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Optical Coatings

Adventures in AR Absorption with aLIGO Core Optics

LSC-VIRGO , 2012

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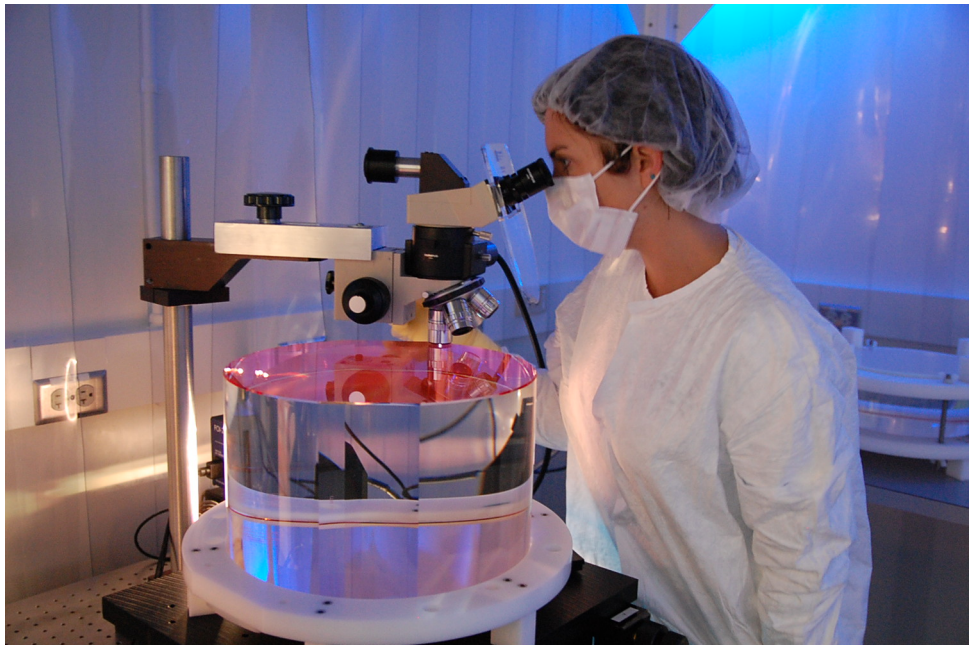

LIGO-G1200960

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Outline

- AR and HR
- Tantala thin films
- Compensation Plate Coating loss
- Anneal Temperature
- AR coatings- aLIGO Beamsplitter
- AR coatings- aLIGO Compensation Plate
- Trial and error!
- Real mechanisms behind AR absorption

HR and AR Coatings on Recycling Cavity Optics

- aLIGO COC optical coatings- made up of silica (SiO2) and tantala (Ta205) layers of varying width.
- Coating absorption- Strict absorption requirements for all aLIGO coatings on optics, <1ppm

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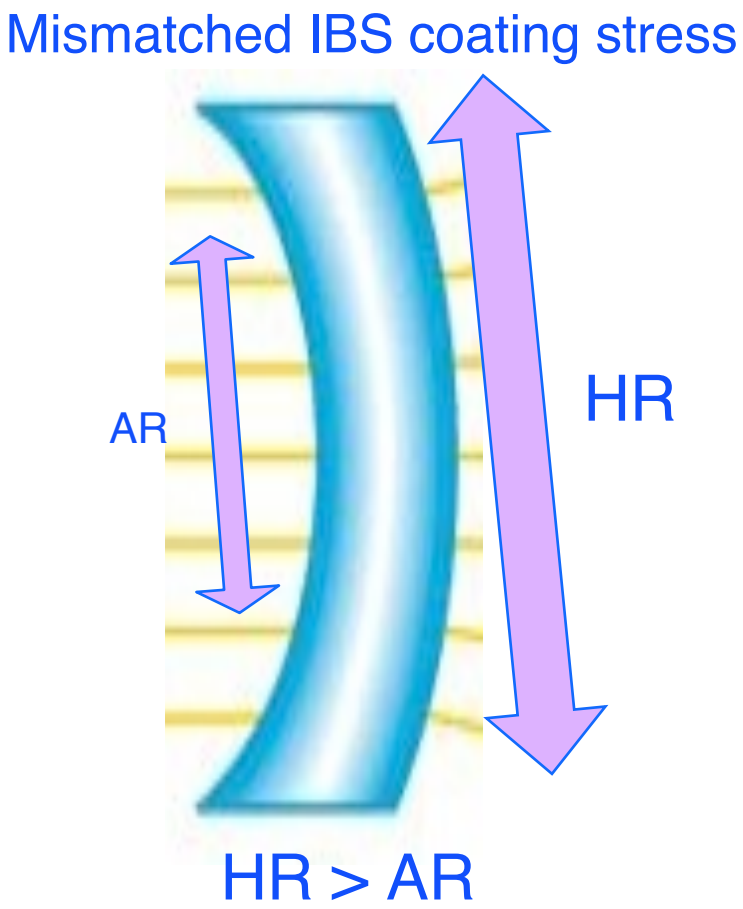
Why use thin film tantala?

- Stress Balance
  - beam splitter design
- Aspect ratio
  - Test masses: ~2:1
  - Beamsplitters ~6:1
- Power term measured before coating BS02: 4.66nm
- Measured after coating BS02: 5.8nm (G. Billingsley)
- But the downsides..



