The new CERN Gamma Irradiation Facility GIF^{++}

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on behalf of the GIF^{++} Collaboration

Instrumentation Days on gaseous detectors June 25-26, 2014 IPNO, Orsay

Outline

- Effects induced by background radiation
- GIF/GIF++ facilities for R&D and detector validation
- The new GIF++ facility:
  - GIF++ collaboration
  - Gamma source
  - Services (infrastructure and gas distribution/system)
  - Fixed setups from users
  - Construction schedule

Effects induced by background radiation

It is imperative that the design of a pp experiment at the LHC takes account of the hostile radiation environment engendered at high luminosity
(CMS Letter of Intent, CERN-LHCC 92-3, 1 Oct. 1992)

Two mechanisms:

- instantaneous particle rate → detector occupancy
  - Related to the background radiation detector efficiency

- cumulative effects → ageing
  - Related to the integrated particle fluence, dose and current in the detector

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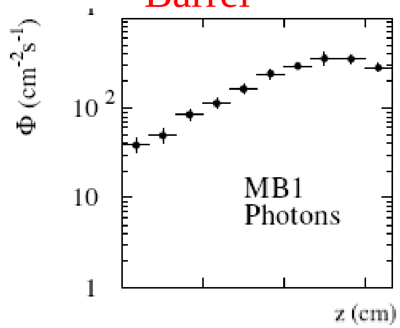
Neutral background

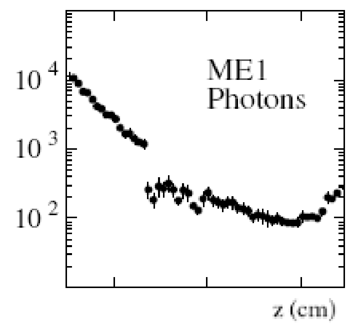
CMS experiment

Max flux:
Barrel ~ 460 Hz/cm^2
Forward ~ 10-50 kHz/cm2
Energy:
between 20 keV - 100 MeV

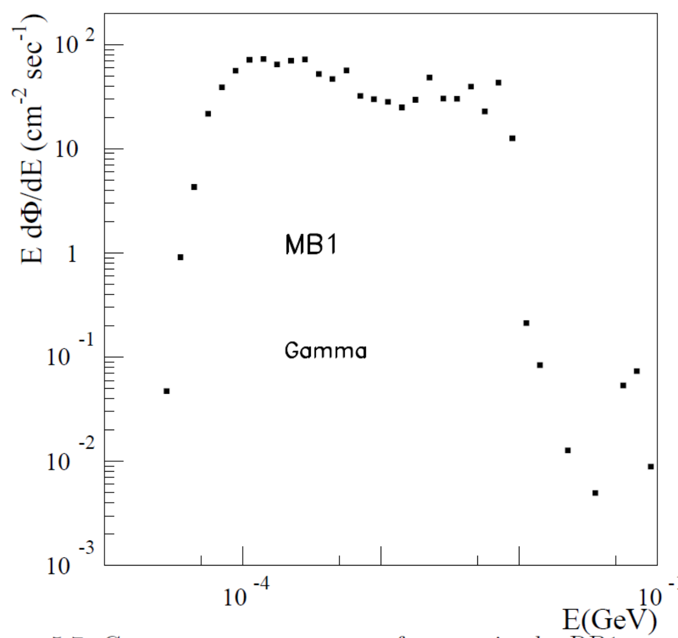
Barrel

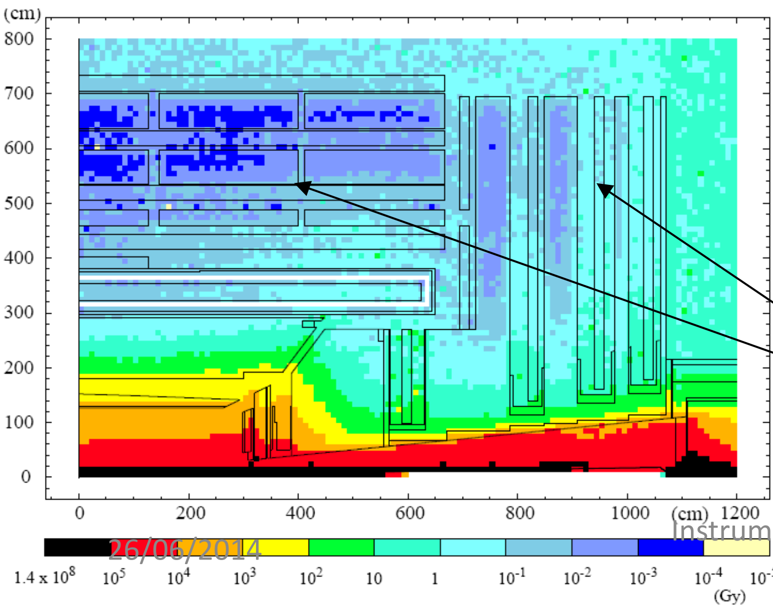


Forward



Energy spectrum





Max Integrated dose 10 years:
(Barrel and most Forward) < 1 Gy

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Ageing test

- Test for possible effect proportional to the fluence. For example:
  - verify detector performance after an accumulated charge equivalent to the one expected on the experiment
  - Fluorine compounds and others pollutants production and their effects on the chambers performance
  - possible long term effects of gas recirculation system on the chambers performance (accumulation of pollutants)
  - ….

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The Gamma Irradiation Facility

GIF was a CERN experimental area where a muon beam was available together with an intense (~650 GBq ^{137}Cs) gamma source.
Many tests performed from 1999 until today

LHC gas detector technologies have been validated at the GIF:

- CMS (RPC, CSC)
- ATLAS (MDT, RPC, TGC, CSC)
- ALICE (TOF, AMS, CPC, RPC)
- LHCb (MWPC)
- COMPASS detectors....

and more.

The GIF was used for LHC
→ GIF++ will be available for HL-LHC upgrade

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Motivation for GIF++

- Strong needs from the LHC and HL-LHC detector and accelerator communities.
- GIF++ follows up on the very successful GIF facility, which lost its access to a particle beam in 2004 and which now has too low source intensity (0.65 TBq vs new 16.6 TBq).
- The GIF++ facility presented takes into account the requirements from the users and has been discussed extensively with them.
- **GIF++ is a unique place for R&D tests:**
    - Strong gamma source
    - Particle beam available
    - Excellent gas and electronic infrastructures
    - Unified control/monitoring system
    - Setups for beam&cosmic trigger, radiation monitoring, environmental monitoring, DAQ, …

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GIF++ collaboration

- The CERN EN-department (EN-MEF)
  - provides the infrastructure for housing the irradiator and detectors: civil engineering components (shielding, false floor …), beam line elements, control room and the supply of general infrastructure (electricity, gas …)
  - provides the gas distribution lines inside the facility (about 5 km)

- The CERN PH-department (PH-DT)
  - provides the irradiator & attenuator, the facility controls (GIF control system), the gas systems, as well as the user management

- The user community
  - providing the detector specific infrastructures (beam trigger, cosmic trigger, …)

Key numbers

Part	**Details**	**Dimensions**
GIF++ facility	Building 887 - H4 beam line in EHN1	225 m^2
Detector preparation area	Area for detector preparation directly accessible from control room	83 m^2
Services area	Hosts large part of the peripheral infrastructure and services (gas supplies and systems)	2 x 40 m^2
Bunker	Contains 14 TBq ^{137}Cs source (662 keV gammas)	100 m^2
Control room	Control rooms for services and users close to the preparation area	

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Key numbers

New Gamma Irradiation Facility: 14 TBq ^{137}Cs gamma source:

- 662 keV gamma
- 30 times stronger than source in the present GIF facility
  → for the same test duration, the integrated dose will be a factor 30 higher

Distance from source	GIF++	Old GIF
1.5 m	58.7	1.8
3.0 m	14.7	0.4
4.5 m	6.5	0.2

Gamma flux ($\cdot 10^6 s^{-1} cm^{-2}$)

(dose rate @ 6.10 m of ~45 mSv/h)

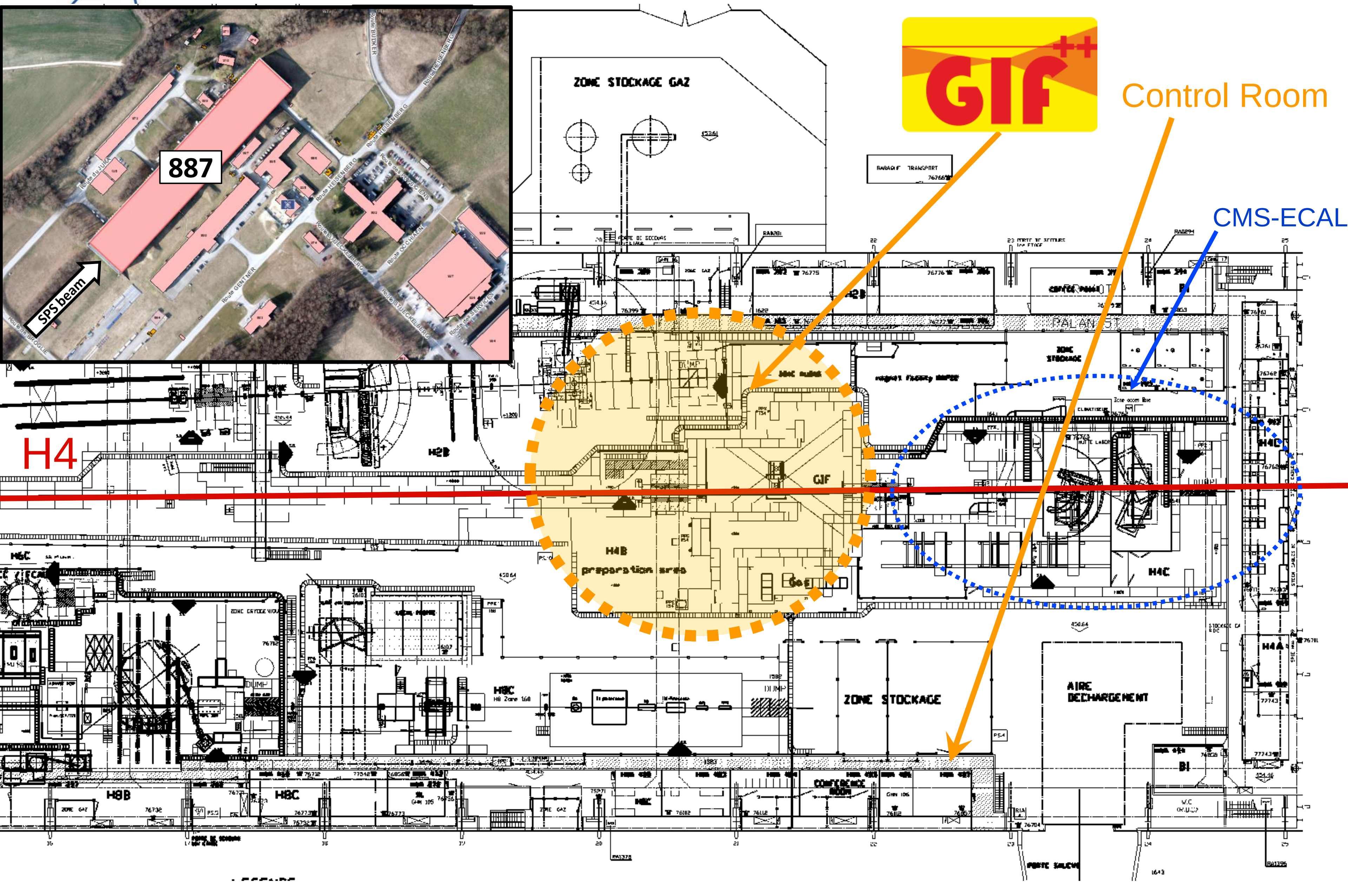
Gamma filters:

- Systems of movable lead attenuators for large irradiation zone that allows attenuation factors between 1 and 100000 in several steps (described later)

