Solving 3D frictional contact problems: Formulations and comparisons of numerical methods.

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RESEARCH REPORT

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Project-Team Bipop

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Abstract: TBW

Key-words: Multibody systems, nonsmooth Mechanics, unilateral constraints, Coulomb friction, impact, numerical methods

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Sur la résolution du problème de frottement tridimensionnel. Formulations and comparaisons des méthodes numériques.

Résumé : TBW

Mots-clés : Systèmes multi–corps, Mécanique non régulière, contraintes unilatérales, frottement de Coulomb, impact, Schémas numériques de résolution

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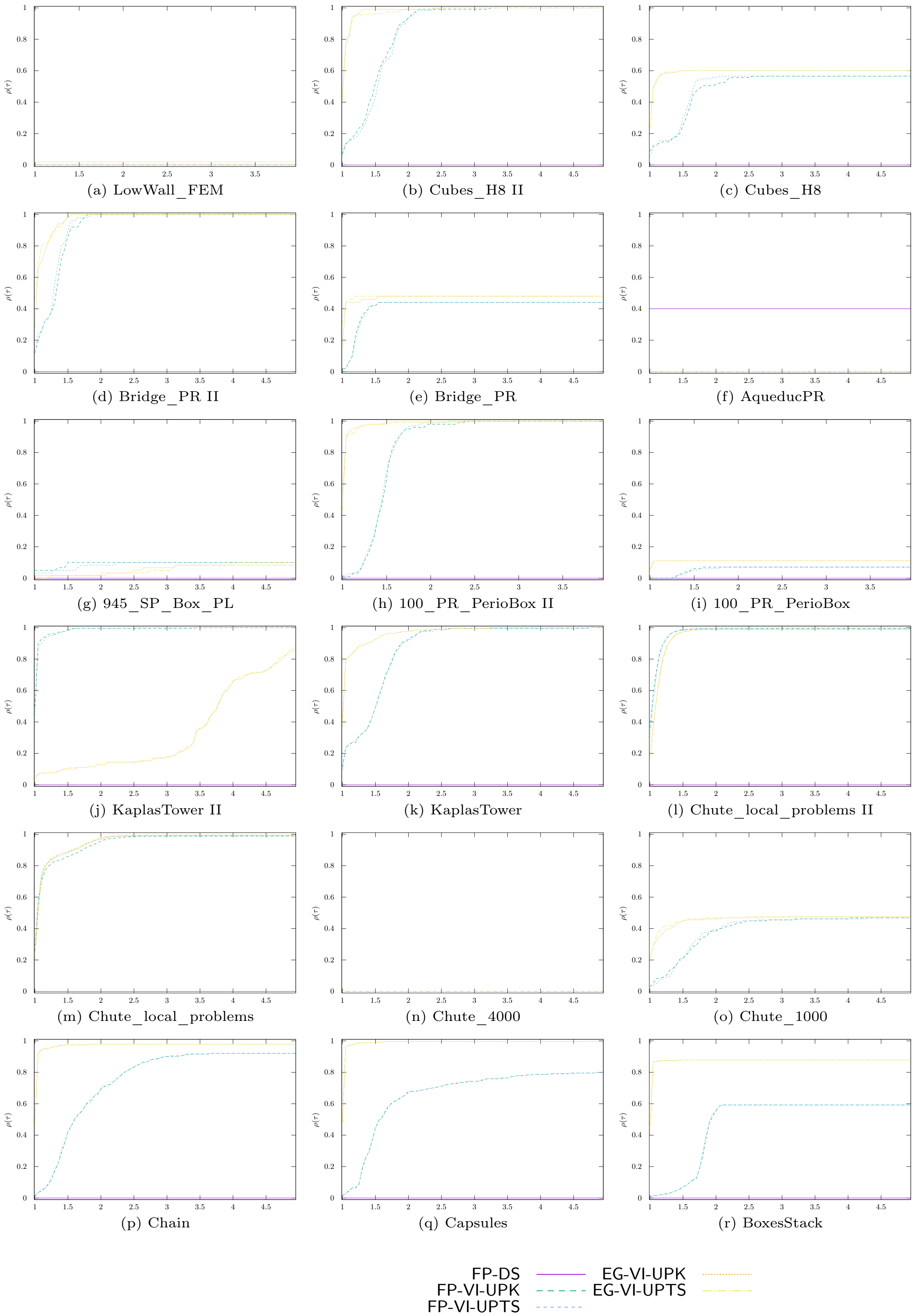

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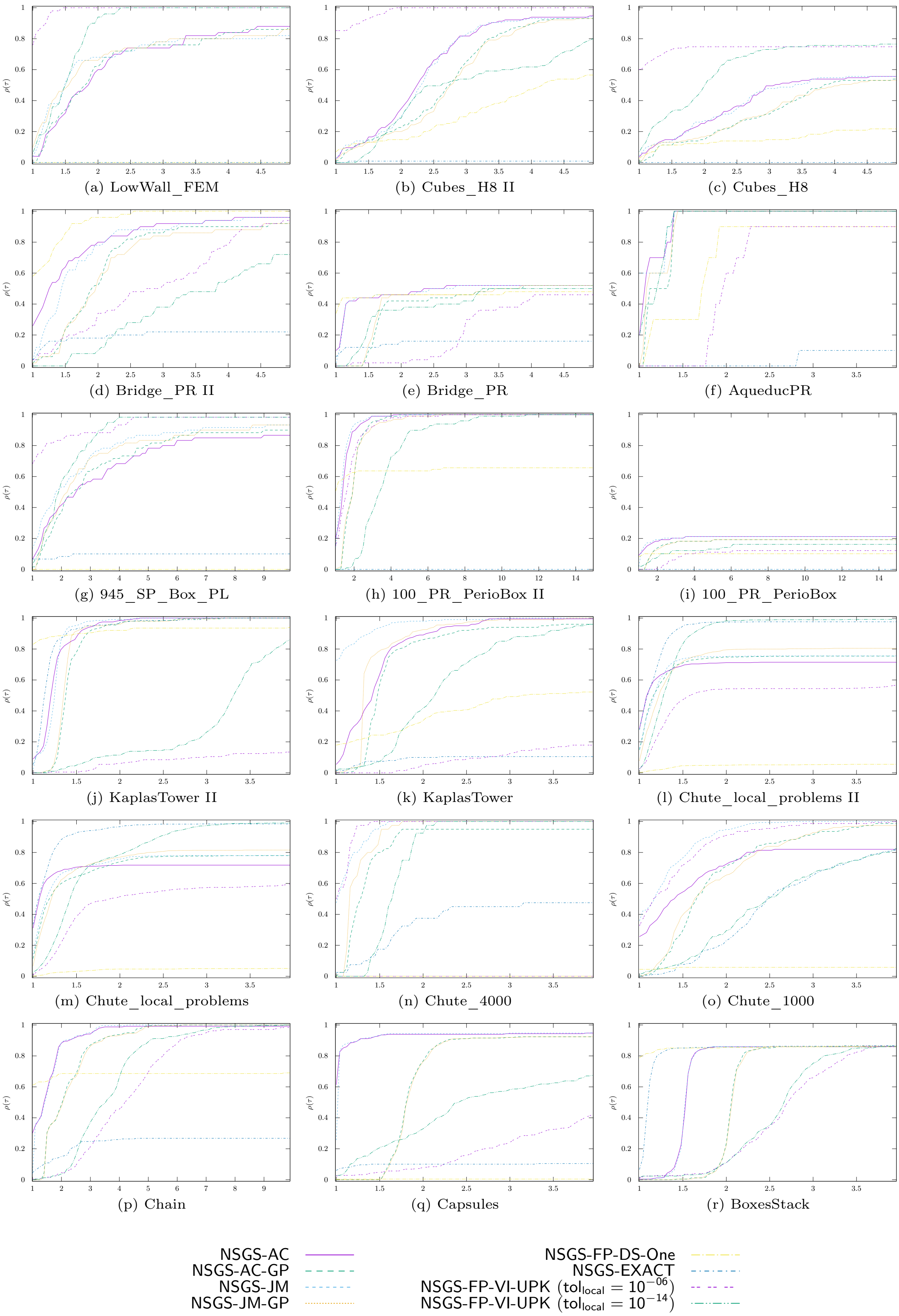

(a) LowWall_FEM (b) Cubes_H8 II (c) Cubes_H8

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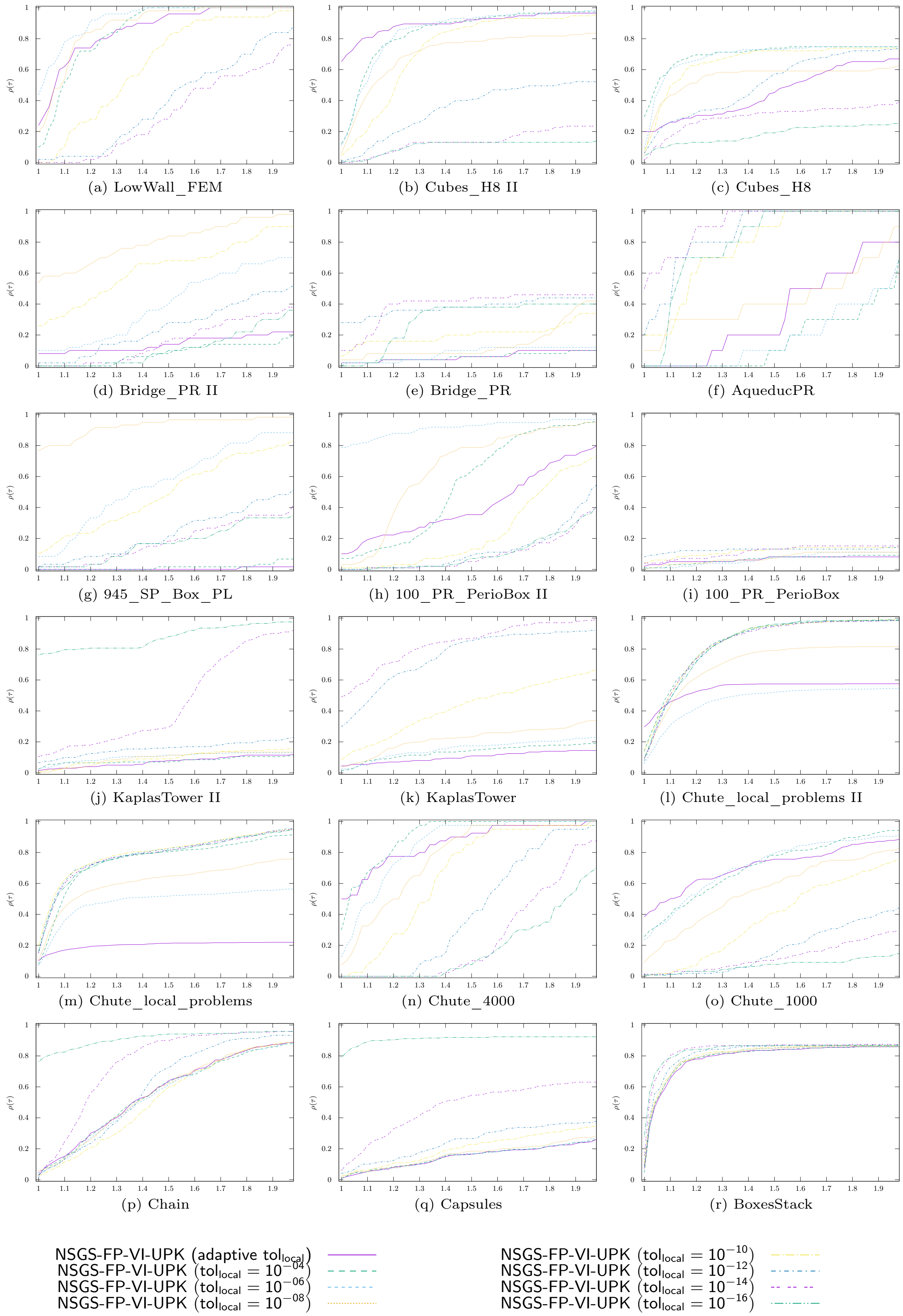

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Influence of the tolerance of the local solver $\mathsf{tol}_{\mathsf{local}}$ in NSGS-FP-VI-UPK algorithms

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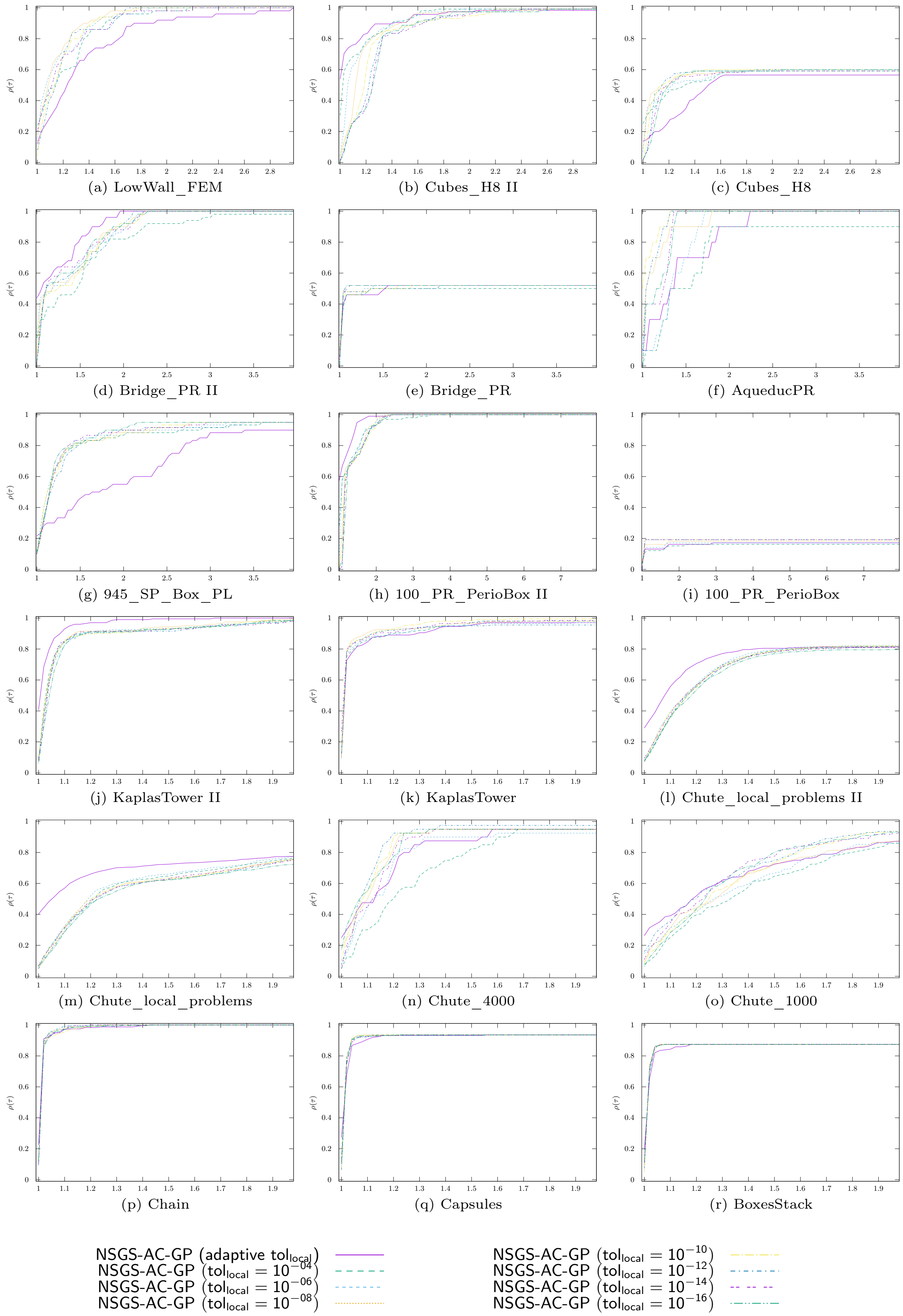

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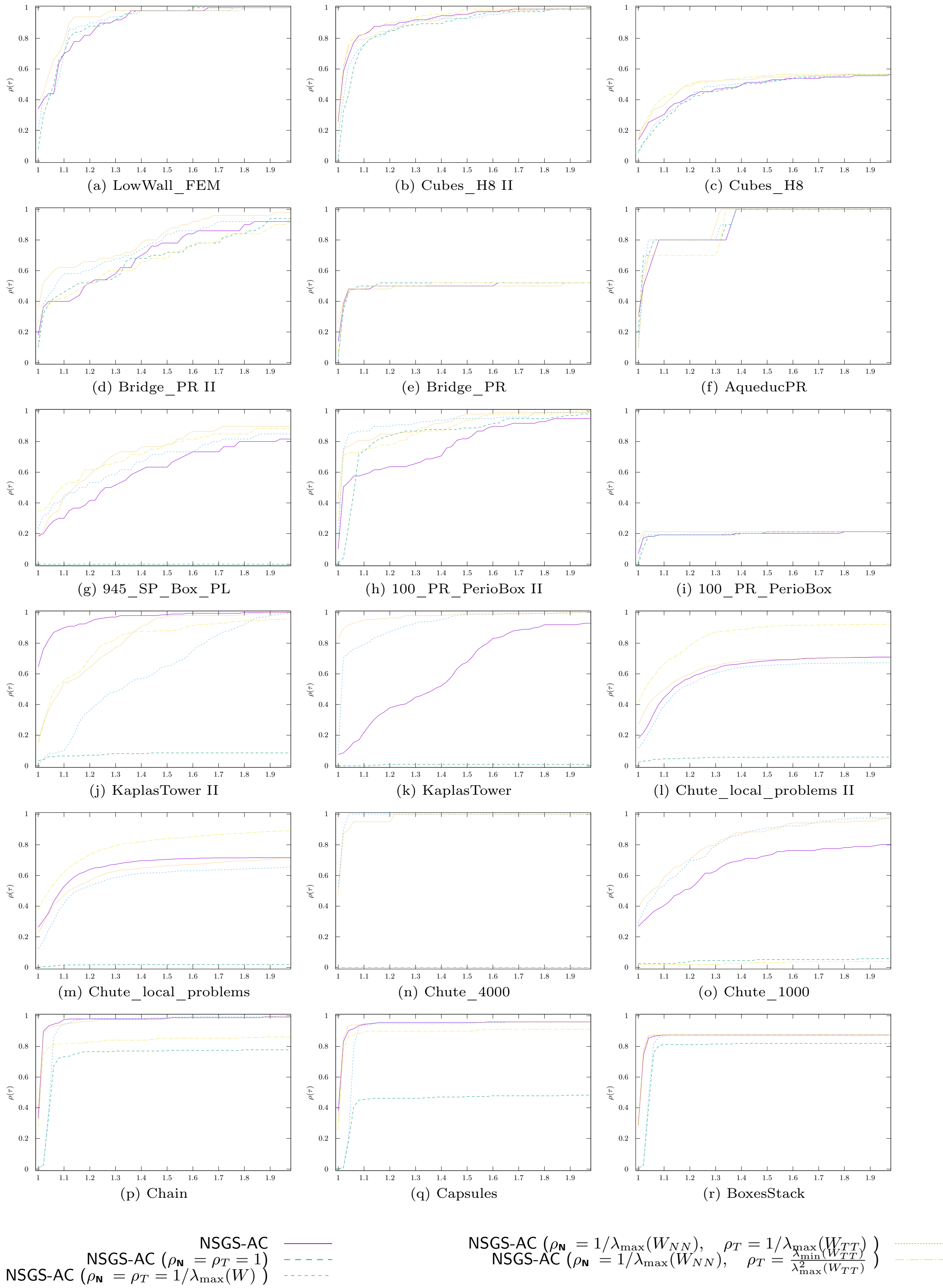

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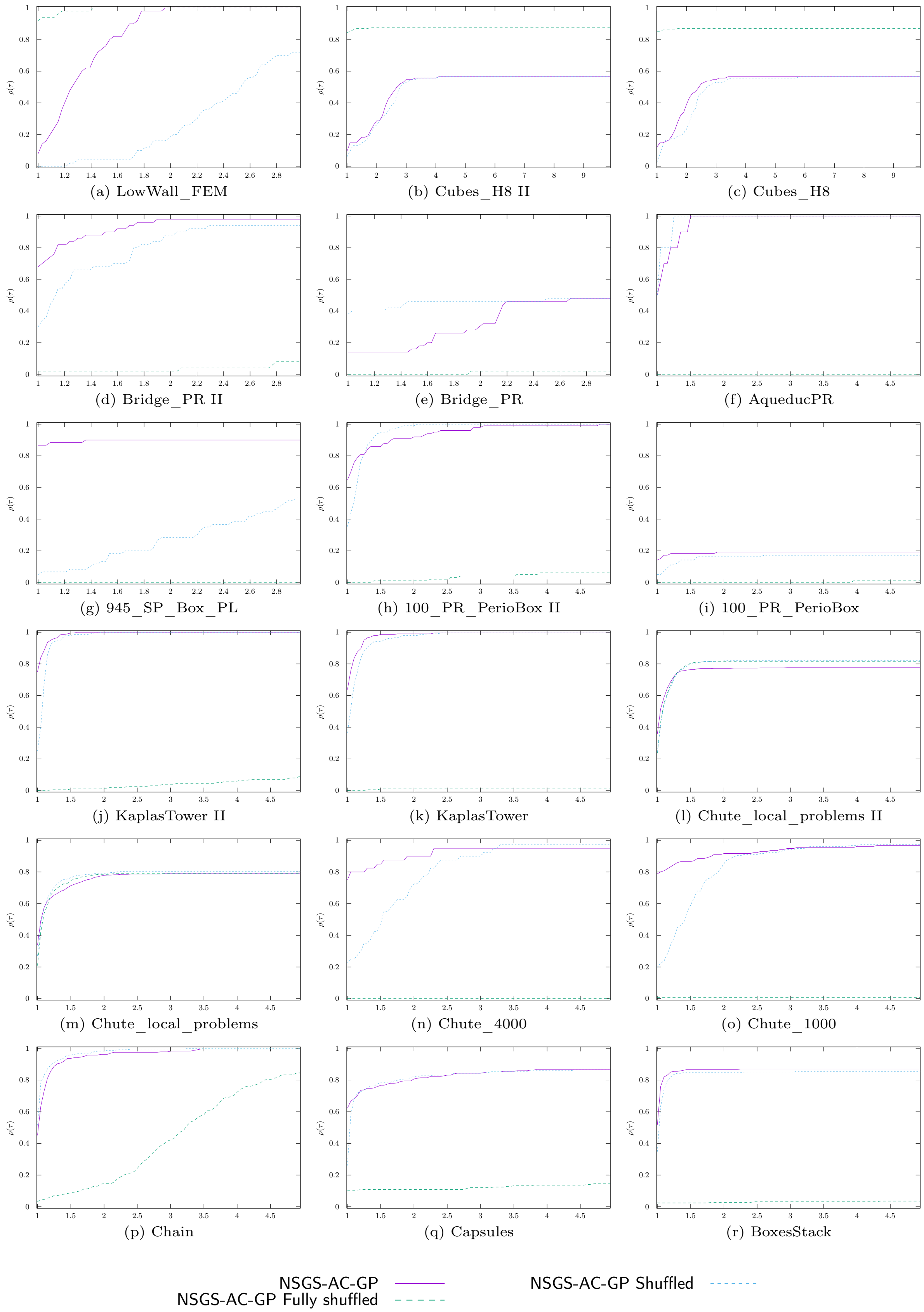

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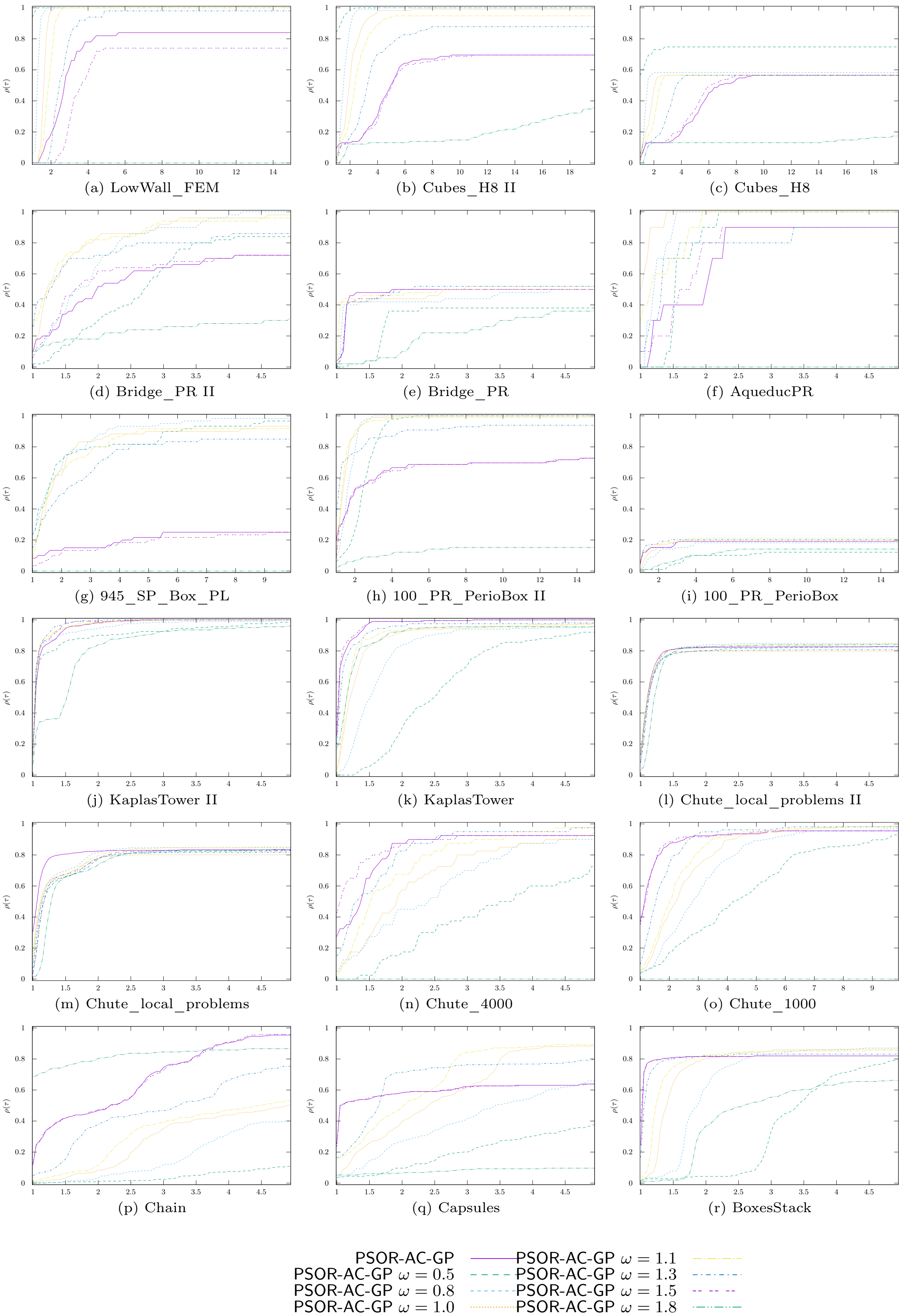

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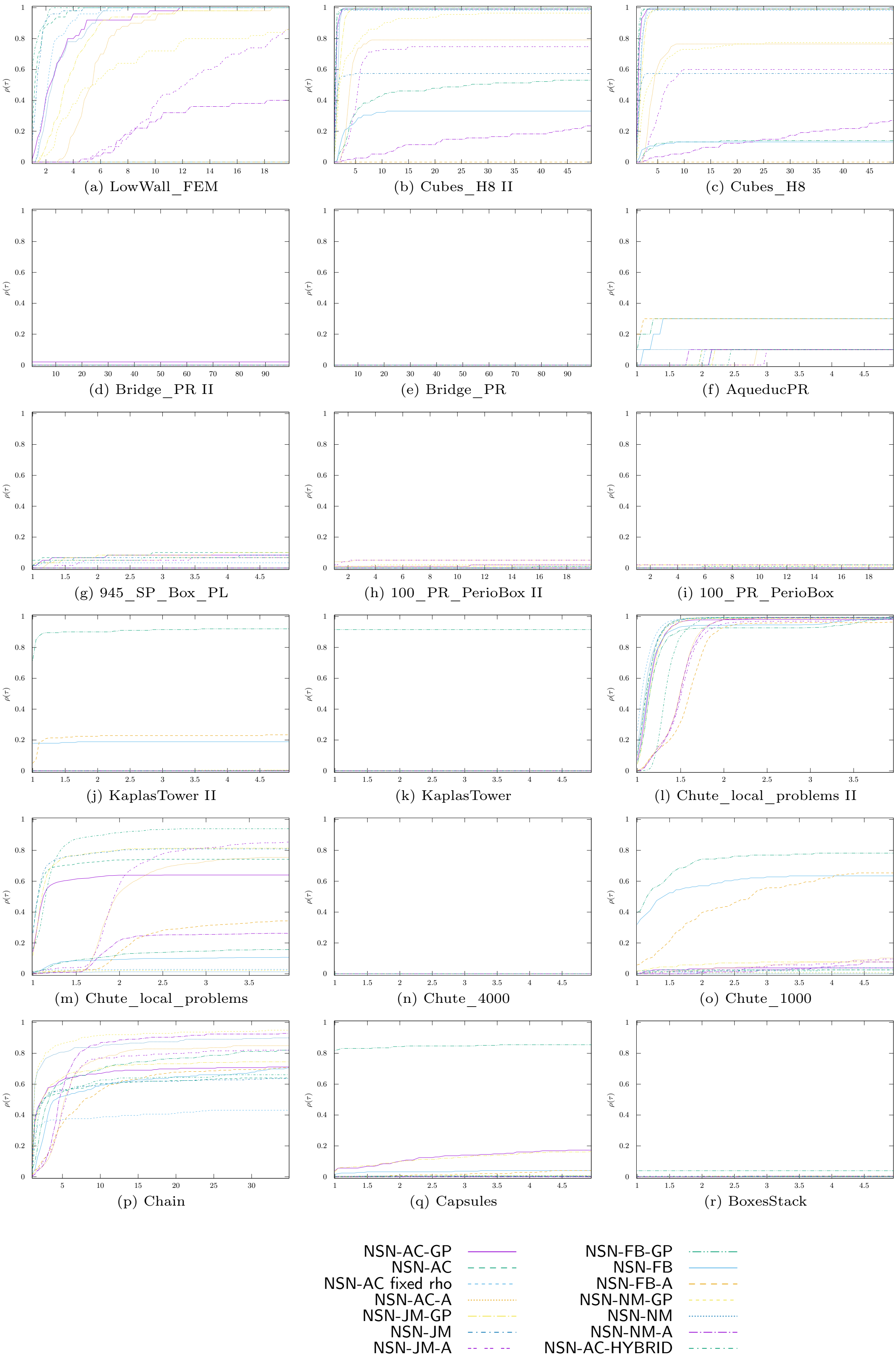

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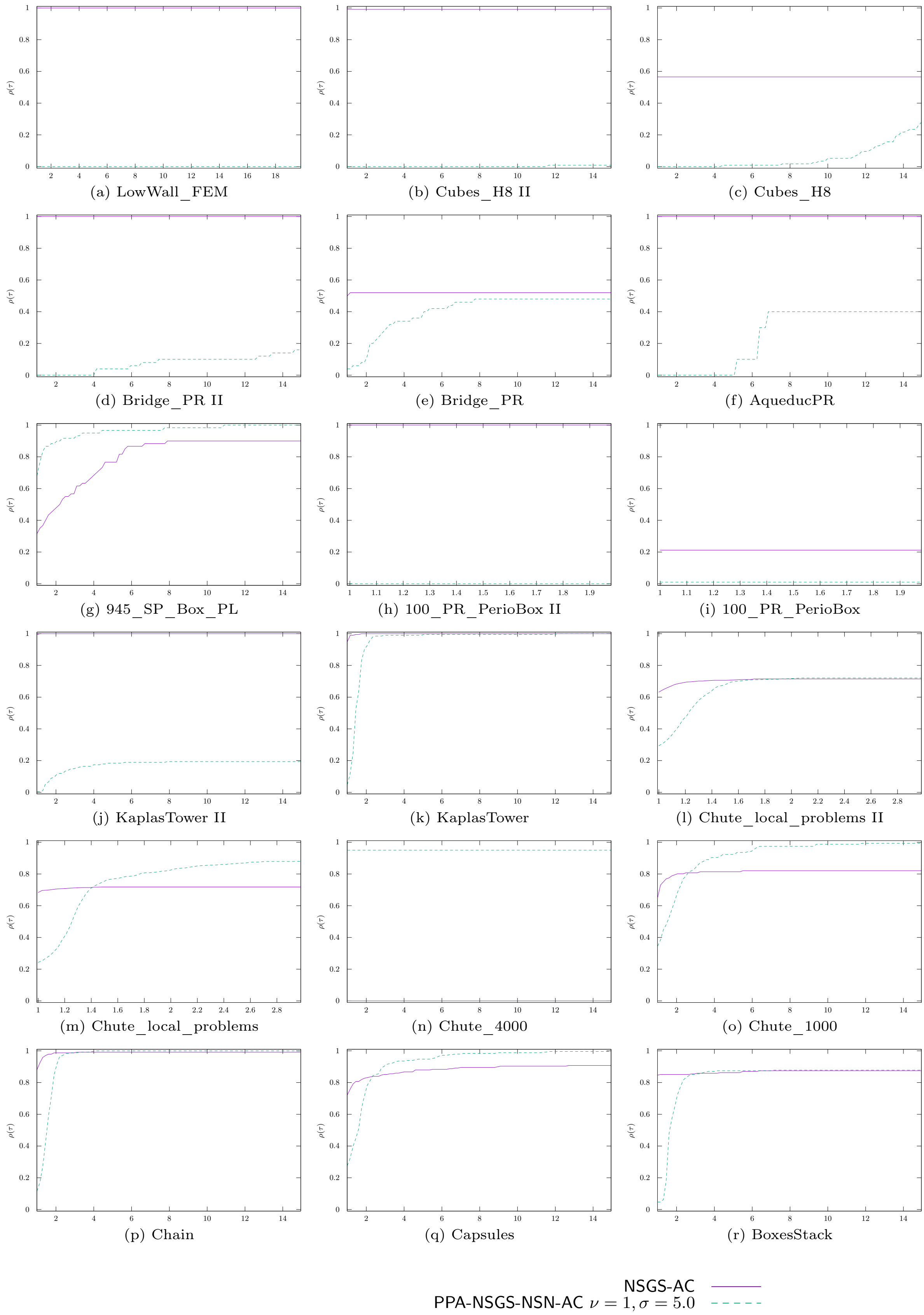

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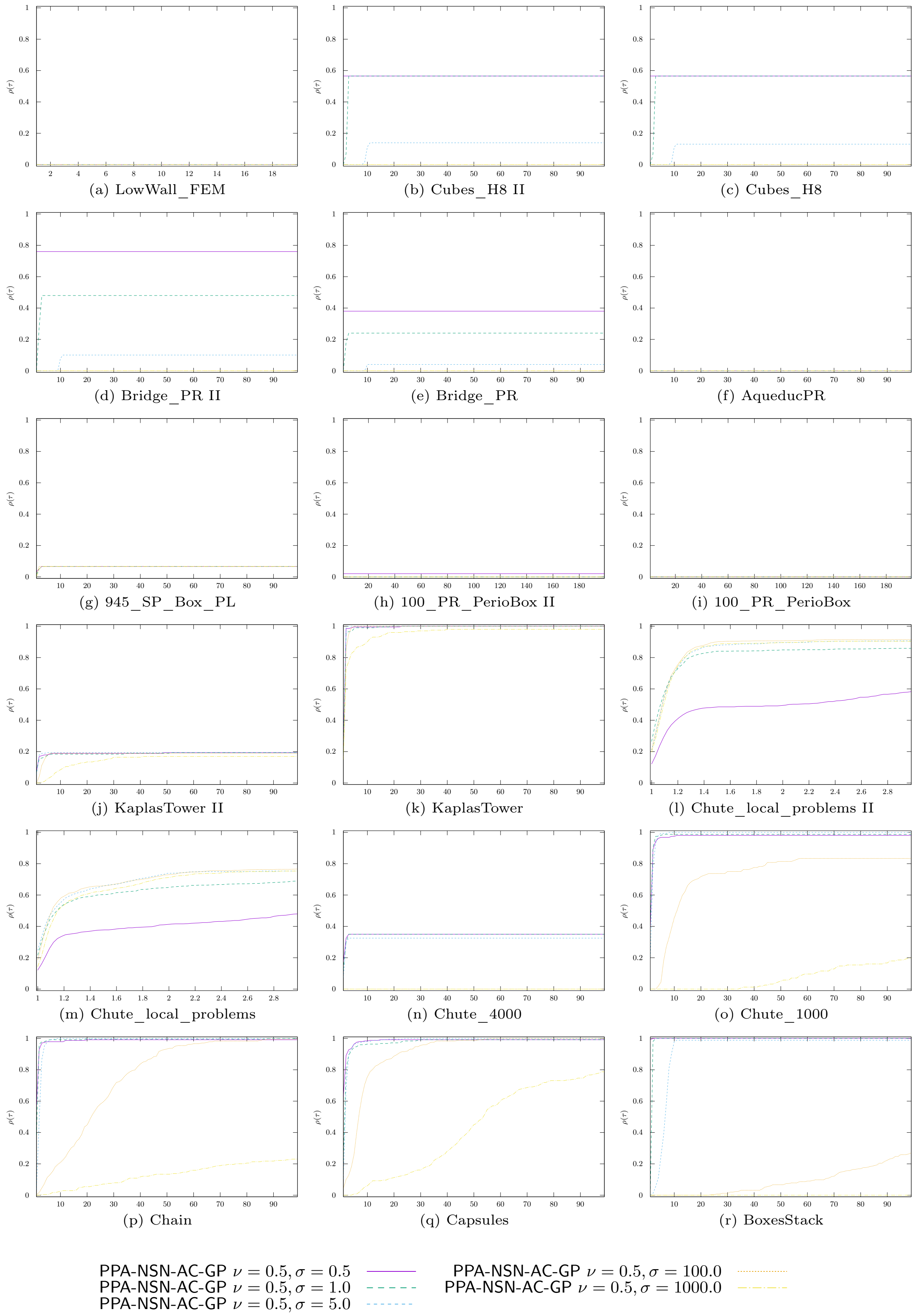

