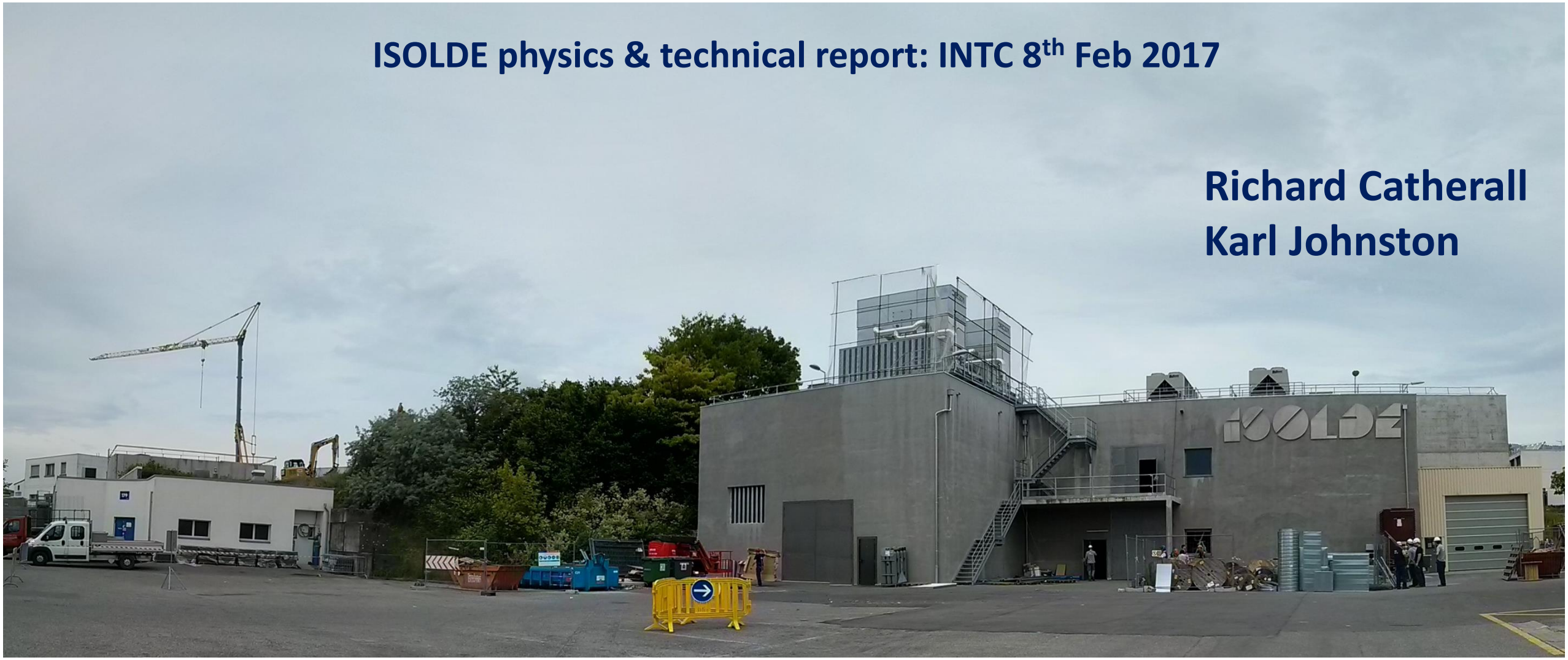
ISOLDE physics & technical report: INTC 8th Feb 2017

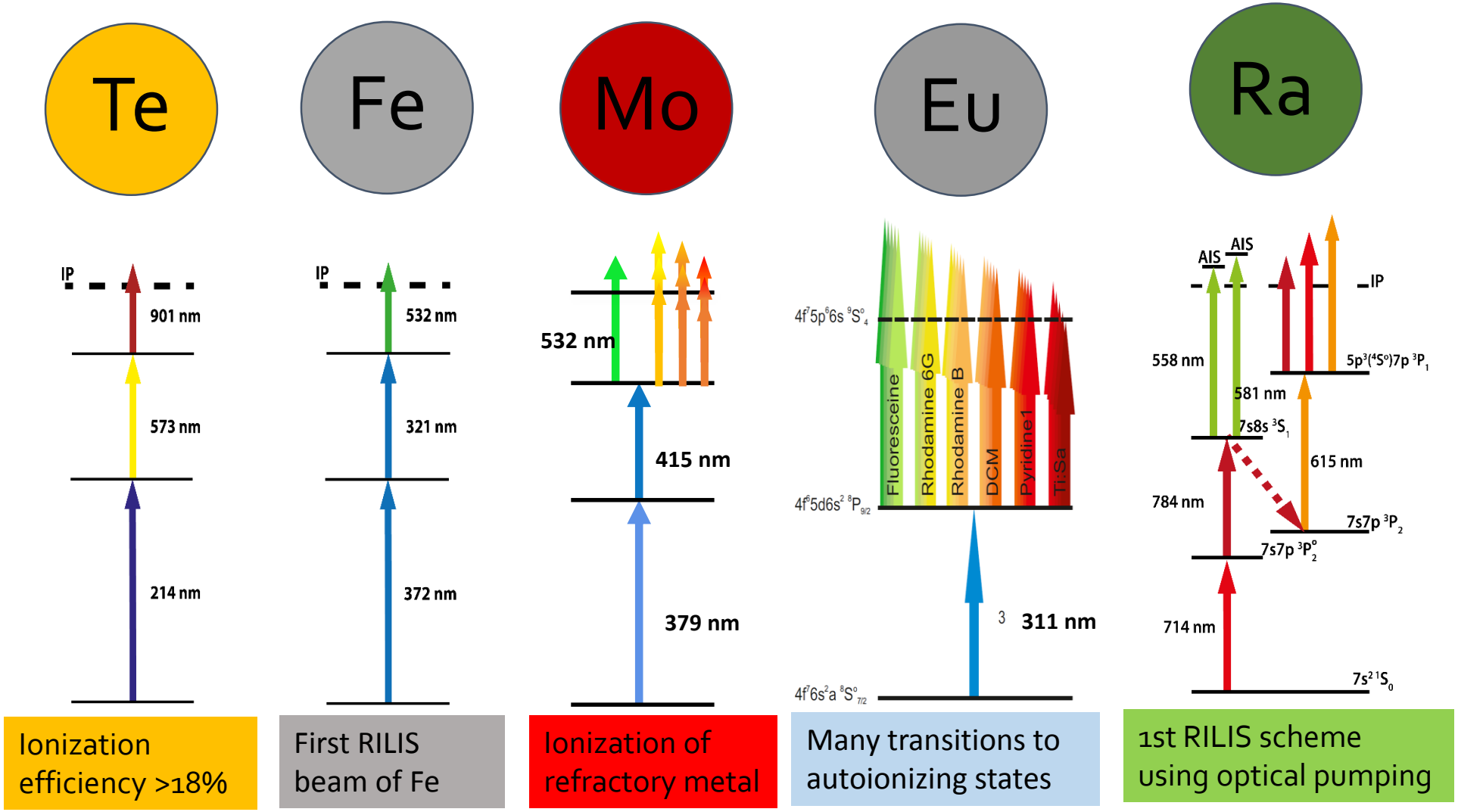
Richard Catherall
Karl Johnston



Technical developments
Status of nano-structured targets

Physics from 2016
Preliminary overview of 2017
Safety/access

Development of ionization schemes in 2016



Ionization efficiency >18%

First RILIS beam of Fe

Ionization of refractory metal

Many transitions to autoionizing states

1st RILIS scheme using optical pumping

RILIS operation in 2016

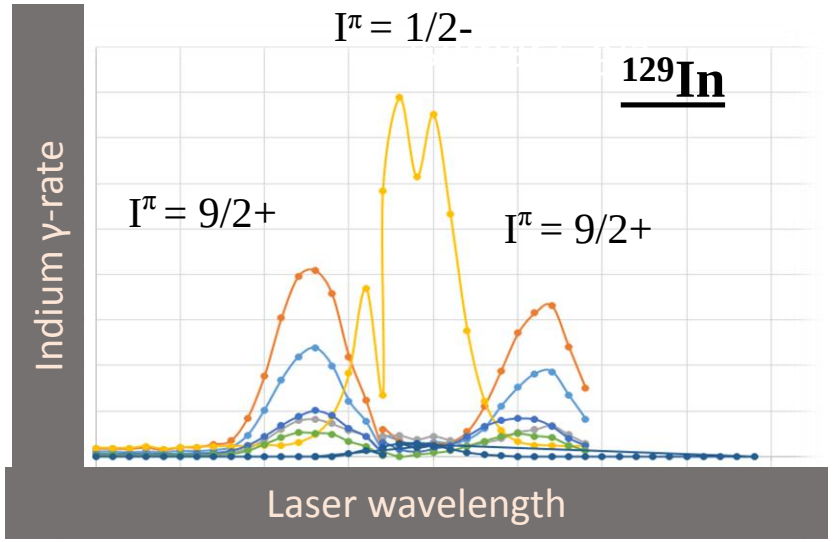
- **130** days of RILIS operation (mostly 24-hr operation)
- **22** separate RILIS runs => **75% of ISOLDE Physics**
- **14** different elements:

