FY22 Research Ramp-up Plan

SoLID Collaboration

September 8th, 2021

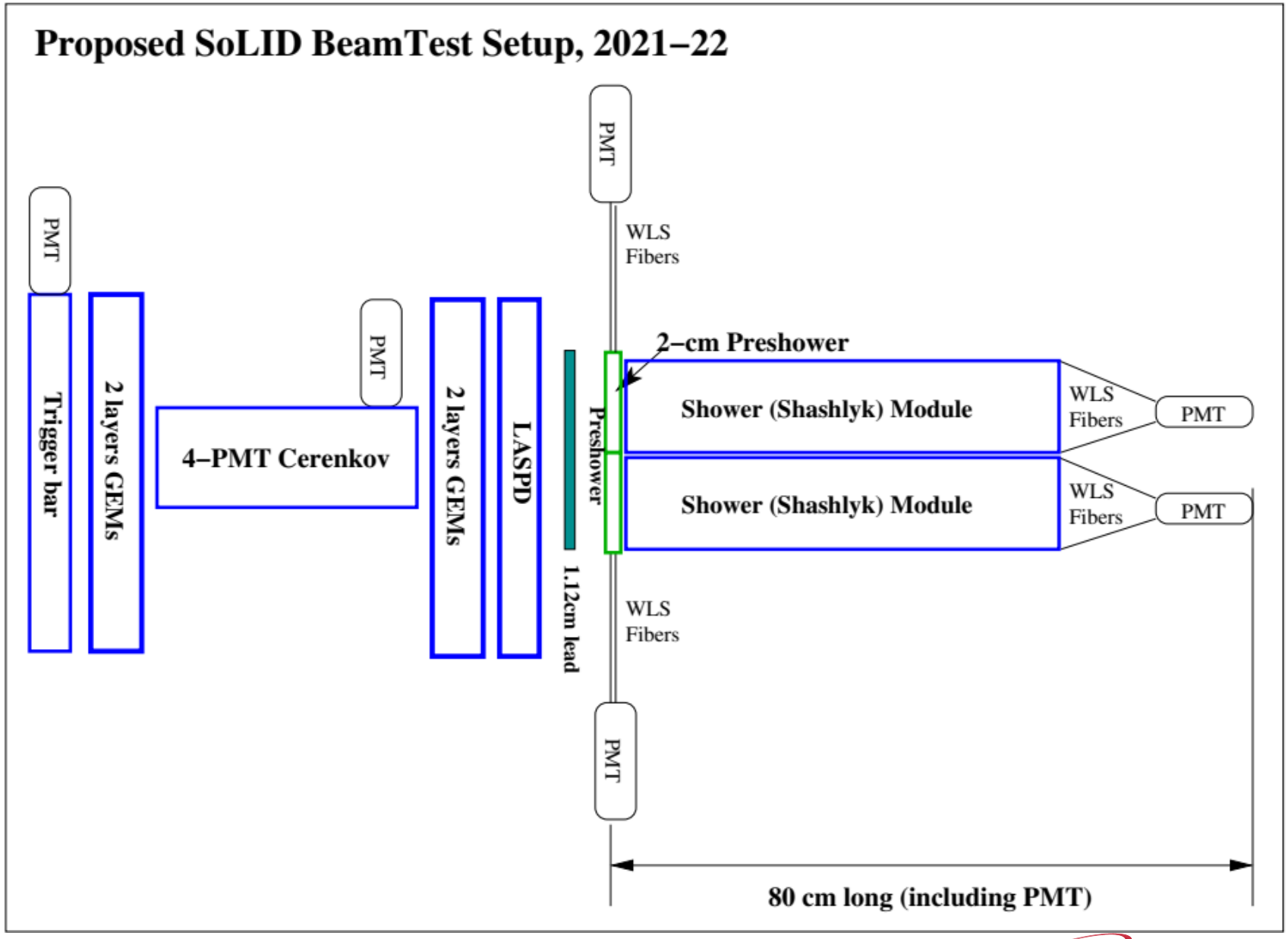
SoLID FY22 Research Rampup Plan

- Beamtest in FY22 – high luminosity (high rate and high radiation) beam test of detector setup and DAQ system, as suggested by the Feb 2021 Director's Review of SoLID
  - Cherenkov detectors had high rate tests in 2020
  - ECal had calibration tests at FTBF, while simulations showed no show-stopper, need high rate beam test
  - GEM with new VMM readout is currently being bench tested with (x-ray mimic) high rate. Needs high radiation test with beam.
  - → 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, optimize design choice, thus reduce cost and scheduling risks.

