Possibilities for (Very) Low Energy beams at CERN North Area

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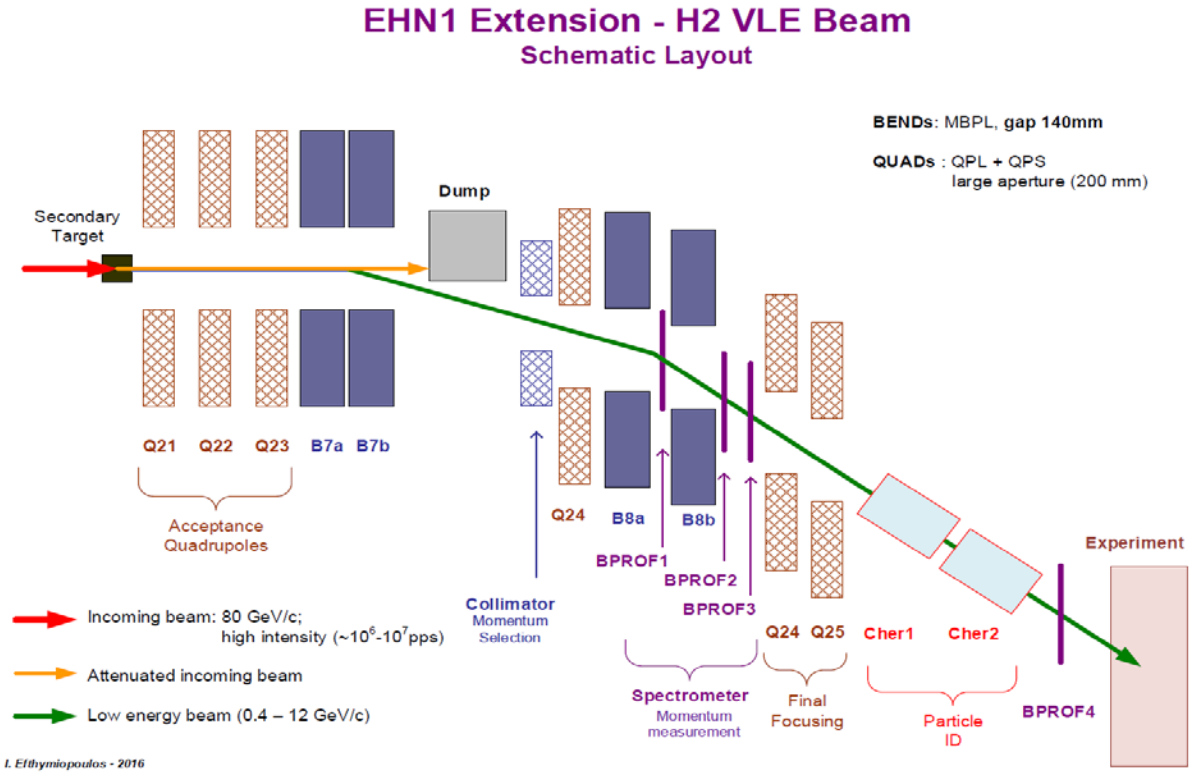
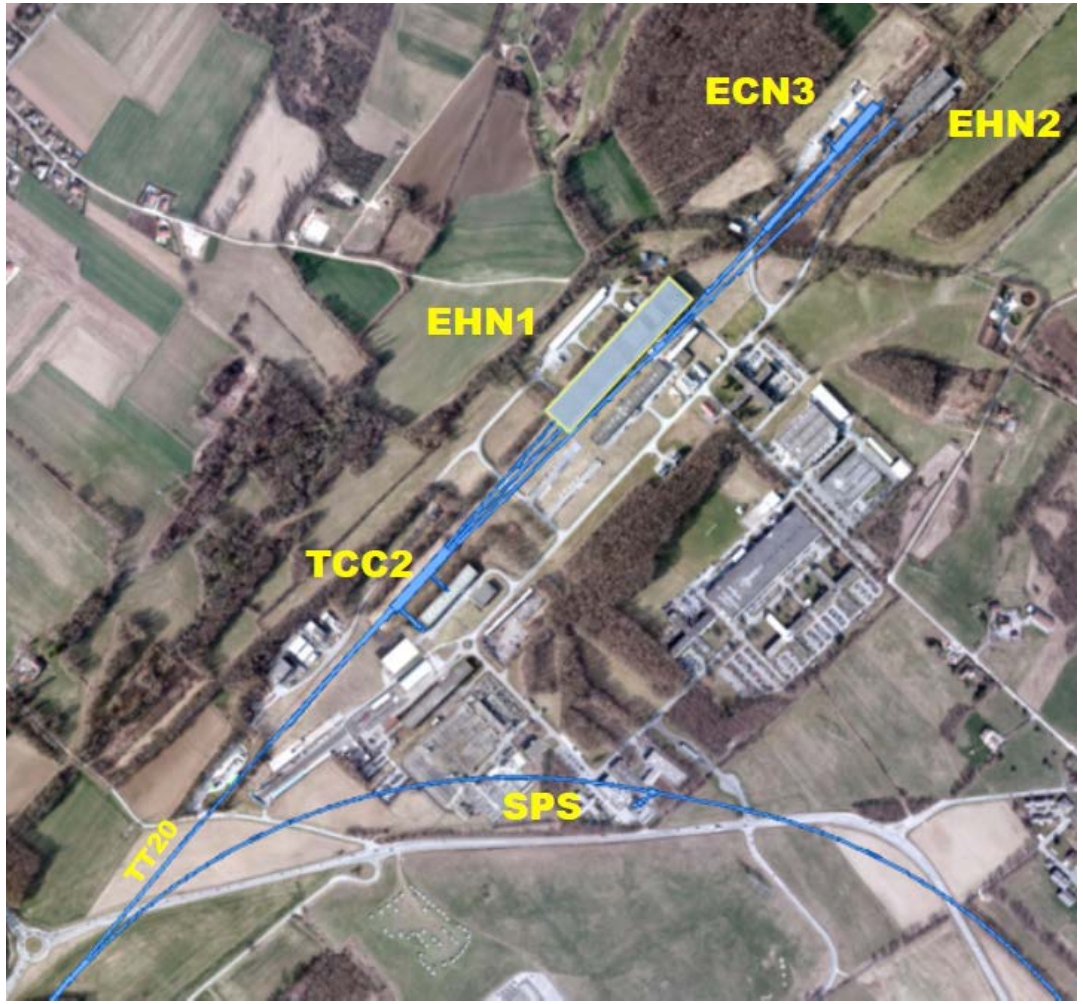


