EBES experiment: Beam dump experiment at KEK Linac for ALP search

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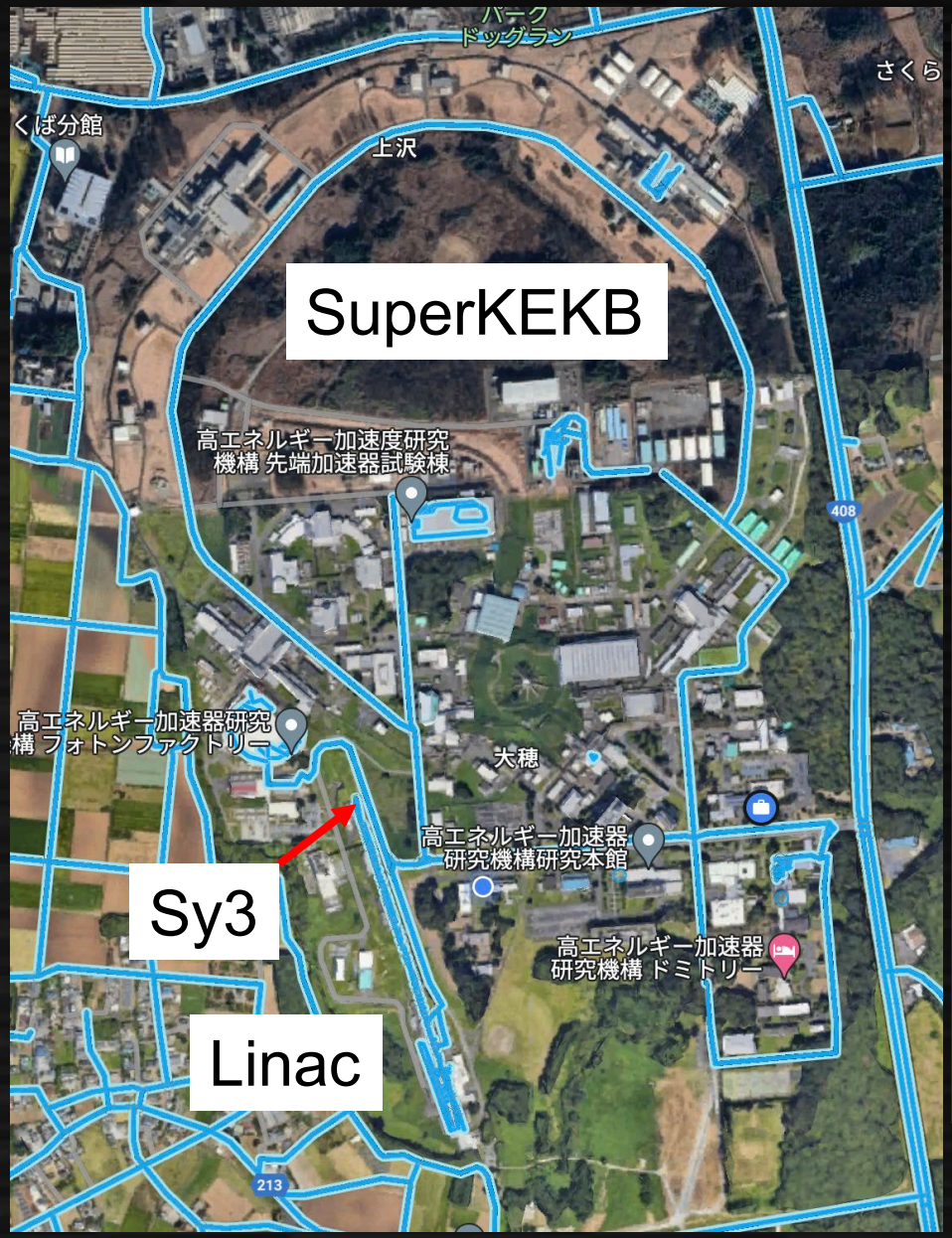
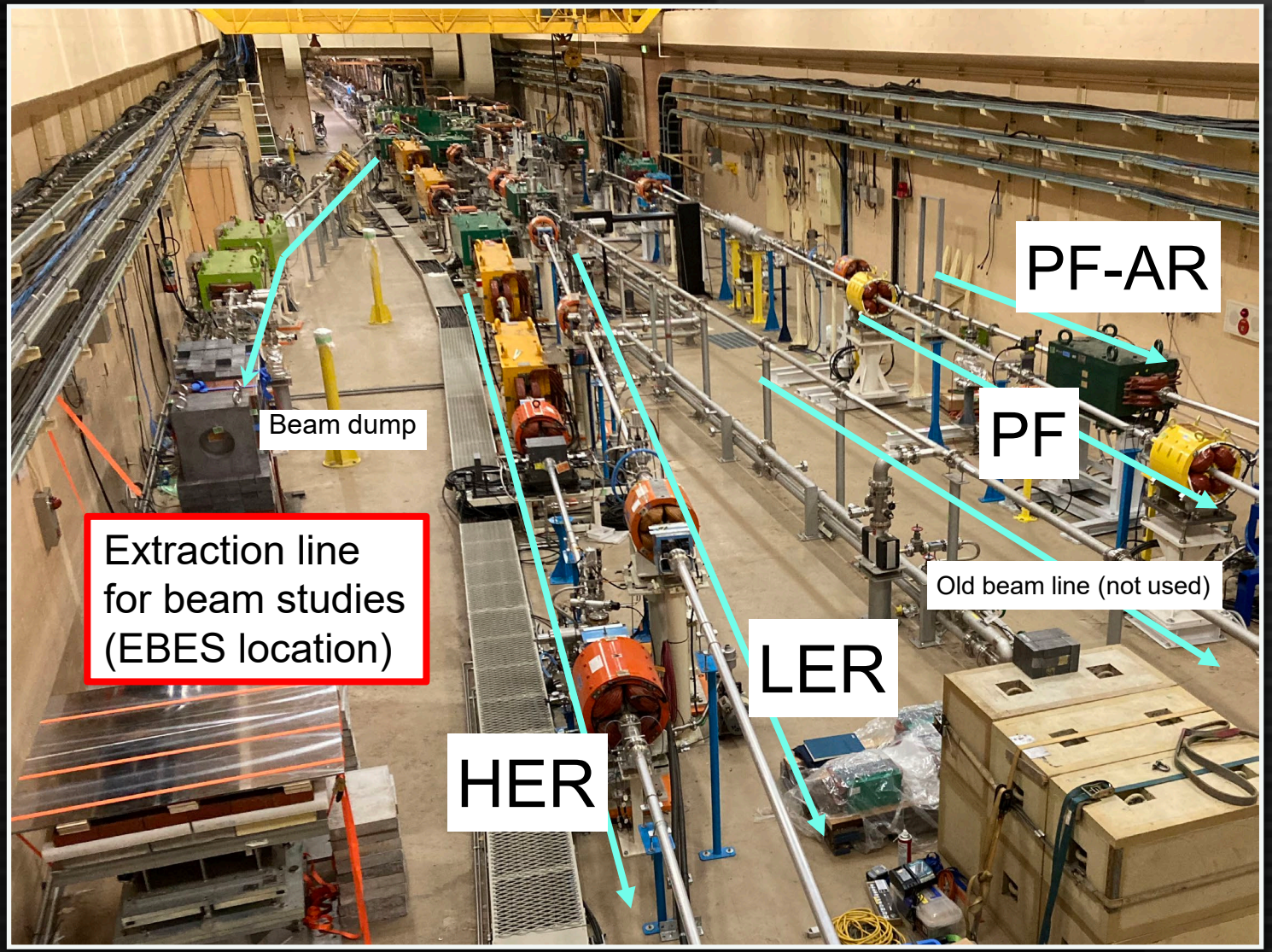
(Ishikawa, Sakaki, Takubo)