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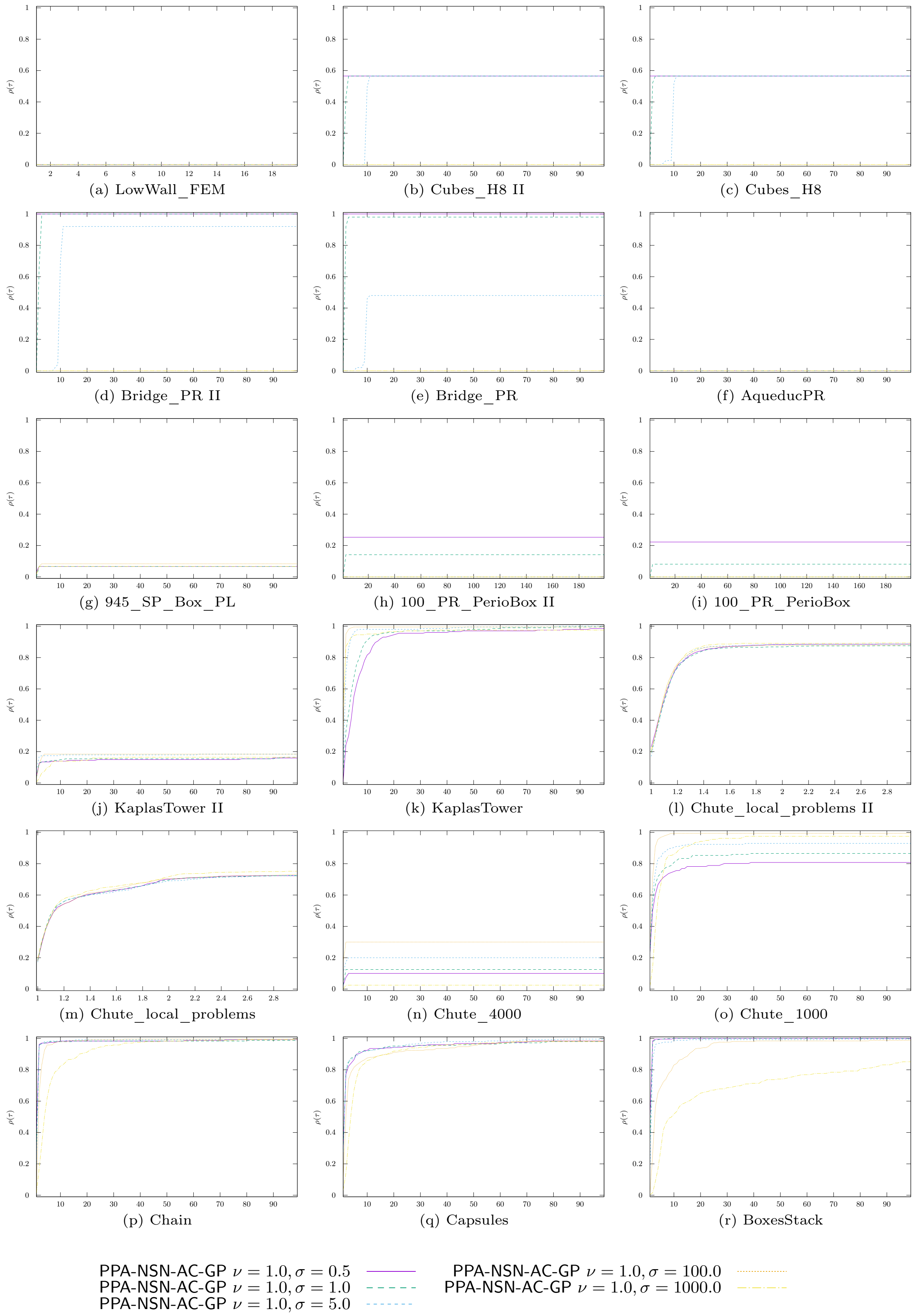

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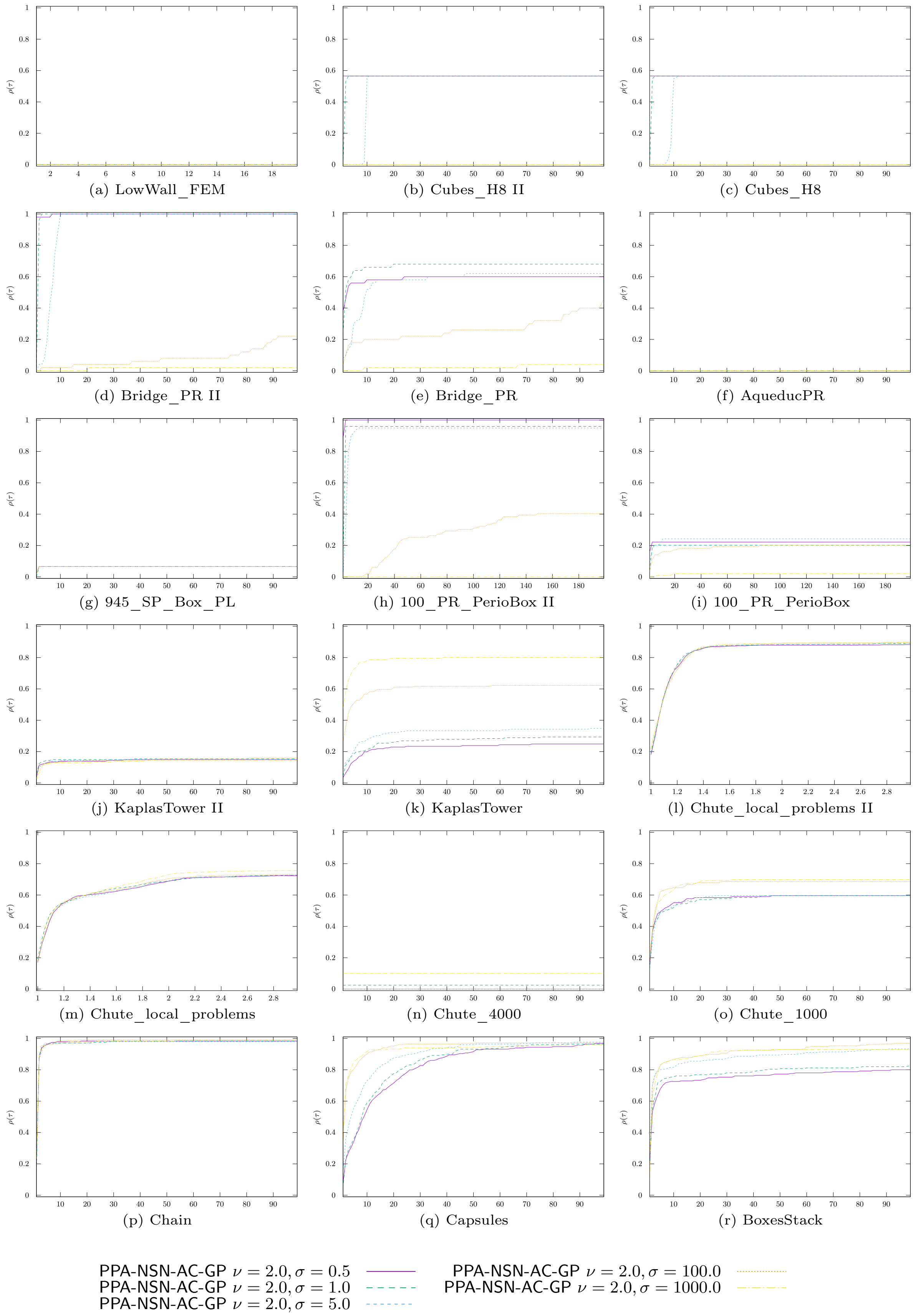

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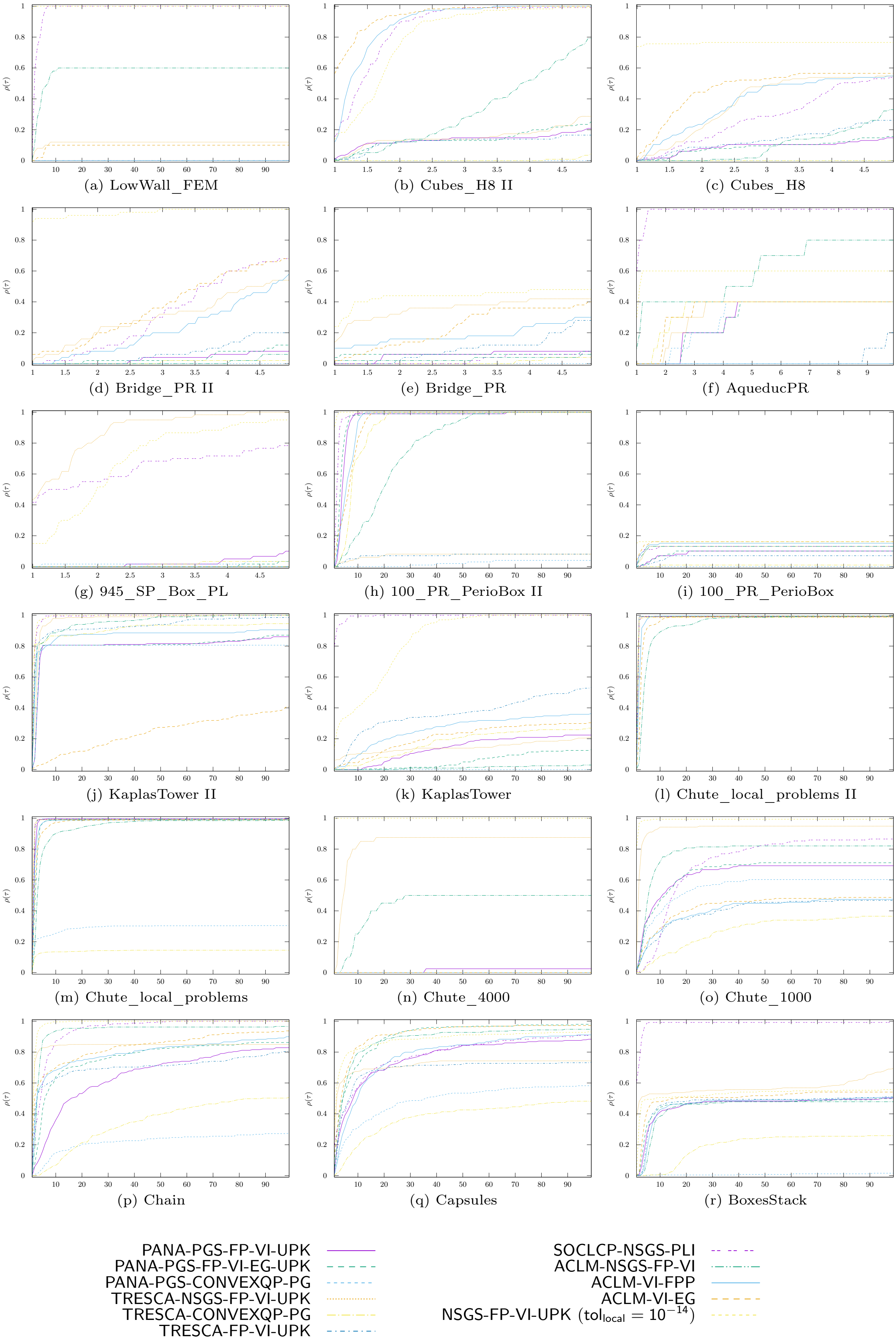

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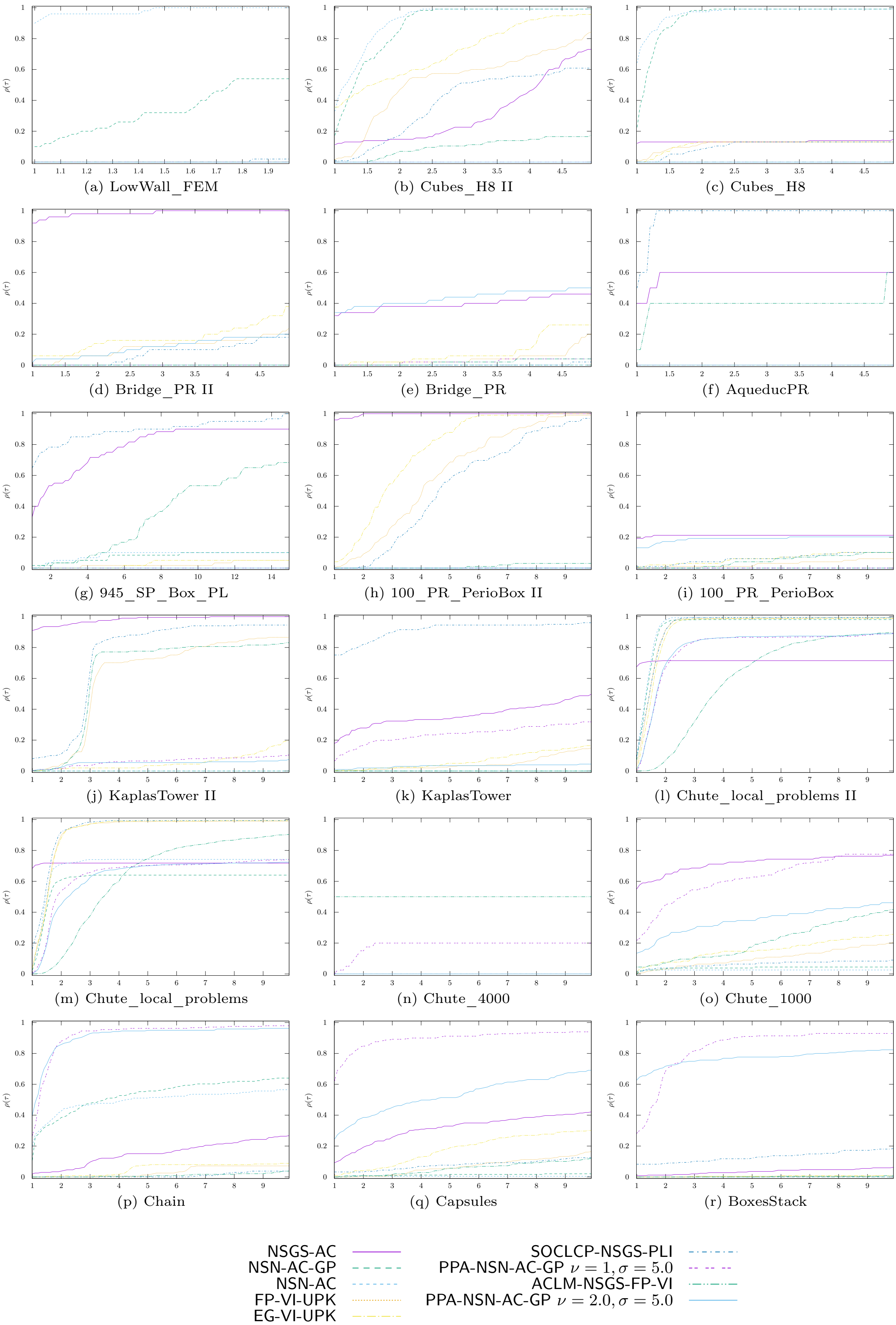

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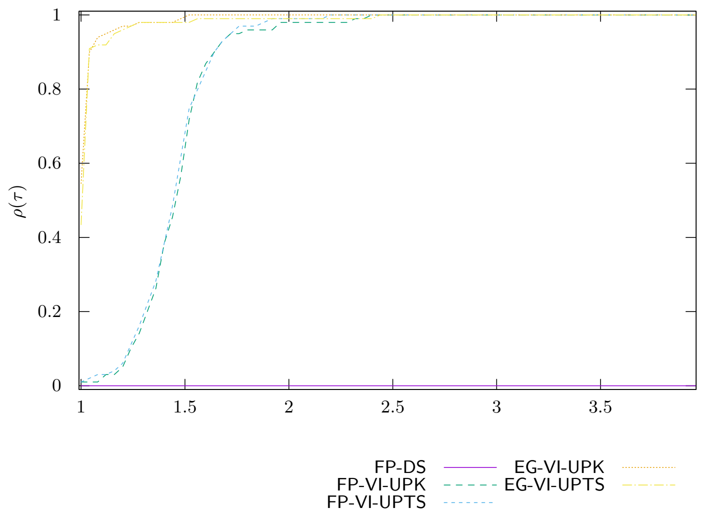
4 LMGC_100_PR_PerioBox precision 1.0e-04 timeout 100



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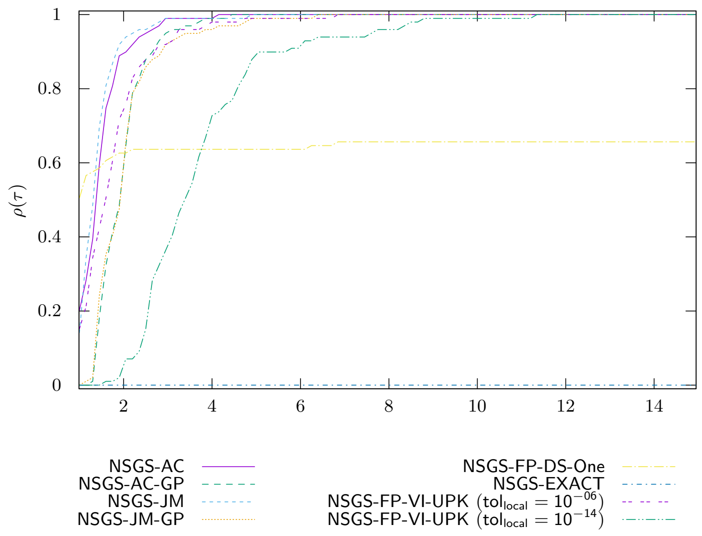

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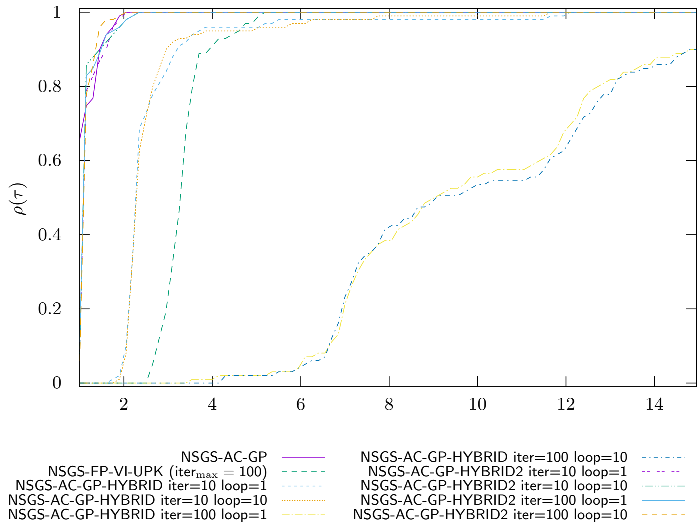

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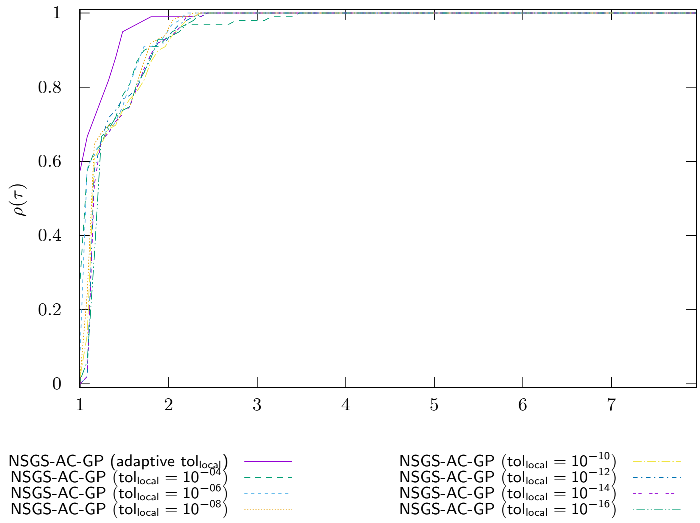

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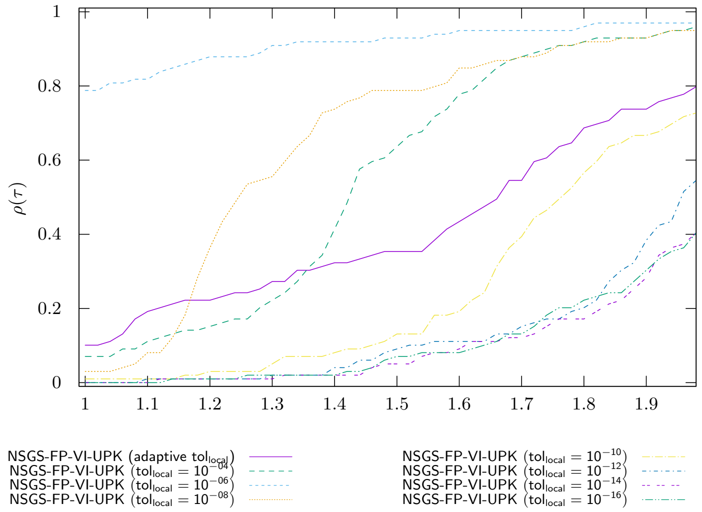

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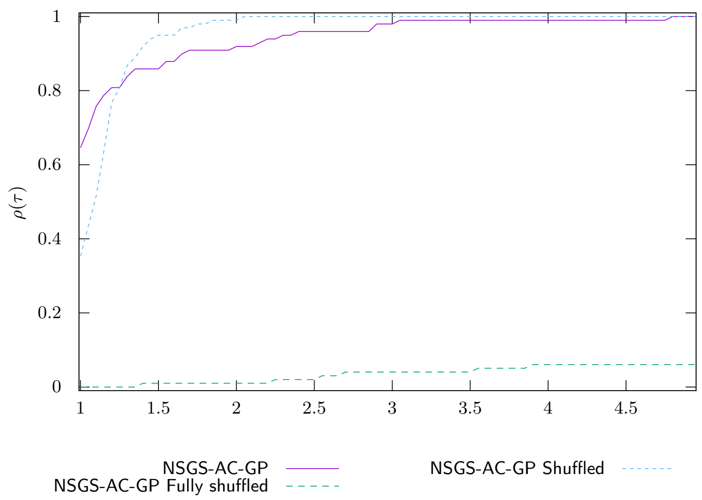

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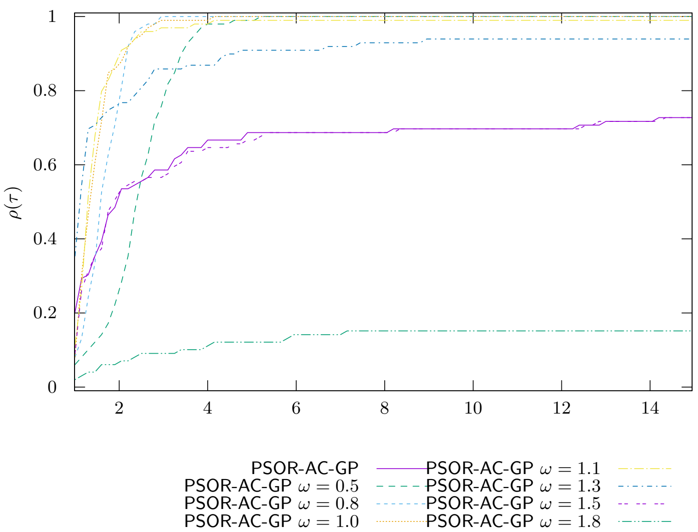

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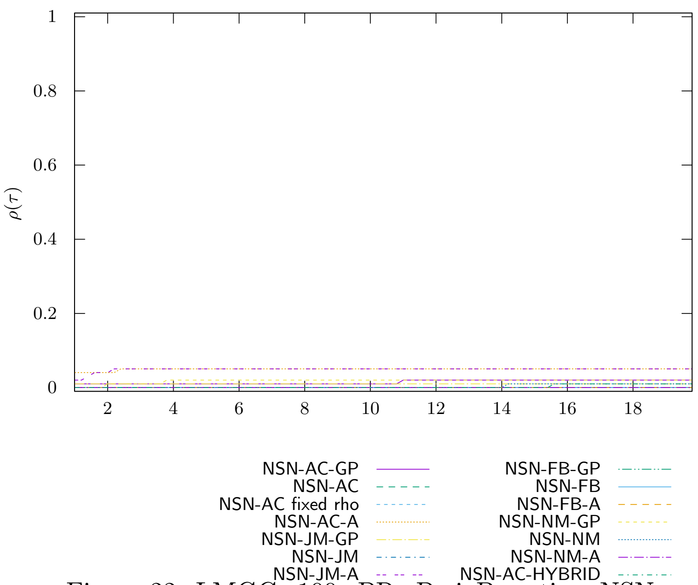

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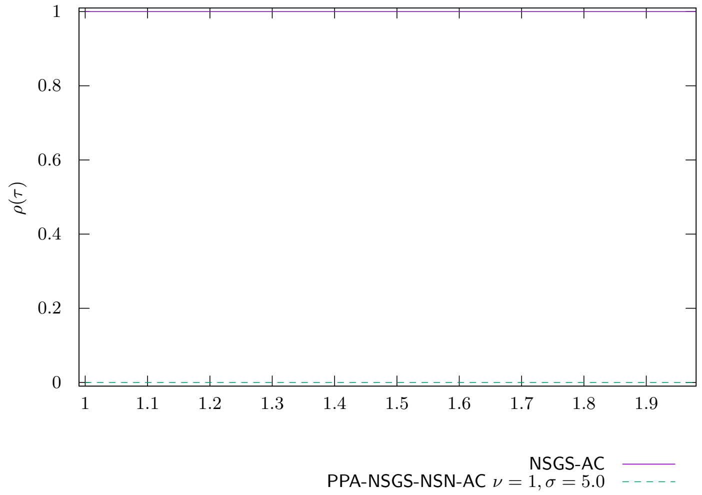

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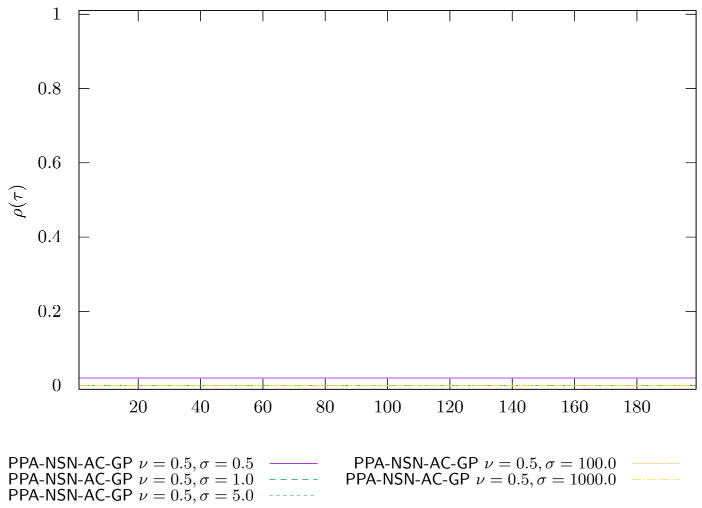

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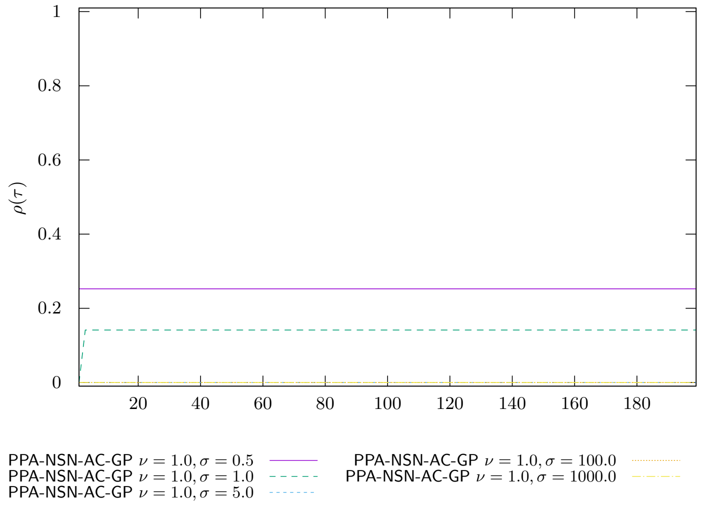

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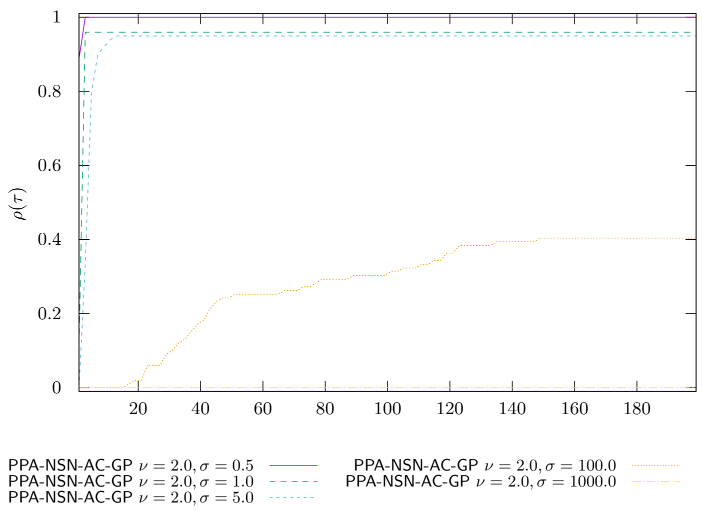

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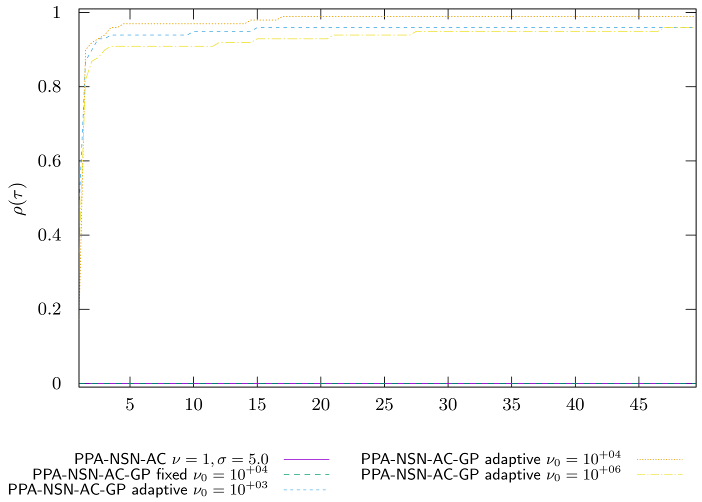

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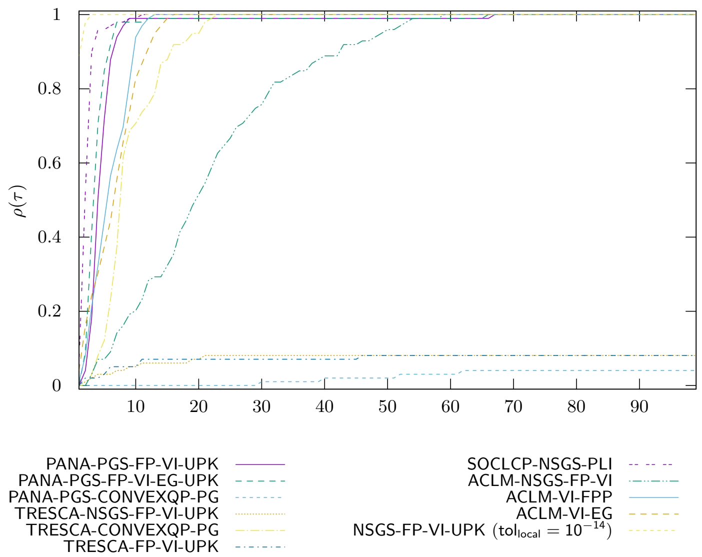


Figure 28: LMGC_100_PR_PerioBox time OPTI

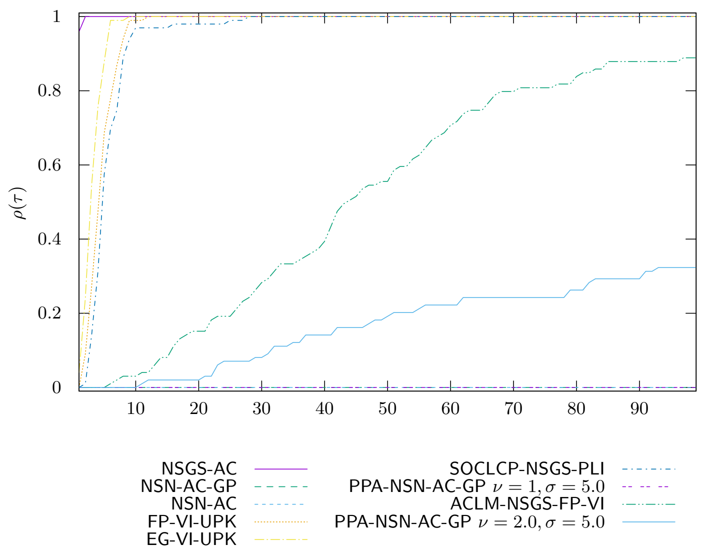


Figure 29: LMGC_100_PR_PerioBox time COMP/large

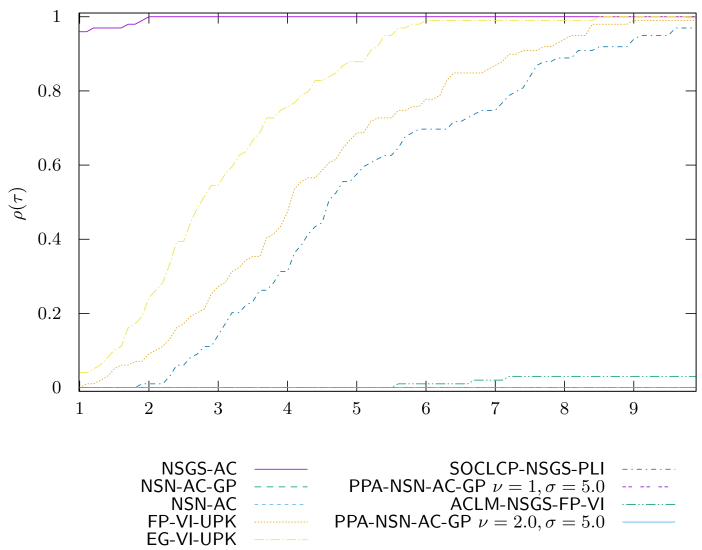


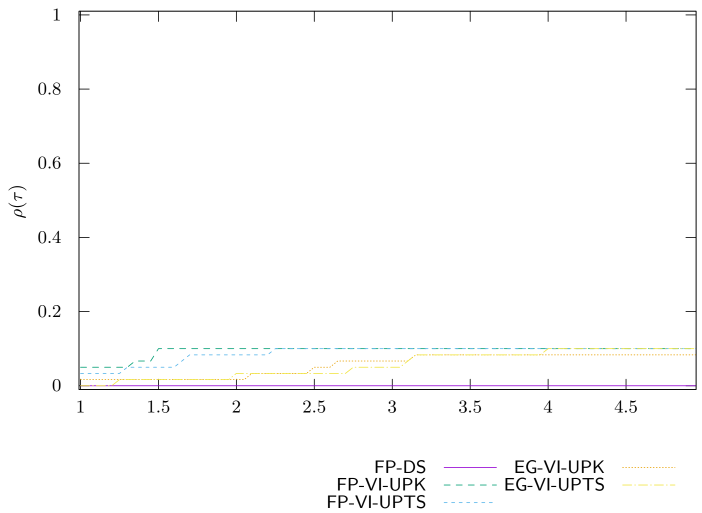
Figure 30: LMGC_100_PR_PerioBox time COMP/zoom

4.1 Comments

1. VI solvers:
   (a) The EG-VI solvers are better than FP-VI solvers.
   (b) The local update rule UPK vs. UPTS is not important
   (c) The update in the loop improves greatly the convergence rate.
2. NSGS Solvers:
   (a) Local solvers
      i. NSN local solvers without line-search are the best solvers. Note that the choice of $\rho_N = \rho_T = 1$ does not degrade the performance.
      ii. GP line-search method is slowing a bit the efficiency of the solver. Since all the problems are solved without line-search procedure, there is no interest in that case to use it to improve the robustness of the NSN local solvers.
      iii. Quite surprisingly, the local solvers based on FP-VI-UPK are also efficient, especially when we limit the number of iteration or the local tolerance of the local algorithm.
      iv. The exact solver is the efficient solver but not robust at all.
      v. The use of hybrid solvers are also not very attractive since all the problems are solved by NSN methods.
   (b) Local Tolerances: The study of the local tolerances of the local solvers shows two differents tendancies for two classes of solvers:
      i. NSN local solvers are not influenced by the local tolerances. We guessed that the problems are sufficiently easy such that the Newton solver converge to tight tolerances in few iterations.
      ii. For the NSGS-FP-VI-UPK, a limited tolerance improves the efficiency without reducing the robustness
   (c) Shuffling techniques: The shuffling of contact does not improve the convergence.
3. PSOR Solvers.
   (a) For the values of the relaxation parameters ω in $[1.3, 1.5]$, the relaxation increases the efficiency of the solver but decreases the robustness
   (b) For low values of the relaxation parameters ω in $[0.5, 0.8]$, the relaxation increases the the robustness but decreases the efficiency
4. NSN and PROX solvers. The direct Newton techniques on such rigid-body test set are inefficient. (link to the distribution of ranks of the matrices)

5. OPTI solvers. On this problem, the ACLM and TRESCA approaches do not improve the efficiency. The problems are also better solved by the SOCLCP technique. Convexification is working well.

