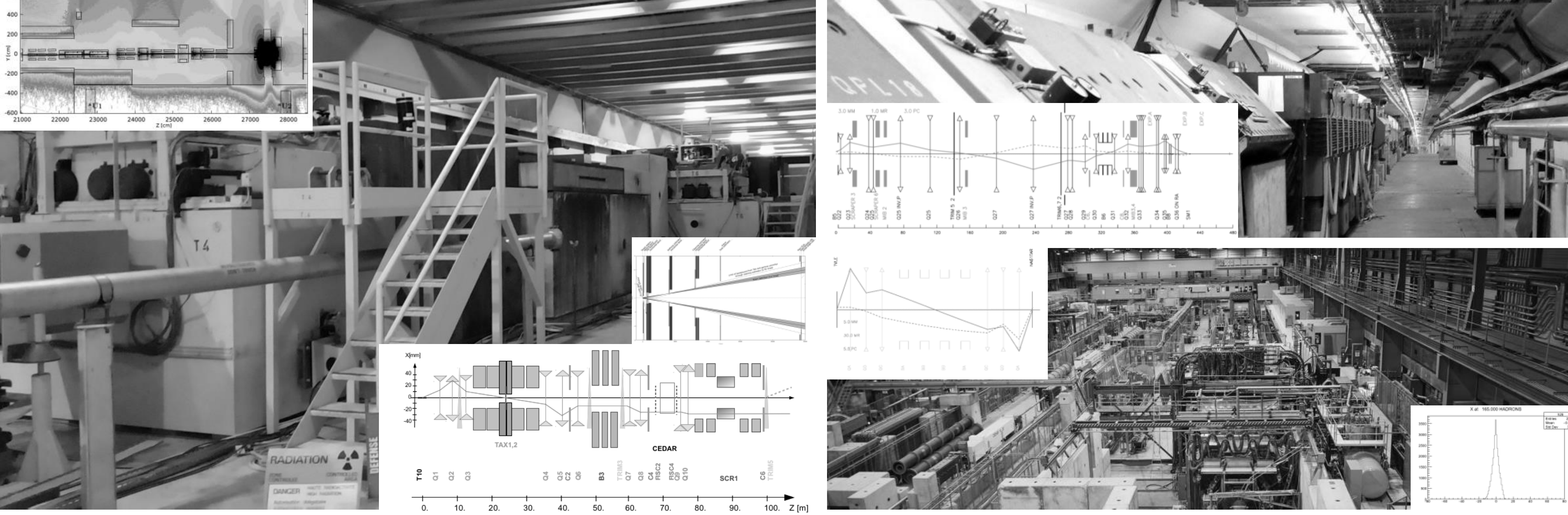


Conventional Beams

Physics Beyond Colliders Annual Meeting, CERN

Johannes BERNHARD and Lau GATIGNON on behalf of the CBWG
17 January 2018

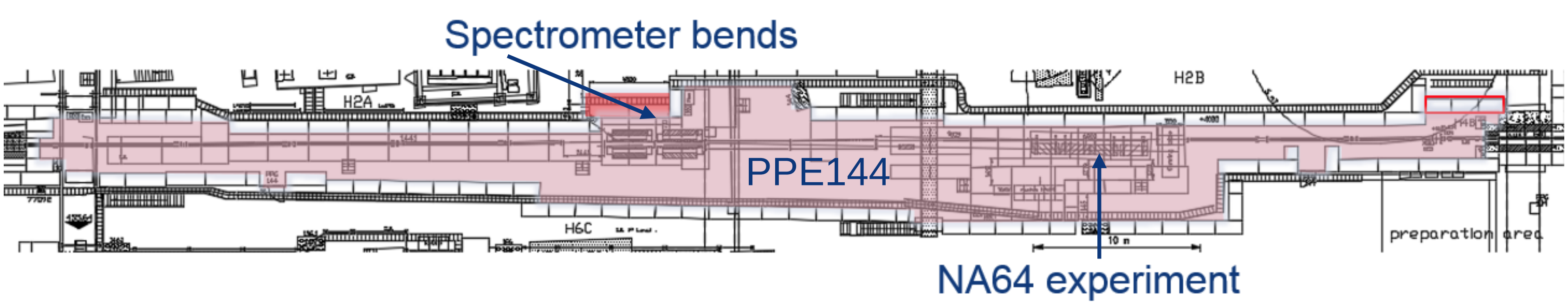
CERN | EN ENGINEERING DEPARTMENT

Physics Beyond Colliders

N. Charitonidis

EHN1: NA61, NA64-e/h

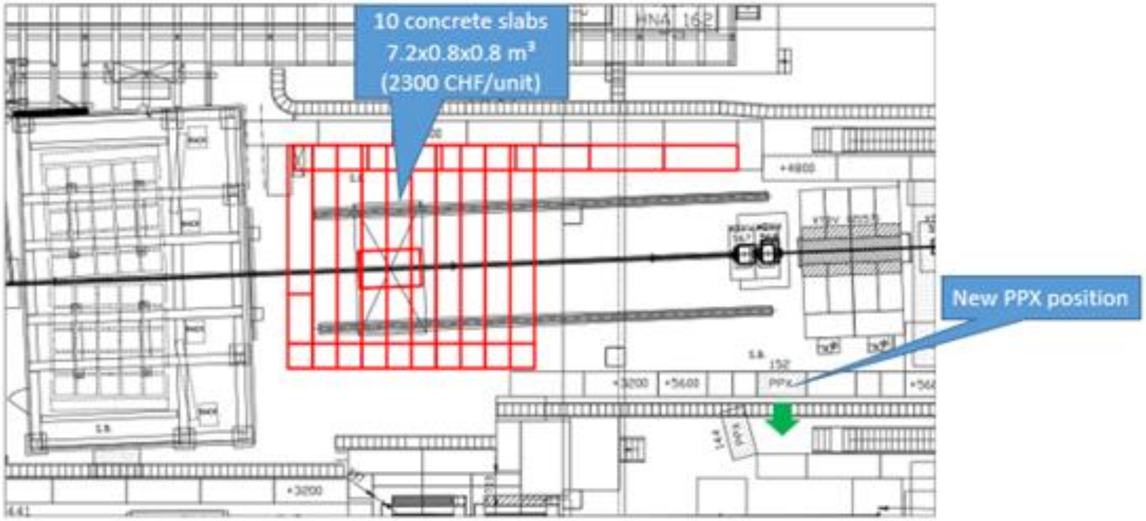
- Continuations / extensions of ongoing experiments:
  - NA61 uses primary and secondary ions as well as hadron beams.
  - NA64 uses secondary electrons and in the future also secondary hadron beams.
- Both aim at highest possible **intensities** and optimum **beam quality.**
- For NA64-e, the present limit seems to be **pile-up** as well as time needed for setting up the experiment each time. The latter was addressed by introducing the new user zone PPE144, which will be ready by 2021.
- By adding two more quadrupoles to this zone, the beam performance could be even further improved.

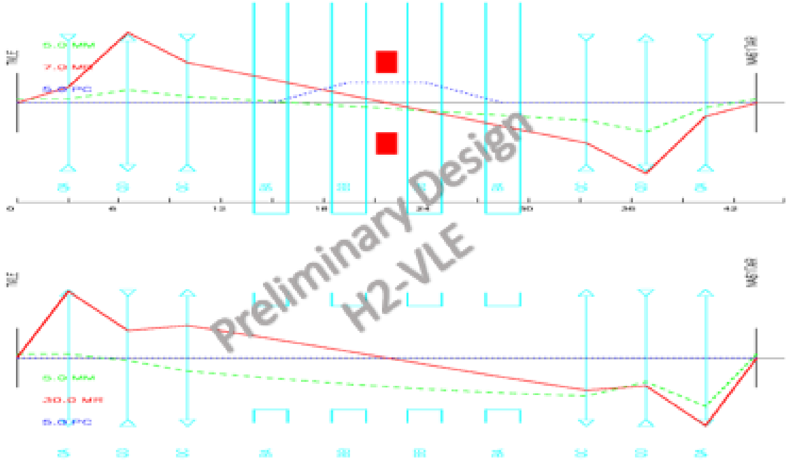


N. Charitonidis

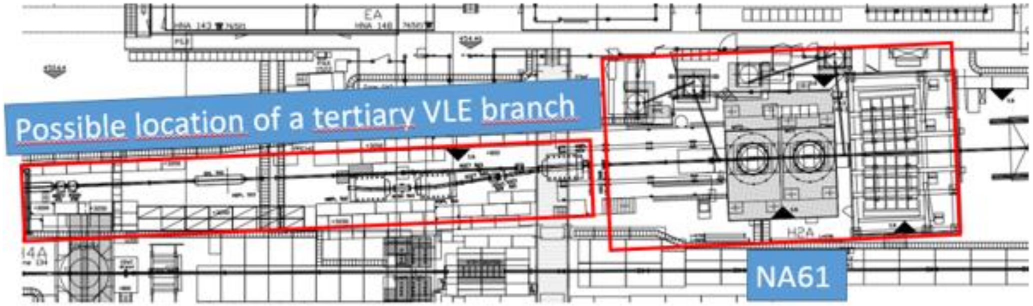
EHN1: NA61++

- For NA61, **shielding** studies and measurements as well as **machine protection** studies were completed, ideas for improvement enter now the integration study phase.