EBES experiment

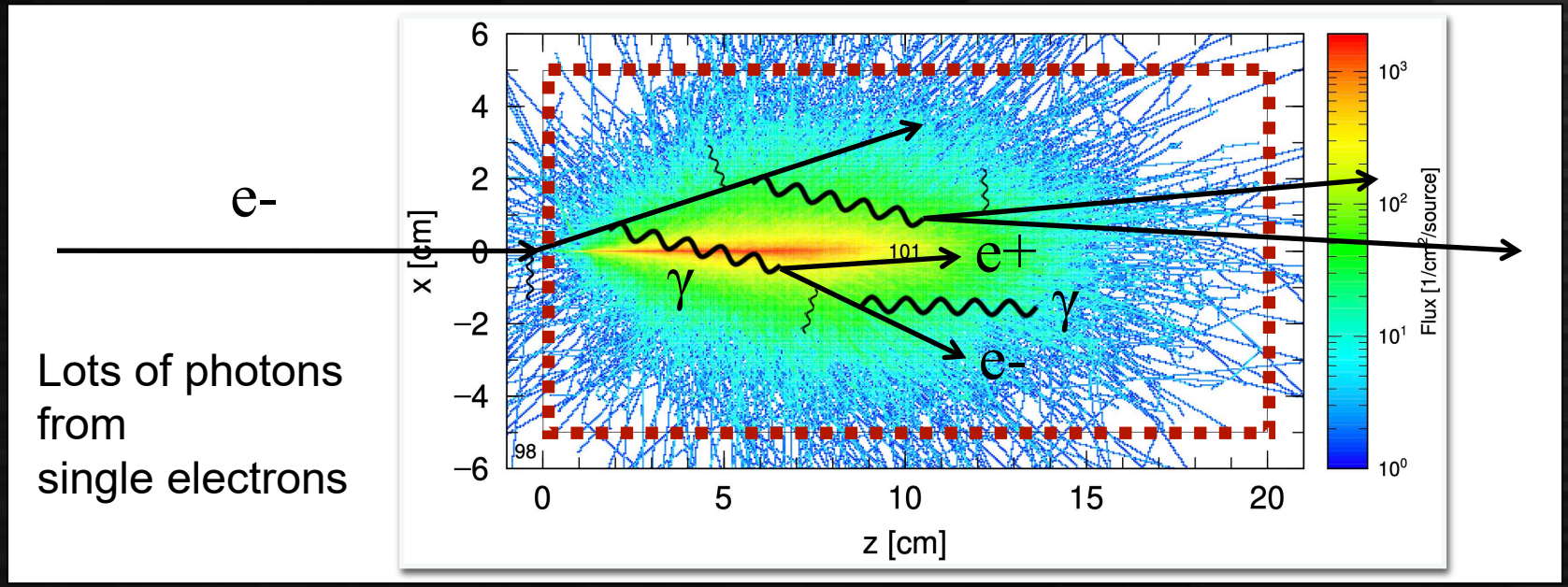
- EBES stands for:
  Electron Beam-dump Experiment at (KEK-Linac) Switching yard 3
- Beam dump experiment using high-intensity beam of KEK Linac
  - Injector of SuperKEKB/Belle II and photon factories (PF/PF-AR)
  - Electron (/positron), 4-7 GeV, ~3 nC x 25 Hz
    - Up to O(10^{18}) electrons-on-target possible
- Aiming for quick realization of the experiment
  - Starting in 2021, pilot runs in 2022/23
  - Reusing existing detector: PbO and high-granular Silicon-tungsten ECAL
    - Developed as detector component of Higgs factories

KEK Linac switching yard 3 (Sy3)

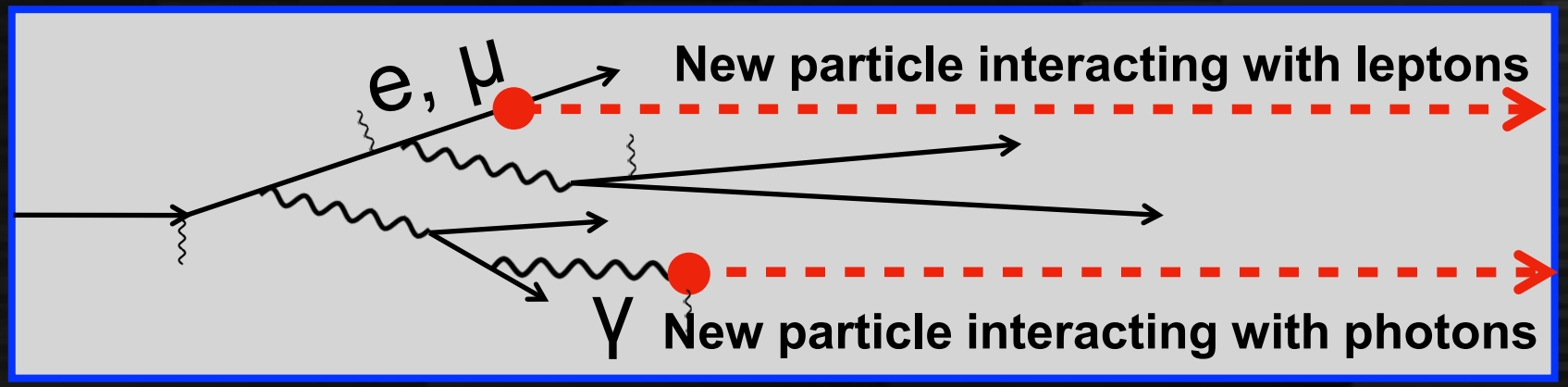




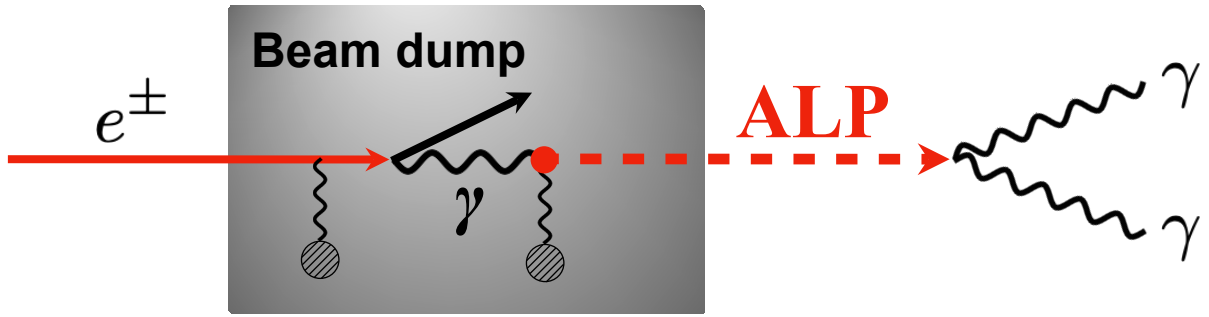
Benefit of beam dump experiment



New particle produced
from numerous particles
inside the beam dump
→ detected behind
the dump
(dump is shielding SM particles)



