Outer detector (OD) calibration system

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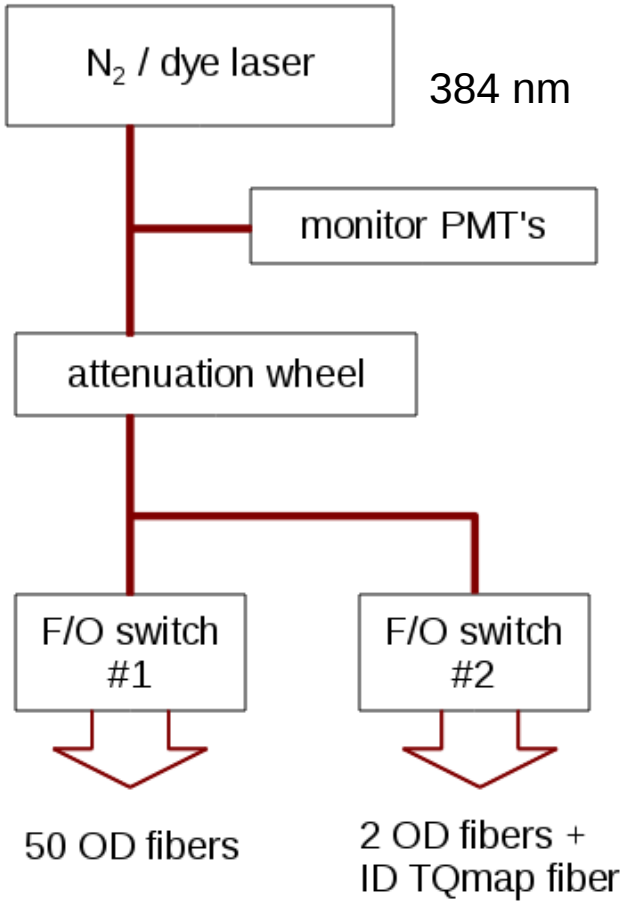
Outline

- OD calibration characteristics
- SK OD calibration system as an example
- adopting SK system to HyperK
- possible improvements and beyond

OD calibration characteristics

- OD's main purpose is to determine whether a track is fully contained or not
  - calibration requirement is not as stringent as ID
- OD sensors in a compartment can't see one light source → need multiple light sources to calibrate them
- need to contend with the support structure between OD sensors and tank wall (except for end caps)
  - in SK, there is no such structure between the tank wall and OD PMT's on the side wall
  - this limits movable light sources to ones on a fixed rail

SK OD calibration system



SK OD calibration system diagram

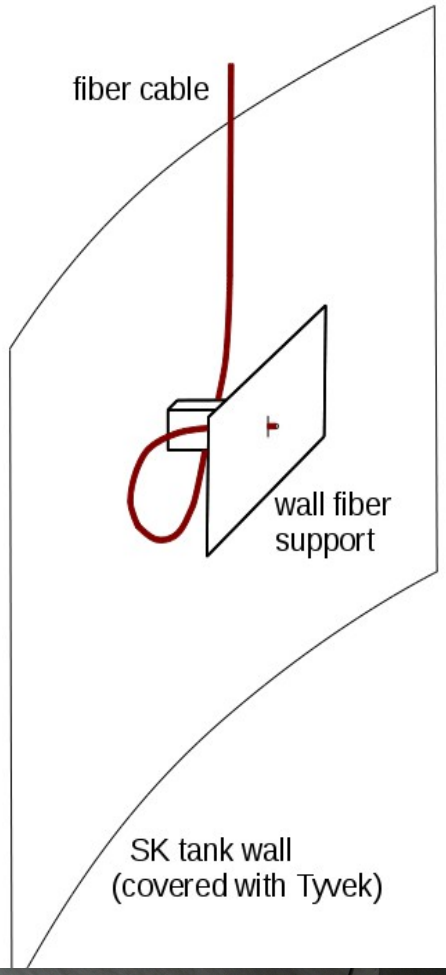
- entire system (except for fibers) is in one cabinet by the central hut
- fibers are positioned in various place throughout the OD area
  (24 on wall and 14 on top / bottom)
- they were instrumented on ad-hoc
- also doubled as a TQ mapping system for ID PMTs
  - possible to send the same laser pulse to ID/OD for timing calibration


