The new IRRAD facility at CERN

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*… presenting the work of many contributors to the **East Area Upgrade** construction project at CERN*
EN holds the overall projects leadership

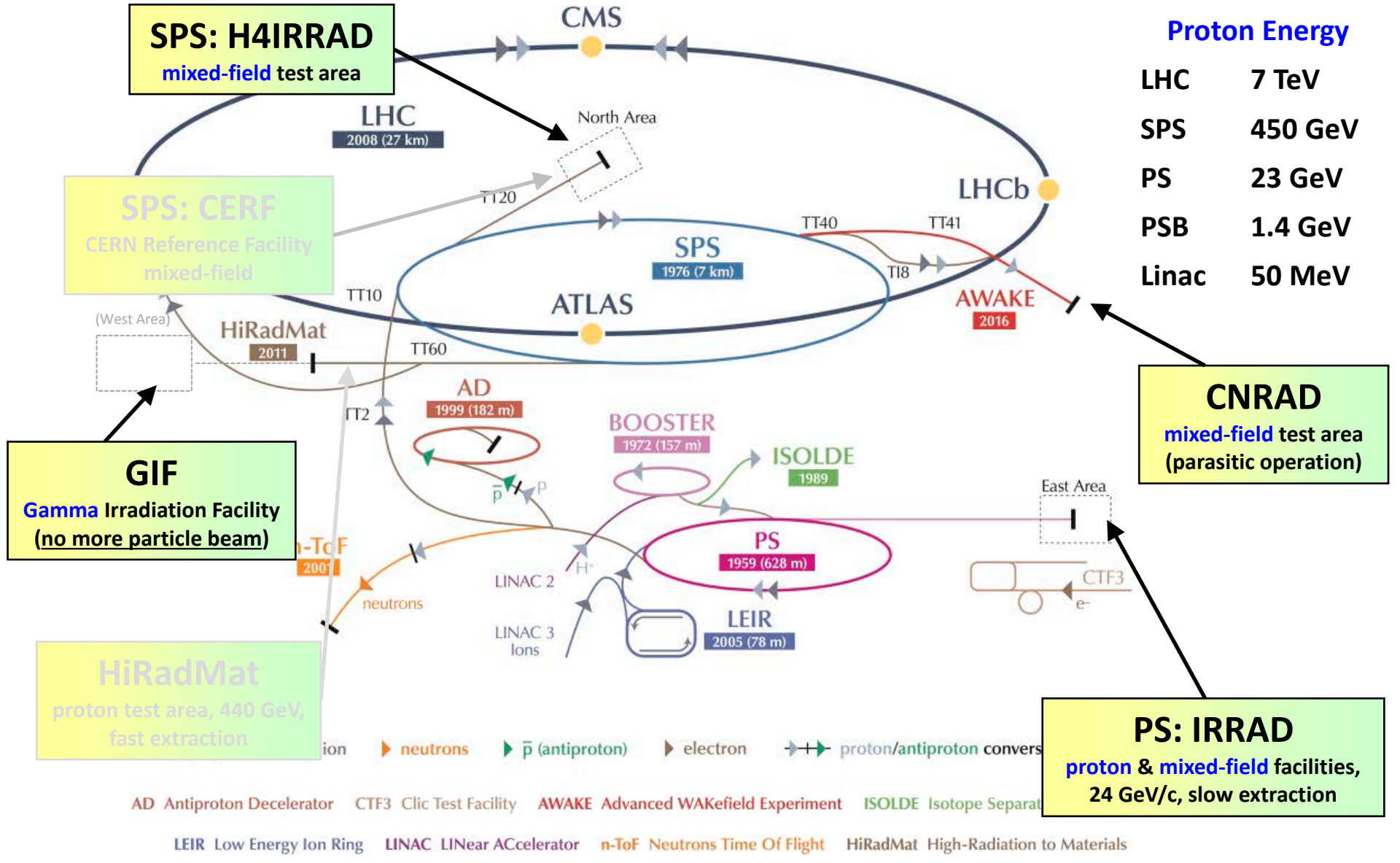
Core teams: ***EA Upgrade Project:*** *D. Brethoux, R. Froeschl, L. Gatignon, M. Lazzaroni, et al.*
R2E Project: *M. Brugger & J. Mekki, et al.*

CERN groups:
EN-MEF *and* ***EN-STI*** *(core teams),* ***HSE*** *and* ***EN-HDO*** *(Projects Safety),* ***DGS-RP****,* ***EN-CV*** *(EA-IRRAD ventilation),* ***EN-HE*** *(exp. areas transports),* ***GS-ASE*** *(access control),* ***BE-BI*** *and* ***TE-CRG*** *(EA-IRRAD cryogenic system), …*

Summary

- Overview (and evolution) of Irradiation Facilities at CERN
- PS East Area Irradiation Facilities until 2012
- New PS East Area Irradiation Facilities (EA-IRRAD)
  - IRRAD Proton Facility
  - CHARM Mixed-Field Facility
- IRRAD Proton Facility Layout
- Conclusion

CERN Irradiation Facilities until 2012



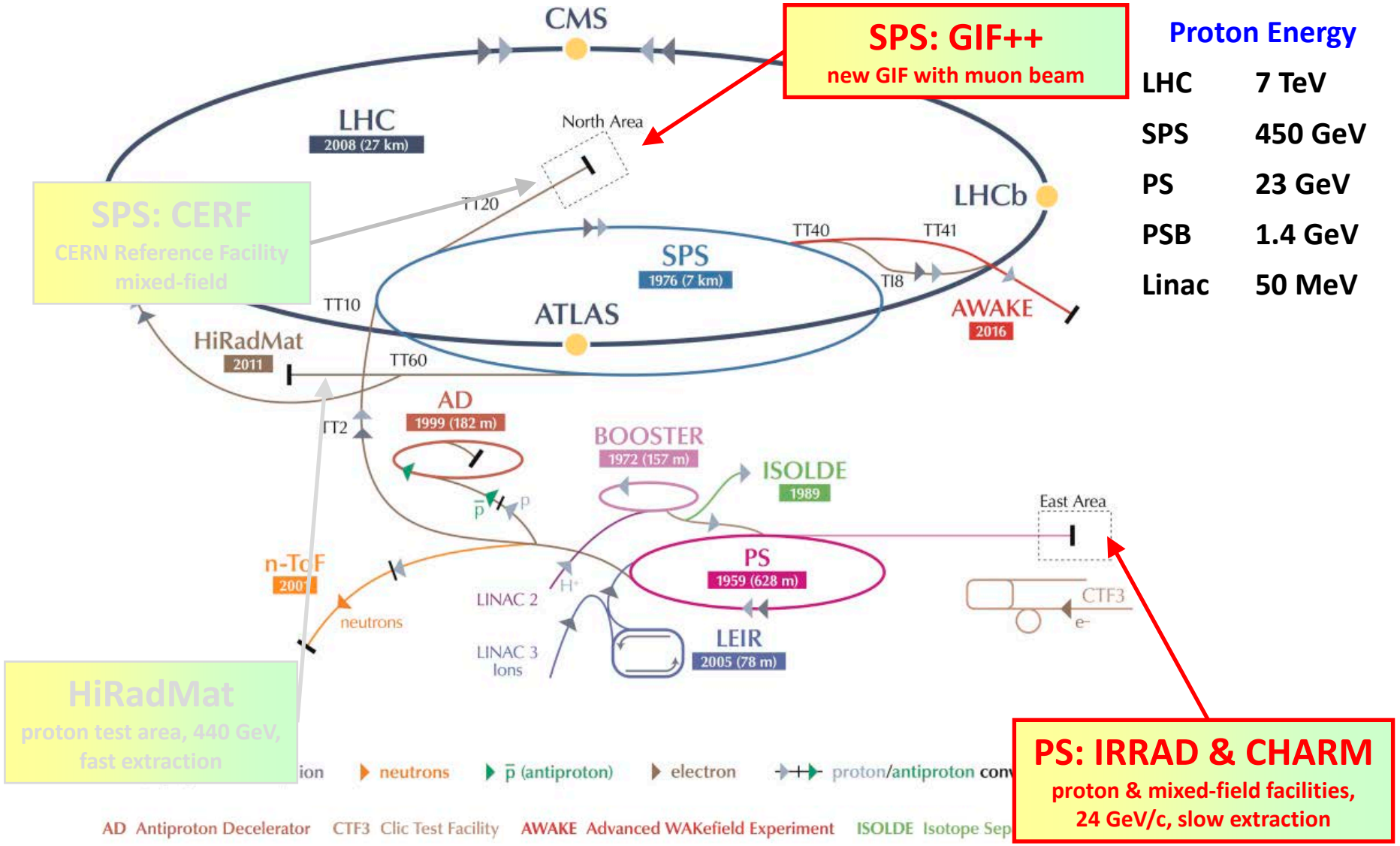
Proton Energy

LHC	7 TeV
SPS	450 GeV
PS	23 GeV
PSB	1.4 GeV
Linac	50 MeV

CNRAD
mixed-field test area
(parasitic operation)

