nBLM SYSTEM STATUS

Laura Segui

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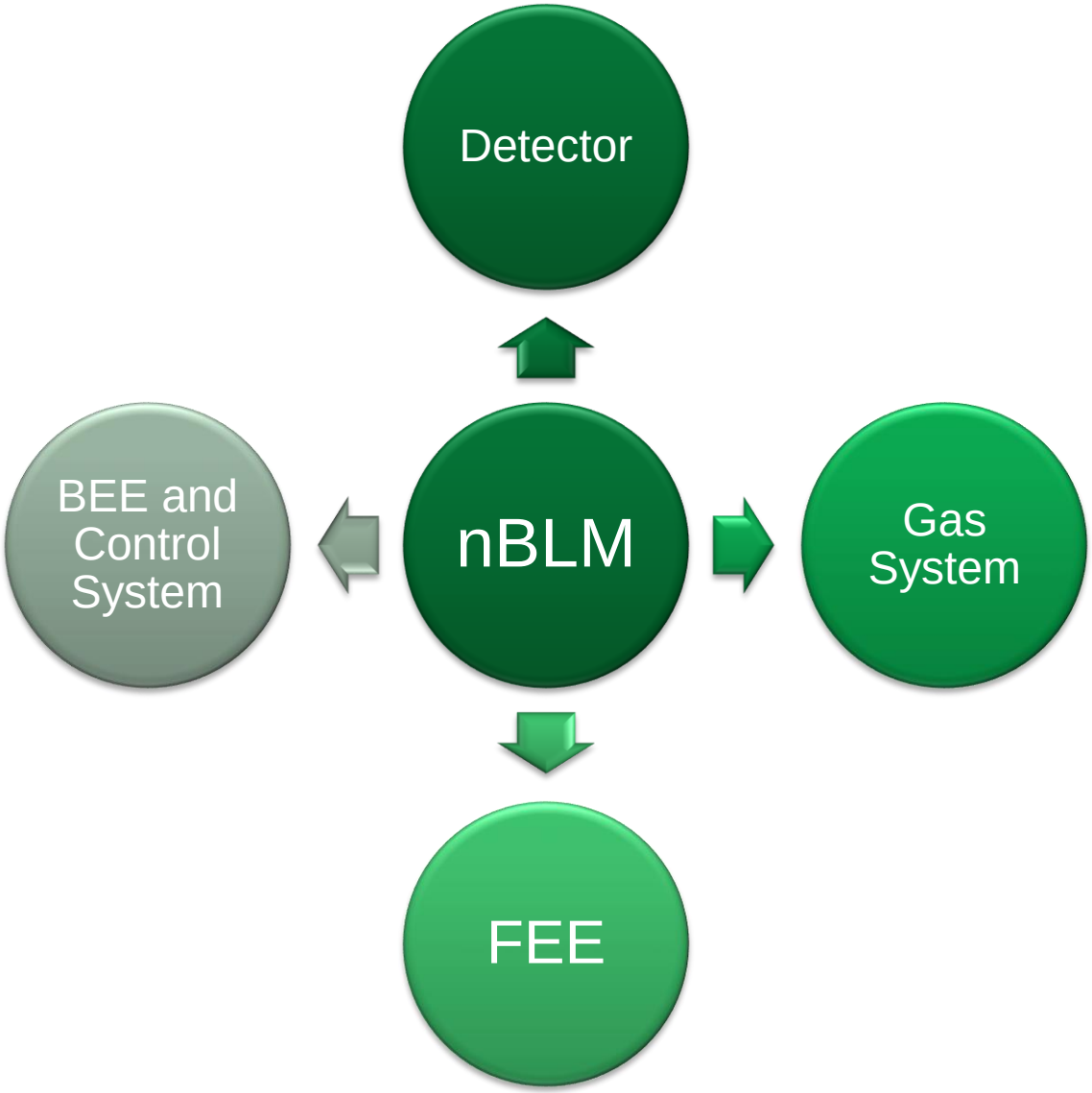
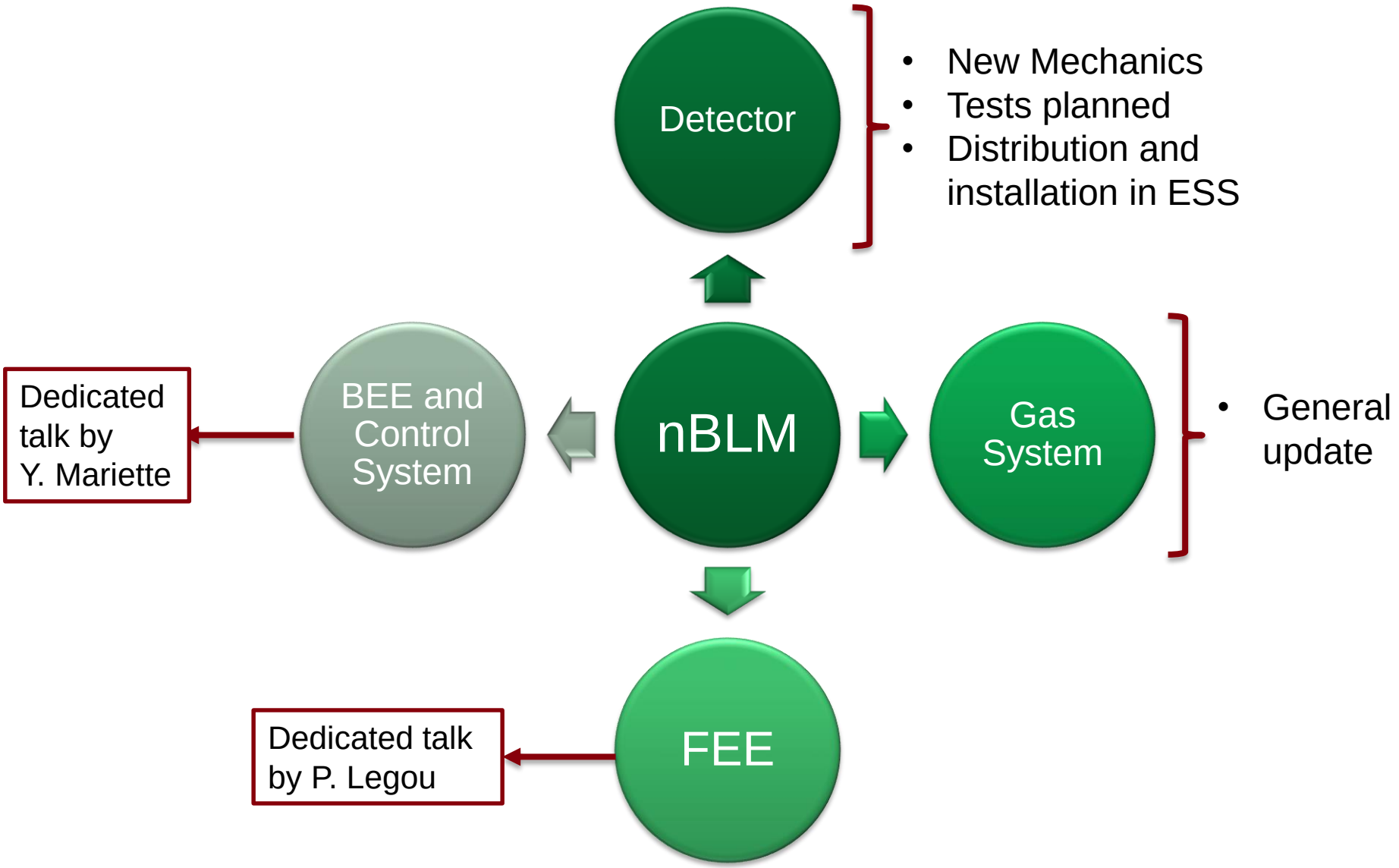
21/11/2017

4th ESS BI Forum

OUTLOOK



OUTLOOK


Detector
New Mechanics
Tests planned
Distribution and installation in ESS
BEE and Control System
Dedicated talk by Y. Mariette
nBLM
Gas System
General update
FEE
Dedicated talk by P. Legou

MOTIVATION

nBLM → neutron Beam Loss Monitoring system based on the detection of fast neutrons with Micromegas detectors. + low sensitivity to gammas and X-Rays.