First target of EBES: ALP search



（Primakoff effect）

Past experiments utilized long shielding
→ insensitive to medium coupling ALP since ALP is reconverted to photons before reaching detectors

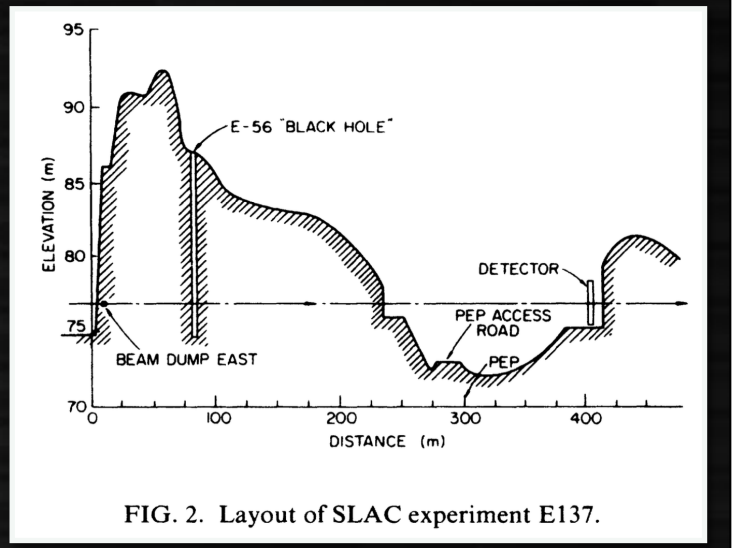
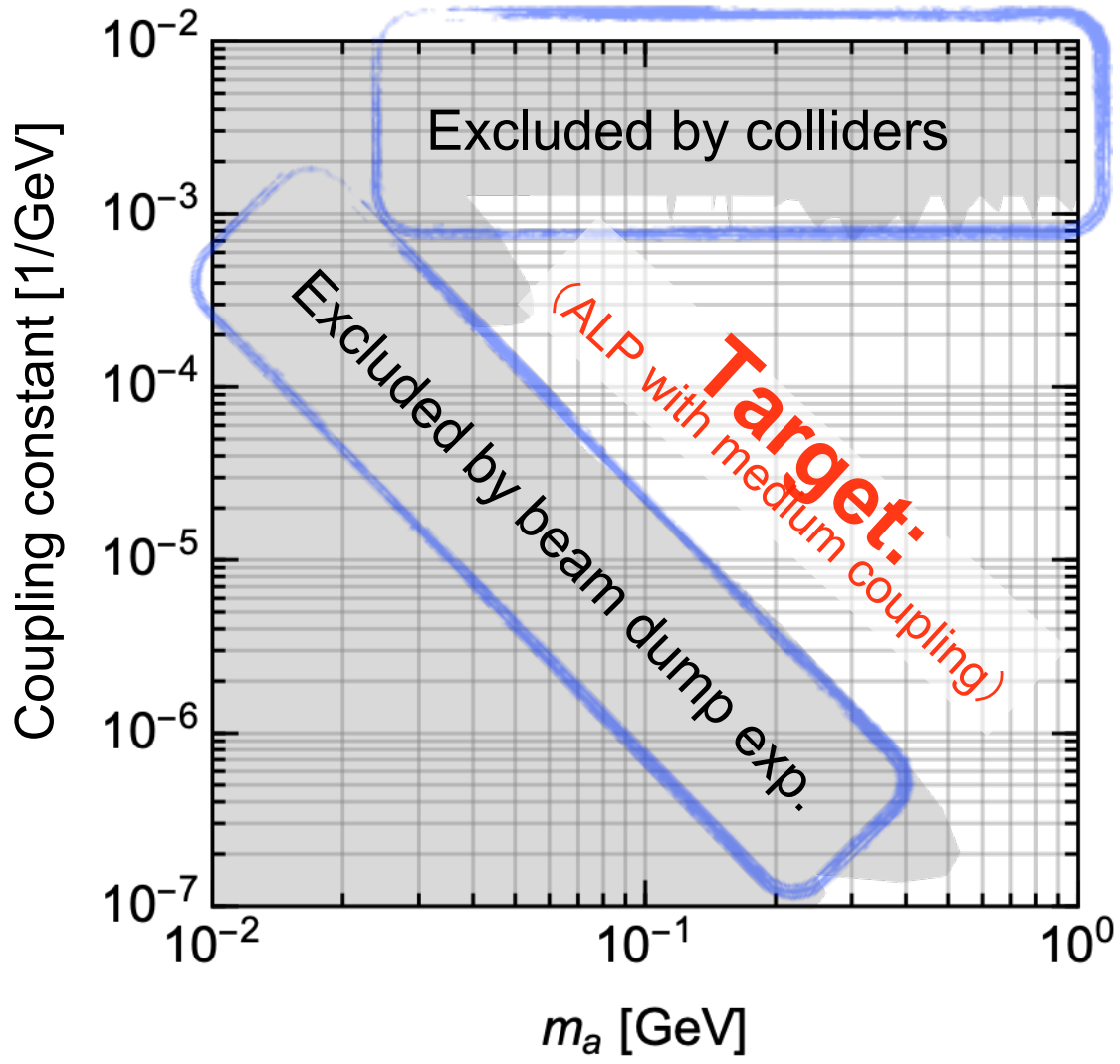


