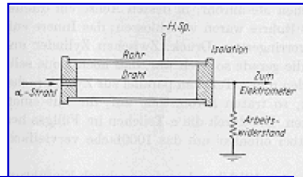


Eols related to RPCs, MPGDs

Silvia Dalla Torre, Beatrice Mandelli

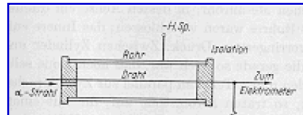


• Preliminary analysis

- EoIs related to *gaseous detectors (GD)*: **34** [related ≠ dedicated]
 - related to **RPCs**: **10**
 - related to **MPGDs**: **18**
 - related to **large volume** GDs and DCs: **6** (2 about drift chamber for HEP, 3 related to HPgTPC for ν physics, Dune near detector, 1 gas studies for DCs)

- A firm classification not always straightforward, f. i. :
 - R&D of GD for calorimetry application : *GD or calorimetry ?*
 - R&D of MPGDs for TPC read-out : *large volume GD of MPGD ?*
 - FE electronics for MPGDs, technology of analysis tool for tracking with GDs: *GD or electronics/data analysis?*

- **Strategy for this report:**
 - Include everything with appropriate comments, apart **large volume GDs & DCs** (different report)



... before starting

- The various proponents have interpreted the Eols prescription differently:
 - Very focused single tasks (sometimes spotting crucial items)
 - Extremely wide research program (sometime so wide to miss focusing power)
 - Well defined task(s) with a wide research program
- **The guidelines are not always followed:**
 - Number of participants (<2; >6)
 - Max total cost (> 600 k€)
 - Missing information (f.i., contact person of a participant)
- **Attitude:**
 - Try to underline the validity of a proposal, in any case
 - “broken rules” will be accounted for later

NOTE:

In the following the labels

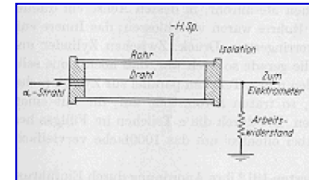
extension

or

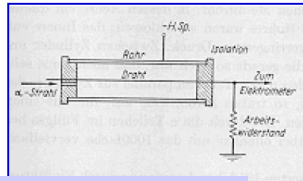
new

are set with reference to AIDA2020, not to world-wide R&D studies:

“new” is not always truly new



RPC



extension

- Eol 56:

Study of eco-friendly gas mixtures for Resistive Plate Chamber detectors

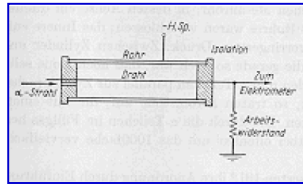
- Tests at GIF++, test beam, cosmics
- Extension with focus on eco-gas irradiation, recirculation and impurities
- of interest IF merged/synergic with novel RPC geometries and materials (Eols: 87, 153, ...)

- Eol 135:

GRPC Digitizer for Hadronic Calorimeter

new

- Glass RPC: simulating with GEANT4 of the signal formation
- SDHCAL applications, but MC approach and gas studies *make it of general interest*
- also in view of gas choice (eco-gasses) [cross-sections are NOT known ...]
- Possibility to merge/synergies with 58 (4-D SDHCAL) or 25 (ultra high res. MRPC by thin glass)

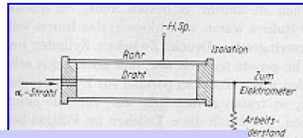


- Eol 33:

New materials for high rate (M)RPC

extension

- new materials: ceramics, low resistivity Bakelite, glasses and new plastics (also mentioned in 11 and 87)
- evaluating the resistivity (bulk, surface), homogeneity and ageing properties
- Method: by rate response and the ageing properties of small area (M)RPCs exposed to intense source/beams
- Merging with 11 (also overlap of Institutions) ?



extension

- Eol 11:

Development of innovative planar gaseous detectors with high time and spatial resolution, and improved rate capability for FCC

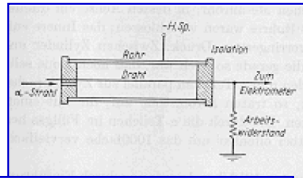
- RPC with lower resistivity for high rates ($O(10 \text{ kHz/cm}^2)$) (also mentioned in 87 and 33)
- sub-mm space resolution (strategy not specified)
- Large scale production
- also low-noise electronics included, both exploring what existing and considering the design of a new ASIC (detail missing)
- Very wide program, not yet well-focused, clarification and prioritization needed
- Merging with 33 (also overlap of Institutions) ?