Presentation outline

- Introduction – CERN North Area Beam Facility
- H2-VLE and H4-VLE beam lines
- Outlook in their performance and characteristics
- Possibilities for NA61 ?
- Summary / Conclusions

The Experimental Hall North 1 – EHN1

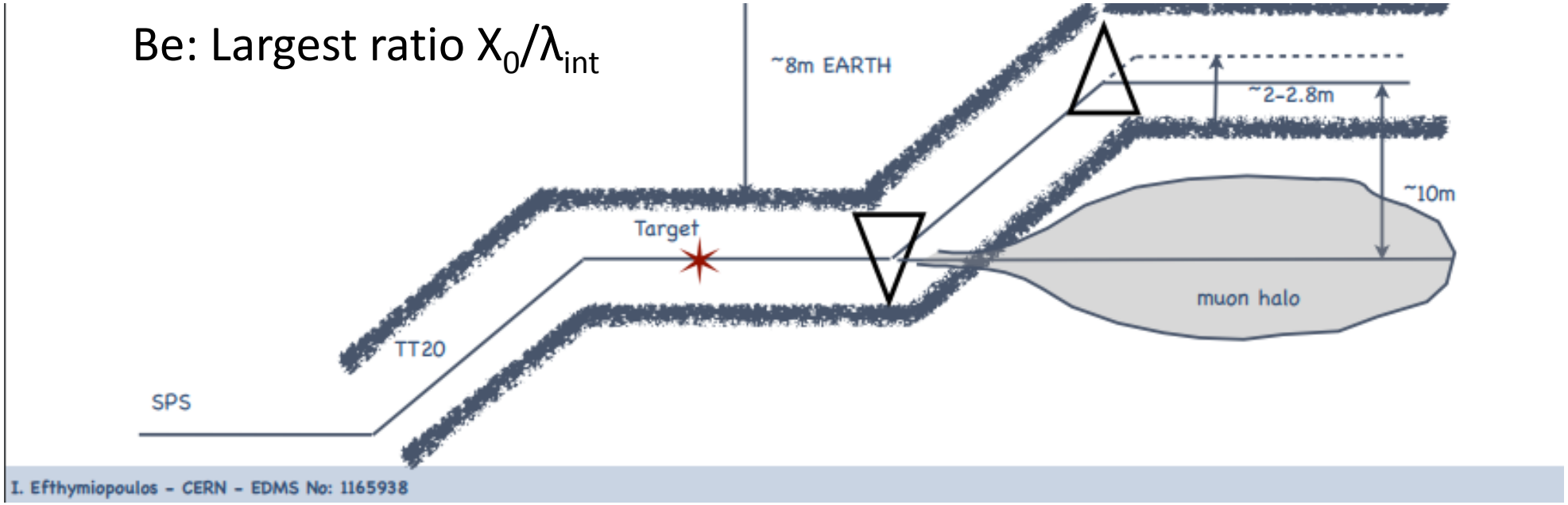
- Part of the SPS North Area complex in the CERN prevessin site



- ~300 m long, 50 m wide industrial type building
- Houses 4 beam lines (H2/H4/H6/H8)
- General purpose building, modular infrastructure, easy to adapt to the needs of the experiments

The North Area Beam Lines – Example H2

H2 : A precise (2% dp/p acceptance), robust, flexible **magnetic spectrometer**



"Wobbling" of the beam *before* and *after* the target allows for flexibility on the particles selected and transported to the experimental areas.