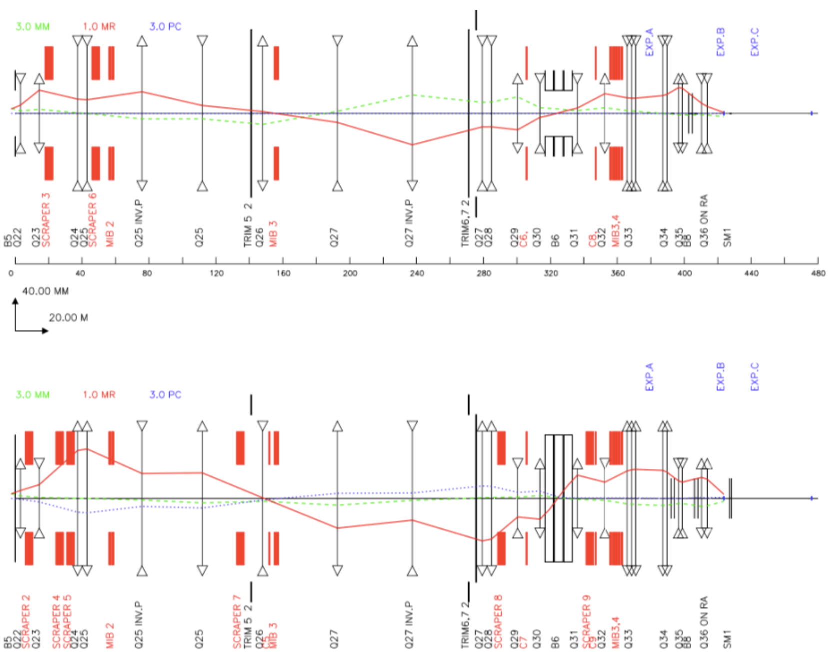
- An initial study for a **low-energy hadron beam** (≦ 9 GeV/c) in H2 for NA61 was completed.

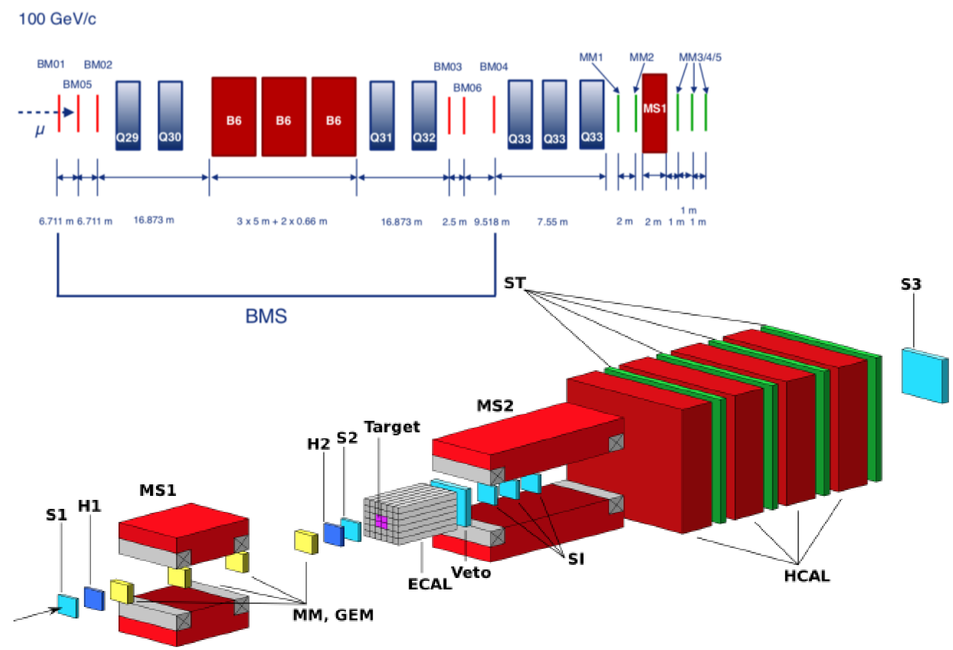


D. Banerjee
J.B.

EHN2: NA64-μ

- Phase 1
  - Upstream location identified in PPE211, compatible with current downstream COMPASS installations.
  - Calculated optics that well fulfil user requirements.
  - Study for optimisation of beam momentum measurement completed.
  - Preliminary cost estimate ready for possible installation in ≧ 2021.

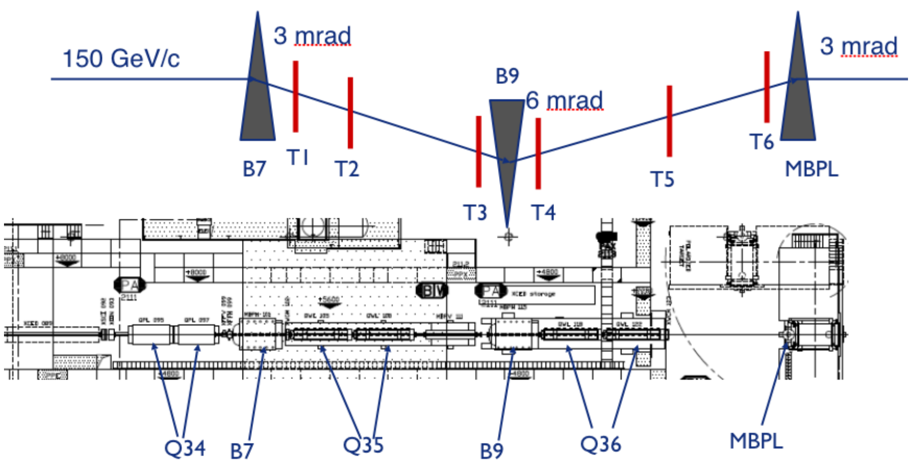




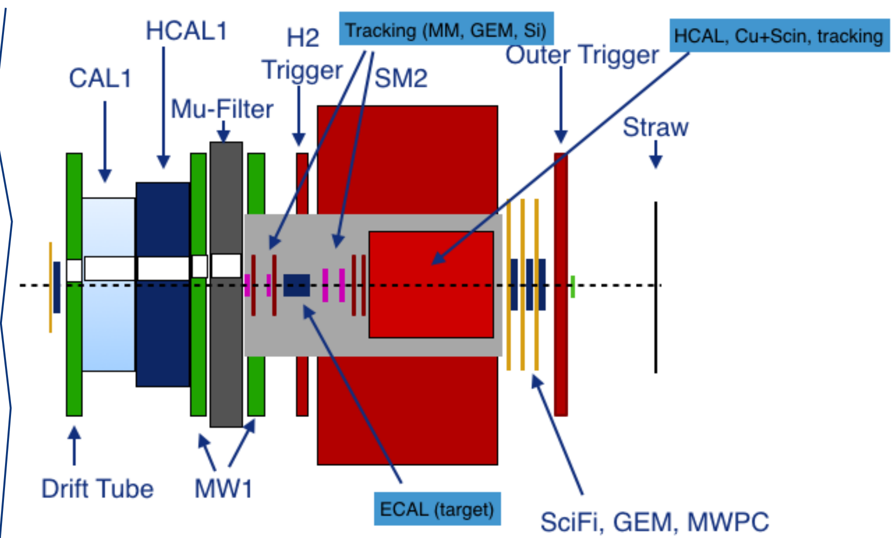
D. Banerjee
J.B.

