

# Report: comparison of 9 global optimization methods on several test problems classes

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## 1 List of the algorithms

- Algorithm of global search (AGS) ([https://github.com/sovrasov/ags\\_nlp\\_solver](https://github.com/sovrasov/ags_nlp_solver))
- Multi Level Single Linkage (MLSL) ([https://nlopt.readthedocs.io/en/latest/NLOpt\\_Algorithms/#mlsl-multi-level-single-linkage](https://nlopt.readthedocs.io/en/latest/NLOpt_Algorithms/#mlsl-multi-level-single-linkage))
- DIRECT ([https://nlopt.readthedocs.io/en/latest/NLOpt\\_Algorithms/#direct-and-direct-l](https://nlopt.readthedocs.io/en/latest/NLOpt_Algorithms/#direct-and-direct-l))
- Locally-based DIRECT (DIRECT $l$ ) ([https://nlopt.readthedocs.io/en/latest/NLOpt\\_Algorithms/#direct-and-direct-l](https://nlopt.readthedocs.io/en/latest/NLOpt_Algorithms/#direct-and-direct-l))
- Dual Simulated Annealing (<https://github.com/sgubianpm/sdaopt>)
- Differential Evolution ([https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.differential\\_evolution.html#scipy.optimize.differential\\_evolution](https://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.differential_evolution.html#scipy.optimize.differential_evolution))
- Controlled Random Search ([https://nlopt.readthedocs.io/en/latest/NLOpt\\_Algorithms/#controlled-random-search-crs-with-local-mutation](https://nlopt.readthedocs.io/en/latest/NLOpt_Algorithms/#controlled-random-search-crs-with-local-mutation))
- Simple (<https://github.com/chrisstroemel/Simple>)
- StoGO ([https://nlopt.readthedocs.io/en/latest/NLOpt\\_Algorithms/#stogo](https://nlopt.readthedocs.io/en/latest/NLOpt_Algorithms/#stogo))

All parameters of the methods can be found in *experiments/solve\_different\_methods.py* script. Since NLOpt hasn't an API to control parameters of the algorithms from Python, it was built with  $\varepsilon = 10^{-4}$  for DIRECT and DIRECT $l$  methods.

## 2 List of the test problems

- Functions from  $F_{GR}$  class. It consists of 100 multi-extremal problems of the same structure. The description can be found in <https://core.ac.uk/download/pdf/82313177.pdf>.
- Functions from classes generated by the GKLS generator (<http://wwwinfo.deis.unical.it/yaro/GKLS.html>).

Each class consists of 100 multi-extremal problems with 10 and more local minima. Problem is considered solved when optimization method placed a new trial point in the  $\Delta$ -vicinity of the known global optima  $x^*$ :  $\|x^* - \tilde{x}\|_{\inf} \leq \Delta$ .

### 3 Results on the $F_{GR}$ class

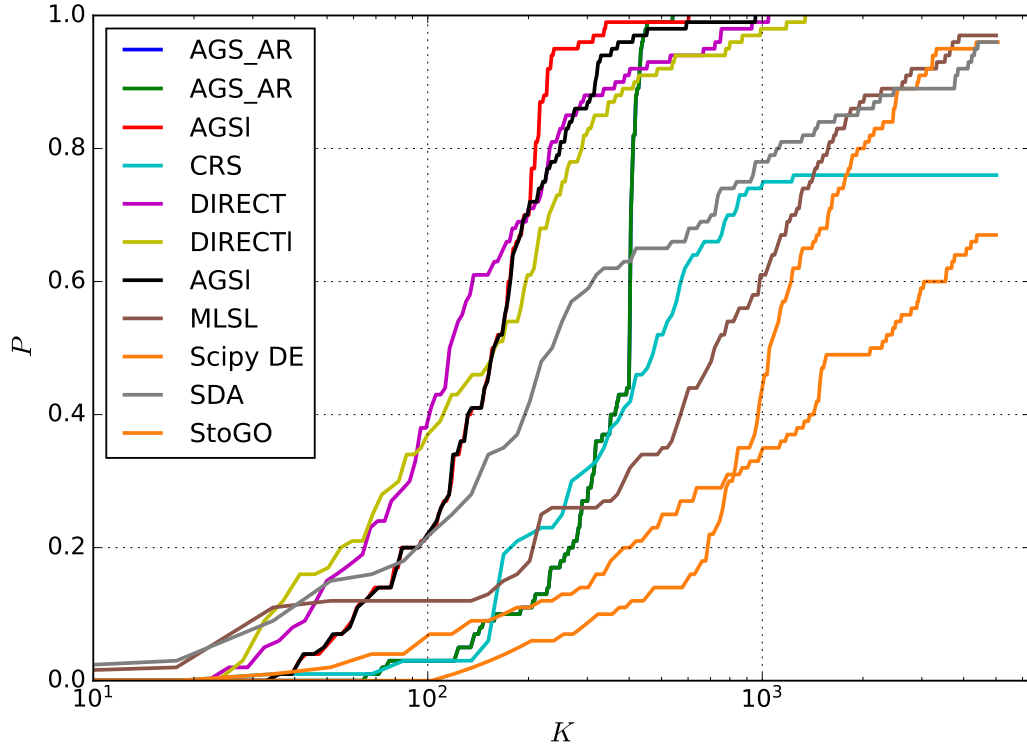


Figure 1:  $\Delta = 10^{-2}$

Method	Average number of trials	Problems solved
AGS_AR	343.18	100
AGS_AR	343.18	100
AGSI	158.30	100
AGSI	180.14	100
CRS	400.30	76
DIRECT	182.25	100
DIRECTI	214.92	100
MLSL	947.18	97
SDA	691.24	96
Scipy DE	1257.34	96
StoGO	1336.78	67

