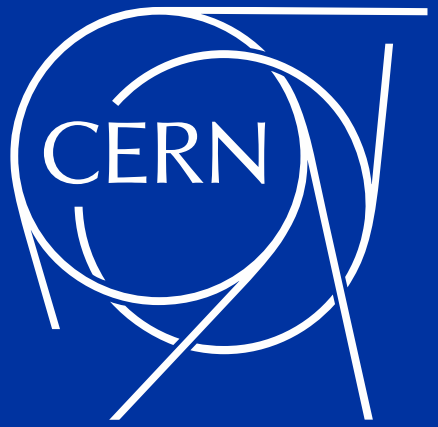


Electron & Positron beams in the CERN secondary areas

N. Charitonidis [CERN, BE-EA] on behalf of BE-EA-LE colleagues

04 September 2025

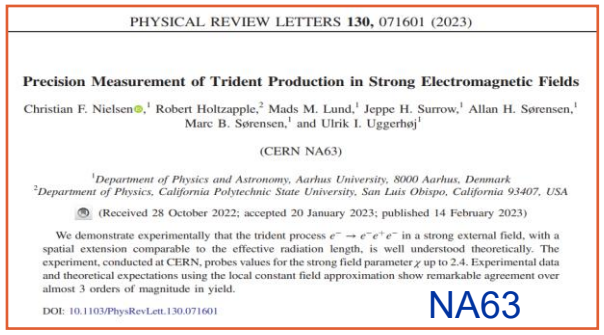
Outline

- **Introduction – Scope of the presentation**
- **Overview of the CERN secondary areas**
- **Possibilities of today's available electron / positron beams at CERN**
- **Outlook for the future !**

Introduction

- **The secondary beam areas of CERN are unique, versatile facilities that can offer particle beams of a very broad range of momenta and intensities.**

- **Electron & positron beams of high purity have been and are available, while they are recently requested more and more for physics & R&D purposes**


PHYSICAL REVIEW LETTERS **130,** 071601 (2023)

Precision Measurement of Trident Production in Strong Electromagnetic Fields

Christian F. Nielsen, Robert Holtzapple, Mads M. Lund, Jeppe H. Surrow, Allan H. Sørensen, Marc B. Sørensen, and Ulrik I. Uggerhøj

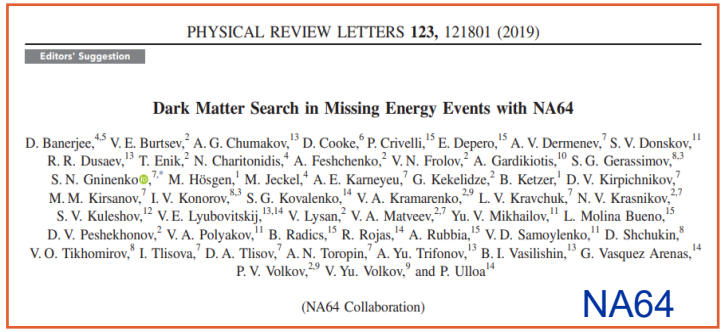
(CERN NA63)

(Received 28 October 2022; accepted 20 January 2023; published 14 February 2023)

We demonstrate experimentally that the trident process $e^- \to e^- e^+ e^-$ in a strong external field, with a spatial extension comparable to the effective radiation length, is well understood theoretically. The experiment, conducted at CERN, probes values for the strong field parameter χ up to 2.4. Experimental data and theoretical expectations using the local constant field approximation show remarkable agreement over almost 3 orders of magnitude in yield.

DOI: 10.1103/PhysRevLett.130.071601

NA63


PHYSICAL REVIEW LETTERS **123,** 121801 (2019)

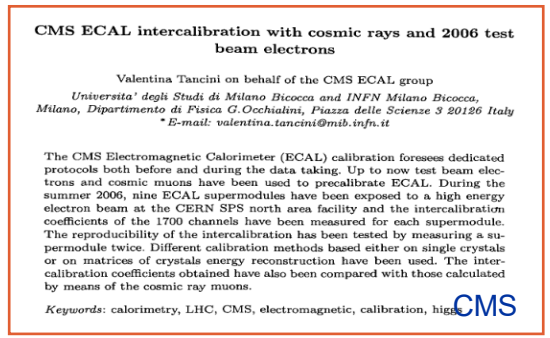
Editors' Suggestion

Dark Matter Search in Missing Energy Events with NA64

D. Banerjee, V. E. Burtsev, A. G. Chumakov, D. Cooke, P. Crivelli, E. Depero, A. V. Dermenev, S. V. Donskov, R. R. Dusaev, T. Enik, N. Charitonidis, A. Feshchenko, V. N. Frolov, A. Gardikiotis, S. G. Gerassimov, S. N. Gninenko, M. Hösgen, M. Jeckel, A. E. Karneyeu, G. Kekelidze, B. Ketzer, D. V. Kirpichnikov, M. M. Kirsanov, I. V. Konorov, S. G. Kovalenko, V. A. Kramarenko, L. V. Kravchuk, N. V. Krasnikov, S. V. Kuleshov, V. E. Lyubovitskij, V. Lysan, V. A. Matveev, Yu. V. Mikhailov, L. Molina Bueno, D. V. Peshekhonov, V. A. Polyakov, B. Radics, R. Rojas, A. Rubbia, V. D. Samoylenko, D. Shchukin, V. O. Tikhomirov, I. Tlisova, D. A. Tlisov, A. N. Toropin, A. Yu. Trifonov, B. I. Vasilishin, G. Vasquez Arenas, P. V. Volkov, V. Yu. Volkov, and P. Ulloa

(NA64 Collaboration)

NA64


CMS ECAL intercalibration with cosmic rays and 2006 test beam electrons

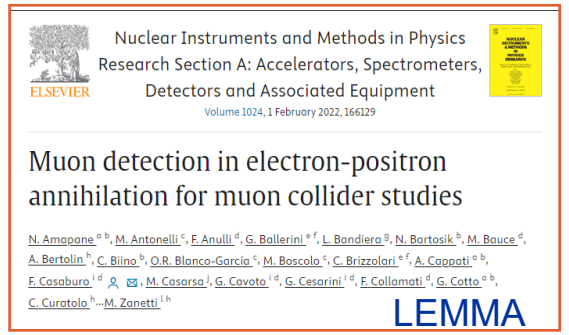
Valentina Tancini on behalf of the CMS ECAL group

Universita' degli Studi di Milano Bicocca and INFN Milano Bicocca, Milano, Dipartimento di Fisica G.Occhialini, Piazza delle Scienze 3 20126 Italy
**E-mail: valentina.tancini@mib.infn.it*

The CMS Electromagnetic Calorimeter (ECAL) calibration foresees dedicated protocols both before and during the data taking. Up to now test beam electrons and cosmic muons have been used to precalibrate ECAL. During the summer 2006, nine ECAL supermodules have been exposed to a high energy electron beam at the CERN SPS north area facility and the intercalibration coefficients of the 1700 channels have been measured for each supermodule. The reproducibility of the intercalibration has been tested by measuring a supermodule twice. Different calibration methods based either on single crystals or on matrices of crystals energy reconstruction have been used. The intercalibration coefficients obtained have also been compared with those calculated by means of the cosmic ray muons.

