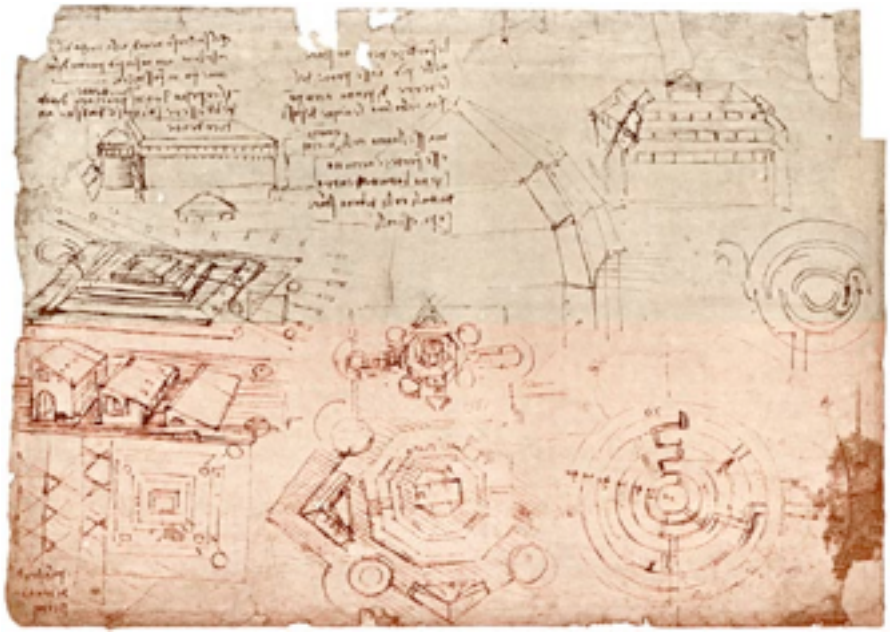
# Experimenter's Dreams for Future Facilities

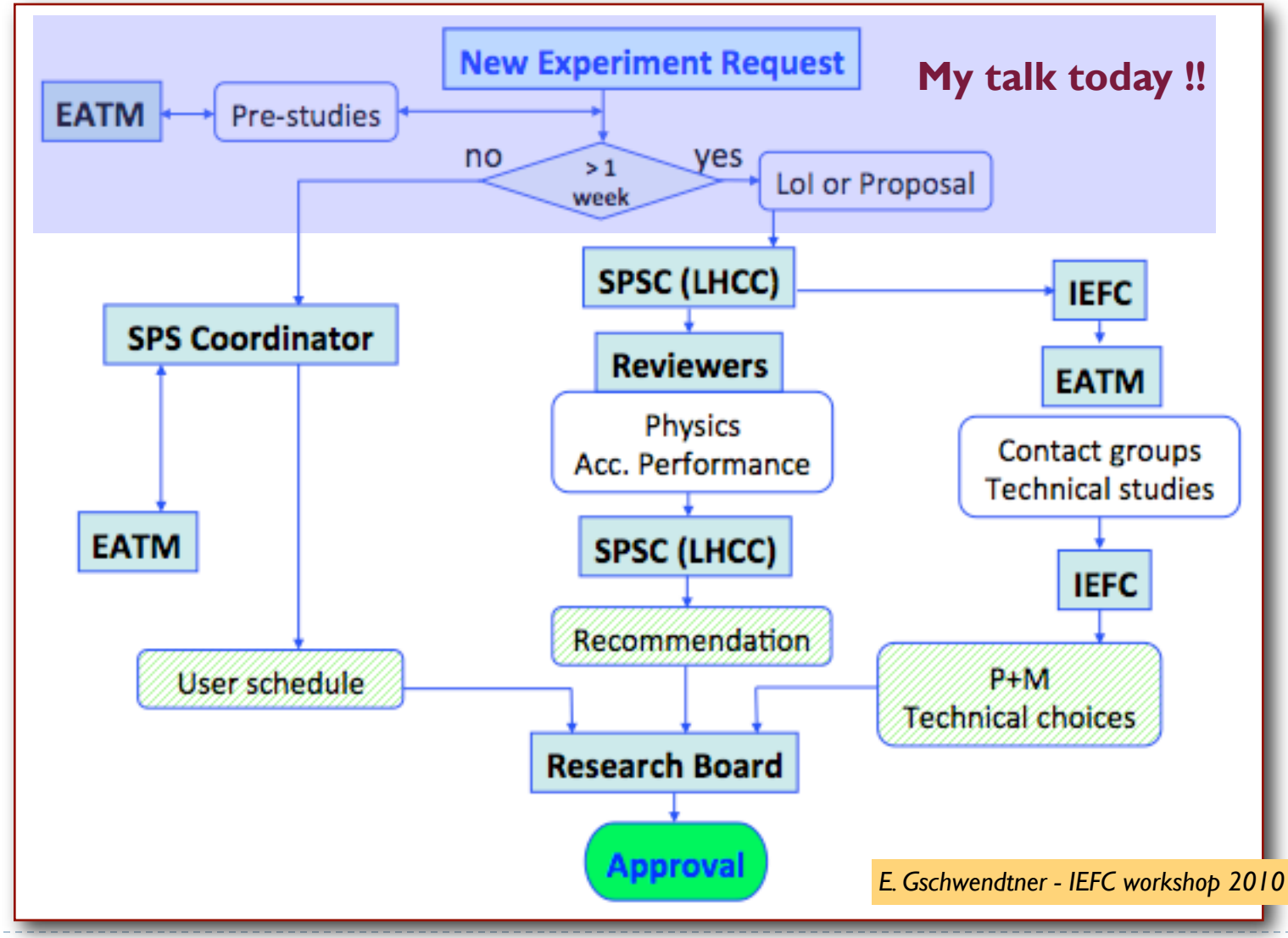
**Ilias Efthymiopoulos, EN/ MEF**

With input and thanks to:

R. Assmann, C. Carli, S. Maury, R. Trant, M. Brugger, R. Steerenberg, B.Biskup



# Reminder - Lifetime path of an Experiment at CERN




*E. Gschwendtner - IEFC workshop 2010*

# Scope of the talk

- Go through the present and (possibly)future projects that can be realized with our injector machines and EAs
  - There is lot of activity beyond or in // to LHC
  - Be informed, so you know what's going on when you hear people talking over coffee
  - May trigger your interest in some of the projects
    - I'll try to limit the physics motivations to the mixed audience level, ask if you want more...

- But please:
  - Don't take everything as granted
    - These are proposals/ideas that have to find their way through the approval process; some may be realized, some not !
  - Don't go to much to technical details or "can't be done" attitude
    - Proposals must be studied and evaluated - there is a start for everything!

- Many thanks to those who provided material
  - It is difficult to judge the right moment to present a new project or idea not to create a negative tsunami!

# The “new” projects around

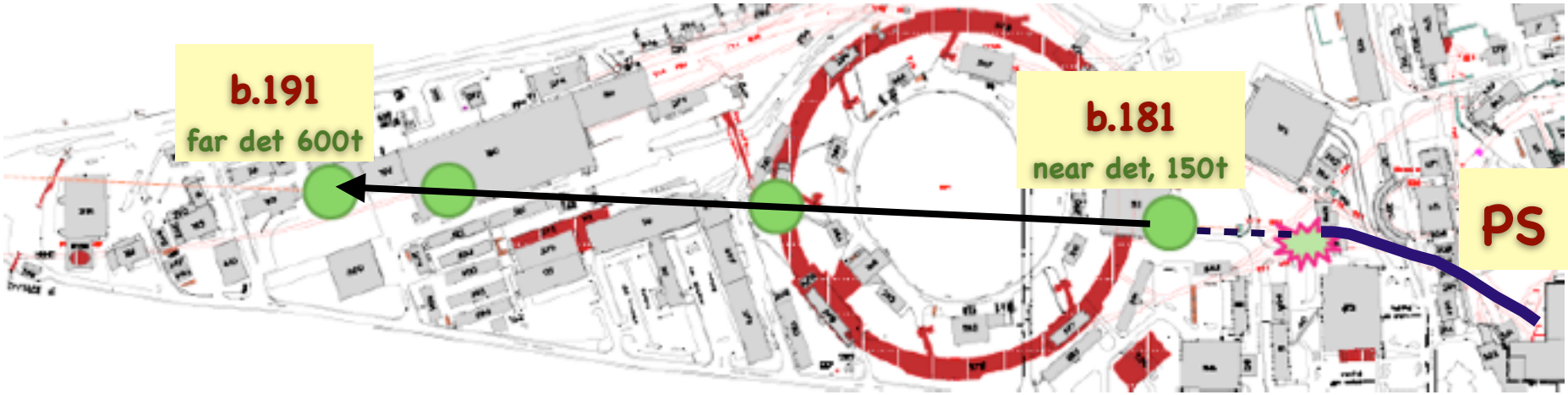
- PS Machine
  - East Area Upgrade, Layout change & new Irradiation Facility (AIDA)
  - New nTOF experimental area
  - ✓ PS neutrino beam for sterile neutrino search
- AD Machine
  - AEGIS experiment
  - Upgrades/modifications of ALPHA, ASACUSA, ACE
  - ELENA ring and probably new experiments to fully exploit it
- ISOLDE - HIE ISOLDE
- LEIR Machine
  - ✓ Facility for radiological studies
- North Area - EHN1
  - ✓ New Gamma Irradiation Facility - GIF++
  - ✓ New electronics irradiation facility - H4IRRAD
  - ✓ AIDA project for new VVLE muon beam in H8 for Neutrino Detector R&D
  - AIDA project for test beam users and Transnational Access - CLIC & LHC detector R&D
  - Ion and proton beams for NA61, NA63 and UA9
- North Area - EHN2
  - COMPASS-II program for the next ~10 years
- North Area - ECN3
  - NA62 Experiment for rare Kaon Physics
- Recognized experiments
- Design studies for future facilities
- Facility for accelerator R&D on materials - HiRadMat

