Status of high power laser development for LIGO at Stanford

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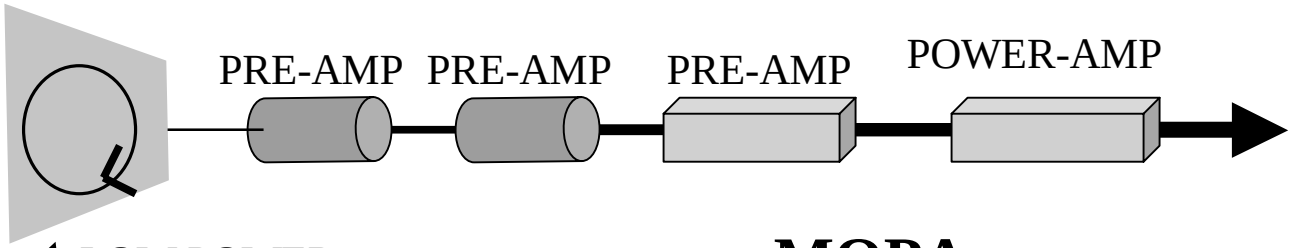
Outline

- Stanford approach to power scaling.
- Experimental setup.
- 100W demonstration results.
- Scaling to 200W.
- Future work.

MOPA vs OSCILLATOR

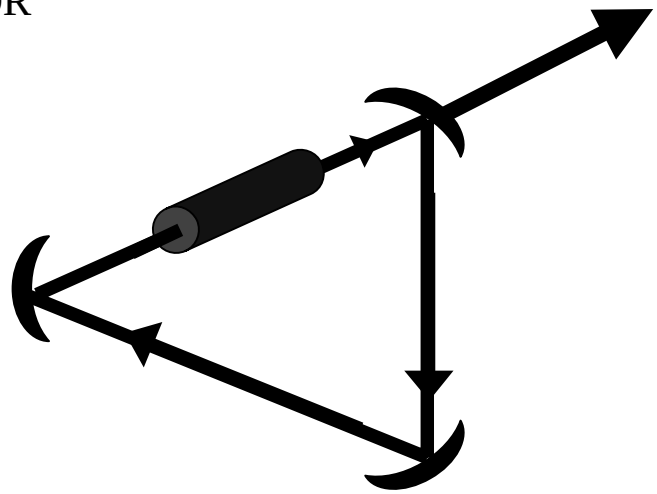
- Rugged
- Scalable
- Single frequency
- Power available despite element failure.
- Less efficient.



LOW POWER,
ULTRA STABLE
MASTER OSCILLATOR

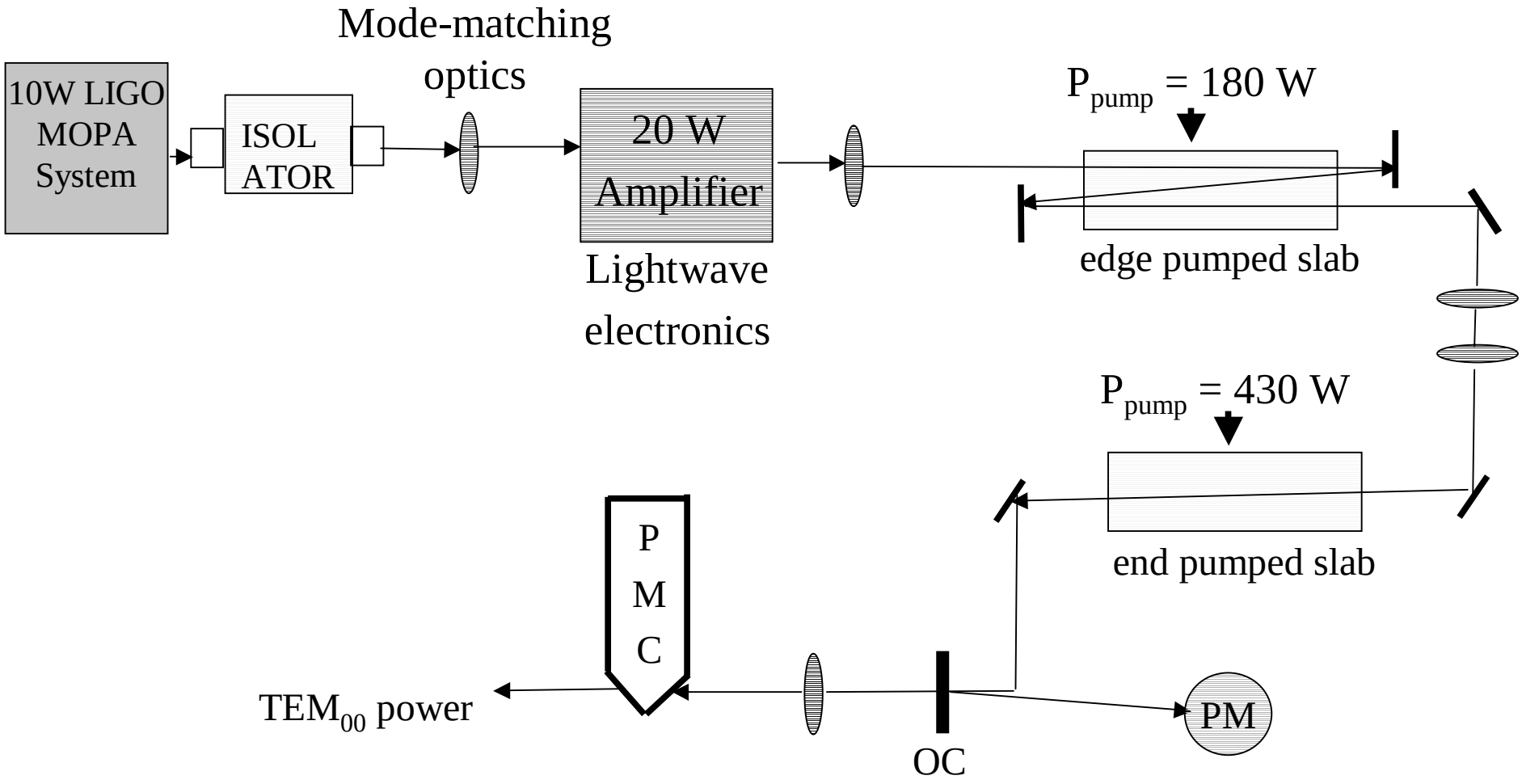
MOPA

- Difficult to control
- Single frequency operation involves injection locking.
- Element failure usually means zero power.
- More efficient.



