

# **FOTOMETRIA DI METEORE NELL'AMBITO DEL PROGETTO "PRISMA"**

(prof. Nicola Rizzi)





switch di rete,  
trasferimento di  
dati con 8 porte



← Castellana Grotte (BA) ↗

nome

Castellana Grotte (BA)

Codice stazione

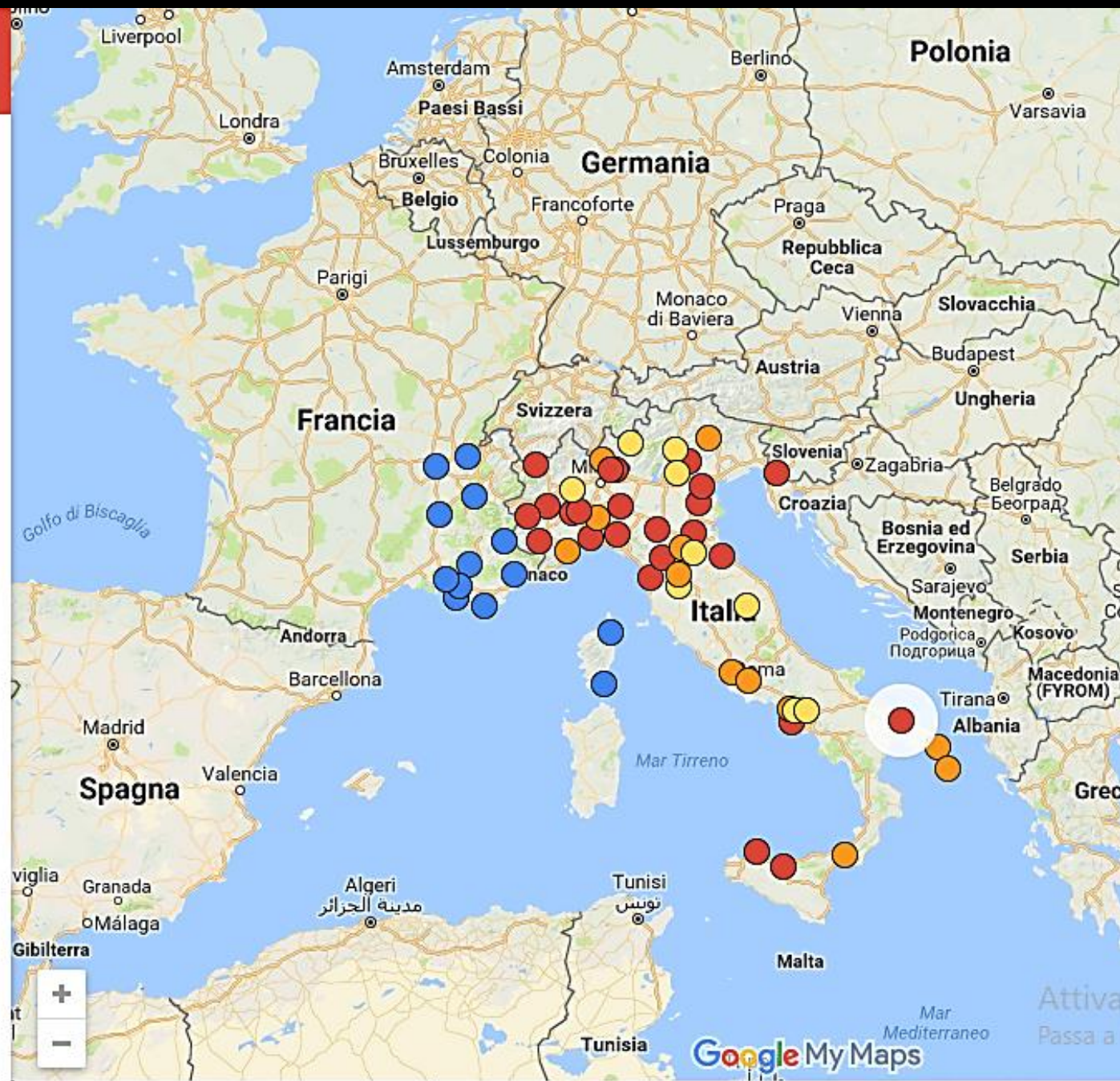
ITPU01

descrizione

Osservatorio Astronomico Sirio

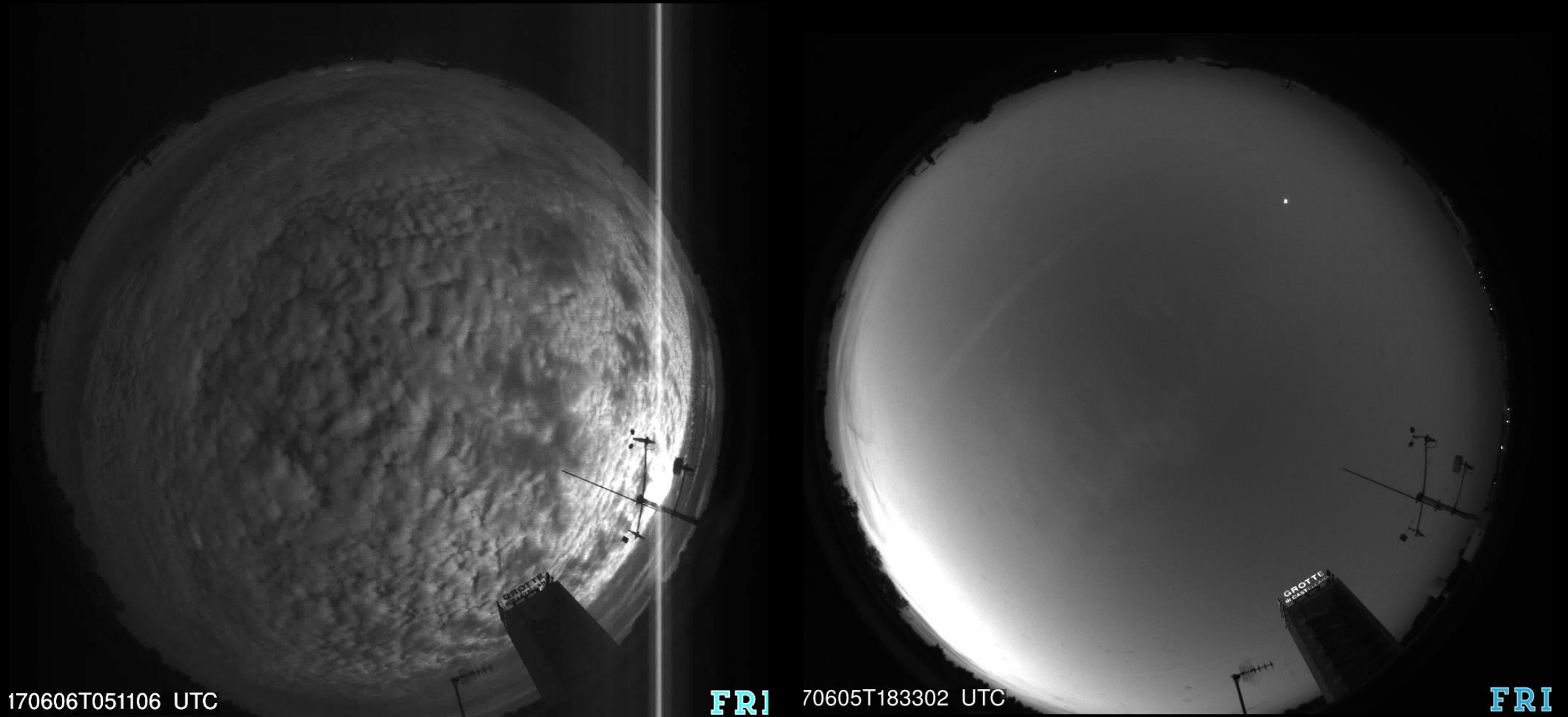
immagine corrente:

[https://www.fripon.org/IMG/jpg/stations/RT\\_ITPU01.jpg](https://www.fripon.org/IMG/jpg/stations/RT_ITPU01.jpg)



prima luce: 28 maggio 2017

[https://www.fripon.org/IMG/jpg/stations/RT\\_ITPU01.jpg](https://www.fripon.org/IMG/jpg/stations/RT_ITPU01.jpg)

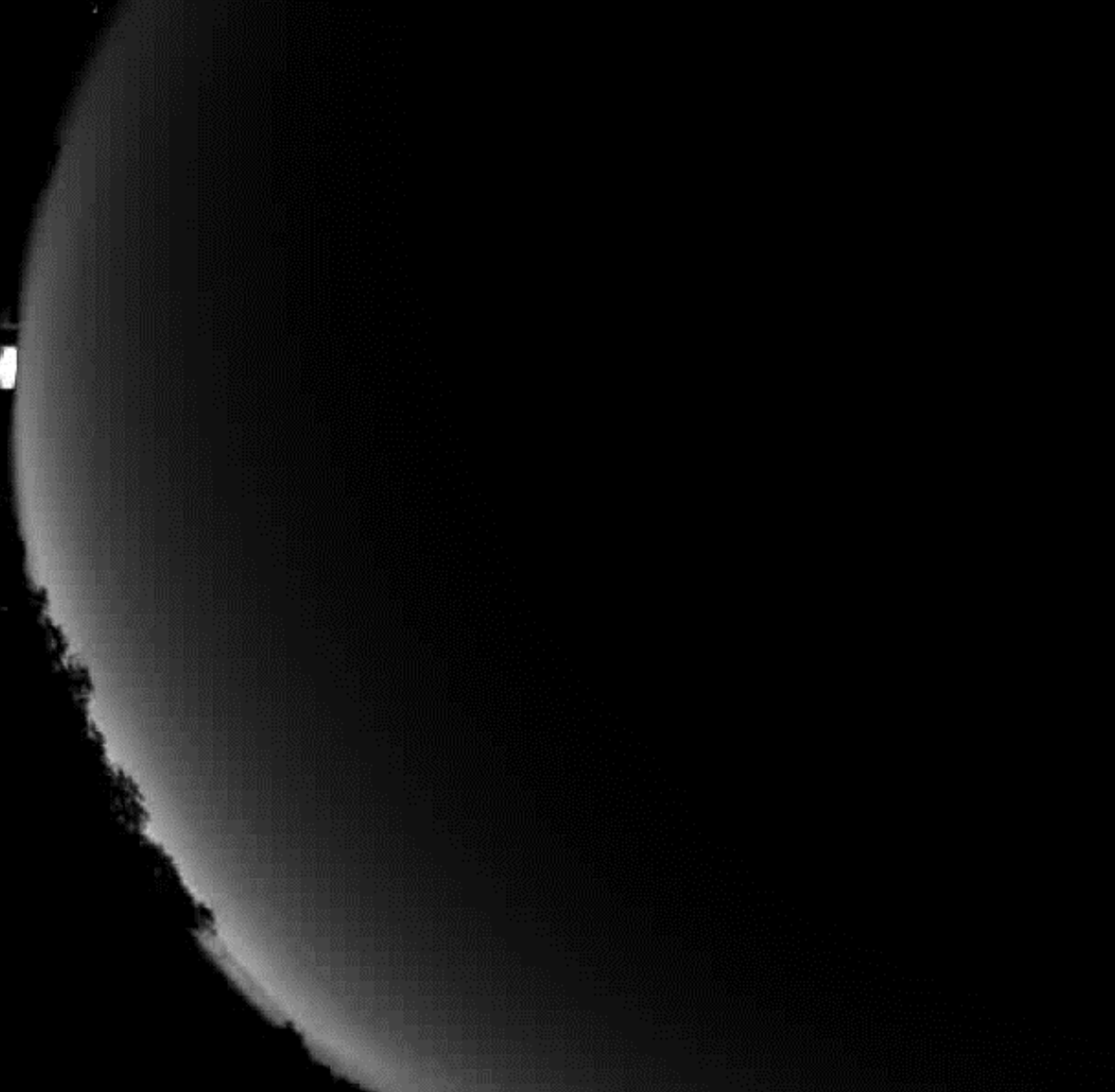


170606T051106 UTC

**FRI**

70605T183302 UTC

**FRI**

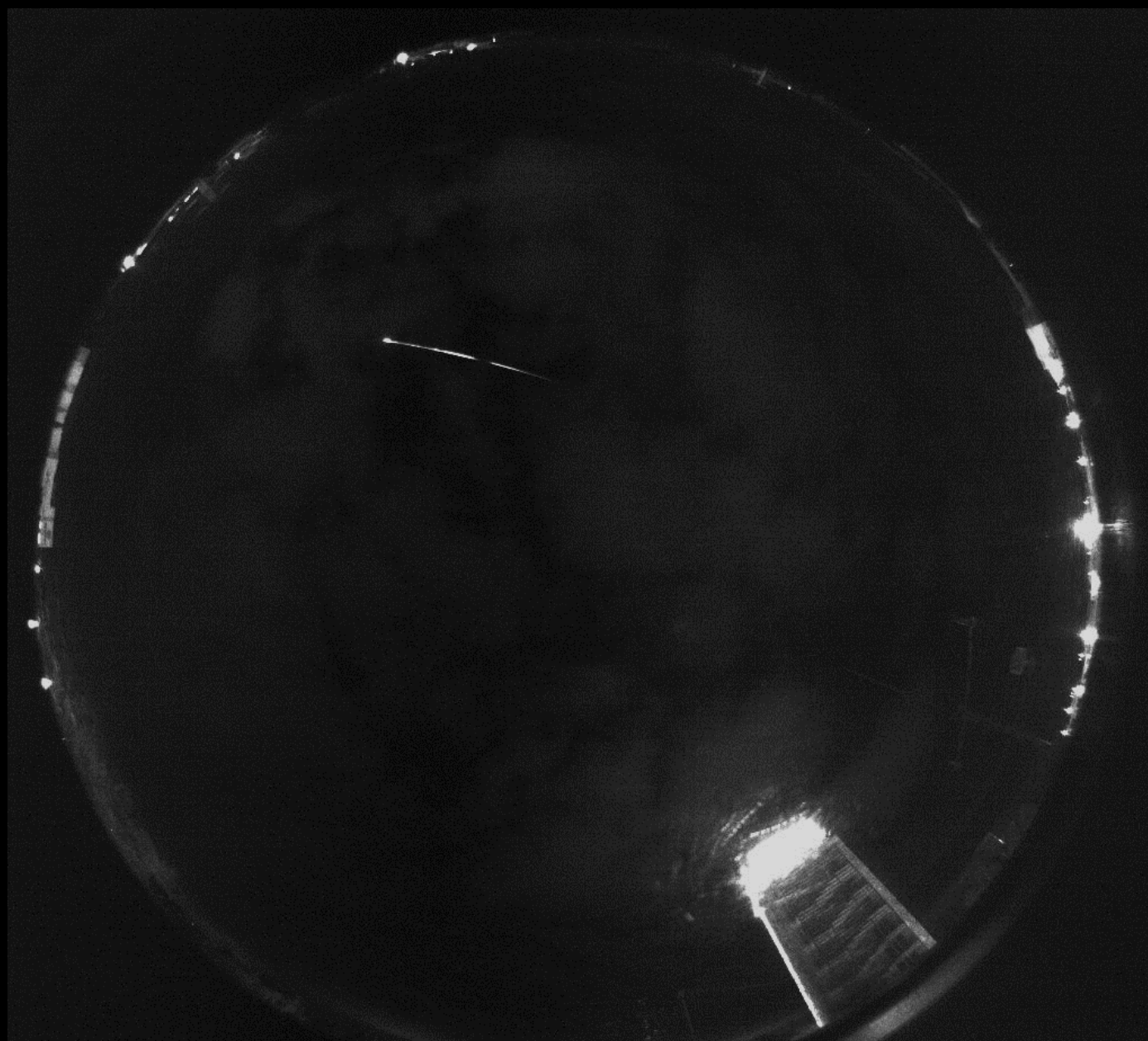
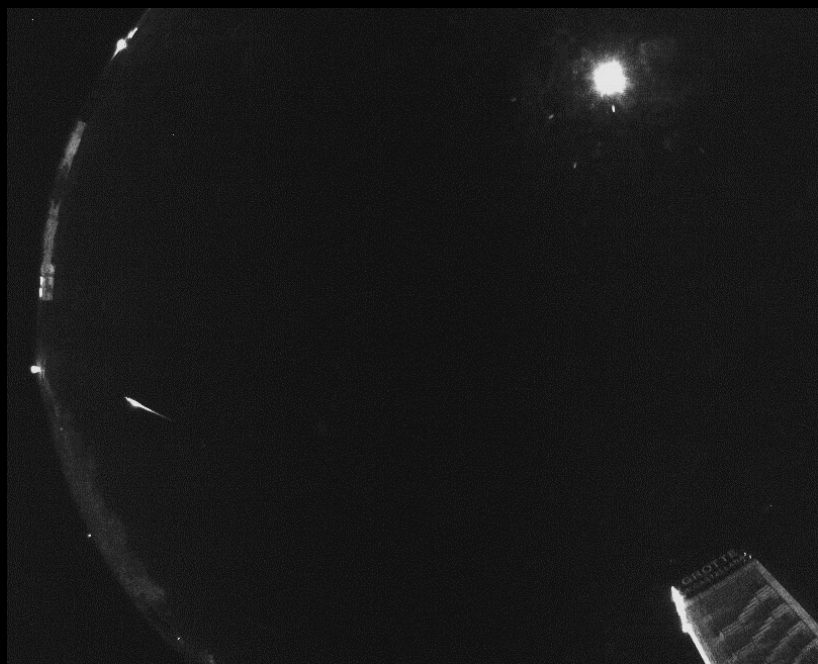


