Brookhaven National Laboratory

Jefferson Lab

U.S. DEPARTMENT OF ENERGY

hpDIRC / pfRICH

Triple I Engineering Meeting Update (7/20/2026)

Alex Eslinger

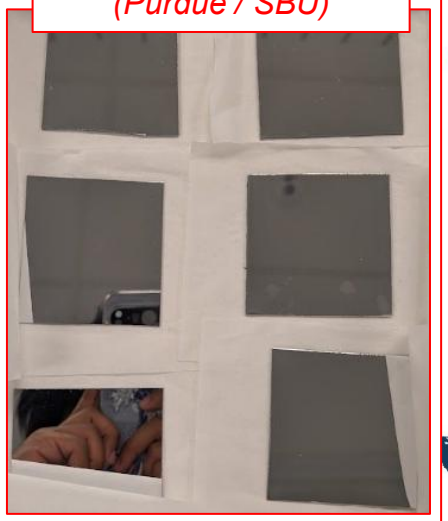
Electron-Ion Collider

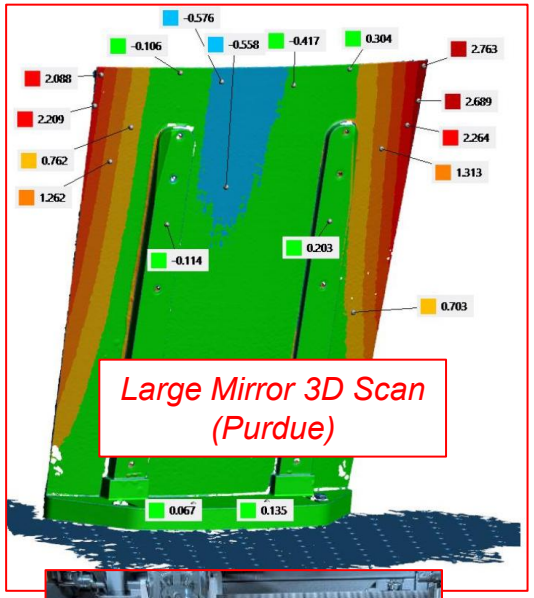
pfRICH General Updates

- Mirror Coating is ongoing
- A “picture-frame” Lexan mirror concept is being explored as an alternative to the complex CF/Lexan bonding approach
- Sealing ring template has been created to verify machining paths; in transit to SBU for fit-up prior to authorizing sensor plane production
- pfRICH beam test at CERN was completed at the end of June
  - Data processing ongoing

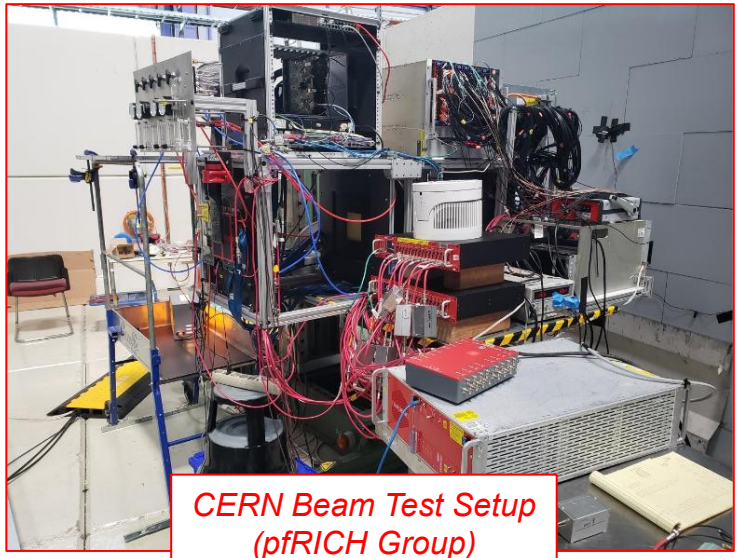
Sealing Ring Template (Purdue / SBU)

Mirror Coating Samples (Purdue / SBU)





Large Mirror 3D Scan (Purdue)

