

BGP in 2025

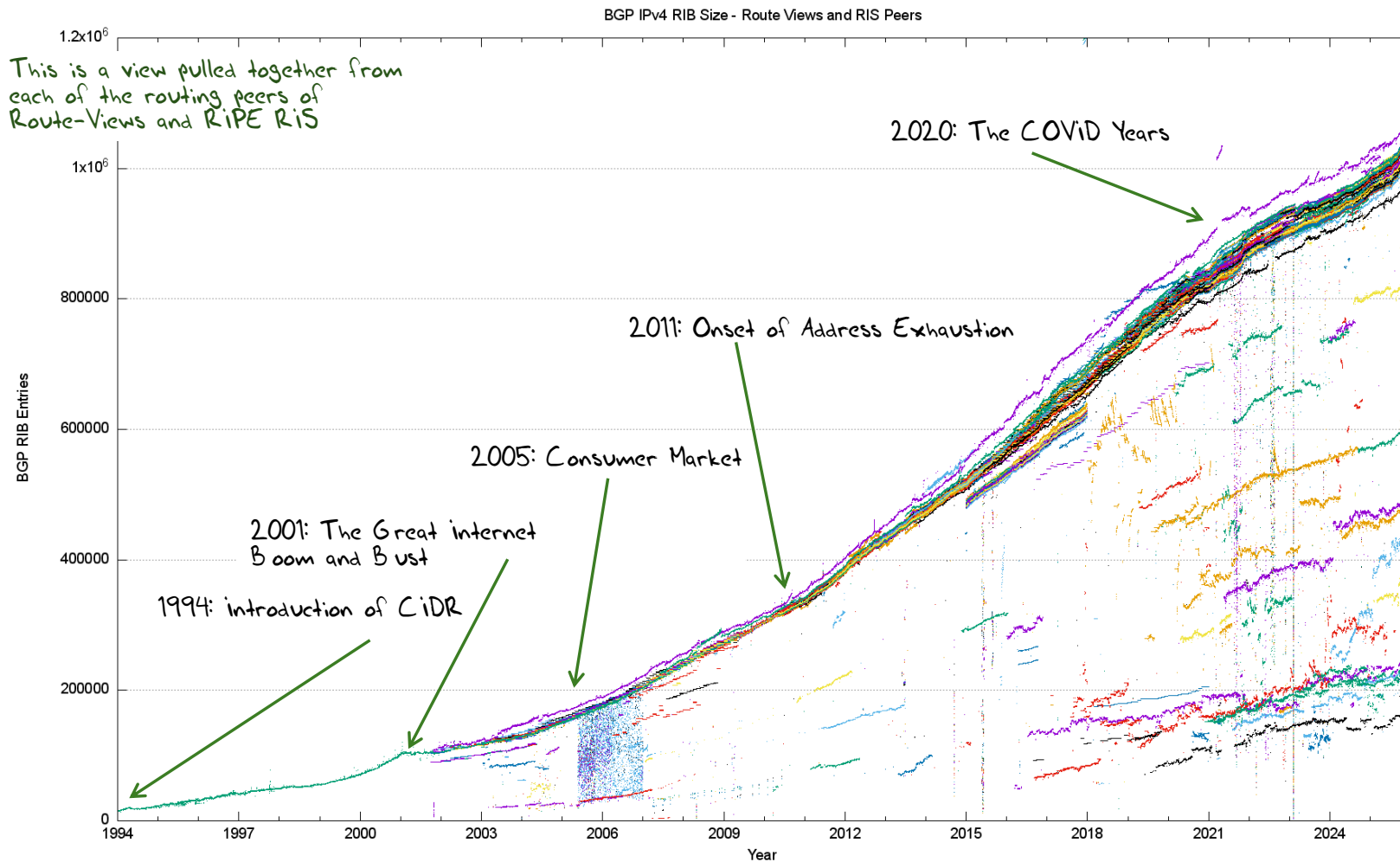
Geoff Huston

APNIC

This presentation

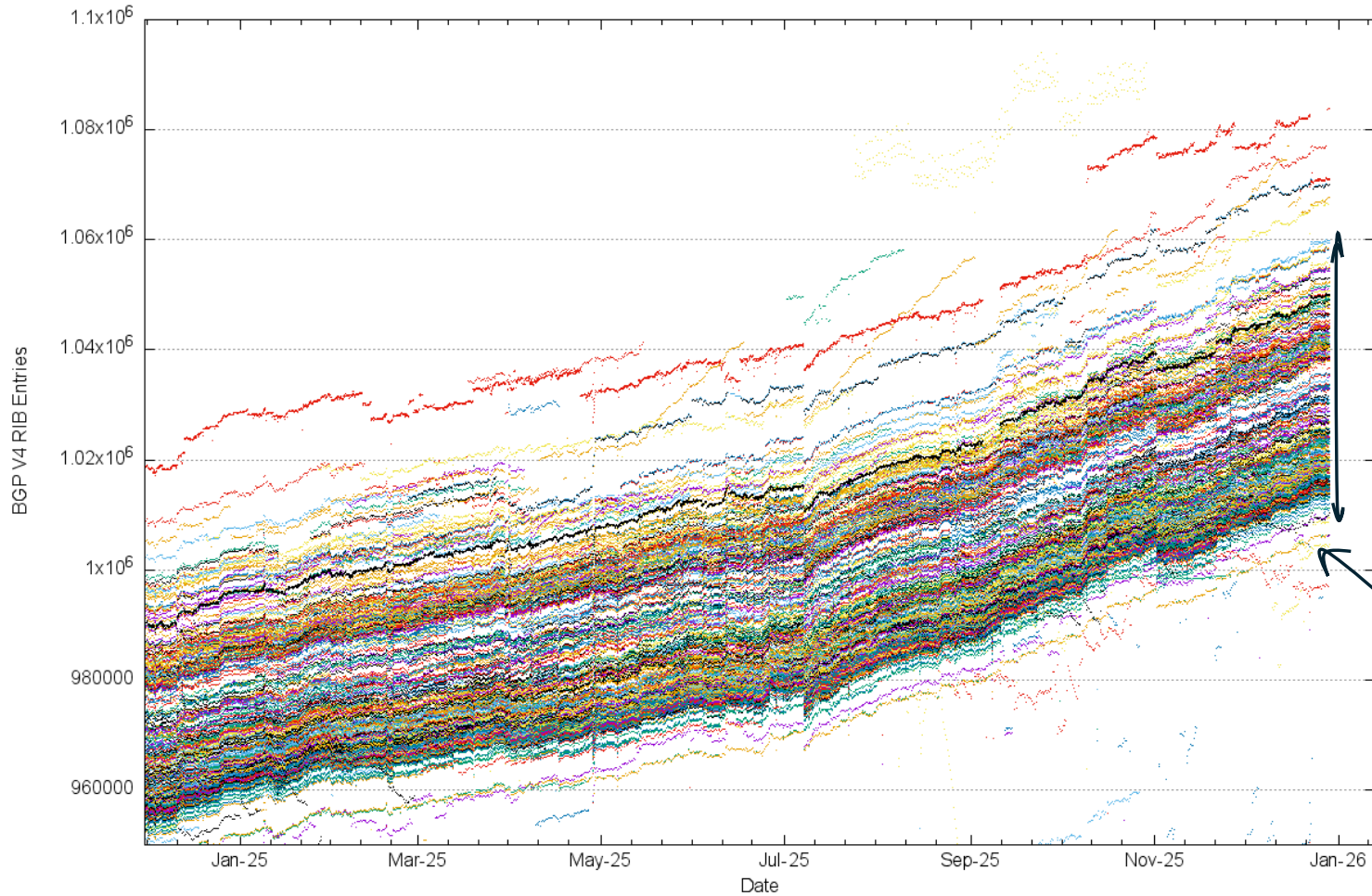
- IPv4 Routing Table
- IPv6 Routing Table
- FIB Projections
- Updates and Churn
- Conclusions

32 Years of Routing the IPv4 Internet - FIB Count



IPv4 in 2025

BGP IPv4 RIB Size - RIS and Route Views Peers

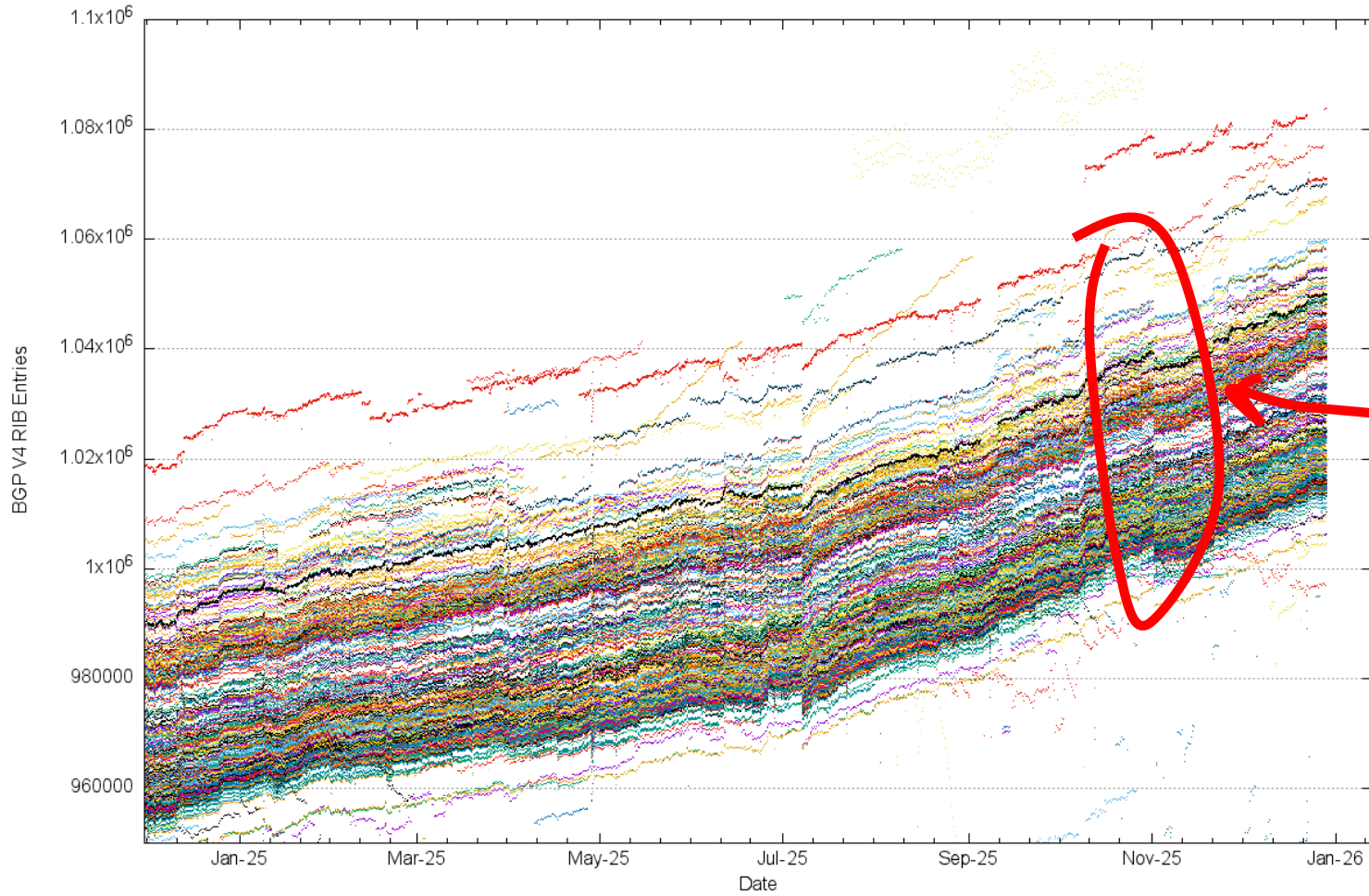


45K entry variation

The DFZ now exceeds 1M entries for ALL BGP peers

IPv4 in 2025

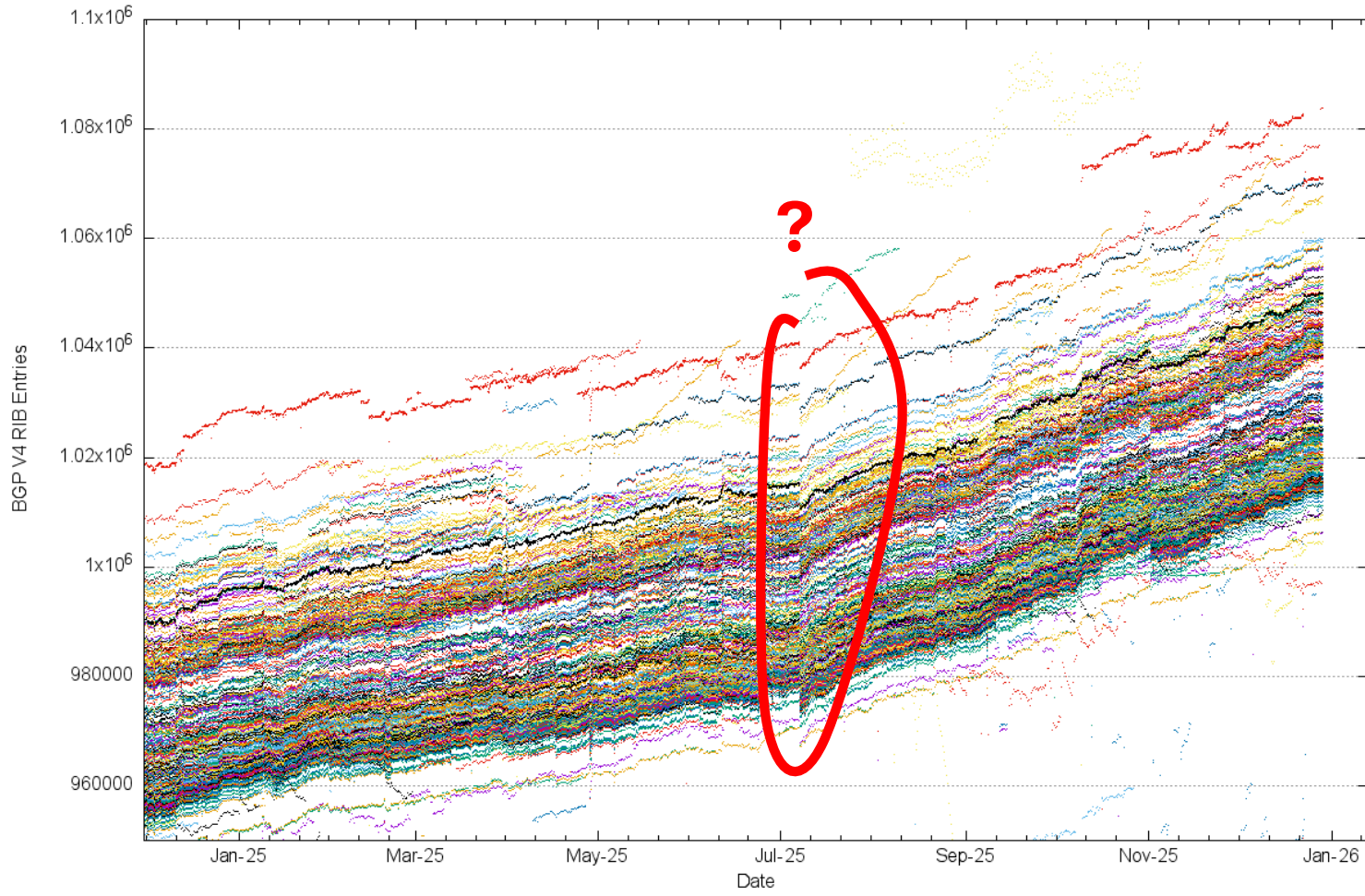
BGP IPv4 RIB Size - RIS and Route Views Peers