Items in black covered in the other talks of the session by
- L. Gatignon
- T. Erikson
- E. Gschwendtner
- A. Pardons
- Y. Kadi

# PS - Short Baseline ν-beam

- **A search for anomalous neutrino $\nu_\mu \rightarrow \nu_e$ oscillations at the CERN PS with LAr-TPC detectors *(C. Rubbia et al.)*** arXiv:0909.0355v3 [hep-ex]

*Courtesy: R. Steerenberg - BE/OP*




- Beam line originally operated in early 80's for PS169, PS181, PS180(BEBC) experiments
- Experiment request: 2.5 $10^{20}$protons/year x 2 years, ready by 2015 (after CNGS)
- **PS beam possibilities (180d, 85% efficiency) :**
  - **6.13 $10^{19}$ ÷ 2.02 $10^{20}$** from zero to max impact to PS users

| | Old neutrino facility | | New neutrino facility | | |
|---|---|---|---|---|---|
| | PS dedicated Feb-Mar 1983 | PS parallel 1983 - 1984 | PS dedicated | PS parasitic | PS ultimate[2] |
| Proton Momentum | 19.2 GeV/c | 19.2 GeV/c | 20 GeV/c | 20 GeV/c | 26 GeV/c |
| Protons/pulse | $1.25 \times 10^{13}$ | $1.2 \times 10^{13}$ | $3 \times 10^{13}$ | $2.6 \times 10^{13}$ | $4 \times 10^{13}$ |
| Max. rep. rate | 1.2 s | 14.4 s | 1.2 s | 1.2 s | 1.2 |
| Beam energy | 38 kJ | 38 kJ | 96 kJ | 84 kJ | 166 kJ |
| Average beam power | 32 kW | 2.5 kW | 80 kW | 70 W | 140 kW |

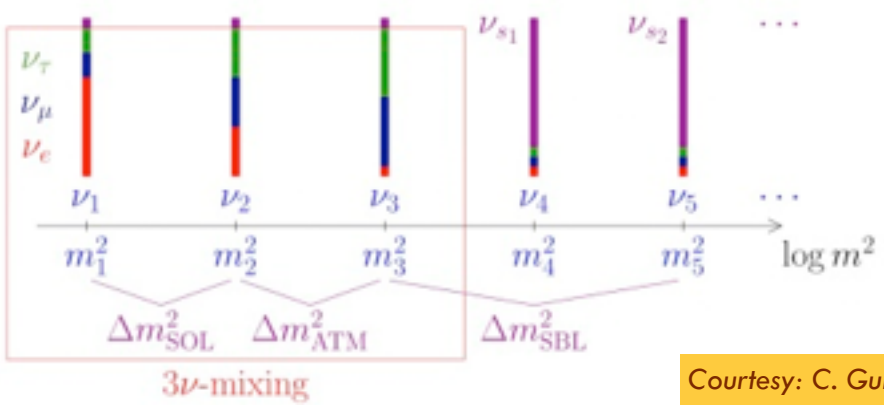
# PS - SBL ν-beam for sterile ν's ?

## ν-physics in a slide !!!

- Facts
  - we know from LEP that there are 3 SM neutrino families: $\nu_e$, $\nu_\mu$, $\nu_\tau$
  - we know from experiments the neutrinos have mass (small) because they seem to oscillate, i.e. over a distance they transform from $\nu_a \rightarrow \nu_b$

- The problem:
  - some experiments (LSND, KAMLAND, MiniBooNe, MINOS,...) observed an anomaly in the oscillation pattern:
    - anti-neutrinos seem to oscillate differently than neutrinos, at least in some energy range
  - to explain the effect CP and even CPT-violation is required, or new physics → sterile neutrinos

- The sterile neutrino hypothesis
- Imagine there are neutrinos into which the known ones can be transformed, but they don't transform back (or transform in a different rate), i.e. don't have SM interactions → sterile
- it turns out that a theory with 2 sterile neutrinons (3+2 theory) fits well (~)all of the present data
- Sterile neutrinos are not needed by the theory, but if found would be a great discovery !!!




Courtesy: C. Guinti

# PS - Short Baseline ν-beam

- Detailed presentation of the PS Neutrino Beam in 2010 IEFC workshop:
  - R. Steerenberg :"Towards reviving the PS Neutrino Beam - what it really involves"

**Status**

- Experimental proposal submitted to SPSC CERN-SPSC-2011-012 ; SPSC-M-773 - under evaluation
- If the physics case is approved, proceed to a design study
- Timing and resources to be defined
  - Experiment requests to have the beam by 2015 assuming the 600t ICARUS detector is transferred form LNGS during the long shutdown in 2013-2014 and no CNGS physics continues

# Facility for Radiobiology Studies

- Aims discussed at the "Physics for Health in Europe Workshop" at CERN in February 2010
  - Provide beams for experiments in support of treatment centers
  - Radiobiology, investigations with different ion species (e.g. C, up to O)
  - Fragmentation studies, dosimetry

- Which machine?
  - The proposal presented at the "Physics for Health" workshop was first to **use the AD** for providing a proton beam a few weeks per year.
    - Not too large investment, technically and in terms of human resources.
  - **LEIR as long-term option**
    - Not (yet?) used all the time
    - Could provide beams during LHC ion periods during "coasts" (with additional source)
    - Could provide beams outside periods for setting up for and operation of LHC with ions
    - No other machines (PS) required → minimum impact on other CERN programs
    - Energy reach of LEIR appropriate for such experiments

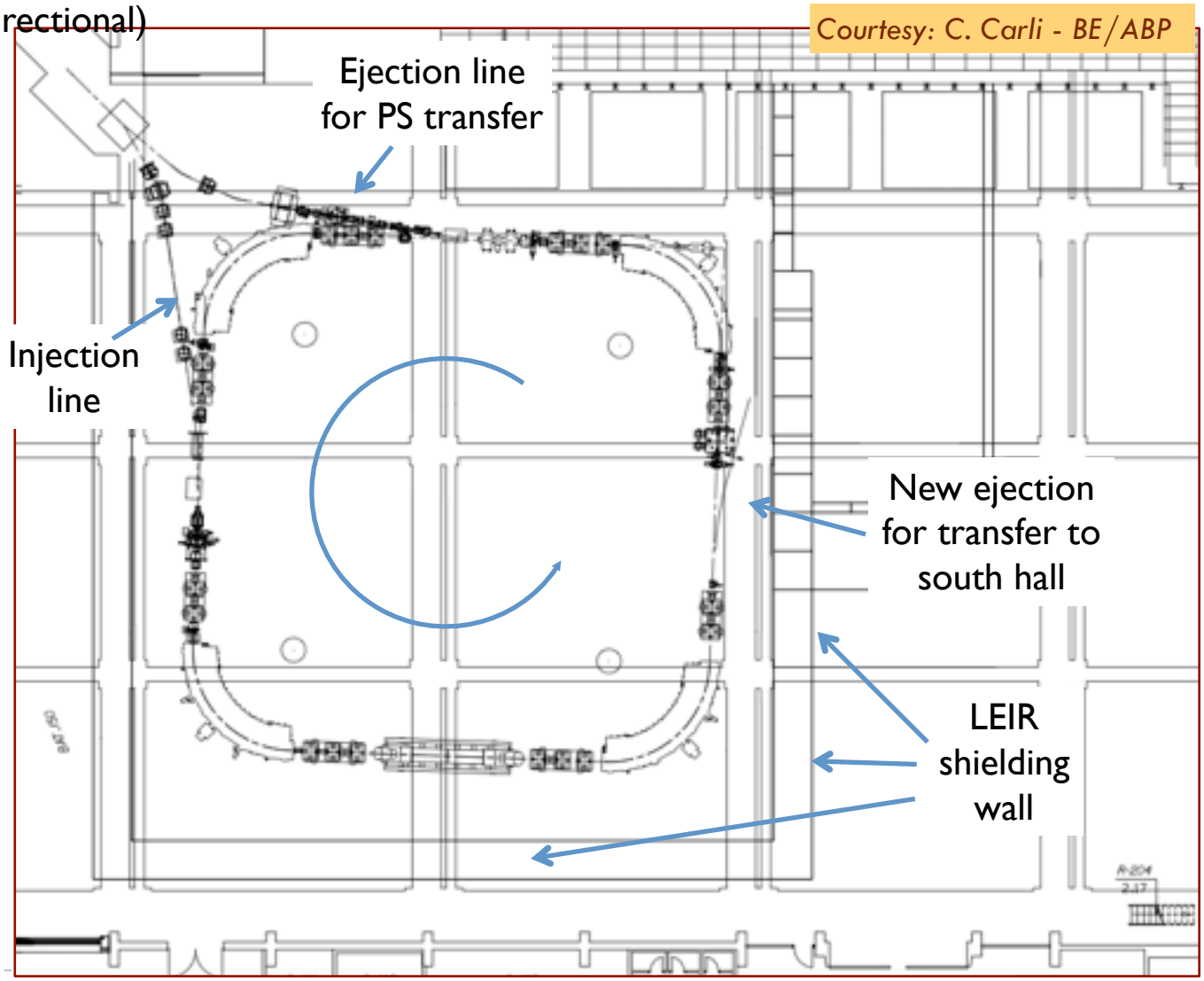
*Courtesy: C. Carli - BE/ABP*


http://indico.cern.ch/event/70767

# Facility for Radiobiology Studies

Transfer lines (bi-directional)
- from Linac3
- towards the PS

- Requirements
  - New ejection channel and a (short vertical?) beam line
  - Slow ejection to be implemented
  - Infrastructure (Radiobiology lab …)
  - Possibly an additional ion source, RFQ …
- Very first studies started only on feasibility and implications



# Facility for Radiobiology Studies

**Possible program**

- A vertical beam (for momentum < 500 MeV/c) could be provided to make irradiation of radiobiological samples easier (LEIR or PS East Area ?)
- An experimental area for biomedical research, providing beams of low-Z ions (from protons to e.g. O) in the MeV/u to hundred MeV/u energy range for hadron therapy-related studies (LEIR - ?)
- A space-research experimental area, providing beams of medium-Z (e.g. up to iron) and high-Z (up to Pb) ions in the GeV/u energy range for space-related radiobiology studies (PS East Area-?)