  Be, Cr, Cu, Mg, Ni, Dy, Mn, In, Bi, Sn, Ra, Cd, Al, Zn

- **1** laser failure which required a factory repair

(it did not adversely affect operation)

Isomer selective ionization of Indium isotopes

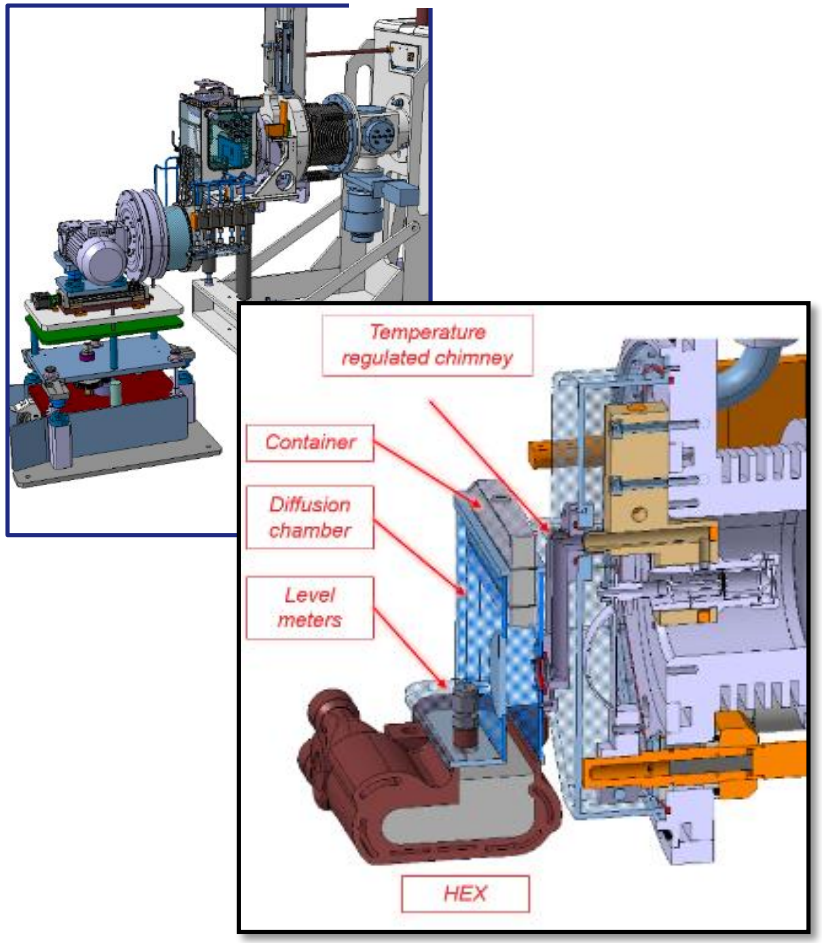


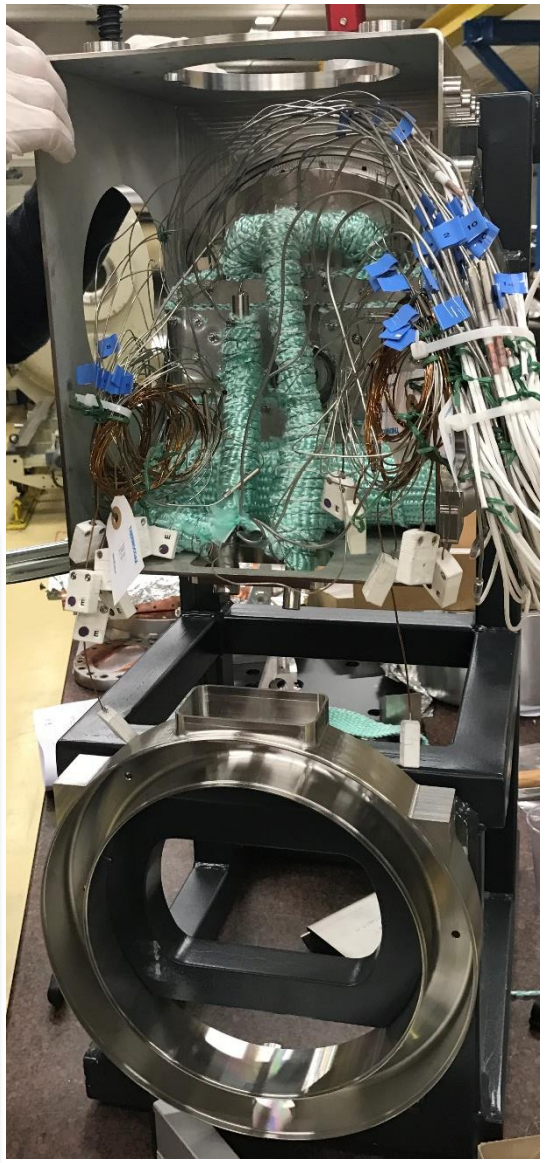
Expected TISD @ ISOLDE

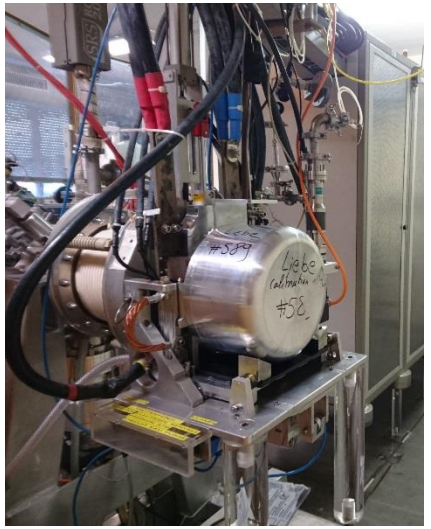
- Sc: Ti foils (CF4, RILIS)
- Te: yields with RILIS
- M(CO)x formation @ MEDICIS irradiation point
- ThO felt + Negative ion source
- LIEBE @ GPS-online
- STAGISO beam test
- Si from UCx (pending INTC endorsement)
- TiC-CNT (pending safety clearance)

The LIEBE target – design & manufacturing

M. Delonca





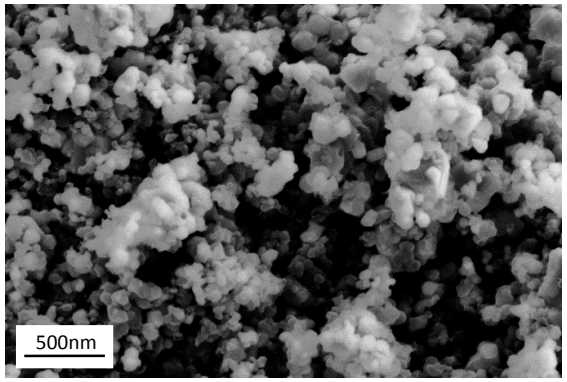


Assembly on-going

Nano Composites: Ti-Carbide

J.P. Ramos

TiC-Carbon black



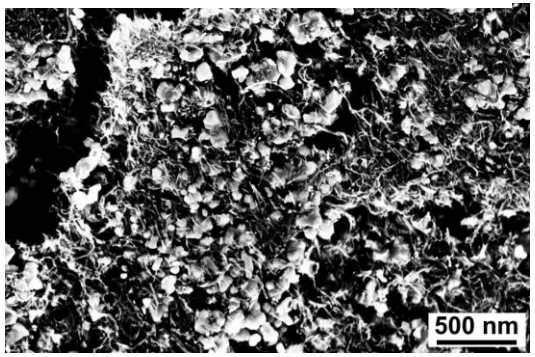
2016

Beams extracted:

- Li (high)
- Na (very high)
- K (similar)
- Ca (much lower)

Probable chemical reaction with carbon black

TiC-Carbon Nano Tubes



2017 ?