- **Objective**: **Protection + monitoring normal operation**
  - ✓ To maintain accelerator activation at a low level (loss << 1 W/m)
  - ✓ For fine beam tuning purpose, particularly for high beam intensity
  - ✓ Machine Protection

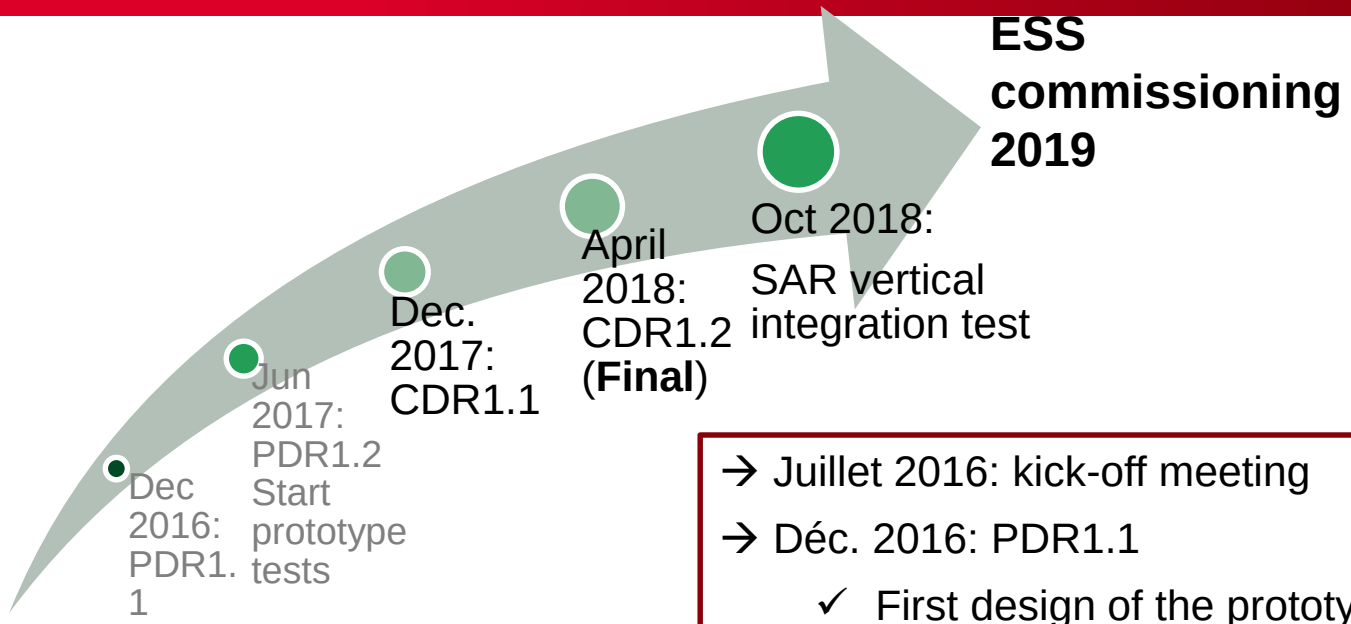
- Project to deliver and commission 42 modules (**84 detectors**) by **April 2019**
- To be installed mainly in the **DTL and Spokes** regions: E_{proton} 3.6 – 216 MeV
  - Some will be tested also at higher energies

- **Why new BLM?**
  - Complementary to the others ESS BLM systems
  - At low beam energy only neutrons and photons can escape beam pipe
  - Photons :
    - X-rays and γ's are highly produced by the RFQ and superconductive cavities
    - Impossible to distinguish contributions coming from beam or RF…
  - Neutrons :
    - Thermal neutrons: no loss locations
    - Fast neutrons: good for beam loss representation

BLM insensitive to photons

BLM insensitive to thermal n's

PROJECT PLANNING



- → Juillet 2016: kick-off meeting
- → Déc. 2016: PDR1.1
  - ✓ First design of the prototype
  - ✓ MC studies
- → July 2017: Final PDR + 1st prototypes tests
- → Dec. 2017 CDR1.2 + new detector design
- → Nov 2017 – Avril 2018 tests at different radiation facilities
- → Avril 2018: CDR1.2 Final
- → Avril-Oct 2018: Detector production and QA/QC
- → System delivered to ESS Nov. 2018
- → ESS hand over: April 2019

NBLM DETECTORS

- Two types of detectors: slow and fast
  - Different physical reaction to create the charged particles from the neutrons
  - Different applications

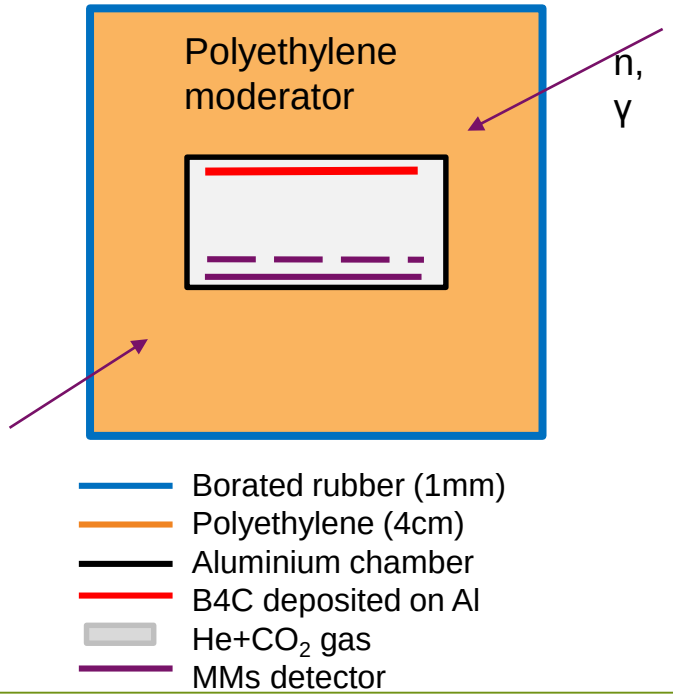
	SLOW	FAST
Convertor	B_4C	Mylar or Polypropylene
Reaction	$(n,\alpha)^{10}B$	(n,p)
Signal	Fast neutrons after moderation	Fast neutrons
Detected energy	~constant	Continuum distribution of energies
Sensitivity	10^{-6} < En < 100 MeV	En > 0.5 MeV
Solid angle	4π	2π, n coming from the front only
Efficiency	~few $n \cdot cm^{-2} \cdot s^{-1}$	~10-100 times smaller
Response time	~200µs	~0.01µs
Objective	Monitoring of small losses	Alarm (in 5 µs) Fine structure of the lost
Shielding	Yes, for thermal neutrons	Not needed

NBLM DETECTORS

➢ Two types of detectors: slow and fast

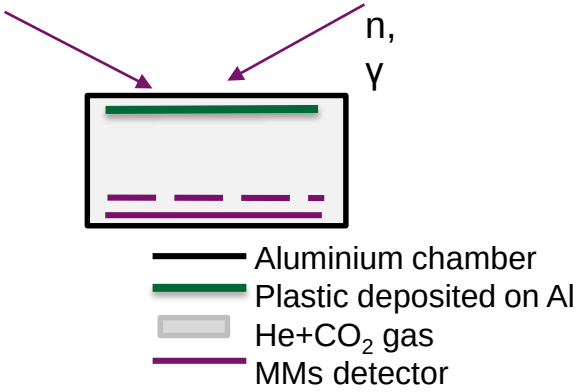
SLOW

- Absorber shielding
- Detection of fast neutrons after moderation in polyethylene (~4cm)
- Gas chamber with layer of B4C
  - (n, α) ^{10}B rea
- More efficient, 4π, but slower response



FAST

- Recoil protons produced by neutrons in polypropylene
- High flux high energy n's (>0.1 MeV)
- Faster response
- Just the gas chamber with polypropylene at the cathode



NBLM DETECTORS

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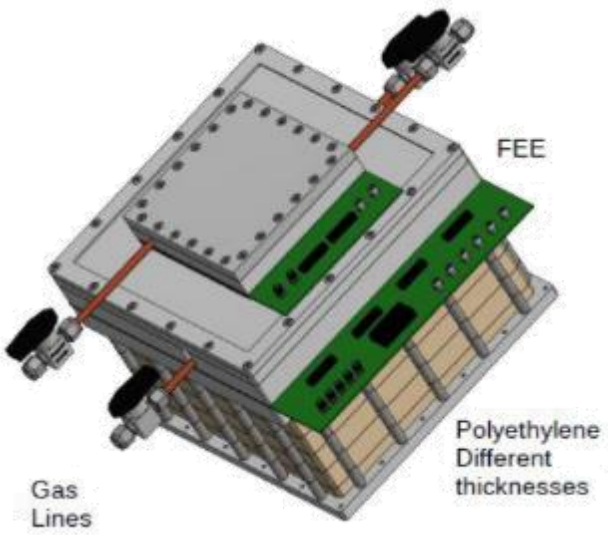
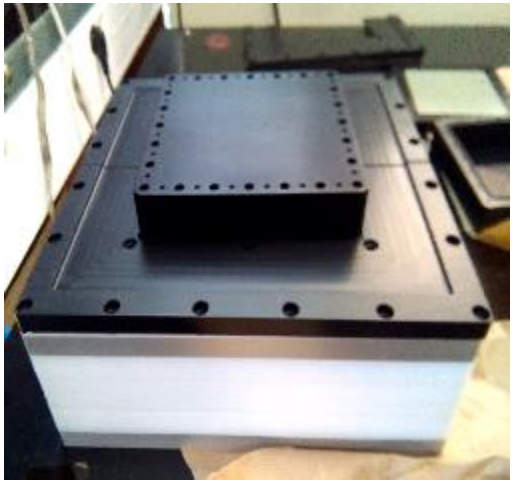
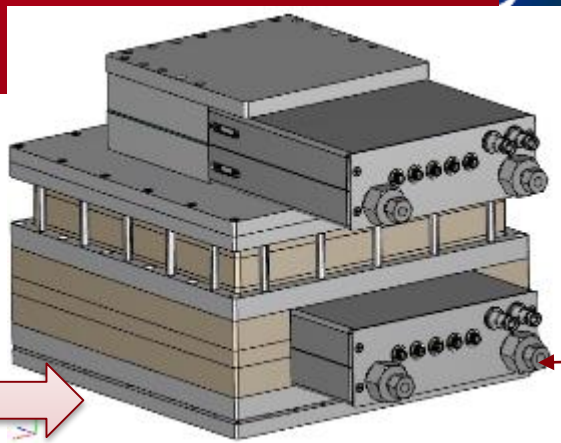


