

Search for Hidden Photon Dark Matter in the Millimeter Wave Region with a Dish Antenna

Takayuki Yamazaki¹, Y. Okesaku², S. Knirck³, T. Inada¹, S. Asai², and T. Idehara⁴

¹International Center for Particle Physics, The University of Tokyo

²Department of Physics, Faculty of Science and Graduate School of Science, The University of Tokyo

³Institute for Theoretical Physics, University of Heidelberg

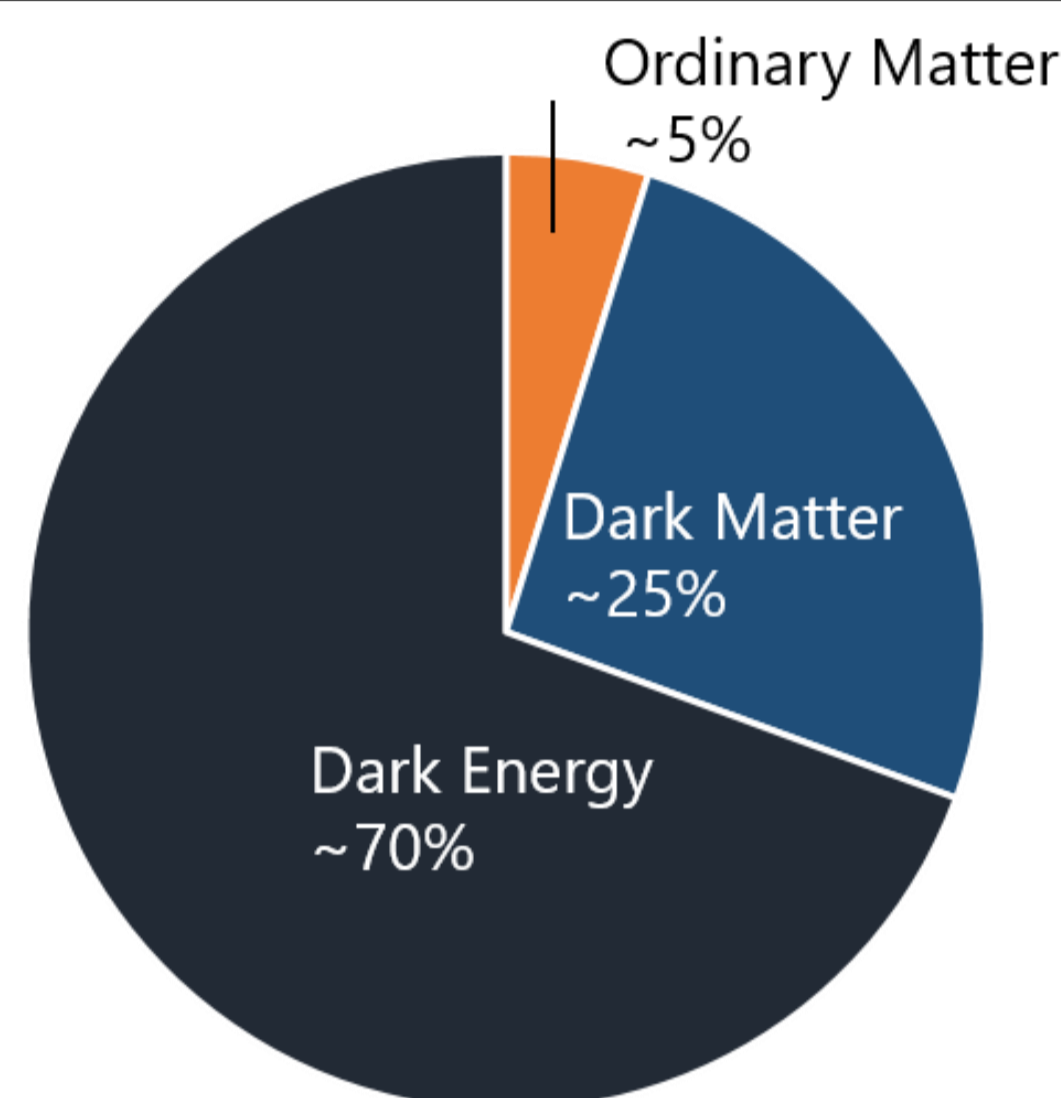
⁴Research Center for Development of Far-Infrared Region, University of Fukui

E-mail: yamazaki@icepp.s.u-tokyo.ac.jp



Dark Matter

Constituents of the Universe



- The Milky Way Galaxy is filled with DM. Local DM density is $\rho_{\text{DM}} = 0.3 \text{ GeV/cm}^3$.
- From standard halo model, local DM velocity dispersion is $v = 220 \text{ km/s}$ ($\beta = v/c = 10^{-3}$).