5 LMGC_945_SP_Box_PL precision 1.0e-04 timeout 100



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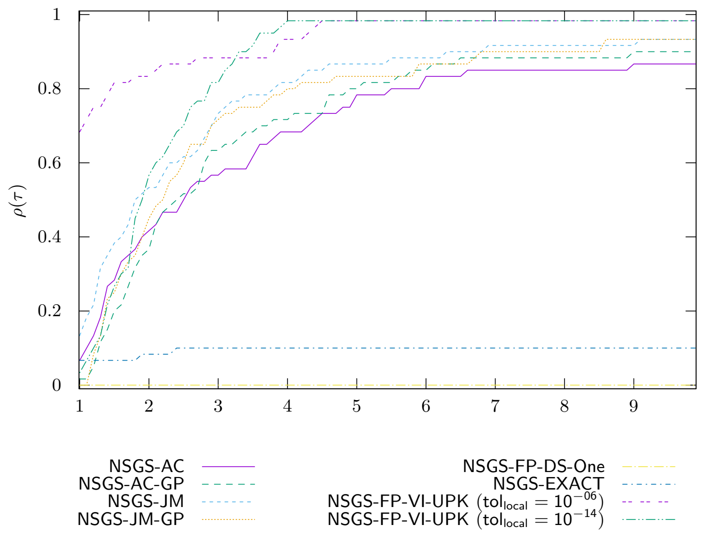
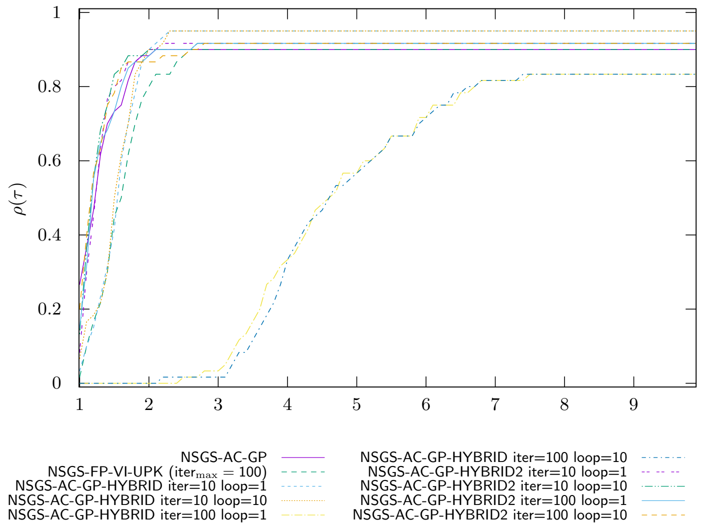


Figure 32: LMGC_945_SP_Box_PL time NSGS/LocalSolver



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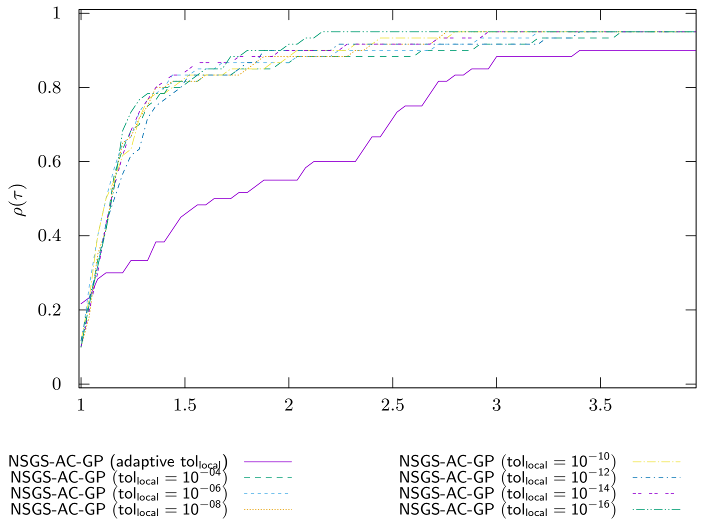


Figure 34: LMGC_945_SP_Box_PL time NSGS/LocalTol

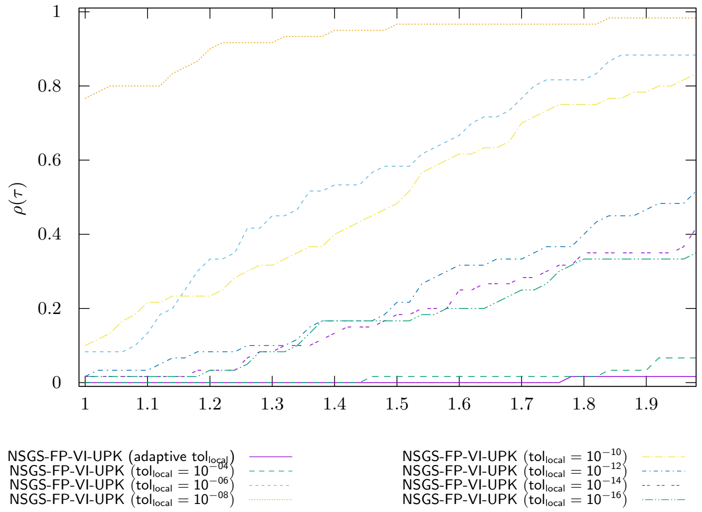


Figure 35: LMGC_945_SP_Box_PL time NSGS/LocalTol-VI

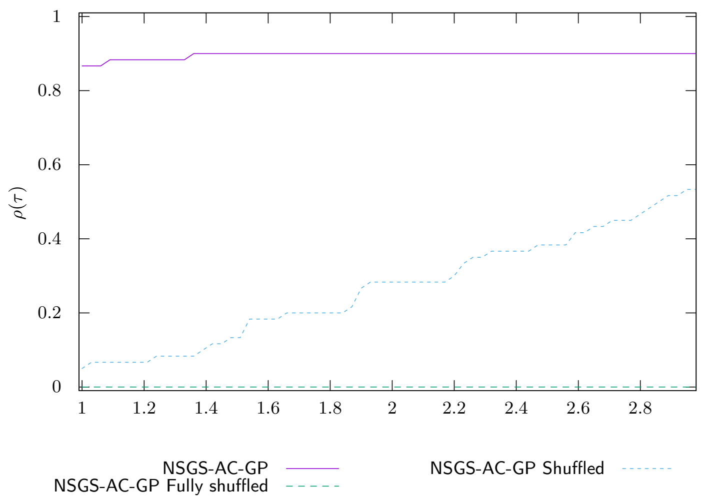


Figure 36: LMGC_945_SP_Box_PL time NSGS/Shuffled

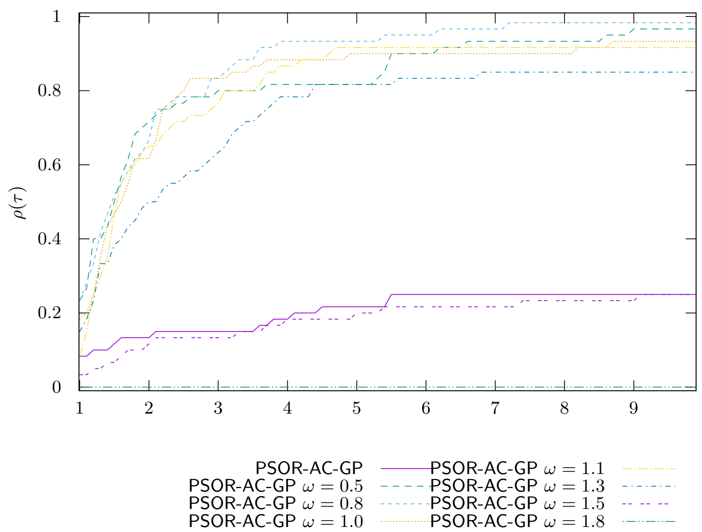
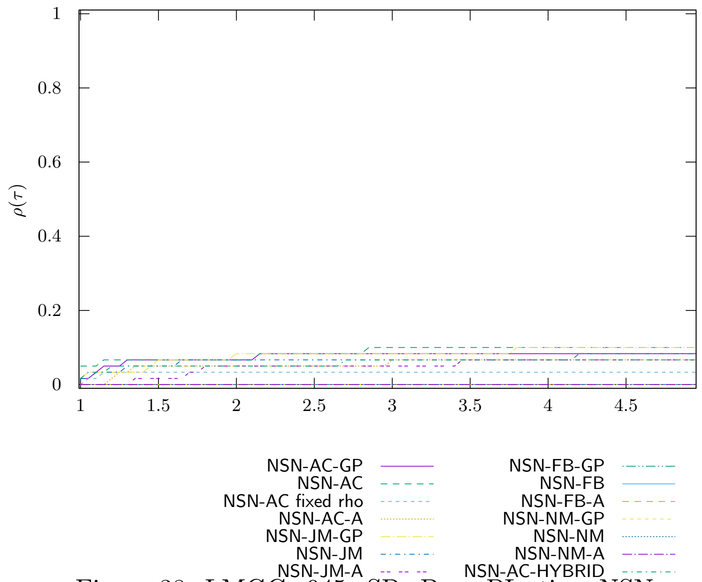


Figure 37: LMGC_945_SP_Box_PL time PSOR



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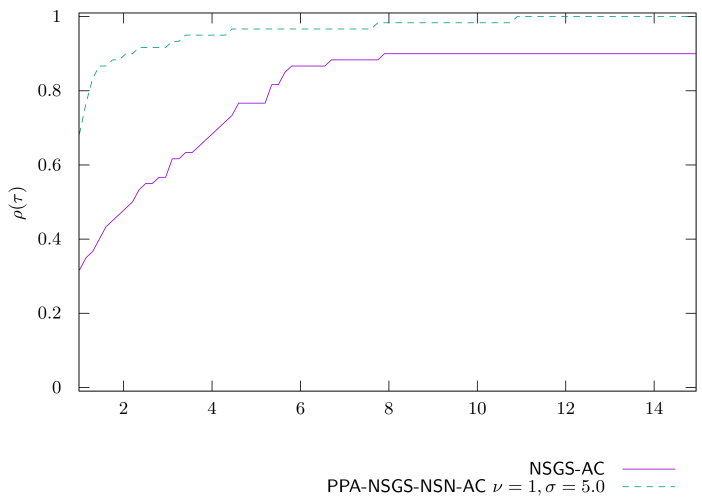

Figure 39: LMGC_945_SP_Box_PL time PROX/InternalSolvers

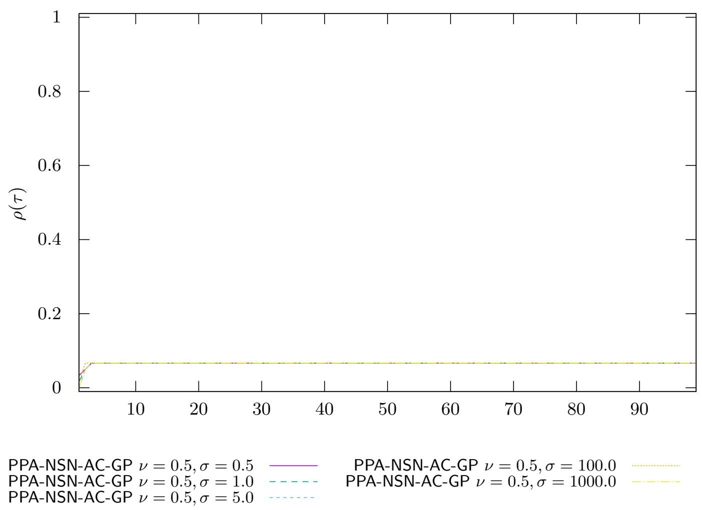

Figure 40: LMGC_945_SP_Box_PL time PROX/Parametric studies $\nu = 0.5$

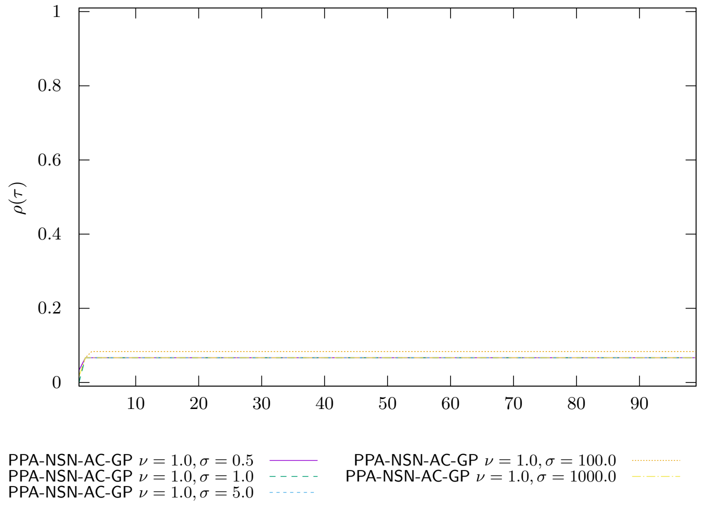

Figure 41: LMGC_945_SP_Box_PL time PROX/Parametric studies $\nu = 1.0$

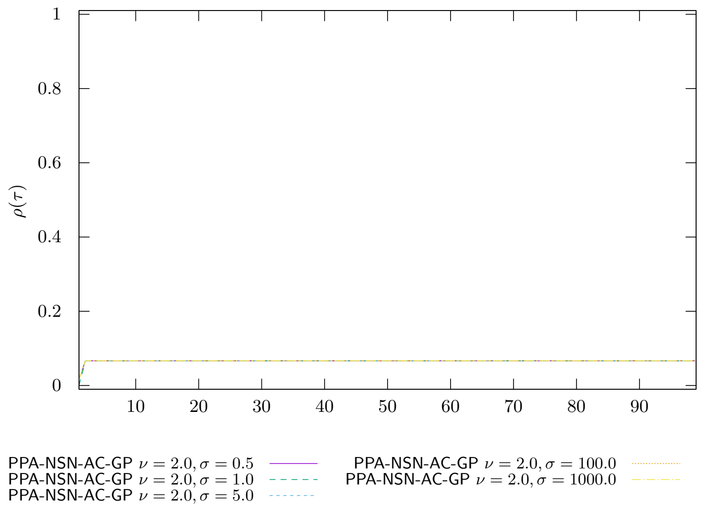

Figure 42: LMGC_945_SP_Box_PL time PROX/Parametric studies $\nu = 2.0$

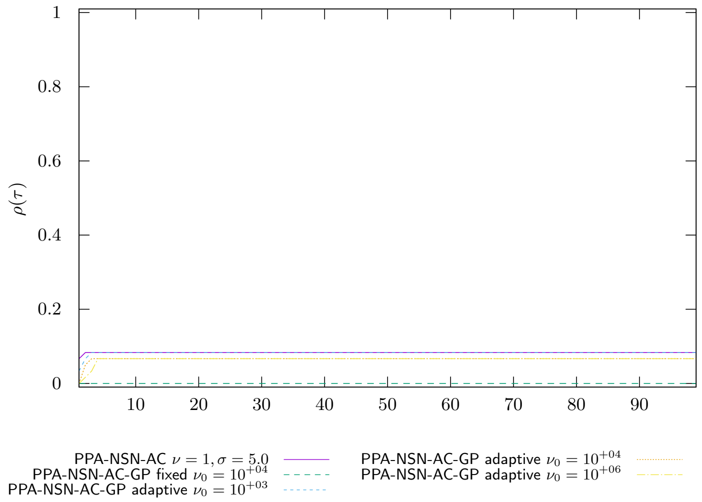

Figure 43: LMGC_945_SP_Box_PL time PROX/Regularized problem

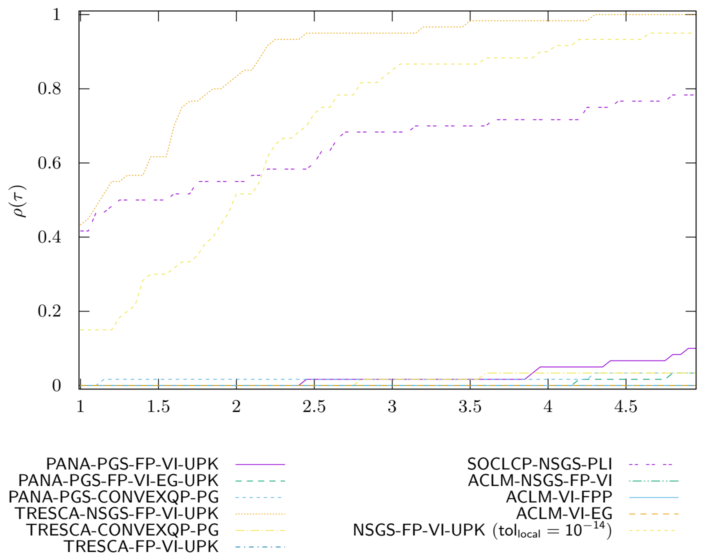

Figure 44: LMGC_945_SP_Box_PL time OPTI

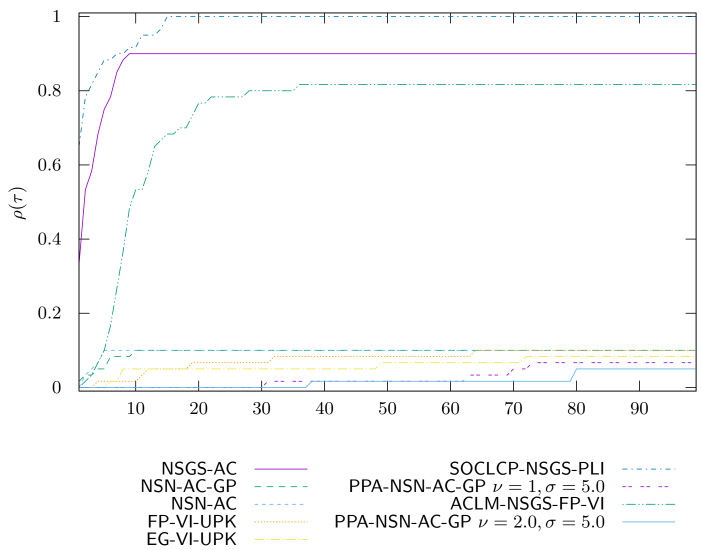

Figure 45: LMGC_945_SP_Box_PL time COMP/large

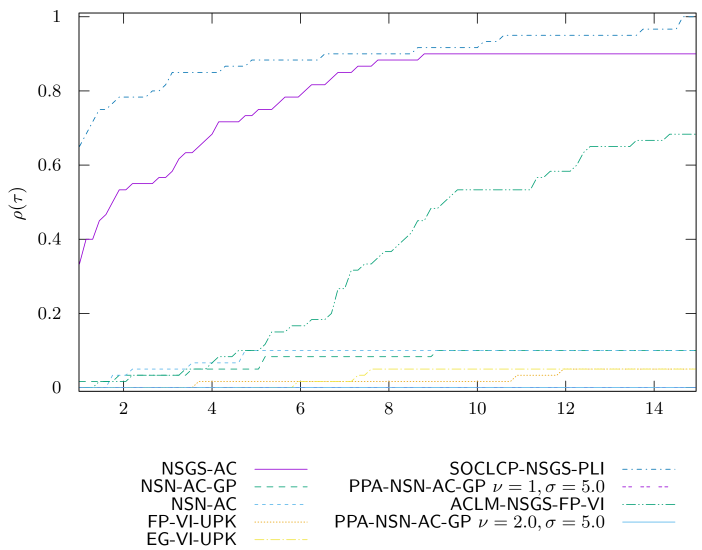

Figure 46: LMGC_945_SP_Box_PL time COMP/zoom

5.1 Comments

1. VI solvers: difficult to draw conclusions since a lot of solvers are not able to converge within timeout

2. NSGS Solvers:

   (a) Local solvers

      i. NSGS-FP-VI-UPK are the best solvers.

      ii. NSGS-NSN suffers from huge robustness problem.

      iii. GP line-search method improves a bit the efficiency of the solver

      iv. Hybrid solvers seems to succeed but it is difficult to say if the Newton method helps to improve results

   (b) Local Tolerances: For the NSGS-FP-VI-UPK, a limited tolerance improves the efficiency without reducing the robustness

   (c) Shuffling techniques: The shuffling of contact does not improve the convergence.

3. PSOR Solvers. No conclusion due to robustness problems

4. NSN and PROX solvers. The direct Newton techniques on such rigid-body test set are inefficient. (link to the distribution of ranks of the matrices)

5. OPTI solvers. On this problem, the TRESCA approach improves a lot the efficiency. The problems are also better solved by the SOCLCP technique/ Convexification is working well.

6 LMGC Aqueduc PR precision 1.0e-04 timeout 200

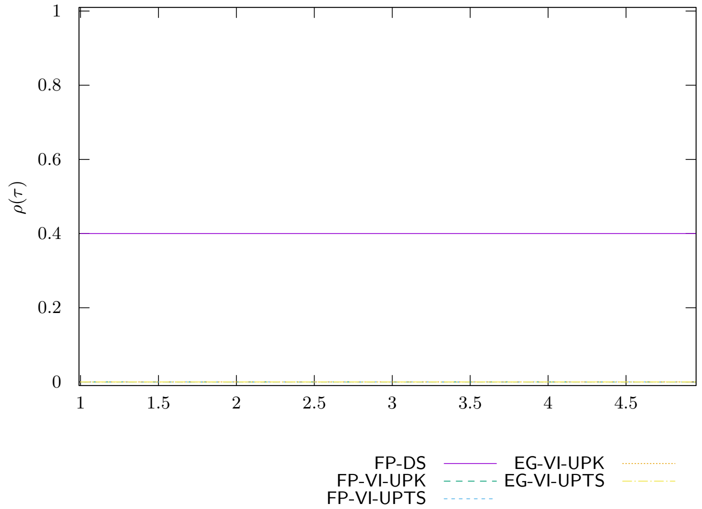

Figure 47: LMGC Aqueduc PR time VI/UpdateRule

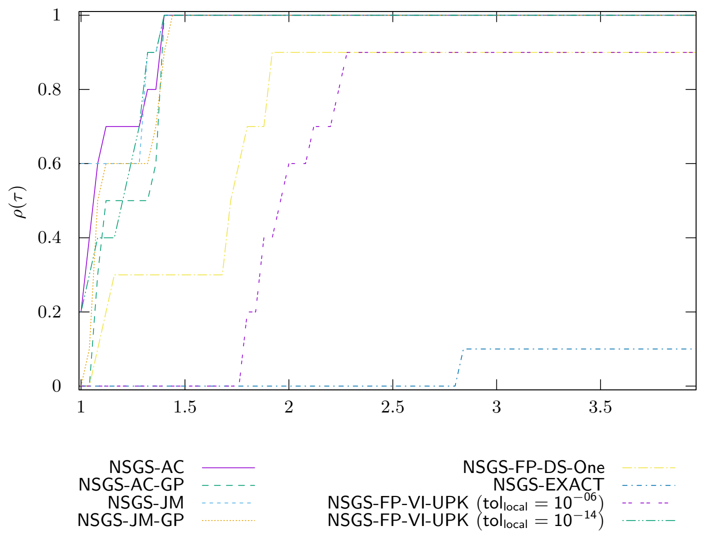

Figure 48: LMGC Aqueduc PR time NSGS/LocalSolver

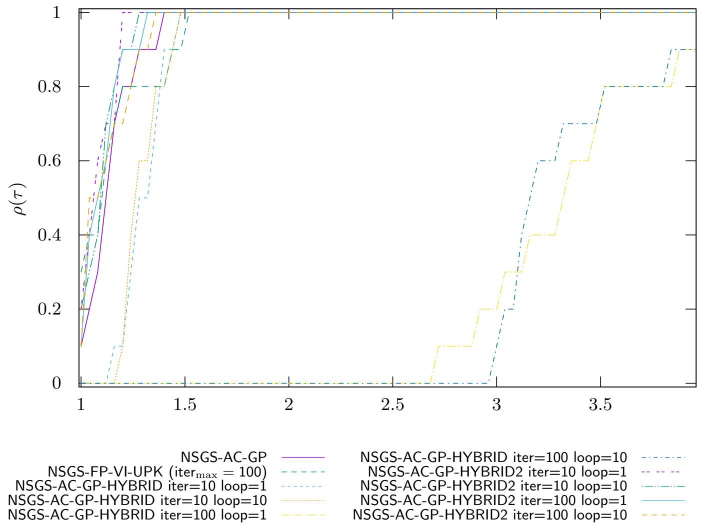

Figure 49: LMGC Aqueduc PR time NSGS/LocalSolverHybrid

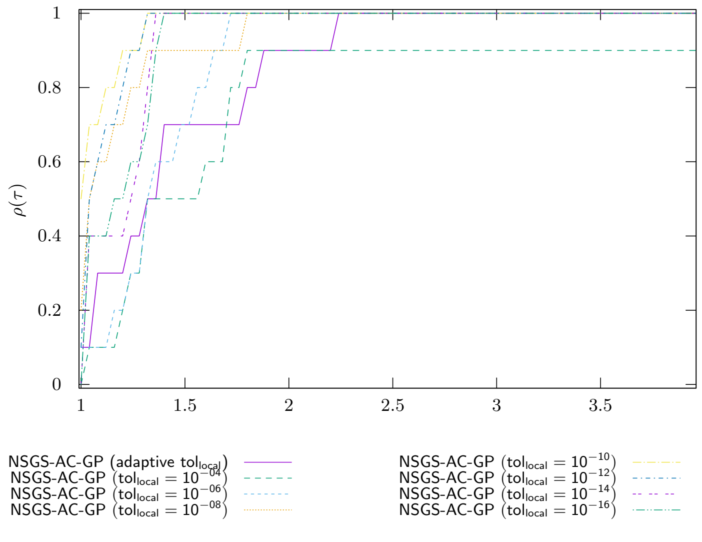

Figure 50: LMGC Aqueduc PR time NSGS/LocalTol

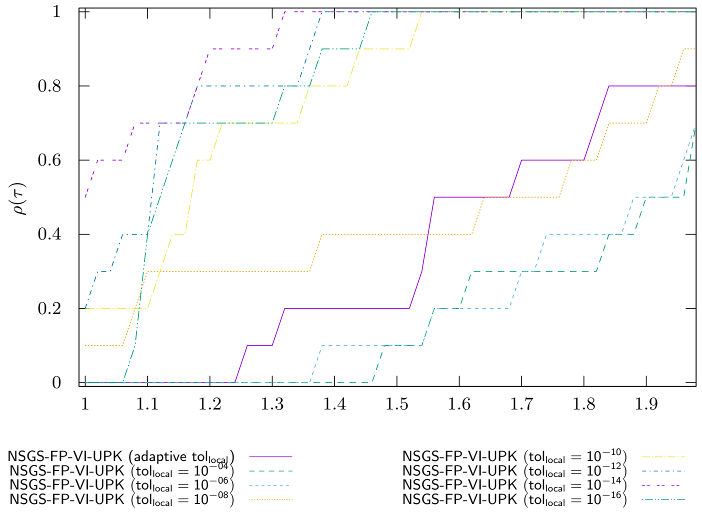

Figure 51: LMGC Aqueduc PR time NSGS/LocalTol-VI

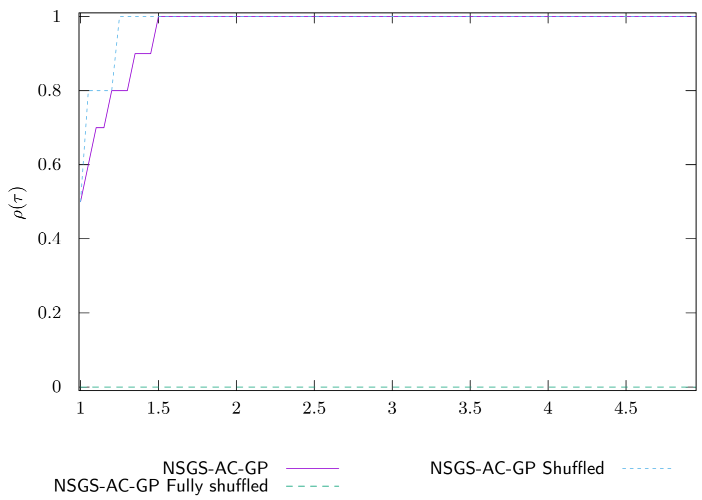

Figure 52: LMGC Aqueduc PR time NSGS/Shuffled

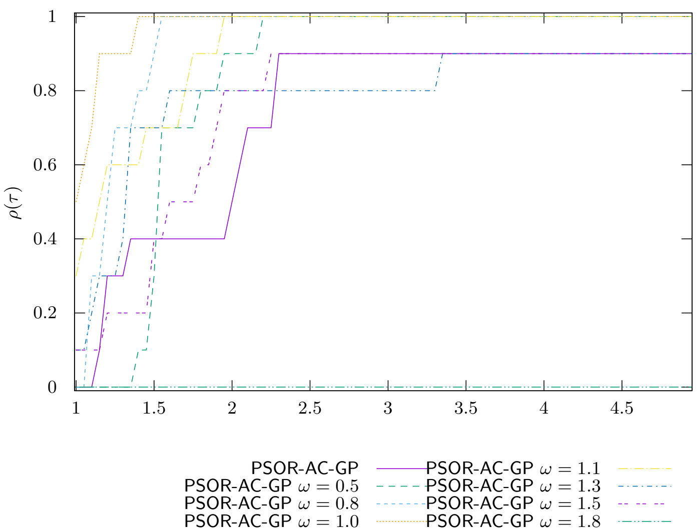

Figure 53: LMGC Aqueduc PR time PSOR

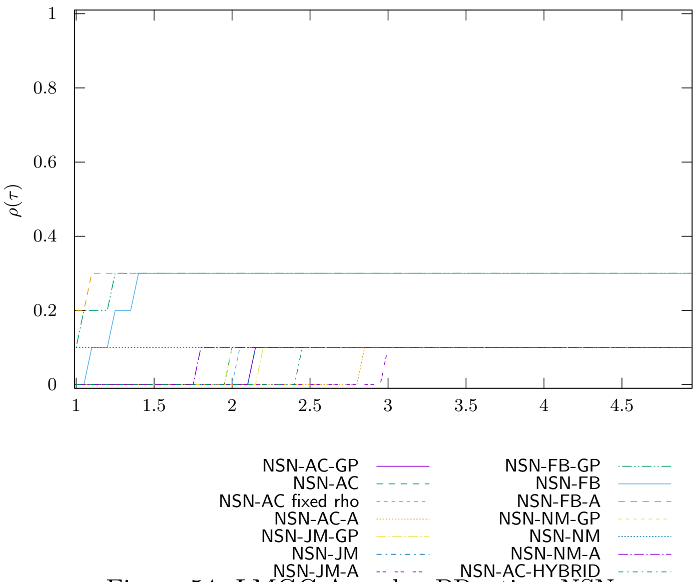

Figure 54: LMGC Aqueduc PR time NSN

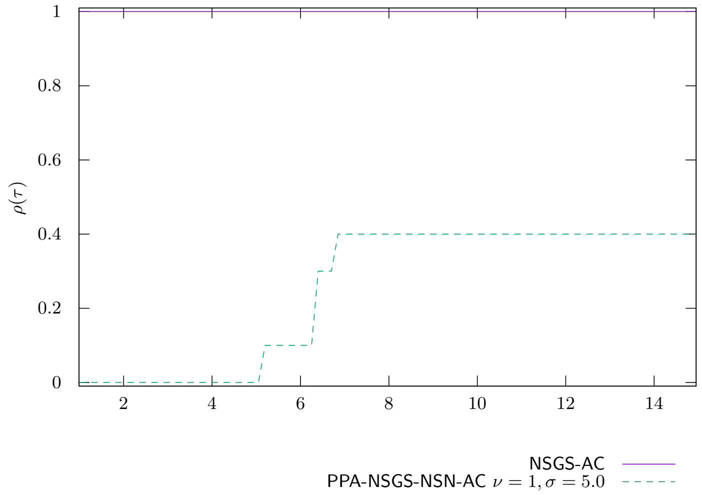

Figure 55: LMGC Aqueduc PR time PROX/InternalSolvers

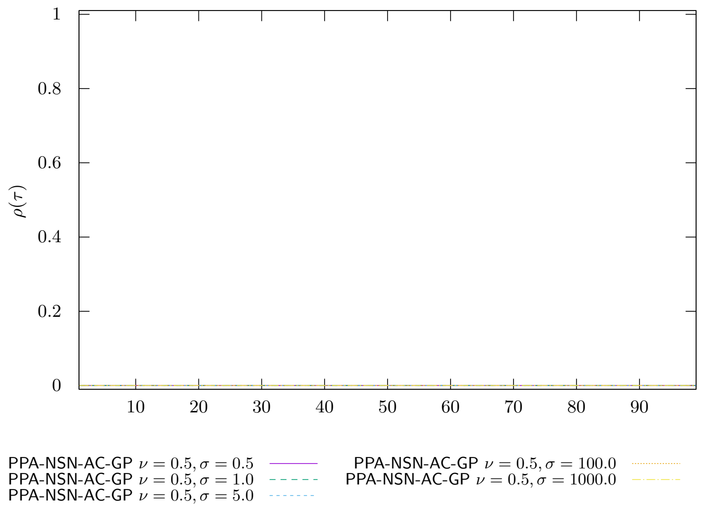

Figure 56: LMGC Aqueduc PR time PROX/Parametric studies $\nu = 0.5$

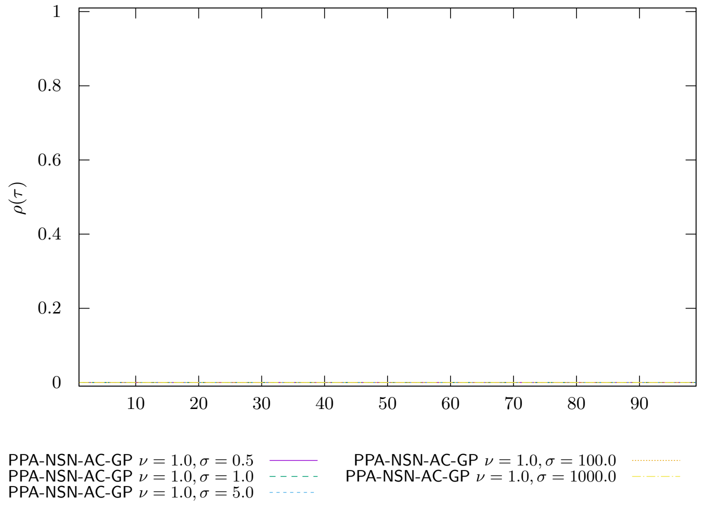

Figure 57: LMGC Aqueduc PR time PROX/Parametric studies $\nu = 1.0$

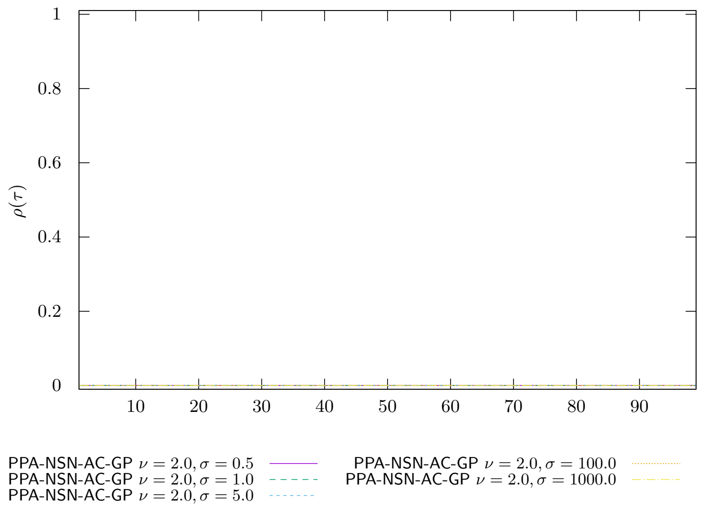

Figure 58: LMGC Aqueduc PR time PROX/Parametric studies $\nu = 2.0$

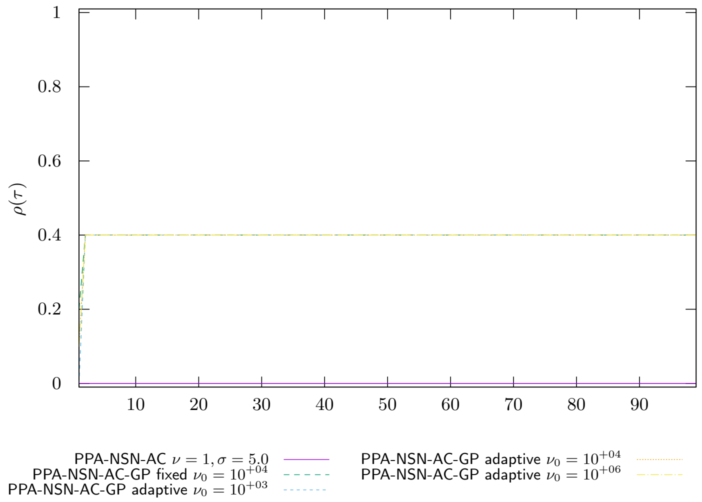

Figure 59: LMGC Aqueduc PR time PROX/Regularized problem

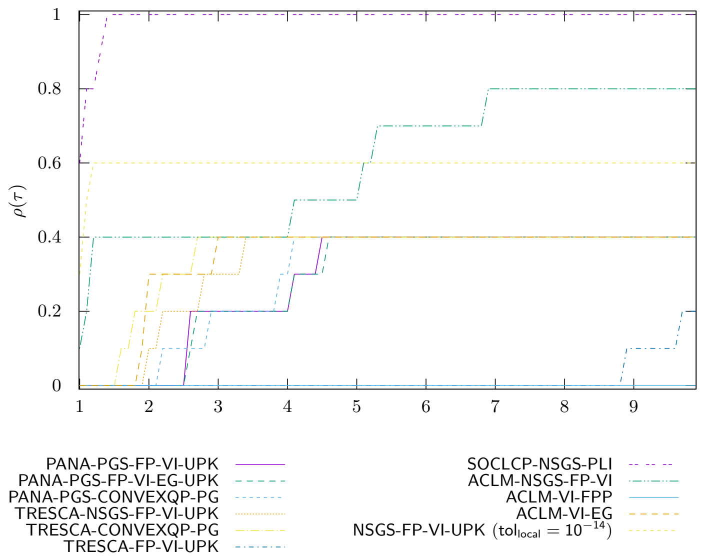

Figure 60: LMGC Aqueduc PR time OPTI

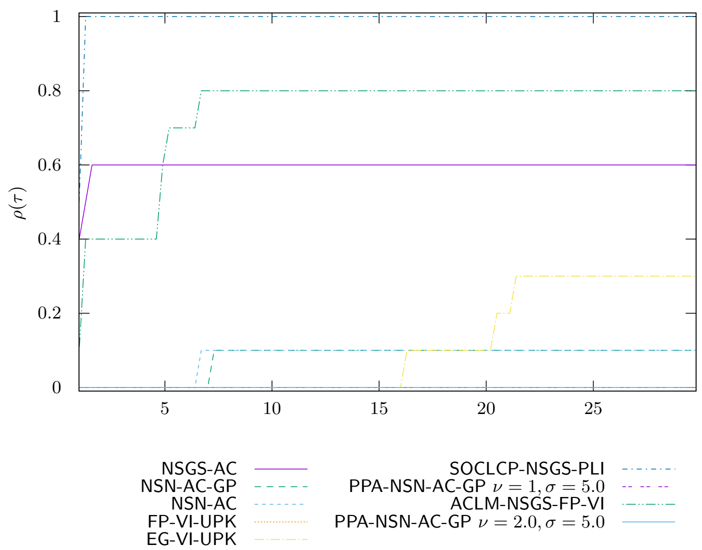

Figure 61: LMGC Aqueduc PR time COMP/large

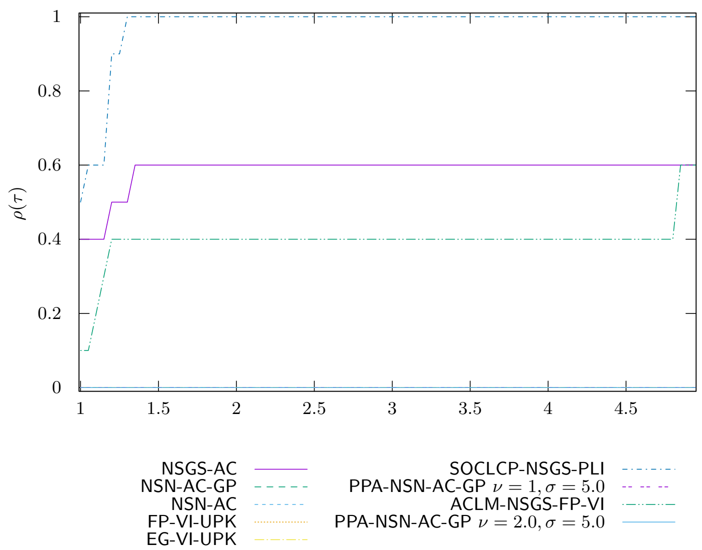

Figure 62: LMGC Aqueduc PR time COMP/zoom

6.1 Comments

1. VI solvers: difficult to draw conclusions since a lot of solvers are not able to converge within timeout
2. NSGS Solvers:
   (a) Local solvers
      i. NSGS-NSN-*-GP are the best solvers. Line search improves efficiency of the solvers.
      ii. Hybrid solvers do not bring new advantages which is not surprising since NSGS-NSN solvers are the best
   (b) Local Tolerances:
   (c) Shuffling techniques: The shuffling of contact does not improve the convergence.
3. PSOR Solvers. The relaxation is not interesting in this example
4. NSN and PROX solvers. The direct Newton techniques on such rigid-body test set are inefficient. (link to the distribution of ranks of the matrices)
5. OPTI solvers. On this problem, the ACLM approach improves a lot the efficiency and the robustness. The problems are also better solved by the SOCLCP technique. Convexification is working well.