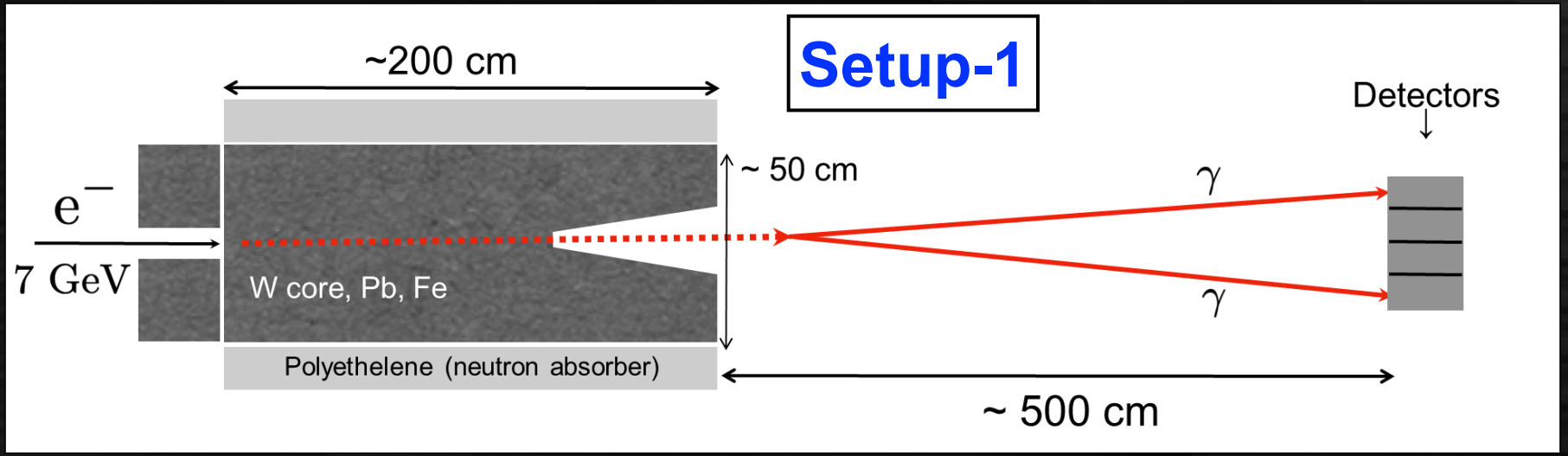
FIG. 2. Layout of SLAC experiment E137.

Short shielding experiment can fill the gap

（Gray: excluded）

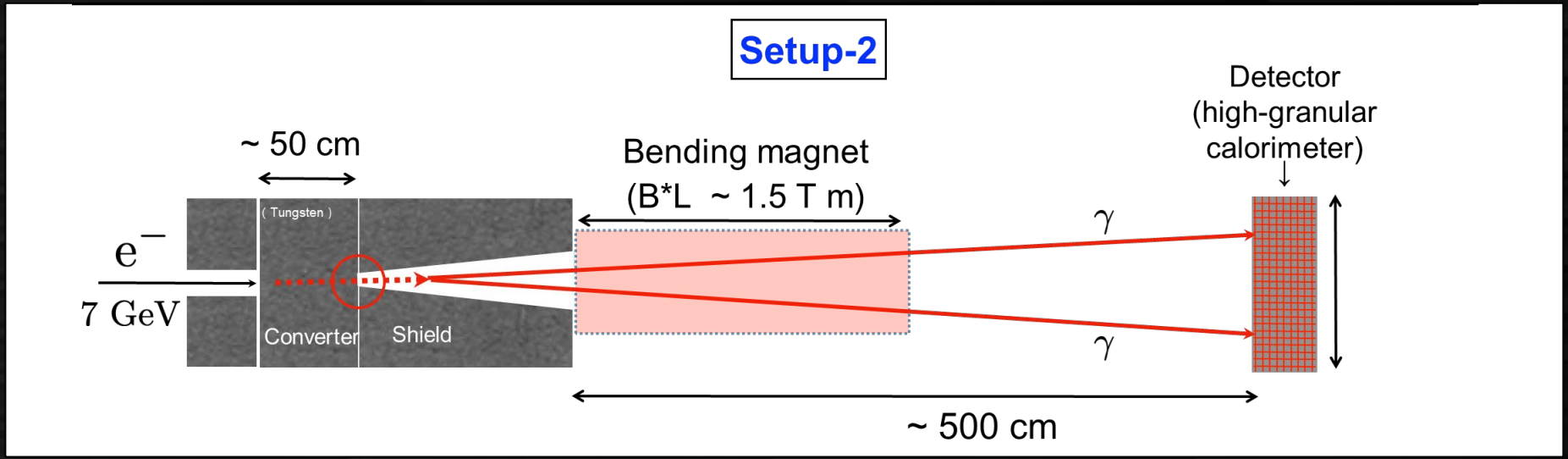


Our planned setup



Thick shield to stop all particles

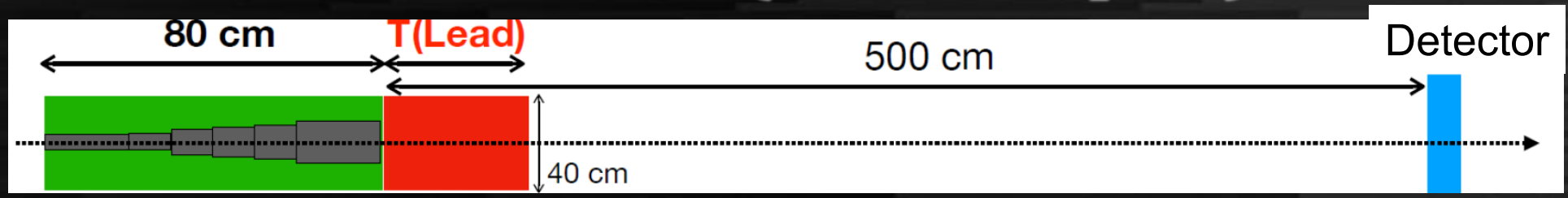
Easier in terms of background



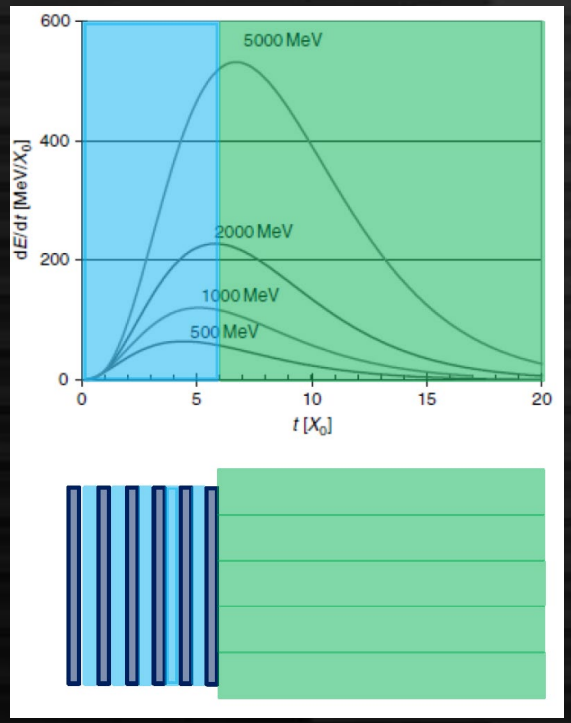
Bending magnet to sweep background (mostly muons)

Sensitive to higher coupling

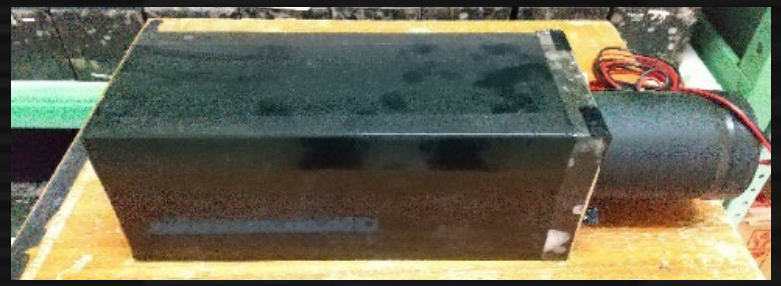
Detectors (for setup-1)



