

# A NEW IRRADIATION FACILITY FOR THE TEST OF LARGE-AREA PARTICLE DETECTORS



Thanks to:

Martin Jaekel, Federico Ravotti and Adrian Fabich for pictures and other material

# Overview



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- Motivation for the new GIF++
- Layout of the facility
  - Fixed Infrastructure: Irradiator, Controls, Attenuators, Gas Systems
  - Monitoring Infrastructure: Contributions by AIDA collaboration
- Project planning and responsibilities
- Conclusion



# Motivation for the GIF+++ facility

# The old GIF in the SPS West Area



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- GIF has been intensively used to simultaneously expose detectors to the photons from a 740 MBq  $^{137}\text{Cesium}$  source and high energy particles from the X5 beam line (until 2004)
- Most LHC gas detector technologies have been validated at the GIF: CMS: RPC, CSC; ATLAS: MDT, RPC, TGC, CSC
- Facility still fully booked all around the year up to now!



# Motivation for GIF++



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- The high-luminosity LHC (HL-LHC) upgrade is setting a new challenge for particle detector technologies
- Increase in luminosity will produce a **10 x higher particle background** with respect to present conditions
- Detailed knowledge of **performance of detectors under high particle fluxes** and precise understanding of possible **ageing of detector materials** under permanent particle bombardment crucial for optimized design and efficient operation mode

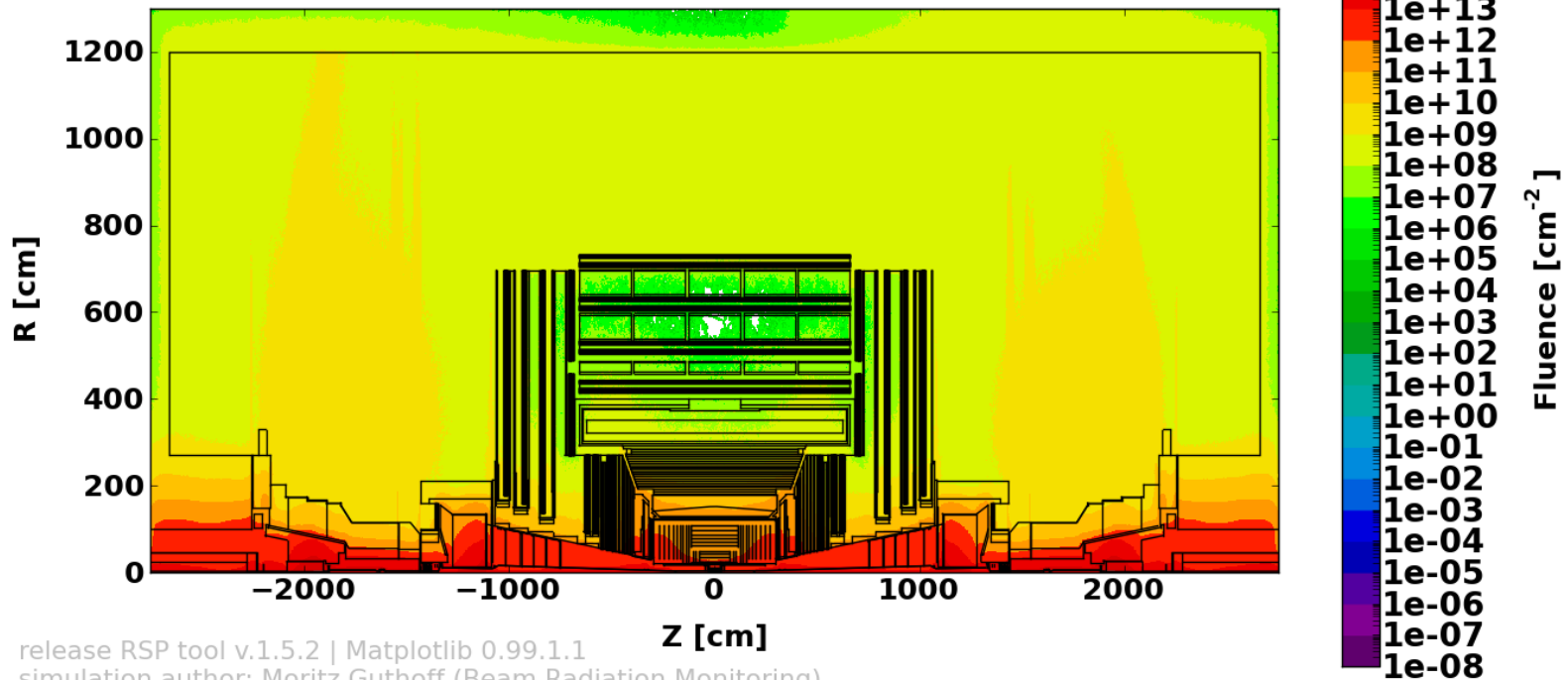
# Particle Fluxes at CMS



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## CMS pp 7TeV FLUKA: All Particles 1.0 [fb<sup>-1</sup>]

for internal CMS use only

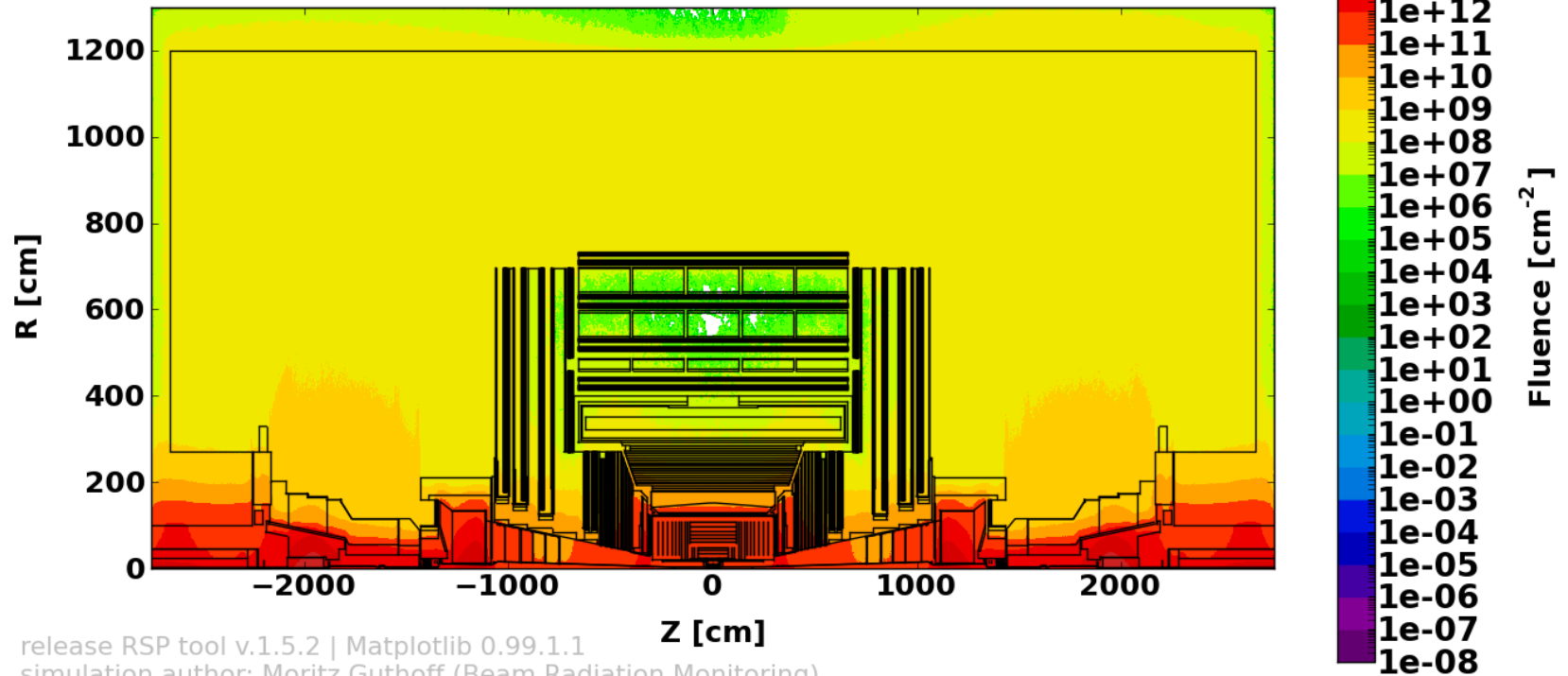


# Neutron Fluxes at CMS



## CMS pp 7TeV FLUKA: Neutrons 1.0 [fb<sup>-1</sup>]

for internal CMS use only





# Radiation Simulation Plotting tool v.1.5.2 HyperNews BRIL Radiation Simulation

[ RSP tool: manage ]

- ◆ Please note that plots generated with this tool are **NOT APPROVED** as CMS official plots, they are intended for internal CMS use only.
- ◆ Plots already **APPROVED** by the CMS Collaboration can be found here: [TWiki: BRILRadiationSimulation](#).
- ◆ For further information please consult the [references tab](#).
- ◆ A parameter drawing of CMS can be found [here](#).

main site

references

features

bug fixes

credits

FAQ

» plot generated in: 20.890000 [sec]

Selected simulation run:

CMS\_pp\_7TeV\_FLUKA

« to step 1

Selected scoring:

All Particles

« to step 2

Selected plot options:

R min [cm]:  R max [cm]:  R rebin:

Φ min [rad]:  Φ max [rad]:  Φ rebin:

Z min [cm]:  Z max [cm]:  Z rebin:

Normalization form & value:

integrated:  [ fb<sup>-1</sup> ]

step 1

step 2

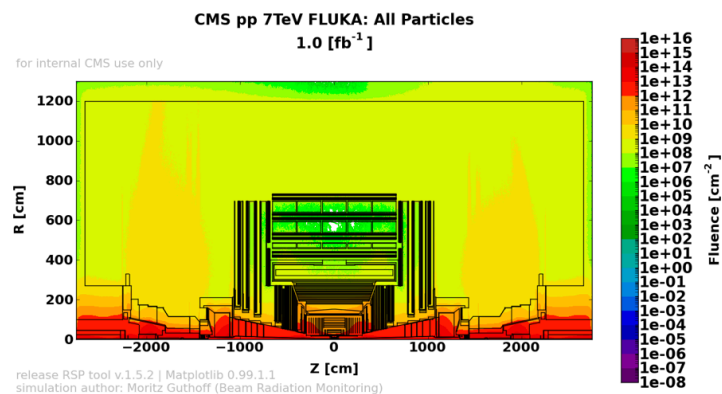
step 3

plot

[ click here ] simulation description

## step 5: PLOT

Please use **[RIGHT\_CLICK]** and save the picture as "PNG" to store the plot or open in new browser tab.



# Radiation tests – why and how?



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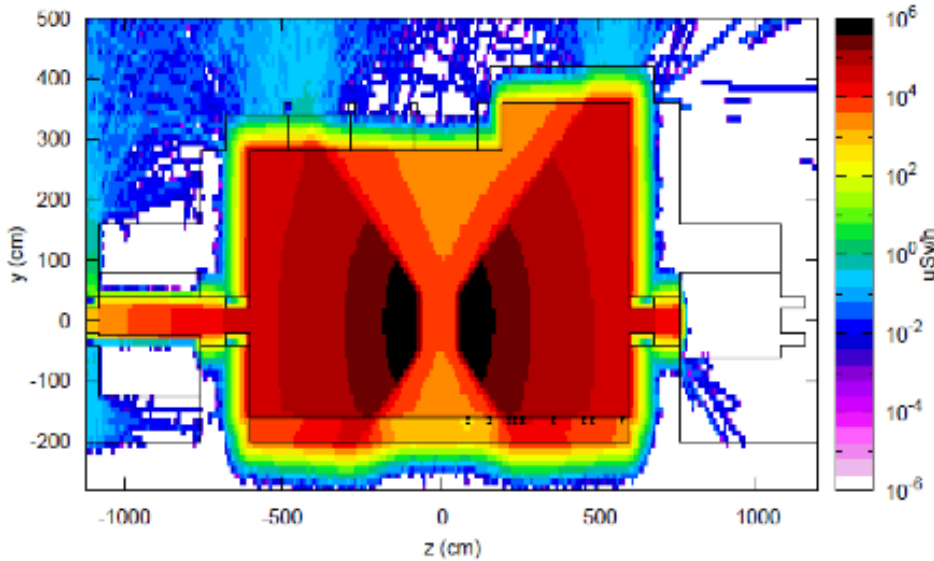
- Aim of the detector tests: Characterization and understanding of long-term behavior of large particle detectors
- Using the secondary beam from SPS (e.g. 100 GeV muons,  $10^4$  particles per spill traversing  $10 \times 10 \text{ cm}^2$ ) as detector signal and the gammas from the 14 TBq  $^{137}\text{Cs}$  source as background, the detector reliability is tested under harsh background conditions
- Setup allows to accumulate doses equivalent to HL-LHC experimental conditions in a reasonable time

