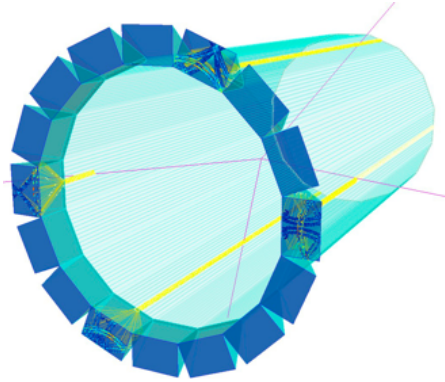


High-performance DIRC (hpDIRC)

Goal:

- Very compact device with coverage beyond 10 GeV/c for p/K, 6 GeV/c for π/K, and 1.8 GeV/c for e/π, pushing performance well beyond state-of-the-art
- First DIRC aiming to utilize high-resolution 3D (x,y,t) reconstruction

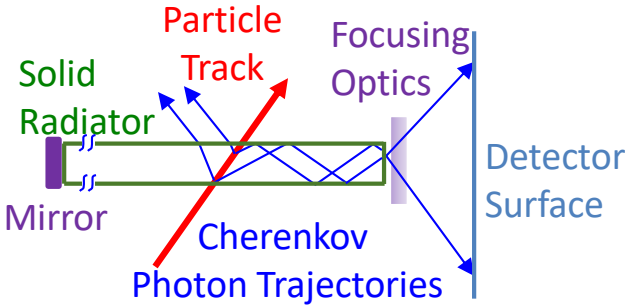
FY 20:

- Transfer the PANDA DIRC Prototype to the U.S.
- Develop Geant simulation for hpDIRC prototype in beam test environment
- Upgrade laser setup for characterization of the optical properties of the three new lens prototypes
- Finalize radiation hardness study of candidate lens materials using both neutron and gamma sources
- Study feasibility of “mini-DIRC” for near-beam ion identification

hpDIRC – overview

hpDIRC simulations

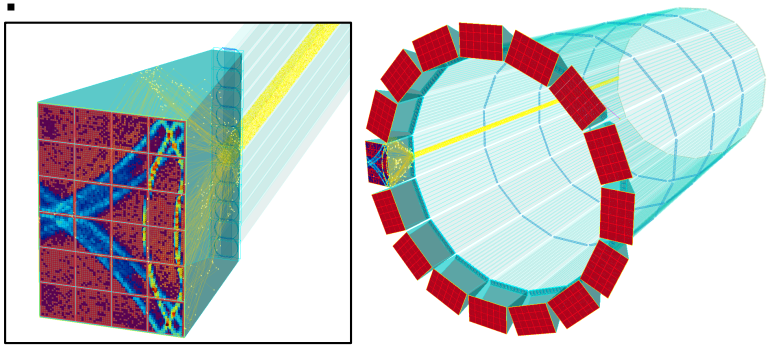
- Parametrization of the hpDIRC baseline design performance to be used as input to the fast EIC detector simulations



High performance DIRC in Geant 4

Development of 3-layer lens and experimental tests:

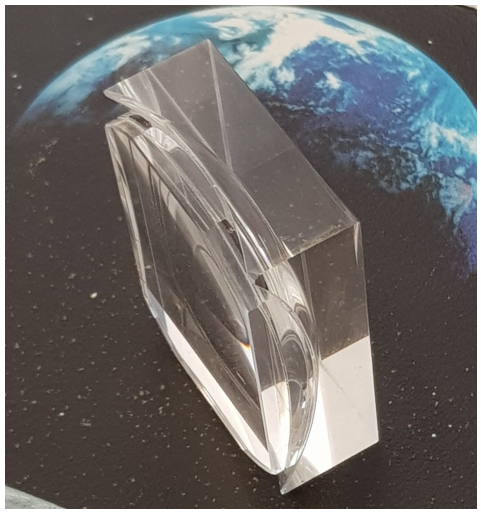
- Detailed radiation hardness test in ^{60}Co source confirmed sapphire and PbF_2 to be radiation hard
- Planned upgrade of the laser setup to characterize three new lens prototypes



