H4-VLE beam line design and performance outlook

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CERN, EN-EA

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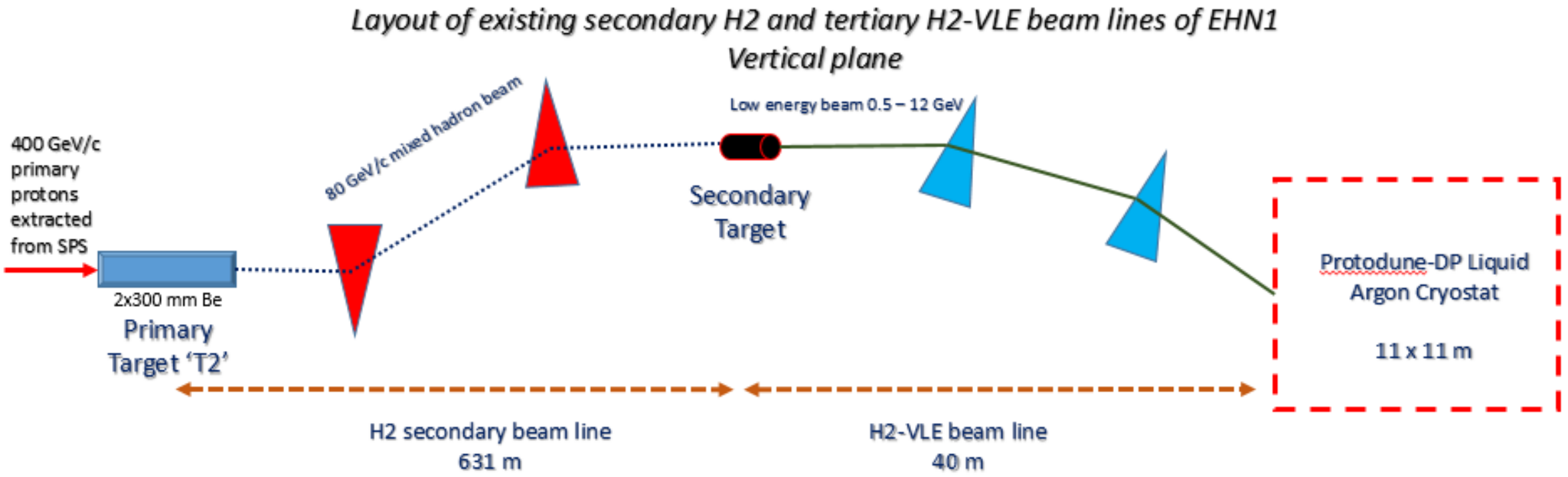
Presentation(s) outlook

- Design considerations
- Layout & Implementation
- Outlook on the expected performance
- Instrumentation to be prepared by EN-EA
- Beam commissioning
- Schedule → Quentin / Integration → Sylvain

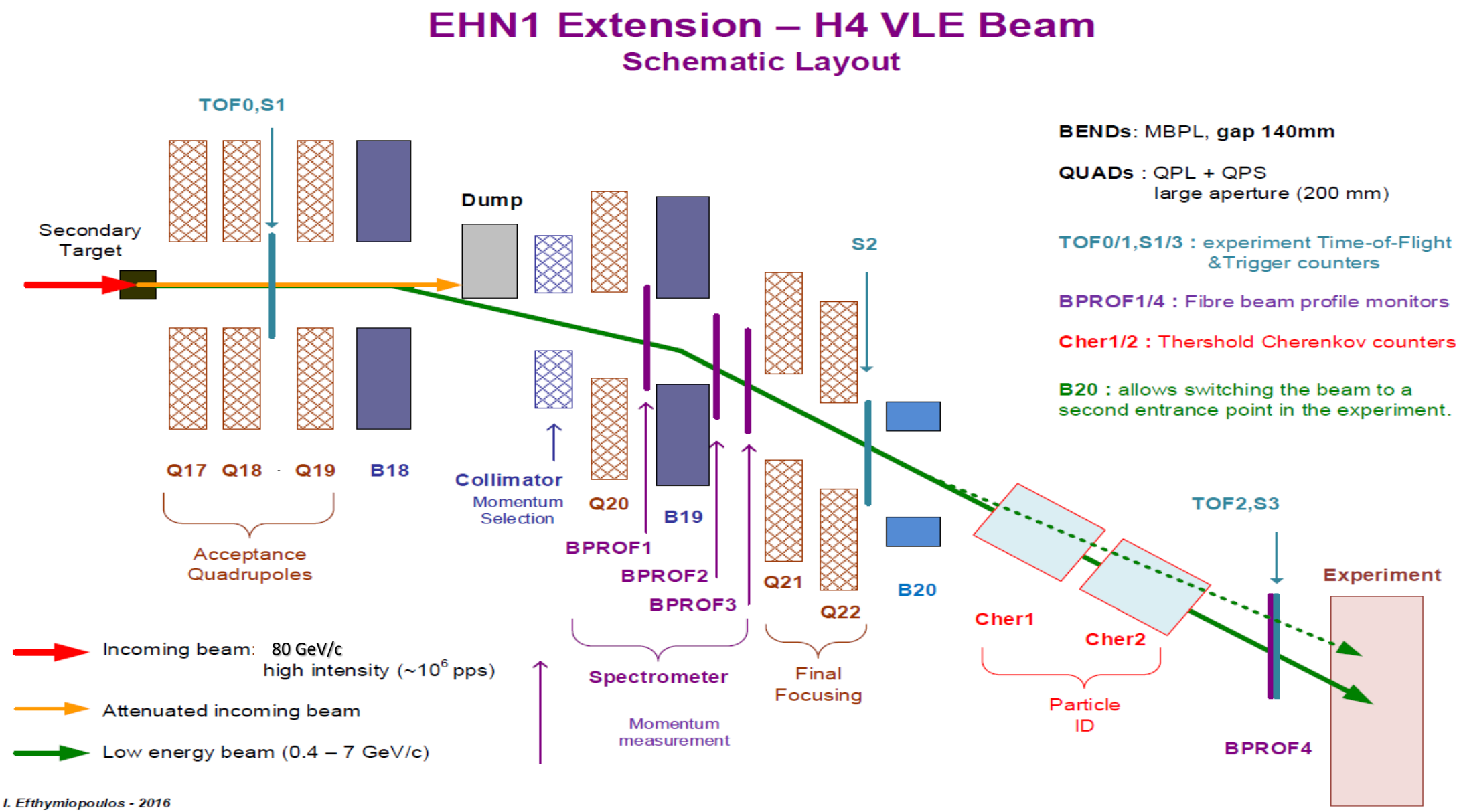
Beam line design considerations - Requirements