- Eol 57:

New readout structure to read out large RPC detectors

new

- RPCs with pads for high rates
- new r-o scheme connecting pads in rows
- coordinate reconstructions thanks to the illumination of several adjacent pads
- Already tested on small-size detectors



- Eol 87:

RPCs for Medium High Rates

new

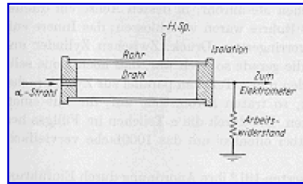
- 1 Khz/cm²
- cover large surfaces
- new materials for the resistive plate electrodes (also mentioned in 33 and 11)
- different gas gap widths different electrodes widths
- Appropriate for merging with 153 and/or 11?

- Eol 153:

100 kHz/cm² classic RPCs with ultimate time resolution working with inexpensive gases

new

- classic RPCs with inexpensive gasses
- new RPC design changing geometry (in particular, electrode thickness) and material resistivity
- Appropriate for merging with 87 ?



- Eol 58:

Timing for SDHCAL

new

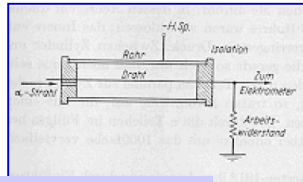
- In SDHCAL replacing RPCs with MRPCS for 5D imaging
- emphasis on new FE chip (new PETIROC), MRPC dedicated, for precise timing
- R&D related to “RPC&MPGD”, to calorimetry, to electronics ?

- Eol 25:

MRPCs for fast timing at high incident flux of charged particles

new

- MRPC with increased t-res (20 ps) and rate capability (50 kHz/cm²);
- thin low resistance glass needed for smaller gaps and increased n. of layers;
- 400um commercial gas (Picotech SAS) to be studied
- t-res dependence on gas flow to be studied
- Highly needed, in particular in the hadron physics experiments

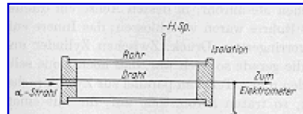


new

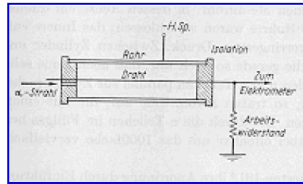
- Eol 12:

Innovative neutron gaseous detectors with solid converters and imaging capabilities

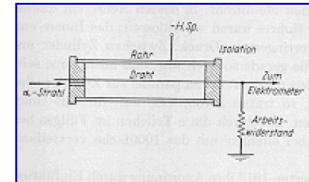
- n detection by MRPC with improved space, time res, rate capability, efficiency
- Converters: Gd (efficiency for thermal n) or ^{10}B (photon discrimination thanks to alpha emission)
- Also for HEP, added value in calorimetry, evaluation in situ of the n-contamination in muon detectors



- **2 innovative Eols where fine time resolution is the central parameter**
 - Different application field:
 - 5D imaging calorimetry 58, PID by TOF in extended systems 25
 - Both for applications highly required by the community: e+e- , h-physics
 - Common approach: MRPC
 - Different emphasis: electronics, new glass and geometrical configuration
 - Clearly distinct projects with synergic aspects
- **1 innovative Eol for n detection** 12
 - Certainly highly needed, less obvious for HEP applications
- **3 Eols dedicated to studies of general interest that can receive added values if merged within targeted projects**
 - extension respect to AIDA2020 (a part signal simulations which is new)
 - Eco-gasses, materials, signal simulation simulations 56, 33, 135
- **4 Eols dedicated to upgrades of the standard RPC**
 - A new idea: new read-out scheme (pads organized in rows) 57
 - Aiming at improved performance, also with elements present in more than one Eol → selection and merging needed 11, 87, 153

