

Surface mechanical properties based on Philae's touchdowns

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Philae's Trajectory

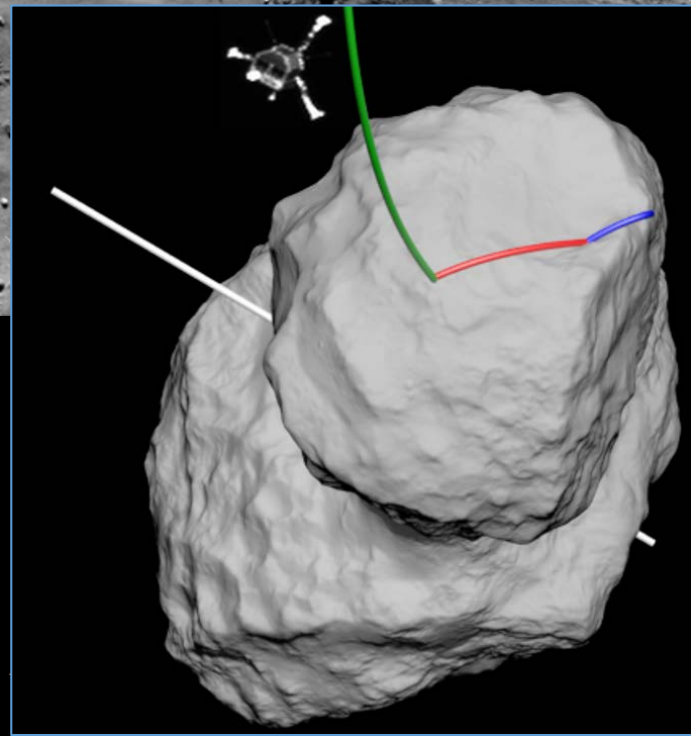
Mosaic of OSIRIS images from 30 km distance

First touchdown
at 15:34

Collision
at 16:20

Second and third touchdown
at 17:25 and 17:31

Reconstructed based on magnetometer/CONSERT data
(Auster et al. 2015)



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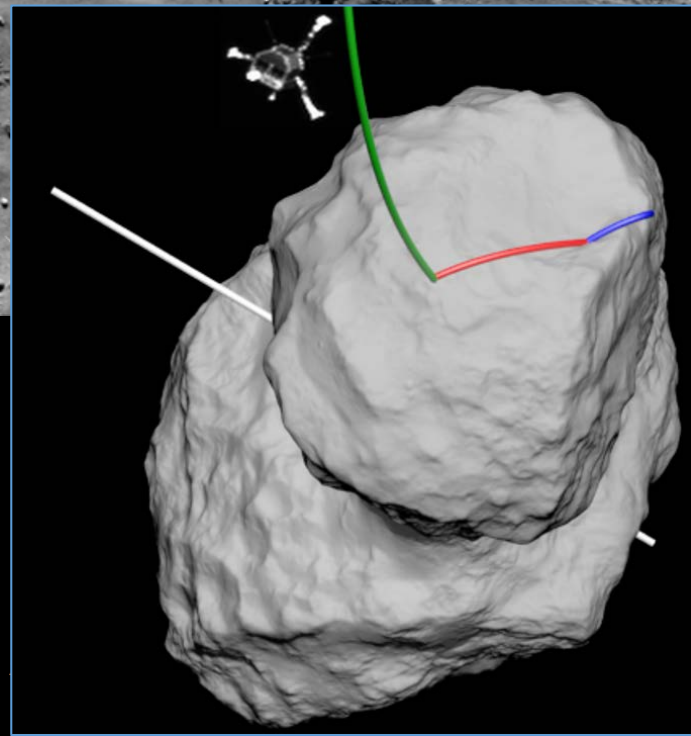
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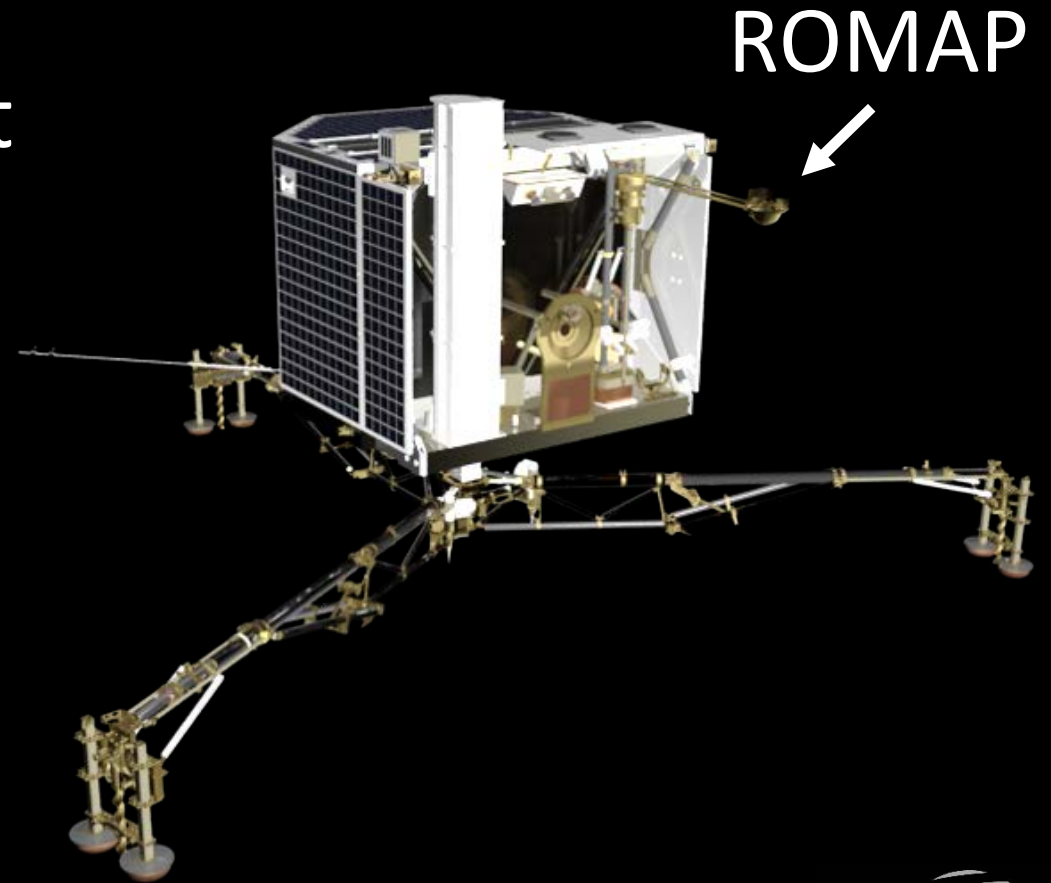
Touchdown Dynamics

