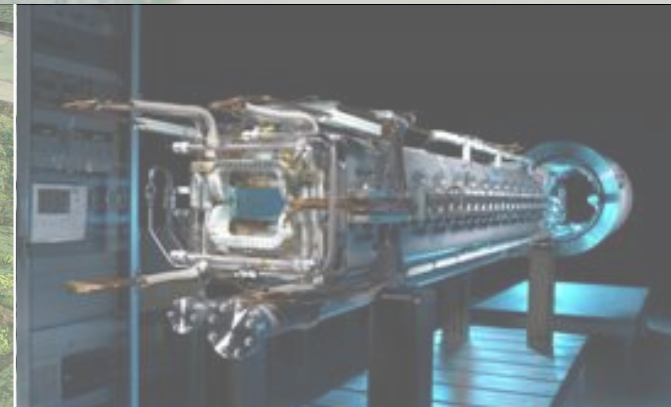


Facility for Antiproton and Ion Research - FAIR

Inti Lehmann
FAIR Europe

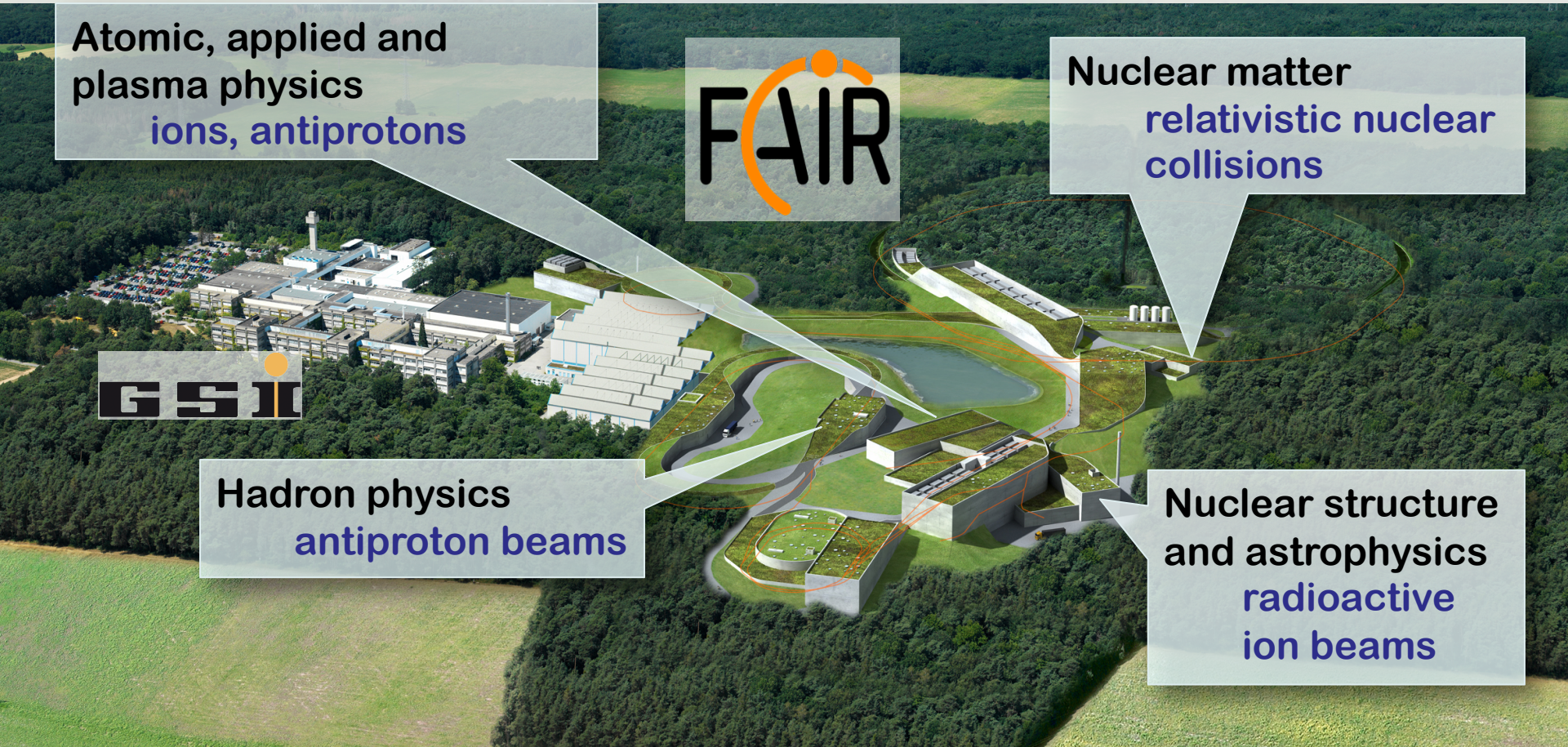


EMMI Workshop: $^{229\text{m}}\text{Th}$ Nuclear Isomer Clock



- **The FAIR facility**
- **The 4 scientific pillars of FAIR**
- **Current status**

The FAIR Facility



Atomic, applied and
plasma physics
ions, antiprotons

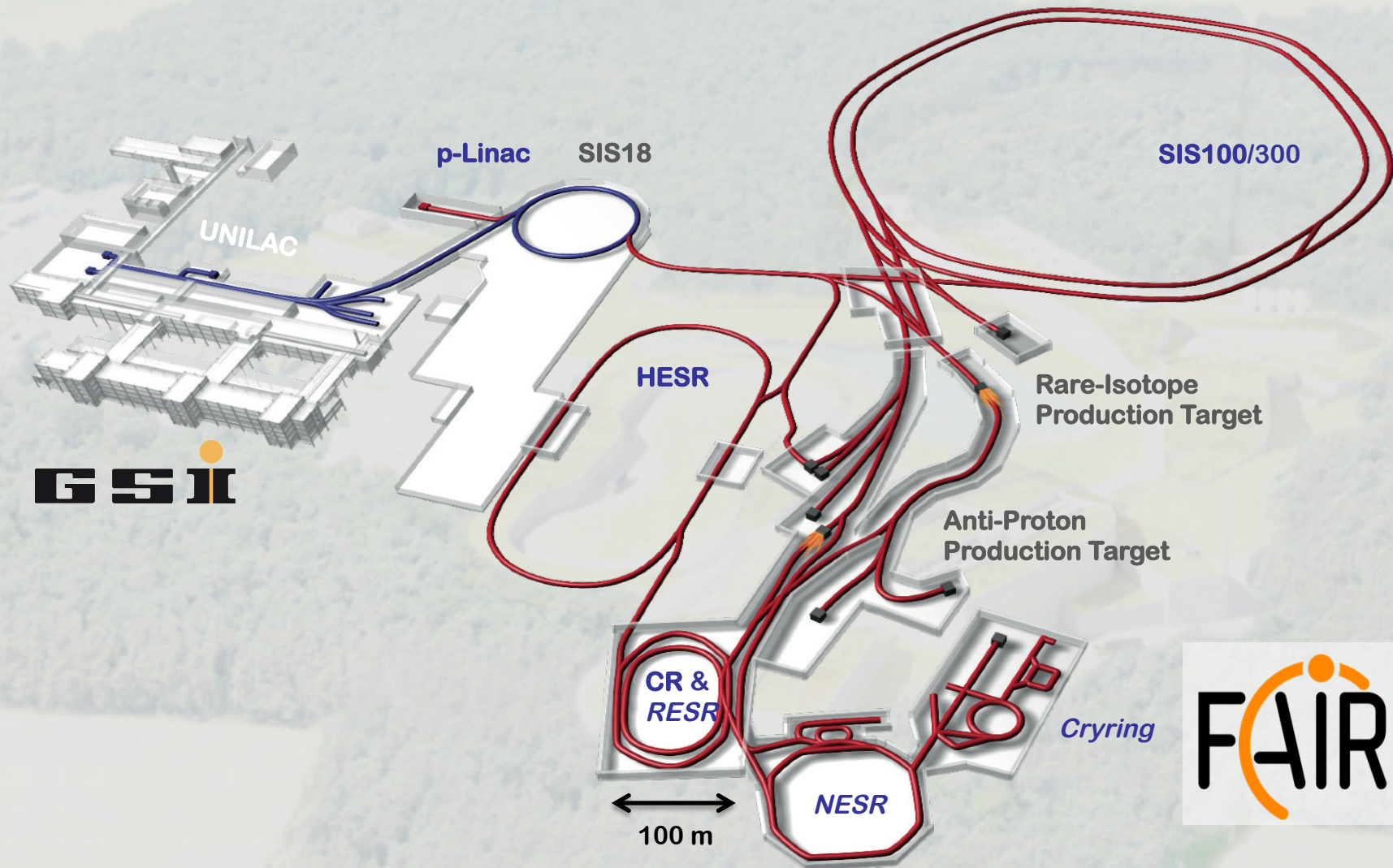


Nuclear matter
relativistic nuclear
collisions



Hadron physics
antiproton beams

Nuclear structure
and astrophysics
radioactive
ion beams





Primary Beams

- $10^{12}/s$; 1.5 GeV/u; $^{238}\text{U}^{28+}$
- $10^{10}/s$ $^{238}\text{U}^{73+}$ up to 35 GeV/u
- $3 \times 10^{13}/s$ 30 GeV protons

Secondary Beams

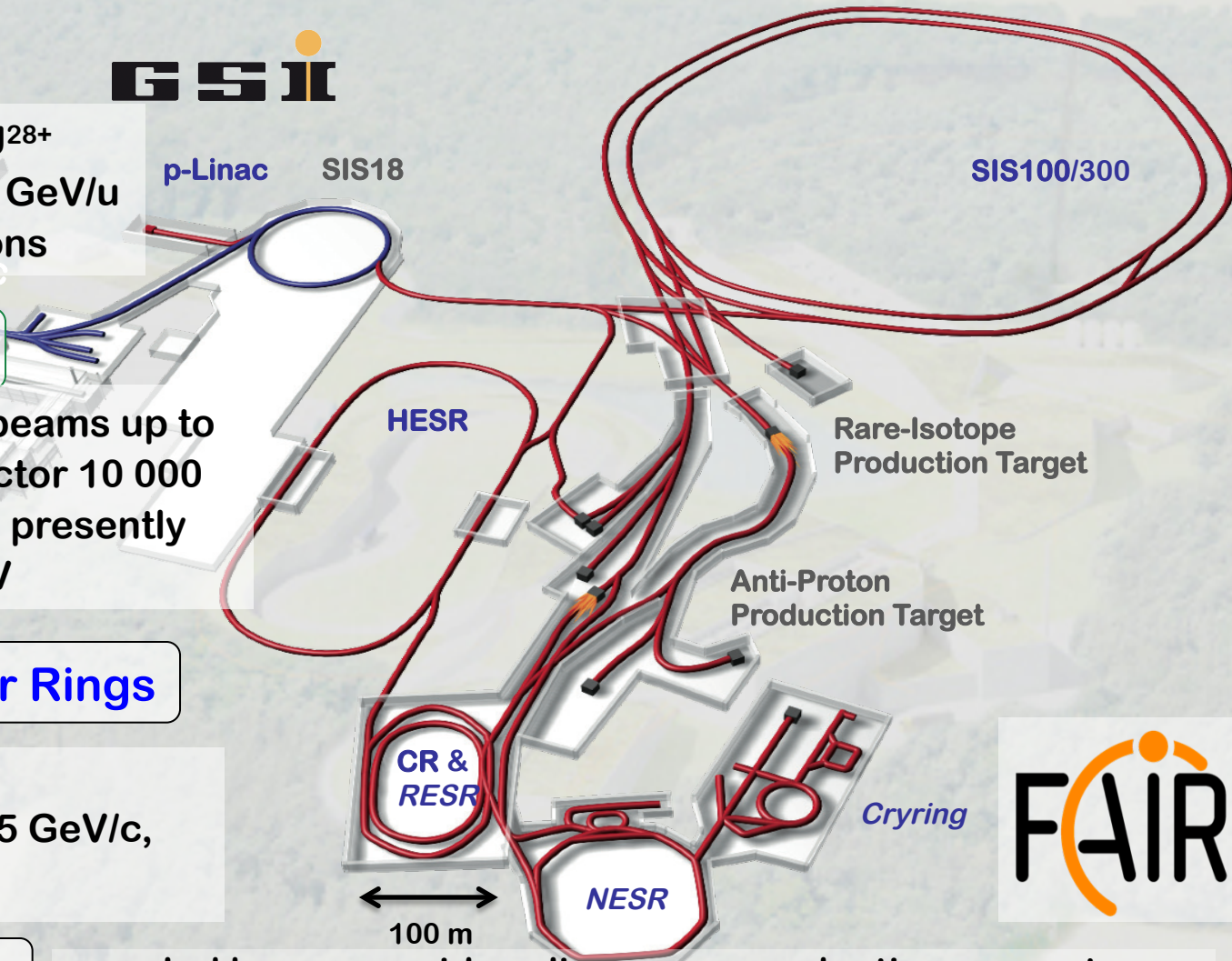
- range of radioactive beams up to 1.5 - 2 GeV/u; up to factor 10 000 higher in intensity than presently
- antiprotons 3 - 30 GeV