## 4 Results on the *GKLS* problems

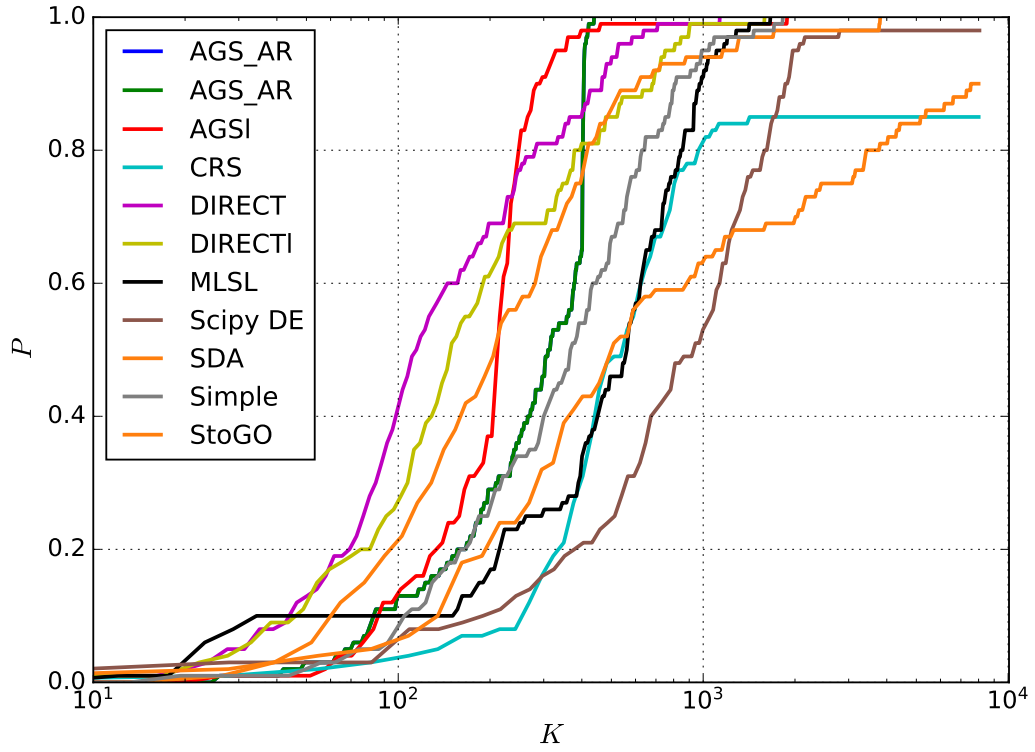


Figure 2: Class GKLS Simple 2d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS_AR	286.93	100
AGS_AR	286.93	100
AGSI	217.60	100
CRS	510.61	85
DIRECT	189.03	100
DIRECTI	255.21	100
MLSL	556.83	100
SDA	356.30	100
Scipy DE	952.16	98
Simple	440.63	100
StoGO	1251.52	90