OSCILLATOR

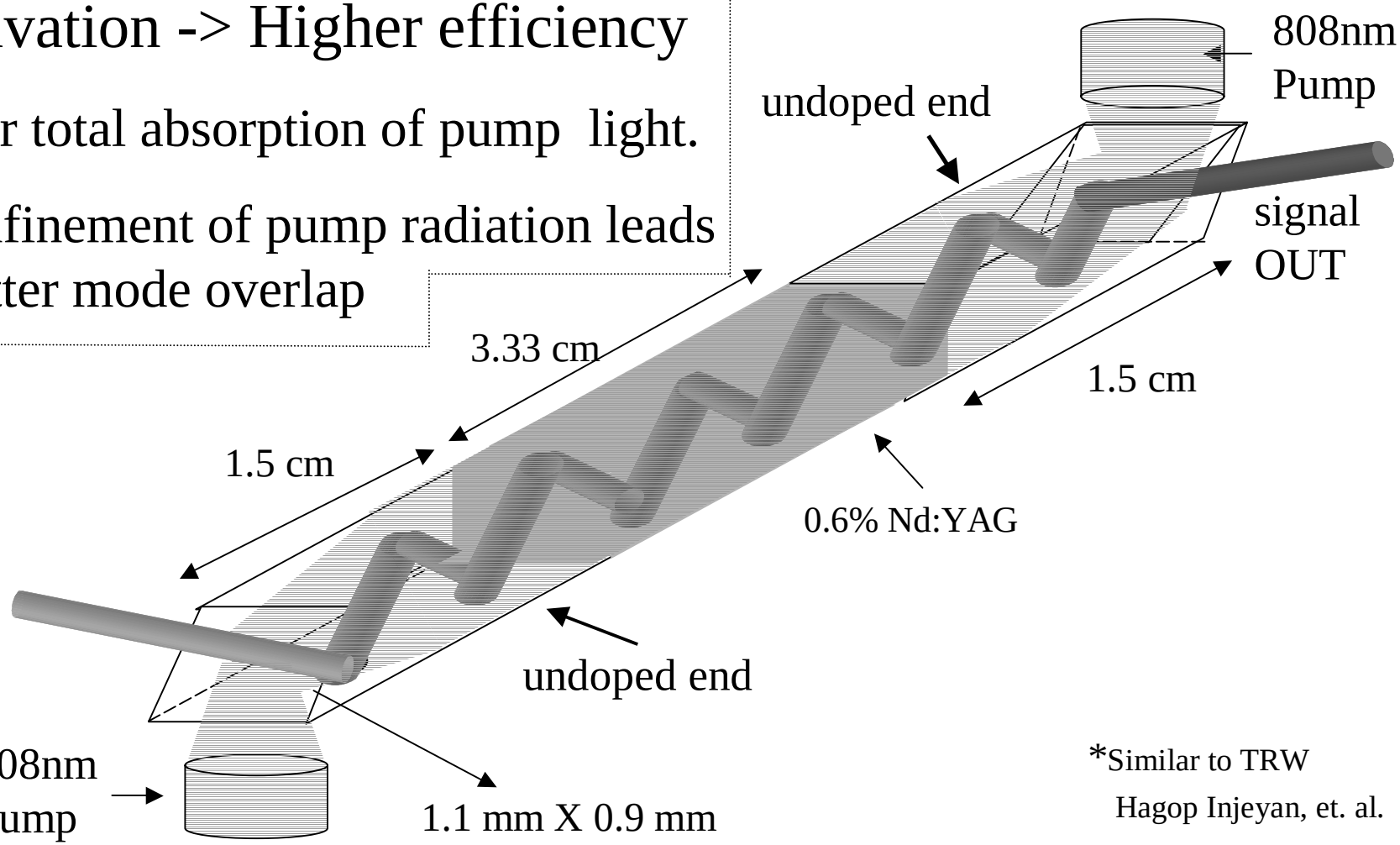
Experimental setup presented at LSC Livingston



End pumped slab geometry*

Motivation -> Higher efficiency

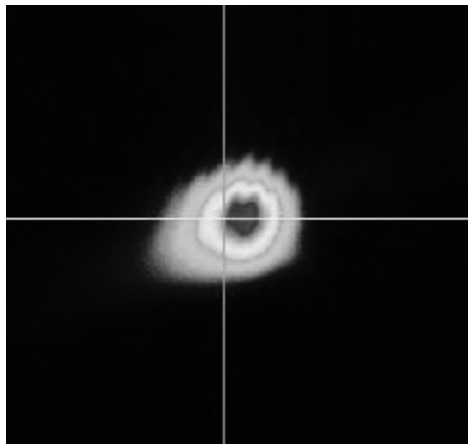
- Near total absorption of pump light.
- Confinement of pump radiation leads to better mode overlap



*Similar to TRW
Hagop Injeyan, et. al.

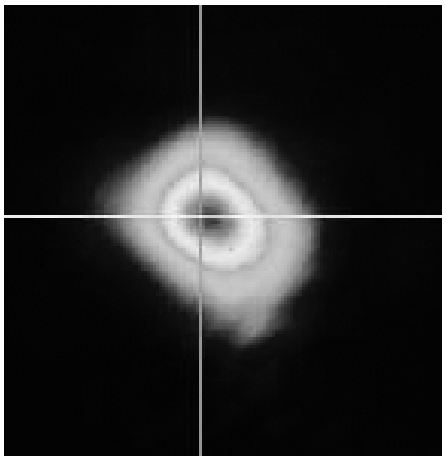
Results of MOPA experiment

- Single Pass Power output ~ 65 W ($M^2 < 1.1$)
- Depolarization ~ 1.5%.
- P-P intensity fluctuations ~ 7%