GROTTE  
di CASTELLANA











9.75 s



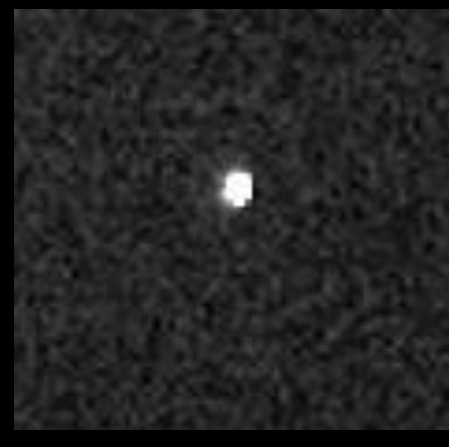
9.82 s



9.85 s



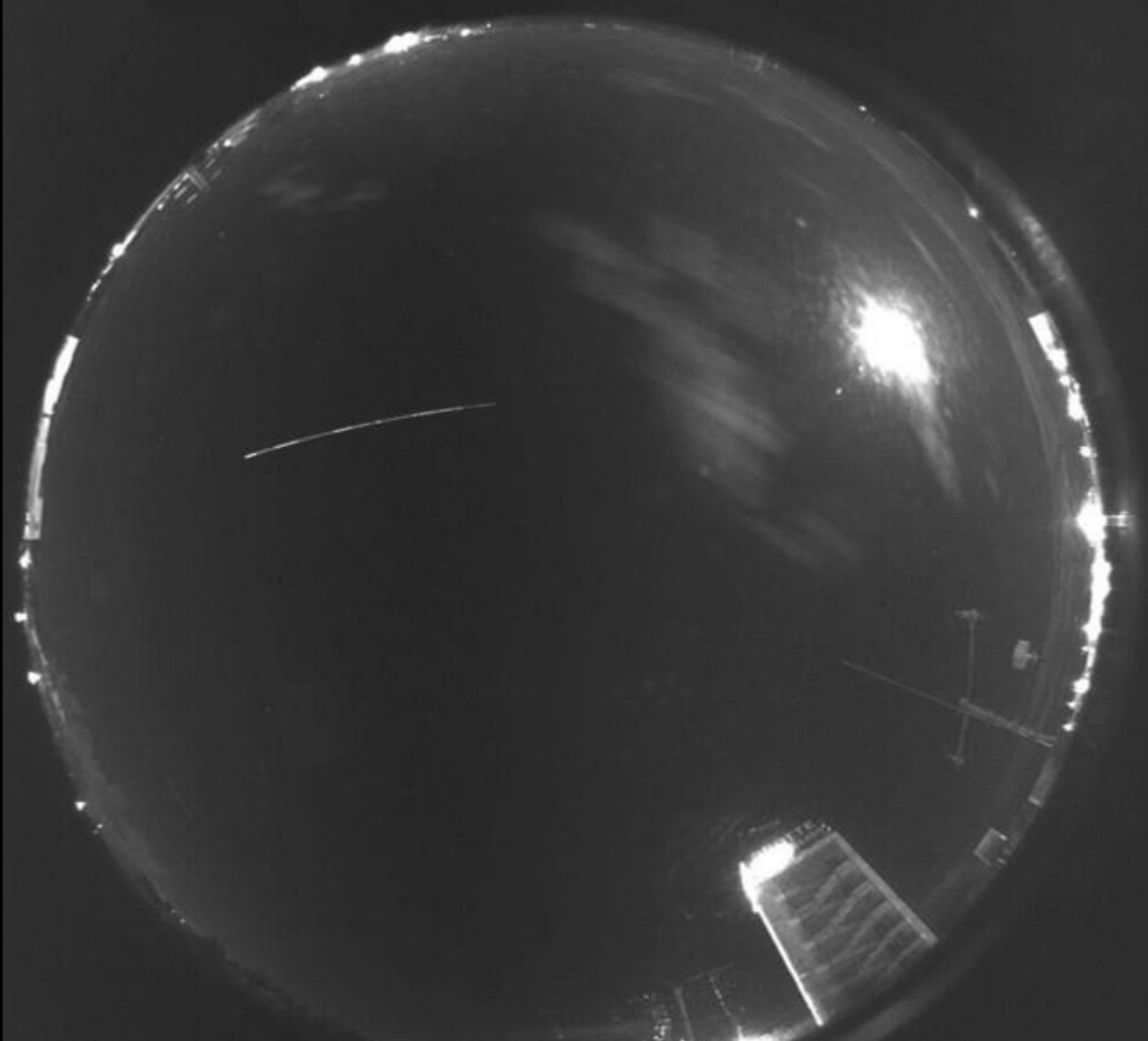
9.89 s



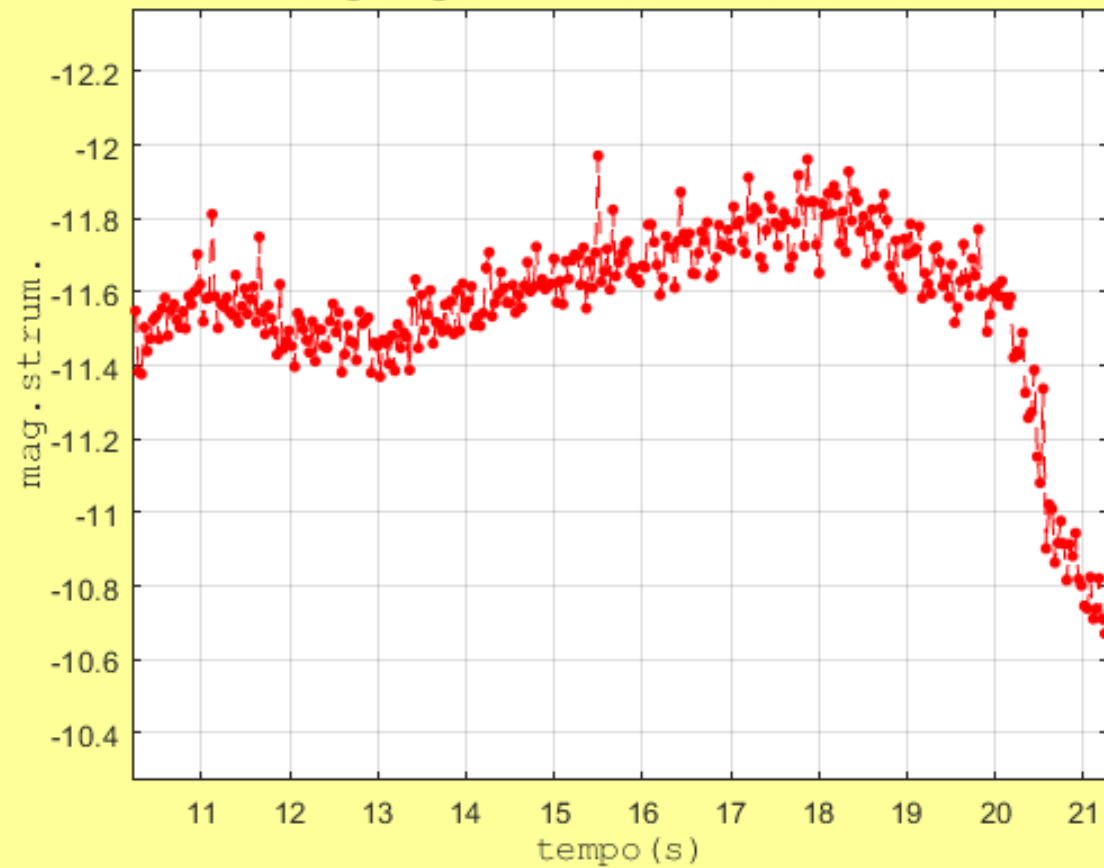
9.92 s

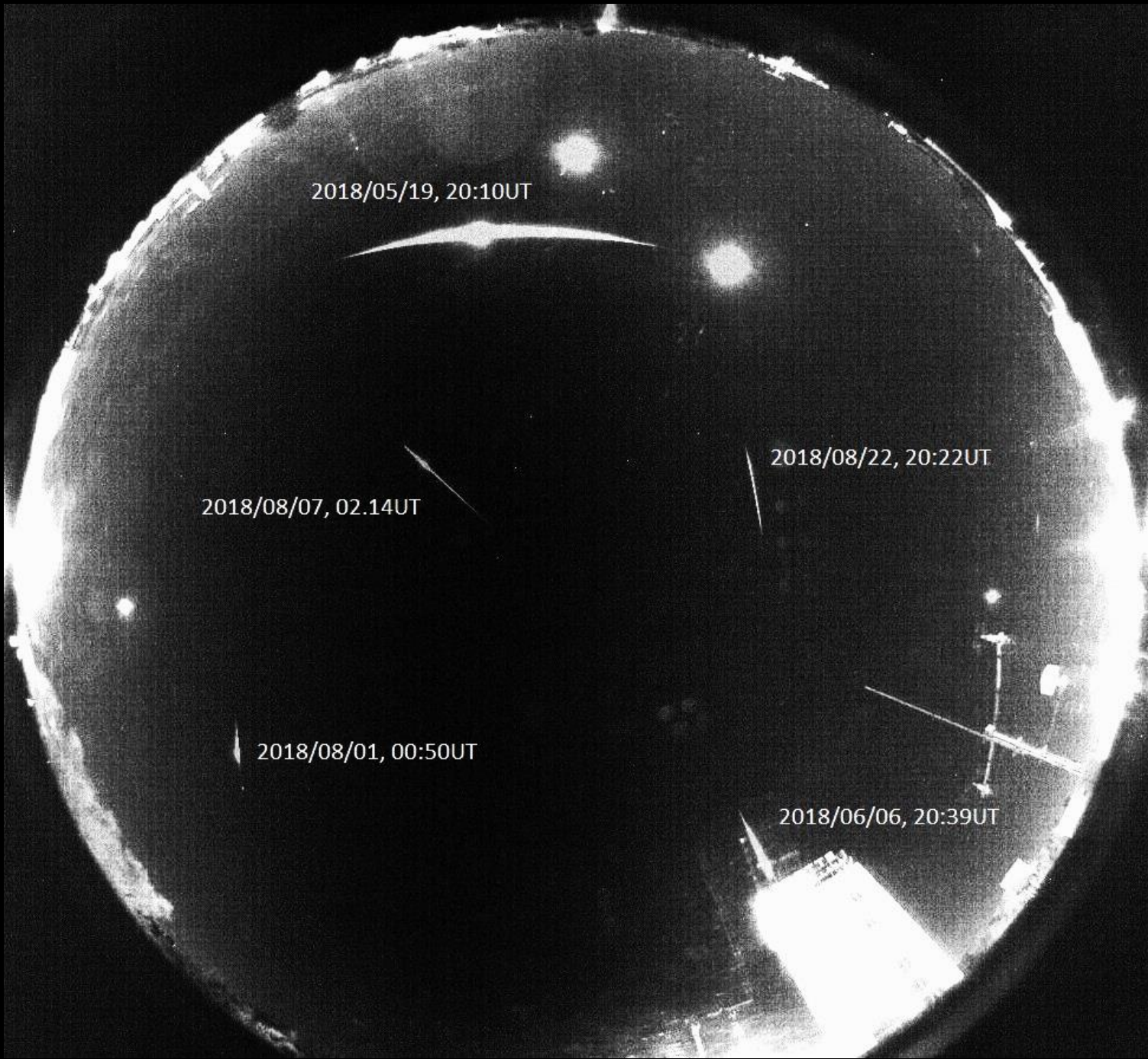


Castellanagrotte\_20180331\_202231UT



TiangGong1 2018/3/31, 20:22UT, Dt = 10.99s





2018/05/19, 20:10UT

2018/08/22, 20:22UT

2018/08/07, 02:14UT

2018/08/01, 00:50UT

2018/06/06, 20:39UT

# FOTOMETRIA DI METEORE

caratterizzare  
le LC

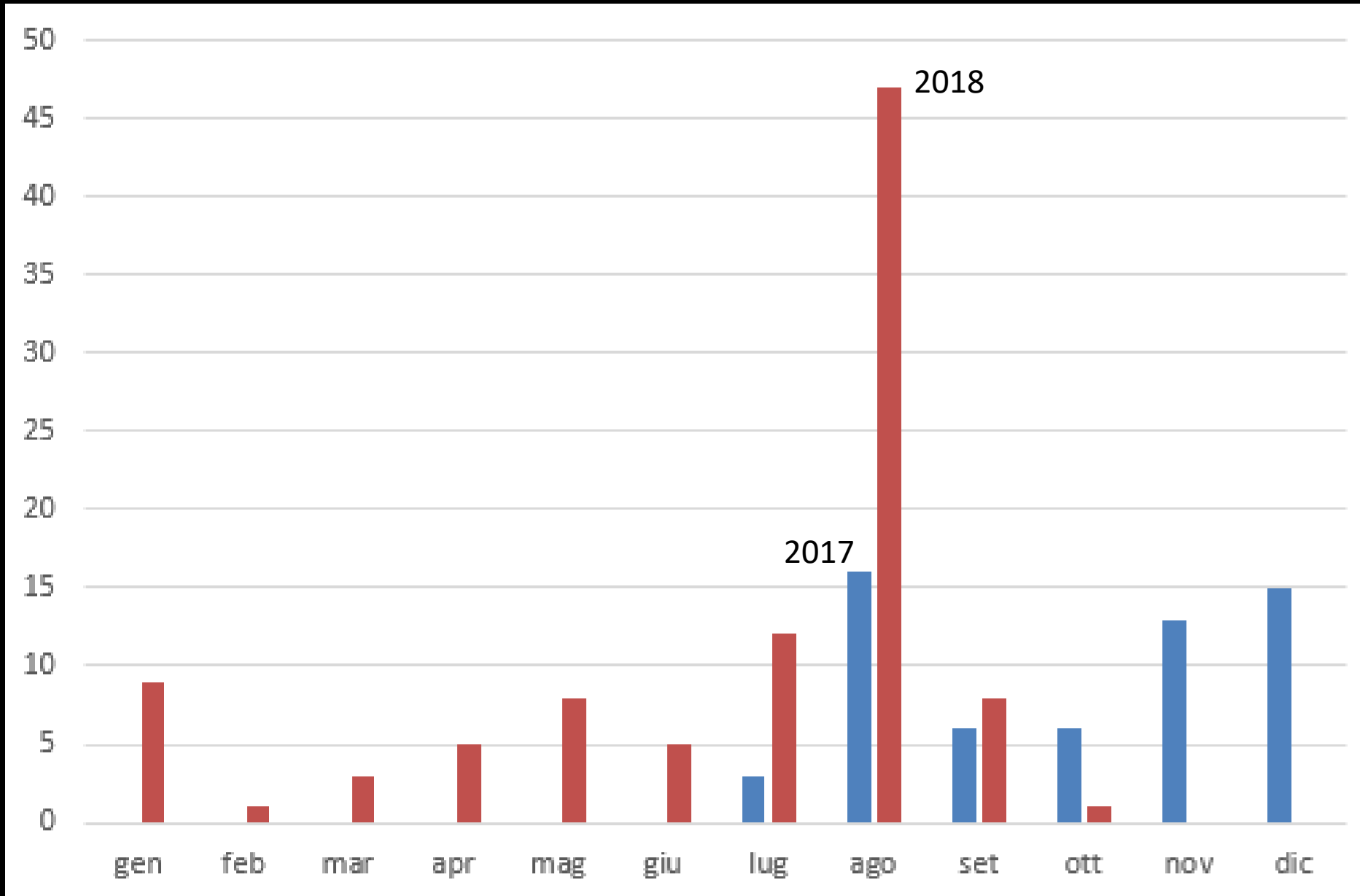
parametrizzare  
i vari sciami  
meteorici