Keywords: calorimetry, LHC, CMS, electromagnetic, calibration, higgs

CMS

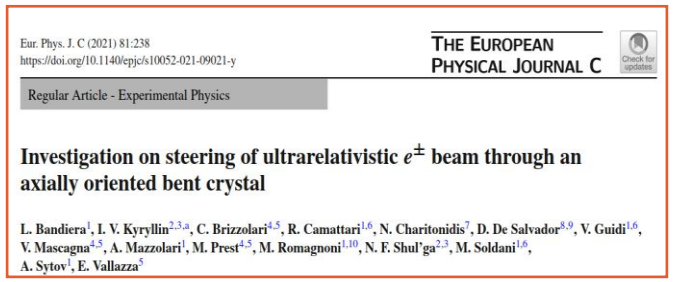

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

Volume 1024, 1 February 2022, 166129

Muon detection in electron-positron annihilation for muon collider studies

N. Amapane, M. Antonelli, F. Anulli, G. Ballerini, L. Bandiera, N. Bartosik, M. Bauce, A. Bertolin, C. Biino, O.R. Blanco-García, M. Boscolo, C. Brizzolari, A. Cappati, F. Casaburo, M. Casarsa, G. Cavoto, G. Cesarini, F. Collamati, G. Cotto, C. Curatolo, M. Zanetti

LEMMA

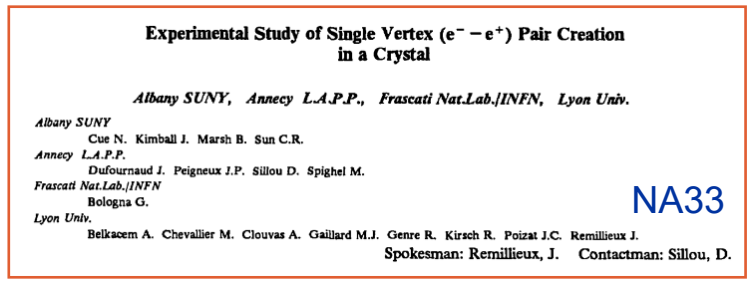

Eur. Phys. J. C (2021) 81:238
https://doi.org/10.1140/epjc/s10052-021-09021-y

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Investigation on steering of ultrarelativistic $e^{\pm}$ beam through an axially oriented bent crystal

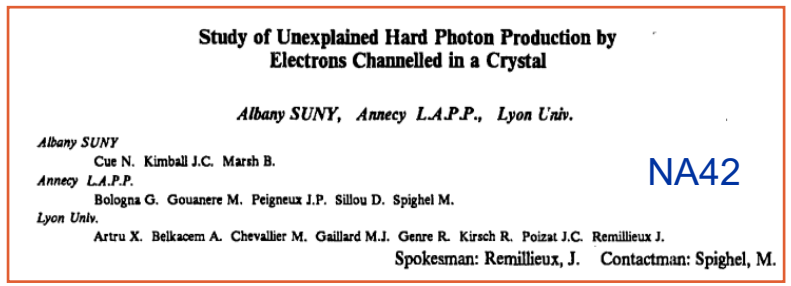
L. Bandiera, I. V. Kyryllin, C. Brizzolari, R. Camattari, N. Charitonidis, D. De Salvador, V. Guidi, V. Mascagna, A. Mazzolari, M. Prest, M. Romagnoni, N. F. Shul'ga, M. Soldani, A. Sytov, E. Vallazza


Experimental Study of Single Vertex ($e^- - e^+$) Pair Creation in a Crystal

Albany SUNY, Annecy L.A.P.P., Frascati Nat.Lab./INFN, Lyon Univ.

Albany SUNY
Cue N. Kimball J. Marsh B. Sun C.R.
Annecy L.A.P.P.
Dufournaud J. Peigneux J.P. Sillou D. Spighel M.
Frascati Nat.Lab./INFN
Bologna G.
Lyon Univ.
Belkacem A. Chevallier M. Clouvas A. Gaillard M.J. Genre R. Kirsch R. Poizat J.C. Remillieux J.
Spokesman: Remillieux, J. Contactman: Sillou, D.

NA33

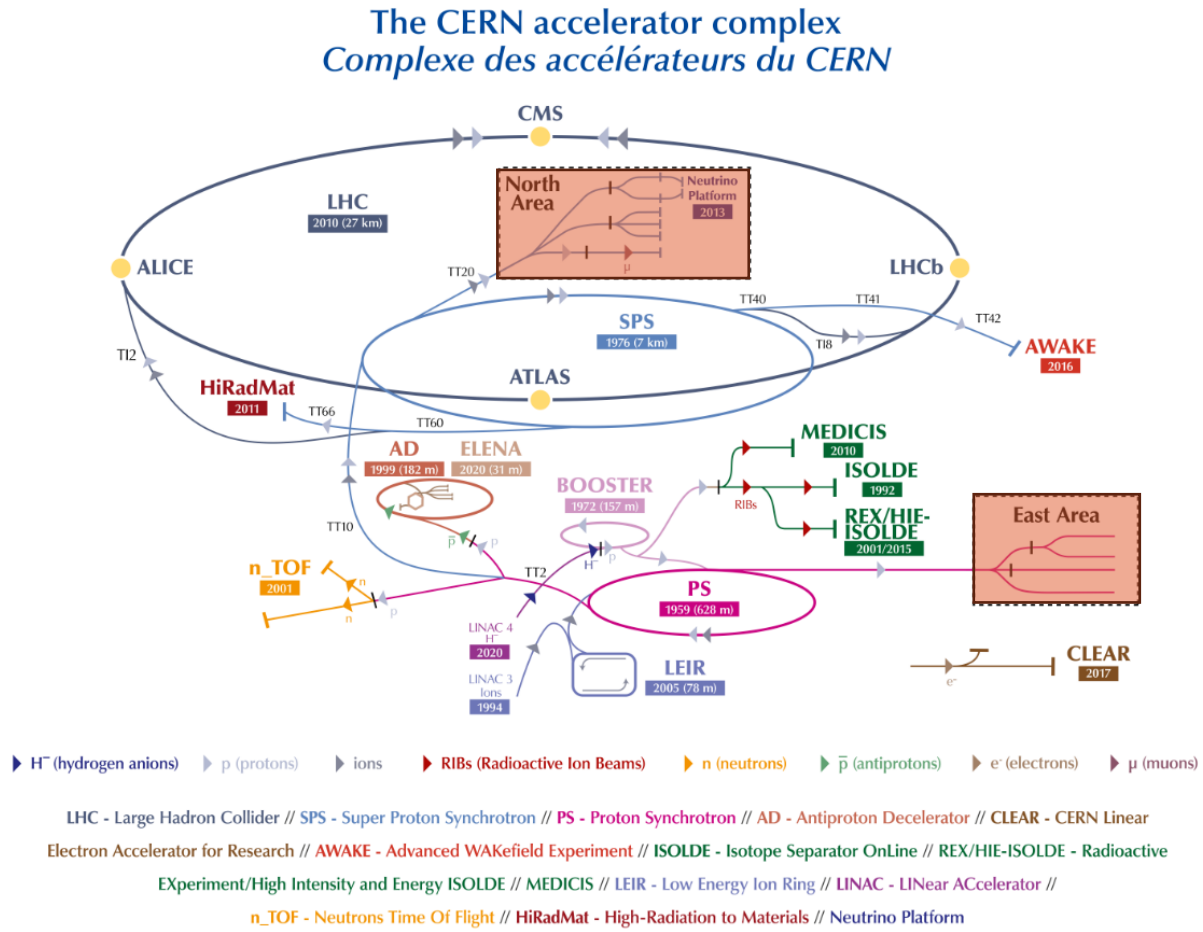

Study of Unexplained Hard Photon Production by Electrons Channelled in a Crystal

Albany SUNY, Annecy L.A.P.P., Lyon Univ.

