Timing Performance of an Ultra Compact Radiation-Hard Calorimeter Concept

RADiCAL

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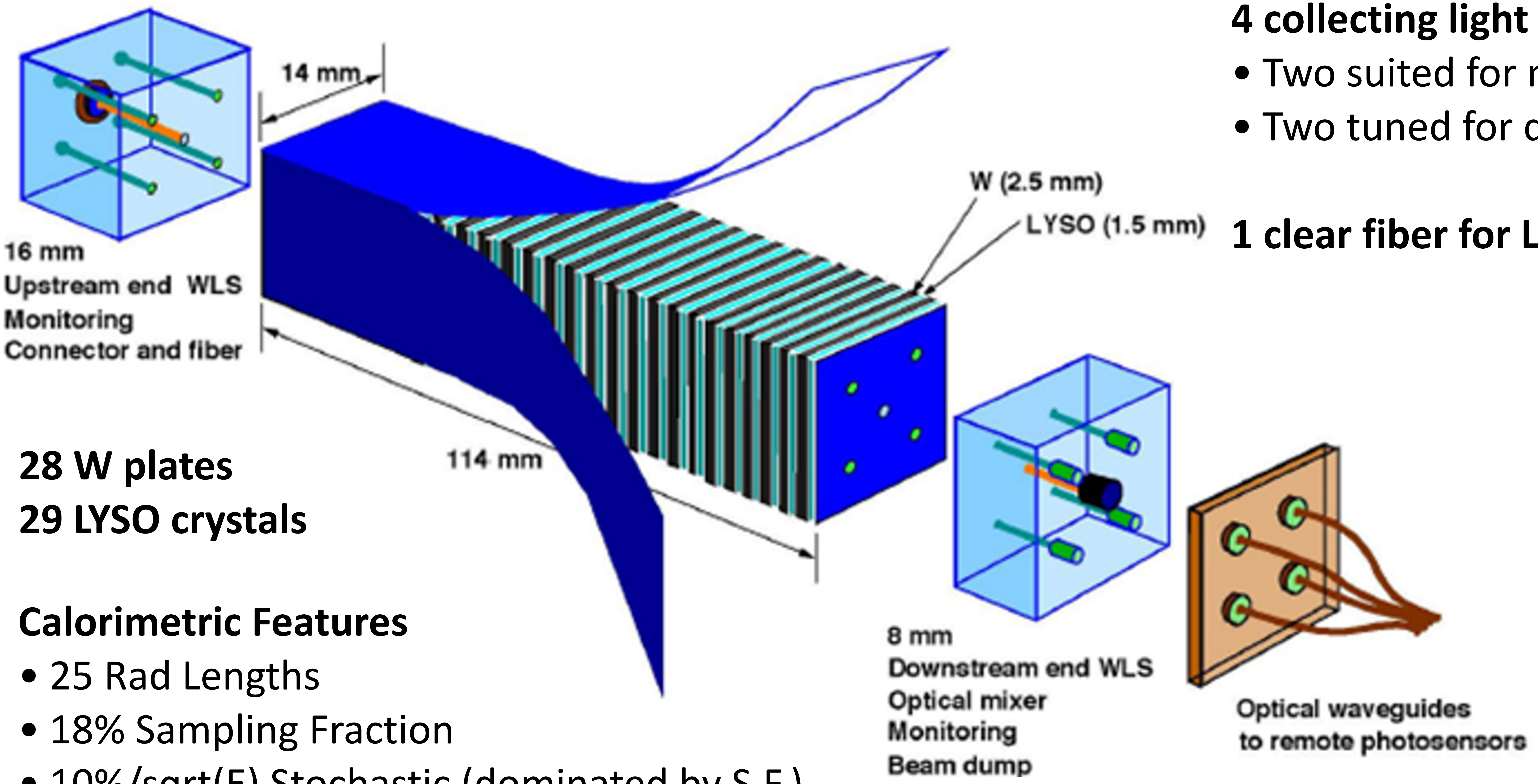
The Coordinating Panel for Advanced Detectors: CPAD 2022

RADiCAL Primitive Unit

4 collecting light capillaries
- Two suited for maximum energy resolution
- Two tuned for quick photon detection

1 clear fiber for LASER calibration (not shown)



28 W plates
29 LYSO crystals

Calorimetric Features
- 25 Rad Lengths
- 18% Sampling Fraction
- 10%/sqrt(E) Stochastic (dominated by S.F.)
- 1% const (dominated by leakage)
- 13.7mm Moliere Radius (great for mitigating PileUp)