# GIF++ Dose Simulation

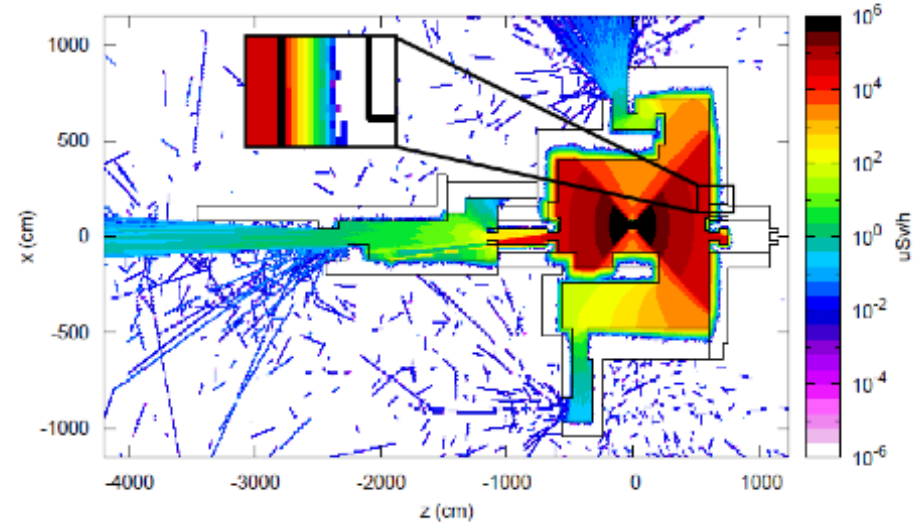


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Dose equivalent rate (40 cm around the beam line vertical position)



Dose equivalent rate (40 cm around the source height)



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

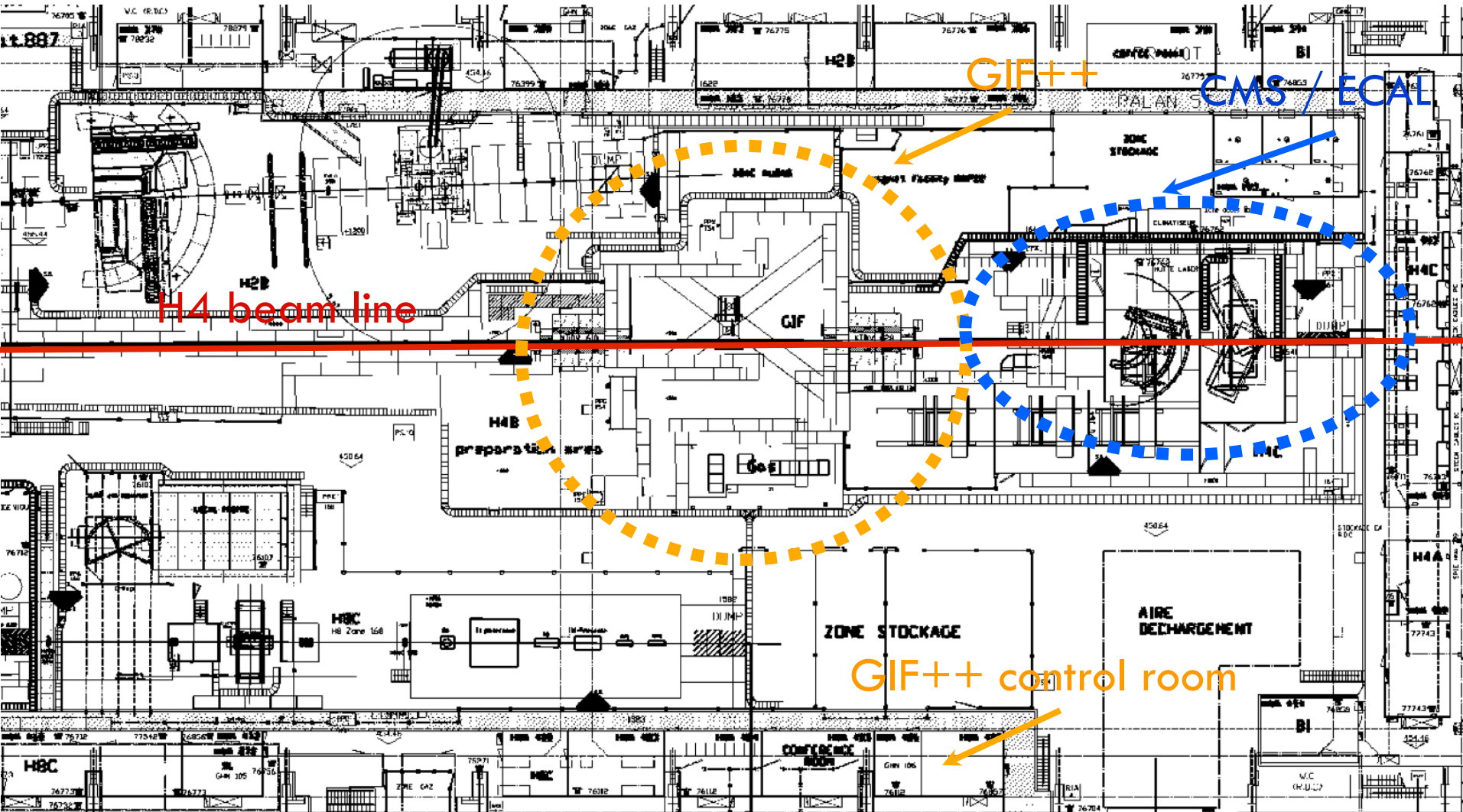


# Layout of the facility

# SPS North Area: EHN1



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# GIF++ - Before construction



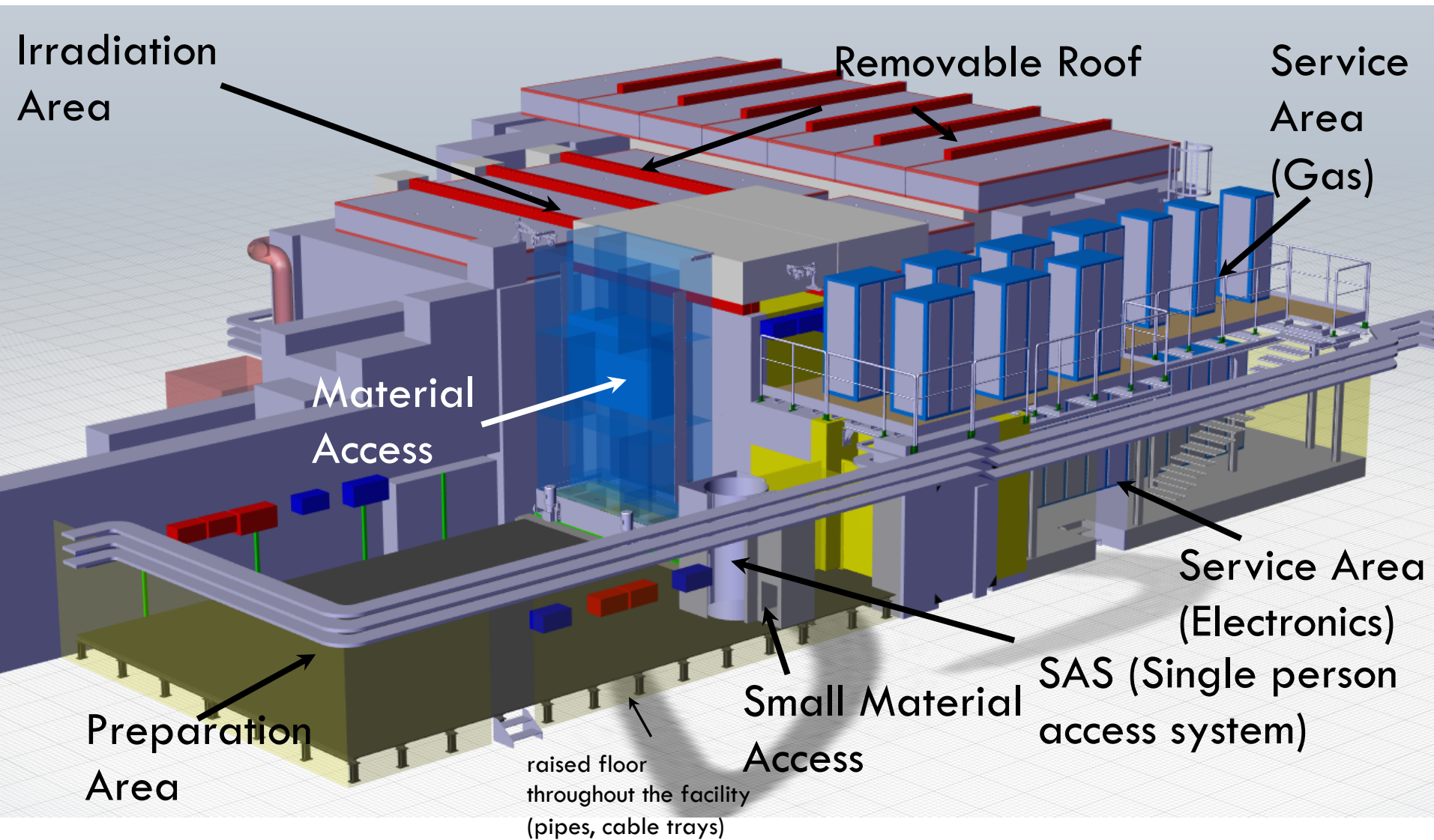
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# GIF++ Facility Layout



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# GIF++ Irradiation Zone



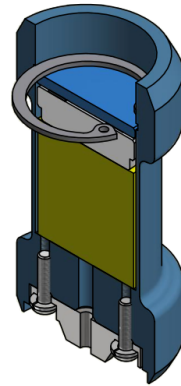
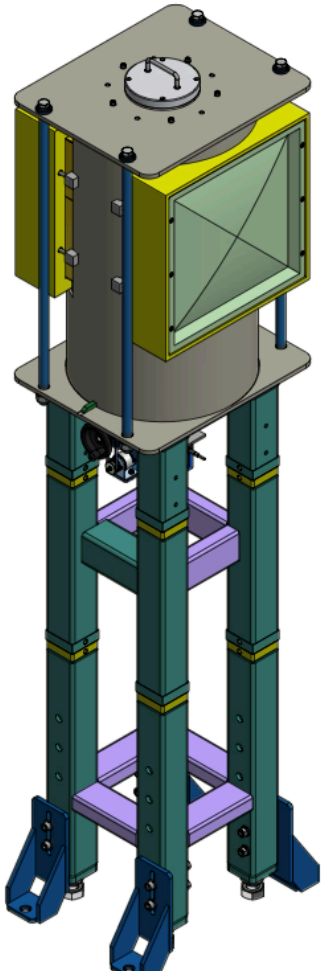
Irradiator can be moved by 150 cm

