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

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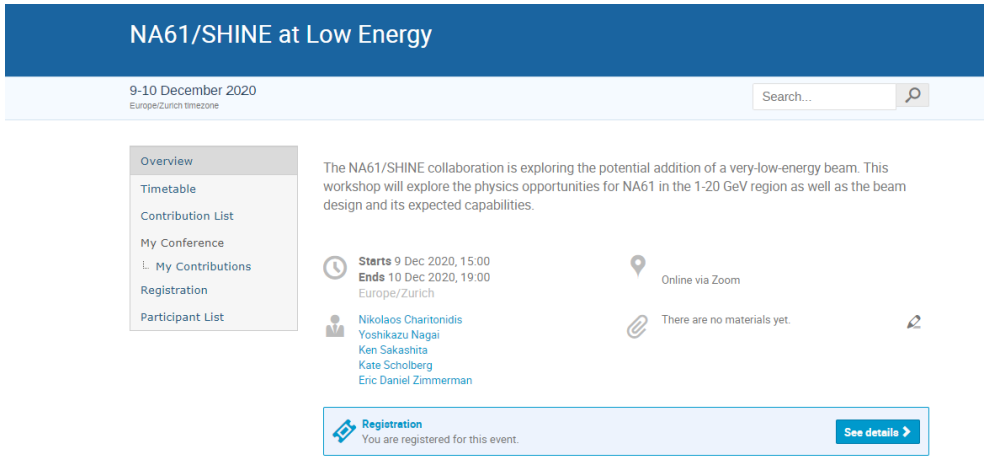
With lots of info/feedback from Y. Nagai, E. Zimmermann & NA61 colleagues

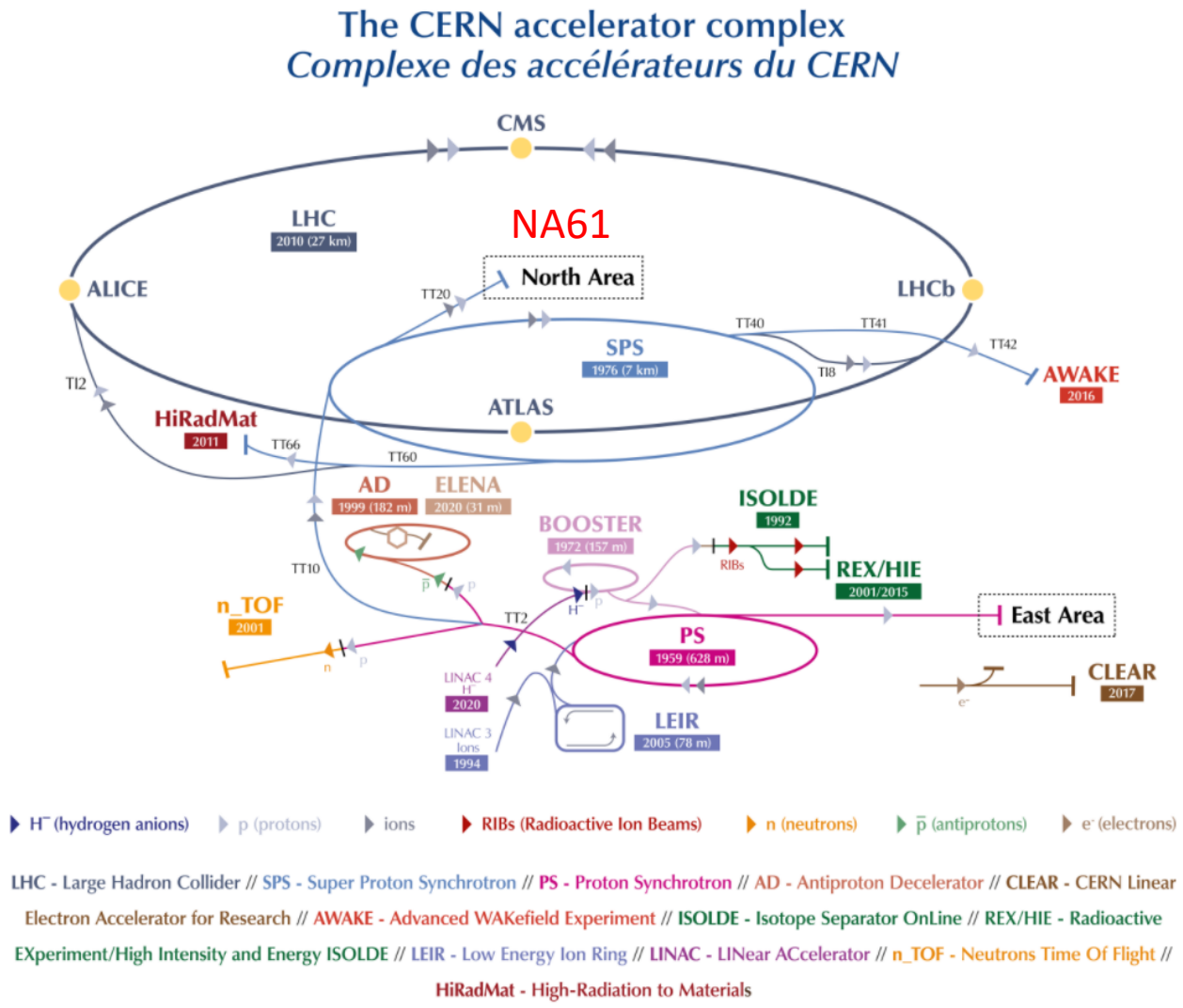
We have advanced....