Beam test

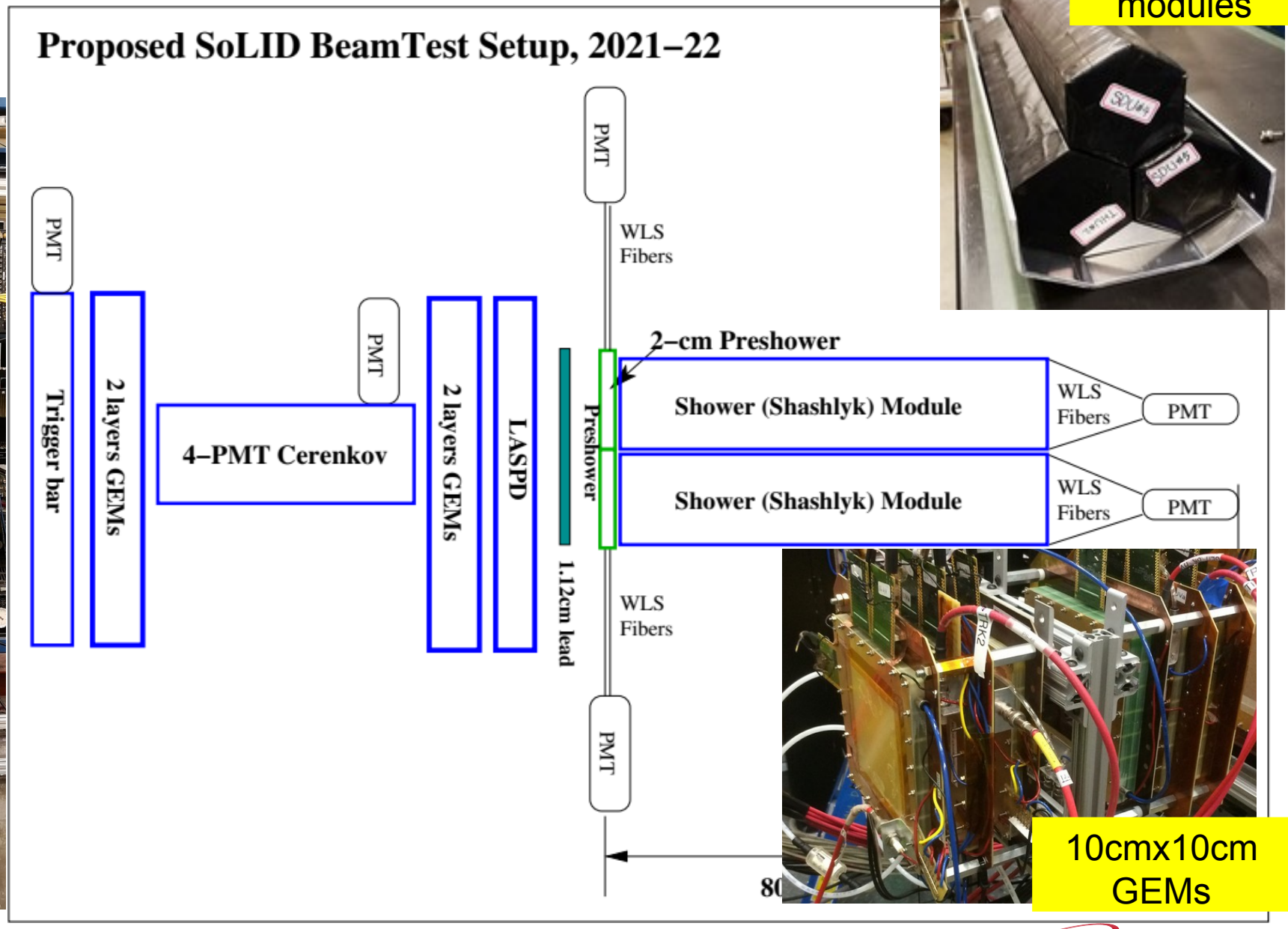
- Realistic detector setup using existing prototypes



