



Status of the PBC – CBWG Studies

N. Charitonidis on behalf of the CBWG members:

D. Banerjee, A. Barrato, J. Bernhard, M. Brugger, L. Gagnon, A. Gerbershagen, G. D' Alessandro, R. Murphy, C. Mussolini, F. Metzger, E. Parozzi, S. Schuh-Erhard, F. Stummer plus all the experimental representatives

02.12.2021

WG mandate



The working group:

- Analyses the **requirements** and **provides support for the experiments** attributed to the working group, namely **design or modifications of secondary beam lines** and **integration** in the existing SPS and PS experimental areas
 - Including also concepts of novel neutrino beam lines.
- Evaluates **the feasibility, compatibility, infrastructure needs, approximate costs and resource requirements** from CERN and collects all this information for the PBC-A&T Committee.
- Experiments followed now by the group: **NA64 μ /h, NA60+, NA62 high intensity / KLEVER, MuonE, SHADOWS, AMBER** (RF-separated beams), **ENUBET** and **NuTAG**.

CONVENTIONAL BEAMS WORKING GROUP

Conveners: M. Brugger, J. Bernhard

Expert Advisor: L. Gatignon

PBC physics representatives, experts, and SPSC referees on demand

CBWG-EHN1

Convener: A. Gerbershagen

- NA60+
- NA64 high intensity / hadrons
- True muonium

CBWG-EHN2

Convener: D. Banerjee

- AMBER (μ & RF-separated beams)
- MUonE
- NA64- μ

CBWG-ECN3

Convener: J. Bernhard

- K_L EVER
- NA62 BD
- NA62 High Intensity
- Shadows

CBWG-NB

Convener: N. Charitonidis

- NA61 VLE
- ENUBET
- NuTAG

- **Already completed : NA64 new user zone, NA61 upgrades. AMBER/NA66 (Phase-I) → Approved by SPSC / RB**
- **REDTOP now out of scope of the CBWG, DIRAC on hold**
- **Regular CBWG meetings synchronised with SPSC meetings.**
- **Technical meetings with subgroups for reports of studies and news depending on progress made.**
- **All meetings on [indico](#).**

Updated Report

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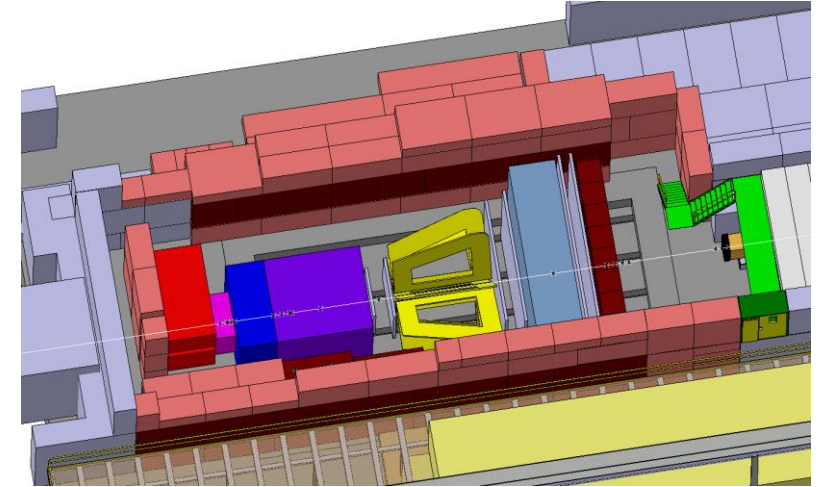
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- Original report available on CDS: [CERN-PBC-REPORT-2018-002](https://cds.cern.ch/record/2819072/files/CERN-PBC-REPORT-2018-002.pdf)
- In final editing, nearing completion

CBWG-EHN1

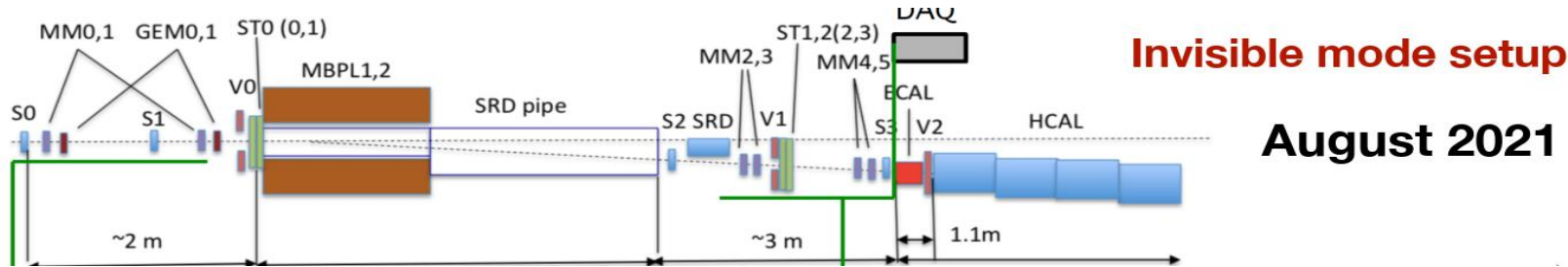
Converner: Alexander Gerbershagen

- **Experiment aiming at the study of dimuon and open charm measurements**
- **Regular technical meetings have already tackled integration and radiation protection issues**
 - 10^7 Pb ions per spill in H8 beam (no longer ECN3)
- **New optics developed for the beam requirements requested**
 - Test beam has been requested for 2022 to validate optics and feasibility
- **Toroidal magnet prototype developed by EP-DT**
 - Construction completed (scale 1:5)
 - Prototype assembled with a first version of the mechanics
 - B-field simulation vs radius compared with measurements
- **Upcoming steps:**
 - Letter of Intent is to be finalized by the end of 2021 or beginning of 2022.



NA64 High Intensity

S. Gninenko, V. Poliakov, P. Crivelli,
N. Charitonidis



- **Continuing the quest of Dark Matter – aiming to probe the parameter space with $\int \sim 4.5 \times 10^{12}$ e.o.t by LS3**
- **New permanent area in PPE144 ready**
- **High intensity beams (1.4×10^7 e⁻ per spill) were delivered in NA64 experiment in August 2021**
 - plus a high intensity positron beam to improve sensitivity for the ~ 100 MeV DM mass region [via the resonant e⁺e⁻ annihilation mechanism](#) (also for True Muonium)
- **Investigations for a crystal to replace the existing converter ongoing in collaboration with INFN Ferrara**
 - Via the neutral channel $\pi^0 \rightarrow \gamma\gamma \rightarrow e^+e^-$ with a converter at the beginning of the line
 - Promising first simulations show a $\sim 20\%$ increase in the electron yield.