Storage and Cooler Rings

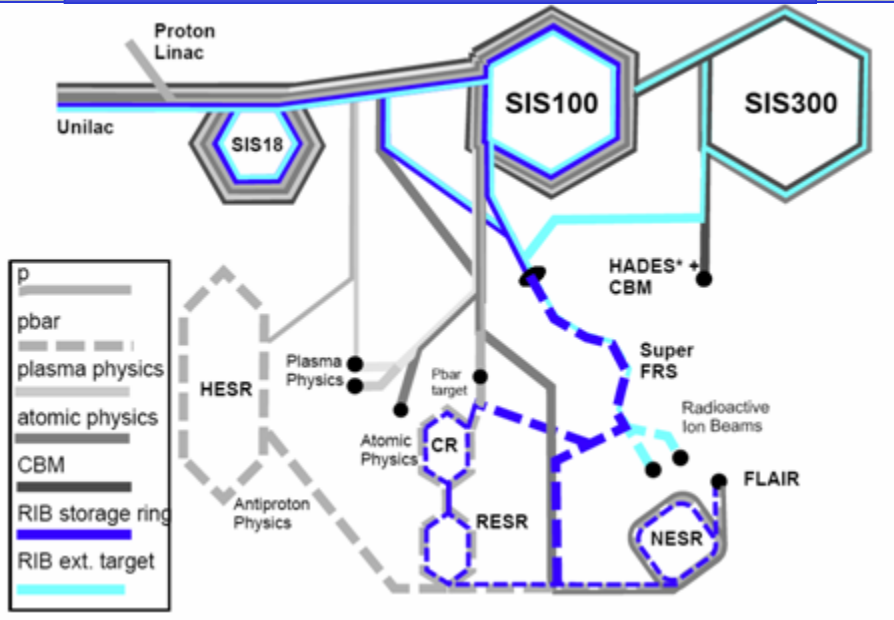
- radioactive beams
- 10^{11} antiprotons 1 - 15 GeV/c, stored and cooled

Technical Challenges

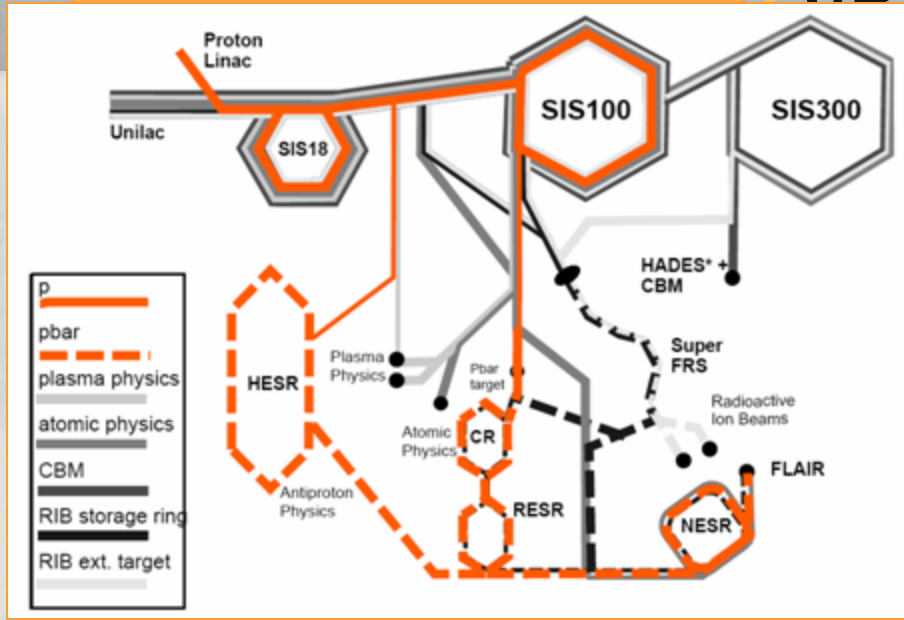
- cooled beams, rapid cycling superconducting magnets



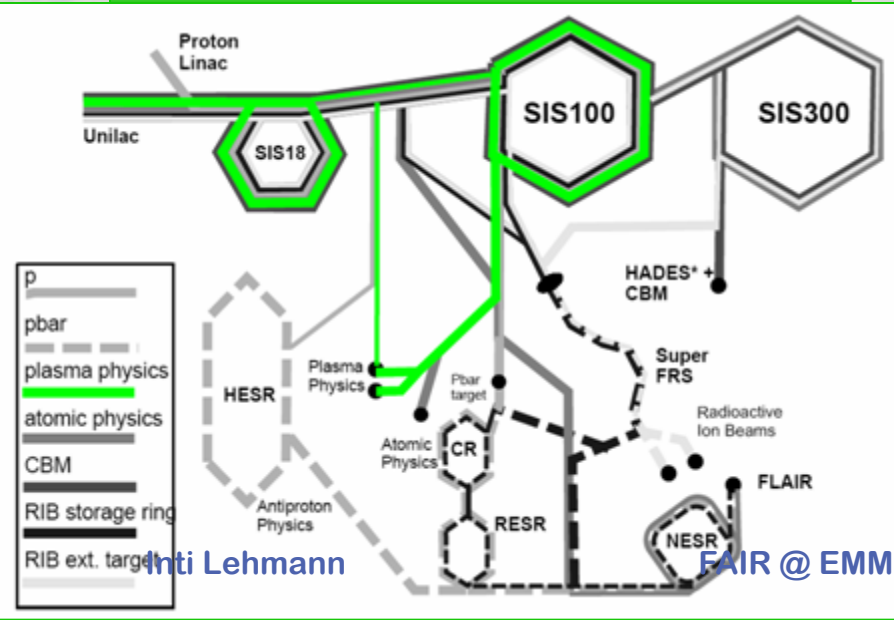
Radioactive Ion Beam Programme



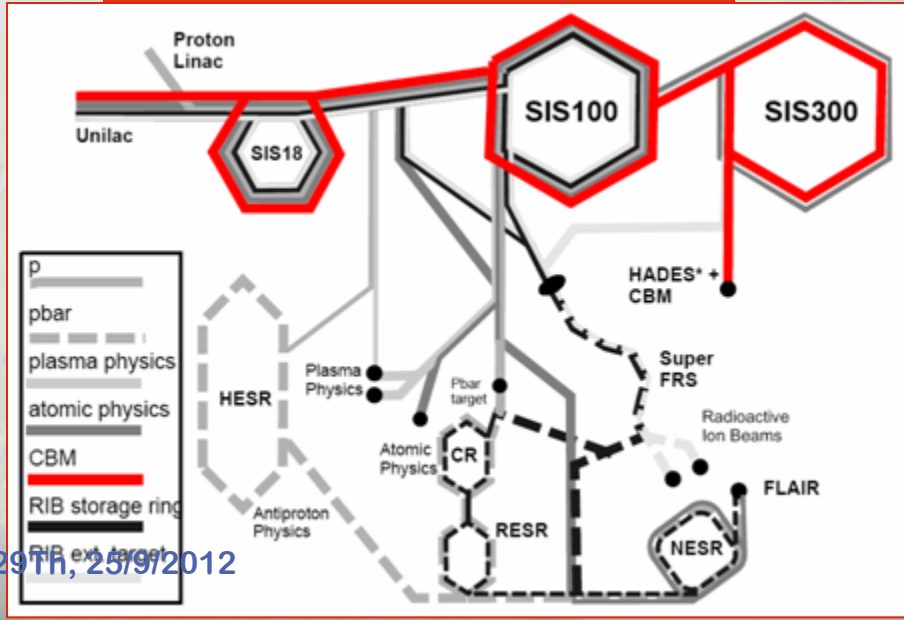
Anti Proton Beam Programme



Plasma Physics Beam Programme



Relat. Ion Beam Programme

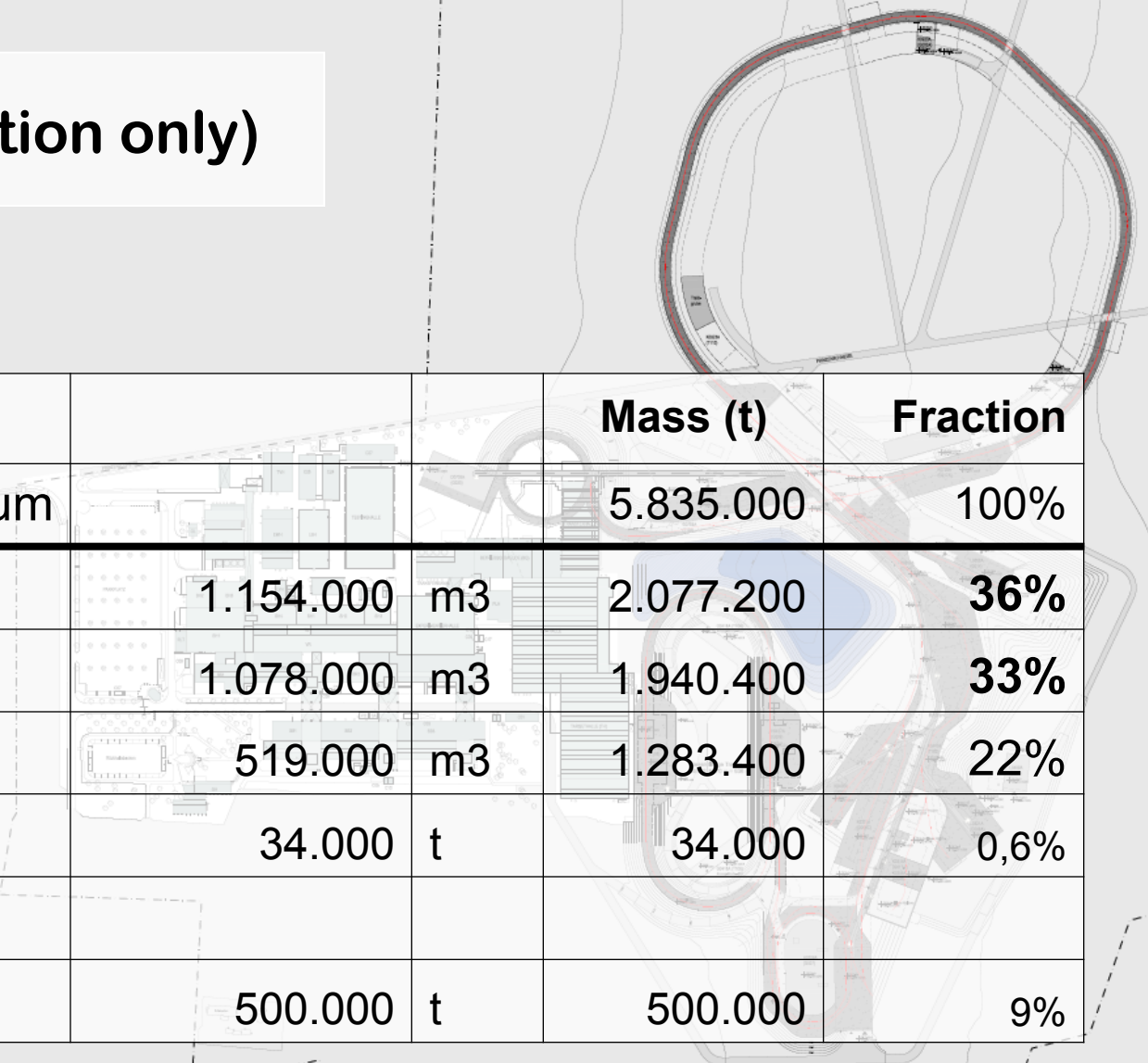


Anti Lehmann

FAIR @ EMMI, 229TH, 25/9/2012

Some Numbers

(Civil Construction only)



