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Enabling Smarter Future

Optical Metrology for Image Quality and Latency Performance of AR Smartglasses

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Total Process Ownership for AR Optical Metrology

- ✓ 18 years of expertise in test automation, optical metrology
- ✓ Off-the-shelf products and tailored test solutions
- ✓ 14000+ delivered systems
- ✓ 450+ true tech geeks worldwide
- ✓ 18 support and service teams on 3 continents
- ✓ Working with all major brands including Google, Nreal, Intel, AMD, Qualcomm, Samsung, Lenovo, Asus, Dispelix, Pico, Sunny Optical
- ✓ HQ and own manufacturing in Finland, EU
- ✓ Engineering offices in Cupertino, CA and Redmond, WA
- ✓ Engineering and manufacturing facilities in APAC
- ✓ Global market leader in AR and Touch display optical metrology and robot-assisted test & measurement systems

AR Smartglasses

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AR Smartglasses

"Both Real and Virtual Images can be seen at the same time"

How it works?

A light engine creates the light, which is coupled into a waveguide combiner's input grating.

The light is then, transmitted along the waveguide (via total internal reflection) towards the output grating where it is guided towards the eye.

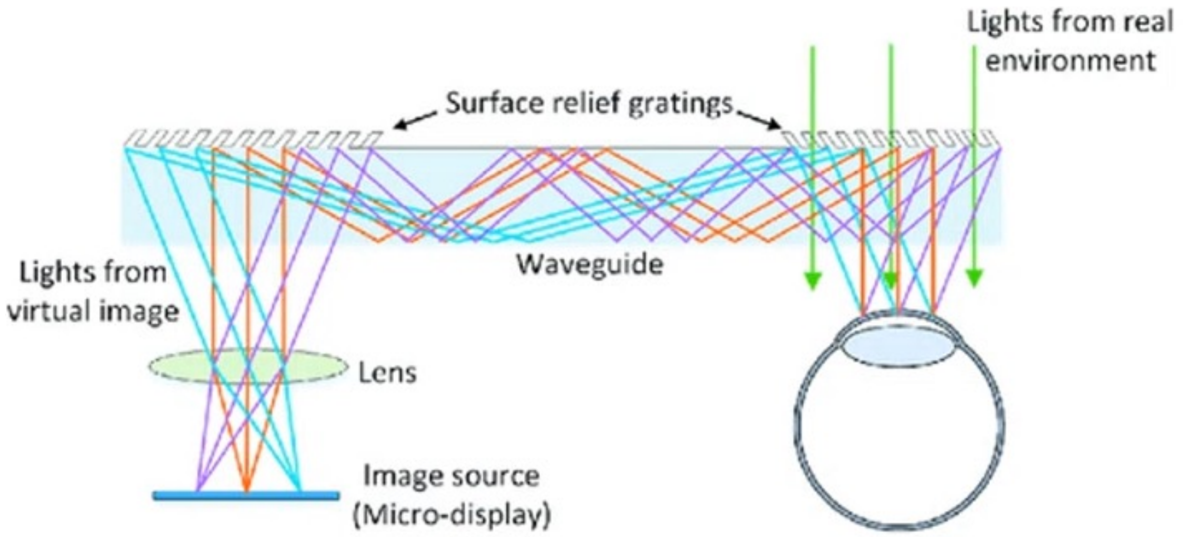

Image reference: doi: 10.3389/frvir.2022.838237

What is expected from AR Smartglasses?

Immersion and **Comfort**

Immersion produces the sensation of presence. Multisensory (display, audio, gestures, haptics, etc.)

Spatial-Temporal - the simulated world is convincing (presence)
Sensory-Motoric - skill challenge (action)
Cognitive - mental challenge (thinking)
Emotional – The user gets invested in a story (feeling)

Comfort provides primarily a subjective user experience.
Wearable - weight, form factor, thermal management, battery life
Visual - IPD, display resolution, sharpness, brightness, FOV, color uniformity
Social – form factor, see-through

How to fulfill these expectations?

Building a comfortable, enjoyable, and immersive AR experience with eyewear starts by selecting the right components for its optical/display architecture.

