ALPS II cavity control with a surrogate field: model and experiment

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ALPS Collaboration Partners

DESY

UF UNIVERSITY of FLORIDA

JG|U JOHANNES GUTENBERG UNIVERSITÄT MAINZ

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

EJT was visiting from University of Wyoming via UF's IREU program

15TH PATRAS WORKSHOP ON AXIONS, WIMPS AND WISPS
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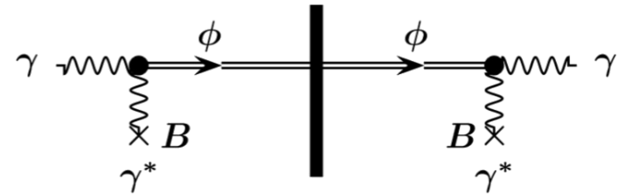
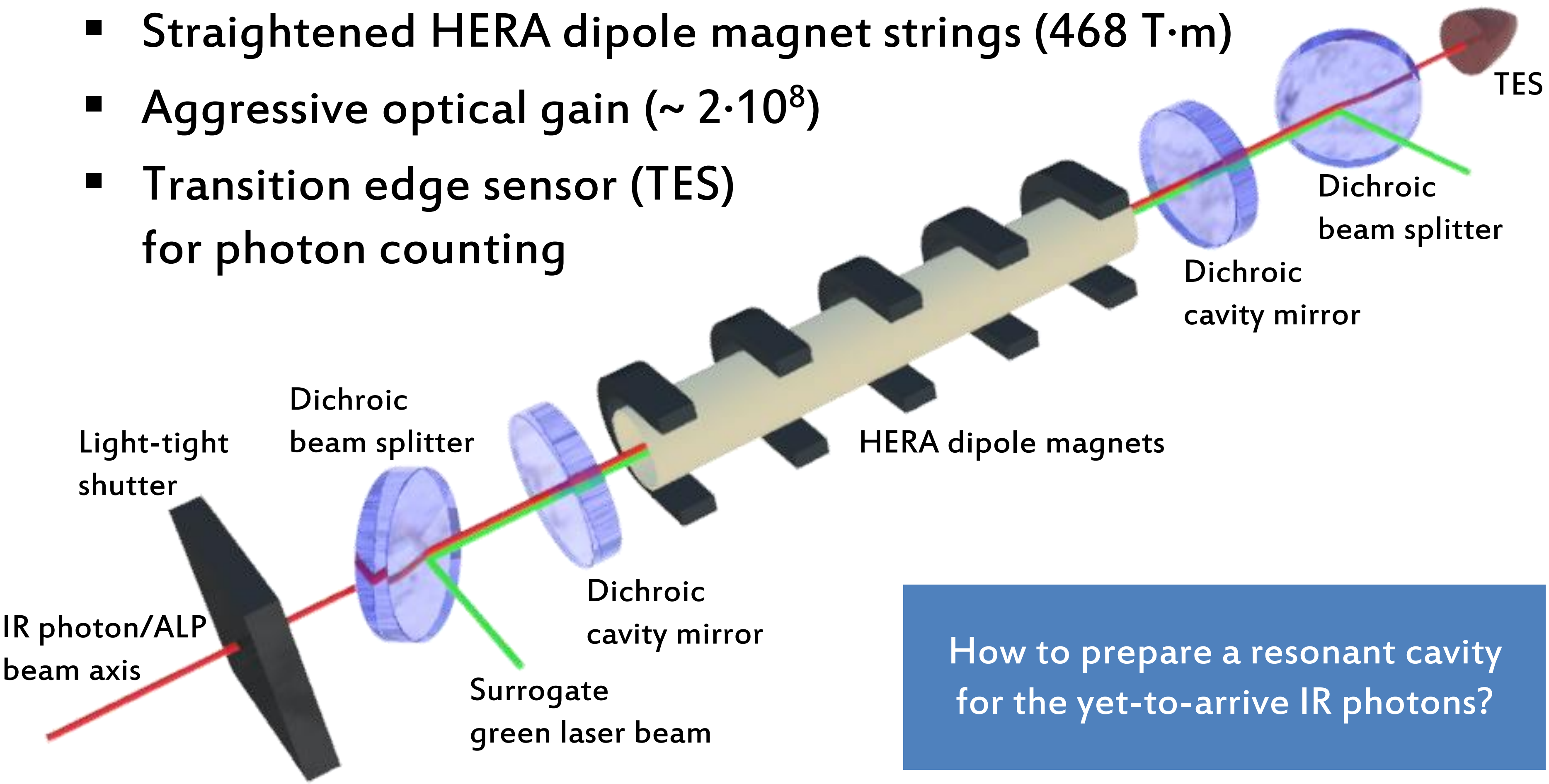
Any Light Particle Search II