7 LMGC Bridge PR precision 1.0e-04 timeout 100

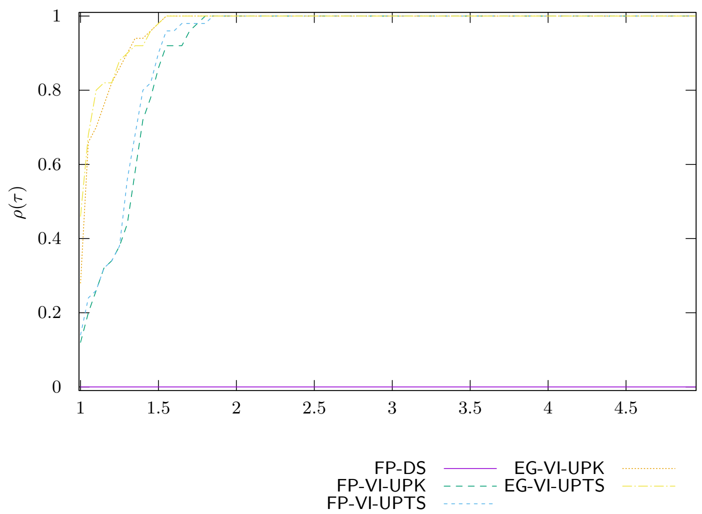

Figure 63: LMGC Bridge PR time VI/UpdateRule

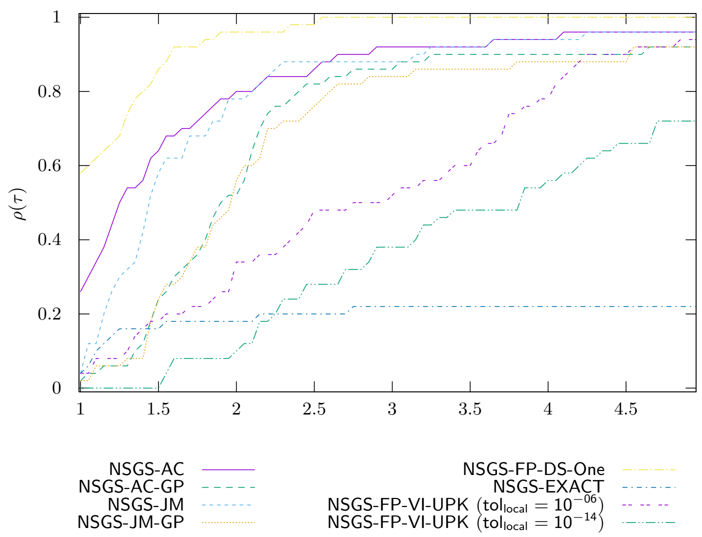

Figure 64: LMGC Bridge PR time NSGS/LocalSolver

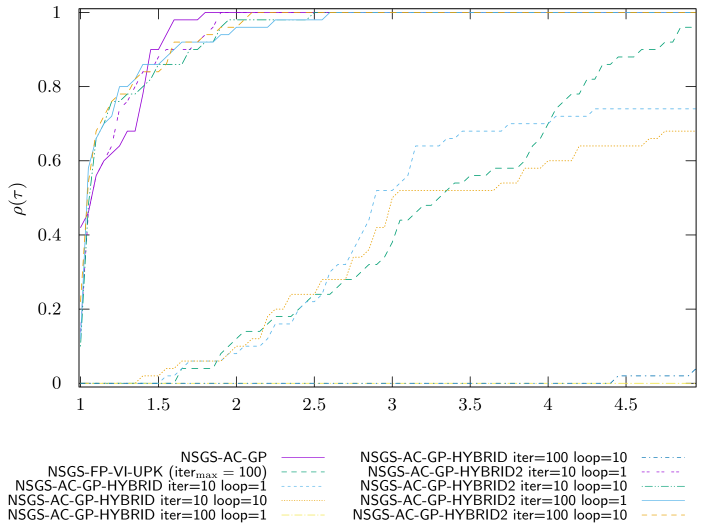

Figure 65: LMGC Bridge PR time NSGS/LocalSolverHybrid

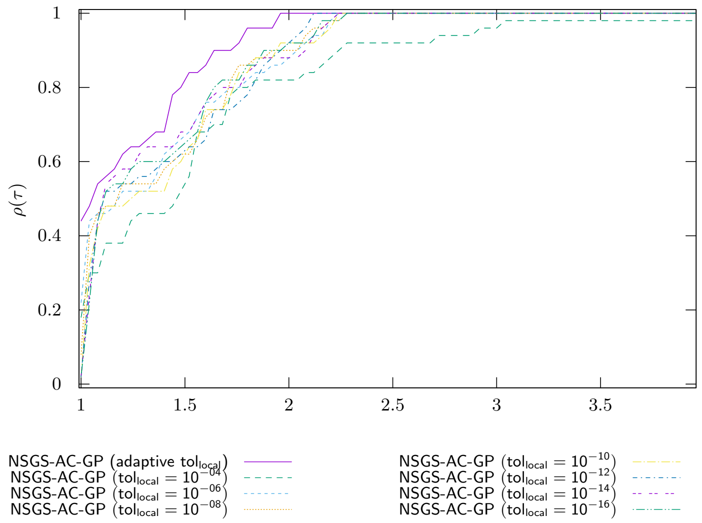

Figure 66: LMGC Bridge PR time NSGS/LocalTol

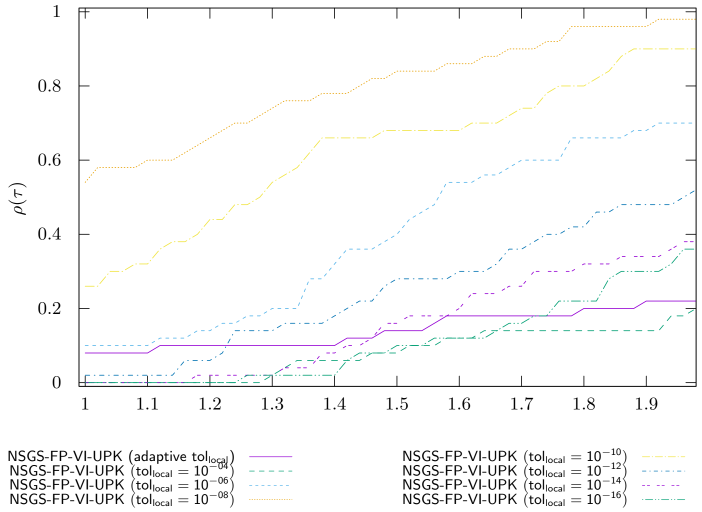

Figure 67: LMGC Bridge PR time NSGS/LocalTol-VI

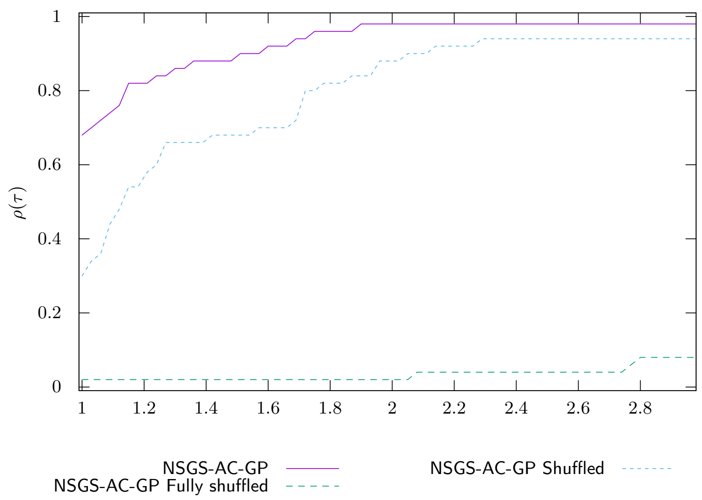

Figure 68: LMGC Bridge PR time NSGS/Shuffled

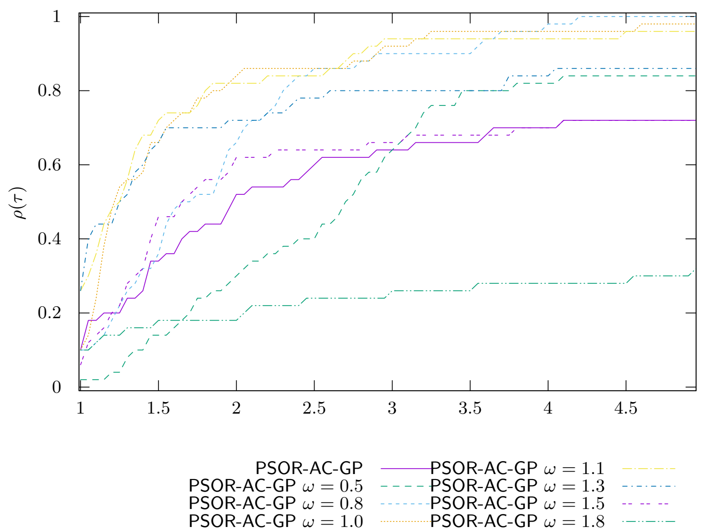

Figure 69: LMGC Bridge PR time PSOR

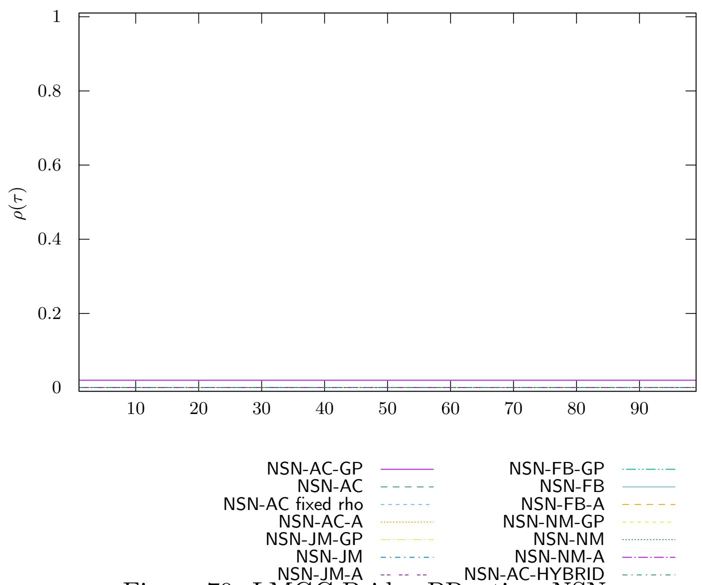

Figure 70: LMGC Bridge PR time NSN

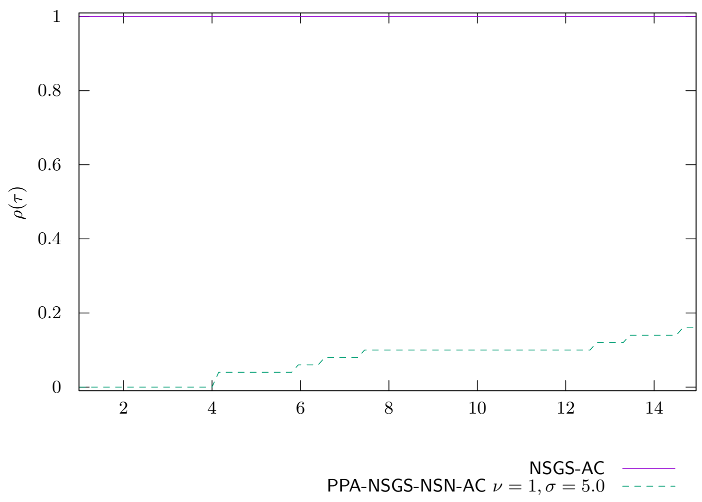

Figure 71: LMGC Bridge PR time PROX/InternalSolvers

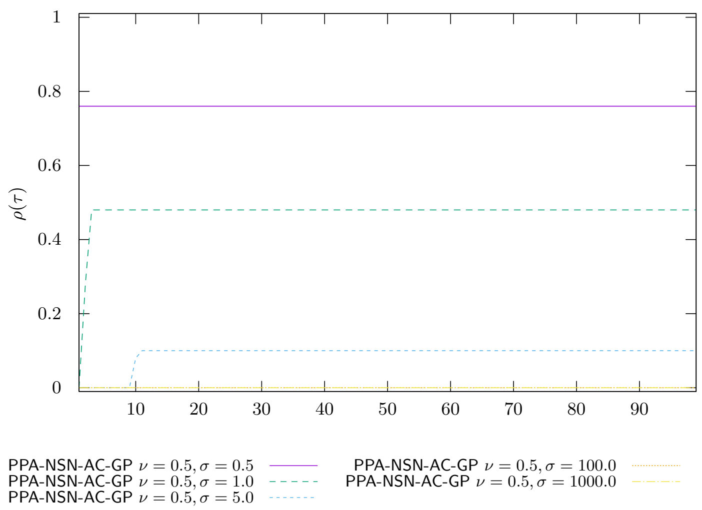

Figure 72: LMGC Bridge PR time PROX/Parametric studies $\nu = 0.5$

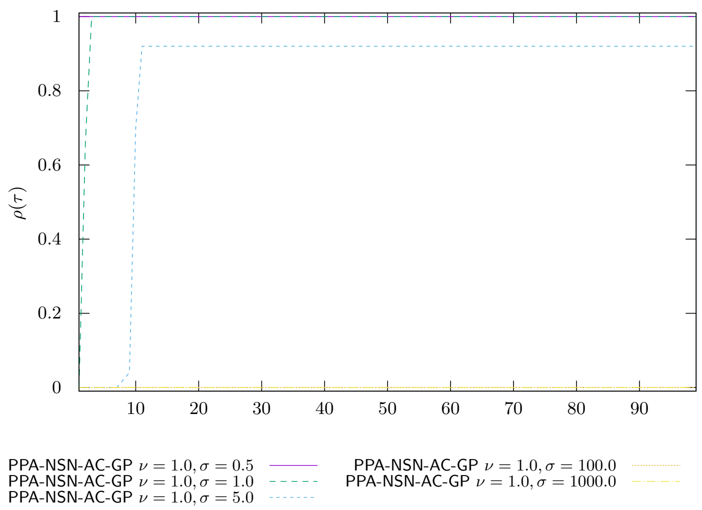

Figure 73: LMGC Bridge PR time PROX/Parametric studies $\nu = 1.0$

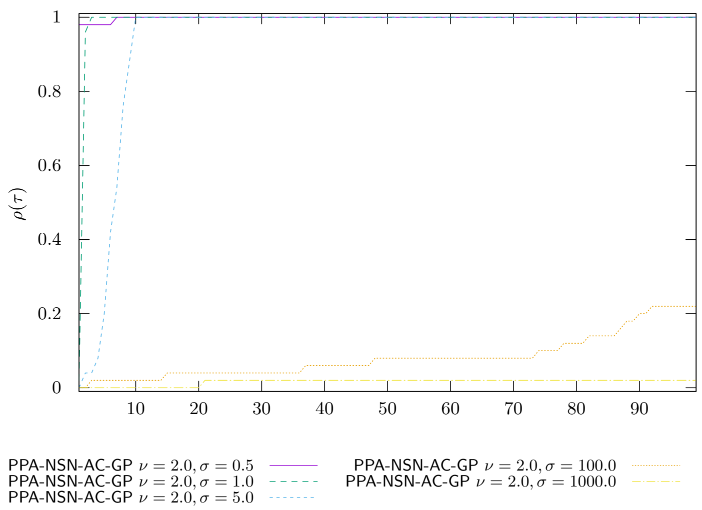

Figure 74: LMGC Bridge PR time PROX/Parametric studies $\nu = 2.0$

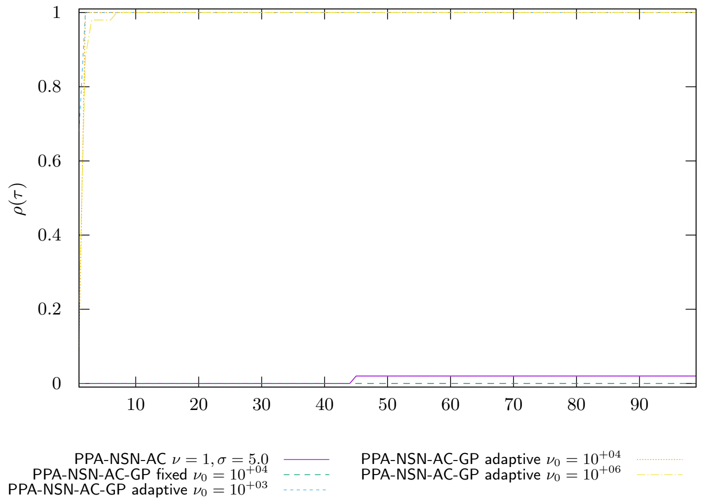

Figure 75: LMGC Bridge PR time PROX/Regularized problem

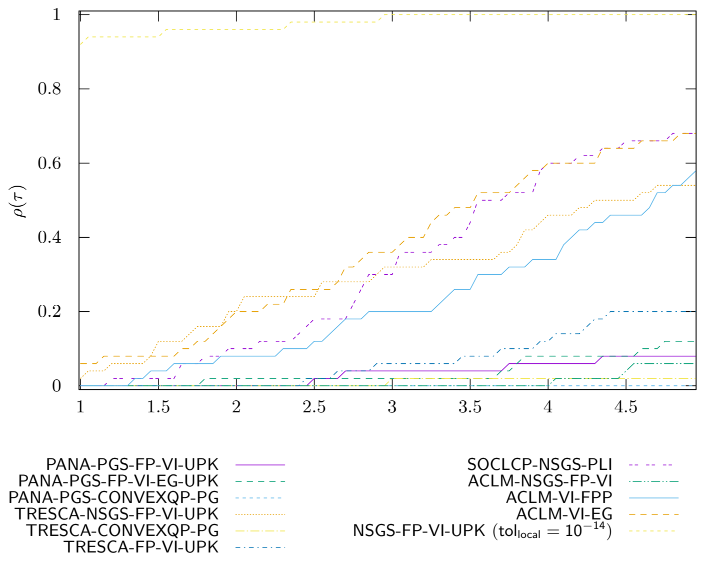

Figure 76: LMGC Bridge PR time OPTI

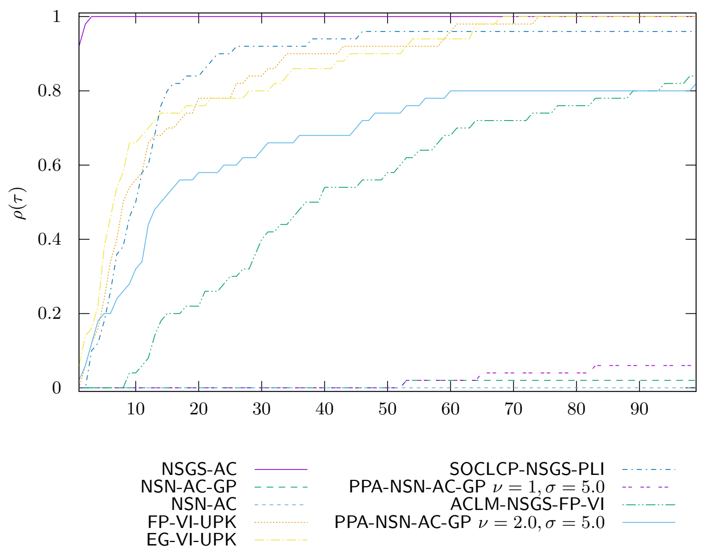

Figure 77: LMGC Bridge PR time COMP/large

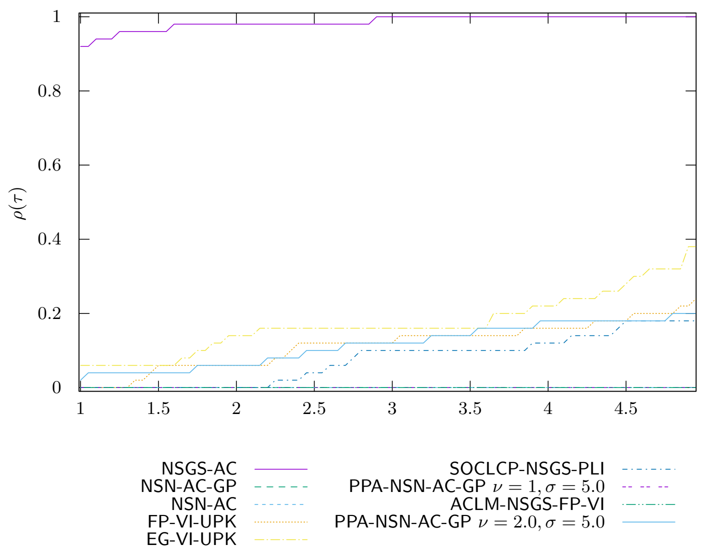

Figure 78: LMGC Bridge PR time COMP/zoom

8 LMGC LowWall FEM precision 1.0e-04 timeout 400

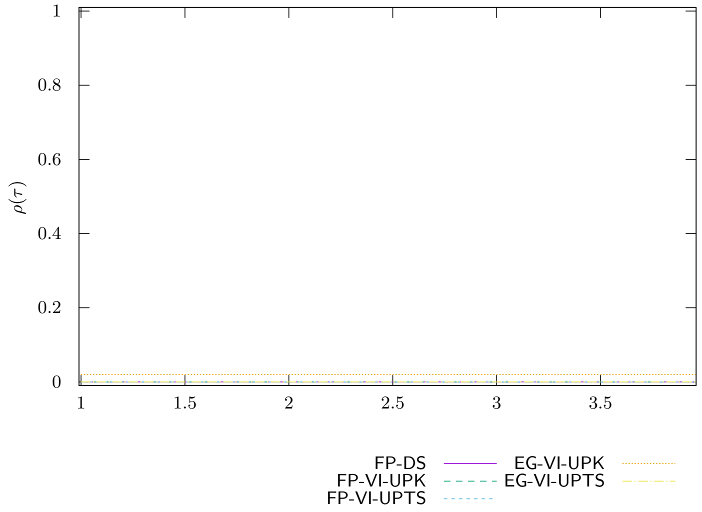

Figure 79: LMGC LowWall FEM time VI/UpdateRule

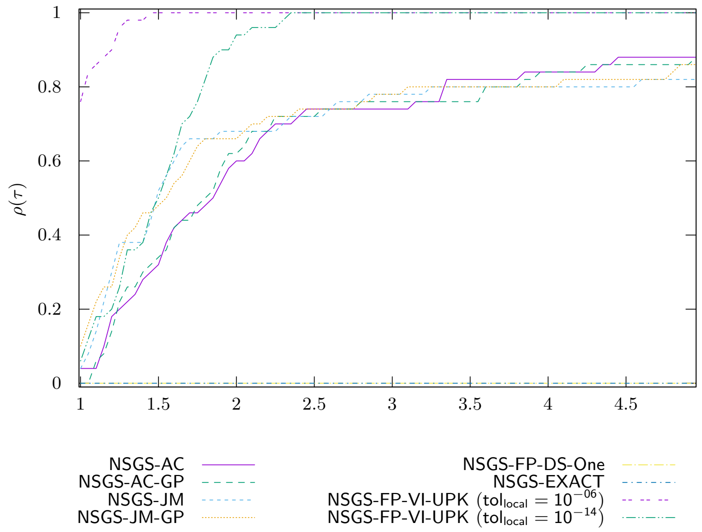

Figure 80: LMGC LowWall FEM time NSGS/LocalSolver

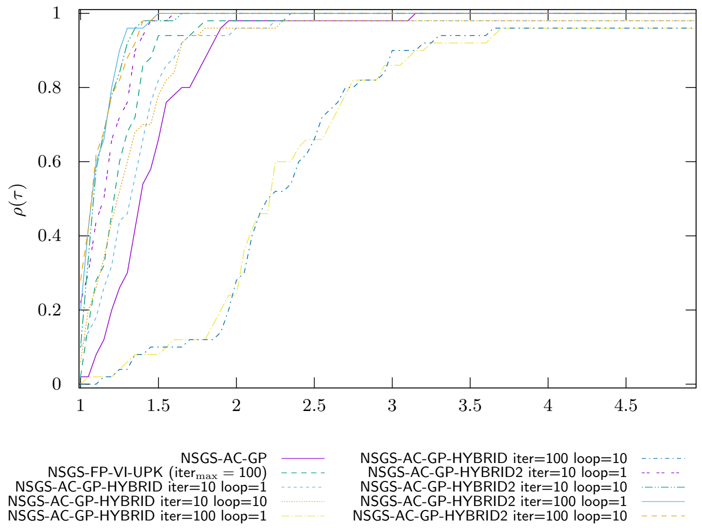

Figure 81: LMGC LowWall FEM time NSGS/LocalSolverHybrid

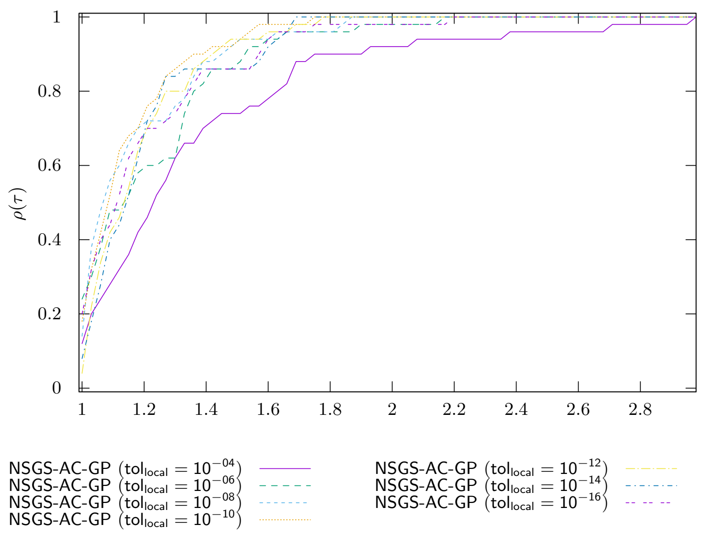

Figure 82: LMGC LowWall FEM time NSGS/LocalTol

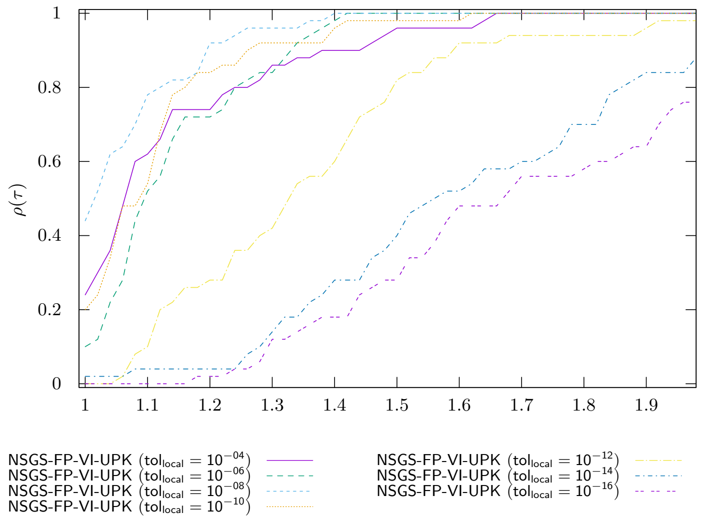

Figure 83: LMGC LowWall FEM time NSGS/LocalTol-VI

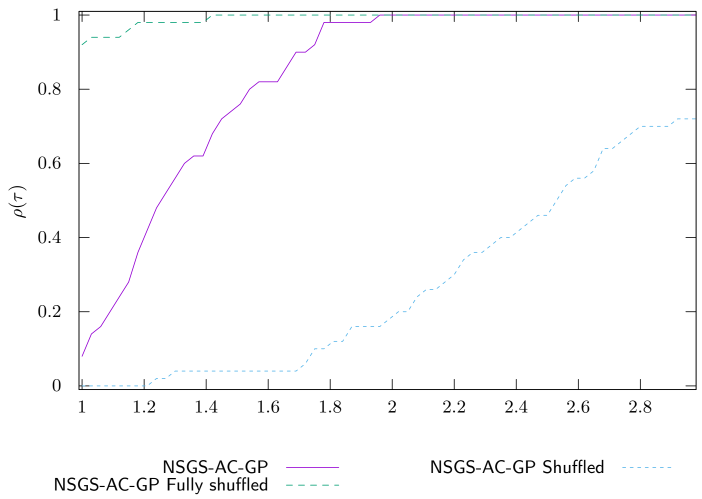

Figure 84: LMGC LowWall FEM time NSGS/Shuffled

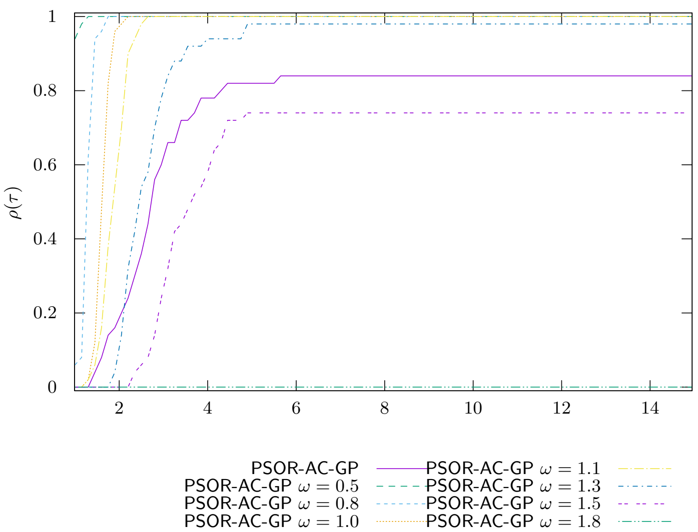

Figure 85: LMGC LowWall FEM time PSOR

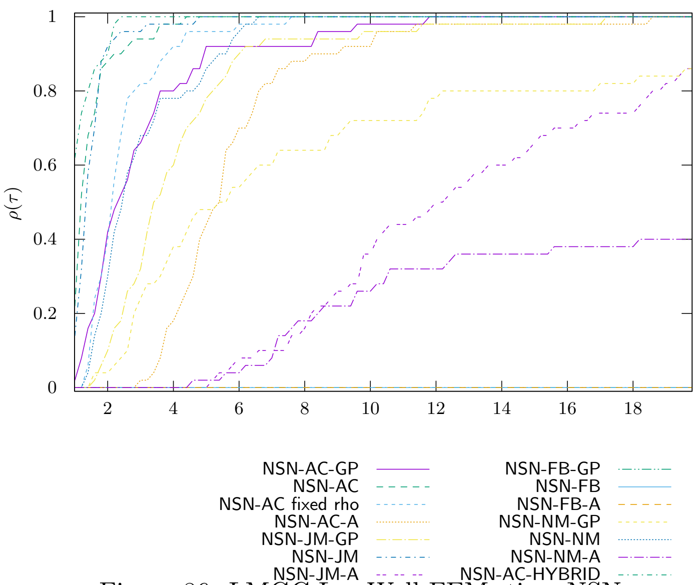

Figure 86: LMGC LowWall FEM time NSN

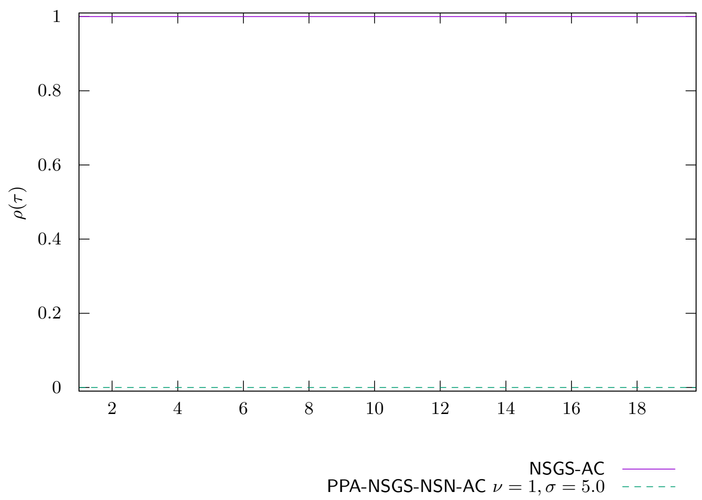

Figure 87: LMGC LowWall FEM time PROX/InternalSolvers

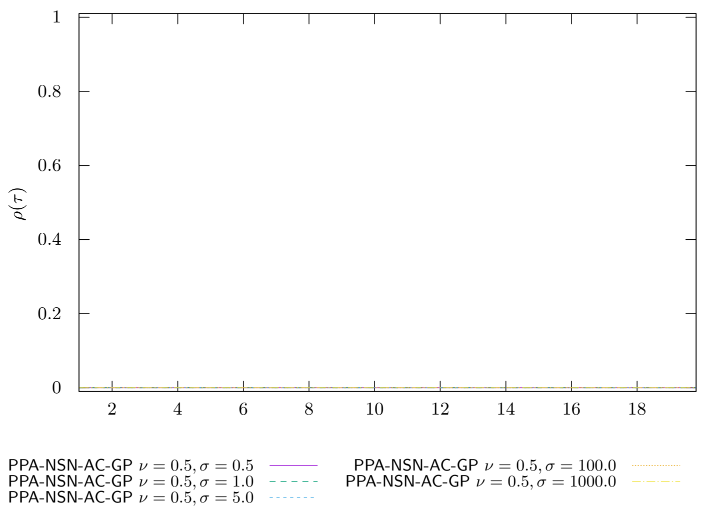

Figure 88: LMGC LowWall FEM time PROX/Parametric studies $\nu = 0.5$

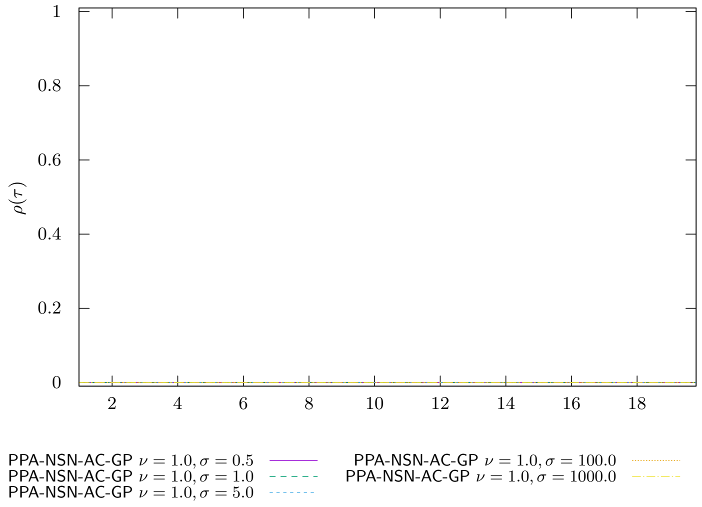

Figure 89: LMGC LowWall FEM time PROX/Parametric studies $\nu = 1.0$

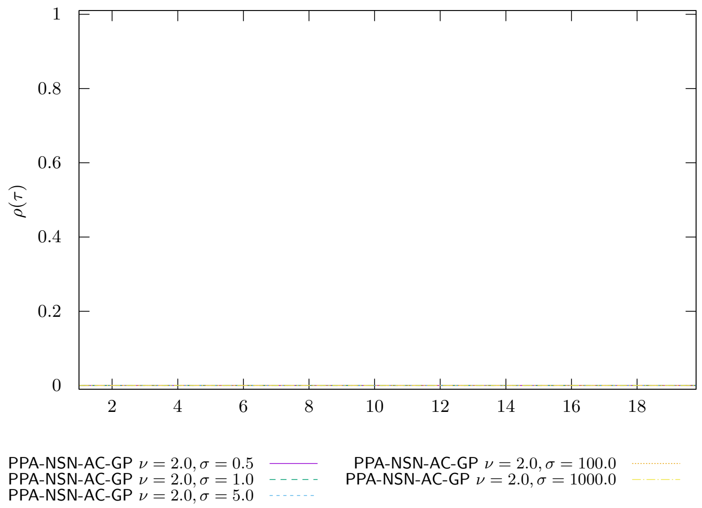

Figure 90: LMGC LowWall FEM time PROX/Parametric studies $\nu = 2.0$

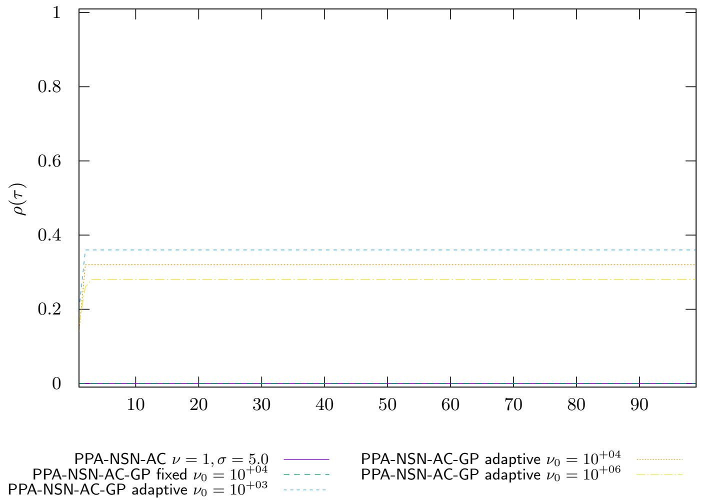

Figure 91: LMGC LowWall FEM time PROX/Regularized problem

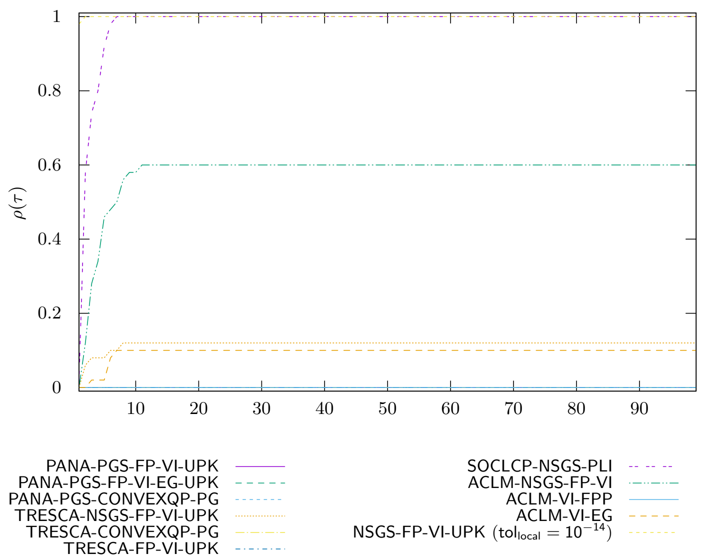

Figure 92: LMGC LowWall FEM time OPTI

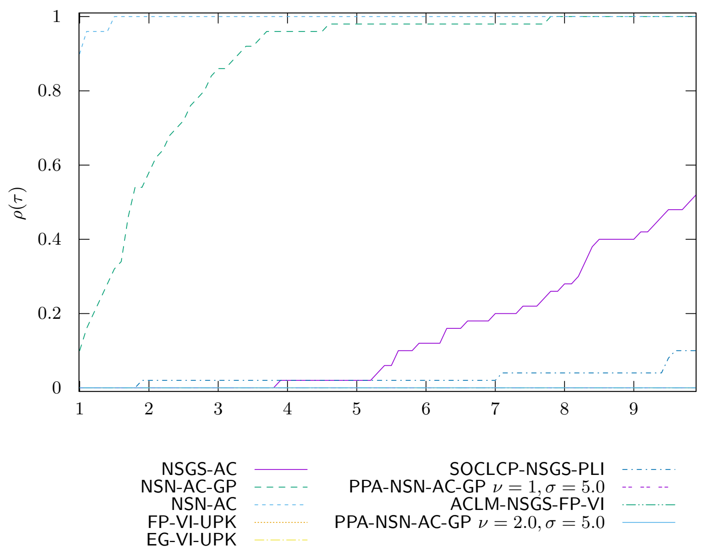

Figure 93: LMGC LowWall FEM time COMP/large

