Not including ISOLDE & nToF
EHN1 extension only for what is part of consolidation
Taking into account previous iterations/analysis
(LS2 Days, East-Area consolidation day, EA/NA/AD summary Reports)

Non-LHC Experiments Activities during LS2

EXPERIMENTAL AREAS CONSOLIDATION

M. Brugger for the EN-EA Group
particular thanks to F. Butin, M. Calviani, T. Erikson, S. Evrard, A. Fabich, L. Gatignon, B. Rae, M. Wilhelmsson, H. Wilkens
…and all contributing equipment and service groups

CERN | EN ENGINEERING DEPARTMENT

INTRODUCTION

- Today the East and North Areas and AD serve a **large user community with many experiments**, some with more than 200 physicists.
- The **upgrades of the LHC detectors** as well as the tests and **R&D for other experiments and technological developments** rely heavily on the unique test beams at CERN.
- **The Directorate has underlined the importance of a diverse physics programme** and will set up a working group to prepare a **strong physics programme including the injectors also after LS2**. This will possibly include new facilities (*e.g,* SHiP), but also aims to prepare a strong continuation of the physics programme in the present facilities
- The **present facilities have aged significantly** (~30 years for AD, 35 years for the North Area, more than 50 years for the East Area).

Experimental Areas & Facilities

East Area | **North Area** | **AD**

PHYSICS & USERS

LHC Detectors | **Experiments** | **Accelerators**

Test Beams | **Physics** | **R&D** | **Radiation Tests**

BEAMS

Primary, secondary and tertiary beams

(Protons, Antiprotons, Ions, Pions, Kaons, Electrons, Muons)

From **very low energies** (AD) to **hundreds of GeV/c** (tunable!)

Quality optimized: high intensity/energy/resolution + polarization

INFRASTRUCTURE, SERVICES & SUPPORT

Magnets | **Power Converters** | **Beam Instrumentation** | **B.-Design**

Targets, Collimators & Dumps | **Electrical Supply, Lights, Cabling**

Operation | **Cooling & Ventilation** | **Cryogenics** | **Vacuum** | **Gas**

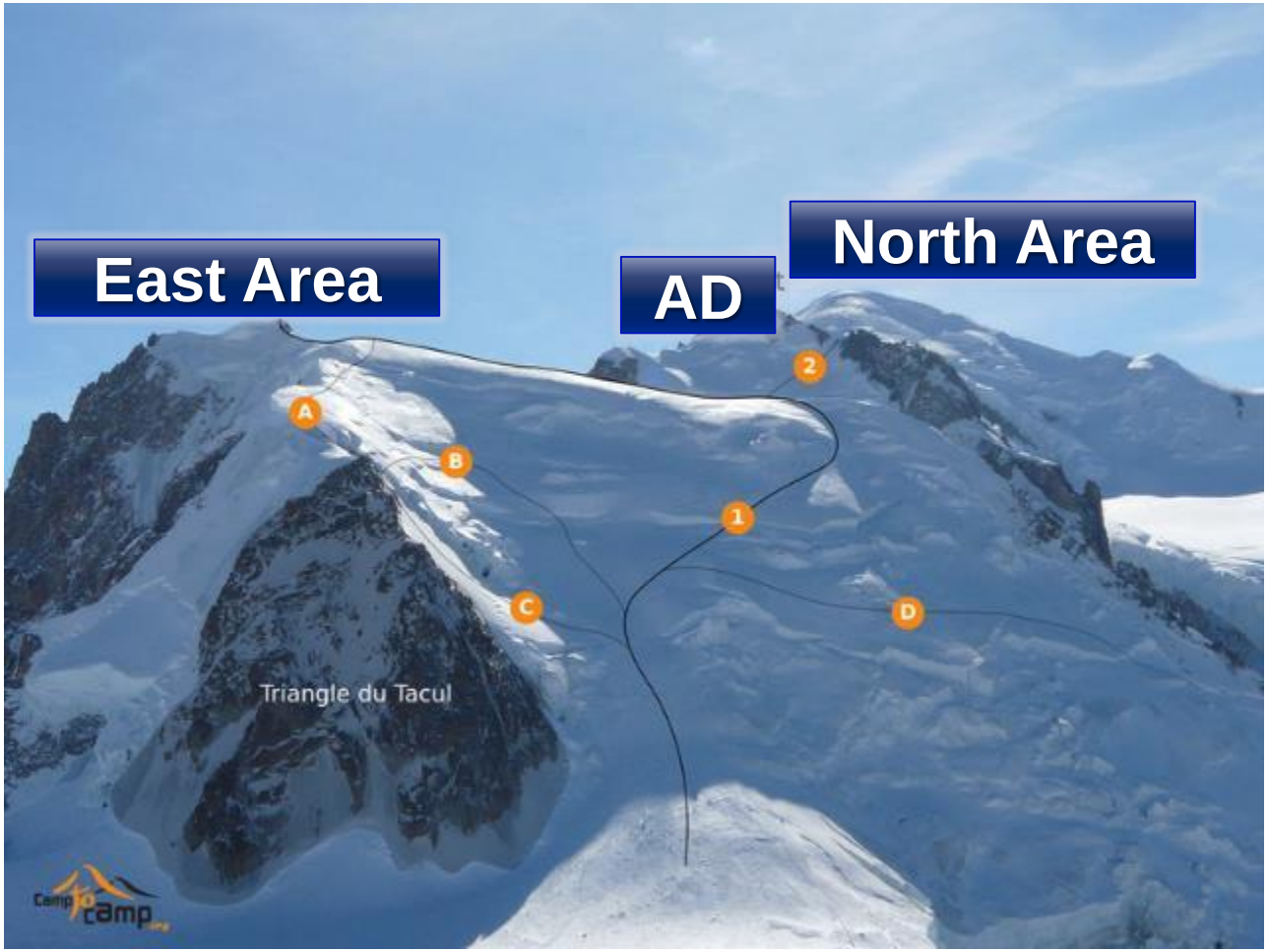
Mechanics | **Handling** | **Alignment** | **Shielding** | **Radiation + RP**

Access System | **Safety Systems** | **Planning & Coordination**

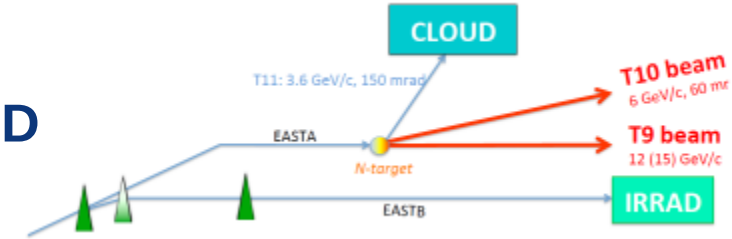
On the Menu…

- Area by area
  - Physics case and user requirements
  - Operational, life-time and safety constraints
  - Consolidation requirements, resources, time-line and strategy
    (focusing on baseline requirements)
- Next

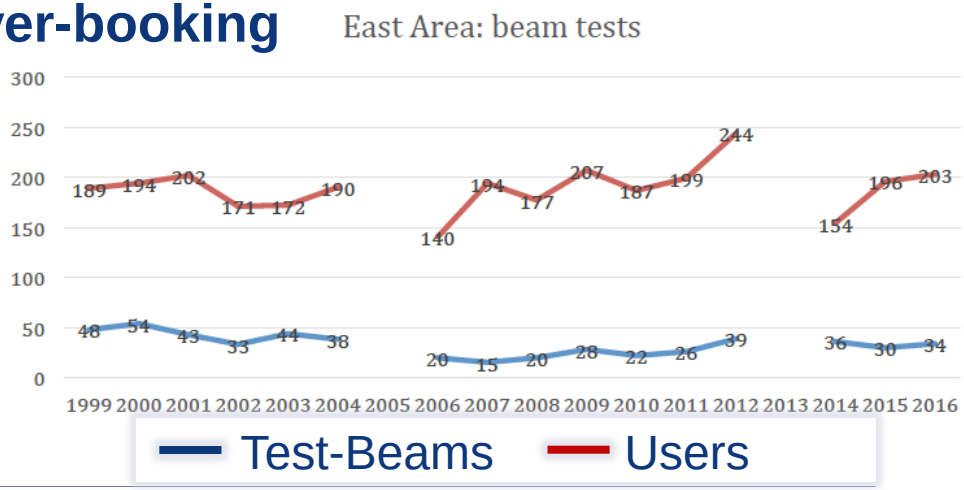
How to Climb/Reach ? Mount Consolidation ?