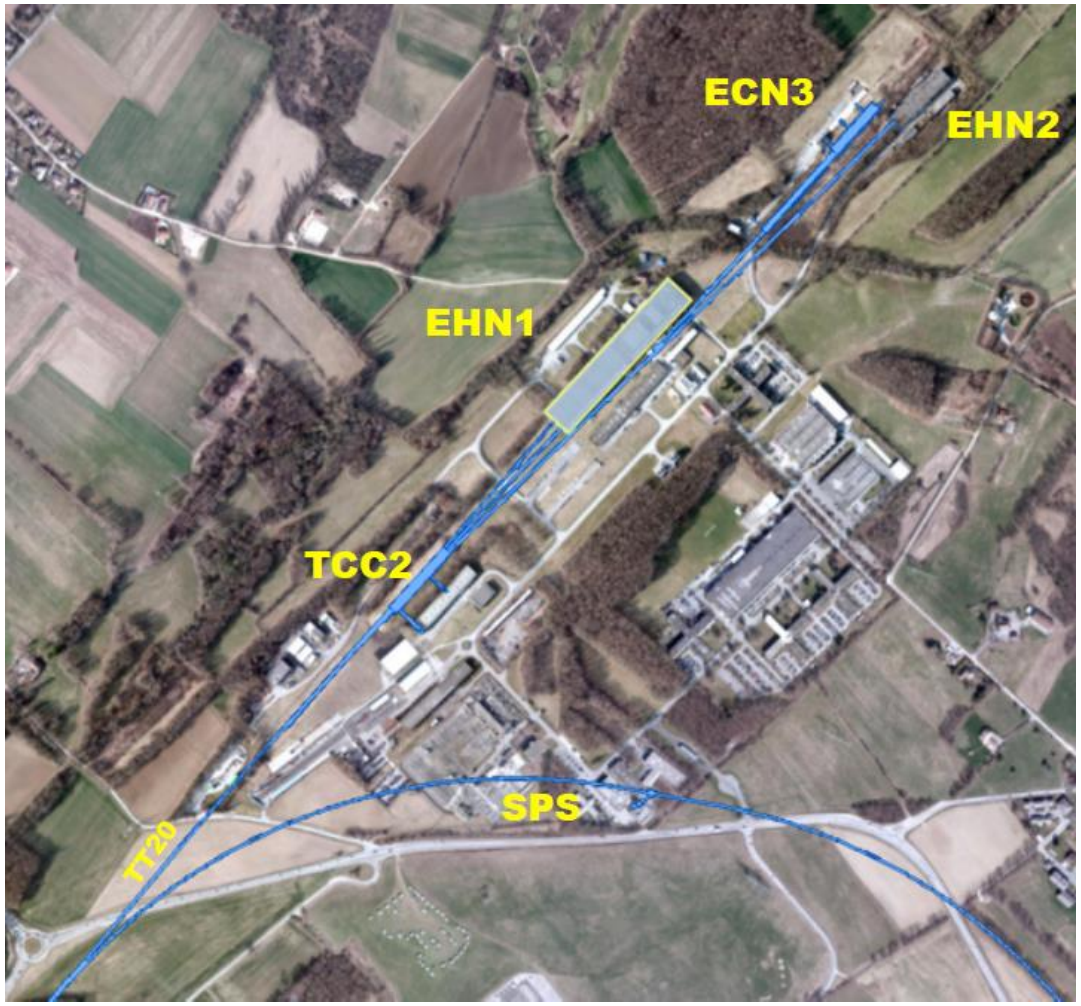


Presentation outline

- Introduction – CERN North Area Beam Facilities
- Current situation
- Possibilities for NA61
  - Requirements (→ See talk of Carlo)
  - Outlook of performance (→ See talk of Carlo)
  - Possible time-line for installation
- Summary / Conclusions

