MICRO BLACK HOLES

NEUTRON STAR SAFETY ASSURANCE CONCERNS TO PARTICLE COLLIDER OPERATION OF TeV-SCALE P-P COLLISIONS

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Abstract

Astrophysical safety assurances based on White Dwarf (WD) longevity and Neutron Star (NS) longevity were proposed by Giddings and Mangano in the 2008 safety report [1] commissioned at CERN regarding the existential risks to Earth from hypothetical micro black holes (MBH) theorised as potentially creatable in Proton-Proton (P-P) collisions at the Large Hadron Collider (LHC) in the event that such TeV-scale MBH once produced would be stable. The WD safety assurance being stated as only applicable to MBH of dimensions D<8 and at no greater than 14 TeV energy levels, the NS safety assurance was therefore provided as the main astrophysical safety assurance (besides Hawking Radiation theory, and accretion estimates) outside these limits.

Amid suggestions in outsider-debate [2][3][4] that the process of Hawking Radiation (HR) theorised on such TeV-scale MBH may prove less effective in practice than in its mathematical model, a closer look at the NS assurance is reasoned herein. This short paper presents concerns regarding the NS safety assurance as a solitary safety assurance for MBH of greater dimensions, and/or for MBH created at greater energy levels (> 14 TeV) than of those which a solid WD safety assurance [3] can provide.

1. Introduction

The basis for the accepted NS safety assurance is the assertion that cosmic-ray (CR) to surface collisions on NS are analogous to P-P collisions at particle colliders, and that, unlike Earth, which can be modelled as unable to capture CR produced MBH due to high velocity unlike collider produced equivalents, NS can be assured of being capable of slowing and capturing MBH produced in such CR collisions. The continued existence of NS is seen as evidence that such hypothetical stable MBH are not produced, or are not dangerous if such are produced.

In considering such as a safety assurance, CR deflection was assessed in detail by Giddings and Mangano [1] due to the ultra-high magnetic field strengths associated with NS, and in doing so also considered both neutrino flux, and more elaborate scenarios of secondary MBH capture from production in binary pairs as alternatives.

Excluding the more elaborate circumstances of secondary MBH capture in binary pairs as over-elaborate, and assurances based on neutrino flux as based on unreliable data, only the hypothetical direct production of MBH on NS, from non-deflected CR impacts on the surface of NS, is reasoned here as a qualifiable safety assurance.

2. Magnetic Fields & Magnetic Deflection

Whereas a lower limit of a 100kG magnetic field strength for CR deflection was set as a criteria in determining safety assurance based on WD observation and measurement [3][1], higher upper limits are applicable [1] for determination of safety assurance based on NS observation and measurement, as magnetic field strength decreases proportional to radius R0 at distance r from a star (R0/r)^3, with NS requiring magnetic fields at 10^3 stronger for equivalent magnetic deflection, equating to a 10^8 G limit. Instead, as all known NS have far stronger magnetic fields, upwards from 10^8 G, a determination of maximum energy penetrable to a typical NS was determined (without error tolerance values provided), for perpendicular impingement of NS with lowest known field strengths, giving collisions just above the LHC CM energy, with other impingements less effective.

Some consideration in the safety report was also given to CR penetration of theorised weaker magnetic fields at the polar regions of NS, though such assurances cannot be supported with verifiable astrophysical measurement. Indeed, the basic structure can be considered multipolar which would dampen weakness at any specific pole [5].

It is also noted that a number of discrepancies in the safety report, regarding the use of uncorrected production rate figures in conclusions on NS safety assurance, have been highlighted in an 'outsider' independent study [4], to the effect that magnetic fields of all known NS are too strong for significant MBH production from direct CR.

It is reasonable to surmise that NS safety assurance based on direct impact of CR is less reliable than assurance based on WD observation and measurement, where magnetic field strengths are far weaker, of the order 1,000:1.

3. Consideration for Sub-Millisecond Pulsars

Pulsars – rapidly rotating highly magnetised neutron stars – have provided accurate references in our Universe due to their regularity and predictability, of which there are now over 2,000 pulsars observed and measured [8].

Each of these pulsars have been measured to have a very distinct and consistent Barycentric period, with periods in a range from several seconds to just over 1 millisecond [8], with older pulsars typically of shorter periods.