Short lived K and Ca beams

Si beams? Molecular?

INTC-I-176

Nanomaterials research and operation is **on hold** until full risk analysis and clearance.

- New glove box for class A lab required
- Request permission to continue work with non-pyrophoric materials launched
- Asking for new and dedicated labs

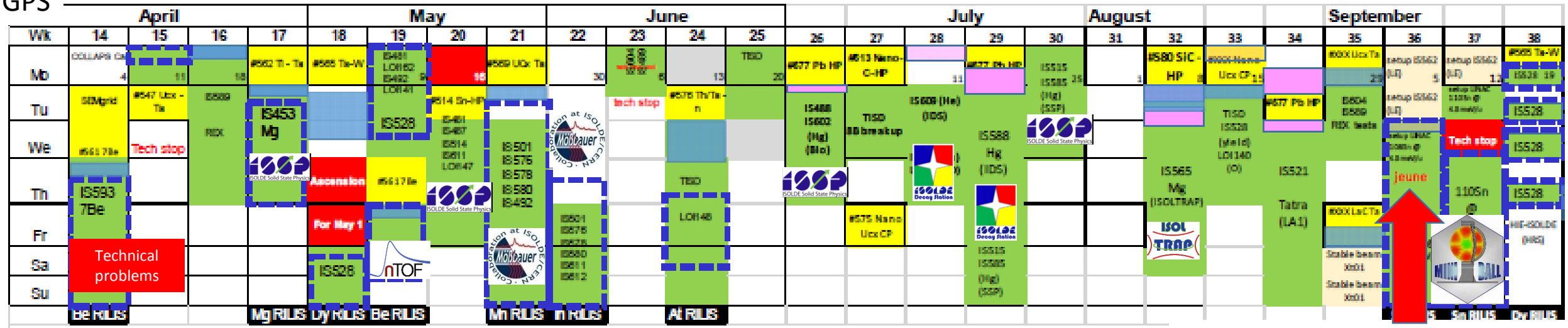
J.P. Ramos, PhD Thesis, EPFL/CERN (2017), CERN-THESIS-2016-247

Status of nano-material production

- Following an incident with the handling of actinide nano-material last year, all production of nano-material targets (with the exception of CaO) is suspended.
- Partly due to a lack of labs to provide a suitable and safe environment for their handling
  - Two labs are required
    - 1 for actinide and 1 for non-actinide
- The scientific program for the following experiments may be jeopardised following this moratorium
- Two propositions have been presented…
  - With full support from EN management
- In the meantime I will ask for a derogation for non-pyrophoric non-actinide materials and investigate a temporary solution for actinide materials.

nano-mat	exp	isotopes
LaCx	IS545	$^{114\text{-}118}$Cs
UCx	P487	^{133}In
	P469	^{11}Be
	P478	^{28}Mg
	P471	$^{78\text{-}80}$Cu
	P470	^{28,30}Mg
	P458	^{52,53}K
	P449	$^{130,\ 135}$In
C	P463	^{8}B
SiC	P459	^{22}Mg
	P366	^{20}Mg

GPS



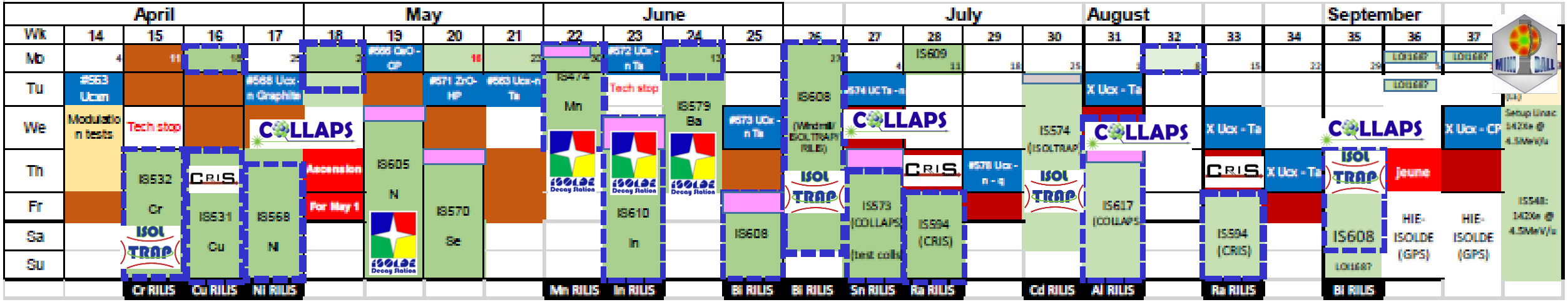
Successful runs for:

- **ISOLTRAP** (Cr Bi, Cd, Mg isotopes,)
- **CRIS** (Cu, Ra)
- **COLLAPS:** (Ni, Sn, Al, Bi)
- **Medical isotopes**: excellent runs with both 149Tb and 152Tb

- **Nuclear Astrophysics**: 16N and 64Ge
- **Solid state physics**: Mg for nitride semiconductors and Mn/In for Mossbauer spectroscopy. Cd, Hg for local structure investigations of graphene and multiferroic materials.
- **IDS:** N, Mn, In, Ba, He, Hg. Inauguration of the new ISOLDE-built neutron time of flight spectrometer.

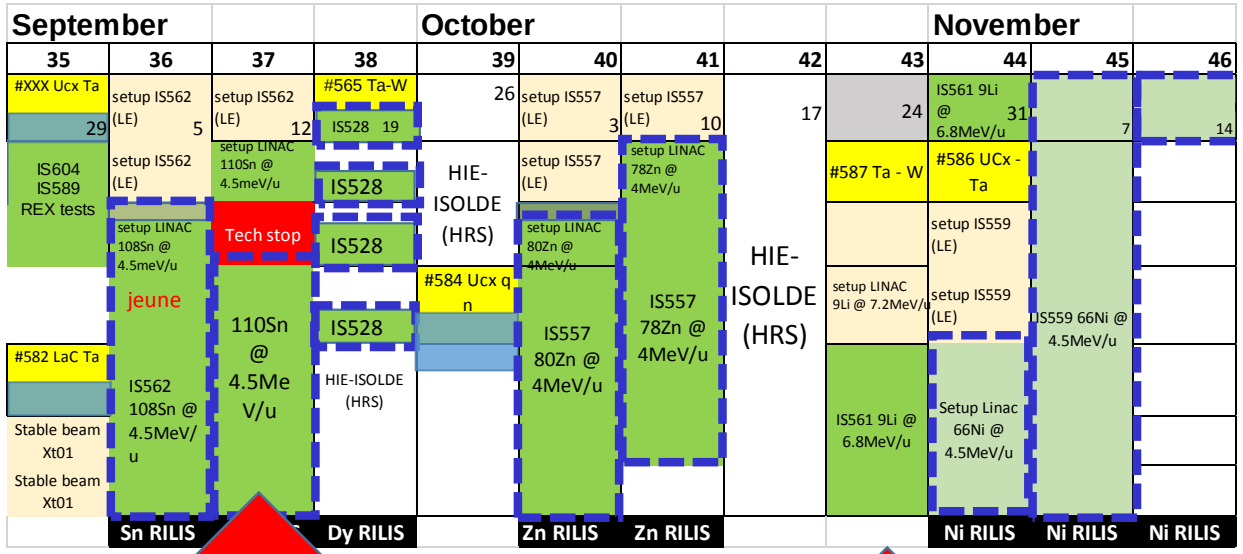
- **Tatra spectrometer**: Hg isotopes
- 7Be collection for **nTof** was finally possible. Promising results….
- Bi run involving ISOLTRAP/Windmill/COLLAPS/RILIS
- First **Miniball** run with 110Sn.