North Area Beam line characteristics

- Very large momentum range from approx. 10 GeV/c → 400 GeV/c (primary beam)
- Mixed hadron or pure electron secondary (or tertiary) beams
- High intensity (limited by the radiation protection rules in the halls) : ~ 1E7 particles / spill (4.8s)

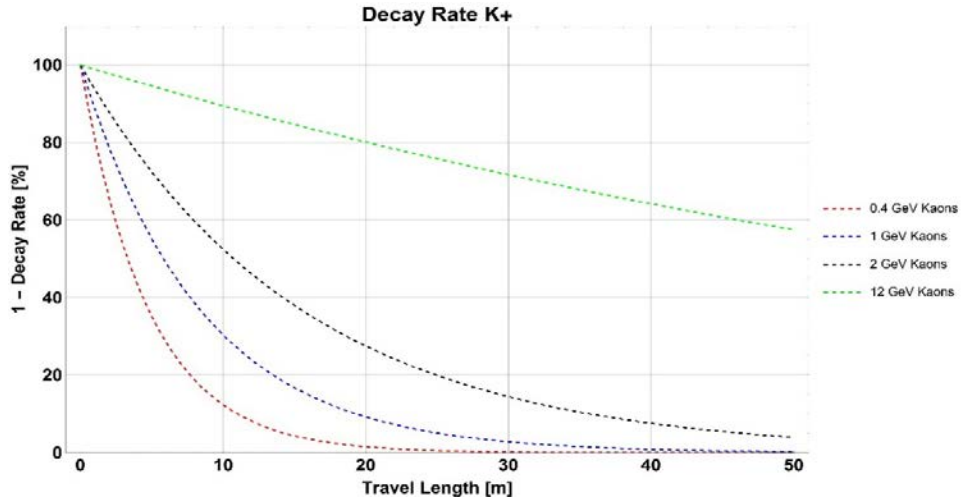
→However : Designed for **high** energies (>300 GeV/c).

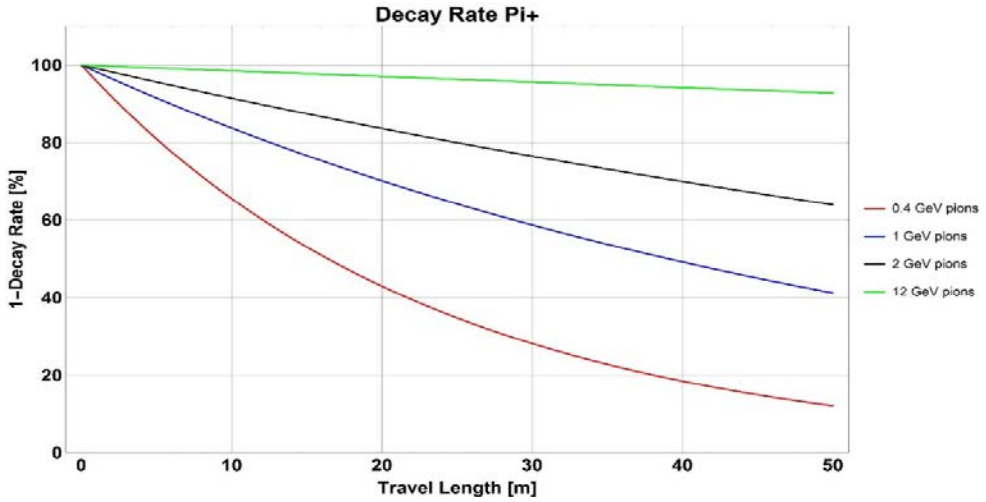
  - Power supplies of bends and quads not very stable when operating in very low currents (for 10 GeV → 31A, setting error 0.2A → 0.6% momentum or 50% acceptance!)
  - Total length (H2) : ~ 600 m – For low energy particles becomes critical
  - Most of the available instrumentation is tuned for high intensities > 1E5 pps

H2 / H4 Magnetic Spectrometer Magnets

But in case of low momenta (< 10 GeV/c)

- Challenges & Specifications :
  - →Short length of the beam line
  - →Minimizing the muon/charged particle background (important for slow read-out detectors, like LAr TPC's…., or in any other detector)
  - →Momentum selection within a few %
  - →Sufficient acceptance → Rate to the experiment



