Towards DRD on Calorimetry Infrastructure and beam test needs

Roman Pöschl

2nd Calorimeter Community Meeting – April 2023

Testbeam facilities – Prologue

- Let us first thank the beam test and radiation facilities operators and the lab and institute managements for the availability of the facilities

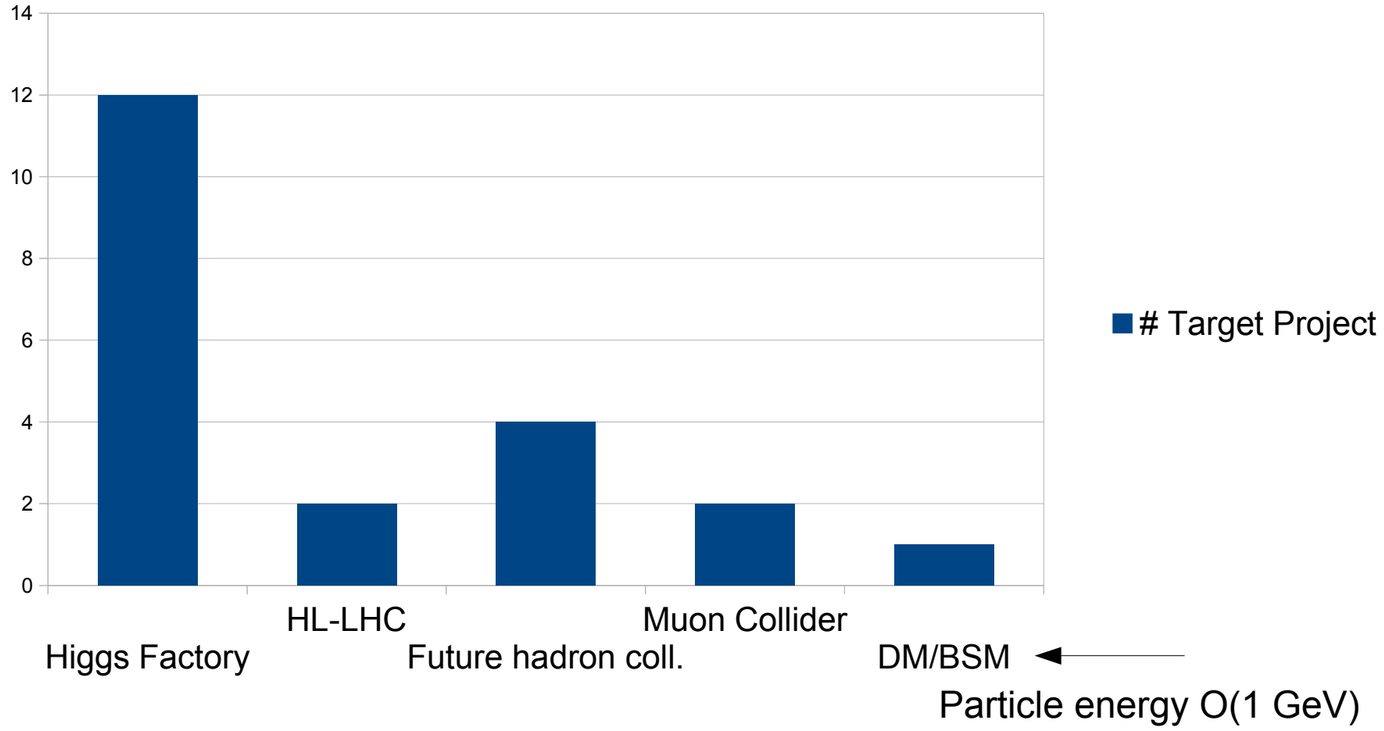
- The following is a mix of information extracted from the input proposals and my own experience and observations

- Let me thank Barbara Holzer of CERN, Marcel Stanitzki of DESY and Carsten Hast of SLAC for having replied immediately to my questions

- A lot of input for this talk came also from the ongoing 11th BTTB Workshop at DESY
  - https://indico.cern.ch/event/1232761/

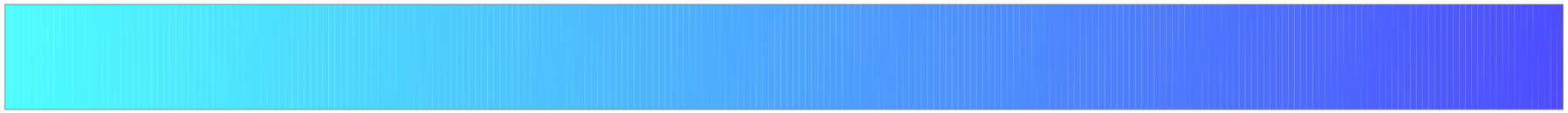
Input proposals and beam tests

- 19 of 23 input proposals have declared that the devices are going to be tested in beam test (no surprise)
- (Main) target projects of input proposals (partially double counted, not mutually exclusive)



- Higgs factories dominate
  - HF includes heavy flavor that target superb elm. energy resolutions
- (Already now) orientation towards future hadron collider and muon collider

Input proposals - “Testbeam schedule”

