

# NASA Breakup Model Implementation Comparison of results

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## Contributions by:

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- **ESA**: M. Oswald (TU Braunschweig)
- **NASA**: P. Krisko

# Purpose of the Internal Task

- To compare the different implementations of the new NASA breakup model for explosions and collisions, as reported in the paper by Johnson *et al.*, *Adv. Space Res*, Vol. 28, 2001.
- The aim is also to better characterise and understand possible differences between the results of the long term evolution models.

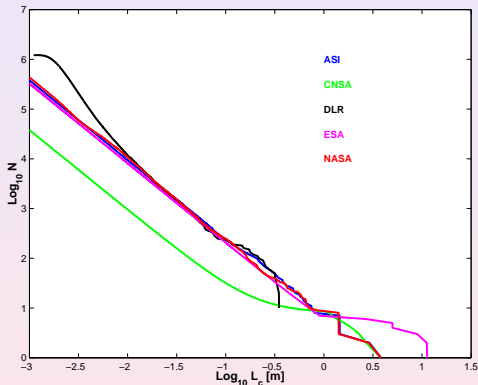
# Explosion case – Study parameters

- The fragmented objects is a **ROCKET BODY**
- The results includes particles down to  $L_c = 1 \text{ mm}$
- Output data:
  - 1 Characteristic length  $L_c$  [m]
  - 2 mass [kg]
  - 3 area [ $\text{m}^2$ ]
  - 4  $\Delta V$  [km/s]

# Explosion case – Results - $L_c$

Number of objects  
larger than **1 mm**:

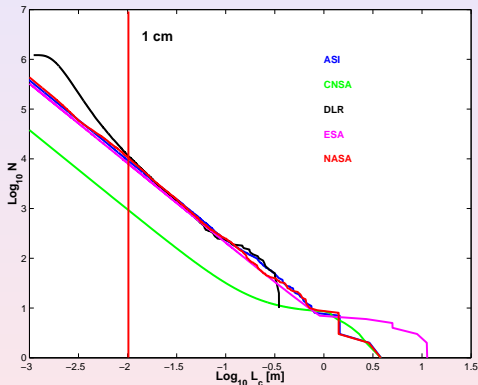
- ASI: 378 581
- CNSA: 37 865
- DLR: 1 217 054
- ESA: 324 886
- NASA: 434 928



# Explosion case – Results - $L_c$

Number of objects  
larger than **1 cm**:

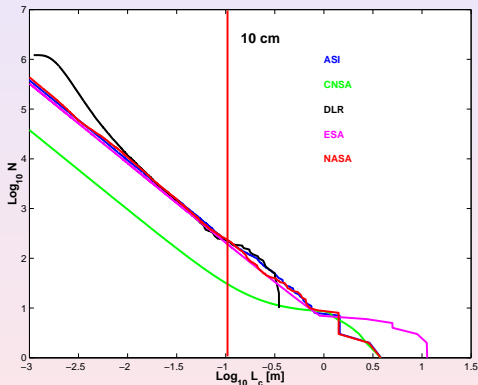
- ASI: 9 403
- CNSA: ~ 960
- DLR: 11 724
- ESA: 8 159
- NASA: 10 731



# Explosion case – Results - $L_c$

Number of objects  
larger than 10 cm:

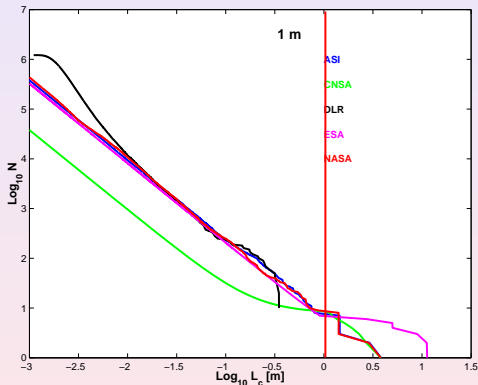
- ASI: 234
- CNSA: ~ 32
- DLR: 230
- ESA: 206
- NASA: 248