EHN2: NA64-μ

- Phase 2
  - Location inside SM2 spectrometer magnet.
  - Optics ready, integration study continues as more details of the experimental detectors become available.
  - Proposal to use magnetic chicane + additional MBPL magnet at current Compass target location as additional magnetic spectrometer.



PPE211



PPE221

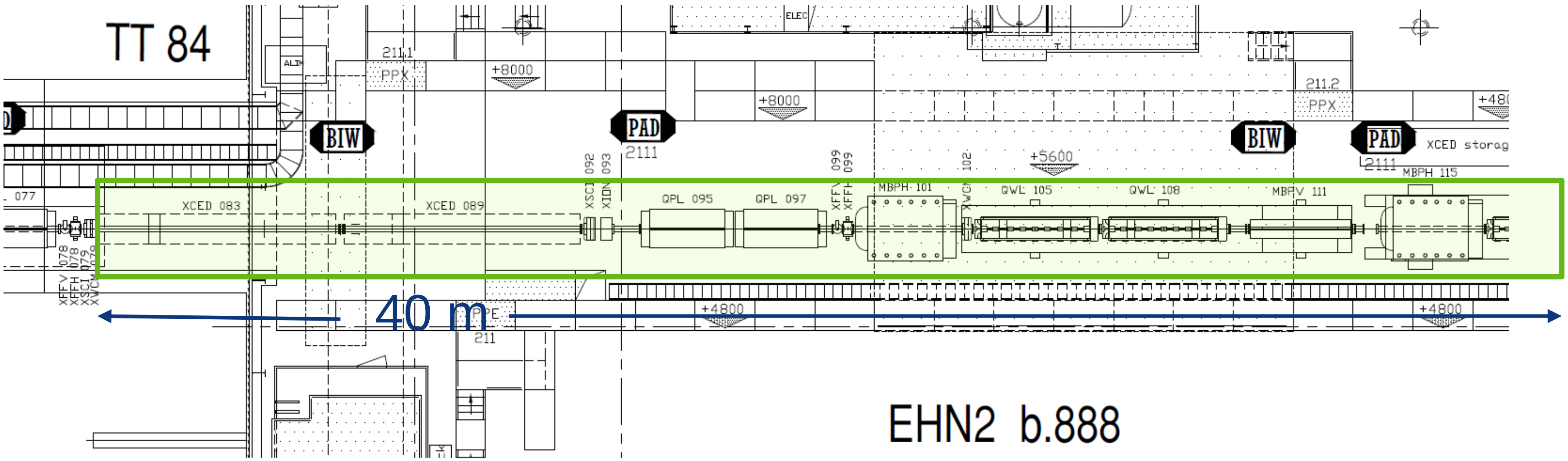
D. Banerjee
J.B.

EHN2: MuonE

- Studies completed for 30 m upstream option and later extended to 40 m space requirements, beam similar to NA64μ phase 1 + optimisation of muon Halo by changes in Scraper settings.
- Added MuonE absorber for muon ID and downstream calorimeter to the study, which would present a significant amount of material.
  - Parallel running with Compass or NA64-μ seems to be excluded, but parallel set-up is feasible.
  - Ideas for integration: Make calorimeter and muon ID absorber easily removable, e.g. mount on rails.
  - Contamination of downstream beam studied with FLUKA and GEANT4, found < 10 ppm hadrons and < 1 % photons and electrons that can be removed by an absorber and sweeping with dipoles.
- Infrastructure requirements defined and preliminary costing available, mostly gas, DAQ needs, counting room.
- High precision measurement at 10^{-5} accuracy, which would profit from additional, detailed studies for environmental stability (thermal conditions, high precision mounting and reproducibility).

D. Banerjee
J.B.

EHN2: MuonE

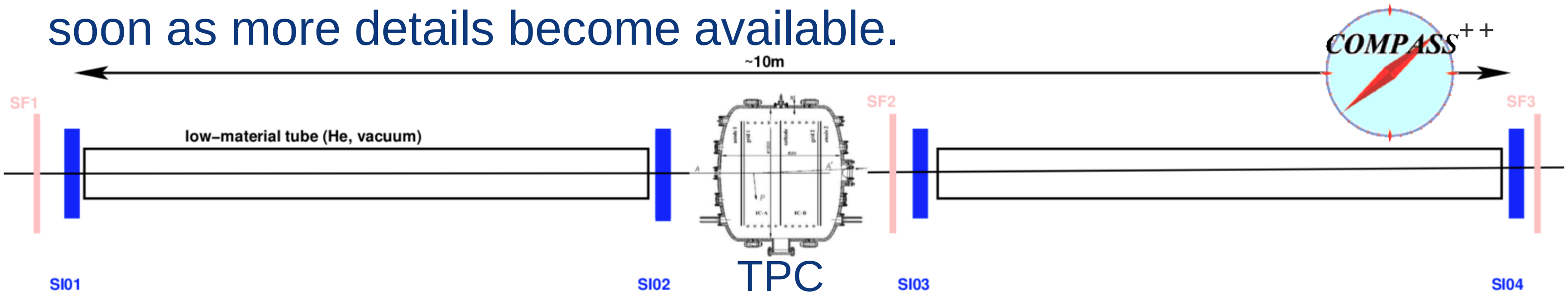


- Changeover to MuonE with > 30 m experimental setup would imply removing most of the final focus for COMPASS, hence only a big beam spot in the COMPASS target region, which is incompatible to both recent COMPASS++ and NA64-µ requirements.

EHN2: COMPASS++/QCD facility

D. Banerjee
S. Cholak
M. van Dijk
J.B.

- Proton Radius Measurement: Required optics are very similar to the currently operated muon beam for an installation of a high-pressure TPC at the COMPASS target position and use of the existing COMPASS spectrometer, only minor integration studies to be done as soon as more details become available.

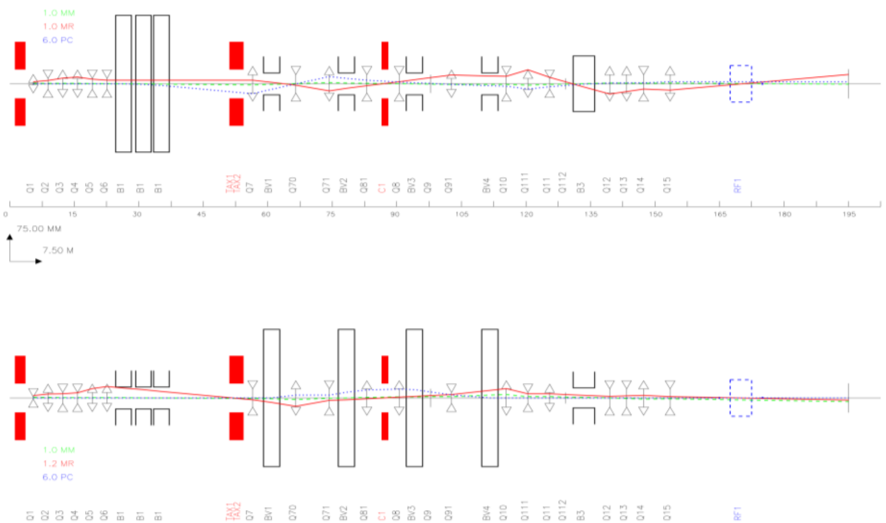


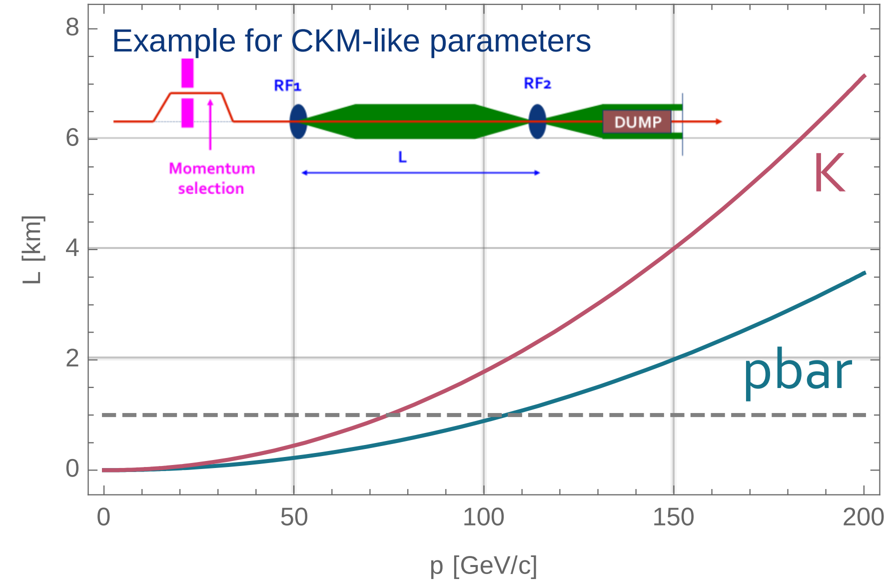
- Low-energy antiproton beam production study done including vacuum revision, study started for dedicated low-energy optics (better momentum selection, higher acceptance).
- High-energy hadron beams: Shielding study completed for higher intensities, validated with RP measurements in the 2018 configuration. Differential absorption study not promising: 2 m polyethylene increase pion content at 190 GeV/c from 25% to only 29.5% at the cost of 86% lost beam and considerable degradation of divergence at CEDARs.