EAST AREA – PHYSICS



- The East Area serves the **CLOUD** experiment (for probably at least a decade), the new **IRRAD** and **CHARM** (for R2E) facilities and **two test beams** in the 0.5 to max.10 GeV/c range
- Its test beam program concerns **LHC**, **Linear Collider**, **NA experiments**, GSI, **Neutrinos** (e.g. Baby-MIND in 2017), Balloon & Satellite experiments, etcetera
- The test beams complement the ones in EHN1, as they cover **lower energies**, and an overlap with the energy range in the NA would be very valuable
- The East Area **copes with EHN1 over-booking**
- The East Area hosts the **Beamline For Schools** outreach program
- The East Area is as popular as ever **Over the last years more than 500 teams were served**



(C) H. Wilkens

EAST AREA – OPERATIONAL CONSTRAINTS

- The **East Area dates from 1959** and is one of the oldest areas at CERN
- The East Area consolidation has been triggered by **frequent magnet problems**, which often lead to months of downtime and in 2006 to a full year loss for DIRAC and the T7 Irradiation facility. Also other equipment is in an extremely poor state.
- The accessibility to equipment in the **primary zone is extremely difficult** and the **radiation levels** are very high due to the design principle. Magnet problems in the upstream part of the extraction line **would stop the PS complex** and thus the SPS and LHC for several days or more.
- **None of the test beams can perform at nominal energy**, because of the poor state of equipment.
- **The power converters are very old (up to 50 years)**. Upgrade to a new generation would also allow very **significant power savings** (reducing from 11 to 0.6 GWhr/year). This upgrade would profit from **synergy with TT2 and nTOF**. However, it requires a number of magnets to be laminated.

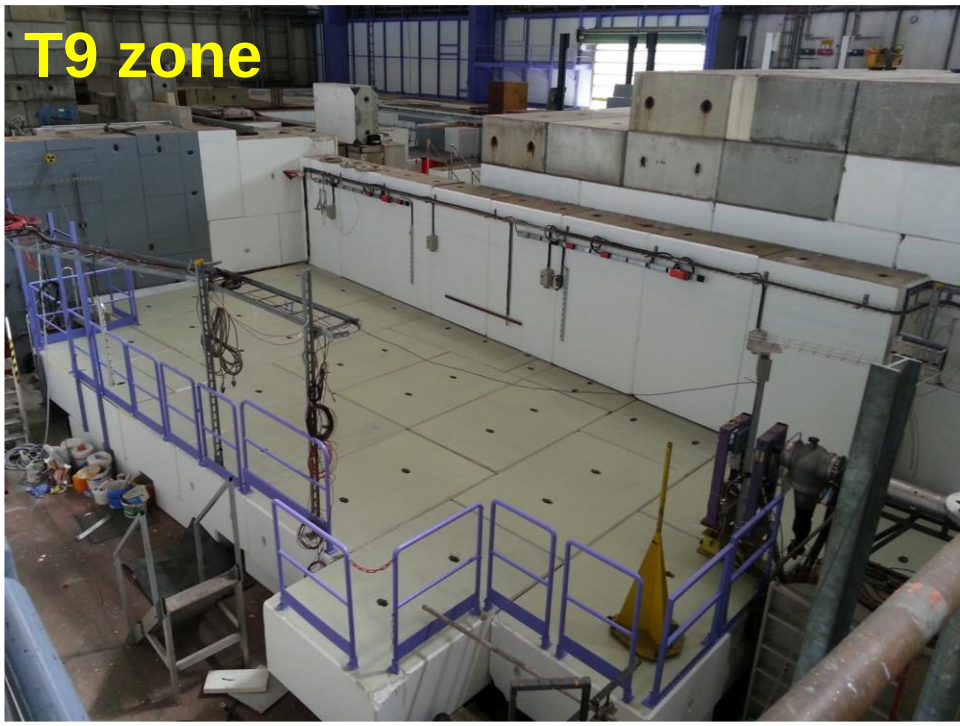
Bad state of equipment

Difficult (and long) to access

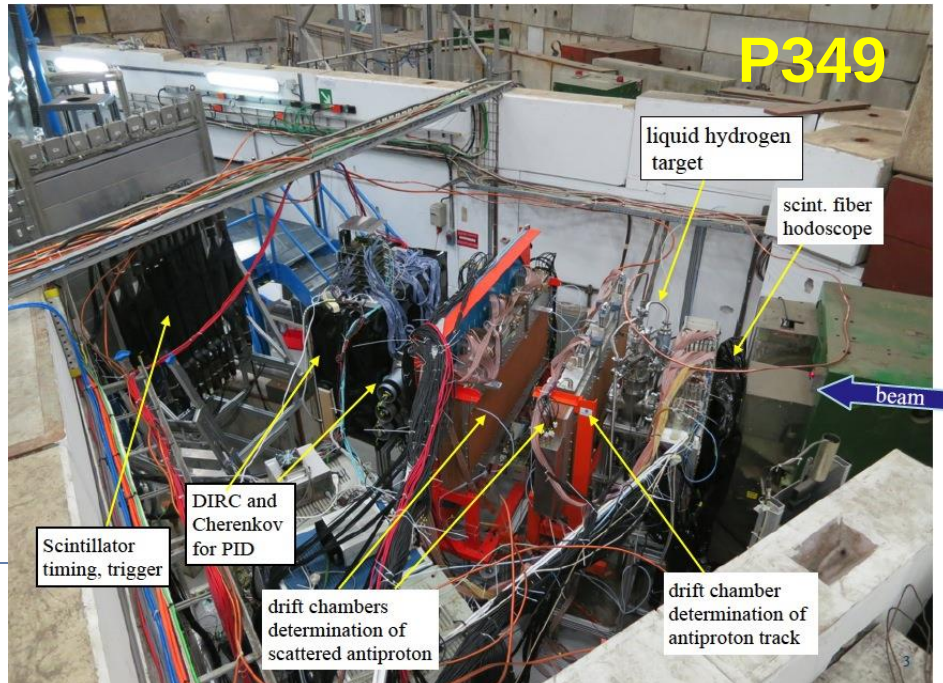
High radiation dose


BLM
Montrac
AVT
Path
Shielding


IRRAD-3



The T9 zone (BLFS) and 2 experiments in T11



EAST AREA – SAFETY CONSTRAINTS

- Interventions in the primary zone lead to **high radiation doses** and the access to the equipment is extremely delicate.
- The lack of ventilation favours ozone formation and leads to quicker **degradation of the beam line equipment**.
- The primary target zone is not ventilated and thus **not conforming to RP requirements**.
- There is a technical possibility to send a **primary proton beam of up to 10^{12} particles per spill directly into the T9** primary zone, if a 10 GeV/c cycle (or lower) is activated in the PS machine.
- Renovate **obsolete equipment** that does not respect today's safety standards.

