Mirror Design for an ARICH Detector in a Hadron Production Experiment

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Mirror Design for an ARICH Detector
in a Hadron Production Experiment

What is the motivation?

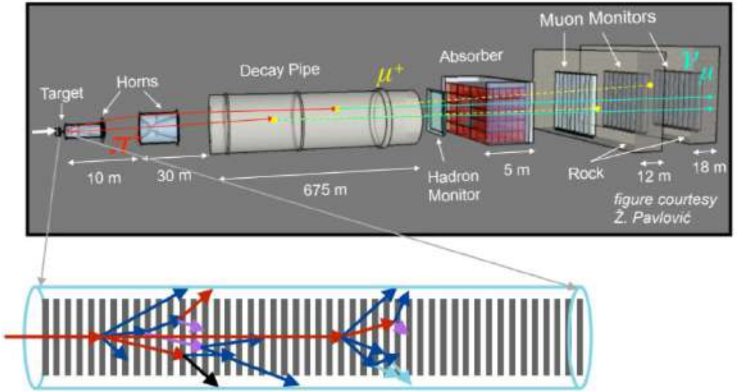
What is an ARICH and why it needs a mirror?

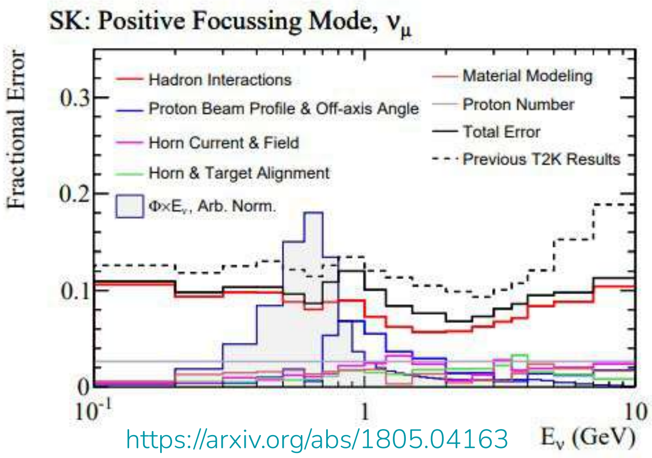
How was the mirror studied?

What is the motivation?

To reduce neutrino production modeling uncertainties in accelerator-based and atmospheric neutrino experiments.

Therefore help in the neutrino nucleus cross-section measurements, sterile neutrino searches, neutrino mass hierarchy and CP violation.





https://arxiv.org/abs/1805.04163

Extremely difficult to measure the neutrino beam flux as a function of energy so Monte Carlo simulations based on hadron interactions and decays are used to make predictions of the neutrino flux.

Many of the hadron interaction data relevant to GeV-energy neutrino flux predictions are insufficient for the precise neutrino flux predictions. Reduction of the flux uncertainty to levels of 3% are necessary.

What is the motivation?

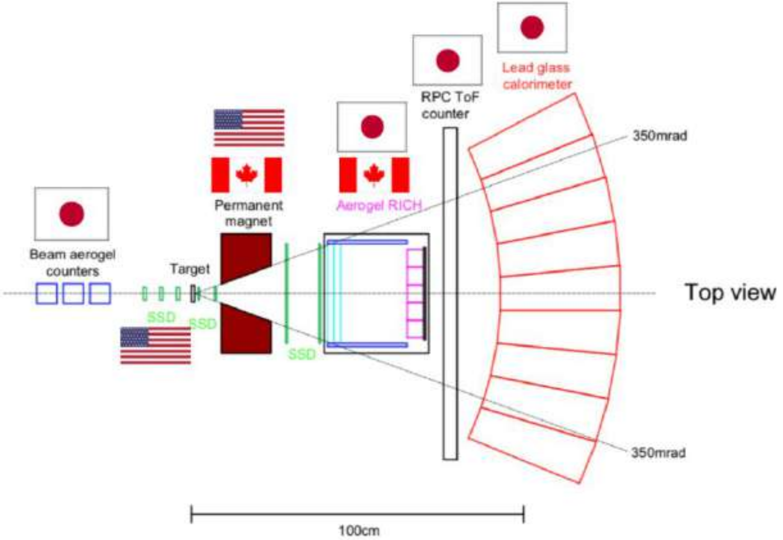
Experiment to Measure the Production of Hadron At a Test beam In Chicagoland

Measurements with beam energies below ~15 GeV (not currently accessible in NA61/SHINE beam line).

