

Distributiile particulelor incarcate injectate intr-o discontinuitate tangentiala unidimensionala

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Ecuatia Vlasov

$$\frac{\partial f}{\partial t} + \vec{v} \cdot \frac{\partial f}{\partial \vec{r}} + \frac{q}{m} (\vec{E} + \vec{v} \times \vec{B}) \cdot \frac{\partial f}{\partial \vec{v}} = 0 \quad (1)$$

- in cazul stationar ecuatiile curbelor caracteristice ale ecuatiei cu derivate parțiale (1) corespund tocmai ecuatiile de miscare ale particulei test cu sarcina electrica q , respectiv masa m , injectata in distributia de camp \vec{E}, \vec{B}

$$\frac{d^2 \vec{r}}{dt^2} = \frac{q}{m} (\vec{E} + \frac{d\vec{r}}{dt} \times \vec{B}) \quad (2)$$

$$\frac{df}{dt} = 0 \quad (3)$$

- campurile electric, respectiv magnetic sunt considerate prescrise; contributia self-consistentă este neglijata
- metoda numerica de integrare a traiectoriilor particulelor test:

- **Runge-Kutta Cash-Karp de ordinul 5 cu pas variabil**

Distributia campului

- **Camp magnetic stationar**

- discontinuitate tangentiala unidimensionala ($B_x = 0$)

$$\vec{B}(x) = \frac{\vec{B}_1}{2} \operatorname{erfc}\left(\frac{x}{L}\right) + \frac{\vec{B}_2}{2} \left[2 - \operatorname{erfc}\left(\frac{x}{L}\right) \right]$$

$$\vec{B}_1 = \vec{B}(x = -\infty) \quad \vec{B}_2 = \vec{B}(x = +\infty)$$

- **Camp electric stationar**

- **Cazul A:** camp electric uniform

$$\vec{E} = \vec{B}_1 \times \vec{V}_0 = \text{const.}$$

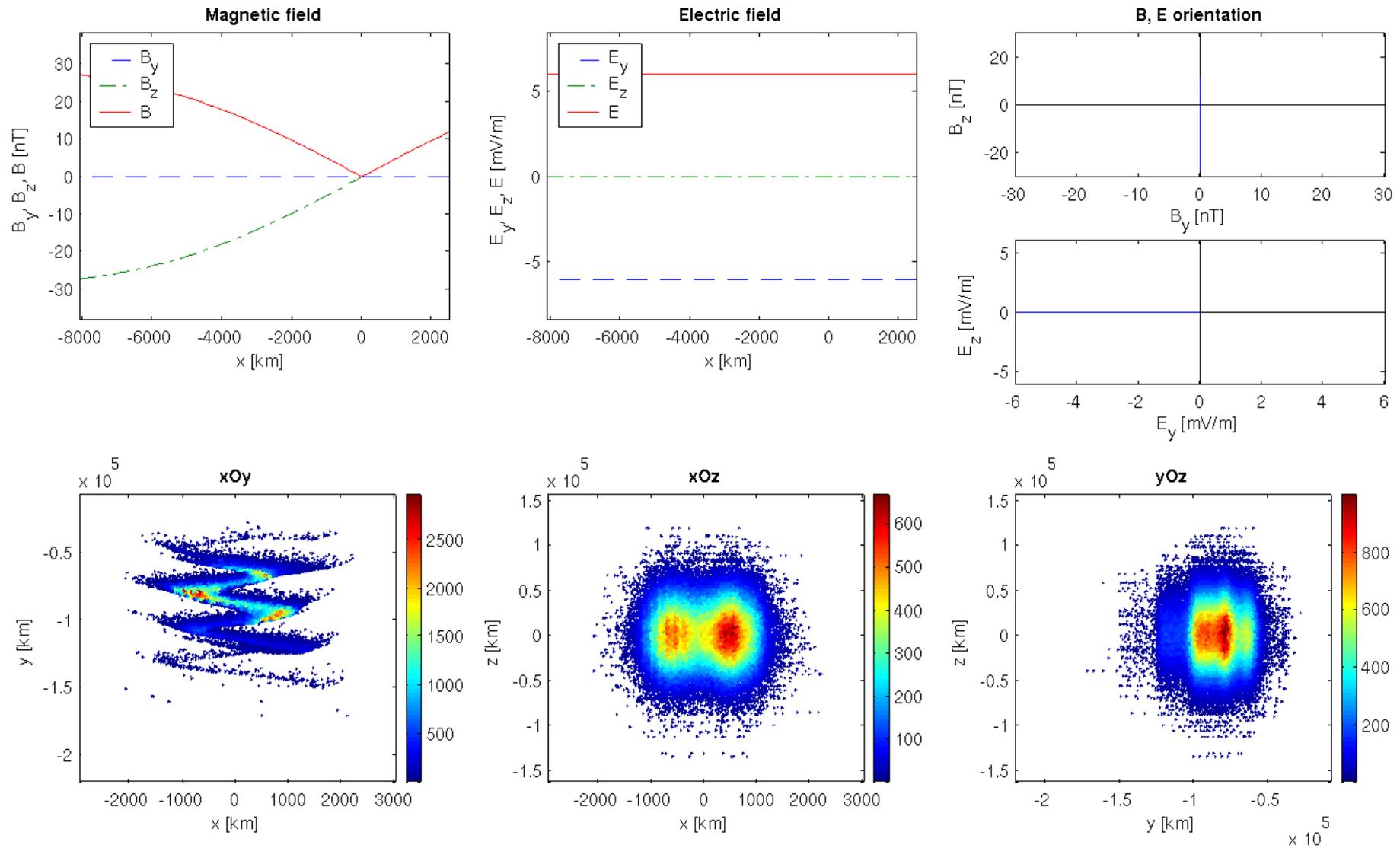
- **Cazul B:** camp electric neuniform ce conserva driftul de ordinul zero

$$\vec{E}(x) = \vec{B}(x) \times \vec{V}_E \quad \text{cu} \quad \vec{V}_E = \vec{V}_0 = \text{const}$$

