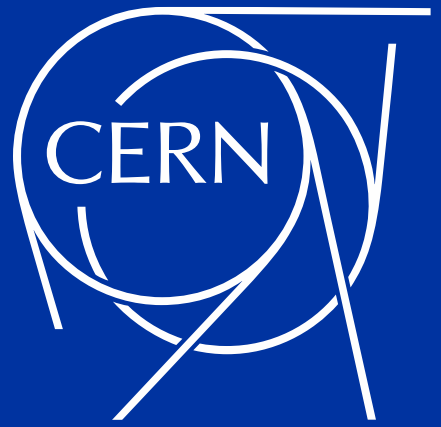
Annual Workshop of Horizon Europe EIC-Pathfinder Project TECHNO-CLS
5–6 Oct 2023
Palazzo Bevilacqua Costabili
Europe/Rome timezone



Electron & Positron beams in the CERN secondary areas

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

05.10.2023

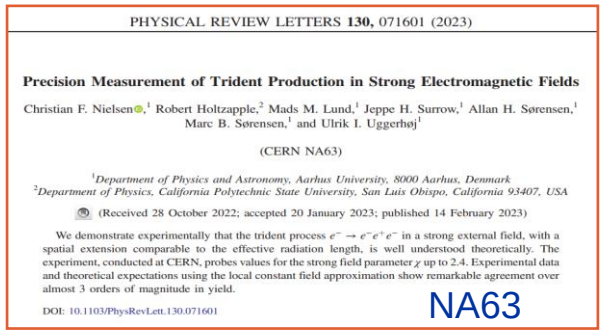
Outline

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

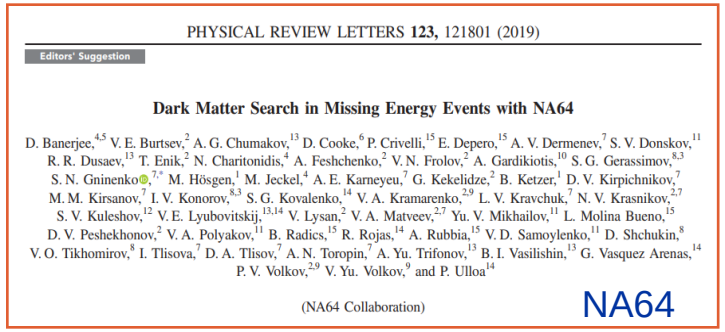
(CERN NA63)

(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)

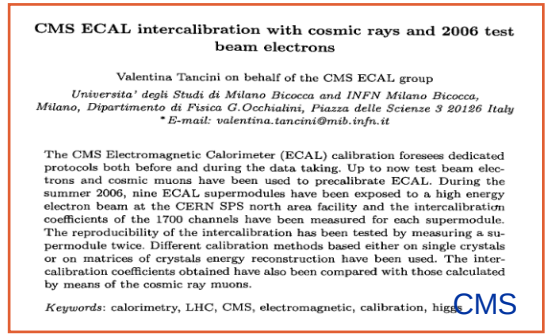
Editors' Suggestion

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

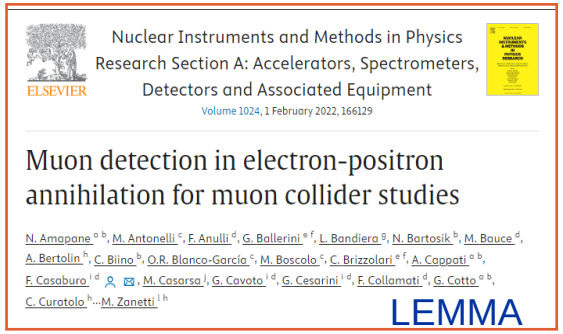
Valentina Tancini on behalf of the CMS ECAL group