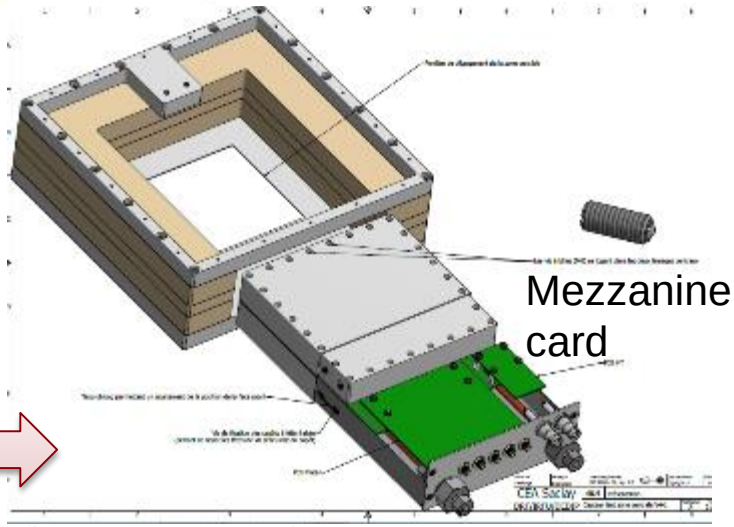


New detectors design

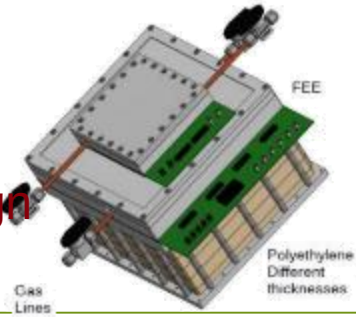
- New mechanics to improve electronic shielding
  - More compact, easier for installation, more “industrialized”
  - All connections in front
  - Same mechanics for fast /slow
- New electronics: mezzanine cards
  - One for signals + PAs; another for HV
  - Fastr replacement
  - Easier to test different options → no need to change detector
  - More details in Philippe’s talk
- Design of closed gas recirculation system via an oxisorb filter
  - Needed for tests at LINAC 4



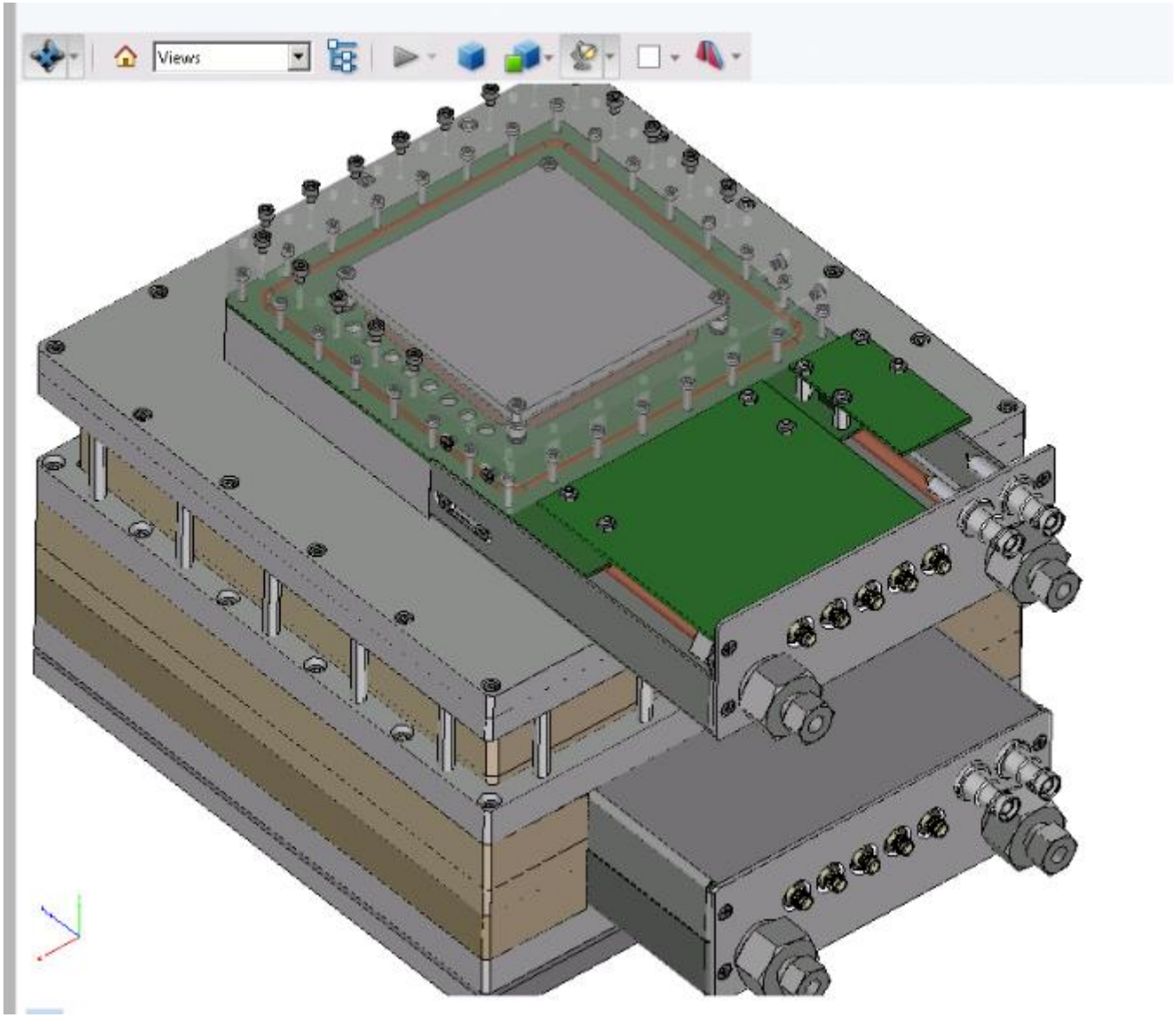
New Design



Old Design



NBLM DETECTORS – NEW DESIGN



NEW DETECTOR PRODUCTION

Mechanics

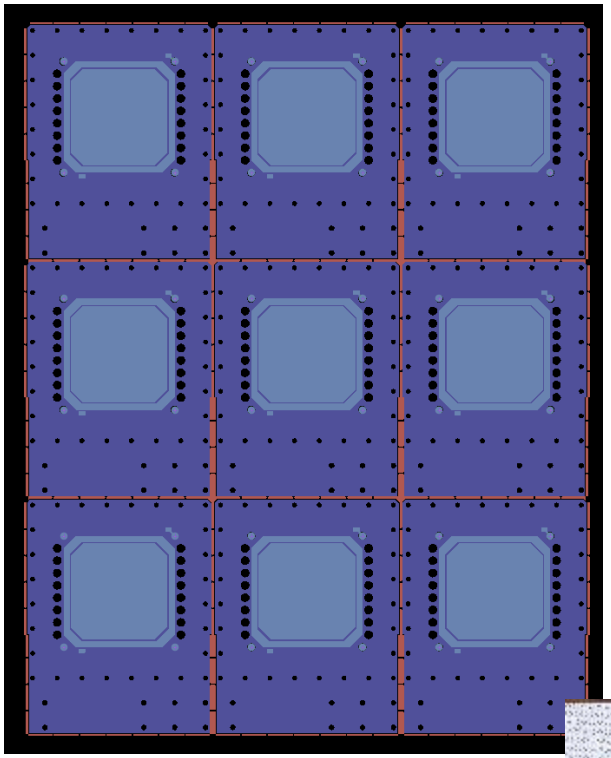
- Initially construct **4 chambers** → for Dec 2017
- When finalized, ~**90 chambers**
- Production to start in ~June 2018

Micromegas

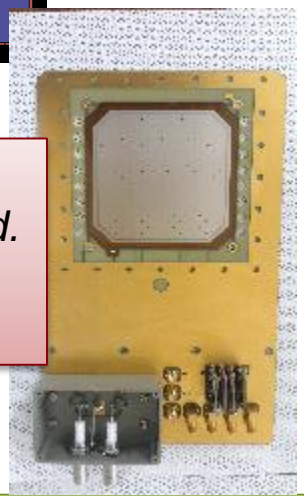
- 3x3 detectors per PCB (hopefully!)
- **2 boards** initially → for Dec 2017 – Jan. 2018
- **10-12 boards** by June 2018
- Bulking at DEDIP lab
- Pre-series production to start immediately

FEE + HV boards

- Design done (*more details in Philippe's talk*)
- First boards will be ordered soon



