More about the reflective properties of plasma, how it works, for 23-cm wave and for the meter wave range. And specifically for the meter wave range, the "Rocket + starting plasma" option.

Reflectivity of plasma for rocket exhausts (λ = 23 cm and meter range)

1. Physics of reflection from plasma

Rocket exhaust plasma is **ionized gas** (temperature ~3000–4000 K), containing:

- **Electrons** (the main contribution to the reflection of radio waves), **Aluminum**
- **particles** (Al_2O_3 from solid fuel, increase dispersion).

Reflection mechanism:

- **For λ = 23 cm (L-band, 1.3 GHz)**:
  - Electrons in the plasma oscillate in the wave field, re-radiating energy (Thomson scattering). **Critical**
  - **electron density** n_e to reflect:

$$n_e = \frac{4\pi^2 \varepsilon_0 m_e f^2}{e^2} \approx 10^{15}\,\text{m}^{-3} \text{ (for 1.3 GHz)}$$

  - Beech exhaust (afterburner) reaches $n_e \sim 10^{16}$-$10^{17}\,\text{m}^{-3}$ → **plasma reflects like metal**. **For the**
- **meter range (λ = 1–2 m, VHF)**:
  - Critical density n falls to 10_e ^{13}-$10^{14}\,\text{m}^{-3}$.
  - Even weakly ionized exhaust ($n_e \sim 10^{14}\,\text{m}^{-3}$) becomes **fully reflective**.

2. EPR of plasma for "Rocket + starting plasma" (meter range)

Plasma plume parameters:

- **Dimensions**: ~1 m (diameter) × 3–4 m (length),
- **Electron density**: $10^{16}\,\text{m}^{-3}$ (peak at start),
- **Radar frequency**: 150–300 MHz (typical for VHF radars, such as P-18).

Calculation of EPR:

1. **Geometric section** plasma plume:

$$\sigma_{geom} \approx \pi r^2 = 0.8\ \text{m}^2 \text{ (for r = 0.5 m)}$$

2. **Reflectivity** R:
   - For $n_e > n_{crit}$: $R \approx 1$ (total reflection).
3. **Effective EPR**:

$$\sigma_{\text{plasma}} = \sigma_{geom} \cdot R \cdot \text{ interference effects} \approx 5\text{–}15\ \text{m}^2$$

Total EPR (rocket + plasma):

- **Meter range**: **10–20 m²** (due to resonance effects at long wavelengths). **Peaks up to 30 m²**
- when the wavelength coincides with the plasma inhomogeneities.

3. Comparison with 23cm range

Parameter	λ = 23 cm (L-band)	λ = 1–2 m (VHF)
Critical n_e	$10^{15} m^{-3}$	$10^{13} m^{-3}$
EPR of plasma	1–5 m^2	10–30 m^2
Penetration depth	Small skin layer (~cm)	Large (~m)
Sensitivity to plasma	Moderate	**Very high**

Example for MH17:

- If the launch of a Buk was detected by VHF radars (for example, the Ukrainian P-18), its launch plasma would give**EPR ~20 m^2**- easily detectable.
- In L-band (23cm) the signal was weaker (~3-5m^2), which explains the gaps in the data.