JÜLICH
FORSCHUNGSZENTRUM

Ξ Spectroscopy and the PANDA ‚Start Setup‘

Sep 13, 2016 | Albrecht Gillitzer, IKP Forschungszentrum Jülich

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Current Version of the PANDA ‚Start Setup'

Day-1 master macros distributed by Stefano July 25 as basis for the physics simulation and analysis studies:

- Cluster Jet Target
- No GEM planes → need MVD or STT_{stereo} for p_z
- No Disc DIRC → no K/π separation
- FTS planes 1 2 3 4 (no 5 6) → poor p resolution
- No RICH

➢ How does this affect Hyperon Spectroscopy & Hyperon Spin Physics?

Need Studies at Different Levels

1. MC event generation, e.g. EvtGen: p_T vs. p_L, θ vs. p

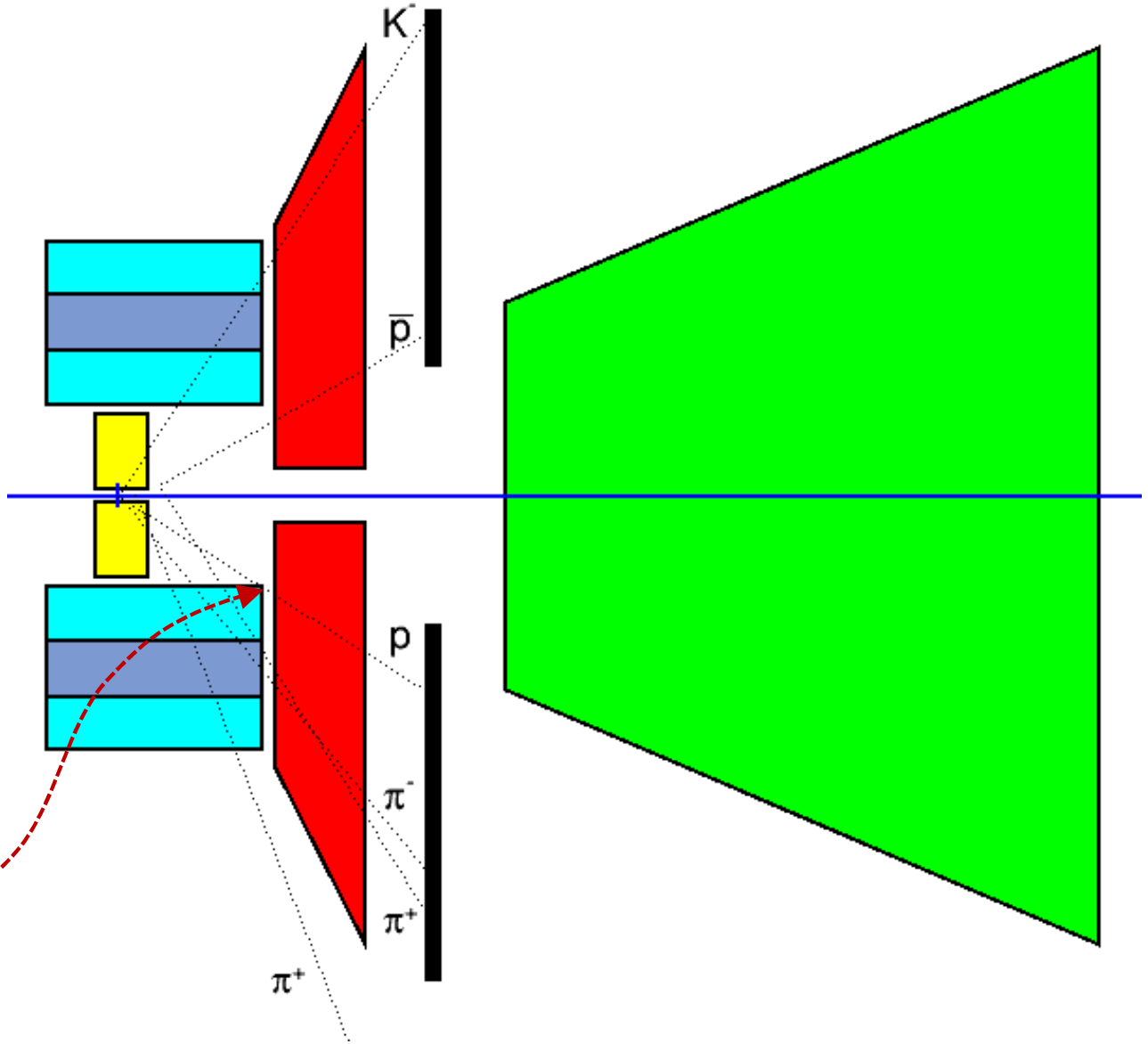
2. PandaRoot simulation, count # hits in each sub-detector

3. PandaRoot simulation and full event reconstruction

Complication: displaced decay vertices of hyperons !
(affects 1. & 3.)

Fast Geometric Analysis with Straight Tracks

- EvtGen events
- 4.1 GeV $\bar{p}p \rightarrow \bar{\Xi}^{+}\Lambda K^{-}$
- $\bar{p}\pi^{+}\pi^{+}p\pi^{-}K^{-}$ final state
- simplified geometry of MVD, STT, GEM, FTS
- neglect magnetic field (conservative)
- evaluate path length in each sub-detector volume & $R(z_{STT})$



Detector Geometry

Detector [1]	Z_{us}	Z_{ds}	R_i	R_o
MVD	-170	230	10	135
STT	-550	1100	150	420
STT_{stereo}	-550	1100	239	331
GEM #1	1194	-	45	450
GEM #3	-	1885	45	740
FwdEndCap(x) [2]	2450	2450	-	[432] [2]
FwdEndCap(y) [2]	2450	2450	-	[214] [2]
FTS	2954	7475	-	-

[1] all values in mm

[2] elliptical opening, $\theta_x = \pm 10^o$, $\theta_y = \pm 5^o$

Scan of 100 Events in Event Display

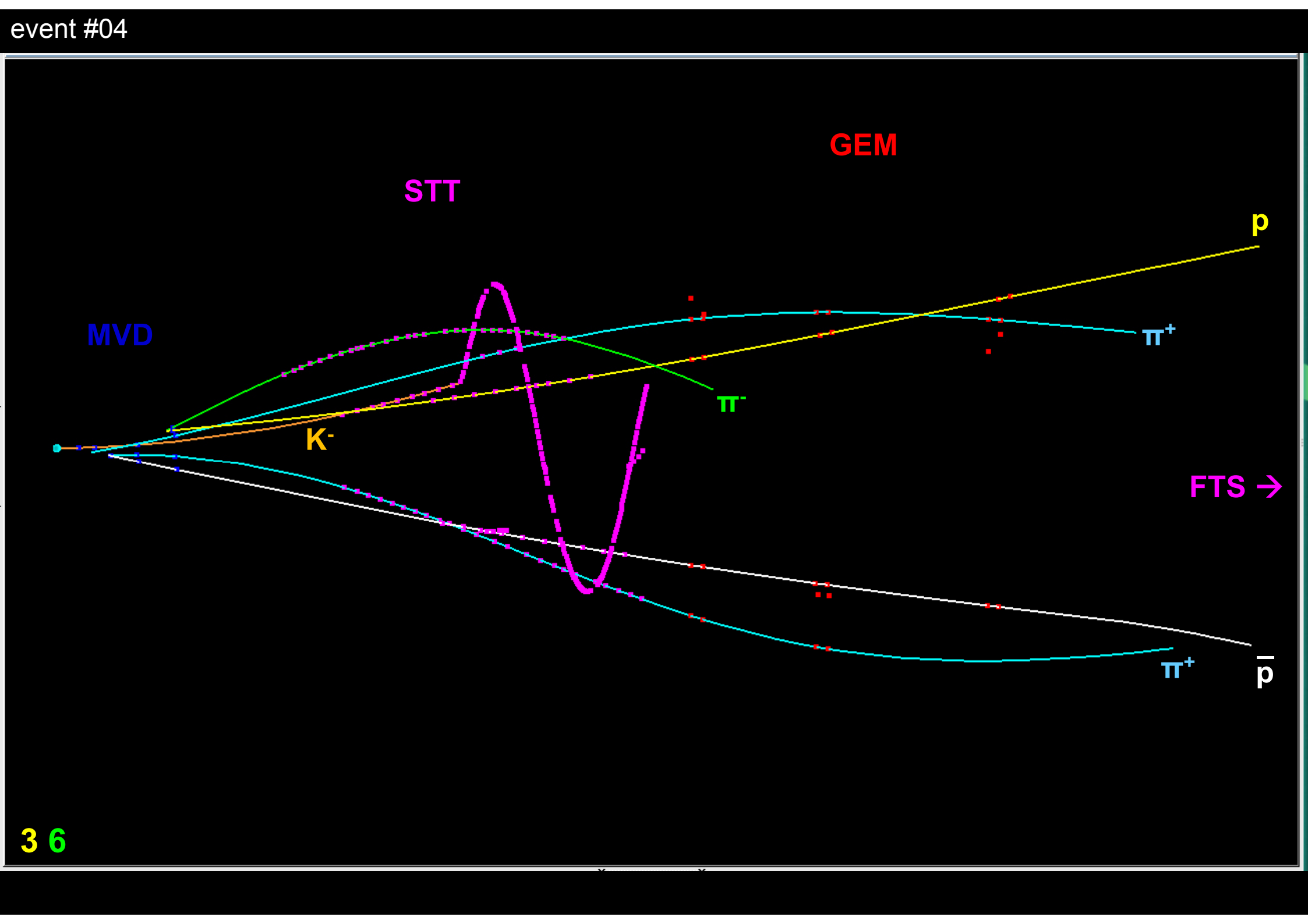
- display primary particles only
- display MVD, STT, GEM, FTS points only
- minimum requirement: all 6 tracks visible on ‚global' scale

➢ how „straight" are the tracks?

➢ what is the event topology?

- **1** : both p & $\bar{p}$ in FTS
- **2** : one of p, $\bar{p}$ in FTS
- **3** : both p & $\bar{p}$ in GEM
- **4** : one of π, K in FTS
- **5** : both p & $\bar{p}$ vertex ‚beyond' MVD
- **6** : one of p, $\bar{p}$ vertex ‚beyond' MVD

any of these disfavors recostruction with MVD & STT only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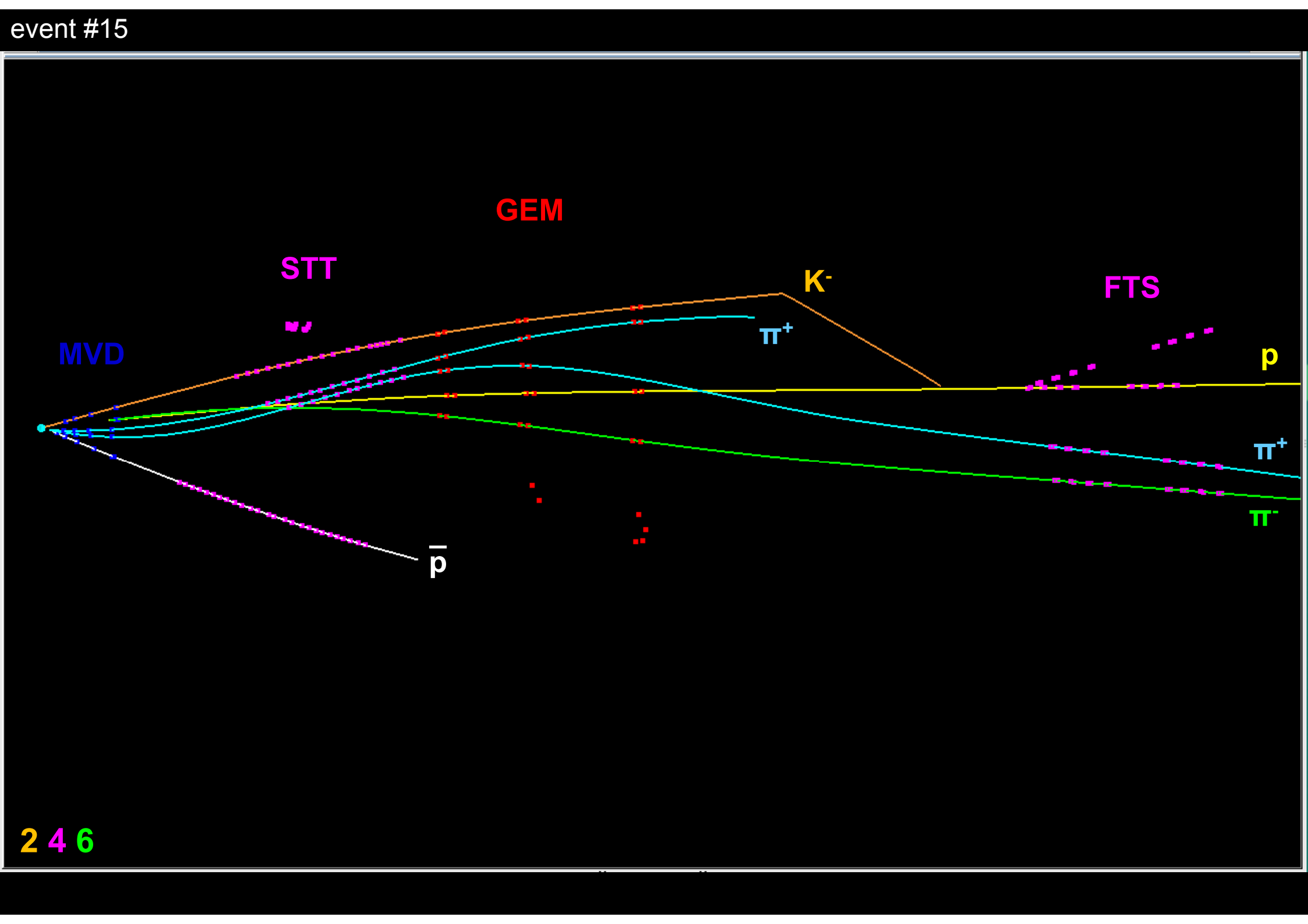
GEM
STT
p
MVD
π+
π-
K-
FTS →
π+
p̄
3 6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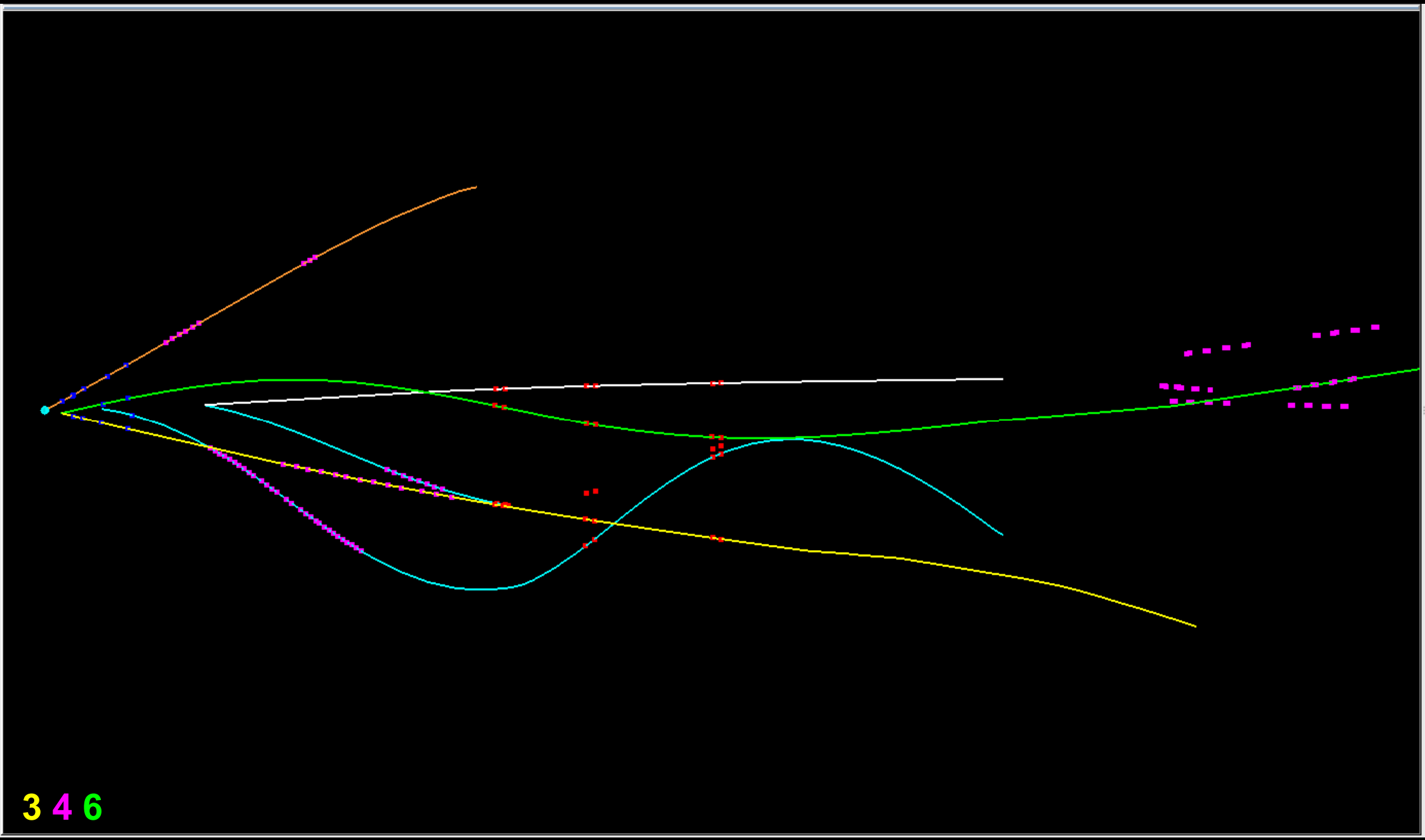
GEM
STT
K-
FTS
MVD
π+
p
π+
π-
p̄
2 4 6

event #17



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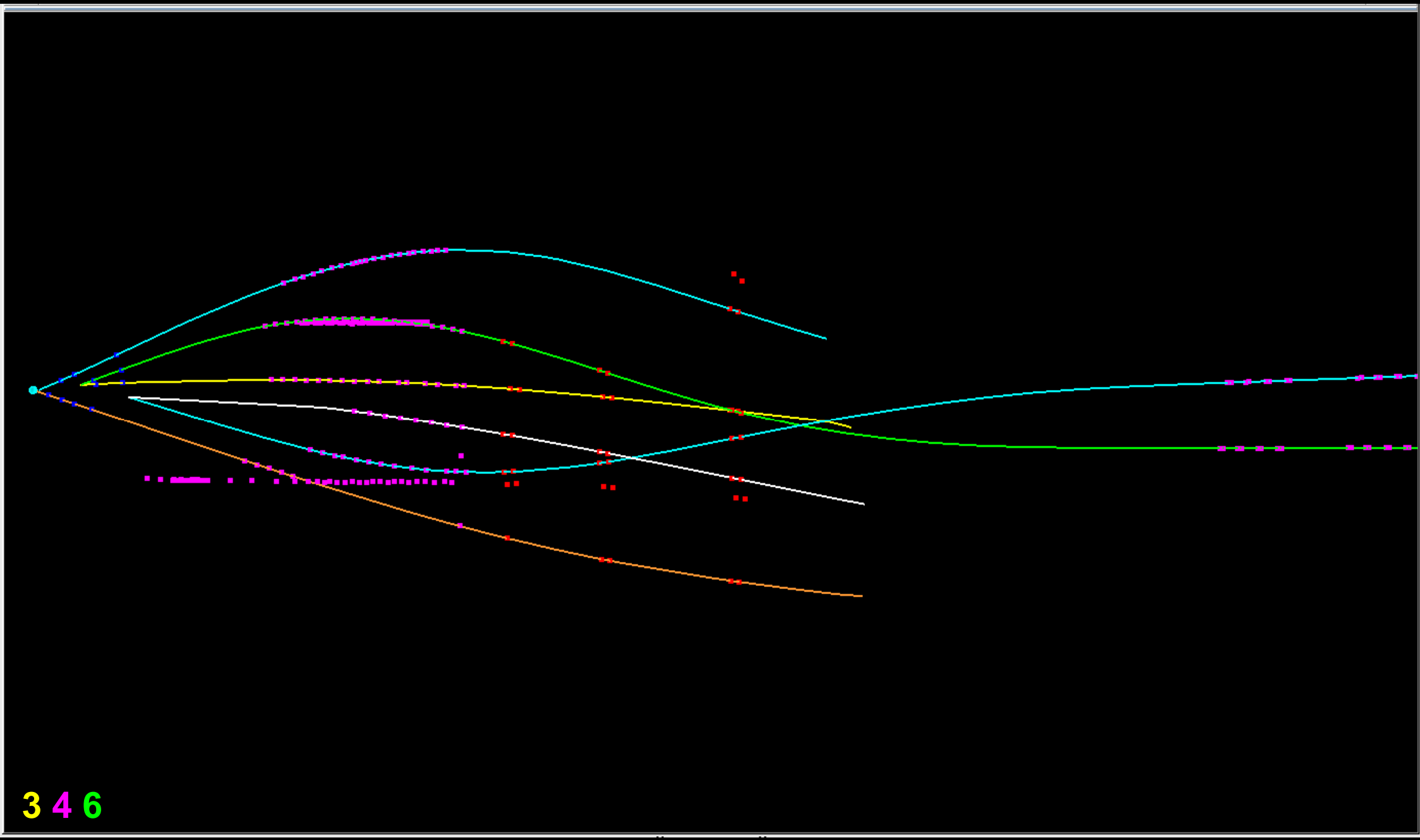

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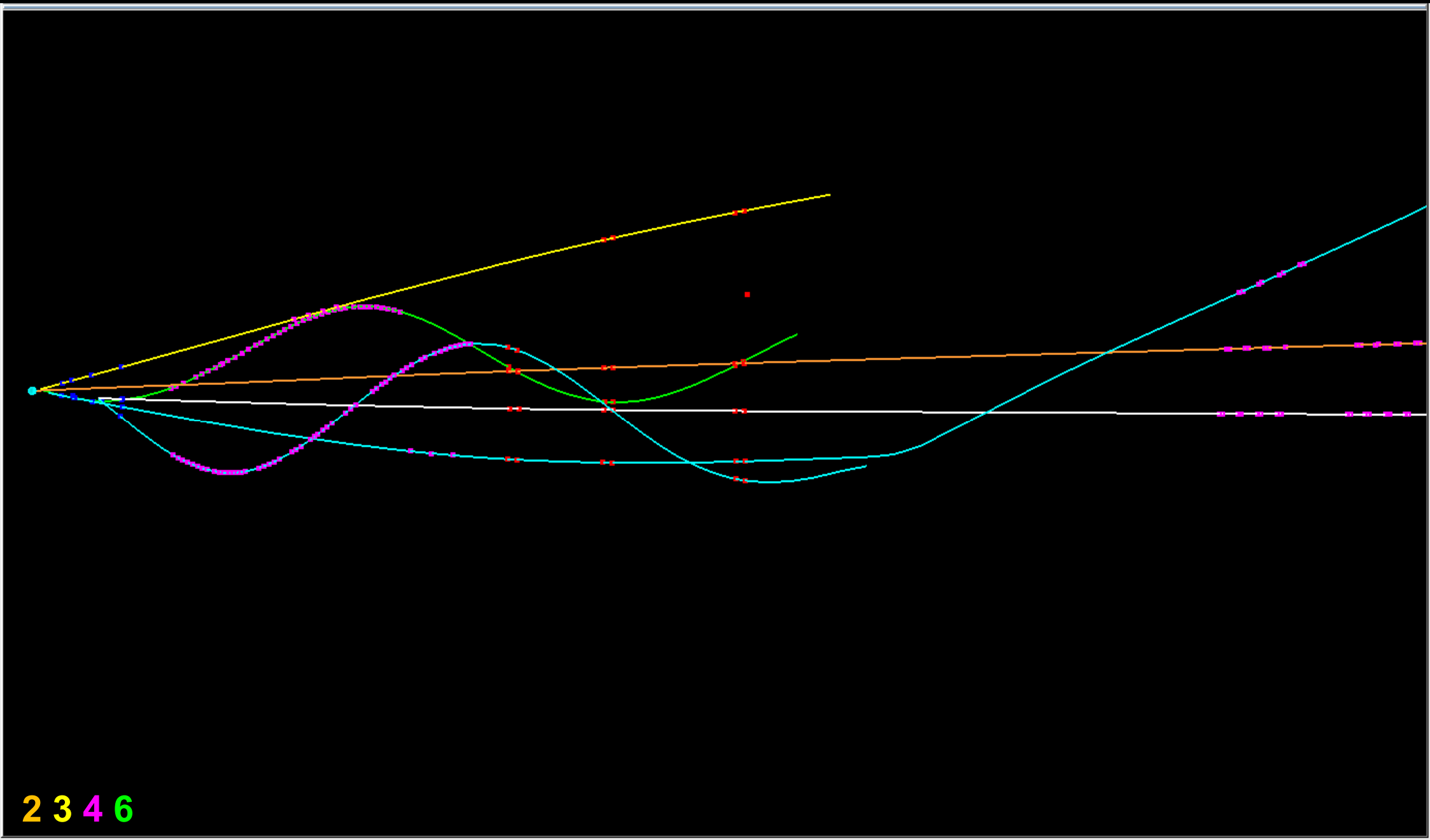

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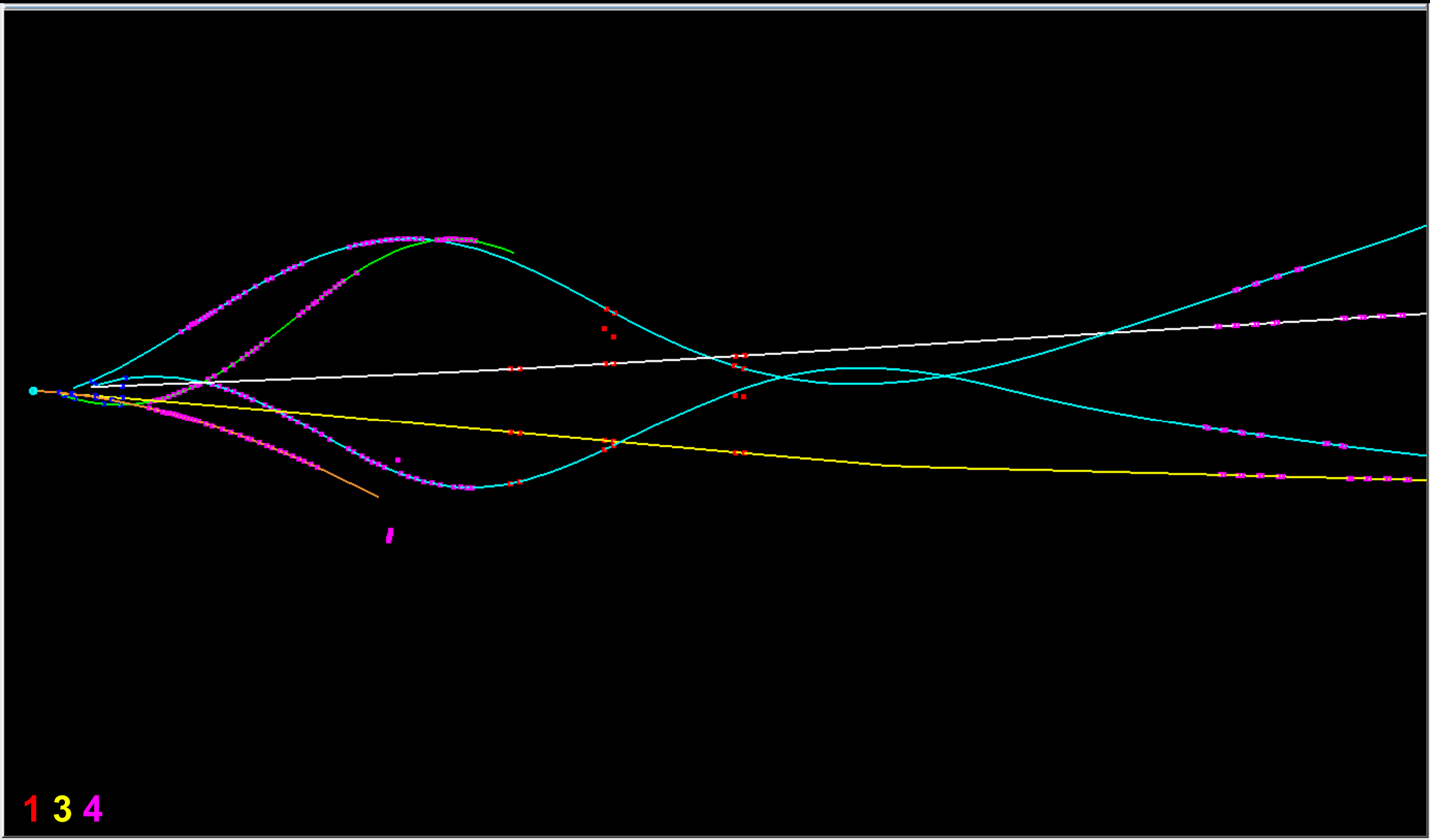

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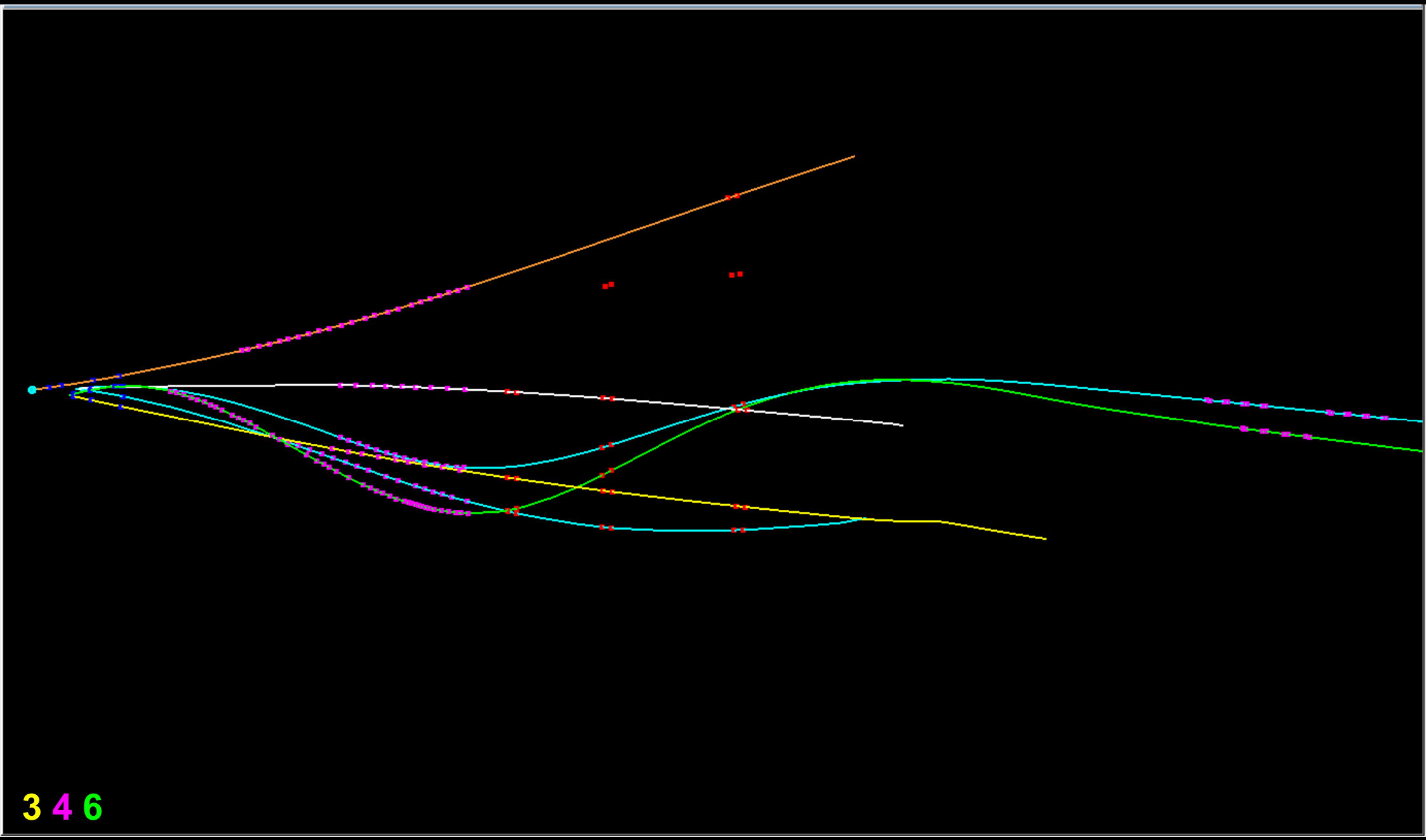

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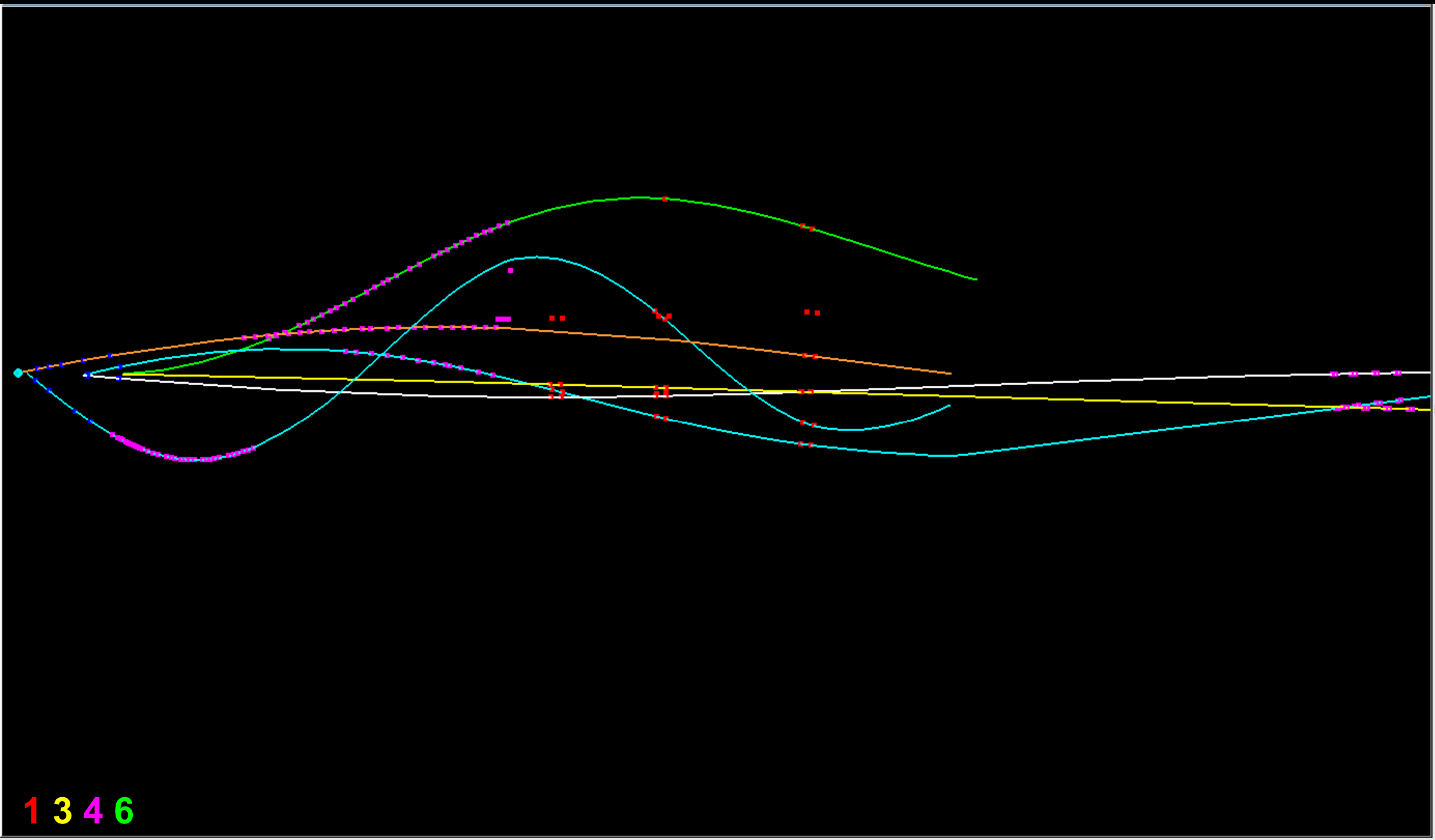

