# The Particle Environment Package on board JUICE: What Can We Learn about Callisto's Atmosphere and Space Environment?

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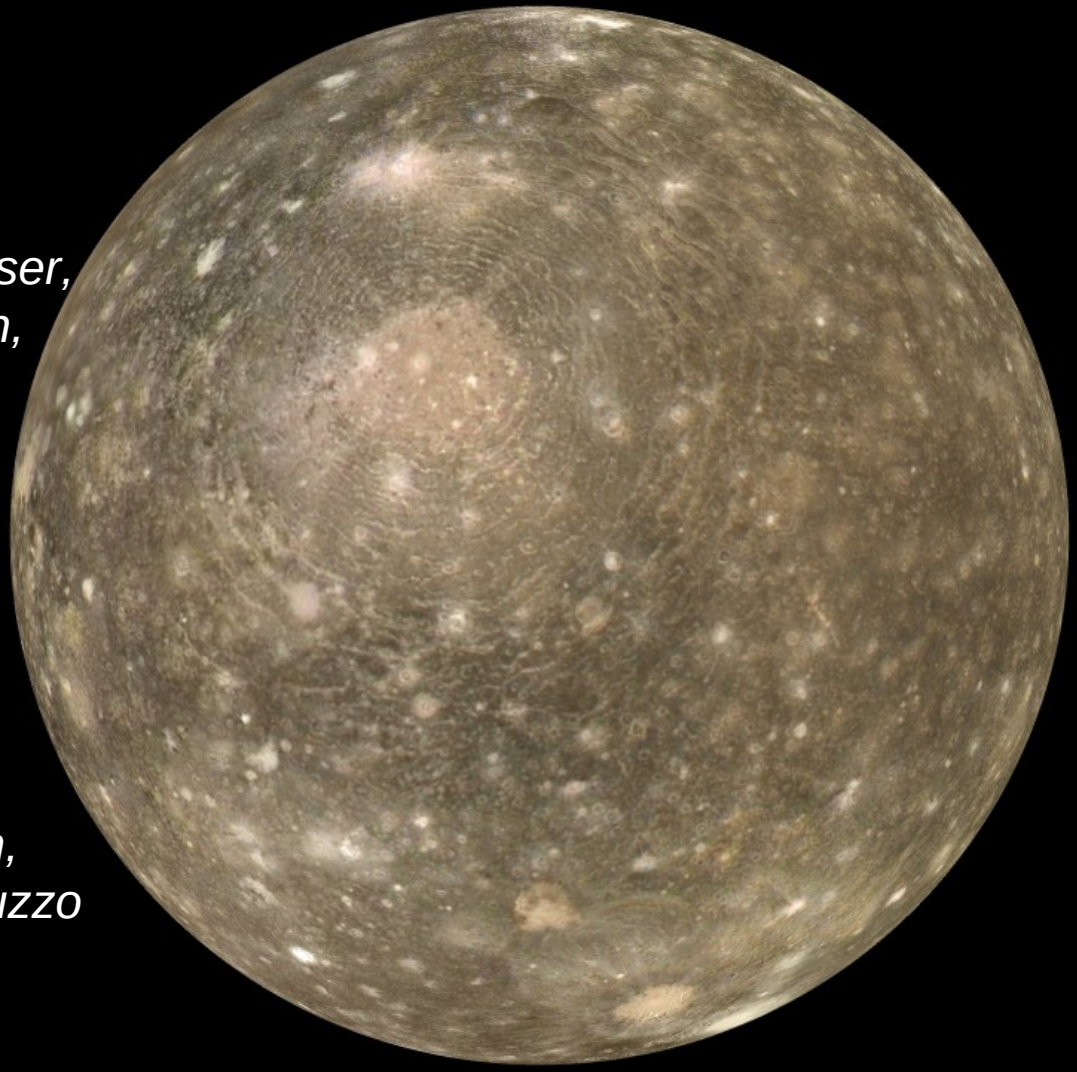



