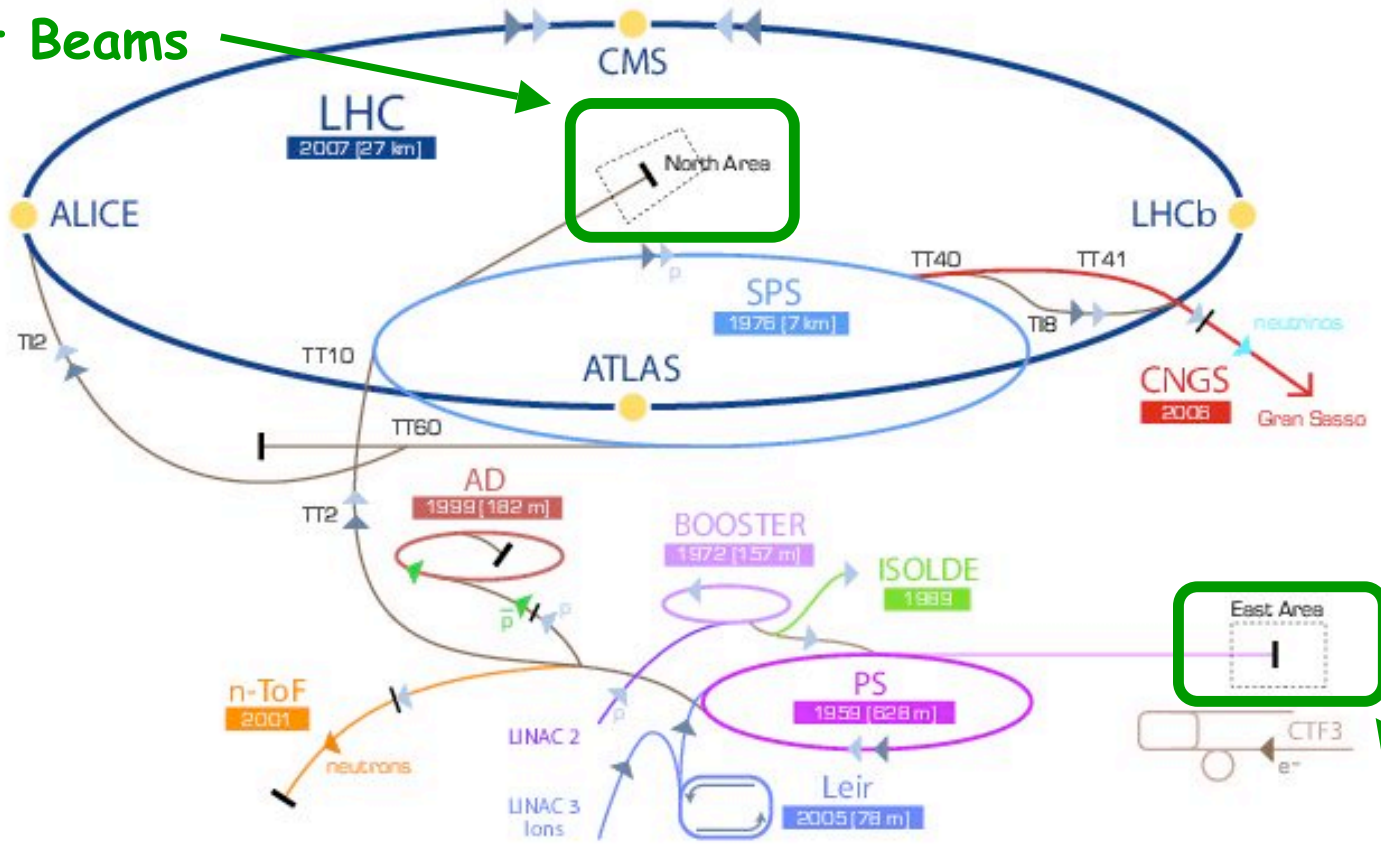
Test Beams at CERN

CERN accelerator chain (operating and approved projects)

SPS Test Beams



PS Test Beams

p (proton) ion neutrons p̄ (antiproton) proton/antiproton conversion neutrinos electron

LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron

AD Antiproton Decelerator CTF3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice

LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight

Experiments/Facilities @ CERN depending on Protons from PS/SPS

PS supplies Protons to

- **East Hall**
  - → DIRAC Experiment (2007 - 2008; continue at SPS)
  - → CLOUD Experiment (2007, for ~7 years)
  - → Proton/Neutron Irradiation (important for upgrade of LHC detectors)
  - → test beams East Area
- **AD** (2007 +2008; program for >2008 will be reviewed by committees)
- **n-TOF** (run in 2007, future program discussed in committees)

SPS supplies Protons to

- **North Area**
  - → COMPASS (run in 2007, program >2007 currently discussed in committees)
  - → NA48/3 (program for 2007 and beyond currently discussed in committees)
  - → test beams North Area
- **CNGS** (start in 2006, program for 5 years)
- **LHC** (start in 2007)

test beams embedded in CERN physics program

CERN Test Beam Lines

(general purpose)