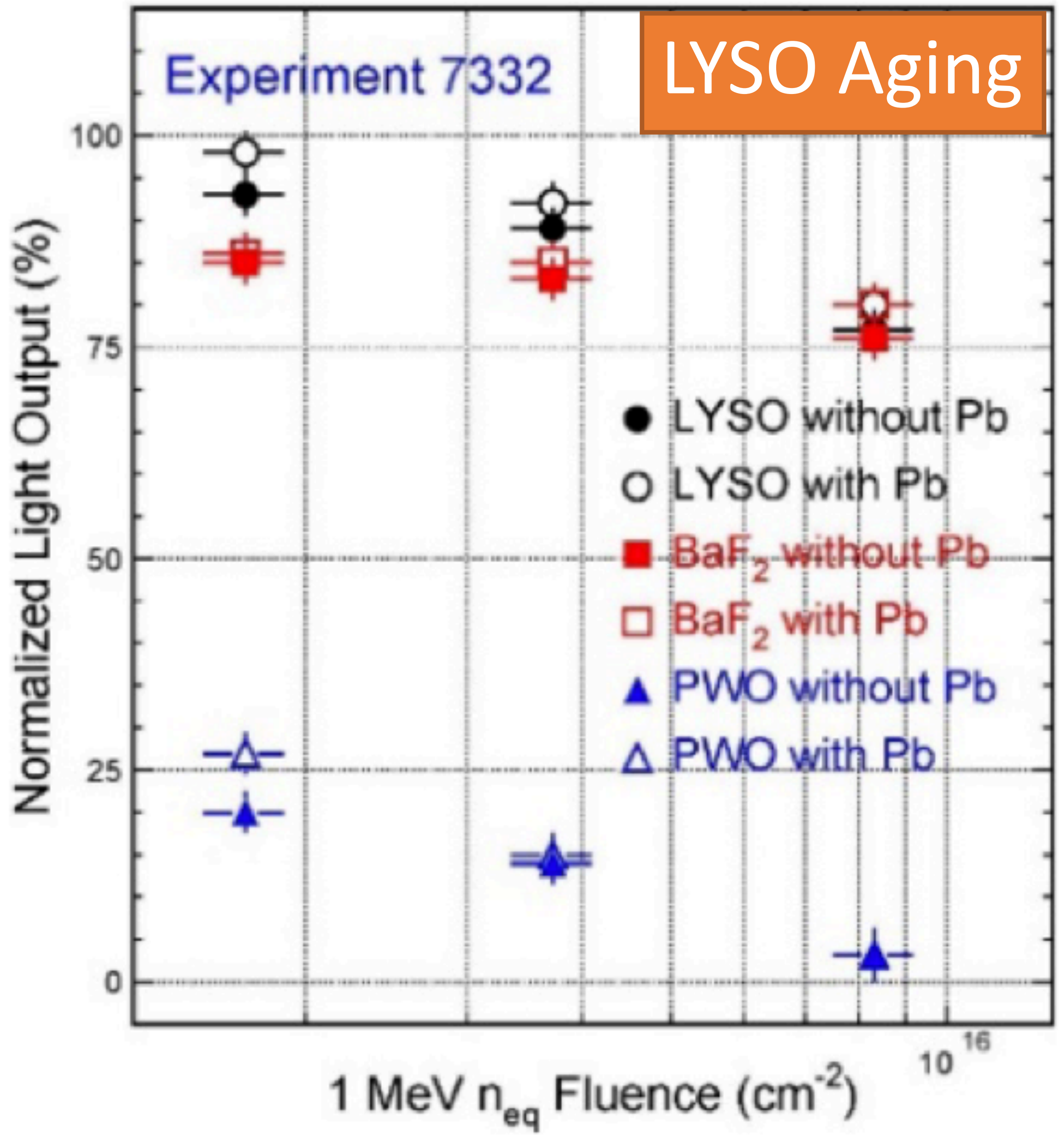
Swiss 1/2 franc
Dia 18.2 mm

Euro 1 cent
Dia 16.3 mm

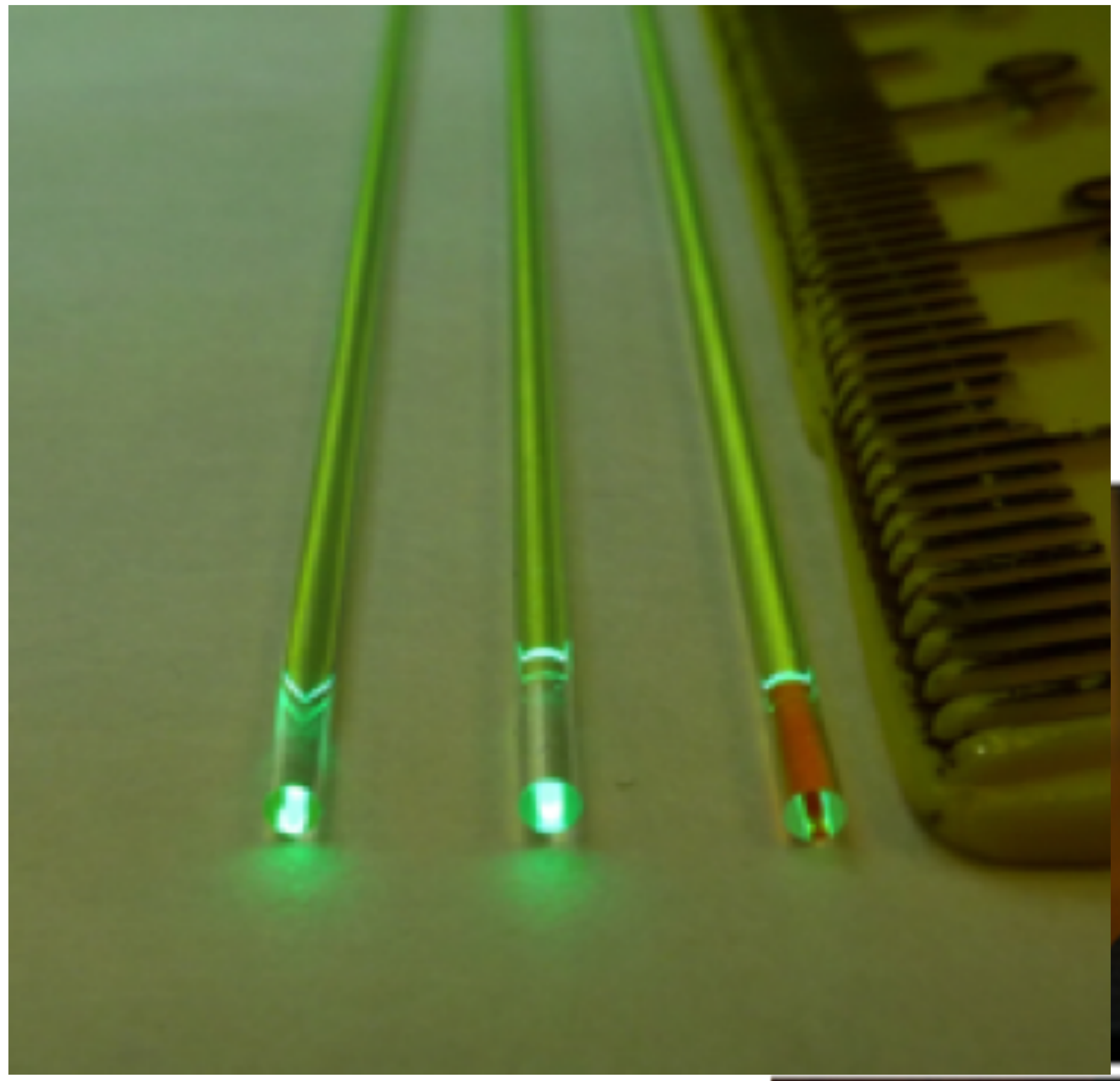
U.S.A. 10 cents
Dia 19.0 mm

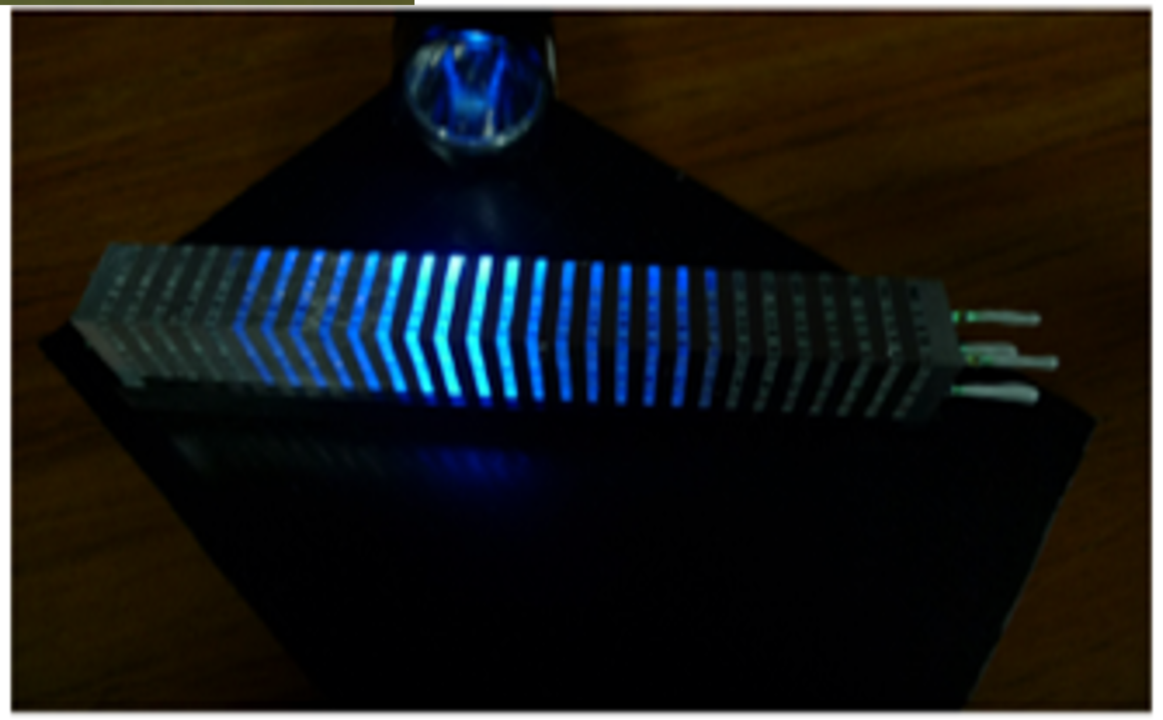
Compact and Scalable

LYSO Aging

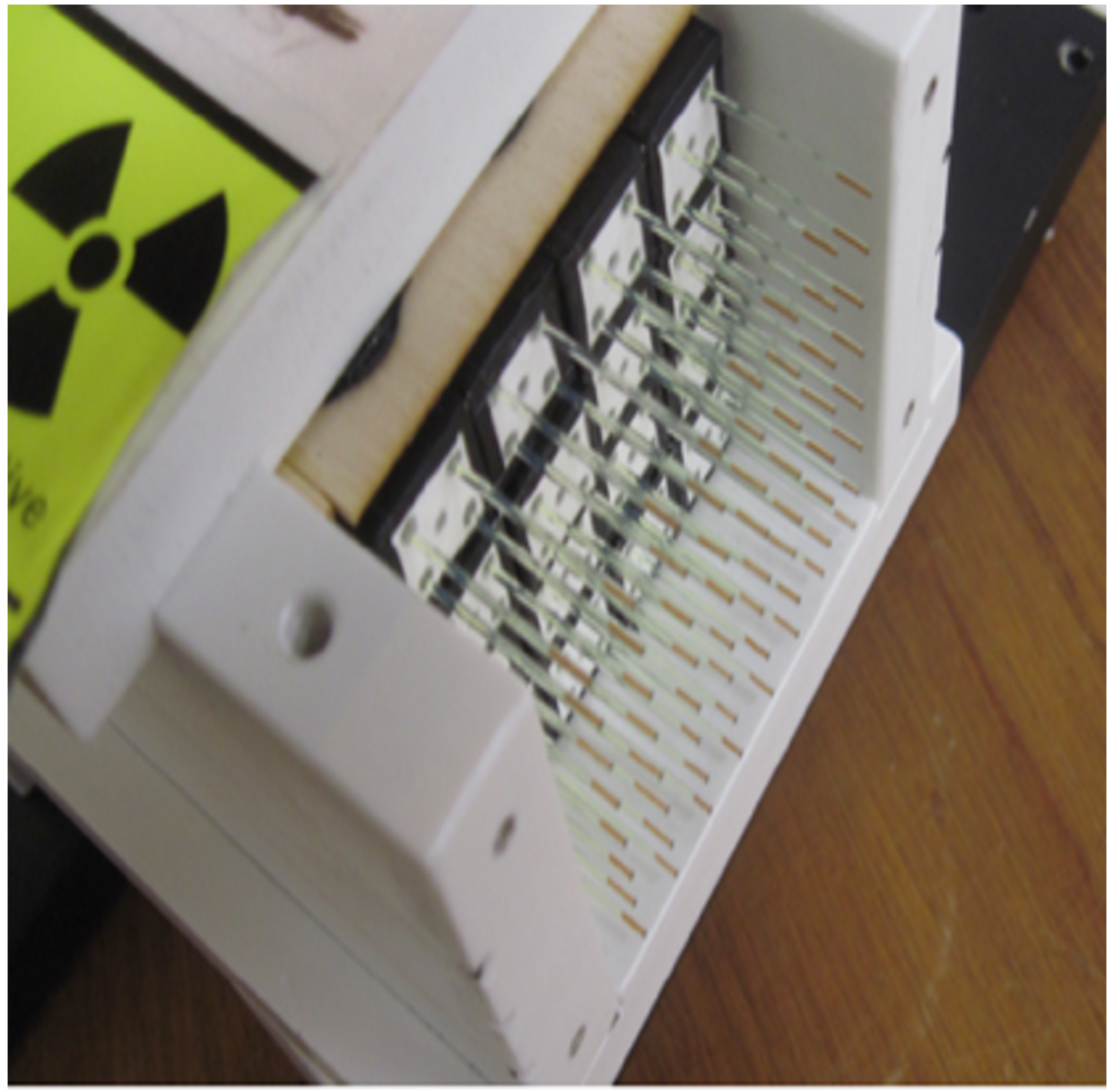


Versatile light collecting element

