NPS Collaboration Meeting

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Jefferson Lab

2-3 February 2023

History of NPS Meetings

- *10 November 2012*: Opportunities for DVCS and other physics with NPS (IPN-Orsay)
- *14 November 2013*: NPS Collaboration Meeting (JLab)
- *19 November 2014*: NPS Collaboration Meeting (JLab)
  - *15-16 June 2015*: NPS and $PbWO_4$ Meeting (JLab)
- *21 January 2016*: NPS Collaboration Meeting (JLab)
- *19 January 2017*: NPS Collaboration Meeting (JLab)
  - *6-7 February 2017*: High-Intensity Photon Sources Workshop (CUA)
- *23 January 2018*: NPS Collaboration Meeting (JLab)
  - *13-15 November 2018*: NPS Frame Meeting (JLab)
- *1 February 2019*: NPS Collaboration Meeting (JLab)
  - *25-26 June 2019*: NPS Frame Meeting (JLab)
- *3 February 2020*: NPS Collaboration Meeting (JLab)
- *1-2 February 2021*: NPS Collaboration Meeting (Remote due to Covid-19)
- *16 February 2022*: NPS Collaboration Meeting (Remote due to Covid-19)
- *16 February 2022*: NPS Collaboration Meeting (Remote due to Covid-19)
- *2-3 February 2023*: NPS Collaboration Meeting (JLab)

NPS passed the ERR in 2019

2021 Assembly postponed due to Covid

Installation and Run Group 1 in 2023

NPS Science Program

Run Group 1a:

- **E12-13-010** (Run status: active): Exclusive Deeply Virtual Compton and Neutral Pion Cross-Section Measurements in Hall C Link
- **E12-13-007** (Run Status: active): Measurement of Semi-Inclusive pi0 Production as Validation of Factorization Link
- **E12-22-006** (Run status: active): Deeply Virtual Compton Scattering off the neutron with the Neutral Particle Spectrometer in Hall C Link

Run Group 2:

- **E12-14-003**: Wide-angle Compton Scattering at 8 and 10 GeV Photon Energies Link
- **E12-14-005**: Wide Angle Exclusive Photoproduction of pi-zero Mesons Link

Run Group 1b:

- **E12-06-114** (35 days moved to Hall C): Measurements of the electron-helicity dependent cross-sections of deeply virtual Compton scattering

NPS+CPS

- **E12-17-008**: Polarization Observables in Wide-Angle Compton Scattering at large s, t, and u Link

NPS+Positrons

- **C12-20-012** (status C2): Deeply Virtual Compton Scattering using a positron beam in Hall C Link

Proposals

- PR12-22-005: A Search for a Nonzero Strange Form Factor of the Proton at 2.5 (GeV/c)2 Link
- C12-18-005: Timelike Compton Scattering Off a Transversely Polarized Proton Link

Many additional ideas: see discussion session today

NPS Phase 1a – on the schedule until March 2024
53 days E12-13-010/007
44 days E12-22-006

Today: discuss checkout with beam run plans etc.

Detector Tasklist from 2022 NPS Meeting – Pre-assembly

https://docs.google.com/spreadsheets/d/1U8uDcosQGinClnzve7itGhXh4Tw2ejAKjddL4y49THE/edit?usp=sharing

NPS Preassembly (dark blue) + Assembly (light blue)		
General Pre-Assembly Tasks		
Check on progress with NPS Final Assembly Space	Brad check with JLab Facilities	Feb-22
NPS Planning Meeting	All	16-Feb-22
Space for Component Testing (Space in EEL 126 and NPS Cleanroom)	Brad, Vladimir	
Decide on travel plans for NPS assembly	Orsay/AANL team, and All	
Identify location and number of all components (crystals, PMTs, dividers, electronics/DAQ…)	Vladimir, Brad	
Ship all components to JLab	All	LV related components (Orsay)
Document electronics/DAQ items in Wiki	Brad, Tanja	ongoing
Organize test lab, initial unpacking, etc.		start ~May (duration ~few weeks)
Prepare at least one fully instrumented crate for readout testing	Brad	2 weeks to set up, cable and debug readout (2--3 people)
Preparation of assembly, docs, and test plan development		
Counting House - DAQ/electronics	Brad	
Mechanical mounting detector	Carlos and Orsay team	
Crystal wrapping	Carlos and Orsay team	
Detector calibrations	Carlos, Julie + AANL team	
Cable maps	Brad+designers	
Resources - onsite personnel	Tanja	