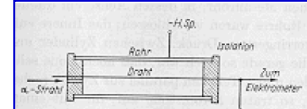


- **7 “new” Eols, 3 “extension” Eols**
 - Good variety of proposals, non-negligible “overlap” of items
- **Eols also related to other sectors**
 - Calorimetry: 58
 - Electronics: 58
 - PID (by TOF): 25
- **Mainly non-HEP applications: 12**
- **Frontier R&D: 25**
- **Synergies/merging (?)**
 - 56-87-153; 25-58-135; 11-33



ABOUT INSTITUTIONS & INDUSTRIES

RPC

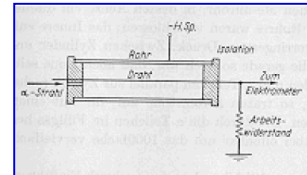


Eol	Institution	non EC institutions	Industries
56	INFN Bari, Bologna, Frascati, Roma2, Torino, CERN, Universiteit Gent		
135	IP2I Lyon, LPC		
33	LIP, Weizmann, CNRS-IP2I, HZDR, IGFAE, INFN Bari, Cosenza, Cagliari		
11	INFN Bari, Cosenza, Cagliari, Centro Fermi Rome, Polytechnic of Torino		
57	University of Lyon/CNRS, Gent University, CIEMAT	SJT University (China)	
87	INFN Roma2, Bologna		
153	INFN Roma2, INFN Bari, University of Ghent	Korea University – dept. of Physics	
58	University of Lyon/CNRS, Clermont-Ferrand, CNRS-Omega, CIEMAT	GWNU (Korea), SJT University (China)	
25	INFN Bologna, LIP, University of Clermont Ferrand	GWNU (Korea), Tsinghua University (China), Benemerita Universidad Autonoma de Puebla (Mexico)	Picotech SAS (FR)
12	INFN Bari, Cosenza, Centro Fermi Rome		

3 PIs	INFN Bari, CNRS Lyon
2 PIs	INFN Roma 2
1PIs	LIP, INFN Bologna

three times: GWNU (Korea)
twice: SJT (China)
ONCE: Tsinghua University (China), Benemerita Universidad Autonoma de Puebla (Mexico)

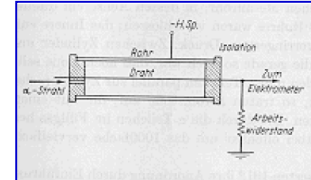
20 EC Institutions (good!), 4 non EC Institutions (good!), 1 industry recursive Institutions suggest some merging (as already mentioned)



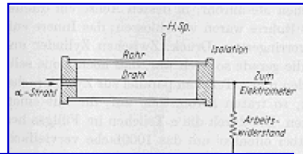
EC beneficiaries

Eol	CERN	GENT (B)	Centro Fermi (I)	CIEMAT (E)	CLERMONT-FERRAND (F)	INFN Bari (I)	INFN Bologna (I)	INFN Cagliari (I)	INFN Cosenza (I)	INFN Frascati (I)	INFN Roma2 (I)	INFN Torino (I)	HZDR (D)	IGFAE €	LIP (P)	LPC (F)	Lyon (F)	OMEGA (F)	Torino politecnico (I)	Weitzmann (IL)
56	1	1				1	1			1	1	1								
135																1	1			
33						1		1	1				1	1	1		1			1
11			1			1		1	1										1	
57		1		1													1			
87							1				1									
153		1				1					1						1			
58				1	1												1	1		
25					1		1								1					
12			1			1			1											

recursive Institutions require attention in preparing the proposal



MPGD



- **Eol 114:**

Development of resistive electrodes for MPGD detectors for future collider experiments

- for GEMs, MMs, uR-WELL
- Main motivation: spark protection = detector stability
- specific applications: photocathode, fully resistive MPGD, signal spread (space res.)
- Various material considered: **DLC, multilayer graphene**
- Synergies/merging with 126
- Complementary to 111

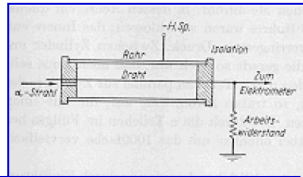
extension/new

new

- **Eol 126:**

Application of Diamond Like Carbon (DLC) coating in Gas Electron Multipliers (GEM) based detectors for future experiments and applications.