1. Provide *relatively very low momentum particles* (0.5 – 12 GeV/c) to ProtoDUNE-DP (NP-02) and ProtoDUNE-SP (NP-04).
   - Using the current infrastructure of the H2/H4 magnetic spectrometers not possible, due to current stability and decay length of low momenta particles.
2. Solution: A *tertiary* beam line, with the low momenta particles to be created closer to the experiments.
   - Similar configurations have been used the past in H2 and H8 for special requests by ATLAS and CMS.
3. Sufficient rate of approx. 100 Hz in both experiments.
   - Maximum angular acceptance of at least 10 mrad in both planes & total beam line length not more than 40 m.
4. Use (as much as possible!) existing magnets of *known performance*, and apply *same well known principles of operation* as in all EHN1, EHN2 and ECN3 beam lines, operating since the early 70's.

Layout and Implementation

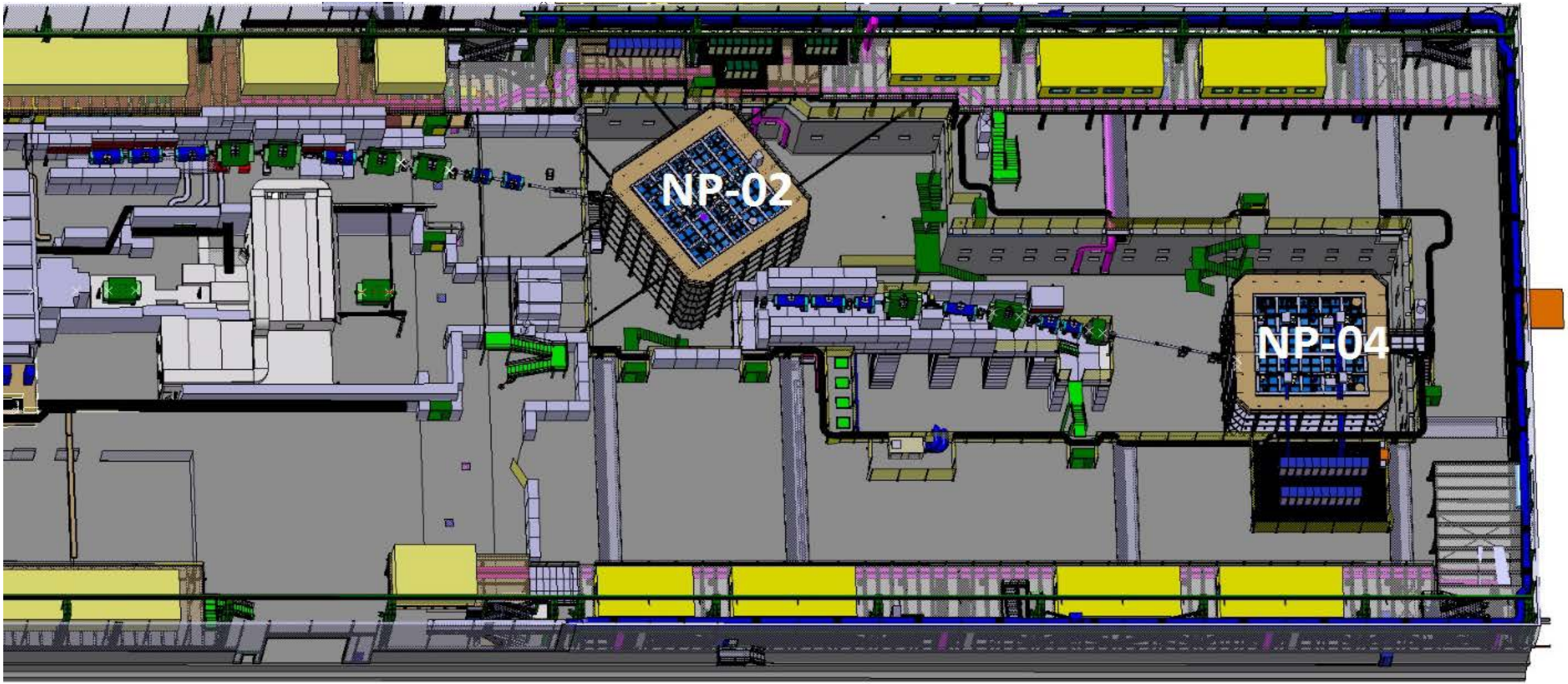


Beam line conceptual design – H4

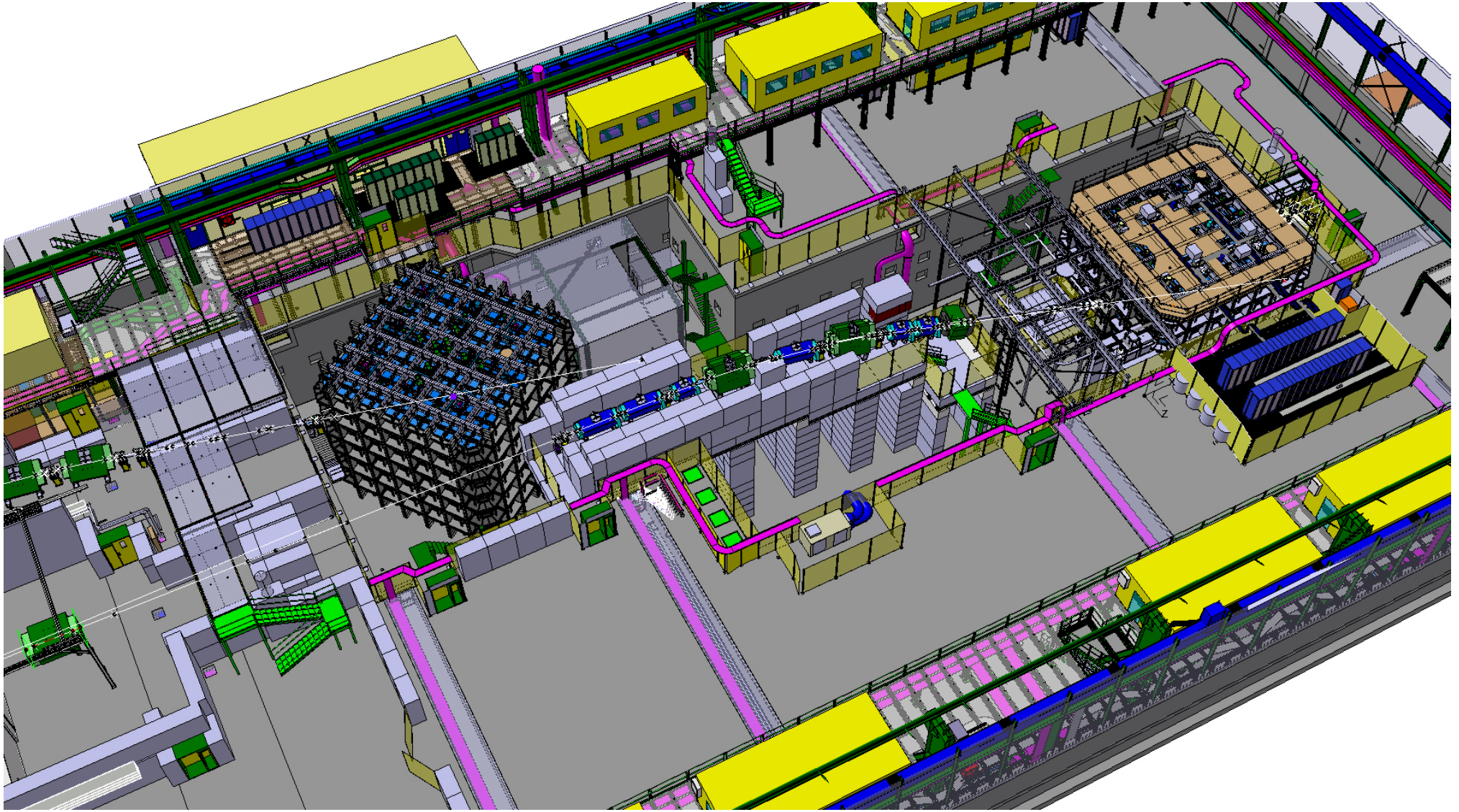


I. Efthymiopoulos - 2016

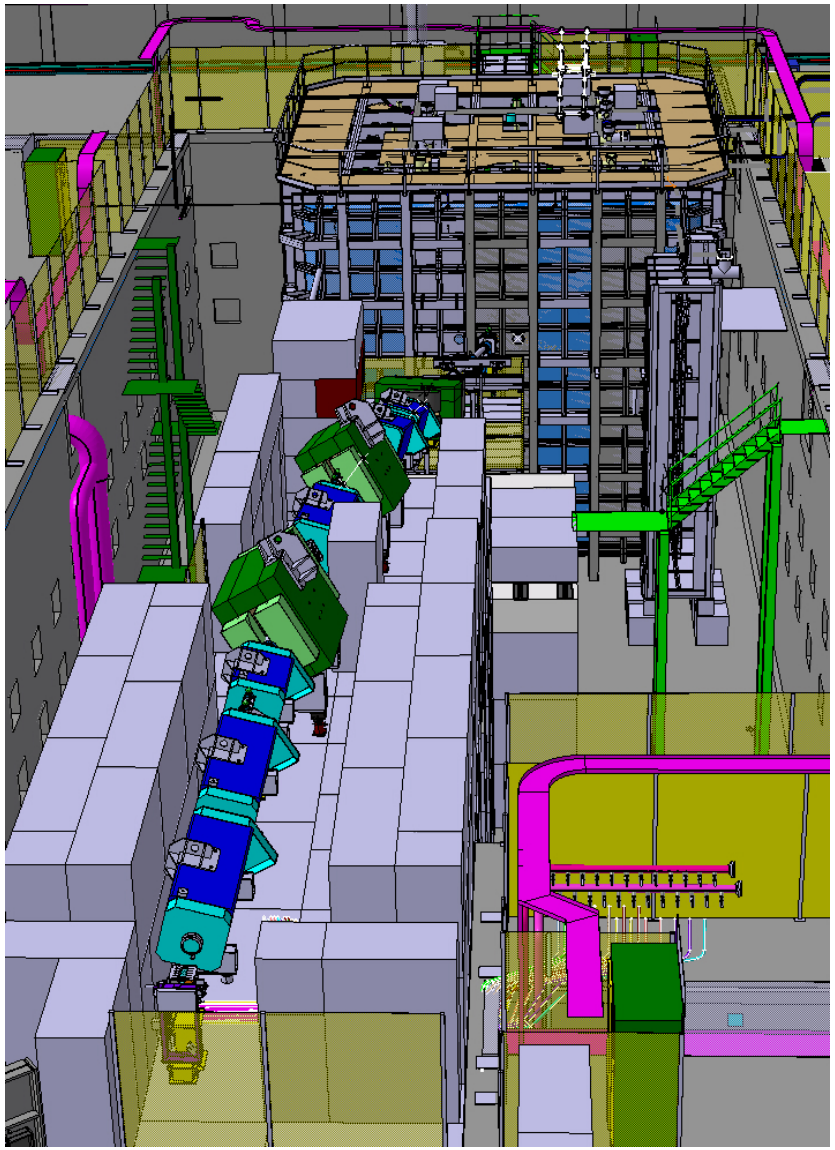
General Layout



General Layout – H4



H4-VLE Layout



- Dipoles tilted by an angle of 56.75 degrees wrt to the floor
- Quadrupoles inversely rotated by -33.25 degrees wrt to the floor (surveying reasons)
- Magnets providing the correct angles for the beam to impinge in the center of the holes as measured

