New opportunities @ JLAB using secondary beams

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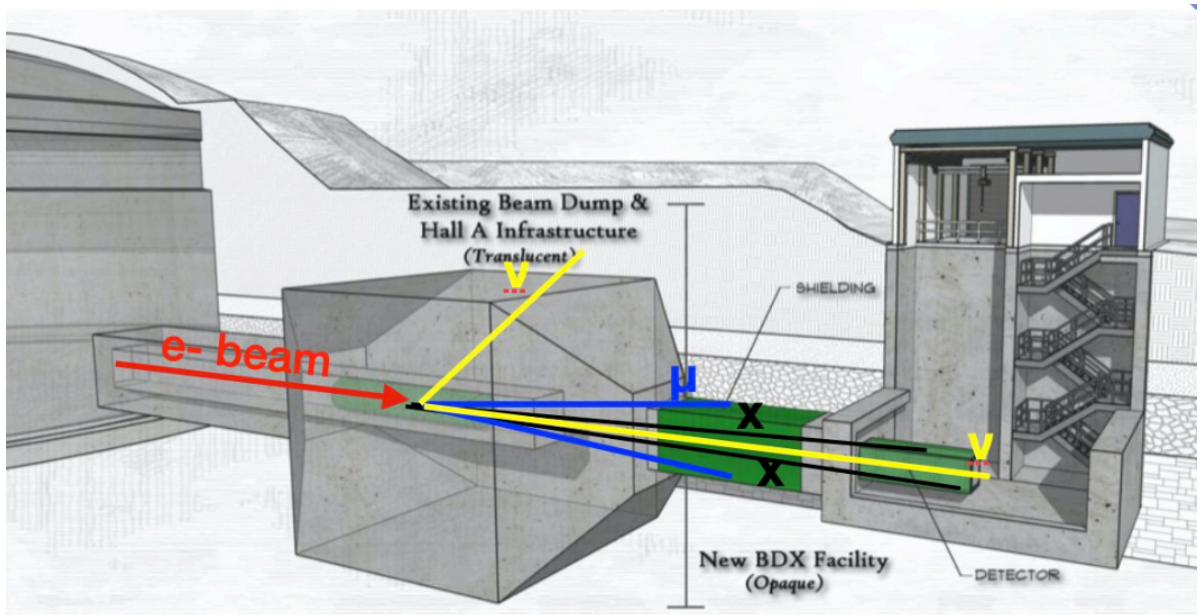
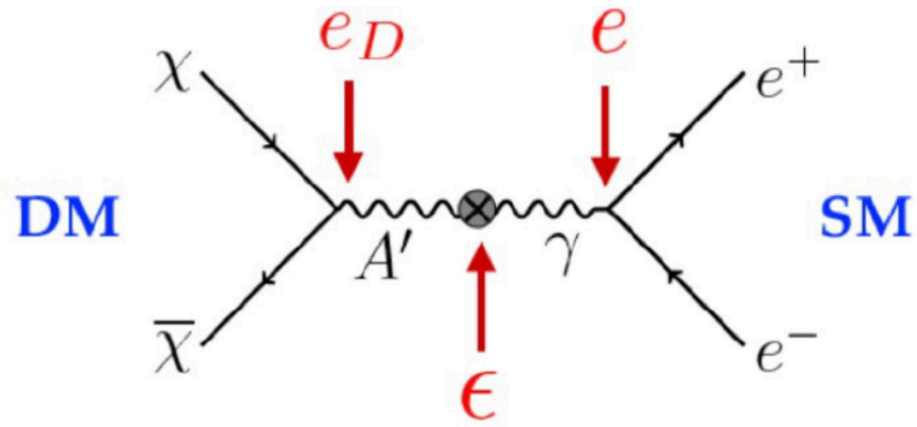
Secondary beams @ JLAB

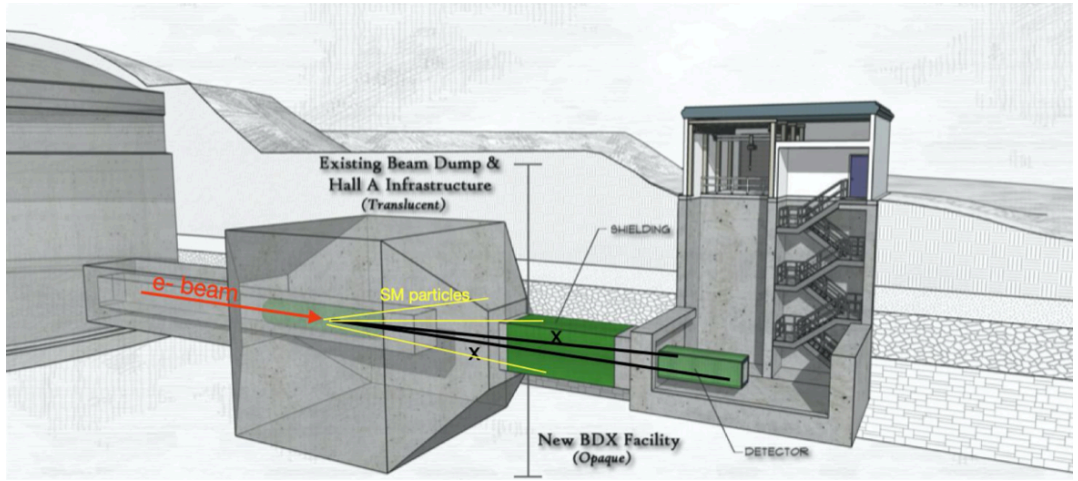
- **JLAB offers the highest intense O(GeV) e- beam in the world**
- Use the primary e-beam to produce high intensity secondary beams
  - Muons
  - Neutrinos
  - Light Dark Matter (if exists)
- Potentially could trigger the interest of new communities
- Studied the secondary beams produced by the interaction of the e-beam and thick target (i.e. Hall A beam dump)



Light Dark Matter “beam”

- Light Dark Matter in the mass range 1MeV - 1GeV
- Simplest model: **vector-portal**.
  - DM-SM interaction through a new U(1) gauge-boson (“dark photon”) coupling to electric charge
- Three main A’ production mechanisms:
  - A’-strahlung
  - Non-resonant e+e- annihilation
  - Resonant e+e- annihilation
- **Beam Dump experiment**: secondary beam of LDM particles produced by the A’ invisible decay and detected in a detector downstream the dump