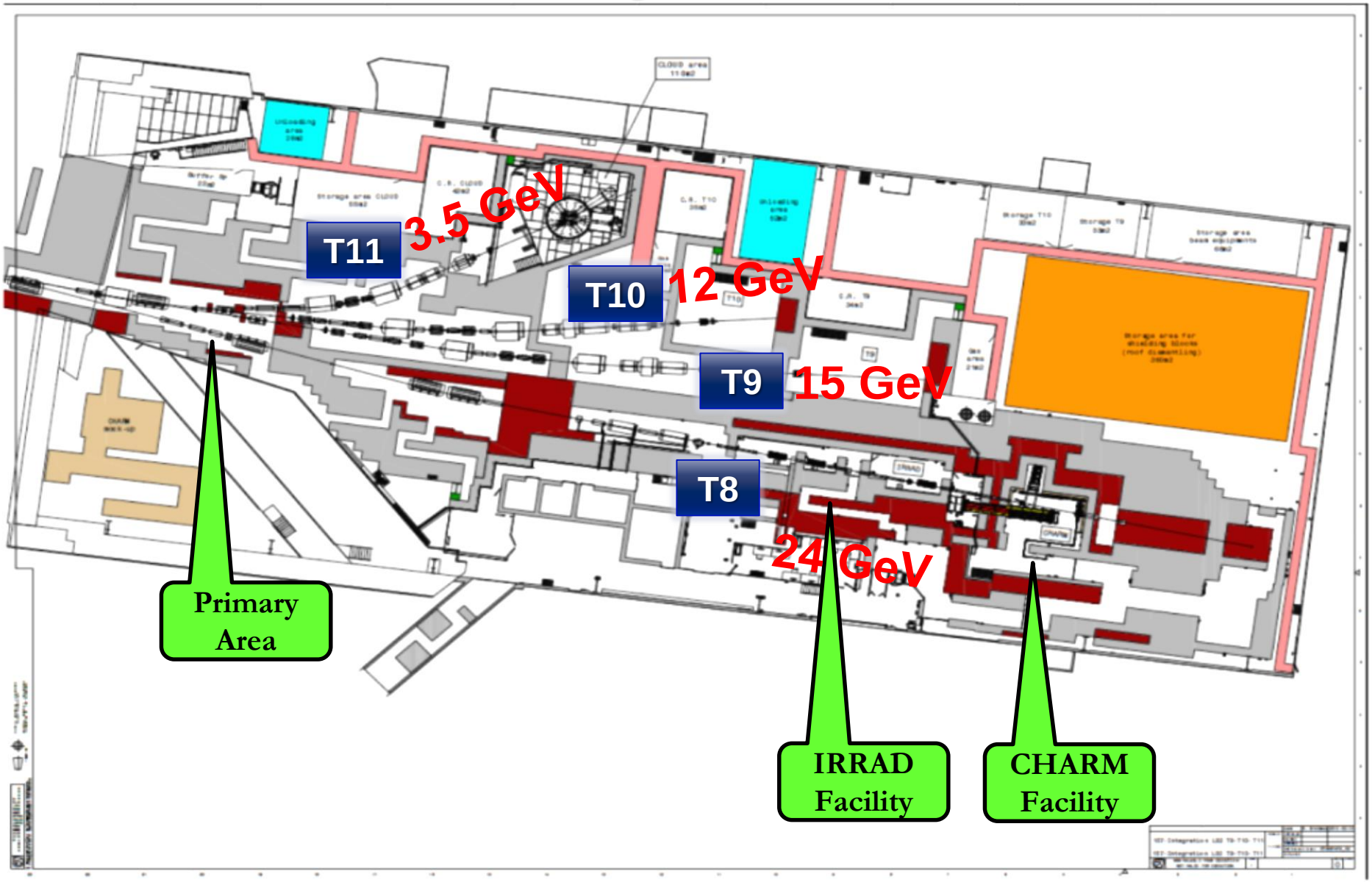
EAST AREA - STRATEGY

A technical proposal has been presented at various IEFCs.
All beam lines have been redesigned to

- Use only **reliable magnet types** with **sufficient spares available**
- Eliminate the radiation issue by having a **small production angle for the T9** beam
- **Reduce the size of the primary area**, restrict the high radiation to the regions around the production targets, including **dedicated ventilation**
- **Reduce power consumption** by laminating the massive magnets and replacing the power converters by modern standards. This is in fact **the only option that can be provided by the TE-EPC** group at this stage and would be a very **important step towards the NA** power converter renovation.
- The whole **layout is optimized to the user requirements** and will be different from today, apart from the CHARM and IRRAD zones (made in LS1)

  (2012 East Area Day: https://indico.cern.ch/event/167761/)

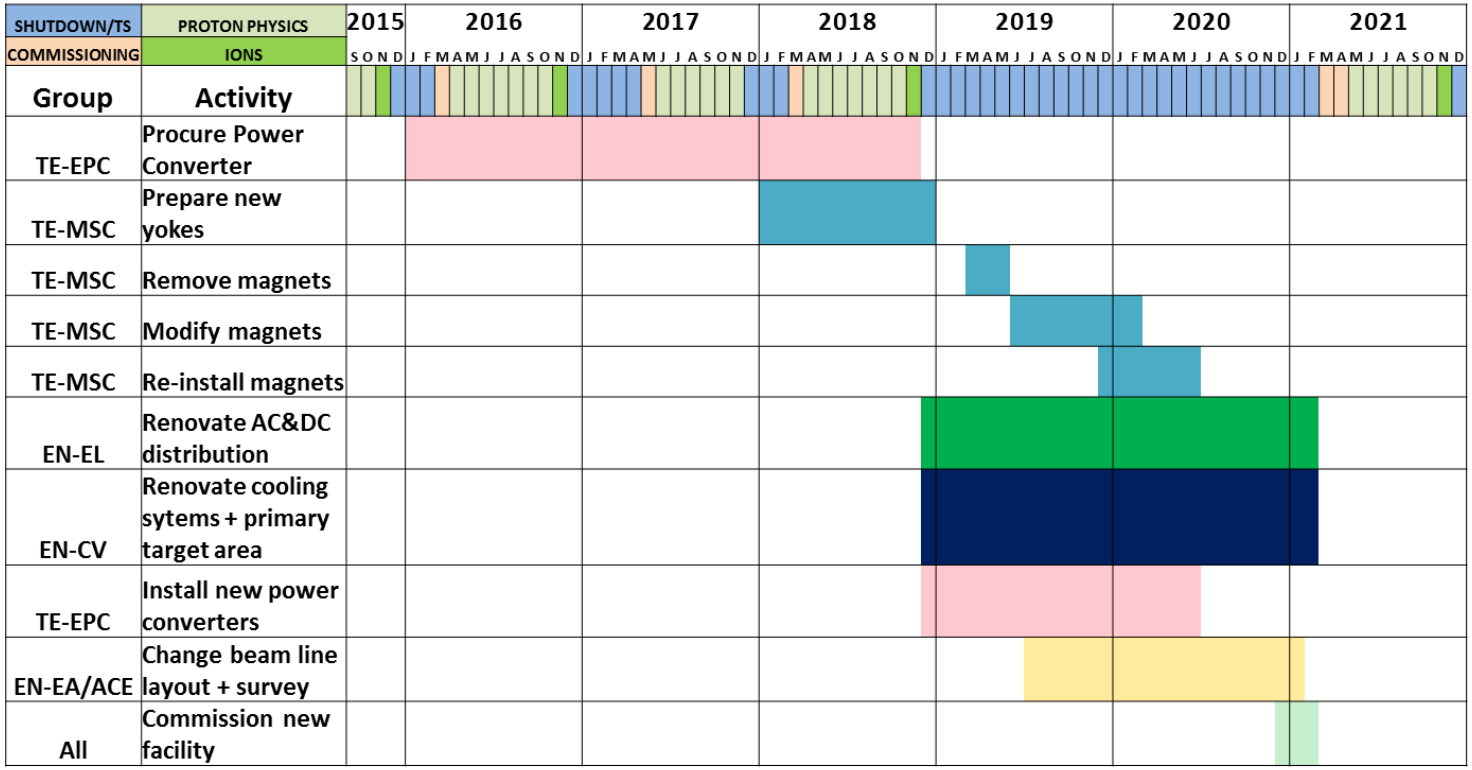
EAST AREA – Layout



EAST AREA - PLANNING

- The duration of the work will be between 1.5 and 2 years fitting into LS2
- Preparation and procurement must start beforehand, in particular for the magnets and for the power converters.

© LS2-Days



+ Other (partly on-going): BTV upgrade, shielding modification, beam stopper, control rooms, collimators.

EAST AREA – Cost and Resources

- The **total cost is estimated to 18.4 MCHF**. A significant part of the cost can be gained back by **energy savings (600 kCHF/yr)**
- The manpower amounts to 15 FTEy, mostly in TE/EPC (6) and TE/MSC(2). EPC efforts have a strong synergy with TT2 consolidation.
- On request by CLOUD, a new T11-like beam is made. It avoids the CLOUD move cost of 800 kCHF.