Tungsten + Iron Lead



SiW-ECAL (5 x 5 mm^2 cells) developed for ILC, ~5 layers



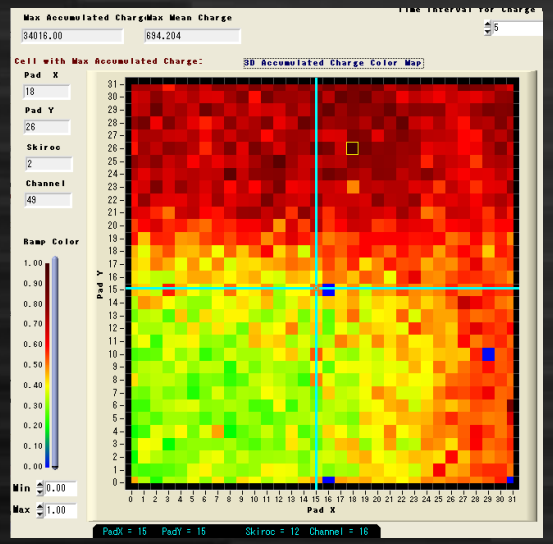
Lead-glass + PMT
from TOPAZ
12x12 cm^2 / module

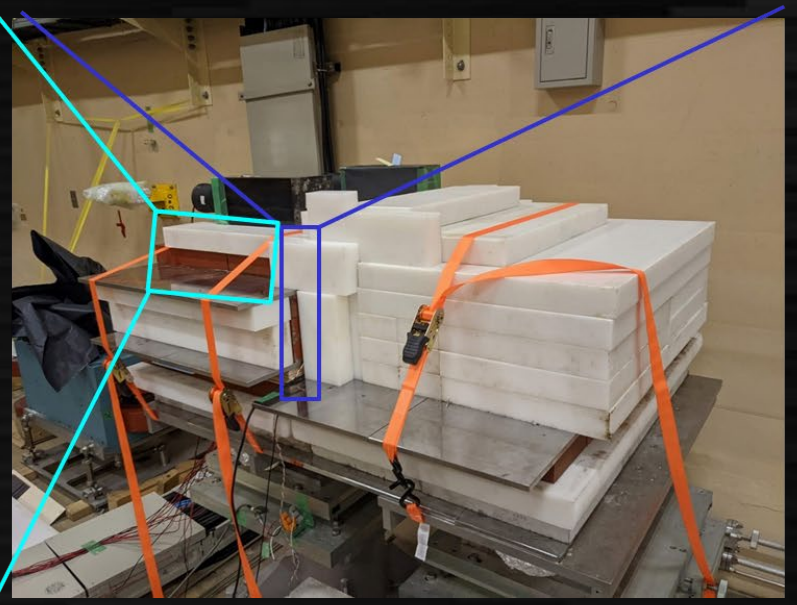
2-photon separation and background veto at forward layers,
total energy at backward layers

The first pilot run in 2022

~1 m of neutron shield (polyethylene) in front of detectors

Using Si stack from IJClab (but only one layer, no tungsten)



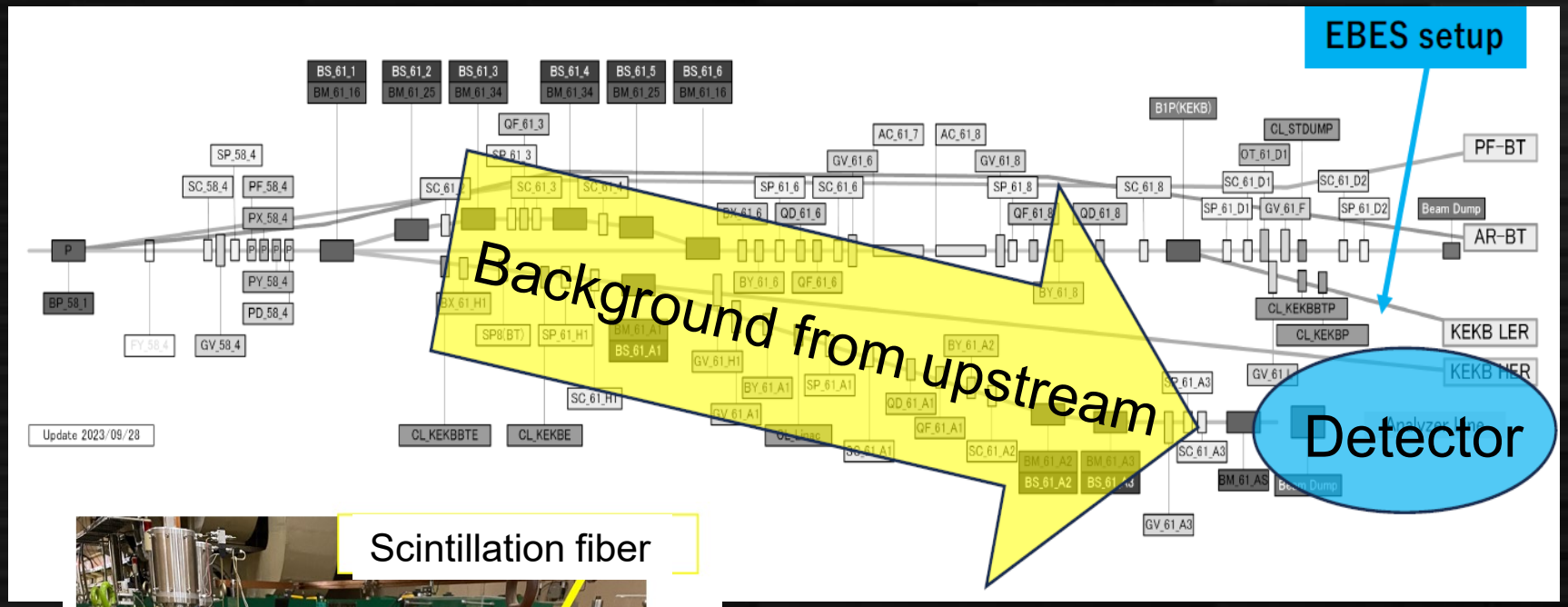


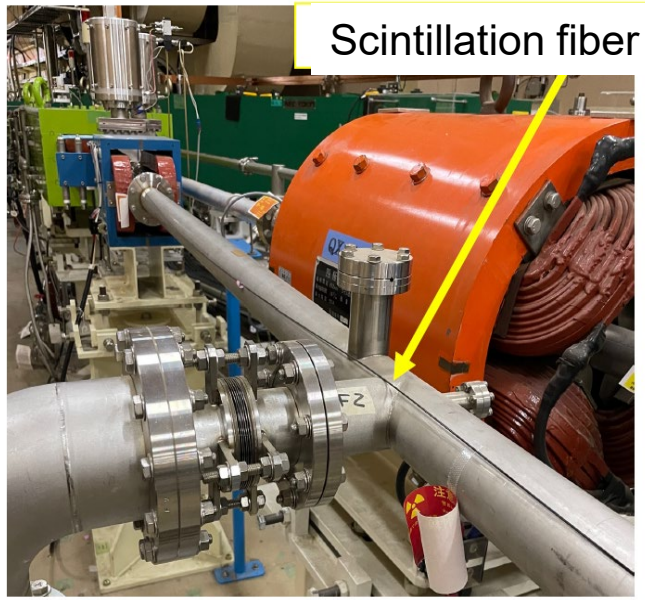
Huge background (~10000 per bunch) from upstream