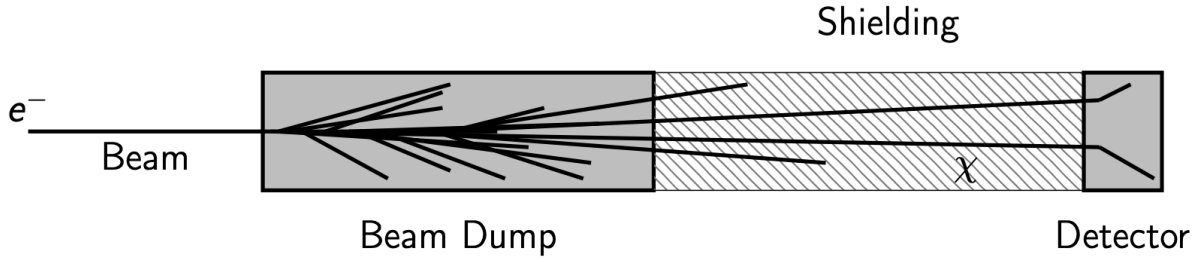


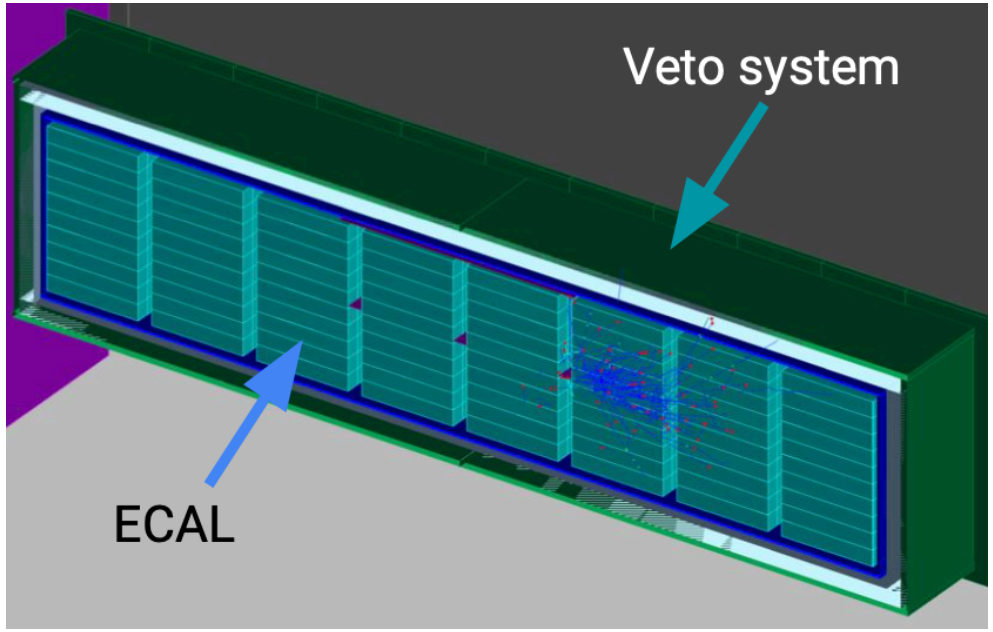


Credit to BDX collaboration

Beam Dump Experiment - BDX@JLAB

- BDX@12 GeV is a JLAB experiment approved by PAC46
- **Experimental setup:**
  - Detector installed in a new Hall O(20 m) behind Hall-A beam dump
  - Passive shielding layer between beam dump and detector to reduce SM beam-related background
- **Detector Design**
  - EM calorimeter (~1m3) based on CsI(Tl) + SiPM
  - Dual active-veto layer made of plastic scintillator counters + SiPMs readout
  - Passive lead layer surrounding the calorimeter