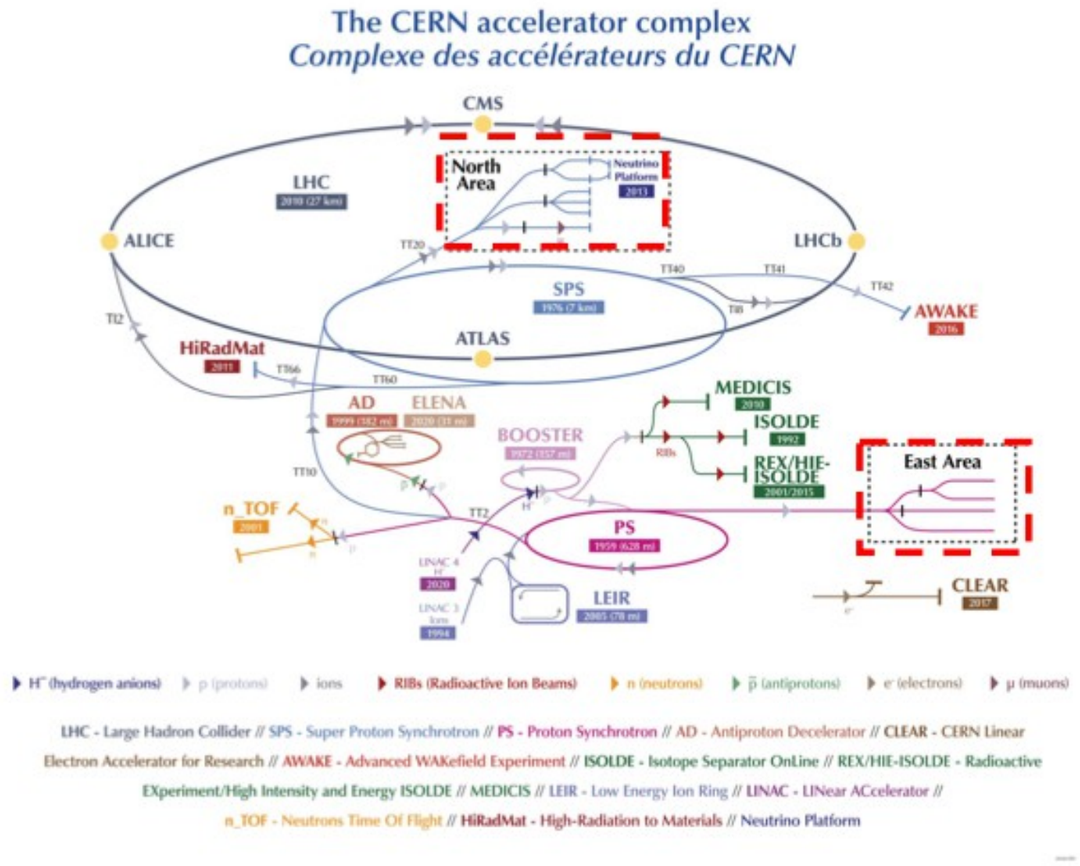


- Input-proposals reveal (relatively) little need at the beginning
  - Start with prototypes that are either existing or currently under construction
  - Benefitting from AIDAinnova and EUROLABS funding
- Relatively high density of beam tests with new (large scale) prototypes after 2025
- The large scale beam tests will be preceded by smaller scale beam tests
  - Individual layers smaller systems before “mass production”

Testbeam facilities – CERN

E.G. Parozzi, 11th BTTB Workshop

CERN Accelerator Complex



Maximum Momenta at the accelerator:

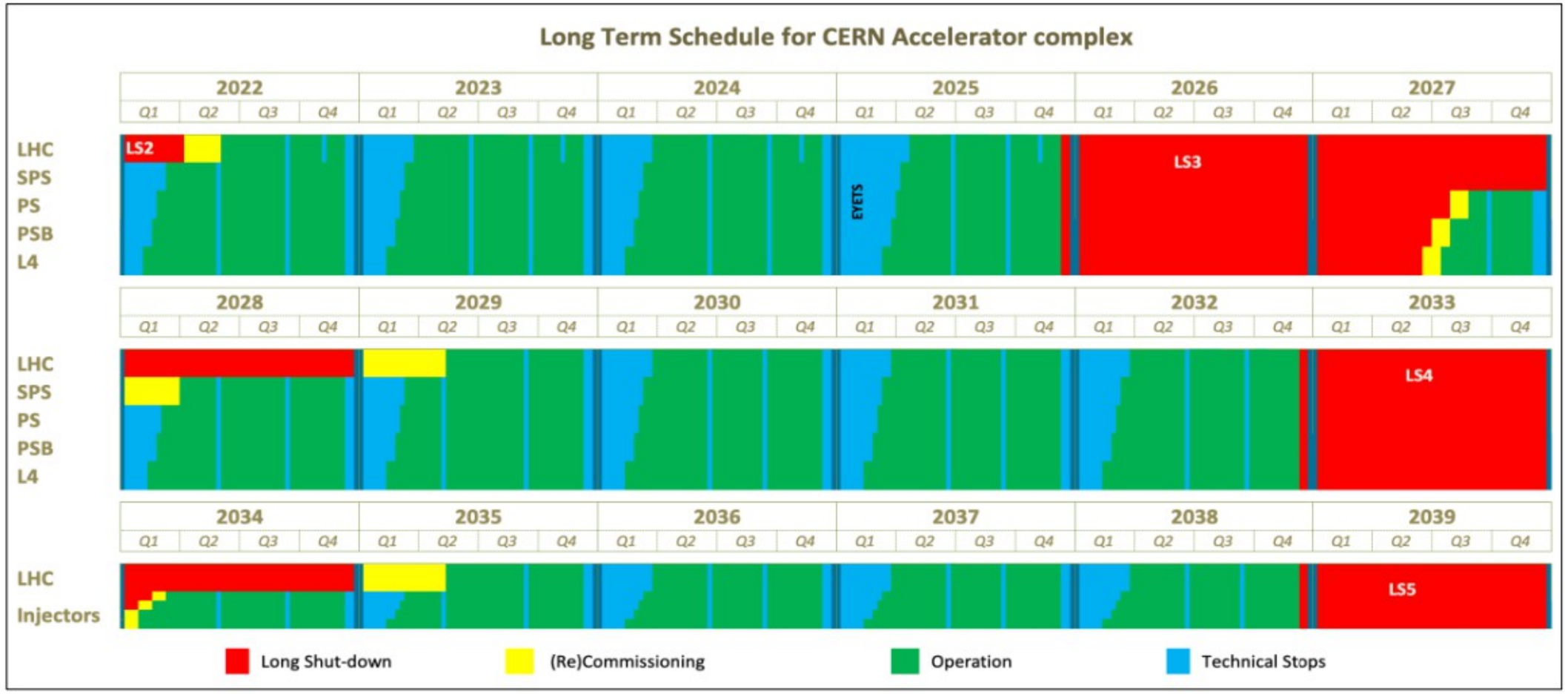
SPS : protons/ions @ 450 GeV/c/Z
PS: protons /ions @ 28 GeV/c/Z