**Issues to clarify:**

- The light ions requested should be defined so that the appropriate source can be designed (O ion and below?)
- LEIR issues, extraction, a new experimental zone should be studied including the cost
- Medical Application program in LEIR could not take place before **2017 at the earliest**

# New Gamma Irradiation Facility - GIF++

- GIF : is a Gamma Irradiation Facility
  - use a powerful source (Cs137) to irradiate detectors or other equipment for performance, or ageing studies
  - strong point: presence of a particle beam to check detector performance, i.e. particle identification, on top of a photon background

R. Fortin (PH) – the Cs source in GIF

Test stand for irradiations

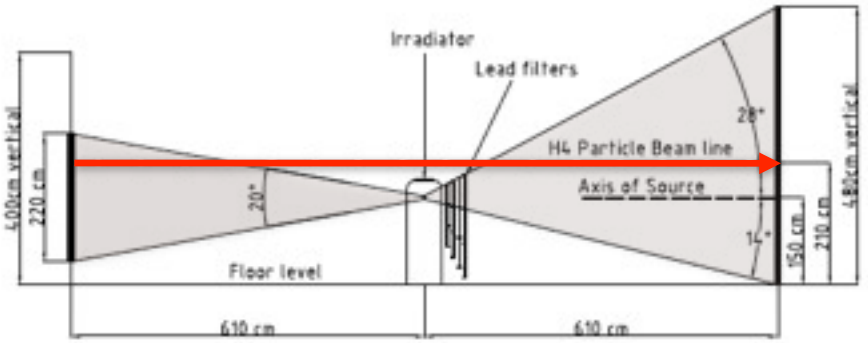
# New Gamma Irradiation Facility - GIF++

*M. Capeans (PH) – SPSC Presentation Sept, 2009*

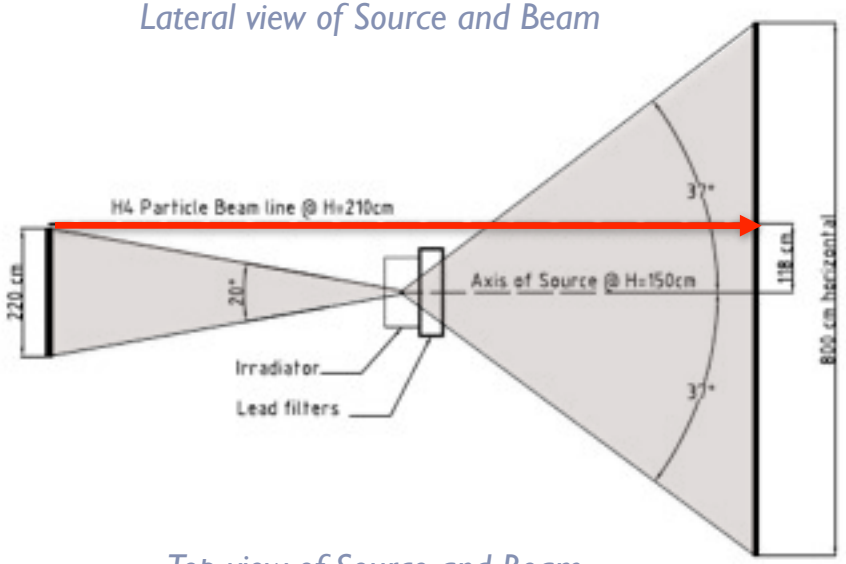
- Source
  - 137Cs, **~7-10 TBq** (×10 of GIF)
  - Up to ~2 Gy/h at a distance of 50 cm
  - 662 keV photons
  - 30 y isotope half-life

| Max. expected doses at sLHC | Equivalent time at GIF++ (~ 50 cm from source) |
|---|---|
| Si-trackers: ~ MGy/y | >> years |
| Calorimeters: ~ 20 kGy/y | < 1 year |
| Muon systems: ~ 0.1 Gy/y | ~ minutes |

- Particle Beam
  - 100 GeV muons, $10^4$ muons/spill in 10x10 $cm^2$
- Infrastructure:
  - Nearby test area for detector preparation
  - Optimized swap of detectors: no uncabling