COLD SLAB

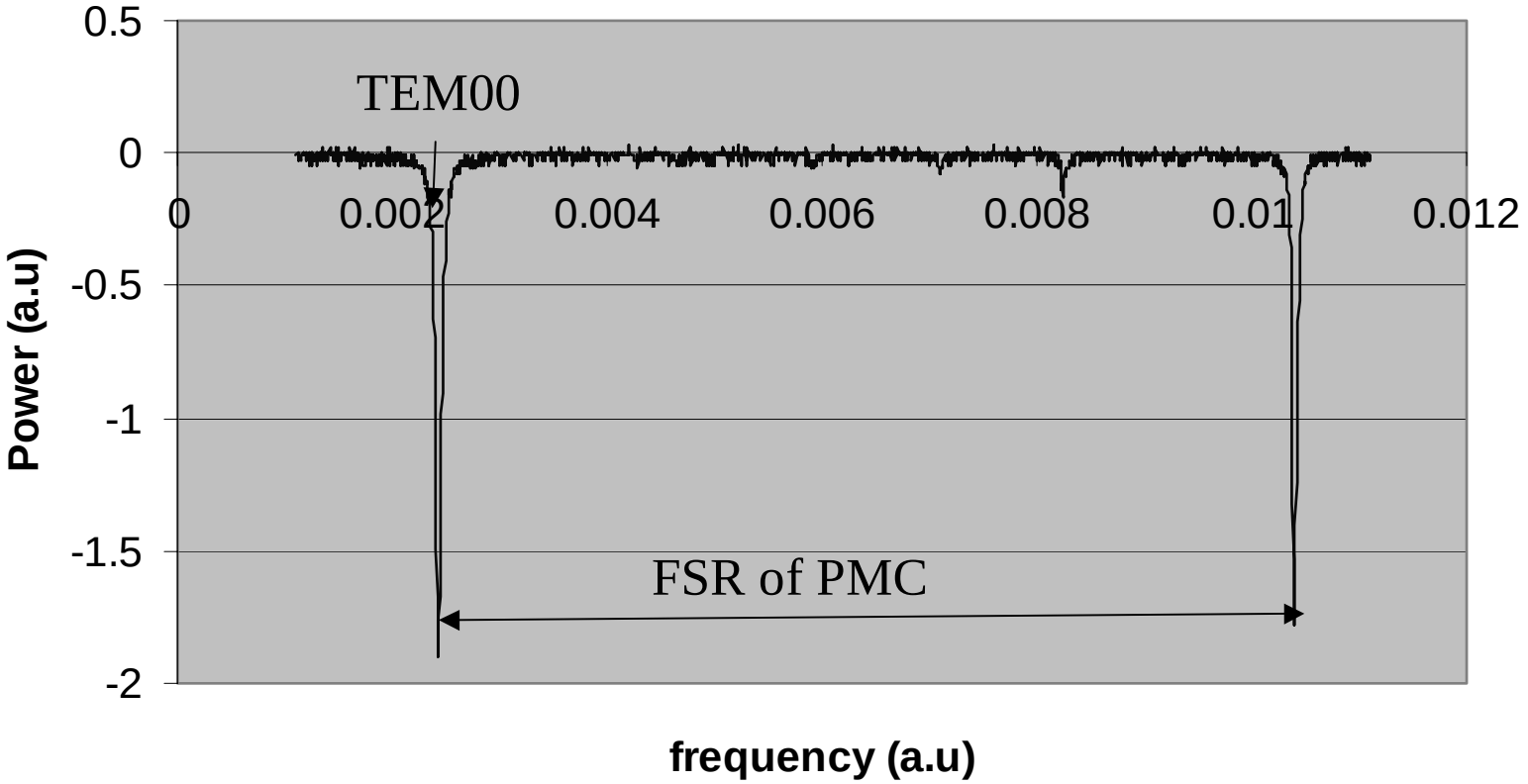
OUTPUT 30 W



PUMPED SLAB

OUTPUT 65 W

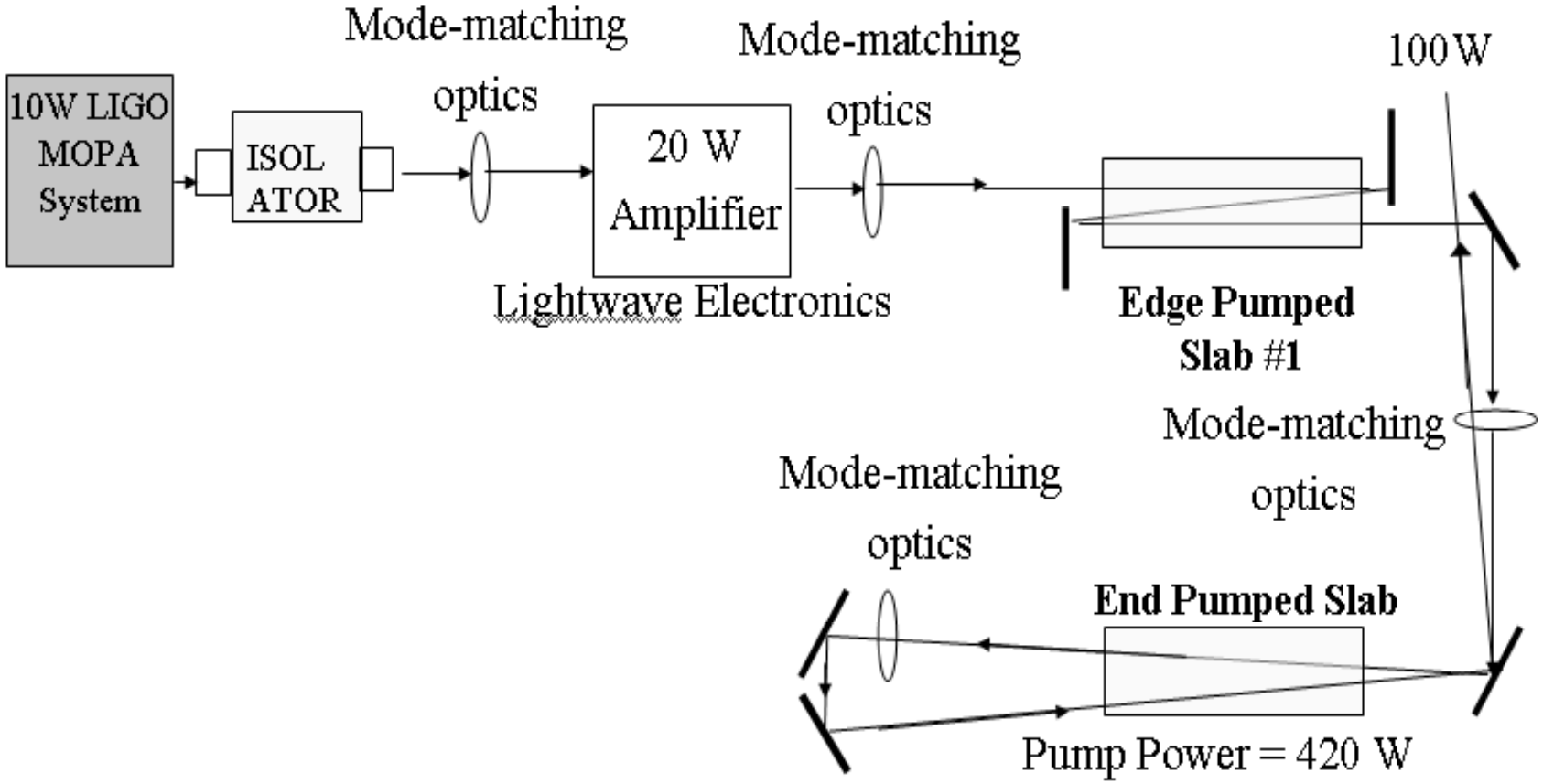
Mode content of 65 W beam



***** 74 % mode content in TEM_{00} *****

P-P intensity fluctuations ~ 2% after PMC

Double pass setup for MOPA experiment

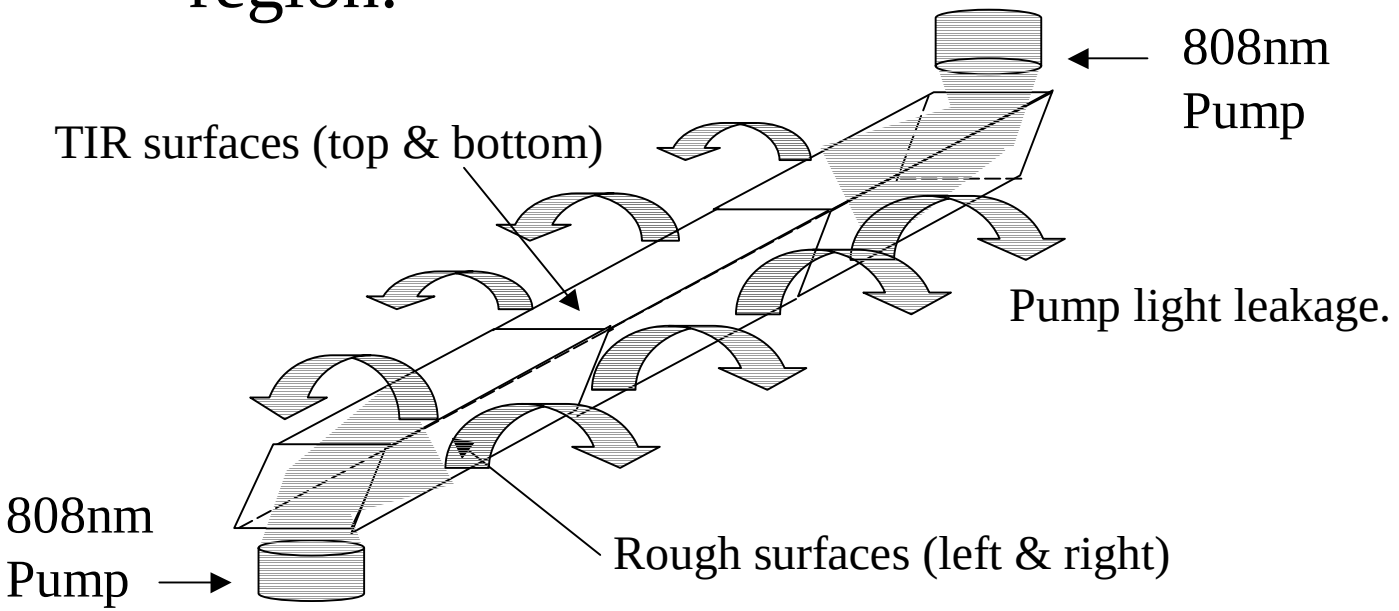


