0.938	-9.046	-9.054
Simulation-9	-0.900	-0.888	-9.046	-9.054
Simulation-10	-0.850	-0.888	-9.108	-9.091
Simulation-11	-0.850	-0.825	-9.108	-9.140
Simulation-12	-0.800	-0.825	-9.145	-9.140
Simulation-13	-0.800	-0.825	-9.195	-9.140
Simulation-14	-0.738	-0.763	-9.195	-9.202
Simulation-15	-0.738	-0.713	-9.257	-9.252
Simulation-16	-0.949	-0.988	-8.984	-8.992
Other electrode voltages	**Voltage [V]**			
os_lens1	-0.990			
os_lens4	-5.210			
qp_bias	-2.112			
ion_defl2	-32.72			
ion_defl4	26.91			
ion_defl3	-32.49			
top_plate	0.14			

Note: All other settings were based on Measured INMS electrode voltages from J. Maurer, U.Mich., March 97 listed at the end of the document.



(a) {-0.738,-0.713,-9.257,-9.252}V
(b) {-0.676,-0.713,-9.257,-9.252}
(c) {-0.676,-0.663,-9.307,-9.302}
(d) {-0.627,-0.663,-9.307,-9.302}
(e) {-0.627,-0.613,-9.356,-9.351}
(f) {-0.577,-0.613,-9.356,-9.351}
(g) {-0.949,-0.938,-9.046,-8.992}
(h) {-0.900,-0.938,-9.046,-9.054}
(i) {-0.900,-0.888,-9.046,-9.054}
(j) {-0.85,-0.888,-9.108,-9.091}
(k) {-0.85,-0.825,-9.108,-9.14}
(l) {-0.800,-0.825,-9.145,-9.14}
(m) {-0.800,-0.825,-9.195,-9.14}
(n) {-0.738,-0.763,-9.195,-9.202}
(o) {-0.738,-0.713,-9.257,-9.252}
(p) {-0.949,-0.988,-8.984,-8.992}

Figure **8**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated energy-azimuth angle response for sixteen QL voltage settings.

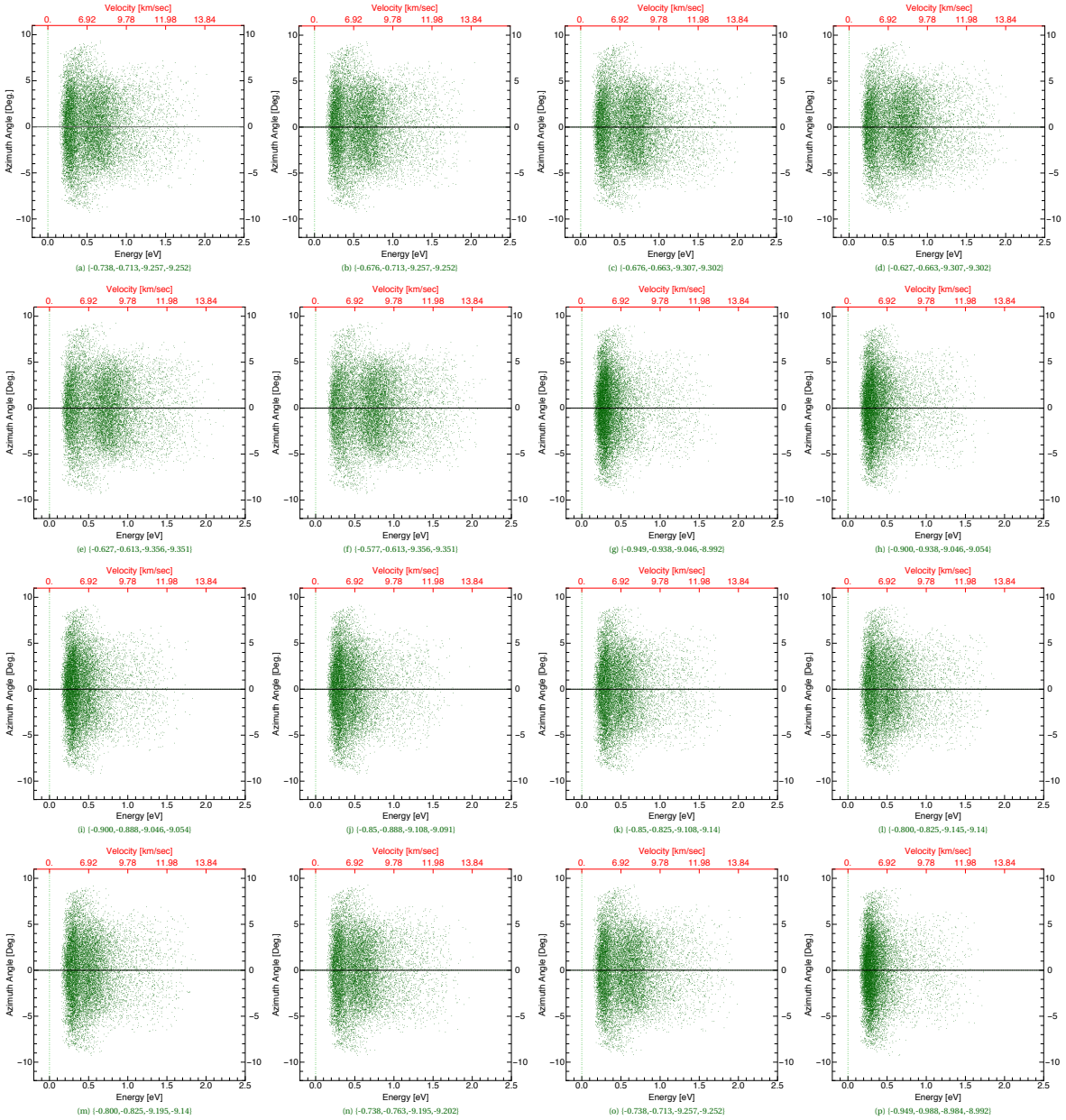


Figure **9**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated azimuth-elevation angle response for sixteen QL voltage settings. No binning used.

