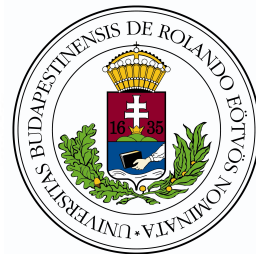


# Workshop Conclusion & Action Items

Yoshikazu Nagai



**ELTE**

Eötvös Loránd  
University

December 10, 2020, NA61/SHINE at Low Energy workshop



















## NA61/SHINE at Low Energy













- Welcome to the workshop!
- **Goal** is to discuss the physics case and the technical feasibility for a new low-energy hadron physics program at NA61/SHINE
  - Need has been developing for a while
  - Main program would be after LS3, but with interest and resources beam could be available as early as 2024
- Two days of talks, ~4 hours per day
- Long talk slots: time for details and discussion
- Sessions will be recorded: please let us know if you do not want your talk recorded.

## Making this physics program happen

### next few years endeavor

- Bringing this to reality will require resources and work by NA61 collaborators, and support from outside the collaboration
- Opportunities abound to join NA61 and contribute to these measurements directly! Many other physics topics are available now and in the next couple of years too.,
- Suggestions — both technical and physics-related — are welcome!
- Please contact the organizing committee and/or NA61 spokespersons Marek Gazdzicki, EDZ (deputy).

9 Dec 2020	
15:00	NA61/SHINE at Low Energy Day 1 - Kate Scholberg (Duke University) Yoshikazu Nagai (University of Colorado Boulder (US)) (until 19:10) ()
15:00	Workshop Introduction - Eric Daniel Zimmerman (University of Colorado Boulder (US)) ()  
15:05	NA61/SHINE introduction and overview - Marek Gazdzicki (Goethe University Frankfurt (DE)) ()  
15:30	Low-energy physics overview - Yusuke Koshio (Okayama University) ()  
16:00	Physics application 1: JSNS2 - Shoichi Hasegawa (J) ()  
16:30	Overview of the beam and possible upgrades - Nikolaos Charitonidis (CERN) ()  
17:00	--- Group picture ---
17:03	--- Break ---
17:20	Plans for the CALICE detector - Lucia Masetti (Johannes Gutenberg Universitaet Mainz (DE)) ()  
17:40	Physics application: COHERENT - Rebecca Rapp (Carnegie Mellon University) ()  
18:10	Physics application: Booster Neutrino Beam - Zarko Pavlovic (Fermilab) ()  
18:40	The EMPHATIC experiment - Jonathan Paley (Fermi National Accelerator Lab. (US)) ()  

10 Dec 2020	
15:00	NA61/SHINE at Low Energy Day 2 - Eric Daniel Zimmerman (University of Colorado Boulder (US)) Ken Sakashita (High Energy Accelerator Research Organization (JP)) (until 19:00) ()
15:00	Physics application: atmospheric neutrinos - Kazufumi Sato (Nagoya University) ()  
15:30	Physics application: Long-baseline (Japan) - Lukas Berns (Tokyo Institute of Technology) () 
15:50	Physics application: Long-baseline (US) - Dr Leonidas Aliaga Soplin (Fermilab) () 
16:10	Gabor lenses - Oliver Meusel (Goethe University Frankfurt) ()  
16:40	--- Break ---
17:00	Low-energy beam design - Carlo Alberto Mussolini (University of Oxford (GB)) ()  
17:30	Instrumentation for a low-energy beam - Ken Sakashita (High Energy Accelerator Research Organization (JP)) ()  
18:00	Practical issues: brainstorming session - Nikolaos Charitonidis (CERN) () 
18:30	Workshop conclusion and action items - Yoshikazu Nagai (University of Colorado Boulder (US)) () 

We discussed detail on physics applications, project detail, and instrumentation, including nice overviews and introduction on relating project

I will not repeat each detail here since physics motivation has been clearly presented by each presenter. Instead, try to identify necessary actions from now and summarize findings during workshop

# Action Items

To be an official project at CERN SPS (SPSC report)

- Write a low-E beamline section in annual NA61's Status Report - to signal our interests on earlier realization to SPSC (Done in October 2020) see: <https://cds.cern.ch/record/2739340>
- An open workshop on the low-E beamline project - to explore the physics opportunities at the H2 beamline (NA61/SHINE) and discuss necessary actions for realization (We are here!)
- Official proposal to the SPSC committee (aiming earlier 2021)