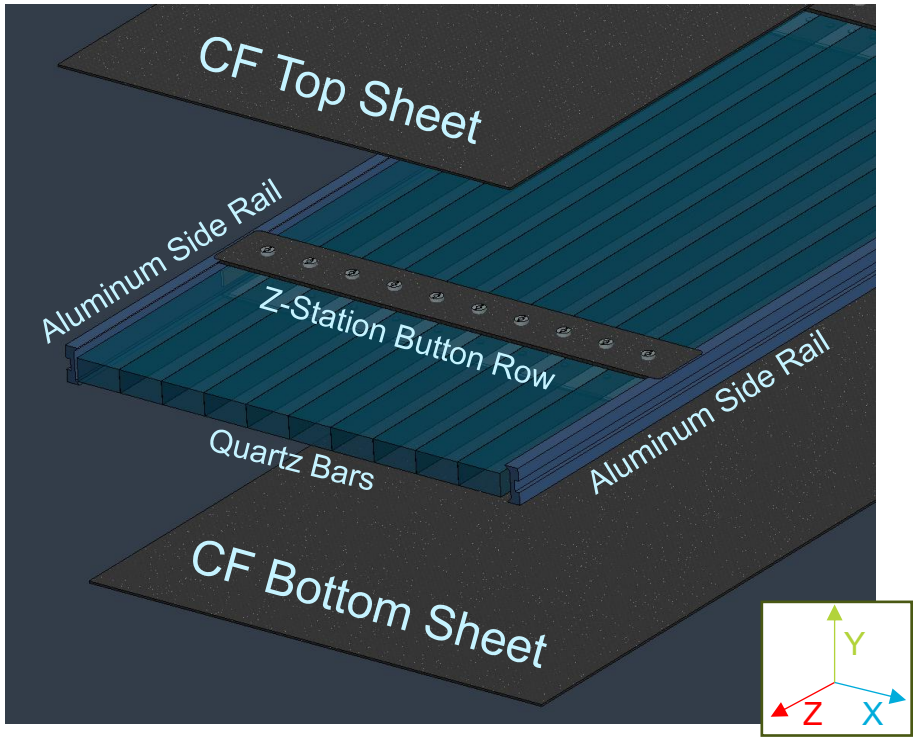


CERN Beam Test Setup (pfRICH Group)

“Picture Frame” Mirror Concept (SBU)