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

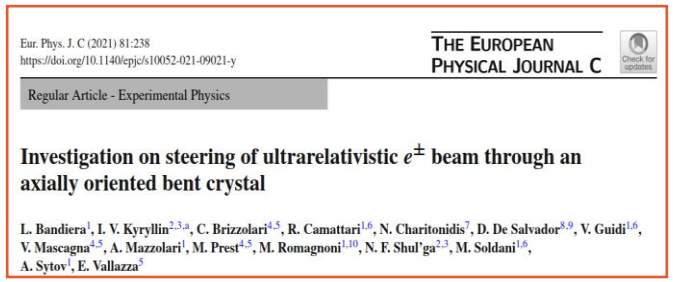

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

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

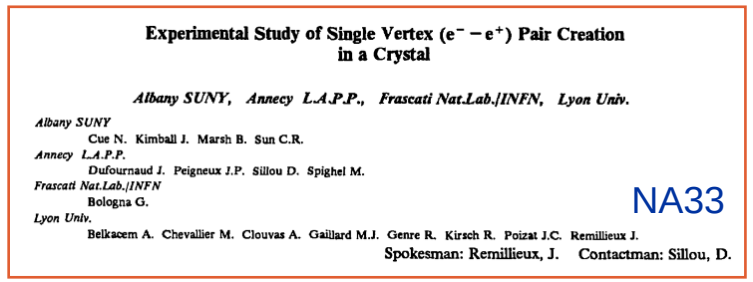

Eur. Phys. J. C (2021) 81:238
https://doi.org/10.1140/epjc/s10052-021-09021-y

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