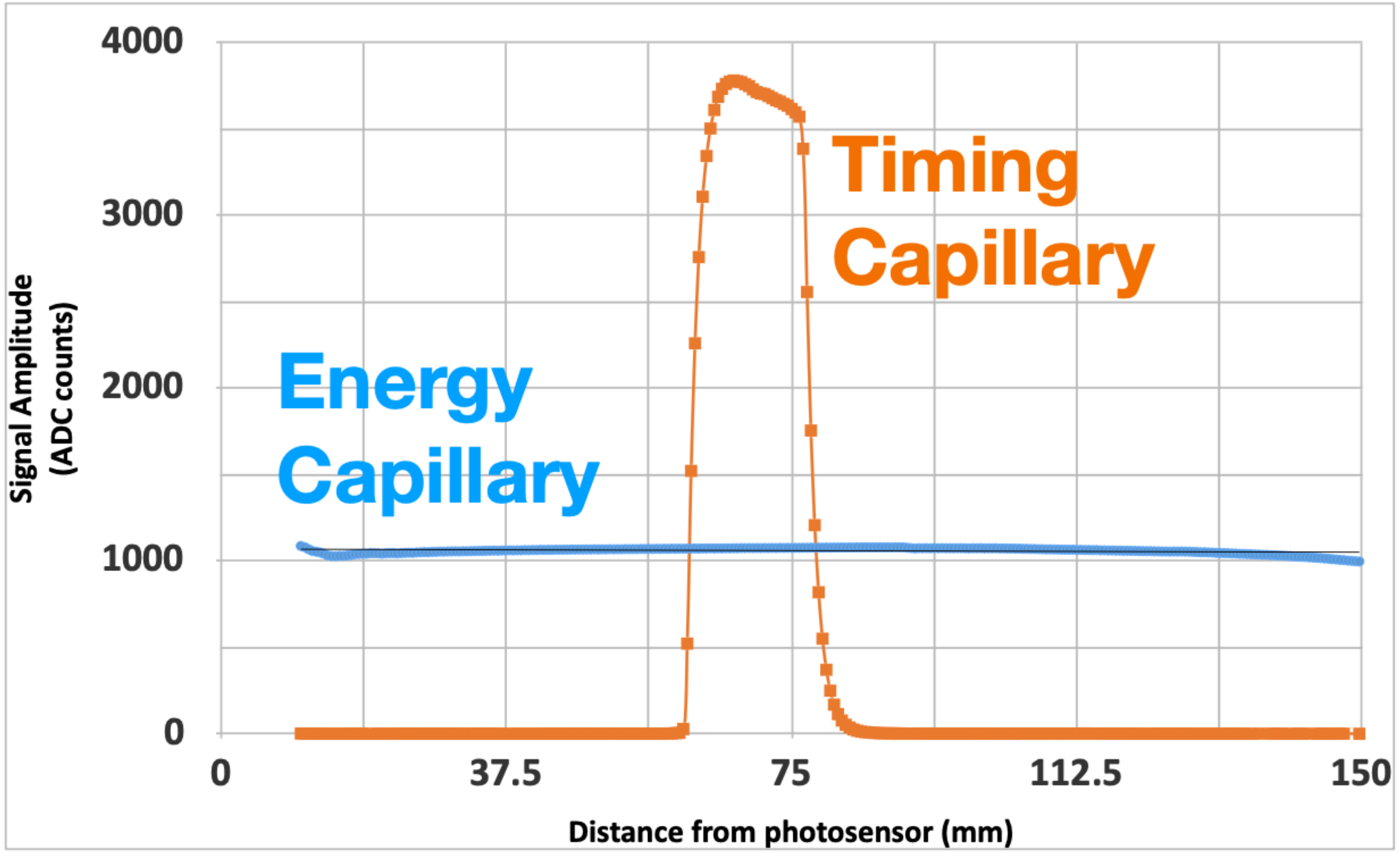


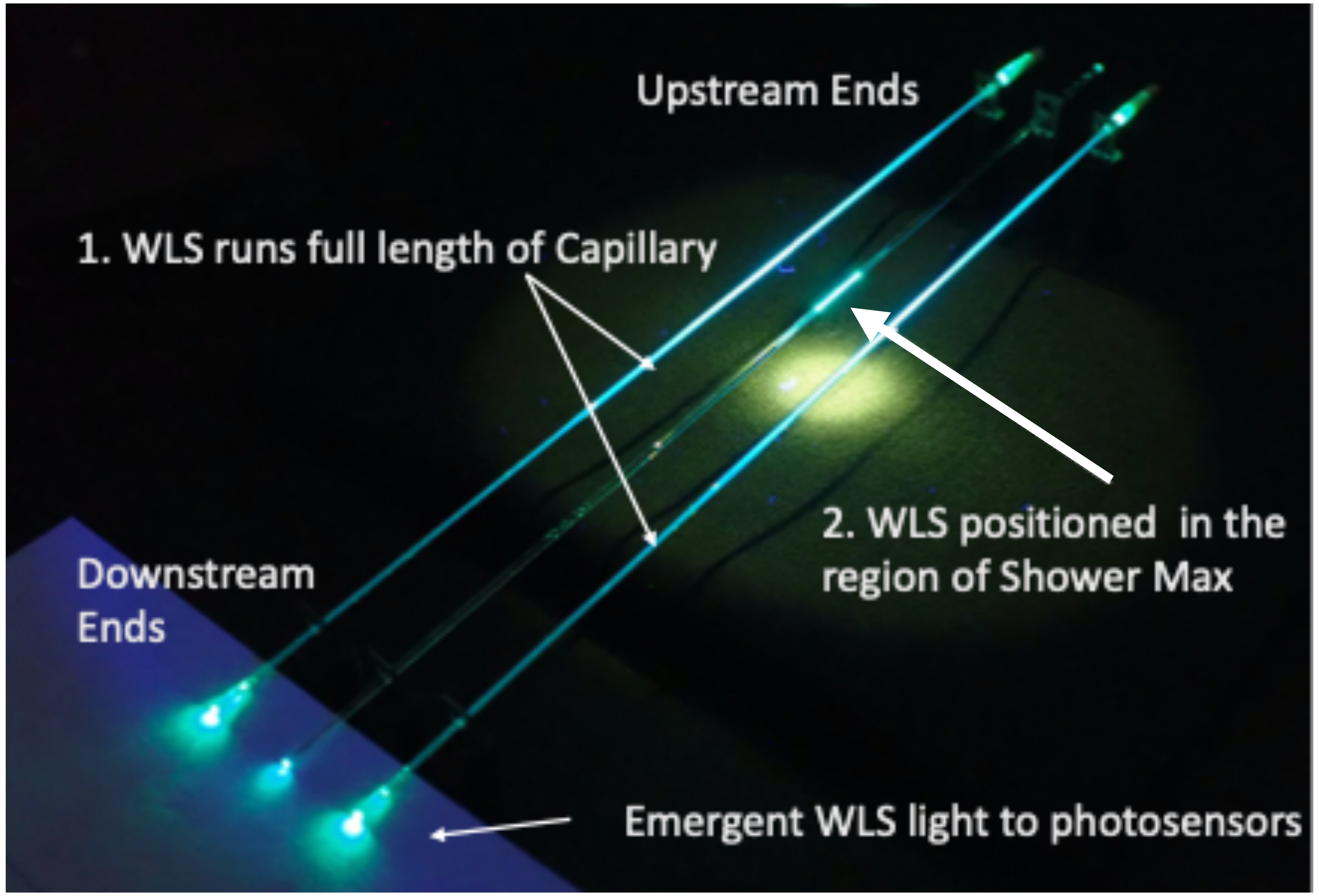


Great scaling capabilities



Capillary Engineering





- Capillaries can be engineered to convert light along the its full axis (for maximum total shower sensitivity)

or

- to convert light only at the position of shower max (for minimal in-path divergency of light produced)