CBWG-EHN2

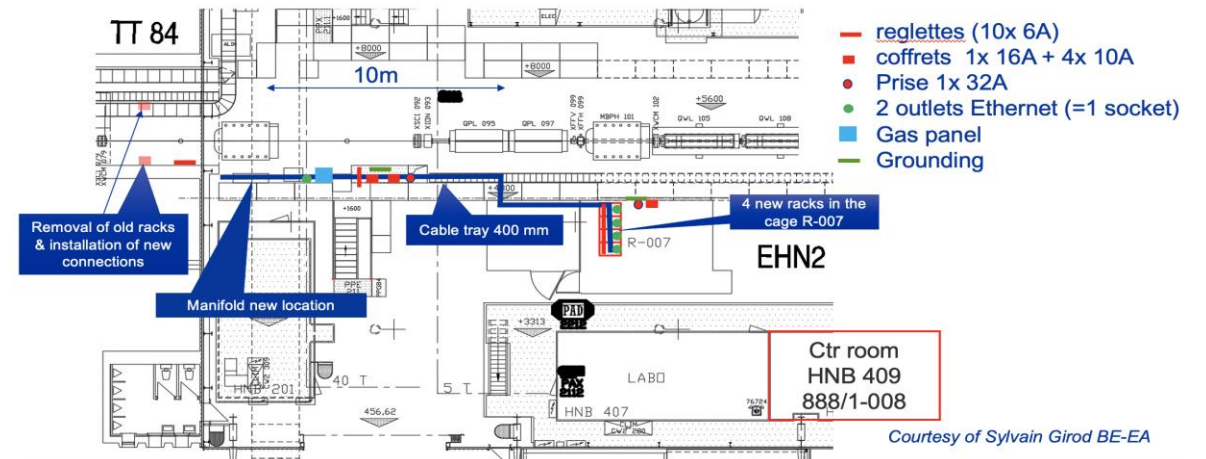
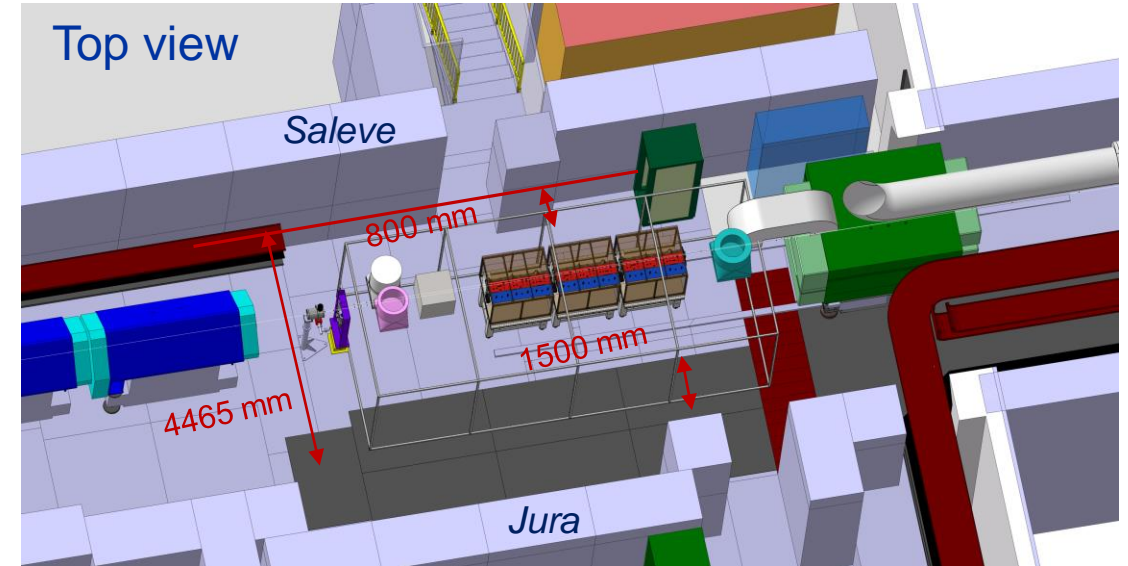
Convener: Dipanwita Banerjee

EHN2 Test Beam Area Preparation

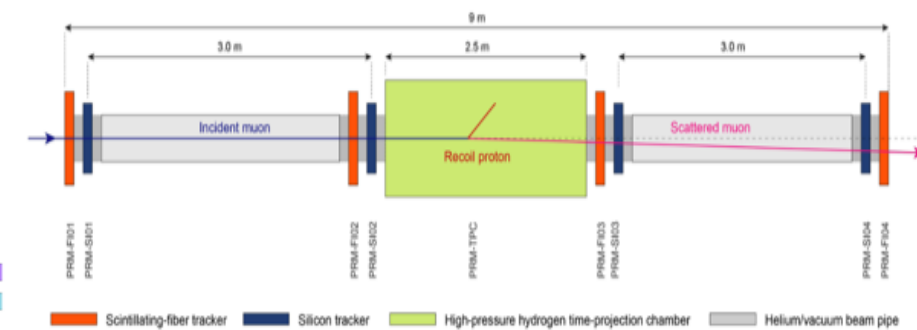
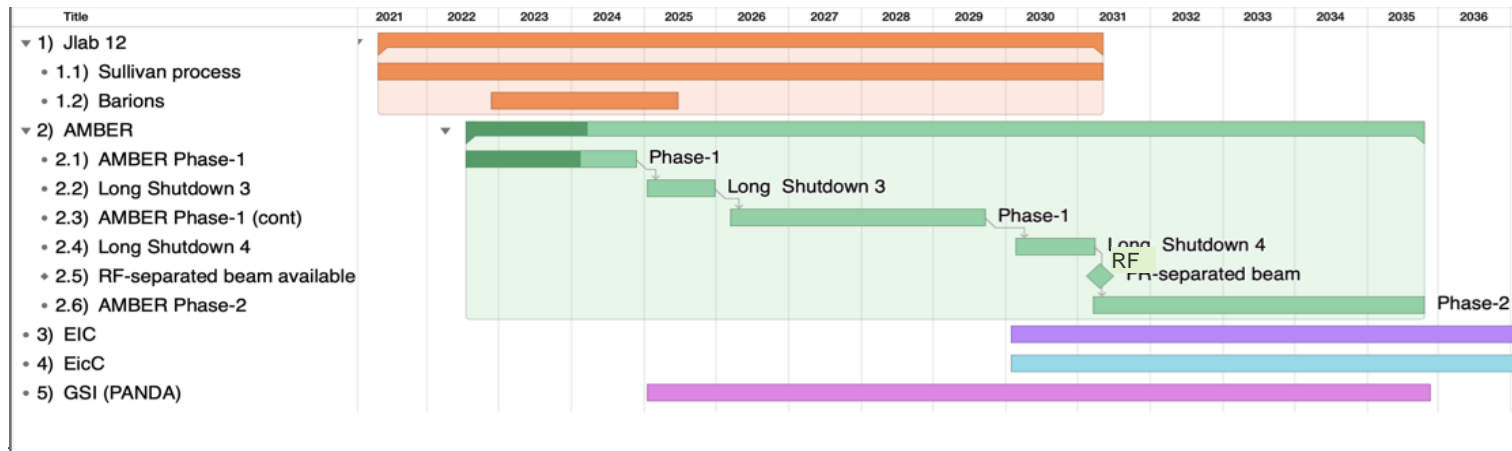
D. Banerjee



- The PPE 221 zone has received the first test-setups for proposed experiments
- Dedicated infrastructure has been made available
 - spectrometer magnet on rails for NA64 μ
 - the complete integration and hydrogen/ATEX infrastructure for the AMBER TPC
 - studying a solution for a temperature-controlled tent for MUonE.
- A new control room and space for DAQ racks has been established enabling the hall to welcome tests also in the future.

