Searching for the parent of the Tunguska Cosmic Body
i.e.
searching for a needle in a haystack

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OCA, Nice, France

SeMeN 2007 CIECHOCINEK

Tunguska explosion - place and time

Time UT	1908 June 30, $0^h13^m35^s$	Pasechnik (1986)
Location (epicenter)	$60^o53'09''$ *N*, $101^o53'40''$ *E*	Fast (1967)

Tunguska explosion - data sources

Scientific expeditions

- Kulik Leonid. A.
- 1921 Kansk, map report
- 1927 Vanovara, maps
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- expeditions 1950-90
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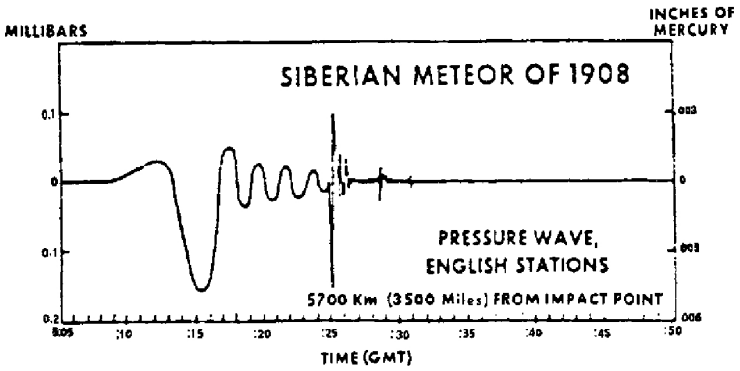

Objective and subjective data

- barometric registrations,
- seismic records,
- forest devastation,
- night sky twilights,
- eyewitnesses reports,
- no meteorite craters,
- no meteorites and micrometeorites.

TCB parameters

T, a, h, V_G

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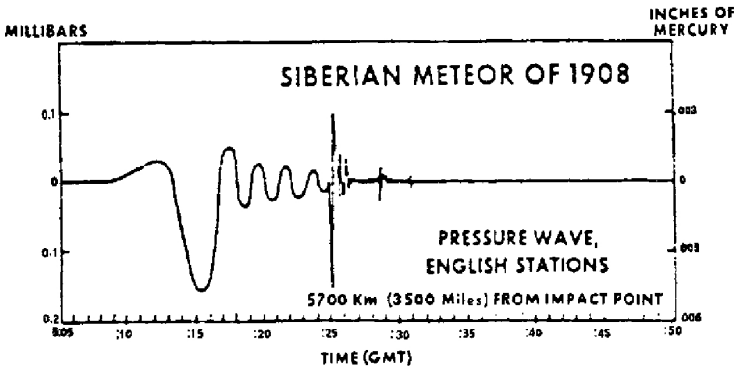

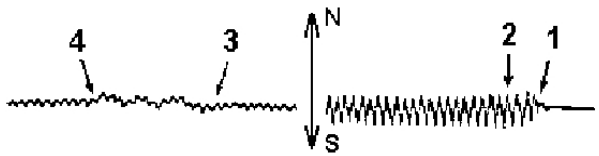

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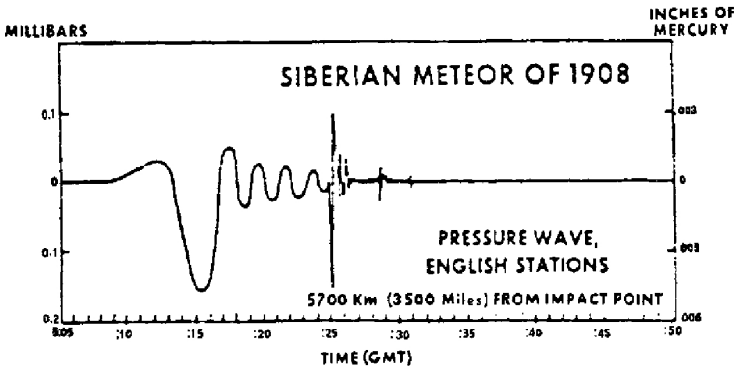

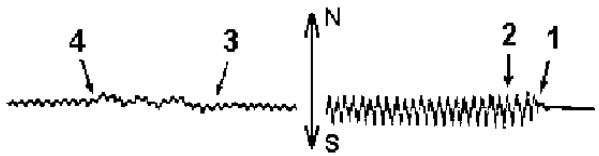

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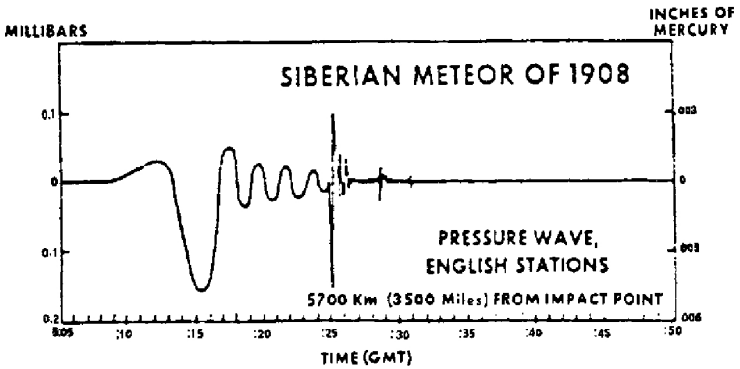

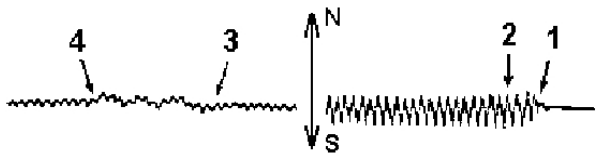

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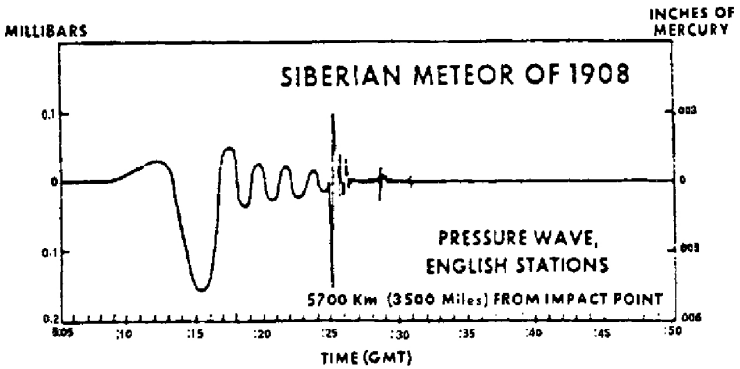

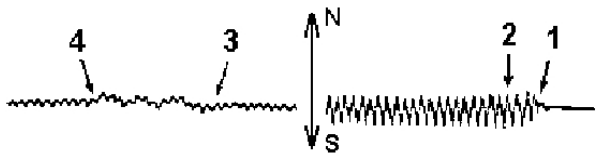

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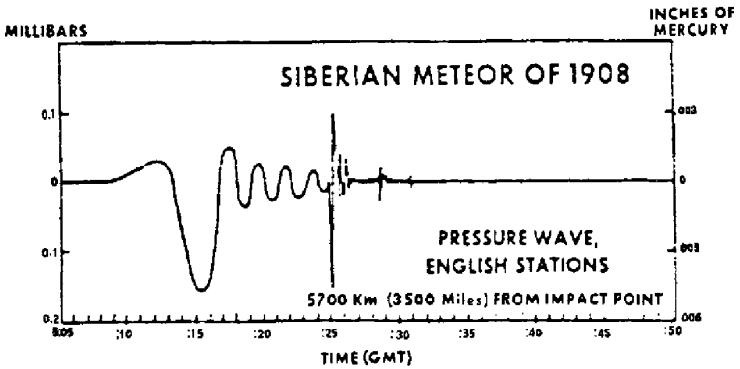