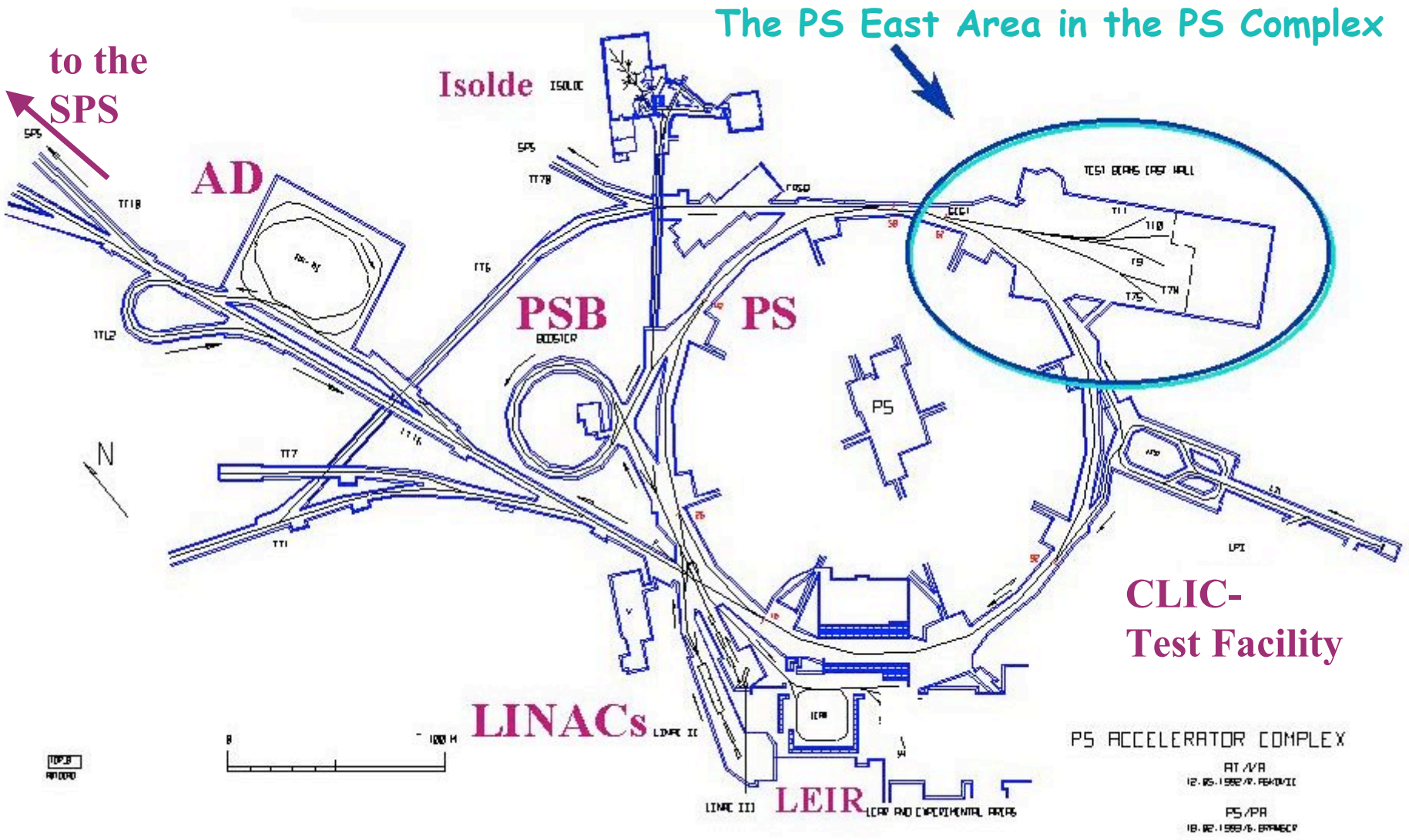
- PS East Hall (Meyrin site, Switzerland)
  - → 4 test beam lines

    (T7, T9, T10, T11) E_{min} - E_{max} = 1 - (10, 15, 7, 3.6) GeV/c
- SPS North Area (Prevessin site, France)
  - → 4 test beam lines

    (H2, H4, H6, H8) E_{min} - E_{max} = 10 (2) - 400 (450) GeV/c
- Irradiation facilities
  - → Gamma Irradiation Facility (GIF), former SPS West Area
    - Cs^{137} source, 662 keV photons, <720GBq

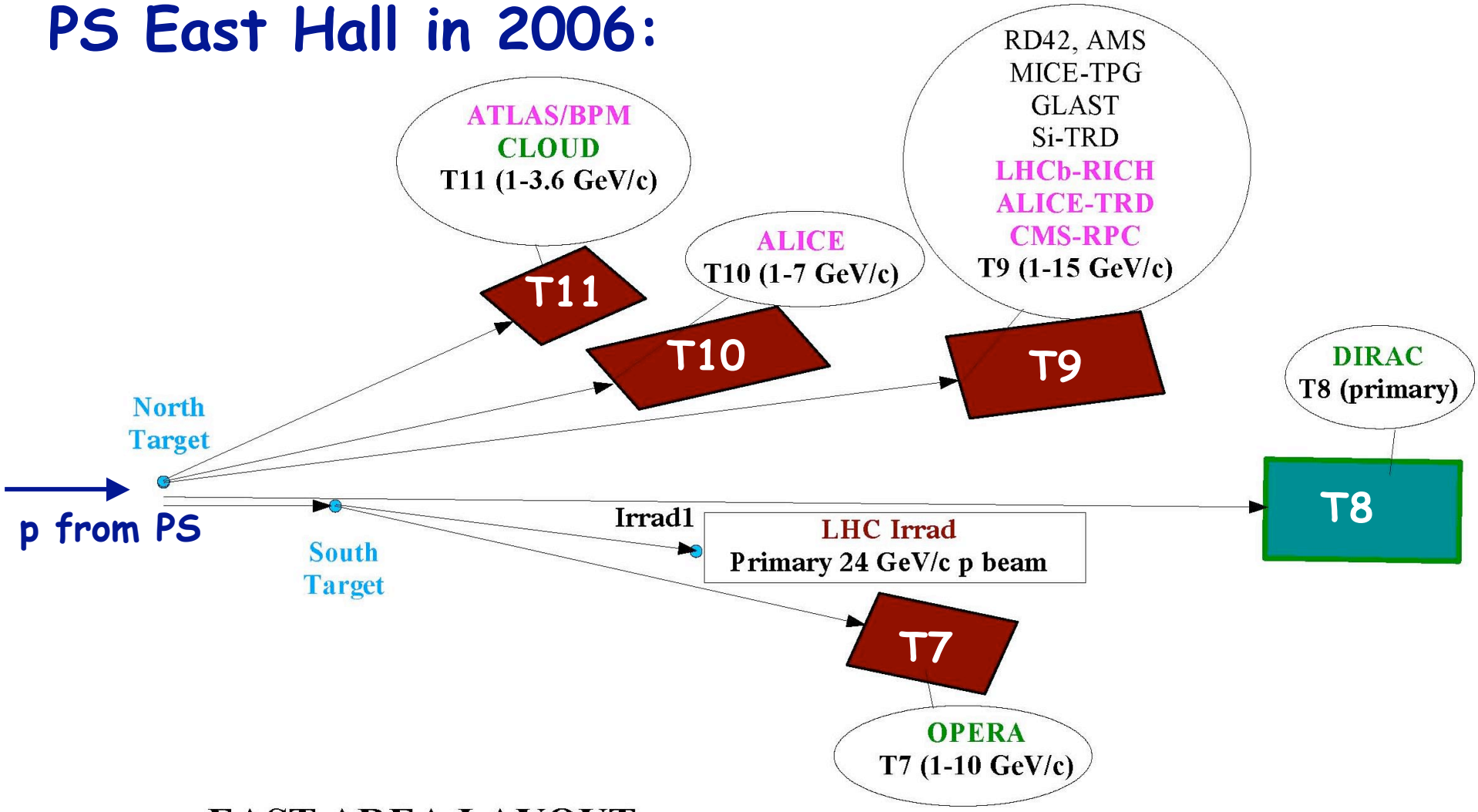
      (2007: last year of GIF operation (?), new facility under discussion)
  - → Proton/Neutron irradiation facilities, PS East Hall
    - 24 GeV/c primary protons from PS, 2*2cm^2 beam spot, $2.5*10^{11}$ protons/spill
    - neutrons from beam dump, spectrum similar to LHC environment