Three parallel studies

- Accelerator design & construction
- Beam instrumentation
- Physics application

Financing

- Identifying and investigating funding options outside CERN

# SPSC



A preliminary idea of a timeline  
(pending budget / schedule clarifications)

Task	S1 2021	S2 2021	S1 2022	S2 2022	S1 2023	S2 2023	S1 2024	S2 2024
Optics, Layout & Integration	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Magnets Refurbishment & construction of elements		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Cabling modifications and installation*					Green	Green	Green	Green
Operation & Data taking							Green	Green

\* Part of the installation should happen in-tandem with beam operation

Immediate step would be to submit a **strong physics request** to get endorsed by SPS-C / RB  
After cost evaluation, investigate options of funding outside CERN ?

9/12/2020

N. Charitonidis - Very Low Energy Beams in EHN1



- Project proposal document
  - Strong physics motivations - as we heard details in this workshop.  
need clear justification, description for measurement plan (PoT, beam type, etc..)
  - Support from community - supporting letters attached to the official proposal.  
We'll contact relating parties (private unofficial conversation has already started)
- Working schedule

Next SPSC: 19th Jan. 2021

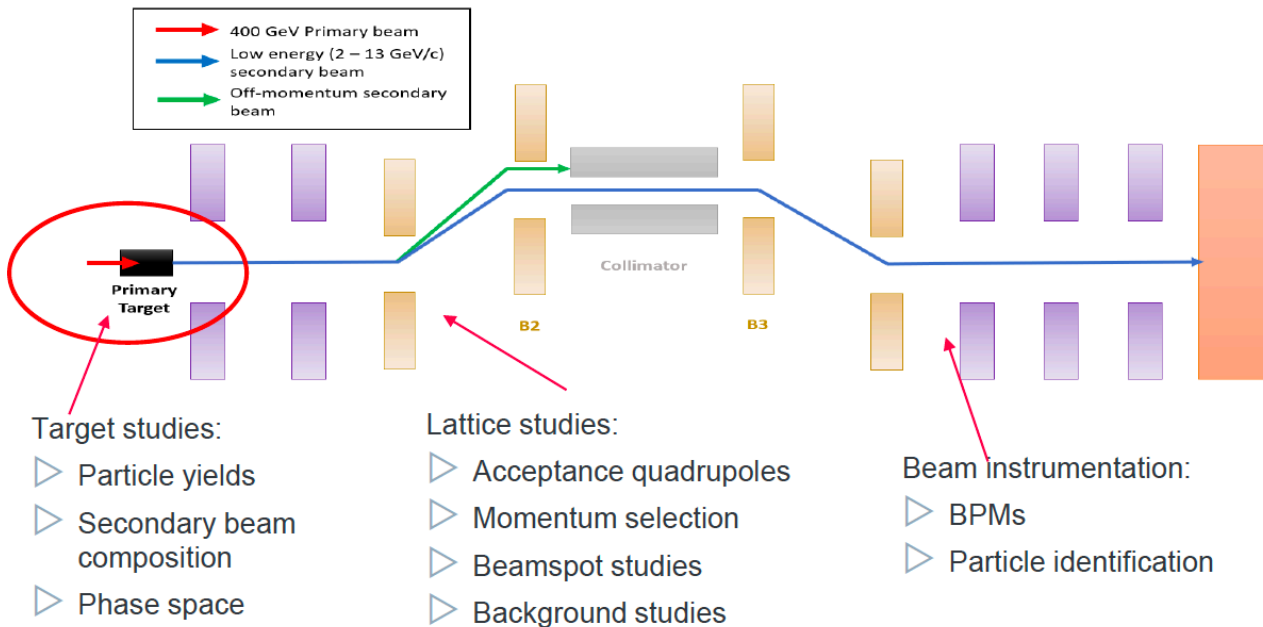
<https://committees.web.cern.ch/spsc>

(Next to Next: April 2021, then June, October)

# Accelerator design & construction

- Project overview and design status

## Low-Energy Beamline Conceptual Design



- Three components:
  - Tertiary target station
  - Beamline optics
  - beam instrumentation