Gherber for 3x3 MMs board



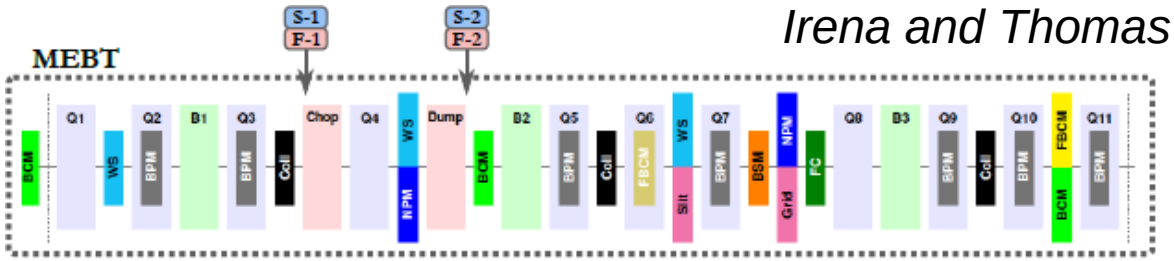
Actual design with electronics on-board. The detector itself does not change

NBLM PLANNED TESTS

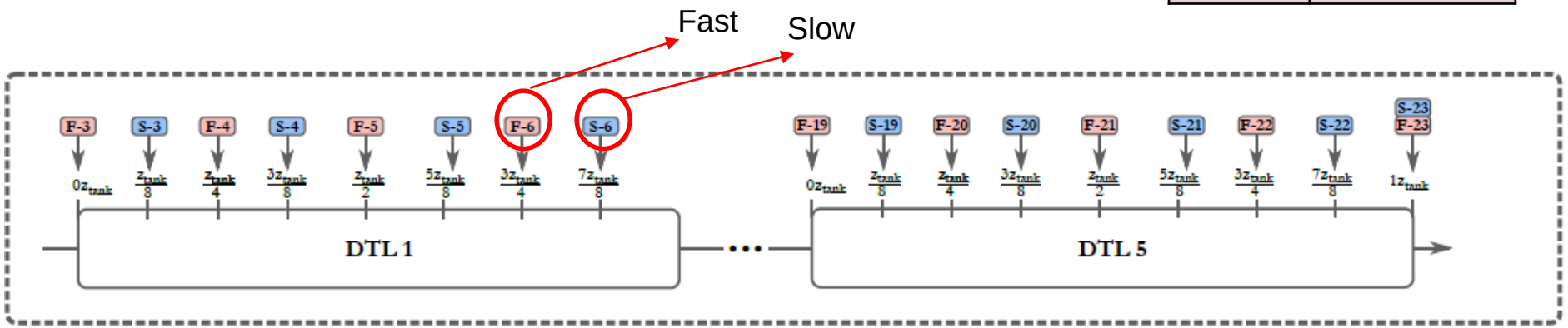
Test Facility	Particle	Test	Date
Birmingham MC40	Protons to material target	- Response under different loss scenarios - Electronics ageing	Nov-17 + in 2018
LINAC-4	Protons	RF backgrounds and response to losses	Feb-April 2018
ORPHEE CEA/Saclay	Thermal neutrons	Response to thermal neutrons	2018
Amande (CEA/Cadarache)	Mono-energetic neutrons	Efficiency studies. Different poly and convertors thickness	Feb or March 2018 (6days)
IPHI	Neutron production	Response study for different energies	From January 2018
Upssala + Saclay	Testing the ESS cryo-modules	Response to RF backgrounds	From January 2018

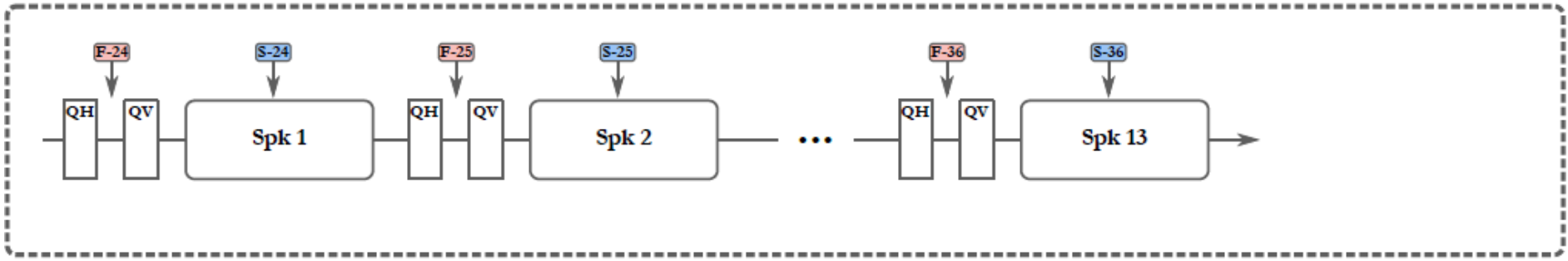
NBLM DETECTORS DISTRIBUTION (I)

Irena and Thomas G. work



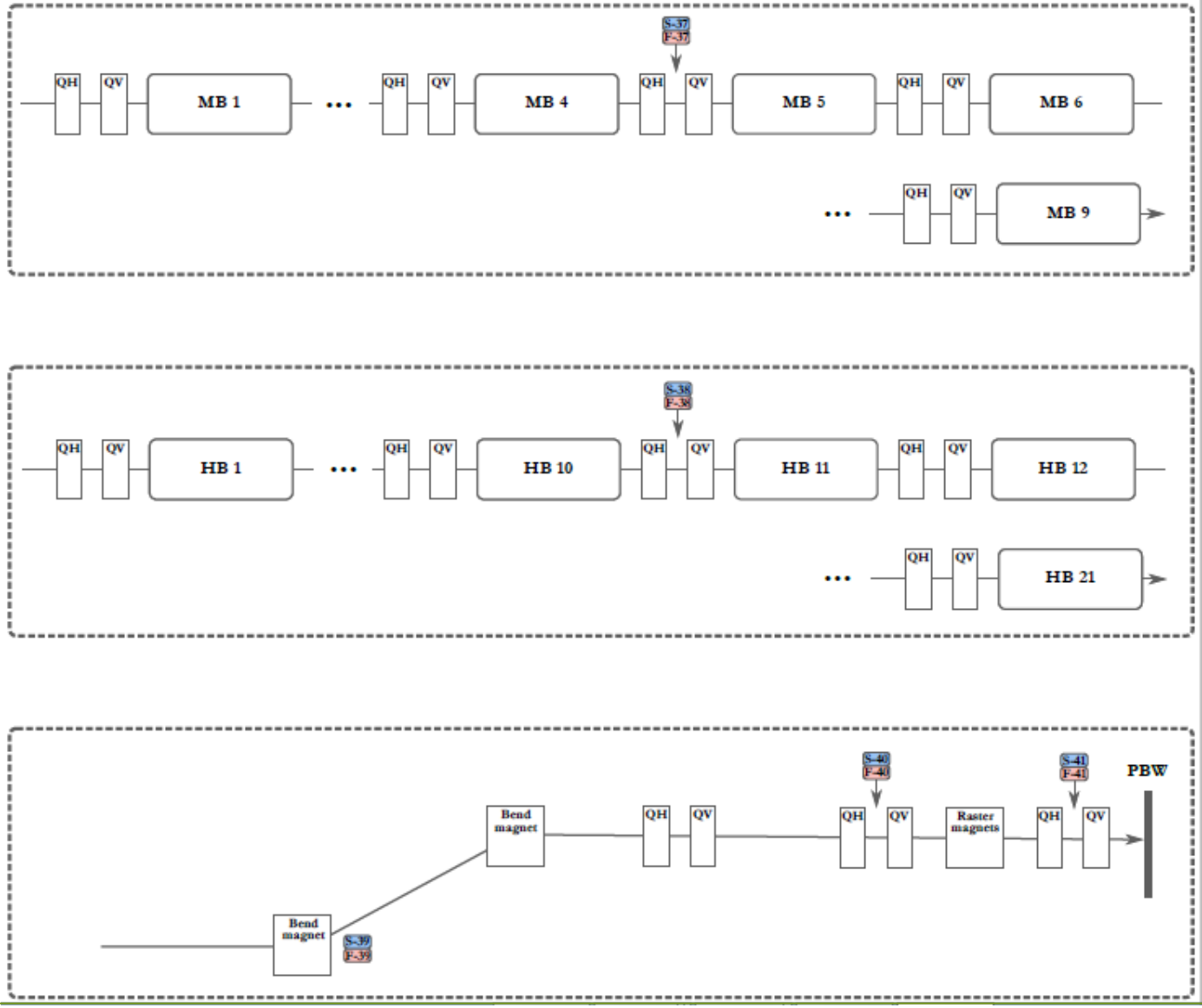
	Detectors
MEBT	4
DTL	42
SPK	26





NBLM DETECTORS DISTRIBUTION (II)