The hpDIRC prototype:

- Last PANDA Barrel DIRC test beam prototype identified the potential for a significant reduction in the number of sensors required to cover the detector plane
- PANDA DIRC prototype transfer to U.S. a key step towards hpDIRC prototype

Square spherical 3-layer lens prototype



„mini-DIRC" for near-beam ion identification

- Proposed pilot study to evaluate the feasibility of „mini-DIRC" for the forward near-beam to detect scattered light ions and heavy-ion fragments.

hpDIRC – validation of 3-layer lens optics

Two radiation-hard 3-layer spherical prototype lenses currently in production, will be available early fall 2019.

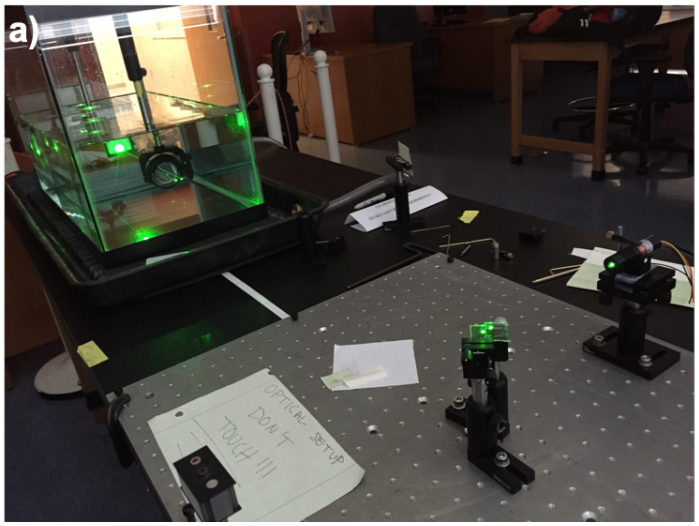
Mapping focal plane of cylindrical 3-layer lens:

- Results of measurements confirm desired flat focal plane for centered laser beams on the lens
- Measurements with off-center laser beams planed for next year.
- Combined results for both lens prototypes planned to be published in FY19.

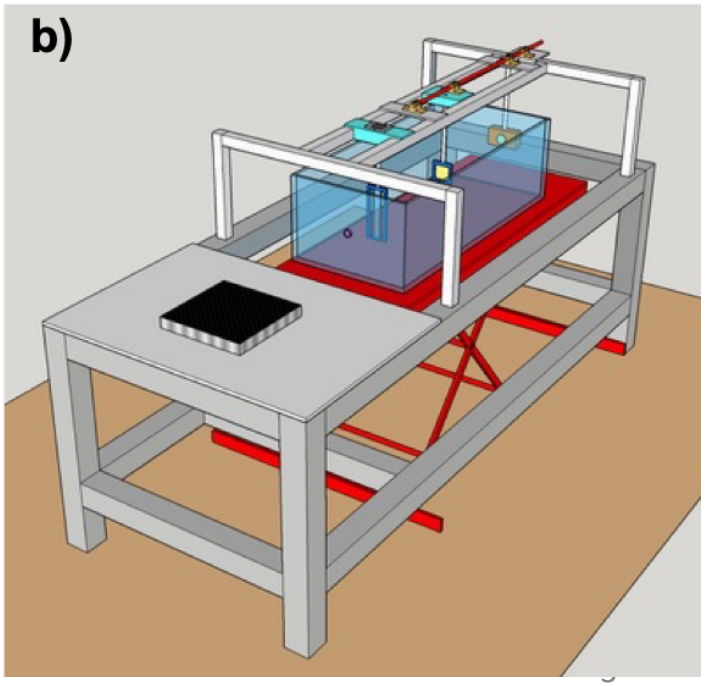
Upgrade of setup will simplify the calibration and the exchange of lenses, and increase the precision and speed of the measurements