Albany SUNY
Cue N. Kimball J.C. Marsh B.
Annecy L.A.P.P.
Bologna G. Gouanere M. Peigneux J.P. Sillou D. Spighel M.
Lyon Univ.
Artru X. Belkacem A. Chevallier M. Gaillard M.J. Genre R. Poizat J.C. Remillieux J.
Spokesman: Remillieux, J. Contactman: Spighel, M.

NA42

The secondary beam areas at CERN

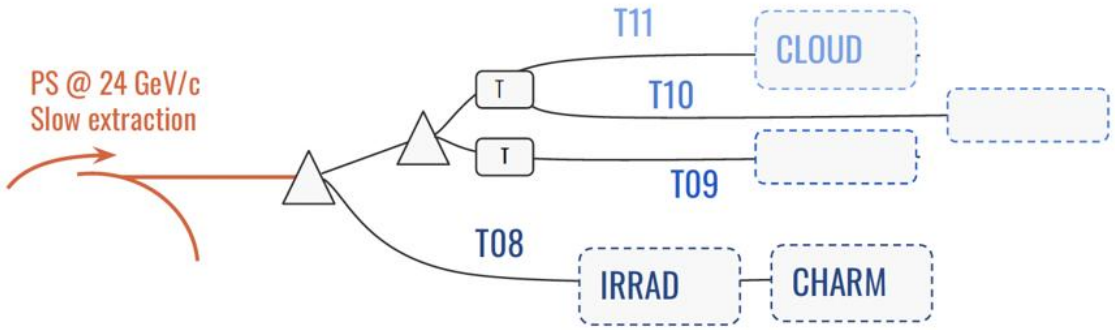


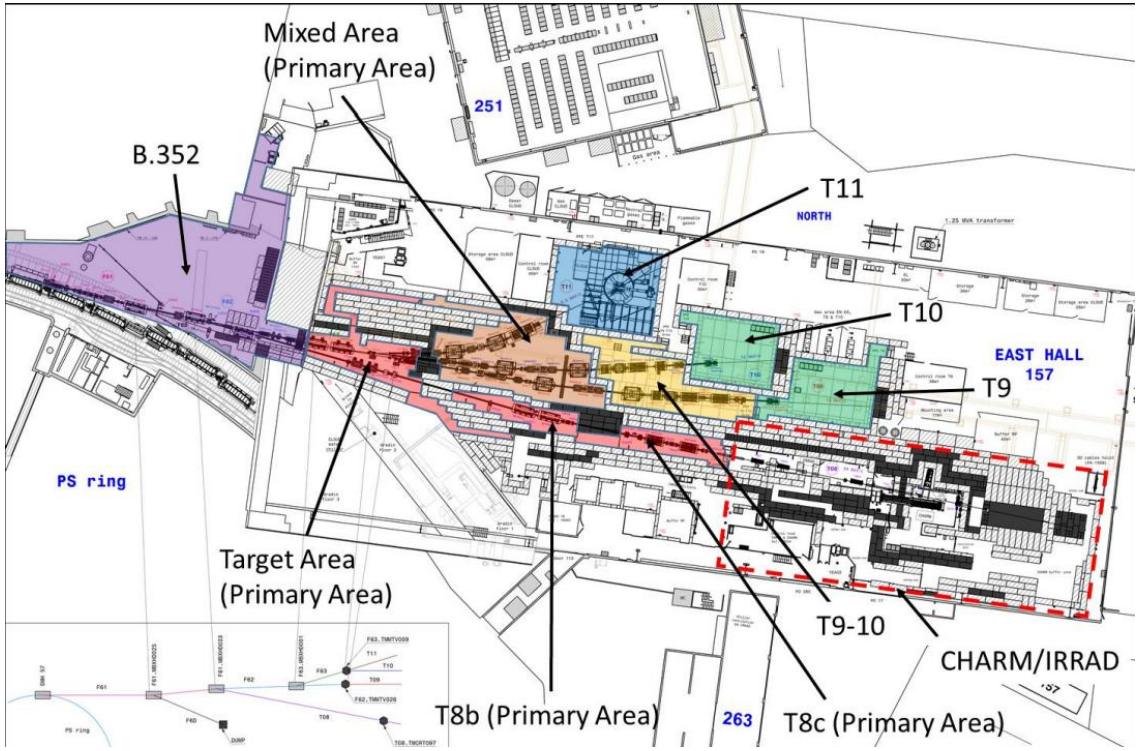
- **SPS : protons/ions @ 400 GeV/c/Z**
- **PS: protons /ions @ 24 GeV/c/Z**

- **North Area → ≤400 GeV/c/Z (primary beam) or ≤ 360 GeV/c/Z (secondary beams)**
- **East Area → ≤ 10 GeV/c secondary beams**
- **Electrons / positrons available both in North & East areas !**

East Area of CERN/PS

- **Two beamlines available for tests : T9 and T10**
- **Flexible areas, with infrastructure support available from the different CERN groups**
- **Quick access, short routes from control to experimental areas !**

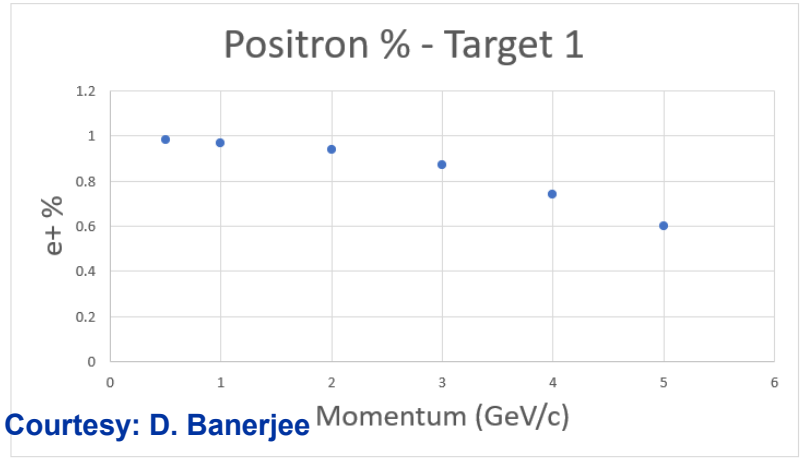




Electron beam properties in the East Area

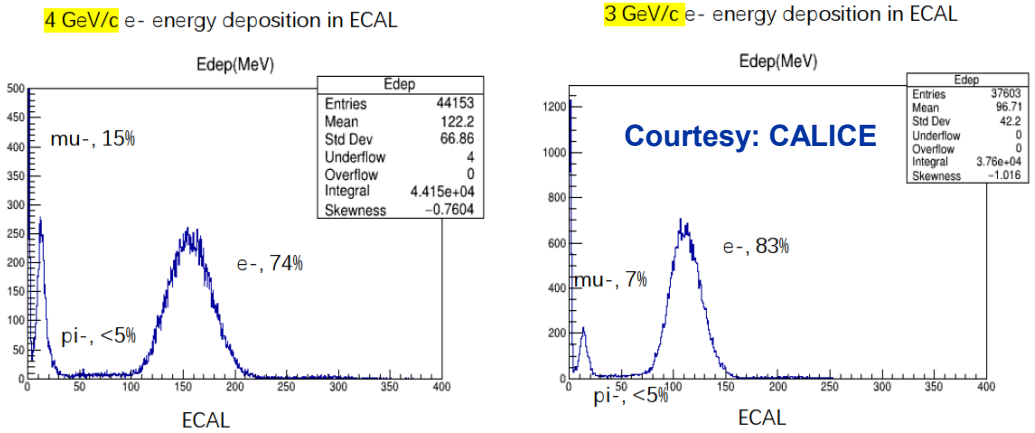
- **Electron beams of various purities and intensities are available, between 0.1 & 5 GeV/c**
- **Electrons & positrons produced equally, choice to transfer one of the two signs in the various experiments.**
- **> 90% electron purity for momenta <5 GeV/c reaching ~99% at 1 GeV/c**
- **Rates, in all momenta up to ~10^5 particles / spill in T09**
- **Spill structure from PS accelerator:**
  - 400 ms spill length
  - ~1 spill every 18s, more on demand

