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**SPIE 2633**

**Derivation of Preliminary Specifications for  
Transmitted Wavefront and Surfaces Roughness for  
Large Optics used in  
Inertial Confinement Fusion**

(Viewgraphs only)

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M. Andre, Howard T. Powell (Eds.), Volume 2633, SPIE  
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# I.C.F. OPTICS SPECIFICATIONS

## Derivation of Preliminary Specifications for Transmitted Wavefront and Surface Roughness for Large Optics used in Inertial **C**onfinement **F**usion

André Roussel - Michael Bray \* CEL-V  
Dave Aikens *et al* \* LLNL



# I.C.F. OPTICS SPECIFICATIONS

- SPECIFICATIONS IN GENERAL
- QUICK LESSON IN NON-LINEARITY
- LOW SPATIAL FREQUENCIES
  - GEOMETRICAL ERRORS
- MID and HIGH SPATIAL FREQUENCIES
  - RIPPLE, ROUGHNESS
- COMPARISON WITH CURRENT FABRICATION
- CONCLUSION

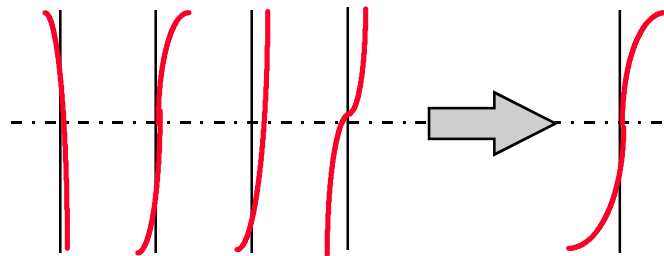


## OPTICS SPECIFICATIONS SHOULD BE ...

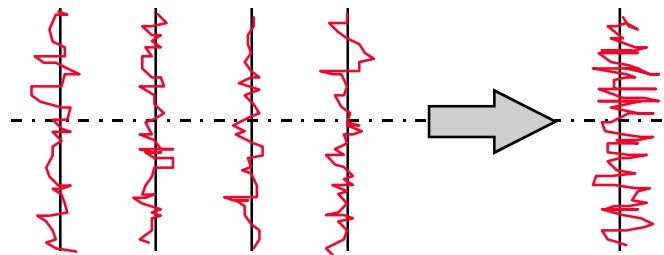
- **SIMPLE :**
  - They must be easy to understand and to apply in the workshop.
- **ACCURATE :**
  - They must reflect the desired quality exactly.



## THE CASE OF "CLASSICAL" OPTICS ...



Large scale errors add  
in **AMPLITUDE**  
(curvature, astigmatism,...)