The challenge of the optical design team is

- **to choose the right balance and the best compromise between**
- **the coupling efficiency**
- **image quality over the eye box and the entire FOV**
- **mass production suitability, and other factors (weight, etc.)**

Once the design is ready,

An evaluation of the end product and its components' performances is needed.

The challenge of the evaluation/testing phase is

Ensuring what and where the measurement is taken in the eye-box and how to repeat it.

This requires:

- **A human eye-mimicking machine vision system that provides a single shot imaging over the entire FOV**
- **High-accuracy robotics to ensure the imaging position and repeatability**

Optical Metrology for Image Quality

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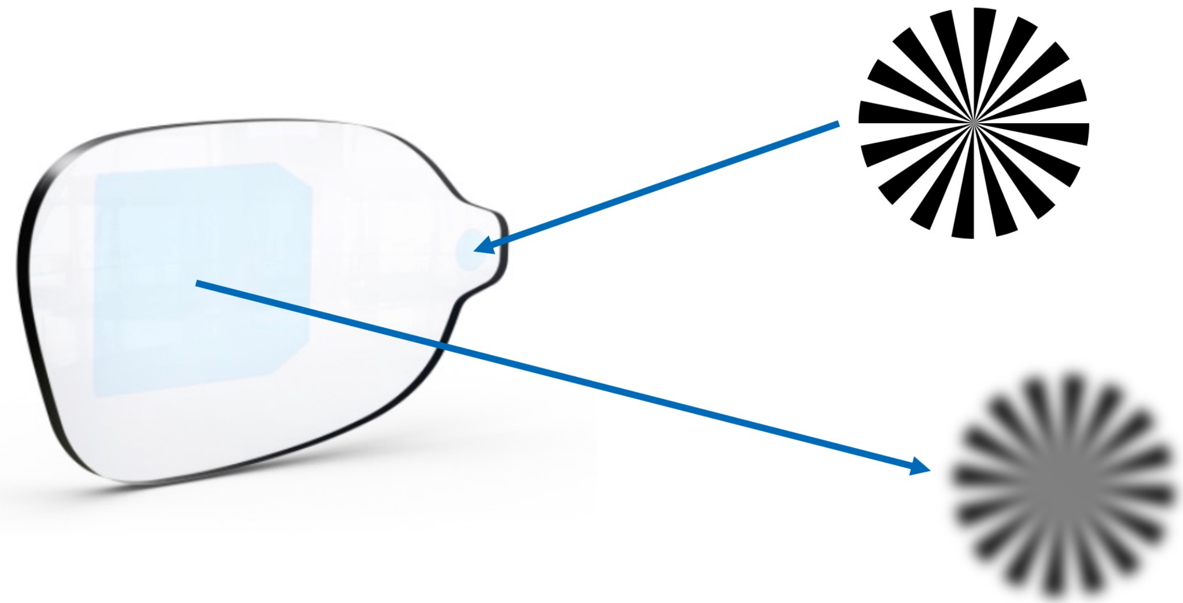
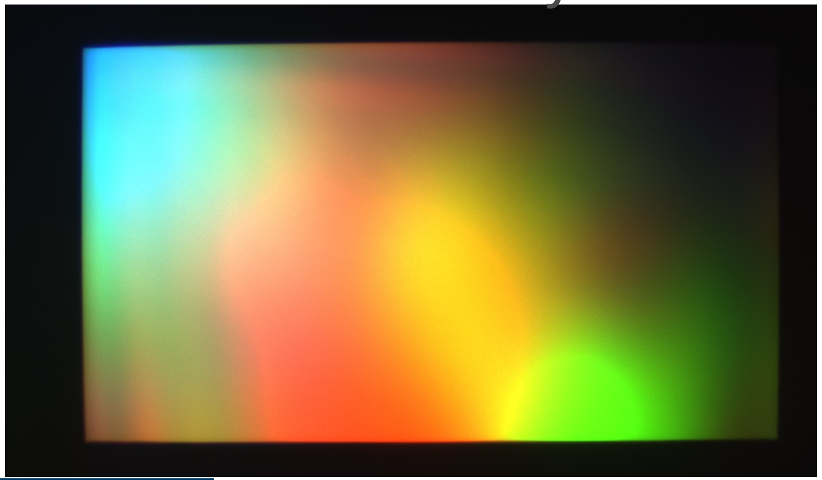
What has been the problem?