PS Complex


The PS East Area in the PS Complex
to the SPS
Isolde
AD
PSB
PS
PS
CLIC-
Test Facility
LINACs
LEIR
N
PS ACCELERATOR COMPLEX

PS East Hall Beams

PS East Hall in 2006:



EAST AREA LAYOUT
(2006 Situation)

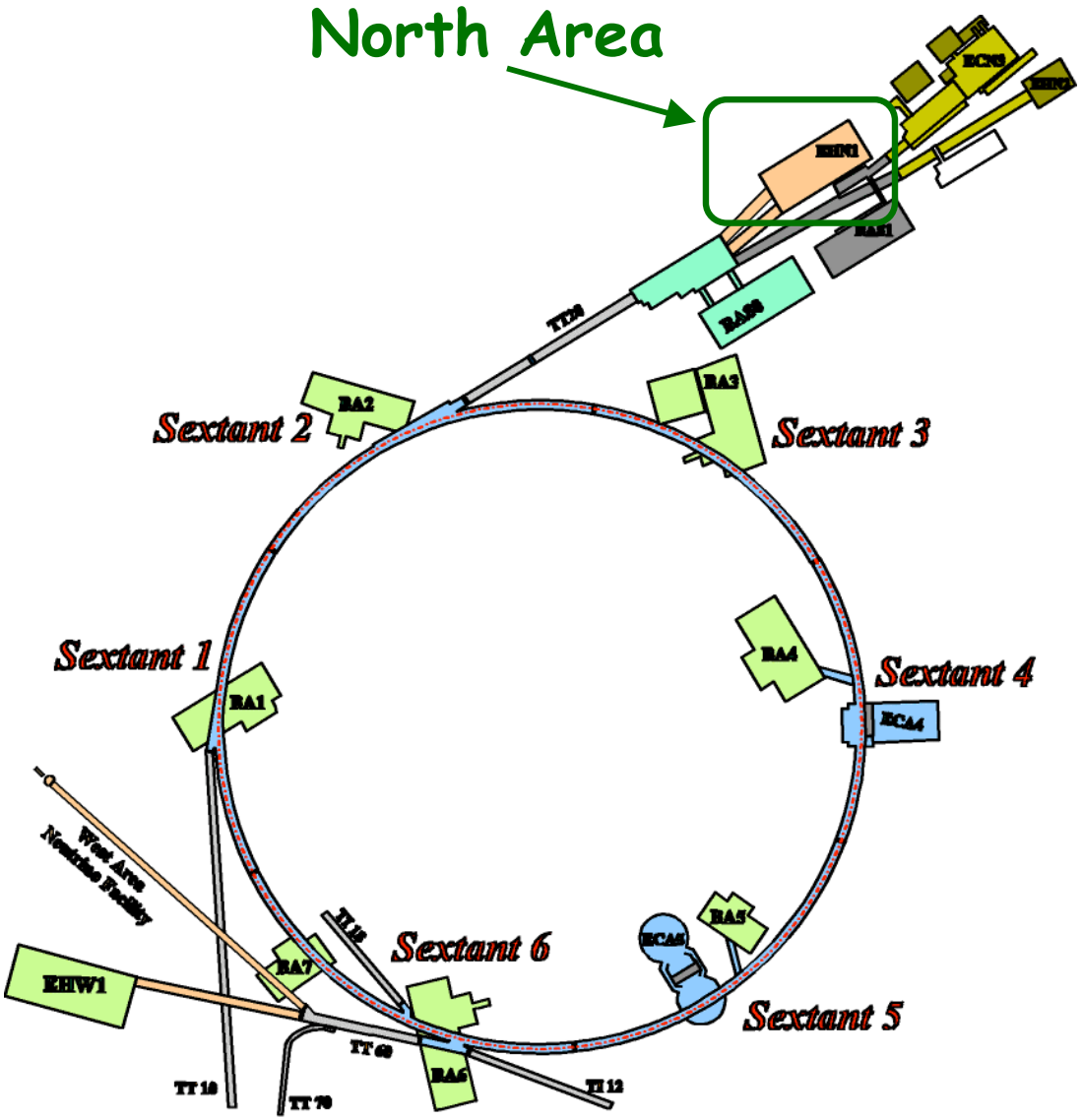
East Hall Beam Characteristics

- Momentum range
  - → minimum 1GeV/c, all beams
  - → max. 3.6GeV/c (T11), 7GeV/c (T10), 10 GeV/C (T7), 15 GeV/c (T9)
- Spill structure from PS
  - → 400ms spill length, typically 2 spills every 16.8s, more on request
- Particle type and intensity
  - → electrons (lower momenta), hadrons, muons
  - → max. 1-2*10^6 particles per spill, typically 10^3 - 10^4 used
- Targets
  - → ~10 different targets, T9/T10/T11 share same (north) target
  - → most frequently used
    - standard hadron target (Al)
    - electron enriched (Al+W converter plate) → 5-10x more e's