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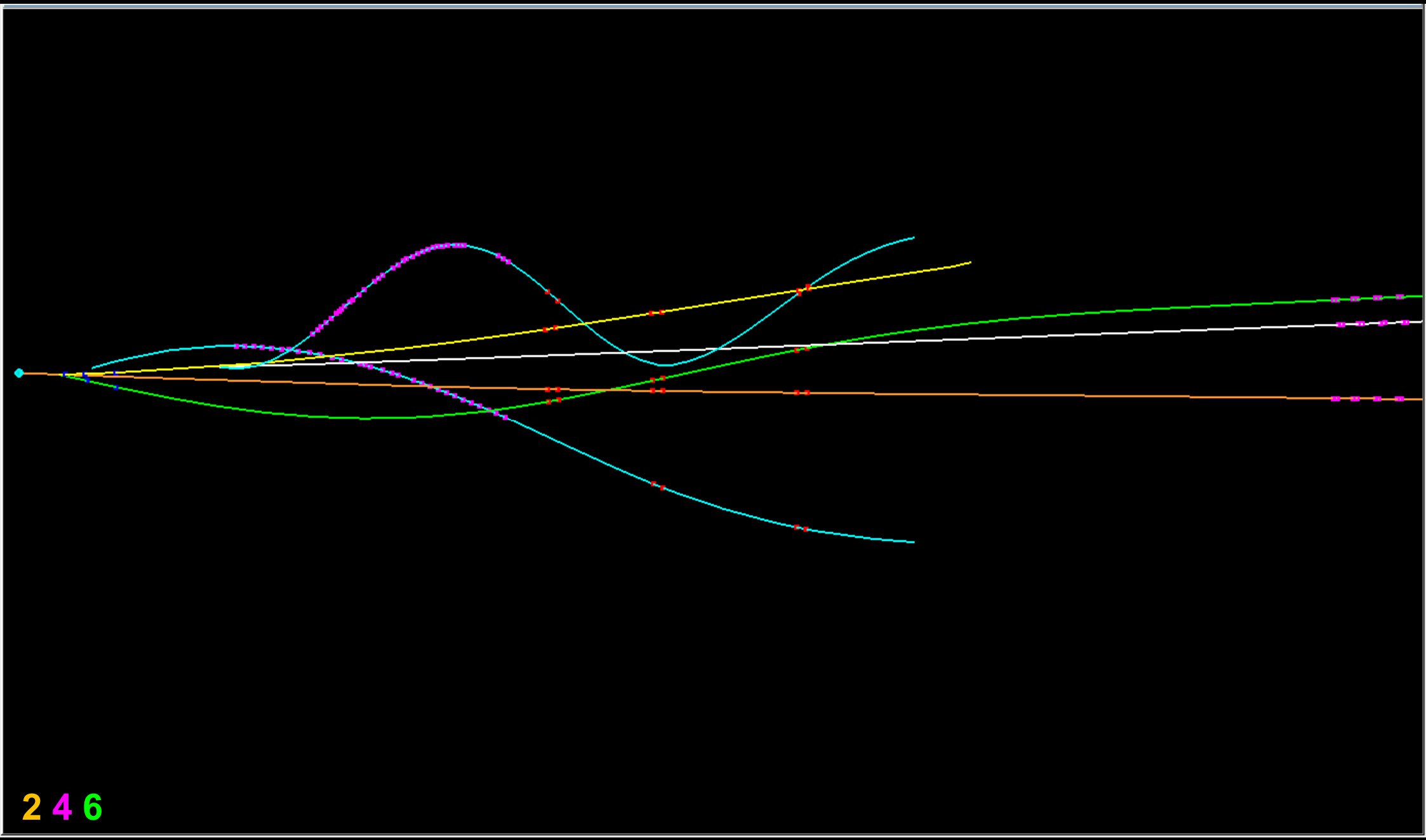

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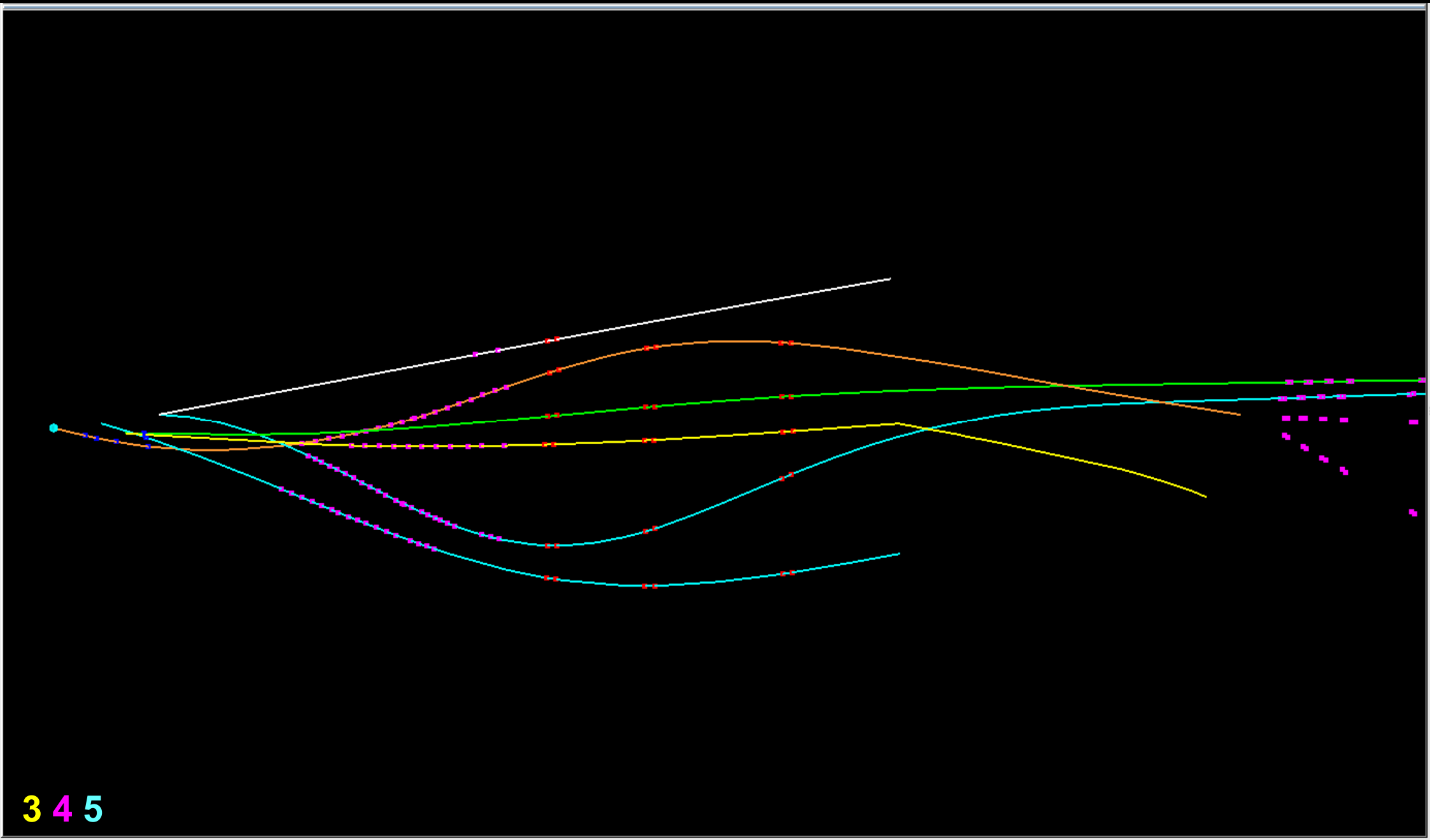

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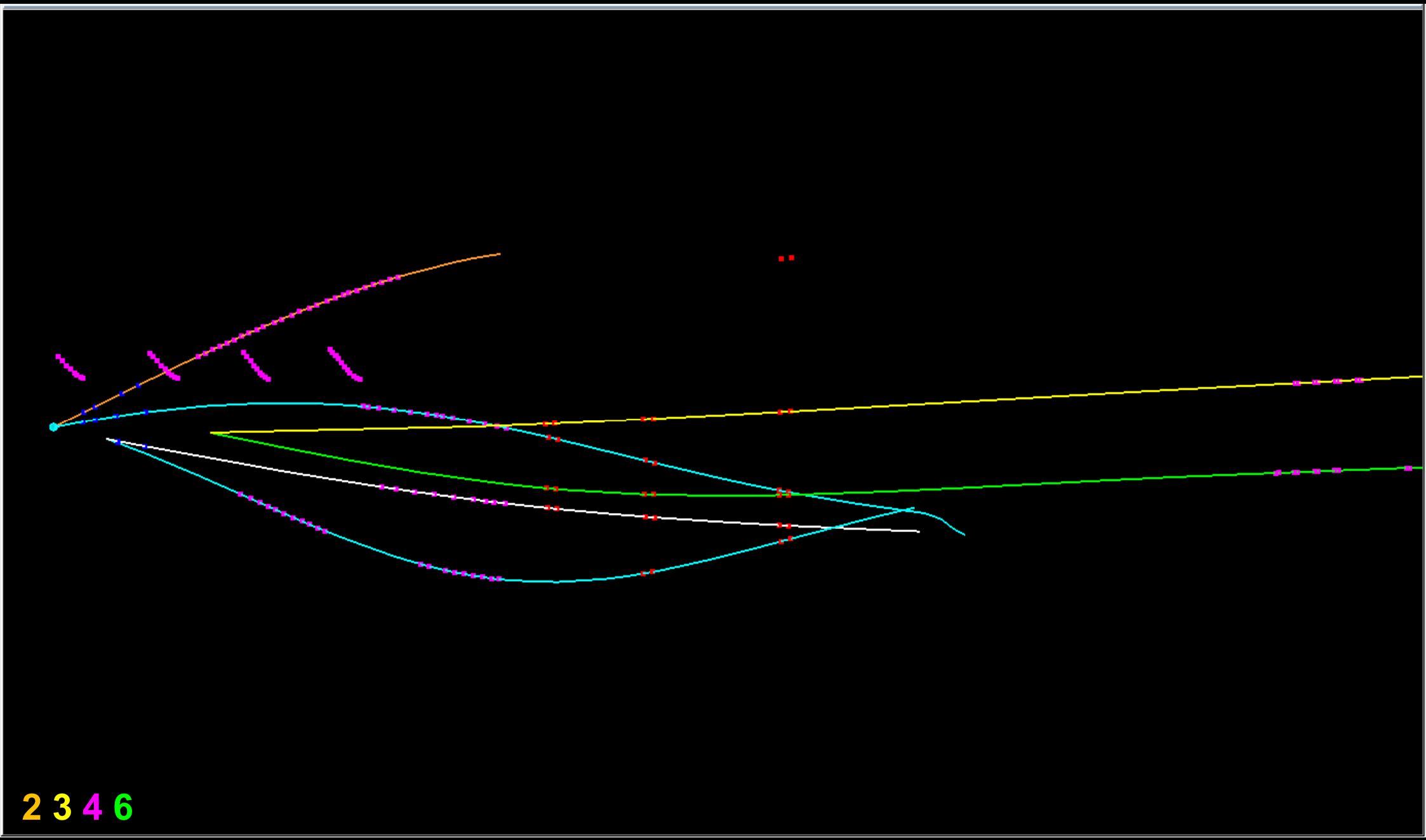

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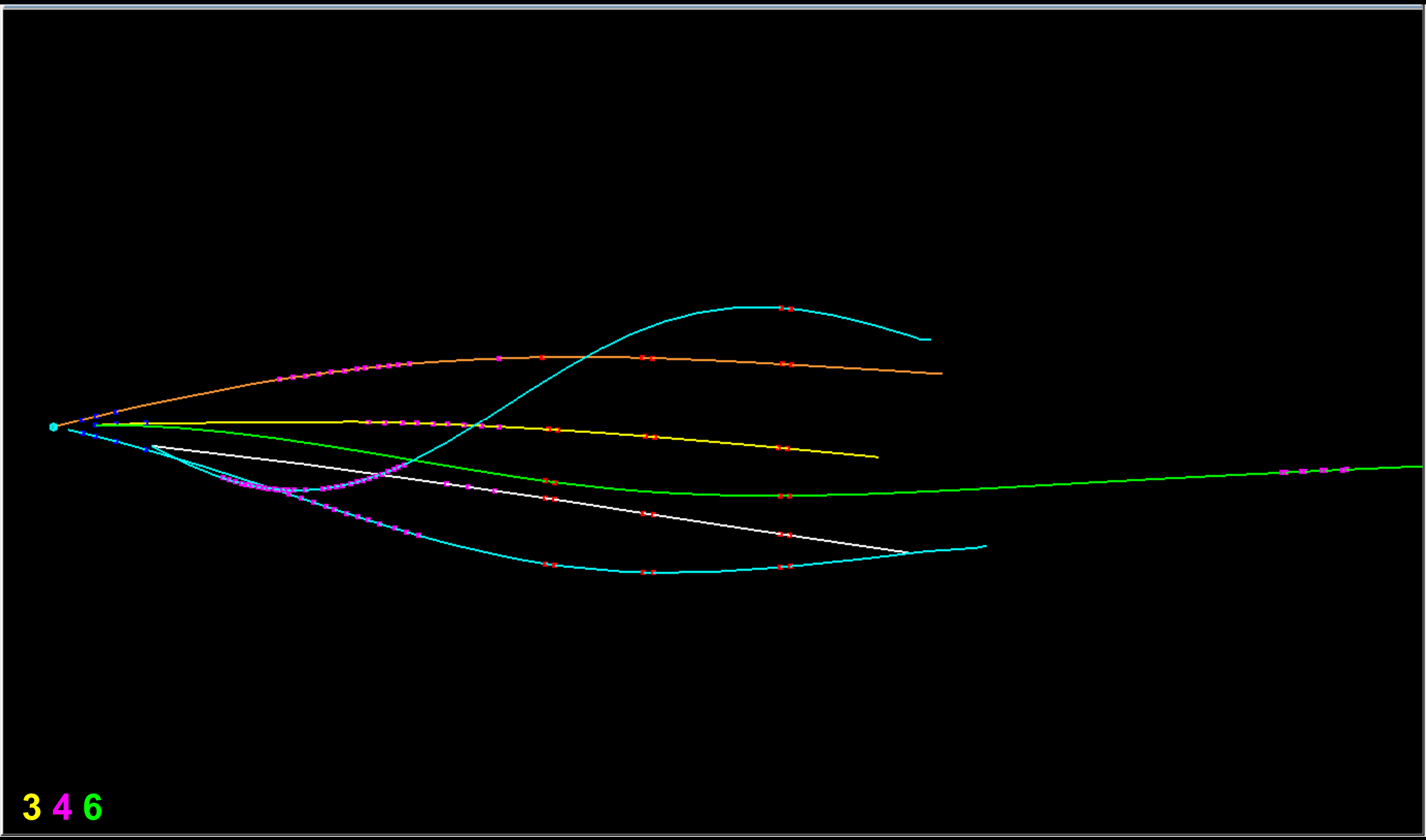

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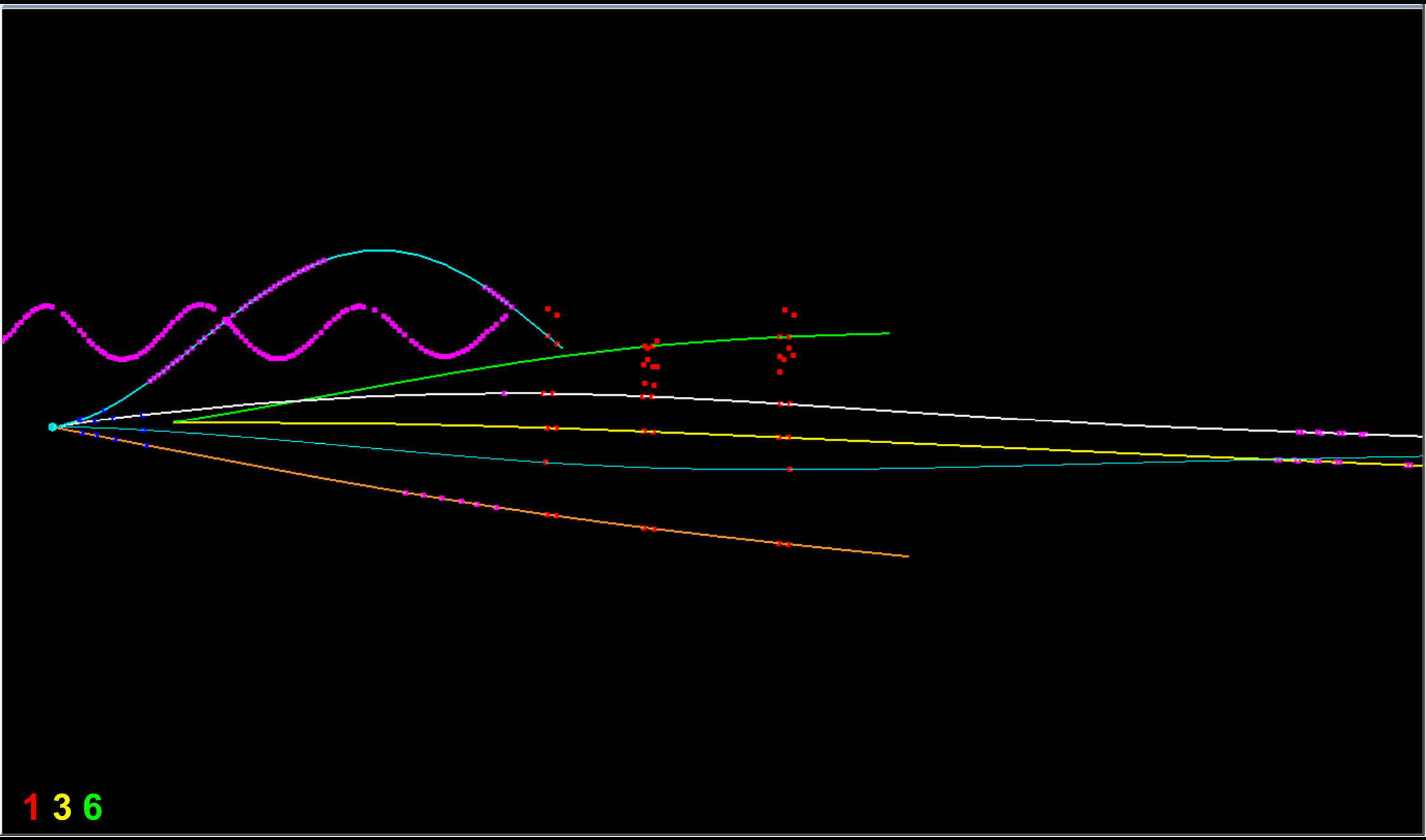

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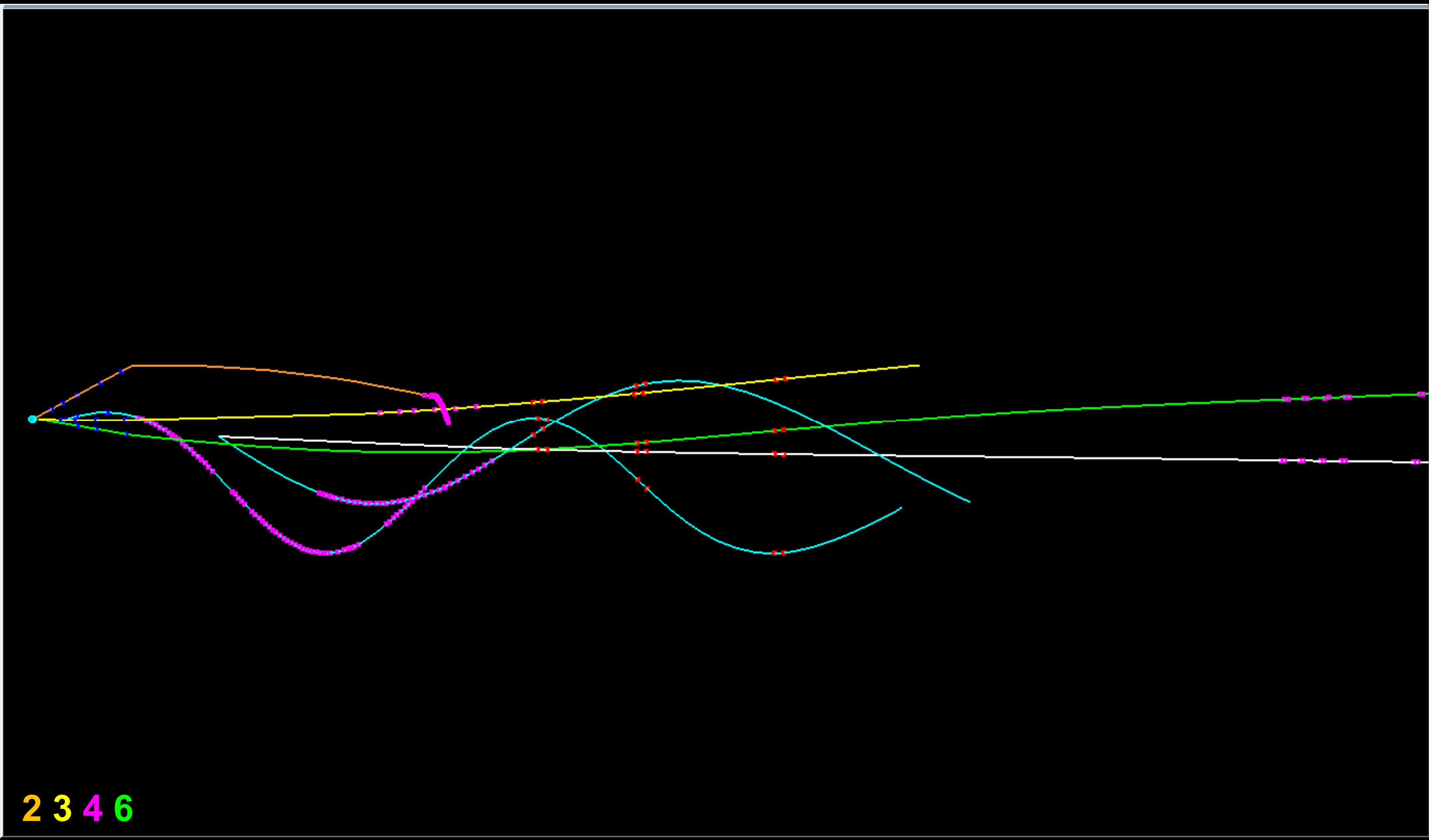

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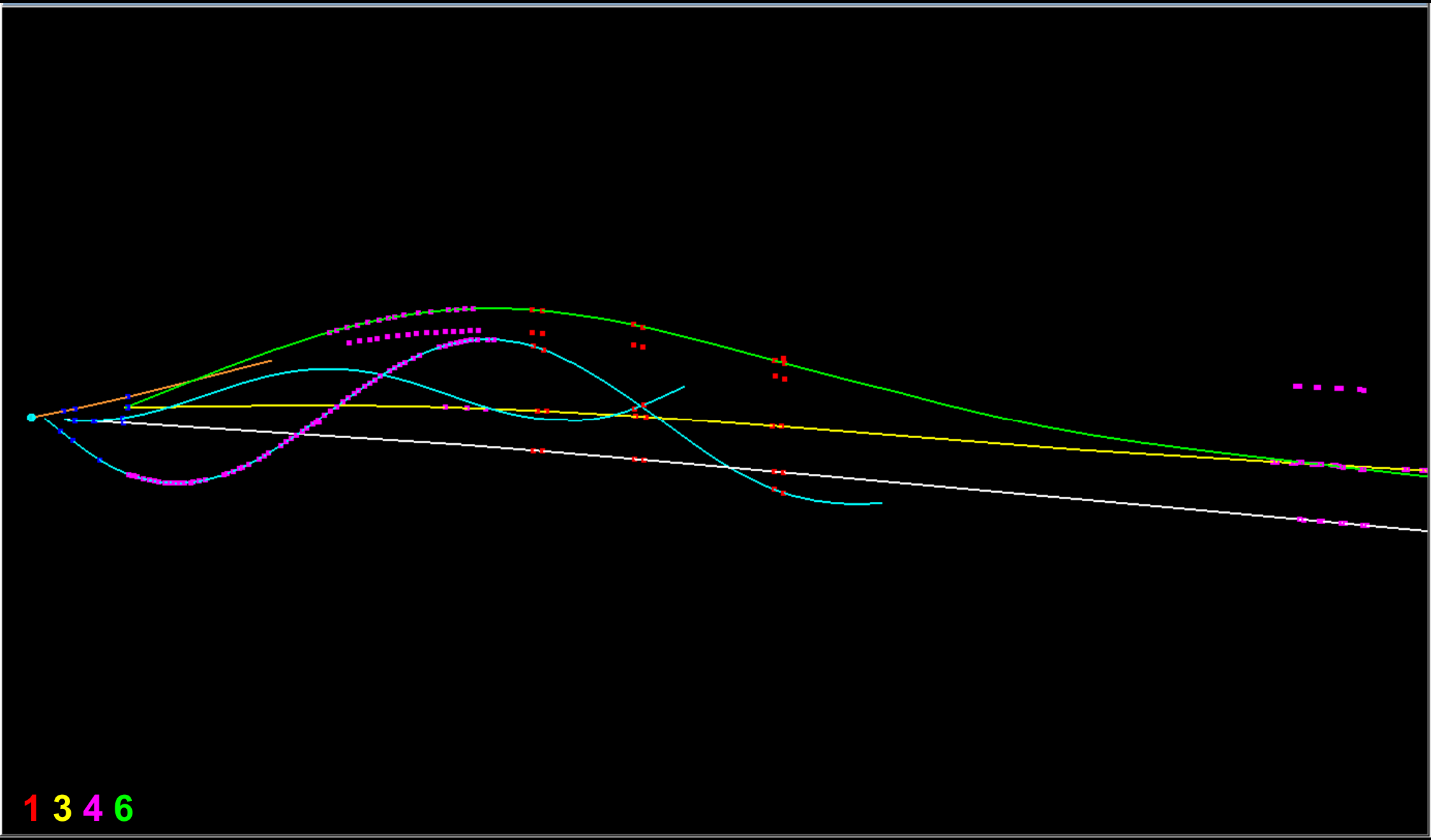

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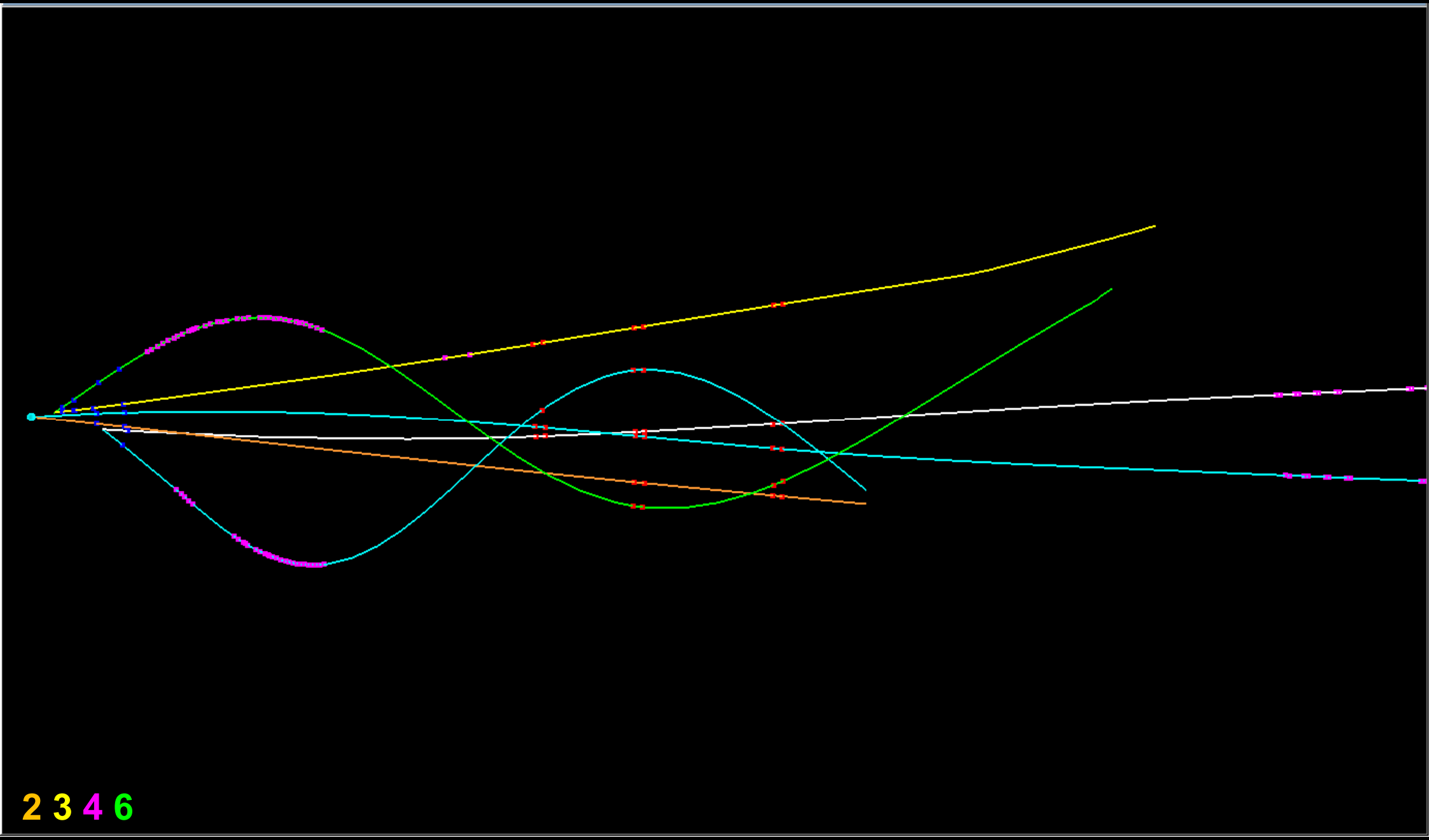

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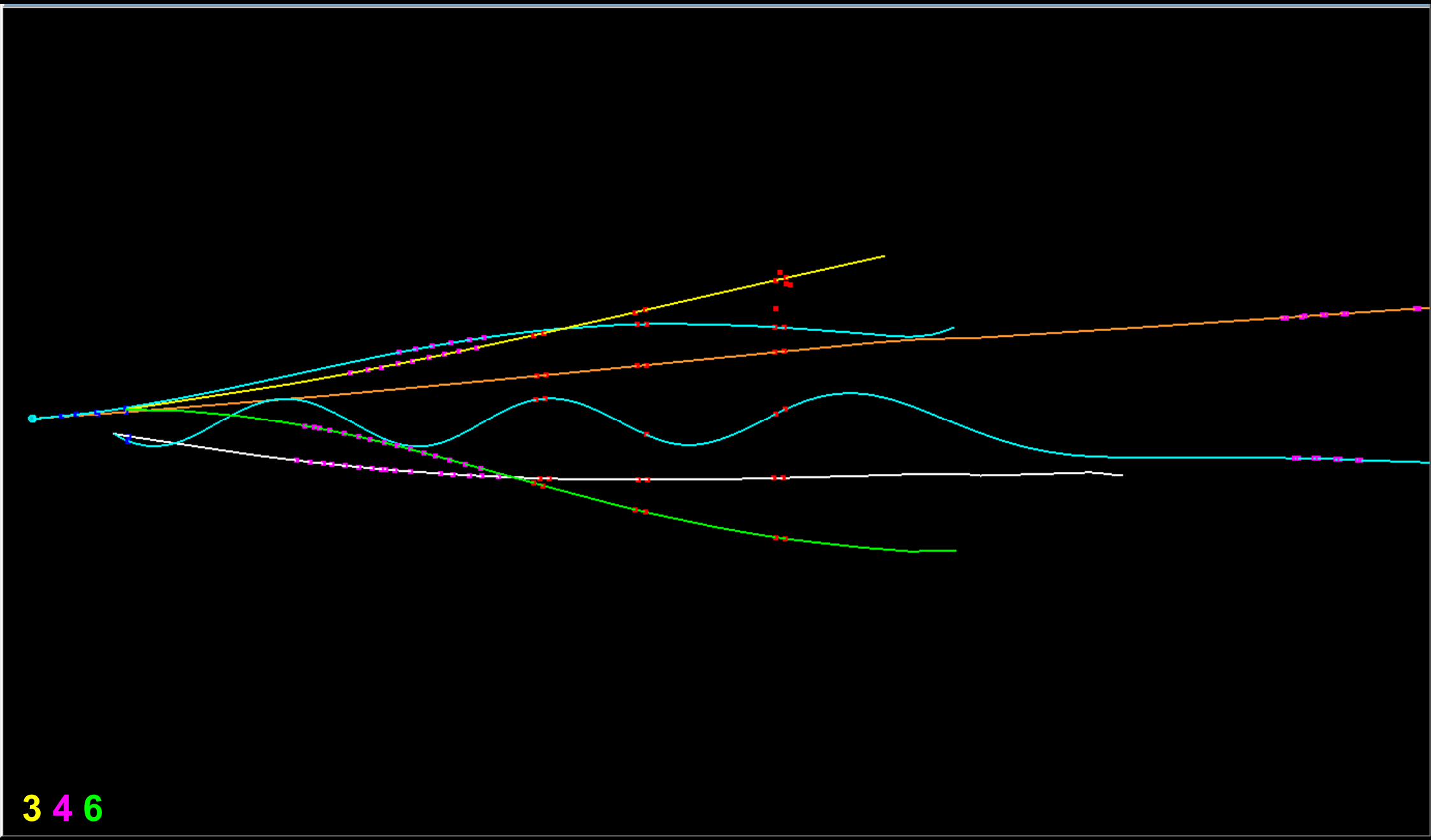