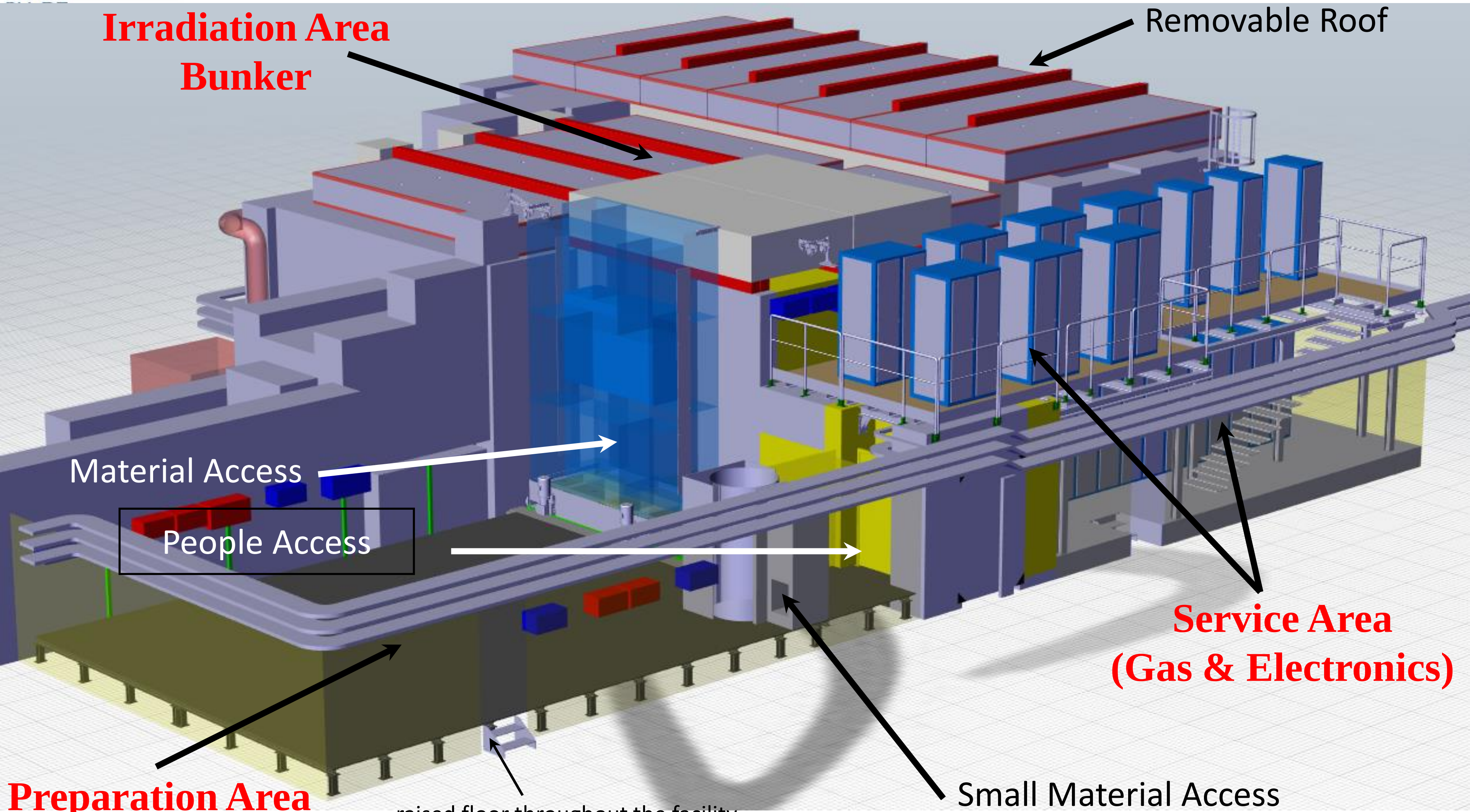
Muon beam:

- a muon beam of 100 GeV and 10^4 muons/spill (core beam size 10 cm x 10 cm) available for detector tests in the large irradiation zone and the small irradiation zone
- 6-8 weeks/year GIF++ will have beam time allocated by the SPS coordinator
- Parassitic beam use will be possible also for some more weeks (to be defined)

GIF++ facility: location



GIF++ facility



raised floor throughout the facility
(pipes, cable trays)

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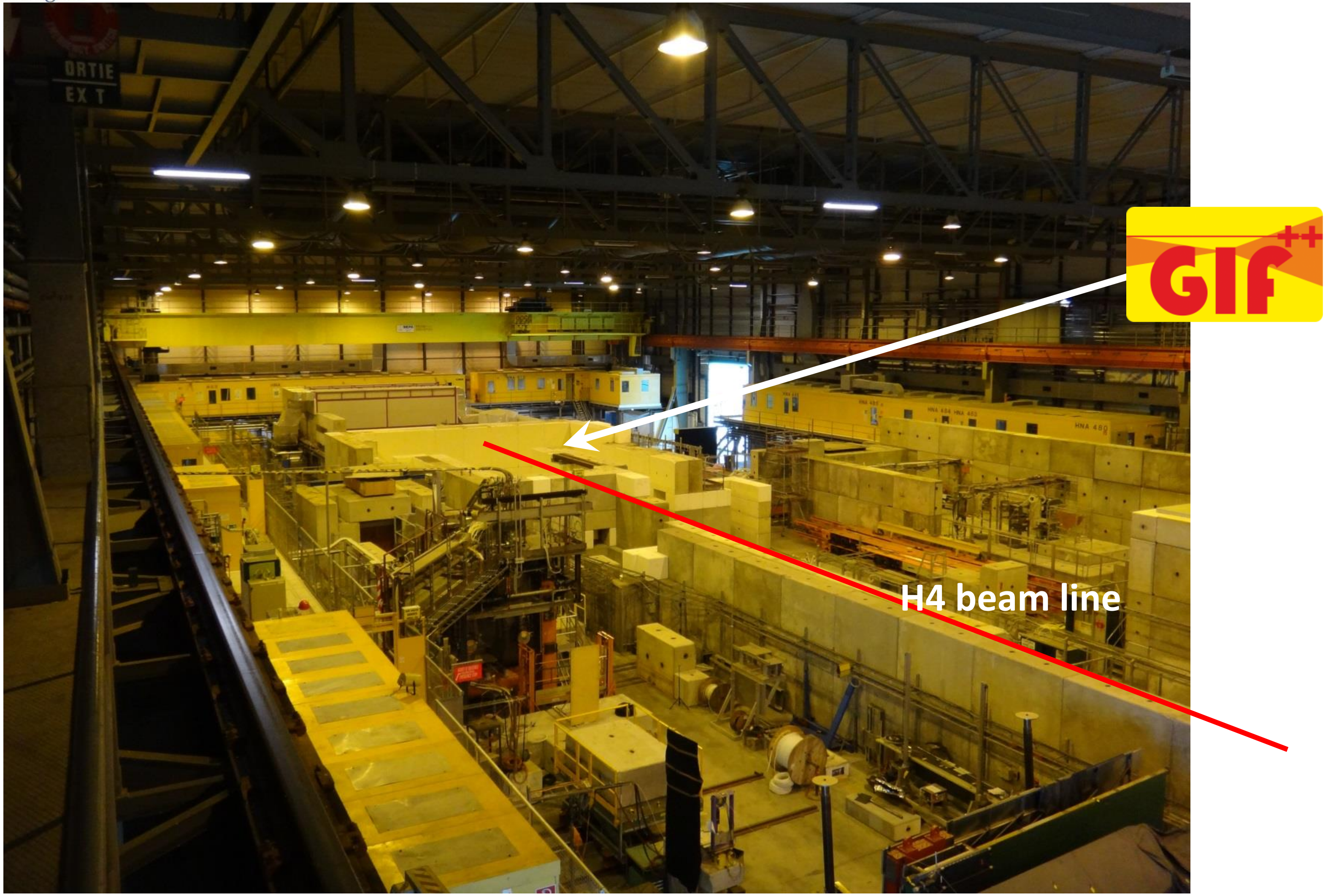
GIF++ facility: construction



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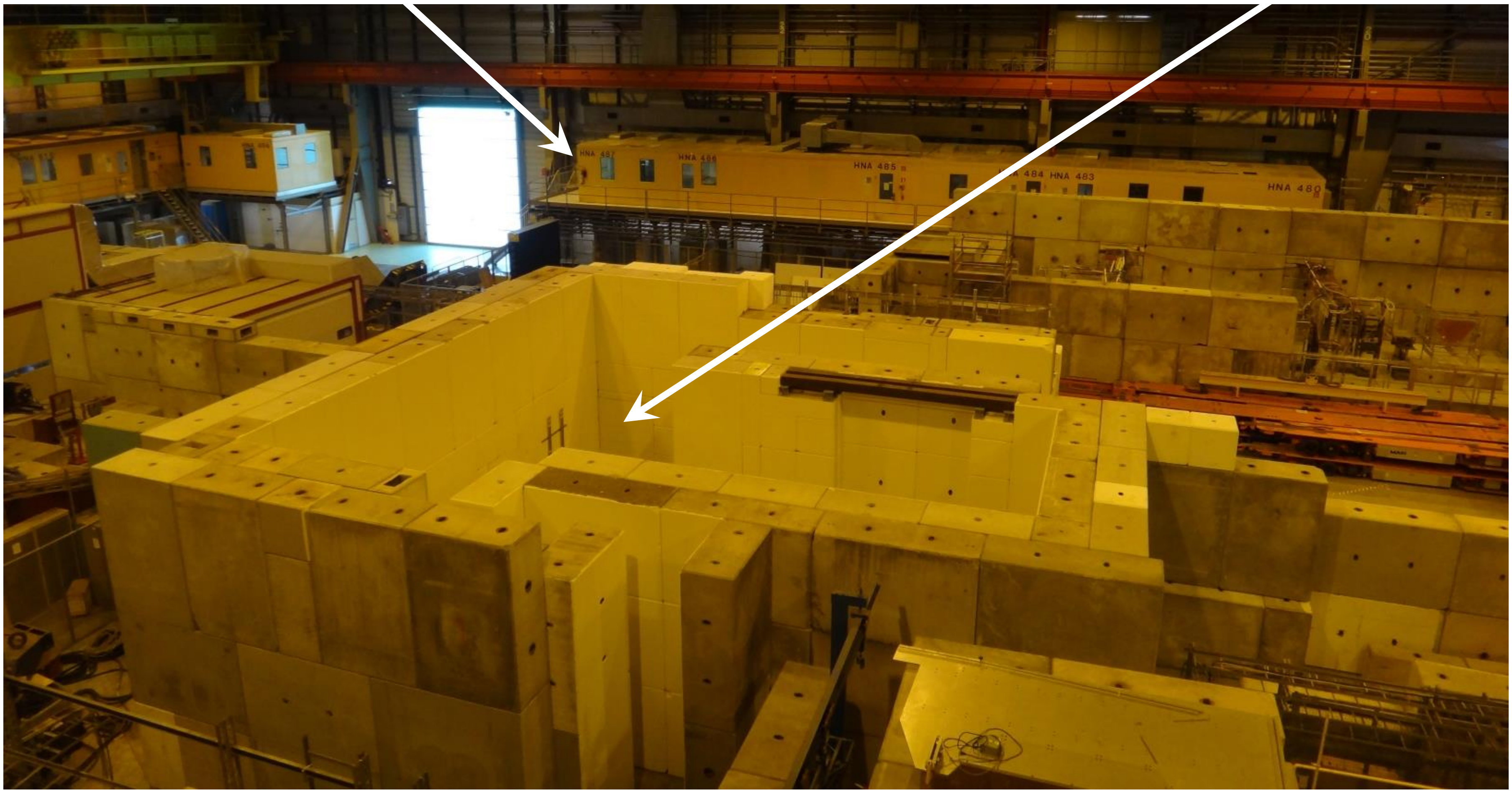
GIF++ facility