determinare massa e  
dimensione dei meteoroidi  
(con ipotesi ad hoc e/o con  
triangolazione)

perfezionare i modelli di  
interazione dei  
meteoroidi con  
l'atmosfera



# 48 meteore (lug-dic)



Cometa	Periodo (anni)	Sciame associato	Data del massimo	ZHR
<b>2003 EH1 (C/1490 Y1)</b>	<b>5,5</b>	<b>Quadrantidi</b>	<b>3 gennaio</b>	<b>120</b>
<b>C/1861 G1 (Thatcher)</b>	<b>410</b>	<b>Lyridi</b>	<b>22 aprile</b>	<b>18</b>
<b>1P/Halley</b>	<b>75,7</b>	<b>Eta Aquaridi</b>	<b>5 maggio</b>	<b>65</b>
<b>96P/Machholz (?)</b>	<b>5,2</b>	<b>Arietidi</b>	<b>7 giugno</b>	<b>54</b>
<b>109P/Swift-Tuttle</b>	<b>134</b>	<b>Perseidi</b>	<b>12 agosto</b>	<b>100</b>
<b>21P/Giacobini-Zinner</b>	<b>6,6</b>	<b>Draconidi</b>	<b>9 ottobre</b>	<b>20</b>
<b>1P/Halley</b>	<b>75,7</b>	<b>Orionidi</b>	<b>21 ottobre</b>	<b>25</b>
<b>2P/Encke</b>	<b>3,3</b>	<b>Tauridi</b>	<b>3 novembre</b>	<b>5</b>
<b>55P/Tempel-Tuttle</b>	<b>33,2</b>	<b>Leonidi</b>	<b>17 novembre</b>	<b>15</b>
<b>3200 Phaethon</b>	<b>1,4</b>	<b>Geminidi</b>	<b>13 dicembre</b>	<b>120</b>
<b>8P/Tuttle</b>	<b>13,6</b>	<b>Ursidi</b>	<b>23 dicembre</b>	<b>10</b>

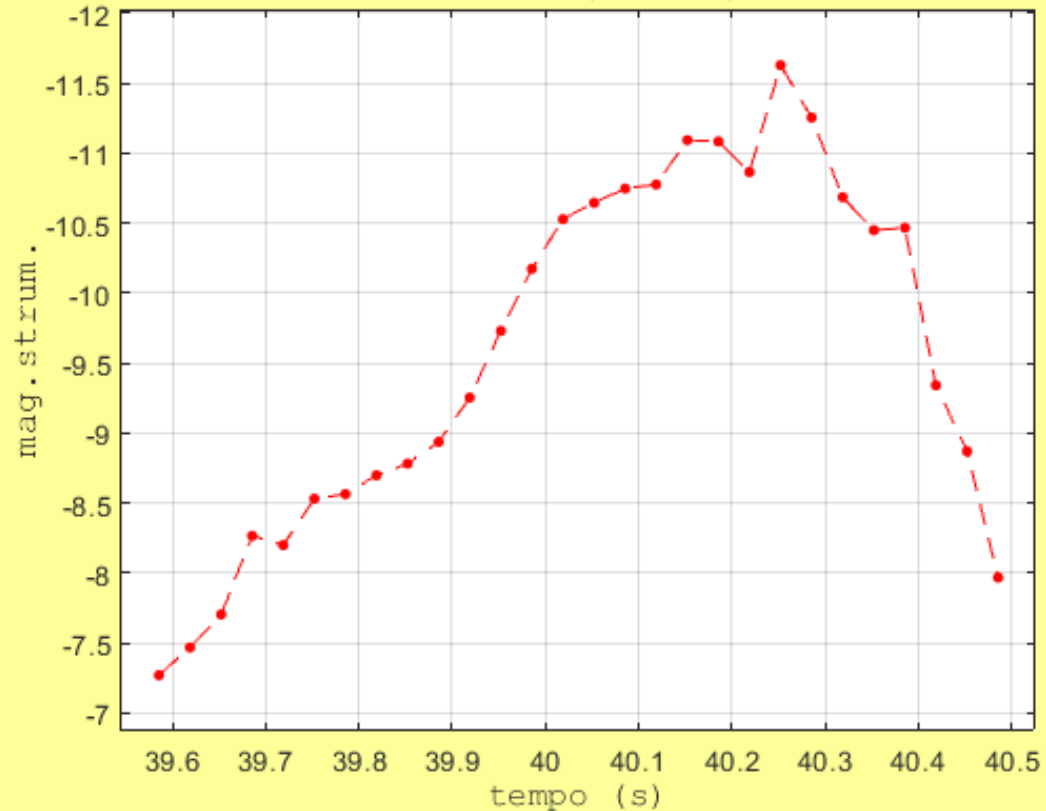
softwares utilizzati:

- IRIS
- EXCEL
- MATLAB
- WOLFRAM MATHEMATICA

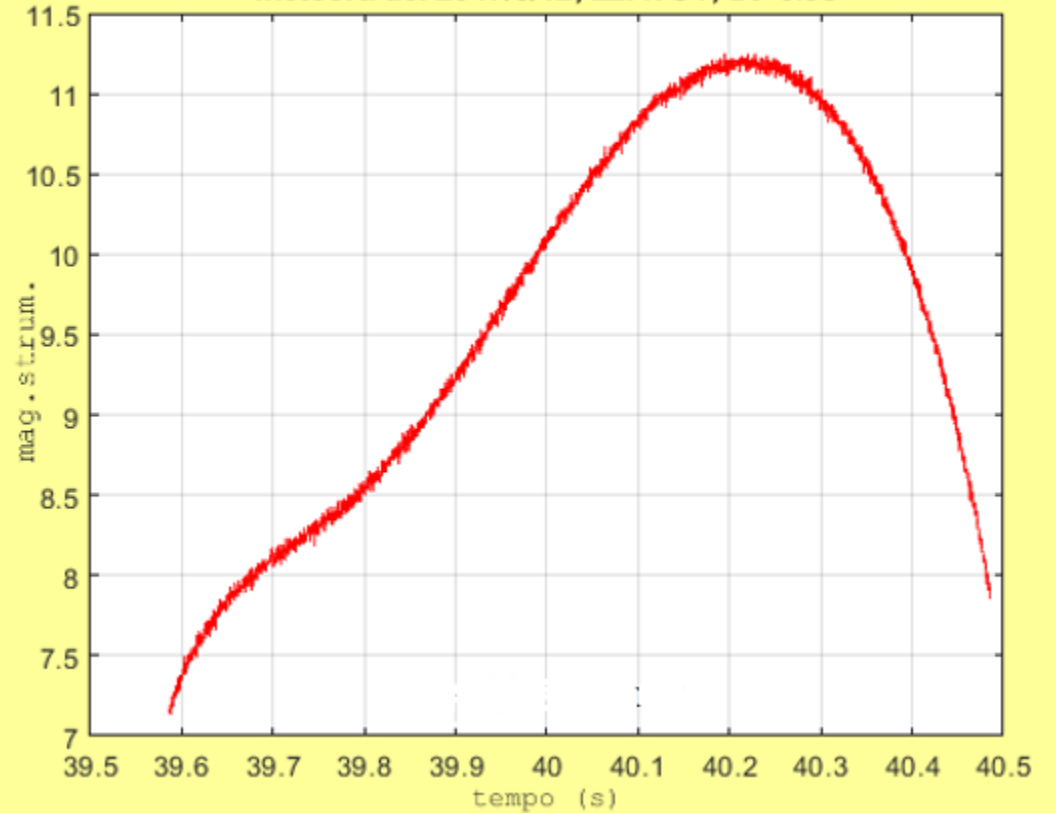


# CURVE DI LUCE

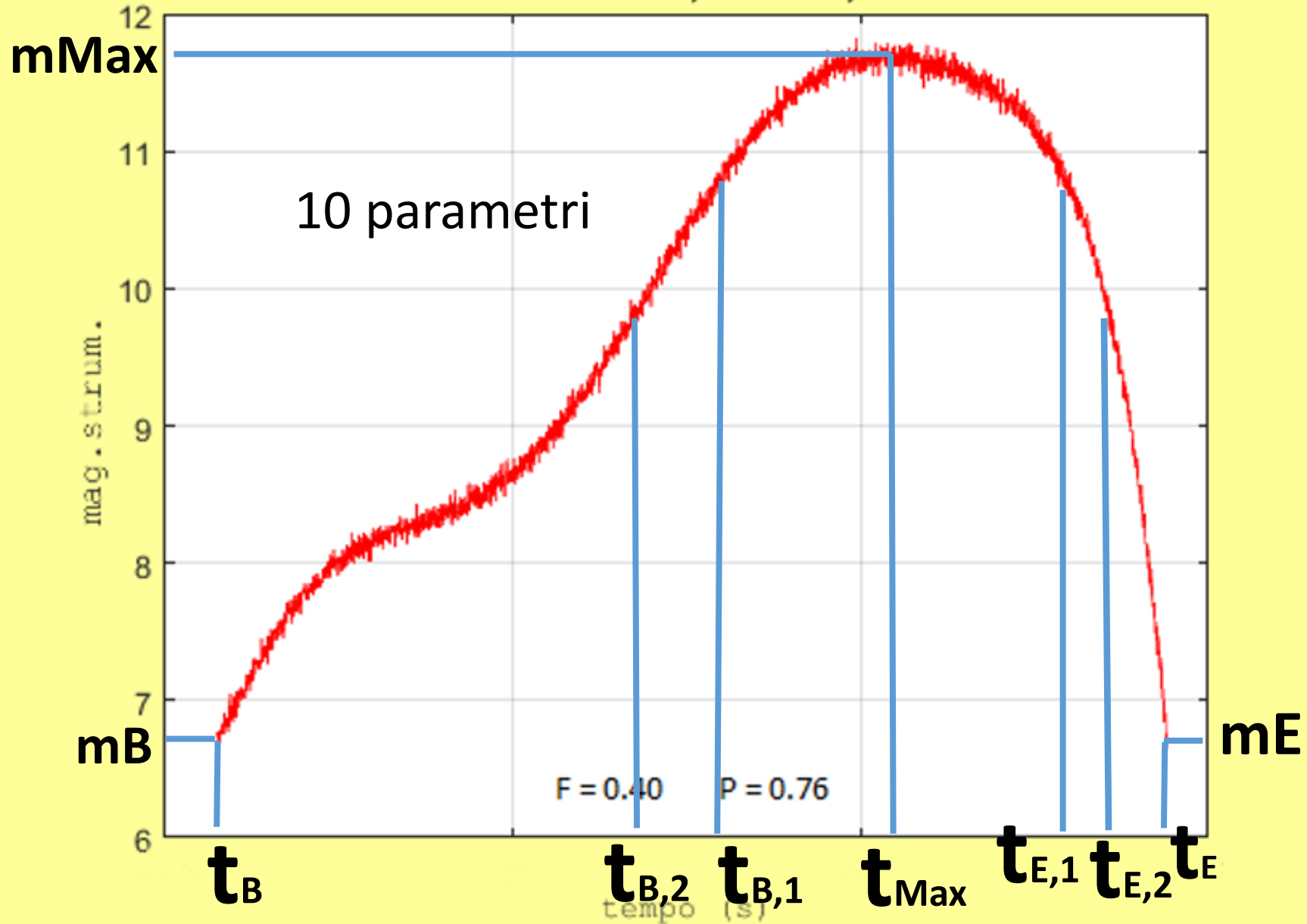
meteora del 2017/8/12, 22:47UT, Dt = 0.90s



meteora del 2017/8/12, 22:47UT, Dt=0.9s



meteora del 2017/11/1, 22:11UT, Dt=1.3667s



***(N. Brosch et al., 2004)***

$$F = \frac{t_{B,1} - t_M}{t_{B,1} - t_{E,1}}$$

$$P = \frac{t_{E,1} - t_{B,1}}{t_{E,2} - t_{B,2}}$$

$$D_1 = t_{Max} - t_B \quad D_2 = t_E - t_{Max} \quad D = D_1 + D_2$$

$$M_1 = m_B - m_{Max} \quad M_2 = m_E - m_{Max}$$

$$S_1 = M_1/D_1 \quad S_2 = M_2/D_2$$

$$A = \max(M_1, M_2) \quad J = \max(\Delta m)$$





$F < 0.35$	$0.35 \leq F \leq 0.65$	$F > 0.65$
9%	61%	30%

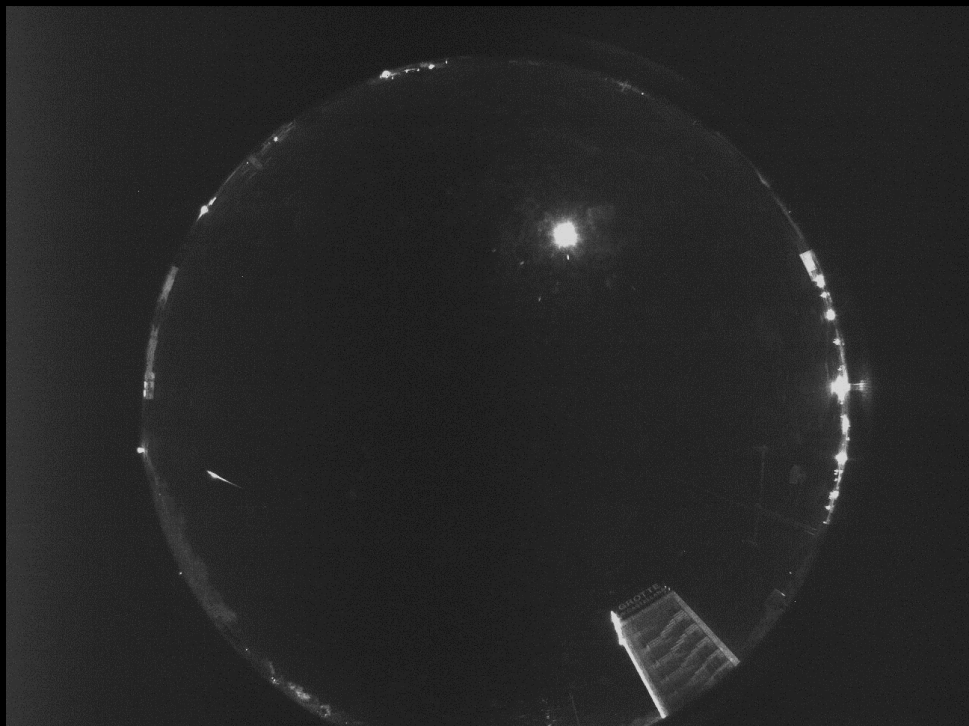
$P \leq 0.4$	$0.4 < P \leq 0.7$	$P > 0.7$
14%	54%	32%