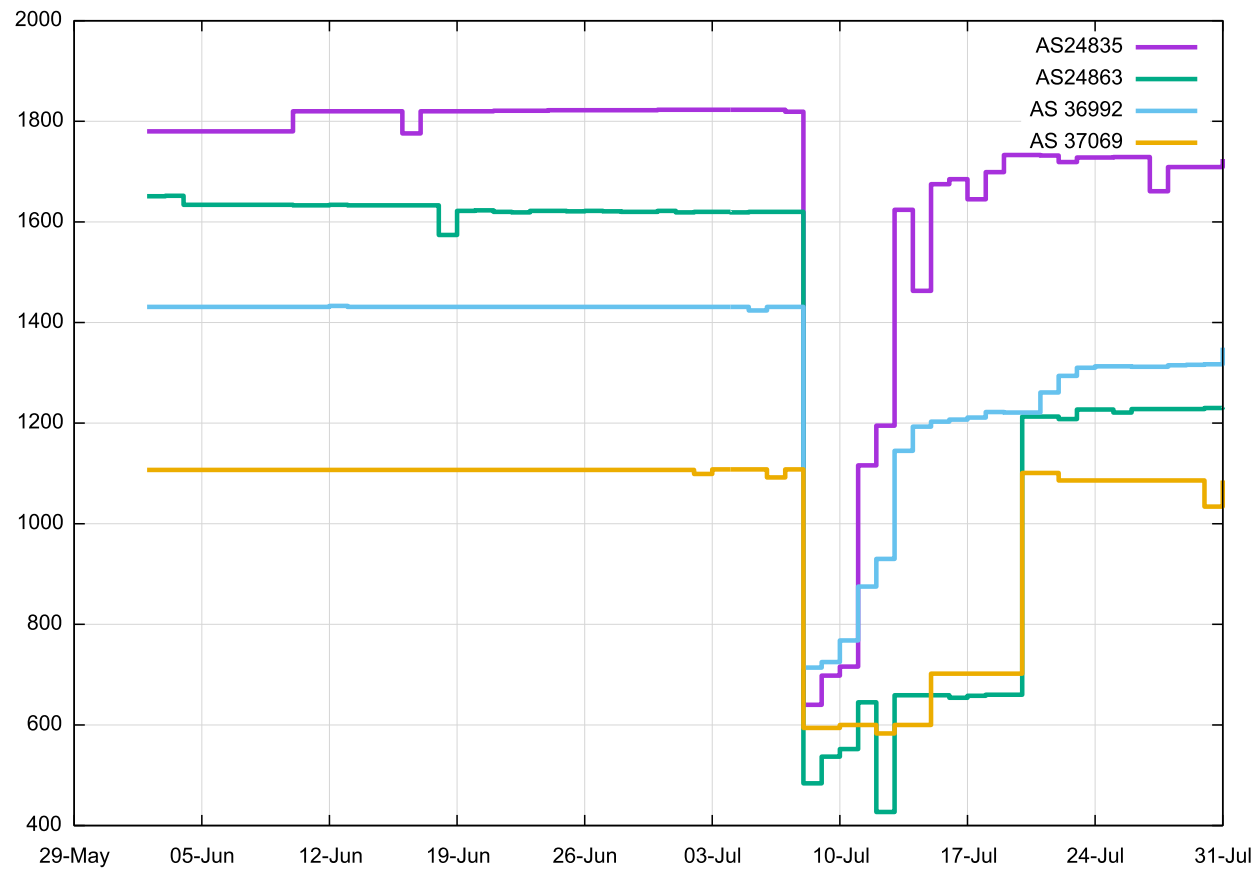
AS4155 - USDA
WDL 3,122 pfxs on 1-Nov

IPv4 in 2025

BGP IPv4 RIB Size - RIS and Route Views Peers



7 July 2025 - Egypt



On July 7, 2025, a major fire broke out at the Ramses Central building in Cairo, a critical telecommunications hub. The fire resulted in four deaths, dozens of injuries, and significant disruptions to Egypt's internet and telecommunications services. The incident also led to a temporary suspension of trading on the Cairo stock exchange and caused severe traffic congestion due to street closures.



Daily News Egypt

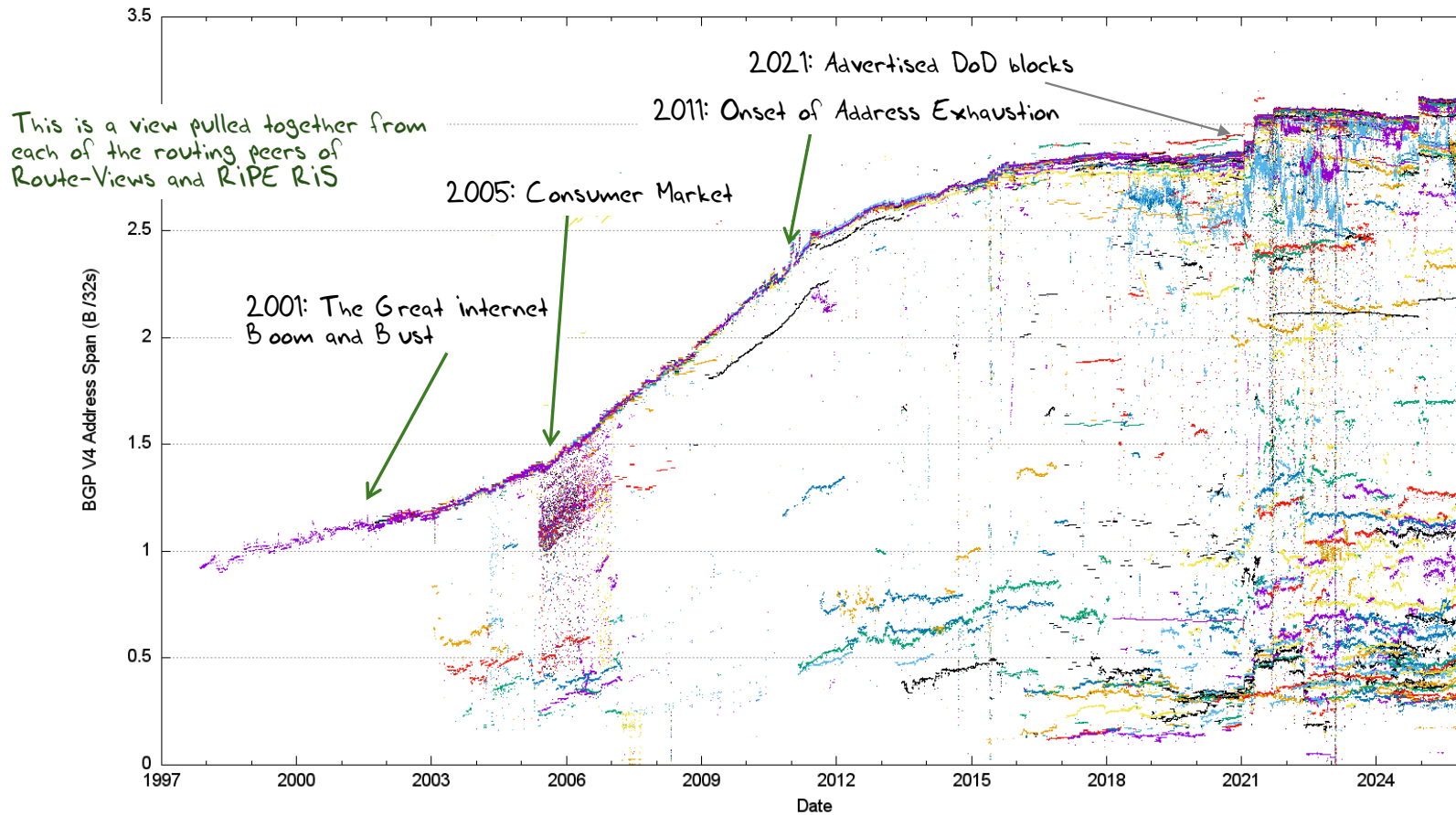
Announced Prefix Changes in 2025

| AS Num | Change | 1-Jan | 31-Dec | AS Name |
|----------|--------|--------|--------|--------------------------|
| AS9808 | 3,283 | 10,099 | 13,382 | China Mobile, CN |
| AS17561 | 1,886 | 948 | 2,834 | Larus, HK |
| AS56046 | 1,771 | 1,630 | 3,401 | China Mobile Jiangsu, CN |
| AS16509 | 1,531 | 12,473 | 14,004 | AMAZON-02,US |
| AS398781 | 1,193 | 41 | 1,234 | OSL-188,US |
| AS22773 | 1,173 | 3,574 | 4,747 | Cox Comms, US |
| AS8151 | 1,130 | 11,563 | 12,693 | UNINET,MX |
| AS11404 | 1,121 | 168 | 1,289 | AS-WAVE-1,US |
| AS6079 | 1,100 | 602 | 1,702 | RCN-AS,US |
| AS7459 | 1,063 | 463 | 1,526 | GRAND ECOM,US |
| AS9304 | 978 | 507 | 1,485 | Hutchison, HK |
| AS56045 | 927 | - | 927 | China Mobile Jiangxi, CN |
| AS44559 | 875 | 267 | 1,142 | ITHOSTLINE, CY |
| AS834 | 870 | 516 | 1,386 | IPXO,US |
| AS7029 | 756 | 1,775 | 2,531 | WINDSTREAM,US |

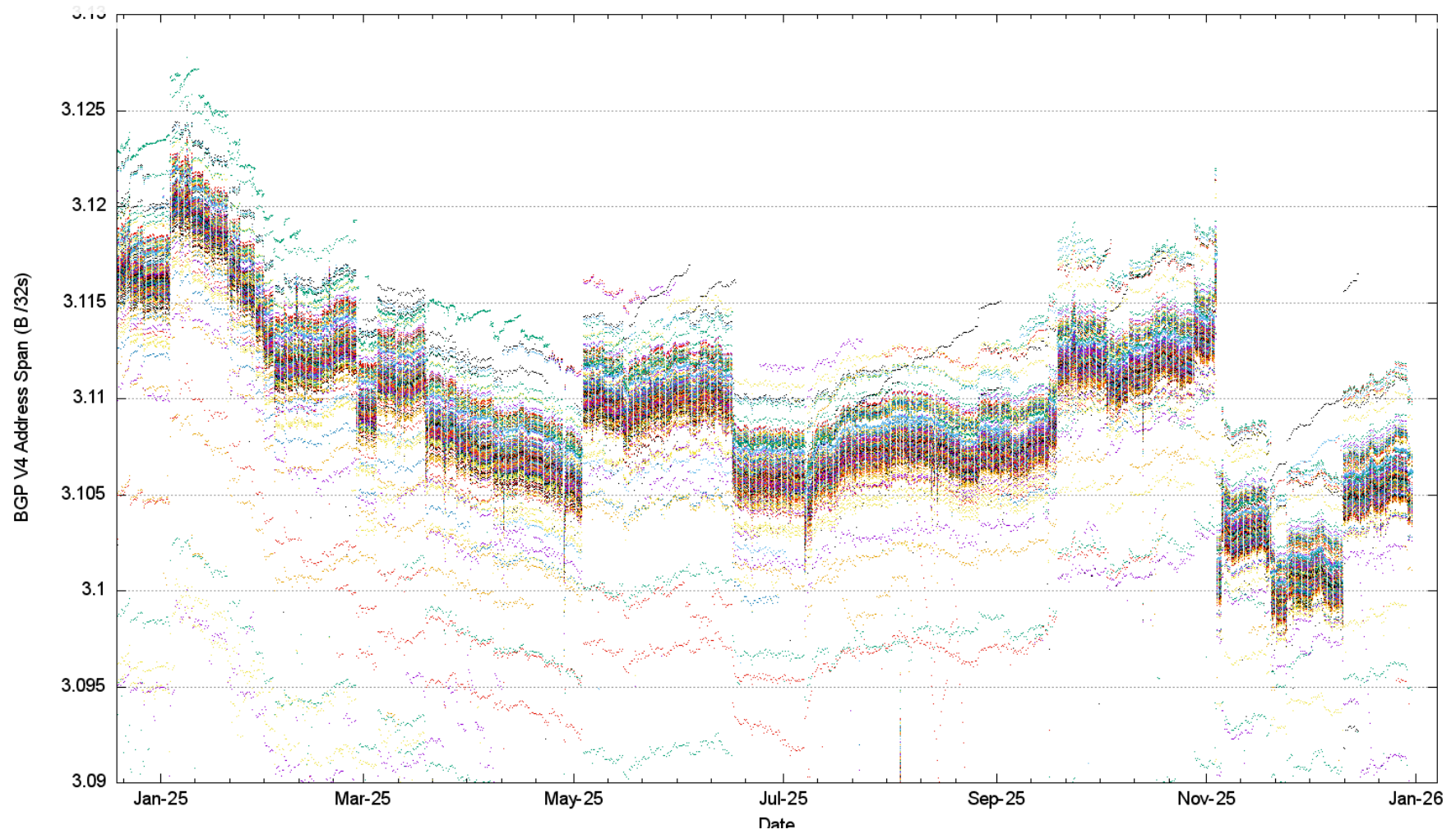
| AS Num | Change | 1-Jan | 31-Dec | AS Name |
|----------|--------|-------|--------|------------------------|
| AS7018 | -2,605 | 3,245 | 640 | AT&T, US |
| AS4155 | -2,268 | 2,291 | 23 | USDA-1, US |
| AS174 | -1,276 | 4,231 | 2,955 | COGENT, US |
| AS28202 | -1,116 | 1,126 | 10 | MASTER SA, BR |
| AS984 | -945 | 1,280 | 335 | OWS-NETWORK, US |
| AS367 | -704 | 2,510 | 1,806 | DNIC, US |
| AS8100 | -647 | 670 | 23 | QUADRANET, US |
| AS6389 | -578 | 633 | 55 | BELLSOUTH, US |
| AS45271 | -510 | 905 | 395 | Vodafone Idea, IN |
| AS140224 | -473 | 498 | 25 | NEBULA, US |
| AS6503 | -441 | 1,167 | 726 | Axtel, MX |
| AS203999 | -428 | 521 | 93 | GEEKYWORKS, IN |
| AS12479 | -420 | 7,700 | 7,280 | UNI2, ES |
| AS29571 | -398 | 1,470 | 1,072 | ORANGE COTE-IVOIRE, CI |
| AS15133 | -384 | 404 | 20 | EDGECAST, US |

32 Years of Routing the IPv4 Internet - Address Span

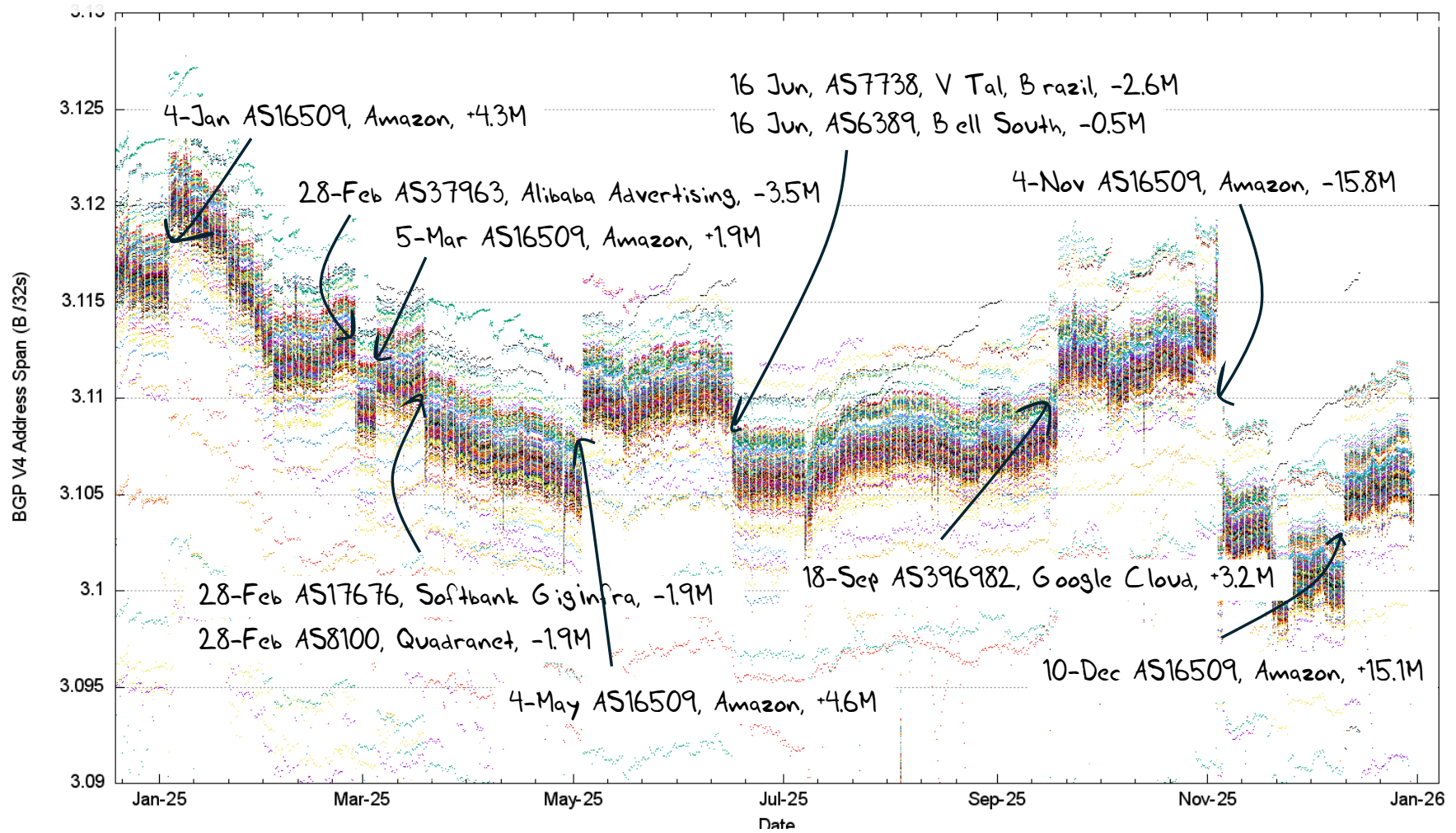
BGP IPv4 Routed Address Span - RIS and Route Views Peers