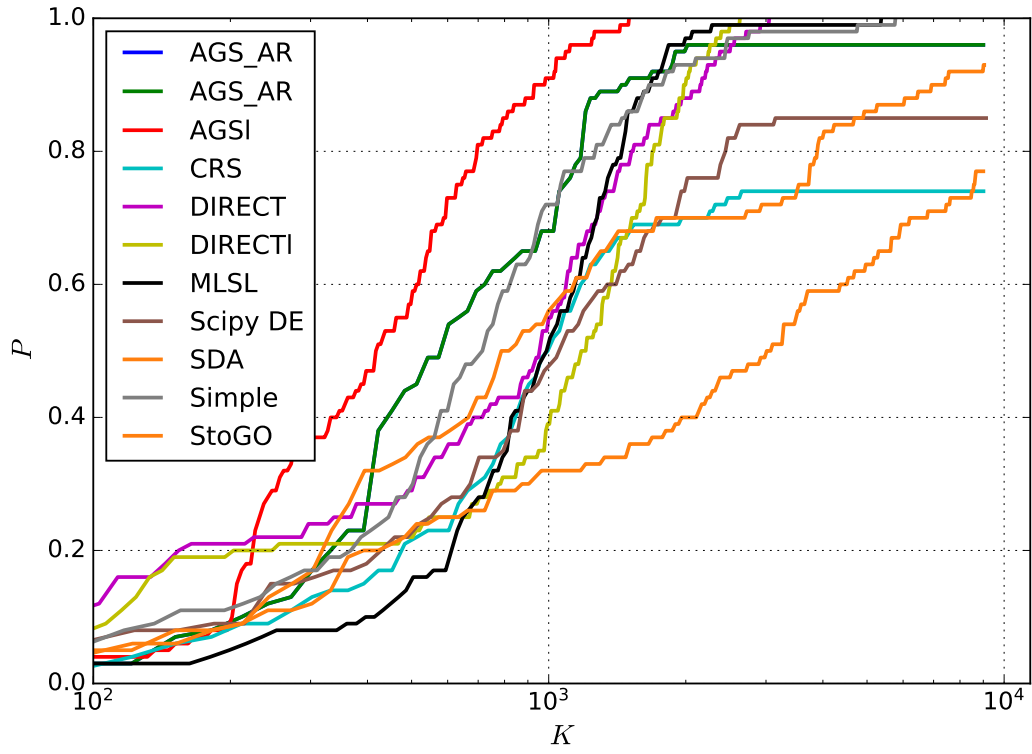


Figure 3: Class GKLS Hard 2d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS_AR	692.03	96
AGS_AR	692.03	96
AGSI	487.96	100
CRS	844.74	74
DIRECT	985.44	100
DIRECTI	1126.65	100
MLSL	1042.54	100
SDA	1637.92	93
Scipy DE	1041.12	85
Simple	898.19	100
StoGO	2532.23	77

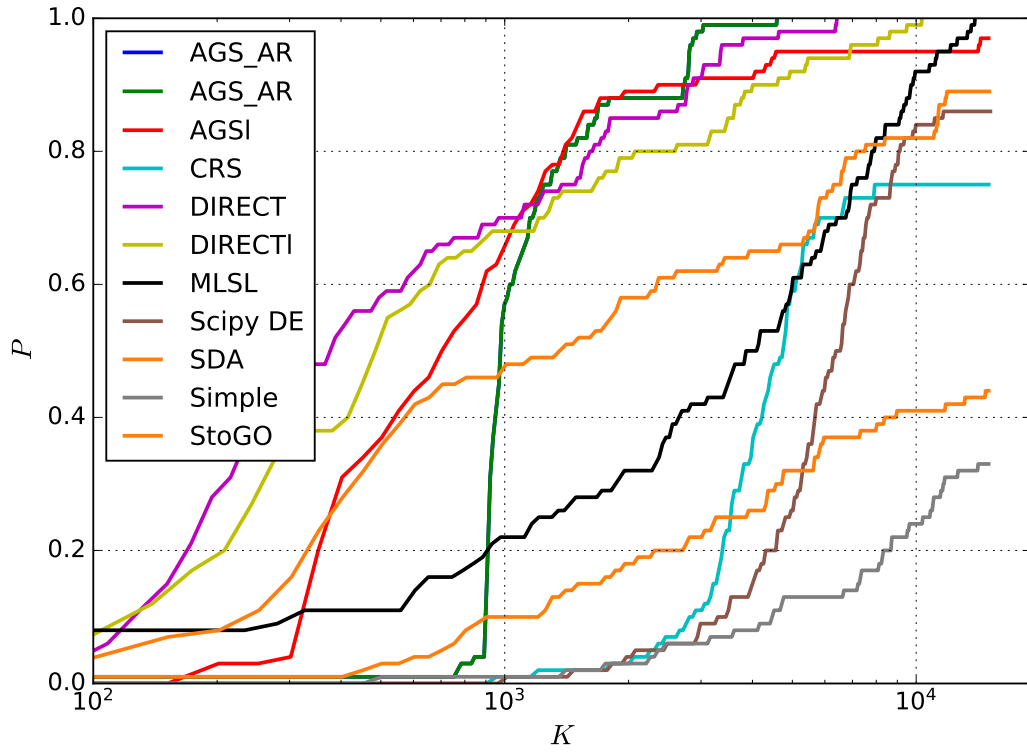


Figure 4: Class GKLS Simple 3d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS_AR	1270.96	100
AGS_AR	1270.96	100
AGSI	1195.32	97
CRS	4145.81	75
DIRECT	973.64	100
DIRECTI	1477.79	100
MLSL	4609.17	100
SDA	2706.52	89
Scipy DE	5956.94	86
Simple	7098.45	33
StoGO	3856.11	44