Capillary Engineering

K. Ford
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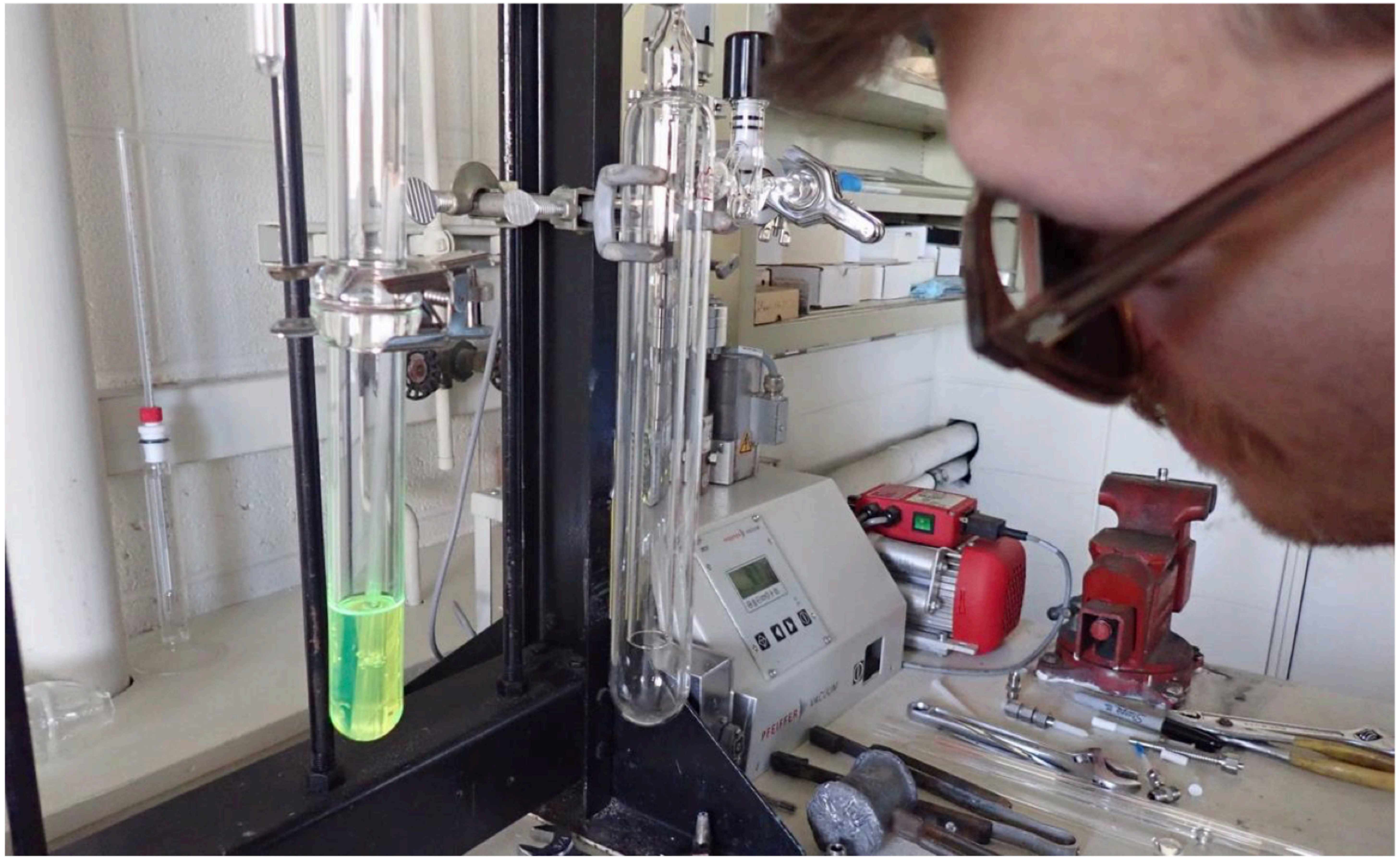
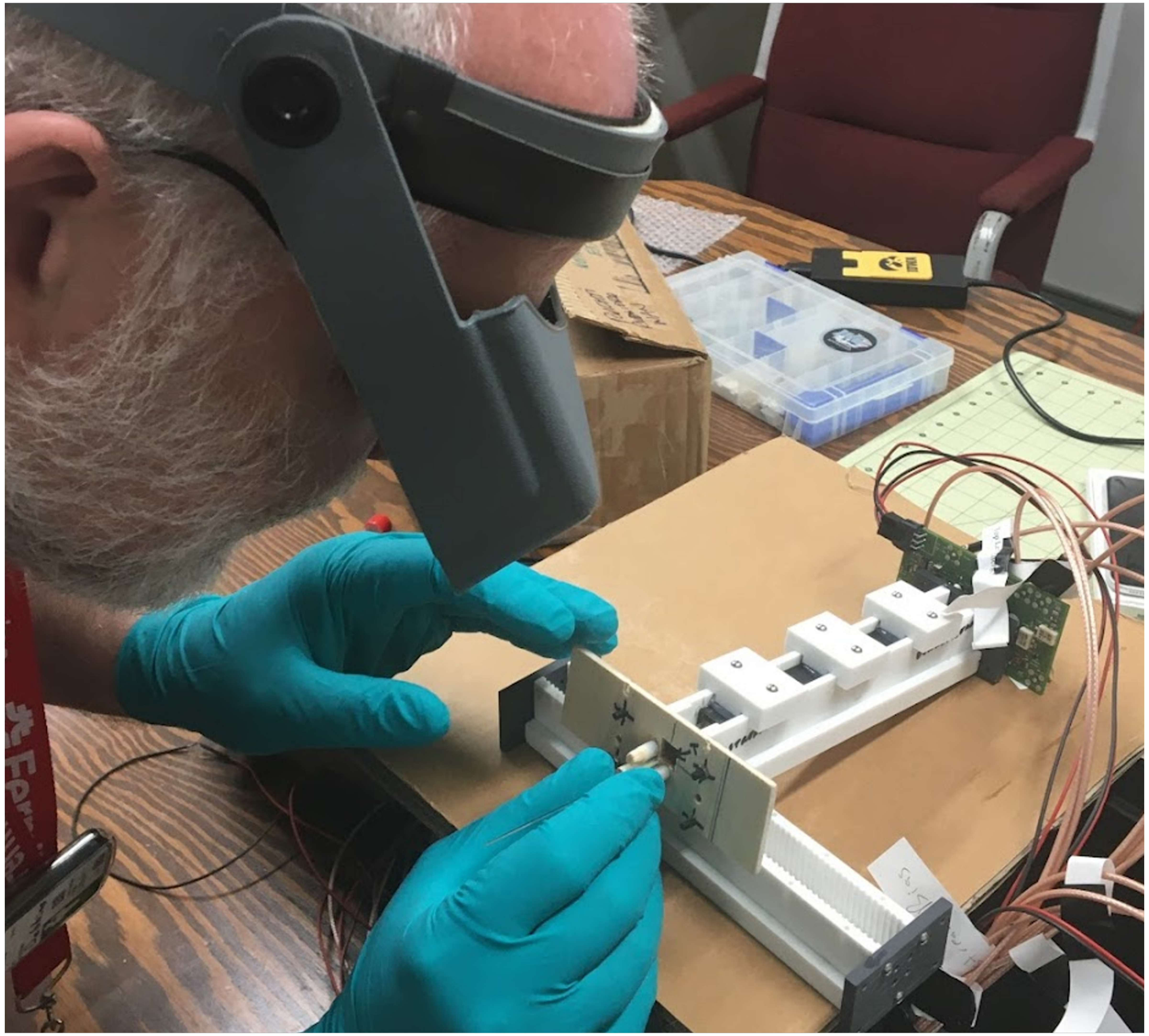
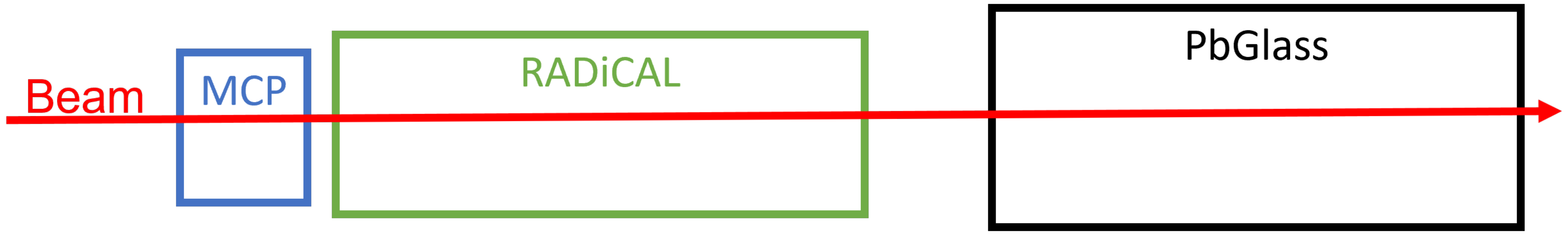
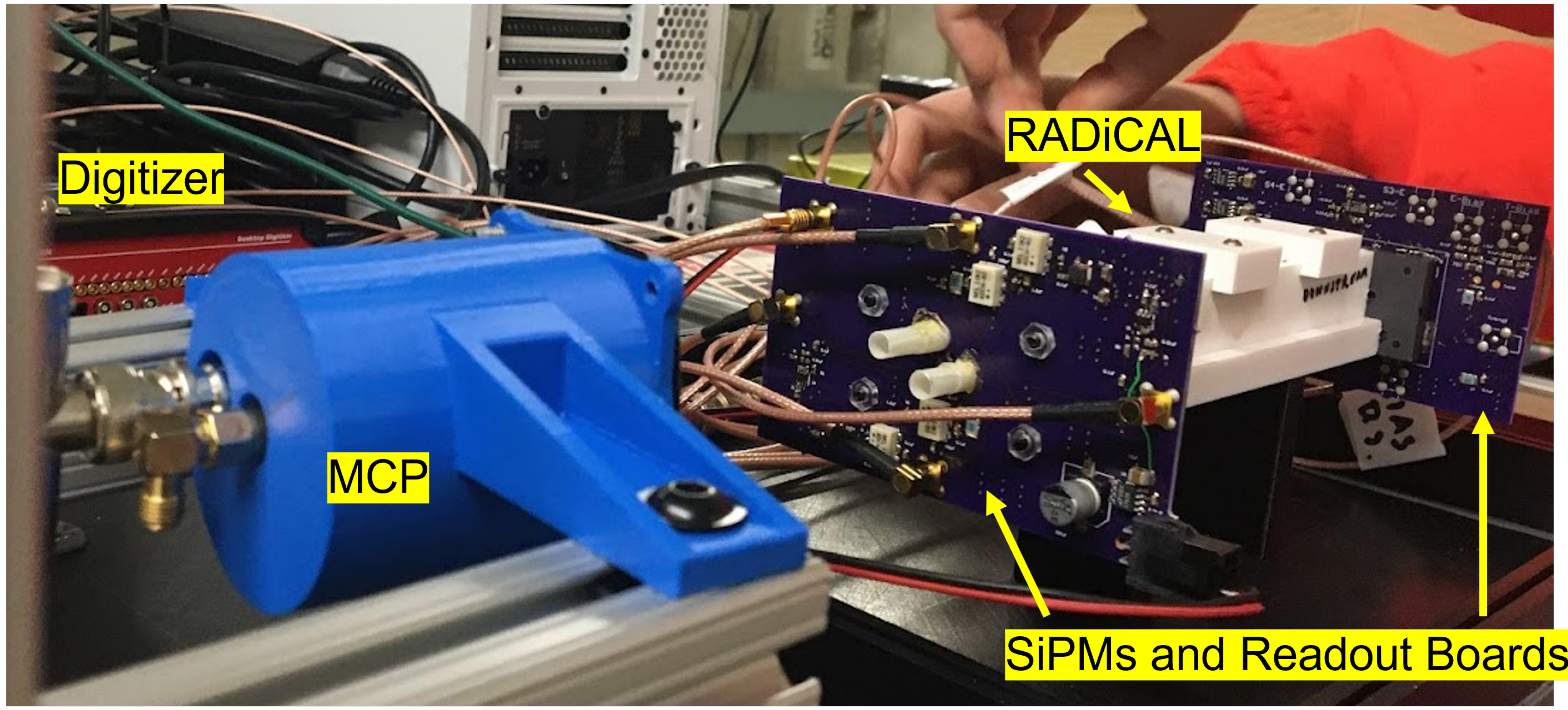
University of Notre Dame Core Facility, Radiation Laboratory, Notre Dame IN 46556