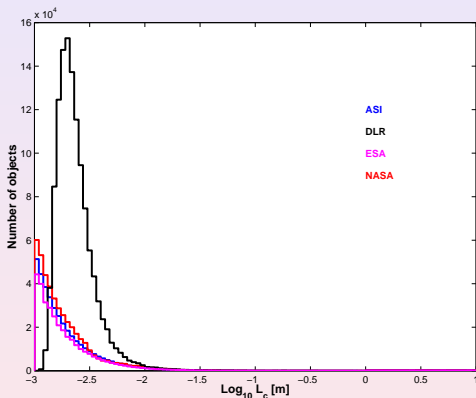
# Explosion case – Results - $L_c$

Number of objects  
larger than 1 m:

- ASI: 7
- CNSA: ~ 9
- DLR: 0
- ESA: 6
- NASA: 8

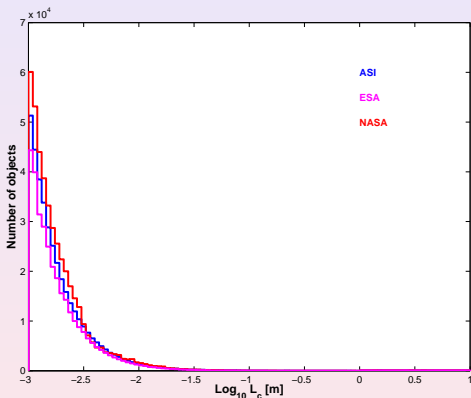


# Explosion case – Results - $L_c$



Distribution in 100 bins

# Explosion case – Results - $L_c$



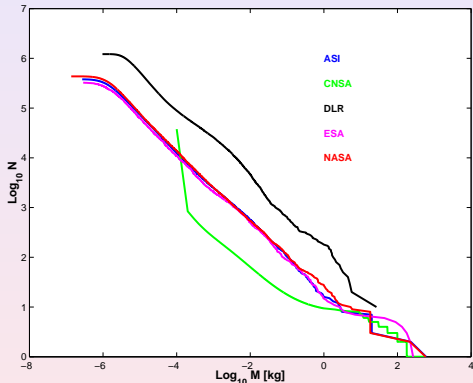
Distribution in 100 bins

DLR results excluded

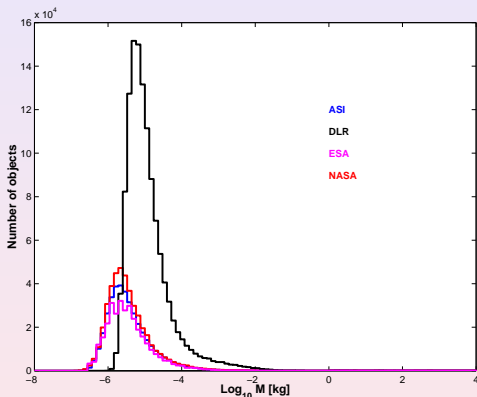
# Explosion case – Results - Mass

Number of objects  
larger than **1 gram**:

- ASI: 2 472
- CNSA: ~ 254
- DLR: 25 844
- ESA: 2 093
- NASA: 2 525

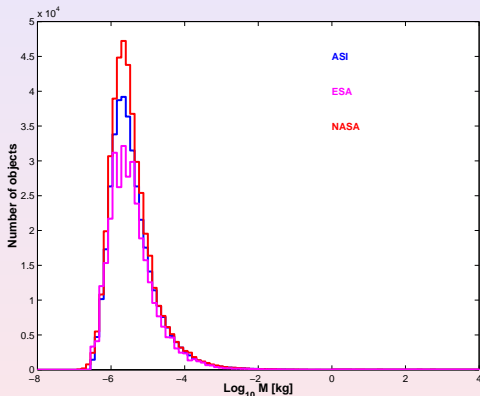


# Explosion case – Results - Mass



Distribution in 100 bins

# Explosion case – Results - Mass



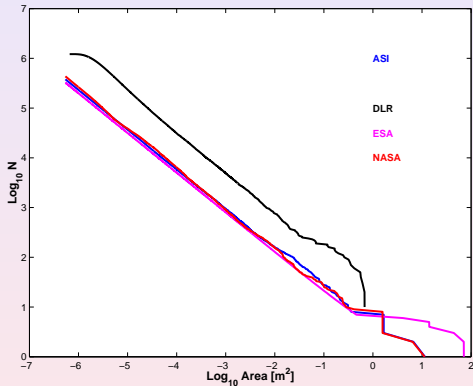
Distribution in 100 bins

DLR results excluded

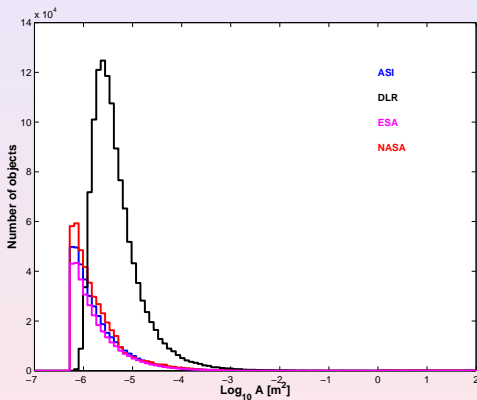
## Explosion case – Results - Area

Number of objects with  
area larger than  $1 \text{ cm}^2$ :

- ASI: 5 878
- DLR: 31 124
- ESA: 5 024
- NASA: 6 416

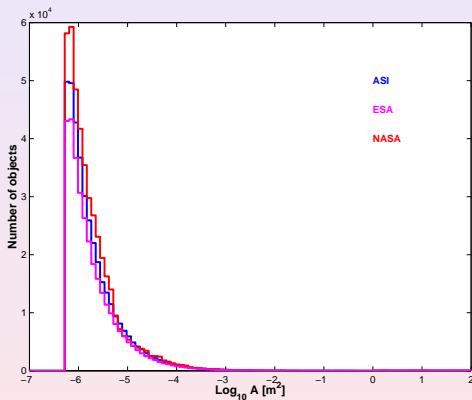


# Explosion case – Results - Area



Distribution in 100 bins.

# Explosion case – Results - Area



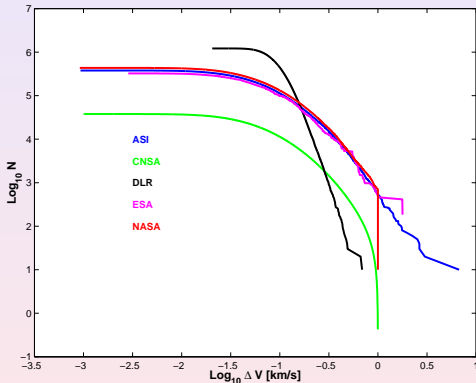
Distribution in 100 bins.

DLR results excluded

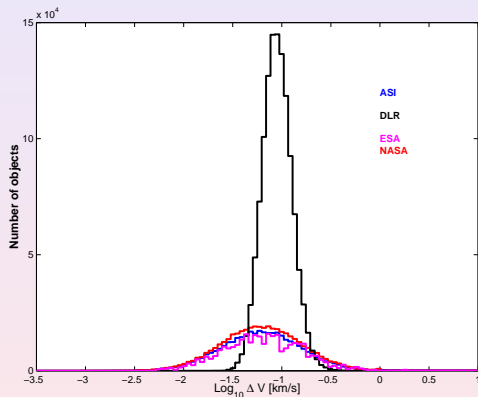
# Explosion case – Results - $\Delta V$

Number of objects with  
 $\Delta V > 100$  m/s:

- ASI: 112 932
- CNSA: ~ 11 380
- DLR: 31 124
- ESA: 98 717
- NASA: 132 032

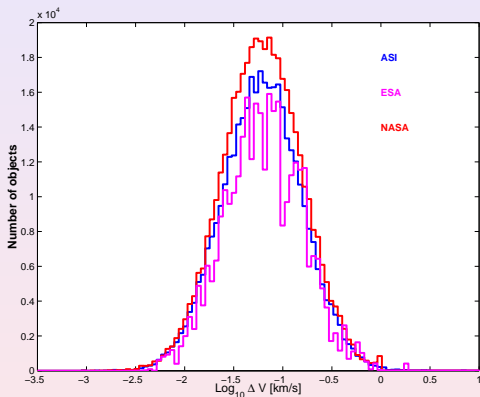


# Explosion case – Results - $\Delta V$



Distribution in 100 bins.