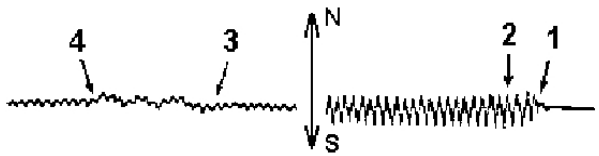

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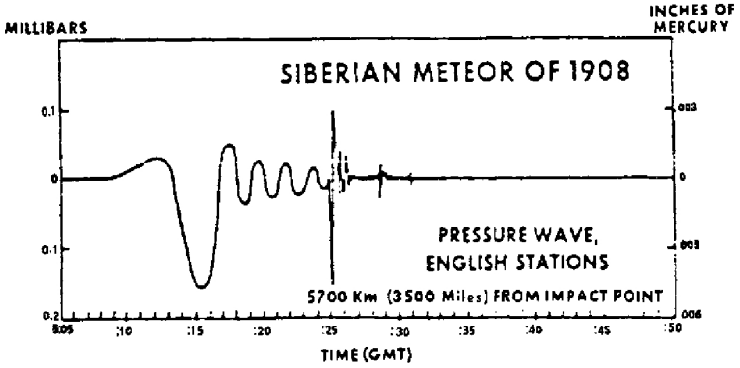

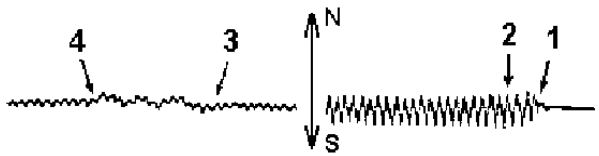

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Unknown nature of the Tunguska Cosmic Body

An asteroid!

- Sekanina (1983,1998),
- Andreev (1990),
- Chyba et al. (1993),
- Foscchini (1999),
- Farinella et al. (2001) — 83% TCB originated in the asteroid source.

A comet!

- in 1926, 1933 Kulik, in 1966 Fesenkov,
- Zotkin (1969), Kresak (1978)
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- Levin and Bronshten (1986), Bronshten (2000)
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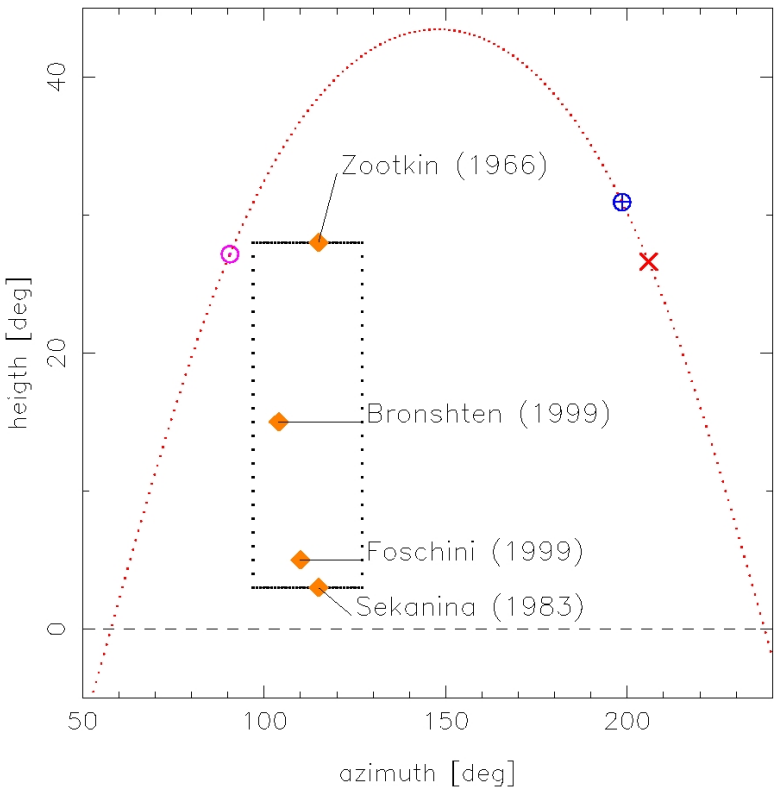

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$60^o53'09''$ N, $101^o53'40''$ E
$H = 8.5$ [km]
$a_{obs} \in (97, 127)$ [deg]
$h_{obs} \in (3, 28)$ [deg]
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TCB particles	3311
NEAs	2656
Comets	582

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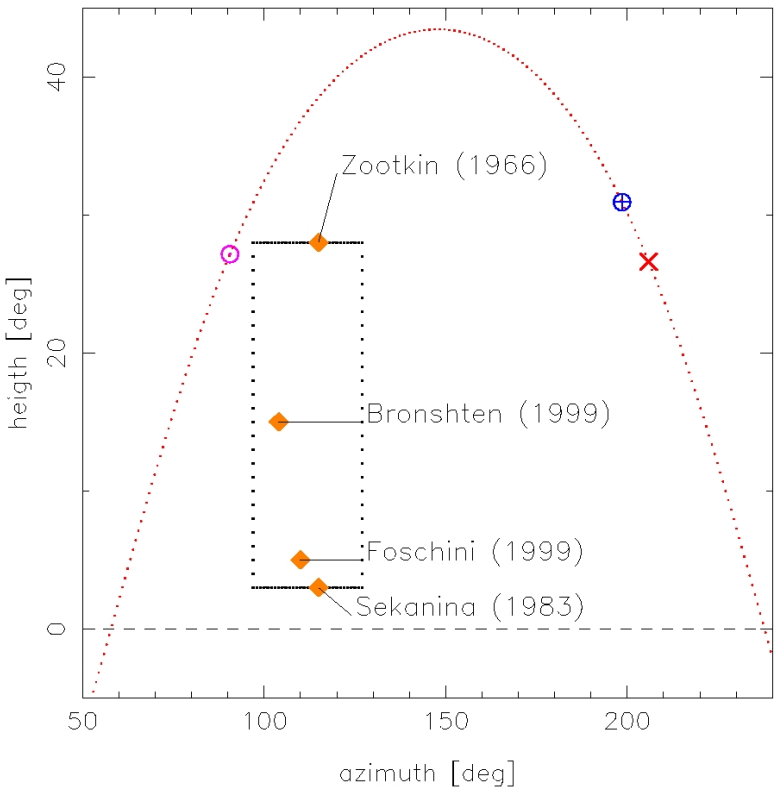