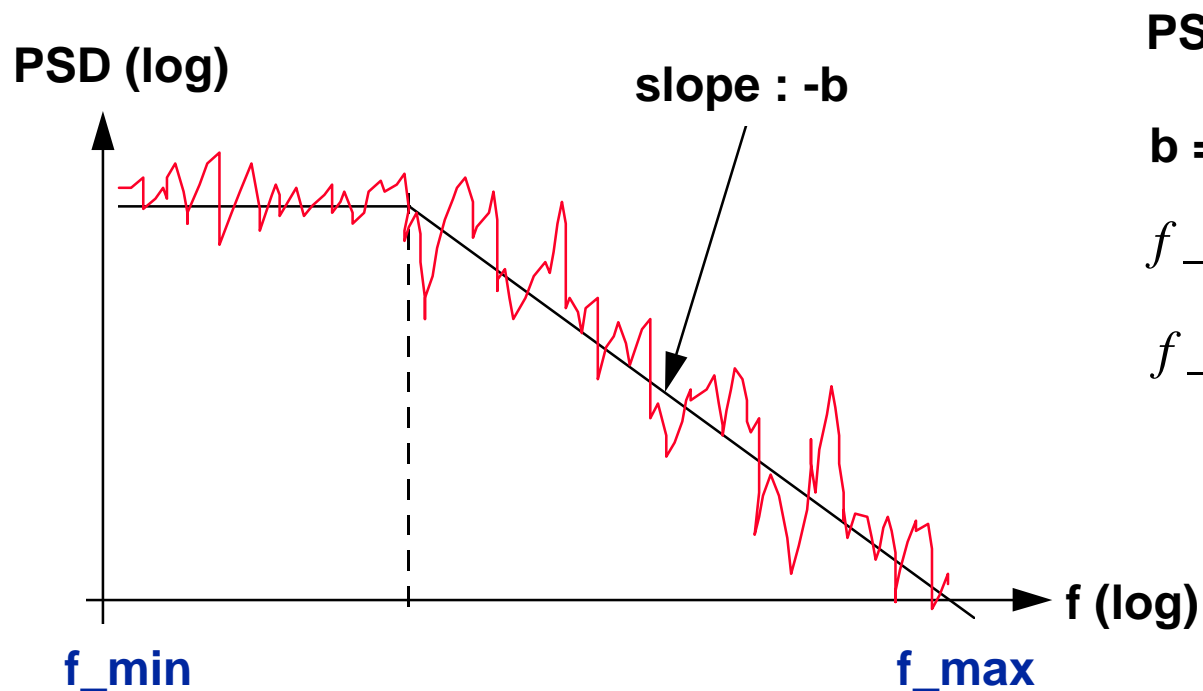


Small scale errors add  
in **POWER**  
(roughness)



# POWER SPECTRAL DENSITY (P.S.D.)

## •POWER SPECTRAL DENSITY - ILLUSTRATION:



$$PSD(f) = a / f^b$$

$$b = 1 \text{ to } 3$$

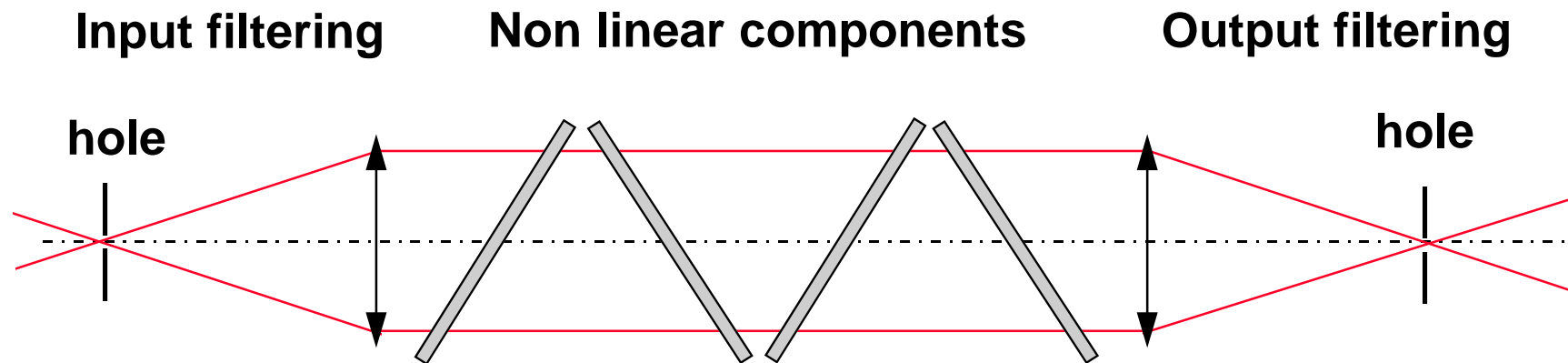
$$\int_{f_{\min}}^{f_{\max}} PSD(f).df = RMS^2$$



## THE CASE OF I.C.F. LASERS ...

- **Large components :**
  - Large dynamic range for defect scale.
- **Long system :**
  - Large dynamic range for Fresnel lengths.
- **Non linear effects :**
  - Very large amplification of certain spatial frequencies.
- **Wide variety of components :**
  - Specifications must adapt to each type of part.

## AMPLIFIER SECTION - illustration



- Typical hole size :  $\pm 100 \mu\text{rd}$  : equivalent to feature size of **10 mm**.
- Features smaller than **10 mm** don't "get through" the output hole.
- Measure of non-linearity :  $B = \Sigma \{ k \cdot \text{length} \cdot \delta n \}$  (in radians).