Maximum Momenta to users at the PS/SPS TB Facilities:

North Area → ≤ 400 GeV/c (primary beam)
≤ 360 GeV/c (secondary beam)

East Area → ≤ 16 GeV/c (secondary beam only)

Accelerator Schedule – CERN



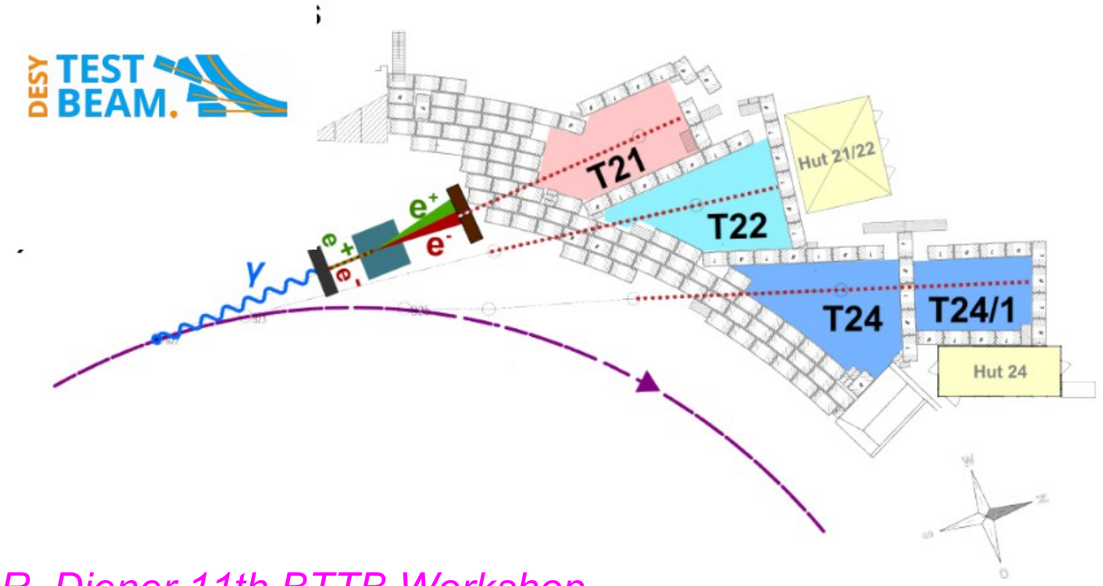
CERN beamtests traditionally oversubscribed (in particular SPS) – Come prepared