HRS



HIE ISOLDE runs in a nutshell

GPS



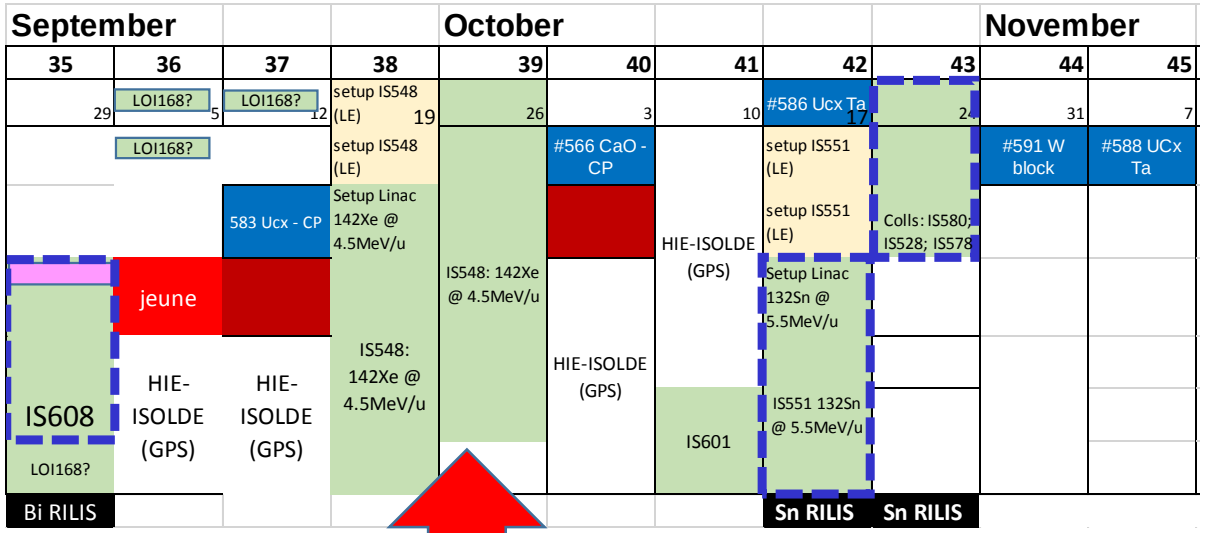
Broken 9-gap Amplifier. Only 110Sn possible

RILIS laser window required replacement. Only 78Zn possible.

Difficult setup. Transmission and alignment questions. First test of XT02

Smooth until target broke

HRS



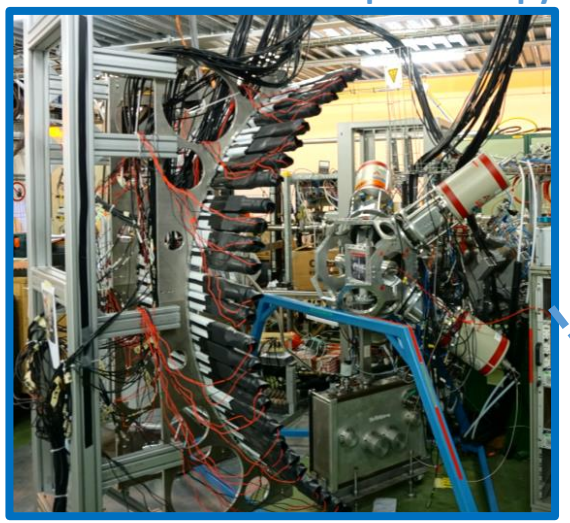
Delay due to repair of Amp; leaking target. 15 shifts instead of 30

SnS molecular beam…machine at full energy for first time: 5.5MeV/u

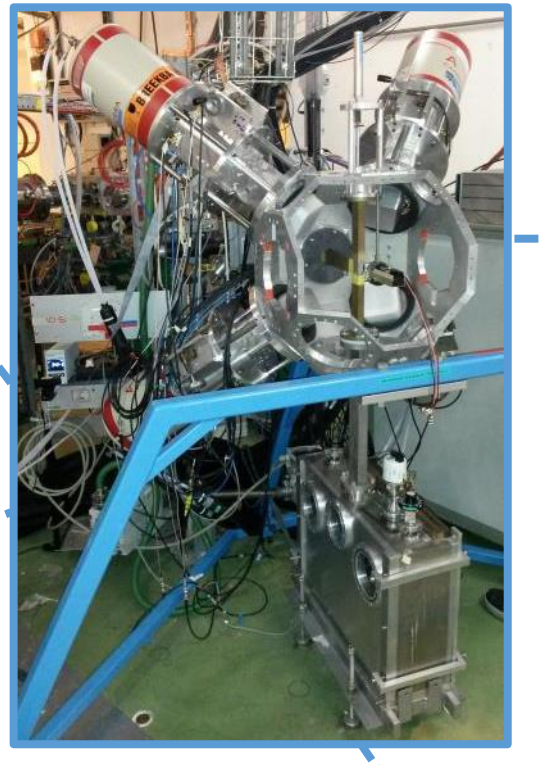
Regular trips of SC cavities: users can reset.
Regular trips of 7-gap…15 mins each time…
Extremely heavy load on operators for each run…

IS609: Study of beta-delayed neutron decay of 8He using the newly comissioned IDS Neutron Detector

Neutron Spectroscopy

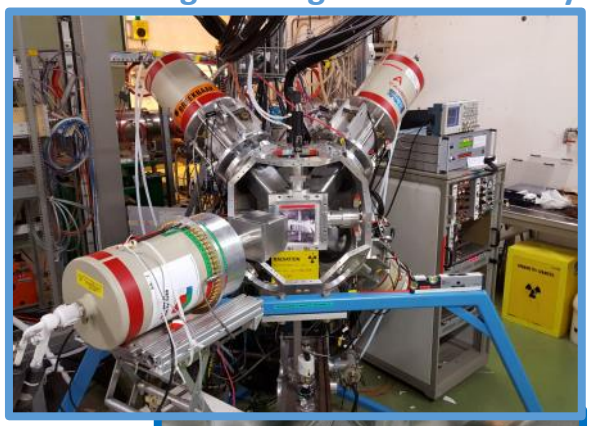


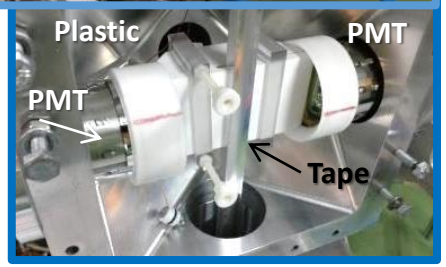
ISOLDE Decay Station 2016



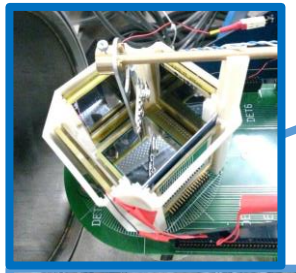
IS588: Study of core breaking and octupole low-spin states in ^{207}Tl through gamma and beta spectroscopy of ^{207,208}Hg

High beta-gamma efficiency

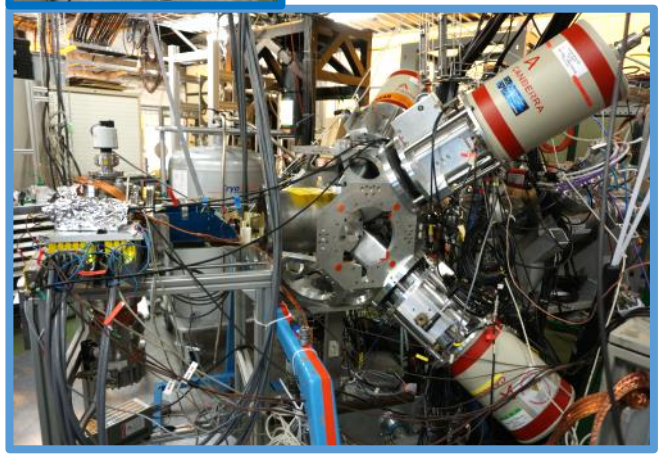




IS610: Gamma-ray and fast-timing spectroscopy of nuclei around the doubly-magic ^{132}Sn nucleus
IS474: Fast-timing studies of nuclei below ^{68}Ni populated in the β-decay of Mn isotopes
IS579: Study of octupole deformation in n-rich Ba isotopes

