Joint ECFA-EPS Session, Ghent, July 13th 2019

Claude Vallée (CPPM Marseille)

PHYSICS BEYOND COLLIDERS

Excerpt from the 2016 PBC mandate by CERN Management:

"Explore the opportunities offered by the CERN accelerator complex and infrastructure to address some of today's outstanding questions in particle physics through experiments complementary to high-energy colliders and other initiatives in the world."

Time scale: next 2 decades

pbc.web.cern.ch

PBC Summary Report: arXiv:1902.00260

PBC BSM Report: arXiv:1901.09966

PBC QCD Report: arXiv:1901.04482

PBC Accelerator Reports:

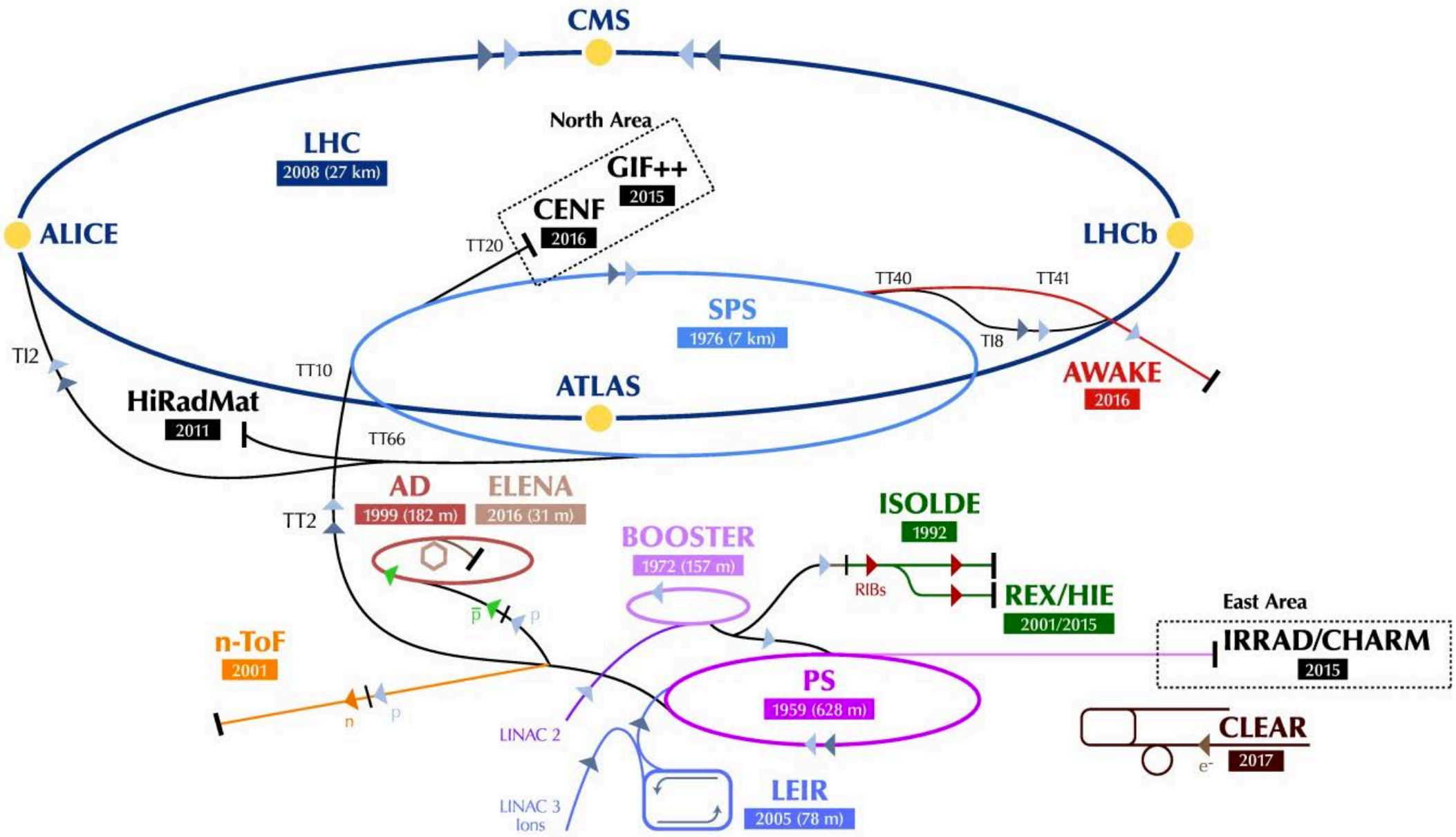
http://cds.cern.ch/collection/PBC%20Reports?ln=en

Latest status to be documented at the next PBC WG meeting

5-6 November: https://indico.cern.ch/event/827066/

THE CERN LHC INJECTOR COMPLEX

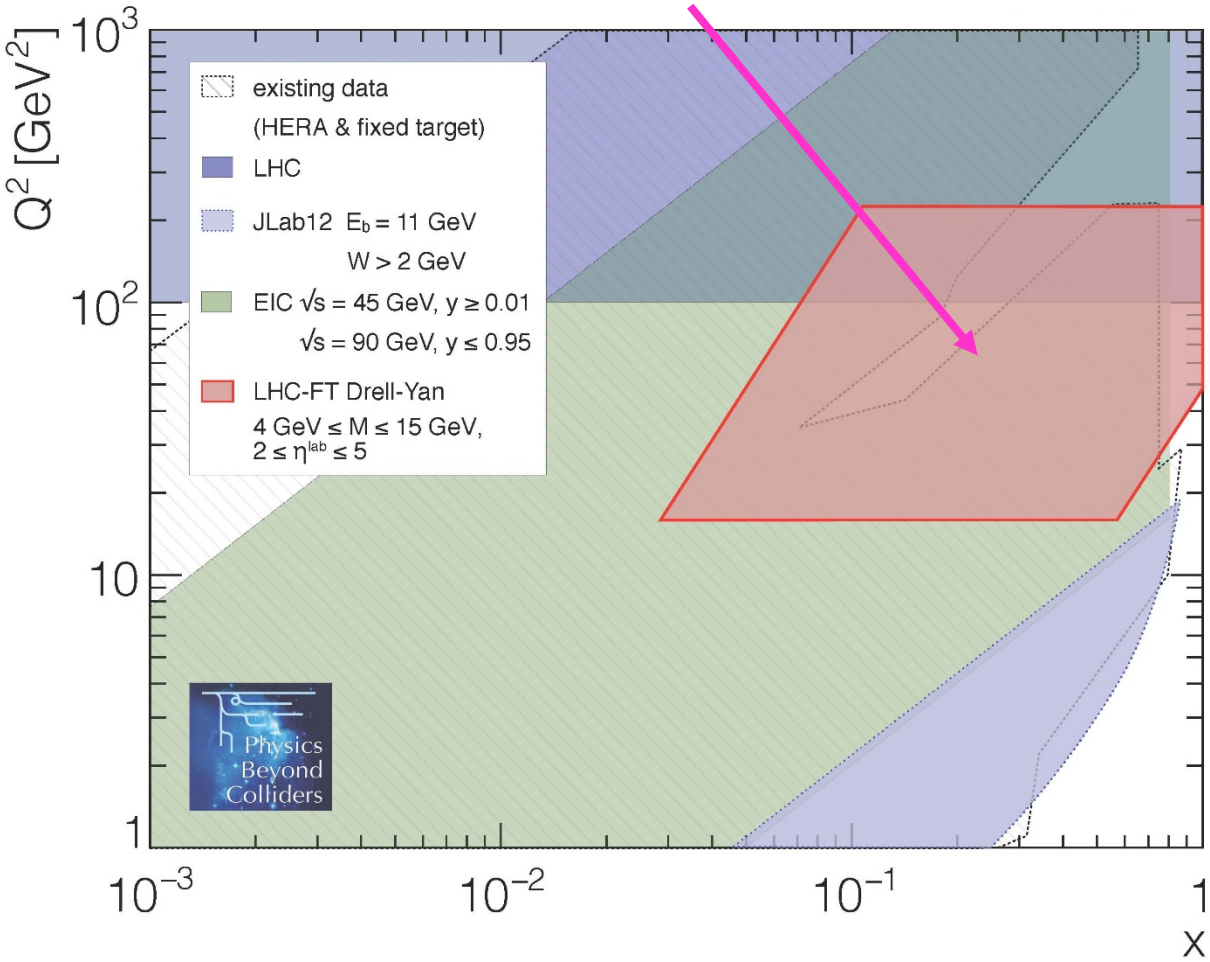
> 1000 physicists
> 20 projects



QCD PROJECTS IN WORLDWIDE LANDSCAPE

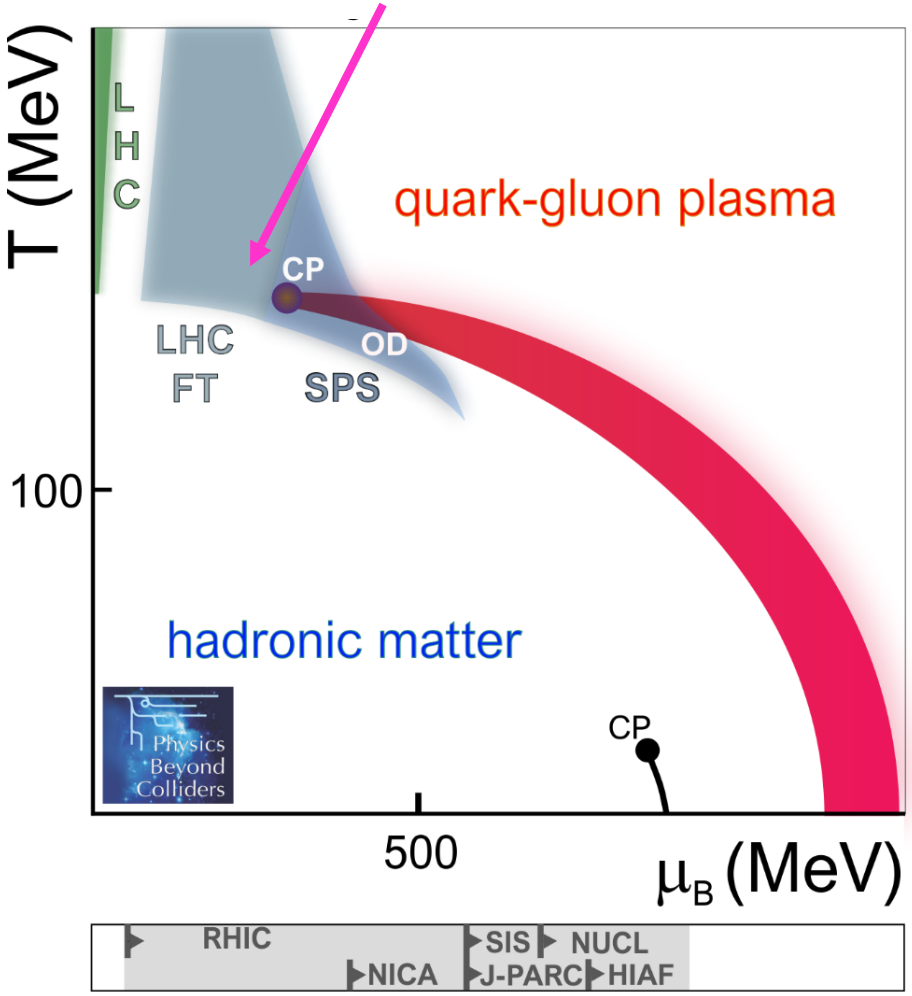
Structure Functions

Unique reach of LHC-FT with high statistics at high-x / high Q^2



QCD Phase Transition

Unique reach of LHC-FT & SPS in transition region to high-μ_B

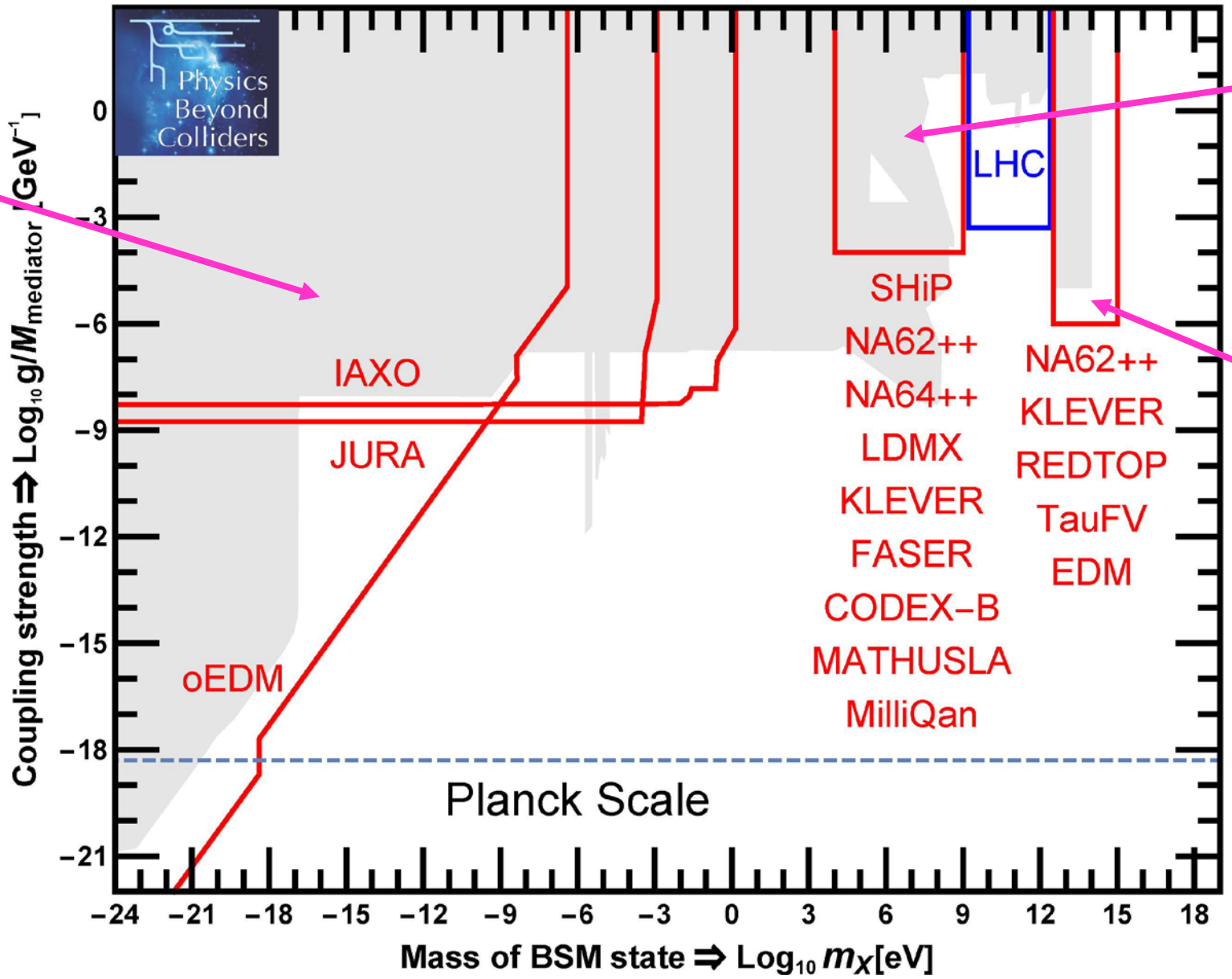


BSM PROJECTS IN WORLDWIDE LANDSCAPE

EDM & non-accelerator projects cover the very low-mass domain

SPS beam dumps probe a specific MeV-GeV domain

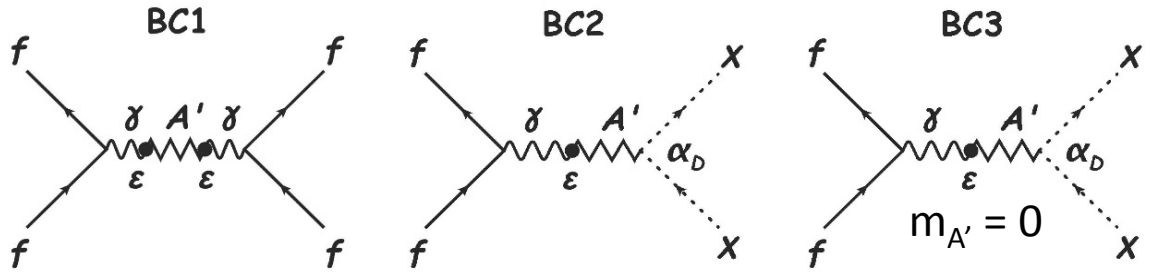
Precision experiments extend reach of high-E colliders



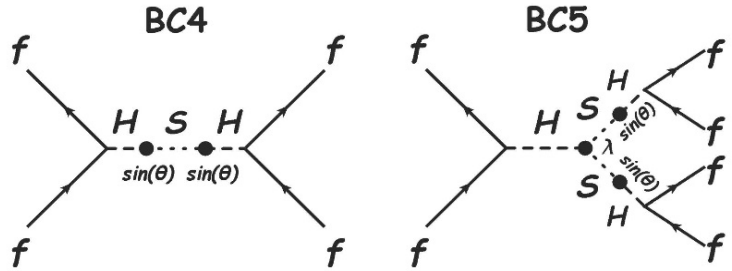
PBC BENCHMARK MODELS FOR HIDDEN SECTOR

defined to cover most signatures and compare reach of projects under same assumptions

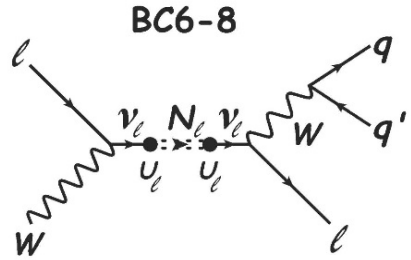
Dark Photons, Dark Matter & millicharged particles



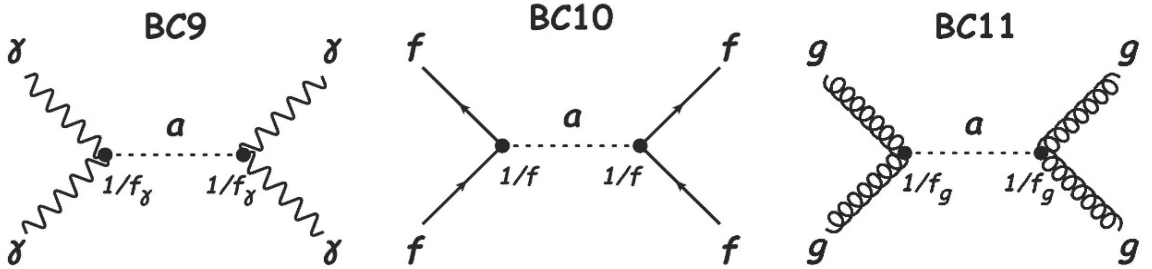
Dark Scalars



Heavy Neutral Leptons



Axion-Like Particles



EXPERIMENTS READINESS

Summarized in a semi-quantitative table

Quote:	A	ready	ready	adequate	< 10 M€	Run 3
	B	need upgrade	under design	to strengthen	10-50 M€	Run 4
	C	to be built	need R&D	to be built	> 50 M€	Run 5

Project	**Physics highlight**	**Beam requirement**	**Detector maturity**	**Collaboration**	**Cost beam+det**	**Earliest operation**
NA61++	QGP Charm	B	B	A	A	A
COMPASS+	R_p & QCD	A	B	A	A	A
COMPASS++	QCD	B	B	B	B	B
MUonE	HVP(g-2)$_\mu$	A	B	B	A	A
LHC-FT	QCD	A	B	B	A	A
LHC-FT++	spin/MM/EDM	A	C	B	A	B
NA60++	QGP phase	C	B	C	B	B
DIRAC++	chiral QCD	C	B	C	B	B
NA62++	dark sector	B	A	A	A	A
KLEVER	$K^0 \to \pi^0 \nu\bar{\nu}$	B	C	B	B	B
NA64++	dark photon	A	B	A	A	A
SHiP	dark sector & ν_τ	C	B	A	C	B
TauFV	$\tau \to 3\mu$	C	C	B	C	C
REDTOP	η decays	B	C	B	B	B
EDM ring	p EDM	C	C	B	C	C
eSPS	dark photon	C	B	B	C	B
AWAKE++	dark photon	C	B	A	B	B
nuSTORM	$\sigma(\nu)$	C	C	B	C	B
γ-Factory	high rate γ	C	C	C	-	C

New projects also constrained by existing beamlines/halls/experiments

SHORT-TERM PROJECTS (RUN 3)

No strategic issue → now under review by SPSC & LHCC

Quote:	A B C	ready need upgrade to be built	ready under design need R&D	adequate to strengthen to be built	< 10 M€ 10-50 M€ > 50 M€	Run 3 Run 4 Run 5
Project	**Physics highlight**	**Beam requirement**	**Detector maturity**	**Collaboration**	**Cost beam+det**	**Earliest operation**
NA61++	QGP Charm	B	B	A	A	A
COMPASS+	R_p & QCD	A	B	A	A	A
COMPASS++	QCD	B	B	B	B	B
MUonE	HVP(g-2)$_\mu$	A	B	B	A	A
LHC-FT	QCD	A	B	B	A	A
LHC-FT++	spin/MM/EDM	A	C	B	A	B
NA60++	QGP phase	C	B	C	B	B
DIRAC++	chiral QCD	C	B	C	B	B
NA62++	dark sector	B	A	A	A	A
KLEVER	$K^0 \to \pi^0 \nu\bar{\nu}$	B	C	B	B	B
NA64++	dark photon	A	B	A	A	A

Among potential highlights:

Improved (g-2)$_\mu$ prediction by MUonE and contribution to R$_p$ puzzle by COMPASS

Extension of LHCb Fixed Target capabilities

Exploration of new dark sector domains by NA64++ and NA62 Beam Dump

LONG TERM PROJECTS

Require EPPSU guidelines to proceed

Quote:	A	ready	ready	adequate	< 10 M€	Run 3
	B	need upgrade	under design	to strengthen	10-50 M€	Run 4
	C	to be built	need R&D	to be built	> 50 M€	Run 5

Project	**Physics highlight**	**Beam requirement**	**Detector maturity**	**Collaboration**	**Cost beam+det**	**Earliest operation**
NA61++	QGP Charm	B	B	A	A	A
COMPASS+	R_p & QCD	A	B	A	A	A
COMPASS++	QCD	B	B	B	B	B
MUonE	HVP(g-2)$_\mu$	A	B	B	A	A
LHC-FT	QCD	A	B	B	A	A
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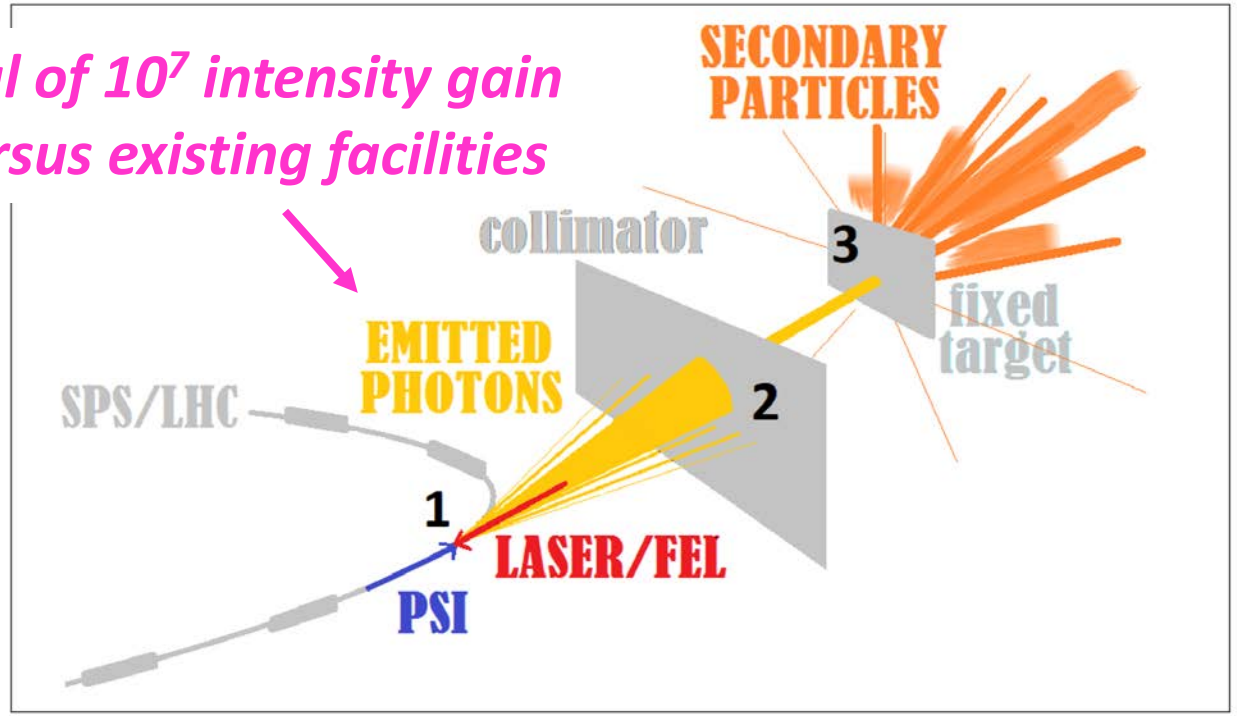
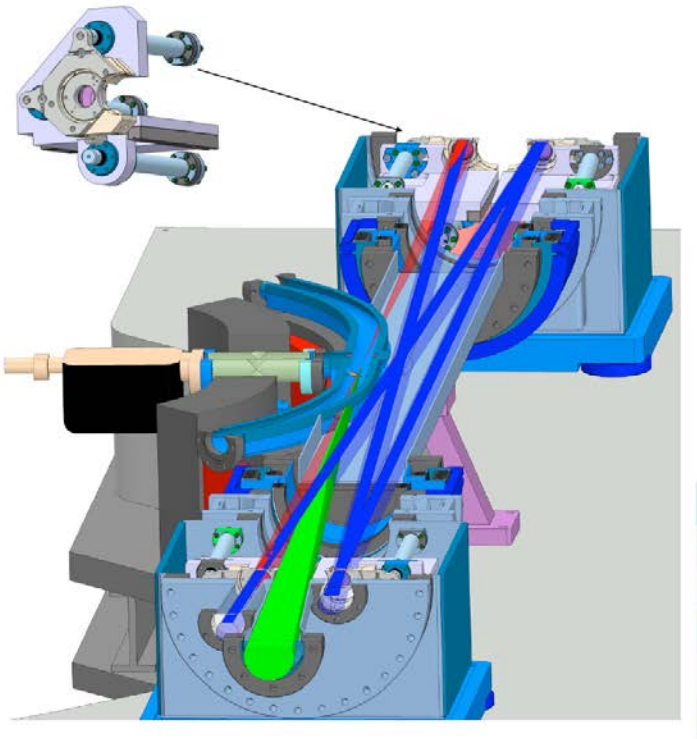
eSPS	dark photon	C	B	B	C	B
AWAKE++	dark photon	C	B	A	B	B
nuSTORM	$\sigma(\nu)$	C	C	B	C	B
γ-Factory	high rate γ	C	C	C	-	C