Attention: No SPS operation in 2026 and 2027

No PS operation between 2026 and middle of 2027

E.B. Holzer, 11th BTTB Workshop

Testbeam facilities – DESY



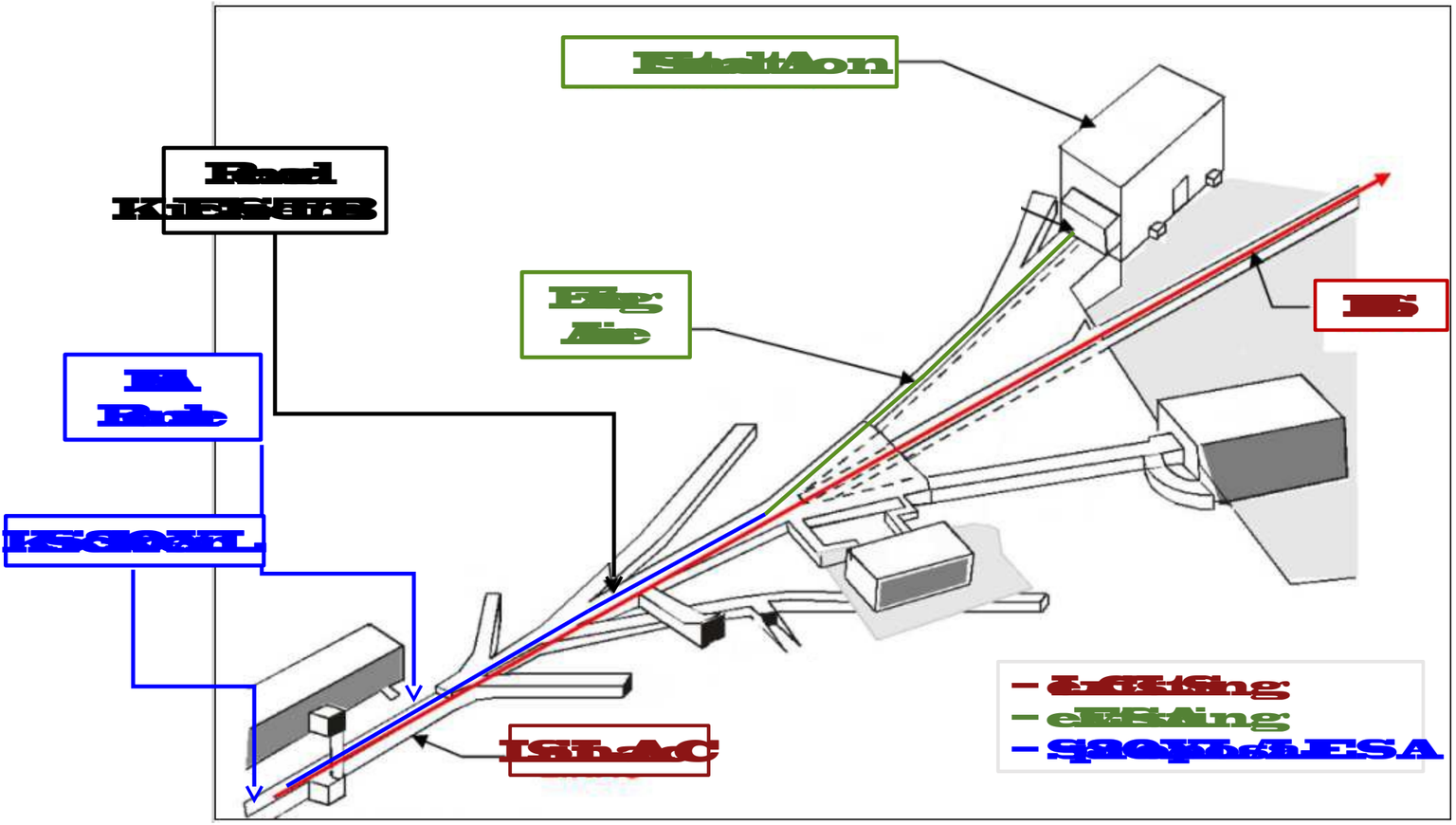
- Three beam lines T21, T22, T24
  - Extracted independently via Bremsstrahlungstargets
  - From DESY II Storage Ring
- e+ or e- beams, 1-6 GeV
- Rate O(1kHz), dependent on energy

R. Diener 11th BTTB Workshop

- DESY plays a very important role during the development cycle of calorimeter prototypes!!!
  - Tests at small electron energies
  - Dress rehearsals before moving to high-energy beams
- Outlook
  - DESY will run “as usual” until 2027
  - Availability of DESY beam test is coupled to approval and operation of PETRA IV
    - If PETRA IV will be approved then there will be a shutdown in 2028/29
    - DESY directorate supports maintaining operation of beam test facility in PETRA IV area

Testbeam facilities – SLAC

Linac to End Station A (LESA)



- Beam Energy
  - Pegged to LCLS-II
  - 4 GeV and then 8 GeV with LCLS-II-HE
  - Can tune energy lower in A-Line (when making secondaries: a few to << 1 e– per pulse)
- Variable Current
  - Up to 25 nA (3000 e–/bunch) with 50% duty cycle (useful for irradiation tests, testing integrating detectors)
  - Down to Poisson average < 1 e– per pulse
- Availability > 2026
- If available ~250 user days

Citation Carsten:

I Hope We Can Continue Electron Test Beams at SLAC's ESA Soon

Details see Carsten Hast at BTTB 11

Testbeam facilities – KEK

I. Nakamura, 11th BTTB Meeting

PF-AR

- PF-AR (Photon Factory Advanced Ring)
  - Photon Source Facility (High Energy X-ray)
  - former booster (8 GeV) of TRISTAN e^+e^- collider
- Maximum 6.5 GeV, 60 mA, Single Bunch (Run at 6.5 or 5 GeV, 50 mA, Top-up)
- 377m Circumference (1.26 μs or 795 kHz)
- Four Expermental Halls North/East/West/South

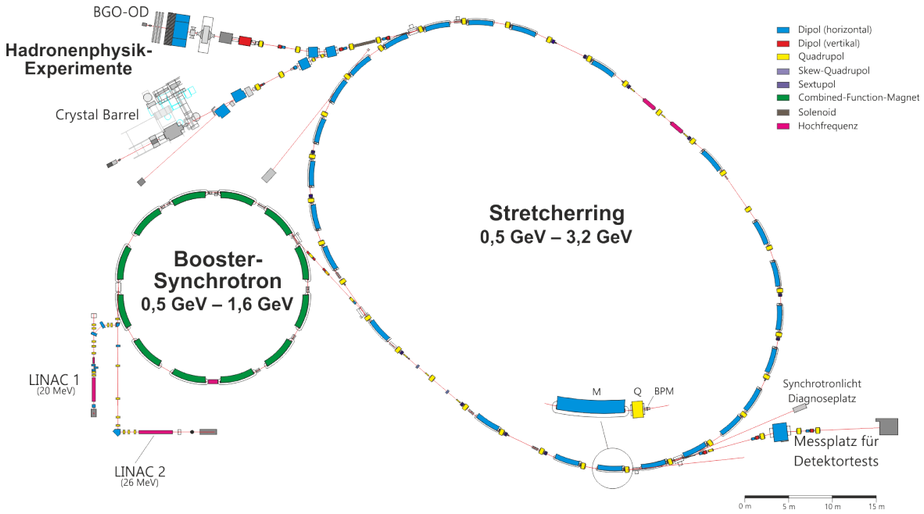
Smaller facilities (Incomplete list)