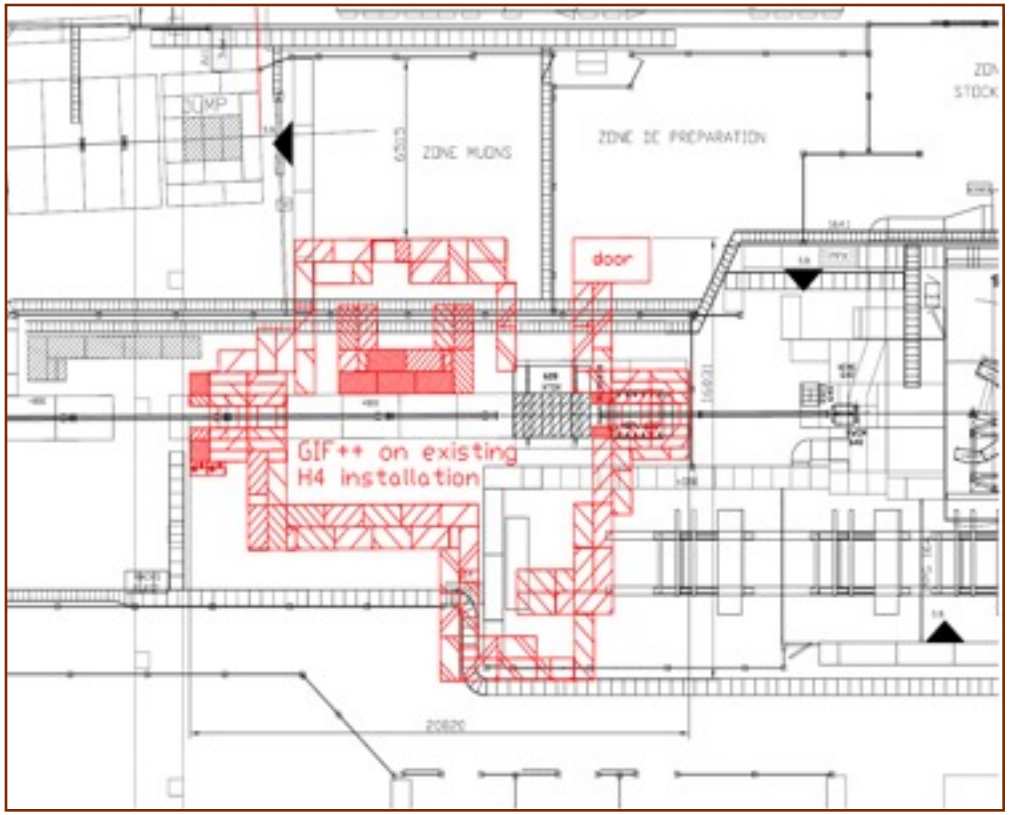



*Lateral view of Source and Beam*



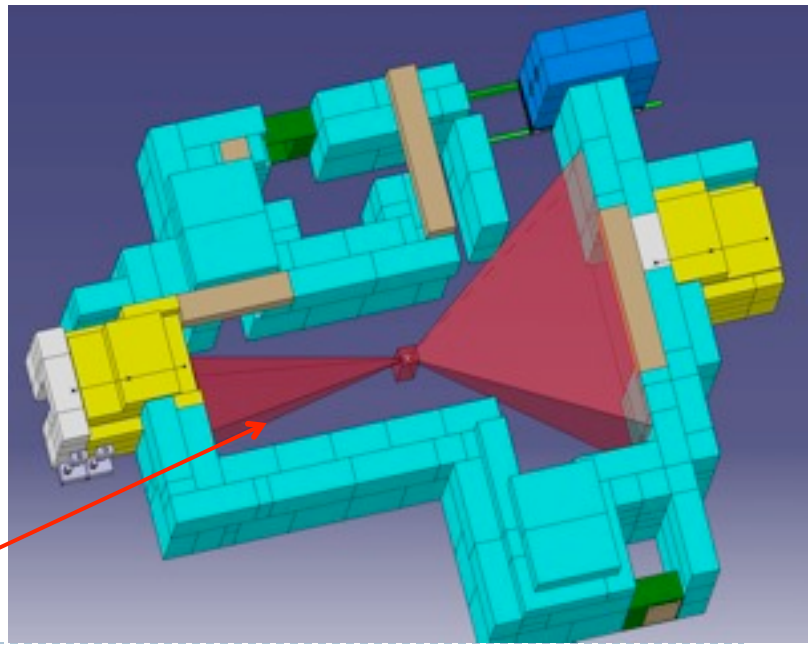

*Top view of Source and Beam*

# New Gamma Irradiation Facility - GIF++




GIF++ Installation overlaid on existing infrastructure - H4 beam line

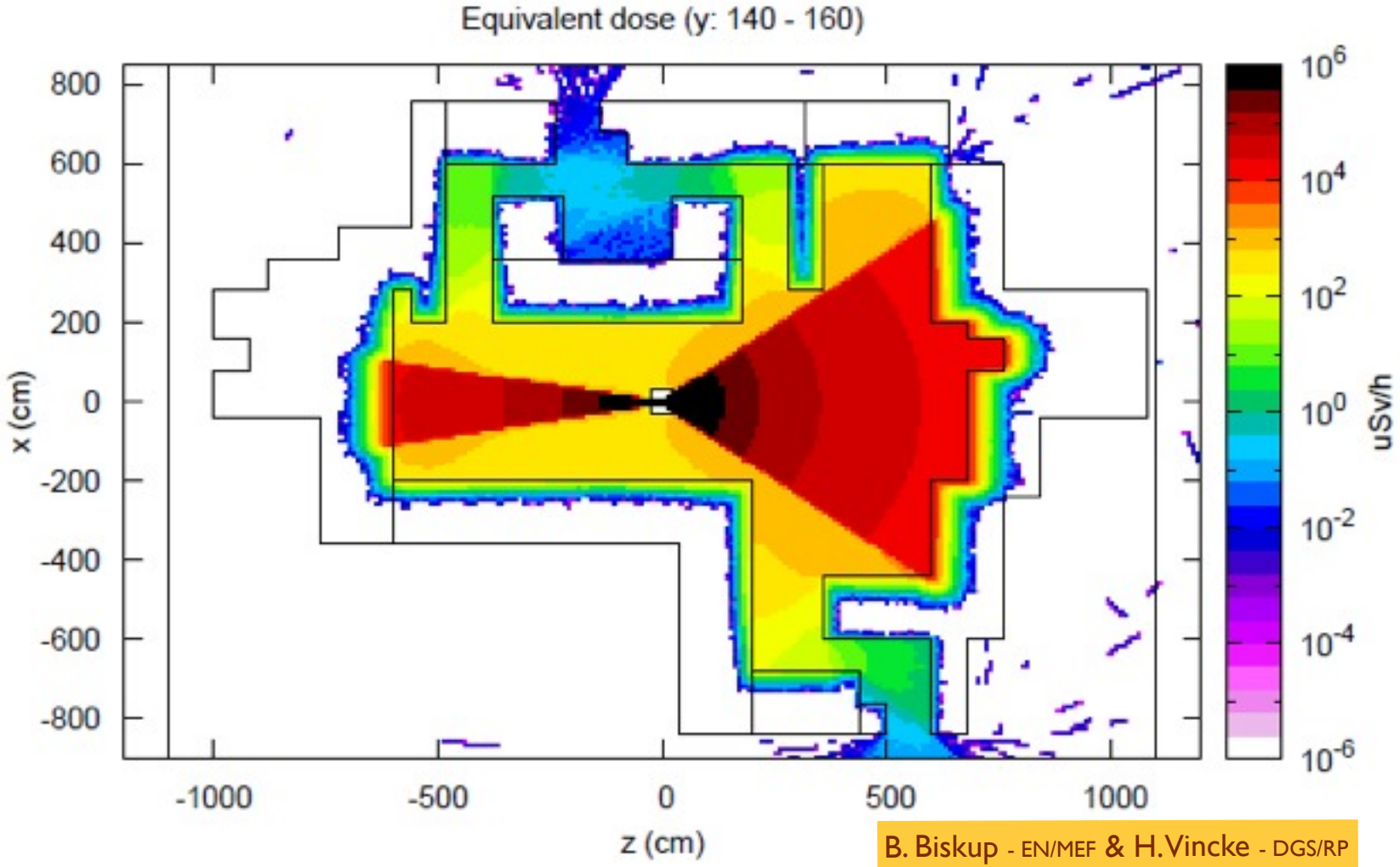
- Proposed installation in H4 beam line in EHN1 building
- Installation, RP study and cost estimate available



Roof shielding of 0.8m concrete over the irradiation area

# New Gamma Irradiation Facility - GIF++

- FLUKA Model and simulation of GIF++




B. Biskup - EN/MEF & H. Vincke - DGS/RP

# New Gamma Irradiation Facility - GIF++

**Status**

- Layout and RP study completed
  - Contacts with specialized company(ies) to provide the source and its shielding and control & safety system
- Cost estimate available
- The GIF++ is part of the AIDA proposal
  - Support for detector specific infrastructure from external labs
- Waiting for funding approval to start installation activities
  - Schedule will be defined accordingly, taking into account other ongoing projects at that time

# Facility for Electronics Irradiation - H4IRRAD

## Radiation To Electronics (R2E) - M. Brugger, M. Calviani

- Presently: radiation tests of existing equipment: TE/EPC, EN/EL, TE/ABT, TE/CRG, BE/BI, EN/STI, TE/MPE,…
  - partly "covered" through **CNRAD** and **external facilities**
  - problematic: parasitic, required services, access, turn-around,…
  - physics: cannot fully cover all LHC test requirements - certain failure modes depend on particle type &energy
- 'Near Future' (2011-2013): component and system testing of new development and upgrades; test of patch-solutions for LHC (2014-2016 operation period)
  - given the time-constraints (upgrade requirements, shutdown planning) → bottle-neck in available beam-time and turn-around
  - test/development of patch-solutions will require quick setups, tests, changes, re-testing
- Long-Term: new developments of LHC tunnel equipment, LHC upgrade requirements
- Besides above constraints, CNRAD will not be available forever; **H4IRRAD** first step towards long-term dedicated test facility (e.g. PS-East Area ? )

# Facility for Electronics Irradiation - H4IRRAD

**H4IRRAD** : A new multi-purpose facility providing mixed radiation fields to cover the needs of equipment testing for R2E

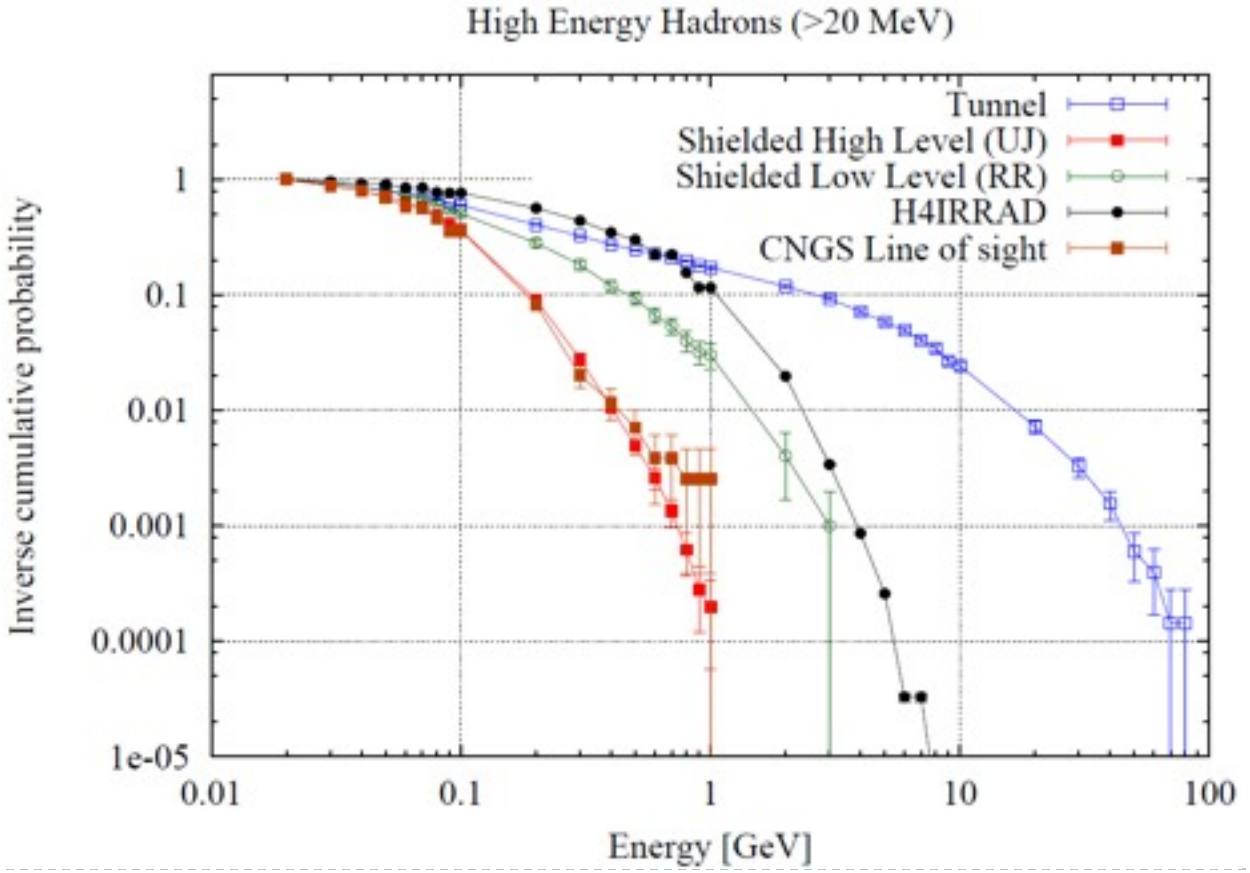
- **Required layout** :
  - High-energy hadron beam on target (e.g., Cu) producing mixed particle and energy spectra
  - attenuation through ('modular') shielding with iron and/or concrete
  - test volume sufficiently far away to allow for 'homogeneous' irradiation (in the order of ~20% uncertainty due to gradient), however for large volumes up to the size of a rack
  - possibility to bring in services (power, communication, cooling)