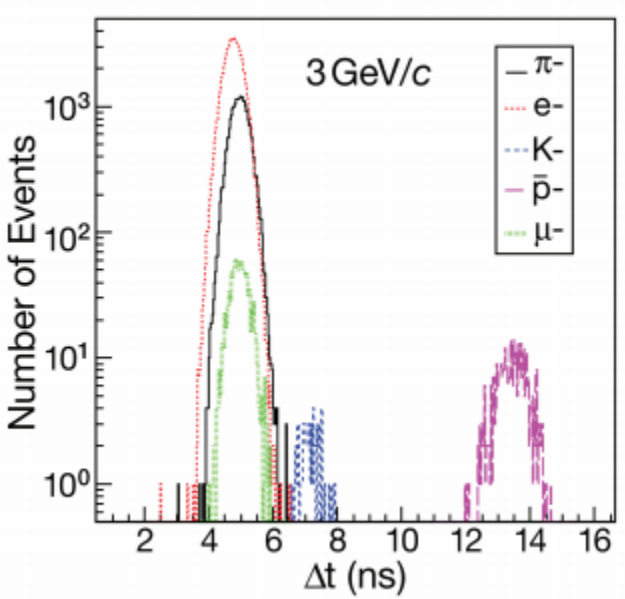


V-L-E Extensions of the secondary beam lines

- A "tertiary" beam line – and a second magnetic spectrometer, with the low-energy particles being created and selected *close* to the experiment
- Not a "new" idea – Successful implementations in the past in H8 (for ATLAS) and H2 (for CMS)
  - https://arxiv.org/ftp/arxiv/papers/1206/1206.2184.pdf
  - CMS NOTE-2008/034

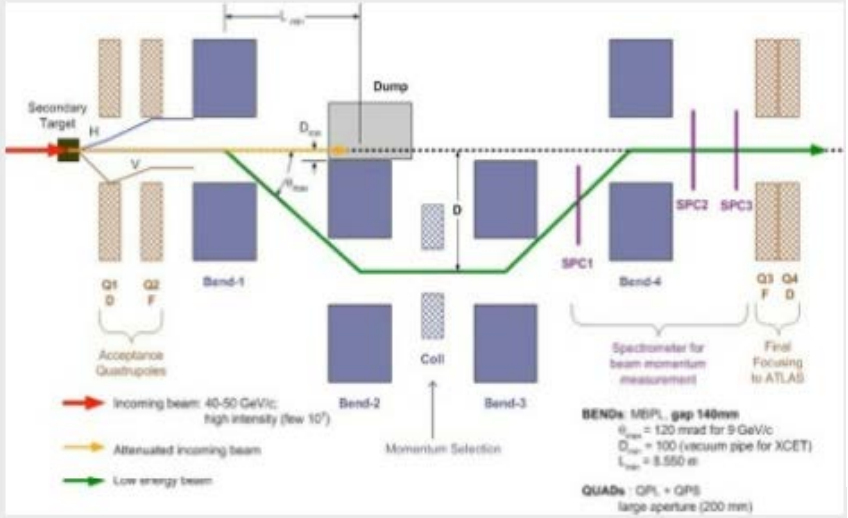
(!) The H2 configuration for CMS

was located just upstream NA61 (PPE142-52)



H2-VLE (2003)

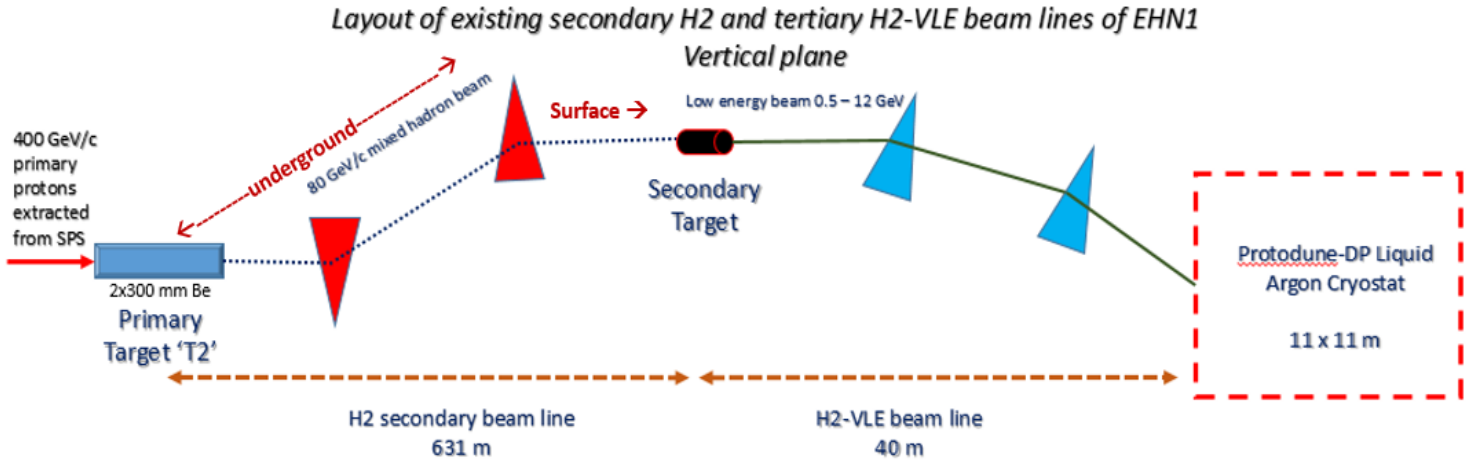
- **Four-bends layout**
  - Available magnets: **MBPL 120mrad for 1-9 GeV beams**