Beam test

- Realistic detector setup using existing prototypes

4-PMT Cherenkov

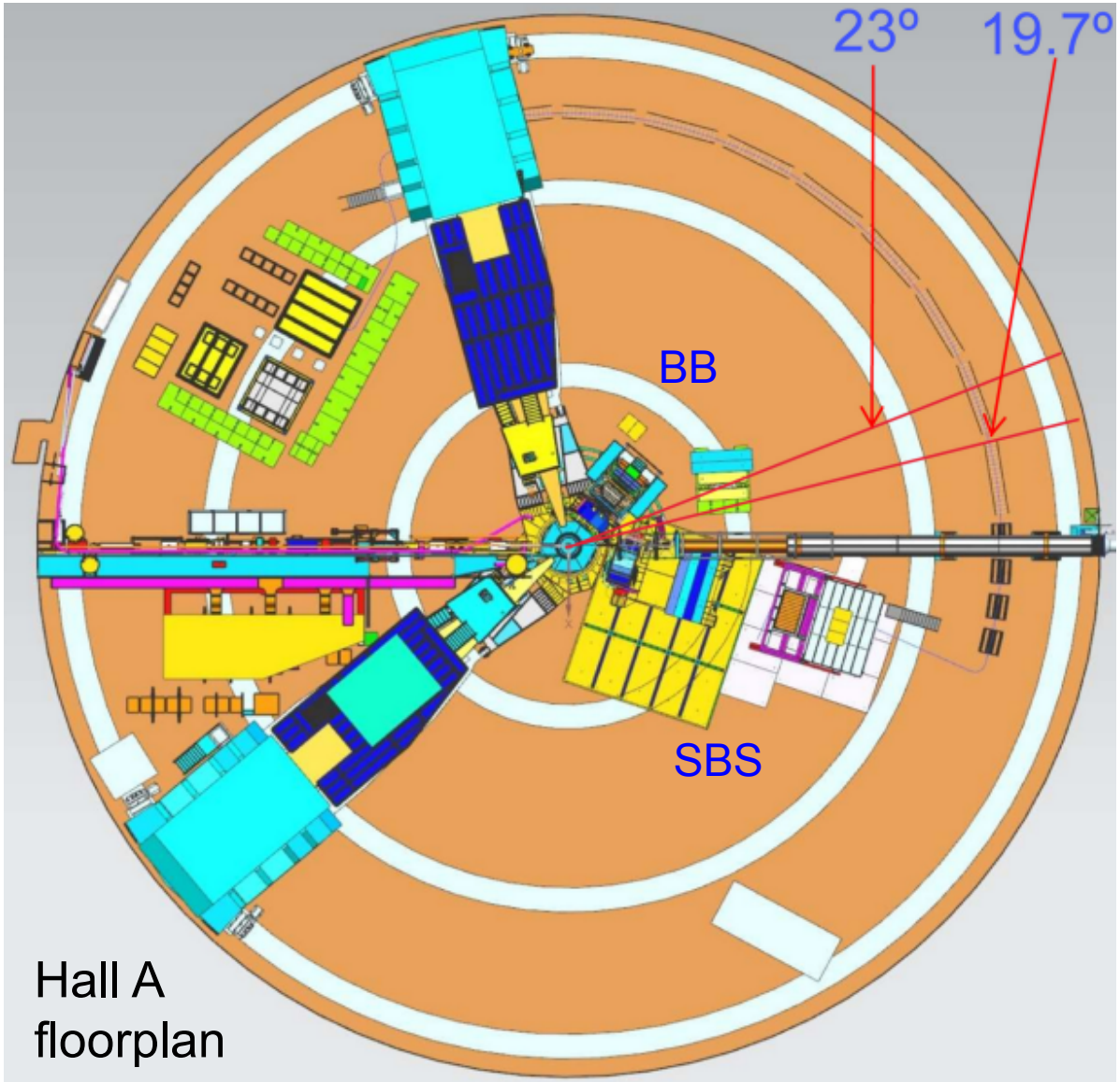


3x shashlyk modules

10cmx10cm GEMs

Beam test – Location

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



Beam test – Resources

- Resources needed:
  - JLab: total 1.5 FTEs, Physics Division provide 0.5 FTE, request 1 FTE
  - User: 2.5 FTEs, existing re-direct effort 1 FTE, request 1.5 FTE
  - Procurement: $200 k

Other Topics (FY22 and/or beyond) – Overview

- Other topics from SoLID collaboration institutions PIs:
  - Cherenkov testing and prototyping (cost saving and risk mitigation) (Michael Paolone/New Mexico State U., Haiyan Gao, Zhiwen Zhao/Duke U.)
  - End-to-end simulation (recommended since Feb 2015 Director's review) (TBD)
  - DAQ Streaming readout (suggested during 2021 Science Review) (TBD)

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

Backup Slides

Cherenkov testing and prototyping

- Cherenkov Mirror Study
  - High cost of CFRP (carbon fiber reinforced polymer) polished mirror blanks pushed collaboration to seek alternative mirror fabrication methods, to reduce cost and scheduling risks
    - attach reflective plastic-lexan film to polished carbon-fiber blanks, need: mirror blank testing, lexan-film adhesion and radiation hardness testing
    - alternative 3D-printing CFRP blanks
  - MAPMT and WLS coating radiation testing
  - Microchannel plate (MCP)-PMT 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

End-to-end software

- A unified end-to-end software framework covering SoLID's entire life cycle is crucial to the success of the project
- Recommended since 2015 Director's Review to develop "with high priority and increased resources"
- Provide important guidance to detector design
- Focus on researching and adopting existing HEP/NP software packages
- 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
  - interface to AI/ML algorithm and compatible with heterogeneous computing environment

➔ Lead institution/PI: TBD

Streaming DAQ

- Suggested during March 2021 Science Review
- Simulation of event size and data processing will be performed to evaluate the amount of resources needed
- A streaming version of the VMM prototype could be built and tested in streaming mode

➔ Lead institution/PI: TBD

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 and AI for PID of combined ECal and Cherenkov
  - 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 $10^{37} – 10^{39}$ $cm^{-2}s^{-1}$