Measurements connecting production from ~2 GeV to 120 GeV beams in single experiment.

Measurements on a broad range of target materials relevant for out-of-target interaction modeling.

New detection methods with independent systematic effects from NA61/SHINE.

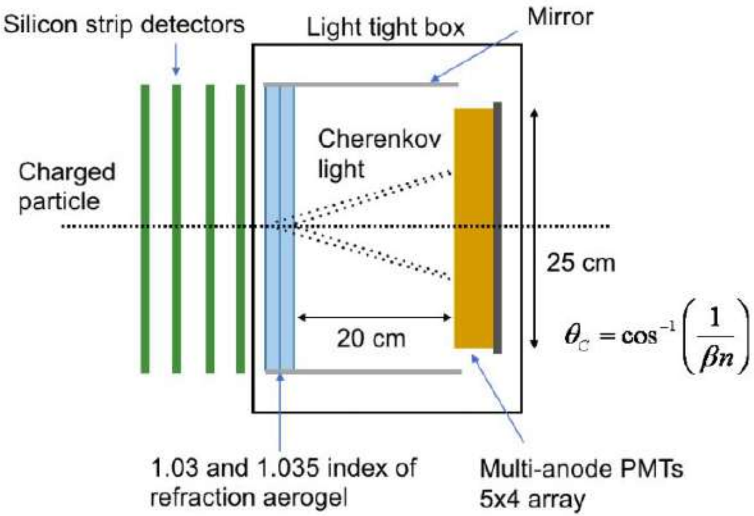


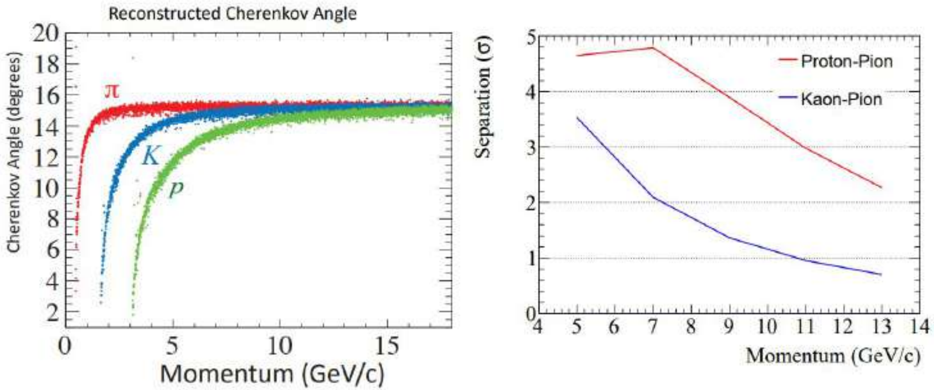
https://arxiv.org/abs/1912.08841

https://arxiv.org/abs/2106.15723

What is an ARICH and why it needs a mirror?

Aerogel **R**ing **I**maging **CH**erenkov detector

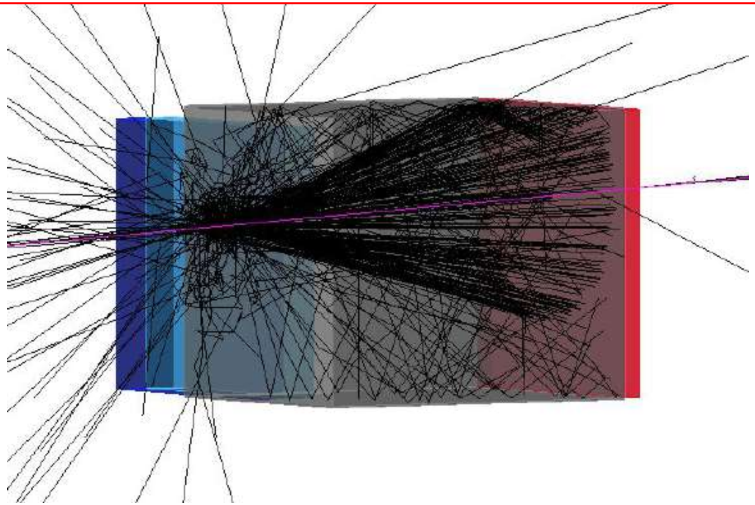


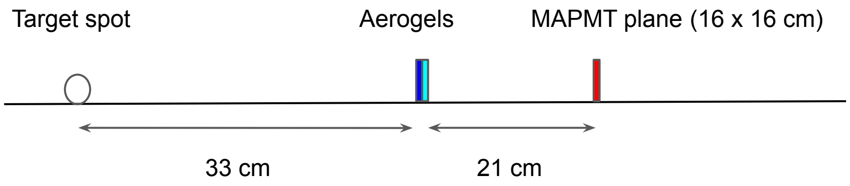


How was the mirror studied?