Necessary to reduce beam-related background

Understanding beam background (2023)

Switching yard 3



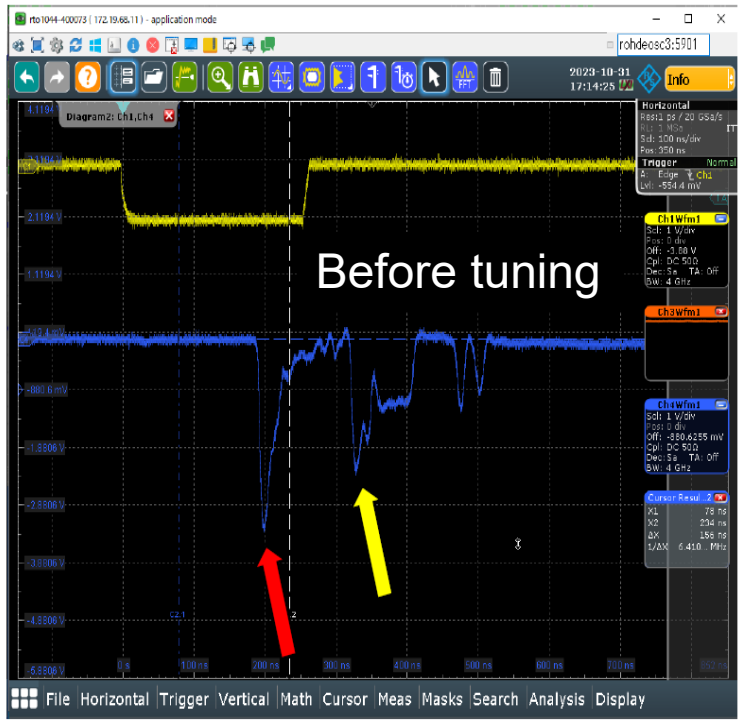


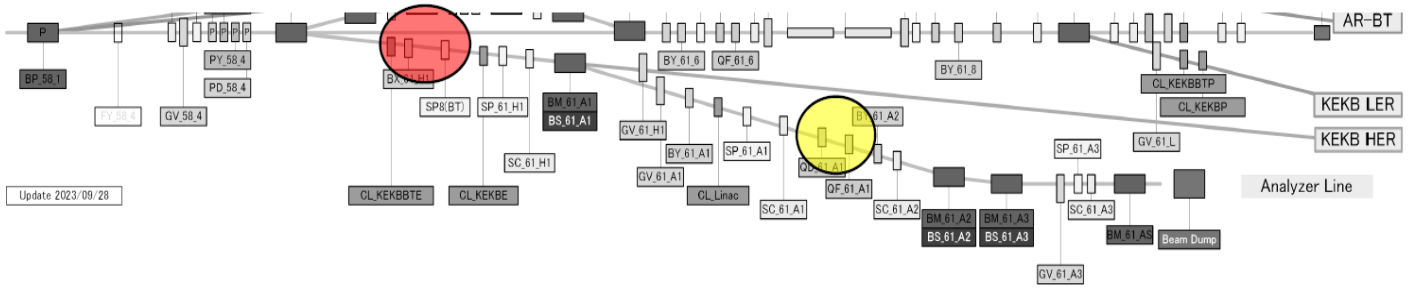
Scintillation fiber produces signal around the beam pipe on which particles hit and produce background

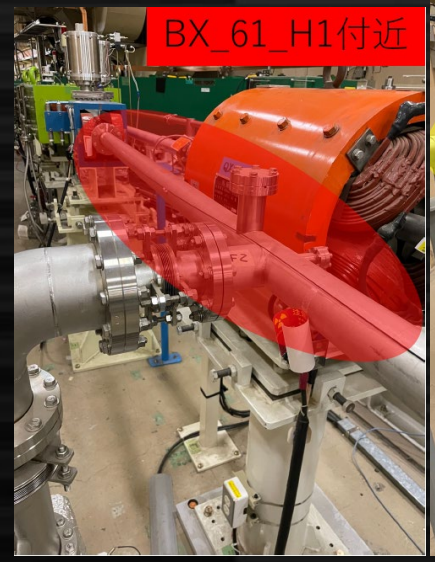
Position can be obtained from timing spectrum