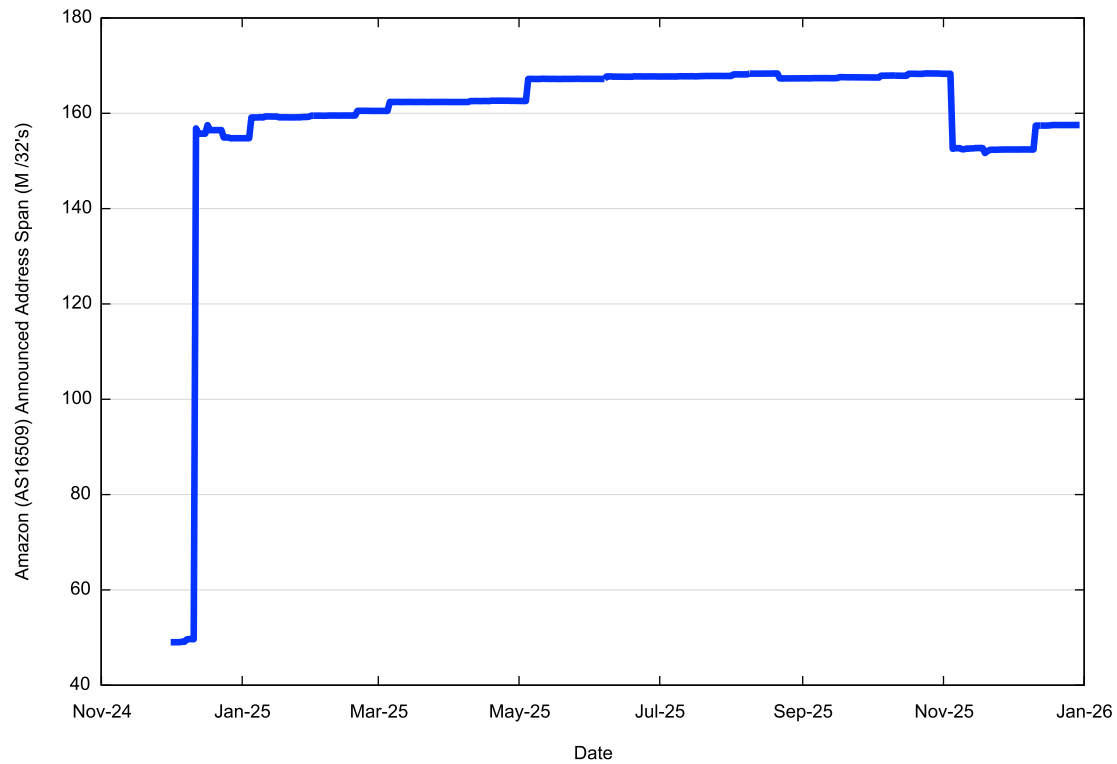
2025 in Detail



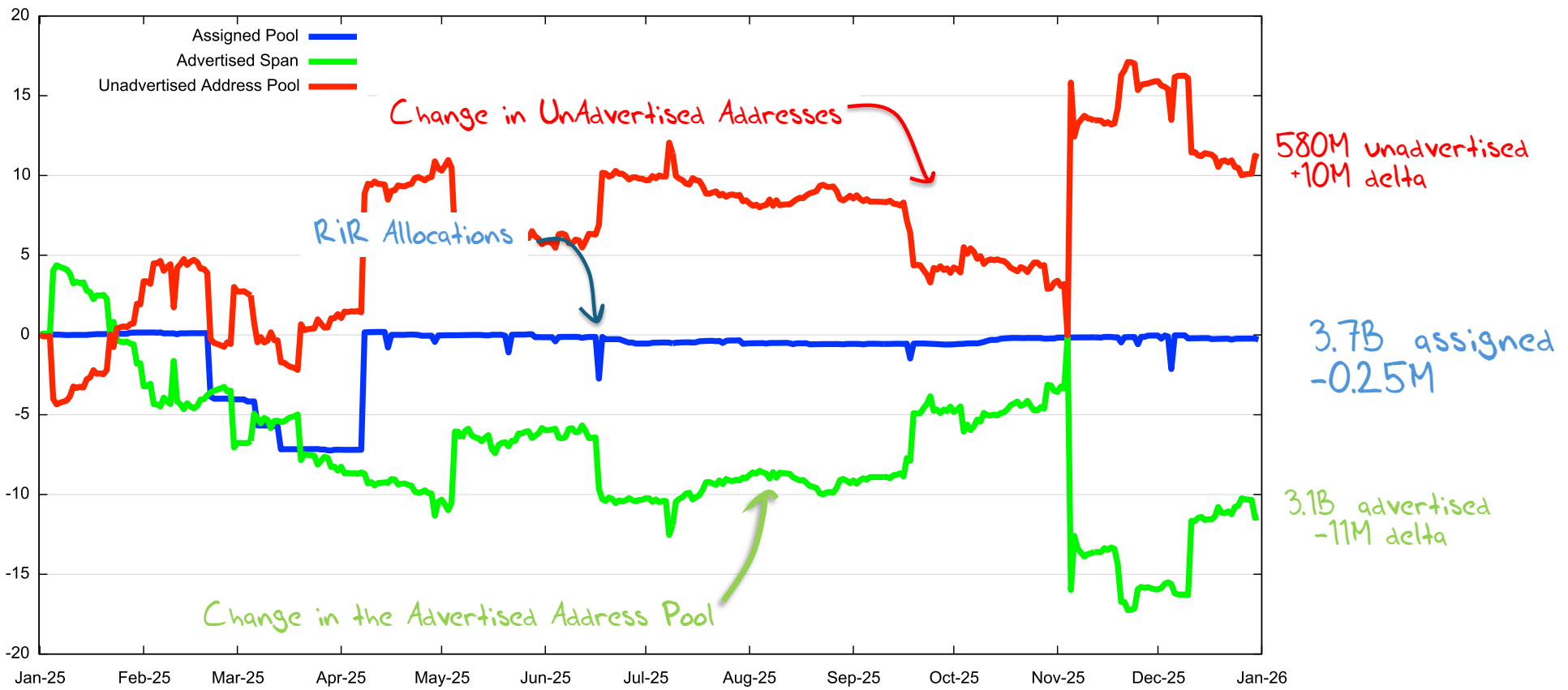
2025 in Detail



AS16509 - Amazon in 2025



2025: Assigned vs Recovered Addresses



Announced Address Span Changes in 2025

| AS Num | Change | 1-Jan | 31-Dec | AS Name |
|----------|-----------|------------|------------|--------------------------|
| AS396982 | 4,935,168 | 14,976,000 | 19,911,168 | GOOGLE-CLOUD, US |
| AS56 | 3,946,752 | 3,818,496 | 7,765,248 | DNIC, US |
| AS2856 | 3,627,776 | 12,266,240 | 15,894,016 | BTnet, GB |
| AS6167 | 3,142,400 | 13,937,408 | 17,079,808 | CELLCO, US |
| AS8434 | 2,646,016 | - | 2,646,016 | TELENOR, SE |
| AS4155 | 2,478,848 | 668,928 | 3,147,776 | USDA, US |
| AS56045 | 1,968,128 | - | 1,968,128 | China Mobile JIANGXI, CN |
| AS9141 | 1,607,680 | 4,608 | 1,612,288 | P4 Play, PL |
| AS31898 | 1,275,136 | 3,305,472 | 4,580,608 | ORACLE, US |
| AS14618 | 1,234,944 | 18,201,344 | 19,436,288 | AMAZON-AES, US |
| AS6079 | 1,152,512 | 1,728,768 | 2,881,280 | Astound Broadband, US |
| AS25019 | 1,149,952 | 4,317,440 | 5,467,392 | SAUDI NET, SA |
| AS11404 | 1,145,600 | 763,136 | 1,908,736 | AS-WAVE, US |
| AS1540 | 1,144,832 | - | 1,144,832 | DNIC, US |
| AS45102 | 1,112,064 | 3,658,240 | 4,770,304 | Alibaba, CN |

| AS Num | Change | 1-Jan | 31-Dec | AS Name |
|---------|------------|-------------|-------------|-------------------------|
| AS15169 | -7,266,816 | 9,153,024 | 1,886,208 | GOOGLE, US |
| AS367 | -4,268,544 | 12,336,640 | 8,068,096 | DNIC, US |
| AS7738 | -3,534,848 | 7,400,448 | 3,865,600 | Vtal, BR |
| AS7018 | -3,494,912 | 96,310,272 | 92,815,360 | AT&T, US |
| AS12576 | -3,493,888 | 3,564,032 | 70,144 | EE, GB |
| AS17676 | -2,830,080 | 40,431,872 | 37,601,792 | GIGA INFRA SoftBank, JP |
| AS37963 | -2,816,768 | 12,052,992 | 9,236,224 | Alibaba, CN |
| AS2119 | -2,648,320 | 6,895,616 | 4,247,296 | TELENOR, NO |
| AS16509 | -2,355,712 | 154,764,288 | 152,408,576 | AMAZON-02, US |
| AS7922 | -2,084,864 | 70,110,720 | 68,025,856 | COMCAST, US |
| AS6830 | -1,637,120 | 2,761,984 | 1,124,864 | Liberty Global, NL |
| AS6389 | -1,311,232 | 5,899,520 | 4,588,288 | BELLSOUTH, US |
| AS37518 | -1,113,344 | 1,114,112 | 768 | FIBER GRID, SC |
| AS984 | -1,037,312 | 1,207,808 | 170,496 | OWS, US |
| AS721 | -996,352 | 73,097,472 | 72,101,120 | DNIC, US |

The advertised table shrunk by 11M /32's over 2025

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The advertised table shrunk by 11M /32's over 2025

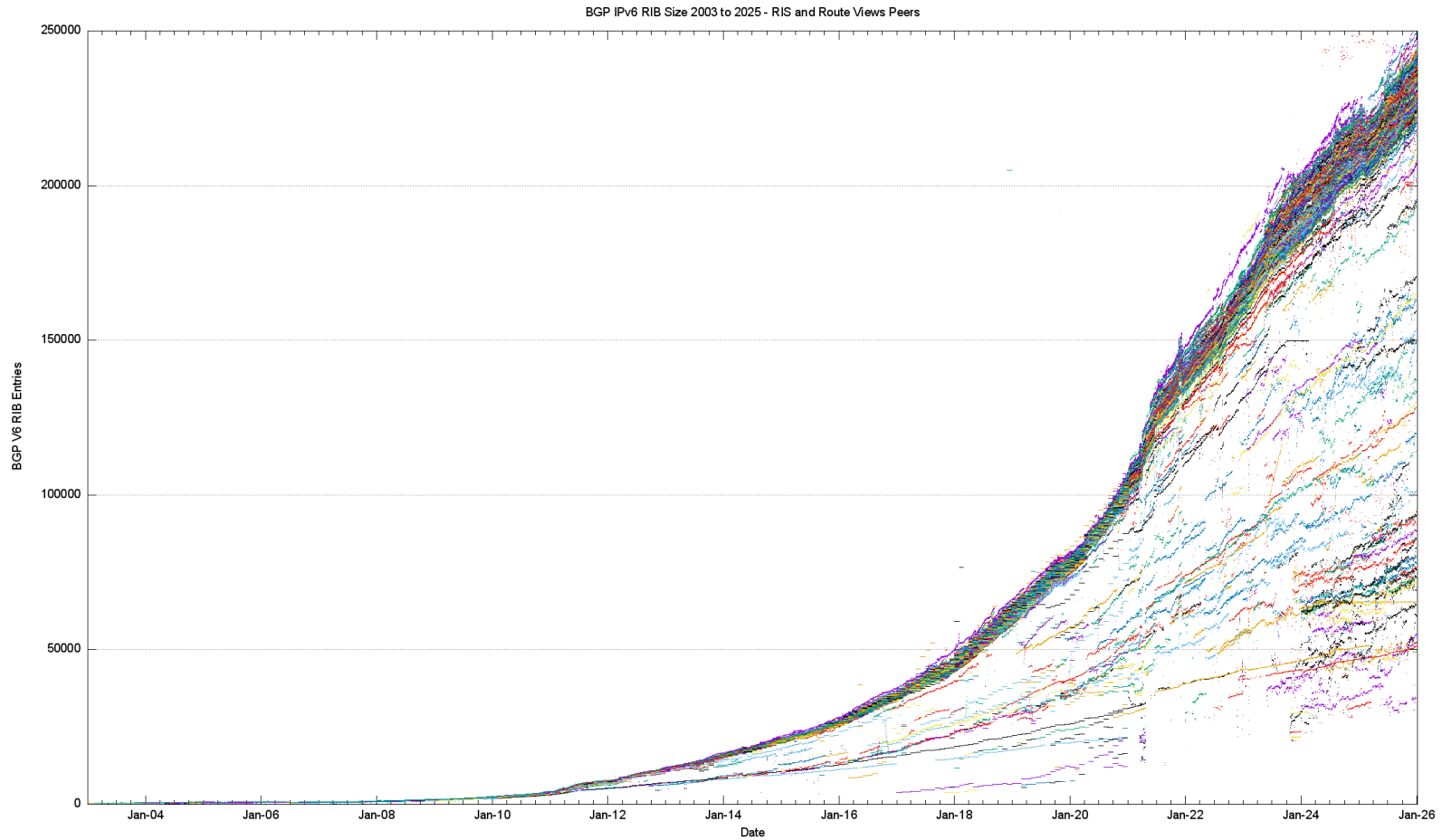
What Happened in 2025 in V4

- The size of the FIB table is growing, but the span of advertised addresses is declining
- V4 Address use in access networks is declining in some markets, notably the US
- V4 address use in Cloud infrastructure is still increasing
- Use of more specific entries in IPv4 fell from 52.9% of all advertised V4 prefixes to 51.8%

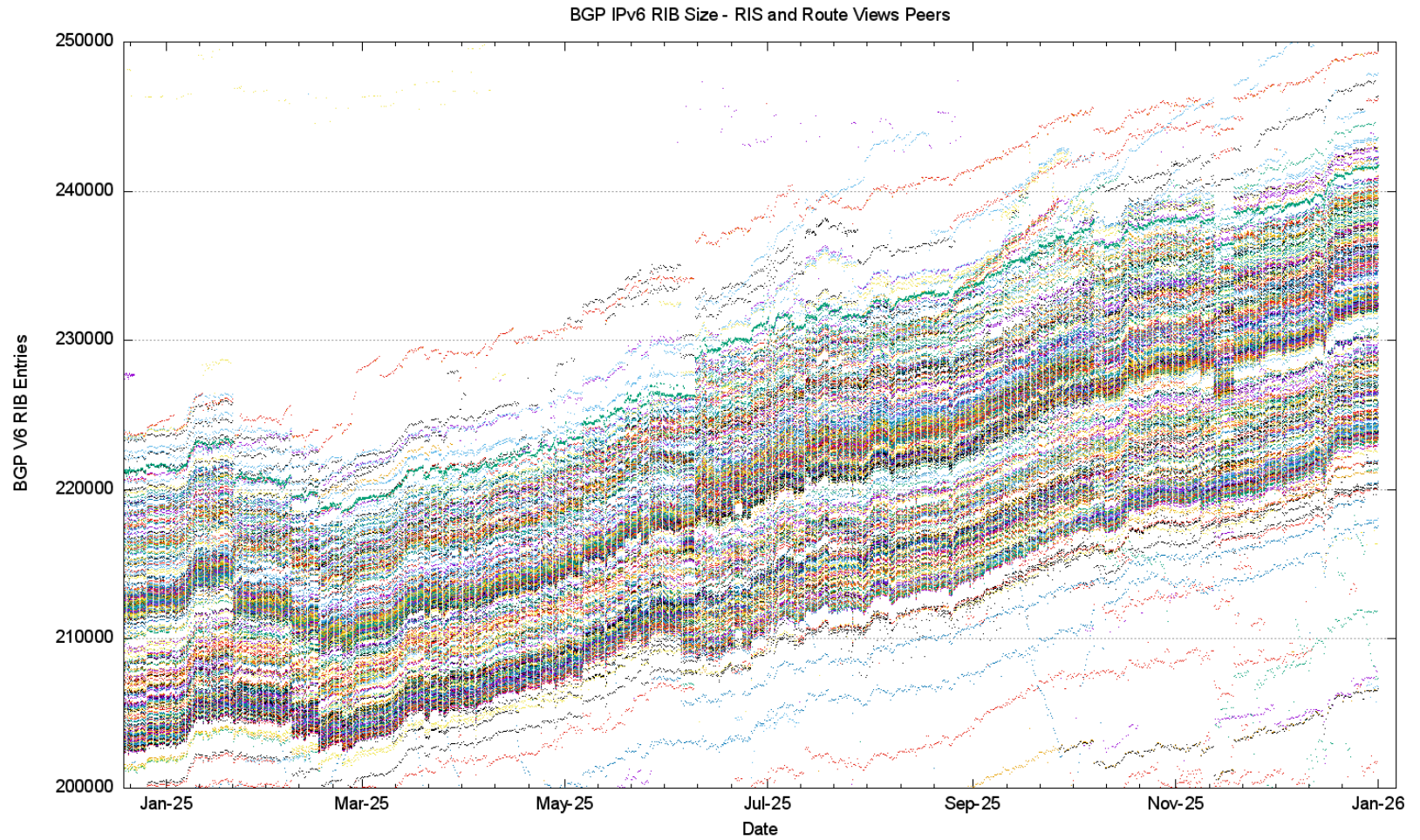
This presentation

- IPv4 Routing Table
- IPv6 Routing Table
- FIB Projections
- Updates and Churn
- Conclusions