CERN's accelerator complex





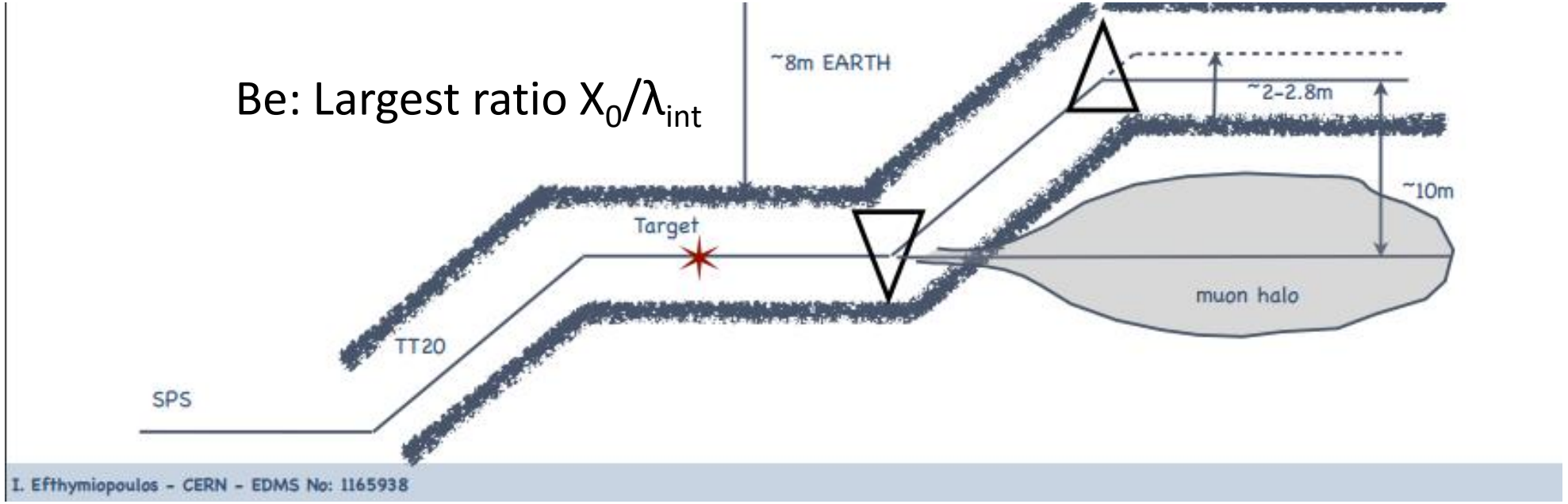
The Experimental Hall North 1 – EHN1

- 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
    - ✓ plus 2 extensions for the new Neutrino Platform
  - General purpose building, modular infrastructure, easy to adapt to the needs of the experiments

→ Synonym: Flexibility !

The North Area Beam Lines – Example H2

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



Principles :

1. **Select momentum precisely**
2. **Reduce the background as much as possible**
3. **Starting from 400 GeV/c → high as possible energies and decent rates !**

North Area Beam line characteristics

- Very large momentum range
  - >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)

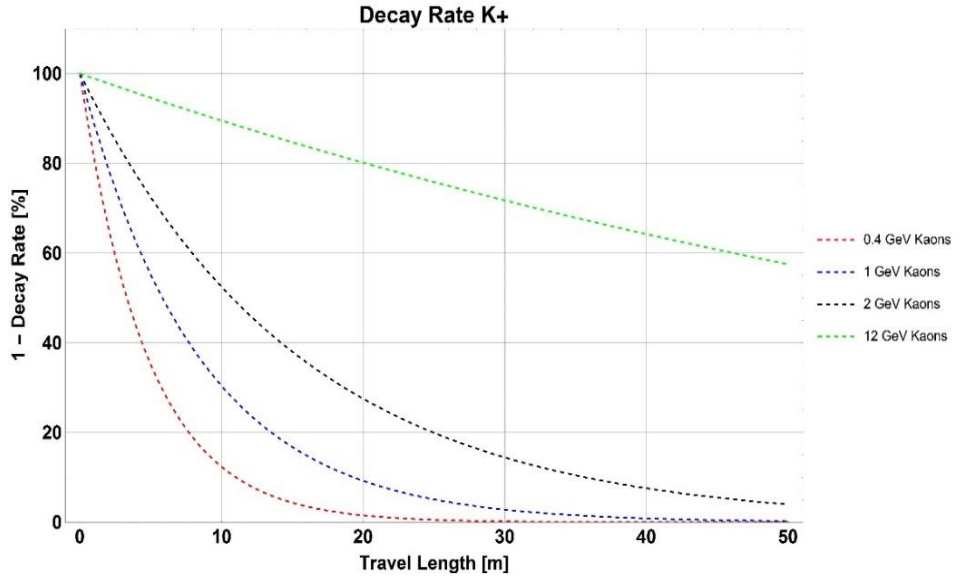
→However : Designed for **high** energies (>300 GeV/c).

