KEKB beam dump experiment and application of SiW-ECAL

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Conceptual paper: arXiv:2107.06431 (Ishikawa, Sakaki, Takubo)

Interest in dark sectors

- Heavy BSM (WIMP): collider physics
  - Not found any in LHC yet
  - Interest of theorists is moving…
- Light BSM (WISP): also good for fixed target
  - Very weak coupling: usually colliders can not see
  - Coupled to photons, ALPs (2γ) or dark photons (1γ)
  - Very wide energy range (10^{-20} eV – GeV)
    - No strong region
    - Wide range of methods from light to (relatively) heavy
  - Beam dump experiment can probe MeV-GeV WISP

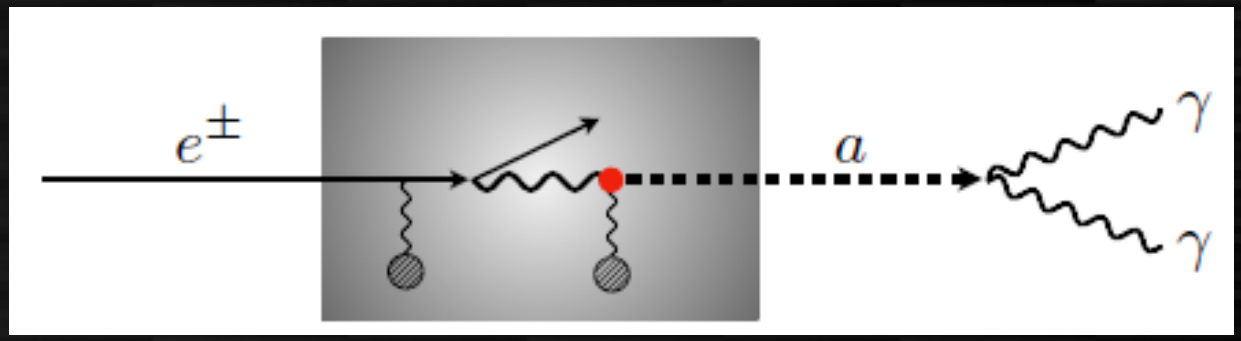
Axion (ALP) search

Consider ALP only coupling to photons

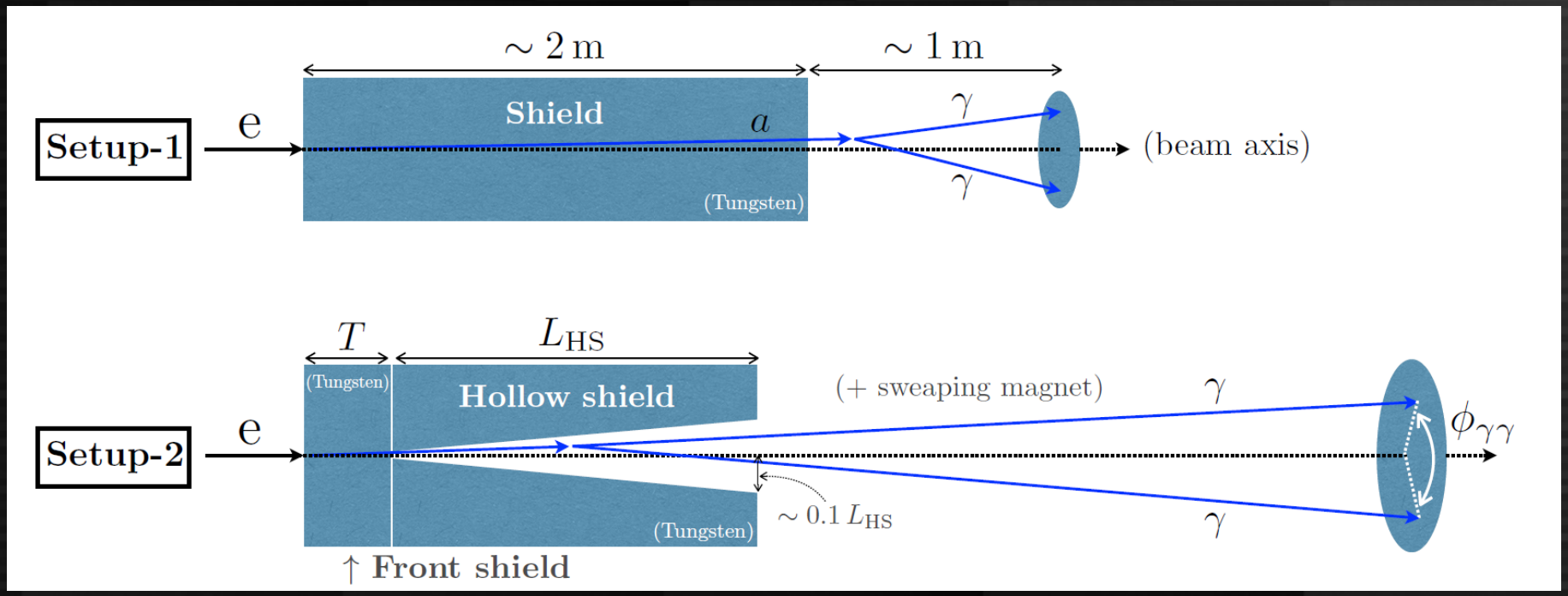
$$\delta\mathcal{L} = -\frac{1}{4}g_{a\gamma\gamma}aF_{\mu\nu}\tilde{F}^{\mu\nu} + \frac{1}{2}(\partial_\mu a)^2 - \frac{1}{2}m_a^2 a^2,$$