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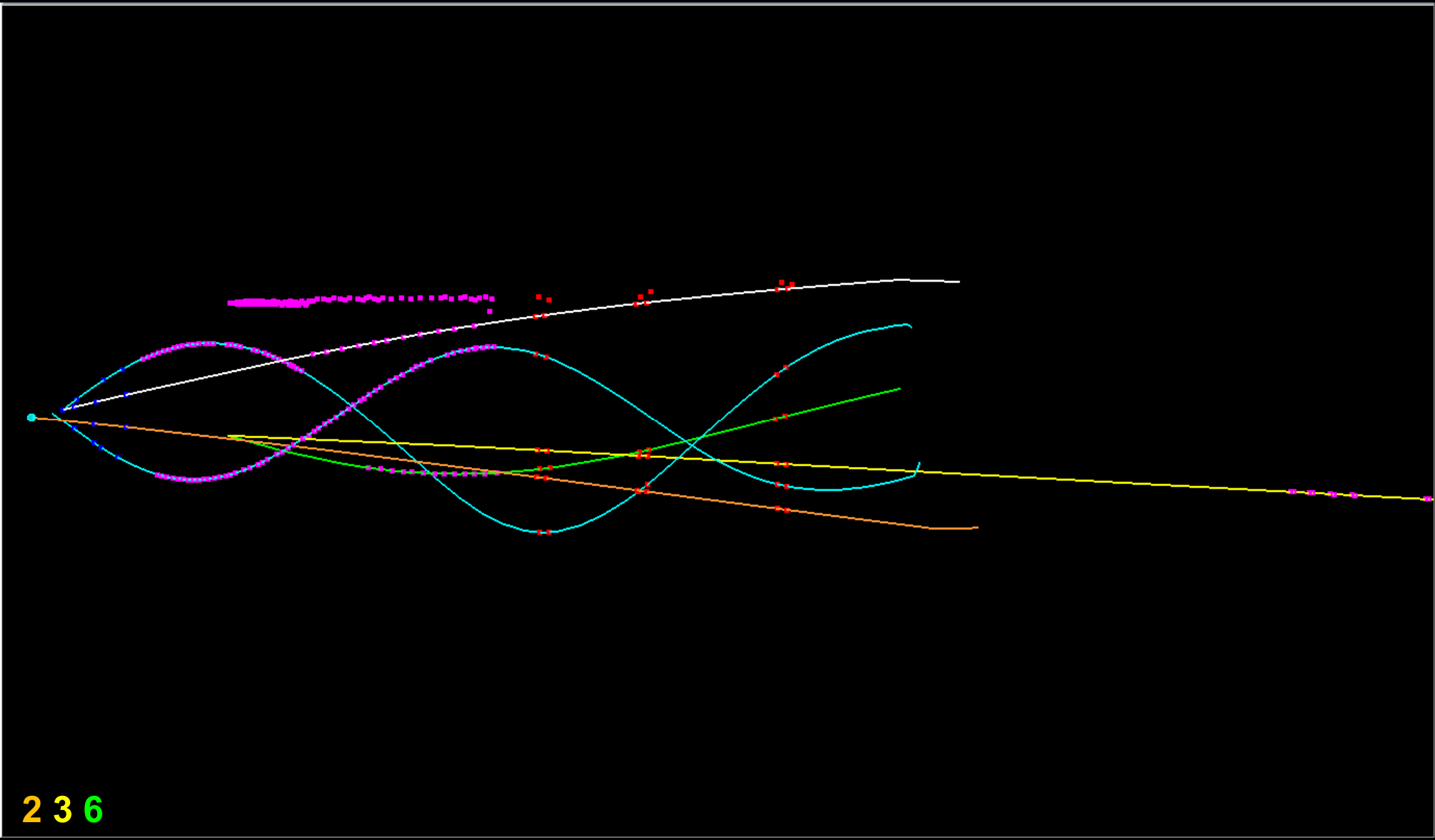

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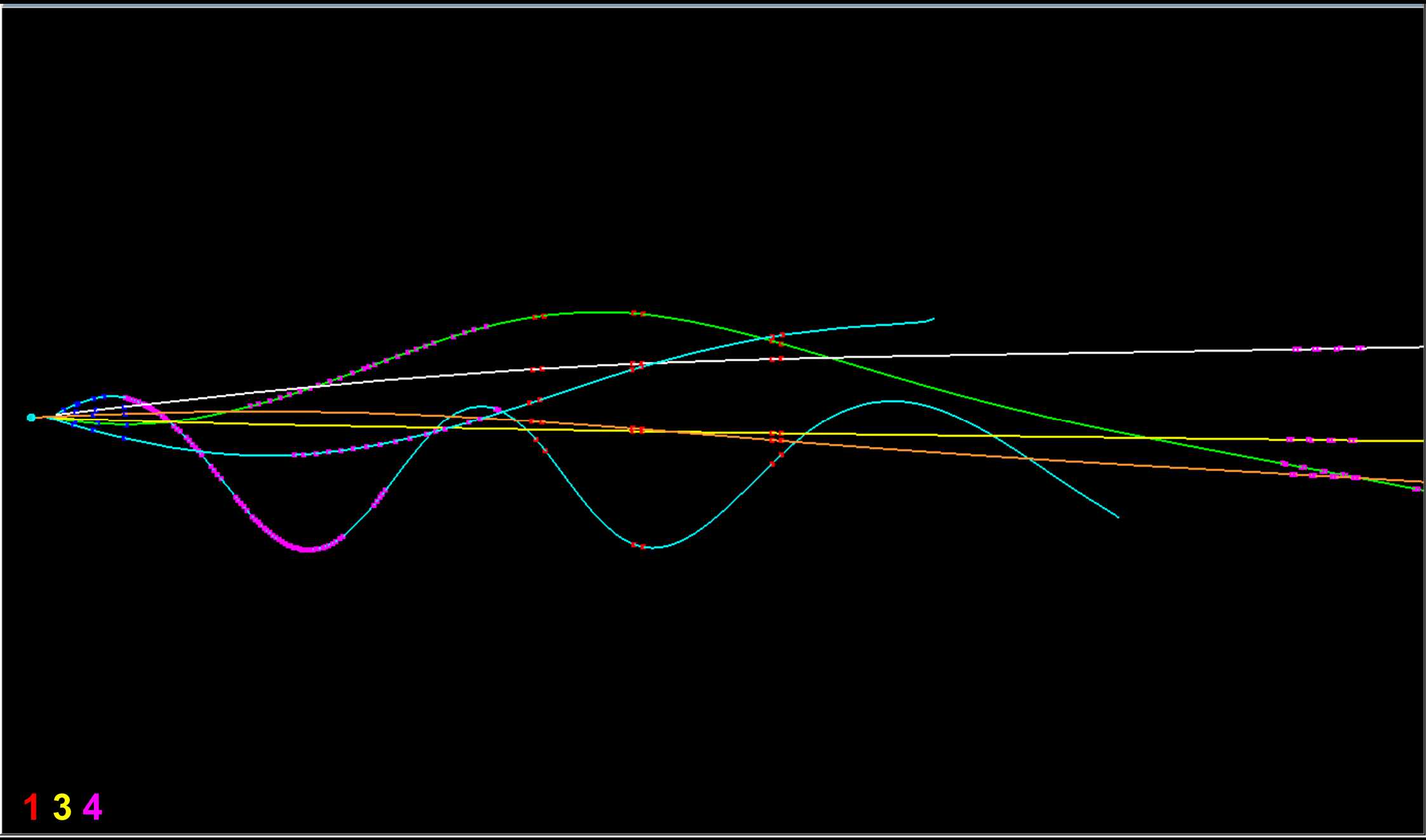

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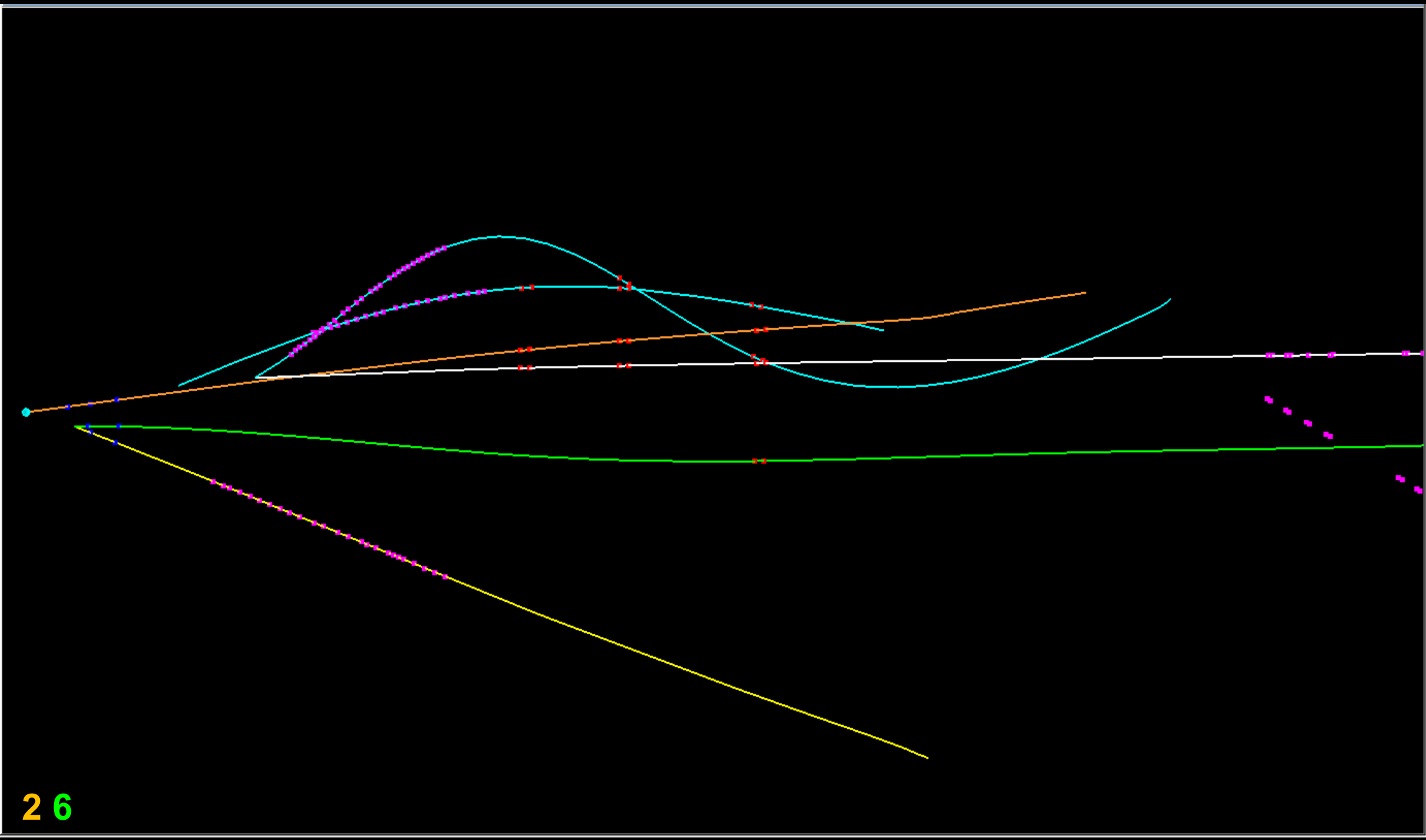

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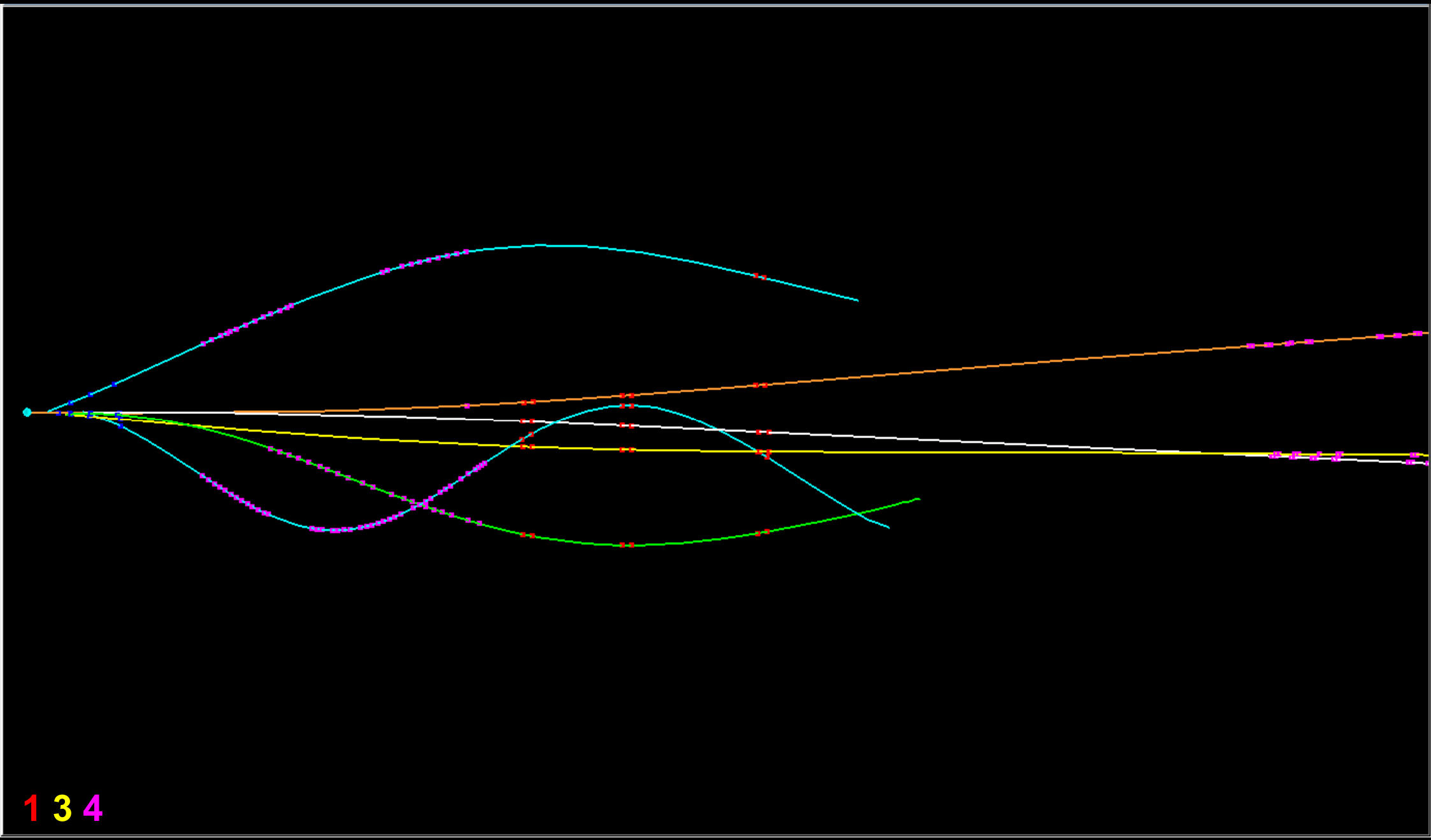

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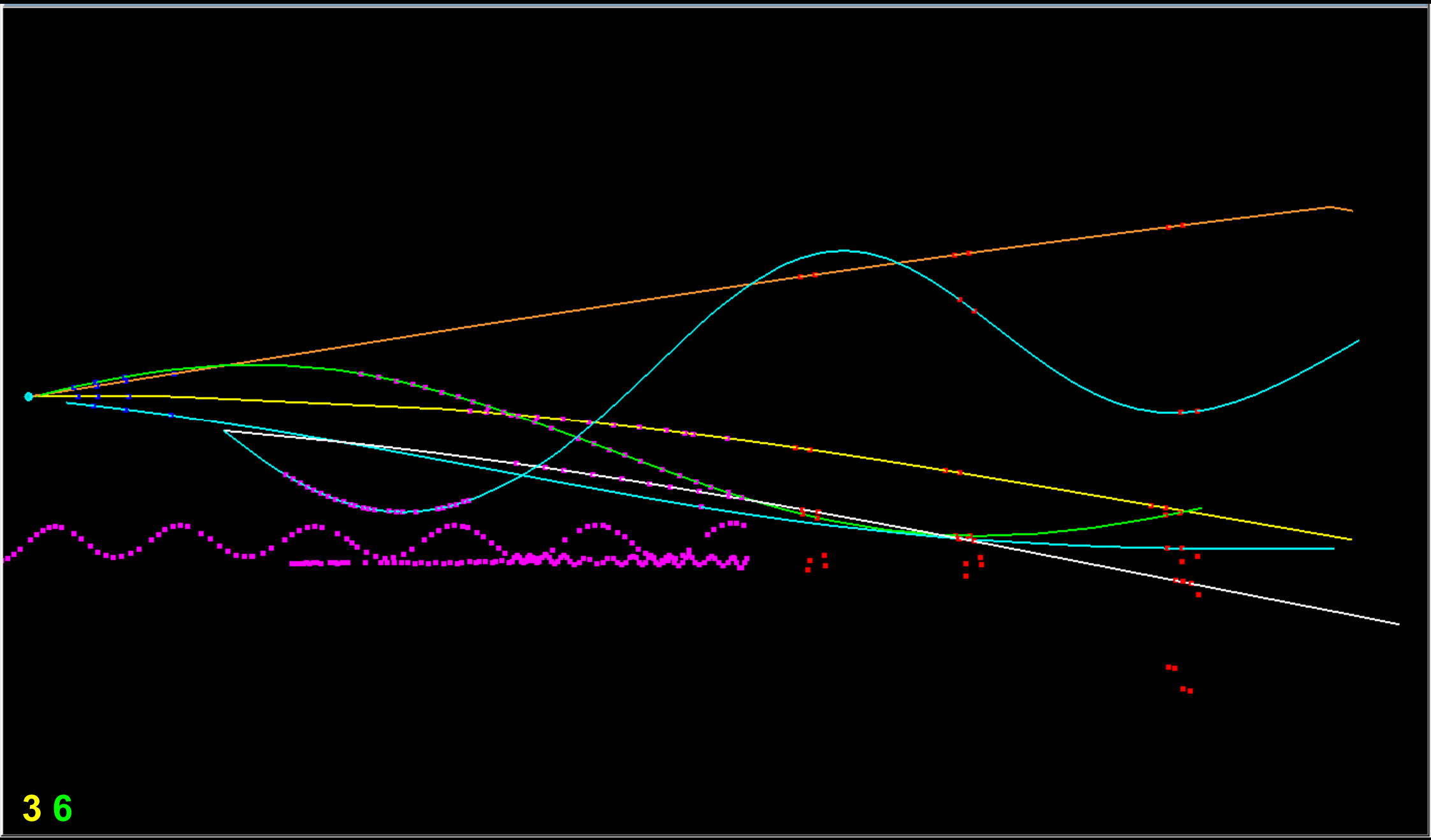

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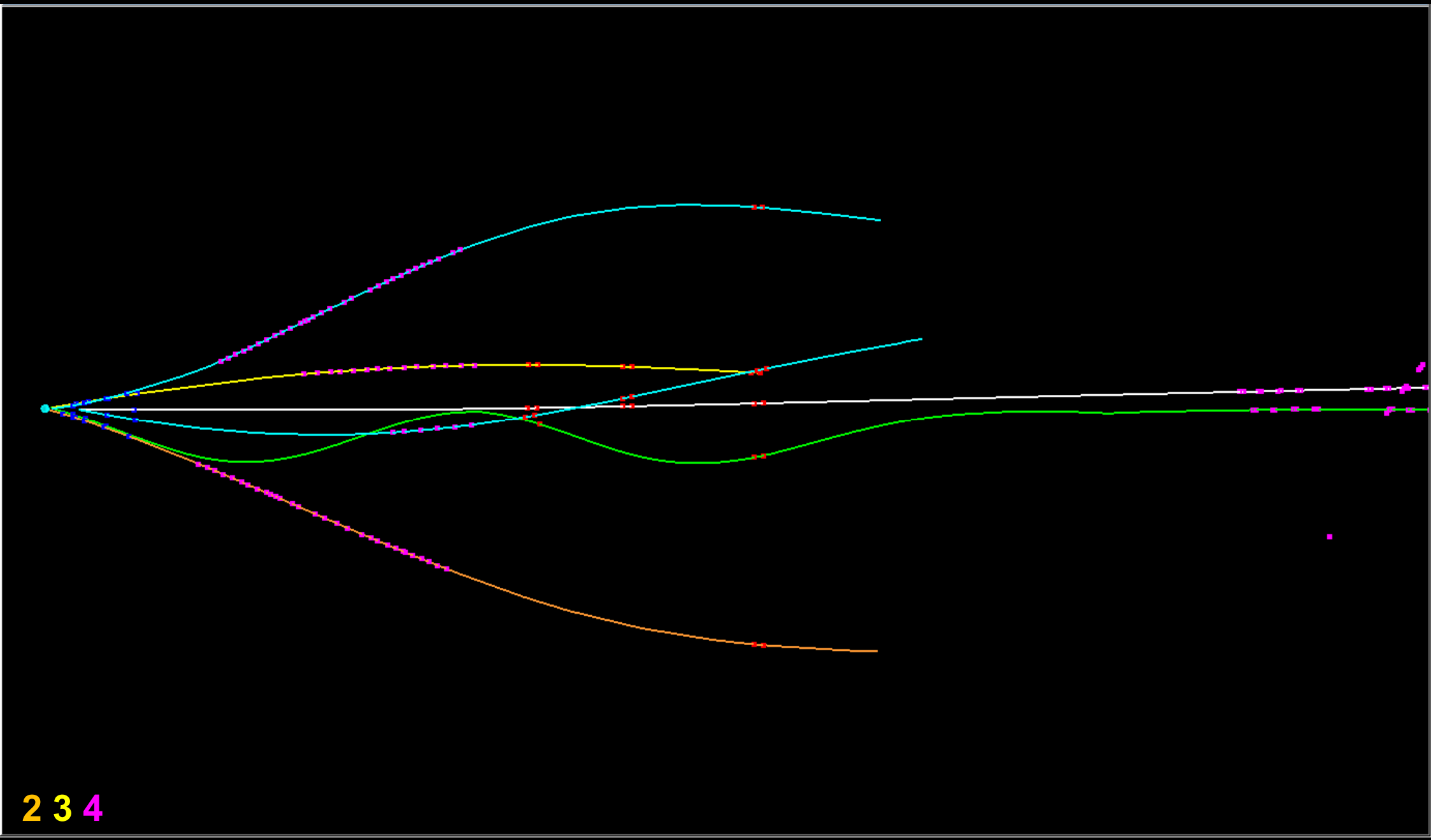

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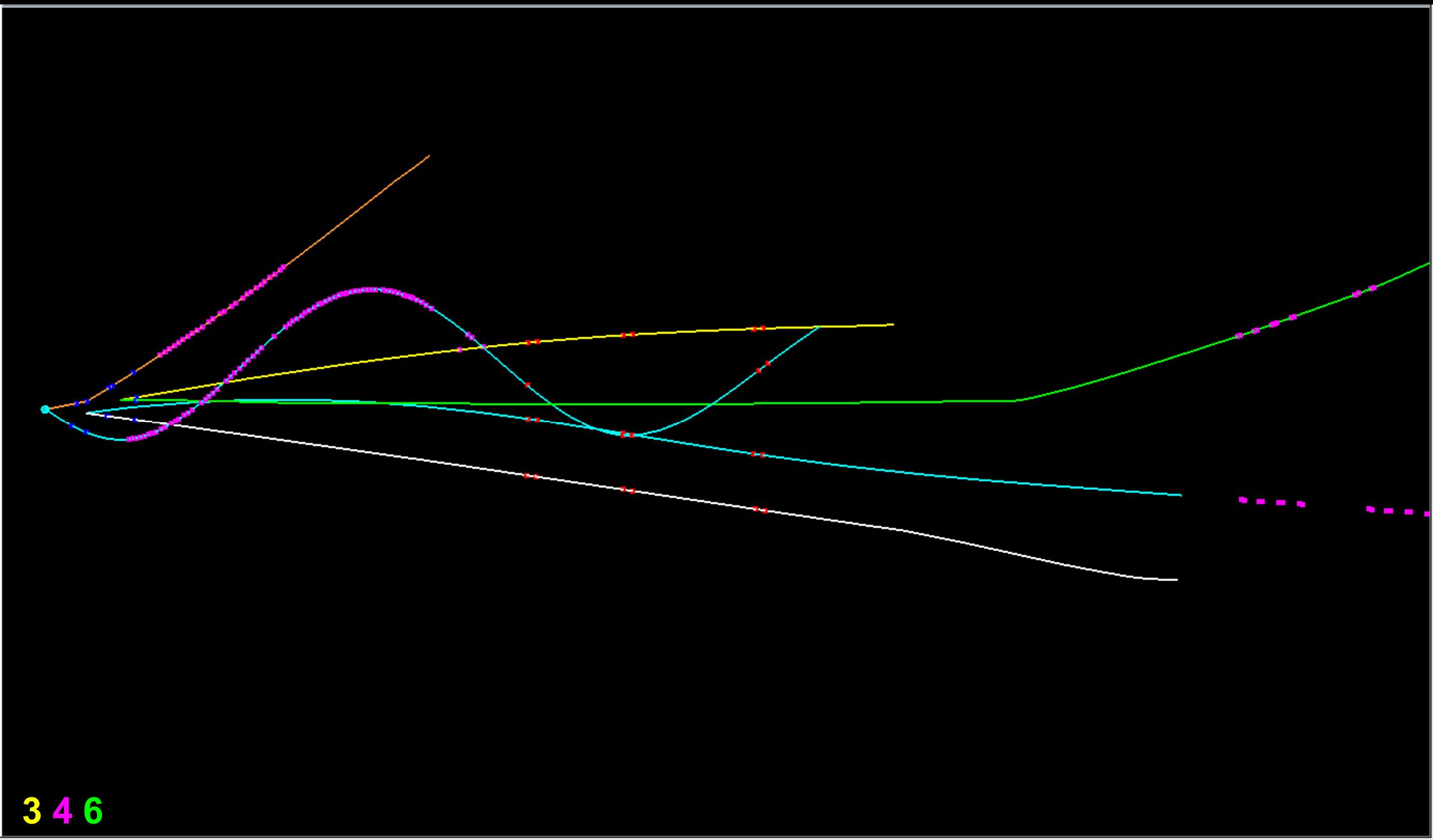

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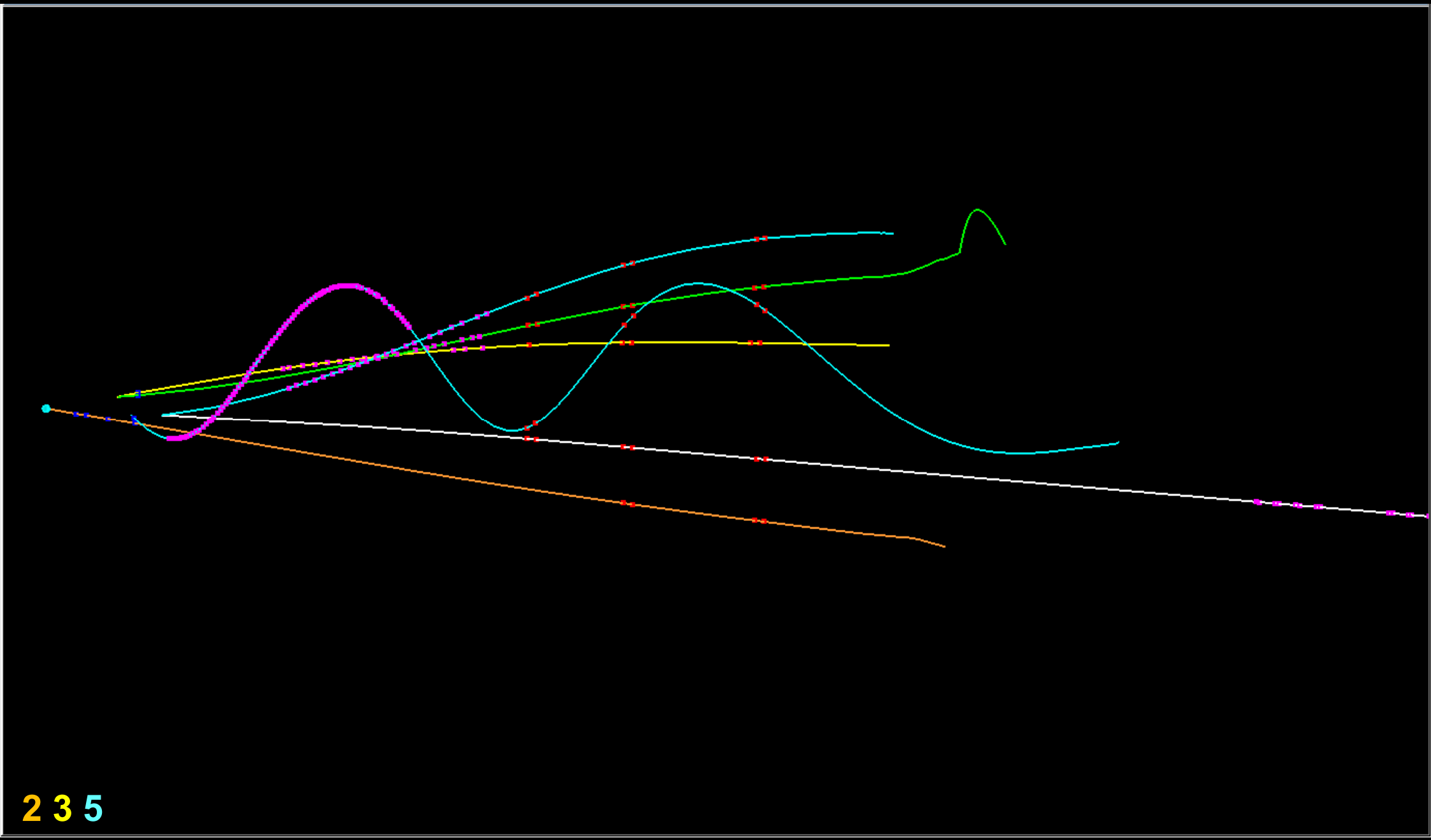

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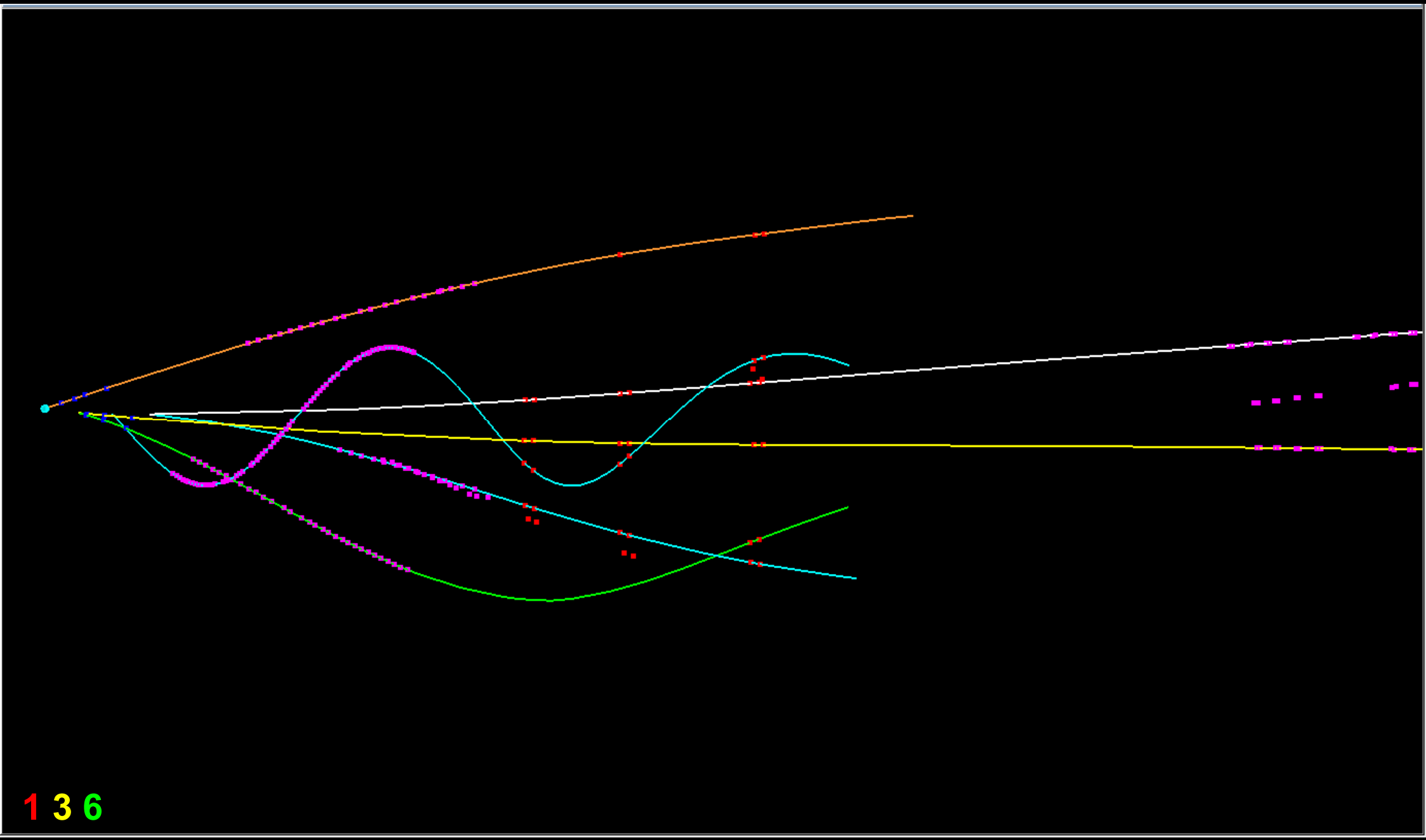

