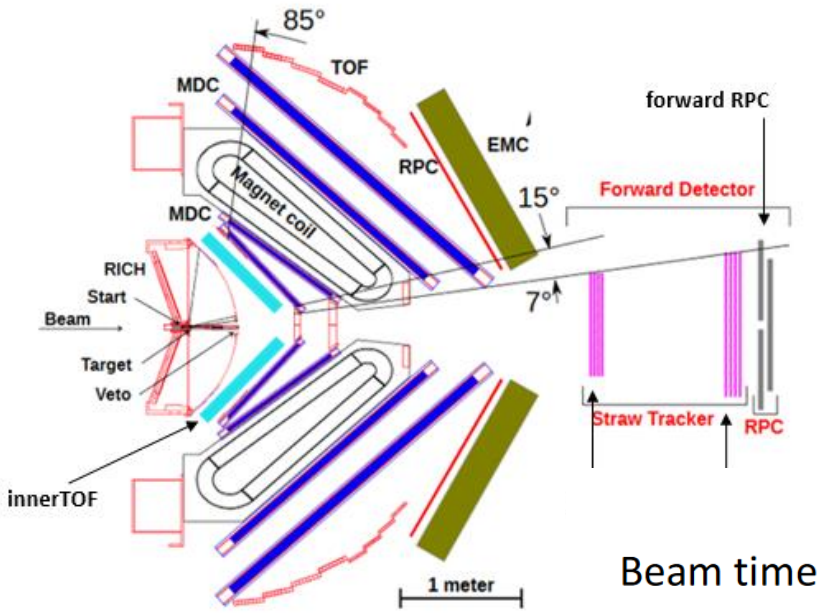
HADES S518 (pp@4.5GeV) Preparation Status

Jerzy Pietraszko, GSI Darmstadt, HADES

❑ **S518 experiment (p+p@4.5 GeV) - Q1 2022**



PRODUCTION AND DECAY OF HYPERONS, AND INCLUSIVE HADRON AND DILEPTON PRODUCTION

in p+p Reactions at 4.5 GeV

The HADES and
HADES-PANDA Collaborations

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

Infrastructure: SIS18, LH_2 target, HADES cave

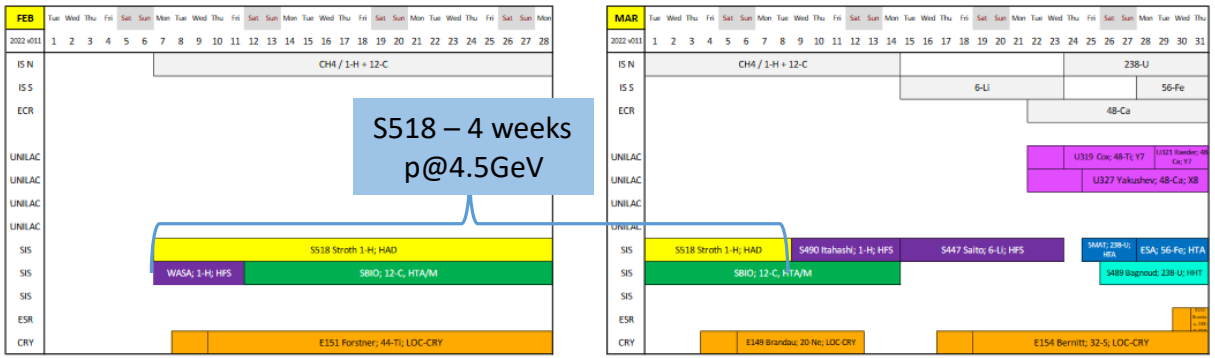
Beam: protons at 4.5 GeV, beam intensity 7.5×10^7 p/s, slow extraction

Beam parameters

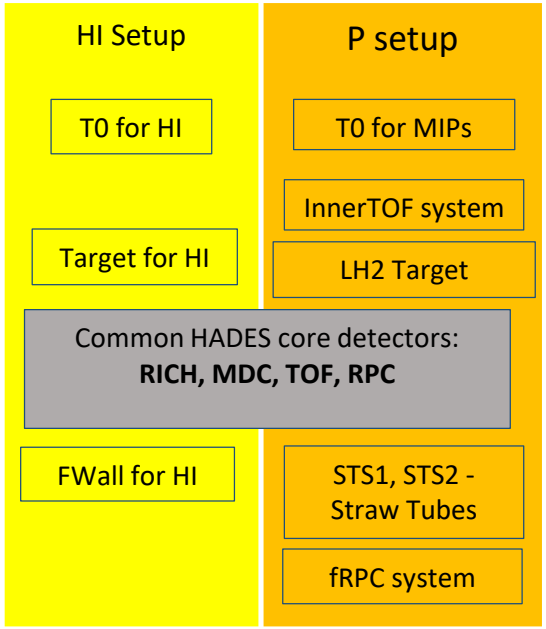
Beam time schedule 2022 v011

Outline:

- HADES subsystems - overview
- Beam line components
- Alignment procedure
- Feb2021 test results
- Improvement options:
  - Alignment
  - Beam diagnostic elements
  - Beam optics simulation
- Beam optic software availability for HADES team (BENO)
- LoI for 2023-2025 requested by G-PAC – pion beam



Heavy Ion vs. Proton HADES setups



New detection systems developed and installed for pp@4.5GeV
– need to be dismounted for HI run

- T0 based on LGADs for MIPs
- Inner ToF system
- STS1/STS2 (PANDA-Straws)
- fRPC detector
- LH2 Target

Parallel operations for mechanical activities are not possible due to:

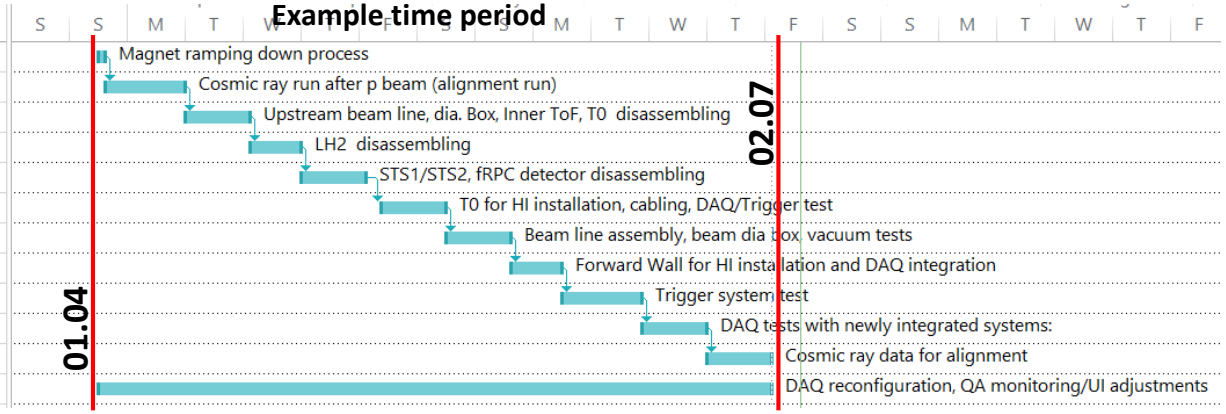
- Safety aspects: magnetic field, liquid hydrogen target
- Space limitations and crane availability
- Sequential mounting of detectors
- Availability of experts

Simplified, realistic project gantt chart

Example time period

GANTT CHART

	Task Name	Duration
1	Magnet ramping down process	1 day
2	Cosmic ray run after p beam (alignment run)	7 days
3	Upstream beam line, dia. Box, Inner ToF, T0 disassembling	7 days
4	LH2 disassembling	5 days
5	STS1/STS2, fRPC detector disassembling	7 days
6	T0 for HI installation, cabling, DAQ/Trigger test	7 days
7	Beam line assembly, beam dia box, vacuum tests	7 days
8	Forward Wall for HI installation and DAQ integration	5 days
9	Trigger system test	7 days
10	DAQ tests with newly integrated systems:	7 days
11	Cosmic ray data for alignment	7 days
12	DAQ reconfiguration, QA monitoring/UI adjustments	67 days



Minimal working time period without contingency: 3 months !

Expected risks:

- Activation of components
- Not enough time for system integration

HADES procedure used to reduce the risk of failure: **Hardware freeze-out 1 month prior to experiment!**

S518 Proposal Beam Requirements

HADES+PANDA PHASE 0 PROGRAM

1. Proton beam @ 4.5 GeV
2. Slow extraction
3. Beam intensity of 10^8 p/s
4. Spill duration > 13 s to improve the duty factor
5. Stable, well focused beam on the HADES LH2 target,
   - beam spot diameter < 0.5cm (+-3sigma, 99,73%)
6. Beam HALO/tail < 10^{-3} at 0.7 cm from the beam axis
7. Desired micro and macro time structure (Q<5)

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HADES

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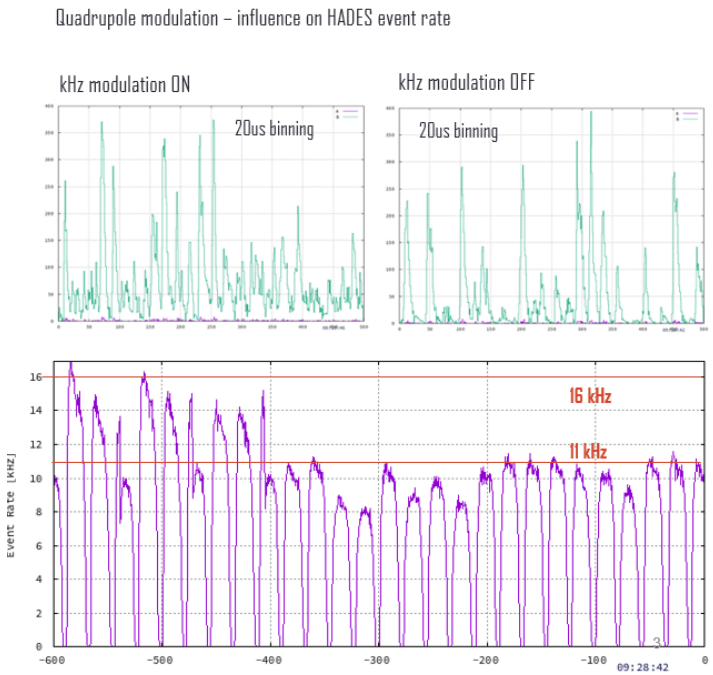
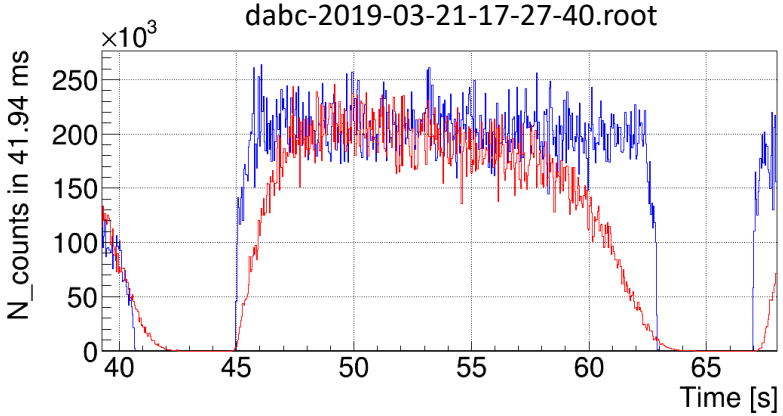
Beam: protons at 4.5 GeV, beam intensity 7.5×10^7 p/s, slow extraction