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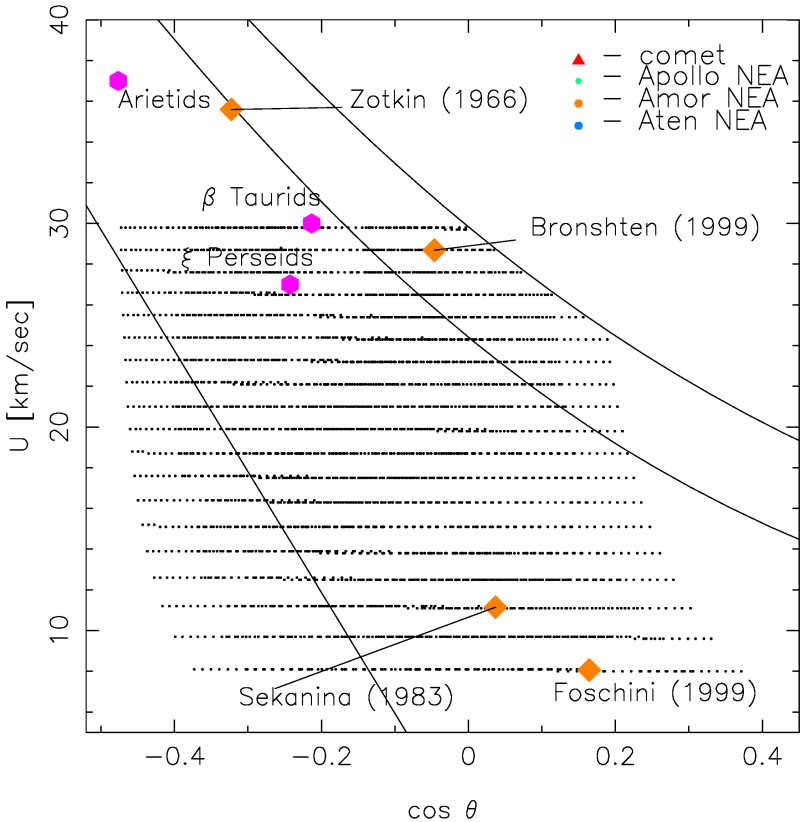

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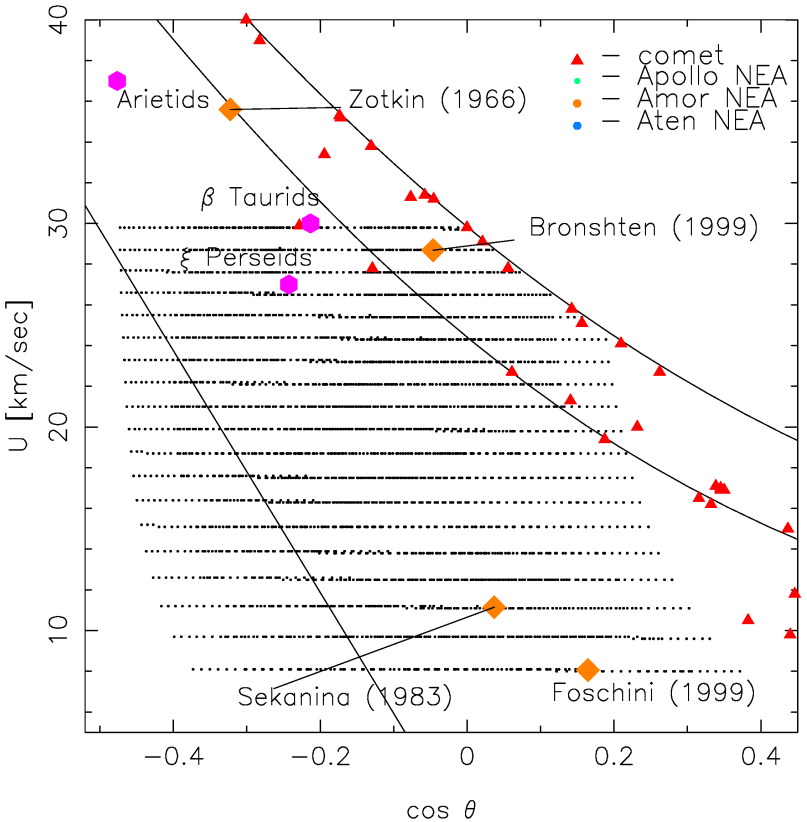

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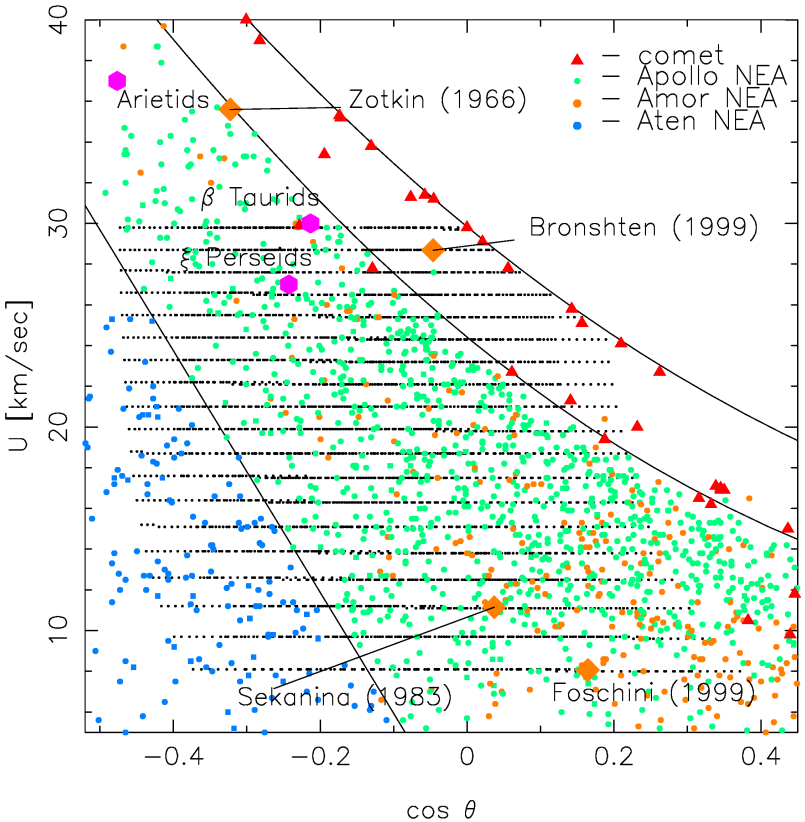

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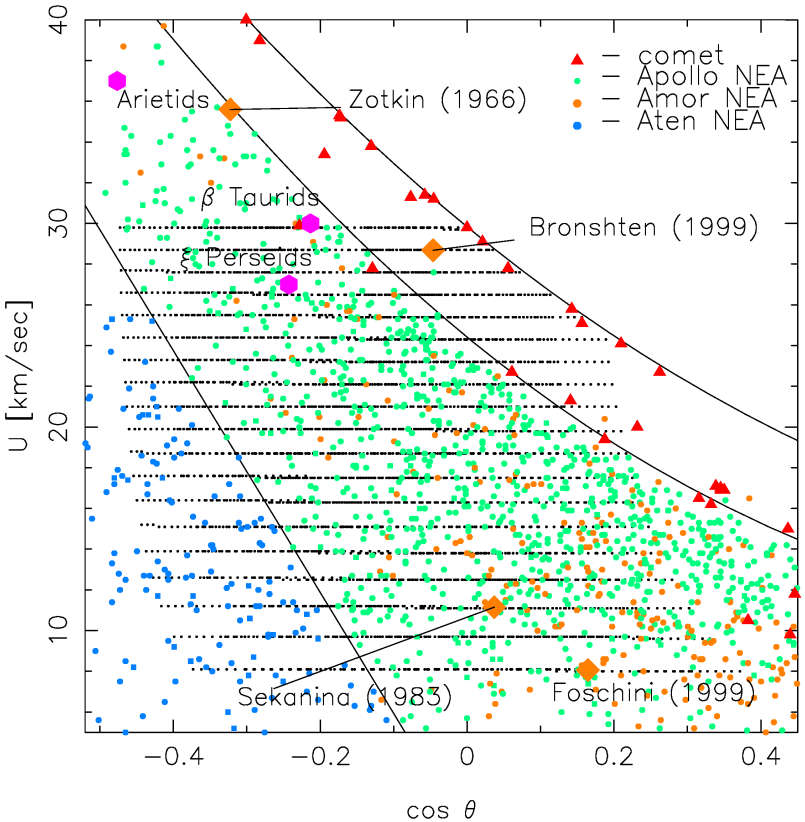