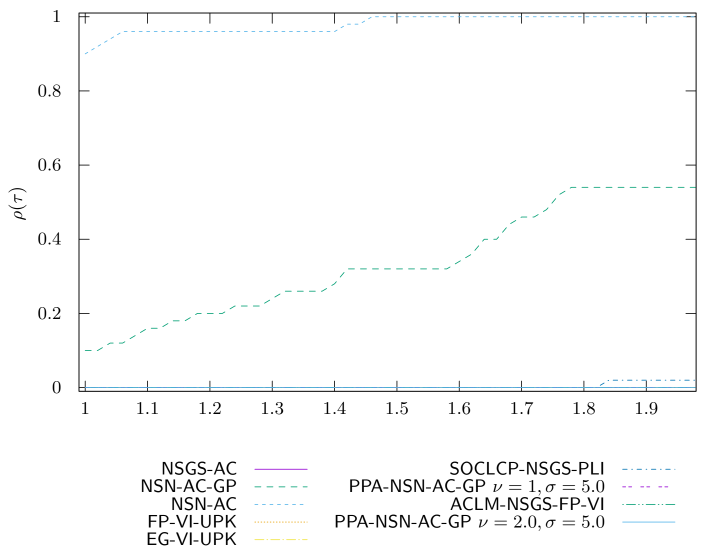

Figure 94: LMGC LowWall FEM time COMP/zoom

9 LMGC Cubes H8 precision 1.0e-04 timeout 100

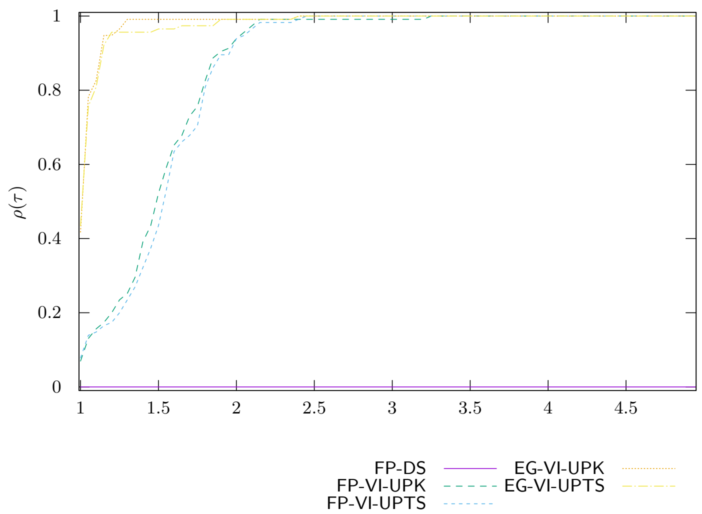

Figure 95: LMGC Cubes H8 time VI/UpdateRule

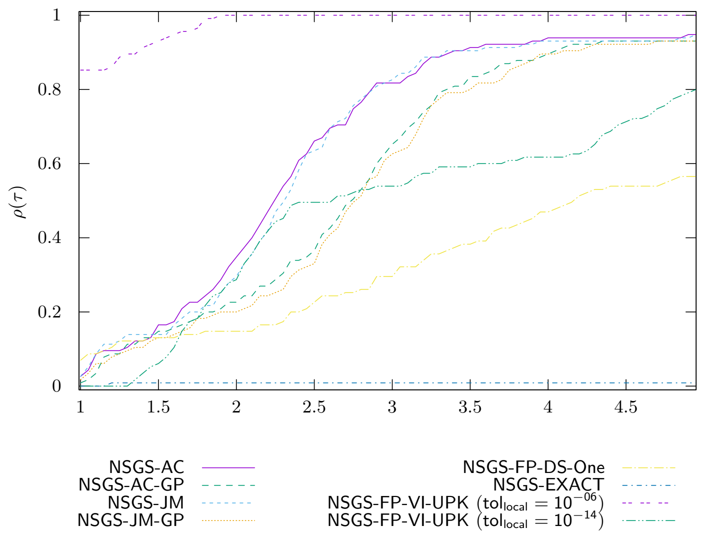

Figure 96: LMGC Cubes H8 time NSGS/LocalSolver

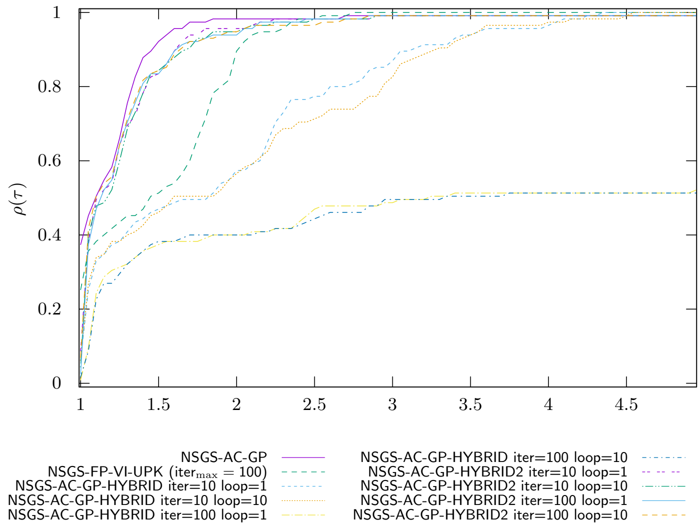

Figure 97: LMGC Cubes H8 time NSGS/LocalSolverHybrid

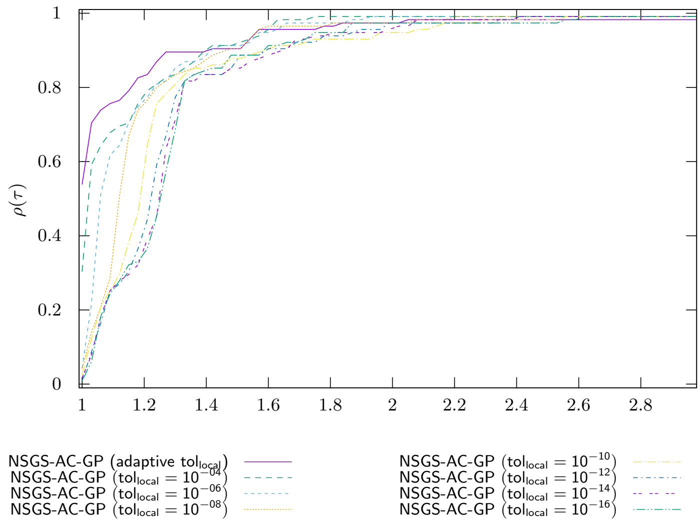

Figure 98: LMGC Cubes H8 time NSGS/LocalTol

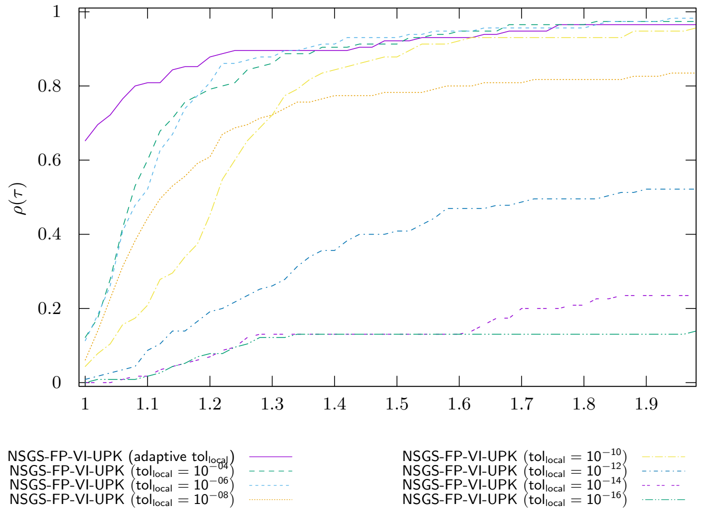

Figure 99: LMGC Cubes H8 time NSGS/LocalTol-VI

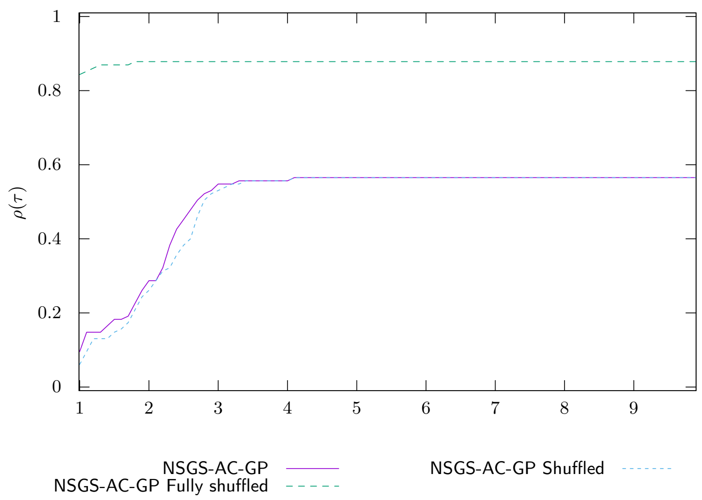

Figure 100: LMGC Cubes H8 time NSGS/Shuffled

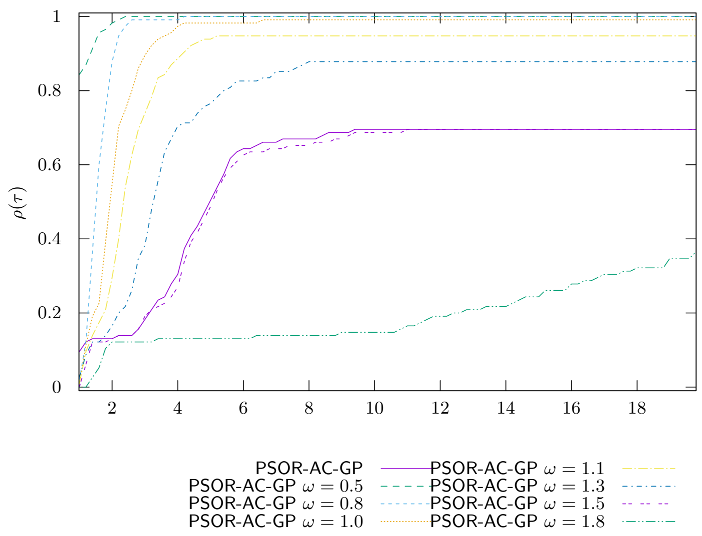

Figure 101: LMGC Cubes H8 time PSOR

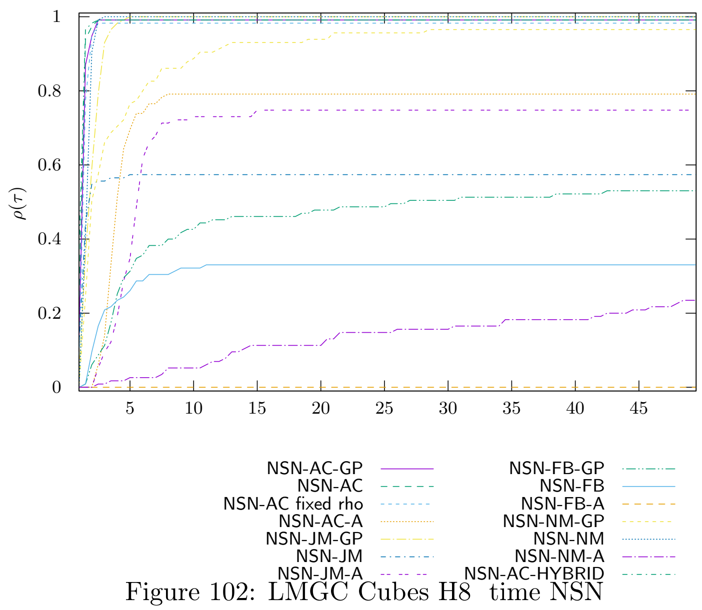

Figure 102: LMGC Cubes H8 time NSN

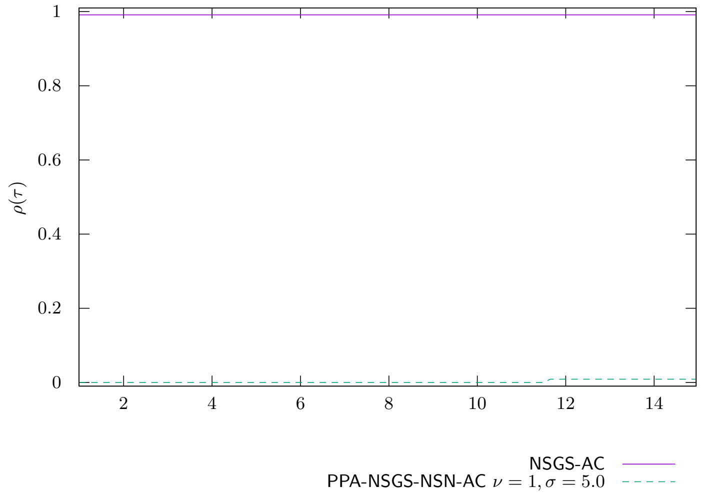

Figure 103: LMGC Cubes H8 time PROX/InternalSolvers

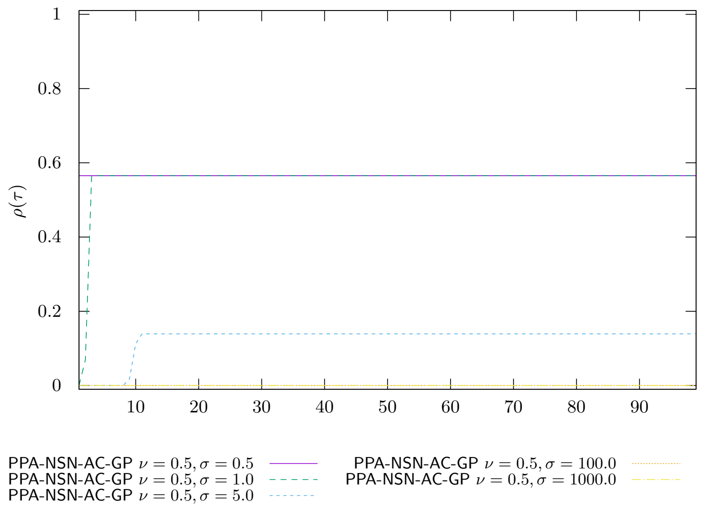

Figure 104: LMGC Cubes H8 time PROX/Parametric studies $\nu = 0.5$

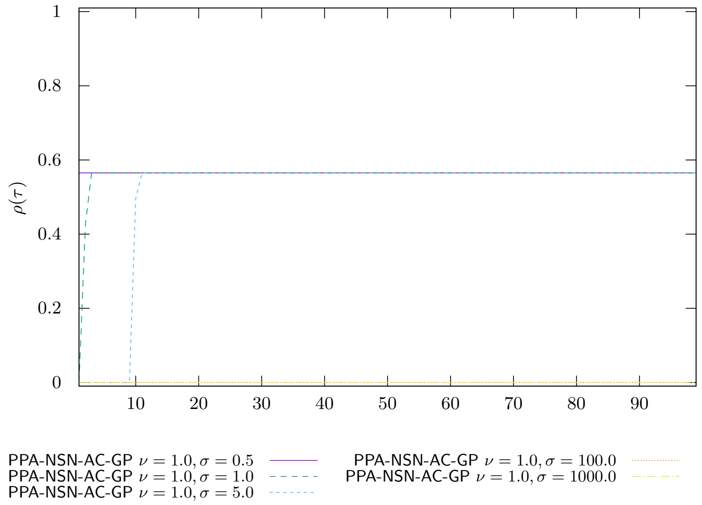

Figure 105: LMGC Cubes H8 time PROX/Parametric studies $\nu = 1.0$

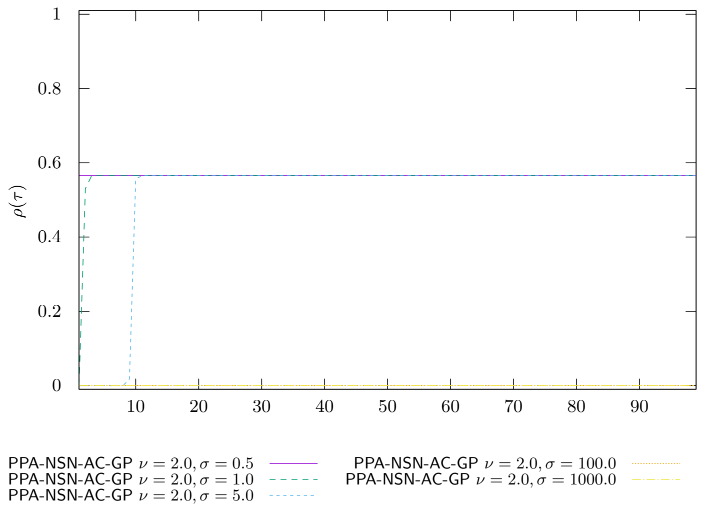

Figure 106: LMGC Cubes H8 time PROX/Parametric studies $\nu = 2.0$

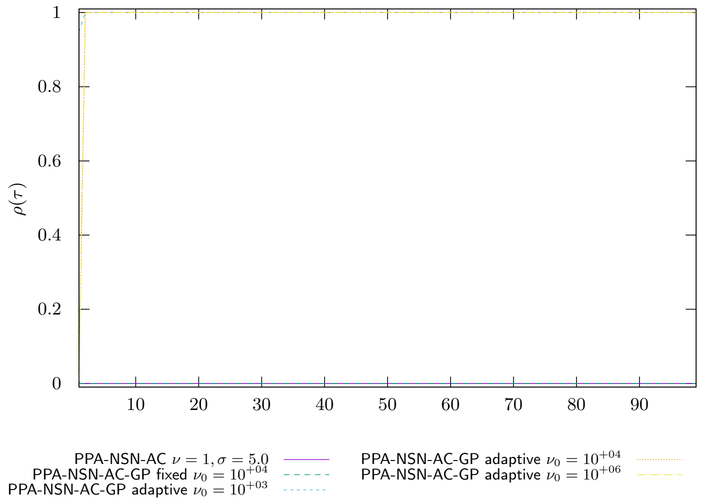

Figure 107: LMGC Cubes H8 time PROX/Regularized problem

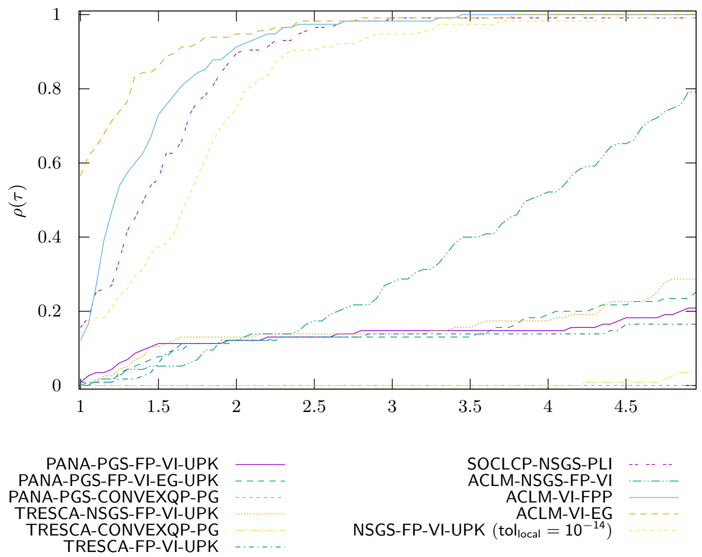

Figure 108: LMGC Cubes H8 time OPTI

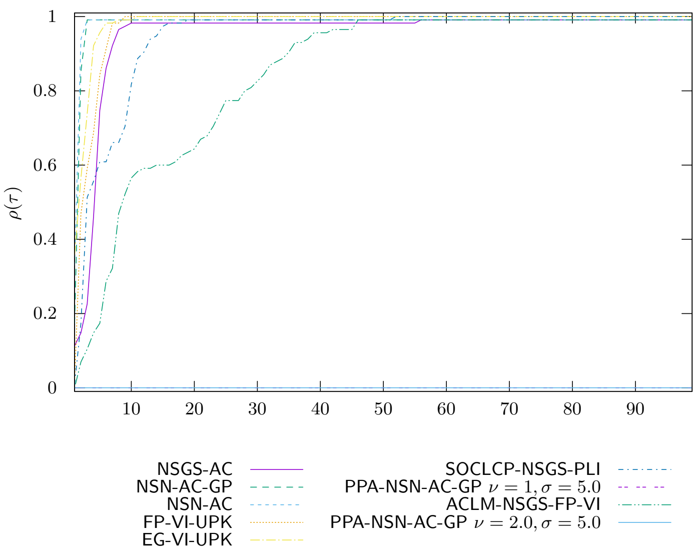

Figure 109: LMGC Cubes H8 time COMP/large

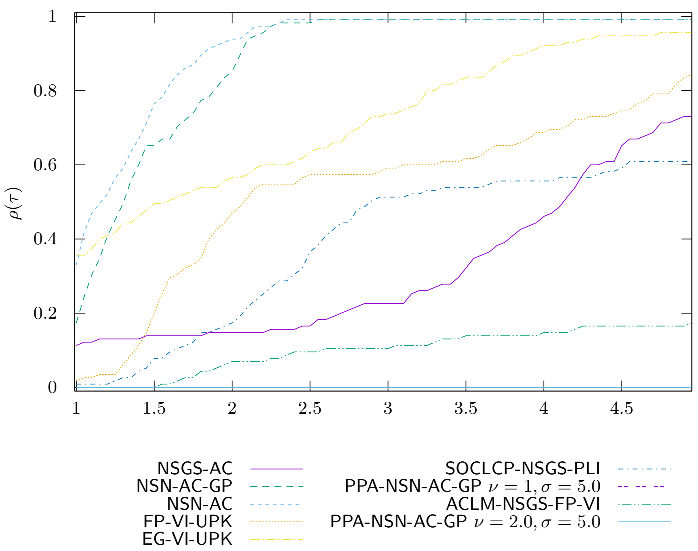

Figure 110: LMGC Cubes H8 time COMP/zoom

10 Capsules precision 1.0e-08 timeout 50

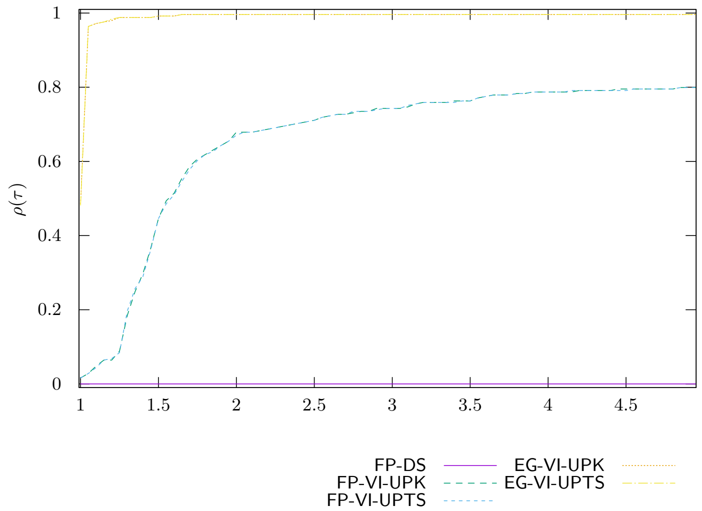

Figure 111: Capsules time VI/UpdateRule

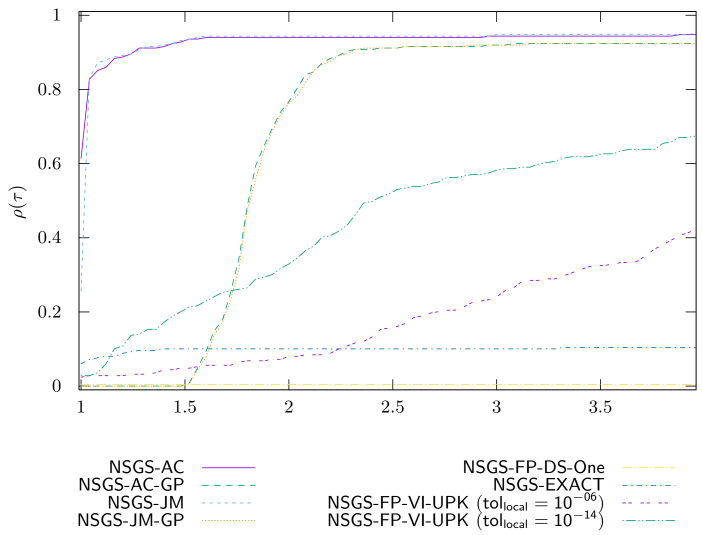

Figure 112: Capsules time NSGS/LocalSolver

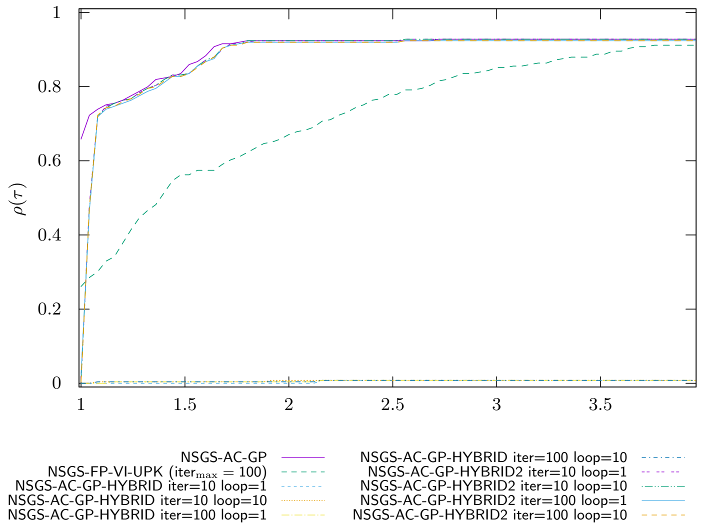

Figure 113: Capsules time NSGS/LocalSolverHybrid

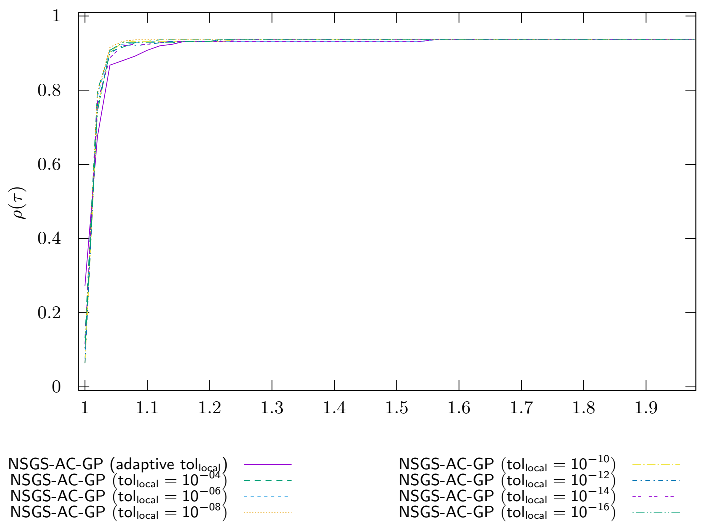

Figure 114: Capsules time NSGS/LocalTol

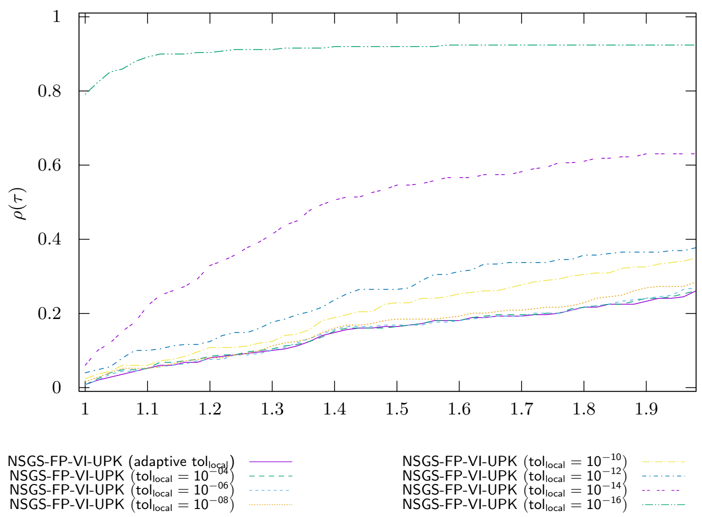

Figure 115: Capsules time NSGS/LocalTol-VI

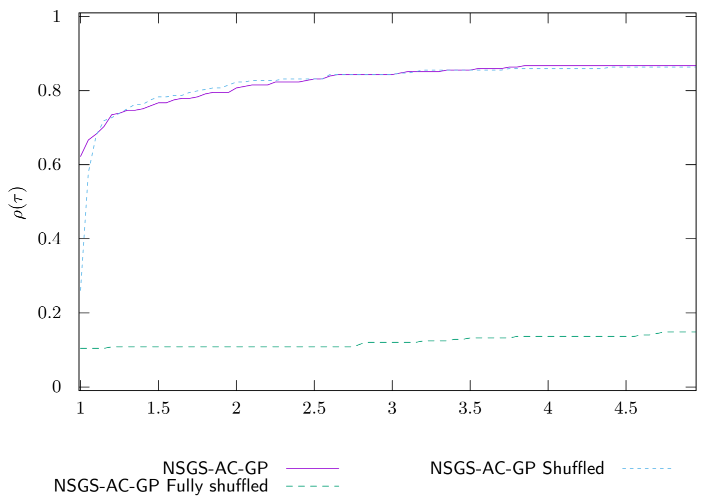

Figure 116: Capsules time NSGS/Shuffled

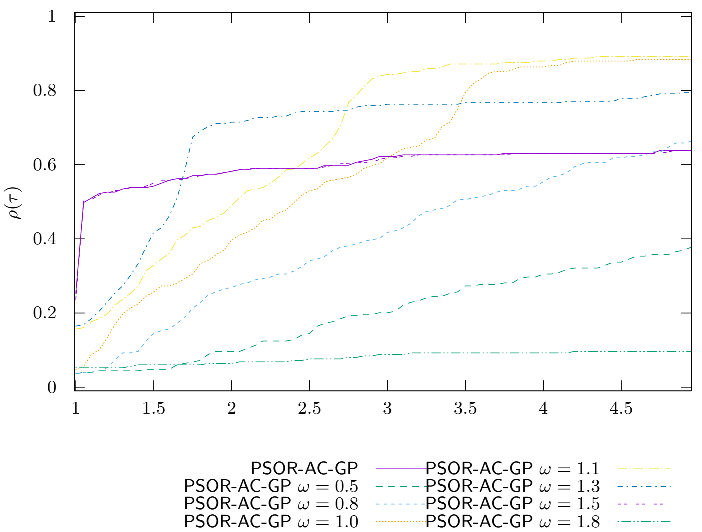

Figure 117: Capsules time PSOR

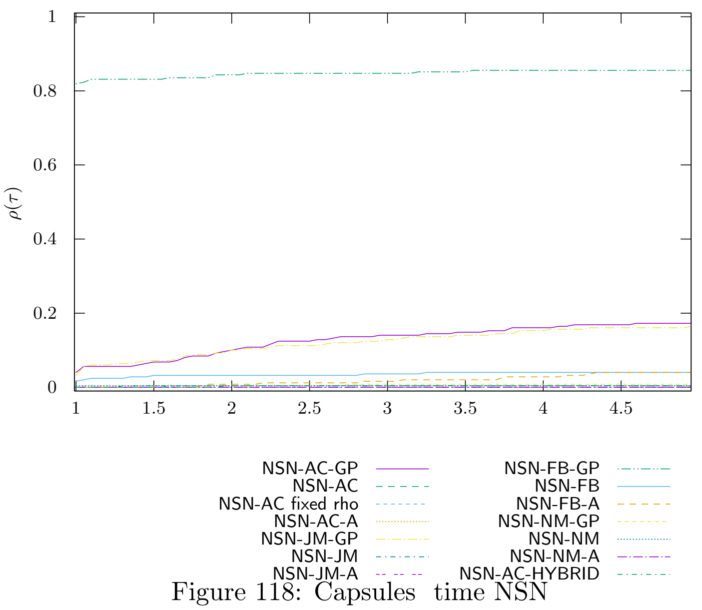

Figure 118: Capsules time NSN

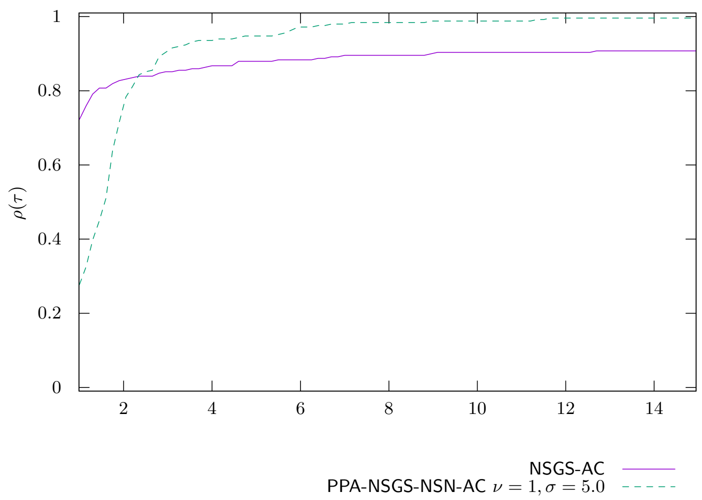

Figure 119: Capsules time PROX/InternalSolvers

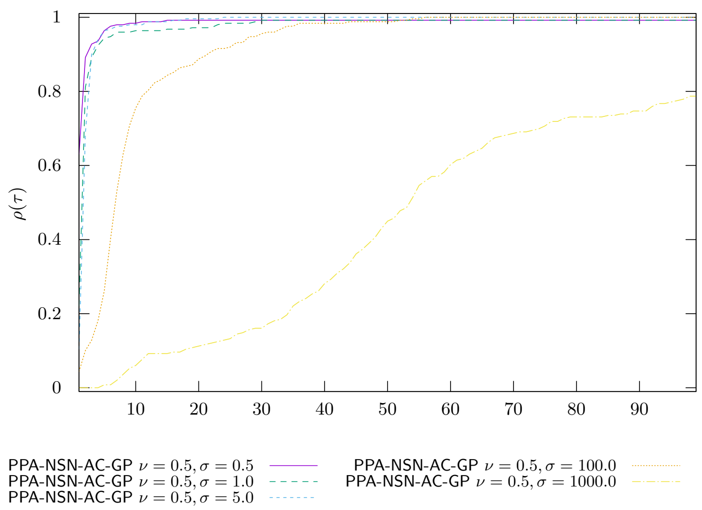

Figure 120: Capsules time PROX/Parametric studies $\nu = 0.5$

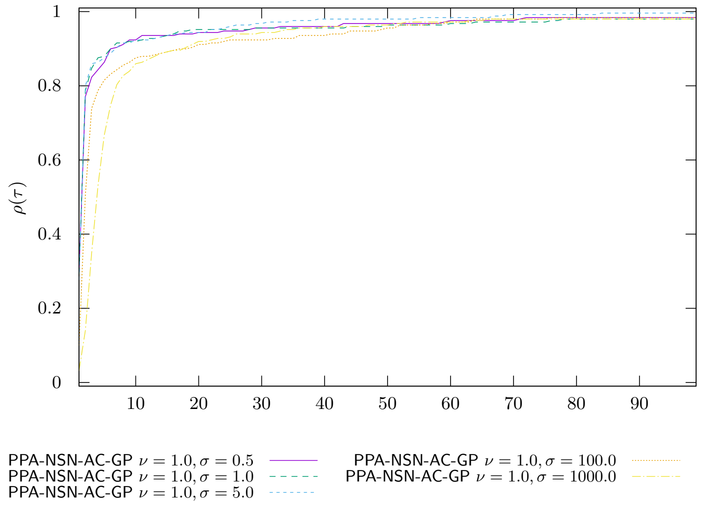

Figure 121: Capsules time PROX/Parametric studies $\nu = 1.0$

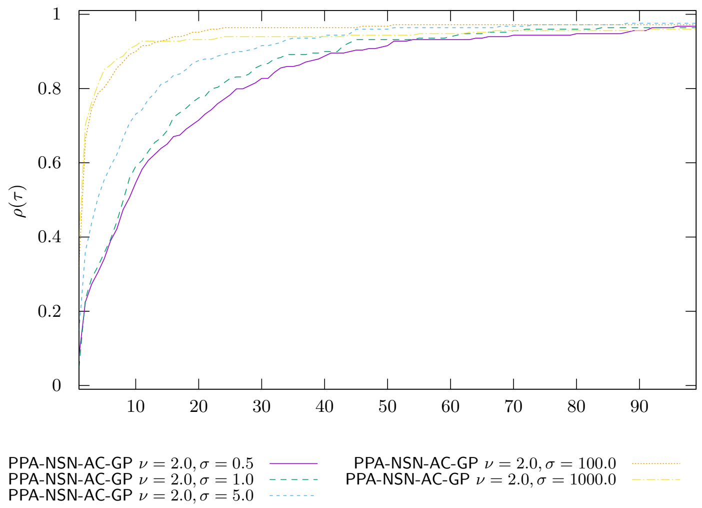

Figure 122: Capsules time PROX/Parametric studies $\nu = 2.0$

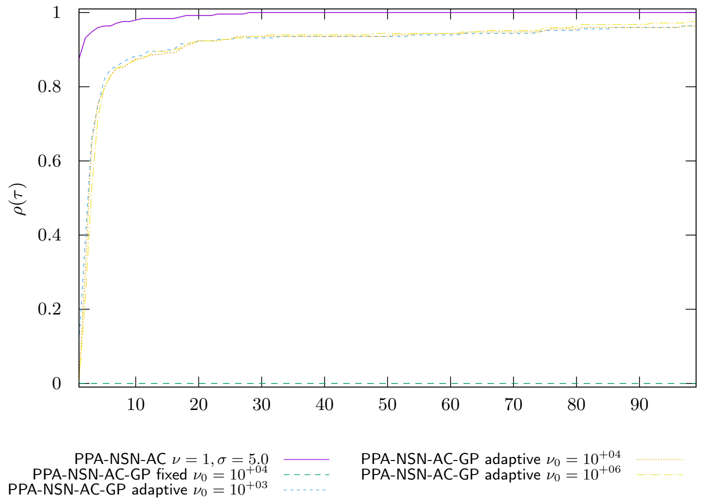

Figure 123: Capsules time PROX/Regularized problem

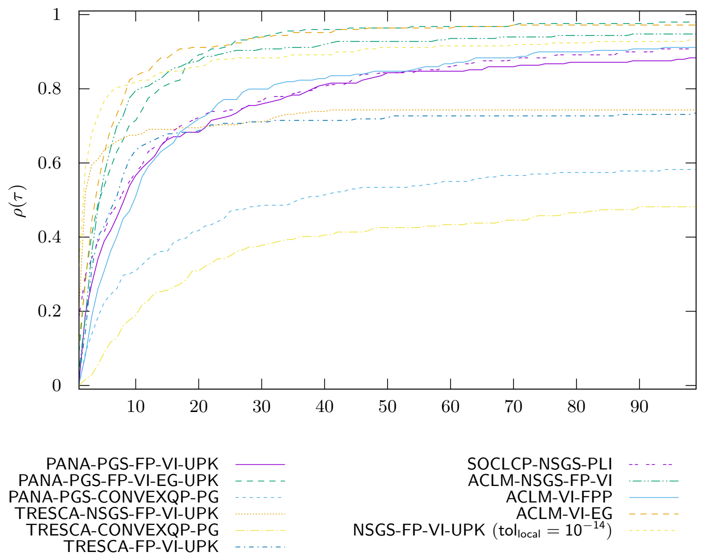

Figure 124: Capsules time OPTI

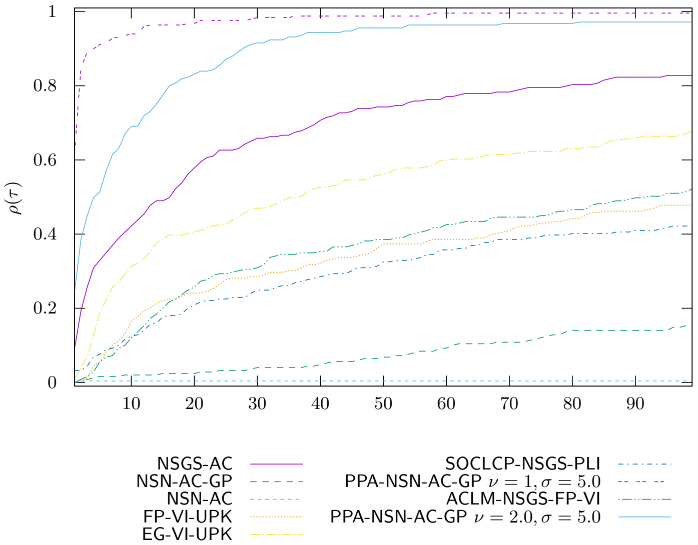

Figure 125: Capsules time COMP/large

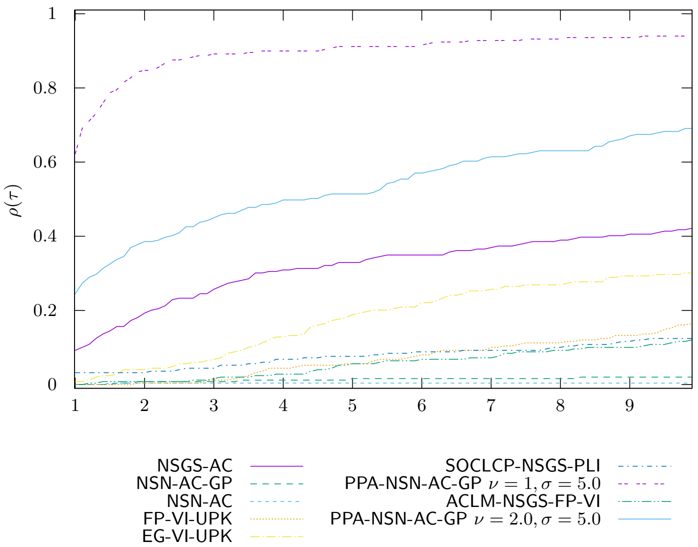