Expectation

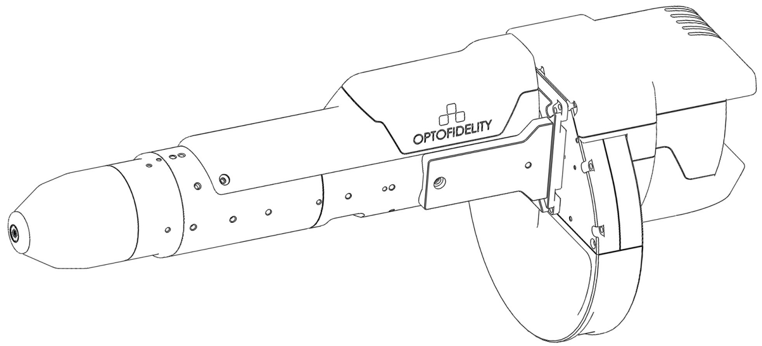
Worst Case Reality



How did we solve it?

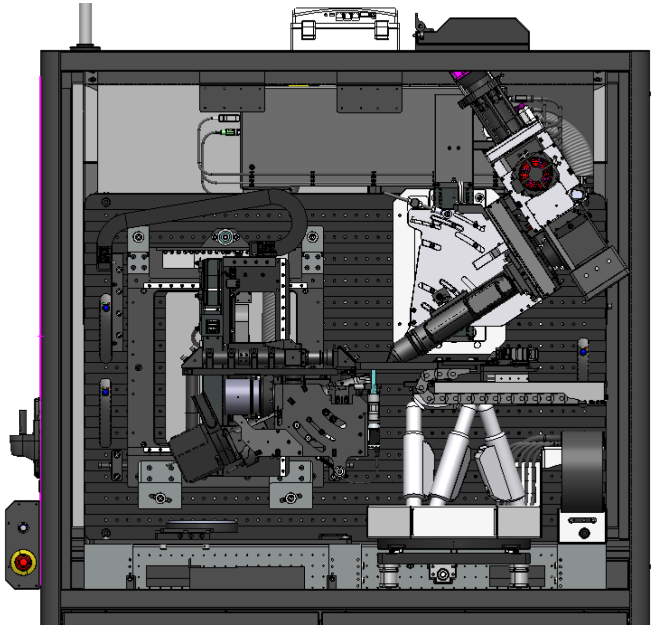
Human-eye mimicking optical setup

- **OptoEYE**, mimics the human eye's radiometric properties
- **OptoColor**, mimics the human eye's colorimetric properties
- **OptoProjector**, mimics a uniform, powerful light engine



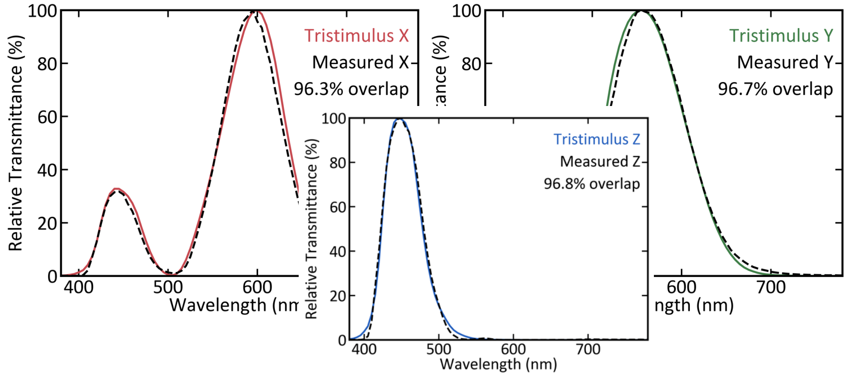
Robotics

- pantoscopic tilts (up to 12°)
- face wraps (±7.5°)
- Rx up to ± 8 dpt
- both world-side and eye-side
- wafers and diced waveguides