Laser setup at ODU to map the focal plane

Current setup:



Proposed upgrade:

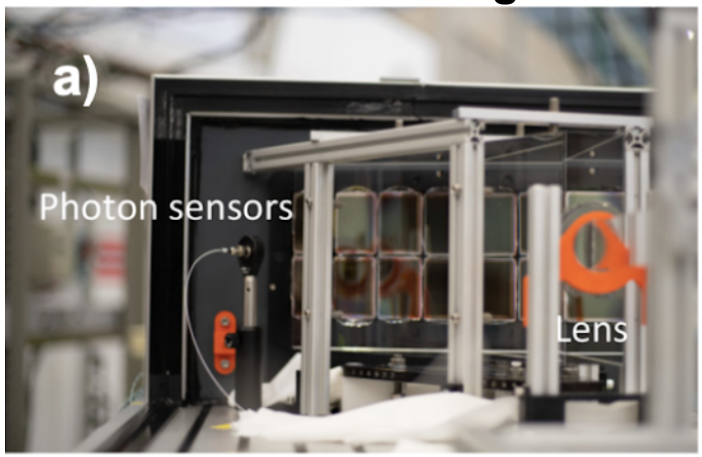


hpDIRC – validation in CERN test beams

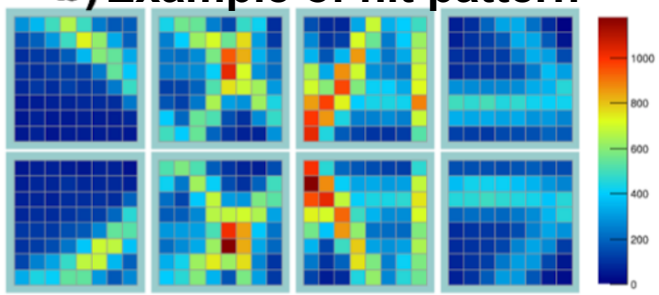
PANDA Barrel DIRC prototype at CERN PS in July/Aug 2018: reduced number of MCP-PMTs.

- Caveat: larger sensor pixels, slower electronics than EIC DIRC → PANDA goal: 3σ π/K separation @ 3.5 GeV/c
- Optics similar to EIC DIRC design:
  narrow bar, fused silica prism, 3-layer spherical lens
- Reduced MCP-PMT coverage by 33% compared to 2017, gaps near prism sides (data analysis ongoing)
- Measured key quantities: photon yield, Cherenkov angle resolution per photon and per particle, and π/K separation power – all in good agreement with simulation (used for EIC DIRC)
- PID performance in 2018 close to 2017 results (photon yield lower but π/K separation still > 3σ)
- Impact of reducing number of sensors promising, has to be tested in EIC simulation