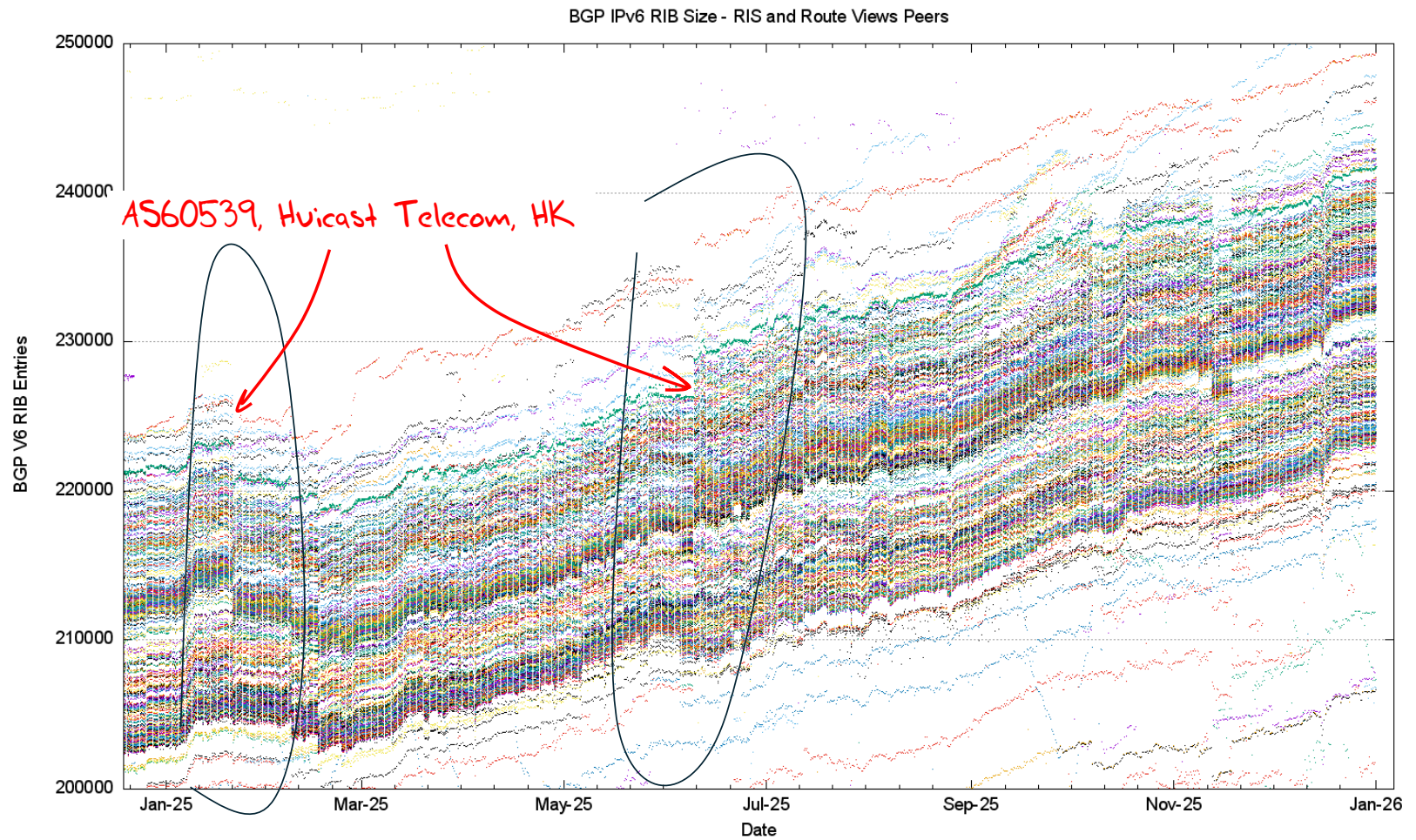
The 20-Year View of IPv6



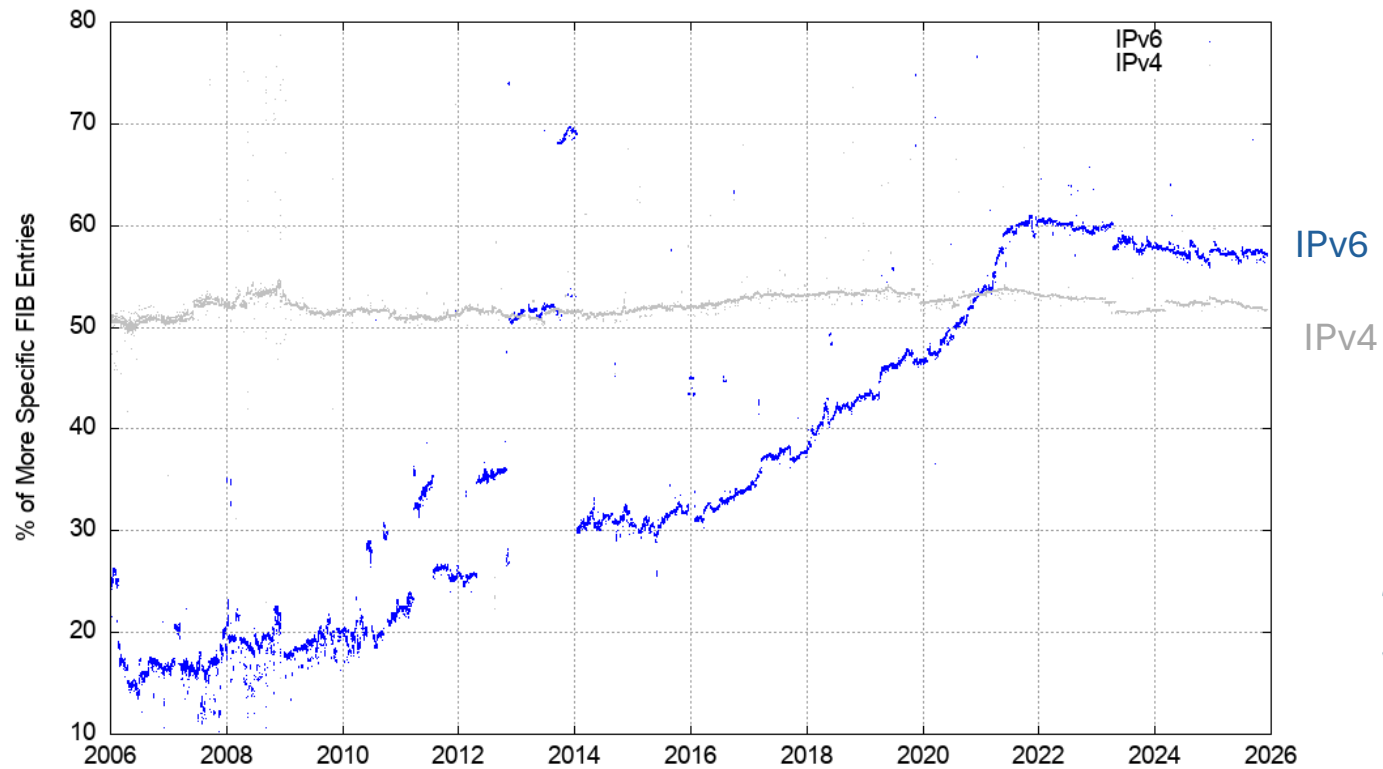
IPv6 in 2025



IPv6 in 2025

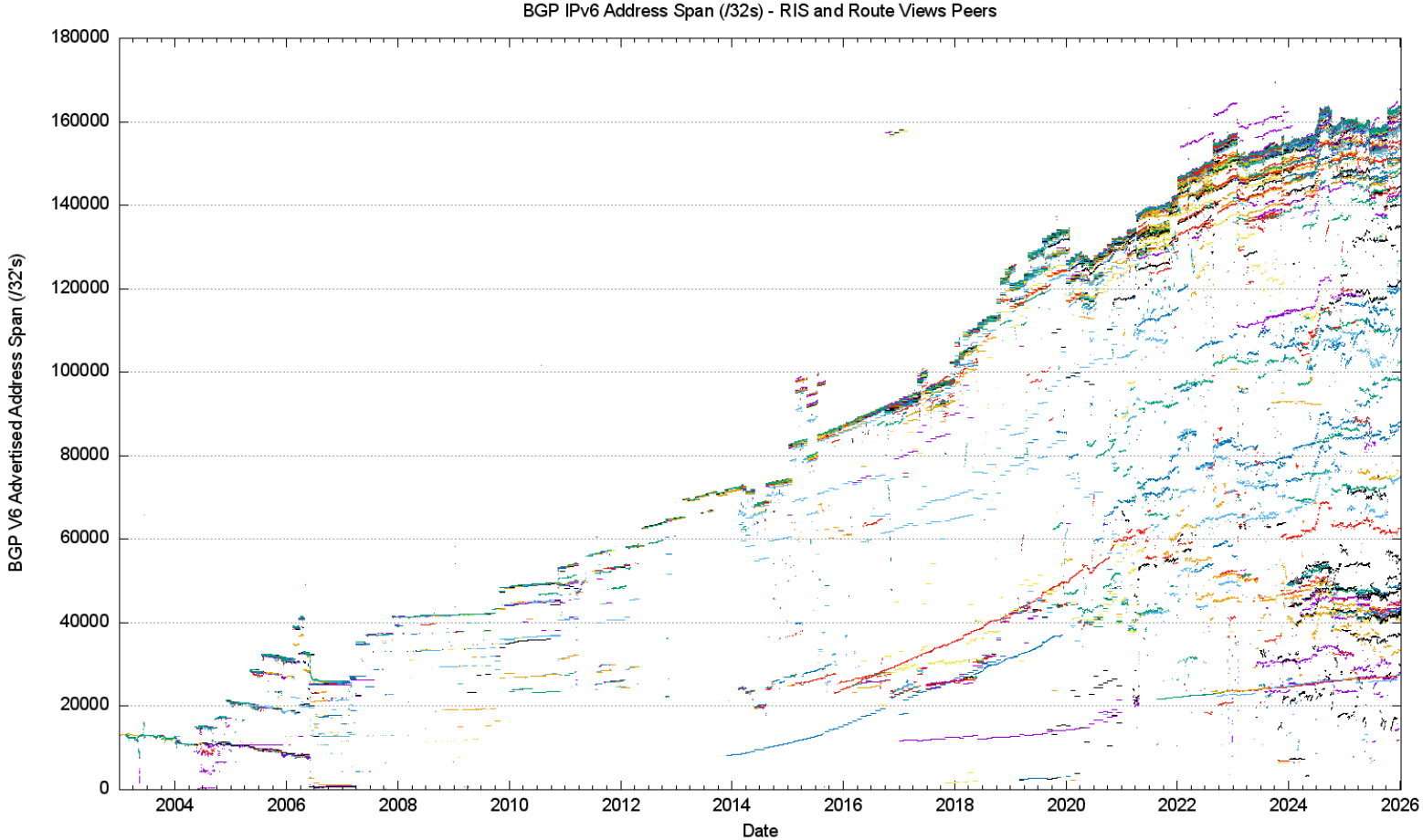


More Specifics in IPv6



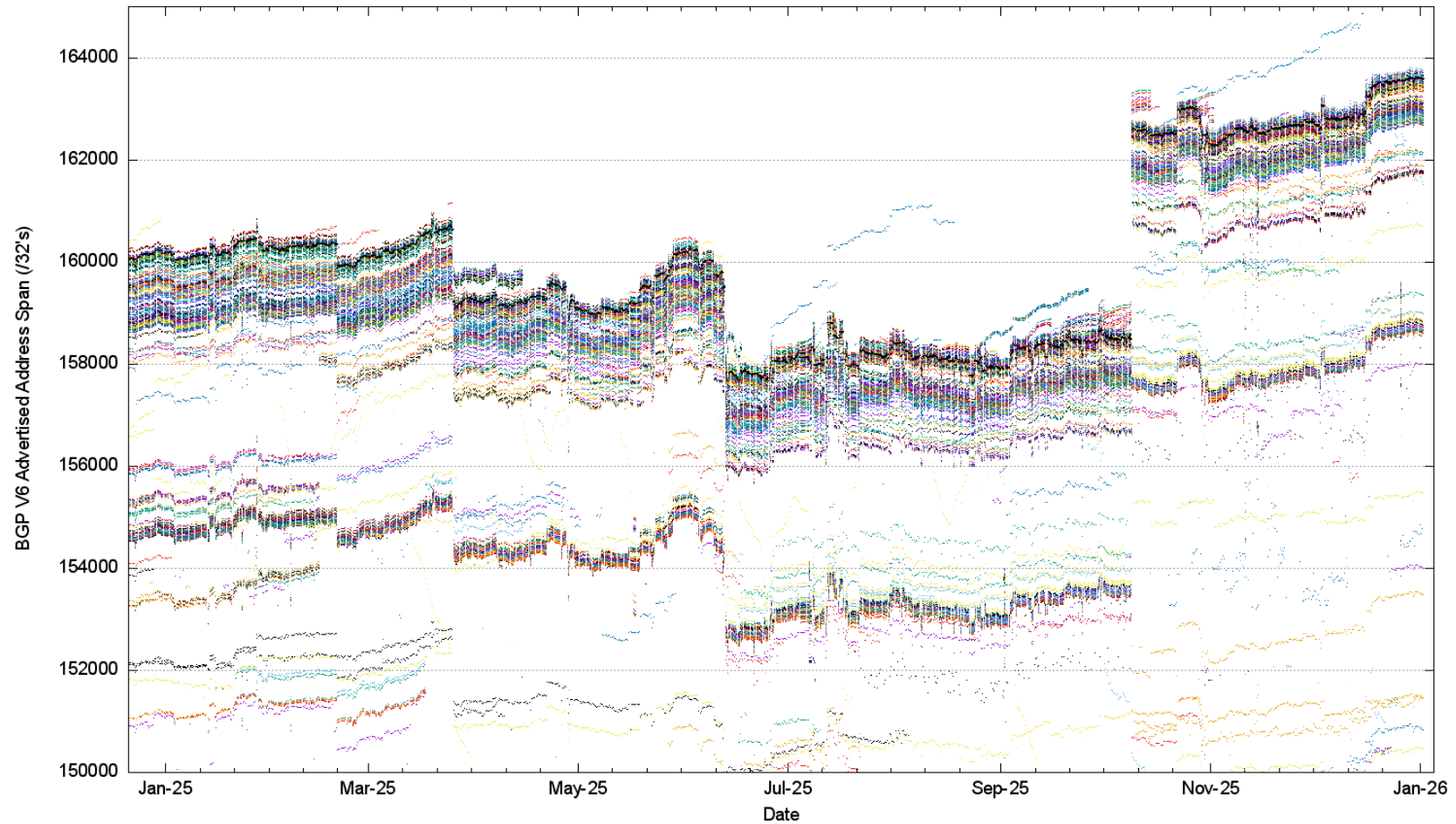
45% of all IPv6
prefixes are /48's

20-Year IPv6 Advertised Address Span



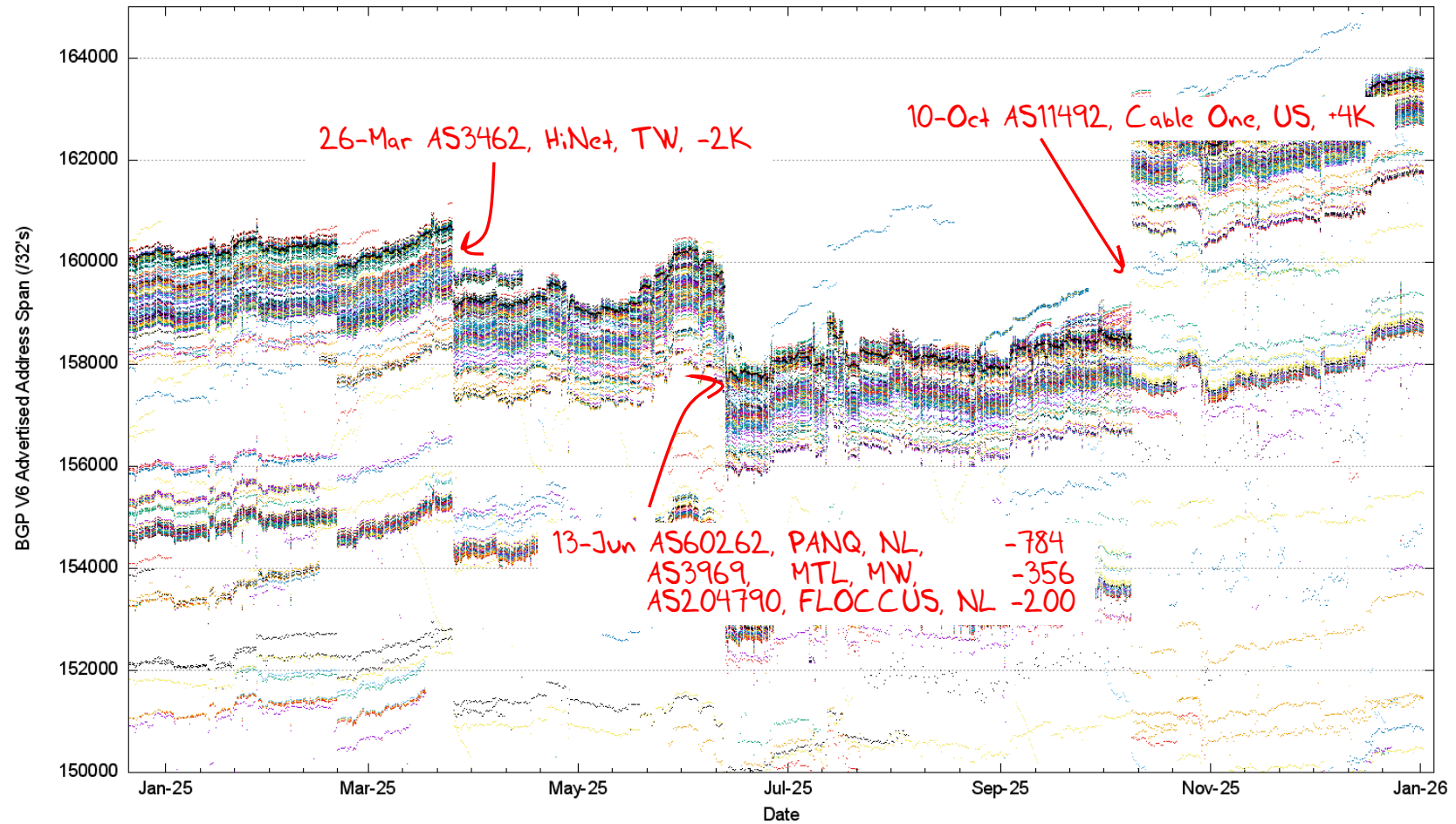
IPv6 Advertised Address Span in 2025

BGP IPv6 Address Span (/32s) - RIS and Route Views Peers



IPv6 Advertised Address Span in 2025

BGP IPv6 Address Span (/32s) - RIS and Route Views Peers



IPv6 in 2025

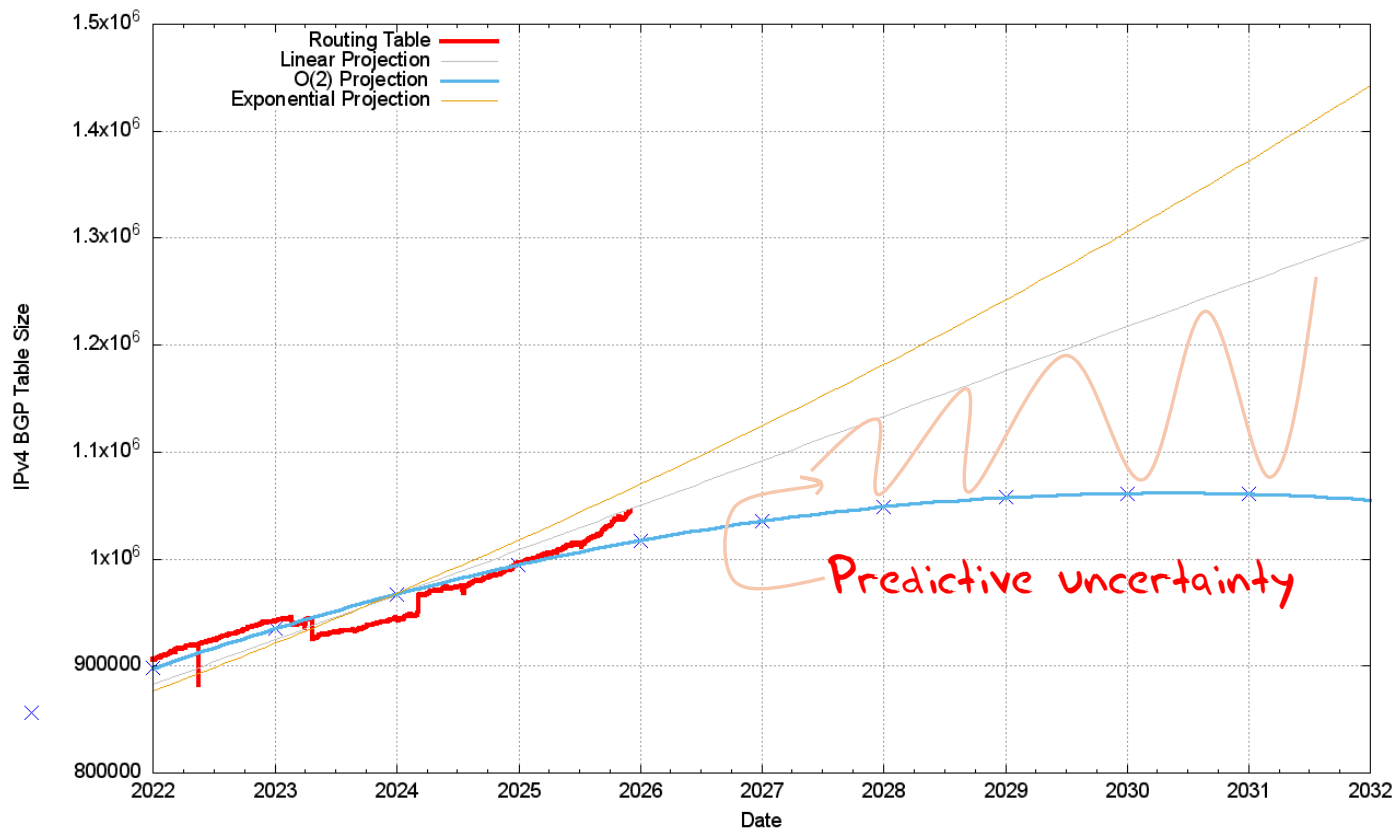
- Overall IPv6 Internet growth in terms of BGP FIB size is still increasing, and is currently at some **20,000 route entries p.a.** (10%)
- The advertised address span grew by just 4K /32s (thanks to Cable One!)
- There were 2096 new AS's advertising IPv6 prefixes through 2025, and 956 AS's ceased advertising IPv6 prefixes
- IPv6 is still expanding – slowly!

This presentation

- IPv4 Routing Table
- IPv6 Routing Table
- **FIB Projections**
- Updates and Churn
- Conclusions

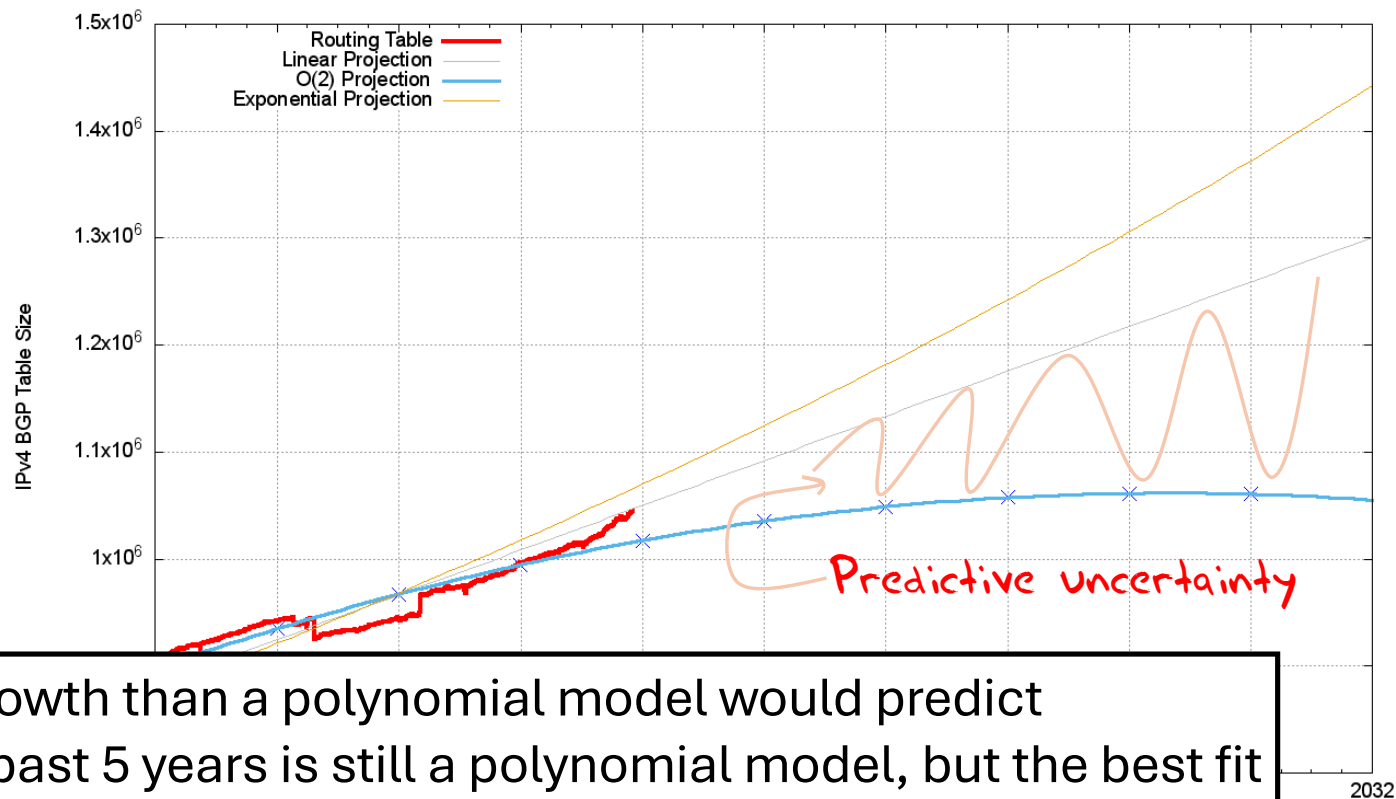
V4 BGP Table Size Predictions

| Year | RIB Size | Prediction |
|------|-----------|------------|