Type			Mass (t)	Fraction
	Sum		5.835.000	100%
Soil out	1.154.000	m3	2.077.200	36%
Soil in	1.078.000	m3	1.940.400	33%
Concrete	519.000	m3	1.283.400	22%
Steel for concrete	34.000	t	34.000	0,6%
Other	500.000	t	500.000	9%

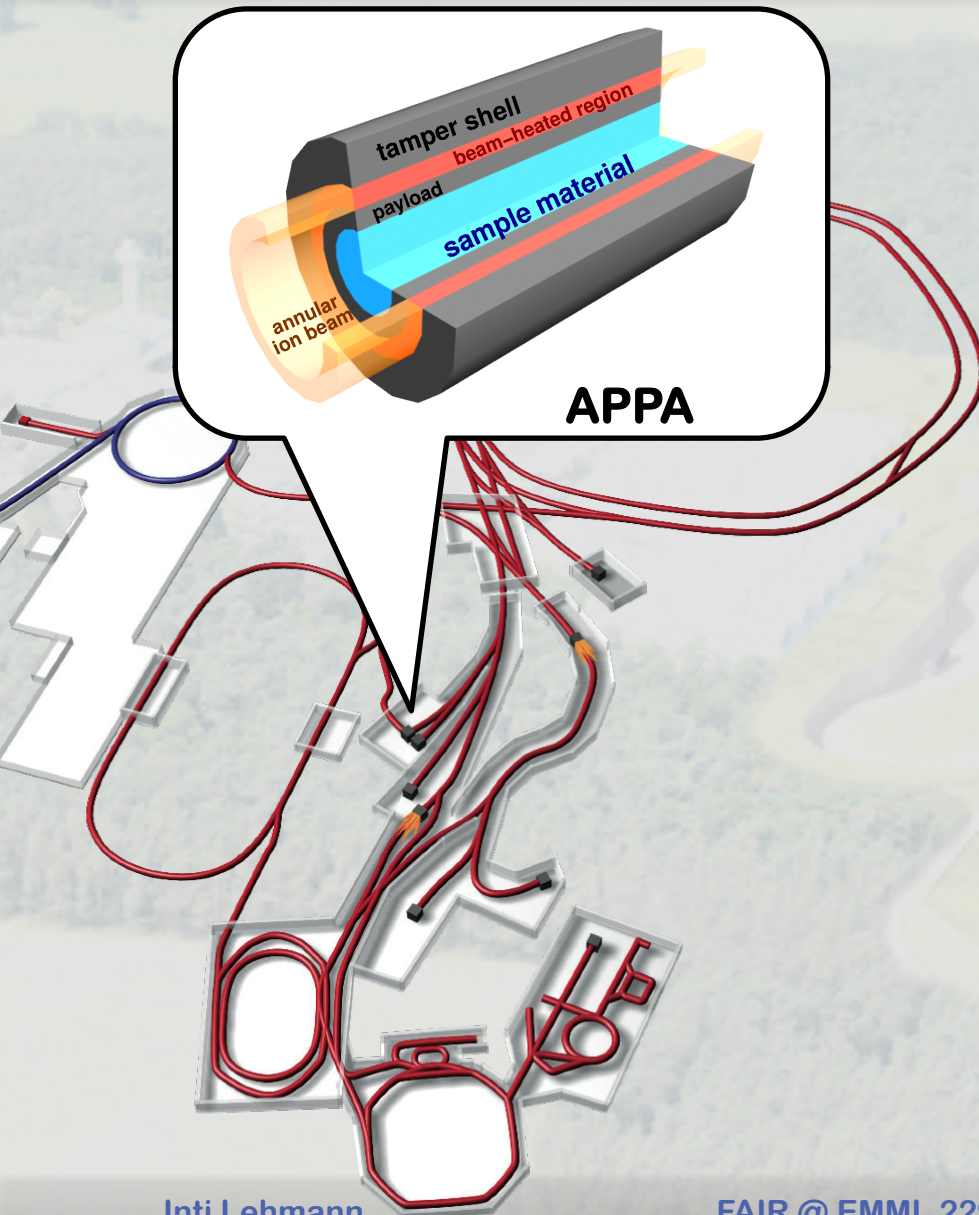
The 4 Scientific Pillars of FAIR

APPA: Atomic, Plasma Physics and Applications

CBM: Compressed Baryonic Matter

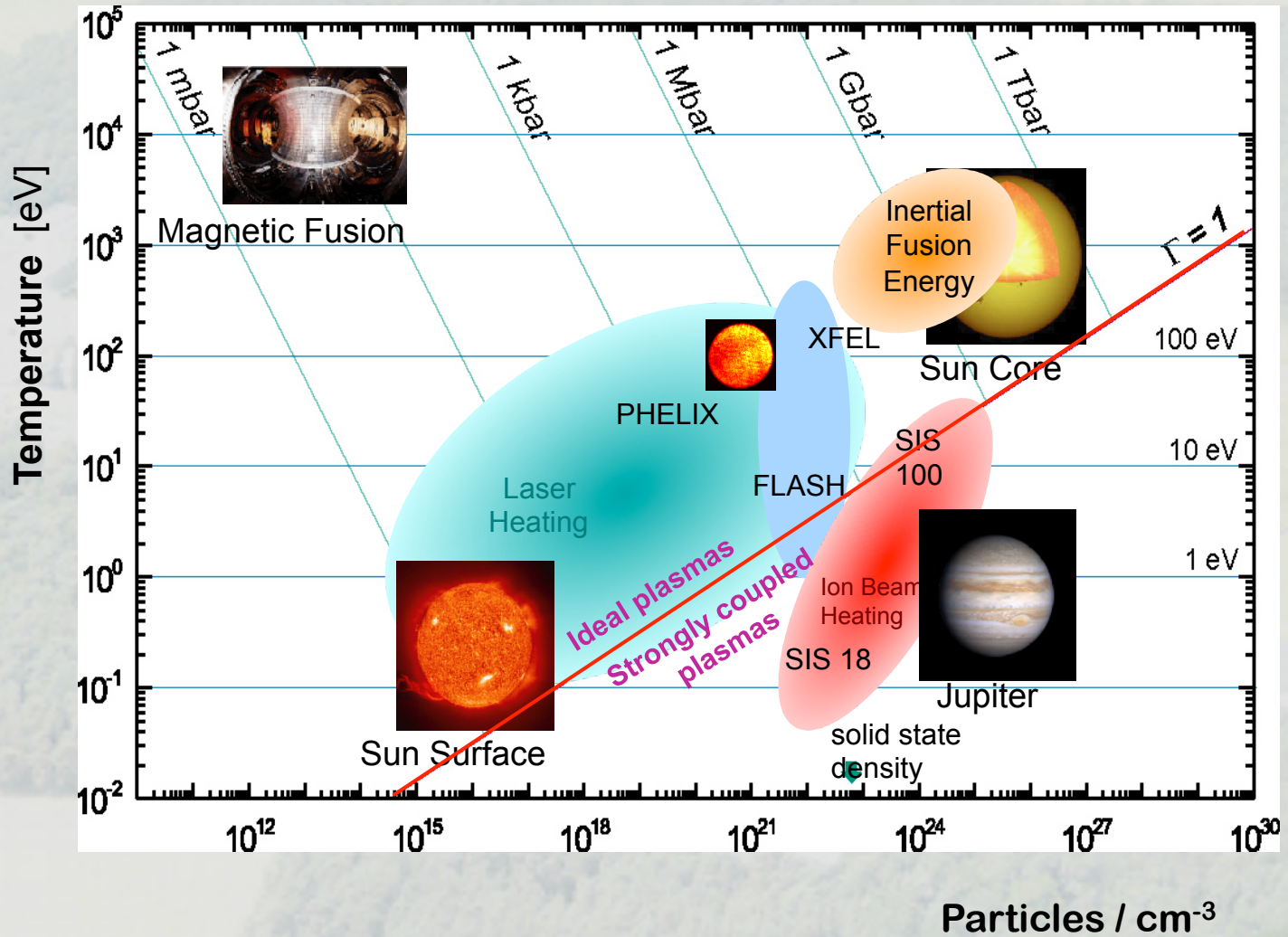
NUSTAR: Nuclear Structure, Astrophysics and Reactions

PANDA: Antiproton Anihilations at Darmstadt

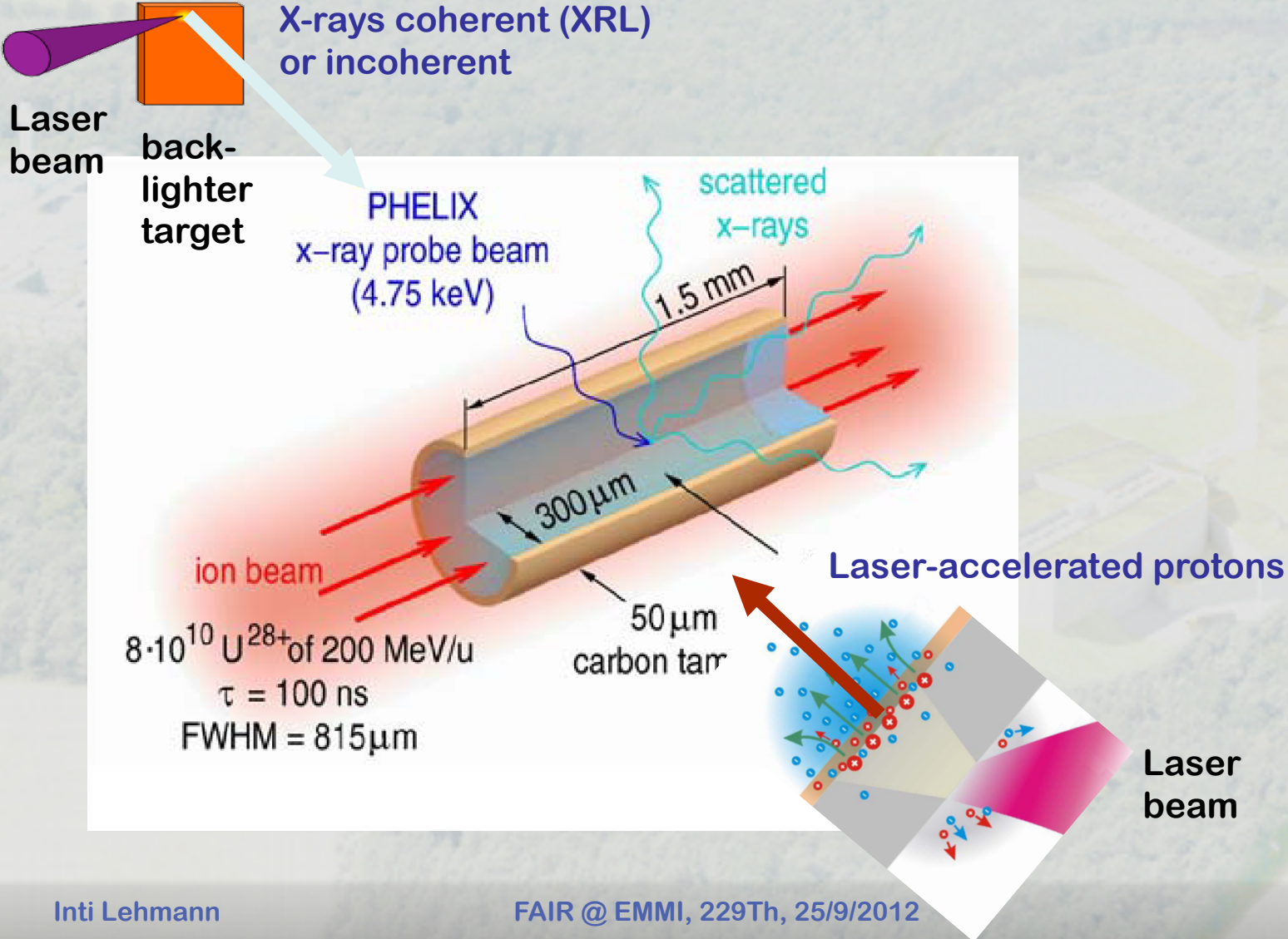


- **Collaboration**
 - About 500 members (with PhD)
 - Board of APPA Collaborations established
- Options explored for experiments at
 - HESR
 - Crying at ESR
- Preparation of TDRs