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

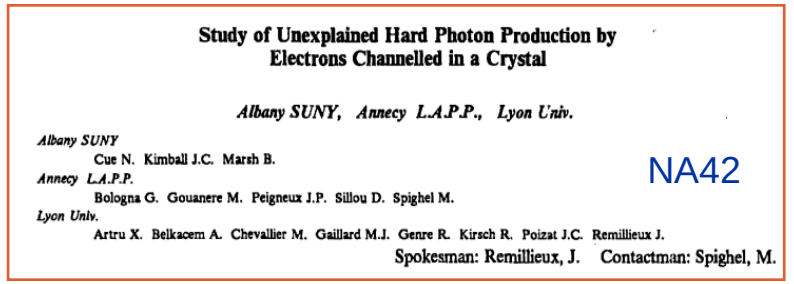
L. Bandiera, I. V. Kyryllin, C. Brizzolari, R. Camattari, N. Charitonidis, D. De Salvador, V. Guidi, V. Mascagna, A. Mazzolari, M. Prest, M. Romagnoni, N. F. Shul'ga, M. Soldani, A. Sytov, E. Vallazza


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

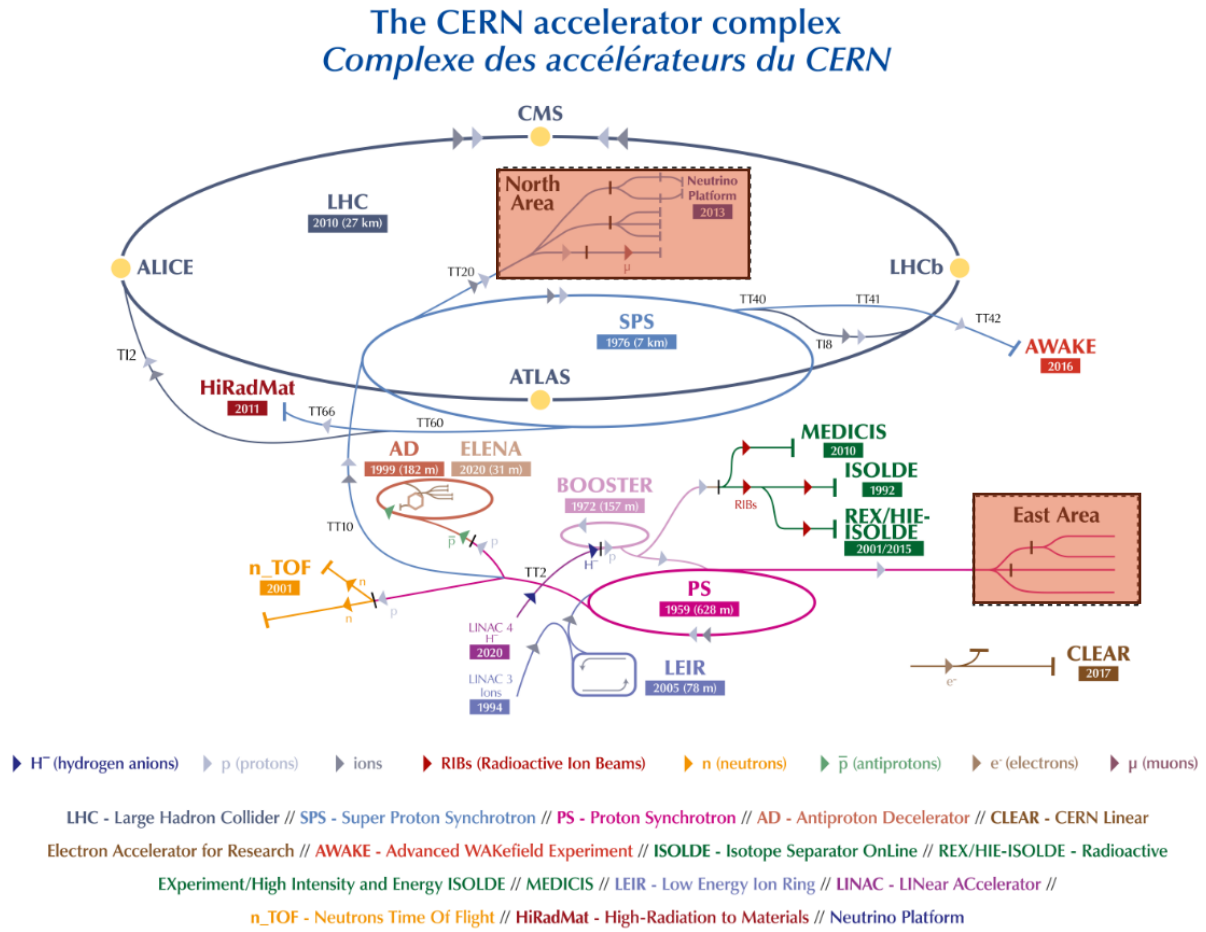
Albany SUNY, Annecy L.A.P.P., Lyon Univ.