Beam pipe (159 mm) for CMS ECAL



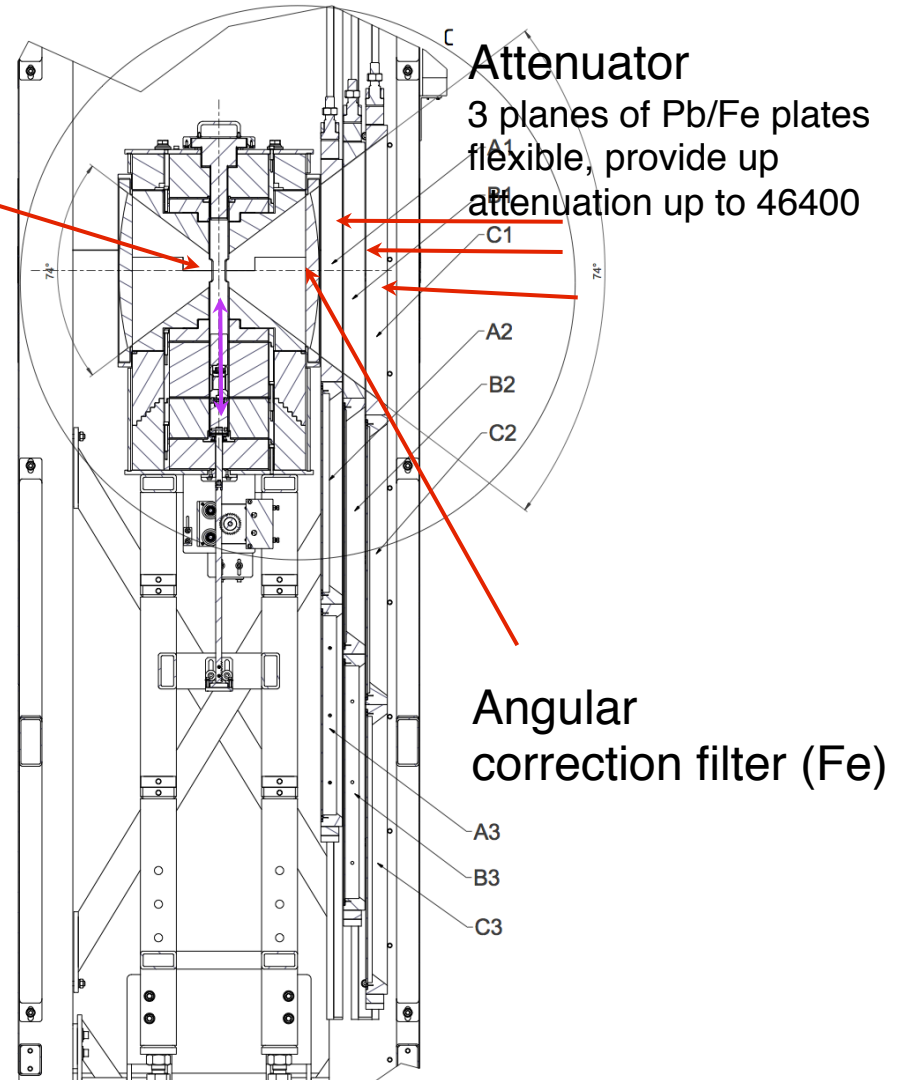
# Fixed infrastructure

# GIF++ Irradiator

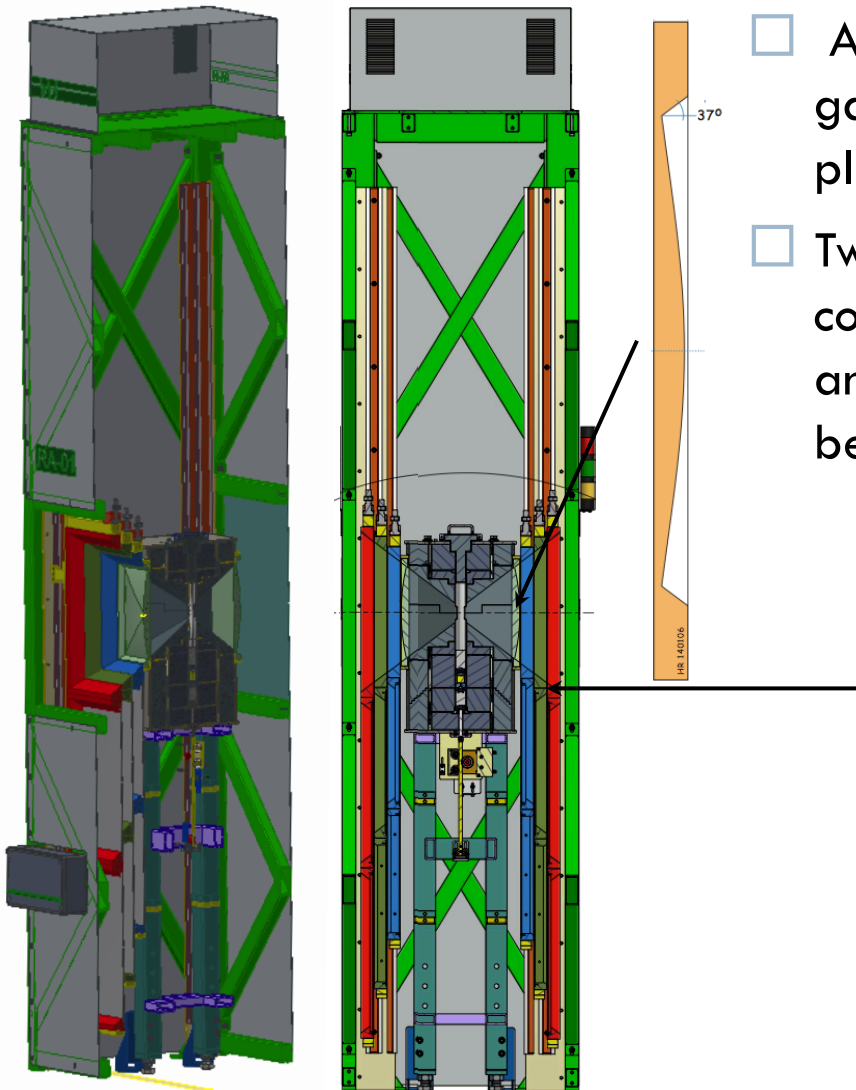


14 TBq  $\text{Cs}^{137}$   
1.Nov.2011 = 14.91 TBq  
260  $\mu\text{Gy/s}$  or 1 mSv/h  
at 1 meter

Source available in Prague  
hot-cell, certificate received.



# GIF++ Irradiator Filter System



- Angular correction filter provides uniform gamma distribution for large area detectors in plane normal to irradiation direction
- Two identical attenuation systems each consisting of one angular correction filter (Fe) and 6 absorption filters allow attenuation between 1 and 46400

Filter System :

A	B	C
0	0	0
10	1.47	2.15
100	100	4.64

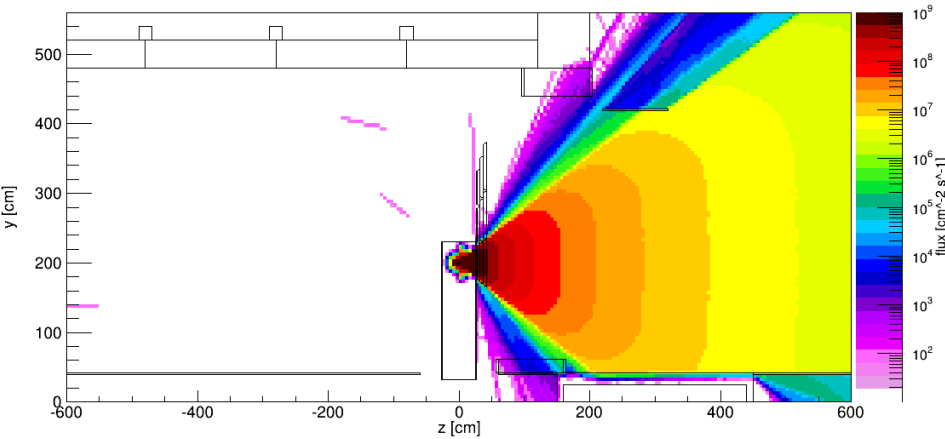
Al  
Pb

# Unattenuated $\gamma$ - flux at source height

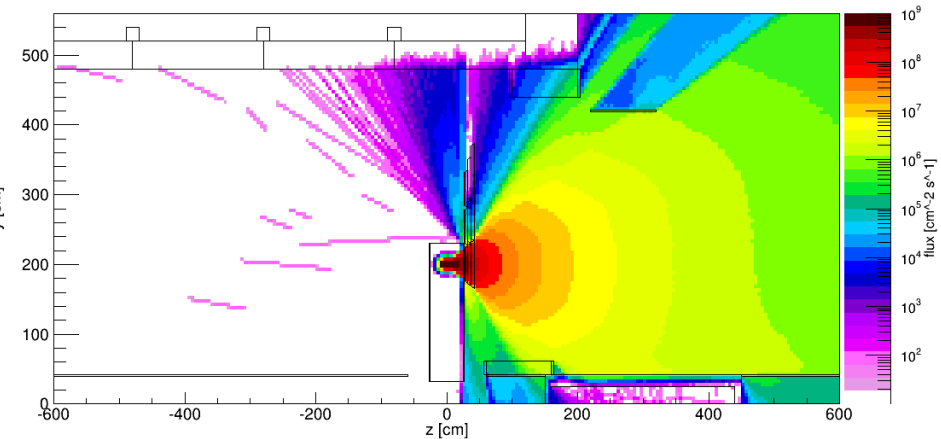


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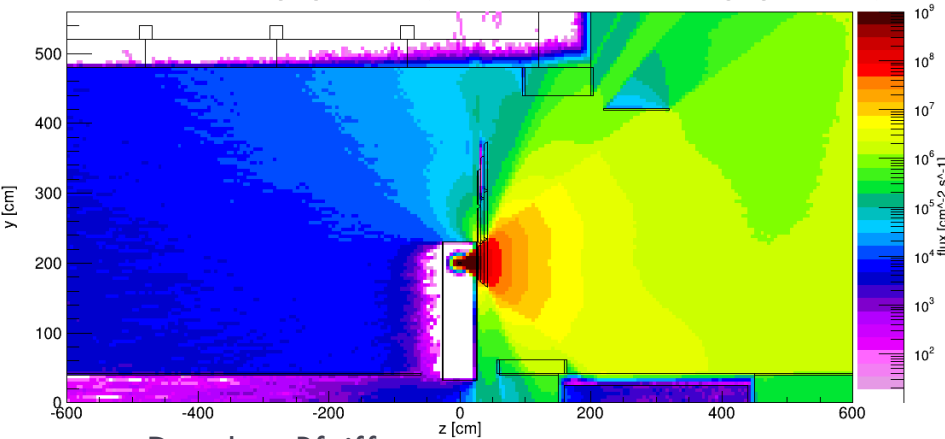
$E \geq 600$  keV