LHC-HOSTED PROJECTS: GAMMA FACTORY

Goal of 10^7 intensity gain versus existing facilities



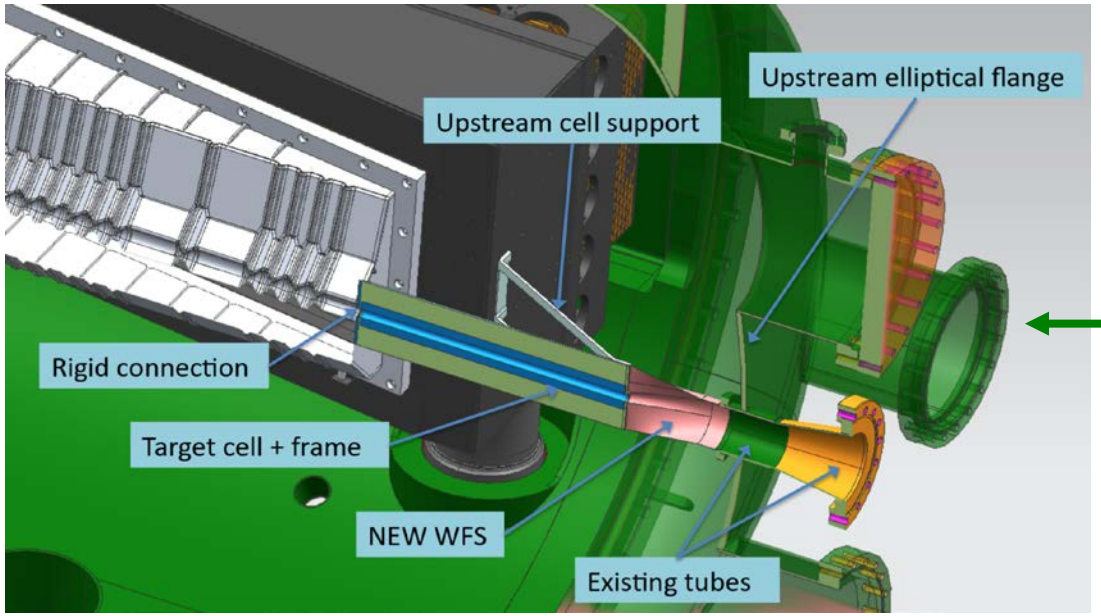


Important milestone reached within PBC with successful acceleration and storage of Partially Stripped Ions in LHC

Proof of Principle experiment with full configuration foreseen at SPS after LS2

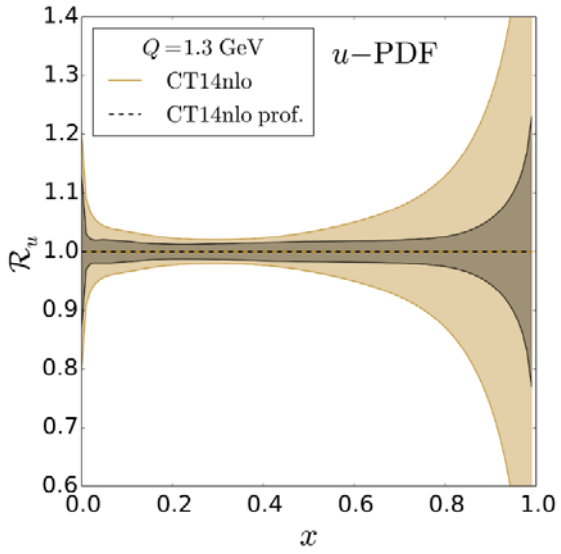
NB: physics reach to be quantified once all ingredients are better understood

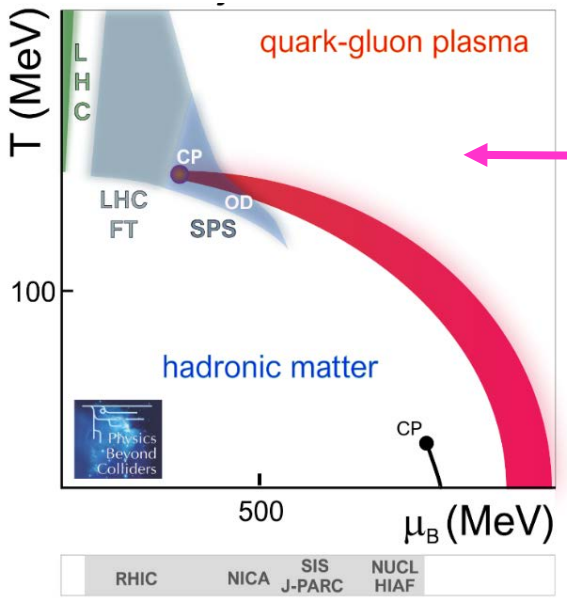
LHC-HOSTED PROJECTS cont'd: FIXED TARGET



Already started by LHCb in run 2 with SMOG.
Promising SMOG2 storage cell development:
FT lumi x ~100 in run 3

ALICE also interested
R&D ongoing on polarized gas targets and double-crystal set-ups





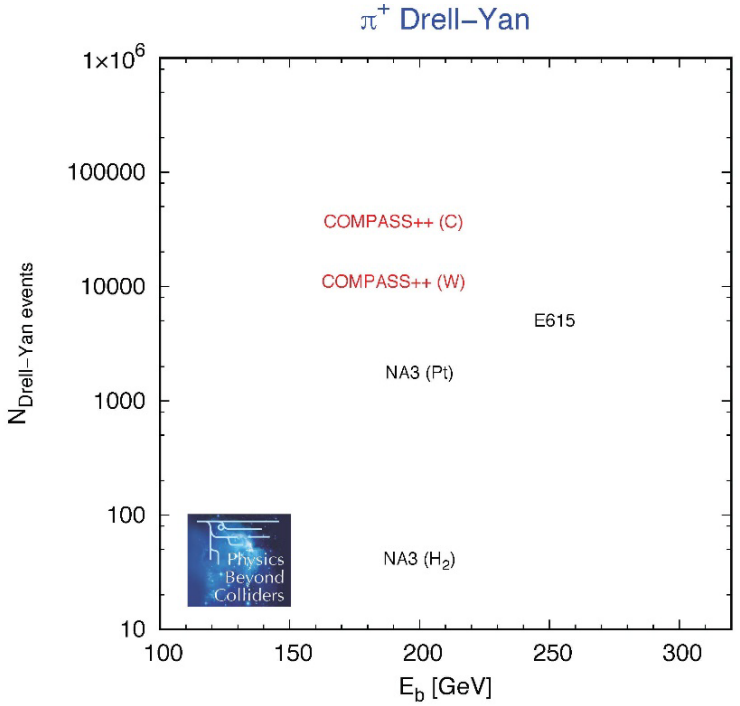
"Simple" storage cells already open unique opportunities in both hadron and QGP physics

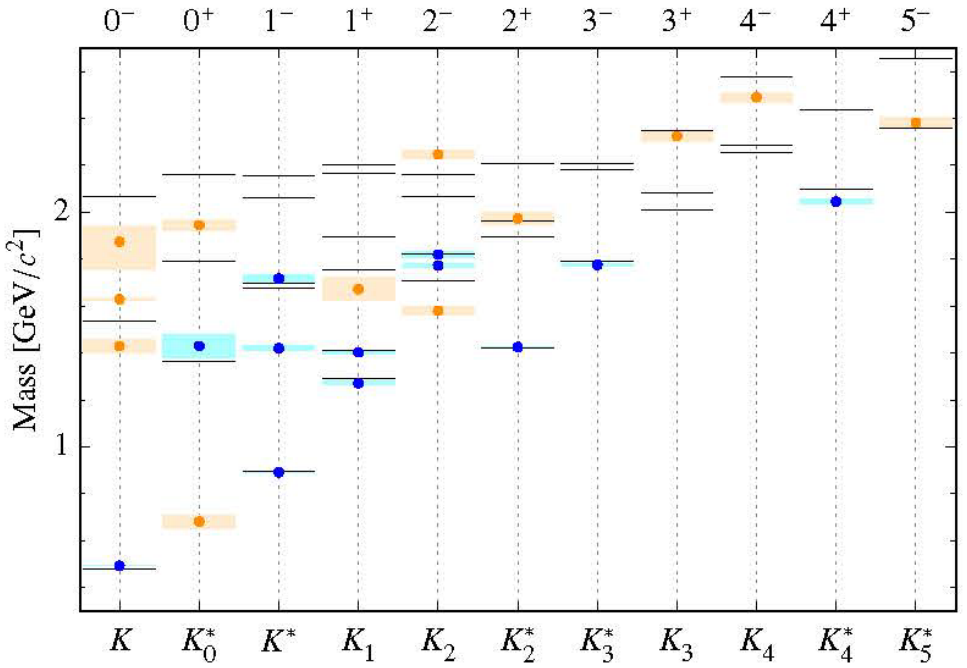
Optimization of FT- and collider-operation required to maximize LHC-FT physics reach

COMPASS++/AMBER "QCD FACILITY"

Competition from growing number of QCD facilities worldwide

Some highlights identified by PBC





With existing beams:

Unique opportunity for higher precision pion structure measurements

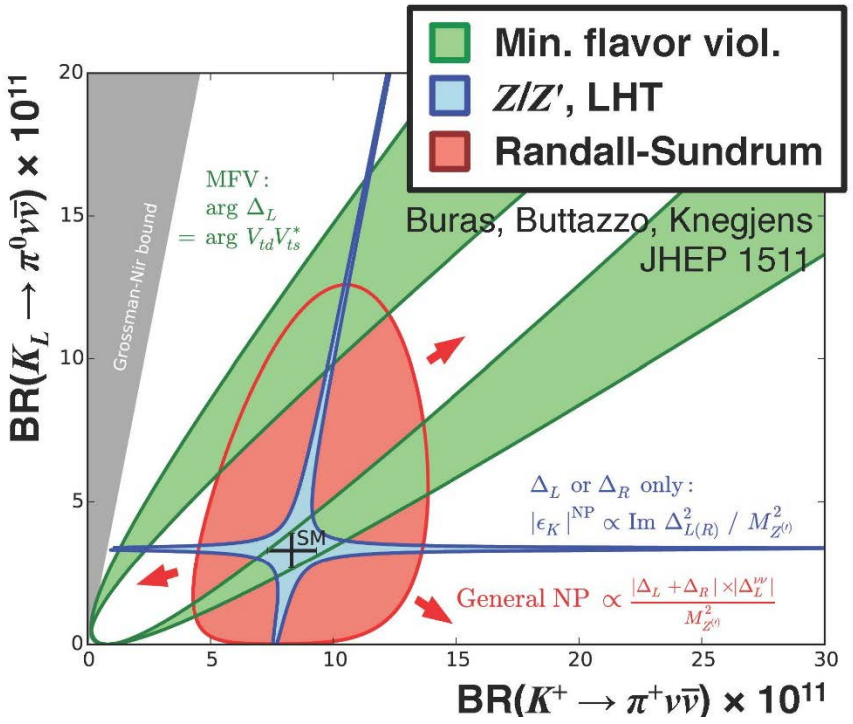
With new RF-separated K-beam:

(significant investment possible for post-LS3):

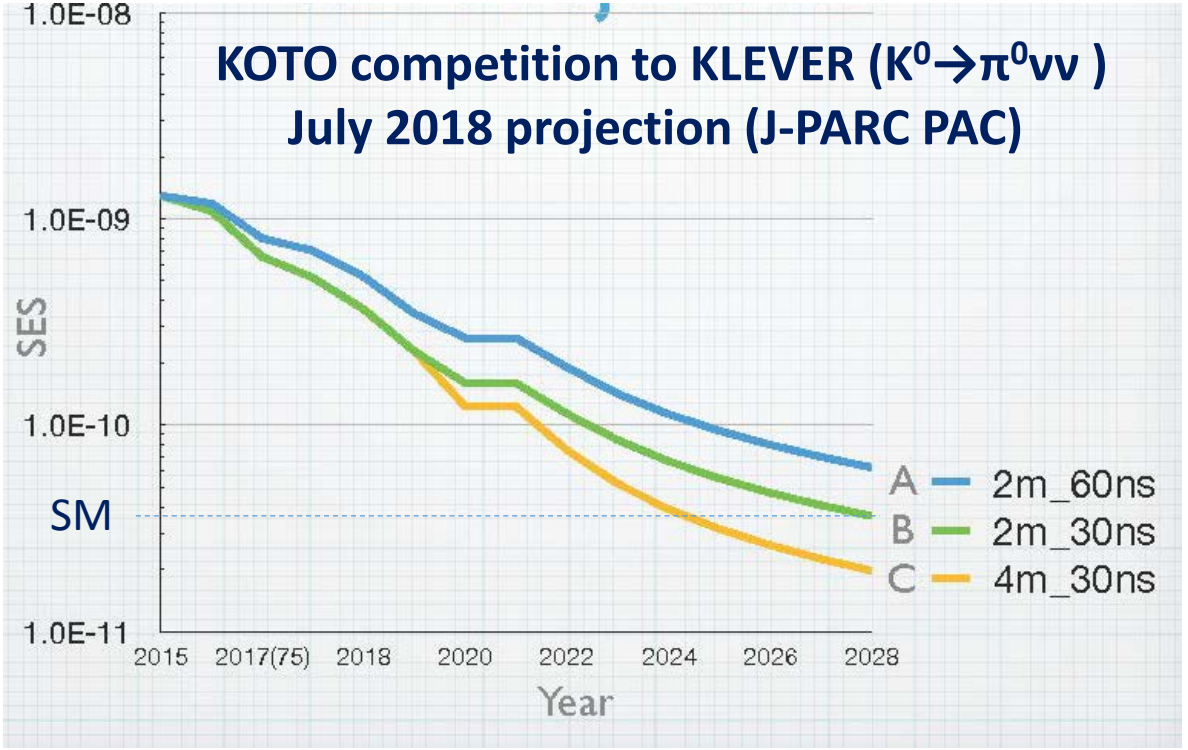
Comprehensive measurement of strange spectroscopy

Physics reach to be quantified as function of RF-separated beam performance

ULTRA-RARE KAON DECAYS: NA62 (K^+) ↔ KLEVER (K^0)



K^+ and K^0 have complementary sensitivity to BSM models



Strong improvement of KOTO performance expected in the coming decade… *and possibly later.*

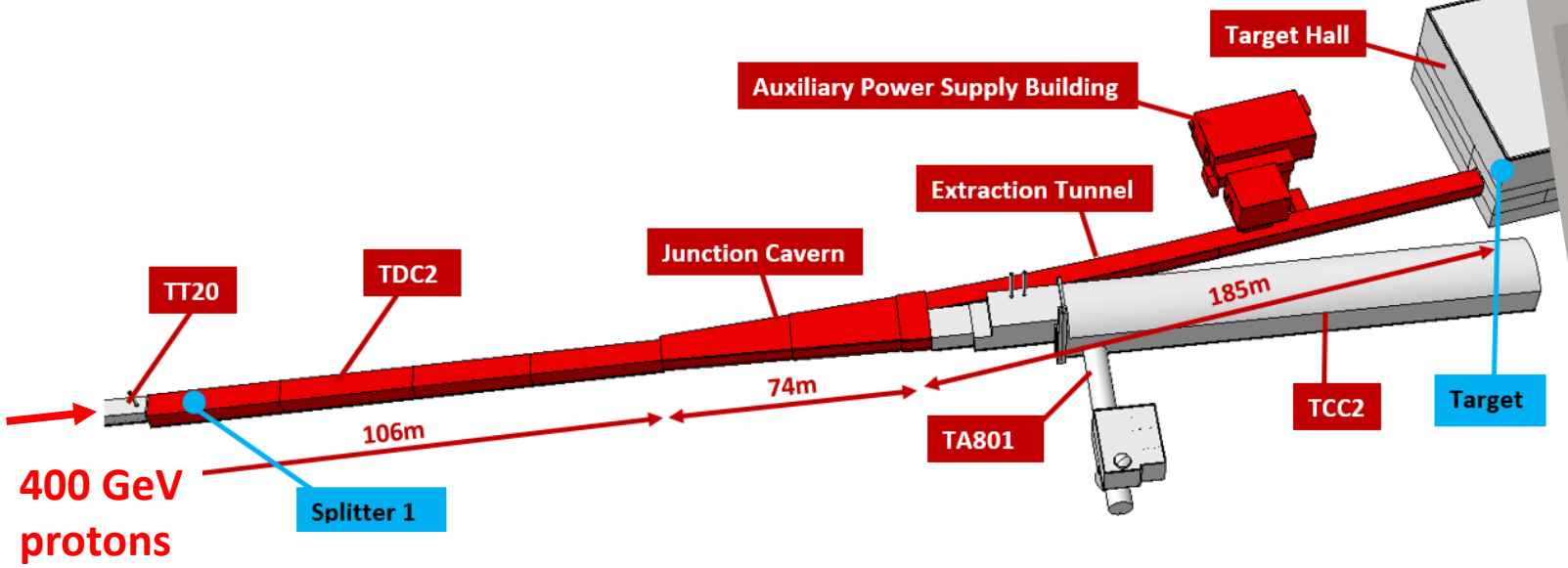
Phasing of KLEVER in NA62 hall is a multi-parameter issue:
K^+ results ↔ K^+/K^0 sensitivity ↔ B-anomalies ↔ KOTO

BDF/SHiP/TauFV

BEAM DUMP FACILITY:

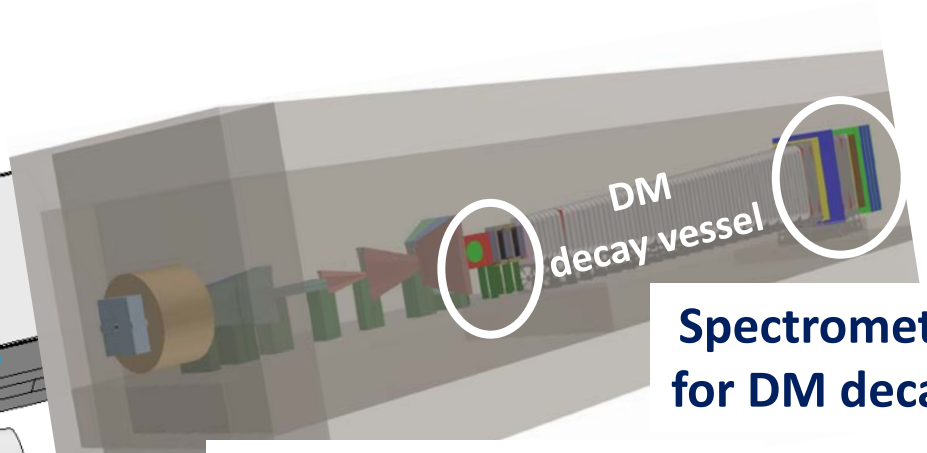
Comprehensive Design Study done

Conceptual Design Report foreseen for end of EPPSU



SHiP:

Dual spectrometer



Spectrometer for DM decays

Emulsion spectrometer for DM scattering + ν_τ physics

BDF/SHiP/TauFV

BEAM DUMP FACILITY:

Comprehensive Design Study done

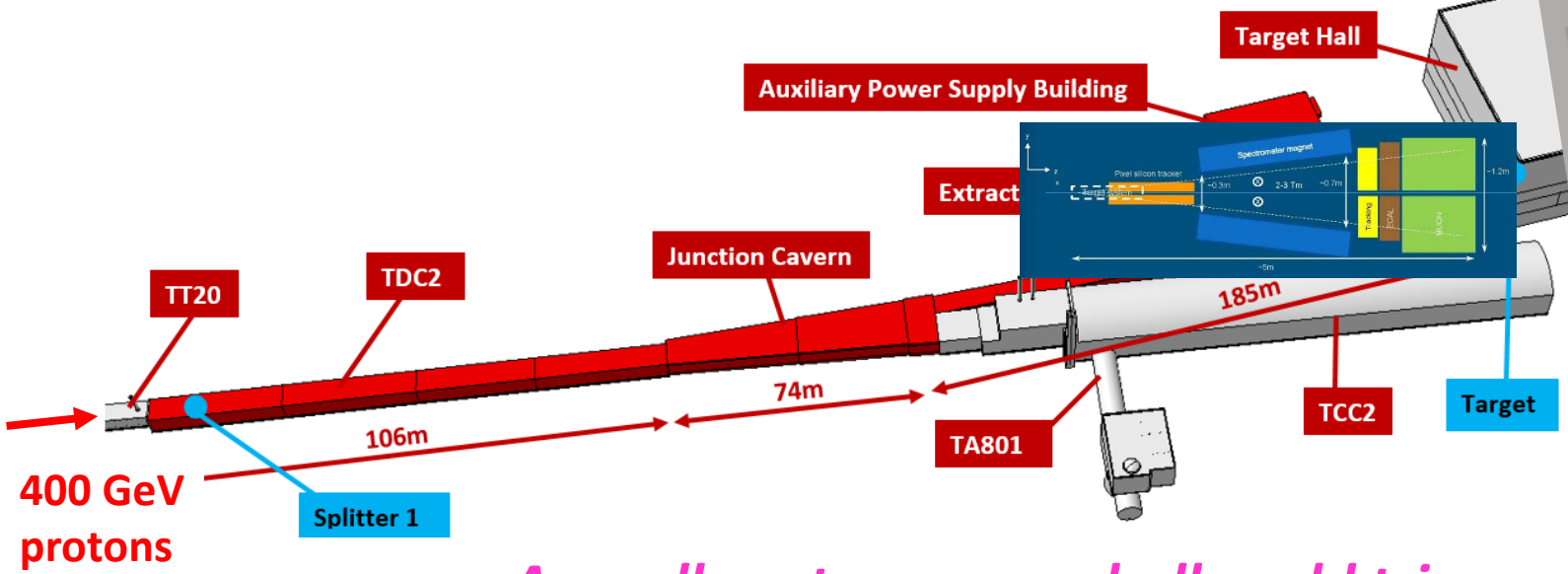
Conceptual Design Report foreseen for end of EPPSU

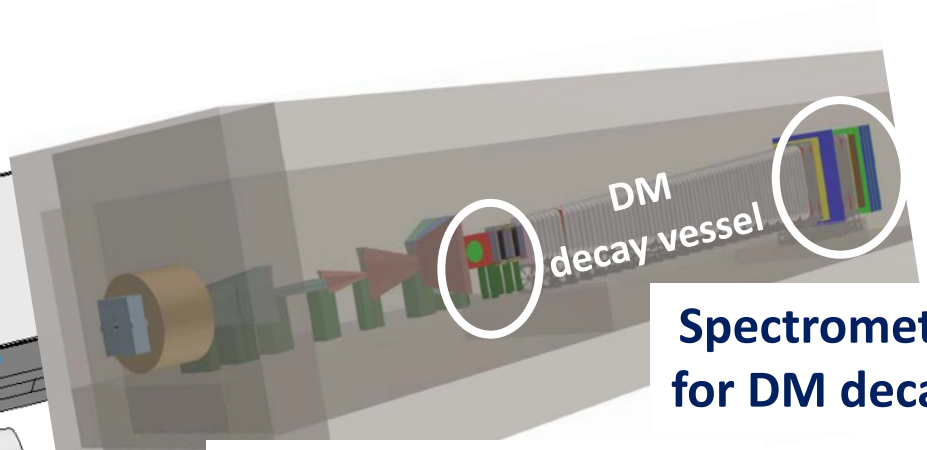
TauFV:

"LHCb-like" detector

SHiP:

Dual spectrometer





Spectrometer for DM decays

Emulsion spectrometer for DM scattering + ν_τ physics

A small upstream exp. hall could trigger a unique rare decay facility

BDF/SHiP/TauFV

BEAM DUMP FACILITY:

Comprehensive Design Study done

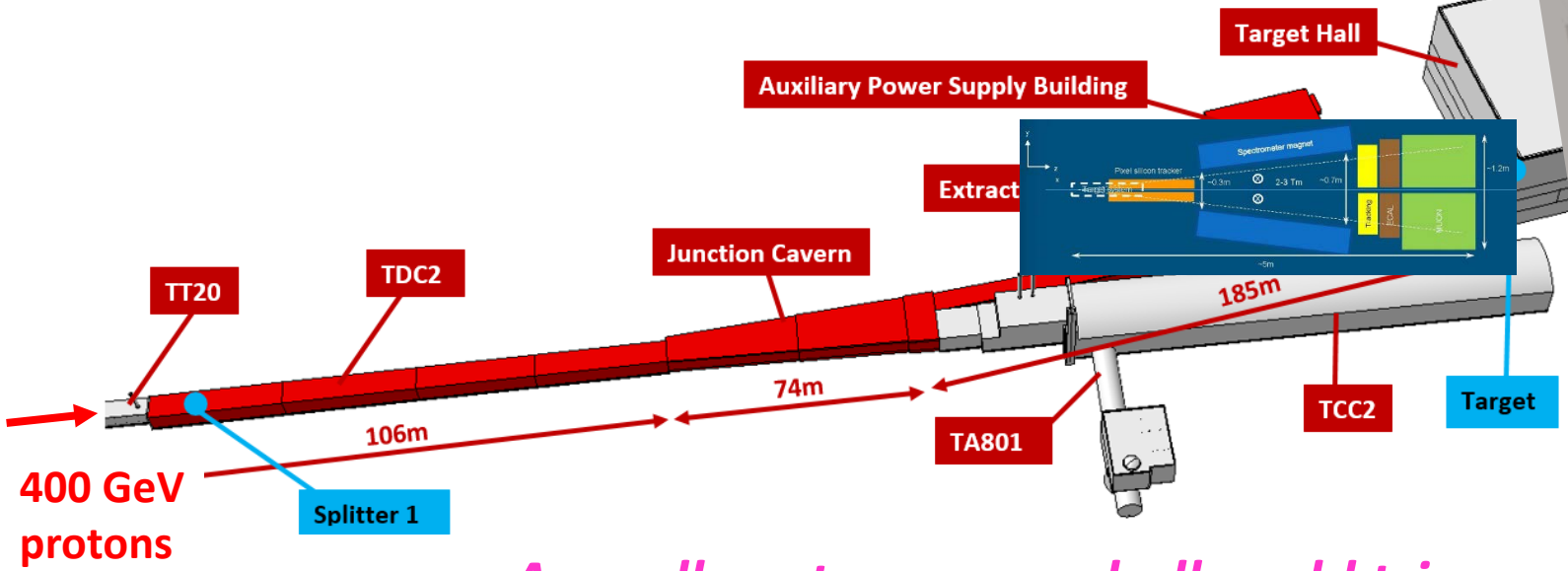
Conceptual Design Report foreseen for end of EPPSU