XCET Data – Plot 2



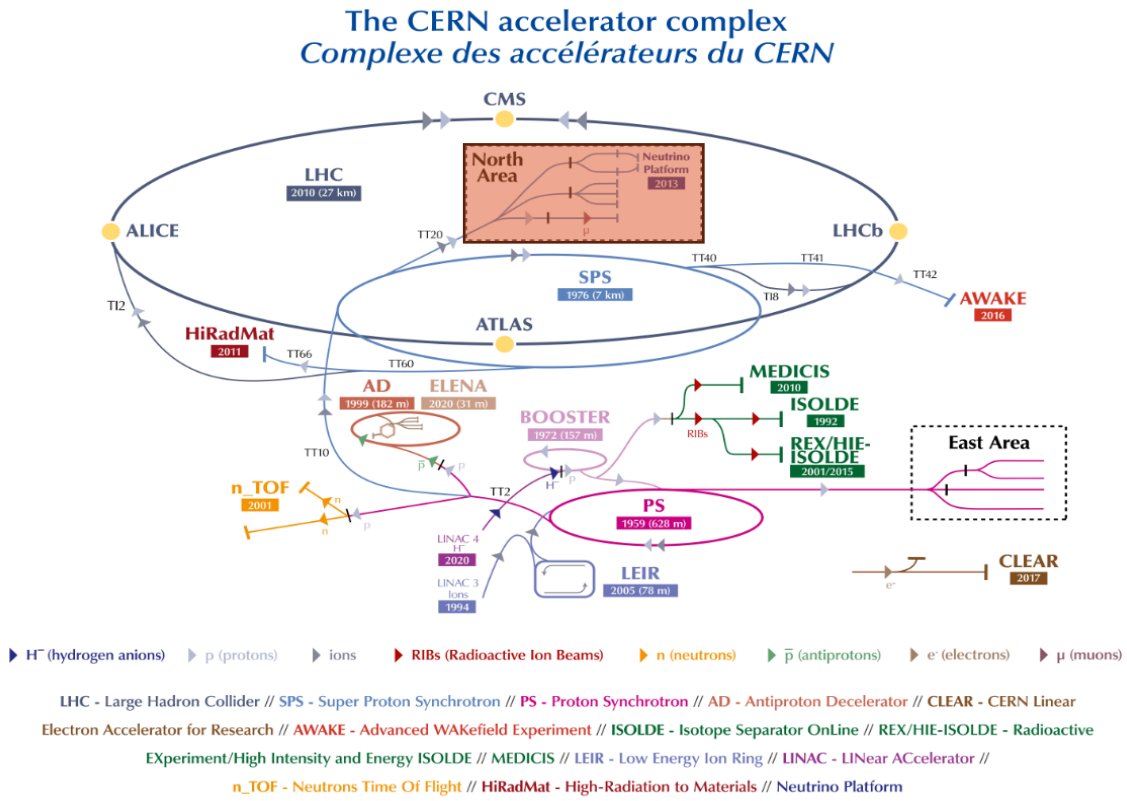
Courtesy: D. Banerjee

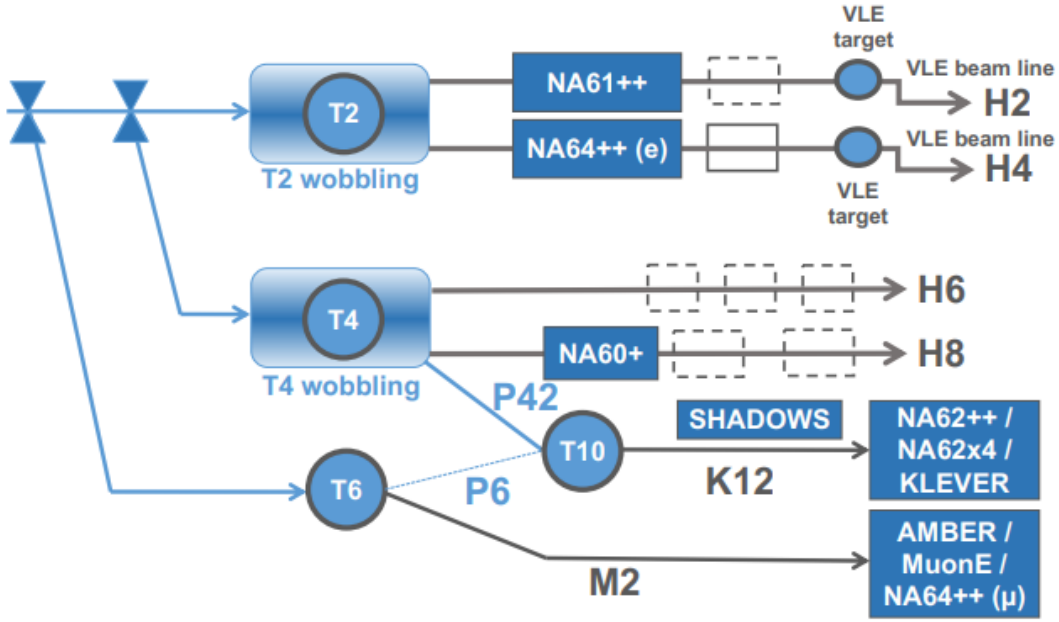
ECAL Energy Response to e-



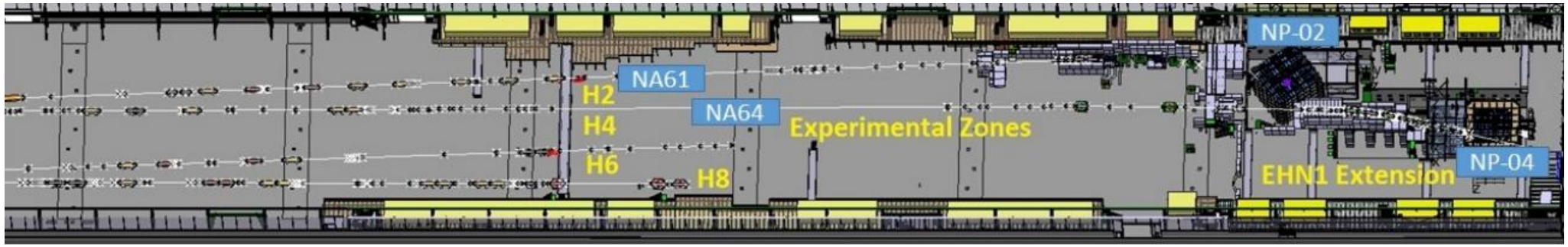
North Area of CERN SPS

Beam from SPS





North Area of CERN SPS

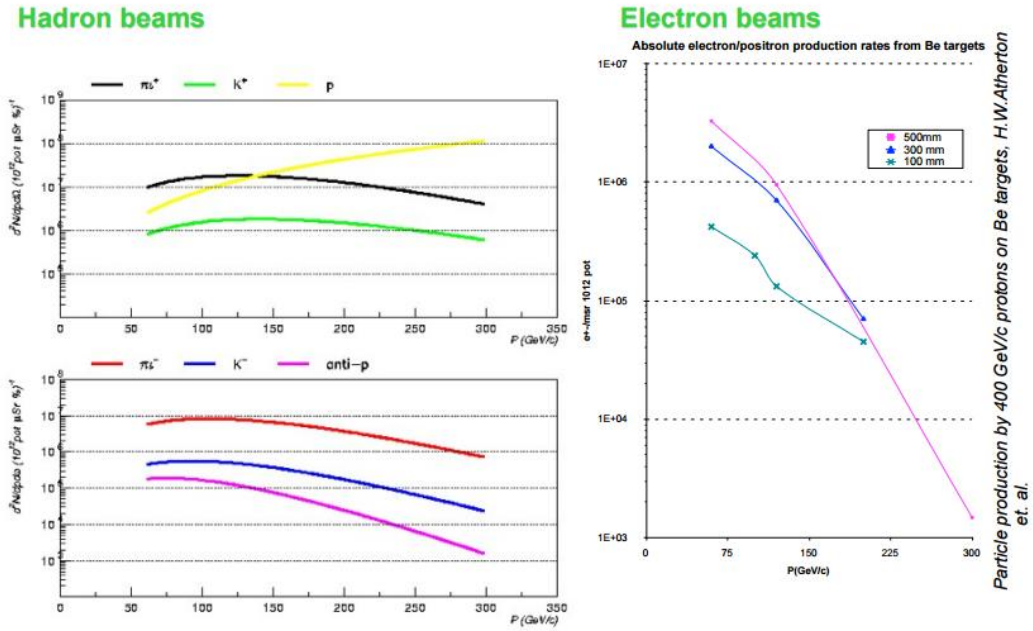


The EHN1 experimental hall

400 GeV/c beam from the SPS impinges on 3 Be targets, producing essentially all the secondaries that can be chosen with the magnetic spectrometers of the secondary lines.