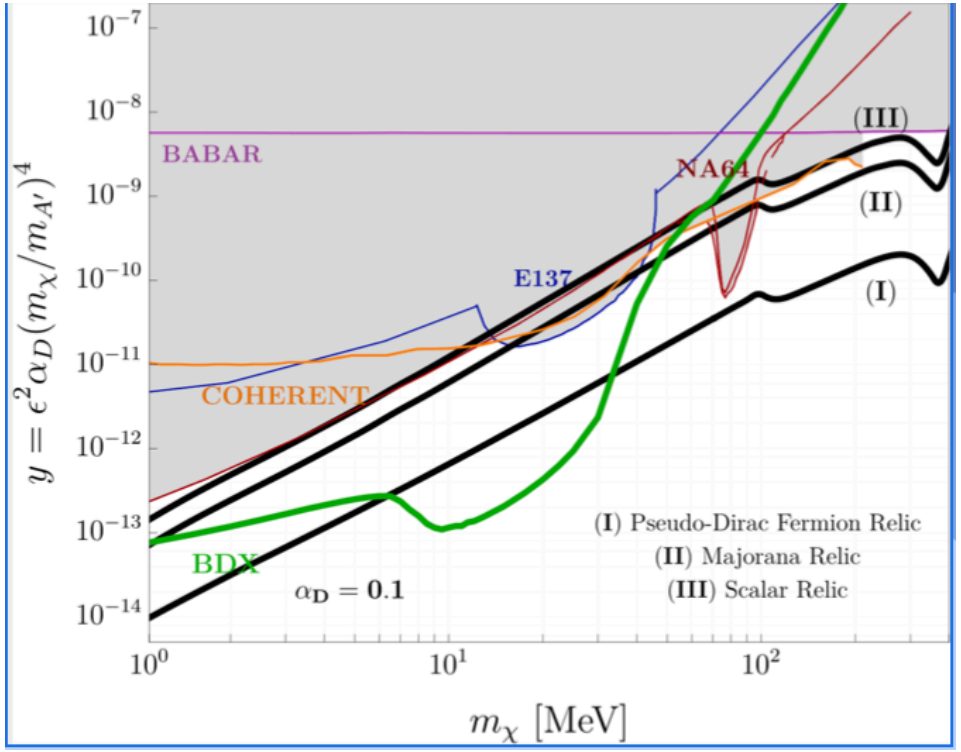


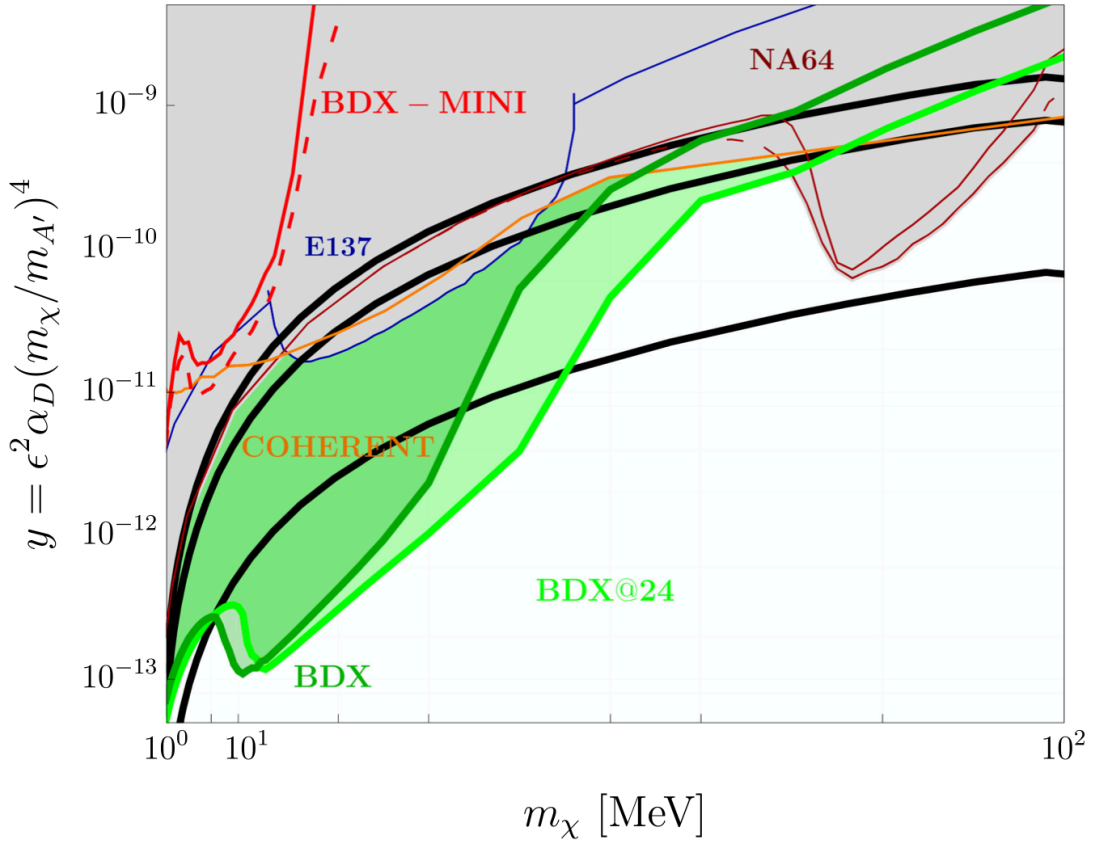


Credit to BDX-collaboration

Beam Dump Experiment - BDX@JLAB

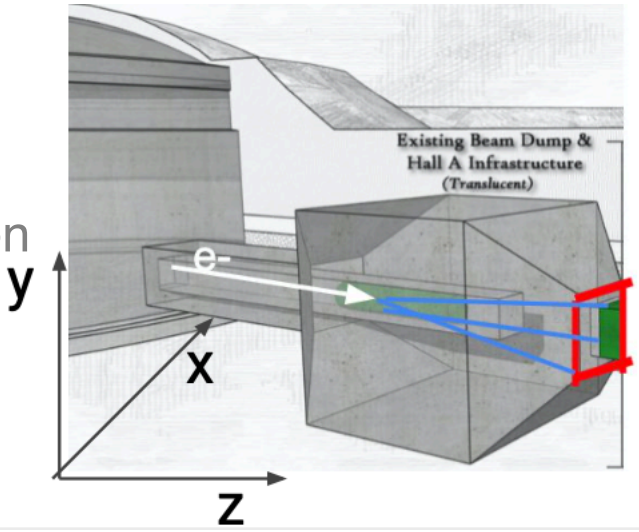
- BDX is optimized to run @ 12 GeV. Accumulated charge : 10^22 EOT in ~ 1 year
- BDX @24 GeV can complement BDX measure