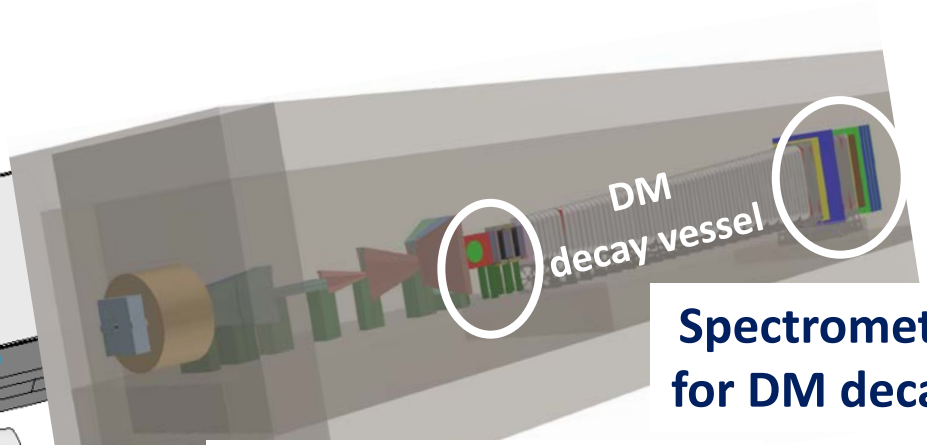
SHiP:

Dual spectrometer

TauFV:

"LHCb-like" detector





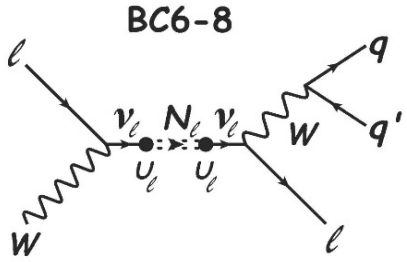
Spectrometer for DM decays

Emulsion spectrometer for DM scattering + ν_τ physics

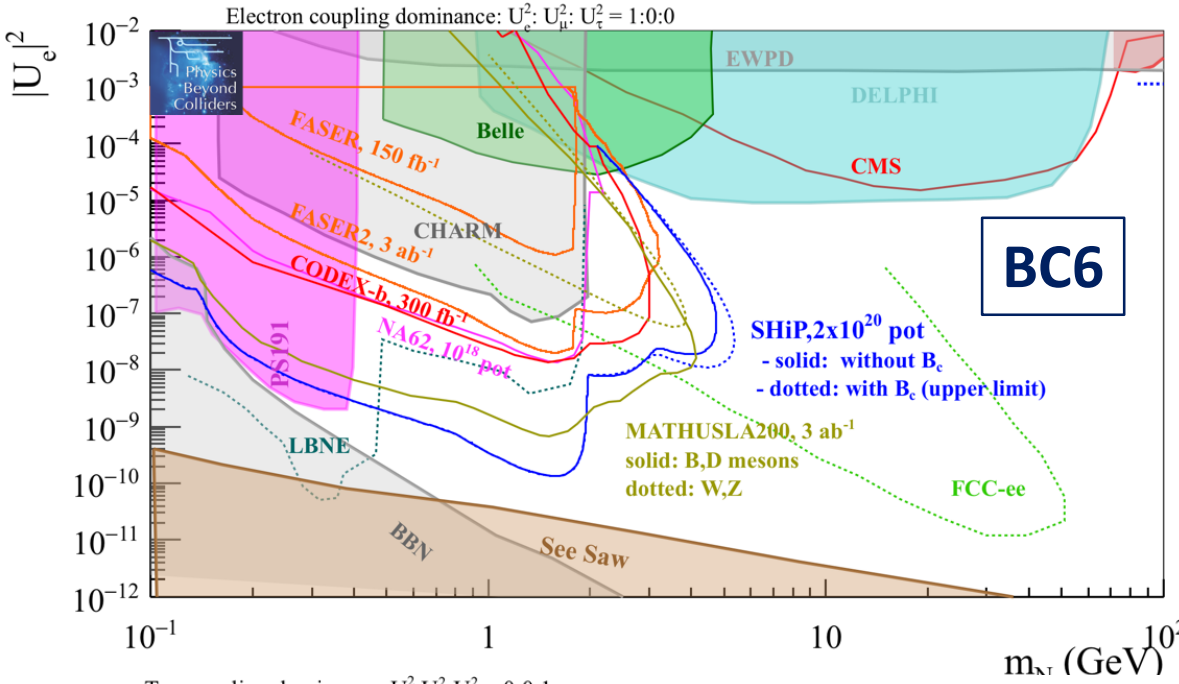
A small upstream exp. hall could trigger a unique rare decay facility

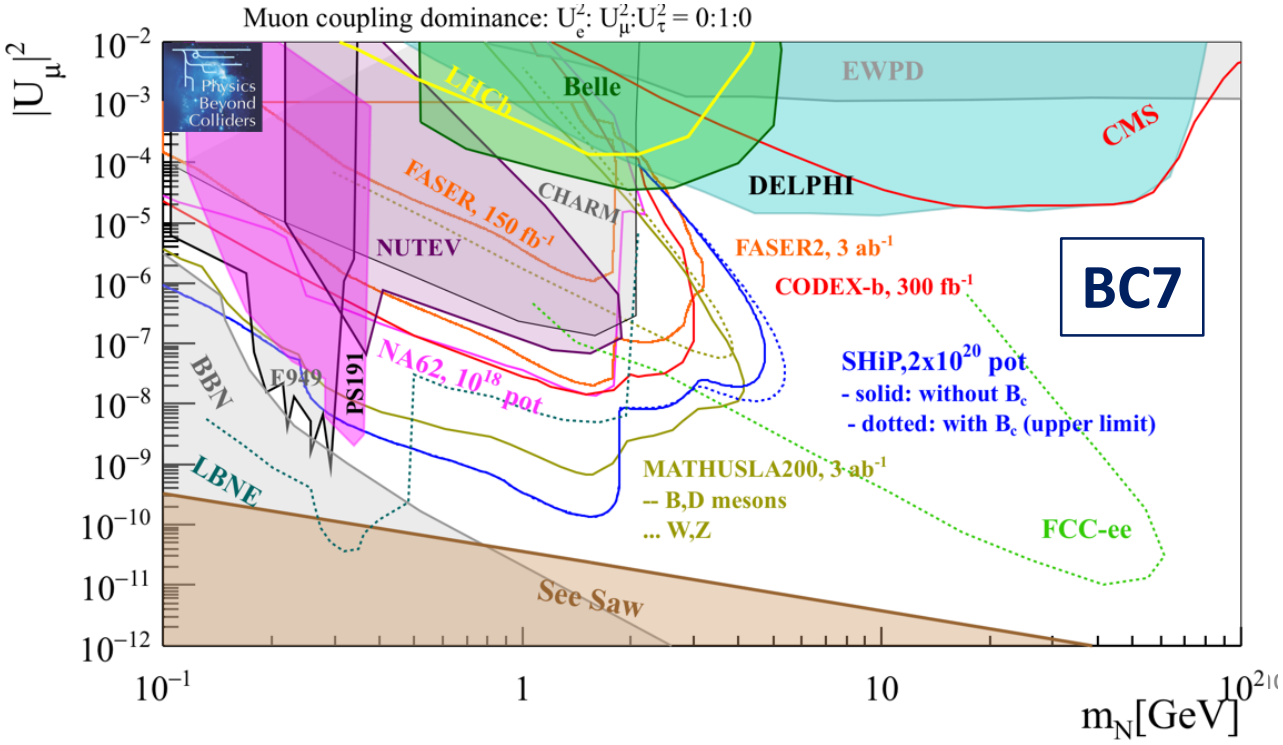
Project mature for an implementation decision pending EPPSU guidelines

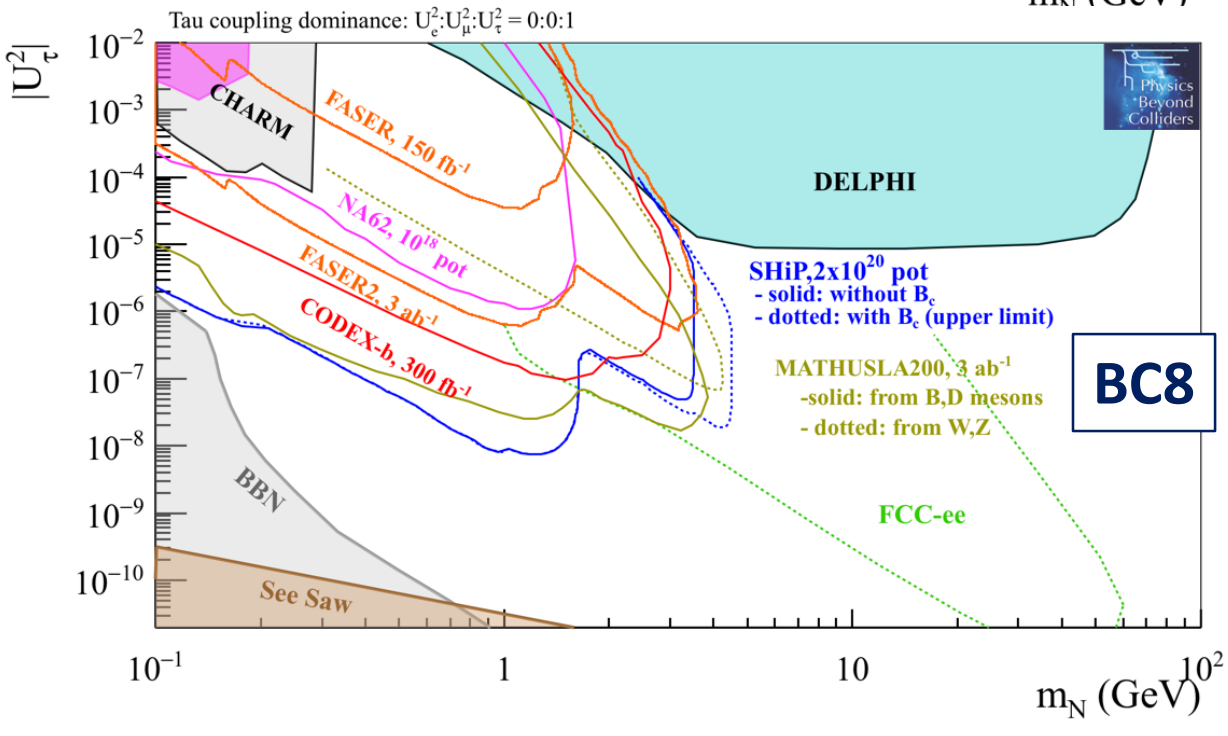
SENSITIVITIES TO DARK FERMIONS (HNL's)



- **Unique short term opportunities with NA62 Beam Dump and FASER**
- **SHiP has the highest reach on the long term**

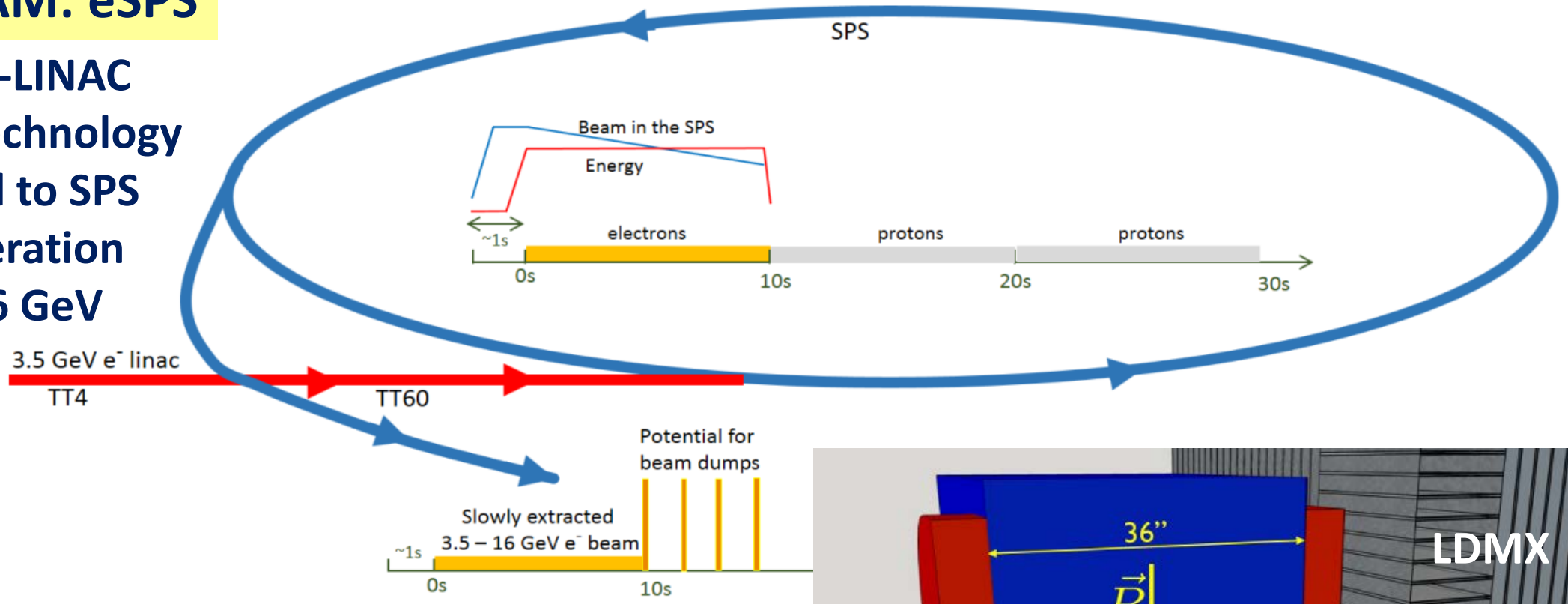


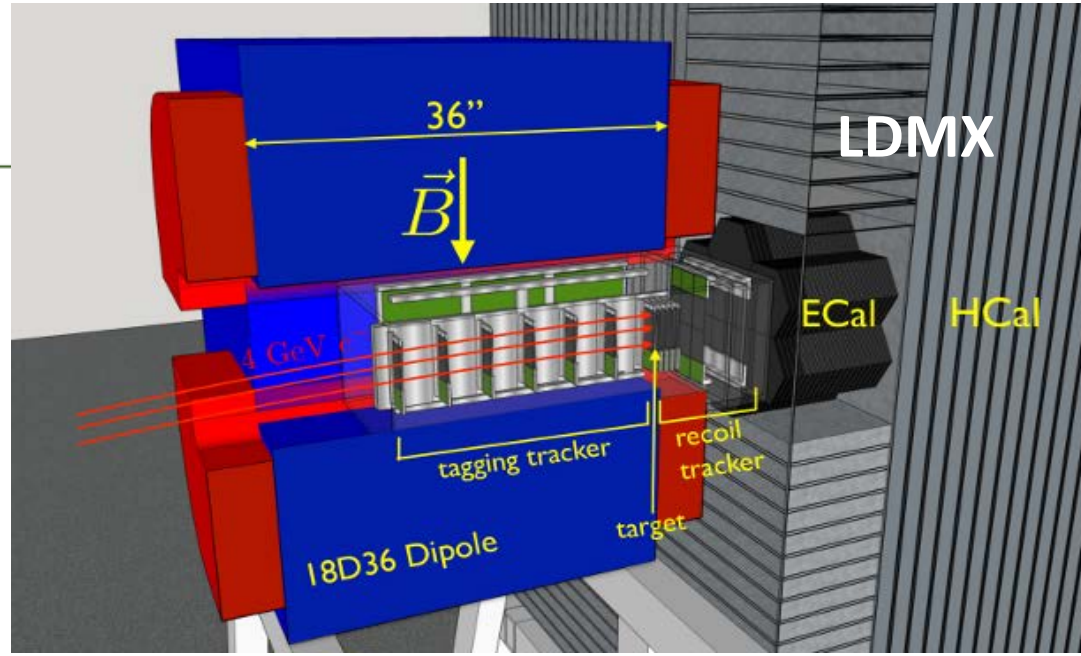




NEW e-BEAM: eSPS

3.5 GeV e-LINAC with CLIC technology connected to SPS for acceleration up to 16 GeV





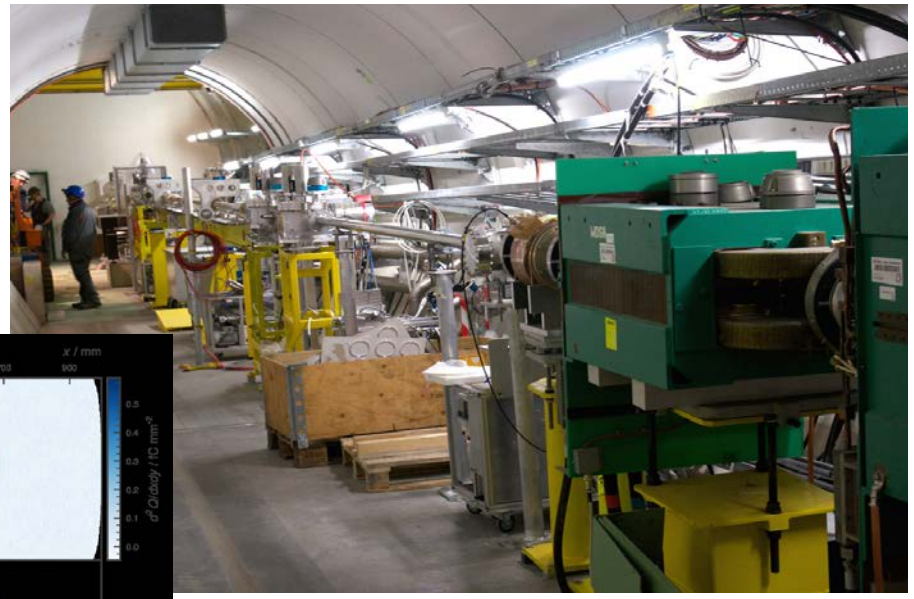
Slow extraction of up to ~10^{16} e/year

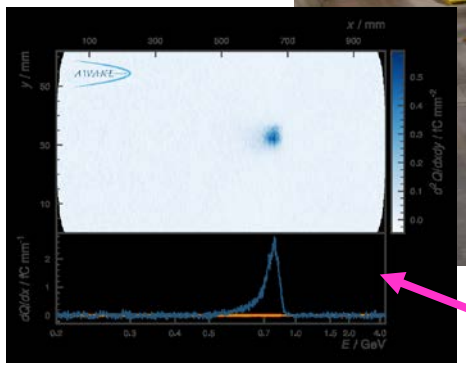
if 1/3 of SPS duty cycle reserved to project

Would allow hidden sector searches in the invisible mode with a LDMX-like detector

NEW e-BEAM: AWAKE++

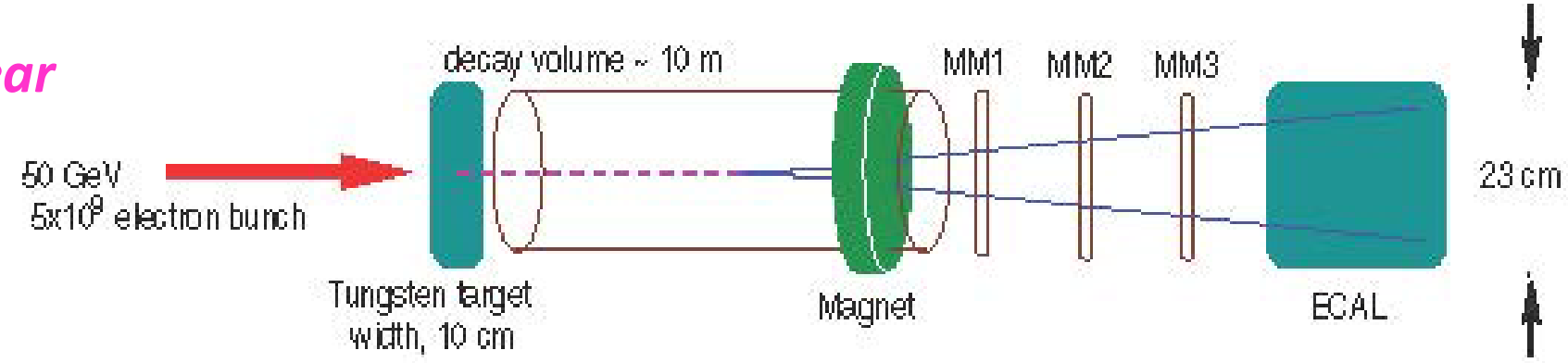
electron acceleration with a plasma cell excited by proton bunches





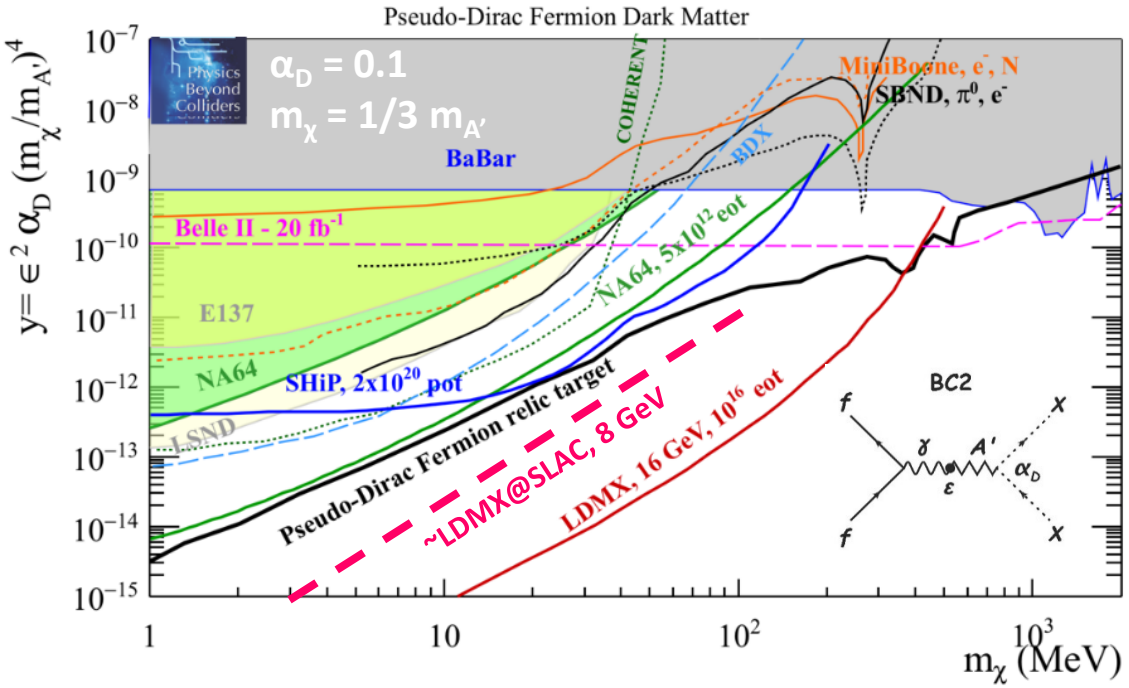
First accelerated e seen in 2018 (~2 GeV) - Phase 2 (~10 GeV) in preparation for run3

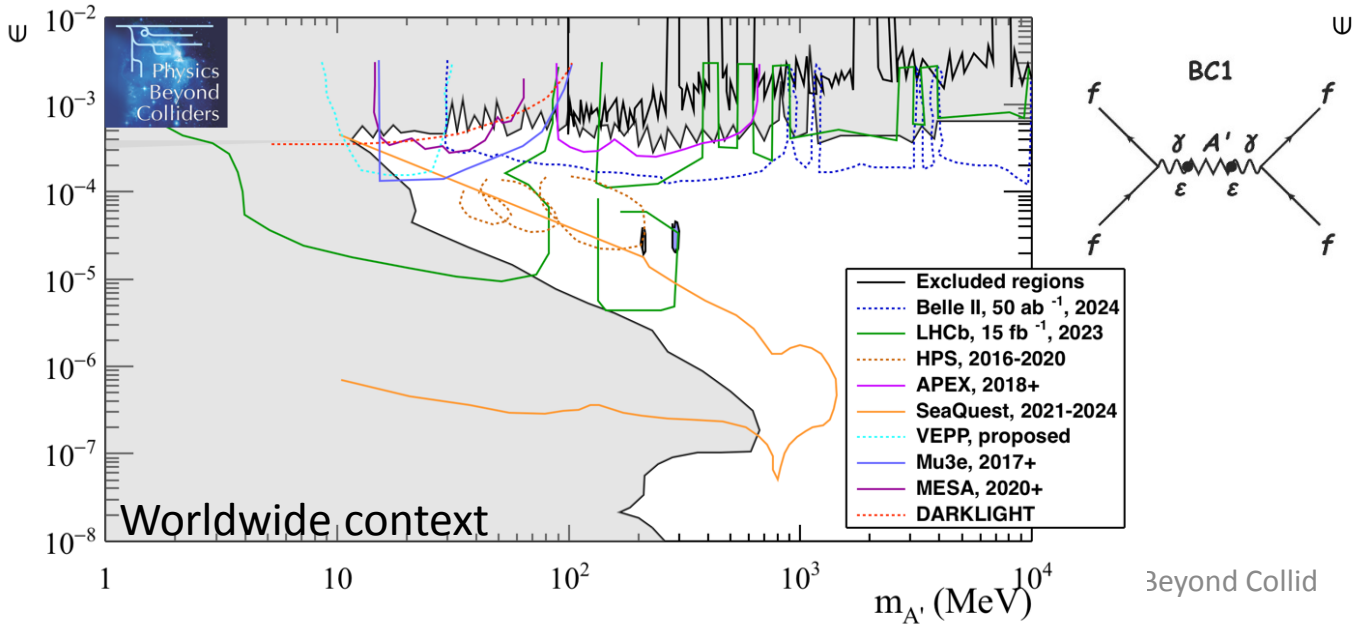
Could provide ~10^{15} ~50 GeV pulsed e's/year in the post-LS3 era for e^+e^- visible searches by an experiment located in the CNGS decay tunnel