APPA: Plasma Physics Reach

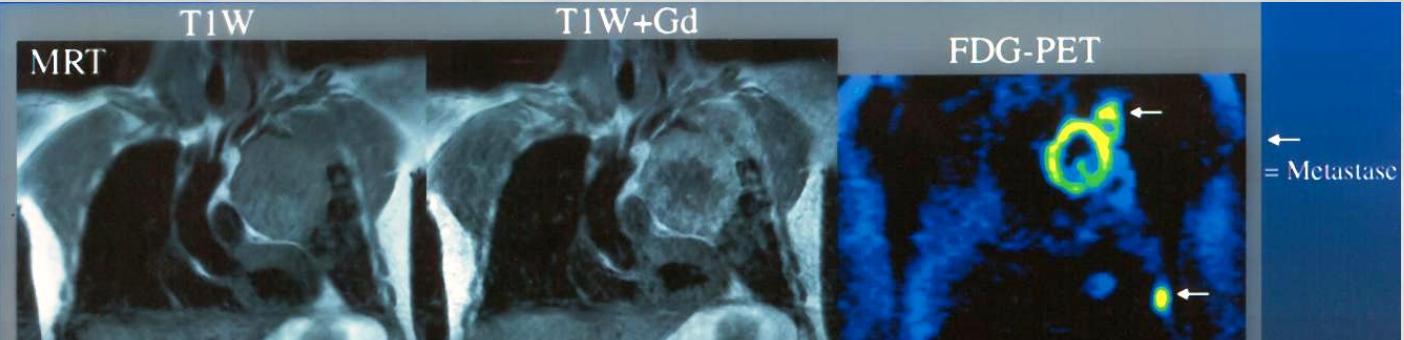


APPA: X-ray or proton diagnostics

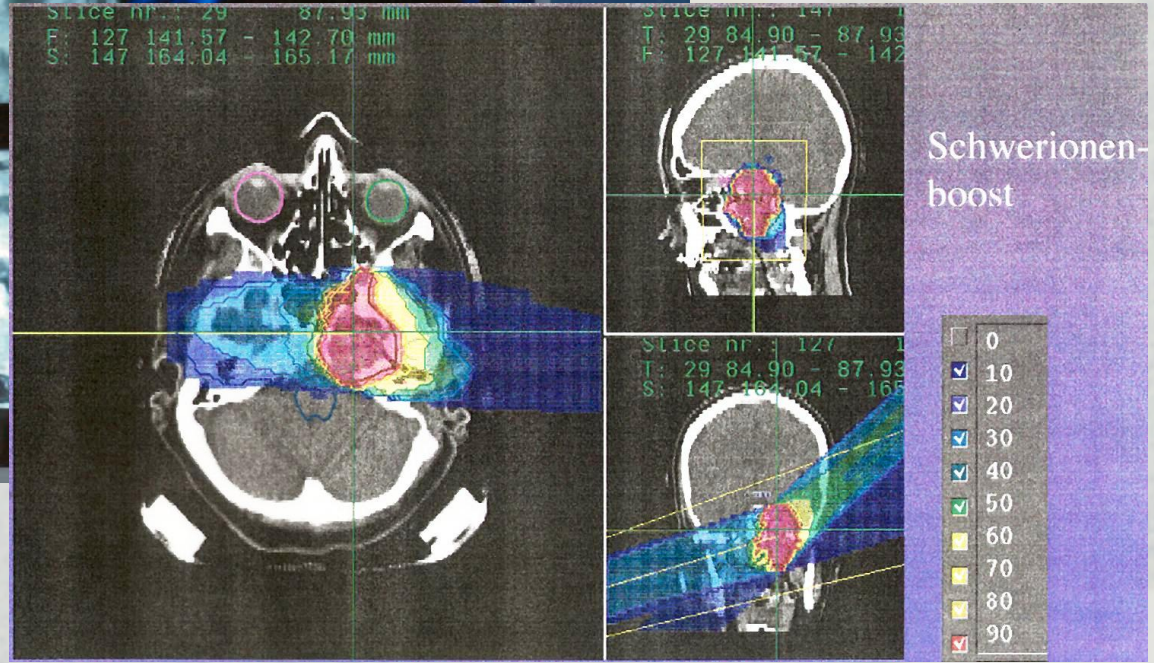


APPA: Nuclear Medicine

Small cell lung carcinoma



¹²C
Therapy
@ GSI



Schwerionen-
boost

Adenoid cystic ca.

APPA: Biophysics

- **Cosmic radiation**: main hindrance toward manned space exploration: moon (2015), Mars (2030), and beyond
- High uncertainty on **biological effects of heavy ions**
- No effective countermeasures
- NASA started a large experimental campaign in **space radiation biophysics** exploiting NSRL at BNL
- ESA approved in 2008 a similar programme (IBER) in the framework of Aurora, based at GSI/FAIR



Extreme Static Fields

Extreme Dynamic Fields

Very High Energy Densities and Pressures

Antimatter and Fundamental Physics

Atomic Physics

SPARC: 284 members from 26 countries

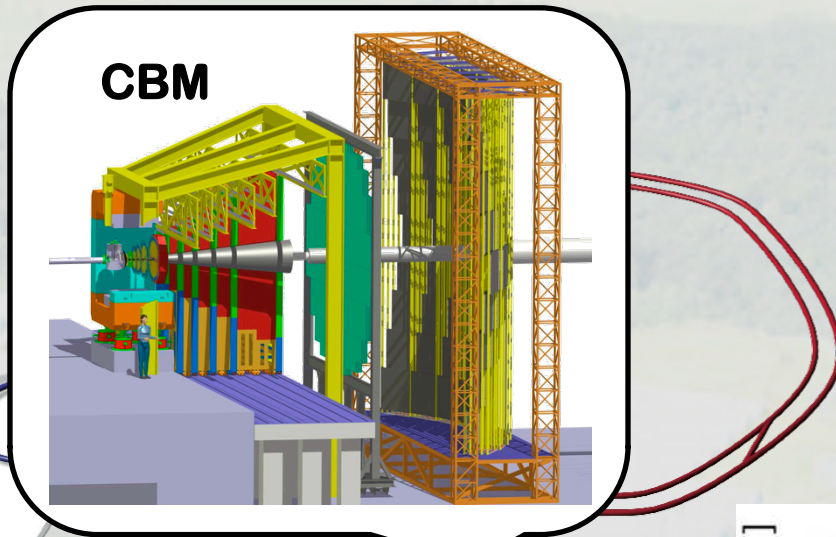
FLAIR: 144 members from 15 countries

Plasma Physics

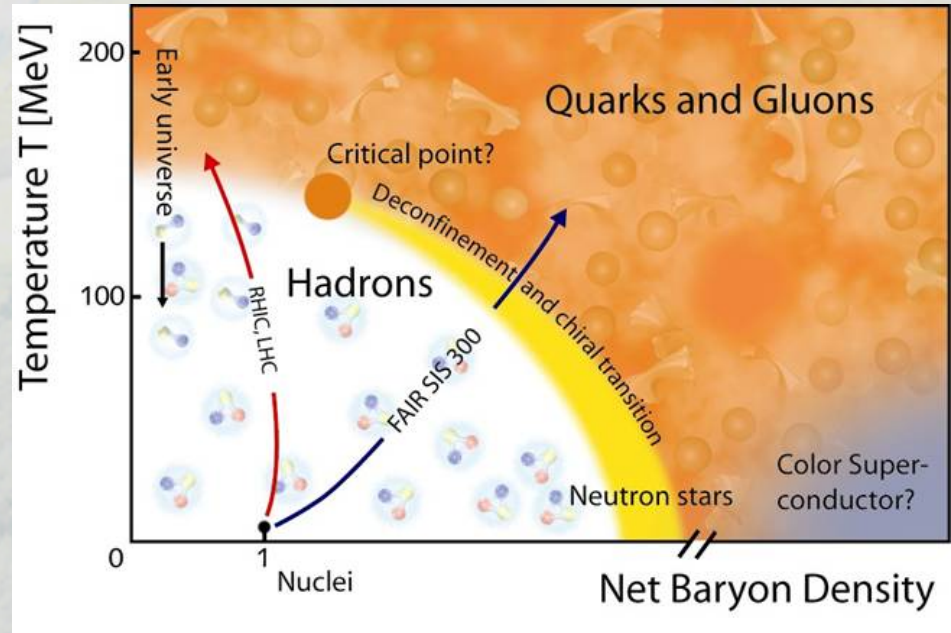
HEDgeHOB & WDM: 175 members from 16 countries

