FUTURE POSSIBLE FIXED TARGET PROGRAM FROM NEW INJECTORS

Experimental Areas with upgraded LHC injectors : (LP)SPL, PS2, SPSU …

Outline

- Impact on SPS North Area beams and Experimental Areas
- Experimental Areas for PS2 machine
- Experimental Areas for low energy beams
- Summary – Next Steps

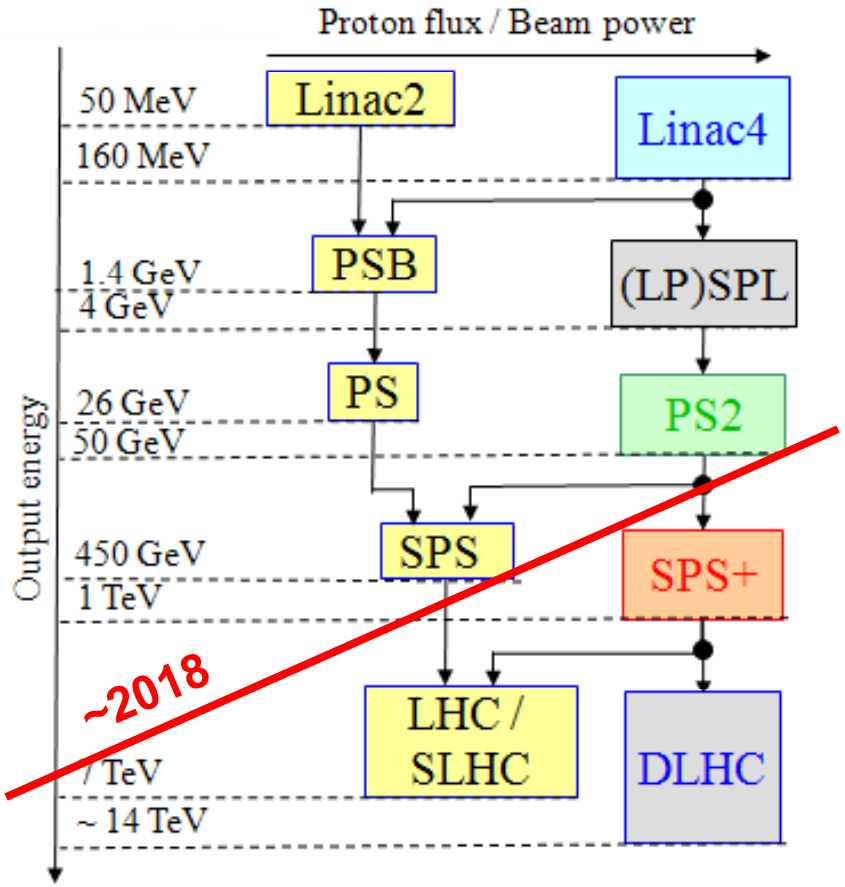
EFTHYMIOPOULOS, I (EN/MEF)