Example from Ag+Ag HADES run



Macro spill structure feedback
spill with feedback: (x 7.2)
dabc-2019-03-21-17-27-40.root

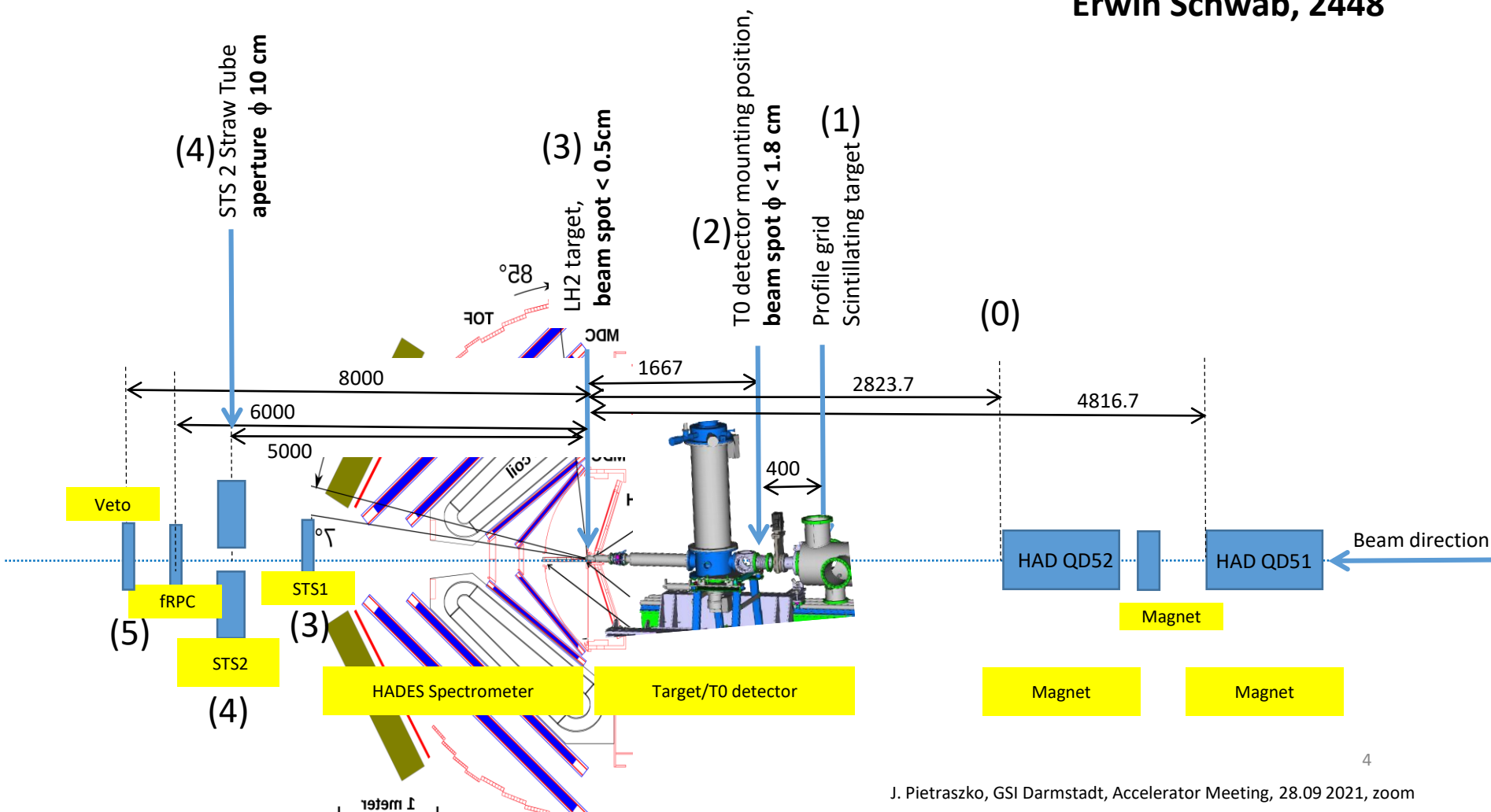


HADES Beam Line Aperture Limitations

Beam aperture in HADES

- (1) Beam spot at the Profile screen < 2cm
- (2) Beam spot at the T0 < 1.8 cm
- (3) Beam spot at the target < 0.5 cm
- (4) Beam spot at the STS2 < 10 cm

HADES beam line contact person:
Erwin Schwab, 2448

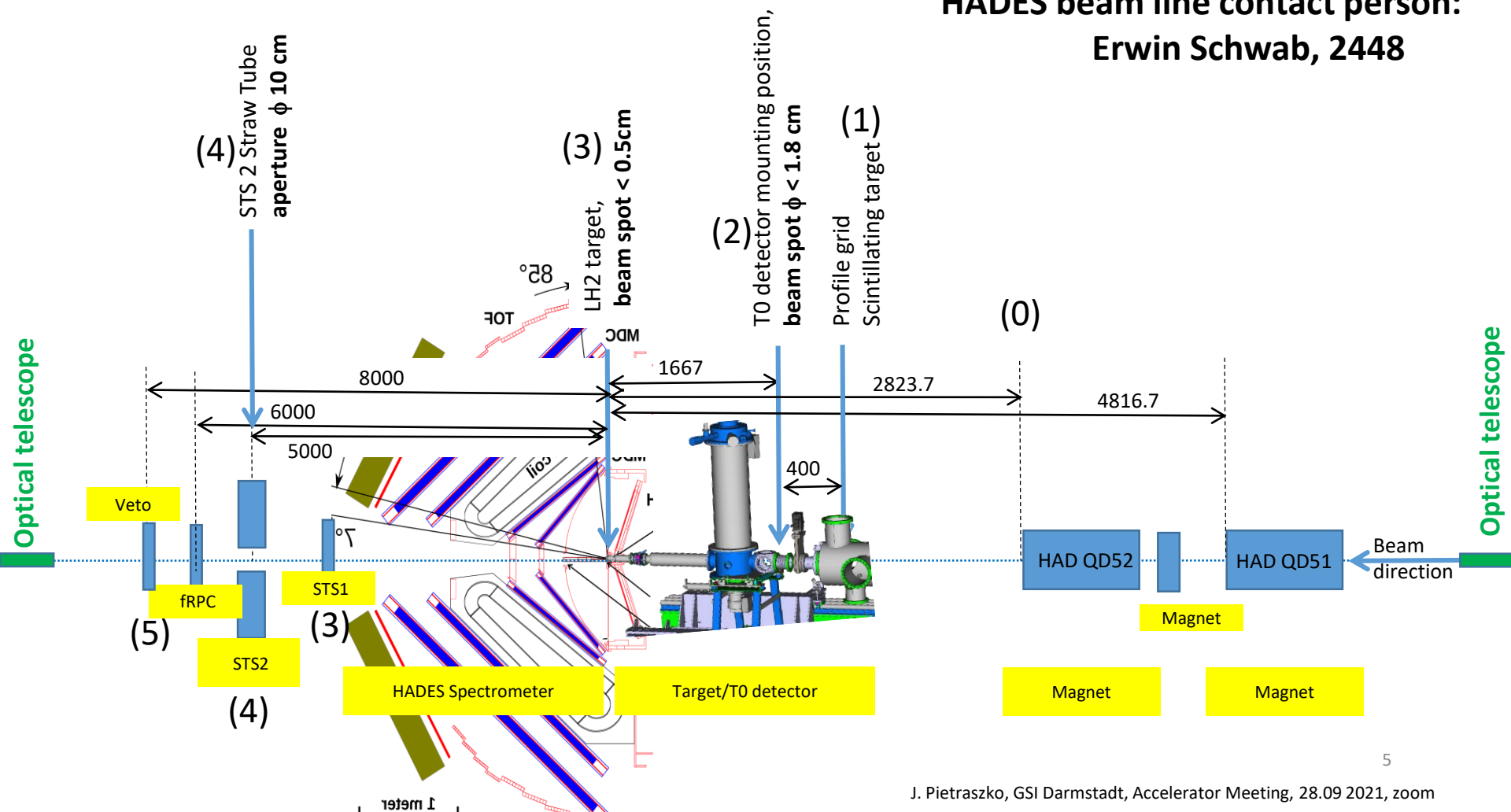


HADES Beam Line Alignment

Two optical telescopes used for alignment procedure

- One upstream of the target
- The second one at the beam dump
- Both will be re-aligned with respect to the beam axis
  - On-going process – this week !