**Promising progress!**

- Schedule:
  - ▷ With the aim of having a first 'feasible design' in May

C. A. Mussolini, N. Charitonidis 4

# Accelerator design & construction

## 10 Day Preliminary Number of Particles

Preliminary numbers for a 10 day run		High Composition Target		Balanced Target		High Yield Target	
		Number	Composition	Number	Composition	Number	Composition
2 GeV/c	Pion+	2,409,000	55.20%	6,237,000	43.80%	10,917,000	25.20%
	Proton	780,000	17.90%	2,700,000	18.90%	3,960,000	9.10%
	Kaon+	33,000	0.80%	93,000	0.70%	168,000	0.40%
4 GeV/c	Pion+	4,851,000	71.00%	14,163,000	68.20%	25,416,000	56.30%
	Proton	960,000	14.10%	2,730,000	13.10%	4,500,000	10.0%
	Kaon+	300,000	4.40%	633,000	3.00%	1,053,000	2.30%
6 GeV/c	Pion+	7,461,000	78.70%	19,476,000	76.10%	40,770,000	69.70%
	Proton	990,000	10.40%	3,210,000	12.50%	6,120,000	10.50%
	Kaon+	663,000	7.00%	1,266,000	4.90%	1,899,000	3.20%
13 GeV/c	Pion+	11,084,100	79.80%	31,800,000	80.80%	75,060,000	81.10%
	Proton	1,290,000	9.30%	4,500,000	11.40%	7,800,000	8.40%
	Kaon+	1,479,000	10.70%	2,451,000	6.20%	5,322,000	5.80%

# Accelerator design & construction

- Further improvement of beam quality may be possible

Logos: NNP Non Neutral Plasma Physics Group, IAP Institut für Angewandte Physik Frankfurt am Main, GOETHE UNIVERSITÄT FRANKFURT AM MAIN

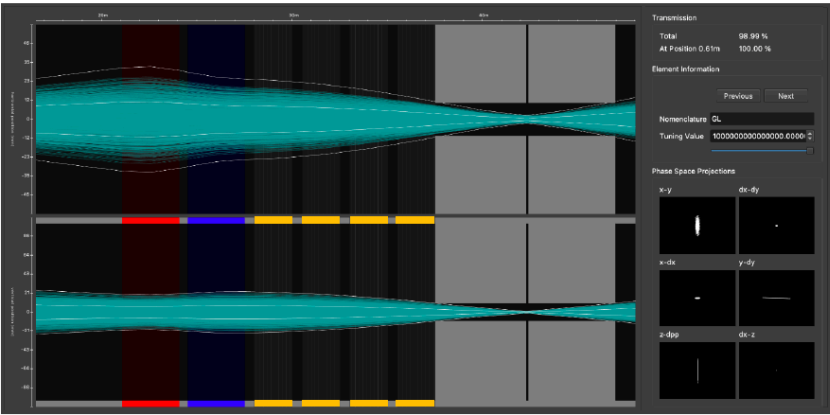
## Motivation

- Accelerator Physics
  - How can we preserve the brightness of hadron beams passing very long transfer lines?
  - Can we combine smooth focussing and a phase space compression to enhance the luminosity for fixed target experiments?
- Non-neutral plasma physics
  - Can we measure the collective interaction of relativistic hadron beams with pure electron plasmas?
  - What can we learn to mitigate the electron cloud effect in synchrotrons like SPS or LHC?
- Advanced electron targets
  - Is there any deep inelastic reaction between hadrons and electrons measurable by the use of Gabor-Lenses?

Logos: NNP Non Neutral Plasma Physics Group, IAP Institut für Angewandte Physik Frankfurt am Main, GOETHE UNIVERSITÄT FRANKFURT AM MAIN

## ... and for VLE

Simulations with 1GeV/c p-beam started and the very first sets looking promising.