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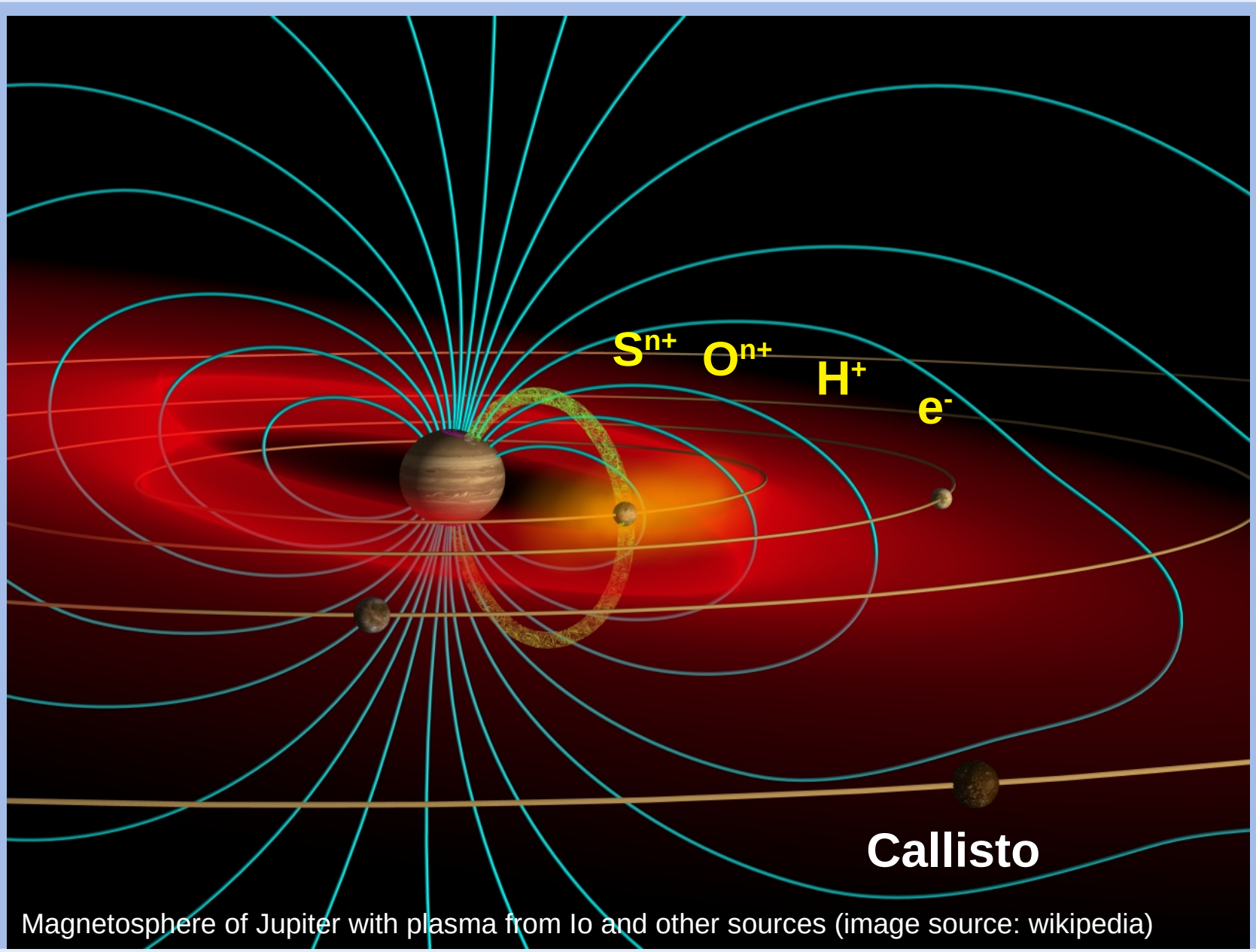
# The Jupiter Icy Moons Explorer (JUICE) will fly by Callisto 21 times before entering into Ganymede's orbit