PS: IRRAD
proton & mixed-field facilities,
24 GeV/c, slow extraction

CERN Irradiation Facilities from 2014



Proton Energy	
LHC	7 TeV
SPS	450 GeV
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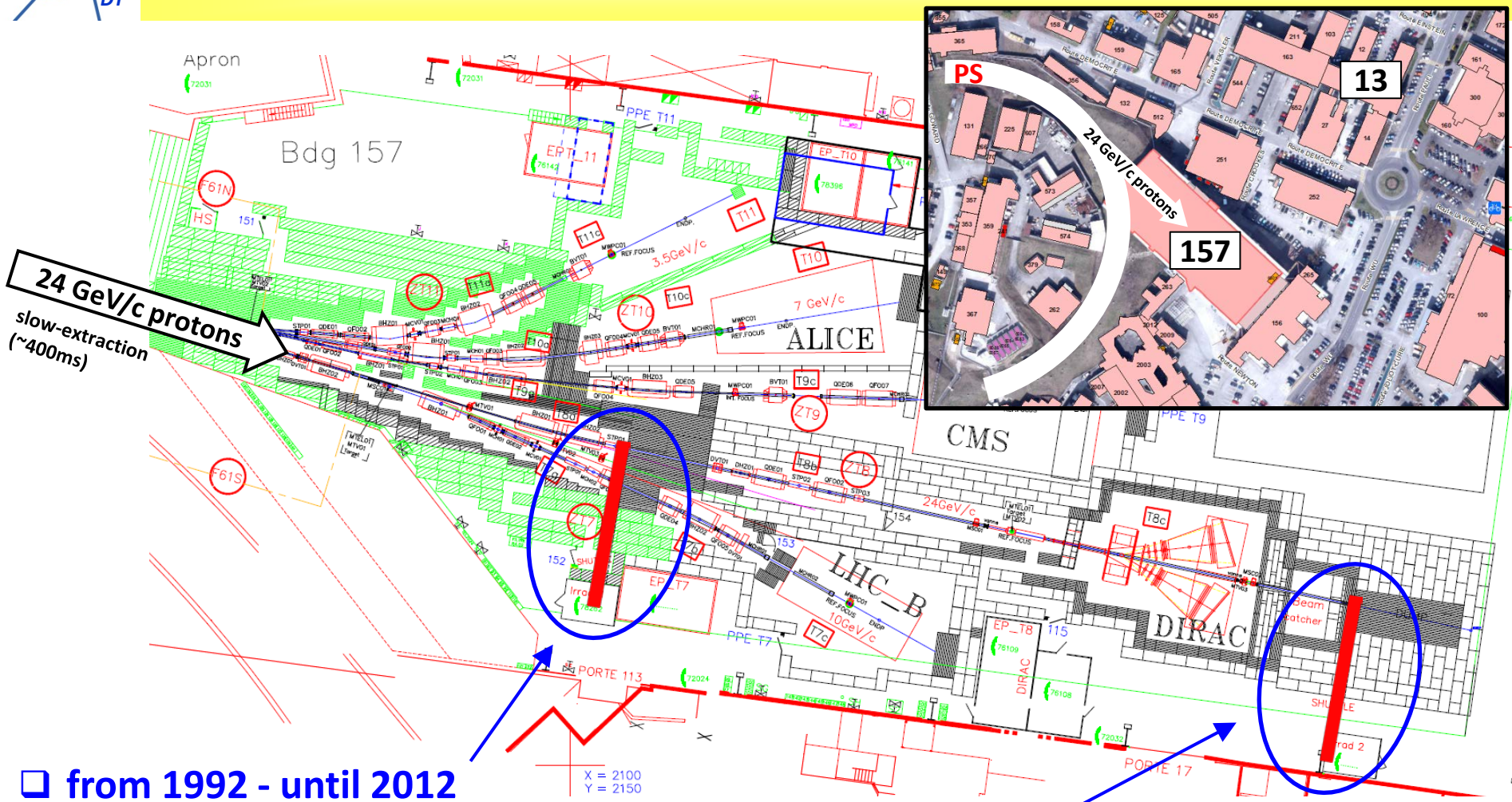
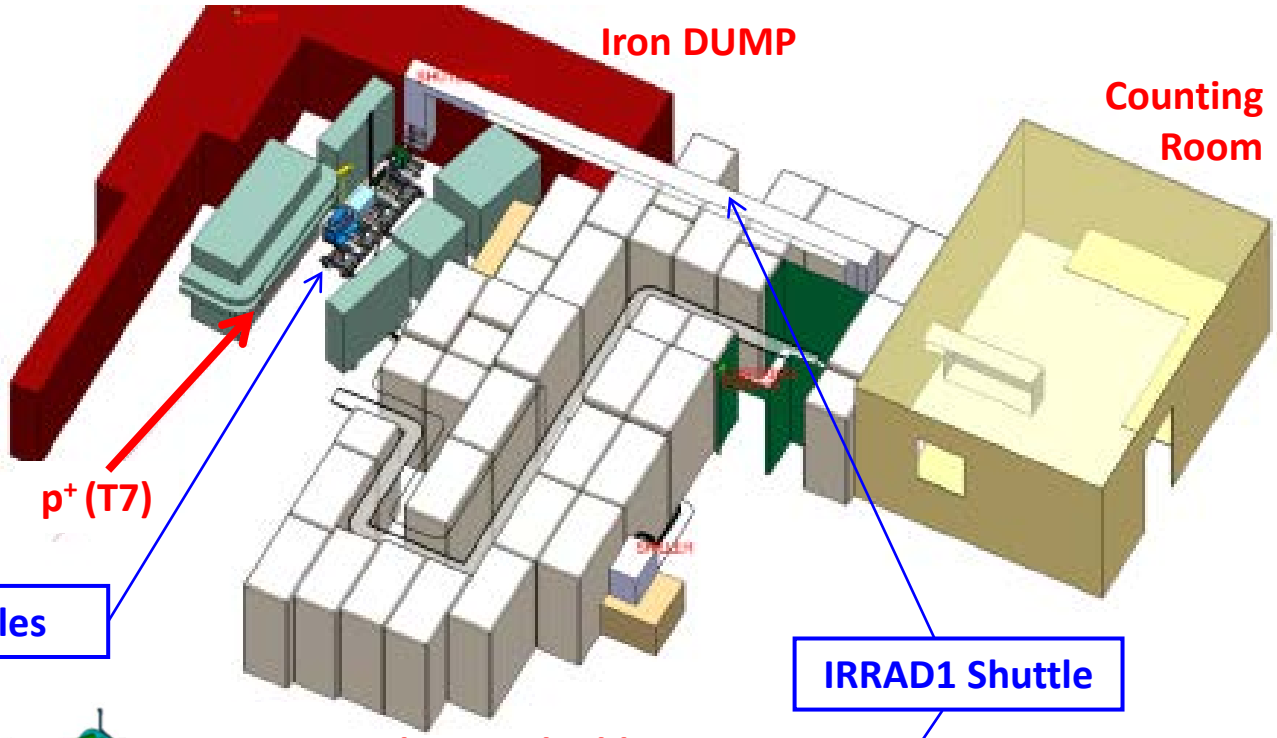
PS-EA Irradiation Facilities until 2012

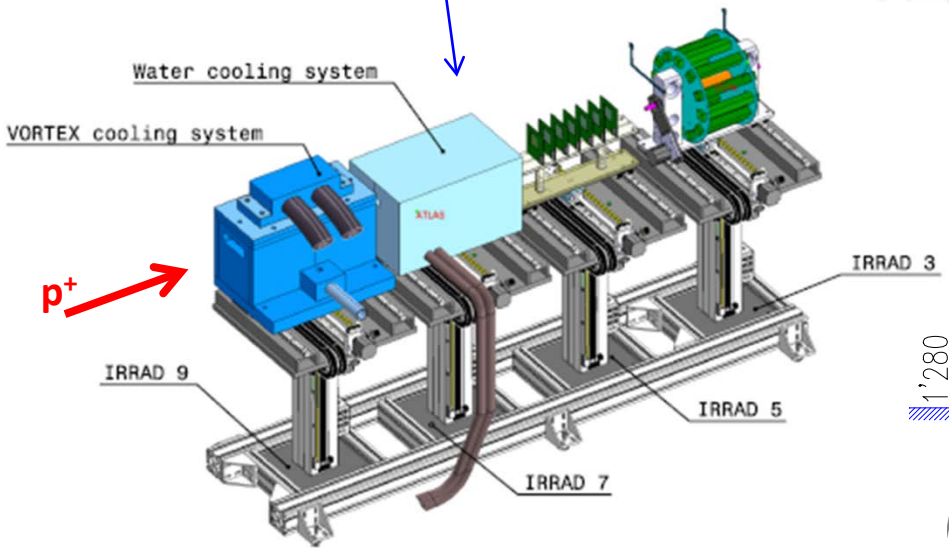


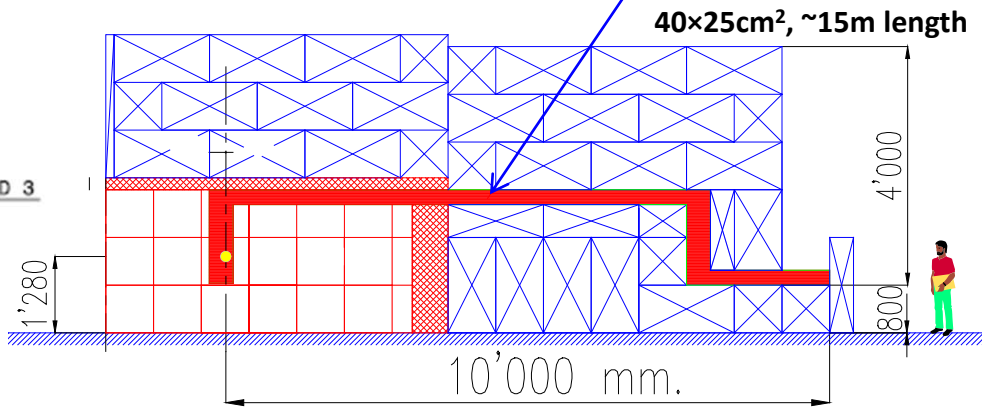
- **from 1992 - until 2012**
- **Proton irradiations (T7)**
  - **Primary 24 GeV/c proton beam** (IRRAD1, IRRAD3, IRRAD5, …)
- **Mixed-field irradiations (T8)**
  - **Mixed field produced in cavity** after **C** (50cm) - **Fe** (30cm) - **Pb** (5cm) **'target'** (IRRAD2)

Proton Irradiation Facility (2012)

- **Beam spot**
  12×12 mm² (FWHM)
- **Beam momentum**
  24 GeV/c
- **Proton flux**
  ~1×10¹⁶ p · cm⁻² 20days⁻¹
  (year average)