→ EDMS 1748071 for H4

EHN1 Extension 17.01.2017

From :
Dirk MERGELKUHL EN/ACE
Konstantinos NIKOLITSAS EN/ACE

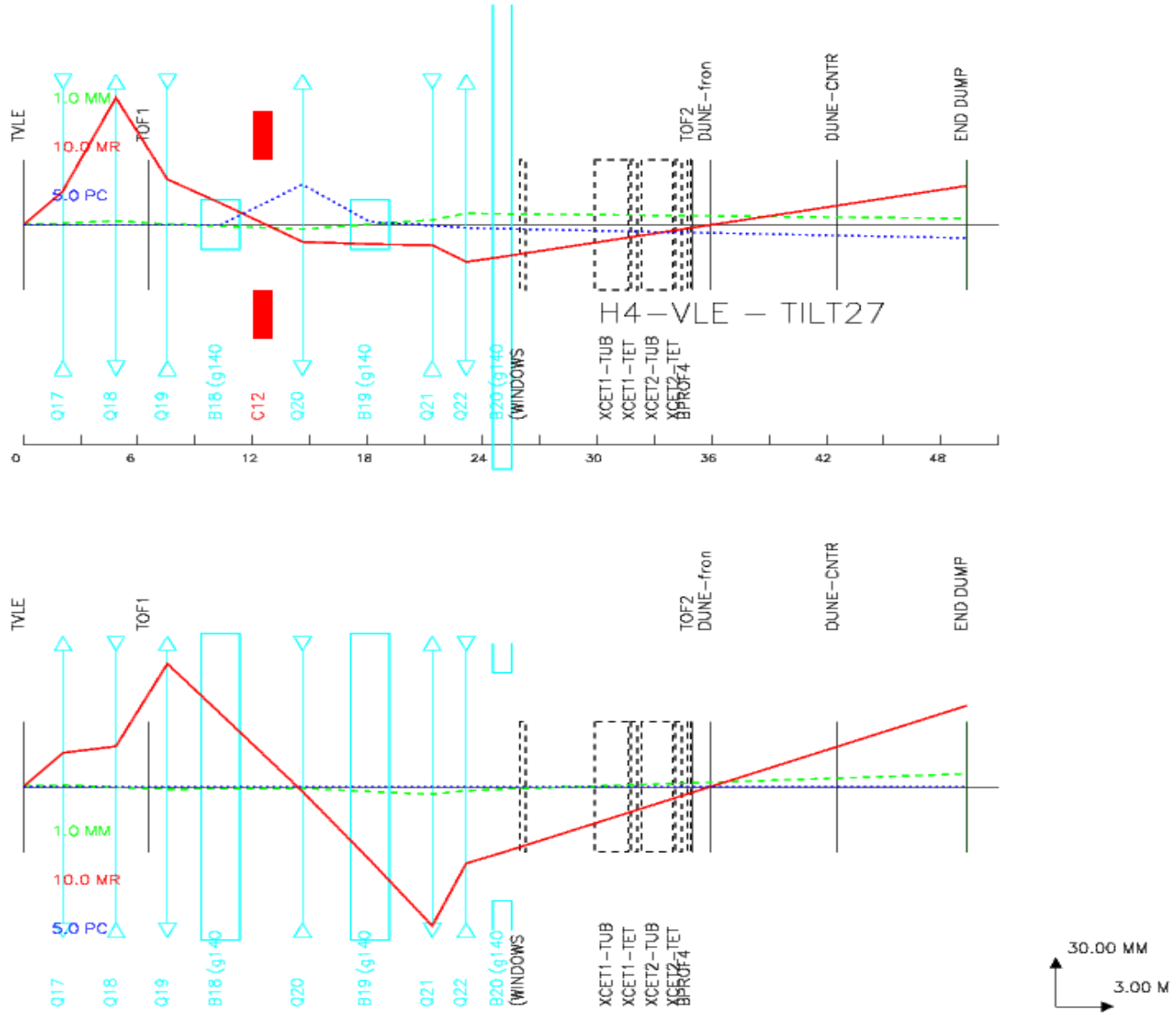
To :

Olga BELTRAMELLO	EP/DI	Dimitar MLADENOV	EP/DI
Nikolaos CHARITONIDIS	EN/EA	Marzio NESSI	RCS/PRJ
Lau GATIGNON	EN/EA	Johann POIROT	EP/DI
Jean-Christophe GAYDE	EN/ACE	Paola SALA	EP/DI
Sylvain GIROD	EN/EA		

EHN1 Extension - NP04
Traced points of holes on wall4 for cryostat NP04
in Cern Coordinate System
Measurement of December 1st and 5th , 2016

H4 Beam Optics design

- Large angular acceptance
  - ➢ (10 mrad both planes)
- Momentum selection
- Total length ~ 36 meters
- Big deflection angles (120mrad)
- ➢ Helps avoiding background as much as possible
- Extra bending magnet allows scanning <u>at cost of a larger spot-size</u>



Magnet Currents

H4 - TILT27 optics - CENTRAL POSITION							
name	position	type		BL, g [TM,TM/M]	Imax mag	Inominal	PS MAX
					[A]	[A]	[A]
Q17	QPL.022.683	QPL	N/A	-11.3705	750	333.53	500
Q18	QPL.022.686	QPL	N/A	14.4785	750	425.03	500
Q19	QPS.022.689	QPS	N/A	-10.2000	700	482.70	500
B18	*MBPL.022.692*	*MBPL*	***STRAIGHT***	*2.7191*	830	488.92	1000
Q20	QPL.022.696	QPL	N/A	13.7895	750	404.49	500
B19	*MBPL.022.699*	*MBPL*	***STRAIGHT***	*2.7191*	830	488.92	1000
Q21	QPS.022.703	QPS	N/A	-9.9900	700	467.91	500
Q22	QPS.022.704	QPS	N/A	8.3335	700	369.09	500
B20	*MBPS.022.706*	*MBPS*	***STRAIGHT***	*1.2959(right)*	675 (left)	344.65	1000
						15.02.2017 - N. Charitonidis	