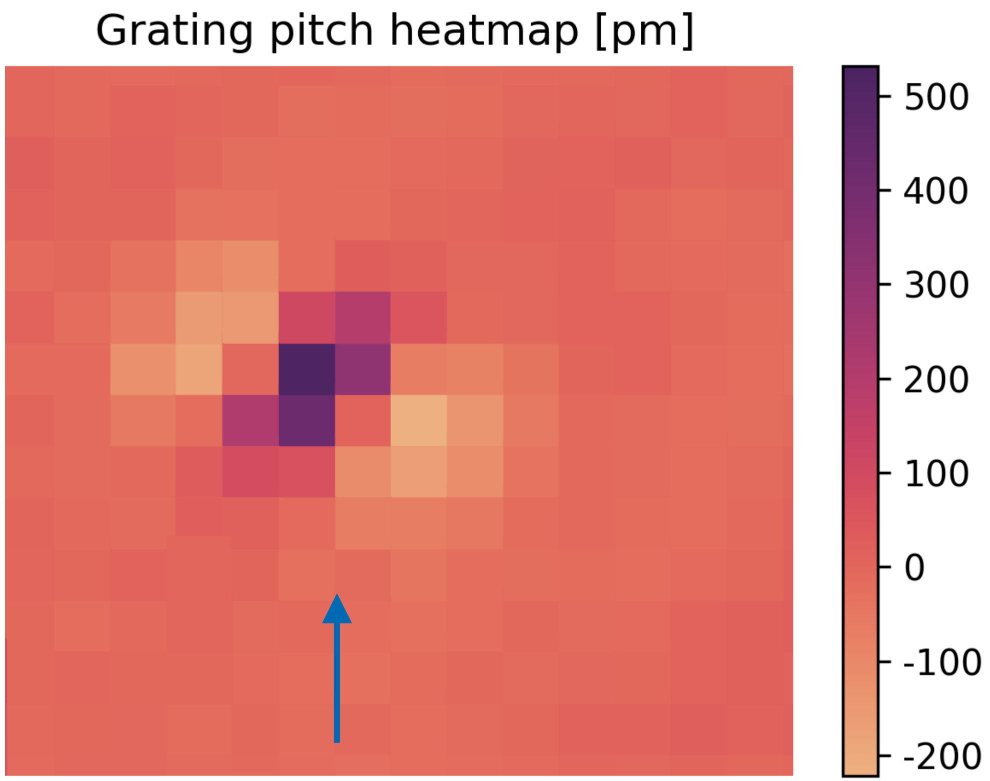


Measurements

- Efficiency
- Checkerboard Contrast
- Field of View
- Luminance & Radiance Uniformity
- Chromaticity & Color Nonuniformity
- Distortion
- CRA
- MTF