SPS Layout

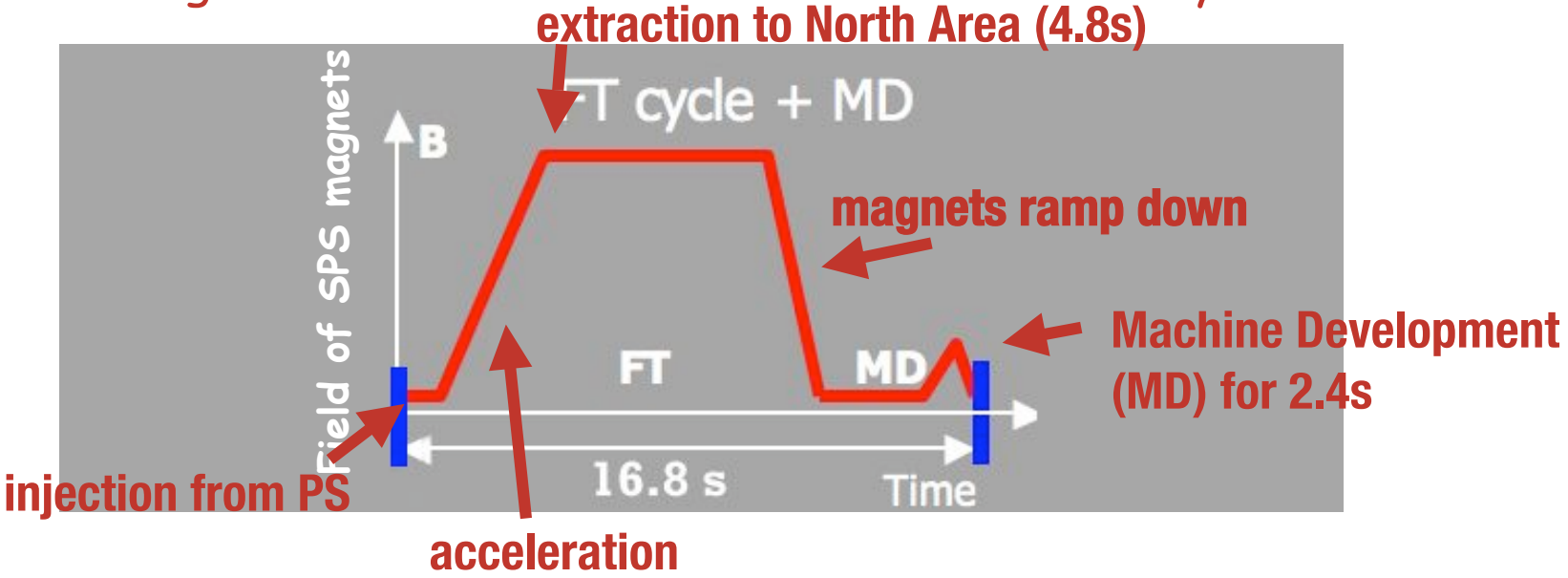
- SPS beam energy
  - → 400 GeV/c (450 GeV/c)
- Beam extraction
  - → 2007: to North Area & CNGS
  - → starting 2008: to North Area, CNGS & LHC
- Spill to North Area (@400GeV)
  - → 4.8s - 9.6 s length
  - → 1 spill every 14s - ~40s
  - → spill length / repetition frequency depend on number of facilities which need SPS extraction

⇒...



Distribution of PS/SPS Protons organised in Super-Cycles (SCs)

- Super-Cycle (SC):
  shortest cyclic sequence of **SPS** operation/extraction to various users
  → SC length/type (operation modus) depends on number of users
- Examples (relevant for 2007 run)
  → 1) fixed target/test beam SC if North Area is the only SPS user



⇒ Length of SC is 16.8s (14.4s without MD)

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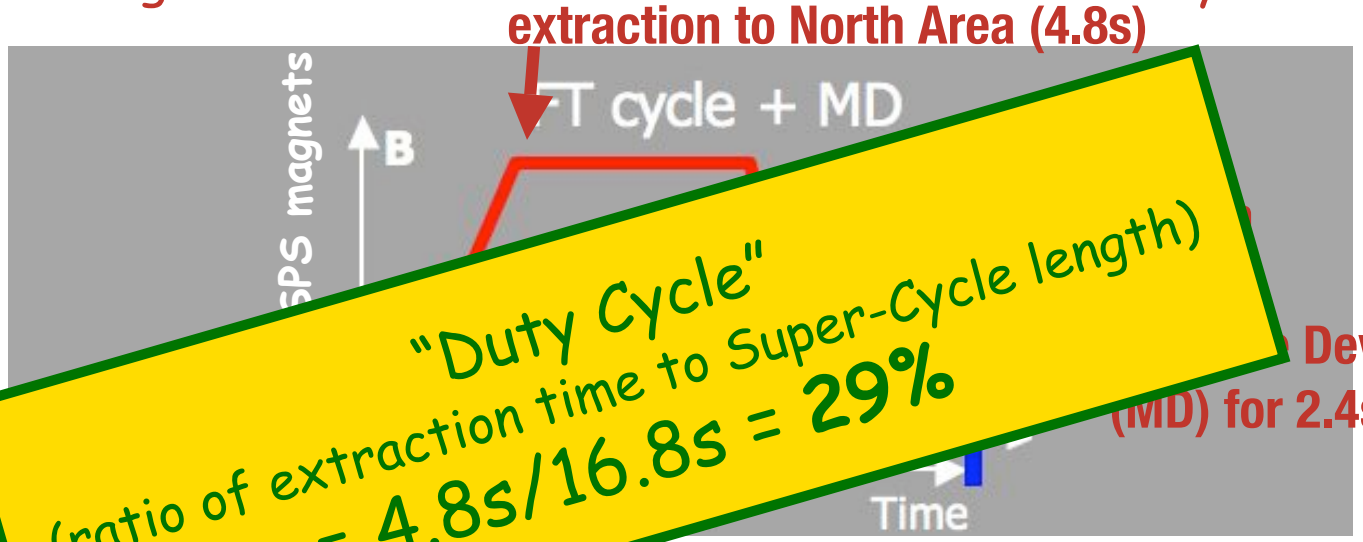