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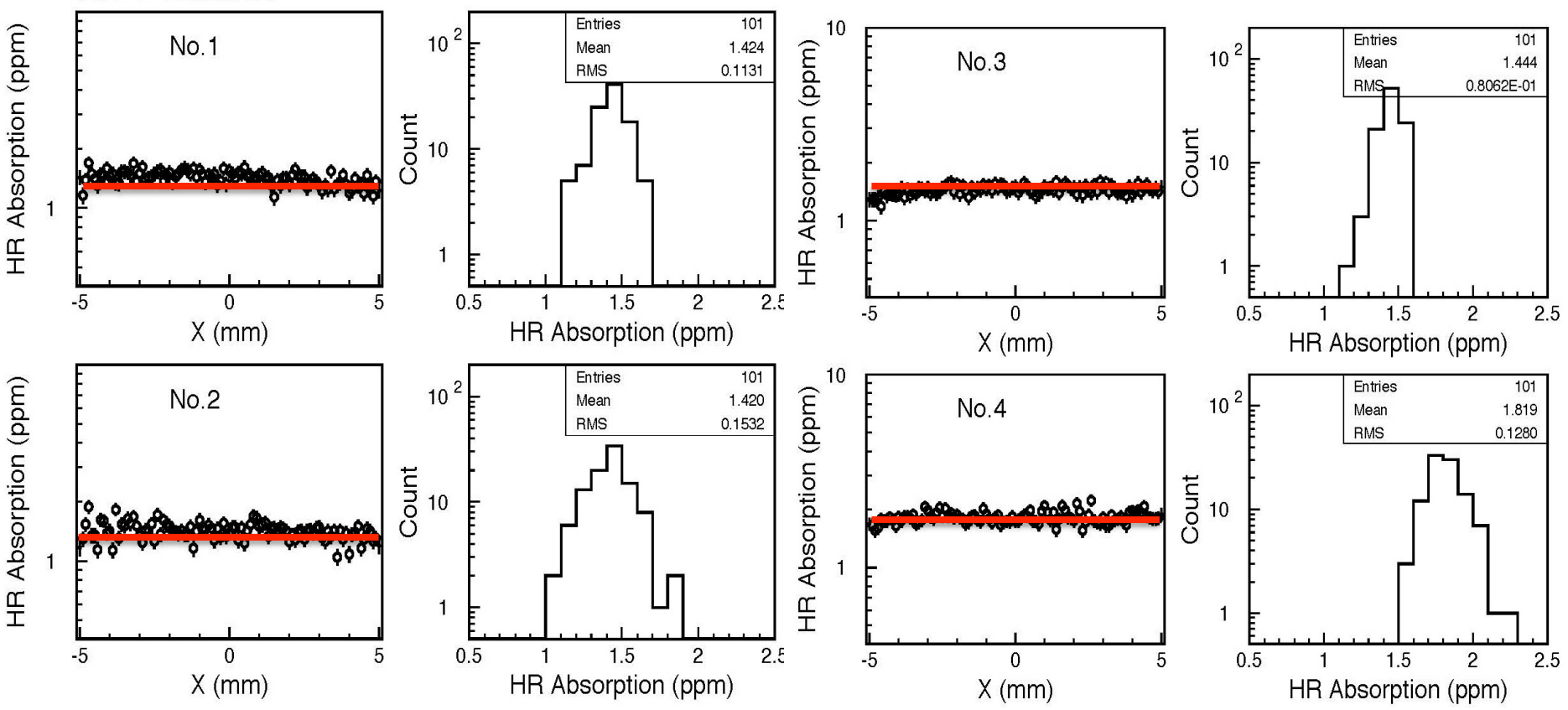
4 Examples-HR side of each



Measured at CIT by Zhang
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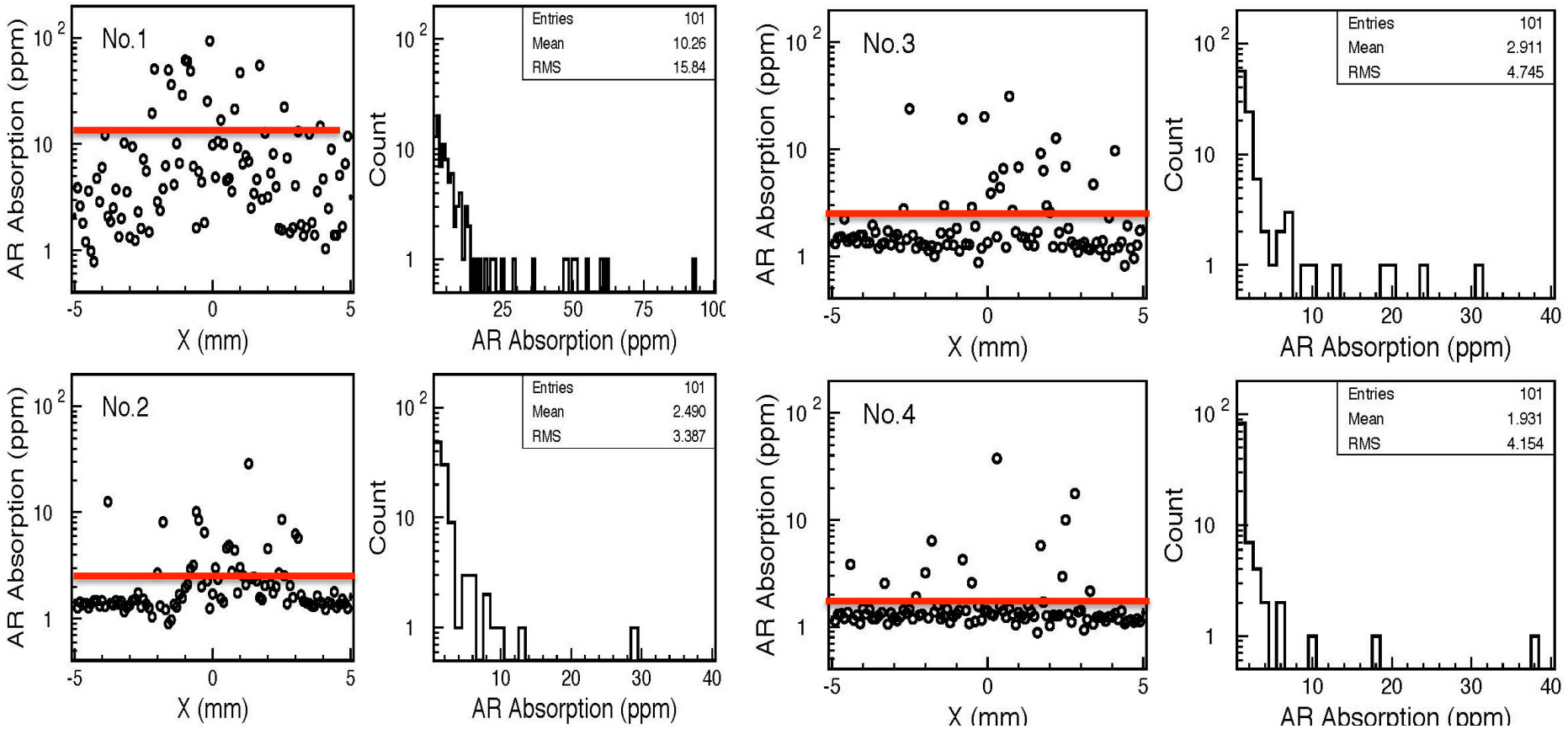
Same optics-AR side