Cazul 1Ap – Distribuție antiparalela a câmpului magnetic. Câmp electric uniform

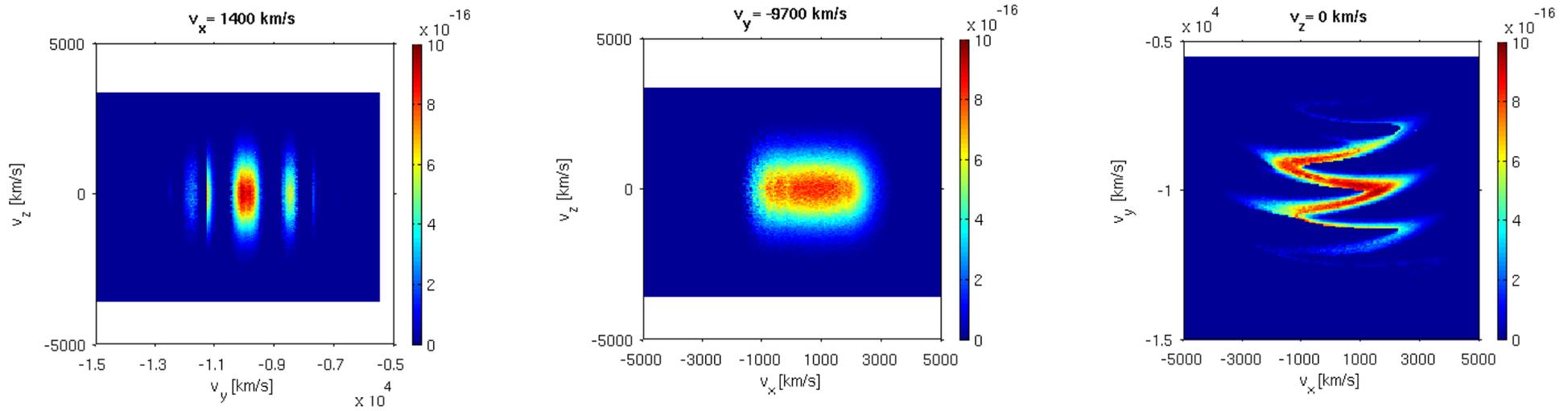
- **Specia:** proton
- **Temperatura:** $T_i = 7 \text{ keV}$
- **Densitatea:** $N_0 = 10^4 \text{ m}^{-3}$
- **Viteza de masa:** $\mathbf{V}_0 = (200,0,0) \text{ km/s}$
- **Câmpul magnetic:** $\mathbf{B}_1 = (0,0,-30) \text{ nT}$, $\mathbf{B}_2 = (0,0,+30) \text{ nT}$, $\mathbf{L} = 6800 \text{ km}$
- **Nr. surse:** 6
- **Pozitia sursei I:** $x_0 = -8110 \text{ km}$
- **Distanța dintre surse:** $dx_0 = 100 \text{ km}$
- **Nr. particule pe sursă:** 10^5
- **Durata de integrare:** $t = 38 \text{ s}$

Cazul 1Ap – Distribuție antiparalela a câmpului magnetic. Camp electric uniform



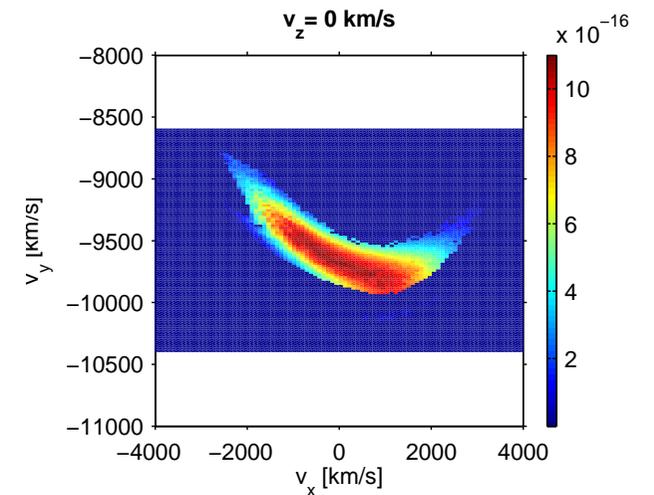
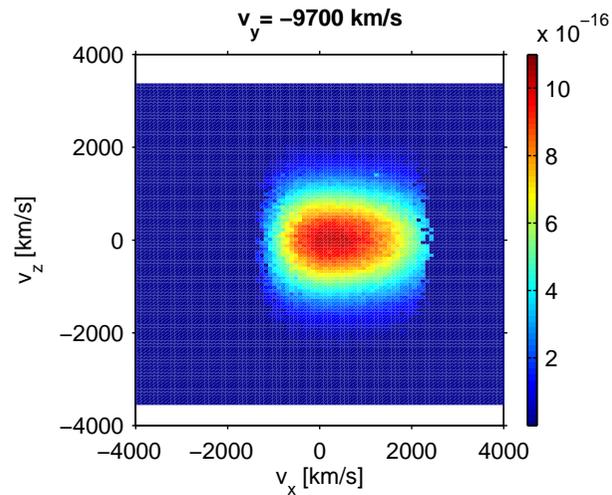
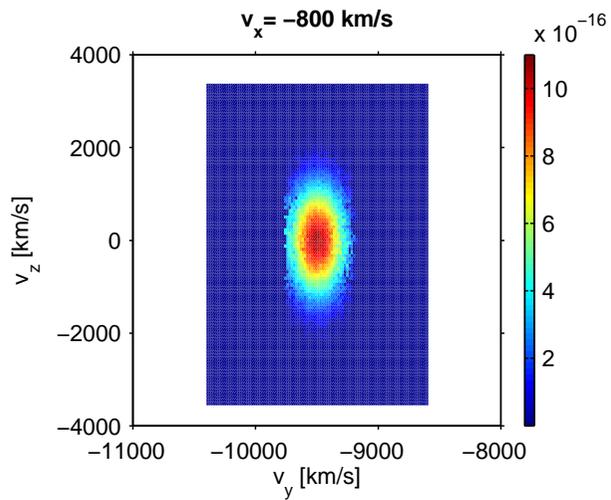
$E = (0.00, -6.00, 0.00)$ mV/m $B_1 = (0, 0, -30)$ nT $B_2 = (0, 0, 30)$ nT $L = 6800$ km $\Delta t = 38$ s $6 \times 100000 = 600000$ particles $r_0 = (-8110, 0, 0)$ km $\Delta r_0 = (100, 0, 0)$ km