$0s \leq D \leq 1s$	$1s < D \leq 2s$	$2s < D \leq 5s$
71%	18%	11%

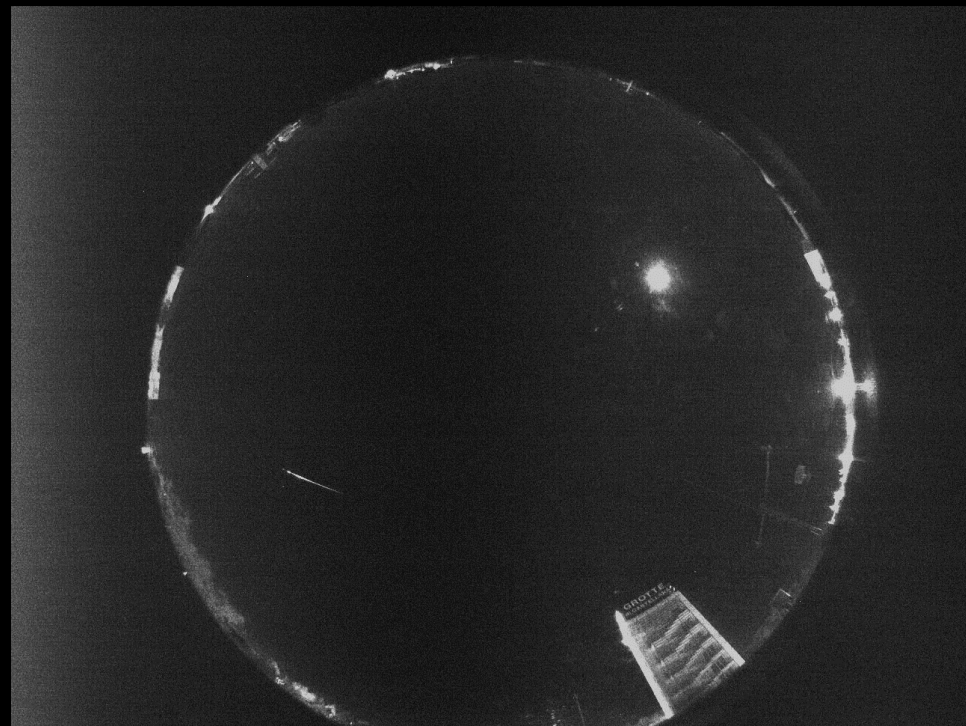
$0 \leq A(\text{mag}) < 3$	$3 \leq A(\text{mag}) < 5$	$5 \leq A(\text{mag}) \leq 8$
31%	44%	25%

# Perseidi 2017

Castellanagrotte\_20170812T012559\_UT



Castellanagrotte\_20170813T005244\_UT



<b>F</b>	<b>P</b>	<b>D</b>	<b>A</b>	<b>S1</b>	<b>S2</b>	<b>J</b>
$0.62 \pm 0.12$	$0.56 \pm 0.11$	$0.69 \pm 0.29$	$3.85 \pm 0.89$	$7.60 \pm 2.81$	$24.22 \pm 12.52$	$1.44 \pm 0.34$

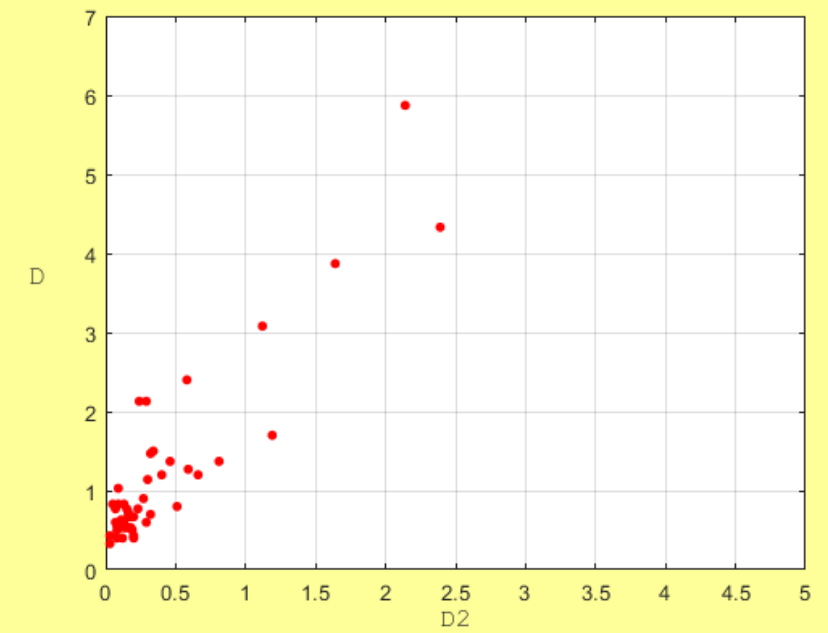
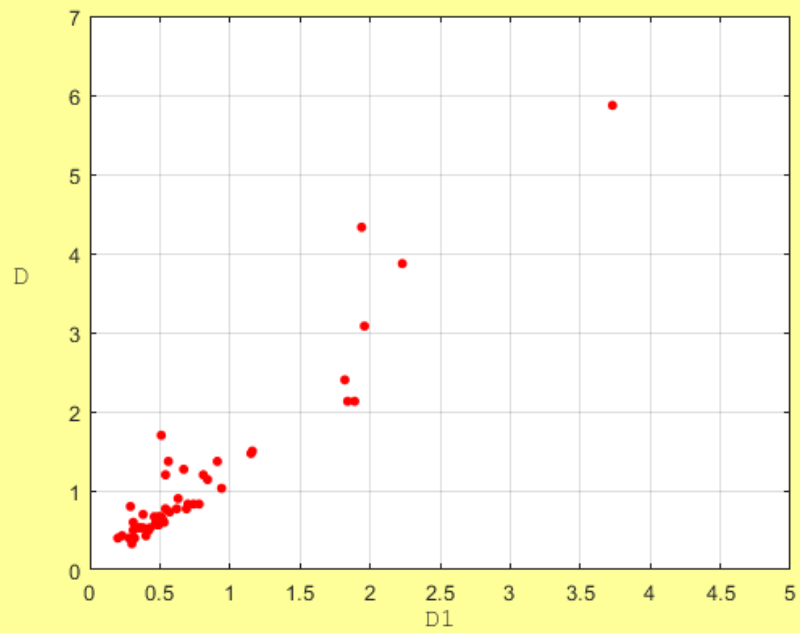
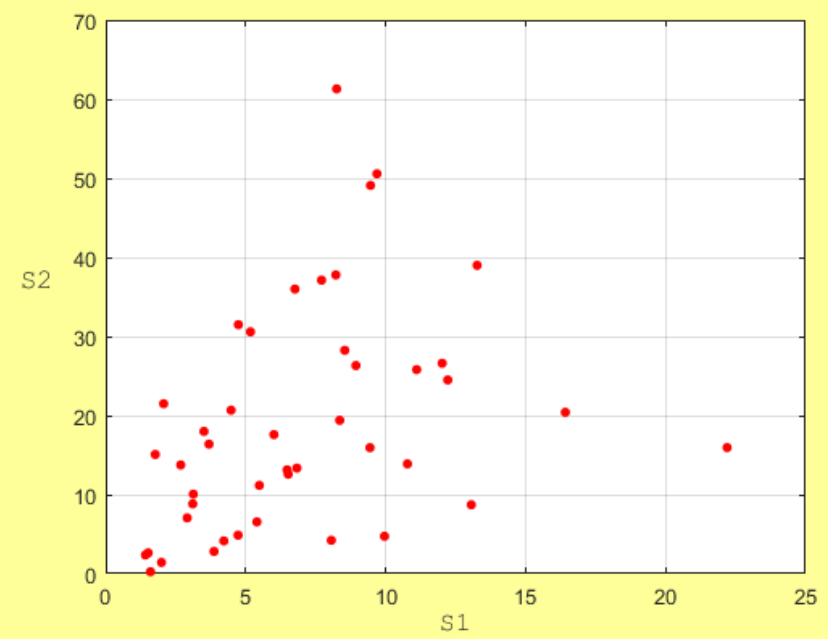
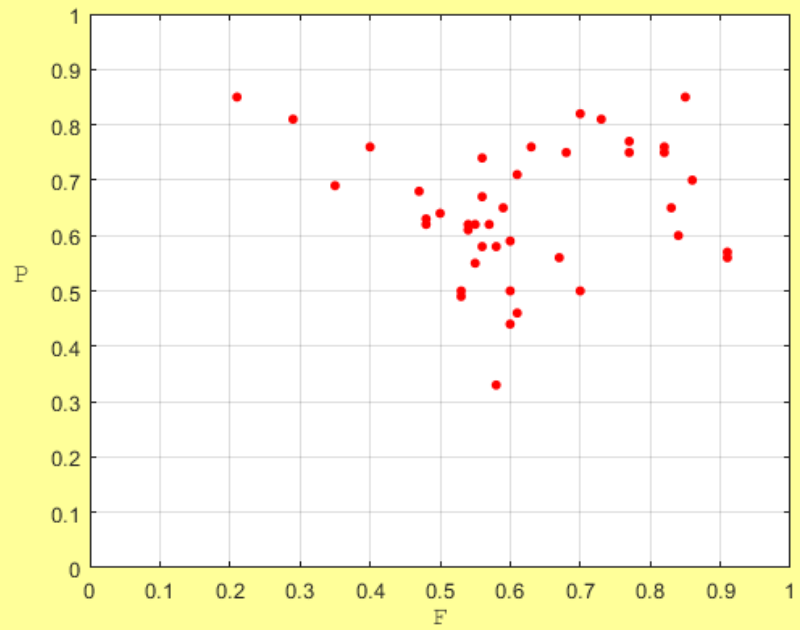


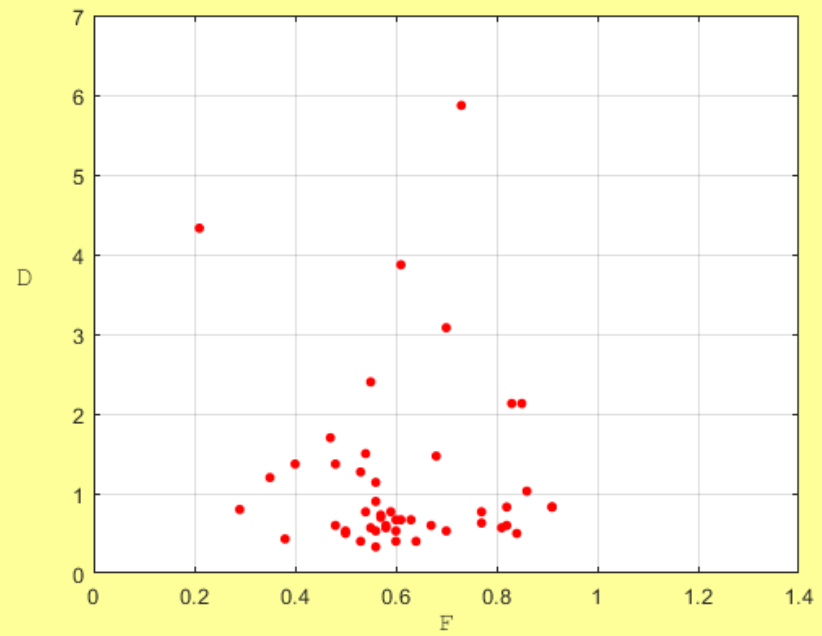
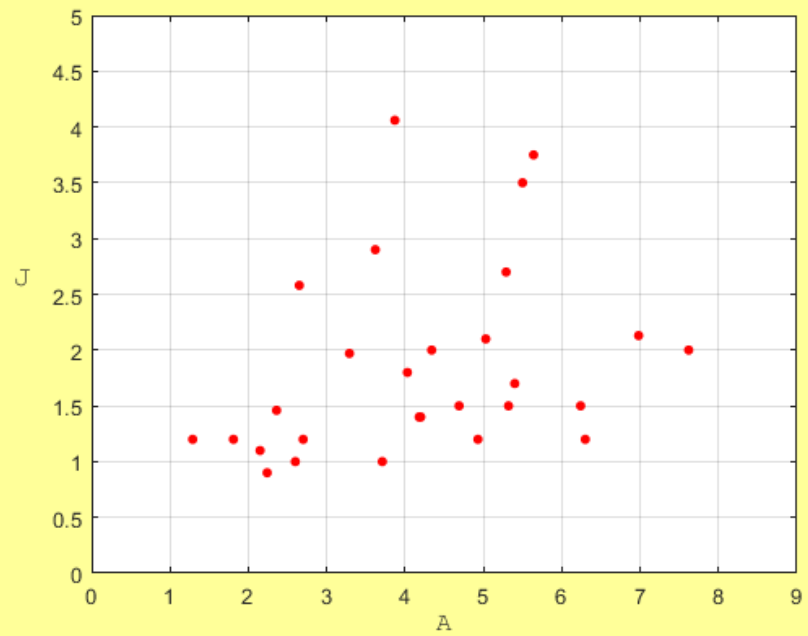
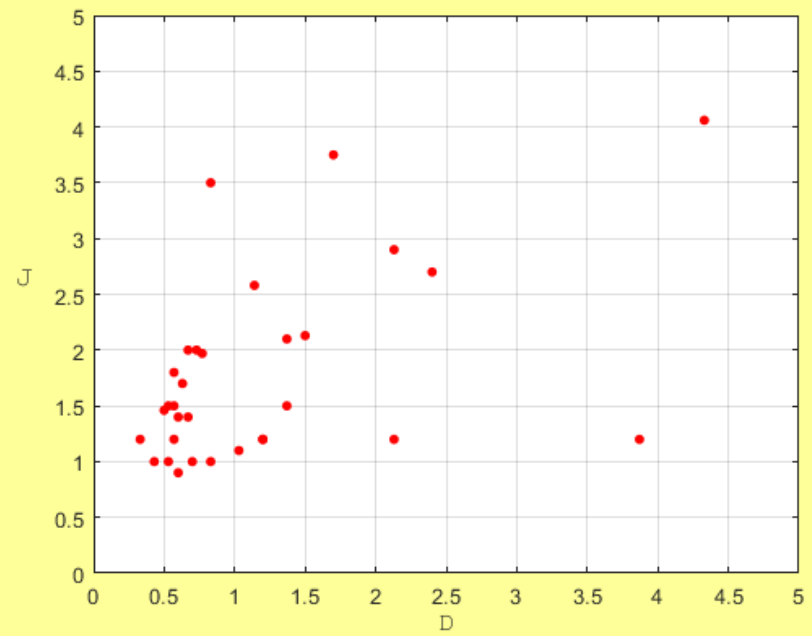
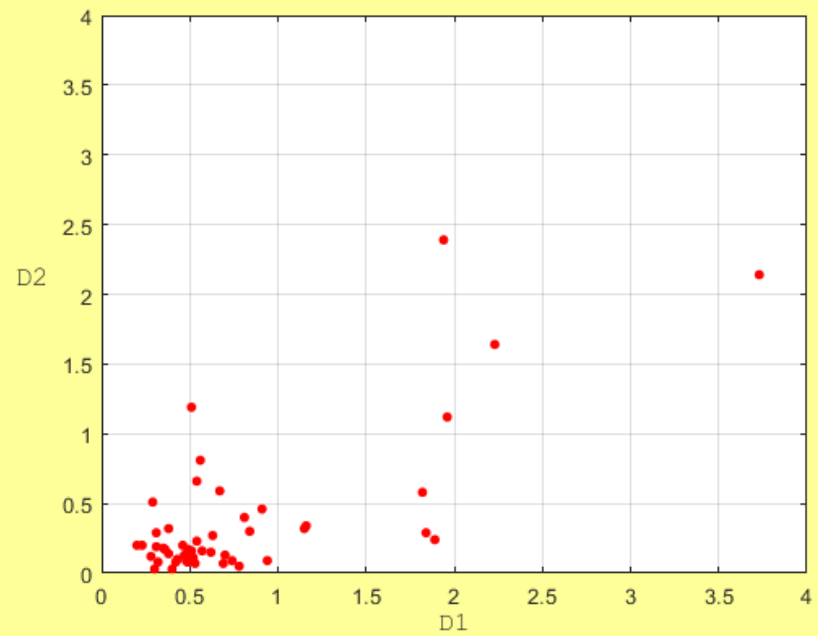
# Perseidi 2017

