LC Vision Community Event:

# Facilities for Beyond Collider Experiments and Technology R&D

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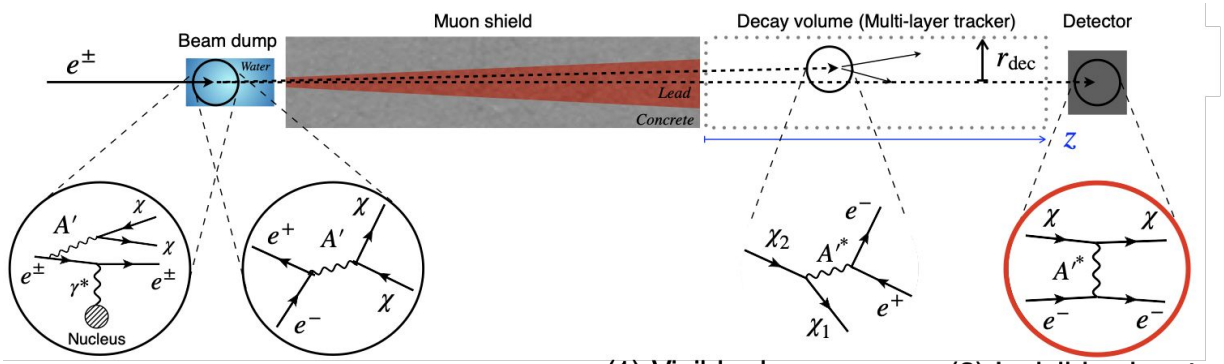
# Locations of Beyond-Collider Facilities

- main beam dump
  - beam dump new physics searches
  - neutron & muon irradiation facilities
- tune-up dump
  - (thin target new physics searches)
  - (high-energy photon source)
  - strong-field QED / beam-laser interaction
  - plasma-wakefield accelerator R&D
- 2nd interaction point
  - strong-field QED / beam-beam interaction

# Main Beam Dump

# Beam Dump New Physics Searches

physics covered in yesterday's talk by Mihoko Nojiri [link]




(1) Visible decay

**Beam dump** is better
(ILC, BDX)

(2) Invisible signature

**Missing searches** is better
(LDMX, NA64)

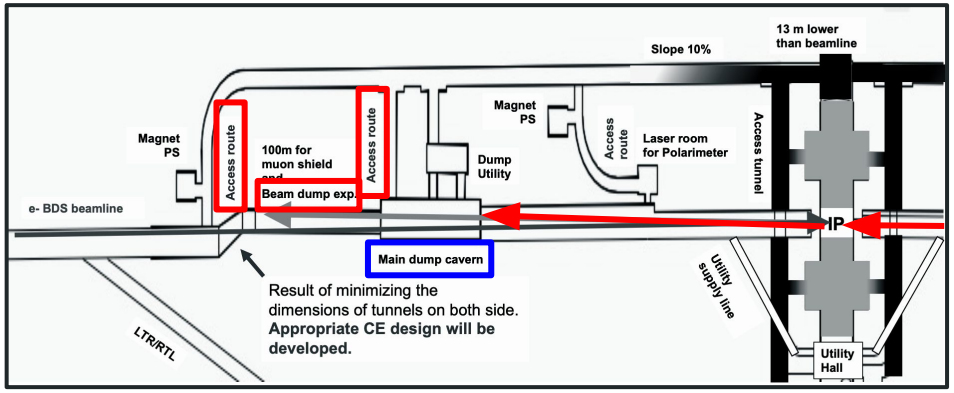
# Extension of the Main Beam Dump Facility

**additional facilities:**

- space downstream of the main dump cavern
  - muon shield (5 x 5 x 50-100 $m^3$)
    + decay volume (5 x 5 x 50-100 $m^3$)
    + detector
  - width depends on the beam crossing angle and the distance from the IP to the dump
- access routes

**advantages of each dump:**

- $e^+$: enhances the signal ($e^+e^-$ ➔ X) and increases the number of high-energy muons.
- $e^-$: allows the use of highly polarized beams.




**courtesy**: N. Terunuma (2024)

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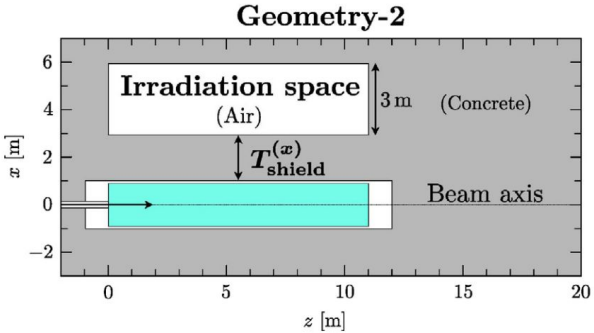
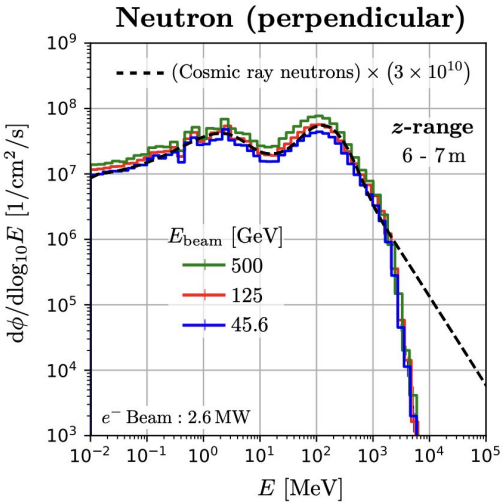
# Neutrons & Muons Irradiation Facilities

