FY22 Research Ramp-up Plan

SoLID Collaboration

September 17th, 2021

SoLID FY22 Research Rampup Plan

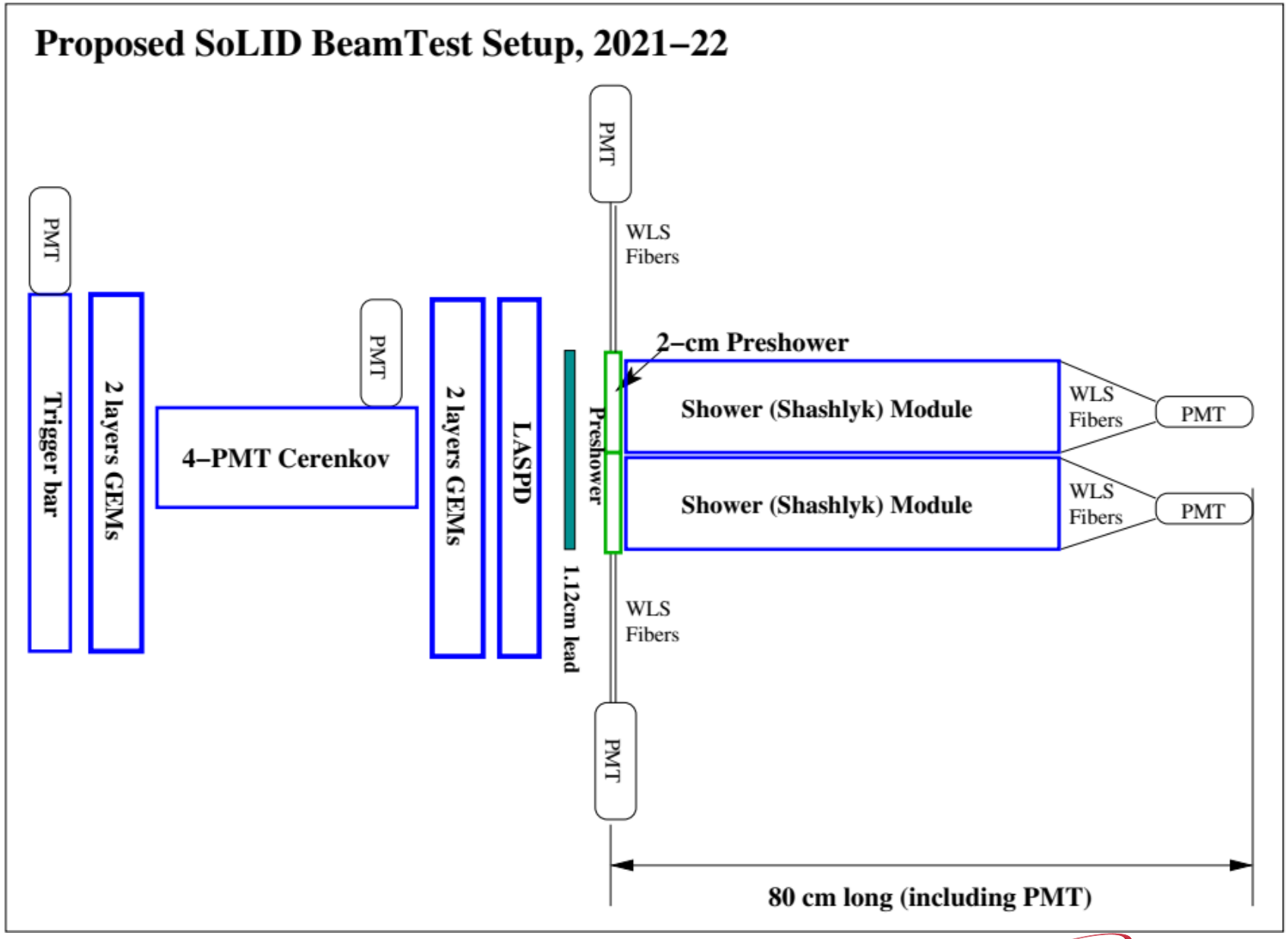
- Beamtest in FY22 – high luminosity (high rate and high radiation) beam test of detector components and DAQ system, as suggested by the Feb 2021 Director's Review of SoLID
  - Cherenkov detectors had high rate tests in 2020 as part of pre-R&D
  - ECal had calibration tests at FTBF, need high rate beam test
  - GEM with new VMM readout is currently being bench tested with (x-ray mimic) high rate. Need high radiation and high rate test with beam in an actual hall environment (SBS lessons learned)
  - → Focus will be high rate on ECal and GEM VMM3 readout

- Beam test of detector and DAQ at high luminosity will help to identify issues and to advance pre-conceptual design.