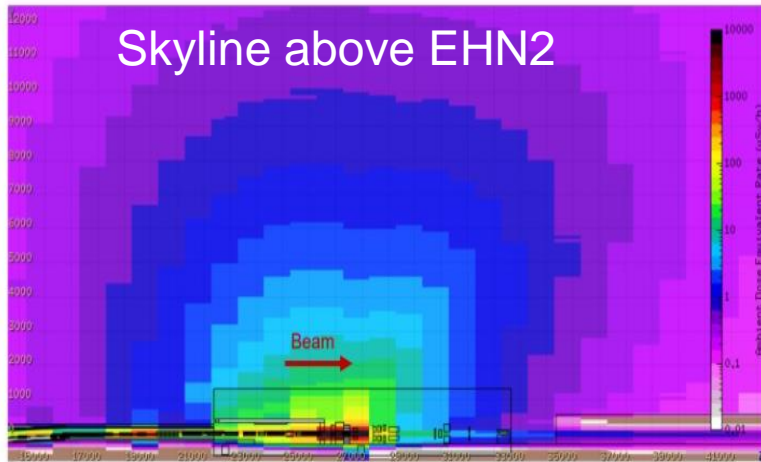


- The AMBER proposal includes the Proton Radius Measurement (PRM), Anti-Matter production and a Drell-Yan Run in Phase 1 as well as an RF separated beam option in Phase 2.
- **New muon optics validated and commissioned successfully in 2021**
 - The PRM pilot run was completed in 2021 with the IKAR TPC. The main TPC will be ready earliest in October 2022 along with the unified tracker stations.
- **A four-week PRM Commissioning run will be requested for the end of 2022.**
 - The goal of this run is to have all detectors commissioned and ready for data taking in 2023.
- **Aiming for a start with the PRM data taking in 2023 followed by the Anti-Matter production Run (2023) and Drell-Yan from 2024.**

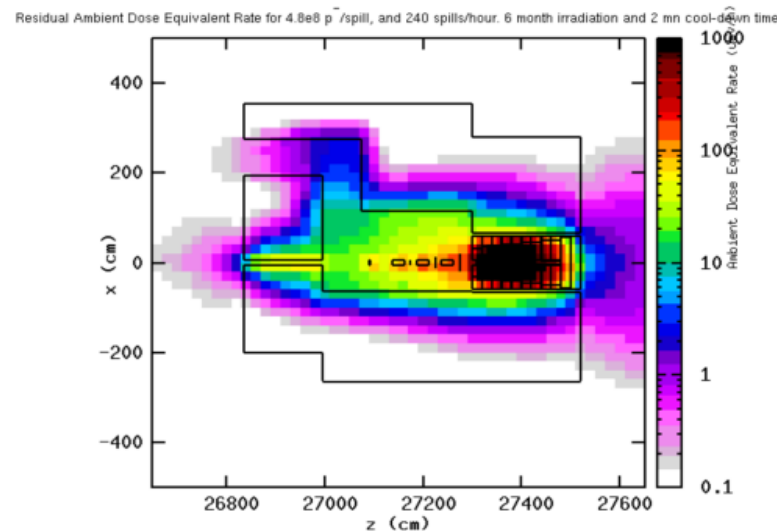


AMBER DY - RP Studies

A. Gerbershagen
D. Banerjee
C. Ahdida
A. Devienne



Ambient Dose Equivalent rate ($\mu\text{Sv/h}$). Intensity: $4.8 \times 10^8 \pi^-/\text{spill}$ and 240 spills/h



- **Dedicated meetings have taken place to discuss the RP issues for the upcoming AMBER Drell-Yan runs.**
 - 5×10^8 hadrons @ 190 GeV/c
- **New shielding configurations have been proposed by RP and are being examined in regards to integration and safety aspects.**
- **For the upcoming run, a zone separation around the AMBER target might be envisaged**
 - However ground load limits have to be respected.

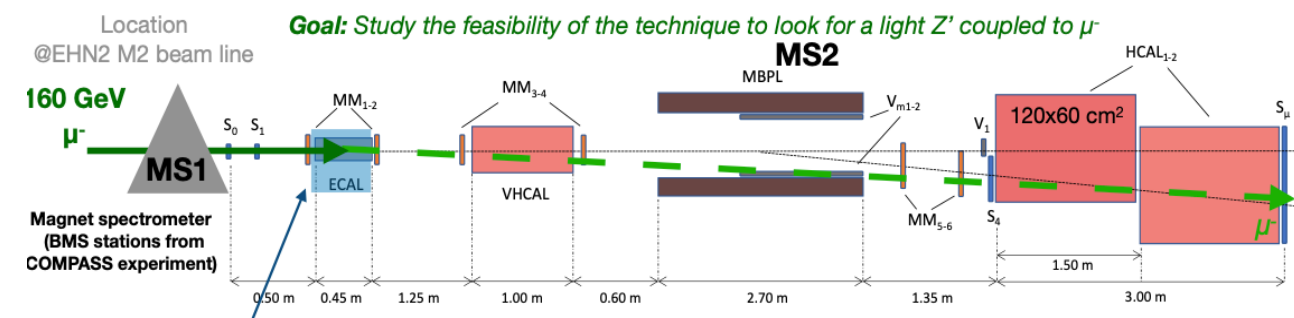
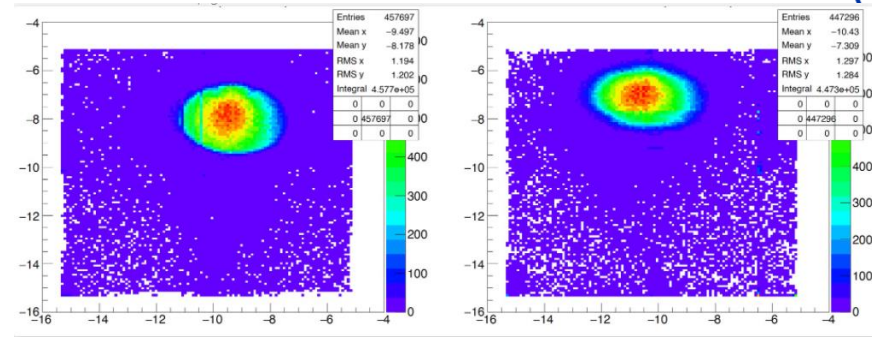
NA64 μ

- NA64 μ aims to collect $> 10^{12}$ μ on target to cover a considerable parameter space for sub-GeV dark matter.
- First milestone: 10^{10} to 10^{12} μ on target for the $(g-2)_\mu$ favoured parameter space for a light Z' coupled to μ .
- Accumulated 5×10^9 muons on target @ 160 GeV/c with new optics during 2021 pilot run
 - Data were taken for hadron contamination measurements
- ~ 2-3 weeks will be requested beginning of 2022 to run with the full setup and the new detectors.