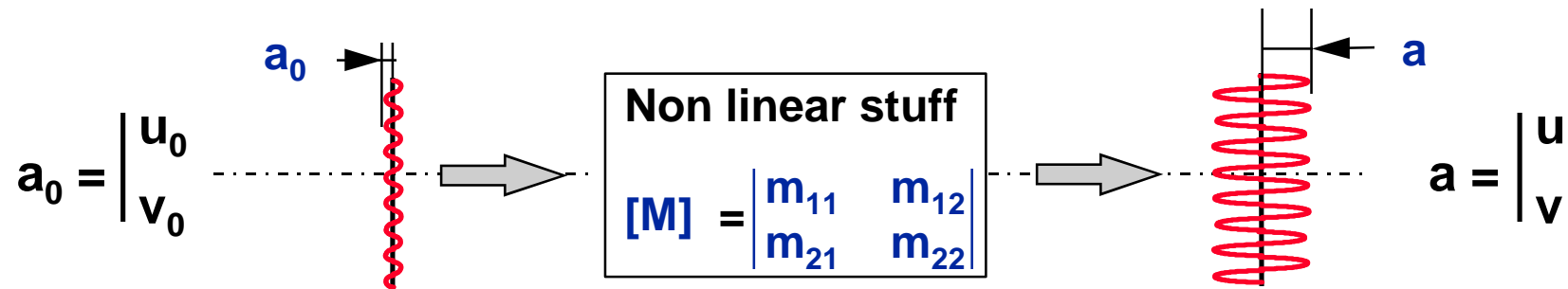
# SMALL RIPPLE AMPLIFICATION

$$E(x,y,z) = E_0 \{ 1 + a(z) \cdot e(x,y) \}$$

$$a(z) = u(z) + i \cdot v(z)$$

u : real part : mode **amplitude**  
v : imaginary part : mode **phase**

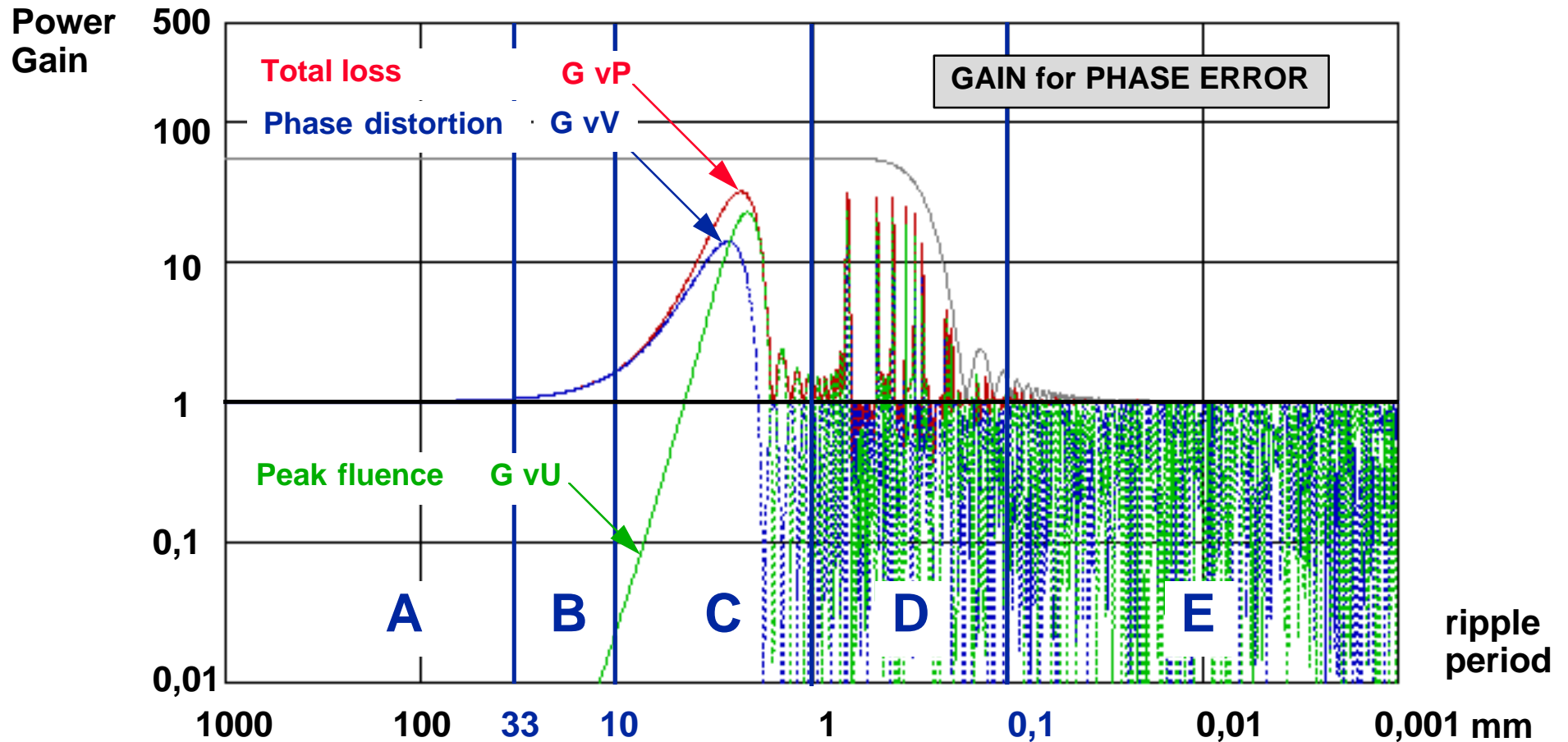
} Mode **Power** :  $u^2 + v^2$



- MODE **AVERAGE POWER** over spatial frequencies relates to **ENERGY LOSS**.
- MODE **PEAK AMPLITUDE** relates to **OPTICS DAMAGE**.