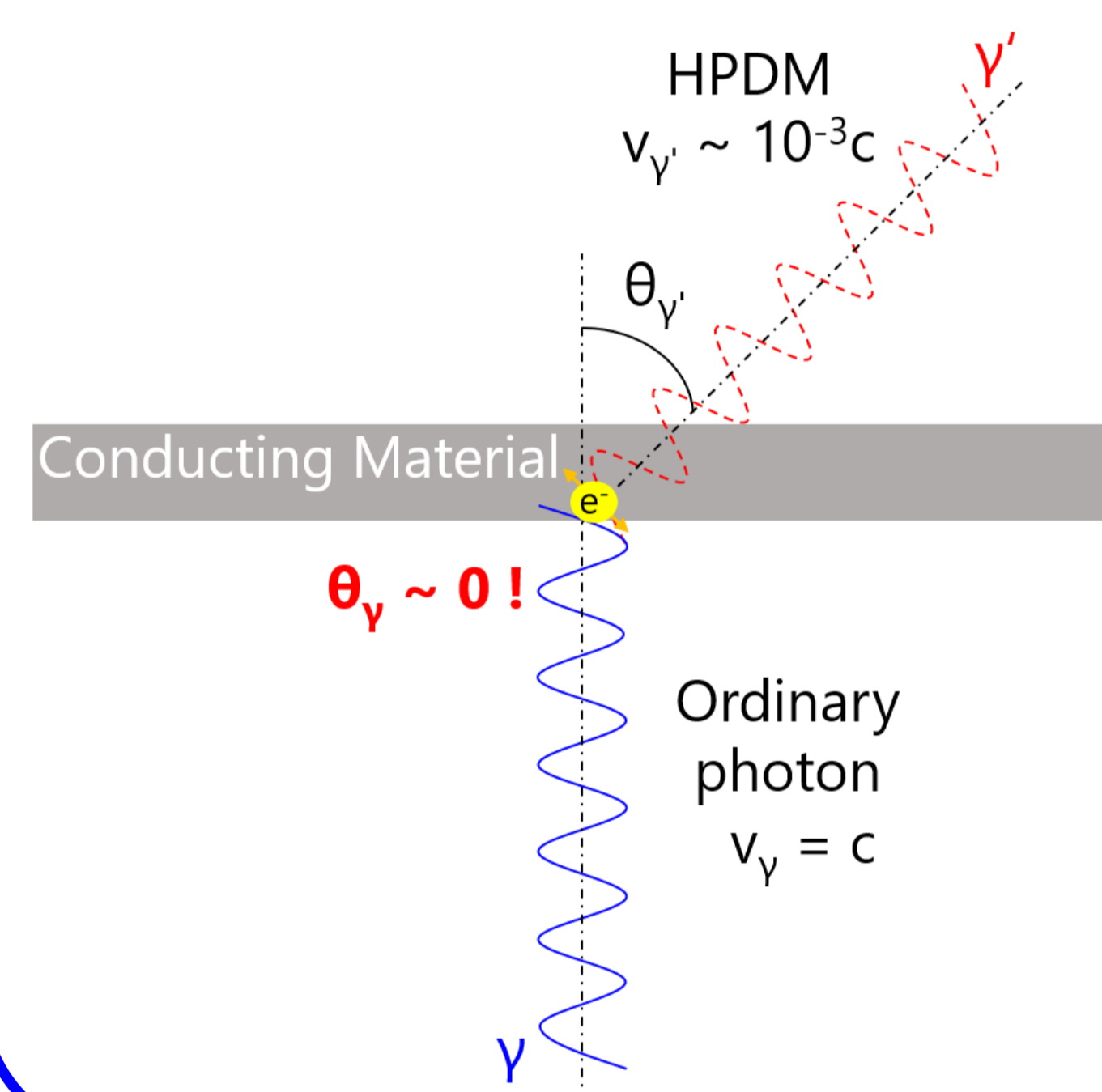
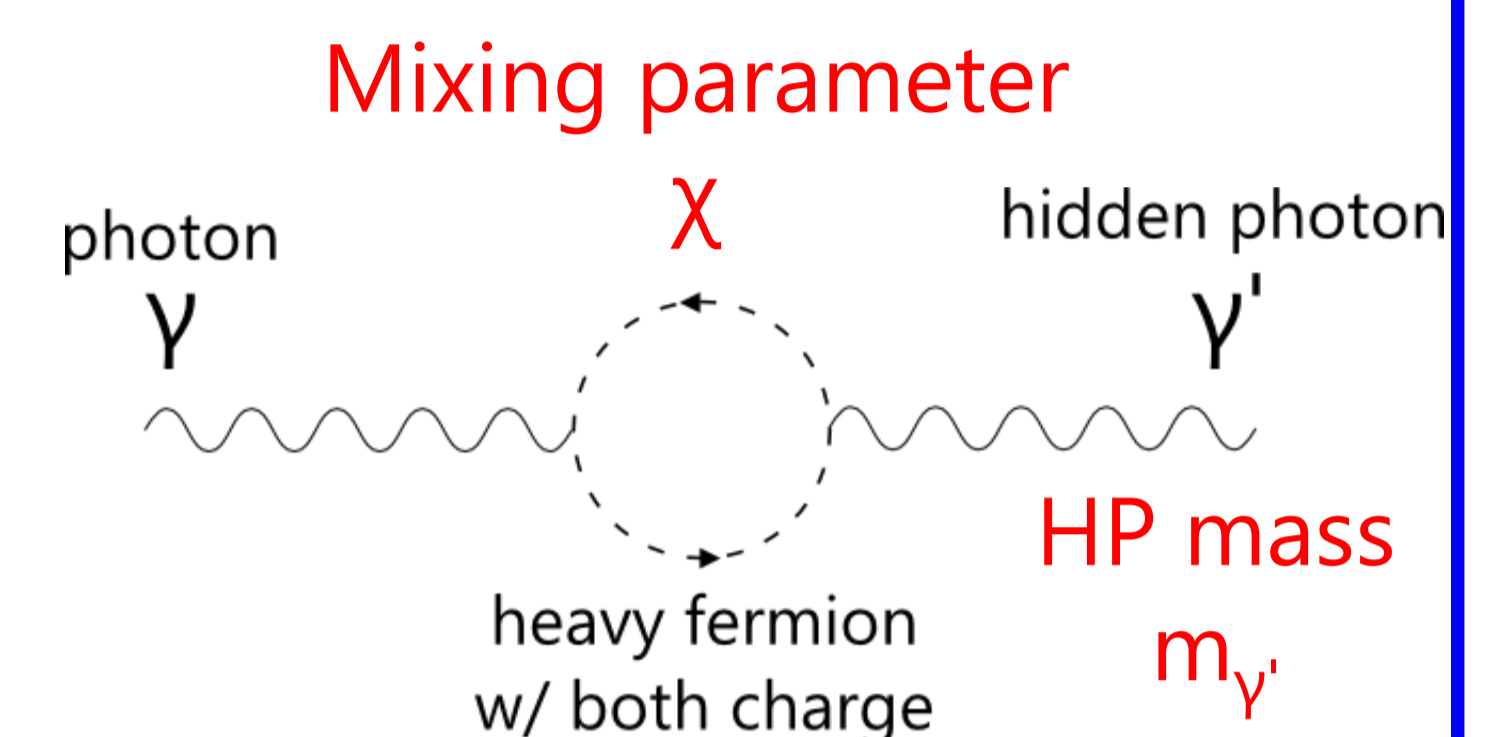
Candidates of DM