- design used for the ATLAS(H8) &CMS(H2) calorimeters in the past
- suffers from large background from the direct secondary beam

Courtesy: I. Efthymiopoulos

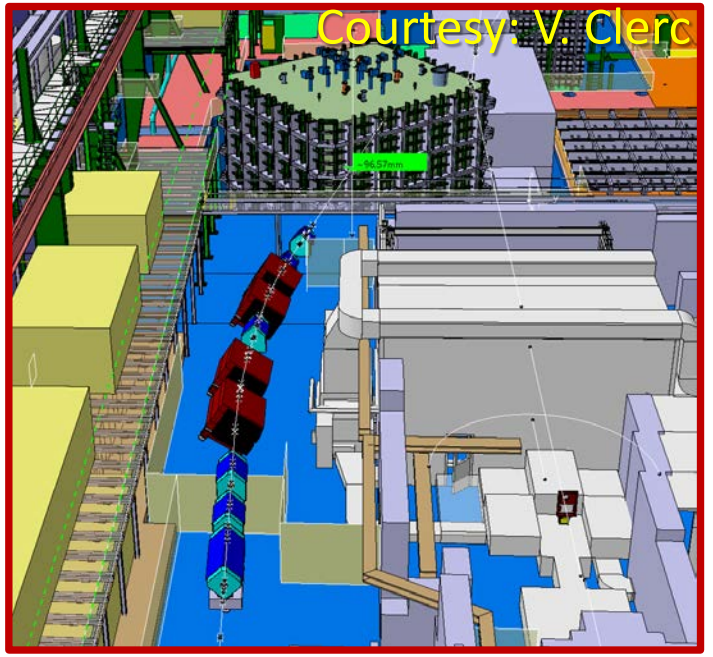
H2-VLE (2017)

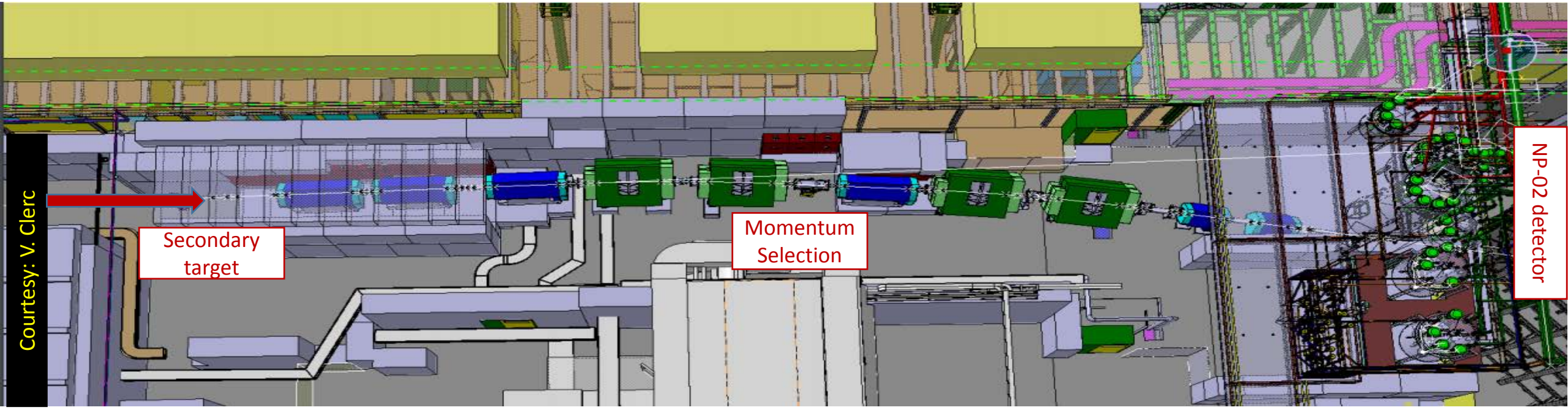


→ Using large angles and off-axis placement of the detector wrt the secondary beam reduces the muon background