Beam position in NP-04

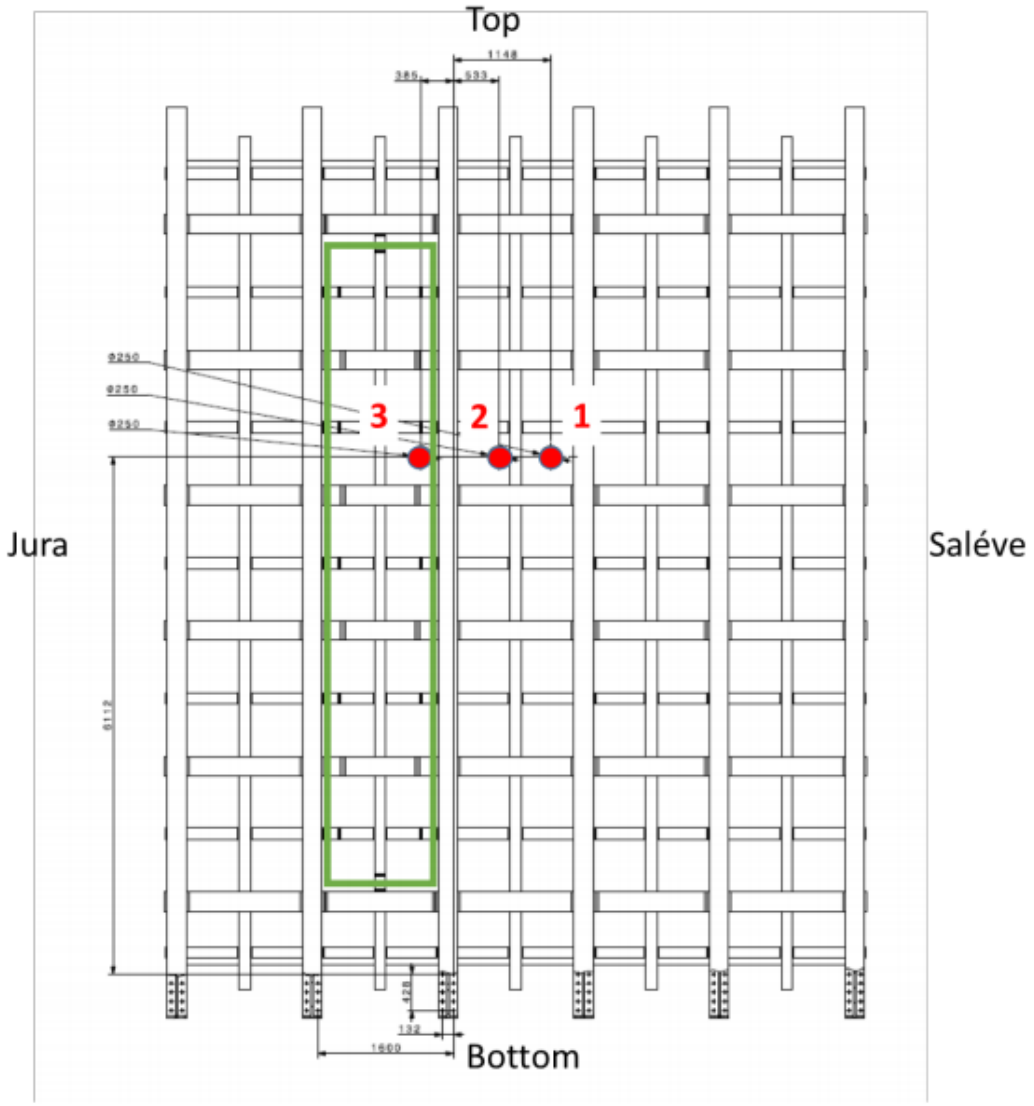
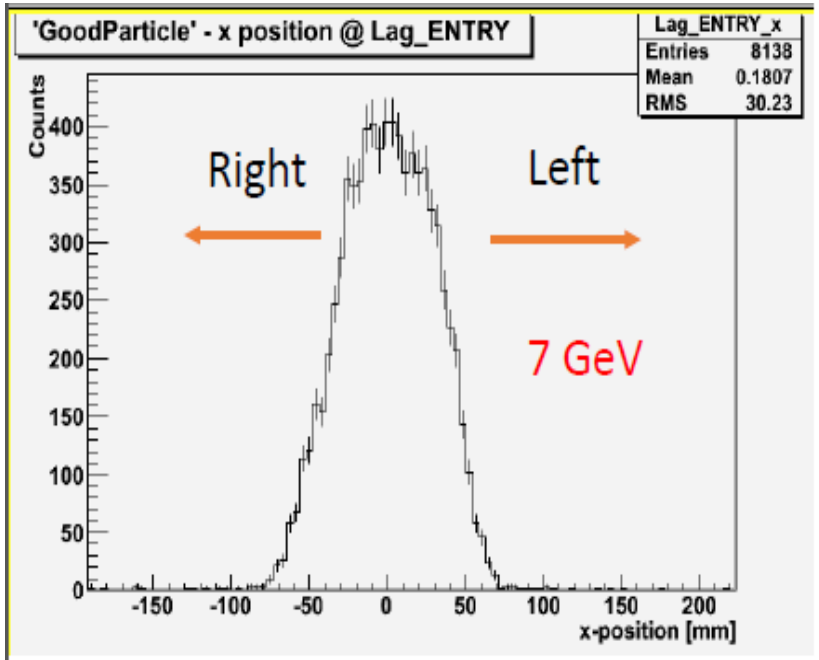


Figure 2: Point distribution on the stainless steel plate of the ***wall 4*** *(EHN1, outside view)*

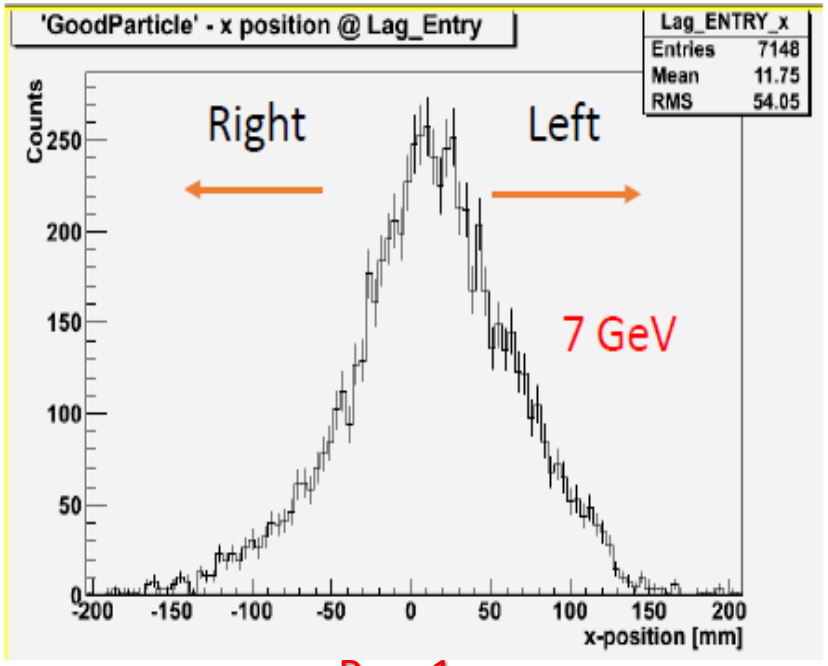
Optics/supports configuration to be finalized

- Two configurations prepared and available, **pending NP-04 final request**.

