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Costing: Civil Engineering EUROnu (cost driver)

E.Wildner, M. Dracos and A. Kurup et al. (specs)
J. Osborne and C. Waaijer (civil engineering)
A. Kosmicki (drawing office)

Elena Wildner, CERN

Outline/Aim of presentation

- The presentation will follow the document by John & Caroline:
  - https://edms.cern.ch/document/1223890/1
- Will be a brief overview
- Base for discussion at this meeting

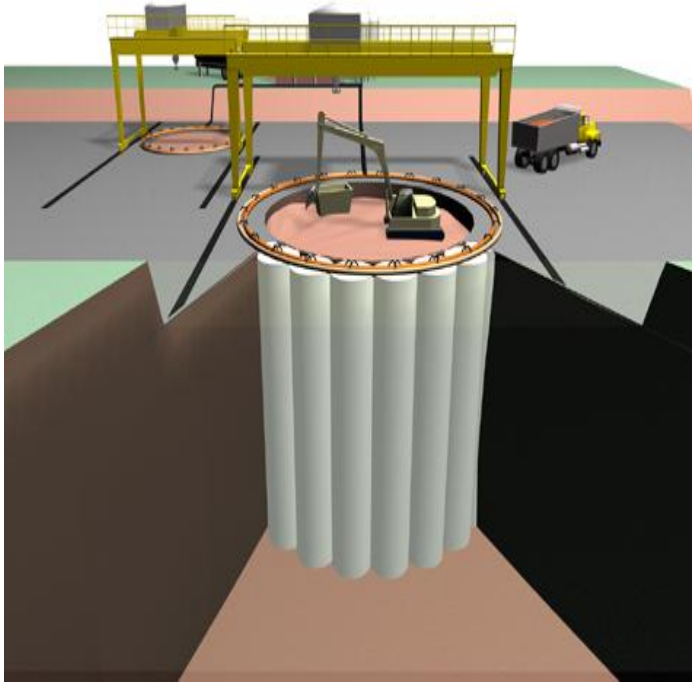
Assumption for estimation

- All underground structures are within the Molasse rocks
- Super Beam Tunnel complex is housed on the Meyrin campus
- Footprints of Beta Beam and Neutrino factory tunnels extend approximately 3km in NW and 3km in NE direction
- Depth of tunnels varies between 25m and 120m
- Tunnels are in a plain inclined by 3.5^{o} and 10.4^{o} (Neutrino factory) in the direction of the detector complexes in Fréjus, France and Pyhäsalmi, Finland.
- Connection to existing CERN complexes such as LINAC 4, PS.
- Connection to the scheduled ~500m long SPL facility
- All underground works will use ‘road header’ or ‘cut and cover’ excavation techniques
- Transfer tunnels, accumulator rings and decay rings are housed within single tunnels with an internal diameter of 3.5m or 4.5m
- Shafts connect the tunnel to the surface and allow access for transportation and maintenance work.
- Caverns housing machine components.

Positioning of the facilities

- We tried together to look for a reasonable positioning
- From accelerator aspects:
  - Length of transfer lines minimized
  - Optics reasonable respected
  - Length of decay tunnels
- From Civil Engineering
  - Surface structures
  - Cooling&ventilation
  - Electrical supply
  - Transport and Installation
  - Drainage, Spoil Dumps
  - Landscaping, Roads, Car Parks
  - Technical Supply for construction work