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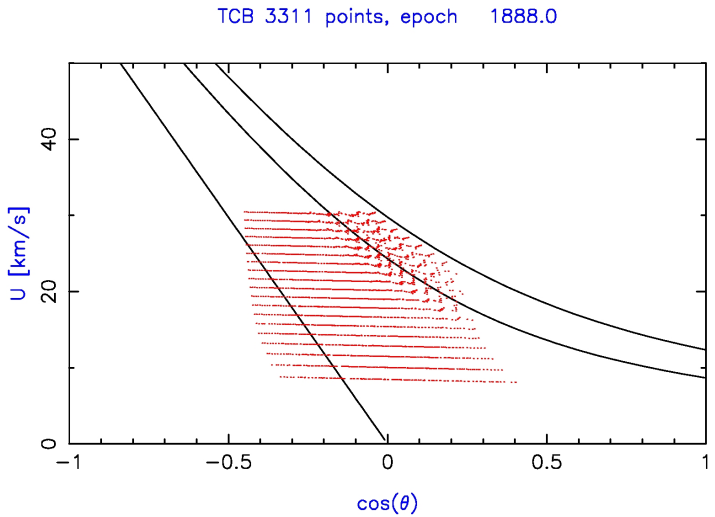

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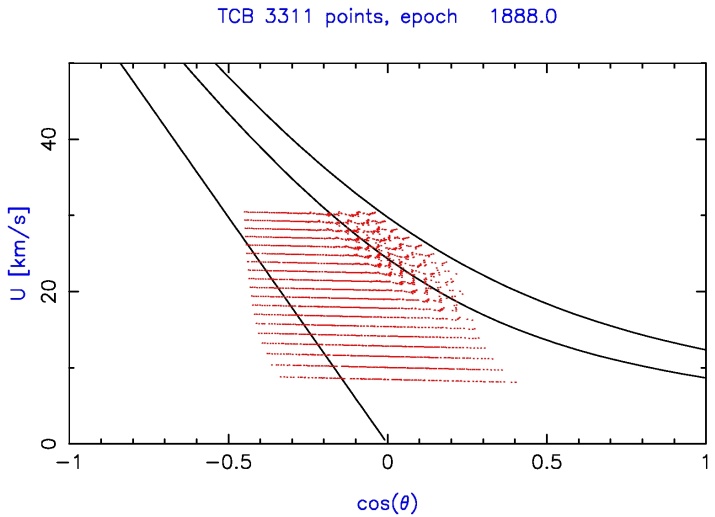

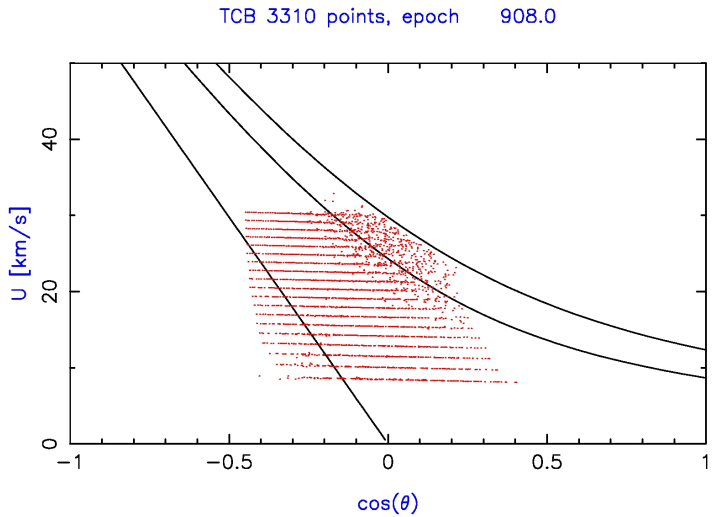

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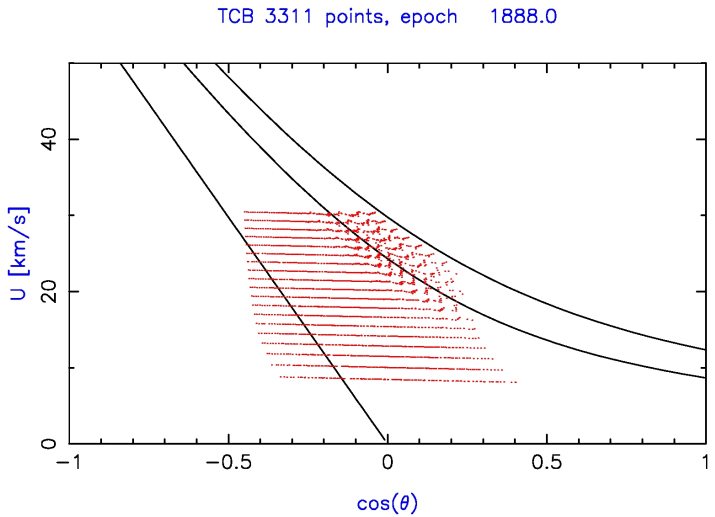