- **DLC in GEMS**
- extensive and complete set of studies: single foil protection, single foil sectorization, discharge mitigation, readout protection, low material budget and metal free electrodes, radiation hardness studies
- Synergies/merging with 114



- **Eol 111:**

Investigation & Mitigation of Discharges in MPGD detectors for future collider experiments

new

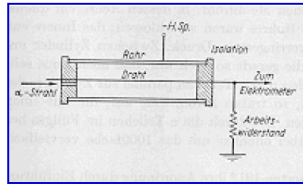
- Complete program to study discharges in GEMs & MMs
- Construction of dedicated acoustic, optical and e.m. antennas
- Simulations (important for deep understanding of discharge phenomena)
- Dependence on gasses and resistivity for MM
- Tests (also under n flux)
- Highly needed for HEP (intensity frontier)
- Complementary to 114

extension

- **Eol 160:**

Systematic quality testing of GEM and ThickGEM type detectors – “Leopard”, gain mapping, optical mapping

- “leopard” application to study the intrinsic properties of GEMs and THGEMs
- also support to producers with in-house studies of uniformity



- **Eol 85:**

R&D towards MPGD based SDHCAL for high radiation environments

new

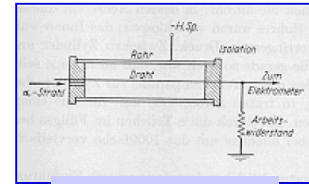
- To increase the rate capability of SDHCAL
- An idea on the table since a while
- Use of RPWELL (resistive plate WELL); also uR-WELL can be considered
- R&D related to “RPC&MPGD”, to calorimetry ?

- **Eol 161:**

Applied optical readout gaseous detectors

new

- MPGD optical read-out with commercial cameras
- **search for possible alternative to CF4**
- applications: beam monitoring, portable version for archeology, ...
- Not in competition with Eol 125

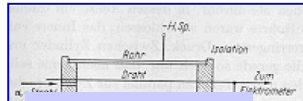


new

- **Eol 5:**

Development of a wide dynamic range, radiation hardness beam monitor based on μ -RWELL detector for use in future accelerators and hadron therapy

- Proposed as replacement of ionization chambers in beam monitoring based on uR-WELL :
 - Effective also at very low fluxes
 - Fundamental science and hadrotherapy
- R&D related to “RPC&MPGD”, to upgrade of infrastructures?



new

- **Eol 124:**

Precise fast timing (tens of psec) with large area segmented Micro Pattern Gaseous Detector: a scalable multichannel PICOSEC MicroMegas detector module

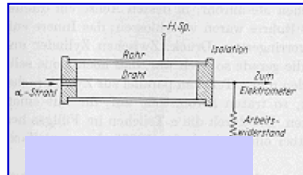
- progress of the picosec project: an engineered PICOSEC MM module scalable up
- photocathodes (protection for CsI and new materials)
- electronics (amplifiers, digitizers)
- Mechanics
- Frontier R&D

- **Eol 125:**

High-speed and time-resolved optical readout of MPGDs with FPGA-accelerated image processing and TimePix readout

new

- MPGD optical read-out
- high-bandwidth interfaces between ultra-high-speed cameras and FPGAs for real-time image processing
- in parallel, photodetection with Timepix3 ASIC
- optical read-out of TPCs; beam monitoring
- Frontier R&D



new

- **Eol 102:**

Pixelated Micromegas Detectors with Innovative Resistive Spark Protection System and Integrated Electronics for High Rates Applications

