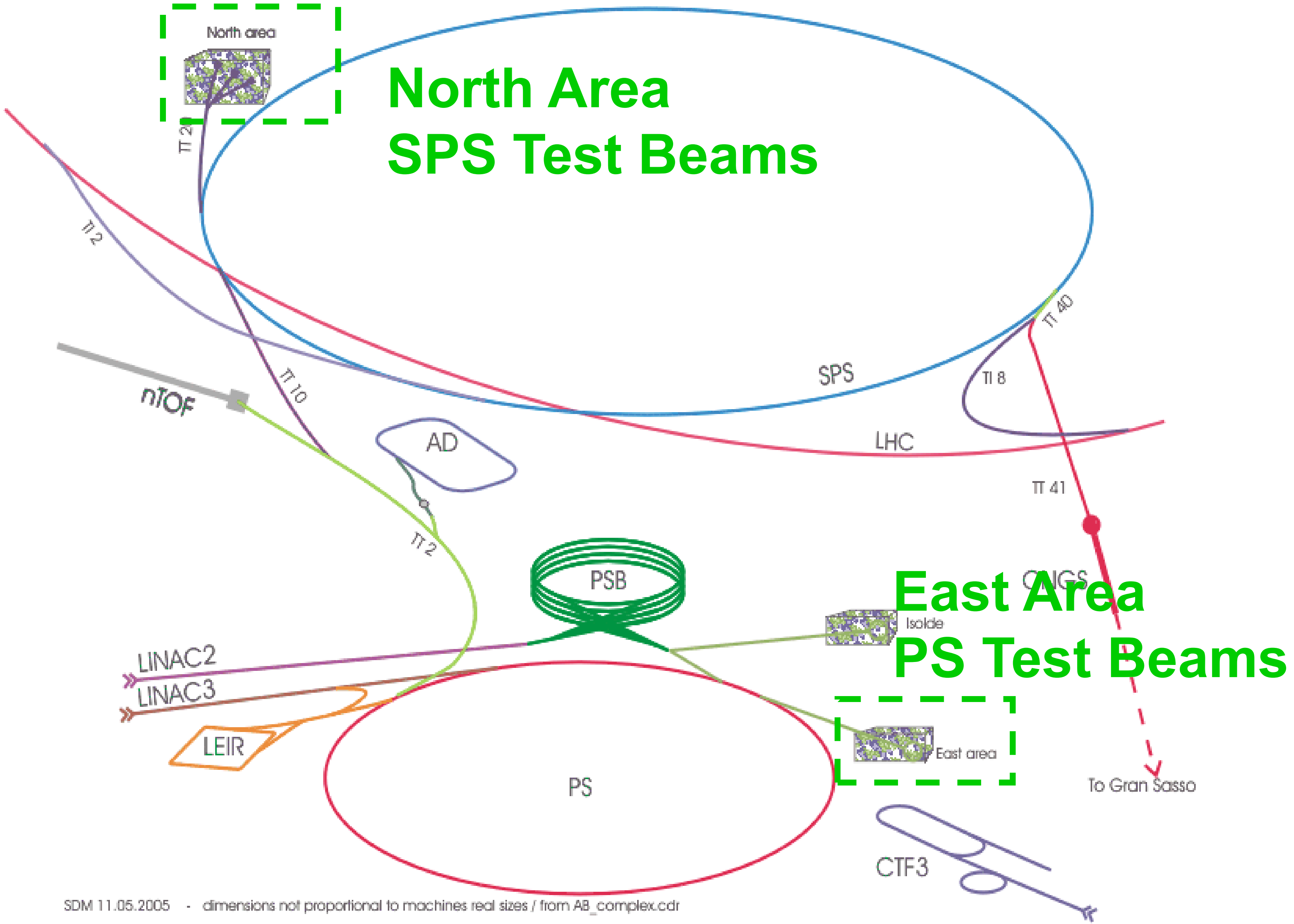
Overview on
CERN Test Beam Facilities
and
Plans for Tests for
Non-Collider Experiments

Edda Gschwendtner, CERN

Overview

- East Area Test Beam Facility
- North Area Test Beam Facility
- Test-Plans for Non-Collider Experiments
- Summary

Test Beam Facilities at CERN



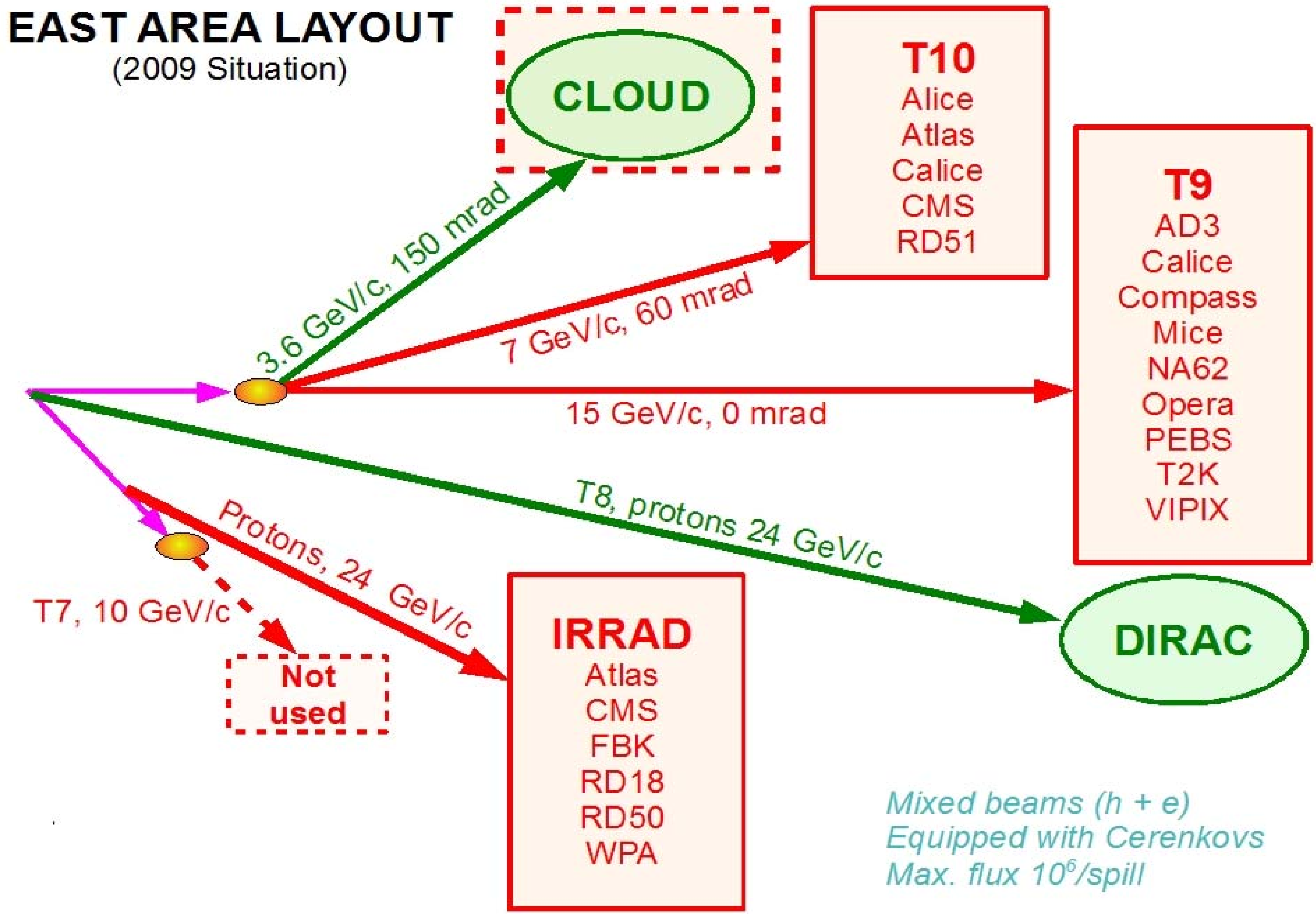
PS East Area

5 beam lines

total length 300m

300 scientists / year performing experiments and tests

The East Experimental Areas at the PS



East Area Beam Characteristics

- Momentum range
  - Secondary beam: 1GeV/c – 15 GeV/c
- Particle type and intensity
  - electrons, hadrons, muons
  - max. 1-2*10^6 particles per spill
    typically 10^3 - 10^4 used
- Spill structure from PS
  - 400ms spill length
  - typically 1 spill every 33.6 s, more on request