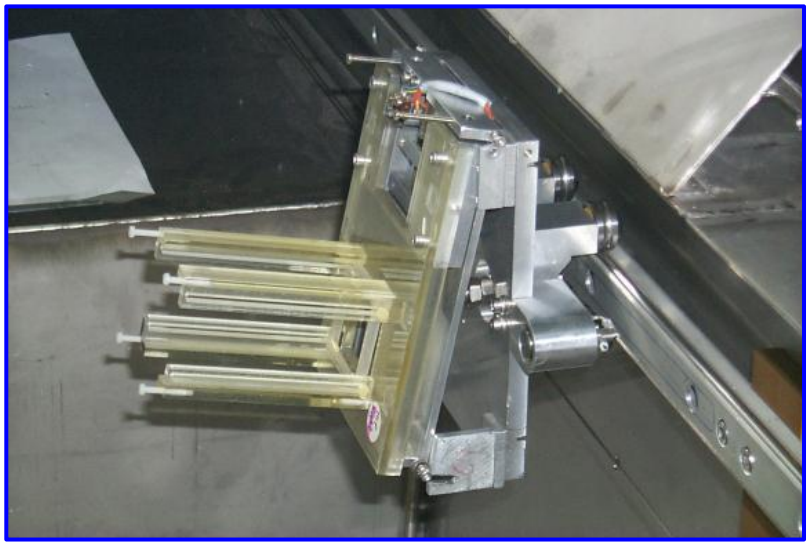


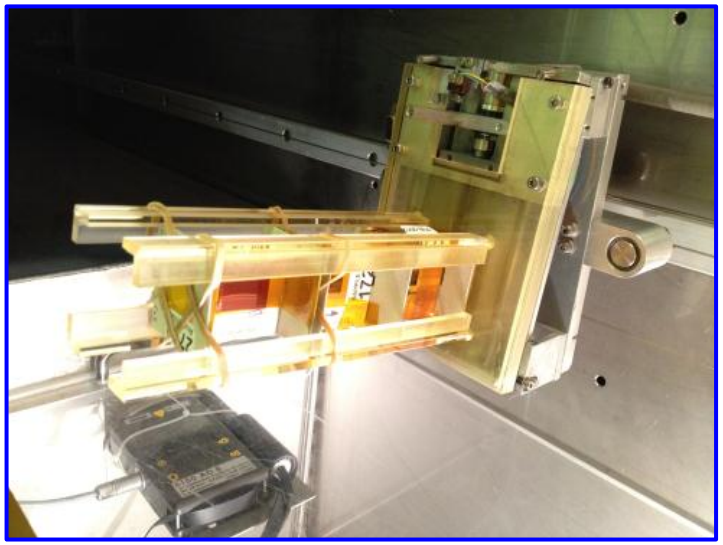


IRRAD1 Shuttle & IRRADx Tables

IRRAD1 Shuttle

V_{max}=5×5×15cm^3

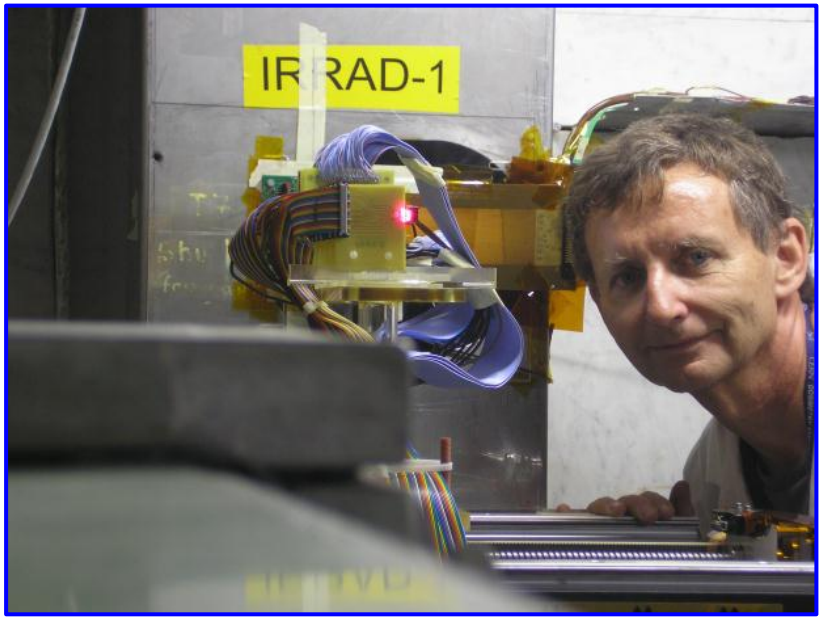


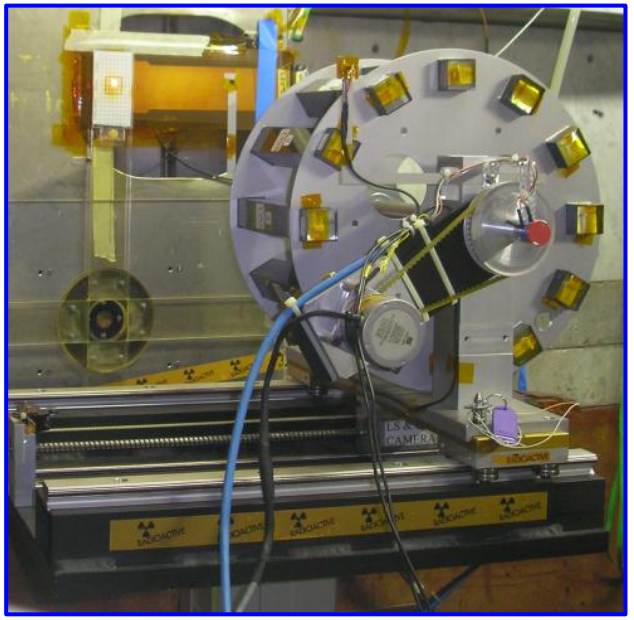


IRRAD3 & IRRAD7 Tables

V_{max}=20×20×50cm^3

scanning over surface

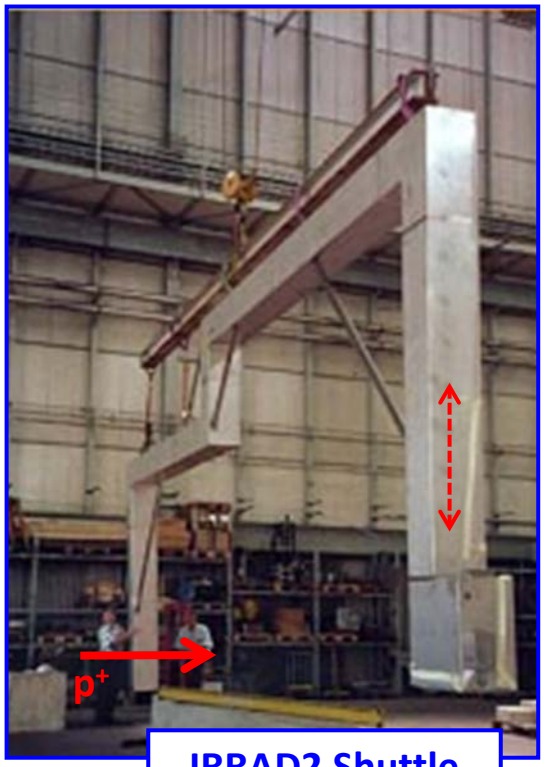




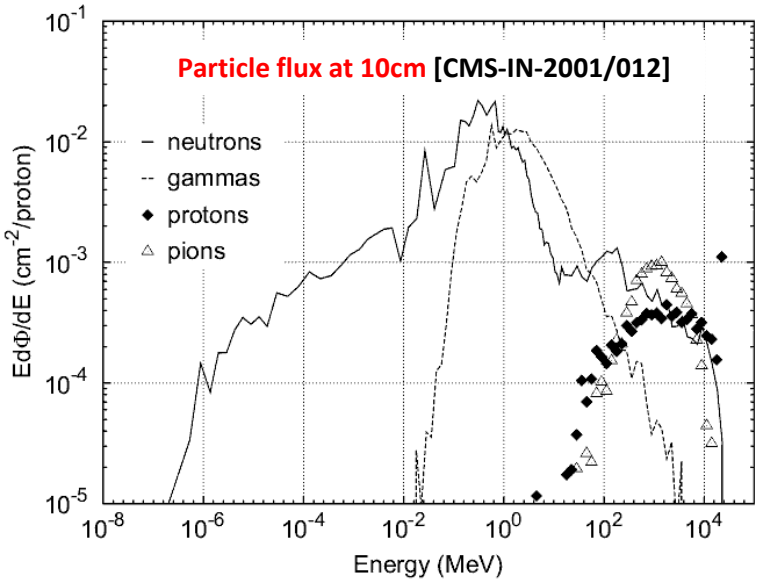
Mixed-field Irradiation Facility (2012)

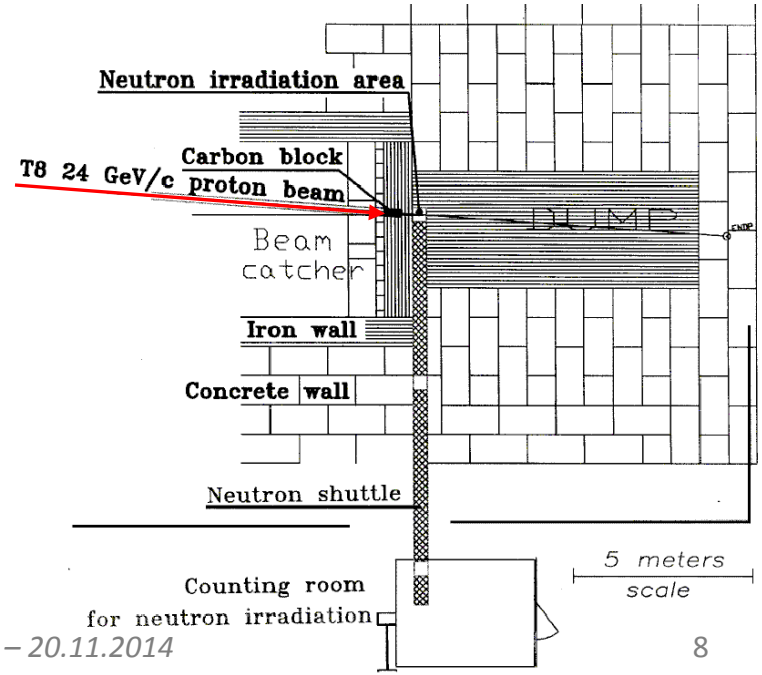
Secondary particles in a cavity (IRRAD2)

- 24 GeV/c proton beam on a C/Fe/Pb target
- **Small volume** (max ~30×30×30cm^3) behind DIRAC
- Spectrum & flux of ***n, p$^+$, π$^+$, π$^-$, γ*** simulated & measured
- **~1×10^{13} n$_{(E>1MeV)}$ cm^{-2} 5d^{-1}** @ 50cm from beam axis