$g_{a\gamma\gamma}$: coupling constant, m_a: mass of ALPs

Photons can convert to ALPs under the strong magnetic field
ALPs can convert to 2 photons



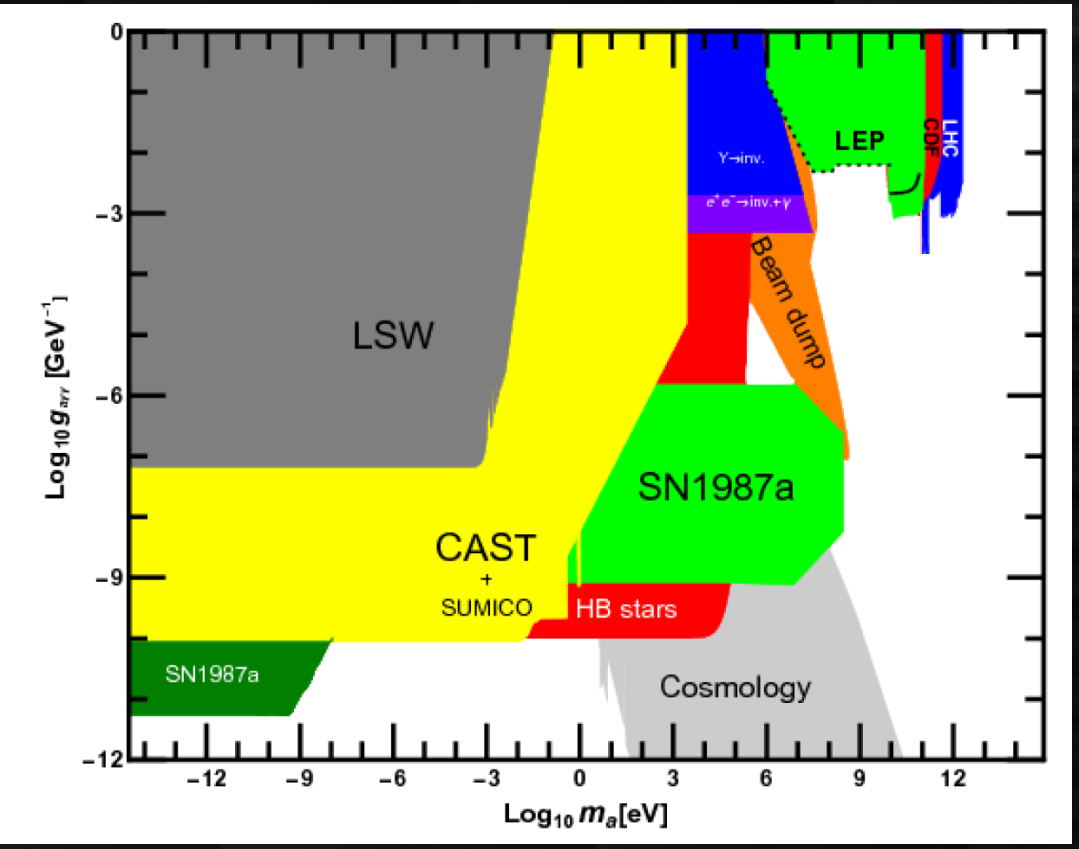
ALP search at beam dump



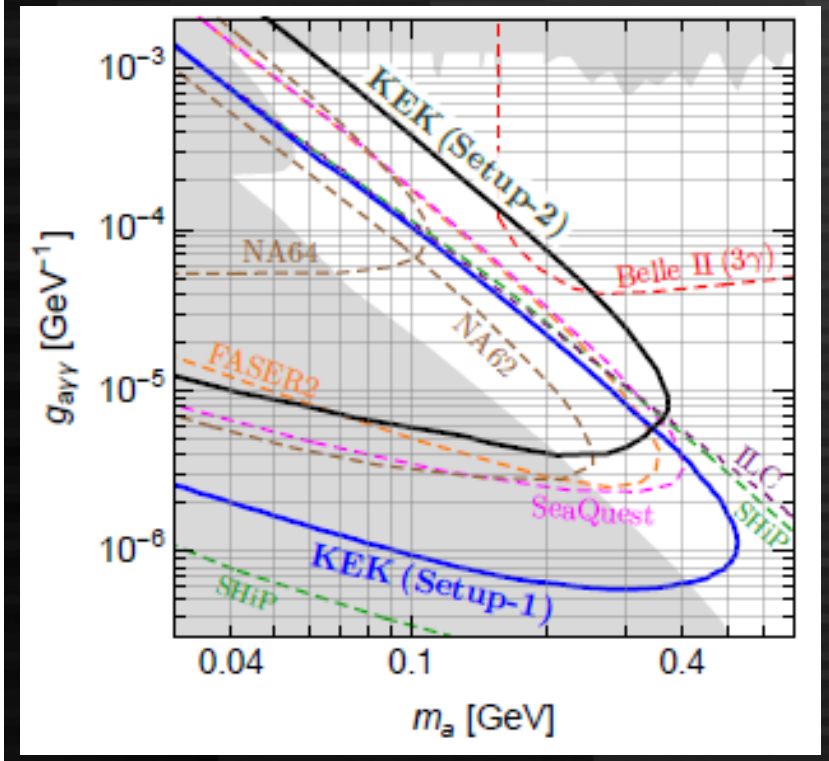
Setup 1: enough shielding to remove all backgrounds
Setup 2: sweeping muons by magnet,
sensitive to ALPs with shorter lifetime