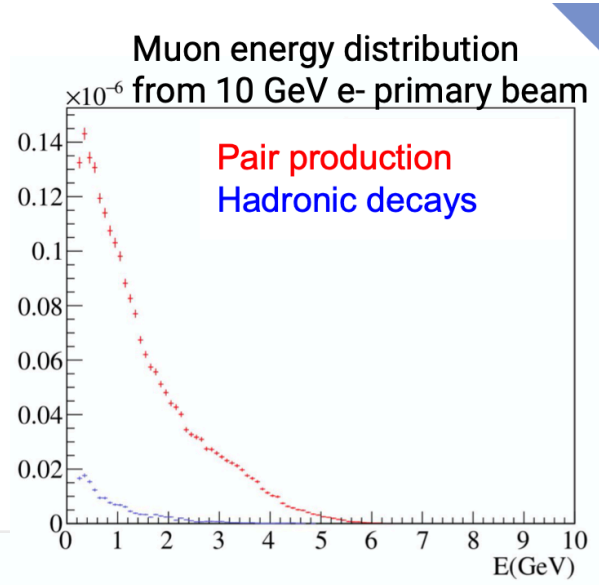


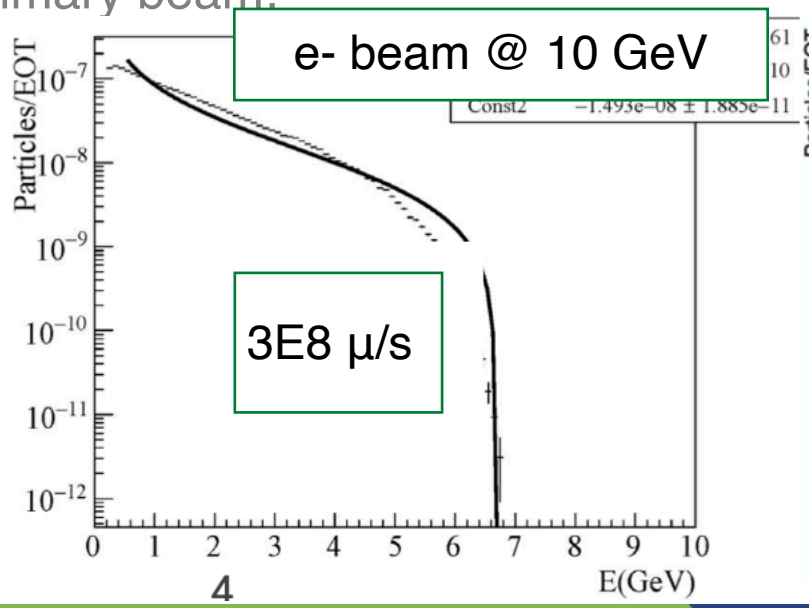


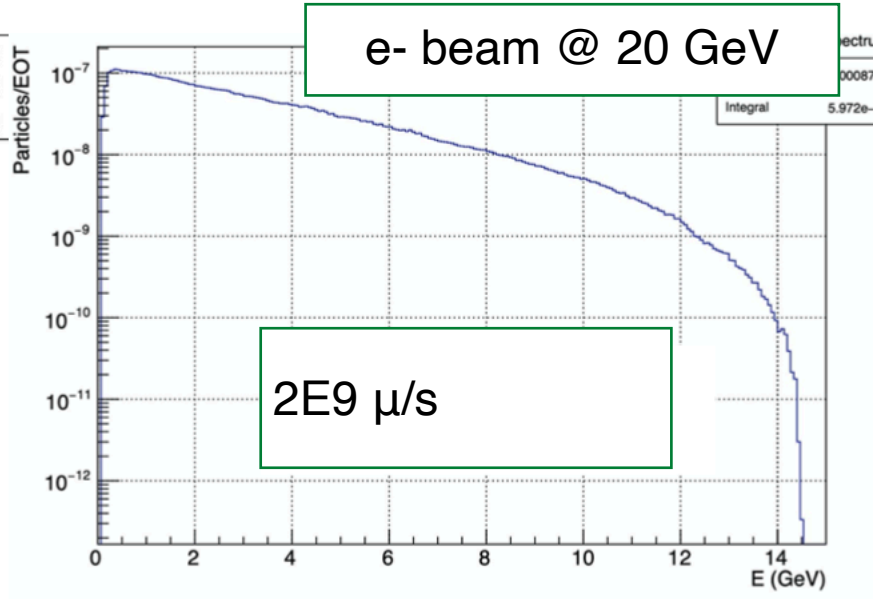
Secondary muons

- Muon estimation through FLUKA-MC simulation
- Produced via 2 processes:
  - Pair production γN->μμN
  - Photo production of π and K
- Energy distributions show a Bremsstrahlung-like energy spectrum
- Flux increases with the energy of primary beam:
  - **@ 10 GeV: ~9E-7 μ/EOT**
  - **@ 20 GeV: ~5E-6 μ/EOT**
- Flux larger than CERN's M2 beam (E>100GeV, rate ~2E7)







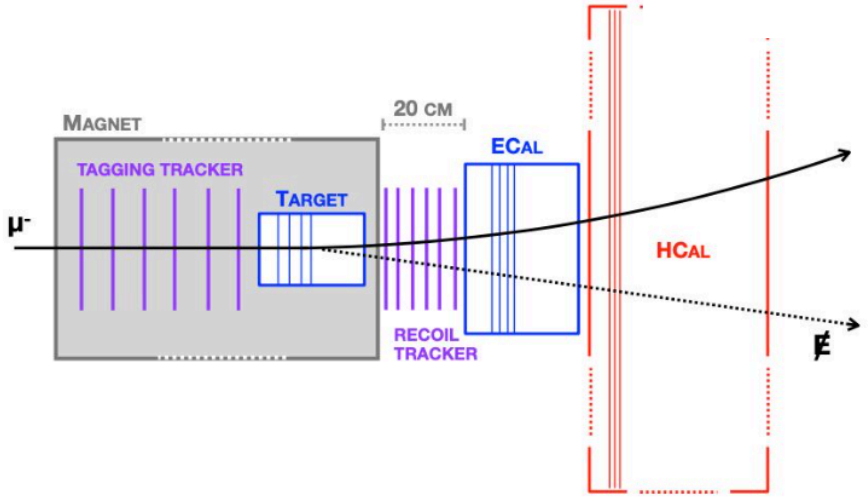


Credit to A. Fulci

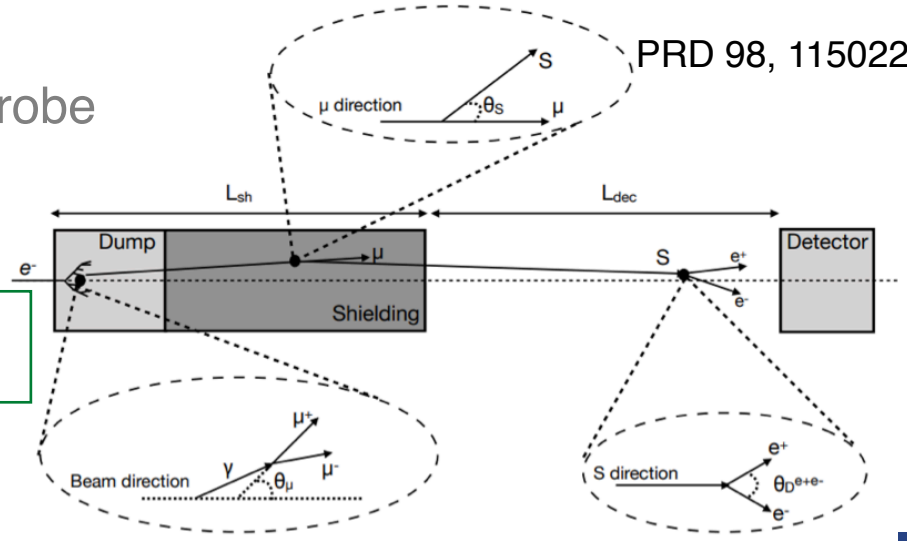
Secondary muons: example of physical case

Missing momentum approach

- Use the secondary muon beam to produce exotic particles
  - Searching for a possible light gauge boson which would couple predominantly to muons and/or taus
    - Its existence would be a viable explanation of g-2 anomaly
- Experimental approaches:
  - Fixed-target, missing-momentum search strategy to probe invisibly decaying particles (M3 experiment @Fermilab like)
  - Muon beam dump experiment to probe the visible decay into e+e- (γγ)