WITH INPUT FROM: M. BENEDIKT, A. CECCUCCI, J. ELLIS, L. GATIGNON, B. GODDARD, E. SHAPOSHNIKOVA

EDMS ID : 999746

LHC Injector upgrade program

2 Landscape sometime in >2018



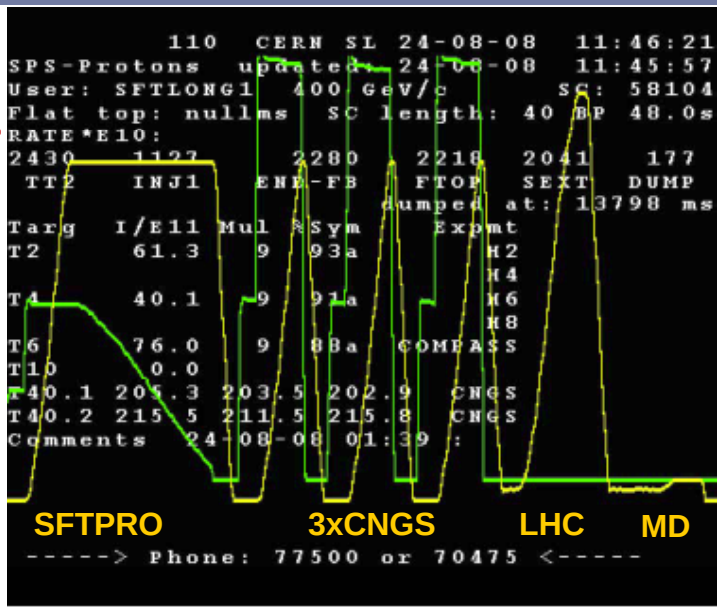
- **LEIR** in operation (since 2010)
  - 2011 ion extraction to NA possible
    - max 10^9 Ions/pulse
    - Pb^{82} and possibly light ions (for NA61)
- **PS2** replaces PS
  - **~5 ÷ 50 GeV/c** beams
  - **1.0×10^{14} ppp**
  - **2.4s cycle fast / 3.5 slow extraction**
  - end of PS-EA, nTOF, AD
    - ISOLDE gets the beam SPL
- **SPS Upgrade**
  - Single injection form PS2 → shorter cycles
  - The machine is upgraded and can handle the PS2 delivered intensity!

Implications for SPS North Area

3 Beam Intensity

Today

- I_{max} (integrated) : **3.5×10^{13} ppp / 9.6s flat-top**
  - instantaneous rate : 3.6×10^{12} pHz
- I_{max} (instantaneous) = **5.0×10^{12} pHz**
  - 2.4×10^{13} ppp / 4.8s flat-top



Future

- The foreseen intensity from PS2/SPSU (**1.0×10^{14} ppp**) represents a factor **2.85 increase in overall beam intensity**
  - In reality ~10% less due to losses at SPS and extraction line
  - Note this is the total – intensity, i.e. for all targets that then is split, etc.

Can the NA infrastructure accept the **×2.5 intensity increase** and the shorter super-cycle (no CNGS, LHC? Is even higher intensity possible if requested for future experiments ?

Implications for SPS North Area

4 Beam cycles

Today

FT flat top	Additional users	Super-cycle	FT duty cycle
9.6(4.8)s	3×CNGS + LHCs + MD	48.0(43.2)s	20(11)%
9.6(4.8)s	LHCs + MD	30.0(25.2)s	32(19)%

Future

FT flat top	Additional users	Super-cycle	FT duty cycle
7.2(9.6)(14.4)s	3×CNGS + LHCs + MD	40.8(43.2)(48.0)s	18(22)(30)%
7.2(9.6)(14.4)s	LHCs + MD	26.4(28.8)(33.6)s	27(33)(43)%

- The single injection from PS2 implies a gain up to **~10%** in cycle length
  - e.g. 43.2s instead of 48.0s for the case of a 9.6s flat top
- The 14.4s flat top, if technically possible, would correspond to **6.95×10^{12} pHz**, 40% more of today's maximum instantaneous rate for the experiments , and a **×2.15** gain in duty cycle compared to today
- *Note: The MD cycle (and LHCs) are needed to maintain the average power in the magnets within limits*

Implications for SPS North Area

5 Limitations – *main issues*

Long flat-top:

- average power to magnets and magnetic extraction septa

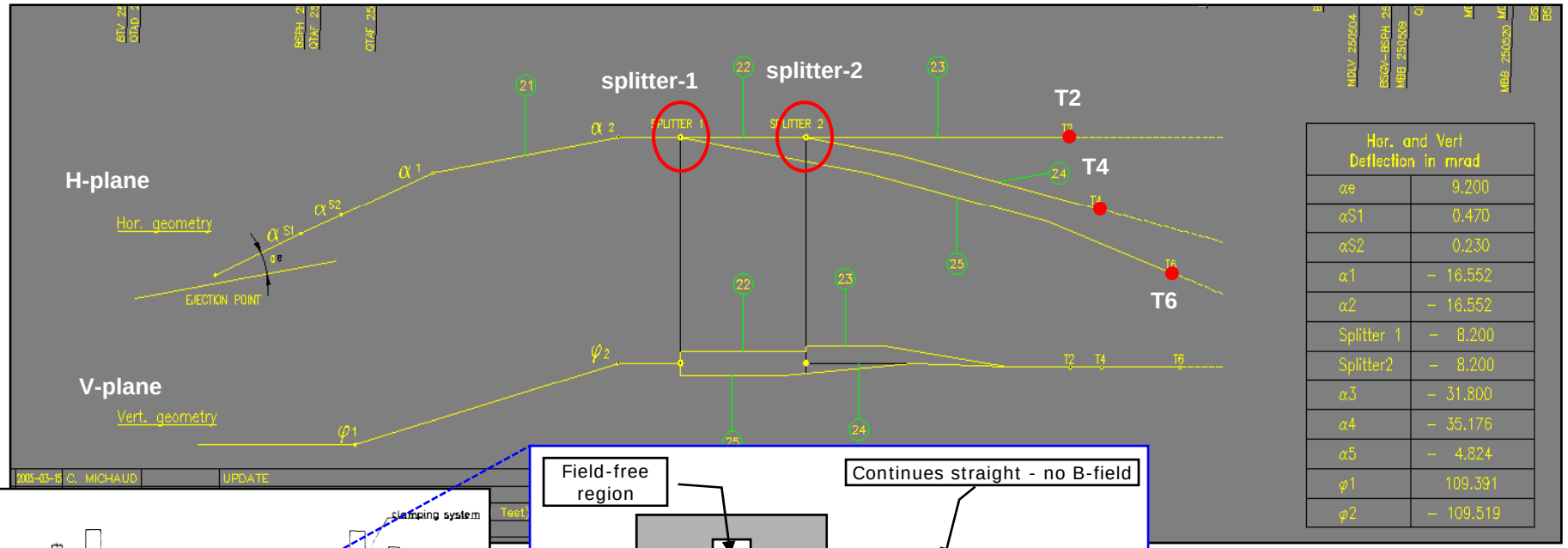
Intensity increase:

- Electrostatic septa:
  - beam losses and induced activation
  - temperature of the wires; sparks
  - Heating and deformation of ion-trap plates
- Losses in beam splitters
- Cooling of targets and TAX blocks :
- Shielding in surface experimental areas (intensity, muons, dumps)
  - EHN1, and EHN2 experimental halls

SPS North Area

6 Beam splitters

TT20 Extraction line from SPS to NA



Hor. and Vert Deflection in mrad	
αe	9.200
αS1	0.470
αS2	0.230
α1	– 16.552
α2	– 16.552
Splitter 1	– 8.200
Splitter2	– 8.200
α3	– 31.800
α4	– 35.176
α5	– 4.824
φ1	109.391
φ2	– 109.519

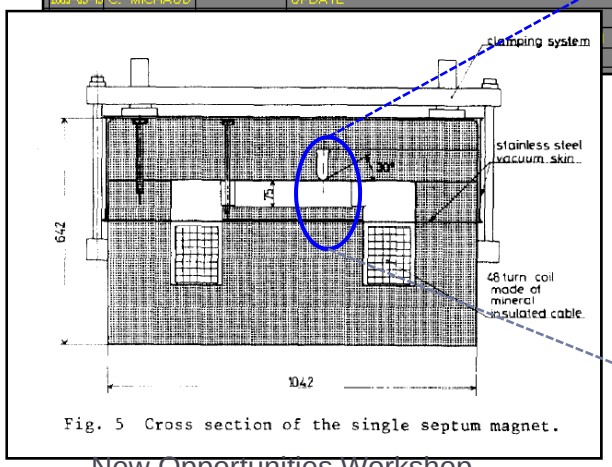
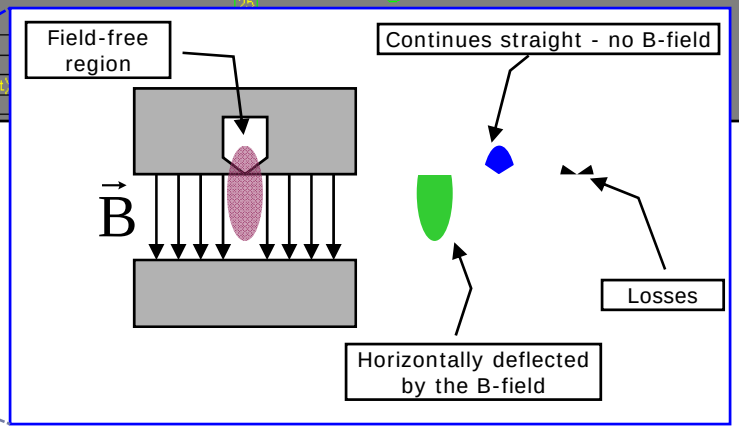
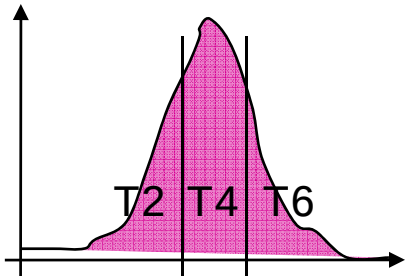