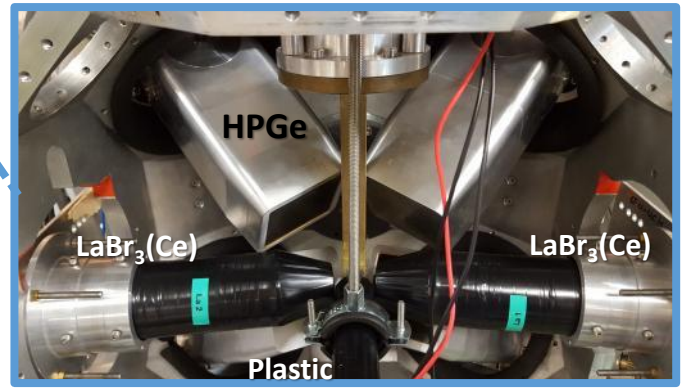


Particle Spectroscopy



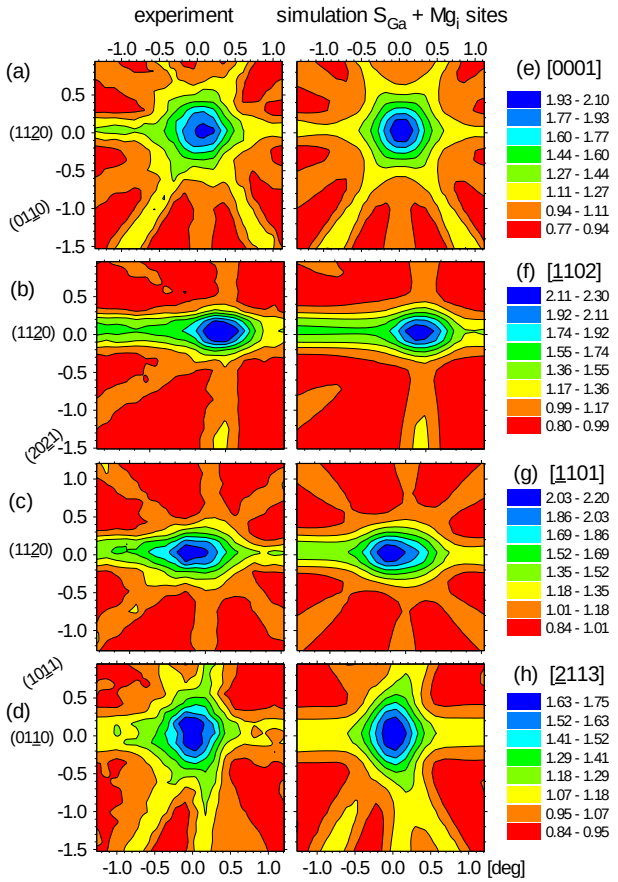
IS605: Absolute measurement of the βα decay of 16N, with significance for astrophysically important CO reaction. Particle detection was performed using silicon strip detectors of varying thicknesses.

Fast-timing studies

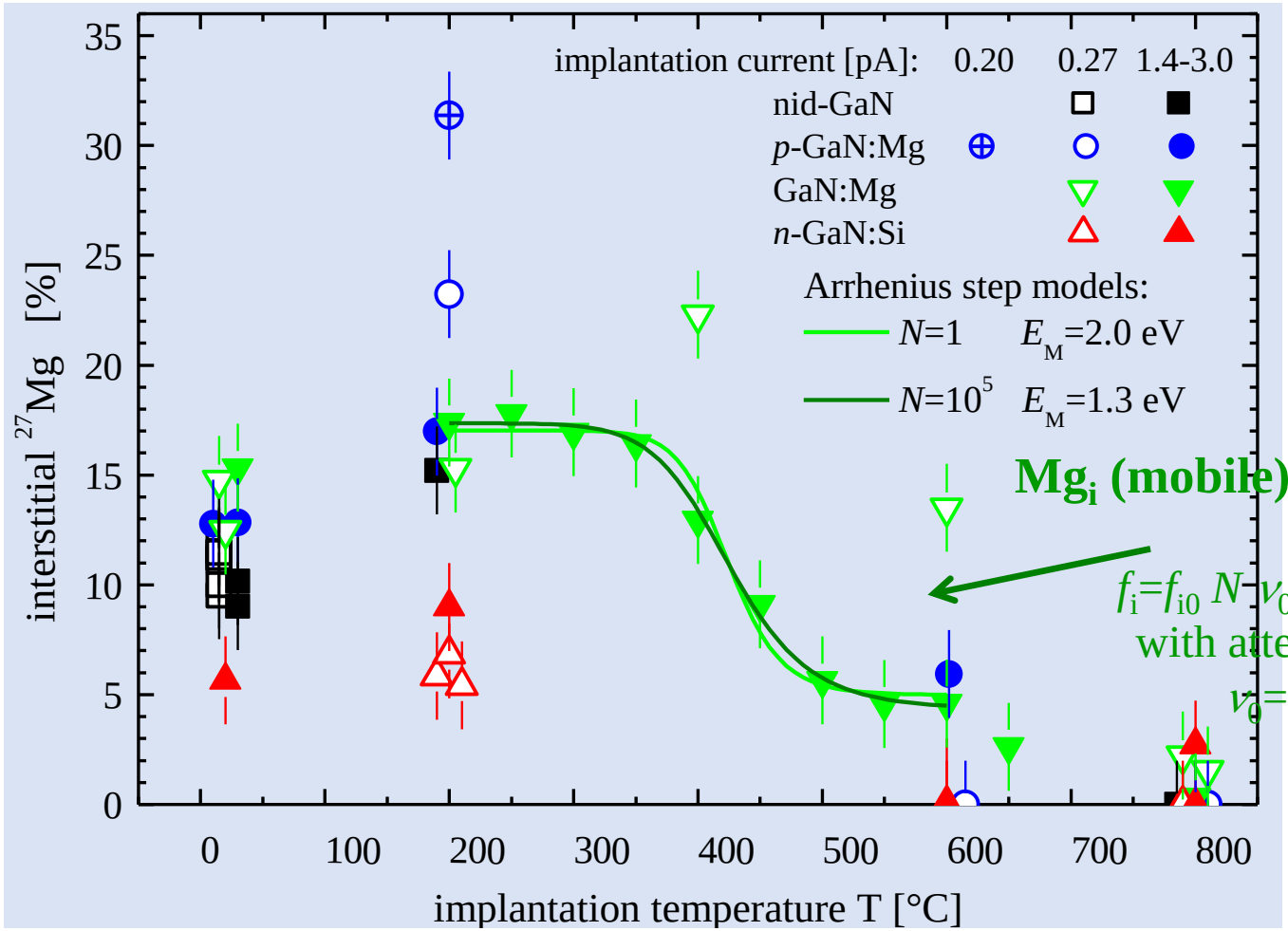


Thanks to Razvan Lica

Interstitial ^{27}Mg in different doping types of GaN



- **Interstitial Mg_i enhanced in *p*-GaN and suppressed in *n*-GaN.**
- **Site change of ^{27}Mg from interstitial to substitutional Ga sites as function of implantation temperature allows to estimate activation energy for migration of Mg_i as $E_M \approx$ 1.3–2.0 eV.**