HADES beam line contact person:
Erwin Schwab, 2448



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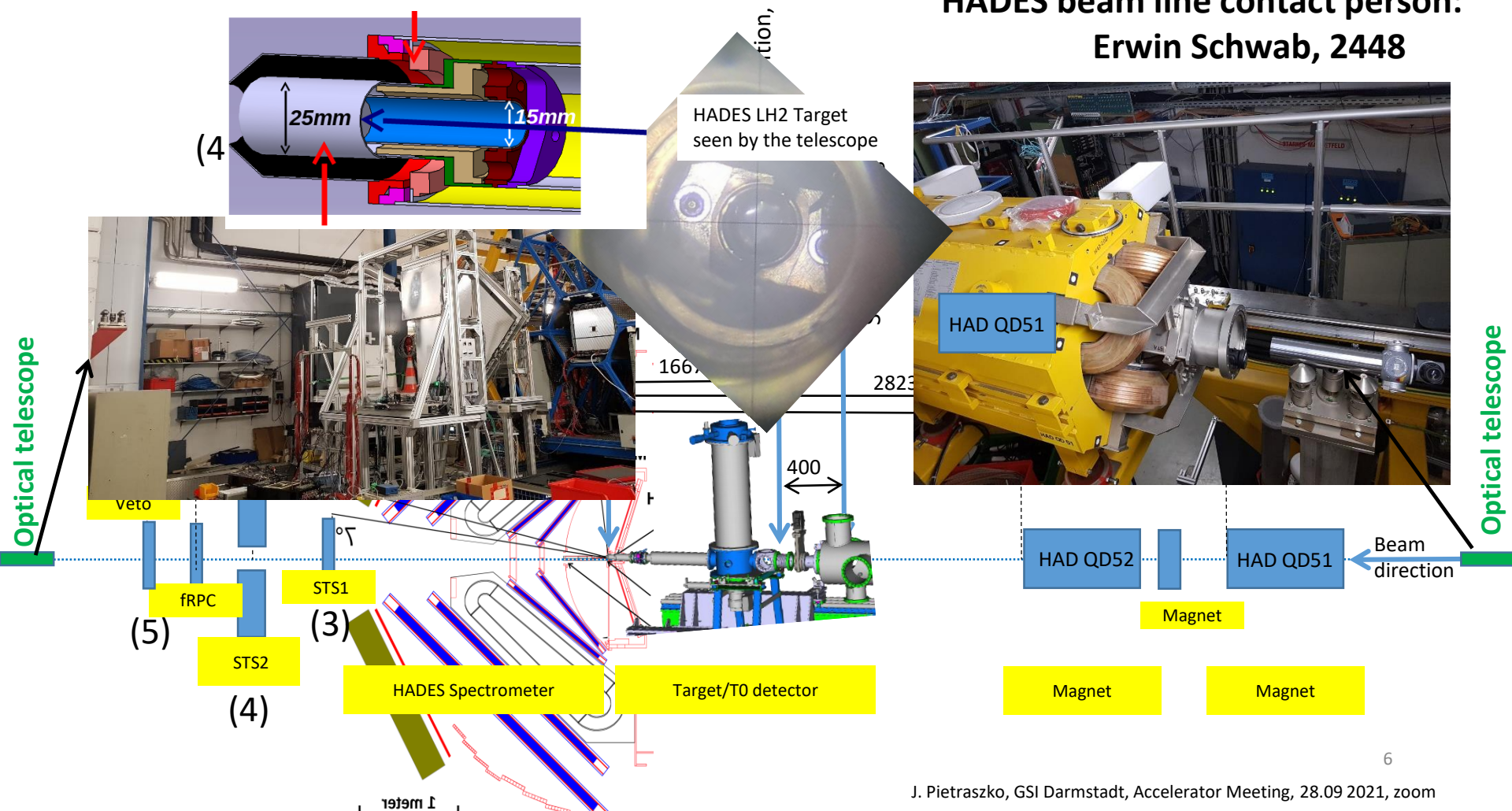
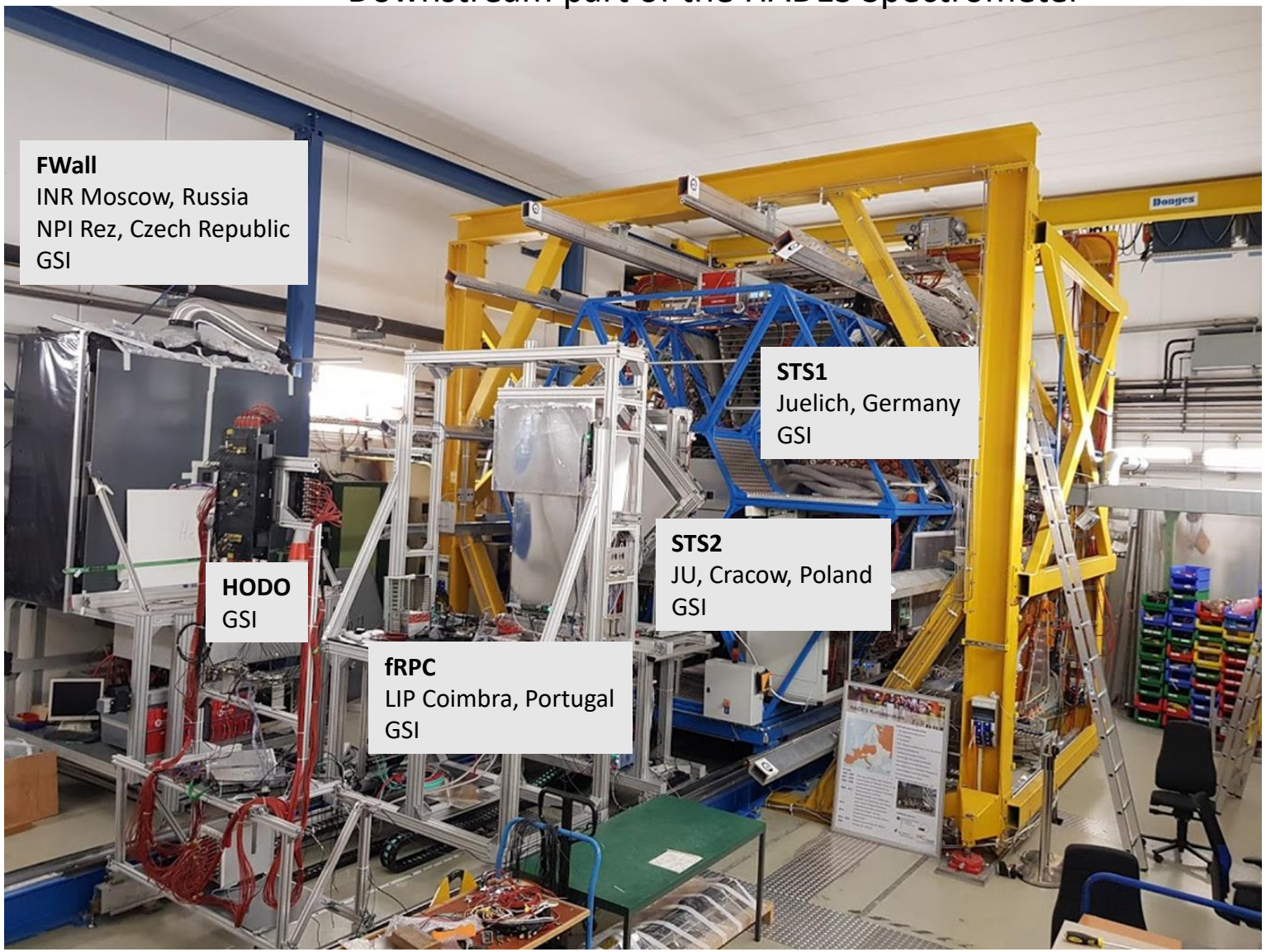
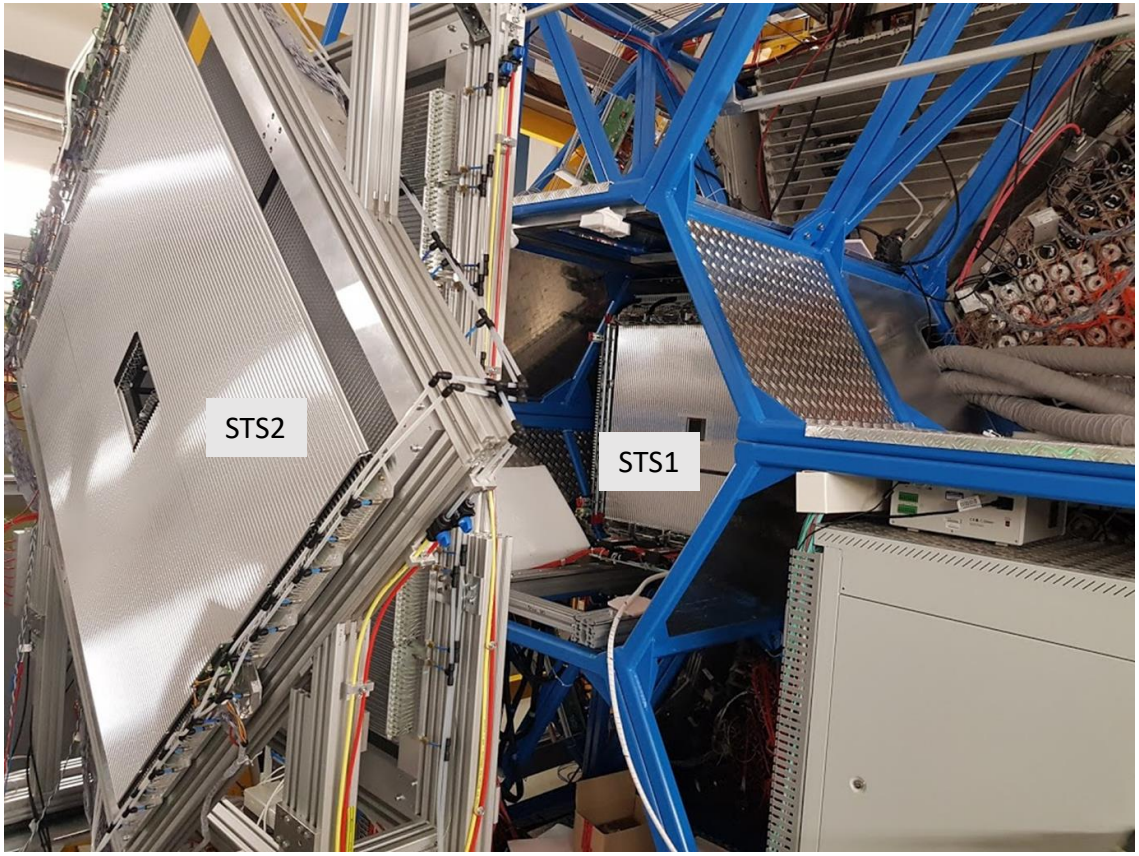