Measured at CIT by Zhang
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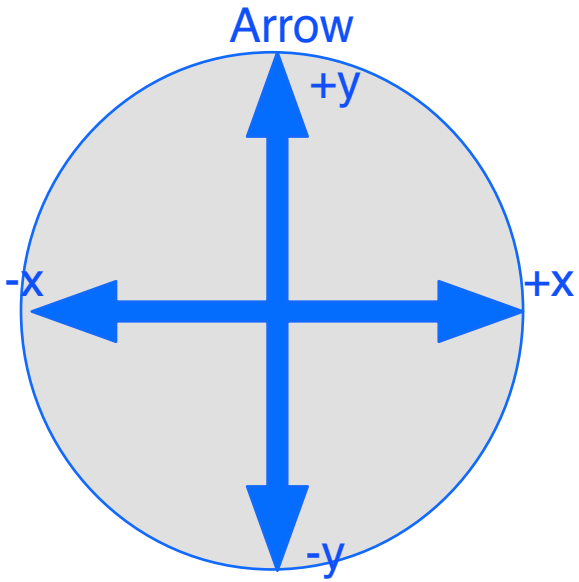
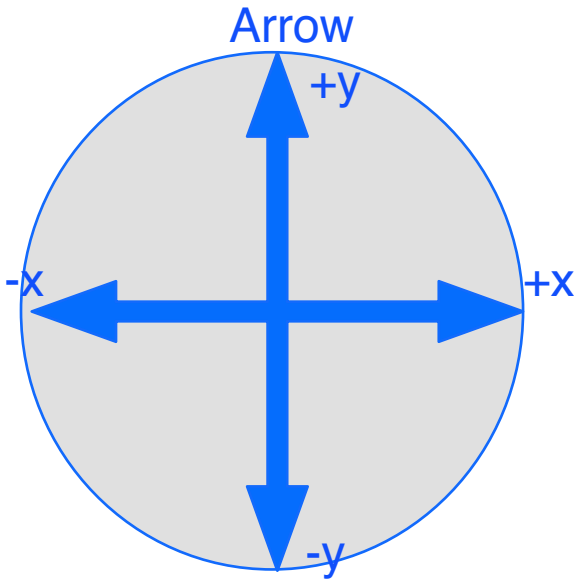
Comparison of Beamsplitter HR Absorption(measured at Caltech)



Measured a 20mm line on each axis

Optic serial number	-x(avg)	+x(avg)	-y(avg)	+y(avg)
BS03	0.48ppm	0.45ppm	0.5ppm	0.37ppm
BS05	0.29ppm	0.29ppm	0.29ppm	0.29ppm
BS06	0.29ppm	0.29ppm	0.29ppm	0.29ppm

Comparison of Beamsplitter AR Absorption(measured at Caltech)