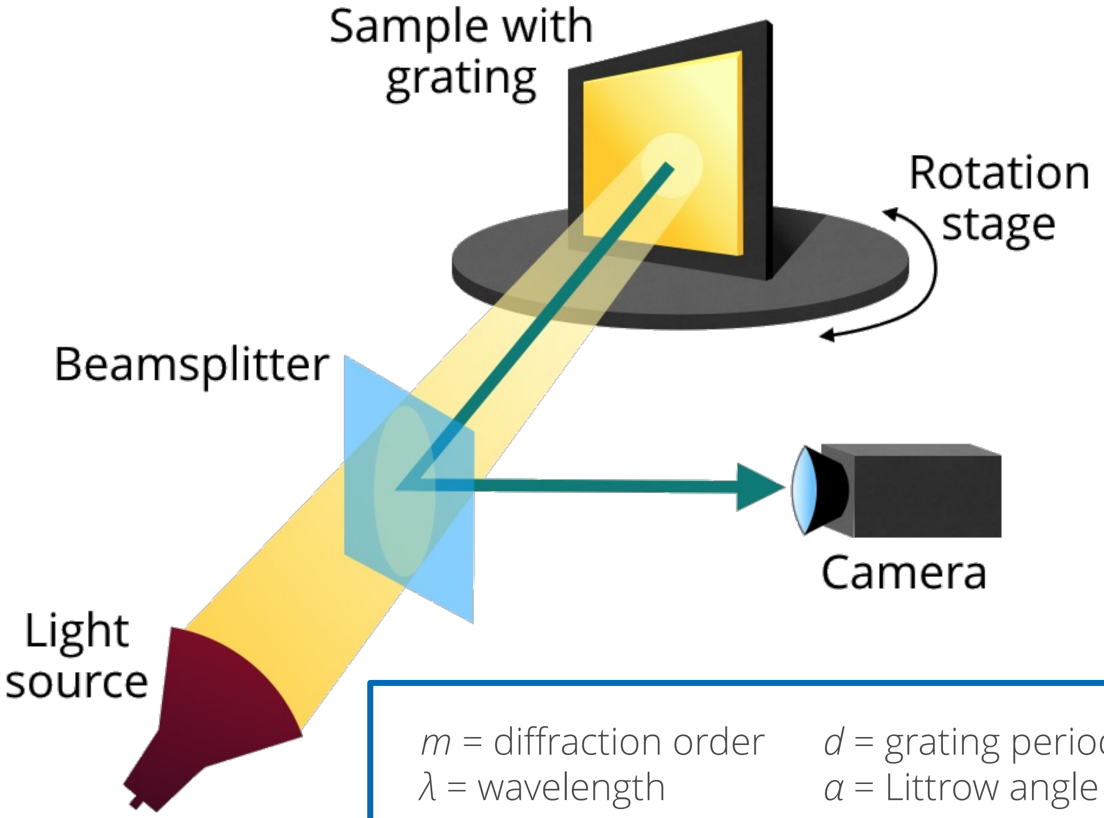


How did we solve it?



500 pm pitch defect

Area: 6 mm x 8 mm



m = diffraction order
λ = wavelength
d = grating period
α = Littrow angle

Optical Metrology for Latency Performance

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Temporal Performance Testing of AR Smartglasses

<u>Anchoring of virtual objects</u> in the real world.

- Hologram stability
- Registration accuracy
- Localization error

Anchoring is achieved by **S**imultaneous **L**ocalization **A**nd **M**apping (**SLAM**)

- Environmental mapping: Triangular mesh
- Eye-wear's location and orientation estimation: pose

Measurement cases for the stability of **world locking** include:

User related changes:

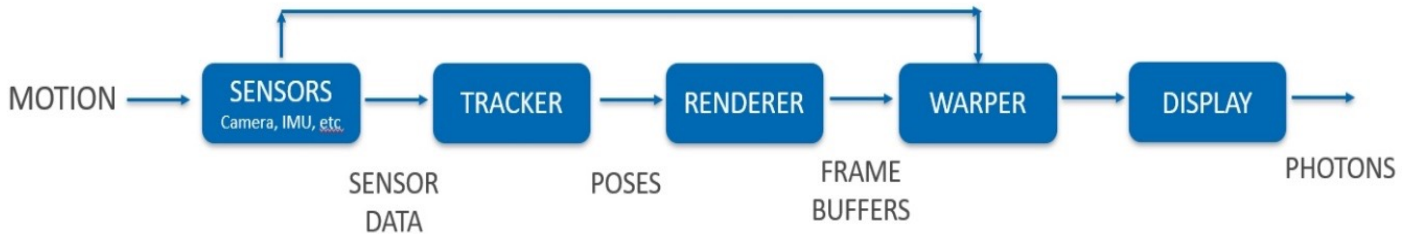
rotation of the head, moving around

Environment related changes:

objects are moved, changed their shapes

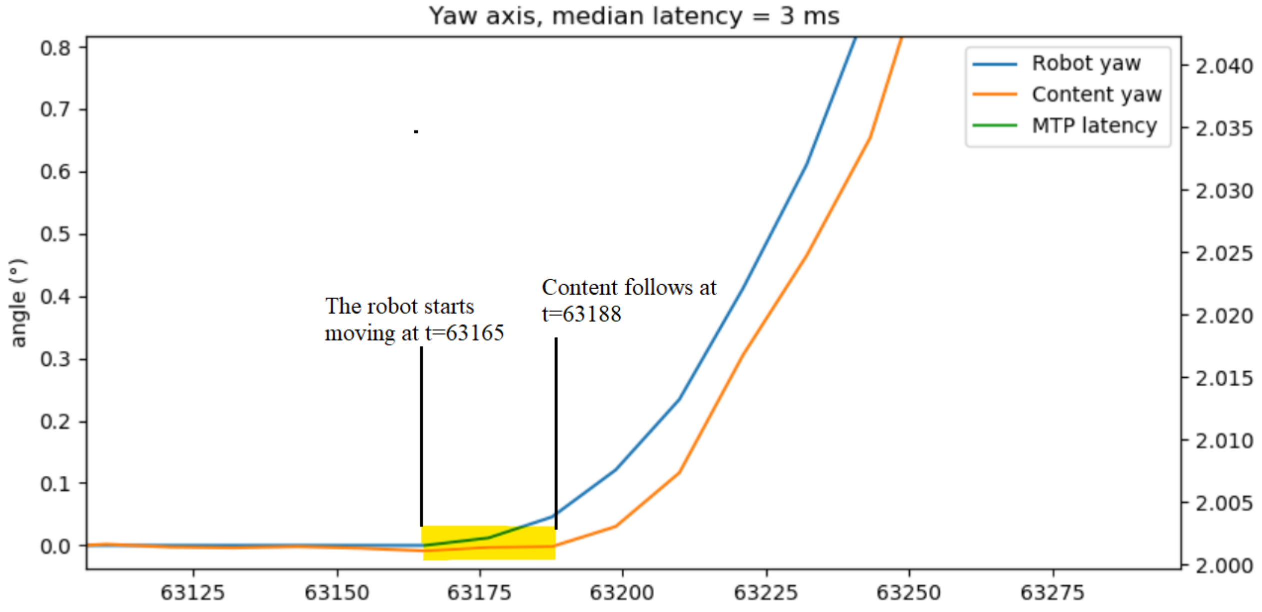
illumination changed

same user but different room for the same tests

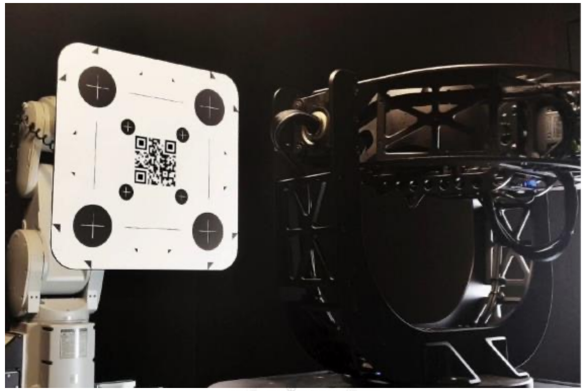


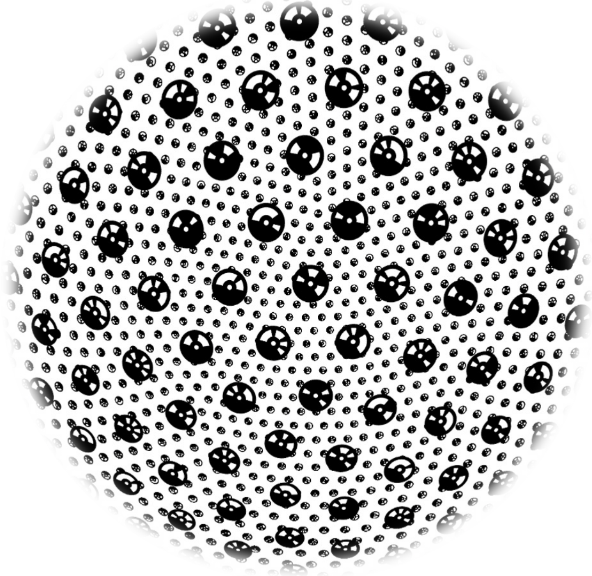
How did we solve it?

E2E M2P, TRACKING, SLAM, HOLOGRAM STABILITY, WORLD LOCKING



CALIBRATION OF IMU/EYE/FACE TRACKING, GESTURE RECOGNITION





Summary

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What else can be done?

AR displays are in constant development mode.
What is the future? None knows.
We will develop many more optical metrology systems, and looking for guidance and collaboration.

AR smartglasses consist of 100s of different components, we directly cover only a few of them. We
Come to us with your testing and metrology challenges.

The mass production is sometime soon, we will need to improve our testing times.
Bring your collaboration ideas, we welcome them!

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Thank you!

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