Testing the Prototype with E Beam



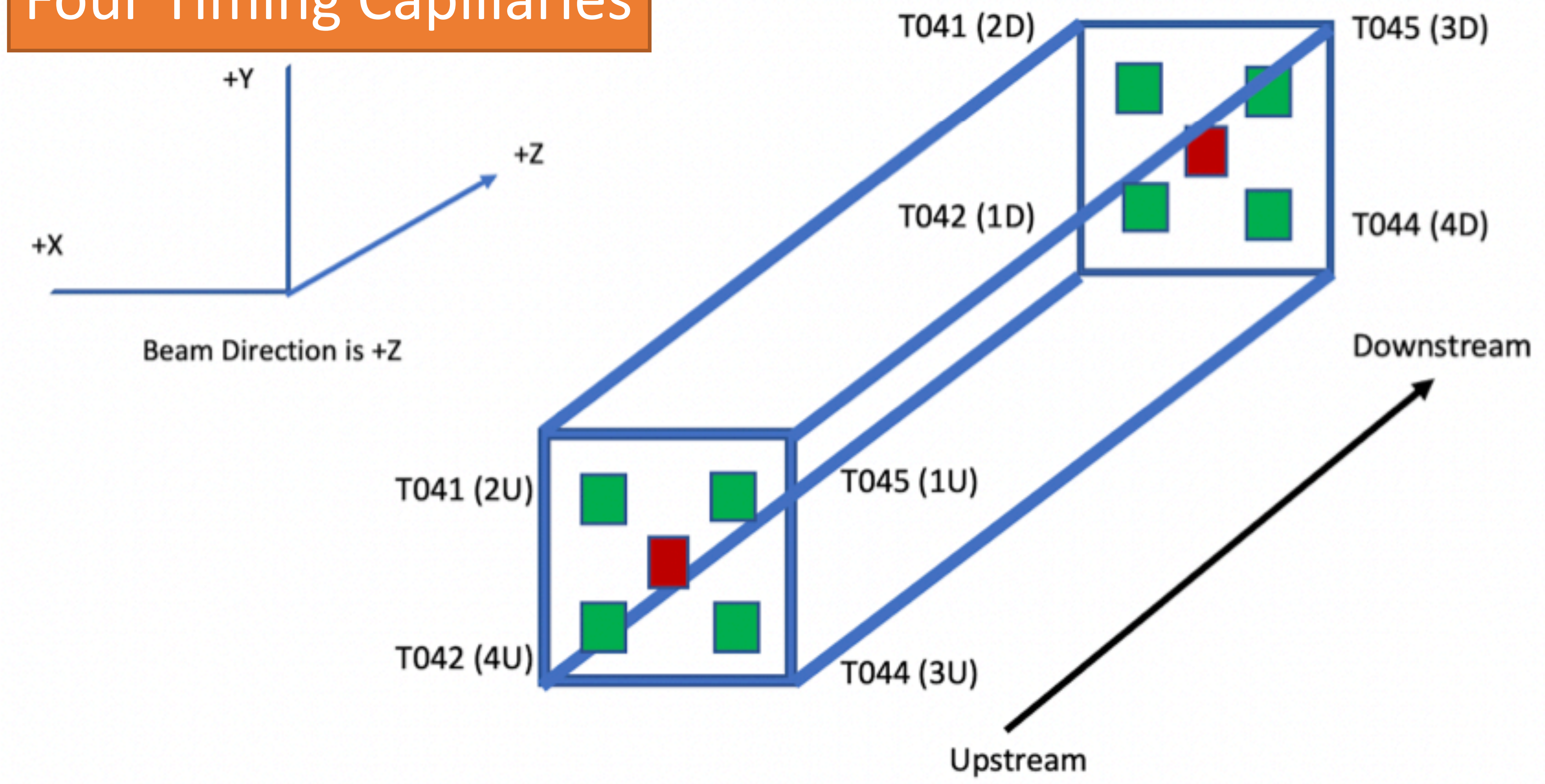


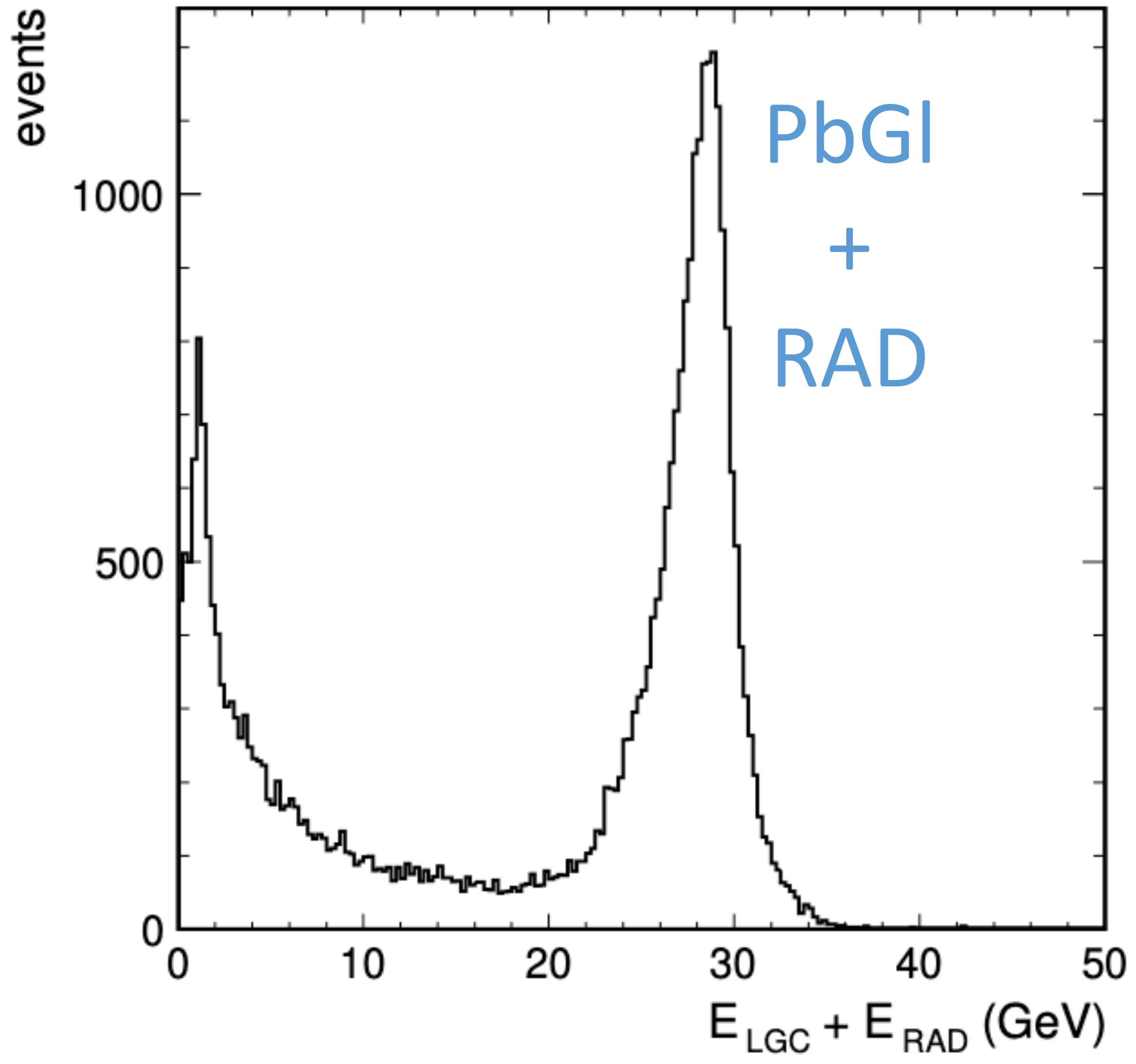


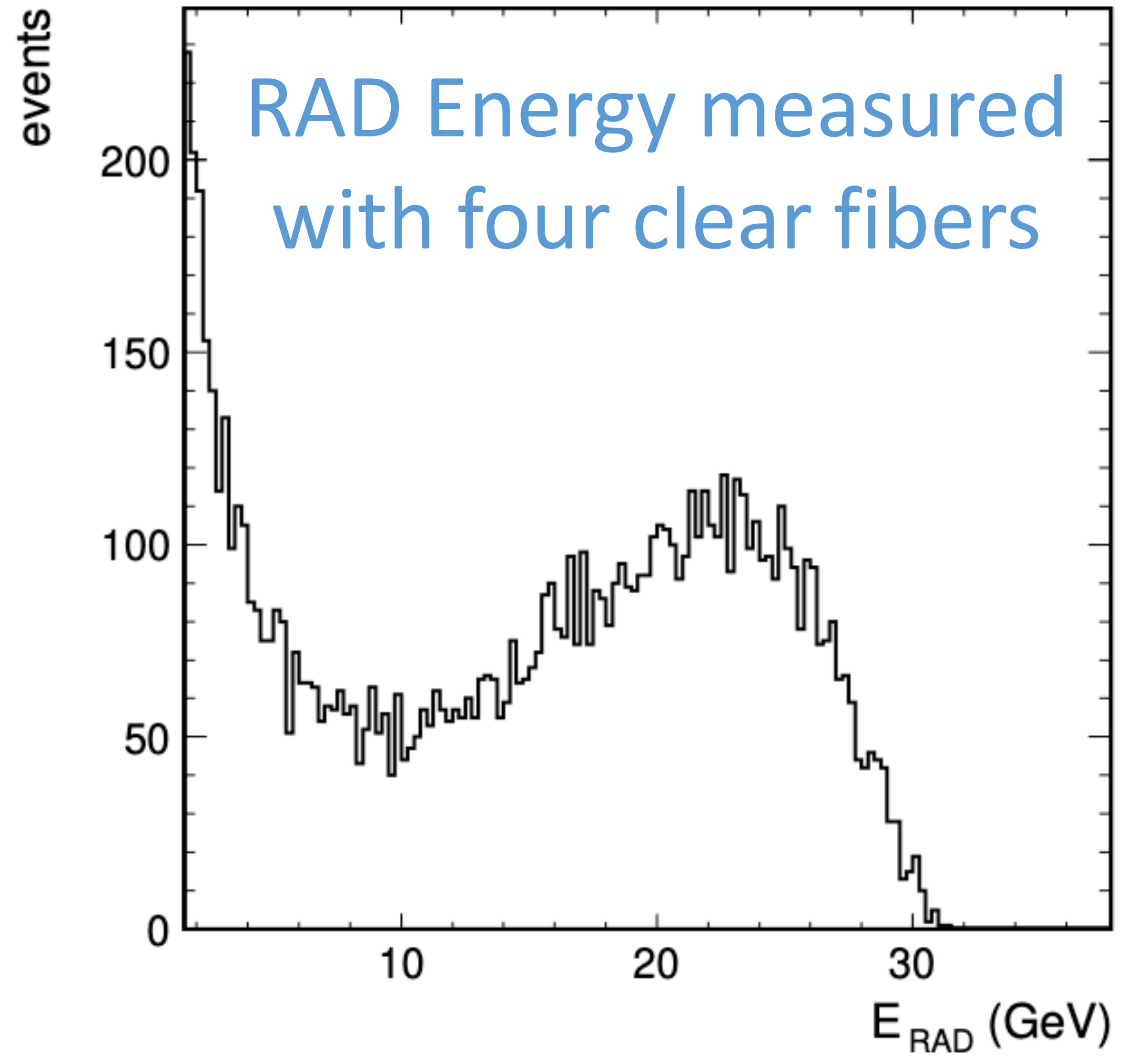
28 GeV Electrons Captured at RADiCAL

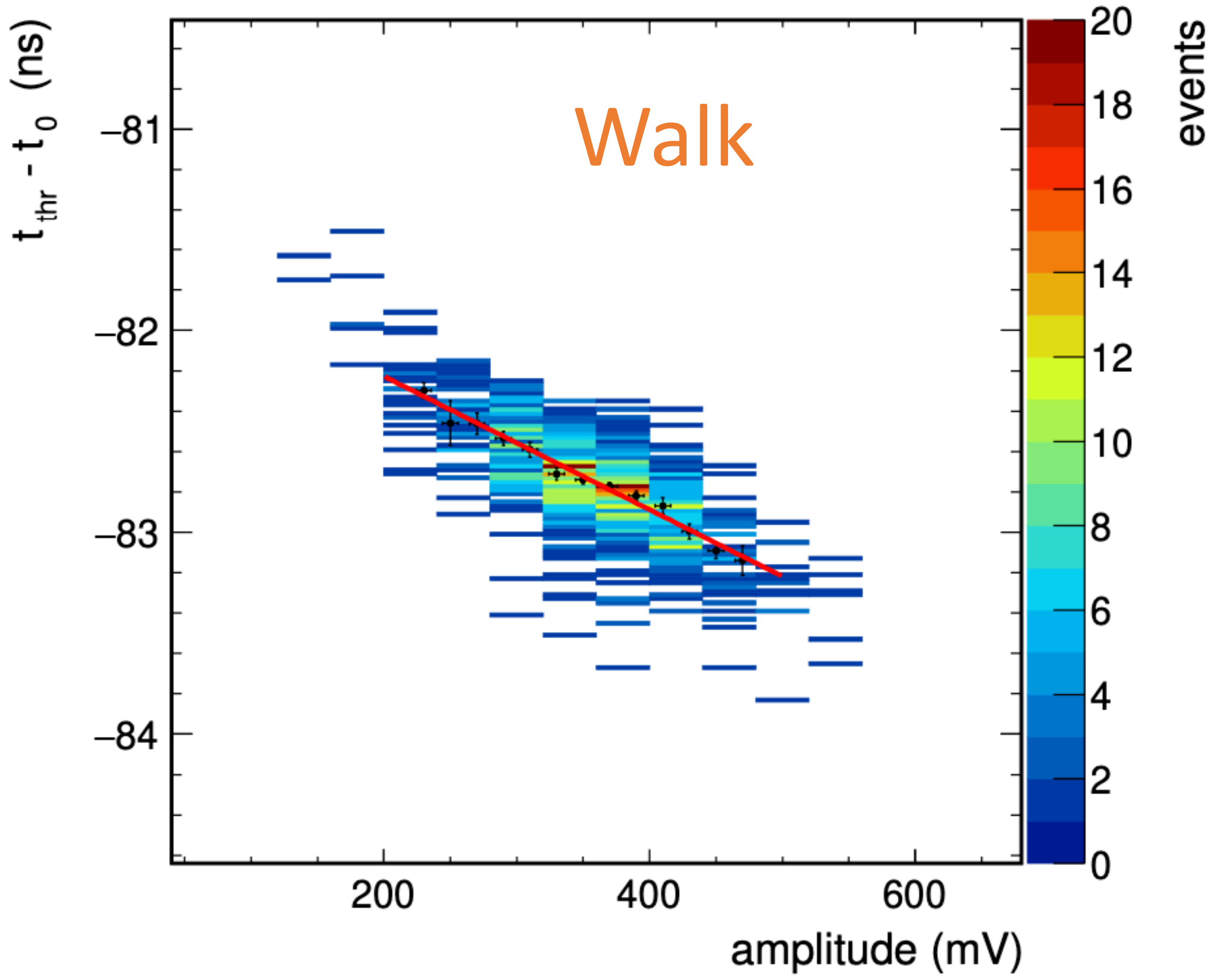
Optimizing RADiCAL for Timing Measurements