Fig. 5 Cross section of the single septum magnet.





SPS North Area

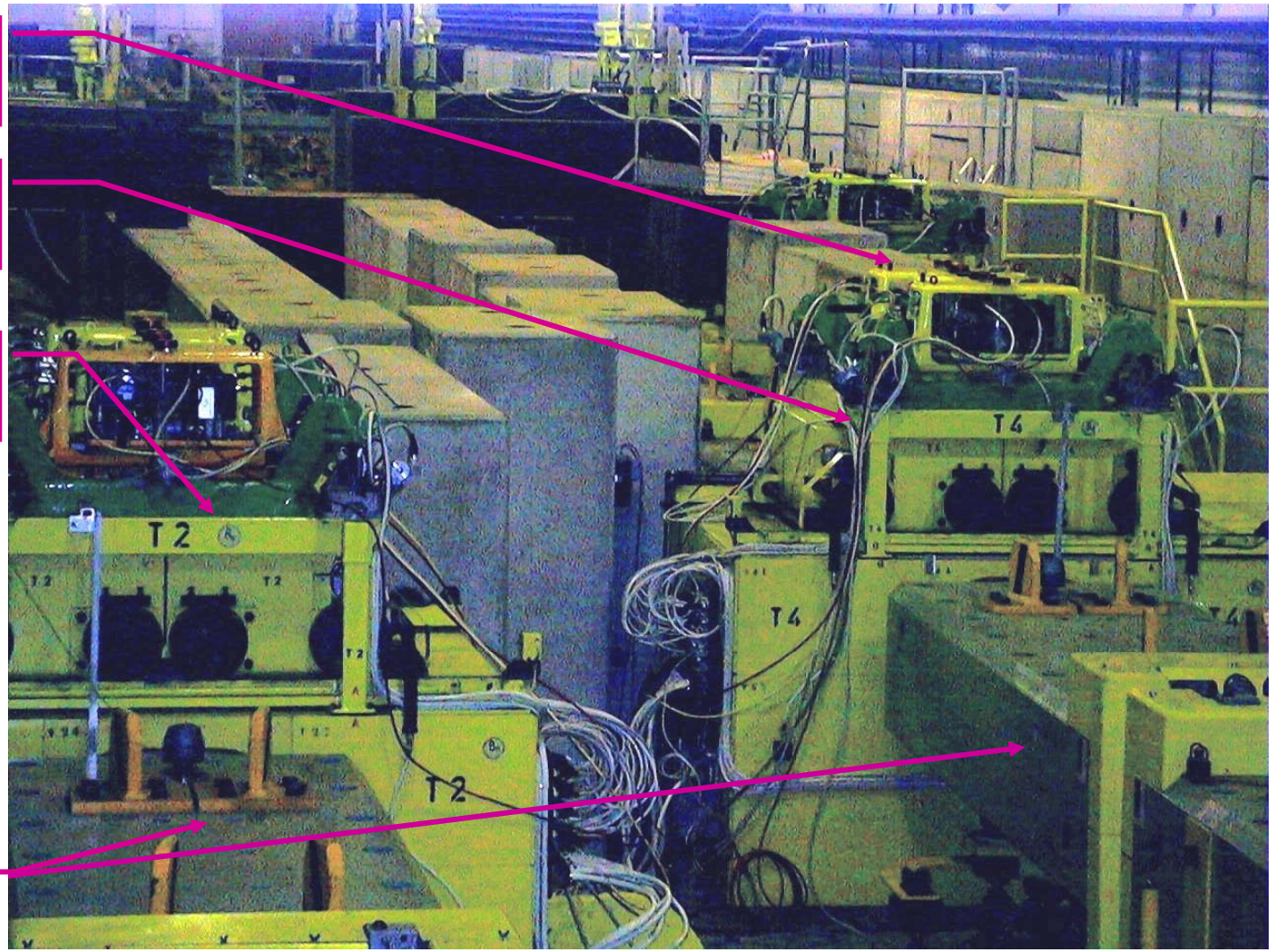
7 Targets

T6 target (M2, COMPASS)

T4 target (H6, H8, P0)

T2 target (H2, H4)

