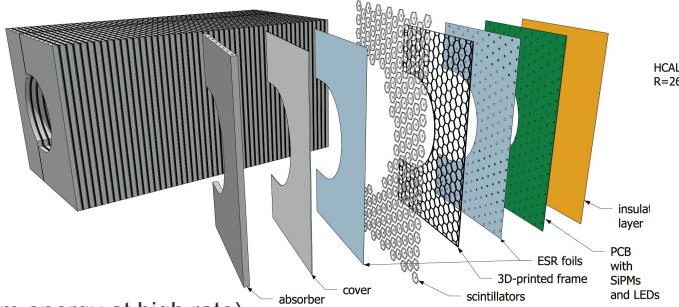
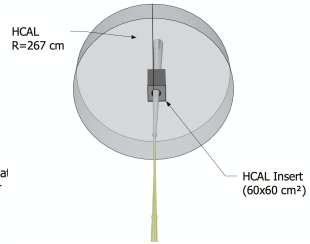
SiPMs for Calorimeter Insert

(note, only O(1000) SiPMs needed to instrument it)





- **What is the dynamic range one needs to cover**
  - Insert covers the region with largest energy depositions (up to close to beam energy at high rate).
  - Per-cell dynamic range: from ~0.5 MIP to ~200 MIPs (shower max for 50 GeV pion) (link to insert design paper)
  - Light yield estimate:
    ~10 photoelectrons per 3mm EJ-212 cell with 1.3 mm 14160 HPK SiPM at +2V (x5 times for 3 mm SiPM). (link to insert light yield paper)
    33% lower light yield if injected molded cells are used instead (link to presentation of results)

  No SiPM saturation expected if 15 microns models are used. Older gen 50 microns are not off the table (depends on rad test, scintillator type)
  Hamamatsu 14160 SiPMs 15 micron models expected to be operated at low-to-medium gain~ few times 10e5.

- **What is the impact of radiation damage of the SiPMs on you system**
  - Fluence up to ~10e12 1 MeV neutron equivalent pear year at nominal luminosity.
  - Rad damage is “Modest” as per Garutti’s review paper. (but unlike most SiPM-on-tile designs, we plan to run without cooling).

  → Increased dark-rate, inability to see single photon peaks, reduced signal-to-noise ratio to the point where threshold might go beyond MIP.
  - This level of damage can be mitigated through high-temperature annealing, which is why it is critical that insert region is designed for easy access to SiPMs.
  - Application specific rad-test study at LBNL. We plan one for June 2023, led by Dr. Barak Schmookler. In-kind contribution from California EIC consortium.

  Goals:
  Measure signal-to-noise ratio for possible SiPM models for various operating voltage points vs neutron fluence, and annealing time.
  Info will be used to determine optimal operating voltage and SiPM model and scintillator material.
  Realistic noise spectra will be included in simulations, and data rate estimates.

- **What specs have you already determined and how? What needs still be determined**

  1) Must ability to calibrate with MIPs on a cell-by-cell level. This is a key aspect of this technology.
  2) Threshold must be no greater than 0.5 MIP for performance (as per CALICE AHCAL) and to enable calibration.

- **How do your SiPM specs impact the readout electronics, especially the FEEs**
  None. Same as fHCAL with HGROC as ASIC (designed for this application).