Mg_i (mobile) + $V_{Ga} \rightarrow Mg_{Ga}$

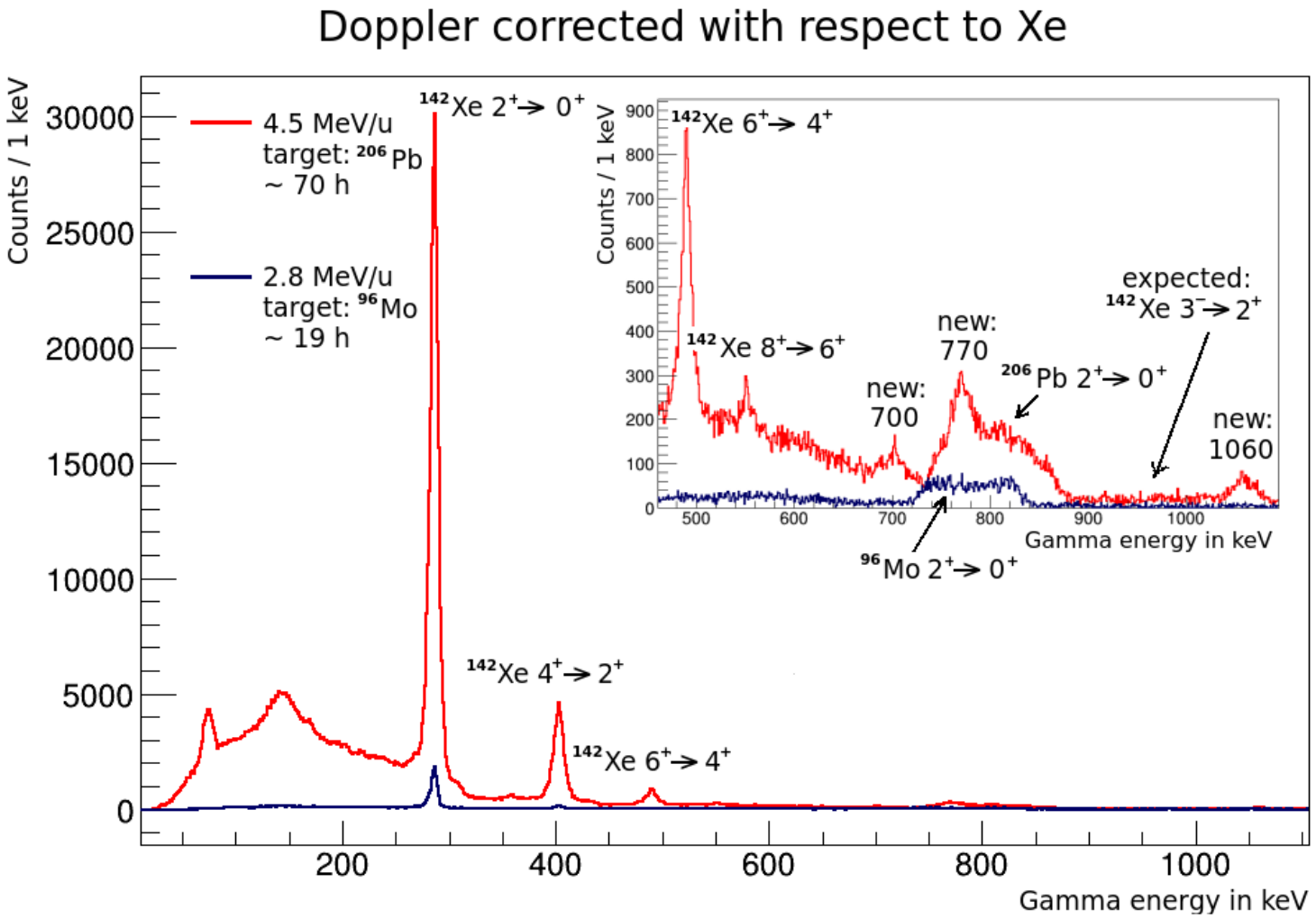
$f_i = f_{i0}\, N \nu_0 \tau \exp[-E_M/k_B T]$
with attempt frequency
$\nu_0 = 2\times10^{13}\ s^{-1}$

Accepted for PRL: Wahl *et al*, 2017

IS624 Irradiation

Ir

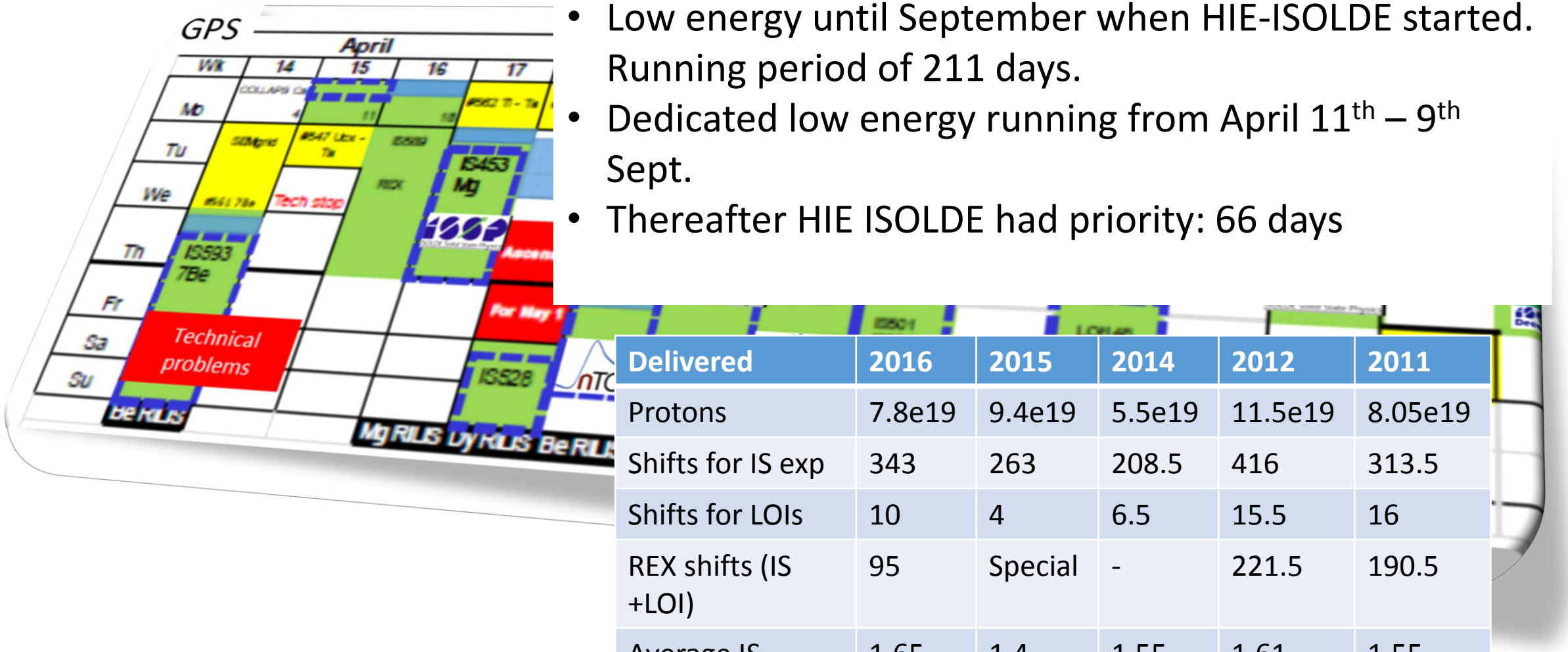
Preliminary data from ^{142}Xe for IS548



