A cold neutron beam facility for particle physics at the ESS

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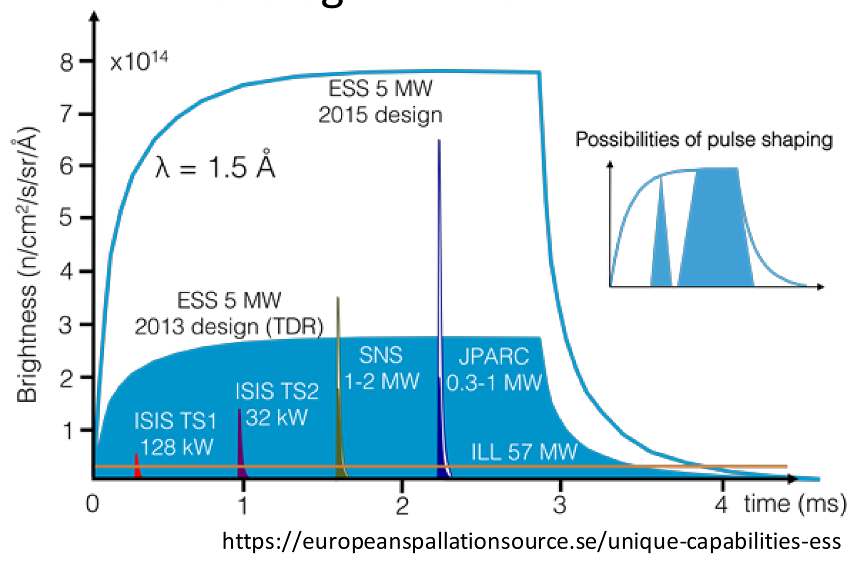
Abstract

Pulsed beams have tremendous advantages for precision experiments with cold neutrons. In order to minimise and measure systematic effects, they are used at continuous sources in spite of the related substantial decrease in intensity. At the pulsed neutron source ESS, such experiments will gain up to a factor of 30 in event rate, and novel concepts become feasible. Therefore, we propose ANNI, a cold neutron beam facility for particle physics, as part of the ESS instrument suite.[6,10]

Advantages of ESS

First pulsed source with higher time-averaged flux than ILL

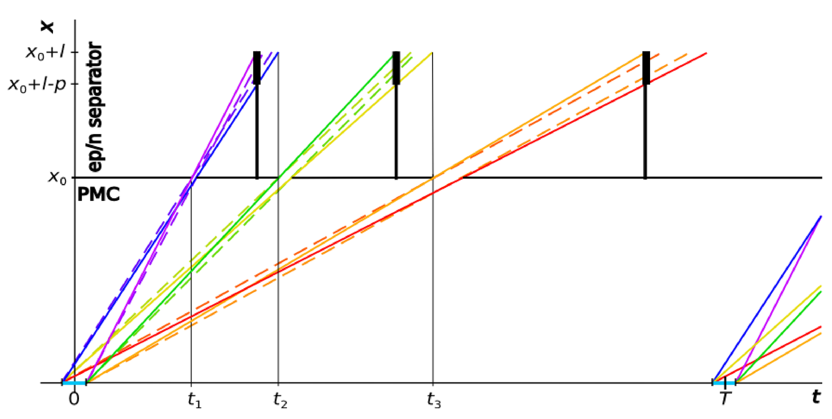


Available without loss of statistics:
→ Information on neutron wavelength/velocity
→ Spatial localization of neutron pulse
→ Time localization of neutron pulse
→ Application of time-dependent neutron optics

Design considerations

- Maximum statistics
- Minimum systematics
- Versatile user instrumentation

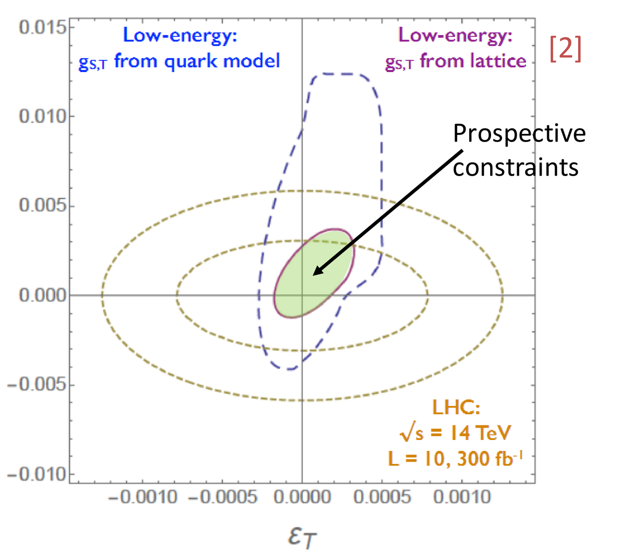
→ Fully exploit pulse structure
→ Assure low background
→ Optimize for beam quality
→ Include polarization
→ Provide flexibility
→ Include **ep/n separator**



Example: Maximize statistics and information on systematics by pulse multiplication (f_{ESS} = 14 Hz)