hpDIRC General Updates

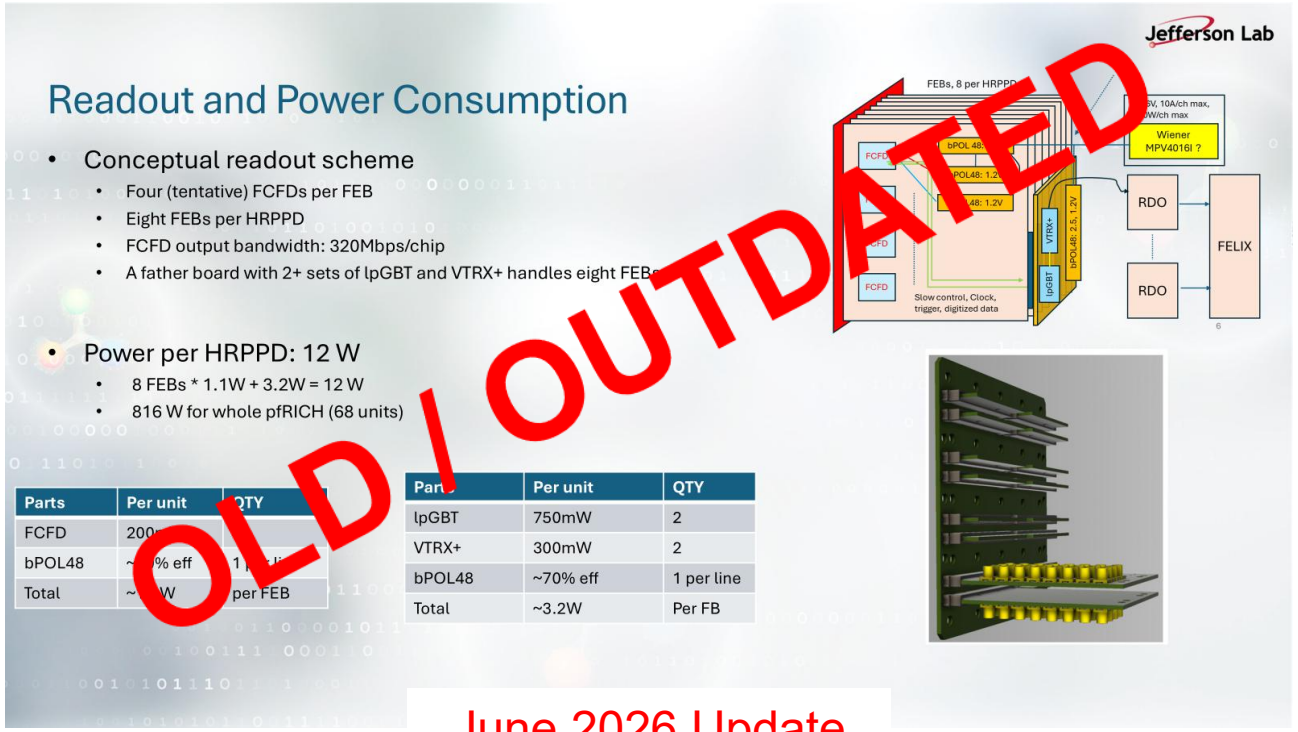
- The hybrid bar-box concept discussed at the last meeting provides a workable design checkpoint
- **GST deflection estimates are needed at five rail-interface locations while:**
  - EEEMCAL installed
  - EEEMCAL removed
  - Maximum opposing-corner adjustment / GST twist
- GST development is ongoing; awaiting a geometry checkpoint
- This information is necessary before moving the design forward because it defines the external constraints



HRPPD Cooling Concept Development

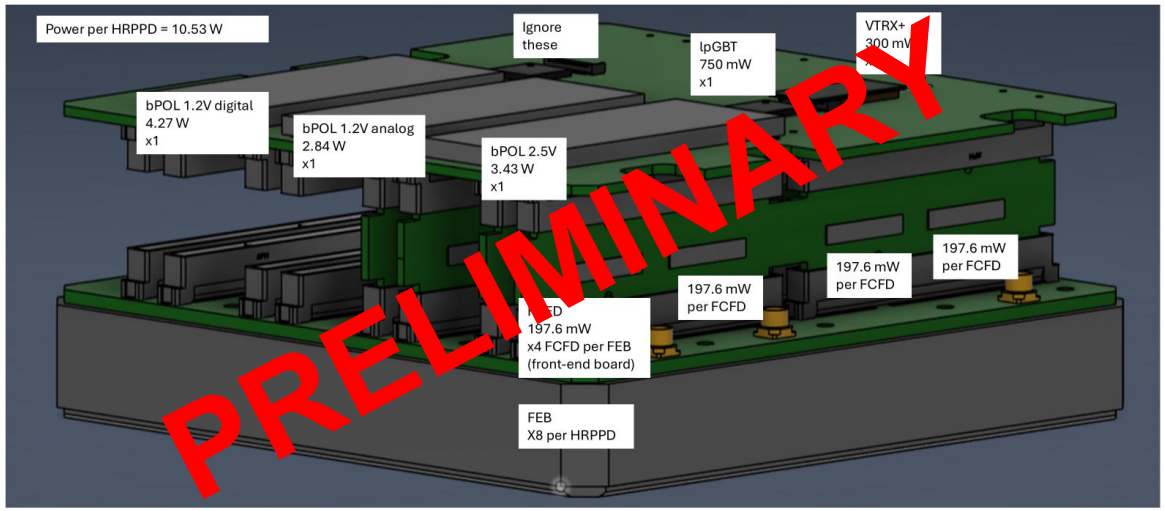
Applicable to hpDIRC and pfRICH

- The previous cooling approach was tied to an older HRPPD/electronics configuration
- The current geometry and electronics arrangement are becoming stable enough to support conceptual cooling work
- EE has clarified the heat-load accounting and confirmed the intended backside thermal path from the FEB ASICs
- The updated design now supports coordinated development of the electrical heat-load basis, PCB thermal interfaces, cold plates, coolant routing, and detector-level flow architecture