- **Beam**:
  - High-energy secondary beam from T2 target, **~320 GeV/c, ~$10^9$ particles/spill**
  - For electronics tests a factor of **10 higher intensity** may be required

- H4IRRAD is nothing but reviving an old configuration for the H4 beam line for the NA31 experiment, where a primary beam of $2\times10^{11}$ protons was used

# H4IRRAD – Representative for LHC

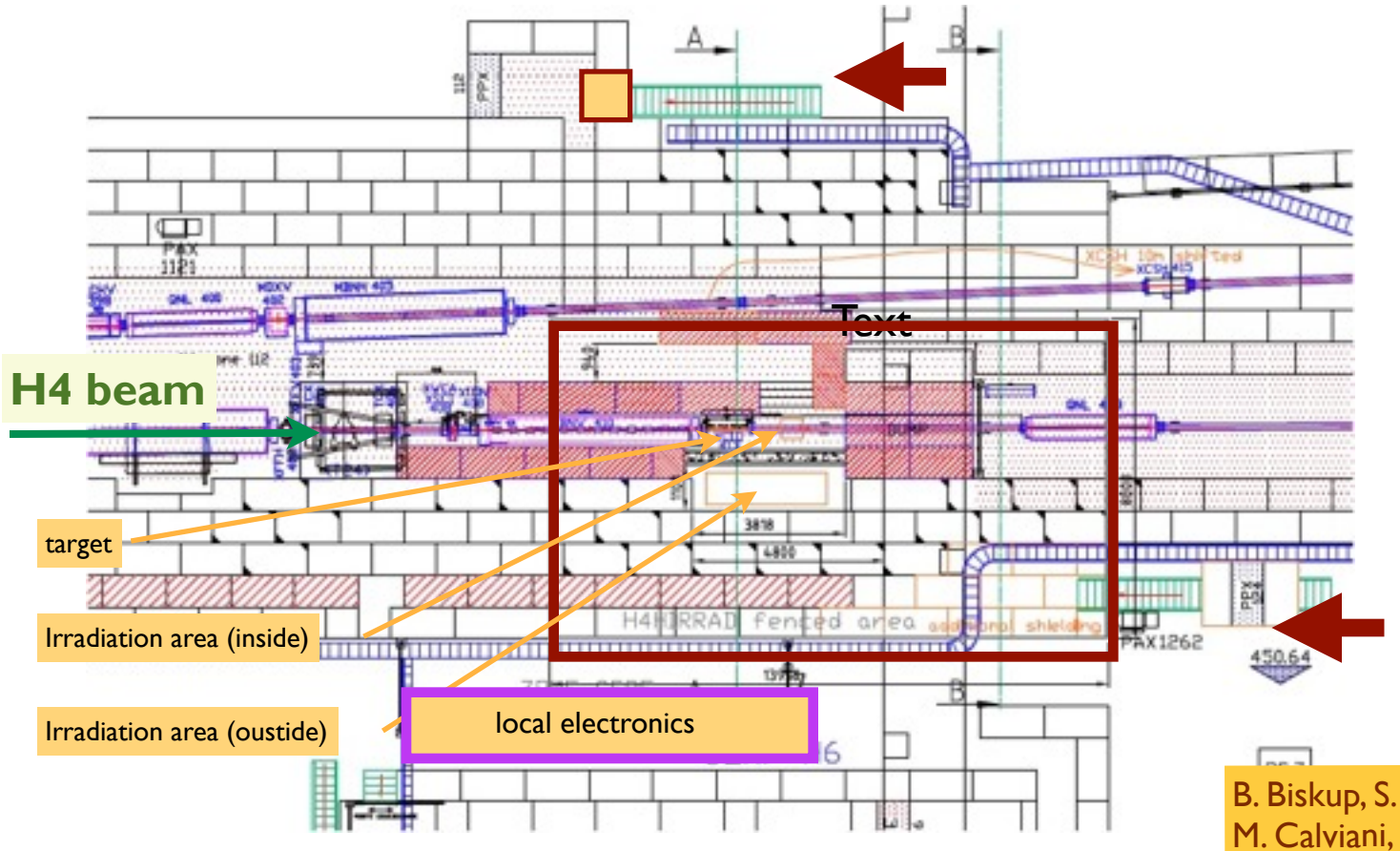
- The H4IRRAD field is covers
  - the UJs and the RRs - important for power-converter development and possible requirements for patch-solutions
  - and tunnel areas(tbc) - example for FGC, QPS, Cryo developments to be studied further




© K. Røed

# Facility for Electronics Irradiation - H4IRRAD

- Layout




**H2 roof access**

- access to stored equipment
- via new PPX112 switches H2&H4 beam off

**H4IRRAD**

- access to equipment via the top (H4 roof open)
- via new PPX124(or PPX134) that switches H4 beam off
- RP veto
- Fenced area to limit to the H4 beam side only

B. Biskup, S. Girod - EN/MEF
M. Calviani, M. Brugger - EN/STI
C. Theis - DGS/RP

# Facility for Electronics Irradiation - H4IRRAD

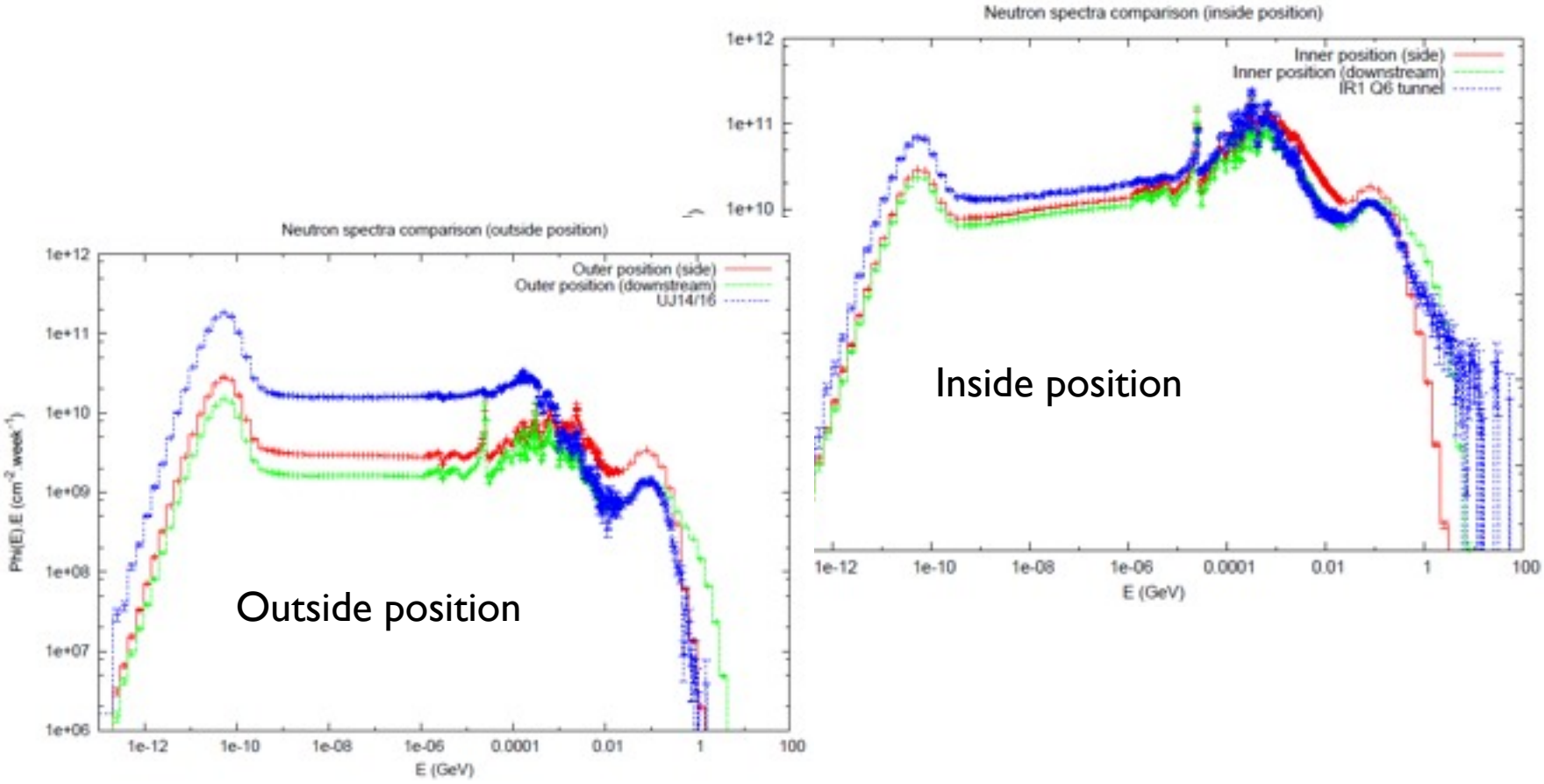
- **Beam**: secondary proton beam @ 320 GeV, 2 cm FWHM
- **Target** : Cu rod 7.5cm diameter, 1m long
- **Layout:**
  - 20cm concrete shielding to the outer racks
  - 160 cm thick Fe roof - removable part above the testing positions