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

Existing Proton-driven Facilities

The secondary beam areas today

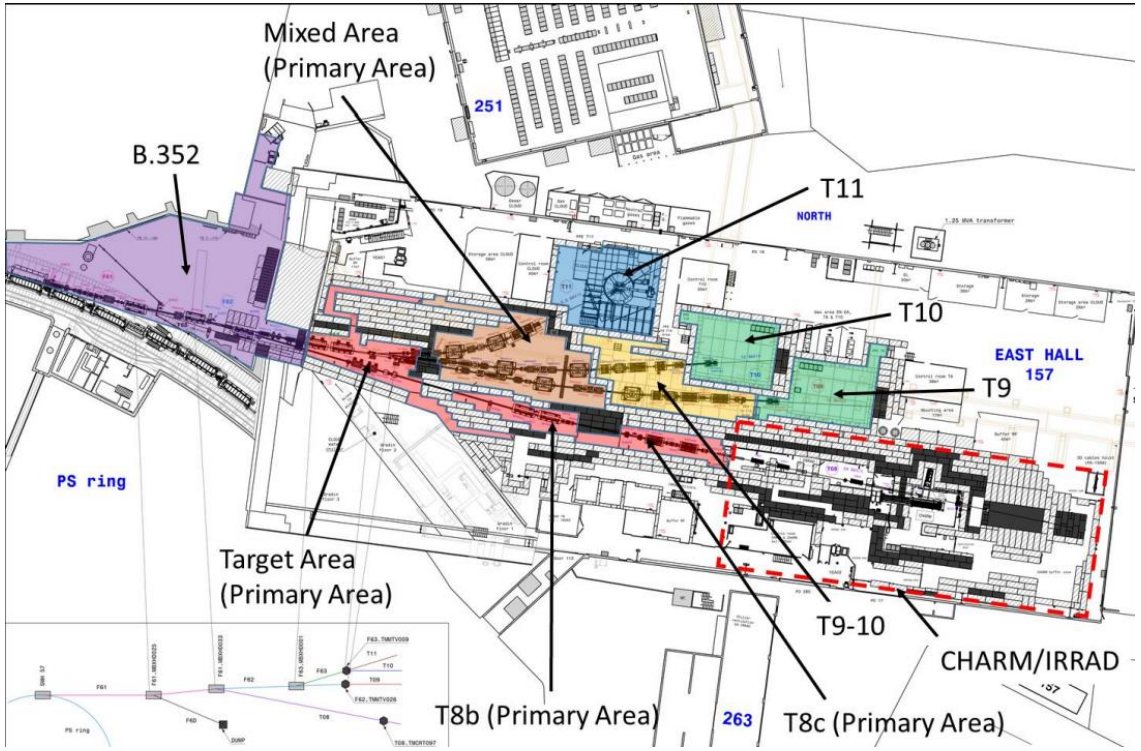


- **SPS : protons/ions @ 400 GeV/c/Z**
- **PS: protons /ions @ 24 GeV/c/Z**

- **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

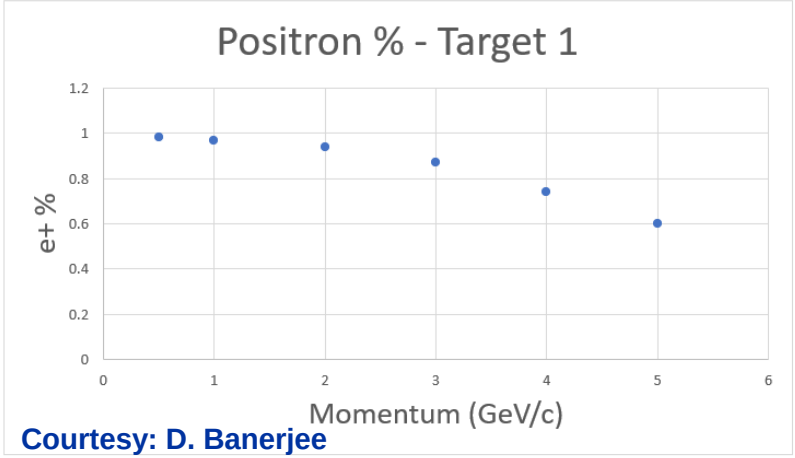
- **Two beamlines available for tests : T9 and T10**
- **Electrons of momenta 0.5 GeV/c – 10 GeV/c available**
- **Purity variable between 99% - 50% (lower – higher momenta)**
- **Spill structure from PS accelerator:**
  - 400 ms spill length
  - ~1 spill every 18s, more on request
- **Quick access, short routes from control to experimental areas**



Electron beam properties in the East Area

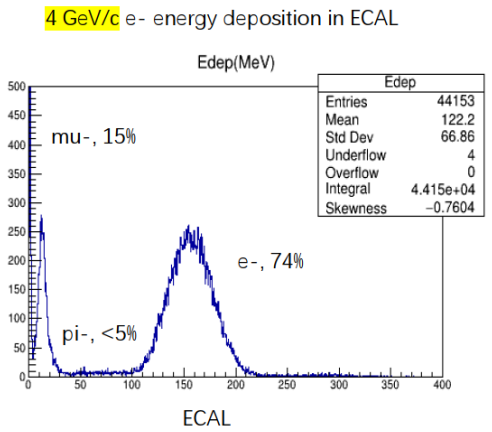
- **Electrons beams of various purities and intensities are available, between 0.1 & 5 GeV/c**
- **Electrons & positrons produced equally, choice to transfer one of the two signs in the various experiments**
- **> 90% electron purity for momenta <5 GeV/c reaching ~99% at 1 GeV/c**
- **Rates, in all momenta up to ~10^5 particles / spill in T09**