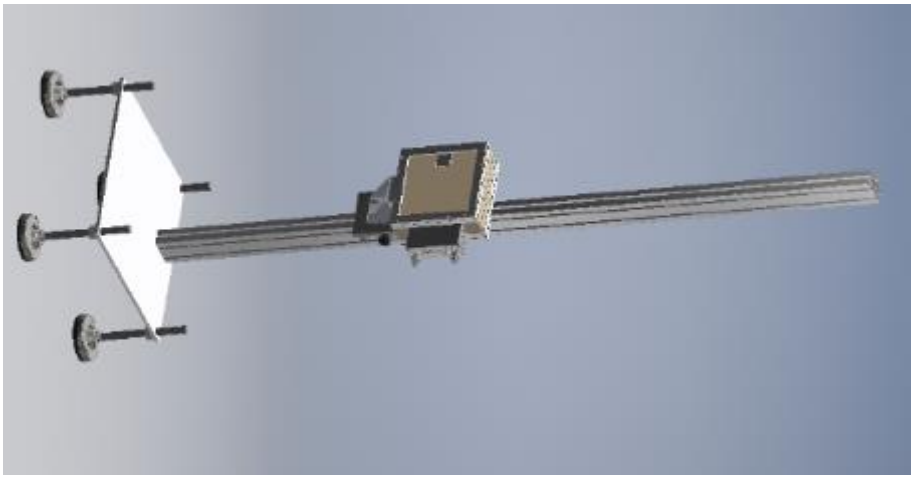
Irena and Thomas G. work



	Detectors
MEBT	4
DTL	42
SPK	26
MB	2
HB	2
PBW	6
Total	**82**

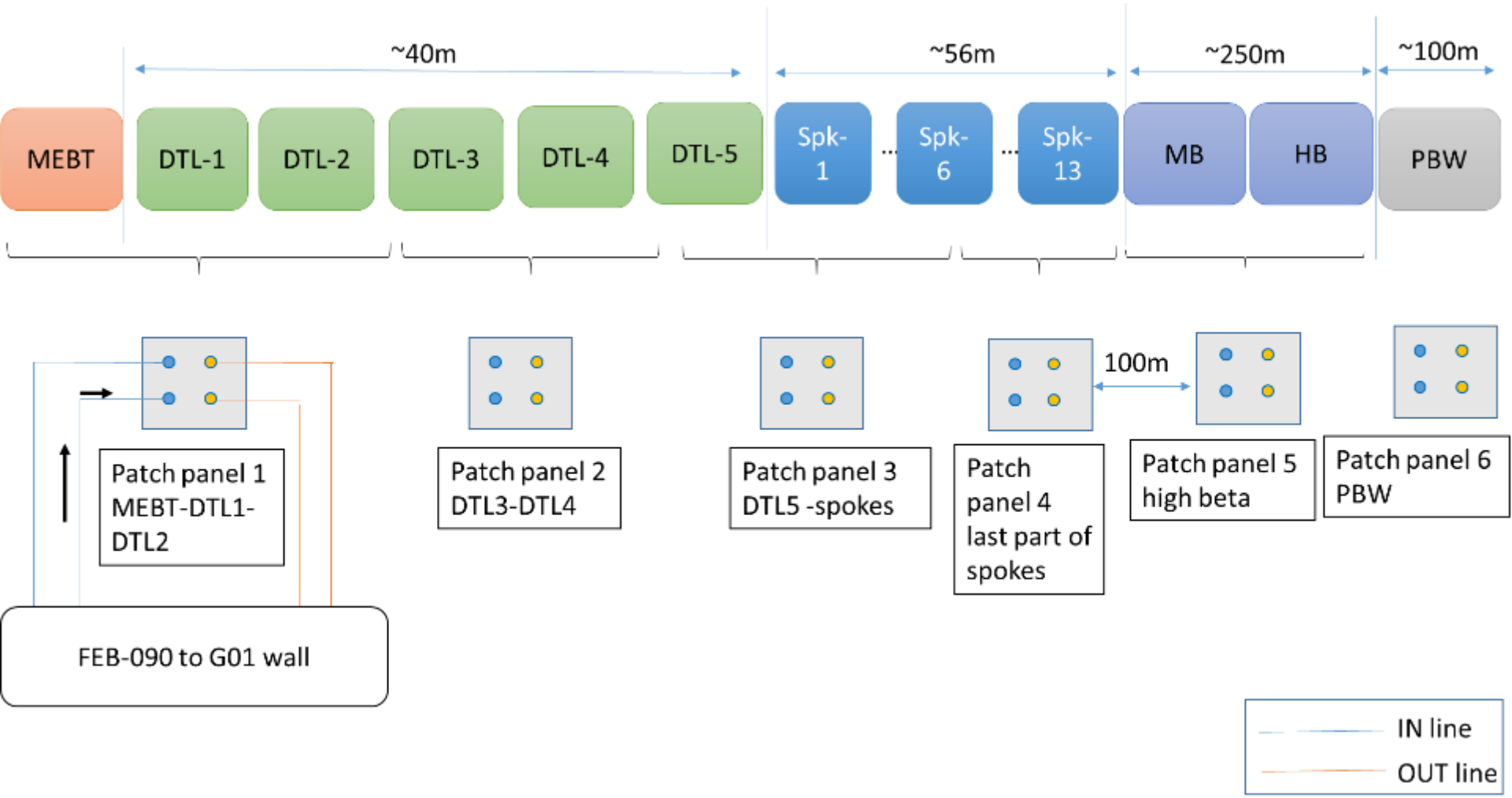
NBLM DETECTORS INTEGRATION IN ESS (I)

- System of 82 detectors will be installed
  - 164 HV cables + 82 signal cables + 3x82 LV cables + gas lines
- Detectors will be grouped for the gas lines and amplifiers low voltage cables
- Two type of patch panels (2x6):
  - Gas
  - Cables connectors
- Start design of detectors support
  - Rail along linac
  - Flexibility to move the detector in order to optimize the beam losses detection



Detectors in	Gas line	# of detectors
MEBT-DTL1	Line 1	12
DTL2	Line2	8
DTL3	Line 3	8
DTL4	Line4	8
DTL5	Line 5	8
SPK1-4	Line6	8
SPK5-8	Line 7	8
SPK9-13	Line8	10
MB-HB	Line 9	4
Bend Magnet	Line 10	6

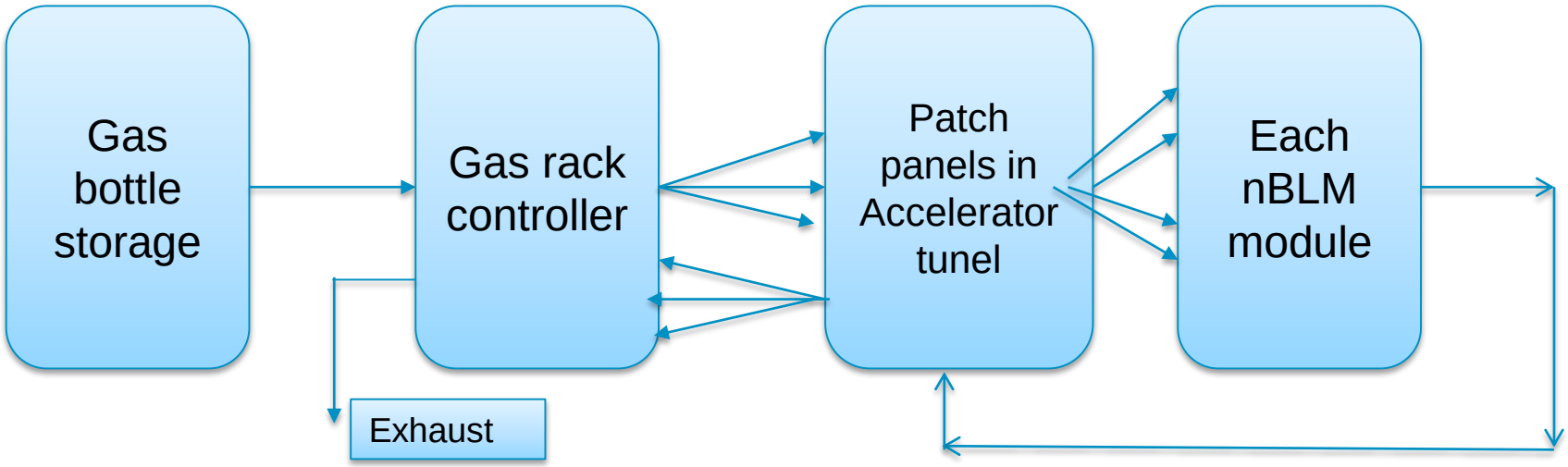
NBLM DETECTORS INTEGRATION IN ESS (II)