E. Montbarbon
J.B.

EHN2: COMPASS++/QCD facility

- RF-separated beams: Frontend for momentum selection studied, achieved higher momentum resolution as required by adding a vertical achromat.



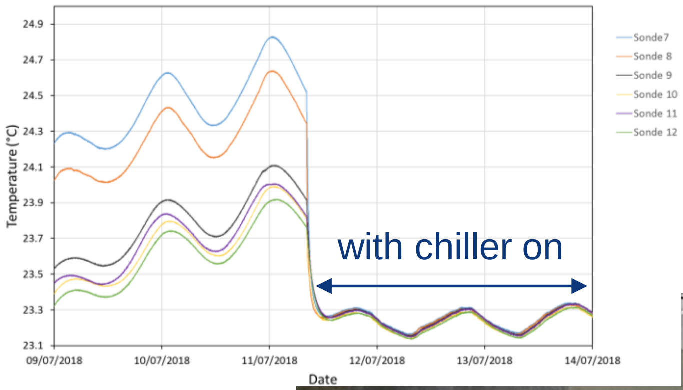


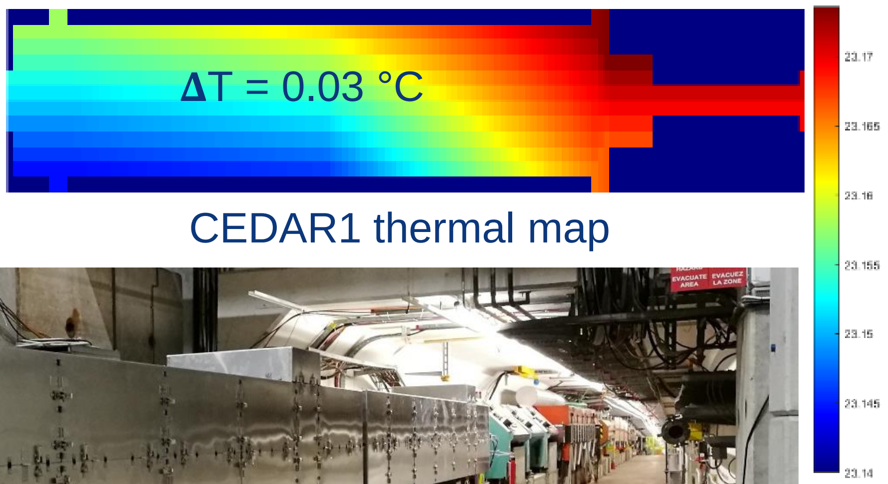
- Crucial for determination of final beam momentum:
  - Optimisation of beam spot in the cavities.
  - Study for highest possible RF frequencies and cavity apertures.
  - Available length between cavities in M2.

S. Mathot
EABI WG

EHN2: COMPASS++/QCD facility

- New CEDAR active thermal housing running very stably without interruptions, temperature control at 0.1°C level.





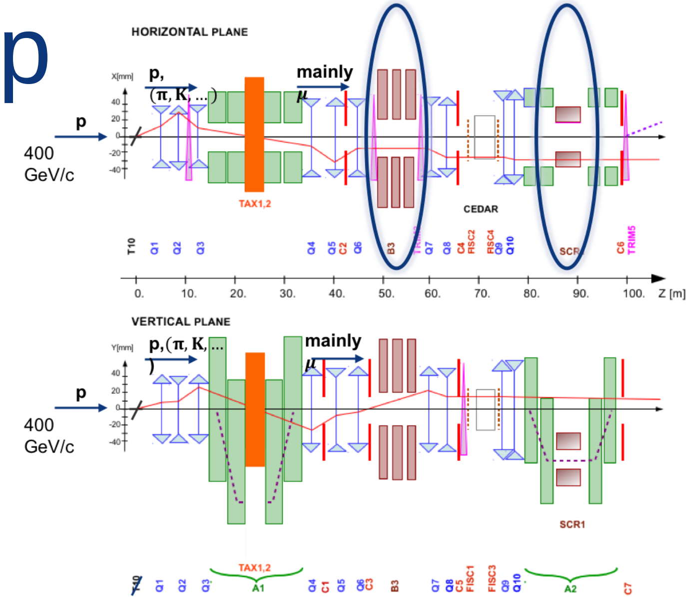
CEDAR1 thermal map

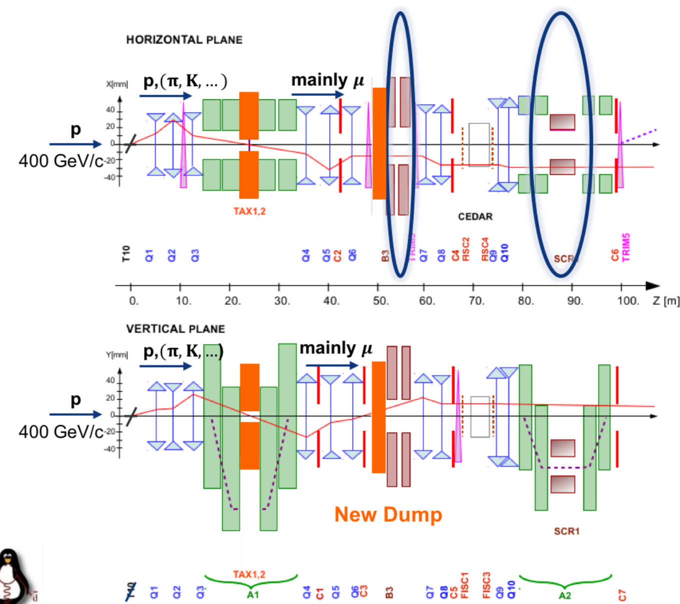
- Further upgrades for beam instrumentation discussed within the Experimental Areas Beam Instrumentation WG, e.g. for beam particle identification.

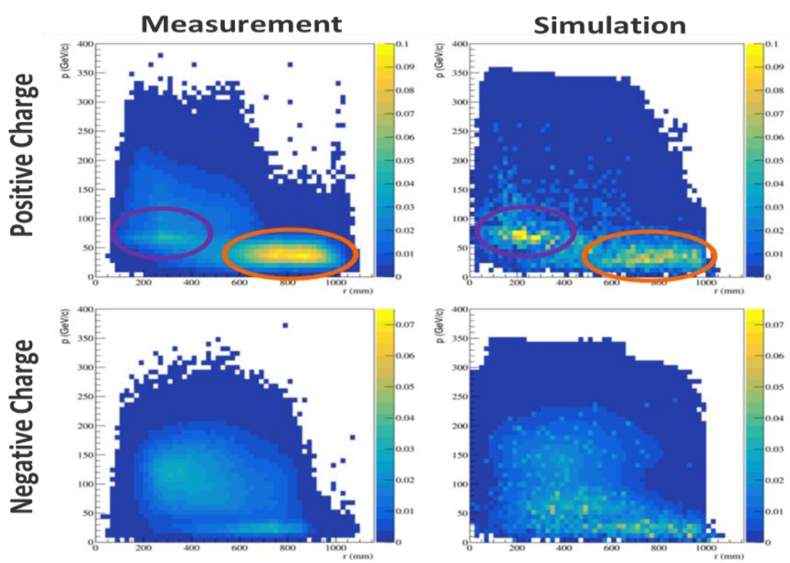
M. Rosenthal

ECN3: NA62 Beam Dump

- Idea: Transfer full proton intensity on TAX with T10 out and reduce flux of upstream pion and kaons decaying to muons. Dark sector particles would be produced in TAX.
- Muons need to be efficiently swept as zero background from SM required.
- Successful benchmarking of simulation with experimental data.