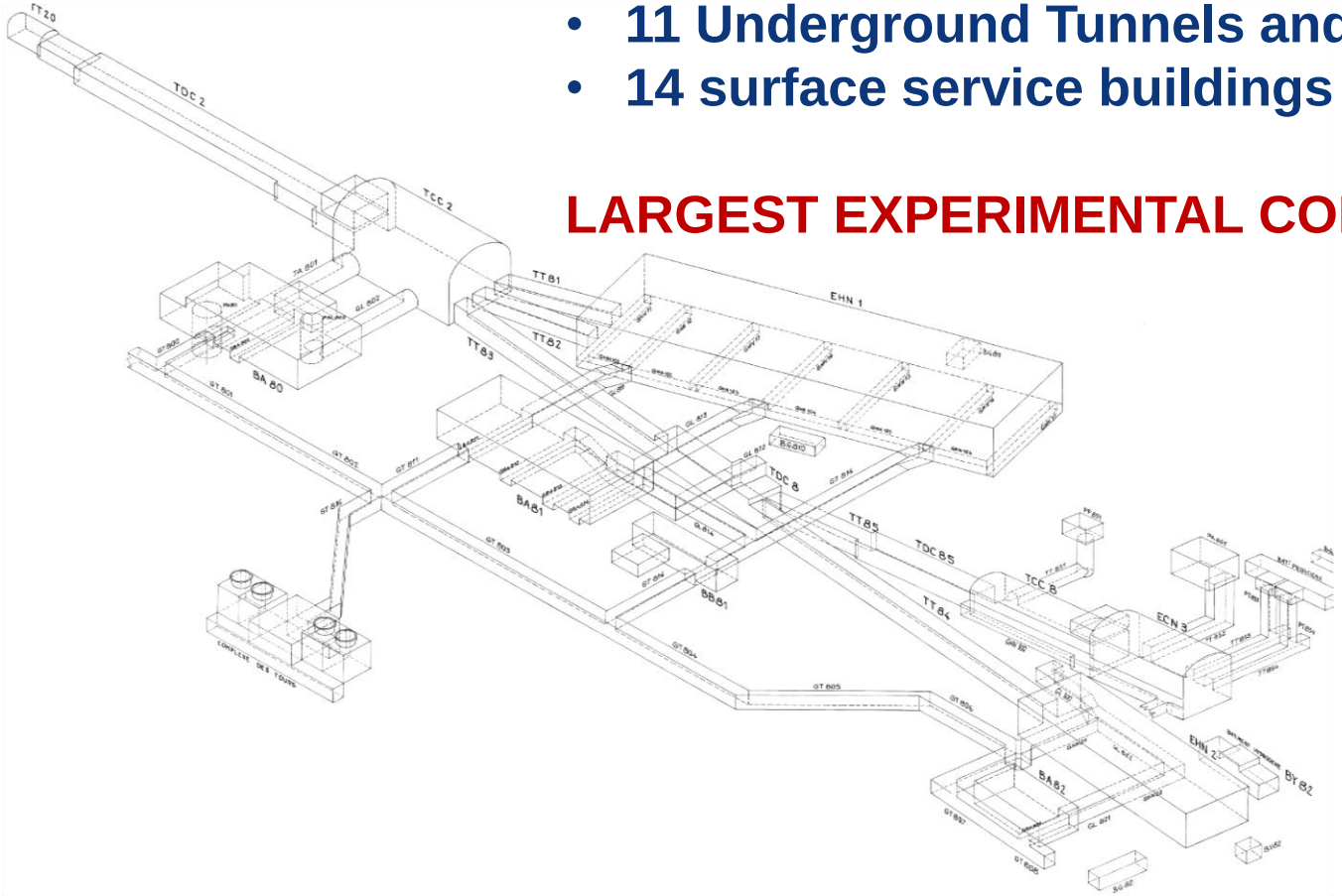
Sub-project	Budget (MCHF)
Magnets and power converters upgrades	***9.9***
Minimal renovation (not possible due to resources)	*2.8*
Extra cost for power saving (the only option)	*4.7*
Lamination of massive magnets	*2.0*
Magnet protection system	*0.4*
Consolidation apart from magnets and converters	**8.5**
(Directly safety related)	*2.3*
Total	**18.4**

IPP not included

North Area Layout

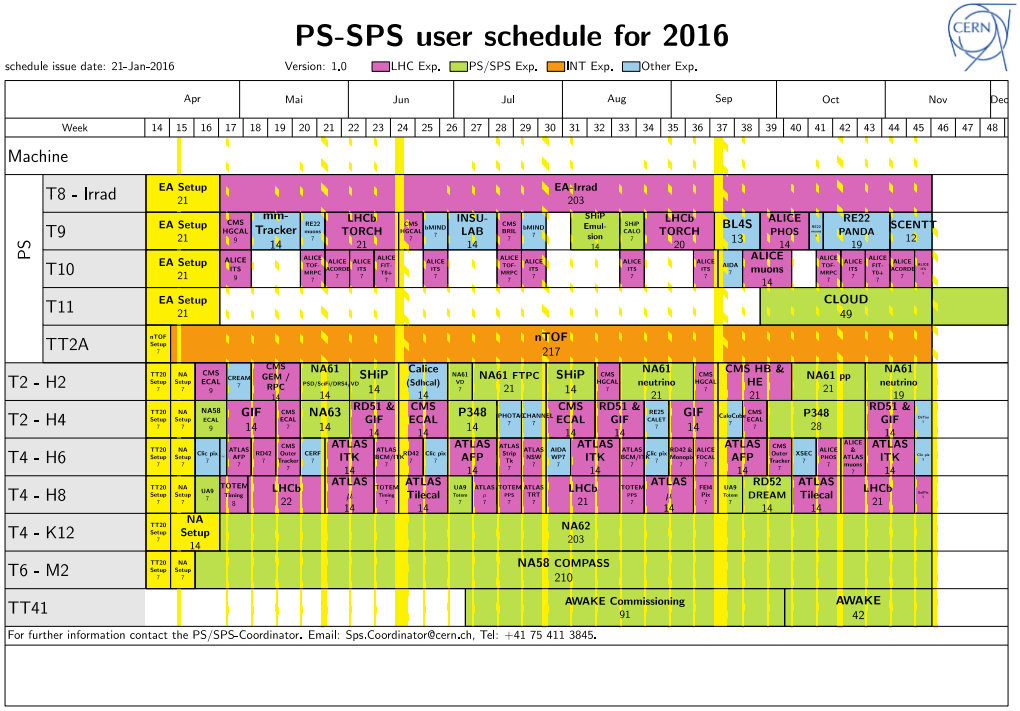
- 6 km of beam lines
- 3 main experimental halls
- 11 Underground Tunnels and Caverns
- 14 surface service buildings

LARGEST EXPERIMENTAL COMPLEX @ CERN



North AREA – PHYSICS

- The North Area serves today several **fixed target experiments** (NA62, COMPASS, SHINE, NA63) [11 dedicated experiments in the last ~15 years], the new **GIF++**, **CERF** and former H4irrad facilities and **four test beam lines (protons, ions, electrons, pions, muons)** in the ten to hundreds GeV/c range.
- The North Area is as popular as ever
- **New proposals in the hidden sector** (*e.g,* P348, SHIP)
- Its test beam program concerns all **LHC Detector R&D and Calibration**, **linear collider activities**, **future collider projects**, **satellite experiments**, etcetera
- **Crucial for LHC experiment upgrades**
- EHN1 extension dedicated for **neutrino platform activities**
- **Users from all around the world** due to unique facilities



North AREA – OPERATIONAL CONSTRAINTS

- The North Area **dates from the 70's**
- Failures occurring more often and on major components leading to **significant downtimes** (often drastically impacting users who have only a short allocated slot)
- Annual maintenance can't cope with the work required (also driven by available resources and priorities).
- **Power converters are reaching the end of their lifetime** (e.g, efficient restart after stand-by is often not possible) -> 200 interventions only in 2015!
- **Obsolescence** of equipment: in several systems it is hard to find replacement parts (*e.g,* existing High Voltage (18kV) supply switchgear for EHN1 was constructed in 1971 and spare parts are no longer available -> risk of long downtimes
- Conformity to modern **safety standards** (*e.g,* electrical).

