Upcoming Experiments at the SPS
What to Expect and the Impact on Operation

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Many thanks to
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Outline

• Introduction
• Approved experiments at SPS
  – NA61 (ion-physics, successor of NA49)
  – NA63 (QED in strong crystalline fields)
  – NA62 (rare Kaon decays, successor of NA48)
  – COMPASS (QCD, hadron structure)
• In pipeline for approval
  – Irradiation Facilities: GIF++
  – Neutrino Detector R&D
• Summary
Beam Facilities at CERN

North Area
SPS Test Beams

East Area
PS Test Beams
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
North Experimental Areas (SPS)
North Area Beam Characteristics

- **H2, H4, H6, H8 (EHN1)**
  - 10 – 400 GeV/c (H6: 205 GeV/c)
  - VLE extension in H2, H8: 1-9 GeV/c
  - Attenuated primary proton beam at 400 (450) GeV/c for H2, H4, H8
  - electrons, hadrons, muons, photons
    - secondary target → tertiary beam
  - max. $2 \cdot 10^8$ particles per spill for secondary beam
  - $< 1 \cdot 10^{11}$ particles per spill for primary protons if proper shielding (H4)

- **M2, COMPASS (EHN2)**
  - High intensity (polarized) muon beam
  - Typically $4 \cdot 10^8$ muons at 160 GeV/c for $2.4 \cdot 10^{13}$ protons on T6 target
  - secondary hadron beam up to 280 GeV/c

- **P42/K12, NA62 (ECN3)**
  - Primary proton beam to target T10
  - ‘Kaon beam’ (mixed beam with 6% $K^+$) up to ±75 GeV/c
User Requests for SPS

SPS Secondary Beams – Experiments and Tests

- Total
- LHC-Exp
- Non-LHC
- FT-Exp
- CNGS

Approved experiments
Approval Path

New Experiment Request

- Yes: Lol or Proposal
- No, >1 week: Pre-studies

SPS Coordinator

Reviewers
- Physics
- Acc. Performance

SPSC (LHCC)

Recommendation

SPSC (LHCC)

Research Board

Approval

EATM

Pre-studies

EATM

User schedule

Contact groups
Technical studies

IEFC

Technical choices

P+M

IEFC

EATM

EATM

SPSC (LHCC)

IEFC
NA61, successor of NA49
NA61/SHINE

SPS Heavy Ion and Neutrino Experiment

Study of hadron production in hadron nucleus and nucleus-nucleus collisions.

- Search for critical point of strongly interacting matter
  - Detailed study of the onset of deconfinement in nucleus-nucleus collisions
  - Measure hadron production at high transverse momenta in p+p and p+Pb collisions as reference for Pb+Pb results

- Data for neutrino and cosmic ray experiments
  - Hadron production reference measurements in p+C interactions needed for neutrino (T2K) and cosmic-ray (Pierre Auger Observatory) and KASCADE experiments
  - Hadron production measurements in the T2K target
NA61/SHINE

2010 Run

- Test runs in May in H2 and T9
- Physics run (18 weeks) in H2 with p+p at 158GeV/c and 10GeV/c and p+T2K target at 31GeV/c

- Test of secondary boron ion beam at 20GeV/c and 80 GeV/c in September/October 2010

Beam instrumentation: pulse height analyzer to identify boron ions

For each energy (20, 80, 100? GeV/c):

- 1 MD to set energies in SPS and extraction
- 1 MD to setup beam-line and data taking
- Test extraction and beam quality @ 10GeV/c

5-7 MDs
NA61 Fragmented Ion Beam

Beam line: double spectrometer with 0.04\% resolution that helps to separate the ion fragments corresponding to a selected magnetic rigidity: $B_\rho$

**H2 Beam Line for Fragmented Ion Beam**

2010

Vertical Plane

**Momentum selection** $B_\rho$

2010: converter

Pb beam (158 A GeV/c)

Degrader (Cu), 400mm dE/dx $\sim Z^2$

$2.2 \times 10^{-4}$/incident Pb ion for the case of $^{32}P^{15+}$

$\rightarrow \sim 2.2 \times 10^5$ selected ions/spill for the maximum intensity of $10^9$ Pb-ions.

$\rightarrow 2010$: $4 \times 10^7$ Pb-ions for B-beam
NA61 Program Plan for >2011

Fragmented beam: 2010 feasibility study
real test (target and detector) + data taking: 2011,...