Crystals/Glass Tasks		
Pre-shape crystal wrapping material and store	Vladimir, ODU, DSG	3-4 months
Storage space in EEL126/NPS Cleanroom (shelves, cabine etc.)	Brad, Vladimir	
Crystal wrapping		~20min/crystal/person (assuming ~3 people)
Decide on final stacking configuration - 3 options	Vladimir, Carlos and Orsay team, Hamlet and AANL team	DONE

Example of a completed task (crystal wrapping) documented in the NPS Wiki

https://wiki.jlab.org/cuawiki/index.php/NPS_Assembly

Task List 2022

- Link to the Google Doc

Resource List

- Onsite Personnel Spreadsheet

Pre-assembly - COMPLETE (5/27/2022)

- On site personnel: **AANL** (Hamlet Mkrtchyan, Vardan Tadevosyan), **CUA** (Vladimir Berdnikov, Josh Crafts, Petr Stepanov), **MSU** (Abishek Karki), **UIC** (ZHeng Huang); **onsite contacts**: Vladimir, Brad
- Reflector pre-shaping procedure and material
  - Pre-shaping ESR
  - ESR pre-shaping procedure for NPS
  - Data sheet for ESR
- Crystal Wrapping Procedure Link
- Crystal Wrapping Documentation
  - Crystal ID Documentation
  - Pictures from crystal wrapping

Cabling - COMPLETE (11/18/2022)

- Onsite contacts: Yeran, Brad
- **Partisipants**
  - **AANL** (A.Alikhanyan National Science Laboratory)
    - Mkrtchyan Hamlet
    - Voskanyan Hakob
    - Tadevosyan Vardan
    - Mkrtchyan Arthur
  - **CUA** (Catholic University of America)
    - Ghandilyan Yeranuhi
  - **MSU** (Mississippi State Universtiy)

Note: during or after the this meeting we should update the Tasklist for tasks completed

Detector Tasklist from 2022 NPS Meeting – Pre-assembly

https://docs.google.com/spreadsheets/d/1U8uDcosQGinClnzve7itGhXh4Tw2ejAKjddL4y49THE/edit?usp=sharing

✓	**Frame**		
✓	Check if Kapton tape should be used around the PMT to insulate it from the mu metal cylinder	Carlos, Orsay and AANL team. Vladimir?	2-3 weeks
✓	Update and post mechanical mounting plan	Carlos and Orsay team	
✓	Add cooling/pressure tests		
✓	Add note to check for bubbles in optical grease layer before attaching PMT to crystal	JLab/Orsay/AANL team	7-8 weeks
✓	Update and post crystal wrapping plan	Carlos and Orsay team	

https://wiki.jlab.org/cuawiki/index.php/NPS_Assembly

✓	**HV Dividers Tasks**	Fernando + FEG	15 weeks
	Component orders	Fernando + FEG	3 weeks
	Contract assembly	Fernando + FEG	3 weeks
	PMT socket removal	Fernando + FEG	3 weeks
	PMT socket installation	Fernando + FEG	3 weeks
	Testing	Fernando + FEG	3 weeks
	Document number of available HV dividers	Fernando + FEG	

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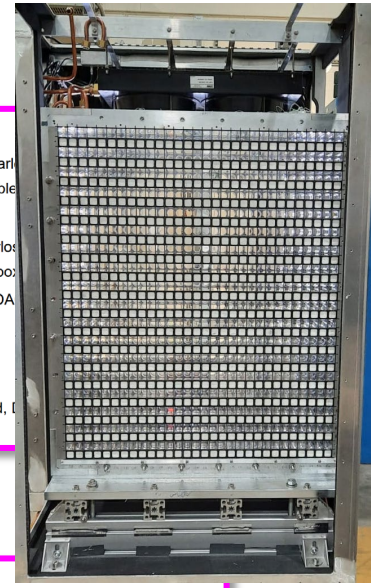
	Responsible Team	Duration (X weeks assuming Y people)
NPS Assembly		**37 weeks**
Final NPS Assembly Space available (earliest 4/28/22)	Facilities JLab	
Tests before moving into the hall		2-3 months
Crystal stacking (detailed instructions available on Wiki)	start Orsay team, assumes wrapping is done	2-4 weeks
Mu metal shield test - using Hall A Helmholtz coil setup?	AANL team	
HV calibration PMT	JLab/Orsay/AANL team	2-3 month
DAQ/Electronics - LED, cluster trigger checking (need to create step-by-step plan)	Coordinator: Brad, Lead: TBD, Participating: OU, ...	2 weeks initial setup
Cooling tests	Orsay team	
Slow controls, interlocks	DSG	2 weeks
Cable bundling and labeling	Yeran, Hakob, et al.	
Cable patch panel (assembly and checkout) and cables from patch panel to racks	Steven L.? check with Jack Segal's group	
Tests after moving into the hall	JLab/Orsay/AANL team	1-2 weeks
Fringe fields in situ	ODU	
Crystal/PMT calibrations	JLab/Orsay/AANL team	3-4 month
Test mechanical movement (lateral)		~1day
DAQ/Electronics - OR, VTP	Coordinator: Brad, Lead: TBD, Participating: OU, ...	