Configuration 1 : Horizontal spot-size ("GoodParticle") at the three positions as notated in EDMS 1748071

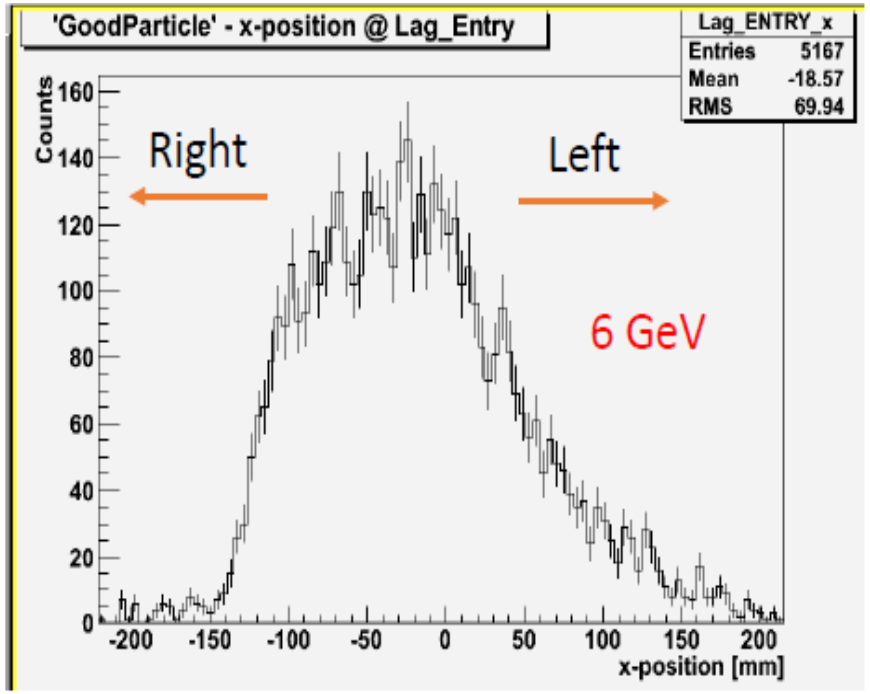


Pos: 2



Pos: 1

Full spot size: typically 4 sigma



Pos: 3

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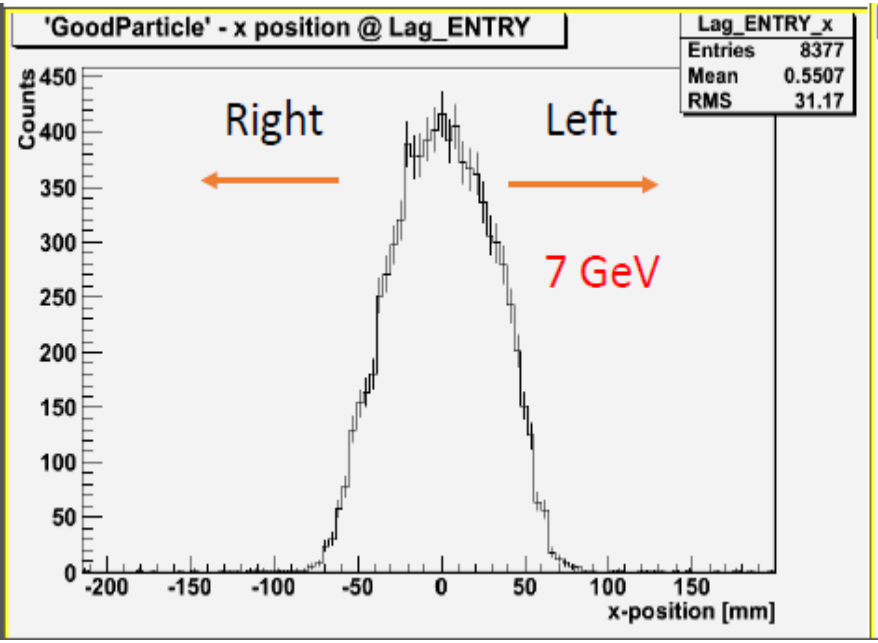
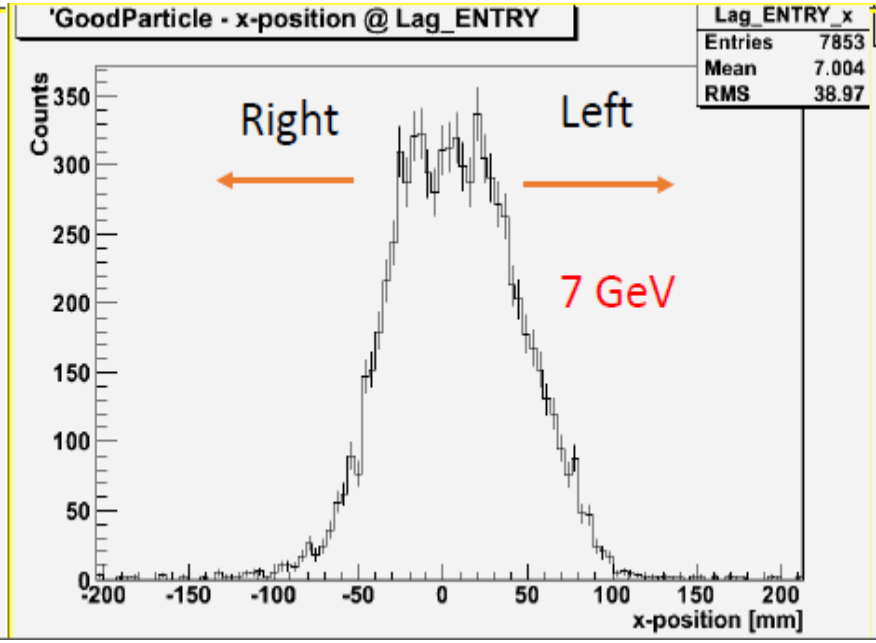
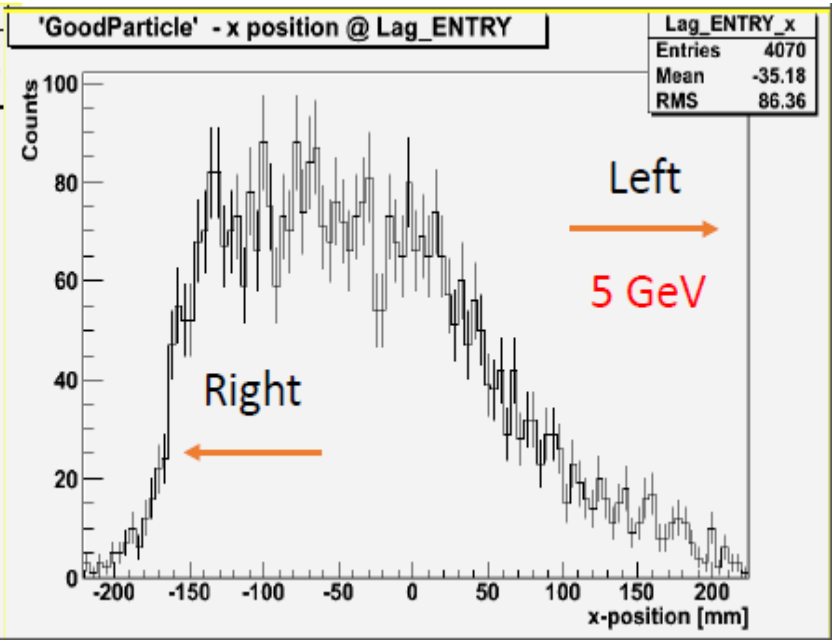