Geant4 Simulation Setup

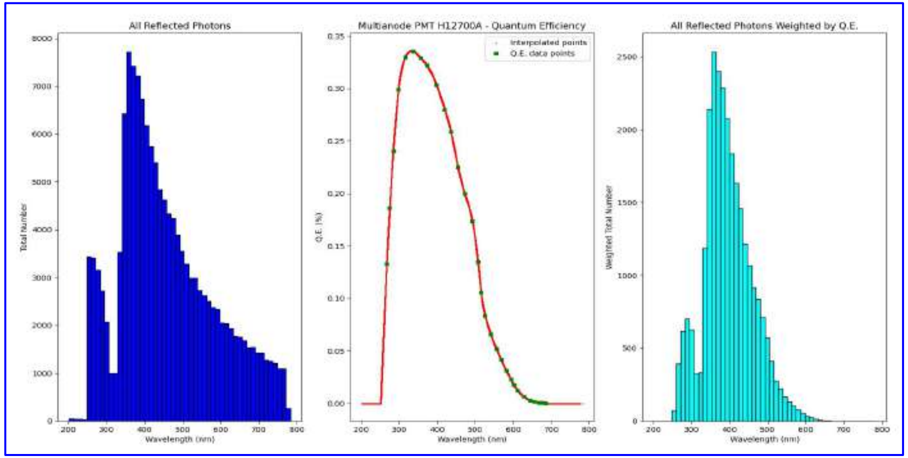
- Photons Tracks
- Aerogel 1.045
- Aerogel 1.035
- Mirror
- Detector Plane
- Incident Particle Track

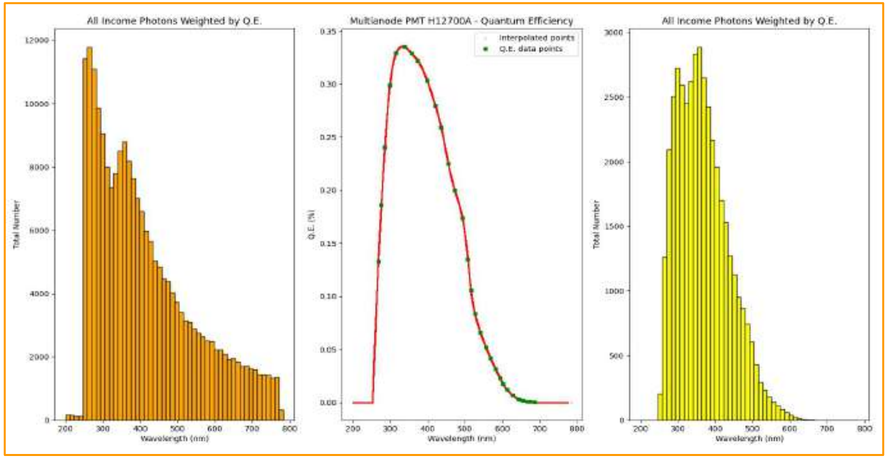




How was the mirror studied?

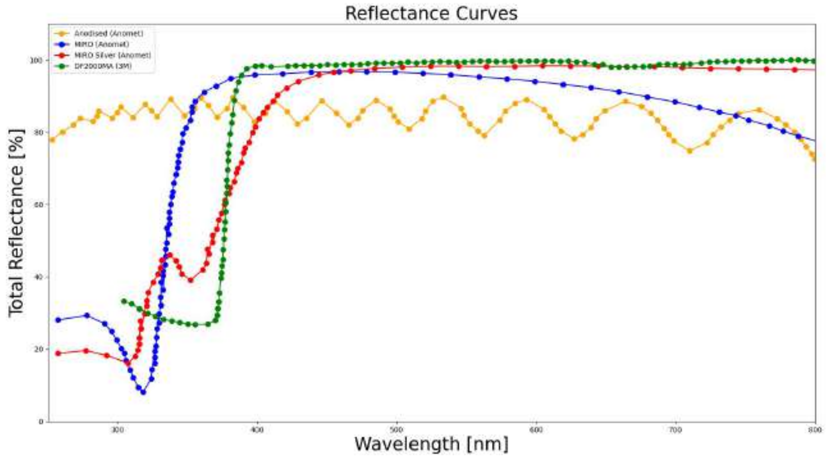
Wavelength from Simulation → Q.E Spline interpolation → Assign weight → Fill Histogram → Calculate the area