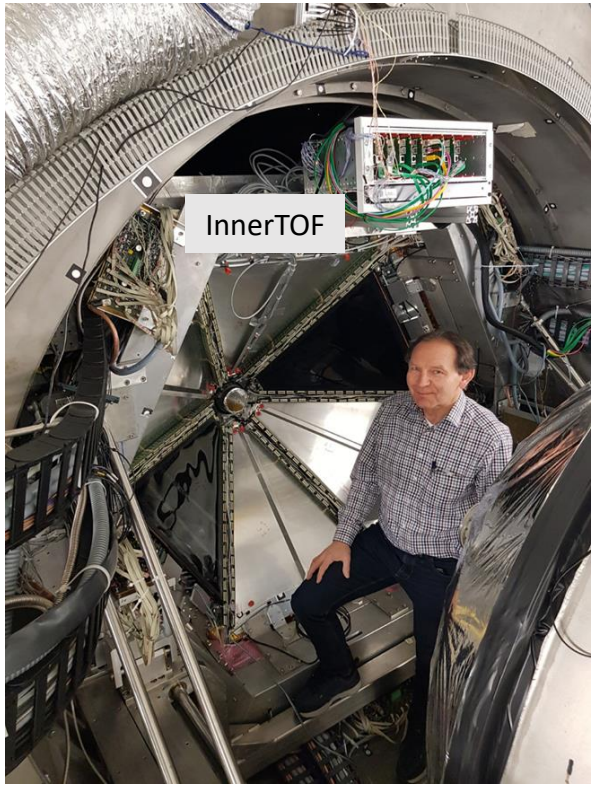
Heavy Ion vs. Proton HADES setups

Downstream part of the HADES Spectrometer



Heavy Ion vs. Proton HADES setups



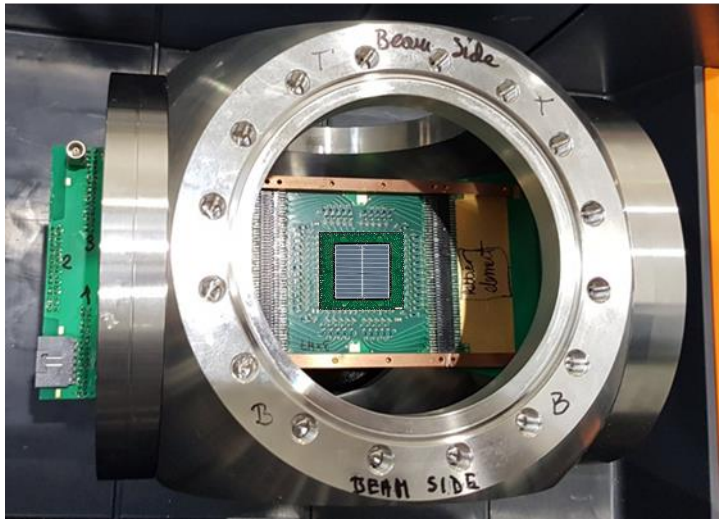


HADES Beam Line Aperture Limitations

Essential beam monitoring

- (1) Beam spot at the Profile screen < 2cm
- (2) Beam spot at the T0 < 1.8 cm

(2) Proton T0 detector

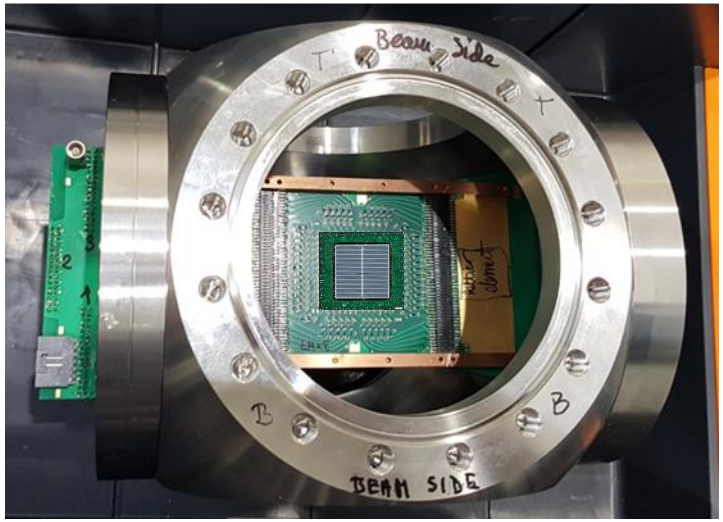


HADES Beam Line Aperture Limitations

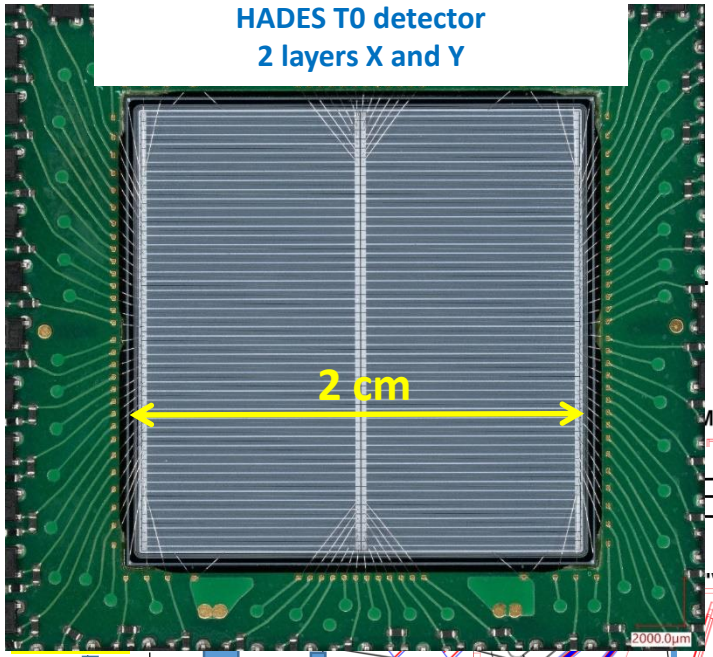
Essential beam monitoring not abailble in Feb 2021!

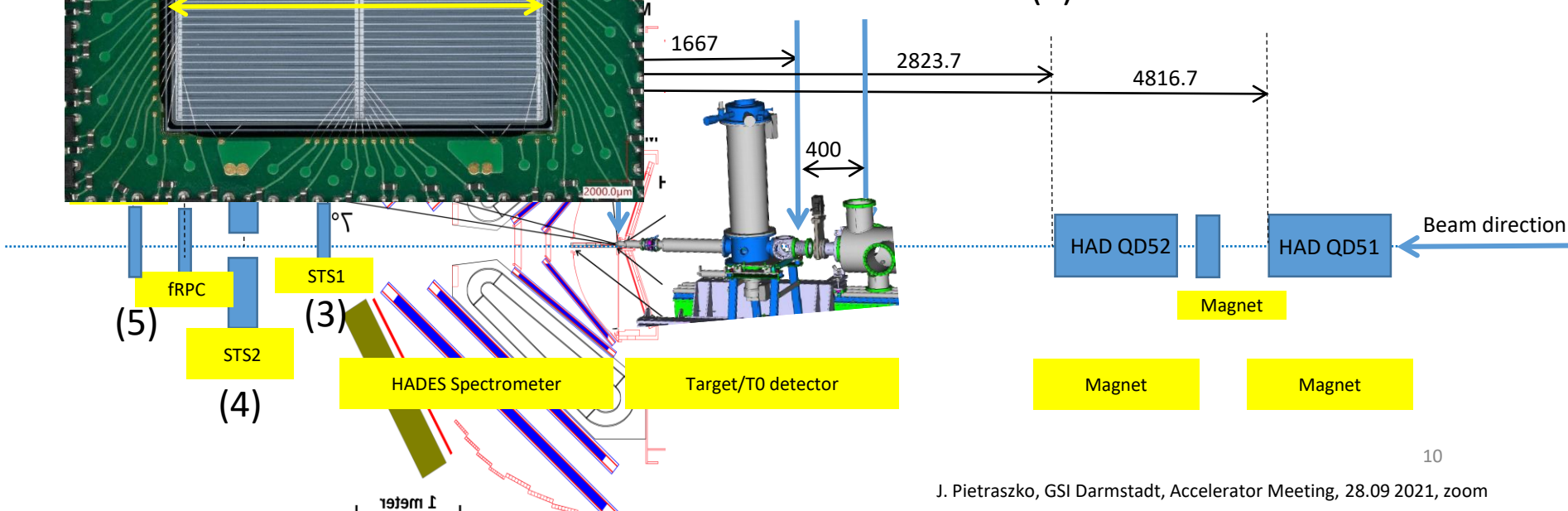
- (1) Beam spot at the Profile screen < 2cm
- (2) Beam spot at the T0 < 1.8 cm

(2) Proton T0 detector



(2) HADES LGAD 2cm x 2cm
HADES T0 detector
2 layers X and Y

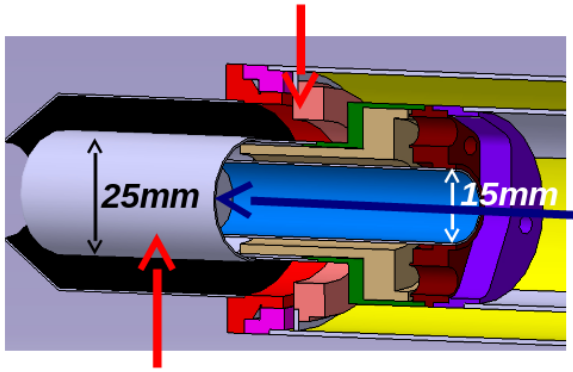




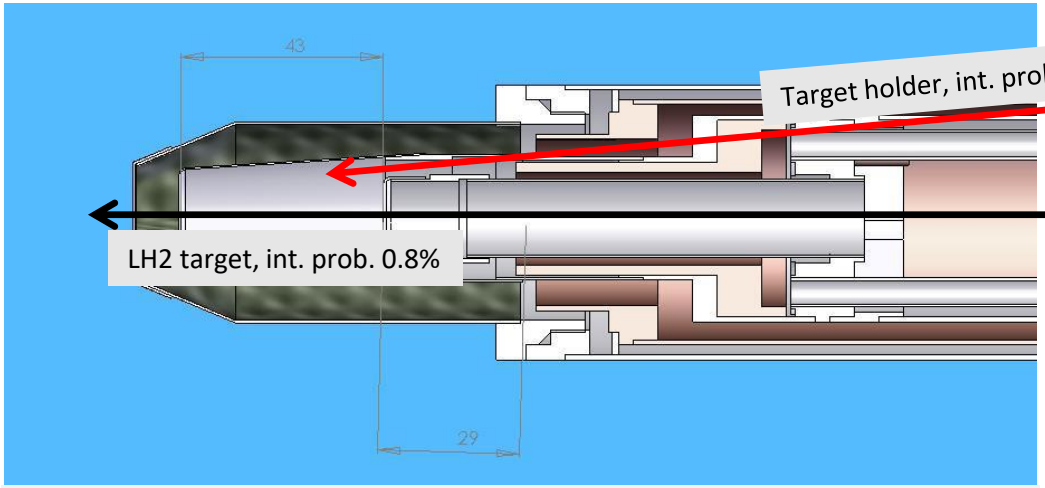
HADES LH2 Target – focusing procedure

Details of the LH2 Target construction

Target holder (metal)
up to 100% interaction probability !!!!