- our lives increasingly rely on larger integrated circuits
- the demand for verifying their reliability grows [link]
  ➔ *assessing the soft error rate of an entire circuit caused by neutrons / muons*
- required conditions for the irradiation field:
  - high intensity
  - large area (to irradiate large systems as a whole)
  - atmospheric-like spectra
- *the vicinity of an LC beam dump meets all these requirements*

# Neutrons & Muons Irradiation Facilities

- cavern of 3 x 3 x 10 $m^3$
- on the **side** of the beam dump
- remote exchange of device under test is highly desirable (a.k.a. required)




**courtesy**: Y. Sakaki et al. (2023)

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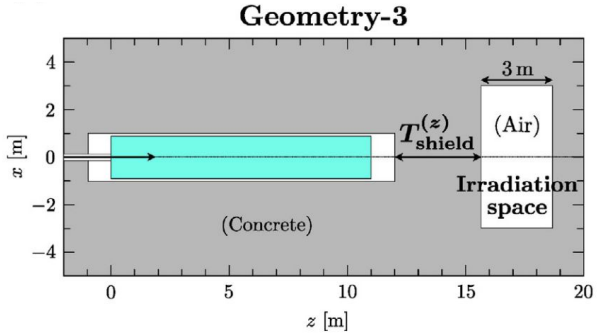
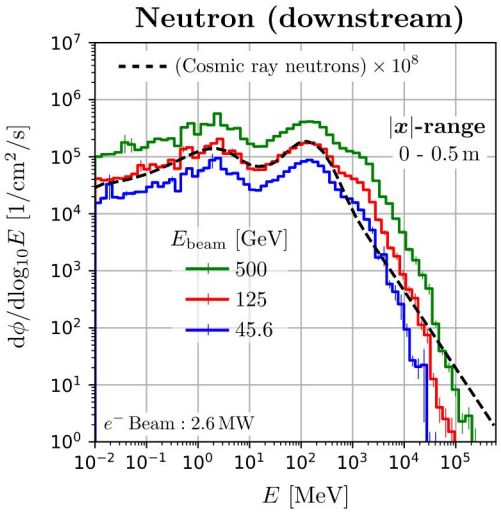
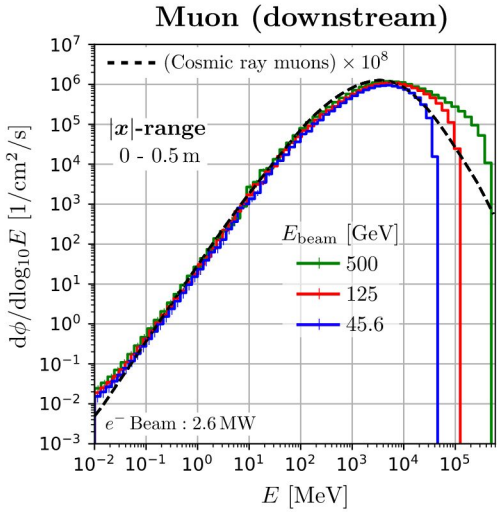
# Neutrons & Muons Irradiation Facilities

- cavern of 3 x 3 x 6 $m^3$
- **downstream** of the beam dump
- remote exchange of device under test is highly desirable (a.k.a. required)




**courtesy**: Y. Sakaki et al. (2023)

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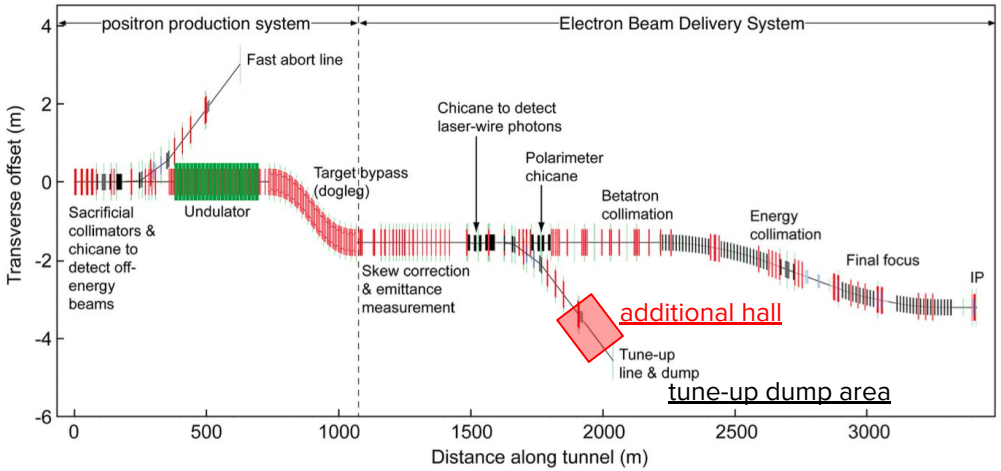
# Tune-Up Dump