Cazul 1Ap – Distributie antiparalela a campului magnetic. Camp electric uniform



FDV reconstruita folosind toate particulele

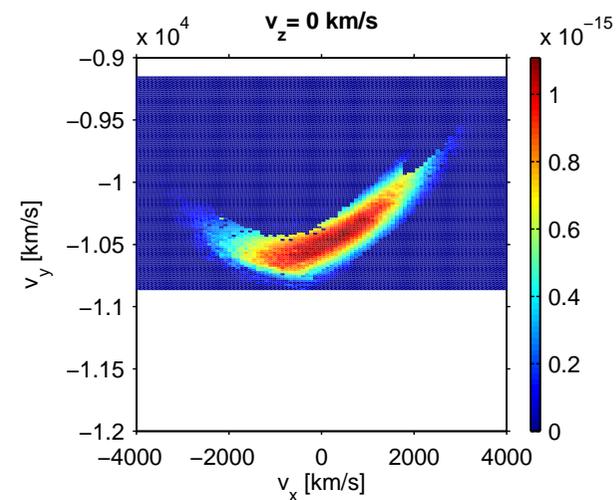
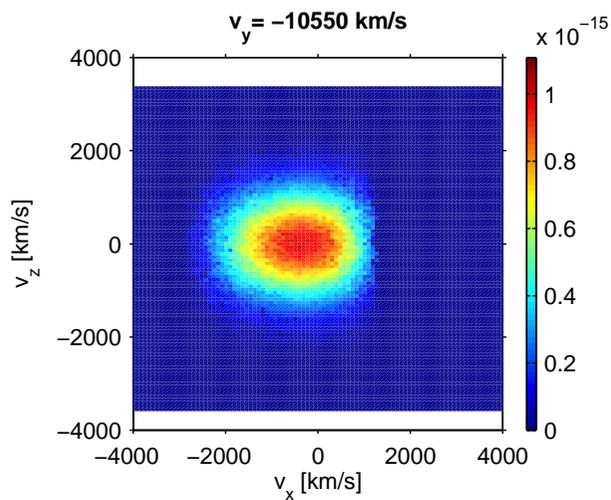
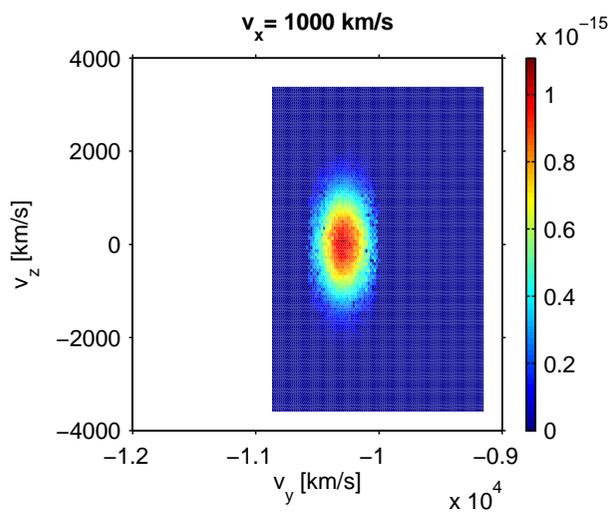
Cazul 1Ap – Distributie antiparalela a campului magnetic. Camp electric uniform