Information on techniques



Layouts, please check text and feed back

- Beta Beam project:
  - Triangular RCS tunnel of ~ 251m length
  - Elliptical Decay ring with a length of ~6912m
  - Chicane of 500m length with an average 14 ^{o} radius bending
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- Super Beam project:
  - Circular ‘accumulator ring’ tunnel of nearly 178m length
  - Target station cavern
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- Neutrino Factory project:
  - Circular ‘accumulator ring’ tunnel
  - A 150m long target station, rotator, pre-linac complex
  - Two Re-circulating accelerator ring tunnels, each with four turnarounds
  - Two detector caverns linked through a tunnel housing an 18m diameter shaft
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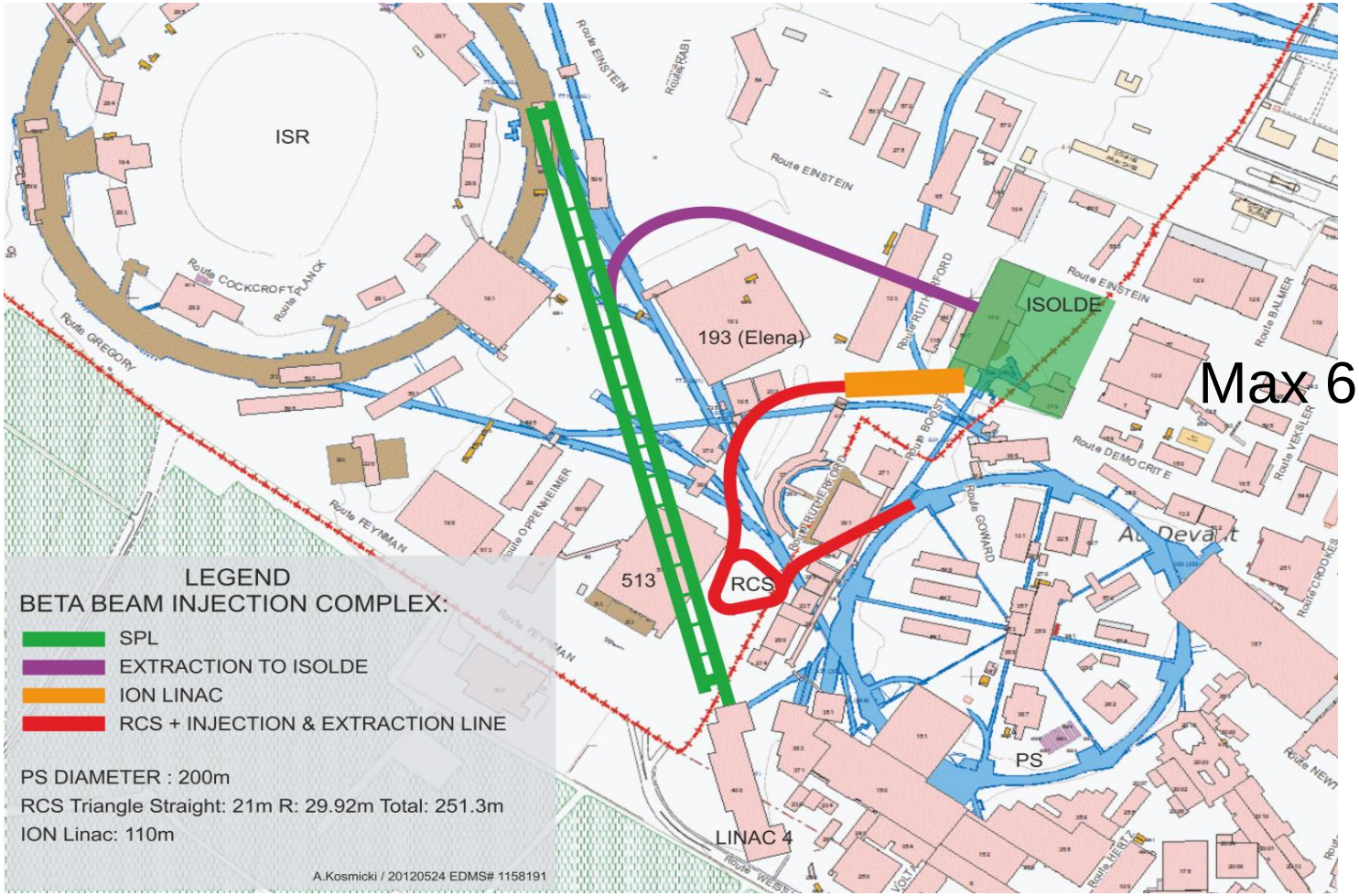
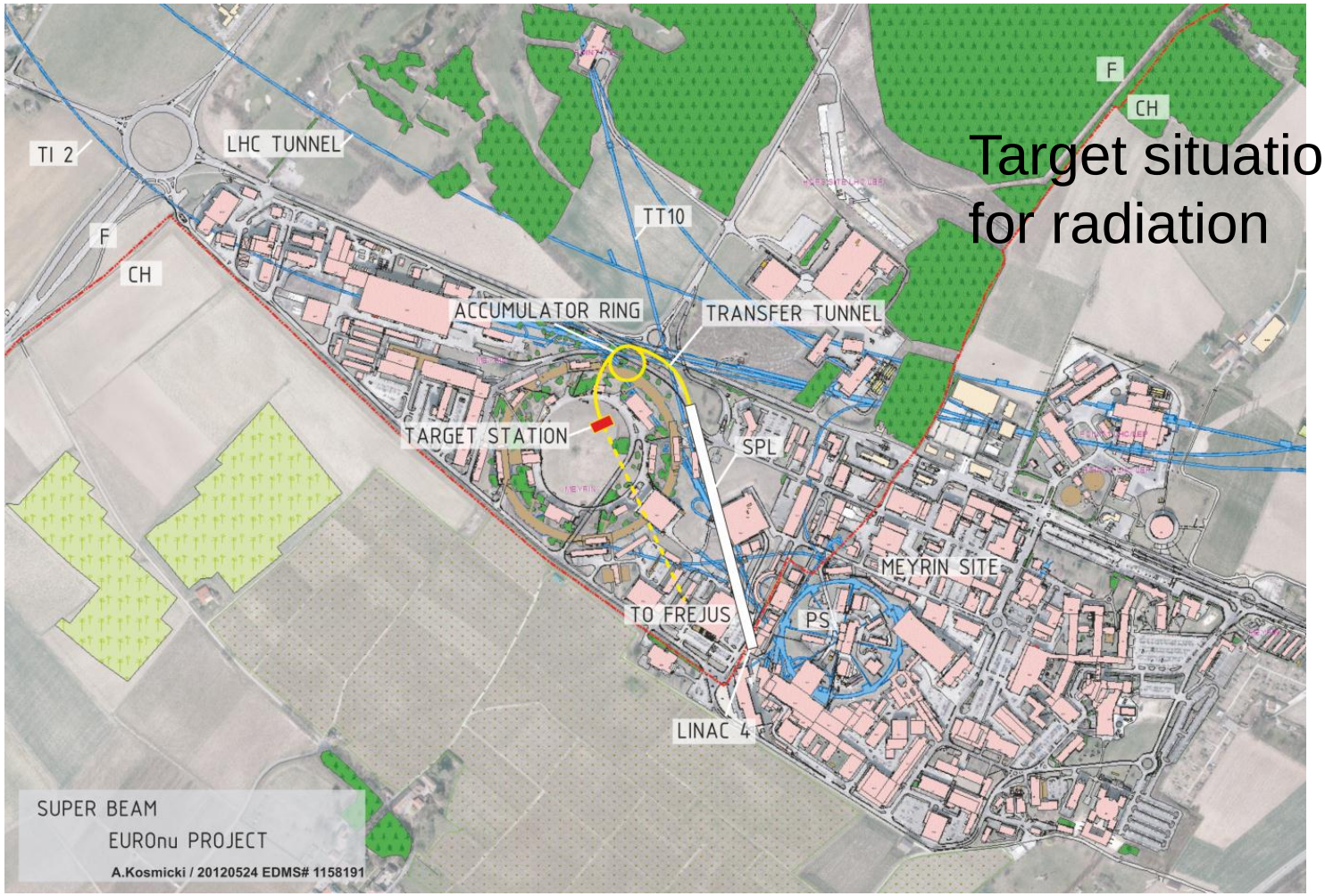
The Beta Beam