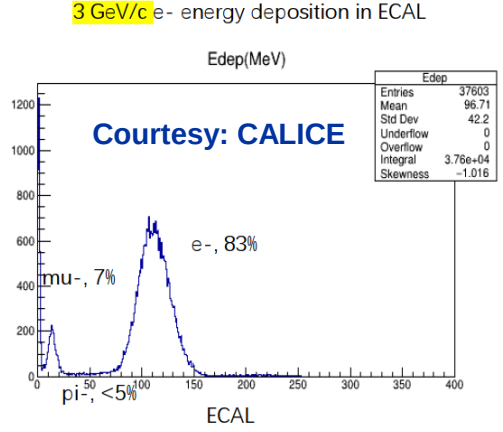
XCET Data – Plot 2



Courtesy: D. Banerjee

ECAL Energy Response to e-





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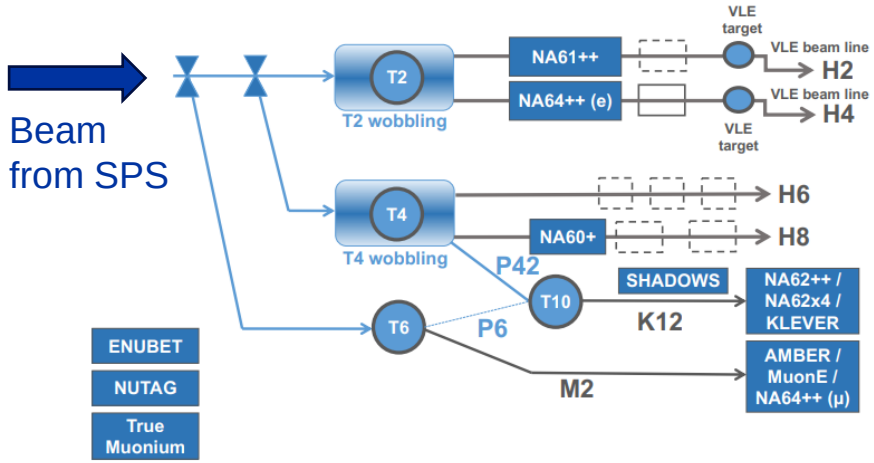
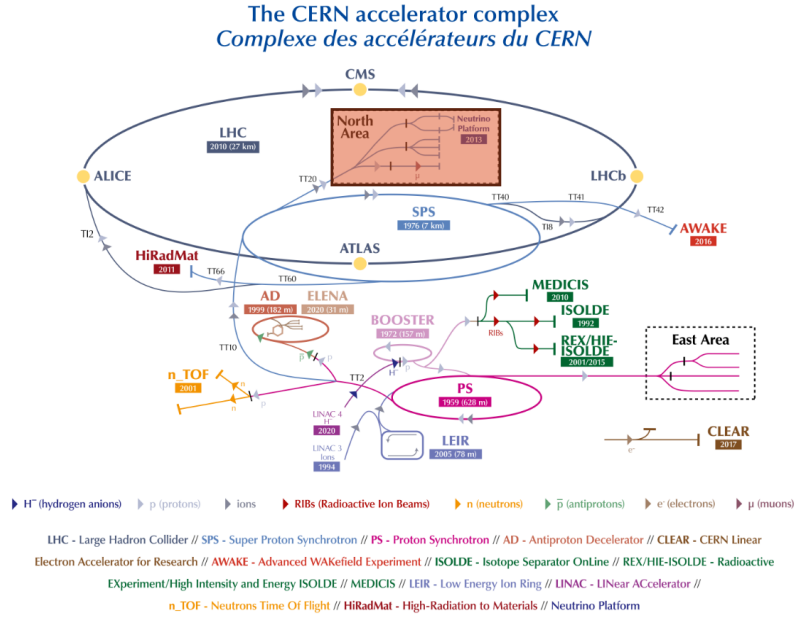
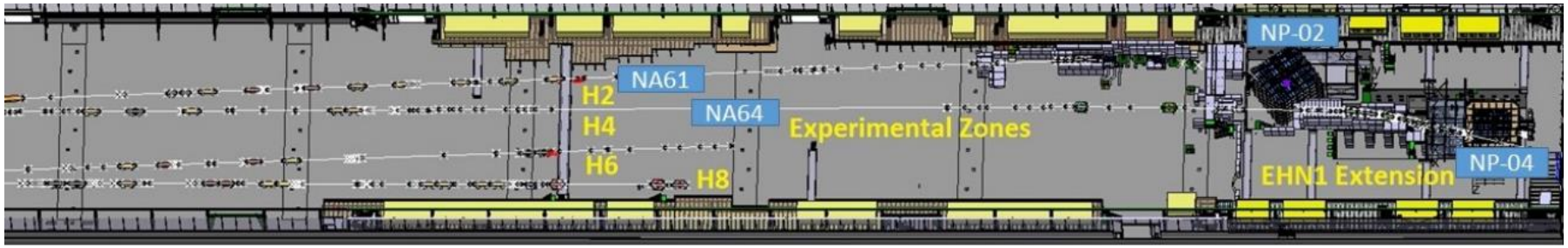
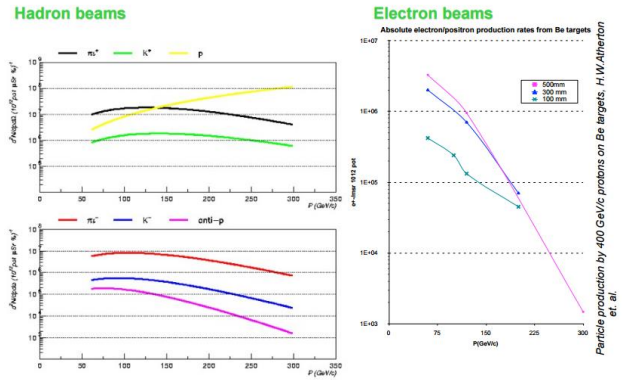
North Area of CERN SPS