Trying setup 1 first

ALP search in the world



arXiv:1509.00476

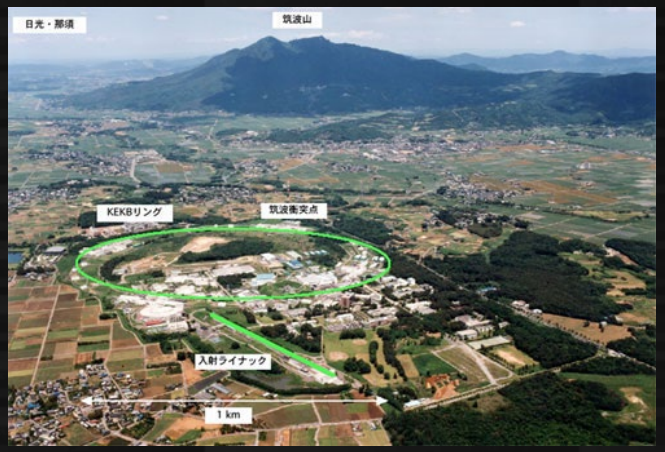


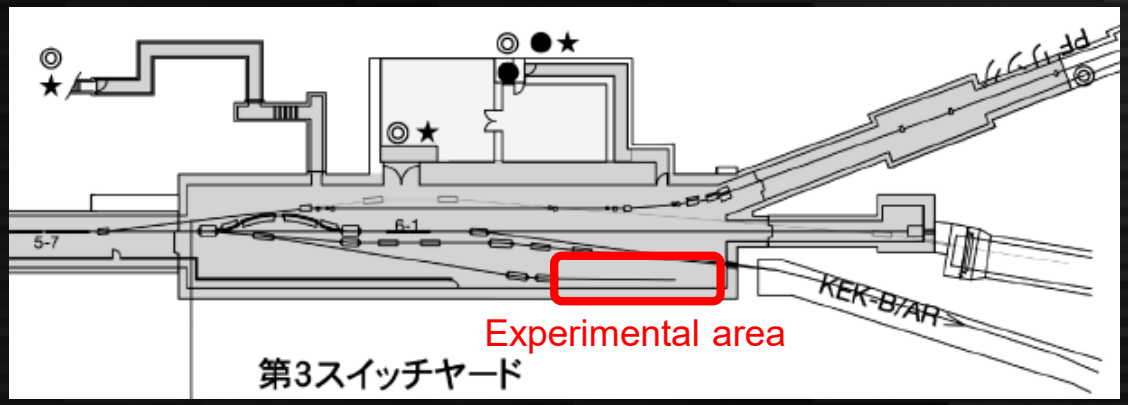
Beam dump experiments

Having sensitivity in Sub-GeV ALPs

The beam line

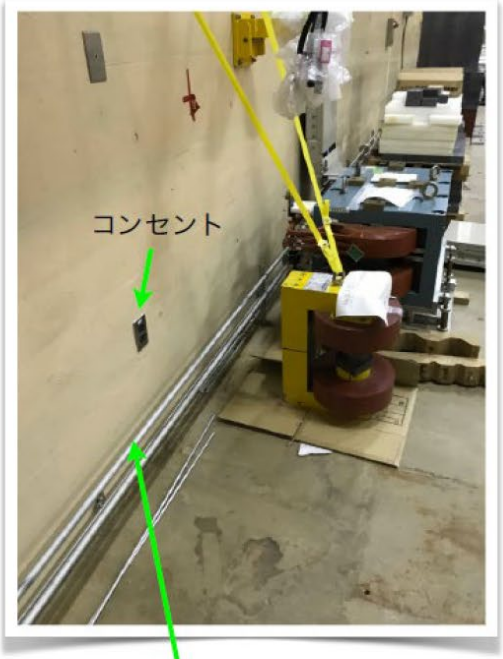
- KEK Linac (for SuperKEKB and Photon Factory)
  - e^- 7 GeV or e^+ 4 GeV, 50 Hz, $10^{9\text{-}10}$ / pulse
  - Beam dump at end of the linac
  - Only usable at the time without KEKB injection
    - This autumn: ~no operation at KEKB because of long shut down to install second layer of DEPFET pixel detector
    - Will have some Linac studies → possibility for experiment

