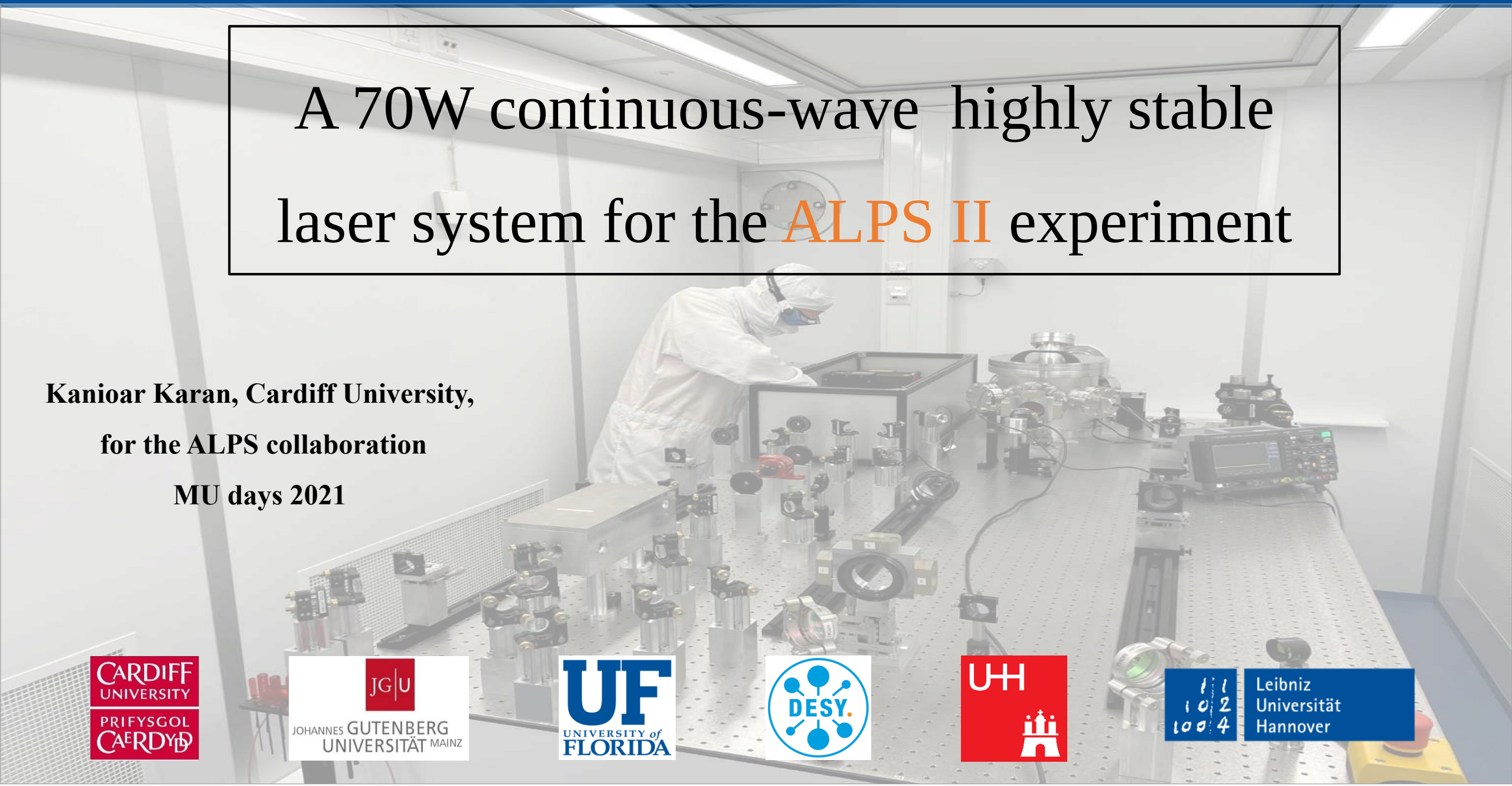
A 70W continuous-wave highly stable laser system for the ALPS II experiment