SPS North Area

7 beam lines

total length 5.8 km

Three experimental halls : **EHN1**, EHN2, ECN3

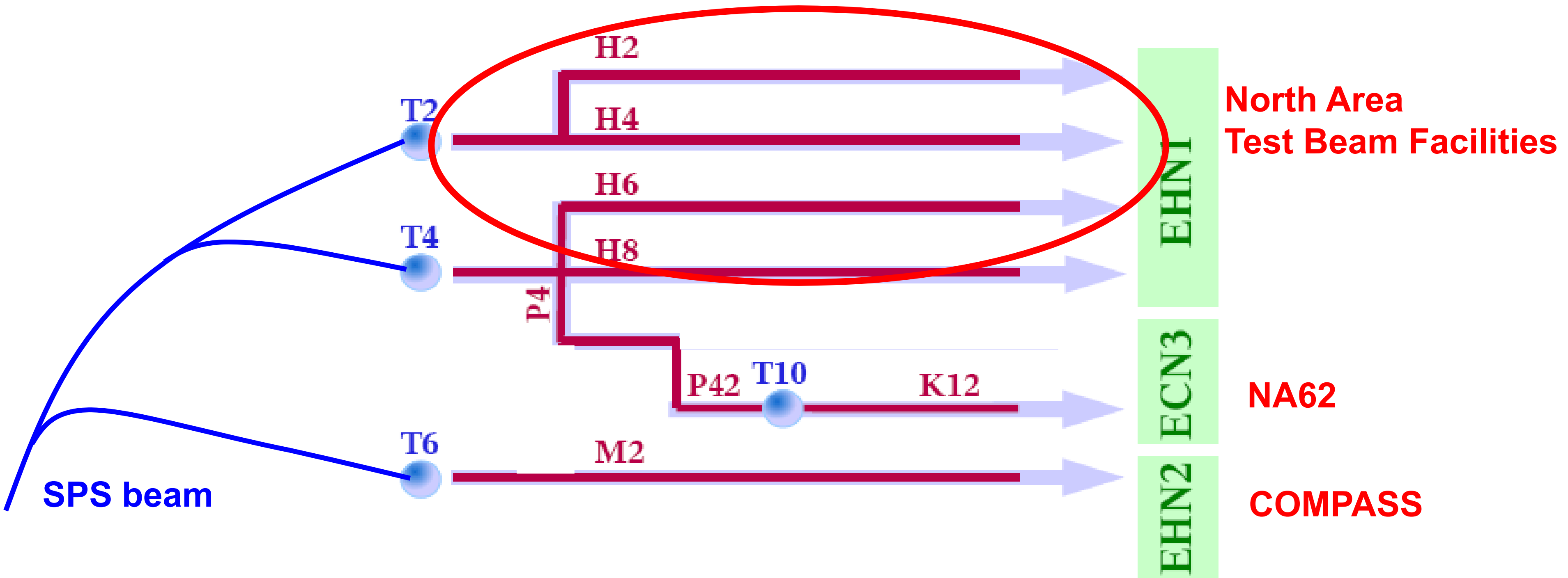
~2000 scientists / year

The North Experimental Areas at the SPS

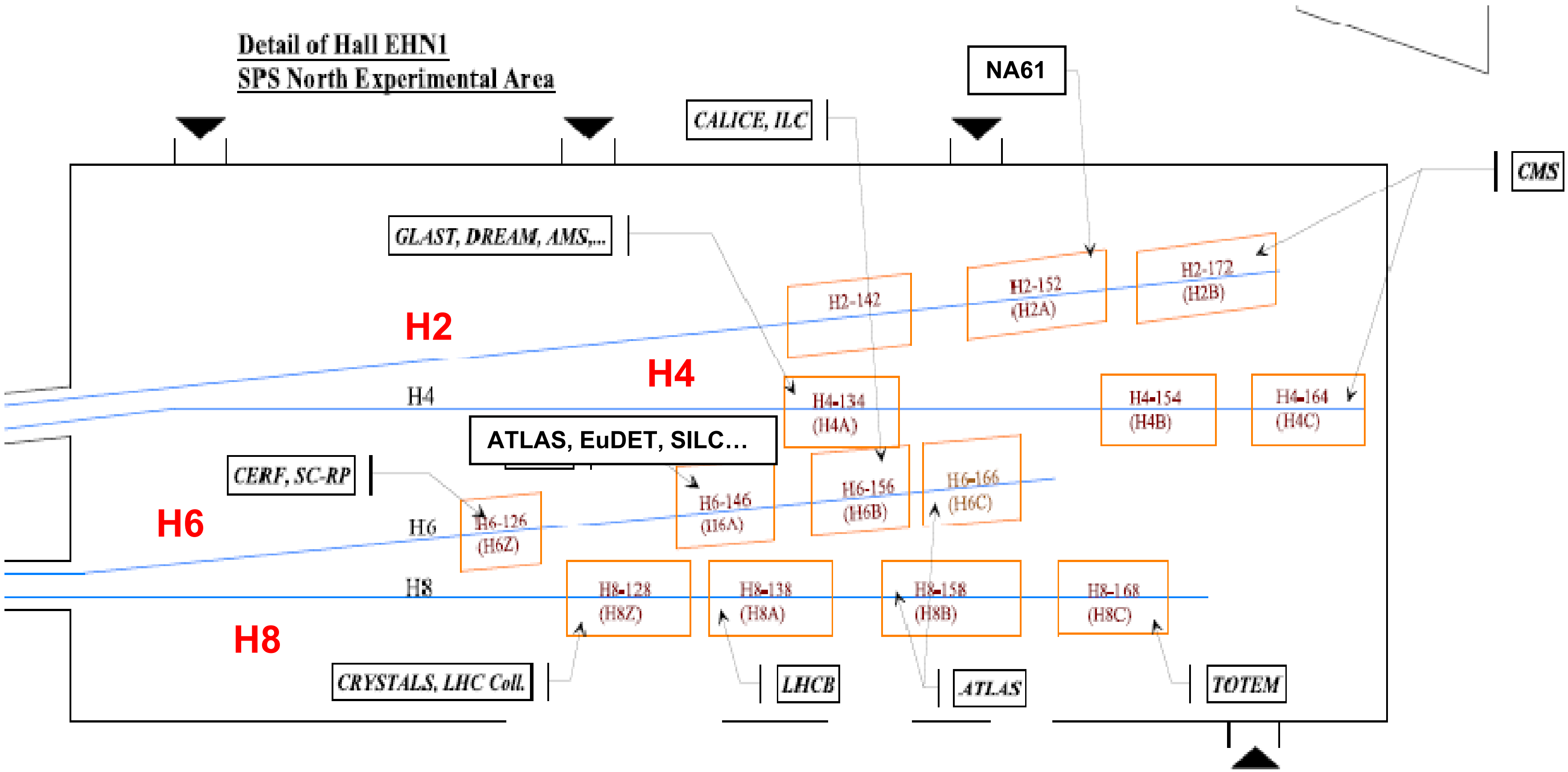
- The SPS proton beam (400/450 GeV/c) slowly extracted to North Area
- Directed towards the three North Area primary targets T2, T4 and T6