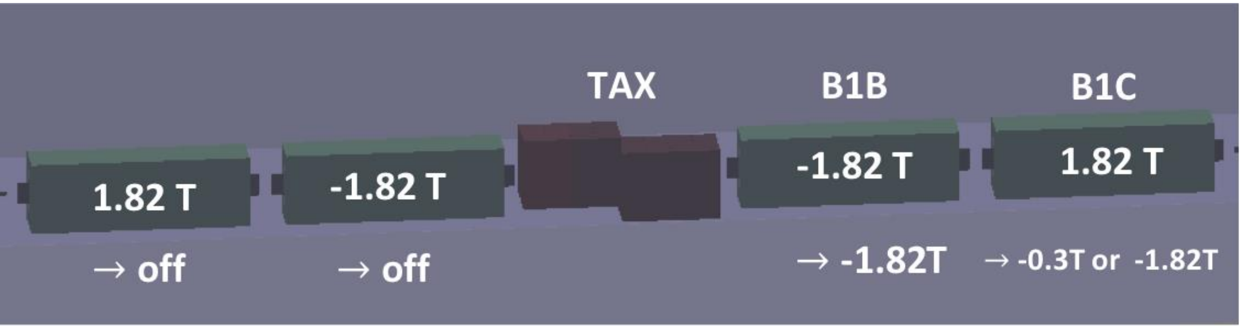




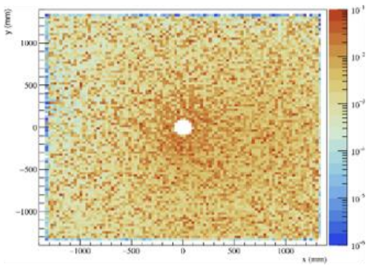
M. Rosenthal

ECN3: NA62 Beam Dump

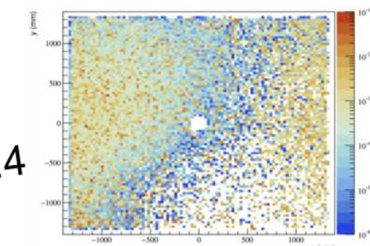
- Configuration with closed TAXes and modified 1st achromat for optimum muon sweeping.



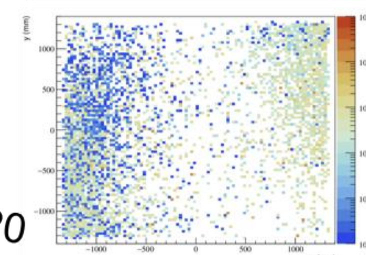
Present configuration in test beam dump runs

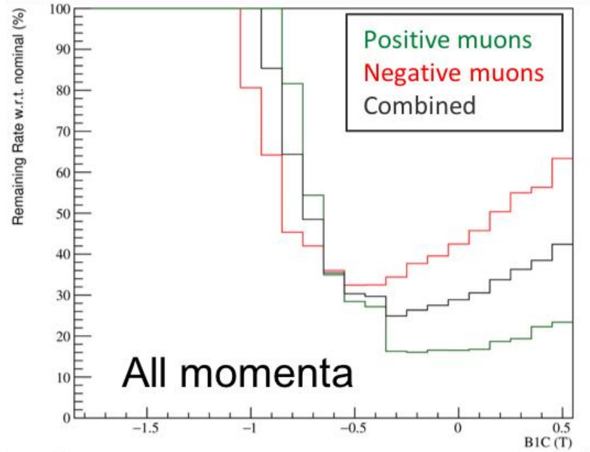


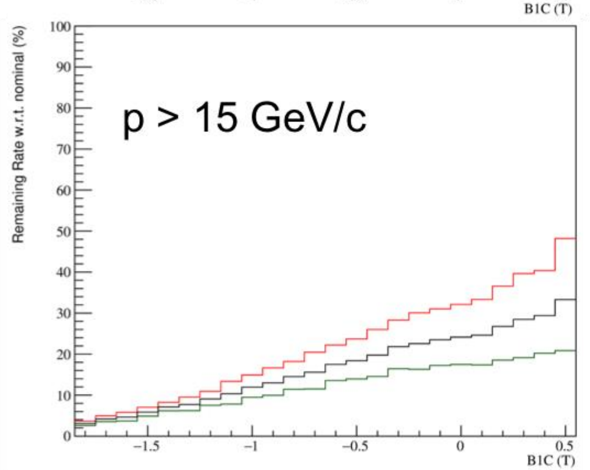
-1.82T, -0.3T
reduction factor:4



-1.82T, -1.82T
p > 15 GeV/c
reduction factor:20



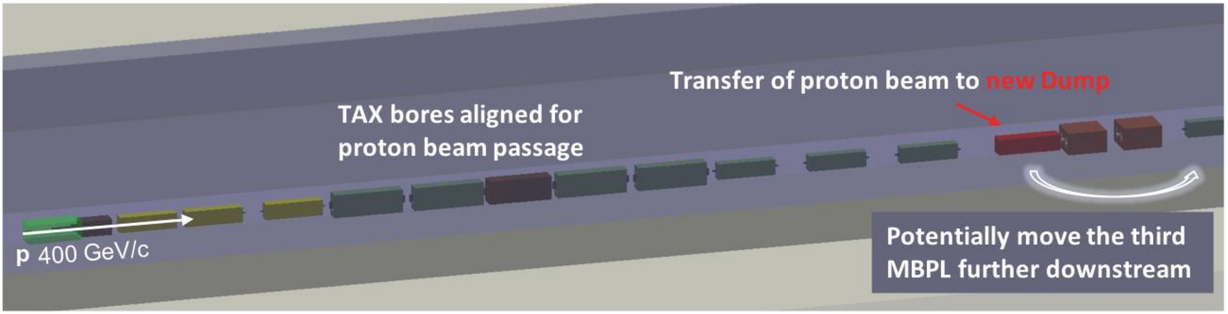




M. Rosenthal

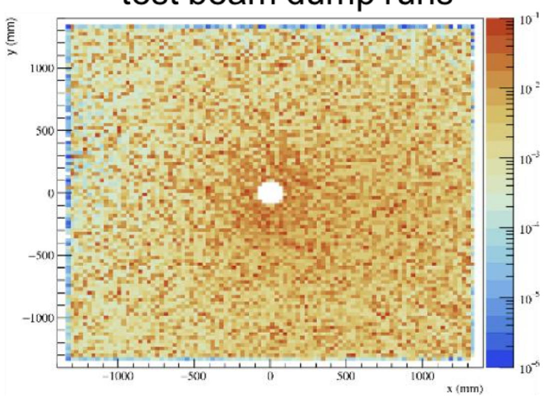
ECN3: NA62 Beam Dump

- Configuration with dedicated beam dump close to Bend 3.

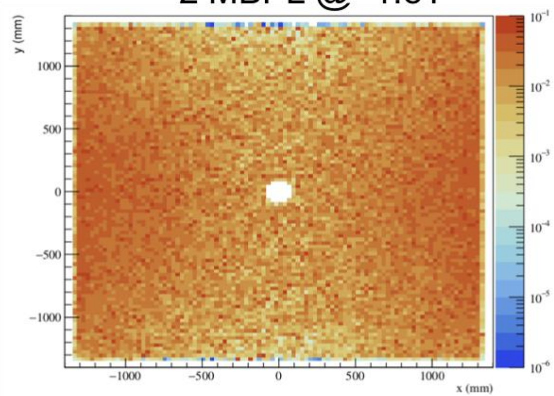


- 2 MBPL:
  - increase by factor 3
- 3 MBPL:
  - All momenta: increase by factor 6
  - p > 15 GeV/c: reduction by factor 5

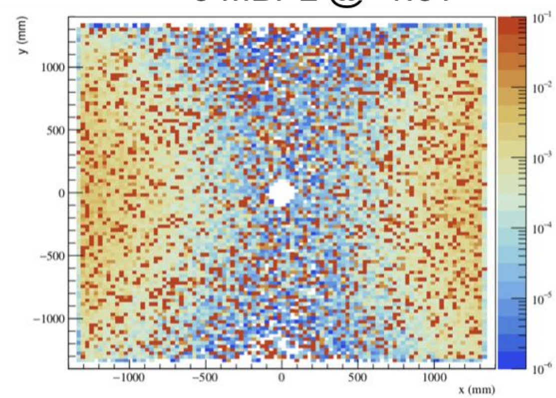
Present configuration in test beam dump runs