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-)**

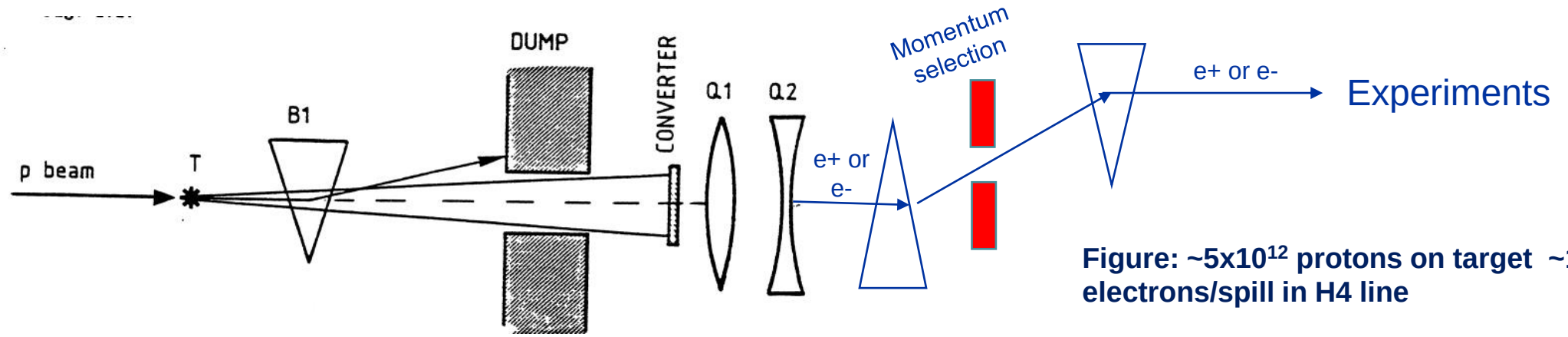
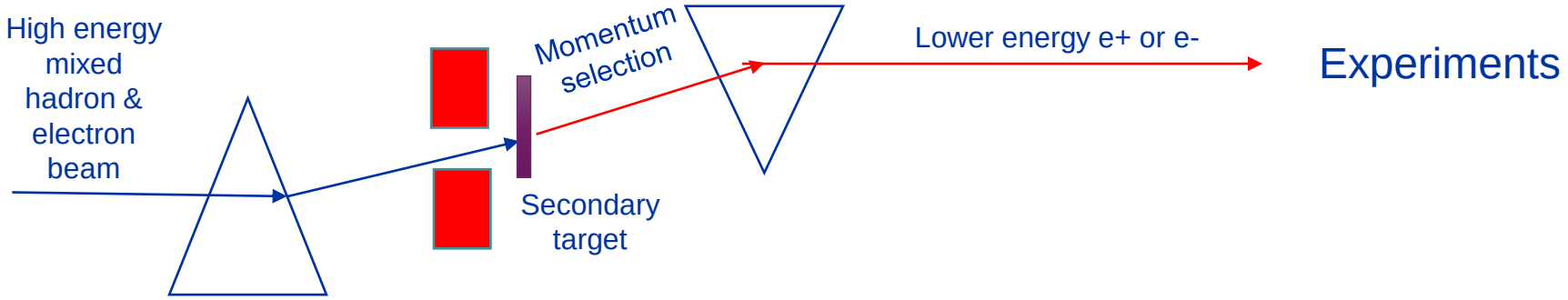


Figure: ~5x10^{12} protons on target ~1E7 electrons/spill in H4 line

- **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**

Electron beam properties in the North Area (2)