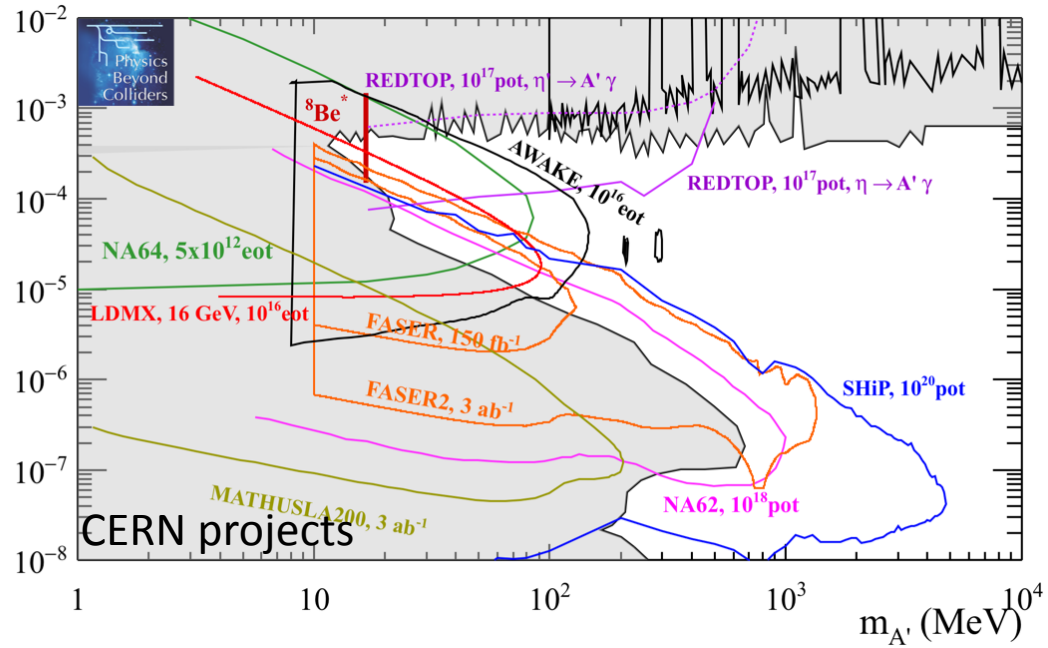


SENSITIVITIES TO DARK PHOTONS

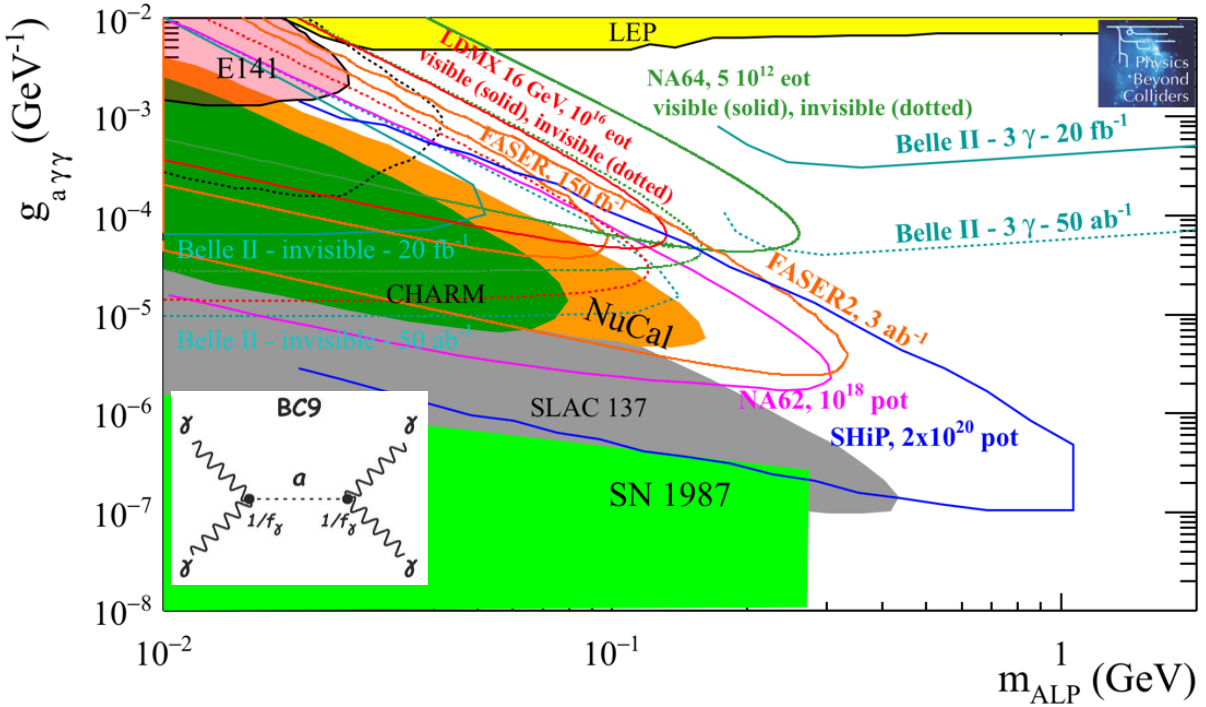
- A significant part of the LDMX potential can be covered at SLAC (in discussion with DOE)
- AWAKE++ domain expected to be covered by the competition in the coming decade
- NA64++ has a unique short term potential
- SHiP has the highest long term potential at high mass / low couplings

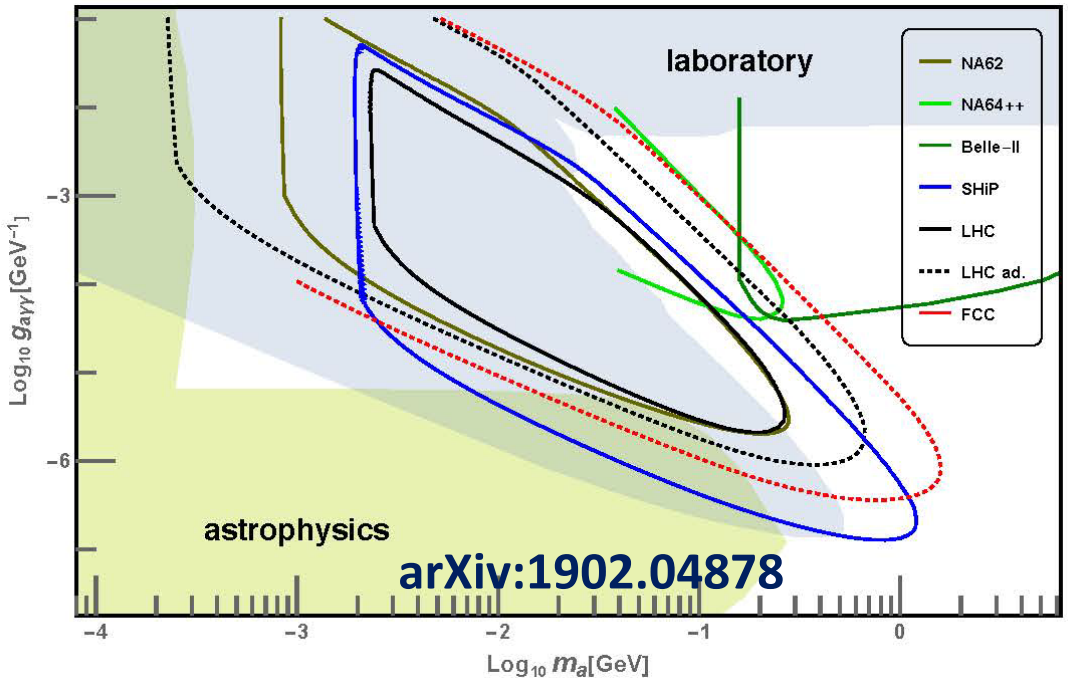






EXPLORATORY STUDY OF HIGHER-ENERGY BEAMDUMPS POTENTIAL
the example of ALPS





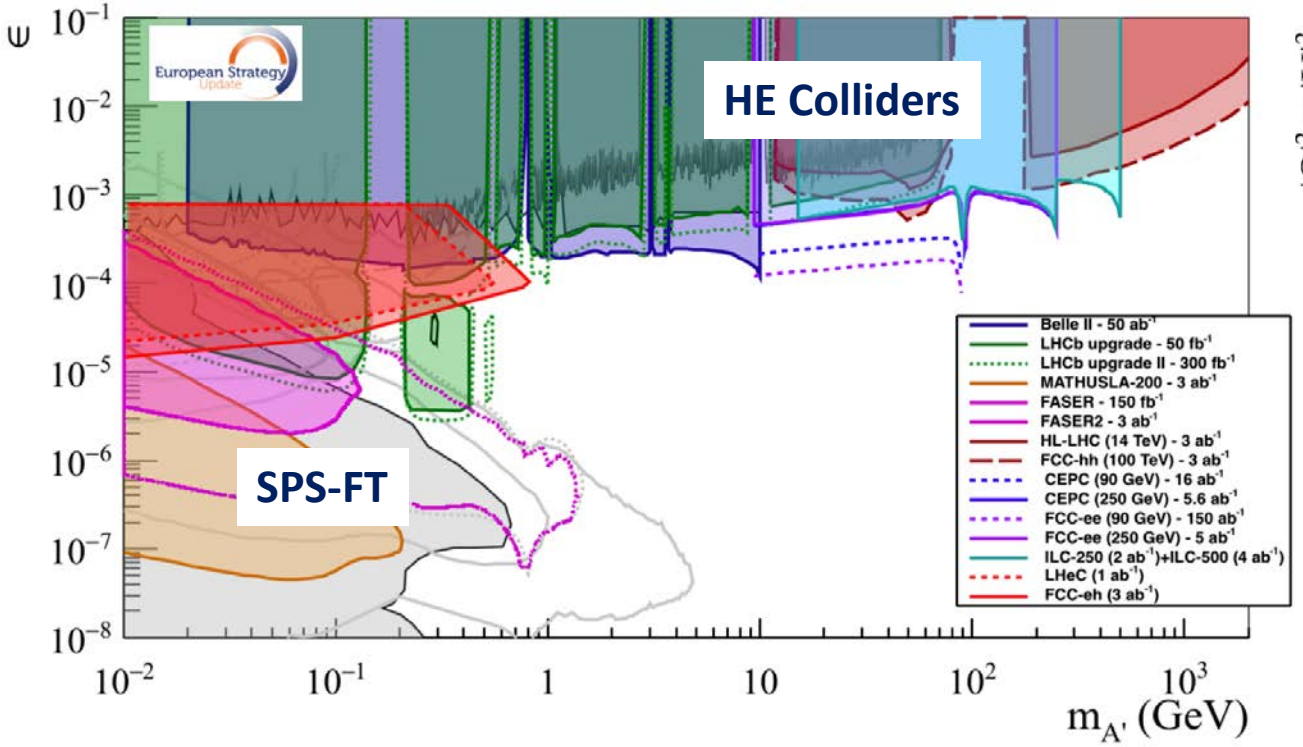
PBC projects have a similar reach as for visible A'
(similar signatures γγ and e^+e^-)

No real breakthrough of LHC/FCC beamdumps:
SPS seems to offer a quite optimal energy-intensity mix in the present context

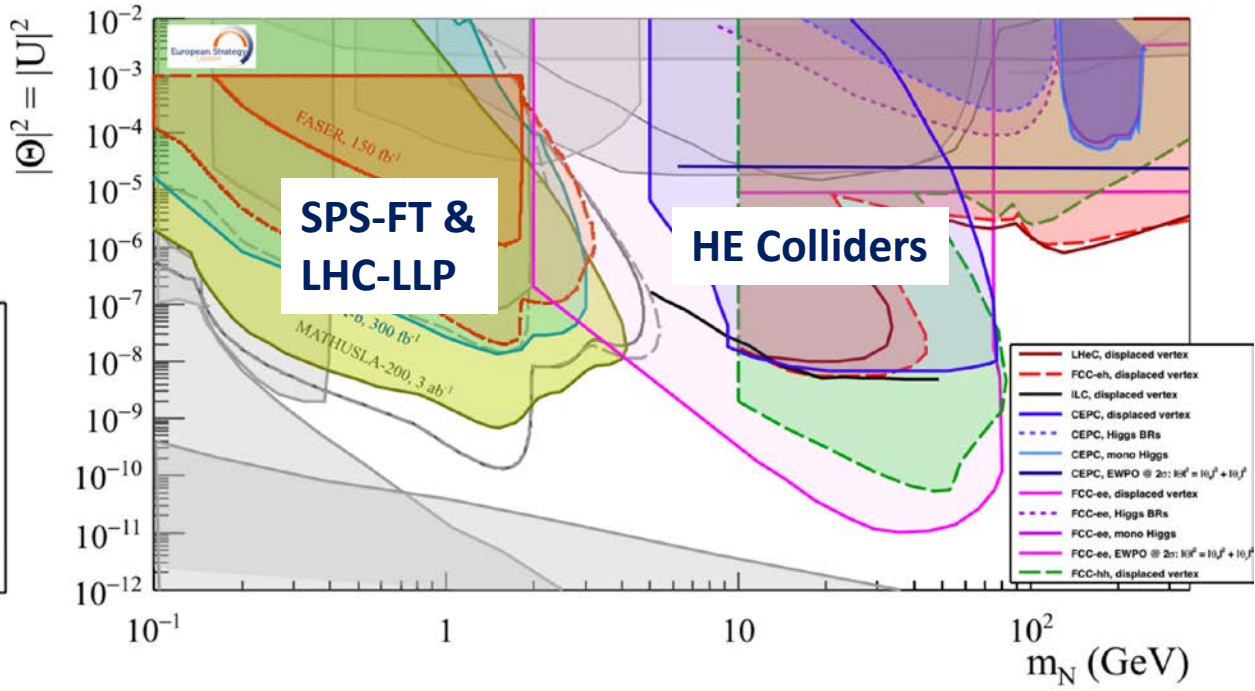
Comparison of SPS FT and HIGH-ENERGY COLLIDERS for hidden searches

(courtesy Gaia Lanfranchi)

Dark Photons



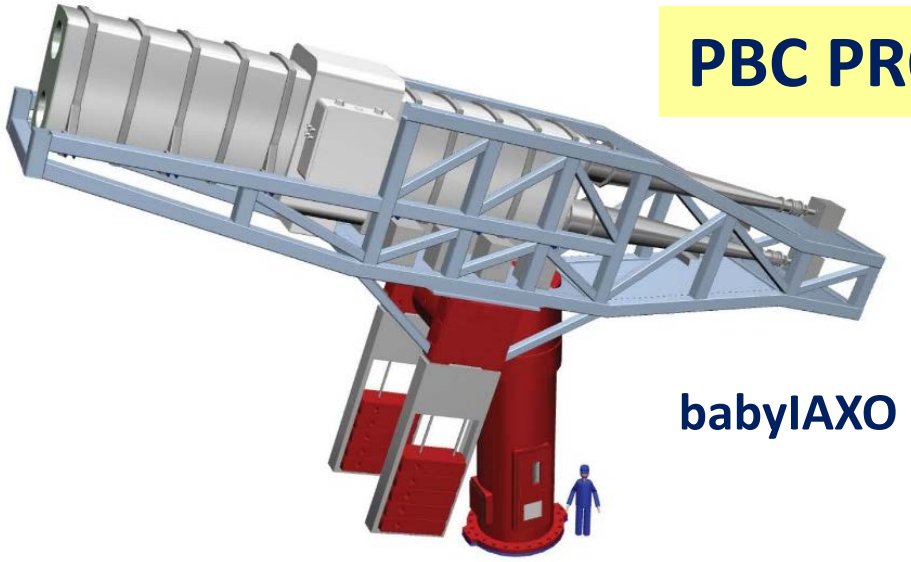
HNLs



Different domains of similar "sizes" explored by the various facilities

→ all approaches needed to cover the full landscape

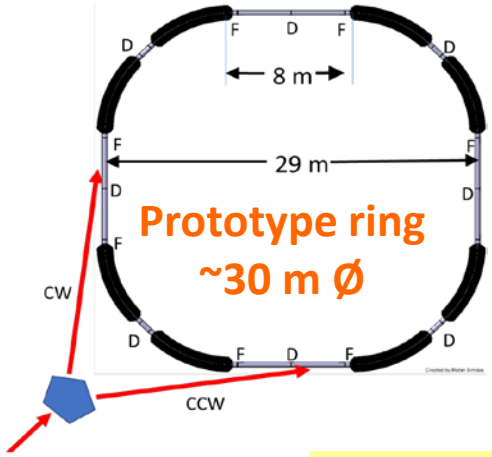
PBC PROJECTS POSSIBLY IMPLEMENTED OUTSIDE CERN



babyIAXO

IAXO (axion helioscope)

Baby-IAXO proposal submitted to DESY
positively reviewed by PRC
A project with good momentum now,
benefits much from CERN support



Proton EDM RING

CPEDM Collaboration built within PBC
Investigations revealed need for a prototype ring
to test and finalize control of systematics.
Possible prototype site: COSY in Jülich

REDTOP (rare η decays)

CERN beams not optimal to provide the required conditions and luminosities
+ Detector still requires significant R&D

C. V → **suggests that an implementation at FNAL, as initially foreseen, would be more efficient.**

THE MAIN PBC MESSAGES TO THE EPPSU

FOR CERN PROJECTS

LHC Fixed-Target opens a worldwide unique domain to both SF and QGP measurements

Requires support for full exploitation of its potential on the LHC lifetime

A SPS Beam Dump Facility would cover a worldwide unique domain for hidden sector searches complementary to high-energy colliders and non-accelerator experiments

A mid-size project now mature for an implementation decision

FOR PROJECTS OUTSIDE CERN

Support is required to fully exploit the potential of National Labs for both non-accelerator projects (e.g. IAXO) and precision physics (e.g. pEDM R&D)

The particle physics potential of the new European facilities such as ESS and DESY XFEL requires support to be fully exploited in the long term.

EXTRA SLIDES

HISTORY OF PBC EVENTS

PBC KICK-OFF WORKSHOP, CERN, September 2016

Call for abstracts → 20 selected for presentation

1st GENERAL WORKING GROUP MEETING, CERN, March 2017

Identification of main issues to be studied

2nd PBC WORKSHOP, CERN, November 2017

Working groups project reports

New call for abstracts → 7 selected for presentation

2nd GENERAL WORKING GROUP MEETING, CERN, June 2018

Status of studies for PBC deliverables

3rd PBC WORKSHOP: CERN, January 16-17, 2019

Summary of inputs to EPPSU and survey of future studies

3rd GENERAL WORKING GROUP MEETING, CERN, 5-6 November 2019

https://indico.cern.ch/event/827066/

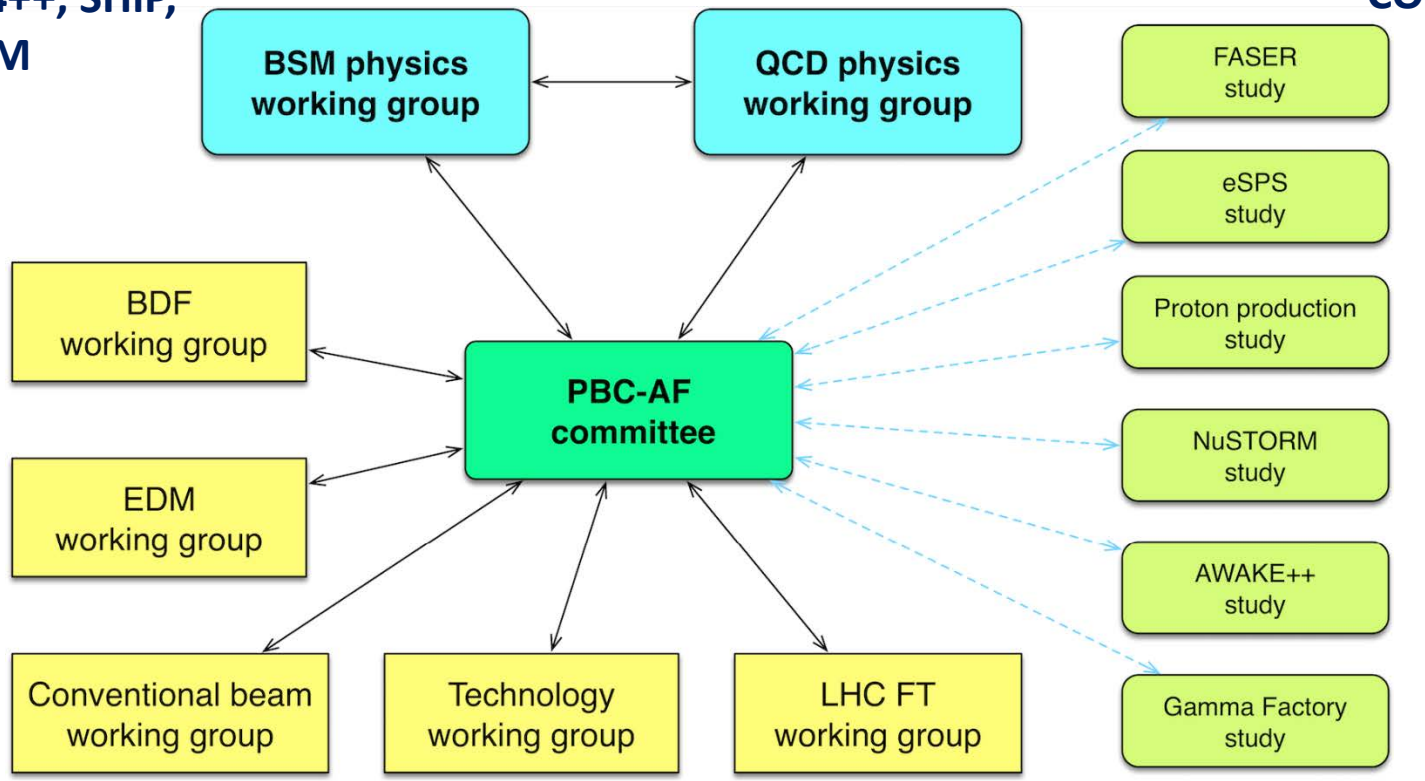
Updated status of projects before EPPSU drafting session

PBC WORKING GROUP STRUCTURE

Main coordinators: J. Jaeckel, M. Lamont, C. Vallée

BSM conveners: C. Burrage, G. Lanfranchi, S. Rozanov, G. Ruoso
+ ext. experts + projects representatives:
NA62++, KLEVER, NA64++, SHiP,
LDMX, IAXO, JURA, EDM

QCD conveners: M. Diehl, J. Pawlowski, G. Schnell
+ ext. experts + projects representatives:
COMPASS++, MUonE, DIRAC++
AFTER, CRYSTAL,
LHCb-FT, ALICE-FT
NA61++, NA60++



~100 core members in the Working Groups **> 200 WG meetings in the past 3 years**

Organisation and follow-up of activities documented on http://pbc.web.cern.ch/

PBC DELIVERABLES: ACCELERATOR WGs

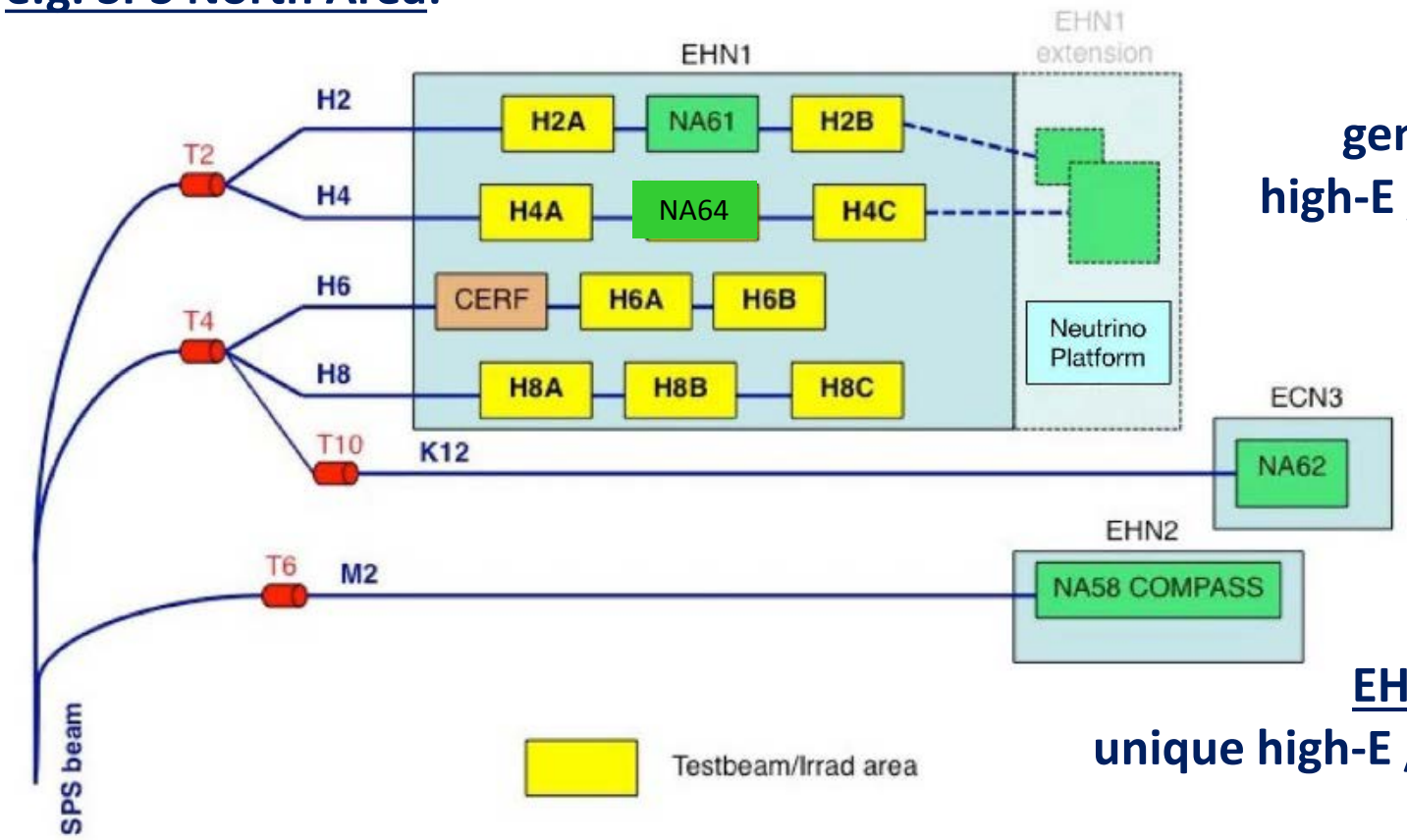
Working group	10 pager for ESPP for 18th December - WG dependent	Possible proponents/clients submitting 10 pager to ESPP	PBC deliverable for 18th December * (referenced by 10 pager)
AWAKE++	Y	Proposed client experiment	Exploratory study
BDF	Y	SHiP, tauFV	Comprehensive Design Study - tauFV as appendix
Conventional beams	Y	NA61, NA62++, KLEVER etc.	Description of the conventional beam upgrades associated to the proposed projects
EDM	Y		3 appendices: COSY; prototype; full ring (feasibility study).
eSPS	Y	LDMX,BD	Technical report on possible implementation at CERN
FASER acc.	N	FASER	Technical report on possible implementation in LHC
Gamma factory	Y		Exploratory study
LHC FT	N	AFTER@LHC, LHCspin, MDM/EDM	Technical study of feasibility
nuSTORM	Y		Broad outline of a possible nuSTORM implementation at CERN
Perf post-LIU	N		Injector complex performance after LIU
Technology	Y	IAXO et al	Exploration and evaluation of possible technological contributions of CERN to non-accelerator projects possibly hosted elsewhere

Reports publicly available on CERN CDS: http://cds.cern.ch/collection/PBC%20Reports?ln=en

IMPLEMENTATION CONSTRAINTS OF NEW PROJECTS

Governed to a great extent by existing beamlines/halls/experiments

e.g. SPS North Area:

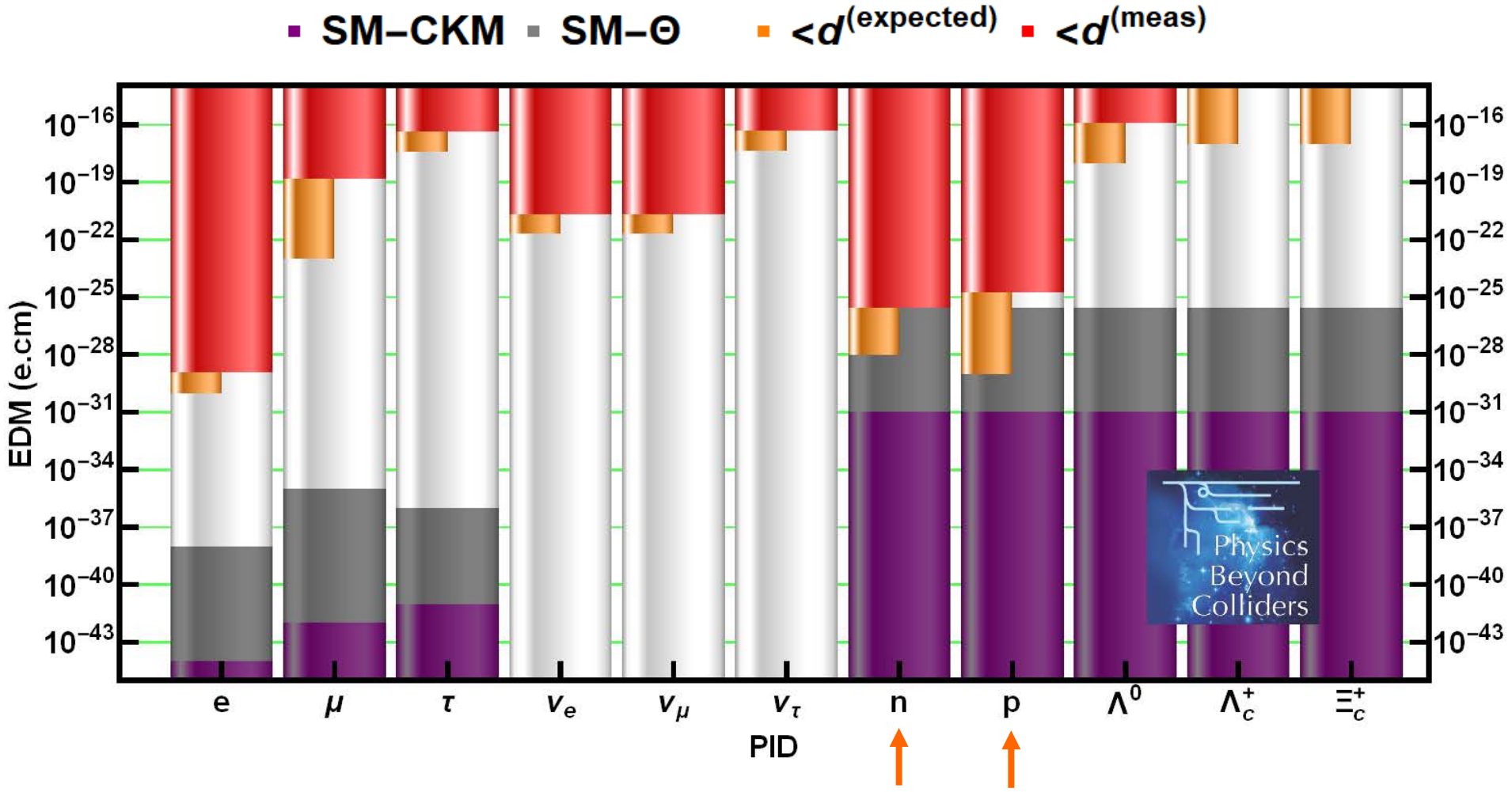


EHN1
general purpose hall with unique high-E / medium-I beams for all particles

ECN3
unique underground hall for high-I hadron beams

EHN2
unique high-E / high-I μ-beam

EDM LANDSCAPE



Neutron EDM is leading the field for hadrons

Catching up in precision is a challenge for the proton

MAIN CURRENT BEAM DUMP PROJECTS OUTSIDE CERN

DP = Dark Photon
DS = Dark Scalar
HNL = Heavy Neutral Lepton
ALP = Axion-Like Particle

EXPERIMENT	PERIOD	BEAM	PARTICLES ON TARGET	SIGNATURE	MODELS
HPS @JLAB	2016-20	e 2-6 GeV	~10^{20}	visible e^+e^-	DP, ALPs
APEX @JLAB	2018-19	e 1-4.5 GeV	~10^{20}	visible e^+e^-	DP, ALPs
BDX @JLAB	~2022	e 12 GeV	~10^{22}	recoil e	DP, ALPs
LDMX @SLAC	> 2022	e 4-8 GeV	2 10^{16}	invisible	DP, ALPs
MiniBooNe @FNAL	2013-14	p 8 GeV	1.8 10^{20}	recoil e, N	DP
SBND @FNAL	>2020	p 8 GeV	6 10^{20}	recoil Ar	DP
SEAQUEST @FNAL	2021-30	p 120 GeV	$10^{18} \rightarrow 10^{20}$	visible e^+e^-	DP, DS, HNL
LBND @FNAL	>2025	p 120 GeV	~10^{21}	recoil e, N	DP, DS, HNL

Recent dedicated experiments demonstrate a regain of interest for beam dumps

Flavour factories (BELLE II, …) have also some sensitivity from exotic decays

BEAM DUMP PROJECTS AT CERN

DP = Dark Photon
DS = Dark Scalar
HNL = Heavy Neutral Lepton
ALP = Axion-Like Particle

EXPERIMENT	PERIOD	BEAM	PARTICLES ON TARGET	SIGNATURE	MODELS
NA64++(e)	2015-24	e 100 GeV	~5 10^{12}	invisible & visible e^+e^-	DP, ALPs
eSPS/LDMX	> 2026	e 16 GeV	10^{16}	invisible	DP, ALPs
AWAKE++	> 2026	e ~50 GeV	~10^{15}	visible e^+e^-	DP, ALPs
NA62++	> 2022	p 400 GeV	10^{18}	visible	DP, DS, HNL, ALPs
SHiP	> 2026	p 400 GeV	2 10^{20}	recoil & visible	DP, DS, HNL, ALPs
NA64++(μ)	> 2022	μ 160 GeV	5 10^{13}	invisible	DZ_μ, ALPs

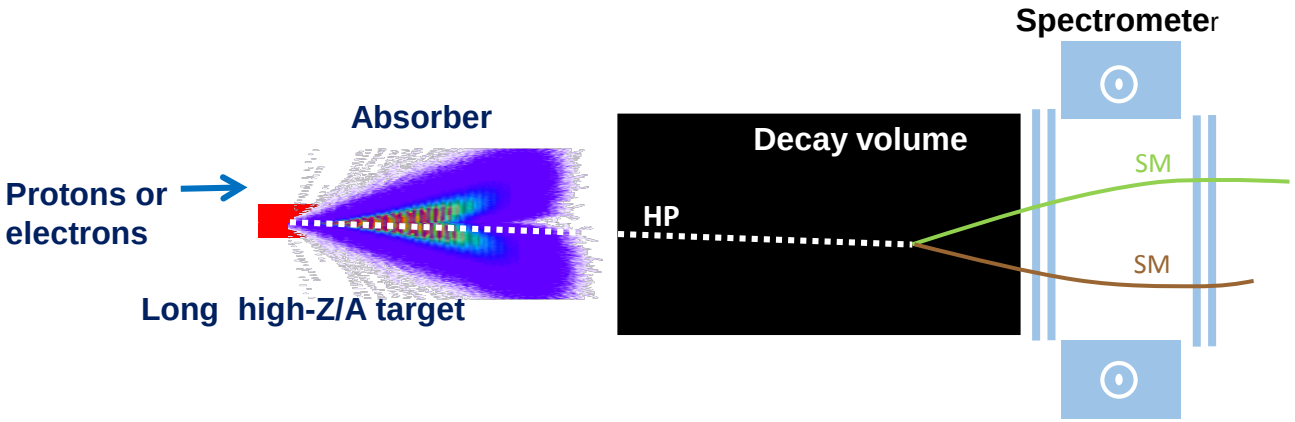
NB: CERN offers unique opportunities with both lepton and hadron beams

LHCb and LHC-LLP dedicated projects (FASER, milliQan, CODEX-b, MATHUSLA) have also sensitivity in similar mass range

LEVEL OF MATURITY OF SENSITIVITY ESTIMATIONS

Project	Background	Efficiency	Inputs
NA62++	0-BG assumed	partly included	10^{16} PoT run in BD mode
KLEVER	partly included	included	fast simulation
REDTOP	included	included	full simulation
NA64++(e)	included	included	real data
NA64++(μ)	0-BG assumed	100 % assumed	M2 μ beamtest
eSPS/LDMX	included	included	full simulation at 4 GeV
AWAKE++	0-BG assumed	100 % assumed	toy model
SHiP	0-BG assumed	included	full simulation
CODEX-b	0-BG assumed	included	full simulation
FASER	0-BG assumed	100 % assumed	BG simulations & in situ measurements
MATHUSLA200	0-BG assumed	100 % assumed	cosmic & LHC BG fluxes
milliQan	included	included	full simulation

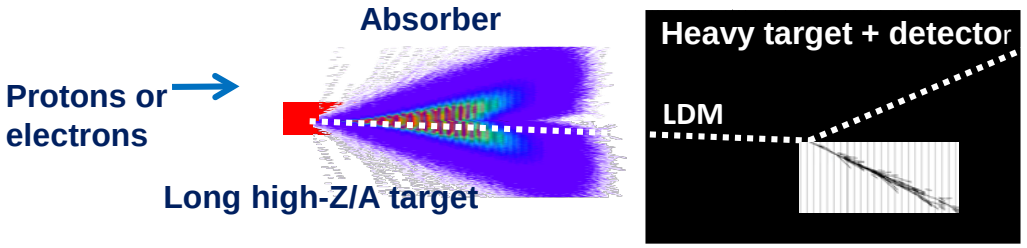
BEAM DUMPS EXPERIMENTAL METHODS



Visible decay to SM particles

$signal \propto \epsilon^4$

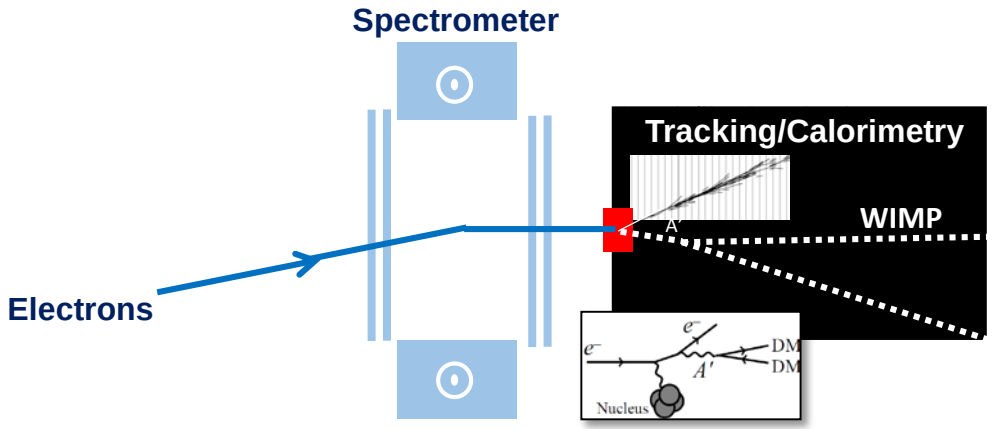
Critical: BG control



Recoil e/N from rescattering

$signal \propto \epsilon^4$

Critical: BG control



Missing energy from invisible decays

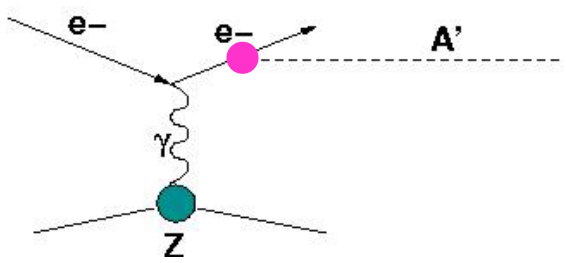
$signal \propto \epsilon^2$

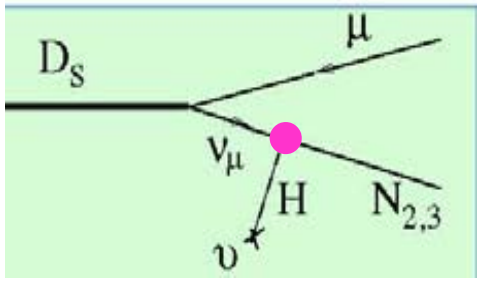
Critical: initial particle and pileup control

Graphics Courtesy Richard Jacobson

NB: reach in (m,ε) depends on many parameters:
beam energy & intensity, decay length, signatures, background …

HIDDEN SECTOR MAIN PRODUCTION MODES





Primakov/Bremstrahlung:
Mass reach mainly in sub-GeV domain, weakly dependent on beam energy

Meson decays:
Mass reach in multi-GeV domain dependent on accessible meson mass thresholds (K,D,B)

EXPERIMENTAL SIGNATURES

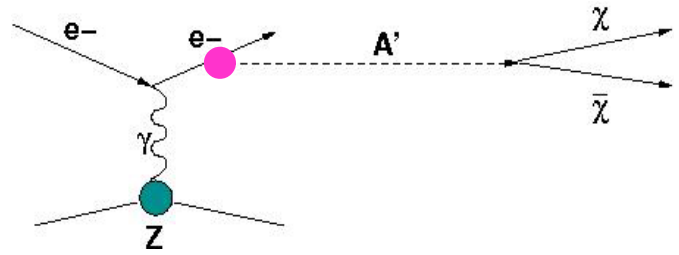
Models	*Final states*
HNL, SUSY neutralino	$l^+\pi^-$, l^+K^-, $l^+\rho^-$ $\rho^+ \rightarrow \pi^+\pi^0$
Vector, scalar, axion portals, SUSY sgoldstino	l^+l^-
HNL, SUSY neutralino, axino	$l^+l^-\nu$
Axion portal, SUSY sgoldstino	$\gamma\gamma$

+ recoil particles or missing energy for rescattering / missing energy methods

"Cheap" setup implemented in 2015 on H4 e test beam

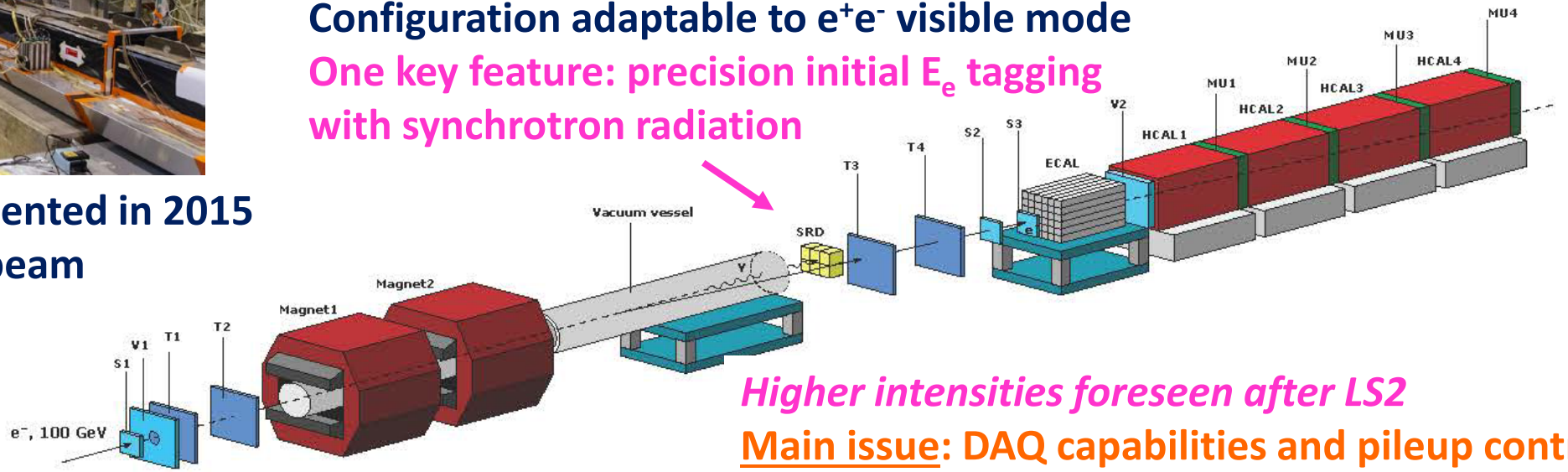
NA64++

Dark Photon search from invisible decays with missing energy



Configuration adaptable to e^+e^- visible mode

One key feature: precision initial E_e tagging with synchrotron radiation



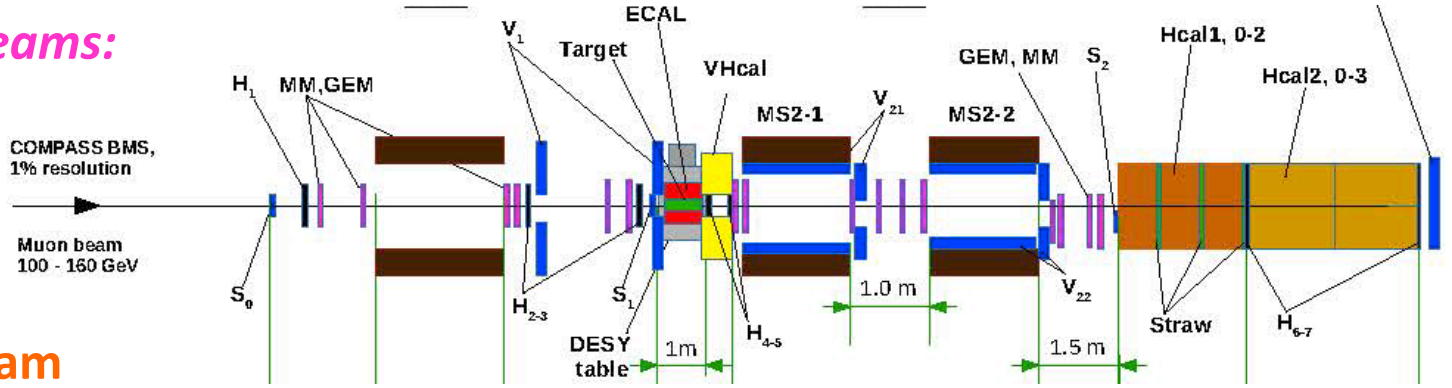
Higher intensities foreseen after LS2

Main issue: DAQ capabilities and pileup control

Wish also to extend the method to μ / hadron beams:

- **Few months of μ beam would test a $(g-2)_\mu$ interpretation**
- **Few years of μ beam would improve limits on millicharged particles**

Main issue: competition with COMPASS on μ beam



NA62 BEAM DUMP

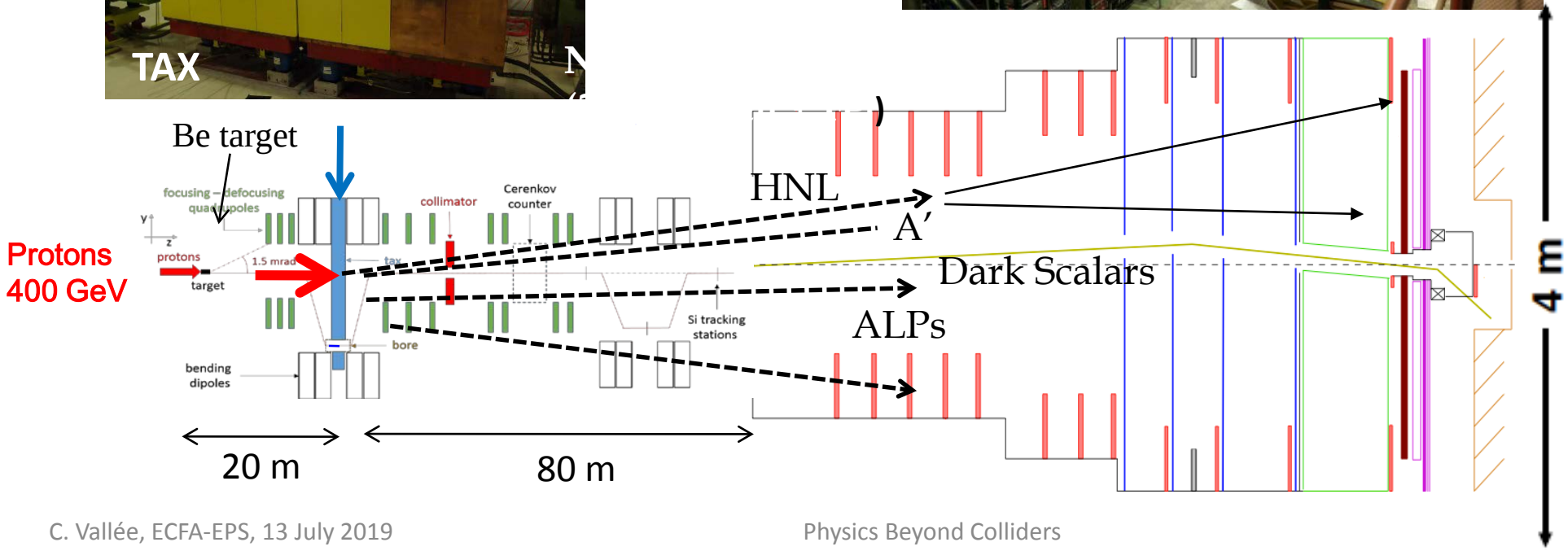
Reminder: main NA62 goal is ultra-rare decay $K^+ \to \pi^+ \nu\nu$

Successful data taking since 2016, more needed after LS2 to reach goal of ~100 events

Some data taking in beam dump mode under consideration during run 3

Achieved by closing the TAX collimator

1 year would correspond to ~10^{18} PoT



Instrumentation of NA62 decay vessel well adapted to searches in visible mode

KLEVER: $K^0 \rightarrow \pi^0\nu\nu$ rare decay

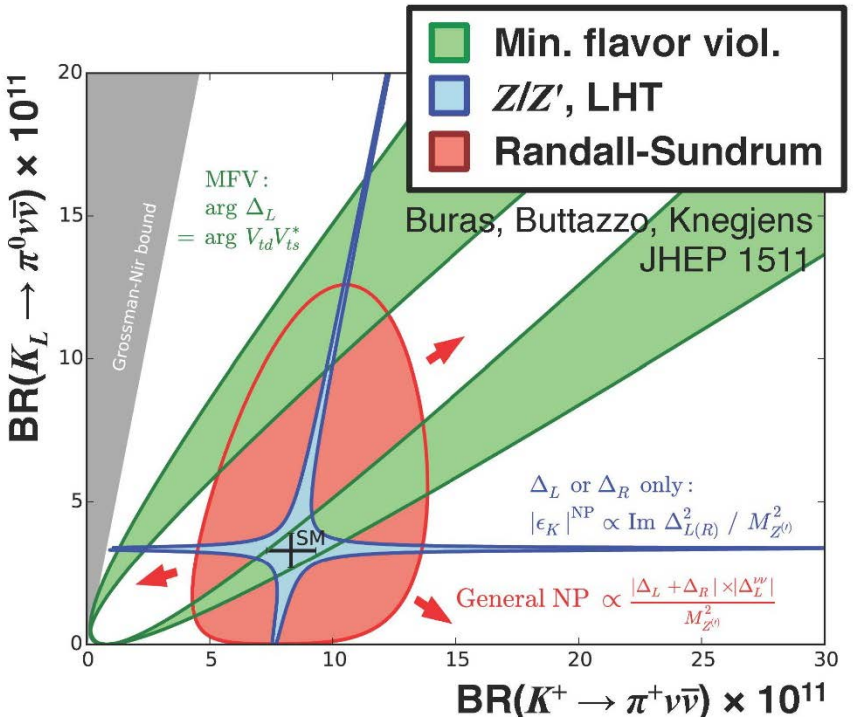
K^0 decays complementary to K^+ decays for the CKM matrix and BSM searches.

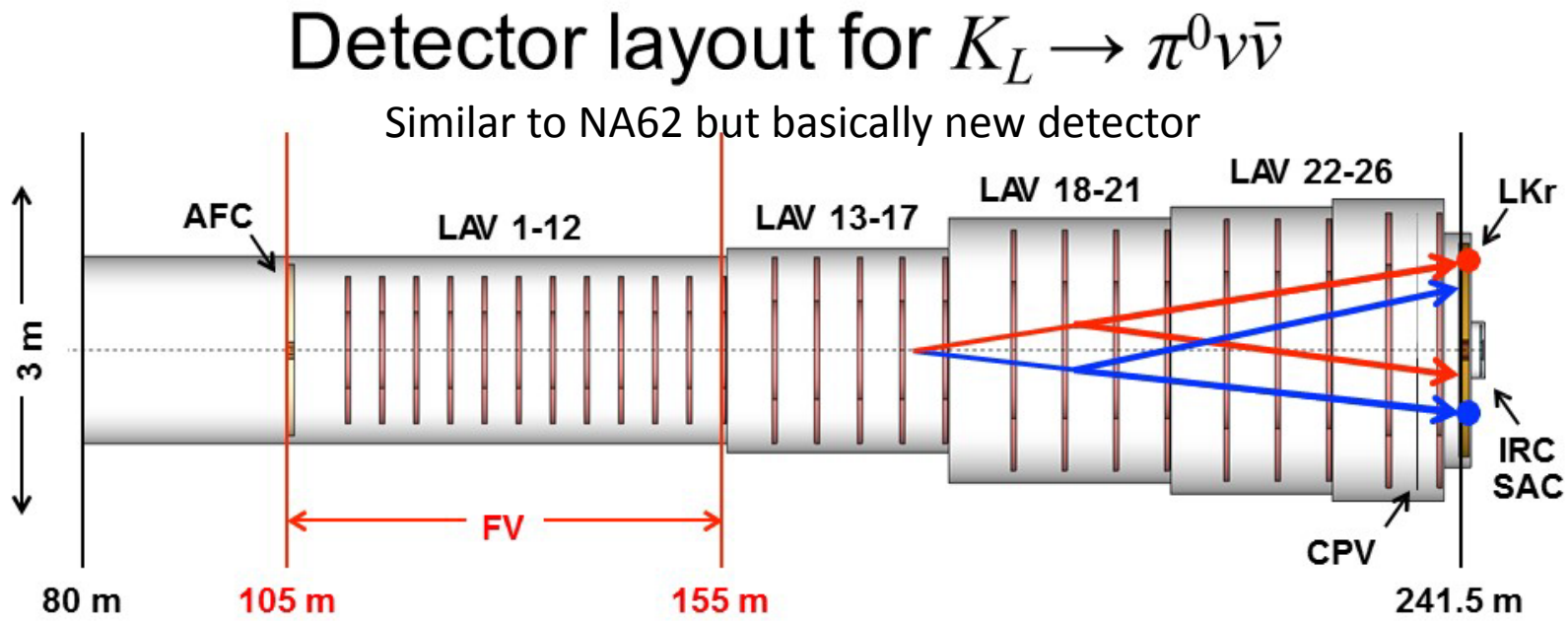
Would require a new high intensity K^0 beam.

~50 events could be collected with a similar but basically new detector.