F	P	D	A	J
$0.62 \pm 0.12$	$0.56 \pm 0.11$	$0.69 \pm 0.29$	$3.85 \pm 0.89$	$1.44 \pm 0.34$

# Leonidi 2002 (Brosch et al., 2008)

F	P	D	A	J
$0.51 \pm 0.09$	$0.70 \pm 0.04$	$0.31 \pm 0.15$	$4.90 \pm 1.40$	$2.20 \pm 0.60$

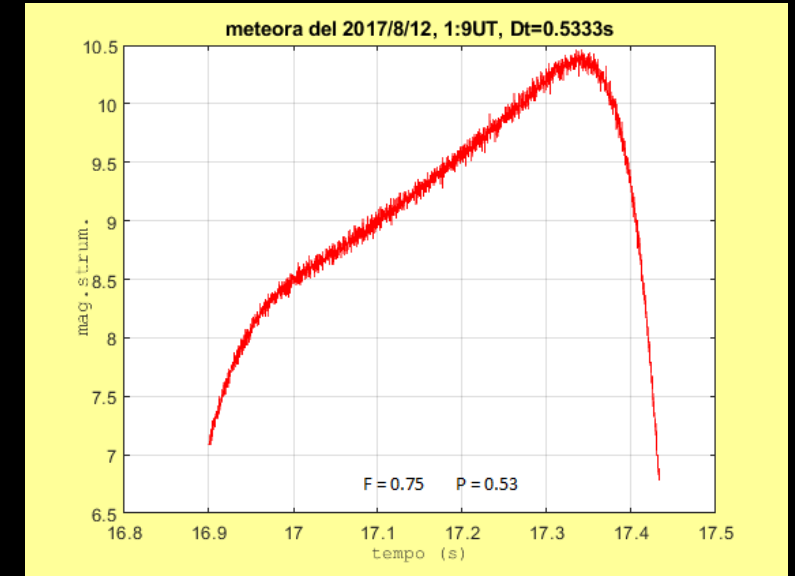
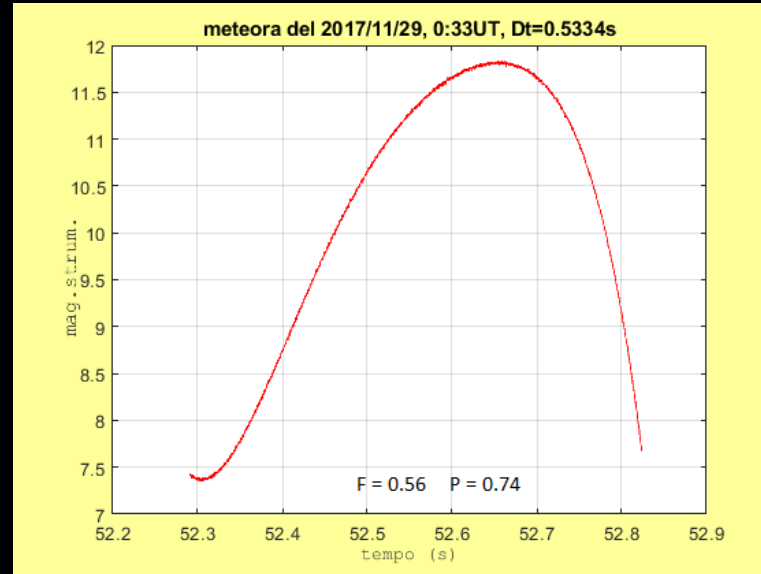
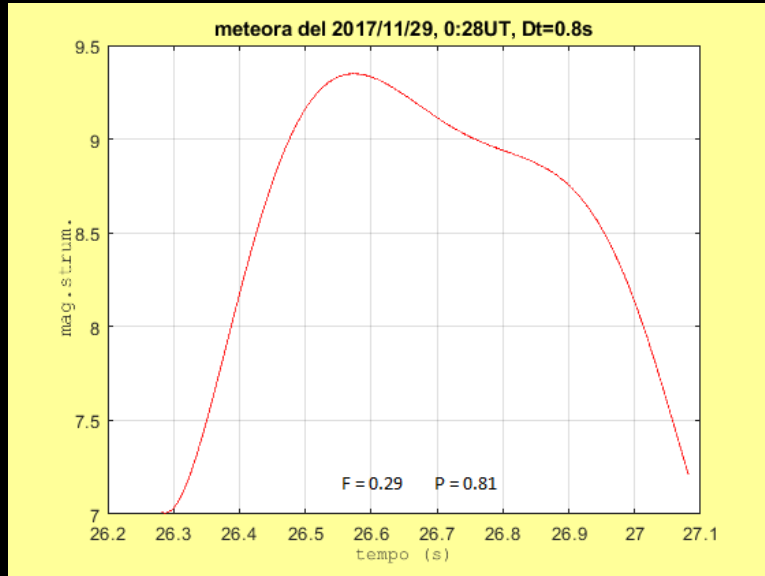




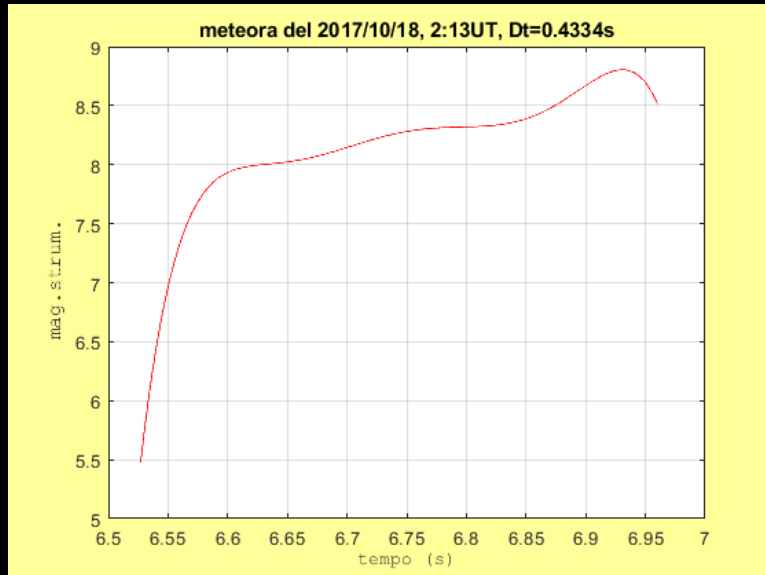
# early peaked

# symmetric

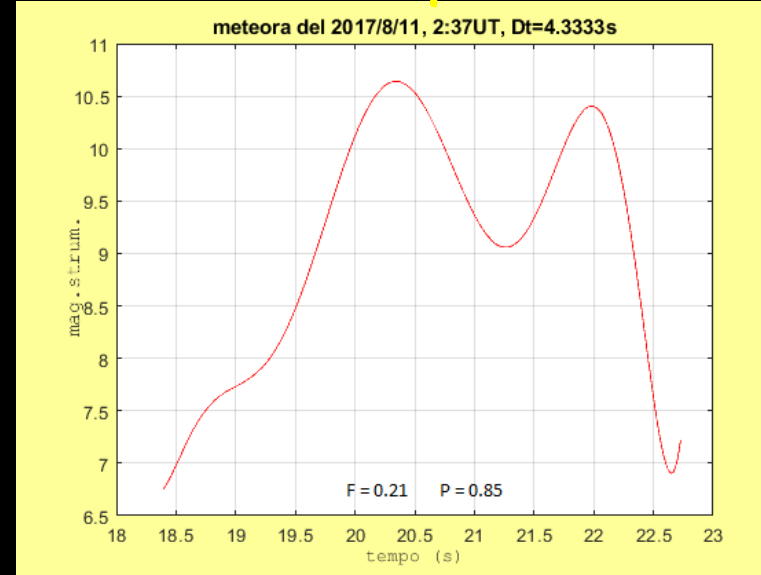
# late peaked



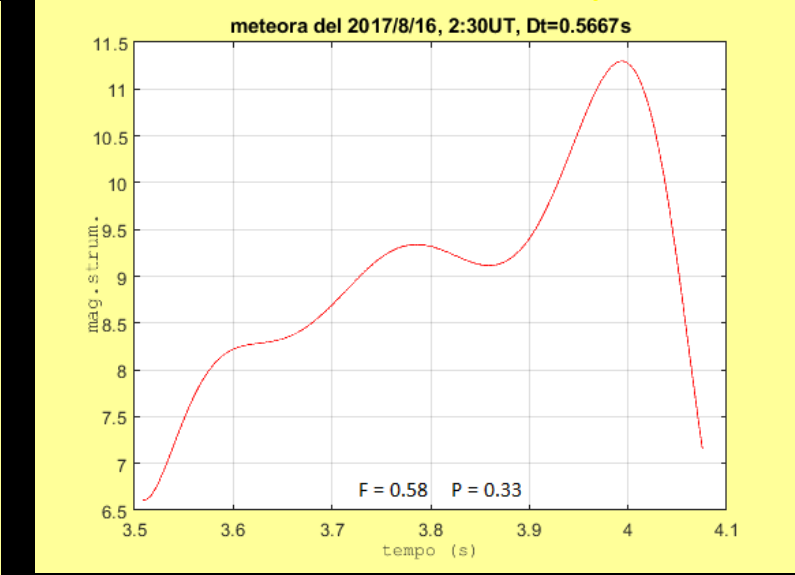
# no increasing-decreasing branch, flat



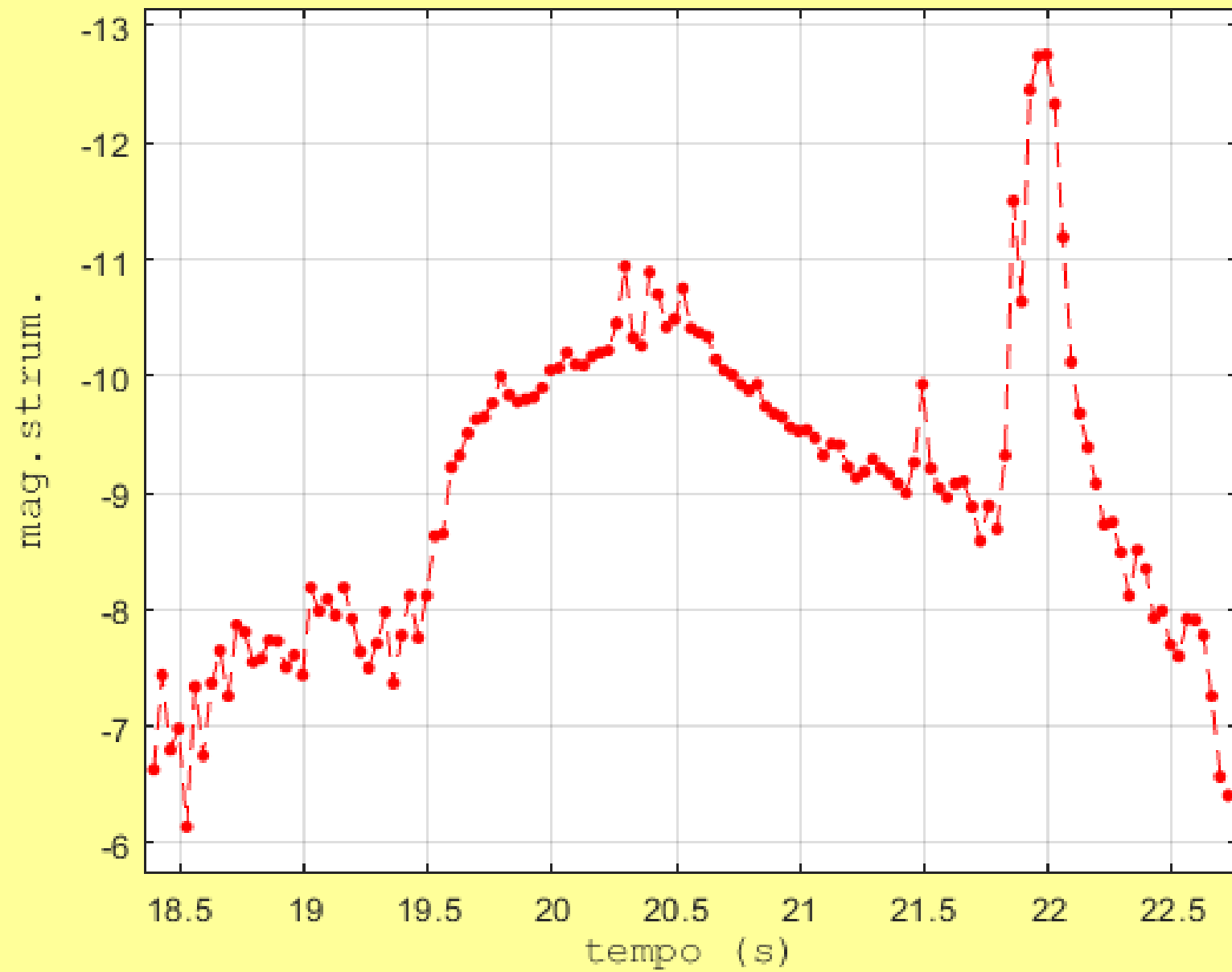
# double peaked



# flare, hump



meteora del 2017/8/11, 2:37UT, Dt = 4.33s





la  
calibrazione  
fotometrica

Assorbimento atmosferico	
Altezza sull'orizzonte (°)	Assorbimento (mag)
1	3.0
4	2.0
10	1.0
17	0.6
21	0.4
32	0.2
43	0.1