# Beamlines for $e^+$ / $e^-$ with Maximum Energy




**courtesy**: ILC TDR I Volume 3.II (2013)

- hall size: 5-10 x 10 x 50 $m^3$
- two possible locations
  - tune-up dump area
  - additional hall
- beam properties at tune-up dump?
- possible to change energy / charge?

**ILC parameters at initial stage**

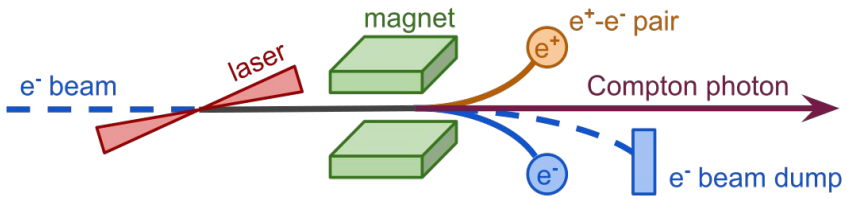
| Quantity | Symbol | Unit | Initial |
|---|---|---|---|
| Centre of mass energy | $\sqrt{s}$ | GeV | 250 |
| Repetition frequency | $f_{\mathrm{rep}}$ | Hz | 5 |
| Bunches per pulse | $n_{\mathrm{bunch}}$ | 1 | 1312 |
| Bunch population | $N_{\mathrm{e}}$ | $10^{10}$ | 2 |
| Linac bunch interval | $\Delta t_{\mathrm{b}}$ | ns | 554 |
| Beam pulse duration | $t_{\mathrm{pulse}}$ | $\mu$s | 727 |

**courtesy**: The International Linear Collider: Report to Snowmass 2021

# Strong-Field QED: Beam-Laser Interaction

**beam-laser interaction:**

- IP chamber (4 $m^2$)
- diagnostics in forward region (20-30 m)
  - (quadrupole imaging system)
  - dipole spectrometer
  - electron/positron detection systems
  - photon detection systems




**laser facility:**

- 200 TW system
  - e.g. Thales QUARK 200
  - container-sized (4 x 4 $m^2$ optical table)
- 10 PW system
  - e.g. ELI-NP, Apollon
  - hall-sized (roughly 20 x 50 $m^2$)
- key requirements
  - building above ground
  - feed-through to IP
  - vibration stability
  - MW power consumption
  - thermal management
  - cleanroom environment

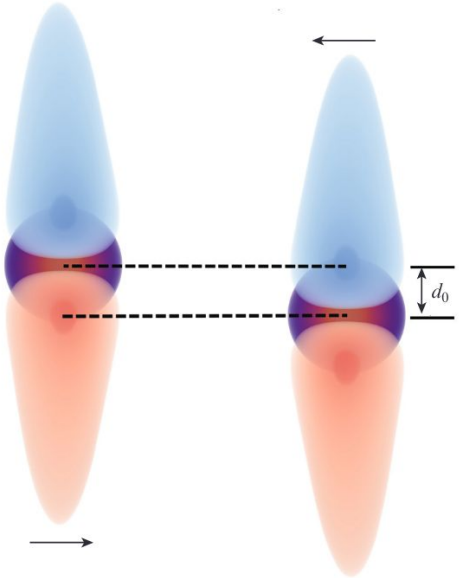
# Plasma-Wakefield Accelerator R&D

- tune-up dump area can/should be used for PWA development and R&D
- facility could also be used to investigate plasma deceleration (e.g. for energy recovery)
- beam requirements similar to FLASH@DESY or FACET-II@SLAC
  - two bunches with separation of O(100 fs - 1 ps)
  - normalized emittance of O(1 µm)
  - beam size of O(1 - 10 µm)
  - ➔ everything to be checked
- for LCF@CERN: proton-driven PWA possible (i.e. AWAKE)

# 2nd Interaction Point

# Strong-Field QED: Beam-Beam Interaction

- systematic investigation of beam-beam interaction crucial for future ($\gtrsim$ 1 TeV) collider
- tuning of interaction parameters (?)
  - beam shape $\sigma_x$ / $\sigma_y$
  - beam displacement $d_0$
  - beam energy
- diagnostics in forward region (?)
  - Beamstrahlung
  - $e^+e^-$ pairs (dipole spectrometer)
- possible to have the 2nd IP further away in a separate interlock to have independent access?




**courtesy**: M. Filipovic et al. (2021)