When one generates a plot of pulsar periods relative to the estimated age of such pulsars (Figure 1), there is a noticeable cut-off at approximately 1.5 milliseconds. In Appendix 1, pulsars are listed in ascending order of Barycentric period, in which it can be seen that there are in fact very few pulsars below 2 milliseconds, and none below 1 millisecond - with the lowest known pulsar measured at just under 1.4 milliseconds (0.00139595482s).

A secondary intrigue on this plot, is the knee at 10^8 years, with most pulsars beyond this limit surviving within binary pairs, and surviving at typically up two orders of magnitude lower Barycentric period.

It has been noted that most neutron star equations of state allow shorter periods, and it has been speculated [6] that the lack of such pulsars with P < 1.5 ms is caused by gravitational wave emission from R-mode instabilities.

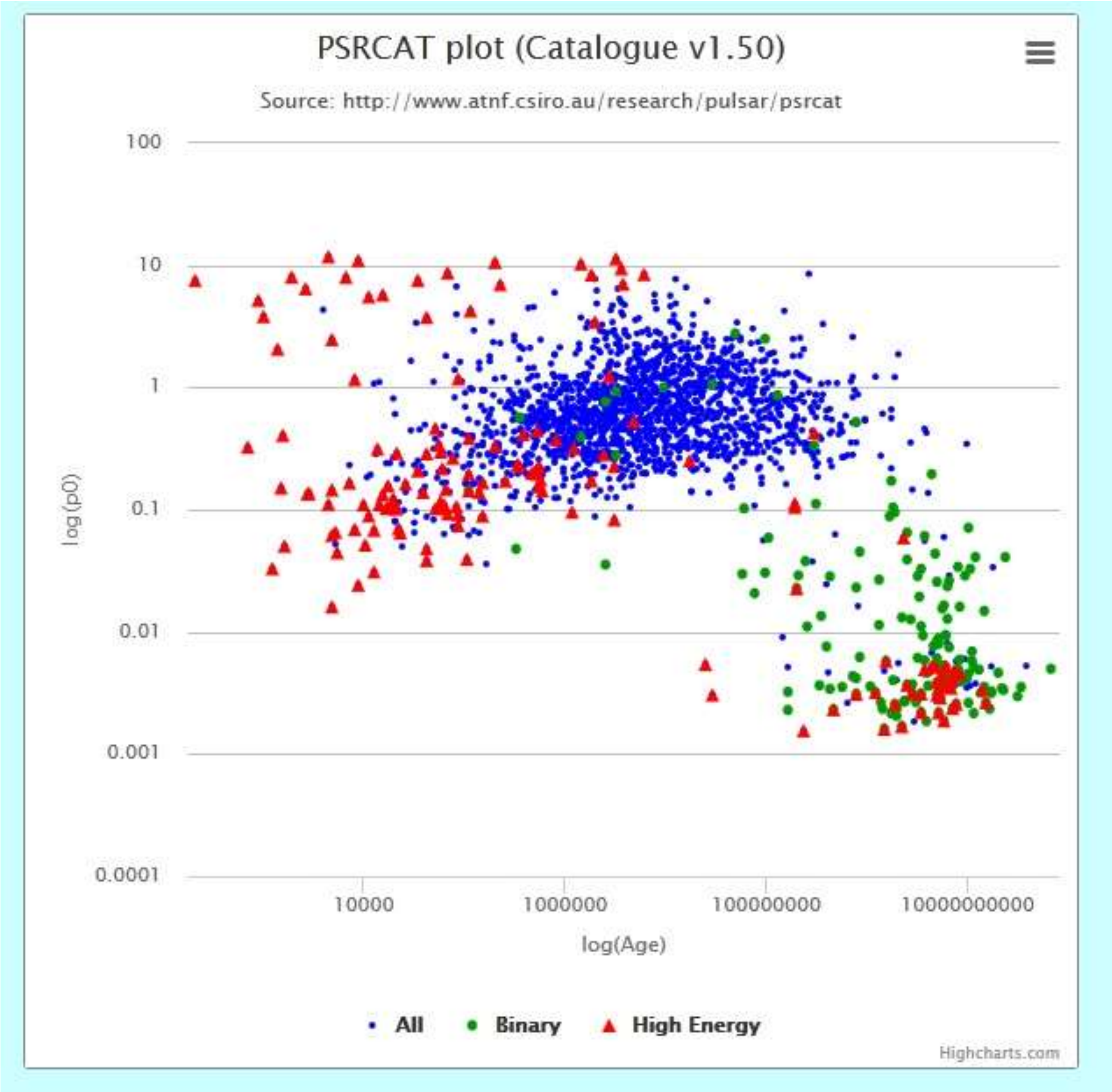

Figure 1: Generated plot of all known pulsars, illustrating Barycentric period (p0) vs estimated Age. Note the distinct lack of pulsars with sub-millisecond p0 periods.