control room **Irradiation bunker**



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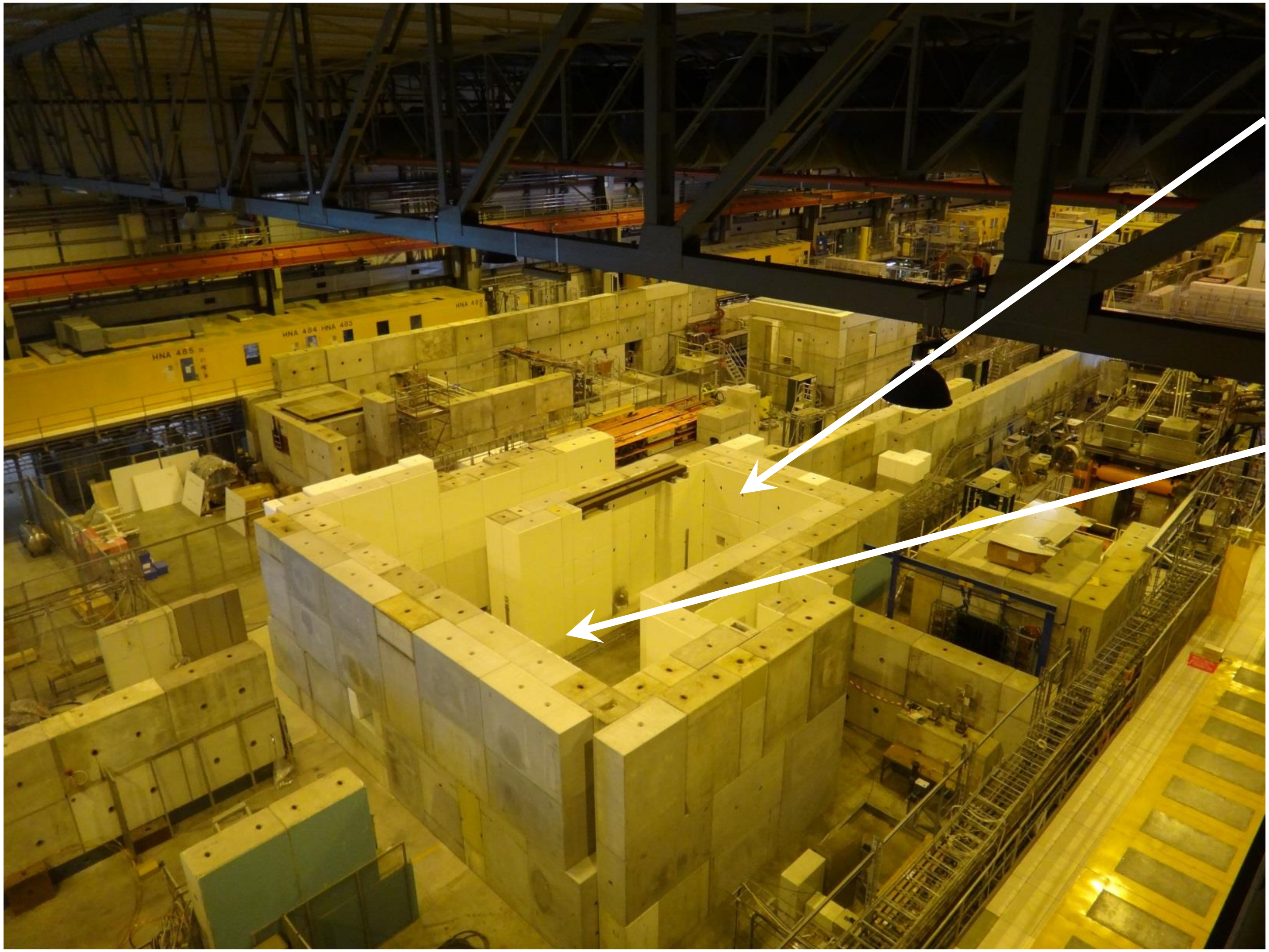
GIF++ facility



Upstream irradiation area

Downstream irradiation area

GIF++ facility

GIF++ facility

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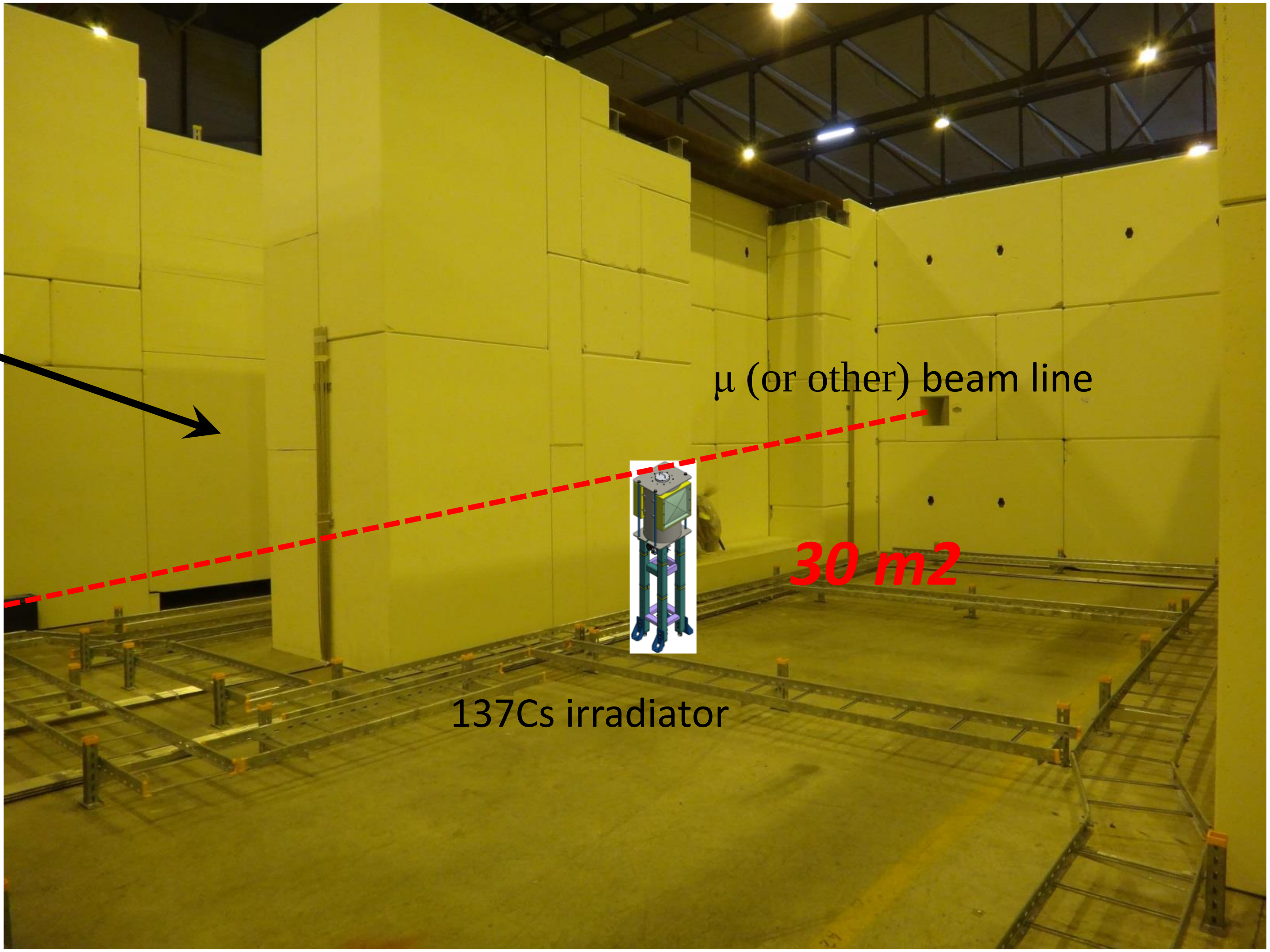
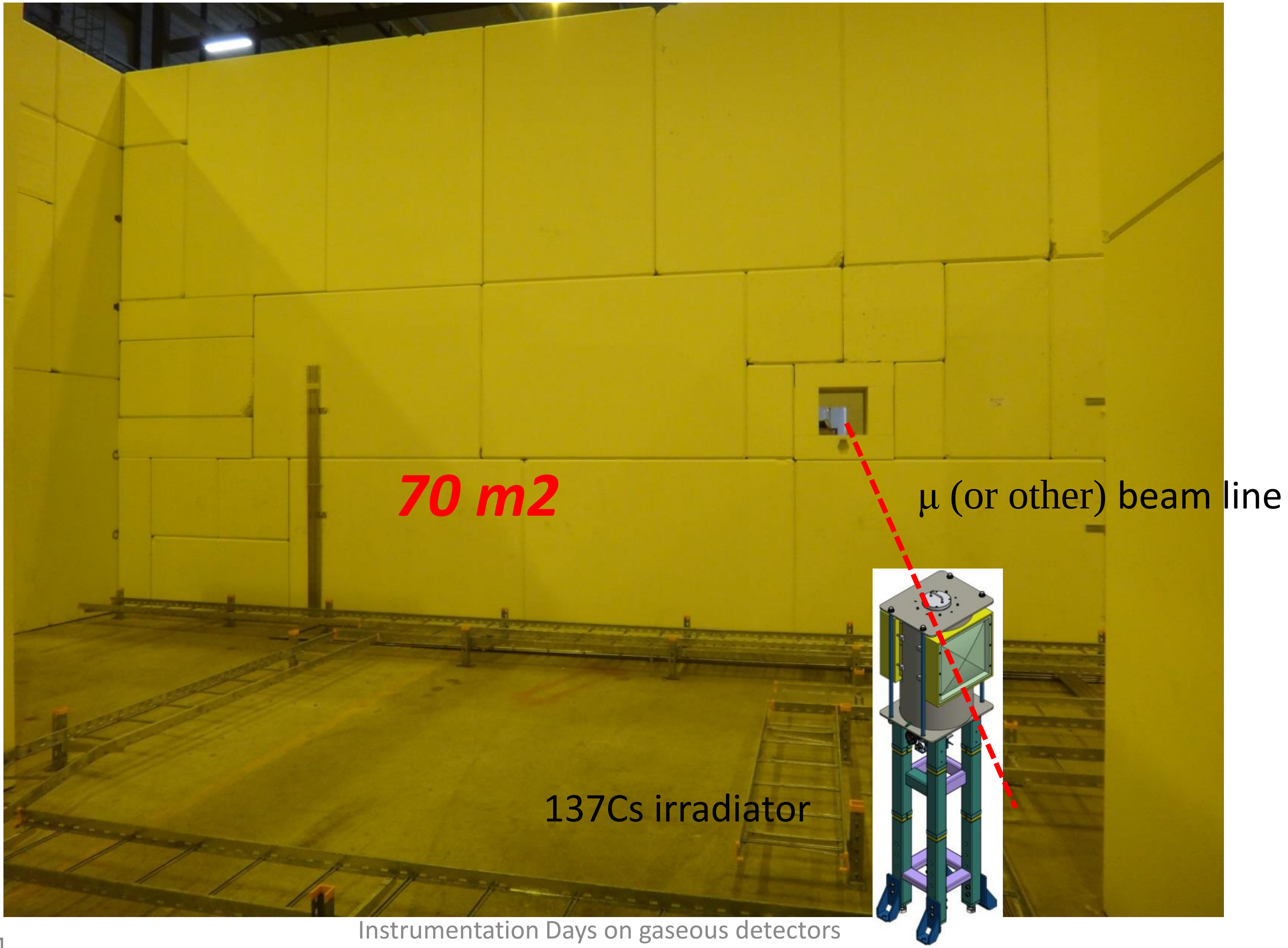
View of the upstream irradiation area