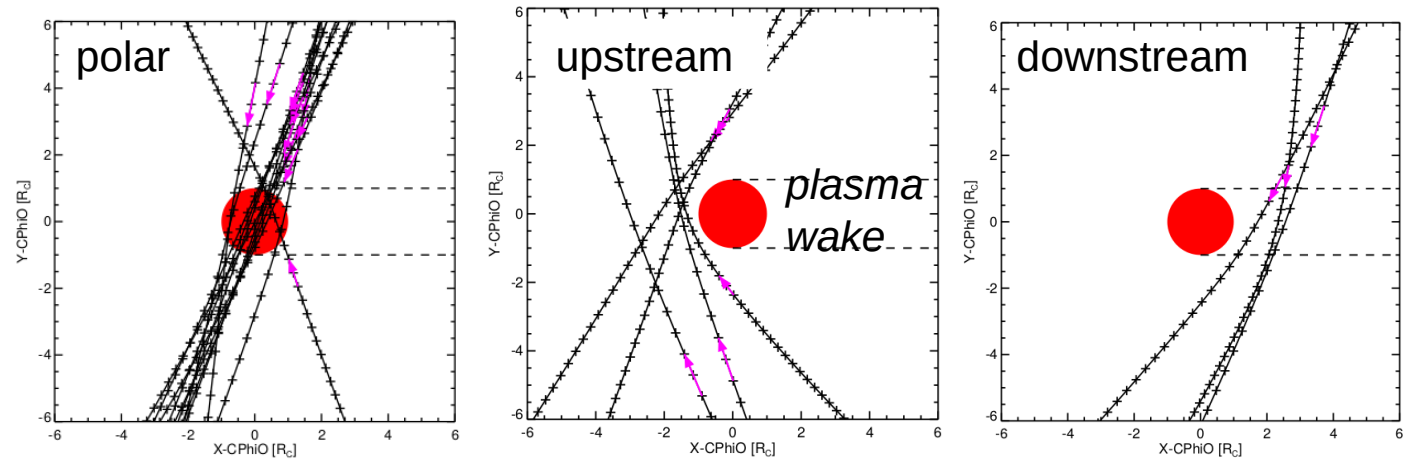



Magnetosphere of Jupiter with plasma from Io and other sources (image source: wikipedia)

# JUICE trajectory implications for Callisto observations

(Baseline: CREMA 5.0 for JUICE launch in September 2021, Reference: www.cosmos.esa.int/web/spice/spice-for-juice)

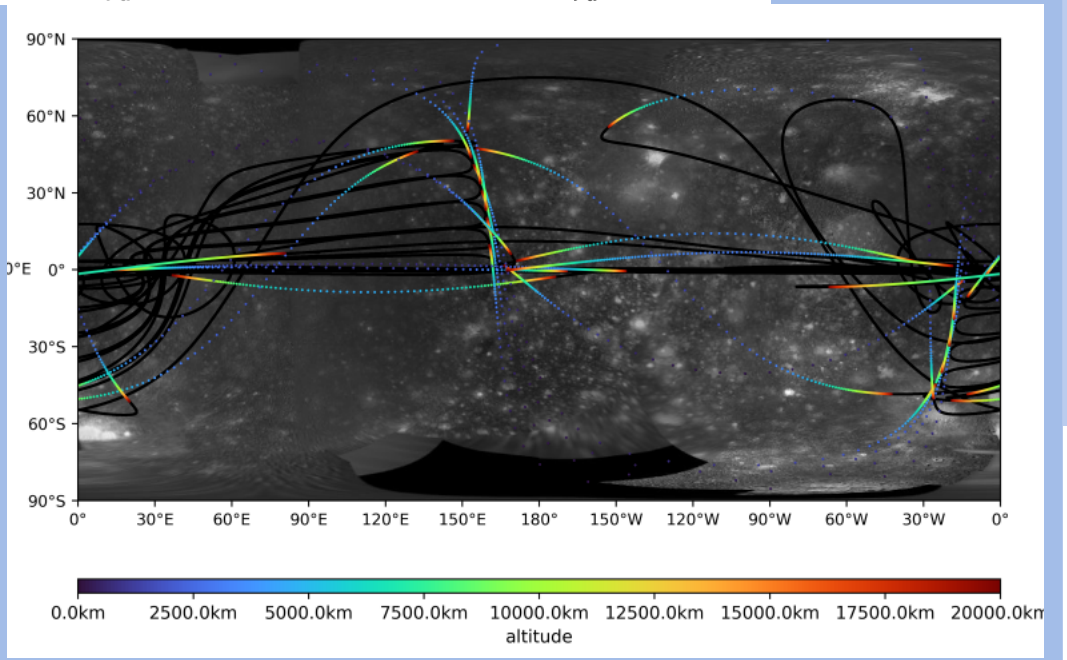
**21 Callisto flybys:** 12x polar, 6x upstream, 3x downstream