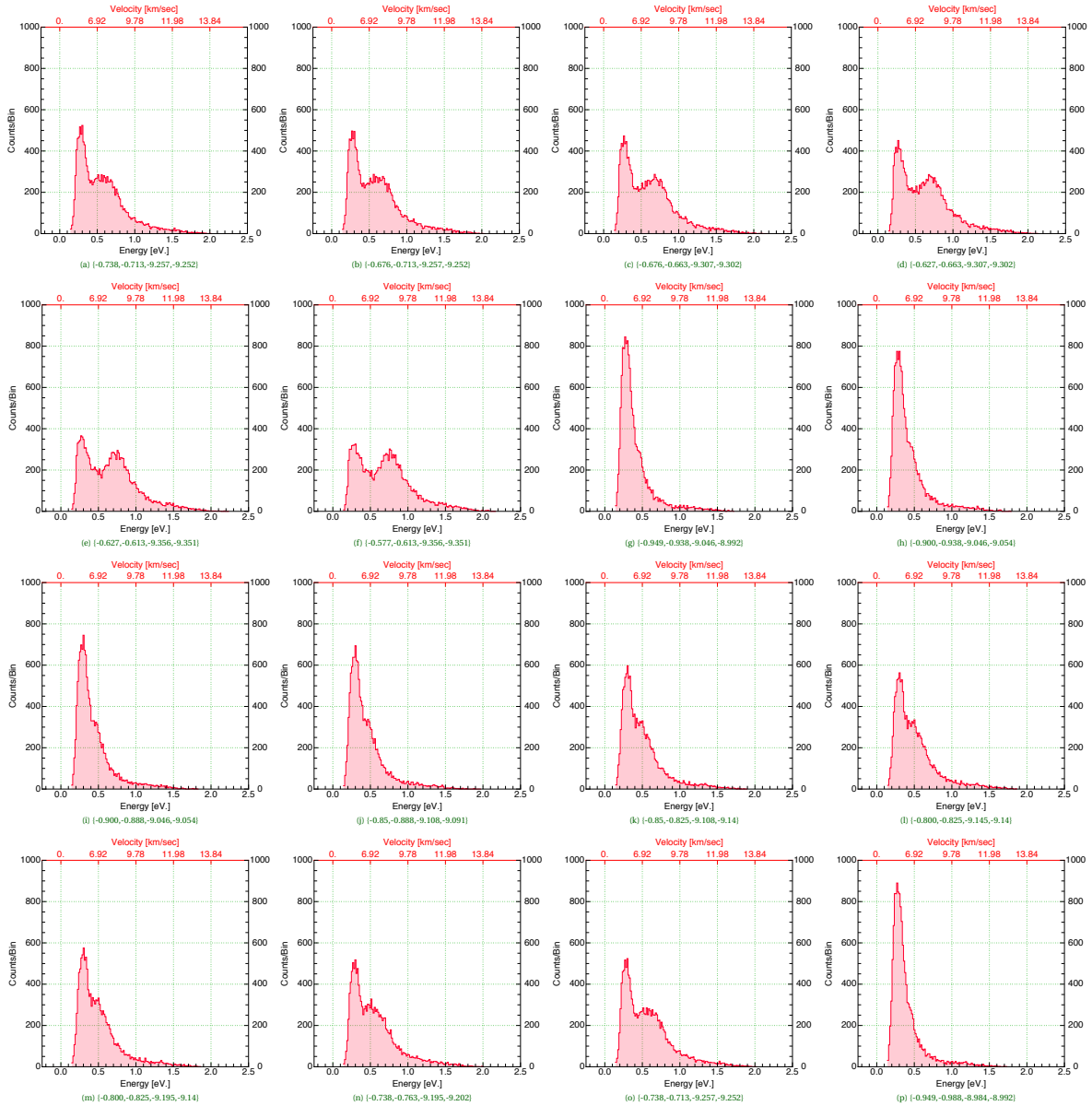


Figure **10**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated INMS energy acceptance response for sixteen QL voltage settings using a flat initial energy distribution.