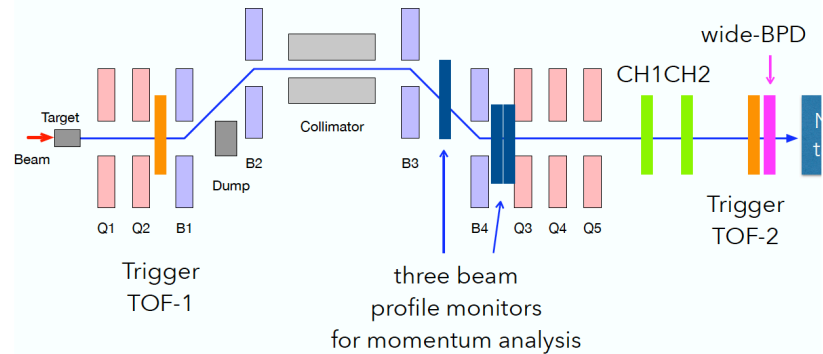
existing Quadrupole    4 Gabor-Lenses    Aperture / Collimator



# Beam instrumentation

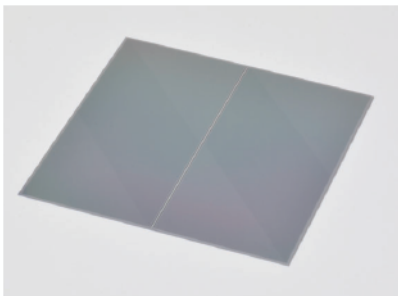
- Necessary additional beam position detector and PID

## Summary of initial idea of beam instrumentation

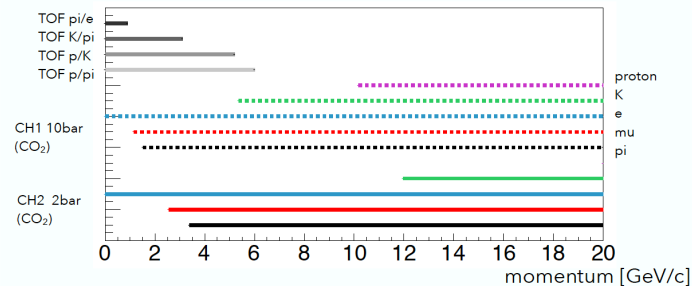


- An idea shown for BPD
  - Silicon strip detector to cover wide-area
- Time-of-Flight based PID
  - Detector technology: **open question**
  - Still need optimization above 5 GeV
- particle-by-particle momentum measurement
  - with beam profile monitors + magnet
- Schedule?

Si strip detector(Hamamatsu S13804)



0.19mm pitch x 512ch x 2



momentum	e	$\pi$	K	p
1	CH1 & CH2	TOF	TOF	TOF
3	CH1 & CH2	TOF & CH1	TOF	TOF
5	CH1 & CH2	CH1 & CH2	TOF	TOF
10	CH1 & CH2	CH1 & CH2	CH1 & CH2	CH1 & CH2
15	CH1 & CH2	CH1 & CH2	CH1 & CH2	CH1 & CH2

optimization is necessary

# Physics application

- Various ideas presented during “physics application” talks

- Very low-E proton beam down to ~1 GeV

Conclusion

## COHERENT and NA61/SHINE

- ◇ Reducing the 10% systematic on the  $\nu$  flux required for precision CEvNS
- ◇ COHERENT will measure  $\nu$  flux at the SNS before the beam energy increases in 2024 (D<sub>2</sub>O)
- ◇ Hadron production data at 1 GeV will benefit our simulation and design efforts
- ◇ Interested in full cross-section: all product angles and momenta
- ◇ Some specific interests for understanding SNS  $\nu$  flux:

Component	Materials	Incident proton energy
<b>FTS target</b>	Hg	$\leq 1.3$ GeV
<b>STS target</b>	W	$\leq 1.3$ GeV
Aluminum window	Al	1 and 1.3 GeV
Inconel window	Ni, Cr, Fe	1 and 1.3 GeV
Shielding	Fe, C	$\leq 1.3$ GeV