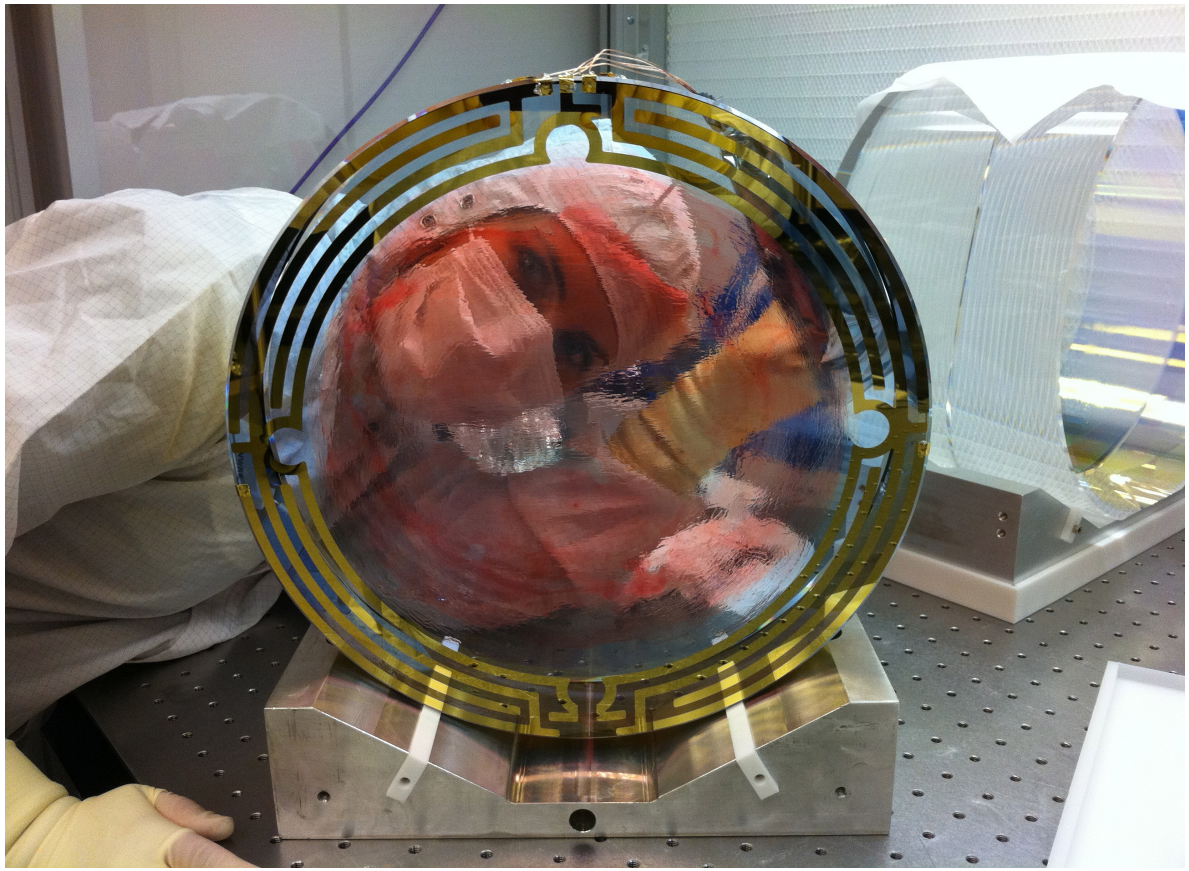


Measured a 20mm line on each axis

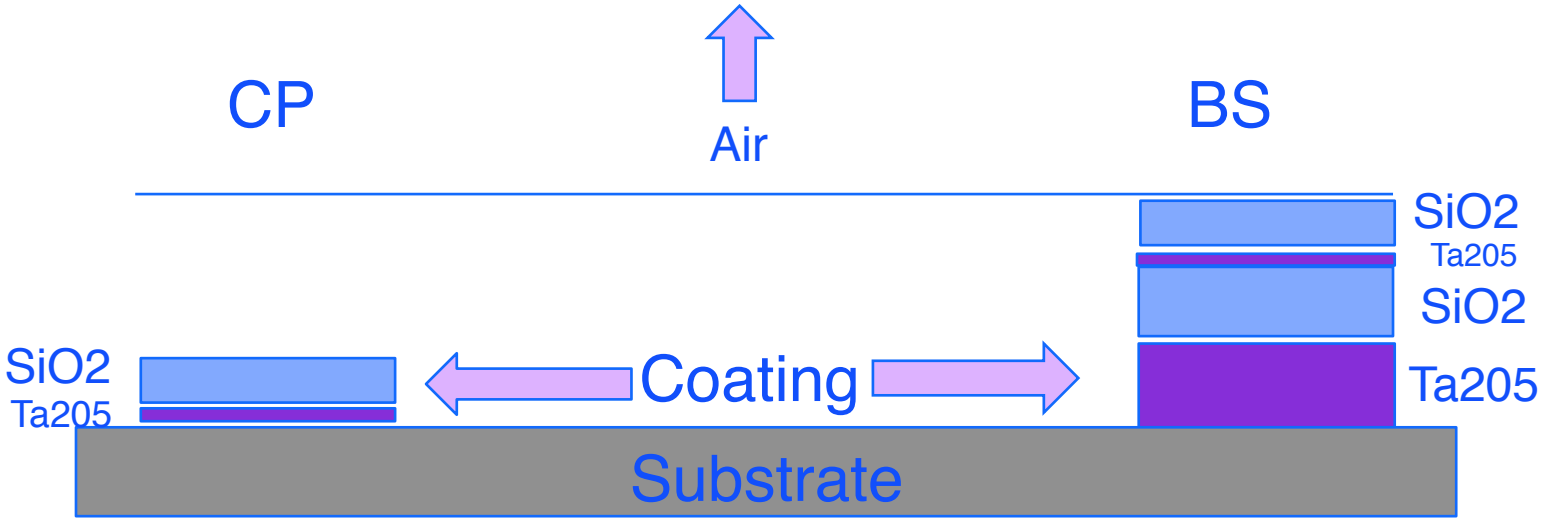
Optic serial number	-x(avg)	+x(avg)	-y(avg)	+y(avg)
BS03	4ppm	2.7ppm	11ppm	2ppm
BS05	16ppm	16ppm	**50ppm**	4ppm
BS06	1.6ppm	1.8ppm	**0.9ppm**	1.4ppm

Is it impossible to get a low loss AR? Actually, no.