***** 104 W demonstrated at $M^2 < 1.2$ *****

Slab Issues for scaling to 200W

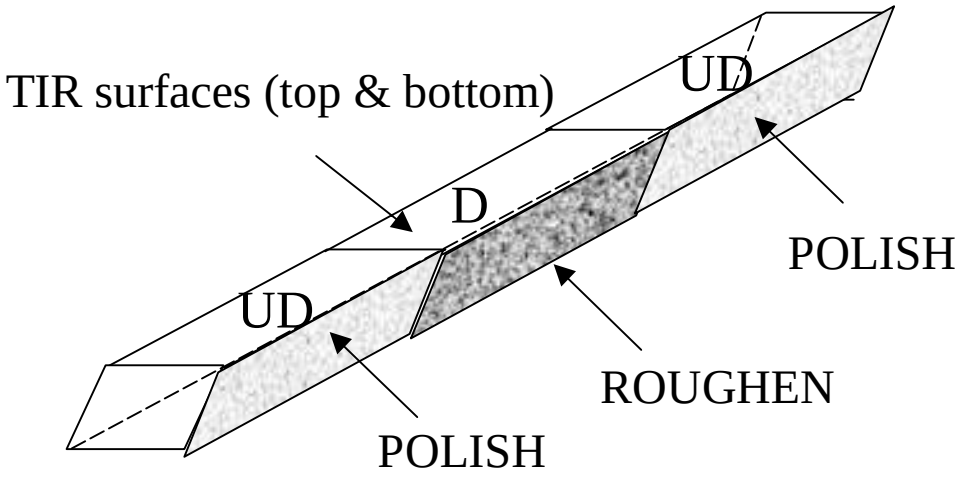
Question: Why is the small signal gain of the end pumped slab much lower than expected?

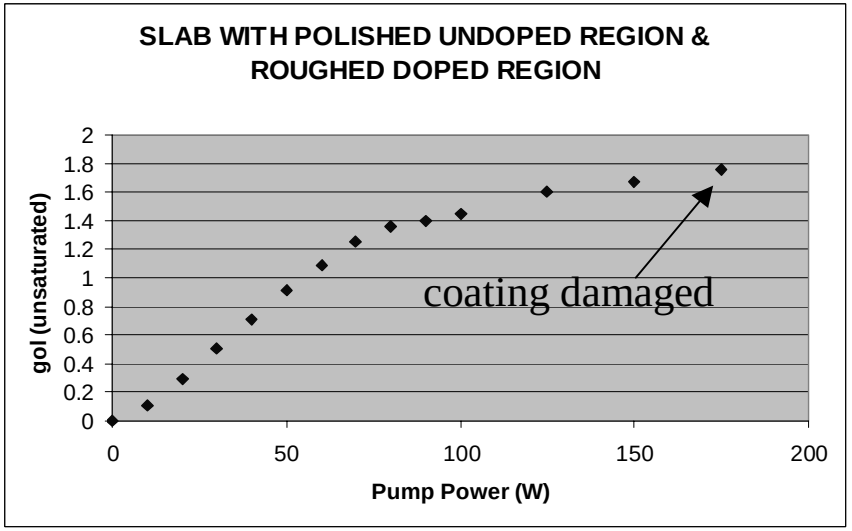
Answer: 30 - 35% pump scattered in undoped region.