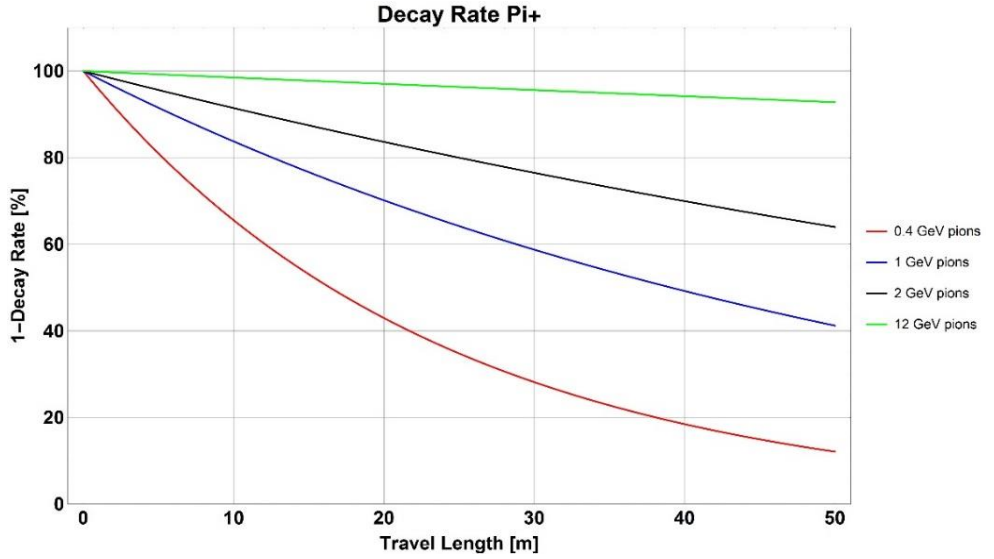
  - Power supplies of bends and quads not very stable when operating in very low currents
  - (for 10 GeV → 31A, setting error 0.2A → 0.6% momentum or 50% acceptance!)
  - Total length (H2) : ~ 600 m – For low energy particles becomes critical

- Most of the available instrumentation is tuned for high intensities > 1E5 pps

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





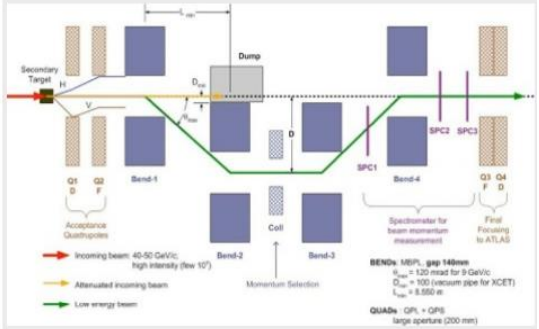
Low Energy Lines in EHN1

- A simple idea : Create the low energy particles closer to the experiment, momentum-select and transport them.
- Various layouts used throughout the years, in H2 ,H4 and H8 lines

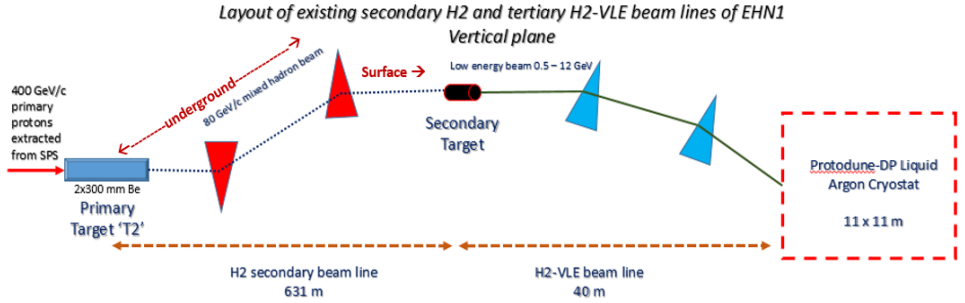
H2-VLE (2003)

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



H2-VLE (2018)

1-12 GeV/c

H8-VLE (2004)

