SUPPLEMENTAL MATERIALS (Meyer et al.)

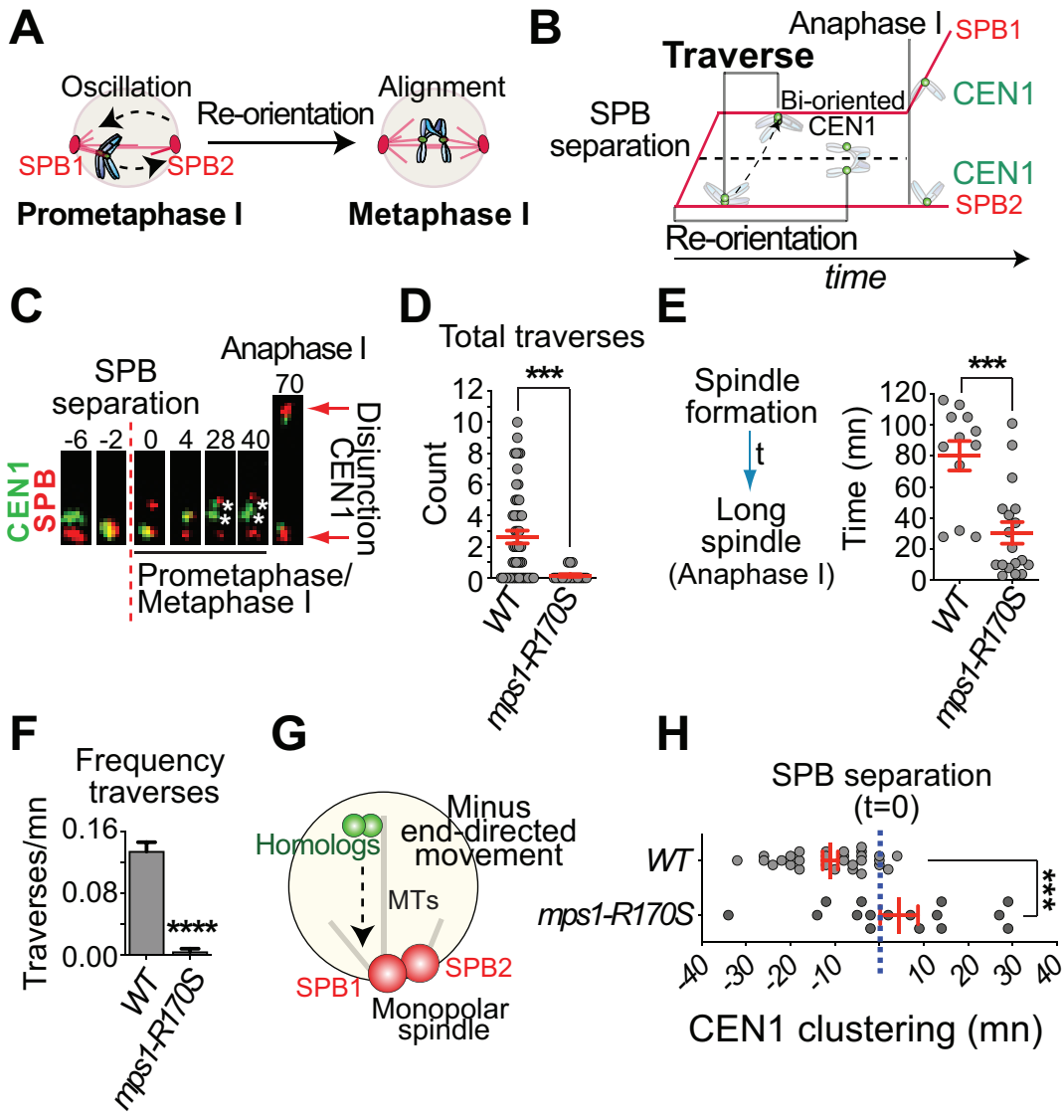

Figure S1. Mps1 is required for the bi-orientation of bivalents in meiosis. A. Cartoon illustrating the process of re-orientation and chromosome alignment. The vast majority of chromosome pairs initially attach to one spindle pole in early prometaphase I, thus the re-orientation process is a necessary step to promote the establishment of bi-oriented attachments for each chromosome pair. **B.** The re-orientation process can be quantified by counting the number of traverses (movements across the entire spindle).