- WIMPs (Weakly Interacting Massive Particles)
- WISPs (Weakly Interacting Slim Particles)
- ✓ Axion Like Particle
- ✓ Hidden Photon (HP)

We are searching for hidden photon dark matter (HPDM) in the MMW region.

Hidden Photon

- Extra U(1) gauge boson predicted by many extensions of the Standard Model
- Interact with an ordinary photon via kinetic mixing (c.f. neutrino oscillation)

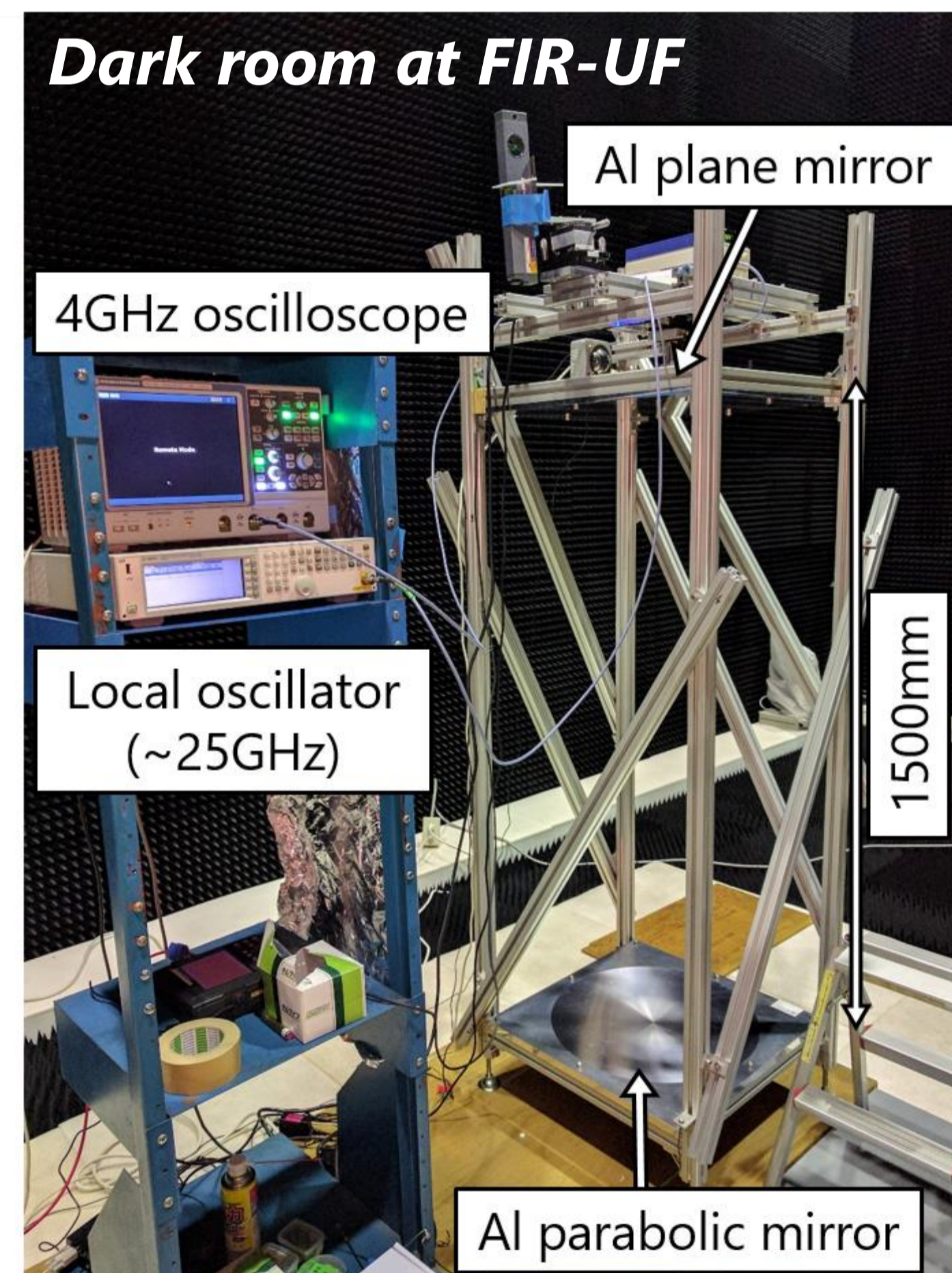
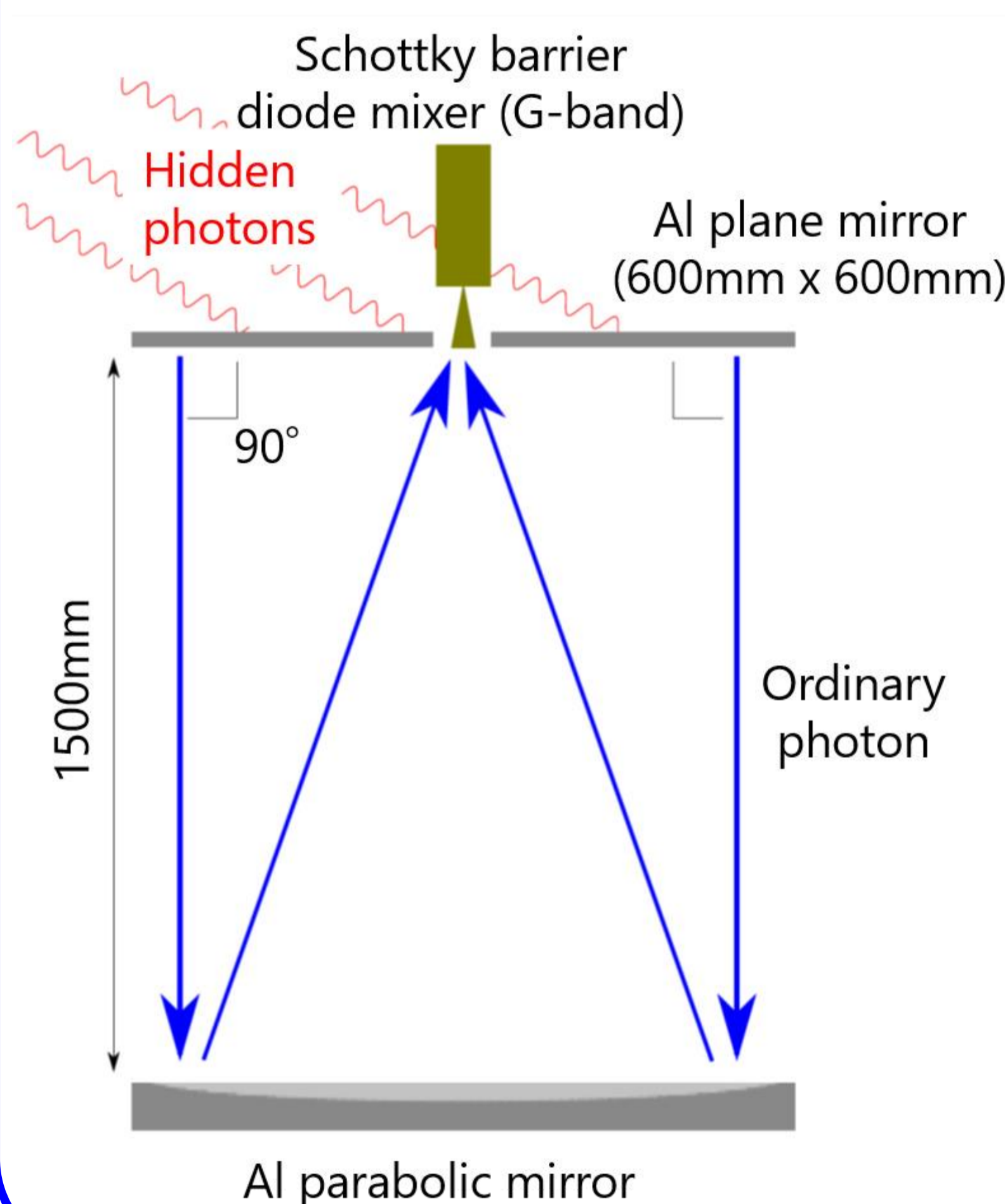