Access corridor



GIF++ facility

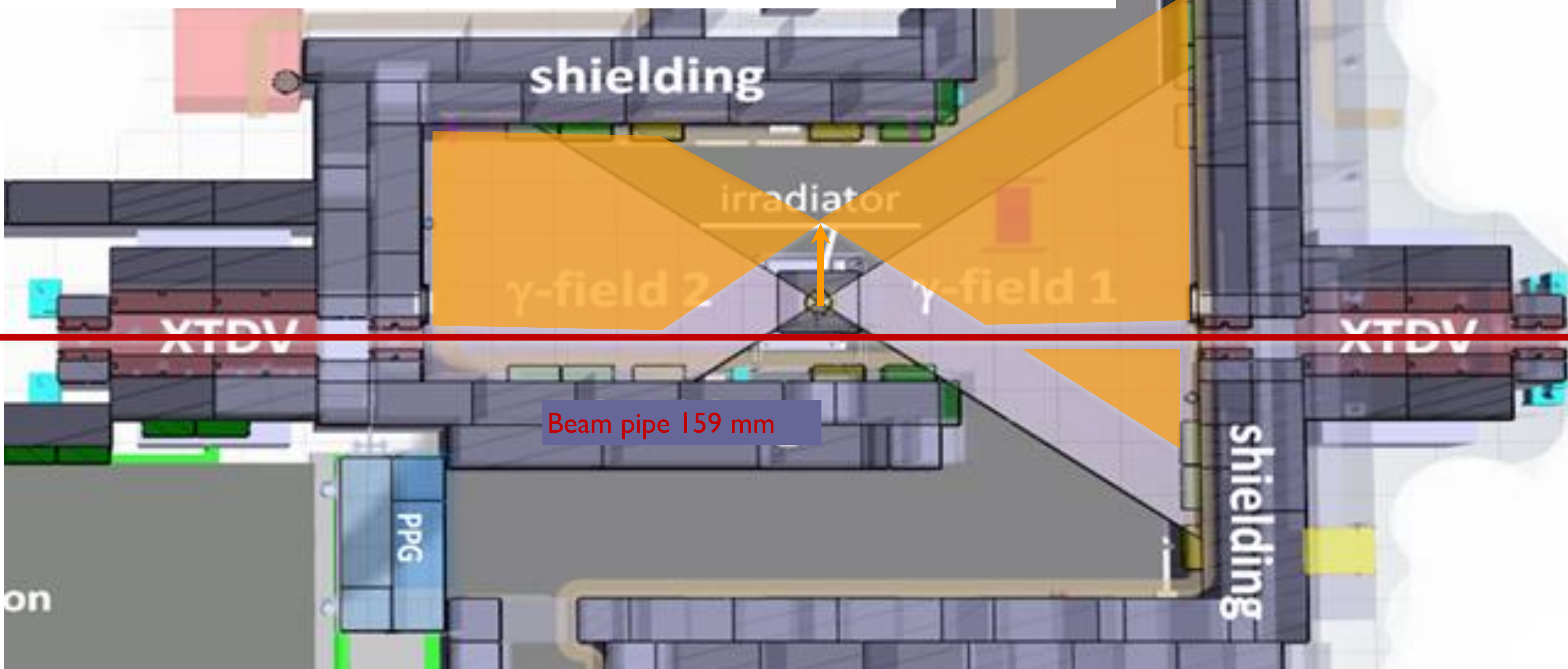
View of the downstream irradiation area



GIF++ facility

e⁻ beam dedicated to CMS-ECAL for ≈ 3 weeks per year

- installation of beam pipe necessary
- γ-irradiation possible
  - Irradiator will move on a side to optimize gamma field



GIF++ irradiator

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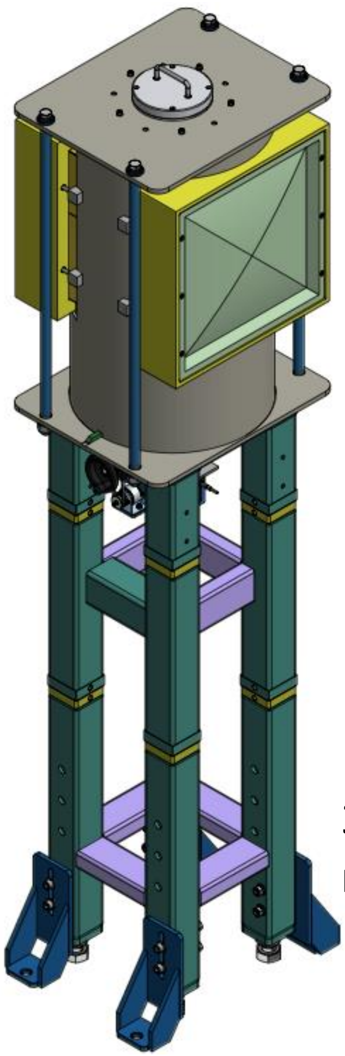
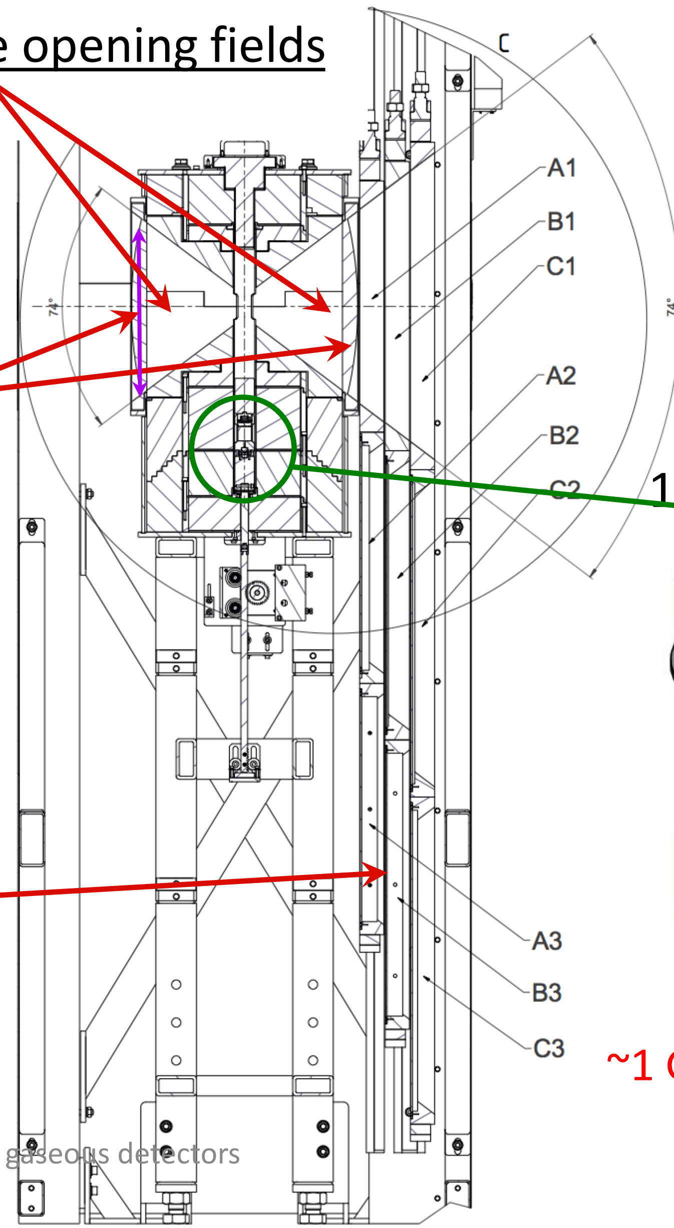
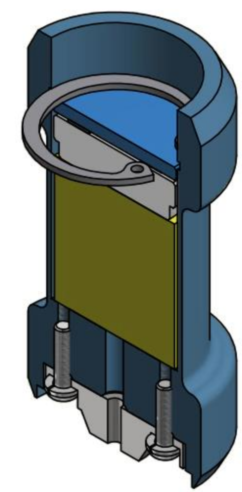


Two identical and wide opening fields

Angular correction lens for uniform photon distribution for large area detectors



14 TBq ^{137}Cs



~1 Gy/h at 1m.

Radiation Attenuator:
3 planes of Pb (Fe) plates,
reduction factor up to 50.000

Lead lens system

Need of gamma absorbers Lead lens and two systems :

- Tune radiation level
- Perform rate capability measurement
- Fundamental for large detector systems

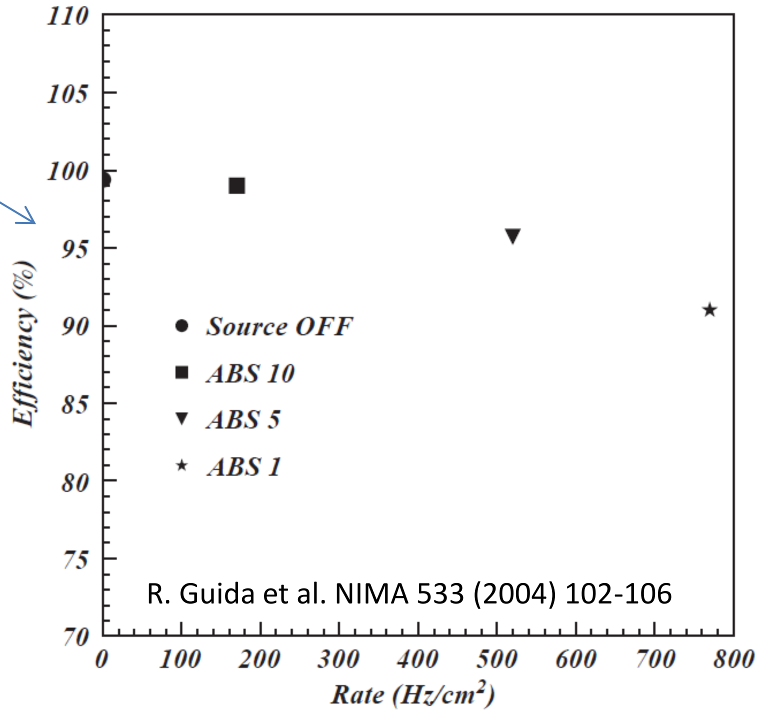


Fig. 5. Maximum efficiency reached by one of the RB1 chambers at different source conditions.

Lead lens system

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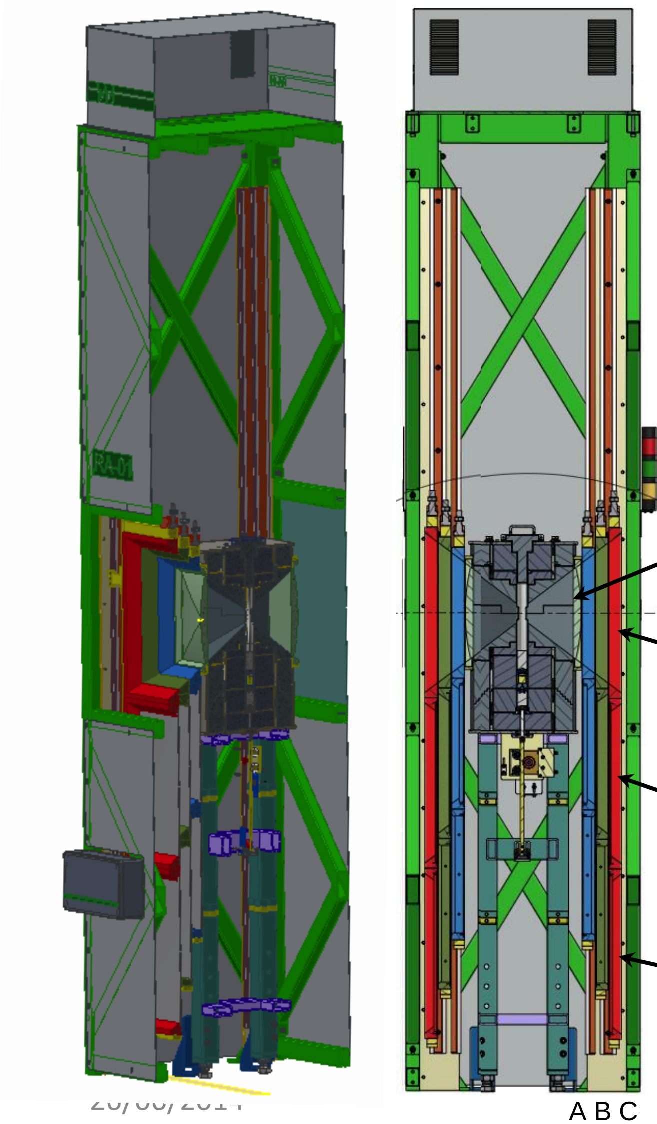
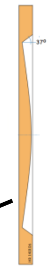
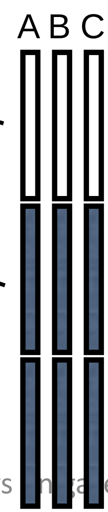
Two identical attenuation systems:

- one angular correction filter (Fe)
- 6 absorption filters (per side)



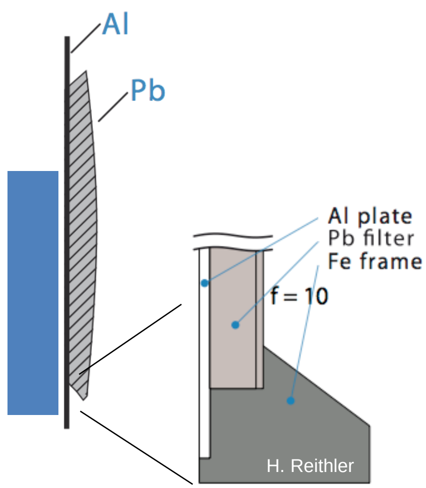


Angular correction filter provides uniform photon distribution for large area detectors



Filter System :