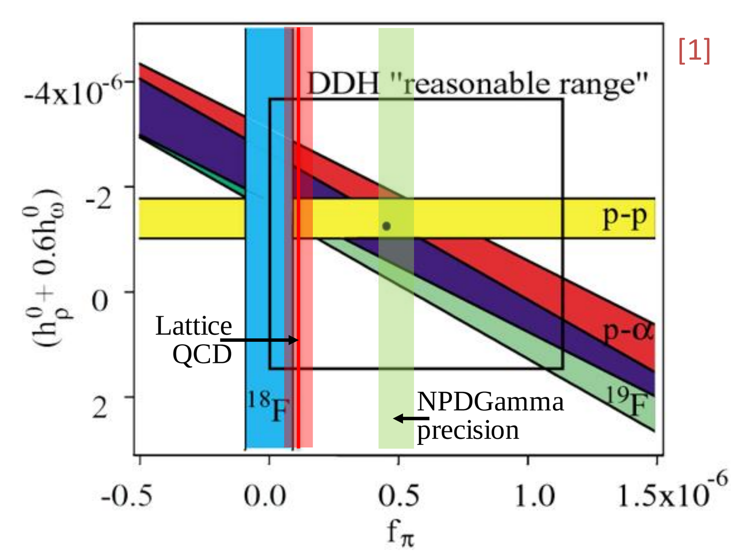
Scientific case

Neutron beta decay [4,5,7]



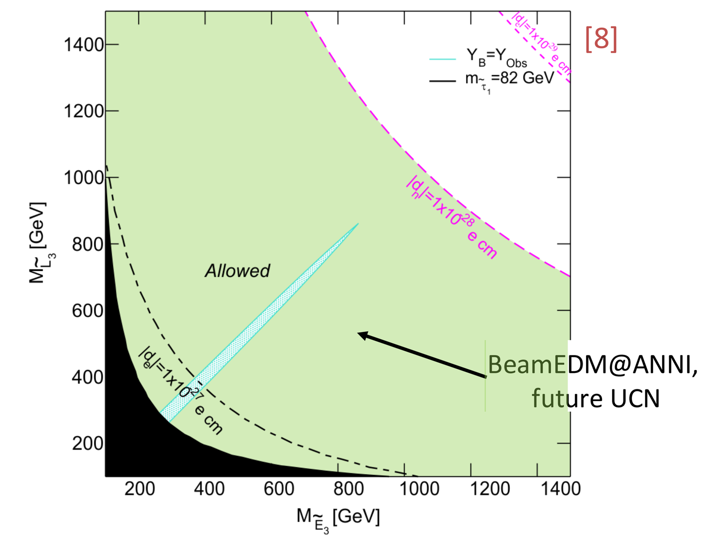
Broad band probe for physics beyond the Standard Model, at mass scales from 1 to 100 TeV[3]

Hadronic weak interaction [1]



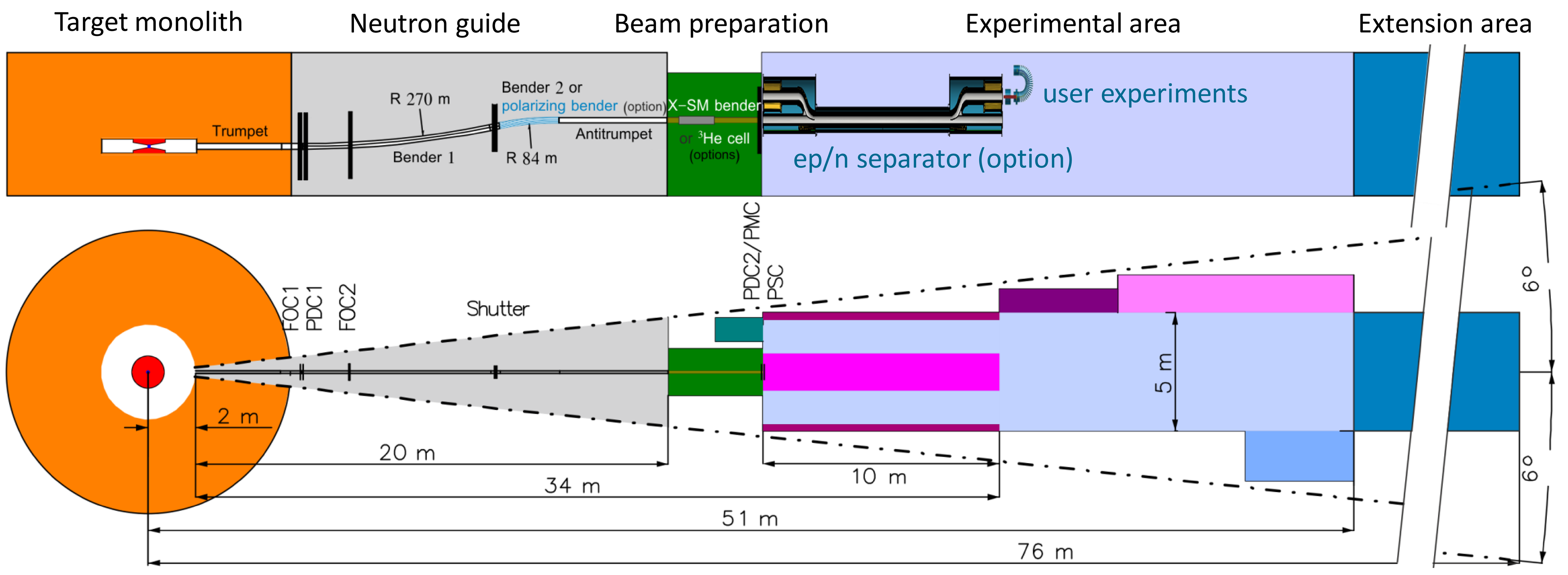
Probe for systematic studies of the non-perturbative limit of quantum chromodynamics