IRRAD2 Shuttle

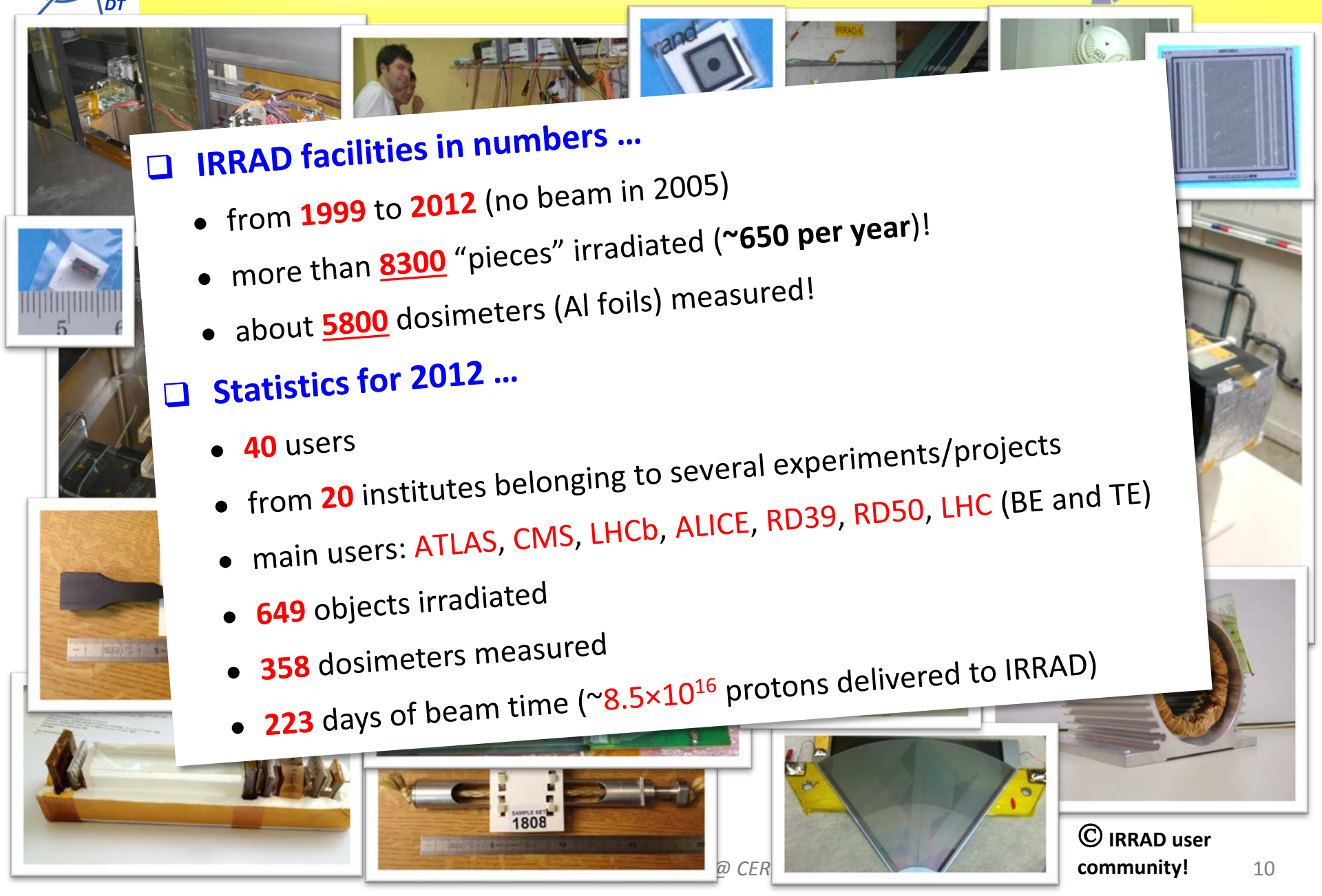




Past Irradiation Experiments

© IRRAD user community!

Past Irradiation Experiments



- **IRRAD facilities in numbers …**
  - from **1999** to **2012** (no beam in 2005)
  - more than **8300** "pieces" irradiated (**~650 per year**)!
  - about **5800** dosimeters (Al foils) measured!
- **Statistics for 2012 …**
  - **40** users
  - from **20** institutes belonging to several experiments/projects
  - main users: ATLAS, CMS, LHCb, ALICE, RD39, RD50, LHC (BE and TE)
  - **649** objects irradiated
  - **358** dosimeters measured
  - **223** days of beam time (~8.5×10^{16} protons delivered to IRRAD)

© **IRRAD user community!**

Drawbacks & Shortcomings

(of the old facilities / test areas with respect to future needs)

❑ Proton IRRAD Facility

- **Located in primary radiation area** (limited access: stop all beam lines of East Area for access)
- **Limited space** (ALARA, difficult to scan beam over big objects, backscattered particles)
- **Limited flux of primary protons** (weakness of the shielding)
- **Safety standards to be improved!**

❑ Mixed-field IRRAD Facility (behind DIRAC)

- **No irradiation positions lateral to target** (missing an important 'particle mix' component)
- **Limited intensity** (present flux not interesting for inner detector community)
- **Too little space and limited accessibility** (access only via shuttle system!)
- **Parasitic to DIRAC operation**
  - ➢ **IRRAD Facilities were located in different beam lines: competing for beam!**

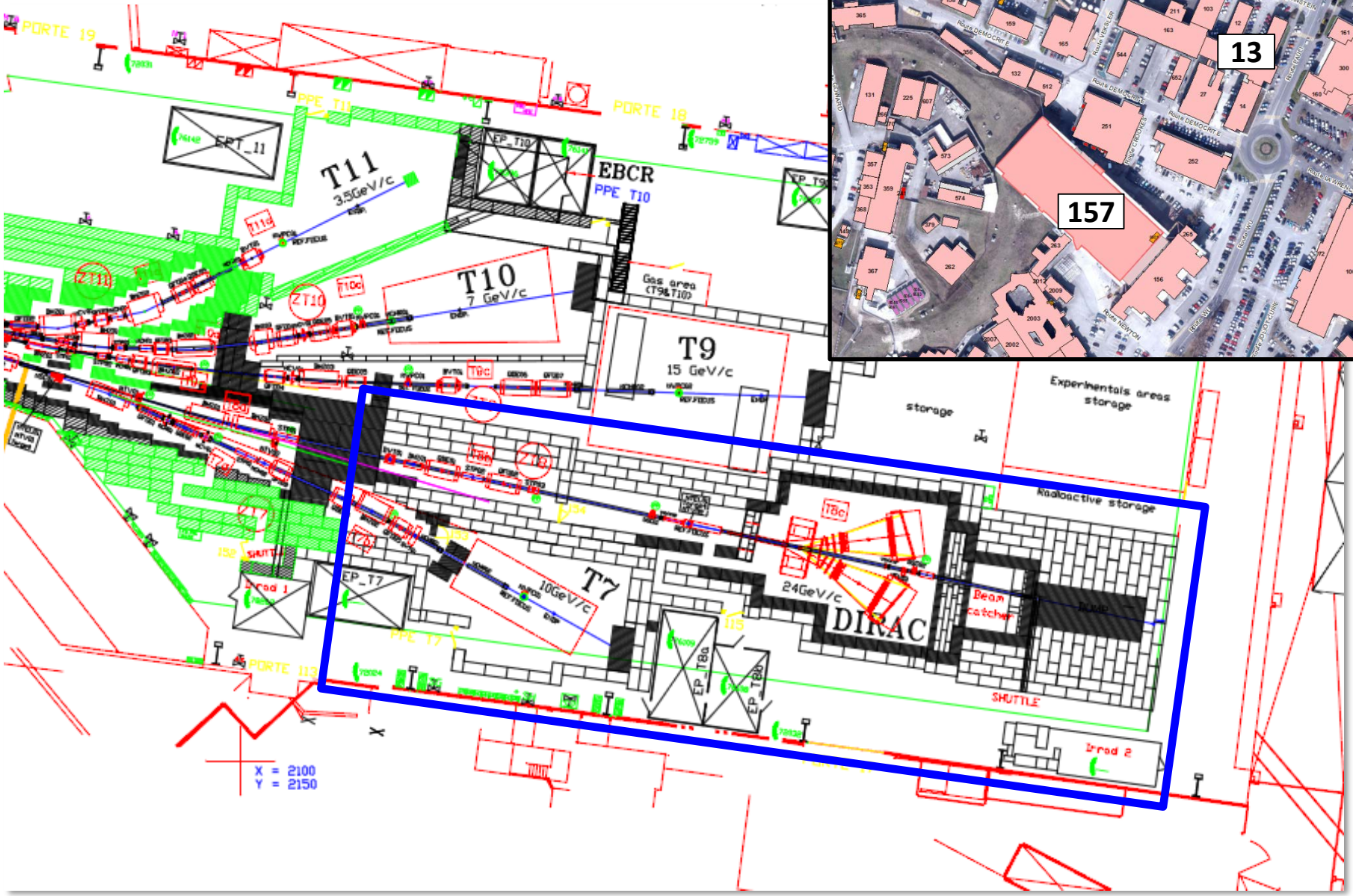
❑ Mixed-field H4IRRAD/CNRAD Test Areas

- CNRAD **not operational** after 2012
- **Limited accessibility** ("ad-hoc installations", lack of flexibility, access required **shielding removal**)
- **Limited** control on **beam intensity**

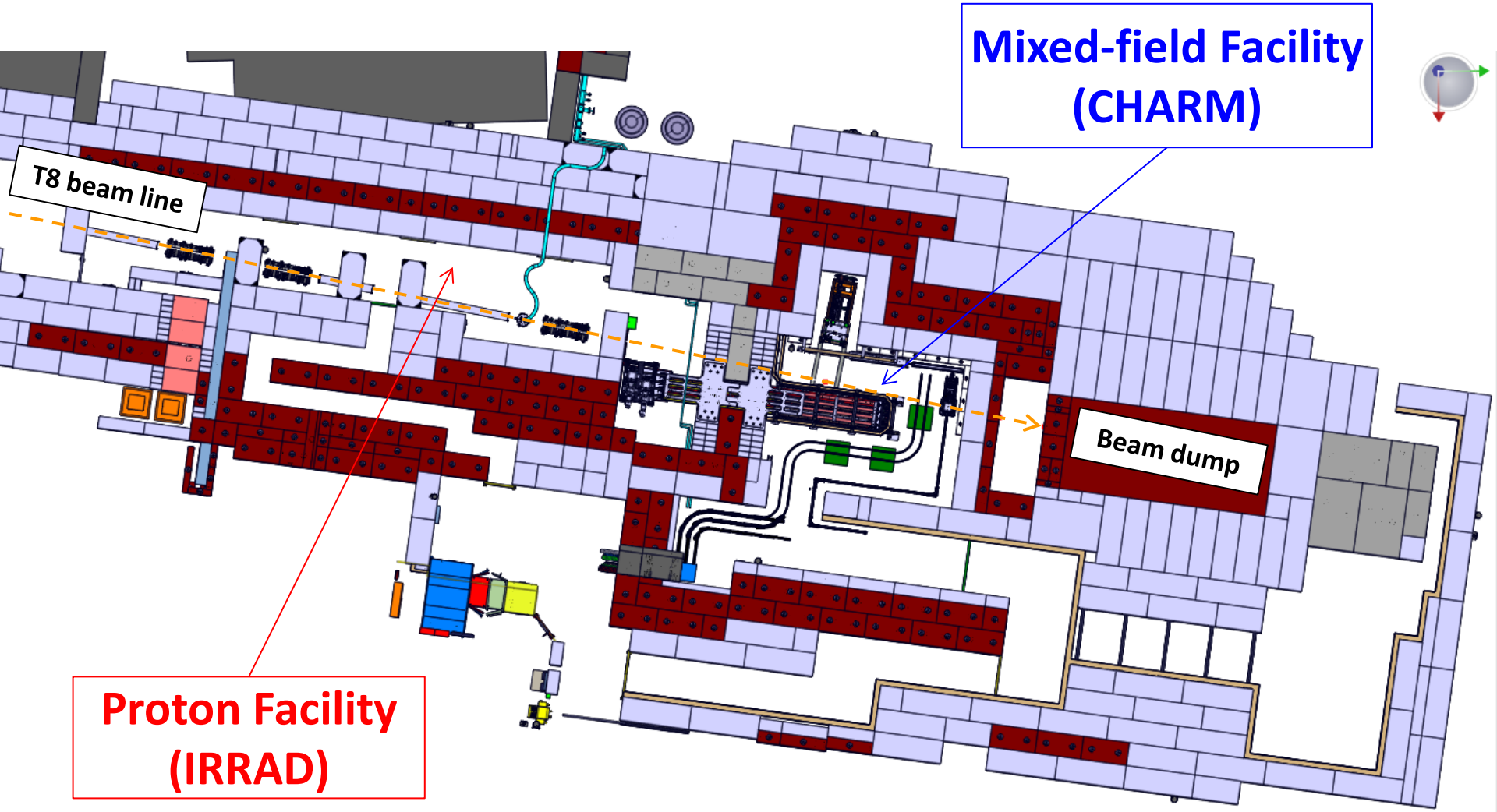
Towards a new EA Irradiation Facility

- **2012: CERN management agrees on EA facilities upgrade**
  - CERN-EN is charged and funded to design and construct the irradiation beam line in the framework of the **EA renovation plan during LS1** (PL: *Lau Gatignon*)
  - CERN-PH through AIDA EU FP7-founded project (Task 8.3)
- **19 Nov. 2012: first technical meeting on upgrade**
  - **R2E project (LHC machine): Mixed-field facility & infrastructure design**
  - **CERN-PH & AIDA: Proton facility & infrastructure design**
- **26 Nov. 2012: last day of operation for the DIRAC experiment**
- **July 2013: dismantling DIRAC & old IRRAD1 and IRRAD2 Facilities**
- **Nov. 2013: removal of IRRAD2 target & beginning of construction**
  - **R2E project: Cern High-energy AcceleRator Mixed-field facility (CHARM)**
  - **CERN-PH & AIDA: proton IRRADiation facility (IRRAD)**
- **10 Oct. 2014: first pilot beam in the new EA-IRRAD facility for commissioning**
- **17 Nov. 2014: first irradiation experiments**