JGU Mainz

MAINZER MIKROTRON

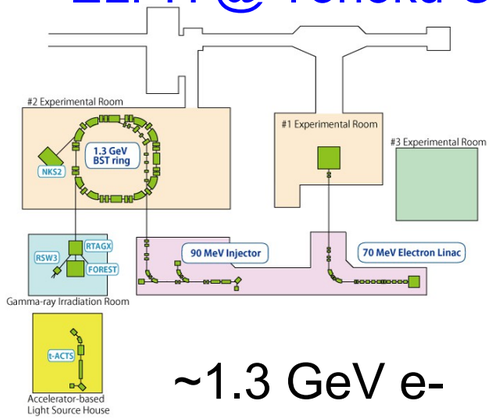
~1 GeV e-

ELSA @ Uni Bonn



~3 GeV e-

ELPH @ Tohoku U

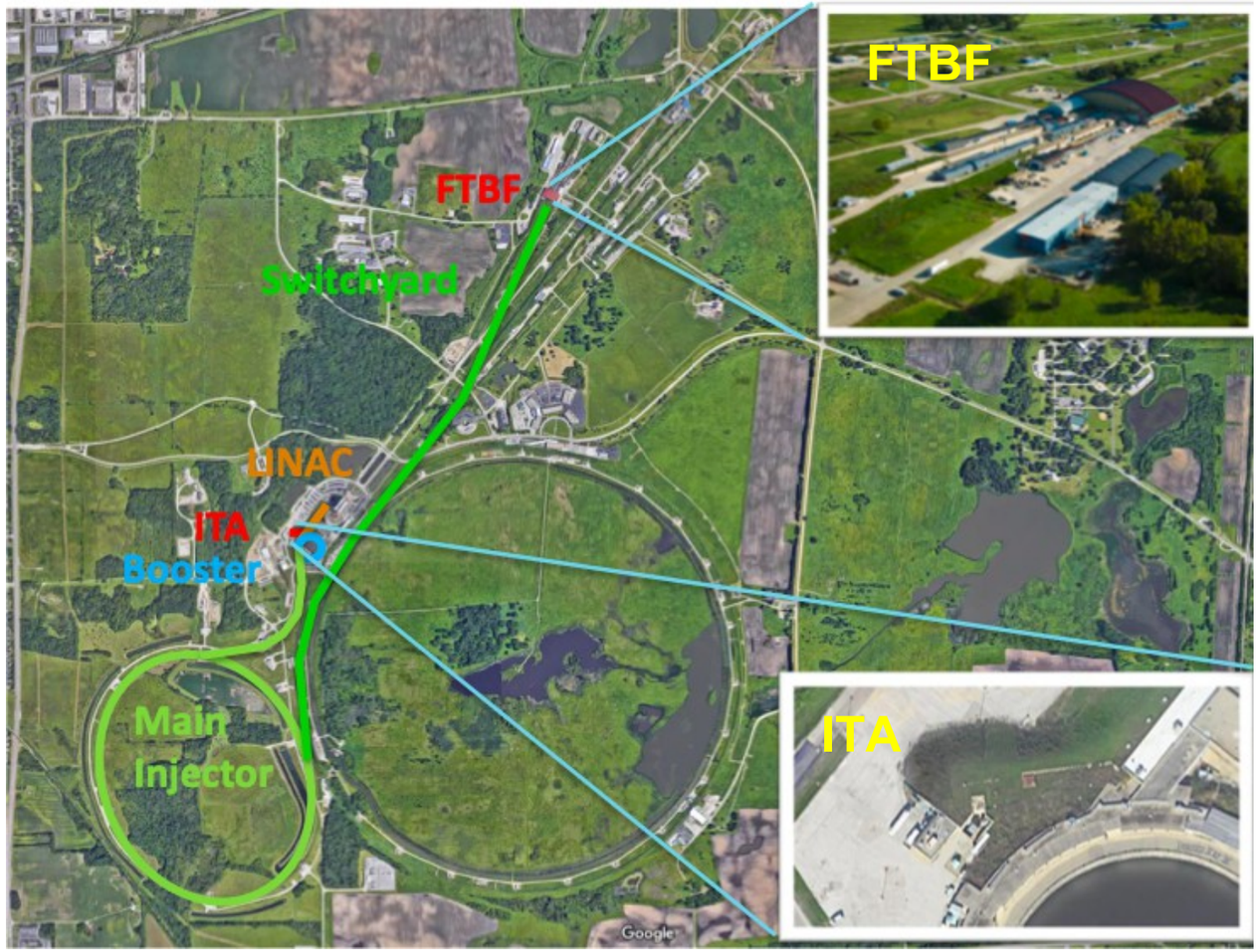


~1.3 GeV e-

- Apologises to those that are not listed
- Please help us to complete this list

Testbeam facilities – FNAL

N.J. Pastika, 11th BTTB Workshop



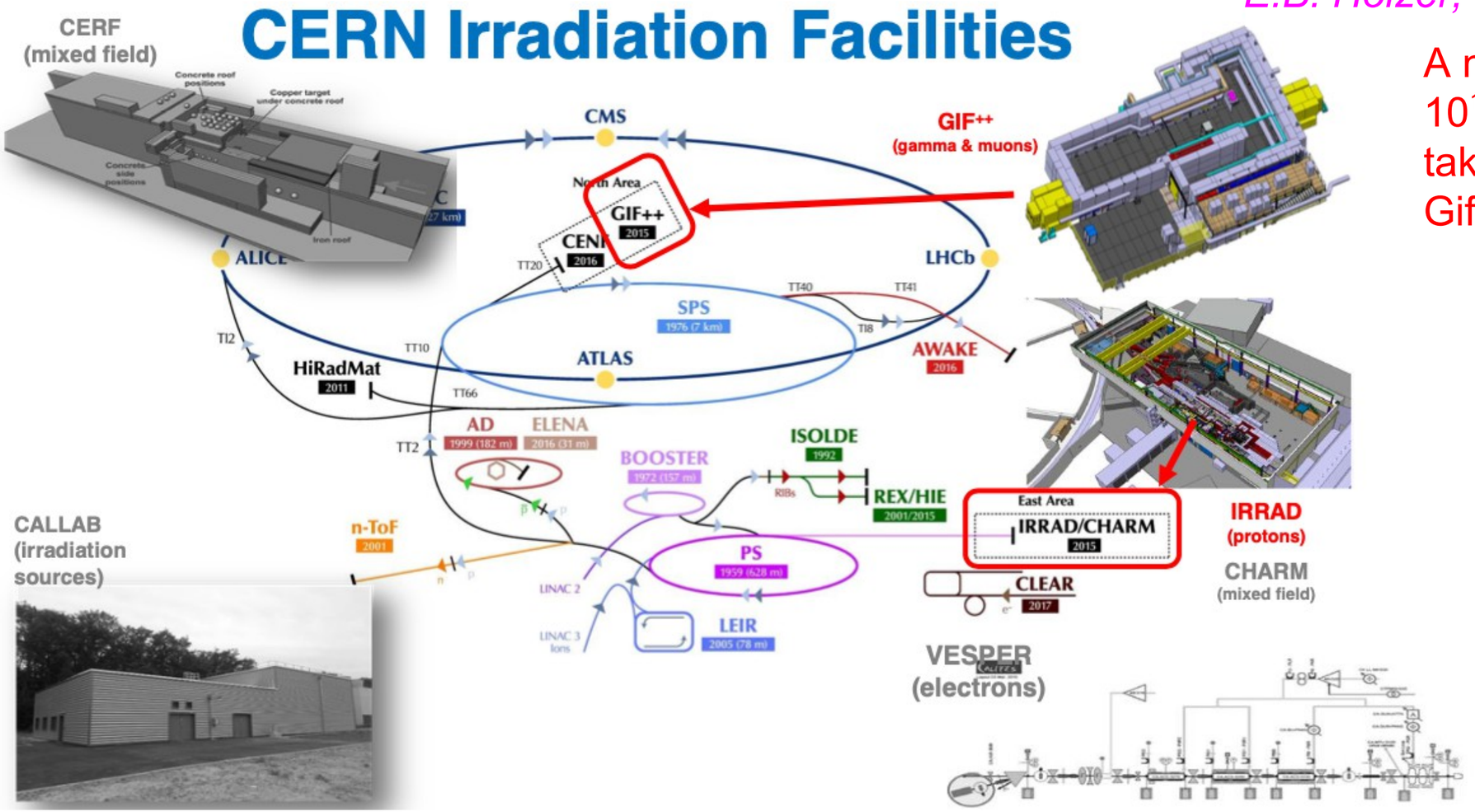
- Two beam lines:
  - Mtest
    - 120 GeV p, 1-66 GeV secondary beam
  - Mcenter
    - Secondary beam
    - Two tertiary beam lines down to 200 MeV

- Irradiation Test Area:
  - Beam rate 2.2 10^{15}/h
  - Total rate 1.3 10^{18}/y

- ITA will end in 2026
- PIP-II upgrade and booster provide an opportunity for a new beam test facility
  - Maybe the moment for the Calo Community to signal interest?