ROMAP Magnetometer:

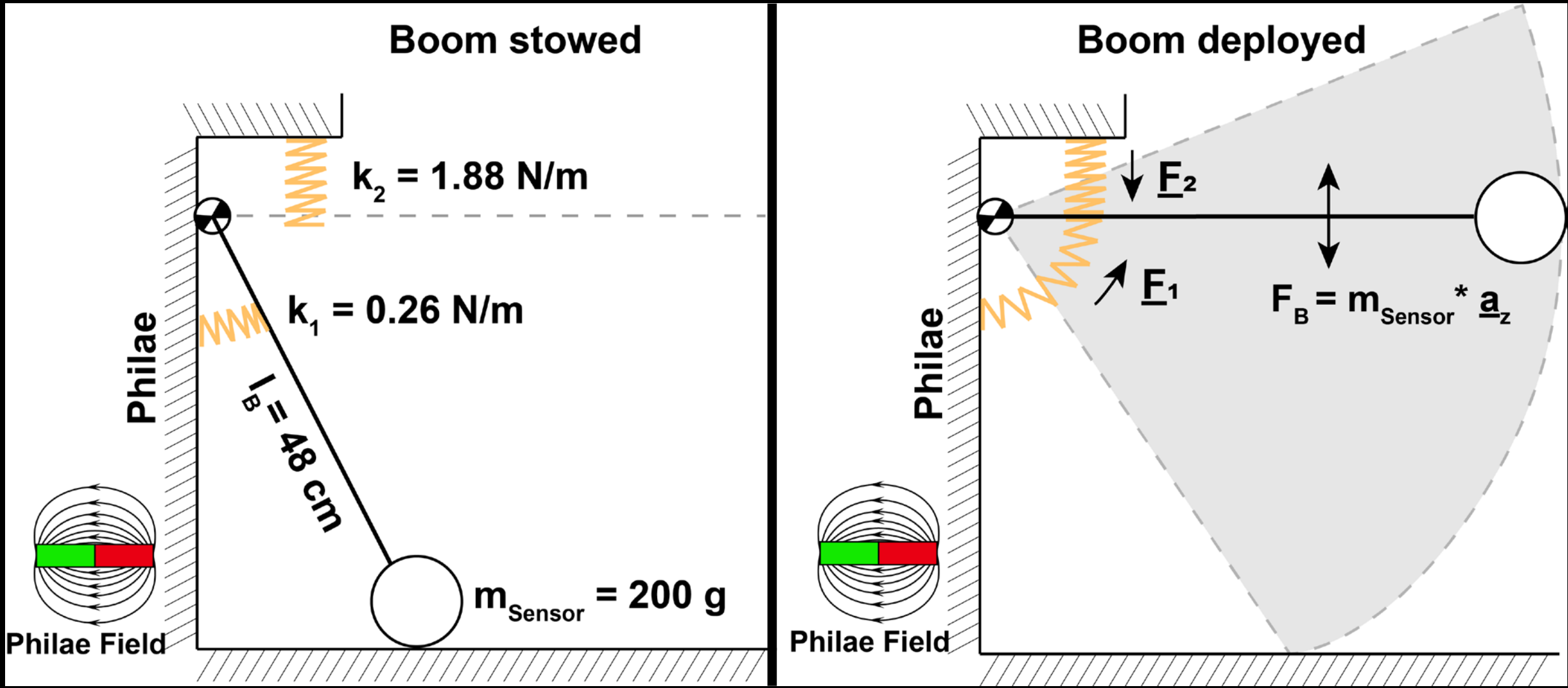
- Acceleration during contact
- Flight dynamics
- Timing