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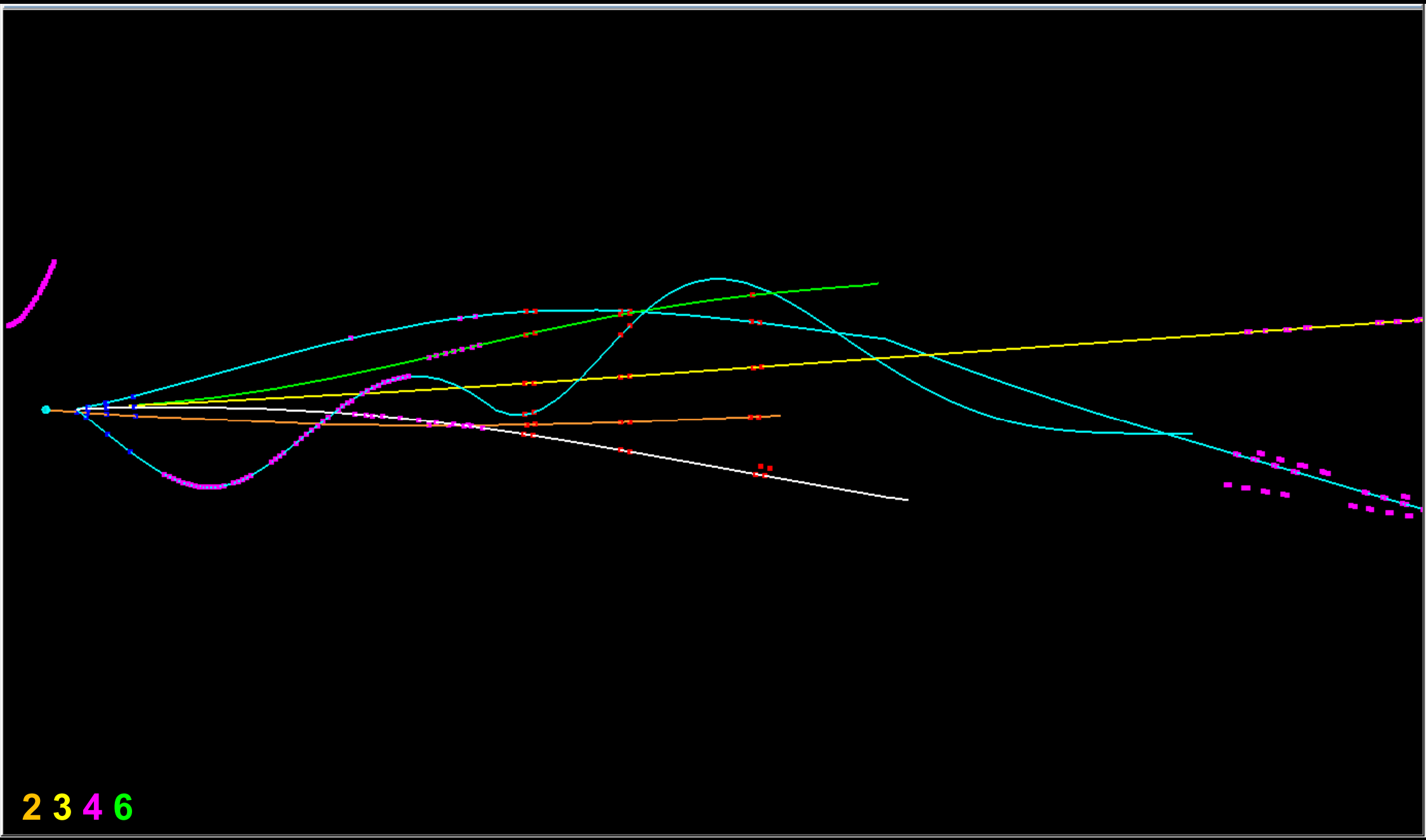

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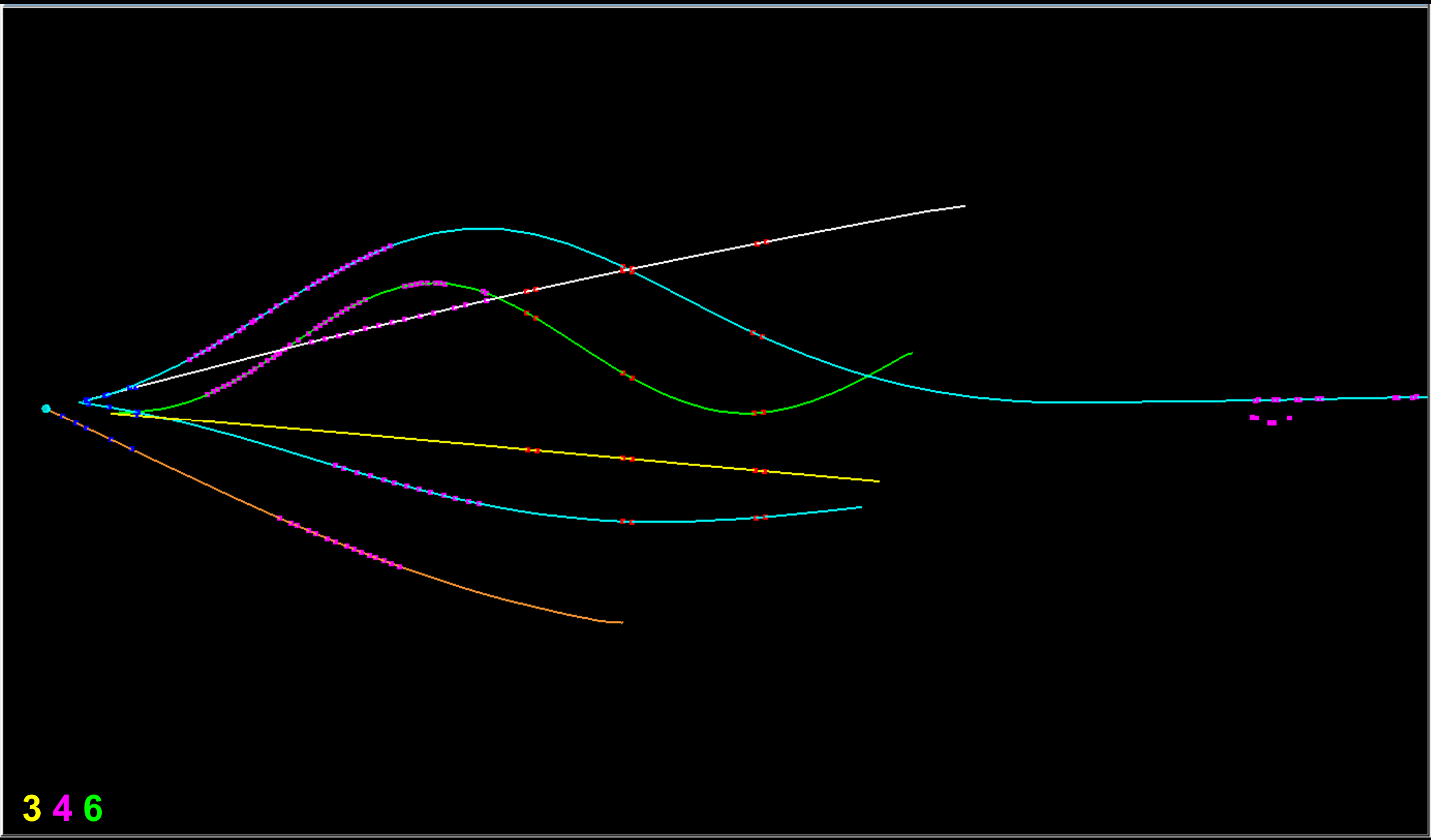

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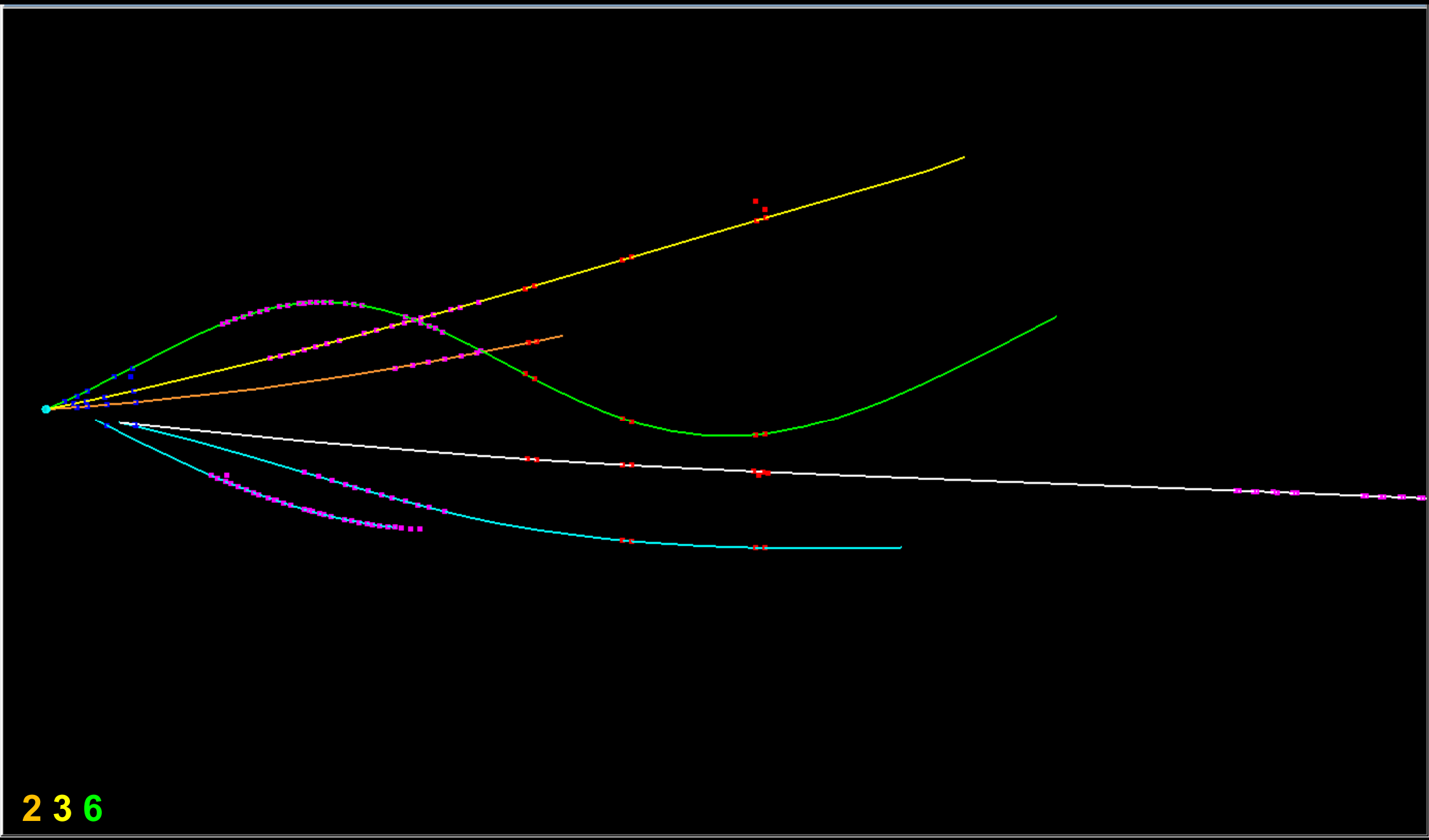

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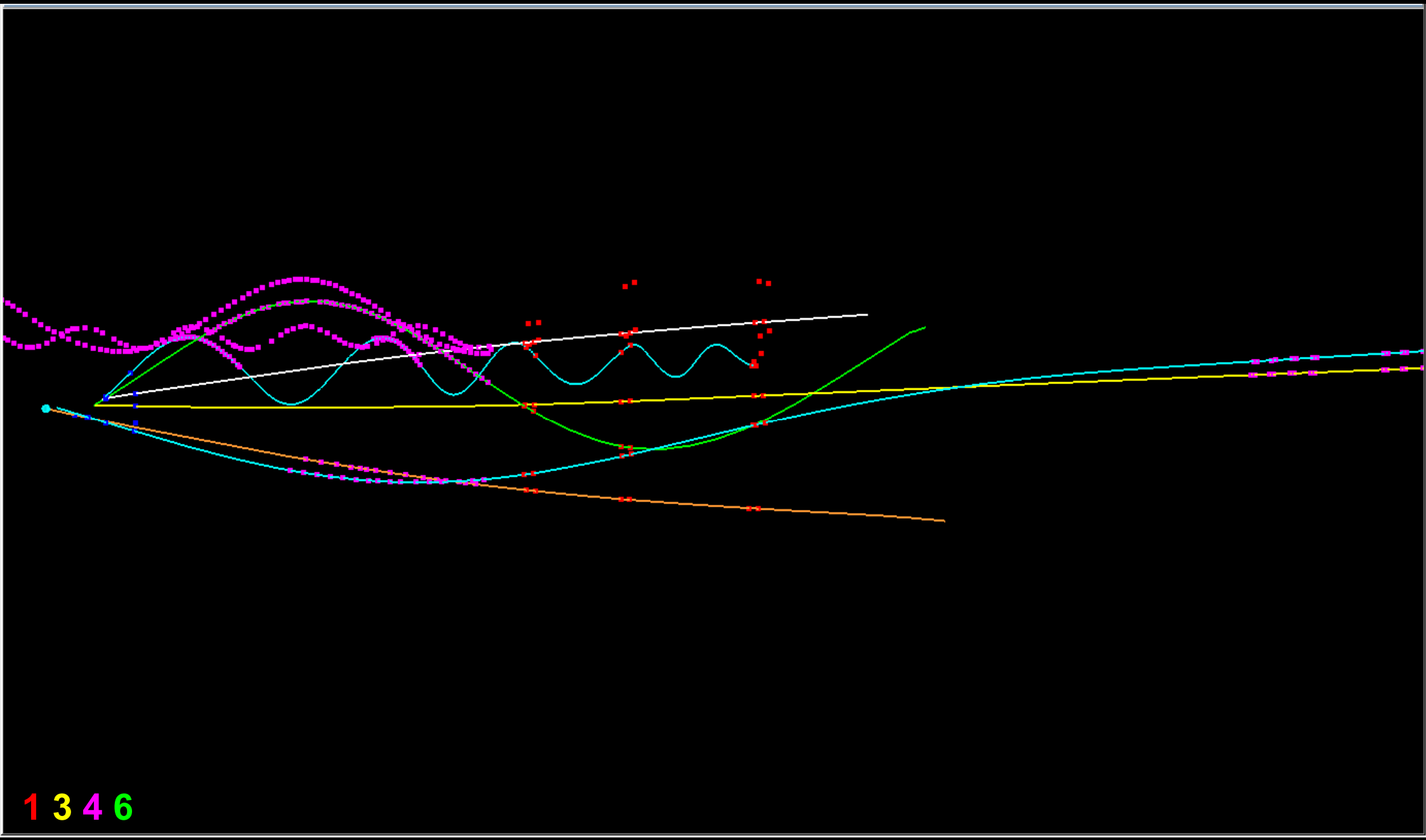

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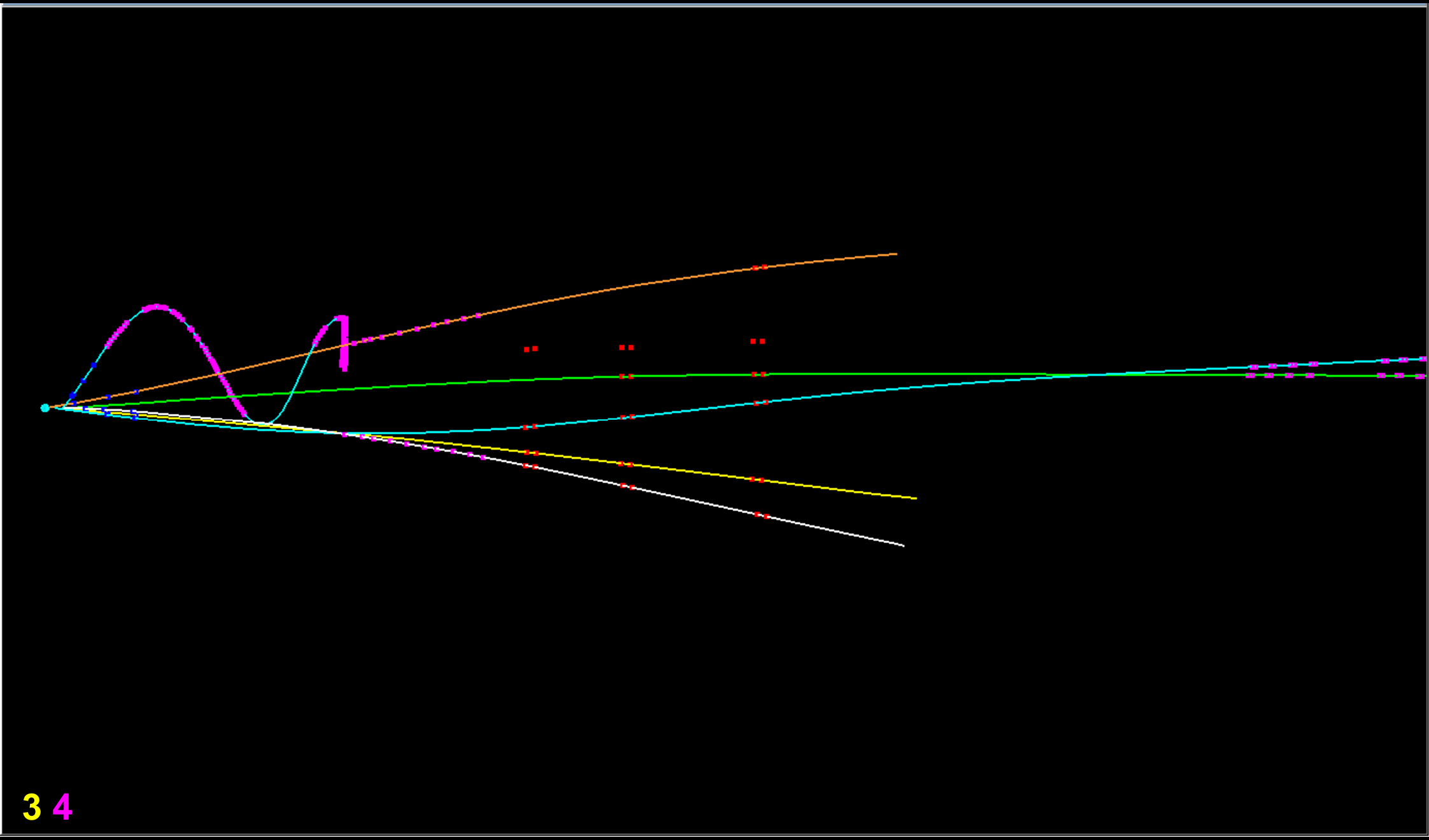

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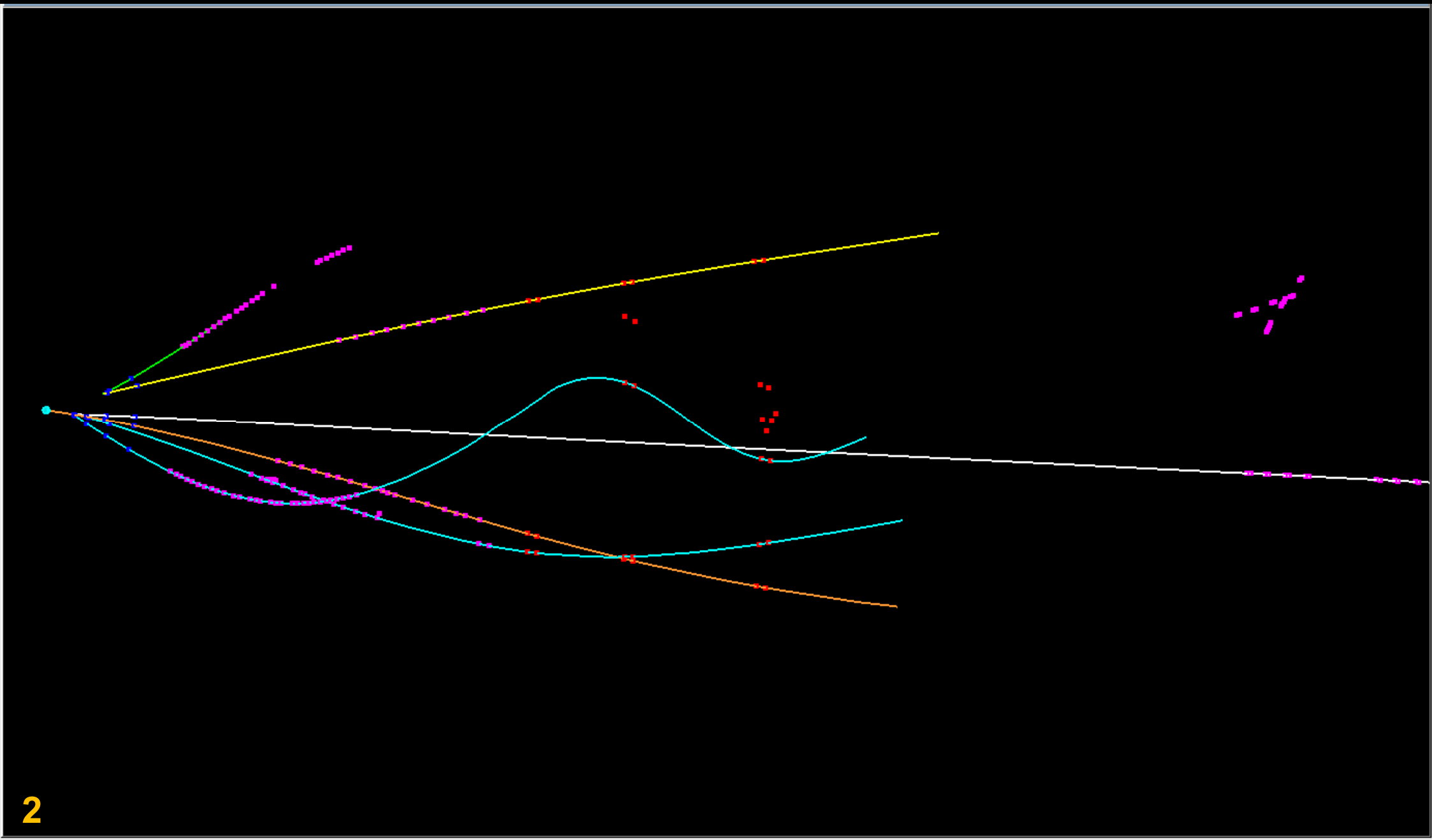

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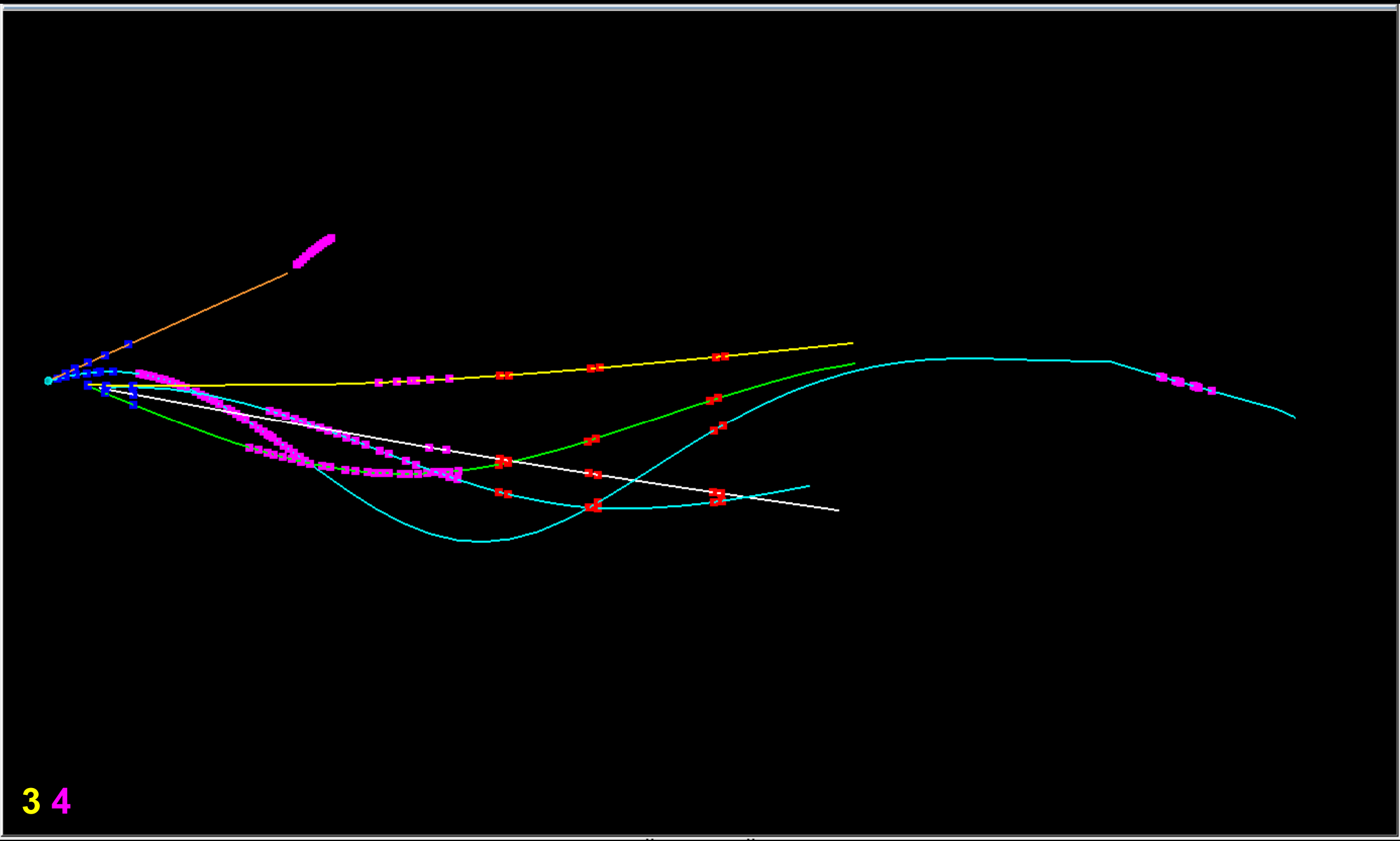

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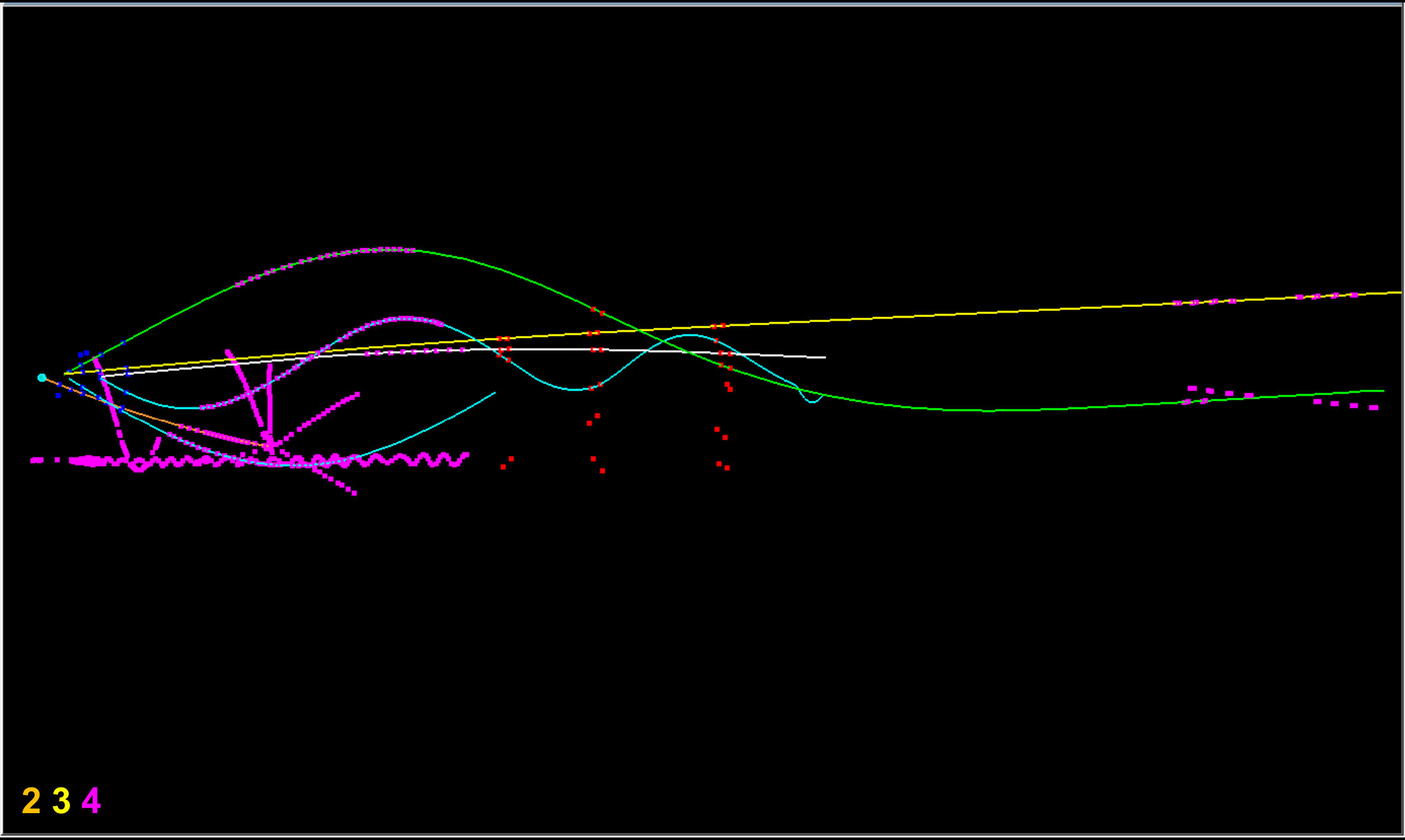

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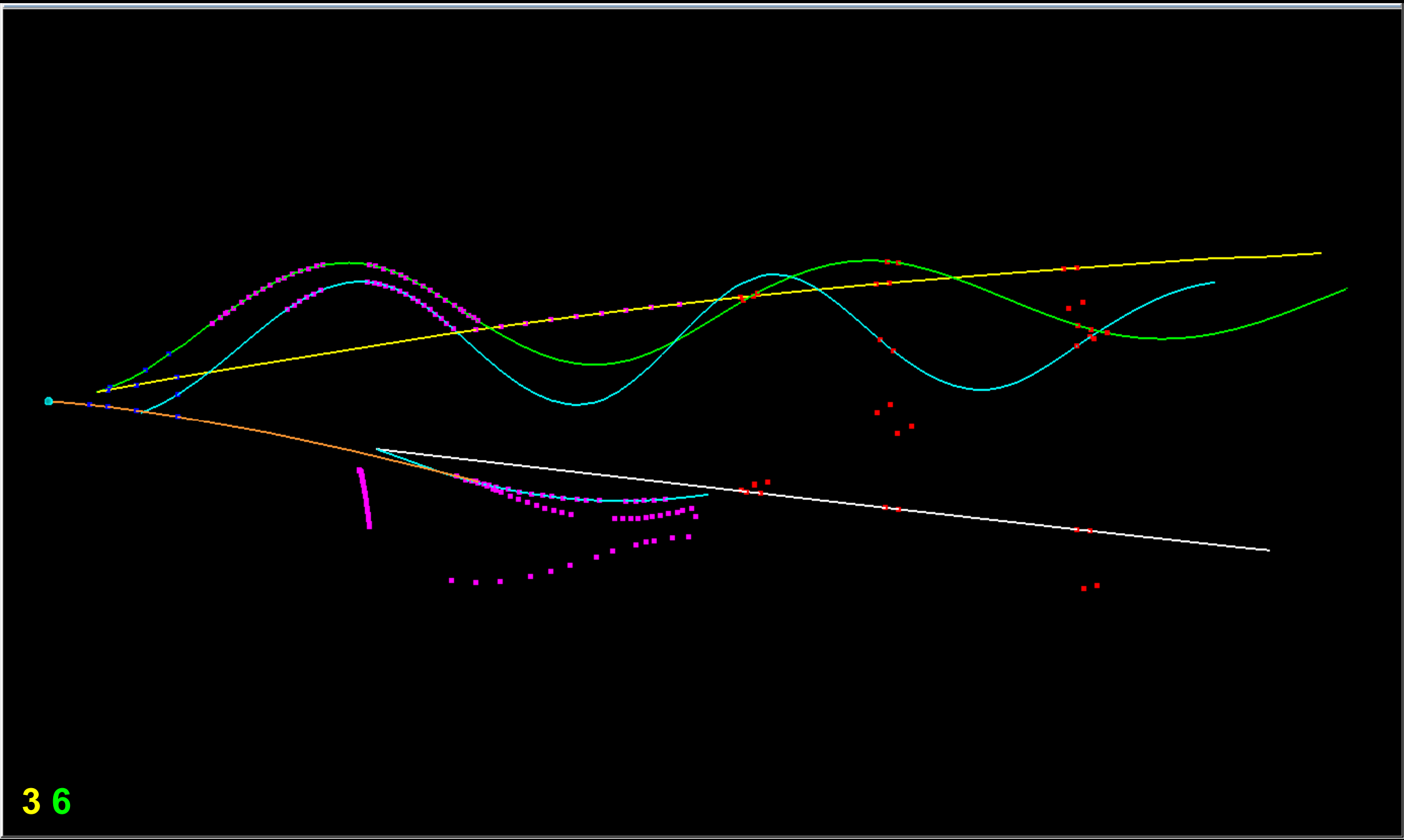

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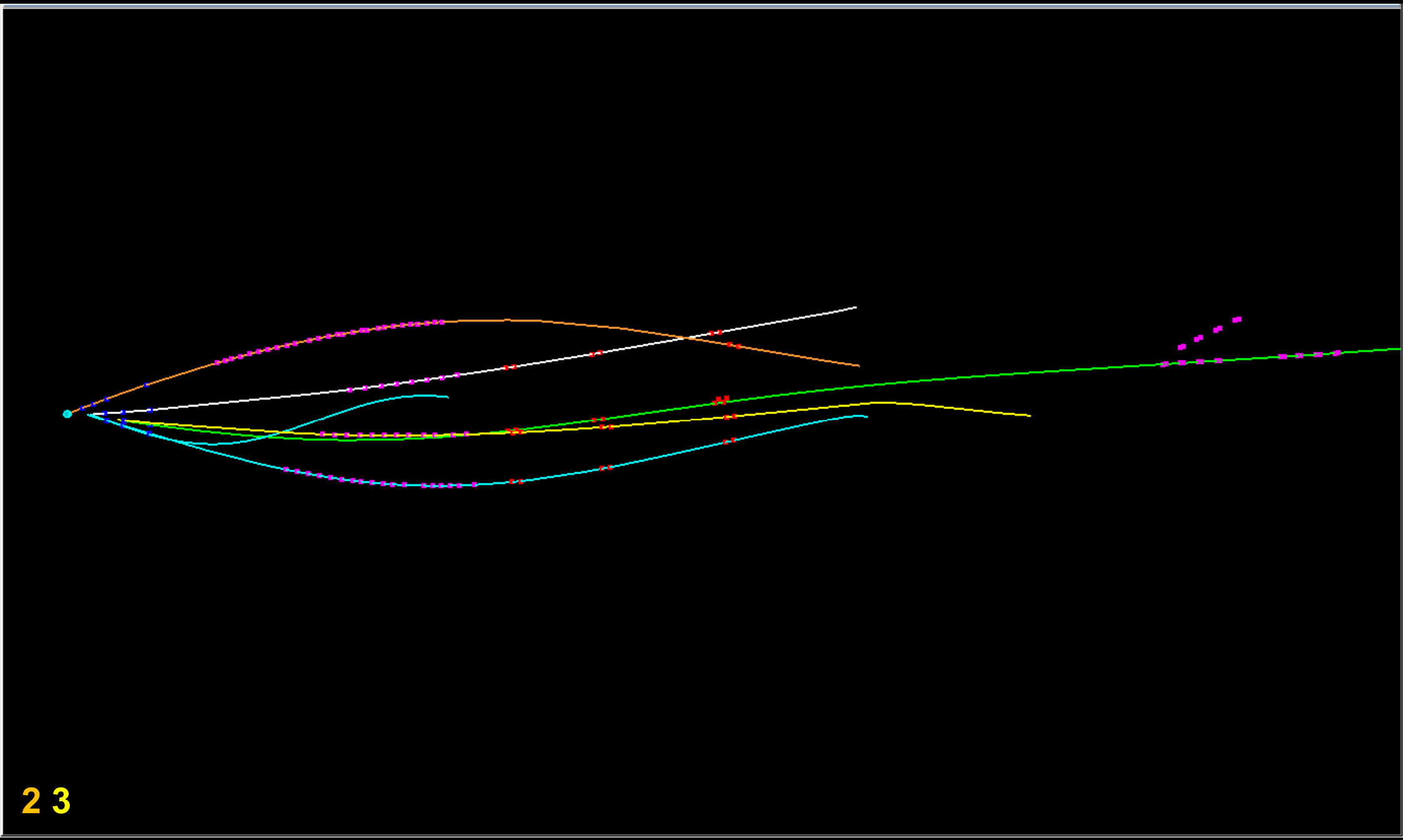