Beam Layout - H2-VLE

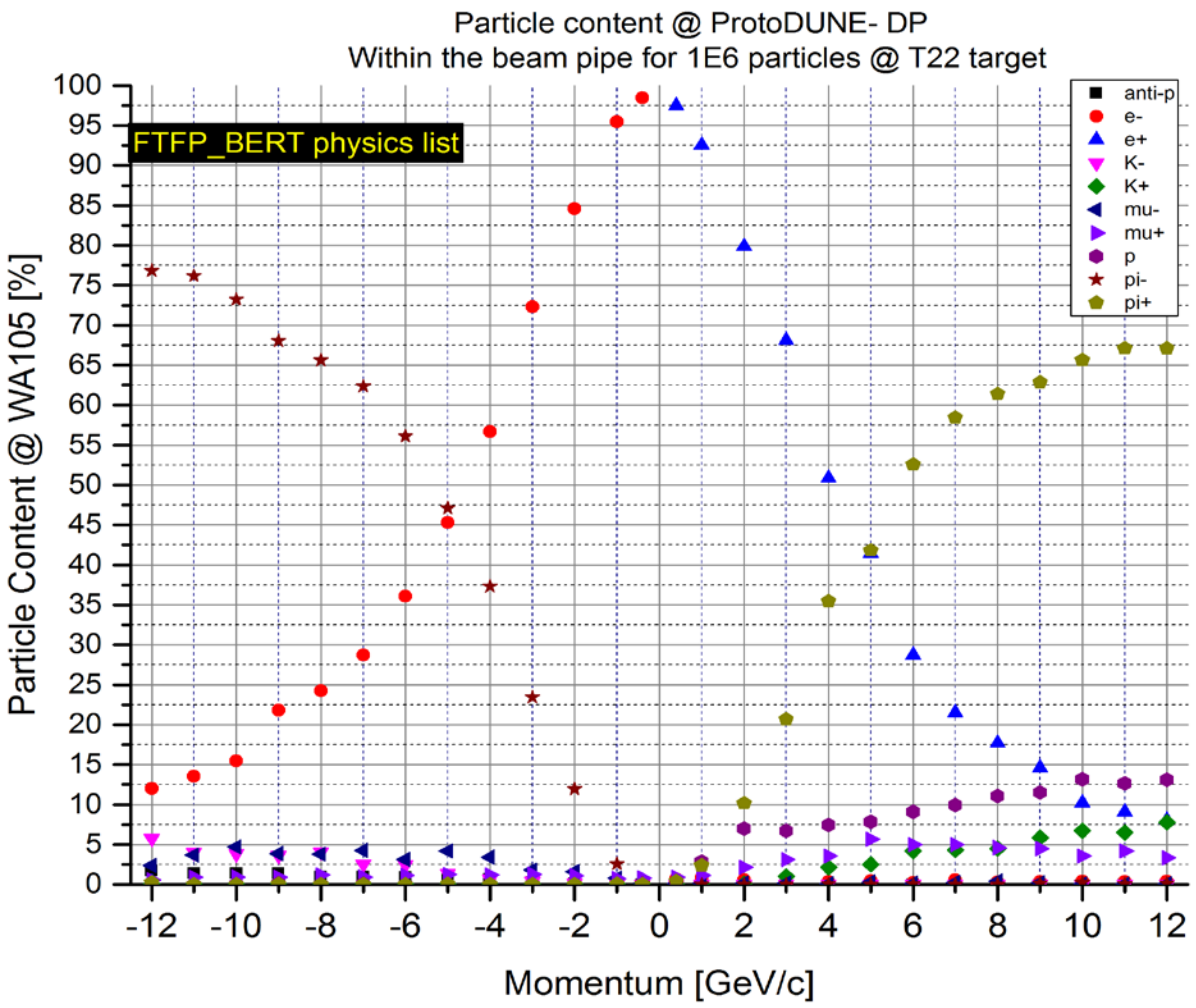
- Tilted dipoles & quadrupoles
  - 34.9 degrees with respect to x-plane
  - Total bend angle : 234.8 mrad in the bending plane
- Momentum selection collimator available
  - Full acceptance δp/p: 5%





Beam Composition

References : CERN-ACC-NOTE-2016-0052, CERN-ACC-NOTE-2016-0059



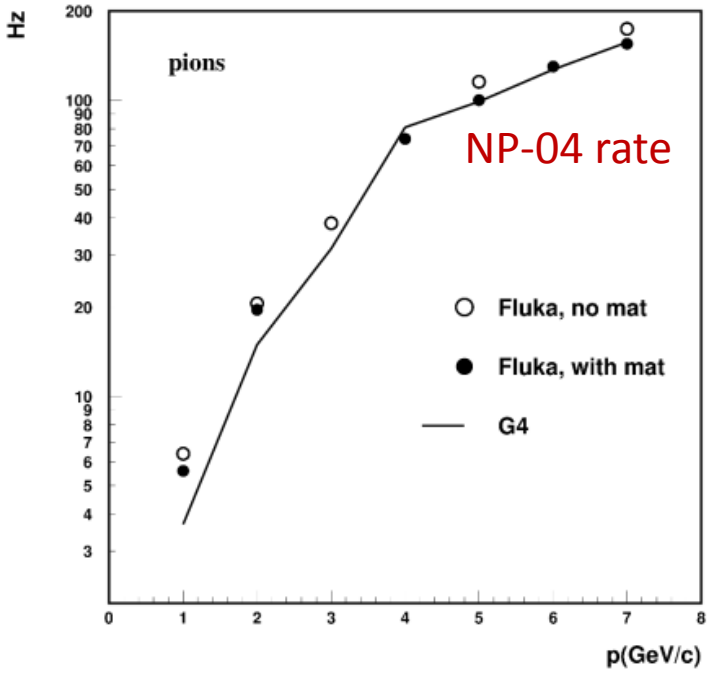
Assuming ~10^6 particles / spill on the secondary target