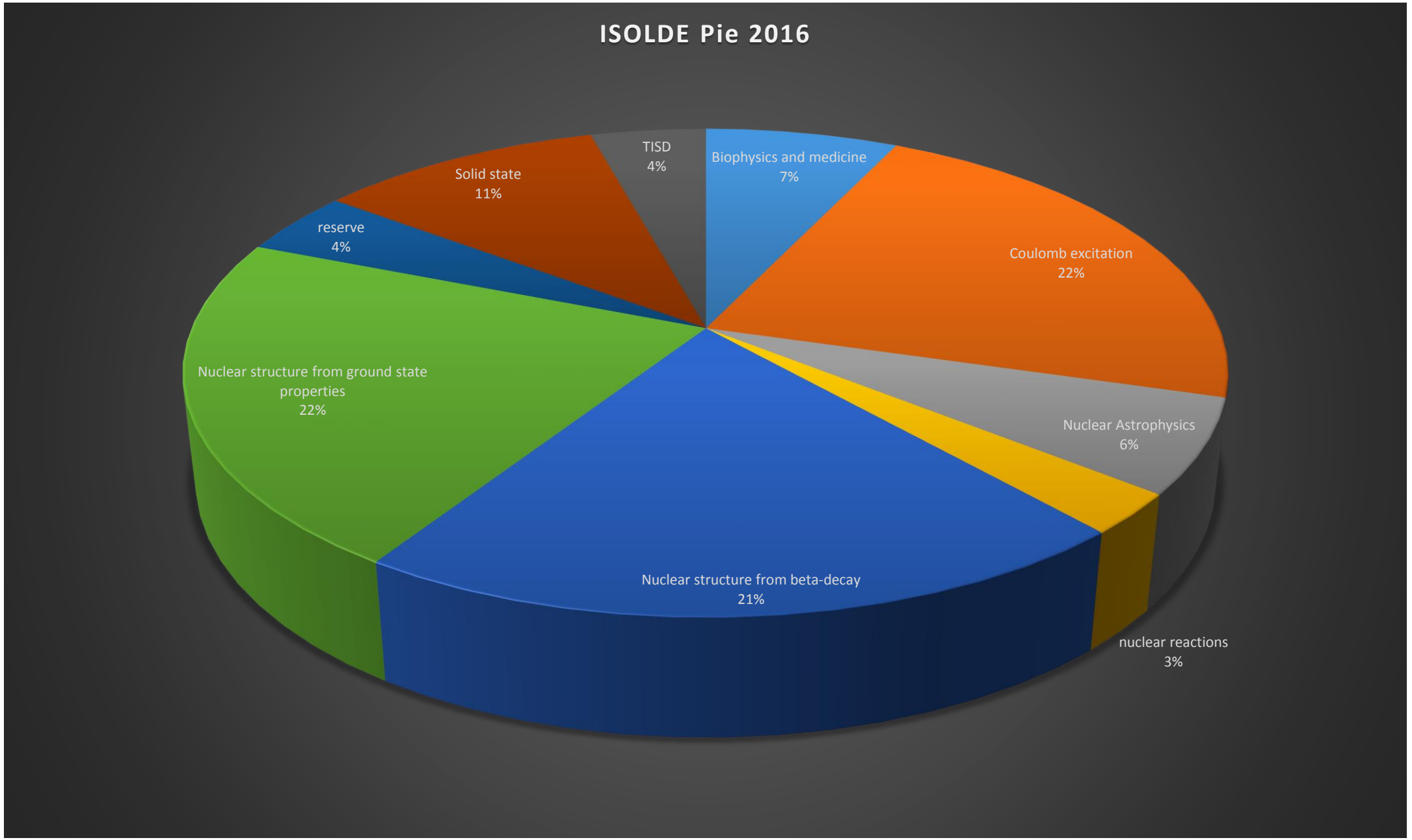
Courtesy of corinna Henrich

2016

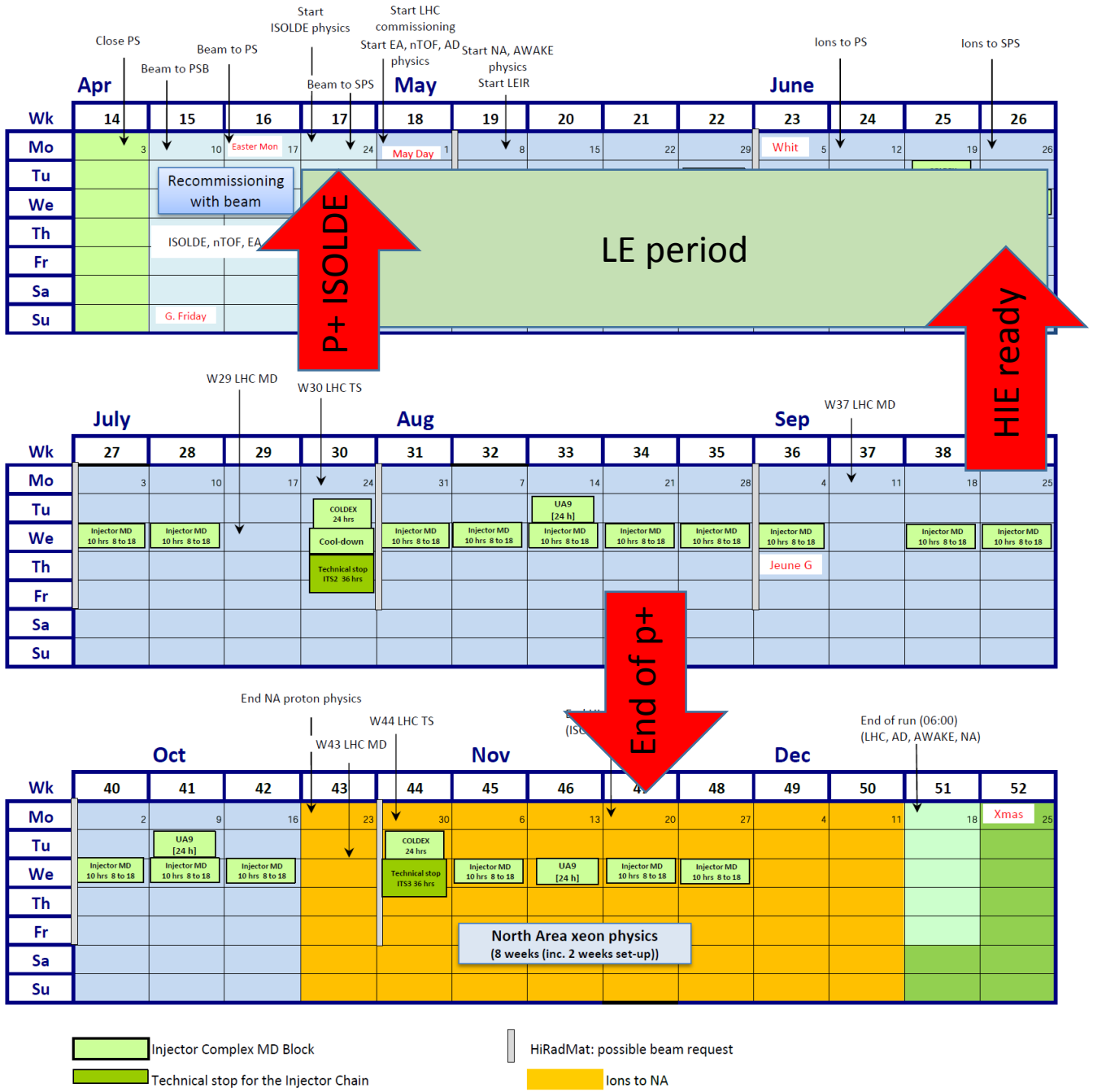
- Protons to ISOLDE since 11 April
- Low energy until September when HIE-ISOLDE started. Running period of 211 days.
- Dedicated low energy running from April 11th – 9th Sept.
- Thereafter HIE ISOLDE had priority: 66 days



Delivered	2016	2015	2014	2012	2011
Protons	7.8e19	9.4e19	5.5e19	11.5e19	8.05e19
Shifts for IS exp	343	263	208.5	416	313.5
Shifts for LOIs	10	4	6.5	15.5	16
REX shifts (IS +LOI)	95	Special	-	221.5	190.5
Average IS shifts/day	1.65	1.4	1.55	1.61	1.55


ISOLDE Pie 2016
TISD
4%
Biophysics and medicine
7%
Solid state
11%
reserve
4%
Coulomb excitation
22%
Nuclear structure from ground state properties
22%
Nuclear Astrophysics
6%
Nuclear structure from beta-decay
21%
nuclear reactions
3%

Schedule 2017



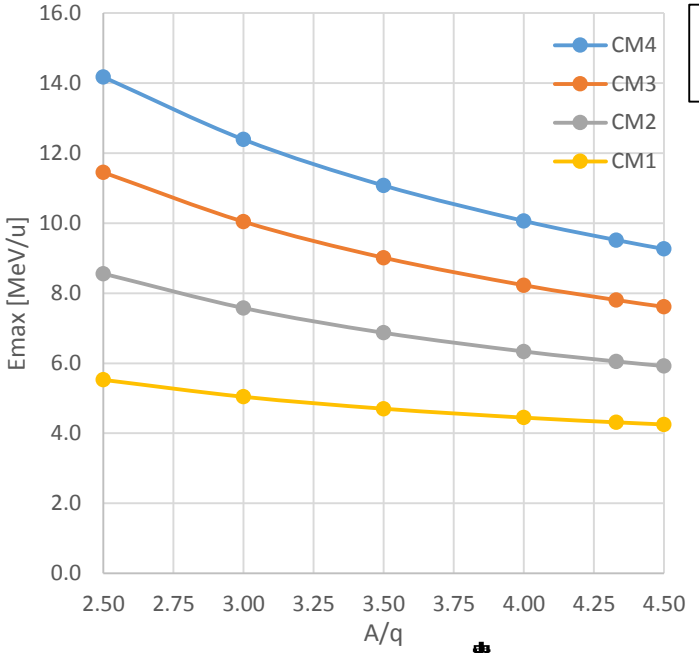
- 24th April: start of physics 2017
- Protons finishing on 20th November
- Running period of 210 days. (perhaps one more week is possible, but too soon to say)
- Low energy until ~ week 26.
- Interleave HIE & LE physics from end of June onwards.
- 3 CMS → some “flexibility” in energy
- Fewer limitations on masses/energy for 2017
- For A/q = 4.33 7.5MeV/u

- 3rd beamline needs to be installed in good time:
  - Expect quite a few demands for the scattering chamber
- Nanostructured Targets for 2017?
- Length of runs….
- Availability of RILIS (
- Autumn:
  - Negative ion run
  - MEDICIS start-up
  - LIEBE tests: block GPS for ~ 3 weeks?