"Dish Antenna Method"

JCAP 04, 016 (2013)

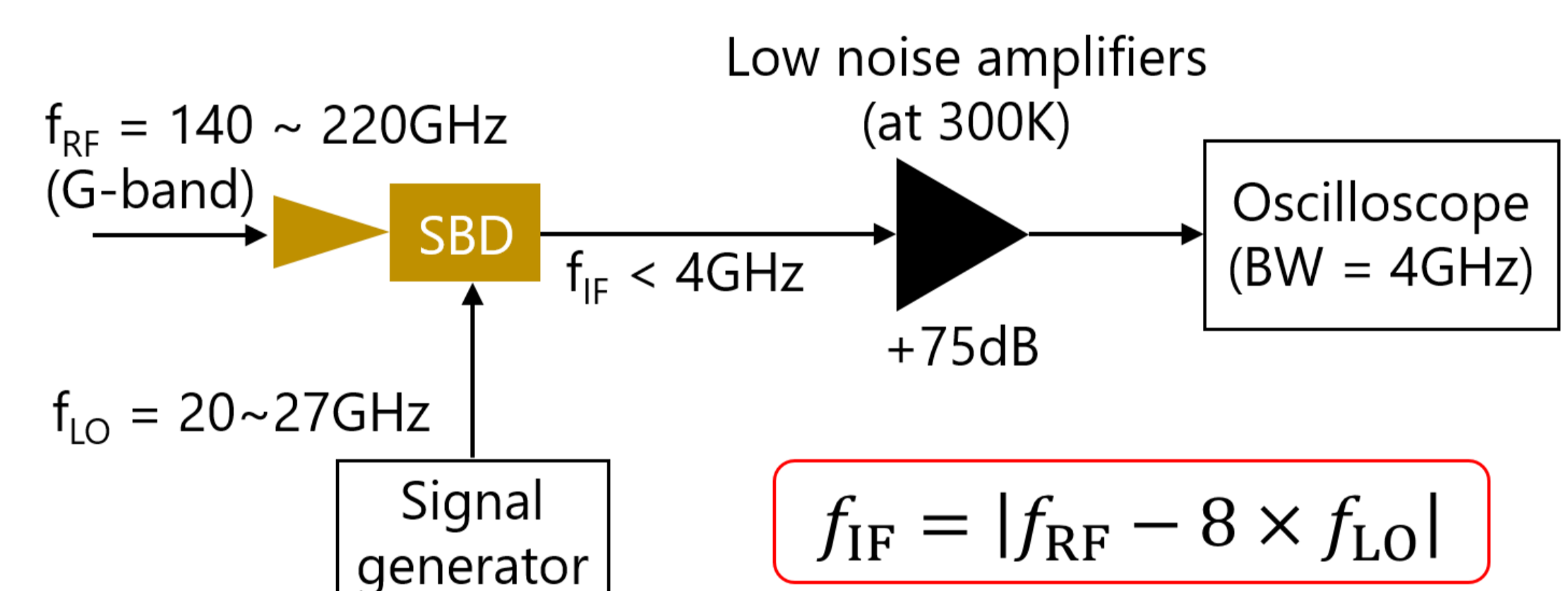
- A HP has a tiny electric field and causes free electrons in conducting material to oscillate. So, a HP is converted into an ordinary photon on a conducting surface.
- Snell's law: $v_{\gamma'} \sin \theta_{\gamma'} = c \sin \theta_{\gamma}$
 $v_{\gamma'}/c = \beta_{\gamma'} = 10^{-3} \rightarrow \theta_{\gamma'} \sim 0!$