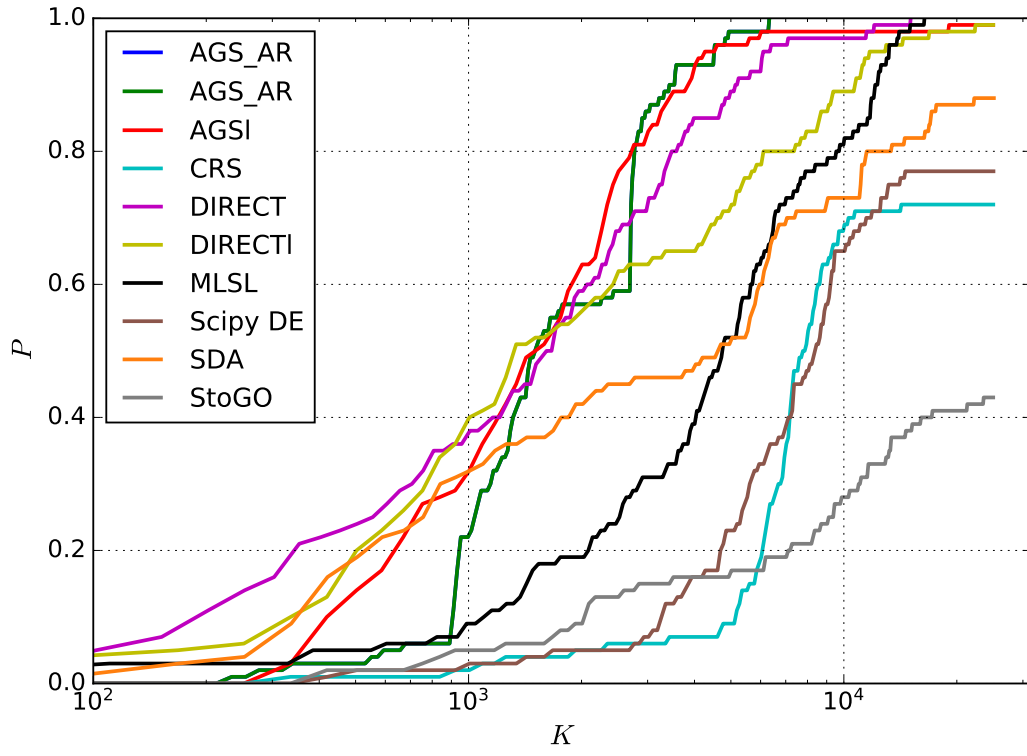


Figure 5: Class GKLS Hard 3d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS_AR	2020.53	100
AGS_AR	2020.53	100
AGSI	1930.49	99
CRS	6786.96	72
DIRECT	2298.74	100
DIRECTI	3553.33	99
MLSL	5640.10	100
SDA	4708.43	88
Scipy DE	6914.34	77
StoGO	7843.23	43

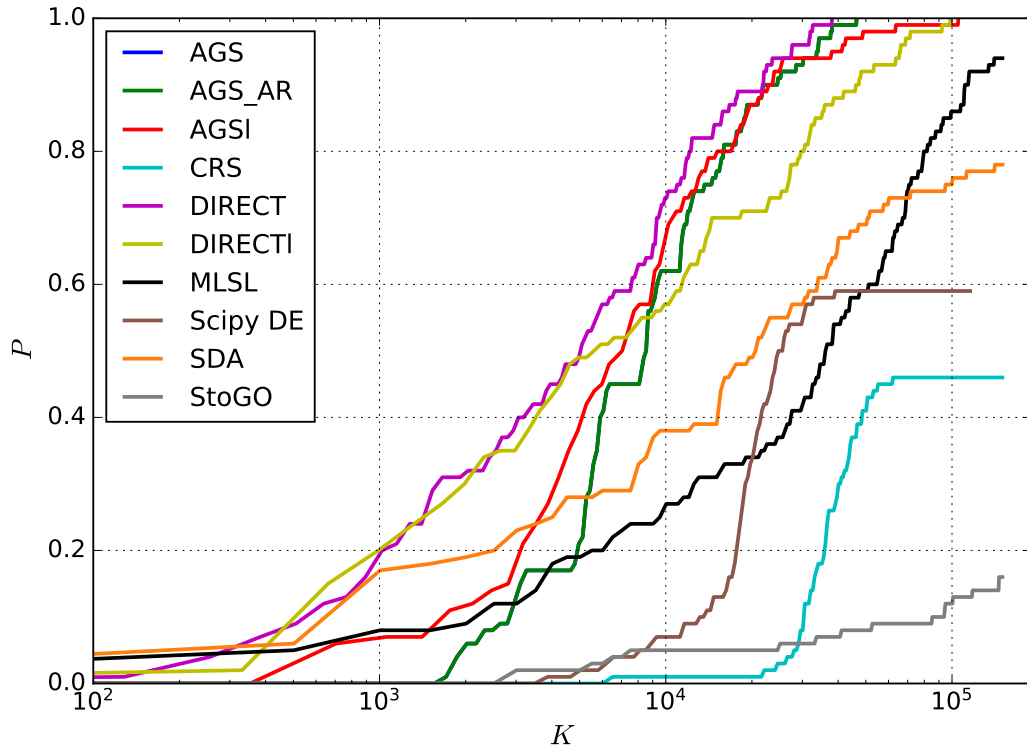


Figure 6: Class GKLS Simple 4d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS	10986.89	100
AGS_AR	10986.89	100
AGSI	11095.65	100
CRS	37436.76	46
DIRECT	7824.32	100
DIRECTI	15994.11	100
MLSL	41514.32	94
SDA	21417.90	78
Scipy DE	19157.73	59
StoGO	59895.44	16