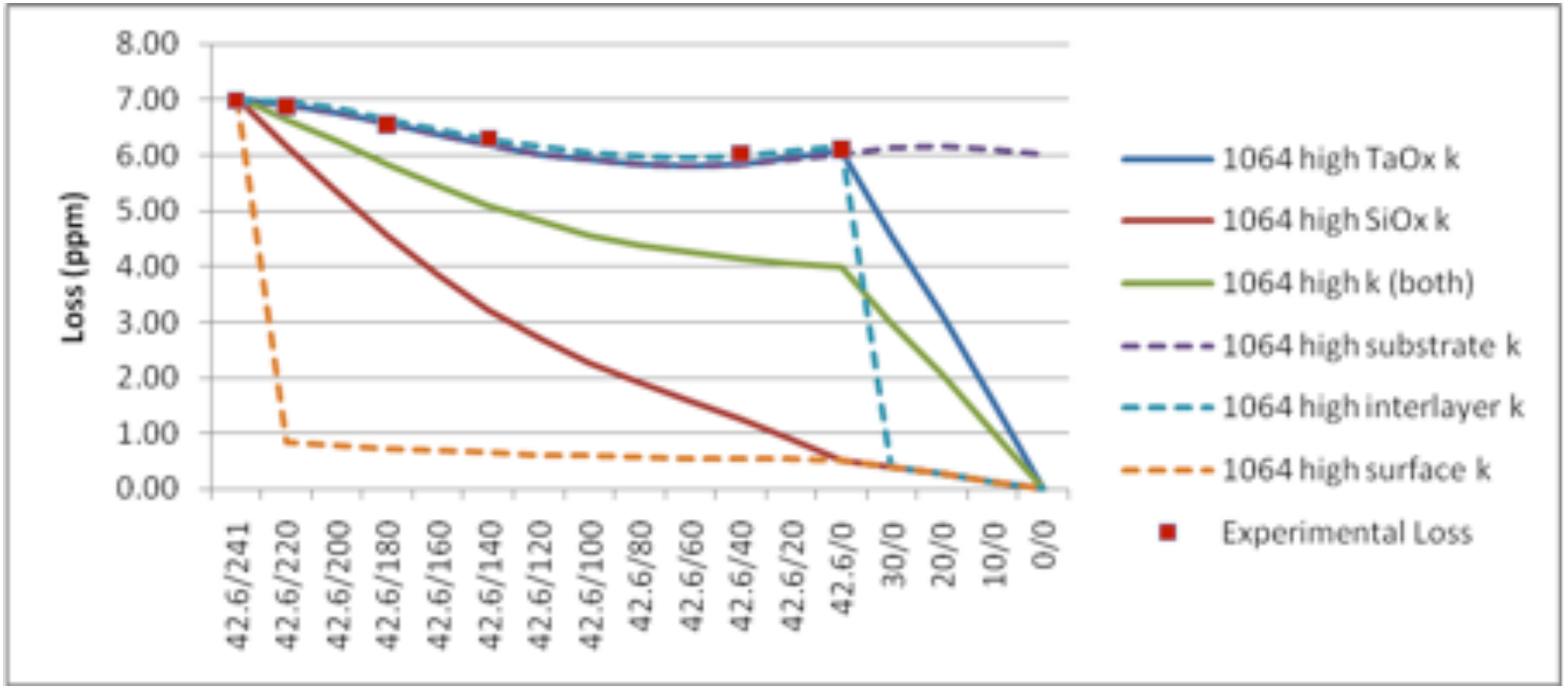
- We have optimized our CP design through trial and error



Differences in BS and CP coating Designs



CPs: Exploring AR Absorption layer by layer



Etch and measurements done at CIT: Phelps and Zhang
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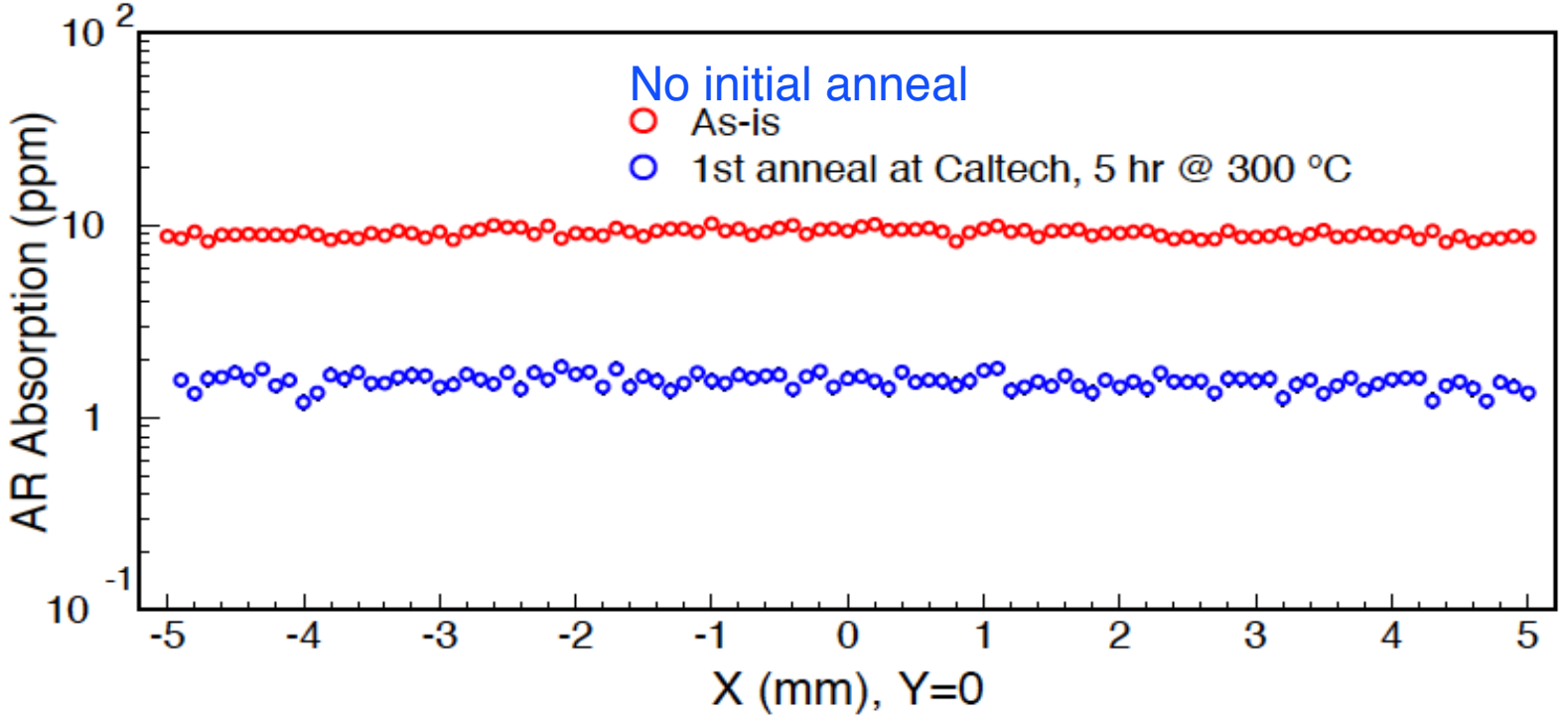
LIGO Goldilocks and the AR Absorption 300 C°, Too cold