Kanioar Karan, Cardiff University,

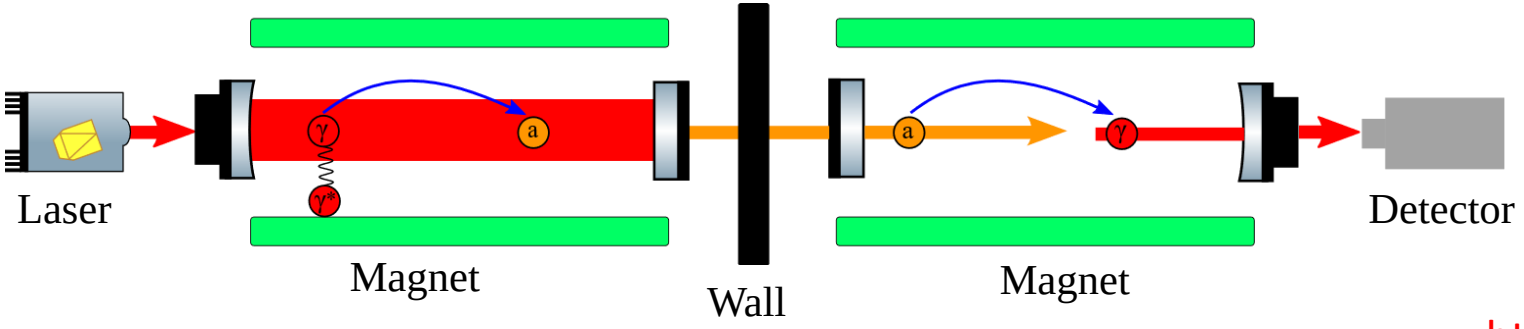
for the ALPS collaboration

MU days 2021



Why a “high power” Laser?

- Axion-Like-Particle (Dark Matter) search via Light-Shining-Through-a-wall



https://alps.desy.de/

- Optical cavities to enhance the process

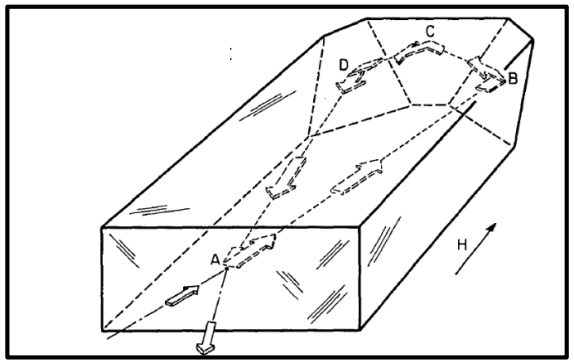
- Number of regenerated photons $\propto P \cdot \left(g_{a\gamma\gamma} \cdot B \cdot L\right)^4 \cdot \beta_{PC} \cdot \beta_{RC}$

Requirements on the laser:

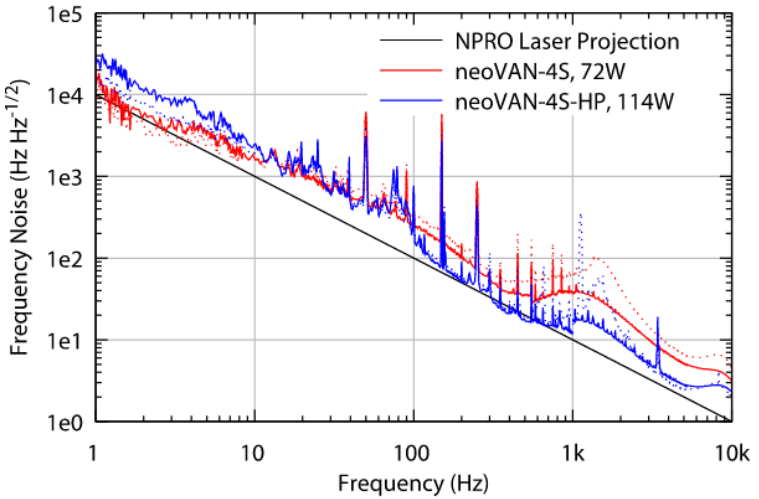
- **Single frequency**
- **Single mode**
- **Low power noise**
- **Low frequency noise**
- **Good beam pointing stability**

Master oscillator + power amplifier (MOPA)

- Non-Planar Ring Oscillator (NPRO)
  - Ultra stable
  - Up to 2W and low power noise
  - Single-frequency and Low frequency noise
  - Pure TEM_{00} mode (Single mode)
- Power amplification via Nd:YVO_4 crystals
  - Up to 70W and low power noise (~ NPRO)
  - TEM_{00}: > 90%
  - Single-frequency and Low frequency noise



Monolithic, unidirectional single-mode Nd:YAG ring laser Thomas J. Kane and Robert L. Byer, Optics Letters, Vol. 10, Issue 2, pp. 65-67 (1985)



Nd:YVO4 high-power master oscillator power amplifier laser system for second-generation gravitational wave detectors, Fabian Thies et al, Optics Letter, Vol. 44, pp. 719-722 (2018)

