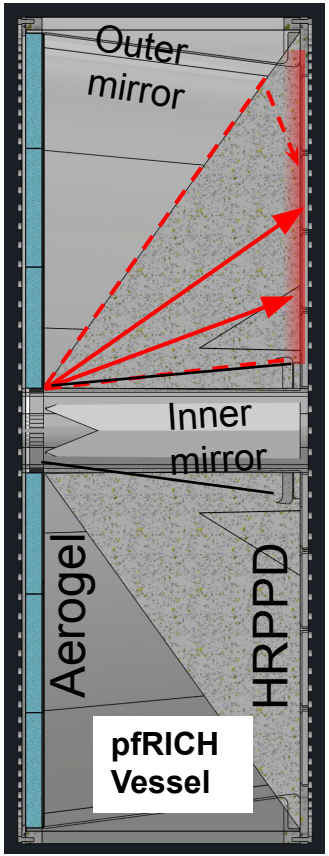
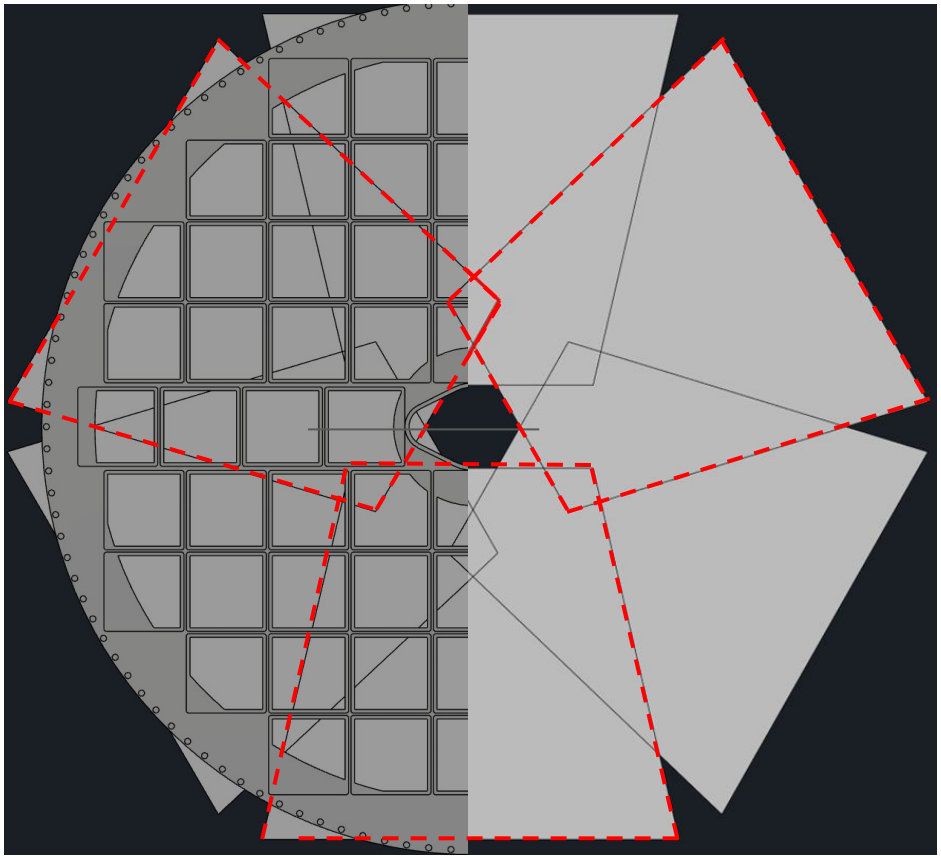
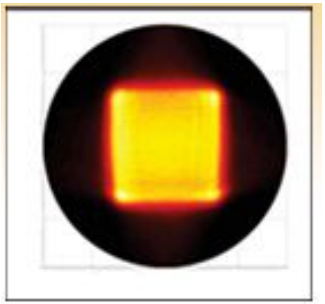
Laser Monitoring Designed for pfRICH