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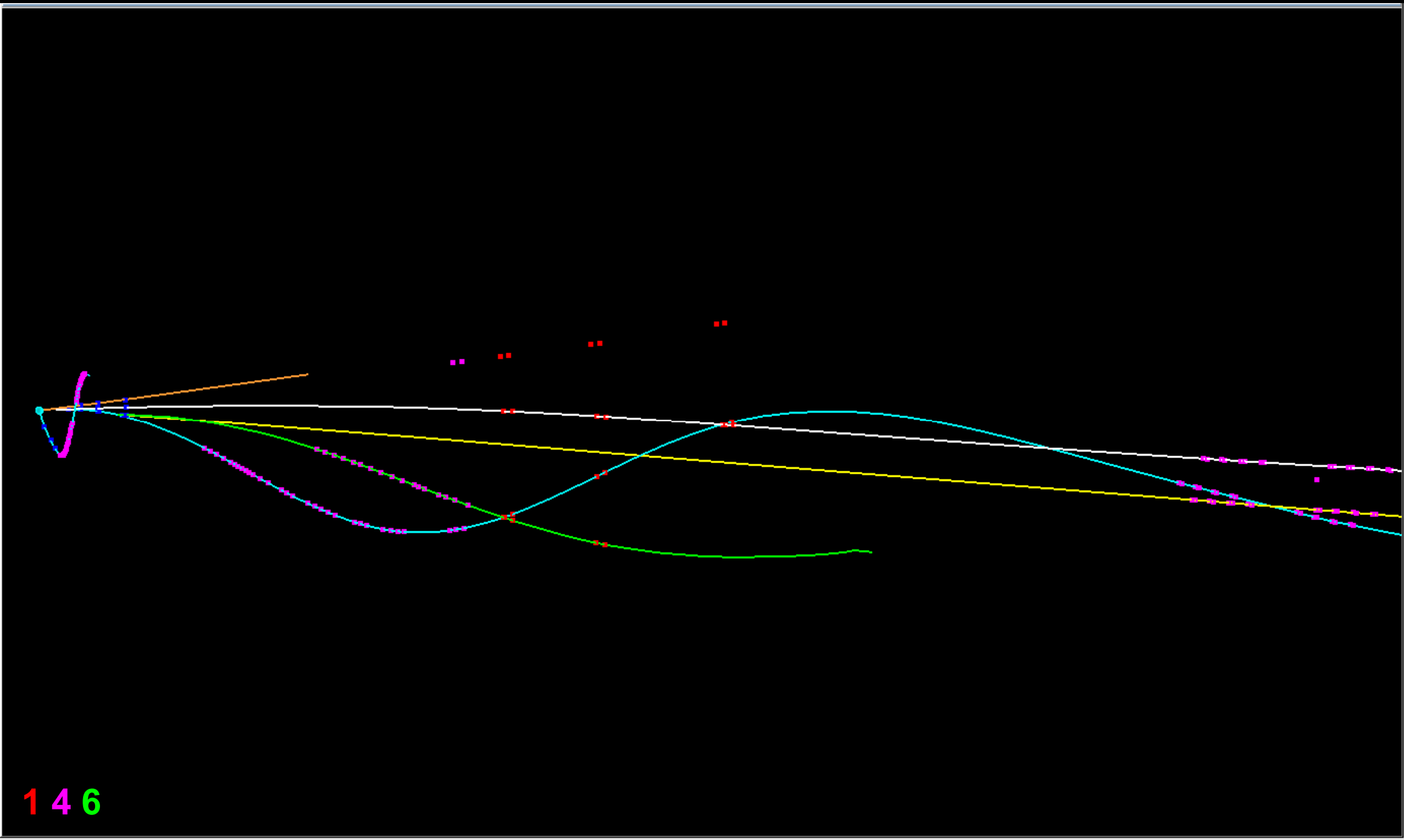

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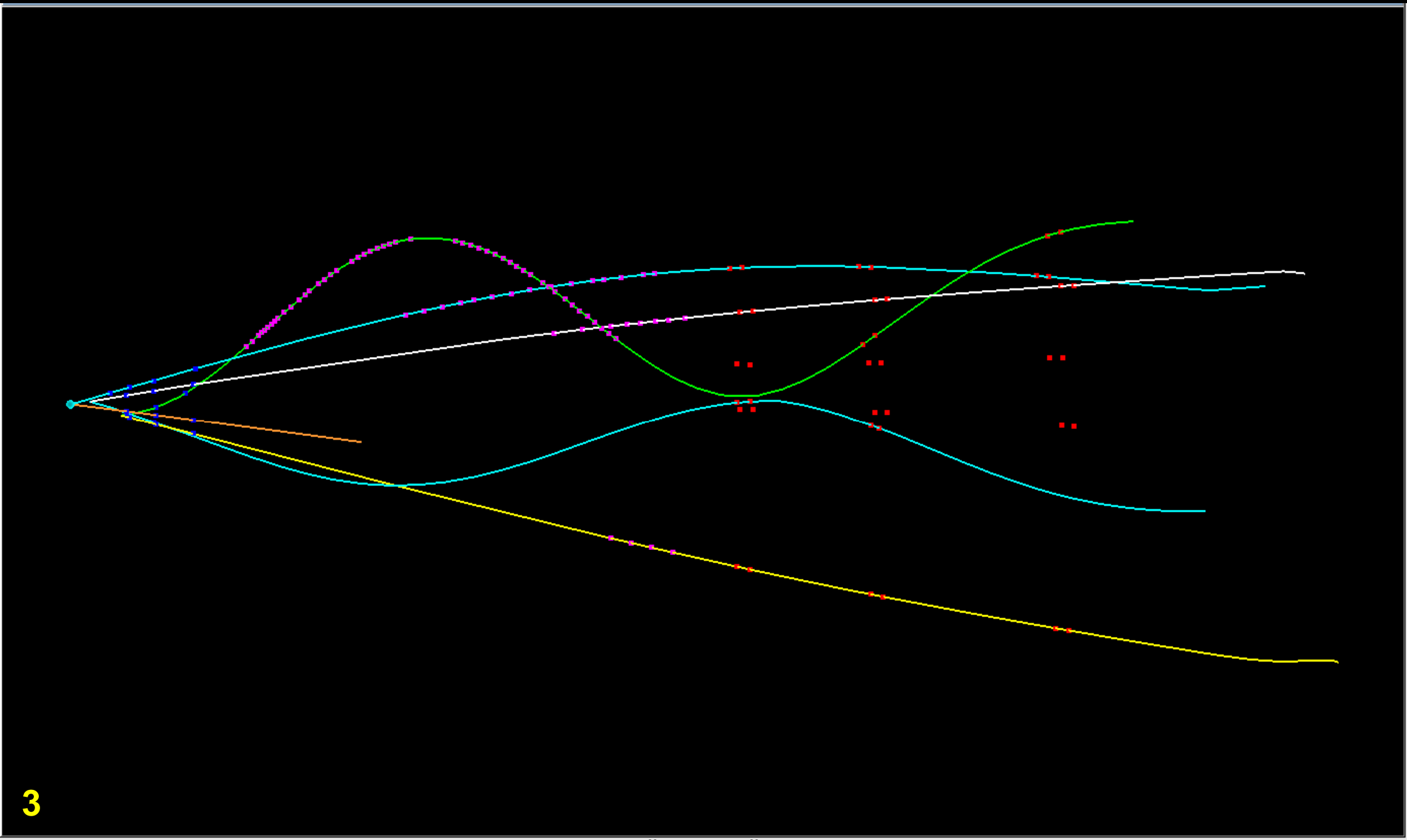

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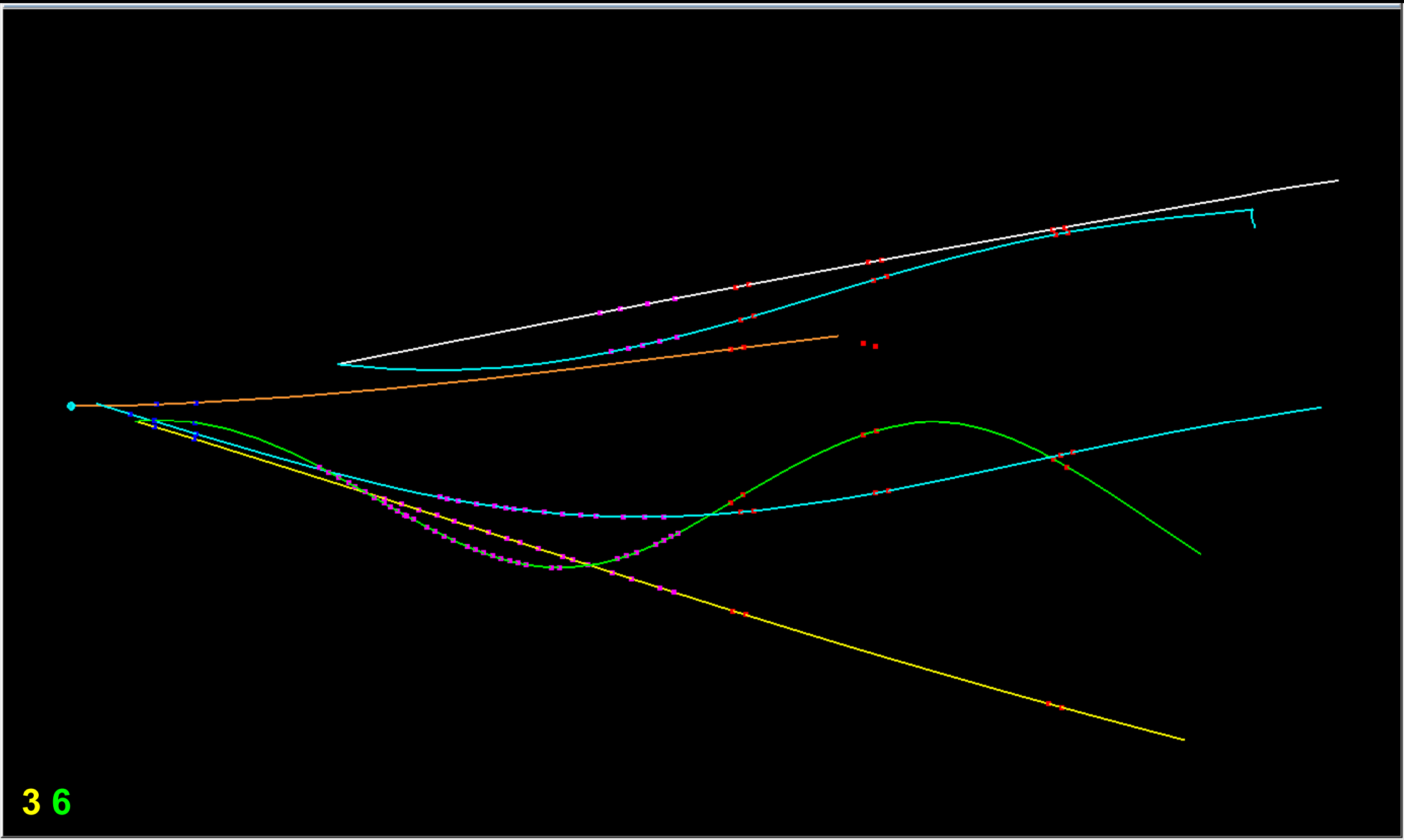

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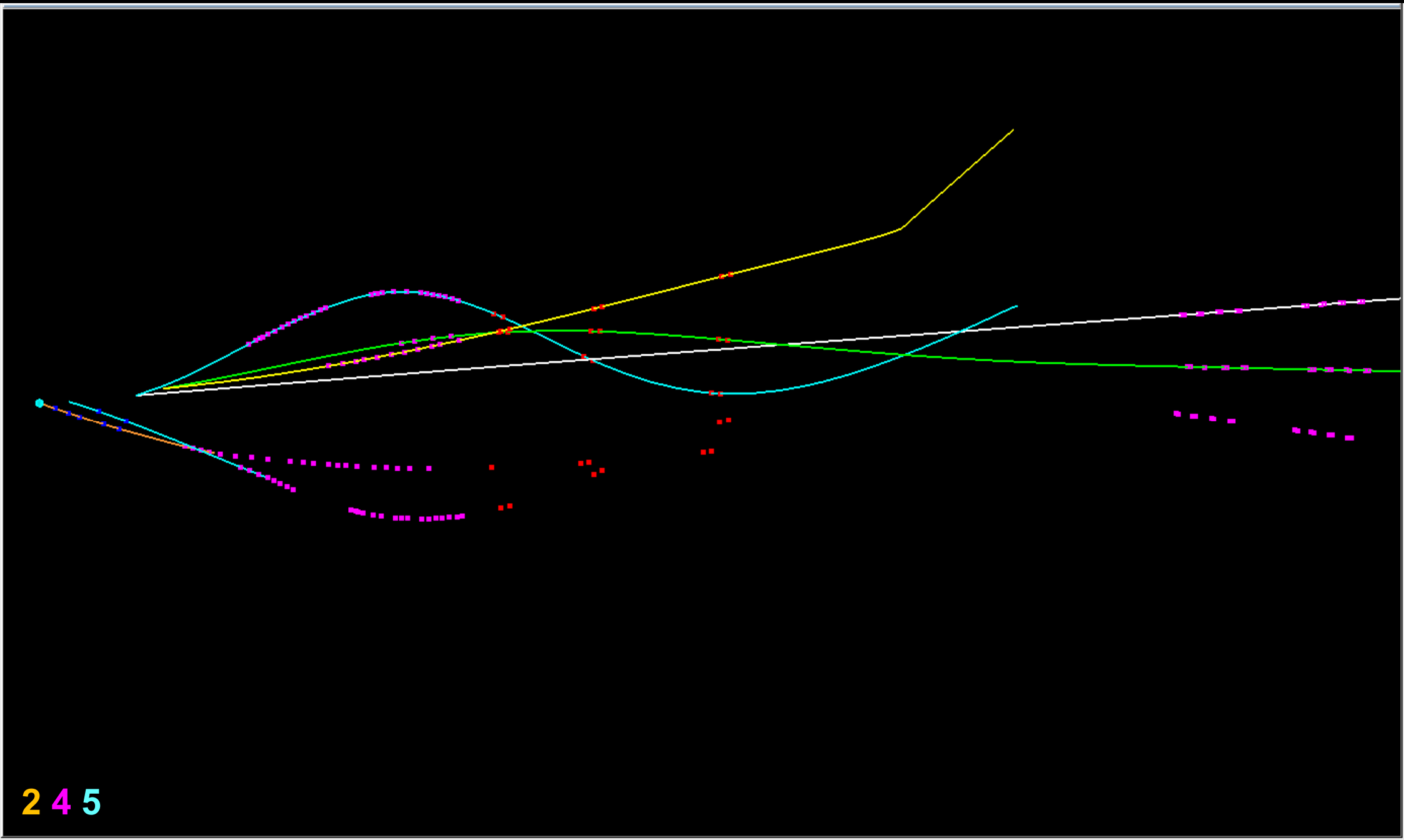

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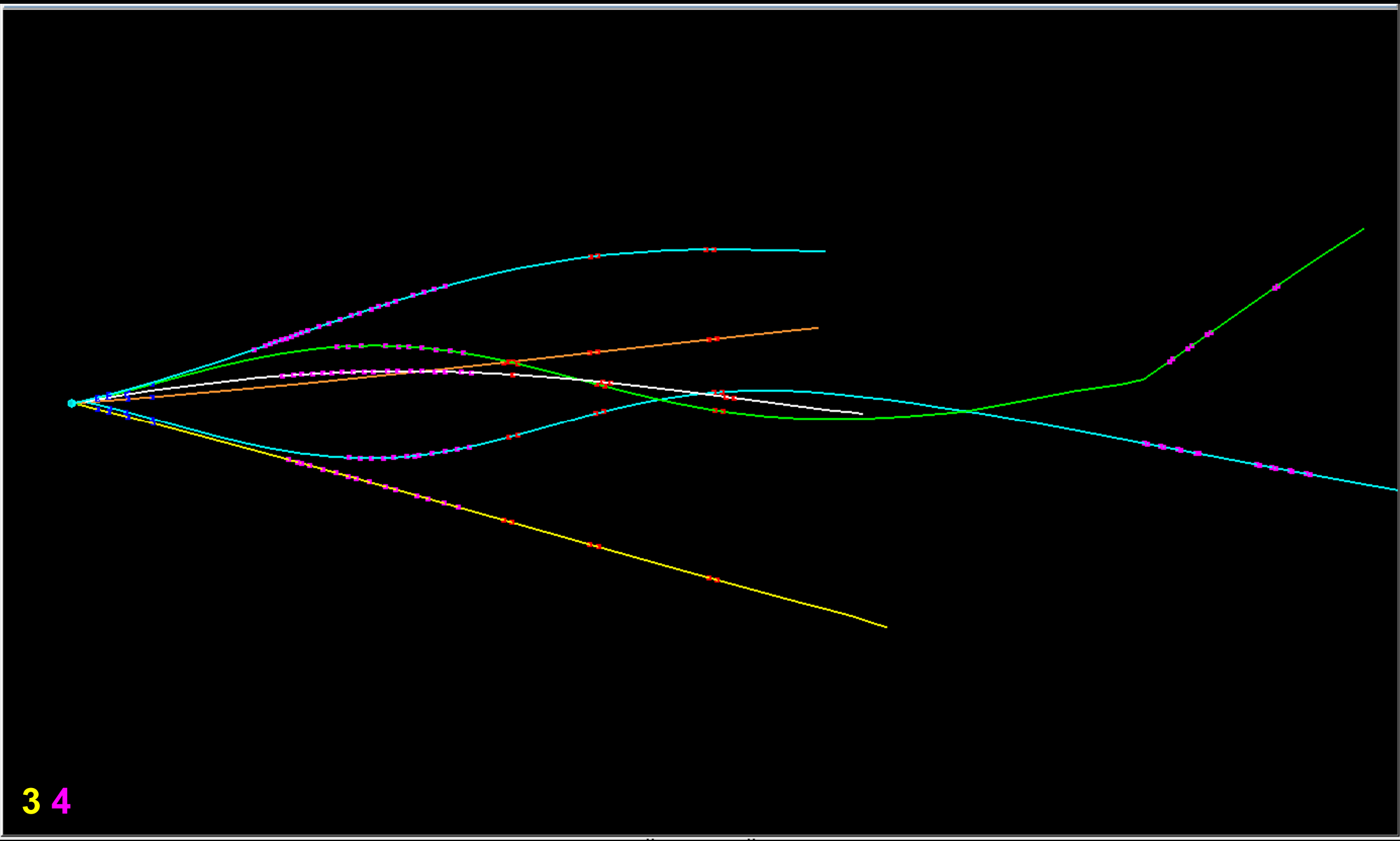

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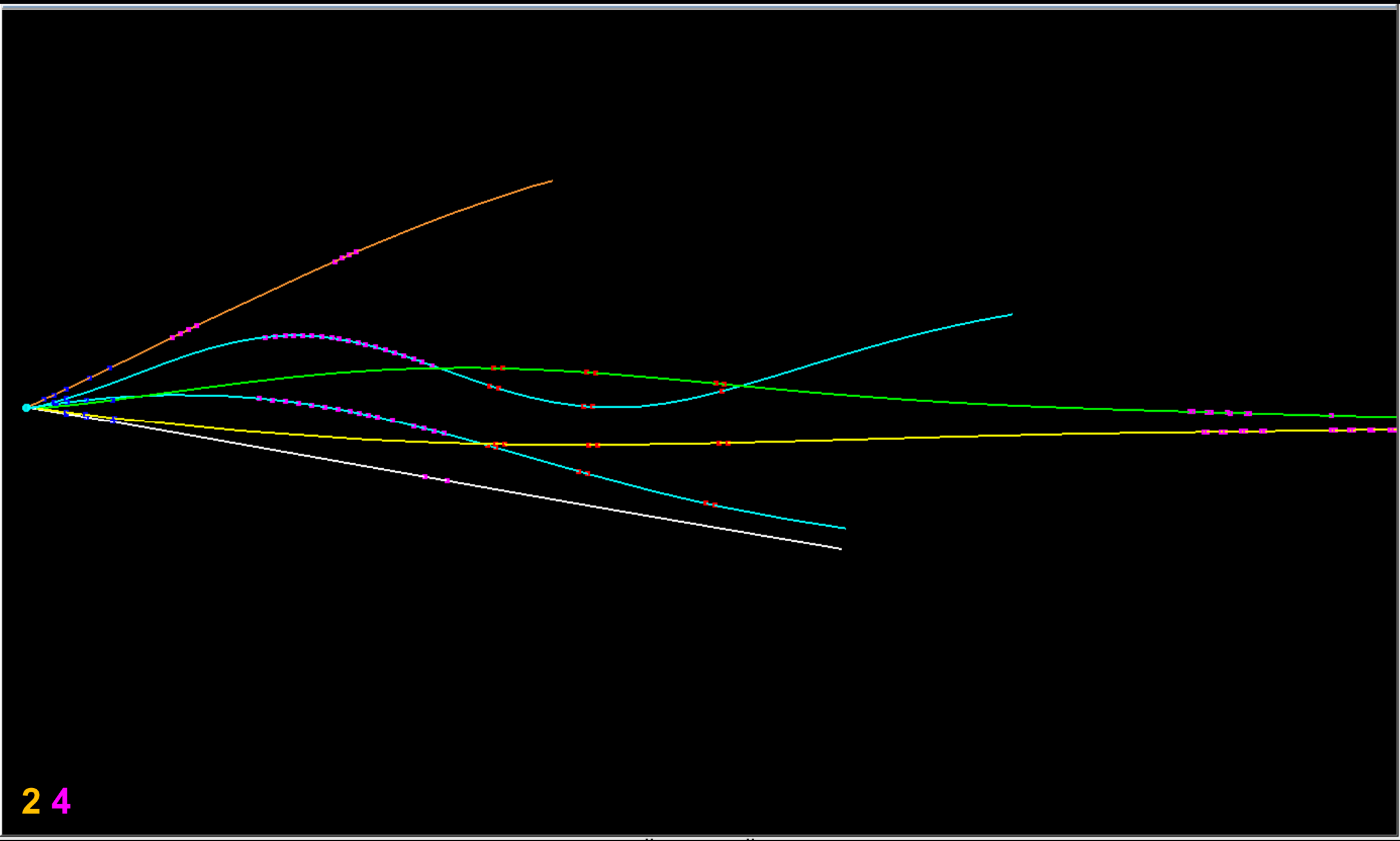

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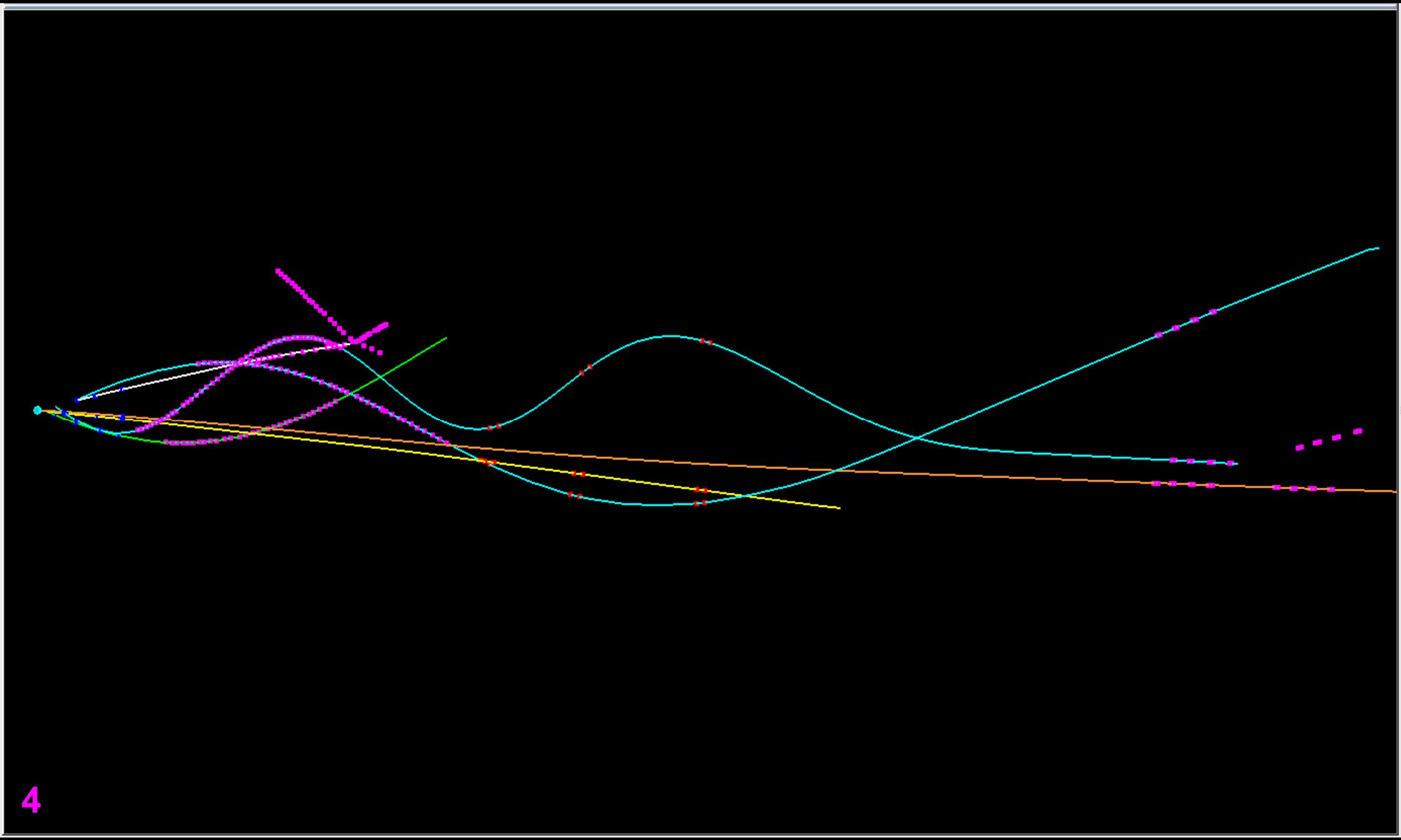

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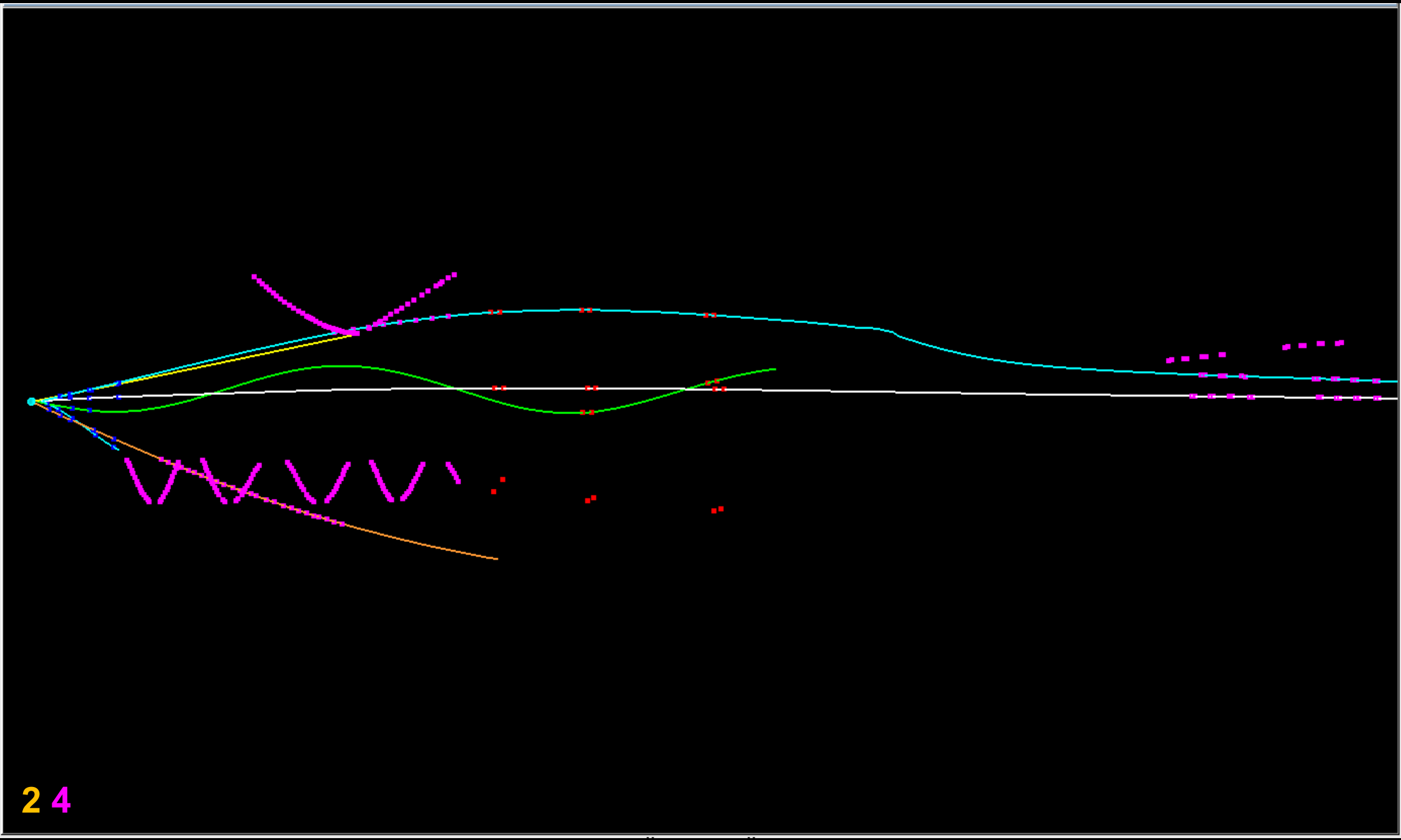

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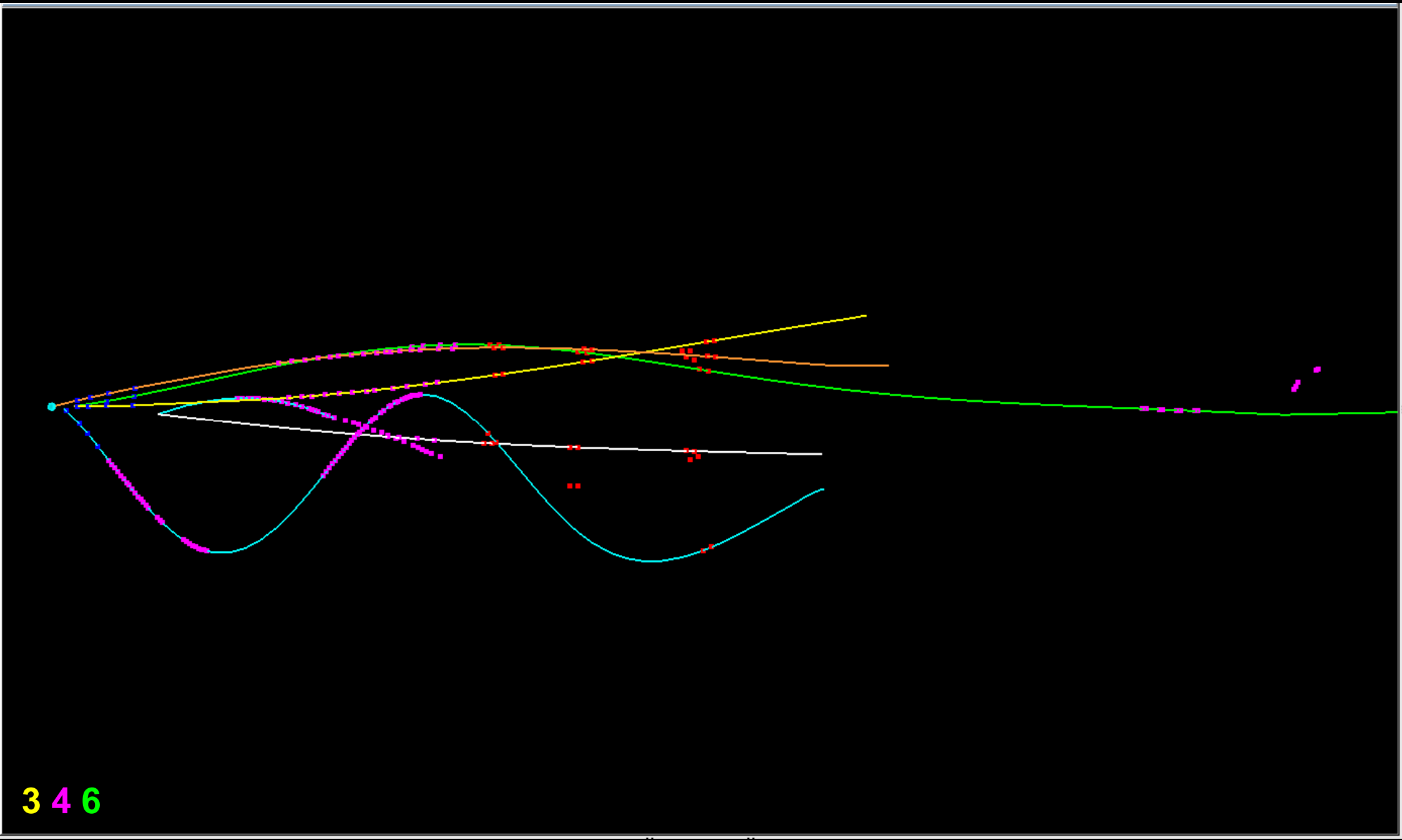