1-9 GeV/c

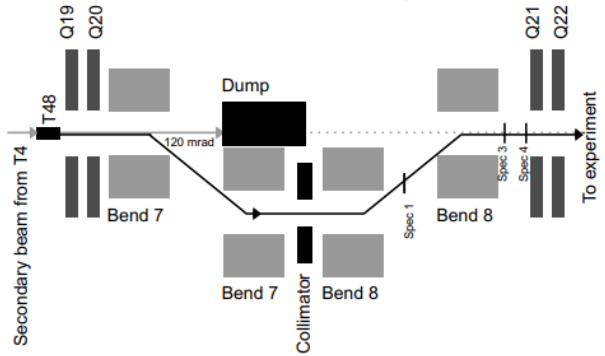
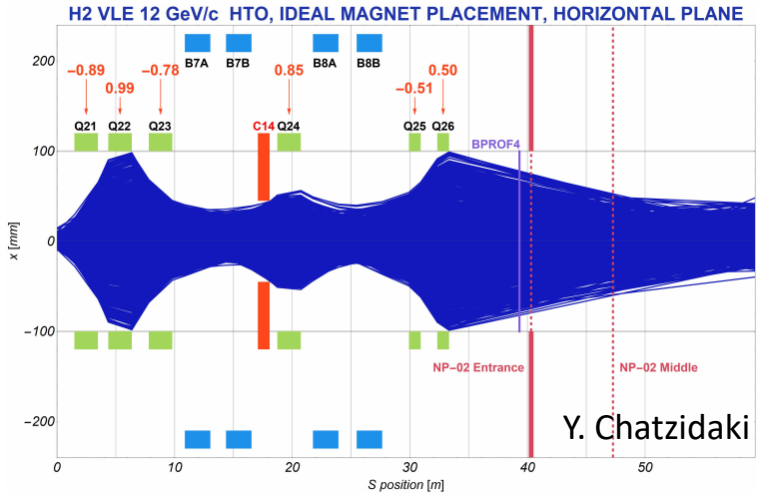
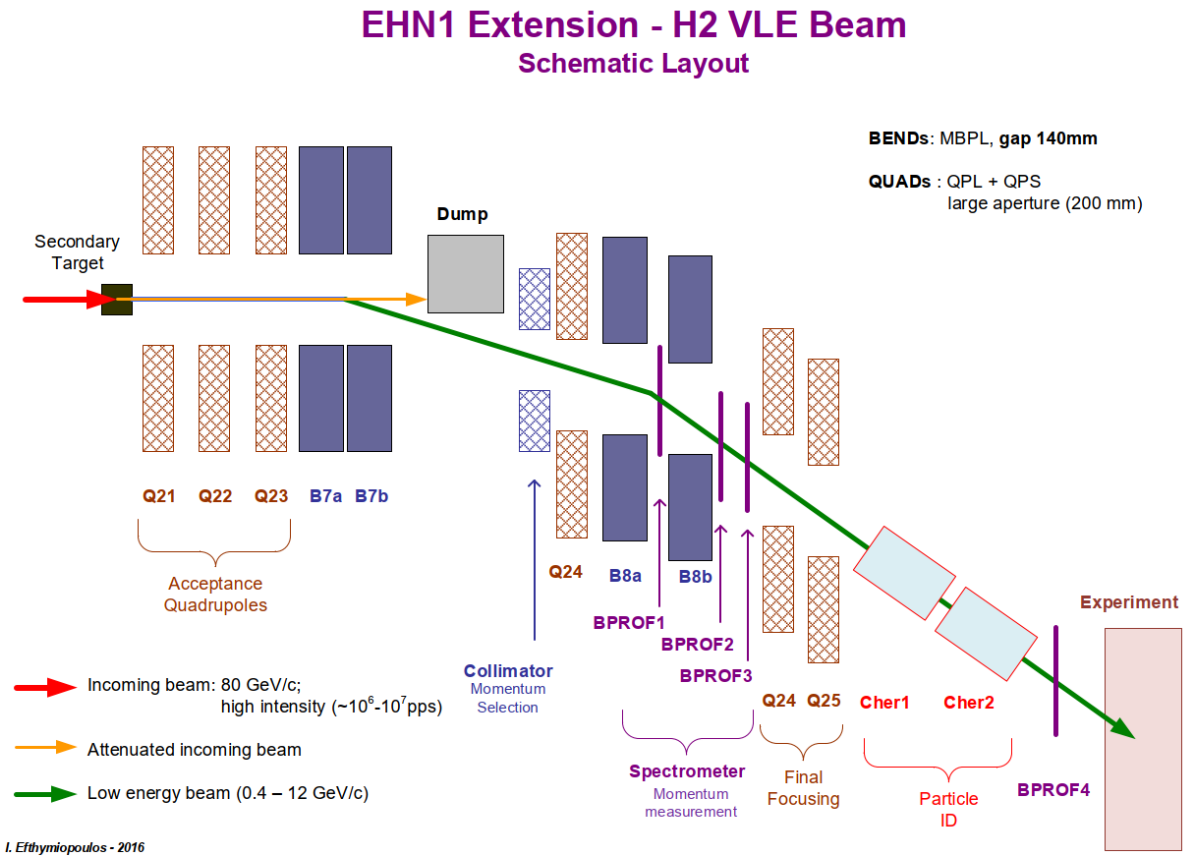


