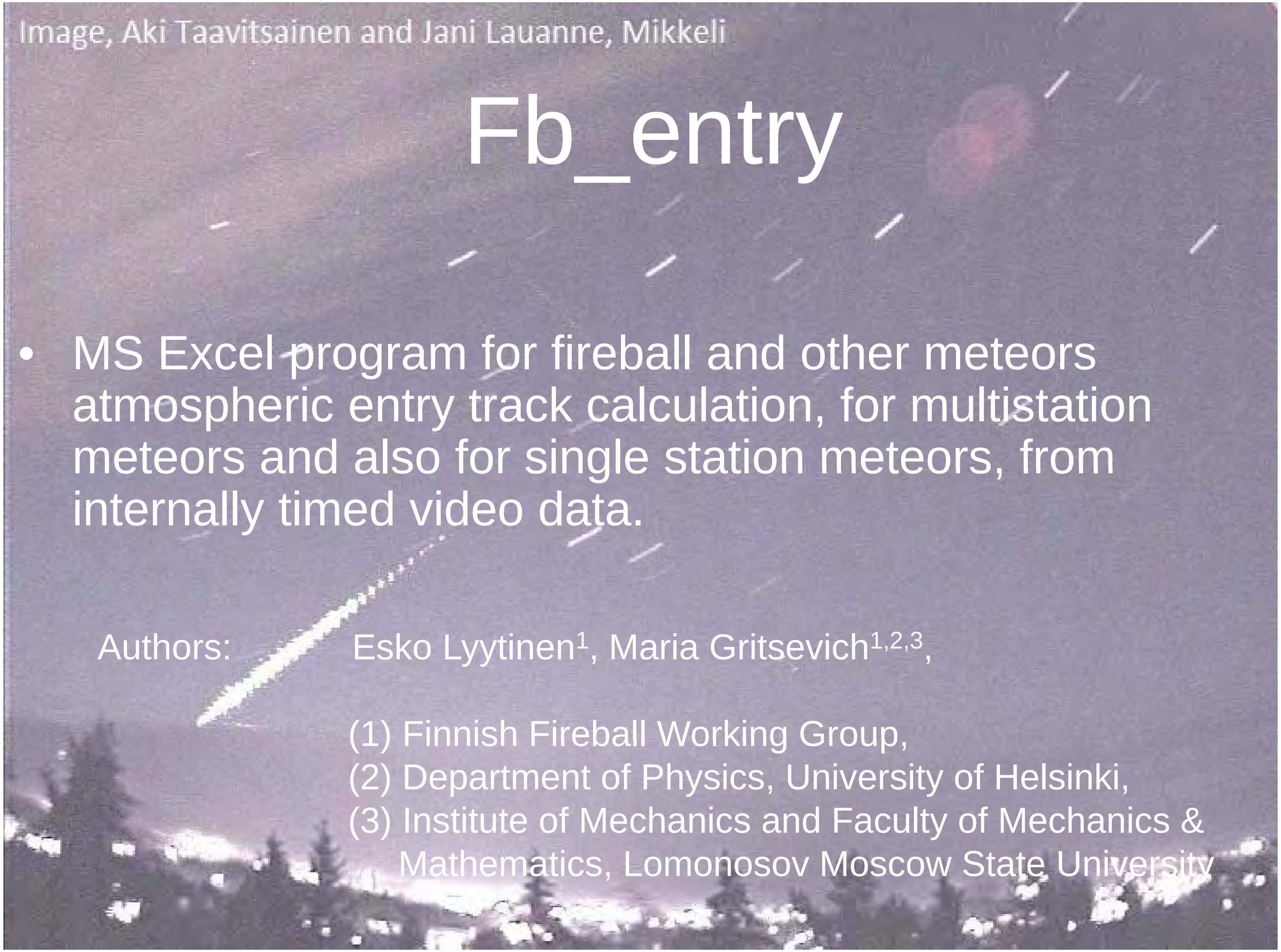
Image, Aki Taavitsainen and Jani Lauanne, Mikkeli
Fb_entry
• MS Excel program for fireball and other meteors atmospheric entry track calculation, for multistation meteors and also for single station meteors, from internally timed video data.
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GENERAL INTRODUCTION

- The fb_entry program is made to calculate accurate meteor atmospheric entry track from observations. Local alt- az-directions are in use. Besides multiple station meteors, also single station meteors can be dealt with.

- The program makes direct fit to internally timed observations. For observations with no timing we put the timings as unknowns.

- In principle original internally timed observations contain more information than is in use with the commonly used planes crossing method.

- Because of this direct fit, one can also (to some degree) derive the entry from single station fireball from internally timed (for example video-) observations. The entry velocity can NOT be solved but a reasonable value can be found by adjusting the velocity and trying to get the resulting beginning height to be mutually consistent. For this to succeed, a lengthy well observed sky-track is desired, from video data, for example.

- This can be further linked into other Excel models, like calculating the solar sytem orbit. We typically have in our group this linked into the Metorb sheet by Marco Langbroek. Link to download this is in the references section of this.

- If there are only sky-tracks (measured from different points of the tracks) observations with nothing timed, the entry-velocity can not be solved, and an arbitrary (reasonable) fixed value is used for this.

- The solving is by means of the Excel (add-in) ”solver” to get a least square best fit to the observations. A genuine MS Excel is needed. Open Office etc spread-sheets can not be used. These may have a "solver", but these are capable of solving only linear models, as far as I know.

- Quite a good understanding of the principles are needed, to get full use of the program. In addition to more normal use, quite a number of tricks can be utilized. Most of these may be of advantage in fireballs with visual observations (only).