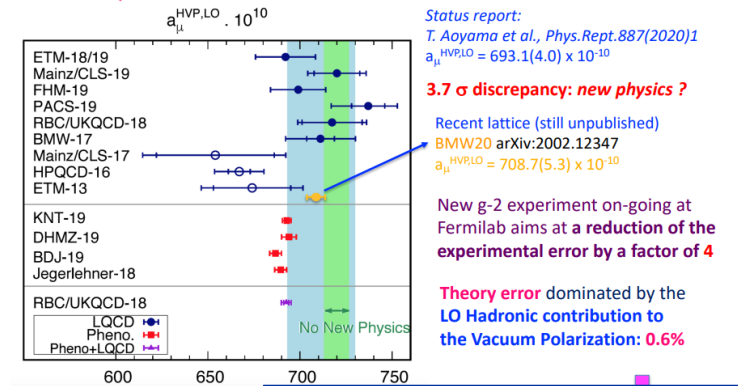
A. Gerbershagen
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J. Bernhard

Beam validation October 2021

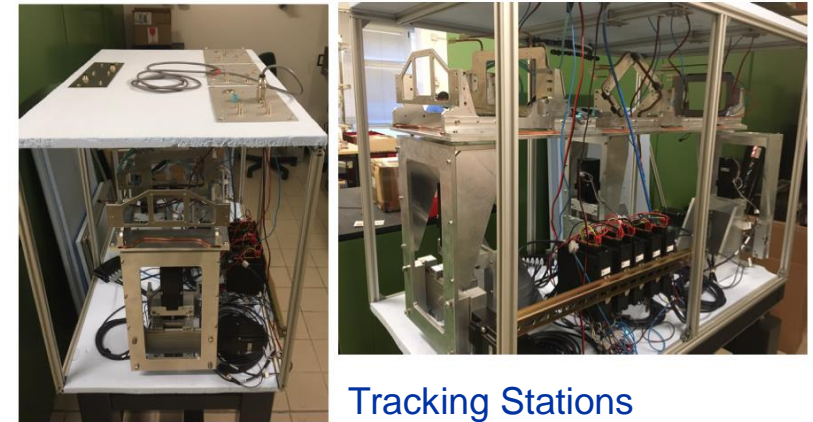


- MUonE aims to measure very precisely the hadronic leading order corrections to the muon $g-2$.
- In 2021 a parasitic run was planned with one station and an ECAL, aimed at testing the readout and the DAQ system
- First demonstration of full chain, with beam this year with promising results \rightarrow Captured ~ 1 TB of data for offline analysis.
- Following the run, in 2022 a proposal to go to an intermediate step of ~ 10 stations will be prepared
 - Checking the compatibility with the two new theoretical predictions
 - Interest and support from CMS

a_μ measurement versus SM



Courtesy: G. Abbiendi



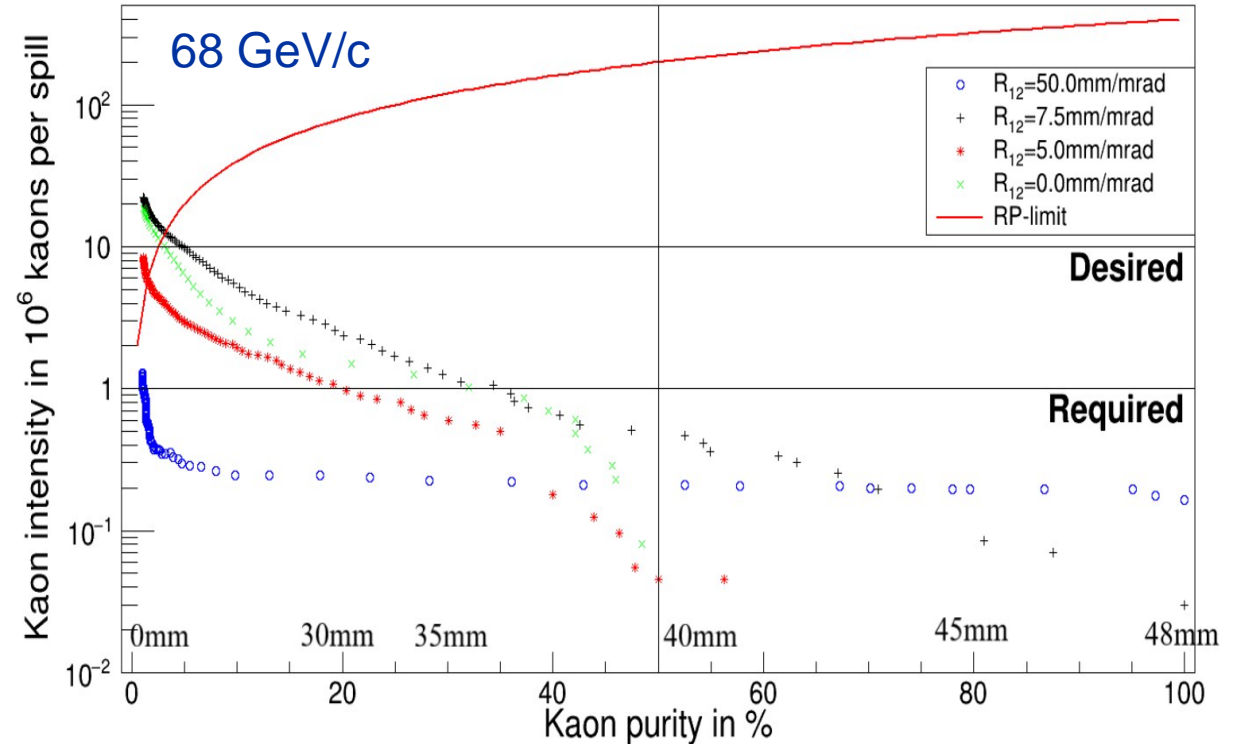
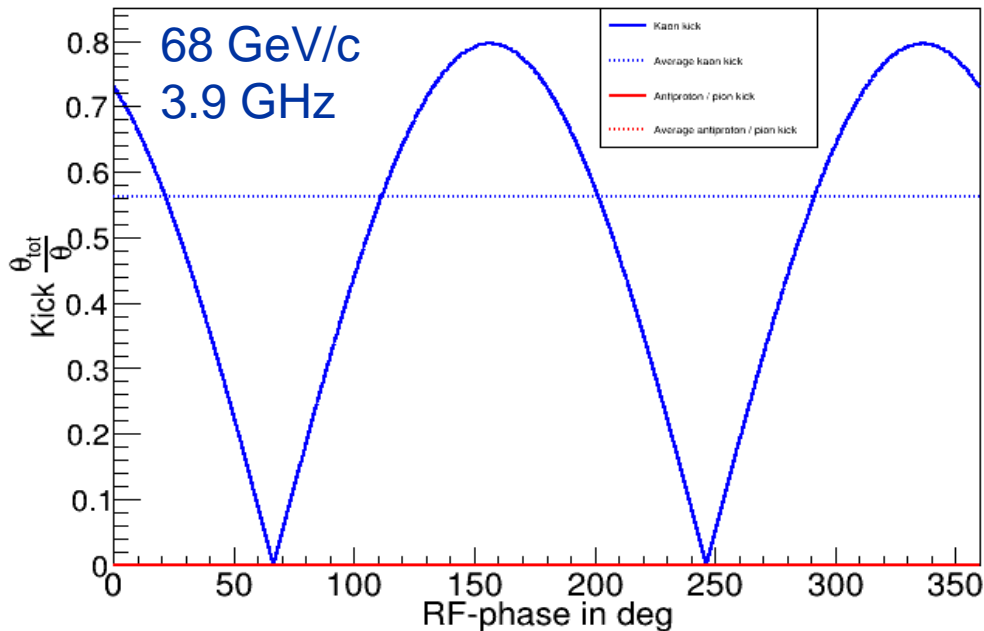
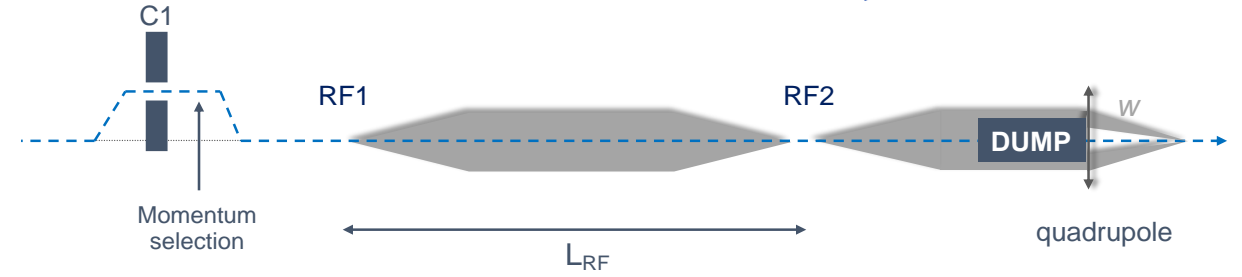
Tracking Stations