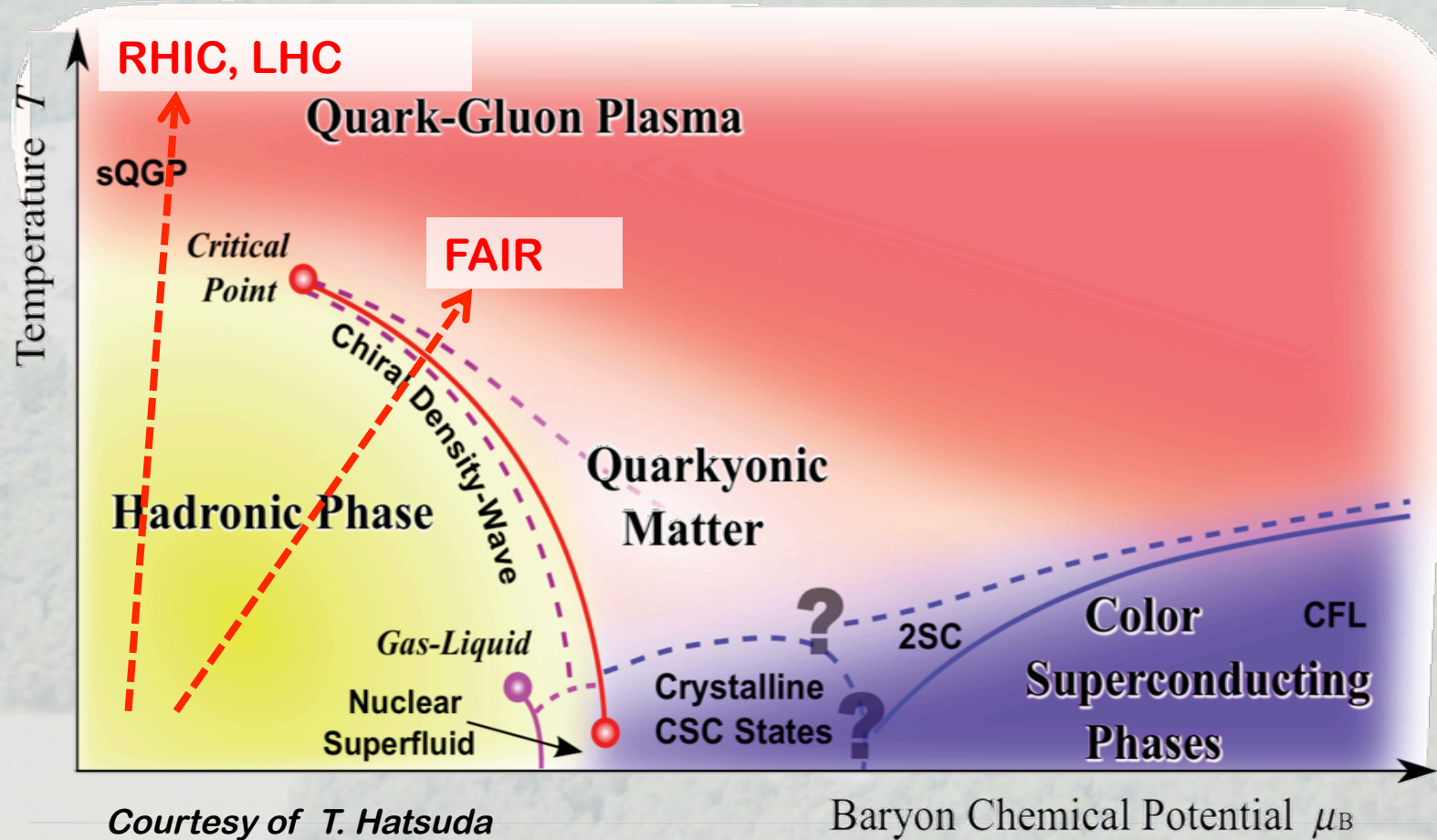
Materials Research and Biophysics

BIOMAT: 110 members from 12 countries



- Collaboration
 - More than 250 members (with PhD)
- Preparation of TDRs

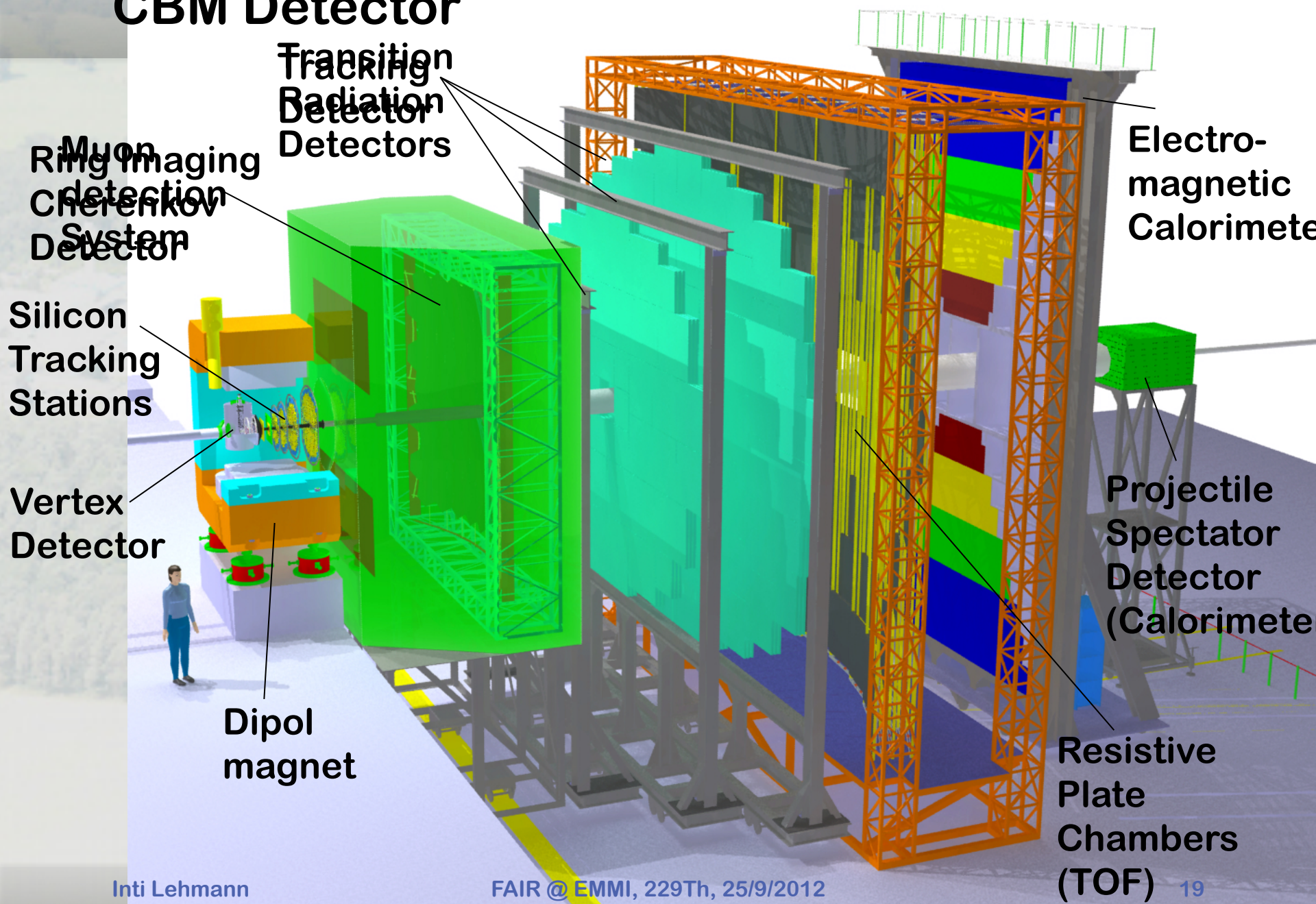




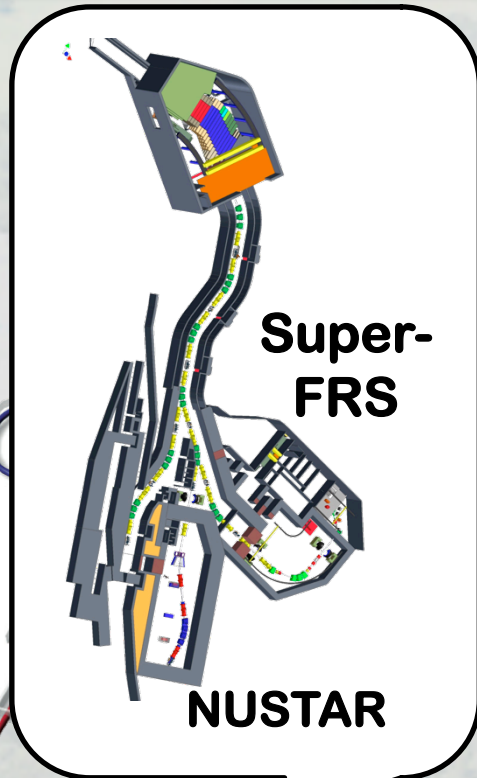
CBM Physics Case

- The equation-of-state at high ρ_B (SIS100/300)
 - collective flow of hadrons
 - particle production at threshold energies (multistrange hyperons, open charm?)
- New phases of strongly-interacting matter (SIS100)
- Deconfinement phase transition at high ρ_B (SIS300)
 - excitation function and flow of strangeness ($K, \Lambda, \Sigma, \Xi, \Omega$)
 - excitation function and flow of charm ($J/\psi, \psi', D0, D_{\pm}, \Lambda_c$)
 - excitation function of low-mass lepton pairs
- QCD critical endpoint (SIS300)
 - excitation function of dynamical event-by-event fluctuations
- Onset of chiral symmetry restoration at high ρ_B (SIS100/300)
 - in-medium modifications of hadrons ($\rho, \omega, \phi \rightarrow e^+e^-(\mu^+ \mu^-), D$)
- Strange matter (SIS100/300)
 - (double-) lambda hypernuclei
 - strange meta-stable objects (e.g. strange dibaryons)

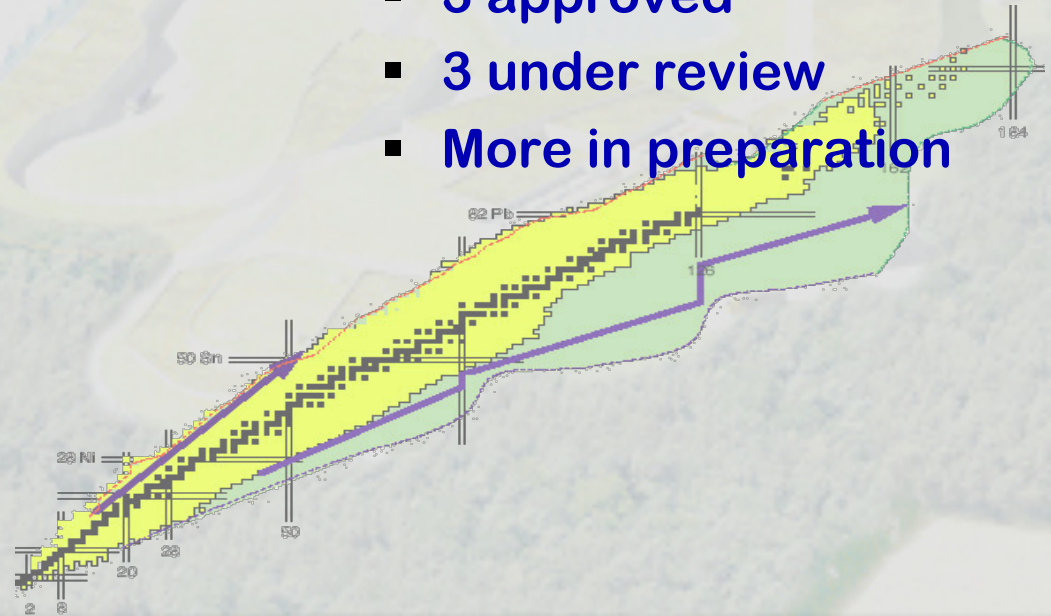
CBM Detector



NUSTAR

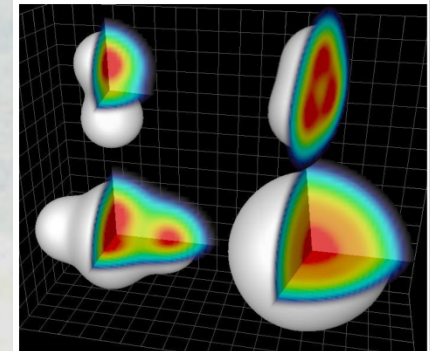


- Collaboration
 - About 600 members (with PhD)
 - Consider options for LEB and at HESR
- TDRs
 - 3 approved
 - 3 under review
 - More in preparation



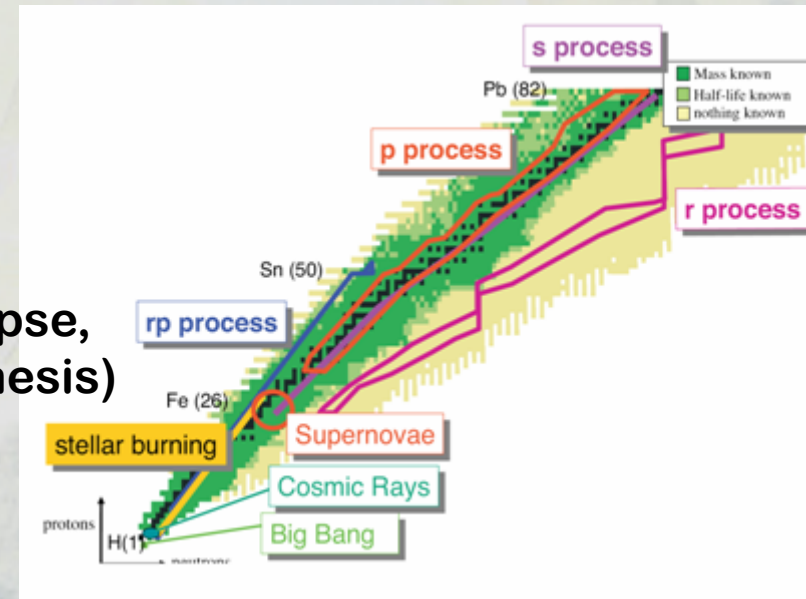
Nuclear structure

- Underlying QCD structure → complex nucleon-nucleon force
- Study of exotic short lived nuclei far off stability (proton/ neutron skins or halos, new magic numbers...)
→ Pave way for theoretical framework with predictive power for nuclei beyond experimental reach