Wobbling magnets



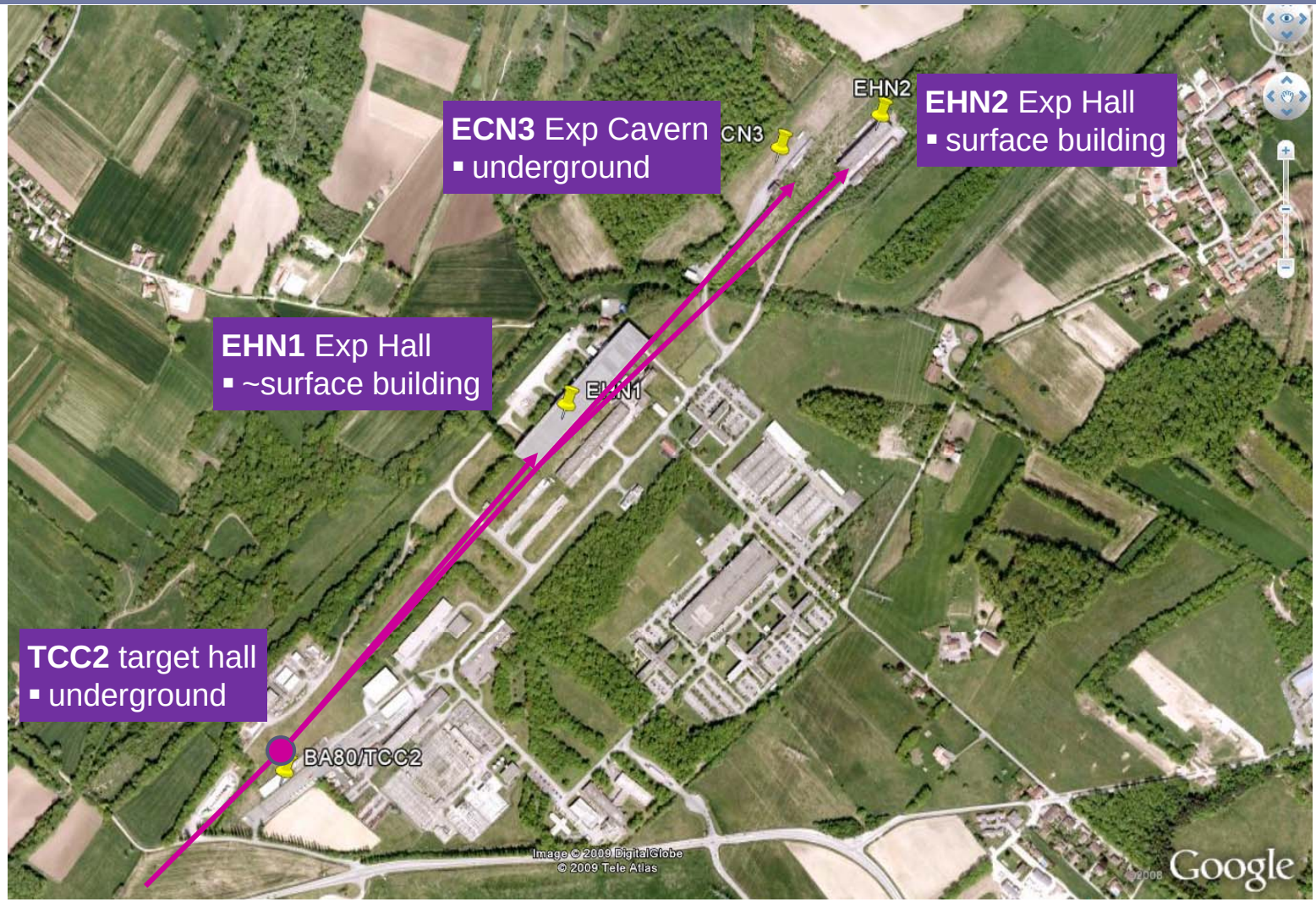
SPS North Area

8 Target Absorber Attenuator - TAX

- Water cooled absorbers to protect the first beam quads from radiation
- Used also as beam dumps of the primary beam

SPS North Area

9 Experimental areas layout



Implications for SPS North Area

10 **Beam performance**

- The **×2.5 higher intensity** and **×2.15 potential gain in duty cycle**, coupled to the high-energy of SPS open unique opportunities for fixed target physics

Example:

- Up to ~×50 sensitivity increase in the challenging channel $K^0_L \rightarrow \pi^0 \nu$ *ν-bar* in a future Kaon experiment, continuation of NA48/NA62
  - *parameters: 26% duty cycle, 50% efficiency, 120 day/year*

Few remarks:

- To operate the North Area with an effective **×5.3 increase** a careful study is required on all critical beam elements of the SPS extraction, transfer lines and secondary beams and areas to address **the technical and safety limitations**

- By 2018 the SPS/NA will be celebrate its **42nd anniversary**!; an upgrade/consolidation program must also be planned to assure the operation of the beams and the experimental areas

- Finally, very likely SPS North Area, and the EHN1 Experimental Hall in particular, will by then be the **ONLY** experimental facilities of CERN that would have to accommodate FT experiments and test beams of constantly increasing number: LHC upgrades, detector R&D for CLIC/ILC, νFact, …

Experimental Areas in PS2

- PS2 as LHC injector will be a machine that would remain idle most of the time!
  - LHC filling is only few times per day, and SPS cycles, in particular FT to NA, are long
  - Even the minimum SPS cycle, eg. CNGS : 4.8s → **75% idle time for PS2**

- Is there a compelling physics program, also looking at competition world-wide, to justify building experimental area(s) attached to the PS2 machine and thus use the available machine time?

  Relevant machine parameters:
  - Beam energy : **~5 to 50 GeV**
  - Intensity : **up to 1.0 × 10^{14} ppp, 3.5s slow extraction cycle**
    - fast extraction is also an option if required

- The presence or not of experimental areas must be integrated in the design of the new machine
  - in particular if a potential physics program would require intensities beyond what is presently foreseen as part of the LHC injector upgrade program, i.e. beyond 1.0 × 10^{14} ppp