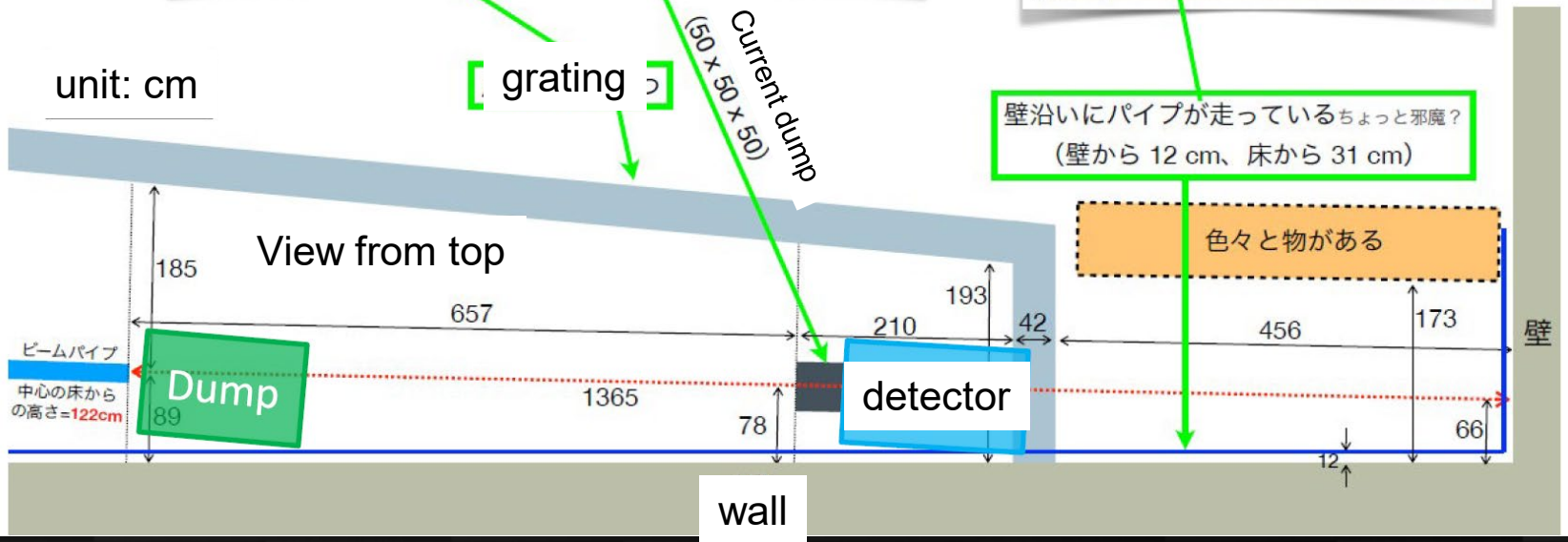




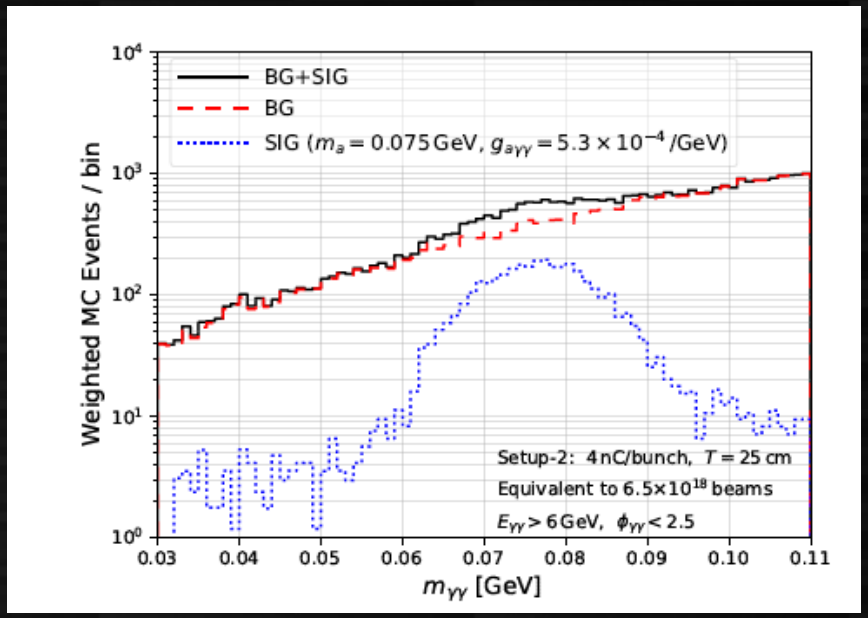
Experimental place

Linac beam port





Signal and background as setup 1



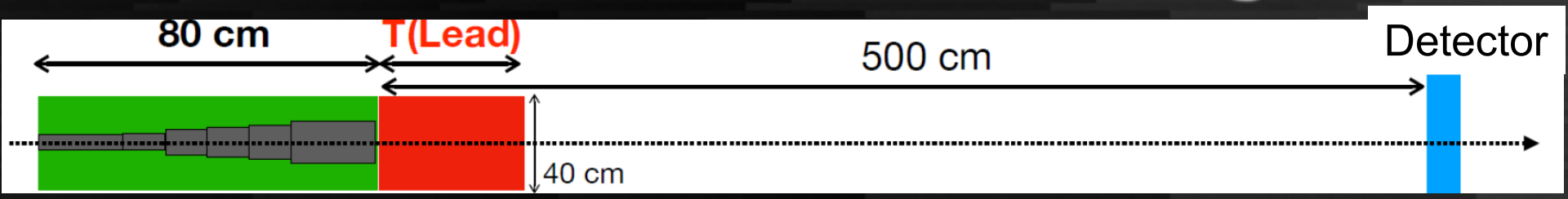
Signal: 2 photons with mass ~ 0.1 GeV

Angular separation needed
→ SiW-ECAL
(E_γ = 2+2 GeV, $m_{\gamma\gamma}$=0.2 GeV, 5m
→ 25 mm separation)

Background:

- Muons: veto charged particle at the front Si layer
  Need shielding to reduce occupancy to ~1%
  (simulation study ongoing)
- Neutrons:
  slow neutrons by timing
  fast neutrons: should be as low as avoiding accidental 2n
- Photons:
  should be lower than n