OSIRIS/CONSERT:

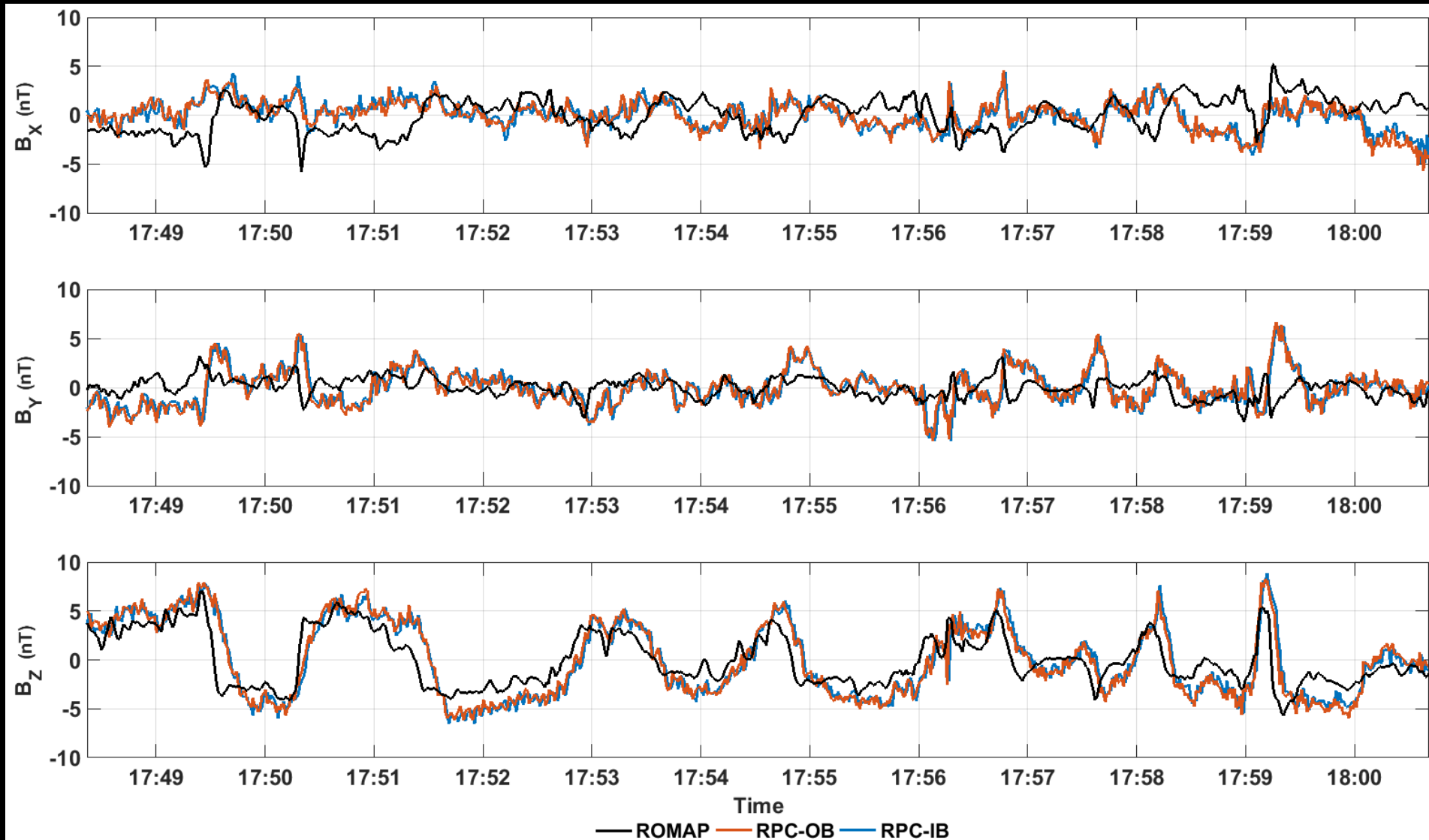
- Contact positions



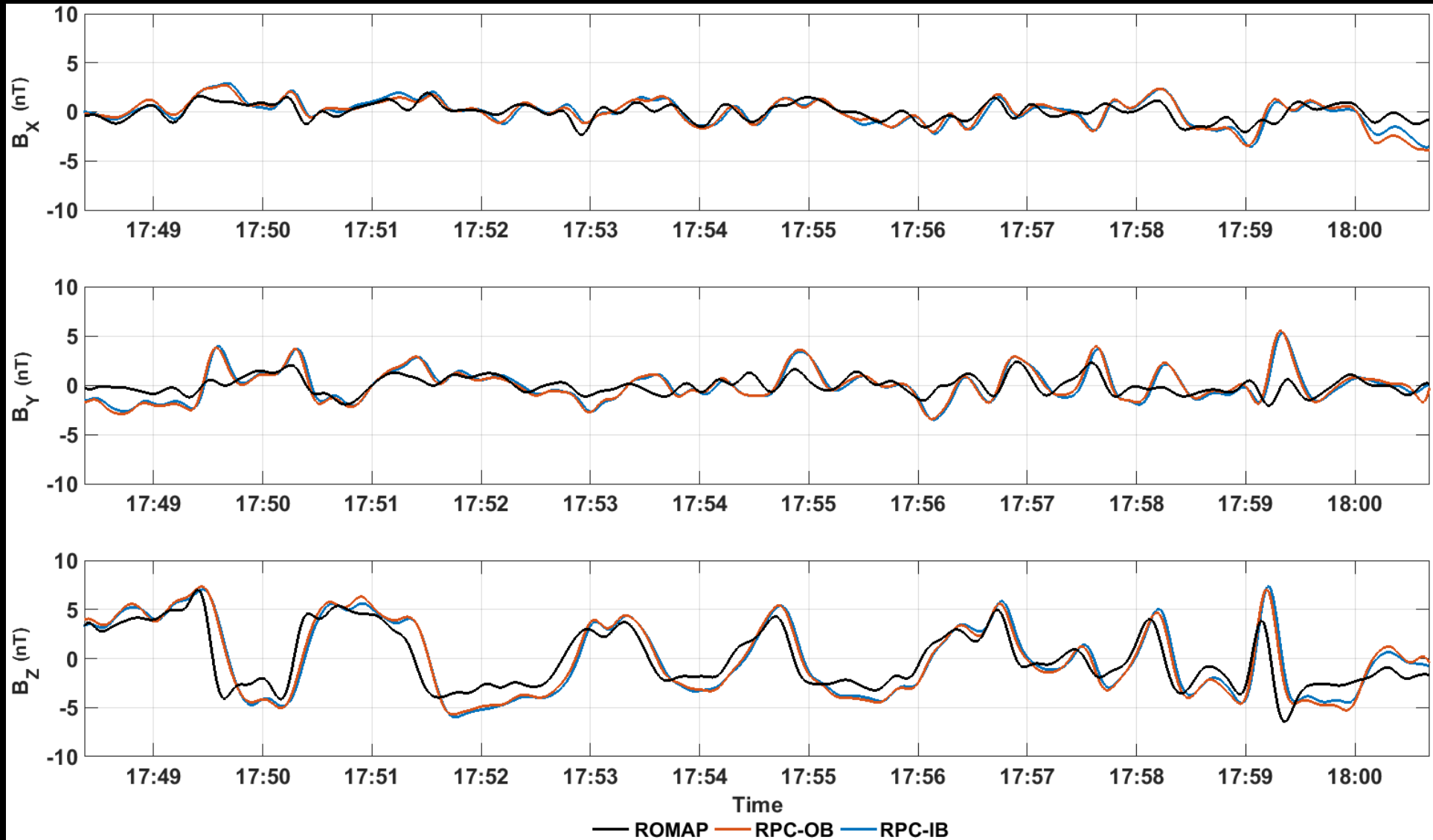
Magnetometer as Accelerometer



Magnetometer for Flight Dynamics



Magnetometer for Flight Dynamics



Touchdown Dynamics

Calculate contact pressure based on energy/work/momentum:

$$p_c = \frac{\Delta E}{A s_c} = \frac{\Delta E}{A v(t) t_c}$$

ΔE : energy lost during contact

A : area of contact

s_c : penetration depth

$v(t)$: velocity during contact (assume $v(t) = v_i/2$)

t_c : contact time (known from MAG data)





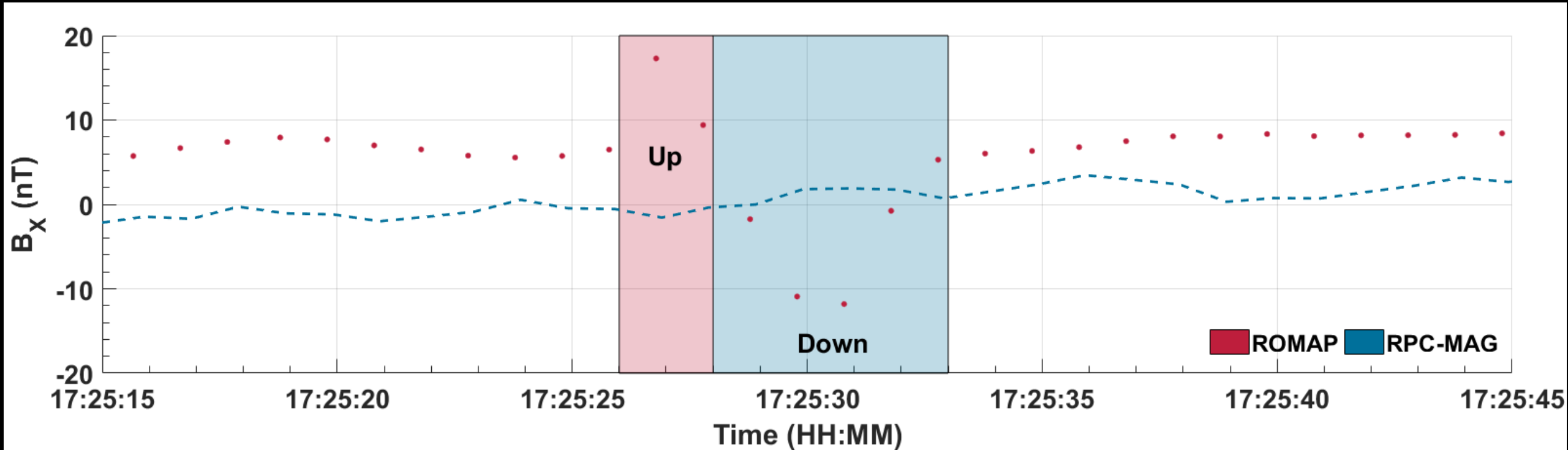
Collision Event 16:20 UTC

- Contact with +X foot (no z-acceleration)
- Contact area $\approx 0.04 \text{ m}^2$
- Contact time $\approx 2 \text{ s}$
- Energy lost $\approx 1.1 \text{ J}$
- CoR ≈ 0.88