Absorption factor		
0	0	0
10	1.47	2.15
100	100	4.64



Gamma field simulation

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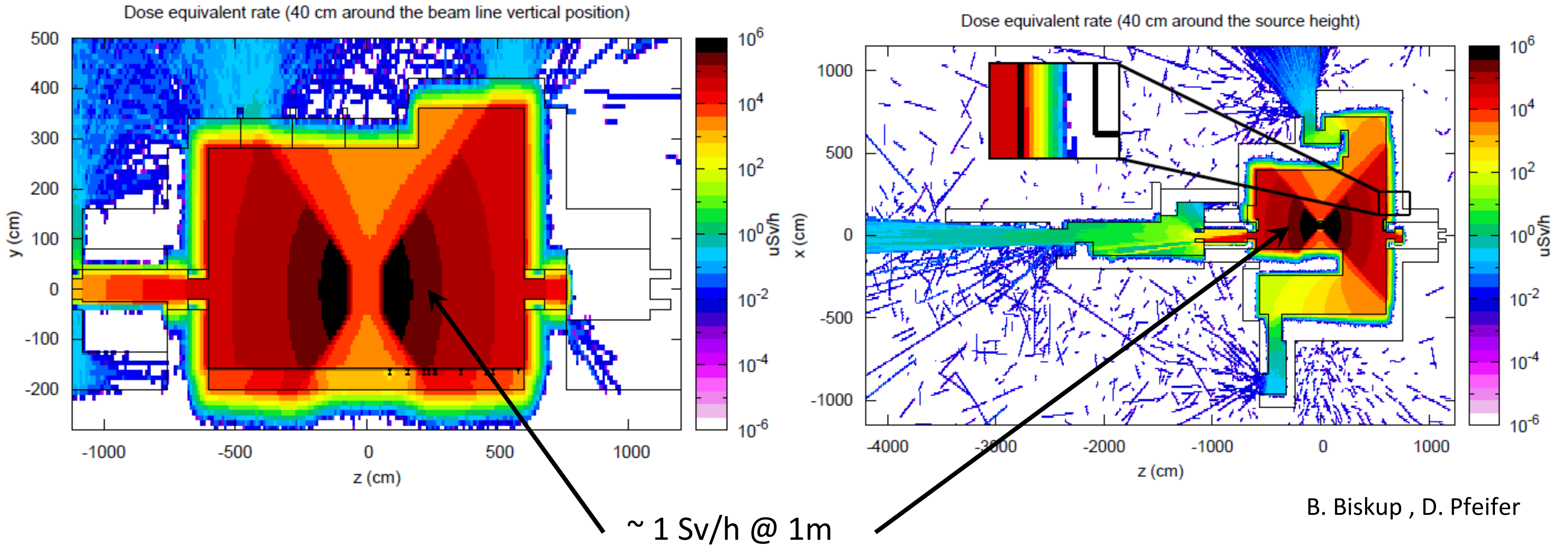
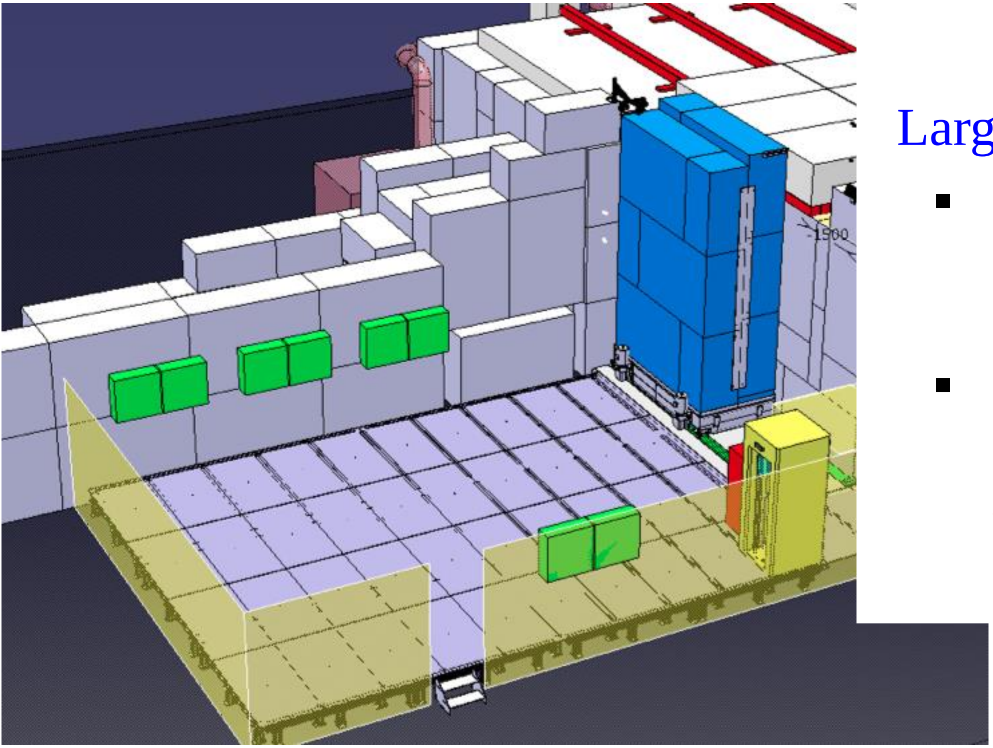


B. Biskup , D. Pfeifer

Max. expected doses at HL-LHC	Equivalent time at GIF++ (~ 50 cm from source)
Si-trackers: ~ MGy/y	>> years
Calorimeters: ~ tens kGy/y	< 1 year
Muon systems: ~< Gy/y	*"hours"*

Preparation area

Setup and pre-test detector & DAQ before entering the irradiation zone



Large Preparation Zone (≈ 80m^2)

- equipped with gas lines, electricity & network. Signal cables and HV/LV patch panels will be added during a first upgrade
- full-size detectors can be setup and commissioned before moved to the radiation zone, already connected to the final DAQ

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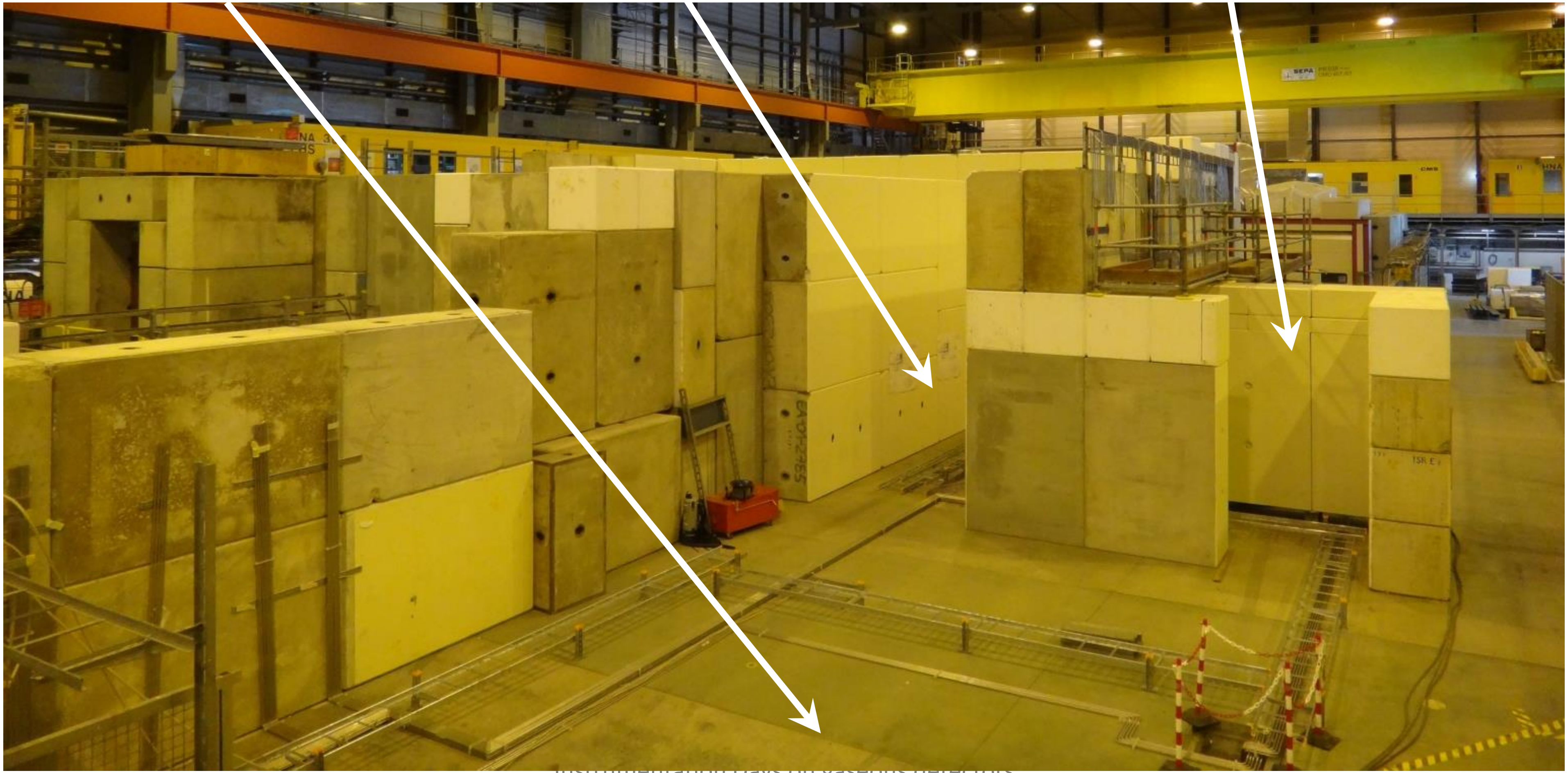
GIF++ facility: detector preparation zone

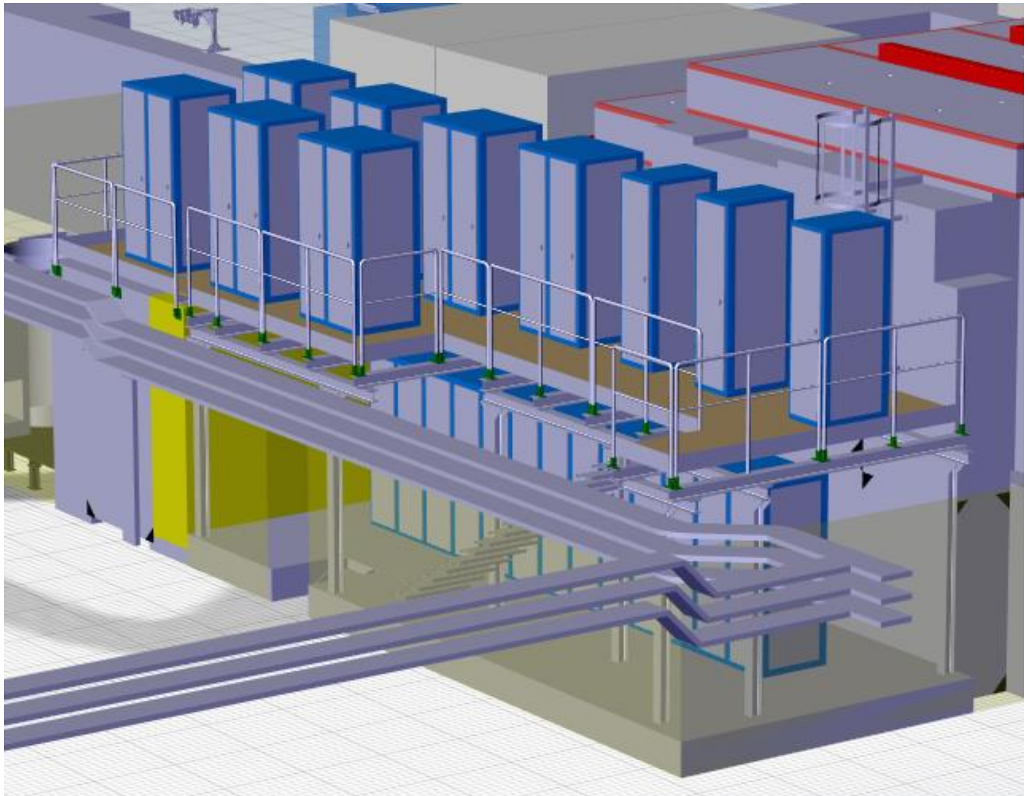
Detector preparation area

Material access door

Personal access door



Services (gas & electronic)



First floor:

17 gas racks and distribution panels (40m^2 net area)

Ground floor:

17 electronic racks hosting the irradiator controls, DCS, user equipment, fire detection, ...