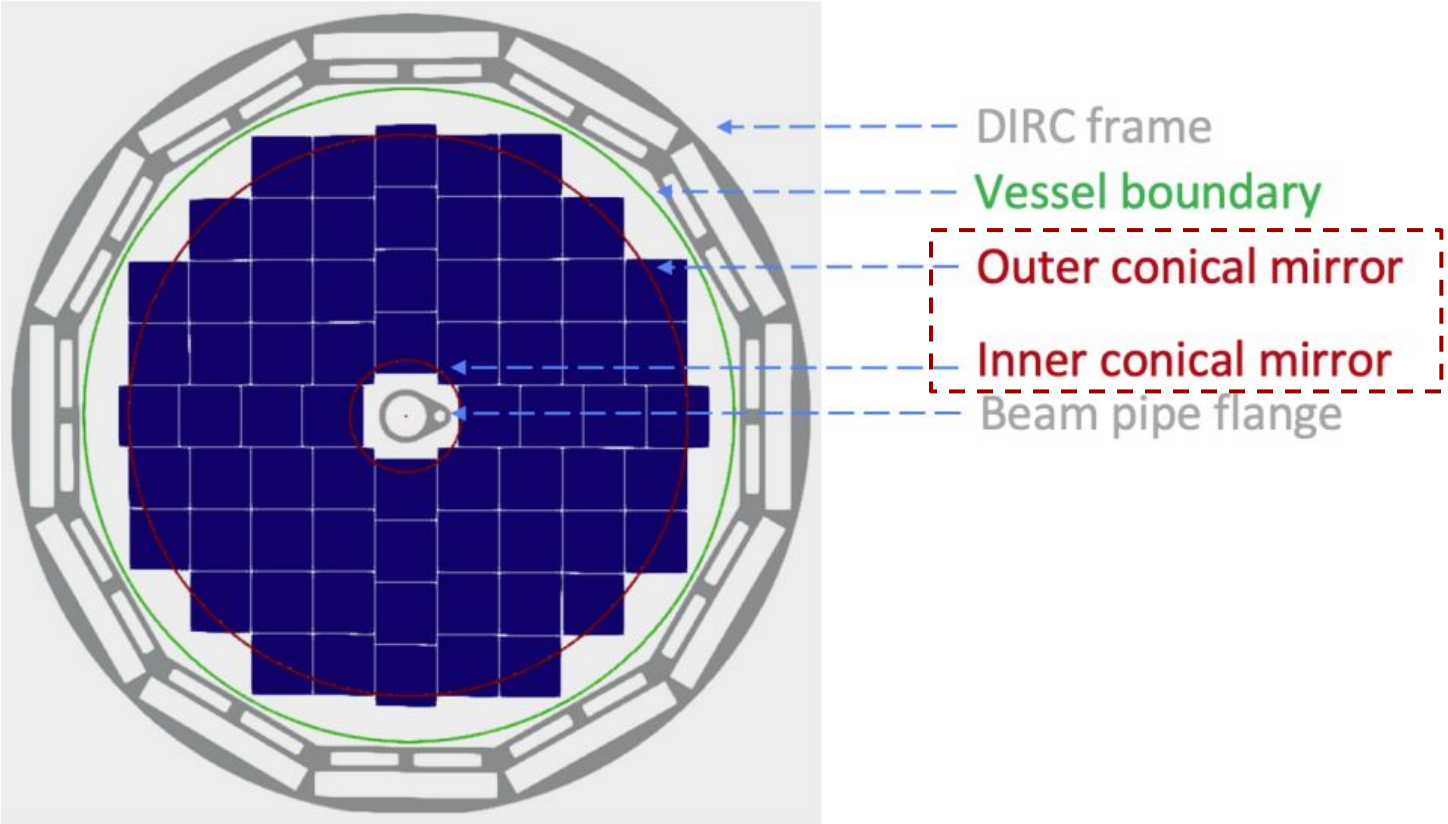
Design considerations

- Array of 6 fibers may be used for direct illumination of HRPPDs + array
- 6 fibers may be used to reflect light off of the mirrors
- 40 cm coverage (50 degree square diffuser)
- “Red” lasers fire 5-10 ns (different fiber length)