NP-02 rate

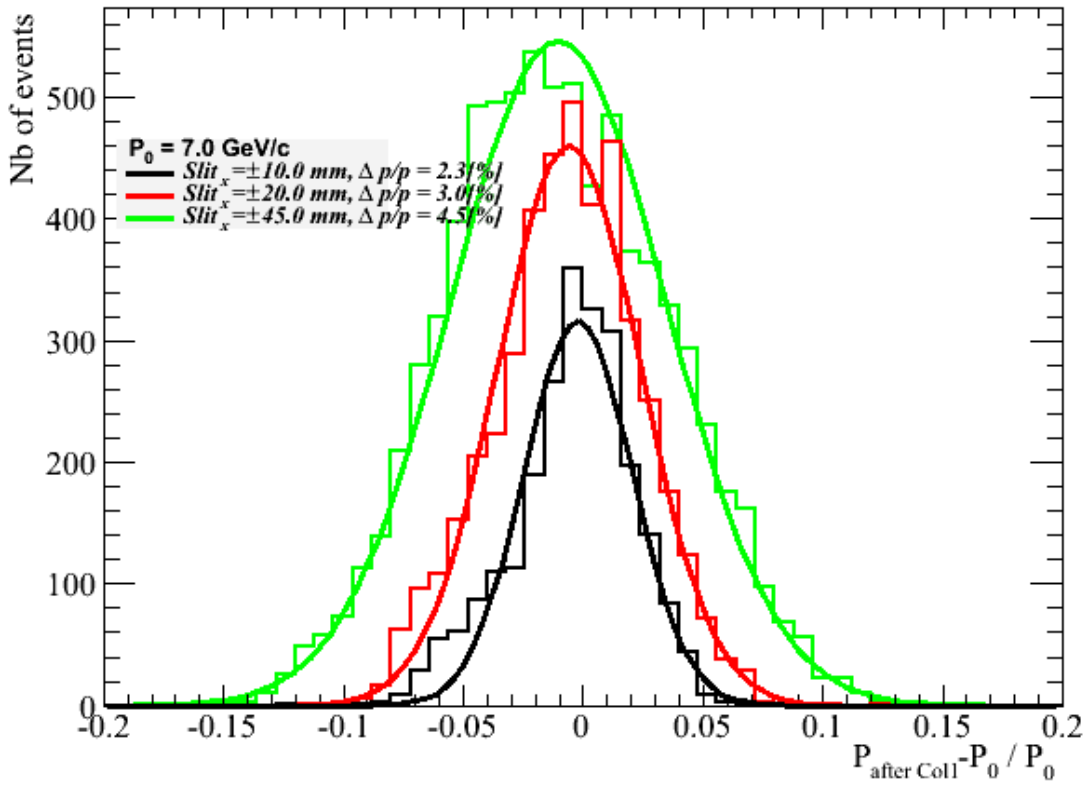
Momentum	e+	K+	mu+	p	pi+	Trigger rate [Hz]
0.4	7	0	0	0	0	7
1	21	0	0	4	3	28
2	17	0	0	7	12	36
3	14	1	1	10	30	56

Momentum	e+	K+	mu+	p	pi+	Trigger rate [Hz]
3	145	1	1	16	49	213
4	117	3	1	16	80	218
5	94	5	2	20	100	222
6	77	9	2	25	133	247
7	69	11	2	28	169	279
8	59	16	3	35	193	305
9	51	19	3	37	227	337
10	46	22	3	45	254	370
11	41	27	3	53	268	393
12	38	29	3	60	292	422