Beam Dump approach



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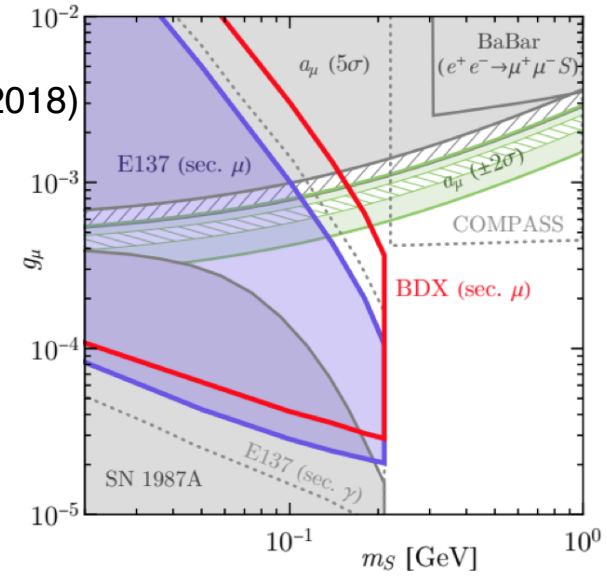
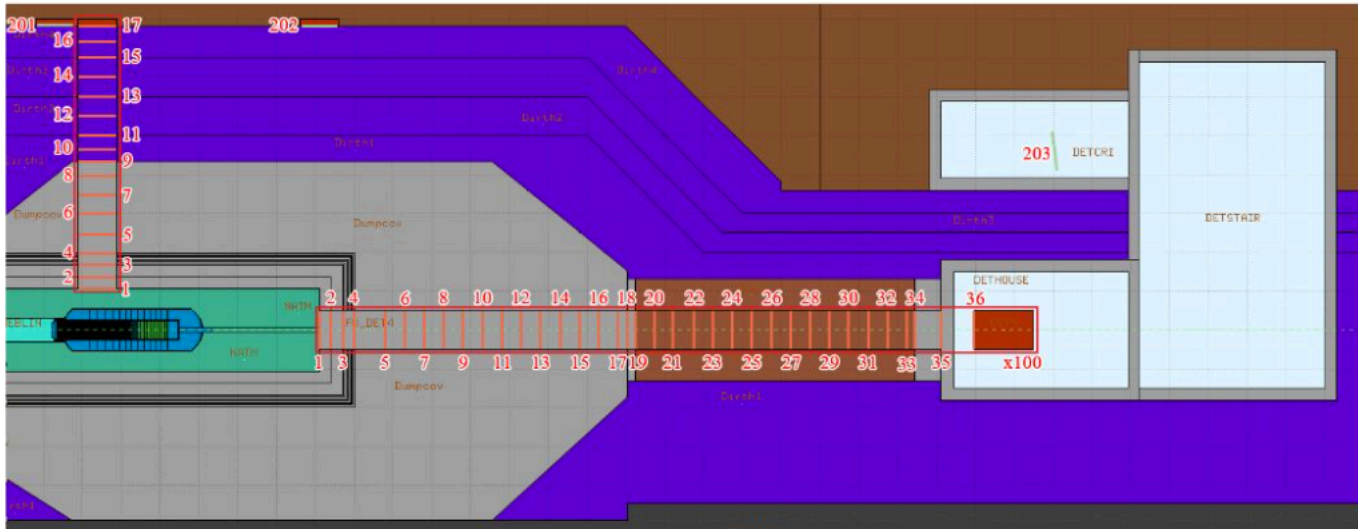


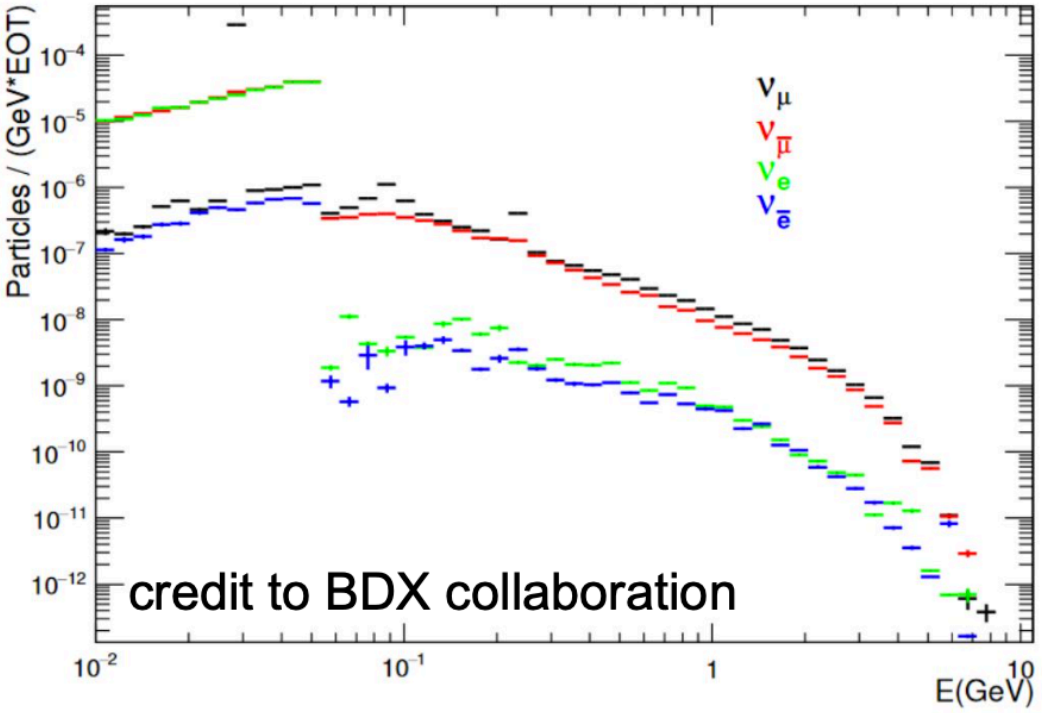
Credit to L. Marsicano, G. Krnjaic

Secondary neutrino beam

- Neutrino flux evaluated both for 10GeV and 20 GeV e- beam through FLUKA simulation
- A large flux of neutrinos is produced in Hall-A beam dump from π and K decay
- Energy range: few MeVs - O(GeV)
  - Low energy part due to pion and muon decay at rest
  - High-energy part from in-flight pion and muon decay