Solutions towards improved pump confinement

1. POLISH UNDOPED SIDES AND ROUGH UP THE DOPED REGION.

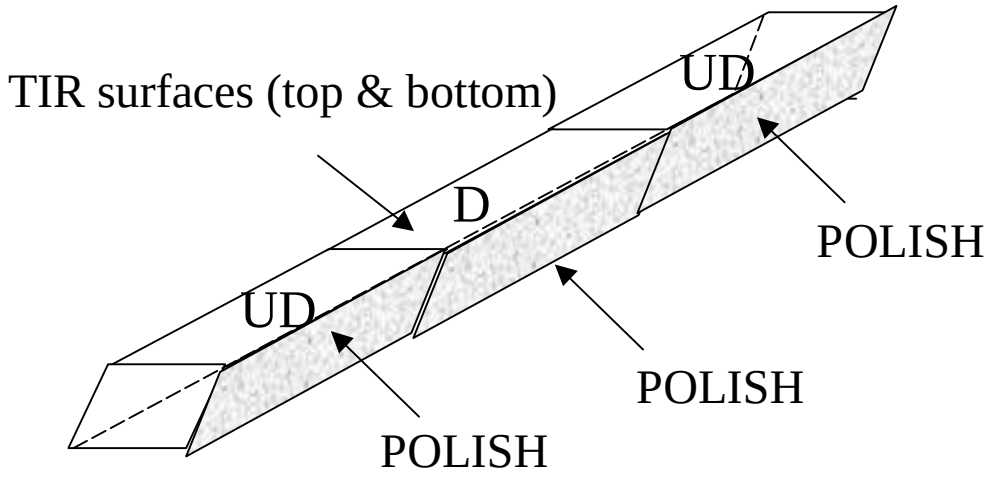


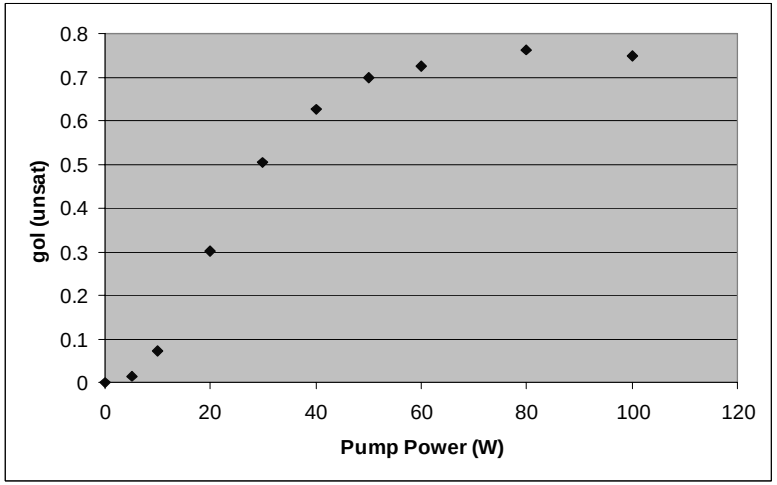


++	Small signal gain improved.
-	Vendor damaged coating during sand blast procedure for roughening up the doped region.

Measurements on fully polished slab.

2. POLISH THE TWO PREVIOUSLY ROUGH SIDES OF SLAB.

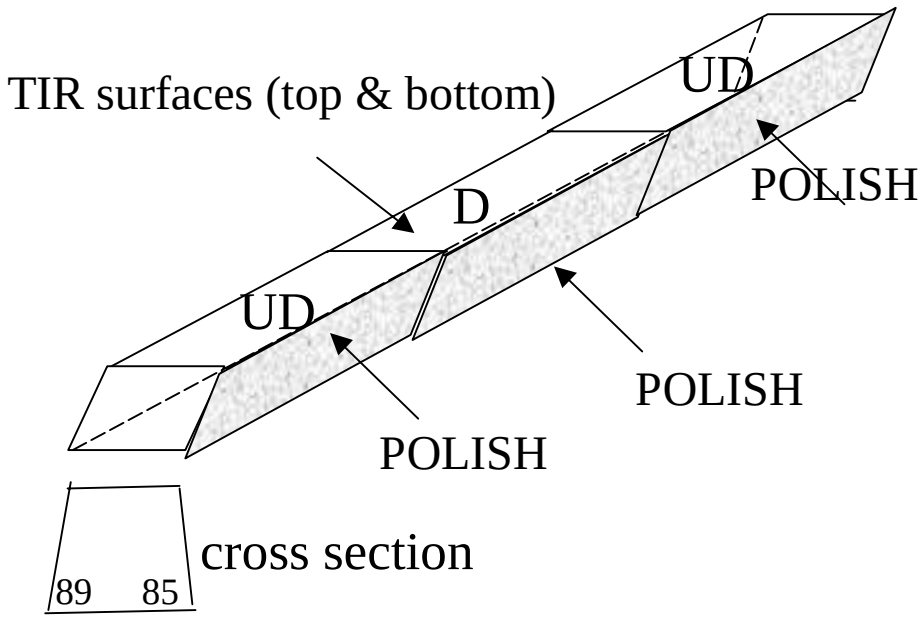


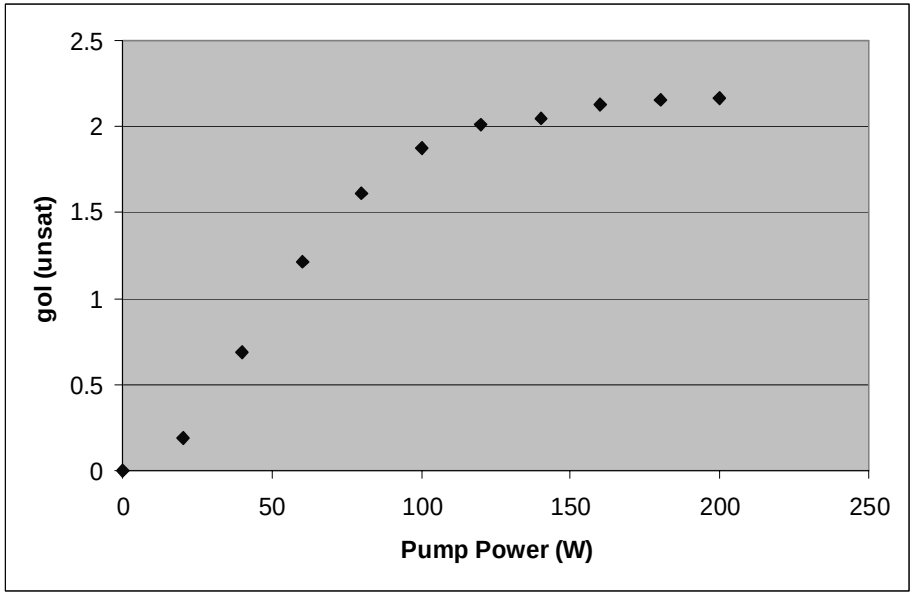


++	Pump light guiding improved to 75-80%.
-----	Parasitic kicks in immediately and clamps the gain.