$m$ ,

$$f = 1367 \cdot 10^{-0.4(26.8+m)}$$

$$E = \int_{t_1}^{t_2} f(t) dt, \text{ in [J/m}^2\text{]}$$

$h = 90 \text{ Km}$

$$d = (h^2 + (h^2 / \text{tg}^2 \alpha))^{0.5}$$

$$S = 4\pi d^2$$

$$E_T = E \cdot S \text{ in [Kton]}$$

$$\eta = 0.12 E_T^{0.115} \text{ (Brown et al., 2002)}$$

$$E_0 = \frac{E_T}{\eta}$$

massa

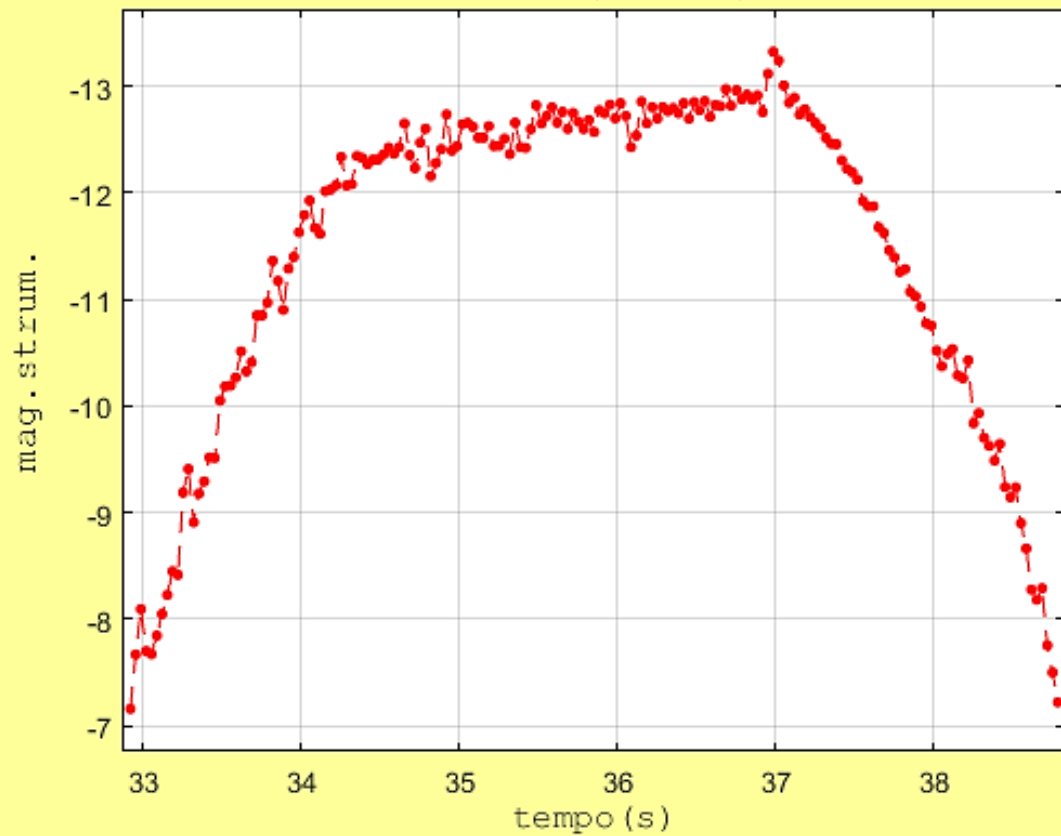
$v, d$

diametro

(Albino Carbognani)

K	L	M	N
	energia totale emessa (J/m <sup>2</sup> )		
	0.002037017		
	0.002037017		
	altezza bolide in atmosf.	altezza sull'orizzonte (°)	
	90	36	
	0.73		
	distanza dall'osservatore (Km)	superf. sf. di luce (m <sup>2</sup> )	
	153	2.9E+11	
	en. tot. bolide (J)	en. (Kton)	
	6.0E+08	1.4E-04	
	en. cin. bolide (J)	eff. lumin. bolide	
	1.4E+10	0.043	
	velocità bolide (Km/s)	densità (g/cm <sup>3</sup> )	
	40	4	
	massa meteoroidi (Kg)	diametro meteoroidi (m)	
	17.3	0.20	
	massa meteoroidi (g)	diametro meteoroidi (cm)	
	17303	20.2	

meteora del 2017/9/9, 19:35UT, Dt = 5.87s



**massa = 4 Kg; diametro = 13 cm**



```
A = 1.2;  
θ = π / 4;  
Λ = 0.5;  
rm = 7874;  
L = 8260000;  
ma = 10-7;  
  
diacm = 2 *  $\left(\frac{3 * ma}{4 * 3.14 * rm}\right)^{1/3} * 100$ ;  
  
NumberForm[diacm, {2, 2}]  
  
c = 440;  
vi = 20000;  
zi = 130000;  
σ = 5.67 * 10-8;  
ε = 0.9;  
Ta = 300;  
  
ra[t_] = Exp[-0.6006 - 0.00011 * z[t] - 2.741 * 10-10 * z[t]2];
```

# bilancio energetico per un meteoroido:

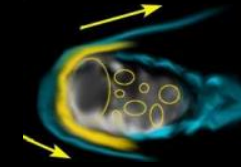
- 1) al corpo in caduta nell'atmosfera viene impartita energia tramite collisioni con gli atomi e le molecole presenti nell'atmosfera
- 2) perdite di energia sono l'emissione elettromagnetica e l'ablazione

$$\left\{ \begin{aligned} v'[t] &= - \frac{ra[t] + A * v[t]^2}{m[t]^{\frac{1}{3}} + rm^{\frac{2}{3}}}, & m'[t] &= - \frac{A * ra[t] + m[t]^{\frac{2}{3}} + A * v[t]^3}{2 * L + rm^{\frac{2}{3}}}, & z'[t] &= - \text{Cos}[\theta] * v[t] \end{aligned} \right.$$

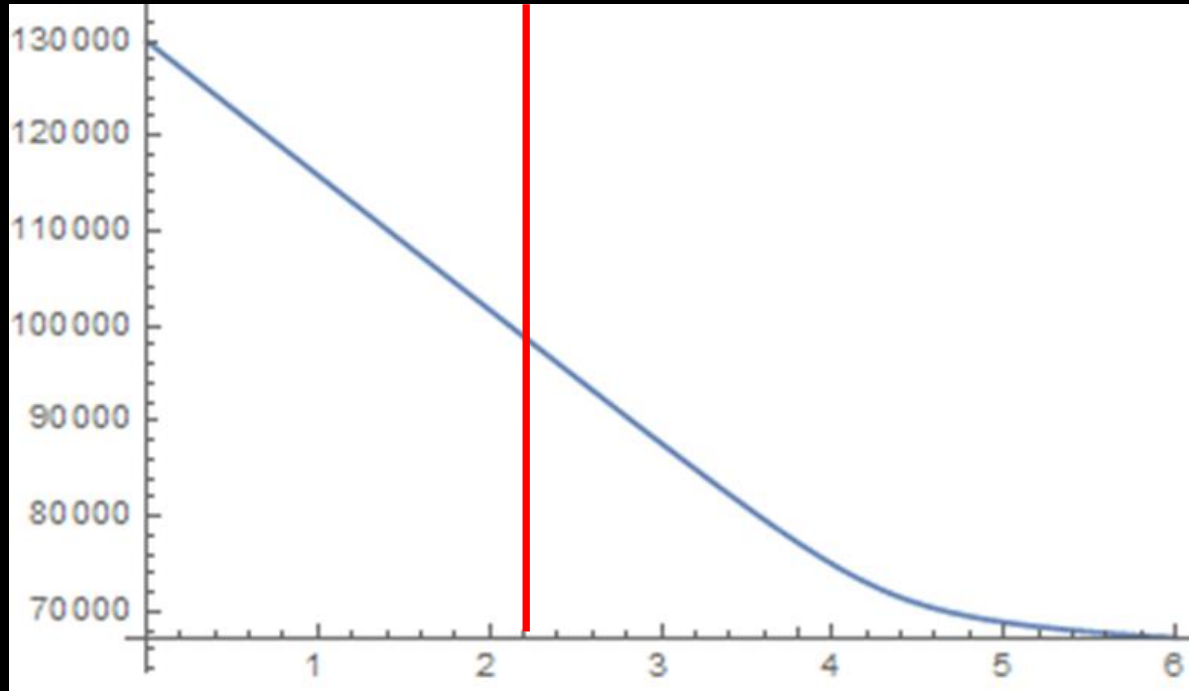
$$T'[t] = \frac{1}{c + m[t]} * \left( A * \left( \frac{m[t]}{rm} \right)^{2/3} * \left( \frac{A * ra[t] + v[t]^3}{2} - 4 * \sigma * \epsilon * (T[t]^4 - Ta^4) \right) - L * \left( - \frac{A * ra[t] + m[t]^{\frac{2}{3}} + A * v[t]^3}{2 * L + rm^{\frac{2}{3}}} \right) \right)$$

$$\text{Plot} \left[ -0.5 * \left( \frac{- \frac{A * ra[t] + m[t]^{\frac{2}{3}} + A * v[t]^3}{2 * L + rm^{\frac{2}{3}}} + v[t]^2}{2} - m[t] * v[t] + \frac{ra[t] + A * v[t]^2}{m[t]^{\frac{1}{3}} + rm^{\frac{2}{3}}} \right) /. s[[1]], \{t, \theta, 6\} \right]$$

# micrometeoroidi ferroso, 0.03 cm

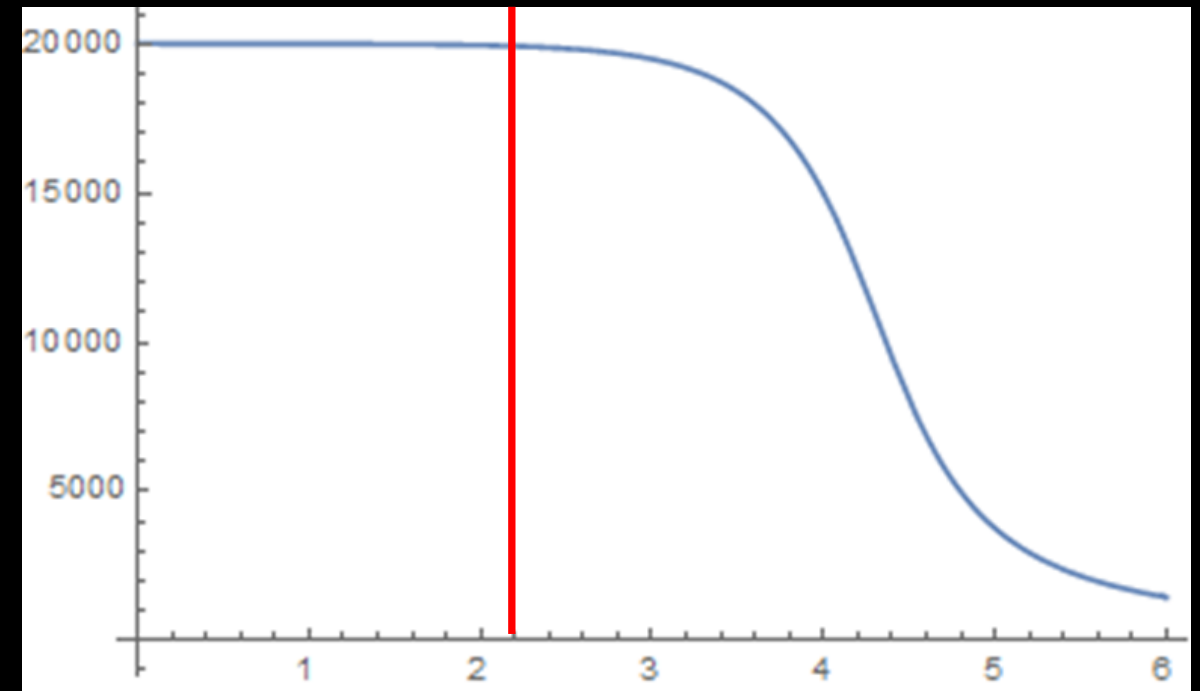


$z(t)$



la velocità rimane costante nelle prime fasi del moto e poi subisce una diminuzione

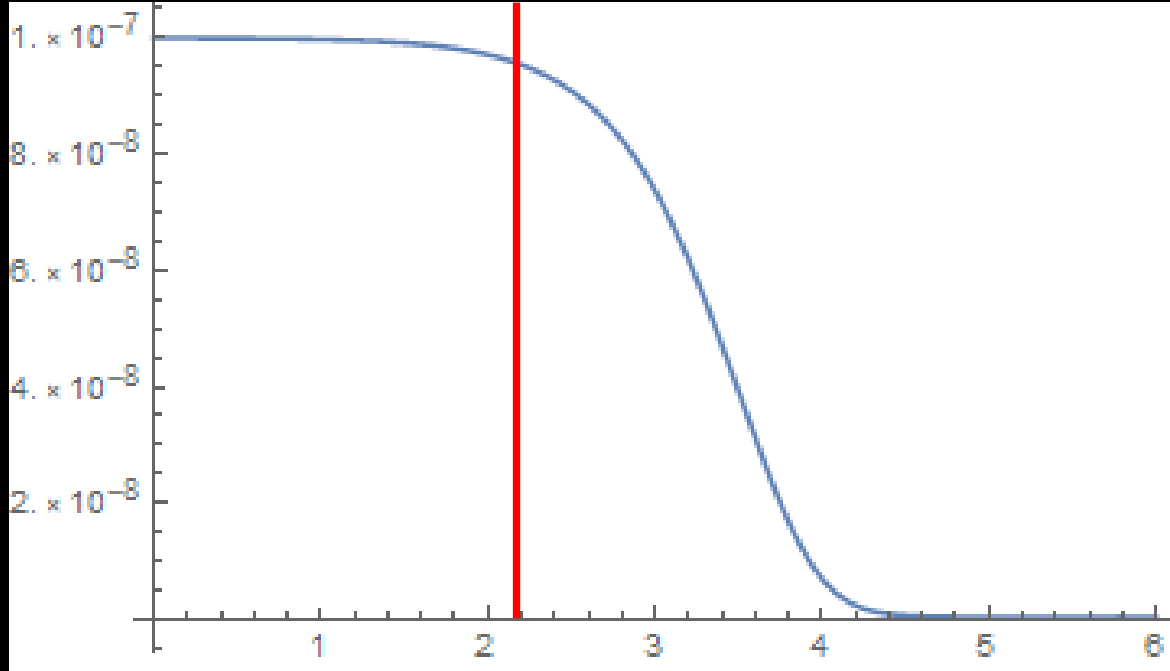
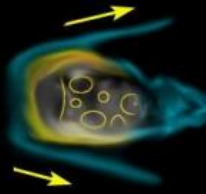
$v(t)$



la diminuzione della velocità è dovuta al fatto che gli strati di aria sono via via più densi e hanno una capacità frenante maggiore



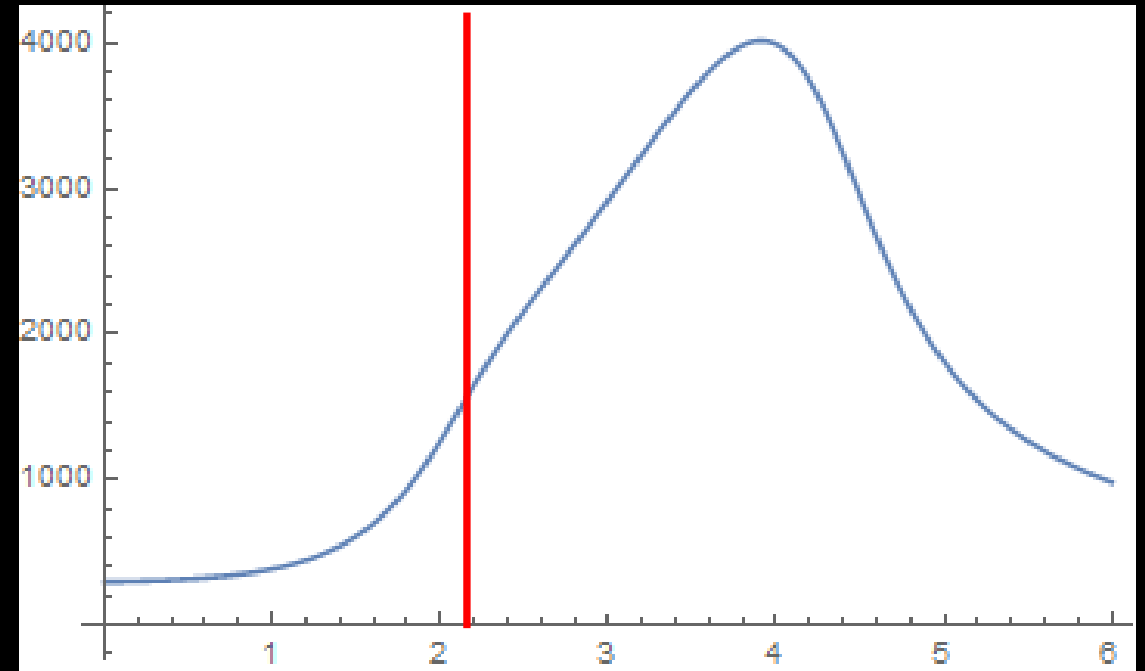
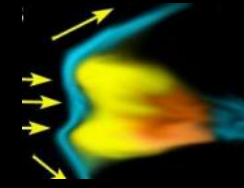
$m(t)$



il processo di ablazione ha inizio in un istante di tempo che si può ritenere di *soglia* per l'inizio della perdita di energia del meteoroido.