top


wall

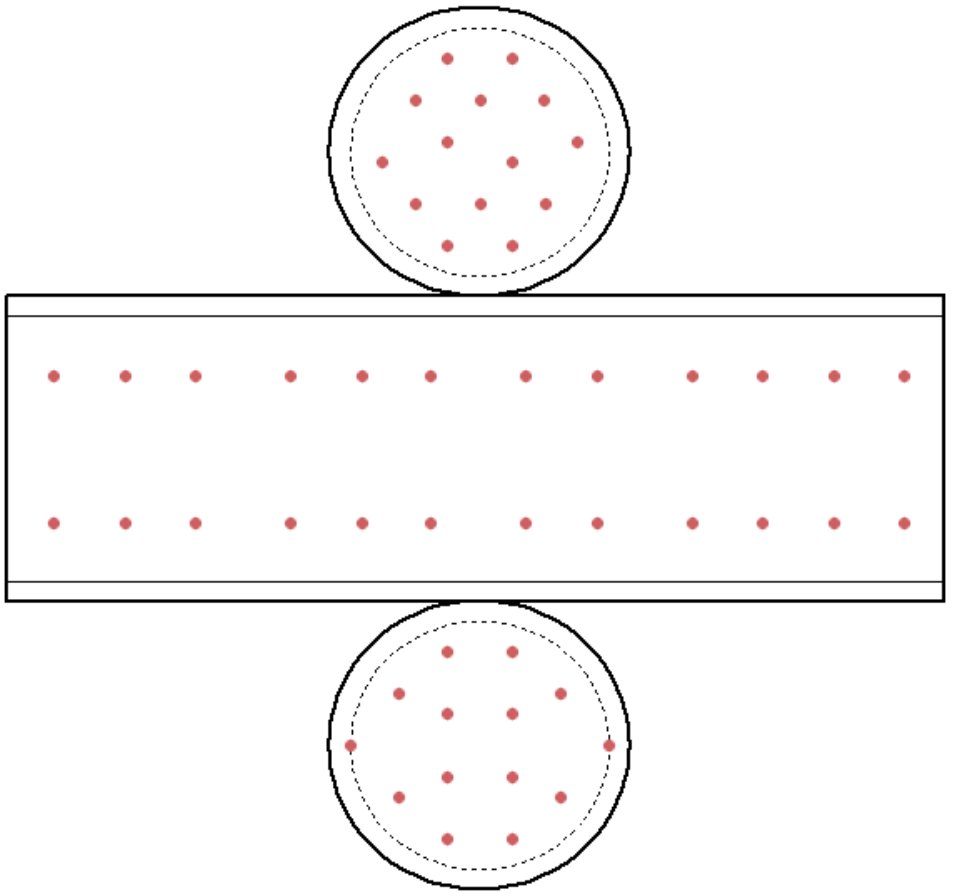

bottom

SK OD calibration fibers



- each fibers are equipped with a light diffusing tip (a blob of epoxy mixed with TiO_2)
- fiber lengths: 72 m for wall and top, 110m for bottom
- wall fibers are ~2.5m away from OD PMTs, but top and bottom ones are ~1.6m away
  - due to space limitation caused by support structure