RF-separated Beams Option

A. Gerbershagen
L. Gagnon
F. Metzger
S. Schuh-Erhard



- **Studies have advanced**
 - [RF-separated beams for AMBER Workshop](#)
- **New optics are in preparation after initial feedback from RF group. Tracking and purity analysis is now available.**



CBWG-ECN3

Convener: Johannes Bernhard

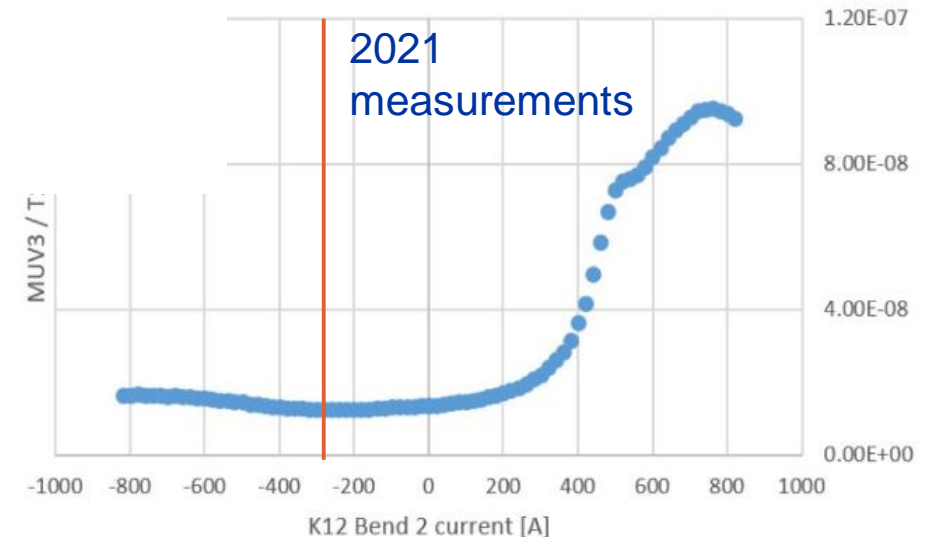
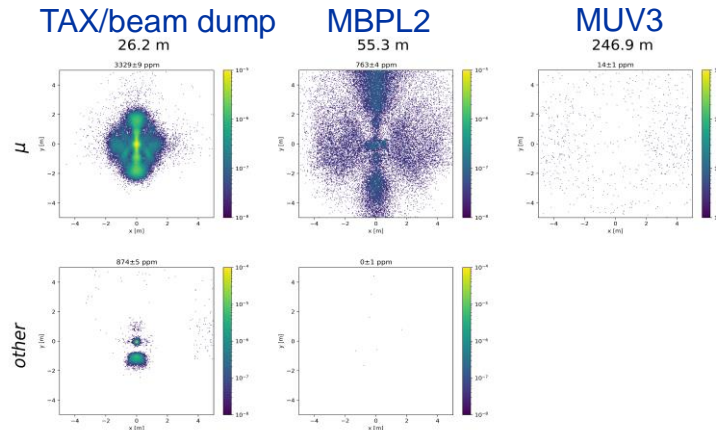
- Recabling of the first achromat of the K12 beamline now allows us switching polarities of the two dipole magnets downstream of the XTAX. Muon sweeping measured this year and in good agreement with the simulations.

- New BDSIM model with modified B-field configuration and with the T10 target removed.

- Future studies will involve background calculations and RP examination.

- TAX studies for higher beam intensities

- A new PhD student (Rob Murphy) has recently started and is working in on these topics.