Square Pattern

Effective region covered by monitoring system



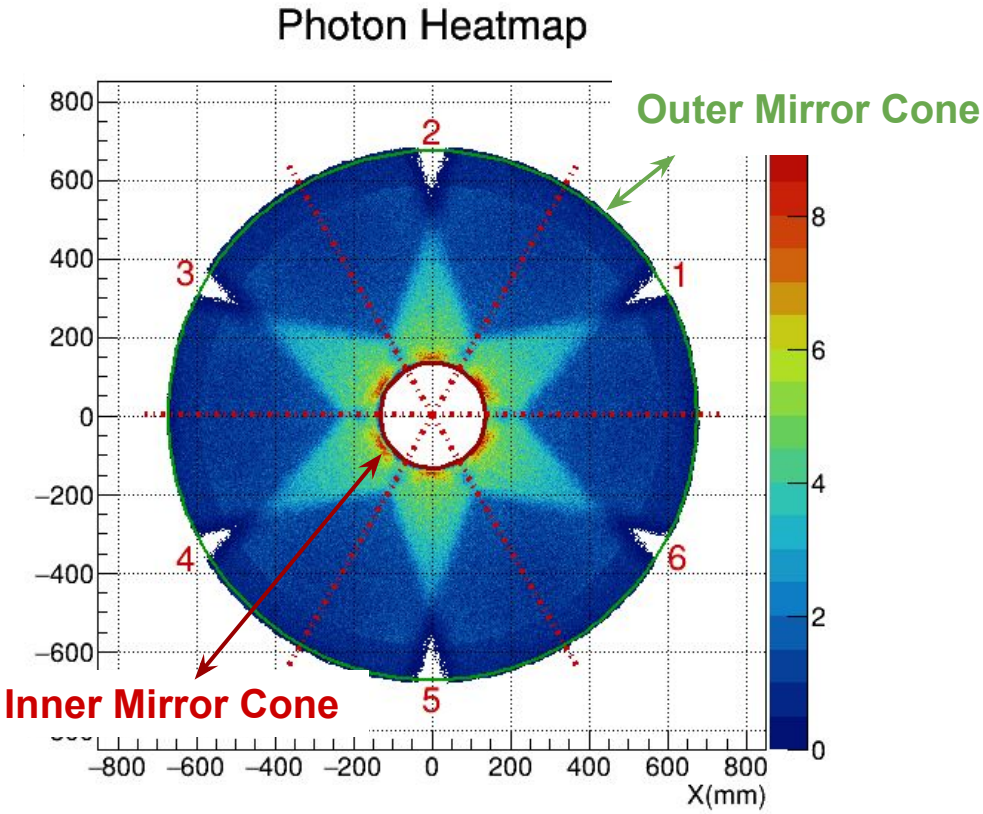
PED Objective

Two main objectives:

1. Measure the light profile from the splitter-diffuser combination (the setup used for this measurement meets the expectation).
    a. Validate the diffuser lay profile.
    b. Study the fiber properties.
    c. Study the light uniformity from the diffuser (See Bob's slides).
    d. Study light coverage from the diffuser. Lead to the diffuser procurement.

2. Assessing the feasibility of the proposed laser system in terms of light profile and generating input for the detector integration.
    a. Finalized light profile, simulated vs measurement.
    b. Design for the mounting. (See Dan's slides)

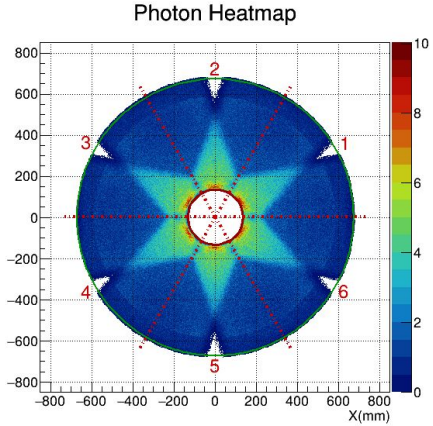
Light profile study from Trace Pro

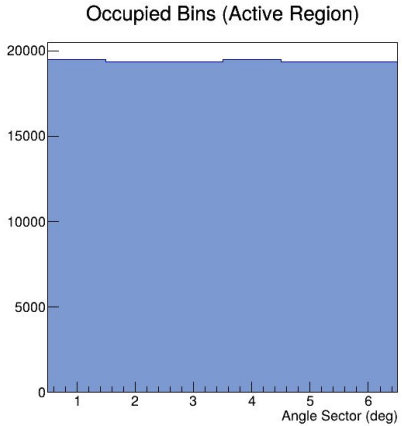


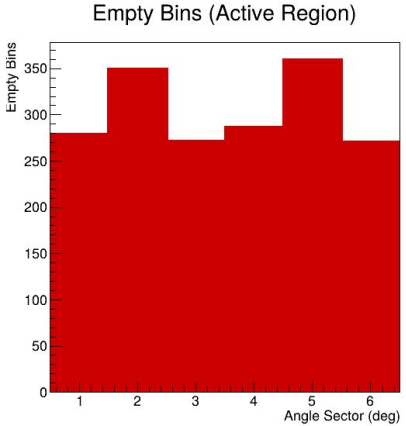
- Assumed 50 diffuser
- Only include inner and outer mirror cone.
  - No sensor plan information included.

