60 years of radiation belt science … and counting

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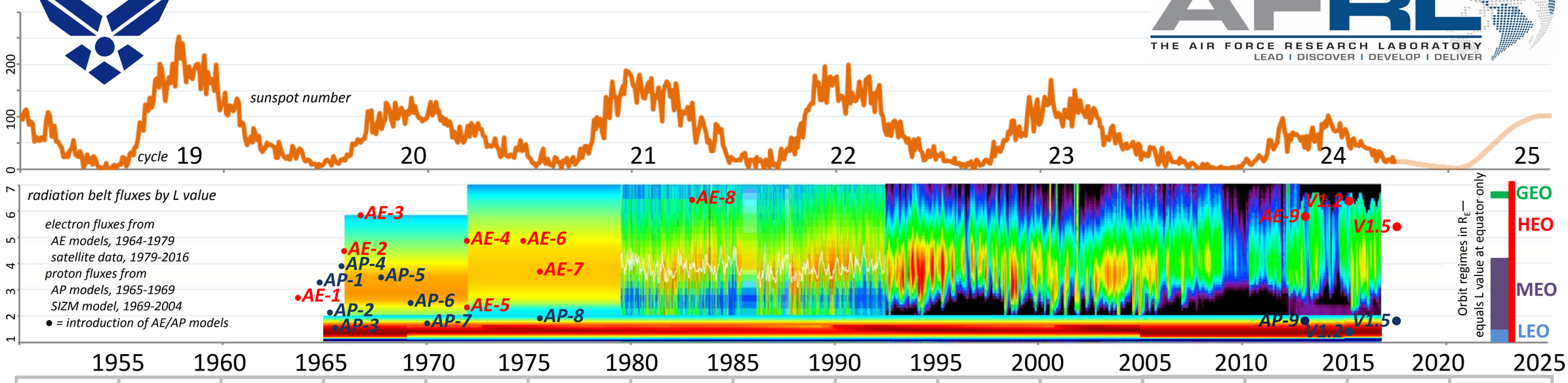
LEAD | DISCOVER | DEVELOP | DELIVER



human spaceflight

Mercury, Gemini, Apollo, Skylab, STS, Mir, Orion, Dragon-V2, ISS, Starliner

LEO

low Earth orbit (alt. = 200-2000 km)

Explorer 1, Explorer 4, Pegasus 1, Pegasus 2, OV1-2, OV1-20, S3-2, Injun 5, S81-1, Injun 1, Injun 3, ISIS 2, OSO 4, P78-1, Alouette 1, Alouette 2, 1963-038C, ASTEX 1, 1963-042A, Azur, Radsat, OGO 2, OGO 4, OGO 6, OGO 1, OGO 3, OGO 5, Explorer 6, Explorer 12, Explorer 14, Explorer 15, Explorer 26, Explorer 45, P-11, Telstar 1, Telstar 2, Relay 1, Relay 2, Midas 3, Midas 4, Midas 5, OV1-13

DMSP: F8, F9, F10, F11, F12, F13, F14, F15, F16, F17, F18, F19

SAMPEX, TSX-5, DEMETER, C/NOFS, TARANIS, ICON, VPM

POES: NOAA-8, NOAA-10, NOAA-12, NOAA-13, NOAA-14, NOAA-15, NOAA-16, NOAA-17, NOAA-18, NOAA-19

Hinotori, TENMA, DE-2

MetOp-A, MetOp-B, MetOp-C

CASSIOPE

HEO

highly eccentric orbit

IMP 1, IMP 2, IMP 3, IMP 4, IMP 5, IMP 6, STARAD, ERS 13, ERS 17, OV1-14, OV1-19, OV3-3, OV3-4

SCATHA, CRRES, ISEE 1, ISEE 2, AMPTE: CCE, IRM, UKS, S3-3, DE-1

HEO-1, HEO-3, POLAR, Van Allen A, Van Allen B, Arase

Cluster 2: Rumba, Salsa, Samba, Tango

Equator-S, Geotail, IMAGE, THEMIS/ARTEMIS: A, B, C, D, E

Akebono, MMS: 1, 2, 3, 4, TacSat-4, Giove-A, Giove-B, DSX

MEO

medium Earth orbit (alt. = 2000-20000 km)

GPS: NS8, NS10, NS18, NS24, NS28, NS39, NS33, NS41, NS54, NS56, NS59, NS60, NS61, NS53, NS58, NS55, NS57, NS48, NS62, NS63, NS65, NS66, NS64, NS67, NS68, NS69, NS71, NS72, NS73, NS70

ICO F2

GEO

geosynchronous Earth orbit (alt. = 35786 km)

LANL: 1976-059, 1977-007, 1979-053, 1981-025, 1982-019, 1984-037, 1984-129, 1987-097, 1989-046, 1990-095, 1991-080, 1994-084, LANL-97A, LANL-01A, LANL-02A, LANL-04A