JUICE ground tracks on Callisto's surface:
**12 flybys at h < 500 km!**

Polar and equatorial regions covered

Check it out yourself at https://juicept.esac.esa.int

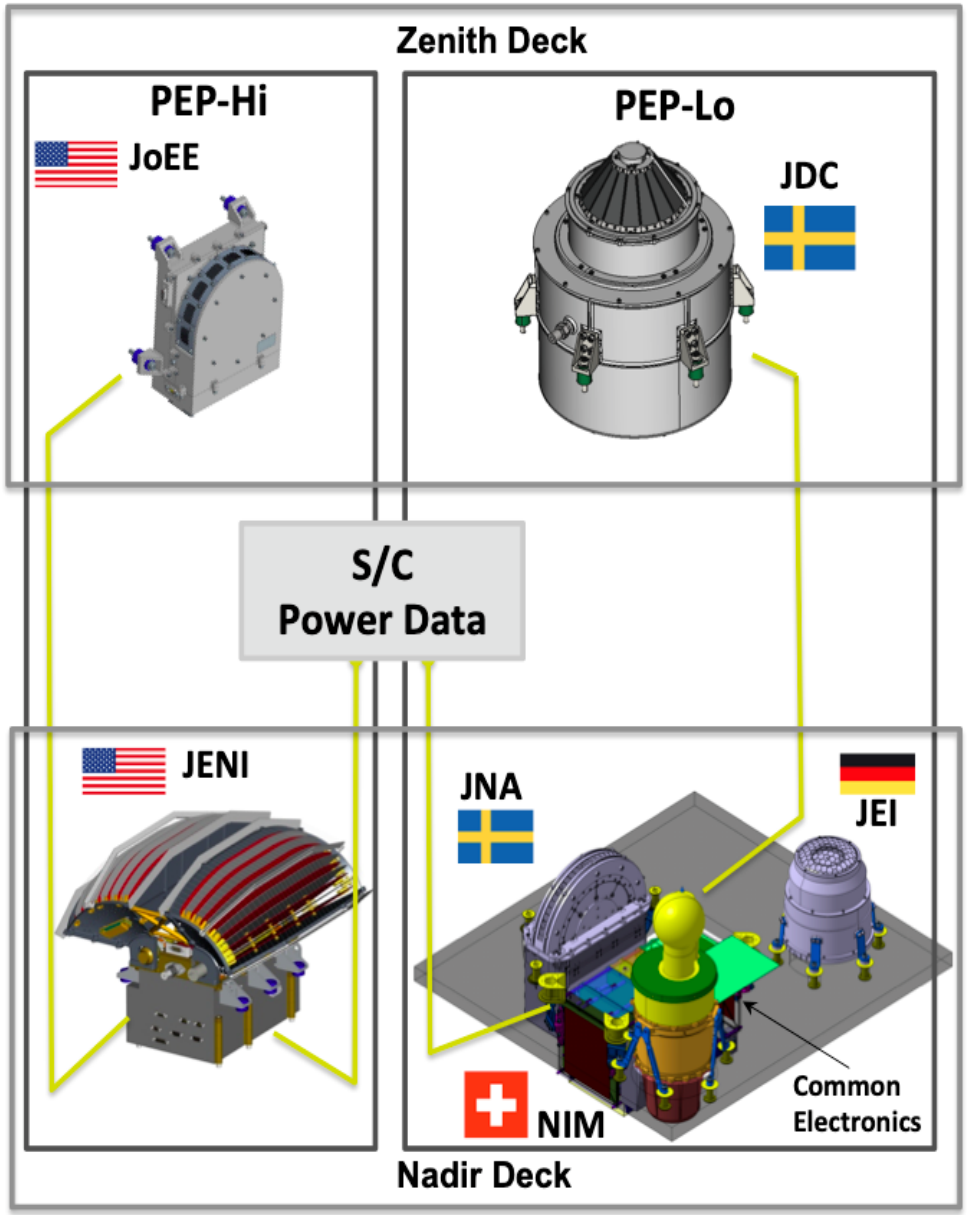



ESA report "Trajectory Analysis Report - CREMA 4.2B/150L0A"

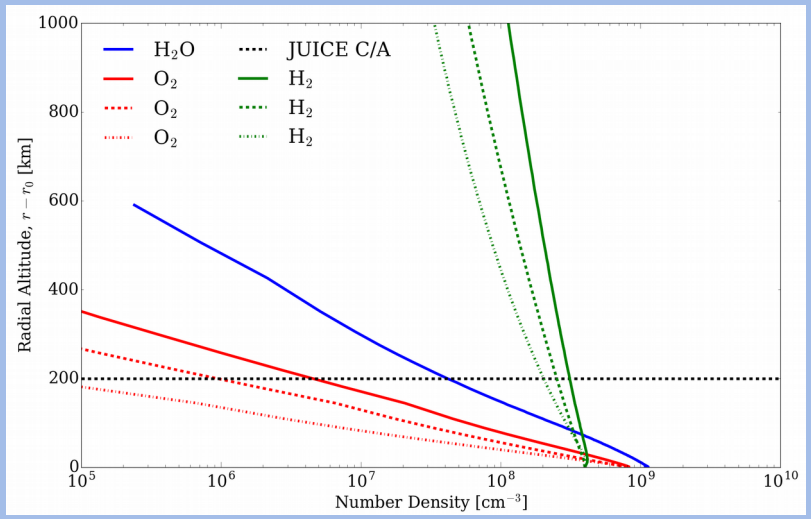
# PEP: Combine in-situ neutrals, ions, electrons, and remote Energetic Neutral Atoms into one big picture