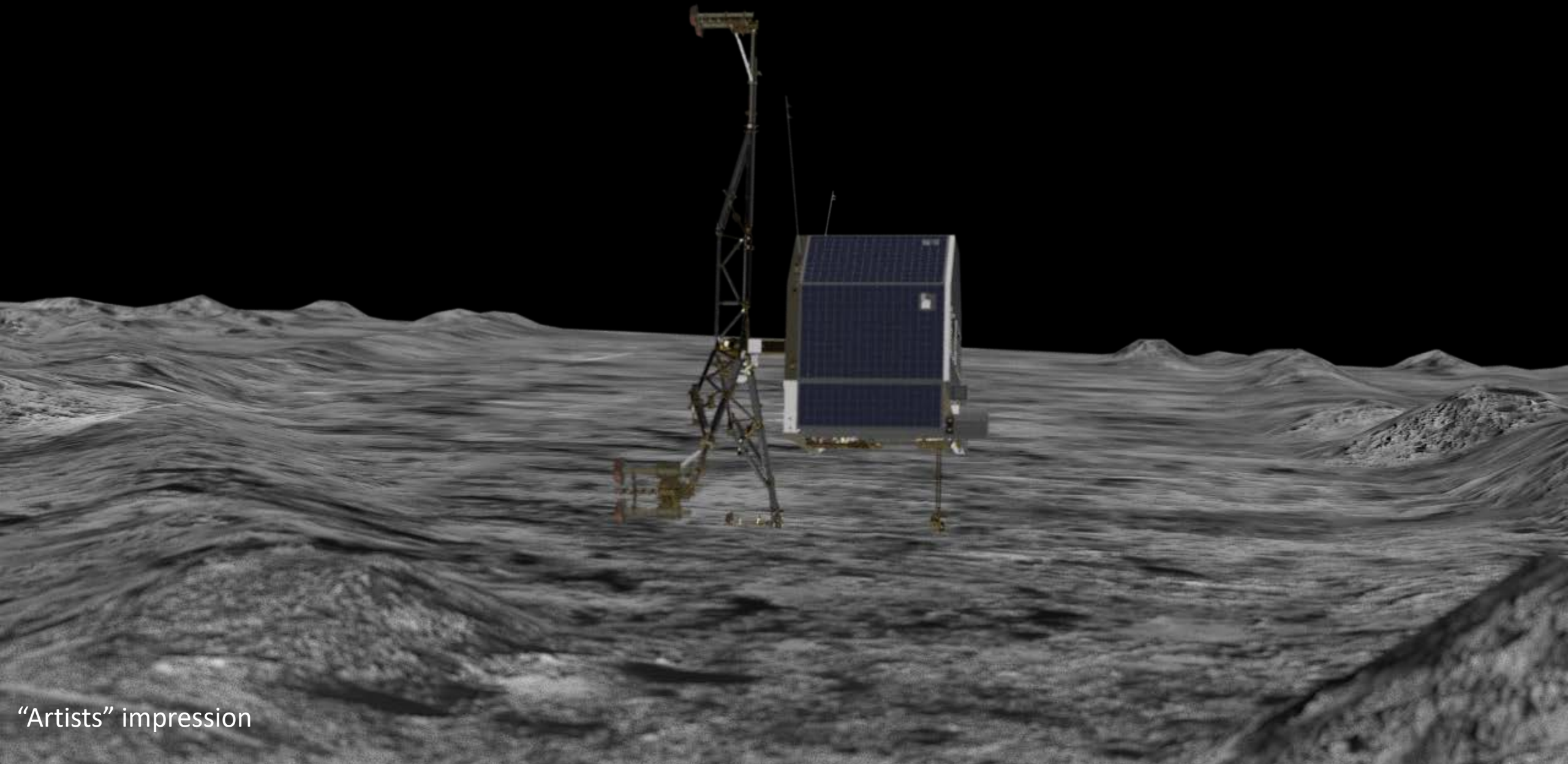
-> Contact pressure: $\approx 100 \text{ Pa}$ (compressive)