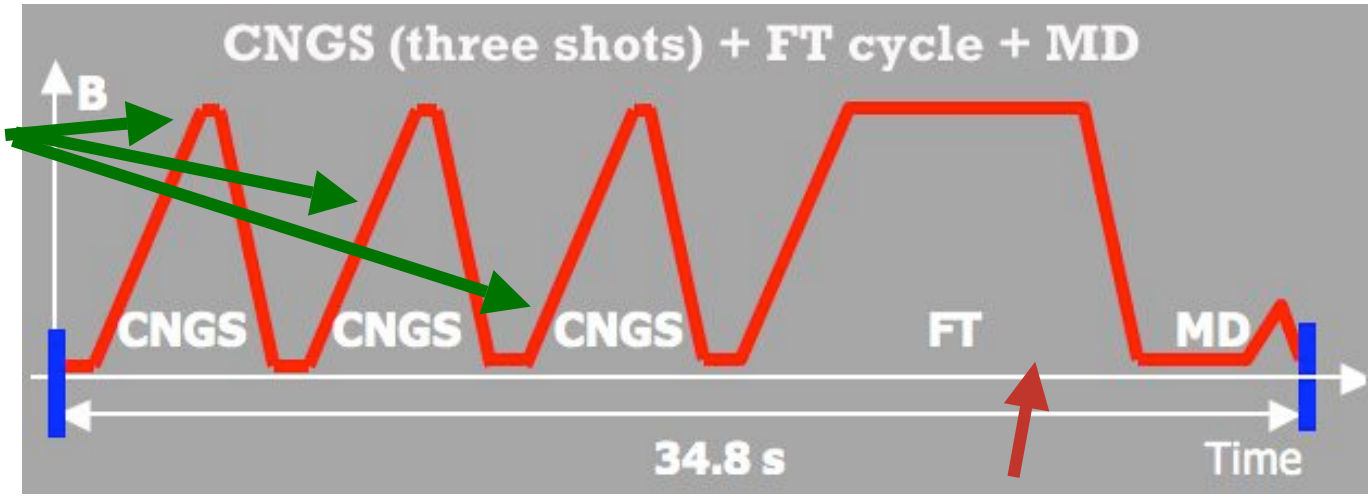
"Duty Cycle"
(ratio of extraction time to Super-Cycle length)
= 4.8s/16.8s = 29%

⇒ Len SC is 16.8s (14.4s without MD)

Distribution of PS/SPS Protons organised in Super-Cycles (SCs)

- Super-Cycle (SC):
  shortest cyclic sequence of **SPS** operation/extraction to various users
  → SC length/type (operation modus) depends on number of users
- Examples (relevant for 2007 run)
  → 2) SC if North Area and CNGS are SPS users

3 extractions to CNGS (short SPS extraction), duration 3x6s = 18s



Standard FT extraction (4.8s) + MD (example 1)

⇒ **Length of SC is 34.8s**

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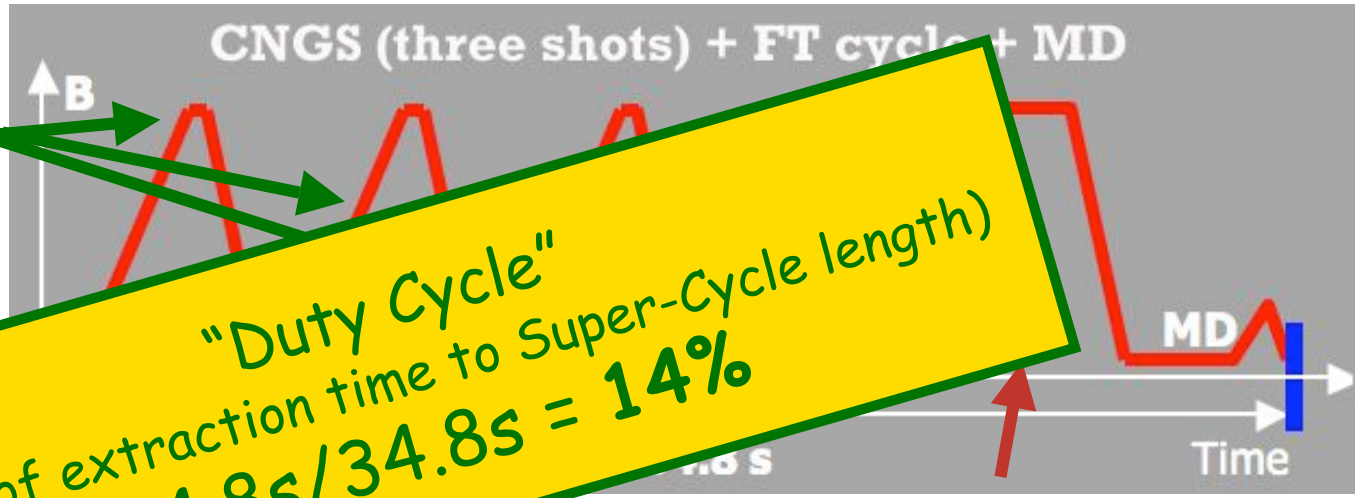


"Duty Cycle"
(ratio of extraction time to Super-Cycle length)
= 4.8s/34.8s = 14%

Standard FT extraction (4.8s) + MD (example 1)