- **FLUKA simulations** : $10^9$ ppp, 44s super-cycle

| Testing position | Dose (Gy/week) | HEH (/week/cm$^2$) | Si 1MeV n (/week/cm$^2$) | Muons (/week/cm$^2$) |
|---|---|---|---|---|
| Inner (side) | 4.80E+01 | 5.94E+10 | 3.93E+11 | 8.06E+08 |
| Inner (downstream) | 4.35E+01 | 6.98E+10 | 2.57E+11 | 1.13E+09 |
| Outer (side) | 3.03E+00 | 7.84E+09 | 3.69E+10 | 1.09E+08 |
| Outer (downstream) | 2.29E+00 | 5.07E+09 | 1.81E+10 | 1.78E+08 |

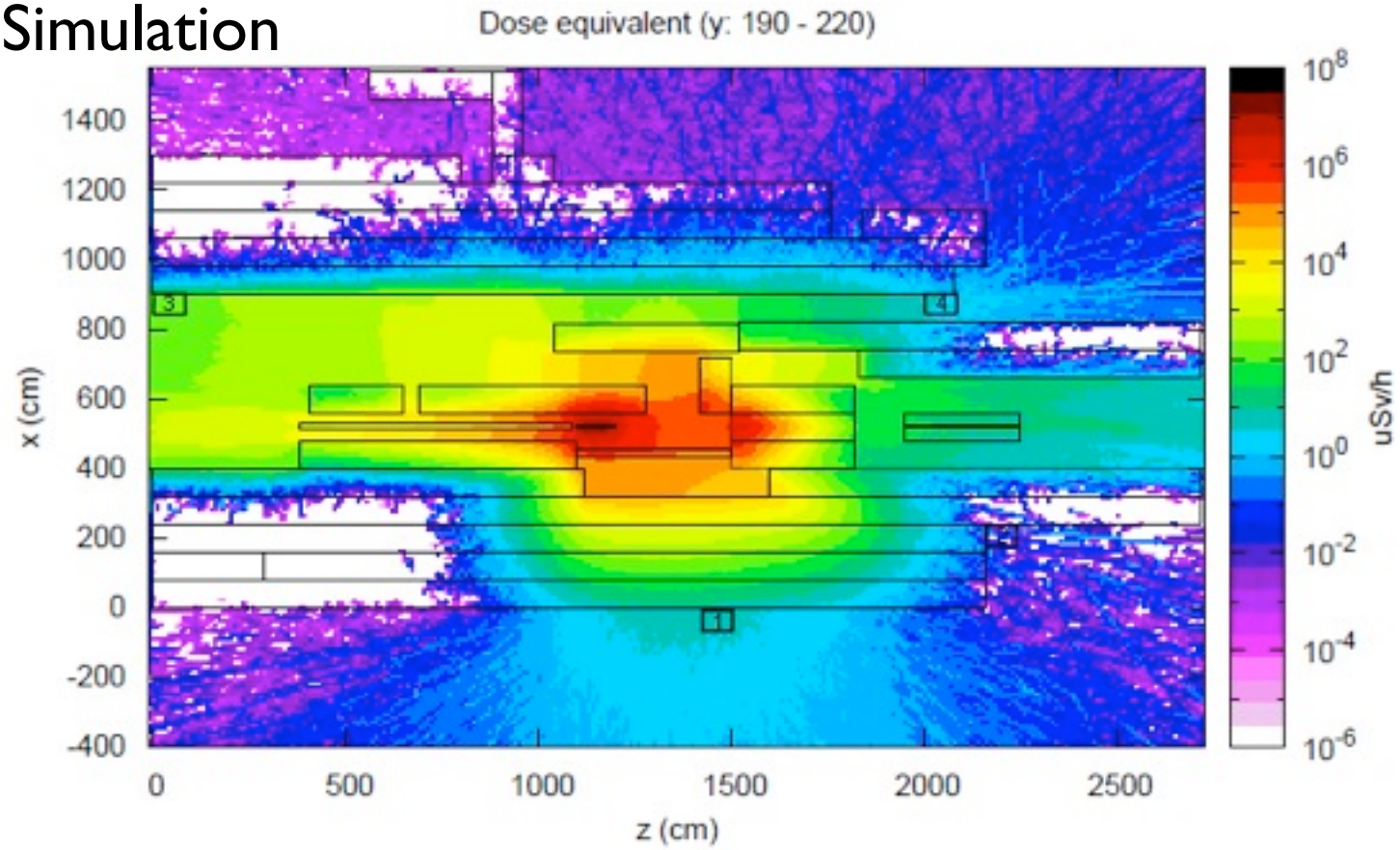
# Facility for Electronics Irradiation - H4IRRAD

- FLUKA Simulation
  - Neutron fluences match well the expected levels at LHC



# Facility for Electronics Irradiation - H4IRRAD

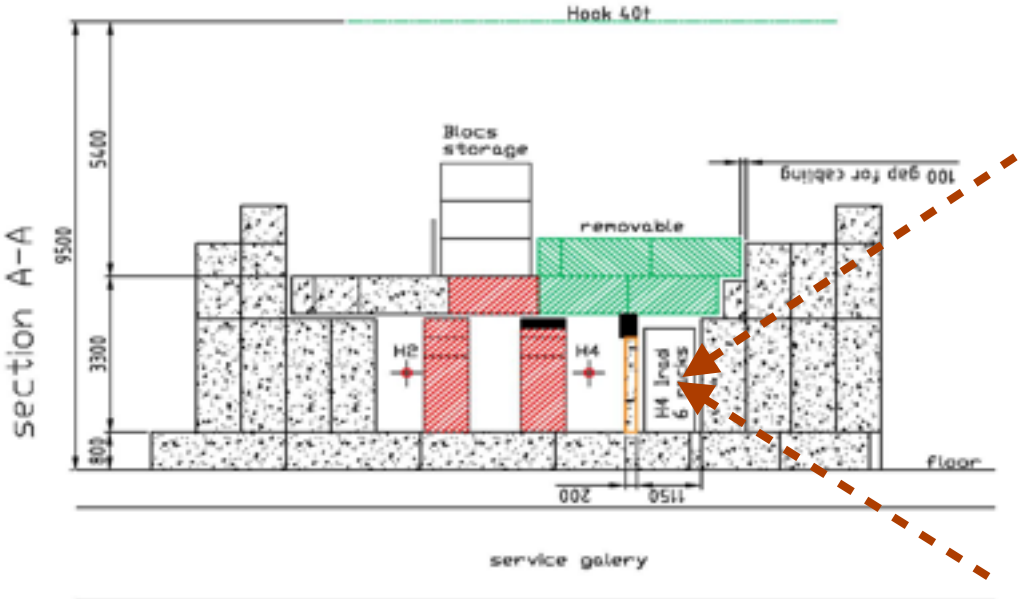
- FLUKA Simulation



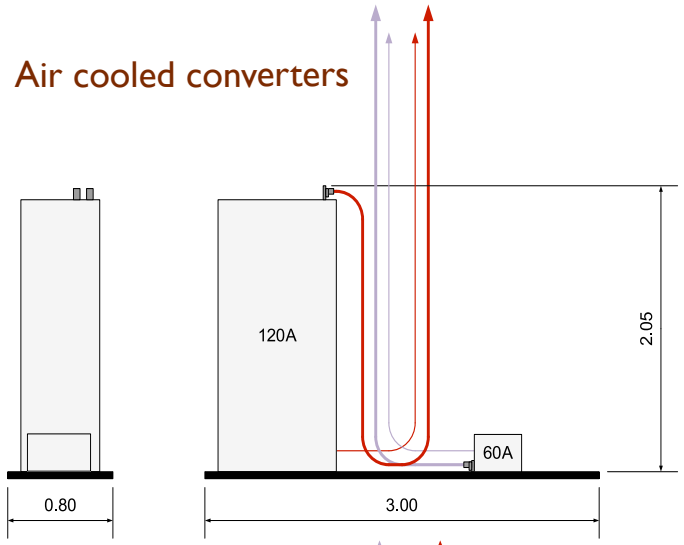

| Detector # | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Dose eq. (μSv/h) | 4.13 (±2%) | 0.15 (±21%) | 168.28 (±0.5%) | 3.34 (±4%) |

# Facility for Electronics Irradiation - H4IRRAD

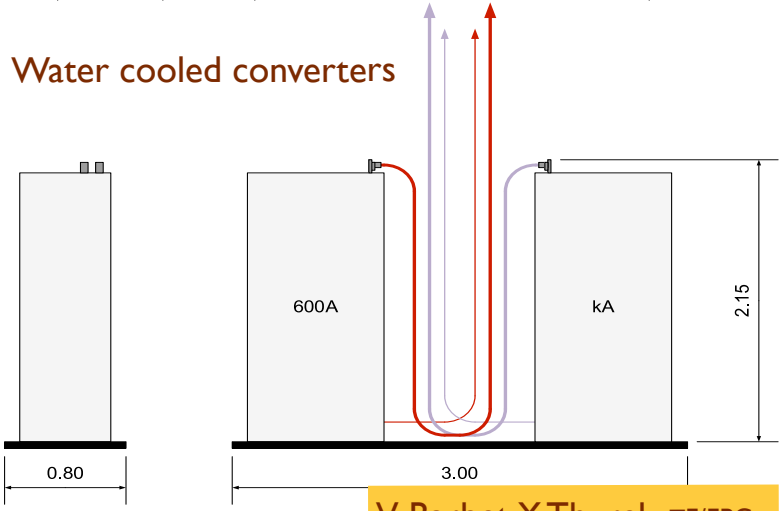
- Equipment access from the roof
  - use specially designed platforms