# Explosion case – Results - $\Delta V$



Distribution in 100 bins.

DLR results excluded

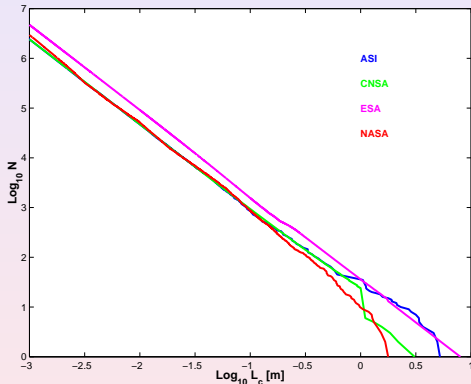
## Collision case – Study parameters

- The fragmented objects is a **ROCKET BODY**
- Target mass: 1000 kg
- Projectile mass: 10 kg
- Impact velocity: 10 km/s
- The results includes particles down to  $L_c = 1 \text{ mm}$
- Output data:
  - 1 Characteristic length  $L_c$  [m]
  - 2 mass [kg]
  - 3 area [ $\text{m}^2$ ]
  - 4  $\Delta V$  [km/s]

## Collision case – Results - $L_c$

Number of objects  
larger than **1 mm**:

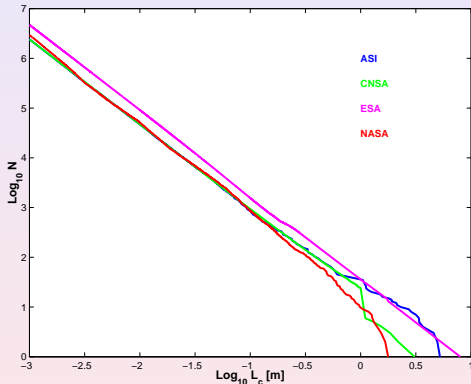
- ASI: 2 416 795
- CNSA: 2 416 790
- ESA: 4 723 391
- NASA: 2 957 159



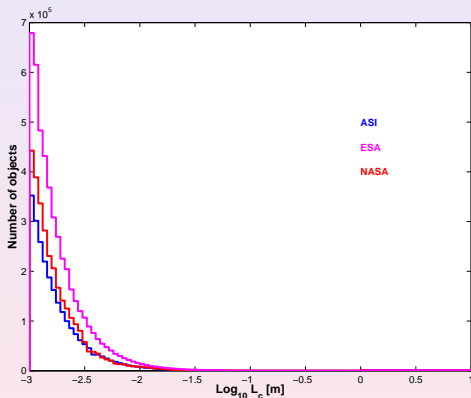
## Collision case – Results - $L_c$

Number of objects  
larger than 10 cm:

- ASI: 850
- CNSA: ~ 935
- ESA: 1 539
- NASA: 862



# Collision case – Results - $L_c$

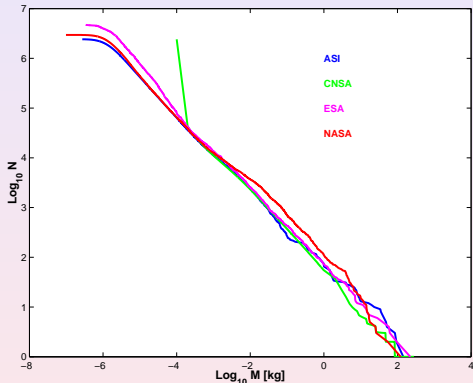


Distribution in 100 bins

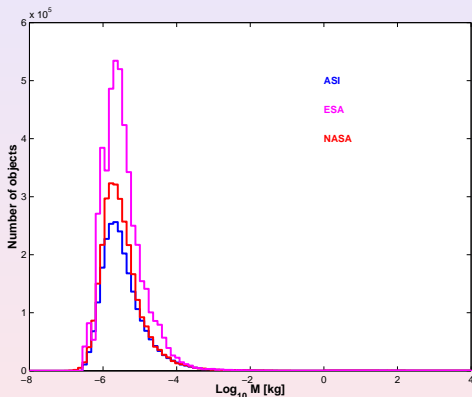
## Collision case – Results - Mass

Number of objects  
larger than **1 gram**:

- ASI: 11 330
- CNSA: ~ 11 125
- ESA: 13 467
- NASA: 12 600



# Collision case – Results - Mass

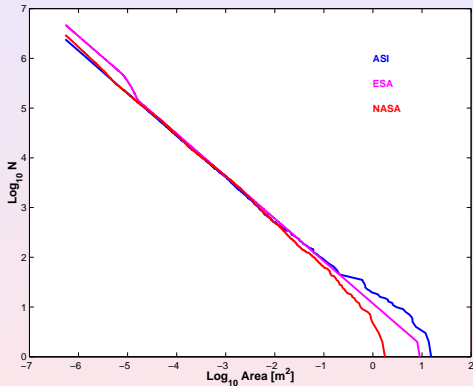


Distribution in 100 bins

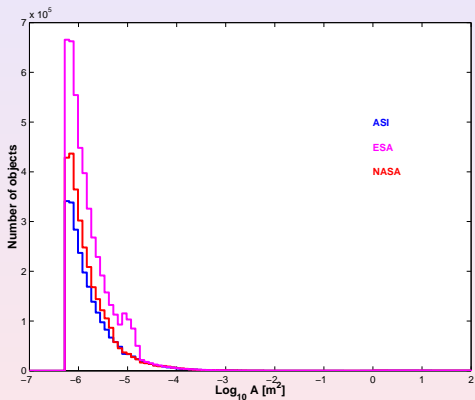
## Collision case – Results - Area

Number of objects with  
area larger than  $1 \text{ cm}^2$ :

- ASI: 27 450
- ESA: 30 366
- NASA: 28 892



# Collision case – Results - Area

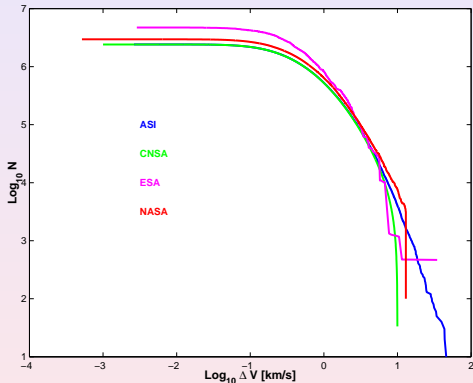


Distribution in 100 bins

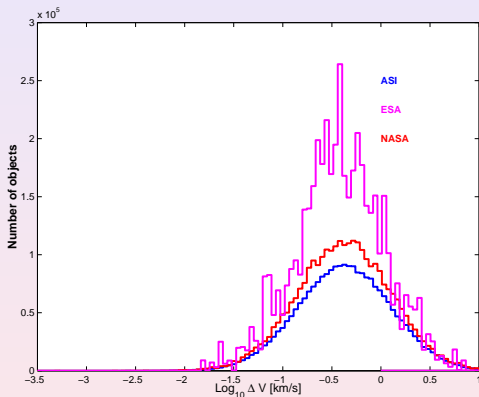
## Collision case – Results - $\Delta V$

Number of objects with  
 $\Delta V > 1$  km/s:

- ASI: 528 301
- CNSA:  $\sim$  523 120
- ESA: 822 539
- NASA: 638 537



# Collision case – Results - $\Delta V$



Distribution in 100 bins