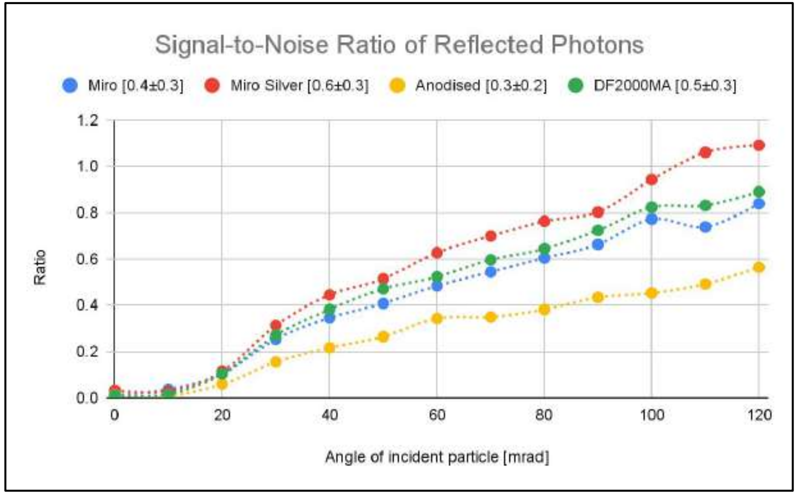




Example:
Photons reflected histogram area: 320232.84
Photons that hit the mirror histogram area: 488112.91
Ratio of the reflected photons : 0.66

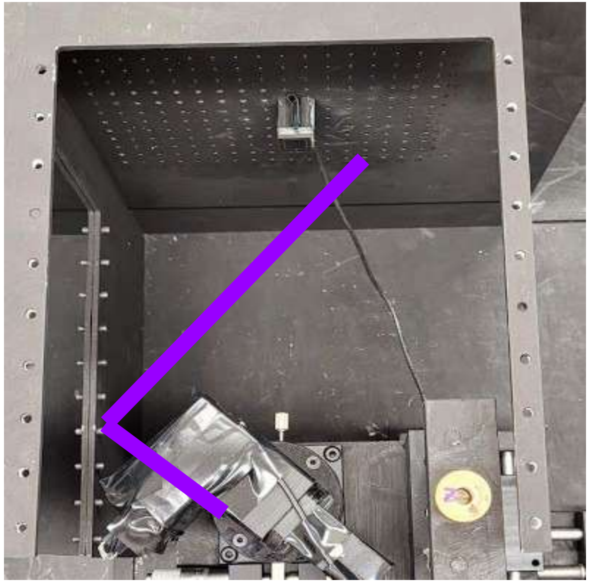
How was the mirror studied?

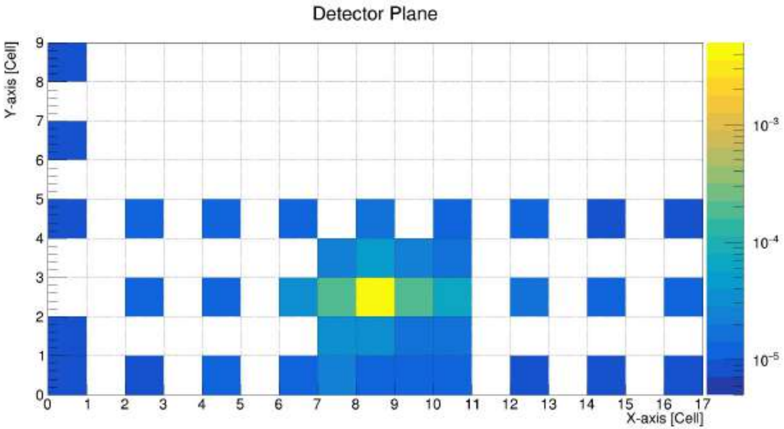




Companies provided the reflectance curves for the mirror materials.
The reflectance was then incorporated into a Geant4 simulation.
Miro Silver material showed a better performance reflecting most of the signal photons.