| 2019 | 760,000 | |
| 2020 | 814,000 | |
| 2021 | 856,000 | |
| 2022 | 906,000 | |
| 2023 | 942,000 | |
| 2024 | 944,000 | |
| 2025 | 996,000 | 994,000 |
| 2026 | 1,040,000 | 1,101,000 |
| 2027 | | 1,035,000 |
| 2028 | | 1,048,000 |
| 2029 | | 1,057,000 |
| 2030 | | 1,060,000 |



V4 BGP Table Size Predictions

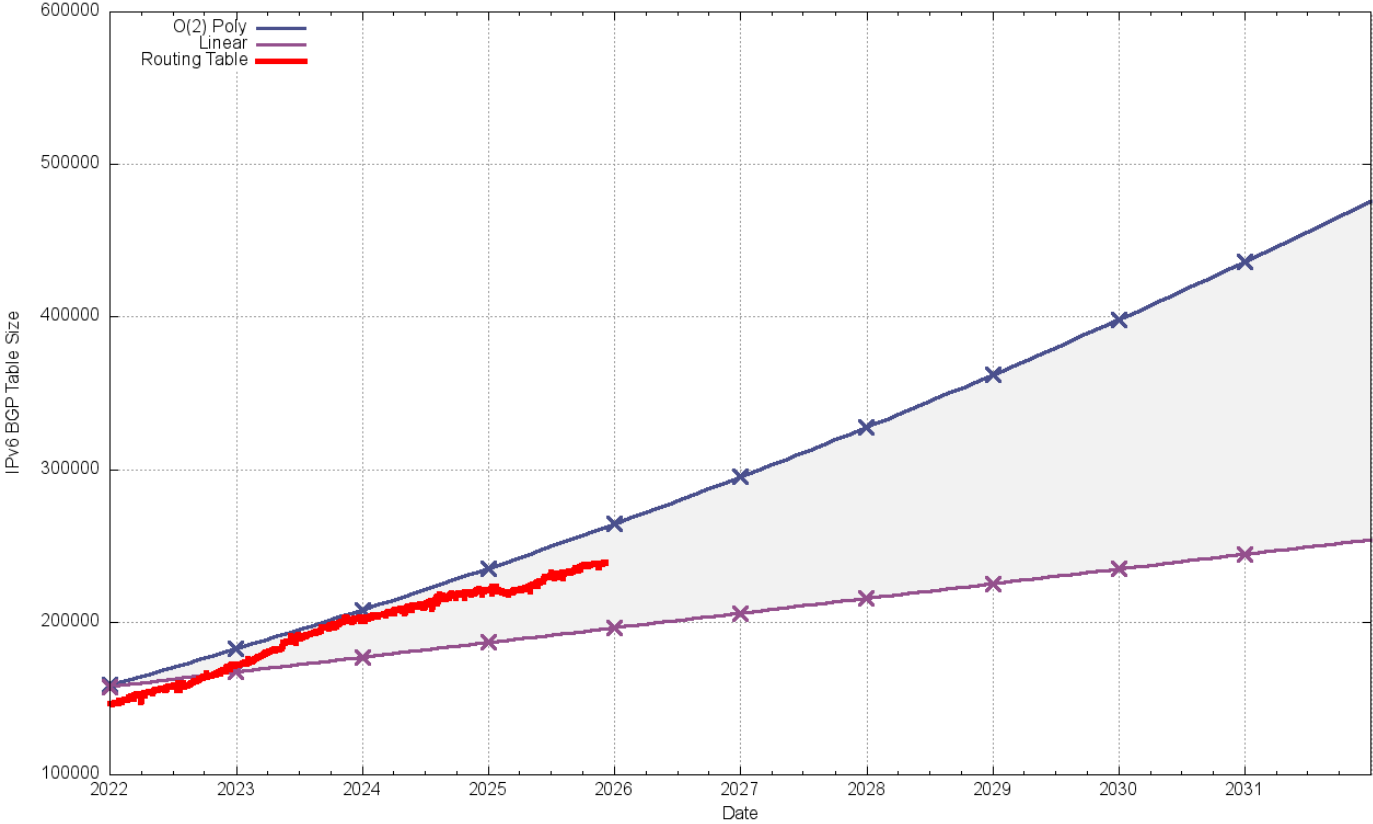
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| 2026 | 1,040,000 | 1,101,000 |
| 2027 | | 1,035,000 |
| 2028 | | |
| 2029 | | |
| 2030 | | |



2025 saw a higher growth than a polynomial model would predict
 The best fit over the past 5 years is still a polynomial model, but the best fit over the past 3 years is a linear model

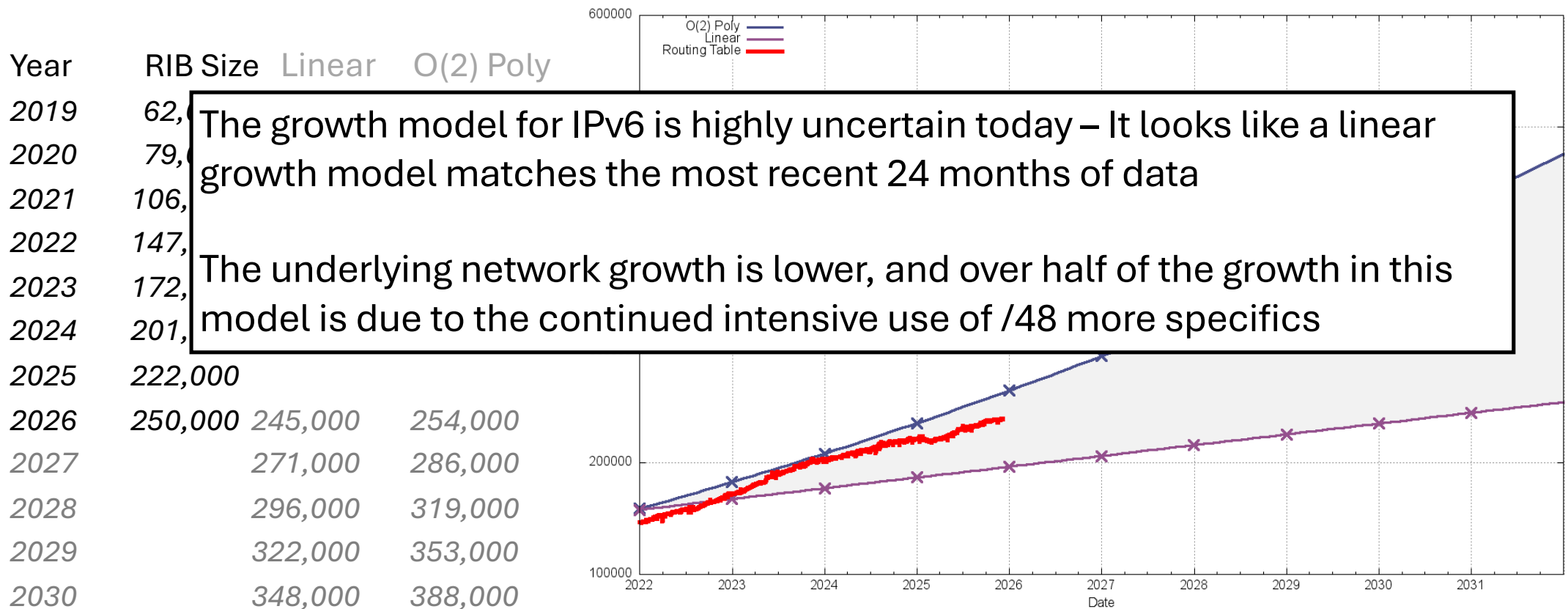
V6 BGP Table Size Predictions

| Year | RIB Size | Linear | O(2) Poly |
|------|----------|---------|-----------|
| 2019 | 62,000 | | |
| 2020 | 79,000 | | |
| 2021 | 106,000 | | |
| 2022 | 147,000 | | |
| 2023 | 172,000 | | |
| 2024 | 201,000 | | |
| 2025 | 222,000 | | |
| 2026 | 250,000 | 245,000 | 254,000 |
| 2027 | | 271,000 | 286,000 |
| 2028 | | 296,000 | 319,000 |
| 2029 | | 322,000 | 353,000 |
| 2030 | | 348,000 | 388,000 |



Note that the IPv6 tables are 128bits wide – i.e. 4x the size of the IPv4 tables!