Study done by Zakia Sultana Tithi (MSU)

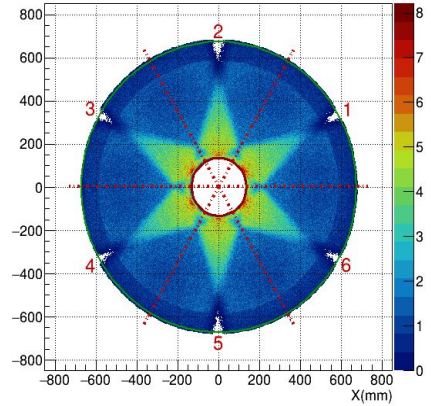
Diffuser Angle Study

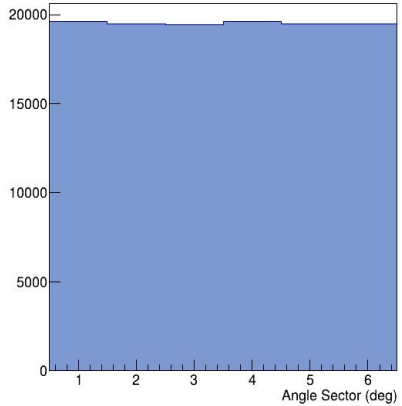


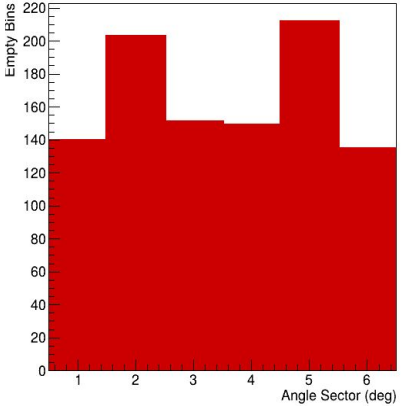




24.23 degree diffuser tilt angle ~98.5% coverage (1.5% empty).







29.23 degree diffuser tilt angle ~99.1% coverage (0.9 empty)

Observation: a controlled and well defined unoccupied region would be very useful for alignment and control sample study.

Study done by Zakia Sultana Tithi (MSU)

Diffusers offered by Thorlab

Standard ED1-S50 square pattern diffuser

- Profile and coverage is idea
- 1” size is too large to be used for pfRICH.

A smaller ED1-S50 square pattern diffuser:

- Dimensions: 5mm x 5mm +/-0.05mm with a 1.2mm thickness +/0.075mm
- A divergence angle of 47.2° x 45.4° +/-5%.
- Intensity profile: flat-top
- Input beam diameter: like the catalog part should be >0.5mm.
- Lead time: 12 weeks.
- Cost: $106.50 each and a minimum order quantity of 40

Near future work

- Repeat the study with 41 degree diffusers.
- Include sensor plane in the study.
- Better understand the reflective rim from the inner and outer mirror cones.
- Implementing the diffusers that reflect of the mirrors.

PED Related Purchase

Item	Per Unit Cost ($)	Quantity	Total Price ($)	Description
M405L4	256.22	1	256.22	LED
SM1L05	13.62	1	13.62	Tube
SM1FC	34.45	1	34.45	FCPC Plate
LEDD1B	355.18	1	355.18	Driver
ED1-S50-MD	158	2	316	50 degree diffuser + mounting parts (1" standard catalog)
KPS201	40.33	1	40.33	Power supply
Trace pro software	1533.33	1	1533.33	
S150C	381.34	1	381.34	compactfiber photodiode(It has shipped through fedex 16.47$)
NarrowBand assembly(1*4)	1123	1	1123	1-4 splitter
			5028.94	

Items	Account ($)
1. Equipment cost	$6,375
2. Software licensing cost	$1,500
3. Machine shop cost	$500
4. Consumable cost	$300
5. Total direct cost (sum over 1 to 4)	$8,675
6. Modified total direct cost (sum over 2 to 4)	$2,300
7. Total indirect cost (46.5% of 6)	$1,070
Grand total cost (5+7)	$9,745