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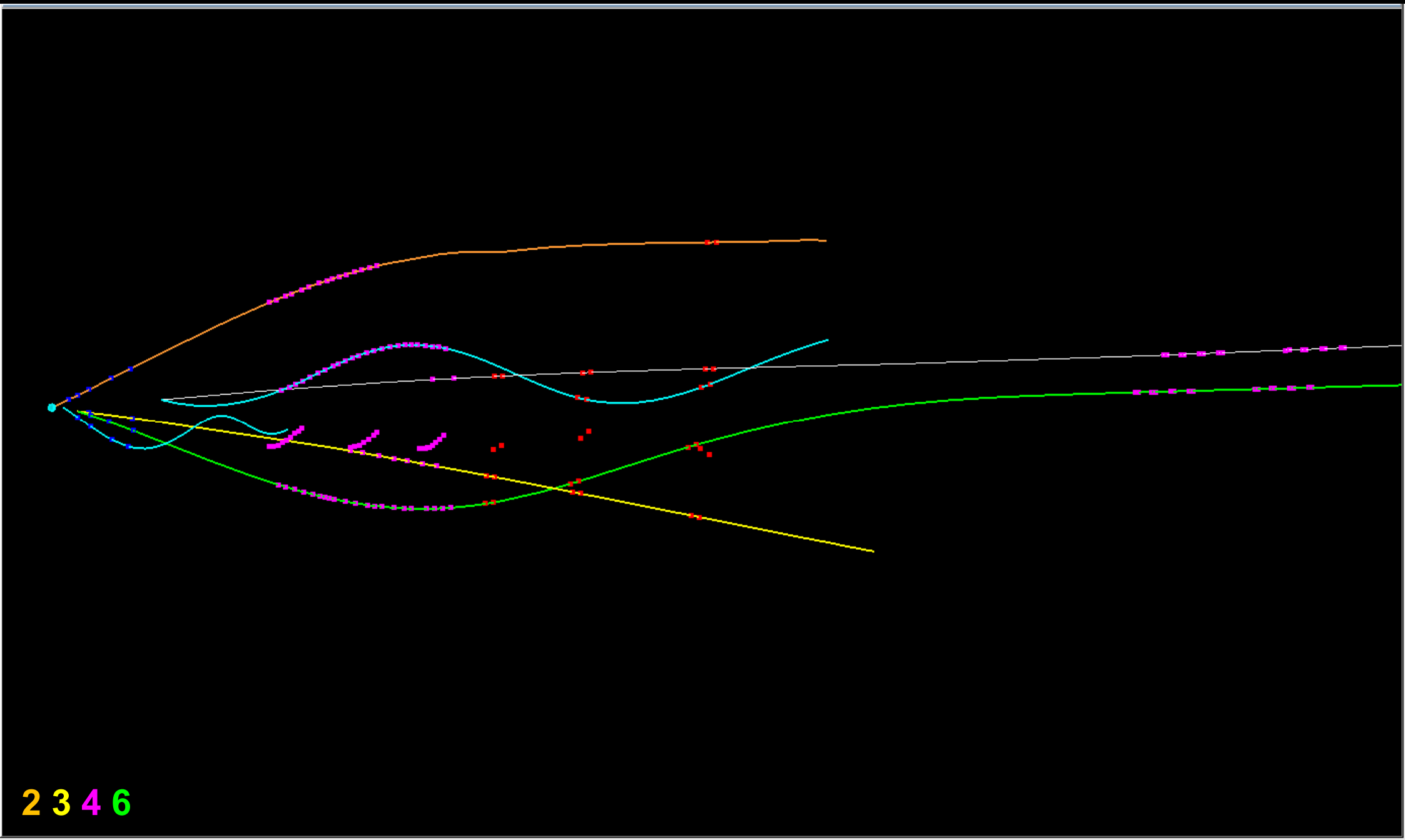

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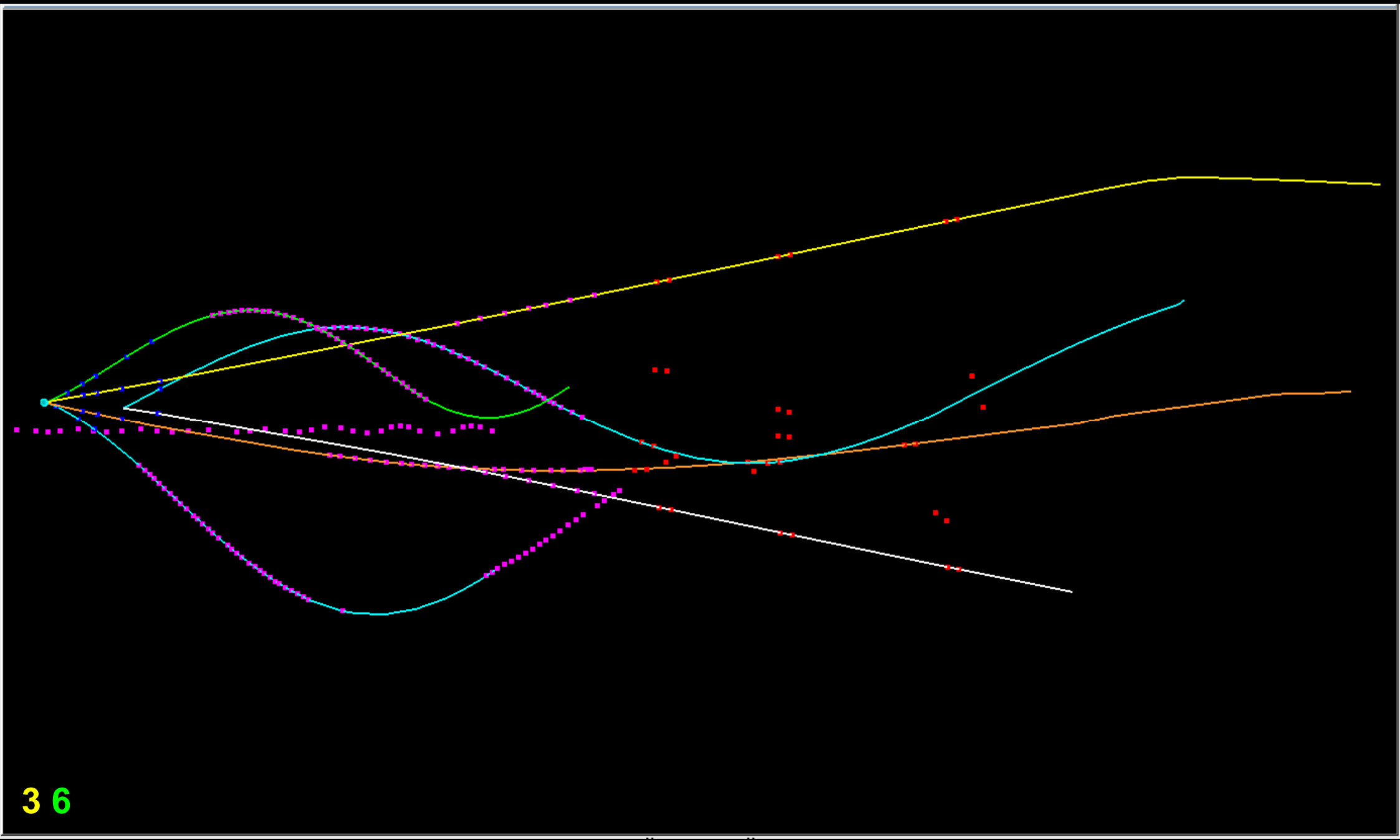

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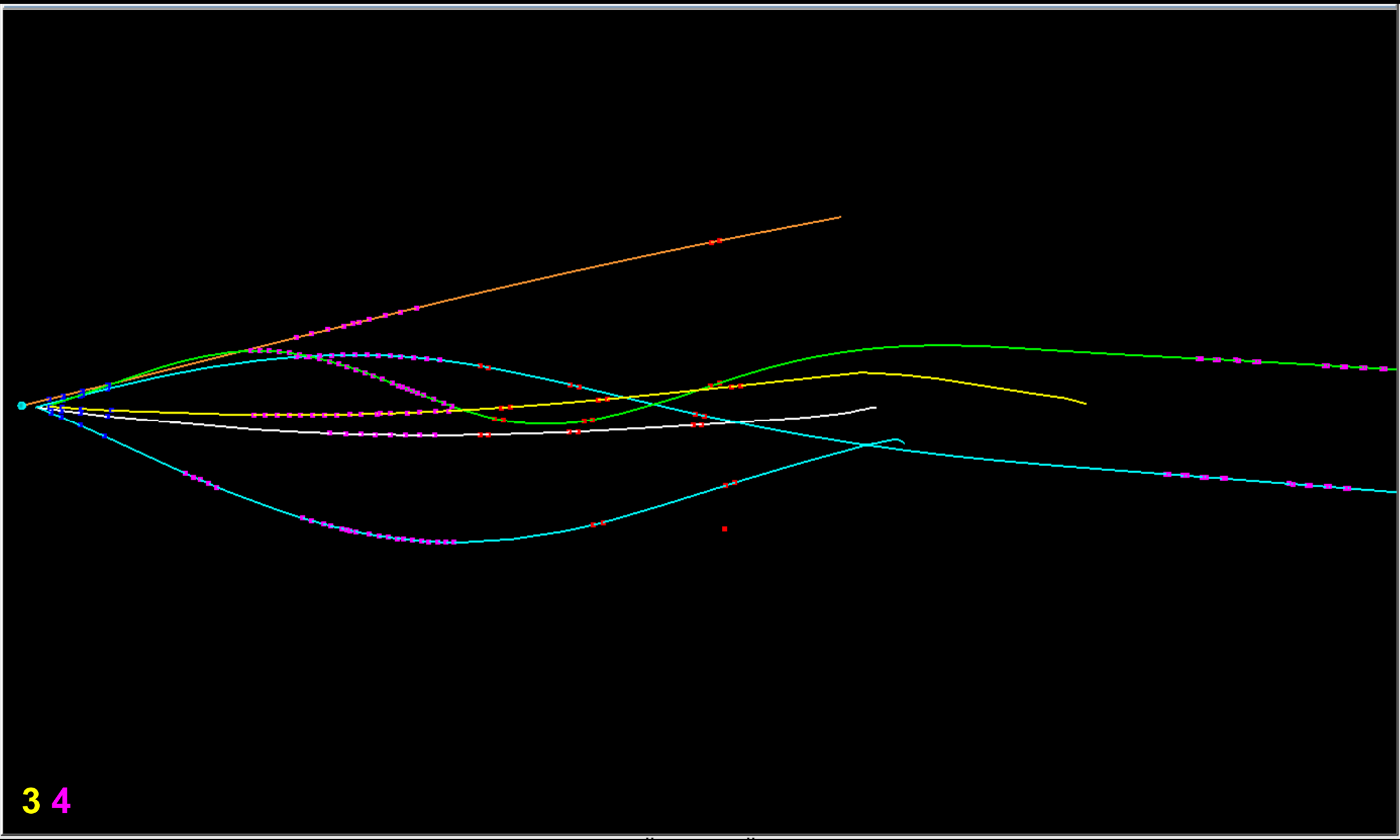

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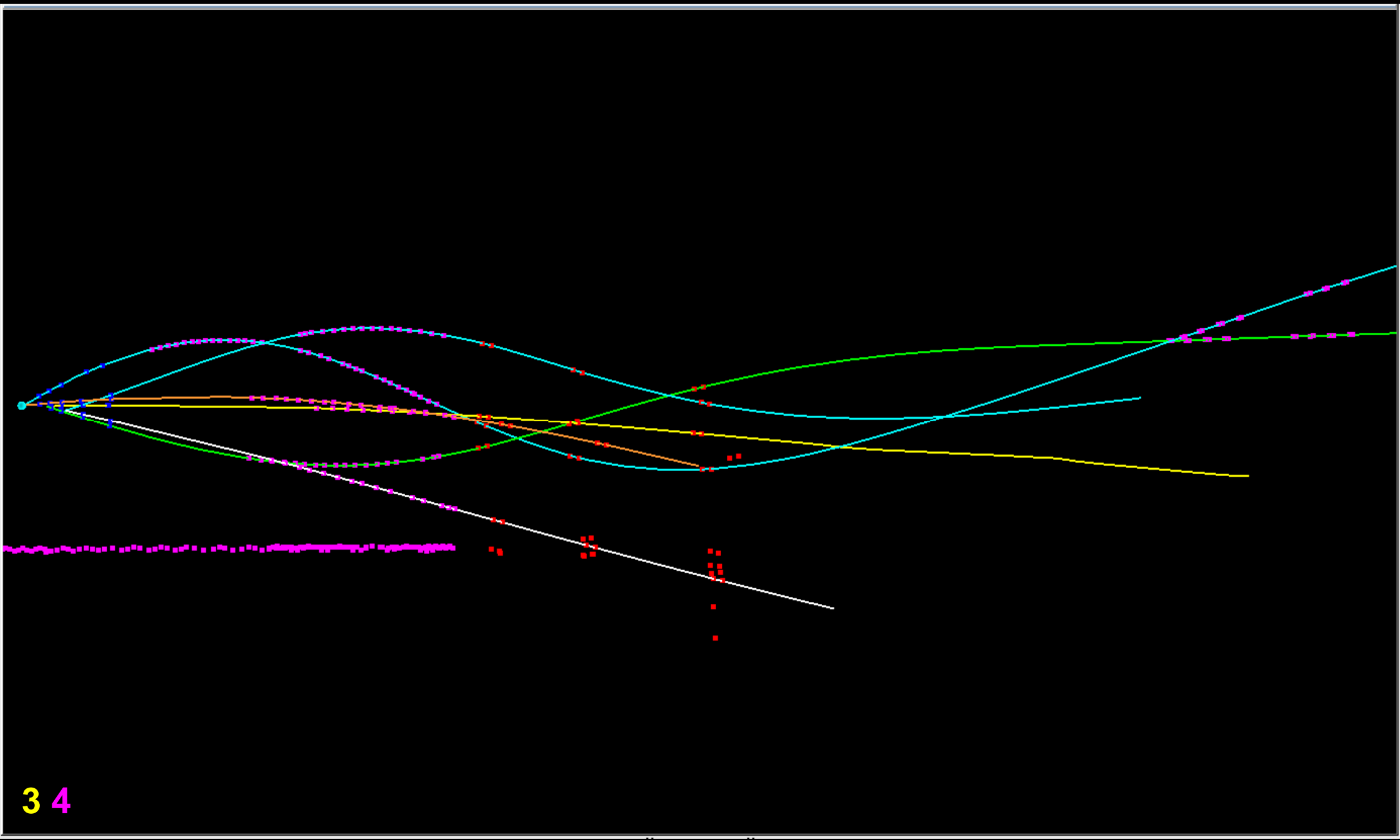

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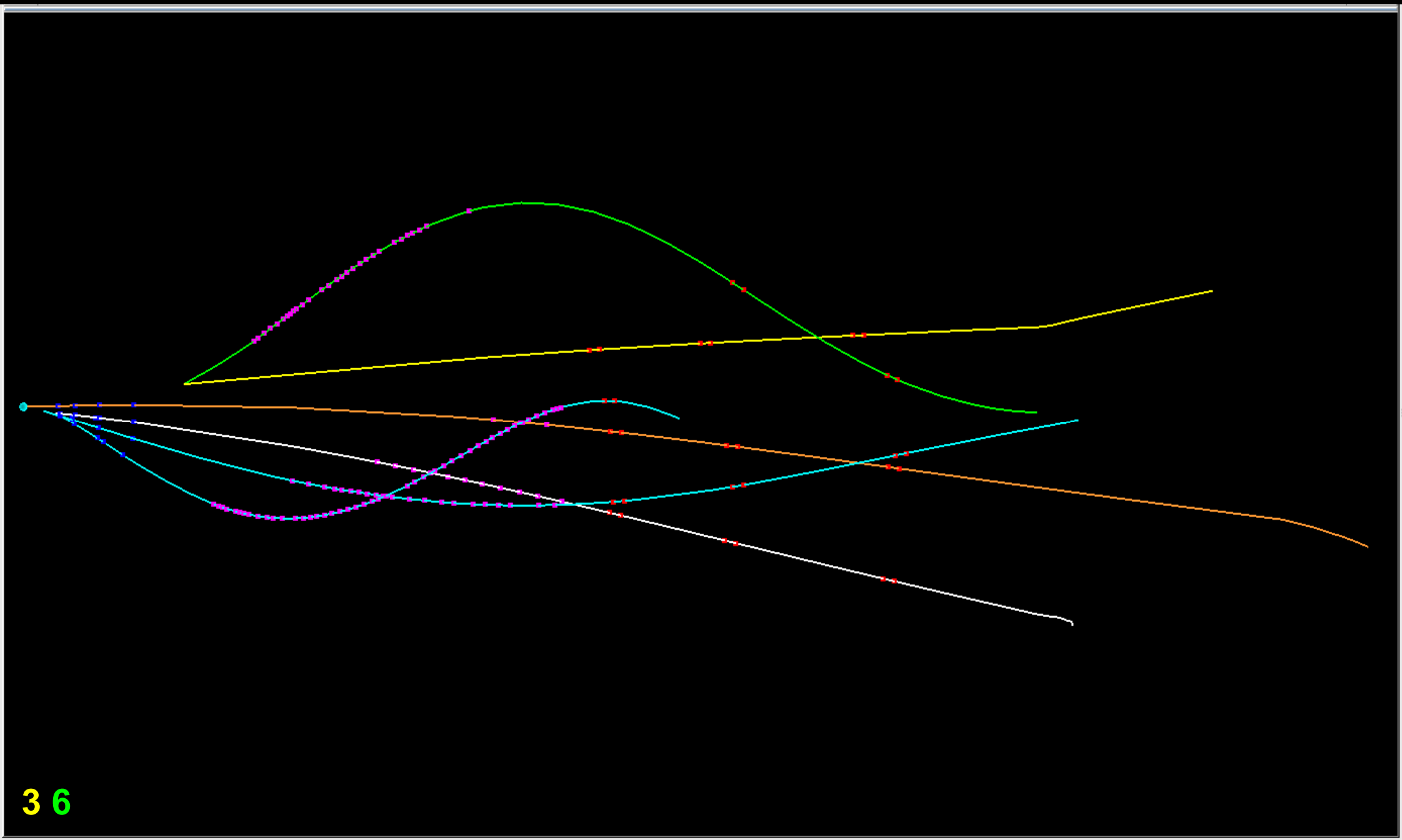

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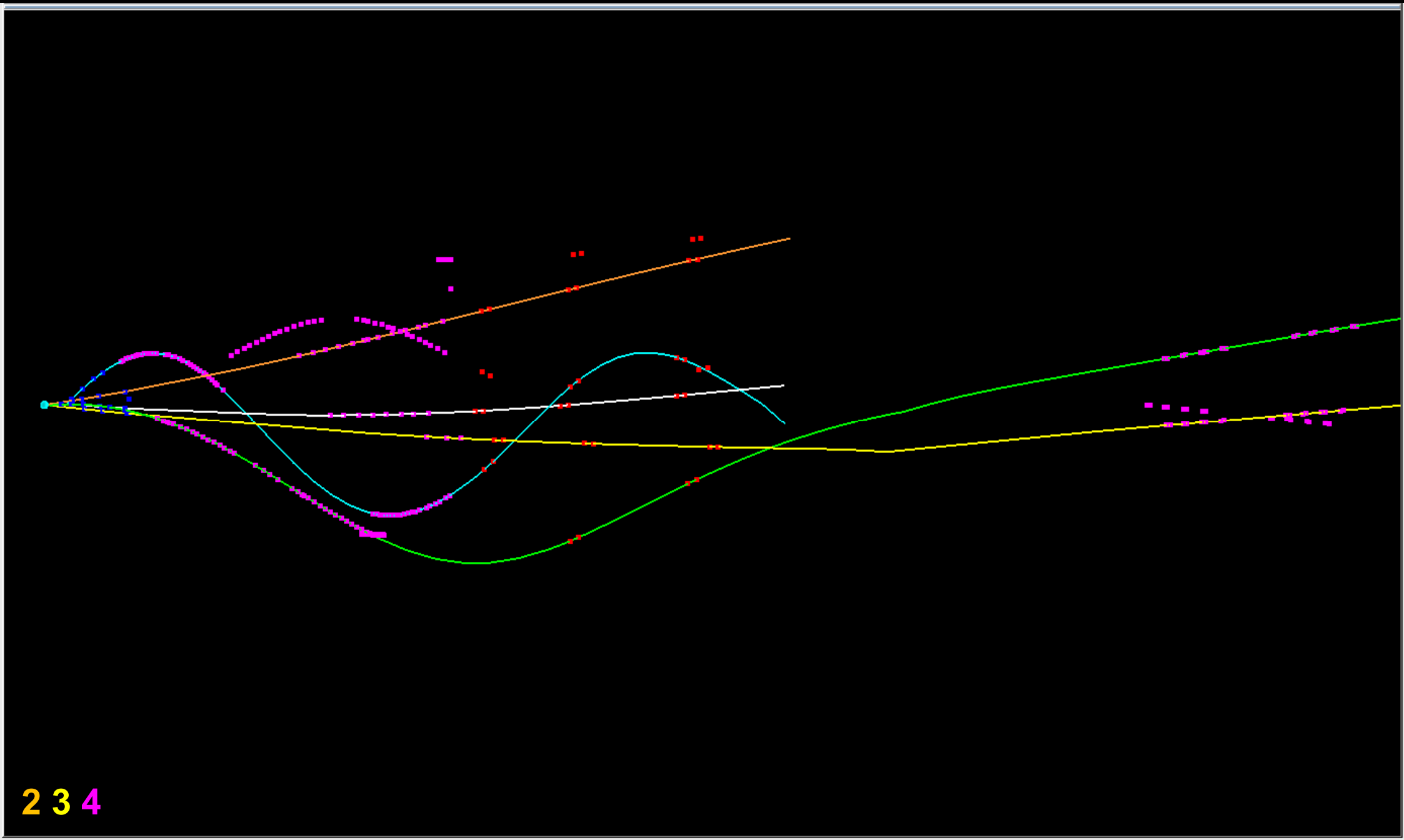

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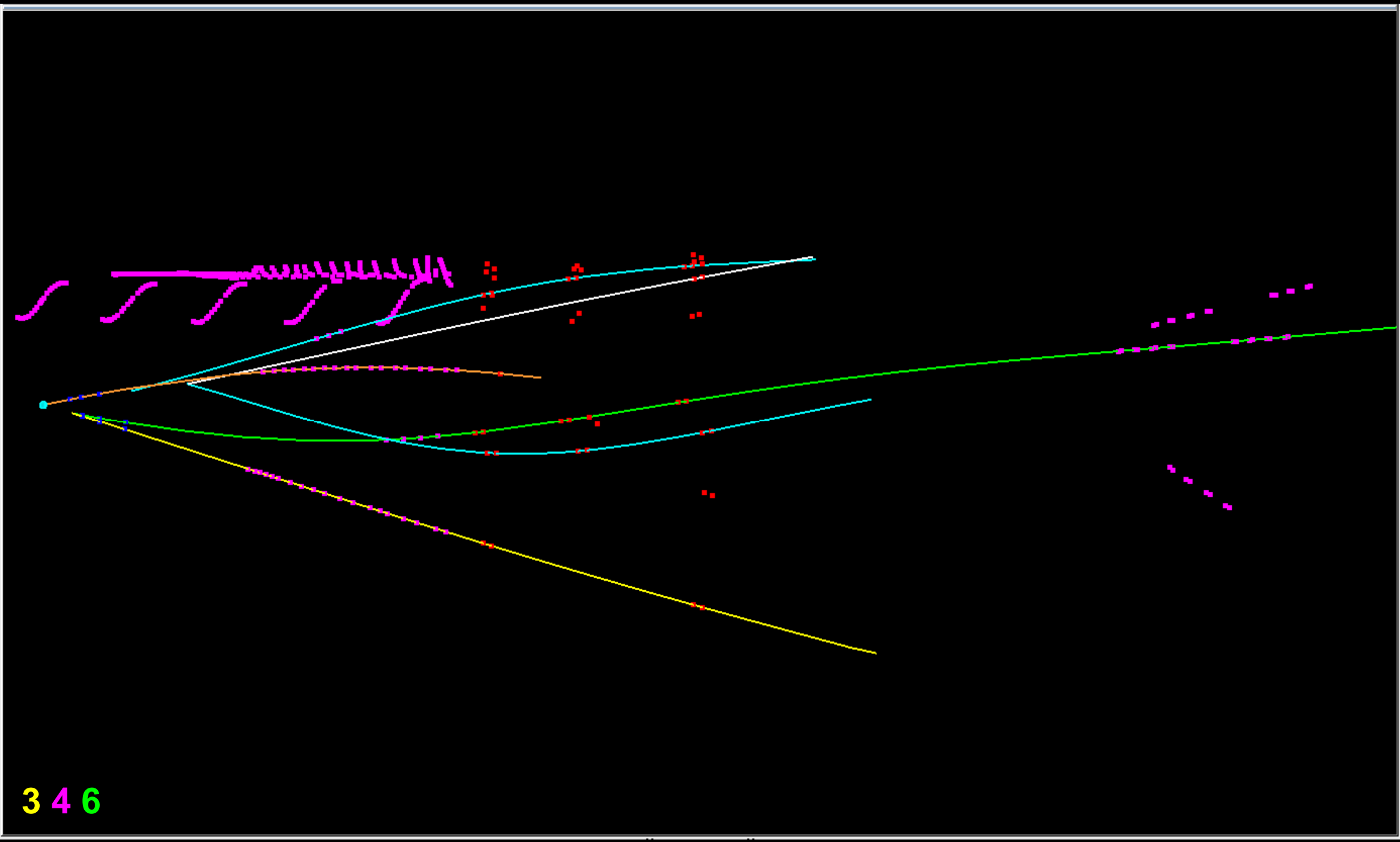
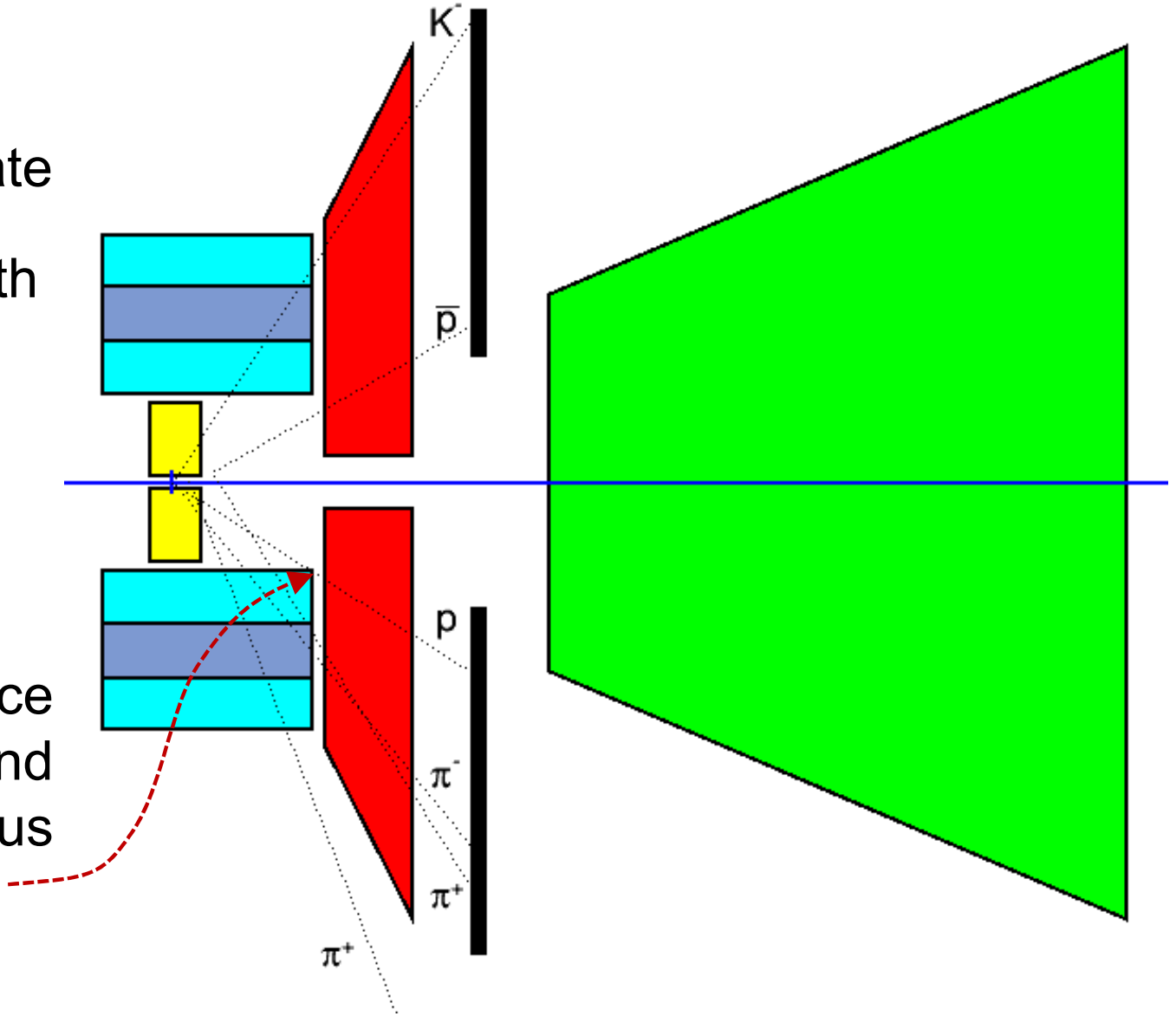


Interim Conclusion based on Event Display

- large number of secondary particles
- about 1/2 of events is lost due to scattering, absorption or decay
- straight track approximation is good for p, $\bar{p}$ and fair for K^-
- most pion tracks (but not all) strongly deviate from straight lines
- reconstruction with MVD and STT *alone* seems to be difficult for *all* scanned events

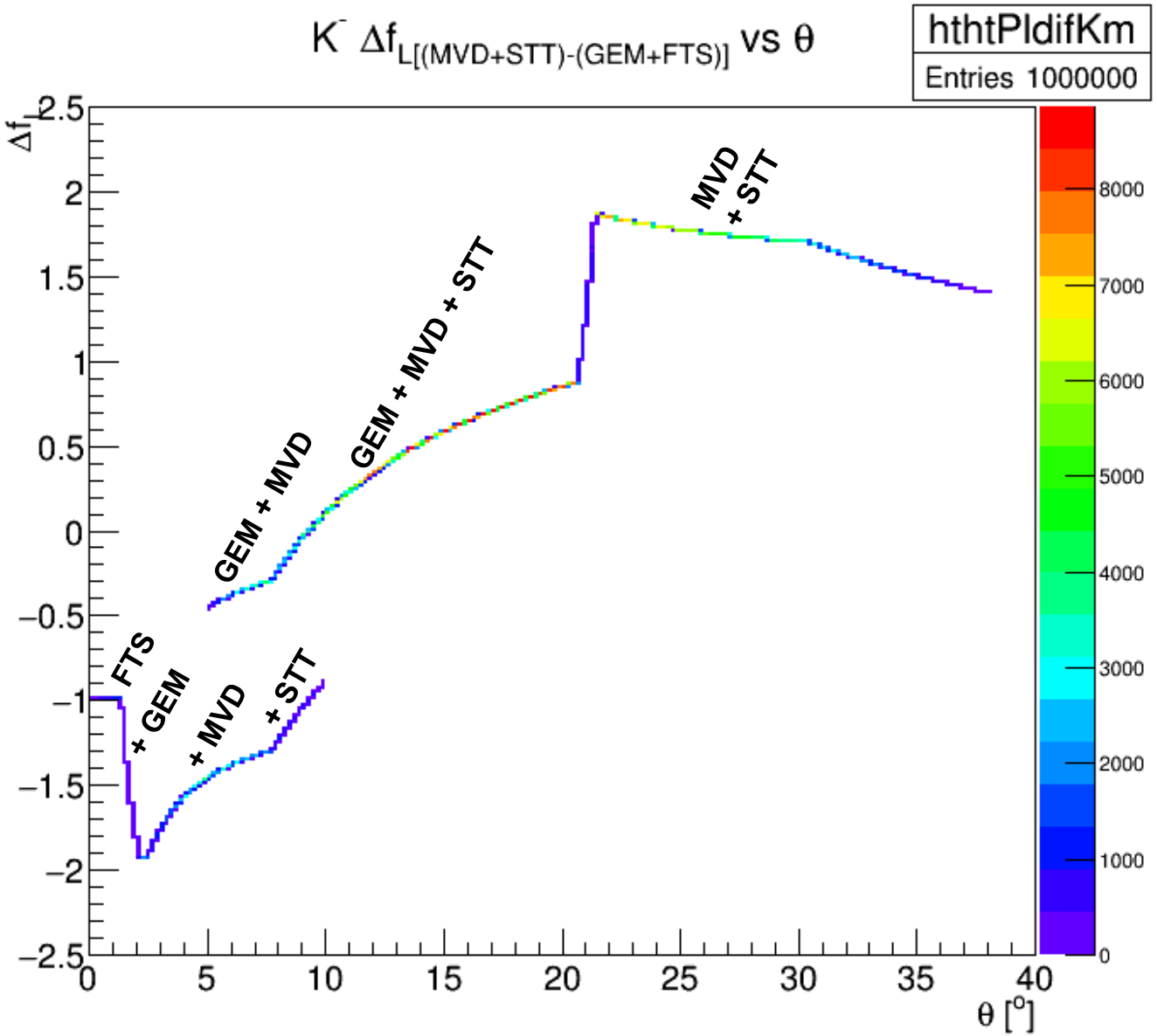
Fast Geometric Analysis with Straight Tracks

- 4.1 GeV $\bar{p}p \rightarrow \bar{\Xi}^{+}\Lambda K^{-}$
- $\bar{p}\pi^{+}\pi^{+}p\pi^{-}K^{-}$ final state
- evaluate fractional path length in each sub-detector volume:
  $f_L = L/L_{max}$
  $\Delta f_L = f_L(MVD) + f_L(STT) - f_L(GEM) - f_L(FTS)$
- compare radial distance of hit on xy plane at end of STT with outer radius of stereo layers