beam direction

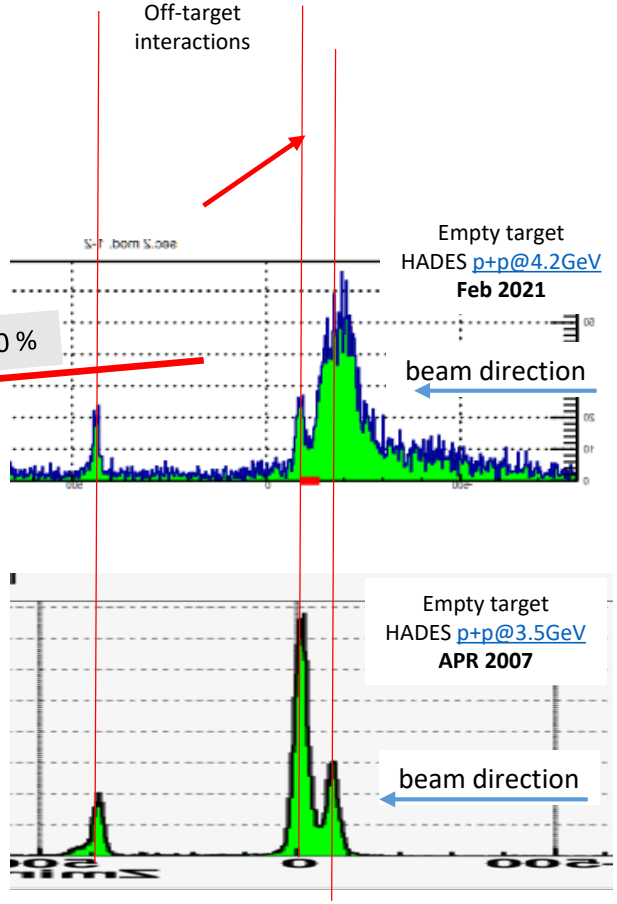


Nominal beam interacting with target holder creates radiation up to 100 times greater than when it interacts with the target

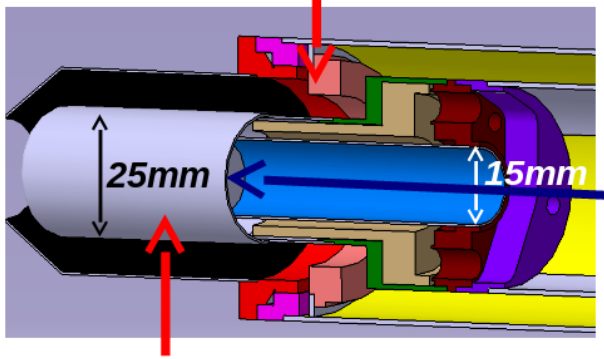
→Safe beam focusing procedure:

(a) Transport the beam up to HADES without sending it to HADES cave
(b) Focus the beam in HADES using intensity of 10^6 p/s

Target reconstruction by means of HADES tracking system

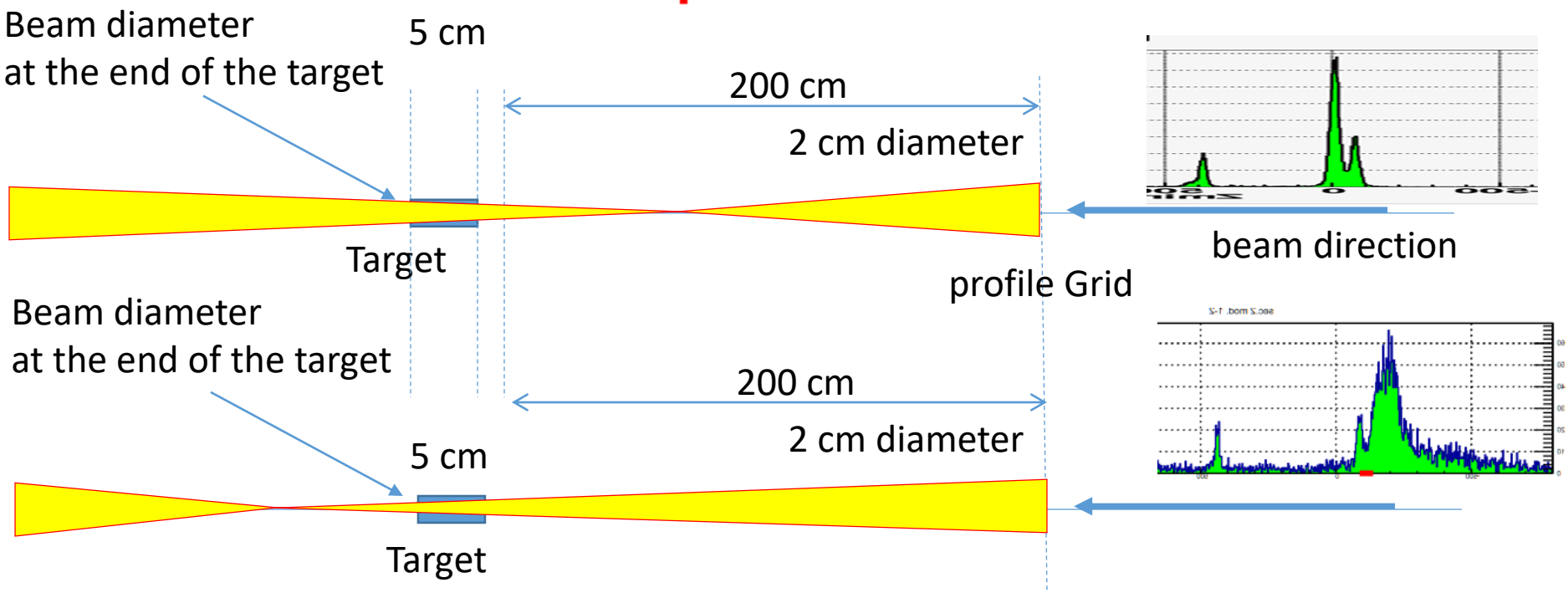


HADES LH2 Target – Z position of the beam focus



Beam parameters to be monitored:

- X/Y beam position
- Z coordinate of the focus point
- Beam tails in both directions

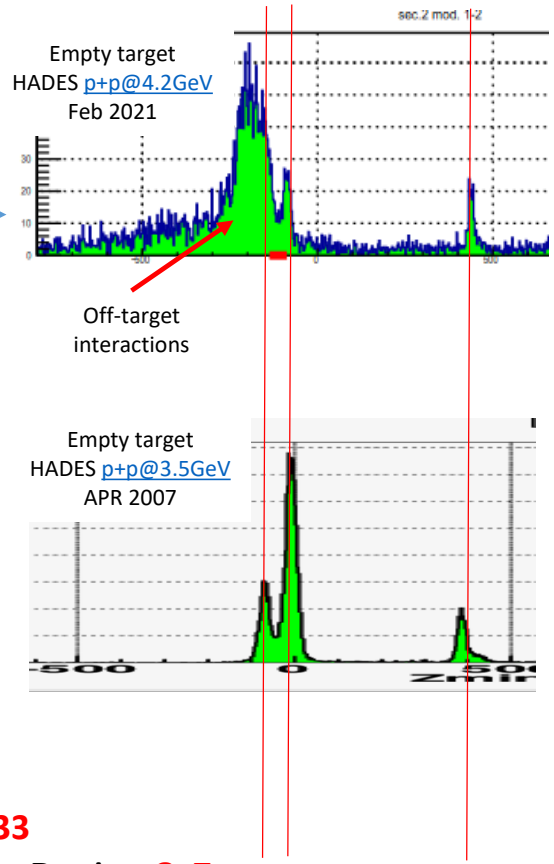


Similar effect seen in Ag+Ag experiment !

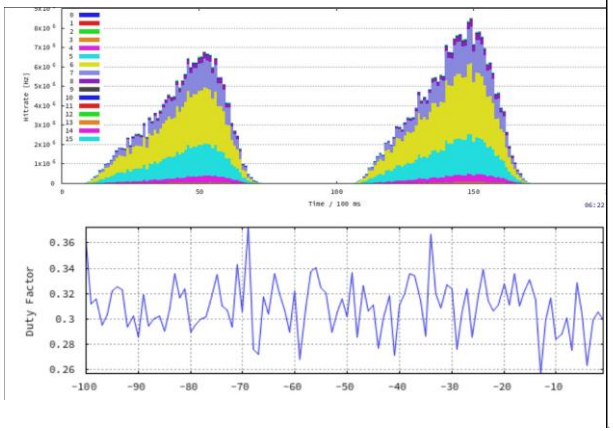
Preparation status based on the Feb2021 test experiment

- Severe difficulty in bringing the beam to the HADES cave
  - Several Power Supply Units damaged due to too high intensity/beam instabilities
    2 PSU of MDC + 5 PSU of RICH burnt ← serious safety issue → beam abort system under construction
- Poor beam focus quality, a lot of reactions outside the target
  - **Feb21: 28 % of useful pp events only**
  - **Apr07: 76 % of useful pp events → Ratio: 0.37**
  - Most likely the beam (halo/tail) was too wide
  - Unstable spill shape
- Poor micro-spill structure, **Q-factor about 18**

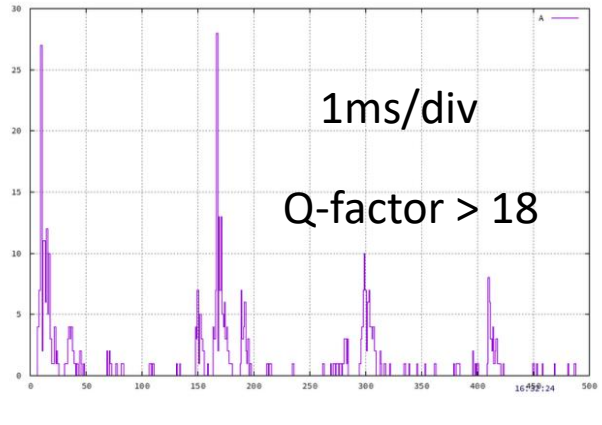
beam direction



Feb 2021 – test beam



Feb 2021 – test beam



Extrapolation from Feb2021(test) → Feb2022(S518)

Reduction factor foressen in the S518 proposal: 0.5 x 0.7 = **0.35**

Feb2021 test reduction factors: 0.3(duty factor) x 0.37 (beam focus) x 0.3 (Q=18) = **0.033**

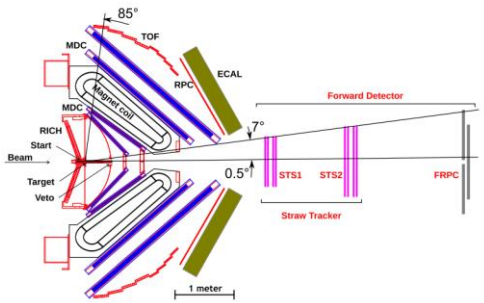
Ratio: **9.5**

4 weeks / 9.5 = 2.9 days effective beam in HADES !