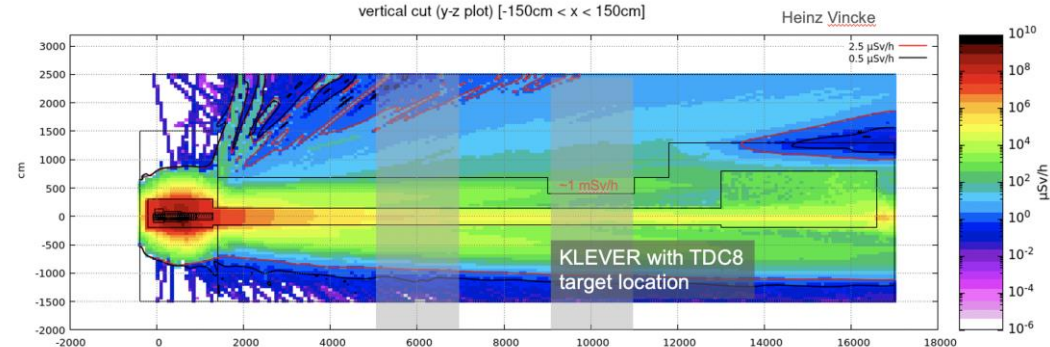


NA62 High Intensity and K_LEVER

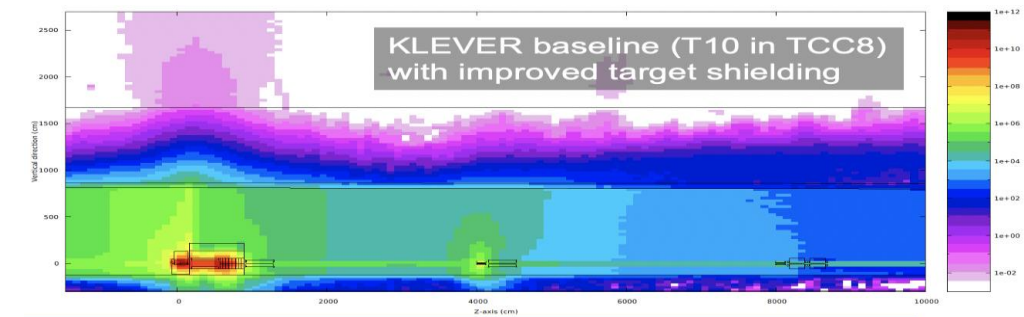
G. D' Alessandro
 J. Bernhard
 L. Gagnon
 A. Gerbershagen
 H. Vincke
 C. Ahdida



- Dedicated discussions are organised jointly by NA62 and KLEVER, which also serve as a platform for discussions of beamline/hardware upgrades, radiation studies and beam-related issues
- **Challenges for higher intensities :**
 - New XTAX
 - Improved machine protection
 - New target design
 - Lambda background for the KLEVER proposal.
- **Several options for the latter are being considered: Extending ECN3 to range out the lambdas (civil engineering), moving of the target more upstream (RP issue), and/or increasing the production angle (much longer run times).**

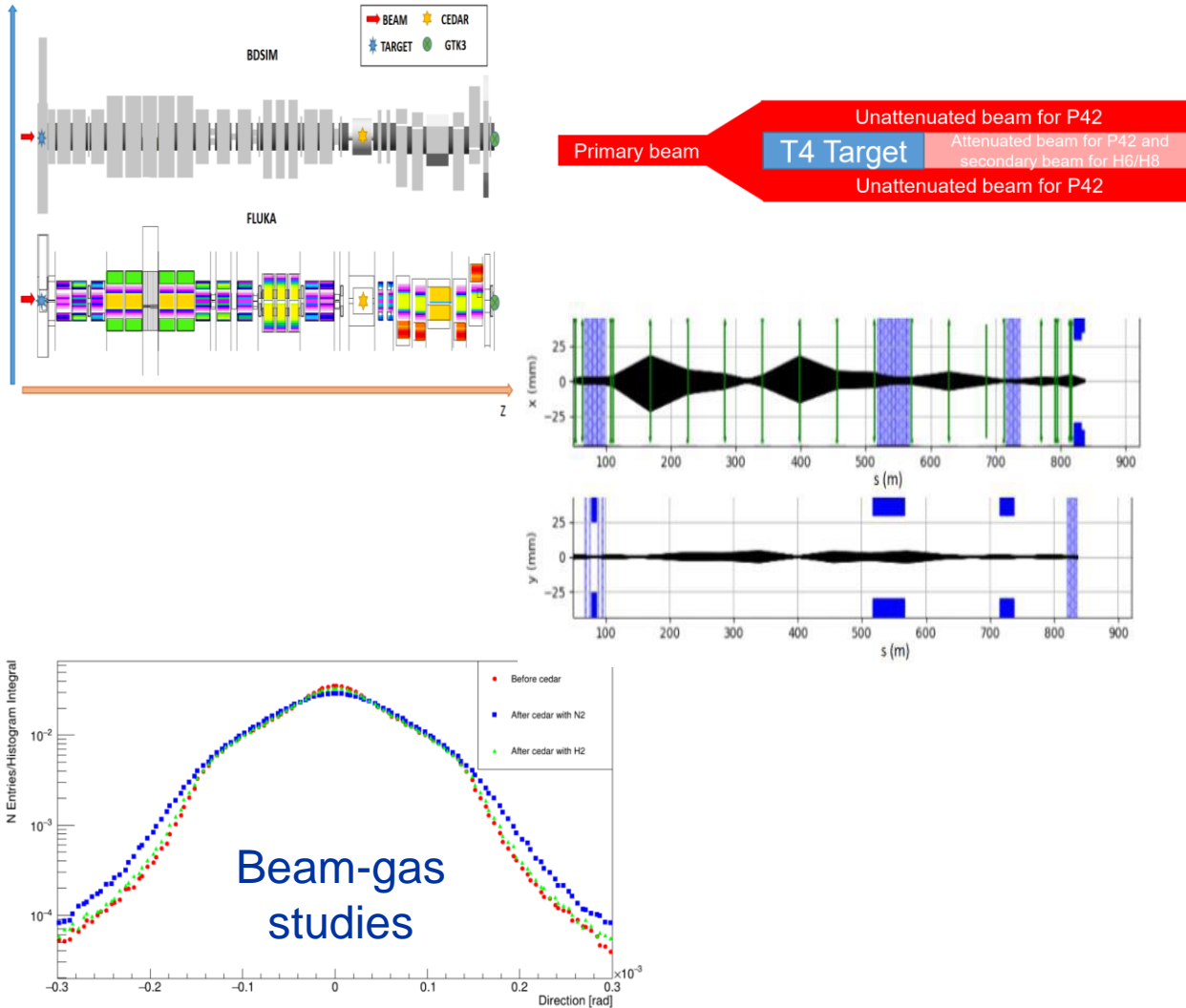


Required concrete around target station: ~ 7.5 m Required soil around beam transfer tunnel : up to 10 m



NA62 High Intensity and K_LEVER

G.L. D'Alessandro
 J. Bernhard
 L. Gagnon
 A. Gerbershagen
 M. van Dijk
 F.M. Velotti



K12 BDSIM model has been improved to a very high level of detail and was benchmarked against NA62 data from 2018.