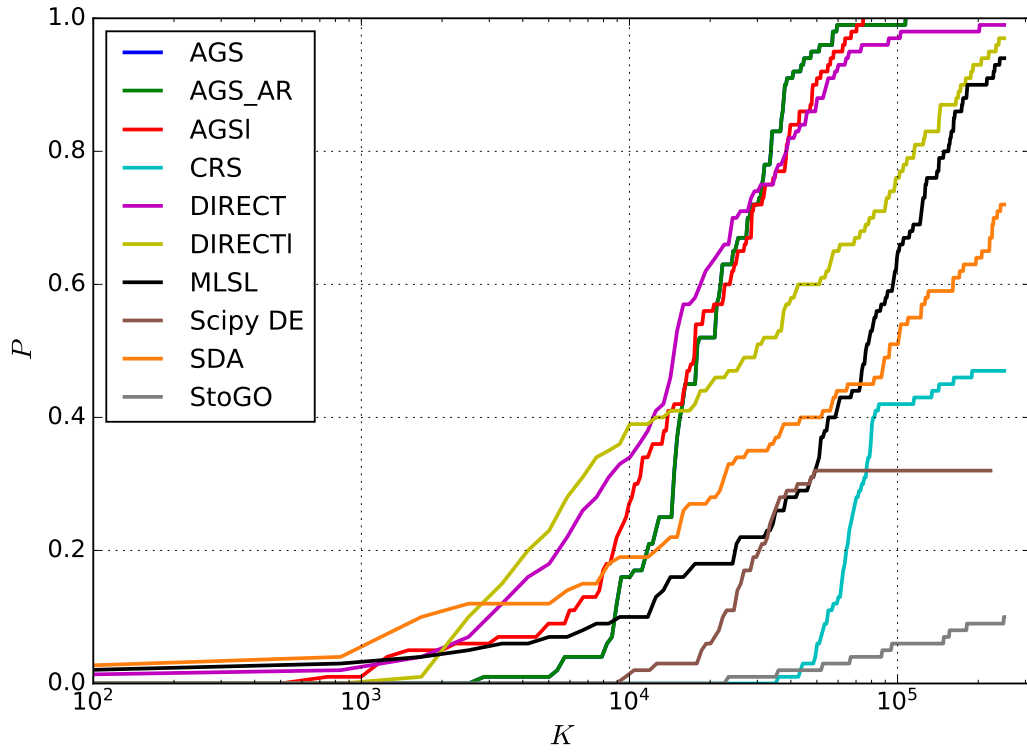


Figure 7: Class GKLS Hard 4d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS	22912.50	100
AGS_AR	22912.50	100
AGSI	23167.84	100
CRS	73779.32	47
DIRECT	23204.38	99
DIRECTI	54489.92	97
MLSL	80247.19	94
SDA	68815.53	72
Scipy DE	27466.06	32
StoGO	109328.10	10



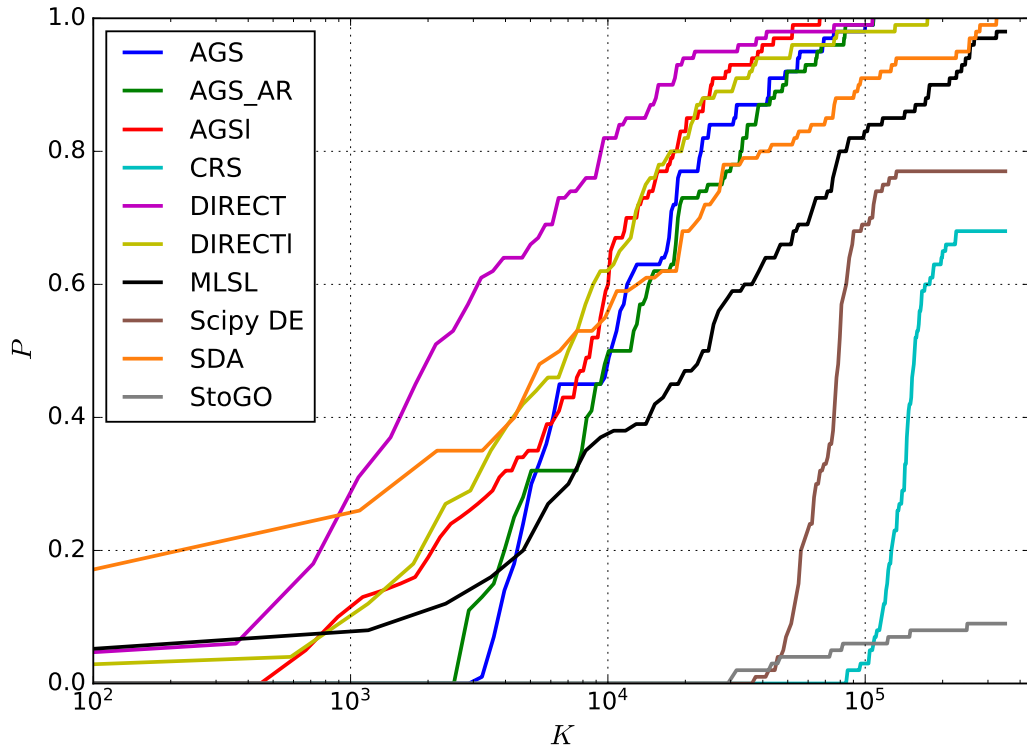


Figure 8: Class GKLS Simple 5d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS	17139.66	100
AGS_AR	19312.33	100
AGSI	11529.03	100
CRS	143574.99	68
DIRECT	7166.49	100
DIRECTI	13970.53	100
MLSL	52647.63	98
SDA	34255.31	100
Scipy DE	73074.52	77
StoGO	91580.44	9