Electromagnetic properties [9]

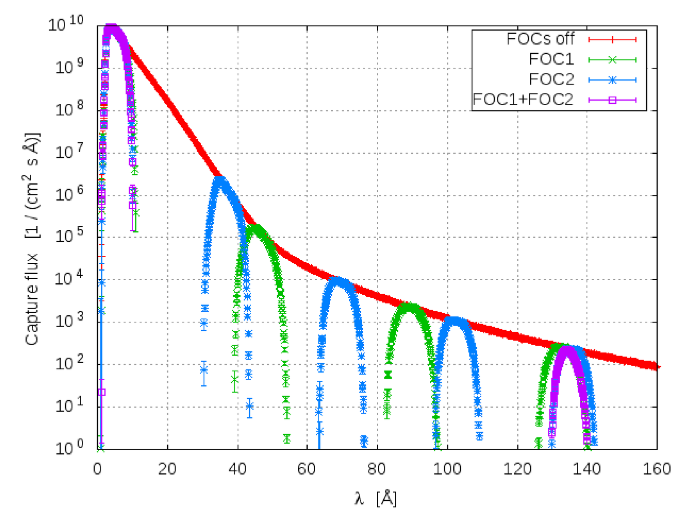


Systematically different probe for matter formation in the Universe or unification of fundamental forces

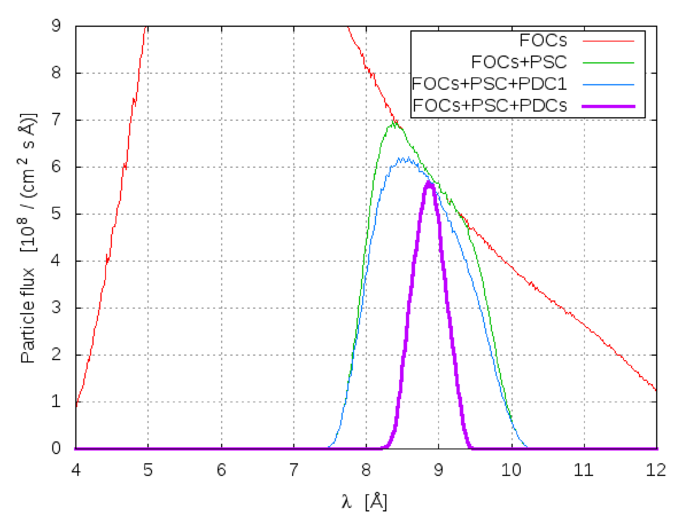
Instrument layout



Chopper system (examples)



Frame overlap suppression until 130 Å



Resolution at 8.9 Å: 0.55 Å FWHM

Polarization

Three options, depending on optimization criteria of user experiment:

1. Moderate polarization at highest intensity
   Bender 2 → Polarizing bender
2. Highest polarization
   Polarizing bender + bender in X-SM geometry (in beam preparation area)
3. Polarization with analytic wavelength dependence
   ^{3}He spin filter (in beam preparation area)

Proposed timeline

2019	2020	2021	2022	2023	2024	2025	2026	2027
Proposal round	Construction						Hot commissioning	User program

Benchmarks

Experiment	Facility	Event rate	S/B
NPDGamma	FnPB (SNS)	**15**	1
PERC	MEPHISTO (FRM II)	**17** **34 (PMC)**	1 1 (PMC)
PERKEO III	PF1B (ILL)	**6** **16 (PMC)**	1 1 (PMC)
*a*SPECT	PF1B (ILL)	1 0.4	**3** **10**
BeamEDM	PF1B (ILL)	**25**	1

World leading even at reduced ESS power

Expected performances

Parameter	Value
Capture flux full spectrum	$5.4\cdot10^{10}$ n/(cm²s) at guide exit $1.8\cdot10^{10}$ n/(cm²s) at start of experimental area
Capture flux 2 – 8 Å (FOCs)	$4.0\cdot10^{10}$ n/(cm²s) at guide exit $1.4\cdot10^{10}$ n/(cm²s) at start of experimental area
Particle flux @ 8.9 Å	$5.8\cdot10^{8}$ / (cm²sÅ) at start of experimental area (with additional guide in beam definition area)
Divergence distribution FWHM	42 mrad horizontal 22 mrad vertical
Instantaneous bandwidth	0.43 Å

ANNI Collaboration

Current members come from

New partners very welcome!

References

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