- Crystal stacking - COMPLETE (10 June 2022)
  - onsite personnel: IJCLab-Orsay (6), AANL (2), CUA (2-3), OU (1-2); onsite contacts: Carl
  - All crystals are stacked and 4 full columns of PMTs and electronics are cabled - assemble
- Preparation for detector checkout - planned for July/August
  - onsite personnel: AANL (2), CUA (1-2), OU (2-3); onsite contacts: Brad, Julie/Paul, Carlos
  - In order to perform the detector tests, there is work to be done outside the calorimeter bo
    - HV cables, signal cables and LV cables need to be put in place and hooked to the DA
    - Power supplies (HV, LV) need to be setup.
    - Same for slow controls (for HV and LED), etc.
- Detector Checkout - planned for August
  - onsite personnel: OU (1-2), AANL (2), CUA (1-2), U. Glasgow (3); onsite contacts: Brad,
  - Detector checkout plans and task lists



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Cabling - COMPLETE (11/18/2022)

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- **Partisipants**
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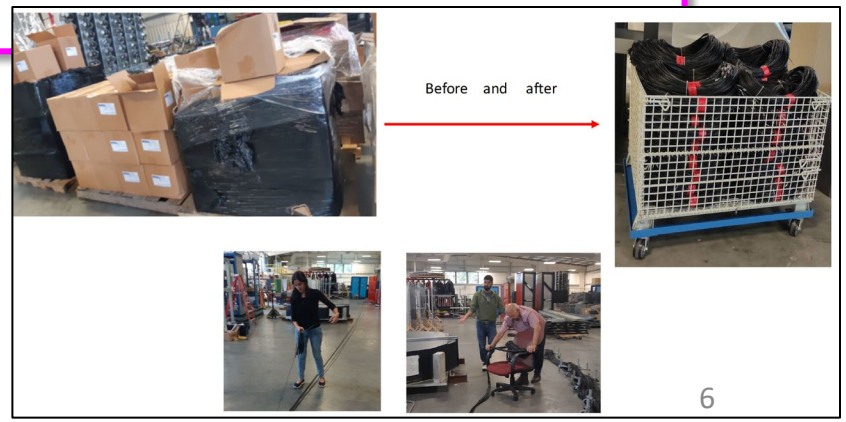

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✓ Crystal stacking (detailed instructions available on Wiki)	start Orsay team, assumes wrapping is done	2-4 weeks
Mu metal shield test - using Hall A Helmholtz coil setup?	AANL team	
complete? HV calibration PMT	JLab/Orsay/AANL team	2-3 month
complete? DAQ/Electronics - LED, cluster trigger checking (need to create step-by-step plan)	Coordinator: Brad, Lead: TBD, Participating: OU, ...	2 weeks initial setup
Cooling tests	Orsay team	
Slow controls, interlocks	DSG	2 weeks
✓ Cable bundling and labeling	Yeran, Hakob, et al.	
Cable patch panel (assembly and checkout) and cables from patch panel to racks	Steven L.? check with Jack Segal's group	
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DAQ/Electronics - OR, VTP	Coordinator: Brad, Lead: TBD, Participating: OU, ...	