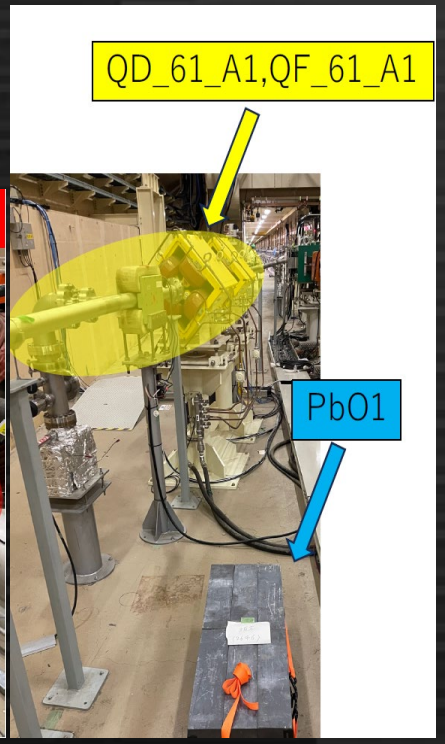
Shielding of beam dump is also updating

Reduction of background by beam tuning





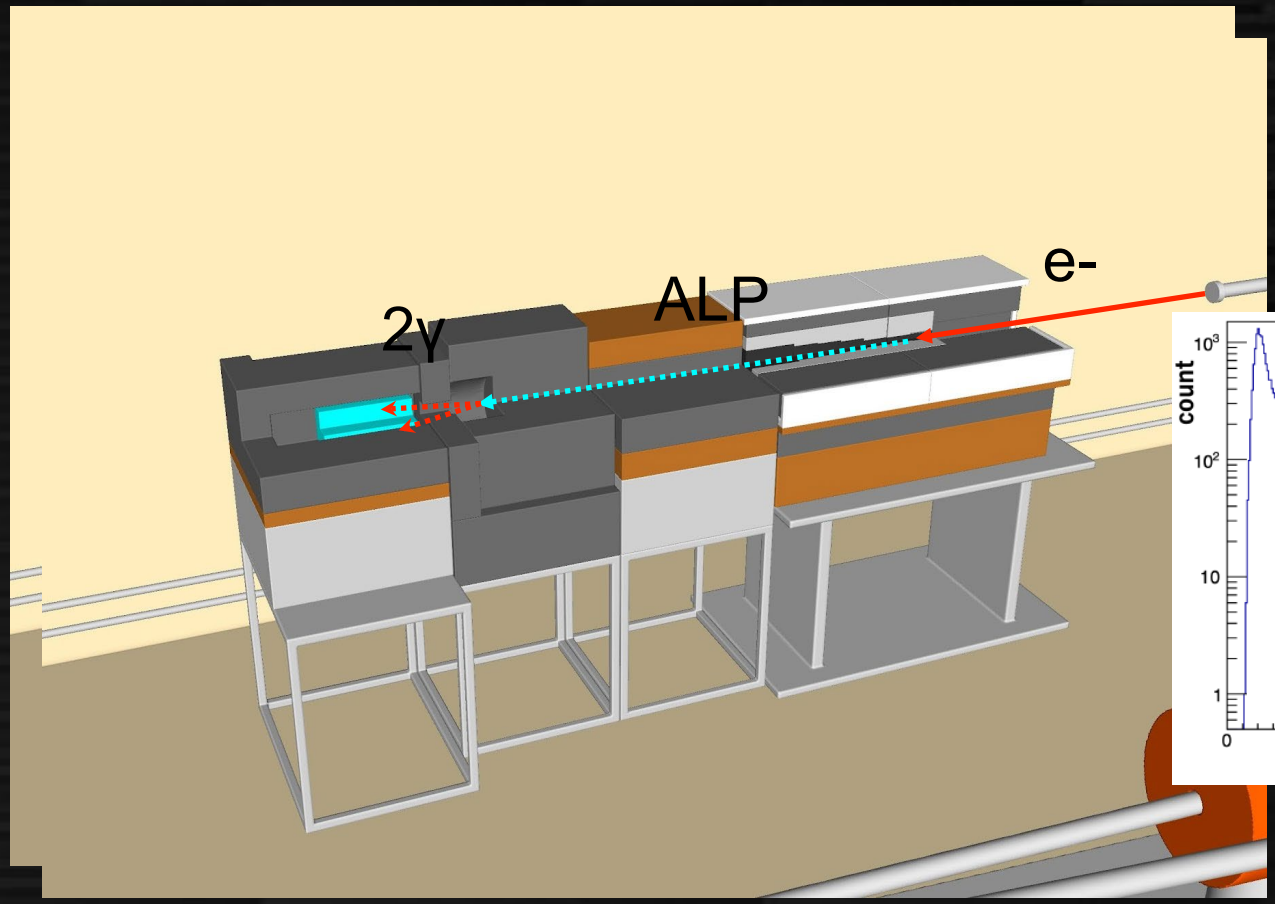


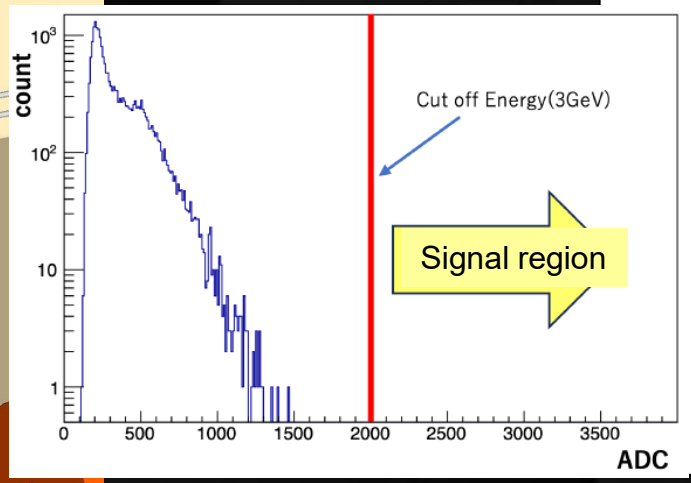


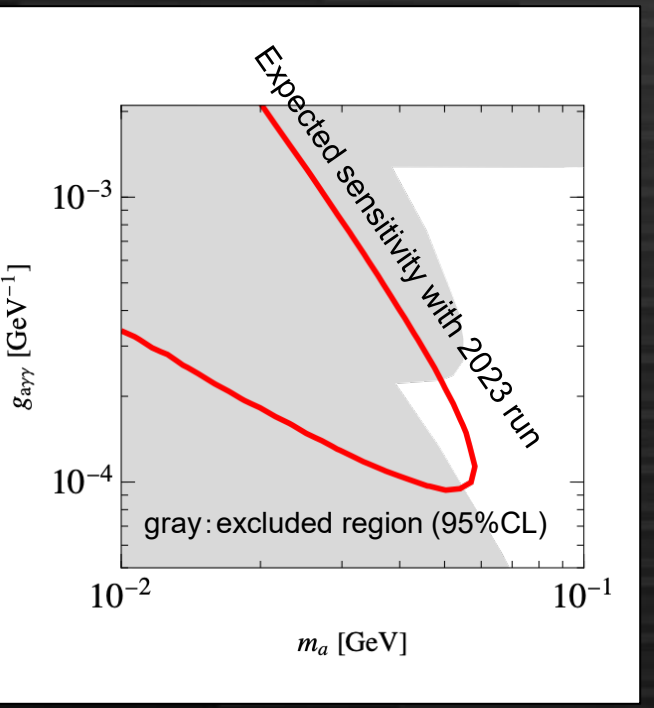
Hitting places found
With beam tuning reduction
of ~2 order of magnitude
obtained (but still not enough)