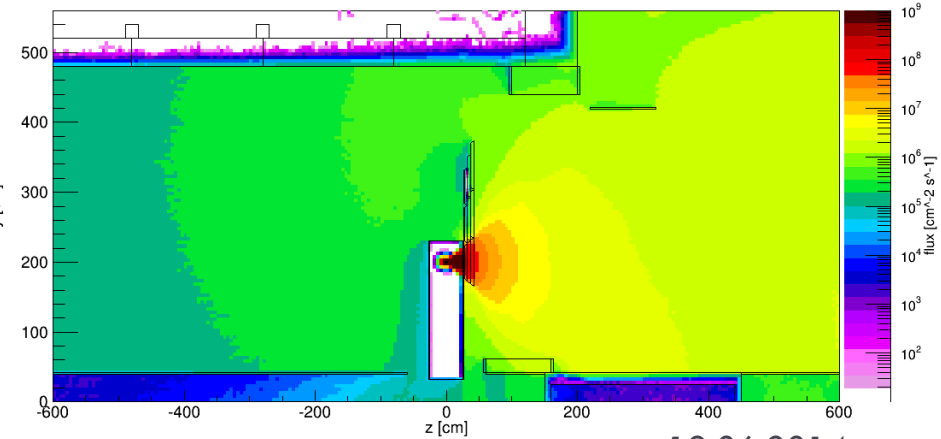
$400 \text{ keV} \leq E < 600$  keV



$200 \text{ keV} \leq E < 400$  keV



$E < 200$  keV

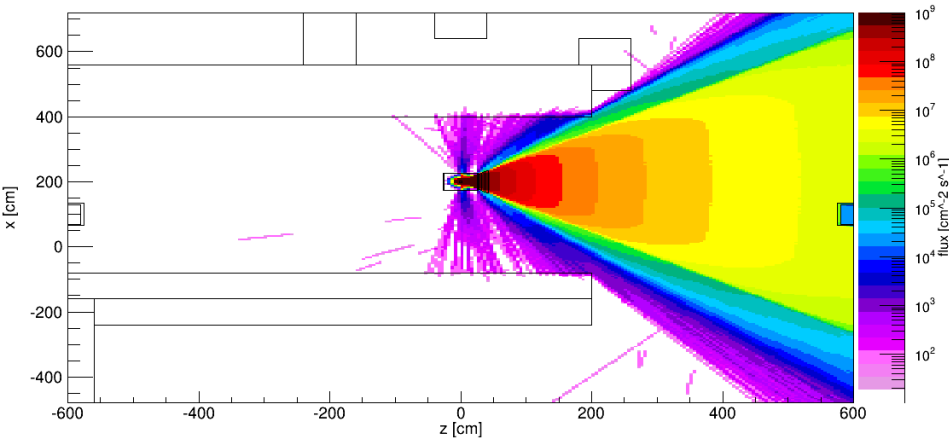


# Unattenuated $\gamma$ - flux at source height

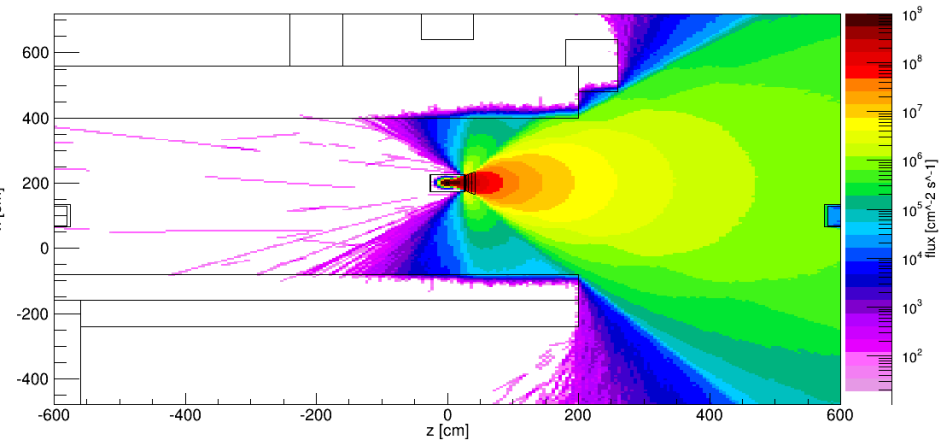


20

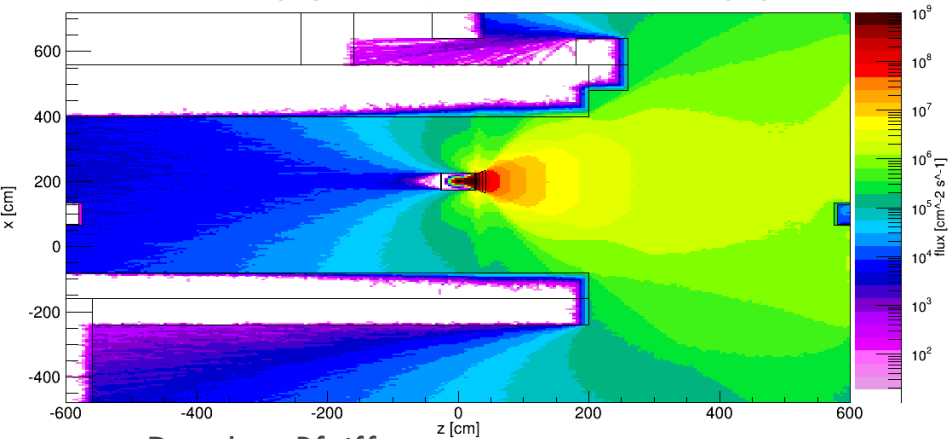
$E \geq 600$  keV



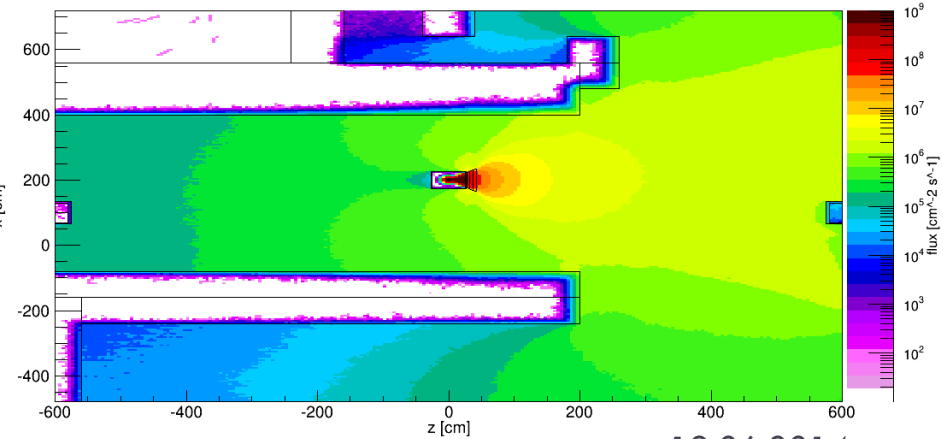
$400 \text{ keV} \leq E < 600$  keV



$200 \text{ keV} \leq E < 400$  keV



$E < 200$  keV

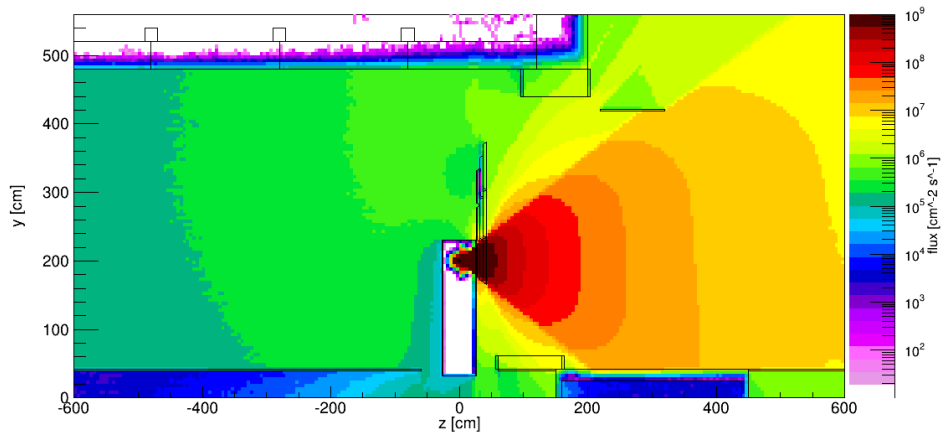


# Attenuated total $\gamma$ - flux at source height

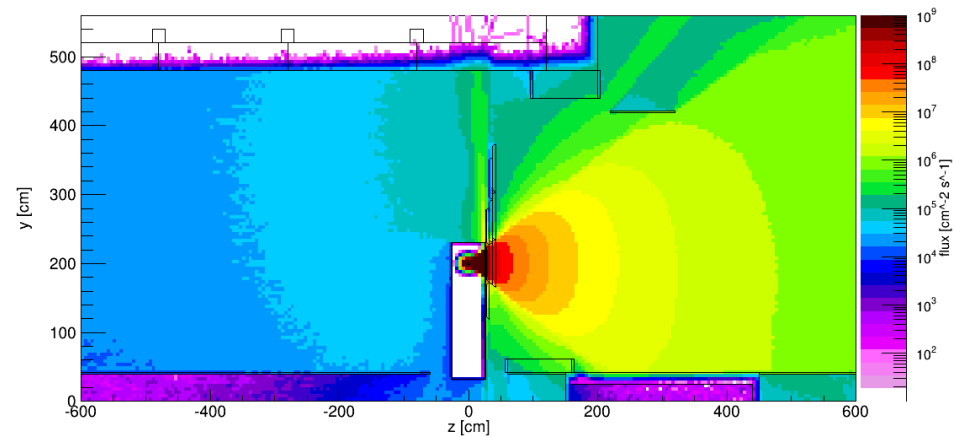


21

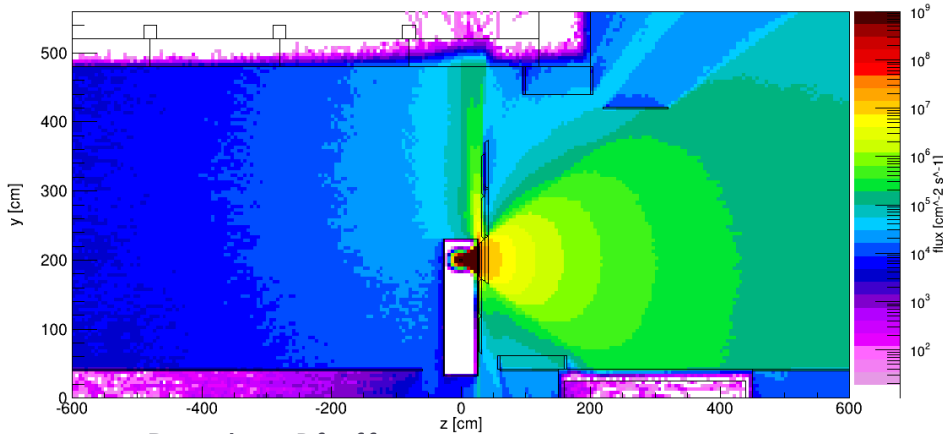
## Unattenuated



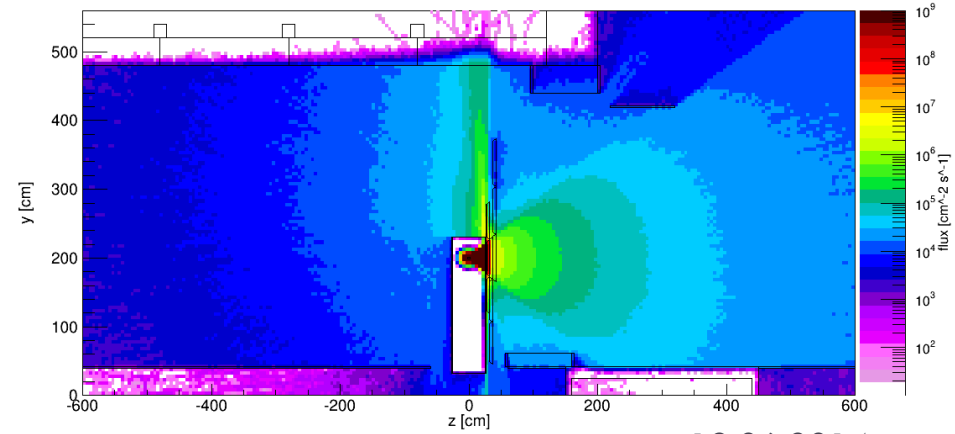
## Attenuation Factor 10



## Attenuation Factor 100



## Attenuation Factor 1000

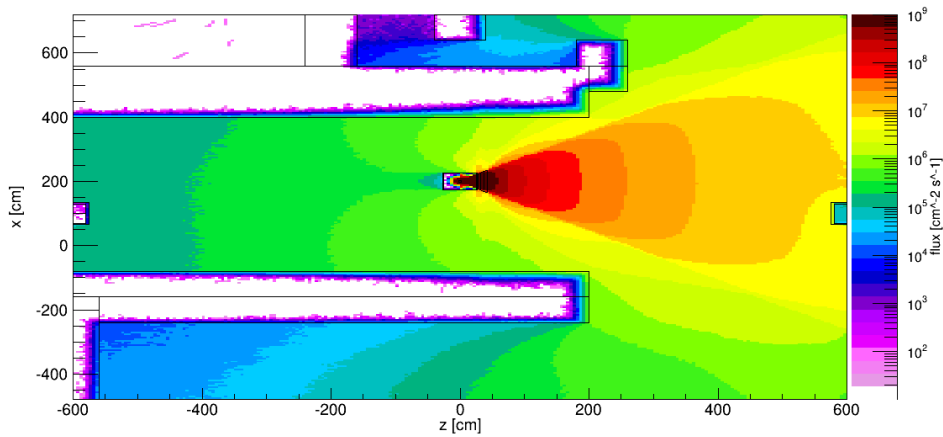


# Attenuated total $\gamma$ - flux at source position

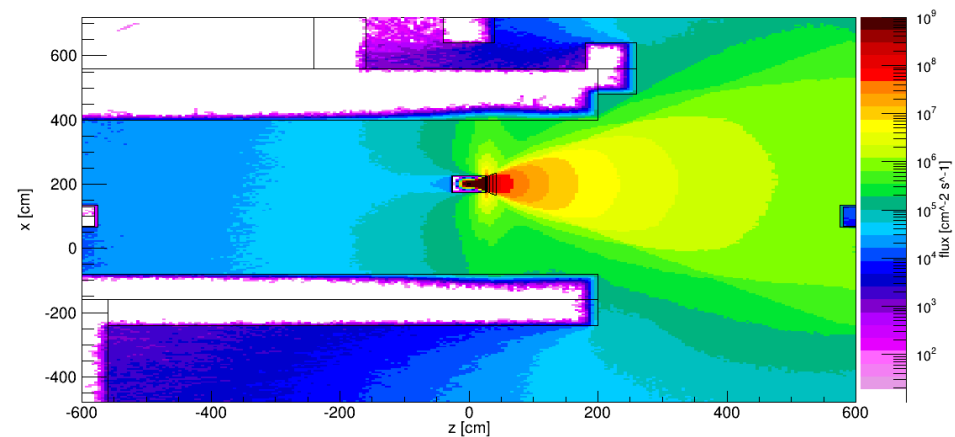


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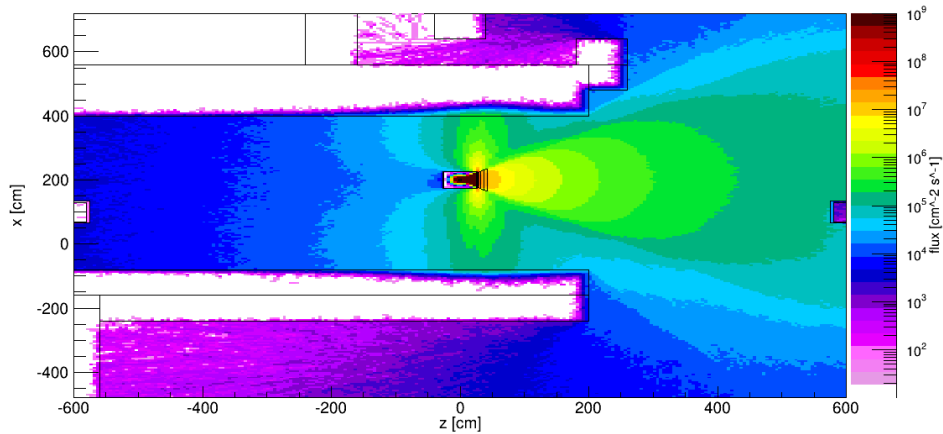
## Unattenuated