70W laser system for ALPS II

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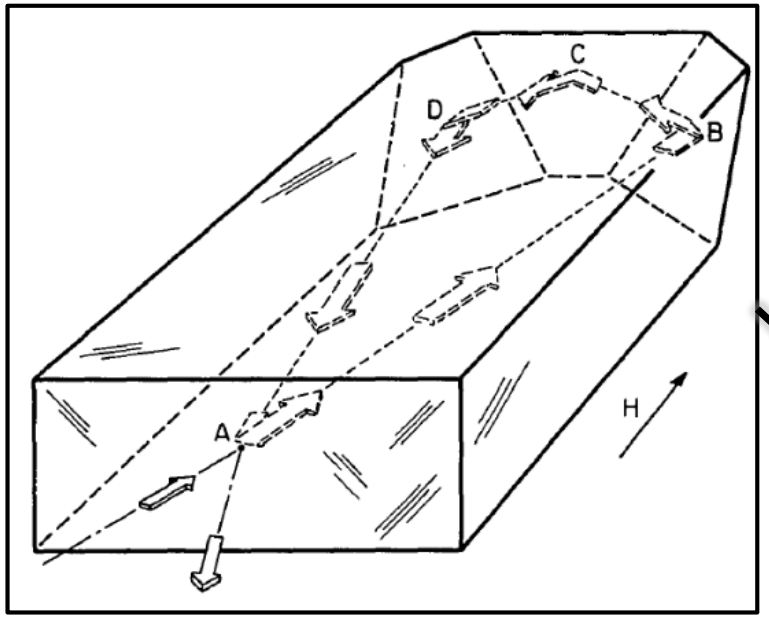
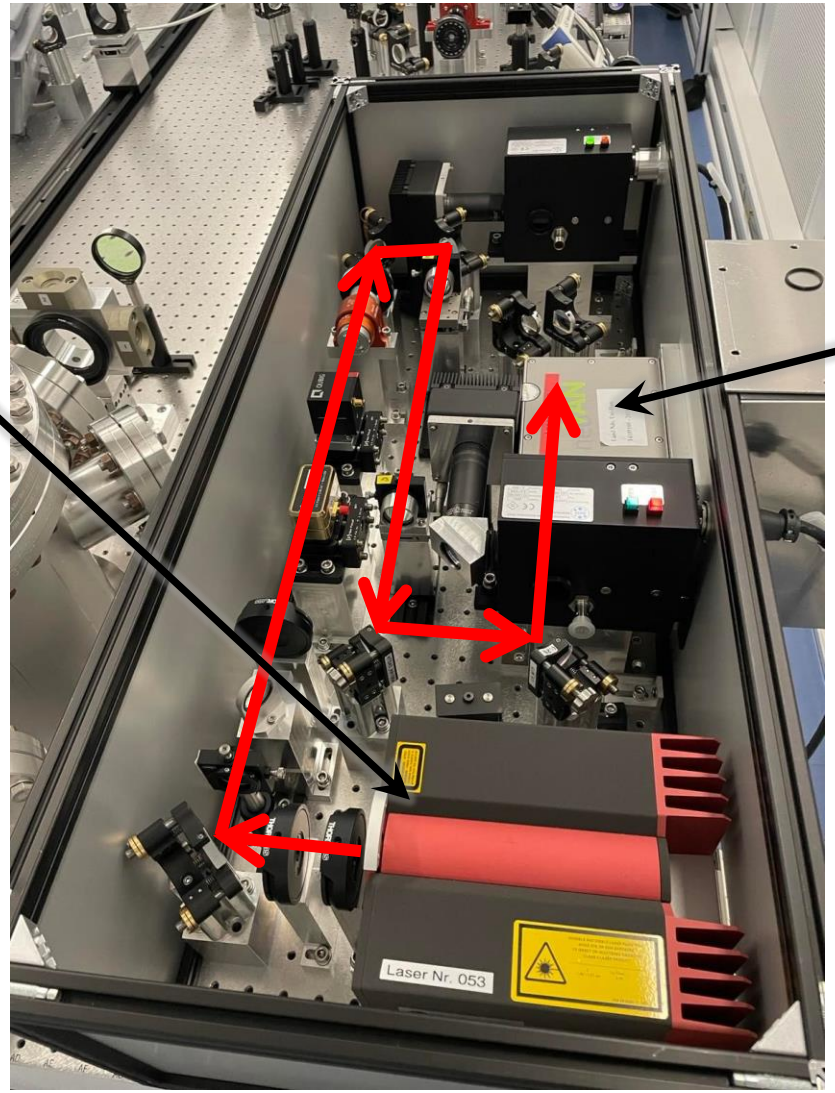
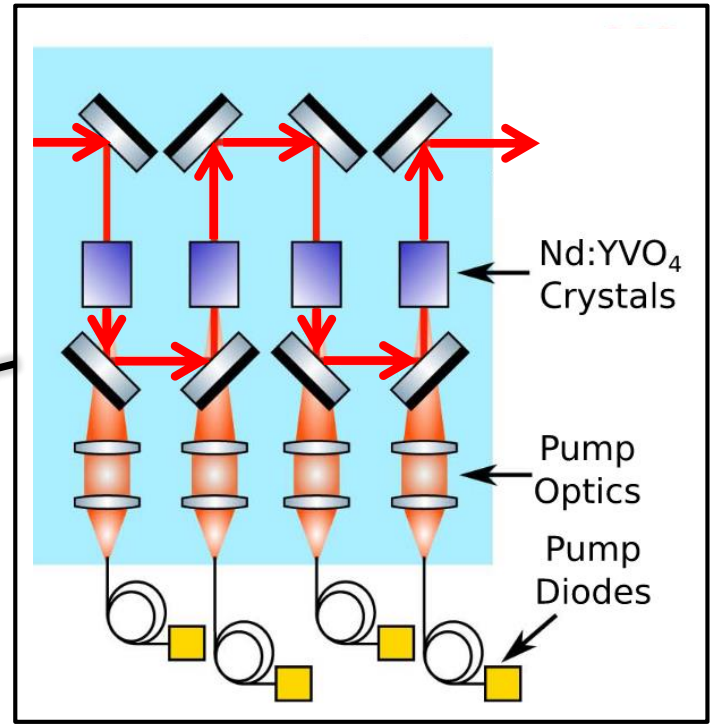