Measurements on beveled slab

3. POLISH AND BEVEL THE TWO SIDES OF THE SLAB TO KICK OUT THE PARASITIC.

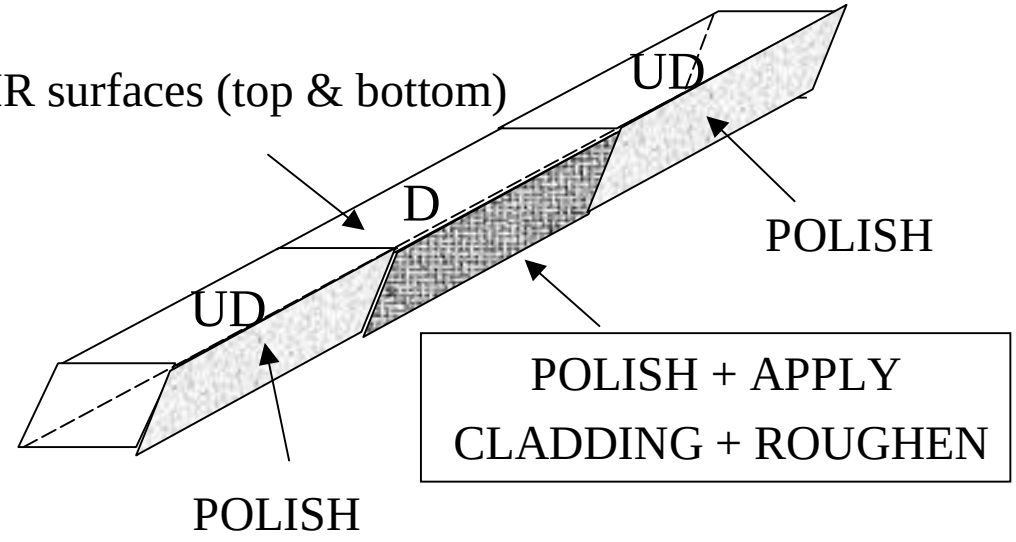


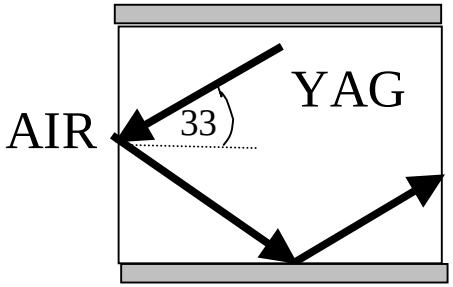


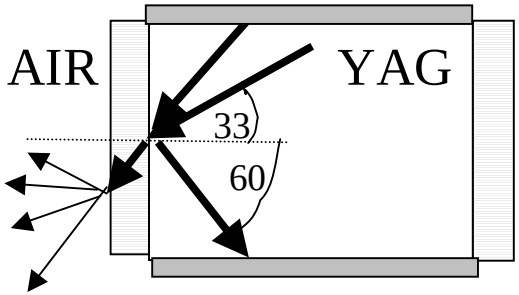
+	Parasitic threshold increased.
--	Parasitic still kicking in well before reasonable gain achieved.