How was the mirror studied?





The reflection profile was measured with a pin-photodiode to study flatness.

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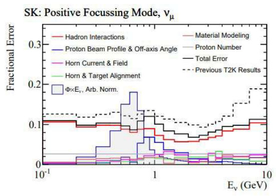
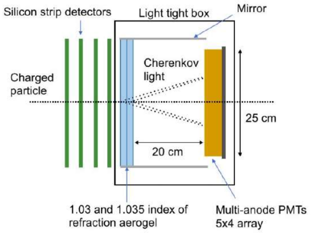
What is the motivation?

Neutrino Flux



What is an ARICH and why it needs a mirror?

Aerogel Ring Imaging CHerenkov detector

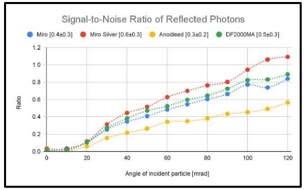


How was the mirror studied?

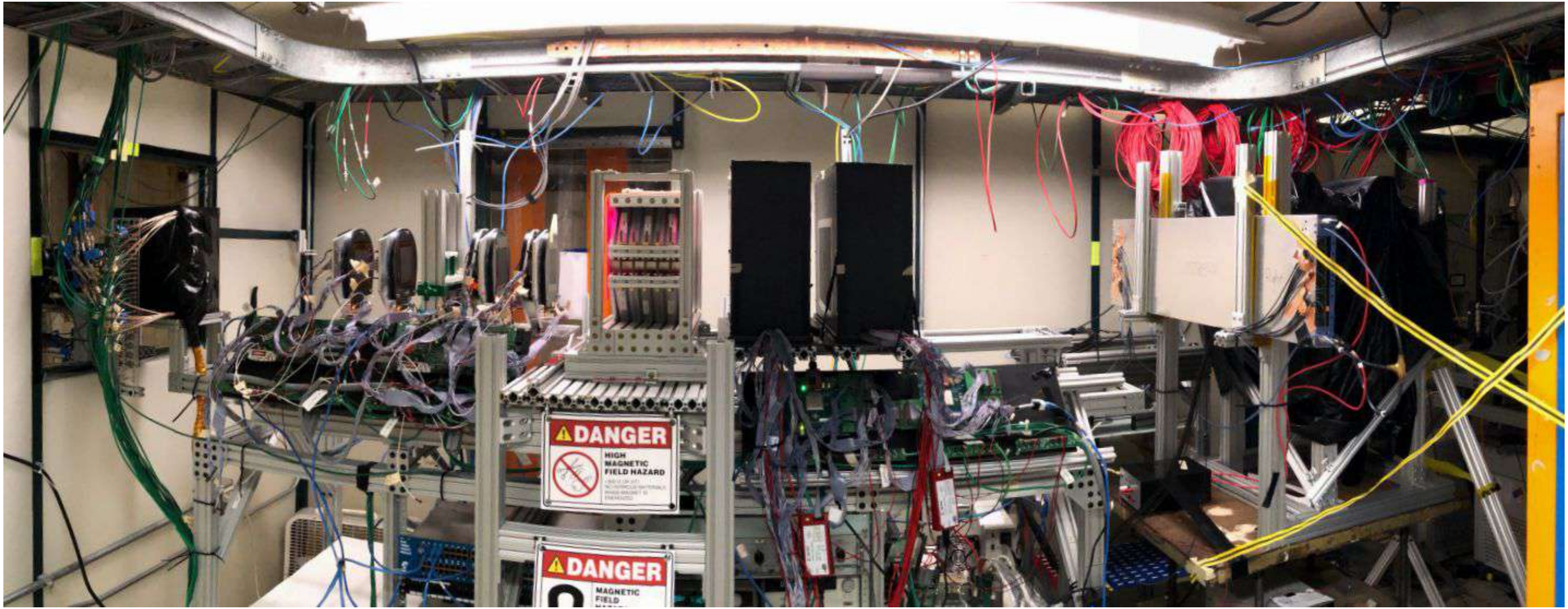
Simulation

&

Experimental measurements

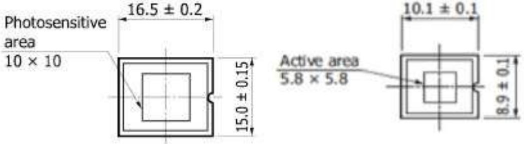


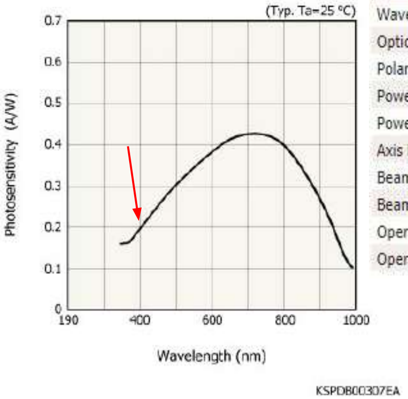
Thank You !




6-2
7-0
HV crys

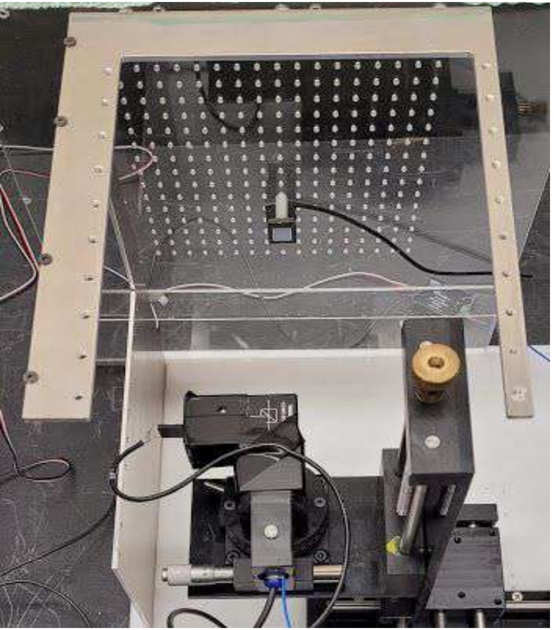
S1227-1010BR Main   S1227-66BR Reference