Max 60 m deep

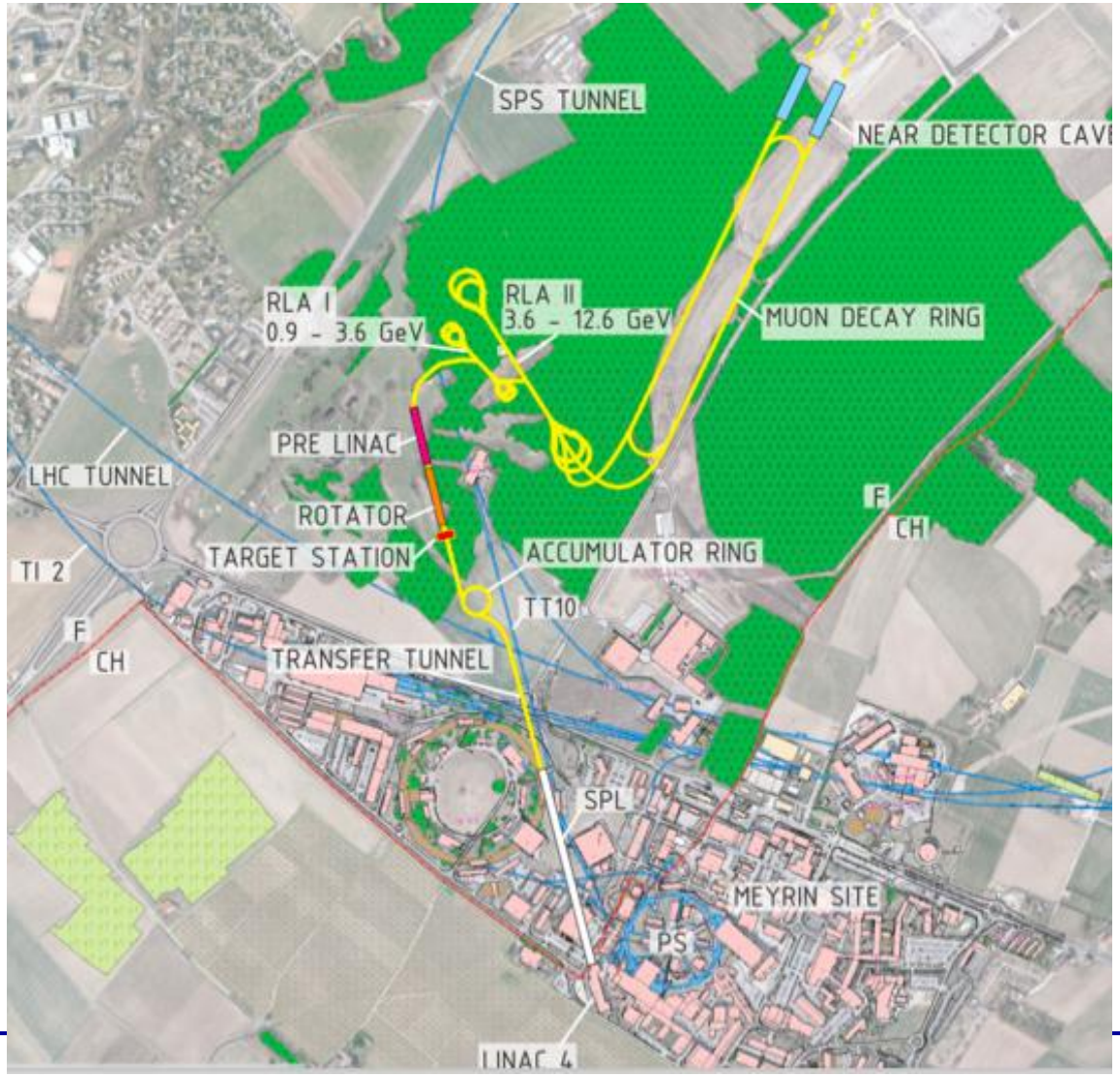
Decay Ring, Beta Beam

EUROnu Super Beam



Target situation checked for radiation

Neutrino Factory



Costing overview

Only underground, how to “scale service buildnings” ?
Road header excavation only
Outsourced consultancy 10 % in addition
Uncertainty about 30 %

Project	Costs	
	Unit	Total
Beta Beam	2012 CHF	137,328,259
Super Beam	2012 CHF	17, 985,850
Neutrino Factory	2012 CHF	123,180,464

Costing: Beta Beam

Table 1: Costing of the Beta beam project (label:T_Osborne2)