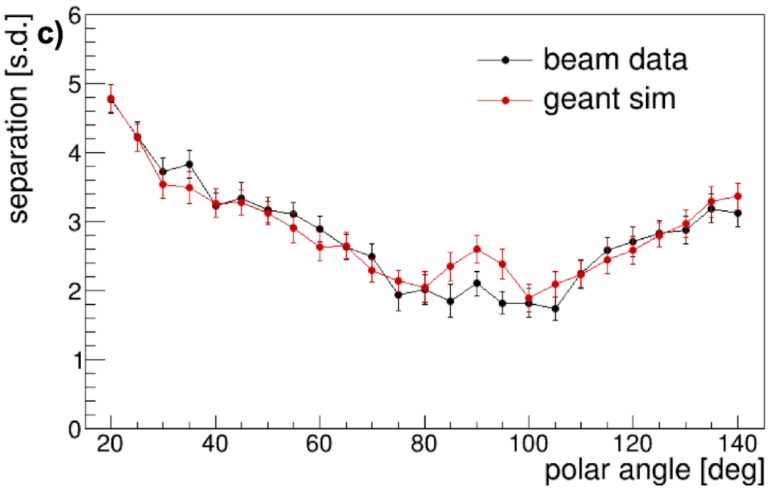
2x4 MCP-PMT arrangement



b) Example of hit pattern

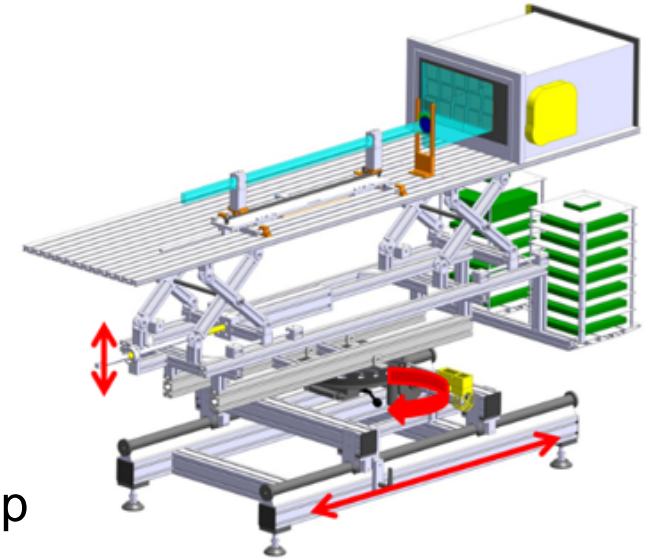


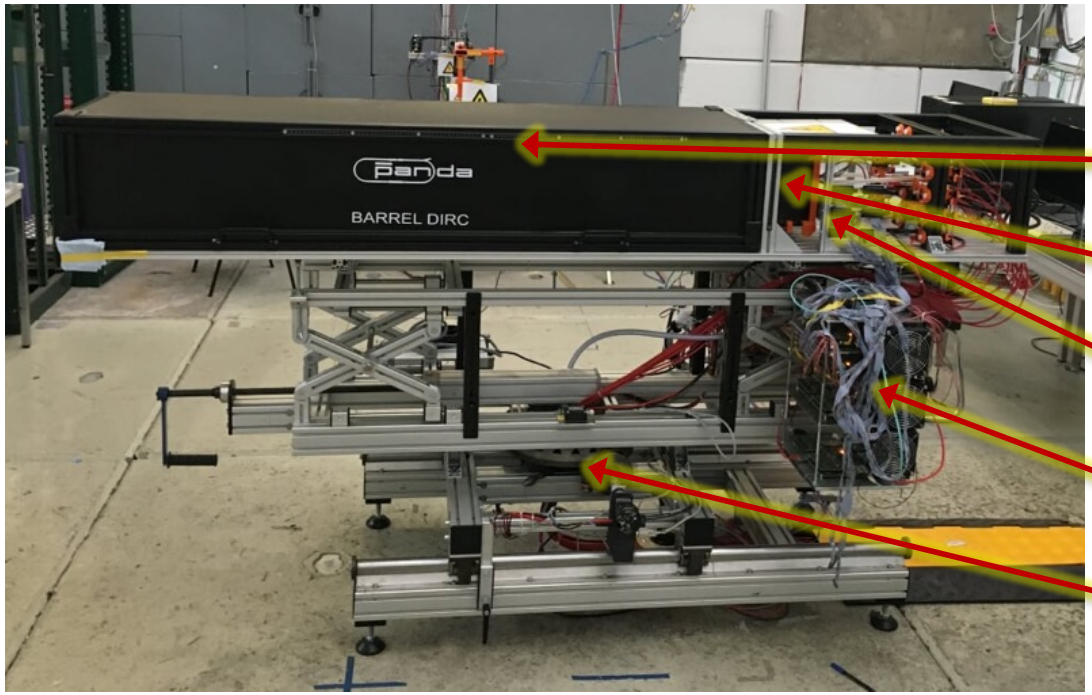
π/p separation power at 7 GeV/c



hpDIRC – transfer of PANDA prototype to U.S.