For simplicity only *CEN1* is represented. **C-H** Strains evaluated were all diploids carrying GFP-tagged centromeres of chromosome *I* (CEN1-GFP*)* and expressing *SPC42-DsRed* to mark the SPBs. Cells were sporulated and released from a pachytene arrest (P_{GAL1}*-NDT80, GAL4-ER*) at 6 hours after meiotic induction by the addition of 5 μM β-estradiol. The diploid cells were observed by time-lapse imaging during meiosis at two-minute intervals for 3-4 hours. **C.** Representative cell from wild-type is shown. The asterisks indicate split homologous centromeres. Diploid cells (wild-type and *mps1-R170S* mutants) that were able to form bivalents (*SPO11*) were analyzed for the following parameters: **D.** The total number of traverses until bi-orientation or until anaphase I (in cases where bi-orientation of chromosome *I* was not achieved) was determined for each cell. **E.** The duration of metaphase I was determined for each individual cell (n≥18) by calculating the time between SPB separation and the formation of a long bipolar spindle (≥3.5 μm). The shortened metaphase in *mps1-R170S* mutants highlights their loss of the spindle assembly checkpoint. **F.** The frequency of *CEN1* traverses per minute during the first twenty minutes of prometaphase (marked by the separation of SPBs) is represented. **G.** Schematic representation of the process of chromosome movement on a monopolar spindle which occurs before bipolar spindle formation. **H.** The timing of the final *CEN1* clustering (when CEN1 reaches the SPB and remains associated with it) was monitored relative to the moment of SPB separation for each individual cell of the indicated genotypes (n≥19). The red dotted line represents the time of SPB separation. ***p < 0.001, ****p < 0.0001 (student's t test).

Table S1: Diploid strain list

Diploid	Parents strain	Figure
DRM3032	X1151 * Y1114	Fig. 2, 3 "*WT*"
DRM2417	X1195 * Y1144	Fig. 2, 3 "*mps1-R170S*"
DRM1658	X1195 * Y1147	Fig. 2, 3 "*mps1-as1*"
DRM1661	X1197 * Y1148	Fig. 2, 3 "*mps1-as1*"
DRM3107	X2297 * Y2145	Fig. 3 "*ndc80-md*"
DRM2549	X1151 * Y2083	Fig. 4, 5 "*WT*"
DRM2550	X1152 * Y2083	Fig. 4, 5 "*WT*"
DRM2525	X1196 * Y2099	Fig. 4, 5 "*mps1-R170S*"
DRM2526	X1197 * Y2100	Fig. 4, 5 "*mps1-R170S*"
DRM2551	X1196 * Y2091	Fig. 4, 5 "*mps1-R170S*"
DRM2552	X1197 * Y2092	Fig. 4, 5 "*mps1-R170S*"
DRM2649	X2297 * Y2187	Fig. 4 "*ndc80-md*"
DRM2650	X2298 * Y2188	Fig. 4 "*ndc80-md*"
DRM3558/ DRM3784	X3217 * Y2771	Fig. 6 "Mitotic *(WT* Diploid*)"*
DRM3451	X3227 * Y2779	Fig. 6, S2B "Meiotic *(WT* Diploid*)", "WT (1-NMPP1)", "WT (metaphase)"*
DRM3452	X3228 * Y2780	Fig. 6, S2B "Meiotic *(WT* Diploid*)", "WT (1-NMPP1)", "WT (metaphase)"*
DRM3455	X3233 * Y2783	Fig. 6, S2B "*mps1-as1 (1-NMPP1)"*
DRM3456	X3234 * Y2784	Fig. 6, S2B "*mps1-as1 (1-NMPP1)"*
DRM3457	X3231 * Y2781	Fig. 6, S2B "*spo11 (prometaphase)", "spo11 WT (1-NMPP1)", "spo11 WT"*
DRM3458	X3232 * Y2782	Fig. 6, S2B "*spo11 (prometaphase)", "spo11 WT (1-NMPP1)", "spo11 WT",*
DRM3459	X3229 * Y2787	Fig. 6, S2B "*spo11 mps1-R170S"*
DRM3460	X3230 * Y2787	Fig. 6, S2B "*spo11 mps1-R170S"*
DRM3479	X3229 * Y2805	Fig. 6, S2B "*spo11 mps1-as1 (1-NMPP1)"*
DRM3480	X3230 * Y2805	Fig. 6, S2B "*spo11 mps1-as1 (1-NMPP1)"*
DRM3893	X3383 * Y2933	Fig. 6, S2B "*STU2-AID*", "STU2-AID* (+Auxin)"*
DRM3894	X3384 * Y2934	Fig. 6, S2B "*STU2-AID*", "STU2-AID* (+Auxin)"*
DRM2405	X1843 * Y1693	Fig. S1 "*WT*"
DRM2415	X1142 * Y1136	Fig. S1 "*mps1-R170S*"
DRM1967	X1103 * Y1092	Fig. S2A "*WT*"
DRM1969	X1142 * Y1124	Fig. S2A "*mps1-as1*"