Beam test

- Realistic detector setup using existing prototypes

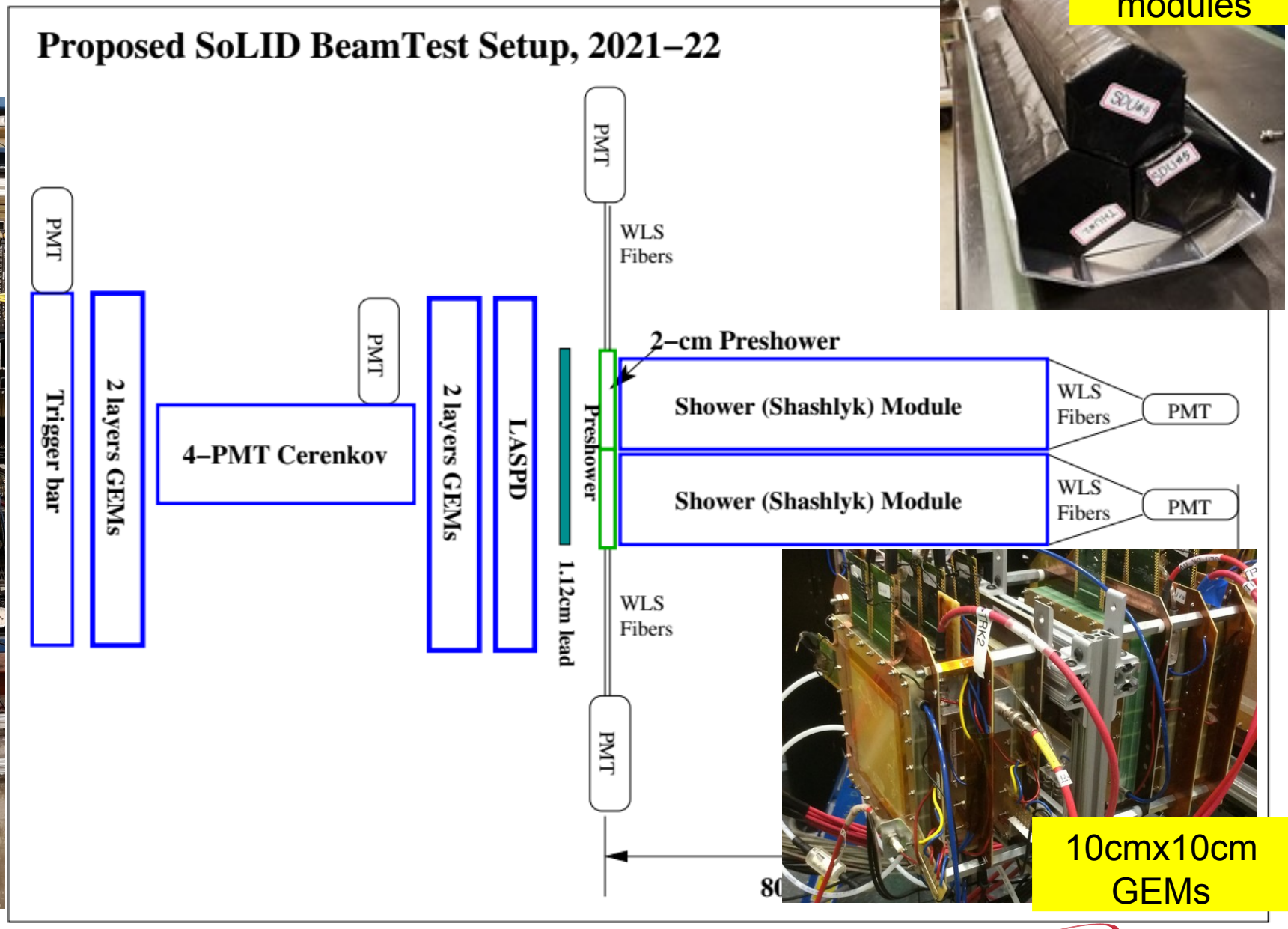
particle direction



Beam test

- Realistic detector setup using existing prototypes

4-PMT Cherenkov

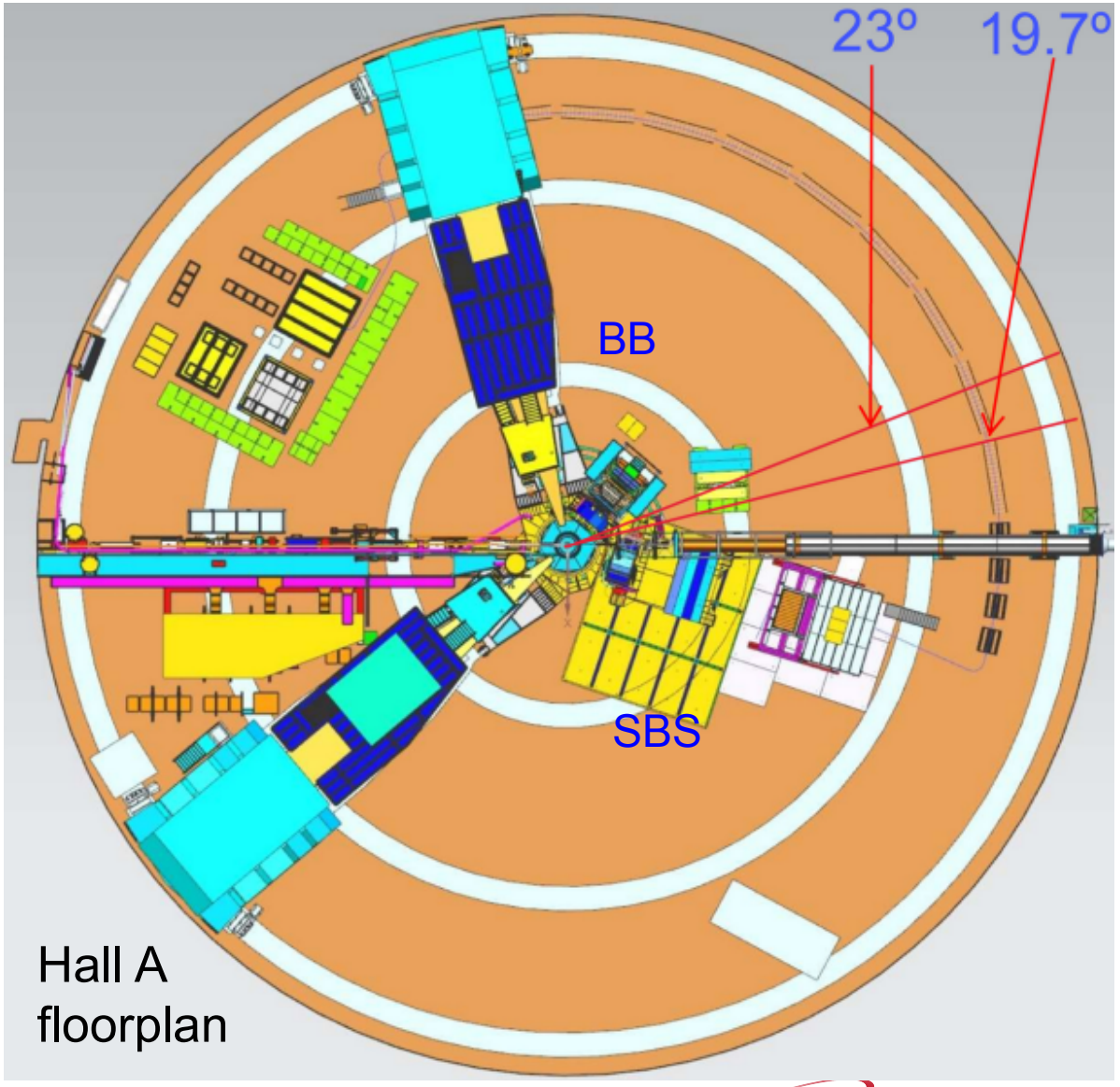


3x shashlyk modules

10cmx10cm GEMs

Beam test – Location

- SBS program in Hall A close to SoLID running
- Hall C also possible



Beam test – Resources

- Resources needed:
  - Total 4 FTEs
    - User redirect and JLab Physics Division provide support → 2 FTE
    - Request 2 FTE
  - Procurement: $200 k