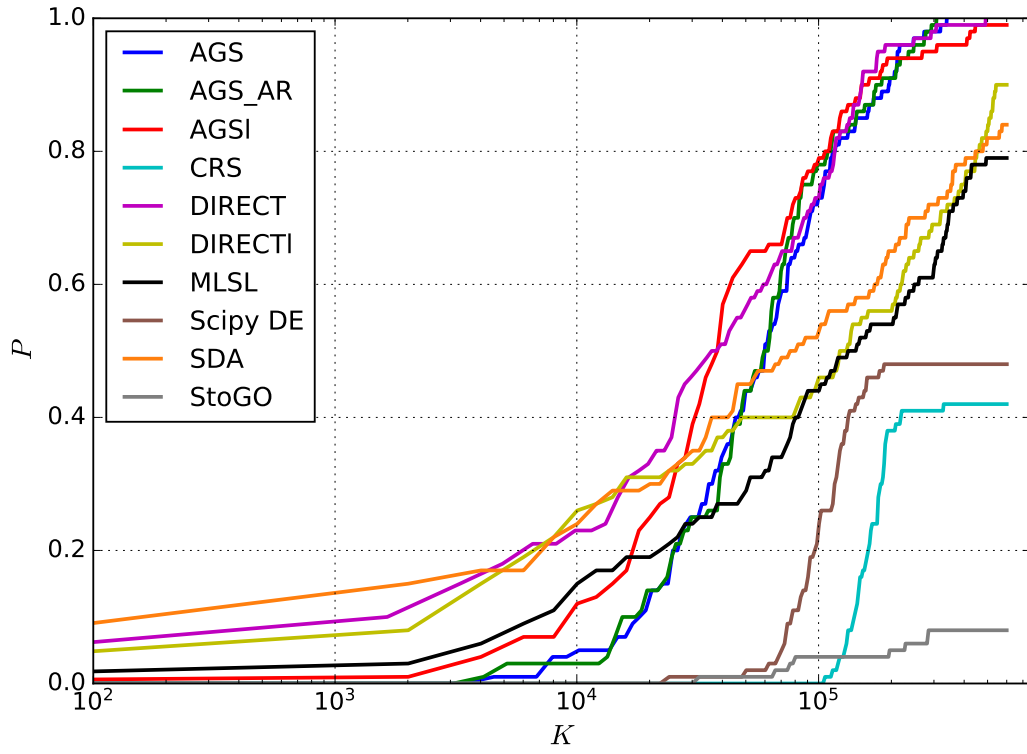


Figure 9: Class GKLS Hard 5d.  $\Delta = 2 \cdot 10^{-2}$

Method	Average number of trials	Problems solved
AGS	80652.63	100
AGS_AR	77941.70	100
AGSI	67652.72	99
CRS	165192.76	42
DIRECT	66327.42	100
DIRECTI	164390.63	90
MLSL	138766.23	79
SDA	116973.10	84
Scipy DE	105496.88	48
StoGO	155123.75	8