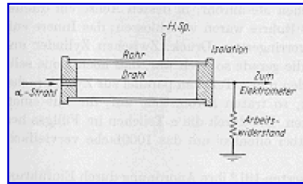
- MMs with minipads
- electronics on the rear face, new anode structure to develop
- applications:
 - pre-shower for an electromagnetic calorimeter
 - muon tracking
 - readout layer of a Time Projection Chamber

- **Eol 120:**

GAseous deteCtOrs for time taGged Neutrino bEams (GASCOIGNE)

- ν -physics
- photon veto using RD51 psec principle (Eol 124)
- prototype of realistic size to be tested at CERN-PS
- Also suitable electronics
- R&D related to “RPC&MPGD”, to ν -physics ?

new

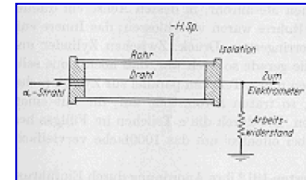


new / extension

- Eol 24:

Photon detectors for hadron particle identification at high momenta with compact RICHes

- Upgraded hybrid MPGD-based single photon detectors
- Comparatively considered: Solid-state (commercial SiPM) and vacuum-based (MPC: LAPPD) single photon detectors
- Both for compact (= short in length) RICHes for high p (> 10 GeV/c)
- Answering one of the major quests in hadron physics
- R&D related to “RPC&MPGD” & to “PID”



- **Eol 106:**

Development of high performance readout electronics for gas detectors

- main requests: designed for MPGDs, radiation tolerant
- new ASIC in CMOS technology, designed using EDA tools
- development of firmware
- An analysis of what exists and what is been developed is missing
- R&D related to “RPC&MPGD”, more to electronics ?

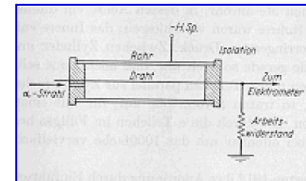
new

- **Eol 127:**

High throughput MPGDs Readout System based on SRS/VMM3a for laboratory, test beam and small-medium size experiment

- Dedicated DAQ system
- High throughput not available in SRS !

new



- **Eol 51:**

Development and characterisation of integrated electronics for the readout of pixelated μ RWELL detectors

- development of ASIC for μ R-WELL
 - ASIC connected to sensor via flip-chip assembly
- Development of dedicated firmware and software
- R&D related to “RPC&MPGD”, more to electronics ?

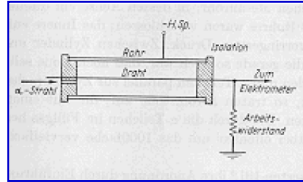
new

- **Eol 62:**

Development of Machine Learning algorithms for Micro Pattern Gaseous Detectors

- Development of ML methods tested by MC data samples
- R&D related to “RPC&MPGD”, to software ?

new

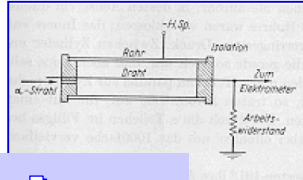


- Eol 147:

UV photocathode characterization and aging test facility for Timing and Particle Identification (RICH) applications at CERN

new

- Characterization of (UV) photocathode
- Absolute QE measurements
- A crucial facility for progress of MPGDs as Psec, for PID photon detectors
- R&D related to “RPC&MPGD” & to “PID”

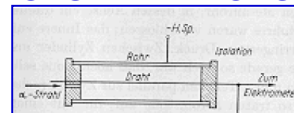


extension

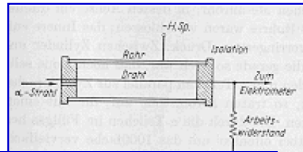
• Eol 52:

Industrial engineering of high-rate μ -RWELL detectors with bi-dimensional readout

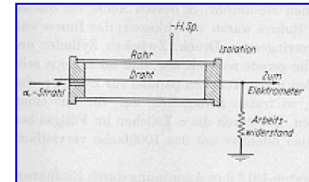
- TT of the high-rate version of μ R-WELL
- Answering to one of the major request in the MPGD sector