FDV pentru zona A

$$-900 < x < -500 \text{ km}; -90000 < y < -70000 \text{ km}$$

Cazul 1Ap – Distributie antiparalela a campului magnetic. Camp electric uniform



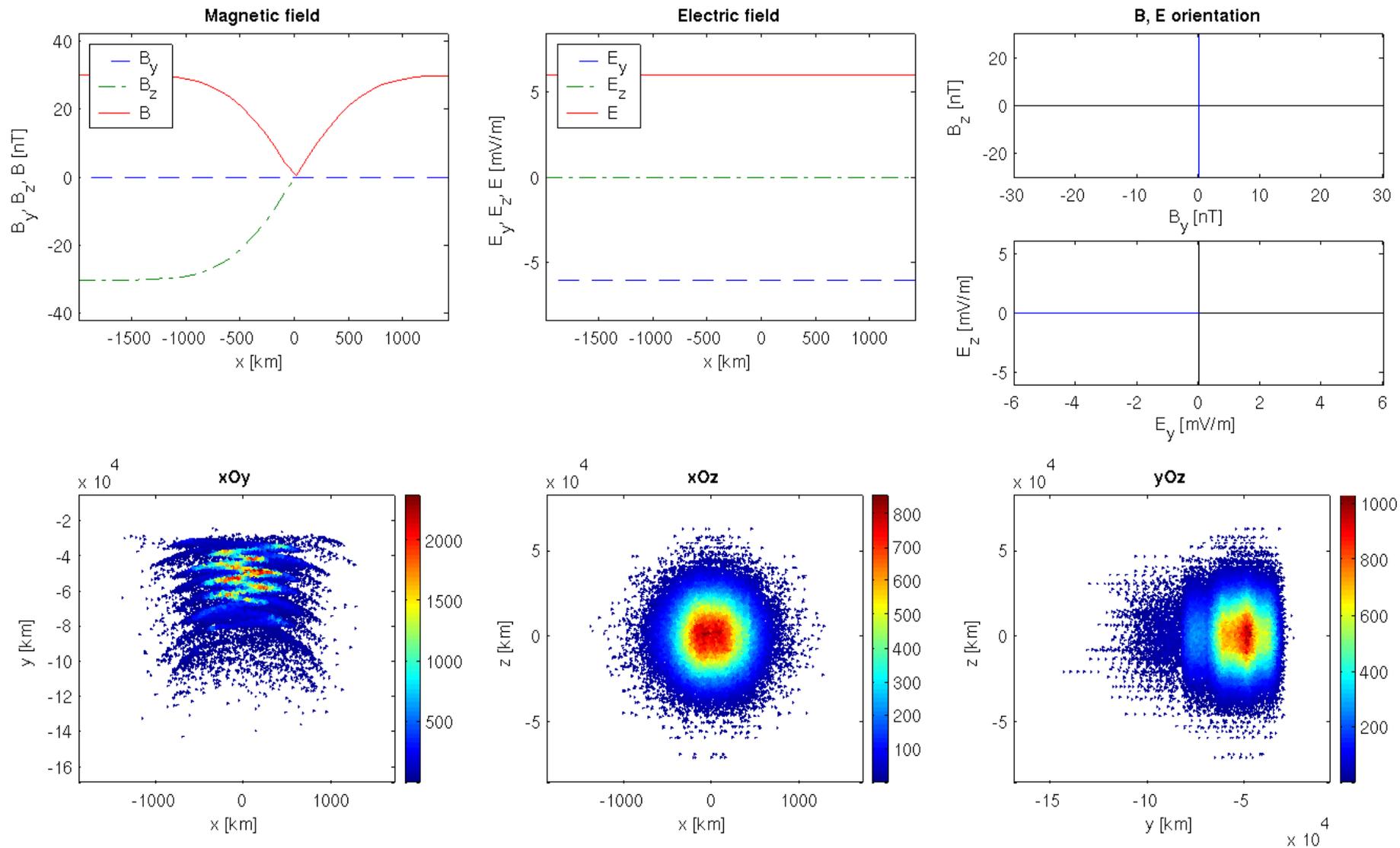
FDV pentru zona C

$500 < x < 900$ km; $-100000 < y < -80000$ km

Cazul 1Bp – Distributie antiparalela a campului magnetic. Camp electric uniform

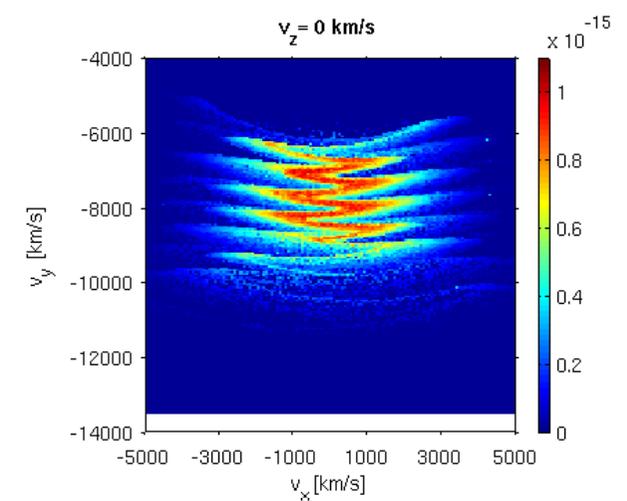
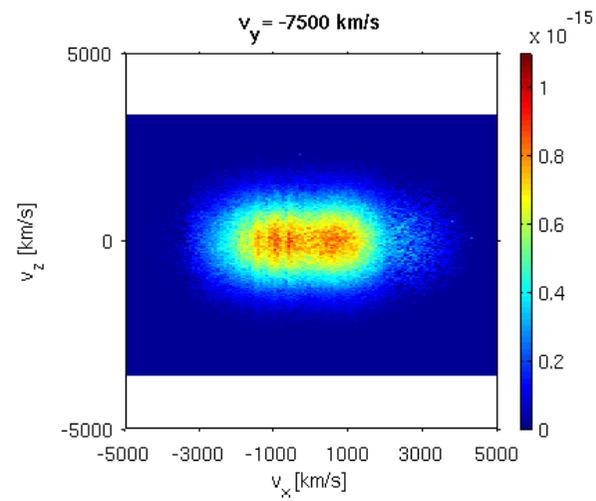
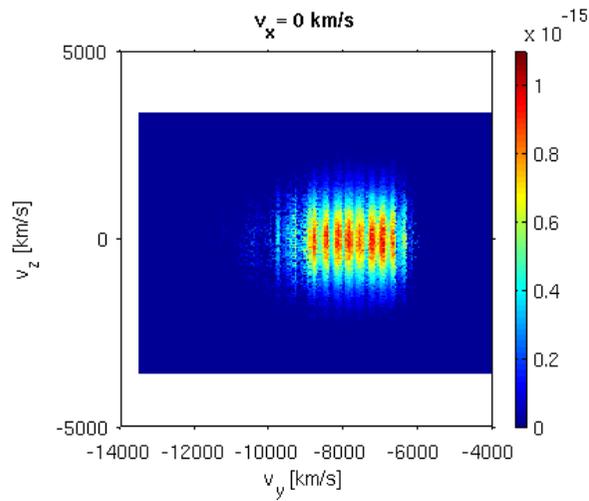
- **Specia:** proton
- **Temperatura:** $T_i = 7 \text{ keV}$
- **Densitatea:** $N_0 = 10^4 \text{ m}^{-3}$
- **Viteza de masa:** $\mathbf{V}_0 = (200,0,0) \text{ km/s}$
- **Campul magnetic:** $\mathbf{B}_1 = (0,0,-30) \text{ nT}$, $\mathbf{B}_2 = (0,0,+30) \text{ nT}$, $\mathbf{L} = 680 \text{ km}$
- **Nr. surse:** 6
- **Pozitia sursei I:** $x_0 = -1990 \text{ km}$
- **Distanta dintre surse:** $dx_0 = 100 \text{ km}$
- **Nr. particule pe sursa:** 10^5
- **Durata de integrare:** $t = 20 \text{ s}$