Anneal and absorption measurements done at CIT: Phelps and Zhang

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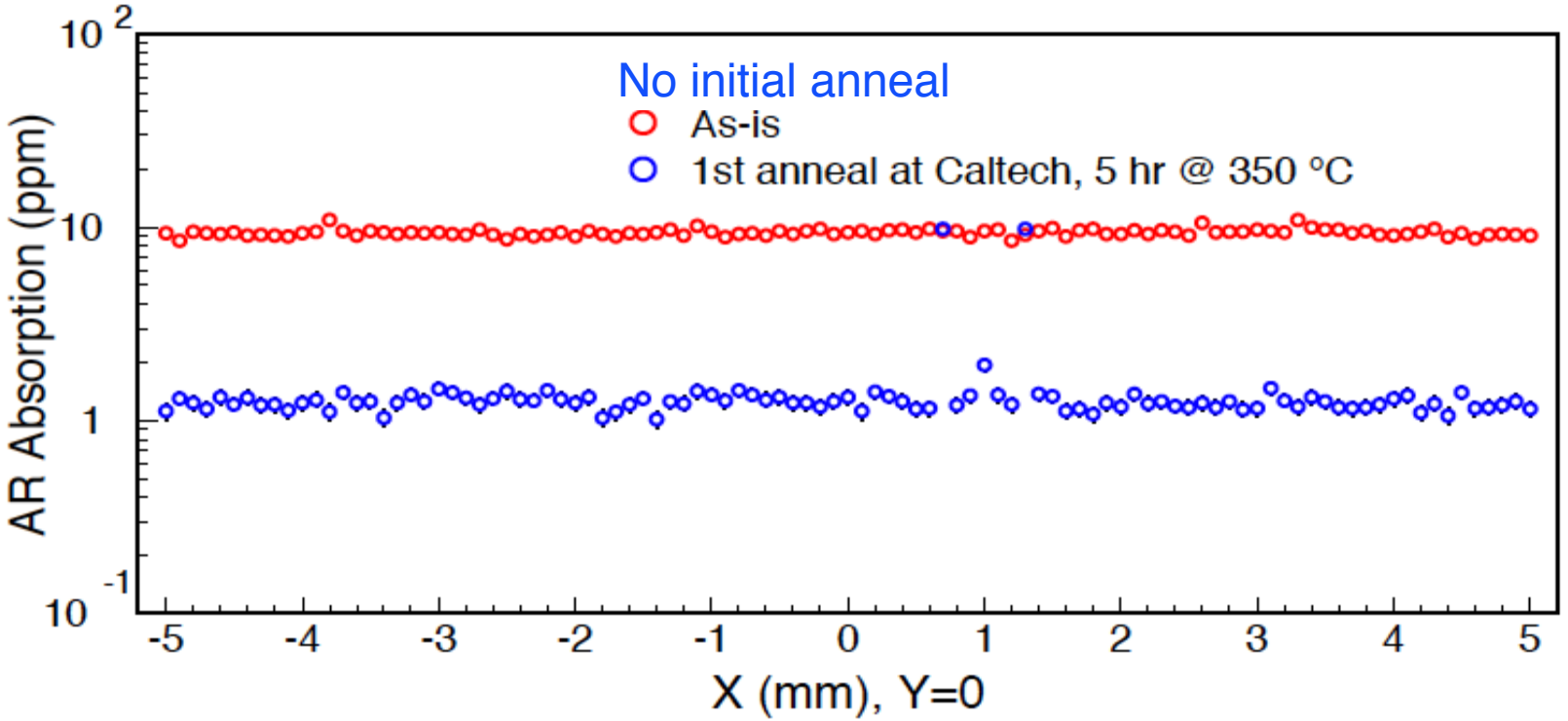
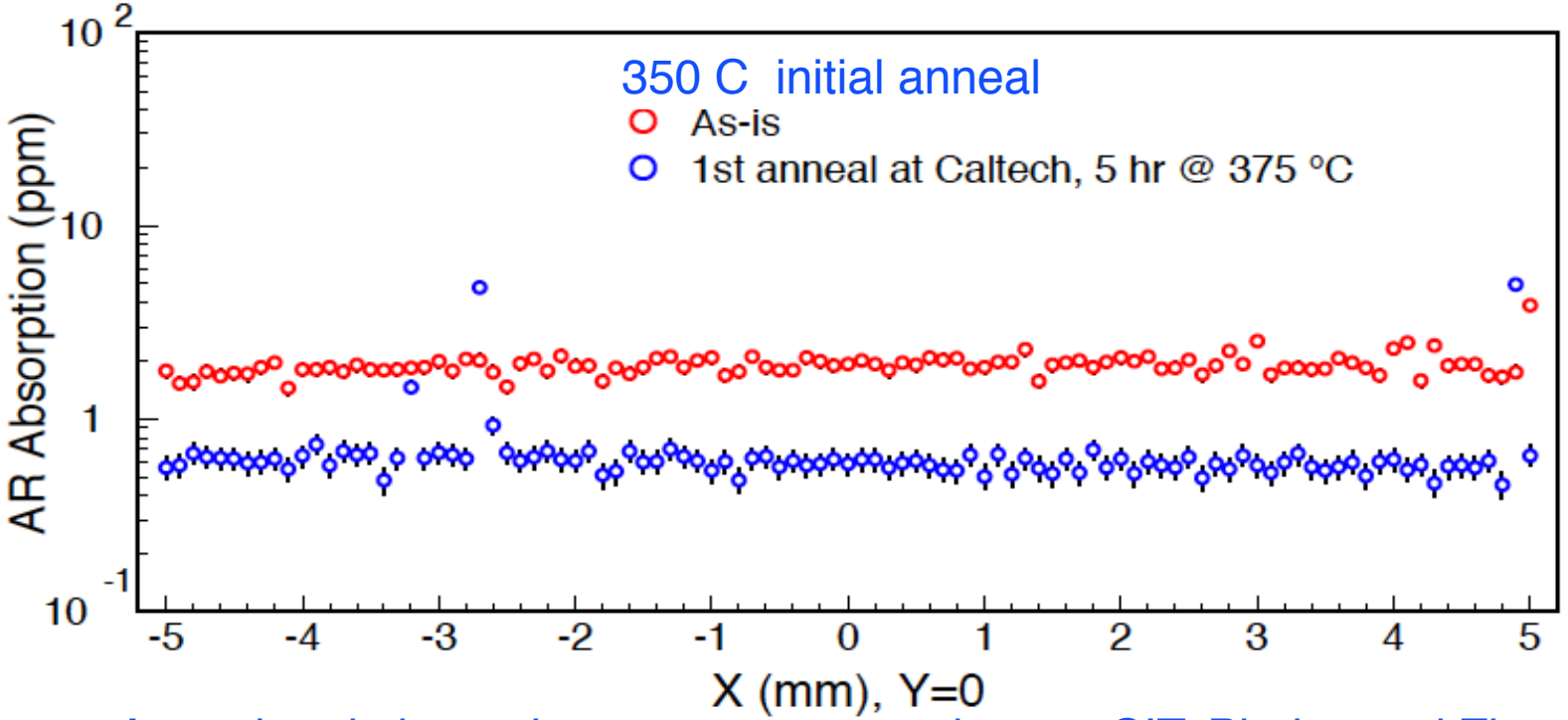
AR Absorption 350 C° Still too cold