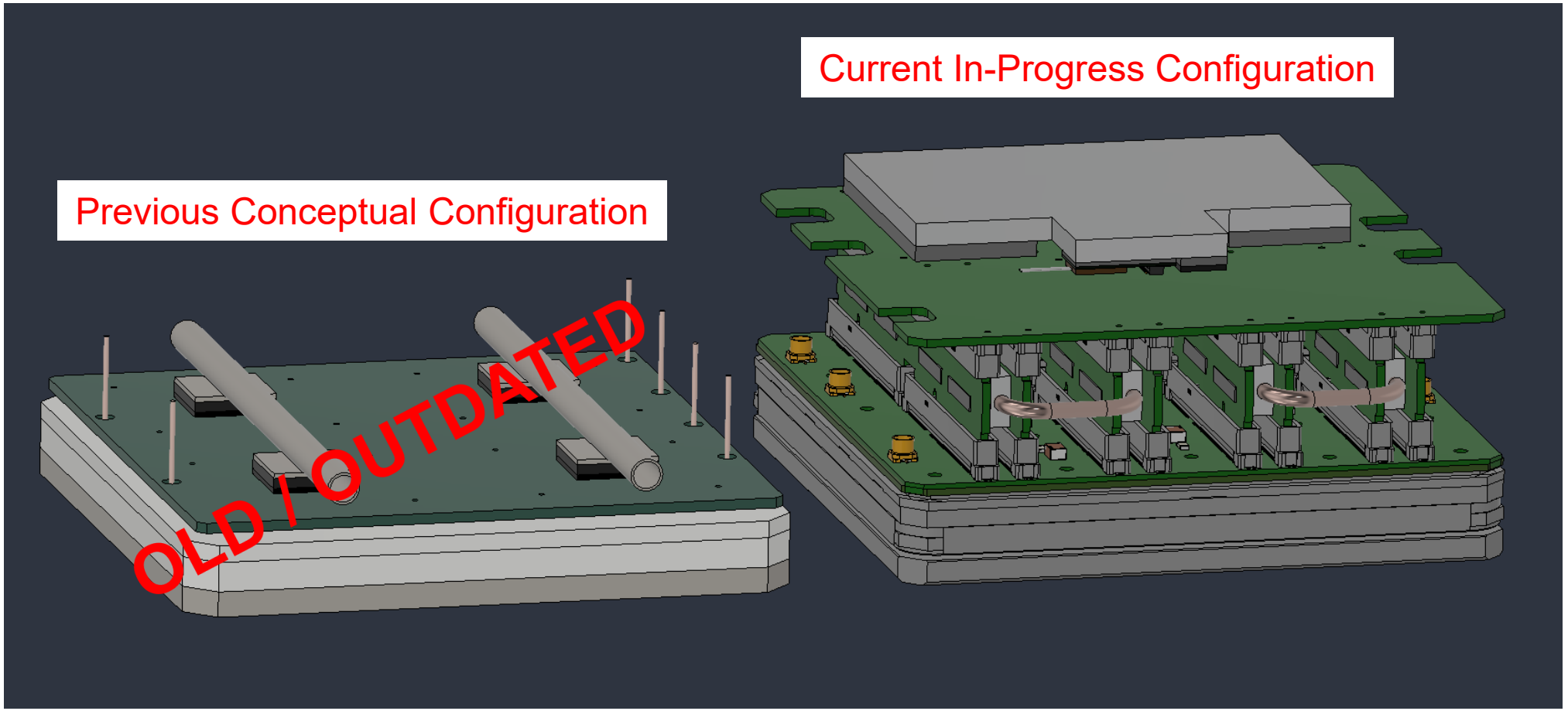


Current HRPPD Heat-Load Basis

- Conceptual electrical heat map received in early July
- **10.53 W** per HRPPD before design margin
- **11.06 W** per HRPPD with the current 5% margin
- Total includes downstream electronics dissipation and bPOL conversion losses
- **70% bPOL efficiency remains a provisional sizing basis**
- Device powers represent active transmit/receive operation; maximum-versus-nominal classification remains open