Detectors and shielding



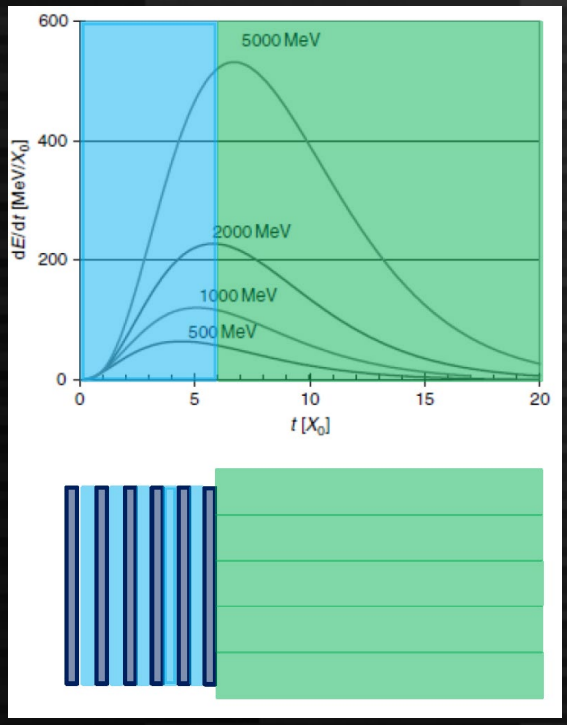
Tungsten + Iron Lead

Shielding study ongoing

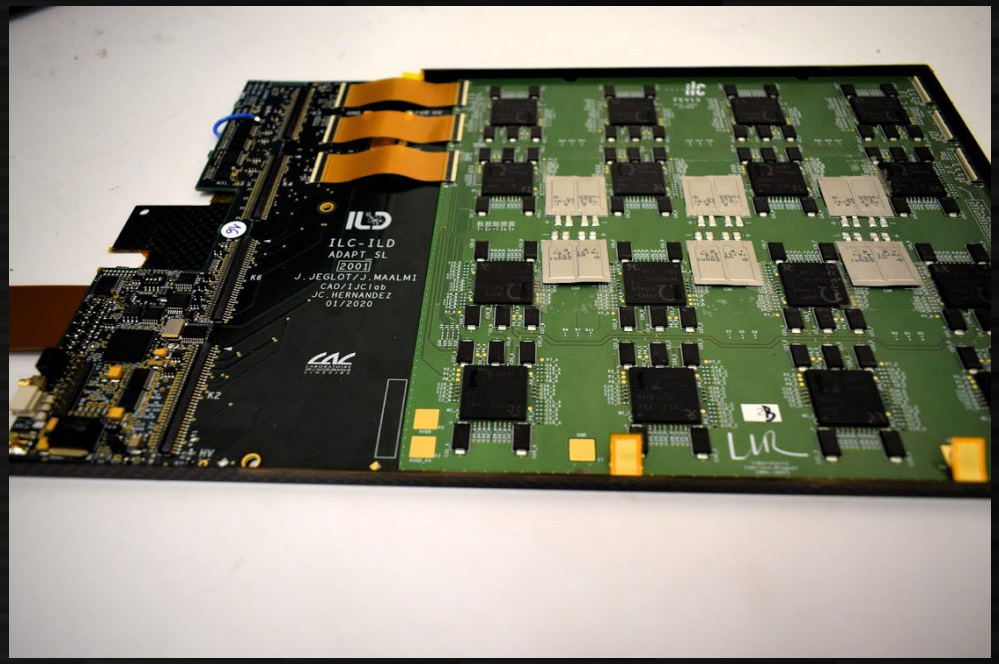
- Need more iron or hydrogen (PE) around the dump to reduce slow neutrons/photons around
- Probably ~2 m of lead needed to reduce muons

Detector

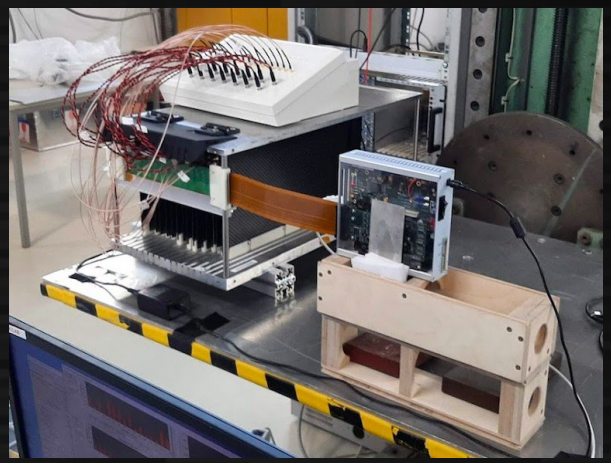
- Segmented layers (SiW-ECAL) in front + lead-glass with PMT for full absorption
  - For availability reasons
- ~40 x 40 cm^2 desired



SiW-ECAL



- 18 x 18 cm^2 / short slab
- ~15 layers (JP + FR)
  - Maximum:
    18 x 18 x 15 layers
    or 36 x 36 x 3-4 layers
- Readout by SL-board
  - 50 Hz marginal
  - TDC?