*Apr07 fraction of pp events: 0.76
Feb21 fraction of pp events: 0.28

Summary

- Difficulties in transporting the beam from SIS to HADES cave
  - → Beam transport simulation from SIS to HADES needed well in advance – experts needed
  - → Two step approach:
    - SIS18-NE5 beam transport
    - Focus in HADES at low intensity, 10^6p/s
- Insufficient focus quality at the HADES LH2 target, beam halo/tail
  - → Beam transport, beam diagnostics (profile grid and scintillating target) are essential at intensities 10^6 p/s
  - → HADES T0 detector
- Hardware damages due to too high intensity/beam instabilities
  - → A fast beam abort system based on HADES detectors
    - HADES part (detector interface and abort signal generation in preparation)
    - Should be ready in 2022
- Beam parameters for S518 experiment
  - → Spill duration > 13s, improved spill shape, duty factor
  - → Micro-spill structure, Q-factor < 5
  - → 4.5 GeV is required
- Final beam optimization, fine tunning needed on the HADES side: X/Y +-3mm, Z+-10cm
  - → Equivalent of MIRCO software (BENO) with direct access to the accelerator during HADES operation available for HADES experts



Expected results

Eur. Phys. J. A (2021) 57:138
https://doi.org/10.1140/epja/s10050-021-00388-w
THE EUROPEAN PHYSICAL JOURNAL A
Regular Article - Experimental Physics

Production and electromagnetic decay of hyperons: a feasibility study with HADES as a phase-0 experiment at FAIR

(HADES collaboration and PANDA@HADES collaboration)

https://doi.org/10.1140/epja/s10050-021-00388-w

HADES plans for 2023-2025 - letter of intent for G-PAC

Pion beam case – open questions.

GSI - Nominal Intensities

This table contains examples of the most frequently requested scenarios. For other ion species, isotopes and charge states, ask your local contact.

ion species	ion source	UNILAC max. rep. rate	UNILAC charge state	UNILAC nominal average particle current	SIS18 max. rep. rate (fast ext.)	SIS18 charge state	SIS18 nominal intensity per cycle @ extraction	ESR charge state	ESR energy/u	ESR stored intensity	Cryring charge state	Cryring nominal intensity per cycle @ injection
U-238	VARIS				0,5 Hz - 1 Hz	73+	2E+09	91+/92+	300-400 MeV	1E+08		
								91+/92+	40 MeV	4E+07		
								91+/92+	10 MeV	5E+06	91+/92+	1E+06
Bi-209	VARIS				0,5 Hz - 1 Hz	68+	2E+09					
Pb-208	VARIS				0,5 Hz	67+	2E+09				78+	5E+06
Au-197	VARIS	25 Hz*	26+	0,1 pµA	0,5 Hz - 1 Hz	65+	2E+09					
Xe-124	MUCIS				0,5 Hz - 1 Hz	48+	3E+09					
Xe-136	MUCIS				0,5 Hz - 1 Hz	48+	5E+08					
Ag-107	VARIS				0,5 Hz - 1 Hz	45+	2E+09				47+	5E+06
Ti-50	PIG	50 Hz	12+	0,8 pµA	0,5 Hz - 1 Hz	22+	2E+08					
N-14	**MUCIS**				**0,5 Hz - 1 Hz**	**7+**						**7E+10**
N-14	MUCIS				0,5 Hz - 1 Hz	7+	7E+10					
C-12	ECR	50 Hz	2+	2,4 pµA	0,5 Hz - 1 Hz	6+	4E+09					
	MUCIS (from CH3 molecule***)				0,5 Hz - 1 Hz	6+	4E+09					
	Cryring ECR										1+	2E+06
H-1	MUCIS (from H3 molecule**)				0,5 Hz - 1 Hz	1+	1E+09					
	MUCIS (from CH3 molecule***)				0,5 Hz - 1 Hz	1+	8E+10					

* 50Hz is possible only with exclusive operation mode
** in parallel operation mode with high MAZ and adopted synchronous phase (higher intensity possible only during exclusive proton operation)
*** C+H parallel high-current operation from molecule source

Baryon couplings to mesons and virtual photons in the third resonance region: vacuum and cold matter studies

Pion induced reactions on CH_2 and C, Ag targets

The HADES Collaboration

Spokespersons: J. Stroth (j.stroth@gsi.de), P. Tlusty (tlusty@ujf.cas.cz)
GSI contact: J. Pietraszko (j.pietraszko@gsi.de)

Infrastructure: SIS18, pion production target and HADES cave
Beam: Nitrogen at 2*A* GeV, maximum intensity, slow extraction

FAIR - Facility for Antiproton and Ion Research in Europe GmbH
GSI Helmholtzzentrum für Schwerionenforschung GmbH
Planckstrasse 1
64291 Darmstadt
Germany

Scientific Managing Director
Professor Dr. Paolo Giubellino
Phone +49-6159-71-2649
P.Giubellino@gsi.de

Prof. Dr. Joachim Stroth
Institut für Kernphysik
Goethe- Universität
Max-von-Laue-Str.1
60438 Frankfurt am Main

13.10.2020

S517: "HADES - II"

Joachim Stroth et al.

Dear Colleague,

The management of GSI/FAIR would like to thank you for submitting a proposal to our latest 'Call for Proposals for Beam Time in 2021/2022'. On August 26-28, 2020, the General Program Advisory Committee (G-PAC) during its 44th meeting has evaluated a total of 95 proposals requesting 3215 shifts of beam time. The considerations of the G-PAC were based on their assessment of the scientific importance of the proposed research, its feasibility and its reliance on unique aspects of the GSI/FAIR facility. Proposals were ranked into the four categories:

A	Experiment proposal recommended for granting of beam time ('to be done')
A-	Proposed experiment is of great scientific interest but due to the large overdraft of beam time can be recommended to run only if beam time becomes available (reserve list)
B	deferred, but encouraged to submit an improved version in a future call
C	no granting of beam time is recommended

In case beam time is granted[1], it is done so exclusively for this proposed experiment, i.e. granted shifts cannot be used to run an experiment with a different scientific scope except it has passed G-PAC again. Also, beam time not taken during the indicated period of the present call will expire.

Your proposal S517 has not been ranked. The G-PAC has formulated the following evaluation with which I concur: 'The committee recognizes the importance and very high quality of the physics case of the proposal. The world-wide unique availability of pion beams at GSI in combination with excellent detection capabilities of the HADES experiment to measure baryon-meson couplings, EM baryon transitions and properties of cold hadronic matter in general will have strong scientific impact and cannot be performed at FAIR (Phase 0). Despite some improvements since the last G-PAC meeting,

[1] Beam time is granted at no charge within the framework of the Helmholtz Association 'Rahmenrichtlinie über die Nutzung von Forschungsanlagen der Helmholtz-Zentren durch Dritte' (1.3.2006), §II. 1.2.

Page 1 of 2

Geschäftsführung:
Professor Dr. Paolo Giubellino
Dr. Ulrich Breuer
Jörg Blaurock

FAIR
Sitz: Darmstadt
Amtsgericht Darmstadt HRB 89372
USt-IdNr.: DE 215 560 927

Commerzbank Darmstadt
IBAN DE03 5004 0000 0132 8306 00
BIC COBADEFF500

GSI:
Vorsitzender des Aufsichtsrates:
Ministerialdirigent Dr. Volkmar Dietz

Sitz: Darmstadt
Amtsgericht Darmstadt HRB 1528

USt-IdNr.: DE 111 671 917

Landesbank Hessen/Thüringen
IBAN DE88 5005 0000 5001 8650 04
BIC HELADEFF

FAIR - Facility for Antiproton and Ion Research in Europe GmbH

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enhancing effic

Sincerely yours,

Prof. Dr. Paolo G
Scientific Managi

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experiments with pion beam strongly rely on further improvements of pion beam extraction. The G-PAC therefore encourages the HADES Collaboration to resubmit the proposal in future and the GSI management to prioritize enhancing efficiency of pion beam extraction.'

LoI deadline is October 15, 2021.

