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Red, hot, and very metal poor: extreme properties of a massive accreting black hole in the first 500 Myr

Roberta Tripodi [*1,2], Nicholas Martis[1], Vladan Markov[1], Maruša Bradač[1], Fabio Di Mascia[3], Vieri Cammelli[4], Francesco D'Eugenio[5,6], Chris Willott[7], Mirko Curti[8], Maulik Bhatt[3], Simona Gallerani[3], Gregor Rihtaršič[1], Jasbir Singh[9], Gaia Gaspar[10], Anishya Harshan[1], Jon Judež[1], Rosa M. Merida[10], Guillaume Desprez[10,11], Marcin Sawicki[10], Ilias Goovaerts[12], Adam Muzzin[13], Gaël Noirot[12], Ghassan T.E. Sarrouh[13], Roberto Abraham[14,15], Yoshihisa Asada[10,16], Gabriel Brammer[17], Vicente Estrada-Carpenter[10], Giordano Felicioni[1], Seiji Fujimoto[14,18], Kartheik Iyer[19], Lamiya Mowla[20], and Victoria Strait[21,22]

Little Red Dots (LRDs) = heterogeneous population / both AGN and SF contribute to observed light
- AGN : broad component in Balmer lines
- SF : Balmer break =>evolved stellar population
- Over massive blackhole compared to MBH-M* relation

CANUCS-LRD-z8.6
- Selection criteria
  - Red rest-optical slope ($\beta_{opt} > 0$)
  - Blue rest-UV slope ($-2.8 < \beta_{UV} < 0.37$)
  - Compact size ($r_h < 1.5 r_{h,stars}$)
- R<70pc
- FWHM_Hb=4200km/s
  => M_BH=1e8 Msun
  => 100x heavier than that in GN-z11
- NIV]1483,1486検出 => AGN
- Only z>7 LRD having clear signature of AGN
- [OIII]4364 detected => Te=40000K <= consistent with AGN
- Z<0.2Zsun
- OHNO diagnostic plot (Fig2)
  => occupies the region of Low metallicity (Z<0.1Zsun) and and high ionization parameter (log(U)~-1.5)
- Bagpipe SED fitting => M*=7.6e9 Msun
  => comparable to z=4.7 QG (GS9209, M*=1.7e10Msun, z_quench=7)
  => this galaxy may be quenched by SMBH?
- M*-MBH relation (Fig3)
  - Above local relation

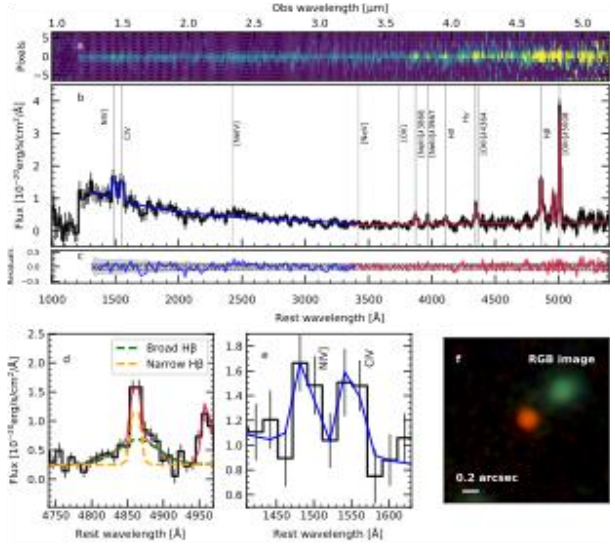

Figure 1: **NIRSpec PRISM spectrum and RGB image of CANUCS-LRD-z8.6 at z = 8.6319 ± 0.0005.** Panel a: 2D spectrum. Panel b: The

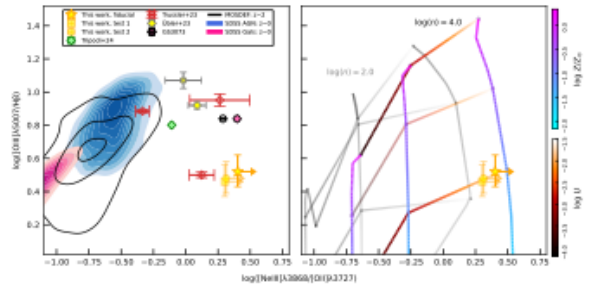

Figure 2: **[O III]λ5007/Hβ–[Ne III]λ3869/[O II]λ3727 narrow line ratio diagram.** The fiducial result for CANUCS-LRD-z8.6 is shown as a yellow

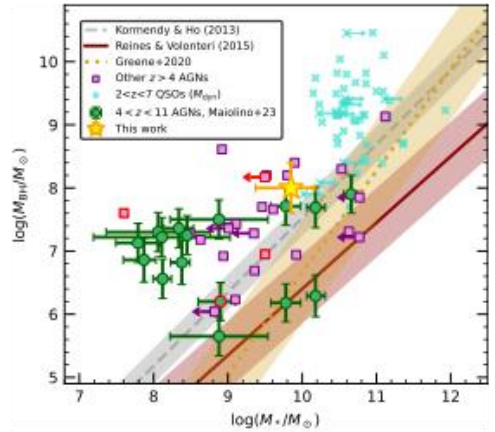

Figure 3: **Black hole mass versus stellar mass.** The results for CANUCS-

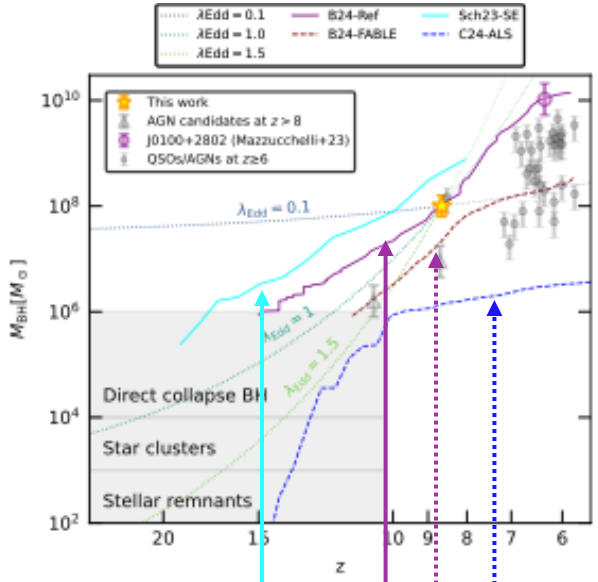

Figure 4: **Black hole mass accretion history.** The growth history of

Formation Scenario
- Simple constant accretion prescription:
  - Current accretion (0.1 Eddington) cannot explain the M_BH
  - Eddington accretion : requires direct collapse BH (>1e4Msun) as a seed
  - Super Eddington accretion : PopIII stars can be a seed, but impossible to sustain super Eddington accretion for a long period
- Semi-analytical models
  - x Eddington Limited model that matches LF @z<9 and local Maggorian relation
  - x Most simulations with standard prescription
    <= AGN feedback prevents BH growth
  - o Super Eddington accretion
  - o Modified models ("mild" super Eddington accretion) that reproduce z~6 10e10Msun SMBHs
- Similar object : UNCOVER 20466 (M_BH~1e8Msun, M*<1e8Msun/Kokorev+23)

Our understanding of early galaxy evolution and its link to the local Universe may need substantial revision, if substantial population of SMBHs @z=8-9