NBLM GAS SYSTEM

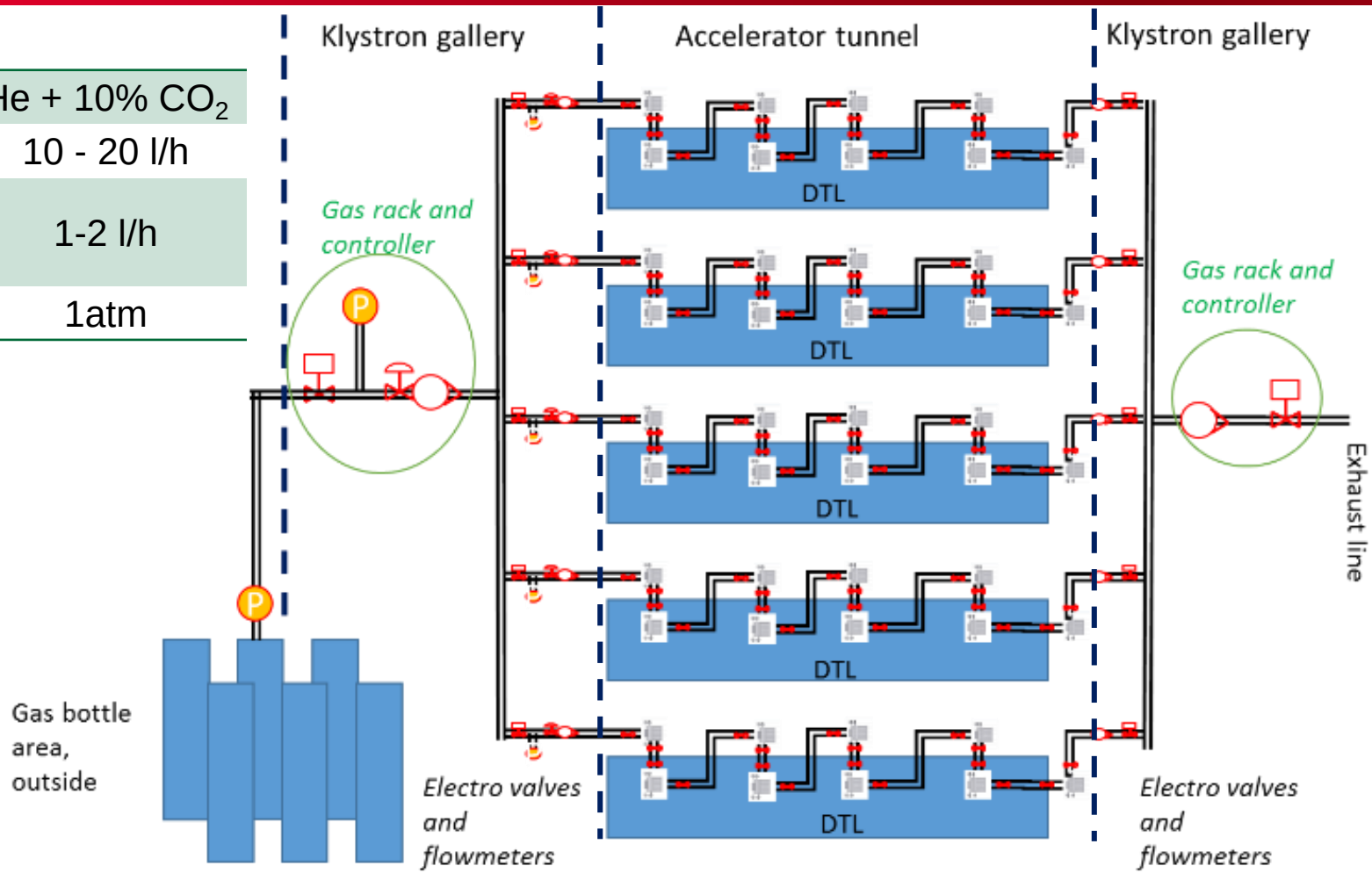
General design

- The gas system consists in 3 parts:
  1. The bottle storage area outside the building
  2. Gas distribution system
     1. Distribution and return lines from (to) the rack to (from) the accelerator tunnel
        - 10 distribution + 10 return lines
  3. Gas Line system fo group of detectors



NBLM GAS SYSTEM

Gas	He + 10% CO_2
Total flow	10 - 20 l/h
Flow per line	1-2 l/h
Pressure	1atm



- Micromegas are gaseous detectors. Work in circulation with open circuit
- High reliable system for the 84 detectors

CONCLUSIONS

- Since last BI Forum
  - ✓ Initial tests with prototypes
  - ✓ → Design of new detectors
    - Mechanics
    - Electronics → Philippe's talk
  - ✓ PDR1.2 approved
  - ✓ Fix distribution of detectors
  - ✓ Start design of detectors supports and their integration in the linac
  - ✓ Definition of analysis algorithm
  - ✓ Specification of control system
  - ✓ GUI development

  } Yannick's talk

- Next months are critical to maintain schedule
  - New detectors ready by beginning next year for full characterisation
  - Finish cable definition for installation.
- First tests with full acquisition system on-going
- Integration of gas pipes design into model on-going → Thank you for the support from ESS!

THANK YOU

DEDIP


Stephan Aune
System de Gaz Détecteurs MicroMegas


Michel Combet
Front-End Electronics


Daniel Desforge
Mechanical Designer


Mariam Kebbiri

Détecteurs MicroMegas


Caroline Lahonde-Hamdoun
Détecteur specialiste


Pascal Le Bourlout
Front-End Electronics


Philippe Legou
Detector et *Front-End Electronics*


Olivier Maillard
Front-End Electronics


Jacques Marroncle

ESS-I WP Diagnostics


Laura Segui,

Post-doc


Thomas Papaevangelou,
Chef de Projet


Georgios Tsiledakis,

Post-doc

DIS


Quentin Bertrand


Françoise Gougnaud


Tom Joannem


Yannick Mariette

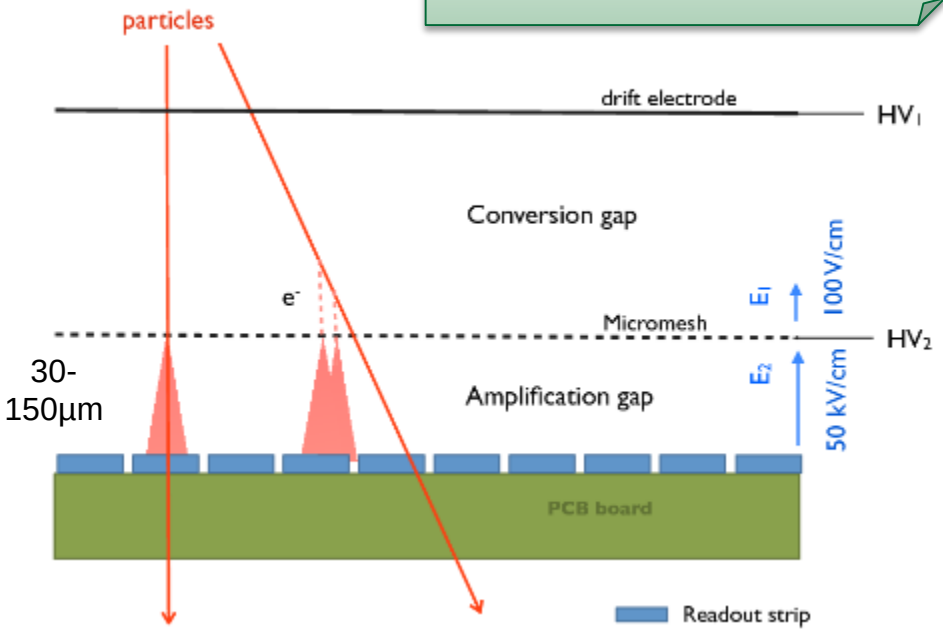

Victor Nadot

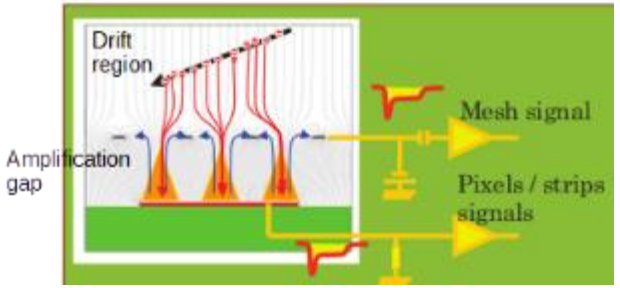
BACK-UP

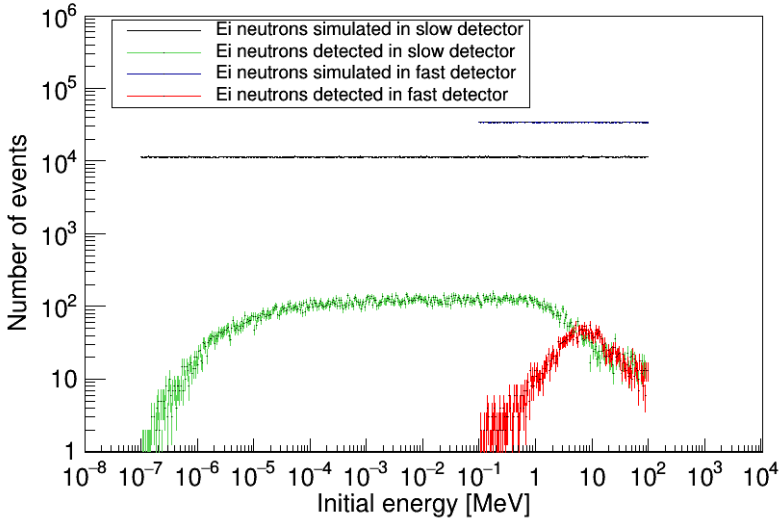
MICROMEGAS DETECTORS

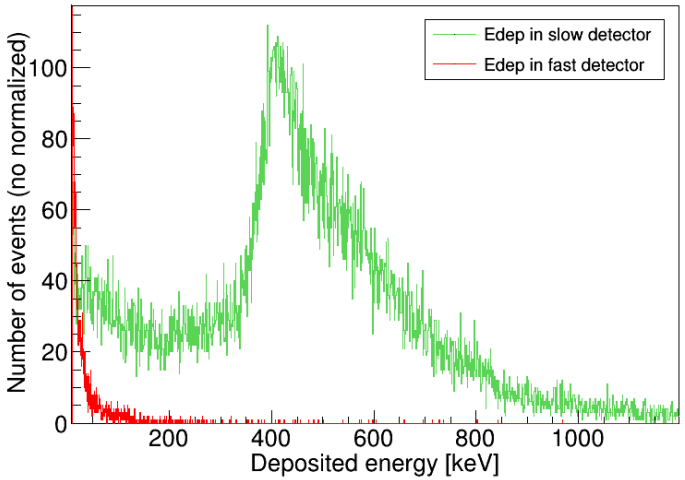
To detect neutrons we need to place a convertor in the entrance of the conversion zone