- **5 Eols dedicated to novel detectors, relevant perspectives for future exp.s**
 - **MPGD Psec** (HiLumi LHC and beyond) 124
 - **Fast optical read-out of MPGDs** (TPC r-o, beam monitoring) 125
 - **far UV single photon detectors for PID** (compact high p RICHes, EIC and flavor physics) 24
 - **Pixelized MMs with embedded FE** (tracking, calorimetry) 102
 - **Psec photon veto for ν -physics** 120
- **4 Eols dedicated to studies of general interest to improve MPGDs**
 - Resistive materials, DLC GEMs, discharge studies \rightarrow **presently at focus** 114, 126, 11
 - Uniformity study with Leopard (also for industrialization) 160
- **3 Eols dedicated to MPGD applications:**
 - **HEP:** beam monitoring by uR-WELL (also for facilities) 5 , SDHCAL by RPWELL 85
 - **Other appl.s:** optical r-o by commercial cameras 161
- **5 Eols dedicated to Tools**
 - 2 dedicated to novel FE ASIC + ... (*rationalization needed !!!, electronics chapter ?*) 51, 106
 - Fast DAQ for VMM3a (needed by the community) 127
 - Facility for photocathode characterization (also highly needed by PID) 147
 - ML (*software chapter?*) 62
- **1 Eol dedicated to industrialization**
 - uR-WELL for high rate \rightarrow **major relevance** 52

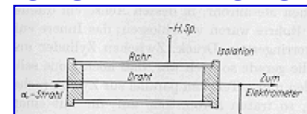


- **15 “new” Eols, 1 “extension” Eols, 2 “new/extension” Eols**
 - great variety of proposals, limited “overlap” of items
- **Eols also related to other sectors**
 - Calorimetry: 85
 - Electronics: 51, 106
 - PID: 24, 147
 - Software: 62
 - ν -physics: 120
- **Mainly non-HEP applications: 5, 161**
- **Frontier R&D: 102, 124, 125, 24**
- **Synergies/merging (?)**
 - 114-126



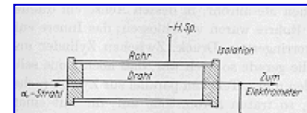
ABOUT INSTITUTIONS & INDUSTRIES

MPGD



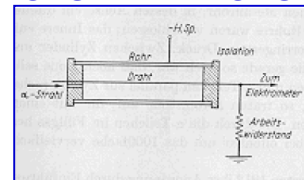
Eol	Institution	non EC Institutions	Industries
114	INFN-BA (Uni-Ba, CNR-Nanotec, CNR-IFN), CERN, INFN-LE (Uni-Sal), INFN-PV (Uni-PV, Uni-BG)		Techtra (PL)
126	CERN (EP-DT-DD GDD), CERN (EP-DT-EF MPT), IFPILM, AGH UST,	USTC (China), KOBE (JP)	
111	INFN (Bari, Napoli, Pavia, Roma3), CERN, TUM, University of Wurzburg		
160	Wigner Research Centre for Physics (Wigner RCP)		
85	Weizmann, Technion		
161	Wigner Research Centre for Physics (Wigner RCP)		
5	INFN-Frascati		CAEN (IT), ELTOS (IT)
124	CERN, IRFU/CEA, HIP, AUTH		CA ATELEC (FR)
125	CERN, CTU, HIP, IRFU/CEA		
102	INFN (Roma Tre, Napoli), CERN		ELTOS (IT)
120	INFN Padova, INFN Milano Bicocca, UNIPD, University of Milano Bicocca		
24	INFN Trieste, Bari, Charles University (CZ)	USTC (China)	Incom Inc (USA)
106	INFN (BA, PV, UniPV, UniBG)		
127	CERN, ESS		SRS Technology (CH)
51	INFN Ferrara, Bologna, LNF, Torino		
62	INFN Ferrara, Bologna, LNF		
147	CERN, HIP Helsinki Institute of Physics	USTC (China)	
52	INFN Frascati, Bologna, Ferrara, CERN		ELTOS (IT)