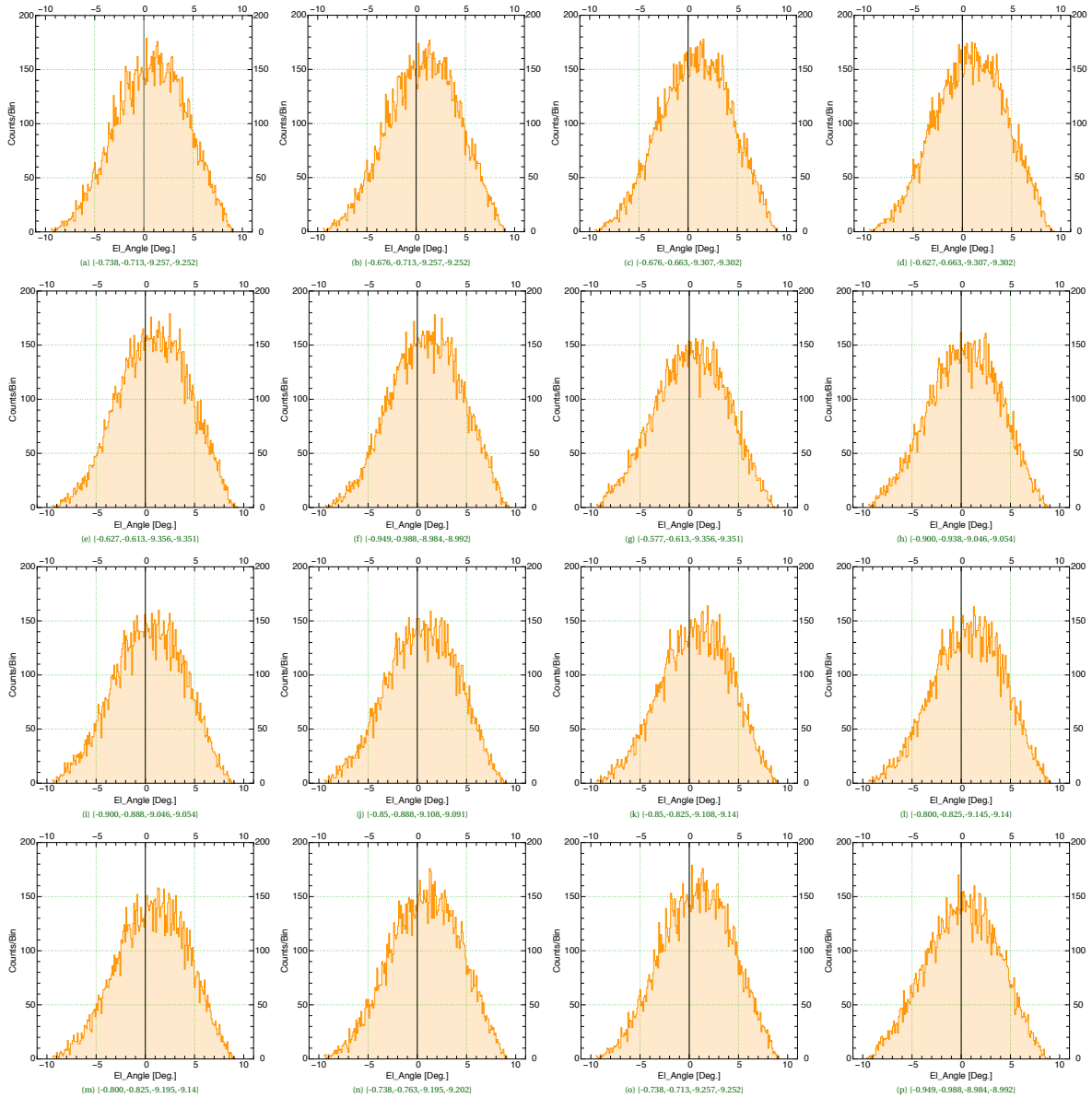


Figure **11**: (*a*..*p*) {QL2V,QL1V,QL4V,QL3V} Simulated elevation angle response for sixteen QL voltage settings.

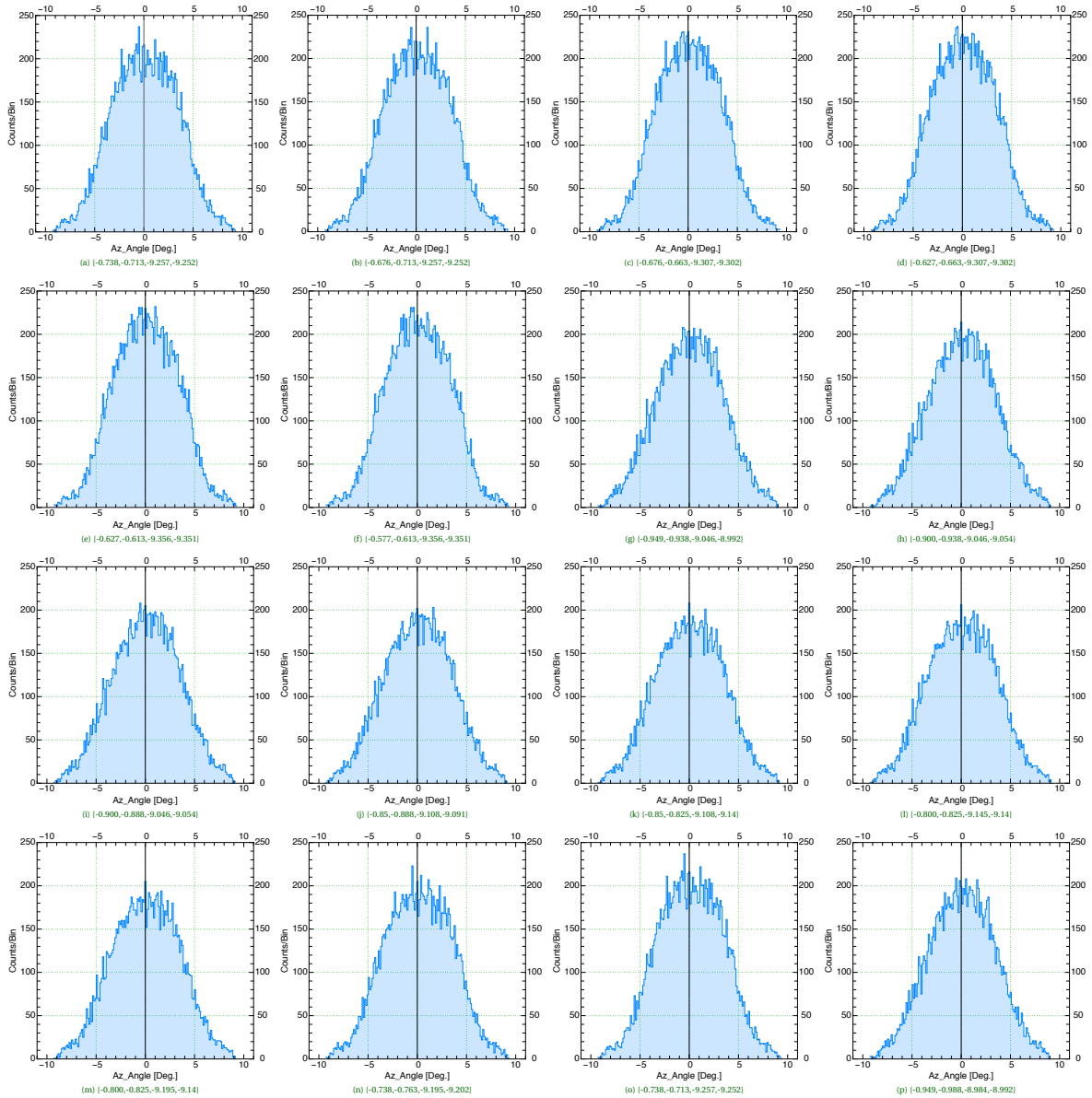


Figure **12**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated azimuth angle response for sixteen QL voltage settings.