Note: during or after the this meeting we should update the Tasklist for tasks completed

Detector Tasklist from 2022 NPS Meeting – pre-installation

	Mechanical design		
✓	Cable routing to SHMS	Brad+designers	Finalize (in CAD) by April
✓	Indicate where cables go		
✓	Continue design work	Designers	DONE
?	Corrector magnet		
✓	Procurement component and materials	Design/Engineering	
✓	Target deck recinforcement		ongoing
✓	Cable trays and support		ongoing
✓	Roof block		DON E
✓	Cable dolleys		DONE
✓	Fabrication components	Design/Engineering	
✓	Plan any work on target platform < May 2022	Design/Engineering	
✓	Documentation	Design/Engineering	
✓	Make small table with time estimate for rotating magnet, moving NPS detector and cabling, moving NPS from one side to another		DONE
✓	Items that can be done in advance, e.g. weld plates on SHMS		
✓	Detailed NPS Installation plan	Design/Engineering	DONE
	Revisit and update		
	Magnet		
?	Accelerator Test Plan	Jay	
✓	Make table of fringe fields vs current and check simulations for physics impact	Charles, Bogdan	Done?
✓	Decide on what fraction of max. current to run magnet for Phase-1 - also determines impact on HMS optics and mitigation needs		

Note: during or after the this meeting we should update the Tasklist for tasks completed

Detector Tasklist from 2022 NPS Meeting – pre-installation

	Support Hardware		
	Patch panel, NPS--> DAQ cabling	Brad	1 week in Hall (w/ Tech Support) if roof block mods included here
	HV crates	Brad+DSG	1 day install (2 people)
✓	Test HV cables	DSG	2-3 weeks
complete?	Samtec connectors: test and document results	DSG	2-3 weeks
✓	HV cables, cable runs and cable motion strategy	Brad+designers	Finalize by April
✓	Check on need for feedthrough cabling, decide on modification of existing roof block or new roof block with penetration	Brad+designers	Finalize by April
	DAQ Hardware and Firmware/SW		
✓	DAQ Hardware Procurement	Brad	Done
✓	VTP boards (5+1)	FEG	Done; boards on-site, need to pass QA by FE group
✓	Reserve dates for F250	FEG	Done; we'll have what we request
complete?	DAQ Firmware and Software	FEG	
	VTP/F250 modifications - sparsification	FEG	
	TI/TM	FEG	
	CODA ROC driver	FEG	

Note: during or after the this meeting we should update the Tasklist for tasks completed

Detector Tasklist from 2022 NPS Meeting – pre-installation

	Slow Controls		
	LED Control System	FEG+DSG; Brad	Want available for use by Fall
✓	Controller/driver design	FEG	Done
✓	Fabrication control board	FEG	Test board ordered (Jan 2021); awaiting delivery
complete?	LED Control GUI	DSG	4-6 weeks
✓	Procure 60 new ribbon cables	FEG+DSG; Brad	Will order once pre-production board certified
✓	**NPS Integrated Controls**	DSG	6 months
	Thermal monitoring/control	DSG	1 week
✓	Rough channel/function list	DSG	1 week
✓	Internal air temp readbacks	DSG	1 week
✓	Multiple detector temp readbacks	DSG	2 weeks
✓	Interlocks	DSG	4-5 months
complete?	**Analyzer Development**	Carlos Y., Steve	
✓	Cluster algorithm development		
✓	Decoder updates for VTP, F250 modes		
	Solve and implement data unblocking issue		
complete?	merge multi-threaded podd with hcana		
	Full DAQ Integration and Testing	Brad	
	Establish plan/timeline/people		

Note: during or after the this meeting we should update the Tasklist for tasks completed

In preparation: a paper on DSG PWO thermal analysis

Thermal Analsyis of PWO

Abstract

Lead tungstate (PWO) crystals have been the most c
ments with electromagnetic reactions, such as at mul
to temperature. To achieve the desired crystal perfor
system and any thermal stabilization. Typically therr
cooling aided by airflow. In this paper we evaluate the
that the temperature of the innermost crystals depend
methods used.

Keywords: PbWO4, crystals, Tracking, Calorimetry,

Preprint submitted to Nuclear Instruments and Methods A

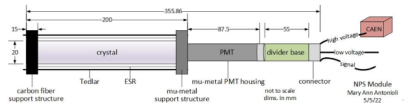


Figure 1: The caption.

Component	Property	Value
$PbWO_4$ crystal	Size	20x2x2 cm
$PbWO_4$ crystal	Thermal conductivity *x*- and *y*-axis	2.4 W/m·K (*x*- and *y*-axis)
$PbWO_4$ crystal	Thermal conductivity *z*-axis	2.0 W/m·K (*z*-axis)
Carbon fiber dividers	Thermal conductivity	0.5523 W/m·°C
Mu-metal dividers	Thermal conductivity	19 W/m·K
Copper cooling shell	Temperature	10°C
Ambient air	Temperature	20°C

Figure 2: The caption.

constant temperature to within 0.1^{o}C to guarantee 0.5% energy stability for absolute calibration and resolution. In this paper we perform a thermal analysis of the NPS design and evaluate the major challenges for keeping a wall of crystals at constant temperature.