Pos: 2



Pos: 1



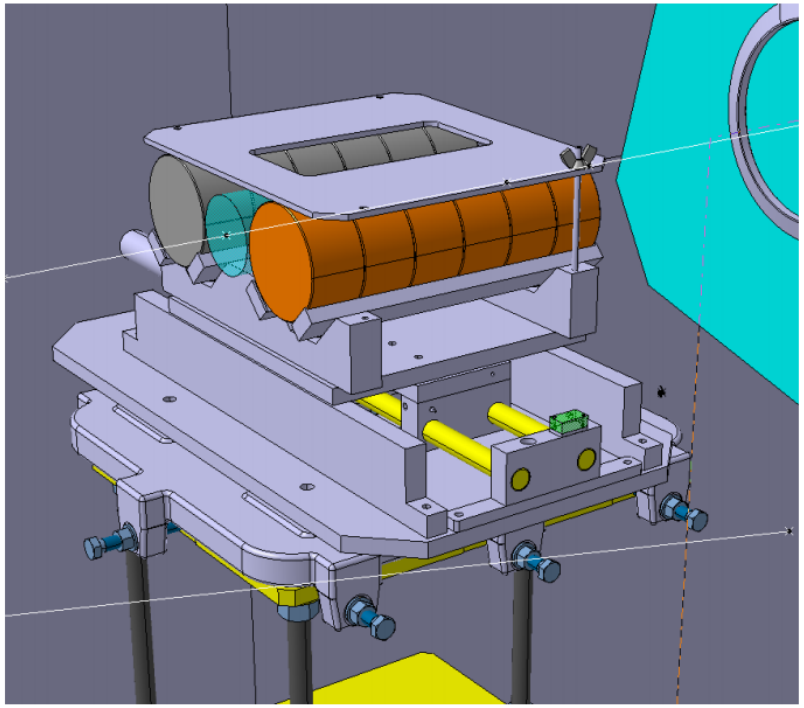
Pos: 3

Secondary Target

- Modular design – W and Cu, remote exchange between the two materials and the “no” target.
- Easily exchangeable/optimizable – 1/2 h intervention.
- W-target exact composition
- Cu-target exact composition

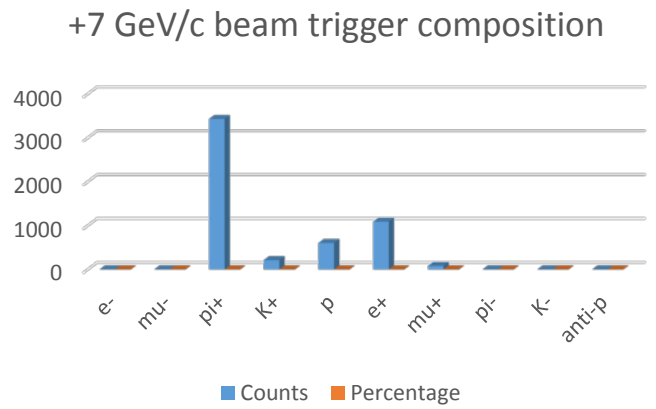
VLE target XCON

- Copper: 6x50mm
- Tungsten: 6x50mm
- Air position at center



Trigger Rates & Composition

- G4BeamLine simulation (upstream line + target + VLE extension)
  - ➢Simulation continuously improving (field maps, magnet geometry, shielding…)
  - ➢Work of M. Rosenthal (EN-EA fellow)