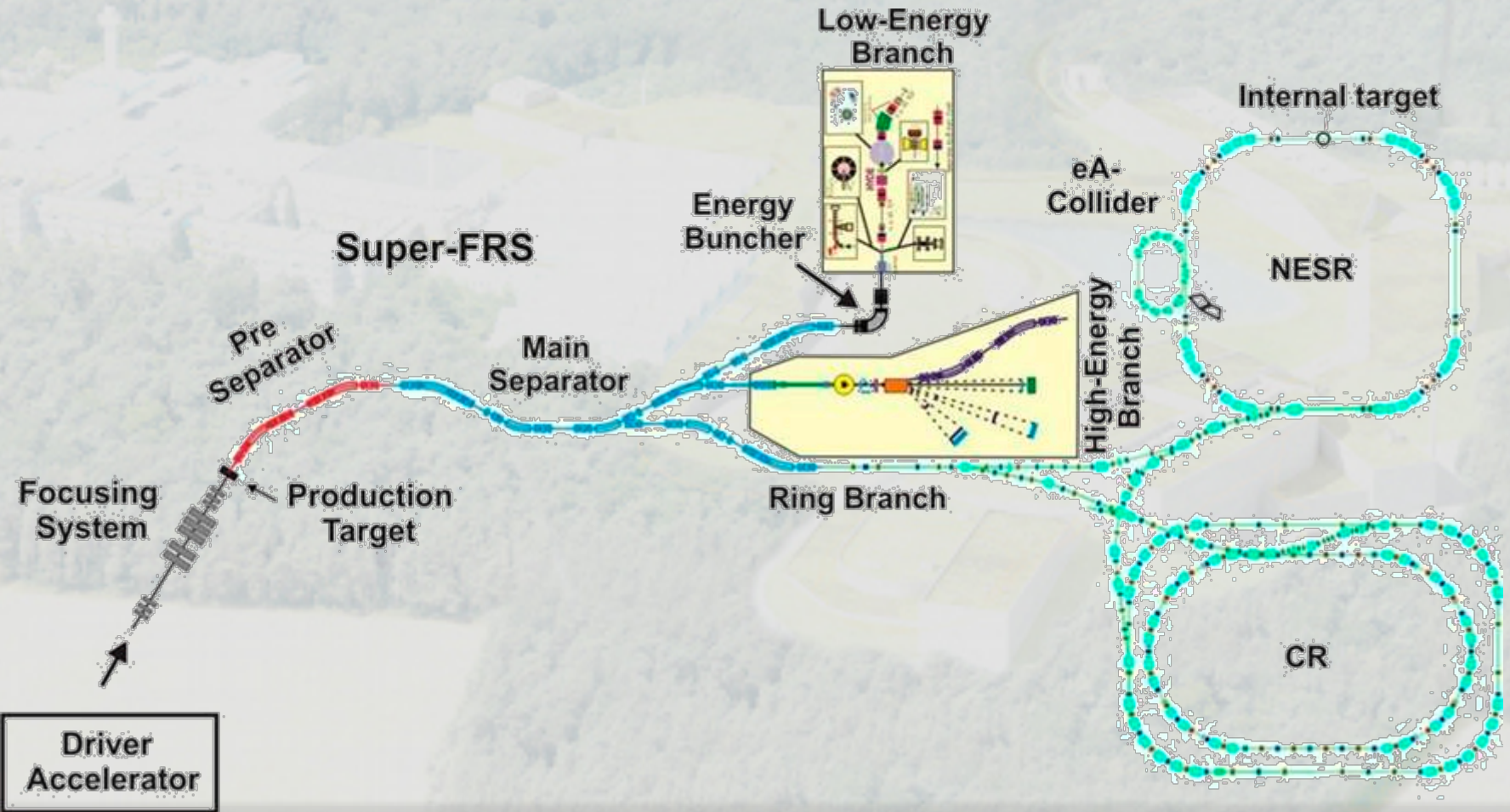


Astrophysics

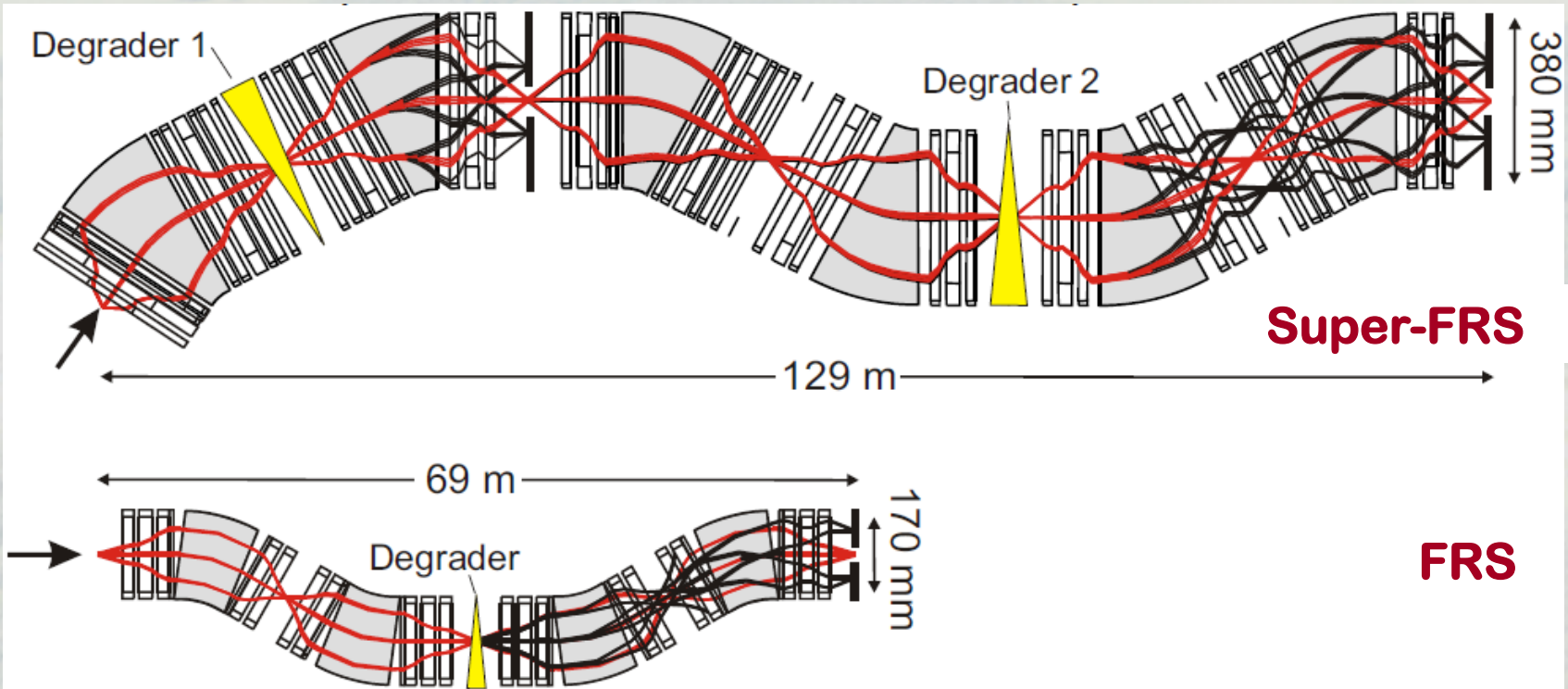
- Origin of the heavy elements?
- Physics of stellar explosions (core-collapse, thermonuclear supernovae, nucleosynthesis)
- Compact objects and the explosions on their surfaces (x-ray bursts)



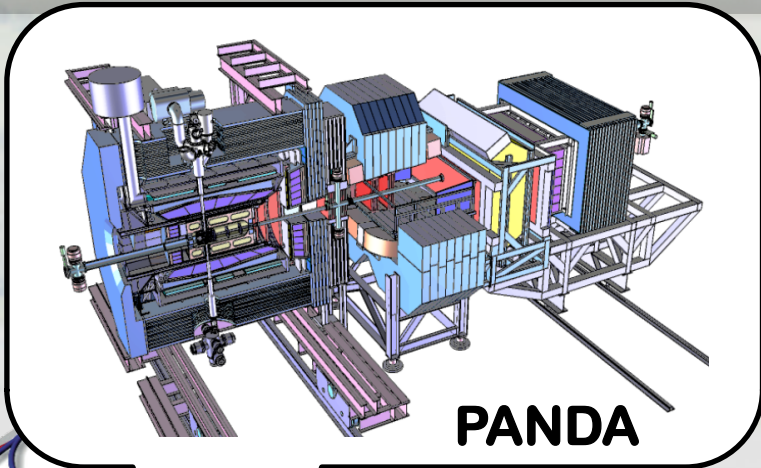
- Production of intensive rare isotope beams by in-flight projectile fragmentation/fission (access to short-lived isotopes)
- Detailed investigations, large variety of experimental techniques



GSI FRS → FAIR Super-FRS



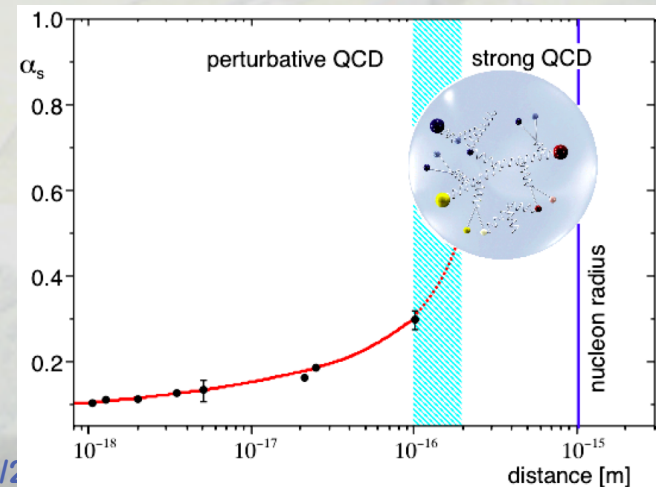
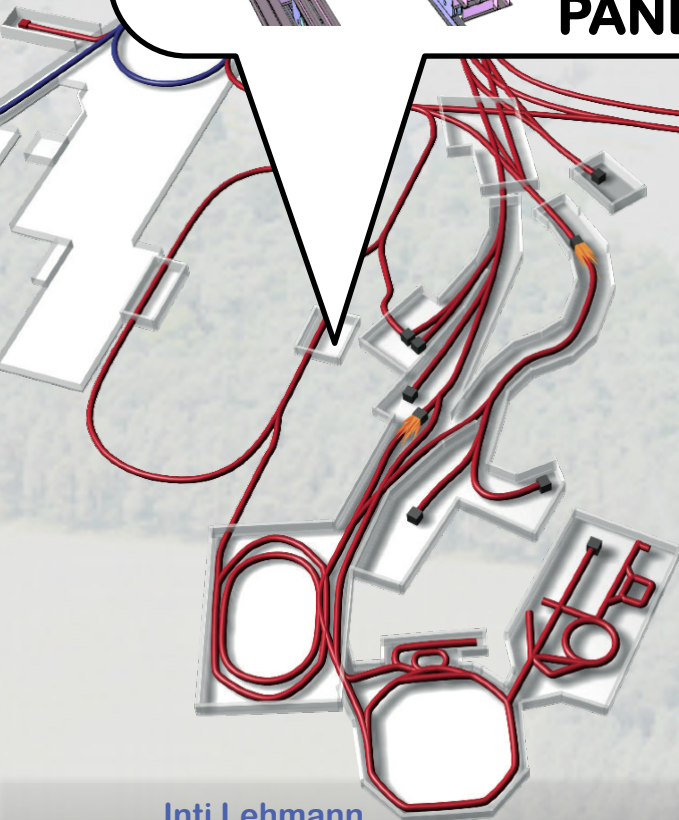
	$B\rho_{\max}$	$\Delta p/p$	$\Delta\Phi_x, \Delta\Phi_y$	resolving power	gain factor	
					^{19}C	^{132}Sn
FRS	18 Tm	1.0 %	$\pm 13, \pm 13$ mrad	1500	1	1
Super-FRS	20 Tm	2.5 %	$\pm 40, \pm 20$ mrad	1500	5	10
				including primary rate	1000	7500