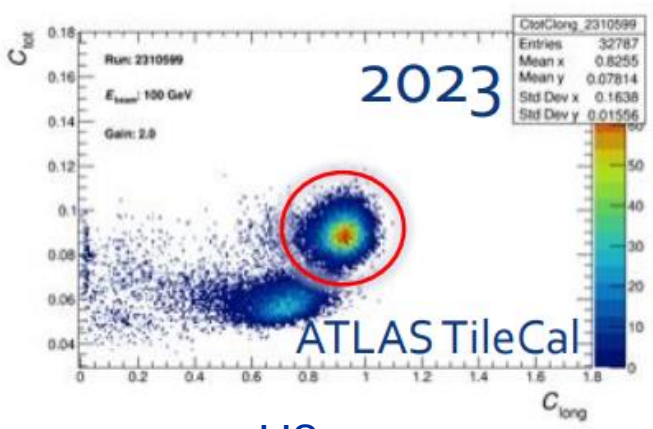
- **Mechanism 2 : Bremsstrahlung of electrons/positrons produced at the upstream targets, using a secondary target**



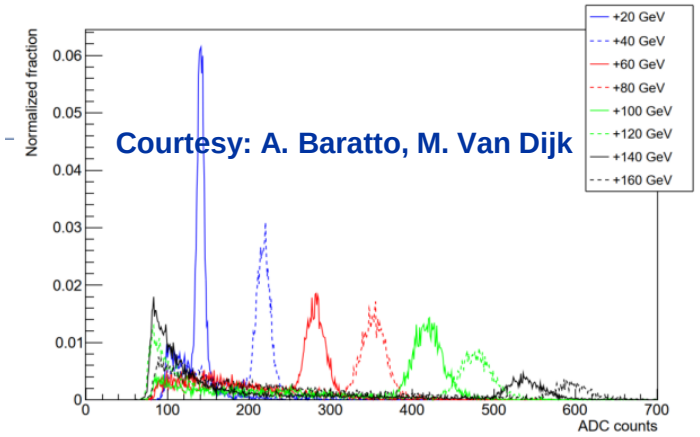
- **Intensities between 10^2– 10^4 particles per spill, depending on the collimation & momentum selection precision**
- **Purity between 10 – 90% depending on the beamline, momentum & exact target station configuration**
- **Secondary target: Cu, Pb, 3 – 300mm**
- **Available in H6 & H8 beamlines**

Examples of electron beams in EHN1

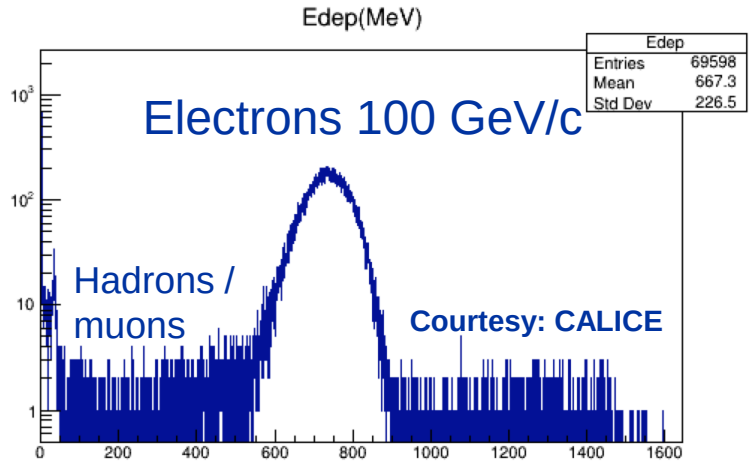
...as measured by the various experiments