Competition from starting KOTO at JPARC:

few events expected in coming years, upgrade by factor ~10 foreseen > 2025



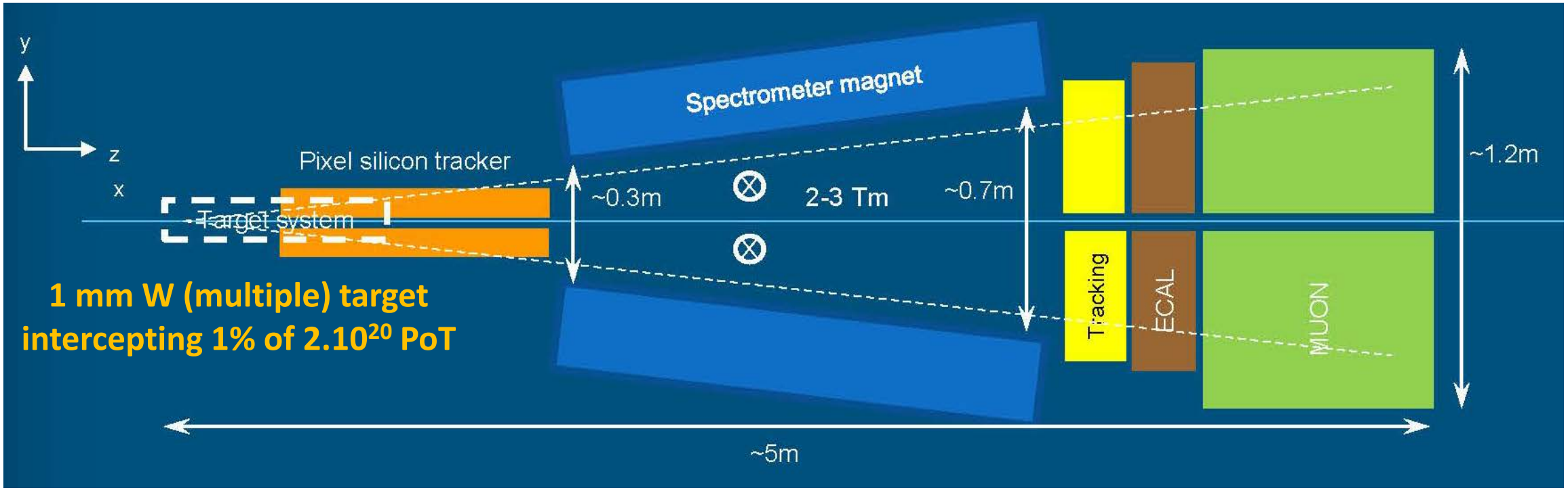


<u>Main issues</u>: actual sensitivity vs competition, cost of new beam and upgraded detector

TauFV

Interception of small BDF beam fraction to look for τ → 3μ decays

Could set limits on branching ratio better than 10^{-10} level (~BELLE-II reach)



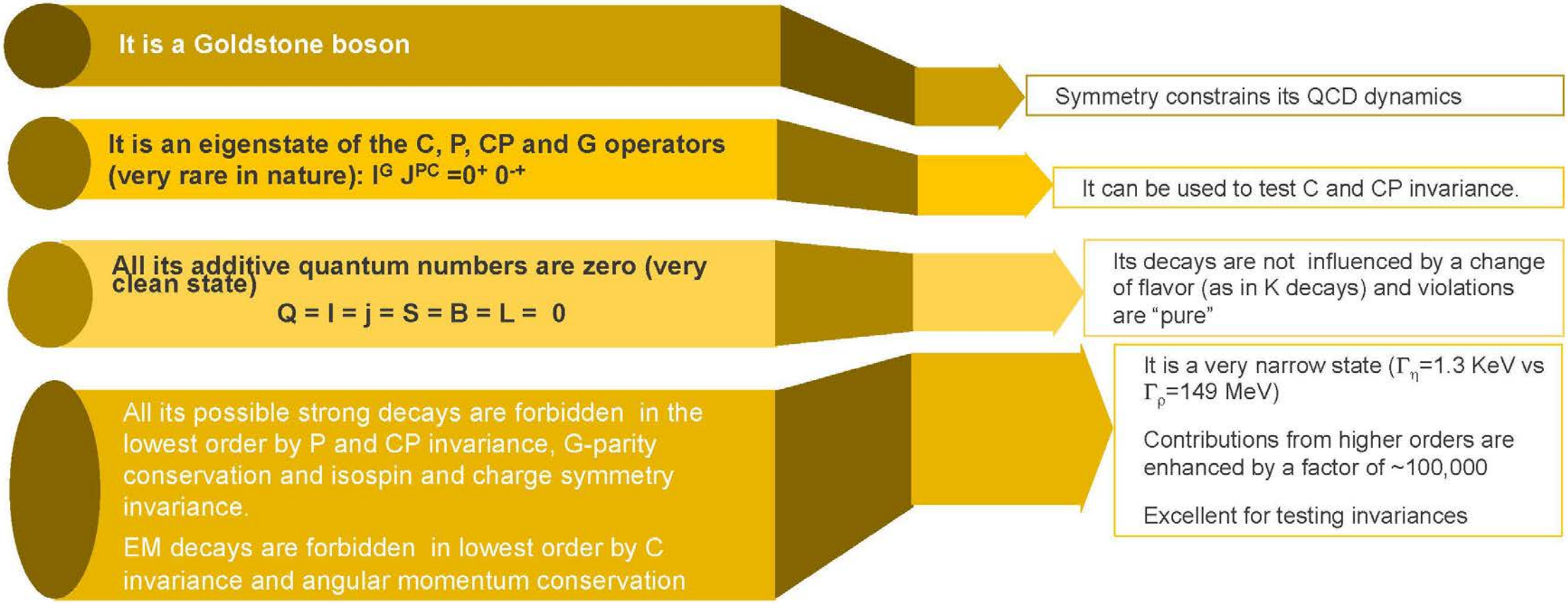
Implementation layout upstream of BDF target under study

A promising option to maximize the physics reach of the Beam Dump Facility

REDTOP a $\eta - \eta'$ meson factory

η factories are excellent laboratories to search for physics Beyond Standard Model

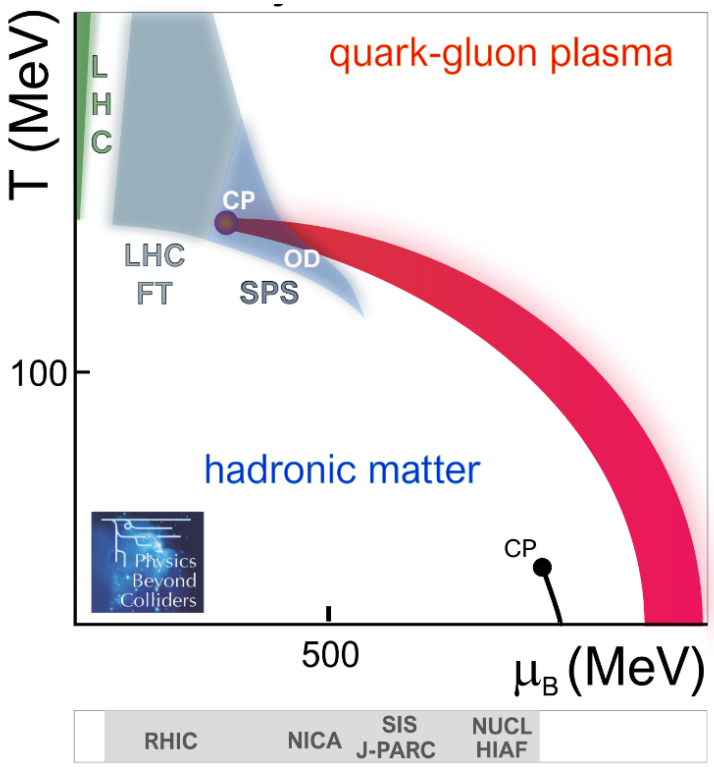
Also in discussion at FNAL

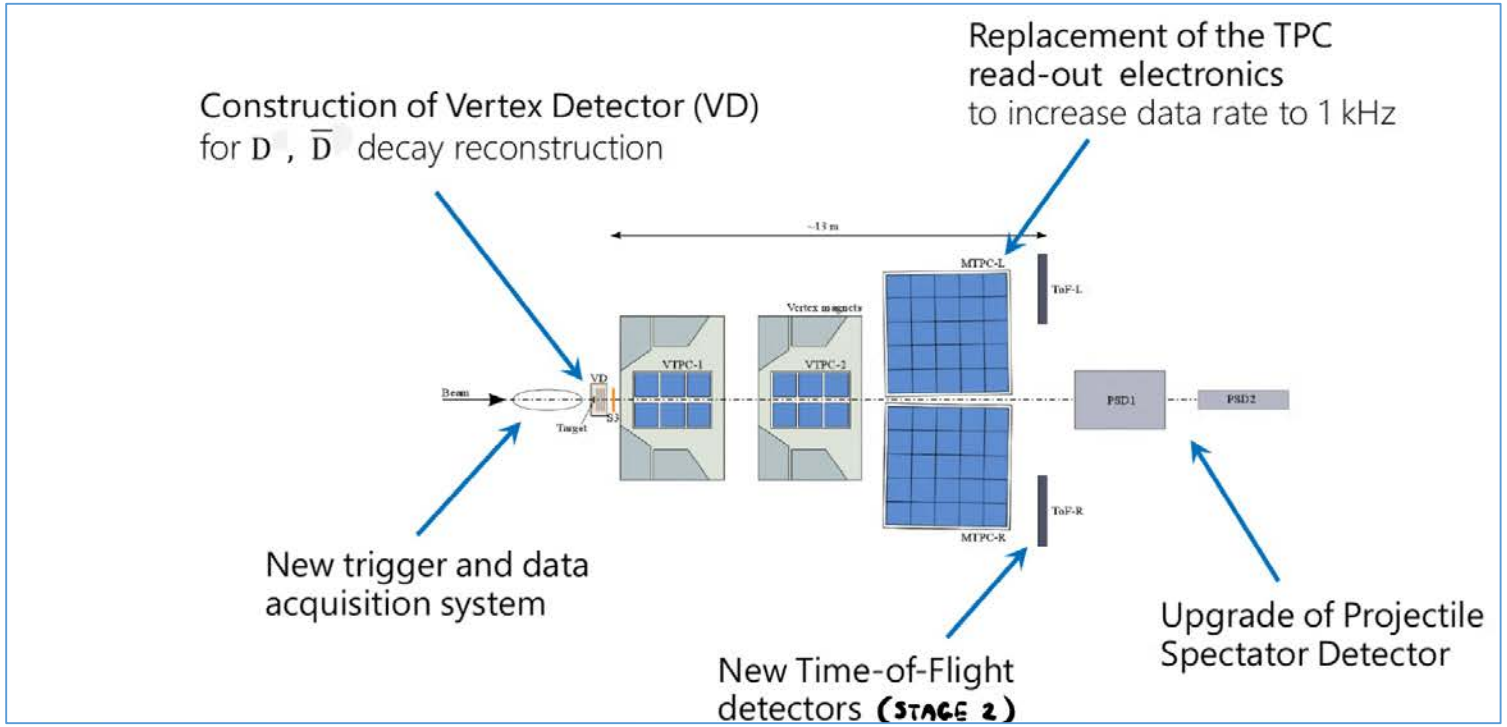


Main issues:

- **2 GeV continuous proton beam (PS best option but non-nominal for REDTOP)**
- **Demanding detector technology (Optical TPC and dual readout calorimetry)**

NA61++





Opportunity to study open charm close to expected CP-region.

Was not done by
1st generation SPS QGP-experiments

Also unique measurements for
ν-beams and cosmics rays

Moderate detector upgrades required,
well under control in collaboration with ALICE

Unique physics reach
No new competition on beamline

NA60++ and DIRAC++

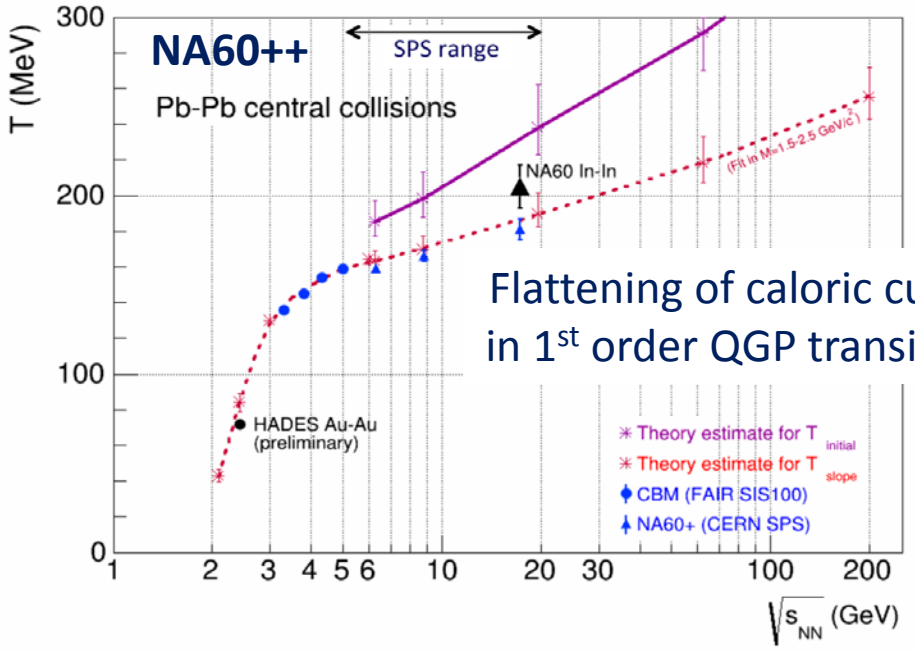
Unique physics reach for both

High hadron beam intensities

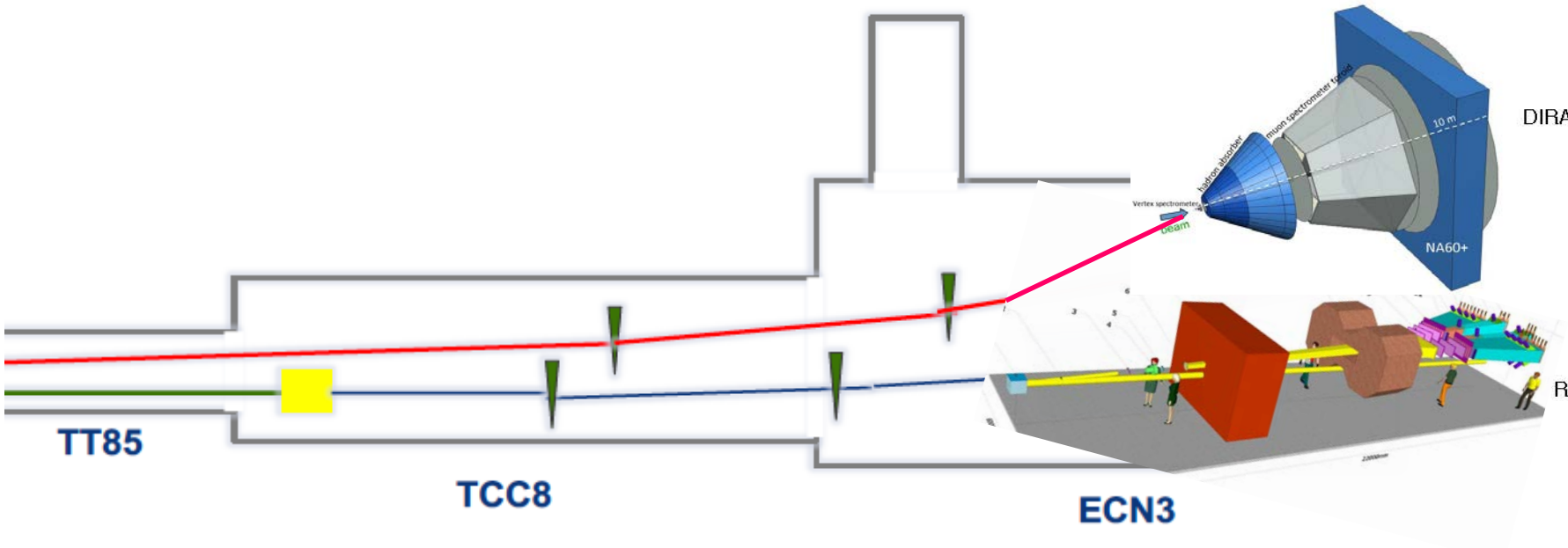
→ only reasonable implementation is in ECN3

Both beams could fit together in ECN3

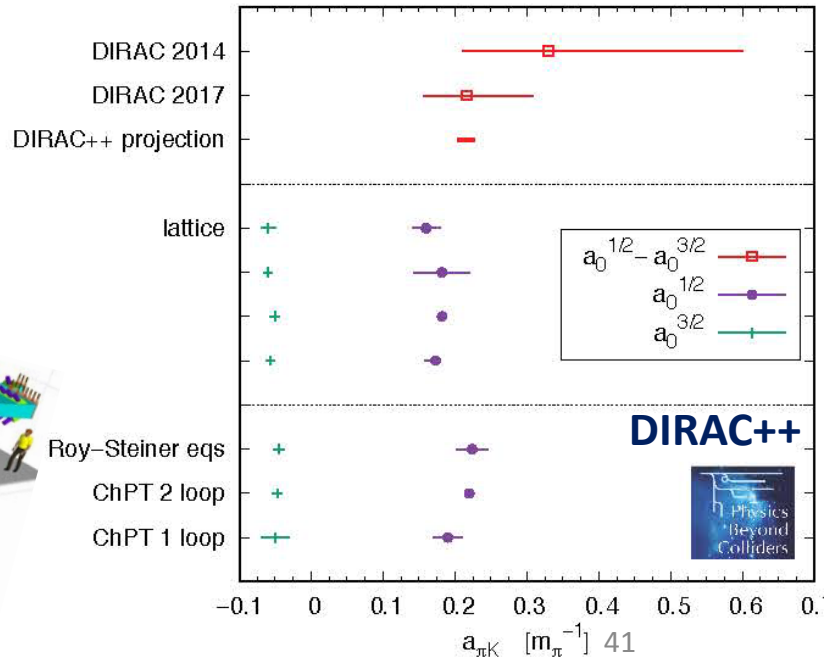
But implementation can be done only once NA62 has freed the hall



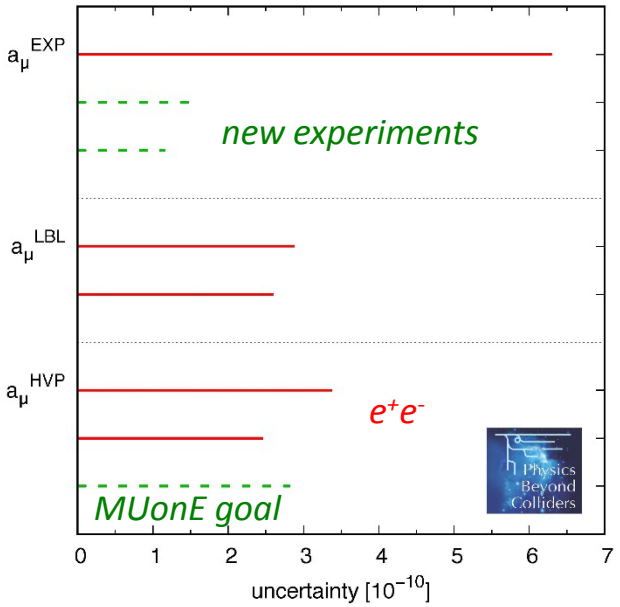
Flattening of caloric curve in 1st order QGP transition



πK scattering lengths



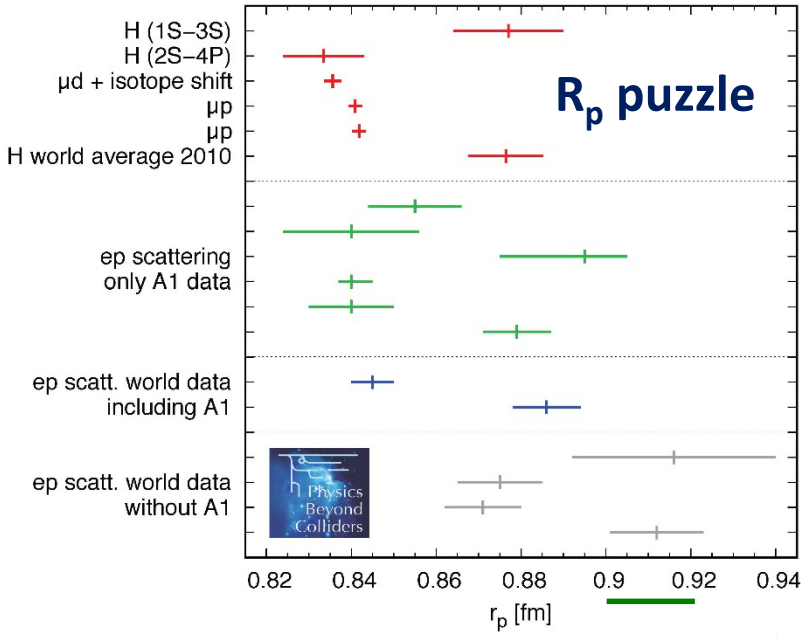
$(g-2)_\mu$ uncertainties

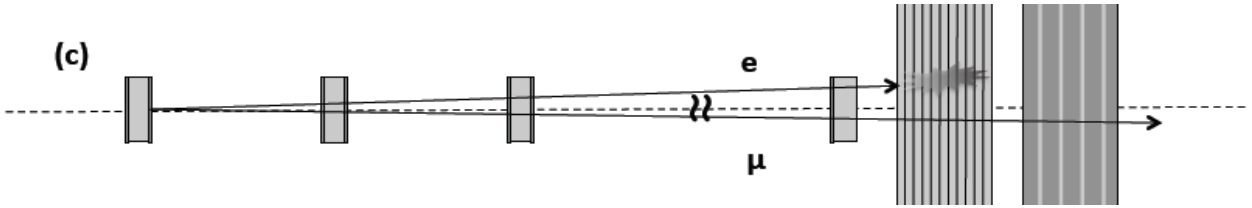


MUonE ↔ COMPASS(R_p)

μ-e ↔ μ-p
elastic scattering

In competition on same μ-beam in EHN2





Suitable MUonE position identified upstream of COMPASS

new COMPASS TPC

→ COMPASS spectro

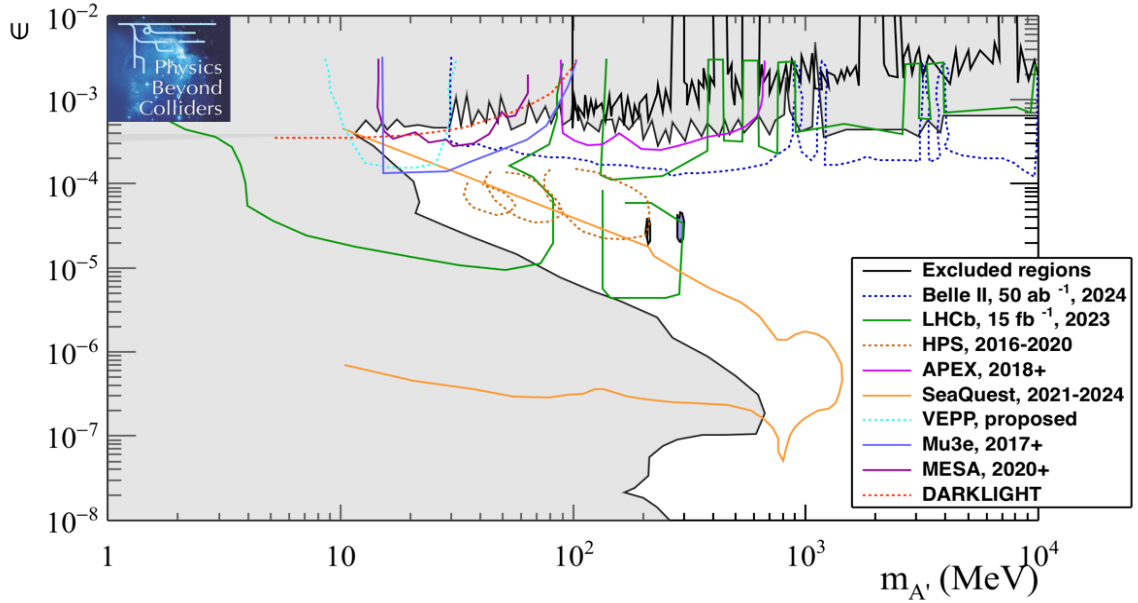
Convincing physics motivation

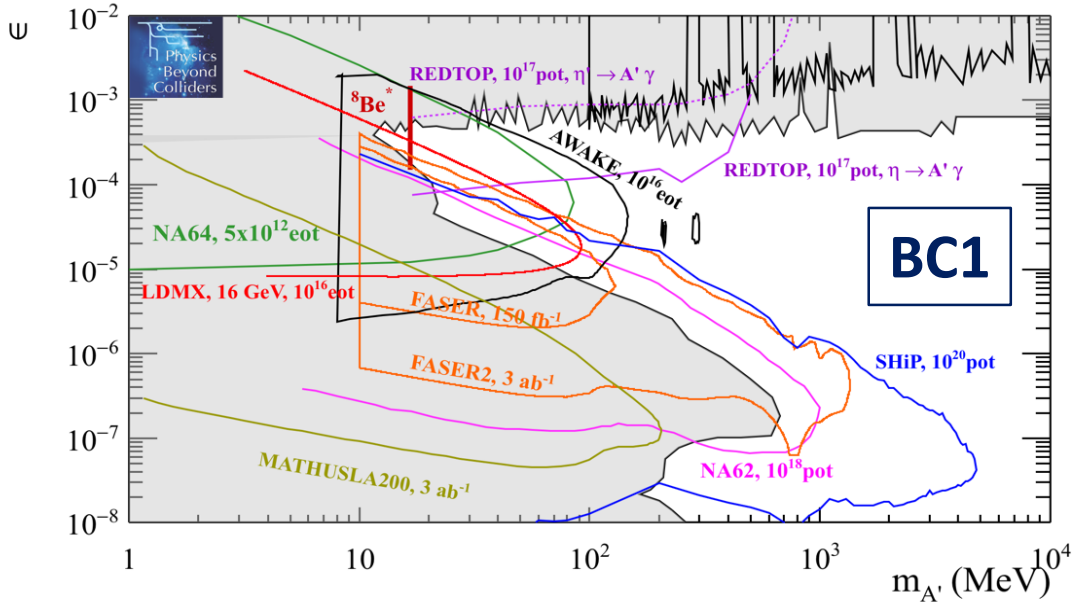
Both projects still need better quantification of feasibility and precision