- **N.B: Slow extraction, 4.8s spill duration, 1 spill ~20 seconds**

- **Electron beams available for test-beams only in EHN1 (H2/H4/H6/H8 lines)**



Electron beam properties in the North Area (1)

- **Mechanism 1 : Production of electrons / positron from the neutral channel (π0→ γγ and then, in a Pb converter γ → e+e-)**

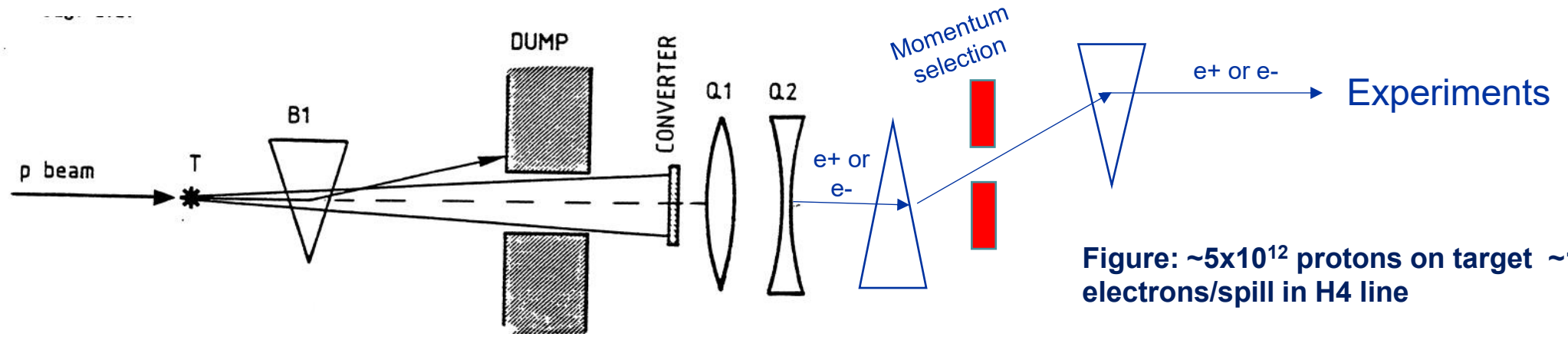
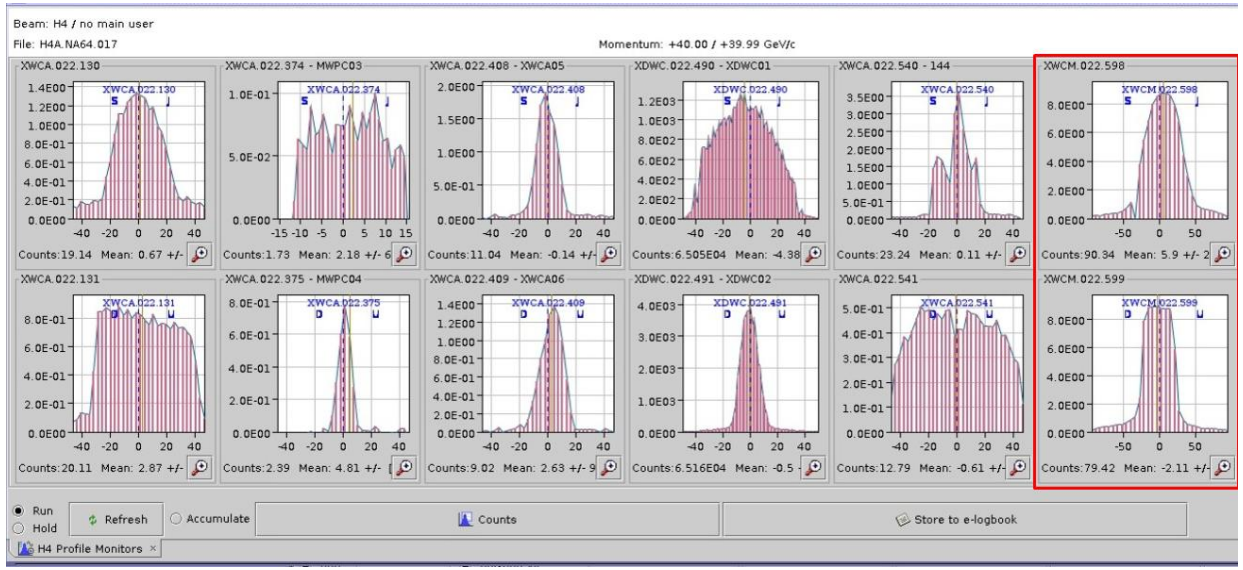
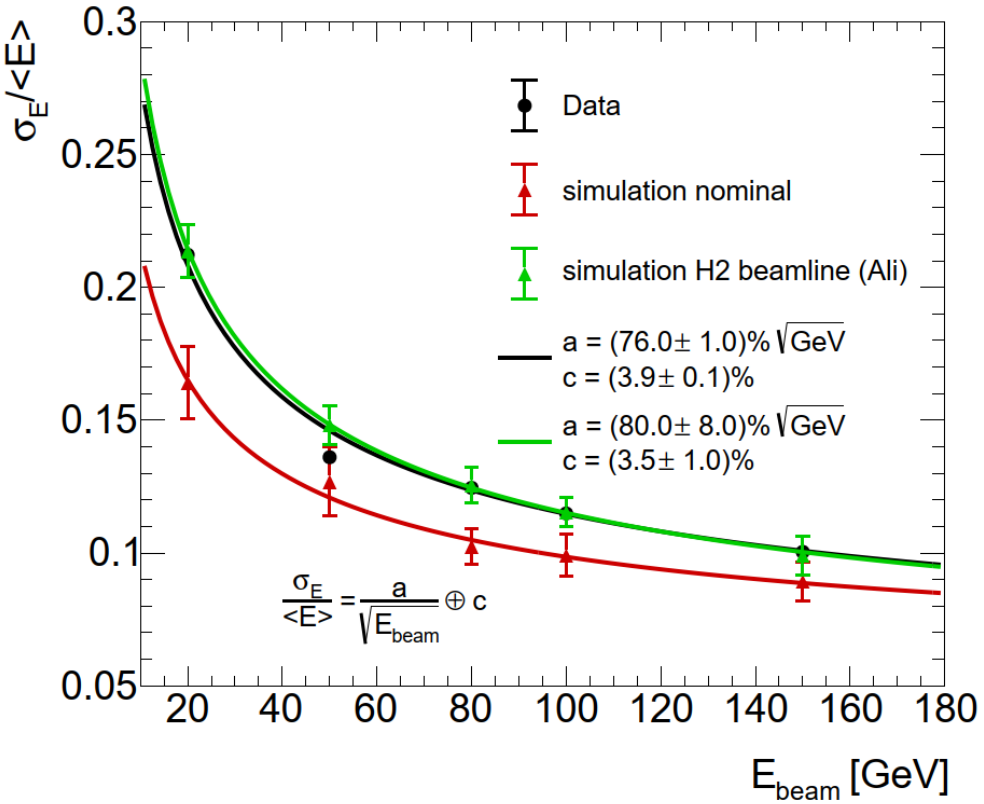