PANDA

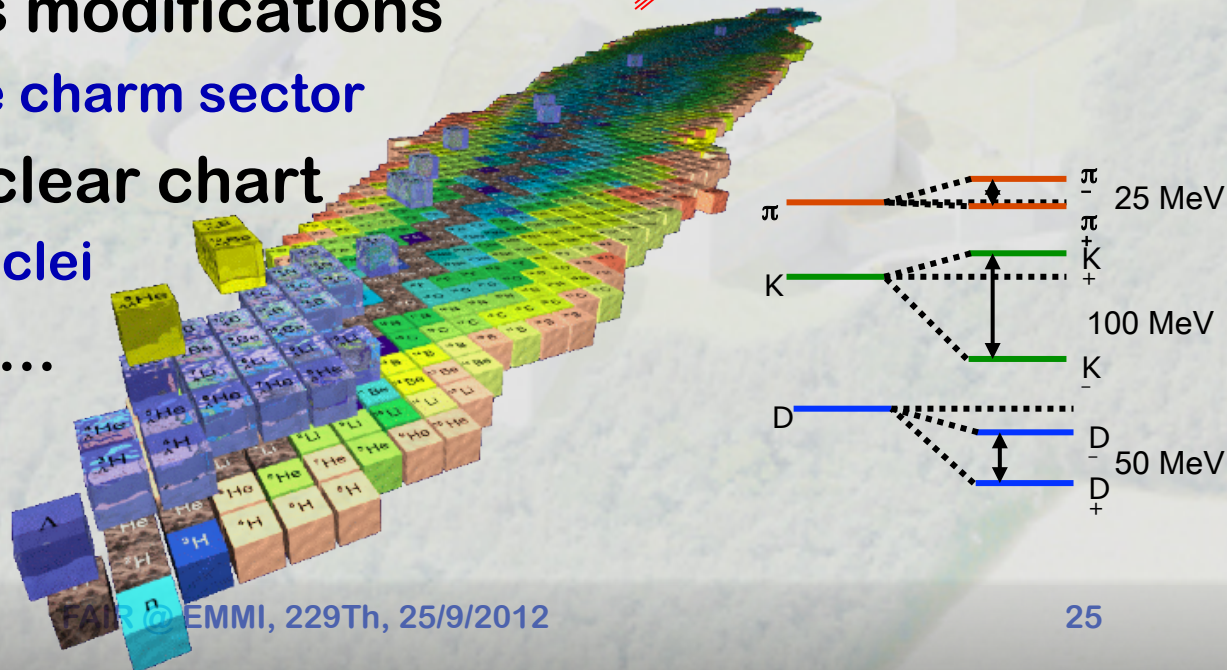
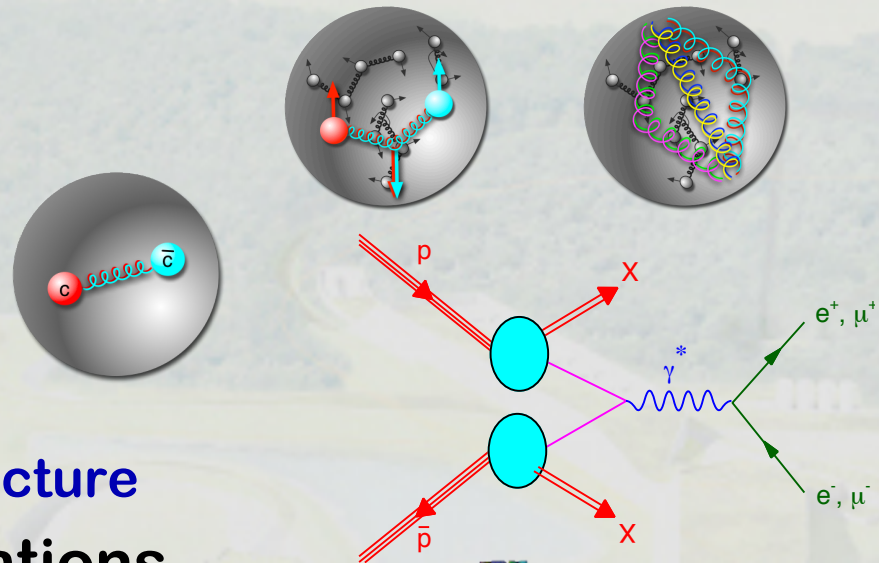
PANDA

- Collaboration
 - About 340 members (with PhD)
 - Premounting at FZJ being prepared
- TDRs
 - 2 approved
 - 3 under review
 - More in preparation

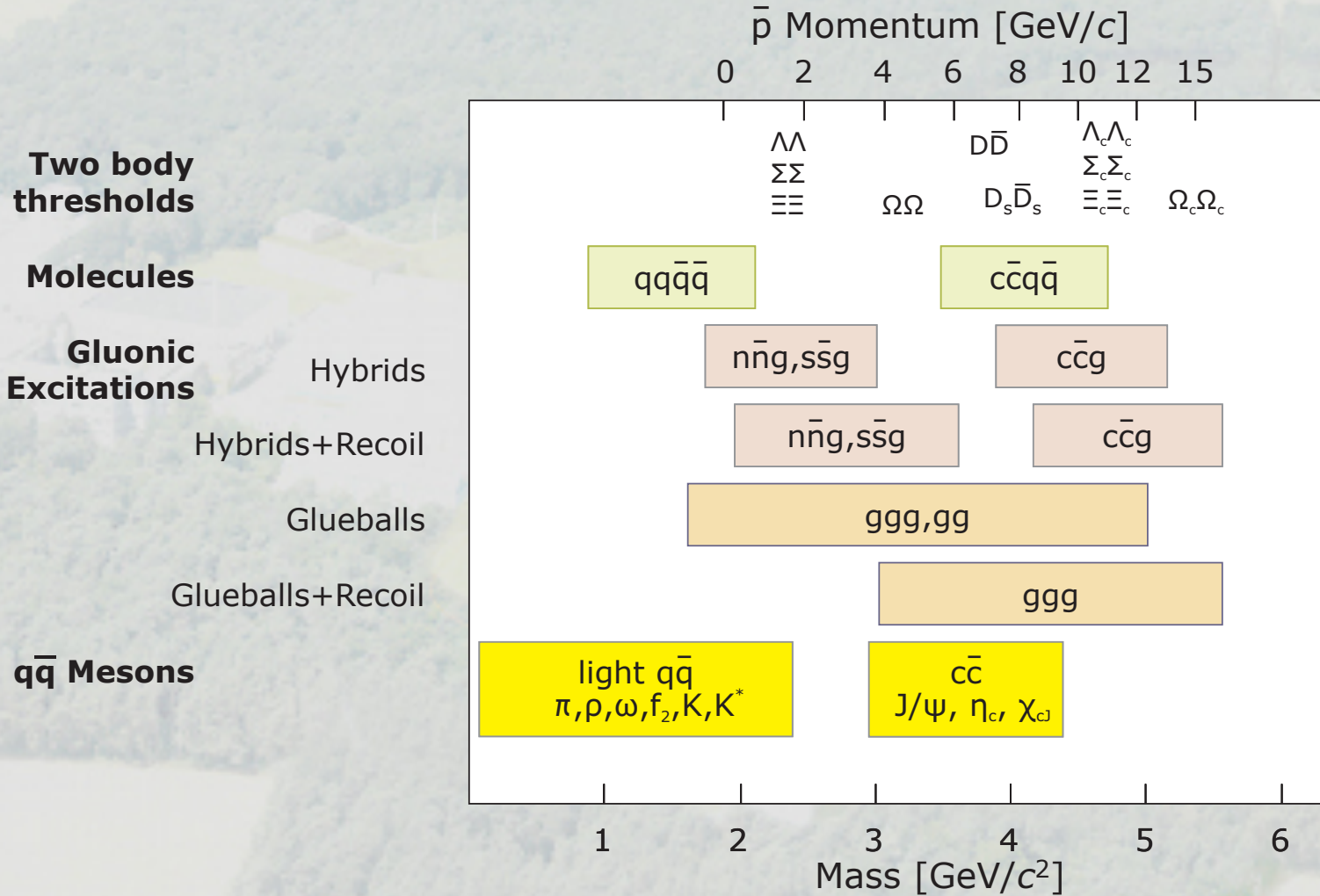


PANDA Physics Case

- **Gluonic excitations**
 - Hybrids, glueballs
- **Charmonium states**
 - Precision spectroscopy
- **Time-like**
 - Form factors, nucleon structure
- **In medium mass modifications**
 - Extension to the charm sector
- **Extension of nuclear chart**
 - Double hypernuclei
- **And much more...**