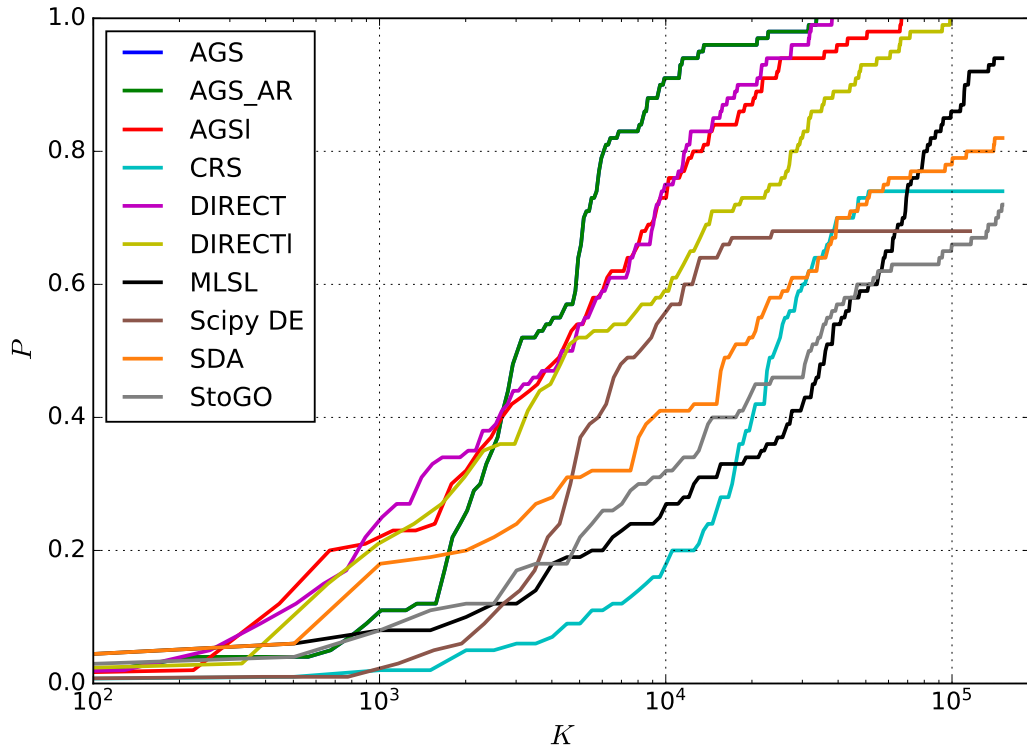


Figure 10: Class GKLS Simple 4d.  $\Delta = 0.0632$

Method	Average number of trials	Problems solved
AGS	4996.27	100
AGS_AR	4996.27	100
AGSI	8847.40	100
CRS	19883.59	74
DIRECT	7328.78	100
DIRECTI	15010.01	100
MLSL	41484.80	94
SDA	22065.96	82
Scipy DE	6271.24	68
StoGO	29359.22	72

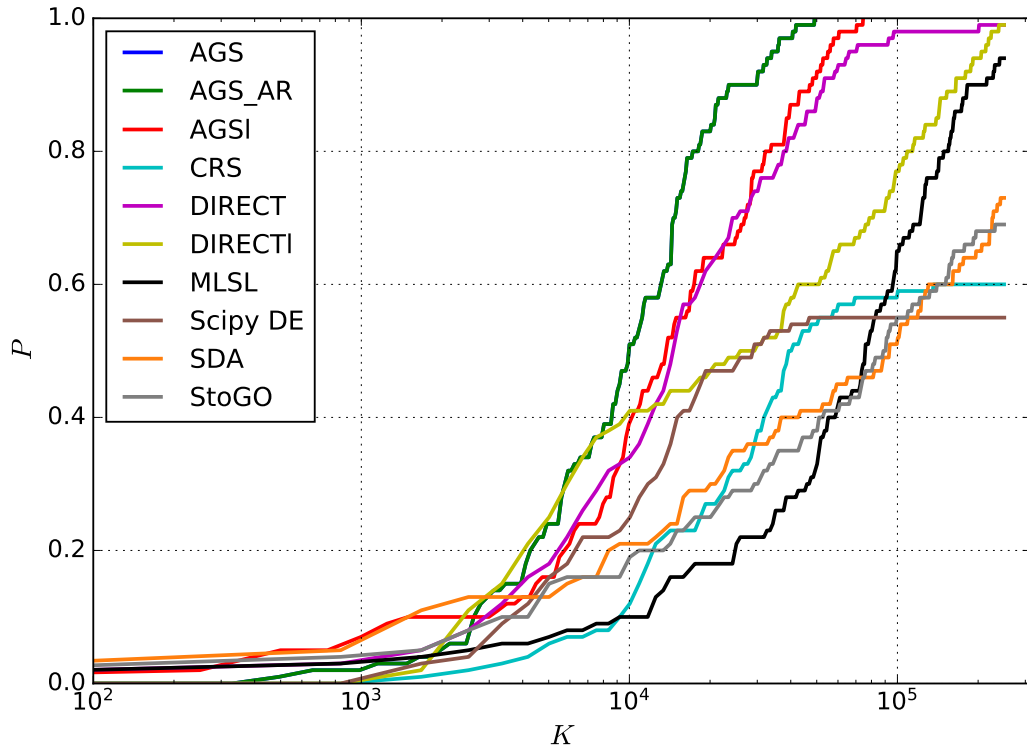


Figure 11: Class GKLS Hard 4d.  $\Delta = 0.0632$

Method	Average number of trials	Problems solved
AGS	12475.47	100
AGS_AR	12475.47	100
AGSI	19826.36	100
CRS	27137.40	60
DIRECT	22884.35	99
DIRECTI	55596.07	99
MLSL	80220.11	94
SDA	68048.01	73
Scipy DE	12487.64	55
StoGO	58925.54	69