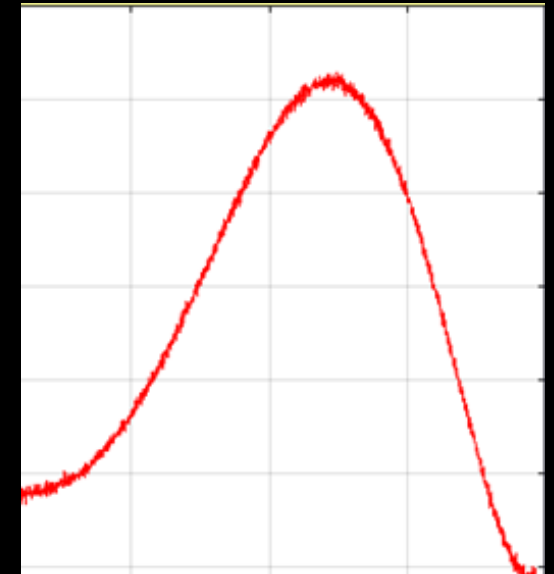
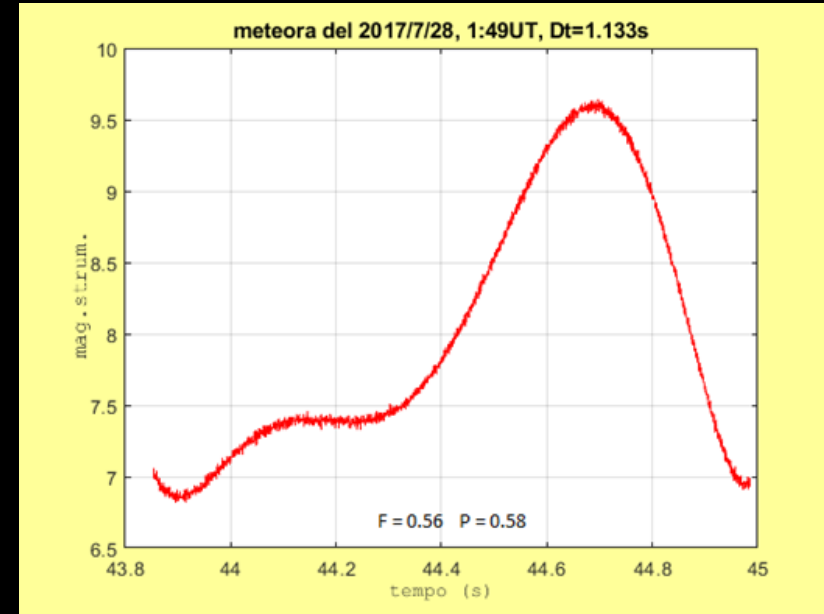
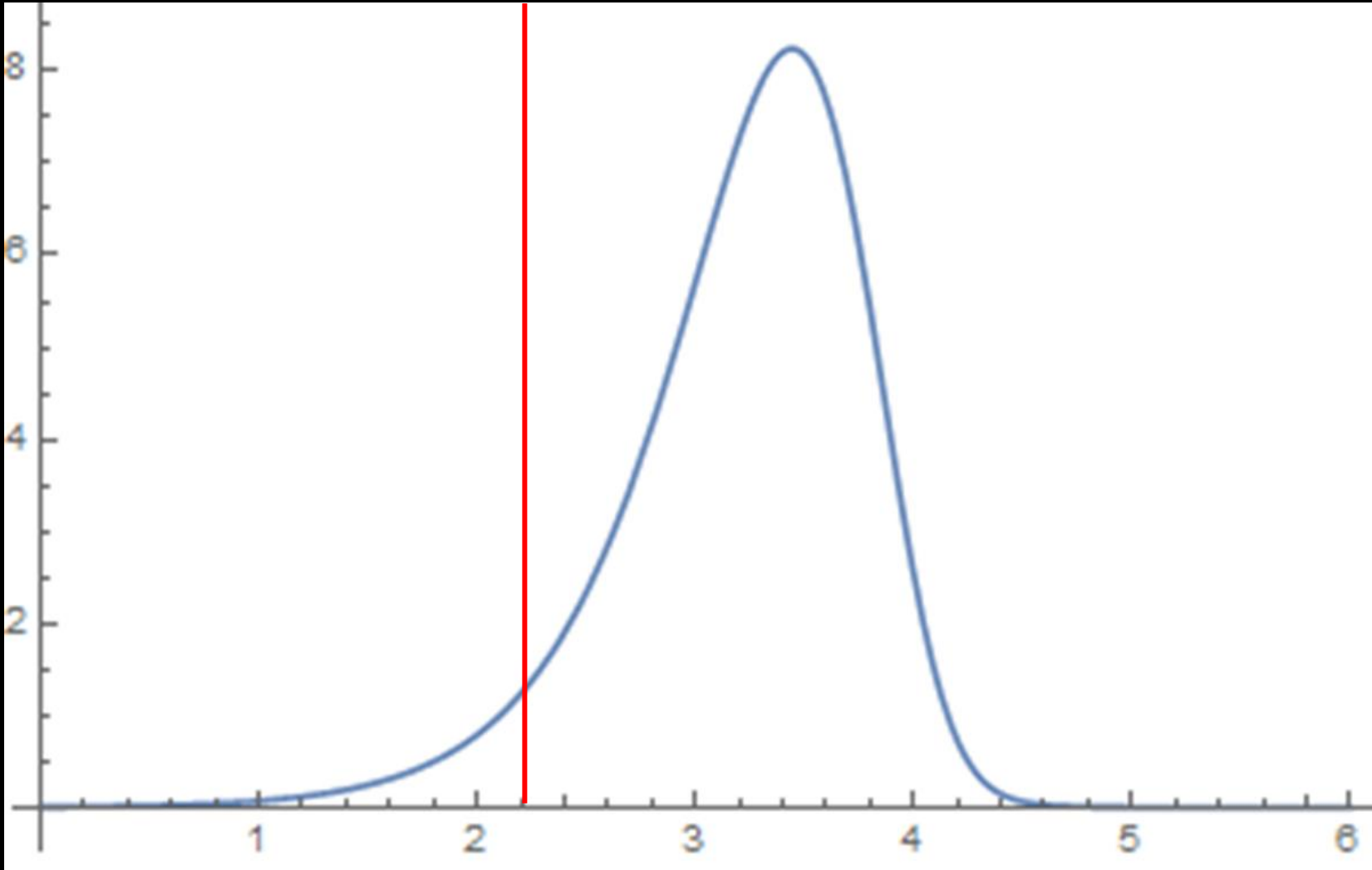
una temperatura di circa 1600 K permette l'ablazione e l'emissione.

$T(t)$



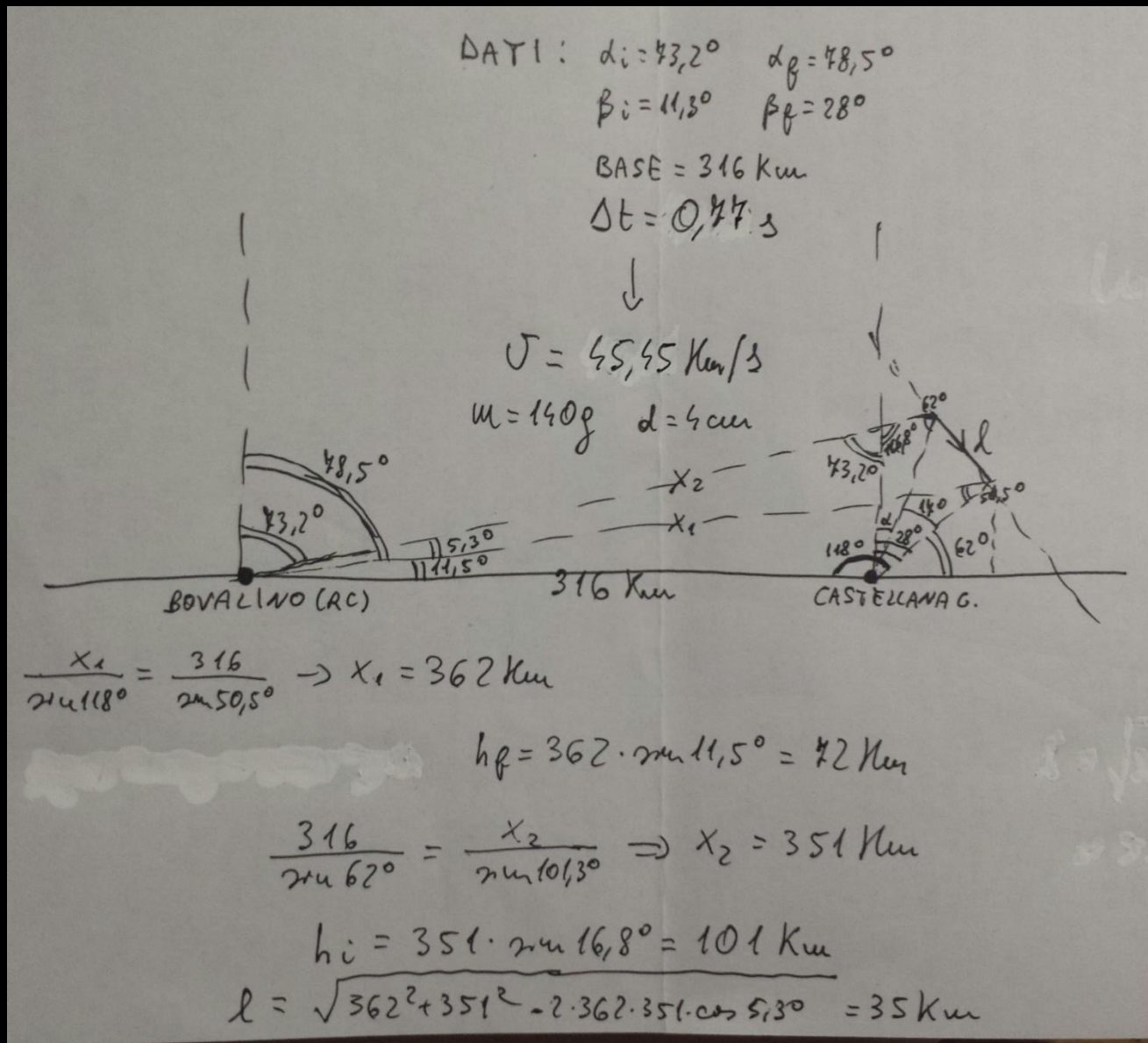
la fase di preriscaldamento procede fino a quando il processo di ablazione ha inizio e si forma il cappello di gas, responsabile poi dell'emissione luminosa; la stessa temperatura si ottiene intorno ai 5s, in fase di raffreddamento, quando il meteoroido ha perso energia: in questa fase l'ablazione non può avvenire e infatti massa e velocità vanno in *plateau* e la pendenza di  $h(t)$  si addolcisce.

$I(t)$



relazione tra i parametri di  
una LC e parametri  
ingresso in atmosfera  
???