BETA BEAM PROJECT						
Structures	Dimensions				Costs	
	Length [m]	Width base [m]	Height [m]	Diameter [m]	Unit [CHF/m]	Total [CHF]
Tunnels						
Injection complex						
- RCS complex	251.3			3.5	9,130	2,294,369
- Extraction to ISOLDE	260			3.5	9,130	2,373,800
Decay Ring (DR)	6911.6			4.5	12,080	83,492,128
TI2-DR transfer tunnel	1827.4			3.5	9,130	16,684,162
End transfer tunnel	200			3.5	9,130	1,826,000
Tunnels TOTAL	**9,450.3**					**106,670,495**
Caverns						
ION LINAC	110	16	9	14	62,700	6,897,000
Junction with TI2	30	11	8	12	62,700	1,881,000
Cavern shaft 1_a	80	11	8	12	62,700	5,016,000
Cavern shaft 1_b	20	12.5	10	14	62,700	1,254,000
Cavern shaft 2	20	12.5	10	14	62,700	1,254,000
Cavern shaft 3	50	11	8	12	62,700	3,135,000
Caverns TOTAL	**310**					**19,437,000**
Shafts						
Shaft 1			50	9	70,130	3,506,500
Shaft 2			60	9	70,130	4,207,800
Shaft 3			50	9	70,130	3,506,500
Shafts TOTAL						**11,220,800**
UNDERGROUND civil Engineering total costs						**137,328,259**

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Costing: Super Beam

SUPER BEAM PROJECT						
Structures	Dimensions				Costs	
	Length [m]	Width [m]	Height [m]	Diameter [m]	Unit [CHF/m]	Total [CHF]
Tunnels						
Transfer tunnel	255			3.5	9,130	2,328,150
Accumulator ring	180			4.5	12,080	2,174,400
Tunnels TOTAL	435					**4,502,550**
Caverns						
Target station	22	39	9	14	62,700	1,379,400
Caverns TOTAL	**22**					**1,379,400**
Shafts						
Target station			30	9	70,130	2,103,900
Shafts TOTAL						**2,103,900**
Consolidation grouting						**10,000,000**
UNDERGROUND civil Engineering total costs						**17, 985,850**

Costing: Neutrino Factory

Table 4: Costing of the Neutrino factory project (label T_Oct0114)

NEUTRINO FACTORY PROJECT						
structures	Dimensions				Costs	
	Length [m]	Width [m]	Height [m]	Diameter [m]	Unit [CHF/m]	Total [CHF]
Tunnels						
Transfer tunnels	1730			3.5	9,130	15,794,900
Accumulator ring	185.5			4.5	12,080	2,240,840
RLA I	216			4.5	12,080	2,609,280
RLA II	510			4.5	12,080	6,160,800
Decay ring	1608.8			4.5	12,080	19,434,304
Tunnels TOTAL	**4973.6**					**46,240,124**
Caverns						
Detector caverns	55	20	35	60	62,700	3,448,500
Rotator – prelinac	150	20	22	14	62,700	9,405,000
Target station	38.4	17.1	21.9	14	62,700	2,407,680
Decay ring						
- Cavern1	80	11	8	12	62,700	5,016,000
- Cavern2	20	12.5	10	14	62,700	1,254,000
- Cavern3	20	12.5	10	14	62,700	1,254,000
- Cavern4	50	11	8	12	62,700	3,135,000
RLA complex						
- Cavern1	25	11	8	12	62,700	1,567,500
- Cavern2	25	11	8	12	62,700	1,567,500
- Cavern3	25	11	8	12	62,700	1,567,500
- Cavern4	25	11	8	12	62,700	1,567,500
Caverns TOTAL	**513.4**					**32,190,180**
Shafts						
Pre linac			60	9	70,130	4,207,800
RLA I-II			60	6	41,315	2,478,900
Decay Ring						
- Shaft 1			60	9	70,130	4,207,800
- Shaft 2			60	9	70,130	4,207,800
- Shaft 3			110	9	70,130	7,714,300
Detector area shaft			110	18	199,400	21,933,560
Shafts TOTAL						**44,750,160**
UNDERGROUND civil Engineering total						**123,180,464**

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Planning

EUROnu construction planning	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6
Land negotiations						
Environmental Impact Study						
Building permits						
Detailed design & tendering						
Construction						

For each project?