

Simulating meteorite impacts - an outdoor field experiment

Part 1



Felix, Uroš en Dušan Bettonvil
IMC 2018 Slovakia

Meteor and meteorite research in The Netherlands can be characterised by its diversity. While many meteor observers are involved in high-tech observations, using all-sky cameras or automated CAMS systems, others are involved in computational aspects of orbits, dark flights and strewn fields; the study meteorites; or just enjoy themselves observing meteors with the unaided eye. Meteoritics in The Netherlands is a flourishing enterprise with dozens of active amateurs and professionals.





BINGO!



HHEBBES!



ASSN- NOVA Fireball patrol camera Dwingeloo
2017:09:21 19:00:00 UT ISO4000 20 cycl/sec 87"

Fireball EN 11032015
11 March 2015 00:00:14 UT

Gaasterland 2015



Computations Marco Langbroek / Felix Bettonvil





Computations Pavel Spurny

Hoenderloo 2013

Background photo Peter van Leute



Gaasterland 2015

Onderzoek naar een mogelijke meteorietval in Friesland

In deze folder willen wij u informeren over een veldonderzoek naar een mogelijke meteorietval in uw omgeving, en u om uw medewerking vragen bij dit onderzoek.

Vrijwilligers van het Nat. Natuurhist. Museum Naturalis, de Universiteit Leiden, NOVA-ASTRON, de Dutch Meteor Society en de KNVWS Werkgroep Meteoren zoeken onder onze leiding in uw omgeving de komende tijd naar de neergekomen brokstukken van een meteoriet.

Voor dit onderzoek vragen wij u om toestemming om met een klein zoekteam uw grond te betreden.

Uiteraard zullen wij daarbij voorzichtig en zonder overlast of schade te veroorzaken te werk gaan.

Wij hopen dat u uw medewerking wilt verlenen aan dit onderzoek. Voor vragen kunt u terecht bij onderstaande personen.

Alvast uw dank!

contact:

- Dr Marco Langbroek

Naturalis Biodiversity Center, Leiden, afdeling geologie
e-mail: marco.langbroek@naturalis.nl
tel: 06-13426037

- Ir Felix Bettonvil

Sterrenwacht Leiden en NOVA-ASTRON, Dwingeloo
e-mail: F.C.M.Bettonvil@strw.leidenuniv.nl
tel: 06-51491504



Achtergronden

Tijdens de nacht van 10 op 11 maart 2015 rond 01:00 Ned. tijd hebben zeven automatische onderzoeks-camera's een zeer heldere meteor (vuurbol) boven het noordwesten van Nederland gefotografeerd.

Het betrof een klein fragment (een steenbrok) van een planetoïde welke vanuit de ruimte de dampkring binnendrong.

Zoekgebied

Kleine restanten ervan (meteorieten) hebben waarschijnlijk het aardoppervlak bereikt, en kunnen zijn neergekomen in het gebied rond Mirnsum - Oudemirdum.

Doele

Het doel van de zoektocht is het bergen van de neergekomen meteoriet ten behoeve van wetenschappelijk onderzoek op het Nationaal Natuurhistorisch Museum Naturalis in Leiden en andere gerelateerde instituten.

Iets gehoord/gezien?

Behalve door het verlenen van betredings-toestemming, kunt u ons misschien ook helpen met informatie.