26 EC Institutions (good!), 2 non EC Institutions, 5 (+1) industries (good!) recursive Institutions suggest some merging (as already mentioned)



Eol	Institution	non EC Institutions	Industries
114	INFN-BA (Uni-Ba, CNR-Nanotec, CNR-IFN), CERN, INFN-LE (Uni-Sal), INFN-PV (Uni-PV)		Techtra (PL)
126	CERN (EP-DT-DD GDD), CERN/EP		
111	INFN (Bari, Ferrara, Frascati, Genova, Padova, Roma Tre, Roma, Trieste, Torino)		
5 PI's	CERN		
3 Pls	INFN Bari		
2 Pls	Wigner, INFN-LNF, INFN-FE		
1 Pls	Weizmann, INFN-RM3, INFN-Trieste, INFN-Padova		
124	CERN, IRFU, INFN-Frascati	three times: USTC (China)	CAEN (IT), ELTOS (IT) CA ATELEC (FR)
125	CERN, CTU, INFN-Ferrara	once: Kobe (Japan)	
102	INFN (Roma Tre, Napoli), CERN		ELTOS (IT)
120	INFN Padova, INFN Milano Bicocca, UNIPD, University of Milano Bicocca		
24	INFN Trieste, Bari, Charles University (CZ)	USTC (China)	Incom Inc (USA)
106	INFN (BA, PV, UniPV, UniBG)		
127	CERN, ESS		SRS Technology (CH)
51	INFN Ferrara, Bologna, LNF, Torino		
62	INFN Ferrara, Bologna, LNF		
147	CERN, HIP Helsinki Institute of Physics	USTC (China)	
52	INFN Frascati, Bologna, Ferrara, CERN		ELTOS (IT)

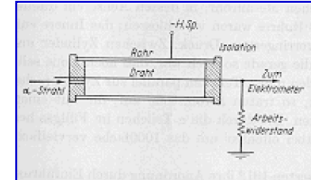
26 EC Institutions (good!), 2 non EC Institutions, 5 (+1) industries (good!) recursive Institutions suggest some merging (as already mentioned)



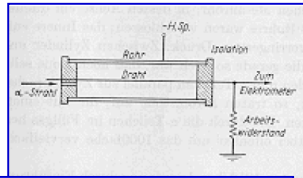
EC beneficiaries

Eol	AGH UST (PL)	AUTH (GR)	CERN Charles University (CZ)	CTU (CZ)	ESS	IFPILM (PL)	INFN Bari (I)	INFN Bologna (I)	INFN Ferrara (I)	INFN Lecce (I)	INFN Frascati (I)	INFN Milano Bicocca (I)	INFN Napoli (I)	INFN Padova (I)	INFN Pavia (I)	INFN Roma3 (I)	INFN Torino (I)	INFN Trieste (I)	HIP (FI)	SACLAY (F)	TECHNION (IL)	TUM (D)	Weitzmann (IL)	Wieger RPC (H)	Wurzburg (D)
114			1				1			1					1										
126	1		2			1																			
111	1						1						1		1	1						1			1
160																									1
85																					1		1		
161																									1
5											1														
124		1	1																1	1					
125			1		1														1	1					
102			1										1			1									
120												1		1											
24				1			1												1						
106							1								1										
127			1		1																				
51								1	1		1							1							
62								1	1		1														
147			1																1						
52			1					1	1		1														

recursive Institutions require attention in preparing the proposal



ABOUT MONEY



- **Organizational questions to be addressed:**
 - EoI relative to which WP ?
- **Political questions to be addressed:**
 - How much space for non-HEP applications?
- **Indication of money also implies a judgement, while this is a comprehensive report ...**
- **Therefore, just a feeling**
With some guessing about these points and using criteria similar to AIDA2020, ~ 1-1.5 M€
(according to how much is moved elsewhere)