Figure 1: *Schematic layout of the VLE setup in H8 beam line.*

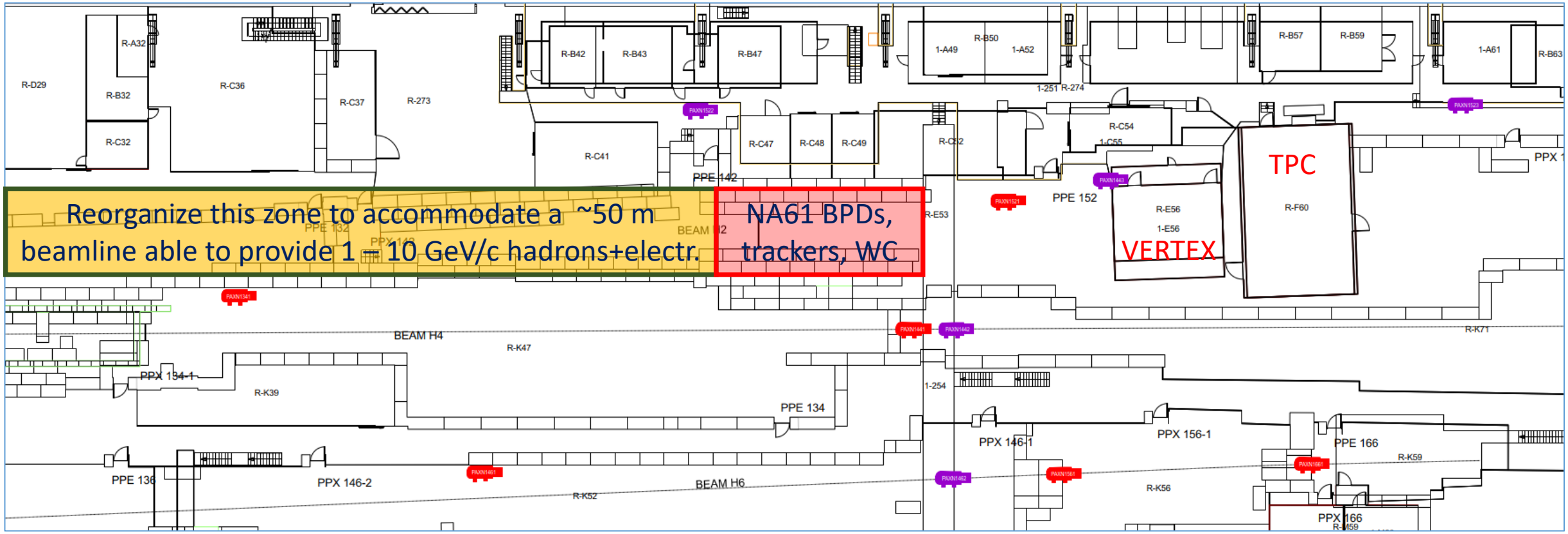
H2-VLE - 2020


H2 VLE 12 GeV/c HTO, IDEAL MAGNET PLACEMENT, HORIZONTAL PLANE
Q21 Q22 Q23 C14 Q24 Q25 Q26
B7A B7B B8A B8B
BPROF4
NP–02 Entrance
NP–02 Middle
x [mm]
S position [m]
Y. Chatzidaki


EHN1 Extension - H2 VLE Beam
Schematic Layout
BENDs: MBPL, gap 140mm
QUADs : QPL + QPS
large aperture (200 mm)
Secondary Target
Dump
Q21 Q22 Q23 B7a B7b
Acceptance Quadrupoles
Collimator
Momentum Selection
Q24 B8a B8b
BPROF1
BPROF2
BPROF3
Q24 Q25
Spectrometer
Momentum measurement
Final Focusing
Cher1 Cher2
Particle ID
BPROF4
Experiment
Incoming beam: 80 GeV/c; high intensity (~10^6-10^7pps)
Attenuated incoming beam
Low energy beam (0.4 – 12 GeV/c)
I. Efthymiopoulos - 2016