- From the primary targets:
  - T2 → H2 and H4 beam lines
  - T4 → H6 and H8 beam lines

    and P42/K12 beam line (NA62)
  - T6 → M2 beam line (NA58/COMPASS)



North Area Test Beams

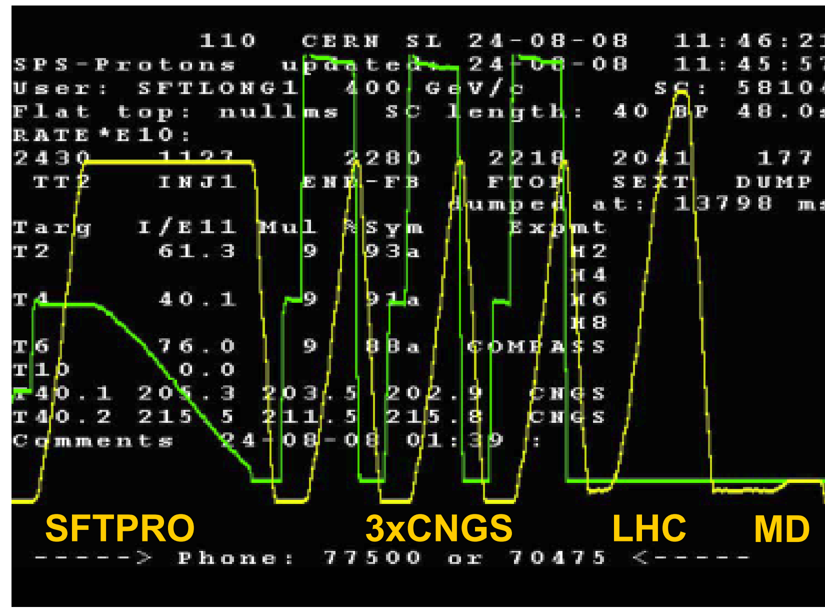


Up to 4 user areas per beam line

- Possibility to take parasitic muons behind main user
- Some areas permanently occupied by LHC users (ATLAS, CMS, LHCb, TOTEM)

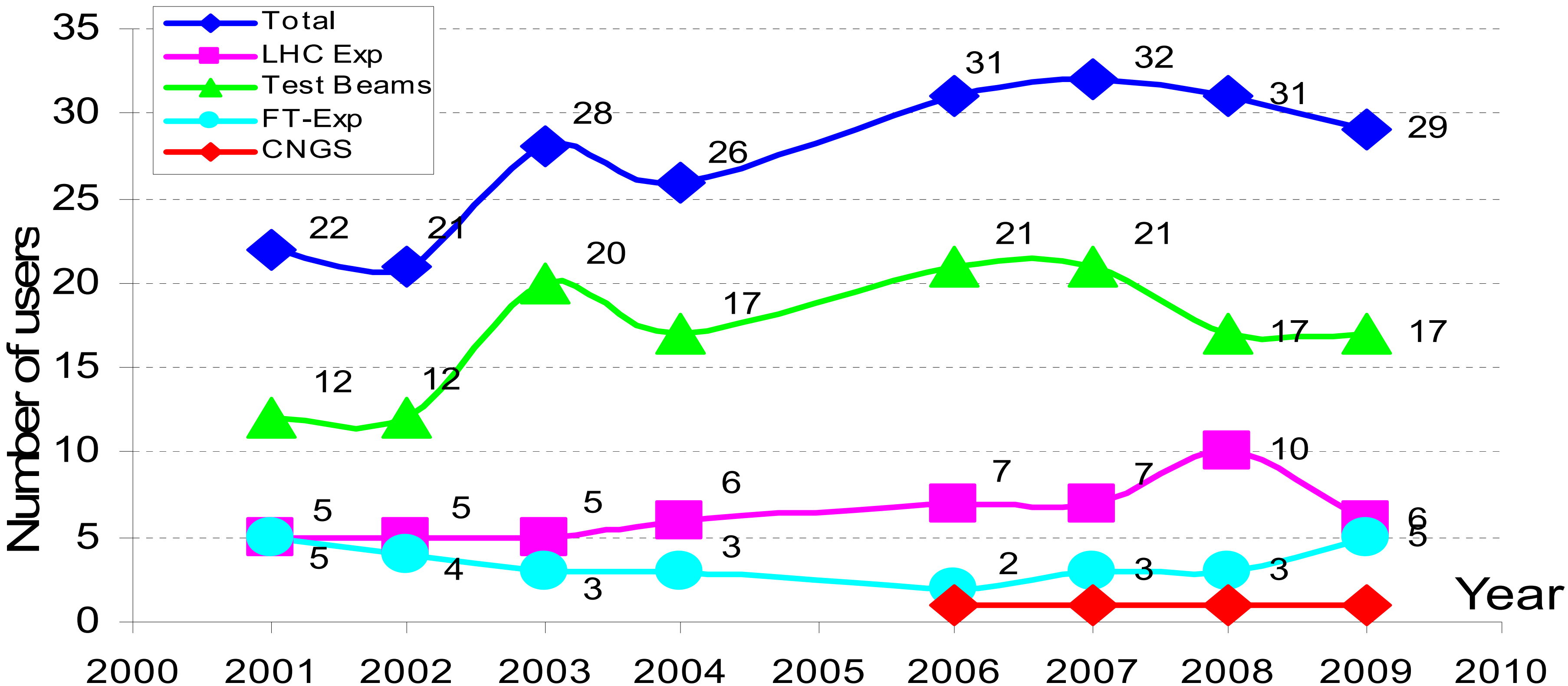
North Area Beam Characteristics

- Momentum range
  - H2, H4, H8:
    - 10 – 400 GeV/c (secondary beam)
    - primary proton beam at 400 (450) GeV/c
  - H6:
    - 5 – 205 GeV/c
- Particle type
  - electrons, hadrons, muons
    → secondary target→ tertiary beam
- Particle intensity
  - max. $2*10^8$ particles per spill
- Spill structure from SPS
  - 4.8s – 9.6s spill length, debunched
  - 1 spill every 14s – ~48s
  - spill length/repetition frequency depend on number of facilities which need SPS extraction (CNGS, LHC)



User Requests for SPS

- SPS Secondary Beams – Experiments and Tests



Coordination:

- Weekly PS/SPS user meetings
- Beam requests to SPS coordinator:
  - Request < 1week agreed and recommended by SPS coordinator
  - >1 week: discussed and recommended by SPSC
  - LHC related request often discussed and recommended by LHCC
  - Final approval by Research Board

Plans for Tests for Non-Collider Experiments

- Production of High-Energy Secondary Beam of Ion Fragments for Experiments and Instrument Tests at CERN SPS
  - I. Efthymiopoulos et al.
- Bremsstrahlung Emission from Relativistic Heavy Ions
  - U. Uggerhoj et al.

Test Beam Plans and Requests for Heavy Ion Physics

- Test Beam Needs for Neutrino Detector R&D Projects
  - A. Blondel et al.
- Test Beam Exposure of a Liquid Argon TPC Detector at the CERN SPS North Area (ePiLAr)
  - A. Rubbia et al.
- Shock Tests of a Solid Target for High Power Proton Beams
  - J. Bennett, R. Edgecock et al.