Flux scored on a plane 25 m downstream HallA-BD

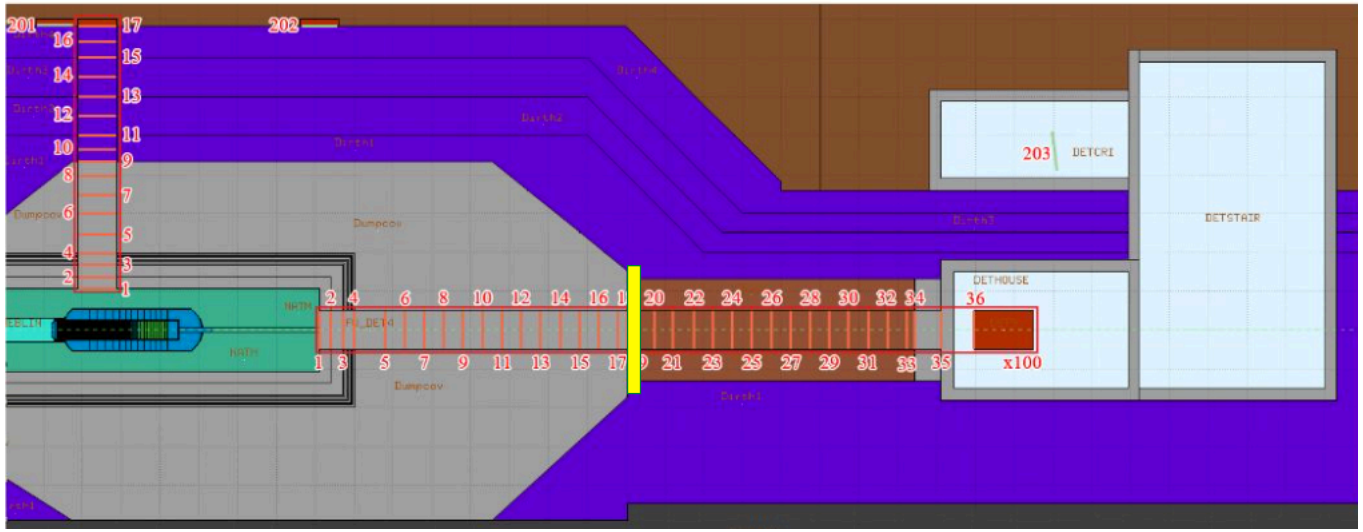


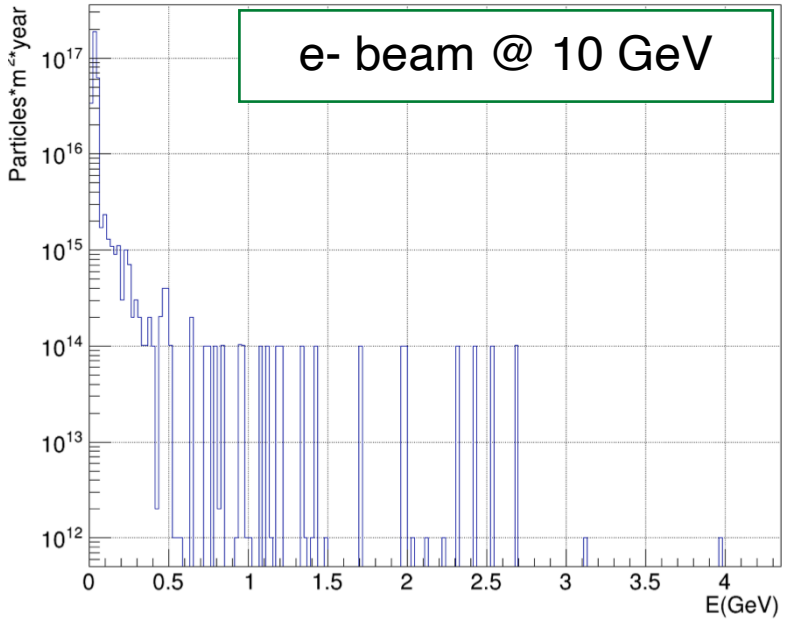
Secondary neutrino beam: on-axis

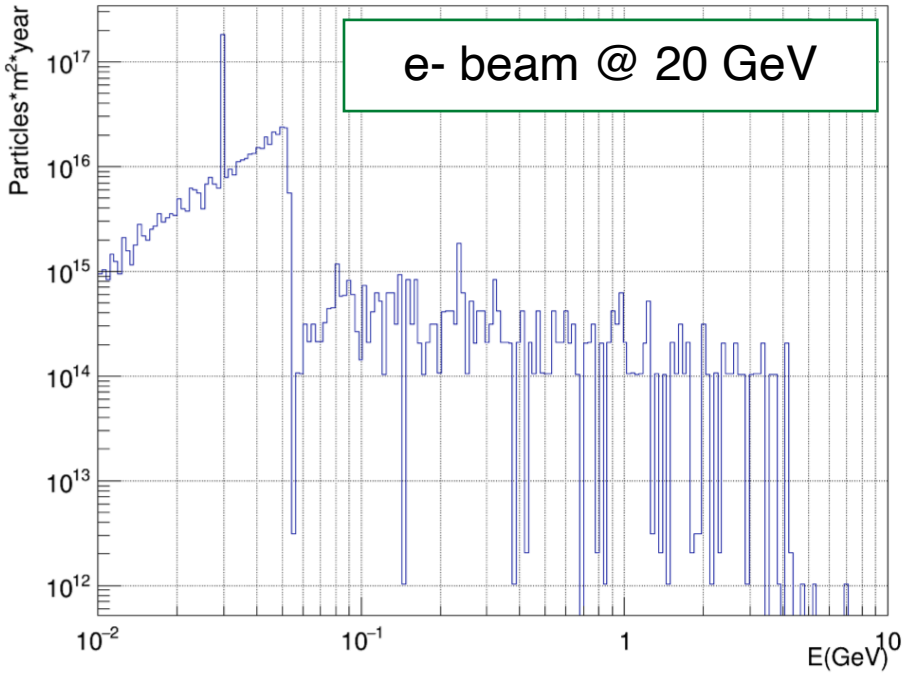
- Rate:
  - 10 GeV e- beam: 3E17 v/m2/year*
  - 20 GeV e- beam: 9E17 v/m2/year*