Cazul 1Bp – Distribuție antiparalela a câmpului magnetic. Camp electric uniform



$E = (0.00, -6.00, 0.00)$ mV/m $B_1 = (0, 0, -30)$ nT $B_2 = (0, 0, 30)$ nT $L = 680$ km $\Delta t = 20$ s $6 \times 100000 = 600000$ particles $r_0 = (-1990, 0, 0)$ km $\Delta r_0 = (100, 0, 0)$ km

Cazul 1Bp – Distributie antiparalela a campului magnetic. Camp electric uniform

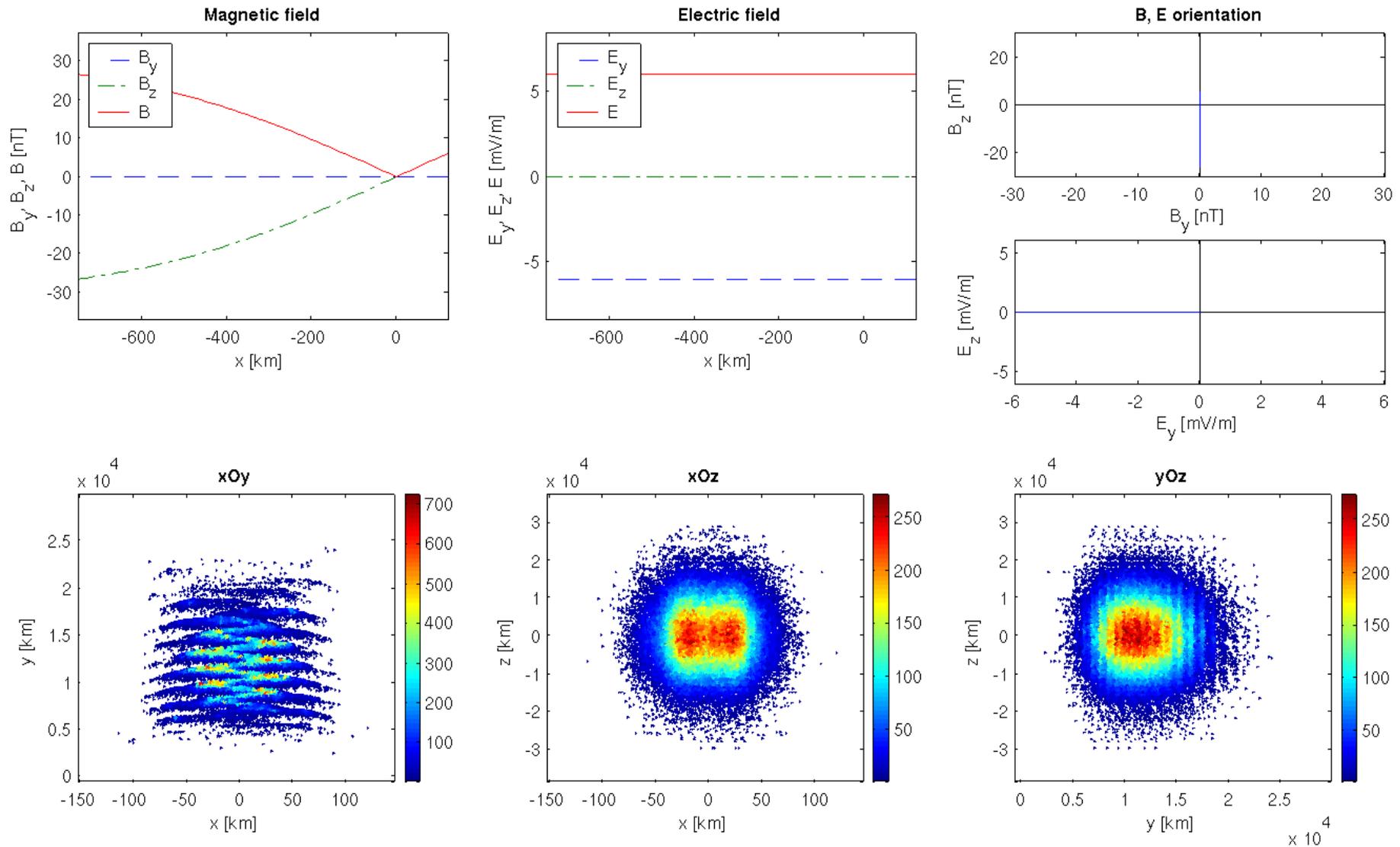


FDV reconstruita folosind toate particulele

Cazul 1Be – Distributie antiparalela a campului magnetic. Camp electric uniform

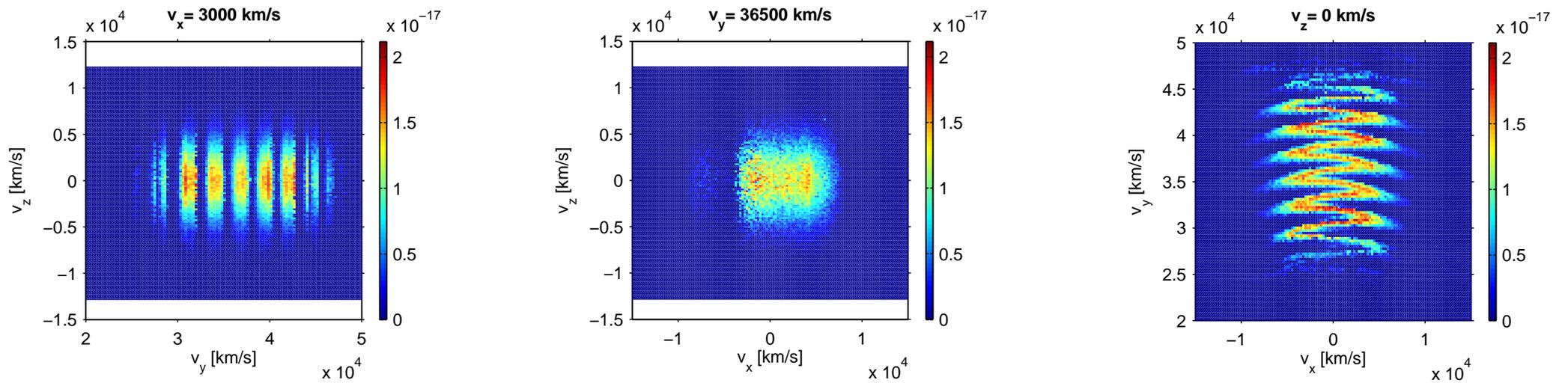
- **Specia:** electron
- **Temperatura:** $T_e = 1 \text{ keV}$
- **Densitatea:** $N_0 = 10^4 \text{ m}^{-3}$
- **Viteza de masa:** $\mathbf{V}_0 = (200,0,0) \text{ km/s}$
- **Campul magnetic:** $\mathbf{B}_1 = (0,0,-30) \text{ nT}$, $\mathbf{B}_2 = (0,0,+30) \text{ nT}$, $\mathbf{L} = 680 \text{ km}$
- **Nr. surse:** 6
- **Pozitia sursei I:** $x_0 = -750 \text{ km}$
- **Distanta dintre surse:** $dx_0 = 8 \text{ km}$
- **Nr. particule pe sursa:** $4 \cdot 10^4$
- **Durata de integrare:** $t = 2.5 \text{ s}$

Cazul 1Be – Distribuție antiparalela a câmpului magnetic. Camp electric uniform



$E = (0.00, -6.00, 0.00)$ mV/m $B_1 = (0, 0, -30)$ nT $B_2 = (0, 0, 30)$ nT $L = 680$ km $\Delta t = 2.5$ s $6 \times 40000 = 240000$ particles $r_0 = (-750, 0, 0)$ km $\Delta r_0 = (8, 0, 0)$ km