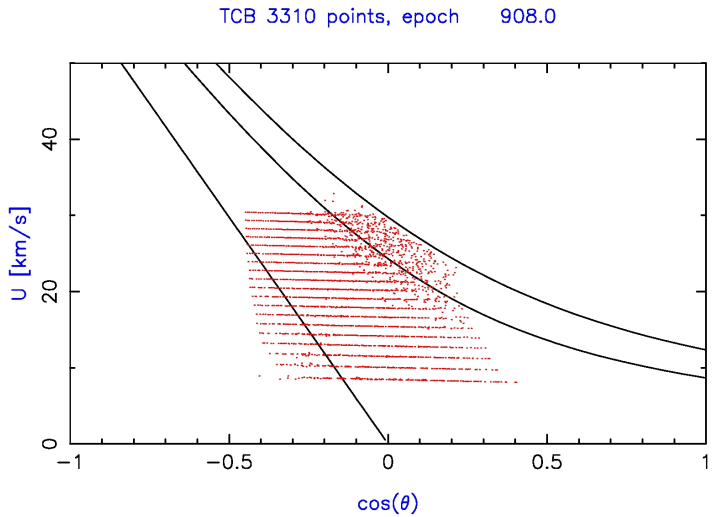

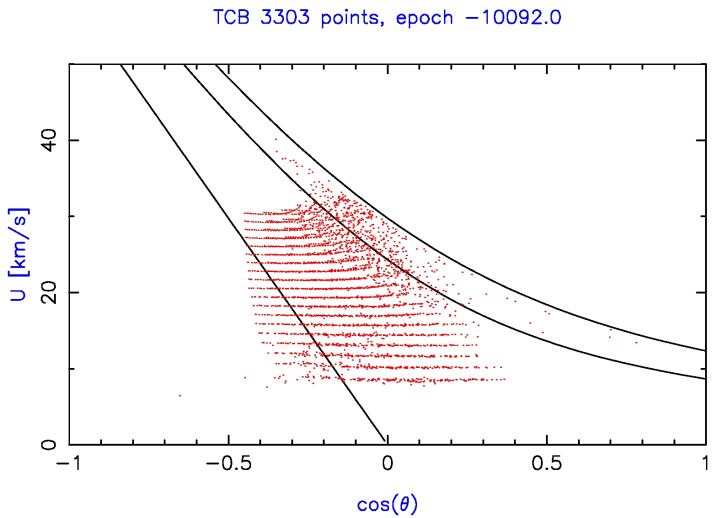

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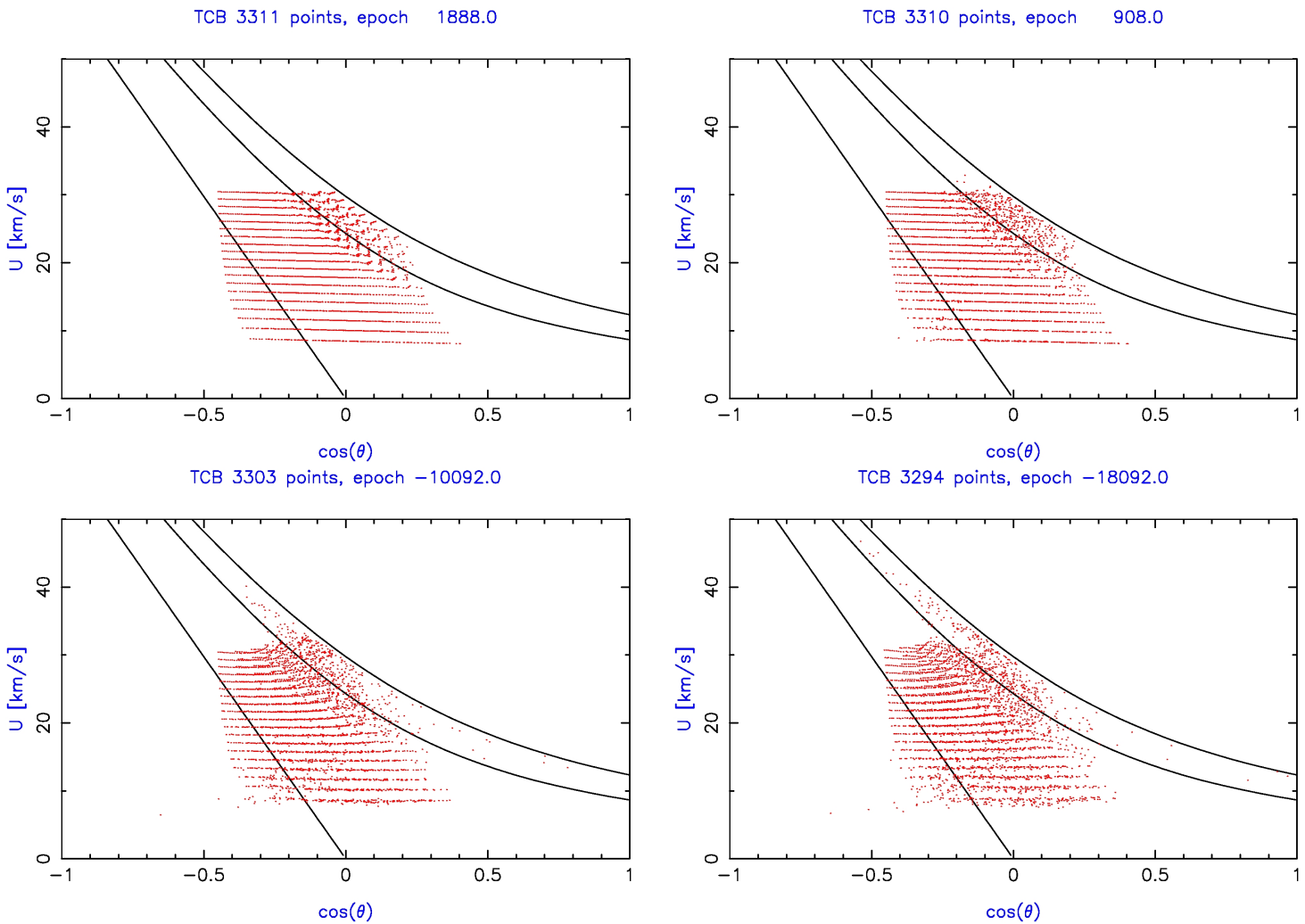

Searching strategy II

The method

The idea taken from the meteor stream searching technique:

- starting from AD 1908, all NEOs and TCBs were integrated for 20 Kyrs in the past,
- every 20 years we calculated: the D_{SH}-values amongst all TCB–NEO pairs and their MOIDs,
- all pairs with very small D_{SH}-values were analysed in details.

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Searching strategy II (2)

General results

- using similarity threshold D_c=0.2, we found 646 NEOs (31 comets) moved on the orbits similar to at least one of TCB particles,
- with D_c=0.1 only 129 NEOs (4 comets) moved at some epoch on the orbits similar to at least one of TCB particles,
- at each of 1000 intermediate epochs we always found an asteroid and TCB particle as similar as $D < 0.06$,
- the highest similarity ($D_{SH} = 0.0237$) we observed at 932 BC among 2000 WK 63 and TCB particle ($a = 97^o$, $h = 26^o$, $V = 26$ [km/s]).

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A hypothesis: TCB originated from 2P/Encke

- Yes! — Zotkin (1969) and Kresak(1978),
- No! — Sekanina (1983, 1998): $\Omega_E = 334.7 \neq \Omega_{TCB} = 279.1$
- Well?!? — Asher and Stell (1998): $\Omega_E \approx \Omega_{TCB}$

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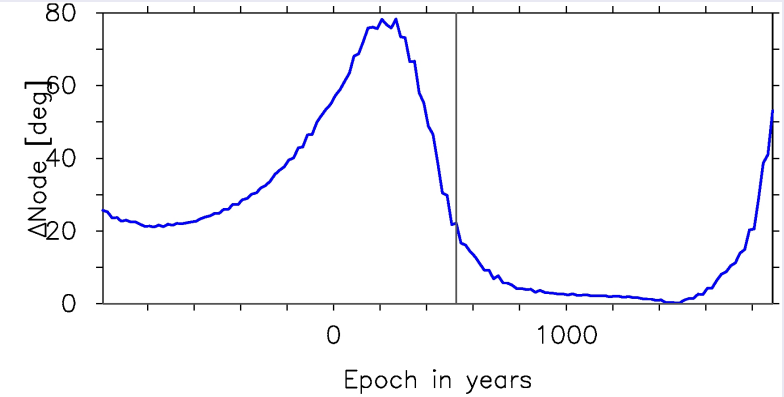