*1year corresponding 1E22 EOT

Credit to A. Fulci





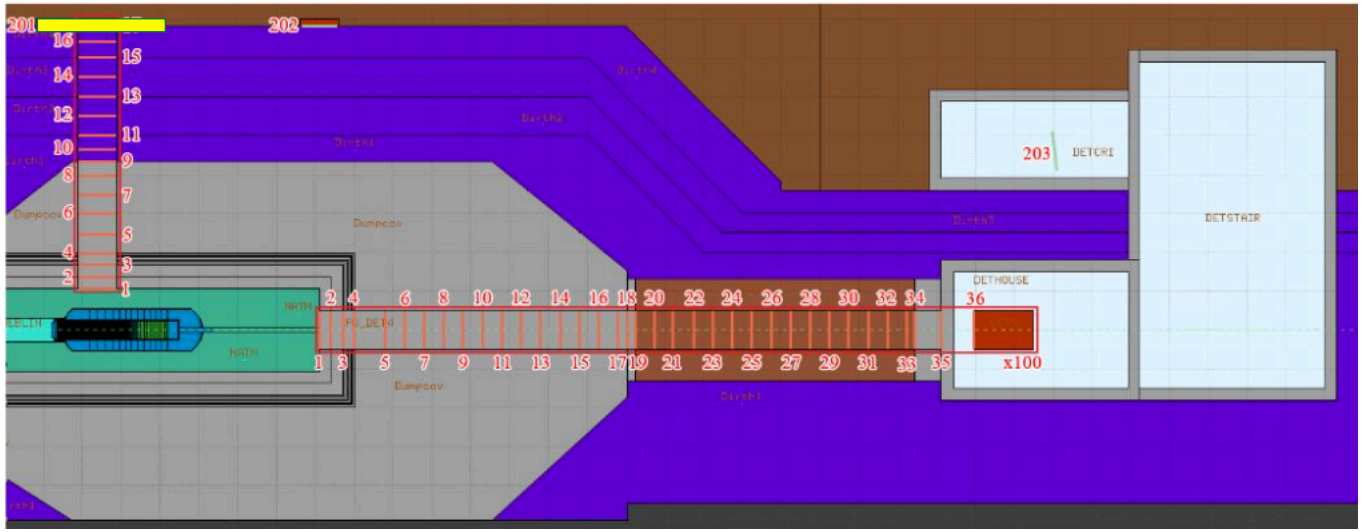


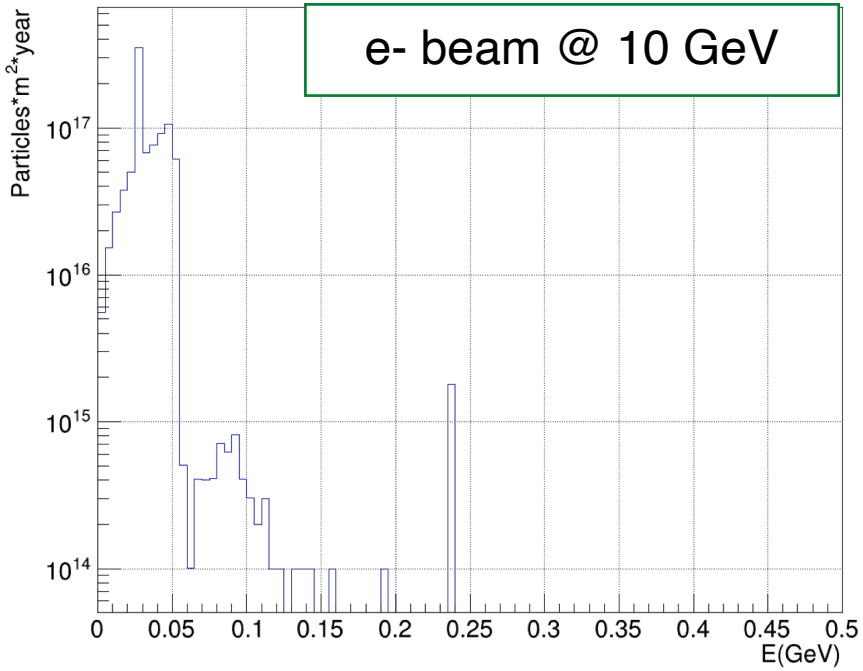
Secondary neutrino beam: off-axis

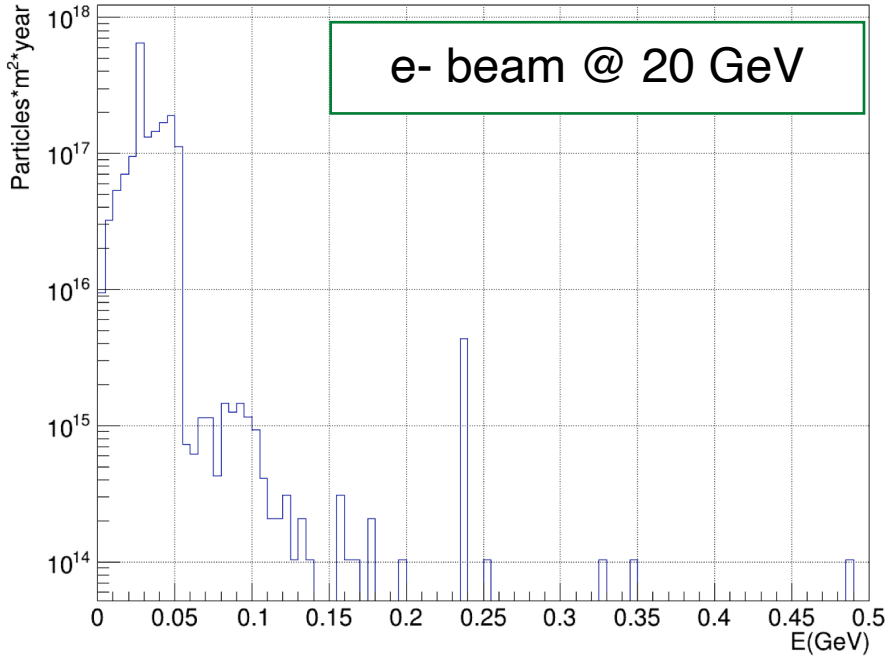
- DAR spectrum
- Flux scored on a plane 10 m above BD
  - 10 GeV e- beam: 9E17 v/m2/year*
  - 20 GeV e- beam: 2E18 v/m2/year*
  - Flux comparable to SNS@Oak Ridge National Lab