- Light-shining-through-a-wall?
- Sensitivity goal: $2{\cdot}10^{-11}\ \mathrm{GeV}^{-1}$
- Straightened HERA dipole magnet strings (468 T·m)
- Aggressive optical gain (~ $2{\cdot}10^{8}$)
- Transition edge sensor (TES) for photon counting

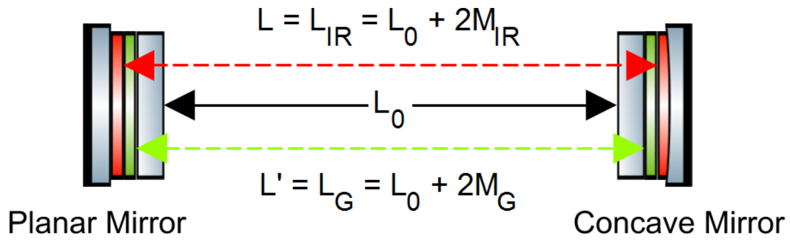


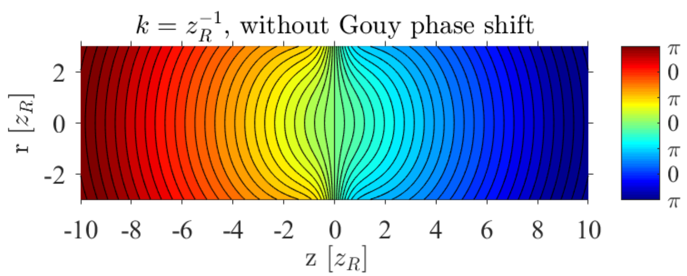


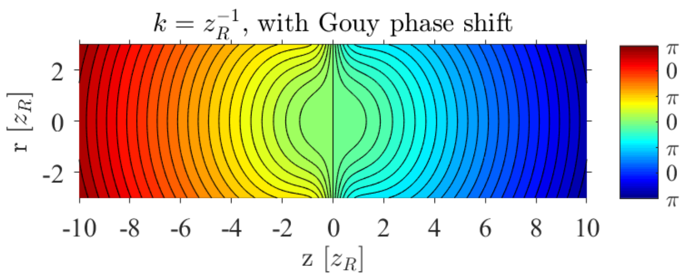
How to prepare a resonant cavity for the yet-to-arrive IR photons?