Pilot run with very short re-conversion length

in Dec. 2023



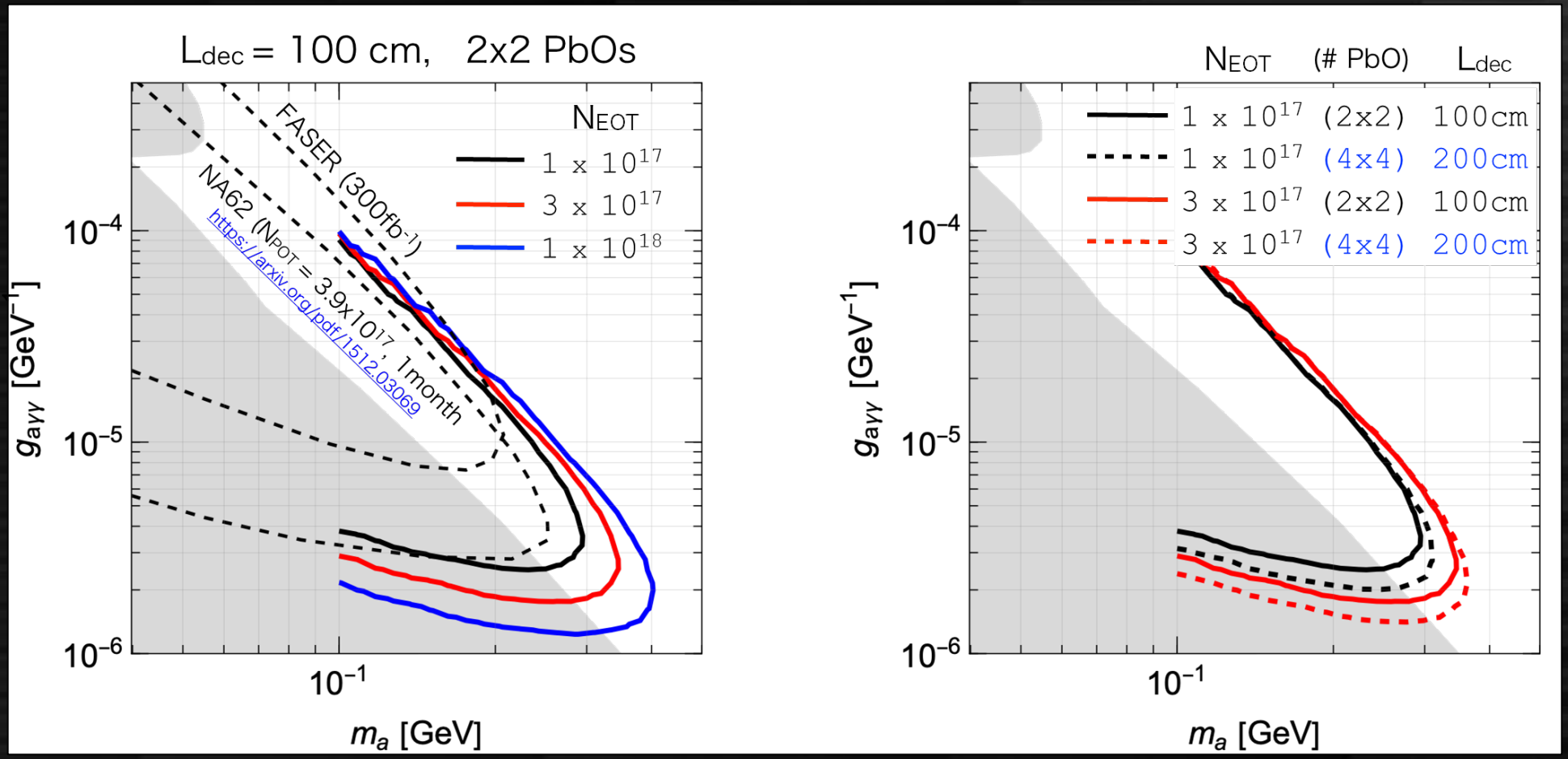




Almost no distance to reconvert ALP → 2γ
but background is shielded by beam dump itself! (background source not seen from detector)

Already should give slight cut of current exclusion limit
(statistics only, need to confirm)

Planned sensitivity



Need to update shielding and improve beam tuning for 100 cm L_{dec}
Additional shielding being prepared, as well as DNN-based tuning method
Also including high-granular silicon calorimeter for background reduction

Plans and future prospects

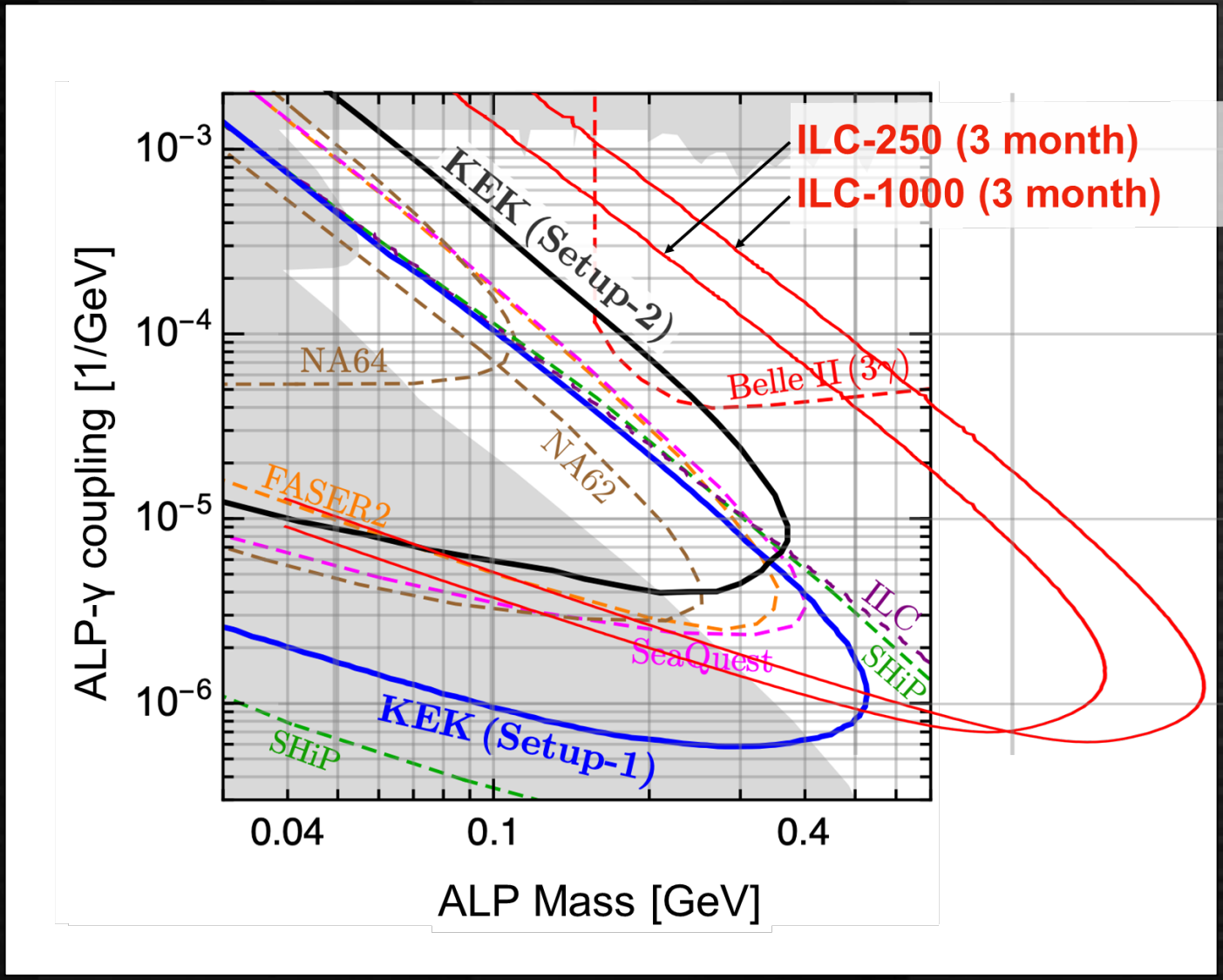
We will try to do a physics run during 2024-2025 (depending on availability of the beam)

- With 50-100 cm L_{dec} depending on background
- SiW-ECAL introduced again (need to optimize mechanics and readout software)

Will proceed to Setup-2 if magnet is available

- Having prospects of magnet

Far future: (I)LC beam dump experiment



LCWS2024 @ Tokyo (Jul. 8-11 – next week!)

~250 onsite participants (+100 remote)

Remote registration still possible
website:
https://agenda.linearcollider.org/e/lcws2024

Also having Sachio Komamiya memorial session on evening of 9th (no registration necessary)