V6 BGP Table Size Predictions



The growth model for IPv6 is highly uncertain today – It looks like a linear growth model matches the most recent 24 months of data

The underlying network growth is lower, and over half of the growth in this model is due to the continued intensive use of /48 more specifics

Note that the IPv6 tables are 128bits wide – i.e. 4x the size of the IPv4 tables!

BGP Table Growth

The good news ...

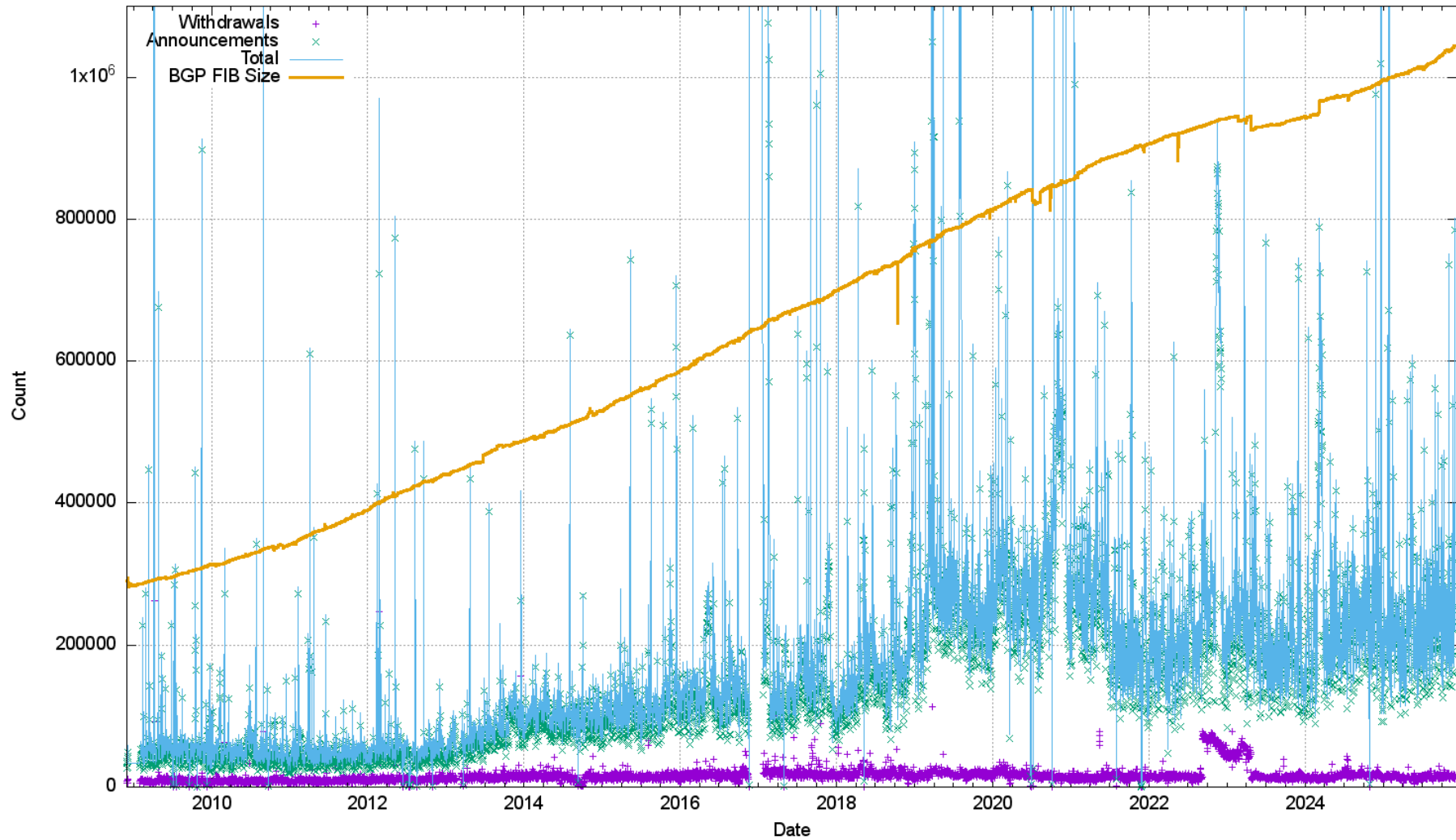
As long as we are prepared to live within the technical constraints of the current routing paradigm, the Internet's use of BGP will continue to be viable for some time yet

The Highlights

- IPv4 FIB Summary
- IPv6 FIB Summary
- FIB Projections
- Churn
- Conclusions

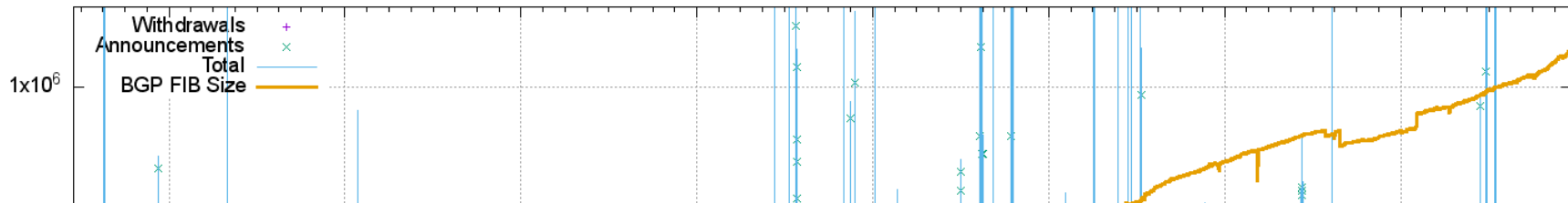
IPv4 BGP Updates - Daily Updates

Daily BGP v4 Update Activity for AS131072



IPv4 BGP Updates - Daily Updates

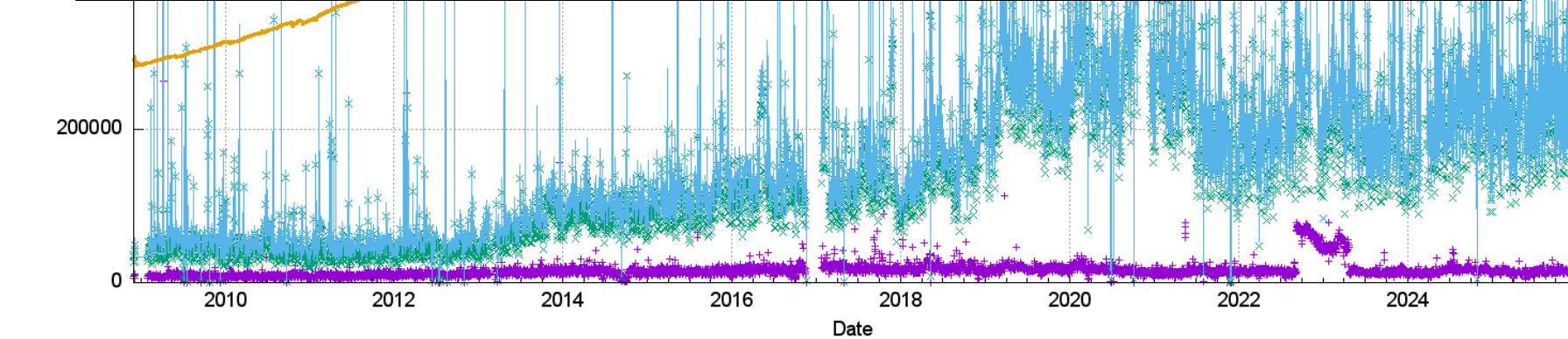
Daily BGP v4 Update Activity for AS131072



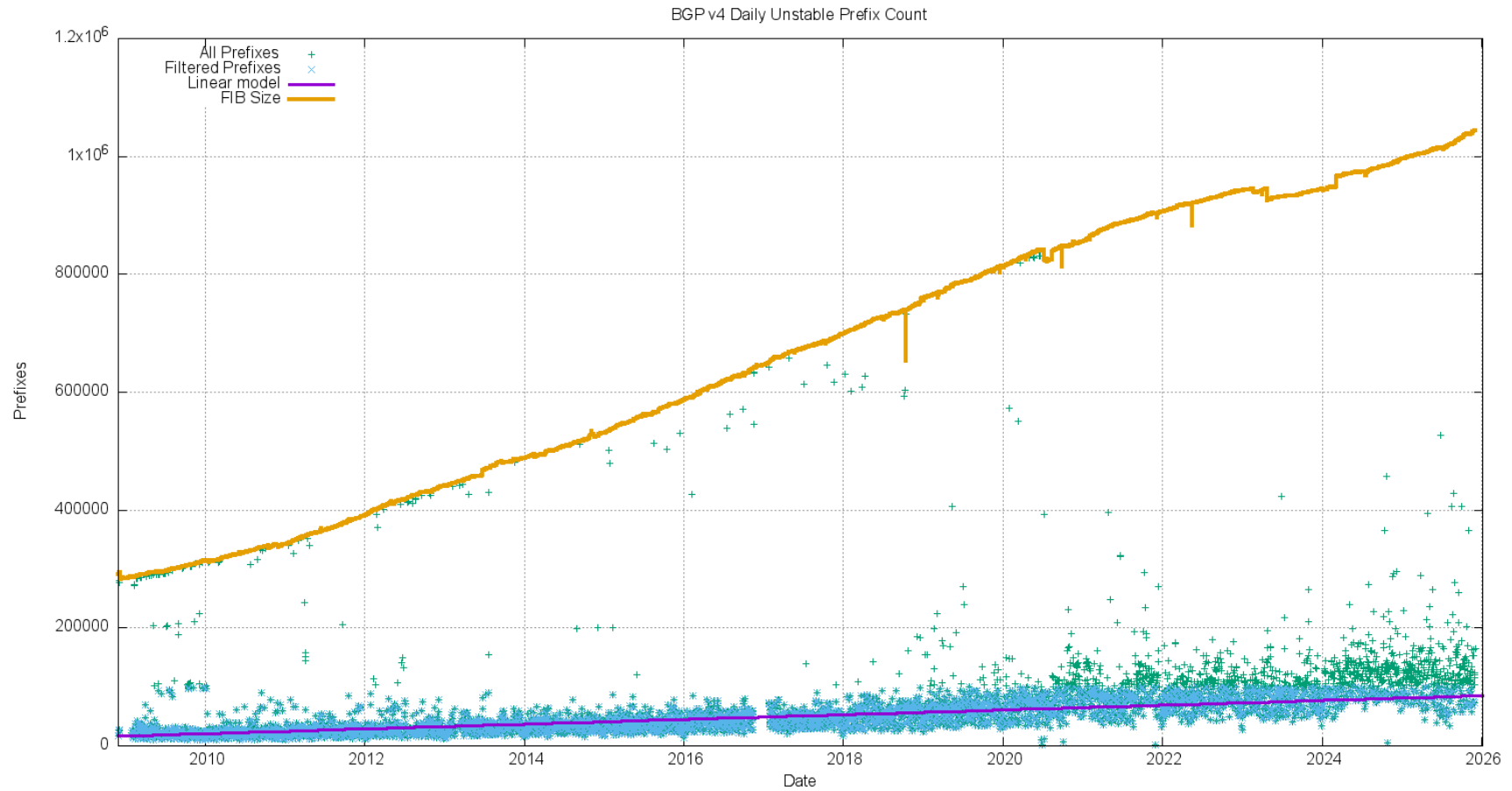
The IPv4 network is surprisingly stable

The number of withdrawals per day has been relatively steady for some 15 years (aside from some increases in 2022/3)

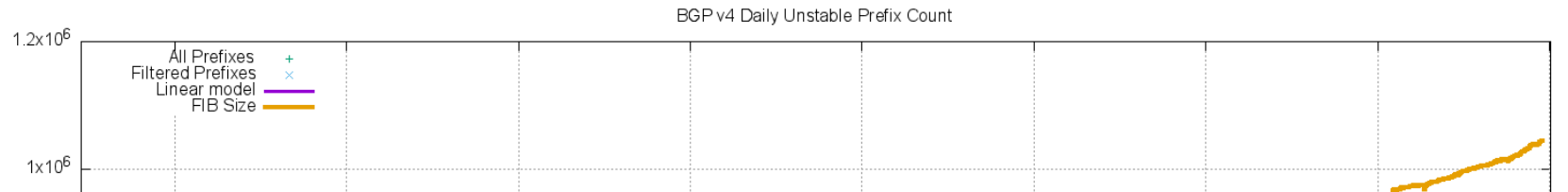
The number of updates per day has been steady through 2025



IPv4 Unstable Prefixes per Day

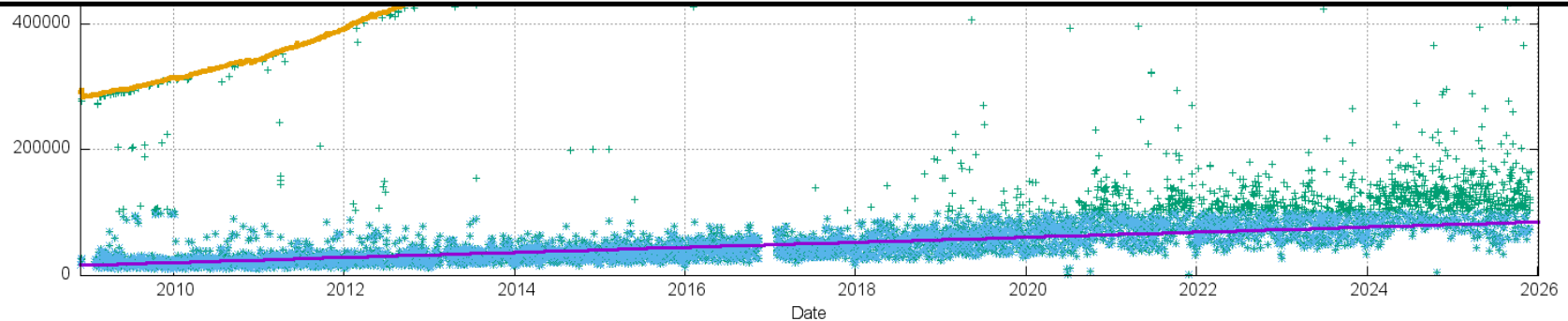


IPv4 Unstable Prefixes per Day

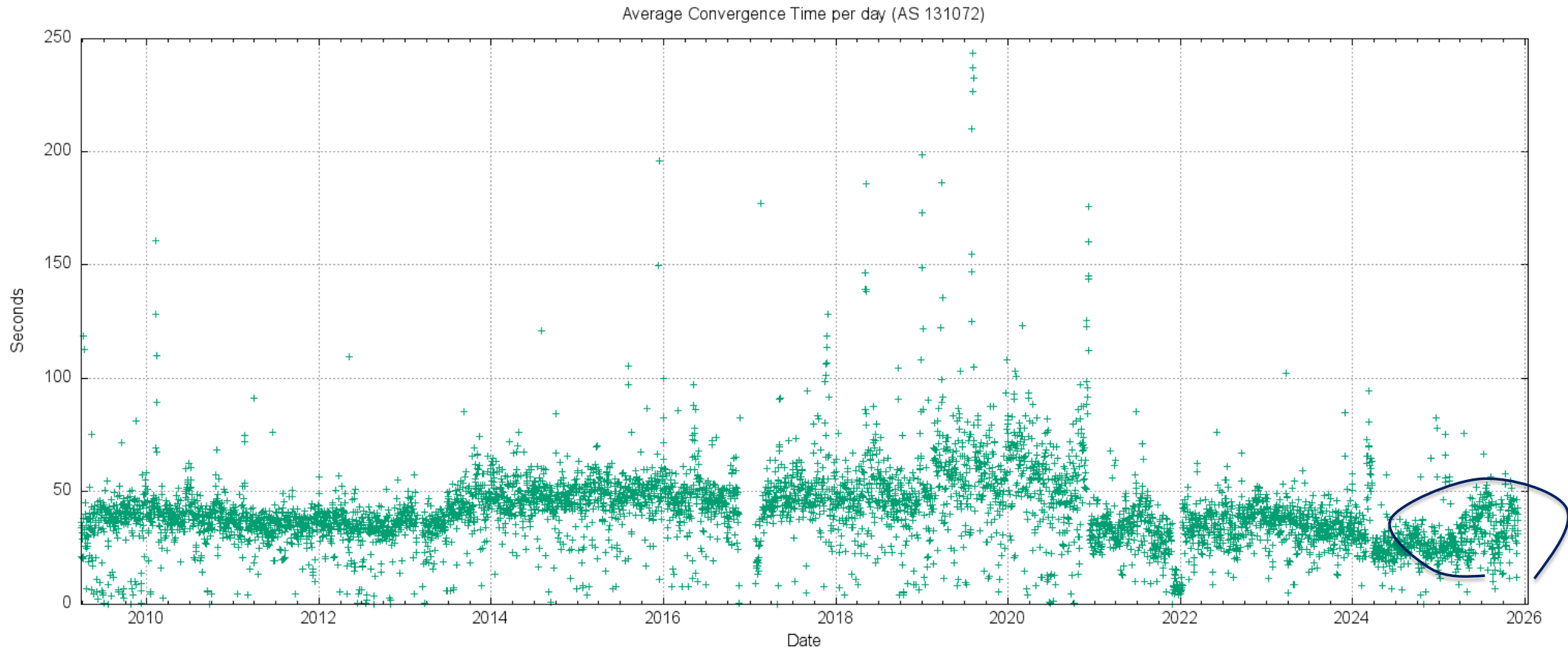


The number of prefixes that are the subject of updates has been slowly increasing over this 15-year period