Bad state of equipment

- **Water infiltration damaging Infrastructure & Equipment**
- **Dated Air handling units**
- **Corroded beam line equipment**
- **Highly activated target stations**

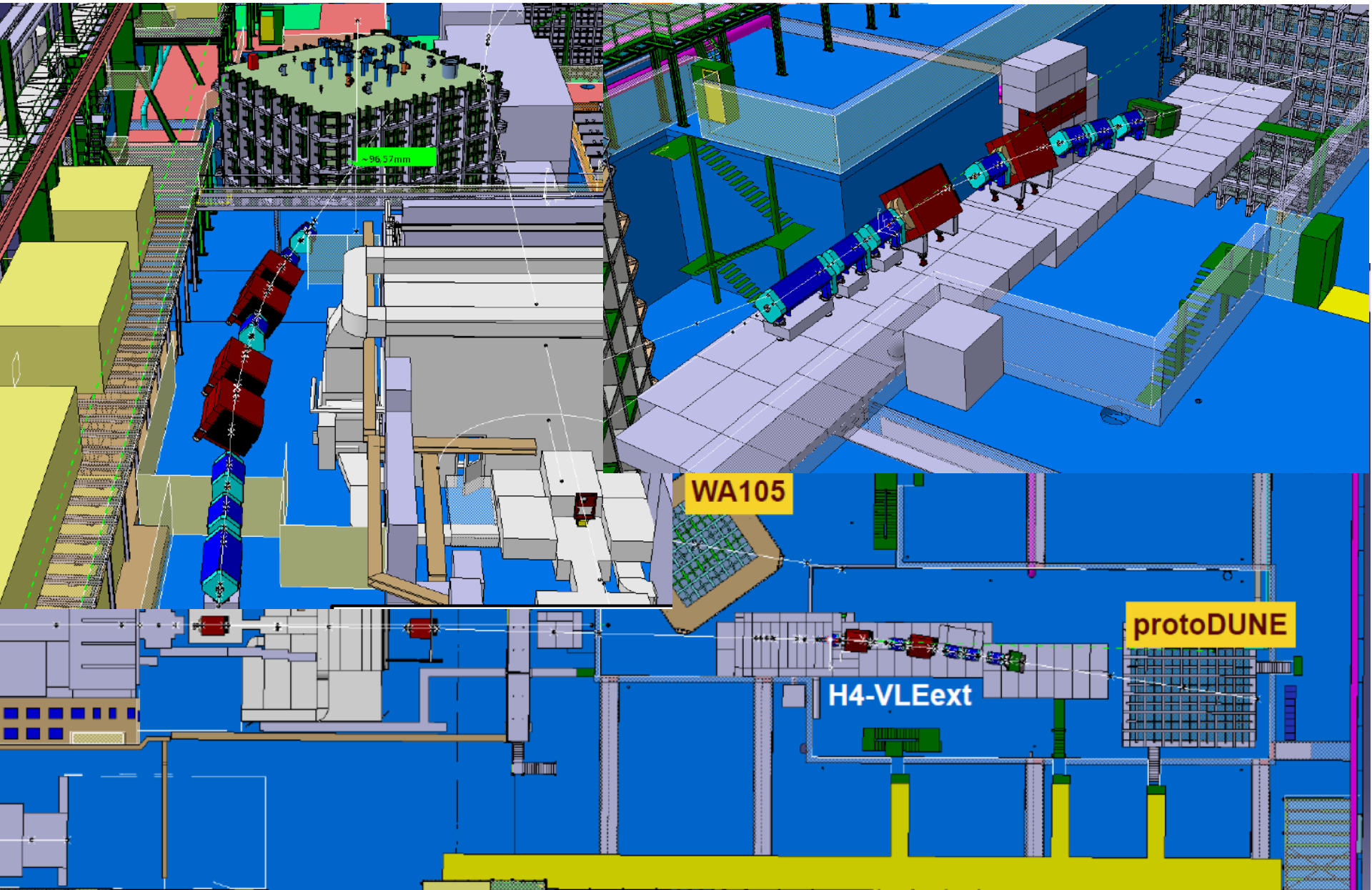
Once consolidated

- New TCSC collimator in TDC2
- Revamped overhead crane in EHN1
- Ventilation units in BA80

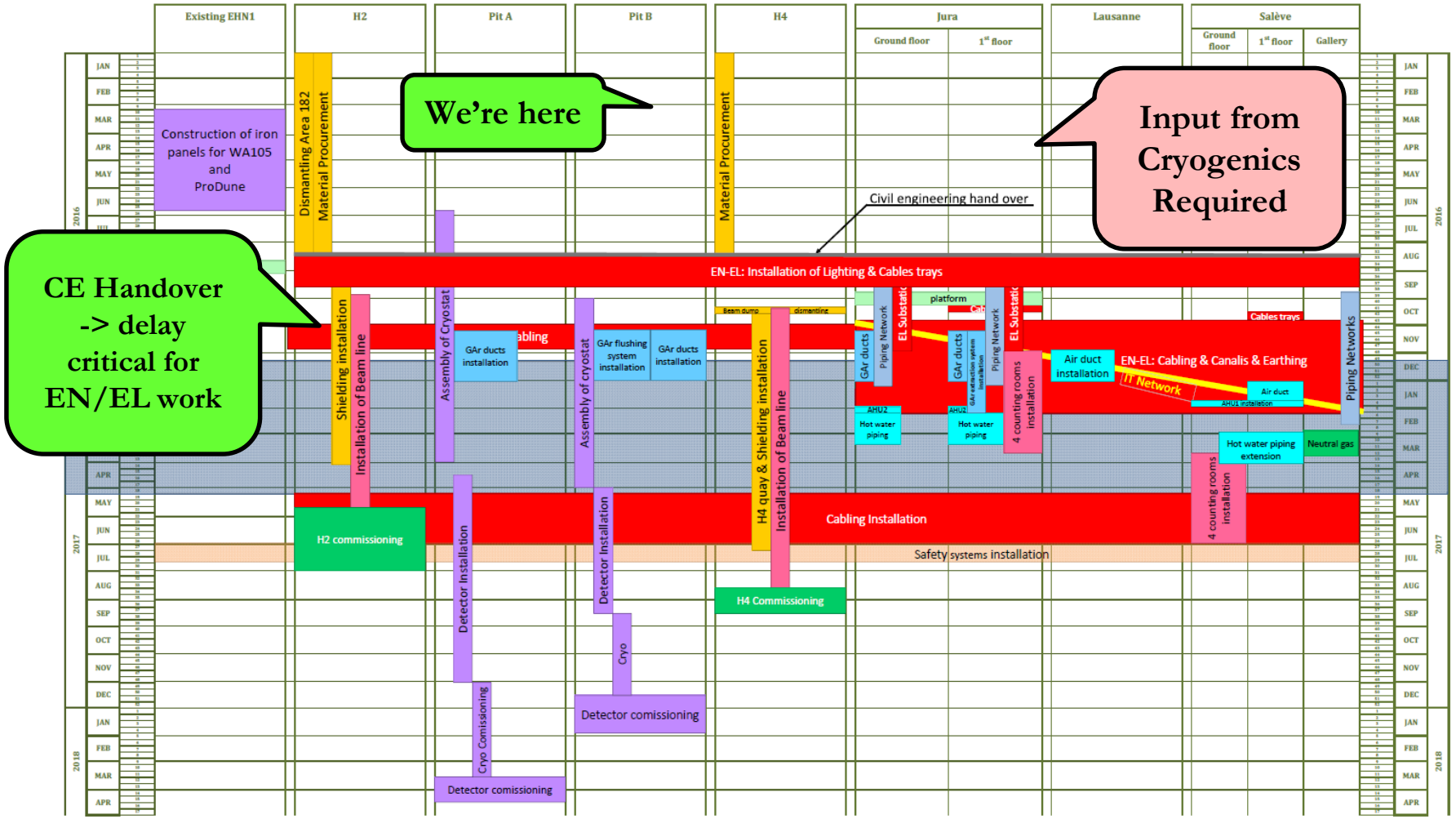
North AREA – STRATEGY

- **Baseline (B):** prevent any imminent damage that would lead to harm of personnel or damage of material and that would therefore jeopardize near-term operation
- **Preservation (P):** maintain current status, compliant with planned operations until 2030+, taking into account foreseen LHC and injector maintenance periods and actions and operation phases
- **Added Value (V):** accommodate new infrastructures or significant upgrades and services in view of needs for experimental and test facilities until 2030+
- Part of baseline and preservation: activities linked to the Neutrino platform, requiring reliable services and infrastructure provided by the North Area complex.
- Energy saving option: for a number of converters, the upgrade to a new generation also leads to significant power savings (~800kCHF/y)

North Area – EHN1 Extension



North AREA – EHN1 Extension



Very tight -> but ok for beam commissioning in 2017 and detector tests in 2018!