Experimental Setup

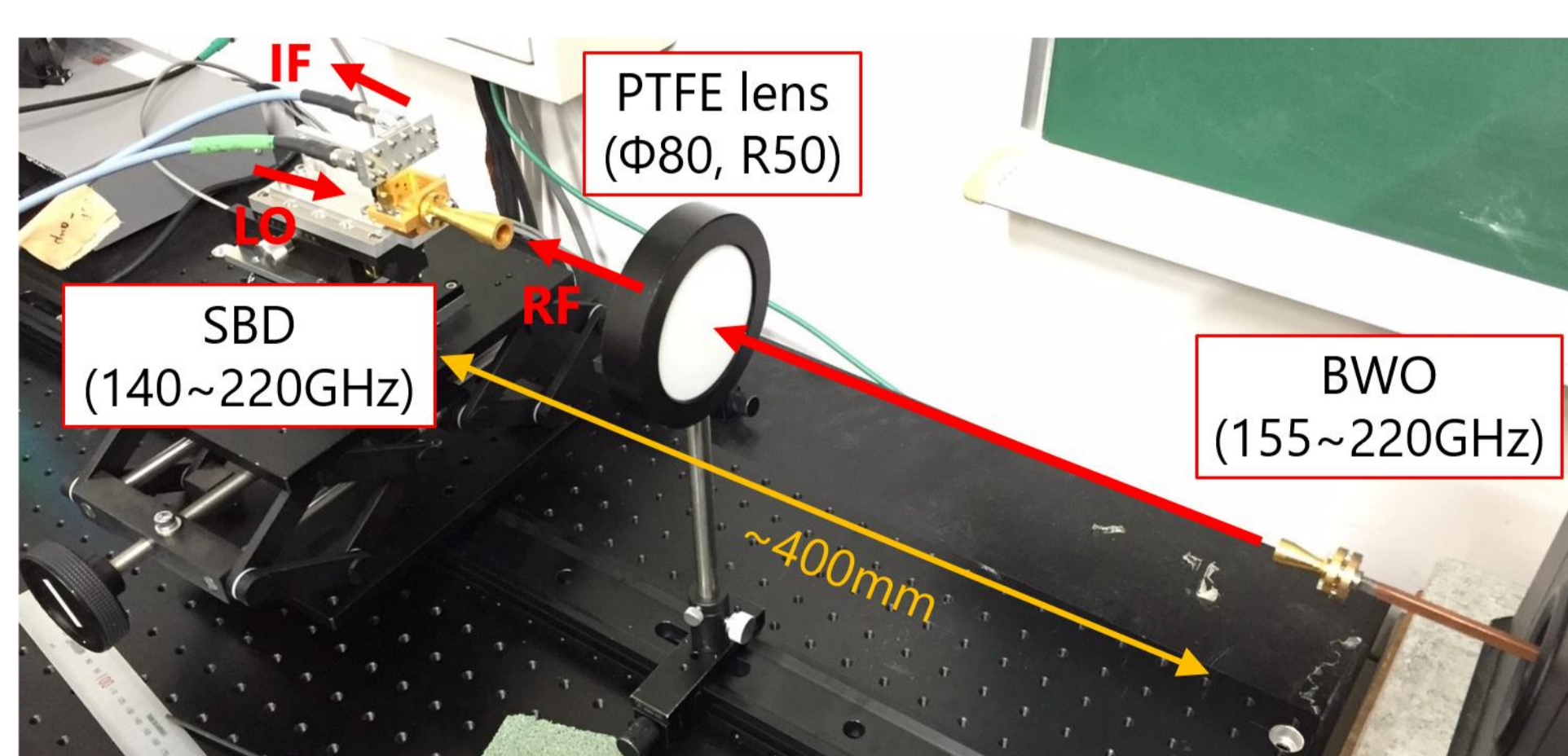


Key Point

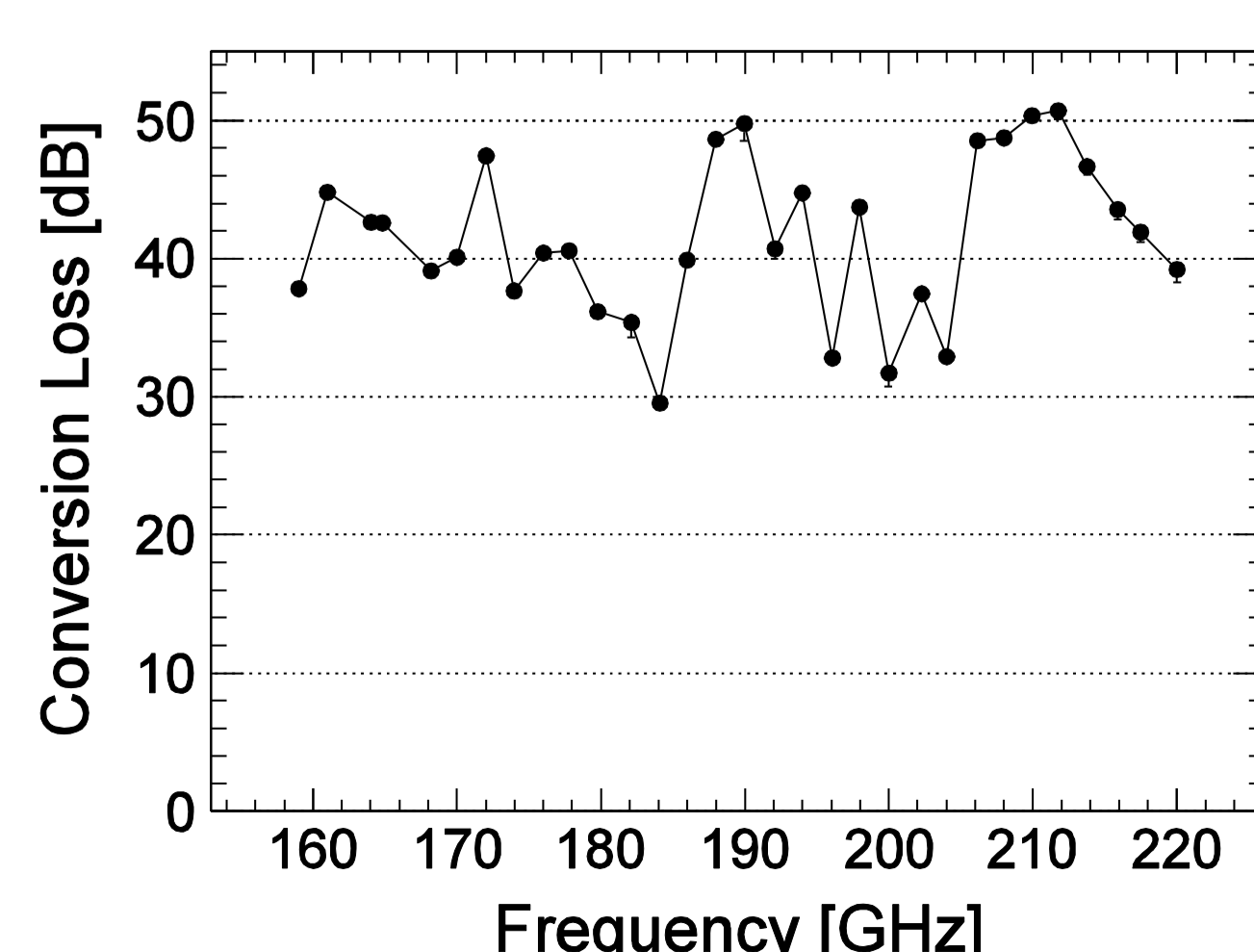
- Large conversion plate
→ 600mm x 600mm Al plane mirror
- Good MMW detector
 - ✓ Low noise
 - ✓ High detection efficiency (or low conversion Loss)
 - ✓ Wide bandwidth
- use Schottky barrier diode (140~220GHz) as a first step