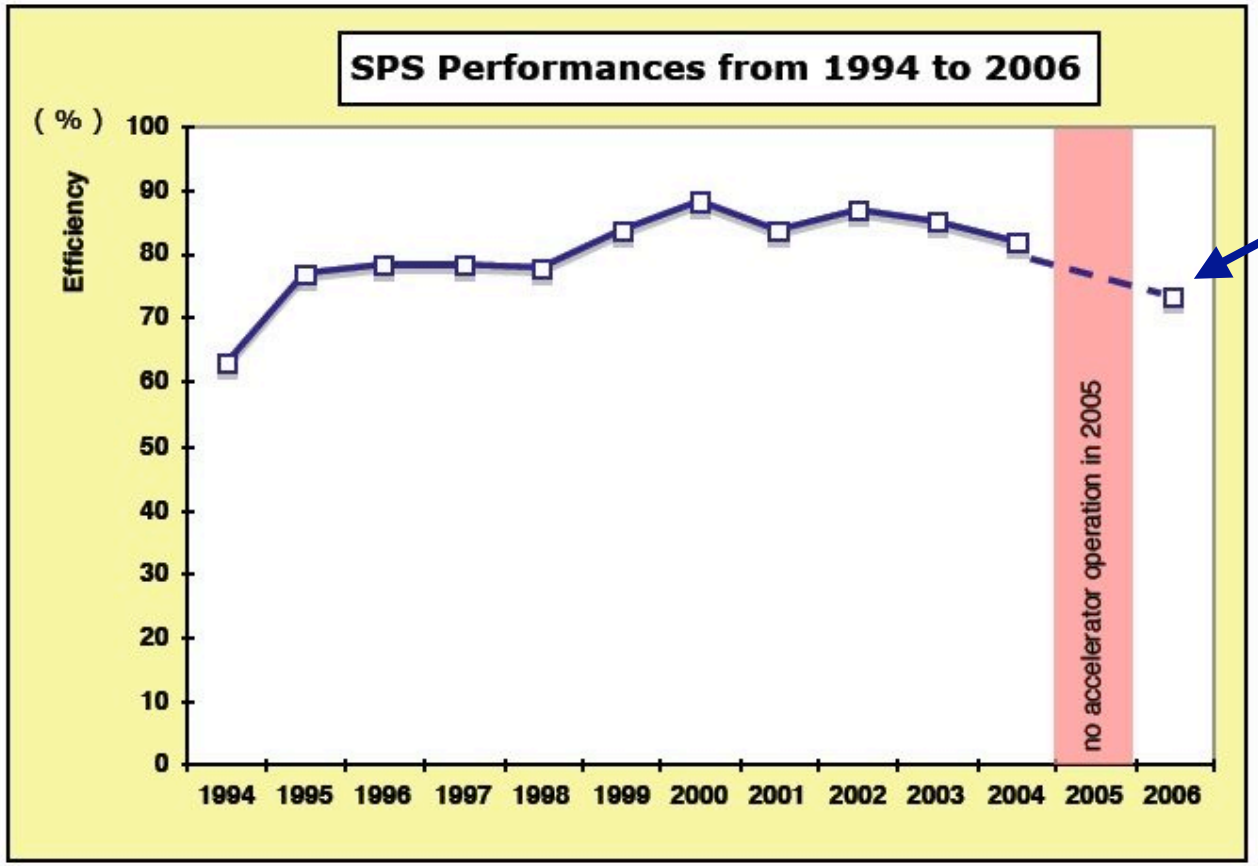
⇒ Length of SC is 34.8s

…even more Super-Cycles possible…

- Example, 2006 run:
39.6s SC with
1 FT, long extraction
(9.6s "**long flat top**")
plus 3xCNGS

⇒standard modus of operation during coming years with CNGS running:
long SCs
(2007: CNGS run subject to OPERA target status)

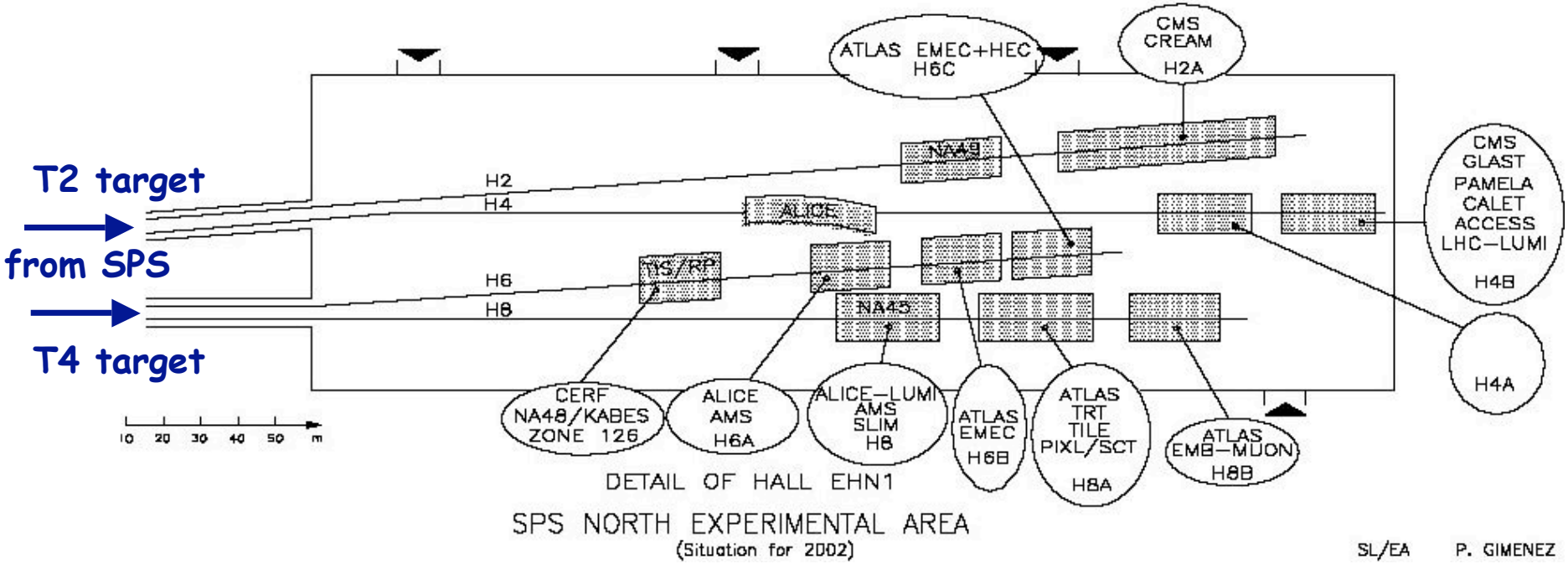
Accelerator (e.g. SPS) Efficiency*



*efficiency:
actual number of hours with physics compared
to number of "physics hours" originally scheduled

- 2006: restart of accelerators after long shut-down (no beams in 2005).
- 2006: lower efficiency caused by start-up problems (PS/SPS main power supplies)
- (SPS efficiency includes PS efficiency)