Slab with cladding

4. APPLY CLADDING ON DOPED REGION OF SLAB TO SPOIL TIR ANGLE FOR TRANSVERSE PARASITIC.

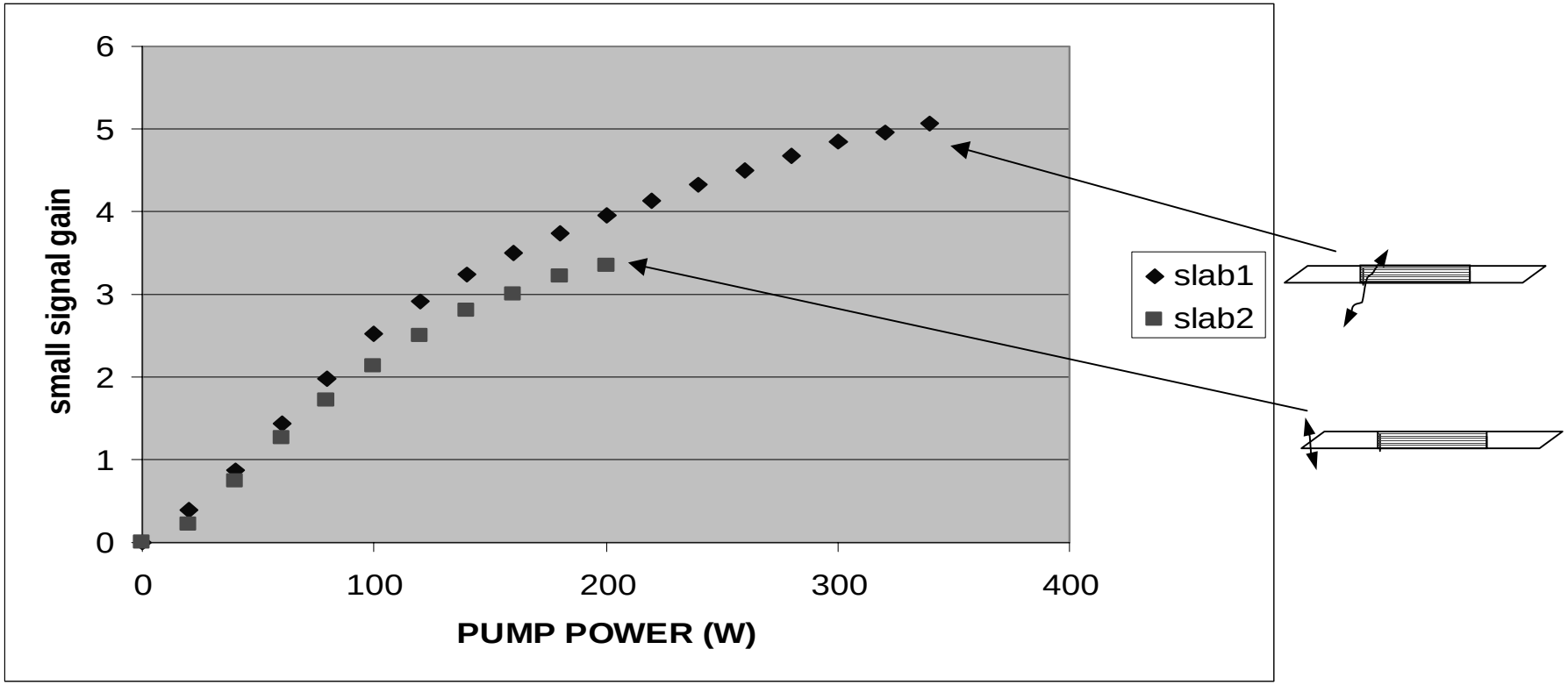






- **CLADDING USED:** Norland 61 optical epoxy n = 1.56
- PARASITIC LEAKS INTO CLADDING AND IS SCATTERED OUT