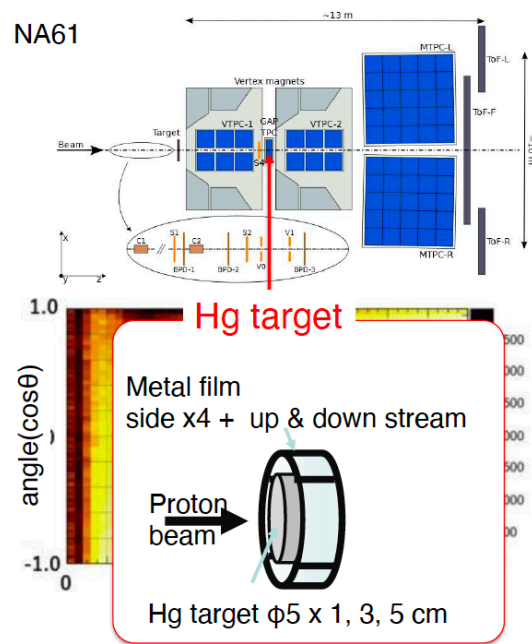
# Physics application

- Various ideas presented during “physics application” talks

- Very low-E proton beam down to ~1 GeV
- Where should we put target?
- 



## Idea



- Beam condition  
Proton beam; 1, 3, 5, 7, 10 GeV

### 1) JSNS<sup>2</sup> Neutrino Flux

- P + Hg → π, K cross section
- Using NA61 detector  
+ thin Hg target (3 type)

### 2) MLF Neutron production

- Set film around target. Then gamma spectrum of activated film is measured with our Ge-detector
- Set neutron detector if event rate is low.

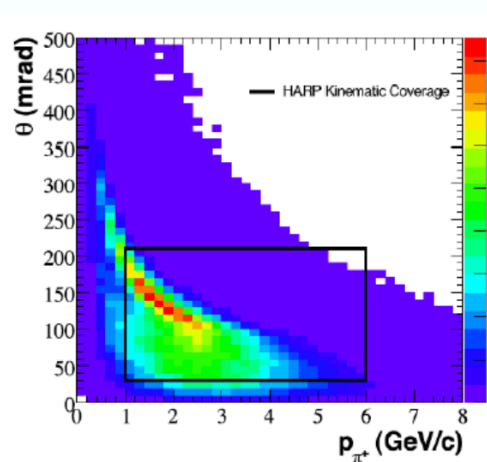


# Physics application

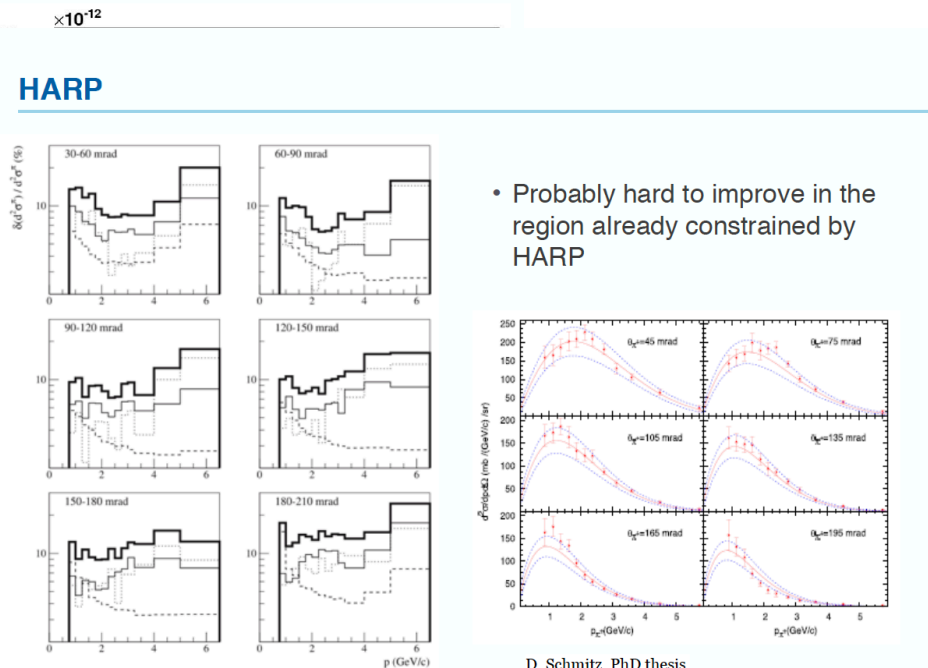
- Various ideas presented during “physics application” talks

## HARP coverage

- Neutrino mode
  - 90% of numu flux from  $p+\text{Be} \rightarrow \pi^+ \rightarrow \text{numu}$
  - 78% of flux from  $\pi^+$  covered by HARP measurement