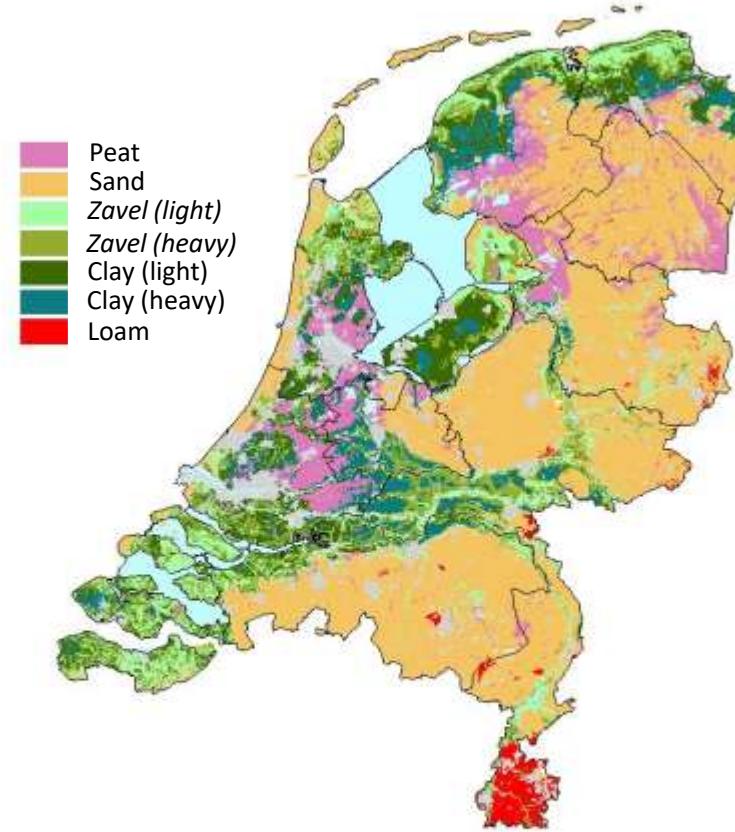
- Heeft u rond 11 maart 's nachts iets vreemds gehoord (knallen, sulzende geluiden)?**
- Heeft u in de periode er na op uw land iets vreemds gezien, bijvoorbeeld aanwijzingen dat iets met grote kracht is neergekomen, of vreemde stenen?**





What to expect?

NETHERLANDS





Sand



Loam

Clay



Peat

Archive – how looks a meteorite ‘crater’?

Meteorite	Year	Penetration Depth	Details
Uden	1840	sand	?
Utrecht	1843	clay layer, sand	75 cm 7 kg
Ellemeet	1925	Meadow, clay?	~0.5 m / 40 cm 0,97 kg & 0.5kg
Diepenveen	1873	sand	40 cm
Glanerbrug	1990	roof	-
Broek in Waterland	2017	roof / peat moor?	-

Can we simulate an impact?

Impact velocities

Fireballs and Meteorite Falls

Only a very few fireballs are connected with meteorite falls. A meteorite may survive its atmospheric flight and may perhaps then be found if at least part of the body is decelerated from its entry velocity down to its free-fall terminal velocity of **about 100 m/s**. According to the models in use (see Wetherill and ReVelle (1981) and references therein) and using the ablation coefficient derived from the Pribram, Lost City and Innisfree falls, less than 50% of the remaining mass will be ablated as soon as the velocity falls below 8 km/s.

Another destructive process which may operate against the fall of a meteorite is fragmentation of the meteoroid. The peak pressures these bodies can stand as derived from large bodies such as the recovered meteorites were found to be about 10^6 N/m^2 . This is much less than the crusting stress of about 10^{10} N/m^2 found in laboratory measurements. The reason may be in the earlier history of the meteorite parent bodies. Observed, a very large

100 m/s

when they reach the ground?

Meteoroids enter the earth's atmosphere at very high speeds, ranging from 11 km/sec to 72 km/sec (25,000 mph to 160,000 mph). However, similar to firing a bullet into water, the meteoroid will rapidly decelerate as it penetrates into increasingly denser portions of the atmosphere. This is especially true in the lower layers, since 90 % of the earth's atmospheric mass lies below 12 km (7 miles / 39,000 ft) of height.