2 MBPL @ -1.8T



3 MBPL @ -1.8T

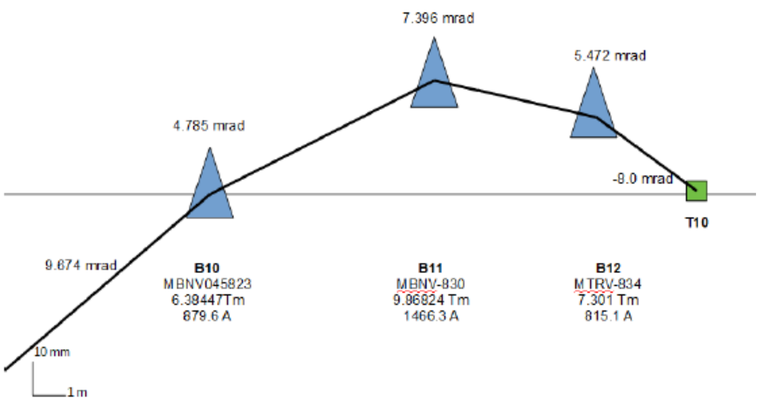


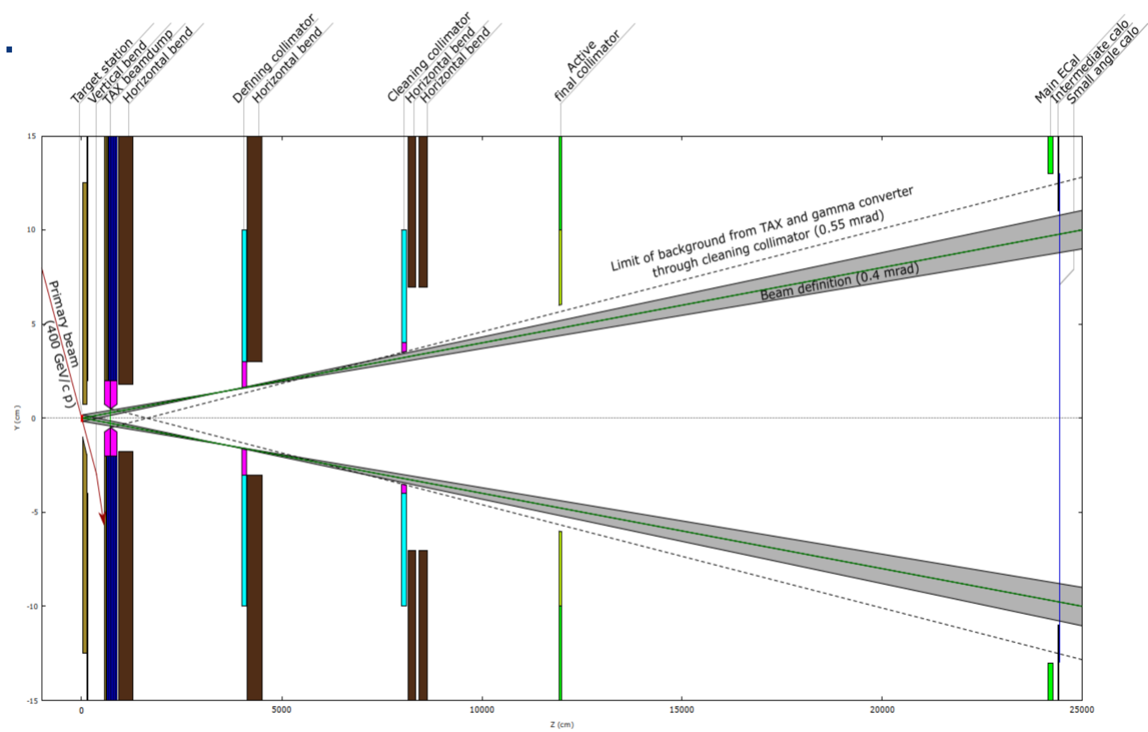
- From a single-charge muon suppression point of view, the technically preferred solution would be to use the TAXes as a beam dump. More studies soon with respect to suppression of both muon charges at the same time.

ECN3: KLEVER

M. van Dijk
S. Pagan

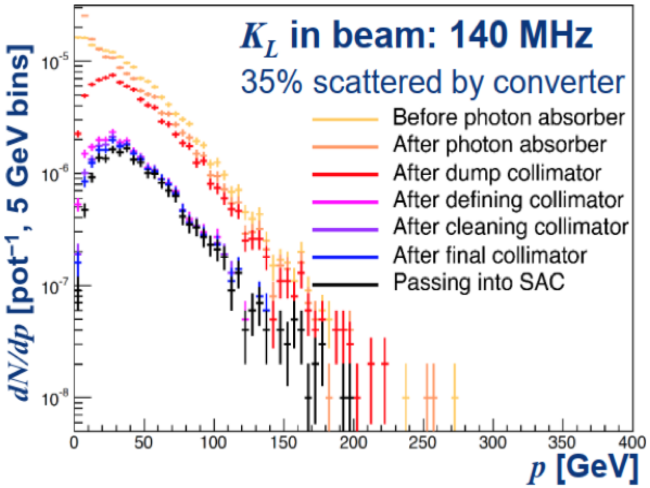
- Modification and optimization of the proton beam transport in P42 to the T10 target.
- Intense target production studies: Production angle on T10 target increased from 2.4 to 8 mrad.
  - Λ production suppressed.
  - Loss in K_L production compensated.