Possibility for a low-E beam to serve NA61

- Study of a transparent, low energy ‘branch’ upstream the NA61 target

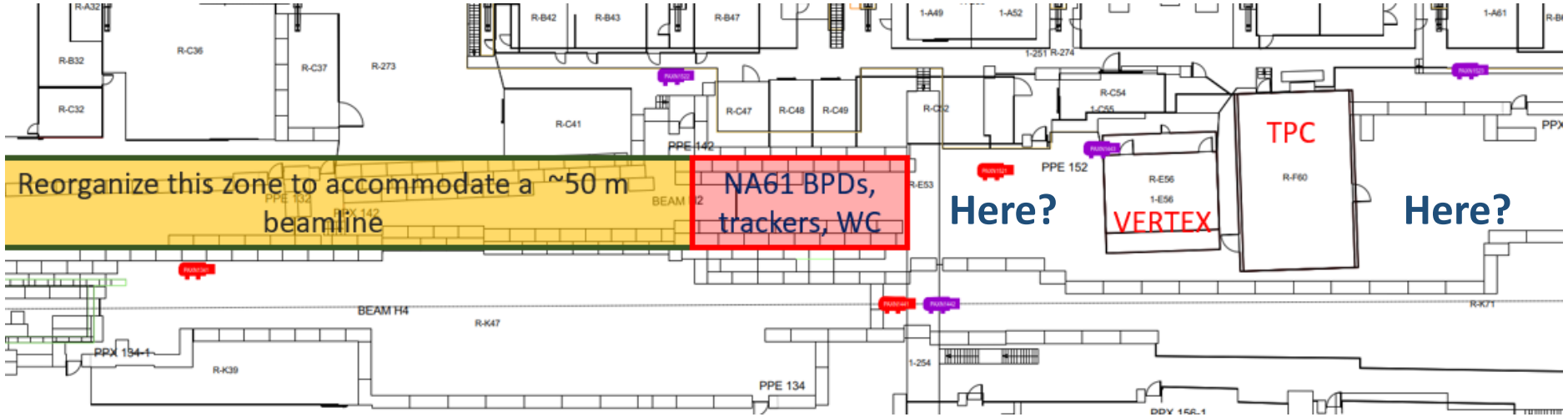


Layout considerations

- The “normal” NA61 beam should be available without or with very minor modifications
  - Same stands for the beams **downstream** NA61 → CALICE, CMS …
- The secondary target should be very well shielded (best if it remains upstream and away from the CR)
- Existing focusing elements (quadrupoles) should be preserved or easily being moved
- Existing magnets (used in the past and existing @ CERN in order to minimize cost. Also well known properties and field-maps, etc..

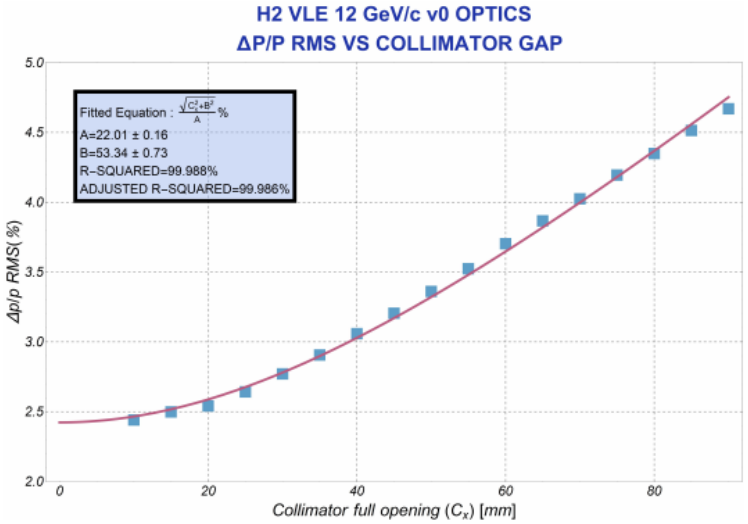
Other considerations

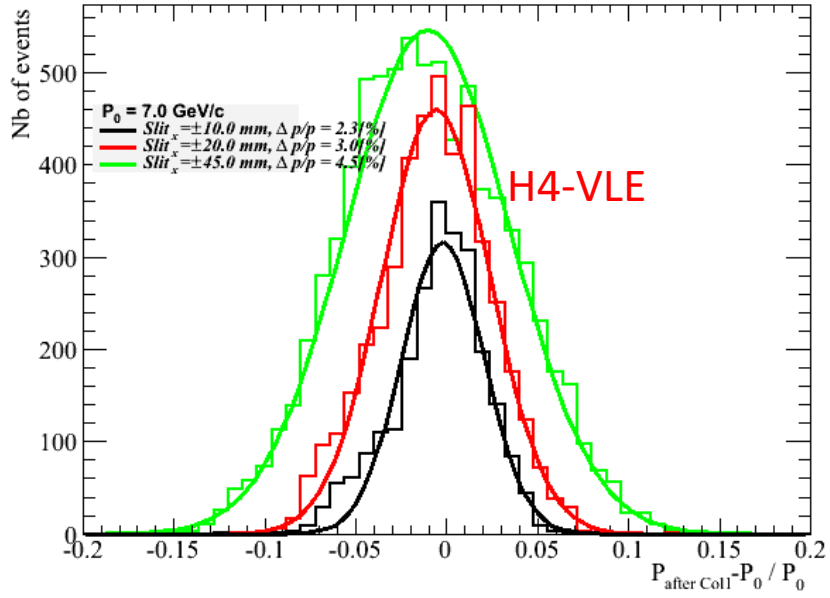
- Background: A high intensity primary beam will be impinging on a thick target.
  - Understand how important it is – it should define the amount of shielding
  - Absorbers / Converters/ Collimators / Magnetized irons ?
- Can we think -just as an idea- of *other experiments* using this beam when NA61 does not ? E.g :