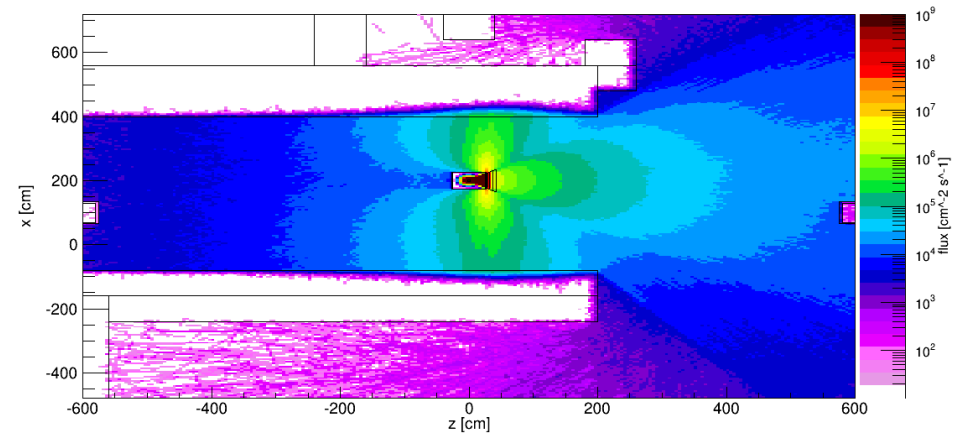
## Attenuation Factor 10



## Attenuation Factor 100



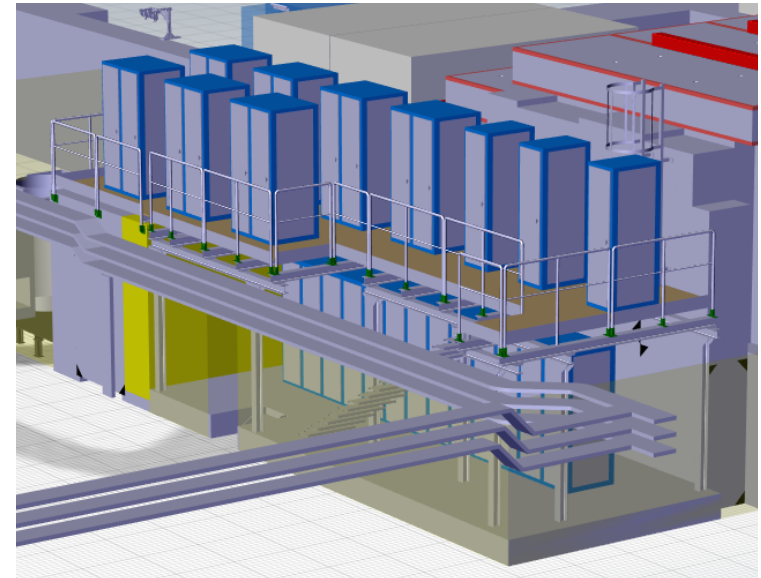
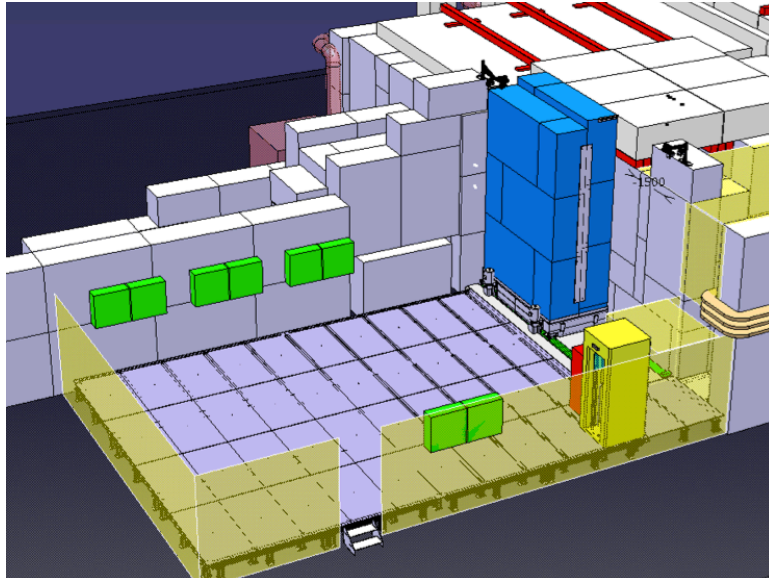
## Attenuation Factor 1000



# GIF++ Preparation & Service Zone



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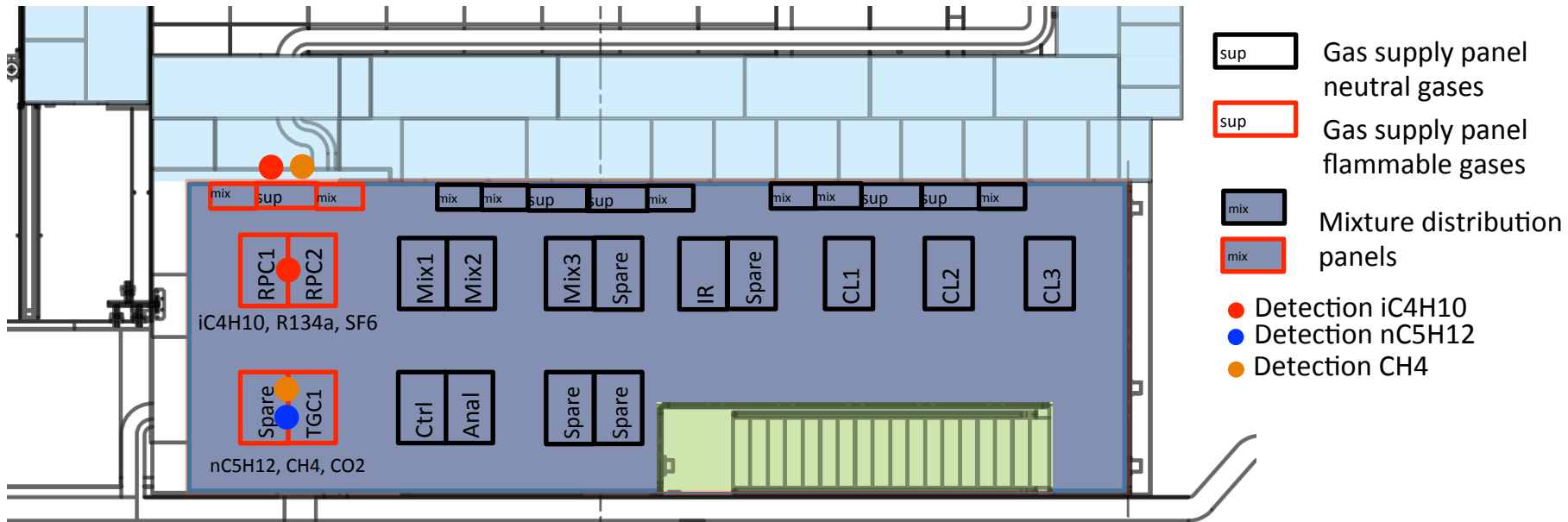
- Large Preparation Zone ( $\approx 80\text{m}^2$ ), equipped with gas lines, electricity & network. Signal cables and HV/LV patch panels will be added during a first upgrade
- Full size detectors can be set up and commissioned before moved to the radiation zone, already connected to the final DAQ

- Ground floor: total of 17 electronic racks hosting the irradiator controls, DCS, user equipment, fire detection
- Top Floor: 17 gas racks and distribution panels. 40 m<sup>2</sup> net area

# GIF++ Gas Mixing Zone



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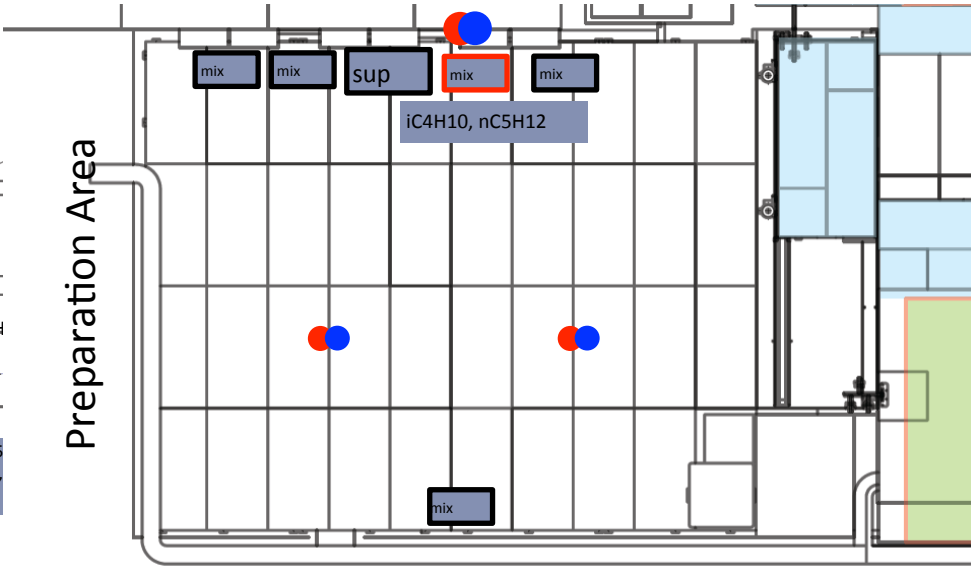
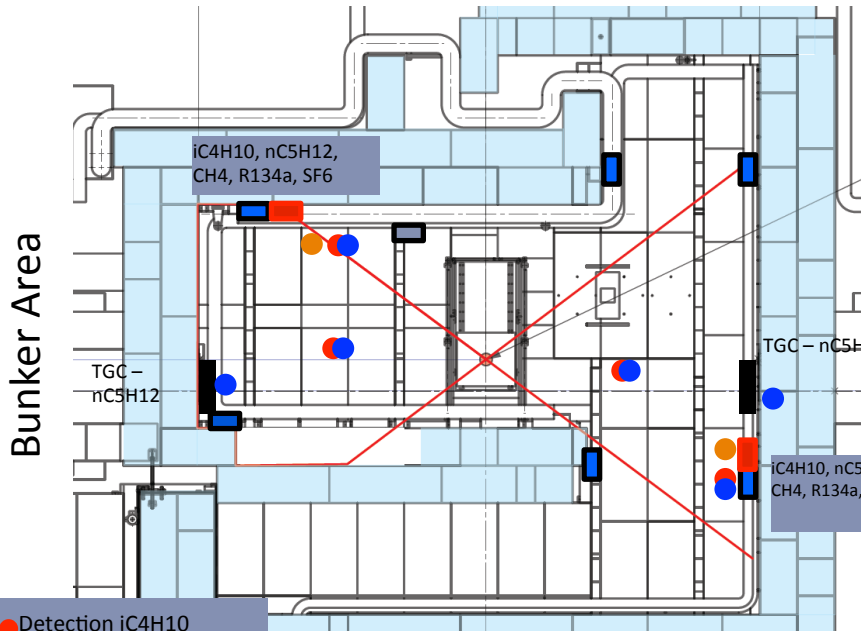


- The mixing zone will contain 6 panels for non-flammable gas and 2 panels for flammable gas
- 4 panels for non-flammable gas and one panel for flammable gas will be equipped with 3-way valves to allow to supply also the preparation area
- All pipes are stainless steel, cleaned at CERN following standard cleaning procedures for gas distribution systems

# GIF++ Gas Panel Distribution

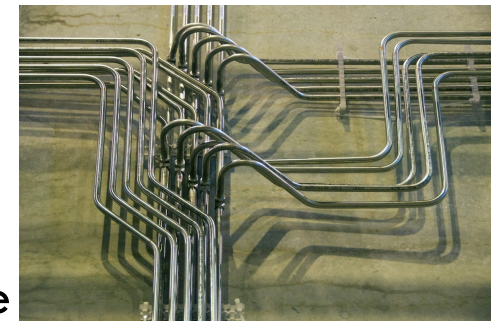


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- Detection iC4H10
- Detection nC5H12
- Detection CH4

- 6 panels for non-flammable gas (blue) and 2 panels for flammable gas (red) in bunker, 4 panels for non-flammable gas (blue) and 1 panel for flammable gas (red) in preparation zone
- In total, 96 pipes are connecting the gas mixing zone with the bunker



# GIF++ Control System



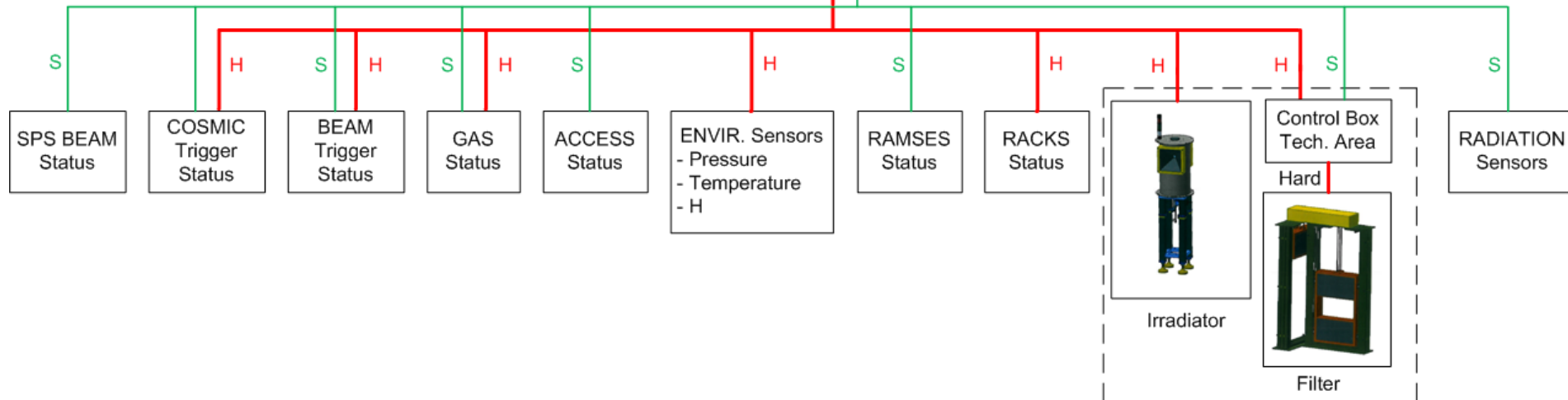
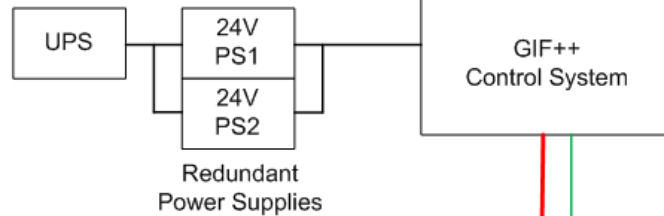
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GIF++ Control System (GCS)  
PVSS Supervisor  
In Control Room