HRPPD Packaging Evolution



Per-HRPPD Preliminary Cooling Basis

Assumptions needing verification:

- Is **22°C** the correct inlet temperature?
- Is the **2°C** rise per HRPPD a reasonable allocation?
- Is **copper tubing** still the required coolant tube material? Are small **stainless-steel** isolation valves acceptable in the coolant loop?

Total Raw Detector Loads
(A/O 17 July 2026)
hpDIRC (72 HRPPDs): **758.16 W**
pfRICH (68 HRPPDs): **716.04 W**

Parameter	Working Basis	Status / Rationale
Raw heat load	**10.53 W per HRPPD**	EE-confirmed accounting basis; numerical value uses the provisional 70% bPOL efficiency
Design heat load	**11.06 W per HRPPD**	Includes preliminary 5% design margin
Cooling medium	**Water**	Current detector cooling basis
Inlet temperature	**22 °C**	Provisional assumption pending cooling-system confirmation
Coolant temperature rise	**2 °C**	Preliminary allocation used for flow sizing
Preliminary Calculated Flow	**0.080 L/min per HRPPD**	Calculated from 11.06 W and 2 °C coolant rise
Branch arrangement	**One HRPPD per parallel branch**	Avoids sequential heating and supports balancing/isolation
Ambient heat credit	**0 W**	Conservative assumption that all electrical heat reaches the coolant

Preliminary conceptual basis — values will be refined as cooling-system conditions and electronics temperature limits are confirmed.

Concept Under Development

Sensor-level concept:

- Primary electronics cooling plate
- Individual FEB cooling spreaders
- PCB backside copper planes and thermal vias
- 1/8-inch copper tube integrated into the cooling structure
- Tight packaging-driven return bends
- Sensor-level isolation

Detector-level concept:

- Parallel sensor branches
- Grouped supply and return manifolds
- Slightly negative-pressure operation as the preferred leak-mitigation basis

Mechanical and System Assumptions

Design Item	Current Concept	Status / Open Issue
Sensor tubing	**1/8-in OD copper tube**	Preliminary material and size selection
Tube wall / ID	**0.020-in wall / 0.085-in ID (2.159 mm)**	Requires verification
Minimum bend radius	**7.5 mm centerline radius**	Packaging-driven target; representative forming test likely required
Primary cooling structure	**Aluminum cooling plate with integrated copper tube**	Geometry under development
FEB thermal interface	**PCB backside copper planes and thermal vias to local aluminum spreaders**	Thermal path confirmed by EE (17 July 2026)
FEB contact footprint	**TBD**	Team will have to define required copper-pad geometry
Sensor isolation	**Isolation at inlet and outlet**	Supports individual removal and servicing
Manifold architecture	**Grouped supply and return manifolds**	Six parallel HRPPD branches per group currently proposed for hpDIRC; configuration for pfRICH in progress
Pressure philosophy	**Slightly negative pressure preferred**	Confirm facility/system capability
Insulation	**Not currently assumed**	Confirm against coolant temperature and IR Hall dew-point targets
Validation work	**CAD refinement, bend coupon, pressure-drop analysis, thermal model**	Currently developing CAD model; once complete, thermal modeling will begin

Supply manifold → isolation valve → one HRPPD cooling circuit → isolation valve → return manifold

Next Steps

- Refine cold-plate geometry and tube routing in CAD.
- Define the FEB backside copper-contact footprint and communicate it to EE.
- Validate the proposed tight-radius copper-tube bends.
- Calculate sensor-branch pressure loss and preliminary flow balance.
- Confirm available coolant temperature, pressure, chemistry, and detector interfaces.
- Develop a representative thermal model once contact geometry and temperature limits are defined.

Questions?