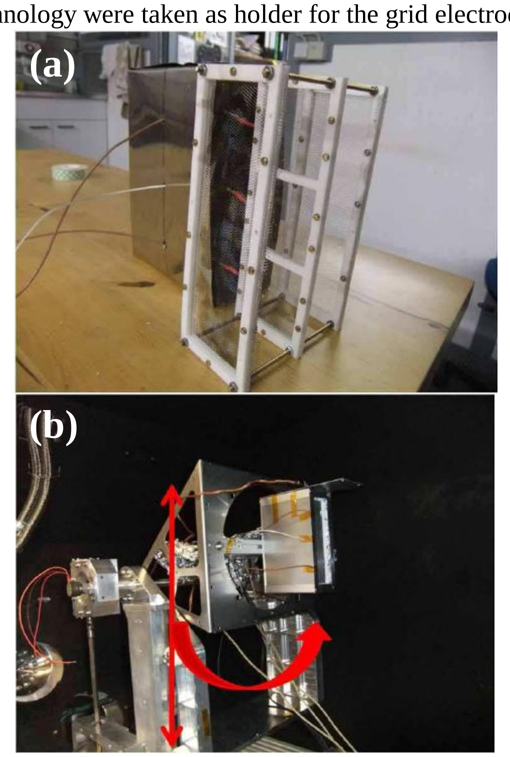
Dust Trajectory Detector Using Single Grid Electrodes Plane. Yanwei Li[1], Ralf. Srama[1] and S. Bugiel[1], [1]IRS, Univercity of Stuttgart, Pfaffenwaldring 29, 70569 Stuttgart, Germany (li@irs.uni-stuttgart.de, Srama@irs.uni-stuttgart.de).

Introduction: There are evidences that the dust grains in space or on the surface of planetary body are charged by plasma or UV light [1]. Using induced charge method to address dust grains has long history both in laboratory study and space mission [2,3]. For some special spacecraft, such as a lander for Rosetta-like missions or a Yutu-like planetary rover, which provide very limit mass and data volume for the payload, a simplified particle trajectory sensor design is required. In this study, we introduced two future simplified designs with less number of electrodes and lower instruments mass with respect to the original Lunar Dust Explorer (LDX) design [4].

Laboratory model tests: The laboratory test model we developed, built up and tested has 3 grid electrodes and contains two shielding grids at the aperture as shown in Figure 1. All electrodes are formed by etched grid segments, which has an open area better than 90 %. The electrodes have a size of 5 cm × 5 cm. The Nylon frames produced by 3D printer technology were taken as holder for the grid electrodes.



(b)

Figure 1. The internal structure of test model (a) and the set up of test model in the dust accelerator. The moving platform has 3 degrees freedom.

Experimental results: The typical induced charge signals are shown in Figure 2. Dust grain pass through the middel grid (channel 2). In center of channel 2, Z = 0, and Z = 20 is the position nearby channel 1. The average induced charge Q_{alpha} and ratio k between the two peaks of the signal on channel 1 takes dust trajectory information:

$$Z=34.84-8.8\times\lg(Q_{alpha}-0.1041) \quad (1)$$

$$\alpha=f_1(Z)-f_2(Z)\times e^{\frac{k}{f_3(Z)}} \quad (2)$$

where,

$$f_1(Z)=378.39-127.84\times e^{\frac{Z}{44.67}} \quad (3)$$

$$f_2(Z)=2.36-1.05\times e^{\frac{Z}{40.43}} \quad (4)$$

$$f_3(Z)=265.76-148.63\times e^{\frac{Z}{46.82}} \quad (5)$$

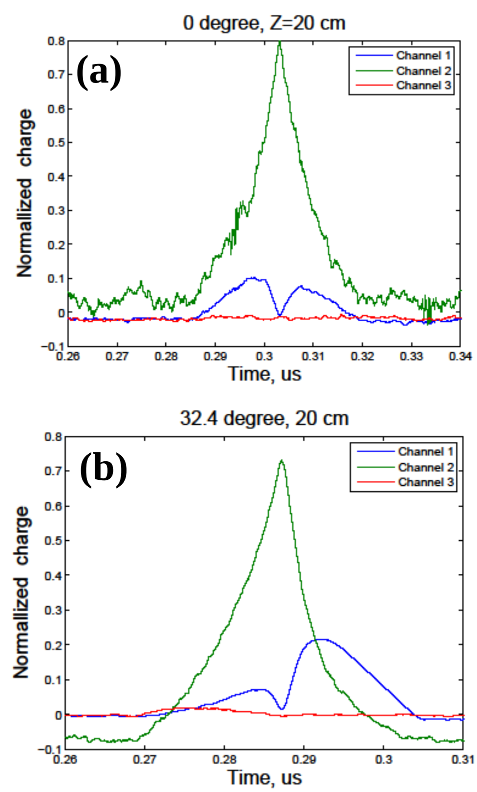


Figure 2. The typical signals of induced charge on grid electrodes. Respect to the horizontal direction: (a) dust trajectory is 0 degree; (b) dust trajectory is 32.4 degrees.