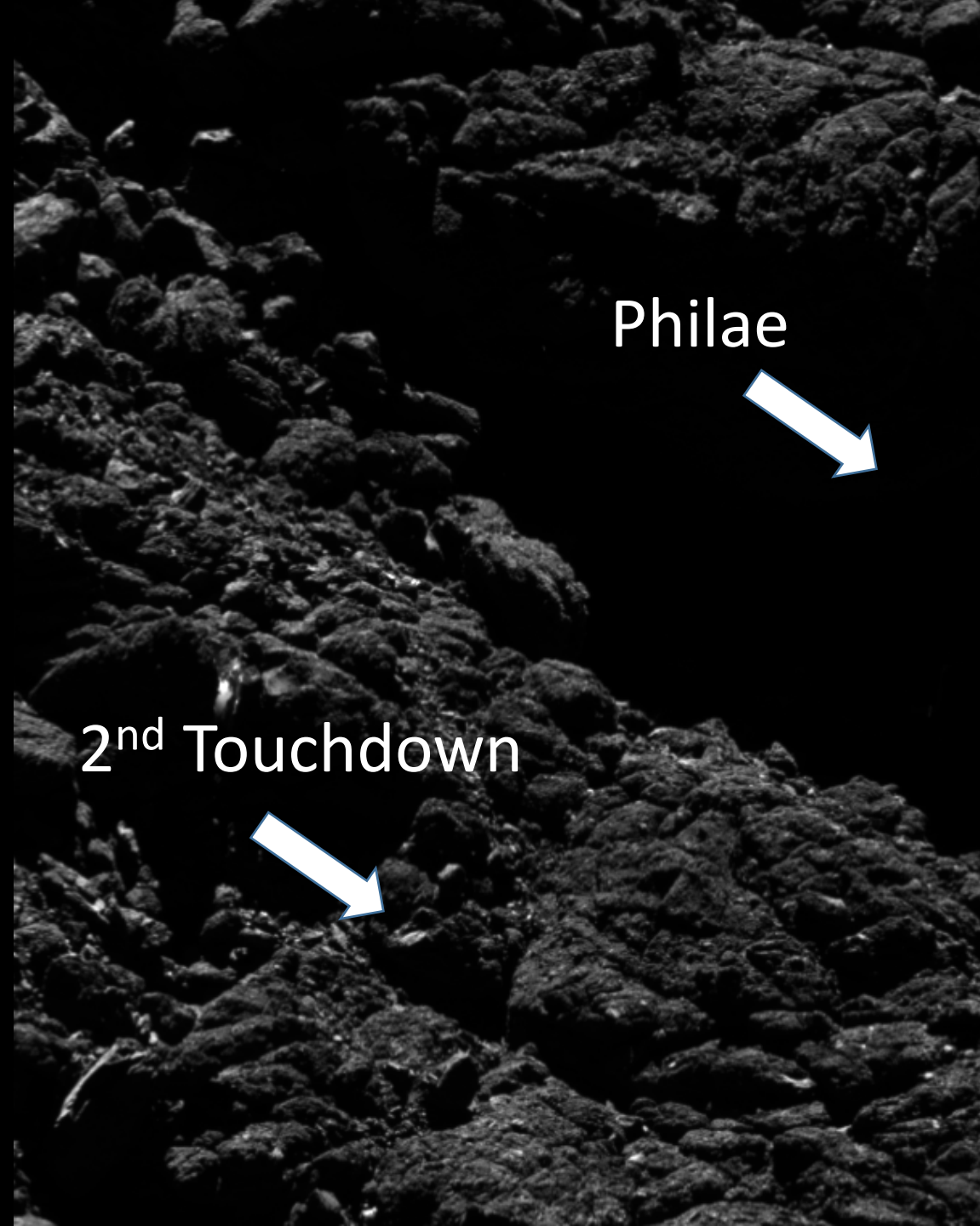
2nd Touchdown 17:25 UTC



2nd Touchdown 17:25 UTC

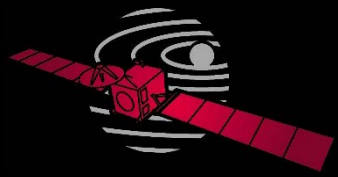


“Artists” impression



Philae

2nd Touchdown



2nd Touchdown 17:25 UTC

- Contact with feet and boom
 - Contact area $\approx 0.08 \text{ m}^2 - 0.20 \text{ m}^2$
 - Contact velocity $\approx 0.25 \text{ m/s}$
 - CoR ≈ 0.44
 - Energy lost $\approx 3 \text{ J}$
- > Contact pressure: $\approx 80 \text{ Pa}$ (compressive)