OLD East Area Layout



NEW East Area IRRAD Layout



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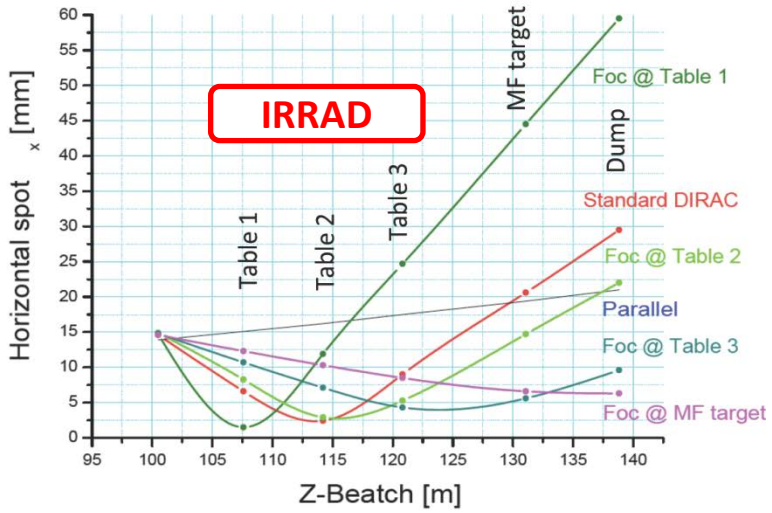
24 GeV/c Proton Beam Parameters

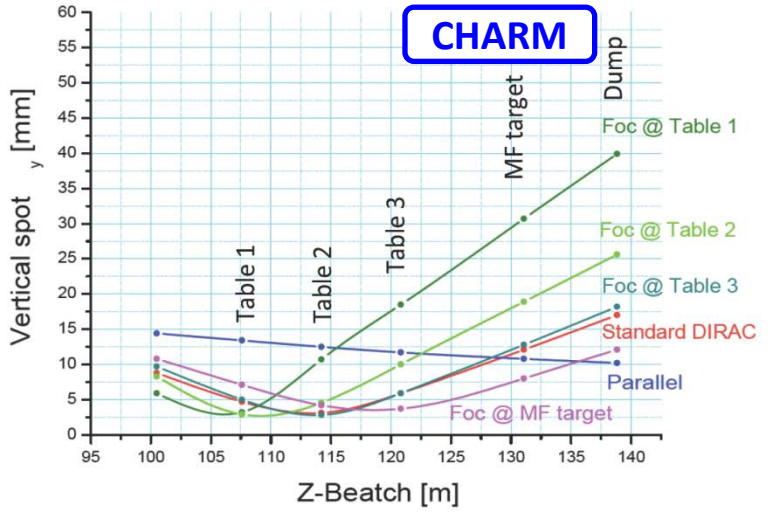
❑ Beam dimensions

- **several optic variants possible on T8**
- standard size: **12x12 mm² (FWHM)**
- spot size from **5x5 mm²** to **20x20 mm² (FWHM)**

❑ Beam intensity (estimations)

- p^+ are delivered in "spills" of ~5×10^{11} p
- number of spills/frequency depends on CPS
- **Typical CPS from 2014: 30s**
- **Typical figures (High Intensity)**: 3 spills per CPS
  - **~1×10^{16} p cm^{-2} 5days^{-1}** (12x12 mm² FWHM)
  - **~4x more than the old facilities**
- **Design figures (maximum):** 6 spills per CPS
  - **~1×10^{17} p cm^{-2} 4days^{-1}** (5x5 mm² FWHM)





© **L. Gatignon, preliminary calculations (EDMS 1270807)**
Here dimensions are mm (RMS)

Ventilation System

❑ Ventilation system (CERN EN/CV)

- area confinement (under-pressure) for air activation, ozone formation, temp. control, etc.
- air **re-circulated during operation** (through filters) and **flushed before access**
- integration of ducts through the shielding:

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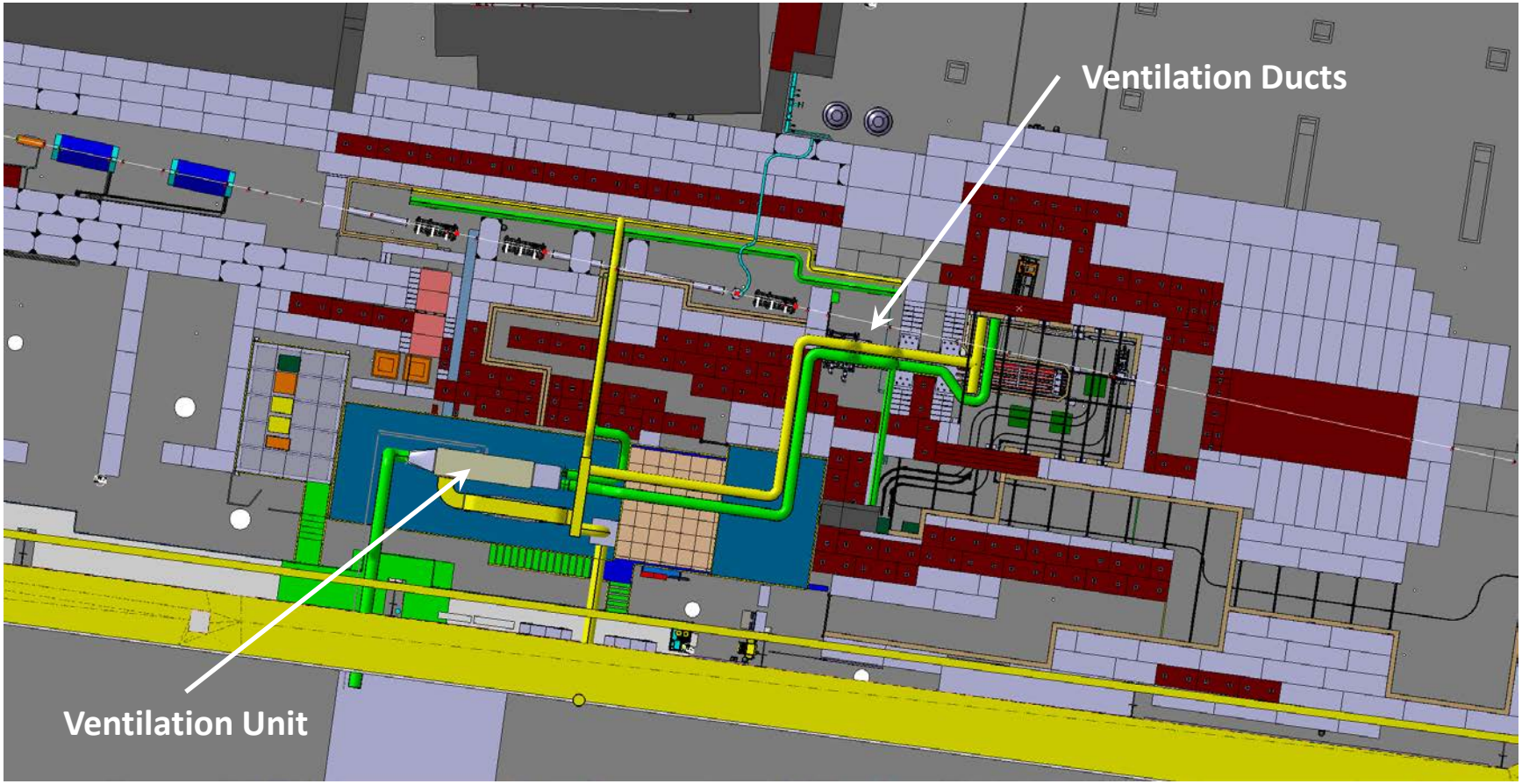
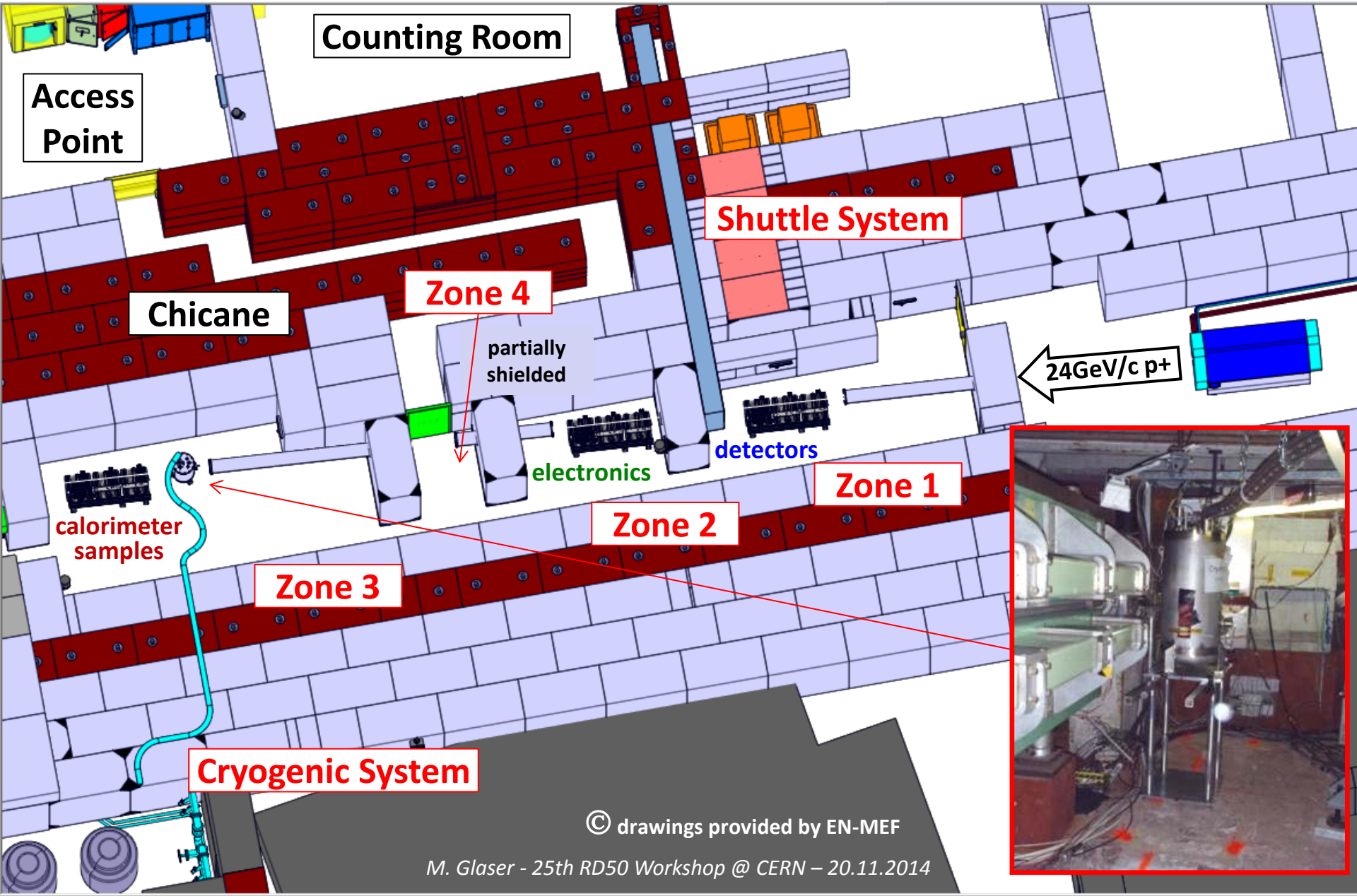