Test Beam Plans and Requests for Neutrino Physics

- Activities for LHC experiments and LC R&D
- Irradiation facilities

→ See next talks

Production of High-Energy Secondary Beam of Ion Fragments for Experiments and Instrument Tests at CERN SPS

EFTHYMIOPOULOS, Ilias (CERN), STROEBELE, Herbert (IKF University of Frankfurt) ; MAURY, Stephan (CERN) ; A.BRAVAR, Alessandro (University of Geneva) ; FODOR, Zoltan (KFKI Research Institute for Particle and Nuclear Physics Hungarian Academy of Sciences) ; GAZDZICKI, Marek (Institut fuer Kernphysik Johann-Wolfgang-Goethe Univ.) ; GUBER, Fedor (Institute for Nuclear Research (INR) Russian Academy of Sciences) ; IVASHKIN, Alesandr (Institute for Nuclear Research (INR) Russian Academy of Sciences) ; PLANETA, Roman Josef (Marian Smoluchowski Inst. Phys. Jagiellonian University) ; POPOV, Boris (Joint Inst. for Nuclear Research (JINR)) ; RYBCZYNSKI, Maciej (Uniwersytet Jana Kochanowskiego Instytut Fisyki) ; SEYBOTH, Peter (Werner Heisenberg-Institut Max-Planck-Institut fuer Physik) ; WLODARCZYK, Zbigniew (Uniwersytet Jana Kochanowskiego Instytut Fisyki)

- Ion beams can be extracted in the SPS North Area as in the past
  - Beam lines : H2, H4, H8
  - New path via LEIR; some work is required in SPS RF system for debunching
  - Start in 2011 with Pb^{82+} as for LHC
    - Length of ion period to be defined
  - Maximum intensity : 10^9 ions/spill
  - Variable ion beam energy possible : (10)20-158 GeV/u (as in the past)

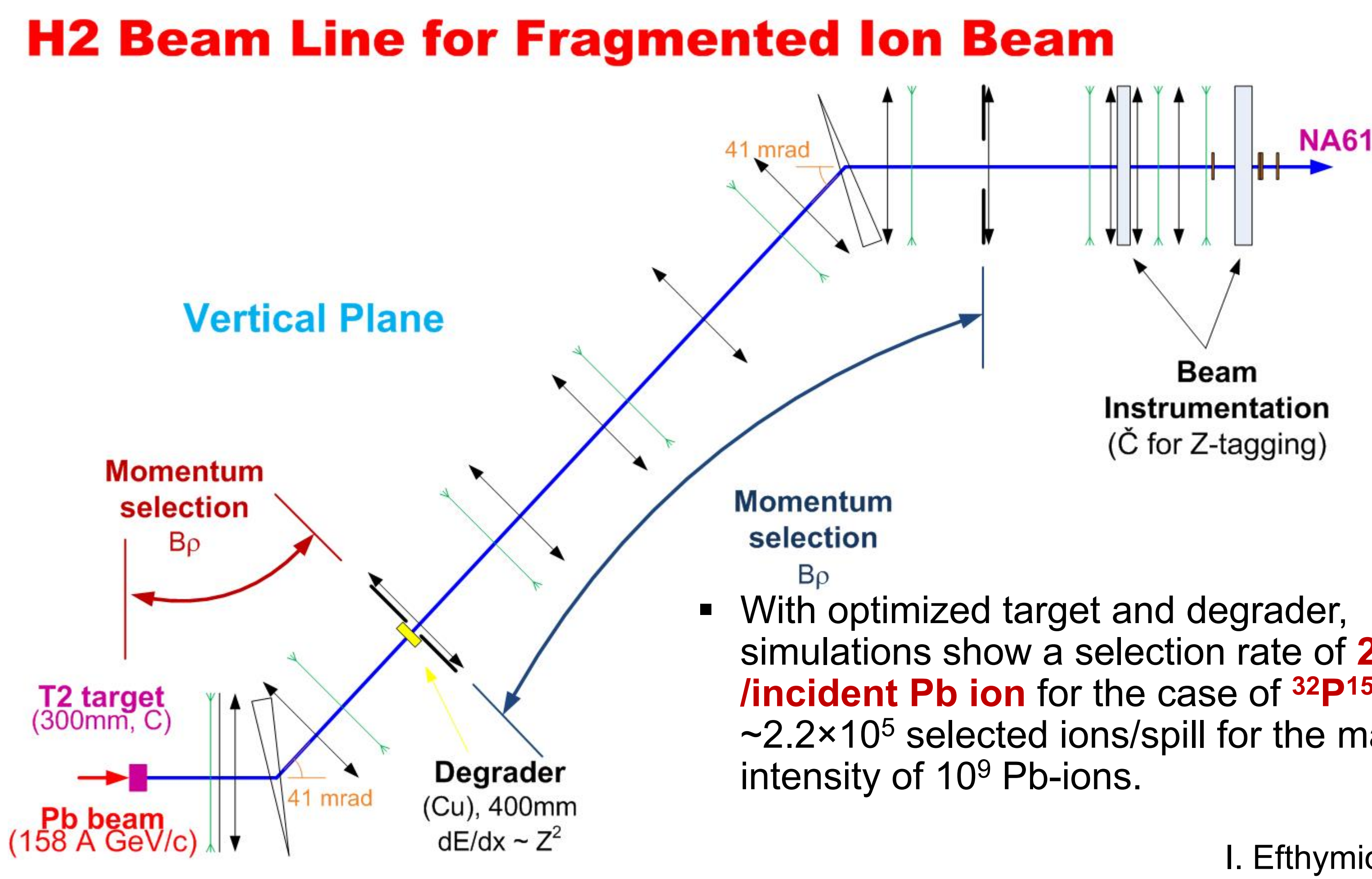
- Fragmented ion beams
  - Under study for NA61

    → scan different species without having to change the ion source and re-tune the whole accelerator chain
    - Species requested : $^{12}C^{6+}$, $^{32}S^{16+}$, $^{115}In^{49+}$, or others to optimize production and physics interest for the experiment
  - Beam studies ongoing in collaboration with the NA61 and GSI colleagues
  - Note: fragmentation beams have been used in the past for the AMS, NA49 and CREAM test setups but without particular attention to purity

I. Efthymiopoulos

Production of High-Energy Secondary Beam of Ion Fragments for Experiments and Instrument Tests at CERN SPS

- Beam line: double spectrometer with 0.04% resolution that helps to separate the ion fragments corresponding to a selected magnetic rigidity : Bρ



- With optimized target and degrader, simulations show a selection rate of **2.2×10^{-4} /incident Pb ion** for the case of **$^{32}P^{15+}$** , i.e. $\sim2.2\times10^{5}$ selected ions/spill for the maximum intensity of 10^{9} Pb-ions.

I. Efthymiopoulos

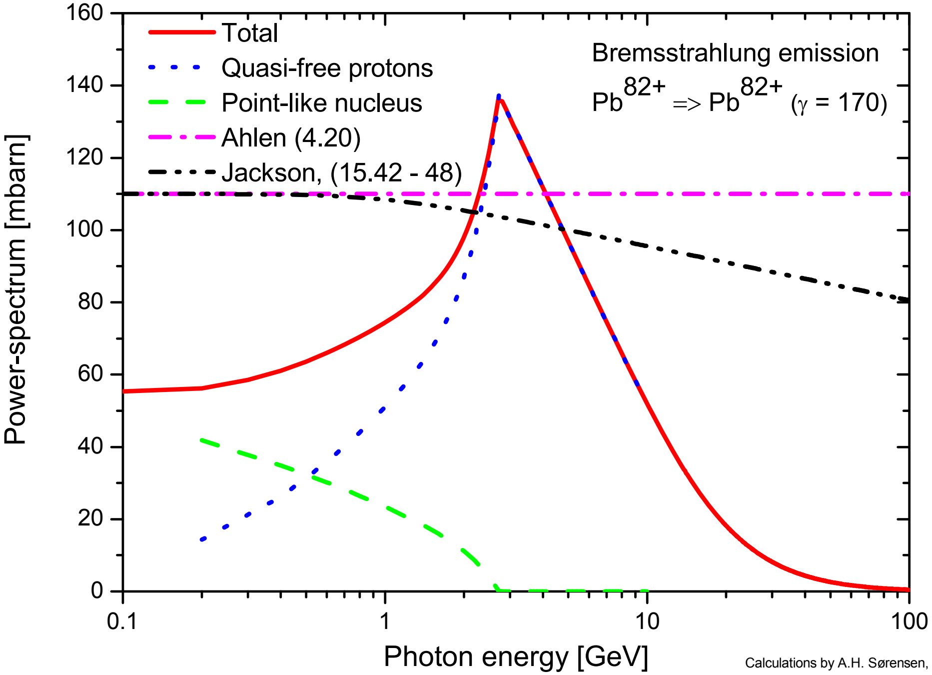
Bremsstrahlung Emission from Relativistic Heavy Ions