Table S2: Haploid strain list

X1843	*MATa, trp1-Δ63, his3-Δ1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1-R, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], natNT2-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2]*
Y1693	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], natNT2-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2]*
X1142	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-PGAL1-NDT80, PCLB2-3HA-MPS1 KANMX6, CEN1::pJN2[lacO256 LEU2]*
Y1136	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, mps1-R170S::his5, CEN1::pJN2[lacO256 LEU2]*
X1151	*MAT∝, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2], spo11::KANMX*
Y1114	*MATa, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, spo11::KANMX*
X1195	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-PGAL1-NDT80, spo11::KANMX, PCLB2-3HA-MPS1 KANMX6, CEN1::pJN2[lacO256 LEU2]*
Y1144	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, spo11::KANMX, mps1-R170S::his5*
Y1147	MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, spo11::KANMX, mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1
X1197	*MAT∝, ura3::pKB80 [P_{GPD1}-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-P_{GAL1}-NDT80, spo11::KANMX, PCLB2-3HA-MPS1 KANMX6, CEN1::pJN2[lacO256 LEU2]*
Y1148	*MATa, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, spo11::KANMX, mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1*
X2297	*MATa, trp1-Δ63, his3-Δ1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1-R, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], natNT2-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2], PCLB2-3HA-NDC80 KanMX6, spo11::HIS3MX6*
Y2145	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], natNT2-PGAL1-NDT80, PCLB2-3HA-NDC80 KanMX6, spo11::HIS3MX6*
Y2083	*MATa, trp1-Δ63, his3-Δ1, leu2, lys2::pLL1[PCYC1-GFP-lacI LYS2], tyr1-2, met13-c, cyh2-1, ura3::pAFS152[URA3 PCYC1-GFP-lacI], SPC42-GFP-TRP1 , natNT2-PGAL1-NDT80, spo11::KANMX*
X1152	*MAT∝, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2], spo11::KANMX*