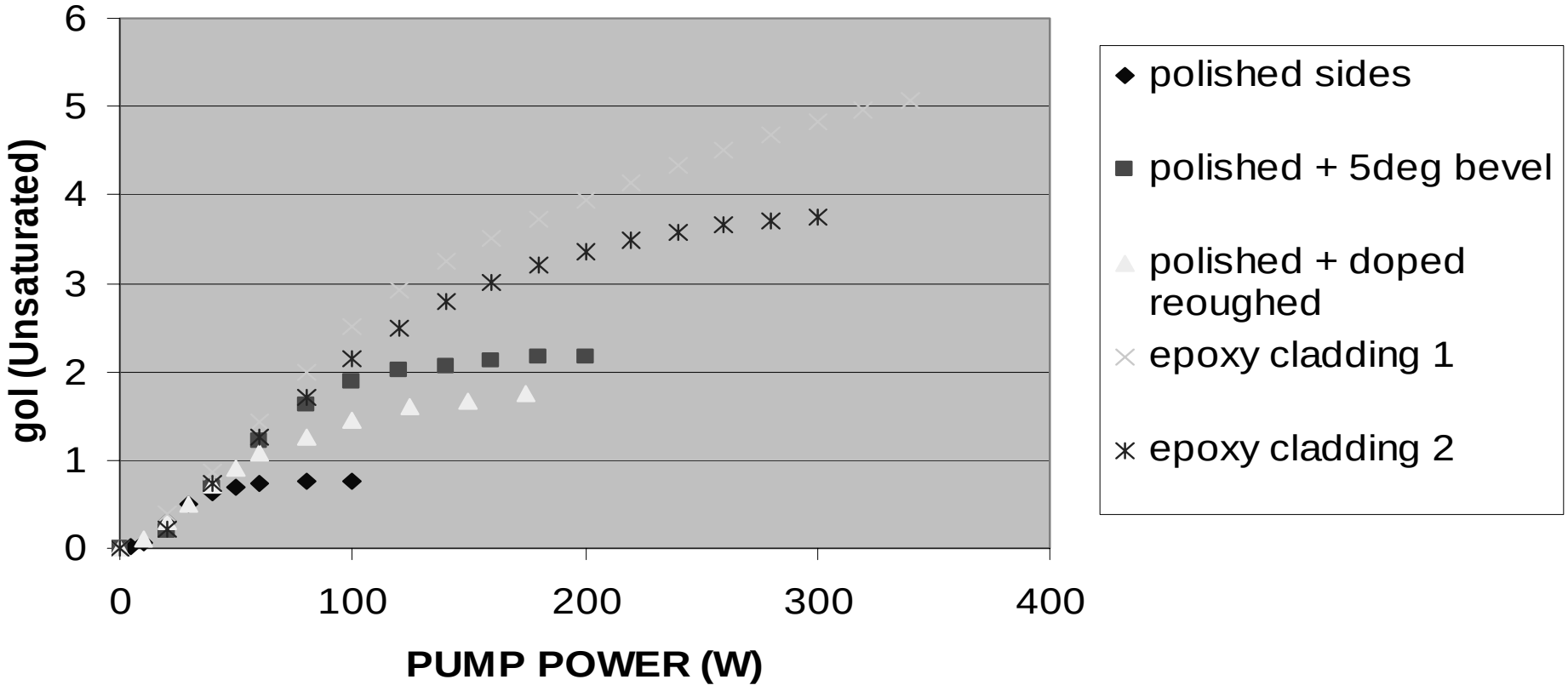
Measurements on slabs with cladding



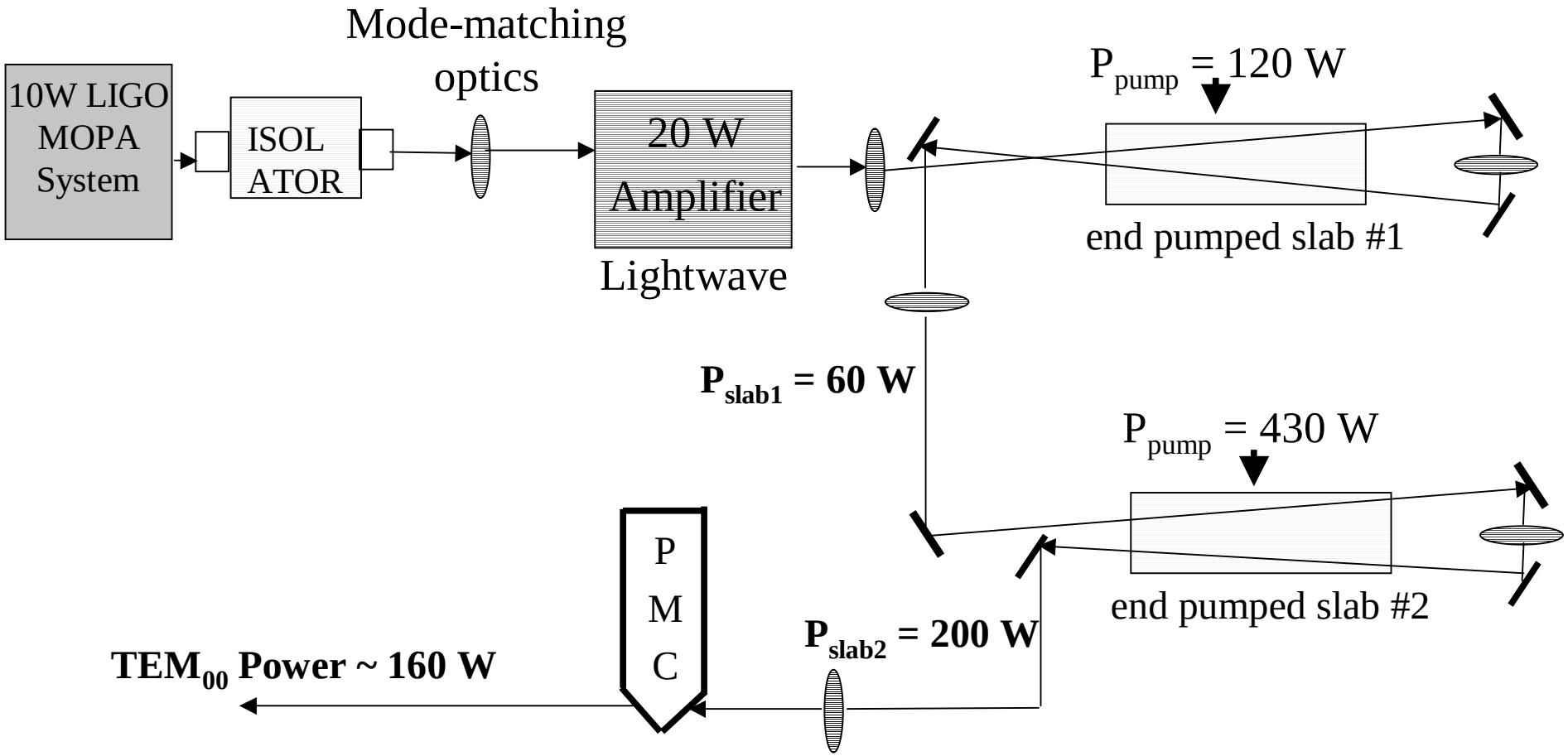
+++ Cladding approach works well for suppressing parasitics.

- Slabs cracked from possible contamination and stresses during polishing.

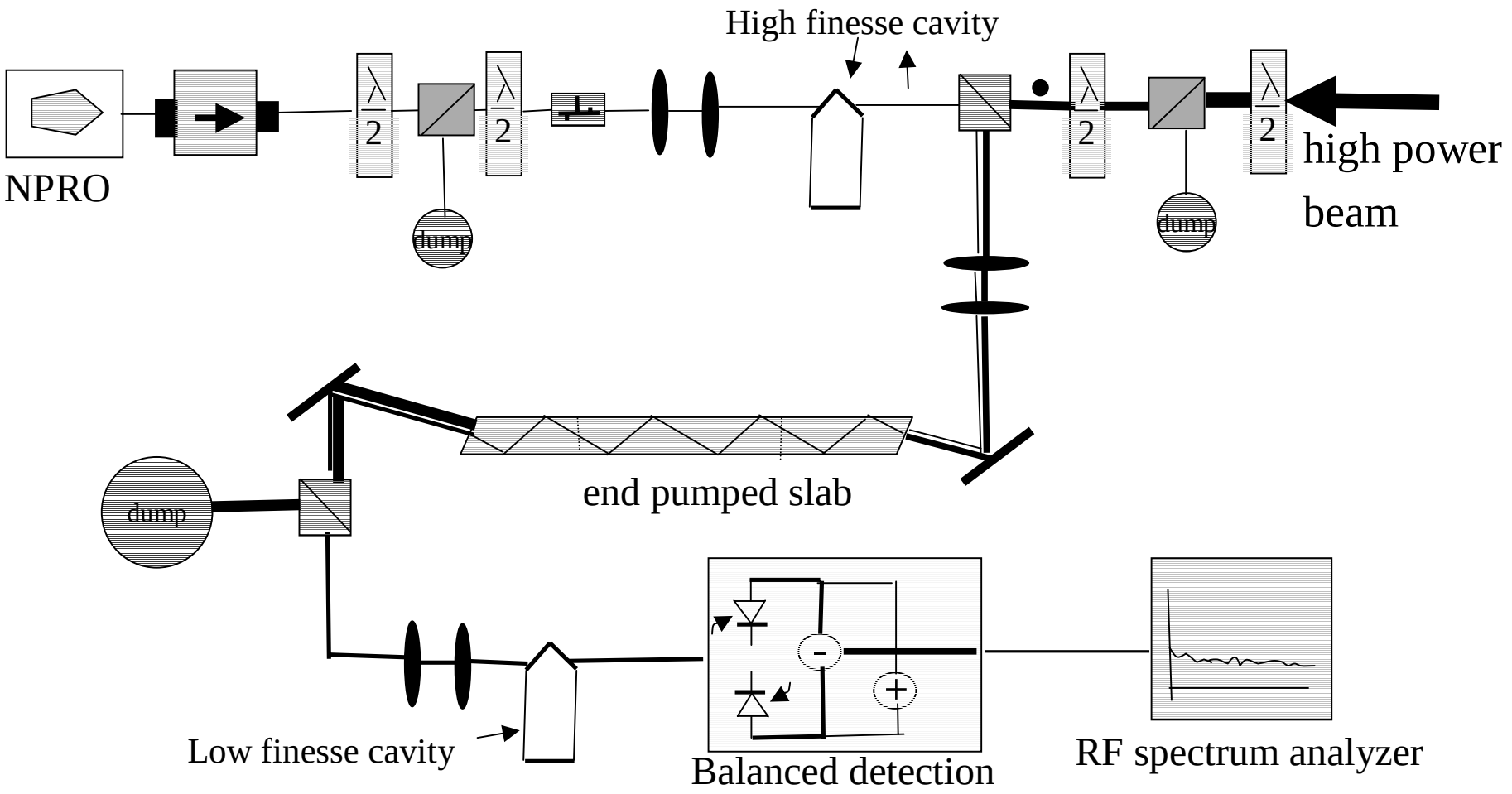
Parasitic control summary



Scaling to 200 W : Experimental Plan



Saturated amplifier noise experiment tentative setup



Future Work

- Get mode content and noise measurements of 100 W beam.

- Power scale to 200 W using 2 end pumped slabs.
  - Build 2 new slabs with parasitic control cladding.
  - Set up pumping scheme for slab #1 (preamplifier).
  - Measure mode and noise characteristics of 200 W beam.

- Complete saturated amplifier noise experiment.