Figure: ~5x10^{12} protons on target ~1E7 electrons/spill in H4 line

- **Intensities between 10^3 – 10^7 particles per spill, depending on the collimation & momentum selection precision**
- **Purity between 50 – 100% depending on the beamline, momentum & exact target station configuration**
- **Converter: Pb, 4mm thickness**
- **Only available in H2 / H4 lines – H6 & H8 don't have this option**

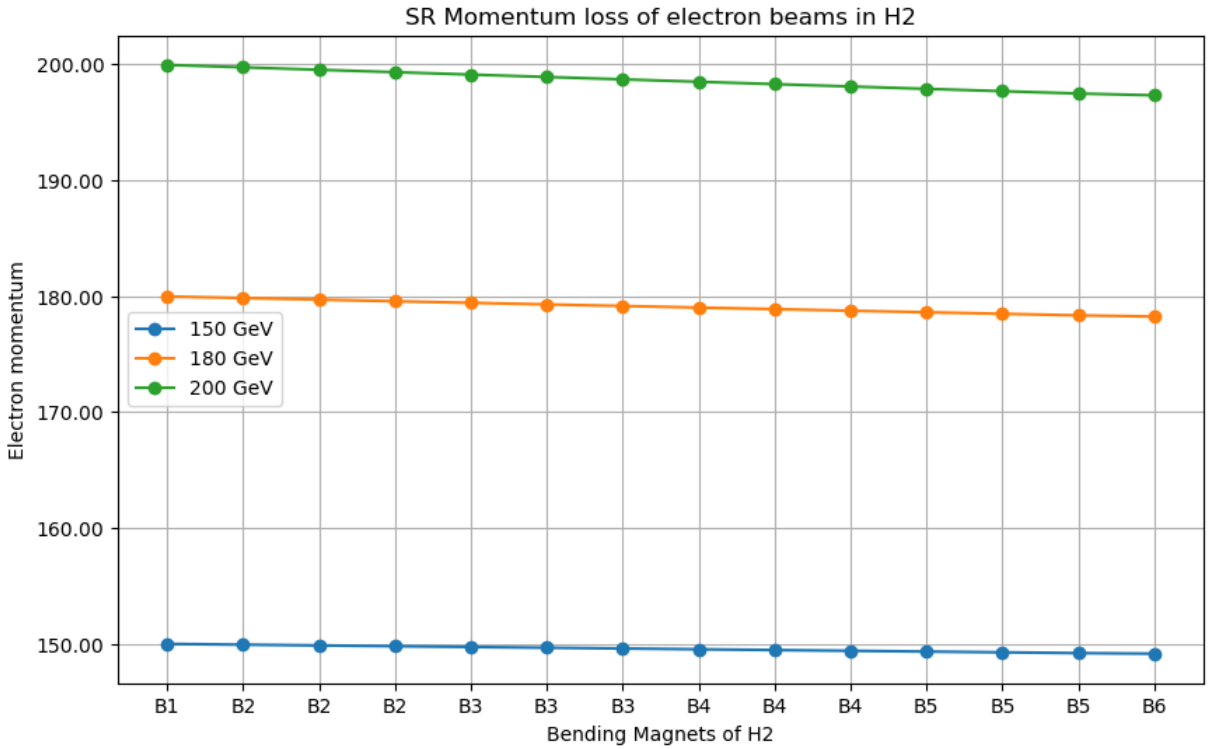
Examples of Electron Beams

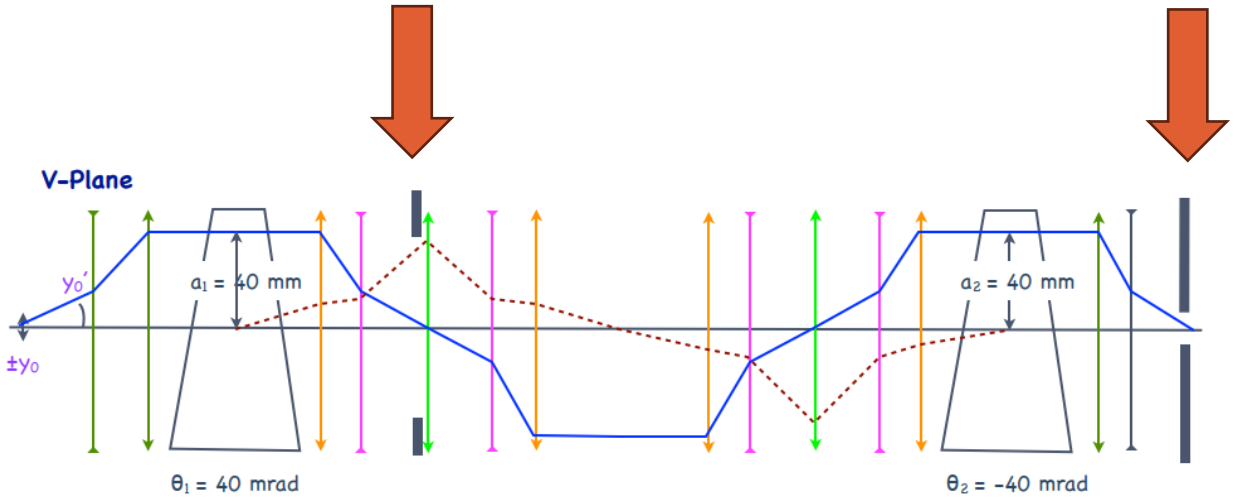




In the high energies: synchrotron radiation helps !