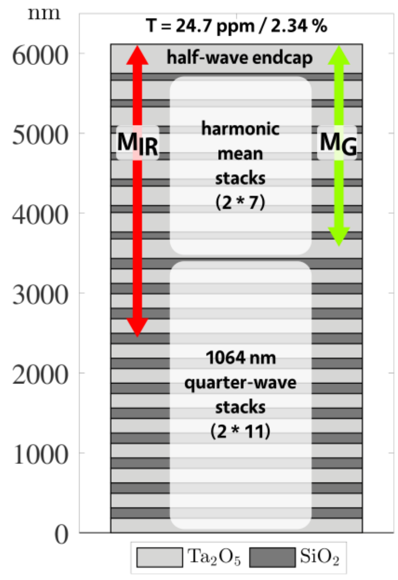
Dichroic cavity control

- Exact harmonic fields generally do not resonate simultaneously with a given cavity
  - Material property: mirror coating reflection phase / penetration depth
  - Gaussian (laser) beam property: Gouy phase shift
- A frequency offset f is anticipated for ALPS II resulting in quasi-harmonic fields
  - Harmonic relation via nonlinear optics (second-harmonic generation)
  - Offset via tunable circuits (PLL) based on stable oscillators (e.g. TCXO)
- ALPS II requires better than 1 Hz cavity resonance
  - Whatever f is, it should not change by more than 1 Hz during data run
  - On top of which we have to produce f accurately and precisely



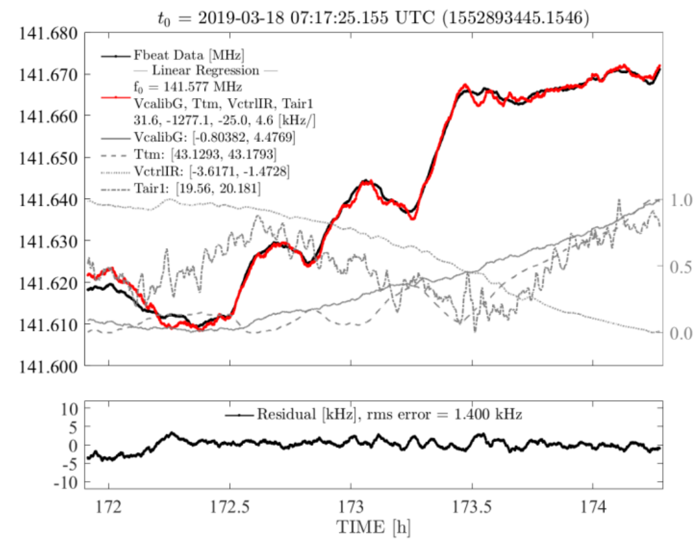






Fidelity of the surrogate: constraining f

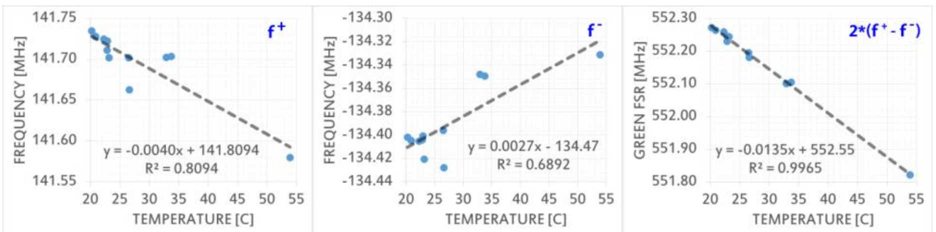
- Dedicated coating design and fabrication
  - Optimized temperature-dependence with Monte-Carlo simulations on tolerances



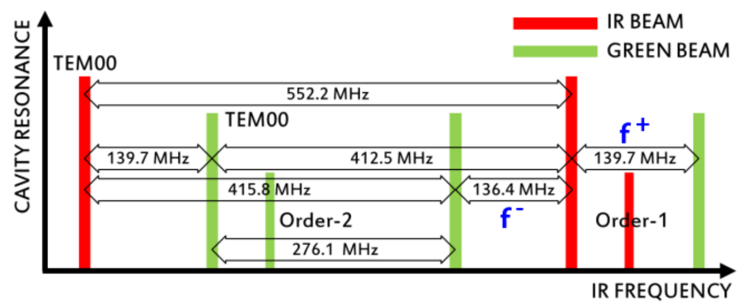
- Dichroic cavity experiment to test the coating

- Equally (or even more) prominent effects
  - Coating wavelength dependence
  - Penetration depth difference