SK OD fiber position

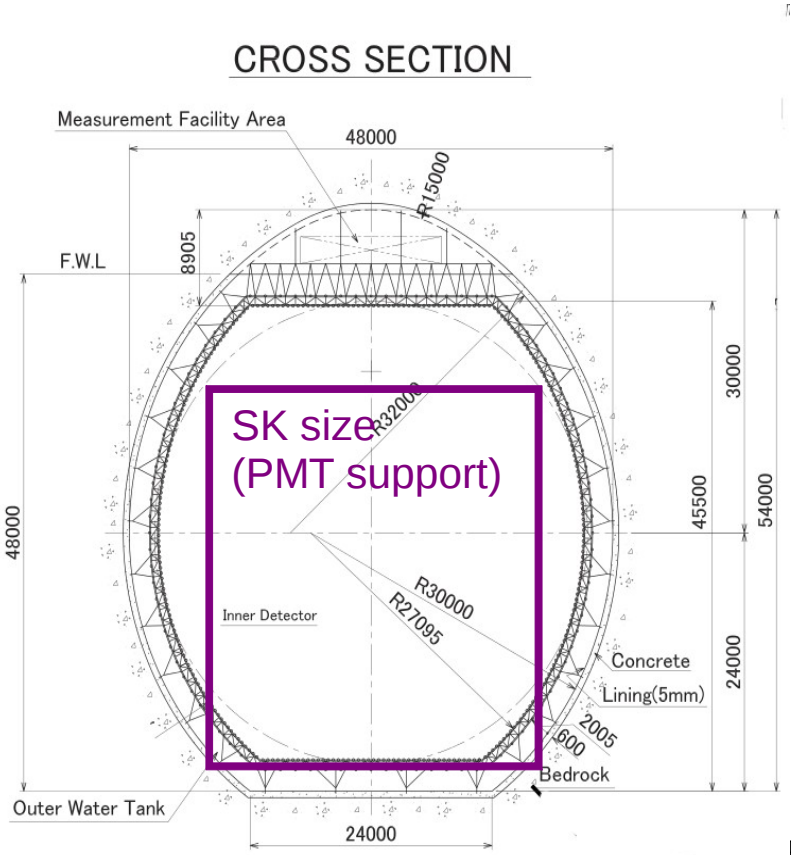


SK OD calibration fiber position (red dots)

- wall fibers:
  ~3840 m^2 / 24 fiber = 160 m^2 / fiber (~53 PMTs / fiber)
- top/bottom fibers:
  ~900 m^2 / 14 fibers = 65 m^2 / fiber (~22 PMTs / fiber)
- actually a little over 1/2 of fibers were seriously used
  - redundancy is necessary, because adding them later is not possible

Adopting SK system to HK

- 1 HK compartment is slightly larger than SK
  - imagine to build one SK like system / compartment



- top/bottom: ~1140x2 m^2 → 34 fibers
- wall: ~2500x2 m^2 → 30 / 76 fibers
  (with SK wall / top density)
- end cap: ~1380 m^2 → 9 (or less)
- wall length = 51 m (SK: 36 m),
  extra 15+15 m is needed → 140 m
- ~110 fibers with 140 m long are needed / compartment

Cost estimate

- laser: $ 15k (400 nm diode laser, 15pJ/pulse, <100 ps width)
  - assuming 20dB loss to tip, 2π uniform diffuser, head on
    → 8” PMT @2m gets ~330 photons, @5m ~60 photons
  - YAG laser seems necessary, but can be shared by 5 comp.
- fiber interface/attenuators with monitor PMTs: $ 10k
  (from an experience of building a similar system in 2011)
- 2 (1-64) optical switches: $ 15k x 2
- 110 x 140 m fiber cable: $ 154k (bare fiber cost)
- cost / compartment is $ 209k → total cost ~ $ 2M
  - does not include all possible volume discounts

Possible improvements

- more reliable light source (LSI laser lasted 2-3 years)
- use the same length fibers to avoid timing ambiguity
- enhance longevity of the calibration fibers
  - design and instrument a longer lasting light diffusing tip
  - use a well protected cable way → plan in advance
- add outward shining fibers to have *in situ* data on Tyvek reflectivity, etc.