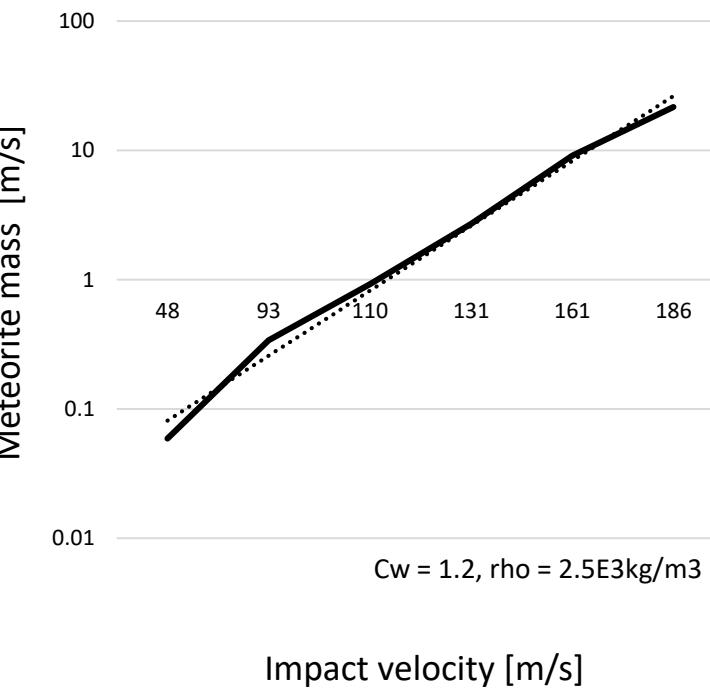
At the same time, the meteoroid will also rapidly lose mass due to ablation. In this process, the outer layer of the meteoroid is continuously vaporized and stripped away due to high speed collision with air molecules. Particles from dust size to a few kilograms mass are usually completely consumed in the atmosphere.

Due to atmospheric drag, most meteorites, ranging from a few kilograms up to about 8 tons (7,000 kg), will lose all of their cosmic velocity while still several miles up. At that point, called the retardation point, the meteorite begins to accelerate again, under the influence of the Earth's gravity, at the familiar 9.8 meters per second squared. The meteorite then quickly reaches its terminal velocity of 200 to 400 miles per hour (90 to 180 meters per second). The terminal velocity occurs at the point where the acceleration due to gravity is exactly offset by the deceleration due to atmospheric drag.