*1year corresponding 1E22 EOT

Credit to A. Fulci

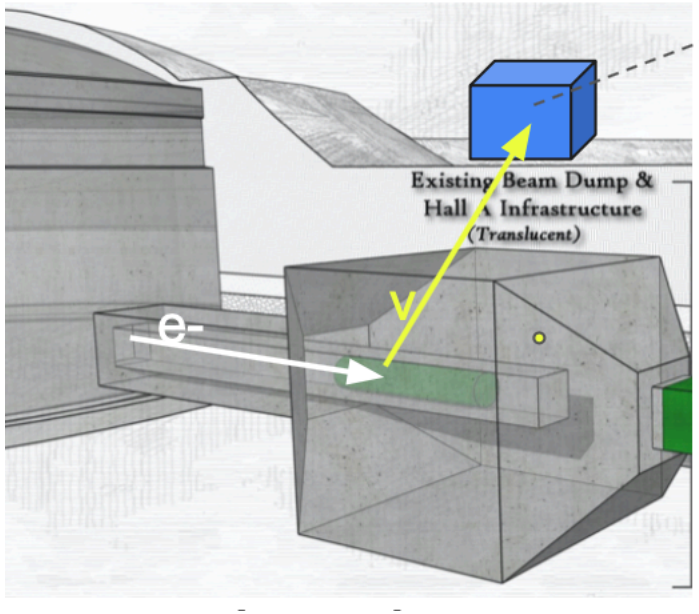


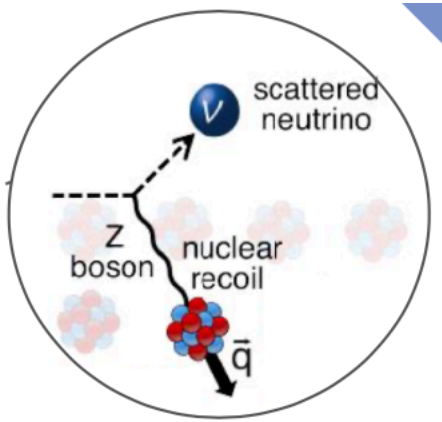




Coherent Elastic Neutrino-Nucleus Scattering @ JLAB

- Low energy neutrinos (E<50 MeV) coherently scatter on target nuclei ($q < 1/R_N$)
- Cross section scaling with N^2
- Low recoil energy due to kinematics O(10keV)
- First measurement in 2017 on CsI(Na)

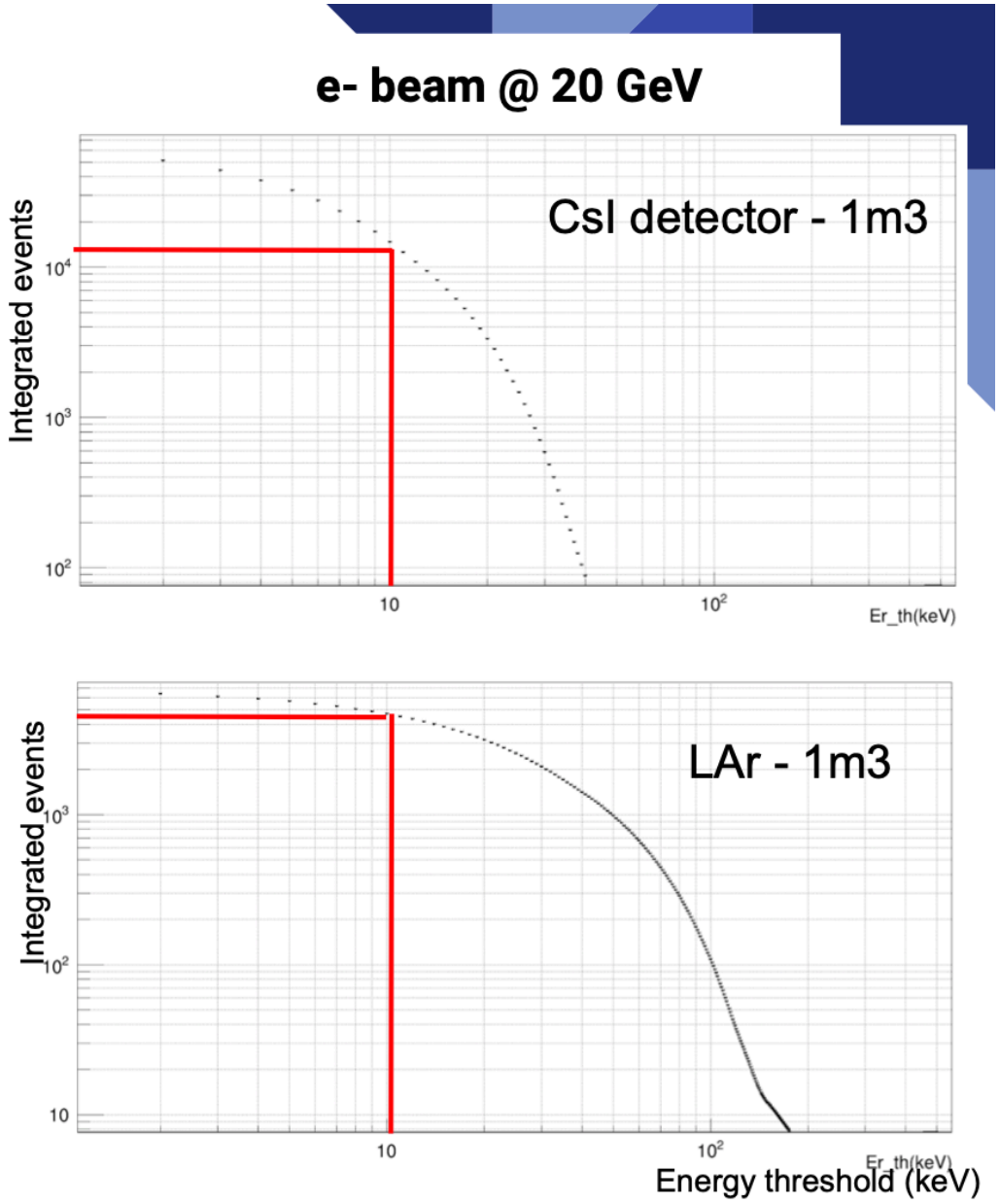




- **Requirements**
  - High-intense v-flux
  - v energy range: few MeV - few 100 MeV
  - detector has ve sensitive to small energy deposition
  - backgrounds need to be sufficiently small to observe the signal

CEvNs @ JLAB: expected yield

Detector	e- @ 10 GeV v flux: 1E8 v/m^2/ yearÂ	e- @ 20 GeV v flux: 2E8 v/m^2/ yearÂ
CsI (1m^3) [thr : 10 keV]	8000	~15000
LAr (1m^3) [thr: 10 keV]	2500	~4500



Credit to A. Pilloni, S. Grazzi

Summary

- High intensity e- beam is a precious source of secondary beams_
  - Light Dark Matter
  - Muons
  - neutrinos
  - …
  - …
- A 24 GeV e- beam impinged on a thick target can produce higher intensity beam than 12 GeV on

- Secondary beams can be exploited to explore “hot” physic scenario