Proton IRRAD Facility (PH)

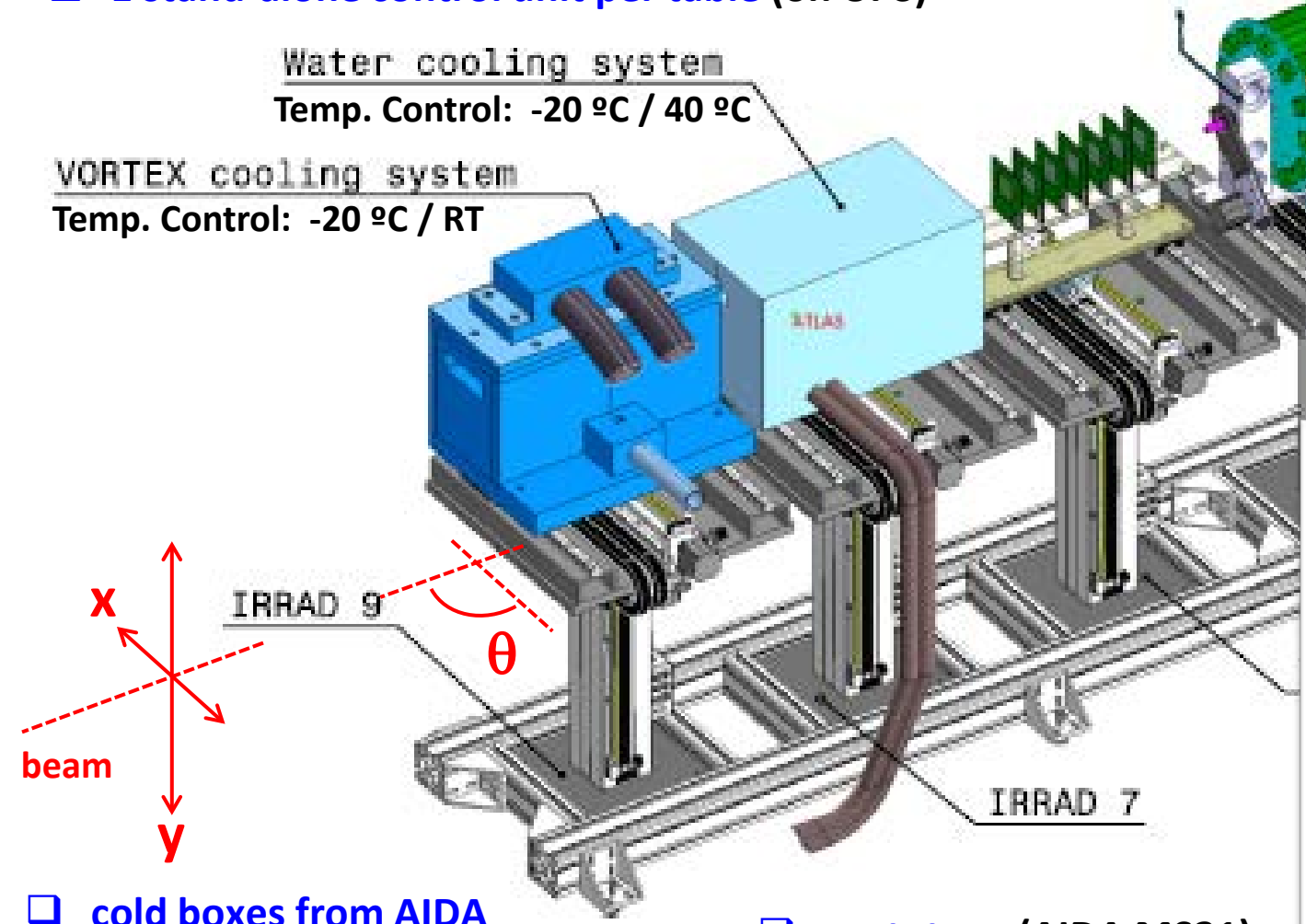


Proton IRRAD Shuttle System

- mainly “passive” samples
- possibility to irradiate samples under bias

IRRAD Remote-controlled Tables

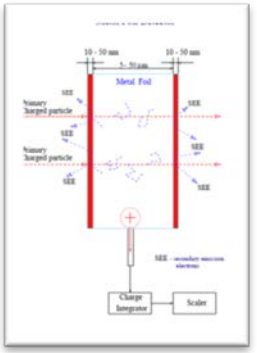
- 3 tables per IRRAD zone; DUTs powered and cooled
- 1 stand-alone control unit per table (on UPS)

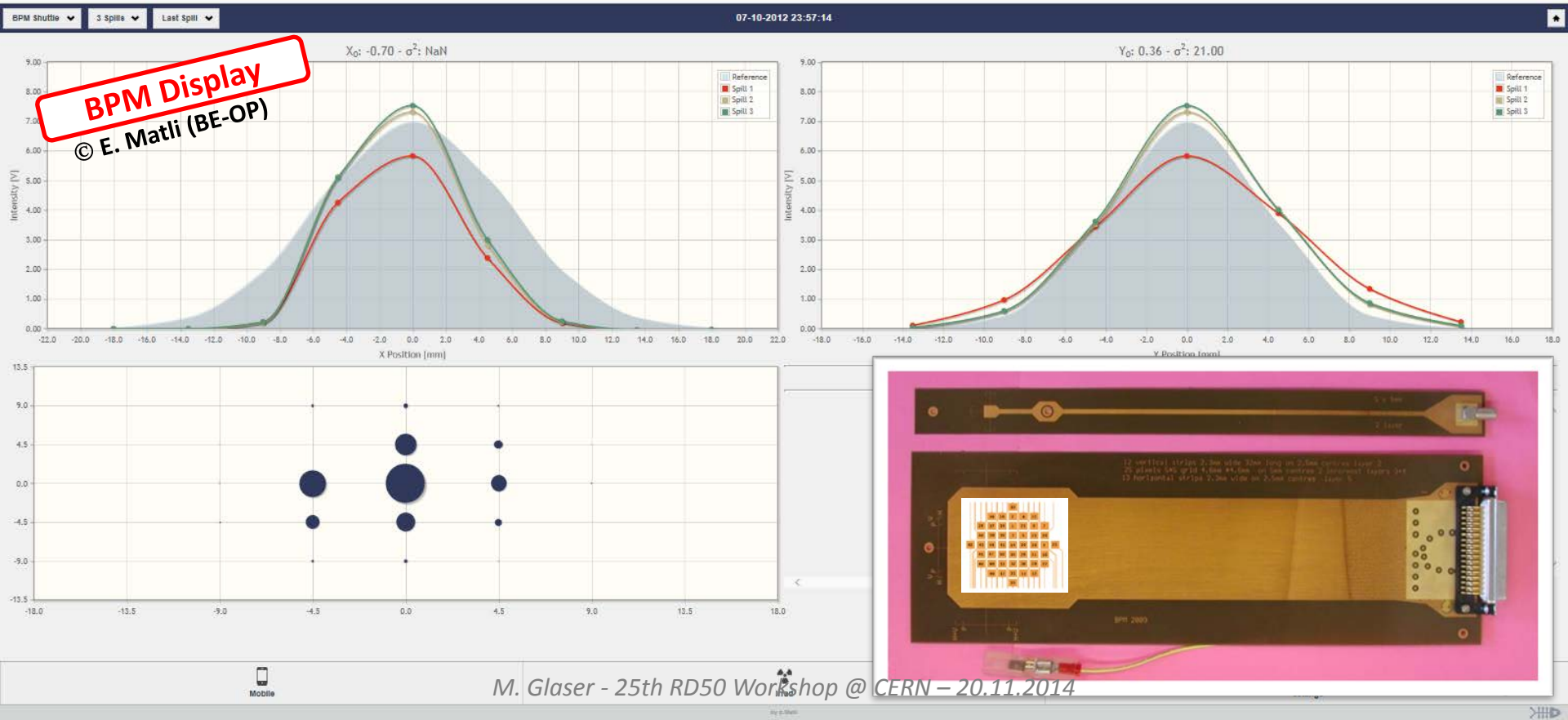


- cold boxes from AIDA (WP8.3.2 QMUL/Sheffield)
- prototype (AIDA MS31)

IRRAD Beam Instrumentation & DAQ

- **New Beam Position Monitors (Metal Foil Detectors)**
- **New Web-application**
  - display **Beam Profile Monitor** data (for IRRAD users and CERN CCC)
  - new database for data storage (ORACLE); can display multiple BPM devices
  - flexible display also for other IRRAD data: **SEC counters**, **table/shuttle positions**, **T.**, …





"CryoBLM" Setup

- **Setup for irradiation in cryogenic conditions (1.8K/4.2K)**
  - clone of the system used for "*CryoBLM*" (BE-BI) experiment in 2012
  - cryogenic line "embedded" in the shielding; bigger cryostat
- **Cryogenic system operated by TE-CRG**
  - manual refilling; dewar outside rad. area
  - installed on a **movable irradiation table**