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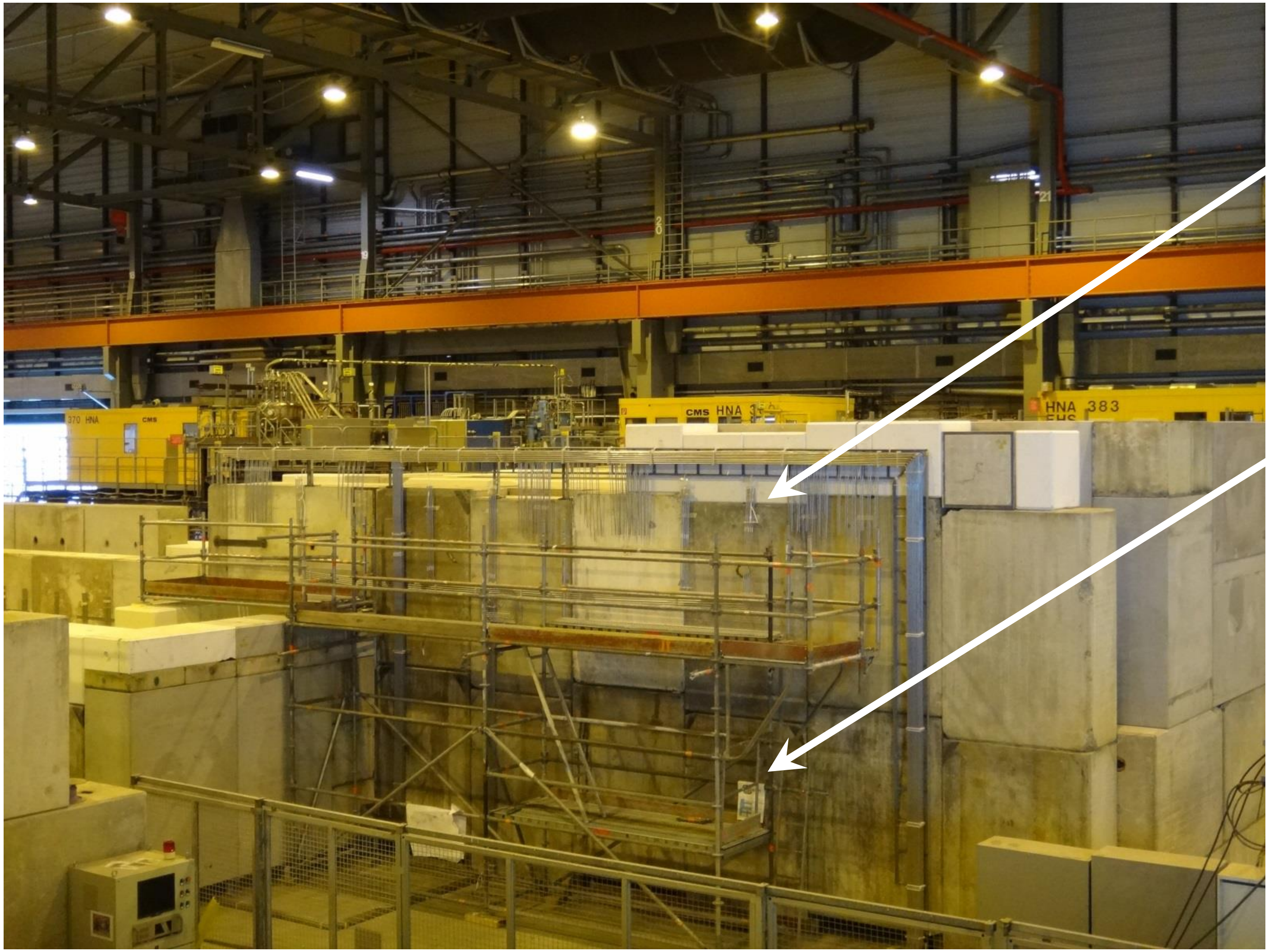
GIF++ service areas



Gas service area

Electronics service area

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Gas service area

Gas service area at start-up will include:

- neutral gases: Ar, CO_2, N_2, He, SF_6, CF_4 and 3 spare pipes
- flammable gases or gases with very low vapour pressure: iC_4H_{10}, CH_4, Ar/H_2(optional), $C_2H_2F_4$ and 2 spares.
- 21 distribution panels (6 lines each)
- Control rack (basic functionality, i.e. connection to remote pvss interface for recording flows, gas systems status, …)
- 2 gas mixing racks for the fixed installations (beam and cosmic trigger setups). Additional mixers need to be requested
- 1 IR analysis rack (needed to operate cosmic trigger gas system). It will be recuperated from GIF.
- 1 analysis rack (O_2+H_2O+gas chromatograph).
- 1 gas recirculation system.

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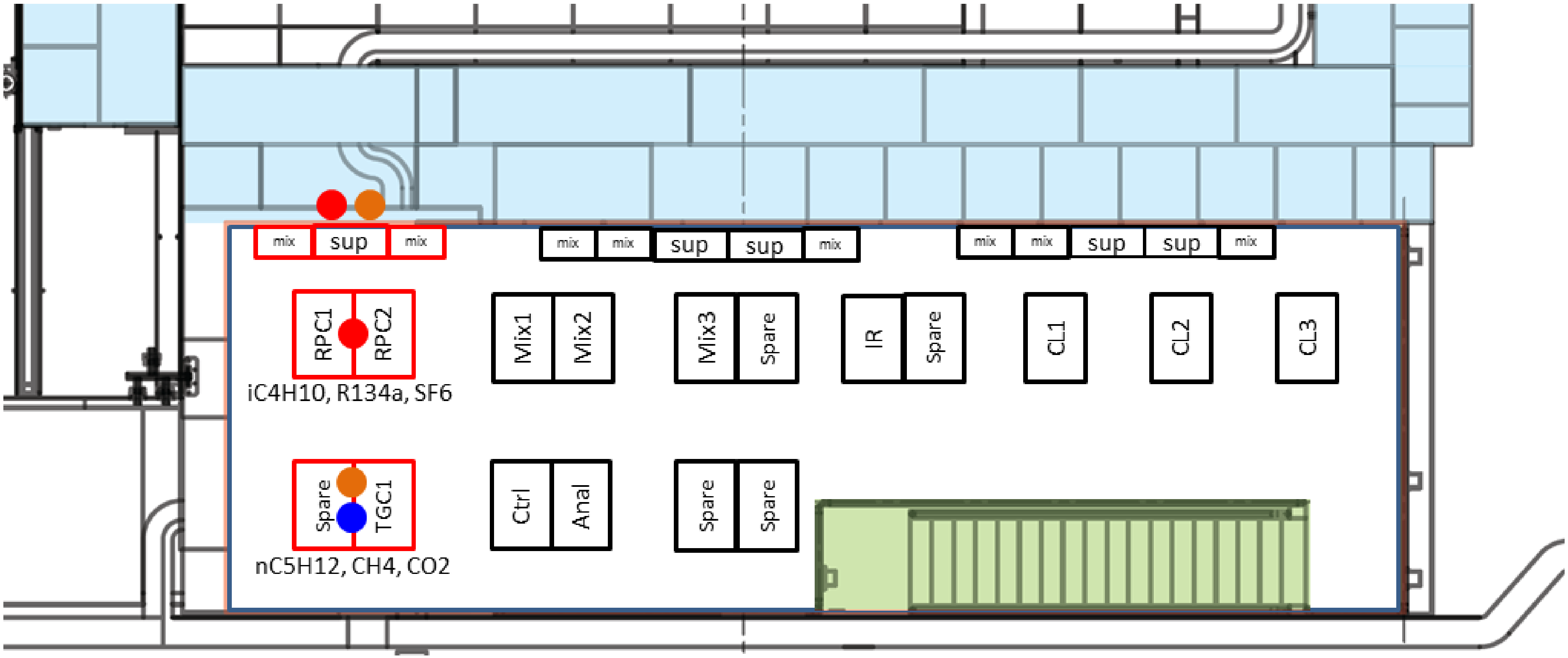
Gas service area



- sup: Gas supply panel neutral gases 80 cm x 40 cm x 35 cm
- sup: Gas supply panel flammable gases 80 cm x 40 cm x 35 cm
- mix / mix: Mixture distribution panels 60 cm x 30 cm x 35 cm

- Detection iC4H10
- Detection nC5H12
- Detection CH4

Gas service area

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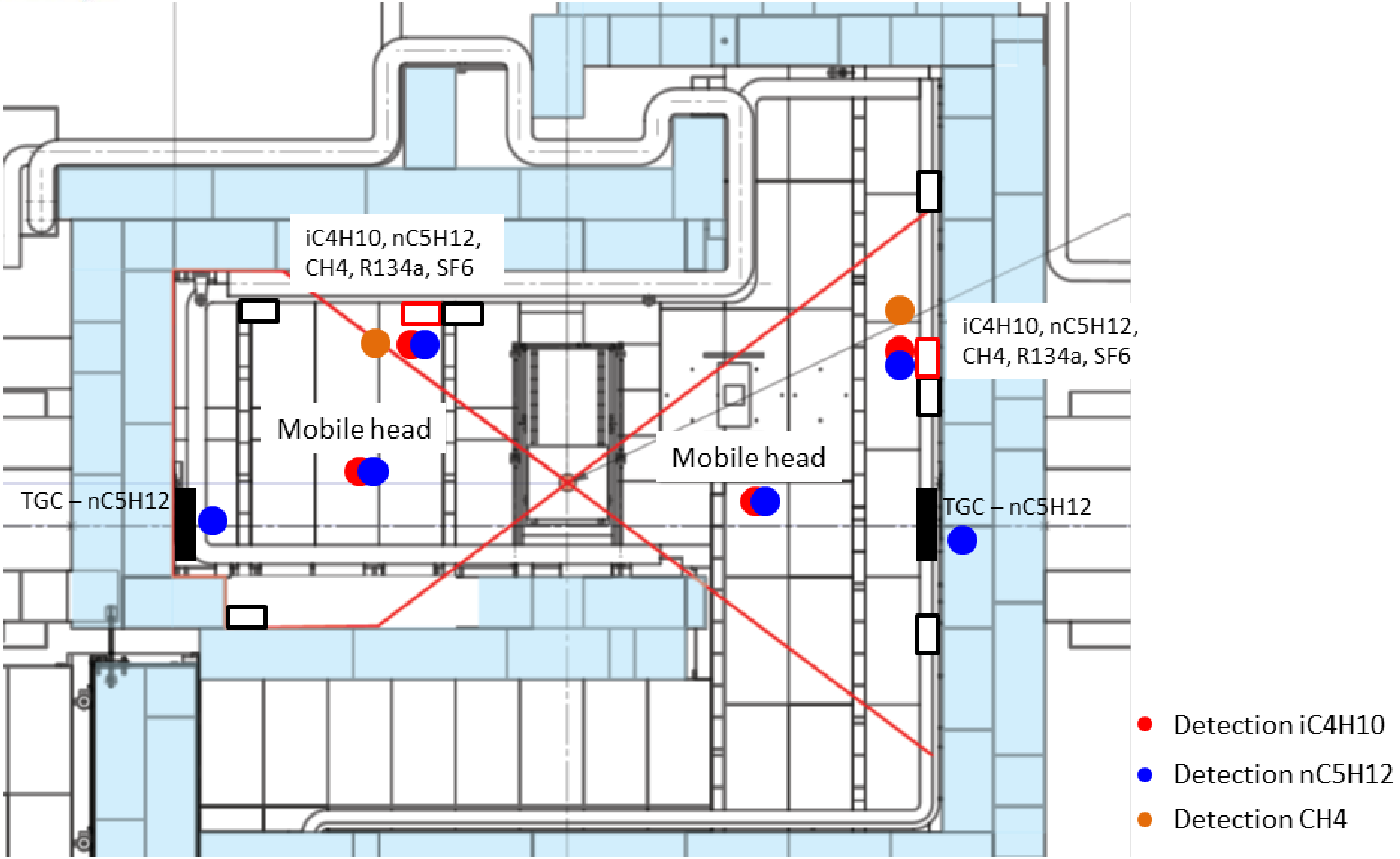

Construction schedule

Milestones:

- ✓ ***Functional specifications: July 2013***
- ✓ ***Complete design facility and services: December 2013***
- ✓ ***Civil engineering work started January 2014***
- ✓ ***Infrastructure installation March-July 2014 (on-going)***
- ***Irradiator delivery September 2014 (2nd half)***
- ***Definitive shutdown of GIF @ 190: September 2014 (2nd half)***
- ***Commissioning: October 2014 (Irradiator & attenuator controls, access system, safety systems, gas system...)***