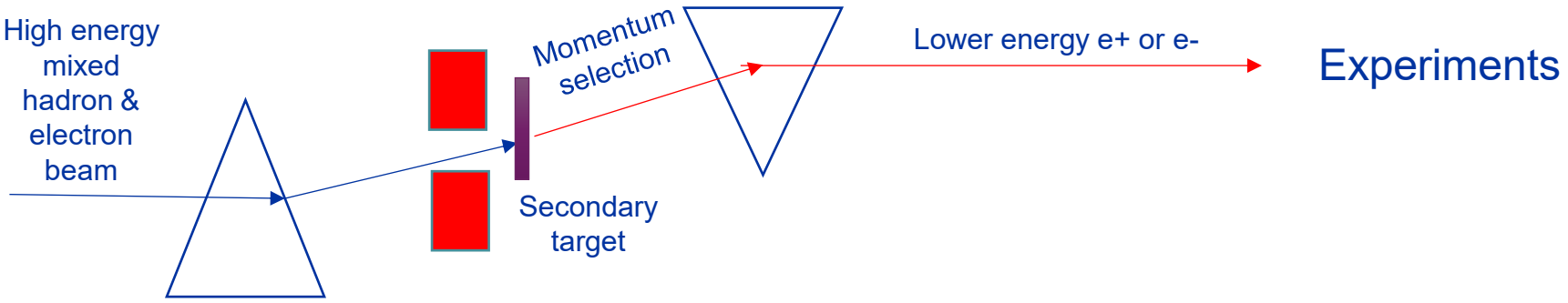
- **In the electron / positron moment > 120 GeV/c, we can ‘clean’ the beam by adjusting the magnets for the lower electron momentum and collimating away the hadrons.**





Electron beam properties in the North Area (2)

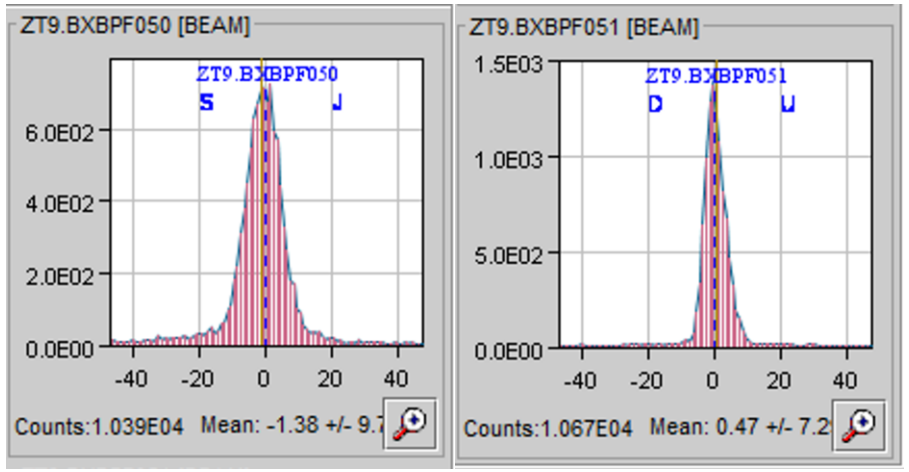
- **Mechanism 2 : Bremsstrahlung of electrons/positrons produced at the upstream targets, using a secondary target**



- **Intensities between 10^2– 10^4 particles per spill, depending on the collimation & momentum selection precision**
- **Purity between 10 – 90% depending on the beamline, momentum & exact target station configuration**
- **Secondary target: Cu, Pb, 3 – 300mm**
- **Available in H6 & H8 beamlines**

Beam Instrumentation in the North and East Area

- **Threshold Cherenkov gas counters (XCET) and CEDARs → used for particle tagging**
  - In the East Area new high pressure XCETs are available that go up to 15bar
  - Refrigerant gases like R218 and R134a can be used for low momenta particle tagging
- **Beam profile & intensity monitors:**
  - Scintillators & Analog / Delay Multi Wire Chambers are installed in several positions along the beamlines
  - In the East Area Scintillating Fibre Hodoscopes (XBPF) are used as profile monitors
  - As part of the consolidation efforts under NACONS all Analog / Delay Wire Chambers will be replaced by XBPFs
- **FISC scanners (only North Area):**
  - Precise slower profile monitors, operating under vacuum
  - Can also be used for measurements of beam divergence
- **Pb glass calorimeter available on request**

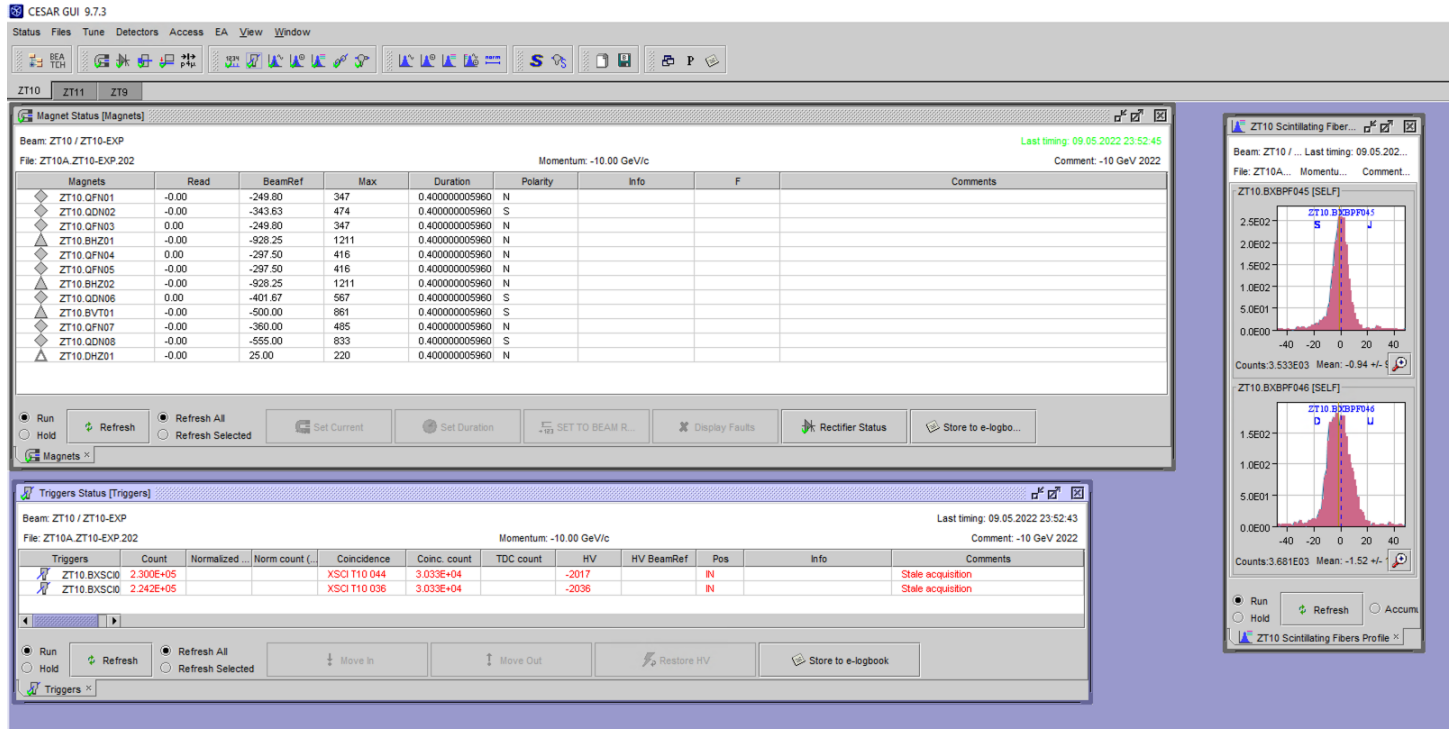


Access and Beam Control Software

- **The beam can be controlled using the *CESAR* interface (will be replaced after LS3)**
  - Magnet currents can be changed, collimators can be controlled, Threshold Cherenkov pressure can be set, beam files can be loaded, beam profiles and trigger information can be accessed etc.,