Meteoroids of more than about 10 tons (9,000 kg) will retain

90 – 180 m/s

Gravitational acceleration / Drag Equilibrium

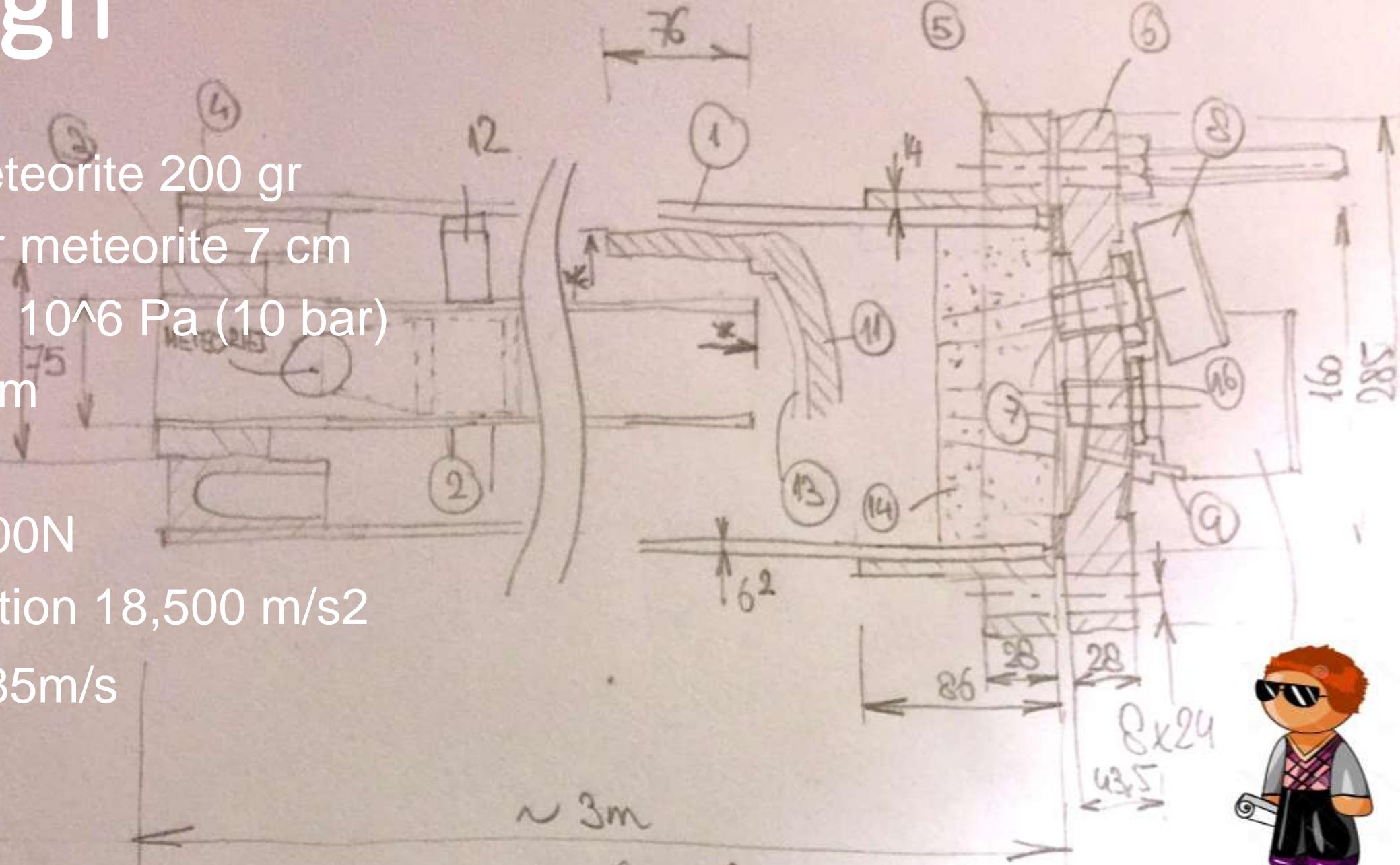




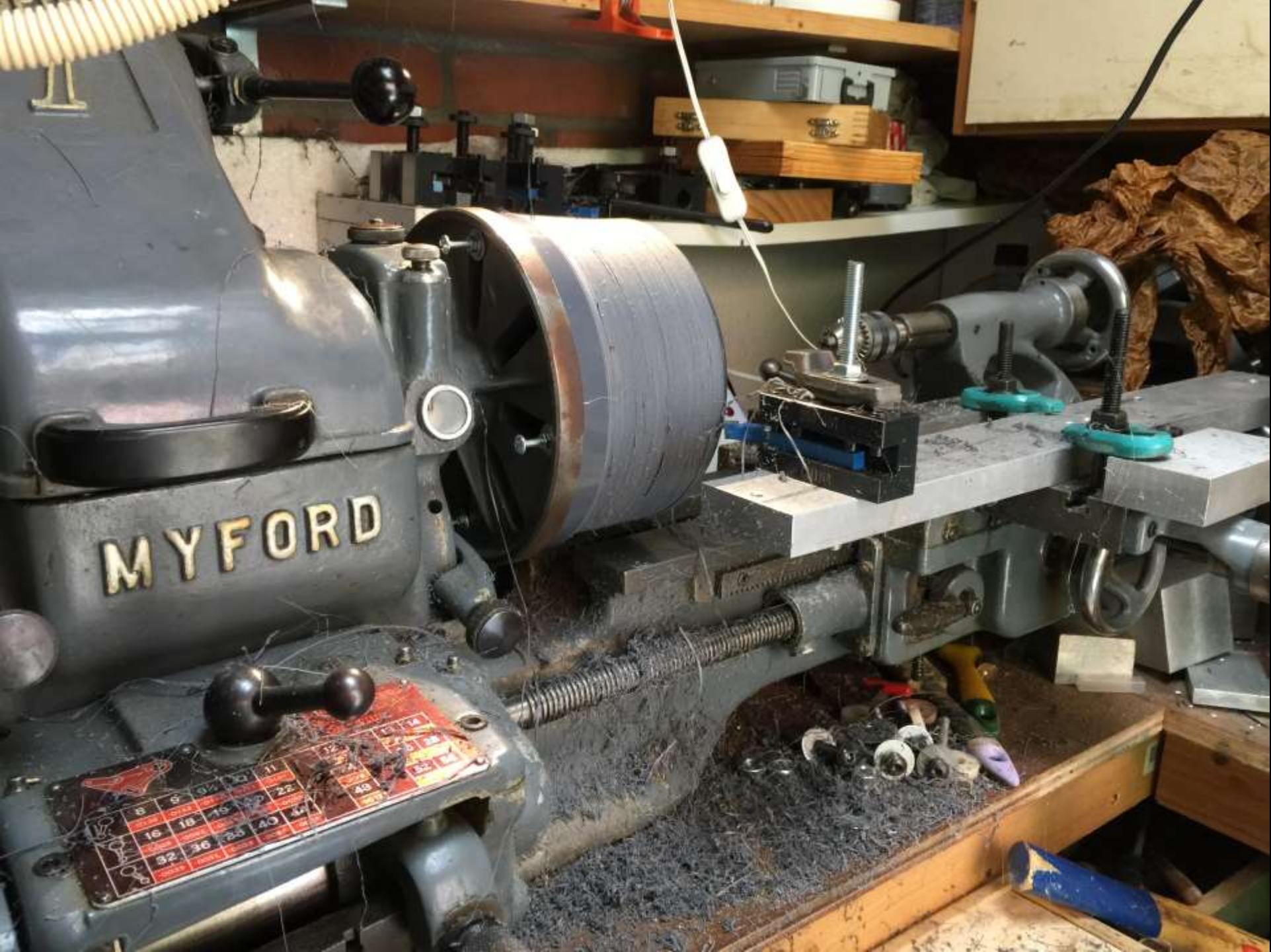


Design

- ✓ Mass meteorite 200 gr
 - ✓ Diameter meteorite 7 cm
 - ✓ Pressure 10^6 Pa (10 bar)
 - ✓ Length 3m
- Trust 3700N
- Acceleration 18,500 m/s²
- $V_{exit} = 185\text{m/s}$



Meteorite mass	Pressure 0.2MPa	Pressure 1MPa
65gr	188 m/s	421 m/s
200gr	107 m/s	240 m/s
500gr	68 m/s	150 m/s