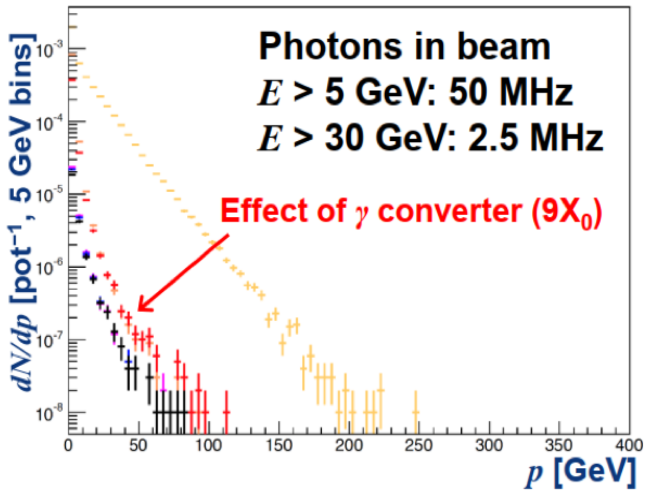


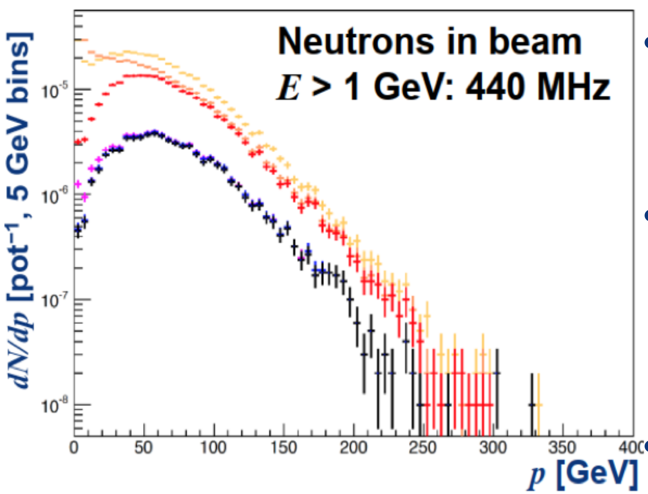


M. van Dijk

ECN3: KLEVER

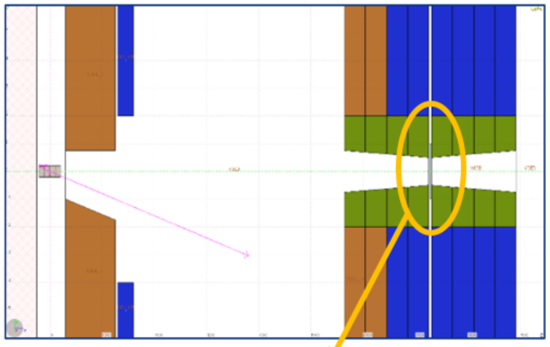


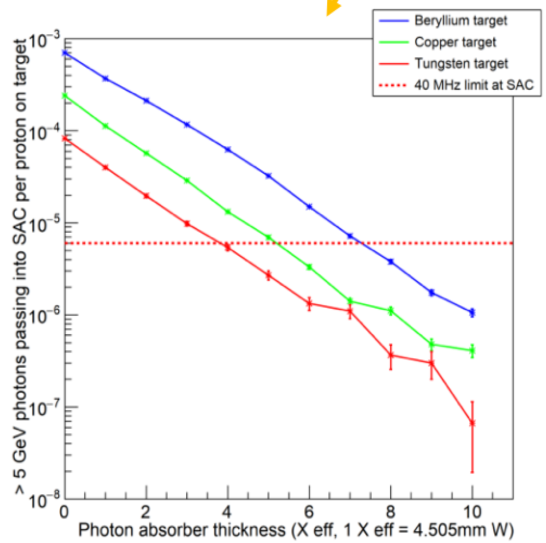




FLUKA simulation of beamline

Detail of target and dump collimator



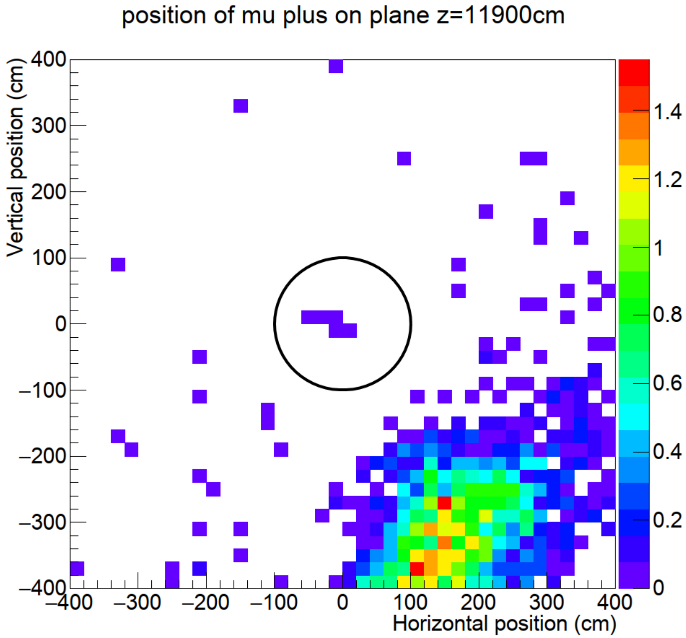


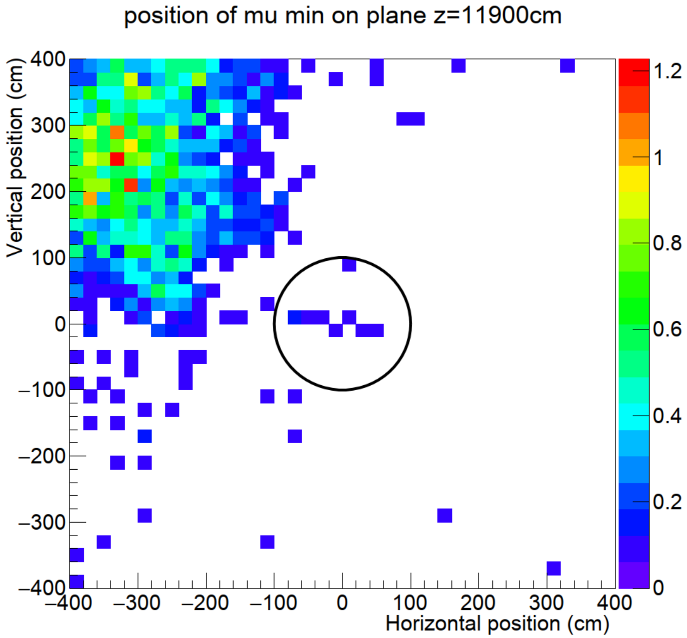
- Detailed rate studies after several stages of collimation.
- Reduce photon background by pair conversion in photon converter, material and thickness study in FLUKA.
- Crystal converter under investigation.

M. van Dijk

ECN3: KLEVER

- Optimize configuration of 3 groups of bending magnets for reduction of muon background with full FLUKA model including magnetic fields.
- Best case identified: First group sweeps left, second and third group sweeps to the right (LRR).
- Remaining muon rates: 2.5 MHz in shashlik and 4.9 MHz in MEC.

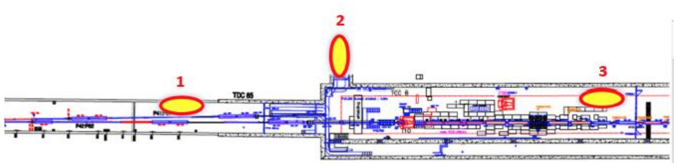


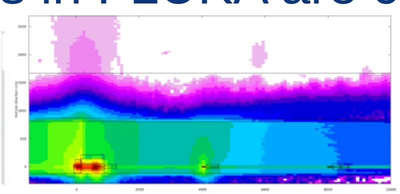
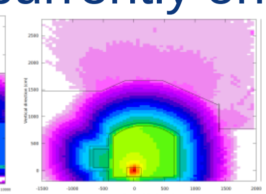
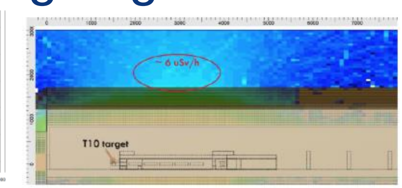


C. Ahdida + RP
M. van Dijk
A. Gerbershagen

Air activation and RP studies

- Calculated air activation around T10 target for NA62 operation significantly higher than measured, but under different conditions than operation (no continuous beam before measurement, target intensity factor 3.4 lower). Measurements were repeated by RP and are being evaluated at the moment.
- Measurements show a very minor to non-existing air flow at strategic locations in TDC85 and TCC8.
- Using a conservative assumption of the soil above the cavern (1.2 g/cm^3), the highest expected dose rate is about 6 µSv/h for an average beam intensity of $2{\cdot}10^{11}$ protons per second (22 mSv/a).
- Measurements with monitor SMS816 above the transfer lines to ECN3 and EHN2 show integrated dose of 0.27 mSv in 2017.
- For the proposed KLEVER setup, requiring even higher proton intensities, radiation studies in FLUKA are currently on-going.