DRTS

ATS 1, ATS 5, ATS 6

GOES: GOES-1, GOES-2, GOES-3, GOES-4, GOES-5, GOES-6, GOES-7, GOES-8, GOES-9, GOES-10, GOES-11, GOES-12, GOES-13, GOES-14, GOES-15, GOES-16, GOES-S

solar

Solar orbit, including Earth-Sun Lagrange L1, L2 positions

Genesis, DSCOVR, SOHO, ACE, STEREO-A, STEREO-B

1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025

Timeline of radiation belt missions and related spacecraft

data from: sunspot nos.—SIDC, WDC-SILSO, Royal Obs. of Belgium, Brussels; NASA models—Vette, 1991, NSSDC/WDC-A-R&S 91-29, & refs.; TIROS data—Miyoshi & Kataoka, 2011, *J. Atm. Sol. Terr. Phys.*, 73:77+; SAMPEX, Van Allen data—Li, et al., 2017, *J. Geophys. Res.*, 122:5224; POES data—NOAA NGDC; SIZM model—Selesnick et al., 2007, *Sp. Weather*, 5:S04003.

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compiled by W. R. Johnston, Air Force Research Laboratory, Space Vehicles Directorate, Kirtland AFB (Sept. 2017)

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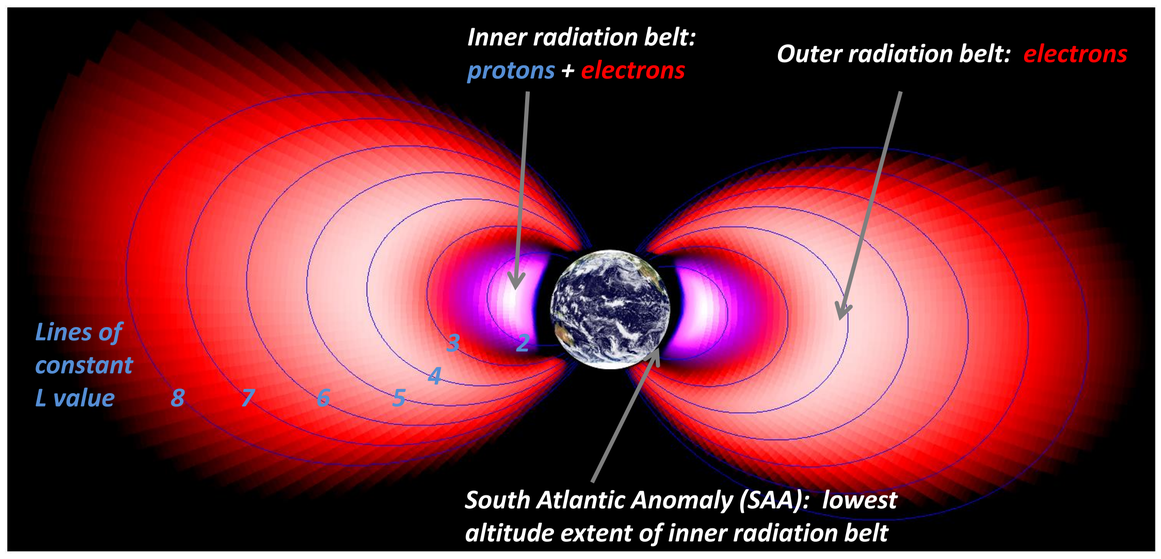
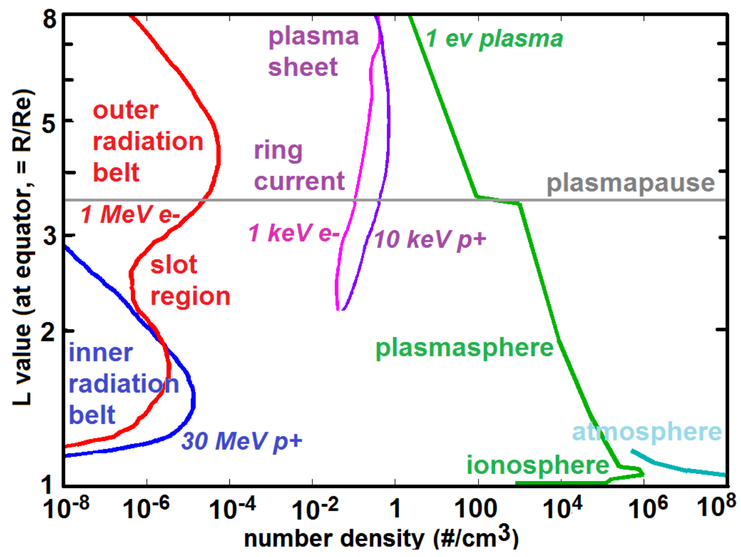
Earth's radiation belts



- *Discovered by Van Allen et al. in 1958, they comprise very energetic charged particles trapped in the geomagnetic field, posing radiation hazards to satellites and astronauts.*
- *These plots show average states, described by the AE9/AP9/SPM radiation belt model.*
- *The belts are dynamic with geomagnetic activity and are the subject of continuing research, including the satellite missions below.*



For more about the **AE9/AP9 radiation belt model**, see the AFRL VDL web site:
https://www.vdl.afrl.af.mil/programs/ae9ap9
or email: AFRL.RVBXR.AE9.AP9.Org.Mbx@us.af.mil

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