- Also adapted for KLEVER
- Beam-Gas studies performed

CEDAR-H design completed, construction approved and preparation for validation well under way

- Goal: To reduce multiple scattering and thus beam-induced background due to interacting beam tails → Next year in H6

The P42 beam has been calculated to the T4 bypass beam option

→ Experimental validation pending

PhD of GL D' Alessandro to be submitted in RHUL

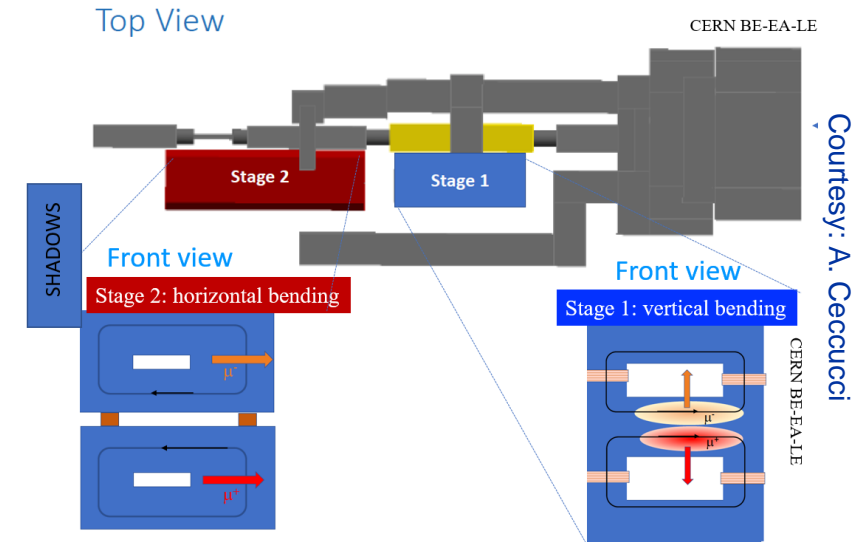
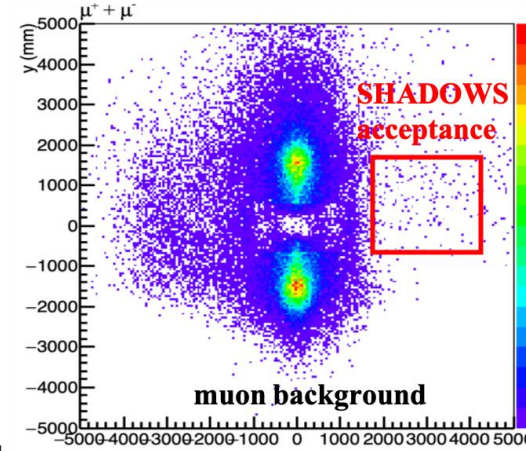


SHADOWS

F. Stummer
G.L. D'Alessandro
J. Bernhard
L. Gatignon
A. Gerbershagen



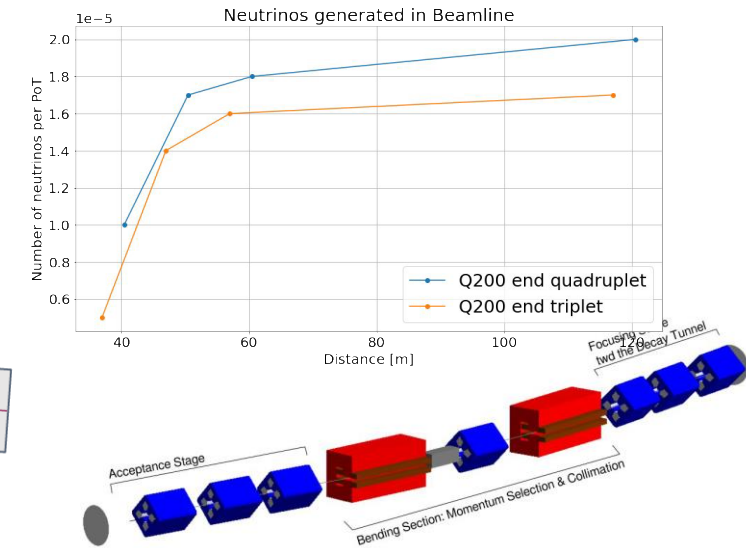
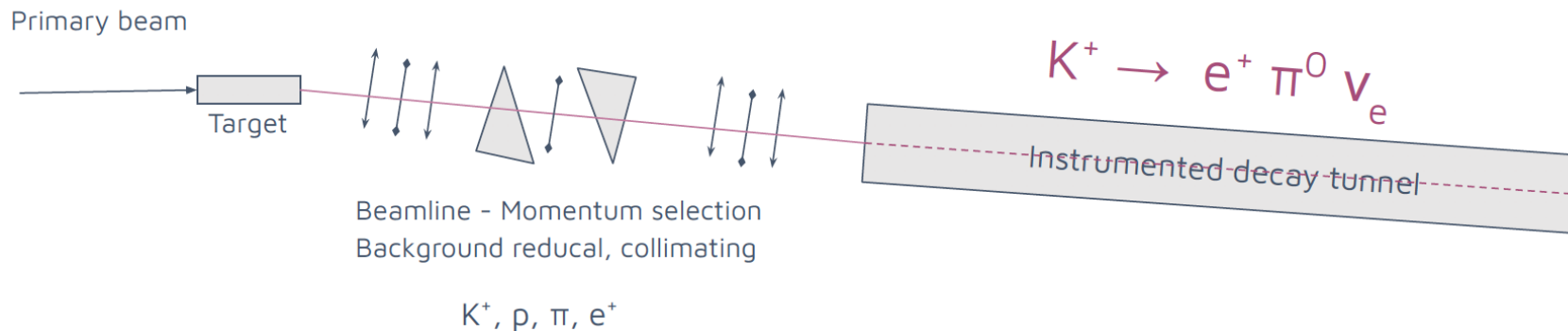
- A new idea for using the dumped proton beam on the K12 XTAX as a potential source of feebly interacting particles.
- The main background for the experiment would be muons, created either in between the T10 target and the XTAX or from further upstream.
 - A dedicated muon sweeping system will have to be designed taking into account also the NA62 and/or KLEVER installation downstream.
- Very first muon sweeping studies have started → Optimisation still pending.
- More studies to follow in 2022
 - Muon background studies
 - Impact on NA62 and NA62-BD mode



CBWG-NB

Convener: Nikolaos Charitonidis

- Study of the Ke3 decay and reduce the uncertainties in the neutrino cross-sections
- Secondary beam line (baseline version + multi-momentum version) well advanced and acknowledged by the SPSC
- Studies on Horn option also advanced and still considered as viable
- Starting now with FLUKA studies (radiation + collimation) and continuing with the understading of the neutrino spectrum at a far detector.
- Dedicated studies for the target will be launched by ENUBET collaboration this year