SPS North Area



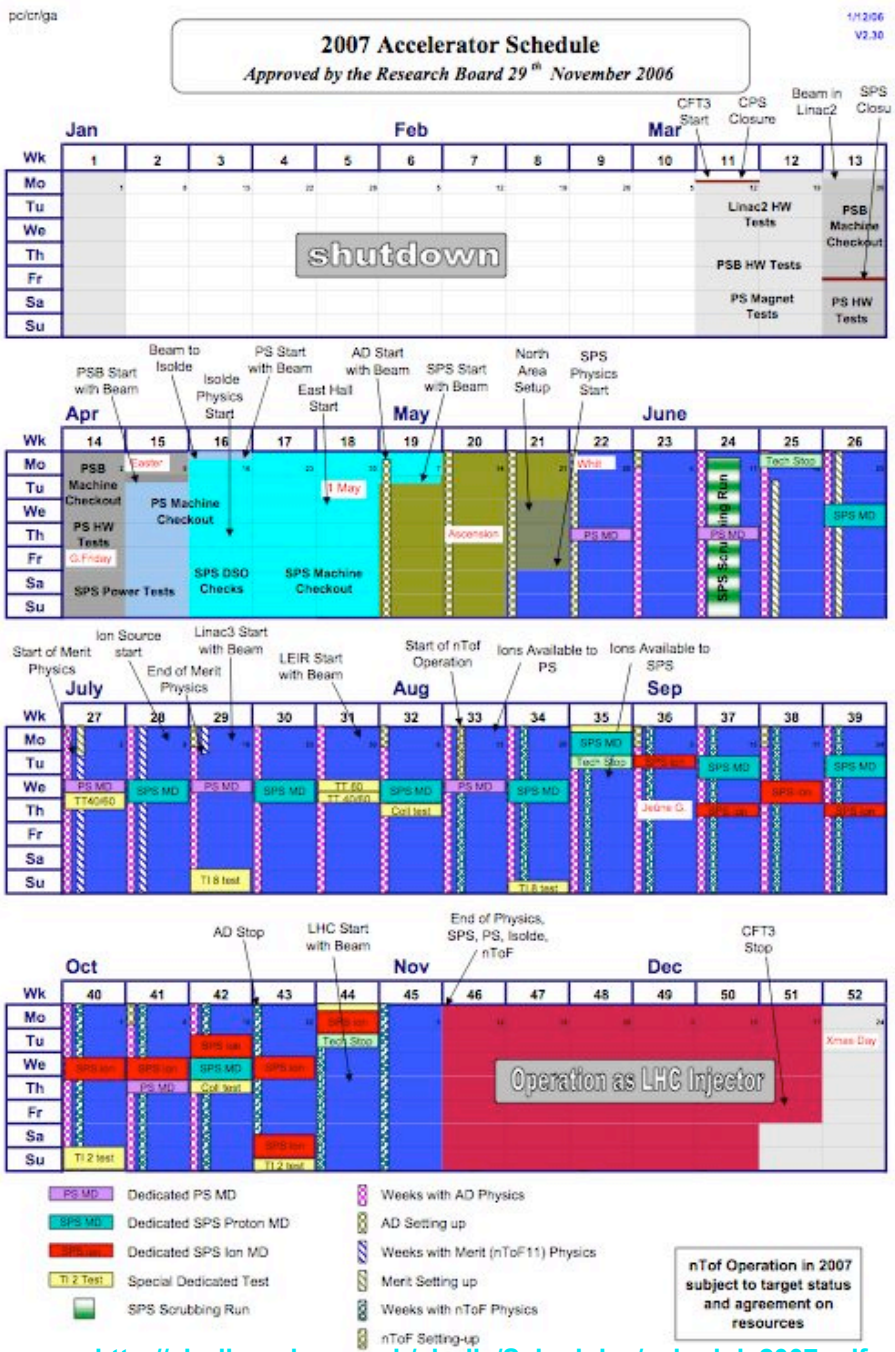
- H2, H4 and H8 beams
  - → 10-400 GeV/c, up to 10^8 particles per spill (π^+)
  - → H4 can be set-up for very clean electron beam (up to ~300GeV/c)
  - → H2 and H8 also have low energy tertiary beams (2-10GeV/c)
- H6 beam
  - → 10-205GeV/c, up to 10^8 particles per spill (π^+)

SPS North Area Beams

- H2/H4 originate from the same (T2) target
  - → due to beam optics, H2 & H4 run with opposite polarity beams
    - e.g. H2: protons or π^+, H4: electrons
    - beam conditions of H2 & H4 users need coordination (in weekly Users Meeting)
- H6/H8 originate from the same (T4) target
  - → due to beam optics, H6 runs at ~half H8 energy
    - otherwise reduced particle intensities
    - also H6/H8 users need coordination
- Up to 3 user areas per beam line
  - → possibility to take parasitic muons behind main user
  - → some areas equipped with moveable tables/platforms
  - → some areas permanently occupied by LHC users (ATLAS, CMS, LHCb, TOTEM)

PS/SPS (Test Beams) in 2007

(requests from 47 groups, O(1500) users)



http://ab-div.web.cern.ch/ab-div/Schedules/schedule2007.pdf

- PS test beams: May 2 - Nov 12 (28 weeks)
  - → requested beam time (T7,T9-T11):
    - ~43% LHC & LHC upgrade
    - ~12% external users
- SPS test beams: May 25 - Nov 12 (23.5 weeks)
  - → requested beam time (H2-H8):
    - ~52% LHC & LHC upgrade
    - ~35% external users
- PS/SPS operate as LHC injectors: start Nov 12