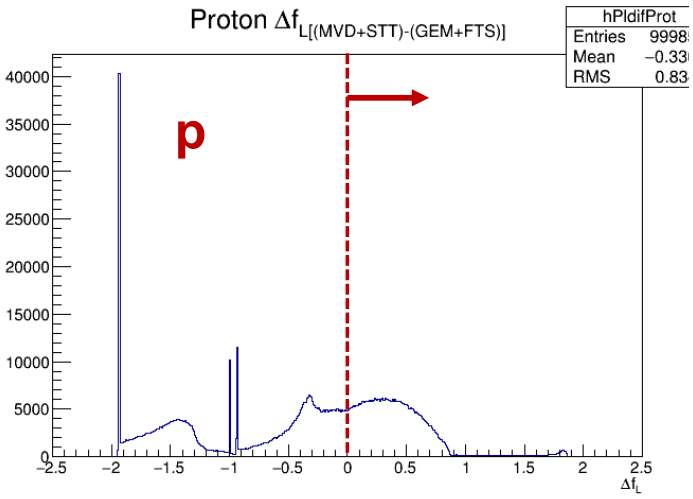


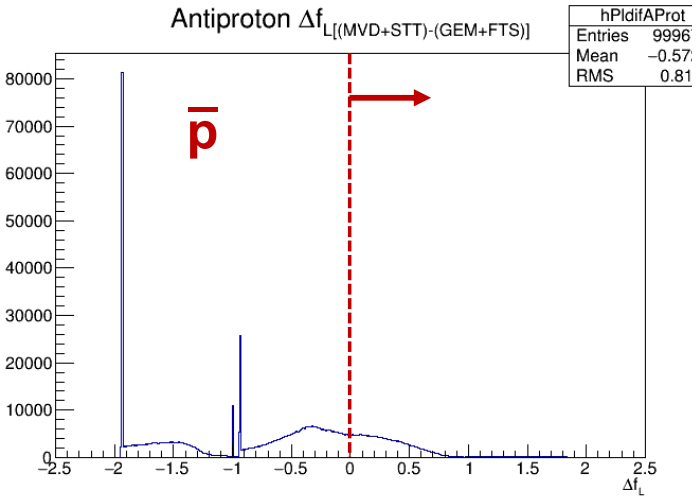
Fractional Path Length in Sub-Detectors

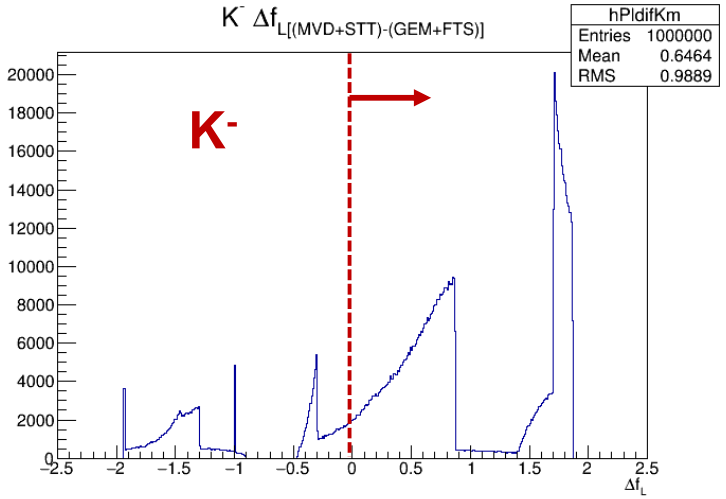
- test model with prompt particles
- K^- is the only prompt particle
- plot fractional path length vs. θ

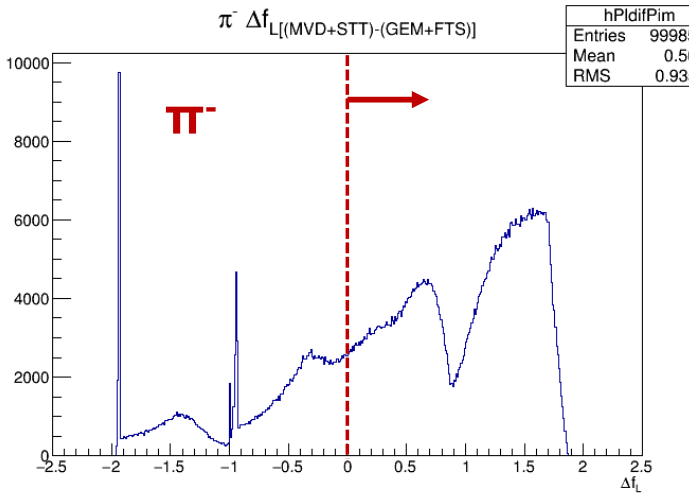


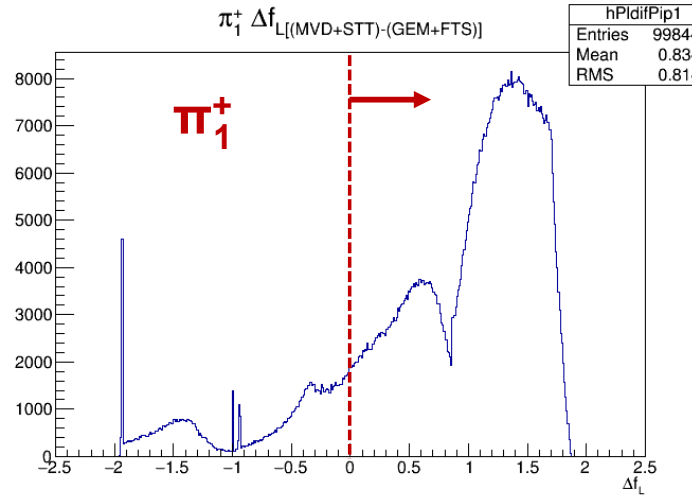
Fractional Path Length Difference (MVD+STT) – (GEM+FTS)

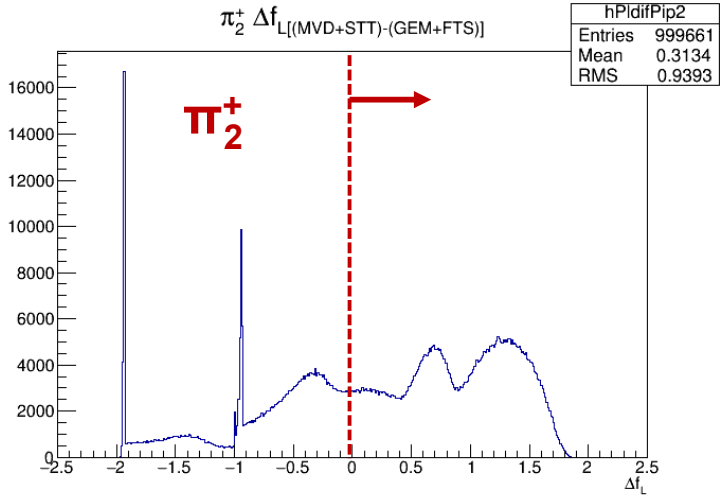






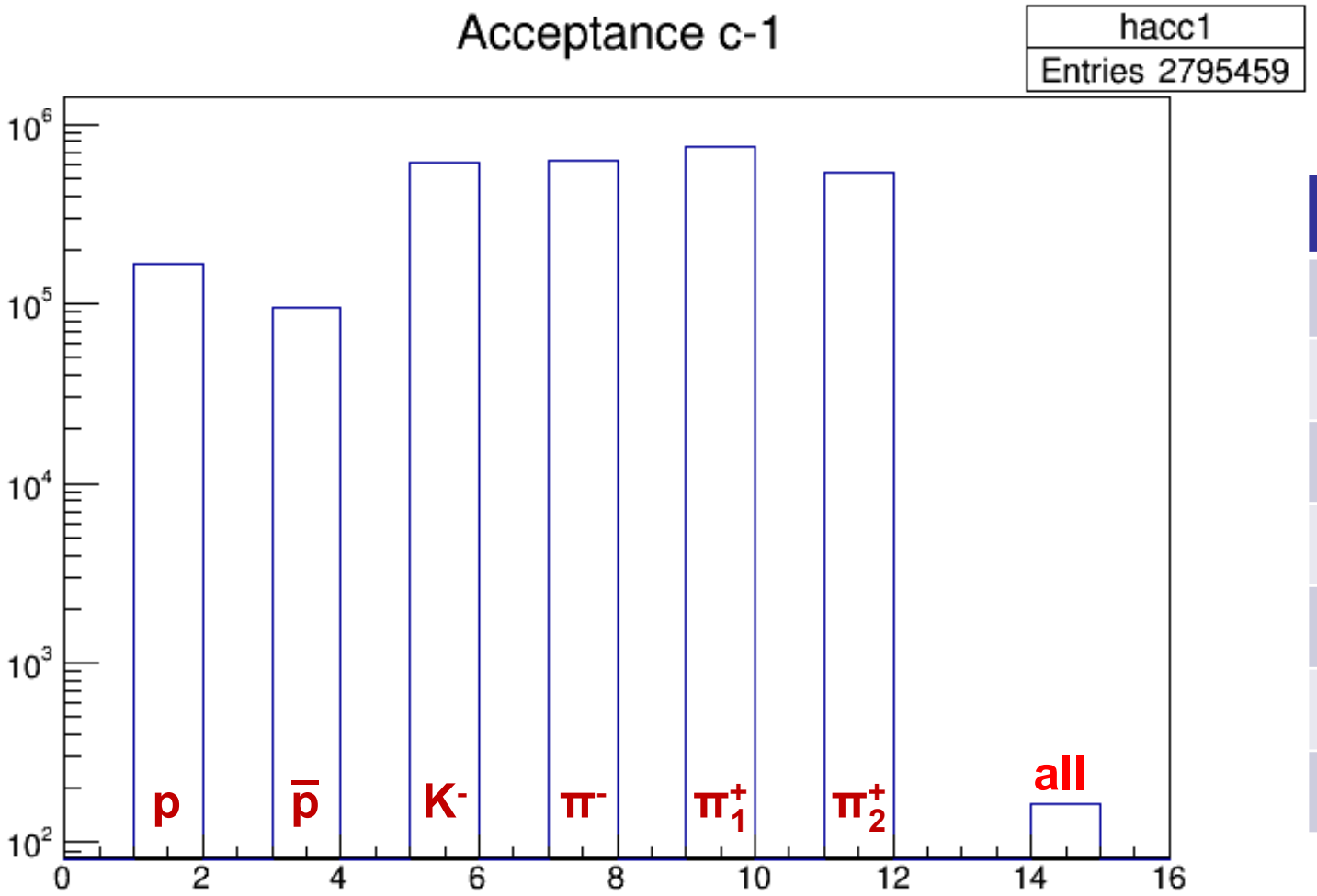






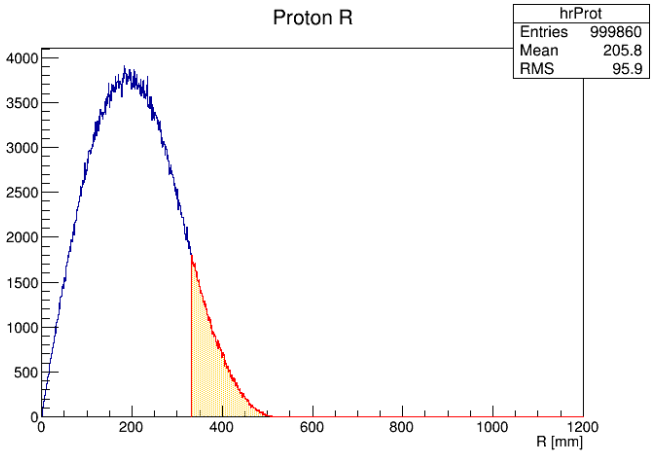
$\Delta f_L = f_L(MVD) + f_L(STT) – f_L(GEM) – f_L(FTS);\ \ f_L = L/L_{max}$

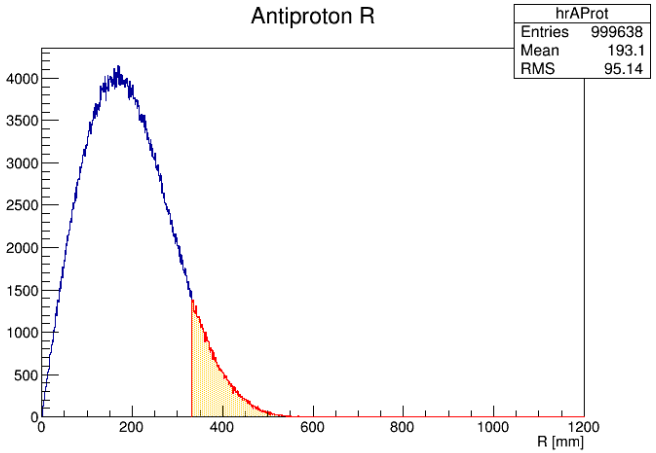
Acceptance ($\Delta F_L > 0$)

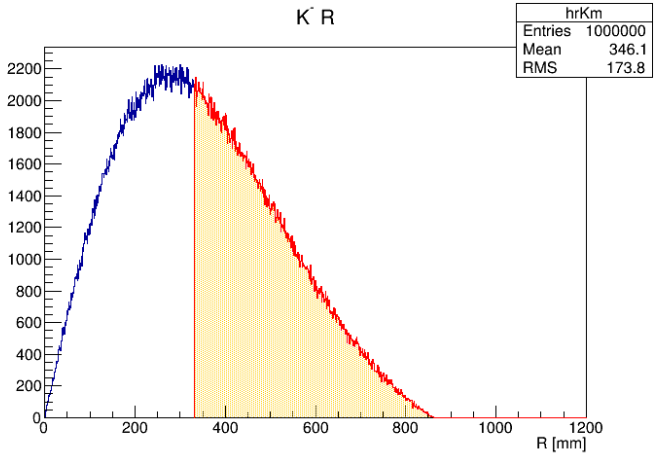


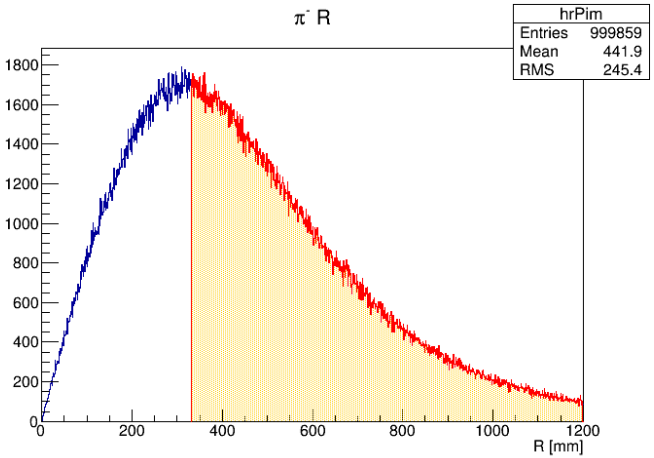
particle	f_{acc}
p	0.425
$\bar{p}$	0.265
K^-	0.808
π^-	0.743
$\pi^+{}_1$	0.856
$\pi^+{}_2$	0.635
all	0.034

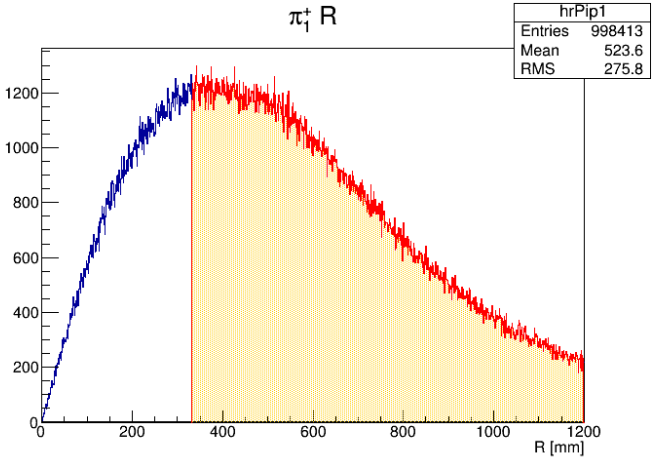
Radial Distribution at STT End Plane

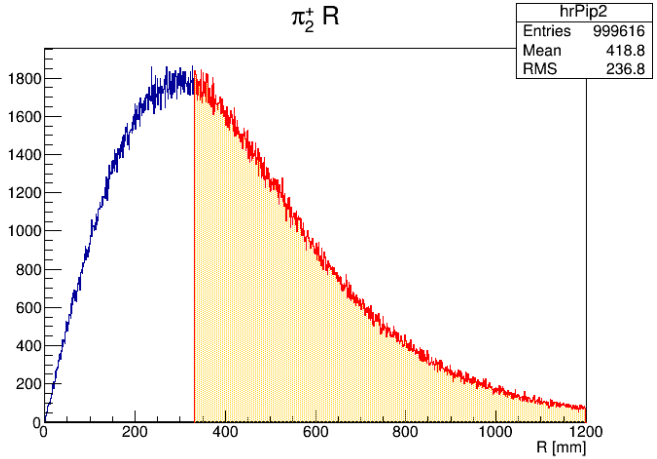




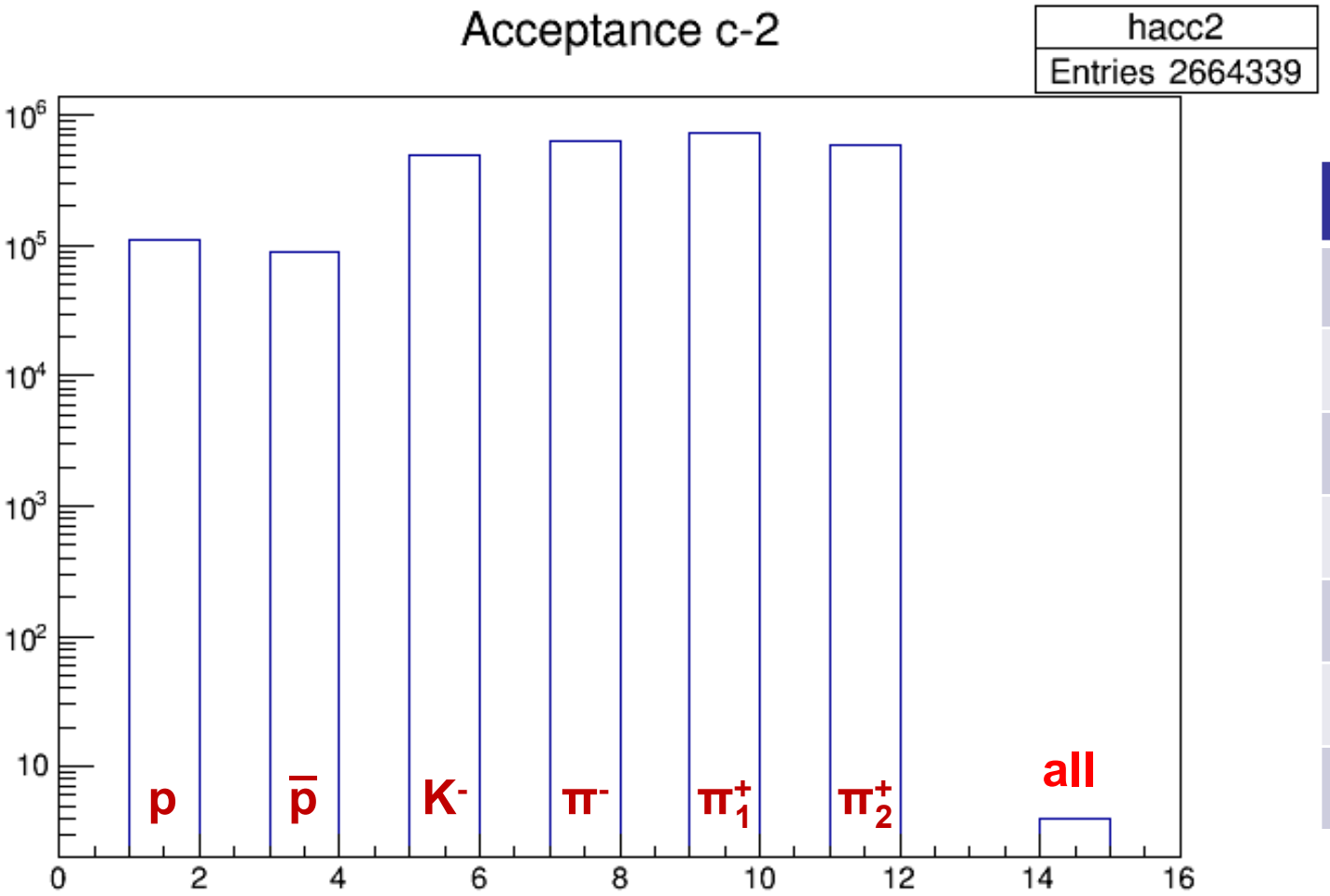








Acceptance (R > R_{crit})



R_{crit} = 331 mm

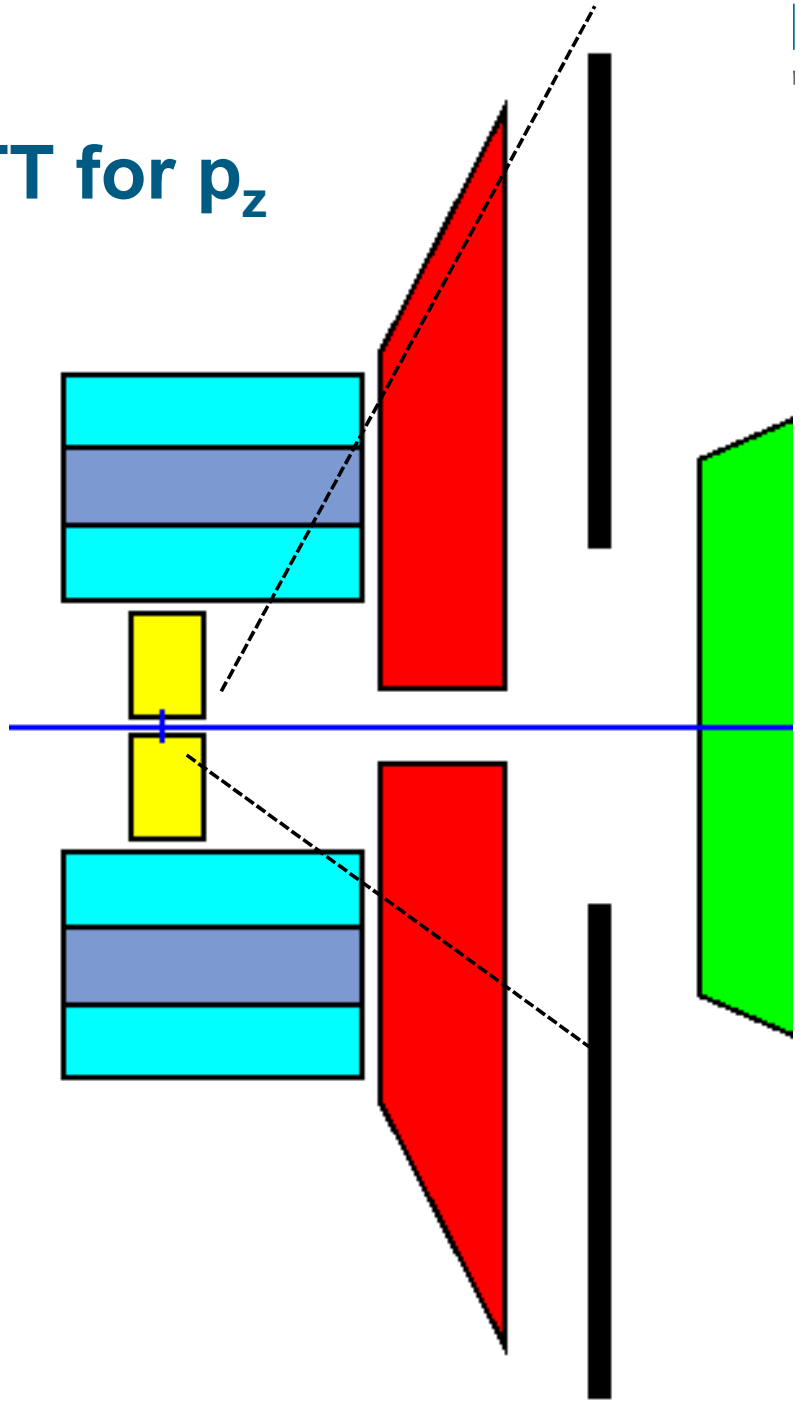
particle	f_{acc}
p	0.109
$\bar{p}$	0.088
K^-	0.498
π^-	0.630
$\pi^+{}_1$	0.745
$\pi^+{}_2$	0.594
all	$4 \cdot 10^{-6}$

→ almost zero efficiency if p_z information from STT is required !

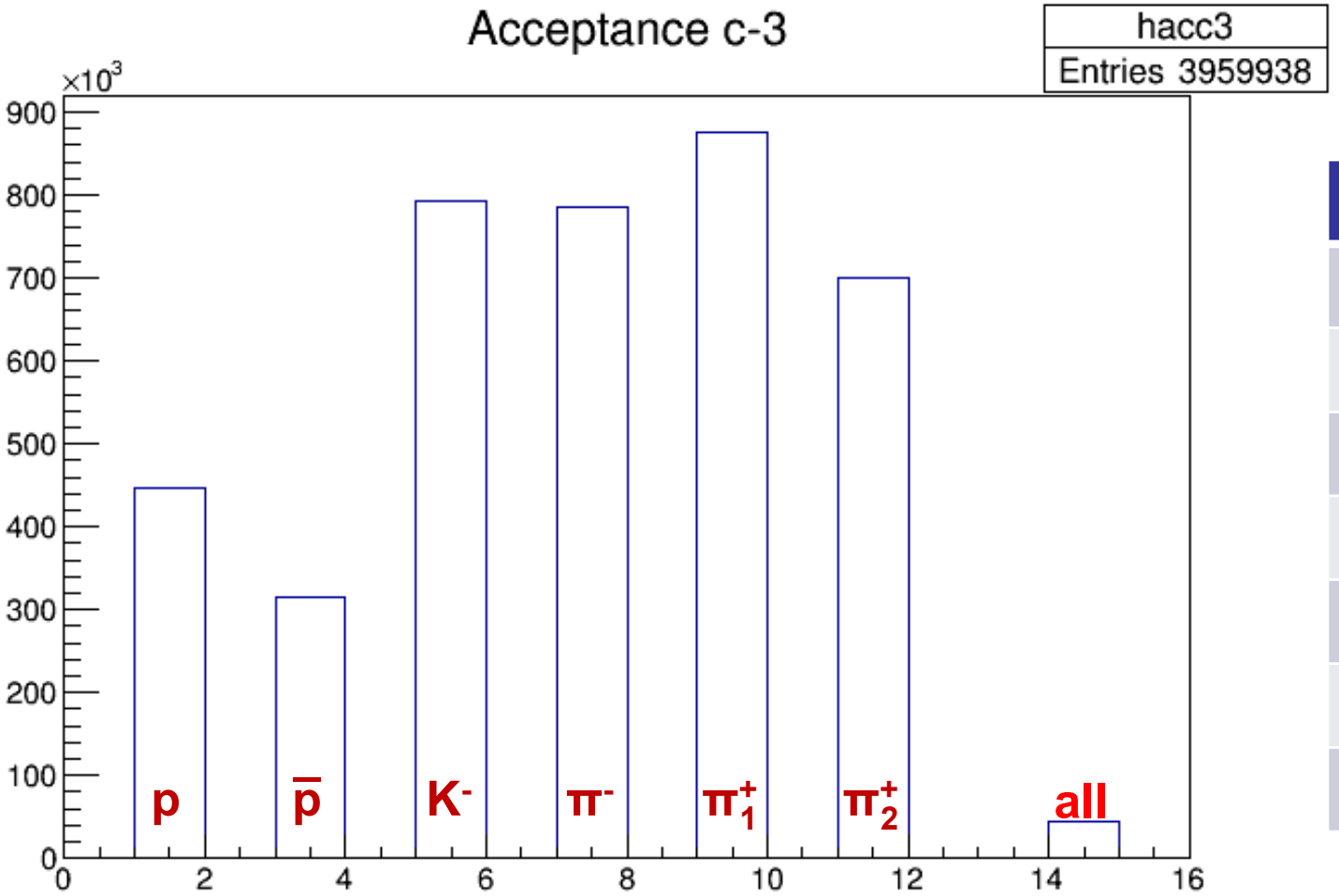
More Realistic: Combine MVD & STT for p_z

- need both p_z and p_T information from central detector
- a track starting downstream of MVD must pass the STT stereo layer
- a track starting inside MVD must at least pass the last two MVD discs and two axial STT double-layers

➢ $L_{MVD} \cdot \cos\theta > 70$ mm
$L_{STT} \cdot \sin\theta > 40$ mm



Acceptance $(R > R_{crit}) \,||\, ((L_{MVD} > L_{c1}) \,\&\&\, (L_{STT} > L_{c2}))$

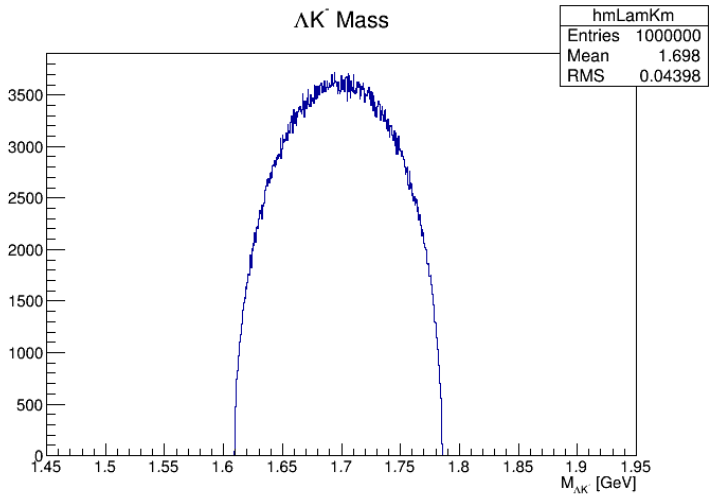


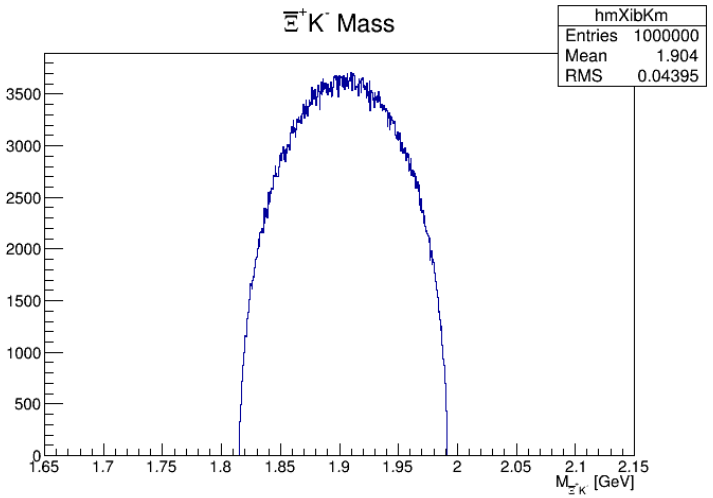
particle	F_{acc}
p	0.447
$\bar{p}$	0.314
K^-	0.793
π^-	0.785
$\pi^+{}_1$	0.876
$\pi^+{}_2$	0.700
all	0.045

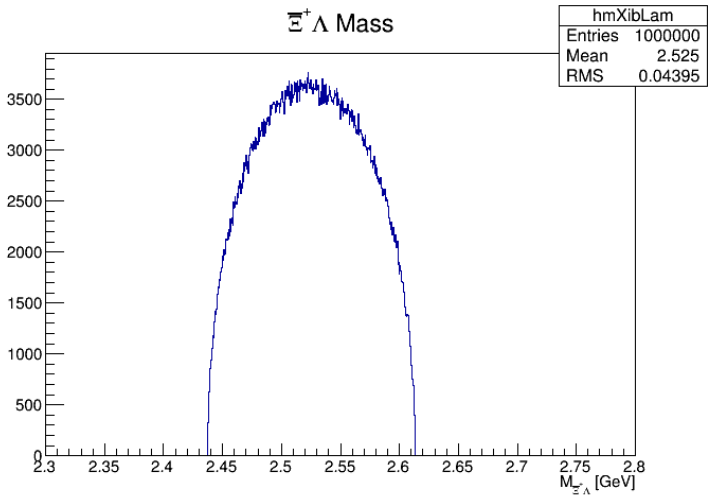
L_{c1} > 70 mm / cosθ : hits in last 2 discs

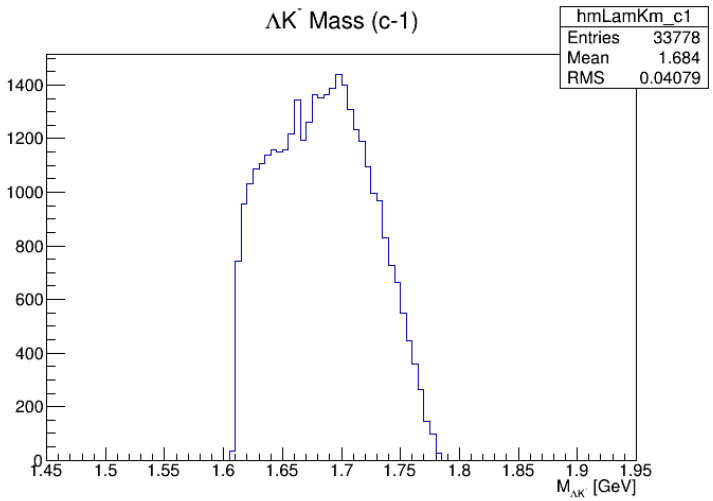
L_{c2} > 40 mm / sinθ : hits in inner two double layers

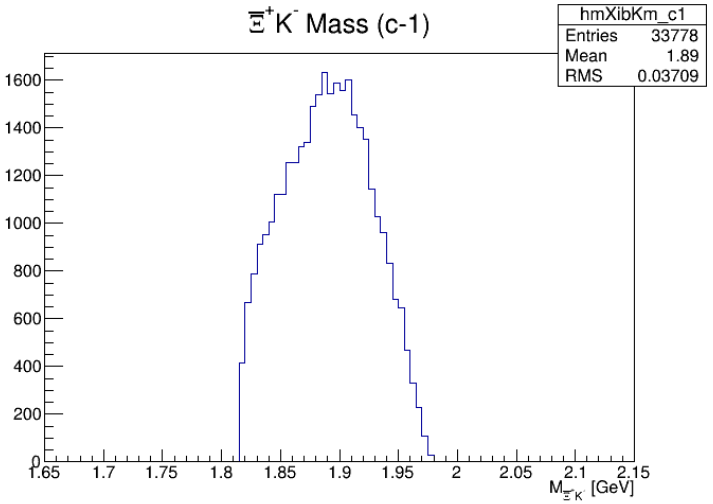
Effect on 2-Body Masses ($\Delta F_L > 0$)