However, if one considers the pulsar as a rotating magnetic dipole, then the surface magnetic field strength can be calculated [6] and can be derived relative to the Barycentric period, giving typical values of 10^12 – 10^8 G.

$$B \propto (P\dot{P})^{1/2}$$

As the existence of millisecond pulsars with 10^8 G fields were used as a safety assurance to LHC collisions, it is reasonable to consider the non-existence of sub-millisecond pulsars which would have fields lower than 10^8.

In the context of such safety assurances, one should consider a non-existence of sub-millisecond pulsars may be due to their lower magnetic fields, allowing for more significant MBH production from direct CR collisions. In other words – a non-existence of sub-millisecond pulsars could be considered observational evidence of not only the production of stable MBH on NS with lower order magnetic field strengths, but NS transformation into BH.

4. Conclusions

In consideration of the NS safety assurance of P-P collisions in the case of MBH of dimensions D>=8, and/or for MBH created at energy levels > 14 TeV, one finds that not only are there discrepancies in safety assurance, but observational evidence suggesting stable MBH might be created from comparable astrophysical processes.

However, other explanations for the absence of observable sub millisecond pulsars are latent, and orthogonal safety assurances also remain in both Hawking Radiation theory and in G&M accretion estimates of stable BH.

Indeed, it has been noted [9] that as pulsars approach 1.0ms rotation, the speed of rotation at the equator would be approximately 60,000km/s (given pulsar radii of the order of 10km), and before reducing to 0.1ms, a pulsar would require an equatorial velocity close to the speed of light. As such it is surmised that it would not be realistic to expect to observe pulsars below 0.5ms, with an equatorial velocity 1/3 of the speed of light, nor perhaps any sub-millisecond pulsars. However, this does not consider relativistic effects. Frame dragging, or Lense-Thirring effects, similar to the processes theorised within the ergosphere of rotating BH, may resolve this.

In the context of the above stated orthogonal safety assurances, a cut-off point on observable pulsars should not be alarming, though the cut-off point at this lower threshold is in need of an analysis for statistical significance.

ABBREVIATIONS & ACRONYMS:

ATNF	Australia Telescope National Facility
BH	Black Hole
CERN	Organisation européenne pour la recherche nucléaire (European Organisation for Nuclear Research)
CM	Centre of Mass
CR	Cosmic Ray(s)
D	Dimension(s)
G	Gauss
HR	Hawking Radiation
LHC	Large Hadron Collider
MBH	Micro Black Hole
NS	Neutron Star
P	Barycentric Period
P-P	Proton-Proton (i.e. Proton-to-Proton Collisions)
TeV	Tera Electron-Volt
WD	White Dwarf

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[7] Consideration for sub-millisecond pulsars – or the lack thereof . Kerwick. 2012. http://lifeboat.com/blog/2012/05/consideration-for-sub-millisecond-pulsars-or-the-lack-thereof

[8] Australia Telescope National Facility Pulsar Catalogue 2014 http://www.atnf.csiro.au/research/pulsar/psrcat/

[9] Email discussion with The LHC Safety Assessment Group (LSAG) at CERN, September 2014.

Appendix 1: List in ascending order of pulsars with shortest periods P0 (source: ATNF)