A.H. Sørensen, U.I. Uggerhøj, S.V. Pedersen, S.P. Møller, H. Knudsen; Aarhus University
P. Sona and S. Ballestrero, Florence University
C. Scheidenberger, GSI

→ Serious background in ALICE

Measurement of Bremsstrahlung of fully stripped Pb Ions on various targets

- Treating the collision partners as structure-less point-like particles is incorrect
- Finite size and compositeness of nuclei can not be neglected



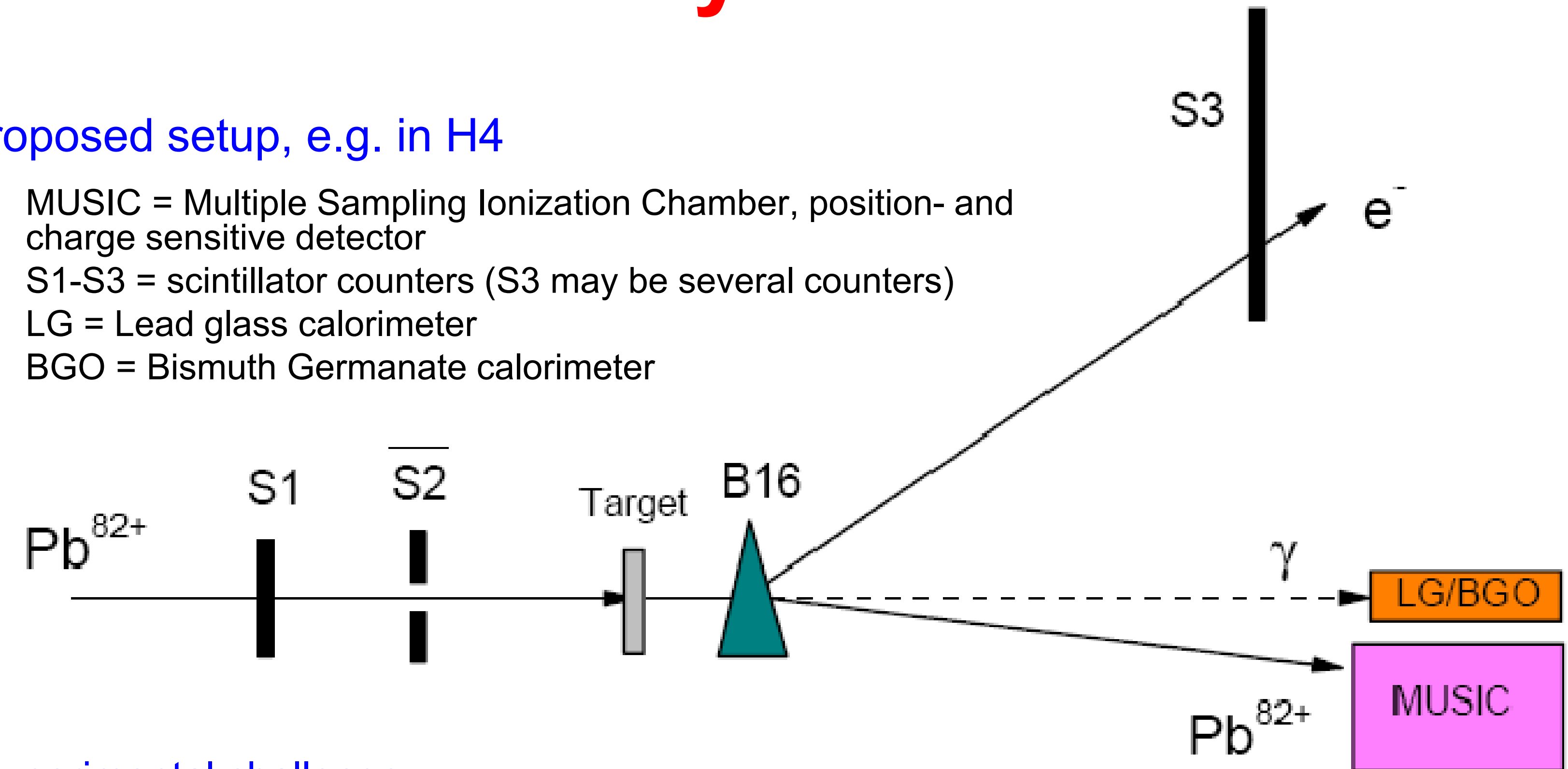
Calculations by A.H. Sørensen, Nucl. Instr. Meth. B **230**, 12 (2005)

U.I. Uggerhøj,

Bremsstrahlung Emission from Relativistic Heavy Ions

Proposed setup, e.g. in H4

- MUSIC = Multiple Sampling Ionization Chamber, position- and charge sensitive detector
- S1-S3 = scintillator counters (S3 may be several counters)
- LG = Lead glass calorimeter
- BGO = Bismuth Germanate calorimeter



Experimental challenge:

Background from bremsstrahlung due to high energy delta-electrons

Timescale:

- few weeks of test-beam
- Ready as soon as SPS is ready to deliver ions (2011)

U.I. Uggerhøj,

Test Beam Needs for Neutrino Detector R&D Projects

International scoping study of a future Neutrino Factory and super-beam facility

RAL-TR-2007-24

Detectors and flux instrumentation for future neutrino facilities

T. Abe[a], H. Aihara[a], C. Andreopoulos[b], A. Ankowski[aj], A. Badertscher[c], G. Battistoni[d], A. Blondel[e], J. Bouchez[f], A. Bross[h], A. Bueno[i], L. Camilleri[g], J.E. Campagne[j], A. Cazes[k], A. Cervera-Villanueva[l], G. De Lellis[m], F. Di Capua[m], M. Ellis[h], A. Ereditato[n], L.S. Esposito[o], C. Fukushima[p], E. Gschwendtner[g], J.J. Gomez-Cadenas[l], M. Iwasaki[a], K. Kaneyuki[a], Y. Karadzhov[q], V. Kashikhin[h], Y. Kawai[r], M. Komatsu[s], E. Kozlovskaya[t], Y. Kudenko[u], A. Kusaka[a], H. Kyushima[r], A. Longhin[v], A. Marchionni[c], A. Marotta[m], C. McGrew[w], S. Menary[h,x], A. Meregaglia[c], M. Mezzeto[v], P. Migliozzi[m], N.K. Mondal[y], C. Montanari[z], T. Nakadaira[aa], M. Nakamura[s], H. Nakumo[a], H. Nakayama[a], J. Nelson[ab], J. Nowak[ak], S. Ogawa[p], J. Peltoniemi[ac], A. Pla-Dalmau[h], S. Ragazzi[ad], A. Rubbia[c], F. Sanchez[ae], J. Sarkamo[ac], O. Sato[s], M. Selvi[af], H. Shibuya[p], M. Shozawa[a], J. Sobczyk[aj], F.J.P. Soler[ag], P. Strolin[m], M. Suyama[r], M. Tanak[aa], F. Terranova[k], R. Tsenov[q], Y. Uchida[ah], A. Weber[ai,b], A. Zlobin[h]