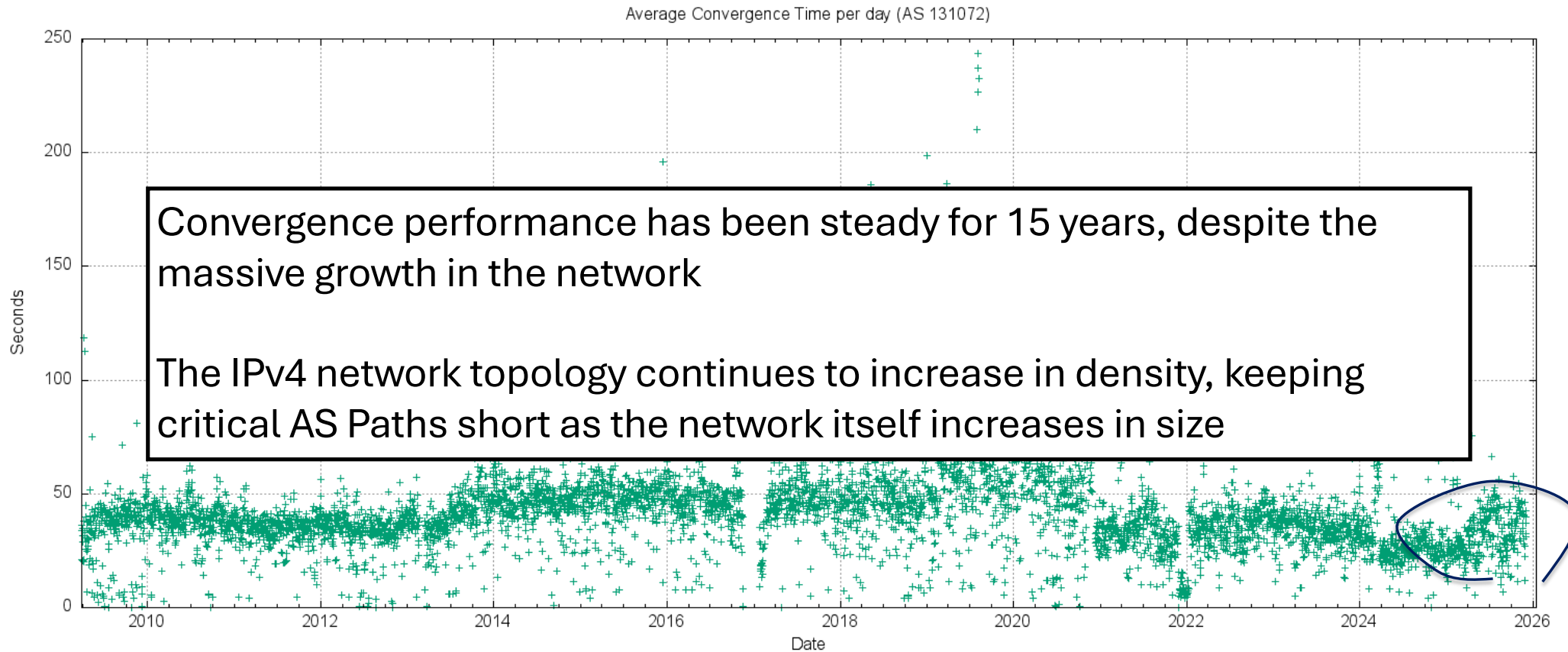
The rate of increase of unstable prefixes is **far lower** than the number of advertised prefixes



IPv4 BGP Convergence Performance



IPv4 BGP Convergence Performance

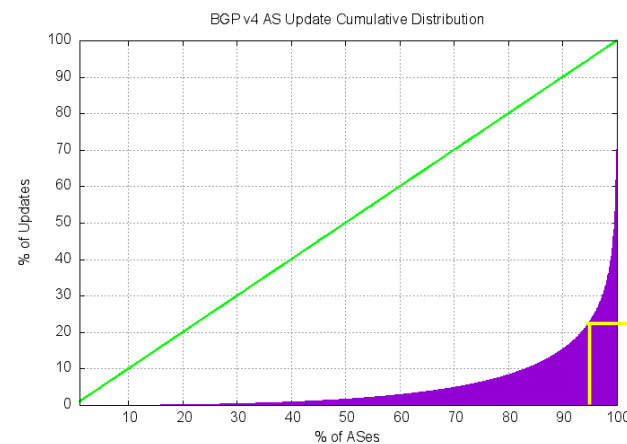
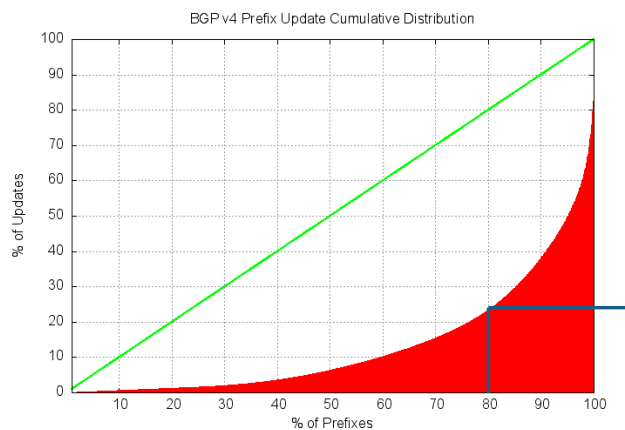


Updates in IPv4 BGP

The IPv4 inter-domain routing system is still highly stable

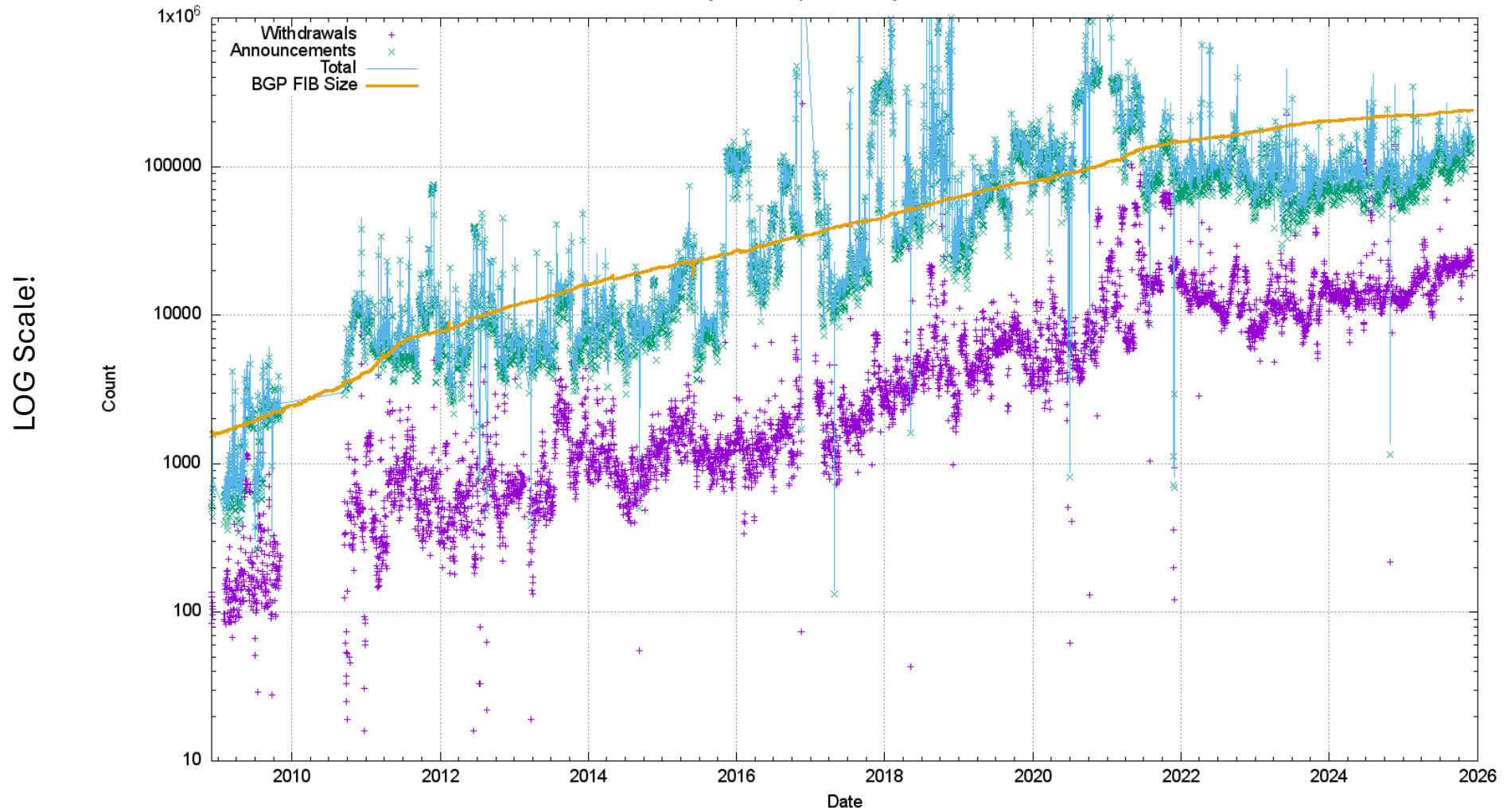
...

- The number of updates per instability event and the time to converge to a stable forwarding state has been relatively constant for many years
- 20% of prefixes generate 77% of all updates. Less than 5% of all origin networks are linked to 78% of all updates. **Routing instability is concentrated in a small number of highly unstable cases.**

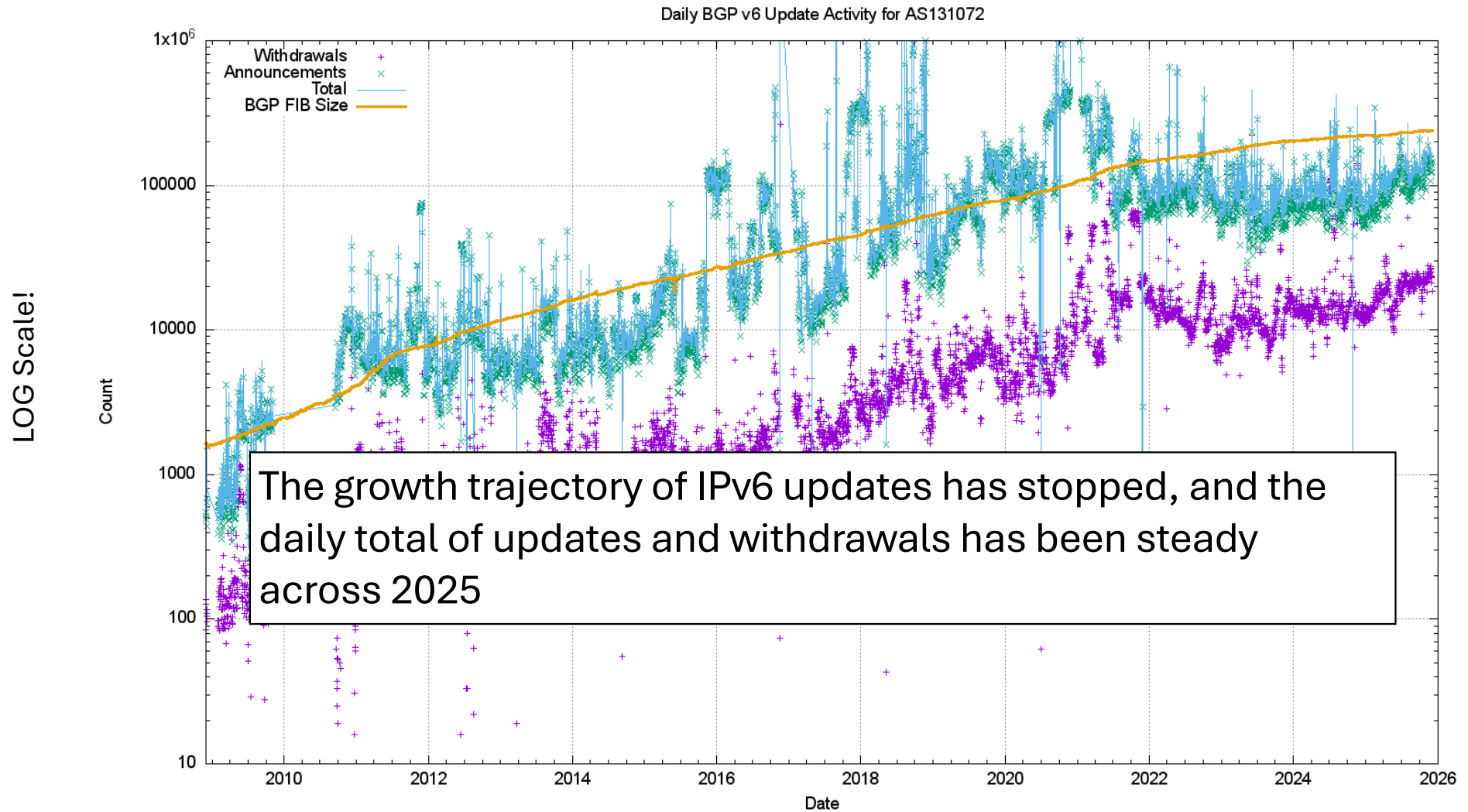


V6 BGP Updates

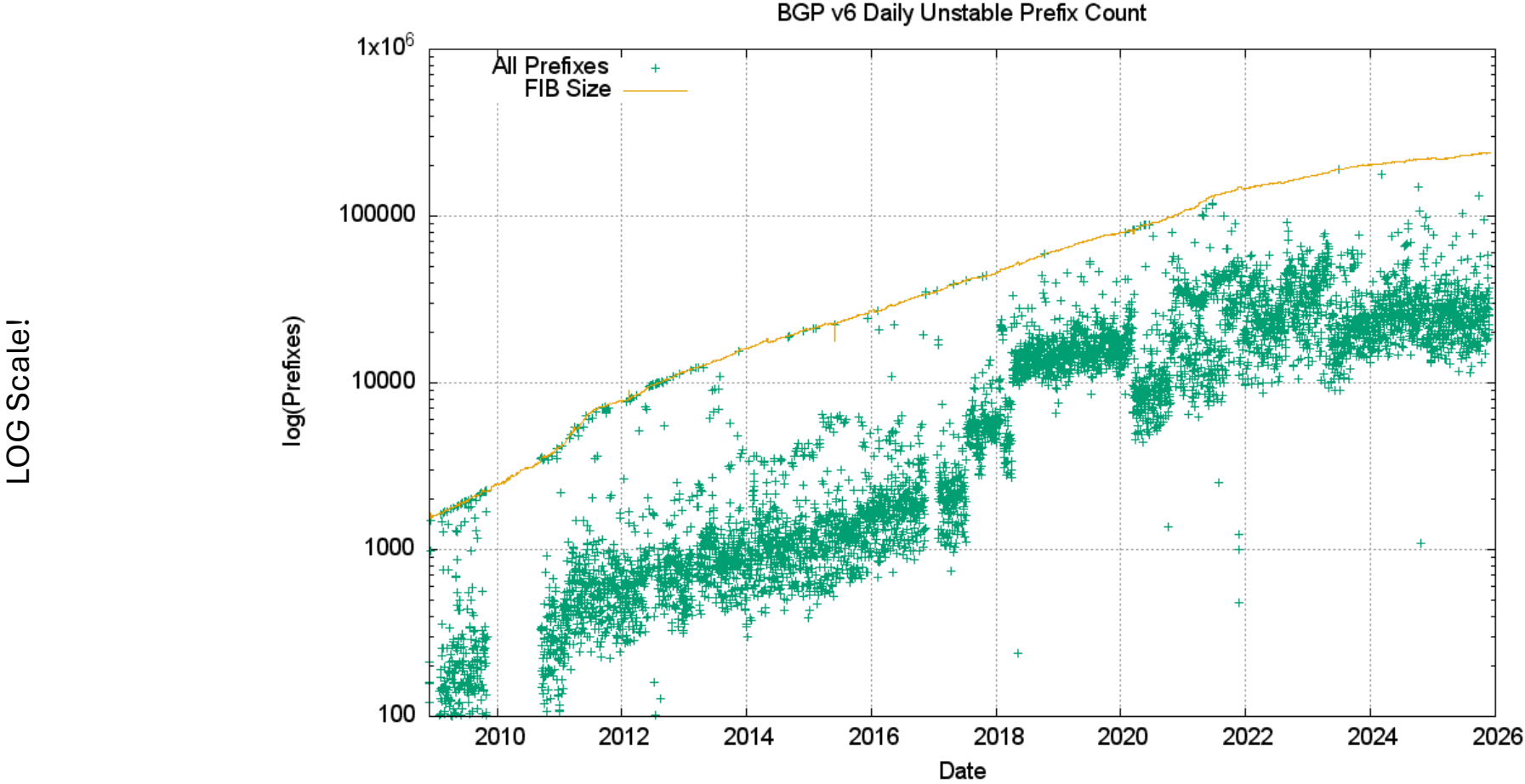
Daily BGP v6 Update Activity for AS131072