- MicroMesh Gaseous Structures (**Micromegas**) are an improved amplification structure used to measure the ionized signal in a gaseous detector.
- The detector consists on two parallel plates:
  - a metallic micromesh suspended over an anode plane by insulator pillars
- The device operates as a two-stage parallel plate avalanche chamber in two stage
  - Conversion zone
  - Amplification zone





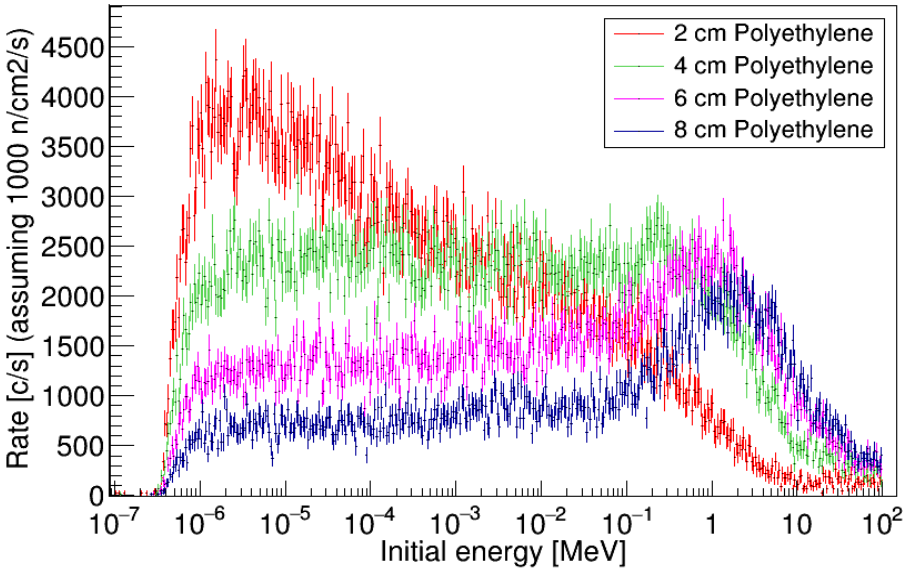

Ei neutrons simulated in slow detector
Ei neutrons detected in slow detector
Ei neutrons simulated in fast detector
Ei neutrons detected in fast detector
Number of events
Initial energy [MeV]


Edep in slow detector
Edep in fast detector
Number of events (no normalized)
Deposited energy [keV]

STUDIES BY MC SIMULATIONS

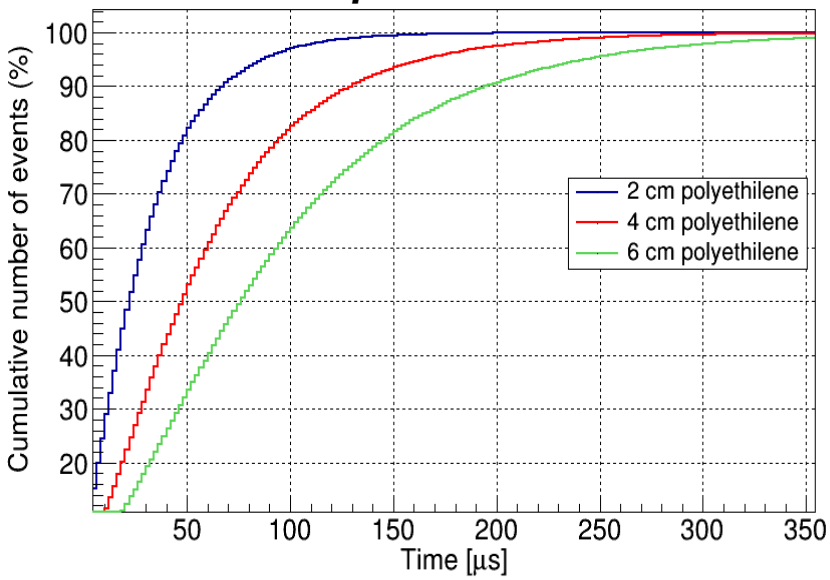
SLOW DETECTOR

Relative efficiency



- Dependency with
  - Moderator thickness
  - MMs size
  - B4C thickness
  - Absorber thickness
- Dependency with initial neutron energy
- **4 cm** gives the most constant response over all range of energies

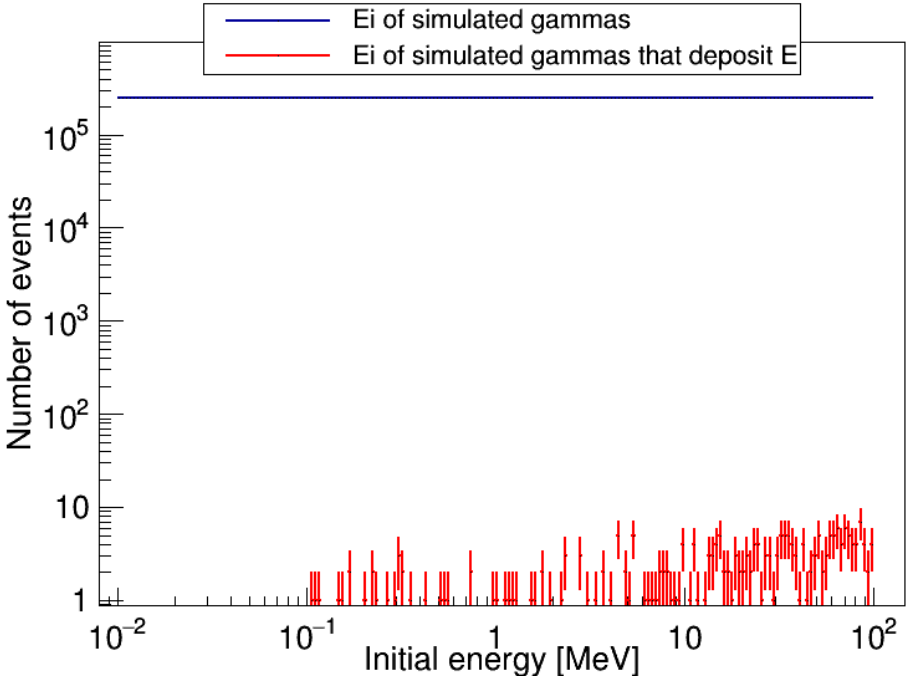
Response time

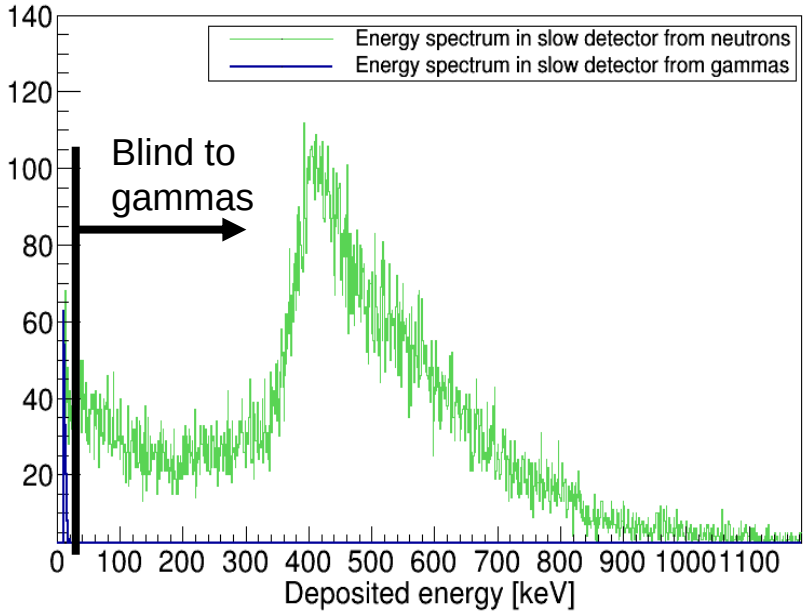


- Dependency with moderator thickness
  - ~5% detected in <1 µs for 4 cm
  - Requirement by ESS 5 µs response in total, 3µs for detection and FEE
- Dependency with initial neutron energy