Cazul 1Be – Distributie antiparalela a campului magnetic. Camp electric uniform

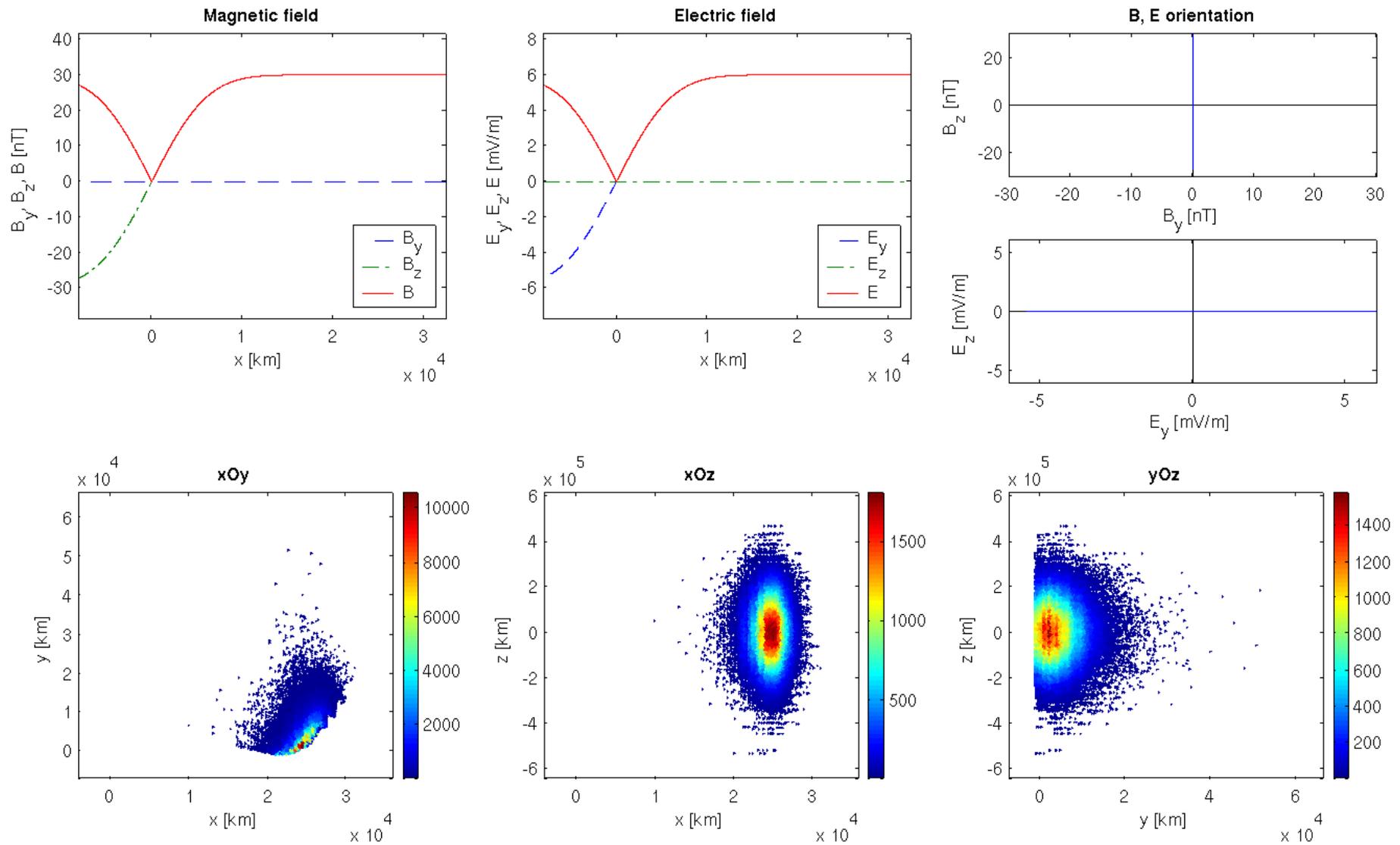


FDV reconstruita folosind toate particulele

Cazul 2Ap – Distribuție antiparalela a câmpului magnetic. Câmp electric neuniform

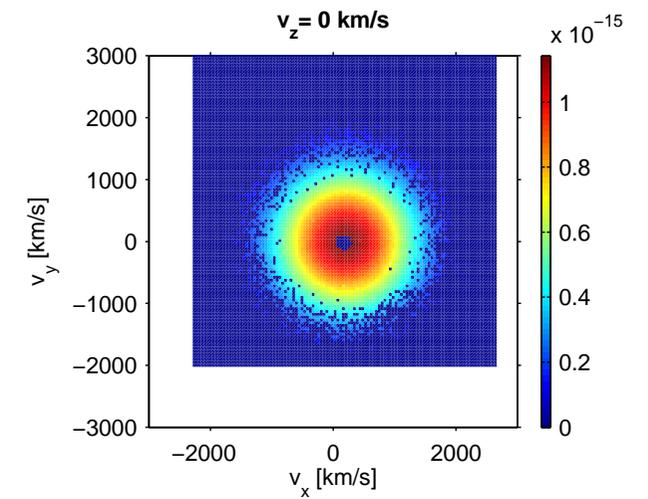
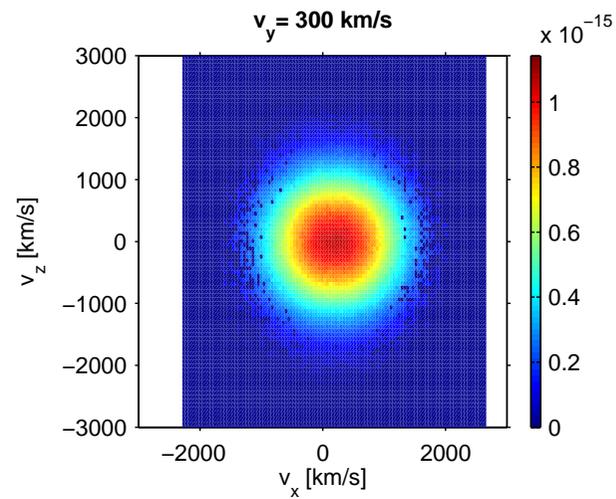
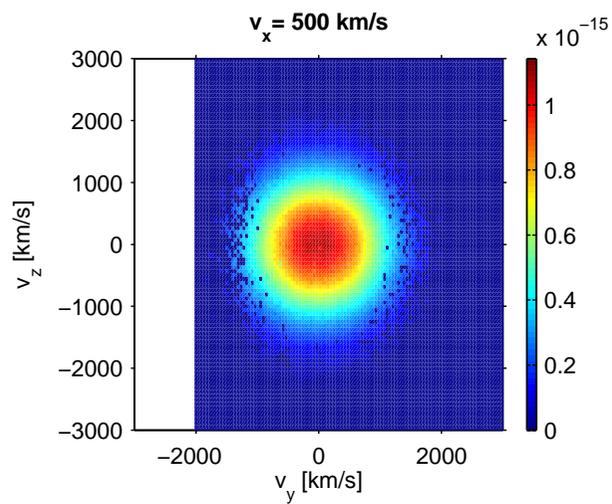
- **Specia:** proton
- **Temperatura:** $T_i = 7 \text{ keV}$
- **Densitatea:** $N_0 = 10^4 \text{ m}^{-3}$
- **Viteza de masa:** $\mathbf{V}_0 = (200,0,0) \text{ km/s}$
- **Câmpul magnetic:** $\mathbf{B}_1 = (0,0,-30) \text{ nT}$, $\mathbf{B}_2 = (0,0,+30) \text{ nT}$, $\mathbf{L} = 6800 \text{ km}$
- **Nr. surse:** 6
- **Pozitia sursei I:** $x_0 = -8110 \text{ km}$
- **Distanța dintre surse:** $dx_0 = 100 \text{ km}$
- **Nr. particule pe sursa:** 10^5
- **Durata de integrare:** $t = 150 \text{ s}$