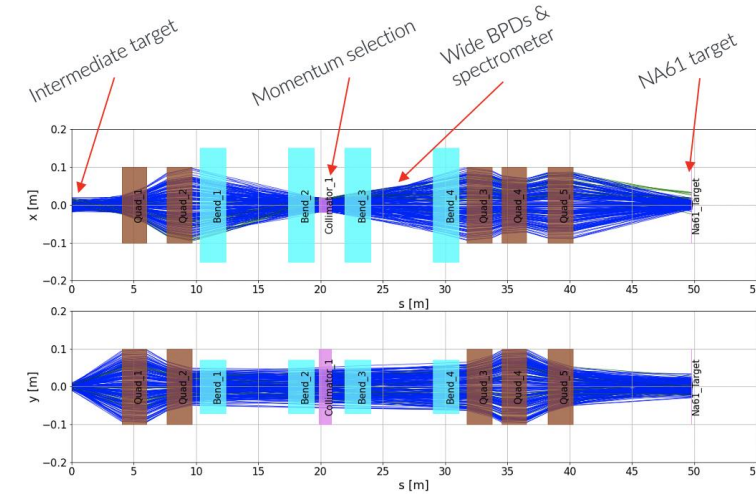


NA61-LE

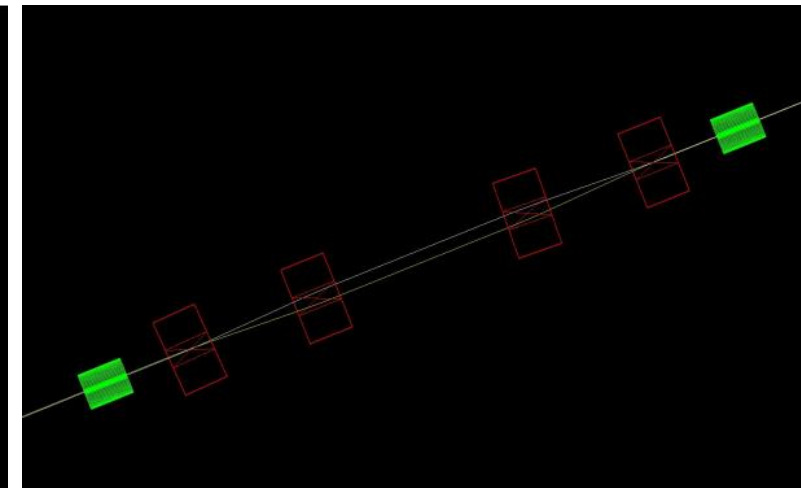
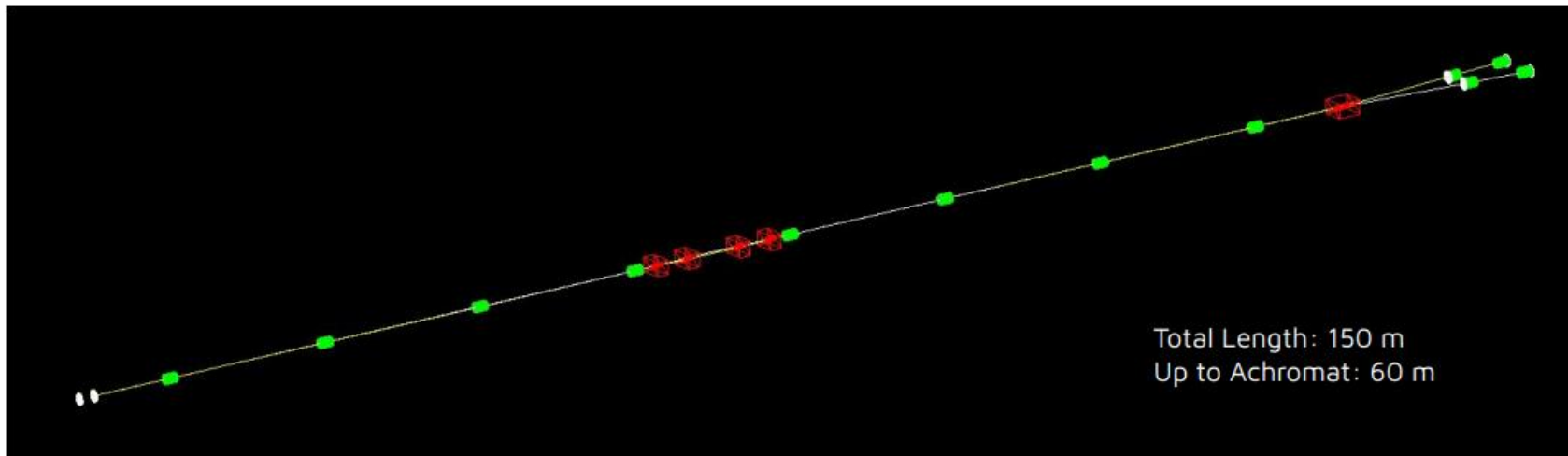
C. Mussolini
N. Charitonidis



- **Strong interest by many neutrino communities for measuring low-energy cross-sections in the range of 1-13 GeV/c**
- **Solution: A Low Energy branch to be constructed in front of NA61 TPC**
- **Pre-studies have now well advanced to a full conceptual design that will soon evolve to a technical feasibility study (power supplies, magnets...)**
- **The simulated performance of the line looks satisfactory in first order.**
 - Next step: An endorsement by the SPSC, in order to proceed with an engineering and layout study aiming for a tentative construction in 2023-24.
- **A benchmark study is in preparation for silicon-based instrumentation**
 - Dedicated test beam time is being planned in Japan for early '22.
 - Aerogel Cherenkovs as well as the NA62-GTK are being considered
 - Possible instrumentation tests are being discussed for the East Area.
 - Also Gabor Lenses as extra elements in order to maximize the line performance.



- Discussions only starting, new project focused on reducing the CP violating phase (δ_{cp})
- Challenging design of the beam line simultaneously focusing π^+ & π^-
- Both a short and a long baseline are being considered
- A dedicated engineering study has been already launched by the proponents and a collaboration between their engineer and the CERN-CB team is currently being initiated.



Summary



- **The CBWG mandate has been renewed and the working group has already well grown into the new substructure, including the new neutrino beam studies as well as several new ideas.**
- **Regular general meetings are now synchronised with the SPSC and technical meetings are held for specific issues and questions.**
- **There has been a good progress on all activities despite the extensive operation and commissioning after LS2.**
- **A new fellow has started that will spend half of her time with CBWG studies.**
- **We are even more happy that now already the very first ideas in the framework of CBWG made it through the SPSC and RB and have seen their first beam this year – throughout EHN1, EHN2 and ECN3.**

PBC-CBWG Team

Support for studies in context of PBC CB

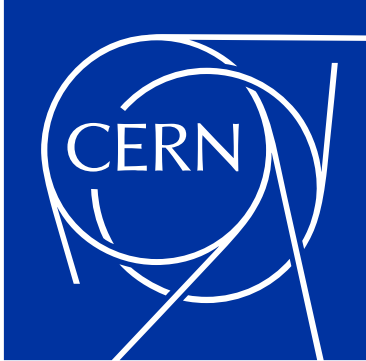
EHN1
NA60+
NA61
NA64 e/h

EHN2
AMBER
RF-separated beams
NA64 μ
MUonE

Neutrino beams
ENUBET
NUTAG

ECN3
KLEVER
NA62 high intensity
NA62 beam dump
SHADOWS

plus integration, engineering and design teams of BE-EA on demand



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