#	P0 (s)			P1_I
1	0.00139595482	6	hrs+06	*
2	0.001557806472448817	3	cbl+95	1.05e-19
3	0.00160740168480632	3	aft94	1.13e-20
4	0.00165	0	kcj+12	*
5	0.00166	0	hrm+11	*
6	0.00167663	0	rhs+05	*
7	0.0016879874440059	4	asr+09	1.02e-20
8	0.00172862	0	rhs+05	*
9	0.00174	0	kcj+12	*
10	0.00184	0	rap+12	*
11	0.0018456662924246	5	hfs+04	*
12	0.001855732795729	11	cls+13	*
13	0.0018771818845850	2	aaa+10b	5.36e-22
14	0.00204816	0	rhs+05	*
15	0.0020569603924157	6	nbb+14	1.59e-20
16	0.00207251	0	rhs+05	*
17	0.00210063354535247	3	fck+03	-1.06e-20
18	0.00214991236434921	5	fbw+11	1.78e-20
19	0.00215928839043292	5	brr+13	*
20	0.002166	1	hrs+07	*
21	0.0021866997715528	15	kjr+11	*
22	0.00219469577985001	7	nbb+14	9.59e-21
23	0.00219666	0	fre08	*
24	0.00219780	0	rhs+05	*
25	0.00224470	0	rhs+05	*
26	0.00229	0	hrm+11	*
27	0.0022947270806719	29	lfrj12	*
28	0.0023230904678309	17	hlk+04	7.60e-20
29	0.00233851444011854	4	nbb+14	2.07e-21
30	0.00234455954688568	11	nbb+14	2.45e-20
31	0.002352344	1	clf+00	*
32	0.00237987896026	4	gfc+12	4.13e-21
33	0.00238	0	rap+12	*
34	0.002389420757786	1	hrs+07	*
35	0.00241	0	hrm+11	*
36	0.00244	0	kcj+12	*
37	0.002451	0	fre08	*
38	0.00246259	0	fre08	*
39	0.002484	1	hrs+07	*
40	0.002487	1	hrs+07	*
41	0.002545	1	hrs+07	*
42	0.0025603710316720	3	pgf+12	*
43	0.0025731519721683	2	kcj+12	4.05e-21
44	0.0026056722466	1	lr11	*
45	0.00261	0	hrm+11	*

46	0.00262357935251098	14	fck+03	6.37e-20
47	0.0026303807397848	8	lfl+06	*
48	0.0026433432972417	3	fck+03	2.96e-20
49	0.0026521296710897	4	bgc+13	2.19e-21
50	0.00266059331683918	7	nbb+14	*
51	0.0026779231971205	2	blr+13	-1.20e-19
52	0.0027191120623197	3	bbb+13	*
53	0.00272	0	rap+12	*
54	0.00273	0	rap+12	*
55	0.00273258863244	9	rsa+14	*
56	0.002812	0	rhs+05	*
57	0.0028304059578772	5	fck+03	*
58	0.002896215815562	2	cgj+11	*
59	0.0029471080681076401	9	vbc+09	1.61e-21
60	0.00296	0	hrm+11	*
61	0.00296965	0	rhs+05	*
62	0.0029778192947556	5	wdk+00	-1.54e-21
63	0.002988	1	hrs+07	*
64	0.00299926	0	fre08	*
65	0.003020060260978	59	lfrj12	*
66	0.00305	0	hrm+11	*
67	0.0030539543462594	4	fck+03	-2.33e-20
68	0.003054315552978	6	vbc+09	1.62e-18
69	0.003059448798020229	30	lfrj12	*
70	0.00306184408653189	4	vbc+09	8.82e-21
71	0.00308	0	rap+12	*
72	0.0030842332007	2	rsm+13	*
73	0.00310221391893416	16	nbb+14	5.85e-20
74	0.003118	1	hrs+07	*
75	0.003119226579079	4	rrc+11	*
76	0.003148669579439	9	rrc+11	*
77	0.0031508076534271	6	dpr+10	-3.87e-21
78	0.00316	0	hrm+11	*
79	0.00316331581791380	2	llww05	1.63e-21
80	0.003170139227806	2	bck+13	*
81	0.003182	1	hrs+07	*
82	0.00319294082	1	hrs+07	*
83	0.0032	0	ksr+12	*
84	0.00321	0	rap+12	*
85	0.0032103407093484	5	fck+03	-3.05e-21
86	0.003232273969155	4	lrfs11	*
87	0.0032337373331158	65	lfrj12	*
88	0.00326618657079054	9	cbp+12	2.05e-21
89	0.00328914	0	fre08	*
90	0.00329	0	hrm+11	*
91	0.00330434	0	fre08	*
92	0.00332	0	rap+12	*
93	0.0033543360829062	1	lrfs11	*
94	0.00339270965933	4	kjr+11	*
95	0.0034177704450548	17	lfrj12	*