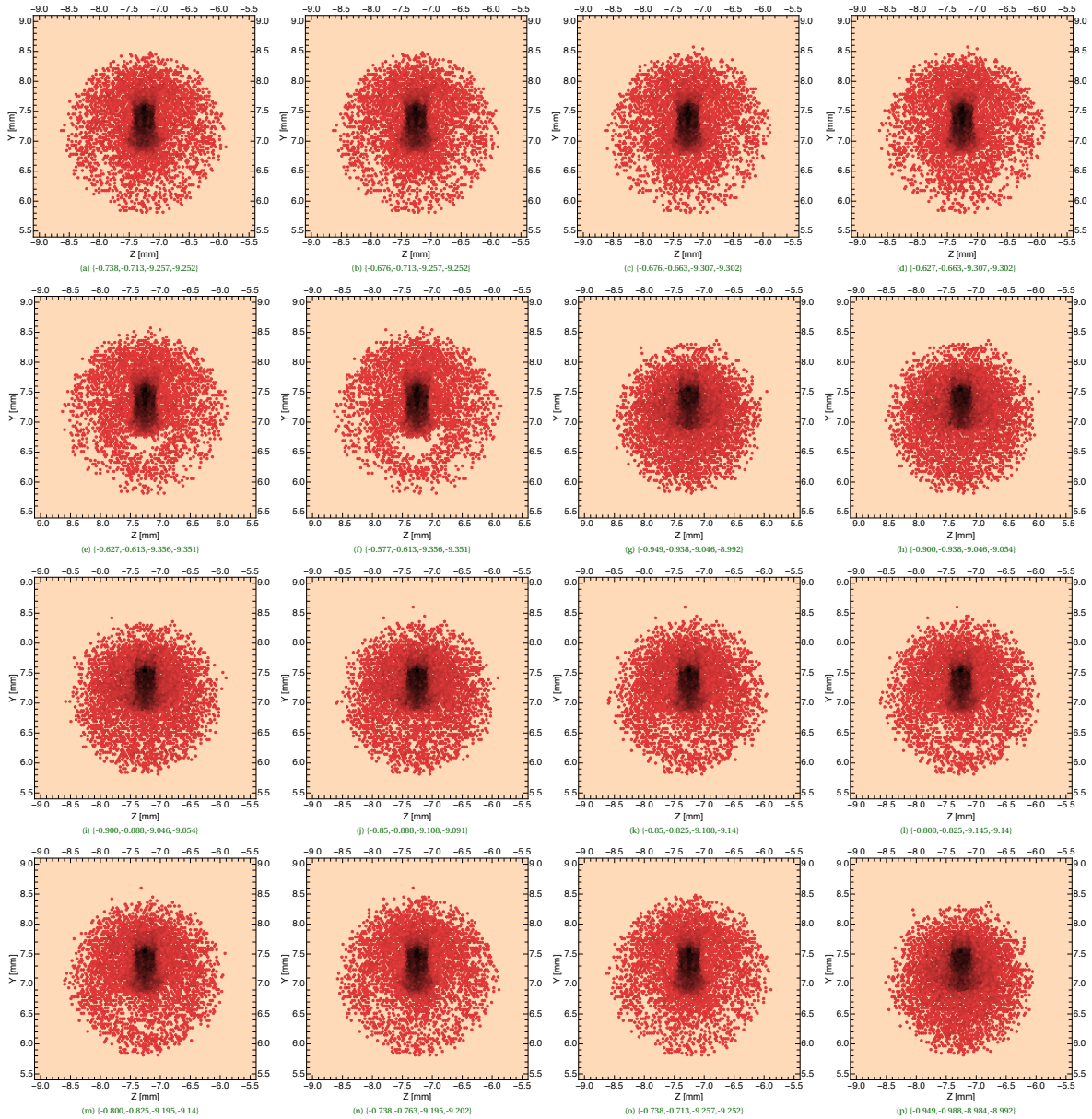


Figure **13**: (*a*..*p*) {QL2V,QL1V,QL4V,QL3V} Aperture entry map for sixteen QL voltage settings. Hexagonal binning used

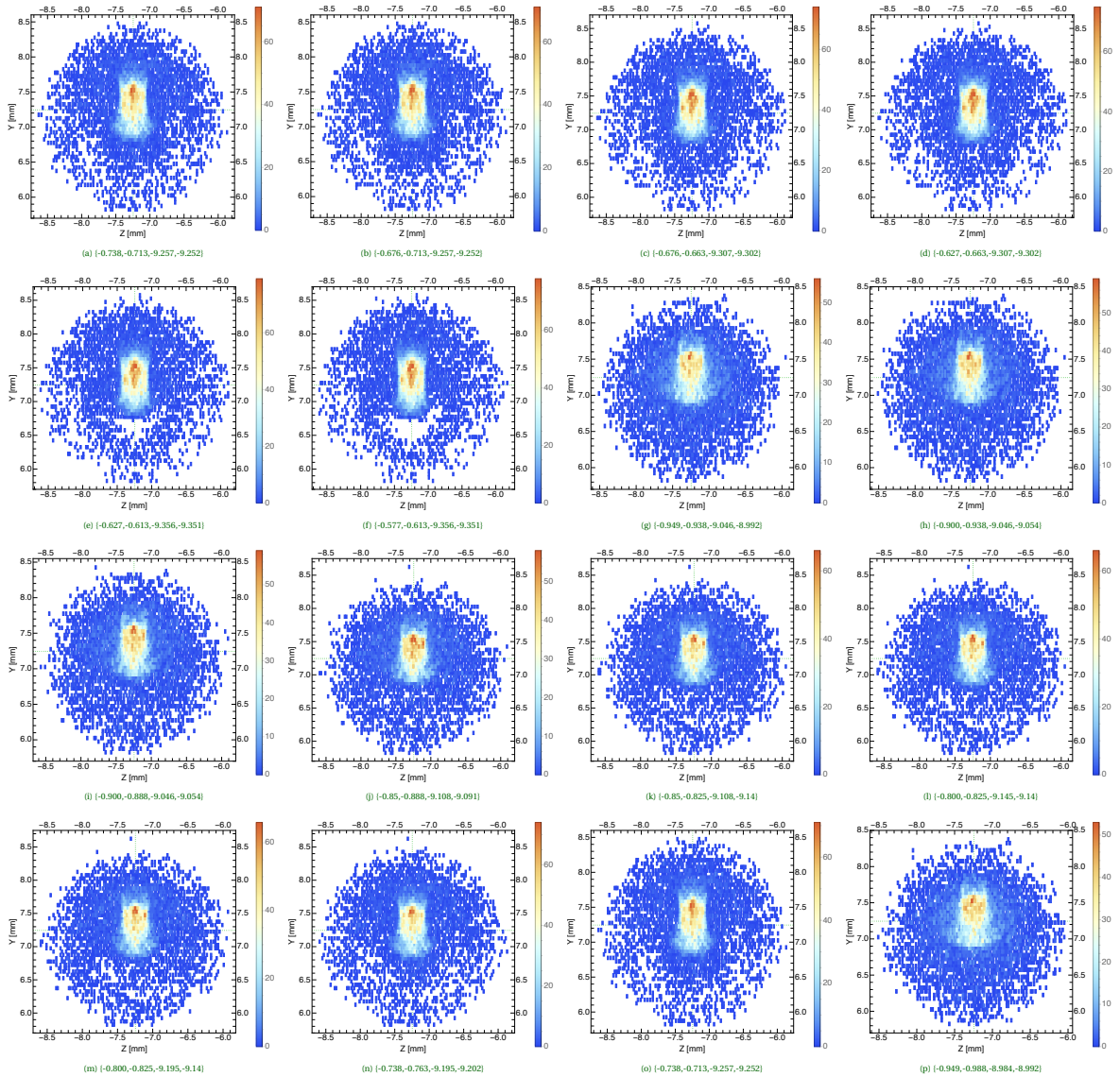


Figure **14**: (*a*..*p*) {QL2V,QL1V,QL4V,QL3V} Aperture entry map for sixteen QL voltage settings. Wand binning used.