- PANDA Barrel DIRC prototype entering retirement after conclusion of their R&D phase
- Available components include:
  fused silica bar and plate, fused silica prism, lenses, few Planacon MCP-PMTs (6.5mm pixels, 25μm pores) with PANDA DAQ cards (PADIWA/TRB, $\sigma_t \approx 200$ps), mechanical support (incl. rotation stage), dark box.
- FY20: transport to U.S. (JLab or BNL/Stony Brook), set up DAQ system, test with laser pulser to prepare for beam.





Dark box for optics (bar, lens, prism)

MCP-PMT array

Frontend electronics (PADIWA) (air-cooled)

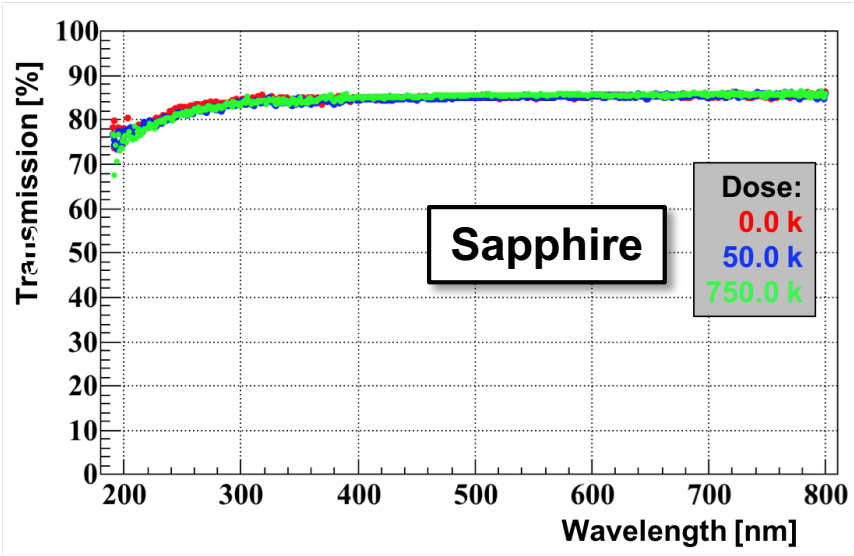
DAQ boards (TRB)

Rotation stage (remote controlled)

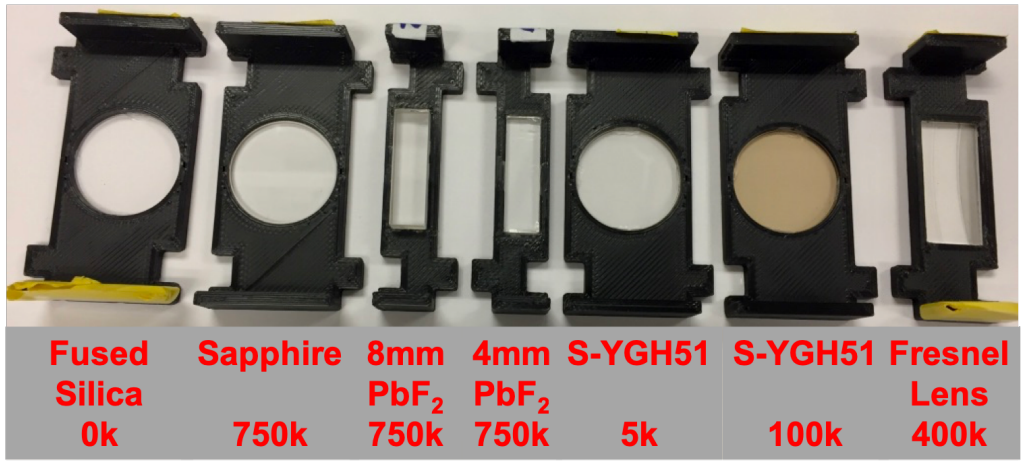
hpDIRC – radiation hardness of 3-layer lens