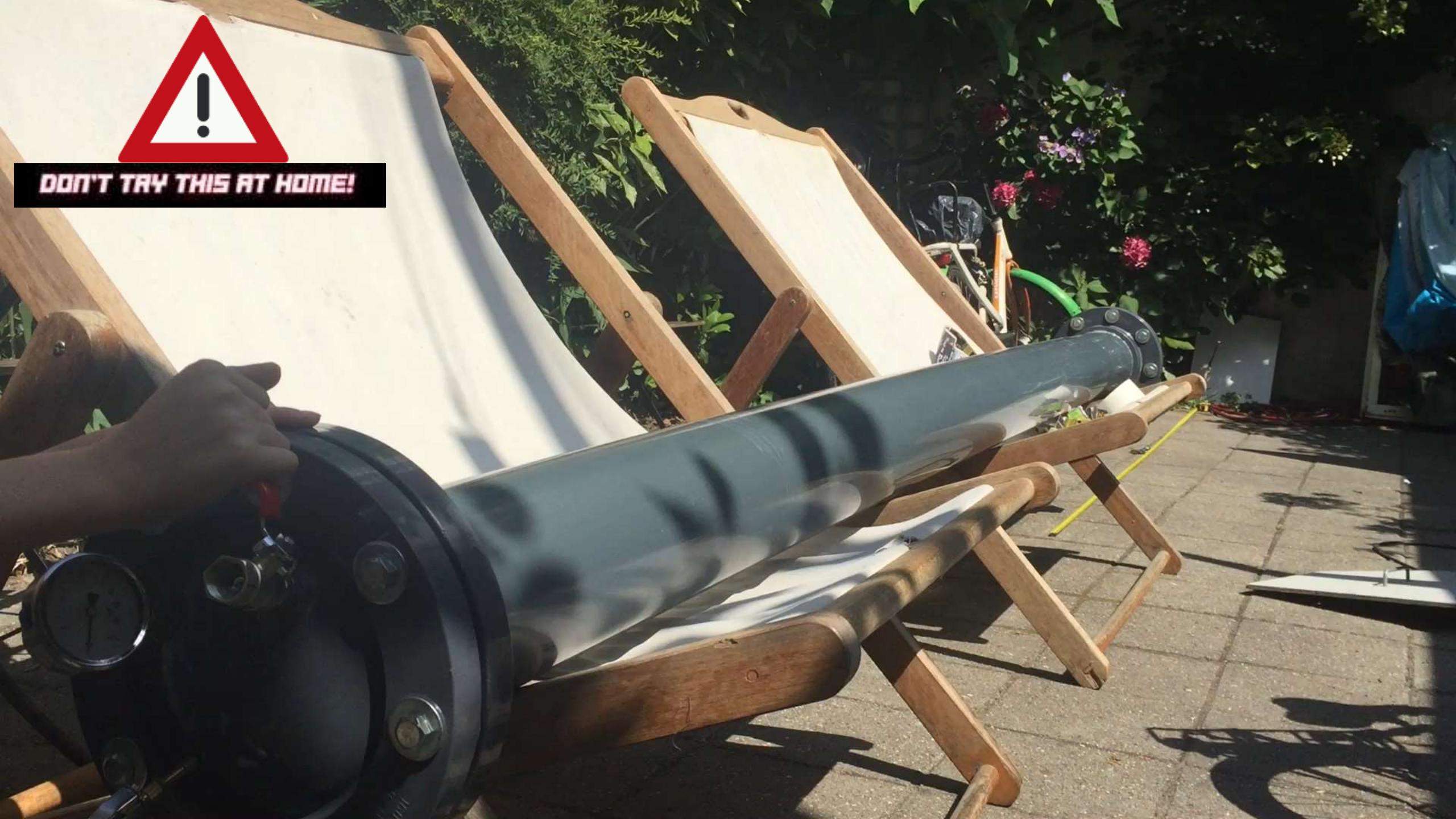
De nieuwe
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be



DON'T TRY THIS AT HOME!