A. Blondel

Test Beam Needs for Neutrino Detector R&D Projects

Detector needs for future neutrino long baseline experiments

- very large scale
- increased resolution
- Increased ability to reduce backgrounds

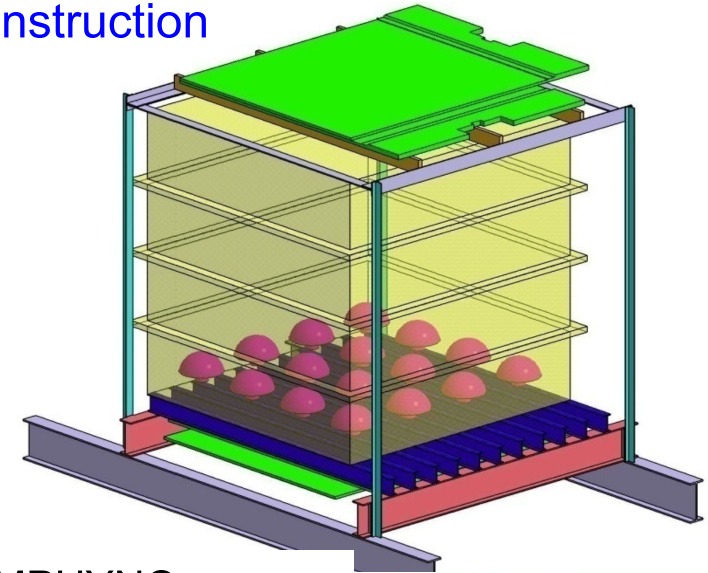
Detector types and test-beam issues:

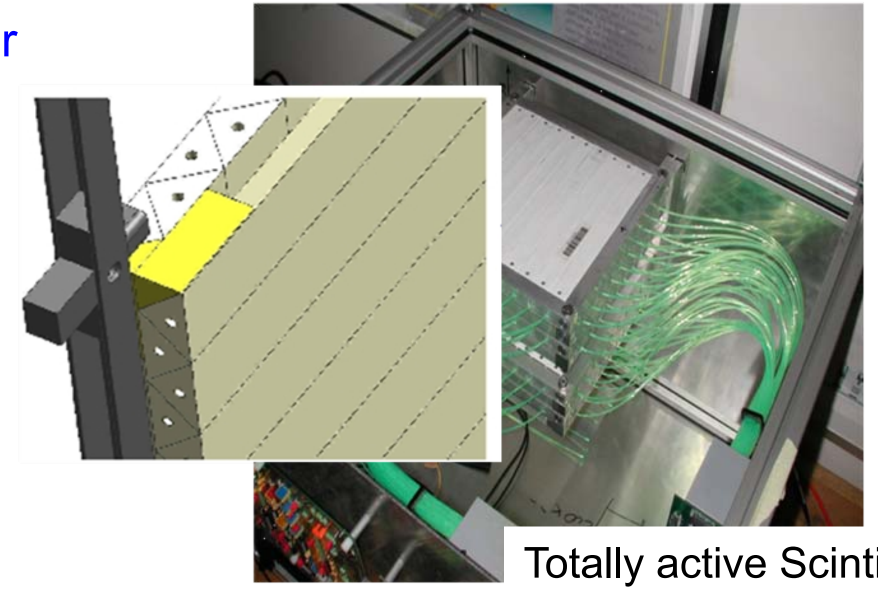
- Non-magnetic detectors: Water Cherenkov, Liquid Argon TPC
  - Energy range: 200 MeV/c – a few GeV/c
  - Electron – π^0 separation, muon-pion separation
  - Development of large scale electronics at low cost and test of performance
- Magnetic detectors: Magnetized iron detector (MIND), fine grained detector embedded in magnetic field (scintillators, emulsion, LAr)
  - Energy range: 200 MeV/c – ~20 GeV/c
  - Pion muon separation
  - Charge identification of muons and electrons as function of momentum
  - Angular and energy resolution on hadronic showers
  - Development of large scale electronics at low cost and test of performance

A. Blondel

Test Beam Needs for Neutrino Detector R&D Projects

Some test detectors existing or under construction





Totally active Scintillator (GVA-Trieste-FNAL)

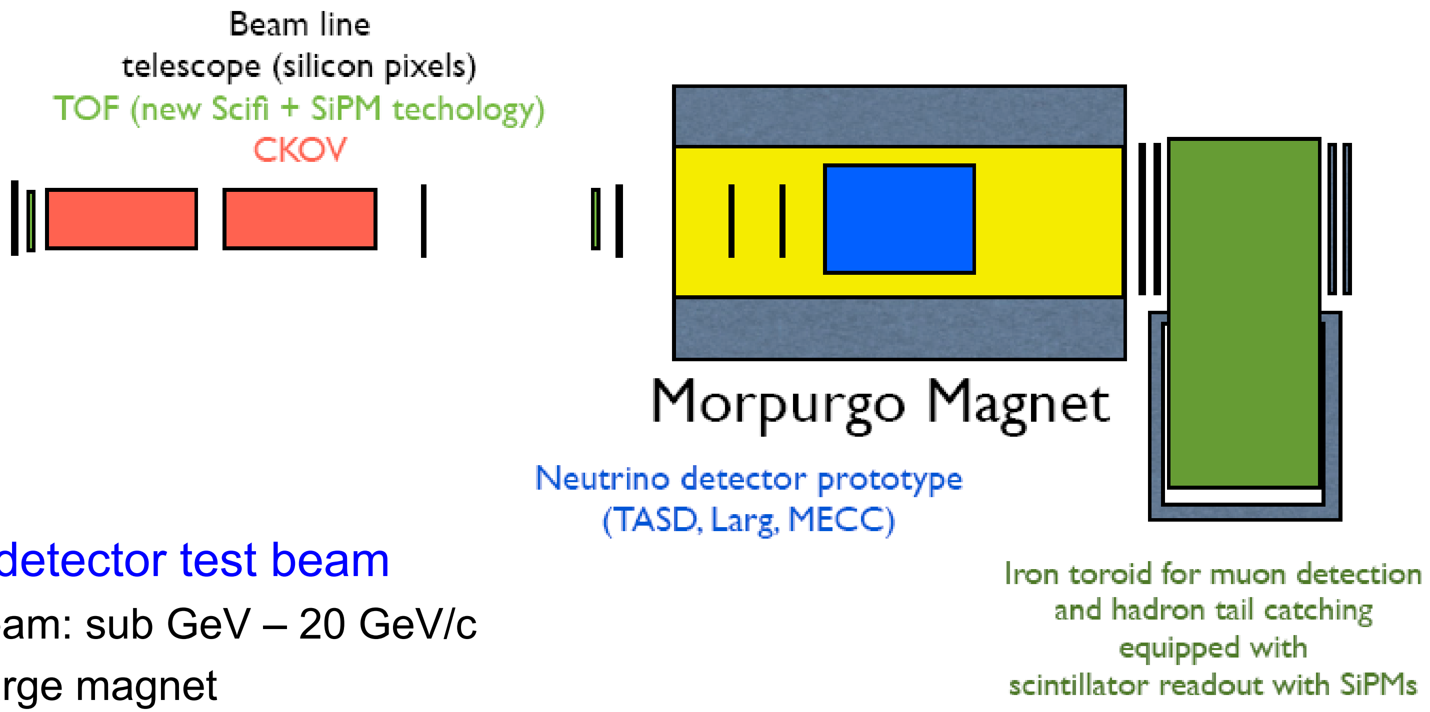
MEMPHYNO (Paris): Prototype for MEMPHYS (Megaton Mass PHYSics)

Liquid Argon R&D (Glacier Collab.)