Irradiation facilities – Example CERN

E.B. Holzer, 11th BTTB Workshop



A number:
10^{17} p/cm^2
take one year at Gif++

I don't forget: JSI Triga, U.o.B Cyclotron, Louvain, ITAINNOVA, Groningen and there are others

Match Irradiation/Beamtest Facilities Detector Needs

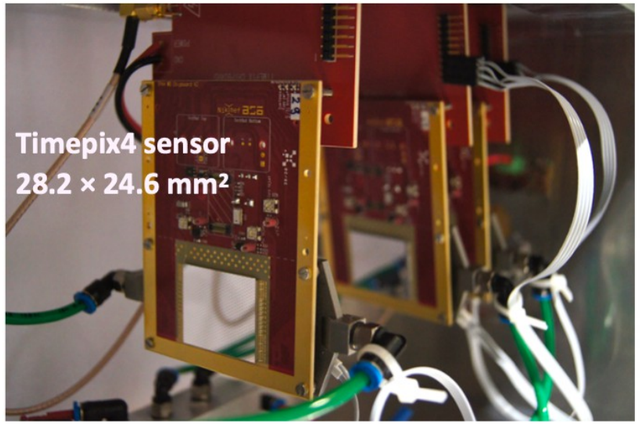
	Energy	Irradiation
Higgs Factory CMS energy 90-1 TeV Radiation <= 10^{14} $n_{eq/}cm^2$	✓	✓
HL-LHC CMS energy 14 TeV (shared by partons) Radiation ~10^{16} n_{eq}/cm^2	(✓)	✓
Muon Collider CMS energy 3-10 TeV Radiation ~HL-LHC	x	✓
Future Hadron Collider CMS energy 100 TeV (shared by partons) Radiation up to ~10^{18} n_{eq}/cm^2	x	x

Testbeam facilities – (Needed) infrastructure

Telescopes:

Cerenkov Counters:

Telescopes with time reference:



Expect: ~50ps with LGADs (enough?)