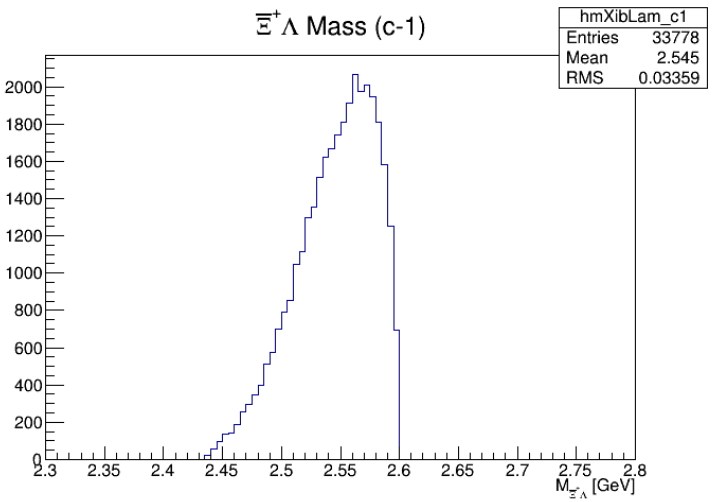




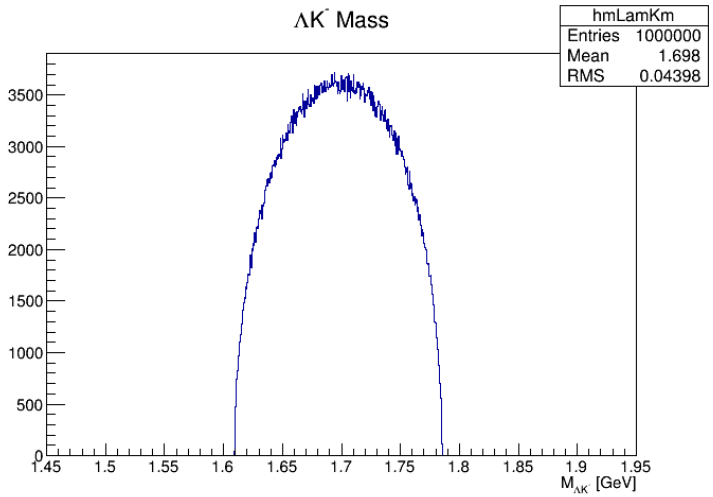


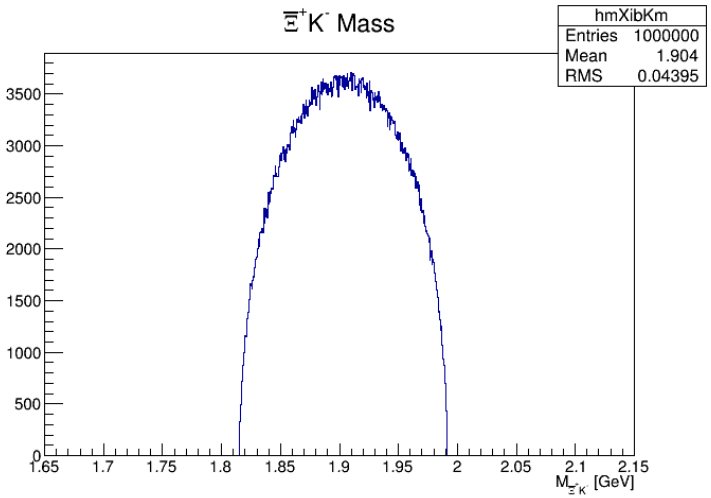


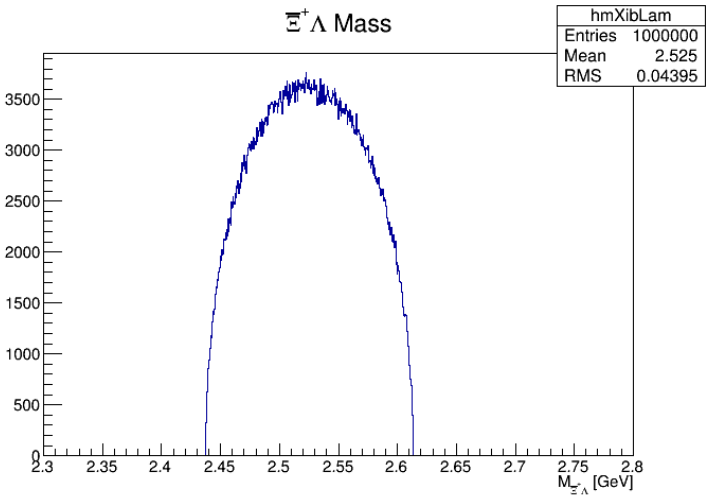


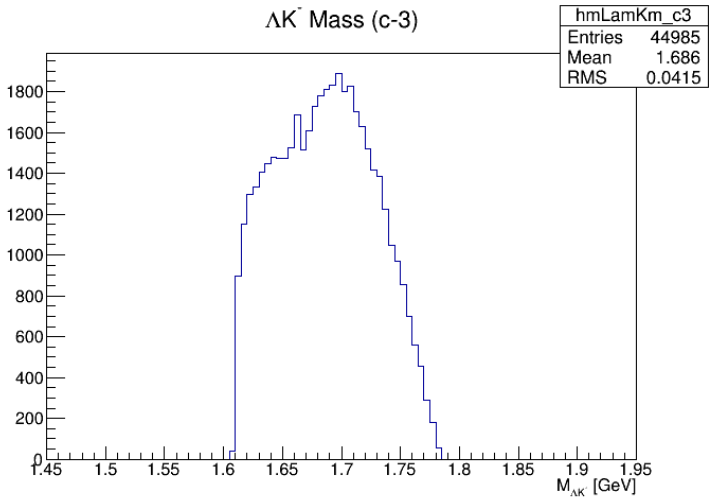


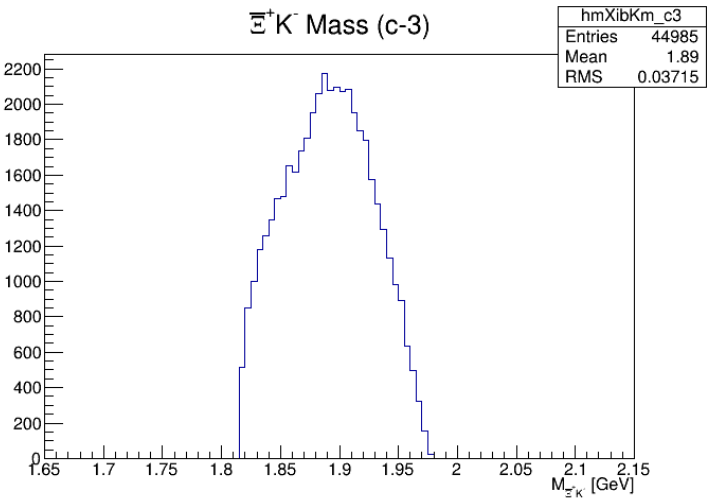
Effect on 2-Body Masses $(R > R_{crit}) \,||\, ((L_{MVD} > L_{c1}) \,\&\&\, (L_{STT} > L_{c2}))$

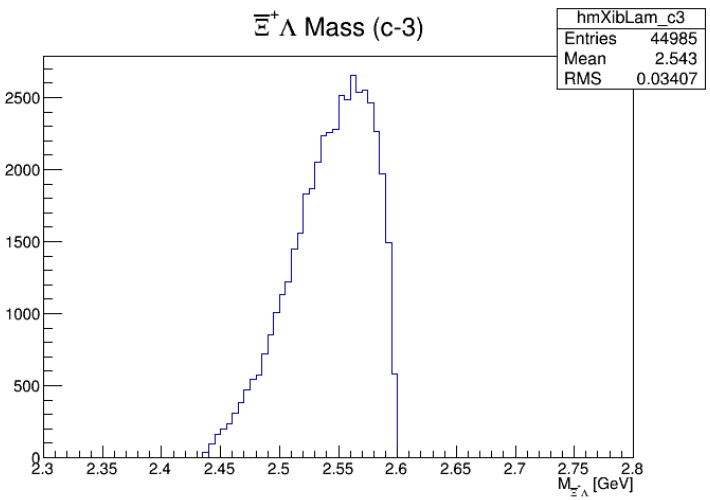




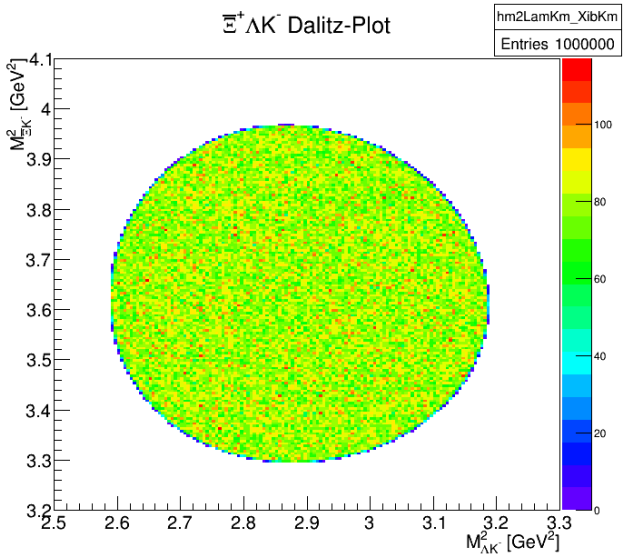


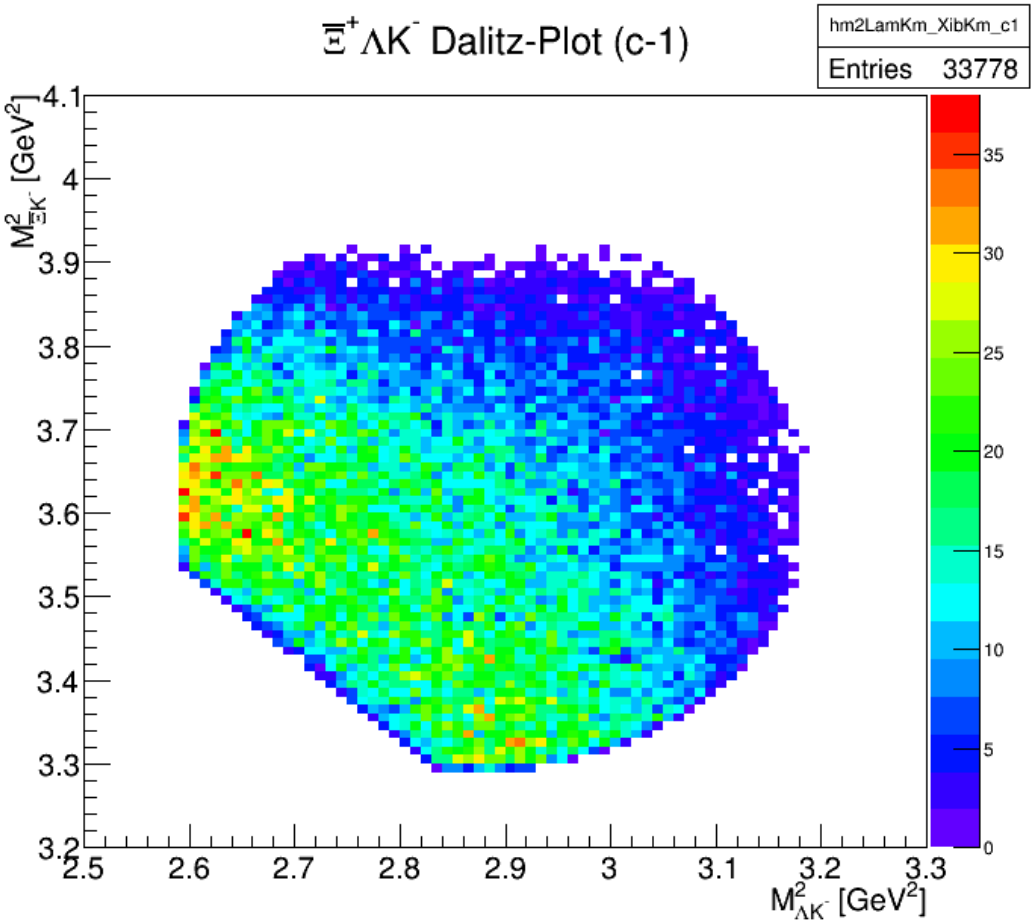


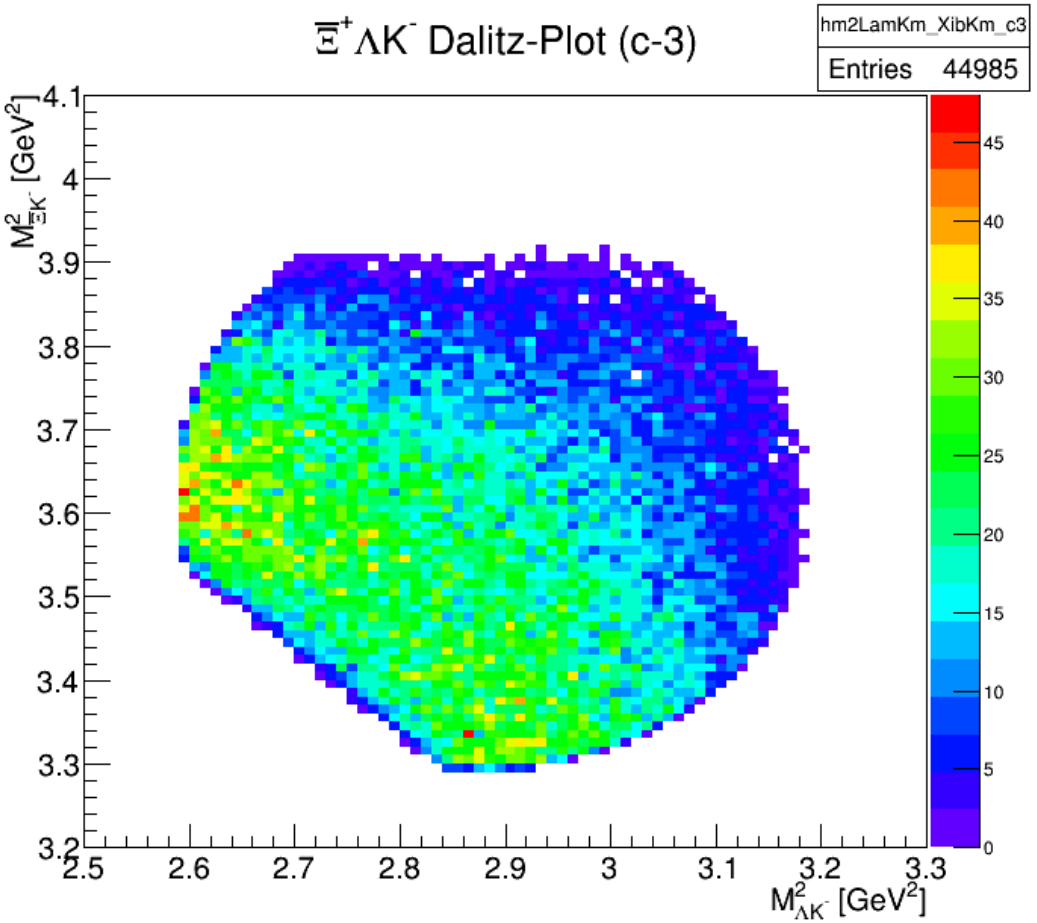




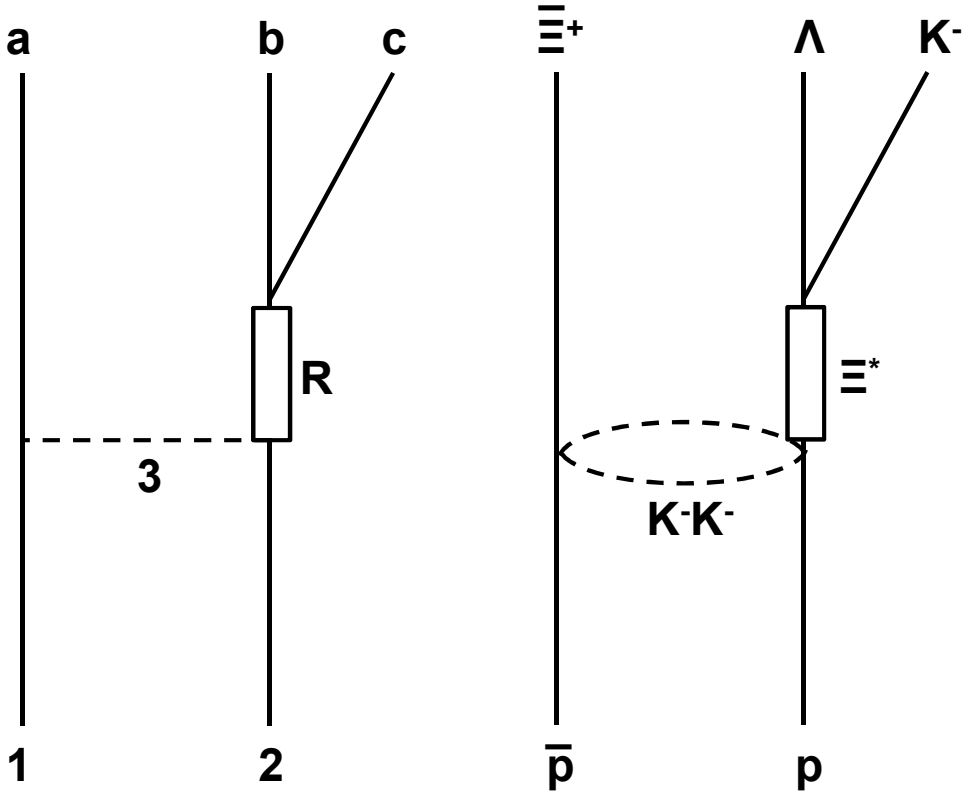
Effect on $\bar{\Xi}^{+}\Lambda K^{-}$ Dalitz Plot





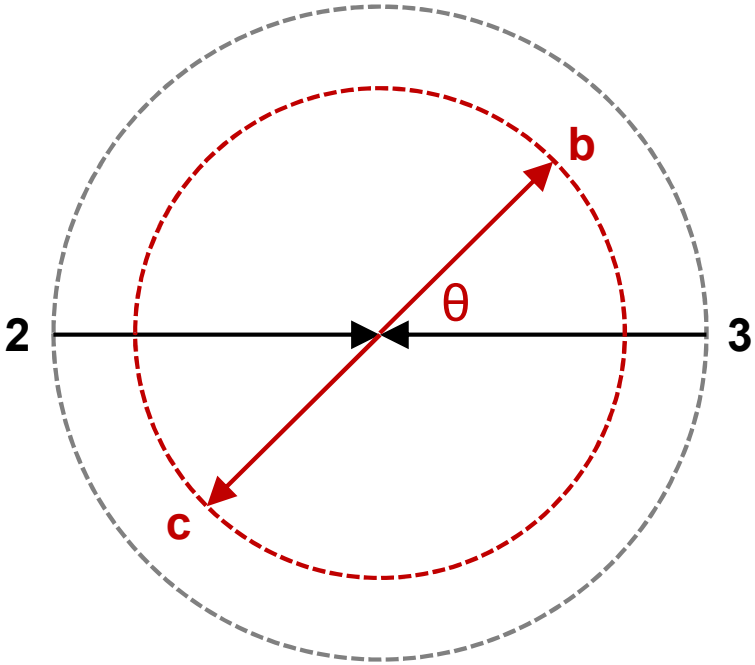


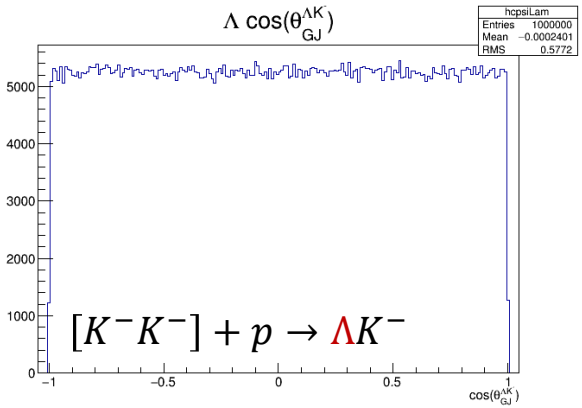
Angular Distribution in Gottfried-Jackson Frame

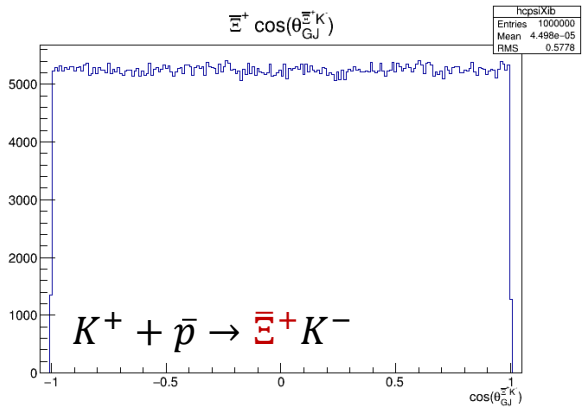


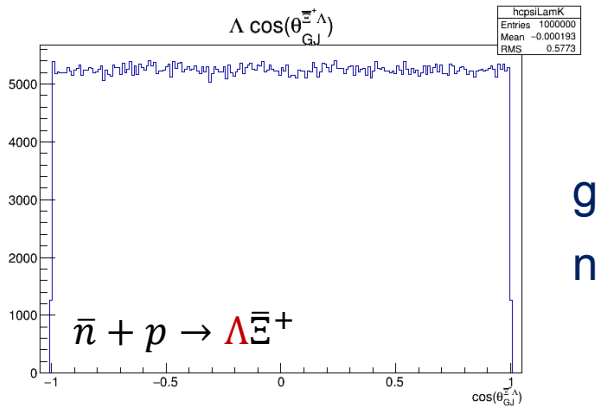
angular momentum visible in

2 + 3 → R → b + c





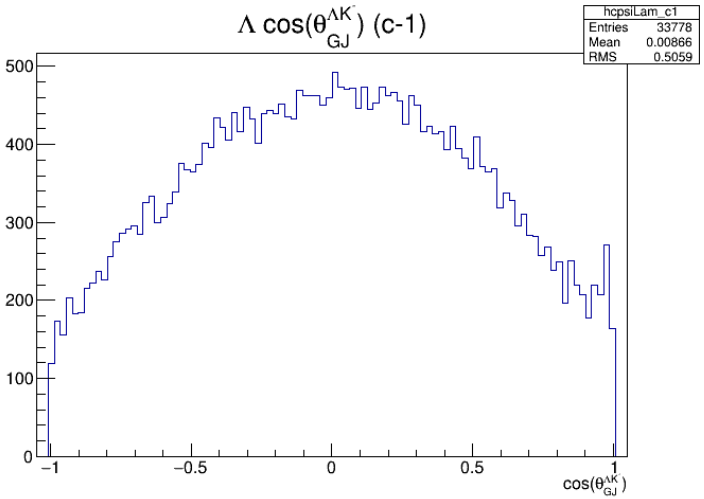


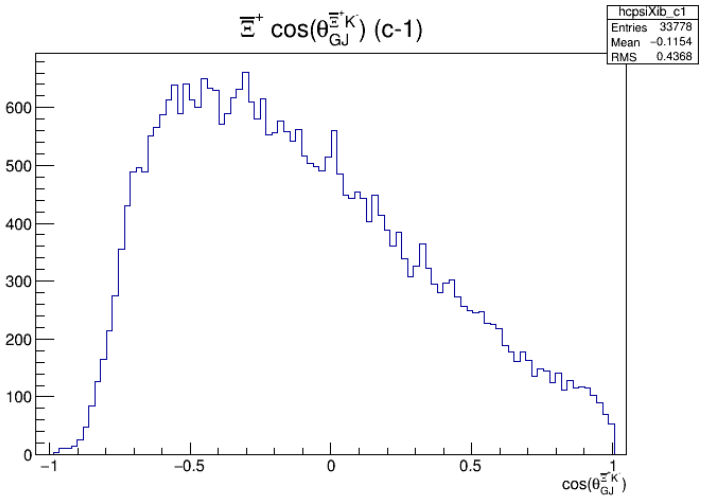


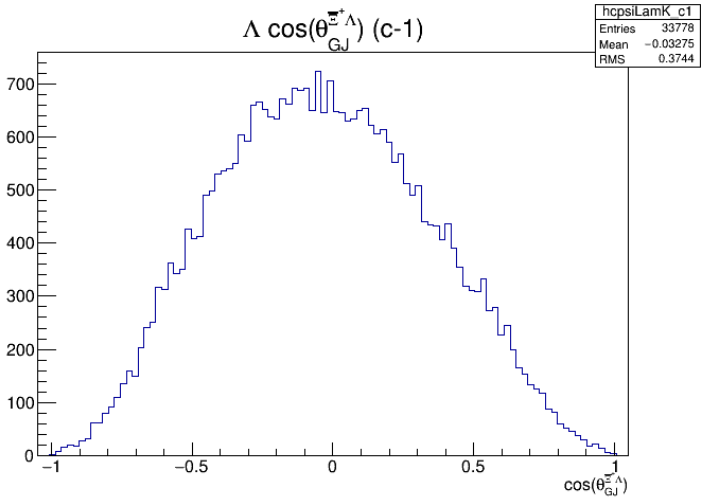
generated events,

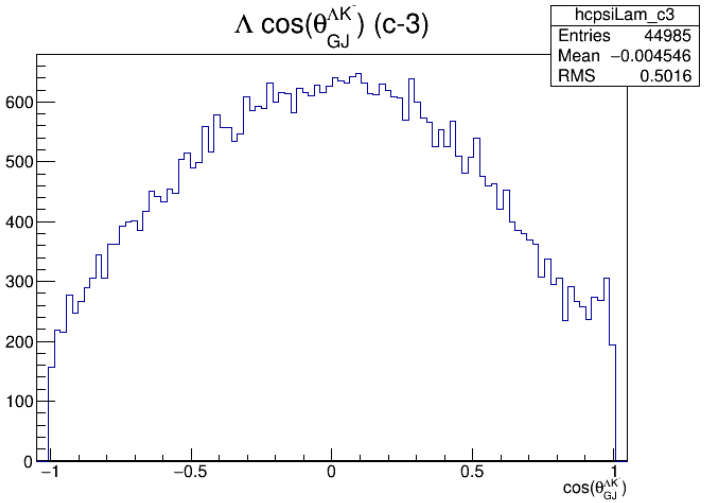
no condition

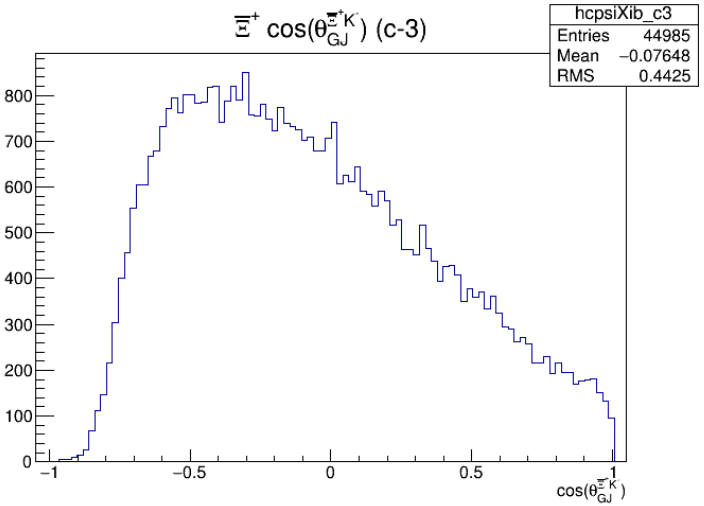
Effect on Angular Distribution (GJ Frame)

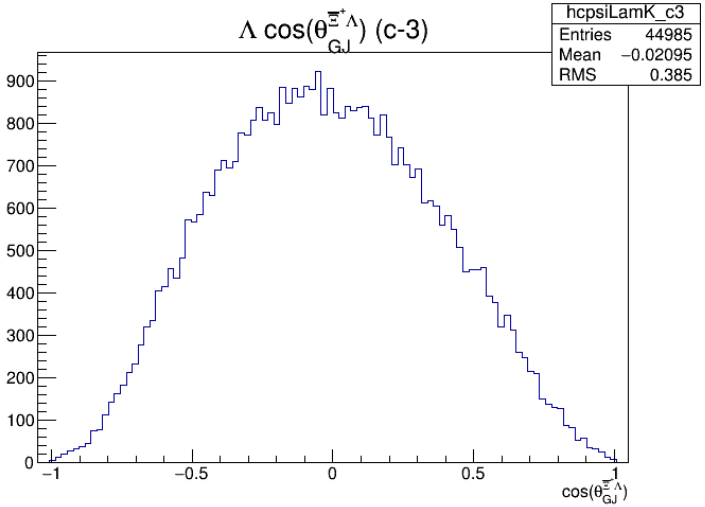










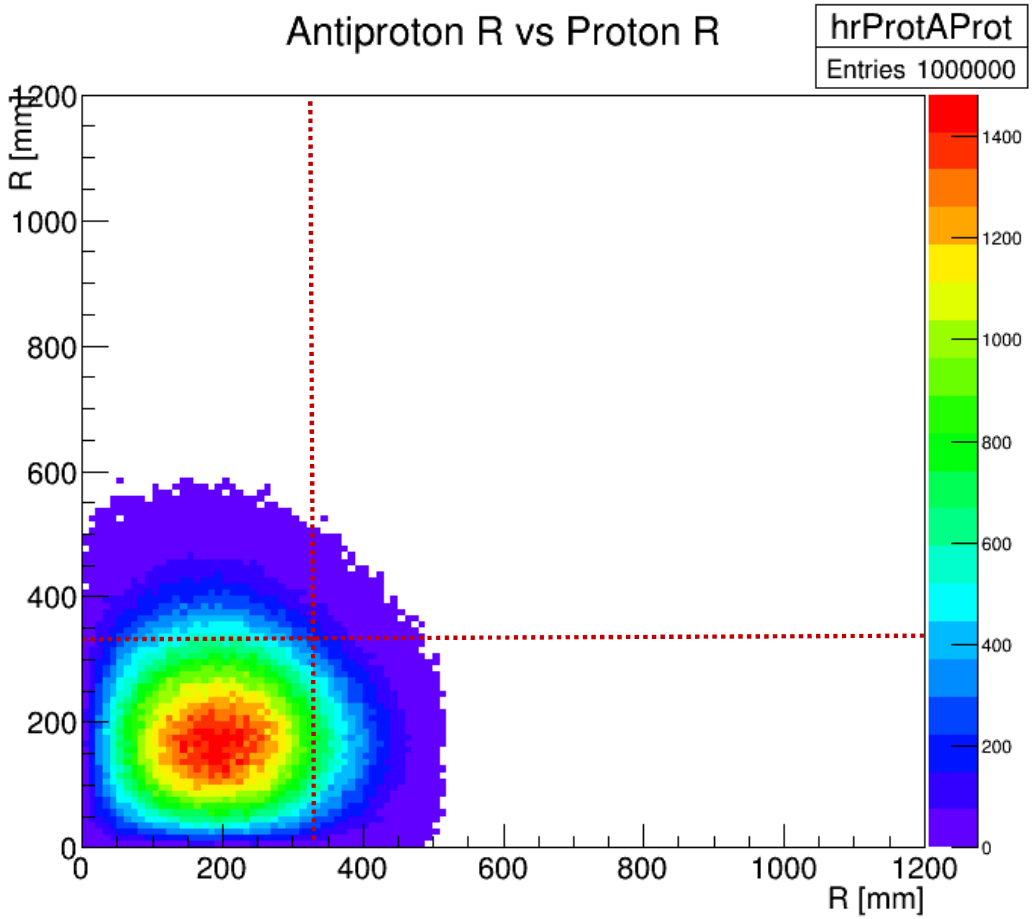


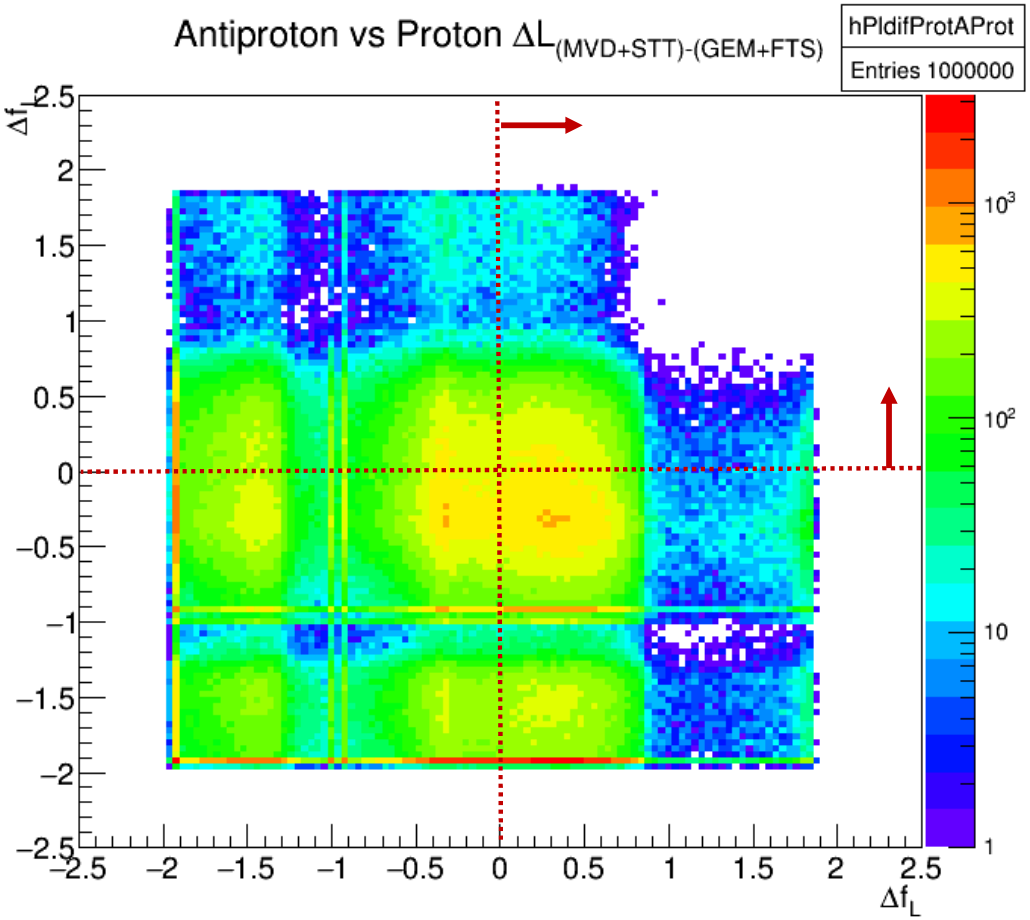
Conclusion

- This analysis is applicable for *all* reactions at *all* momenta.
- One obtains a qualitative but *quasi-immediate* answer on the effect of missing GEM and incomplete FTS.
- For the reaction 4.1 GeV/c $\bar{p}p \rightarrow \bar{\Xi}^{+}\Lambda K^{-}$, relevant for the study of $\Xi(1690)$ it demonstrates the importance of GEM & FTS; *using the "Start Setup" for this reaction will result in a dramatic loss of efficiency.*
- My personal conclusion: not a proof but strong evidence that GEM & FTS are mandatory for strange baryon spectroscopy; at least one of the two must be complete.

SPARE

$\bar{p}$ p Correlations





$R > R_{crit}$: $4.7 \cdot 10^{-3}$

$\Delta L > 0$: 0.101