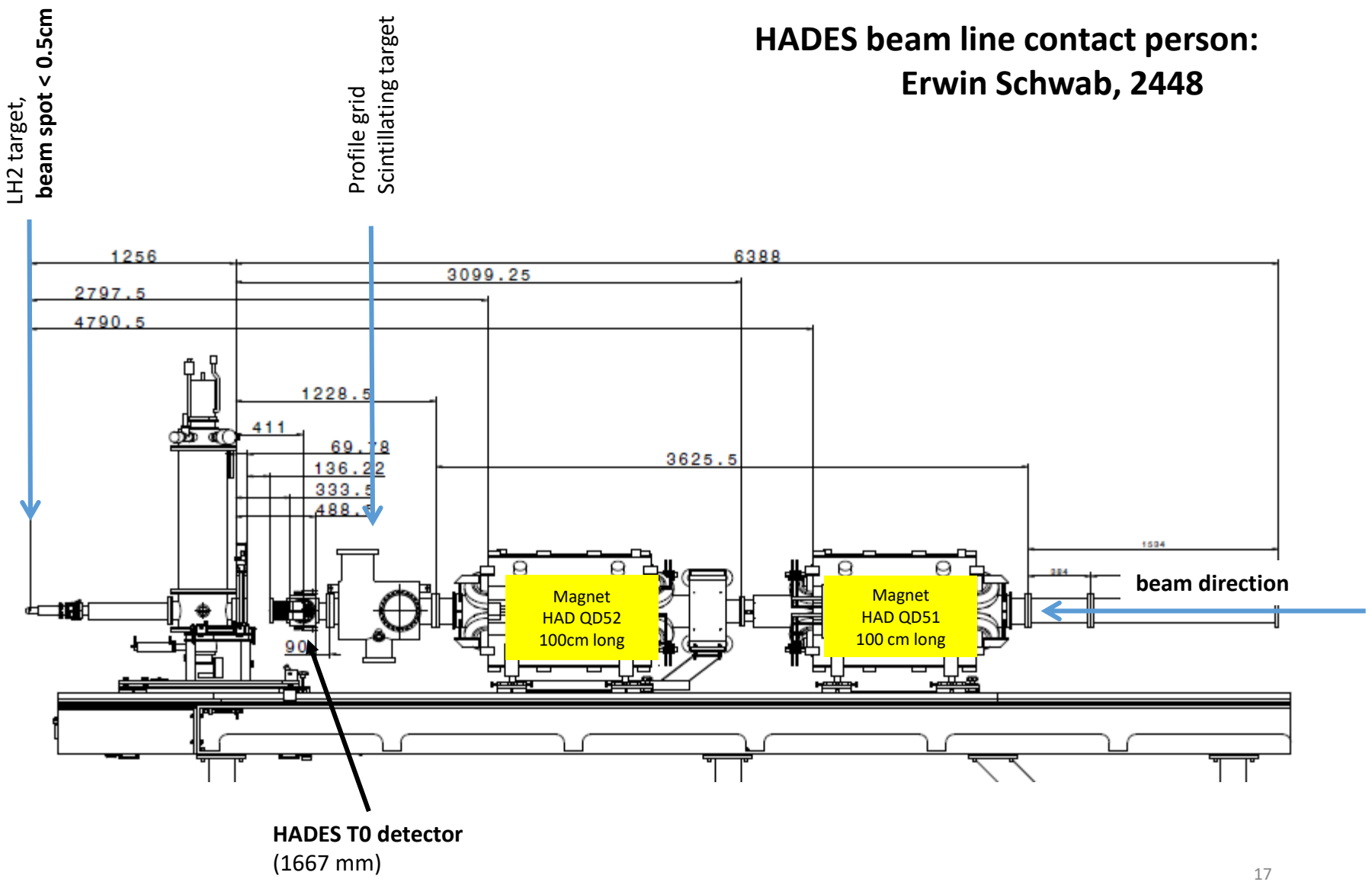
Page 2 of 2

Thank you

backup slides
⇓

HADES Beam Line Upstream of the LH2 Target

HADES beam line contact person:
Erwin Schwab, 2448

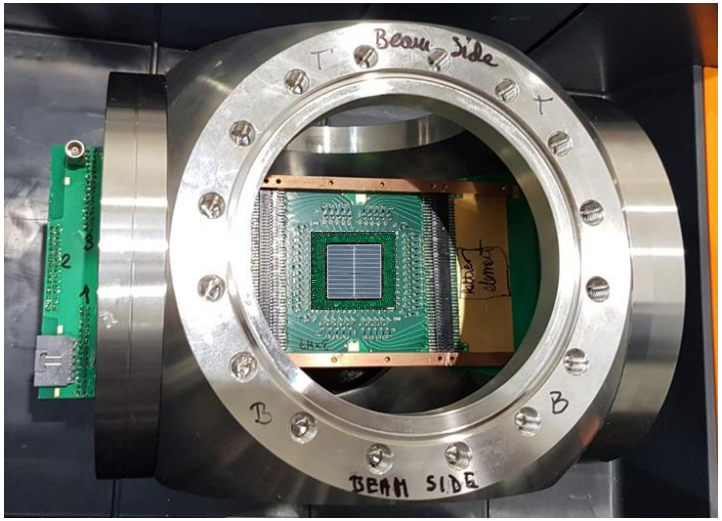


Heavy Ion vs. Proton HADES setups

Liquid Hydrogen Target

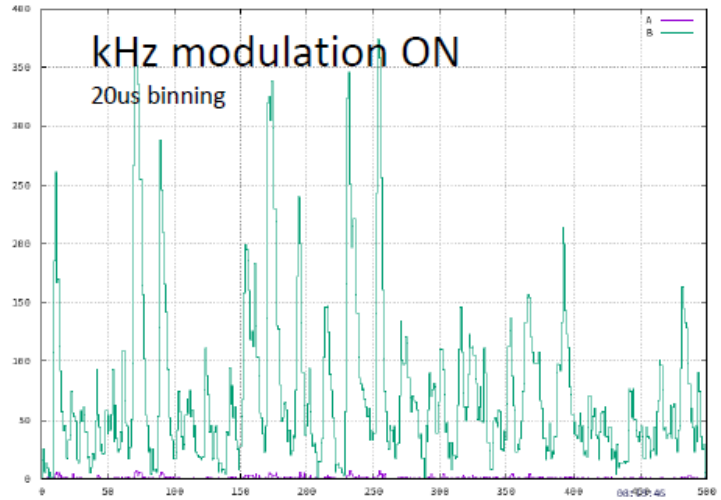
- Cryo infrastructure
- Safety infrastructure
- Power/H supplies

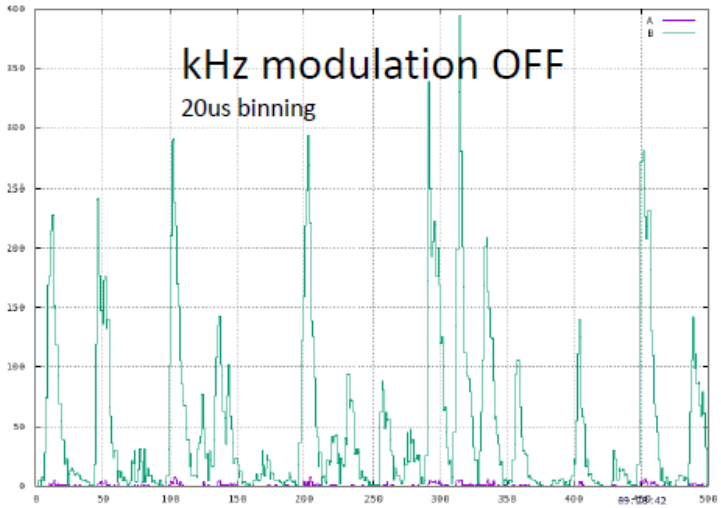
Proton T0 detector

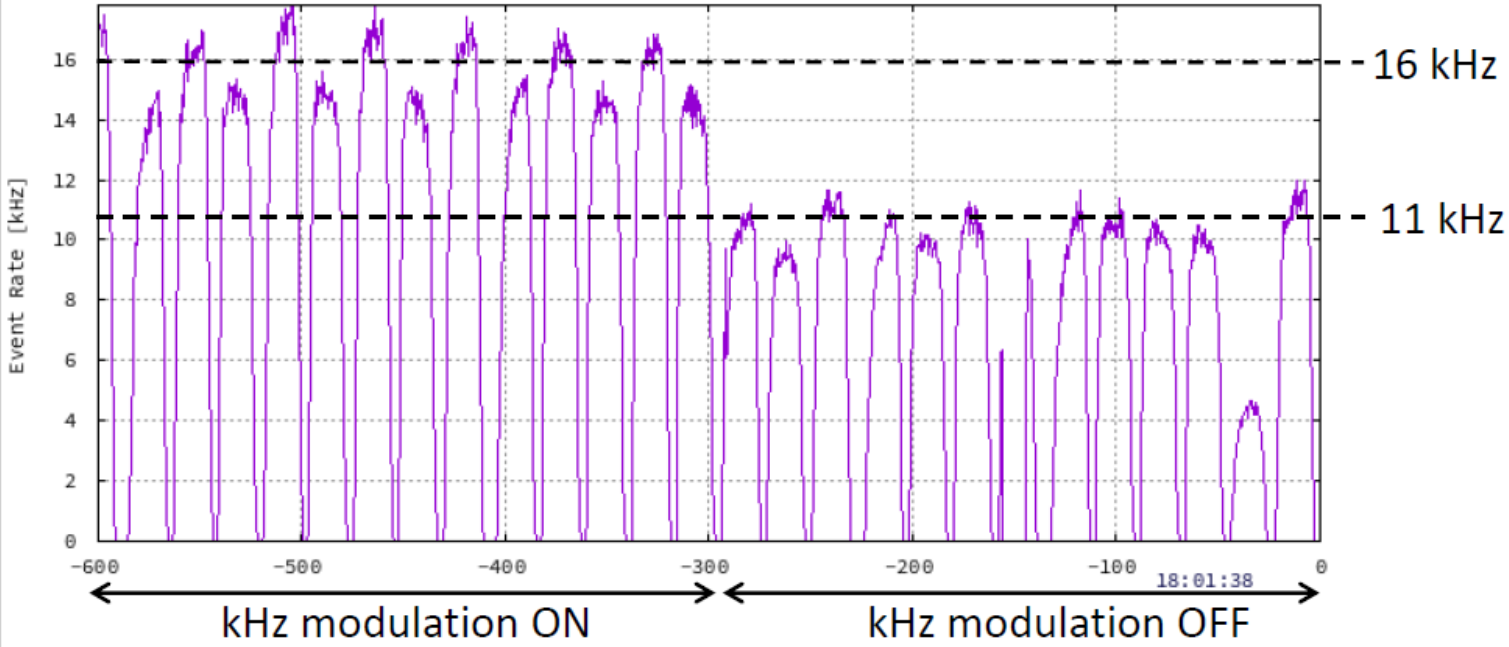


HI segmented target

kHz magnet modulation (Rahul Singh - RS method)
– influence on HADES event rate



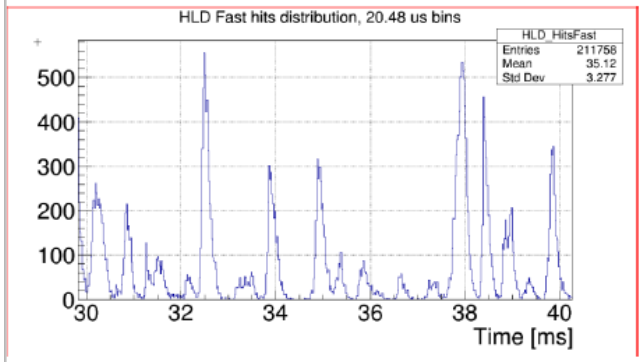




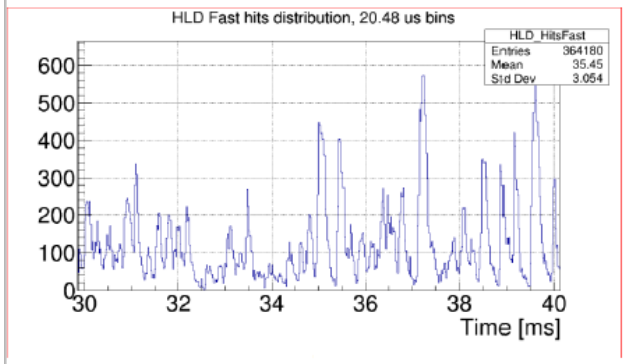
kHz magnet modulation (Rahul Singh -RS method)
– influence on HADES event rate