TCPIP  
Technical Network

Database





# Monitoring infrastructure

# GIF++ User Infrastructure



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## WP-8.5.3: GIF++ User Infrastructure

- Bulgaria: INRNE
- Greece: NTUA, AUTH, Demokritos, NCUA
- Israel: Weizmann, Technion, Tel-Aviv U.
- Italy: INFN-Bari, -Bologna, -LNF, -Rome2



# AIDA

## Deliverable: Infrastructure installed/commissioned 30/09/2014

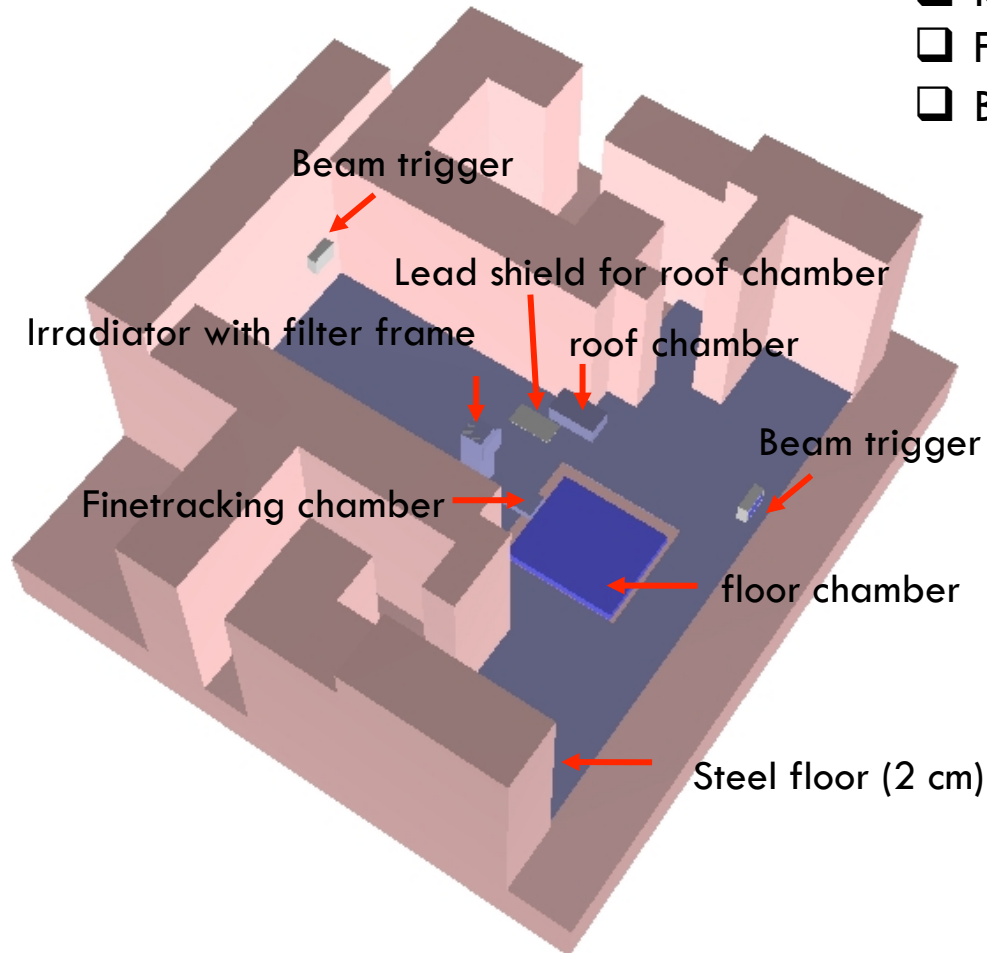
- Beam tracker
- Cosmic tracker
- Gas + Environmental monitoring
- Radiation monitoring
- Detector Control System
- DAQ system

# GIF++ User Infrastructure Geometry



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- ❑ RPC chambers surrounded by 4 cm of steel
- ❑ Floor chamber also covered by 17 cm of steel
- ❑ Beam trigger shielded by 5mm Tungsten rubber



# GIF++ Beam Tracker



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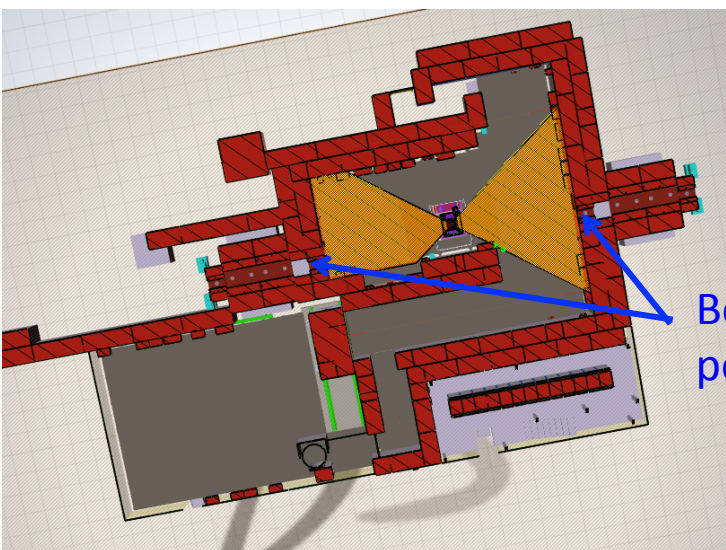


## □ Detectors

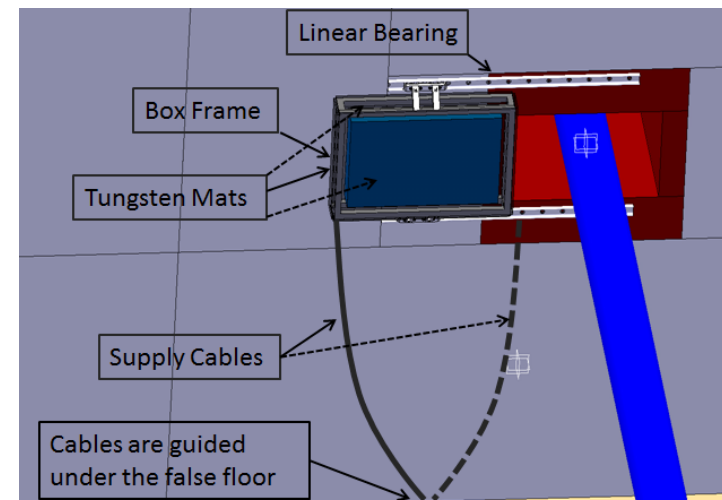
- Two Thin-Gap-Chamber (60cmx40cm) quadruplets with strips, wires and pads in each gap
- Test beam spatial resolution:  $80 \mu\text{m}$

## □ Electronics

- 4 of 8 layers will be equipped with temporary front-end and readout electronics during 2014
- final electronics for all layers will be implemented in 2015



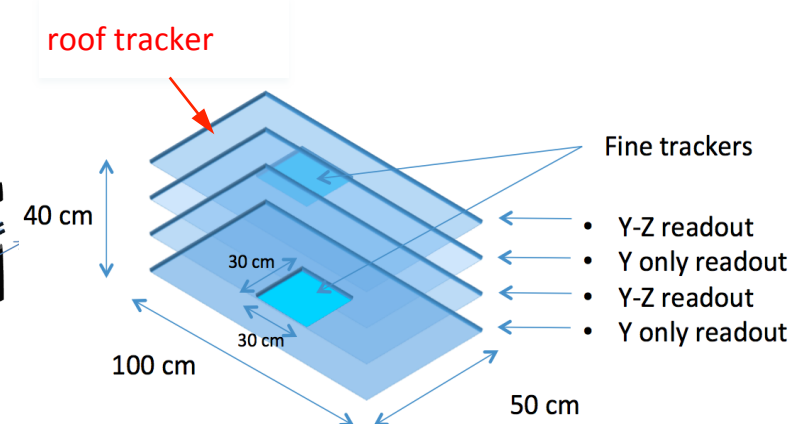
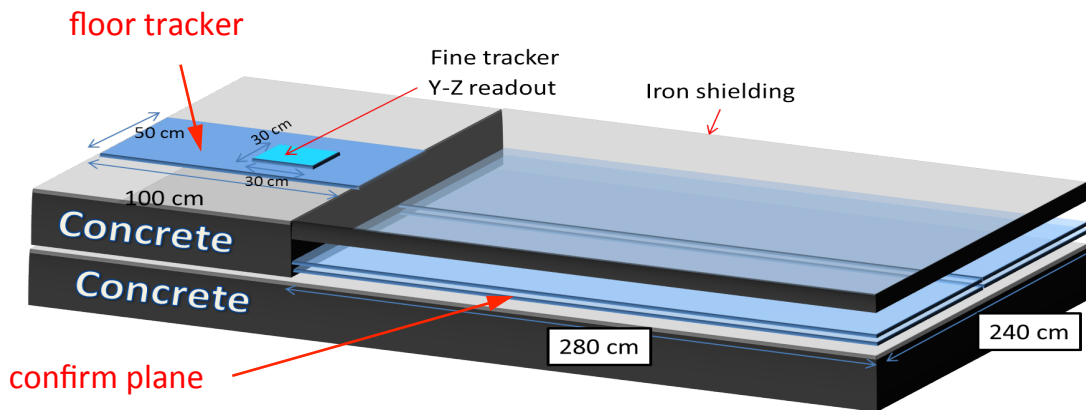
Beam tracker positions



# GIF++ Cosmic Tracker

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- ❑ Roof tracker
  - ❑ 4 independent Resistive Plate Chambers 1.0 x 0.5 m<sup>2</sup>
  - ❑ readout strips 3 cm wide
  - ❑ 1 or 2 fine tracking RPC 30x30 cm<sup>2</sup> with X-Y strips 1 cm wide
- ❑ Floor tracker
  - ❑ 1.0 x 0.5 m<sup>2</sup> chambers as for the roof
  - ❑ 1 fine tracking RPC chamber 30x30 cm<sup>2</sup> as for the roof
- ❑ Underground detector (confirm plane)
  - ❑ Double layer RPC chambers 2.8 x 2.4 m<sup>2</sup> with 4 cm strips in XY

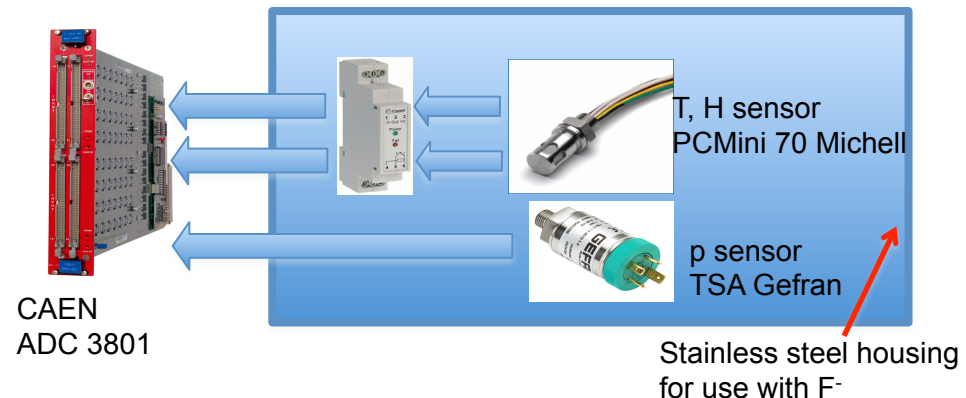
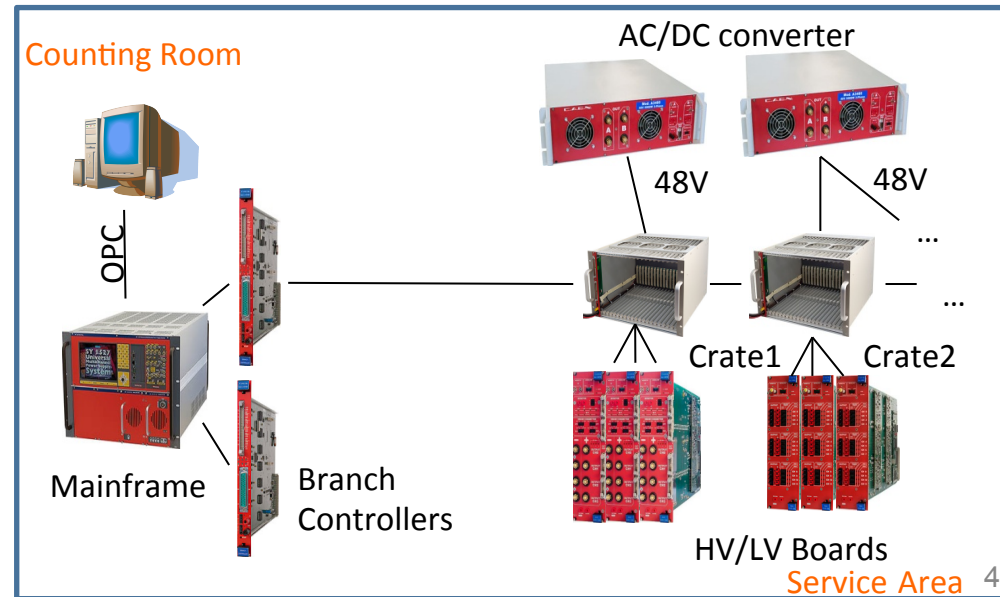