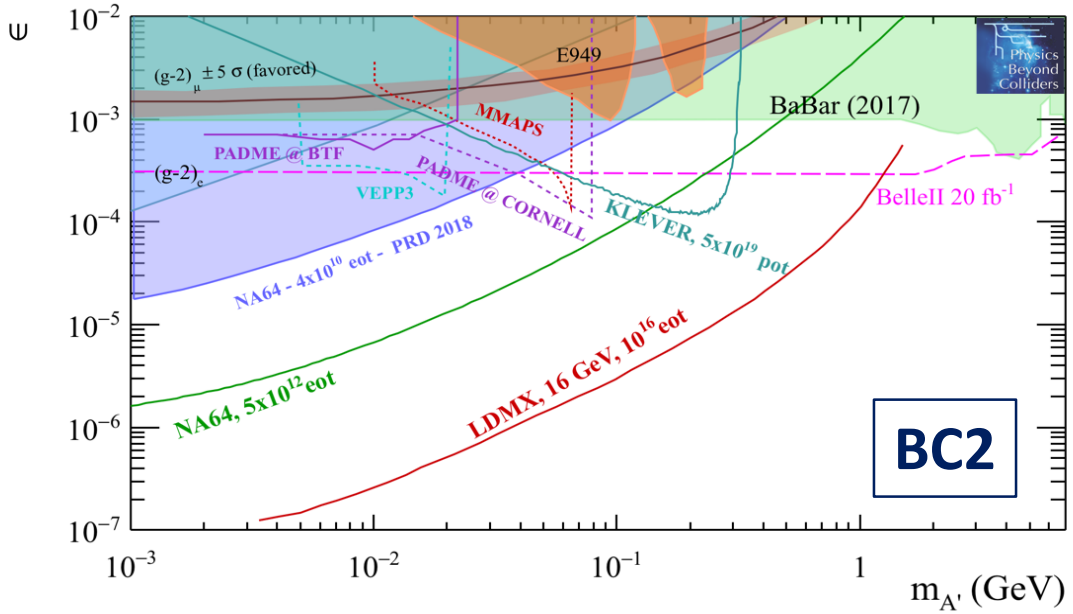
Studies for common siting and/or operation to be strengthened

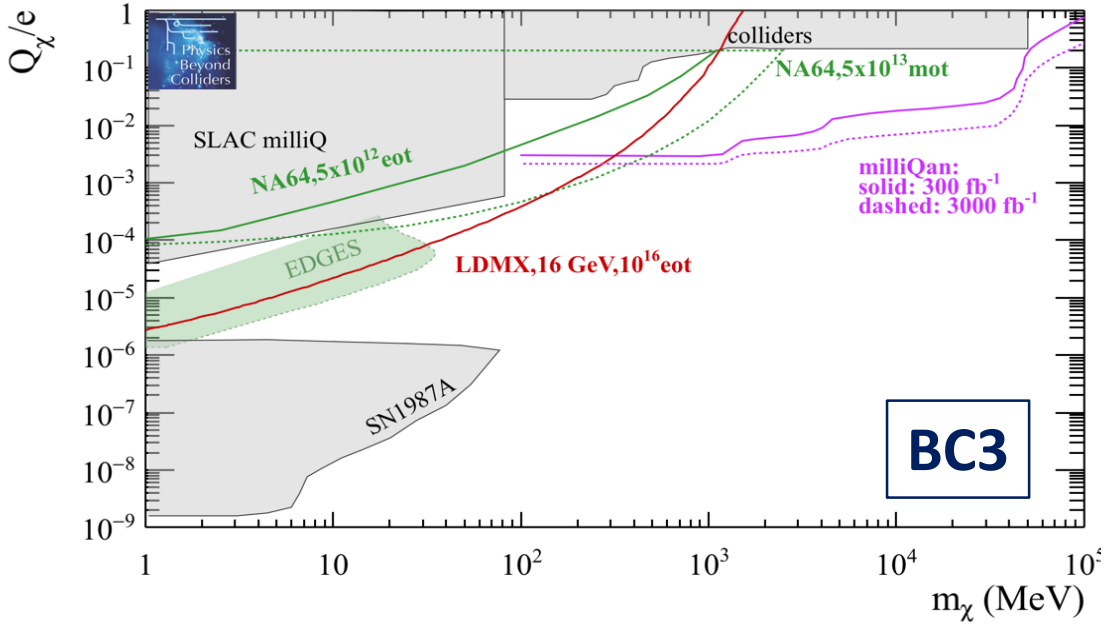
DARK VECTORS

BC1 worldwide context



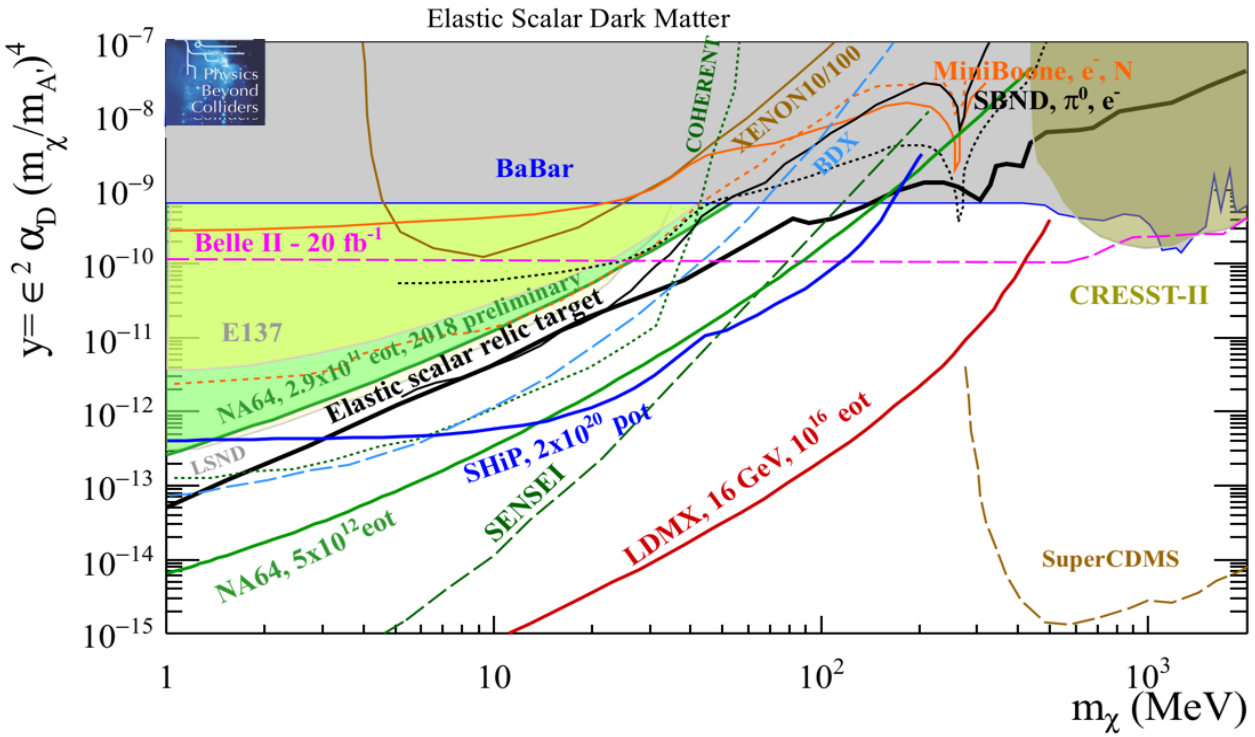


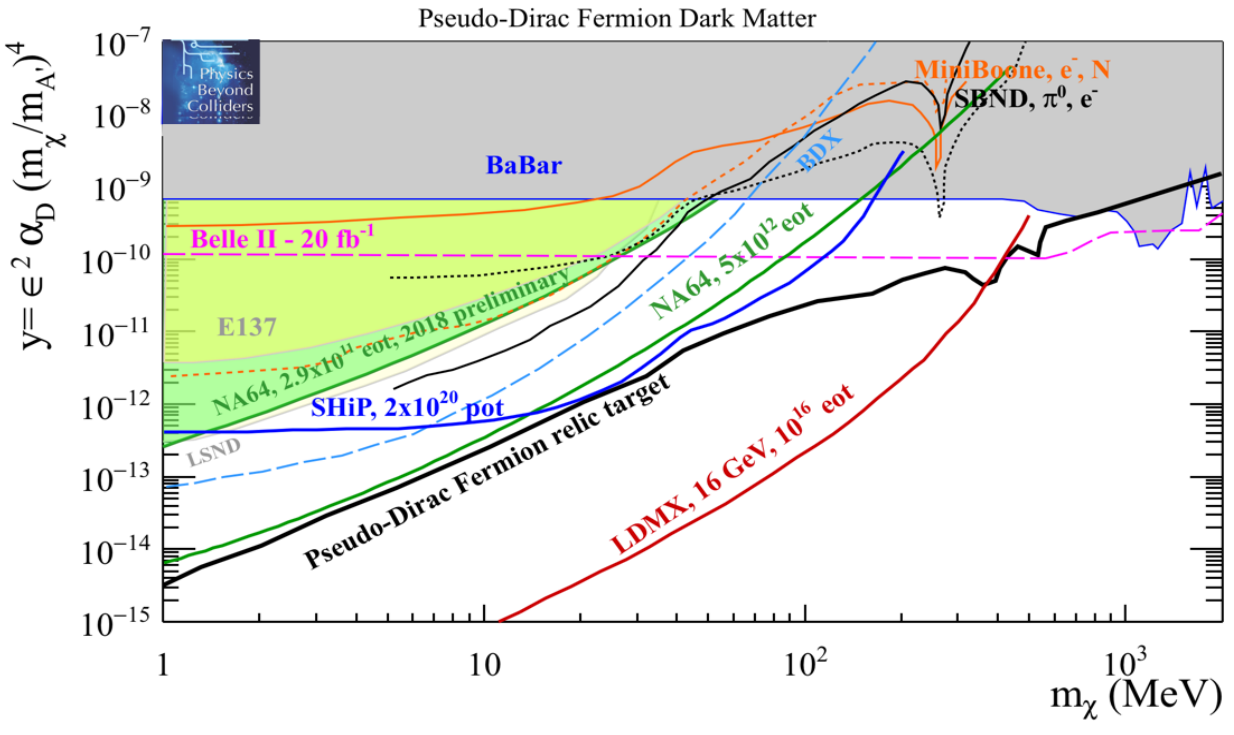




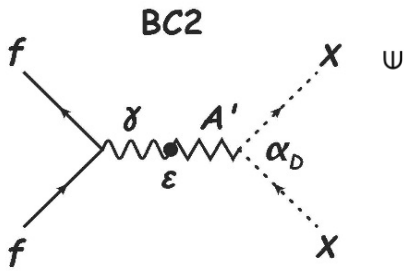
DARK VECTORS IN DM PARAMETER SPACE (BC2)

$\alpha_D = 0.1$ $m_\chi = 1/3\ m_{A'}$

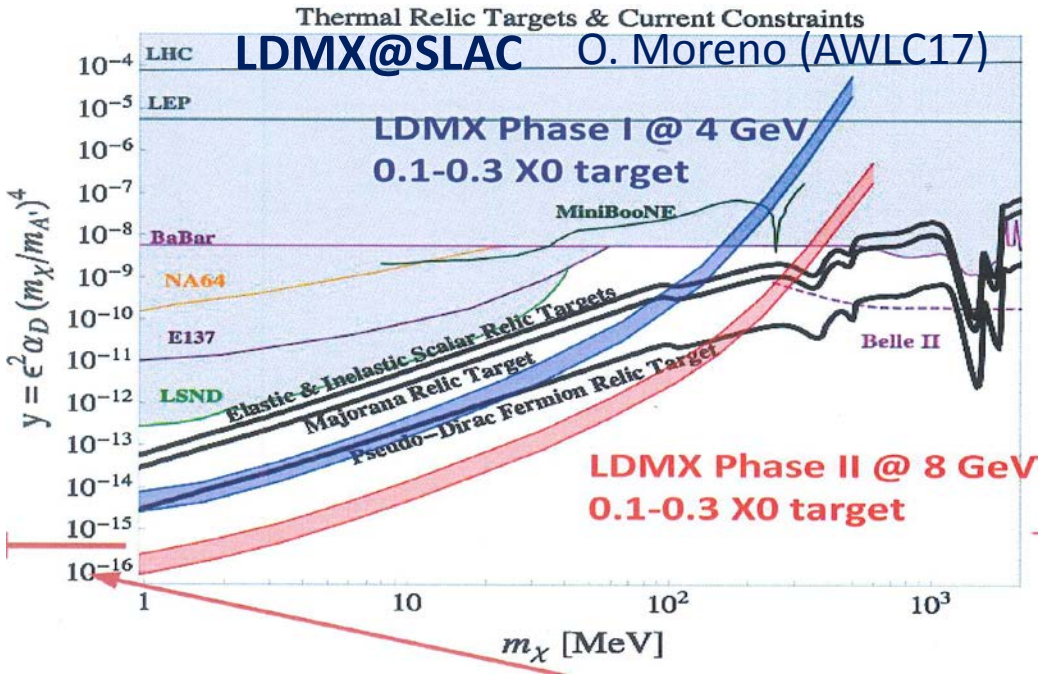




Dark Photon invisible mode

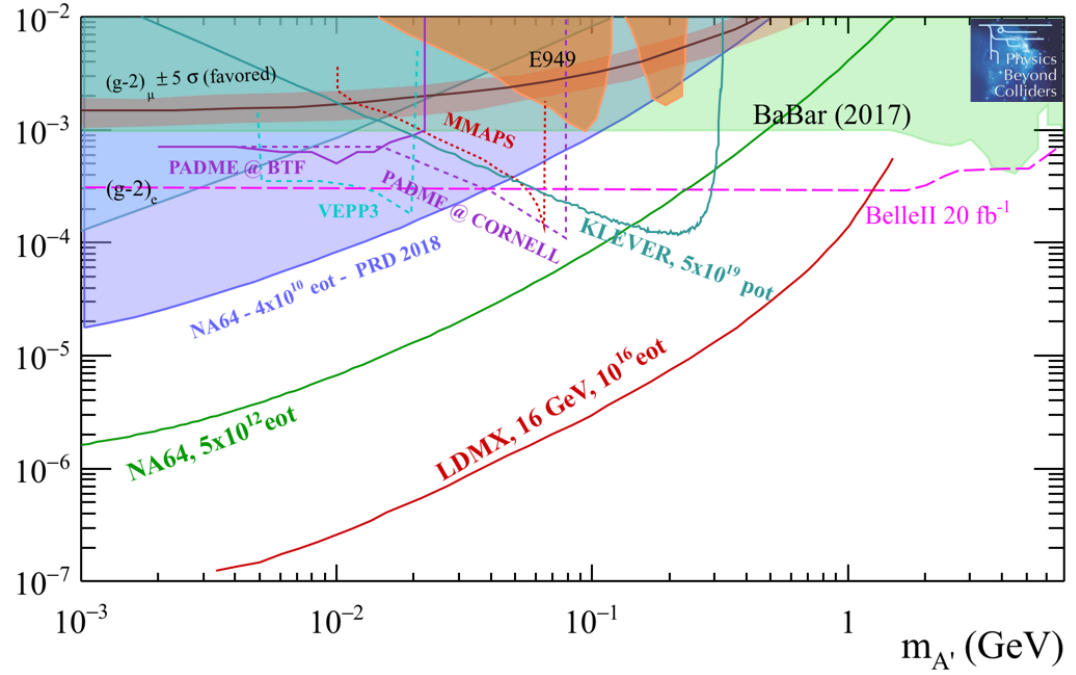


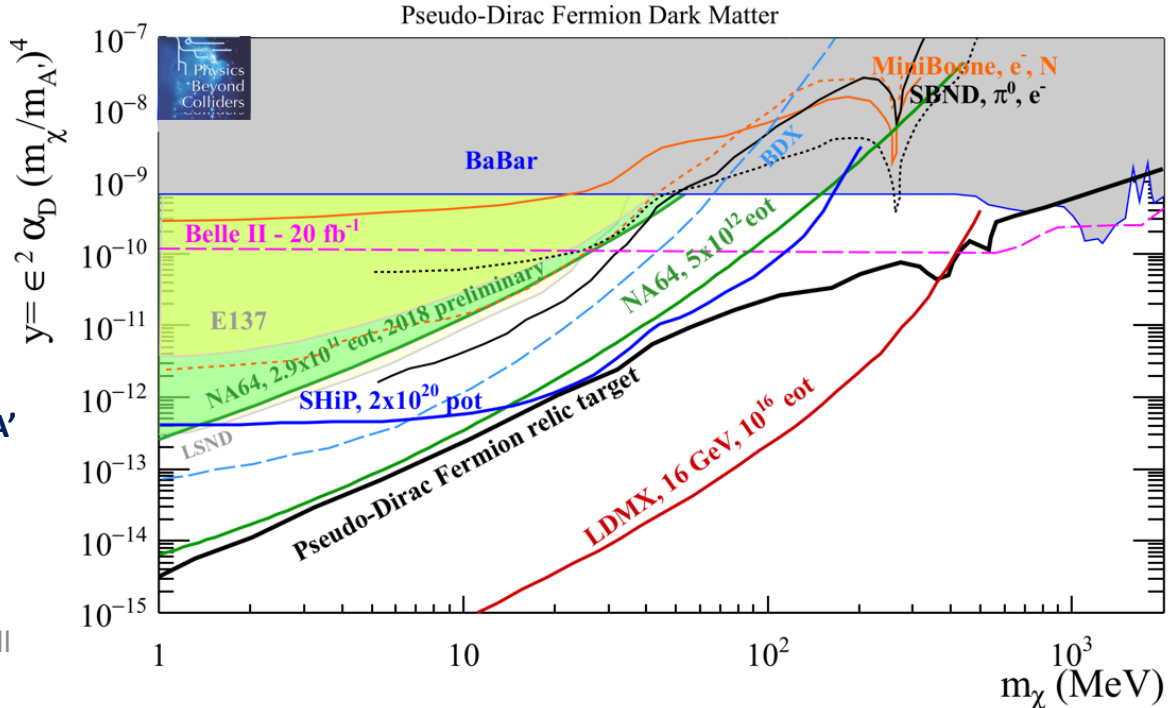
- **Unique NA64++(e) short term opportunity to explore the relevant DM parameter space**
- **Significantly higher reach of LDMX@eSPS, to be put in regard with a possible faster&cheaper implementation of LDMX at SLAC** ***(pending approval of LCLS-II beam extraction)***