Sketch of two future designs: We developed two future designs based on the test model above: (1) Cylindrical design LDX-c. There are four circle segment electrodes with a central circular electrode. This types of sensor requires 7 measurement channels in total including two trigger grid electrodes, as shown in Figure 3. LDX-c design has a size of about 10 cm × 10 cm × 20 cm. (2) Square design LDX-s. The square design has four parallel tripes. With two trigger grid electrodes, there are 6 channels in total, as shown in Figure 4. LDX-s design has a size of about 10 cm × 15 cm × 10 cm.

A sunshade was developed for LDX-c design to avoide the UV light photoelectron noise on electrodes.

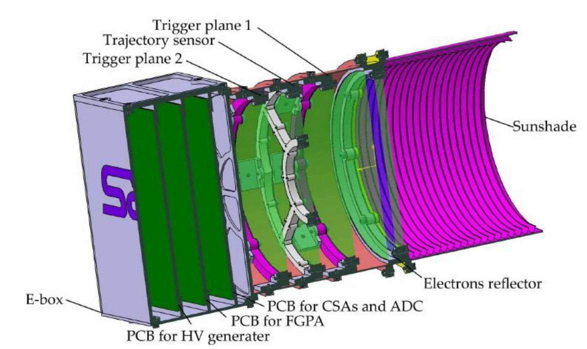


Figure 3. Sketch of the LDX-c design with sunshade and electronics box.

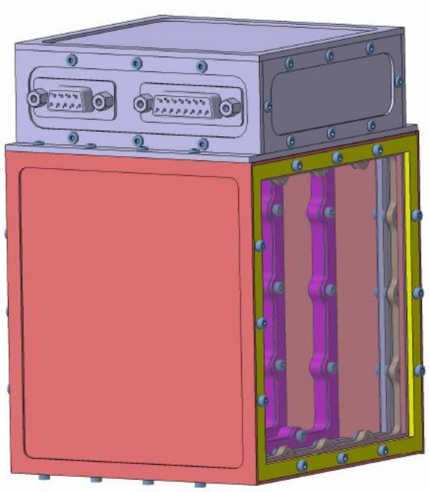


Figure 4. Sketch of the LDX-s design with electronics box on the top.

Parameters of LDX-like instruments: We calculated the power and voltage requirements for the LDX-like instrument, and with the help of CAD software we get the mass of instruments, as shown in Tabel 1. What should be noted is the voltages and powers requirements here are only for charge sensitive amplifiers.

Conclusion: The LDX-like dust trajectory detectors have low mass and data volume requirements and simple structure for both circle and squire design. These instruments can be used for the mission such as a rover, a small lander or a mini-satellite to study many science questions, such as the dust levitation, dust cloud above planetary bodys, the ring system and the evolution of interplanetary dust grains.

References: [1] Horányi M. (1996) Annu. Rev, Astrophys. 34, 383-418. [2] Srama R. et al. (2007) ESA SP-643. [3] Auer S. et al. (2010) Nucl. Instrum. Mwthods A. [4] Li Y. W. et al. (2014) *Adv. Space Res.*, *54*, 2094–2100.

Table 1. The parameters of LDX-like instruments.

Sensor	Parameters	Part name	Value
LDX	Open area		400 cm^2
	Mass	House structure	781 g
		fastener	36 g
		E-box	384 g
		SUM	1200 g
	Voltage	CSAs	12 V
	Power	CSAs (18)	1.1 W
	User data Rate		83.7 kbit/s
LDX-s	Open area		100 cm^2
	Mass	House structure	340 g
		fastener	15 g
		E-box	330 g
		SUM	685 g
	Voltage	CSAs	12V
	Power	CSAs (6)	0.36 W
	User data Rate		83.7 kbit/s
LDX-c	Open area		80 cm^2
	Mass	House structure	265 g
		fastener	10 g
		E-box	330 g
		Sunshade	100 g
		SUM	705 g
	Voltage	CSAs	12V
	Power	CSAs (7)	0.42 W
	User data Rate		83.7 kbit/s