# GIF++ Detector Control System



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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
- Radiation, gas and environmental sensors to monitor atmosphere and gases: p, T, rH



# GIF++ DAQ System



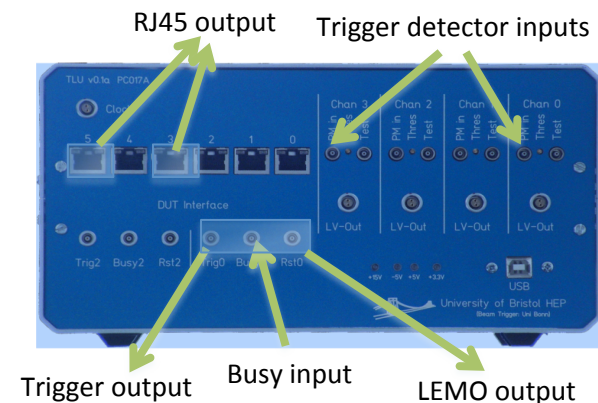
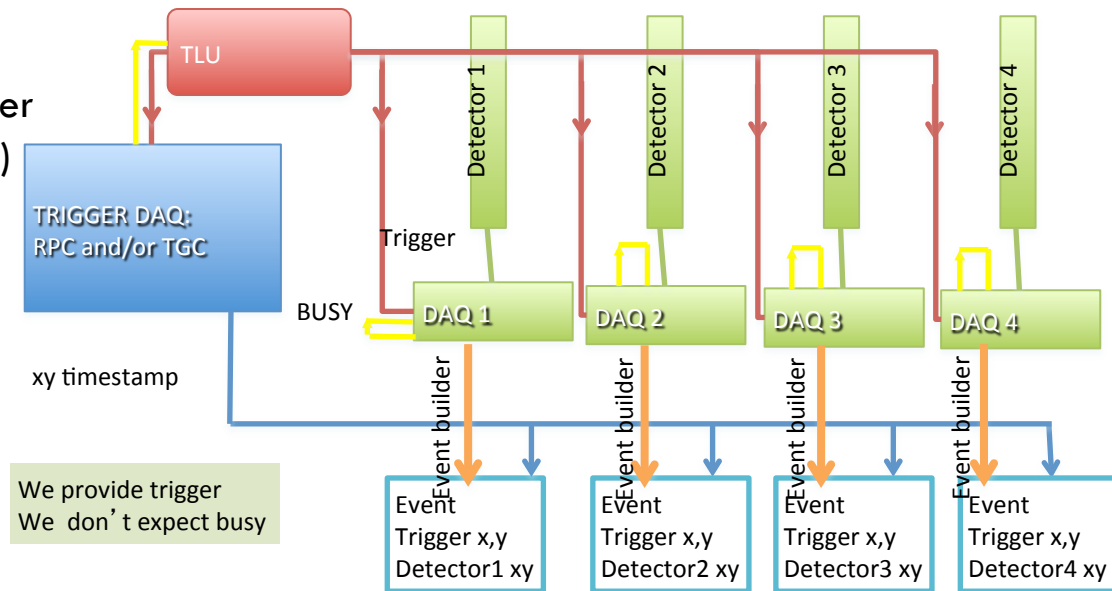
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## Requirements

- 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 (FP7: standardized test beam setup for high resolution detectors) 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





# Project planning and responsibilities

# GIF++ - A Joint Project



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**EN** Engineering Department



PH-DT  
Detector Technologies



**HSE**  
Occupational Health & Safety  
and Environmental Protection Unit

**FP** Procurement & Industrial Services Group



**RWTHAACHEN**  
UNIVERSITY



Responsible for the EHN1 building and the installations inside, thus for the new of the GIF++

- During **planning and construction** phase (**project engineer**)
  - Compiles facility requirements and plans construction
  - Builds the facility and provides the infrastructure for housing the irradiator and detectors
  - Supplies general infrastructure
    - Civil engineering components (shielding, false floor), control room
    - Beam line elements and access system
    - Electricity and gas distribution to the boundary limits of the service zone and the control room
- During **operations** responsible for the H4 beam line (**beam line physicist**)
  - Sets up muon beam as specified by the user
  - Responsible for access system and operation of all beam line elements

Responsible for all irradiation facilities and experimental areas at CERN

- During **planning and construction** phase (**manager irradiation facilities**)
  - Acts as interface to the users of the facility and collects their requirements
  - Procures the irradiator and attenuators
  - Develops the facility controls (GIF control System)
  - Develops and installs the gas systems inside the facility
- During **operations** responsible for the running of the facility and the user management (**technical coordinator users**)
  - Helps users to install detector systems under test
  - Irradiation time for users will be allocated via the SPS coordinator like other H4 beam time, one main user and up to five other parasitical users in parallel
  - Responsible for space management inside the facilities
  - Responsible for running of irradiator and attenuator systems

# GIF++ Responsibilities



AIDA



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The responsibilities of the GIF++ user community (a very diversified group)

- During **planning and construction** phase (**AIDA, all users**)
  - Specifies requirements for the facility (GIF++ is a facility FOR the users)
  - Provides the detector specific infrastructures within the framework of the FP7 AIDA project (beam trigger, cosmic trigger and tracker chambers, sensors, DAQ)
- During **operations** various groups will test their equipment in GIF++
  - ALICE, ATLAS, CMS, LHCb, COMPASS, NA62 experiments
  - LHC Beam loss monitors
  - RD-50 and RD-51 Collaborations
  - Different CERN groups

# GIF++ Webpage



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EN Engineering Department

<https://cern.ch/gifpp>



Secondary Beams & Areas

GIFpp

[Home](#) [Webpage EN-MEF-LE](#) [Secondary Beams and Areas](#)

GIF Project

Organization

Members

Documents

EDMS

Pictures

Useful Links

Glossary

Meetings

Installation meetings

Project meetings

Indico

All Site Content

## GIF++ Project Organization

### Overall Management/Physicist in Charge

**Ilias Efthymiopoulos, Adrian Fabich (EN-MEF-LE)**

Technical Support Area and Infrastructure  
Design and Integration  
PH [Responsible Irradiation Facilities](#)  
Users Technical Coordinator  
Spokesperson and Physics Coordinator

Michael Jeckel (EN-MEF-EBE)  
Sylvain Girod (EN-MEF-EBE)  
Martin Jaekel (PH), Federico Ravotti (PH-DT-DI)  
Richard Fortin (PH-DT-DI)  
Roberto Guida (PH-DT-DI)

Operational RP Supervision  
RP Supervision Source  
Project Safety Officer

Chris Theis (DGS-RP-AS), Daniel Perrin(DGS-RP-IL)  
Joffrey Germa(DGS-RP-RW)  
Thijs Wijnands (EN-HDO)

### Contacts

Access system  
Transport  
Civil engineering  
CV  
HSE Unit Safety Correspondant  
BE Department Safety Contact

Didier Vaxelaire, Vitor Martins de Sousa (GS-ASE-AC)  
Caterina Bertone (EN-HE-HH), Jean-Louis Grenard (EN-HE-HT)  
Raul Fernandez Ortega (GS-SE-DOP)  
Michele Battistin (EN-CV-PJ)  
Saverio La Mendola (DGS-SEE)  
n.a.n.

<https://edms.cern.ch> - the CERN chess equivalent. It kind of works..

Welcome to the CERN  
Engineering & Equipment Data Management Service

**PH Department**

Reset    Set as Top    Search    Re-login  
DPFEIFFE

**Secondary Beams & Areas**

Reset    Set as Top    Search    Re-login  
DPFEIFFE

**Question:** Why are their two GIF++ folders?

**Answers:**

- a: to confuse people
- b: because it makes perfect sense
- c: because intra-departmental collaboration has its limits (never let a person from another department manage your EDMS folder)

- Microfabrication
- CO2 cooling projects
  - Traci 100W
  - Marco 1kW
  - Atlas IBL
  - CMS Pix TIF
  - CMS Pix P5
    - Management
    - Technical documentation
    - Tests & QA
    - Operation
- Microcooling Projects
- FOS projects
- Publications
- PH IRRADIATION FACILITIES
  - East Hall: IRRAD Facility on T7
  - East Hall: EA-IRRAD Facility on T8
  - Enw: Gamma Irradiation Facility (GIF)
  - EHN1: New Gamma Irradiation Facility (GIF++)**
    - Preparatory Documents
    - Cs-137 Irradiator
    - Systems
    - Operational procedures
    - GIF Control System
    - GIF Gas system
- Design Jobs
- SAFETY

- Secondary Beams & Areas**
  - General
  - SPS North Area
  - CNGS Secondary Beam
  - PS East Area
  - AD Experimental Area
  - nTOF
  - Projects
    - GIF++**
      - Documentation
      - Integration
      - Images
      - Impressions
      - Presentations
      - Integration
      - Systems
      - Coordination
    - EHN1: New Gamma Irradiation Facility (GIF++)
      - Preparatory Documents
      - Cs-137 Irradiator
      - Systems
      - Operational procedures
      - GIF Control System
      - GIF Gas system



## WP7 - Facilities and Component Analysis for Detector R&D GIF installation meetings

This series of meetings serves the coordination of EN-MEF work for the GIF project in EHN1.

### May 2014

- 15 May [GIF++ Weekly Irradiator Meeting](#)
- 09 May [GIF++ Weekly Irradiator Meeting](#)

### April 2014

- 04 Apr [GIF++ Weekly Irradiator Meeting](#)

### March 2014

- 20 Mar [GIF++ Weekly Irradiator Meeting](#)
- 13 Mar [GIF++ Weekly Irradiator Meeting](#)

### February 2014

- 27 Feb [GIF++ Weekly Irradiator Meeting](#)
- 12 Feb [GIF++ Users meeting](#)

There are 1 events in the *future*. [Show them.](#)

### July 2014

- 29 Jul [GIF installation meeting](#) (protected)
- 22 Jul [GIF installation meeting](#) (protected)
- 15 Jul [GIF installation meeting](#) (protected)
- 08 Jul [GIF installation meeting](#) (protected)
- 01 Jul [GIF installation meeting](#) (protected)

### June 2014

- 24 Jun [GIF installation meeting](#) (protected)
- 17 Jun [GIF installation meeting](#) (protected)
- 10 Jun [GIF installation meeting](#) (protected)
- 03 Jun [GIF installation meeting](#) (protected)

# GIF++ Documents



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CERN  
CH-1211 Geneva 23, Switzerland

EDMS No.	Rev	Validity
<b>1280118</b>	<b>0.6</b>	<b>RELEASED</b>

REFERENCE
<b>GIF++ Project – 2013-01</b>

Date: 26/04/13

CERN  
CH1211 Geneva 23  
Switzerland



EN Engineering Department

EDMS NO.	REV.	VALIDITY
<b>1326312</b>	<b>1.0</b>	<b>RELEASED</b>

REFERENCE
<b>EHN1 – GIF project</b>

Date : 2014-03-17

## REQUIREMENTS

### GIF++ A New Gamma Irradiation Facility

#### Abstract

GIF++ (Gamma Irradiation Facility) in the North Area will replace the existing GIF of the West Area. GIF++ will meet the demand for higher photon radiation fields and will restore the possibility of a simultaneous, secondary muon beam. This document summarizes the requirements and specifications from the users. The document does not specify the responsibilities for procurement, installation and operation.

## REPORT

### RADIATION-PROTECTION SHIELDING OF(F) THE GAMMA IRRADIATION FACILITY IN EHN1

#### Abstract

This document summarizes the radiation-protection studies, using the FLUKA Monte Carlo code, for the new Gamma Irradiation Facility in EHN1 of the CERN SPS North Area. Optimization of the facility layout is discussed and the radiation levels for the final design are given.