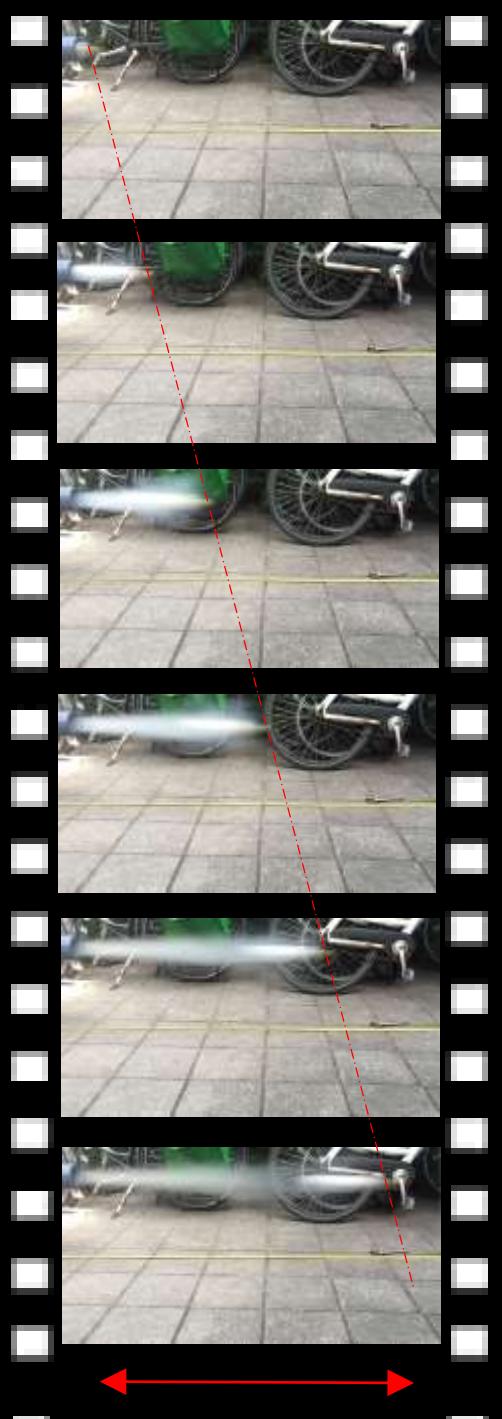




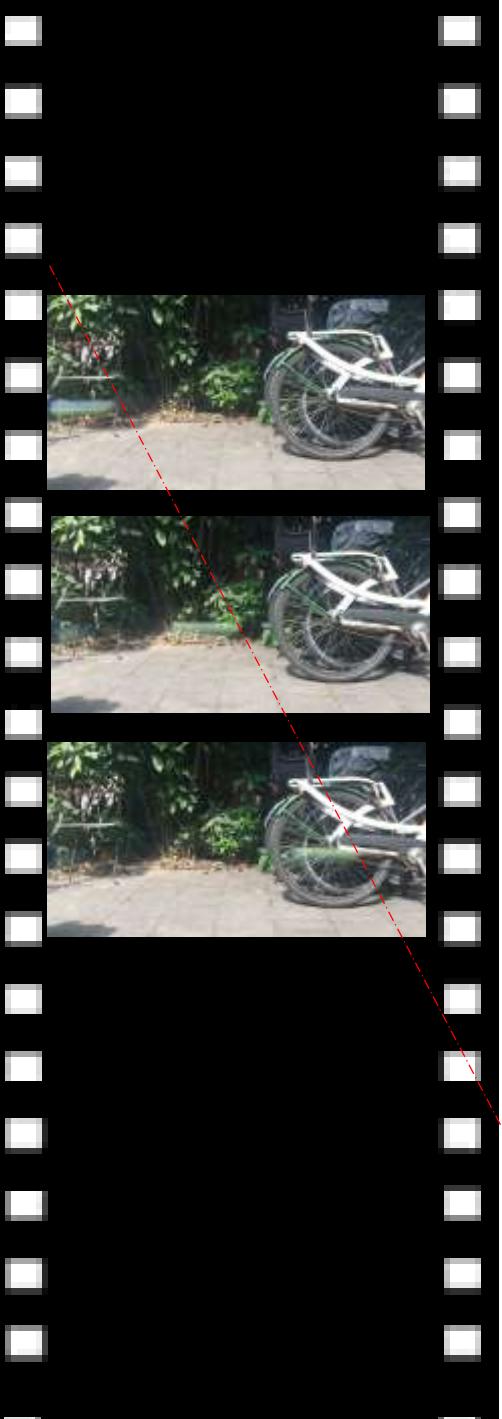




150cm in 5 frames @ 240 fps = **72 m/s**



120cm in 2 frames @ 240fps= ms = **144 m/s**



Results

size	Pressure	Design speed	Measured	Expected
65gr	2x10E5 Pa	188 m/s	144 m/s	60 m/s
500gr	2x10E5 Pa	68 m/s	72 m/s	80 m/s



Part 2

- Use the meteorite injector to simulate meteorite impacts
 1. at typical and different Dutch bottom types
 2. In different seasons
 3. Monitor the weathering process