- The method described in (Gural, 2012) has some similar principles, in the fit to the observations.

Some more details

- To some degree a rough original solution will be needed as the base to ascertain the convergence to the actual solution. Without this it may converge towards somehing non reasonable. But no other program will be needed. There is a practical procedure to follow, that will most probably lead the program to converge to the correct solution.
- If there may be difficulties in the convergence, as there some times are, this normally is the result of some real error in the data. For example there is a real error in one observing station coordinates. Starting from some previous sheet, one may forget to alter something needed for the new one.
- Deceleration can also be derived. Originally there has been a power model to this, that can be altered to constant deceleration near the end of luminous flight for meteorite falling cases.
- There is also a more new version that has the deceleration modeled by means of approximate analytical solution formula (Gritsevich, 2009). Practically, at the moment, this can be used only with mutually (internally in one station) timed obsevations, like video observations.

- The solution of single a single station meteor is in principle achieved from changing angular velocity (although this is not explicitely soved as such). Even though the geometry and deceleration both affect to this, these effetcs can at least to some degree been separated by the program, for long and accurate enough track. This is because the deceleration mainly affects near the end of luminous flight.
- The program has been in use in the Finnish Fireball Working Group since the year 2005. There are other programs in use for quick loookup, but if accurate results are hoped for and if the data may allow that, the entry is dealt with this fb_entry program.
- There has not been a count fof this, but more than a hundred bright meteor entries have been calculated with this, among them a number of abroad cases.
- Unfortunately no meteorites from these entries have been found. Some of these have been searched. The Finnish terrain is very unfavorable for meteorite search.

Program packages

- The program is in principle available to those interested.
- A zipped package can be downloaded from: http://lyytinen.name/esko/fb_entry_vers_1.zip This contains some example sheets, that are versions of actual cases and with detailed instructions.
- There are for example versions with the original (power) deceleration model and also versions with the approximate analytical velocity formula.
- The package will be updated with new versions in new update-pakages.
- The updates are expected to contain some different type cases with explanations, with different ”tricks” as examples.

Ref.time, zerc	2[illegible]	
Ventry	15.69847531	
"Head_X"	20.31453814	26.39099005
"Head_Y"	-39.48042408	62.14496022
"Head_Z"	0	
rad. az.	0.043558756	
rad. altitude	33.06667118	
Mikkeli	10.94093629	timing data unk
Mikkeli	16.70604208	
Pukinmäki fra	13.13062336	
	<- unknowns ->	
deceleration params. in two ways, below		
alpha	66.53332312	66.53332312
beta	0.386288321	0.386288321
deceleratic	5.67E-01	5.67E-05
deceleratio	4.940559489	

frame id	above s	station lon	latitude				(in Cartesian coordinate			azimuth	elevation	az. conv.	elev. c	Timing	"adj. timing to	
Pukinmäki, framedata							X	Y	Z						to modell dec.	
15	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.26934	9.385921	14.16891	11.68655882	13.12037397	13.12037395	0
16	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.3585	9.226084	14.25855	11.526621	13.15370697	13.15324674	0
17	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.42515	9.135777	14.32557	11.43623436	13.18703997	13.18609644	0
18														13.22037297	13.21892434	
21	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.4815	9.1768	14.3824	11.47718858	13.32037197	13.31733948	
22	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.47273	9.071256	14.37342	11.371655	13.35370497	13.35006914	0
23	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.45972	9.041937	14.36027	11.34235258	13.38703797	13.38277062	0
24	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.52205	9.027833	14.42304	11.32816986	13.42037097	13.41544282	0
25	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.5203	9.006722	14.42125	11.307061	13.45370397	13.4480842	
26	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.58512	8.895239	14.48638	11.19549427	13.48703697	13.48069317	0
37	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.76391	8.6287	14.66605	10.92870705	13.85369997	13.83901663	0
39	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.79239	8.58993	14.69468	10.88989609	13.92036597	13.90316015	0
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51	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.86565	8.067427	14.76762	10.36728419	14.32036197	14.2858048	0
52	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	13.96911	8.043748	14.87172	10.34344404	14.35369497	14.31687076	0
53	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.02772	7.987242	14.93062	10.28684354	14.38702797	14.34783302	0
54	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.04065	8.016568	14.94368	10.3161481	14.42036097	14.37870791	0
55	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.05186	8.024758	14.95497	10.32431987	14.45369397	14.4094943	0
56	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.08029	7.985929	14.98352	10.28544315	14.48702697	14.44019056	0
57	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.13113	7.963466	15.03465	10.26289473	14.52035997	14.47079502	0
58	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.19916	7.893958	15.103	10.19326875	14.55369297	14.50130589	0
59	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.17849	7.898726	15.0822	10.19807265	14.58702597	14.53172133	0
60	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.32996	7.691453	15.23425	9.990528783	14.62035897	14.56203936	0
61	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.34026	7.559829	15.24437	9.858885074	14.65369197	14.59225788	0
62	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.40993	7.511367	15.31437	9.810292503	14.68702497	14.62237466	0
63	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.379	7.647786	15.28351	9.946770119	14.72035797	14.6523873	0
67	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.46667	7.433558	15.3713	9.732374732	14.85368997	14.77201097	0
68	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.46667	7.433558	15.3713	9.732374732	14.88702297	14.80147201	0
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71	0.04	24.9887	60.25	3173	5514.4	3172.486	-56.002	-250.2	-5.111	14.46925	7.335992	15.3737	9.63480379	14.98702197	14.8890631	0

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