158 GeV requires transformer in SPS (extraction only when $1 \cdot 10^9 < N < 2 \cdot 10^{11}$)
NA63
Electromagnetic Processes in Strong Crystalline Fields

- 2010 program approved:
  - 10 days in H4
    - low-Z LPM (Landau-Pomeranchuk-Migdal) study related to low-Z targets
- Proposals for > 2011
  - 2011: 2 weeks in H4
    - Studies of magnetic suppression of incoherent Bremsstrahlung
    - MBWs available, requires area and layout studies and modifications
NA63

2012:
- 2 weeks in H4 with ion beam for heavy ion bremsstrahlung studies when fully stripped Pb ions penetrate amorphous targets
- Ion beam with 158 GeV, so needs transformer in SPS
- Not possible to have ion beam in both H2 and H4 at the same time, so NA63 request is in addition to NA61 request

Plans for beyond 2012:
- Strong interest in positron production studies with aligned crystals to be used e.g. in CLIC
- Application for funding in preparation (FP7)
NA62, successor of NA48
NA62 (P326)

Sensitivity to new physics and possibility to determine CKM matrix elements in processes not affected by new physics

→ Measure very rare kaon decay $K^+ \rightarrow p^+ \nu \nu'$
   - Branching ratio of $10^{-10}$
   - Extract a 10% measurement
   - Sensitivity of 55 events/year with 13-17% background

Approved for 2 years 2012/2013

For > 2014:

→ Measure $K^0_L \rightarrow p^0 \nu \nu'$
   - Branching ratio of $\sim 10^{-12}$
NA62

- SPS primary p: 400 GeV/c
- Unseparated beam:
  - 75 GeV/c
  - 800 MHz
  - $\pi/K/p$ ($\sim$6% $K^+$)

Dismantling NA60, NA48

New beam-line
NA62: Schedule

Very tight schedule!

- NA60, NA48 dismantled by mid 2010
- Beam survey in early 2012
  - Beam to be rebuilt
  - Costing under way, work packages being defined and discussed
- First full data taking expected in 2012

• 2010: test-beam
  - Large Angle Veto (T9, 3 weeks, June)
  - Gigatracker (T9, 2 weeks, September)
  - Straws (H6, 3 weeks, June)
COMPASS

NA61

NA63

GIF++

CERF++

T2

H2

H4

H6

H8

P42

T10

K12

M2

SPS beam

T4

T6

EHN1

EHN2

ECN3

Neutrino R&D

Ion-Exp.
COMPASS (NA58)

→ **1910:** Rutherford:
  study **atomic structure** with **alpha particles**

→ Planetary model of atoms!
  nucleus with whole positive charge and atom’s mass, electrons circling

→ **2010:** COMPASS:
  Study the **hadron structure** and **hadron spectroscopy** with high intensity **muon** and **hadron beams**.
COMPASS Experiment

- **Two-stage spectrometer**
  - Large angular acceptance
  - Broad kinematical range
  - ~250000 readout channels
  - 2009: 1.4 PB/year

1998 approved, first data in 2002
2002-2004: $\mu^+$ 160 GeV/c
2004: 2 weeks $\pi^-$ 190 GeV/c
2006-2007: $\mu^+$ 160 GeV/c
2008-2009: $\pi^-$ 190 GeV/c

- Polarized beam (~75%) and target (~50%)

- ~250 physicists from 28 institutes

- Two-stage spectrometer
  - Large angular acceptance
  - Broad kinematical range
  - ~250000 readout channels
  - 2009: 1.4 PB/year

- Polarized beam (~75%) and target (~50%)
COMPASS Program

Approved for 2010/2011

• Longitudinal structure function
• Transverse spin structure
  → muon beam, intensities as now, i.e. as high as possible

Proposals

• Generalised Parton Distribution (GPD)
  → 2012 positive and negative beams, minor upgrade
  → 2014 only positive beam, new transversely polarized NH3 target
  → 4 x higher luminosity?! (upgrade of M2 beam-line) → unrealistic!

• Drell-Yan
  – production of lepton–antilepton pairs in hadron collisions
  → secondary hadron beam 50-200 GeV/c
  → higher intensities, absorbers after target
  → two year data taking
  → RF separated antiproton beam in a second phase? (later)

• Double Charged Baryons
  → 450 GeV/c proton beam
  → needs design and rebuilt of complete M2 beam line
COMPASS Future Plans

<table>
<thead>
<tr>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hadron Spectroscopy</td>
<td>...</td>
<td>p,π,K beam</td>
<td>Transversity</td>
<td>DIS / SIDIS</td>
<td>GPD</td>
<td>μ beam</td>
</tr>
<tr>
<td>approved</td>
<td>Drell-Yan</td>
<td>π beam</td>
<td>DCB</td>
<td>...</td>
<td>p beam</td>
<td>π beam</td>
</tr>
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COMPASS submitted LoI, common proposal to follow
Strong wish to involve new groups
Radiation Facilities

- CERN wide irradiation facilities working group (DG, PH, BE, TE, EN)

