Applications for high energy physics (HEP)

- modern big particle detectors require extensive R&D, simulation and testing
- test beams are available only at big accelerator labs
- e- from PA may pioneer complementary ways to test & calibrate detectors

but there are considerable differences:

- in conventional test beams
  - variety of available particles: $\pi^{\pm}$, $K^{\pm}$, p, n, $\mu^{\pm}$, $e^{\pm}$, gamma
  - particles arrive randomly «one at a time» (= time that can be resolved by the detector), low average current, low pile-up (desired)
- in LWFA generated beams:
  - only electrons (primary beam)
  - electrons arrive at the same time: massive pile-up, $p < 5$–10 GeV/c

currently available test beams

- example: CERN North Area secondary beam
  - SPS: p(450GeV) ➔ primary target ➔ π^+,π^-,π^0
  - π^+,π^- ➔ secondary target ➔ $\mu^+ \mu^-$, neutrinos
  - π^0 ➔ decay to 2γ ➔ secondary target ➔ e^+,e^- (max 180 GeV/c)
  - energy selection by dipole and collimator slit ($\Delta p/p < 1$ ‰)
  - one SPS “spill” (4sec) every 17sec
  - also: ions, neutrons, kaons, ….
- users are happy with (and actually want)
  - less than one particle every few nanoseconds (on average)
- large panel of users
  - physics experiments
  - particle detector development and calibration ->

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Applications of e- beams for high energy physics (HEP)

Lab simulation of high E energy EM showers

Calorimetry (in HEP)

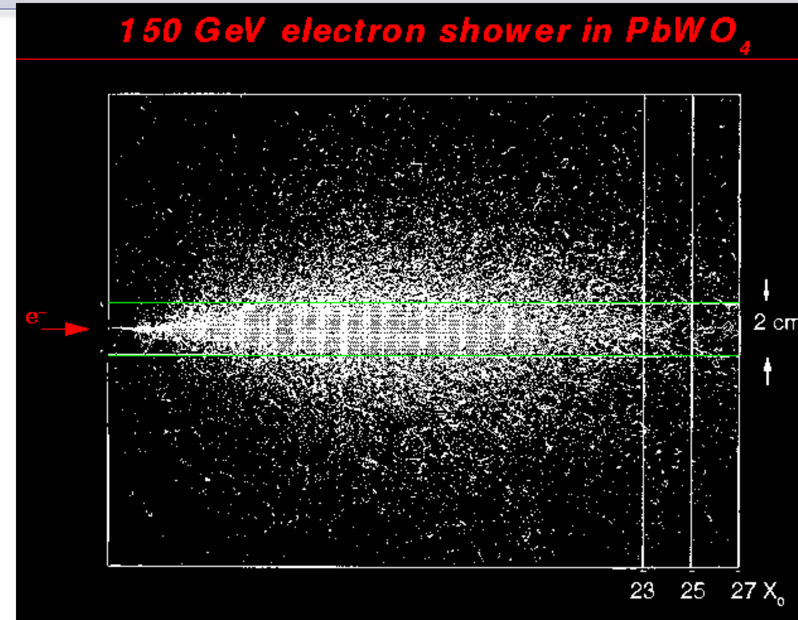
- measurement of particle energy by total absorption ➔ particle shower

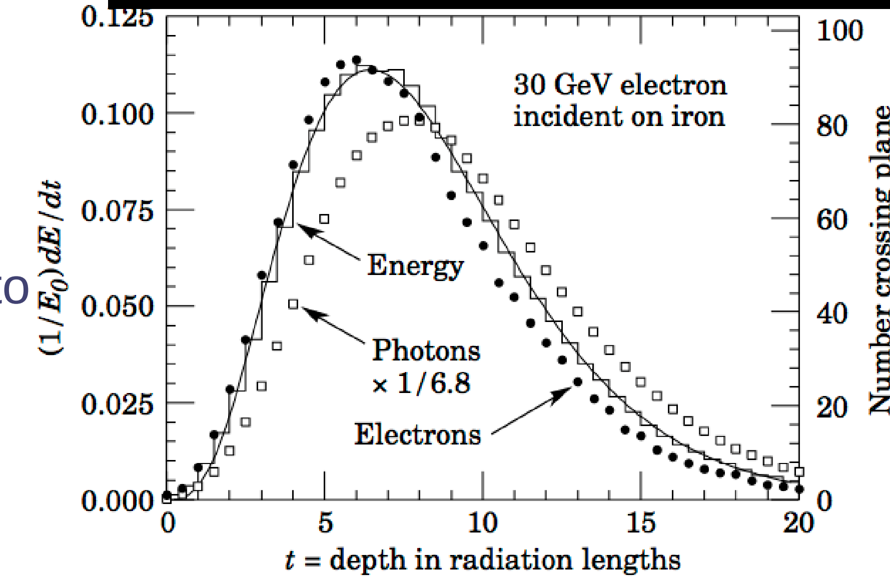
Motivation

- response linearity
- readout saturation
- detector calibration at unavailable energies

Method

- Produce bunch of N electrons with identical energie E_e (p selection)
- Measure N precisely (enough):
  $\Delta E_B \sim \Delta N/N \times E_B$
- concentrate to spot of the size of an EM shower after a few X0
- What bunch characteristics are needed to simulate best energy deposit of one particle E_0