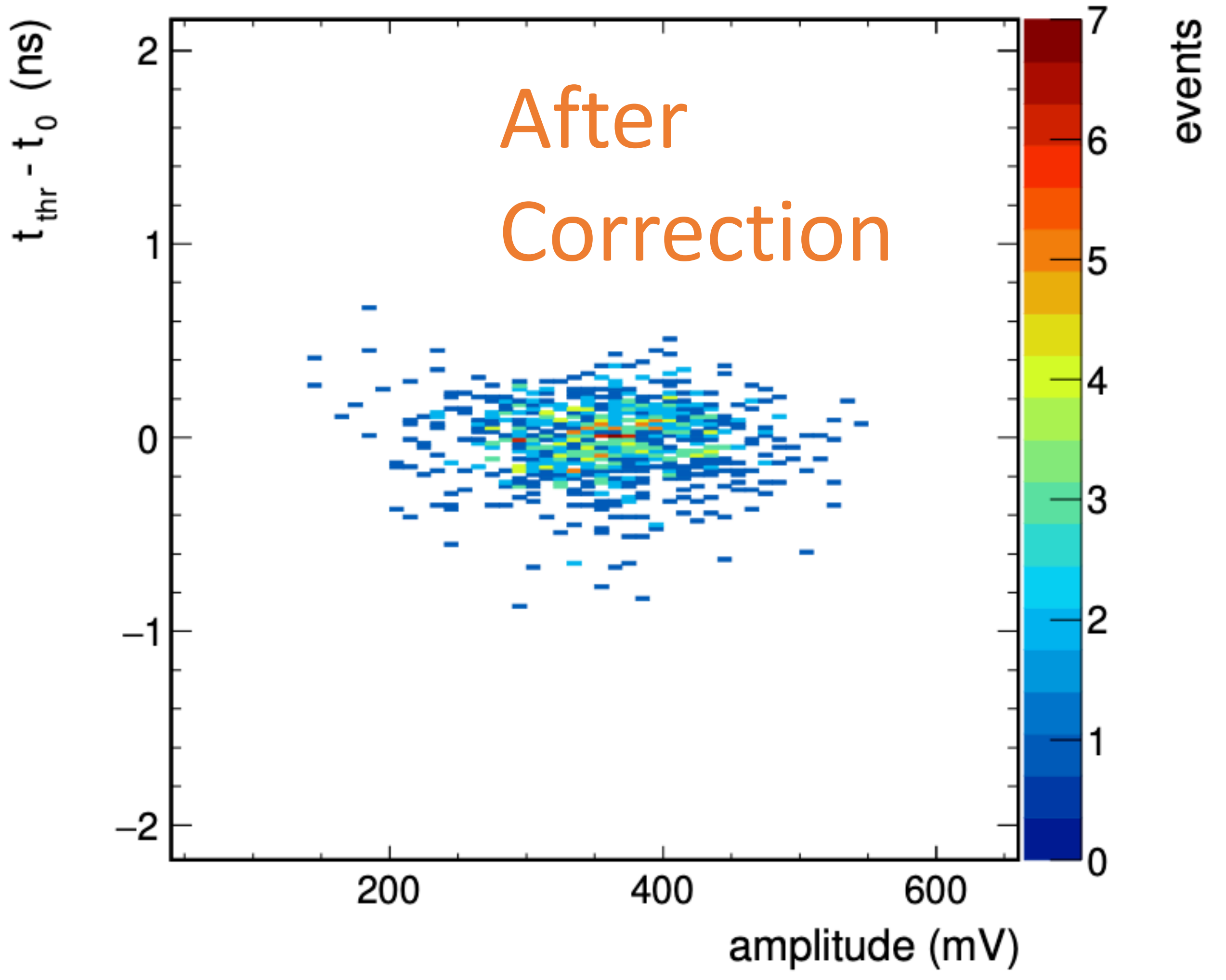
Four Timing Capillaries

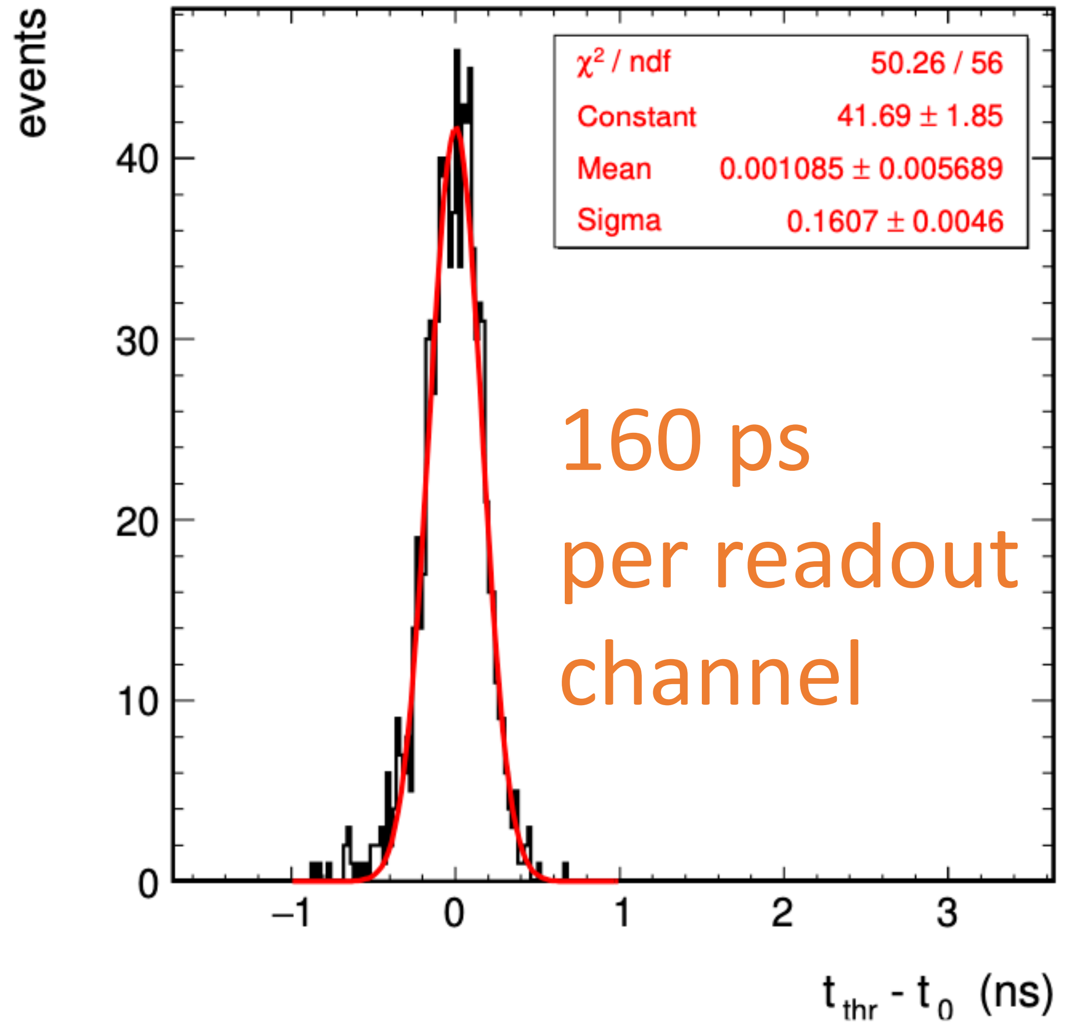








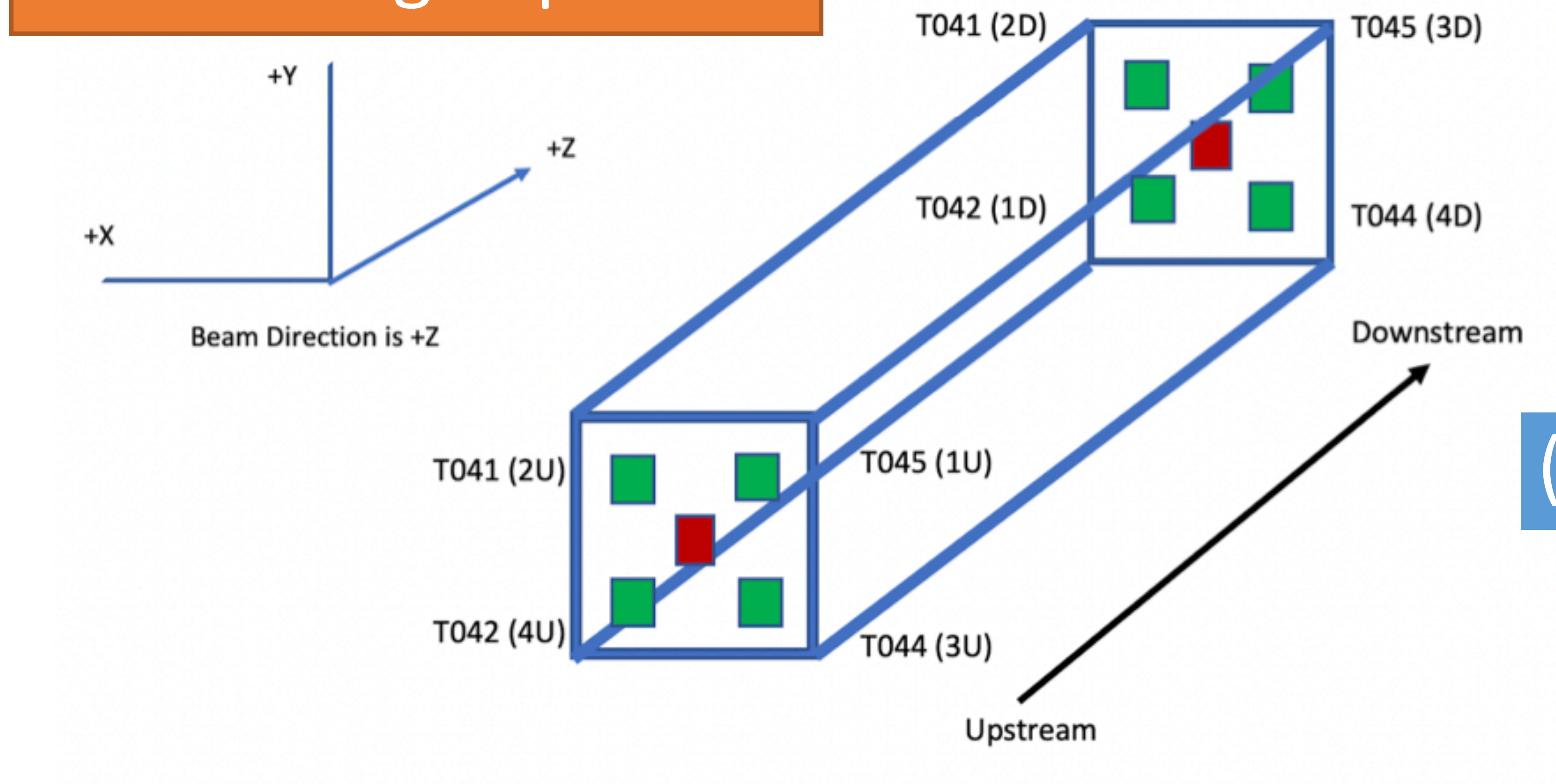




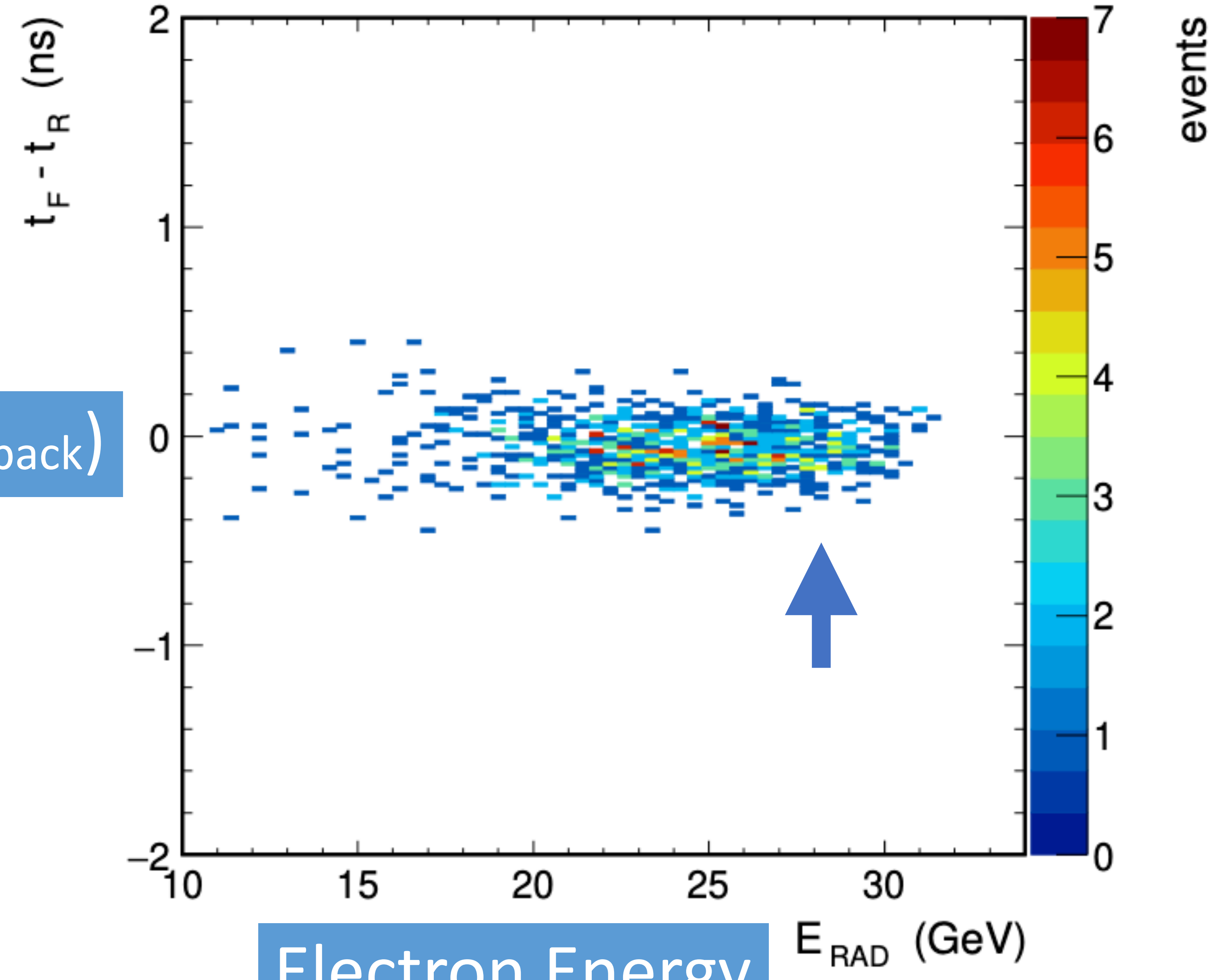
28 GeV electrons injected in center of module (6mm diameter)