Cazul 2Ap – Distribuție antiparalela a câmpului magnetic. Camp electric neuniform



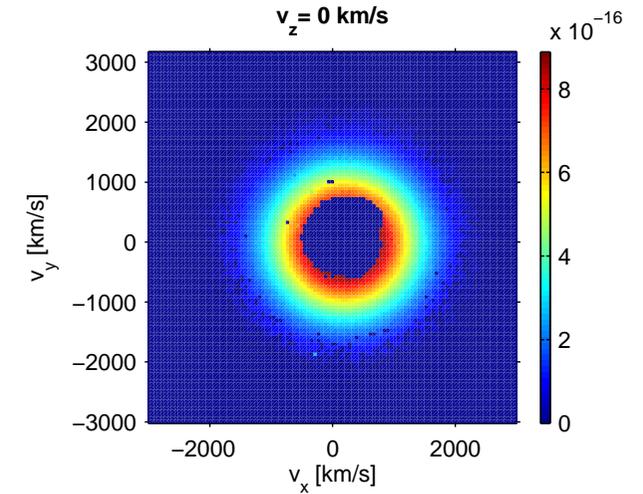
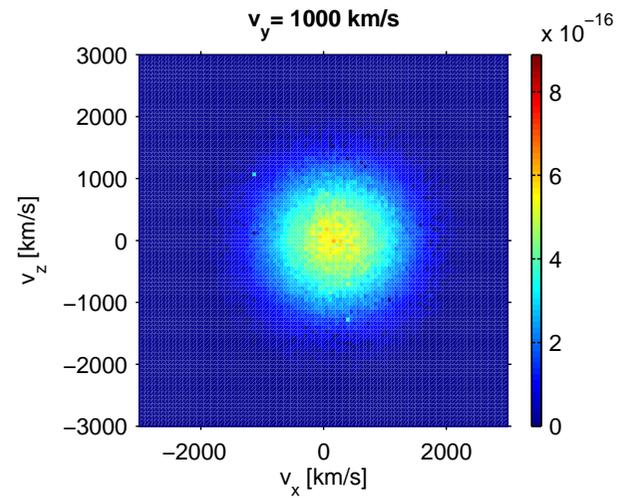
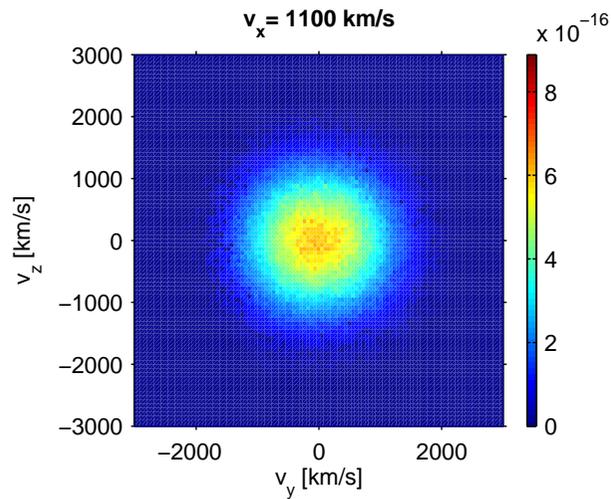
UE = (200.00,0.00,0.00) km/s B1 = (0,0,-30) nT B2 = (0,0,30) nT L = 6800 km $\Delta t = 150$ s $6 \times 100000 = 600000$ particles $r_0 = (-8110,0,0)$ km $\Delta r_0 = (100,0,0)$ km

Cazul 2Ap – Distribuție antiparalela a câmpului magnetic. Camp electric neuniform



FDV pentru zona A
 $23000 < x < 24000 \text{ km}$

Cazul 2Ap – Distribuție antiparalela a câmpului magnetic. Camp electric neuniform



FDV pentru zona C
 $25000 < x < 26000 \text{ km}$

Concluzii

- in cazul unei distributii antiparalele a campului magnetic, respectiv un camp electric constant, rezultatele simularilor arata formarea unei foi de curent paralela cu discontinuitatea si centrata in regiunea in care $\mathbf{B}=0$
- FDV atat pentru protoni, cat si pentru electroni prezinta o anizotropie pronuntata
- in cazul electronilor, structura atat in spatiul pozitiiilor cat si in spatiul vitezelor are o scala mult mai redusa decat in cazul protonilor
- FDV reconstruita pentru diverse regiuni din spatiu evidentieaza caracteristicile imprimate de catre mecanismul de accelerare
- in cazul unei distributii antiparalele a campului magnetic, insa in prezenta unui camp electric neuniform perpendicular pretutindeni pe campul magnetic si a carui modul varieaza astfel incat sa conserve driftul de ordin zero, norul de particule penetreaza discontinuitatea deplasandu-se in partea “dreapta” a acesteia