12 12/08/2020



- Probably hard to improve in the region already constrained by HARP

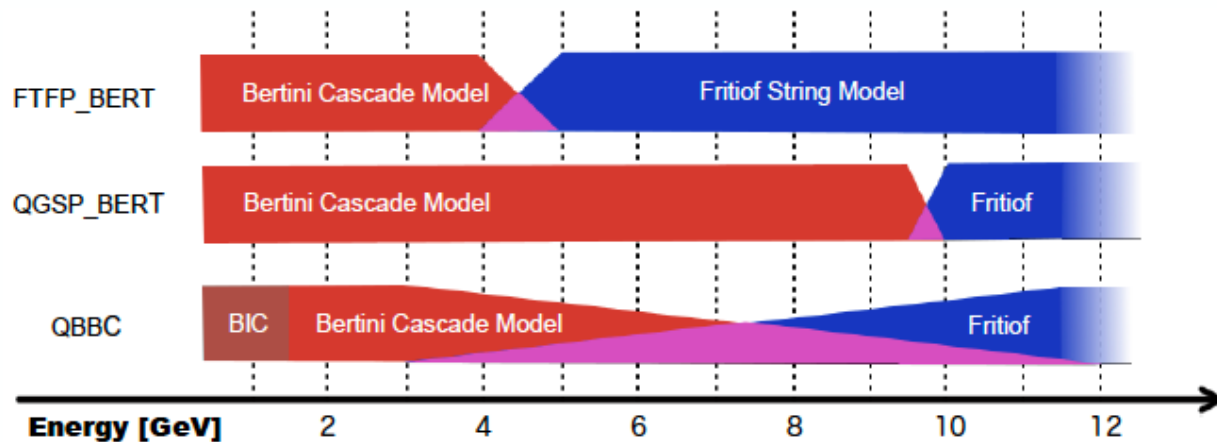
D. Schmitz, PhD thesis

- Very low-E proton beam down to  $\sim 1$  GeV
- Where should we put target?
- Possible extension of phase space?
- Possible precision improvement?

11 12/08/2020

# Physics application

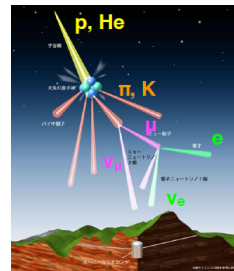
- Various ideas presented during “physics application” talks



- Very low-E proton beam down to ~1 GeV
- Where should we put target?
- Possible extension of phase space?
- Possible precision improvement?
- Wide E-range at the same beamline

# Physics application

- Various ideas presented during “physics application” talks



- Very low-E proton beam down to  $\sim 1$  GeV
- Where should we put target?
- Possible extension of phase space?
- Possible precision improvement?
- Wide E-range at the same beamline

and more..!?

(Marek) NA61/SHINE has limited membership system to grant access to the official software framework

—> Feasibility study is possible immediately !!

## Misc.

- The earliest realization of the low-E beamline: end of 2023 or 2024
  - There is a chance for one year data taking before LS3 starts (2025-2026)
    - > For people requiring the urgent measurements, this is very good opportunity (so far we heard from JSNS<sup>2</sup>)
    - > Need to be prepared beforehand (in next 1-2 years)
  - Of course, post-LS3 will be a main beam time utilizing this new beamline!

# Announcement

- We have ~monthly meetings for the low-E beamline project (**open everyone!**)
  - Typically, Friday afternoon in Europe time (but we can try to find an optimum slot)
- Please subscribe to the dedicated e-group  
“na61-lowE-beamline” from here: <https://e-groups.cern.ch>  
(or contact me if you cannot)
  - Meeting announcement is sent to this list
  - Next meeting will be determined later

## November 2020

 20 Nov **(Canceled!)** [H2 low-E beamline meeting](#)

## October 2020

 30 Oct [H2 low-E beamline meeting](#)

## September 2020

 18 Sep **(No meeting!!)** [H2 low-E beamline meeting](#)

## August 2020

 28 Aug [H2 low-E beamline meeting](#)

## July 2020

 09 Jul [H2 low-E beamline meeting](#)

## May 2020

 06 May [H2 low-E beamline meeting](#)

## February 2020

 04 Feb [H2 low-E beamline discussion](#)