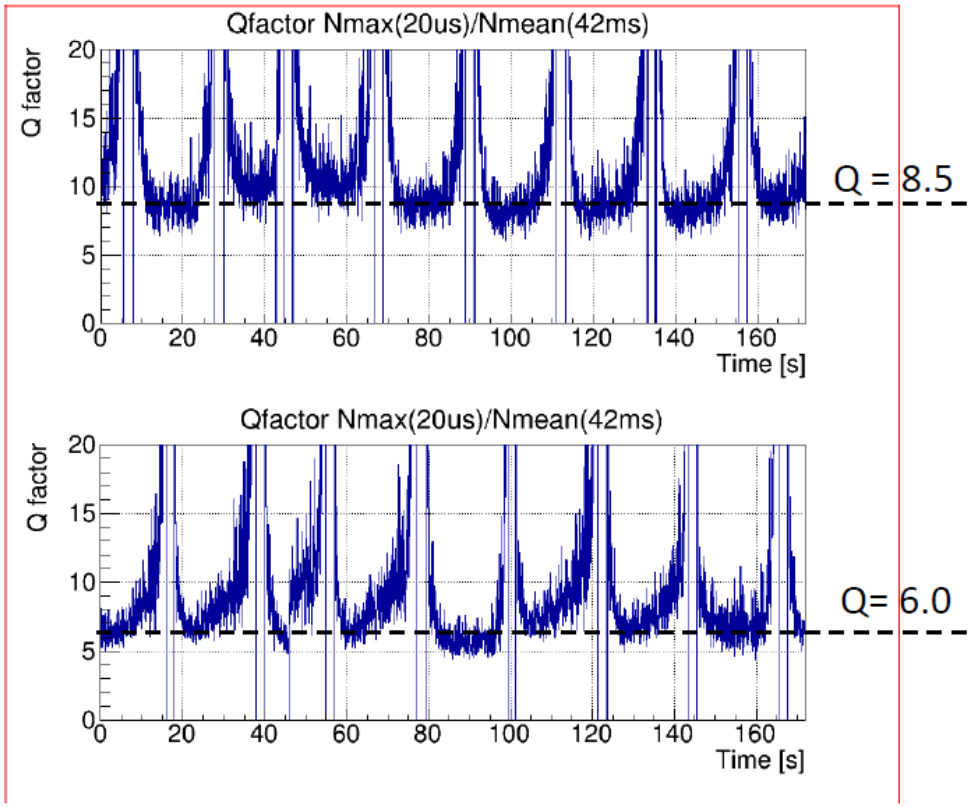
HADES

kHz modulation OFF



kHz modulation ON



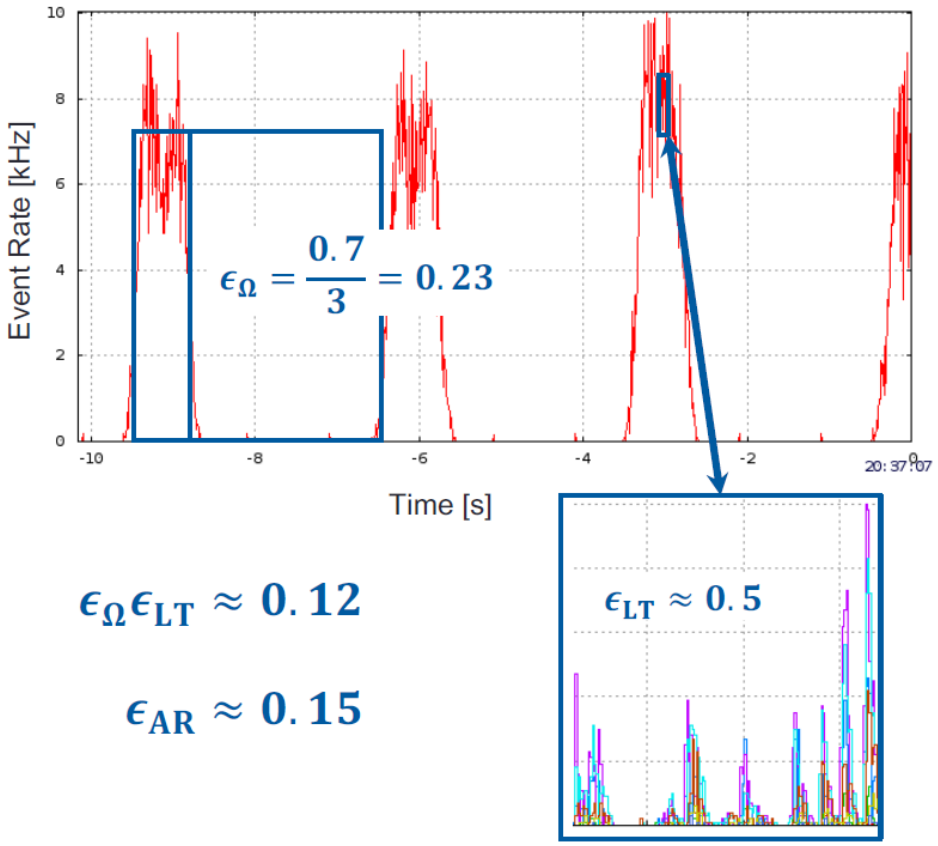


Data taking performance – case SEP14

We use two performance factors in our beam time estimates and which are influenced by the beam quality:

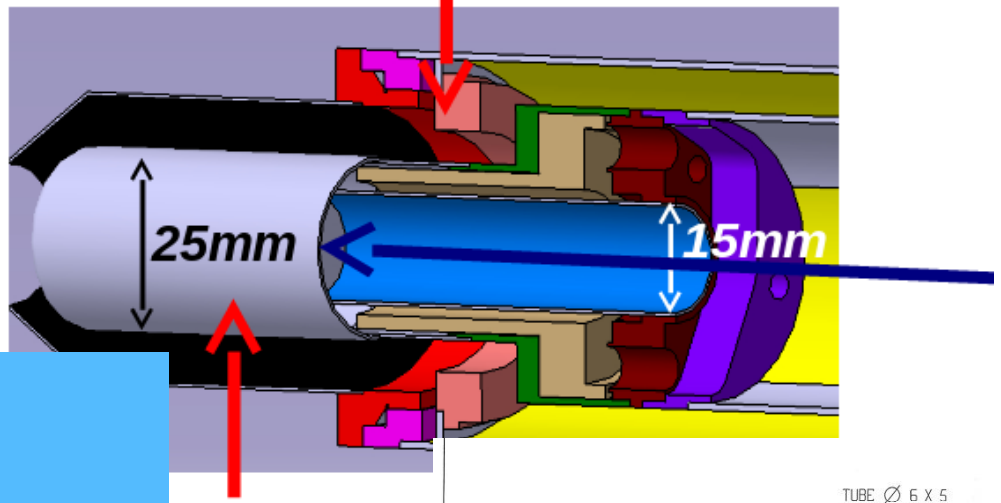
- ϵ_{Ω} (duty factor): Fraction of time we are in the flat top.
- ϵ_{LT} (lifetime): the fraction of events accepted during flat top relative to the trigger rate.
- ϵ_{AR} (detection performance): the fraction of recorded events which survive reconstruction and all analysis cuts. This quantity depends substantially on the physics case:

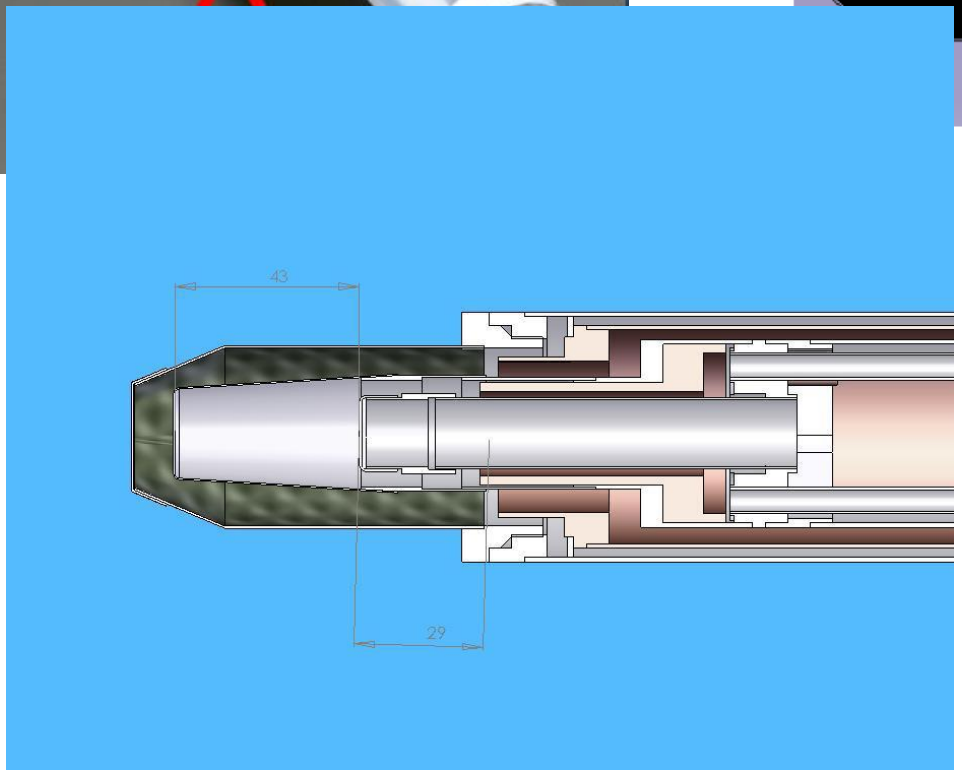
Under optimal conditions a factor increase in data/shift ($\epsilon_{\Omega}\epsilon_{LT}\epsilon_{AR} = 0.6\times0.6\times0.9 \approx 0.3$).

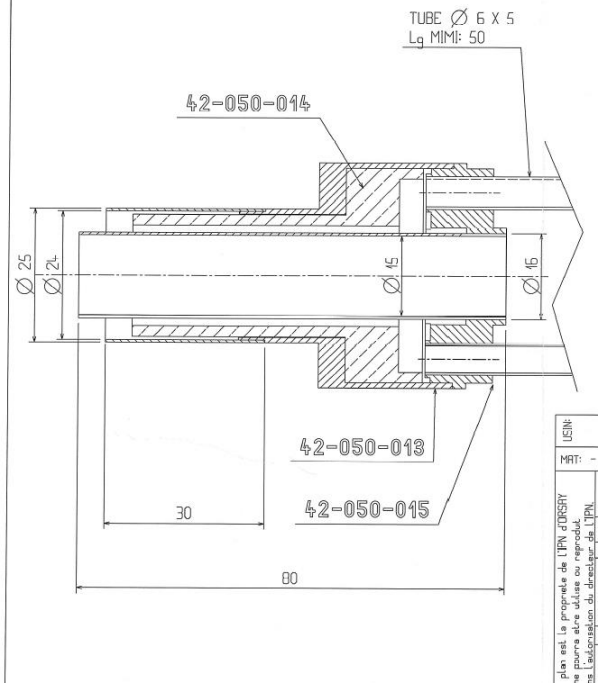


LH2 Target w/o coverage (service)

Target holder (metal)
up to 100% interaction probability !!!!







more details in tech drawings