Construction schedule

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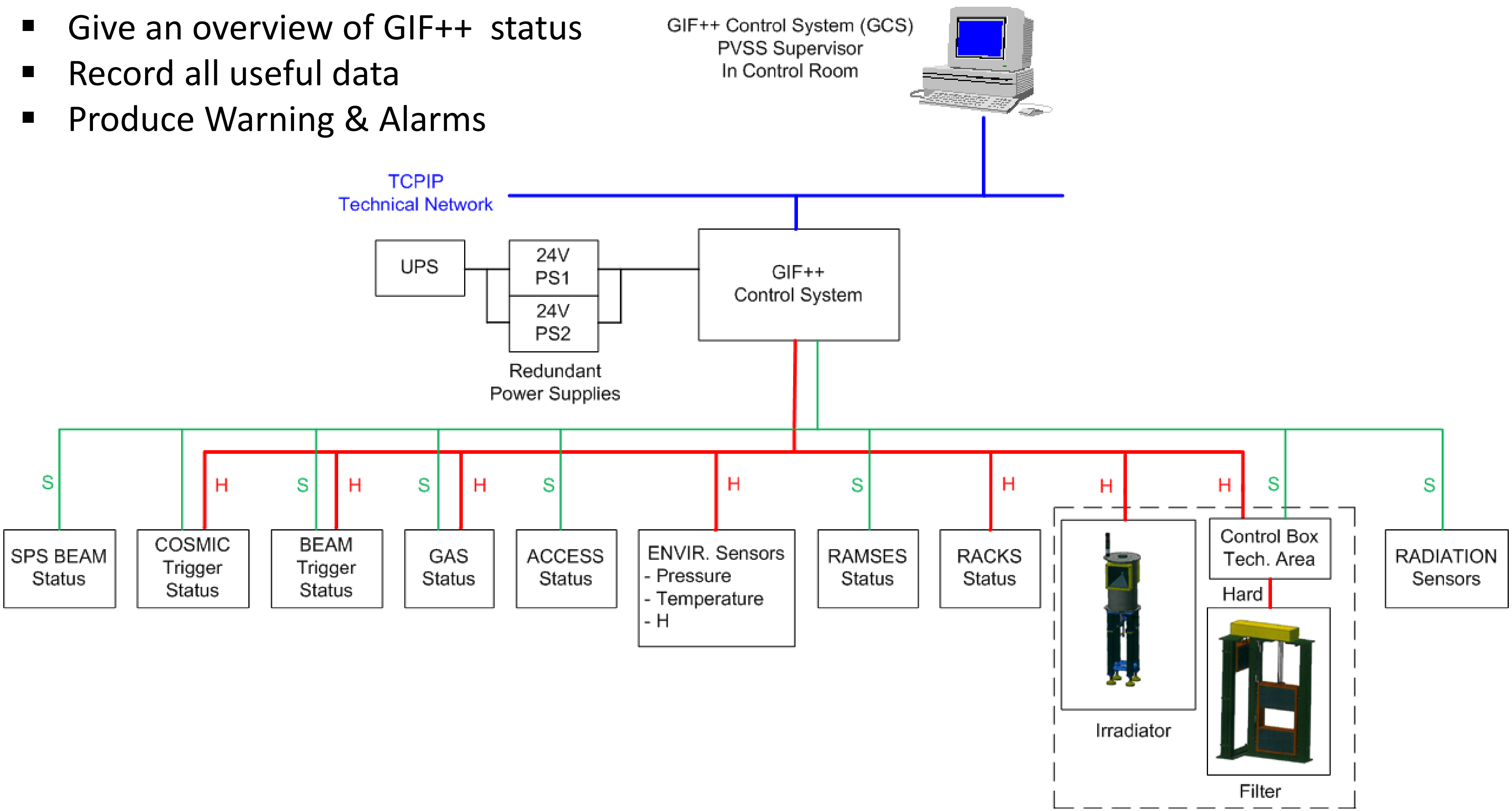
GIF ++ Operation:

- 16. October- 2. November : No access (CMS-ECAL beamtime)
- 1-2. Dec. : First dedicated beam time (Commissioning of Trigger system, DAQ....)
- Early 2015 : Users operation

GIF Control System

- Give an overview of GIF++ status
- Record all useful data
- Produce Warning & Alarms



Users’setups: Beam trigger setup

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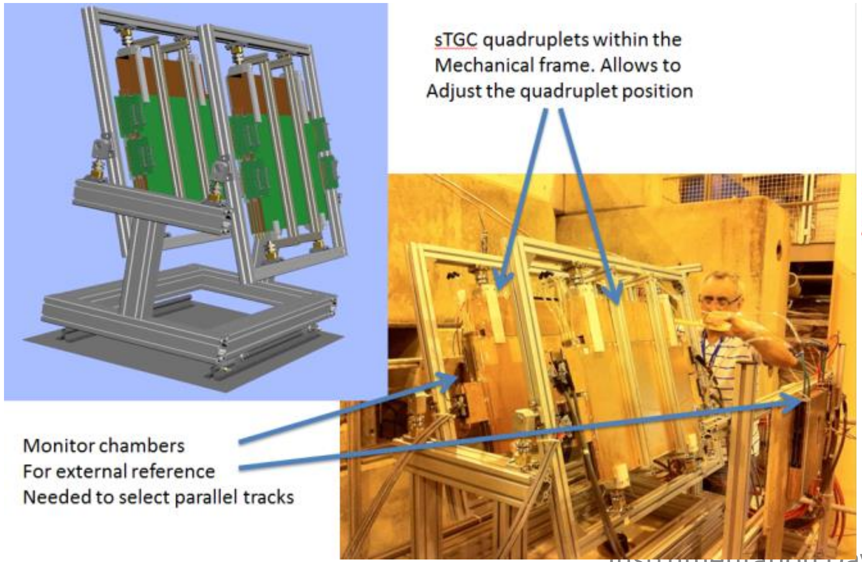
George Mikenberg (ATLAS-TGC group)

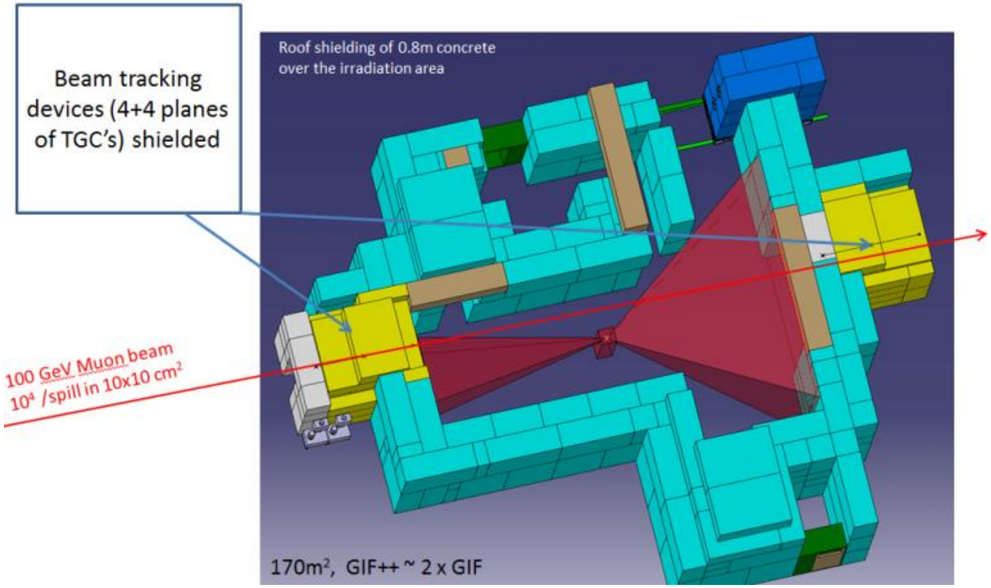
Using the beam, it is possible to see inner structure of the detector and to make detector alignment.

Resolution between 110 -180 um depending on the angle (however, at the GIF the angle will be quite small → resolution close to 110 um).
New electronics under development.

System ready for installation in 2014.

Positioned upstream and downstream the facility





Users'setups: Cosmic ray trigger setup

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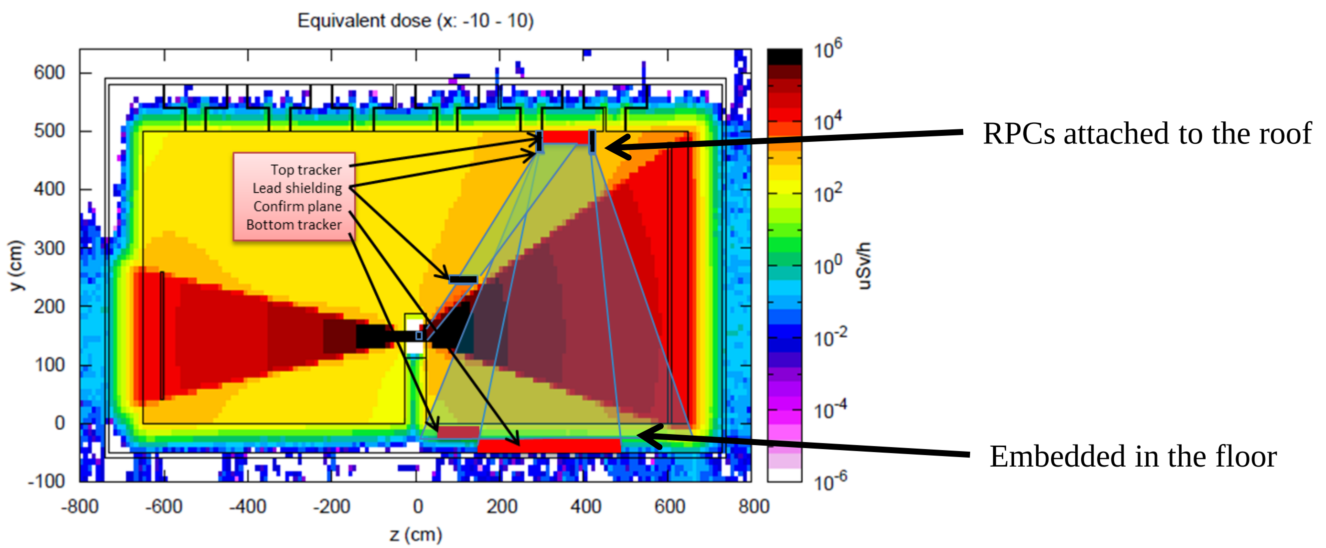
G. Aielli, R. Cardarelli, R. Santonico (ATLAS-RPC group)

Ensure test operation for most of the time

4 independent detectors area 1x0.5 m^2 + small area (30x30 cm^2) high resolution tracker Timing performance ~0.5 ns to provide a clean trigger and good TOF capability

Detector attached to the roof and under the floor
High rate to be sustained ~1 kHz/cm^2 if no shielding is applied.