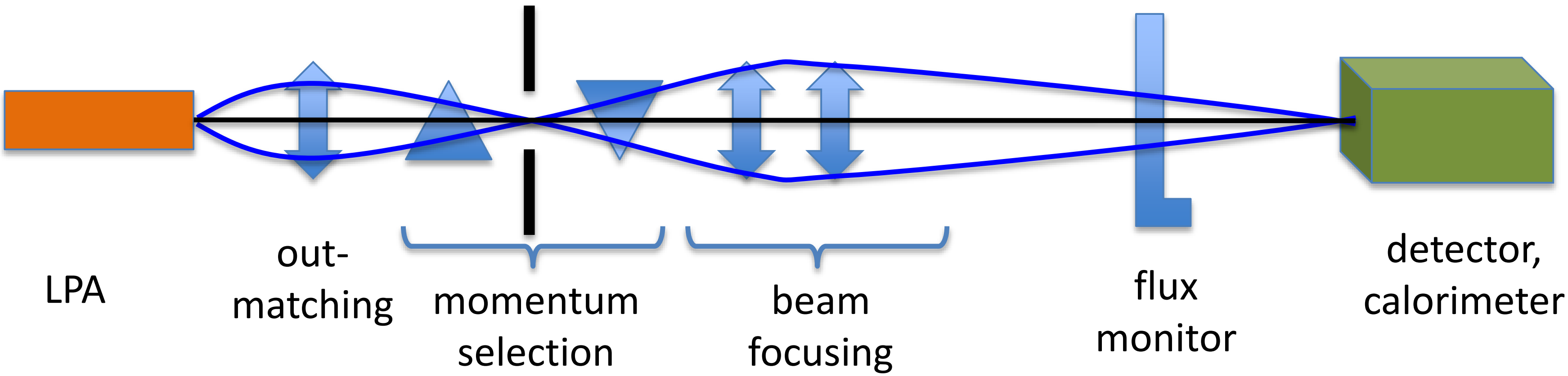


Testing particle detectors at high occupancies

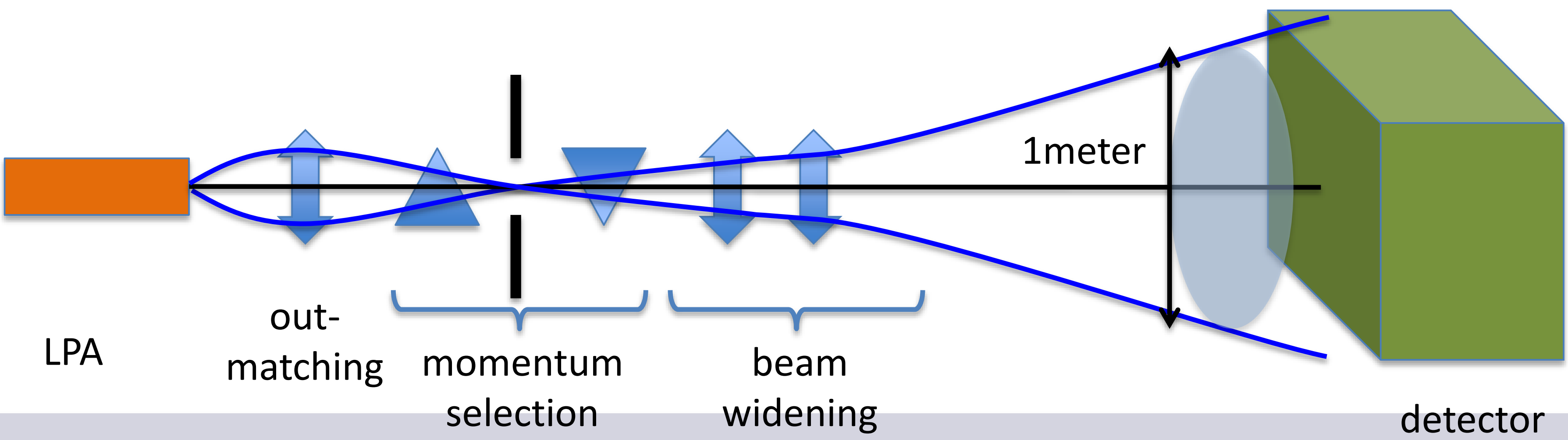
- **Trackers, calorimeters**
  - in general: detectors with intrinsic particle separation capabilities
  - fine granularity: CMS HGCAL, LC detectors fine
  - particle flow analysis (PFA) may work only at <1TeV energy
- **occupancy:** number of particles arriving simultaneously in one detector cell (transverse)
- **Fast calibration of big detector modules (alternative to position scanning) at “low” energies (1-5 GeV)**
- **also: DAQ stress test (low rate, big events)**
- **study of reconstruction and particle separation**

beam conditioning for HEP applications

HE electromagnetic shower simulation (« 1000x5GeV=5TeV »)



simultaneous iradiation of detectors at high occupancies



Challenges for HEP applications

- ❑ reducing the peak particle flux (➔ momentum selection)
- ❑ focussing the selected beam to shower size dimensions
  ➔ emittance
- ❑ measuring particle flux to sufficient precision

HE electromagnetic shower simulation:

- What bunch of N electrons of identical energy E_B= O(1-5GeV) generates a shower that ressembles most a shower generated by one electron (positron, gamma) of E=NxE_B?