INO-BABY-MIND (Imperial – GVA- Glasgow -Valencia-India) E.g. magnetized iron interleaved by active detector elements

A. Blondel

Test Beam Needs for Neutrino Detector R&D Projects



Neutrino detector test beam

- beam: sub GeV – 20 GeV/c
- Large magnet
- Possibly test beam area in **H8**

Timescale

- 2010/11

A. Blondel

Test Beam Exposure of a Liquid Argon TPC Detector at the CERN SPS North Area (ePiLAr)

D.Autiero[a], A. Badertscher[b], G. Barker[c], Y. Declais[a], A. Ereditato[d], S.Gninenko[e], T. Hasegawa[f], S. Horikawa[b], J. Kisiel[g], T. Kobayashi[f], A.Marchionni[b], T. Maruyama[f], V. Matveev[e], A. Meregaglia[h], J.Marteau[a], K. Nishikawa[f], A. Rubbia[b], N. Spooner[i], M. Tanaka[f], C.Touramanis[j], D. Wark[k],l, A. Zalewska[m], M. Zito[n]
(a) IPN Lyon (b) ETH Zurich (c) University of Warwick (d) Bern University (e) INR, Moscow (f) KEK/IPNS (g) University of Silesia (Katowice) (h) IPHC Strasbourg (i) University of Sheffield (j) University of Liverpool (k) Imperial College (l) RAL (m) IFJ-PAN, Krakow (n) CEA/SACLAY

The realization of the ultimate LAr TPC that will compete with the planned third generation water Cerenkov detectors offers great promise and many challenges.

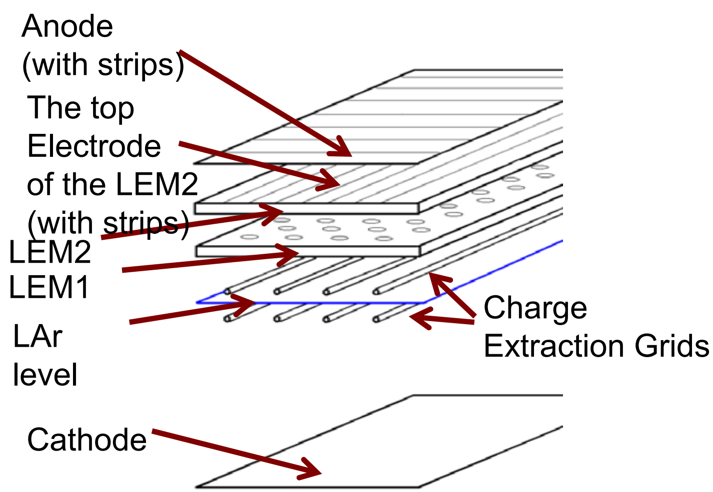
The new concept « GLACIER », scalable to a single detector unit of mass 100 kton, was proposed in 2003: it relies on a cryogenic storage tank developed by the petrochemical industry (LNG technology) and on a novel method of operation called the LAr LEM-TPC

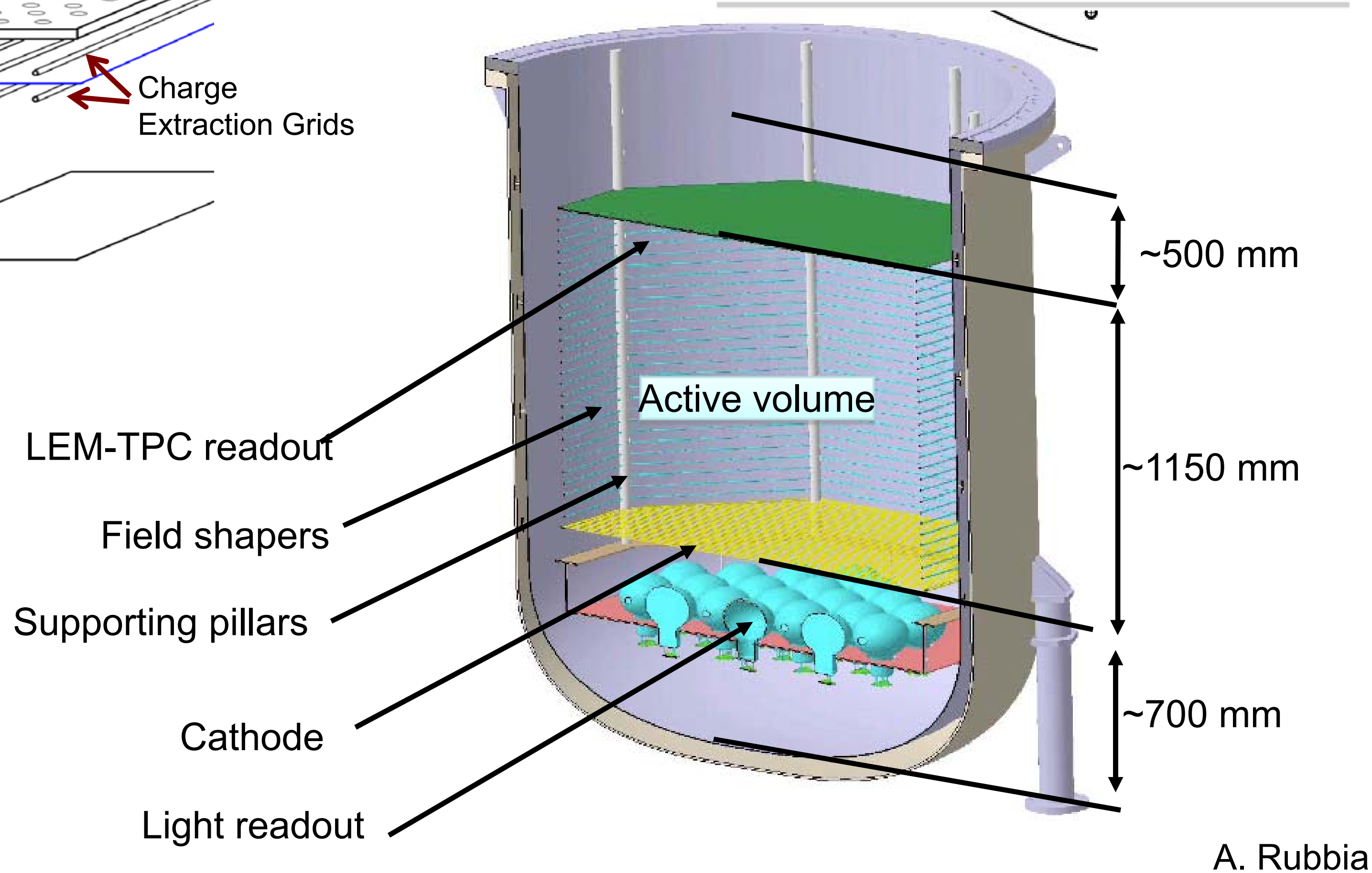
A. Rubbia

Test Beam Exposure of a Liquid Argon TPC Detector at the CERN SPS North Area (ePiLAr)

Based on ArDM-1t design

Readout area: ≈ 2.5 m^2
Drift length: ≈ 1.15 m
Instrumented volume : ≈ 2.8 m^3
Instrumented mass: ≈ 3.9 tons





A. Rubbia

Test Beam Exposure of a Liquid Argon TPC Detector at the CERN SPS North Area (ePiLAr)

- Calorimetry: the 100% homogeneity and full sampling calorimetry with low energy particles (0.5-5 GeV/c e/mu/pi). To determine the ability to reconstruct neutrino events in the GeV-range.
- Hadronic secondary interactions: exclusive final state study of pion secondary interactions will be attempted.
- [+ purity tests in non-evacuated vessel, cold readout electronics, DAQ development, ...]