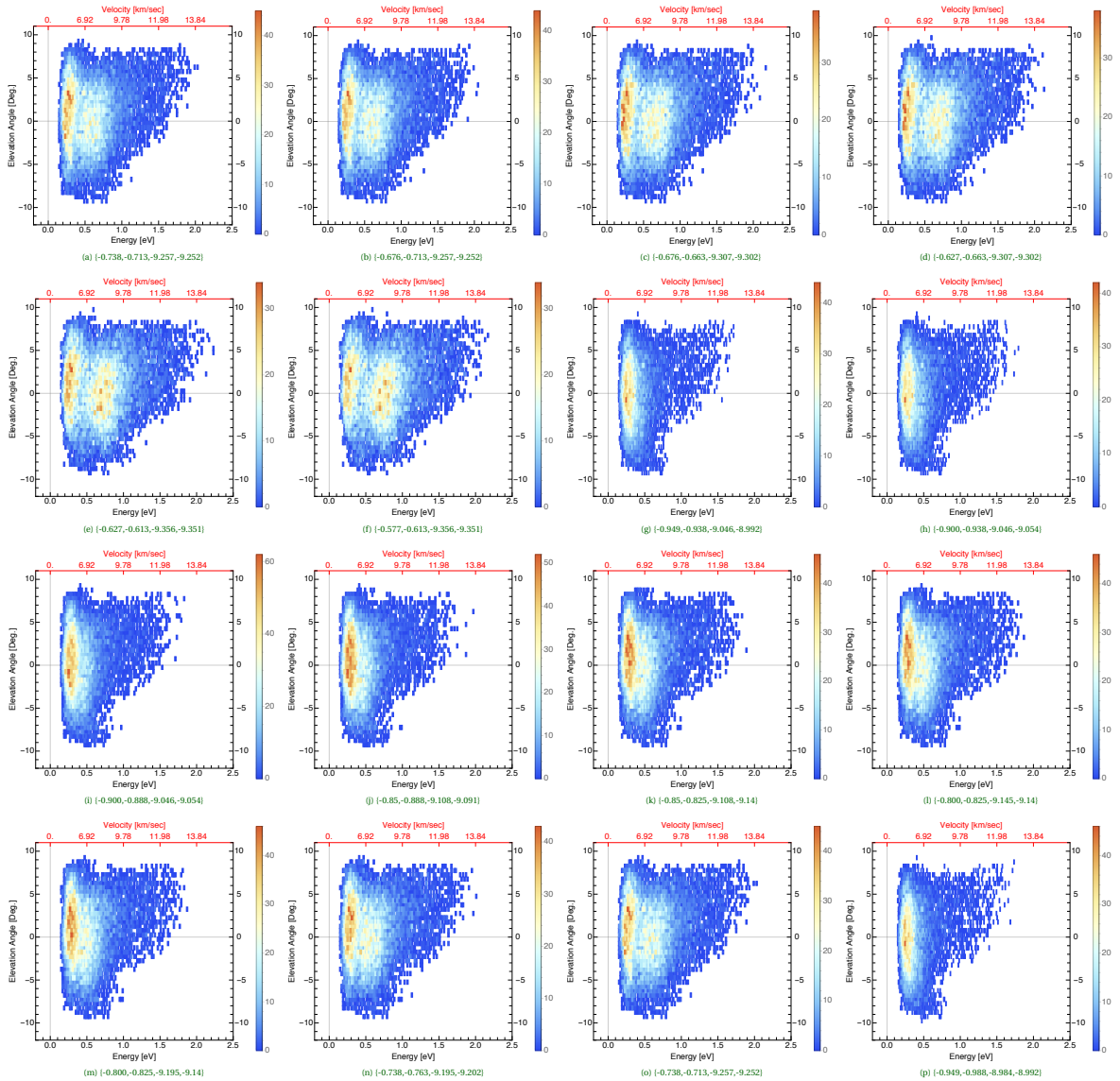


Figure **15**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated energy-elevation angle response for sixteen QL voltage settings. Wand binning used.