Particle Environment Package (PEP) = six different instruments:

- NIM: Neutral gas and ion mass spectrometer (thermal energies)
- JDC: Ion spectrometer and mass analyzer (electron capabilities)
- JEI: Electron spectrometer (ion capabilities)
- JoEE: Energetic electrons spectrometer
- JNA: Low energy ENA imager
- JENI: Energetic ion spectrometer and ENA imager (electron capabilities)

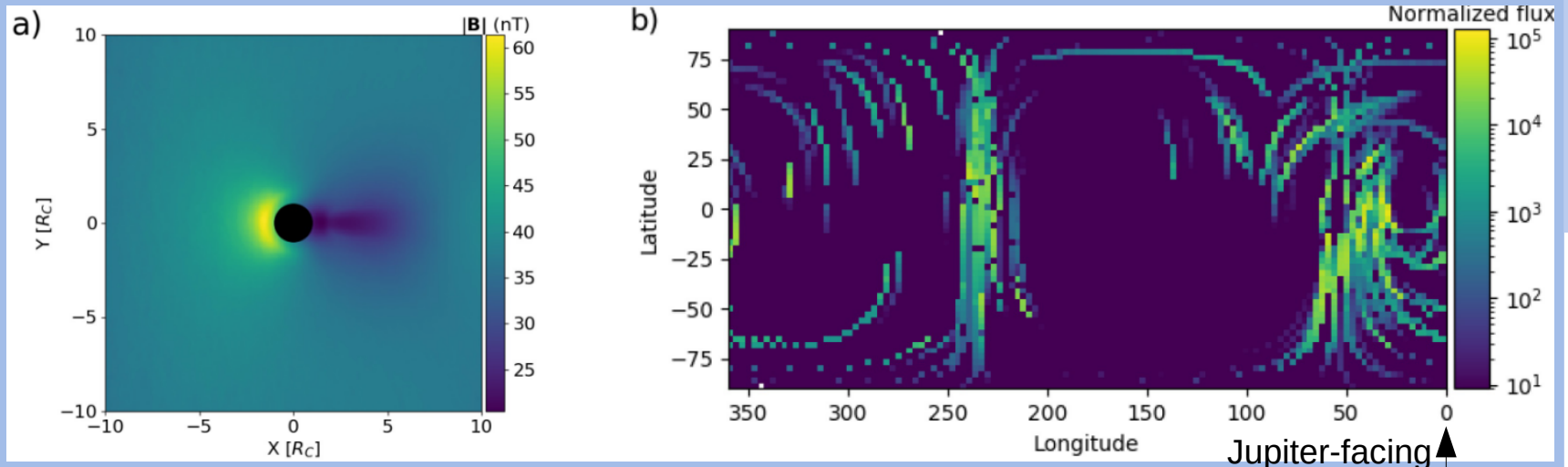


# Planning PEP Operations during Callisto flybys: Neutrals, plasma, and Energetic Neutral Atoms




Predicted profiles of the major atmospheric neutral species (Carberry Mogan et al., 2021) for various solar zenith angles; solid lines: 0°, dashed lines: 90°, dotted lines: 180°; JUICE closest approach at 200 km altitude; detection threshold would be 1 cm$^{-3}$

Magnetic field structure (left) and predicted ENA emissions from Callisto (right panel), caused by energetic ions charge-exchanging with neutrals



# Summary

- JUICE trajectory 5.0: 21 flybys in total, 12 flybys at altitude < 500 km, dayside and nightside. Good for Callisto surface coverage; for plasma science and atmospheric loss studies more downstream flybys would be preferable.
- Neutral densities: Low flyby altitude is crucial to detect heavy species, in particular for nightside flybys.
- PEP: Try to get parallel electron, ion, and neutrals data on the way to closest approach, after closest approach no useful neutrals measurements possible.
- PEP: ~10s shortest measurement interval except for electron data (~1s).
- PEP: Background rates due to radiation levels in Jovian magnetosphere at Callisto much lower than near Europa or Ganymede.
- Implications for models and theory:
  → Ongoing improvement of atmosphere models (1d, 2d, 3d, collisions,…).
  → Combine plasma and atmosphere models of Callisto.
  → First model predictions of Energetic Neutral Atoms images from Callisto done, more details will be published in separate paper.
- PEP input for models: more accurate and localized measurements of plasma, neutral atmosphere (spatial distribution), and surface composition to better constrain models of the Callisto atmosphere and plasma environment.
- *Questions and comments? Write to andre.galli@unibe.ch.*
  *Publication of this study is in preparation.*