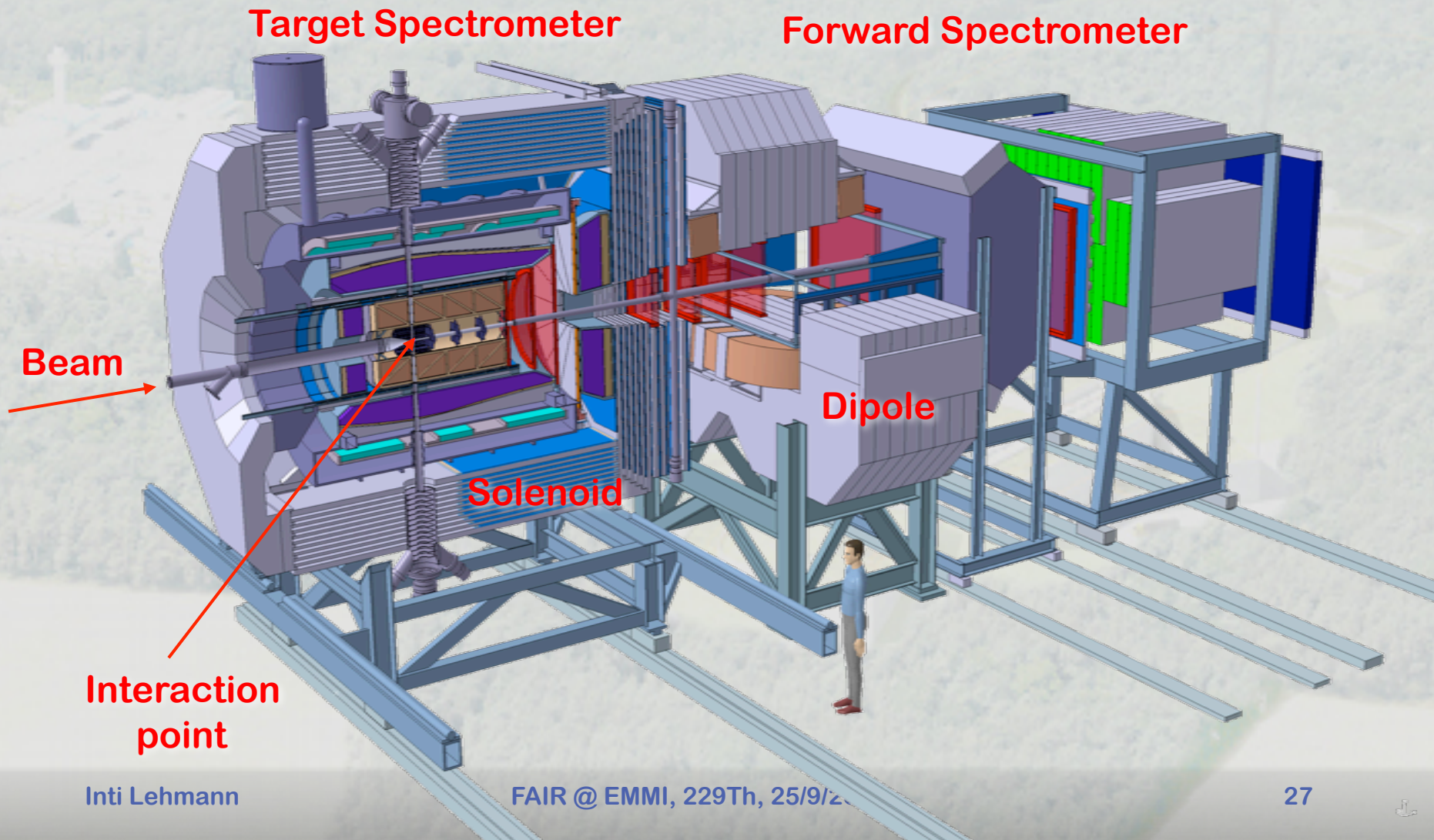


PANDA Energy Range



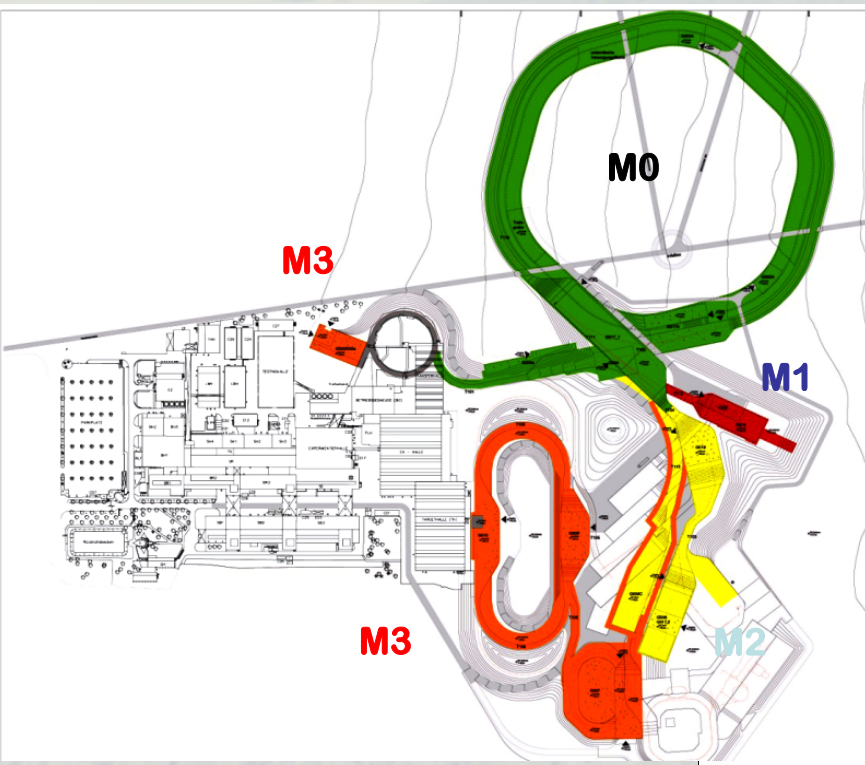
PANDA Experimental Set-Up

- Fixed target magnetic spectrometer experiment

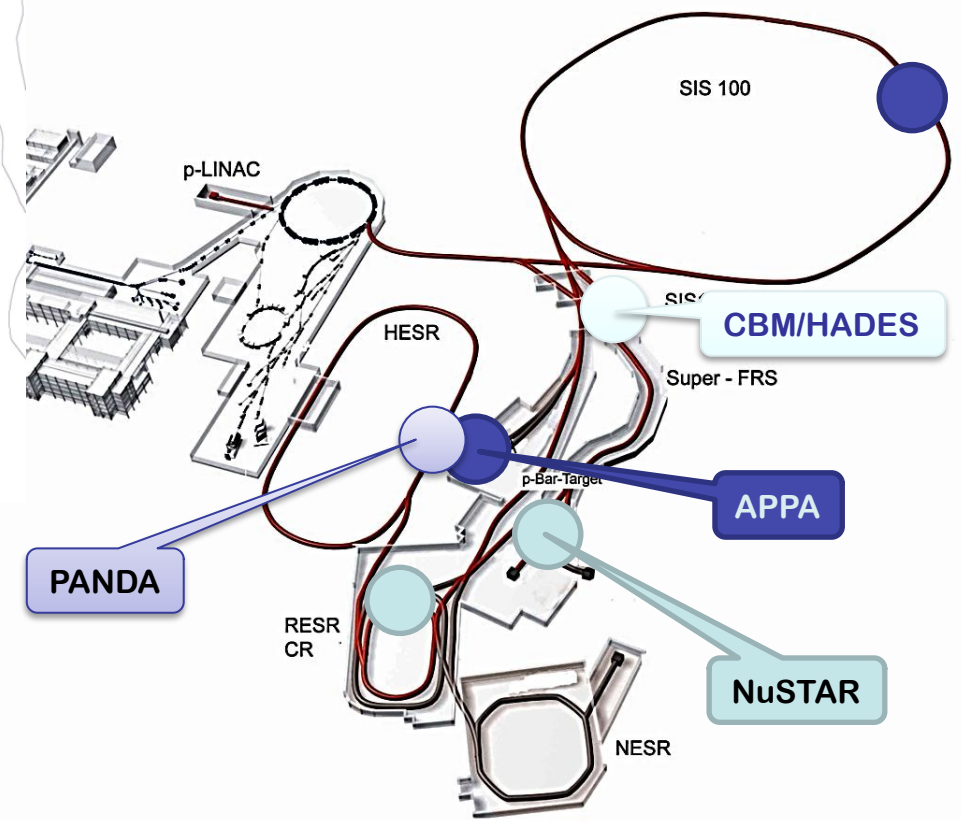


Current Status

Modularised Start Version



M0: SIS100



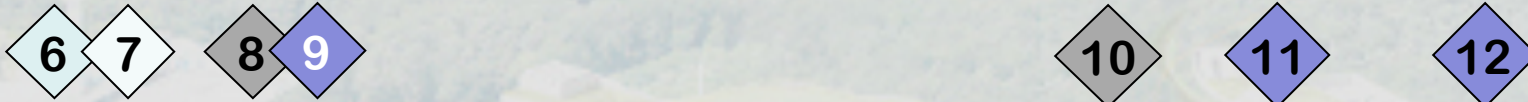
Experiments








- M1: APPA
- M1: CBM/HADES
- M2: NuSTAR
- M3: PANDA

Contracting Party	Contribution (in 2005 M€)
Finland	5.00
France	27.00
Germany	705.00
India	36.00
Poland	23.74
Romania	11.87
Russia	178.05
Slovenia	12.00
Sweden	10.00
Total	1.008,66

- **All numbers in 2005 € (escalation until 2018 ca. +50%)**
- **Spain expected to join soon (with 11.87 M€)**
- **China and the UK are potential Associate FAIR Members and will contribute to the experiments (6.6 M€)**

Timelines



-  **6** Submission building permits
-  **7** Site preparation
-  **8** Civil construction contracts
-  **9** Building of accelerator & detector components
-  **10** Completion of civil construction work
-  **11** Installation & commissioning of accelerators and detectors
-  **12** Data taking

First Post Drilling 31/8/2011



FAIR Construction Site 2012

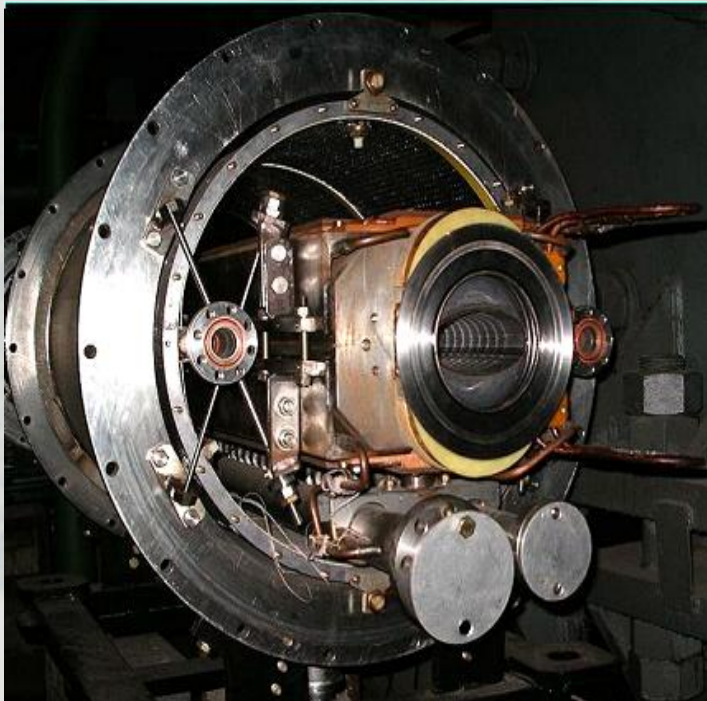


Preparatory Work

	02 / 12	03 / 12	04 / 12	05 / 12	06 / 12	07 / 12	08 / 12	09 / 12
Stripping of Topsoil (area tree felling)		➔						
Site Roads (Messeler Parkstr.)	➔							
Site Roads (southern traffic link)		➔						
Site Roads (northern traffic link)		➔						
Alternative routing pedestrian		➔						
Tender for pillars and site roads						➔		



Compact & cost effective
Fast cycling superconducting magnets
 $dB/dt \sim 4T/s$



- Ordered for SIS100 from Babcock Noell in Jan. 2012 (German in-kind contribution, BMBF grant to GSI)
- Many other parts of SIS100 and CR in preparation (in-kind or tender)
- HESR ready to go out for tender (BMBF grant through FAIR)
- IKRB meeting at FAIR on 9/10/12
- MAC meeting at FAIR on 26/11/12

First SuperFRS Magnet





Signing of the FAIR Convention by representatives of the founding countries Finland, France, Germany, India, Poland, Romania, Russia, Slovenia and Sweden in Wiesbaden on **4/10/2010**

Funding Early 2012

- Cheques
 - 50 M€
 - +Verbundforschung
 - 64+ M€



Funding July 2012

- 526 M€ for construction
 - largest BMBF grant ever

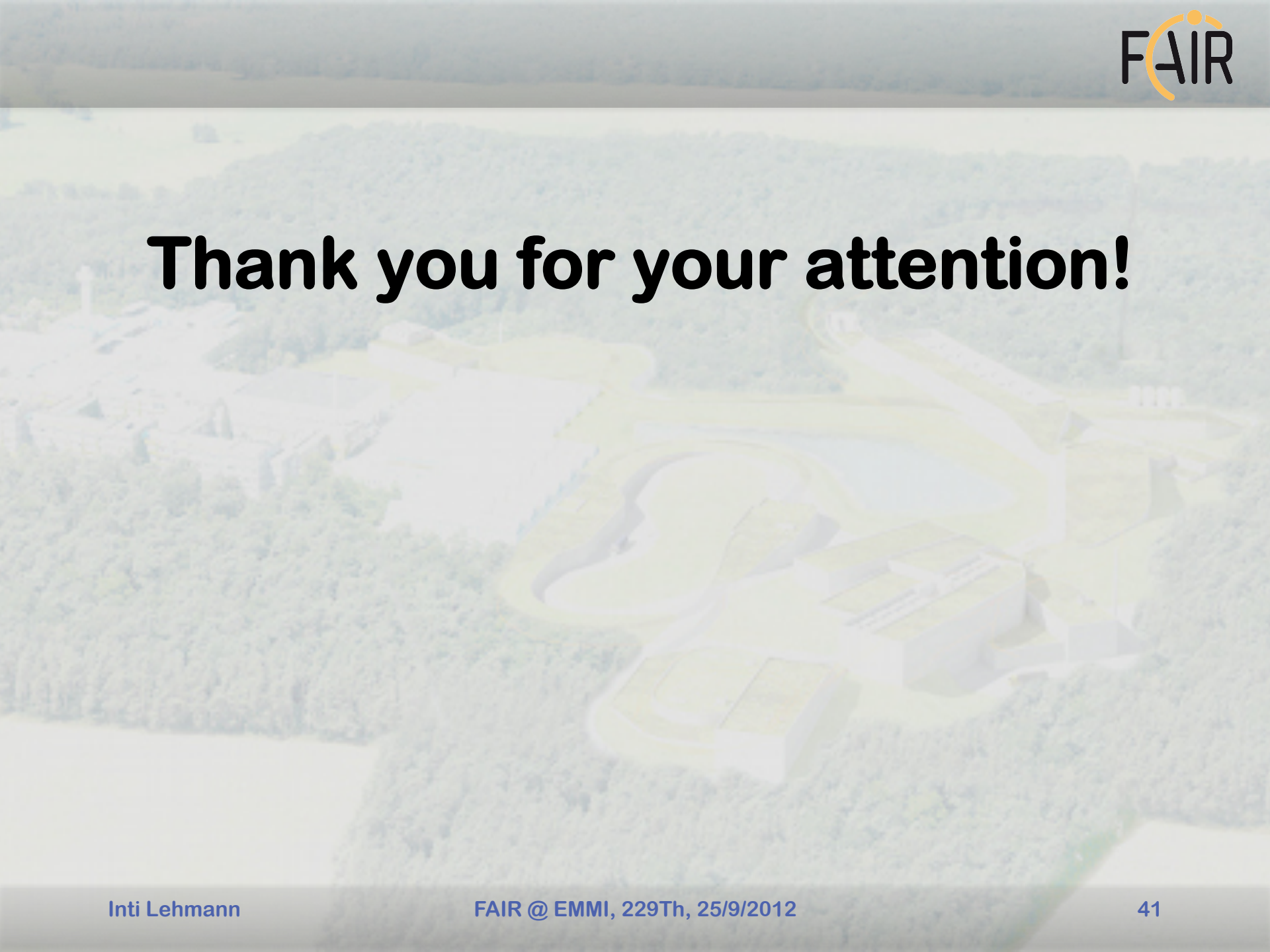


Funding July 2012

- 526 M€ for construction
 - largest BMBF grant ever



Now picking up speed!



Thank you for your attention!