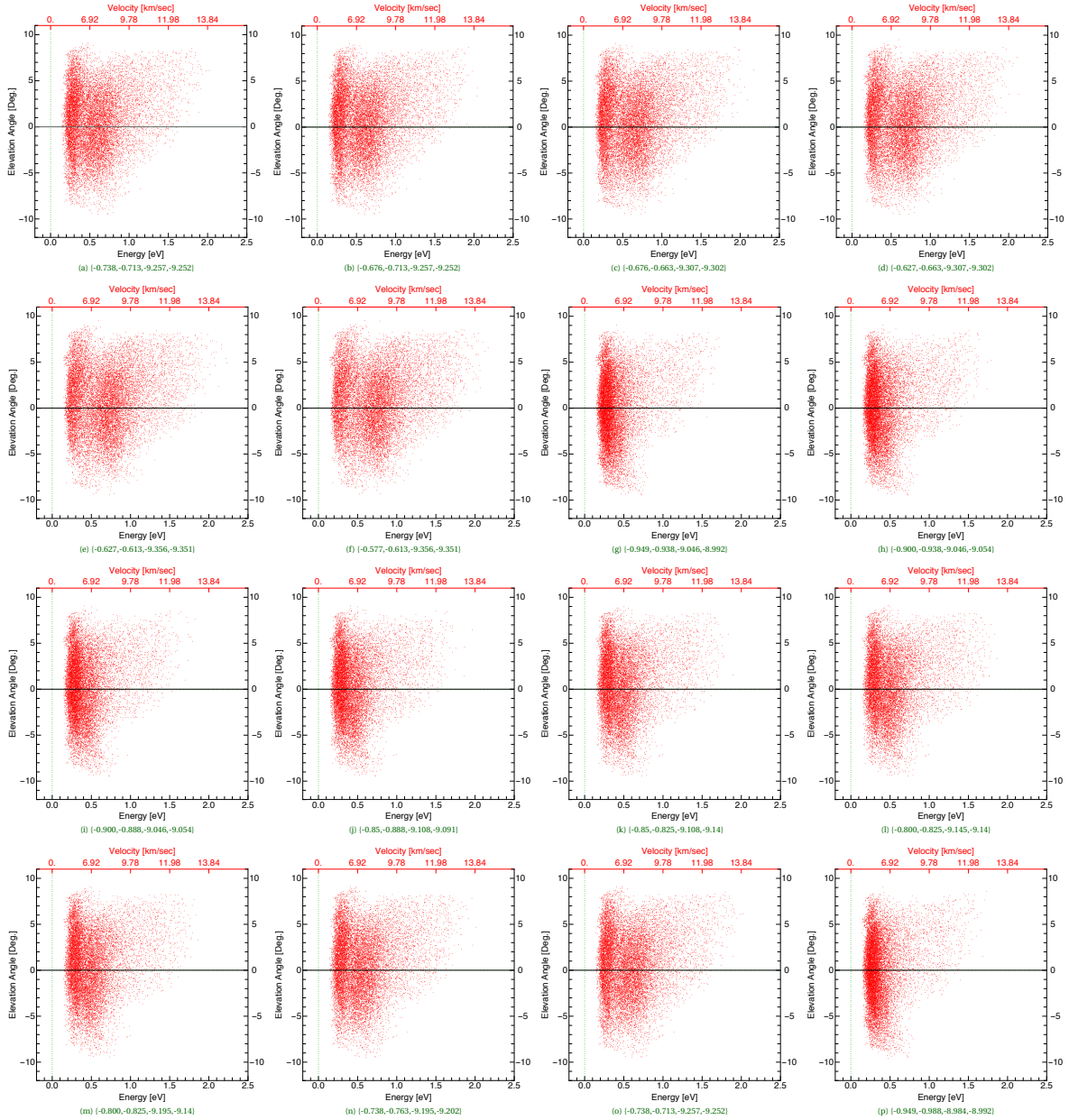


Figure **16**: $(a..p)$ {QL2V,QL1V,QL4V,QL3V} Simulated energy-elevation angle response for sixteen QL voltage settings. No binning used.

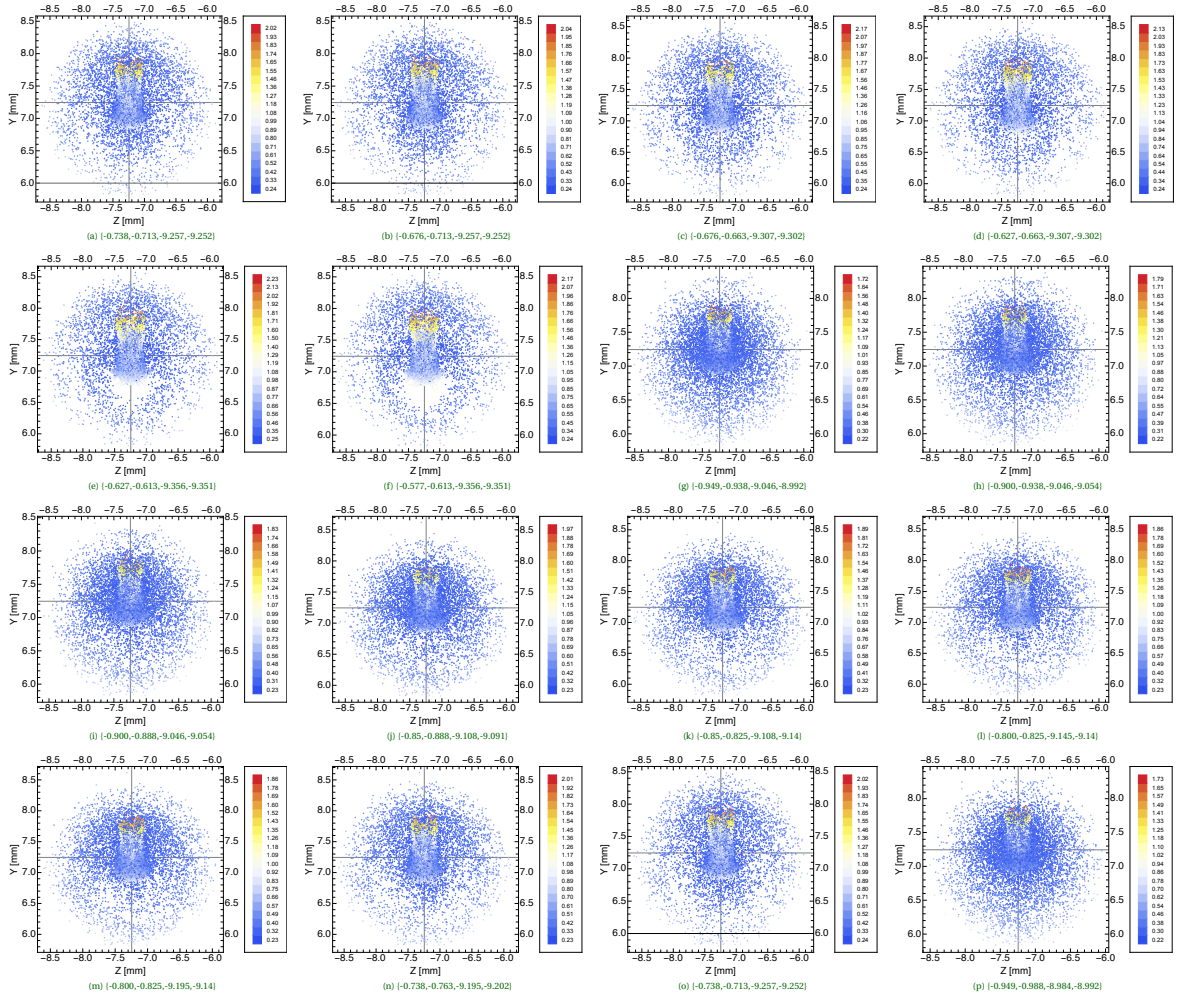


Figure **17**: (*a*..*d*) {QL2V,QL1V,QL4V,QL3V} Particle energy aperture maps for sixteen QL voltage settings.