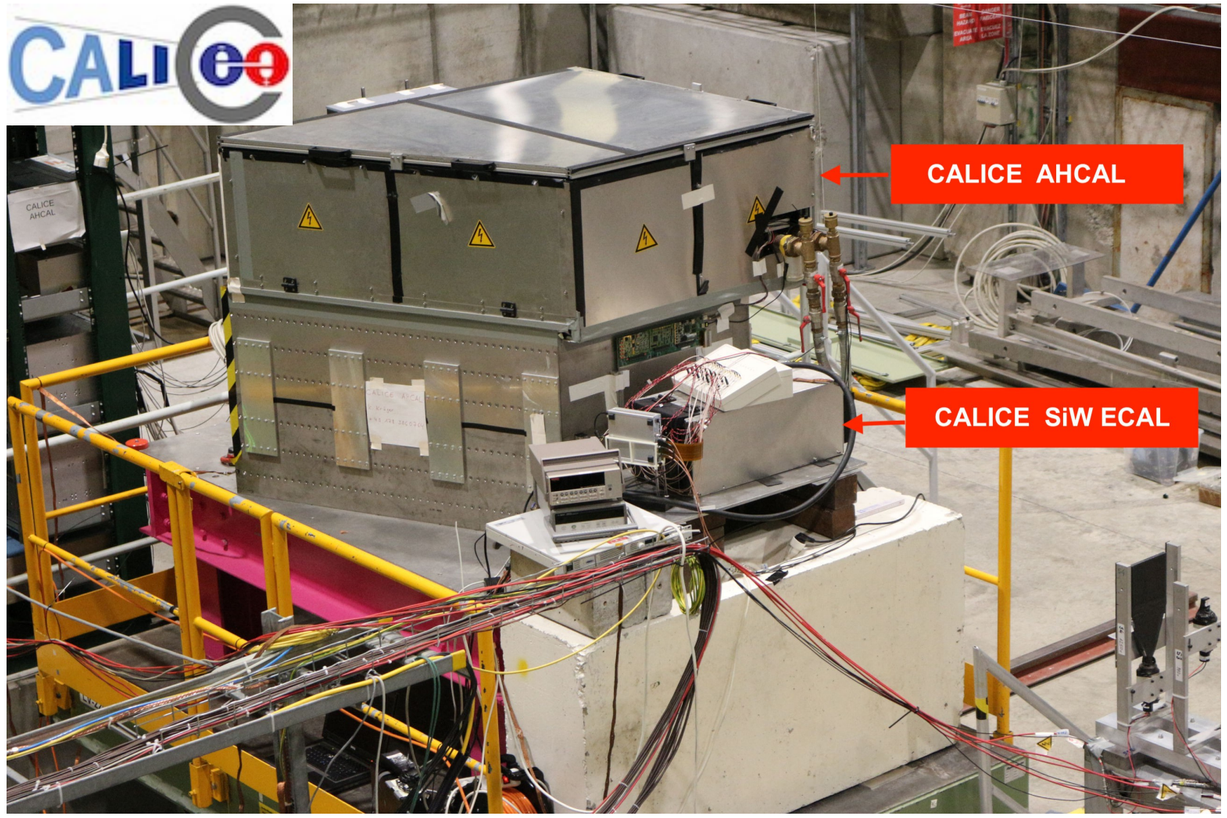
Magnets:

Interaction between DRD and facilities

- Facilities have to provide the beams, the beamline devices and the user support
  - Facilities have to be enabled to provide this support

- User support is not customer service
  - DRD has/have to provide contacts and to cooperate with facilities

Dedicated Calorimeter Beamline?



Common setup at CERN June 2022

- Calorimeters are typically large objects
  - A beam test is similar to a small experiment
- Difficult for facility managers to schedule calorimeter beam tests
  - No concurring running with other devices possible
- Takes lots of expertise to carry out a successful beam test campaign
  - Implies use of infrastructure
- A dedicated beam line maybe with dedicated slots during a year may help curing these issues
  - Would need sustained expertise on the beamline

Beam tests – Funding opportunities

Access to Research Infrastructures for
Nuclear Physics - Accelerator R&D – Particle Physics

- 4 year project started September 2022
- Transnational Access to a range of facilities – emphasis on students and post-docs
  - Access to e.g. DESY and CERN
  - Full list of facilities in backup

Summary and Conclusion

- The importance of beam tests during detector development cannot be underrated
  - Interest has to be repeated continuously to lab managements
  - Particle physics sometimes in competition with other disciplines
- Maybe more than other detectors calorimeters need a large variety of particle momenta, particle types and beam rates
- The input proposals promise a rich beam test program
  - Have to align our plans with schedules of facilities!
- An efficient conduction of this program requires close collaboration across actual project boundaries
  - Full exploitation of beams (of course) and of beam line devices --> support on both sides
  - Software is needed before, during and after the beam tests
- Need to phase in our plans with availability of facilities
- The current facilities seem to be sufficient to cover needs for Higgs Factory Detector R&D Development
  - A future muon collider and in particular hadron would require new capabilities
  - Analysis to be carried out

Backup

Testbeam facilities – General remarks

- Let us first thank the beam test and radiation facilities operators and the lab and institute managements for the availability of the facilities

- The importance of beam tests during detector development cannot be overrated
  - Recent refurbishment of various beam test sites witness that this is recognised by the lab managements

- Maybe more than other detectors calorimeters need a large variety of particle momenta, particle types and beam rates

- The portfolio of the EPPSU comprises projects supposed to run between now and 2080-2090
  - During all these decades we need versatile beam test and radiation facilities to accompany the R&D program
  - ... including competent staff to run these facilities (-> investment in accelerator and instrumentation experts)
  - Maybe some steps can be executed with powerful computing, AI or whatever the future brings
  - However, it can never be desirable that the first beam a detector sees is the beam in the final experiment
    - Despite the fact that the return vessel of Apollo 11 has also never been tested before ;-)