Beam Properties for 2017: Beam Energy and Energy Spread

Expected for 2017:

- A third cryomodule is currently being installed and should be ready for the 2017 Physics campaign
- The third HEBT line (XT03) should also be ready
- Highest reachable energy of a beam with A/q = 4.0:
  - If average SRF gradient is 6.0 MV/m: 8.2 MeV/u
  - If average SRF gradient is 5.5 MV/m: 7.8 MeV/u
  - If average SRF gradient is 5.0 MV/m: 7.3 MeV/u



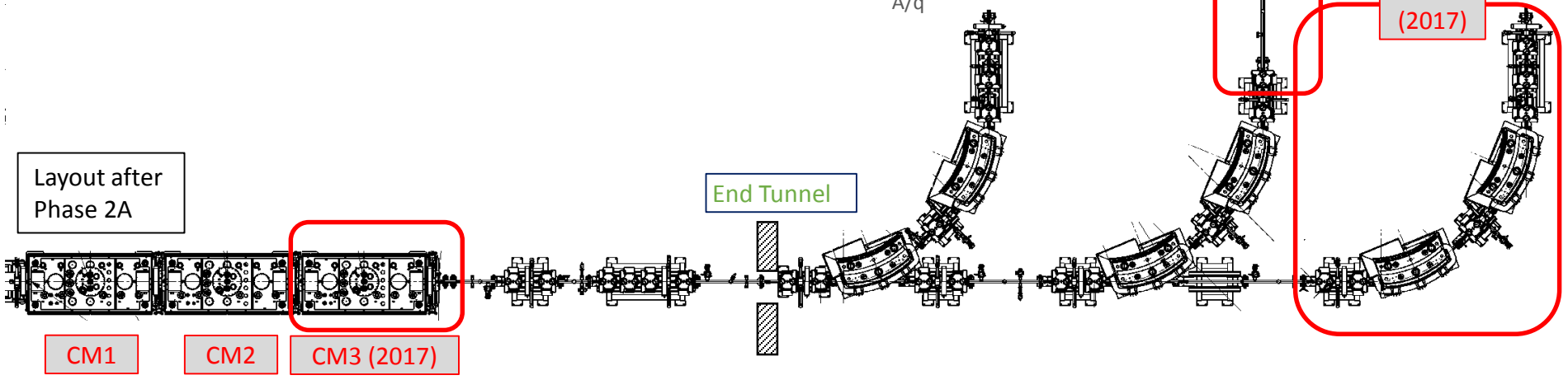
Highest beam energy (assuming all cavities at 6MV/m) for different A/q

A/q	CM1	CM2	CM3	CM4
2.5	5.5	8.6	11.4	14.2
3.0	5.0	7.6	10.0	12.4
3.5	4.7	6.9	9.0	11.1
4.0	4.4	6.3	8.2	10.1
4.3	4.3	6.1	7.8	9.5

Phase 2A of the HIE-ISOLDE project

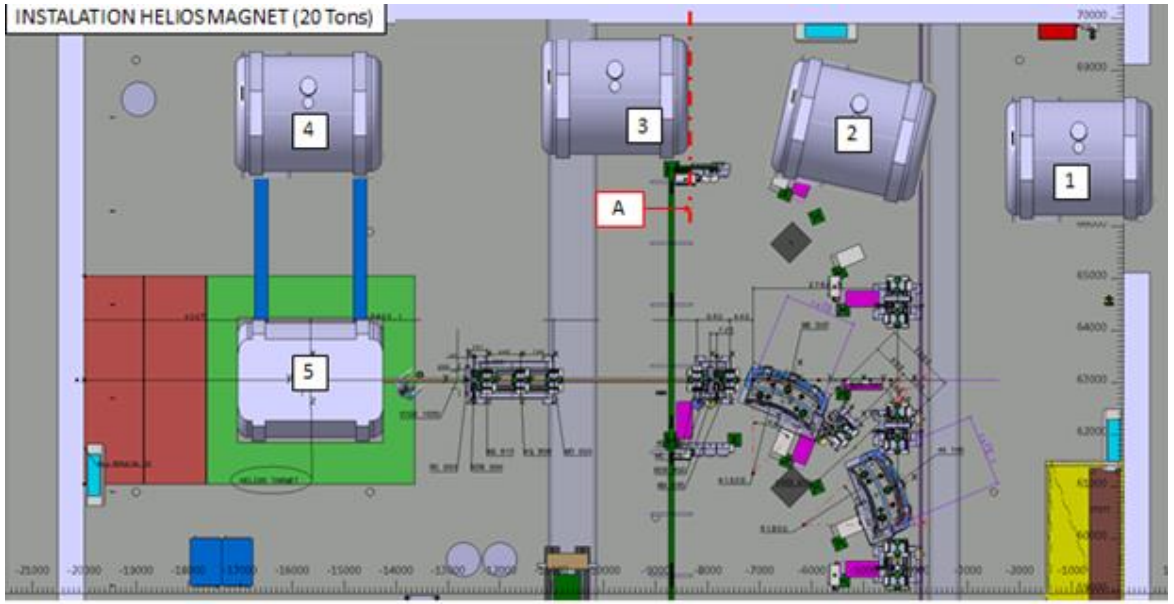
# Cryomodules	3
# HEBT lines	3
E [MeV/u] (A/q = 2.5)	11.4
E [MeV/u] (A/q = 4.3)	7.8

Layout after Phase 2A



Courtesy of Lefteris Fadakis

ISS installation preparations



The ISS magnet weight is close to 20T. The overhead crane at ISOLDE is 10T.
ISS will need to be rolled in.
Latest date set for 3 March.

- XT03 installation can only start after ISS is in position.
- All XT03 elements at CERN

- XT02 experimental setup dismounted and removed.
- ISS feet holes and XT02 triplet extension holes drilled and inserts done.
- All necessary XT03 supports and concrete dipole block removed. Cables rolled back.

Main preparations done. CV and EL work to be finished.b

Courtesy of Erwin Siesling and Liam Gaffney

Safety and training etc

Required training for **ISOHALL**

Online:

- Safety at CERN
- RP supervised (changed since last year)
- Basic electrical awareness

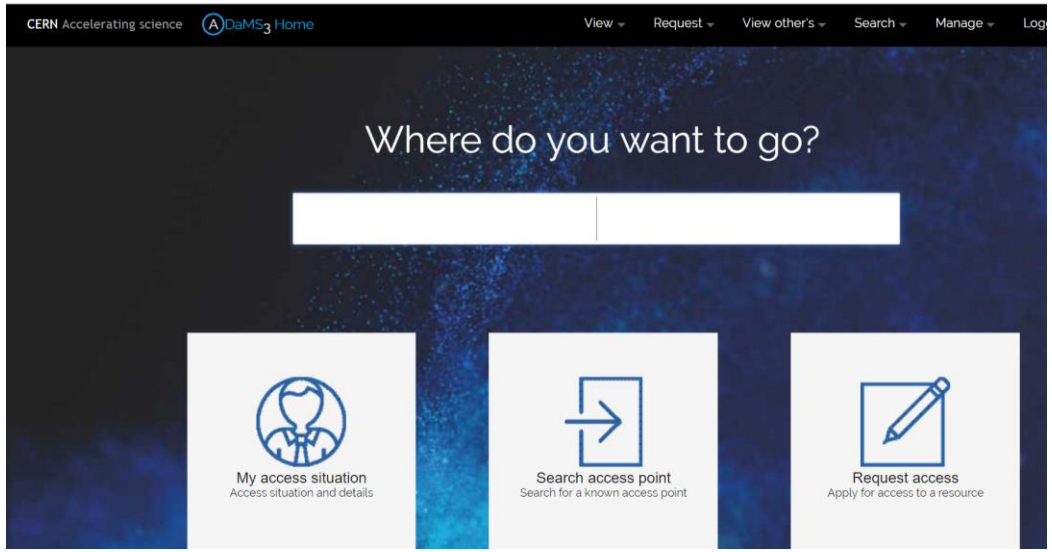
Hands-on:

- Electrical awareness
- RP hands-on

Every Tuesday @ 1300 – 1700), training centre Prevessin.

External trainer: try to have confirmation of participation 3 weeks in advance.

Registration in EDH…



Access now via ADAMS rather than EDH.

Helmets and safety shoes in the hall….

Control on entering and leaving

ISOLDE block booking will run from April 15th till ~ Nov 20.

15 rooms available up to one month before arrival

If rooms can't be obtained using the usual booking online then these can be availed of.

ENSAR2

TNA support available for scheduled experiments. Details sent to spokespeople after schedule is released.