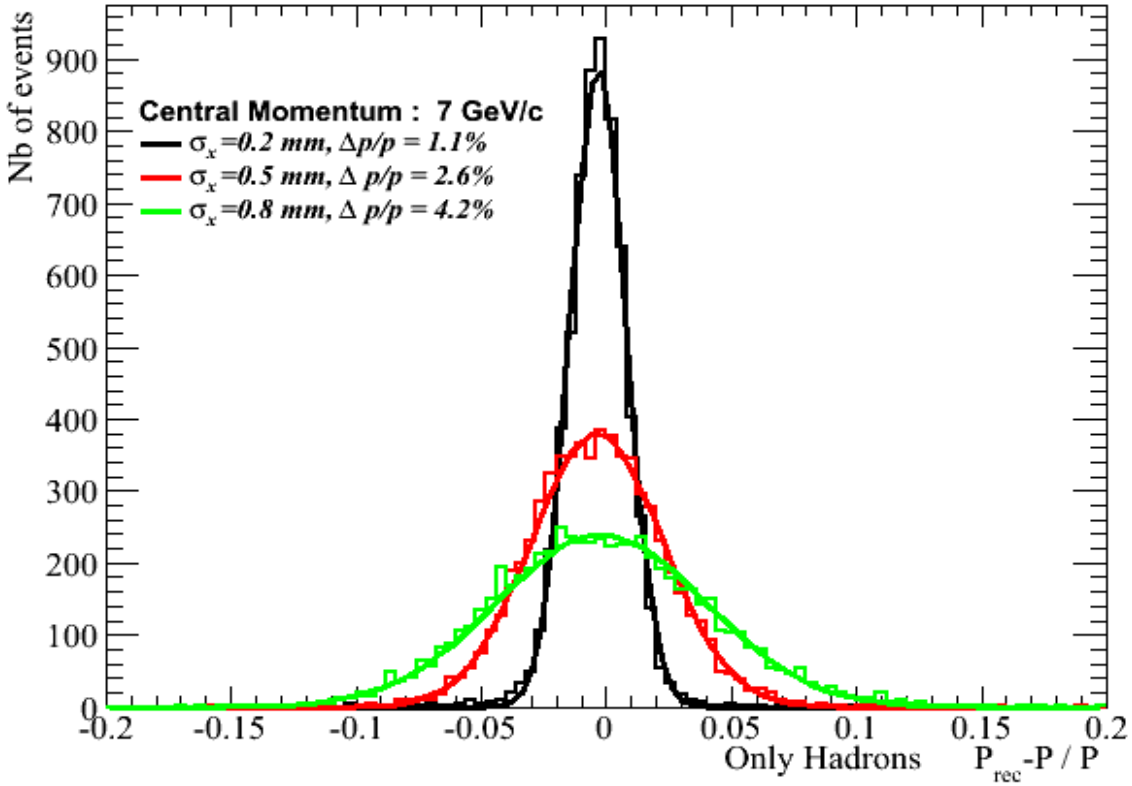
Table 2: Trigger rate for a Cu (0.4 – 3 GeV/c) target and a W (4-12 GeV/c) target.



Momentum Resolution



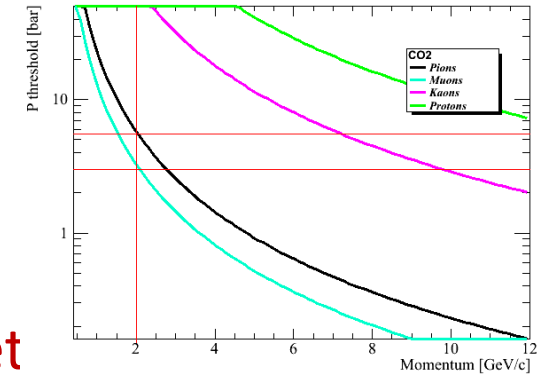
Beam lines equipped with a momentum selection station which can offer a dp/p down to 2.3%

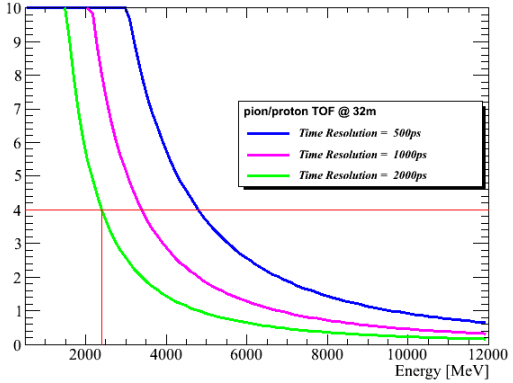


Further improve of the resolution with a spectrometer (using 3 profile monitors) around a bending magnet

References : CERN-ACC-NOTE-2016-0052, CERN-ACC-NOTE-2016-0059

Instrumentation





- Beam momentum spectrometer
  - ➢3 profile monitors around a bending magnet
- 2 Gas Cherenkov Detectors per beam line
  - ➢ R134a & CO2 gases (1 high and 1 low pressure)
  - ➢p/K/pi separation from >2 GeV/c
  - ➢e- tagging
- ToF using scintillating fiber detectors or ionization detectors
  - ➢p/pi separation <2 GeV/c
- Profile/Intensity monitors
  - ➢Necessary for beam tuning

→All of the above combined with the triggers of the experiment !

→ A challenging exercise !

Possibilities (and challenges) for NA61 low-energy configuration

- The possibility of a “dogleg” or similar configuration could be studied in PPE142-PPE152 (upstream NA61)
  - Magnets and power supplies availability ?
  - Space availability with NA61 in place – with minimal disturbance to the downstream experiments and the ‘normal’ operation of the beam line ?
  - Acceptance/rate to be achieved ?
- Composition, background to the experiment & instrumentation
  - Low proton content in tertiary beams (~5-10%) ?
  - Muons from the secondary beam – can they be vetoed ?
  - Rate does not exceed ~a few hundred of Hz

Conclusions

- VLE (Very Low Energy) beam lines have been designed, implemented and operated in the past in EHN1 with success
  - Two new VLE extensions will be operational in 2018 to serve NP-02 and NP-04.
- They are able to provide mixed hadrons (p,pi+,k+) and/or pure e+, in a short length and with a maximum momentum bite of 5%
- The spot size is large ~ 10x10 cm2 – tunable depending on the exact line configuration
- A possibility for implementing such a configuration for NA61 can be studied.