Air cooled converters




Water cooled converters




V. Barbet, Y. Thurel - TE/EPC

# Facility for Electronics Irradiation - H4IRRAD

- Equipments to be tested in 2011

V. Bardet, Y. Thurel - TE/EPC

| | | |
|---|---|---|
| LHC60A-08V |  | Air-Cooled Power Converters |
| LHC120A-10V |  | Air-Cooled Power Converters |
| LHC600A-10V |  | Water cooled Power Converter |
| LHC4-6-8kA-08V |  | Water Cooled Power Converter. Power Part made of several Power Modules + Control Mod. |
| Digital Controller (FGC) |  | Converter Digital Electronic |

# Facility for Electronics Irradiation - H4IRRAD

## Status

- Work is advancing on the layout and installation of the area
- Safety issues being looked at - reports and safety documents in preparation
- H4IRRAD is scheduled for first beam in May'11 - tight schedule we'll try to make it....
  - This is a commissioning run to measure rates and characterize the facility
    - Full FLUKA simulation of the facility, compare simulation results with real data from monitoring equipment
  - Real tests latter in the summer with EPC equipment

# Advanced European Infrastructures for Detectors at Accelerators - **AIDA**

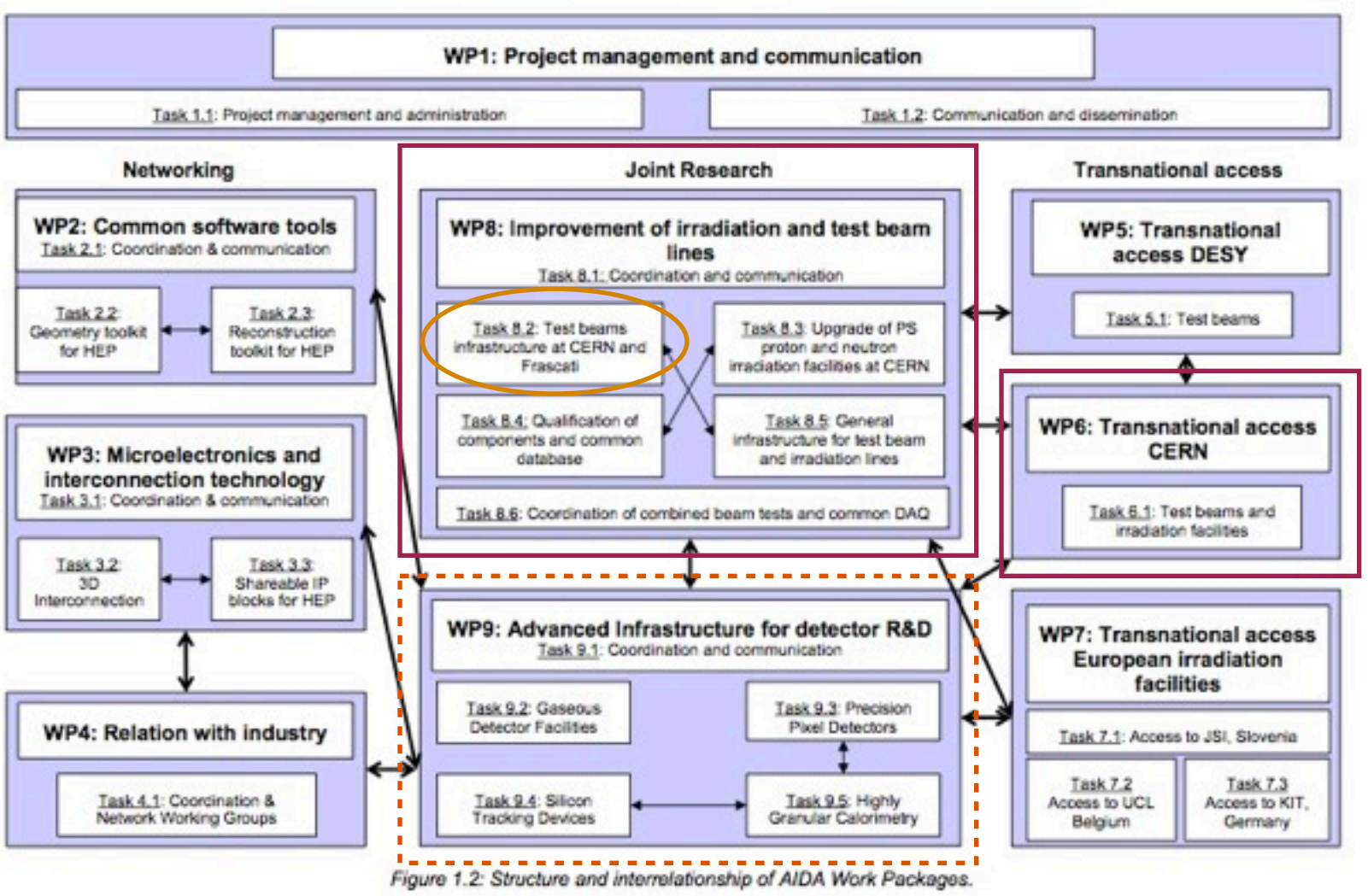



*Figure 1.2: Structure and interrelationship of AIDA Work Packages.*

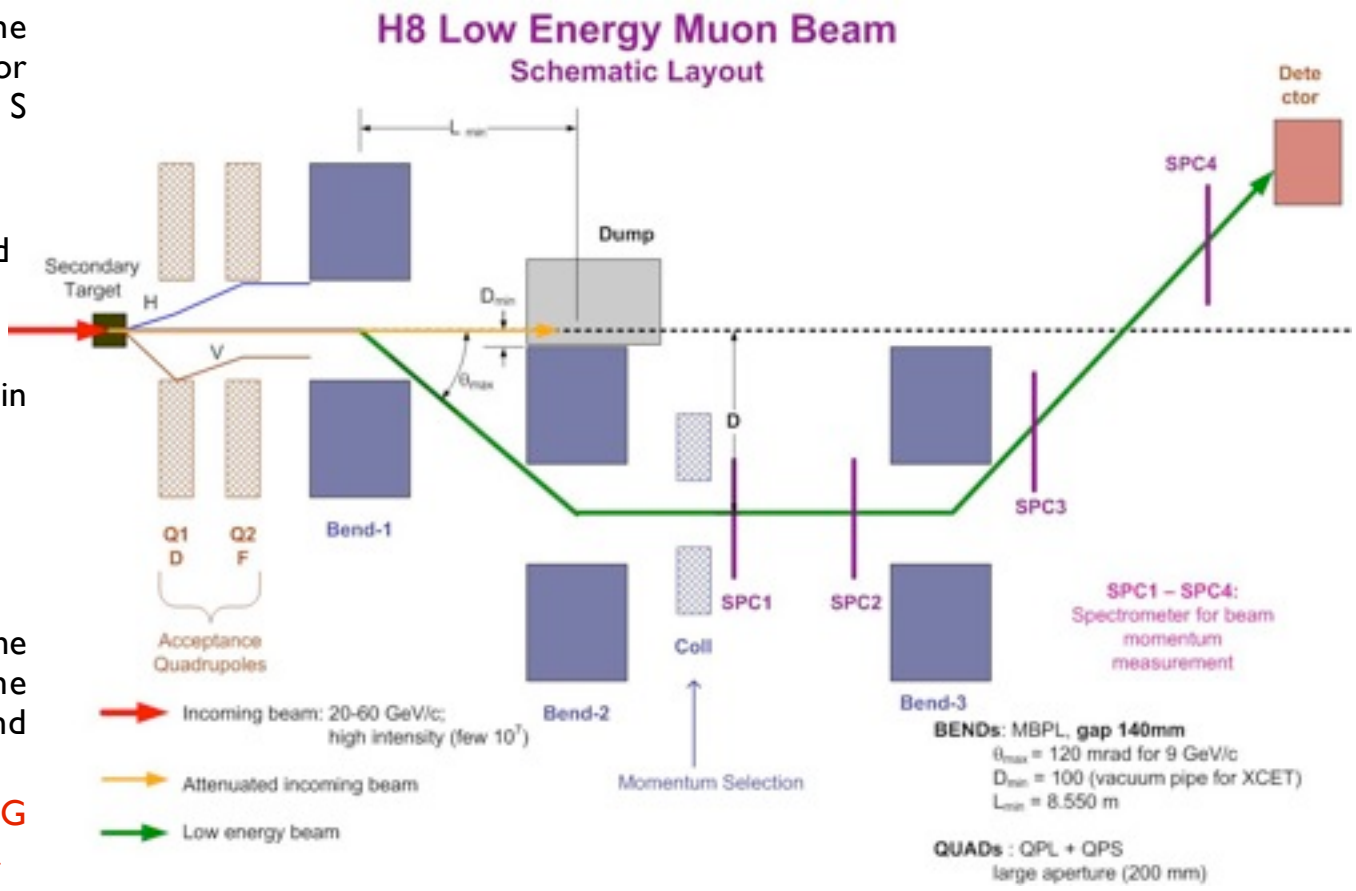
# AIDA - new VVLE muon beam in H8 for Neutrino Detector R&D

- **Task 8.2** : *CERN will perform a feasibility, design and implementation study on a low energy beam to the range of 1 (or possibly less) to 10 GeV. Such beam could be used to validate neutrino detectors or test calorimeter responses at low energies. The beamline will be designed to deliver electrons, muons and hadrons.*

- Similar design to the previously VLE beam for ATLAS and CMS detectors
- Tertiary beam produced via a secondary target
- Design activity to start in 2012
  - EU funded PJAS

**Note:**

- design is fine, but the SPACE to install the detectors at the end should be found !!!
- SPACE is getting a BIG issue in the North Area



# AIDA - new VVLE muon beam in H8 for Neutrino Detector R&D

- A Low Energy Muon beam in H8 line
- Layout

# Recognized experiments

Courtesy: R. Trant - DGS

- **Belle II**
  - Belle II (web site: http://belle2.kek.jp/) is an experiment, planned for the **KEK Super B Factory**
  - Belle II requests **access to CERN test beams** for detector R&D and test of prototypes. The currently estimated need is up to four weeks per year.