SECTION 3

Measured INMS electrode voltages from J. Maurer, U. Mich., March 97

Table 1: Cassini INMS Flight Unit: Header-1 (Bottom)

Header (Bott				Fil 1				Fil 2			Fil 3		Fil 4	
			SPRL Nom	Hi eV Step 16 3/6/97	3/14/97	Lo eV Step 37 3/14/97	Hi eV Lab 3/13/97	Step 18 3/15/97	Lo eV Step 35 3/15/97	Hi eV Step 20 3/6/97	3/15/97	Lo eV Step 33 3/15/97	Hi eV Step 23 3/15/97	Lo eV Step 31 3/15/97
Pin	Name													
1	QL3	D	±100	-53.7	-53.7	-53.7	-54.5	-53.5	-53.6	-87.9	-87.9	-88.0	-88.0	-87.8
2	QL5	D	±100	0.2	0.1	0.1	0.0	0.1	0.1	+0.1	0.0	+0.1	0.1	0.2
3	B. S. Lens	A	-9.5	-9.5	-9.6	-9.6	-10.1	-9.6	-9.6	-9.6	-9.6	-9.7	-9.7	-9.6
4	Lens 5A	A	-42.4	-42.4	-42.5	-42.5	-42.5	-42.4	-42.5	-42.5	-42.5	-42.5	-42.4	-42.5
5	Lens 4A	A	-406	-406.0	-408.8	-408.8	-416.1	-408.8	-408.8	-408.8	-408.9	-408.8	-408.8	-408.8
6	Filament 1? -Cl	*	-70	-27.0	-27.7	-27.7	-71.0	-27.7	-27.7	-69.5	-69.5	-26.7	-27.7	-27.7
7	EF1B+ -Cl	*	-65	-26.0	-26.1	-26.1	-66.8	-26.1	-26.1	-65.3	-65.3	-25.3	-26.1	-26.1
8	Lens 2 /Lens 3	A	-205	-205.0	-206.4	-206.4	-209.9	-206.4	-206.4	-206.4	-206.4	-206.4	-206.4	-206.4
9	N.C.													
10	QL4	D	±100	-53.0	-53.6	-53.6	-54.5	-53.6	-53.6	0.0	0.0	0.0	0.0	0.0
11	Filament 1? -Op	*	-70	-68.8	-68.8	-25.0	-0.2	-9.8	-8.5	-0.7	-1.0	-0.6	-1.0	-2.2
12	Filament 1+ -Cl	*	-70	-27.7	-27.7	-27.7	-71.0	-27.7	-27.7	-69.5	-69.5	-26.7	-27.7	-27.7
13	EA1 -Cl		+10	+3.9	+4.0	+3.9	+10.3	+4.0	+3.9	+10.6	+10.5	+4.5	+3.9	+3.9
14	Lens 1	D	±60	-29.4	-29.3	-29.4	-29.8	-29.4	-29.4	-2.7	-2.7	-2.7	-2.7	-2.7
15	N.C.													
16	EF1A - Lower -Op	*	-66	-66.9	-66.9	-24.6	-0.2	-2.4	-1.2	-0.6	-0.6	-0.6	-0.6	-0.6
17	Filament 1+ -Op	*	-70	-68.8	-68.8	-25.0	-0.2	-9.9	-8.5	-0.7	-0.6	-0.5	-0.6	-1.0
18	Fil. Shield 1 -Op	*	-72.5	-71.1	-71.1	-26.1	0.0	-2.5	-1.2	-0.6	-0.6	-0.6	-0.6	-0.6
19	Anode 2 -Cl		30	29.3	29.3	29.3	30.0	29.3	29.3	29.2	29.2	29.2	29.2	29.2
20	EF1A -Cl	*	-68	-27.2	-27.2	-27.2	-69.6	-27.2	-27.2	-68.1	-68.1	-26.4	-27.2	-27.1
21	Fil. Shield 1 -Cl	*	-78.5	-31.3	-31.3	-31.3	-79.8	-31.3	-31.2	-78.5	-78.5	-30.4	-31.3	-31.3
22	N.C.													
23	Opens Lens 2	D	±60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	Restrictor 1 -Op		41	40.7	40.8	41.1	39.9	41.5	41.9	41.2	41.4	41.2	41.2	41.2
25	EA1 -Op		21	20.9	21.0	21.0	-0.3	20.2	20.3	20.5	20.7	20.6	20.6	20.6
26	EF1B - Upper -Op	*	-66	-66.6	-66.9	-24.5	-0.3	-2.4	-1.1	-0.6	-0.6	-0.6	-0.5	-0.6
27	Ion Repeller -Cl		1	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	0.9
28	Nozzle -Cl		-390	-389.4	-389.5	-389.4	-395.6	-389.4	-389.4	-389.4	-389.4	-389.4	-389.3	-389.5
29	Anode 1 -Cl		30	29.3	29.3	29.3	30.1	29.3	29.3	29.2	29.2	29.2	29.2	29.2
30	N.C.													
31	N.C.													
32	Opens Lens 4	D	±60	-29.8	-29.8	-29.8	-30.1	-29.7	-29.8	-29.9	-29.8	-29.8	-29.8	-29.8
33	Top Plate Lens	D	±100	0.1	0.1	0.2	-0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.2
34	Ion Deflector 3	D	±30	-20.3	-20.3	-20.3	-40.3	-20.3	-20.3	-20.3	-20.3	-20.3	-20.3	-20.3
35	Ion Deflector 2	D	±30	-20.4	-20.4	-20.4	-40.4	-20.4	-20.3	-20.4	-20.5	-20.4	-20.4	-20.5

***** = D/A controlled for Hi or Lo eV. All values must be normalized for comparsion.
A = Fixed voltages from AM divider string. All voltages are measured with Hi-Meg probe.

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Table 2: Cassini INMS Flight Unit: Header-2 (Top)