Projected PED spending: $5028.94 + $4264.0 (Diffuser cost) = $9292.94

PED Objective with timeline

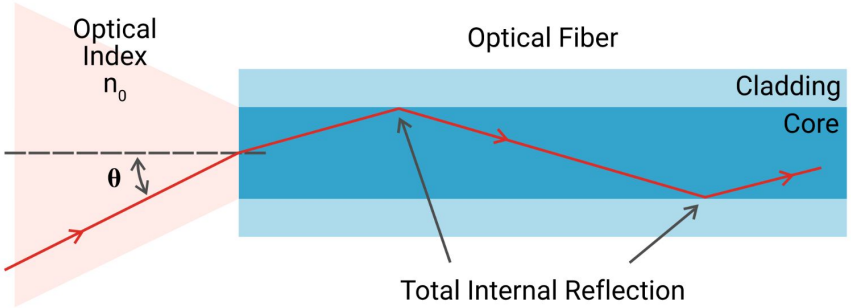
Two main objectives:

1. Measure the light profile from the splitter-diffuser combination (the setup used for this measurement meets the expectation).
    a. Validate the diffuser lay profile.
    b. Study the fiber properties.
    c. Study the light uniformity from the diffuser (See Bob's slides).
    d. Study light coverage from the diffuser. Lead to the diffuser procurement. [October 2025]

2. Assessing the feasibility of the proposed laser system in terms of light profile and generating input for the detector integration.
    a. Finalized light profile, simulated vs measurement. [May 2026]
    b. Design for the mounting.

Backups

Numerical Aperture Calculation



$$NA = nsin\theta$$

Fiber numerical aperture: 0.22
UV optical fiber index of refraction: 1.475

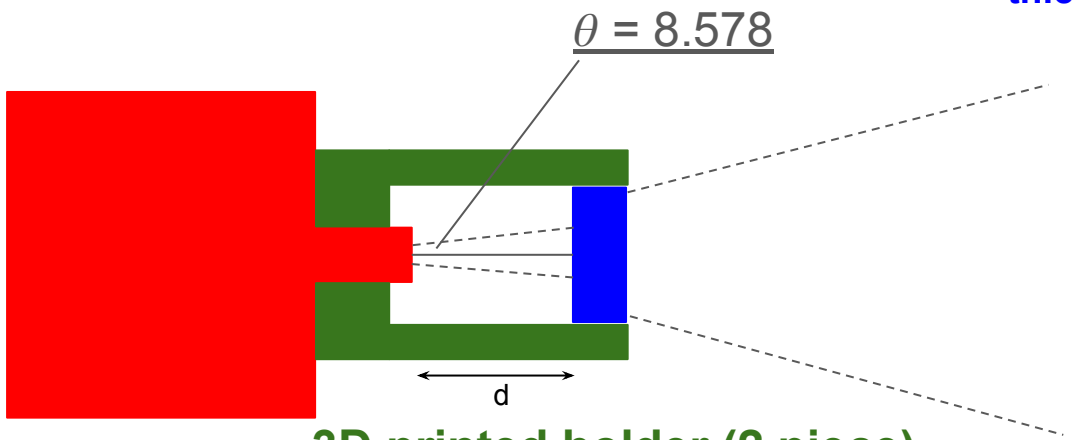
$$\theta = \sin^{-1}\left(\frac{NA}{n}\right)$$

Angle: 8.578

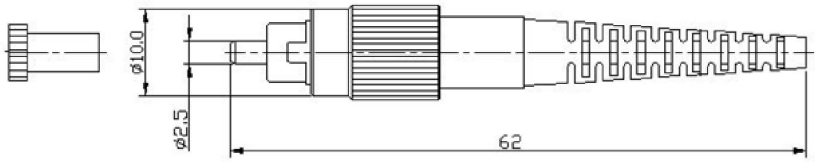
Numerical Aperture Calculation

FC/PC connector (Ferrule size 2mm)

Square Diffuser (costumed made ED1-S50): 5mm x 5mm +/-0.05mm with a 1.2mm thickness +/0.075mm