# meteora del 7 agosto 2018, 04:13 UT



$h_i = 101 \text{ Km}$

$h_f = 72 \text{ Km}$

lunghezza scia =  $35 \text{ Km}$

velocità =  $45 \text{ Km}$

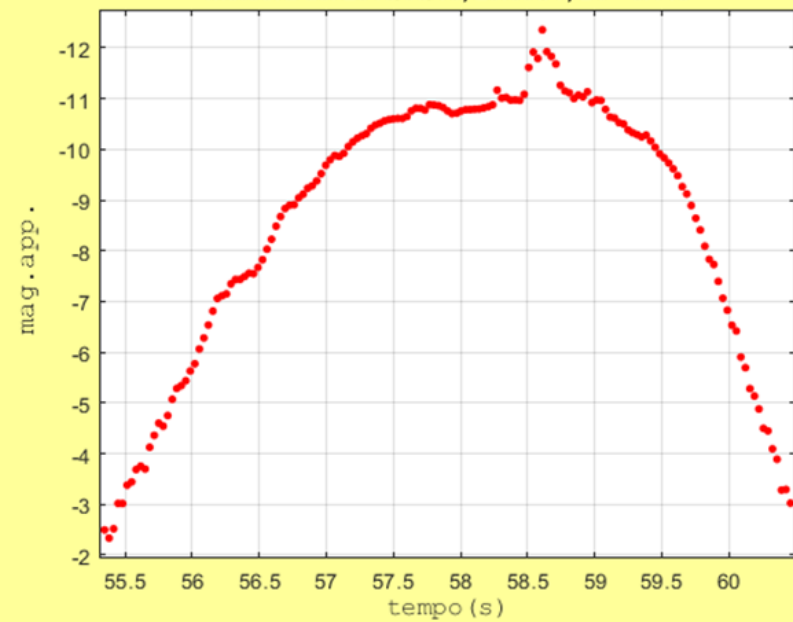
bolide del 19 maggio 2018, 20:09 UT



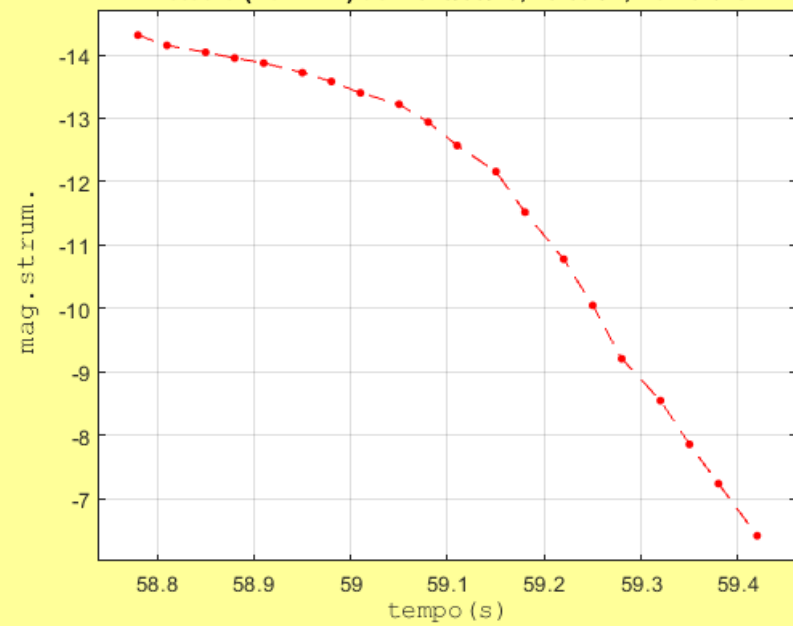


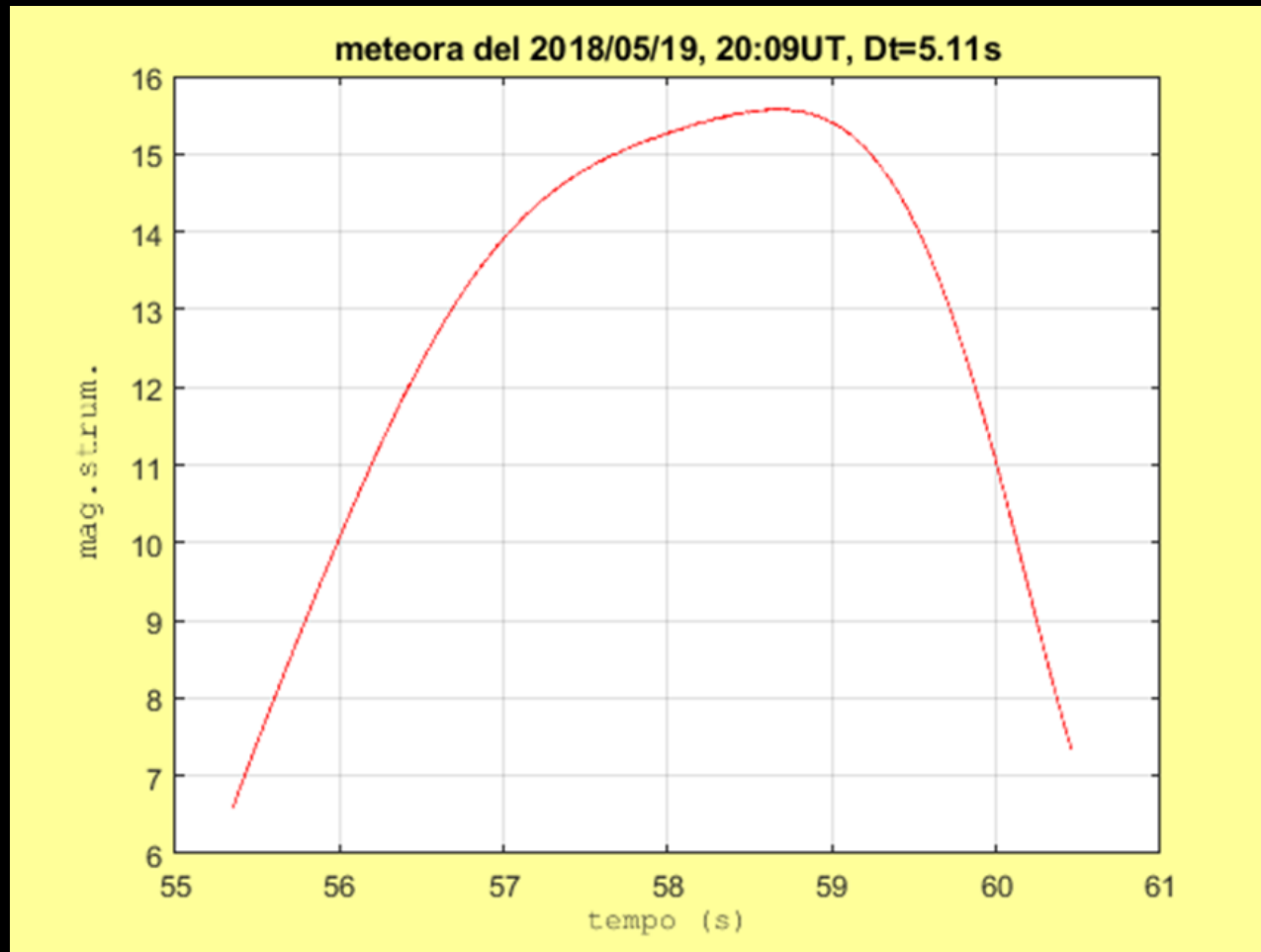


meteora del 2018/05/19, 20:09UT, Dt = 5.11s

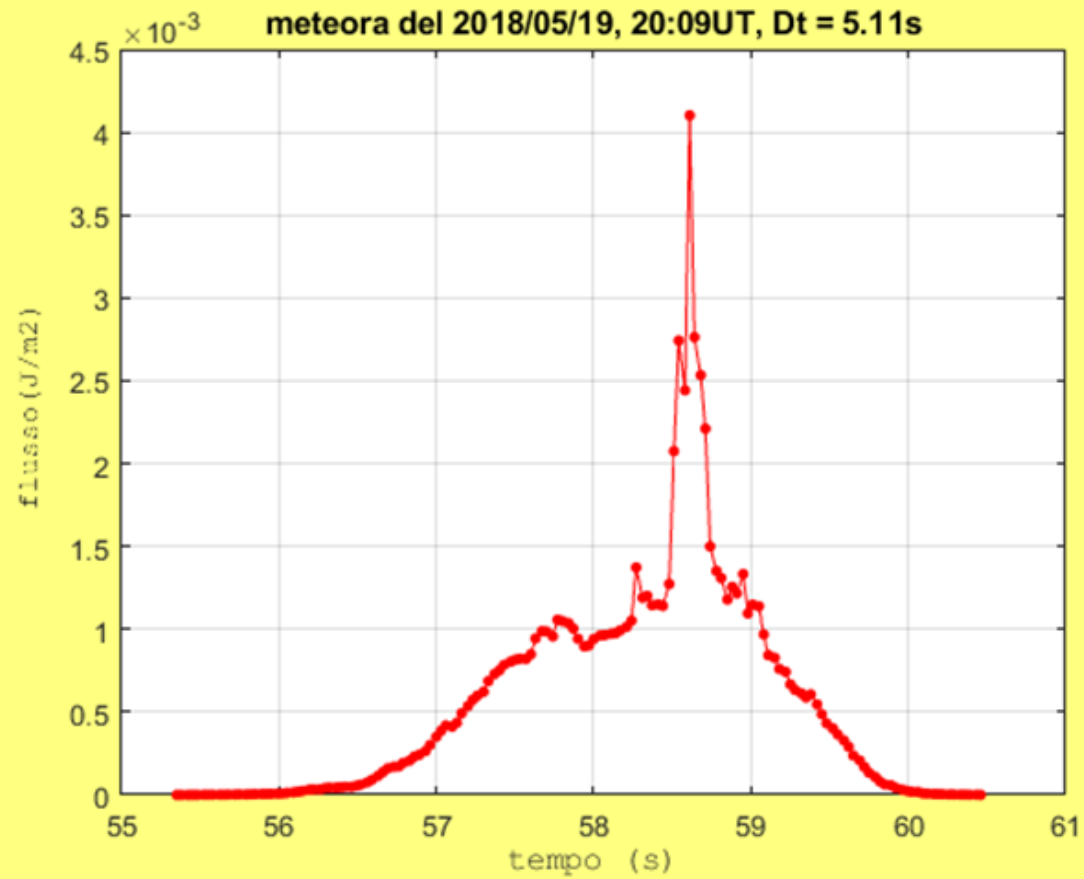


meteora (framm.B) del 2018/05/19, 20:09UT, Dt = 0.64s



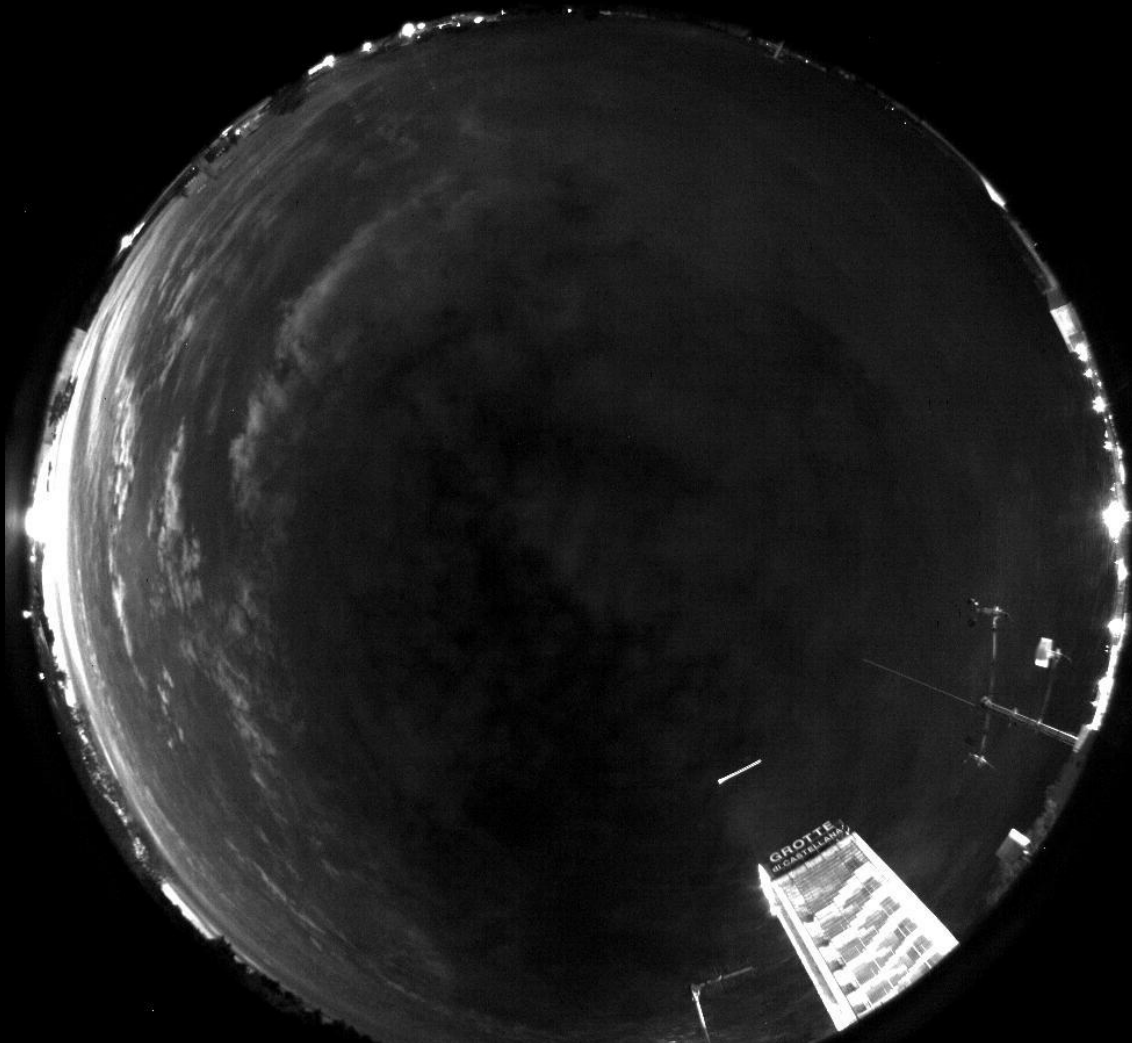


F	P	S1	S2	A	D1	D2	D1/D2	D	J
0.59	0.72	2.76 mag/s	4.44 mag/s	8.80 mag	3.19 s	1.92 s	1.66	5.11 s	1.40 mag

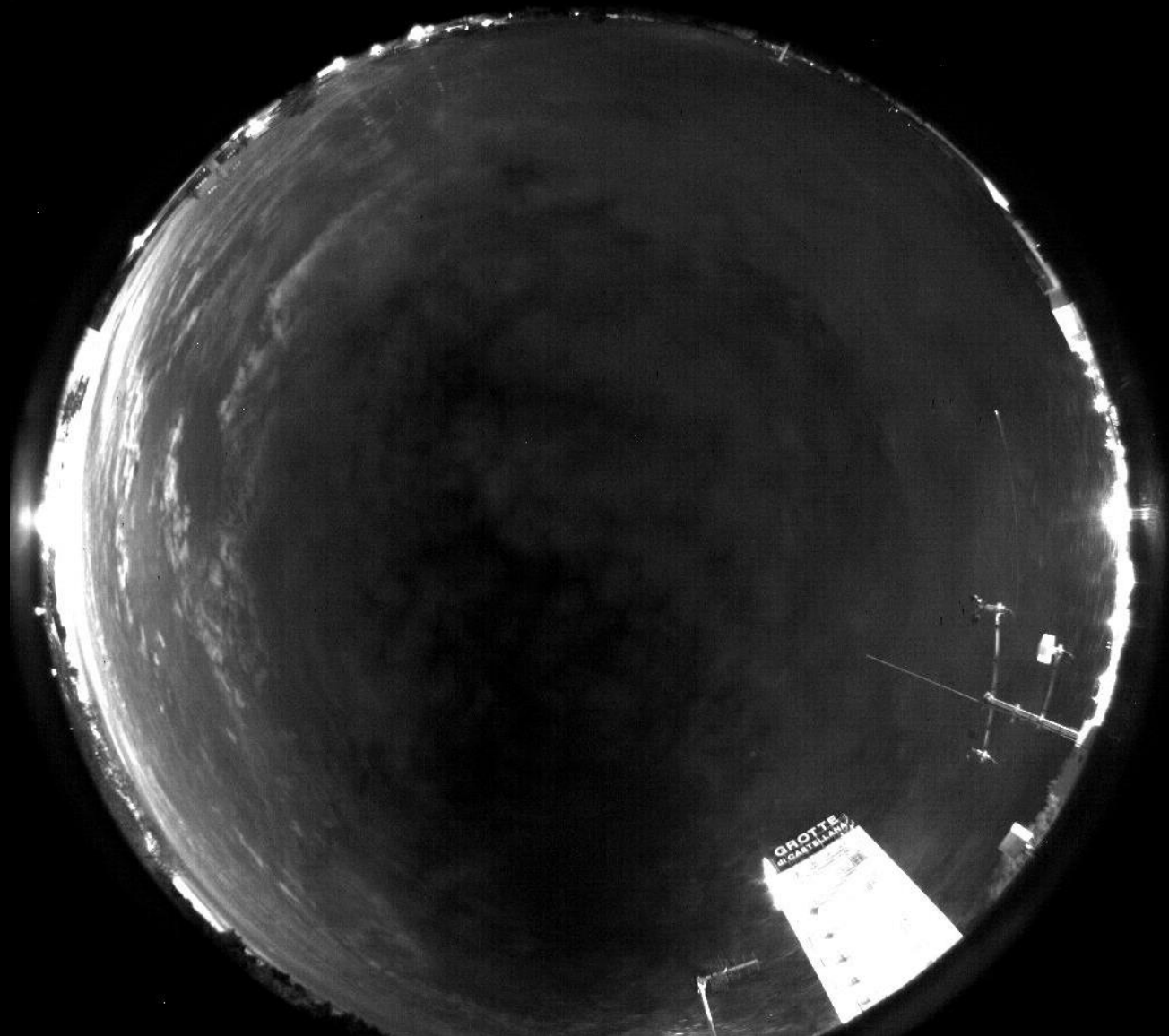


altezza bolide stimata	altezza misurata sull'orizzonte
90 km	36°
velocità bolide stimata	densità stimata
40 Km/s	4 g/cm <sup>3</sup>
massa meteoroidi	diametro meteoroidi
<b>130 Kg</b>	<b>20 cm</b>

Castellanagrotte\_20180928T172512\_UT



Castellanagrotte\_20180928T172746\_UT



una sezione di fotometria  
all'interno di PRISMA  
?????





*Grazie per l'attenzione!*