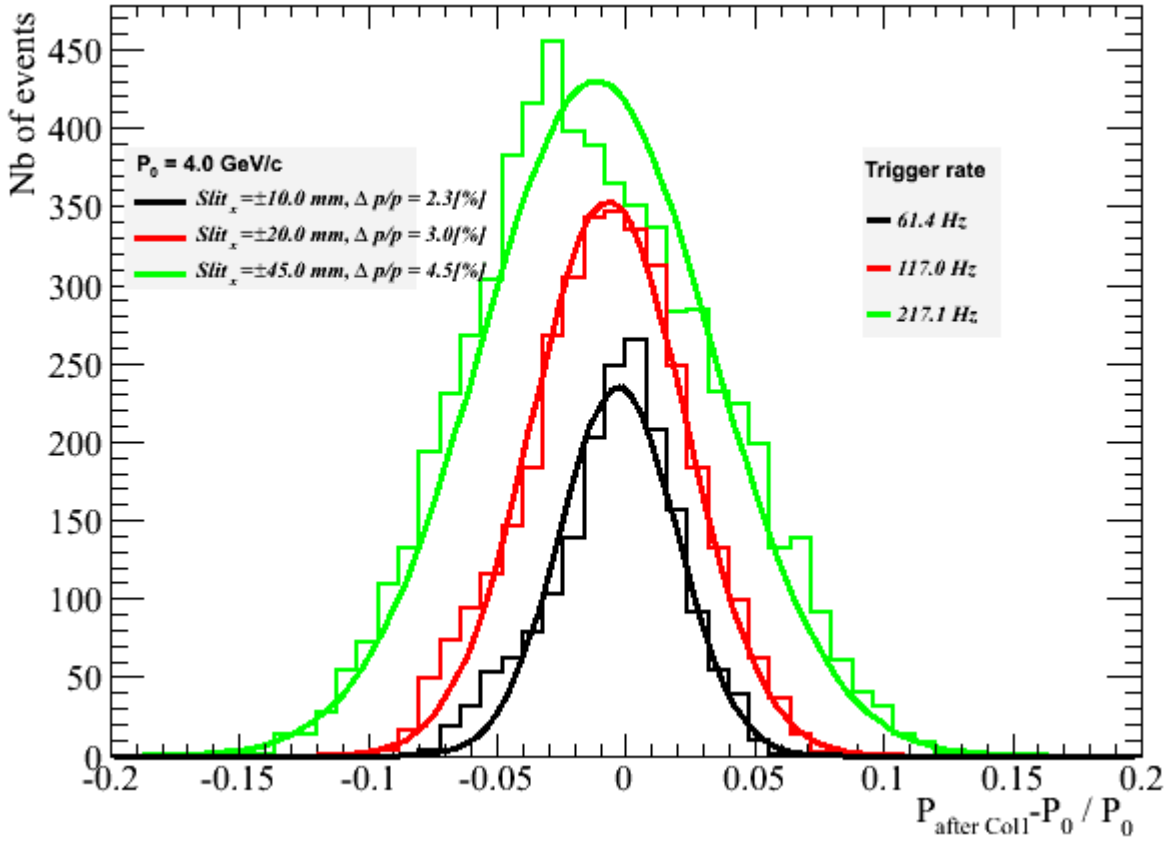
Particle	Counts	Total	Percentage	Error
e-	0	5406	0	0
mu-	0	5406	0	0
pi+	3428	5406	0.63411	0.006551
K+	210	5406	0.0388457	0.002628
p	602	5406	0.111358	0.004278
e+	1088	5406	0.201258	0.005453
mu+	78	5406	0.0144284	0.001622
pi-	0	5406	0	0
K-	0	5406	0	0
anti-p	0	5406	0	0

Results without shielding and a first version of geometry :

CERN-ACC-NOTE-2016-0052

Momentum selection

- Beam line equipped with a momentum selection collimator. Full GEANT-4 simulation demonstrates the effect of the collimator in the momentum bite (dp/p) of the beam.



Momentum measurement - spectrometer

- In order to further improve the momentum measurement, without any expense on the rate, three profile monitors in a spectrometer configuration will be placed around the 2nd bending magnet.
- Technique applied also in the past using XDWC's
  →I.Efthymiopoulos & A. Fabich – CERN-AB-2005-036
- In detail described in a paper submitted in PRAB.
- Full simulation & reconstruction of the particle momentum demonstrated in CERN-ACC-NOTE-2016-0052

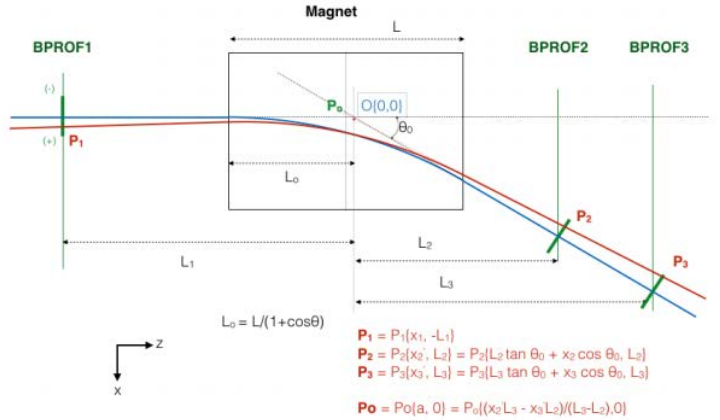
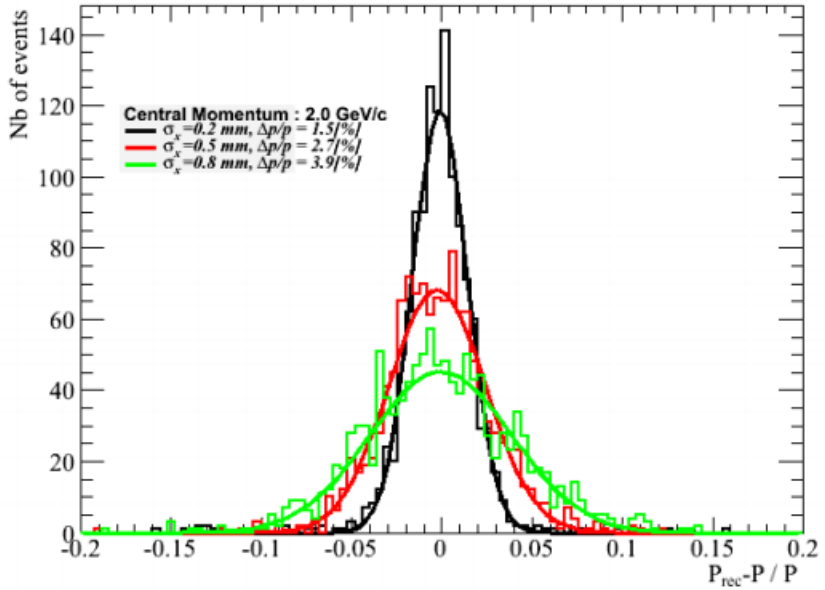


Figure 18: Layout of the H2-VLE (and similarly H4-VLE) momentum spectrometer around the last dipole.



Although the beam particle momentum can be precisely determined as demonstrated above, the material in the line downstream the spectrometer will also deteriorate the particles' momentum reaching the active volume of the detectors. Figure 24 shows the ratio between the beam momentum in the middle of the cryostat (the liquid argon inside the detector itself is ignored) and the momentum at the position of the TOF0 detector. At low energies, a significant tail and shift in the mean momentum is observed that should be considered in the data analysis by the experiment, in particular for the low-energy electron beams.

Background at the experiment – Ongoing Studies

- Detector final position measured
- Shielding being optimized

  → To satisfy also RP requirements
- Additional shielding to optimize the experiments' background.

  → Ongoing work
- Solutions like flip-charge under investigation

  →Muon measurement in the pits during beam operations being organized by both NP-02 and NP-04 collaborations with the support of EN-EA

Questions ?

Backup slide