© B. Rae

North AREA – URGENT ITEMS

- Power Converter exchange for SM2/Compass (EYETS2016-2017) — A
- TCC2:
  - Irradiated cabling campaign (LS2) — R
  - Magnet cooling circuit (LS2) — A
  - Target boxes T2-T4-T6 exchange (in progress, YETS2015-2016) — A
- EN-CV activities will cover chilled water circuit, AHU, cooling station refurbishment (chilled water approved, rest pending) — A?
- EN-EA will renovate 44 collimators until end of LS2 — A?
- BE-ICS will consolidate the underground gallery access system in EHN1 (EYETS 2016) — A
- EHN1 extension needs some urgent consolidation (EN-EL, EN-CV, EN-HE) — A A?

NA consolidation: Schedule

SHUTDOWN/TS	PROTON PHYSICS	2015	2016	2017	2018	2019	2020	2021
COMMISSIONING	IONS	S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D
Group	**Activity**							
TE-EPC	Change SM2 Power Converter							
EN-EL	TCC2/TDC2 cable campaign							
TE-MSC	Magnet cooling panoply							
EN-STI	Replace T2,T4,T6 target boxes							
EN-MEF	Align H2 & H4 + possible corrections							
EN-EA	Renovate Collimators							
EN-CV	Renovate cooling sytems							
GS-ASE	Renovate U-gallery access							
EN-EL	Consolidate EHN1 infrastructure							
EN-CV	Consolidate EHN1 infrastructure							
EN-HE	Consolidate PR534							

Schedule to be discussed with groups in preparation of the next consolidation day!

LS3 activities: power-converters, electrical network and cooling remainders

North AREA – Cost and Resources

- The total cost requirement is:
  - **~43 MCHF for the baseline** option as well as an additional ~**34 MCHF for the preservation**. However, given budget and resource constraints in the 2016-2025 time scale, only baseline activities can be achieved
  - A significant part of the cost can be gained back by **energy savings (800 kCHF/yr)**
- The required manpower needs to be iterated (consolidation day)

Sub-project	Budget (MCHF)
Baseline Consolidation: ensure near-term operation *Power converter and magnets* *Cooling and Ventilation* *Electrical network*	***42.6*** *22.8* *8.8* *4.4*
Consolidation items (preservation / safety related)	**3.5**
Consolidation items *not in the baseline but needed for EHN1 extension*	**1.5**
Total (2016-2015)	**47.6**

IPP not included

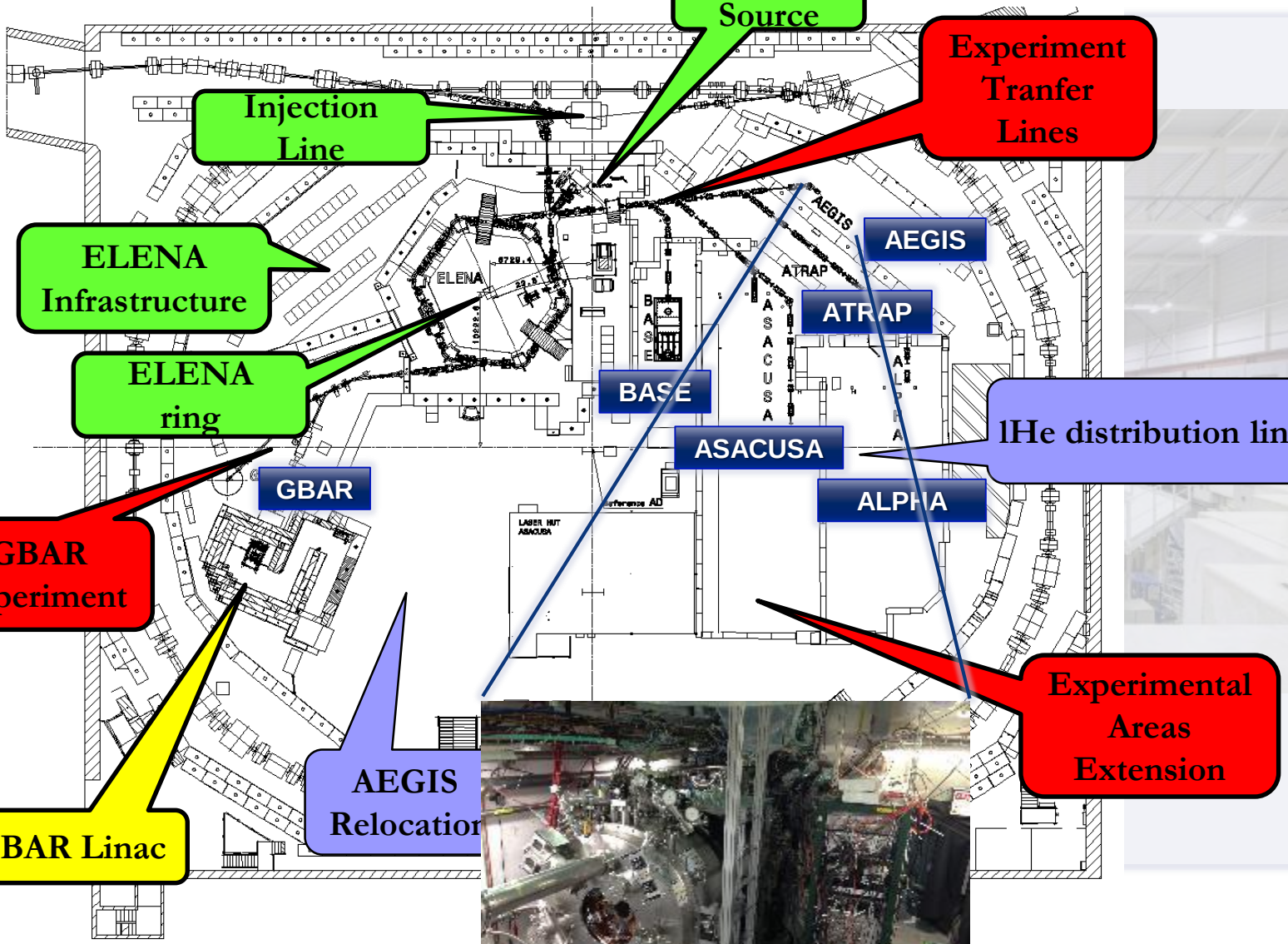
AD/ELENA

In progress

2016

2017

Later ?