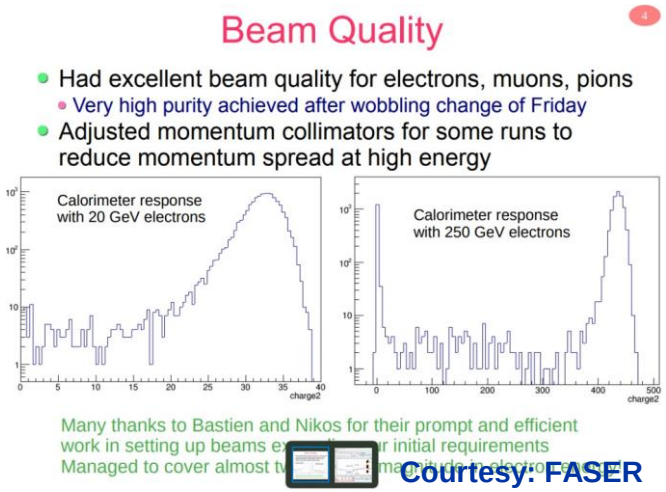
H8



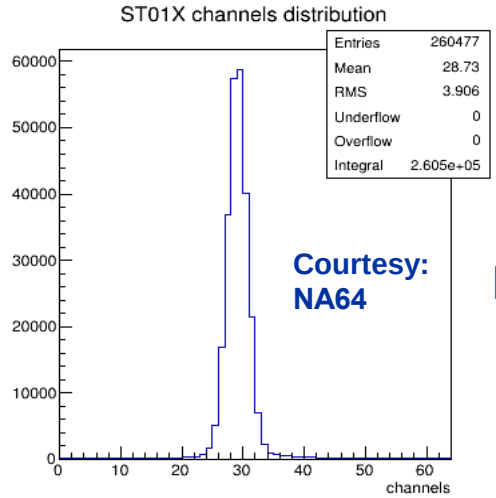
H8



H2



H4



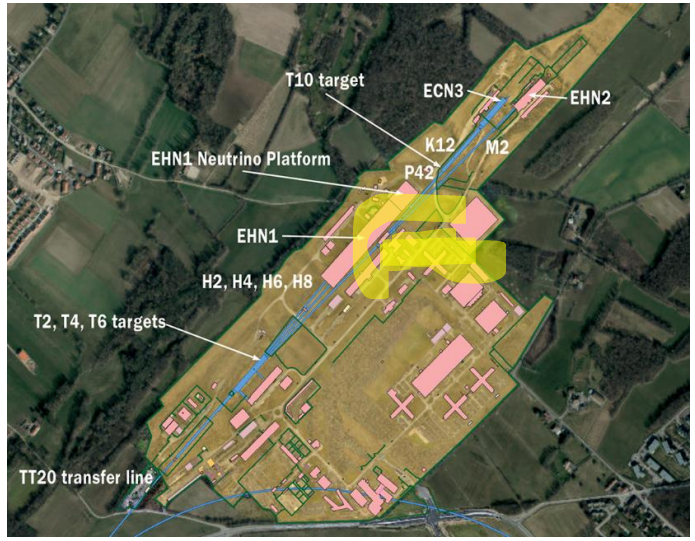
H4

Future Proton-driven Facilities

Future Proton Facilities – CERN HI ECN3

- **New proposals are coming up for the North Area**

- **Within the Physics Beyond Colliders initiative and the ECN3-HI TF, three proposals are being considered for post-LS3 (2029) operation :**
  - **HIKE** : A proposed expansion of the current NA62 experiment for studying rare decays of charged kaons and (later) neutral kaons ;
  - **SHADOWS** : A new experiment that would look for visible feebly-interacting particle (FIP) decays off-axis and could run in parallel to HIKE ;
  - **BDF/SHiP** : A proposal that would allow a full investigation of hidden sectors in the GeV mass range.



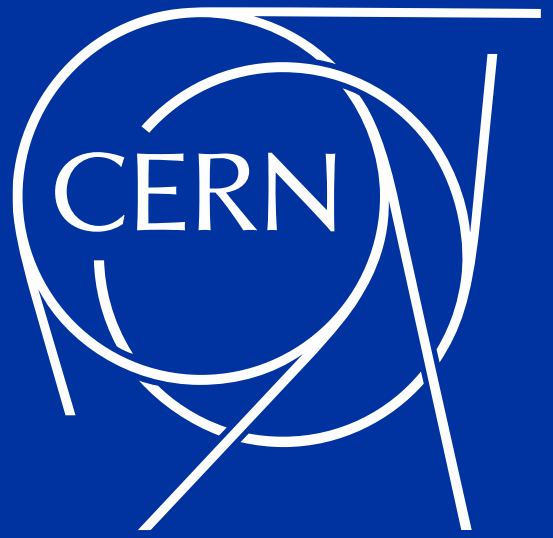
- **All experiments would require unprecedented intensity extracted towards the CERN North Area (4x10^{13} protons / slowly extracted spill – O(10^{19}) protons per year)**

- **More requests for electron beams are to come up ?**
  - higher intensities...?
  - Crystal studies ...? More collimated and bright beams ?

https://cds.cern.ch/record/2802785/files/2204.03549.pdf

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" has yet to be fully explored – also many new ideas will be coming from Physics Beyond Colliders or other inititatives in the upcoming years**
- **If there are requests for exciting experiments, don't hesitate to contact us !**


CERN