- A future hadron collider would require to make a test beam facility part of the LHC programme

EUROLABS Participating Institutes

Participants

- 34 participating Laboratories
- Access to 43 Research Infrastructures (RIs)
- Spread in 12 countries across Europe

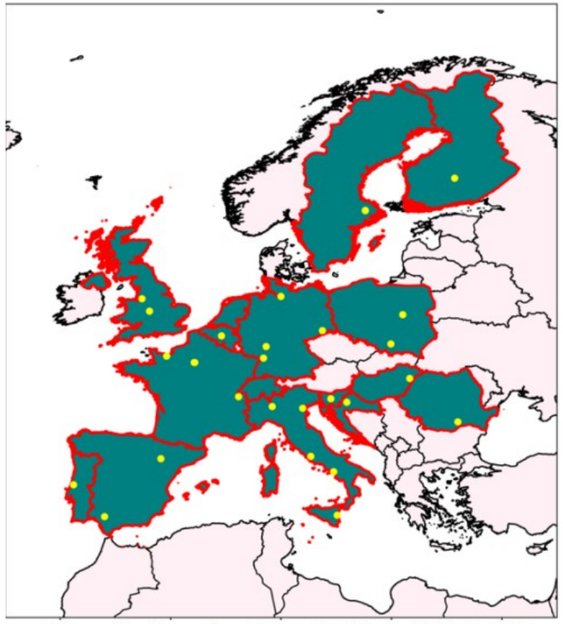


Figure 1 - Map of participating RIs in EURO-LABS

Participant short name	Participant name	Country	Country Code	Role	WP
INFN	**National Institute for Nuclear Physics**	**Italy**	**IT**	**Coordinator**	WP1, WP2, WP3, WP5
GANIL	GRAND ACCELERATEUR NATIONAL D'IONS LOURDS	France	FR	Partner	WP2, WP5
CERN	European Organization for Nuclear Research	Switzerland	CH	Partner	WP1, WP2, WP3, WP4
JSI	INSTITUT JOZEF STEFAN	Slovenia	SI	Partner	WP4
IFJ-PAN	THE HENRYK NIEWODNICZANSKI INSTITUTE OF NUCLEAR PHYSICS, P	Poland	PL	Partner	WP2, WP4
DESY	STIFTUNG DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY	Germany	DE	Partner	WP4
UCLouvain	UNIVERSITE CATHOLIQUE DE LOUVAIN	Belgium	BE	Partner	WP4
RBI	RUDER BOSKOVIC INSTITUTE	Croatia	HR	Partner	WP4
CNRS	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	France	FR	Partner	WP2, WP3, WP5
FBK	FONDAZIONE BRUNO KESSLER	Italy	IT	Partner	WP2
ITAINNOVA	INSTITUTO TECNOLOGICO DE ARAGON	Spain	ES	Partner	WP4
UoB	THE UNIVERSITY OF BIRMINGHAM	UK	UK	Partner	WP4
UNIWARSAW	UNIWERSYTET WARSZAWSKI	Poland	PL	Partner	WP2
GSI	GSI HELMHOLTZZENTRUM FUR SCHWERIONENFORSCHUNG GMBH	Germany	DE	Partner	WP2, WP5
IFIN	INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE PENTRU FIZICA	Romania	RO	Partner	WP2, WP5
USE	UNIVERSIDAD DE SEVILLA	Spain	ES	Partner	WP2
IST	INSTITUTO SUPERIOR TECNICO	Portugal	PT	Partner	WP2
ATOMKI	ATOMMAGKUTATO INTEZET	Hungary	HU	Partner	WP2
JYU	JYVASKYLAN YLIOPISTO	Finland	FI	Partner	WP2
UU	UPPSALA UNIVERSITET	Sweden	SE	Partner	WP3
CEA	COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERN	France	FR	Partner	WP2, WP3, WP5
KIT	KARLSRUHER INSTITUT FUER TECHNOLOGIE	Germany	DE	Partner	WP3
UKRI	UNITED KINGDOM RESEARCH AND INNOVATION	UK	UK	Partner	WP3
UMCG	ACADEMISCH ZIEKENHUIS GRONINGEN	Netherlands	NL	Partner	WP2
FEP	Fraunhofer Institute for Organic Electronics, Electron Beam and Plasm	Germany	DE	Partner	
INCT	INSTYTUT CHEMII I TECHNIKI JADROWEJ	Poland	PL	Partner	WP3
CSIC	AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENT	Spain	ES	Partner	WP5
PSI	*PAUL SCHERRER INSTITUT*	*Switzerland*	*CH*	*Associated*	WP4
JINR	*JOINT INSTITUTE FOR NUCLEAR RESEARCH*	*Russian Federation*	*RU*	*Associated*	
RIKEN	*RIKEN THE INSTITUTE OF PHYSICAL ANDCHEMICAL RESEARCH*	*Japan*	*JP*	*Associated*	
MSU	*MICHIGAN STATE UNIVERSITY*	*USA*	*US*	*Associated*	
TUD	*TECHNISCHE UNIVERSITAET DRESDEN*	*Germany*	*DE*	*Associated*	
UMIL	UNIVERSITA DEGLI STUDI DI MILANO	Italy	IT	Partner	WP2
LIP	*LABORATORIO DE INSTRUMENTACAO E FISICA EXPERIMENTAL DE F*	*Portugal*	*PT*	*Associated*	