96	0.0034452510710225	2	cnt96	1.51e-21
97	0.0034787707831873l	3	nss+05	7.66e-21
98	0.003480463	1	clf+00	*
99	0.0034849920616611	5	fck+03	-4.72e-20
100	0.0034966337827001 6	19	jsb+10	2.90e-21
101	0.003528072	5	and92	*
102	0.0035363291527603l	13	fck+03	9.69e-20
103	0.003539375658423	3	lfl+06	*
104	0.003543431438847	1	jbo+07	*
105	0.003559763768043	6	csl+12	*
106	0.00356957	0	rhs+05	*
107	0.0035752886188471 2	12	bbb+13	*
108	0.00359	0	kcj+12	*
109	0.0035938521270515	34	lfrj12	*
110	0.0035979285086554 7	3	vbc+09	8.42e-21
111	0.00360	0	rap+12	*
112	0.0036	0	dsm+13	*
113	0.003617993078111	7	csl+12	*
114	0.003618524251059	2	fhn+05	*
115	0.0036250966601209	18	lfl+06	-4.09e-21
116	0.0036257455713977	5	tsb+99	6.25e-21
117	0.00363	0	rap+12	*
118	0.003643021	1	clf+00	*
119	0.00365032889720	1	dpm+01	*
120	0.00365859	0	fre08	*
121	0.0036766432175977	10	fck+03	*
122	0.003683878711077	3	rrc+11	-2.11e-20
123	0.00372	0	mlb+12	*
124	0.003722	1	hrs+07	*
125	0.0037263484829664 1	5	vbc+09	2.02e-20
126	0.00373869966067	2	lrfs11	*
127	0.0037471544	6	jbo+07	*
128	0.00377	0	hrm+11	*
129	0.0037844047882356	3	gsf+11	4.08e-21
130	0.0037851238	4	kek+13	*
131	0.0037881555196130 3	52	lbr+13	4.04e-21
132	0.003793629114948	3	frb+08	*
133	0.0038613247042986	6	bjd+06	3.36e-21
134	0.003889	0	drr11	*
135	0.0039148731963690	6	sfl+05	*
136	0.003931852642	2	pfb+13	*
137	0.0039345240803312 4	11	nss01	2.56e-21
138	0.00402704270710	15	and92	*
139	0.0040331811845700	5	fck+03	*
140	0.004039	0	fre08	*
141	0.0040403791435629	4	fck+03	-4.34e-20
142	0.0040745459408540 22	9	vbc+09	7.10e-21
143	0.0040917973814561 6	3	gsf+11	8.53e-21
144	0.0041	0	dsm+13	*
145	0.004100	0	fre08	*
146	0.0041105439567658	12	bbb+13	*

147	0.004159	0	fre08	*
148	0.0041750173128551	8	blr+13	*
149	0.004185543936664	3	csl+12	*
150	0.0041861772028408 9	25	lfrj12	*
151	0.004200101791882	7	lcm13	*
152	0.00420518	0	rhs+05	*
153	0.004226532003547	3	lrfs11	*
154	0.00423	0	rap+12	*
155	0.00429	0	rap+12	*
156	0.00430	1	fsk+04	*
157	0.0043428266963896	4	fck+03	9.33e-20
158	0.0043461679994601	14	fck+03	*
159	0.00439	0	rap+12	*
160	0.004394	0	fre08	*
161	0.004397	0	fre08	*
162	0.00444803	0	fre08	*
163	0.004461	0	fre08	*
164	0.0045051589484591	7	nbb+14	1.02e-20
165	0.0045086417449716	2	dlk+01	1.23e-20
166	0.004553527919736	4	bbb+13	*
167	0.004554	0	fre08	*
168	0.00457013652508278 2	7	sns+05	8.07e-21
169	0.004571765939750	2	cpl+06	*
170	0.0046216415169981 8	15	vbc+09	1.82e-20
171	0.0046259624652639	15	lfl+06	*
172	0.004629	0	fre08	*
173	0.0046311962778409	2	lwf+04	1.48e-21
174	0.00465143521539	13	and92	*
175	0.00471398	0	rhs+05	*
176	0.004771	0	fre08	*
177	0.004791822704	3	mlb+12	*
178	0.0048028043457	3	and92	*
179	0.0048084282098381	4	nt95	4.11e-21
180	0.004810	1	clf+00	*
181	0.00484	0	rap+12	*
182	0.004850	0	fre08	*
183	0.0048654532073692	3	aaa+09e	1.01e-20
184	0.0048727658629793	17	dfc+12	8.11e-21
185	0.004888	1	hrs+07	*
186	0.004909239016418	5	csl+12	*
187	0.00492589	0	rhs+05	*
188	0.0049311149407398 8	5	vbc+09	1.07e-20
189	0.00496515	0	fre08	*
190	0.0049835839405651 1	3	gsf+11	8.44e-21
191	0.004990575114114	3	frg07	*
192	0.00502854	0	rhs+05	*
193	0.00507	0	rap+12	*
194	0.00508691	0	fre08	*
195	0.005116387644239	12	eklk13	*
196	0.00511971	0	fre08	*
197	0.005139936774902	4	frb+08	*