Figure 126: Capsules time COMP/zoom

11 Chain precision 1.0e-08 timeout 50

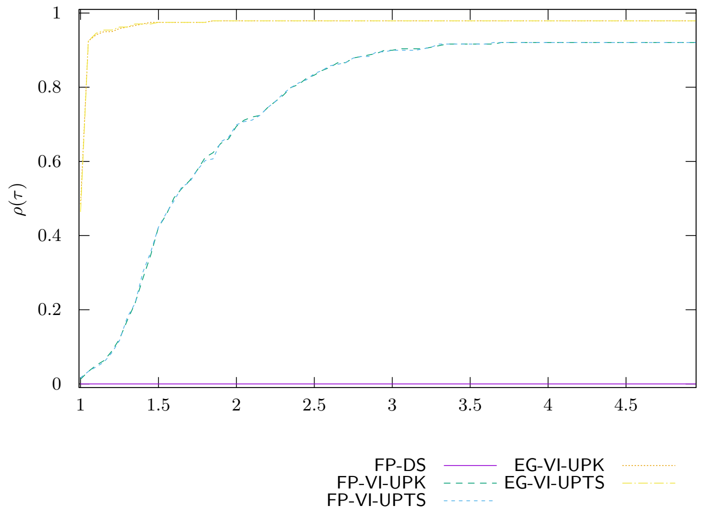

Figure 127: Chain time VI/UpdateRule

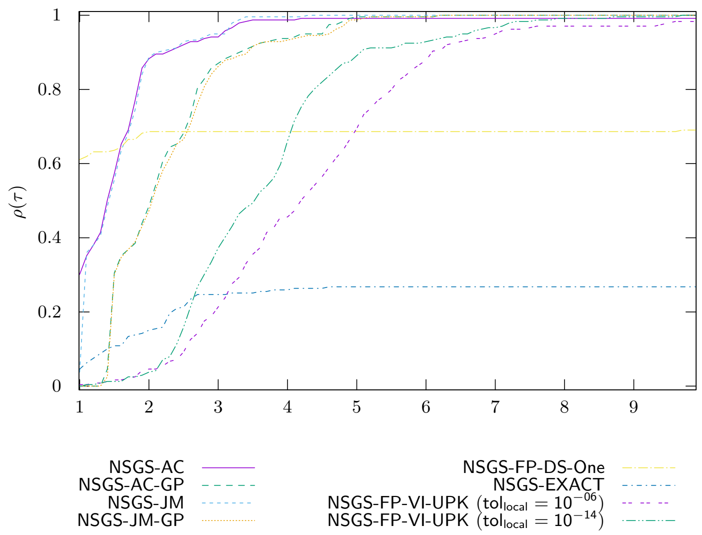

Figure 128: Chain time NSGS/LocalSolver

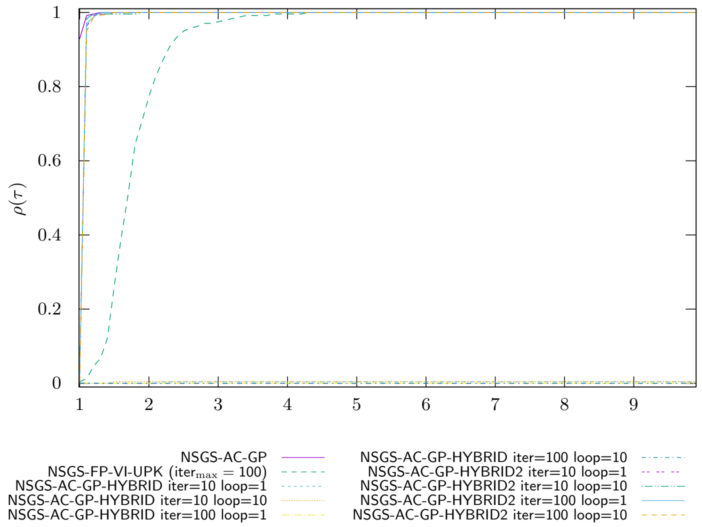

Figure 129: Chain time NSGS/LocalSolverHybrid

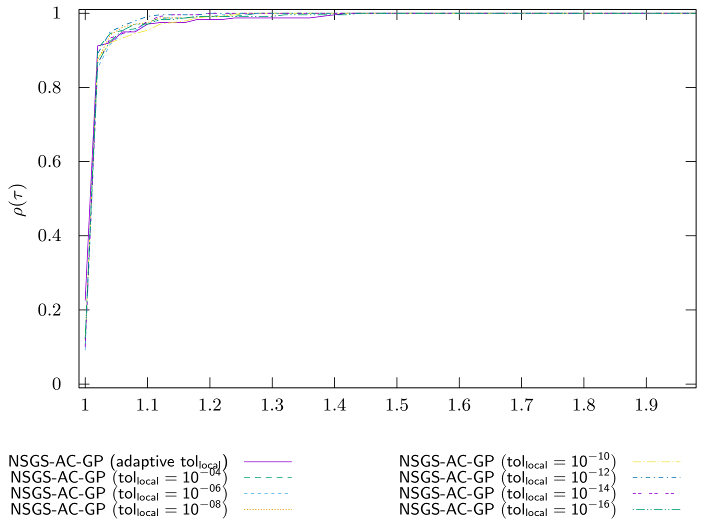

Figure 130: Chain time NSGS/LocalTol

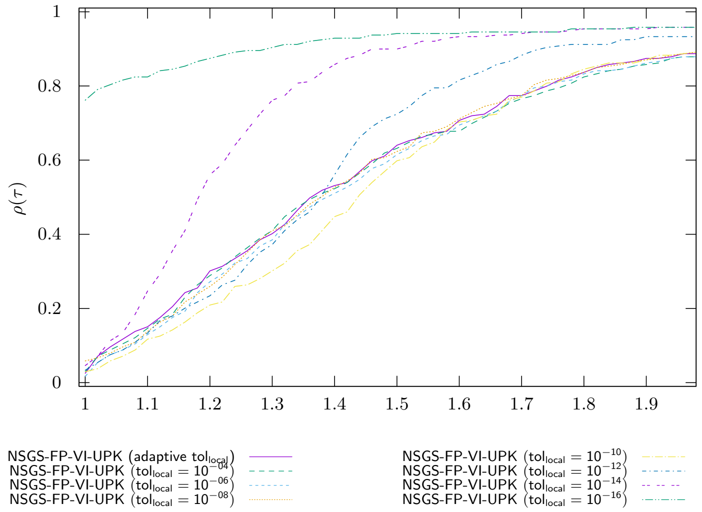

Figure 131: Chain time NSGS/LocalTol-VI

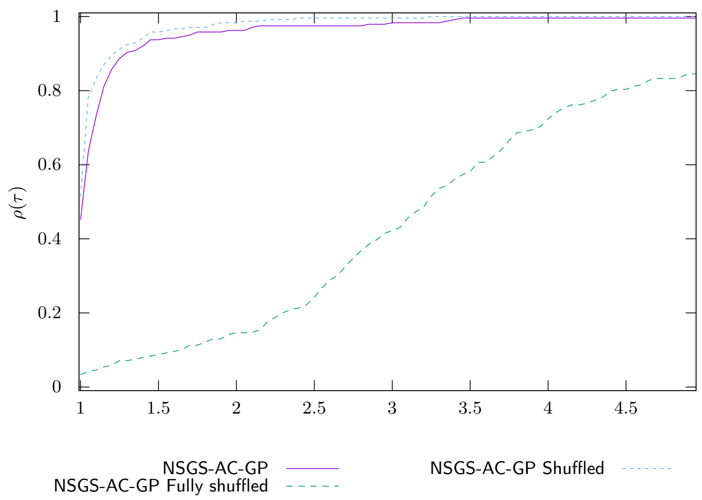

Figure 132: Chain time NSGS/Shuffled

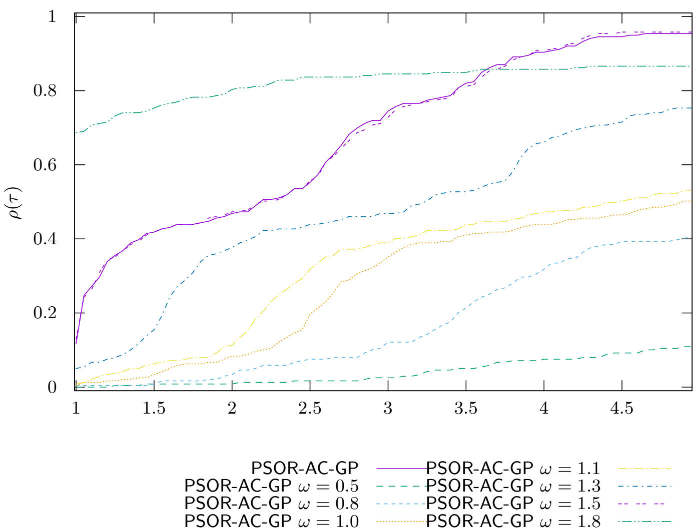

Figure 133: Chain time PSOR

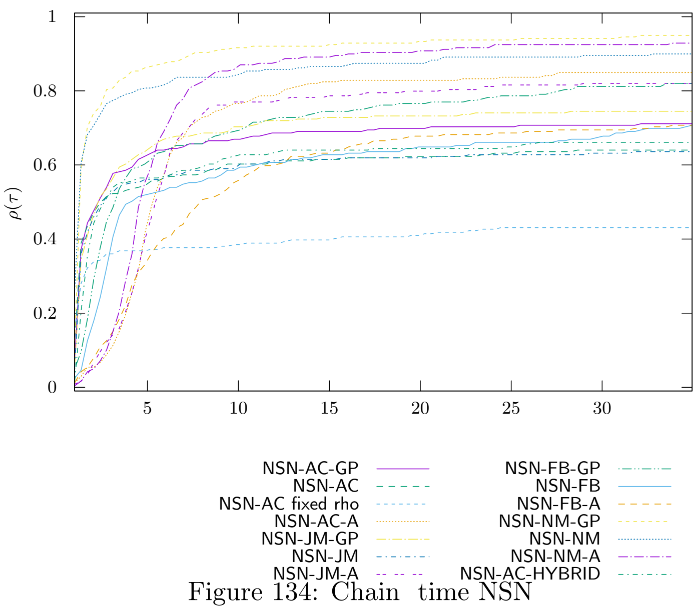

Figure 134: Chain time NSN

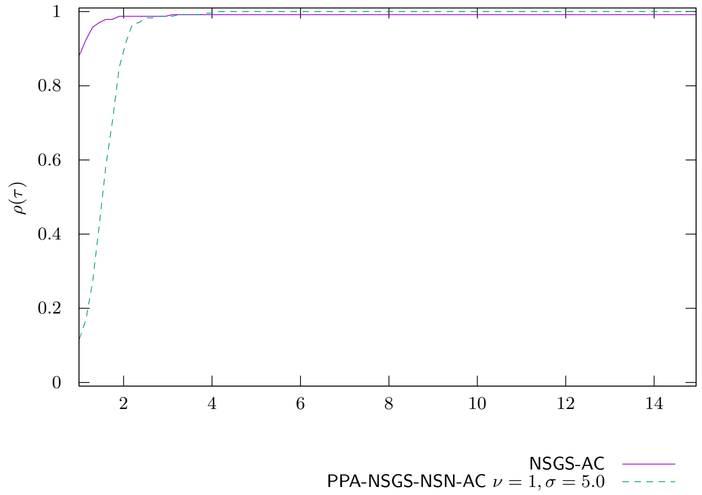

Figure 135: Chain time PROX/InternalSolvers

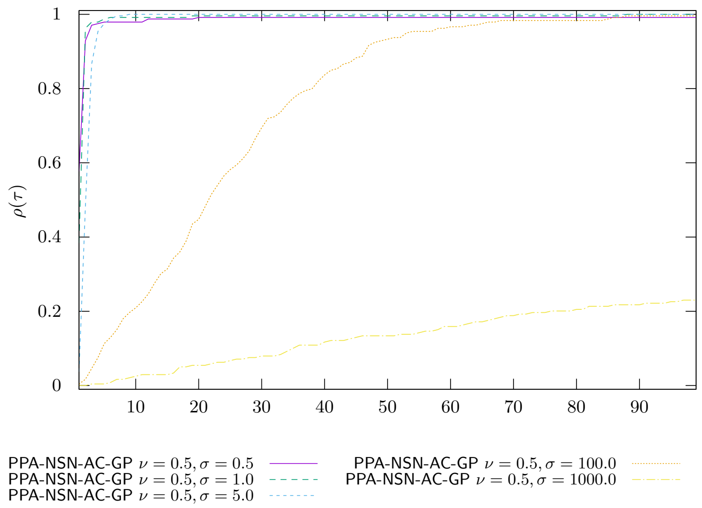

Figure 136: Chain time PROX/Parametric studies $\nu = 0.5$

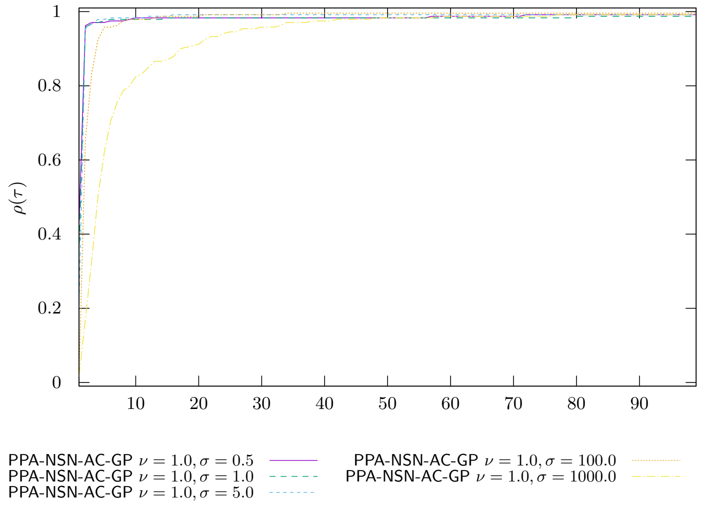

Figure 137: Chain time PROX/Parametric studies $\nu = 1.0$

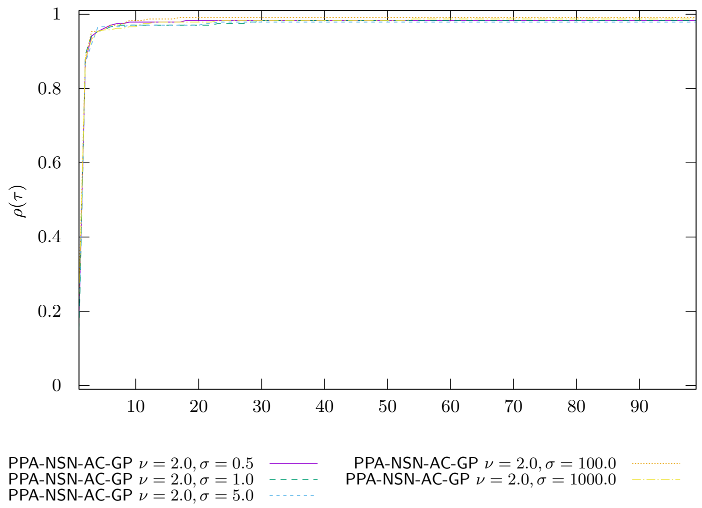

Figure 138: Chain time PROX/Parametric studies $\nu = 2.0$

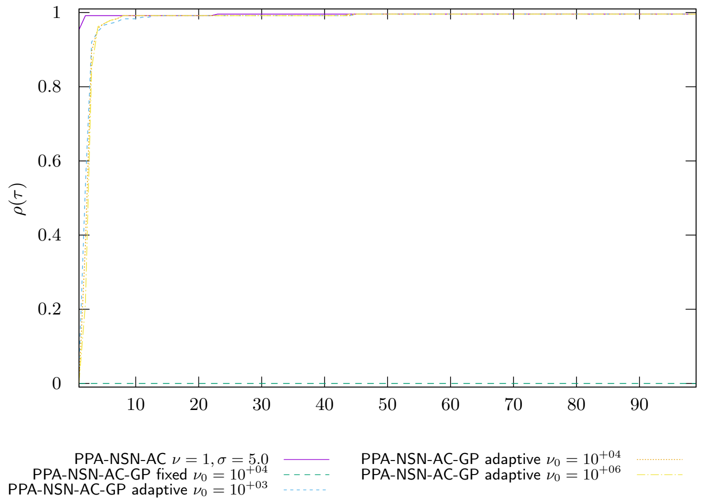

Figure 139: Chain time PROX/Regularized problem

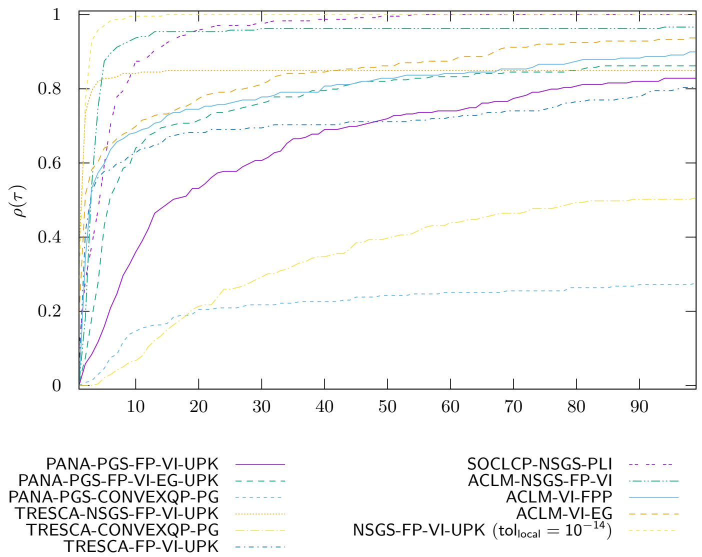

Figure 140: Chain time OPTI

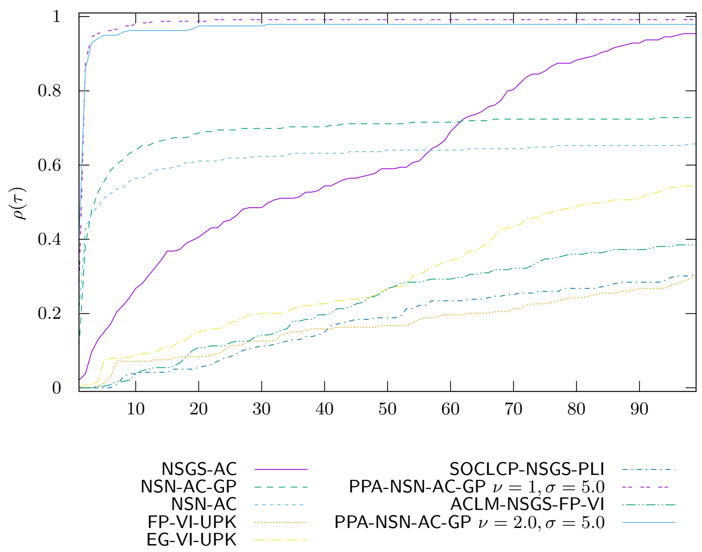

Figure 141: Chain time COMP/large

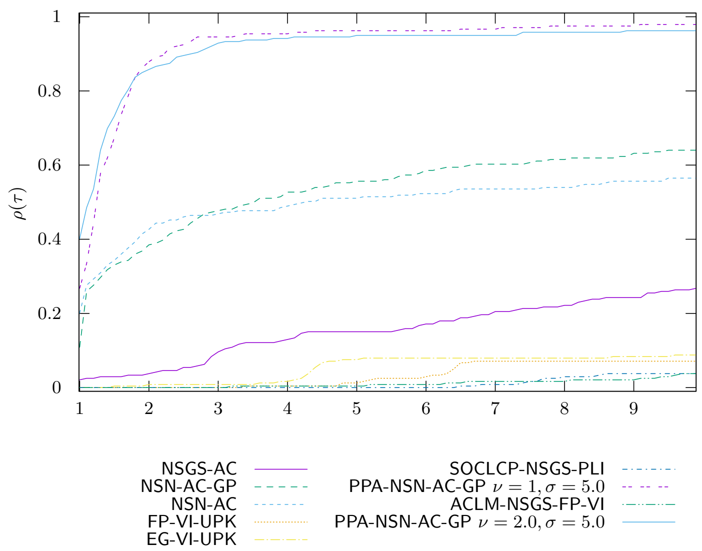

Figure 142: Chain time COMP/zoom

12 BoxesStack1 precision 1.0e-08 timeout 100

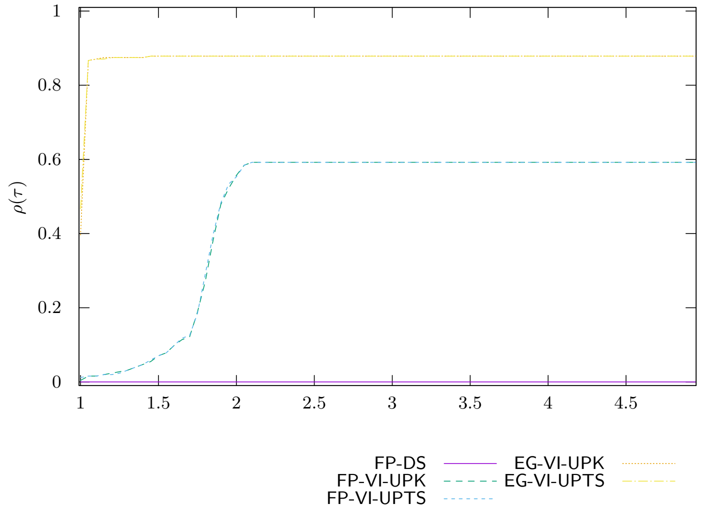

Figure 143: BoxesStack1 time VI/UpdateRule

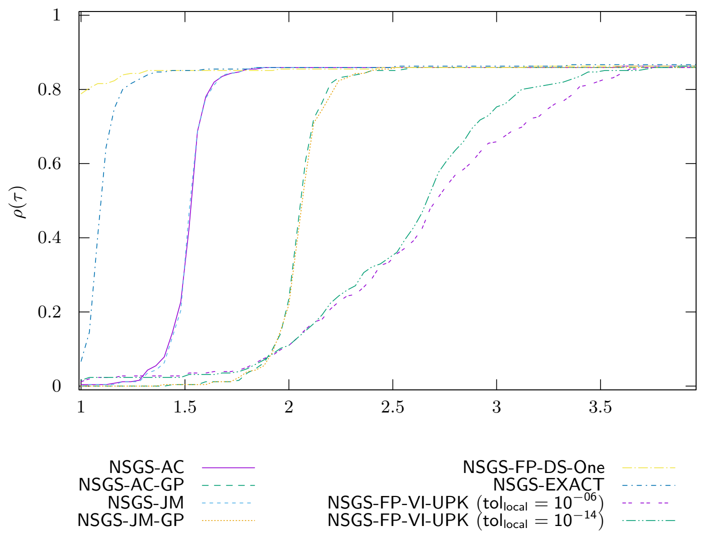

Figure 144: BoxesStack1 time NSGS/LocalSolver

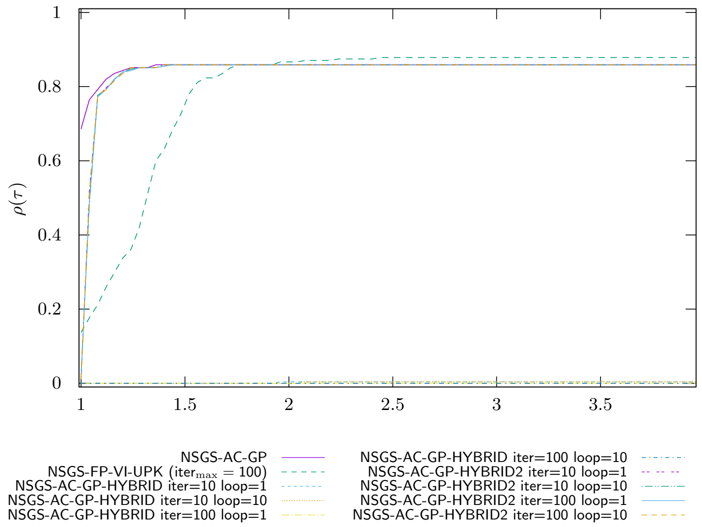

Figure 145: BoxesStack1 time NSGS/LocalSolverHybrid

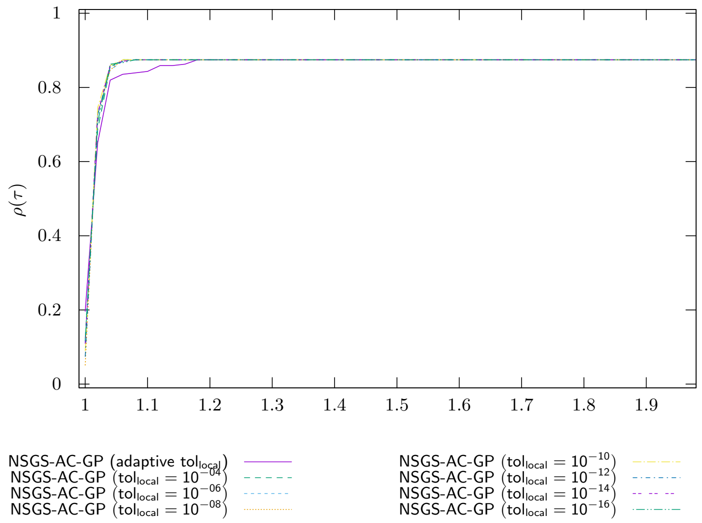

Figure 146: BoxesStack1 time NSGS/LocalTol

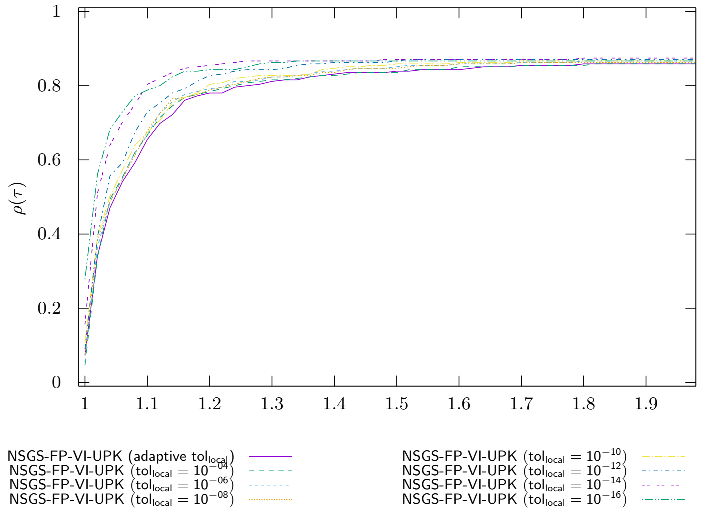

Figure 147: BoxesStack1 time NSGS/LocalTol-VI

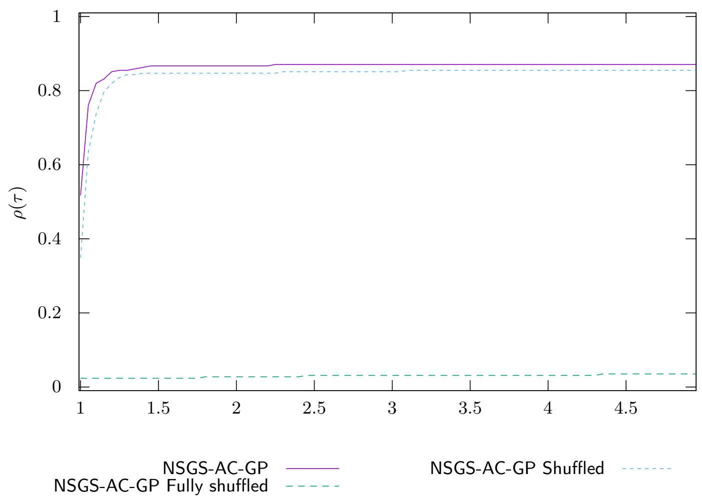

Figure 148: BoxesStack1 time NSGS/Shuffled

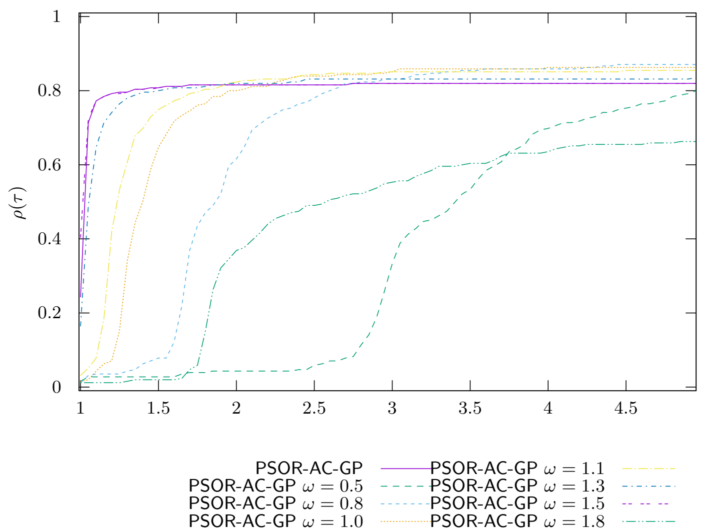

Figure 149: BoxesStack1 time PSOR

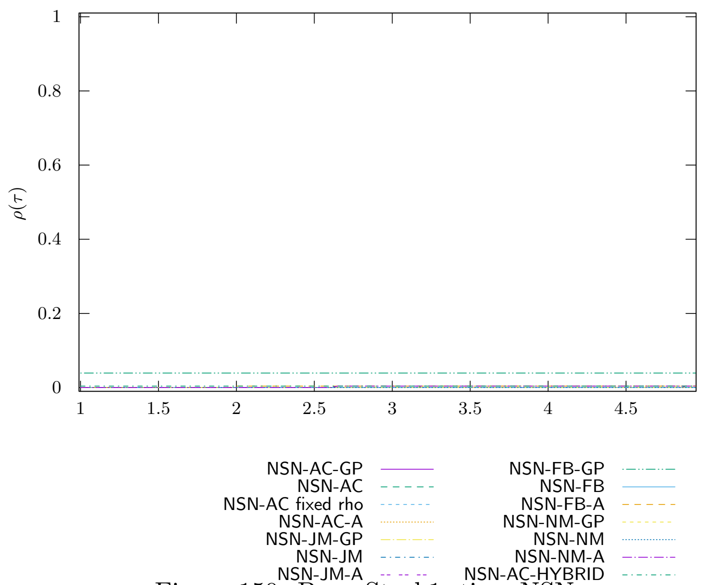

Figure 150: BoxesStack1 time NSN

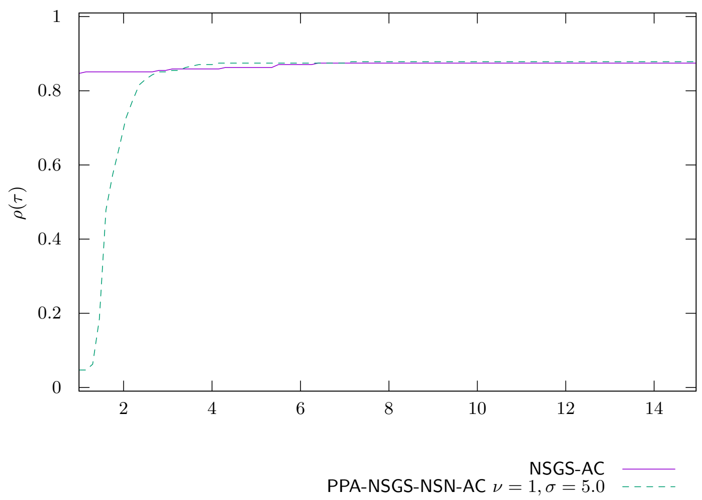

Figure 151: BoxesStack1 time PROX/InternalSolvers

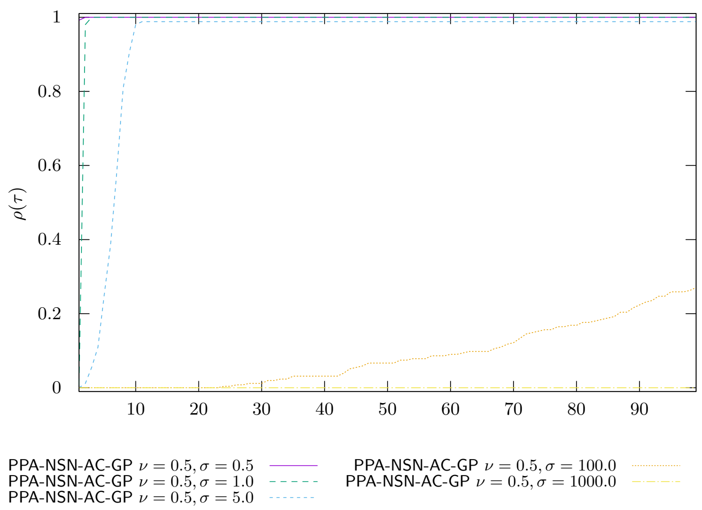

Figure 152: BoxesStack1 time PROX/Parametric studies $\nu = 0.5$

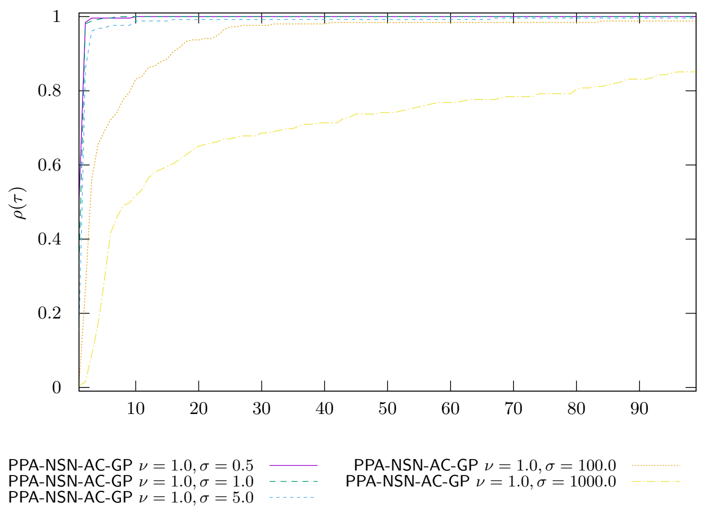

Figure 153: BoxesStack1 time PROX/Parametric studies $\nu = 1.0$

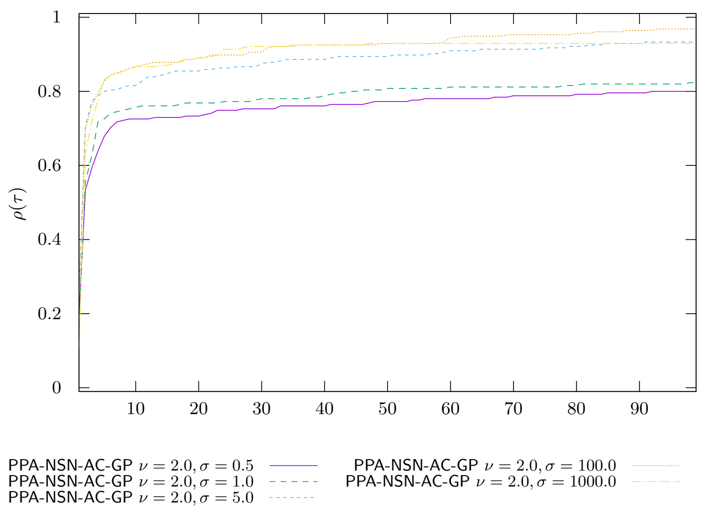

Figure 154: BoxesStack1 time PROX/Parametric studies $\nu = 2.0$

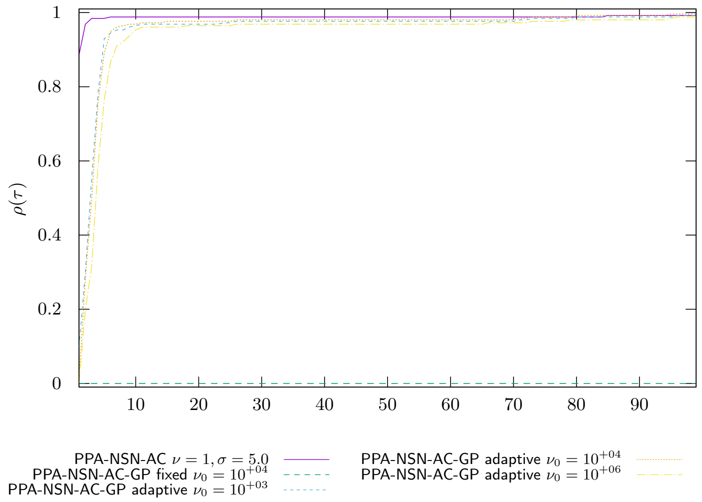

Figure 155: BoxesStack1 time PROX/Regularized problem

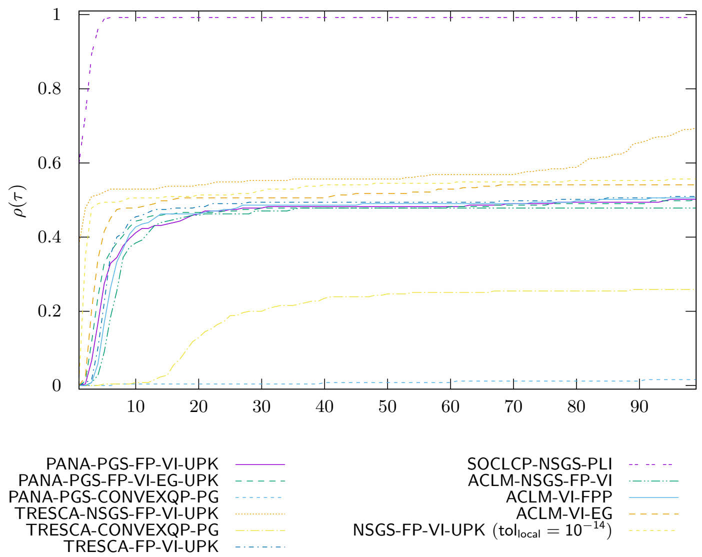

Figure 156: BoxesStack1 time OPTI

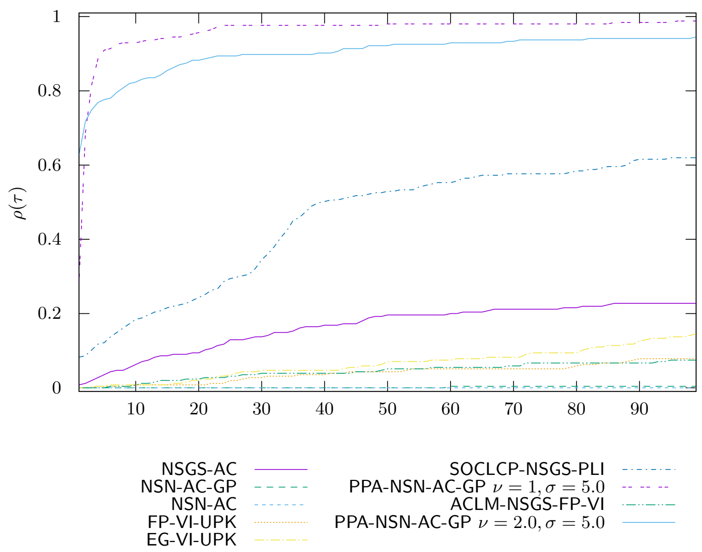

Figure 157: BoxesStack1 time COMP/large

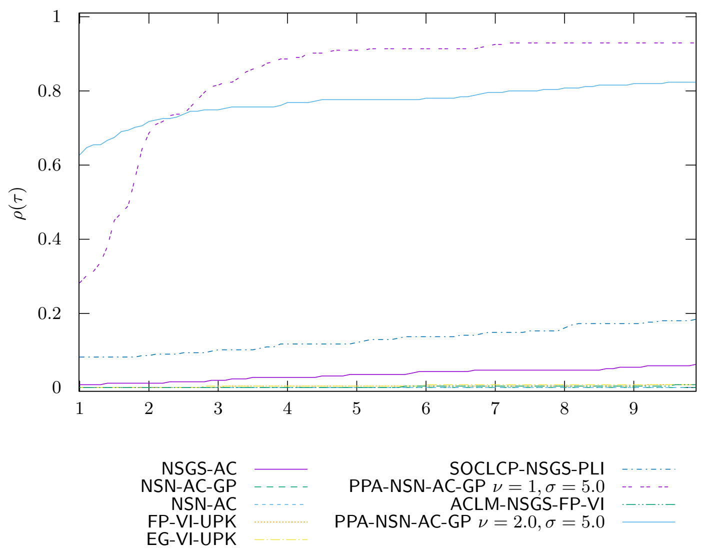

Figure 158: BoxesStack1 time COMP/zoom

13 KaplasTower precision 1.0e-04 timeout 100

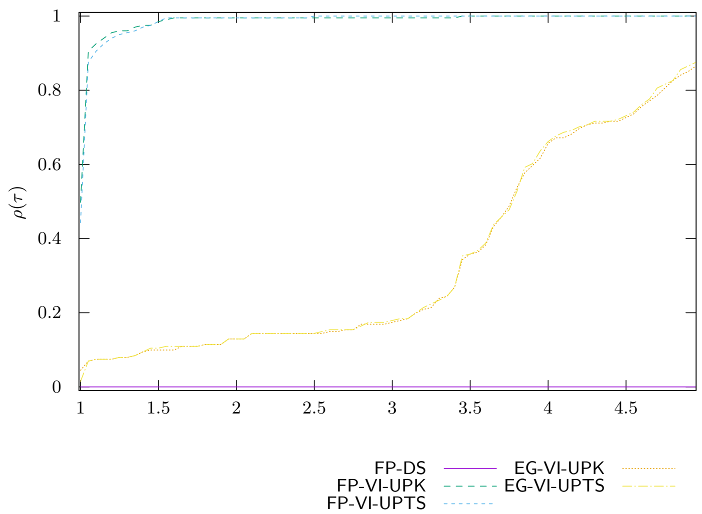

Figure 159: KaplasTower time VI/UpdateRule