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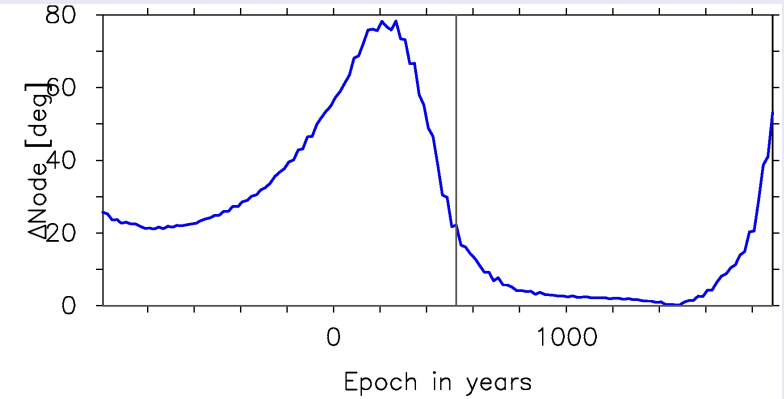

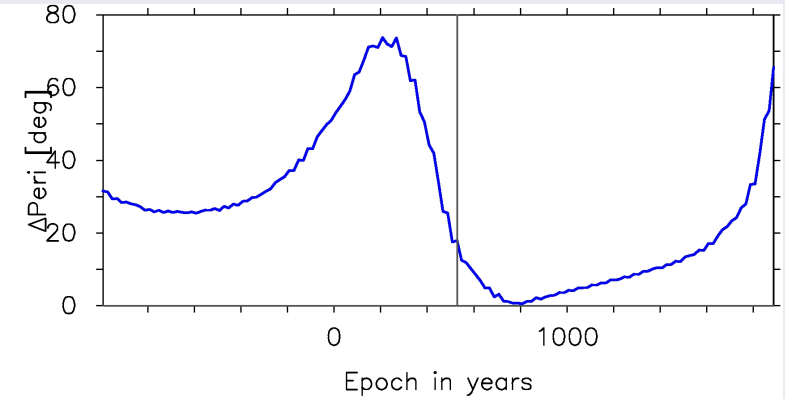

TCB and comet 2P/Encke (in continuo)

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- the closest similarity, D=0.1471 at 5812 BC,
- D=0.1490, (for the other particle) at 528 AD,
- for remaining 6 particles, D-values $\in (0.1787, 0.1969)$,
- for these 8 particles the radiant parameters: $a \in (97^o, 107^o)$, $h \in (26^o, 28^o)$, $V \in (27, 32)$ [km/s],
- considering tools applied in this study, the comet 2P/Encke is NOT related to TCB,
- Ω_{TCB} of the TCB orbits can be very similar to Ω_E of 2P/Encke, and such coincidence refutes Sekanina strictures.
- close similarities among remaining orbital elements (TCB and 2P/Encke) occurred at separate epochs.
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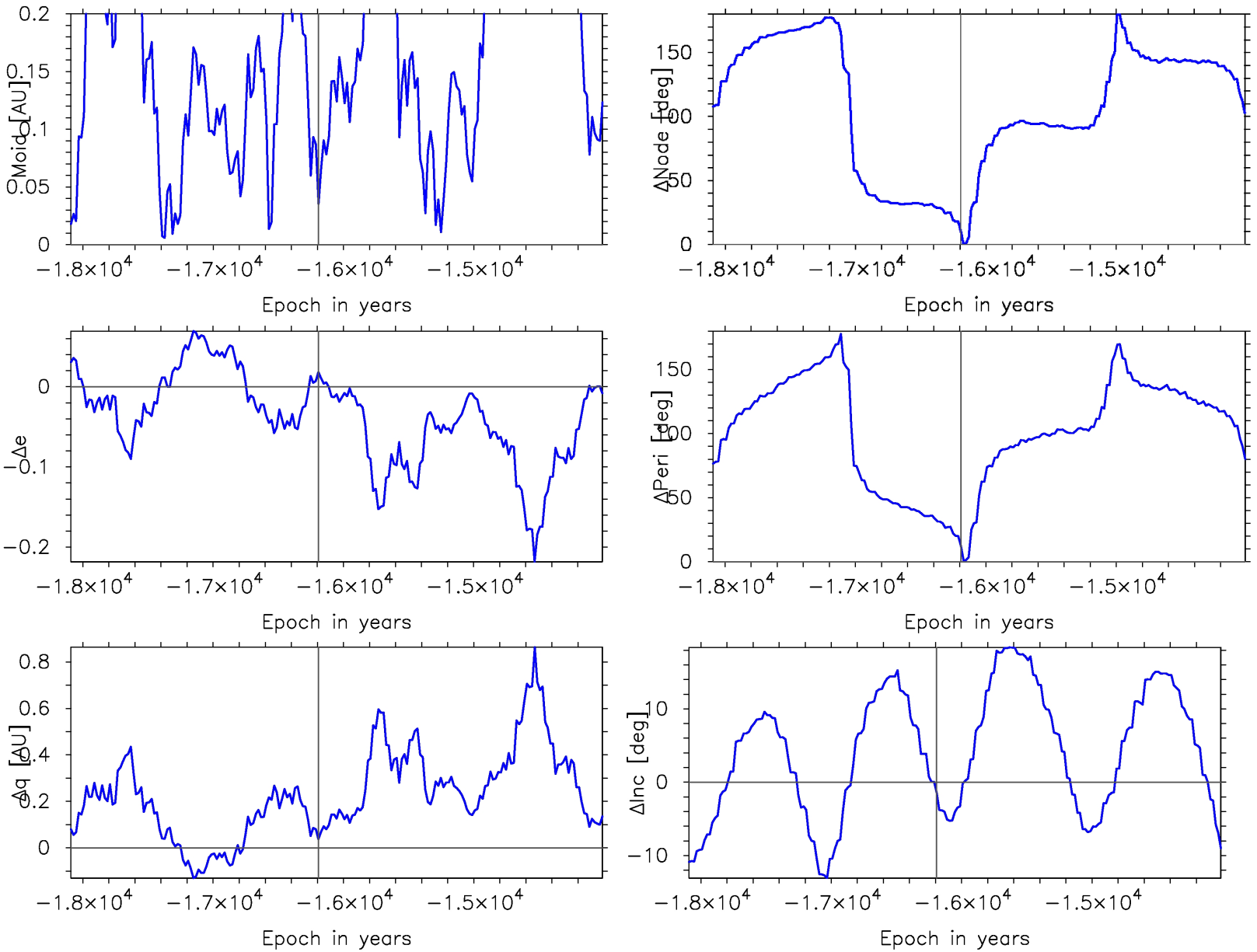
Very close similarity: TCB and comet 97P/1906



Asteroidal origin of the TCB

More cases of the close simllarity and a different pattern of similarity than in the case of comets.

- D_c=0.1 — 125 of the NEAs more similar to one of the TCB orbit than in the case of comet 2P/Encke,
- at each of 1000 intermediate epoches the smallest D-value always occurred amongst the NEA and TCB orbits (mostly $D < 0.05$),
- at 932 BC we found the minimum value D=0.0237 among 2000 WK63 and the TCB particle No 2207 ($a = 97^o$, $h = 26^o$, $v = 26$ km/s),
- at 632 BC the same object proved to be very similar (D=0.0306) to the particle No 2208 ($a = 97^o$, $h = 27^o$, $v = 26$ km/s),
- for the same pairs the high similarities maintained over several epochs, e.g. 2001 OY13 and particle No 375 ($a = 97^o$, $h = 13^o$, $V = 16$ [km/s]) moved on the orbits highly similar ($D \sim 0.045$) from AD 1888 till AD 1288.