Optimizing RADiCAL for Timing Measurements

Four Timing Capillaries

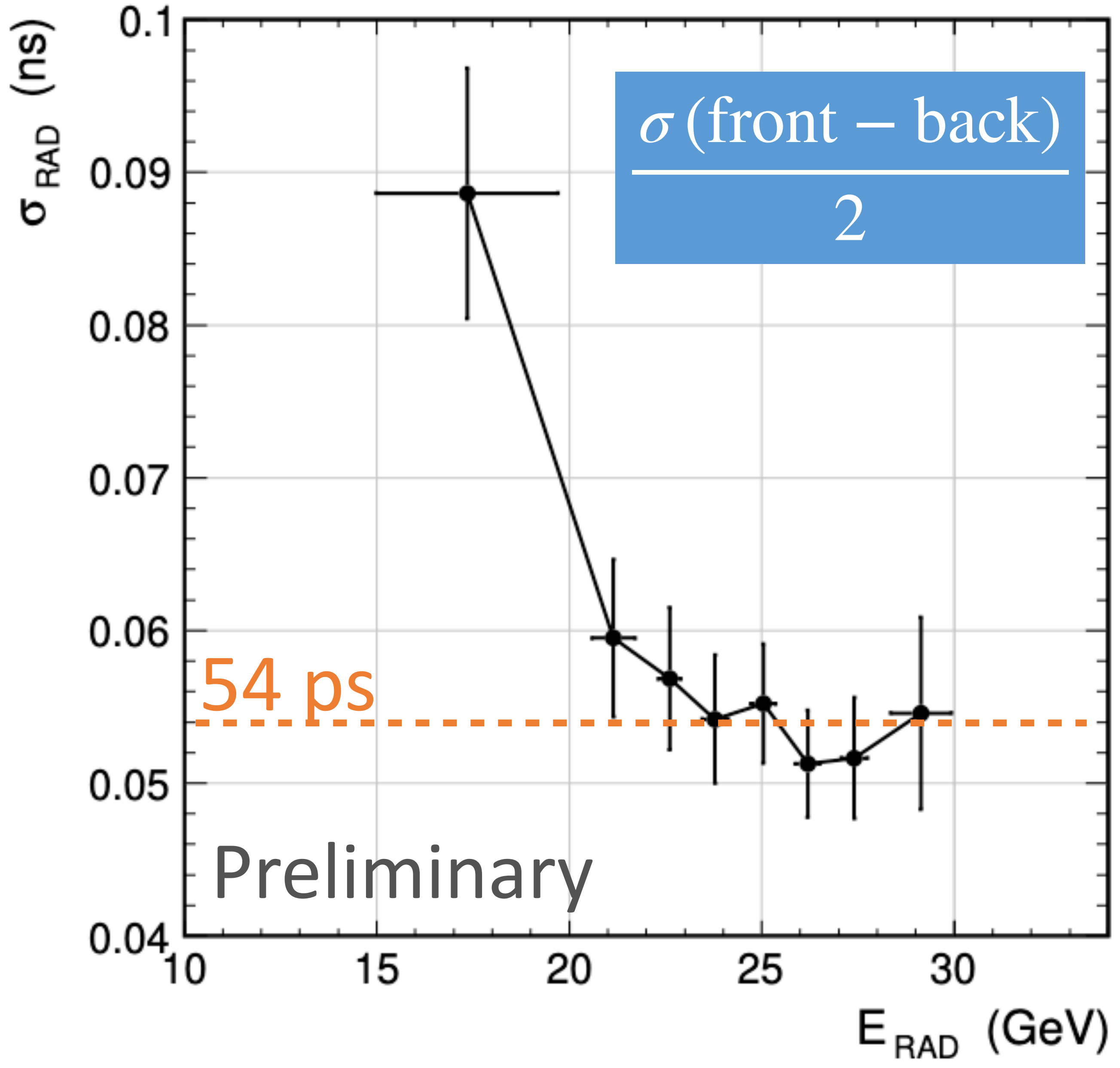


$(T_{front} - T_{back})$

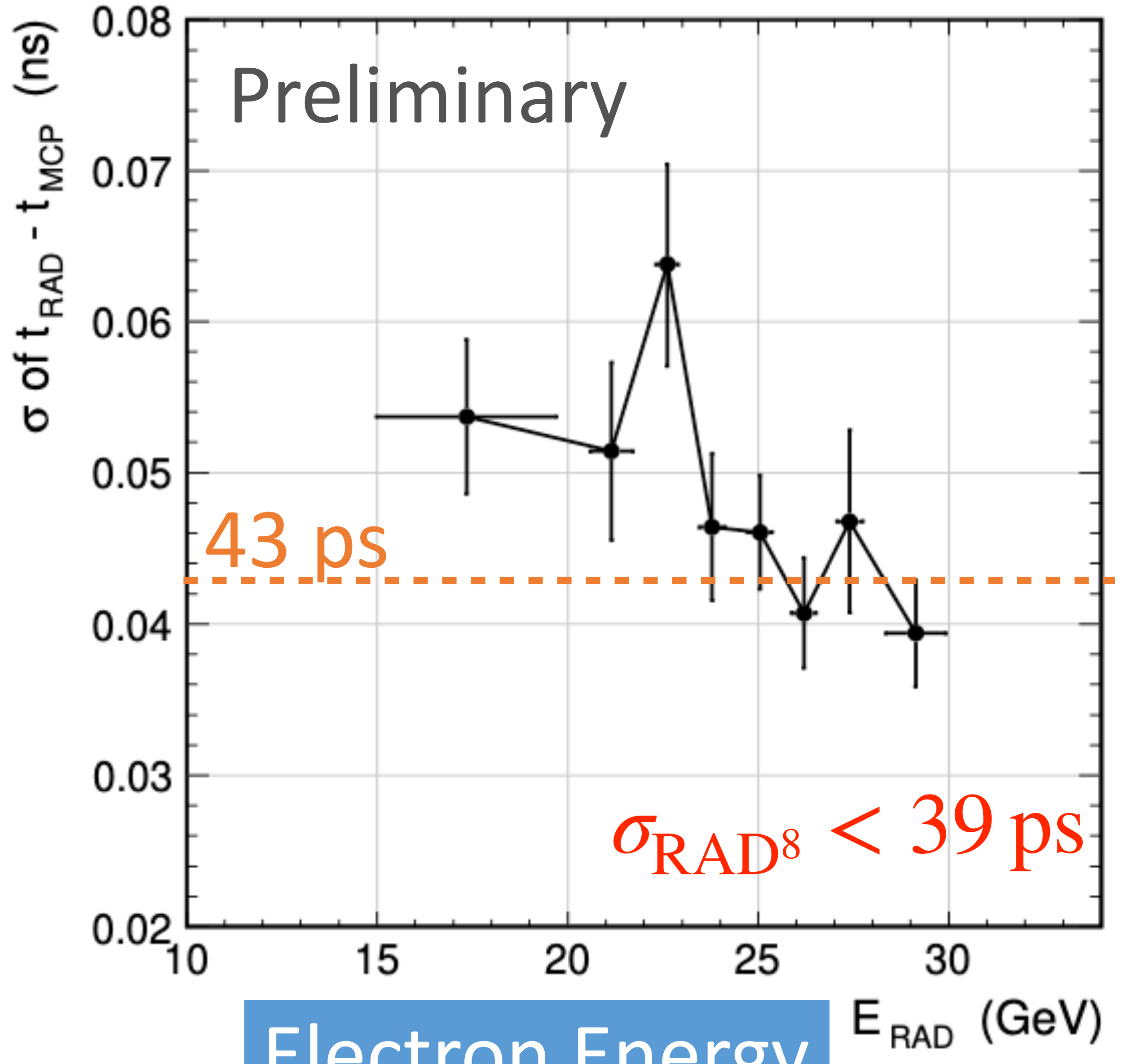


Electron Energy

$\frac{\sigma(\text{front} - \text{back})}{2}$



$\sigma(\text{RAD} - \text{MPC})$



Electron Energy

- Data presented is for 28 GeV electrons at the center of the module
- σ_{RAD} cancels largely the correlated (longitudinal) contribution
  - Transversal anti-correlated contribution currently under study
- Strong dependence with energy of Abs timing resolution under study
- More differential studies are planned to be studied on Jan’23 at FNAL

Summary

- The RADiCAL concept has been presented: Rad Hard Calorimeter equipped with High Precision Timing.
  - The detector builds on top of shashlik det. which has proven resilience under extreme radiation env.
  - Several capillary technologies are investigated to maximize timing resolution.
- Preliminary results confirm that timing capillaries, when combined, are able to resolve < 40 ps for a 28 GeV electron beam.
- For 150 GeV electrons, 1/sqrt(E) scaling suggests a resolution should improve to <20ps: i.e. very suitable for FCC EndCap EM calorimeters.
- Further tests will be performed at FTBF in Jan'23 for electrons at medium energies and possibly later at CERN for energies up to 200 GeV.