PS/SPS (Test Beams) in 2008…

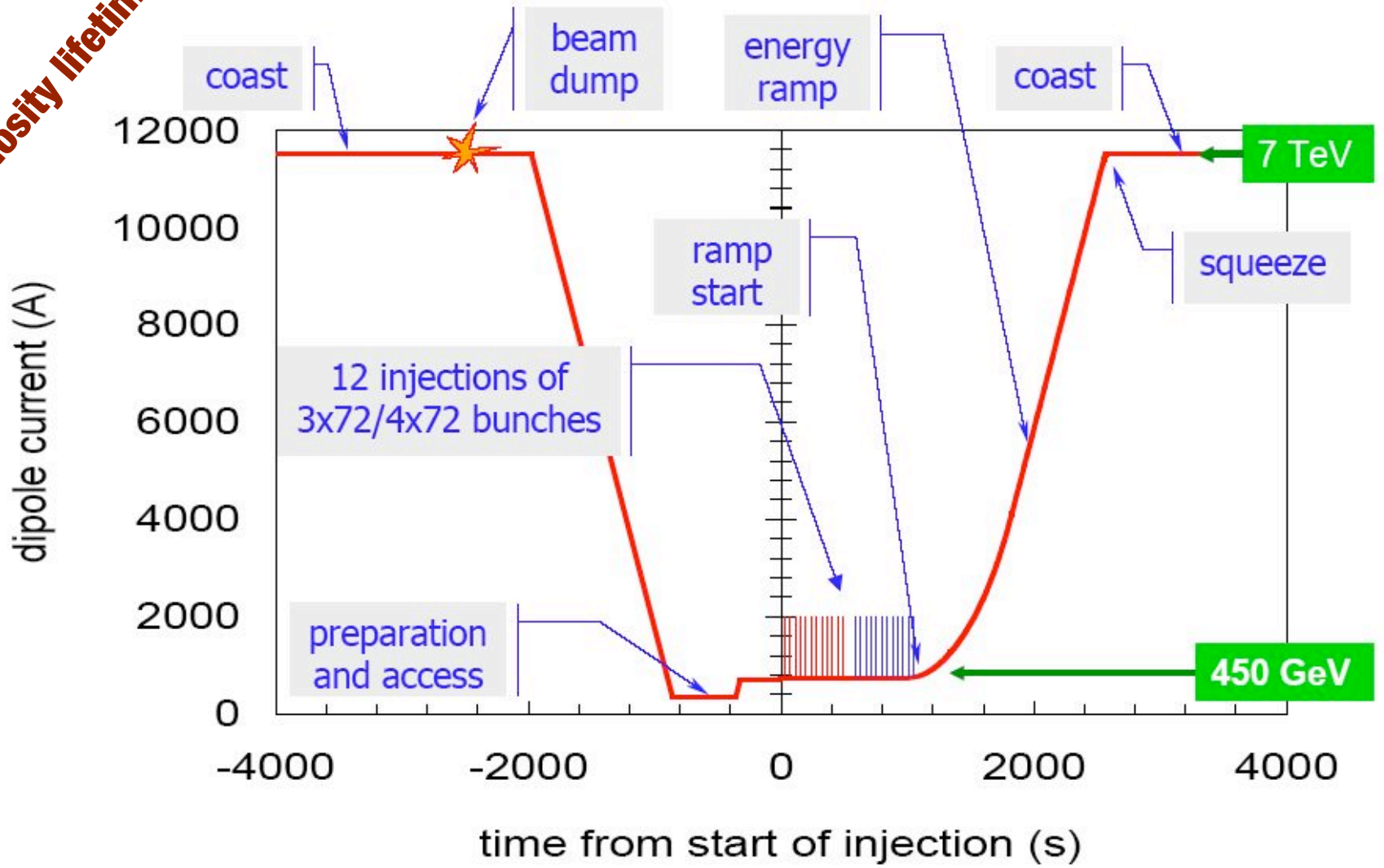
…and later

- SPS operation modus and Super-Cycles will depend on LHC status and LHC beam request (LHC highest priority for SPS beam!)
- Three different operation modes
  1. LHC filling mode (LHC single user)
  2. LHC setup mode (multiple SPS users)
  3. CNGS-FT (test beam) mode
- Fraction of modes in **2008** **(2011)**
  (study and report of the High Intensity Protons Working Group, CERN-AB-2004-022 OP/RF)

1:15%, 2:35%, 3:50%
(5%, 10%, 85%)

LHC Operation Cycle

luminosity lifetime > 10 h



SPS operation modus 3 | SPS operation modus 1 or 2 | modus 3

Support by CERN
(all free of charge)

- Basic installation support
  - → electronics hut with beam control terminal
  - → computer network connection
  - → crane usage (with operator)
- Assistance for beam tuning and operation
  - → provision of beam position monitors
    - MWPC in East Hall
    - delay wire chambers and wire filament scanners at SPS (higher accuracy)
  - → provision of (threshold) Cerenkov counter(s)
    - usually 1 counter available per beam line, 2 can be requested
    - also more sophisticated differential Cerenkov's (CEDAR) available at SPS (only on ***strong*** request)
- Usually NOT available: storage space, office space

(Some) Practical Details

- When working at CERN
  - → need to register as CERN user or short term visitor (<3 months/year)
  - → might need visa for Switzerland and/or France (SPS North Area)
- When working in test beam areas
  - → each test beam activity need responsible person for safety (GLIMOS)
  - → need film badge (see http://service-rp-dosimetry.web.cern.ch/service-rp-dosimetry/)
  - → safety course obligatory (every day, two courses, see http://safety-commission.web.cern.ch/safety-commission/SC-site/index.html)
  - → may need access / search patrol authorisations
- Your equipment
  - → only halogen free cables allowed
  - → use of flammable gas requires advance contact to CERN Safety officers
- safety inspection obligatory before beam start (ISIEC form to be filled)

Conditions to Use

- External users = users/groups NOT related to an approved CERN experiment
  - → can nevertheless use CERN beams without any charge
- Beam requests should be sent to the PS/SPS Physics Coordinator (SPS.Coordinator@cern.ch)
- Maximum time to request (to be allocated by the Coordinator)
  - → PS Eat Hall: 2 weeks per year and group (can be split)
  - → SPS North Area: 1 week per year and group
- More beam time requires to write detailed proposal
  - → to be submitted to the relevant CERN Scientific Committee = SPSC for PS and SPS beams
  - → needs to be recommended by SPSC and finally approved by the CERN Research Board

Contact Persons & More Info

- General contact, PS and SPS beam requests, schedules, any problems…
  → PS/SPS Physics Coordinator (= Christoph Rembser presently)

- Beam Physicists of PS and SPS experimental Areas (direct contact concerning technical help, beam conditions, user areas etc.)
  → PS East Hall: Lau Gatignon
  → SPS North Area (H2-H8): Ilias Efthymiopoulos

- Irradiation facilities
  → Gamma Irradiation Facility (GIF)
    - Mike Clayton (Technical Coordinator), C. Rembser (User Schedule)
  → Proton/Neutron Irradiation Facilities
    - Maurice Glaser, Michael Moll

- More Information
  → about beam requests, schedules, test beam areas, registration, etc.
  → http://spsschedule.web.cern.ch/SPSschedule/pindex.html

…see you at the CERN test beams!

designed by a
summer student in 1998