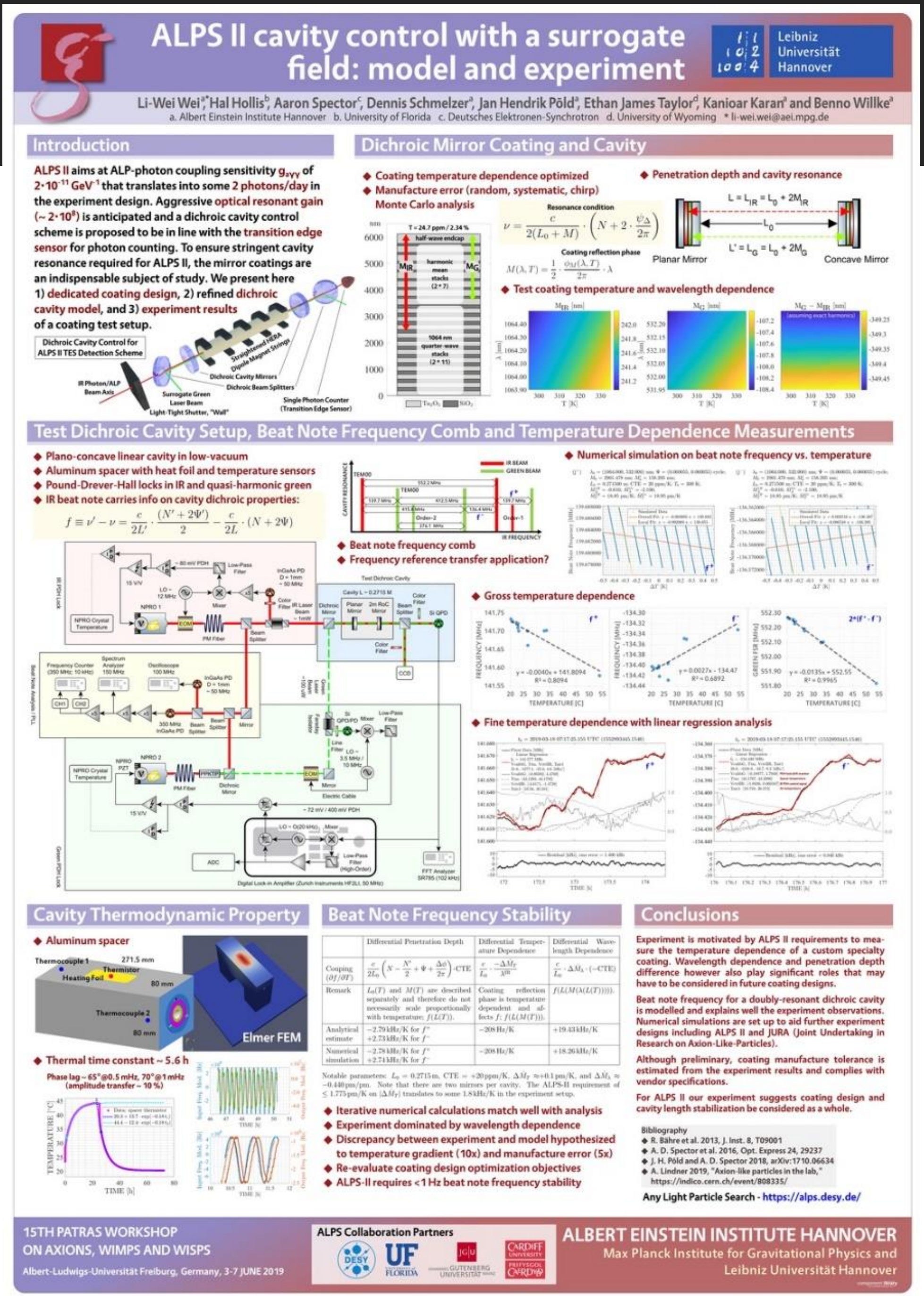
  (depends on cavity configuration)



- Numerical simulation
  - Pictures the highly entangled system
  - Matches analytic analysis
    (with approximates and linearization)



Thank you.



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