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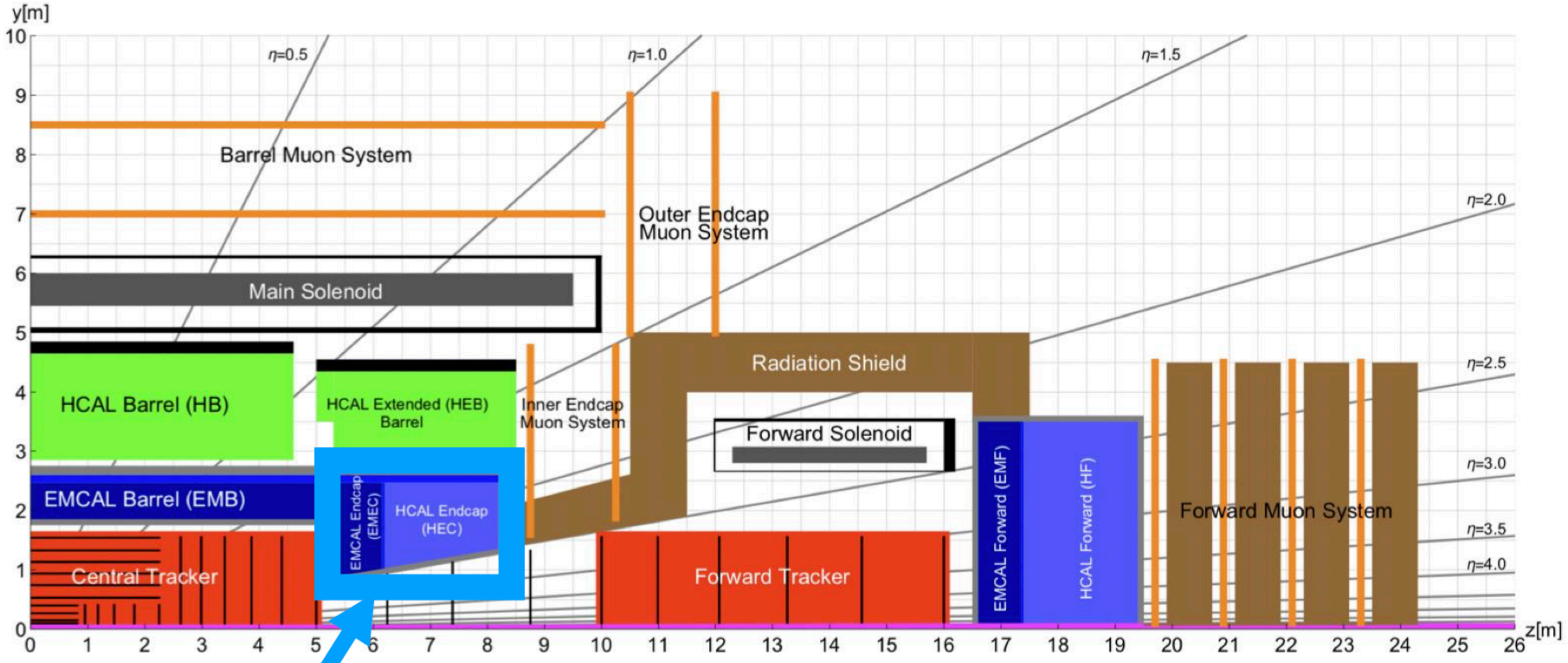
and US NSF grant NSF-PHY-1914059

Thanks!

Backup

Possible Applications

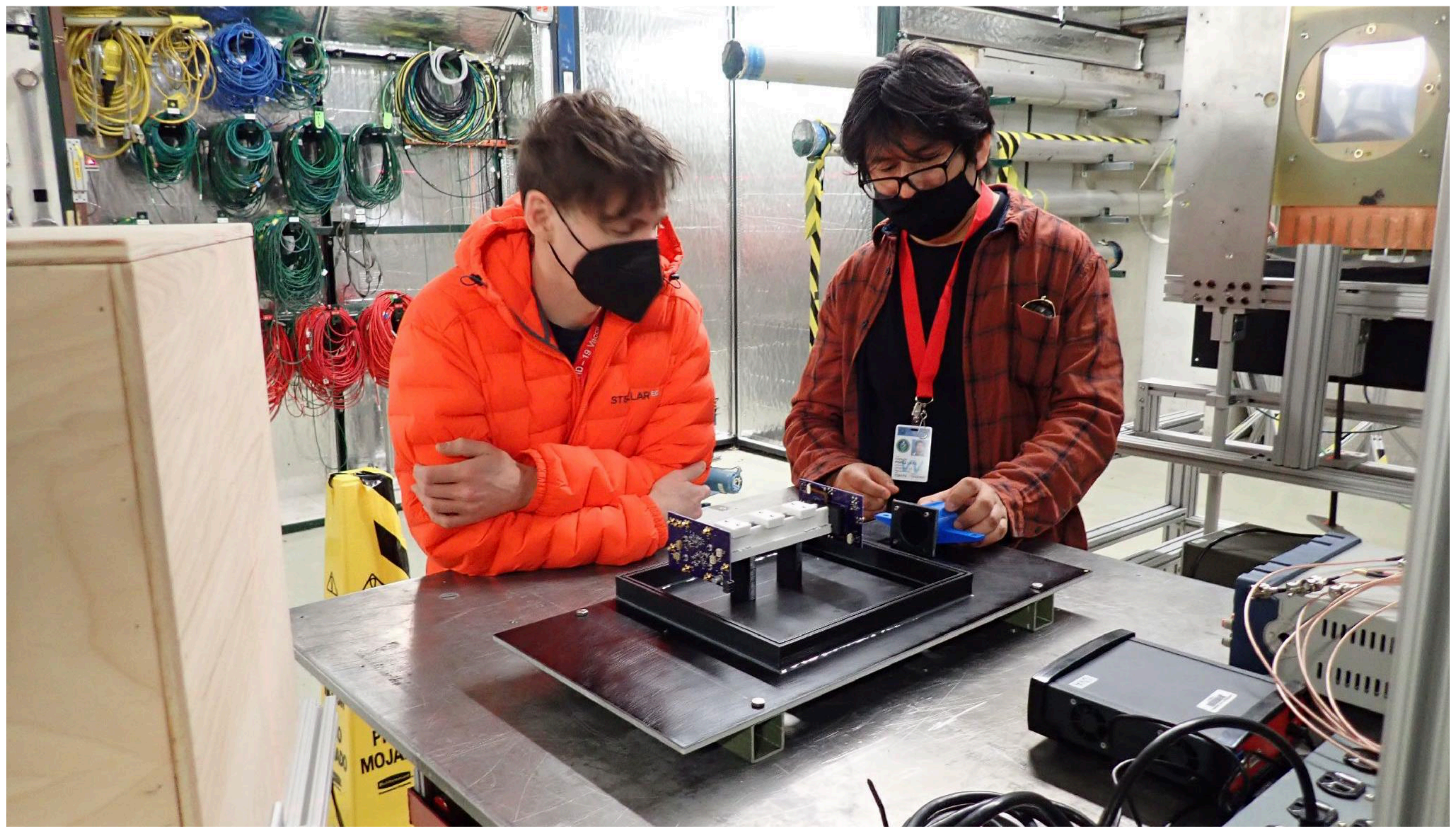
An example FCC-hh Detector

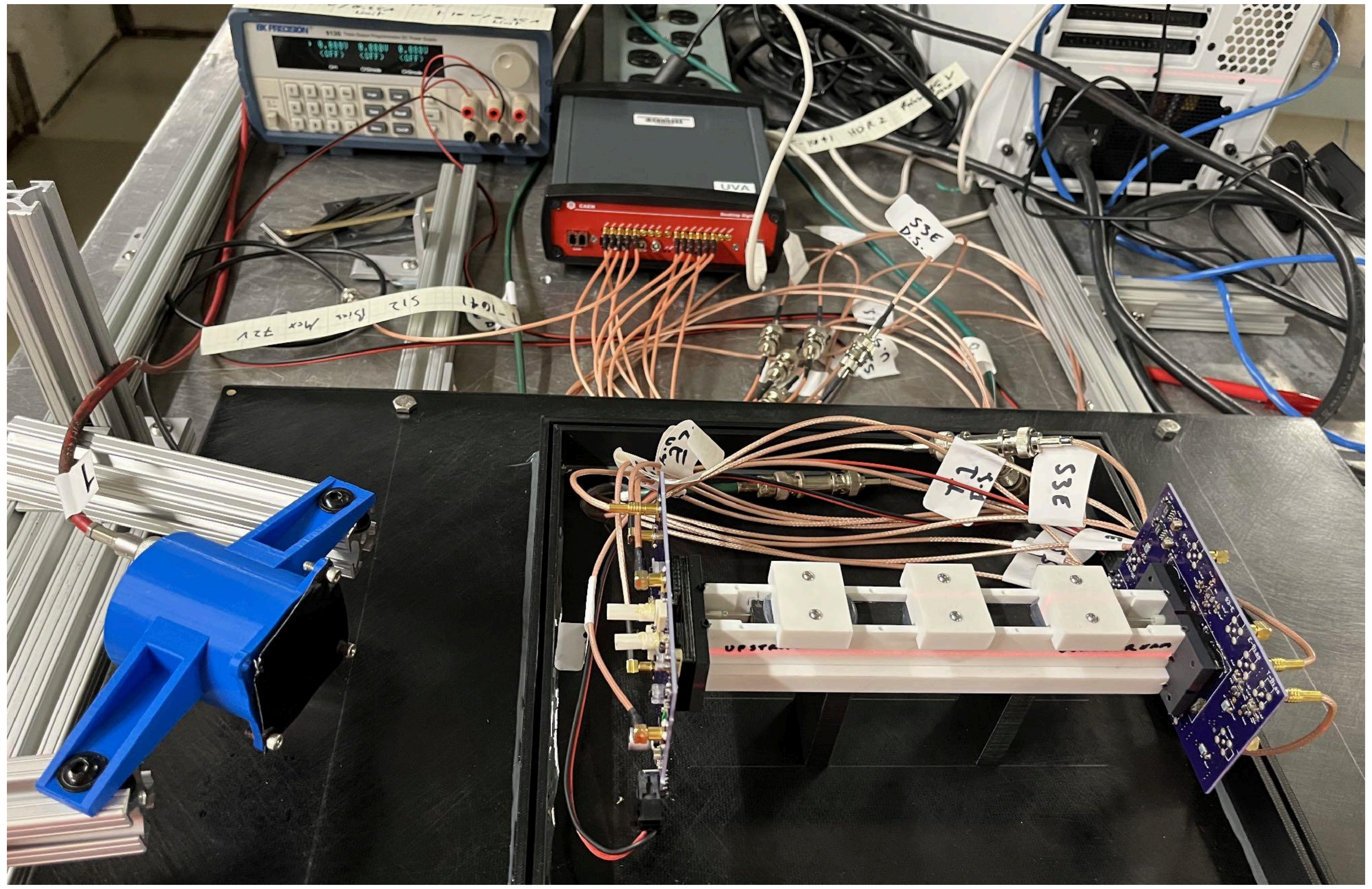


	R_{min}	R_{max}	z coverage	η coverage	Dose	1 MeV n_{eq} fluence
Unit	m	m	m		MGy	$\times 10^{15}$ cm^{-2}
EMB	1.75	2.75	$\|z\| < 5$	$\|\eta\| < 1.67$	0.1	5
EMEC	0.82–0.96	2.7	$5.3 < \|z\| < 6.05$	$1.48 < \|\eta\| < 2.50$	1	30
EMF	0.062–0.065	3.6	$16.5 < \|z\| < 17.15$	$2.26 < \|\eta\| < 6.0$	5000	5000
HB	2.85	4.89	$\|z\| < 4.6$	$\|\eta\| < 1.26$	0.006	0.3
HEB	2.85	4.59	$4.5 < \|z\| < 8.3$	$0.94 < \|\eta\| < 1.81$	0.008	0.3
HEC	0.96-1.32	2.7	$6.05 < \|z\| < 8.3$	$1.59 < \|\eta\| < 2.50$	1	20
HF	0.065–0.077	3.6	$17.15 < \|z\| < 19.5$	$2.29 < \|\eta\| < 6.0$	5000	5000

Calorimeters for the FCC-hh, M. Aleksa et al. CERN-FCC-PHYS- 2019-0003, 23 December 2019

Testbeam at Fnal





JAMES WETZEL - SCINT22 - SEPTEMBER 23rd, 2022 37