Anneal and absorption measurements done at CIT: Phelps and Zhang

AR Absorption 375 C° getting warmer



Anneal and absorption measurements done at CIT: Phelps and Zhang

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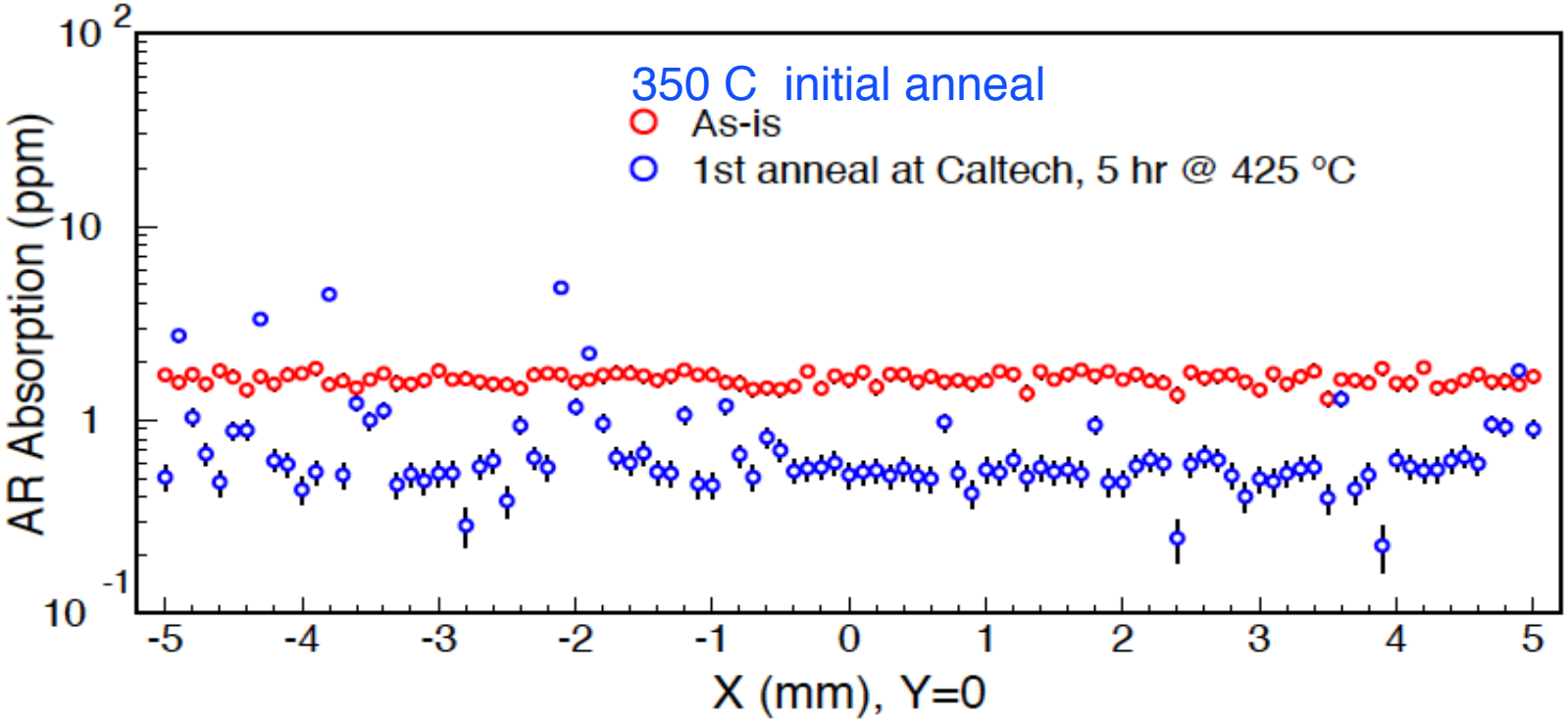
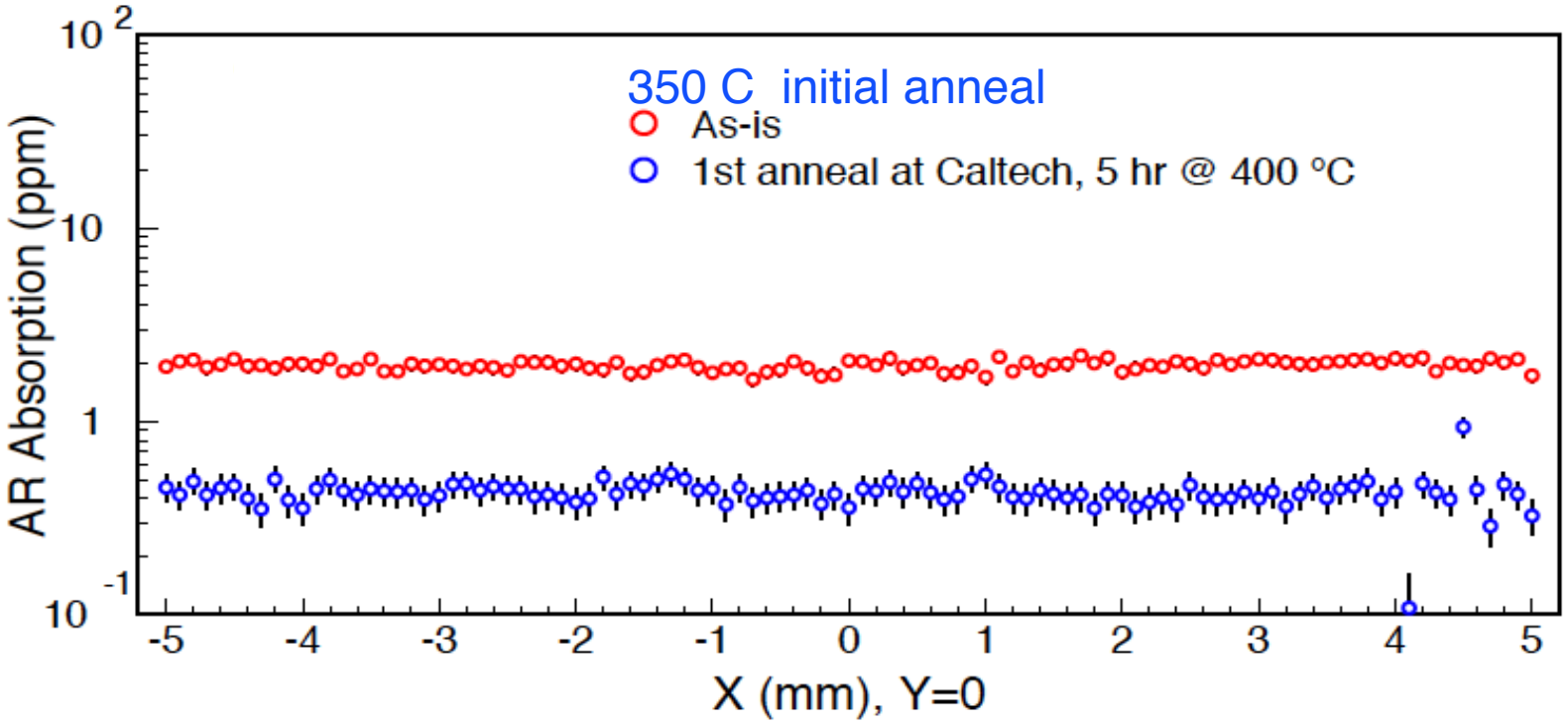
AR Absorption 425 C° too hot



Anneal and absorption measurements done at CIT: Phelps and Zhang

AR Absorption 400 C° Just right!



Anneal and absorption measurements done at CIT: Phelps and Zhang

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Conclusion

- Found clues to mechanisms behind AR absorption
  - » Absorption is either in the tantala layers or in the interfacial layer between the tantala and silica(from etching tests)
  - » Anneal environment is important, esp. temperature(from anneal tests)
  - » Tantala film thickness and position in coating stack(looking at CP vs BS)
  - » HR behaves differently than AR(no energy in deeper layers of HR)
- the CP design has been optimized, now applying those lessons to correct the beamsplitter absorption
- Hope to help answer some fundamental questions about how tantala coatings work