CERN | EN ENGINEERING DEPARTMENT

AD – PHYSICS

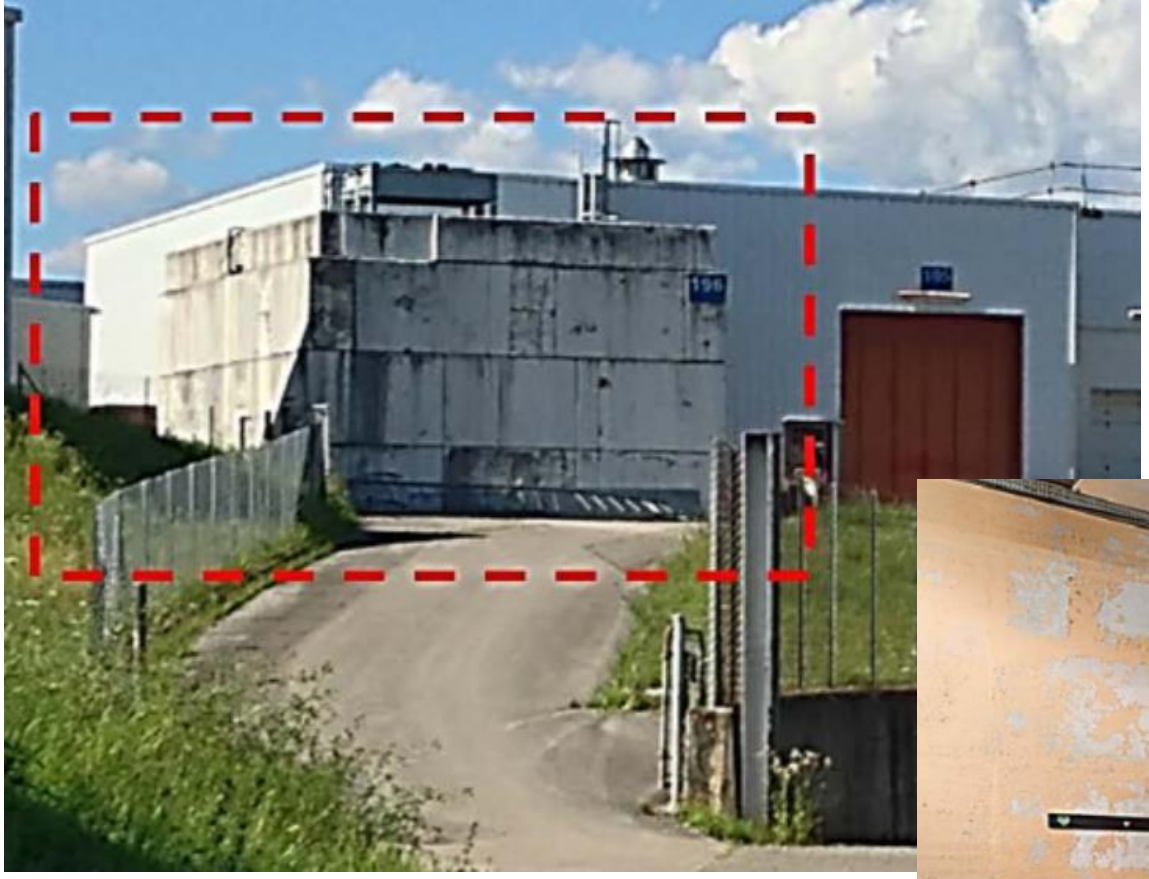
- **AD physics, large and increasing program**:
  - Antihydrogen spectroscopy, precision measurements of Pbar mass, Annihilation cross-section measurements, g-factor precision measurements of 1 trapped Pbar, gravitational studies on antihydrogen, cell irradiation with Pbars etc.etc.
- **ELENA:**
  - Substantial increase (up to 2 orders of magnitude) in number of trapped Pbars at the experiments thanks to **Pbars extracted at 5.3 MeV and cooled down to 100 keV/c**
  - Allows **operation of up to 4 experiments simultaneously** thanks to multi-bunch AD extraction using fast deflectors in the ejection lines
  - ELENA ring commissioning starts this year
- Increased space in AD hall and extension of existing experimental areas => **new experiments and new measurements** (Gbar, ASACUSA2, ALPHAg…)
- **AD life expectancy greatly increased !**

AD – Operational Constraints

- Most of **AD dates from ~1985** => most of the main components are >30 years old
- Due to other important CERN programs, **only urgent issues were addressed** for the first ~10 years of AD operation
- A small consolidation program (~2.3 MCHF), separated from the LHC program, started in 2009 in view of running AD until ~2016
- After **approval of the ELENA** project, the scope of the consolidation increased and is aimed at continued operation of AD for at least 10-15 years after ELENA physics has started which means to **2030** and possibly beyond
- First activities of the consolidation program started in 2013

AD (target) – SAFETY CONSTRAINTS

- **Target area:**
  - High dose rates, **delicate interventions**
  - Use of special handling and transport systems to reduce exposure
  - **Infrastructure in very bad state**, was built to last for “a few years”
  - Ventilation system recirculates, filters or vents zone, also in a bad state and obsolete
- **Consolidation strategy for target area:**
  - **LS2: long cool-down period**
  - **Simplify as much as possible**: new air cooled target (was water) and horn, final focussing with permanent magnets, new chariots for target and Horn movement (reliability)
  - Improved instrumentation and monitoring
  - **Preparation has started for work and installations in LS2 (ECR available)**



AD Target Ventilation Building

Water infiltration

High-Radiation Target/horn area

AD (target area)

- New targets (new design) — A
- Spare Horns + components and test bench — A
- Target/Horn chariots consolidation — A
- Ventilation/cooling system renewal — A
- Services, instrumentation etc — A
- Surface building B196 renewal: necessary (linked to other items), planning well advanced — A?
  Budget/approval to be clarified
- RP detectors: Budget/approval to be clarified — A?

AD (ring & area)

- Helium distribution and recovery line (prior LS2, approval?) — R
- Vacuum system: finalise complete upgrade (prior LS2) — A
- Magnets, target area Budget/approval to be clarified — A?
- C10 RF system: obsolete valves and few spares; complete re-design (high cost) or re-manufacture missing spare valves (no final approval as cheaper solutions are investigated) — A P
- Stochastic cooling amplifiers: prototyping now for possible new design — A
- Electron cooler: old design, missing spares; replace with state-of-the-art design — A
- Power converters: standardisation and renewal — A

AD – Budget

- The total cost for both the **AD target area and the AD hall consolidation** activities amounts to ~**24 MCHF**.
- Some AD Hall activities still in iteration (also for budget optimization)
- The manpower required needs also to be iterated (consolidation day)

Sub-project	Budget (MCHF)
AD Target Area	**6.1**
AD Ring	**11.1**
Cooling & Ventilation *(target area and hall)*	**7.2**
Total	**24.4**

EA Magnet Status

- there are **four super-conducting magnets** in the North-Area (EHN1):
- **three major events during 2015 operation:**
  - **VTX-1 (NA61):** a fast dump of the magnet -> the magnet doesn't run for more than 2 hours at nominal current since then
  - **Morpurgo (ATLAS):** local power triggers a fast dump of the magnet -> ~1uOhm resistance is observed in the coil and the magnet protection system triggers at ~50% of nominal current
  - **M1 (CMS):** magnet control upgraded -> during a powering test in the second part of the ramp down (dump) Helium pressure built-up and was released in the hall through a rupture disk instead through the safety valve (then to be fed into the He recuperation system)
- **Consequences:**
  - NA61 intends upgrading the magnet protection system of VTX1 & VTX2
  - ATLAS should be able to do the same for Morpurgo (MPS as for the VTXs)
  - M1 repair ongoing; new procedure in preparation
- In addition: **responsibilities to be defined for the normal conducting EP magnets**: such as SM1, SM2 (COMPASS), MNP33 (NA62) and MNP22

Staging & Saving

- **EHN1 Extension – Neutrino Platform:** on-going, launched
- **EA:** User & Risk driven + TT2 synergy,
- **NA:**
  - First: high risk and schedule driven
  - Second: baseline focus to maintain until 2030+
- **AD:** target area and long-term operation focus
- **Long-term energy saving (EA/NA):** 10y = 14MCHF
- **Other "savings":**
  - lower costs of power converters (TT2 synergy)
  - reduced maintenance requirements
  - reduced cooling requirements


OH CRUD, HOW AM I GONNA GET PAST THIS GUY.
CONSOLIDATION
PLEASE HELP
CARTOONSTOCK .com
Search ID: gra070806
guy & rOdd
© Guy & Rodd/Distributed by Universal Uclick via CartoonStock.com