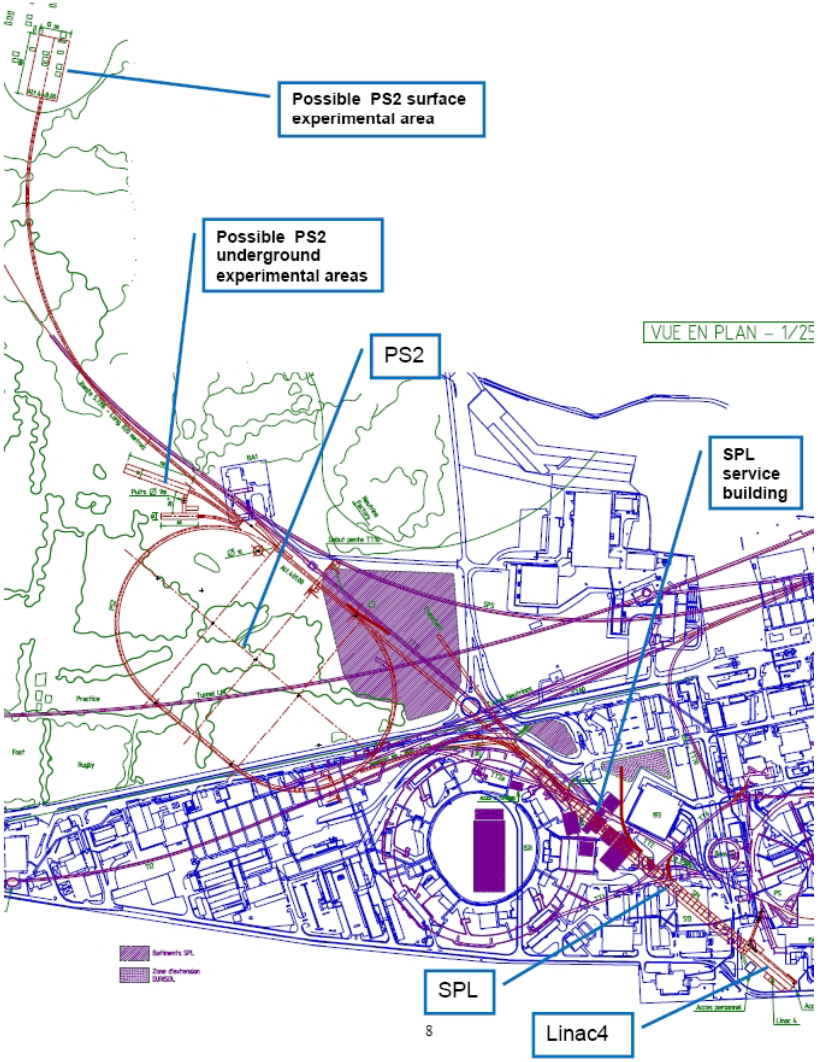
Experimental Areas in PS2

General considerations

- The PS2 machine will be at -50m underground to match the TT2/SPL injection and extraction to SPS
- Deep underground experimental areas can be suitable for high-intensity experiments but not for test beams
- Bringing the beam to the ~surface would require about 700m of beam transfer line (6% slope)
- Experimental areas are quite expensive as they require :
  - Electrical buildings for power supplies
    - secondary beam magnets powered individually, plus large spectrometers for the experiments
  - Infrastructure: cooling, cryogenics(?), cranes, large footprint
  - Offices for users, surrounding shielding