V6 BGP Updates

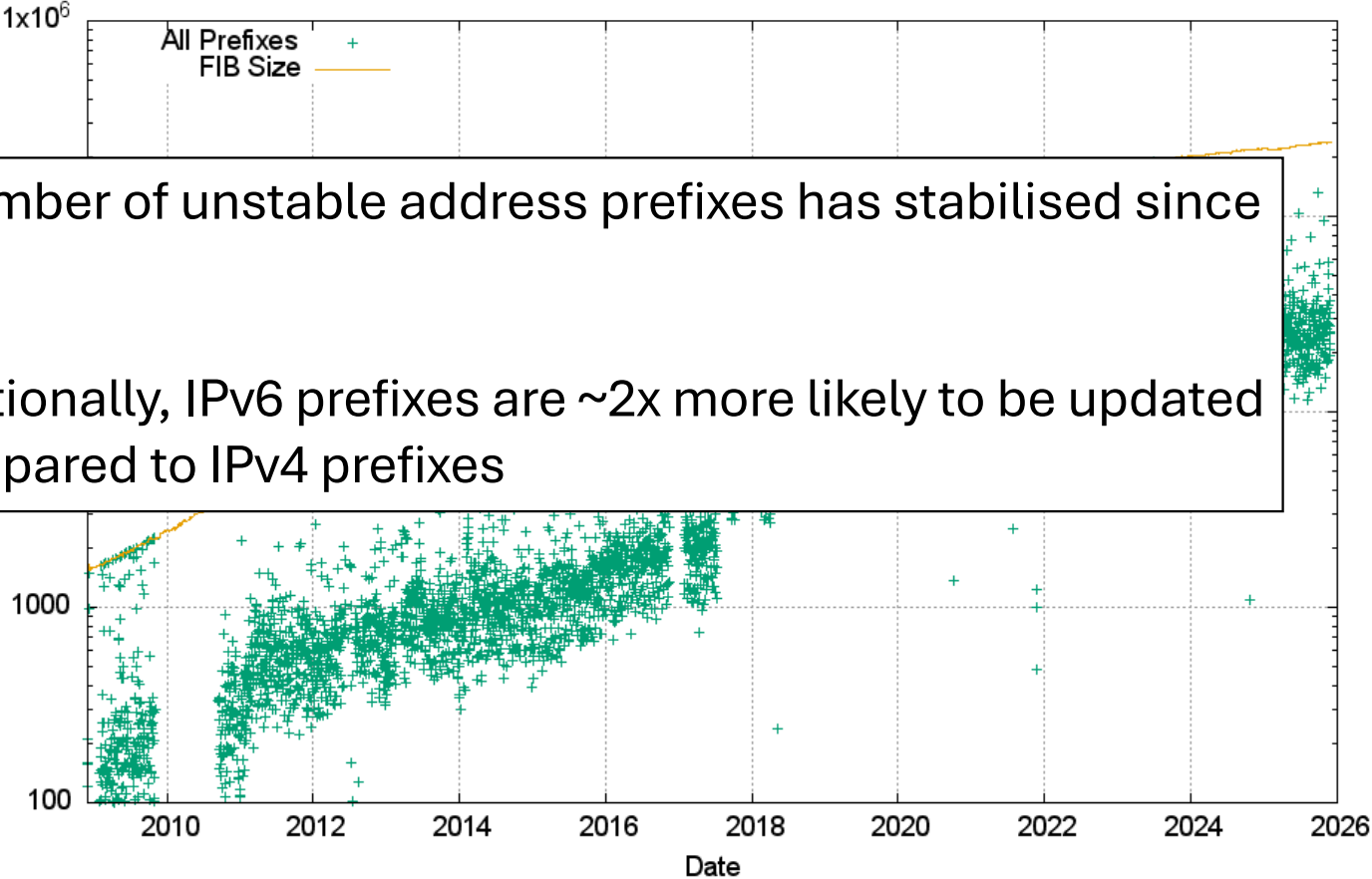


V6 Unstable Prefixes

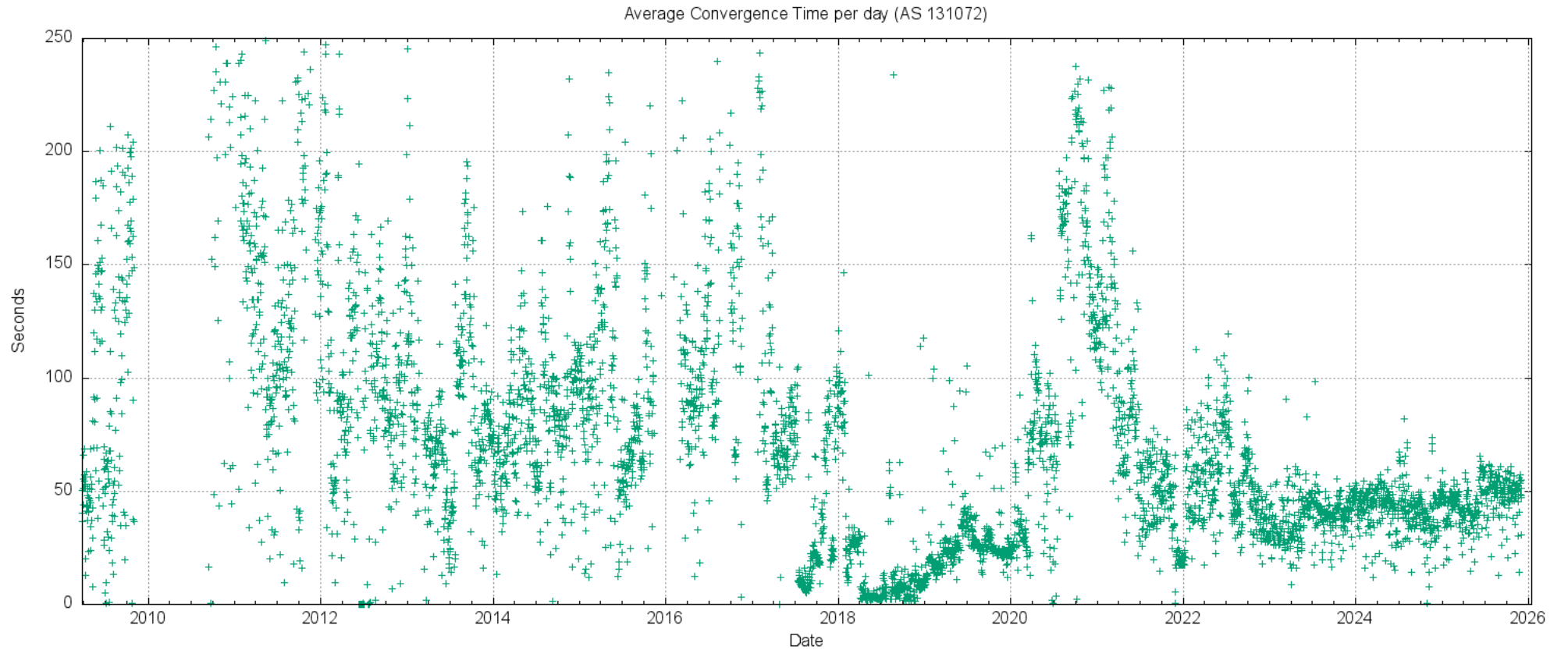


V6 Unstable Prefixes

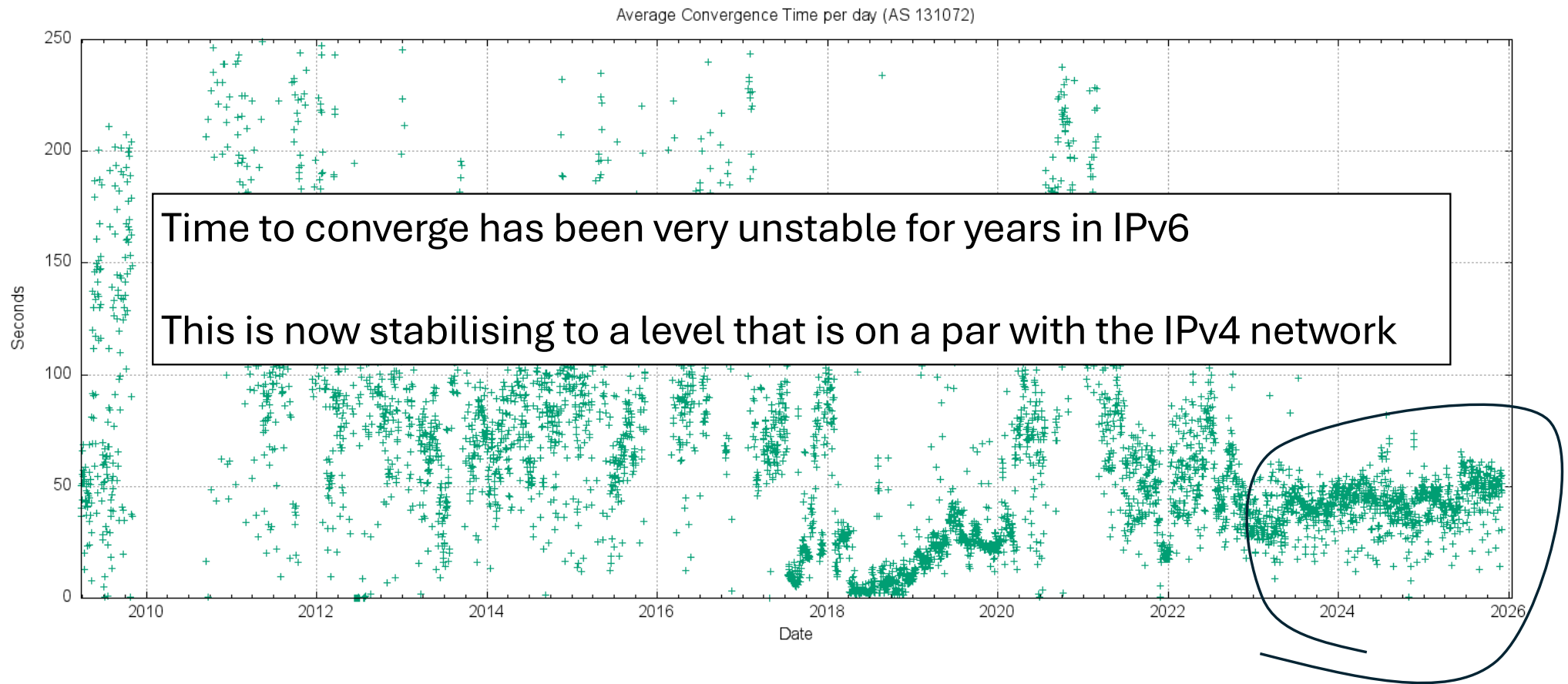
BGP v6 Daily Unstable Prefix Count



V6 Convergence Performance



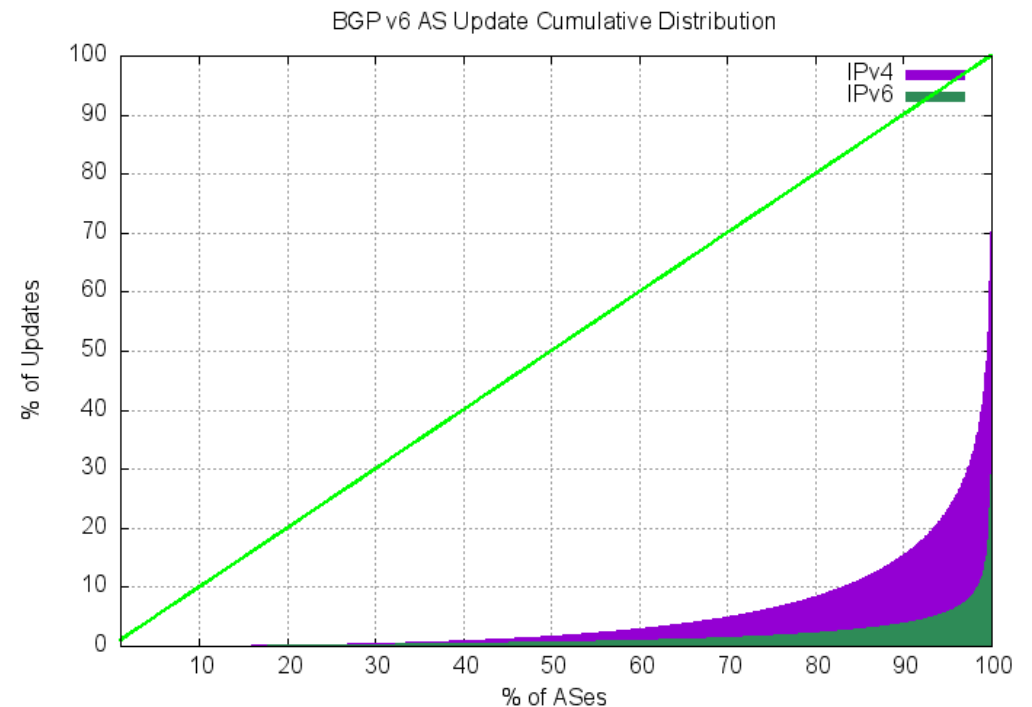
V6 Convergence Performance



Updates in IPv6 BGP

- Compared to IPv4, the IPv6 network has exhibited a high level of skew of routing instability, where a small number of networks contribute disproportionately to the overall level of BGP updates in IPv6.
- Just 3 AS's generated 20% of the BGP IPv6 update load in early December 2025. IPv6 routing instability is still concentrated in a small number of pathologically unstable cases.

<https://www.potaroo.net/bgpupds/reports/v6-bgpupd.html>



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- Conclusions

Routing Futures

- There is no further acute scaling pressure from BGP as a routing protocol – the relatively compressed inter-AS topology and stability of the infrastructure links tend to ensure that BGP remains effective in routing the internet.
- Instability levels are high, generally driven by a small set of highly unstable “super update generators”

Routing Futures

- The frenetic pace of expansion in the routing infrastructure of the Internet has slowed down in recent years. The IPv4 BGP network grew slightly in 2025, while IPv6 FIB size growth has slackened off
- The drivers for growth were the product of the population of networks with discrete routing policies and the need to balance incoming traffic across multiple paths (traffic engineering) – the rapid increase in the use of CDN platforms has reduced the dependence on transit routes to provide content and services to end users.
- Much of the overall volume of long-haul traffic has shifted to privately operated cloud platforms, and the demands on the public routed common infrastructure are in relative decline

Some Practical Suggestions

For those network operators whose service needs are dependent on the BGP network to some extent (which is mostly everyone)

Know your network's limits:

- Understand your routing FIB capacity in the default-free parts of your network
- There may be some default max prefix setting of ~1M FIB entries which will cause a BGP session shutdown when tripped
 - AS 4804 (Optus) in Australia appeared to encounter this situation in October 2023
- Use a max prefix exceeded setting which avoids session shutdown where possible

Some Practical Suggestions

Know your network's limits

Review your routers' settings

- Review your IPv4 / IPv6 portioning in the FIB tables - a dual-stack eBGP router will conservatively need a 1.2 M 32-bit IPv4 slots and 350K 128-bit IPv6 slots for a full eBGP routing table in line cards by 2026 if they are using a complete uncompressed eBGP FIB load (plus internal routes of course). That's roughly the same memory footprint for IPv4 and IPv6!

Some Practical Suggestions

Know your network's limits

Review your routers' settings

Default routes can be helpful

- Judicious use of **default** routes in your internal network may allow you drop this high-speed line card memory requirement significantly

Some Practical Suggestions

Know your network's limits

Review your routers' settings

Default routes can be helpful

Time for hot caching in line card FIBs?

- Using a hot cache for line card FIB cache would reduce the high-speed TCAM memory requirement significantly without visible performance cost

That's it!



Questions?