- Test beam requirements
  - 0.5-5 GeV/c e/mu/pi with well defined momenta
  - Possibility to reach lower momenta (200, 400 MeV/c)
  - Low intensity of particles during spill (< 1kHz)
  - Liquid Argon infrastructure

H8

- Timescale
  - 2010
  - duration of the tests: 2 to 3 years

A. Rubbia

Shock Tests of a Solid Target for High Power Proton Beams

J. R. J. Bennett1, R. Edgecock1, G. Skoro2, J. Back3, C. Booth2, S. Brooks1, R. Brownsword1, C. J. Densham1, S. Gray1 and A. J. McFarland1
1 Rutherford Appleton Laboratory, Chilton, Didcot, Oxon. OX11 0QX, UK
2 Department of Physics and Astronomy, University of Sheffield, Sheffield. S3 7RH, UK
3 Department of Physics, University of Warwick, Coventry. CV4 7AL, UK.

The Neutrino Factory Target

Proton beam

Energy	2-30 GeV
Current	2-0.03 mA
Power	4 MW
Pulse	<1000 ns, 50 Hz

Target (high *z* material such as tungsten)

Dimensions	20 cm long (2 interaction lengths), 1-3 cm diameter
Power Dissipation	~1 MW
Power Density	~4-16 kW/cm^3 (average)
Energy Density	~300-1200 J/cm^3/pulse

Demonstrate viability of solid target:

– simulate thermal shock from a beam similar to neutrino factory conditions

Timescale:

– for life tests: 10^5 – 10^7 pulses

– 6 – 12 months notice to prepare for the experiment

Isolde, future HiRadMat

J. Bennett

Summary

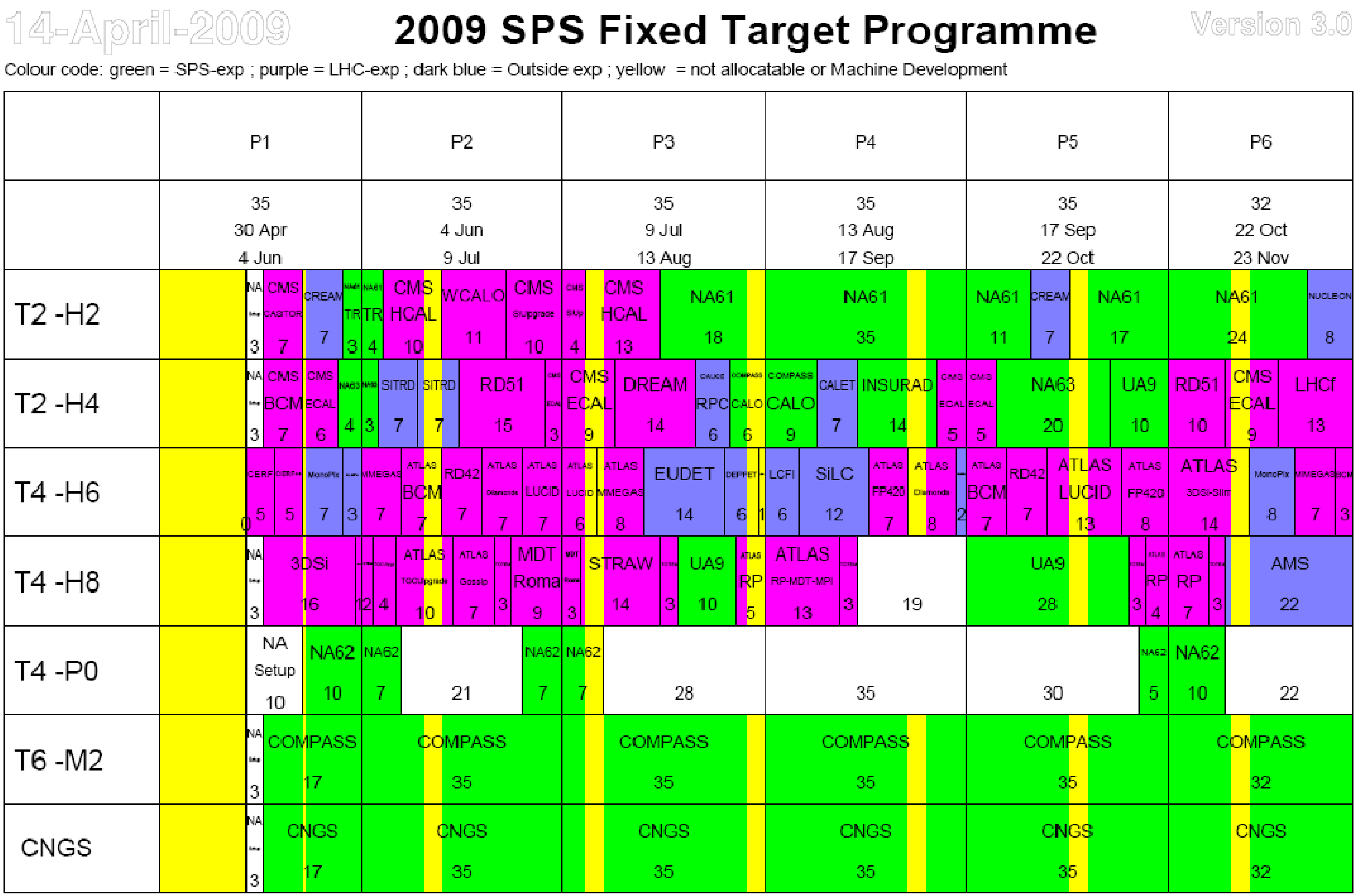
- CERN has worldwide unique opportunity for detector and physics tests
  - PS and SPS beam-lines
  - Technical support and infrastructure provided by CERN
- Facilities are heavily used
  - Always fully booked
- Future requests
  - Interest in Heavy Ions
    - Needs additional preparation: e.g. radiation safety issues
    - Short-medium term (up to 2012)
  - R&D for Neutrino Detectors
    - Large objects
    - Looking for more permanent installation
    - Additional infrastructure (magnets, cryogenics)
    - High-Power targets

→ Exciting new ideas for future experiments
→ New technologies
→ All experiments need test beams

Additional slides

2009 Test Beams

SPS



2009 Test Beams

- PS

14-April-2009

2009 PS Fixed Target Programme

Version 2.0

Colour code: green = PS/SPS-exp ; purple = LHC-exp ; dark blue = Outside exp ; yellow = not allocatable or Machine Development

		P1	P2	P3	P4	P5	P6
		35 30 Apr 4 Jun	35 4 Jun 9 Jul	35 9 Jul 13 Aug	35 13 Aug 17 Sep	35 17 Sep 22 Oct	32 22 Oct 23 Nov
T7	Setup 7	Irradiation 35	35	30; 5	Irradiation 35	Irradiation 35	Irradiation 32
T8	Setup 7	DIRAC 35	DIRAC 35	DIRAC 35	DIRAC 35	DIRAC 35	DIRAC 32
T9	Setup 7	T2K-ECAL 35	T2K ECAL 14; CALICE RPC 17; OPERA 4	2; COMPASS CALO 14; MICE EMR 14; AD3 5	AD3 TRACKER 12; 13; 10	10; NA62 16; VIPIX 9	NA62 15; PEBS 17
T10	Setup 7	ALICE PMD 14; 6; CALICE MMEGAS 15	ALICE TOF 14; ALICE VHMPID 13; CMS BCM 8	ALICE TOF 15; RD51 CALICE 15	30; ATLAS GOSSIP 10	ATLAS GOSSIP 5; CALICE MMEGAS 15; ALICE VHMPID 7; ALICE TOF 8	ALICE TOF 7; ALICE HPTD 16; ALICE VHMPID 9
T11	Setup 7	35	18; CLOUD 17	CLOUD 35	35	CLOUD 35	CLOUD 32