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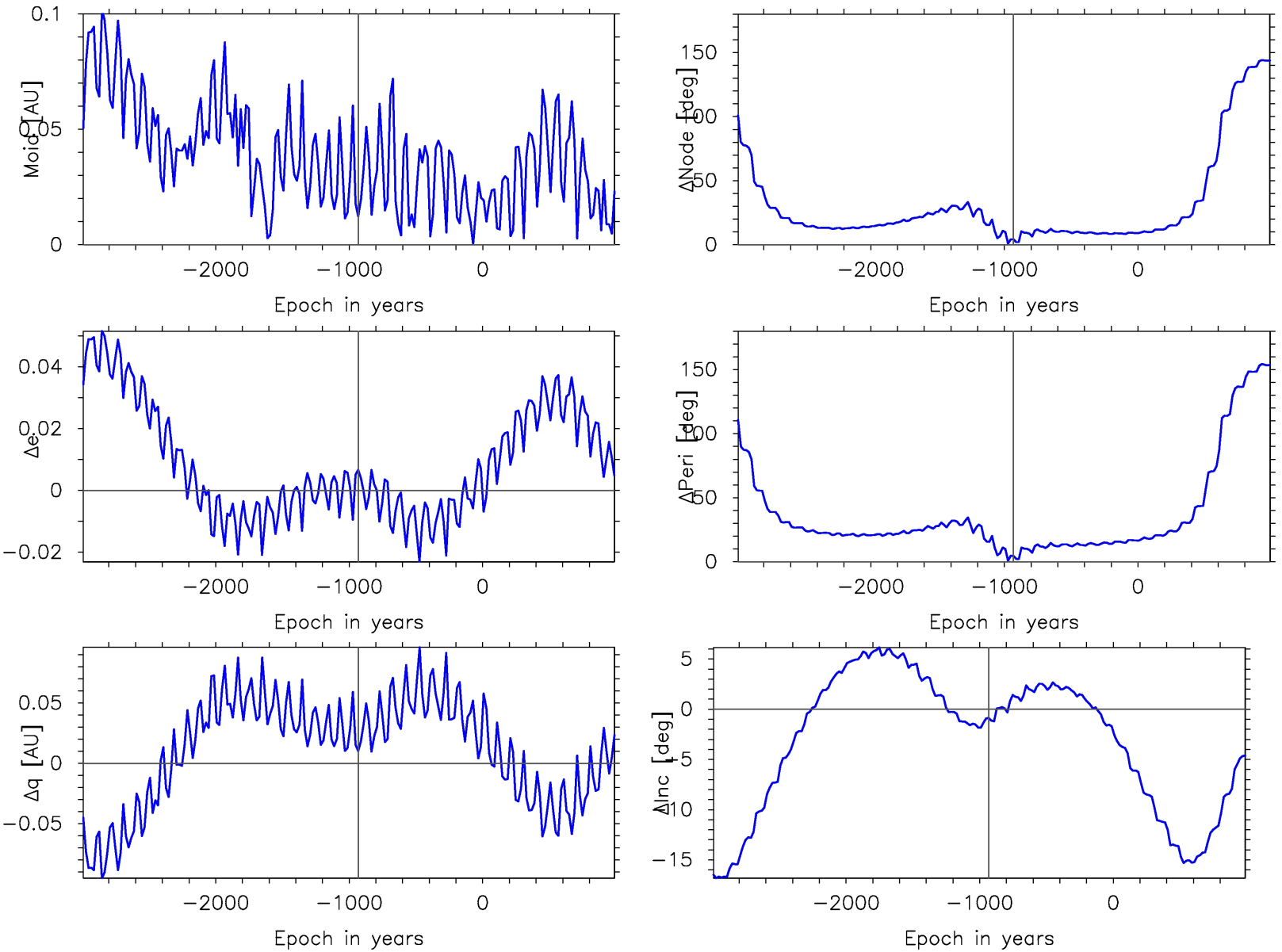
The case of closest similarity: TCB and asteroid 2000 WK 63



Conclusions

- the parent body of the Tunguska object was not found,
- instead, we have noticed, that between 1908 AD and 18 000 BC about 130 NEOs moved on the trajectories highly similar to some of the TCB orbits,
- very high orbital similarity occured more often for NEAs than for comets (125 to 4) and this result is in agreement with the paper Farinella et al. (2001),
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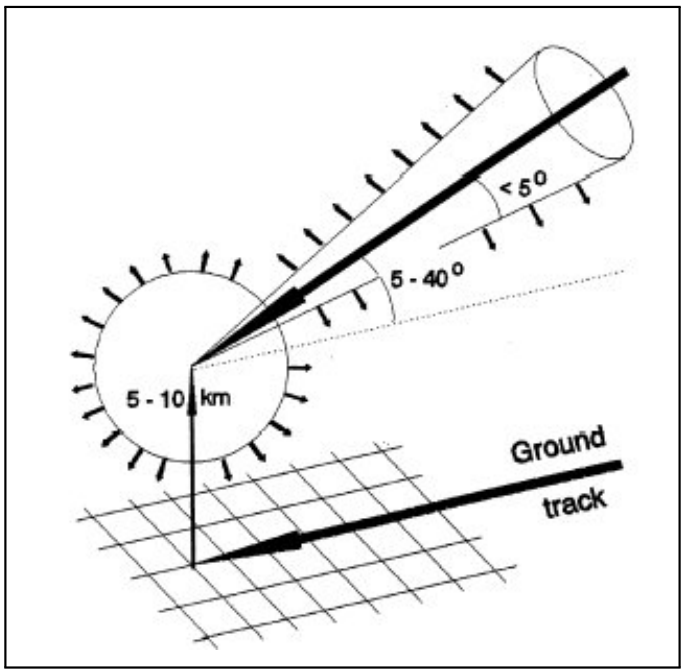
Searching for the parent of the Tunguska Cosmic Body
i.e.
searching for a needle in a haystack

Tadeusz J. Jopek, Christiane Froeschlé,
Robert Gonczi, Piotr A. Dybczyński

OA UAM, Poznań Poland
OCA, Nice, France

SeMeN 2007 CIECHOCINEK

Tunguska explosion - epicenter



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Tunguska explosion - data sources