X1196	*MATa, ura3::pKB80 [P_{GPD1}-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 ®, ZIP1-TEV?, KanMX-P_{GAL1}-NDT80, spo11::KANMX, PCLB2-3HA-MPS1 KANMX6, CEN1::pJN2[lacO256 LEU2]*
Y2099	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-GFP-TRP1, spo11::HIS3MX6, natNT2-PGAL1-NDT80, mps1-R170S::his5*
Y2100	*MATa, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-GFP-TRP1, spo11::HIS3MX6, natNT2-PGAL1-NDT80, mps1-R170S::his5*
Y2091	*MAT∝, trp1-Δ63, his3-Δ1, leu2, lys2::pLL1[PCYC1-GFP-lacI LYS2], tyr1-2, met13-c, cyh2-1, ura3::pAFS152[URA3 PCYC1-GFP-lacI], SPC42-GFP-TRP1 , natNT2-PGAL1-NDT80, spo11::KANMX, mps1-R170S::his5*
Y2092	*MATa, trp1-Δ63, his3-Δ1, leu2, lys2::pLL1[PCYC1-GFP-lacI LYS2], tyr1-2, met13-c, cyh2-1, ura3::pAFS152[URA3 PCYC1-GFP-lacI], SPC42-GFP-TRP1 , natNT2-PGAL1-NDT80, spo11::KANMX, mps1-R170S::his5*
Y2187	*MAT∝, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-GFP-TRP1, natNT2-PGAL1-NDT80, PCLB2-3HA-NDC80 KanMX6, spo11::HIS3MX6*
X2298	*MAT∝, trp1-Δ63, his3-Δ1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1-R, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], natNT2-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2], PCLB2-3HA-NDC80 KanMX6, spo11::HIS3MX6*
Y2188	*MATa, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-GFP-TRP1, natNT2-PGAL1-NDT80, PCLB2-3HA-NDC80 KanMX6, spo11::HIS3MX6*
X3217	*MATa, ura3-13, trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
Y2771	*MAT∝, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
X3227	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80*
Y2779	*MAT∝, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80*
X3228	*MAT∝, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80*
Y2780	*MATa, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80*
X3233	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, PCLB2-3HA-MPS1 KANMX6*
Y2783	*MAT∝, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1*
X3234	*MAT∝, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, PCLB2-3HA-MPS1 KANMX6*
Y2784	*MATa, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1*

X3231	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX*
Y2781	*MATα, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX*
X3232	*MATα, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX*
Y2782	*MATa, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX*
X3229	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX, PCLB2-3HA-MPS1 KANMX6*
Y2787	*MATα, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX, mps1-R170S::his5*
X3230	*MATa, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1-1, lys2-1, can1-R, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, spo11::KANMX, PCLB2-3HA-MPS1 KANMX6*
Y2805	*MATα, leu2-?, lys2-2, met13-c, tyr1-2, ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1], natNT2-PGAL1-NDT80, mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1, spo11::KANMX*
X3383	*MATa, trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1::[HIS5 pCUP1-AFB2], lys2-1, can1-R, STU2-AID*-9xMYC-HIS3MX6, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], natNT2-PGAL1-NDT80, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
Y2933	*MATα, leu2-?, lys2-2, met13-c, tyr1::[HIS5 pCUP1-AFB2], ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, STU2-AID*-9xMYC-HIS3MX6, natNT2-PGAL1-NDT80, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
X3384	*MATα, trp1-Δ63, his3-Δ1, leu2-?, met13-d, tyr1::[HIS5 pCUP1-AFB2], lys2-1, can1-R, STU2-AID*-9xMYC-HIS3MX6, ura3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], natNT2-PGAL1-NDT80, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
Y2934	*MATa, leu2-?, lys2-2, met13-c, tyr1::[HIS5 pCUP1-AFB2], ura3-1, trp1-Δ63, cyh2-1, his3-Δ1, STU2-AID*-9xMYC-HIS3MX6, natNT2-PGAL1-NDT80, TUB1-OPL447[pHIS3p:mEos2-Tub1+3'UTR::TRP1]*
X1103	*MATa, URA3::pKB80 [PGPD1-GAL4(848)-ER-URA3::hphNT1], trp1-63, his3-1, leu2, met13-d, tyr1-1, lys2::pLL1[PCYC1-GFP-lacI LYS2], can1 (R), ZIP1-TEV?, KanMX-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2]*
Y1092	*MATα, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2]*
Y1124	*MATα, ura3::pAFS152[URA3 PCYC-GFP-lacI], trp1-Δ63, his3-Δ1, leu2, lys2::pMDE798[PDMC1-GFP-lacI], tyr1-2, met13-c, cyh2-1, SPC42-[MDE1145: URA3 SPC42-DSRed], KanMX-PGAL1-NDT80, CEN1::pJN2[lacO256 LEU2], mps1Δ::KANMX, TRP1::10Xmyc-mps1-as1*