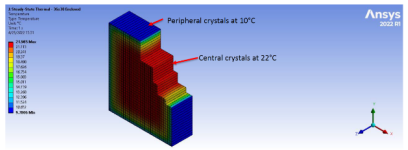
2. Method

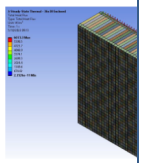
2.1. NPS Module Dimensions Model

The NPS design may be categorized into three zones. The crystal zone that contains the 1080 PWO crystals that will be kept at 18 degC ±0.1 degC, the intermediate zone that consists of the photosensors (glass and vacuum of the PMTs) and thermal insulator and cold copper plate, and the heating zone that consists of the readout electronics and produces 500 mW/channel for a total of 540 W. All three detector zones are surrounded by the external zone that is kept at the ambient temperature of 20-22 degC. Figure 1 shows the dimensions of one crystal module assembly. The assembly components are part of each of the three zones described above.

2.2. Ansys Steady-State Thermal Analysis and Thermal Calculations

Our thermal analysis consists of several activities and components. The thermal model is a physical model that closely represent the real NPS system being modeled. We also assign numerous properties and boundary conditions assigned to the thermal model. A table of the components and their thermal properties are shown in Table 2. These properties and boundary





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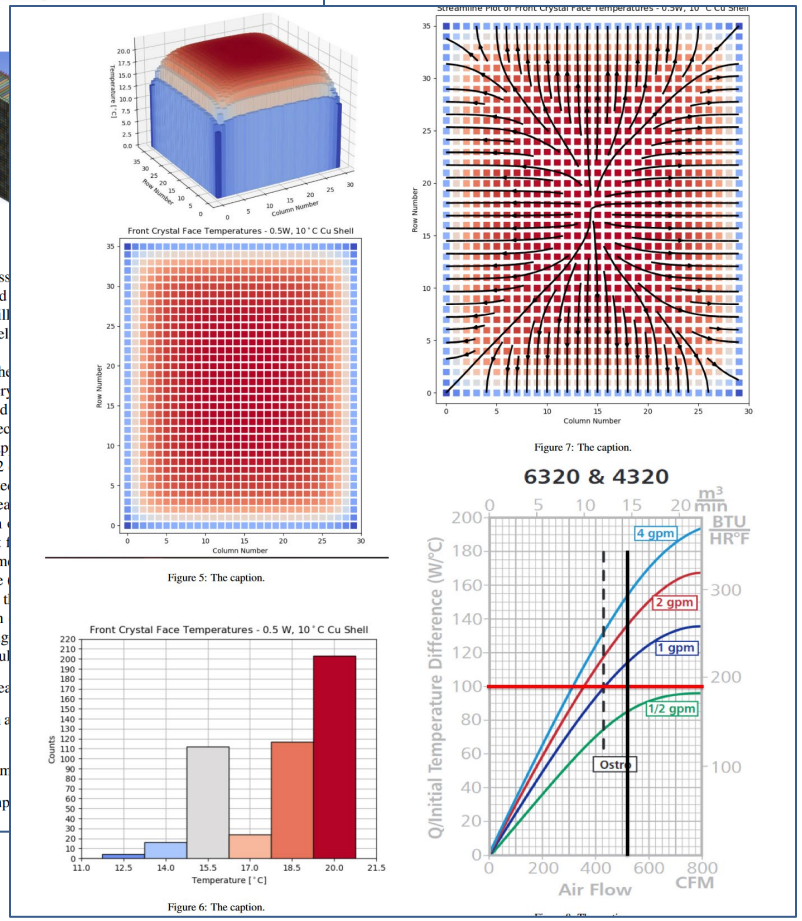

Figure 7: The caption.

Figure 5: The caption.

Figure 6: The caption.

Goals of this meeting

- Review status of the detector – components readiness
  - Update task list for tasks completed – did we forget anything
- New Physics ideas with NPS
- Preparing for the first NPS run (Phase 1a)
  - Installation Plan
  - Checkout with beam
  - Run Plan
  - Preparations for final ERR
- Additional discussion
  - NPS Phase 1b
  - NPS Phase 2 (scheduling request, ERR, etc.)

Formulate 2023 action items for NPS installation and science