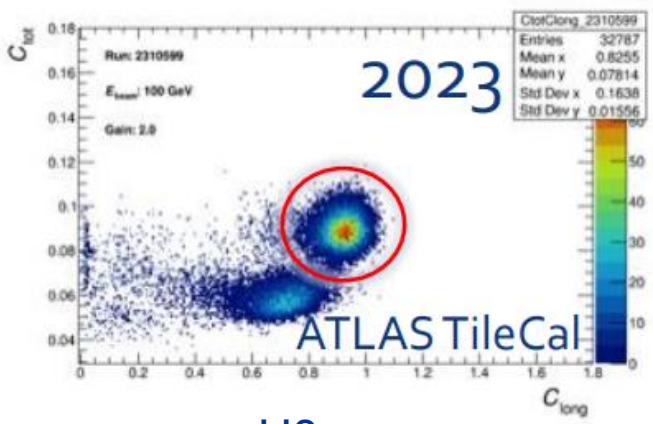
- **The zone can be accessed with a dosimeter and safety equipment**
  - Helmet, safety shoes
  - No special access request is needed

- **2-3 members from each user group are given the “patrol” rights**
  - Required only to turn on the beam
  - Needs on-site training

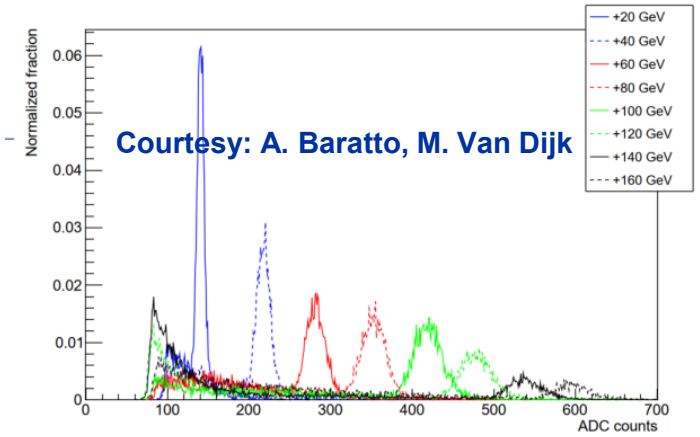


Examples of electron beams in EHN1

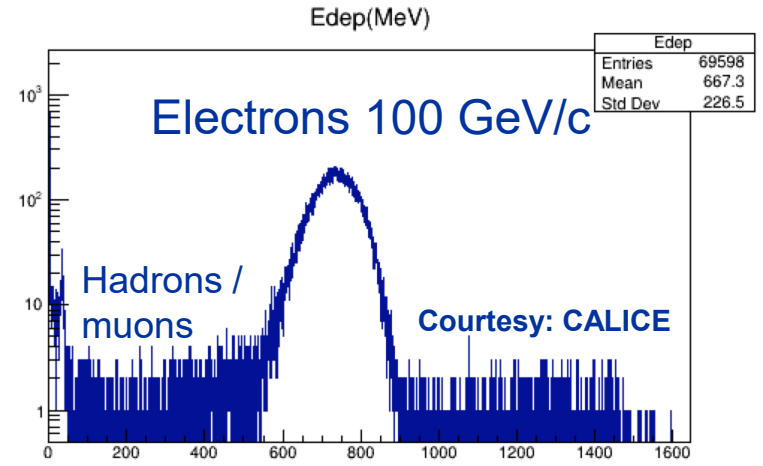
...as measured by the various experiments



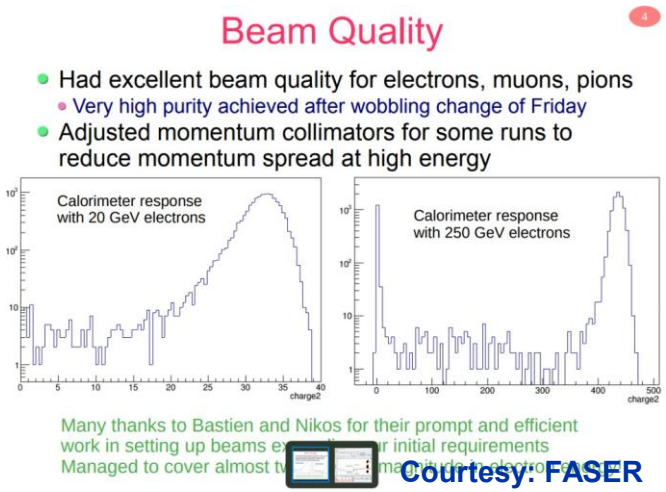
H8



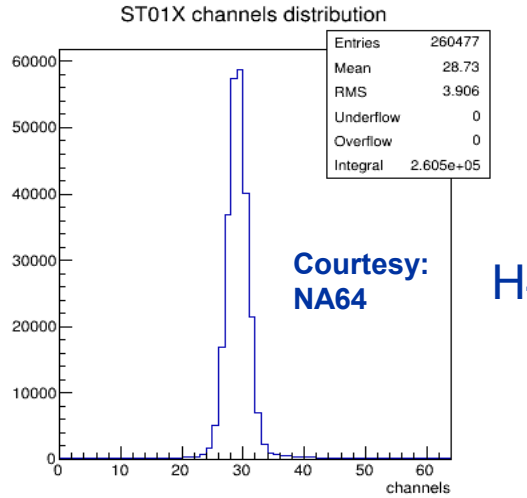
H8



H2



H4



H4

Future Proton-driven Facilities

Future Proton Facilities – CERN ECN3

- **New proposals are coming up for the North Area**
- **BDF/SHiP : An experiment that would allow a full investigation of hidden sectors in the GeV mass range.**
- **SHiP would require unprecedented intensity extracted towards the CERN North Area (4x10^{13} protons / slowly extracted spill – O(4x10^{19}) protons per year)**
- **More requests for electron beams are to come up ?**
  - higher intensities...?
  - Crystal studies ...? More collimated and bright beams ?

Summary

- **The CERN's secondary beam areas are excellent facilities for providing high quality electron beams, in a variety of intensities and purities**
  - Many fixed target experiments & R&D efforts have made use up-to date and more are to come
- **The future "landscape" will include higher proton intensities extracted towards the NA targets**
- **If there are requests for exciting experiments, don't hesitate to contact us !**

Looking forward to seeing you (also) at CERN!

Don't hesitate to contact us :

sba-operation@cern.ch

https://be-dep-ea.web.cern.ch/

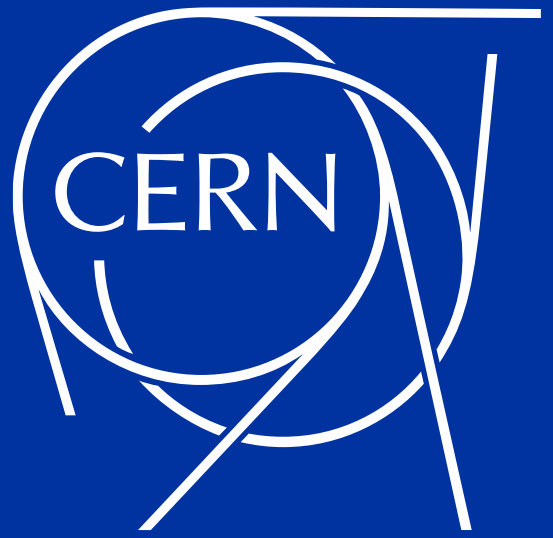
For test-beam applications:

sps.coordinator@cern.ch

https://ps-sps-coordination.web.cern.ch/ps-sps-coordination/

East Area – Secondary Beamlines

North Area Secondary Beamlines


CERN