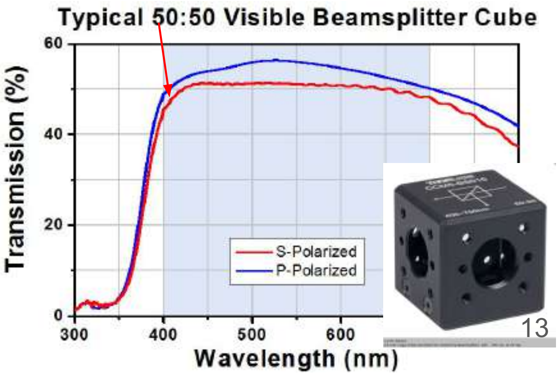


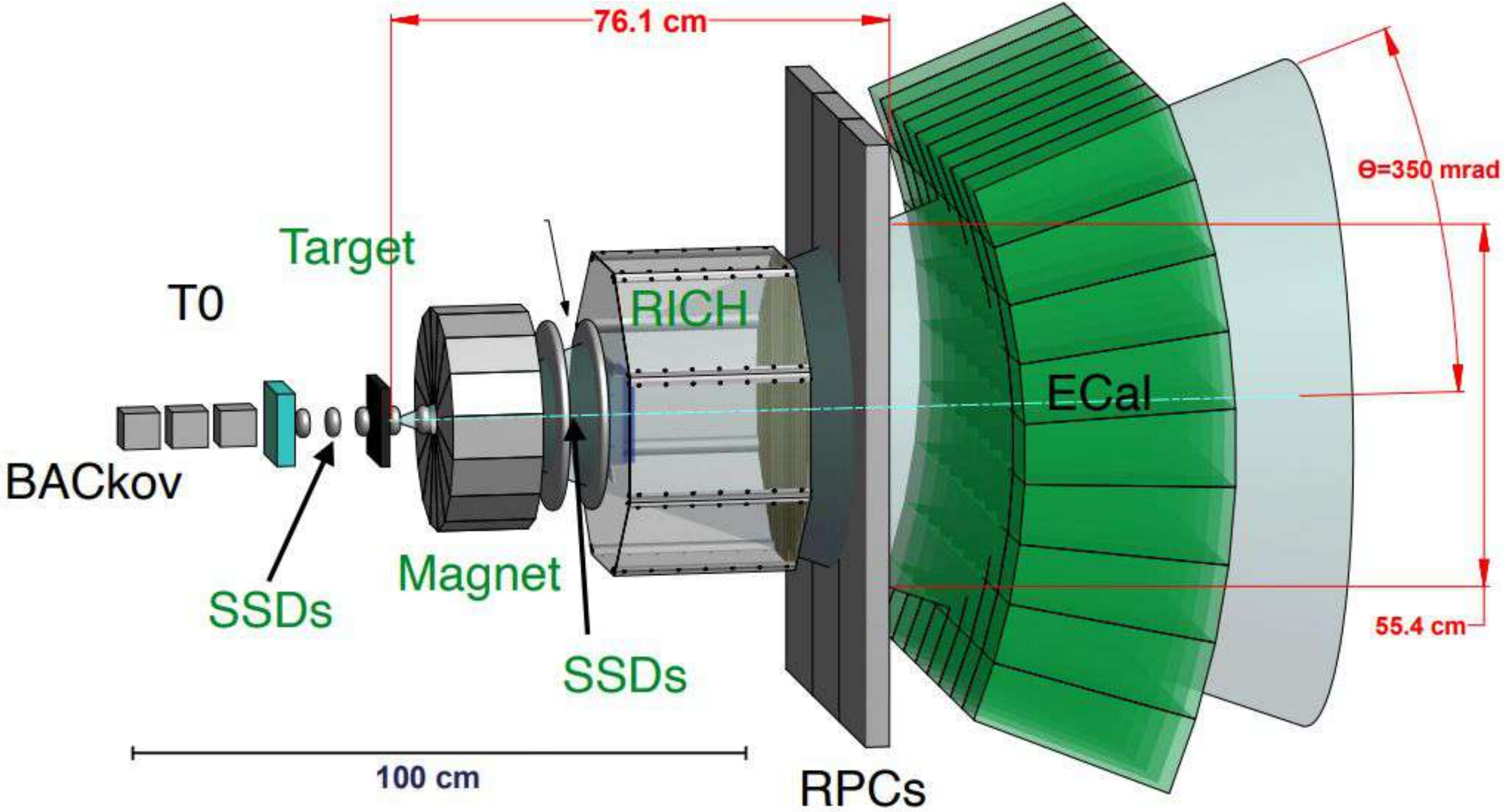
Characteristic	MIN	TYP	MAX	UNIT
Wavelength	400	405	410	nm
Optical Output Power (CW)	0.8	0.9	<1.0	mW
Polarization State Extinction Ratio	-	20	-	dB
Power Stability (8 Hours)	-	-	5	%
Power Stability (1 Minute)	-	-	0.5	%
Axis Deviation[b]	-	-	5	mrad
Beam Diameter[c]	-	3.0	-	mm
Beam Divergence[d]	-	~0.6	-	mrad
Operating Voltage	4.9	-	5.2	V
Operating Current (CW)	-	70	90	mA

Isolated Thermocouple Phidget
ID: TMP1100_0



7001 Switch Device   6487 Picoammeter




76.1 cm
Θ=350 mrad
Target
T0
RICH
ECal
BACkov
Magnet
SSDs
SSDs
55.4 cm
100 cm
RPCs

EMPHATIC Measurement Plan

Was supposed to be Spring 2020, but then COVID-19 happened…

1 (Engineering run)	Fall 2021	Beam Aerogel counter FTBF SSDs Small aperture magnet Small aperture A-RICH ToF counters Lead glass calorimeter	4, 8, 12, 20, 31, 60, 120 GeV/c	C, Al, Fe	• Low-acceptance (150mrad) hadron production with PID up to 8 GeV
2	Spring/Fall 2022	Beam Aerogel counter FTBF SSDs Large-area SSDs Full aperture magnet Full aperture A-RICH ToF counters Lead glass calorimeter	4, 8, 12, 20, 31, 60, 120 GeV/c	C, Al, Fe, H_2O, Be, B, BN, B_2O_3	• Full-acceptance (350mrad) hadron production with PID up to 8 GeV
3	2023	Same as Phase 2 + Extended RICH	20, 31, 60, 80, 120 GeV/c	Same as Phase 2 + Ca, Hg, Ti	• Full-acceptance (350mrad) hadron production with PID up to 15 GeV
4	2024	350 mrad acceptance spectrometer	120 GeV/c	Spare NuMI target and horn	Charged-particle spectrum downstream of horns

Tracking Algorithm