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Dorothea Pfeiffer – PH/DT

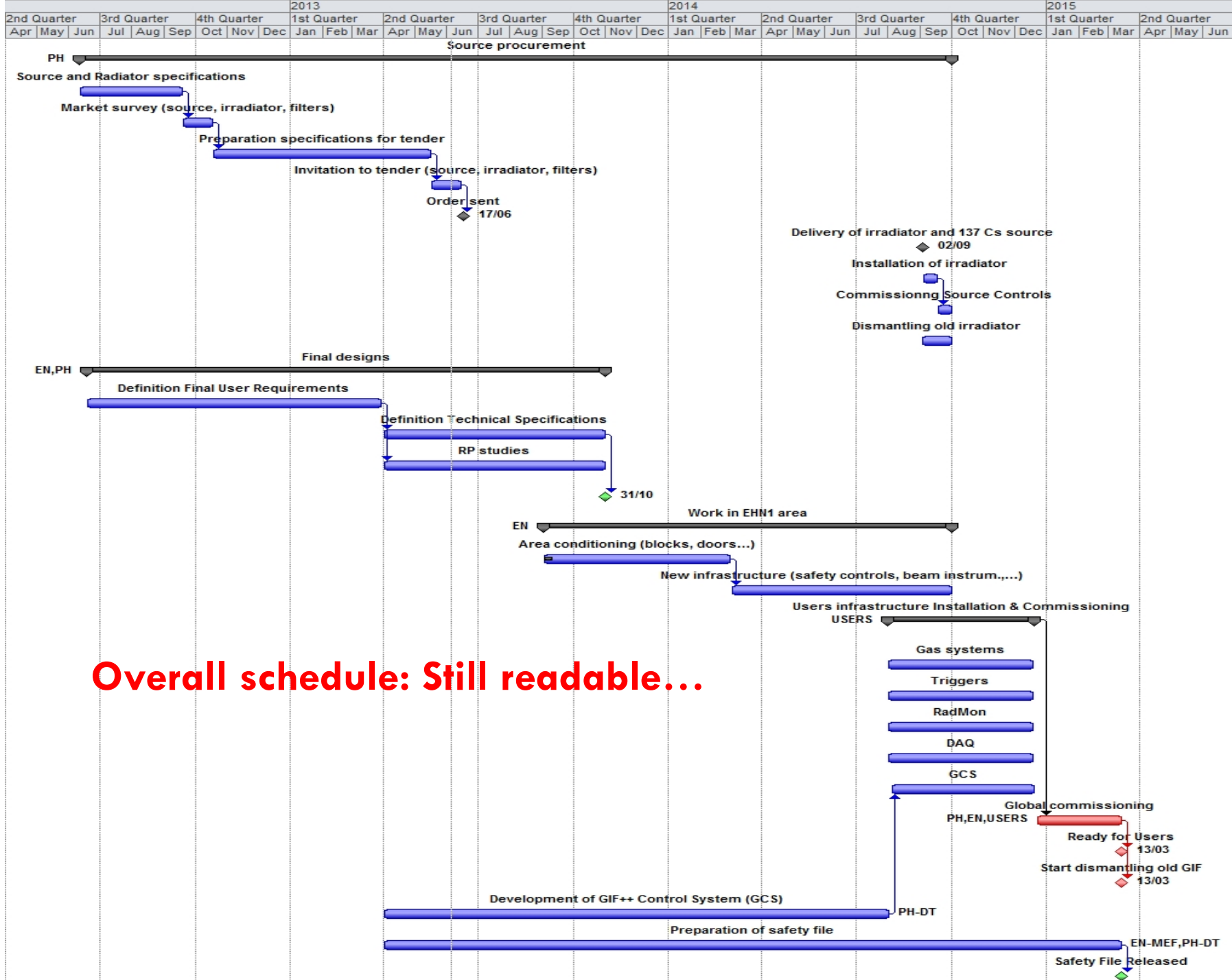
DOCUMENT CHECKED BY:  
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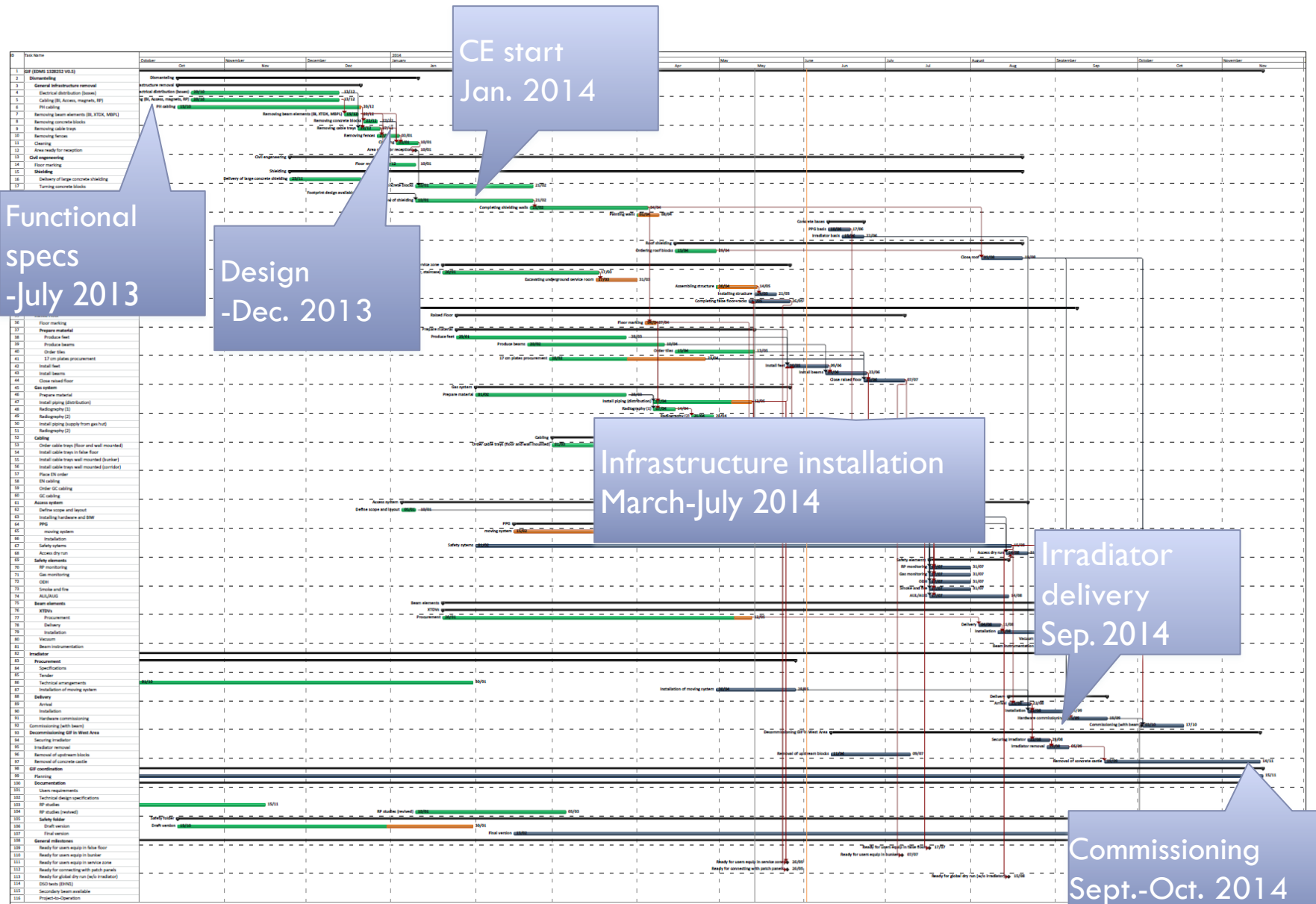
Checked by :  
A. Fabich – EN/MEF  
F. Ravotti – PH/DT

Approved by :  
M. Capeans – PH/DT  
I. Efthymiopoulos - EN/MEF



**Overall schedule: Still readable...**

# Construction schedule: less readable...



# GIF++ Construction Overview



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**Services area: June 2014**

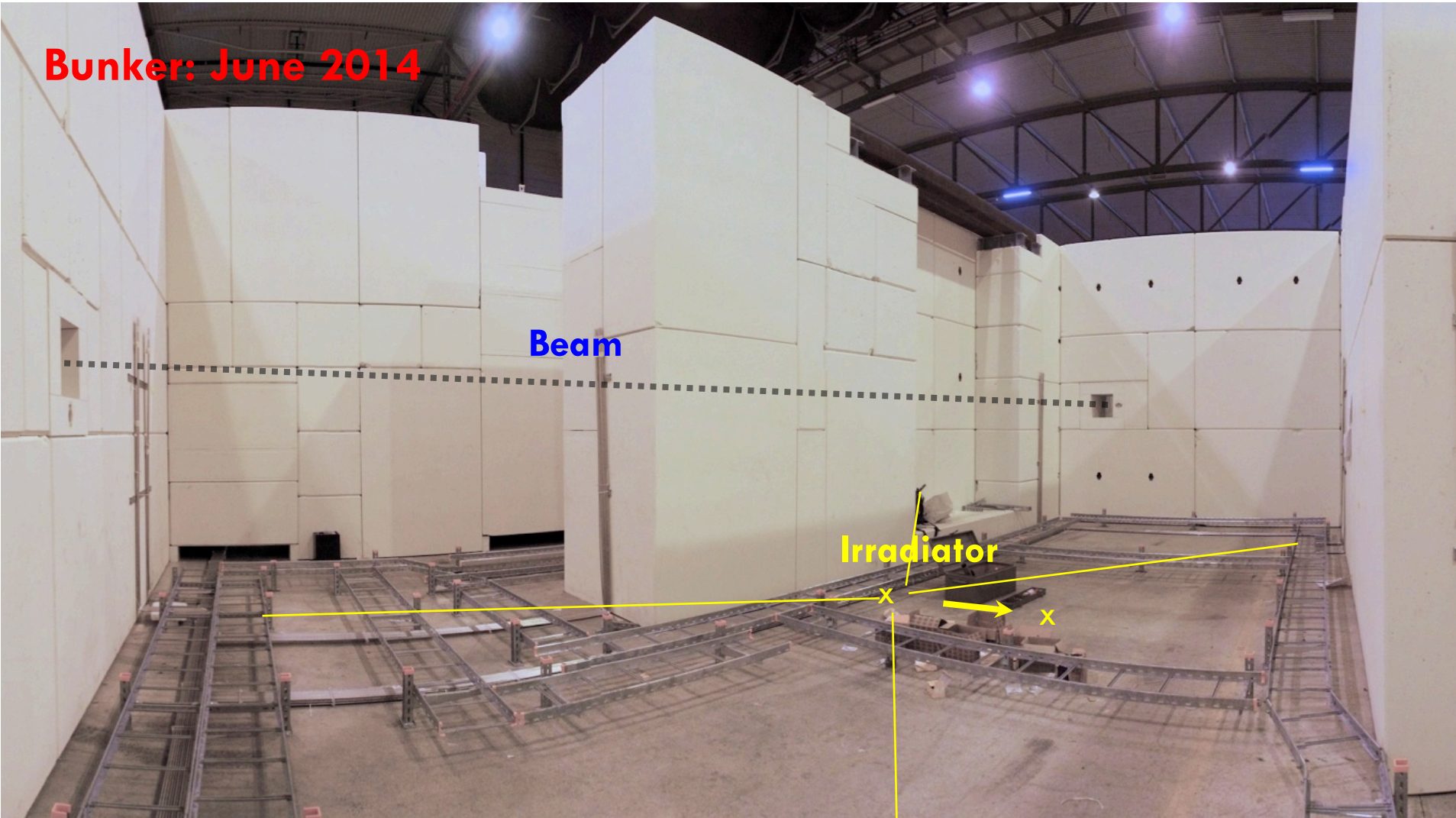


# GIF++ Construction Overview



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**Bunker: June 2014**



# GIF++ Construction Overview



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**EHN1: June 2014**





# GIF++ Schedule

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- Late September : Arrival of new irradiator  
(Start of dismantling of old facility in mid-September)
- Early October: First part of commissioning: Irradiator & attenuator controls, access system, safety systems, gas system
- 16. October to 2. November : No access  
(CMS-ECAL beam-time)
- 1-2. December: First dedicated beam time for GIF++  
(Second part of commissioning: Trigger system, DAQ)
- Early 2015 : User operation



# Summary



# GIF++ Highlights

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- GIF++ will be a unique place where high energy charged particle beams from H4 are combined with a 14 TBq  $^{137}\text{Cs}$  source
- High energy Muon beam from T2 target available 6-8 weeks per year for GIF++ as main user, around 30% of the SPS operation time parasitical use of halo muon beam
- The 100 m<sup>2</sup> GIF++ irradiation bunker has two independent irradiation zones, making it possible to test real size detectors of up to several m<sup>2</sup> as well as a broad range of smaller prototype detectors and electronic components



# GIF++ Highlights

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- Both irradiation fields ( $\pm 37^\circ$ ) equipped with independent attenuator systems that allow to tune the gamma flux individually (reduction between 1 and 46400)
- Irradiator on both sides equipped with exchangeable angular correction filter
- Fixed installed beam-trigger and cosmic-trigger
- Central Control System
  - Records environmental parameters, beam parameters, filter settings, gas
  - Provides interlocks (e.g. for wrong gas mixtures)
- Wide range of available gases (including custom gases), gas patch panels in bunker and service zone

# GIF++ Summary



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- GIF++ well on track to be fully operational early next year !
- Allocation of space and access to the inside of the bunker will be done via the IMPACT tool ([impact.cern.ch](http://impact.cern.ch)). You can already start to fill in activity requests.
- For staying informed, please subscribe to [GIF-active-users](mailto:GIF-active-users@cern.ch) e-group ([e-groups.cern.ch](http://e-groups.cern.ch))
- For questions about radiation time, please contact [IMPACT-GIF-Coordination@cern.ch](mailto:IMPACT-GIF-Coordination@cern.ch)

**THANK YOU**

**FOR YOUR ATTENTION!**