Low Energy Line Performance

- In general, rate ~3 orders of magnitude lower than the “primary”
  - Still should be OK – We can go up to 1E7 particles / spill on the secondary target
- Momentum selection station (dipoles + collimator) to reduce the momentum spread on the target to dp/p = 5-10%.
  - Is this necessary ? What spread is “acceptable” ?
- Spot-size of the order of ~cm → Can be tackled → See talk of Carlo





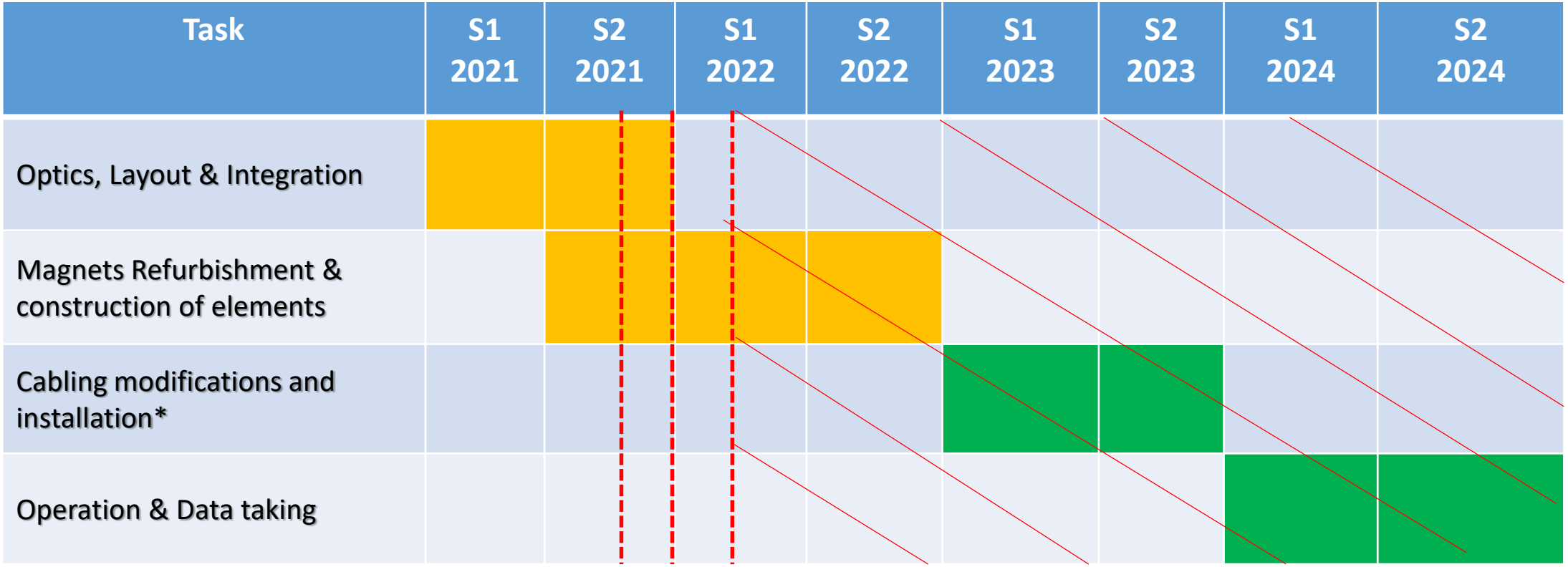
Possibilities & Ongoing Studies

- The possibility of a “dogleg” or similar configuration is being investigated in PPE132-PPE142 (upstream NA61)
  - Magnets and power supplies availability ?
    → ~ 8 magnets & ~4 power supplies

- Composition, background to the experiment & instrumentation
  - Proton content in tertiary beams → See Carlo’s studies
  - Rate → See Carlo’s slides
- Instrumentation → Talk of Sakashita-san

- Aiming for a “Cost and schedule” review in Summer 2021

A preliminary idea of a timeline (pending budget / schedule clarifications)



* Part of the installation should happen in-tandem with beam operation

Immediate step would be to submit a **strong physics request** to get endorsed by SPS-C / RB

After cost evaluation, investigate options of funding outside CERN ?

Conclusions & open points

- VLE (Very Low Energy) beam lines have been designed, implemented and operated in the past in EHN1 with success
  - A possibility of a new one to serve NA61 and other experiments is open
- Ideas, requirements and interest for such a beam should come up in this workshop that will help define the project scope
- Interest from other teams outside NA61 ? Integration possible ?
- A dedicated study is ongoing on the performance, cost & schedule to be evaluated next year.