Heade (Top)					Fil 1			Fil 2			Fil 3		Fil 4	
			SPRL Nom	Hi eV Step 16		Lo eV Step 37	Hi eV Lab		Lo eV Step 35	Hi eV Step 20		Lo eV Step 33	Hi eV Step 23	Lo eV Step 31
Pin	Name			34033	3/15/97	3/15/97	34040	3/15/97	3/15/97	3/6/97	3/15/97	3/15/97	3/15/97	3/15/97
1	Filament 2? -Op	*	-70	-8.8	-8.0	-8.9	-69.2	-68.5	-24.9	-68.8	-0.5	-1.0	-0.5	-0.5
2	Lens 6	A	-486	-487.3	-487.3	-487.3	-493.9	-487.3	-487.3	-487.2	-487.3	-487.3	-487.3	-487.3
3	N.C.													
4	QL6	D	±60	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	Ion Rep Shield		1	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	Filament 2+ -Op	*	-70	-8.8	-8.9	-8.0	-69.2	-68.5	-24.8	-68.4	-0.5	-0.6	-0.7	-0.7
7	Lens 5B	A	-42.4	-42.4	-42.5	-42.5	-42.7	-42.5	-42.4	-42.4	-42.5	-42.5	-42.5	-42.5
8	QL1		±100	-6.2	-6.2	-6.2	-6.1	-6.2	-6.2	-6.2	-87.9	-88.0	-88.0	-87.9
9	QL2		±100	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	0.2	0.2	0.3	0.2
10	Filament 2? -Cl	*	-70	-28.9	-28.9	-28.9	-72.1	-29.0	-28.9	-72.5	-28.9	-28.9	-72.5	-27.9
11	EF2B -Cl	*	-67	-27.7	-27.7	-27.7	-68.4	-27.7	-27.7	-69.3	-27.7	-27.7	-69.3	-27.0
12	EA2 -Op		10	20.2	20.4	20.4	20.9	20.9	20.9	21.1	20.7	20.7	20.6	20.6
13	Lens 4B	A	-406	-408.9	-408.8	-408.8	-415.9	-408.9	-408.8	-408.9	-408.8	-408.8	-408.8	-408.8
14	Fil. Shield 2 -Op	*	-73	-1.5	-1.5	-0.9	-71.9	-71.2	-26.2	-71.2	-0.6	-0.6	-0.6	-0.6
15	N.C.													
16	N.C.													
17	Filament 2+ -Cl	*	-70	-29.0	-28.9	-28.9	-72.1	-28.9	-28.9	-72.5	-28.9	-28.9	-72.5	-27.9
18	EF2A -Cl	*	-67	-27.7	-27.7	-27.7	-68.4	-27.7	-27.7	-69.3	-27.7	-27.7	-69.3	-27.0
19	EF2A - Lower -Op	*	-67	-1.4	-1.5	-0.8	-66.3	-65.6	-24.1	-65.5	-0.5	-0.6	-0.6	-0.5
20	EF2B - Upper -Op	*	-70	-1.4	-1.5	-0.8	-69.6	-68.8	-25.3	-68.8	-0.5	-0.6	-0.6	-0.6
21	Restrictor 2 -Op		41	41.6	42.0	41.9	41.7	40.7	40.9	41.2	-41.5	41.2	41.2	41.3
22	N.C.													
23	N.C.													
24	Fil. Shield 2 -Cl	*	-78.7	-31.4	-31.4	-31.4	-77.5	-31.4	-31.4	-78.5	-31.4	-31.4	-78.6	-30.5
25	Ion Focus A -Cl	A	-125	-125.2	-125.2	-125.1	-126.6	-125.2	-125.2	-125.2	-125.2	-125.2	-125.2	-125.2
26	EA2 -Cl		10	4.1	4.1	4.1	9.9	4.1	4.1	10.9	4.1	4.1	10.9	4.7
27	Ion Deflector 1	D	±30	16.0	16.1	16.1	40.9	16.0	16.1	16.0	16.1	16.0	16.1	16.1
28	Ion Deflector 4	D	±30	15.3	15.3	15.3	41.0	15.3	15.3	15.2	15.3	15.3	15.3	15.3
29	Opens Lens 3	D	±60	-12.8	-12.8	-12.7	-5.0	-12.8	-12.8	-12.7	-12.7	-12.8	-12.8	-12.8
30	Opens Lens 1	D	±60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	N.C.													
32	N.C.													
33	N.C.													
34	Ion Accelerator -Cl	A	-3	-3.0	-2.9	-3.0	-3.1	-3.0	-2.9	-3.0	-2.9	-2.9	-3.0	-2.9
35	Ion Focus B -Cl	A	-301	-301.9	-301.8	-301.8	-306.9	-301.8	-301.8	-301.9	-301.9	-301.8	-301.8	-301.8

* = D/A controlled for Hi or Lo eV. A = Fixed voltages from AM divider string.
All voltages are measured with Hi-Meg probe.

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Table 3: Cassini INMS Flight Unit: Detector Header

Detec Heade				Fil 1			Fil 2			Fil 3		Fil 4	
			SPRL Nom	Hi eV Step 16	Lo eV Step 37	Hi eV Lab	Step 18	Lo eV Step 35	Hi eV Step 20		Lo eV Step 33	Hi eV Step 23	Lo eV Step 31
Pin	Name			3/6/97	3/16/97	3/15/97		3/16/97	3/15/97	3/6/97	3/15/97	3/15/97		3/15/97
1	Anode A (Cnt 2)		0											
2	N.C.													
3	Mult Pos (Gnd) A		0	0.0	0.0			0.0						
4	Mult Neg A	D	3.3KV max	-19.0	-2883.0			-2883.0						
5	Def Grid B **		0	0.0	-2679.0			-2679.0						
6	Mask II		0	0.0	0.0			0.0						
7	Window		0	0.0	0.0			0.0						
8	Faraday Cup		0	0.0	0.0			0.0						
9	Ion Shield A		0	0.0	0.0			0.0						
10	Anode B (Cnt 1)		0	0.0	0.0			0.0						
11	N.C.													
12	Mult Pos (Gnd) B		0	0.0	0.0			0.0						
13	Mult Neg B	D	3.3KV max	-19.0	-2678.0			-2678.0						
14	Def Grid A		3.3KV max	-19.0	0.0			0.0						
15	Mask I		0	-76.4	-76.4			-76.4						
16	Einzel Lens	A	-77	0.0	0.0			0.0						
17	N.C.													
18	Shield B		0	0.0	0.0			0.0						
org	Quad Rod Plus					-24.4		-24.5	-24.5		21.9	-23.9		-23.9
yel	Quad Rod Minus					21.4		21.4	21.5		-23.9	21.9		21.9
	Quad Bias (Calc)					-1.5		-1.6	-1.5		-1.0	-1.0		-1.0
	hp Scope Fil I rms							0.975	0.980			1.130	1.124	

** As of 3/16/97 multiplier B is now designated as prime, or counter 1. Voltages not measured but shown are what would be measured.
1.) The non-active open source filament will pull to -8V
2.) The minimum filament voltage for the open source is 0 at DAC = 0.
3.) The minimum filament voltage for the closed source is 26 volts at DAC = 0.
4.) is only one voltage for the dectector header, called Einzel on schematic. i.e. -77 volts on the blue wire!

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File Name: INMS_meas_volts.xls
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Index