3rd Touchdown 17:31 UTC



Philae found on
3 OSIRIS NAC images



3rd Touchdown 17:31 UTC

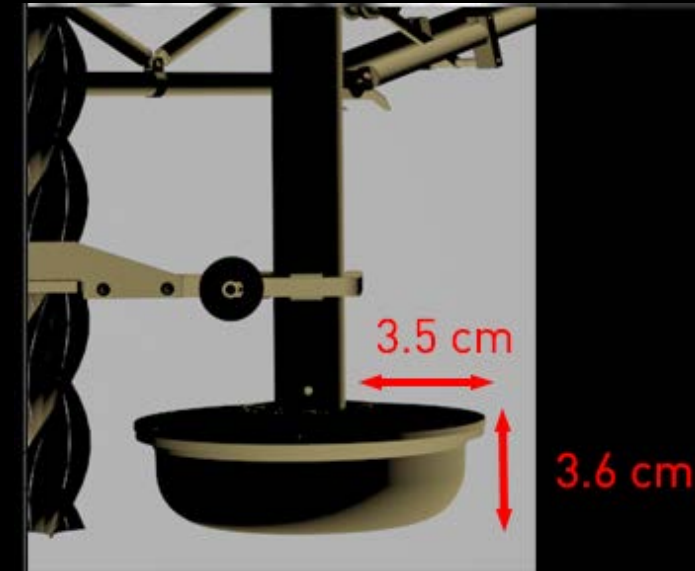
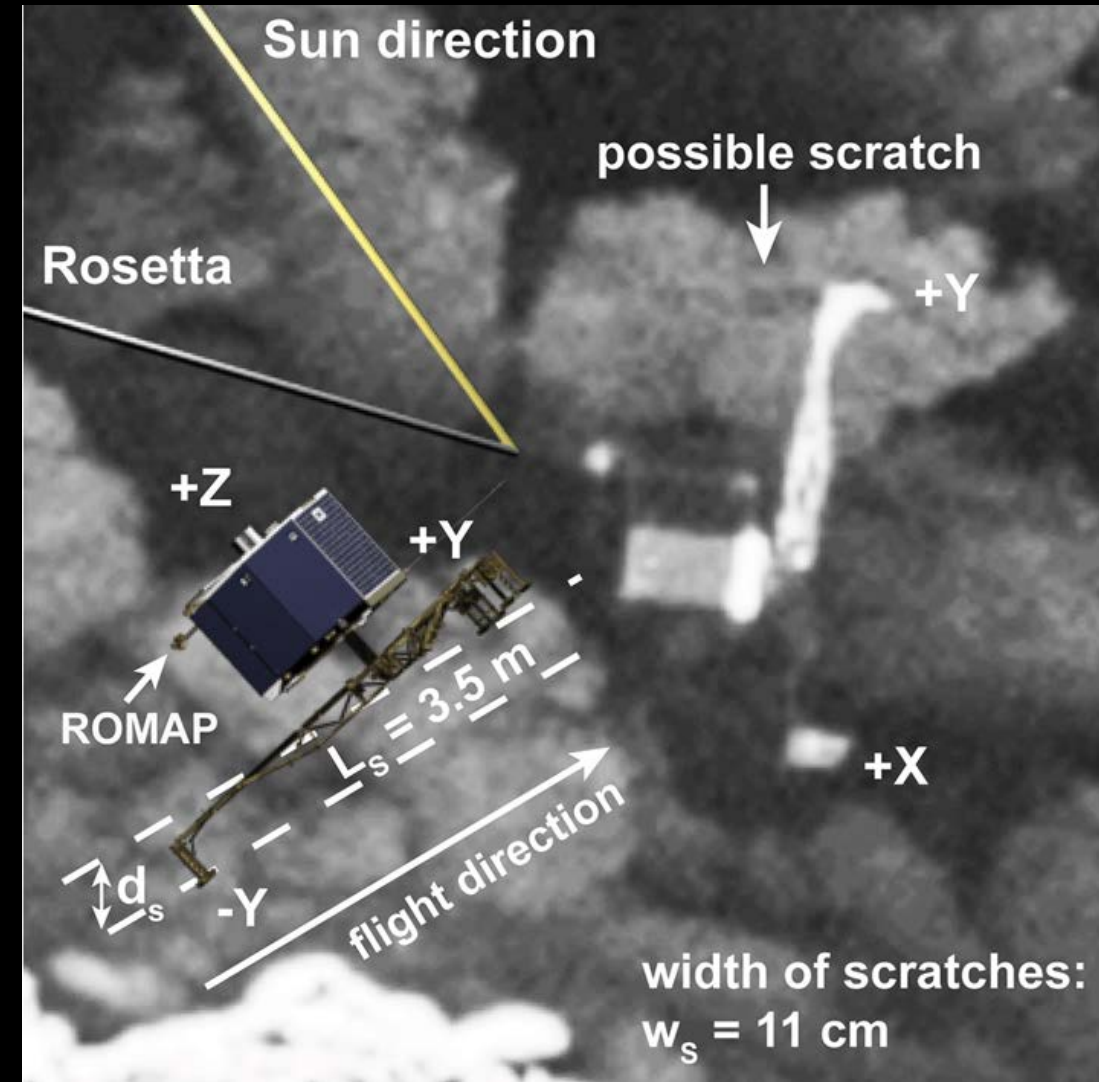


Two parallel “scratches”
visible on all images in
front of Philae



3rd Touchdown 17:31 UTC

- Contact with two soles (0.003 m^2)
- approx. 0.6 J lost between TD2 & TD3
- > Contact pressure per sole: 15 Pa
- > Shear / Compressive strength?



Conclusion

- MAG data and OSIRIS images allowed flight reconstruction
- TD dynamics based on MAG data
 - > Determination of energy balance & contact forces
- Collision: 100 Pa
- Touchdown 2: 80 Pa
- Scratches: 15 Pa

-> Aggregates?