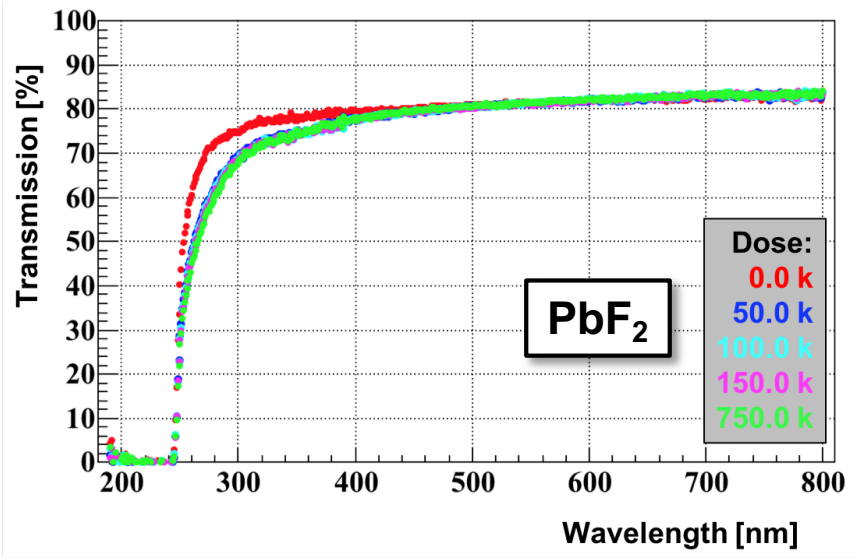
^{60}Co irradiation results

- Five materials studied, radiation hardness of sapphire and PbF_2 confirmed up to 750krad!



Tested samples

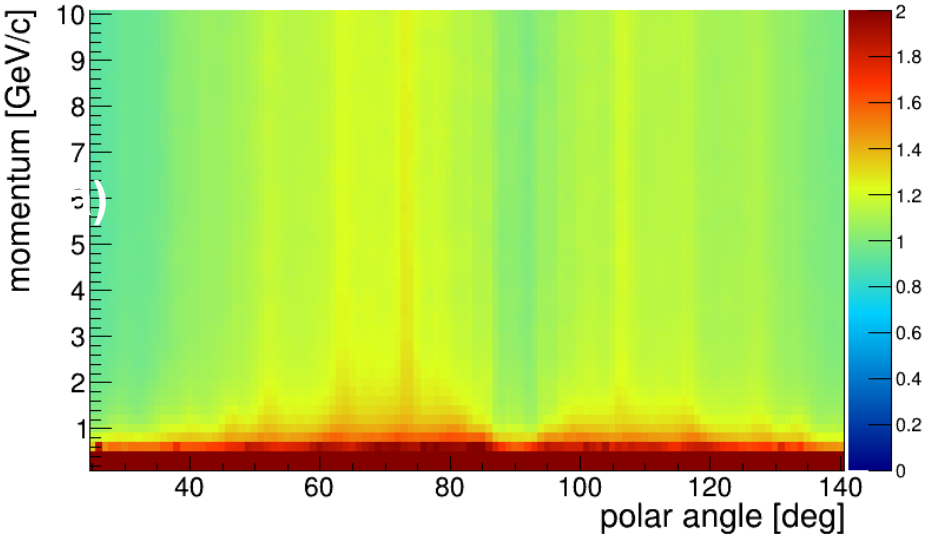




hpDIRC – parametrization of hpDIRC for fast simulation

- A special C++ class was designed and released to the EIC software community
- Geant4 simulation of the current hpDIRC baseline design used to calculate the Cherenkov track resolution (CTR)
- The fast simulation returns the deviation of the smeared Cherenkov angle from the expected values in units of CTR
- The derived π/K separation power in standard deviations is a result of the fast reconstruction

Geant4 simulated Cherenkov track resolution



Derived π/K separation power (tracking resolution of 0.5 mrad)