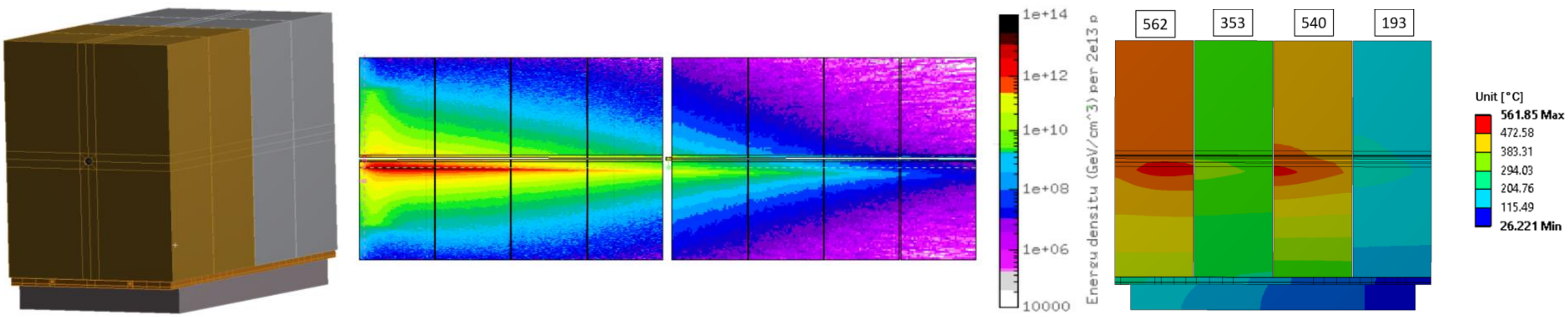


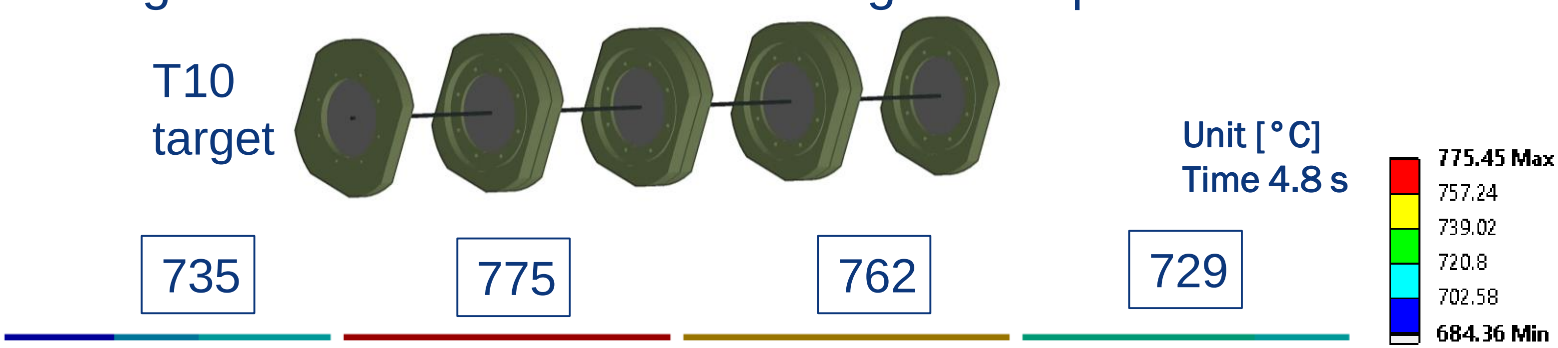
Targets and TAXes

N. Solieri, M. Calviani
M. van Dijk, M. Rosenthal
A. Gerbershagen

- Targets and TAXes need to survive the increased proton intensities, e.g. for the KLEVER proposal.



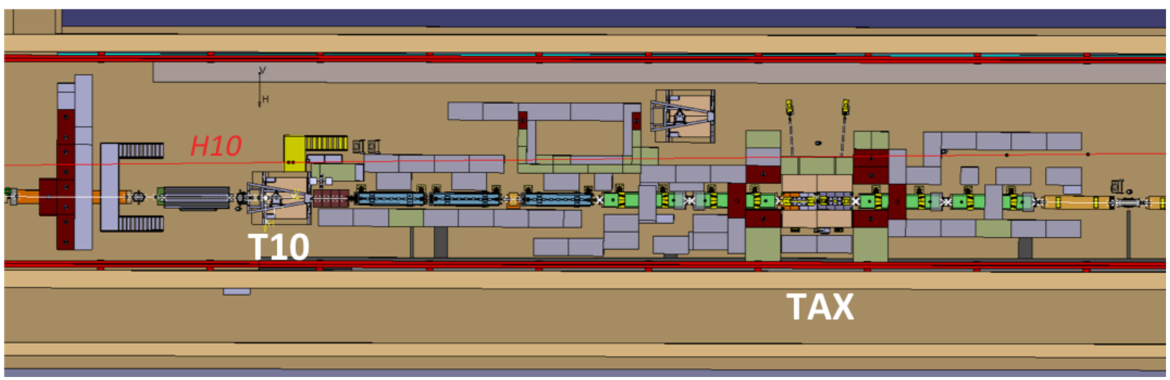
- First studies of the heat load on the proposed setup show that modifications of the present design are mandatory, most probably using different materials and cooling techniques.

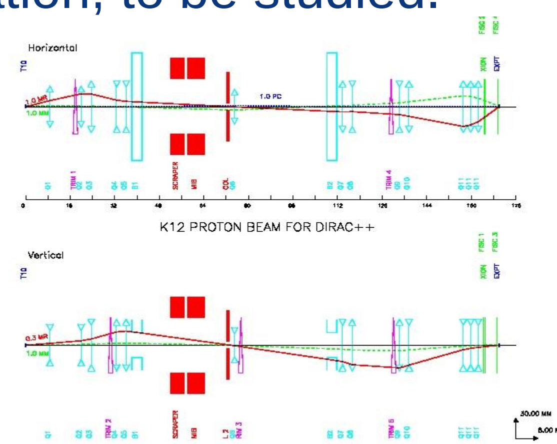


L. Gatignon

NA60++ / DIRAC++

- If K12 beam line and NA62 are dismantled, cohabitation of both experiments in principle possible.
  - Requires re-establishing the end of P41 and H10 beam lines for NA60++ (beam optics existing and available).
  - New optics for proton delivery beam line to DIRAC++ calculated.
  - Reactivation of H10 has severe impact on front-end shielding and place for detector maintenance.
  - Front-end shielding considered vital for radiation protection above and behind ECN3 cavern (limits available space for π decays into μ).
  - DIRAC++ operation might require ECN3 ventilation, to be studied.





L. Gatignon

REDTOP

- REDTOP is an experiment for very rare eta decays, originally proposed for FERMILAB. Discussions with several machine experts have taken place concerning implementation at CERN. They request 10^{18} pot per year and hence a duty cycle of 80% or more.
- In **LEIR** the beam energy is too low and many machine aspects would need serious studies and investment. In particular LEIR is not a shielded machine.
- The upgraded **PSB** energy after LS2 would match perfectly, but here the implementation would also be difficult and penalising for the other users.
- At the **PS** slow extraction into a heavily shielded facility (like the IRRAD+CHARM bunker in the East Hall) has been looked at. No showstopper has been identified. Again many studies would be required and the impact on the rest of the PS physics program would be very significant. Reduced flux requirements could ease the situation.
- For the moment this study is put on hold and any further study should be done in a more machine oriented working group.

Preliminary Cost Estimates

Building	Beam	Proposal	Upgrades foreseen	Cost
EHN1	H2	NA61	Shielding, interlocks	C1
	H2	NA61	New very low energy beam	C2
	H4	NA64-e/h	New permanent location	C1
EHN2	M2	NA64-μ	New location on beam	C1
		NA64-μ	Phase 2	C1
	M2	MuonE	Installation on M2 beam	C2
	M2	COMPASS++	Low-energy beam	C2
		QCD facility	New RF-separated beam	C4
ECN3	K12	NA62 BD	Re-cabling for m sweeping	C1
	K12	KLEVER	Upgrades and new beam	C3
	K12	NA60++	Revive H10 beam line	C2
	K12	DIRAC++	New K12 beam line	C3

Nota bene: These are very preliminary estimates for the beam infrastructure, not including the prosed experiments!

C1: Up to a few 100 kCHF
C2: From few 100 KCHF to 1 or 2 MCHF
C3: From 1 or 2 MCHF to 5 to 10 MCHF
C4: Of the order of ≥ 10 MCHF

Summary and Outlook

- The CBWG studies give good indications of the feasibility and implications of the beams and infrastructure modifications associated with the proposed experiments in most of the studied cases.
- These studies need to continue, in particular in case of planned implementation. Some of the proposals will rapidly evolve into SPSC proposals for first data-taking even before LS3, a few already have.
- In a next step, more detailed studies will include the advanced RF-separated beam design, the technical implementation of KLEVER and intensity increase in ECN3 and EHN2, details on the H10 beam, safety aspects and synergies with the North Area Consolidation Study, and more precise cost estimates.
- Implementation studies and test preparations shall continue, focusing on remaining R&D studies, detailed integration studies and required test preparations required after LS2.

Documentation

- Full report:
  [CERN-PBC-REPORT-2018-002]
- Executive Summary:
  [CERN-PBC-Notes-2018-005]
- Technical notes:
  [CERN-PBC-Notes-2018-002]
  [CERN-PBC-Notes-2018-004]

CERN-PBC-REPORT-2018-002 17 December 2018

Physics Beyond Colliders

PBC CONVENTIONAL BEAMS

Report from the Conventional Beams Working Group to the Physics beyond Collider Study and to the European Strategy for Particle Physics

D.Banerjee, J.Bernhard, M.Brugger, N.Charitonidis, G.L.d'Alessandro, N.Doble, M.van Dijk, L.Gatignon, A.Gerbershagen, E.Montbarbon, M.Rosenthal
on behalf of the Conventional Beams working group

Contact person: Lau Gatignon, email Lau.Gatignon@cern.ch

- Several conference presentations and proceedings in preparation, e.g. at IPAC'19. Already available online: M. Rosenthal et al., ICAP'18, SUPAG05, 2018 (to be published).

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