$\alpha_D = 0.1$

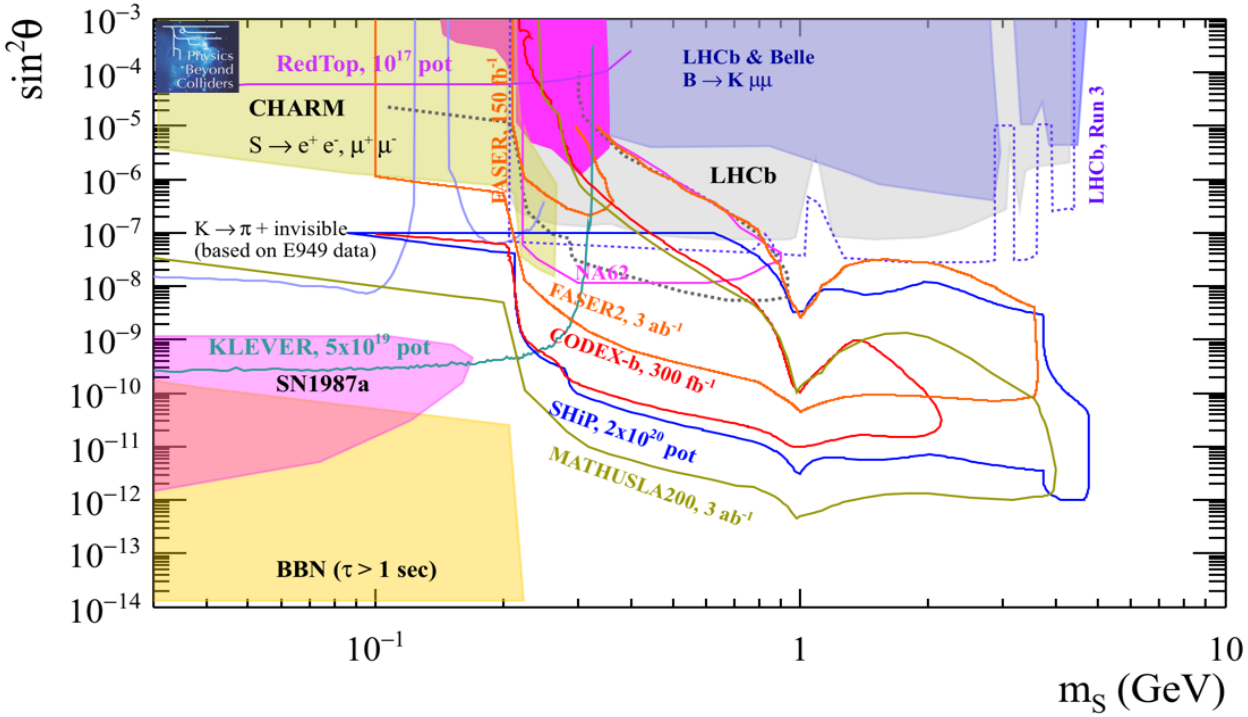
$m_\chi = 1/3\ m_{A'}$



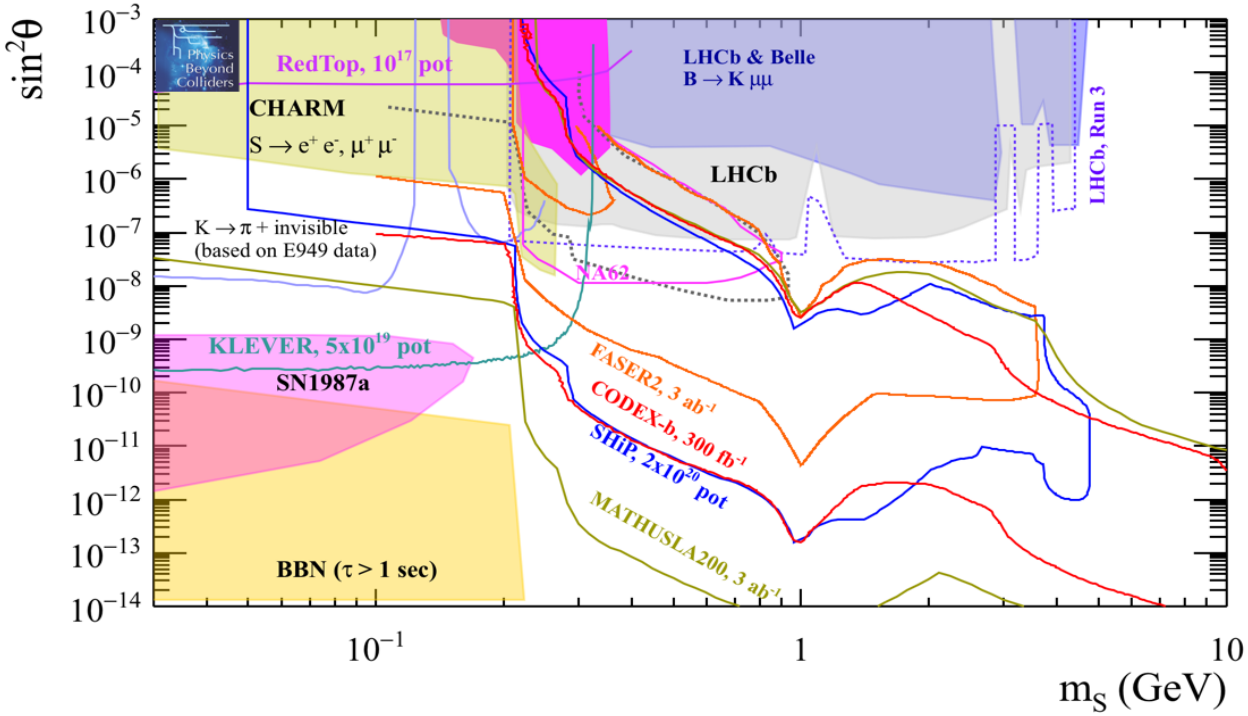


DARK SCALARS

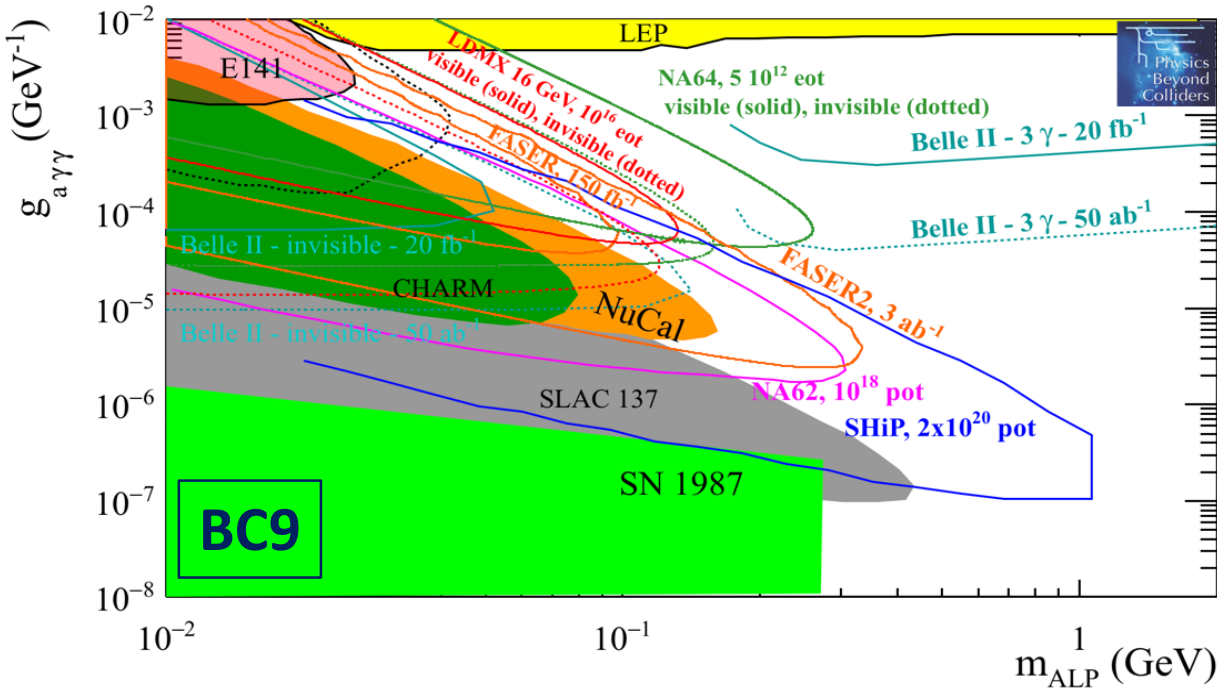
BC4

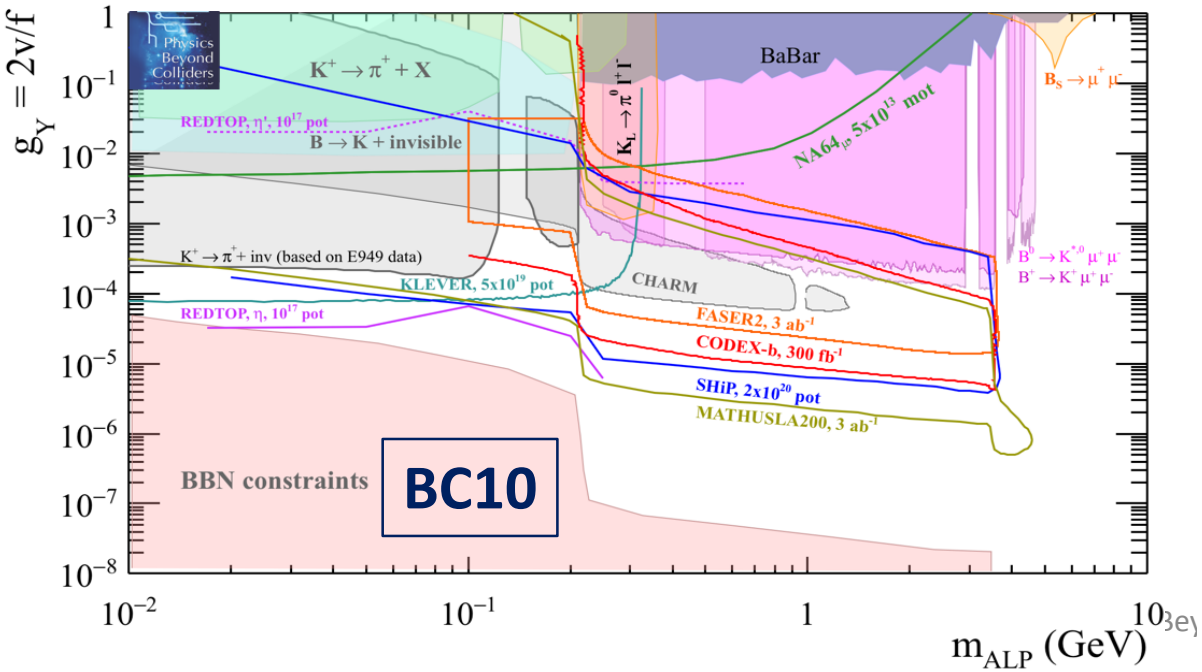


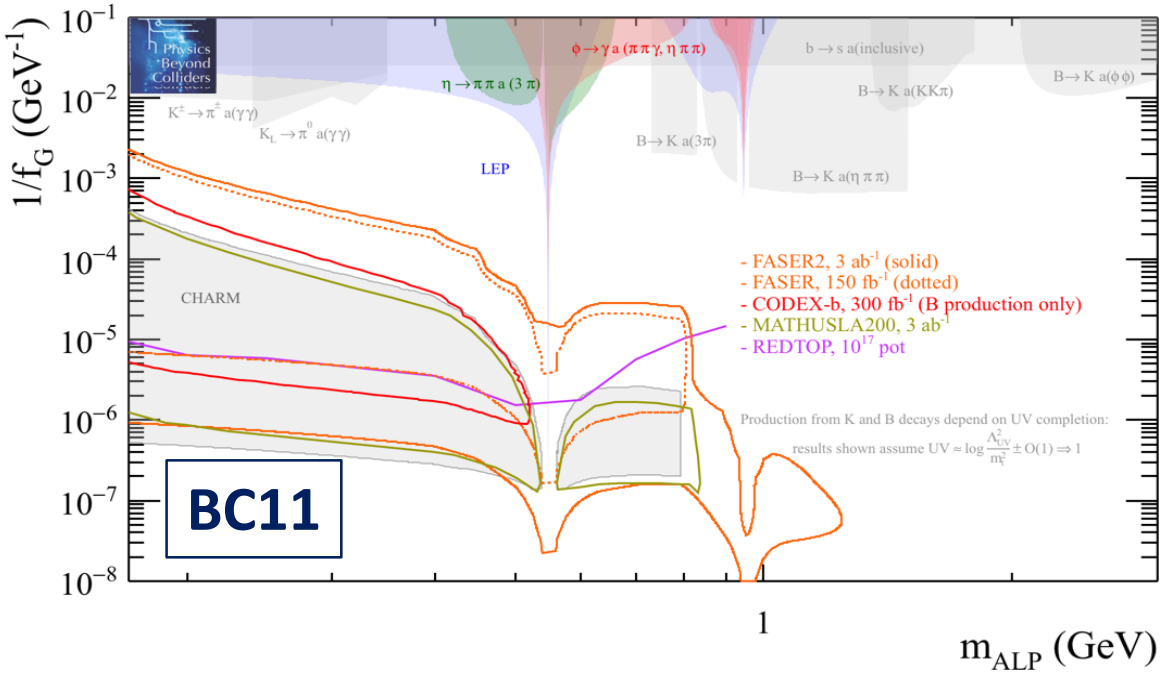
BC5



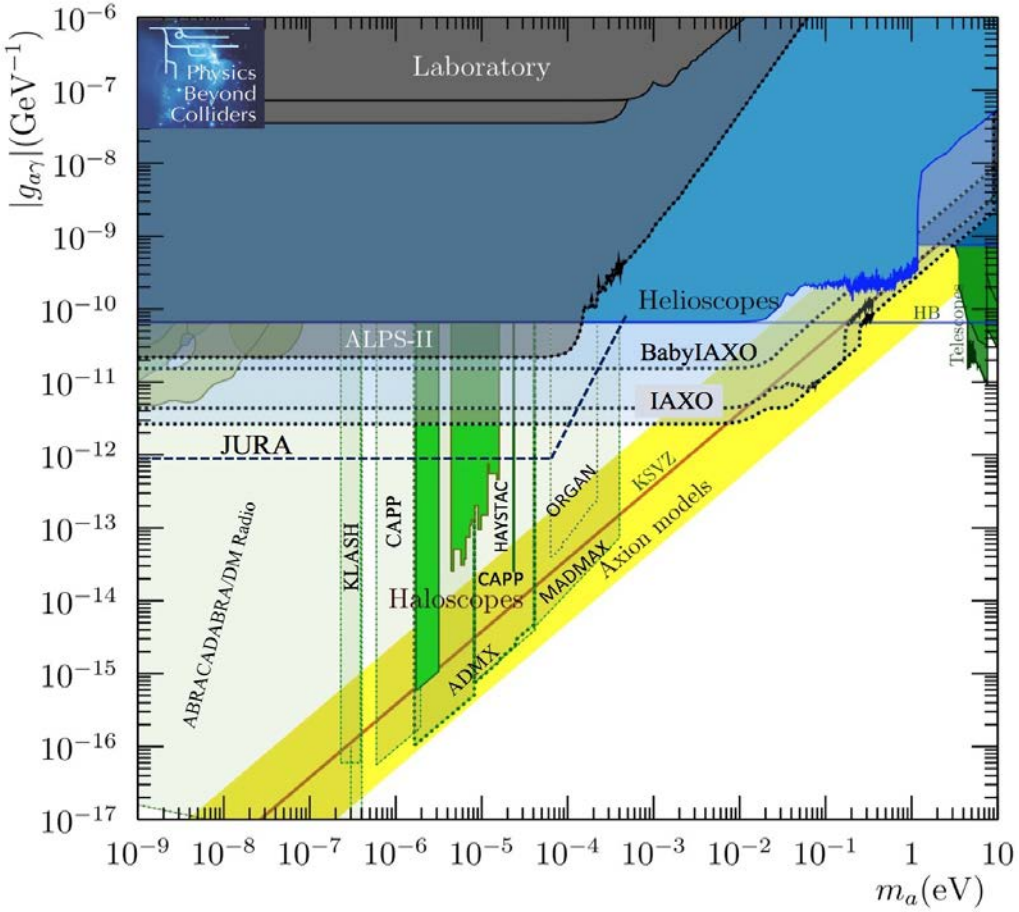
ALPS IN BEAMDUMPS







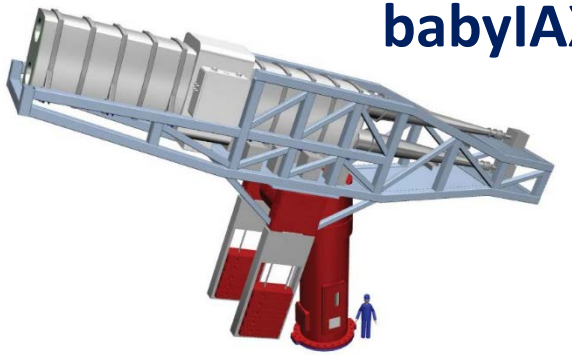
NON-ACCELERATOR PROJECTS



Unique sensitivity to low-mass ALPs

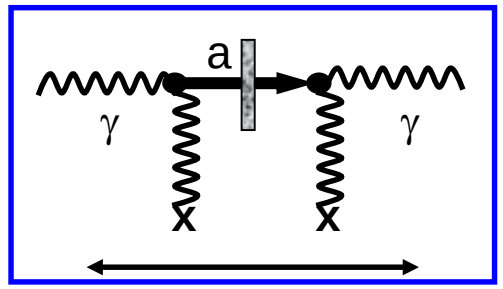
(Baby)IAXO (helioscope successor of CAST) supported by CERN for magnet design
DESY considered as candidate site

JURA possible long term LSW experiment combining state-of-the-art ALPS II optics and high-field CERN magnets



babyIAXO

JURA

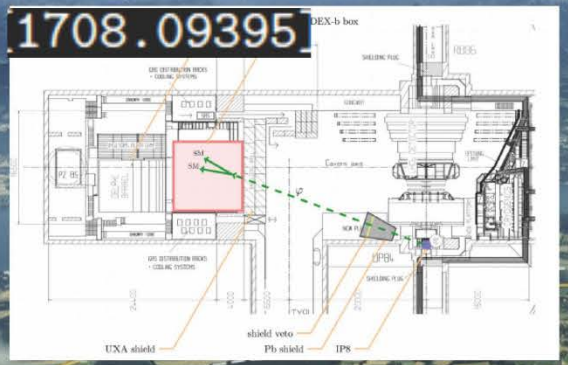


LHC-LLP DEDICATED PROJECTS

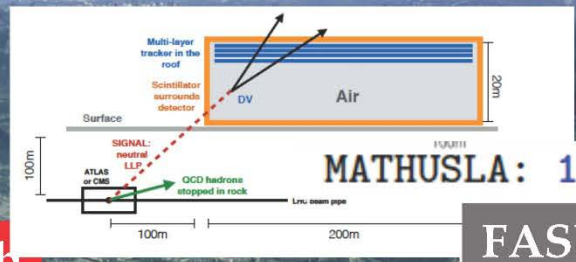
MilliQan, MATHUSLA, FASER, Codex-b @ the LHC IPs

Codex-b @ LHCb IP

1708.09395

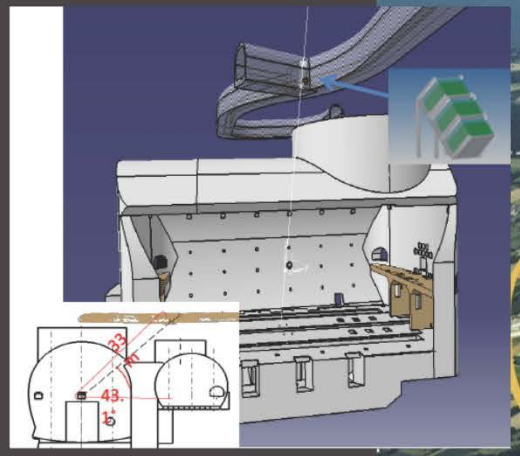


MATHUSLA @ ATLAS or CMS IPs



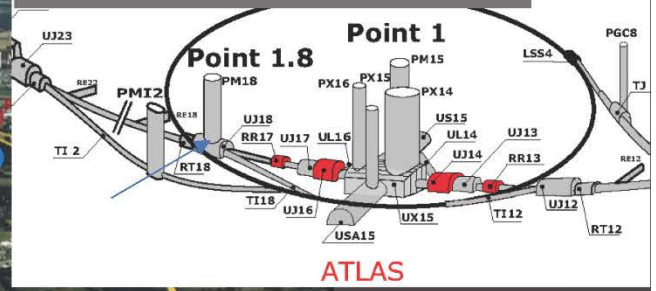
MATHUSLA: 1606.06298

MilliQan @ CMS IP



MilliQan: 1607.04669

FASER @ ATLAS IP

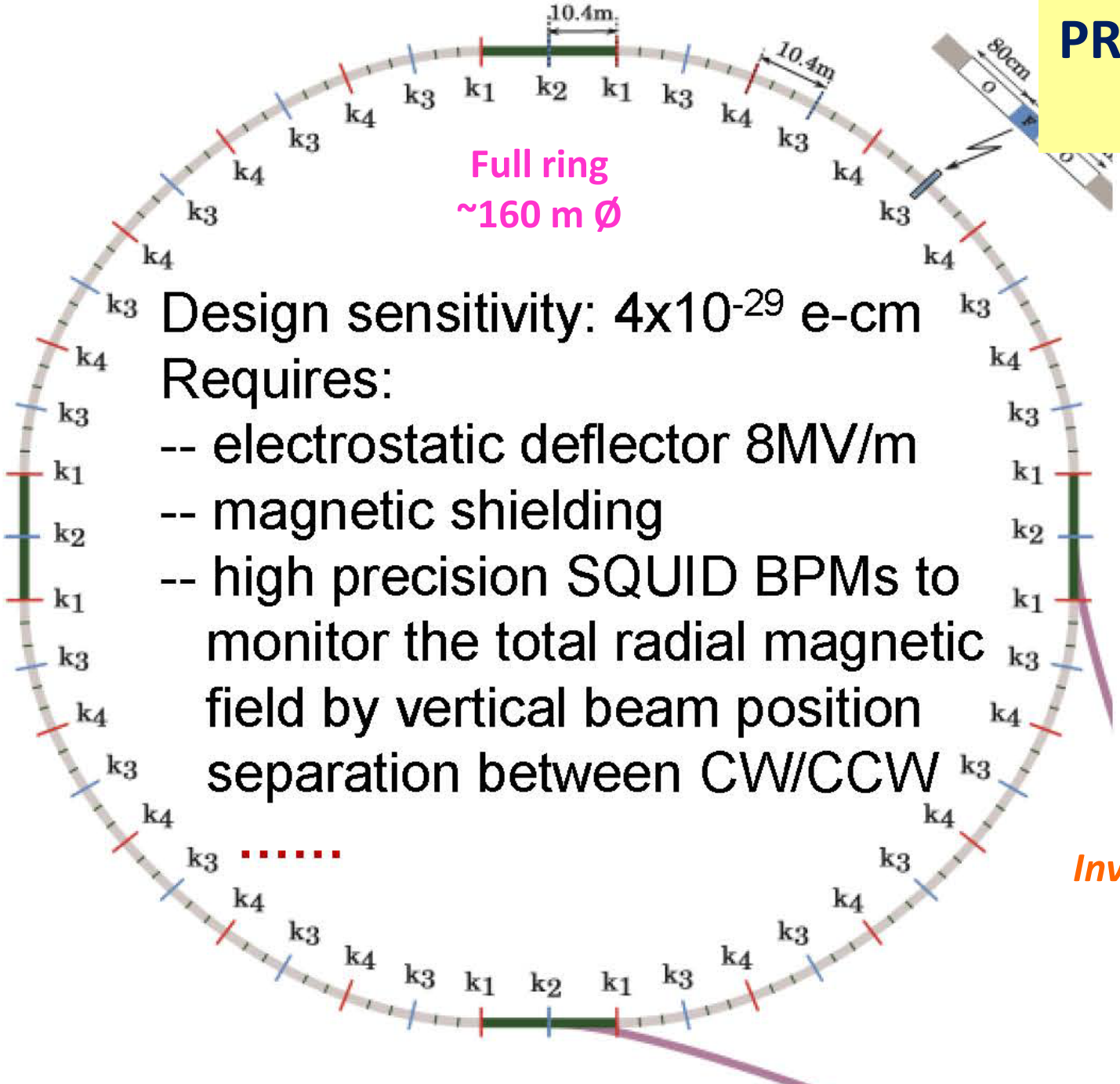


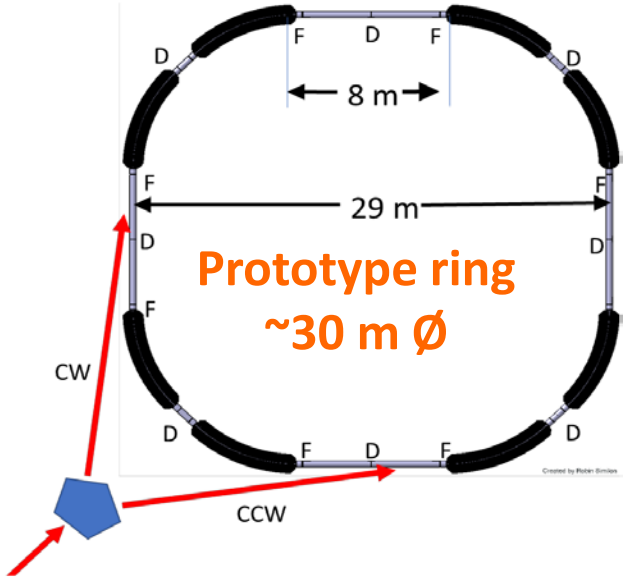
FASER: 1708.09389

Phase I recently approved for run 3

NB: all "small scale" projects except MATHUSLA

PROTOTYPING OF NEW FACILITIES: EDM RING





CPEDM Collaboration built within PBC

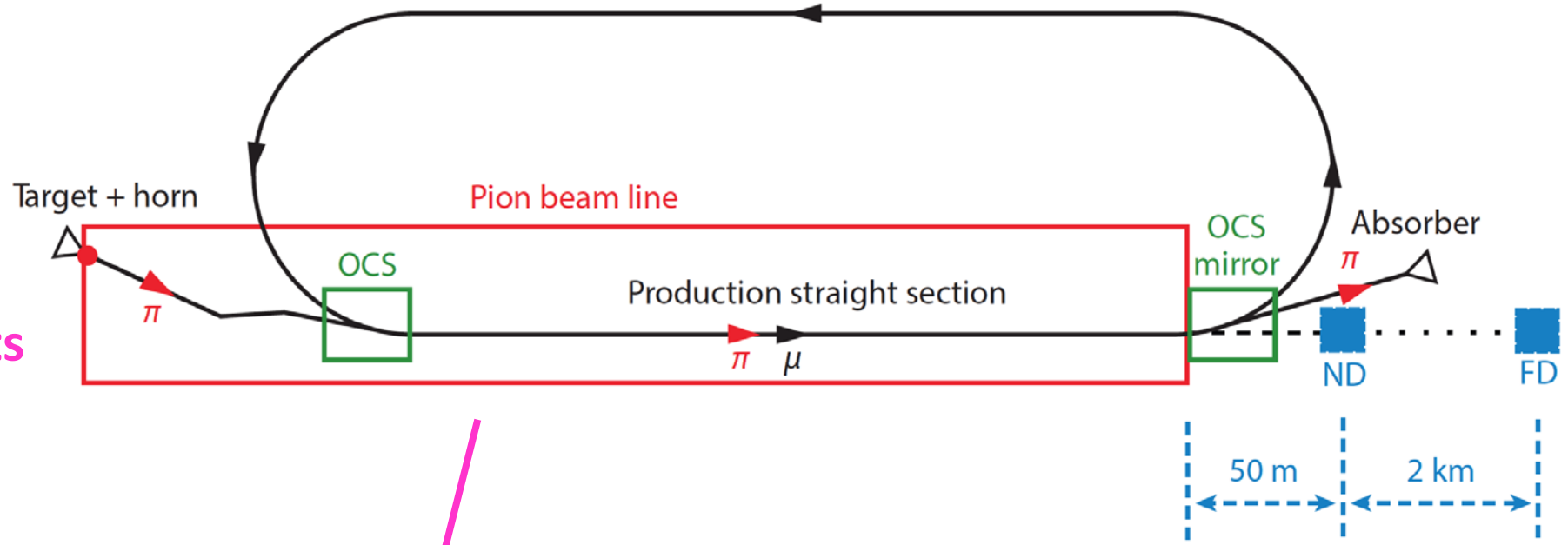
Investigations revealed need of a prototype ring to test and finalize control of systematics.

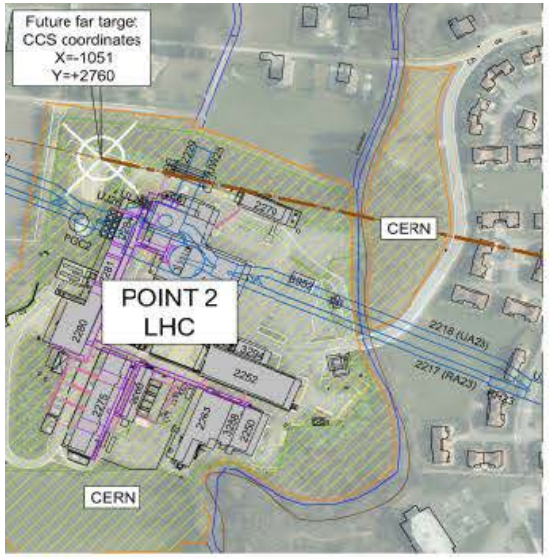
Possible prototype site: COSY in Jülich

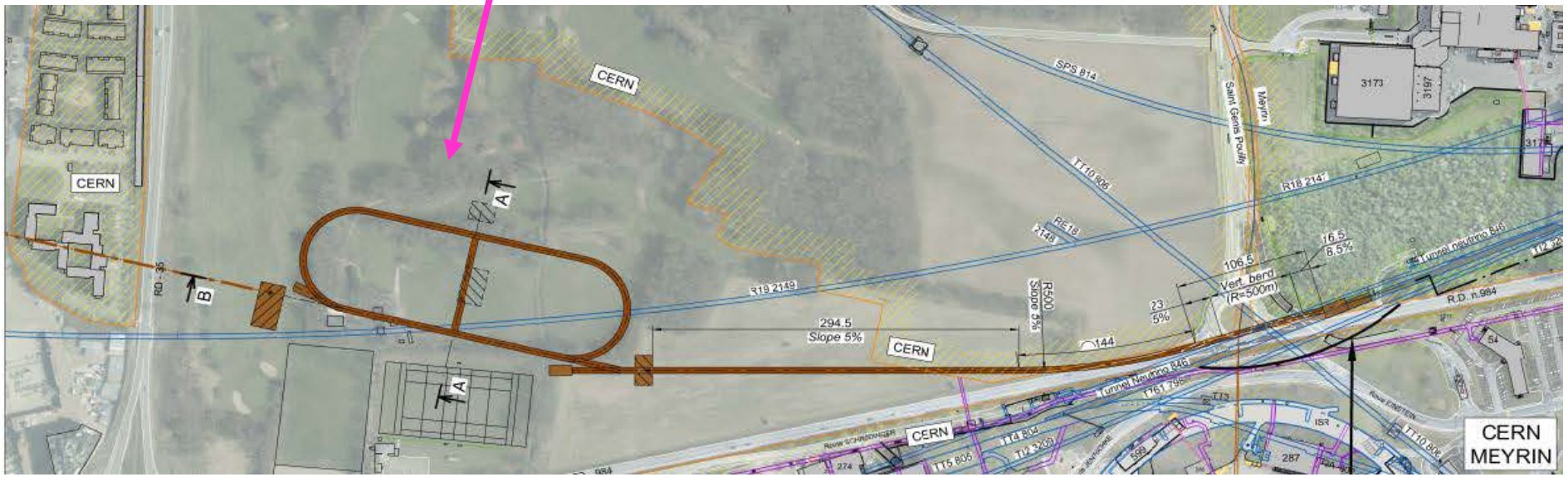
NuSTORM

Well controlled ν beam from a μ storage ring

Precise σ(ν) measurements and a path towards a ν factory or a μ collider.

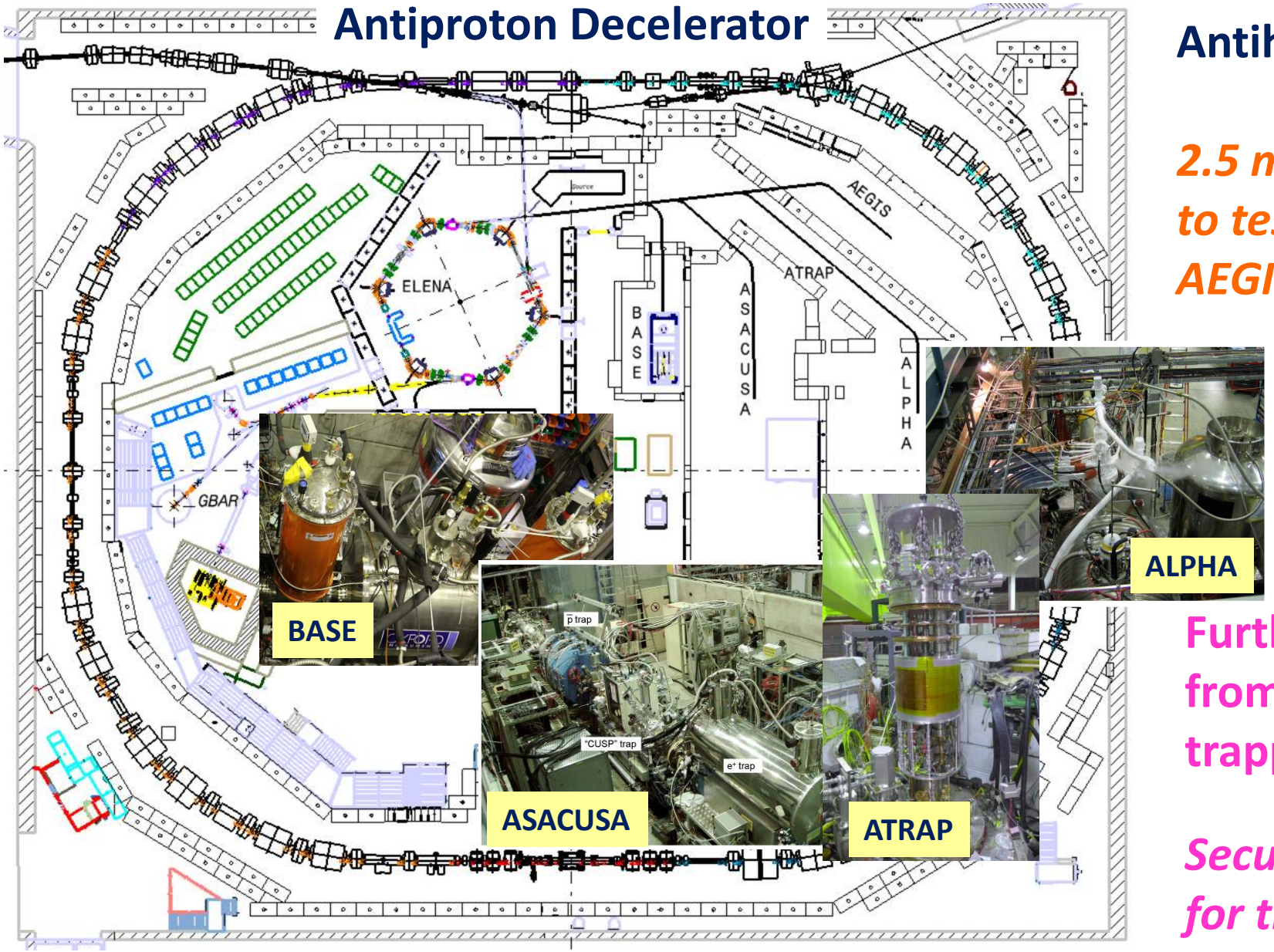






ANTIMATTER FACTORY

Antiproton Decelerator



4 running experiments devoted to Antiproton and Antihydrogen Properties

2.5 more in preparation to test gravity of Antihydrogen: AEGIS/GBAR/ALPHA-g

***AFTER LS2:* ELENA**

Further deceleration of pbar from 5 MeV to 100 KeV → trapping efficiency x ~100

Secures antimatter physics for the next decade