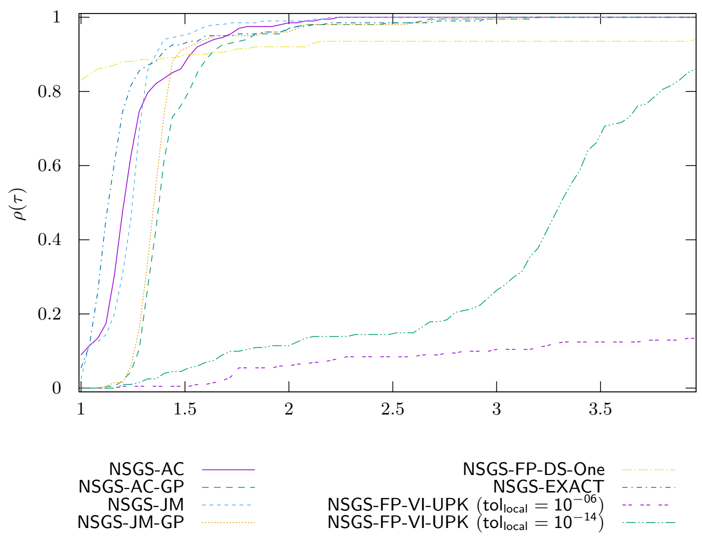

Figure 160: KaplasTower time NSGS/LocalSolver

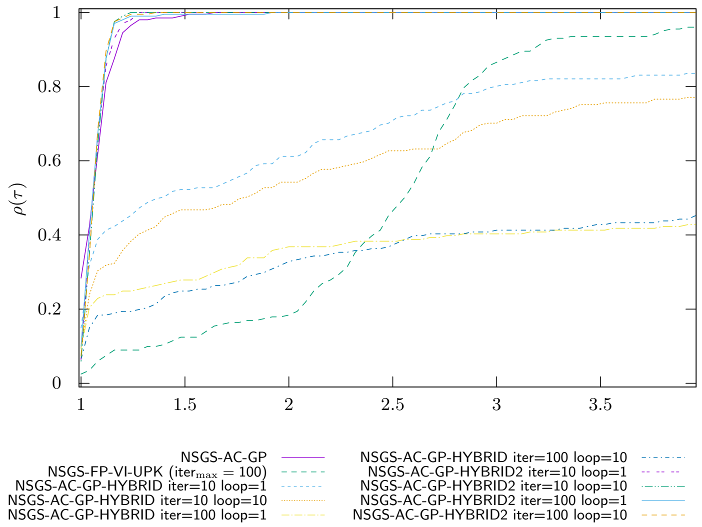

Figure 161: KaplasTower time NSGS/LocalSolverHybrid

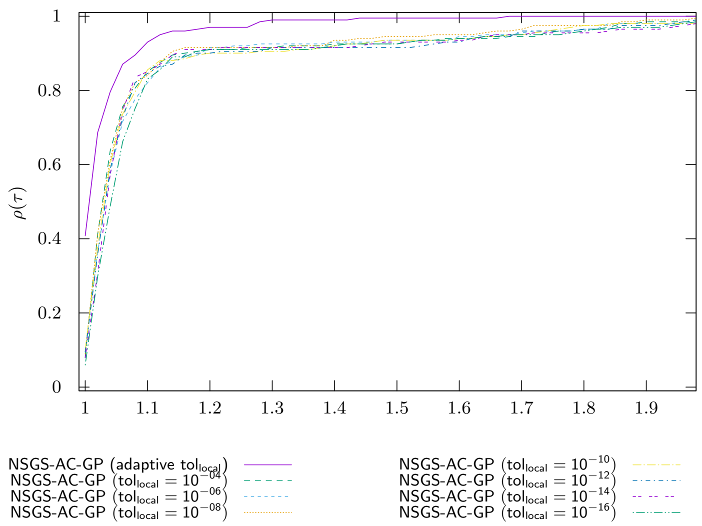

Figure 162: KaplasTower time NSGS/LocalTol

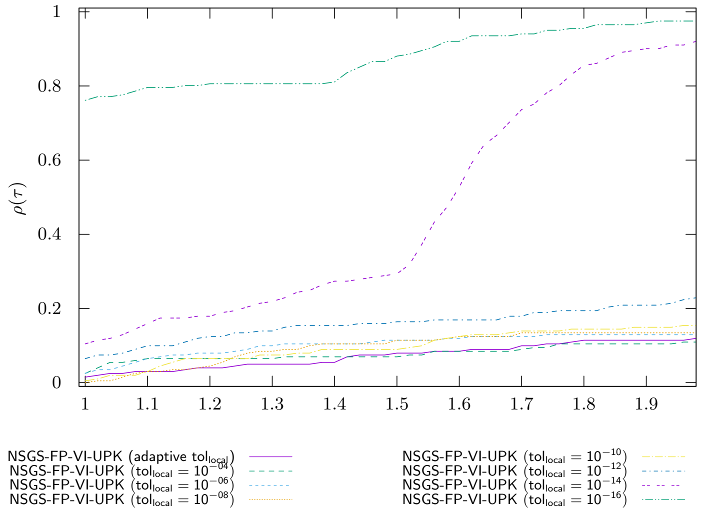

Figure 163: KaplasTower time NSGS/LocalTol-VI

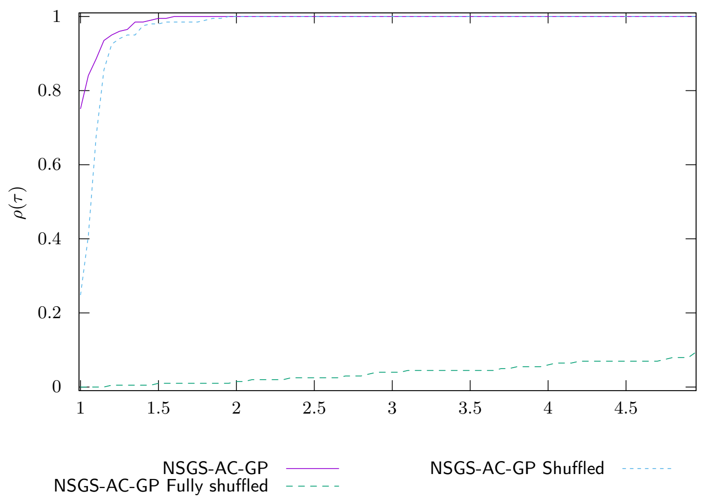

Figure 164: KaplasTower time NSGS/Shuffled

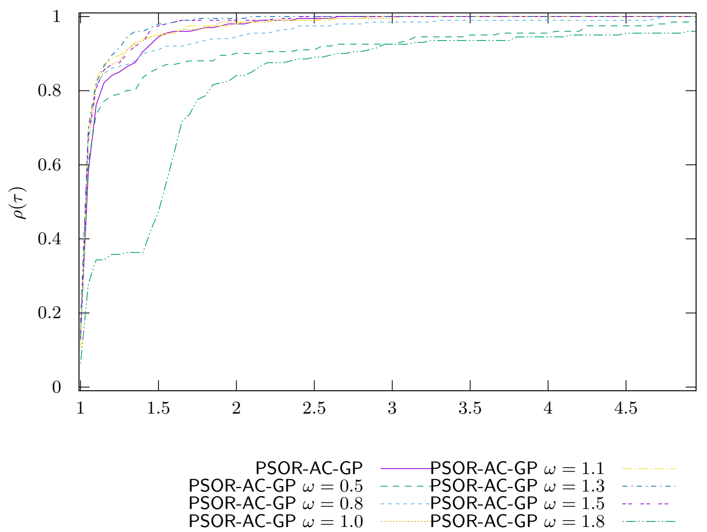

Figure 165: KaplasTower time PSOR

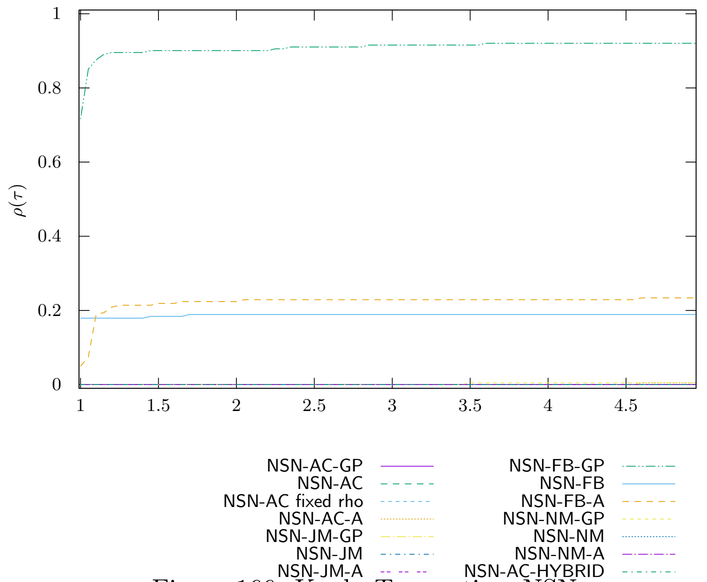

Figure 166: KaplasTower time NSN

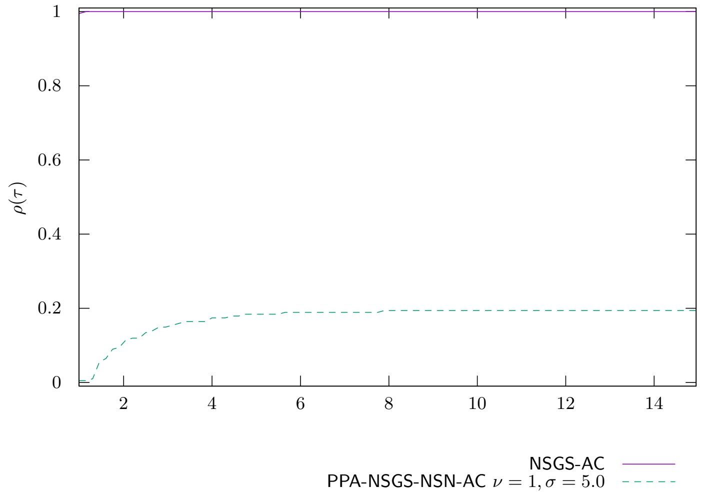

Figure 167: KaplasTower time PROX/InternalSolvers

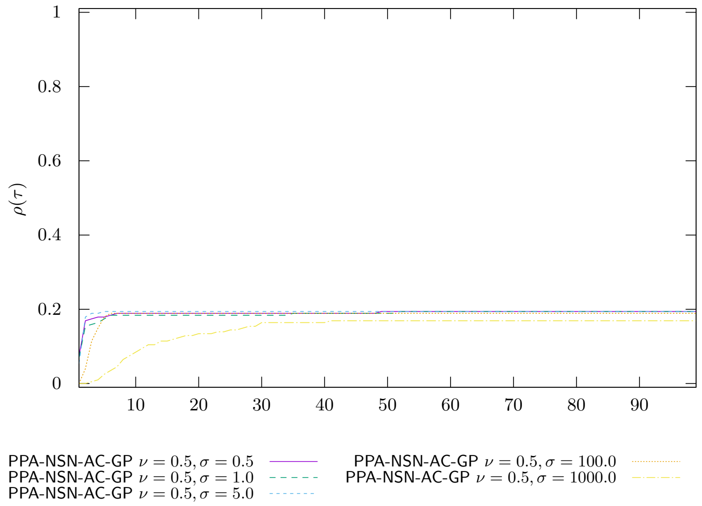

Figure 168: KaplasTower time PROX/Parametric studies $\nu = 0.5$

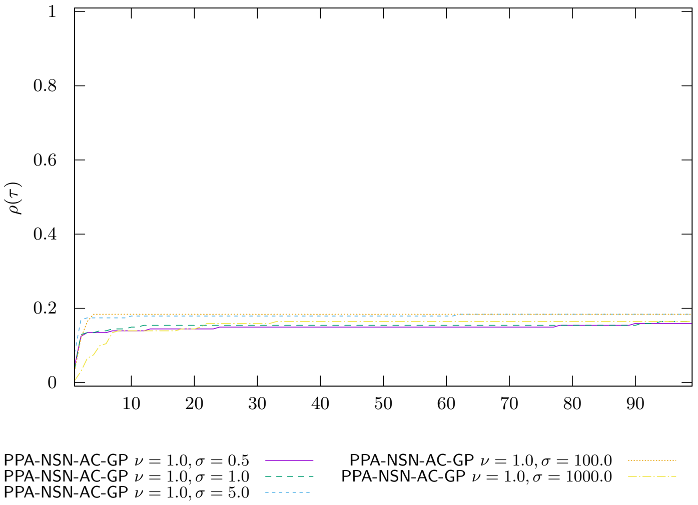

Figure 169: KaplasTower time PROX/Parametric studies $\nu = 1.0$

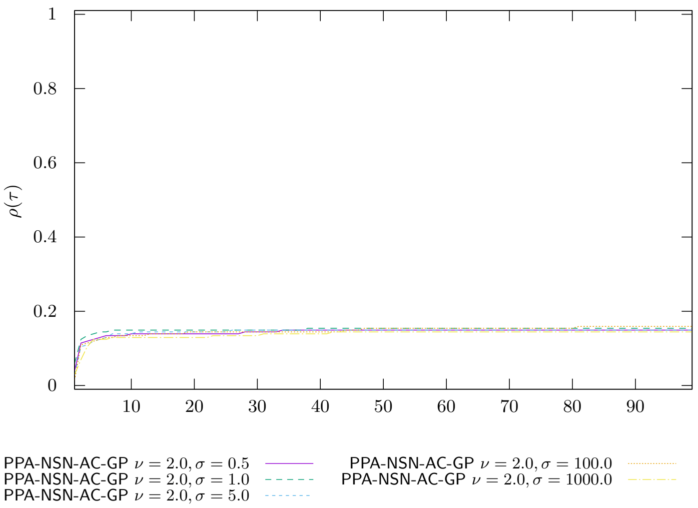

Figure 170: KaplasTower time PROX/Parametric studies $\nu = 2.0$

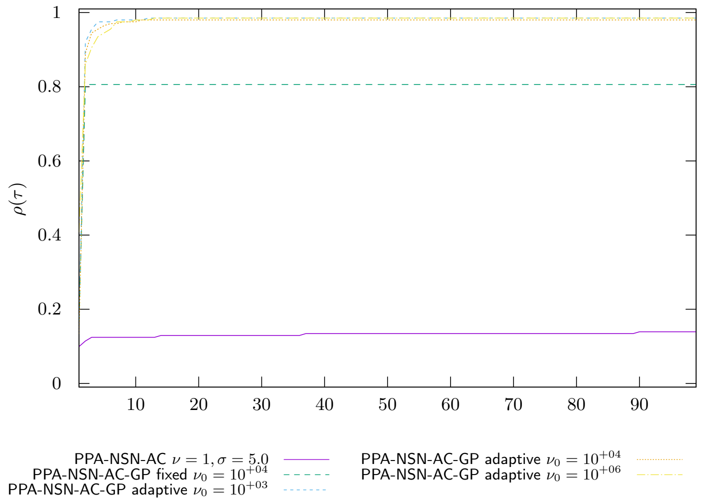

Figure 171: KaplasTower time PROX/Regularized problem

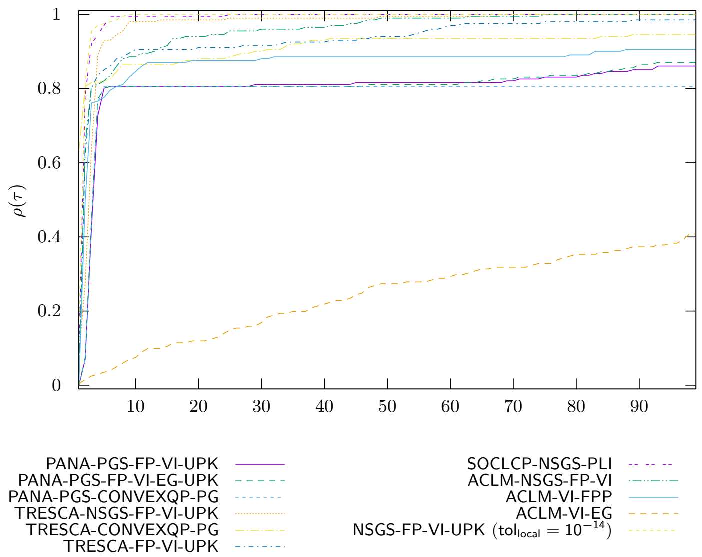

Figure 172: KaplasTower time OPTI

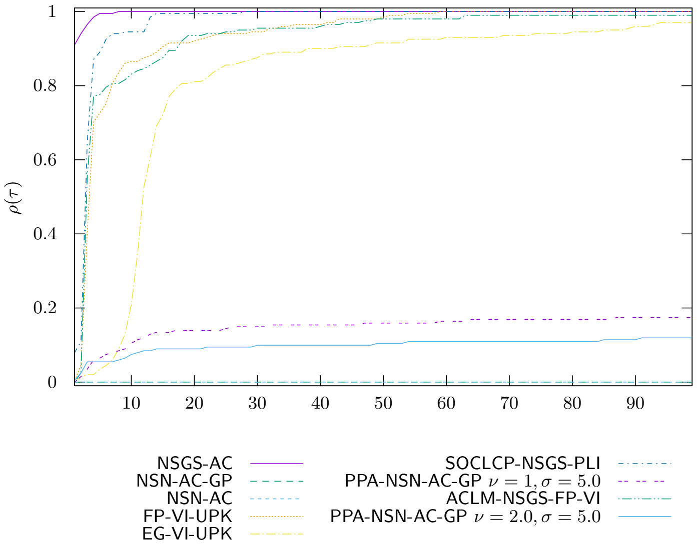

Figure 173: KaplasTower time COMP/large

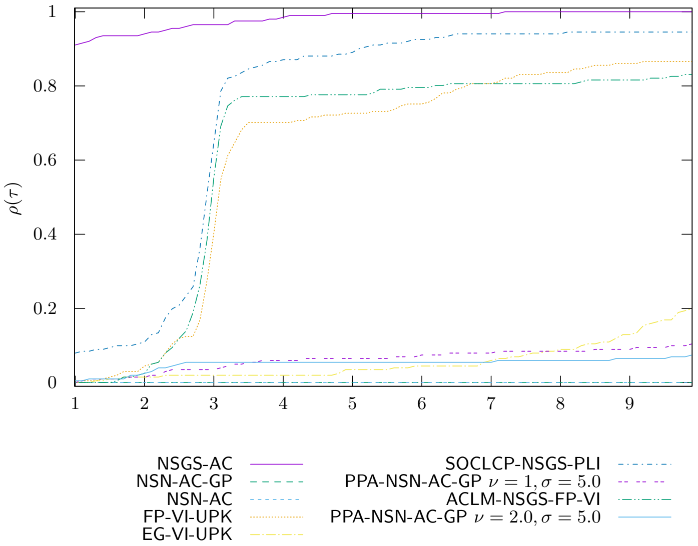

Figure 174: KaplasTower time COMP/zoom

14 Chute_1000 precision 1.0e-04 timeout 200

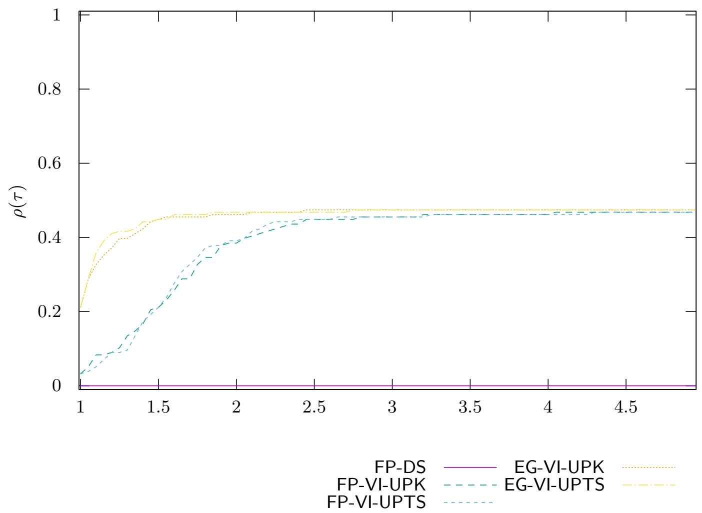

Figure 175: Chute_1000 time VI/UpdateRule

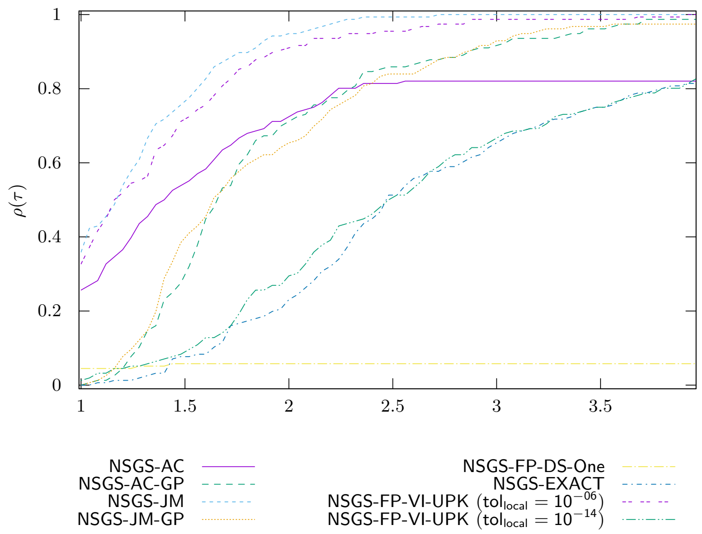

Figure 176: Chute_1000 time NSGS/LocalSolver

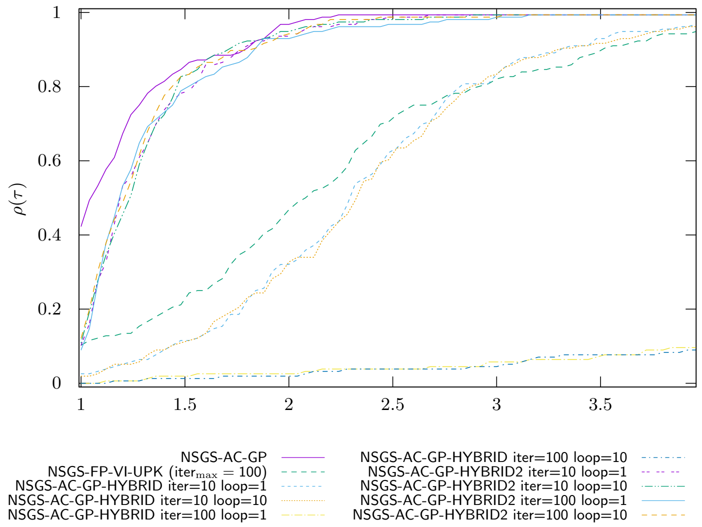

Figure 177: Chute_1000 time NSGS/LocalSolverHybrid

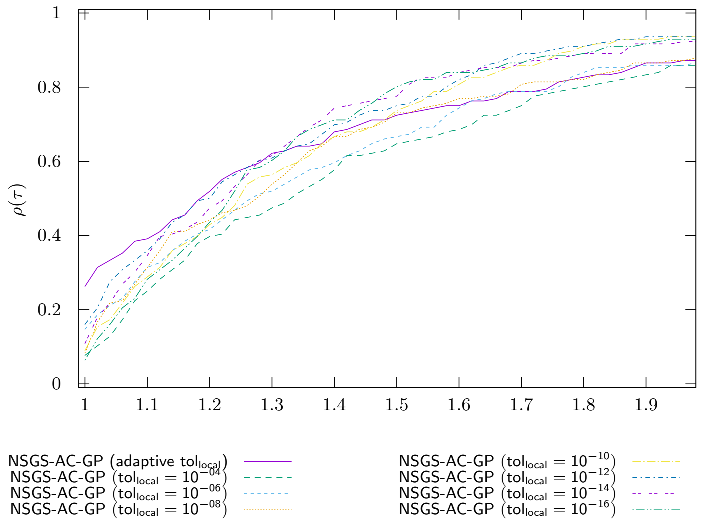

Figure 178: Chute_1000 time NSGS/LocalTol

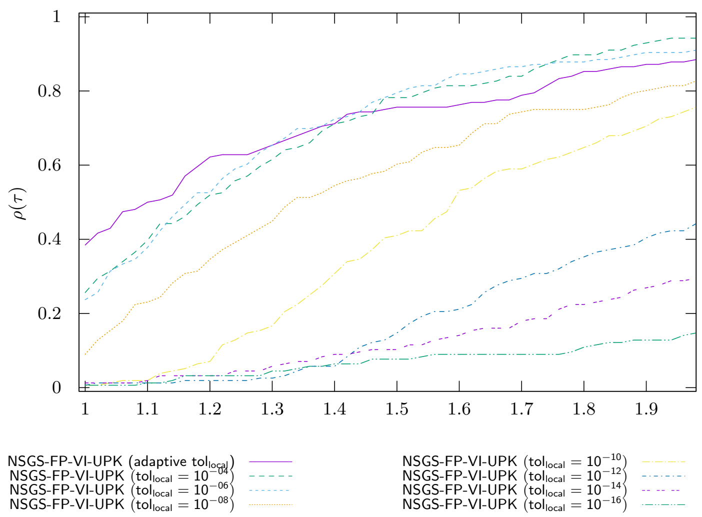

Figure 179: Chute_1000 time NSGS/LocalTol-VI

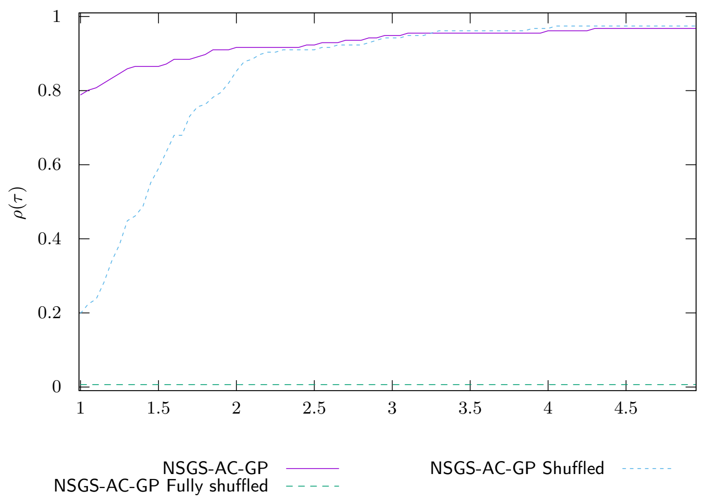

Figure 180: Chute_1000 time NSGS/Shuffled

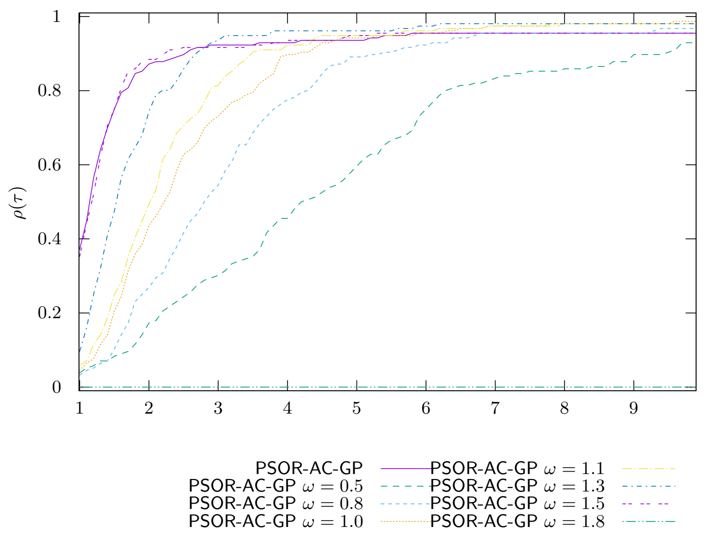

Figure 181: Chute_1000 time PSOR

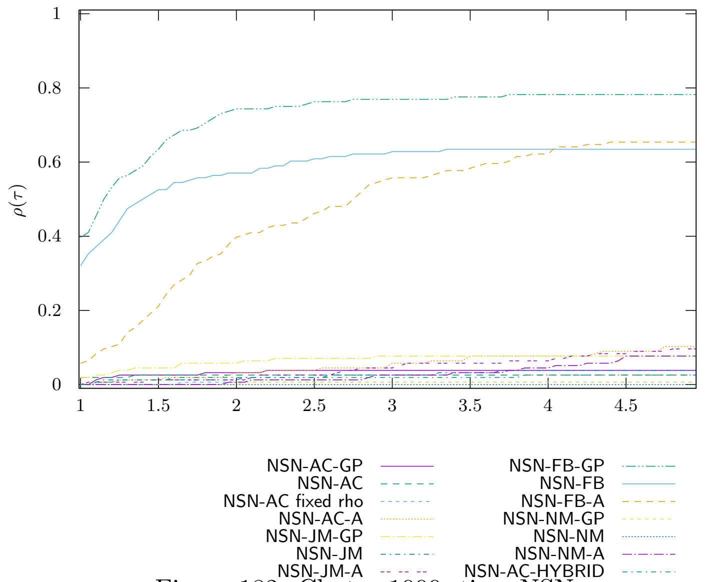

Figure 182: Chute_1000 time NSN

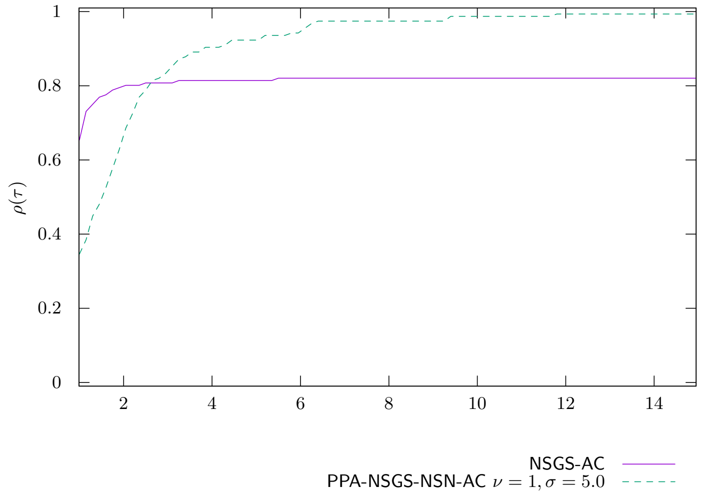

Figure 183: Chute_1000 time PROX/InternalSolvers

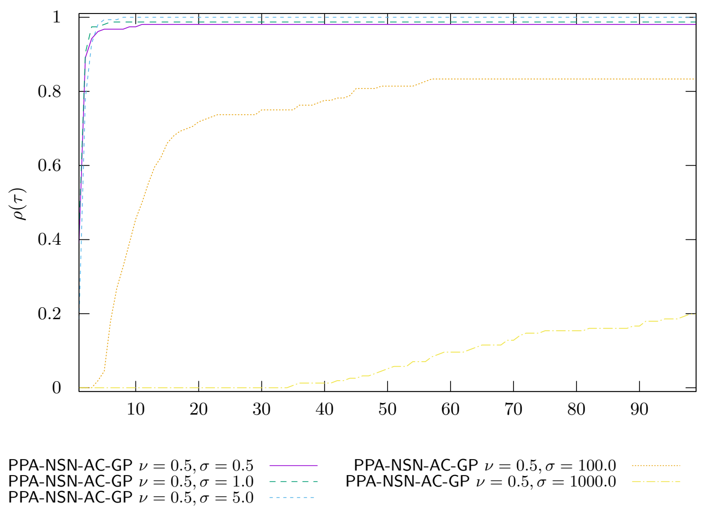

Figure 184: Chute_1000 time PROX/Parametric studies $\nu = 0.5$

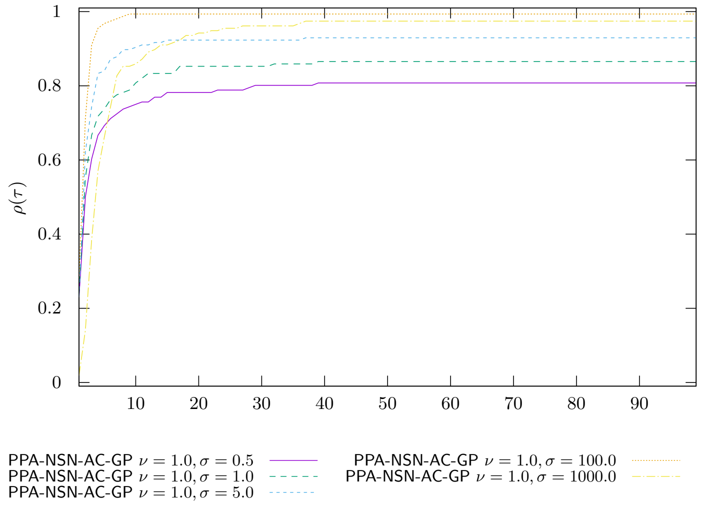

Figure 185: Chute_1000 time PROX/Parametric studies $\nu = 1.0$

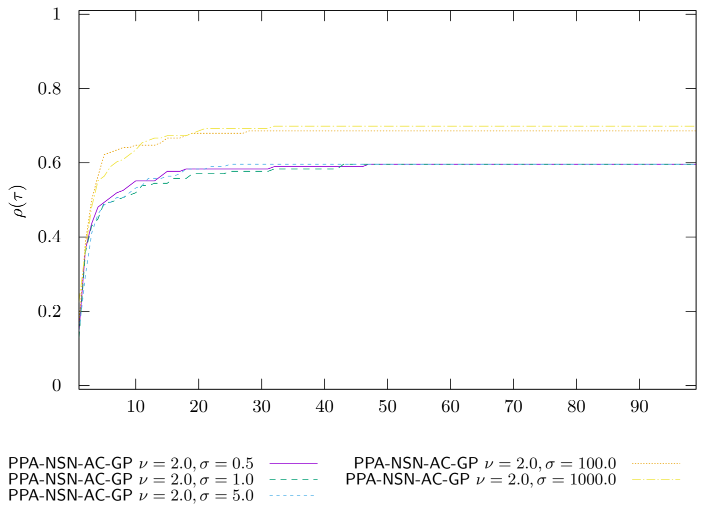

Figure 186: Chute_1000 time PROX/Parametric studies $\nu = 2.0$

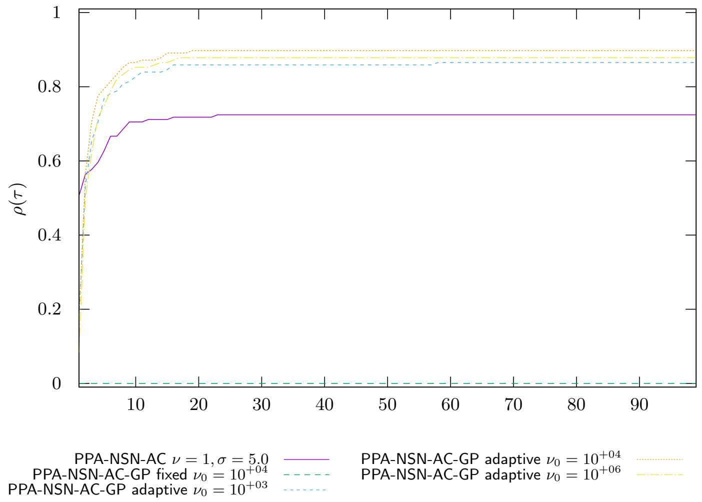

Figure 187: Chute_1000 time PROX/Regularized problem

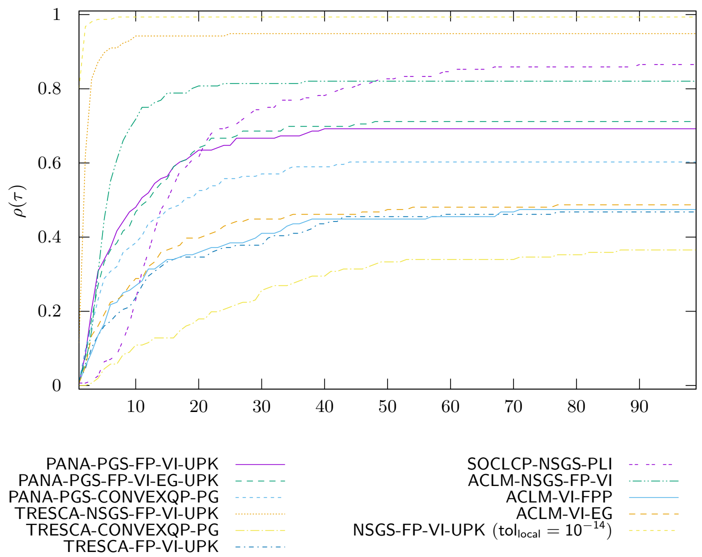

Figure 188: Chute_1000 time OPTI

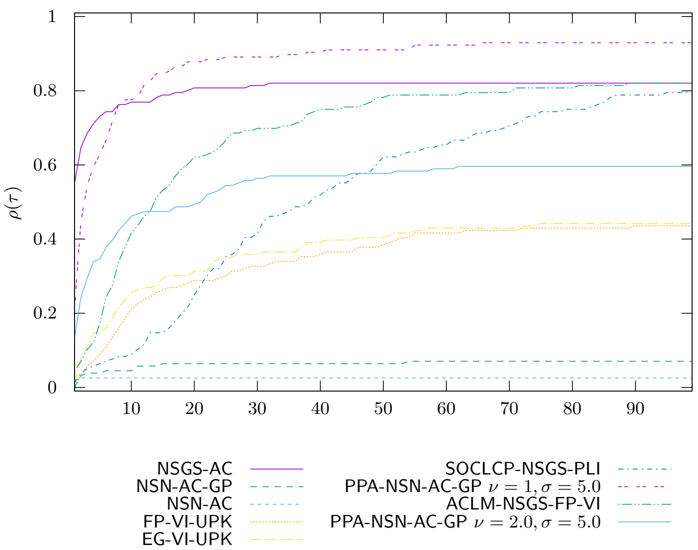

Figure 189: Chute_1000 time COMP/large

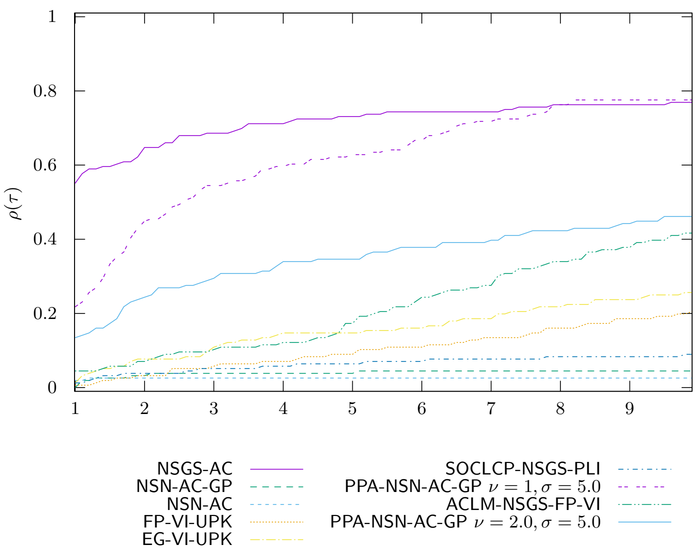

Figure 190: Chute_1000 time COMP/zoom

15 Chute_4000 precision 1.0e-04 timeout 200

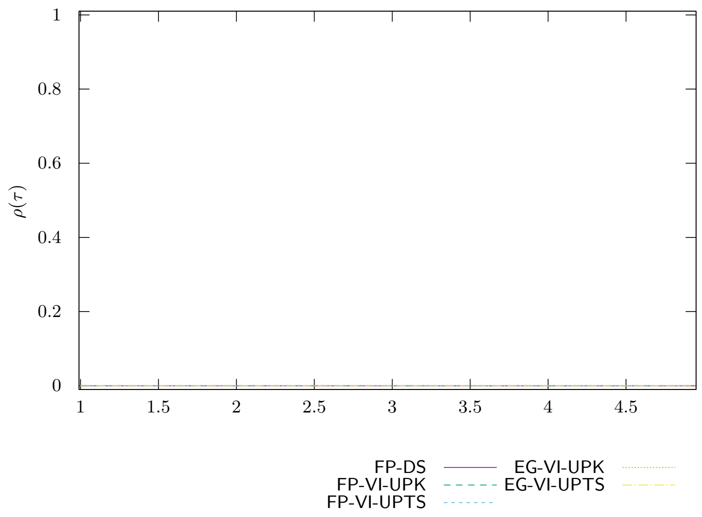

Figure 191: Chute_4000 time VI/UpdateRule

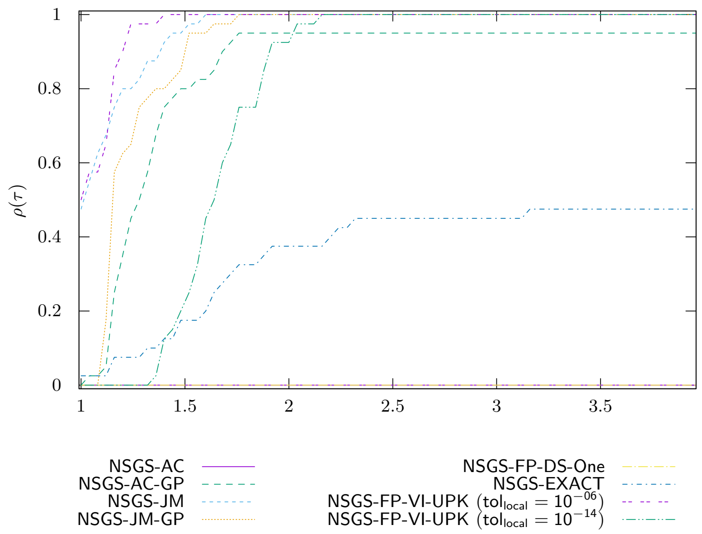