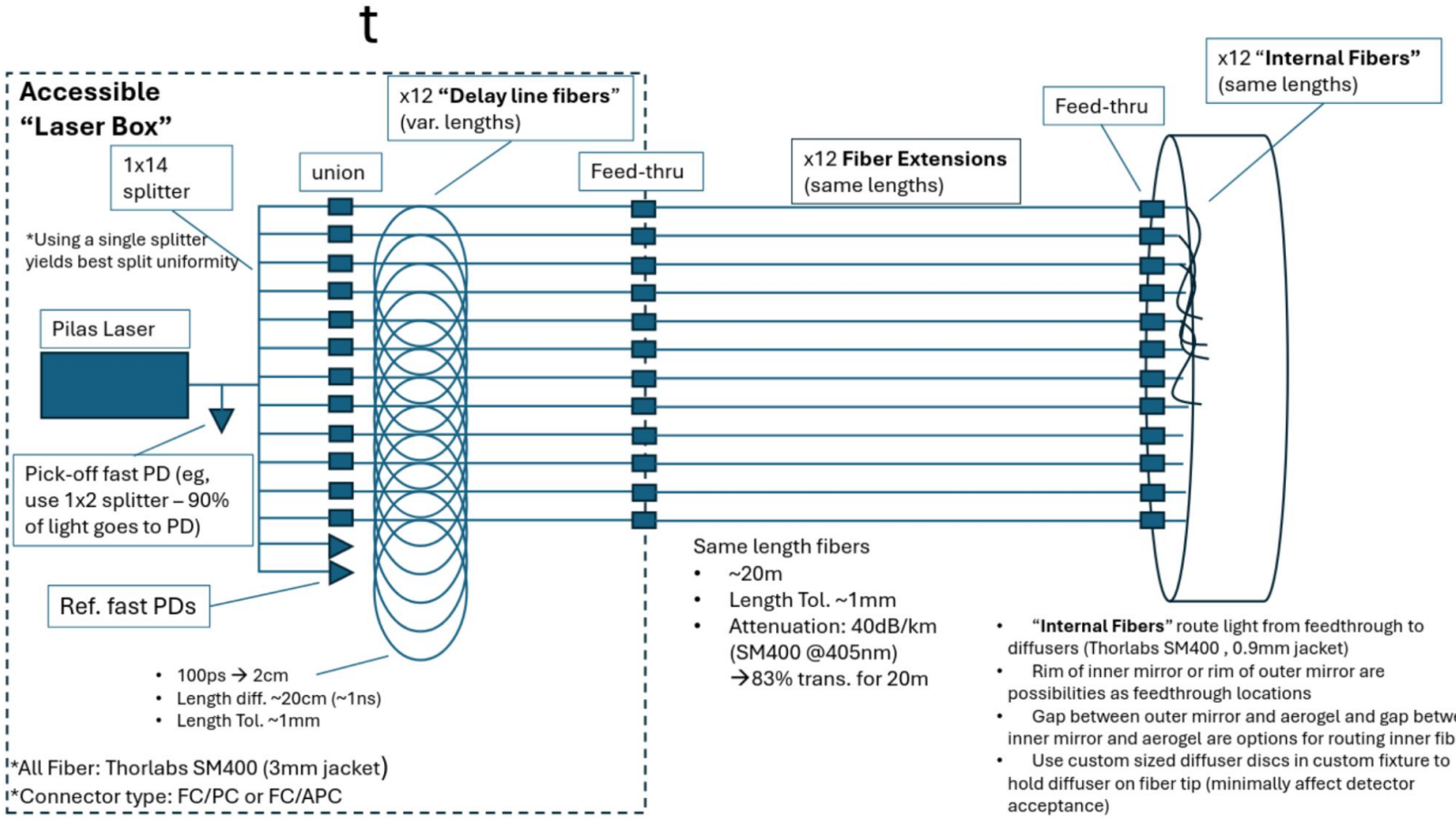
3D printed holder (2 piece)



Design consideration:

- Incoming signal size at the diffuser: > 0.5mm
- Outgoing signal size: 47.2° x 45.4° +/-5%
- Assume θ = 8.578, 0.75 mm spot size onto the diffuser, d = 2.5 mm
- Assume θ = 8.578, 0.90 mm spot size onto the diffuser, d = 3.0 mm
- Assume θ = 8.578, 3.00 mm spot size onto the diffuser, d = 9.94 mm

System Layout Designed by Bob Azmoun



Synergistic among PID Systems

- **Common Laser Trigger pulse**
  - Controlled pulse triggers pfRICH, dRICH and hpDIRC laser system simultaneously.
  - A team of experts monitor and calibrate the timing profile for all PID systems
- **Same hard components**
  - Common spare parts repository for expensive items, such as the Pilas laser system
  - Same grade of fiber and diffuser
- **Same design engineering considerations**
  - Timing resolution requirement
  - Laser signal diffused patterns: coverages and over laps
  - Mounting themes and holders
- **Ongoing PED effort to answer common questions**
  - Small profile diffuser (0.5x0.5 square pattern) with square pattern possible? (Integration)
  - Minimum bending radius and signal loss? (Engineering)
  - Validate and optimize the envelopes with Ray Trace program

Integrated monitoring system pfRICH + hpDIRC + dRICH