198	0.005162204637121	4	vbc+09	-3.41e-21
199	0.0051852019041260	3	clm+05	9.58e-21
200	0.005192324646411	7	cgj+11	*
201	0.005223271015190	1	jbo+07	*
202	0.0052415662037958	29	lfrj12	*
203	0.00525574901411968	12	lcw+01	1.14e-20
204	0.0052773269323093	15	cpl+06	-3.07e-23
205	0.00531255028907845	9	vbc+09	*
206	0.00535757328486266	18	fck+03	-4.48e-21
207	0.005362	0	vbc+09	1.74e-20
208	0.005384325706188	9	fhn+05	*
209	0.00542	0	fre08	*
210	0.0054400041632727	31	lfrj12	*
211	0.00544297516	6	hrs+07	*
212	0.005471	1	fsk+04	*
213	0.00549096850013900	13	vbc+09	8.74e-21
214	0.00554014	0	rhs+05	*
215	0.00555	0	rb13	*
216	0.005553592524205	2	awkp97	*
217	0.00575677999551320	17	fck+03	-5.20e-20
218	0.005757451924362137	99	vbv+08	1.37e-20
219	0.00578804	0	fre08	*
220	0.0057901517700238	5	nbb+14	5.17e-21
221	0.0057923027349664	4	lmcs07	1.09e-20
222	0.005840	0	fre08	*
223	0.00585	0	rap+12	*
224	0.0058500957646929	6	jac04a	2.28e-20
225	0.005909	0	fre08	*
226	0.0059489575348502	6	spl04	8.02e-21
227	0.0060006034432179	19	eb01b	*
228	0.006074542086503	6	frb+08	*
229	0.00611664	0	rhs+05	*
230	0.0061331665102401	8	gsf+11	2.83e-20
231	0.00621853194840048	3	kw03	3.05e-20
232	0.006226932720487	3	frb+08	*
233	0.006284	1	fsk+04	*
234	0.006547	0	fre08	*
235	0.0067433942397	3	and92	*
236	0.006907549392921	3	bbb+13	*
237	0.00708491	0	rhs+05	*
238	0.00709	0	hrm+11	*
239	0.007101	0	dpm+01a	*
240	0.0071756146066706	8	lrfs11	*
241	0.007453584373467	3	nbb+14	-1.71e-20
242	0.00747422422621133	12	vbc+09	1.74e-20
243	0.007588479807364	5	fck+03	*
244	0.0076128487111379	68	lfrj12	*
245	0.00762	0	hrm+11	*
246	0.00764587288390884	4	jsb+10	2.35e-20
247	0.00780	0	mlb+12	*
248	0.007946940657879	21	awkp97	*

249	0.007987204796261	4	hlk+04	1.57e-20
250	0.00812279804398456	14	vbc+09	*
251	0.008357798500844	2	cpl+06	*
252	0.0084360953044	1	lmbm00	*
253	0.00848628211574	6	nbb+14	*
254	0.00866690	0	rhs+05	*
255	0.008869961227277	4	eb01b	*
256	0.009035285247765	4	cpl+06	*
257	0.009343030685703	7	hlk+04	*
258	0.009347972210248	7	clm+01	*
259	0.009423406717798	17	nbb+14	1.24e-20
260	0.00957019	0	rhs+05	*
261	0.00968	0	mlb+12	*
262	0.009684273	2	kek+13	*
263	0.0099	0	dsm+13	*