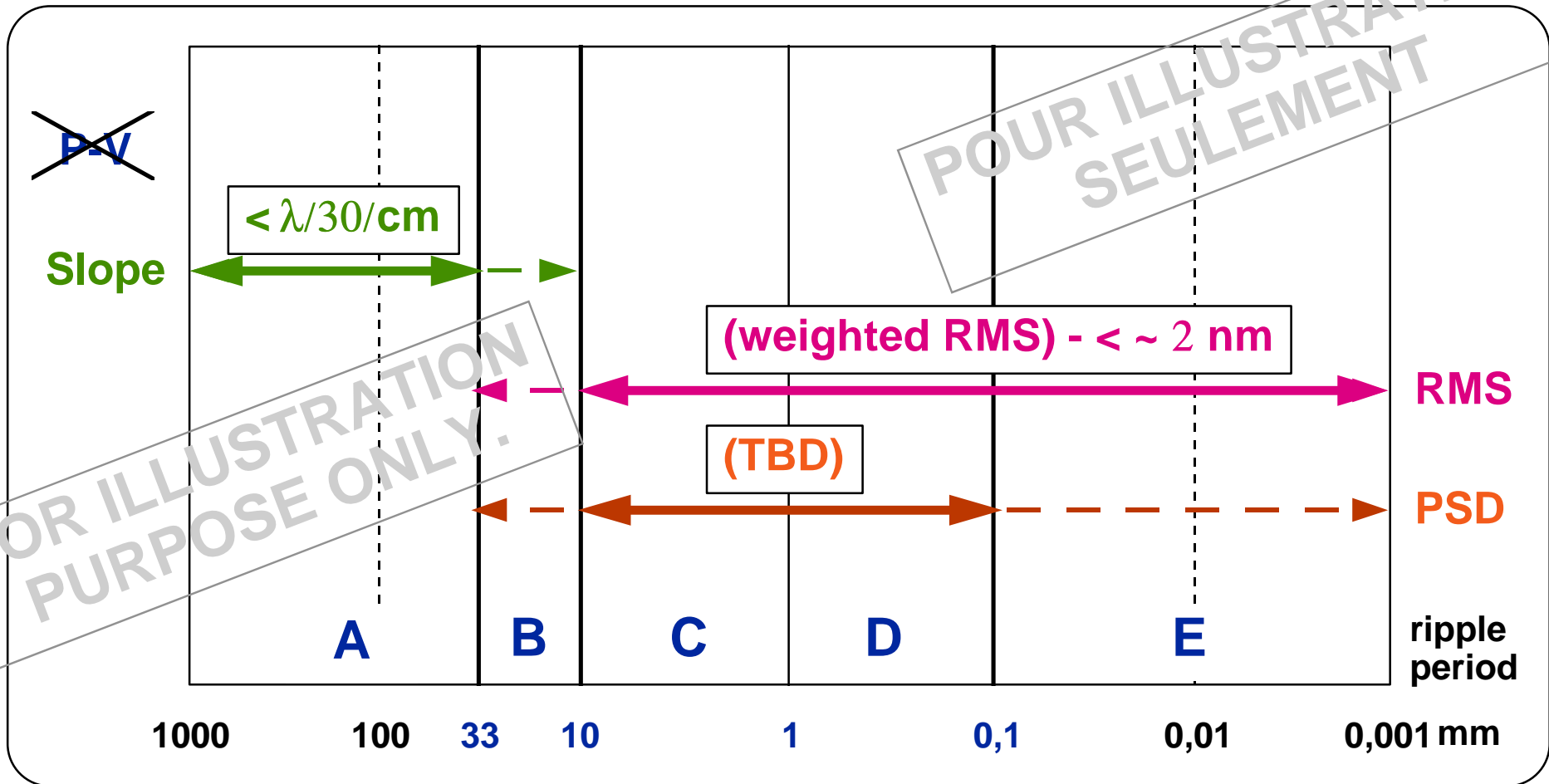


# AMPLIFIER GAIN SPECTRUM - illustration



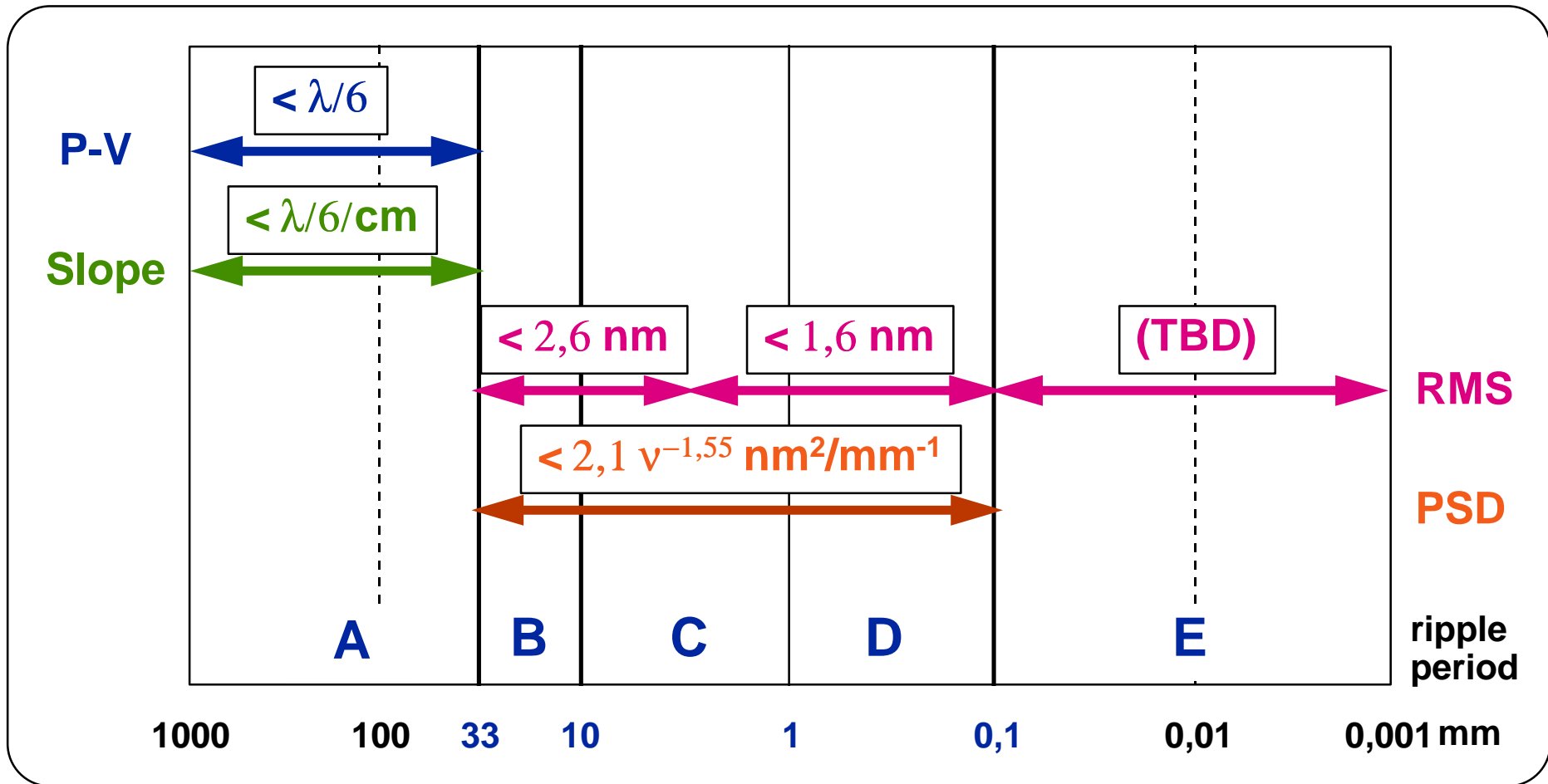


# SPECS (I) - based on FIRST PRINCIPLES



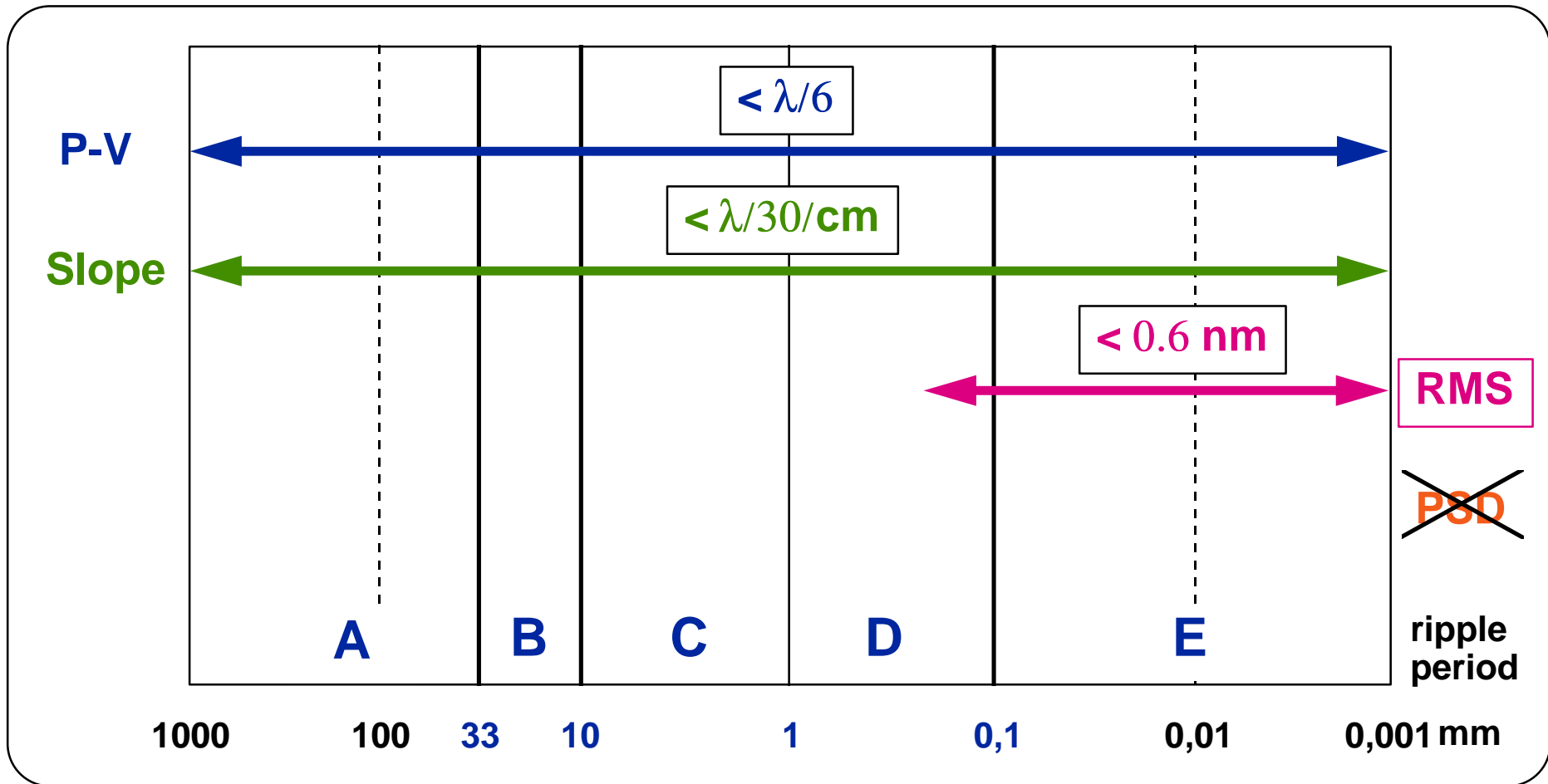


# SPECS (II) - based on METROLOGY (to date)





# SPECS (III) - BEAMLET (1991)





## CONCLUSION

**We have shown how optical specifications for MégaJoule and NIF have been derived, using first principles :**

- **They are highly correlated to the final performance of the laser system, making them efficient.**
- **They define spatial frequency bands, which was not explicitly done previously, making measured values independant of measurement devices.**
- **They are simple enough that they can be used in industry with little training, using existing metrology devices.**