Conversion Loss of SBD

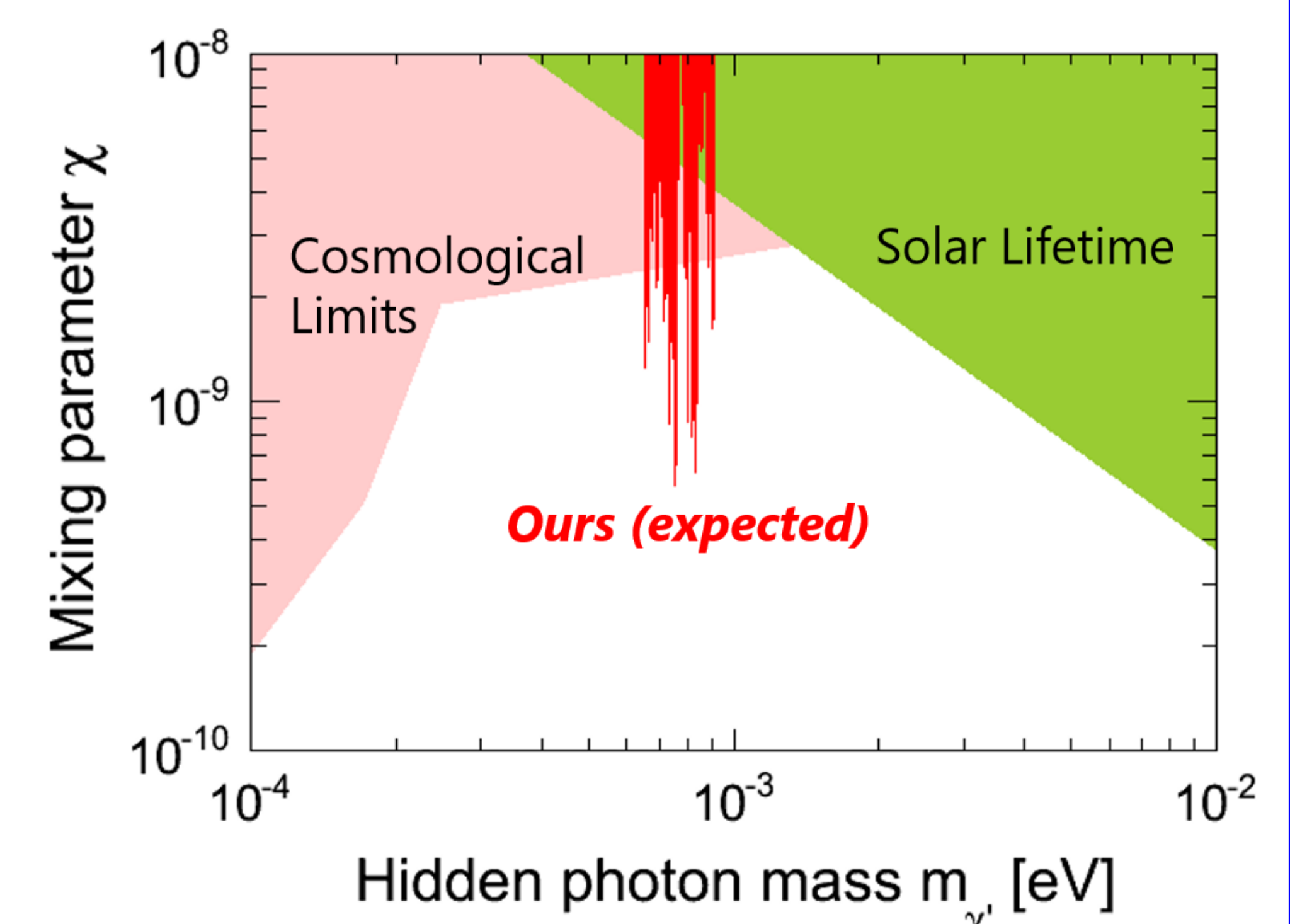


- Need to measure the conversion loss of the SBD to estimate sensitivity to HP signals
- Use BWO (Backward Wave Oscillator) which can change frequency from 155GHz to 220GHz



Current Status

- Now taking physics data (until April 2017)
- Our experiment is the first search for HPDM in the MMW region, and can evade a new parameter space.



- The sensitivity is limited by the large conversion loss of the SBD, so we are planning to use low noise superconducting detector, such as SIS, in the future.