SLOW DETECTOR

Gamma discrimination





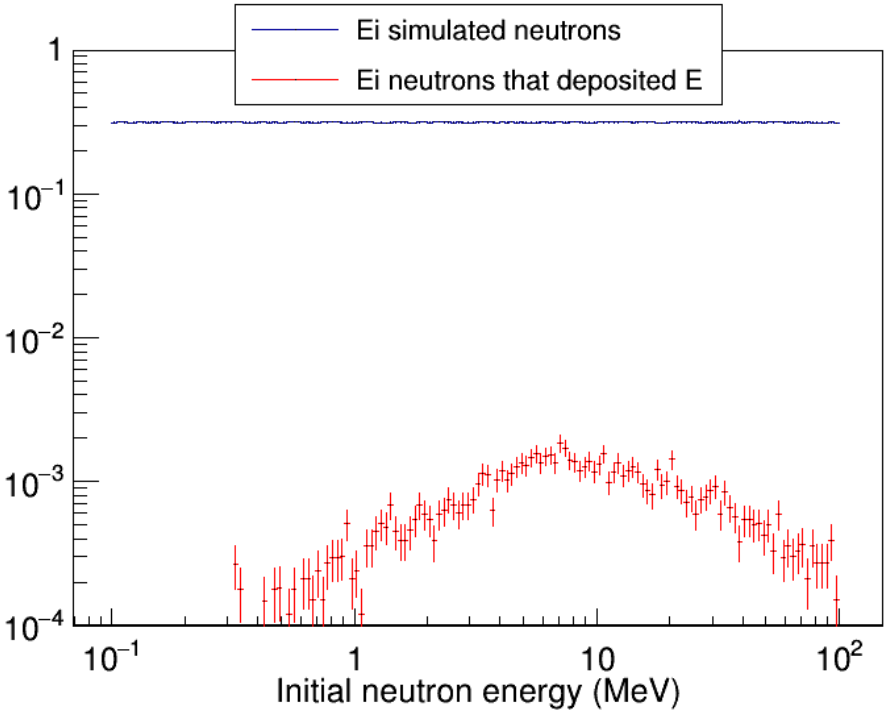
- Only sensitive to high energie gammas
- With an energy threshold we can reject them

➢ **Thermal neutrons**

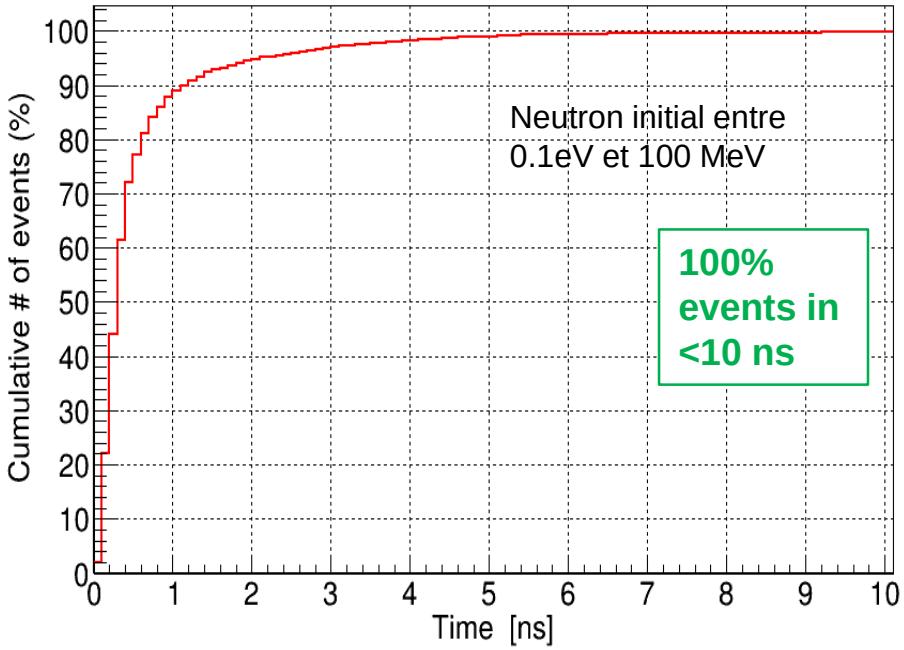
- Energies between 0.01 and 1 eV
- Efficiency of < 0.007 % already with an energy deposited threshold of 10keV

FAST DETECTOR

Neutron efficiency
Initial neutrons from 0.1eV to 100 MeV



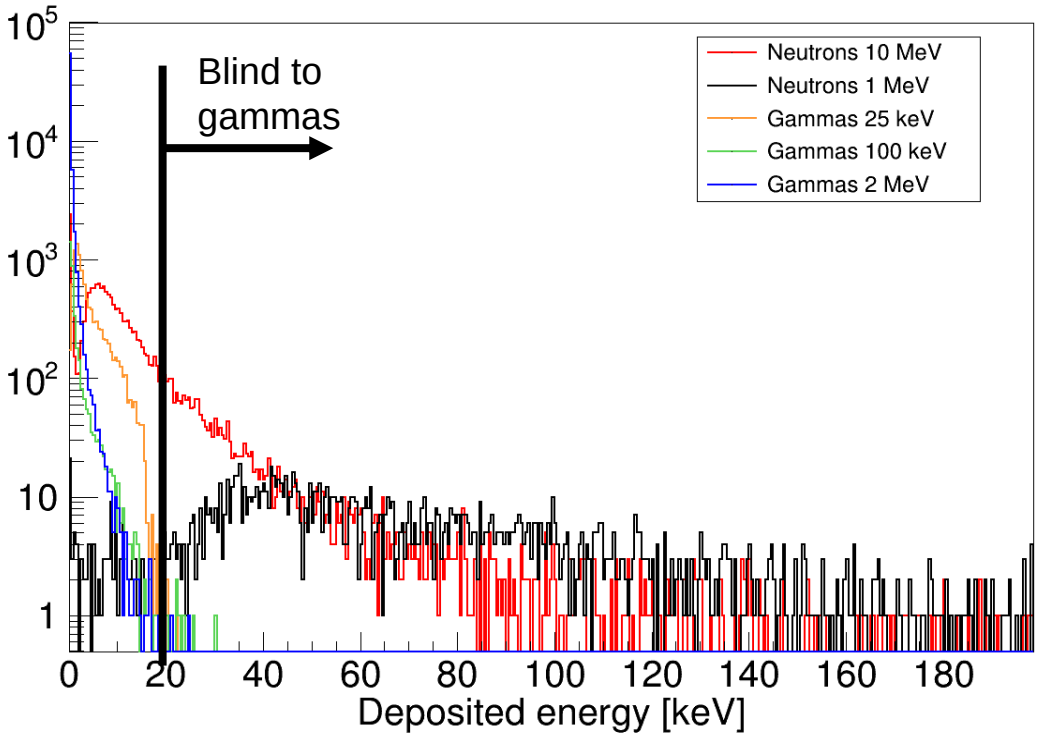
Time response:
just ToF, detector immediate response



- Only sensitive to energies >0.5 MeV

FAST DETECTOR

Gamma discrimination

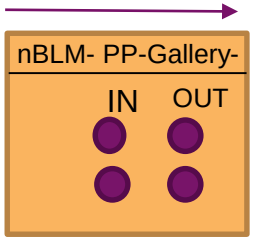


NBLM GAS SYSTEM

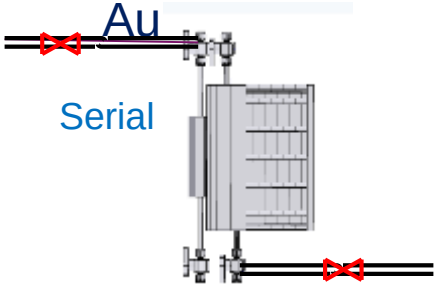
- Gas: He + 10% CO_2
- Flow: ~ 5 l/h, in recirculation
- P ~ 1 atm
- Volume/detector ~ 0.25 l
- Leak tight and low outgassing
- Gas bottle storage: 6-12 rack premix
  - ~200 bar/bottle, 50 l →
  - 2 IN/2 OUT lines (1 in use, 1 spare)
  - Outside gallery
- From gas bottle to gas rack to patch panel to tunnel
  - Distribute in 5 lines → one per DTL, in parallel
    - 5 IN/5 OUT Lines going to tunnel (+ spares)
  - Electrovalve in/out in Klystron gallery
    - Isolate system
  - Flowmeter in/out in Klystron gallery
    - Leak monitoring
- Gas in serial for detectors in DTL

Bottle rack

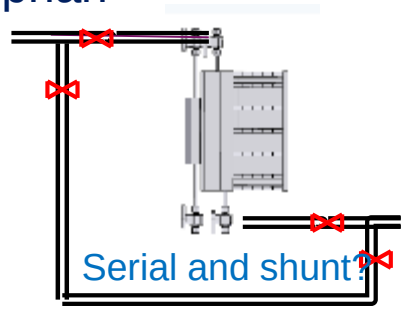
Gas controller



Designed by Stephan Au



Serial



Serial and shunt?

NBLM DETECTORS INTEGRATION IN ESS (III)

Detail of one nBLM gas distribution patch-panel