- 2008: Survey on future needs
  - Memorandum on ‘status report and conclusion’ to management in December 2008

- Identified needs from survey:
  - High-energy and high-intensity proton (ion) irradiations → HiRadMat
  - High-intensity proton irradiation → PS East Area
  - Mixed field irradiations → CERF++
  - Gamma irradiations with beam → GIF++
Gamma Irradiation Facility GIF++

- **GIF++**
  - Powerful photon source (Cs137) to irradiate detectors and other equipment for performance, radiation and ageing studies
  - In addition: presence of particle beam to check detector performance on top of a photon background

- **GIF: Present installation in Bat 190**
  - Phased out due to dismantling of the West Area → no beam

- **Users**
  - Muon trackers of LHC experiments, detector or accelerator electronics components, beam diagnostic equipment

- Proposal submitted to SPSC in September 2009
- Proposal presented to Research Board in December 2009
  - Presentation to the IEFC to be prepared in order to evaluate the exact location of the GIF++ area

- On hold to find budget; conditioned with new LHC upgrade schedule?

  When approved: ~1.5 years for installation
GIF++ Impact on Beam and Facility

- Annual running of 48 weeks with gamma source
- Beam request: 6-8 weeks/year
  - Mainly muon beam with 100 GeV/c
- Source
  - $^{137}$Cs, ~1TBq, 662 keV photons, 30 y half-life

<table>
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<tr>
<th>Max. expected doses at sLHC</th>
<th>Equivalent time at GIF++ (~50cm from source → 2Gy/h)</th>
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<tbody>
<tr>
<td>Si-trackers: ~ MGy/y</td>
<td>&gt;&gt; years</td>
</tr>
<tr>
<td>Calorimeters: ~ 20 kGy/y</td>
<td>&lt; 1 year</td>
</tr>
<tr>
<td>Muon systems: ~ 0.1 Gy/y</td>
<td>~ minutes</td>
</tr>
</tbody>
</table>

- Irradiation area is Prohibited Area
  - ~10Sv/h at distance of 30cm
  - adequate side and roof shielding
- EHN1 is Supervised Area
  - < 3µSv/h at permanent workplaces
  - < 15µSv/h in low occupancy areas
  - limits to achieve outside the shielding
GIF++ in North Area/H4 beam line

Other test areas ~100m upstream the GIF++ bunker:
- e.g. NA63, RD51, COMPASS-Cal, CALET, INSURAD, CMS-ECAL/BCM, LHCf, SiTRD

Roof shielding of 0.8m concrete above the irradiation area
Other (Semi-permanent) Facilities in the Pipeline

- **Neutrino Detector R&D Projects**
  - Neutrino detector prototype (TASD, Larg, MECC)
  - Iron toroid for muon detection and hadron tail catching equipped with scintillator readout with SiPMs
  - Liquid Argon TPC Detector
  - Beam line telescope (silicon pixels)
  - TOF (new Scifi + SiPM technology)
  - Large area Mmegas chambers (Saclay)
  - Active volume

- **H8**
  - beam: sub GeV – 20 GeV/c, modifications needed
  - Large magnet
  - low intensity (1kHz)
  - Liquid Argon infrastructure
  - Duration: >2 years

- **Ion Experiments** (NA60-Future,…), CERF++, DREAM, Linear Collider…
Summary

• CERN has a worldwide unique opportunity for versatile physics programs and detector tests
  – PS and SPS beam-lines
  – Technical support and infrastructure provided by CERN

• Facilities are heavily used, very popular
  – Always fully booked
  – List of priorities for requests might be needed

• Very broad Fixed Target program
  – Lifetime >10 years

• Many more proposals in pipeline
  – Large objects
  – Looking for more permanent installation
  – Additional infrastructure (magnets, cryogenics)

→ Consolidation
Additional Slides
CERF++

Mixed field irradiations:
- Study impact on system components exposed in radiation fields
- Primary use: LHC accelerator and detector components (SEE studies), radiation monitoring calibration

Today: CERF
- SPS H6 secondary beam, 120 GeV/c hadrons
- Max $10^8$ protons/pulse
- In operations since 1991, 1-2 weeks/yr
  - Test/calibration of passive and active detectors for dosimetry or radiation monitoring
  - FLUKA benchmarking, beam loss monitor studies
  - **but:** limited dose rate, muons from TCC2
CERF++ Mixed Field Irradiation Facility

- Beam intensity: $<1 \times 10^{11}$ p/spill
- Transport attenuated proton beam in H4 up to the entrance of the EHN1 hall
  - (Feature last used for NA31 in 1986)
- Measurement locations around the thick target

Implementation studies for this facility are just starting (450GeV/c, 24GeV/c, 4GeV/c)

→ Pending funding, more mature proposal needed