In Summary

- A strong physics case and requirement
- Needs a (physics driven) decision
- Experimental Area Consolidation – has to become a (or several) project(s)
  - addressing work together with the respective user communities
  - further optimizing resources & planning
  - exploiting synergies whenever possible


CERN
EN
ENGINEERING
DEPARTMENT

EAST AREA – COST AND RESOURCES

Activity	2016	2017	2018	2019	2020	Total
Magnets maintenance		50	100	100	50	
Change magnets to laminated	340	681	679	150	150	
Rectifiers with energy recovery[1]		2000	4000	1500	0	
Magnet protection system				400		
Collimators			75			
Obstacles control (colls, XCON, m-targets)	40	40	20	50	30	
Vacuum	30	200	200	270	200	
Shielding modifications				100		
Electrical infrastructure AC				1650		
Electrical infrastructure DC					130	
Ventilation system in primary zone				200	200	
Magnet cooling			750	750		
Controls upgrade					70	
Beam loss monitors					20	
Beam stoppers		200	200			
Control rooms					300	
Transport and handling				300	300	
Radiation protection				111	164	
Layout change of beam lines				285	200	
Various items				100	125	
Total	**410**	**3171**	**6024**	**6866**	**1939**	**18410**

(kCHF)

NORTH AREA – BUDGET BREAKDOWN

PBS	Activity		Budget [kCHF] Total (Baseline)	Total (Preservation)
1	Infrastructure		16'009	22'684
1.1	Electrical network		4'004	11'681
1.2	Handling		1'055	1'055
1.3	Buildings & tunnels		0*	0
1.4	Cooling and ventilation		8'800	5'770
1.5	Cryogenics		1'000	650
1.6	Experimental gases		850	800
1.7	Safety systems		300	2728
2	Beam Lines and Experimental Areas		26'638	11'362
2.1	Magnets		1'763	2'400
2.2	Beam Safety Systems		1'650	0
2.3	Electrical Power Systems		20'992	7'012
2.4	SBA provisions		550	1'100
2.5	Beam Obstacles		1'683	0
2.6	Beam instrumentation		0	850
		Total	**42'647**	**34'046**

AD – Budget

The target area consolidation, excluding the ventilation, magnets and BI part amount to **6.1 MCHF** in the following breakdown

- 1.375 MCHF for targets
- 850 kCHF for horns & co.
- 725 kCHF for chariots
- 300 kCHF for decontamination and repainting
- 1.28 MCHF for building 196
- 350 kCHF for safety systems and services for building 196
- 300 kCHF for RP detectors and air sampler VGM
- 300 kCHF for transport consolidation in target area
- 200 kCHF for electrical infrastructure
- 230 kCHF for support, integration and manpower
- 190 kCHF for reconstruction of mobile curtain
- 60 kCHF for fire detection system

AD – Budget

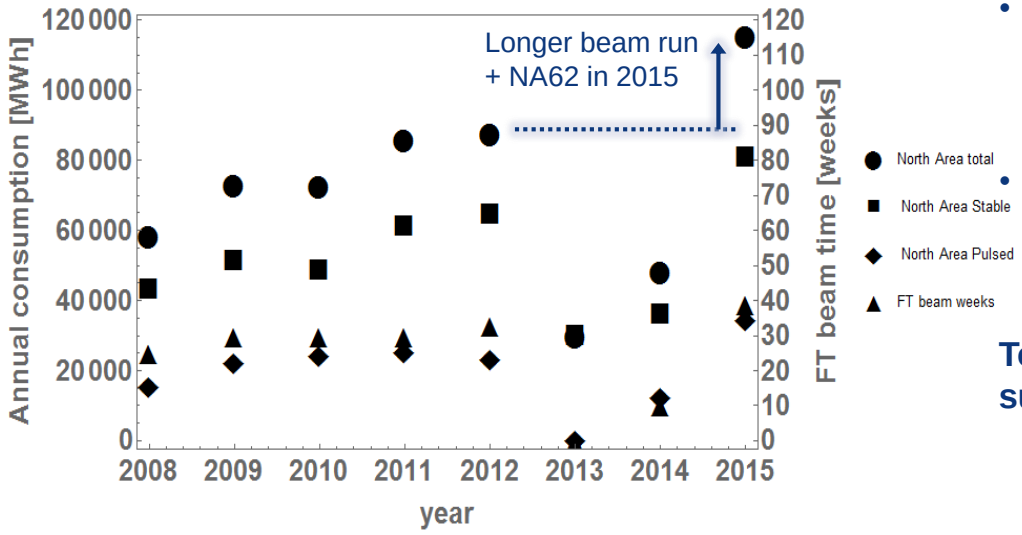
Group	Item	2016	2017	2018	2019	2020	Total
EN/CV	Cooling/ventilation AD hall + Target area			42	4121	3076	7239
EN/STI	Target area Renovation	675	705	710	1040	360	3490 (to be updated)
SMB/SE	B196 (Target area)	125	375	350	350		1200
BE/RF	C10 HL + LL	40	1000	1500	1500		4040
BE/RF	C02 LL + new cavity		30	60	260		350
BE/BI	Electron cooler	800	900	500	200		2400
BE/BI	Instrumentation	300	150				450
TE/EPC	Power converters	200	300	500	500	500	2000
TE/MSC	Magnets (TA + ring/lines)	155	240	100			495
TE/VSC	Vacuum system	275	195	112			582
TE/CRG	Helium distribution			800			800
Total		2570	3895	4674	7971	3936	23046

DESY (D)	3	e+, e- (sec.) e- (prim., planned for 201X)	1 - 5 GeV/c 6.3 GeV/c	Trigger systems and beam telescopes, magnet (~1T)	10 months per year, 2013: 7 - 9 months Duty cycle ~ 50%
FERMILAB (US)	2 (MTest operational, MCenter is currently being refurbished, resume operation in 2013	p (prim.) e, h, μ (sec.) h (tert.)	120 GeV/c 1 - 300kHz 1-66 GeV/c 200 MeV/c	Cherencov, TOF, lead glass calorimeters	2013: 6 months 12 hours per day, duty cycle ~5%
IHEP Bejing (CN)	2	e (prim.) e (sec.) p, π (sec.)	1.1 - 2.5 GeV/c 100 - 300 MeV/c 0.4 - 1.2 GeV/c	MWPC, TOF Cherencov, CAMAC system, platform	Availability: 3 mouths per year, duty cycle depends on BEPCII operation mode
PSI / piE1, piM1, etc. (CH)	2-4	π+-, μ+-, e+-, p	50-450 MeV/c rate $<10^9$ sec^{-1} 20nsec structure continuous beam at very high rate		6-8 months per year
PSI / PIF (CH)	1	p	100 - 700 MeV/c rate $<10^9$ sec^{-1}, typical 10^8 cm^{-2} sec^{-1}, energy and beam spot selectable by user		6-8 months per year during weekends
SLAC (US)	1	e (prim.) e (sec.)	2.5 - 15 GeV/c 1 - 14 GeV/c		Starting July 2012, 9 months per year, 50% duty cycle
SPRING-8, Compton Facility (JP)	1	photons (tagged) e+, e- (conversions)	1.5 - 3.0 GeV/c 0.4 - 3.0 GeV/c		>60 days per year

North Area – Power consumption

Analysis based on 2015

- 115 GWh annual (jenergy)
  - general infra (40 GWh), Cryo (16 GWh), CV and 52 GWh electricity to magnets
- Pulsed: 5 GWh
- DC: 22 GWh due to solid yoke magnets
- Spectrometers: 25 GWh (SM1, SM2, MNP33 …)



Present power supplies are not reliable

about 200 interventions (first line/piquet) annually

- loss in physics time
- Not usable for automatic stand-by during access/no-beam

Power saving in PULSED mode only:

saving 19 GWh

- Reliable power supplies also allow automatic stand-by (pulse-by-pulse)

saving 0.7 GWh additionally

- Stand-by for spectrometers during no-use (periods larger than 1 hour of access/no-beam)

saving 1 GWh additionally

To be added: savings on reduced support/maintenance effort and cooling