Mechanical structure
to be considered
(probably based on IJClab design)

Lead-glass + PMT + SAMPIC

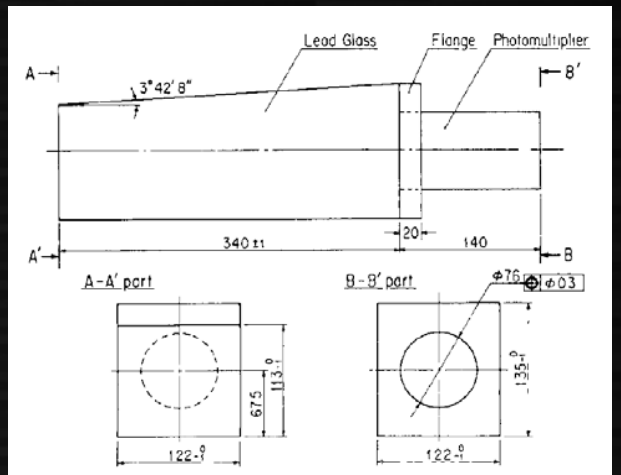
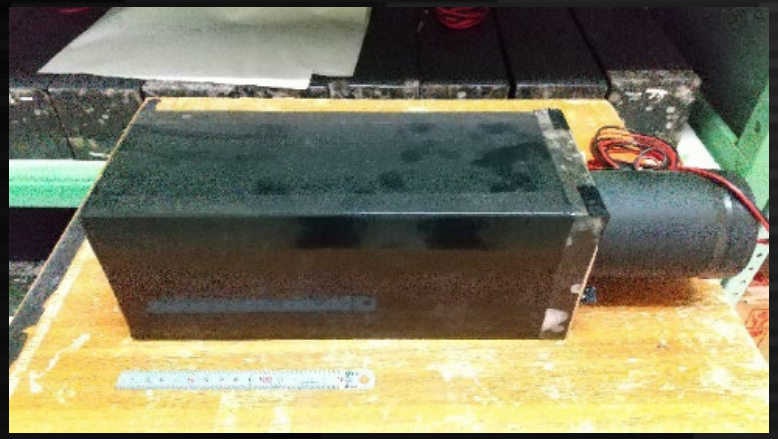


Fig. 3. The design of a lead-glass Cherenkov counter.



Lead-glass Cherenkov from old Tristan
Being activated (cosmic seen)

SAMPIC module from IJClab
16 ch readout 64 memory cells
with 1.6 (-10) GSPS clock

Concurrent run with SL-board
discussed with IJClab
(need firmware update)

Synchronized running

Core-module for SiW-ECAL SAMPIC for lead-glass

Acc. clock 50 Hz

trig

clock

filtered trig

- 50 Hz from acc. is used for start acq. for FEVs
  - Filtered if readout not finished in 20 msec
- Filtered trigger sent to SAMPIC for “enable”
  - Trigger counter and timing available as SAMPIC output used for synchronization
- Core-module send 5 MHz to SAMPIC, converted to 1.x GHz acquisition clock
- DAQ run independent, with concurrent time stamping

First beam time – planned in July

- A few SiW-ECAL layer + 16 Lead-glass
- Main purpose: background measurement
  - Particle: muon, photon, neutron
  - Energy distribution
  - Testing muon veto
  - Dependence on shielding
  - Spatial distribution (by moving detectors)
- Confirming concurrent run of ECAL + SAMPIC with beam trigger of 50 Hz
- Effect of radiation (is electronics OK?)
- (If spare-time) do a bit of first measurement
- Next beam time: hopefully autumn 2022 (for a week?)

Summary

- ALP search experiment planned in KEK linac
- SiW-ECAL is used to separate 2 photons (and also separating background)
- Lead-glass with SAMPIC readout concurrently runs with SL-board
- Preparation for July test beam ongoing rapidly
- First physics run expected in this autumn with setup-1 (no background)
- Setup-2 with sweeping magnet also being considered as next step