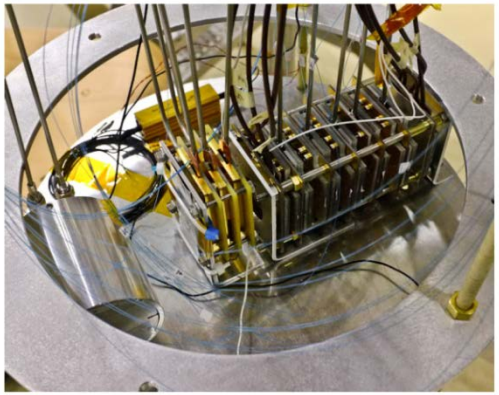
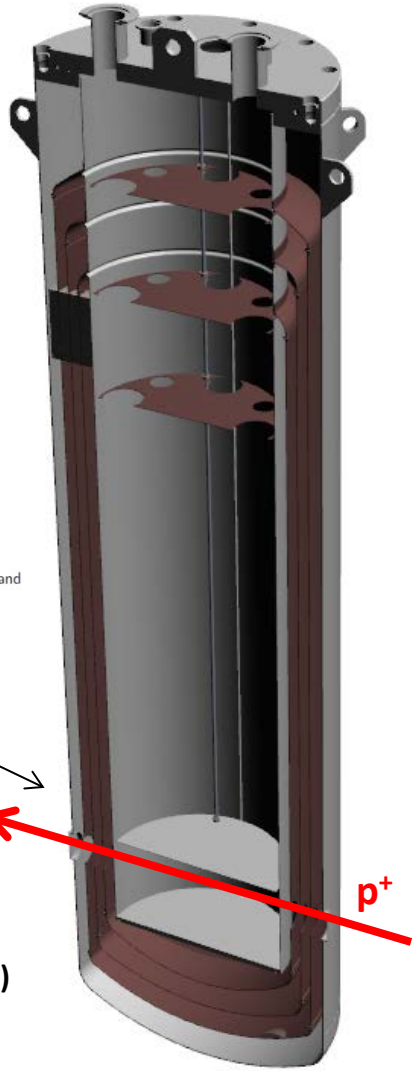


Figure 6.16: Detector modules mounted on the support plate and ready for cooling down and irradiating.



© Bernd Dehning (BE-BI)

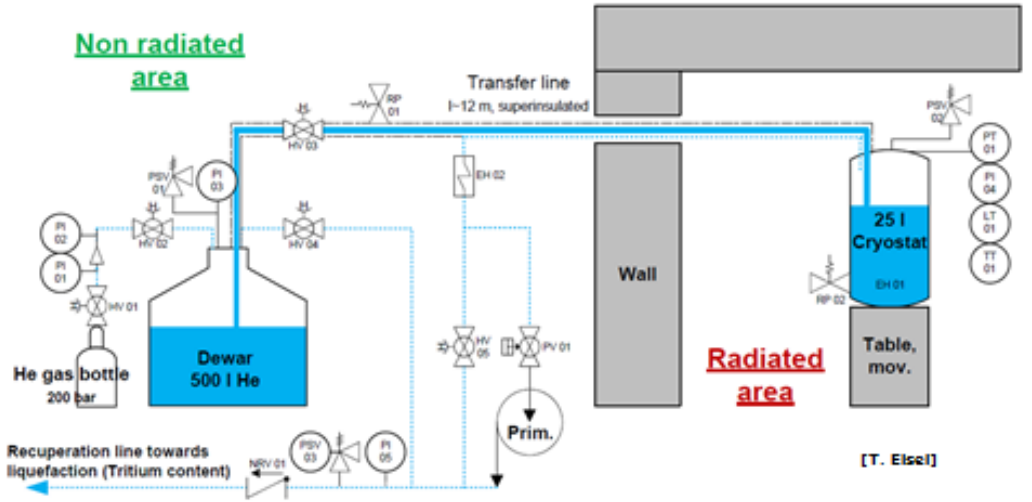
Marcin Ryszard Bartosik (BE-BI)

Christoph Kurfuerst

Thomas Eisel and TE-CRG

Past installation - overview

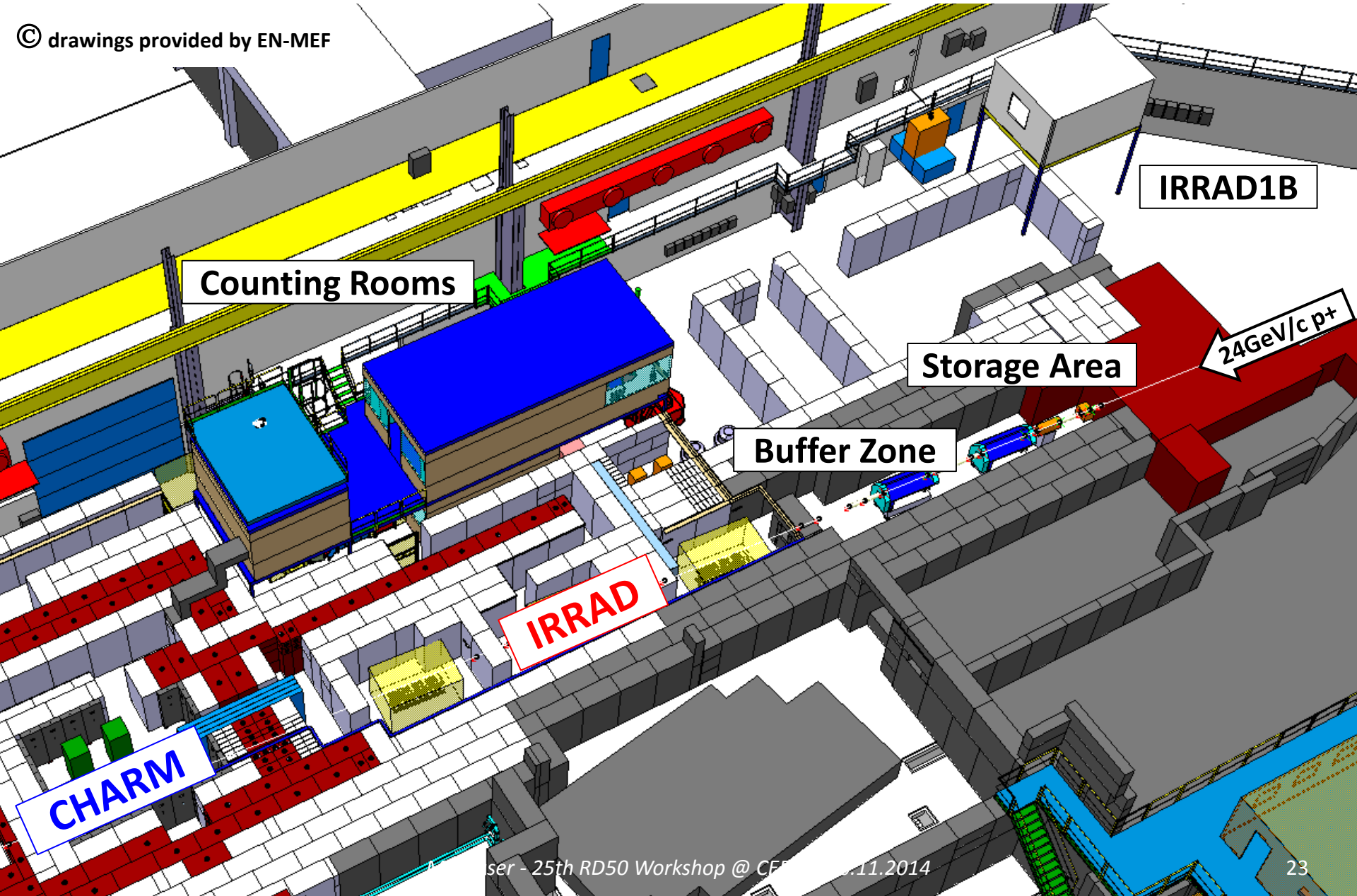
- P&I Diagram
  - Manual refilling
  - Temperatures between 1.8 K and 4.2 K