Experimental Areas in PS2

13 Possible implementation



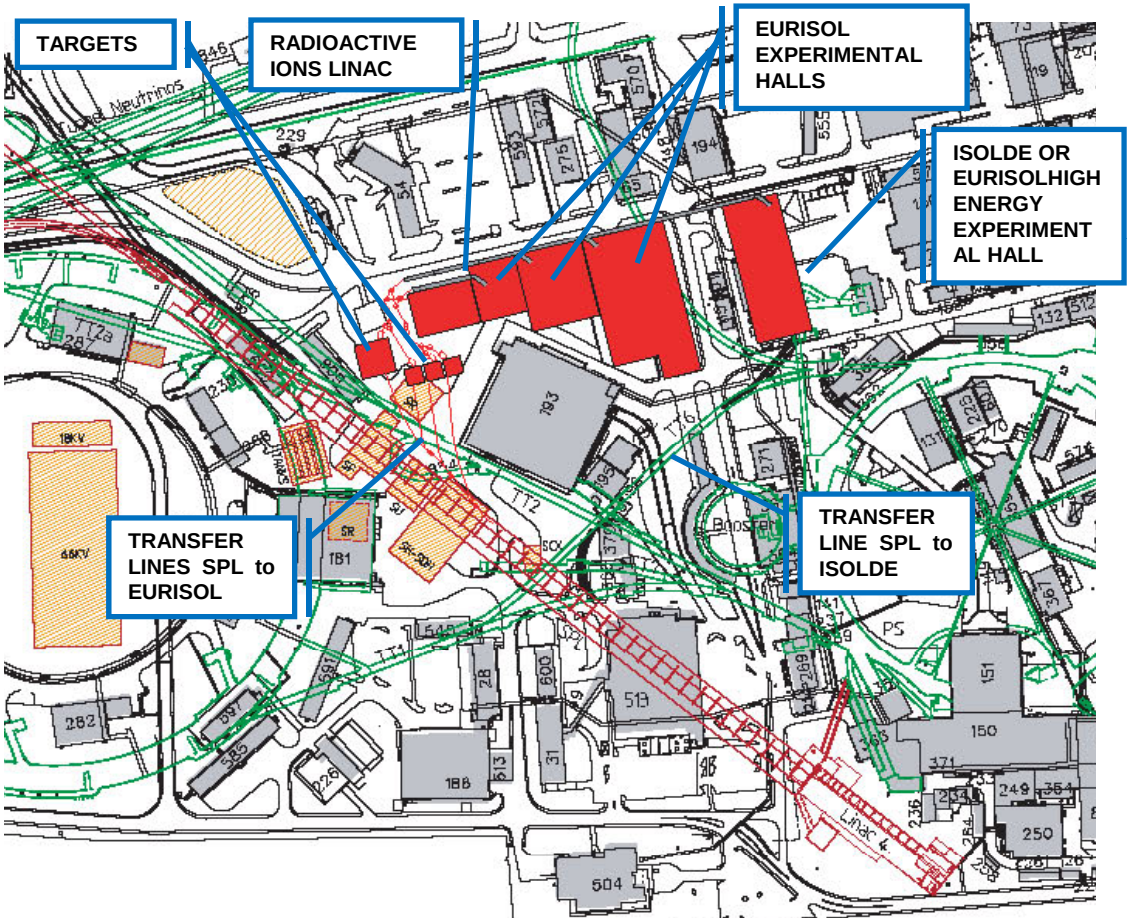
PS2 Exp. Areas layout (ideal scenario)

- **Underground caverns**:
  - beam splitting switchyard
  - two underground areas
    - FT high-intensity experiment(s)
    - high-intensity test facility
  - *nTOF*
- **Semi-surface(-5m) Experimental Hall**
  - transport attenuated primary beam (or secondary beam) to medium-intensity targets
  - hall for FT experiments and test beams
    - nearby SPS Point-2 zone
    - PS East Area type of layout and beams
- Exp. Areas can be staged, but they must be included in the design of the machine

Exp. Areas for low energy beams

14 Possible implementation

- SPS NA could provide beams from **5÷400 GeV**
- Producing tertiary beams of lower energies although technically possible is rather inefficient and challenging for the experiments (large backgrounds)
- Lower energy test beam areas could be envisaged coupled to the ISOLDE (or future EURISOL) facility with beams provided from SPL (<~5 GeV)



Summary

- An overview of the Experimental Areas in about 10 years ahead when the new injectors will become operational was presented

- With the baseline program of the LHC injector upgrades (SPL, PS2, SPSU), and assuming a rigorous upgrade/consolidation program for the SPS North Area is realized, beams with ×2.5 higher intensities and improved duty cycle could be provided

- The **input from the user community**, triggered by this workshop, is mandatory to setup a competitive physics program (protons and ions) with these beams for the SPS North Area, and make the case of experimental areas attached to the PS2 machine.

Next steps

- In particular for PS2 experimental areas, a **study group** was formed by the CERN management to
  - trigger discussions and collect experimental requests,
  - explore the possible fixed-target options using beams from PS2,
  - summarize in particular, any physics arguments for an intensity greater than that required for the LHC upgrade

  Members: M. Benedikt, A. Ceccucci, I. Efthymiopoulos, J. Ellis, L. Gatignon

  - A report will be provided to the CERN management by **June'09**

- Looking forward to **your input** during the workshop and/or afterwards ….