Seed laser:

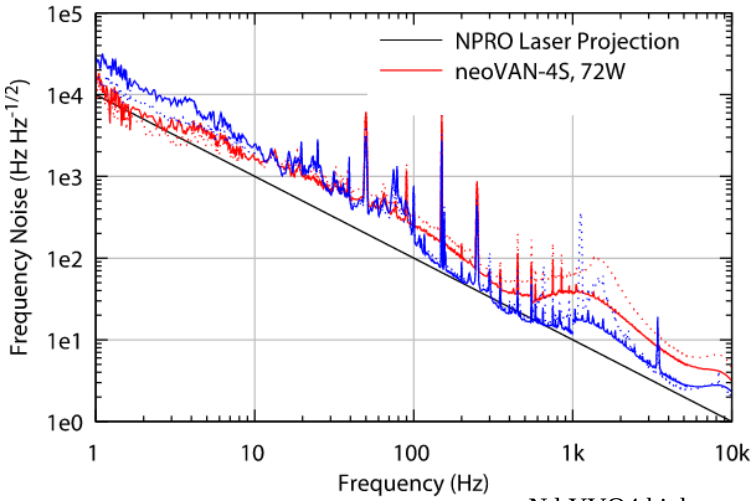
- Non-Planar Ring Oscillator (NPRO)
- 1064nm
- Ring cavity
- Monolithic (Nd:YAG)
- Single-Frequency
- Single-mode

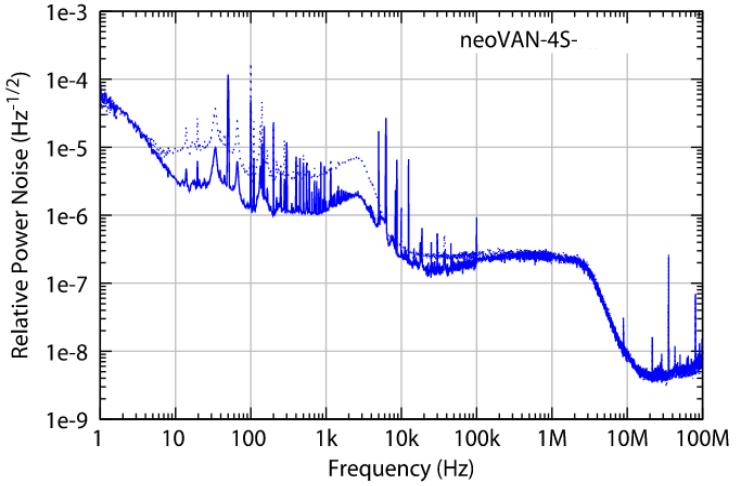
Amplifier stage(neoVAN):

- - Four Nd:YVO_4 crystals
- - Fiber-coupled pump diodes

70W laser system for ALPS II performance

- Overall power at 1064nm: **70W**
- Circulating power within the cavity: 150kW
- TEM_{00}: **> 90%**
- Low frequency noise (~NPRO)
- Low power noise (~NPRO)





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