New IRRAD Facility

Counting Room

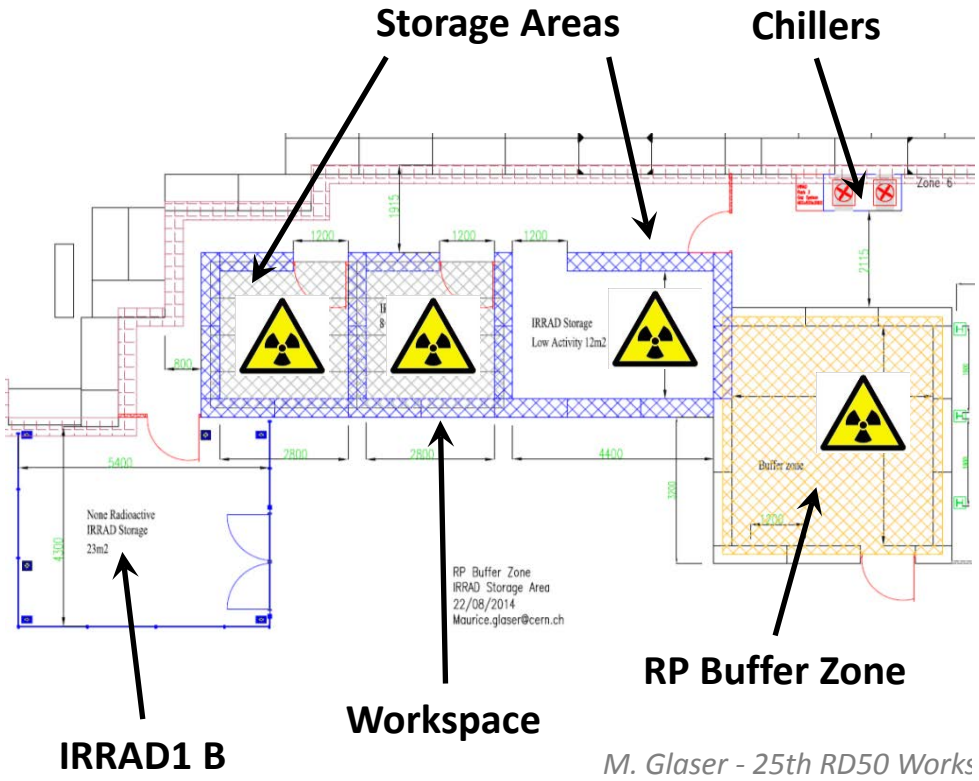
East Area EA-IRRAD Infrastructure

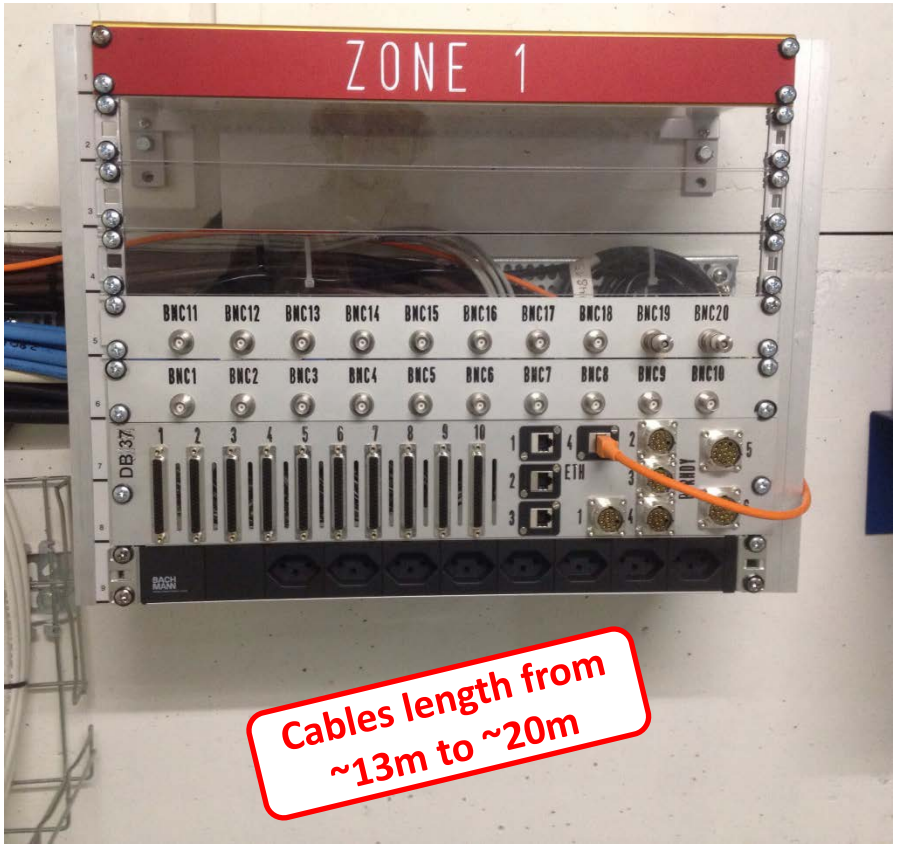


Proton IRRAD Infrastructure

❑ Storage area

- shielded zones for **cool-down** and **storage at room and low temperature** of IRRAD (and CHARM) irradiated equipment
- workspace to handle and **perform (setup) measurements** on irradiated equipment

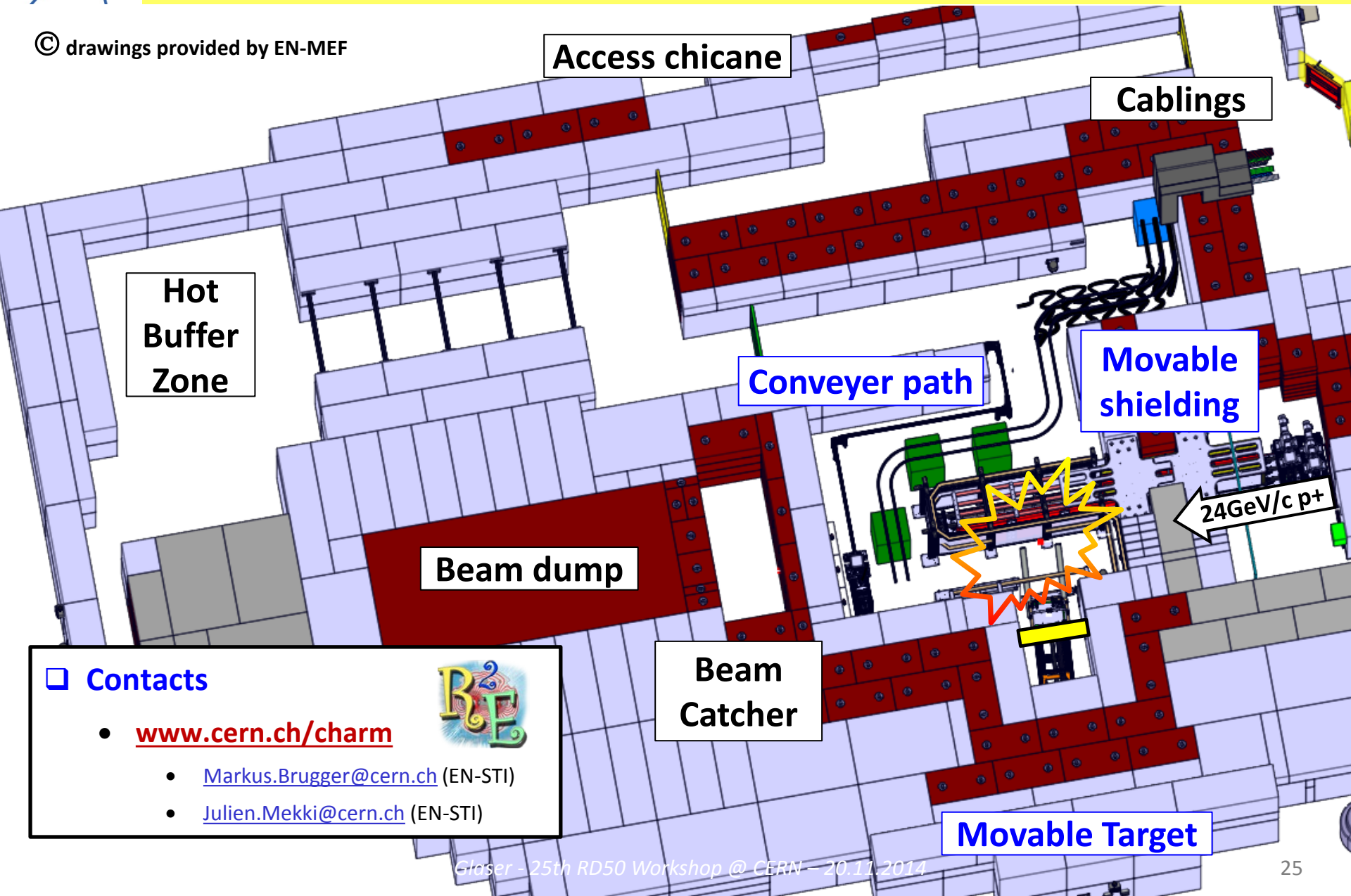




❑ Fixed cabling/piping infrastructure

- **4 Patch-Panels** installed along IRRAD
- twisted-pairs, coaxial, power HV/LV, …
- space for **custom users-cabling** (optical fibers, etc..)

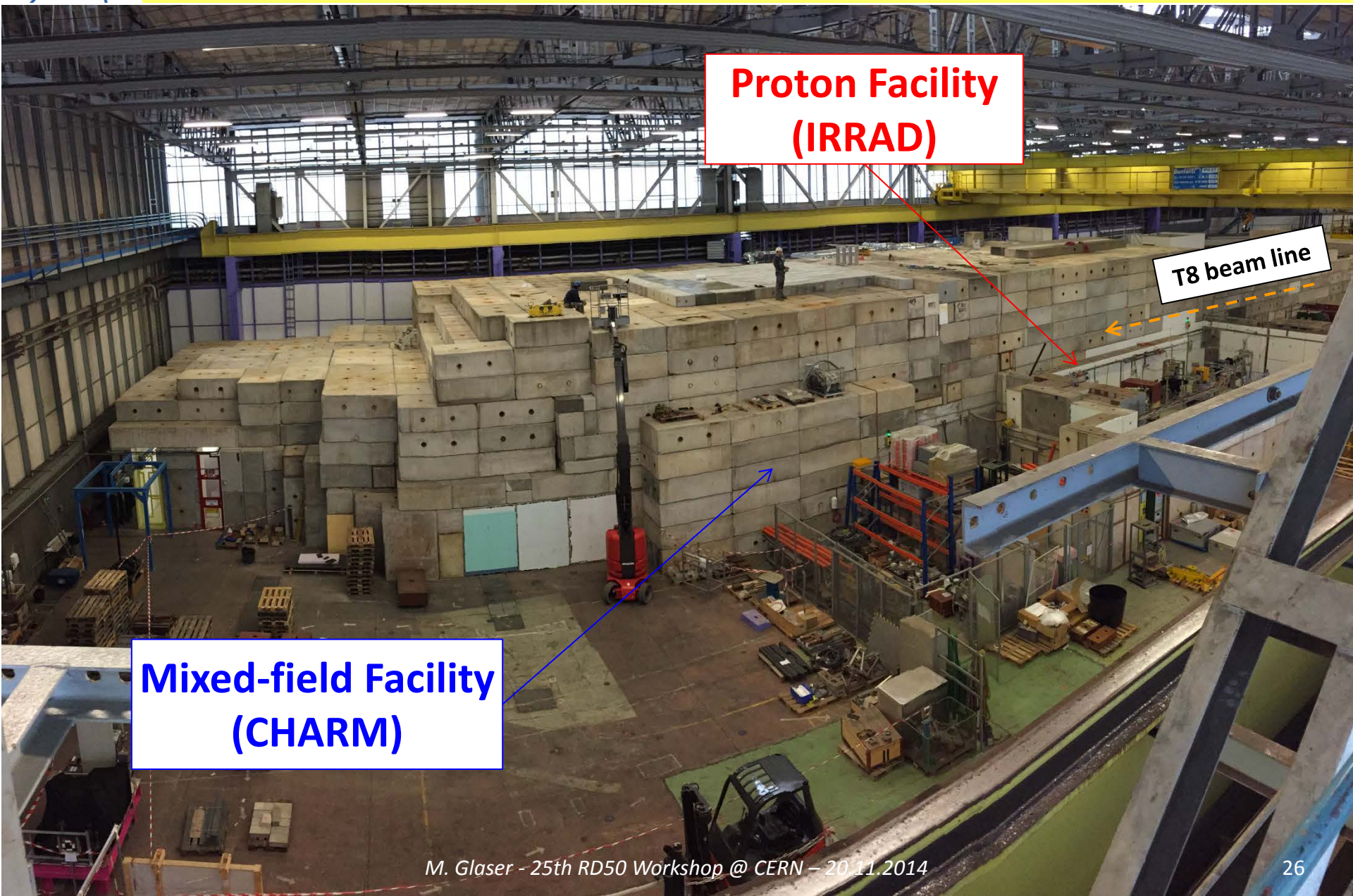
Mixed-field CHARM Facility (EN)



❑ **Contacts**

- www.cern.ch/charm
  - Markus.Brugger@cern.ch (EN-STI)
  - Julien.Mekki@cern.ch (EN-STI)

EA-IRRAD Aerial View



Summary

- **New EA-IRRAD facility is now being commissioned (fully operational in 2015)**
  - Experimental community (PH): **Proton** facility (**IRRAD**)
  - Accelerator community (EN): **Mixed-field** facility (**CHARM**)
- **IRRAD Proton Facility in 2014**
  - 2 Tables operational (no cooling): IRRAD 7 & IRRAD 9
  - Limited time/space (16 experiments registered!)
- **More to come in 2015**
  - IRRAD1 Shuttle System
  - Additional tables, cooling systems
  - Users space for testing irradiated samples
  - Storage area being assembled
  - …
- **New web-site**
  - www.cern.ch/ps-irrad