Users'setups: Environmental sensors

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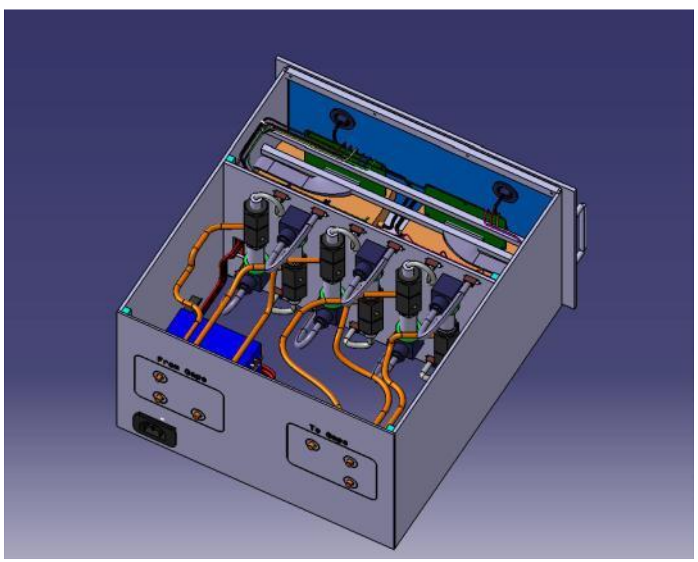
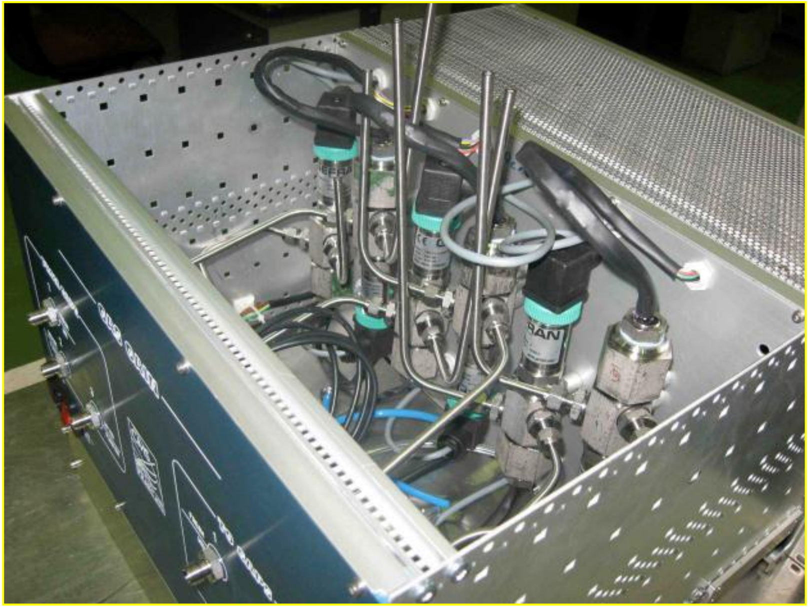
S. Bianco, Frascati and Napoli (CMS-RPC group)

Environmental sensors to monitor atmospheric pressure, temperature, relative humidity.
Sensors for water vapour concentration in gas mixture (needed for RPC)

Precision ±0.2 ºC, ±2 %RH
Order of ~ 10 sensors
Integration in GIF++ dcs (pvss like interface)

Example of baseline design in operation at CMS: sensors box used for the GasGainMonitoring system for the CMS-RPC





Users'setups: Radiation sensors

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Plamen Iaydjiev (University of Sofia, CMS-RPC group)

Monitor the dose rate inside the GIF++ facility and, as an "old" user, I would add close to the detectors (useful to measure the attenuation produced by other setups and to evaluate long term stability with very simple measurements)

Two sensors for different dose ranges:
Thick oxide → up to 10 Gy
Thin oxide → up to 200 Gy
System/DAQ proposed for 10 sensors.

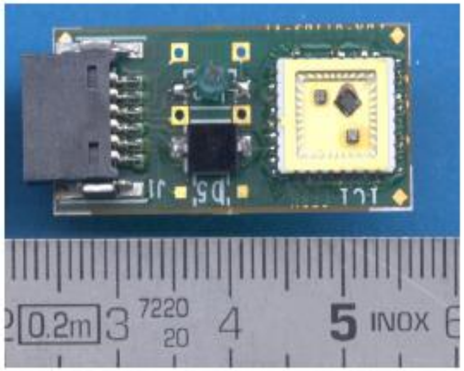
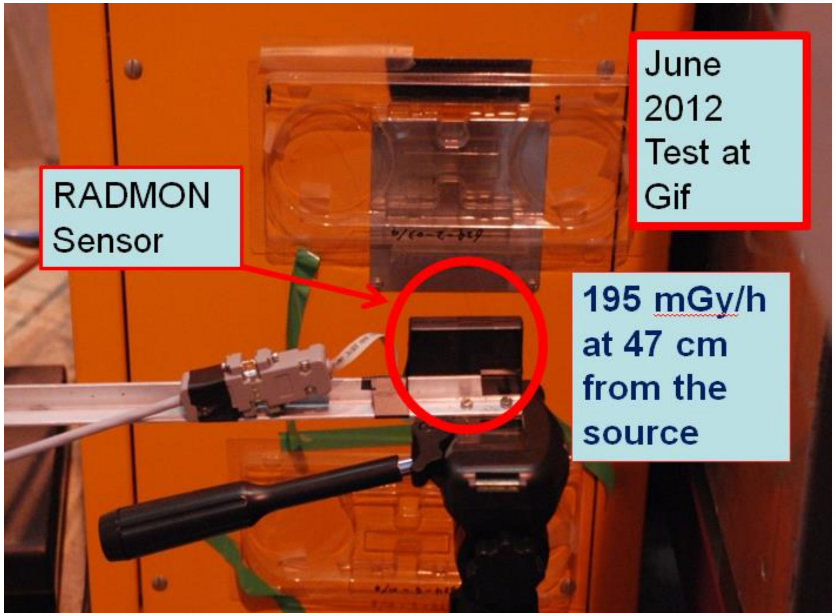


Fig. 3: Integrated Sensor Carrier (ISC)



Users'setups: detectors DSC

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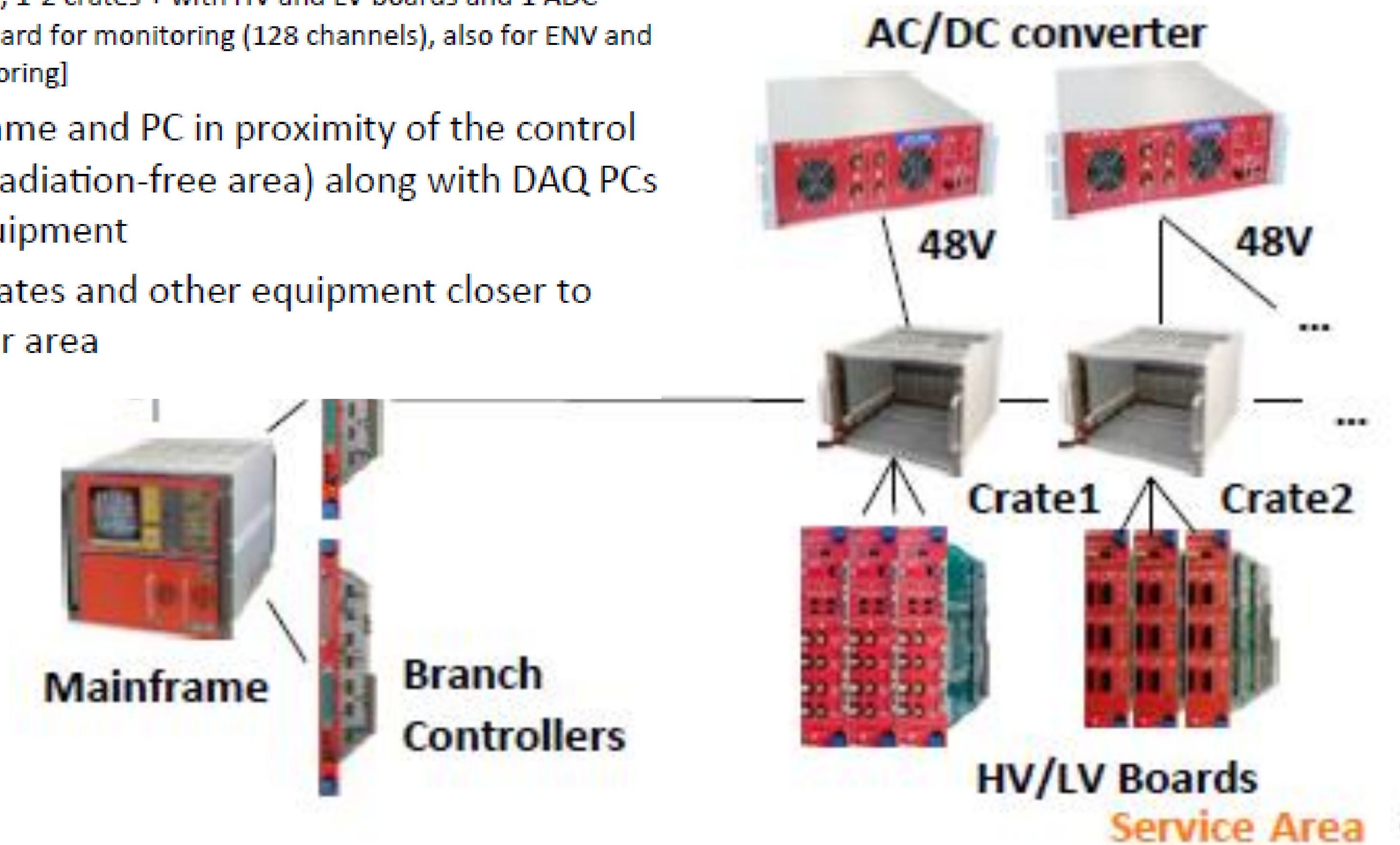
- Use PVSS/WinCC OA (as in LHC experiments)
- CAEN Easy Power System [1 mainframe, 1 Power Generator, 1-2 crates + with HV and LV boards and 1 ADC A-3801 board for monitoring (128 channels), also for ENV and gas monitoring]
- Mainframe and PC in proximity of the control room (radiation-free area) along with DAQ PCs and equipment
- EASY crates and other equipment closer to detector area



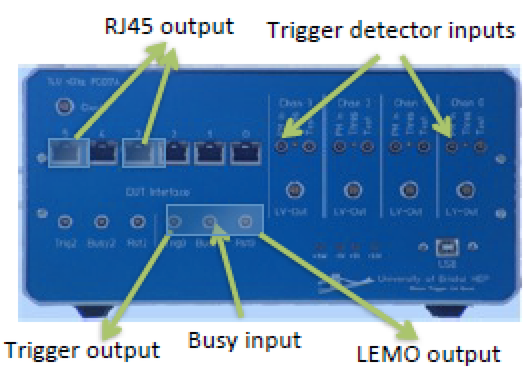
Users'setups: centralized DAQ

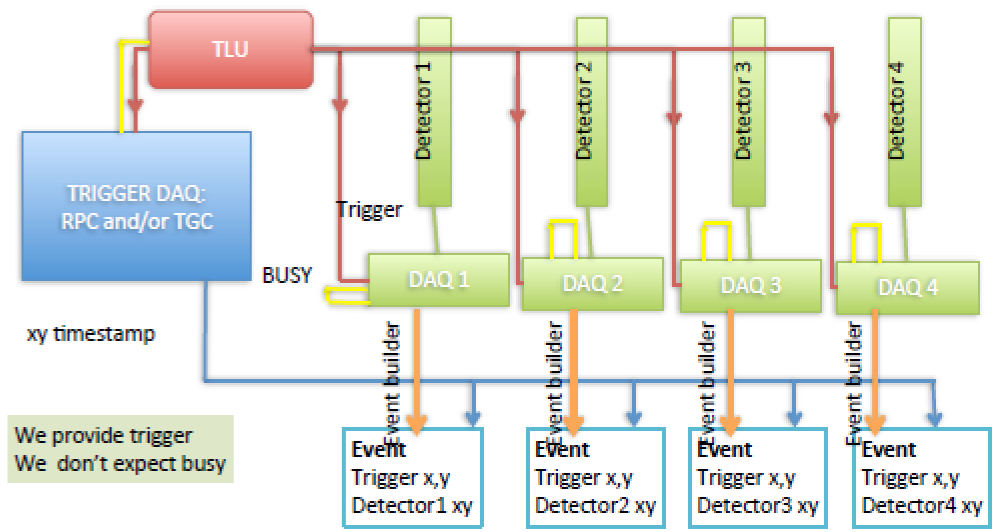
Requirements

- Create a trigger from beam tracker (TGC) and/or cosmic tracker (RPC)
- Distribute the trigger to different Detectors Under Test (currently up to 5 DUTs)
- Synchronize the events from the TGC/RPC with the DUTs for tracking/efficiency purpose

Implementation

- Based on a **Trigger Logic Unit** module provided by EUDET community and intensively used in test beams (DESY, CERN, FERMILAB, ...)
- Unit provides **trigger signal** and **trigger number** to all detector DAQs
- Requires busy signal from detectors DAQs
- This module synchronizes the different DAQ systems





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Conclusions

- Construction of new Gamma Irradiation facility in progress:
  - GIF++ is a unique place for R&D tests: Strong gamma source, particle beam available, excellent gas and electronic infrastructures, unified control/monitoring system, setups for beam&cosmic trigger, radiation monitoring, environmental monitoring, DAQ, …
- Operation will start end-December 2014
- GIF++ Users'meetings: every 4-6 months
- ***Next meeting July 11th: https://indico.cern.ch/event/326207/***
- ***Agenda will be distributed soon***
- ***All past, present and future users are invited***