- **CBM**
  - CBM (Compact Baryonic Matter, web site: http://www.gsi.de/forschung/fair_experiments/CBM/index_e.html) is an approved fixed-target experiment that is being prepared for the **FAIR facility at GSI**.
  - CBM has participated in **CERN test beam runs** in collaboration with the ALICE TRD team.
  - Test beam requests of up to two weeks each at the PS and SPS per year are envisaged.

- **PANDA**
  - PANDA (Proton Antiproton Darmstadt, web site: http://www-panda.gsi.de/) is an approved experiment in preparation for the **FAIR facility at GSI**.
  - PANDA would like to use **CERN test beams** in 2011 at the rate of one week each for T10 and H4.

# Design Studies - Future facilities

- Plasma Wakefield Acceleration R&D

- Future Neutrino Facilities
  - **EUROnu**/FP7 Design study for:
    - Super-Beams , Beta-Beams, Neutrino Factory
  - **LAGUNA-LBNO**(1) Design study for:
    - CNGS upgrade possibilities, power-beams as a staged approach to a Neutrino Factory
      - 500(300)kW presently → 750kW with upgrades → 2MW with SPL+HPPS

  - Important to maintain the high-intensity options for the injectors to support a competitive ν-physics program in // or as post-LHC project

  - (1) Large Apparatus for Grand Unification and Neutrino Astrophysics - Long Baseline Neutrino Oscillation Experiment

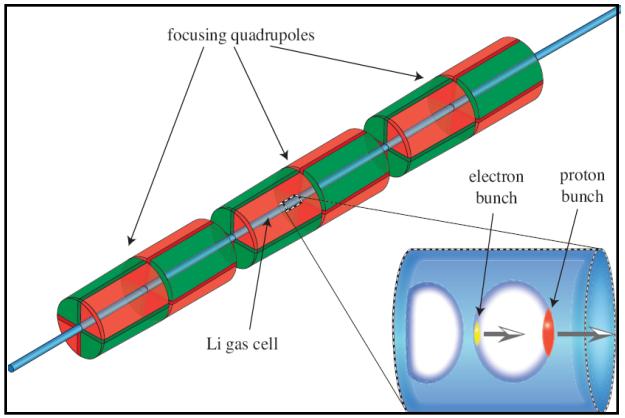
# CERN Experiment on Plasma Acceleration

Courtesy: R. Assmann - BE/ABP

- Proton-driven plasma acceleration was proposed as **innovative way to drive high energy linear colliders.**

  *A. Caldwell et al, MPI for physics*

- CERN has the proton beams to test this proposal.




*G. Xia - MPI*

- A collaboration prepares a letter of intent, encouraged by CERN directorate.
- Collaboration: **MPI, UCL, JAI, UCLA, CERN, DESY, KIT, …**

- From CERN: Small fractions of *R. Assmann, F. Zimmermann, S. Hillenbrand, S. Fartoukh, I. Efthymiopoulos, B. Goddard, C. Hessler, G. Geschonke, …* **CERN work coordinated by R. Assmann.**

# CERN Experiment on Plasma Acceleration

Courtesy: R. Assmann - BE/ABP

## CERN Experimental Area?

- Transform old west area **TT4** and **TT5** (now used for storage) into test facility for novel acceleration methods.

- Bring together:
  - proton-driven wakefield plasma accelerator
  - conventional e- gun (20 MeV, long bunch)
  - laser-driven e- plasma injector (1GeV, 1.5 fs)

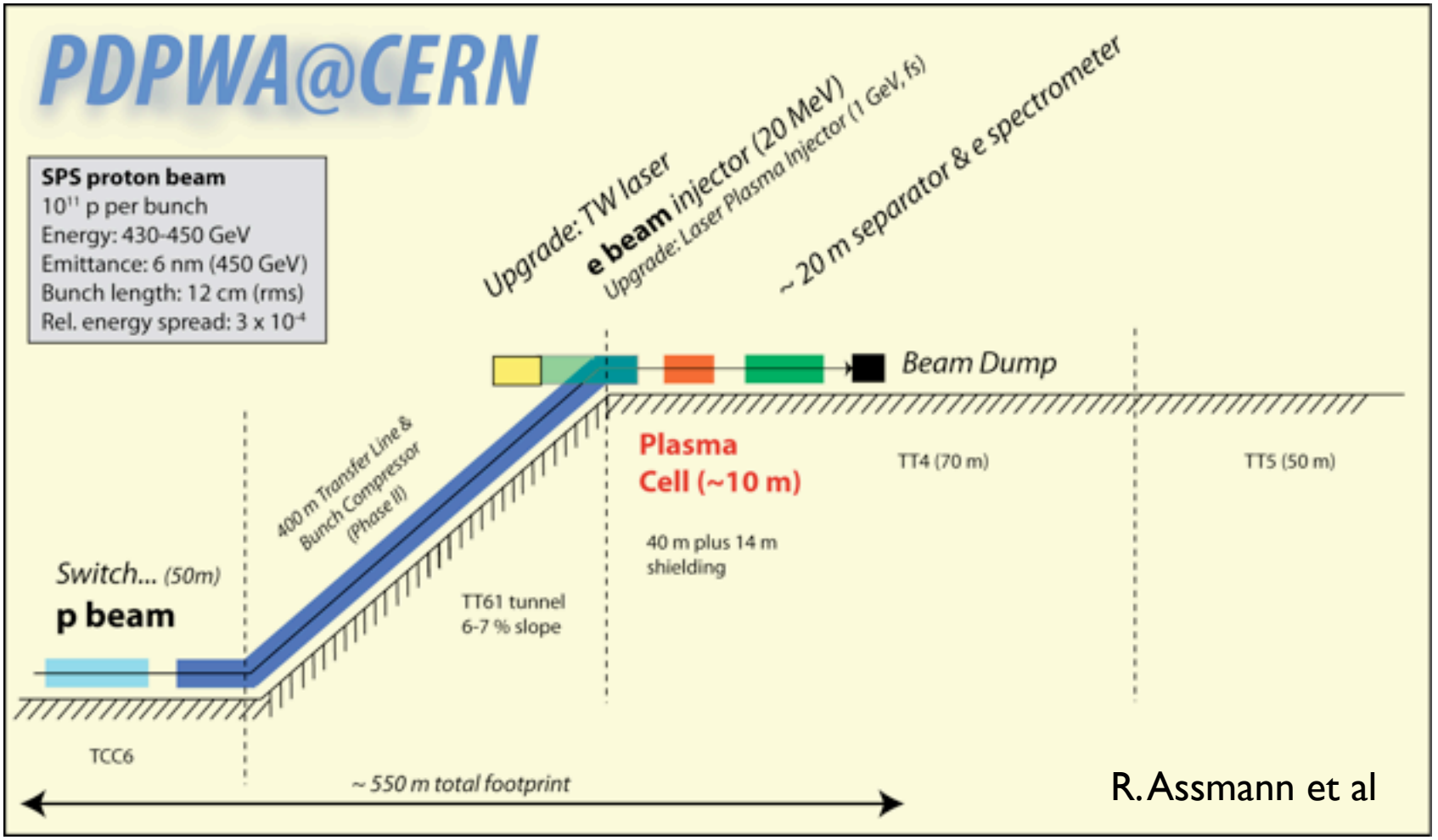
- **Unique test facility**, would bring CERN to the forefront of accelerator research in ultra-high gradients.

- Rely on **external collaborators** for bringing in equipment, manpower and expertise!

# CERN Experiment on Plasma Acceleration

Courtesy: R. Assmann - BE/ABP

- Possible conceptual layout



# CERN Experiment on Plasma Acceleration

Courtesy: R. Assmann - BE/ABP

- Embedded in **EuroNNAc** [http://www.cern.ch/euronnac]
  - EuroNNAc = European Network on Novel Accelerators
- Launched, supported by **EuCARD, ESGARD, EU, CERN, ...**
- Coordinators: R. Assmann (EuCARD & CERN), H. Videau (Ecole Polytechnique), J. Osterhoff (DESY)
- First workshop: **May 2–6 at CERN** [http://indico.cern.ch/event/EuroNNAc]
- Will bring together leaders in this field from Europe, US and Asia.
  - Register if you are interested…
- **Goals**: Define European strategy in coherence with world efforts. Prepare a substantial European proposal by 2013.

# Super(Power) ν-beams from CERN to LAGUNA sites

# Summary

- The use of the secondary beams and injector machines continues to trigger interesting ideas for experiments
- Some of them for sure they will find their way to approval in the next years
- Resources [M+P] in parallel to the LHC activities and foreseen upgrade preparations is an issue to be resolved by the management
- A serious consolidation effort to the EAs would also be required to ensure they remain usable and under improved safety conditions

# Experimenter's Dreams for Future Facilities

- Dreaming on what the future will bring is healthy
- ... but should not be exaggerated

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