Figure 192: Chute_4000 time NSGS/LocalSolver

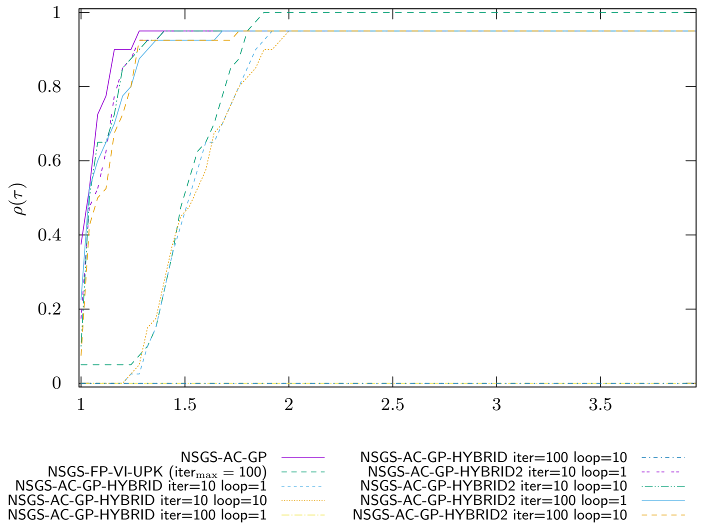

Figure 193: Chute_4000 time NSGS/LocalSolverHybrid

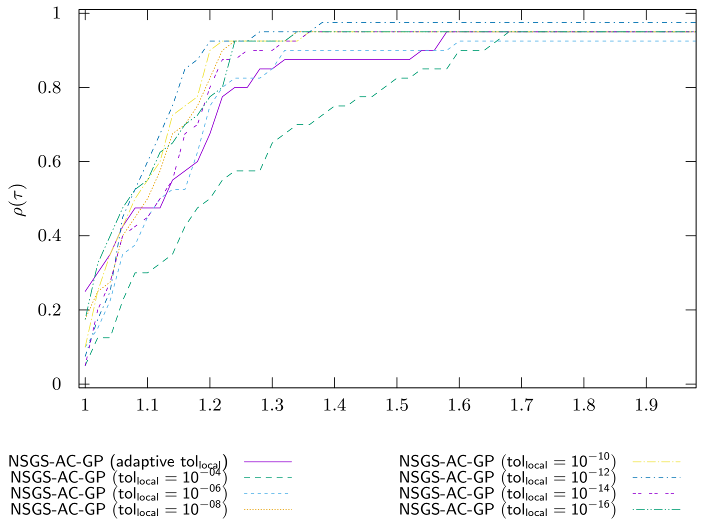

Figure 194: Chute_4000 time NSGS/LocalTol

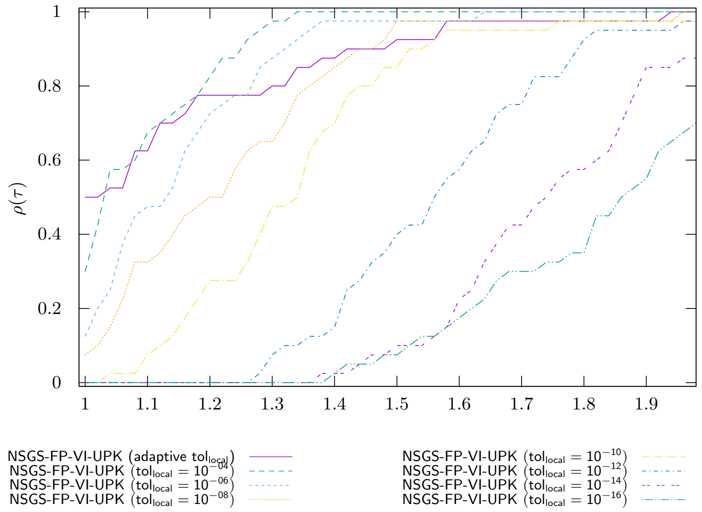

Figure 195: Chute_4000 time NSGS/LocalTol-VI

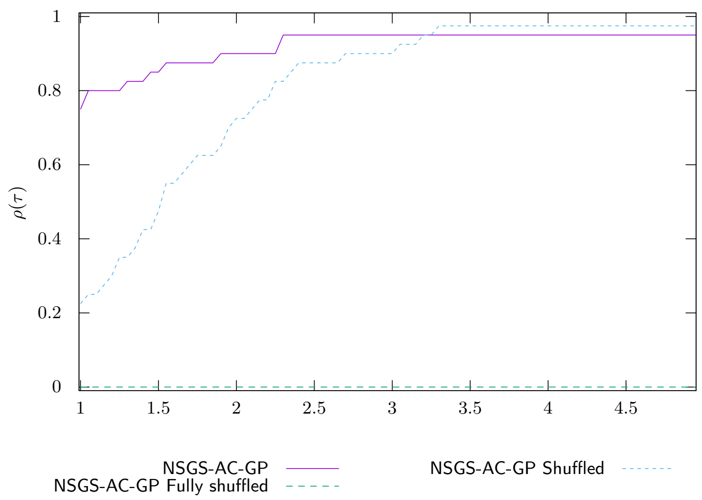

Figure 196: Chute_4000 time NSGS/Shuffled

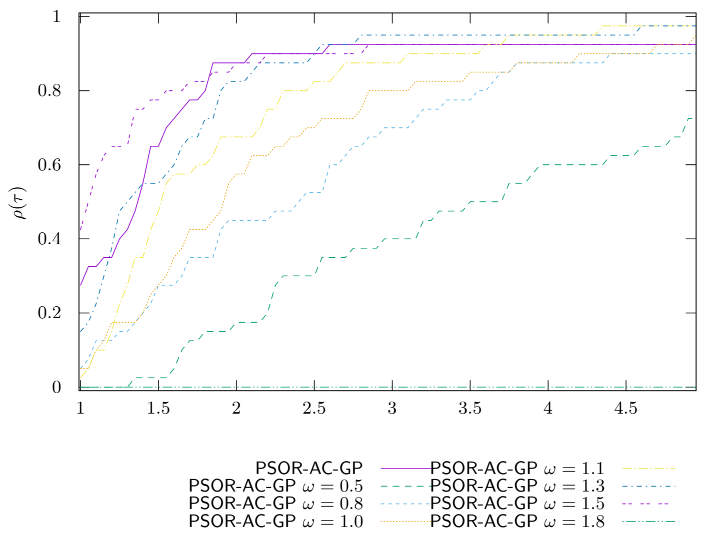

Figure 197: Chute_4000 time PSOR

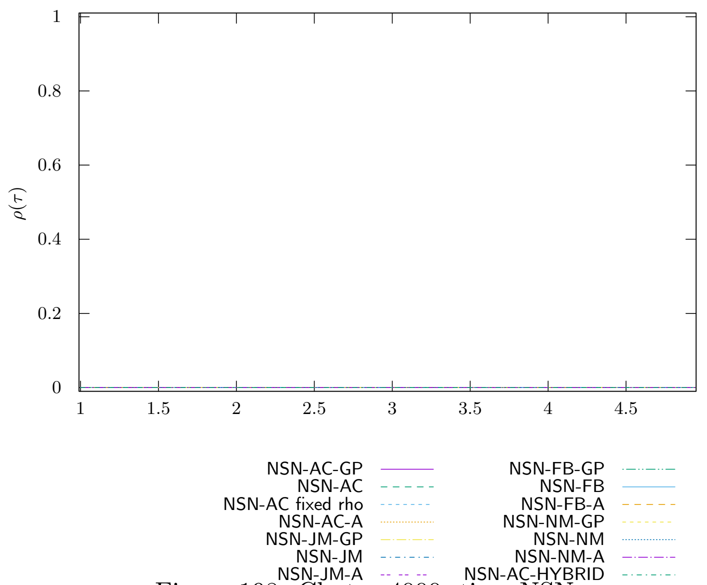

Figure 198: Chute_4000 time NSN

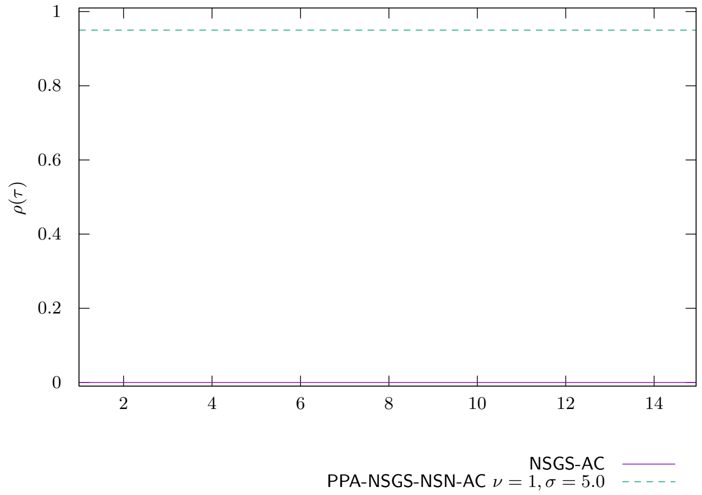

Figure 199: Chute_4000 time PROX/InternalSolvers

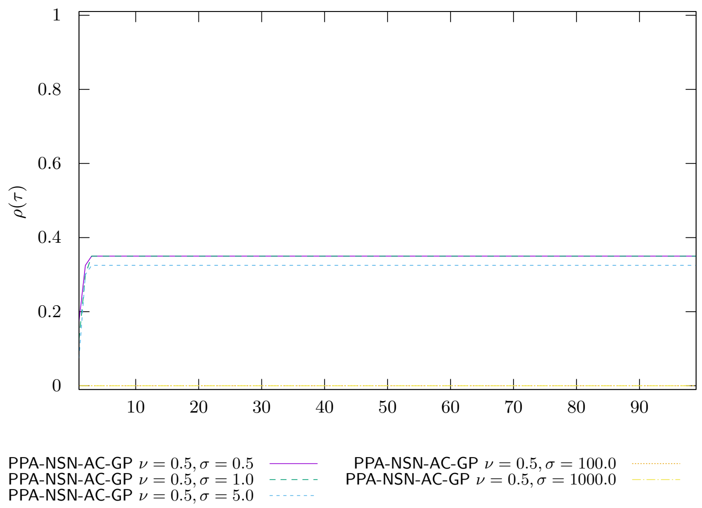

Figure 200: Chute_4000 time PROX/Parametric studies $\nu = 0.5$

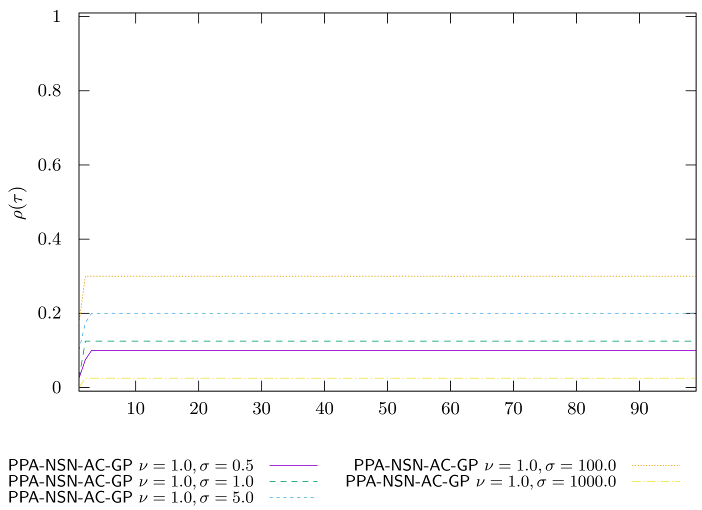

Figure 201: Chute_4000 time PROX/Parametric studies $\nu = 1.0$

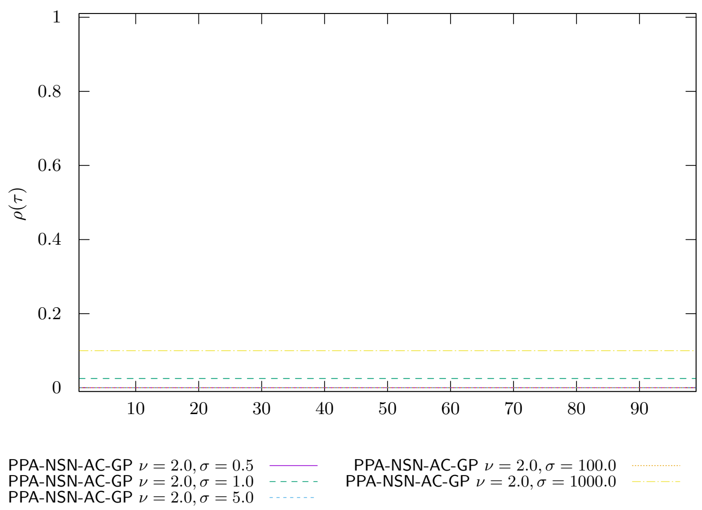

Figure 202: Chute_4000 time PROX/Parametric studies $\nu = 2.0$

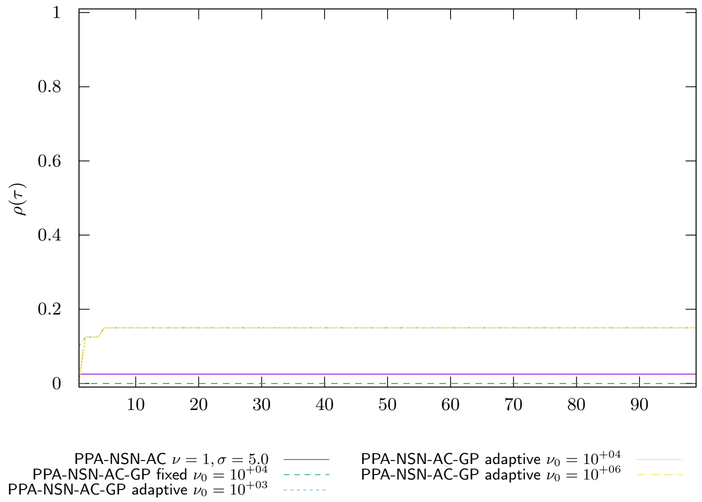

Figure 203: Chute_4000 time PROX/Regularized problem

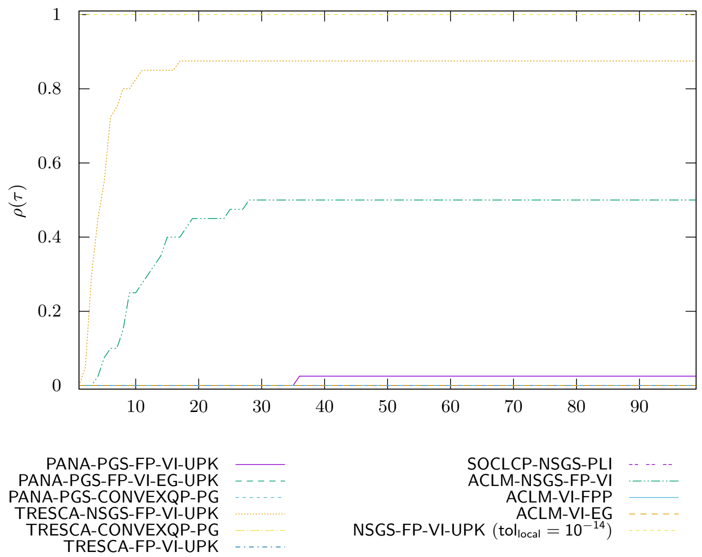

Figure 204: Chute_4000 time OPTI

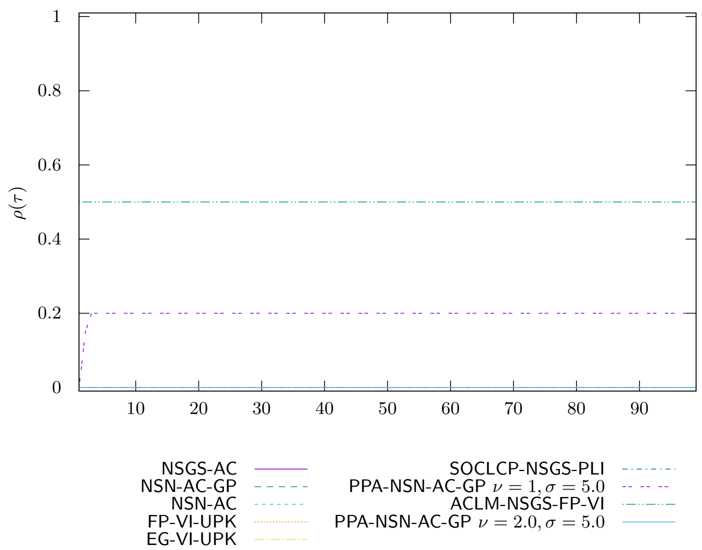

Figure 205: Chute_4000 time COMP/large

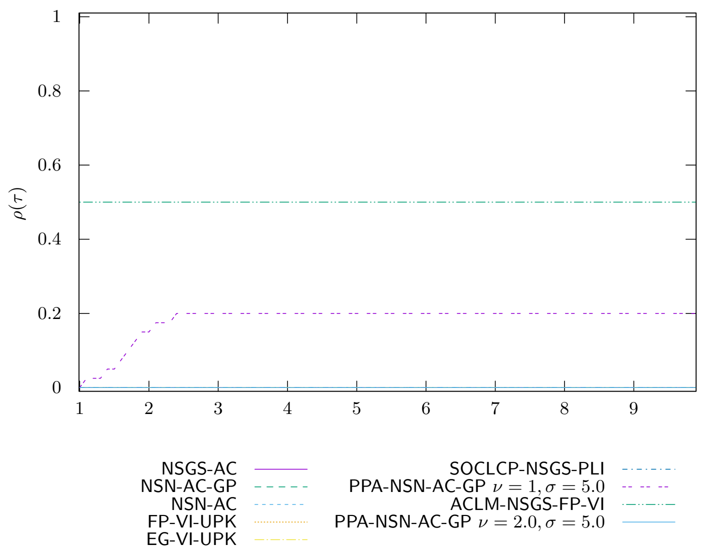

Figure 206: Chute_4000 time COMP/zoom

16 Chute_local_problems precision 1.0e-04 timeout 10

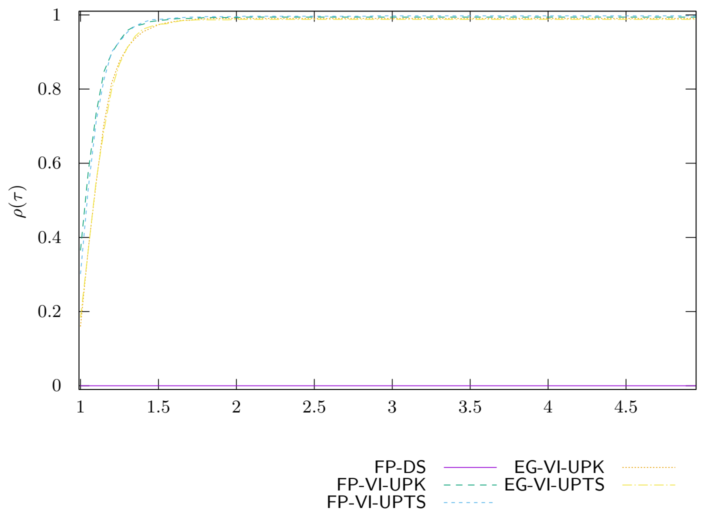

Figure 207: Chute_local_problems time VI/UpdateRule

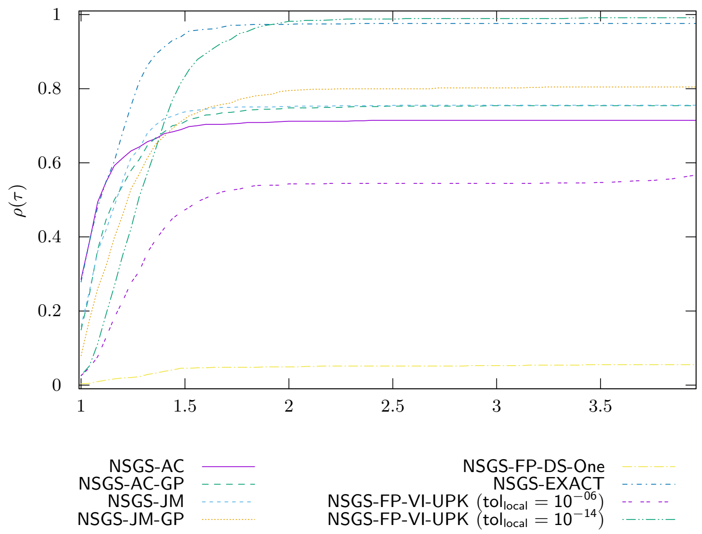

Figure 208: Chute_local_problems time NSGS/LocalSolver

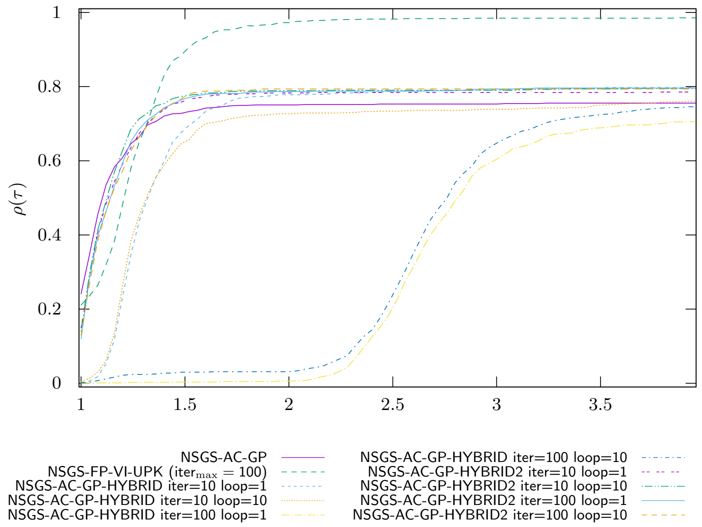

Figure 209: Chute_local_problems time NSGS/LocalSolverHybrid

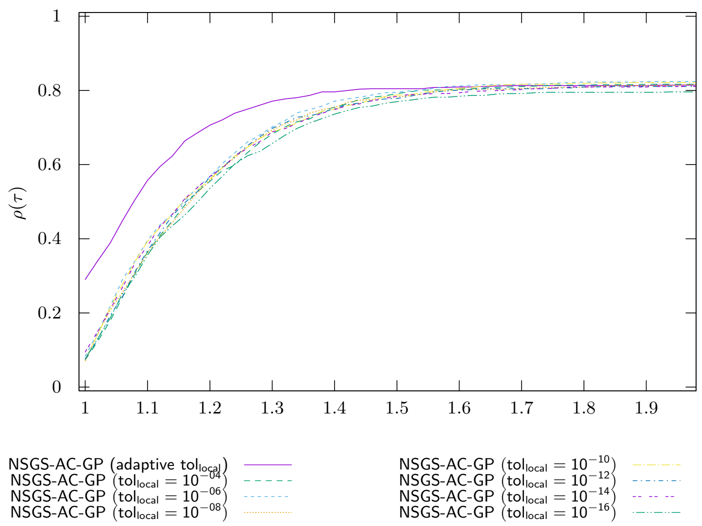

Figure 210: Chute_local_problems time NSGS/LocalTol

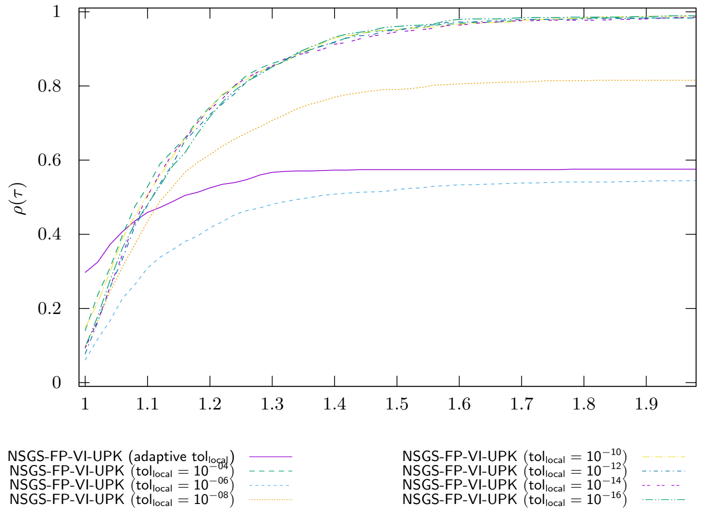

Figure 211: Chute_local_problems time NSGS/LocalTol-VI

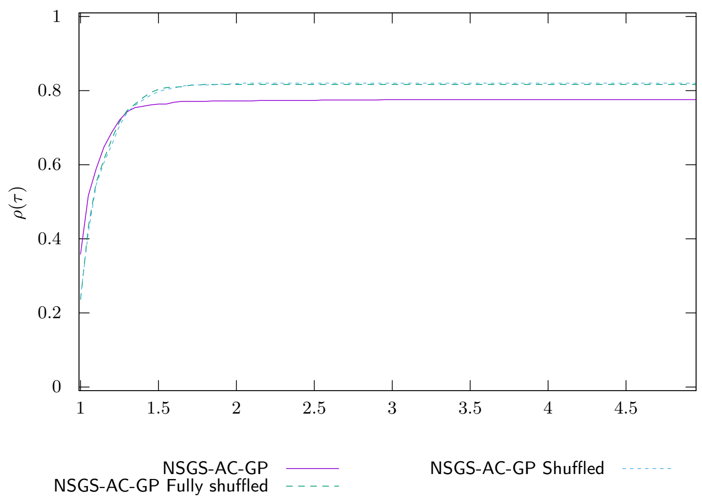

Figure 212: Chute_local_problems time NSGS/Shuffled

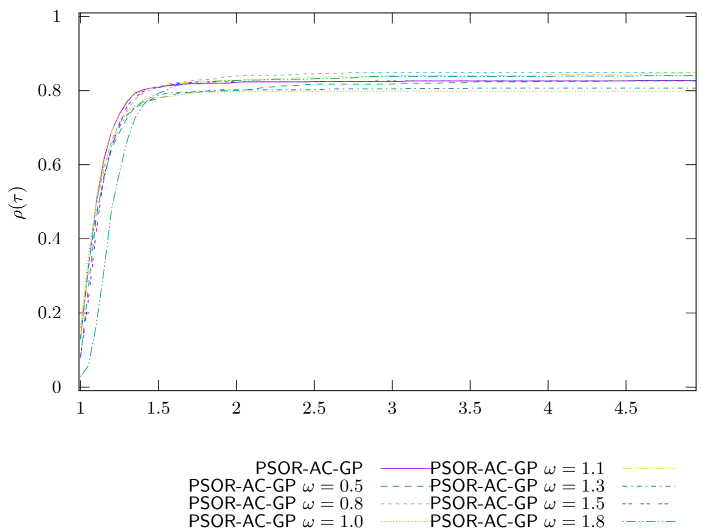

Figure 213: Chute_local_problems time PSOR

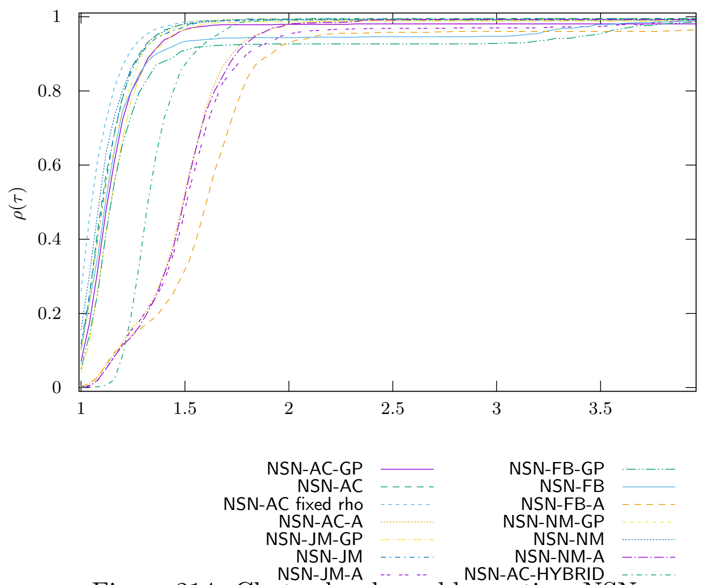

Figure 214: Chute_local_problems time NSN

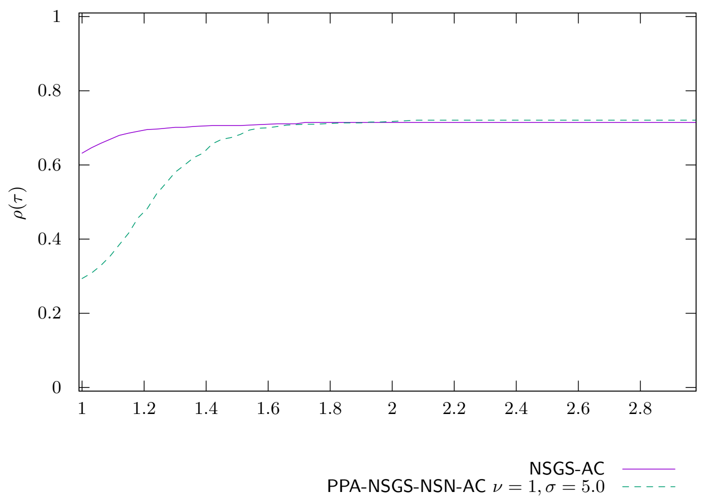

Figure 215: Chute_local_problems time PROX/InternalSolvers

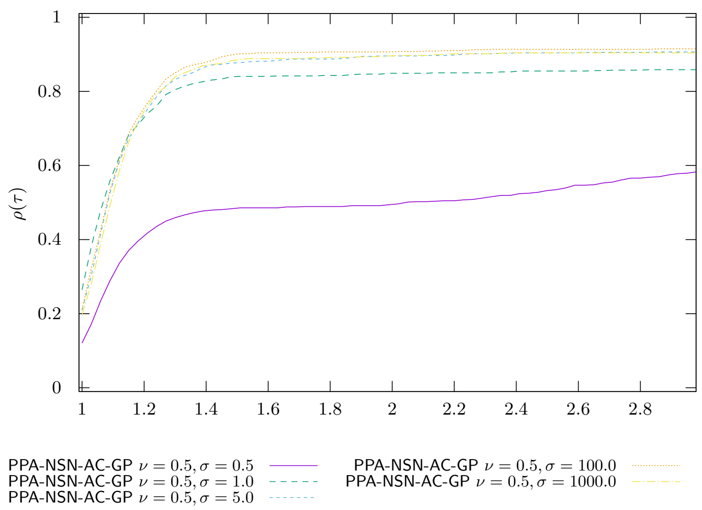

Figure 216: Chute_local_problems time PROX/Parametric studies $\nu = 0.5$

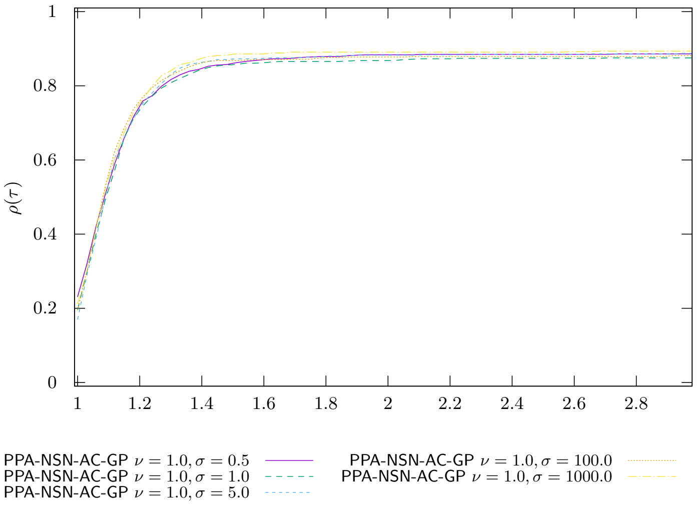

Figure 217: Chute_local_problems time PROX/Parametric studies $\nu = 1.0$

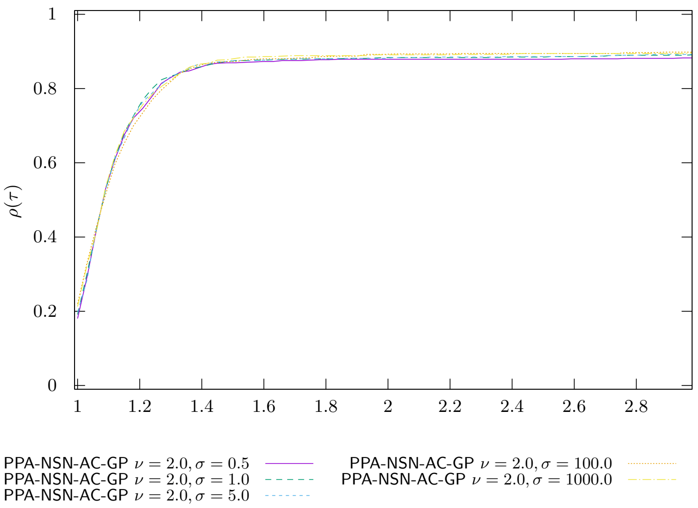

Figure 218: Chute_local_problems time PROX/Parametric studies $\nu = 2.0$

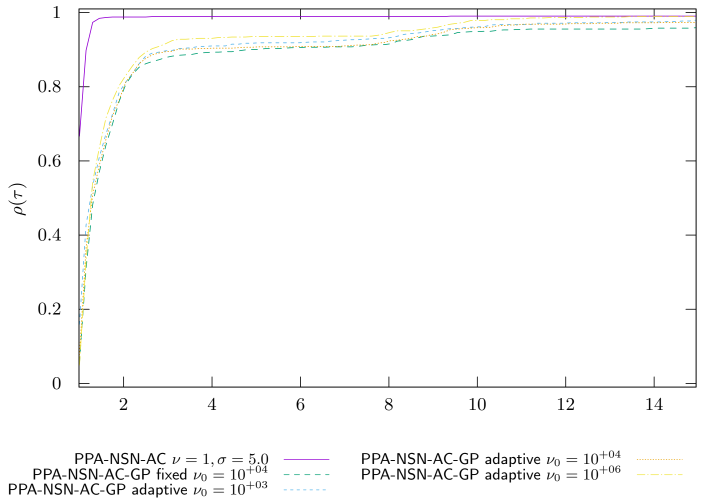

Figure 219: Chute_local_problems time PROX/Regularized problem

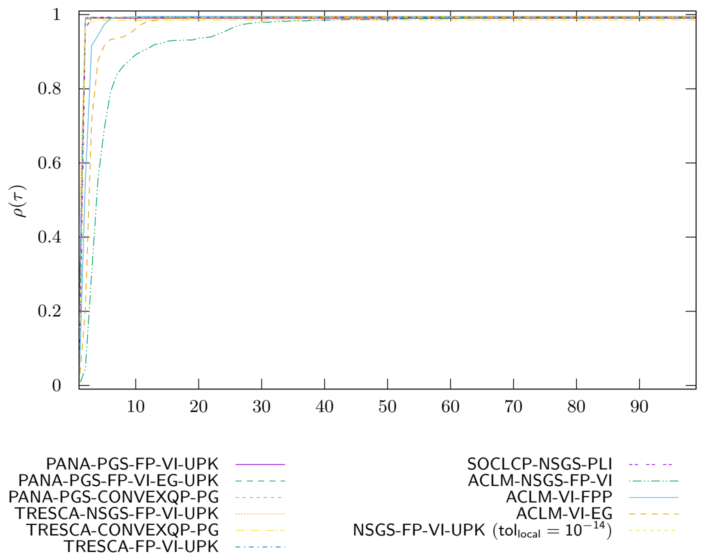

Figure 220: Chute_local_problems time OPTI

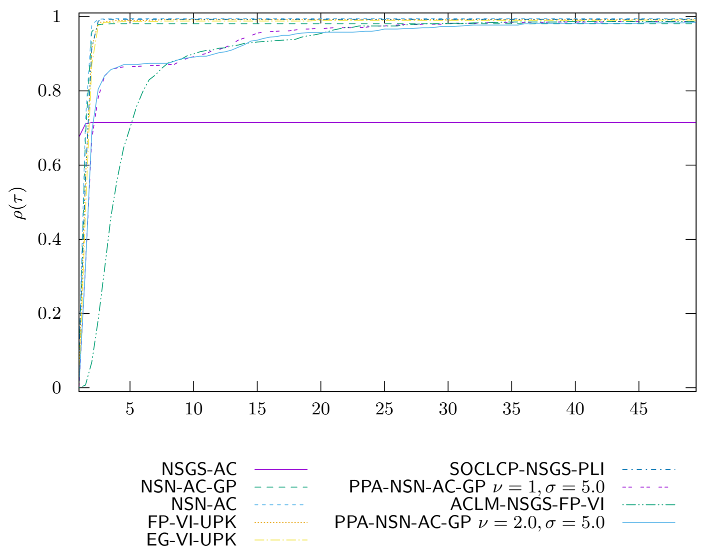

Figure 221: Chute_local_problems time COMP/large

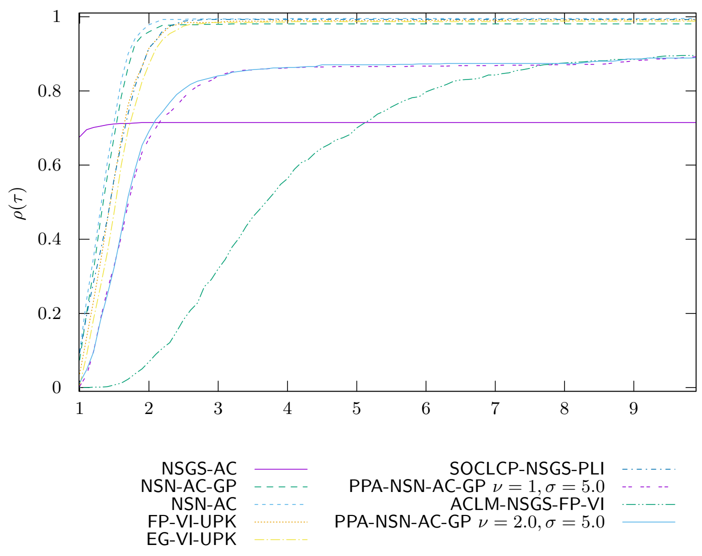

Figure 222: Chute_local_problems time COMP/zoom

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