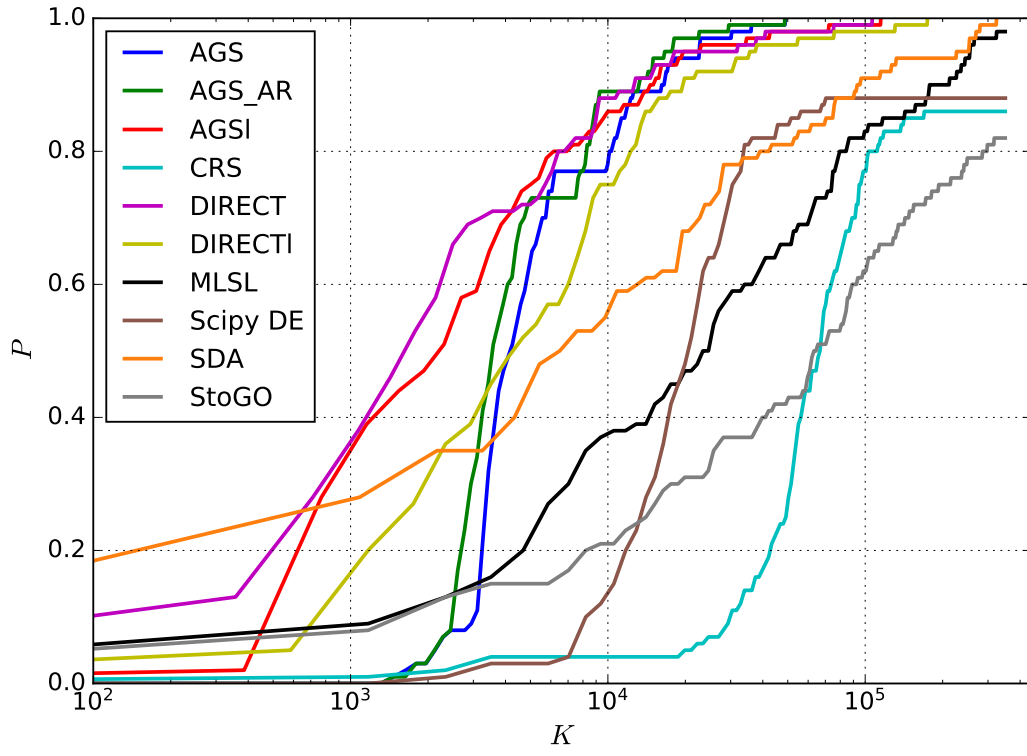


Figure 12: Class GKLS Simple 5d.  $\Delta = 0.0796$

Method	Average number of trials	Problems solved
AGS	6986.36	100
AGS_AR	5930.43	100
AGSI	6314.25	100
CRS	62921.69	86
DIRECT	5966.13	100
DIRECTI	10795.46	100
MLSL	52609.18	98
SDA	34208.83	100
Scipy DE	20859.38	88
StoGO	69206.76	82

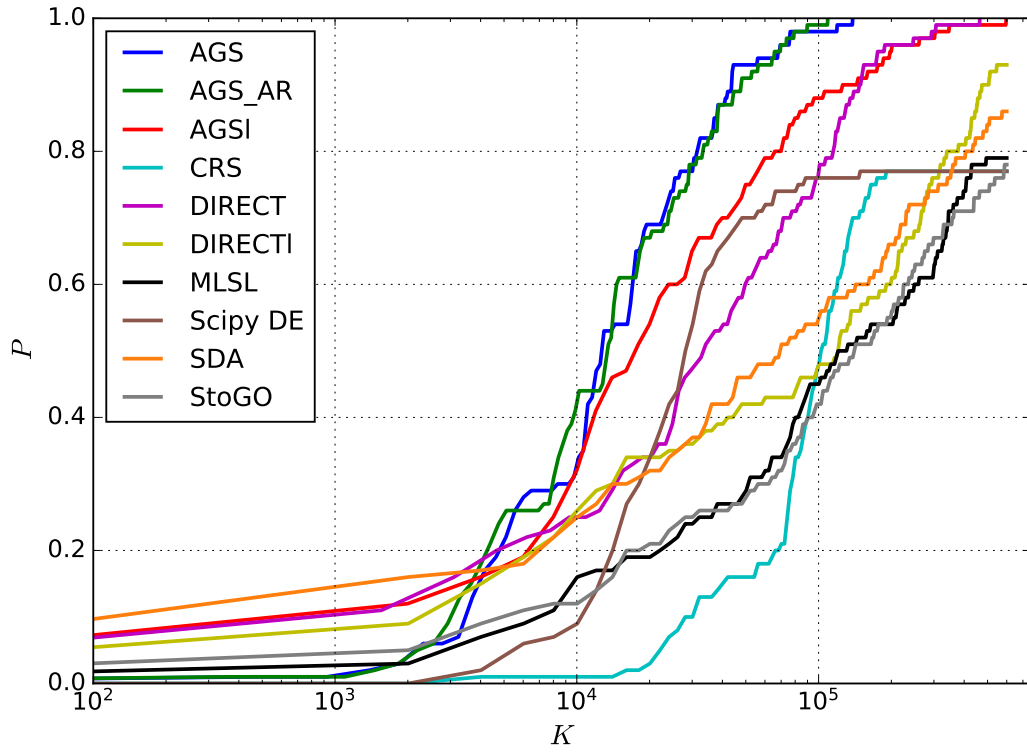


Figure 13: Class GKLS Hard 5d.  $\Delta = 0.0796$

Method	Average number of trials	Problems solved
AGS	20509.36	100
AGS_AR	20310.52	100
AGSI	48514.29	100
CRS	87563.88	77
DIRECT	61657.32	100
DIRECTI	148637.82	93
MLSL	138011.78	79
SDA	115634.59	86
Scipy DE	26850.04	77
StoGO	141886.49	78