Subjetive data: eyewitnesses reports

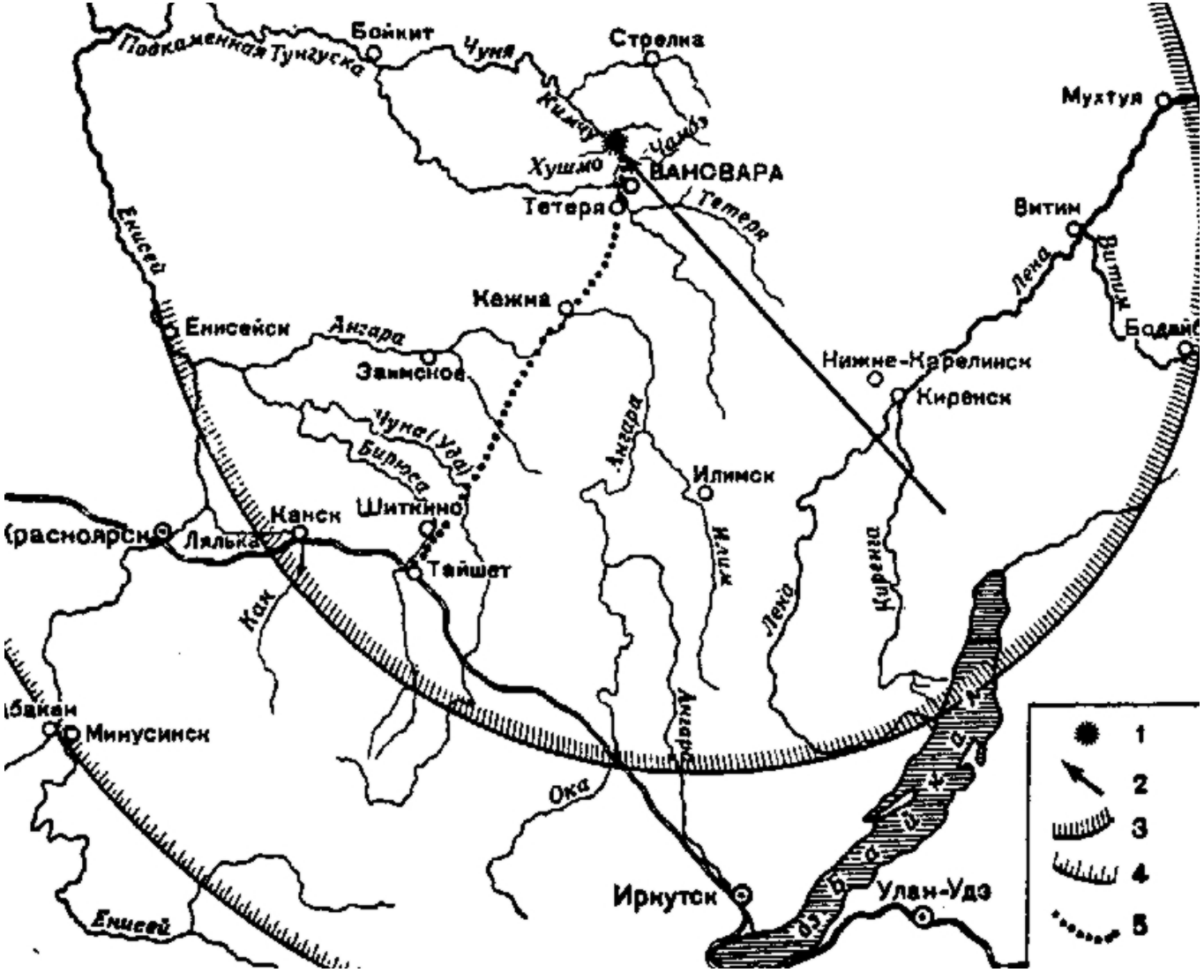
"On the History of the Bolide of 1908 June 30," by L. Kulik*

Translated by Lincoln La Paz *and* Gerhardt Wiens,
Departments of Mathematics and German, The Ohio State University

The agent of the intermediate station Philimonovo, I. I. Ilyinsky, questioned by the author at this station on the 4th of October, 1921, related the following: "I have served at the flagstation Philimonovo since 1910. Before that I was stationed at the siding Lyalka, 14 versts† to the east of the station Kansk, on the old railroad line. The phenomenon described in the calendar[5] did not happen when I was at Philimonovo, but [when I was] at the siding Lyalka. I, myself, was a witness of it. Just at the time of the fall I happened to be on duty and was on the platform awaiting the arrival of freight train No. 92 from Kansk. Suddenly I felt something like a strong vibration of the air and heard a rumbling sound. I became very much confused, thinking that this was an earthquake or some other natural phenomenon. Train No. 92 was at that time 1.5 versts from Lyalka. The locomotive engineer on No. 92, Gryasnov, was so frightened by the rumbling sound and the vibration of the air that he stopped the train, fearing that it was derailed, and, after arriving at the siding, he even proposed that the train be inspected to see whether an explosion of some of the freight might not have oc-

*Published originally in the *Journal of the Russian Academy of Sciences*, 1927 A, pp. 393-8; read by the Academician V. I. Vernadsky on April 20, 1927.
Translated from the Russian of L. Kulik by Gerhardt Wiens, Department of

Tunguska explosion - data sources



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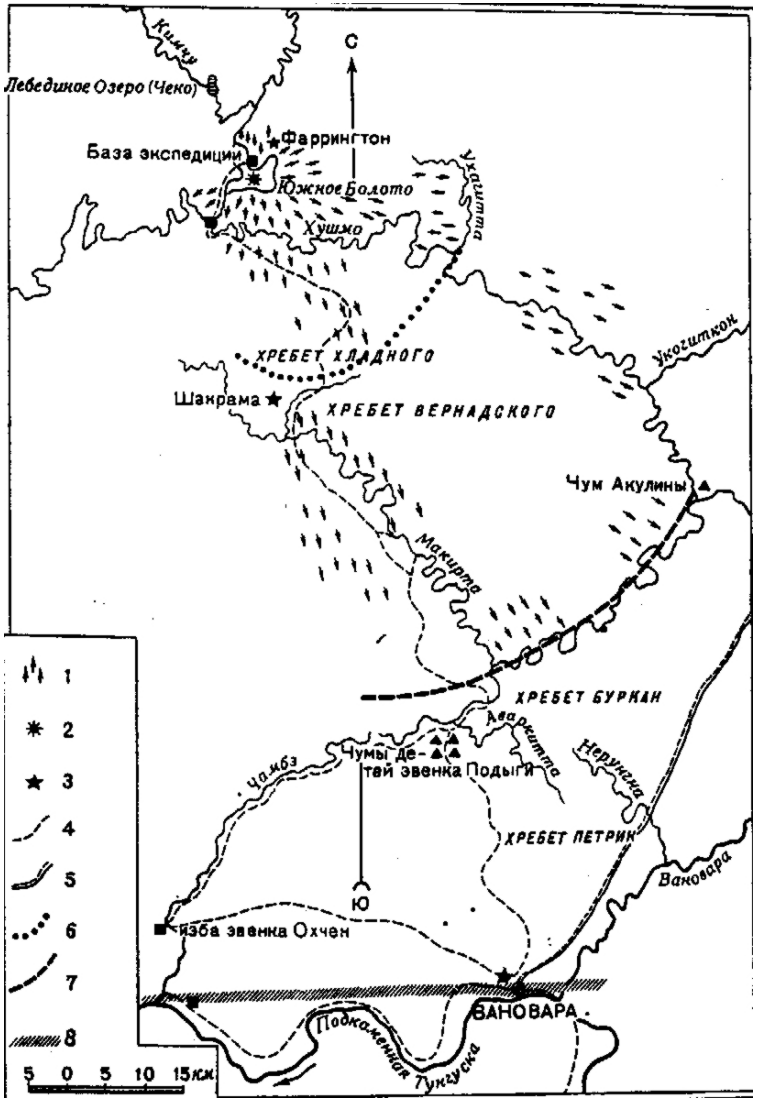

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