Other Topics (FY22 and/or beyond) – Overview

- Other topics from SoLID collaboration institutions PIs:
  - Cherenkov testing and prototyping (to advance pre-conceptual design) (Michael Paolone/New Mexico State U., Haiyan Gao, Zhiwen Zhao/Duke U.)
  - End-to-end simulation (recommended since Feb 2015 Director's review) (multiple groups)
  - DAQ Streaming readout (suggested during 2021 Science Review) (Ron Gilman/Rutgers U.)

- Artificial Intelligence/Machine Learning – possible multi-institution proposal responding to new AI-focused FOA in 2022.

Backup Slides

End-to-end software

- A unified end-to-end software framework covering SoLID's entire life cycle from design to construction to physics analysis
  - Recommended since 2015 Director's Review to develop "with high priority and increased resources"
  - Provide important scientific guidance to detector design
  - Integration of streaming readout and use of AI/ML in SoLID commissioning and data taking, to ultimately high-level physics data analysis and expedient extraction of physics results
- Existing efforts cover some components below, but additional efforts are needed to choose and convert into end-to-end software
  - event generation (physics and background)
  - detector simulation (GEANT4-based)
  - signal digitization
  - data analysis and extraction of physics results

➔ Lead institution/PI: TBD

Cherenkov testing and prototyping

- Cherenkov Mirror Study
  - Pursue mirror fabrication methods to advance pre-conceptual design
    - attach reflective plastic-lexan film to polished carbon-fiber blanks, need mirror blank testing, lexan-film adhesion and radiation hardness testing
    - alternative 3D-printing carbon-fiber reinforced polymer blanks
  - MAPMT and WLS coating radiation testing

➔ Lead institution/PI: New Mexico State U./Michael Paolone

- Prototyping of HGC mirror mounting and testing of gas tightness for readout
  - Study how to mount large HGC mirrors of 137x33 cm for optical alignment
  - Test gas tightness for electronic readout at 1.7atm

➔ Lead institution/PI: Duke U./Haiyan Gao, Zhiwen Zhao

Streaming DAQ

- Suggested during March 2021 Science Review
- Tracking in high background and high rate is a large hurdle for SoLID
  - build and test a streaming version of the VMM prototype
- Simulation of event size and data processing will be performed to evaluate the amount of computing and storage resources needed

➔ Lead institution/PI: Rutgers U./ Ron Gilman

Artificial Intelligence/ Machine Learning for SoLID

- AI/ML has power of recognizing patterns within vast amounts of data generally surpasses traditional methods in terms of speed and accuracy
- It is ideal for SoLID's high rate and high background at luminosity 10^{37} – 10^{39} $cm^{-2}s^{-1}$
  - AI for GEM tracking, PID of combined ECal and Cherenkov, and background reduction
  - Improve efficiency and speed
  - Optimization from multiple input variables more than traditional methods can handle
- SoLID-specific AI/ML study and optimization will provide feedback to detector design
- Be an integrated part of the end-to-end software

We will utilize existing simulation tool and FTBF test data, along with new data expected from the upcoming high-rate beam test → possible multi-institution proposal responding to AI-focused FOA in 2022

2015 Director's Review Report:

1. Physics Relevance and Risks

1a. Findings:End-to-end physics simulations for the core measurements are lacking.

- Recommendations: End-to-end simulations with realistic subsystem responses and material budgets, and complete track finding and reconstruction should be developed.

1b. Findings: The SoLID simulation framework is in the beginning stages of development.

Recommendations: The development of a simulation framework with realistic reconstruction and analysis should be pursued with high priority and increased resources.

2021 Director's Review Report:

3. The new experimental and theoretical research efforts and technical capabilities needed to accomplish the proposed scientific program.

Comments:

- From the presentations it was not possible to understand how far the R&D on the different detectors has been progressed to ensure the chosen technologies are able to perform to the physics requirements, especially to the occupancy expected due to the high luminosity of $10^{37} – 10^{39}$ $cm^{-2}s^{-1}$