And beyond

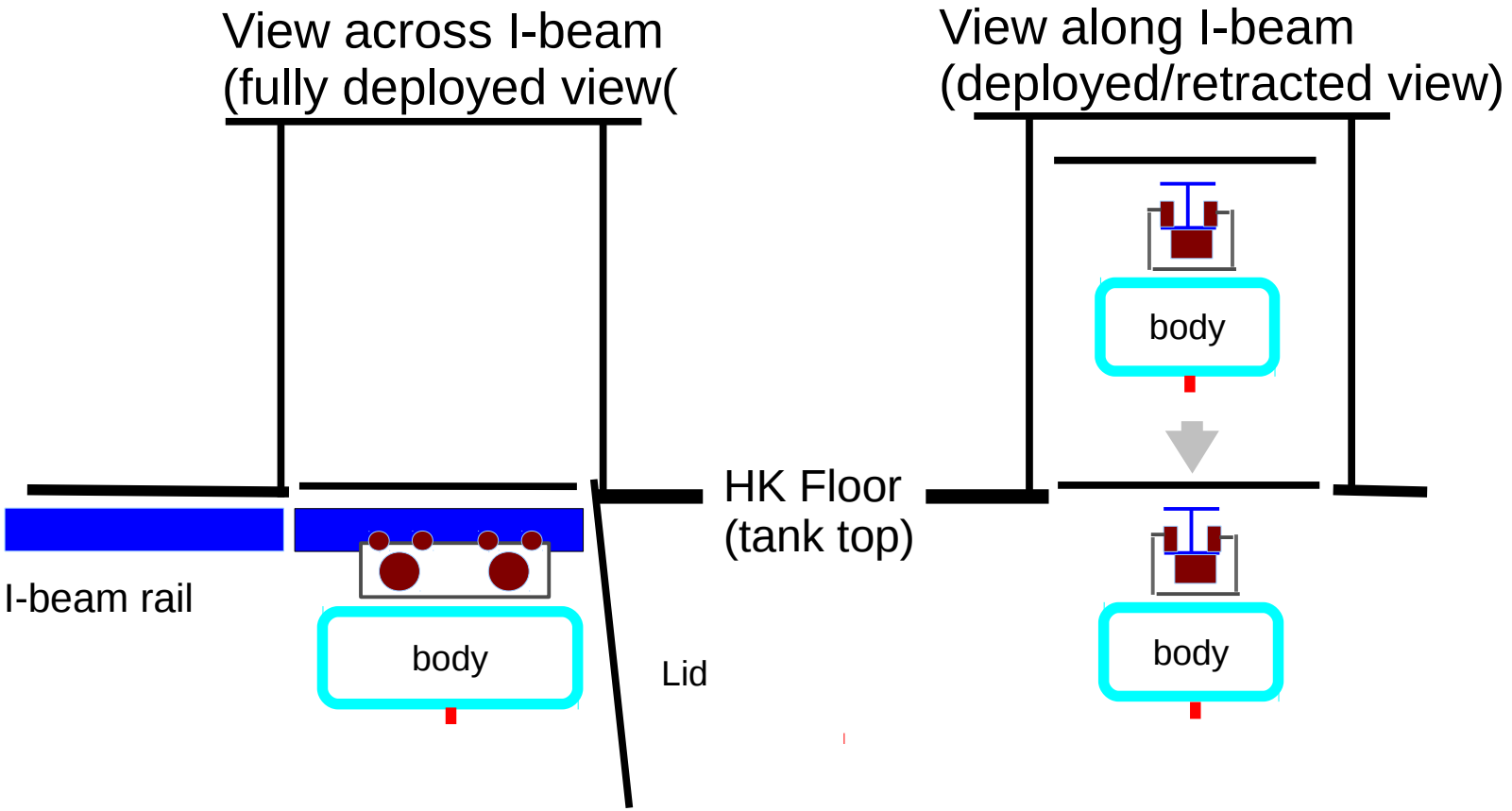
- a calibration light source for every light sensor (LED flasher with a power line trigger), instead?
  - $2M / 25k ~ $80 / sensor, to be price competitive
- Self contained movable light source (battery powered, wireless communication) on mono-rails?
  - need to deploy I-beam rail on tank wall, but I beam is much steadier than fiber cable
  - probably need deploying hole of ~2' across, judging from the size of diode laser

Summary

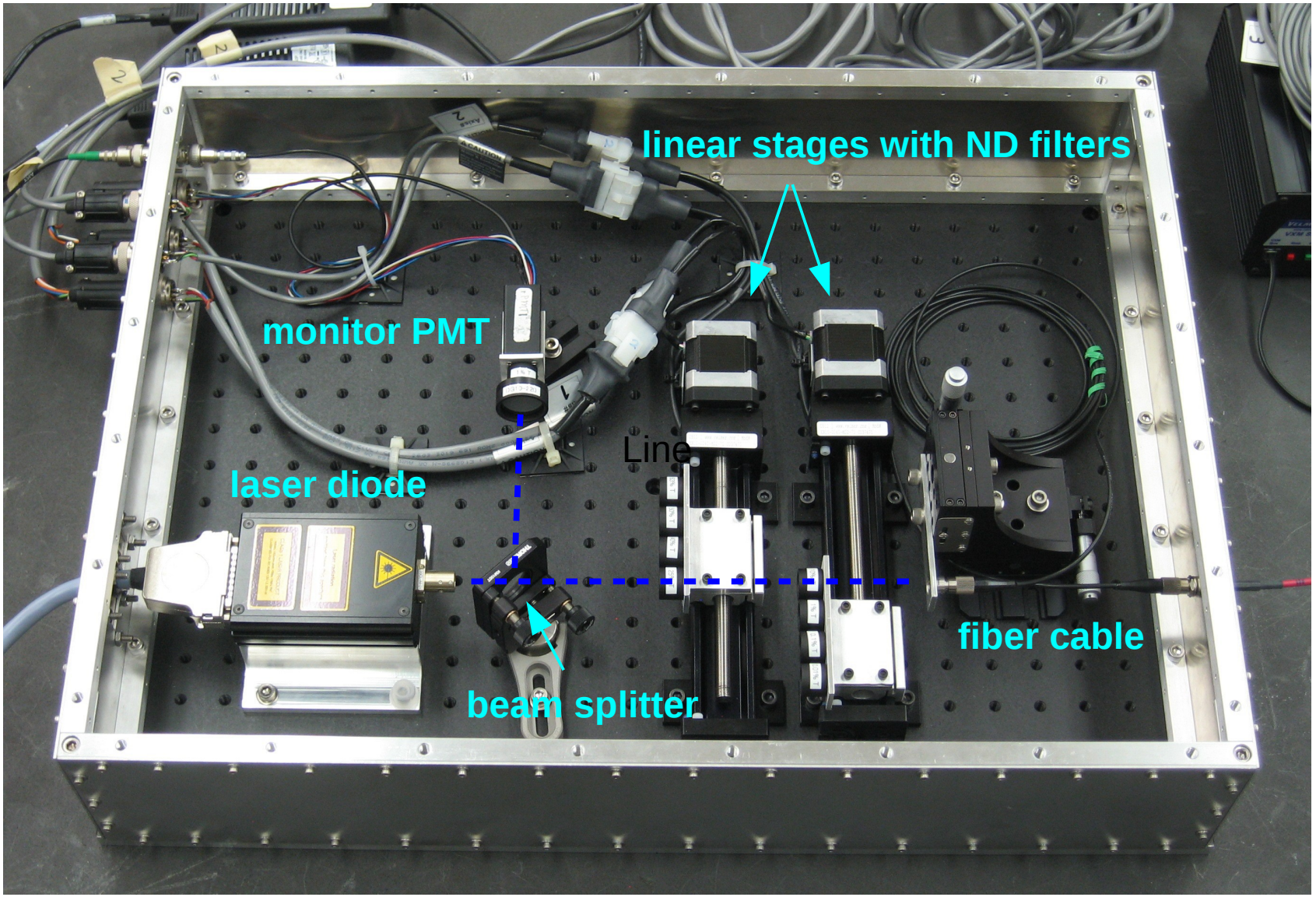
- SK OD calibration system is described as an example
- Can a SK like system be used for HK?
  - seems feasible to adopt it to HK compartment
  - total cost estimated ~$ 2M (some questions on the light source)
- possible improvements are discussed
- some other possibilities are presented

Extra

SCORPION conceptual drawing



A photo of laser light source



possible bottle necks for fiber system

- access to wall area where movable gondolas / floating floor (used in SK) seem hard to use
  - fiber cable installation is rather delicate operation
    - → need at least a physicist supervision
  - individual light source on each sensor has advantage

- anything else?